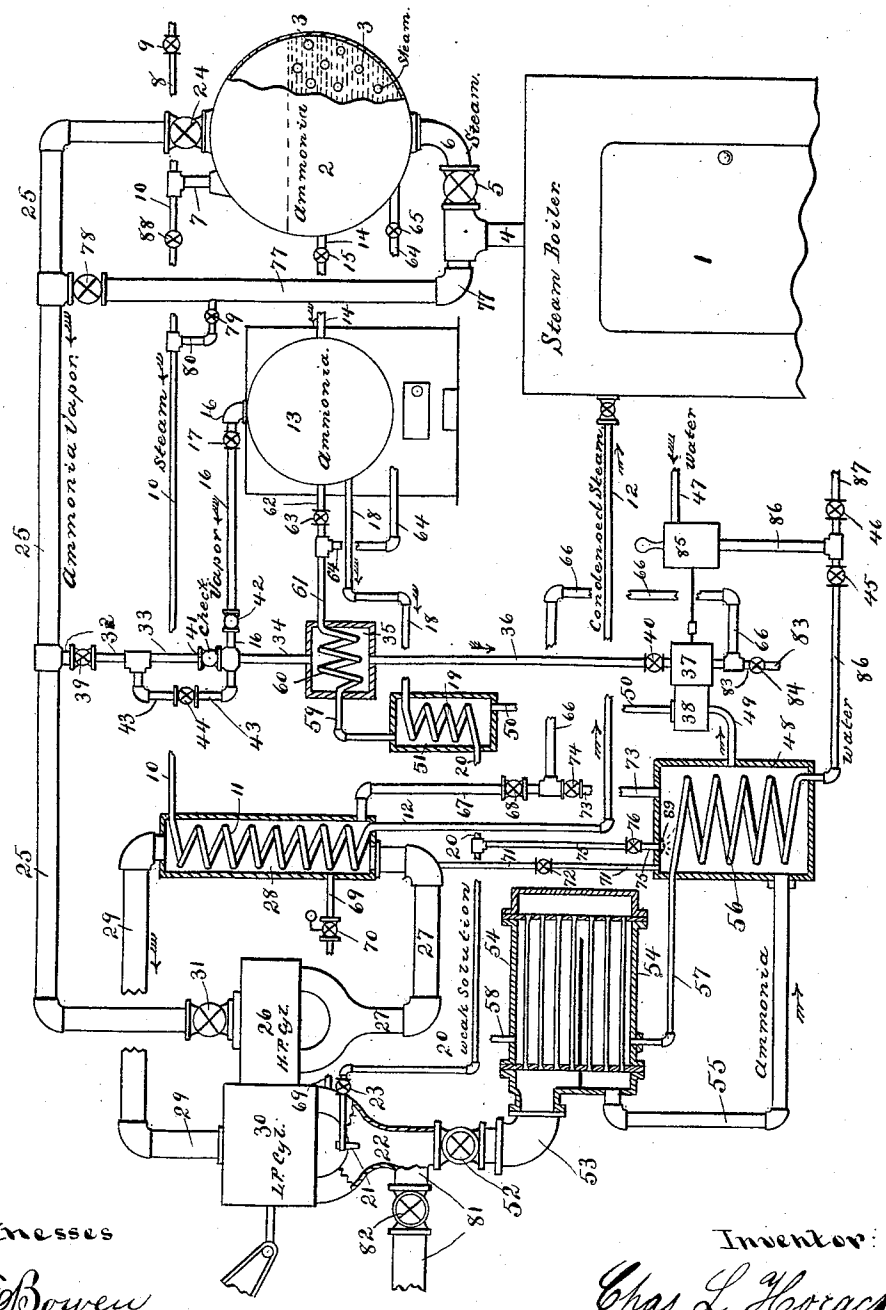
(No Model.)

C. L. HORACK.

METHOD OF AND APPARATUS FOR OPERATING AQUA-AMMONIA ENGINES.

No. 453,444. Patented June 2, 1891.



Witnesses

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METHOD OF AND APPARATUS FOR OPERATING AQUA-AMMONIA ENGINES.

SPECIFICATION forming part of Letters Patent No. 453,444, dated June 2, 1891.

Application filed January 2, 1890. Renewed March 14, 1891. Serial No. 385,008. (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in a boiler or generator by heat, and the gas, after propelling the piston of an engine, is reabsorbed by weak liquid withdrawn from such boiler and cooled, exhaust-gas and absorbing-liquid being thereupon returned jointly to such boiler or generator.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 efficiency of an ammonia-engine by employing a strong solution, from which the gas for operating an engine may be expelled while obtaining a very weak solution for purposes of absorption, and by combining in an apparatus having two engines and two ammonia-boilers either engine with either ammonia-boiler, so as to obtain the best possible results, according to the requirements of the case; to promote the circulation of the steam used as heating agent for the aqua-ammonia while applying the heat remaining in the steam after it leaves the ammonia-boiler to the vapor operating the engine; to regulate the pressure in a compound aqua-ammonia engine, and to dispose of the liquid which may reach parts of the same, and to be able to substitute, promptly, steam in the engine-cylinder in the place of ammonia-gas without being obliged to withdraw the aqua-ammonia from the ammonia-boiler. In order to accomplish these objects, I subject the absorbing-liquid to a second heating after its having passed through an ammonia-boiler, thereby further freeing it from ammonia-gas, which gas is used for propelling an engine, while the remaining liquid, after being cooled, is used for reabsorbing the exhaust-vapor. I further so connect two ammonia-boilers with each other and with an engine and with the absorbing apparatus of an engine as to be capable of either running the two ammonia-boilers jointly, using the second boiler as heater for liquid that has first passed through the first boiler, or else to be able to use either of the two boilers independently for generating power. I further, in an apparatus having two ammonia-engines, of which one is of the compound type, while the other has a single cylinder, so connect the exhaust-pipe of the last-named engine as to make it capable of discharging its vapor either directly into an absorbing apparatus or else into passages leading to the low-pressure cylinder of the compound engine. I further so discharge the absorbing-liquid into the absorbing apparatus and so arrange suitable valves therein as to be capable of operating one of the engines with ammonia, while keeping the other engine and its exhaust-pipe free from contact with ammonia. I further impart to ammonia-vapor while in transit between the admission and the exhaust ports of an engine heat from steam or from its water of condensation, which steam is also, or has also been, employed as heating agent in the ammonia-boiler. I further regulate the pressure in a compound engine by connecting the passage between its high-pressure and its low-pressure cylinder with the absorbing apparatus having a suitable automatic valve. I further run a pipe with suitable valve from said passage to the absorbing apparatus, so as to drain such passage of liquid when desired. I further provide proper pipe connections and valves between a steam-boiler, an ammonia-boiler, and an engine, and in the exhaust or absorbing appliances between the exhaust-ports of the engine and the receiving-well, so as to be able to change promptly from the use of ammonia-vapor in the engine to that of water-steam, and vice versa.

These and other features of my invention are more fully described in the following specification and are set forth in the claims.

In the accompanying drawings I have shown a side elevation, partly in section, of an ammonia-engine apparatus constructed according to my invention.

1 is a steam-boiler.

2 is an ammonia-boiler wherein aqua-ammonia is heated by steam circulating in it through suitable pipes 3 3, connected with suitable chambers at the ends of said am-

monia-boiler. Any other proper form of ammonia-boiler might, however, be used instead. The steam employed therein as heating agent enters the said ammonia-boiler through pipe 4, valve 5, and pipe 6, and leaves the same through pipes 7 and 8 when cock 9 in pipe 8 is open, or may be conveyed through pipes 7 10, coil 11, and pipe 12, so as to reach the liquid-space of boiler 1 in condensed condition.

13 is an additional ammonia-boiler provided with a separate furnace, so as to permit of heating its contents without depending upon the heat developed in the furnace of steam-boiler 1. Such ammonia-boiler 13 might, however, in addition, be provided with a coil or pipes conveying any other heating agent capable of imparting an increased temperature to liquid conveyed to it from ammonia-boiler 2, so as to perform additional heating of such liquid therein, if necessary, without the use of the furnace under said ammonia-boiler 13.

Ammonia-boilers 2 and 13 will hereinafter be termed "generators."

The pipe 14 carries from the lower part of generator 2 weak aqua-ammonia into generator 13, where further ammonia-gas, together with some water-vapor, will be expelled from said liquid by the heat applied to it therein. 15 is a cock in said pipe 14. The gas or vapor so developed in generator 13 will be discharged through pipe 16, having valve 17, near the top of said generator, while the remaining liquid will pass through pipe 18, coil 19, and pipe 20, which latter terminates in spray-jet 21 within exhaust-pipe 22 of the engine.

23 is a cock for regulating the flow of the liquid through pipe 20.

24 is the main valve for admitting ammonia-vapor from generator 2 to the main vapor-pipe 25, which pipe leads to the high-pressure cylinder 26 of a compound engine, from which the vapor, after propelling the piston therein, passes through pipe 27 into the reservoir 28 on its way to pipe 29 and low-pressure cylinder 30, from which, after propelling its piston, it is exhausted into exhaust-pipe 22.

31 is the throttle-valve of the engine.

Through pipes 32 33 34, casing 35, and pipe 36, vapor may be conveyed from main vapor-pipe 25 to feed-pump 37 38 for propelling the piston of its vapor-cylinder 37.

39 is a cock in pipe 32, and 40 a cock in pipe 36, while 41 is a check-valve in pipe 33, closing upward. Pipe 16 connects with pipes 33 and 34 and contains a check-valve 42, closing toward generator 13.

43 is a by-pass around check-valve 41 and contains a cock 44. It will be seen that when cock 44 is closed and cock 39 is open check-valve 41 will be opened and check-valve 42 will be closed when the pressure in main vapor-pipe 25 exceeds that in generator 13, thus causing vapor from pipe 25 to be supplied to pump-cylinder 37, the cock 40 then being open, while the vapor leaving generator 13 when its pressure exceeds that in pipe 25 will open valve 42 and close valve 41, and will thus pass to pump-cylinder 37. I thereby at all times secure a sufficient supply of vapor for pump-cylinder 37, which, in addition to operating the piston in feed-pump cylinder 38, is also shown to be connected with the cylinder 85 of a water-pump, which pump, in addition to supplying cooling-water through pipe 86 for the absorbing apparatus, may also be employed to supply water through branch pipe 87 for general purposes.

45 is a cock in pipe 86, and 46 a cock in pipe 87.

47 is the suction-pipe of said pump.

While it is desirable to propel the pistons in the main engine as far as practicable with gas developed in generator 2, which gas will be freer from water-vapor than that developed in generator 13, it may happen that vapor will be developed in generator 13 faster than pump 37 requires. Immediate relief can then be had by opening temporarily cock 44, thus discharging said vapor through by-pass 43 into main vapor-pipe 25 until such development of vapor in generator 13 can be checked.

The absorbing-liquid, in order to cool it properly, may be deprived of part of its heat by having feed-pump cylinder 38 discharge the cool feed-liquid withdrawn from well 48 through suction-pipe 49 by means of discharge-pipe 50 into casing 51, which surrounds and incloses coil 19, through which said absorbing-liquid passes. In addition cooling-water, refrigerating-gas, or brine or other suitable means might be employed for further lowering the temperature of such liquid, as the lower such temperature is where the liquid meets the exhaust-vapor the greater an amount of gas will be absorbed at once and the better will be the vacuum obtained in the exhaust-pipe of the engine, and consequently in the low-pressure cylinder 30. After exhaust-vapor and absorbing-liquid have been brought in contact with each other in exhaust-pipe 22 they pass downward through valve 52, pipe 53, the tubes and passages in an absorber 54, and pipe 55 into receiving-well 48, being subjected on their way to repeated cooling operations in absorber 54 and well 48, in order to carry off the heat of absorption which is constantly being developed as the gas is gradually being taken up by the liquid. The cooling-liquid is supplied by pipe 86, passing through coil 56 in well 48, pipe 57, around the tubes in absorber 54, and leaving such absorber through pipe 58. The result of the repeated coolings described will be to impart to the contents of well 48 a low temperature, which makes the liquid withdrawn from said well and forced into casing 51 particularly suitable to act as a cooling medium therein.

I do not claim any novelty in regard to the absorbing appliances employed by me, and would state that any other form of absorber suitable for combining ammonia-gas and ab-

sorbing-liquid might be substituted for absorber 54.

The feed-liquid after leaving casing 51 is forced through pipe 59, coil 60, and pipe 61, reaching either generator 13 through pipe 62 when cock 63 therein is open, or generator 2 through pipe 64 when cock 65 is open. When cock 15 in pipe 14 is closed, generator 13 may be heated and vapor may be expelled therein from the liquid supplied through pipe 62 for the purpose of operating pump 37 38 85 independent of generator 2, owing to the independent feed-pipe provided for each generator, as described above. This is an advantage, particularly at times where there is no occasion for running the main engine. The feed-liquid while passing through coil 60 in casing 35 receives heat from the vapor entering said casing through pipe 34. Such transfer of heat may be particularly of advantage where the exhaust from cylinder 37 is carried directly to the absorbing apparatus, as mentioned hereinafter, as said vapor, when coming from generator 13, will have a higher temperature than the vapor in pipe 25 and as not as great a range of temperature is called for in operating the piston in cylinder 37 as there is required for operating the high-pressure and the low-pressure cylinder of the main engine.

When generator 13 is not heated, its interior simply acts as a part of the system of pipes and passages conveying absorbing-liquid from generator 2 to the absorbing-jet, and therefore in such case the same results would be obtained if the said liquid by means of a by-pass with suitable valves were conveyed from pipe 14 to pipe 18 around generator 13, instead of through the same.

66 is the exhaust-pipe of cylinder 37, and is connected by pipe 67, having cock 68, with reservoir 28, through which also passes the vapor in transit from high-pressure cylinder 26 to low-pressure cylinder 30. By adding there the exhaust-vapor of pump-cylinder 37 to that from cylinder 26 I am enabled to use such exhaust-vapor again in low-pressure cylinder 30, thus making pump-cylinder 37 a complement to high-pressure cylinder 26. This is desirable, as it would be impossible to utilize in the small vapor-cylinder of said pump the great range of temperatures which the high degree of heat imparted to the vapor in the generator and the low temperature at which ammonia-gas liquefies under moderate pressure permits of. As the amount of the exhaust-vapor from pump-cylinder 37 so discharged into reservoir 28 might cause injurious back-pressure on cylinder 26, I connect said reservoir with exhaust-pipe 22 by means of pipe 69, containing weighted valve 70, which valve is adjusted to open when a certain pressure is reached in reservoir 28, thus discharging automatically the excess of vapor through said pipe into the exhaust-pipe of the main engine, where it will be absorbed and carried with the spraying-liquid toward well 48. Such relief-pipe 69 might, however, be connected with any other suitable part of the absorbing apparatus instead of with the exhaust-pipe near the engine.

The vapor developed in generator 13, which vapor principally serves to propel pump 37 38, is apt to contain much more water-vapor in proportion than that developed in generator 2. As this, as well as the carrying over with the gas of water and water-vapor passing through cylinder 26, might eventually result in the accumulation of water in reservoir 28 and pipe 27, I provide the drip-pipe 71 with cock 72 between the same and well 48.

When the larger engine 26 30 is not in operation or is operated by steam, as mentioned hereinafter, it is still possible to operate pump 37 38 85 by ammonia-vapor from generators 13 and 2, discharging, however, its exhaust into well 48 through pipe 73, cock 74 in said pipe being then open and cock 68 being closed.

75 is a spray-pipe branching out from pipe 20, which conveys absorbing-liquid into well 48 through spray-nozzle 89 when cock 76 is open. The liquid so discharged serves not only to absorb such gas, which may pass in a free condition upward through the body of liquid in said well, but may also be utilized to absorb the vapor entering said well through pipe 73, particularly when cock 23 and valve 52 are closed, which will take place when engine 26 30 is not being operated by ammonia-vapor.

As it may happen that some part of the apparatus employed in generating the ammonia-gas or in reabsorbing the same after its passage through the engine-cylinder may become defective while the engine is in operation and require prompt repairing and that a leak may occur in any part of the apparatus, thus causing loss of ammonia as well as inconvenience on account of the penetrating smell of the escaping gas, I provide means for substituting promptly in the engine-cylinder steam in the place of ammonia and to dispose of the exhaust-steam without being obliged to withdraw the aqua-ammonia from the generators or from the spray-pipe, the receiving-well, or other parts of the apparatus intended to contain ammonia only. For such purpose I provide the main steam-pipe 77, leading into and connecting with the main vapor-pipe 25, a proper valve 78 being placed at the point of connection. By closing valves 5 and 24 and cocks 68 and 39 I at once prevent any further passage of steam through generator 2 and of ammonia-gas into pipe 25 and into engine 26 30, and I so deprive said engine of its supply of vapor. I am, however, still able to operate the pumps by vapor developed in generator 13 and to draw absorbing-liquid from said generator, cool it, and discharge it through nozzle 21 for the purpose of absorbing ammonia-gas still contained in exhaust-pipe 22 and for the further purpose of reducing the pressure in generator 2 by forcing the cooled solution back into the same. The closing

of valves or cocks 23 and 52 will, however, completely exclude ammonia-vapor from contact with any part of the main engine, thus leaving it in proper condition to be operated by steam. By opening valve 78 I am now enabled to direct steam from boiler 1 through pipes 4, 77, and 25 to engine-cylinders 26 and 30, exhausting the same into pipe 22. By connecting pipe 10 with pipe 77 and providing a suitable cock 79 in the connecting-pipe 80 steam may be supplied to coil 11 for superheating the contents of reservoir 28 whether the engine be operated with ammonia or steam. When operated by steam, cock 88 in pipe 10 would have to be closed. The exhaust-steam will leave pipe 22 through pipe 81, valve 82 in said pipe being then open. Pipe 81 would either exhaust the steam into the atmosphere or into a suitable condensing apparatus, such as commonly employed in connection with steam-engines. It would also be feasible to substitute steam for ammonia-gas in cylinder 37 by opening valve 39, closing valves 17 and 74, and discharging the exhaust-steam through pipe 83 with proper valve 84 either into the atmosphere or into a steam-condensing apparatus.

It will readily be seen that in order to change from the use of steam in either engine back to that of ammonia the operations described above as to opening and closing certain valves would have to be reversed Excepting where in the following claims the engine is particularly referred to as being of the compound type, a single-cylinder engine or a rotary engine might be substituted.

Instead of utilizing part of the heat of the steam which circulates through the generator for also heating the contents of reservoir 28, such heat might instead be applied in the jacket of an engine-cylinder, or, where the engine is of the compound type, in jackets of either one or both of its cylinders, so as to make up, while the vapor is in transit through the engine, for all or for a part of the heat converted therein into work.

By running a pipe having a proper valve from steam-pipe 77 to cylinder 37 direct auxiliary engine 37 38 85 could be propelled by steam while the main engine was being operated by ammonia.

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

1. The method herein described of heating aqua-ammonia in a generator and expelling from it gas for operating an engine, thus weakening the solution originally fed into it, withdrawing part of the liquid from said generator, and further reducing it in strength by subjecting it to additional heating, thus expelling additional gas therefrom and operating a second engine by means of said additional gas, withdrawing the remaining weak solution and conducting it to an apparatus where exhaust-vapor and weak solution are reunited, substantially as set forth.

2. The method herein described of heating aqua-ammonia in a generator, thus weakening the solution originally fed into it by expelling from it part of its gas, withdrawing part of the liquid from said generator, subjecting it to additional heating in a second generator, thereby expelling additional gas for use in an engine, and further reducing the strength of the liquid and supplying automatically gas to said engine from the first generator when the pressure therein exceeds that in the second generator and discharging the remaining weak solution from the second generator, substantially as set forth.

3. The method herein described of expelling gas from aqua-ammonia in a generator, withdrawing part of the liquid so weakened and heating it in a second generator, thus generating additional gas, and reabsorbing the gas from both generators, after having passed the same through an engine or engines, in an absorbing apparatus, wherein the gas developed in both generators is brought in contact with the weak solution withdrawn from said second generator and cooled, substantially as set forth.

4. In an aqua-ammonia-engine apparatus provided with two generators for consecutively heating aqua-ammonia and expelling gas therefrom, the method herein described of utilizing the second generator exclusively, which consists in withholding the feed-liquid from the first generator while conveying it to said second generator, heating it therein after closing the connection between the first and second generators, and withdrawing weak solution from such second generator while the heating is proceeding therein, substantially as set forth.

5. In an aqua-ammonia-engine apparatus provided with two generators for consecutively heating aqua-ammonia, the method herein described of utilizing one of said generators only, which consists in introducing the feed-liquid into said generator and heating it therein after closing the connections between said generators and withdrawing from the generator so heated gas and absorbing-liquid for operating an engine, substantially as set forth.

6. The method herein described of heating aqua-ammonia in a generator, thus expelling gas from it, withdrawing part of said liquid and subjecting it to additional heating to further free it from gas, and imparting heat of the gas expelled by the second heating operation to the feed-liquid, substantially as set forth.

7. The method herein described of heating aqua-ammonia in a generator and expelling from it gas for operating a compound ammonia-engine, withdrawing part of the liquid thus weakened and heating it in a second generator, thus expelling additional gas, and passing gas from said second generator into a chamber between the high-pressure and low-pressure cylinders of the engine for use in said low-pressure cylinder, and absorbing

the exhaust-vapor from said low-pressure cylinder by liquid withdrawn from the generators and cooled, substantially as set forth.

8. The method herein described of expelling ammonia-gas from aqua-ammonia in a generator for propelling the piston of an engine-cylinder, expelling ammonia-gas from aqua-ammonia in a second generator for propelling the piston of a second engine-cylinder, using the exhaust-vapor of both cylinders combined for operating the piston of another and low-pressure cylinder, and absorbing the exhaust-vapor from said low-pressure cylinder by cooled weak solution withdrawn from one of the generators, substantially as set forth.

9. The method herein described of operating the pistons of two engine-cylinders with vapor of ammonia, using exhaust-vapor from both cylinders for operating the piston of a low-pressure cylinder, and absorbing the exhaust-vapor from said low-pressure cylinder by means of cooled weak solution withdrawn from a generator, substantially as set forth.

10. In a compound aqua-ammonia-engine apparatus having a second high-pressure cylinder operated by ammonia-gas and supplying its exhaust-vapor to the low-pressure cylinder of the compound engine, the method herein described of operating such second high-pressure cylinder independently of such low-pressure cylinder, which consists in closing the connection between the exhaust-pipe of said second high-pressure cylinder and the vapor-supply pipe of the low-pressure cylinder and opening a connection between the exhaust-pipe of said second high-pressure cylinder and an apparatus wherein the exhaust-vapor is absorbed by liquid withdrawn from the generator wherein the ammonia-gas was expelled from aqua-ammonia, substantially as set forth.

11. The method herein described of producing ammonia-gas in a generator by heating aqua-ammonia contained therein by steam from a steam-boiler, propelling the piston of a high-pressure cylinder by such gas, superheating the exhaust-vapor from said cylinder by the steam employed for heating said aqua-ammonia or by the water of condensation resulting from such employment of the steam in the generator, and afterward propelling the piston of a low-pressure cylinder with such superheated ammonia-vapor, substantially as set forth.

12. The method herein described of producing ammonia-gas in a generator by heating aqua-ammonia contained therein by steam and imparting also heat of such steam or of the water of condensation resulting from such employment of the steam in the generator to the ammonia-gas while in transit between the admission-valve of the engine and its exhaust-ports, substantially as set forth.

13. In aqua-ammonia engines, the method herein described of operating two high-pressure cylinders with mixtures of ammonia-gas and water-vapor, the constituents of said mixtures being in different proportions in said two cylinders, and afterward combining and mixing the exhaust gases and vapors of both said high-pressure cylinders for the purpose of passing the same through a low-pressure cylinder, substantially as set forth.

14. The method herein described of regulating the operation of an ammonia-engine having a high-pressure and a low-pressure cylinder, in combination with an auxiliary engine or a pump propelled by vapor of ammonia, which consists in passing vapor of ammonia through such high-pressure cylinder and passing other such vapor through the cylinder of said auxiliary engine or pump, and afterward passing the exhaust-vapor from said two cylinders combined into a reservoir for supplying vapor to the low-pressure cylinder aforesaid and adjusting the pressure in said reservoir by employing excessive pressure therein to automatically open a passage leading into an apparatus where such excess of gas is reabsorbed by liquid withdrawn from the generator and cooled, substantially as set forth.

15. The method herein described of regulating the pressure in a compound aqua-ammonia-engine apparatus, which consists in passing the ammonia-vapor through the high-pressure cylinder into a reservoir for supplying the low-pressure cylinder, and discharging any surplus vapor and relieving said reservoir or the low-pressure cylinder of excessive pressure automatically into an apparatus wherein such excess of gas is reabsorbed by liquid withdrawn from the generator for the purpose of absorbing the exhaust-vapor of the engine, substantially as set forth.

16. The method herein described of arresting the passage of liquid ejected from the high-pressure cylinder of a compound aqua-ammonia engine, which consists in conducting such liquid from the passage between the high-pressure and the low-pressure cylinder into a well which receives the exhaust-vapor of the engine combined with absorbing-liquid withdrawn from the generator, substantially as set forth.

17. The method herein described of preventing the passage of liquid ejected from the high-pressure cylinder of a compound aqua-ammonia engine into the low-pressure cylinder, which consists in forcing such liquid back into the generator through a by-pass around the low-pressure cylinder, substantially as set forth.

18. The method herein described of substituting in an ammonia-engine apparatus steam as propelling medium in place of ammonia-gas without withdrawing the aqua-ammonia from the generator, which consists in closing the connections between the vapor-space of the generator and the engine-cylinder and between the exhaust-pipe of the engine and the appliances containing aqua-ammonia or absorbing-liquid and closing pas-

sages used for conveying steam into the generator for heating purposes, and in opening a connection between the steam-space of a steam-boiler and the engine-cylinder and between the exhaust-pipe of the engine and the atmosphere or between said exhaust-pipe and a steam-condensing apparatus, substantially as set forth.

19. In operating an aqua-ammonia-engine apparatus, wherein aqua-ammonia is heated by steam passing through the generator, the method herein described of substituting and employing steam as propelling medium for the engine in place of the ammonia-gas developed in the generator, which consists in closing the connections between the generator and the boiler supplying the steam for heating the aqua-ammonia between the vapor-space of the generator and the engine-cylinder and between the exhaust-pipe of the engine and the appliances containing aqua-ammonia or absorbing-liquid and in opening a connection between the steam-space of the aforesaid steam-boiler and the engine and between the exhaust-pipe of the engine and the atmosphere or a steam-condensing apparatus, substantially as set forth.

20. In an aqua-ammonia-engine apparatus, the combination of a generator having its vapor-space connected with an engine, a second generator having its vapor-space connected with a second engine, a connection between the liquid-space of the first generator and the interior of the second generator for the purpose of conveying liquid from the first to the second generator and subjecting it to successive heating operations in both generators prior to conveying the gas developed in the second generator to the second engine for propelling the same, and a pipe for conveying weak solution from said second generator to the apparatus for absorbing the exhaust-vapor, substantially as set forth.

21. In an aqua-ammonia-engine apparatus, the combination of a generator and a pipe leading from its vapor-space to an engine, a second generator and a pipe leading from its vapor-space to a second engine, the liquid-space of the first generator being connected with the interior of the second generator, a pipe connecting said vapor-pipes of the two generators and provided with a suitable valve for admitting vapor developed in the first generator to the second engine and vapor developed in the second generator to the first engine, and a pipe for conveying weak solution from one of the generators to an apparatus for absorbing the exhaust-vapor of both engines, substantially as set forth.

22. In an aqua-ammonia-engine apparatus, the combination of a generator with a pipe leading from its vapor-space to an engine, a second generator having a pipe connecting its vapor-space with the aforesaid pipe, a pipe connecting the liquid-spaces of the two generators, a pipe for conveying absorbing-liquid from one of the generators to the absorbing apparatus of the engine, a pump for forcing the combined absorbing-liquid and exhaust-vapor into the generators, and two feed-pipes connected with such pump, one leading into the first generator and the other into the second generator, each of the aforesaid pipes being provided with a suitable cock or valve for the purpose of permitting, of including in, or excluding from the circuit described by the liquid in its passage from one of the generators to the absorbing apparatus and back into such generator the other generator, substantially as set forth.

23. In an ammonia-engine apparatus, the combination of generator 2, pipe 25, leading from its vapor-space to the cylinder of an engine, a generator 13, a pipe connection leading from its vapor-space to the cylinder of a second engine, a pipe 33 32, connecting said two vapor-pipes, an automatic valve 41, placed in pipe 33 32 and closing toward pipe 25, an automatic valve 42, placed in the vapor-pipe of the second engine between valve 41 and generator 13 and closing toward said generator, a pipe connecting the liquid-space of generator 2 with the interior of generator 13, an absorbing apparatus for the exhaust-vapor, to which liquid properly cooled is conducted from one of the generators and wherein the exhaust-vapor of both engines is absorbed, and means for conducting the combined exhaust-vapor and absorbing-liquid back into the generators, substantially as set forth.

24. In an ammonia-engine apparatus, the combination of generator 2, pipe 25, leading from its vapor-space to the cylinder of an ammonia-engine, a pipe connection with suitable valve leading from the vapor-space of a generator 13 to the cylinder of a second engine, a pipe connection with suitable valve between said two vapor-pipes for the purpose of conducting vapor from either generator to either of said engines, an absorbing apparatus into which enters an exhaust-pipe from each engine, a pipe for conducting absorbing-liquid from one of the generators to said absorbing apparatus, and a feed-pump for withdrawing saturated solution from said absorbing apparatus and having a pipe connection with a proper valve between its discharge end and generator 2 and another one between its discharge end and generator 13, substantially as set forth.

25. In an ammonia-engine apparatus, the combination of a generator 2, heated by steam, having a vapor-pipe with suitable valve leading to an engine, a second generator 13, having a vapor-pipe with suitable valve connecting with the aforesaid vapor-pipe, a pipe conveying liquid from generator 2 to the interior of generator 13, such pipe being provided with a suitable cock or valve, a pipe conveying weak liquid from generator 13 to the absorbing apparatus of the engine, and feed-pipes with proper valves leading into each of said generators for the purpose of forcing aqua-ammonia into the same, said

generator 13 being provided with a furnace for the purpose of developing ammonia-gas therein for use in the engine when generator 2 is not being operated by steam, substantially as set forth.

26. In an ammonia-engine apparatus, the combination of two generators 2 and 13 and an engine, pipe connections with proper valves from the vapor-space of each generator to the engine, an absorbing apparatus, a spray or absorbing-jet discharging into the absorbing apparatus and connected with the liquid-space of each generator by passages provided with proper valves, and a feed-pump with two branch pipes connecting with its main discharge-pipe, each branch pipe being provided with a suitable cock or valve, one of said branch pipes leading into generator 2 and the other into generator 13 for the purpose of permitting the operating of the engine by vapor developed in one of the generators only or in both, and the reabsorbing of the exhaust vapor by liquid deprived of part of its gas in one generator only or in both, substantially as set forth.

27. In an ammonia-engine apparatus, the combination of a generator with a compound engine receiving its supply of ammonia-vapor from said generator, an intermediate chamber between its high-pressure and low-pressure cylinders, and suitable passages for conducting steam from said steam-boiler to said generator and to said intermediate chamber, so as to impart heat of such steam to the contents of said generator and to the contents of said intermediate chamber, substantially as set forth.

28. In an ammonia-engine apparatus, the combination of a generator containing aqua-ammonia with an engine receiving its supply of ammonia-vapor from said generator, and a suitable steam-conduit passing first in contact with the contents of said generator and afterward in contact with passages through which ammonia-vapor circulates between the ingress and egress ports of the engine, substantially as set forth.

29. In an aqua-ammonia-engine apparatus, the combination of a generator containing aqua-ammonia, an engine receiving its supply of ammonia-vapor from said generator, a steam-conduit in contact with passages through which ammonia-vapor circulates between the ingress and egress ports of the engine, and two passages, each with a proper valve and leading from a steam-boiler to aforesaid steam-conduit, one of said passages leading through the generator and the other leading around the same, substantially as set forth.

30. In an aqua-ammonia-engine apparatus, the combination of two high-pressure cylinders exhausting into a common receiving-chamber, a low-pressure cylinder receiving its supply of vapor from such receiving-chamber, an absorbing apparatus wherein the exhaust-vapor of the low-pressure cylinder is absorbed by liquid withdrawn from the generator, and a passage leading from such chamber into the absorbing apparatus and provided with an automatic valve adjusted to open when a given pressure has been reached in said chamber, substantially as set forth.

31. In an aqua-ammonia-engine apparatus, the combination of a compound engine with an absorbing apparatus wherein the exhaust-vapor of the low-pressure cylinder is absorbed by liquid withdrawn from the generator, and a drip-pipe with suitable valve leading from the passage connecting the high-pressure cylinder with the low-pressure cylinder into the absorbing apparatus, substantially as set forth.

32. In an aqua-ammonia-engine apparatus, the combination of a compound engine and a pipe with suitable valve, such pipe forming a connection between an intermediate chamber between the high and the low pressure cylinders, and passages through which exhaust-vapor and absorbing-liquid are conducted back toward the generator, substantially as set forth.

33. In an aqua-ammonia-engine apparatus, in combination with a compound engine and its absorbing apparatus, an independent high-pressure cylinder discharging its exhaust-vapor into the low-pressure cylinder of such compound engine through a pipe having a suitable valve, and a branch exhaust-pipe with suitable valve for conveying the exhaust of such independent cylinder to the absorbing apparatus direct, such branch exhaust-pipe being made to branch out of the main exhaust-pipe of such independent high-pressure cylinder at a point located between its exhaust-ports and the first-named valve, and such absorbing apparatus being supplied with absorbing-liquid by a pipe leading from the liquid-space of the generator to said apparatus, substantially as set forth.

34. In an aqua-ammonia-engine apparatus, the combination of an engine adapted to be propelled either by ammonia-gas or by steam, a generator 2, heated by steam from a steam-boiler, valve 24, vapor-pipe 25, leading to the engine, exhaust-pipe 22, spray-pipe 20, with a suitable cock or valve and a discharge-nozzle, valve 52, a suitable absorbing apparatus, and means for forcing the combined exhaust-vapor and absorbing-liquid back into the generator, together with steam-boiler 1, steam-pipe 77, valve 78 for conveying steam to the main vapor-pipe of the engine, and branch exhaust-pipe 81, with valve 82, all for the purpose of being able to operate the engine either with ammonia or with steam, substantially as set forth.

35. In an aqua-ammonia-engine apparatus, an engine adapted to be propelled either by ammonia-gas or by steam, in combination with generator 2, valve 24, vapor-pipe 25, leading to the engine, exhaust-pipe 22, spray-pipe 20, with a suitable cock or valve and a discharge-nozzle, valve 52, a suitable absorbing appara-

tus, and means for forcing the combined exhaust-vapor and absorbing-liquid back into the generator, together with steam-boiler 1 and a pipe with proper valve for conveying steam from said boiler to said generator for heating its contents, and proper pipes and connections for withdrawing the steam from the generator after its having heated the aqua-ammonia therein, and a by-pass with proper valve around such generator and connecting the steam-space of the steam-boiler with the vapor-pipe 25, leading to the engine for the purpose of changing the course of steam developed in the steam-boiler from the passages in contact with the contents of the generator to the engine-cylinder and to propel said engine therewith, substantially as set forth.

36. In an aqua-ammonia engine-apparatus, in combination with the main vapor-pipe 25, supplying the engine-cylinder with vapor, the generator 2, and valve 24, and two steam-conduits leading out of a steam-boiler, each conduit-pipe being provided with a proper valve, one of said conduits being made to lead through said generator and the other to lead into main vapor-pipe 25 for the purpose of conveying either ammonia-gas expelled from aqua-ammonia by the heat of the steam or steam to said engine-cylinder, substantially as set forth.

37. In an ammonia-engine apparatus, in combination with two generators, a vapor-pipe with suitable valve leading from one of said generators to an engine, a vapor-pipe with suitable valve leading from the second generator to a second engine, a steam-boiler having a pipe with suitable valve leading from its steam-space to the first-named engine, so as to permit of introducing in it steam as propelling medium in place of ammonia-gas, an absorbing apparatus with which the exhaust-pipes of both engines connect at different points, a pipe with suitable valve 82, connecting the exhaust-pipe of the first-named engine with the atmosphere or with a steam-condensing apparatus, a suitable valve 52, placed in the absorbing apparatus between the points where the exhaust-pipes of both engines connect with the same, and two nozzles having outlets controlled by suitable valves and discharging absorbing-liquid, such outlets being located one on each side of valve 52, thus permitting the operation of either engine with ammonia or of the first-named engine with steam while the second one is being operated by ammonia, all substantially as specified.

38. In an ammonia-engine apparatus, in combination with a generator, pipes with proper valves leading from its vapor-space to each of two engines, one of said engines being also connected by a pipe with proper valve with the steam-space of a steam-boiler and having a branch pipe with proper valve 82 connecting its main exhaust-pipe with the atmosphere or with a steam-condensing apparatus, each engine having its exhaust-pipe connecting with a joint absorbing apparatus, a nozzle 89, with suitable valve for discharging absorbing-liquid into the absorbing apparatus, and a suitable valve 52 so located in said absorbing apparatus as to have valve 82 on one side and the absorbing-nozzle on the other side, said valve 52 being also located between the points where the exhaust-pipes of the two engines connect with the absorbing apparatus, 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.