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LATENT HEAT STORAGE IN A FIFTY-FIVE GALLON ROLLING CYLINDER

by

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SUMMARY

A laboratory size latent heat storage rolling cylinder incorporating Glauber's Salt (sodium sulfate decahydrate) has been scaled-up to a fifty-five gallon, 68,000 Btu store.

Common barrels show metal fatigue causing leaks, and solids build-up on the interior walls. Barrels with heavier walls, rolling rings, and without internal crevices work satisfactorily.

Results obtained with the fifty-five gallon rolling cylinder were as good as the laboratory size units.

KEY WORDS heat storage, latent heat, rolling cylinder, Glauber's Salt, 55 gallon

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INTRODUCTION

Preliminary work in laboratory-size rolling cylinders has encouraged work on a larger heat storage device incorporating Glauber's Salt (sodium sulfate decahydrate) as the latent heat storage medium.

In previous work, the experimental rolling cylinder had been scaled-up in size three times to a 1.4 gallon unit while maintaining satisfactory performance. For convenience we chose the next larger unit to be a 55-gallon barrel, a scale-up ratio of 39X, with a nominal storage capacity of 68,000 Btu.

This report is a brief account of the results obtained with a fifty-five gallon rolling cylinder using Glauber's Salt.

Results obtained in the 1.4 gallon unit[1] were reconfirmed in the 55-gallon unit:

- 100% crystallization
- repeatable melt-freeze cycling
- reliable nucleation
- excellent heat transfer--no solid build-up on the cylinder walls
- melt-freeze volume change not a problem
- low noise level

Discussion of Experimental Set-Up:

The project is divided into two phases: exploratory tests (three separate barrels with three separate loads of Glauber's Salt, Systems I, II and III) and a working prototype (final barrel and load, System IV). The experimental set-up for both phases follows the arrangement shown in Figure 1.

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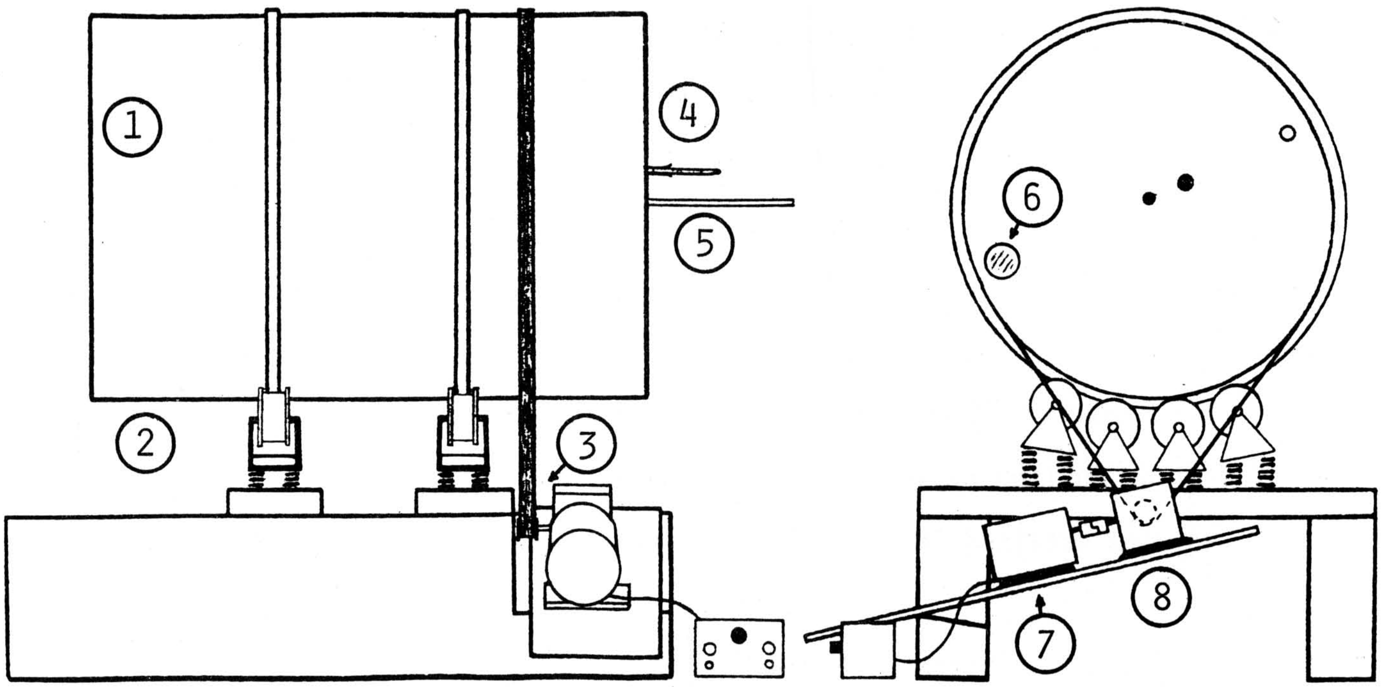

Figure 1

KEY:

1 55 Gallon Barrel with I-Bar Rolling Rings

2 Roller Support System on Springs

3 Pulley and Drive Belt

4 Thermowell and Thermometer

5 Nucleator

6 Glass Viewport

7 Variable Speed Motor

8 Speed Reducer

A standard, commercially available, fifty-five gallon shipping and storage barrel was filled 95% full with 350 lbs of water (53.5% by weight) and 300 lbs of commercial grade sodium sulfate (46.5% by weight) to achieve a storage medium of Glauber's Salt (sodium sulfate decahydrate) at a 10% excess sodium sulfate. A support system for rotating the barrel on its side was arranged to allow use of a floor crane for mounting and dismounting the barrel. The rolling supports consisted of steel disc casters, strategically placed to maintain the barrel's rolling position. Rotary motion was supplied by a variable speed motor coupled to a reducer and a belt around the periphery of the barrel. Radiant heaters supplied heat for melting and portable air conditioners removed stored heat during the freeze cycle.

The nucleator was a 1/4" O.D. stainless steel tube, about 14 inches in length, filled with sodium sulfate and water, mounted at the axis of rotation at one end of the barrel. Adjacent to the nucleator, a six inch long thermowell protruded into the barrel to hold a mercury thermometer. A clamp-on ammeter monitored the power input to the motor to measure work of rotation and electrical/mechanical losses. No quantitative calorimetric measurements were made. A glass viewport inserted in a large bung near the outer periphery of one end wall allowed qualitative visual observation of the interior. Periodically the bung was removed so that exploratory probing could confirm the presence or absence of solids adhered to the walls.

EXPERIMENTAL RESULTS

Exploratory Tests:

The exploratory work consisted of three separate barrels with three separate loads of Glauber's Salt, Systems I, II and III, as described in Appendix A.

Two problems became immediately apparent, both of a mechanical nature:

1) Fatigue of the barrel wall at the support points, causing cracks in the barrel and leaking of the material.

2) An inadequate roller support system caused rapid failure of the rollers.

A commercially available barrel with I-bar rolling rings solved the first problem. Changing the roller support system to eight rollers mounted on springs, reduced roller wear and solved the second problem.

During every exploratory freezing cycle two rings of solid Glauber's Salt formed on the wall, one ring at either end of the barrel, originating from the corners where the barrel construction forms a crevice. Solid ring formations continued to increase in area and thickness until approximately 50% of the heat transfer surface was effectively covered, thus reducing the heat removal rate. This salt formation was caused by particles of the granular sodium sulfate becoming mechanically trapped in the two crevices where they initiated crystal growth adhering to the walls.

To confirm that the crevice was causing the problem, the bottom crevice of a standard barrel was eliminated by filling it with RTV silicone rubber. The contents of System III were transferred to this barrel and cycled twice before failure of the barrel wall. No solids adhered to the wall in the bottom 3/4 of the barrel. As before, a ring of solid did grow from the crevice where the removable top joined the barrel walls.

Working Prototype:

Sanitary barrels have a smooth rounded joint replacing the bottom crevice. Being primarily for food related service they are made of 304 stainless steel. System IV, a commercial sanitary barrel with rolling rings illustrated in Figure 2, was filled with Glauber's Salt as in previous experiments. In four melt-freeze cycles, no solid ring formed in the bottom portion. There was no convenient method for eliminating the crevice where the removable top joined the barrel walls, therefore the ring of solid formed at that location was just ignored.

The phase change performance in the 55 gallon barrel was qualitatively the same as that obtained in the laboratory size rolling cylinders. The work was terminated at this point. Figure 3 shows the contents near the point of complete solidification.

SUMMARY

A fifty-five gallon, 68,000 Btu rolling cylinder heat store was built, a 39X scale-up over the 1.4 gallon laboratory size unit. After solids-trapping crevices were eliminated from the structure, performance was equal to previous laboratory results:

- 100% crystallization
- repeatable melt-freeze cycling
- reliable nucleation
- excellent heat transfer--no solid build-up on the cylinder wall after crevices are eliminated

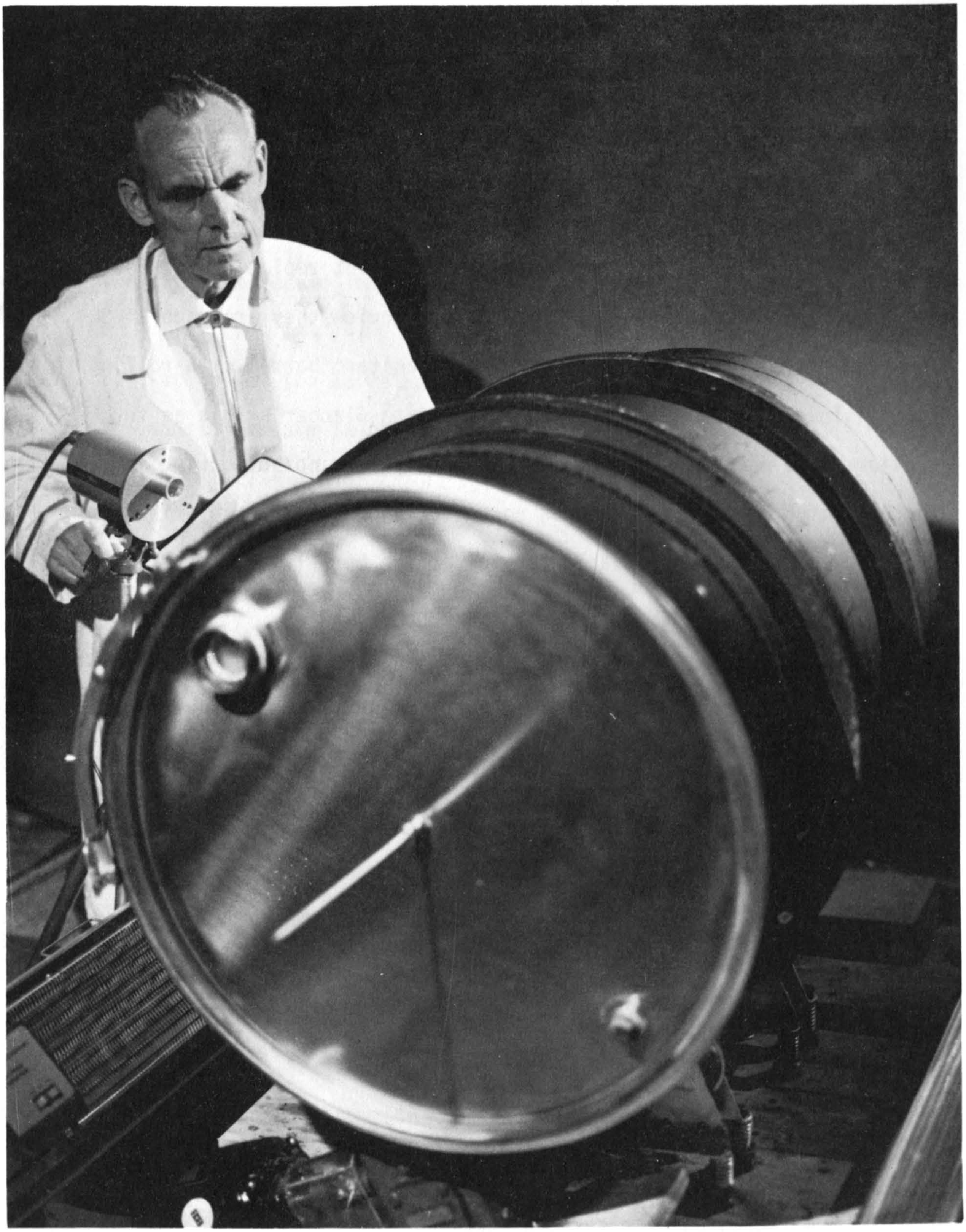

Figure 2

The working prototype heat store -- a fifty-five gallon rolling cylinder. Mounted on spring loaded rollers, it rotates at 3 RPM on I-bar rolling rings, as radiant heaters supply heat to melt the latent heat material.

Figure 3

Glauber's Salt is a free flowing crystalline solid similar in size and appearance to rock salt. Here the fifty-five gallon rolling cylinder has been opened to display the contents after about 80% solidified.

- melt-freeze volume change not a problem
- low noise level

REFERENCES

1. C. S. Herrick and D. C. Golibersuch, "Qualitative Behavior of a New Latent Heat Storage Device for Solar Heating/Cooling Systems", General Electric Company Report No. 77CRD006, March 1977.

APPENDIX A
EQUIPMENT DESCRIPTION

	System	Barrel Type	Barrel Support System	DRIVE SYSTEM: Motor, Reducer, Controller	DRIVE SYSTEM: Belts and Pulleys
Exploratory Tests	I & II	Standard commercial steel barrel, 18 gage (0.048 inch), open top 55-gallon.	4-4"x1$\frac{1}{4}$" rigid type steel disc casters, 300 lb capacity each, mounted 2 rows of 2 (with 12" center to center in rows with 13" between rows). Rubber on wheel would ride just outside front and back chines. (casters mounted directly on platform)	$\frac{1}{4}$ horsepower variable speed motor (1740 RPM max. speed) with controller. Coupled to a 15:1 right angle reducer.	2 pulleys connected to output shaft of reducer to drive 2-V-belts, type 80A, placed around periphery of drum.
Exploratory Tests	III	Commercial 304 stainless steel barrel, 16 gage (0.060 inch), open top, I-bar rolling ring, 55-gallon	8-4" x 1$\frac{1}{4}$" rigid type steel disc casters, 300 lb capacity each, mounted 2 rows of 4 (13" between rows). Rubber removed from casters to allow casters to accomodate I-bar rolling rings, casters individually mounted on 4 compression springs each. Springs of music wire, free length = 2$\frac{1}{2}$", rate = 38 lbs/in.	(same as above)	1-1" wide $\frac{1}{2}$" pitch gear belt, with gear belt pulley.
Working Prototype	IV	Commercial 304 stainless steel barrel, sanitary seamless construction, 16 gage (0.060 inch), open top, I-bar rolling rings, 55-gallon			

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