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DEVELOPMENT OF SOLAR DRIVEN ABSORPTION AIR CONDITIONERS AND HEAT PUMPS

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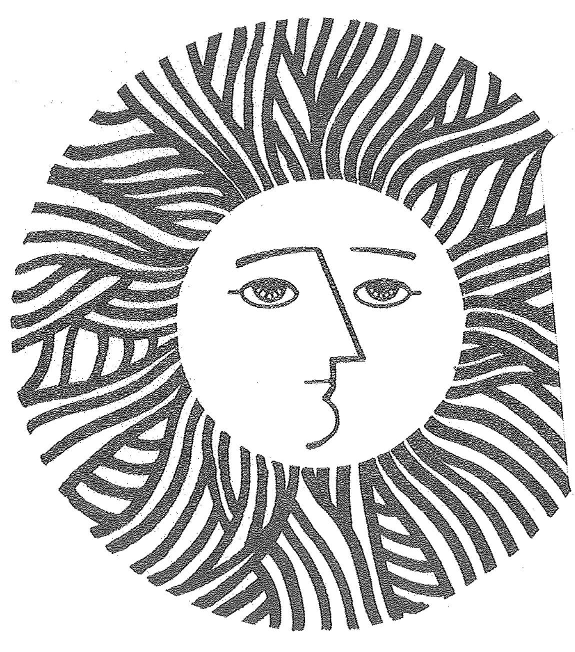

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DISCLAIMER

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OBJECTIVE AND APPROACH

The objective of this project is the development of absorption refrigeration systems for solar active heating and cooling applications.

The approaches being investigated are those using air-cooled condenser-absorbers and those leading to coefficient of performances (COP) that increase continuously with heat source temperature.

This is primarily an experimental project, with the emphasis on designing, fabricating and testing absorption chillers in operating regimes that are particularly suited for solar energy applications.

SUMMARY

The first phase of this project has been concluded and has experimentally demonstrated that the conventional single-effect ammonia-water absorption cycle can be used (with minor modifications) for solar cooling[1]. The optimum operating temperature ranges for this kind of system are:

Heat source	:	200 to 230°F
Cooling air	:	95°F
Leaving chiller water	:	50° to 40°F
COP	:	0.65 to 0.72

The second phase of this project explores the commercial potential of the single-effect (SE) NH_3/H_2O absorption air conditioner. A completely new 3-ton SE unit was engineered and designed to achieve high performance and low cost[2,3]. The key components of this new unit are tube-in-tube heat exchangers for high effectiveness and low cost, and a pair of piston drivers and pumps for the recuperation of the mechanical energy from the returned strong absorbent.

The success of the SE unit will not obviate the need for development of more efficient advanced chillers that can improve significantly the economics of solar cooling. These advanced air-conditioners are designed to achieve high COP at high heat source temperatures compatible with recently developed collectors. Accordingly, the third phase of this project is the development of advanced absorption cycles whose COP increases with temperature, maintaining a relatively constant fraction (about 0.6) of the Carnot COP over a wide range of operating conditions[4,5].

TECHNICAL ACCOMPLISHMENTS

The design and fabrication of the SE ammonia-water absorption air conditioner to be developed in the second phase of this project has been completed. Design characteristics and performance have been reported in references (2) & (3). This experimental unit has been installed and its "debugging" phase has been started. The performance testing phase of this basic single-effect air-conditioner should be completed by August 1980.

Detailed computer analysis of a new advanced absorption cycle (called the Double-effect Regenerative Absorption Refrigeration cycle or cycle 2R) has been completed and has served as the basis for the design of the components of the "2R chiller".

The engineering and detail design of all components of the 2R chiller have been completed. Fabrication of the critical new component, the multistage pump, has just been completed. This pump will be subjected to extensive tests before being integrated with the rest of the 2R chiller. Fabrication of other chiller components will begin as the working drawings are completed.

The configuration of the 2R chiller is shown in Fig. 1. More details on the conceptions of cycle 2R can be found in reference (4). Essentially, the cycle 2R is constructed by adding a boiler, a multistage pump with its driver (labeled DM in Fig. 1.), and a recuperator to the basic conventional single-effect cycle which consists of the generator, the preheater, the rectifier, the absorber, the condenser and the evaporator.

All heat exchangers of this 2R chiller are of the tube-in-tube configuration. The design rated capacity is 3 tons. Other design conditions are:

Heat source temperature	:	280°F
Heat sink (cooling air)	:	95°F
Cold source (chilled water	:	45°F
Net COP	:	0.87

The off-design performance is summarized in Fig. 2. The net COP (shown in Fig. 2) is defined here as the COP obtained after deduction of the amount of high pressure vapor used to run the pump drivers DM and DV.

FUTURE ACTIVITIES

The fabrication of the 2R chiller should be completed by June 1981, and its performance testing and evaluation should be completed by May 1982.

Investigation of another possible advanced absorption cycle (cycle 1R reported in reference (5)), that has the potential for better performance and lower cost than the cycle 2R, will continue in 1980. The search for high temperature refrigerant-absorbent pairs suitable for this advanced cycle is continuing. The search consists of subcontracting the measurement of a minimum set of key properties of a number of preselected pairs. From the key properties all other mixture properties of these pairs can be approximated for use in cycle calculations. Selection of the best pair will be done by comparative performance analyses. Following the selection of the working pair, the design and fabrication of the experimental cycle 1R chiller will proceed.

FOOTNOTE AND REFERENCES

* This work has been supported by the Active Building Systems Branch, Systems Development Division, Office of Solar Applications, U.S. Department of Energy, under Contract No. W-7405-ENG-48.

1. "Performance of an Experimental Solar-Driven Absorption Air-Conditioner", K. Dao, M. Simmons, R. Wolgast, and M. Wahlig, Lawrence Berkeley Laboratory Report LBL-5911, Jan. 1977.

2. Solar Energy Program, Annual Report 1977, Energy & Environment Division, Lawrence Berkeley Laboratory, Report Pub-248, pages 13-16.

3. Solar Energy Program, Annual Report 1978, Energy & Environment Division, Lawrence Berkeley Laboratory, Report LBL-9630, pages 15-18.

4. K. Dao, "Conceptual Design of an Advanced Absorption Cycle: The Double-effect Regenerative Absorption Refrigeration Cycle", Lawrence Berkeley Laboratory Report LBL-8405, Sept. 1978.

5. K. Dao, "A new Absorption Cycle: The single-effect Regenerative Absorption Refrigeration Cycle", Lawrence Berkeley Laboratory, Report LBL-6879, Feb. 1978.

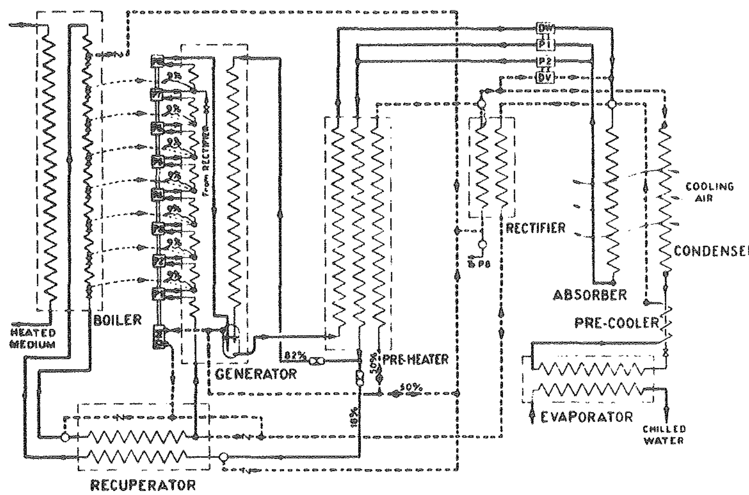

Figure 1. Schematic flow diagram of the "2R chiller"

The dotted lines are vapor paths.
The solid lines are liquid paths.
DM: multistage pump driver, driven by high pressure vapor.
DW: main circulation pump driven by strong absorbent.
DV: main pump driven by high pressure vapor.
restrictors
check valves
zig-zag lines are tube-in-tube heat exchangers.
small wavy lines are bleeded liquid to rectify the vapors.

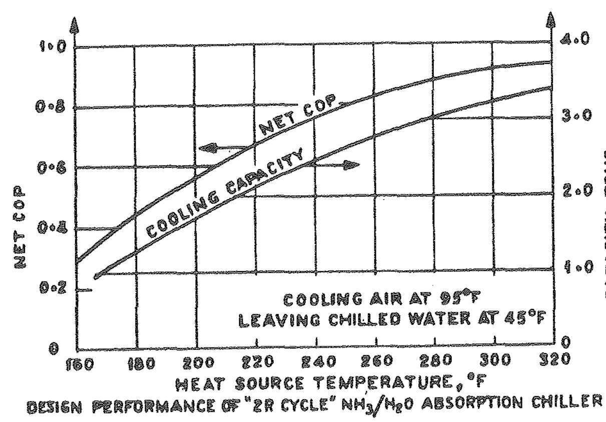

Figure 2. Design performance of "Cycle 2R" chiller. The dots on the curves are rated design points.