Intermittent Ammonia-Water Refrigeration System

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The objective of this group project has been to actually get hands on experience on the construction and operation of the intermittent ammonia-water system. This report, thus, gives the basic activities in the construction and operation of the NH_3/H_2O system, simplified in such a way that it could be used as laboratory working guidelines.

Problems on the existing unit in the TAET are discussed and possible commercially viable modifications are also suggested.

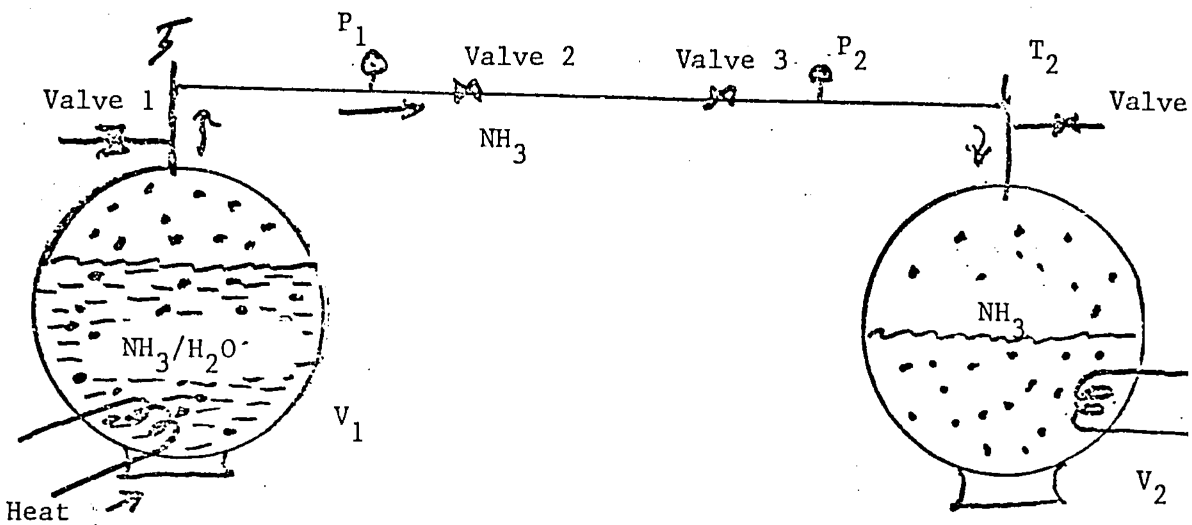


Figure 1

The Intermittent Ammonia-Water Refrigeration Unit

Components

2 propane tanks (20 lb) (V_1 & V_2)

Stainless steel piping

2 pressure gauges (P_1 & P_2)

4 regular middle valves

2 type-k thermal couple probes

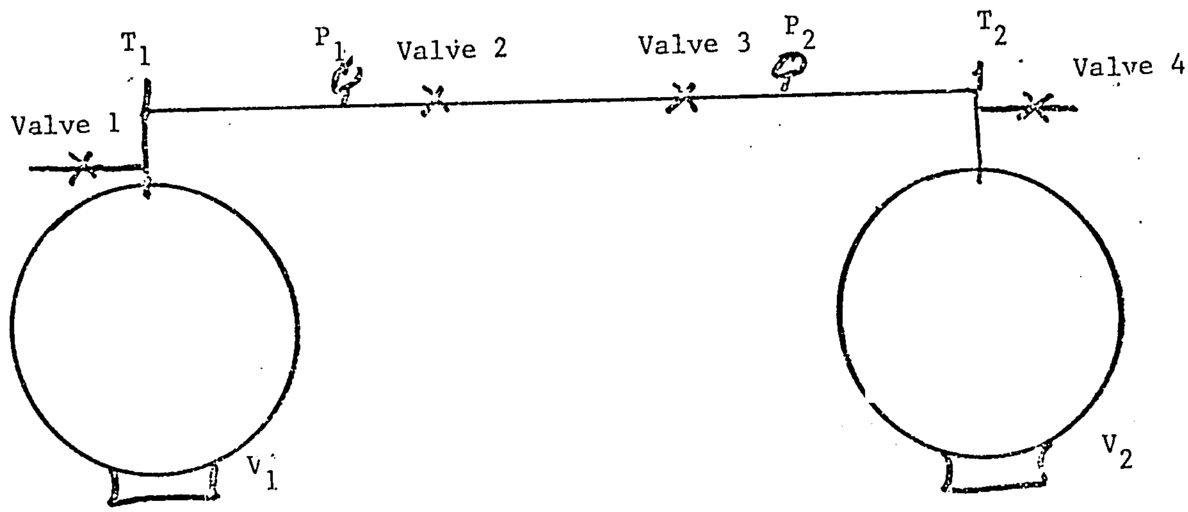


Figure 2

Operation

1 Pressure Testing

a) Open valves 1, 2 and 3 and leave Valve 4 closed.

b) Pump enough water into the system to completely fill the 2 tanks and the piping arrangements.

c) The system is now kept under a pressure of approximately 125 to 150 pounds per square inch for several hours (24 hr).

d) All leaks discovered during this testing process are tightly closed or sealed by either welding or tightening the screws.

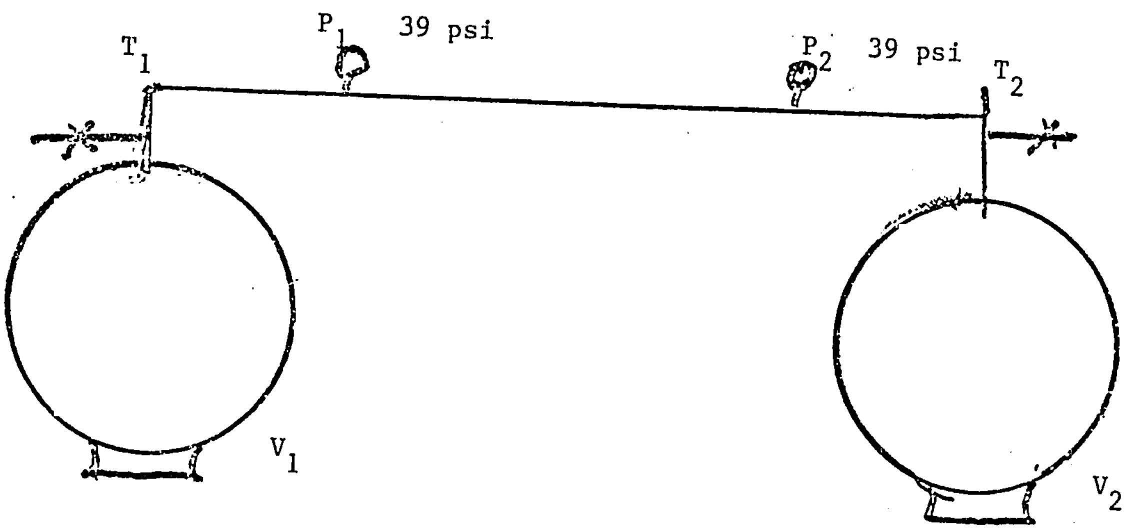


Figure 3

e) Drain the system of all the water.

f) Pull a vacuum on the system by hooking a regular vacuum pump at Valve 1 and leaving all valves open except 4. Run the vacuum pump until a lowest possible pressure is obtained as indicated by the pressure gauges, P_1 and P_2. In ideal laboratory conditions a vacuum pressure of as low as 30 psi can be obtained. However in this case a pressure of 39 psi was reported.

g) Before removing the vacuum pump all valves are closed and then the pump is removed. The unit is now ready for charging.

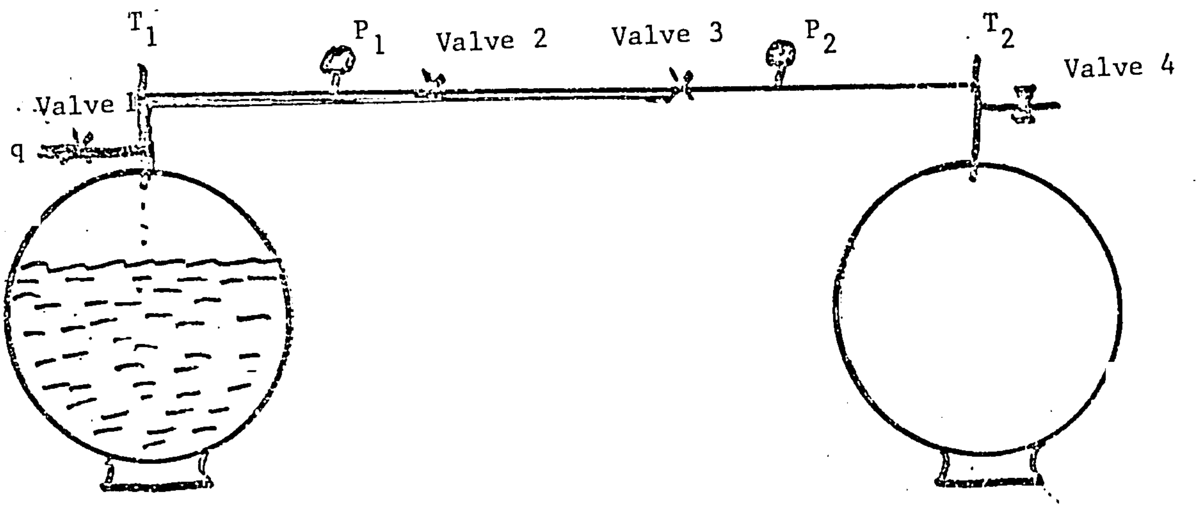


Figure 4

2 Charging the System

a) A weighed quantity of distilled water is taken in a bucket and connected to the system through opening q. Valves 1 and 2 are opened.

b) Next ammonia is introduced in a similar manner as water in an amount that will give 60% by weight of ammonia. With still some vacuum left in V_1, after adding water the ammonia will spontaneously flow into V_1. Valves 1 and 2 are now closed and the hose is removed. At this stage the system is in a generating mood, or ready for operation.

Generation of the NH_3 as Part of Operation of the System

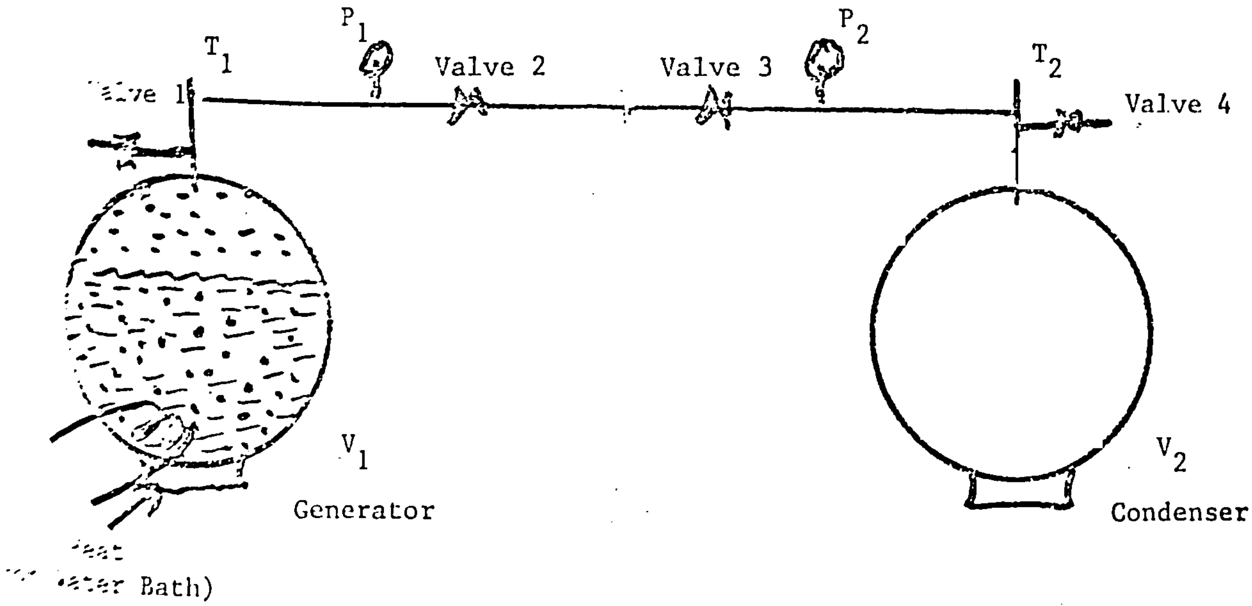


Figure 5

a) To operate the system, heat is added to V_1 now referred to as the generator. In doing this, Valves 1, 3 and 4 are kept closed. This will permit initial pressure to build up in the generator.

b) Next, Valves 2 and 3 are allowed to open and NH_3 to flow into the condenser. At this stage heat at V_1 is removed. During the ammonia generation process V_2 was being cooled to increase the condensation process of ammonia. All valves are now closed.

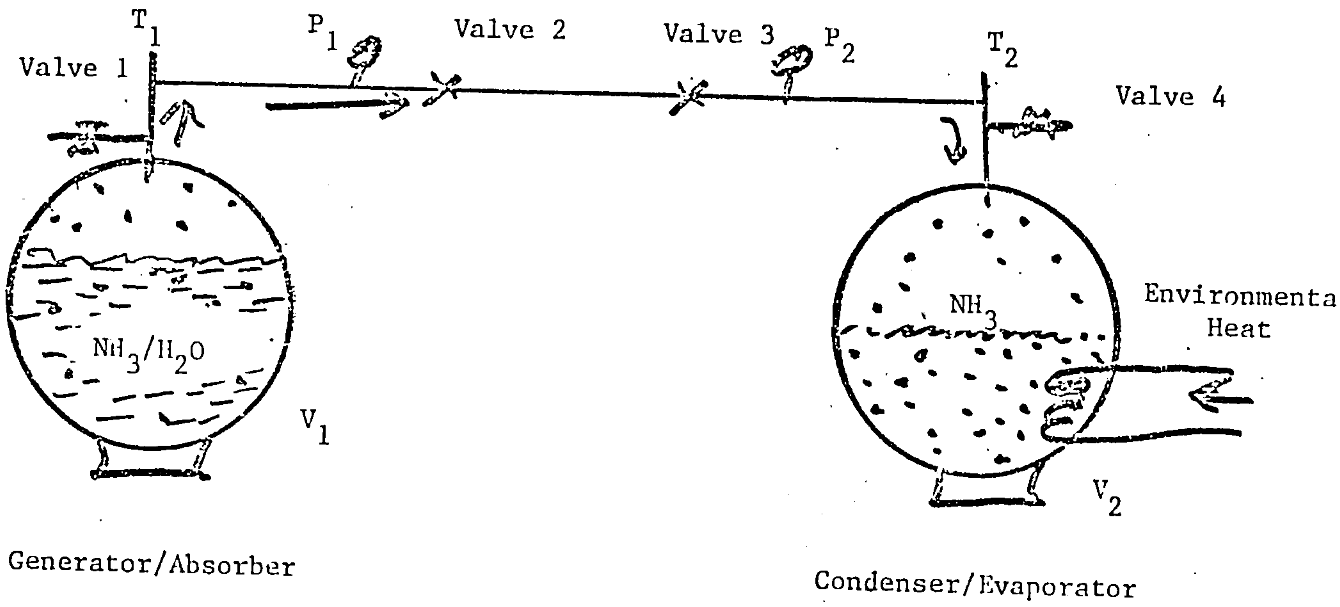


Figure 6

c) At this stage, V_2 is cool. After an approximate equilibrium is achieved between ambient temperature and T_1, V_2 is placed into a conformed area to be cooled and V_1 is further cooled to increase ammonia absorption. Here, V_1 is acting as an absorber of ammonia and V_2 is the evaporator. As the evaporation of ammonia is an endothermic reaction, it absorbs heat from the environment, resulting in the cooling of that environment. In this case, an insulated box is used as the environment to be cooled.

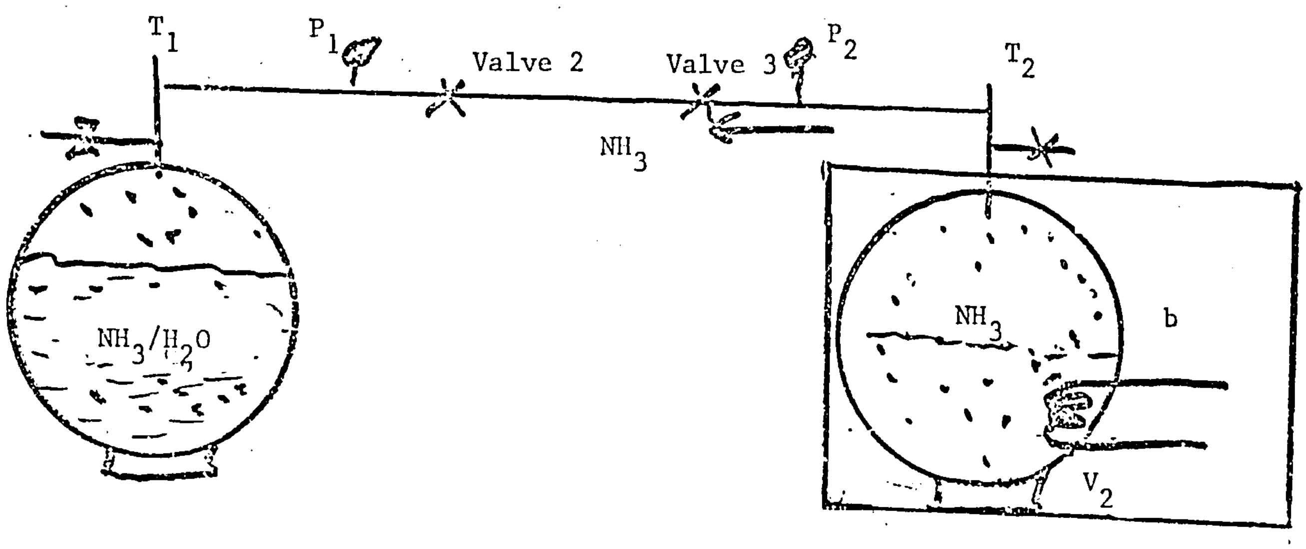
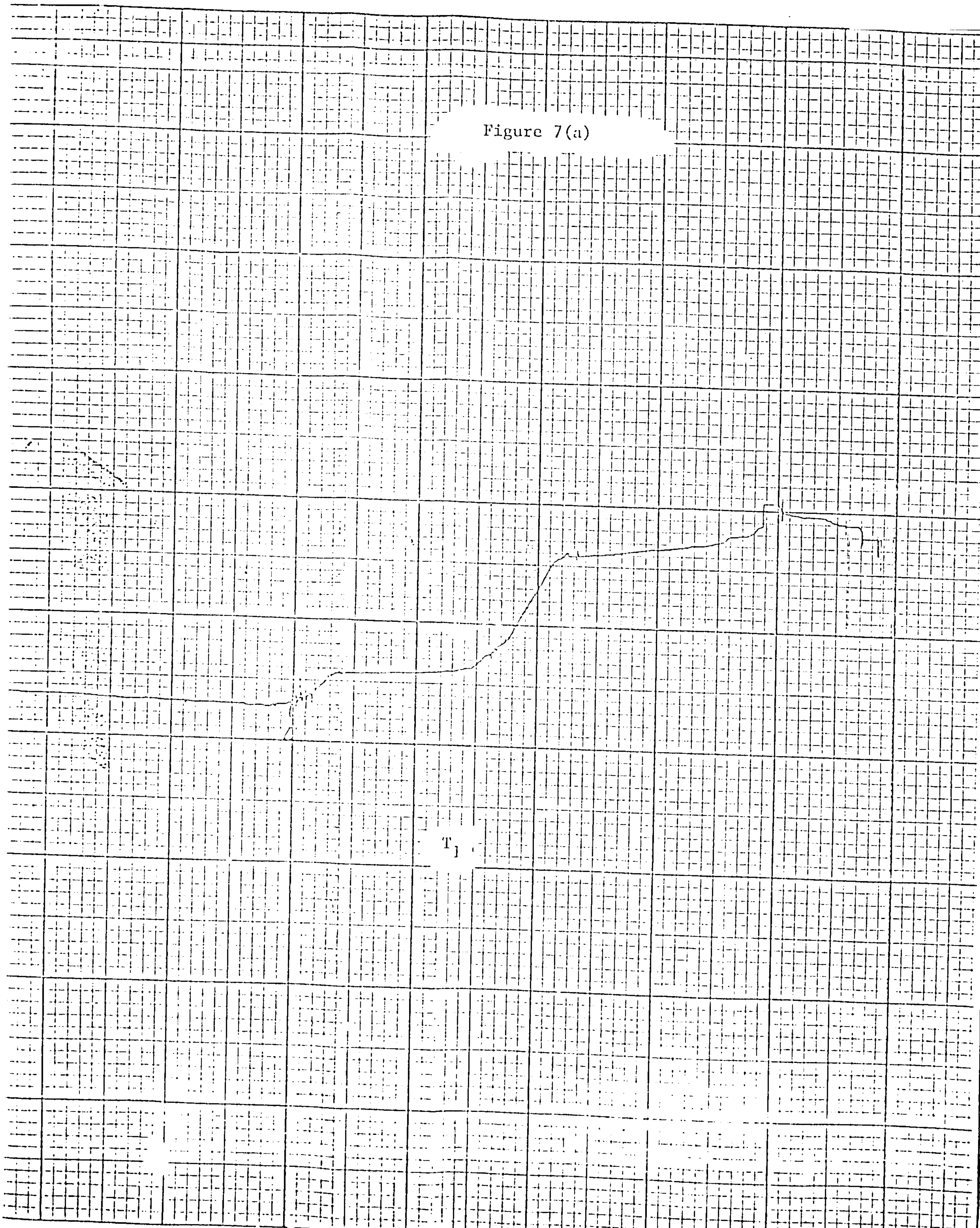


Figure 7

Results

Generation time	2 hours
Temperature of NH_3/H_2O mixture, T_1	160°F
Temperature T_2 during heating	85°F
Temperature T_2 during the cooling mode	36°F
Ambient air temperature	77°F
Temperature of Box b	59°F
Cooling time	1 hour
Quantity of water in the system	4 lb
Quantity of ammonia in the system	8 lb

Figure 7(a)



Observations

1. In order to accelerate the absorption process of ammonia in V_1 during the cooling process, the propane tank V_1 containing the NH_3/H_2O mixture has to be manually shaken. Agitation of the NH_3/H_2O mixture accelerates the absorption of NH_3 from V_2 and hence, the more shaking done, the more cooling achieved.

   In effect: shaking increases the surface area between NH_3 and H_2O for a more rapid absorption.

   $$NH_3 + H_2O \leftrightarrows NH_3/H_2O$$

   Ice can be obtained if mixing is sufficiently rapid and efficient.

2. From theoretical results, it is known that for every pound of ammonia absorbed, there are 500 lb Btu of cooling.

   At this rating, this unit is a 40,000 Btu unit at a 100% ammonia generation and reabsorption, or it is a 3 ton unit. However, its performance was found to be far less than this.

Disadvantages of the System

1. The system has to be charged and shaken manually often requiring extensive time and physical strength for the mixing.
2. The time frame between charging and the time when cooling of the box begins is so large that it is difficult to maintain a continuously low temperature of the box being cooled.

Advantages of the System

1. The components of the system are simple, and fairly simple techniques are needed to understand, construct and operate it.
2. The temperatures needed to operate the unit are fairly low, so that there are several alternatives for obtaining the necessary solar heated water.

This suggested model (Figure 10) consists of two generators/absorbers (a) that permit the total system to work continuously. While the left generator is being heated by the heat source the right generator is being air cooled by a fan. This fan can work on the same energy from the heat source. After ammonia is discharged from the right the fan arm is rotated so that the left is now being heated while the right is being cooled.

(b) serves as condenser of the NH_3 generated and flowing through the outer pipe. Cooling water can be run from the regular pipeline if the system is on a very large scale.

(c) serves as the cooling chamber for condensing and collecting NH_3. The box area, which can be larger, is then cooled and the evaporated ammonia is returned to generator (a) through the by-passing pipe that runs through the center of the larger outer pipe.

Suggested Modifications