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ARMORED MEDICAL RESEARCH LABORATORY

FORT KNOX, KENTUCKY

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Report On

STUDY OF THE HEAT RETAINING CAPACITIES OF
INSULATED JUGS

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Project No. 1-20

December 9, 1942

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ARMORED FORCE MEDICAL RESEARCH LABORATORY
Office of the Commanding Officer
Fort Knox, Kentucky

Project No. 1-20
File No. 727-1

December 9, 1942

STUDY OF THE HEAT RETAINING CAPACITIES
OF INSULATED JUGS

1. PROJECT: Heat Retaining Capacities of Insulated Jugs.

a. Authority - Letter Commanding General, Headquarters Armored Force, Fort Knox, Kentucky, 400.112/6 GNOHD, date September 24, 1942

b. Purpose - To determine the effectiveness of thermos containers, vacuum and insulated, in keeping food hot during cold weather operations.

2. DISCUSSION:

a. Methods - The following Stanley type, thermos containers manufactured by Landers, Frary and Clark were tested:

- One (1) - 1.7 qt. vacuum bottle
- One (1) - 3.5 qt. insulated, semi-vacuum jug
- One (1) - 7.6 qt. insulated jug with spigot
- One (1) - 18.2 qt. insulated jug with spigot

All containers were preheated by filling them with water at 100°F one-half hour before use. At the end of the preheating period the water was poured out, the containers filled with the test material and placed in the cold room at -30°F. (A few tests were carried out at +6°F.) The temperatures of the contents of the containers were followed for periods of from 7 to 8 hours by means of thermocouples. Details of procedure and analysis of results are given in the appendix.

3. CONCLUSIONS:

a. An insulated thermos jug of 18.2 quart capacity will keep food hot for at least 4 hours and adequately warm for periods up to eight hours. The rate of fall in temperature of the food contained is approximately 0.3°F per quart per hour, the rate being in part dependent upon the temperature of the food at the time it is placed in the container.

b. Vacuum bottles also have excellent heat-retaining properties but due to their fragility and cost are not as suitable for transportation of hot food as the more durable insulated jugs.

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c. Insulated jugs are effective in keeping food hot and provide an excellent means for the transportation of foods during extreme cold weather.

d. The larger insulated jug, 18.2 quart, is more efficient than the smaller jugs of 3.5 and 7.6 quart capacity.

e. To provide for most efficient performance, thermos containers should be filled completely.

4. RECOMMENDATIONS:

a. Insulated thermos jugs up to five-gallon capacity be purchased for test in the field during winter operations.

b. That manufacturers be contacted regarding the possibility of constructing an insulated thermos jug on the general plan of the present water container.

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Table I
Graphs 3
Appendix

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APPENDIX

The need for making available to men not only food but hot food as well has been emphasized in many reports from battle-front areas. In the case of outposts, patrols and other small units engaged in operations which separate them from company kitchens, and in situations where fires are not permissible or time is not available to build them, special provisions for food and drink are required. The necessity for hot food for men engaged in cold weather operations is quite obvious. Thermos containers would seem to provide a solution to the problem. Cold weather also poses a big problem in the transportation of perishable foods, such as fresh fruit, without freezing and resulting spoilage.

Four thermos containers, a 1.7 quart vacuum bottle, a 3.5 quart semi-vacuum and insulated jug, a 7.5 quart insulated jug, and an 18.2 quart insulated jug, the latter two having bottom spigots, were subjected to test to determine their suitability for transporting hot foods to or with troops in the field. The thermos containers were preheated by filling with water at approximately 100°F. After about one-half hour the water was poured out and the food to be tested was placed in the containers. These were then taken into the cold room (+6 or -30°F), and thermocouples inserted at several levels. The temperature was recorded at intervals during the six or eight hour exposure to cold. In some experiments the jugs were agitated every half hour while in others they were left untouched throughout the duration of the experiment. Water, coffee, beef stew (Field Ration), Cream of Wheat, oatmeal gruel, scrambled eggs, and fresh apples were used in the tests.

RESULTS:

The data obtained from experiments conducted under the most severe of the two conditions, -30°F, are summarized in Table I. As a unit, the vacuum bottle, No. 1, is the most efficient, although the large insulated jug approaches it in efficiency in all but one experiment. As units, jugs 2 and 3 are approximately identical. From a practical standpoint the insulated jug with a capacity of 18.2 quarts, is the best. A comparison of the rate of cooling of oatmeal gruel in the two best thermos containers, 1 and 4, is shown in Figure 1. The jugs were not agitated during the test. More rapid cooling of the surface resulted from the incomplete seal around the thermocouples which entered the jug through the cover. The cooling curves for water in the containers are shown in Figure 2. The similarity in behavior between the vacuum bottle and the largest insulated jug is striking. The two remaining jugs (2 and 3) cooled off at approximately identical rates.

In one experiment the 18.2 quart insulated jug was only one-fourth filled with oatmeal gruel. The temperature fell much more rapidly than in another experiment in which the jug was completely filled. The gradual infiltration of cold air under the rim of the lid resulted in more rapid cooling of the contents of the jug having the greatest air space. The

APPENDIX
(Cont'd)

necessity for completely filling the jugs is evident. Beef stew was kept hot for five hours and remained moderately warm for 3 additional hours (Figure 3). When this was eaten after being at -30°F for 8 hours, it was very palatable, although a layer of fat, about one-half inch thick had solidified on top of the stew. The stew was then left at room temperature (20°C) for sixteen hours and when sampled at that time, had become slightly rancid and was inedible. As may be anticipated, these thermos containers will not preserve food for long periods of time.

Several experiments were conducted with coffee in the jugs. The jugs proved to be excellent for keeping coffee hot. During mealtime at Headquarters Company Mess the temperatures of cups of coffee was obtained prior to the time the men would start to drink them. The average initial drinking temperature was found to be 138°F . If coffee is placed in 18.2 quart jugs at around 200°F , at the expected rate of cooling, the coffee would still be above the average drinking temperature ten hours later.

The possibility of safe transportation of perishable foods during extreme cold was investigated. Apples were used in these experiments. In a typical experiment with one of the least efficient jugs (number 2) the apples were in excellent condition after 24 hours of exposure to -30°F . The apples on the top were frozen to a depth of $1/8$ to $1/4$ of an inch. The ones beneath were in perfect condition. The cover was replaced and the jug returned to the cold for another twelve hours. As before, the top few were slightly frozen, but, the bottom ones were not harmed. Even though slightly frozen at the periphery the fruit was edible and of good flavor. The apples were then left in a warm room and at the end of several hours became slightly mushy on the surface. They were edible but did not have the flavor of the apples when eaten in the cold. Experiments using the other two insulated jugs followed the same pattern.

These experiments indicate that hot foods and certain perishable foods can be transported by insulated thermos jugs to or with groups who will be out of contact with field kitchens for periods of time up to eight hours. A field trial of these jugs is necessary. Several minor alterations, involving shape, fit of lid, and spigot arrangement, would make these jugs more efficient and allow for better stowage in Armored Vehicles.

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STANLEY INSULATED JUGS
 RATE OF COOLING OF CONTENTS IN ROOM AT -30°F
 All Temperatures are in °F.

Hrs	Water				Water				1 Beef Stew			2 Cream of Wheat			Oatmeal		Coffee			Scr. Eggs	Alr		
	1*	2*	3*	4*	1	2	3	4	1	4	4	1	4	4	1	4	4**	4	3	3	3	1	3
0	116	108	111	116	188	181	180	169	140	160	164	147	-	-	149	166	93	165	181	155	176	117	65
1	114	100	104	109	185	180	174	167	140	159	155	146	-	-	143	161	85	160	176	139	166	106	36
2	109	92	95	104	173	160	160	156	137	147	140	142	-	-	140	157	72	153	160	119	155	94	36
3	106	86	89	100	167	146	146	151	135	142	133	138	-	-	131	153	63	150	146	109	140	83	-14
4	102	79	83	97	160	139	139	145	130	136	128	132	-	-	123	141	59	147	142	105	130	78	-17
5	98	73	78	91	156	132	131	139	126	131	124	128	-	-	119	131	50	142	134	101	119	70	-19
6	97	69	73	88	149	121	122	131	121	127	118	123	-	-	114	126	46	134	120	89	109	66	-18
7	94	65	70	83	142	111	111	123	115	120	110	119	-	-	-	121	42	130	107	81	100	60	-19
8	91	61	64	79	-	-	-	-	109	118	105	116	-	-	106	115	36	125	105	79	96	55	-18
all	25	47	47	37	46	70	69	46	31	42	59	31	-	43	51	-	40	76	76	80	62	83	
per Hr.	1.8	1.7	0.8	0.3	3.9	3.0	1.3	0.4	2.4	0.3	0.4	2.3	-	0.3	3.7	-	0.3	1.2	1.2	1.3	4.5	1.4	

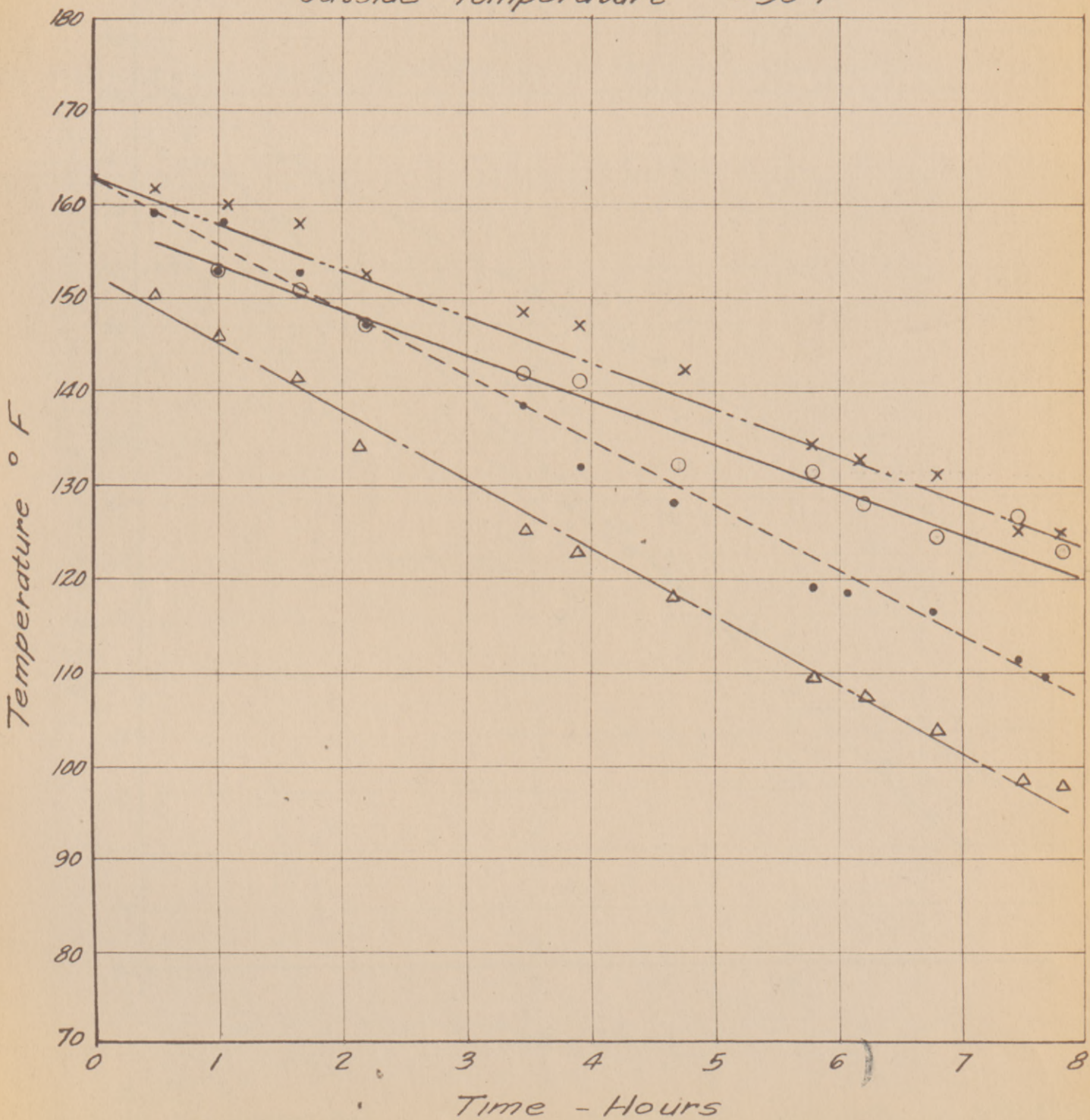
*1 = 1.7 quart Vacuum Bottle
 *2 = 3.5 quart Insulated jug (semi-vacuum)
 *3 = 7.6 quart Insulated jug
 *4 = 18.2 quart Insulated jug

1 Average of 2 experiments
 2 Average of 2 experiments

** Jug was only one-quarter filled

COOLING CURVES OF OATMEAL GRUEL

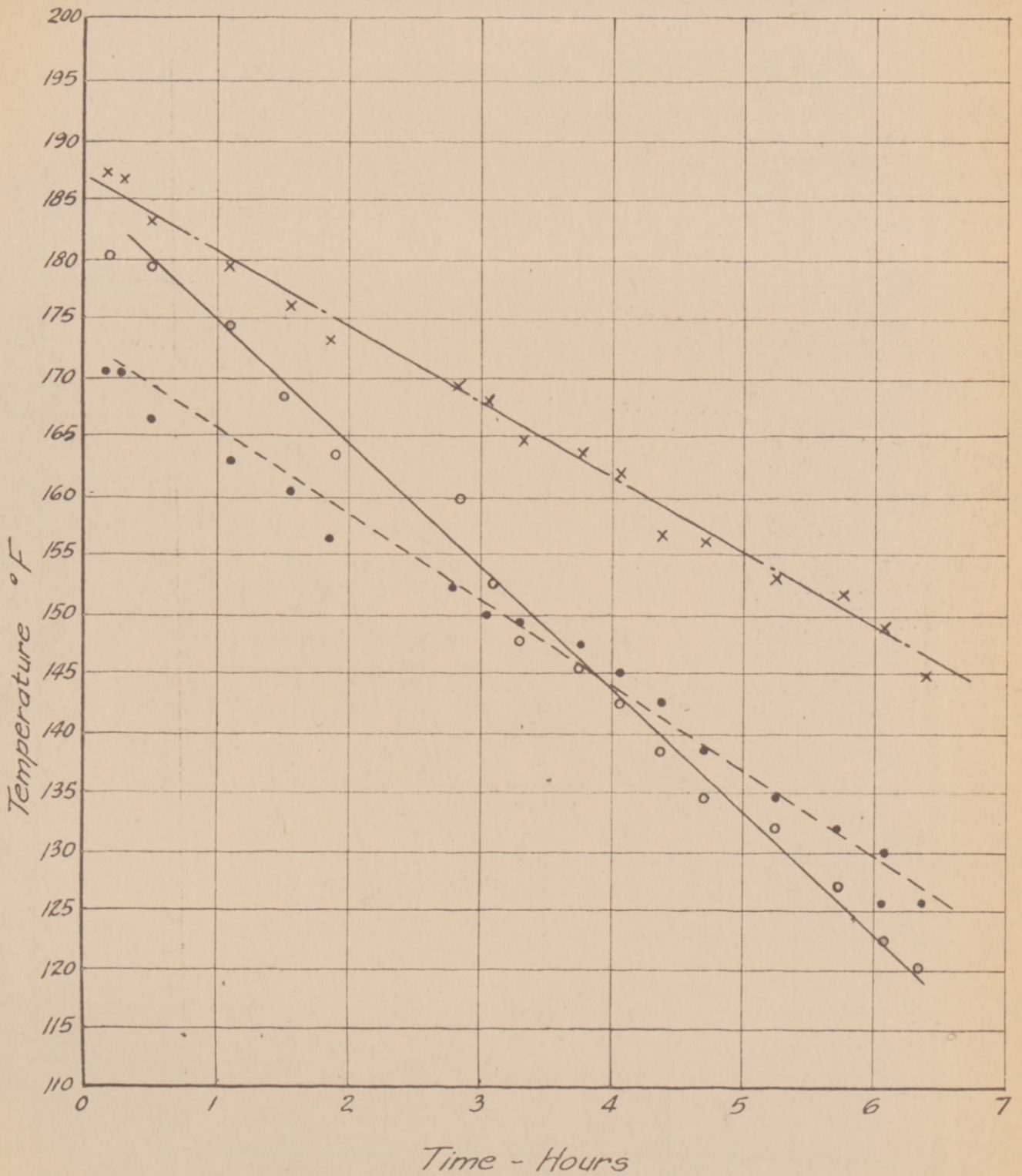
Outside Temperature -30°F



KEY

- x Middle of 18.2 Qt. Jug
- Surface of 18.2 Qt. Jug
- o Middle of 1.7 Qt. Jug
- Δ Surface of 1.7 Qt. Jug (Fig. 1)

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KEY

- 18.2 qt. Insulated Jug
- x 1.7 qt. Vacuum Jug
- o 3.5 & 7.6 qt. Insulated Jug

COOLING CURVES OF WATER
IN THERMOS JUGS

Outside Temperature -30°F

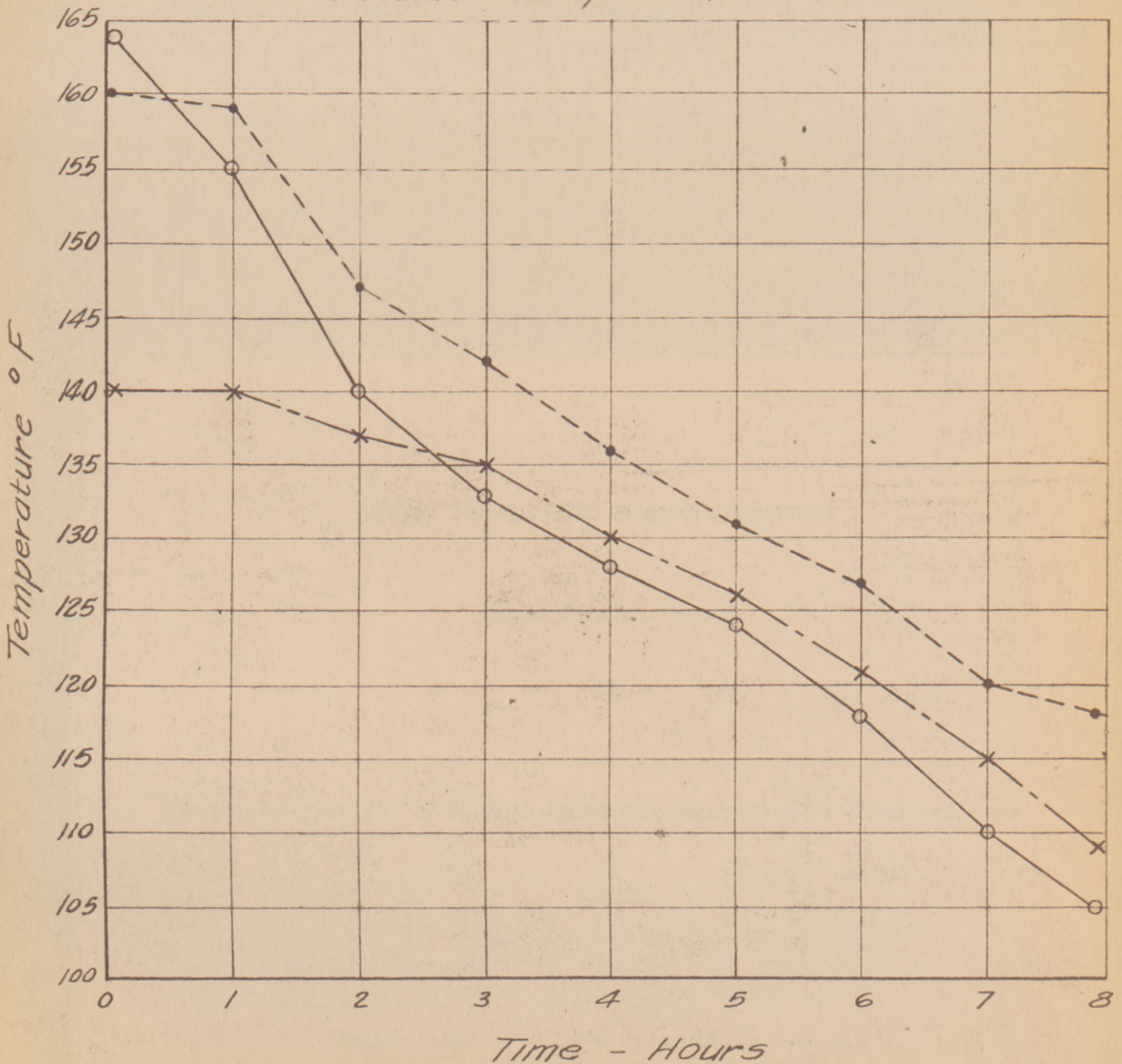
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(Fig. 2)

COOLING CURVES OF BEEF STEW

FIELD RATION

Outside Temperature -30°F



KEY

- 18.2 qt. Insulated Jug - First run
- 18.2 qt. Insulated Jug - Second run
- × 1.7 qt. Vacuum Jug (Fig. 3)

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