ARCTIC AEROMEDICAL Laboratory

ARCTIC SURVIVAL RATIONS

PROJECT NUMBER 22-1101-0002
REPORT NUMBER 1

LADD AIR FORCE BASE
A L A S K A

at various stages of the experiment, it is observed that, apart from the acetone, no abnormalities were detected during the experimental phase. During the field phase, small traces of albumin occurred in members of all three groups, together with the occurrence of white blood cells.

Acetone

The incidence and severity of ketosis during the experimental and field phases are indicated in tables 29 and 30, respectively. As would be expected, carbohydrate afforded considerable protection against the ketogenic effects of low caloric intake and exercise, although under the more rigorous field conditions, the quantity administered was not sufficient to suppress ketonuria completely. It is interesting to note that while conditions evidently were more conducive to the development of ketosis during the field phase than during the experimental phase, as shown by the increased ketone body excretion of the subjects on carbohydrate, there was no further significant increase in the ketonuria of the subjects on the meat diet during the field phase.

The primary concern of this study was with the short-term effects of possible components of survival rations which would be intended for use over limited periods only. Considering this fact, the mildly ketogenic effect of the meat diet is of no practical importance. The highest value obtained was 866 mg. per 24 hours (meat diet, fifth day of experimental phase). It is true that this value does not include the B-hydroxybutyrate. However, it is evident from Friedmann's data and graphs (Friedmann, 1942) that the ratio of B-hydroxybutyrate to the other ketone bodies would be less than one at this low level of ketonuria. If we assume a ratio of one, the total ketone body excretion of this subject was 1.8 gm, or 0.40 m M/Kilo/24 hr. This rato, which represents a maximum for one individual and which was not maintained on succeeding days, is still much lower than is often encountered during complete fasting. Other than ketonuria, no objective symptoms of ketosis developed in any of the subjects during any of the phases.

Blood findings

The results of routine blood examination in the subjects prior to the commencement of the study are given in table 25. Table 26 shows the individual results of blood examinations at various stages of the experiment, and table 27 shows the mean blood changes during the different phases. No significant change was detected in the blood picture.

The mean values for the fasting blood sugar (table 28) were slightly lower during the experimental and field phase than during the standardization phase in the meat group while they remained almost unchanged in the carbohydrate group and in the group receiving both meat and carbohydrate. The lowest figure observed in the meat group was 66 mg. per 100 ml. Molnar et al. (1942) reports fasting blood sugar values of the same order (65-80 mg. per 100 ml.) in 7 men on a mixed diet of 3,600 calories in an Arctic bivouac at Fort Churchill.

DISCUSSION

In the discussion of Arctic survival rations, it is necessary to consider the wide range of conditions encountered in the different parts of the Arctic regions.

According to the standard definition, the Arctic regions include the areas where the average temperature for the warmest month is below 50° F., and which have an average temperature below 32° F. for the coldest month. On the basis of this definition, the Arctic regions include about 1/4 of Alaska, a great part of the Canadian Archipelago, all of Greenland, Spitzbergen and other eastern Arctic islands, the northern fringe of Norway, and northern Siberia.

TABLE 24. SHOWING URINARY ACETONE

	Standardization Phase			Experimental Phase					Field Phase									
	Day 1	Day 2	Day 3	Day 1	Day 2	Day 3	Day 4	Day 5	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10
Meat Group																		
Subject No. 1 Qualita.	neg	neg	tr	+++	+++	+++	+++	+++	-	++++	++++	++++	++++	++++	++++	++	++++	++++
" " 1 Quant.mg	-	-	-	113	209	227	352	291	-	-	271	254	335	370	478	300	625	340
" " 5 Qualit.	neg	neg	-	++++	++++	++++	++++	++++	neg	++++	++++	++++	++++	++++	++++	++++	++++	++++
" " 5 Quant.mg	-	-	-	118	88	173	867	503	-	226	(lost)	227	169	421	634	164	471	568
" " 6 Qualit.	neg	neg	tr	+++	+++	+	++++	++++	neg	++++	++++	++++	++++	++++	++++	++++	++++	++++
" " 6 Quant.mg	-	-	-	124	159	139	207	209	-	114	111	148	207	93	205	106	423	426
" " 10 Qualit.	neg	neg	neg	tr	+	neg	+	++	neg	+	++++	++++	++++	++++	++++	++++	++++	++++
" " 10 Quant.mg	-	-	-	38	133	-	70	98	-	-	(lost)	102	128	75	154	141	124	125
" " 12 Qualit.	+	neg.	neg	neg	tr	++	++++	++++	neg	+++	-	++++	++++	++++	++++	++++	++++	++++
" " 12 Quant.mg	63	-	-	-	-	156	159	260	-	134	-	300	849	526	757	482	211	210
" " 4 Qualit.	neg	neg.	neg	tr	+++	++	++	++++										
" " 4 Quant.mg	-	-	-	86	91	146	163	150										
" " 8 Qualit.	neg.	neg.	neg	tr	+	++	++++	++++										
" " 8 Quant.	-	-	-	55	422	226	300	106										
Mean:	9	0	0	76	157	152	303	231	0	95	76	206	338	297	446	239	371	334
Carbohydrate Group																		
Subject No. 2 Qualit.	neg.	neg	++	neg.	neg	tr	neg	neg	neg	neg	+++	neg	neg	++	+	neg	tr	++++
" " 2 Quant.mg	-	-	23	-	-	57	-	-	-	-	58	-	-	133	31	-	-	181
" " 3 Qualit.	neg	neg	neg	neg	neg	neg	-	neg	neg	+	-	+	neg	neg	+	neg	neg	neg
" " 3 Quant.mg	-	-	-	-	-	-	-	-	-	-	-	30	-	-	31	-	-	-
" " 7 Qualit.	neg	neg	tr	neg	neg	neg	neg	neg	neg	neg	neg	tr	neg	neg	+	neg	-	neg
" " 7 Quant.mg	-	-	64	-	-	-	-	-	-	-	-	-	-	-	46	-	-	-
" " 9 Qualit.	neg	neg	neg	neg	neg	neg	neg	neg	neg	neg	++	++	+	neg	neg	neg	neg	neg
" " 9 Quant.mg	-	-	-	-	-	-	-	-	-	-	52	62	-	-	-	-	-	-
" " 11 Qualit.	neg	neg	neg	neg	neg	neg	neg	neg										
" " 11 Quant.mg	-	-	-	-	-	-	-	-										
Mean:	0	0	17	0	0	12	0	0	0	0	28	23	0	33	27	0	0	45

TABLE 24. (Cont'd).

		Field Phase									
		Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10
Meat-Carbohydrate Group											
Subject No. 4	Qualit.	neg	neg	+++	++++	+++	+	++	++	++	tr
" "	Quant.mg	-	-	79	141	246	67	120	90	87	64
" " 8	Qualit.	neg	neg	+++	++++	+++	++	+++	++++	++++	neg
" "	Quant.mg	-	-	(lost)	167	128	67	163	383	170	-
	Mean:	0	0	40	154	187	67	142	237	129	32

TABLE 25. SHOWING THE RESULTS OF BLOOD EXAMINATION IN SURVIVAL RATION SUBJECTS PRIOR TO THE TEST

	Hemoglobin, G.	RBC	WBC	Neutrophiles	Stabs	Metamyelocytes	Myelocytes	Lymphocytes	Eosinophiles	Basophiles	Sedimentation Rate	Hematocrit	
Subject No. 1	15.0	4,800,000	7,000	52	-	-	-	45	2	-	1	2	51
" " 2	14.0	4,590,000	7,300	62	-	-	-	37	1	-	-	2	49
" " 3	16.0	5,170,000	7,200	55	-	-	-	44	-	-	1	9	51
" " 4	13.0	4,260,000	14,400	48	3	-	-	40	3	6	-	9	51
" " 5	13.0	4,280,000	7,700	58	1	-	-	38	2	1	-	9	46
" " 6	13.0	4,360,000	7,150	47	-	-	-	46	-	1	-	4	47
" " 7	14.5	4,660,000	11,700	51	4	-	-	38	3	3	1	6	52
" " 8	16.0	5,200,000	11,100	67	-	-	-	31	1	1	-	12	50
" " 9	15.0	4,910,000	13,900	78	2	-	-	19	1	-	-	19	50
" " 10	15.0	4,810,000	8,300	61	-	-	-	39	-	-	-	4	49
" " 11	14.0	4,560,000	8,000	38	1	-	-	46	2	12	1	12	50
" " 12	13.0	4,300,000	4,600	67	-	-	-	30	-	3	-	7	50

TABLE 26. SHOWING THE RESULTS OF BLOOD EXAMINATION AT VARIOUS STAGES OF THE EXPERIMENT.

Subject No. / Meat Group	Date	Hemoglobin, gm.	RBC	WBC	Neutrophiles	Stabs	Metamyelocytes	Myelocytes	Lymphocytes	Monocytes	Eosinophiles	Basophiles	Sedimentation Rate	Hematocrit
Subj. No. 1	5 January 1952	15.0	4,840,000	8,150	42	-	-	-	56	-	3	-	15	47
" " "	12 January 1952	15.0	5,020,000	6,250	29	-	-	-	65	-	4	2	4	48
" " "	1 February 1952	15.0	4,980,000	7,550	42	-	-	-	55	-	3	-	2	49
" " "	5 February 1952	14.5	4,870,000	6,800	64	-	-	-	34	1	1	-	4	48
" " "	11 February 1952	14.5	4,960,000	5,900	43	-	-	-	57	-	-	-	3	49
" " 5	5 January 1952	13.0	4,200,000	6,350	52	-	-	-	47	-	1	-	11	43
" " "	12 January 1952	14.0	4,760,000	6,500	40	-	-	-	39	-	1	-	14	47
" " "	1 February 1952	14.0	4,480,000	7,000	62	-	-	-	38	-	-	-	14	46
" " "	5 February 1952	13.5	4,600,000	7,350	56	1	-	-	42	1	1	-	10	46
" " "	11 February 1952	13.5	4,870,000	5,950	53	-	-	-	47	-	-	-	8	47
" " 6	5 January 1952	14.0	4,510,000	10,250	38	-	-	-	62	-	-	-	5	45
" " "	12 January 1952	14.0	4,890,000	10,150	37	-	-	-	63	-	-	-	4	47
" " "	1 February 1952	13.0	4,730,000	7,900	37	-	-	-	60	-	2	1	3	45
" " "	5 February 1952	13.0	4,560,000	6,800	54	-	-	-	42	1	2	1	5	45
" " "	11 February 1952	14.0	4,780,000	8,300	44	-	-	-	56	-	-	-	6	45
" " 10	5 January 1952	15.0	4,740,000	6,950	50	-	-	-	49	-	-	-	2	48
" " "	12 January 1952	14.0	4,670,000	7,900	56	-	-	-	44	-	-	-	2	49
" " "	1 February 1952	15.5	4,870,000	6,000	44	-	-	-	55	-	1	-	1	50
" " "	5 February 1952	15.0	4,980,000	8,050	66	-	-	-	33	-	1	-	2	48
" " "	11 February 1952	14.0	5,050,000	6,150	68	-	-	-	32	-	-	-	2	49
" " 12	5 January 1952	13.5	4,330,000	4,850	53	-	-	-	46	-	-	1	2	44
" " "	12 January 1952	14.0	4,770,000	6,650	47	-	-	-	51	-	2	-	8	48
" " "	1 February 1952	13.0	4,570,000	4,350	57	-	-	-	43	-	-	-	10	44
" " "	5 February 1952	12.0	4,160,000	4,300	61	1	-	-	34	1	2	2	7	42
" " "	11 February 1952	13.0	4,600,000	5,400	61	1	-	-	33	-	5	1	6	44

TABLE 26. (Cont'd)

Subject No.	Date	Hemoglobin, gm.	RBC	WBC	Neutrophiles	Stabs	Metamyelocytes	Myelocytes	Lymphocytes	Monocytes	Eosinophiles	Basophiles	Sedimentation Rate	Hematocrit
Carbo-hydrate Group														
Subj.No.2	5 January 1952	14.0	4,710,000	8,000	48	-	-	-	49	-	3	-	4	45
	12 January 1952	15.0	5,160,000	6,200	27	-	-	-	71	-	2	-	3	49
	1 February 1952	14.0	4,690,000	7,400	50	-	-	-	49	-	1	-	3	48
	5 February 1952	14.0	4,740,000	7,050	55	1	-	-	43	-	1	1	3	45
	11 February 1952	14.5	5,010,000	5,500	34	-	-	-	64	-	2	-	5	47
Subj.No.3	5 January 1952	15.5	4,930,000	6,750	58	-	-	-	41	-	-	1	5	48
	12 January 1952	15.0	5,250,000	6,950	37	-	-	-	61	-	-	2	8	49
	1 February 1952	14.5	4,860,000	7,600	39	-	-	-	59	-	-	2	13	47
	5 February 1952	14.0	4,750,000	7,650	54	-	-	-	46	-	-	-	8	47
	11 February 1952	14.5	4,950,000	8,700	52	1	-	-	46	1	-	1	5	48
Subj.No.7	5 January 1952	15.0	4,740,000	10,400	56	-	-	-	43	-	1	-	9	50
	12 January 1952	15.0	5,090,000	7,650	41	-	-	-	57	-	2	-	14	52
	1 February 1952	15.0	5,000,000	6,500	50	-	-	-	43	-	7	-	8	49
	5 February 1952	15.0	5,020,000	7,650	58	-	-	-	40	-	1	1	4	49
	11 February 1952	14.5	4,950,000	5,700	42	-	-	-	53	-	4	1	4	47
Subj.No.9	5 January 1952	16.0	5,010,000	7,800	63	-	-	-	36	-	1	-	16	48
	12 January 1952	15.5	5,430,000	10,050	53	-	-	-	46	-	1	-	6	53
	1 February 1952	15.0	4,900,000	7,400	66	-	-	-	31	-	3	-	6	51
	5 February 1952	15.0	5,010,000	7,300	70	-	-	-	24	1	5	-	11	49
	11 February 1952	16.0	5,240,000	9,000	67	-	-	-	33	-	-	-	4	51
Subj.No.11	5 January 1952	13.5	4,300,000	7,650	34	-	-	-	54	-	11	1	10	42
	12 January 1952	14.0	4,640,000	7,700	32	-	-	-	60	-	8	-	12	47
	1 February 1952	-	-	-	-	-	-	-	-	-	-	-	-	-
	5 February 1952	-	-	-	-	-	-	-	-	-	-	-	-	-
	11 February 1952	-	-	-	-	-	-	-	-	-	-	-	-	-

TABLE 26. (Cont'd.)

Subject No.	Date	Hemoglobin gm.	RBC	WBC	Neutrophiles	Stabs	Metamyelo-cytes	Myelocytes	Lymphocytes	Monocytes	Eosinophiles	Basophiles	Sedimentation Rate	Hematocrit
Meat-Carbohydrate Group														
No.4	5 January 1952	13.5	4,370,000	9,450	55	-	-	-	42	-	1	2	7	45
	12 January 1952	14.0	4,810,000	8,800	43	-	-	-	53	-	4	-	14	47
	1 February 1952	13.5	4,800,000	6,150	48	-	-	-	45	1	3	3	23	47
	5 February 1952	13.0	4,360,000	5,450	53	-	-	-	42	1	-	4	16	45
	11 February 1952	14.5	4,930,000	6,300	45	-	-	-	52	-	1	2	10	47
No.8	5 January 1952	15.5	4,960,000	8,650	59	-	-	-	38	-	3	-	4	50
	12 January 1952	14.0	4,950,000	8,150	53	-	-	-	44	-	3	-	6	48
	1 February 1952	14.5	4,940,000	7,300	49	-	-	-	47	-	2	2	7	49
	5 February 1952	15.0	5,030,000	8,100	79	2	-	-	19	1	1	-	8	47
	11 February 1952	14.5	4,690,000	8,300	59	3	-	-	41	-	-	-	18	45

TABLE 27. SHOWING MEAN BLOOD CHANGES AT VARIOUS STAGES OF THE EXPERIMENT.

	Hemoglobin, gm.	RBC	WBC	Neutrophiles	Stabs	Metamyelocytes	Myelocytes	Lymphocytes	Monocytes	Eosinophiles	Basophiles	Sedimentation Rate	Hematocrit
Meat Group.													
Standard. Phase	14.2	4,564,300	7,070	50	-	-	-	49	-	1	-	7	46
Experim. Phase	14.2	4,838,600	7,770	43	-	-	-	51	-	2	-	7	48
Before Field Phase	14.1	4,726,000	6,560	49	-	-	-	50	-	1	-	6	47
On 5th Field Day	13.6	4,634,000	6,660	60	-	-	-	37	1	1	-	6	46
End of Field Phase	13.8	4,852,000	6,340	54	-	-	-	45	-	1	-	5	47
Carbohydrate Group.													
Standard. Phase	14.8	4,738,000	8,120	52	-	-	-	45	-	4	-	9	47
Experimen. Phase	14.9	5,114,000	7,710	38	-	-	-	59	-	3	-	9	50
Before Field Phase	14.6	4,862,500	7,225	54	-	-	-	46	-	4	-	8	49
On 5th Field Day	14.5	4,880,000	7,413	59	-	-	-	38	-	2	-	5	48
End of Field Phase	14.9	5,037,500	7,225	69	-	-	-	49	-	3	--	4	48
Meat-Carbohydrate Group.													
Before Field Phase	14.0	4,870,000	6,150	48	-	-	-	46	-	3	2	15	48
On 5th Field Day	14.0	4,695,000	6,775	66	1	-	-	31	1	2	2	12	46
End of Field Phase	14.5	4,810,000	7,300	52	2	-	-	47	-	1	1	14	46

TABLE 28. FASTING BLOOD SUGAR.

		Standard. Phase	Experimental Phase	Field Phase		
		5 January 1952	12 January 1952	1 February 1952	5 February 1952	11 February 1952
Meat Group	Subj.No. 1	116	84	91	95	66
	" " 5	84	79	103	100	89
	" " 6	104	66	96	108	86
	" " 10	118	65	88	81	86
	" " 12	97	106	88	95	96
	" " 4	92	83	-	-	-
	" " 8	114	108	-	-	-
	Mean:	103	84	93	96	85
Carbohydrate Group	Subj.No. 2	114	111	104	100	106
	" " 3	93	88	94	107	92
	" " 7	97	111	98	128	87
	" " 9	115	109	88	116	102
	" " 11	95	96	-	-	-
	Mean:	103	103	96	113	97
Meat-Carbohydrate Group	Subj.No. 4	92	-	83	93	92
	" " 8	114	-	100	112	110
Mean:		103		92	103	101

TABLE 29. INCIDENCE AND SEVERITY OF KETOSIS DURING THE EXPERIMENTAL PHASE

Day of Phase	Carbohydrate Diet (5 Subjects)		Meat Diet (7 Subjects)	
	No. of Positive Reactions	Range *	No. of Positive Reactions	Range *
1	2	0-64	0	-
2	0	-	6	0-117
3	0	-	6	0-421
4	1	57	6	0-227
5	0	-	7	70-866
6	0	-	7	98-503

* Range = acetone - acetotacetic acid expressed as mg. of acetone/24 hr.

TABLE 30. INCIDENCE OF KETONURIA DURING FIELD AND RECOVERY PHASES

Day of Phase	Carbohydrate Diet (6 Subjects)		Meat Diet (5 Subjects)	
	No. of Positive Reactions	Range *	No. of Positive Reactions	Range *
Field Phase				
1	0	-	0	-
2	0	-	3	0-226
3	3	51-79	2	111-271
4	4	0-167	5	102-300
5	3	0-246	5	128-849
6	3	0-133	5	75-526
7	5	0-163	5	31-757
8	2	0-383	5	106-482
9	2	0-170	5	124-625
10	2	0-181	5	125-568
Recovery Phase				
11	1	23	1	49
12	0	-	0	-

* (Same as previous)
** Incomplete data. On this day urine specimens from 3 carbohydrate and 4 meat diet were lost. None of the remaining samples was negative.

When considering the most extreme conditions, as judged by the mean temperature of the coldest month, Alaska is in a very favorable situation compared with the rest of the Arctic areas, the mean temperature of the coldest month of northern Alaska being only -20° F, as against -30° F in the greater part of the Polar Basin, and -35° F in the northern Canadian Arctic.

As already pointed out in the introduction, the availability of water in the Arctic has been emphasized in previous reports as a major problem which has greatly influenced the concepts of Arctic survival rations. It should be remembered, however, that in most parts of the Arctic there is an abundance of streams, rivers, and lakes (fig. 16) where water can be readily obtained during the summer or through the ice during the winter months. Under the most extreme conditions the accumulation of lake ice seldom exceeds 40-60 inches. Melt water can be expected in the Polar Basin from early May until the end of September, and between early April and October in the rest of the Arctic, i.e., about 50 percent of the time.

In addition, there are many ways of obtaining water by melting snow or ice. For centuries the Eskimos have produced their drinking water in the winter while hunting on the sea ice by melting snow in bags of walrus intestines carried underneath their parkas. In this way, ample quantities of drinking water were obtained without any discomfort, with the utilization of body heat which more or less would have been wasted otherwise.

In an experiment conducted in connection with the survival ration study, almost a quart of water was produced in this way by one person over a period of 5 hours, during a 6-mile march, and normal camp activities. No unpleasant effect was observed, no cooling effect was experienced, and the bags did not restrict the movements. It is highly recommended that this technique be adopted in Arctic survival.

Under Arctic conditions heat, and the facilities for preparing at least one hot meal a day, are very important. This was clearly realized by the early Arctic travellers who solved this problem by a great variety of methods. Sixty years ago Fridtjof Nansen developed a cooking apparatus, known as the Nansen Cooker (fig. 17), which he and Johansen used during their march towards the North Pole from the Fram. This apparatus enabled them to cook two hot meals a day and to melt an abundance of water over a period of 120 days, using a total of about 4 gallons of fuel, i.e., approximately 150 ml. fuel per day. If the number of hot meals were reduced to one meal a day, the fuel consumption would amount to about 30 ml,

Fig. 13. The Meat Ration

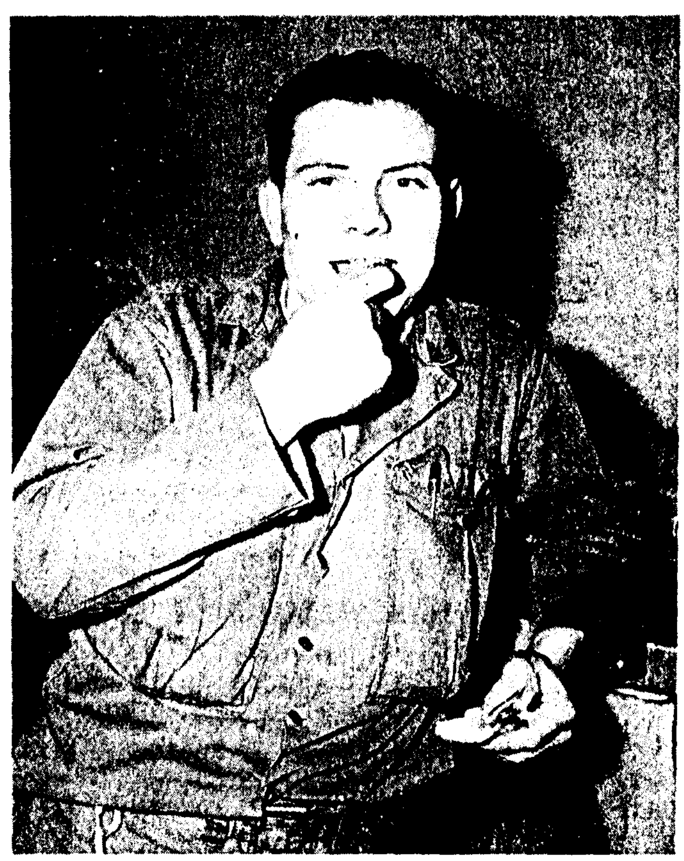

Fig. 14. The Carbohydrate Ration

per person per day. No doubt the modern technique could improve the efficiency of the apparatus, and adapt it to the most rigid survival conditions. In view of the importance of this question, the following paragraphs are quoted from Nansen (1897):

"The cooking apparatus we took with us had the advantage of utilizing to the utmost the fuel consumed. With it we were able, in a very short space of time, to cook food and simultaneously melt an abundance of drinking water, so that both in the morning and in the evening we were able to drink as much as we wished, and even a surplus remained. The apparatus consisted

Fig. 15. SubjectNo.1 before (a,c) and after (b,d) field phase

of two boilers and a vessel for melting snow or ice in, and was constructed in the following manner: Inside a ring-shaped vessel was placed the boiler, while underneath this again was the lamp. The entire combustion output was thus forced to mount into the space between the boiler and the ring-shaped vessel. Over this was a tight-fitting lid with a hole in the middle, through which the hot air was obliged to pass before it could penetrate farther and reach the bottom of a flat snow-melter, which was placed above it. Then, after having delivered some part of its heat, the air was forced down again on the outside of the ring-shaped vessel by the help of a mantle, or cap,

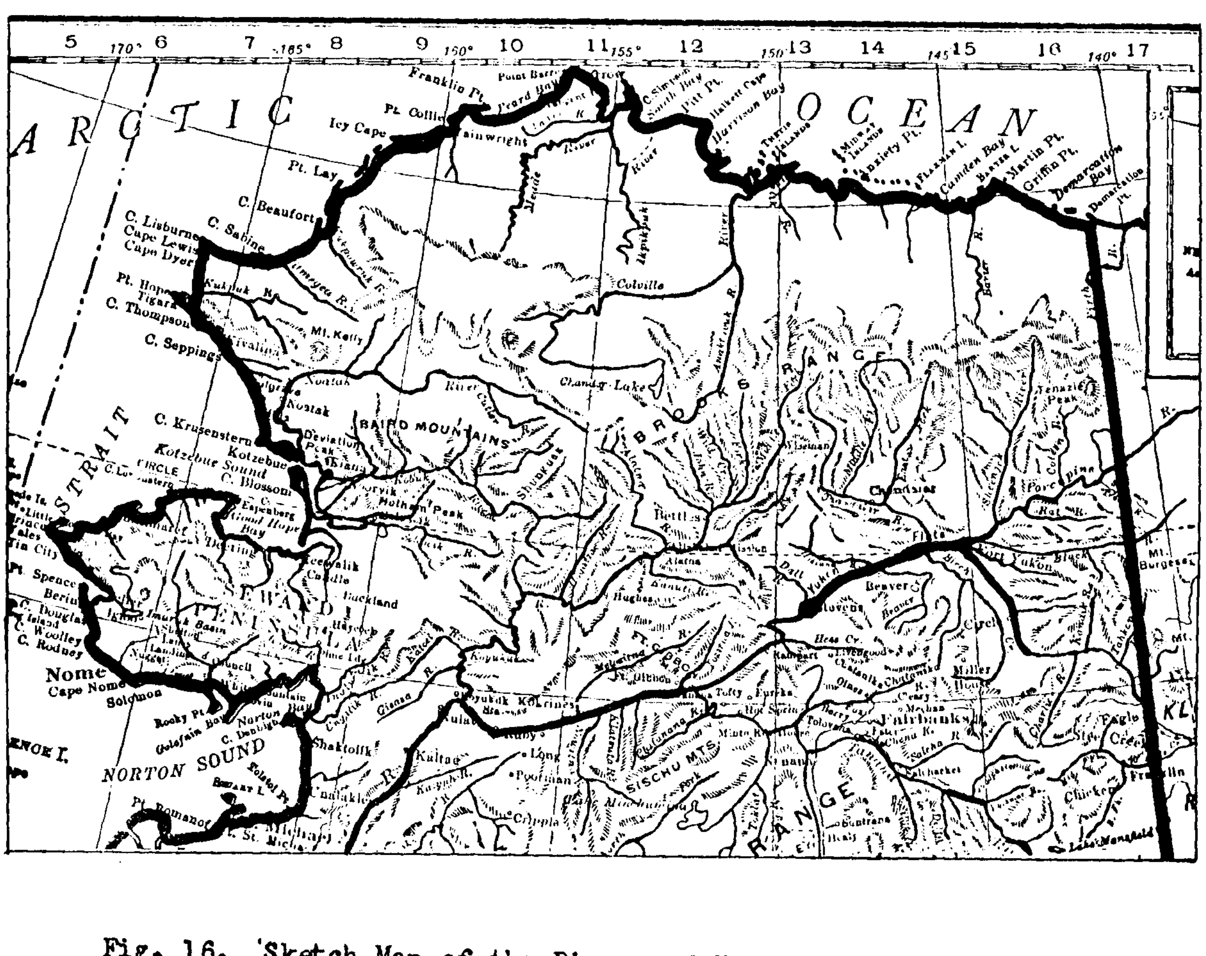

Fig. 16. Sketch Map of the Rivers of Northern Alaska

which surrounded the whole. Here it parted with its last remaining warmth to the outer side of the ring-vessel, and finally escaped, almost entirely cooled, from the lower edge of the mantle.

For the heating was used a Swedish gas-petroleum lamp, known as the "Primus," in which the heat turns the petroleum into gas before it is consumed. By this means it renders the combustion unusually complete. Numerous experiments made by Professor Torup at his laboratory proved that the cooker in ordinary circumstances yielded 90 to 93 percent of the heat which the petroleum consumed should, by combustion, theoretically evolve. A more satisfactory result, I think, it would be difficult to obtain. The

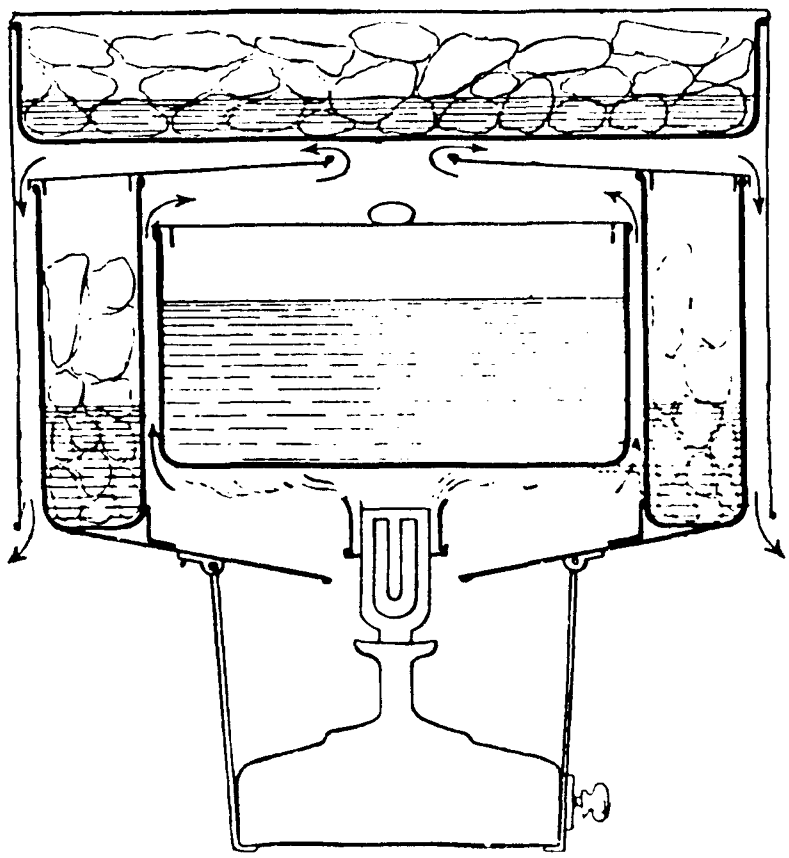

Fig. 17. The Jensen Cooker.

vessels in this cooker were made of German silver, while the lid, outside cap, etc., were of aluminum. Together with two tin mugs, two tin spoons, and a tin ladle, it weighed exactly 8 pounds 13 ounces, while the lamp, the "Primus," weighed $4\frac{1}{2}$ ounces.

As fuel, my choice this time fell on petroleum ("snow-flake"). Alcohol, which has generally been used before on Arctic expeditions, has several advantages, and, in particular, is easy to burn. One decided drawback to it, however, is the fact that it does not by any means generate so much heat in comparison with its weight as petroleum when the latter is entirely consumed, as was the case with the lamp used by us. As I was afraid that petroleum might freeze, I had a notion of employing gas-oil, but gave up the idea, as it escapes so easily that it is difficult to preserve, and is, moreover, very explosive. We had no difficulties with our "snowflake" petroleum on account of the cold. We took with us rather more than 4 gallons, and this quantity lasted us 120 days, enabling us to cook two hot meals a day and melt an abundance of water."

In the present study, the water consumption was on an average 1,500 ml. per day in the meat group, as against an average of 850 ml. in the carbohydrate group. In view of the foregoing consideration, this difference should be of little importance.

The second important problem is the question of ketosis. It is clearly realized that the determination of ketone bodies is subject to considerable inaccuracy. However, the reported data indicate that under the conditions of the test the excretion of urinary acetone in the meat group never exceeded 1 gm. a day. The highest figure recorded was 866 mg. which is a very small amount.

According to Peters and Van Slyke (1946), ketones are regularly found in the urine of healthy persons leading a normal life. Van Slyke found as much as 280 mg. ketones per 1,000 ml. urine. Others have reported figures between 7 and 125 mg. daily.

Under conditions such as total starvation when all energy is derived from protein and fat, the production of ketone bodies by the liver is accelerated and the excretion of ketones in the urine increases. In normal adults the appearance of gross ketonuria, according to Peters and Van Slyke (1946) does not reach its height until 3 to 5 days of the fast have elapsed. As starvation proceeds ketosis gradually diminishes. He states that in the normal male, ketosis of starvation does not reach serious proportions because sufficient carbohydrate is derived from protein and oxidized, and that the levels of blood ketones are not high enough to tax severely the mechanism for the preservation of acid-base equilibrium. In one subject about 6 gm. of B-hydroxybutyric acid were excreted daily in the urine for the last two weeks of a 31-day fast. In diabetic acidosis ketonuria may reach values 10 times higher than this.

p. Compared with these figures the amounts of acetone excreted in the urine in our subjects on the meat ration are insignificant, and it appears that this slight ketonuria observed under these conditions for the periods considered likely as the duration of a survival situation would have no appreciably harmful effect.

Exercise greatly increases the ketosis, and a 10-mile walk in the morning without breakfast will produce distinct ketonuria in a healthy person who otherwise is living on a normal diet (Courtice and Douglas, 1936).

A number of evidences indicate a mechanism of adaptation to ketosis. In or Eskimo studies it is observed that the degree of ketonuria is less than what is normally observed in Whites on a similar diet. On the other hand, an Eskimo soldier who had lived for several months on the normal Army mess rations excreted the same amounts of acetone as the normal White soldiers when given a "ketogenic" diet (table 24, subject No. 12). In the subjects studied by McClellan and DuBois (1930) the ketonuria diminished after several months on a carbohydrate-free diet.

Deuel and Gulick (1932) have demonstrated that ketosis develops more rapidly and attains greater intensity in women than in men.

It has been repeatedly observed that ketosis frequently occurs under strenuous field conditions regardless of the diet, and Sargent and Consolazio (1951) showed that the ketosis is reduced when the same subject undergoes repeated field tests, indicating some evidence of adaptation.

In an Arctic bivouac at Fort Churchill the approximate caloric expenditure was 4,000 calories per day. The caloric intake was about 3,600. Under these conditions all the men showed trace quantities of urinary ketones almost every day, starting on the third day in the bivouac (Molnar et al., 1942).

Of the great variety of physical fitness tests (Cureton, 1947), the Treadmill Test was selected for practical reasons. It should be emphasized, however, that physical fitness is exceedingly difficult to evaluate, not only because the meaning of physical fitness is far from clear, but also because the result of the test is greatly dependent upon a number of factors beyond the control of the observer.

In all cases we observed an improvement at the end of the field phase, most marked in the carbohydrate group, associated with approximately 10-pound weight loss (7.5 percent).

It should be noted that the subjects had been living on a caloric deficit of the order of 2,000 calories a day, and performing daily route marches of 10 miles.

In the case of untrained personnel in poor physical condition, one would expect an improvement in physical fitness during the field phase. Our subjects, however, were all well trained and in excellent physical condition at the onset of the experiment. The factor of physical training therefore can hardly explain the difference in the physical fitness score.

On the other hand, it appears that the weight loss may be the most important factor in explaining the observed difference. The subjects started off probably slightly overweight and the loss of 7 percent of their body weight would tend to increase their physical performance, since there is less weight to carry during the exercise. This is in conformity with general experience under similar conditions. It is observed that the carbohydrate group, which had the greatest weight loss, also showed the greatest improvement of physical fitness score.

The purpose of the experimental phase was to study the effect of the experimental diet on various physiological functions as compared with the levels during the normal conditions during the standardization phase. The results indicate the following effect: Both in the carbohydrate group and in the meat group, there was an increase of the physical fitness scores, most pronounced in the carbohydrate group. It is probable that the weight, at least in part, may account for this improvement. The weight loss was greater in the carbohydrate group (4.6 lb.) than in the meat group (2.5 lb.). The basal heat production was 13 percent higher at the end of the experimental phase than during the standardization phase in the meat group, while a reduction of 7 percent occurred in the carbohydrate group. This difference is probably due to the specific dynamic action of protein. During the experimental phase the meat group consumed 300 ml. more fluid per day than the carbohydrate group, while all subjects in the meat group were in a positive nitrogen balance, the subjects in the carbohydrate group showed a negative balance of 6.3 gm. on an average. Ketonuria occurred in all meat subjects and in three of the carbohydrate subjects.

During the field phase the factor of climatic stress was added to the experimental conditions, and the following results were obtained.

No significant difference was observed in the physical performance of the subject on the meat ration, the carbohydrate ration, or on the meat-and-carbohydrate ration during the actual field phase. The physical fitness scores were improved in all three groups at the end of the field phase, and this improvement was greatest in the carbohydrate group which also had the greatest weight loss. The psychiatric evaluation revealed no distinct differences between the three groups. There was no significant deterioration in morale, but an increase in carelessness, irritability and desire to sleep which occurred in all three groups. The weight loss was 7.0 percent in the meat group, 7.5 percent in the carbohydrate group, and 6 percent in the group receiving both meat and carbohydrate. There was an increase in the basal heat production of 9 percent in the meat group and 7 percent in the meat-carbohydrate group, while the carbohydrate group showed a reduction of 7 percent in the BMR. The water consumption was 1,500 ml. in the meat group, 850 ml. in the barbohydrate group, and 1,200 ml. in the meat-carbohydrate group. All three groups showed negative nitrogen balance, which was most pronounced in the carbohydrate group, where it was approximately 7 gm., as against approximately 2 gm. in the meat group. Ketonuria occurred in all three groups, most pronounced in the meat group.

On the basis of these findings, and the foregoing discussion of the significance of water requirement, ketonuria, and the assessment of physical fitness scores, it may be concluded that the carbohydrate ration offered no significant advantage under conditions of arctic survival as simulated in the present study. In terms of heat production and nitrogen balance, the high meat ration is preferable. It is evident from this study that under survival conditions, which necessitate caloric expenditure, between 2,500 and 3,000 calories per man per day, including travel of approximately 10 miles a day, 1,000 calories per man per day is sufficient for a period of at least 10 days.

It would therefore seem logical that survival rations developed for Arctic use should consist of protein, fat, and carbohydrate in proportions which would serve to utilize the specific dynamic action of a high protein diet, the high caloric density of fat, and the physiological advantages of carbohydrates.

Protein-fat rations with high caloric density such as various types of pemmican, have already been successfully used for more than half a century by Arctic travellers. It would appear advisable to base future Arctic survival rations on the principle of a high meat-fat ration as the main meal of the day prepared in the evening, and an all-carbohydrate component of the ration to be consumed in the middle of the day while on the trail.

ACKNOWLEDGMENTS

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December 1952

DEFENSE—SAN ANTONIO

THIS REPORT CONCERNS . . . .
the physiological requirements for survival rations to be used in Arctic conditions.

IT IS FOR THE USE OF . . . .
physiologists, nutritionists, and agencies within the USAF concerned with problems related to survival rations.

THE APPLICATION FOR THE AIR FORCE IS . . . .
to aid in determining what type of ration would yield the maximum efficiency under the survival conditions in the Arctic.

ARCTIC SURVIVAL RATIONS

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CHARLES R. SHAW
HORACE F. DRURY

Department of Physiology

PROJECT NUMBER 22-1101-0002
REPORT NUMBER 1

ARCTIC AEROMEDICAL LABORATORY
LADD AIR FORCE BASE, ALASKA
December 1952

PRECIS

OBJECT

To consider a high carbohydrate versus a high protein survival ration with particular reference to physiological adequacy, and the evaluation of problems related to water requirements and the physiological and clinical significance of ketosis under Arctic survival conditions.

SUMMARY AND CONCLUSIONS

Recent reports on Air Force survival ration studies have emphasized the desirability of an all-carbohydrate ration for Arctic survival. In a series of laboratory experiments followed by field experiments under simulated survival conditions, the physiological adequacy of low calorie survival rations have been studied in groups of normal men under conditions which necessitate travel under various Arctic conditions. The rations studied contained approximately 1,000 calories per man per day and consisted of an all-carbohydrate ration and a high protein-fat ration. On the basis of the presented data it may be concluded that from a physiological standpoint the all-carbohydrate ration offered no significant advantage over the high meat ration under the conditions of the study. The requirements for Arctic survival rations are discussed with suggestions for future work.

ARCTIC SURVIVAL RATIONS

INTRODUCTION

In recent years a variety of different rations has been tested during a number of field ration studies under Arctic or subarctic conditions. In the case of Air Force survival rations, there has been a tendency to emphasize the desirability of an all-carbohydrate ration (Mellinger, 1948; Roth, 1948; Dyme, 1950).

The views on the type of survival ration preferable under Arctic conditions are still conflicting. Further systematic research in this field on a continuous basis is highly desirable in order to obtain a definite answer as to what type of ration would yield the maximum efficiency under the survival conditions in the Arctic on the basis of the space and weight allocation available for survival rations in the aircraft.

In previous studies, one argument in favor of an all-carbohydrate ration has been the reduced water requirements on a carbohydrate ration. The assumption has been that the supply of water is a critical problem in the Arctic as it is in the Tropics. A second argument in favor of the carbohydrate ration has been its antiketogenic effect, assuming harmful effect of ketosis under these conditions.

Frantz (1948) concluded as the results of a survival ration trial in Alaska that thirst is a serious problem for men eating the USAF emergency ration, although 800 ml. fluid per day was adequate to maintain water balance on this ration. He found that 1400 ml. gasoline was required per man for 10 days to melt this quantity of water from snow under the conditions of the test.

Mellinger (1948) recommended that a more efficient snow-melting apparatus should be developed. He also stated that because of limitation of fuel supply for melting snow, the problem of water balance in the Arctic is similar to that encountered in survival at sea. He concluded on the basis of all-weather room experiments that with caloric expenditures of 4,000 to 4,500 calories, 100 gm. of carbohydrate is adequate to prevent ketosis and to spare body protein to the extent of about 50 percent of the loss during fasting and that, although physical deterioration occurred on this regimen, it was possible to maintain a caloric output of 4,000 to 4,500 calories per day for 6 days. It should be noted, however, that this conclusion does not agree very well with his reported data, as acetonuria also occurred in both subjects on the carbohydrate ration, although slightly less than during fasting.

A comprehensive report by Roth (1948), stressing the problem of water supply in the Arctic and the significance of ketosis suggests a ration essentially composed of carbohydrate with a small amount of protein (up to 5 gm.) and fat (up to 10 percent of the calories) as an all-purpose survival ration, supplying 1,000 calories per day for the Arctic environment and 500 calories for the tropical areas.

In a later survival ration study, reported by Dyme (1950), the all-carbohydrate ration ST-1 (500 cal/man/day) was found to impose a very large caloric deficit under the conditions of the test, and failed to prevent ketosis. For this reason it was found inadequate as an all-purpose, global survival ration.

The purpose of the present study was to consider a high-carbohydrate versus a high-protein diet, with particular reference to physiological adequacy, and an evaluation of problems related to water requirements and the physiological and clinical significance of ketosis under Arctic survival conditions.

During a survival ration conference of representatives from the Aeromedical Laboratory and the Arctic Aeromedical Laboratory held on 9 November 1950, it was concluded on the basis of previous experiences that a limited space survival ration should contain approximately 1,000 calories per man per day. The rations examined in the present study were therefore limited to 1,000 calories.

In the past it has been the usual policy to remain with the aircraft. It appears that it is now realized that the necessity for escape and evasion in the case of hostilities would in many cases mean travel under various Arctic conditions from the scene of the crash to a neutral zone or a pick-up point. On this basis, the evaluation of survival ration requirements should include this factor, which would necessitate higher caloric expenditure. For this reason, the present study was performed under conditions which necessitated travel under various Arctic conditions.

It has been customary in the past to consider 10 days as a reasonable survival period. This, obviously, will depend on a number of factors influencing the actual survival situation. If the aircrew is down with the aircraft intact, it would seem likely that the available radio and signaling equipment would greatly facilitate the search and thus increase the chances for an early rescue. In that case, a 10-day supply of survival rations might be reasonable. If on the other hand the aircrew is stranded with a completely demolished aircraft or in the case of bail out, the problem is entirely different, particularly if the crew is stranded in the area of the Polar Basin where conditions are extreme.

For the purpose of this study, however, the 10-day period was chosen as the duration of the actual field phase, taking into consideration the apparent physical and mental resources of the subjects at the completion of this period.

PROBLEM

In view of the great variety of Arctic environments (the pack ice in the Polar Basin, the Arctic coast, the tundra, the inland ice of Greenland, the inhabited areas such as Arctic Norway, and the inhabited mountain regions of Alaska, Arctic Canada, etc.) — each representing different survival problems, and because of the varying conditions for the survival depending on whether the survivors bail out or crash land, the problem of Arctic survival rations cannot be solved in a single experiment.

The problem which formed the basis for the present study was limited to the consideration of an all carbohydrate ration versus a high protein ration, and was intended as a link in a series of studies designed to establish the physiological requirements for survival rations to be used in Arctic conditions.

METHODS AND PROCEDURES

A. Arrangement of the Experiment

1. Control studies

a. Standardization phase. During a control period of 4 days beginning 3 January 1952, two groups of 5 and 7 normal men were subject to comprehensive clinical and laboratory examinations while subsisting on unlimited quantities of the normal mess ration, with a certain caloric expenditure. The examinations included complete physicals, x-rays, routine blood and urine examinations, quantitative determination of total acetone bodies in the urine, and determinations of fasting blood sugar. The studies included careful estimations of the caloric, water and nitrogen balances and turnover rates for each subject. These were calculated on the basis of complete individual food weighings and fluid consumption records, hourly time-activity data, repeated basal metabolic rate determinations, measurements of urine volume and nitrogen content and daily body weight determinations. Observations were made regarding physical fitness, and a psychological evaluation of each subject was prepared by a psychiatrist.

b. Experimental phase. An experimental period of 6 days followed the standardization phase. During this phase the same investigations were made in the same subjects while subsisting on the experimental ration, the conditions otherwise being unchanged. One group received 1,000 calories in the form of the all-carbohydrate ration (ST-1). The second group received the same amount of calories in the form of a specially prepared meat diet (boiled ground steak).

Both groups consumed their rations at the same time, i.e., twice daily, in the morning and in the evening. The water intake was recorded throughout the experimental phase, by using measured paper cups.

Twenty-four-hour urine samples were collected throughout the experimental phase, from 0630 to 0630 hours in labelled canteens. The subjects were thoroughly briefed in the method of urine collection.

The body weight, nude, was recorded daily immediately following the emptying of the bladder in the morning. Body temperature, blood pressure, and pulse rate was recorded twice daily.

Environmental studies were made during the entire control period.

The subjects lived in a separate, isolated barracks throughout the study and were under the observation of a technician at all times.

2. Field studies

During a third period following a suitable recuperation period, the experiment was repeated with the same rations on the same subjects under simulated survival conditions in the field, which involved similar caloric expenditure. The investigations carried out during this period were essentially the same as during the previous period. In this study two of the subjects who originally received the meat ration received a combination of the meat and the carbohydrate ration.

The subjects were admitted to the laboratory in the afternoon of 31 January 1952, bringing with them their standard adequate field clothing and equipment, such as skis and snowshoes. After briefing, medical examination and supper, the subjects were confined to the sleeping quarters under the supervision of a technician. An inspection was made to insure that no food was brought.

The following morning, i.e., the first day of the field phase, the urine was voided at 7:00 A.M., the body weight recorded, and a fasting blood sample collected for fasting blood sugar, etc. Following this, the first rations were issued and consumed, after which the men and the equipment together with the field observers were transported to the camp site by truck.

During the entire field phase, which lasted 10 days, the rations were issued and consumed twice daily, i.e., in the morning and in the evening. Hot tea and/or coffee without sugar and cream were available for all three groups.

Each day all subjects traveled approximately 10 miles, half of this in the morning and the other half in the afternoon. The distance was covered by foot, on skis, or on snowshoes. All three groups lived and travelled together, and the conditions, apart from the rations, were as similar as possible for all groups.

A complete meteorological station was established at the camp site in advance, and temperature and humidity readings were also made in the tents.

The urine was collected from each subject throughout the field phase. A fasting blood sample was collected on the fifth day and at the conclusion of the test.

On the tenth daythe subjects were taken back to the laboratory where physical examinations were made. Physical fitness tests were conducted and psychological evaluations performed.

In the morning of the eleventh day, i.e., February 11, the last urine sample was collected. A fasting blood sample was taken, and the BMR recorded. Following this a light lunch was consumed, and the subjects returned to normal conditions.

3. Recovery studies

The subjects were observed during a period of three days during recovery prior to proceeding on convalescent leave.

During this period, the subjects were allowed to consume food and water in unlimited quantities. The body weight was recorded daily.

B. Subjects

A total of 12 normal infantry personnel, 19 to 23 years old, from the Third Battalion, 4th Infantry Regiment, were used for this study. These men were thoroughly indoctrinated and well trained in Arctic survival, accustomed to Arctic field activities and well disciplined. Eleven of the subjects had spent 17½ months in Alaska, and one of the subjects, who was an Eskimo, had lived in the territory all his life.

Medical examination, including medical histories and complete physical examination, revealed no pathological condition in any of the 12 subjects selected from a group of 14 men. Routine blood and urine examination showed normal findings (see tables 22 and 25).

The subjects were divided into two groups: one group of 5 men was given the carbohydrate ration; a second group of 5 men was given the meat ration. A third group of 2 men was, for the purpose of another study, given the meat diet, during the control studies, while during the field study they received a combination of both rations. A senior NCO was included in each of the two main groups. The NCO's, who were well acquainted with the men, were in charge of the personnel during the test.

One of the subjects, subject No. 11, developed a hand infection after the conclusion of the control studies, and was therefore unable to take part in the field study.

For the purpose of motivation, the subjects were to receive convalescent leave to the States upon completion of the field study. During the first 4 days of the field study no leave would be accumulated. From the fifth field day, the leave would be accumulated as follows:

For the 5th day: 1 day's leave
For the 6th day: 2 days' leave
For the 7th day: 3 days' leave
For the 8th day: 4 days' leave
For the 9th day: 5 days' leave
For the 10th day: 5 days' leave

C. Rations

1. Carbohydrate ration. As a carbohydrate ration, the starch-jelly bar from the ST-1 ration was used. It contained 355 calories per 100 gm.

2. High-protein ration: As a high protein ration, boiled ground round steak was used. It was minced, thoroughly mixed, boiled, skimmed, strained, and carefully weighed prior to consumption.

Analyses of five different random samples of the prepared meat ration gave the following average results:

Water:	60.4 percent
Fat:	12.5 percent
Protein:	27.3 percent
Carbohydrate:	0.0 percent

3. The meat-carbohydrate group received 270 gm. of the meat ration and 116 gm. of the carbohydrate ration daily divided into two meals of equal size, one in the morning and one in the evening.

D. <u>Test location</u>

The camp for the field study was located at Birch Hill, on the outskirts of Ladd AFB (fig. 1). The camp was accessible by road, and the surrounding terrain was suitable for travel on foot along the road, on skis along the ski trail, and by snowshoes through the woods. The camp consisted of 4 tents for the subjects and 1 tent for the observers (fig. 2). No heat was allowed in the tents except for the use of a Colman stove (fig. 6) for half an hour in the morning and evening for the purpose of melting snow for the preparation of beverage (tea and coffee).

During the field study the temperature at the camp site ranged between -36° F. and $+12^{\circ}$ F., the mean temperature being -15° F. The meteorological data from Ladd AFB, for the period of the study, are given in tables 1-3. The mean temperature inside the tent was about zero degrees Fahrenheit (minimum -20° F.; maximum $+20^{\circ}$ F.).

SURVIVAL RATION CAMP AREA

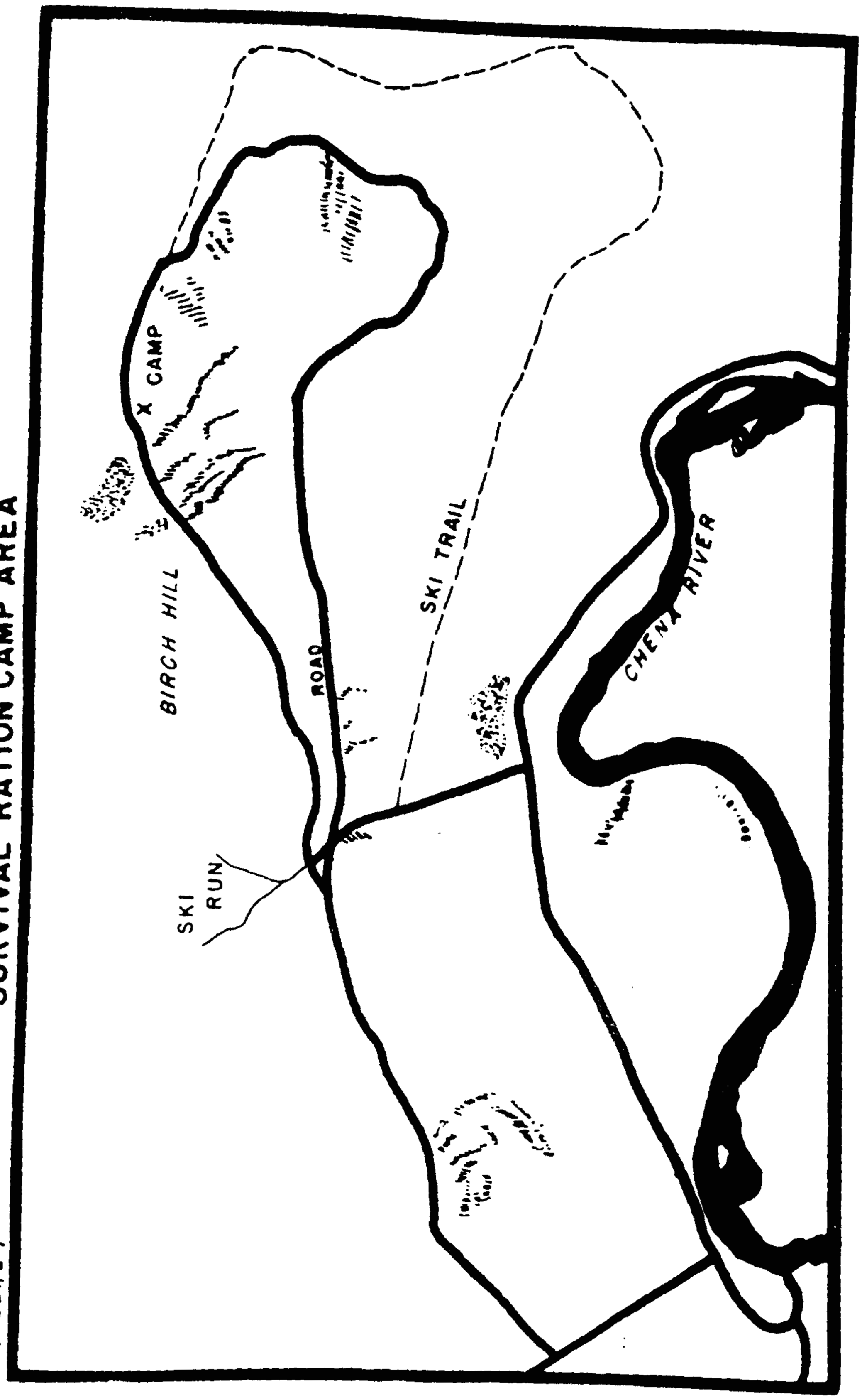

FIGURE I

Fig. 2. The Survival Camp

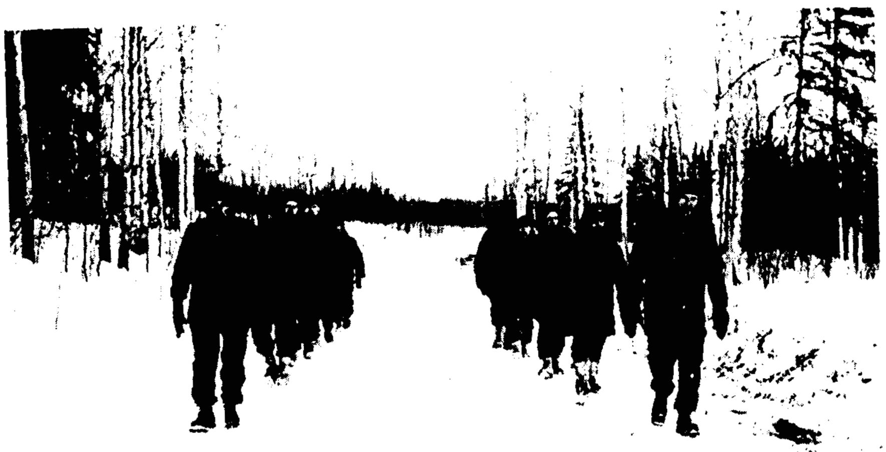

Fig. 3. Route March

Fig. 4. The Ski Trail.

Fig. 5. Snowshoeing

Fig. 6. Melting Snow in the Tent

E. Field Observers

Two observers remained with the subjects at all times. They spent the nights in a separate tent in the camp, and accompanied the subjects in their daily activities and while traveling. The subjects, therefore, were under almost constant observation. Notes were made of the performance and behavior of each of the subjects, with particular emphasis on the following points:

1. Personal care. The subject's ability to take care of himself, his attitude to current problems, precautions, interest in personal well-being and comfort, ability to make the best of a given situation, tendency to give up or surrender when faced with a critical situation.

TABLE 1. DAILY MEAN METEOROLOGICAL DATA. STANDARDIZATION PHASE.

Date	Time	Wind			Temperature			Baro-Metric Pressure	Total Sky Cover	Total Precipi-tation	Snow Cover	Rela-tive Humidity (Mean)
		Peak Gust	Direction	Mean MPH	Maximum	Minimum	Dry Bulb (Mean)					
January 3	0603	13	E	1.4	15	- 6	+7.2	28801	8.5	T	20"	83.8
January 4	1744	31	WSW	3.4	16	- 11	+3.9	29078	9.7	.08	20"	82.0
January 5	0953	16	E	3.3	-11	- 33	-24.7	29303	4.2	0	21"	73.3
January 6	0956	3	E	0.2	-32	- 45	-38.6	29374	4.9	0	20"	-
Mean	-	-	E	2.3	- 3	-23.7	2.3	29139	6.8	0.02	-	79.7

TABLE 2. DAILY MEAN METEOROLOGICAL DATA. EXPERIMENTAL PHASE

Date	Time	Wind			Temperature			Baro-Metric Pressure	Total Sky Cover	Total Precipi-tation	Snow Cover	Rela-tive Humidity (Mean)
		Peak Gust	Direction	Mean MPH	Maximum	Minimum	Dry Bulb (Mean)					
January 7	-	Calm	-	-	- 40	- 48	-44.7	29602	7.3	0	19"	-
January 8	-	Calm	-	-	-45.0	-51.0	-47.2	29703	6.0	0	19"	-
January 9	1400	2	ENE	0.1	-47	-53	-49.6	29751	5.9	0	19"	-
January 10	-	Calm	-	-	-48.0	-54.0	-51.2	29926	7.7	0	18"	-
January 11	-	Calm	-	-	- 4	-48	-21.8	29354	9.5	2.4"	10"	-
January 12	1000	16	SW	3.8	- 3.0	-32	-25.2	29738	8.0	2.3"	22"	60.6
				-	[illegible]	-47.7	-40.0	29677	7.4	0.78	-	60.6

TABLE 3. DAILY MEAN METEOROLOGICAL DATA. FIELD PHASE.

Date	Time	Wind			Temperature			Baro-metric Pressure	Total Sky Cover	Total Precip-itation	Snow Cover	Rela-tive Humidity
1952		Peak Gust	Direction	Mean MPH	Maximum	Minimum	Dry Bulb (Mean)					
1 February	2230	3	E	1.60	- 1	-15	-5.6	28896	4.8	T	-	66.5
2 February	-	Calm	-	-	- 7	-25	-12.9	29079	5.6	T	-	77.6
3 February	-	Calm	-	-	- 6	-19	-11.7	29099	5.6	T	27"	
4 February	0940	5	SE	0.21	-10	-28	-18.0	29213	4.8	-	-	76.3
5 February					- 7	-27	-17.5	29131	4.5	T	27"	75.2
6 February	2328	3	NW	0.09	+ 5	-16	- 8.4	28983	4.5	0	26"	75.4
7 February	2352	5	E	0.79	+ 5	-13	+ 3.8	28335	4.0	0	25"	82.4
8 February	-	11	ENE	0.33	+12	-10	-17.5	28526	4.1	0	24"	82.1
9 February	1930	5	SW	0.33	+ 8	- 1	- 2.4	28708	7.2	0	22"	84.6
10 February	-	Calm	-	-	+ 7	- 3.9	+ 3.1	29114	9.5	16	23"	85.6
Mean	-	-	-	0.56	-	-	- 9.0	28908	5.5	-	-	78.3

2. Physical performance. Physical strength, stamina, signs of fatig whether or not more easily fatigued than normal, shortness of bre ability to keep up with the group, difficulties with gear and equipment.

Notes were made of the intervals between rest periods, speed of travel distance of travel per day, time required to perform certain details such dressing, etc, gait (whether steady or swaying), initiative and will-power, competition among the subjects as to physical performance.

3. Abnormal performance and manifestation of pathological conditions. Anything unusual was recorded, and precautions were taken to see that no food was hidden or consumed other than the official ration. Notes were made of the time of food consumption, and the occurrence of fatigue in relation to meal times. Occurrence of hunger pains, fainting, or symptoms of malaise were recorded, and also whether or not the subject felt cold. The observer carefully watched for the possible occurrence of frostbite.

F. Laboratory methods

For the routine blood and urine examination the standard methods were used.

The composition of the meat ration was determined in the usual way; t water content was determined by drying to constant weight at 104° C., the f content by extraction in the Soxhlets apparatus, the protein content by th Kjeldahl method.

During the standardization phase the food consumption was determined by careful individual weighing of the food consumed at each meal, using paper plates and cups (fig. 12). During the experimental and field phase the rations were weighed and issued at each meal and totally consumed. Th caloric expenditure was estimated by using time-activity sheets which were filled out with the assistance of observers.

For assessing the physical fitness of the subjects at the various stages of the experiment, the treadmill test of physical fitness for hard muscular work, described by Johnson et al. (1942), was used. Repeated tests were performed, considering the possible factor of learning. In addition, the performance of each subject was evaluated by personal observations by the observers.

The basal metabolic rate was determined both by the Benedict-Roth and by the Sanborn Waterless apparatus (fig. 11). The technique has been described in detail in a previous report (Rodahl 1952).

The subjects were allowed to consume water ad libitum, but the water consumption was measured.

Fig. 7. Chopping Wood

Fig. 8, The Camp Fire

Fig. 9. The Standard Clothing.

Fig. 10. In the Sleeping Bag

Twenty-four-hour urine samples were collected in individual, labeled canteens which were kept at the ambient temperature. This meant that each increment was frozen almost as soon as collected. Each morning the canteens were collected and replaced with empty ones. The urine was thawed and analyzed immediately after being brought in from the field. After thorough mixing and determination of the volume, nitrogen and ketone body determinations were made as follows:

1. Nitrogen. Following appropriate dilution and thorough digestion with sulfuric acid and potassium persulfate, the nitrogen content was determined by the Nessler reaction. Readings were made at 540 mμ with the Klett Photoelectric colorimeter and corrected to mg/ml. with the aid of a calibration factor (straight line relationship).

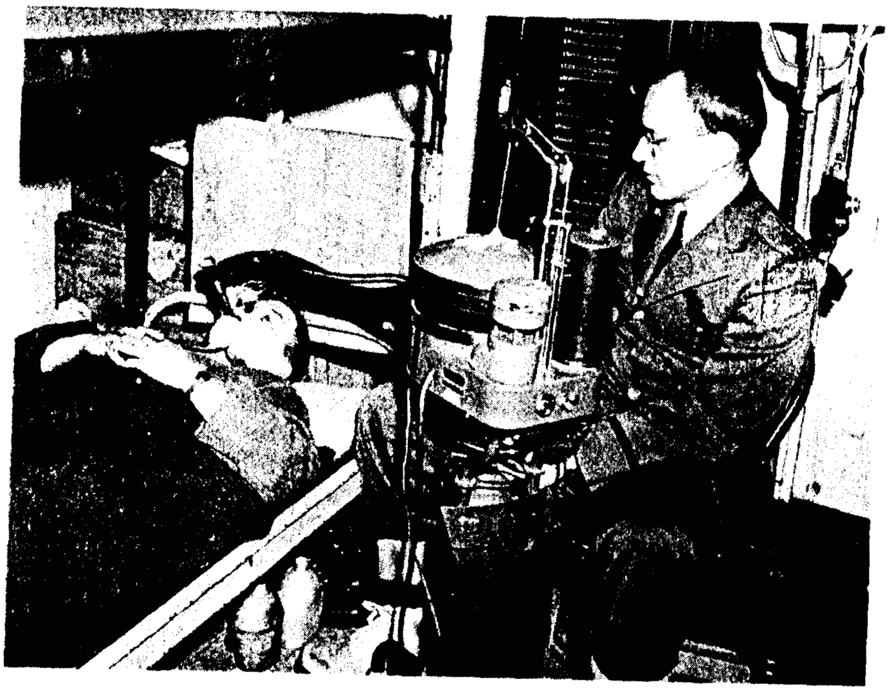

Fig. 11. The Basal Metabolism Test

Fig. 12. Nutritional Survey During the Standardization Phase

2. Ketone bodies. Each 24-hour sample of urine was tested qualitatively for the presence of acetone and acetoacetic acid with the aid of prepared nitroprusside powder (Denco). In every case in which a trace or more of acetone was indicated, the acetone and acetoacetate were determined quantitatively by titration of the distillate from an acidified sample with standard iodine and thiosulfate solutions. Unfortunately, limitations of time, trained personnel, and available facilities did not permit determination of B-hydroxybutyric acid. However, in view of the mildness of the ketosis revealed by the acetone and acetoacetate assays, the B-hydroxybutyrate content and the total ketone body excretion may be assumed to have been too low to warrant more intensive study.

Attempts to collect carmine-dyed feces for the purpose of nitrogen determination were only partially successful because of the small quantities of feces produced and the delayed excretion during the experimental phase and the field phase. From the incomplete data obtained, it appears that the nitrogen loss through feces was not in excess of 10 percent of the total nitrogen intake. There appeared to be a decrease in fecal nitrogen during the field phase.

On the basis of our incomplete data, which agreed with the generally accepted figures for nitrogen elimination (DuBois, 1928), the following figures for fecal nitrogen have been used in this study.

Standardization phase:		1.5 gm.
Experimental phase:	Meat Group	1.0 gm.
	Carbohydrate Group	0.5 gm.
Field phase:	Meat Group	1.0 gm.
	Carbohydrate Group	0.5 gm.
	Meat-Carbohydrate Group	1.0 gm.

RESULTS

Environmental conditions

While the temperature and humidity in the quarters were maintained at approximately the same level both during the standardization and the experimental phase, the mean outdoor temperature was -2° F. during the standardization phase as against -40° F. during the experimental phase. During the field phase the mean temperature at Ladd Field was -9° F., and approximately -15° F. at the camp site. Small changes in the relative humidity was recorded, and the wind velocity was insignificant throughout the study (tables 1,2,3).

Food intake

During the standardization phase when the subjects were living on their normal mess ration and were allowed to consume unlimited quantities, the average daily consumption of calories was about 3,000 calories per day, varying between 2,000 and 4,000 (table 4). Approximately 12 percent of the calories was derived from protein, 42 percent from fat, and 46 percent from carbohydrate.

During the experimental phase and the field phase, the average caloric consumption was as close as possible to 1,000 calories per day in both the meat group and the carbohydrate group (tables 5 and 6). In the carbohydrate group all calories were derived from carbohydrate, while in the meat group, approximately 50 percent of the calories came from protein and the remaining 50 percent from fat. The meat-carbohydrate group, which had the same caloric consumption as the other two groups, obtained 30 percent of the calories from protein, 30 percent from fat, and 40 percent from carbohydrates.

TABLE 4. MEAN FOOD INTAKE DURING STANDARDIZATION PHASE

DAY	Calories	Water gm.	Protein gm.	Fat gm.	Total Carbohydrates gm.	Calcium mg.	Phosphorus mg.	Iron mg.	Copper mg.	Vitamin A I.U.	Vitamin B_1 mg.	Vitamin B_2 mg.	Nicotinic Acid mg.	Vitamin C mg.
Day 1. (Jan. 4)	1992	616.0	61.2	98.9	210.2	432	913	20.7	1.08	8199	1.78	1.00	1.44	55
Day 2. (Jan. 5)	3919	1090.2	116.4	184.1	471.2	940	1880	19.1	3.38	5524	6.42	4.09	3.78	125
Day 3. (Jan. 6)	3113	897.8	104.5	143.3	352.7	1231	1523	13.7	17.6	28300	3.10	2.07	1.85	79
Mean:	3008	868.0	94.0	142.4	344.7	868	1439	14.5	20.7	5518	3.43	2.39	2.36	86

TABLE 5. CONSUMPTION DURING EXPERIMENTAL PHASE

DAY	Calories	Water gm.	Protein gm.	Fat gm.	Total Carbohydrates gm.	Calcium mg.	Phosphorus mg.	Iron mg.	Copper mg.	Vitamin A I.U.	Vitamin B_1 mg.	Vitamin B_2 mg.	Nicotinic Acid mg.	Vitamin C mg.
MEAT GROUP														
1.	913	249.5	112.7	51.6	0.0	41	909	12.4	0.41	0	0.33	0.83	20.7	0
2.	913	249.5	112.7	51.6	0.0	41	909	12.4	0.41	0	0.33	0.83	20.7	0
3.	995	271.8	122.9	56.3	0.0	45	990	13.5	0.45	0	0.36	0.90	22.5	0
4.	1106	302.0	136.6	62.6	0.0	50	1100	15.0	0.50	0	0.40	1.00	25.0	0
5.	1106	302.0	136.6	62.6	0.0	50	1100	15.0	0.50	0	0.40	1.00	25.0	0
MEAN:	1006	275.0	124.3	56.9	0.0	45	1002	15.7	0.45	0	0.36	0.91	22.8	0
CARBOHYDRATE GROUP														
1.	927	0.0	0.0	0.0	232.3	0	0	0.0	0.00	0	0.00	0.00	0.0	0
2.	927	0.0	0.0	0.0	232.3	0	0	0.0	0.00	0	0.00	0.00	0.0	0
3.	927	0.0	0.0	0.0	232.3	0	0	0.0	0.00	0	0.00	0.00	0.0	0
4.	927	0.0	0.0	0.0	232.3	0	0	0.0	0.00	0	0.00	0.00	0.0	0
5.	927	0.0	0.0	0.0	232.3	0	0	0.0	0.00	0	0.00	0.00	0.0	0
MEAN:	927	0.0	0.0	0.0	232.3	0	0	0.0	0.00	0	0.00	0.00	0.0	0

TABLE 6. DAILY FOOD CONSUMPTION DURING FIELD PHASE

	Calories	Water, gm.	Protein, gm.	Fat, gm.	Total Carbohydrate, gm.	Calcium, mg.	Phosphorous, mg.	Iron, mg.	Copper, mg.	Vitamin A., I.U.	Vitamin B., mg.	Vitamin B_2, mg.	Nicotinic acid, mg	Vitamin C, mg.
Meat Group	998	273.0	123.4	56.6	0.0	46	994	13.6	0.46	0	0.36	0.90	22.6	0
Carbohydrate Group	927	0.0	0.0	0.0	332.3	0	0	0.0	0.00	0	0.00	0.00	0.0	0
Meat-Carbohydrate Group	1008	163.0	73.8	33.8	103.2	28	594	8.2	0.28	0	0.22	0.54	13.6	0

Caloric expenditure.

The average daily caloric expenditure for all 12 subjects during the standardization phase was estimated at 2,400 calories, on the basis of time-activity data. During this period a slight weight gain was observed (table 19), while there appeared to be no water retention.

During the experimental phase the average daily caloric expenditure was estimated at 2,300 calories, and at approximately 2,700 during the field phase. The average daily caloric expenditure appeared to be quite uniform in all three groups (tables 7 and 8).

During the entire field study, which lasted 10 days, a total distance of 100 miles was covered (table 9), varying between 9 and 12 miles daily, with the exception of the first day in the field, when only 5 miles were covered, because most of the day was spent in establishing the camp.

Performance and physical fitness scores

During the experimental phase while the subjects were living on the experimental rations in the laboratory, but engaged in outdoor activities similar to their normal duties, no hunger was experienced, although one of the subjects on the meat ration (the Eskimo, subject No. 12) and one of the subjects on the carbohydrate ration, complained of weakness. One of the subjects in the meat group and one in the carbohydrate group complained of excess flatus. One of the subjects in the meat group felt slightly dizzy on the fourth and fifth day when standing up suddenly. Some of the carbohydrate group felt that they did better than the meat group in the treadmill.

Prior to the commencement of the field phase, one of the subjects from the carbohydrate group (subject No. 11) had been admitted to the hospital for a severe hand infection which developed after the conclusion of the experimental phase. He was thus unable to take part in the field study.

TABLE 7. ESTIMATED DAILY CALORIC EXPENDITURE DURING EXPERIMENTAL PHASE

	7 January 1952	8 January 1952	9 January 1952	10 January 1952	11 January 1952	Mean for Entire Period
Meat Group						
Subject No. 1	2940	2655	2420	2525	2425	2593
" " 5	2585	2450	2250	2195	2110	2318
" " 6	2590	2445	2310	2220	2065	2326
" " 10	2440	2390	2290	2370	2300	2358
" " 12	2535	2320	2140	2015	2055	2213
" " 4	2515	2385	2265	2230	2035	2286
" " 8	2650	2385	1905	2210	2075	2245
Mean:	2608	2433	2226	2252	2152	2334
Carbohydrate Group						
Subject No. 2	2665	2515	2315	2400	2250	2429
" " 3	2545	2545	2100	2170	2080	2288
" " 7	2400	2365	2125	2215	2040	2229
" " 9	2475	2550	2055	2120	2110	2262
" " 11	2505	2460	2195	2200	2055	2283
Mean:	2518	2487	2158	2221	2107	2298

TABLE 8. ESTIMATED DAILY CALORIC EXPENDITURE DURING FIELD PHASE.

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Mean for Entire Period
Meat Group											
Subject No. 1	3415	3385	2520	2940	2690	2620	2870	2630	2410	2700	2818
" " 5	3080	2775	2560	2955	2350	2375	2940	2570	2405	2475	2649
" " 6	2715	2740	2640	2545	2285	2475	2655	2660	2420	2625	2576
" " 10	3060	2660	2570	2605	2635	2550	2575	2585	2555	2640	2644
" " 12	3070	3010	2720	3180	2485	2930	3000	3025	2635	2390	2845
Mean:	3068	2914	2602	2845	2489	2590	2808	2694	2485	2566	2706
Carbohydrate Group											
Subject No. 2	2860	2850	2655	2735	2355	2495	3295	2575	2830	2615	2727
" " 3	3155	3080	2310	2740	2285	2180	2735	2600	2205	2500	2579
" " 7	2930	2855	2425	3010	2505	2415	3315	2470	2405	2445	2678
" " 9	2775	2785	2400	2835	2330	2520	3280	2895	2320	2380	2652
" " 11	-	-	-	-	-	-	-	-	-	-	
Mean:	2930	2872	2448	2830	2369	2403	3156	2635	2440	2485	2659
Meat-Carbohydrate Group											
Subject No. 4	2755	3480	3020	3360	2725	2695	3370	2985	2535	2485	2941
" " 8	2685	3020	2440	3100	2435	2470	2900	2575	2400	2320	2635
Mean:	2720	3250	2730	3230	2580	2583	3135	2780	2468	2403	2788

TABLE 9. DISTANCES COVERED DURING FIELD STUDY

Day 1	Skiing	5 miles
Day 2	Skiing	12 miles
Day 3	Walking	12 miles
Day 4	Skiing	10 miles
Day 5	Walking	10 miles
Day 6	Walking	12 miles
Day 7	Skiing	10 miles
Day 8	Walking 5 miles, skiing 5 miles	10 miles
Day 9	Walking	10 miles
Day 10	Walking	9 miles
	Total:	100 miles

At the commencement of the field phase all subjects were found to be in excellent physical condition; and the body weights were now almost the same as during the standardization phase.

It is very difficult to obtain an accurate appraisal of the individual performance under the existing field conditions. Although the group consisted of well-disciplined and well-trained infantry soldiers, the individual differences in initiative, attitude, and personality caused quite wide variations in energy expenditure from one subject to another. Some of the subjects would be more willing than others to secure wood for the fire. Some of them took part in the various camp details with hesitation, and others preferred to stand or sit around the fire, inactively, with the result that their feet became cold by the time they were about to crawl into their sleeping bags. As a result of this, they would remain cold throughout the night, causing loss of sleep, which in turn might affect their performance the following day. Some of the men would keep most of their clothes on inside the sleeping bag, and said that they remained warm and slept well. Others undressed, and stated that they were unable to keep warm in the bag, and therefore slept poorly.

The second day was particularly strenuous, as a long trail was broken on skis through deep snow and difficult terrain. Although subjects were fair, good, or excellent skiers, they were all extremely tired. The morale was good, however, and there were no complaints. One of the men had slightly burned one of his boots. One of the hardest workers in the meat group (subject No. 1) mentioned that he could feel the effect of lack of food, being easily tired. Subject 7 in the carbohydrate group talked about food and had a craving for meat.

On the third day, subject No. 2, in the carbohydrate group complained of nausea from the starch jelly bars, and was unable to eat the entire ration at one time. The general spirit was excellent. During the route march they held a brisk, steady pace. They did not appear very tired at the end of the 12-mile walk, except subject No. 2.

The following day, the fourth day of the field phase, the morale was still very good. Several of the subjects stated that this regimen was not as hard as some of their recent maneuvers. There was no evidence indicating that any of the subjects might discontinue the test because of physical or mental exhaustion. The health appeared very good; no complaints relative to exposure were heard, and no evidence of fatigue was observed during the exercise. Two of the subjects on the carbohydrate ration had difficulty digesting the amount given.

On the fifth day the subjects stated that they felt better than they had the previous two days, although they were noted to move more slowly during the exercise at this stage of the experiment. They all complained of feeling slight stiffness in the legs. The meat group stated that they felt short of breath. No disciplinary difficulties or personal clashes were observed. There were no complaints of hunger or fatigue. The spirit was good and the morale was excellent.

The subjects walked with a fairly quick pace during the route march on the sixth day. One of the subjects had dreamed about food; there were no complaints and there was no griping. At this stage the men moved about no more than they had to and showed no eagerness to police the area or to chop wood for the campfire. They no longer responded well to orders or instructions. However, they stated that none of them felt hunger or thirst. In fact, several of the subjects receiving the meat ration said they could hardly force the food down and felt constantly stuffed. The meat-carbohydrate group was envied by the subjects of the other two groups, who would have liked to trade with each other. There was some evidence of personal clashes between two of the subjects, subject No. 1 on the meat diet, and subject No. 3 on the carbohydrate ration. Some antagonism had existed between these two men long before the commencement of this study. That day a candle in one of the tents had burned through the cardboard base and caused a small fire before it was discovered.

On the seventh day, the spirit seemed improved. They arose without any difficulty early in the morning, policed the camp, and cleaned the tent without hesitation. There were some minor grumblings about the rations in all three groups. During the exercise they moved fast and completed the entire distance without more than two breaks. The morale was good, and there were no complaints.

On the eighth day of the field phase, none of the subjects had any significant physical complaints. Almost all of them felt stronger than they had anticipated.

The following day the general spirit was still good, although the men were less active and less talkative than during the earlier part of the study. Although they did not appear tired, they definitely walked more slowly than at the beginning of the study during the route march.

During the last day of the field study there was much talk about food. They stated that they all tired more easily, and they all felt it was harder to warm up their sleeping bags at night as compared with the earlier part of the study. The subjects themselves could not see any difference between meat eaters and carbohydrate eaters, except that the meat eaters felt that they were more short of breath when exercising. To the observers, no difference between the different groups could be detected by personal observations. In general, all subjects seemed cheerful but quiet. The observers concluded that there had been no visible change since the fifth day of the experiment. No tension or any personal conflicts were observed at this time. When one of the observers asked the Eskimo, subject No. 12 why he was always the most active woodchopper, the Eskimo replied, "To keep my whole body warm; the fire only warms the front." He stated that he was no less tired than the others.

As the result of specific questions directed to each of the subjects during the latter part of the field phase, the following information was revealed: All subjects smoked more during the field phase than usual. They stated that they did not feel bored, but that the time passed quickly. It was the general feeling among the subjects that they could have continued this regimen for another 10 days. They were of the opinion that the meat group was more short winded during exercise than the carbohydrate group.

A feeling of weakness was first observed on the third to seventh day in the meat group, on the fourth to seventh day in the carbohydrate group. In the meat-carbohydrate group one subject felt weak on the third day, and the other subject experienced no weakness.

Hunger was experienced on the fourth to seventh day in 3 of the meat subjects, while 2 did not experience any real hunger. In the carbohydrate group hunger was experienced by all subjects from the first to third days. In the mixed group hunger appeared on the third and fourth days.

Three of the subjects (one on meat, one on carbohydrate, and one on meat and carbohydrate) had no bowel movement during the field phase. The remainder had 1-2 defecations during this period.

Two of the carbohydrate group had had headaches during the test (on the fourth and seventh days) while none of the others suffered from headache, or any other pains, except subject No. 10, who had slight pains in the left hypochondrium when walking. He had had similar pains prior to the study.

Two of the meat group had slight dizzy spells during the field phase, No. 12 on the fifth day, and No. 5 on the eighth day of the test. Similar dizzy spells were experienced by the two subjects on meat and carbohydrate rations (on the fourth and the sixth days), and by one of the subjects in the carbohydrate group, subject No. 3 on the eighth day.

When asked on the eighth day of the field phase what dish they would select if given a choice, the following answers were given:

Meat group:	Subject	#1.	Steak
	"	5.	Ice cream
	"	6.	Meat loaf
	"	10.	Pancakes
	"	12.	Steak
Carbohydrate group:	"	2.	Steak
	"	3.	Cheeseburger
	"	7.	Steak
	"	9.	Pea soup
Meat-carbohydrate group:	"	4.	Steak
	"	8.	Veal cutlet

Personal interviews with each subject on the last day of the field phase revealed the following:

I. Meat Group

Subject No. 1. He has no complaints but feels tired. He has slept well throughout the field phase. He has had no hunger, pains, or other complaints, except a slight cold during the field phase. He has felt hunger since the fifth day; prior to that he felt stuffed. He drank more water than usual. He sweated less than normal. He believes that his urine volume is slightly less than normal. He cannot feel that he has lost weight. He states that he would have been able to continue the test. If given a choice, he would have selected candy since, "Candy would have been easy to carry and eat."

Subject No. 5. No complaints. He has felt tired since the sixth day. He has not felt cold. No hunger pains. He has not felt hungry previously, but feels hungry today. He is drinking more than normal. No abnormal sweating. He feels that he has lost weight. He felt it was easier after the first day. He would prefer both candy and meat if given a choice.

Subject No. 6. No complaints. He has felt tired since the fifth day. He did not feel cold. Hunger since the fourth day but no hunger pains. Slightly weak. He has not been drinking much more than usual. No abnormal sweating. He would prefer candy if given a choice.

Subject No. 10. No complaints. Hunger since the fifth day. Gas pain in stomach after meal. Has not felt cold. Has been drinking more than usual. Tired since the sixth day. He would have preferred candy, because it is easier to carry and he would obtain " a lot more energy from it."

Subject No. 12. No complaints. He has not felt particularly tired except after 10-mile hike today, carrying 30 pounds. He was hungry once in a while since the third day, but the hunger was slight. No pains. Slightly weak. Has been drinking more than normal. He has slept well, was never cold. He would have preferred meat with some candy. The meat tasted like caribou meat to him but was difficult to swallow.

II. Carbohydrate Group

Subject No. 2. No complaints. He has felt tired ever since the 6th day. He has slept well. He has had no pains, except "cramps" one day. He has felt hunger since the sixth day, but no hunger pains. He drinks about the same amount of water as usual. No abnormal sweating. He feels weak, and feels that he has lost weight. If given a choice, he thinks that he would have preferred meat. He feels that he could have carried on another 10 days.

Subject No. 3. No complaints. Since the fifth day, his legs have been weak when marching. Headache once. Has slept well except for last night. when he woke up frequently. Hungry since the seventh day, intermittently

in the day. Drinks more than usual, but no abnormal sweating. No hu
pains. He has not felt cold. If given a choice, he believes he woul
prefer candy.

Subject No. 7. He feels hungry, but has no other complaints. H
not tired, but feels weak; his legs are weak. He slept well, had no
had been very hungry since the first day with no apparent hunger pain
Drinking was normal. He had been sweating less than usual, felt that
had lost weight. He has felt cold the past 4-5 days, has been unable
keep his feet and hands warm. He stated that he would have preferred
because he likes meat, and dislikes candy.

Subject No. 9. He feels fairly good except a little weak, cough
intermittently. He has been hungry off and on all the time. He has
tired or weak the last 7-8 days, has drunk more than normal. He was
cold while in the field, but possibly nothing more than usual. There
no abnormal sweating. He does not feel that he had lost weight. He
he would have taken meat if given a choice.

III. Meat-carbohydrate Group

Subject No. 4. At present no complaints. He slept well during
test and did not feel cold. He was hungry since the second day, but
no hunger pains. He felt tired the last five days after march, exper
no abnormal sweating. He drank more than normal. He feels that he c
have carried on another 10 days.

Subject No. 8. He feels all right except for slight hunger whic
had felt since the fourth day. There are no hunger pains. He has be
drinking less than normal. He has been a little tired the last coupl
days when walking, sweating less than usual. If given a choice he wo
have picked meat because it makes him feel full.

When comparing the so-called physical fitness scores obtained by the treadmill test at the various stages of the experiment, it is observed that by the standards established by Johnson et al.(1942), all subjects came within the category "good scores" (76-90) during all periods. During the standardization phase, two subjects were superior (16 percent). The physical fitness scores at the end of the experimental phase remained unchanged or were higher than during the standardization phase in all cases but one. The average score for the meat group was slightly higher at the end of the experimental phase than during the standardization phase. In the carbohydrate group, this improvement of the scores was considerably greater. When comparing the scores at the end of the field phase with the scores during the standardization phase, an improvement is observed in every case. This improvement is greatest in the carbohydrate group. At the end of the field phase the scores were 10 percent higher in the meat group, 30 percent higher in the carbohydrate group, and 7 percent higher in the meat-carbohydrate group than during the standardization phase.

According to the Johnsons' standards, all scores except one were superior at the end of the field phase (table 10).

Psychiatric evaluation (by Joseph J. Reidy, M.D., psychiatric observer).

Eleven infantry men from K Company, 4th Infantry, volunteered to participate in this experiment. All of these men had been in Alaska more than 17 months, had all been well trained in Arctic survival and were in good physical condition. The education of the men was from the sixth to the twelfth grade, two having completed high school and all of the others except two having completed grammar school. The family background of eight of the men was judged to be good to excellent and that of the remaining three was judged to be poor to very insecure. One of these three had been abandoned by his parents in infancy. Another came from a home broken by divorce and the mother of the third died from tuberculosis when he was an infant.

There were three main reasons for the soldiers' volunteering. They wanted the furlough which was promised on successful completion of the

TABLE 10. PHYSICAL FITNESS SCORES.

	Subject No.	Physical Fitness Scores		
		Standard. Phase	Experimental Phase	
		5 January 1952	8 January 1952	11 January 1952
Meat Group	No. 1	92	91	94
	5	92	91	82
	6	88	87	87
	10	88	89	98
	12	86	88	87
	4	82	89	82
	8	84	81	88
	Mean:	87	88	88
Carbohydrate Group	2	77	86	89
	3	76	88	85
	7	87	93	96
	9	77	80	89
	11	86	91	104
	Mean:	81	88	92
Meat-Carbohydrate Group	4	82	-	-
	8	84	-	-
	Mean:	83	-	-

experiment; they were bored with routine military life; and they were interested in the project to the extent that they wanted to see if they were able to take the hardships. None of the soldiers were serious offenders, but six members of the group had been given military punishments for moderately serious offenses, such as being AWOL and for drunken and disorderly conduct. All of the members were thoroughly screened from a psychiatric standpoint before the project started, and none of them could be diagnosed as having an actual or latent psychosis, psychoneurosis, or character disorder. Three of the men were classified as immature personalities and two of the soldiers were above the average in maturity and reliability. Of these, one was a sergeant first class and the other a sergeant and they were selected as group leaders.

From the beginning of the experiment, it was recognized by the subjects and the investigators that several factors of emotional importance were excluded. The soldiers were all in good health and were well clothed. They were assured of having almost immediate medical care if necessary. They had been recently examined physically, had been x-rayed, and undergone laboratory testing so that they were in excellent physical condition. They had contact with the outside world through their observers, by going to the Company area to wash and colloct mail three times during the project, and by being at all times on the military reservation. They were not lost and they knew that the project would last only 10 days. Almost all sources of anxiety and fear were therefore removed, and whatever the emotional difficulties would arise could be attributed to the diet, the inconveniences of camping out, the cold, and personality maladjustments.

The cold as a promoter of fear and anxiety had very little influence since the men were used to cold weather and had many times been on field maneuvers in temperatures 60-80° below freezing. The range of temperature during the experiment was -36° F. to +12° F. and the mean temperature was -15° F.

Both by observation and by interview with the men after the completion of the experiment, the following observations were made:

1. There was an increase in carelessness. The soldiers had all been thoroughly indoctrinated in taking care of themselves and of their equipment, and it was expected that they would continue to show the results of this training. On one occasion a fire was started in one of the tents; and several of the soldiers burned their socks and shoes. The men stated that they noticed no increase in carelessness, but the observers and the sergeant in charge of the group did notice this carelessness.

2. Five of the men noticed an increased desire to sleep, and they slept from 1-6 hours more than usual. Some reasons given for this were that there was not enough to do, that they went to sleep to keep warm, that they were tired from the exercise and low energy diet.

3. The leaders of the group noticed that most of the men were more irritable and inclined to quarrel, especially on the last two days of the experiment. Two of the men admitted that they noticed themselves to be more irritable, but the others noticed no change in themselves or in others.

4. All of the men stated that they had less energy on each succeeding day of the experiment and the group leader noticed that the men were slower to respond in obeying orders.

5. Six of the men noticed occasional dizzy spells on postural changes and during exercise. Three of these were on meat diet, two on sugar, and one on the combination of meat and sugar. Two men had sharp abdominal pains

during exercise and one man had moderate cramps in the calf muscles on exercise. Two of these were on sugar diet, the other on combination diet.

6. All of the men thought more of food than usual and were inclined to talk about food much more frequently. However, some of them would leave the group when the conversation turned to food. Five of the men had dreams of food.

7. There was no increase nor decrease in sex thoughts and fantasies.

8. Two men on a meat diet noticed increased thirst, three noticed increased hunger. But most on the meat diet experienced difficulty in eating all of their ration. Of those on candy alone, two found increased thirst, and four increased hunger. Of those on the combination diet, there was no increase in thirst, but two found increased hunger. None of these complaints were felt to be due to emotional factors.

9. All of the men gained an increase in their confidence to withstand physical hardships. Before the beginning of the experiment, all but two men felt that they would not be able to last the entire ten days. At the close of the experiment, all of the men felt that they could have continued on for 5-10 days more.

Basal heat production

The average basal metabolic rate in all the twelve subjects on the second test during the standardization phase was 6 percent lower than the DuBois standard. standard.

At the end of the experimental phase (5 days) the average basal metabolic rate in the meat group was 13 percent higher than during the standardization phase. In the carbohydrate group it was 7 percent lower at the end of the experimental phase than during the standardization phase. Thus, in the meat group there was an increase of 13 percent, while a reduction of 7 percent in the BMR occurred in the carbohydrate group (table 11).

TABLE 11. BASAL METABOLIC RATES DURING THE STANDARDIZATION AND EXPERIMENTAL P

	Subject No.	Basal Metabolic Rates. Deviation from DuBois Standard in Percent			Differe in Percen
		Standard. Phase	Experimental Phase		
			9 January 1952	11 January 1952	
Meat Group:					
	No. 1	- 9	- 3	+ 8	+ 17%
	No. 5	- 17	- 5	+ 3	+ 20%
	No. 6	± 0	+ 2	- 8	- 8%
	No.10	- 15	- 11	+ 8	+ 23%
	No.12	- 4	+ 2	+ 10	+ 14%
	No. 4	- 16	- 4	+ 1	+ 17%
	No. 8	- 2	+ 16	+ 4	+ 6%
	Mean	- 9	± 0	+ 4	+ 13%
Carbohydrate Group:					
	No. 2	- 10	- 16	- 17	- 7%
	No. 3	∓ 7	- 6	- 19	- 12%
	No. 7	- 0	+ 2	-	-
	No. 9	+ 12	± 0	+ 1	- 11%
	No.11	- 12	- 15	- 9	+ 3%
	Mean	- 3	- 7	- 9	- 7%

When comparing the BMR at the end of the field phase with the BMR during the standardization phase we find an increase of 9 percent in the meat group, an increase of 7 percent in the group receiving the meat-carbohydrate ration, and a reduction of 7 percent in the carbohydrate group (table 12).

Oral temperature, pulse rate, and blood pressure

The average oral temperature (tables 13, 14) and the pulse rate (tables 15, 16) were almost the same at the end of the experimental phase as during the standardization phase. The blood pressure was slightly

TABLE 12. BMR IN THE THREE GROUPS AT THE END OF THE FIELD PHASE COMPARED WITH THE "STANDARD" BMR.

	Subject No.	BMR Deviation from DuBois Standardization: Standard. Phase	BMR Deviation from DuBois Standardization: Field Phase 11 Feb. '52	Difference in Percent
Meat Group				
	No. 1	- 9	+ 6	+ 15%
	No. 5	- 17	- 7	+ 10%
	No. 6	± 0	- 1	- 1%
	No.10	- 15	- 2	+ 13%
	No.12	- 4	+ 3	+ 7%
	Mean:	- 9	± 0	+ 9%
Carbohydrate Group				
	No. 2	- 10	- 11	- 1%
	3	- 7	- 20	- 13%
	7	± 0	+ 4	+ 4%
	9	+ 12	- 5	- 17%
	11	- 12	-	-
	Mean:	- 3	- 8	- 7
Meat-Carbohydrate Group				
	No. 4	- 16	- 2	+ 14
	No. 8	- 2	- 1	+ 1
	Mean:	- 9	- 2	+ 7

lower at the end of the experimental phase than during the standardization phase (tables 17, 18).

Body weight

The individual and average weight changes during the various phases of the study are given in table 19. During the experimental phase an average total weight loss of 2.5 pounds occurred in the meat group, while the subjects

TABLE 13. MORNING ORAL TEMPERATURES AT VARIOUS STAGES OF THE EXPERIMENT

	Standardization Phase			Experimental Phase			
	4 January	6 January	Average	9 January	11 January	11 February	Average
Meat Group.							
Subject No. 1	97.8	96.4	97.1	96.2	96.8	96.8	96.6
5	-	97.4	97.4	97.4	98.3	97.2	97.6
6	96.6	96.2	96.4	97.0	97.4	96.9	97.1
10	-	97.2	97.2	96.7	97.0	97.0	96.9
12	-	97.6	97.6	97.2	98.2	97.0	97.5
4	-	97.0	97.0	97.4	97.9	97.3	97.7
8	98.0	96.4	97.2	97.3	97.3	97.8	97.5
Mean:	97.5	96.9	97.1	97.0	97.5	97.1	97.3
Carbohydrate Group.- No. 2	-	97.2	97.2	97.0	97.5	97.6	97.2
3	97.0	96.4	96.7	96.7	95.4	97.6	96.6
7	97.6	97.0	97.3	97.3	97.8	97.2	97.5
9	97.6	97.6	97.6	97.6	98.0	96.6	97.4
11	-	97.5	97.5	97.5	98.6	-	98.1
Mean:	97.2	97.1	97.3	97.2	97.5	97.3	97.4

TABLE 14. EVENING ORAL TEMPERATURE AT VARIOUS STAGES OF THE EXPERIMENT

	Standardization Phase			Experimental Phase					
	5 January 1952	6 January 1952	Average	7 January 1952	8 January 1952	9 January 1952	10 January 1952	11 January 1952	Average
Meat Group.									
Subject No. 1	97.6	97.5	97.6	98.4	97.7	97.9	97.6	97.4	97.8
" " 5	96.8	98.6	97.7	98.0	97.9	98.2	98.0	98.0	98.0
" " 6	97.2	96.4	96.8	97.3	98.6	98.0	98.3	98.2	98.1
" " 10	96.7	97.4	97.1	97.0	98.0	97.2	97.8	97.8	97.6
" " 12	97.2	97.5	97.4	96.0	98.2	97.8	99.4	98.0	97.9
" " 4	97.0	97.2	97.1	97.7	98.5	98.0	98.6	97.8	98.1
8	96.7	97.0	96.9	97.1	98.4	97.4	98.6	98.6	98.0
Mean:	97.0	97.5	97.2	97.5	98.2	97.8	98.3	98.0	97.9
Carbohydrate Group. " " 2	97.0	98.0	97.5	97.5	97.6	96.8	98.2	97.6	97.5
" " 3	97.9	97.2	97.6	98.0	98.4	98.4	98.4	97.8	98.2
" " 7	98.0	97.8	97.9	98.2	98.2	98.2	98.0	98.1	98.2
" " 9	97.2	97.2	97.2	97.3	97.6	97.4	98.6	98.0	97.8
" " 11	97.4	97.2	97.3	97.6	-	98.6	98.4	97.8	98.1
Mean:	97.5	97.5	97.5	97.7	98.0	97.9	98.3	97.9	98.0

TABLE 15. PULSE RATES AT VARIOUS STAGES OF THE EXPERIMENT, MORNING

		Standardization Phase			Experimental Phase			
		4 January	6 January	Average	9 January	10 January	11 January	Average
Meat Group.	Subject No. 1	60	56	58	44	48	40	43
	" " 5	62	56	59	62	56	54	54
	" " 6	58	60	59	72	56	62	63
	" "10	68	68	68	50	52	64	55
	" "12	66	48	57	48	48	42	46
	" " 4	60	56	58	64	52	50	55
	" " 8	56	52	54	64	44	48	52
	Mean:	61	57	59	58	51	51	53
Carbohydrate Group	" " 2	-	54	54	58	50	50	54
	" " 3	52	52	52	56	40	38	44
	" " 7	60	50	55	64	52	62	59
	" " 9	64	64	64	68	56	44	56
	" "11	58	48	53	54	56	-	55
	Mean:	58	54	56	60	51	48	54

TABLE 16. PULSE RATE AT VARIOUS STAGES OF THE EXPERIMENT , EVENING

	Standardization Phase			Experimental Phase					
	5 January 1952	6 January 1952	Average	7 January 1952	8 January 1952	9 January 1952	10 January 1952	11 January 1952	Average
Meat Group.									
Subject No. 1	64	66	65	60	58	52	58	60	58
" " 5	64	72	68	72	72	68	72	72	71
" " 6	76	76	76	80	80	66	72	80	76
" " 10	64	60	62	68	64	72	68	60	66
" " 12	60	52	56	60	58	62	56	64	60
" " 4	60	68	64	60	64	64	68	82	68
" " 8	56	56	56	52	72	56	60	68	62
Mean:	63	64	63	65	67	63	65	69	66
" " 2	60	62	61	56	62	68	60	58	61
" " 3	64	74	69	64	68	68	64	62	65
" " 7	64	72	68	72	80	68	64	72	70
" " 9	64	64	64	60	64	68	68	72	66
" " 11	58	58	58	56	60	64	60	60	60
Mean:	62	66	64	62	67	67	63	65	65

TABLE 17. MORNING BLOOD PRESSURE OF VARIOUS STAGES OF THE EXPERIMENT.

		Standardization Phase			Experimental Phase			
		4 January	6 January	Average	9 January	10 January	11 January	Average
Meat Group.	Subject No. 1	102/68	104/68	103/68	105/60	102/62	110/68	105/63
	" " 5	134/70	105/65	120/68	104/68	104/66	104/72	104/69
	" " 6	118/84	110/75	114/80	110/72	104/78	105/65	106/72
	" " 10	110/72	110/70	110/71	100/60	106/74	95/65	100/65
	" " 12	120/70	100/65	110/68	85/50	110/72	95/60	97/61
	" " 4	104/60	105/60	105/60	110/54	112/58	98/60	107/57
	" " 8	108/68	115/70	112/69	110/64	106/60	110/70	109/65
	Mean:	114/70	107/69	112/69	103/61	106/67	102/65	104/65
	Subject No. 2	-	110/65	110/65	102/54	102/68	100/65	101/62
	" " 3	104/84	110/75	107/80	105/65	104/74	110/80	106/73
	" " 7	130/82	125/80	128/81	142/92	112/72	120/80	125/81
	" " 9	120/78	110/70	115/74	112/70	110/80	115/80	112/77
	" " 11	106/62	115/70	111/66	100/60	98/58	-	99/59
	Mean:	115/61	114/72	114/75	112/68	105/70	111/61	108/70

TABLE 18. EVENING BLOOD PRESSURE AT VARIOUS STAGES OF THE EXPERIMENT.

		Standardization Phase			Experimental Phase					
		5 January	6 January	Average	7 January	8 January	9 January	10 January	11 January	Average
Meat Group.	Subject No. 1	108/64	118/74	113/69	118/88	120/78	104/70	104/62	102/68	110/73
	" " 5	106/68	118/72	112/70	110/76	104/70	104/62	114/62	122/82	111/70
	" " 6	112/88	116/88	114/88	124/90	116/74	108/76	122/74	114/72	117/77
	" " 10	110/78	106/68	108/73	108/82	104/78	104/68	96/66	104/72	103/73
	" " 12	90/62	98/76	94/69	94/68	110/68	98/62	104/68	110/68	103/67
	" " 4	120/70	124/66	122/68	126/78	112/68	114/78	106/62	118/68	115/71
	" " 8	122/70	128/80	125/75	132/84	125/86	120/80	112/72	118/78	121/80
	Mean:	110/71	116/75	113/75	116/81	113/75	107/71	108/67	113/73	111/74
Carbohydrate Group.	" " 2	102/76	102/68	102/72	122/82	106/82	102/72	98/70	114/72	108/77
	" " 3	130/84	128/92	129/88	112/78	122/82	112/84	108/72	120/80	115/79
	" " 7	128/80	130/88	129/84	132/88	118/80	118/80	122/84	126/84	121/83
	" " 9	120/72	124/82	122/77	110/84	112/84	102/68	106/68	100/68	106/74
	" " 11	106/78	108/64	107/71	118/70	116/70	98/64	92/54	98/68	104/65
	Mean:	117/78	118/79	118/78	119/80	115/80	106/74	105/70	112/74	111/76

TABLE 19. SHOWING THE BODY WEIGHT AT VARIOUS STAGES OF THE EXPERIMENT.

	Standardization Phase			Experimental Phase						Field Phase			Recovery Phase			
	4 January 1952	6 January 1952	Average	8 January 1952	9 January 1952	10 January 1952	11 January 1952	12 January 1952	Total Weight Loss	1 February 1952	5 February 1952	11 February 1952	Total Weight Loss	12 February 1952	13 February 1952	14 February 1952
Meat Group																
Subj. No. 1	193.0	193.0	193.0	190.5	190.0	189.0	189.0	190.0	0.5	194.0	187.7	182.7	11.3	187.5	194.0	193.0
" " 5	158.0	159.0	158.5	158.0	156.0	154.2	152.2	152.2	5.8	158.0	152.7	147.5	10.5	153.0	155.0	157.0
" " 6	136.0	136.0	136.0	129.7	129.0	127.2	127.7	127.5	2.0	137.0	130.5	126.5	10.5	132.5	134.0	135.0
" " 10	149.0	149.0	149.0	147.2	146.0	145.0	144.5	144.2	3.0	150.0	143.5	140.5	9.5	146.5	148.0	146.5
" " 12	146.0	146.0	146.0	144.5	142.5	142.2	141.0	139.0	5.5	145.0	139.5	133.0	12.0	140.5	144.0	146.0
" " 4	146.0	146.0	146.0	143.5	143.0	142.2	141.0	141.0	2.5	-	-	-	-	-	-	-
" " 8	162.5	164.5	163.5	162.0	160.0	158.2	159.0	163.5	-1.5	-	-	-	-	-	-	-
Mean:	155.8	156.2	156.0	153.6	173.6	151.1	150.6	151.1	2.5	158.8	150.8	146.0	10.8	152.0	155.0	155.5
Carbohydrate Group																
Subj. No. 2	136.0	136.2	136.1	134.5	132.2	132.2	131.1	130.7	3.8	137.0	132.0	128.5	11.5	134.0	135.5	-
" " 3	162.5	164.0	163.2	163.0	161.2	158.7	160.0	-	3.0	167.0	157.5	153.0	14.0	159.7	164.5	164.0
" " 7	227.0	227.0	227.0	224.2	220.2	218.2	216.0	216.2	8.0	225.0	216.5	215.5	10.5	220.0	224.0	226.0
" " 9	139.0	139.0	139.0	136.2	134.2	134.2	131.0	130.5	5.7	143.0	135.0	130.5	12.5	134.0	136.0	136.0
" " 11	135.0	135.0	135.0	132.0	130.0	129.0	128.7	129.7	2.3	-	-	-	-			-
Mean:	159.9	160.2	160.1	158.0	155.6	154.5	153.4	151.8	4.6	168.0	160.3	156.9	12.1	161.9	160.0	175.3
Meat-Carbohydrate Group																
Subj. No. 4	146.0	146.0	146.0	-	-	-	-	-	-	148.0	143.5	138.5	10.5	142.0	148.0	147.5
" " 8	162.5	164.5	163.5	-	-	-	-	-	-	166.0	159.5	159.0	7.0	164.0	164.0	161.0
Mean:	154.3	155.3	154.8	-	-	-	-	-	-	157.0	151.5	148.8	8.8	153.0	156.0	154.3

on the carbohydrate ration lost 4.6 pounds on an average. At the end of the field phase the average total weight loss in the meat group was 10.8 pounds (7.0 percent), 12.1 pounds (7.5 percent) in the carbohydrate group, and 8.8 pounds (6.0 percent) in the group receiving both meat and carbohydrate. At the end of three days during the recovery phase practically all of the 12 subjects had regained the weight loss which occurred during the field phase.

Fluid consumption and urine volume

From table 20 it is observed that during the experimental phase the meat group consumed approximately 1,500 ml. free fluid, while the carbohydrate group consumed approximately 1,200 ml. During the field phase the consumption in the meat group was approximately 1,500 ml., 850 ml. in the carbohydrate group and about 1,200 ml. in the meat-carbohydrate group. The average urine volume during the experimental phase was approximately 1,500 ml. in the meat group and 1,250 ml. in the carbohydrate group. During the field phase the urine volume was approximately 1,100 in the meat group, 600 ml. in the carbohydrate group, and 1,000 ml. in the meat-carbohydrate group.

Nitrogen balance (table 21)

During the experimental phase all subjects in the meat group were in a positive nitrogen balance, while the subjects in the carbohydrate group showed a negative balance of 6.3 gm. on an average. During the field phase all three groups showed a negative nitrogen balance, which was most pronounced in the carbohydrate group, followed by the meat-carbohydrate group, the meat group being the lowest, with a negative balance of 2.2 gm., including the estimated fecal nitrogen.

Urine findings

Routine urine examination prior to the test showed normal findings (table 22). From table 23, showing the results of routine urine examination

TABLE 20. SHOWING WATER INTAKE AND URINE VOLUME

	Standardization Phase		Experimental Phase		Field Phase	
	Water Intake ml.	Urine Volume ml.	Water Intake ml.	Urine Volume ml.	Water ml	Urine ml.
Meat Group						
Subject No. 1	1067	1253	1680	1848	1830	1179
" " 5	1300	958	1530	1130	1525	1139
" " 6	767	1542	1125	1373	1388	1100
" " 10	700	1238	1270	1301	1350	769
" " 12	1700	1975	1530	1522	1388	1500
" " 4	1050	1940	1925	1651	-	-
" " 8	1500	1638	1530	1659	-	-
Mean:	1155	1506	1513	1498	1496	1137
Carbohydrate Group						
Subject No. 2	750	1307	855	746	613	456
" " 3	1550	1371	1670	1840	1088	621
" " 7	1725	1388	1470	1027	875	598
" " 9	1000	1463	1260	973	846	554
" " 11	998	1000	818	1620	-	-
Mean:	1205	1306	1215	1241	856	557
Meat-Carbohydrate Group						
Subject No. 4	1050	1940	-	-	1175	996
" " 8	1500	1638	-	-	1275	945
Mean:	1275	1789	-	-	1225	971

TABLE 21. NITROGEN BALANCE.

	Standardization Phase					Experimental Phase					Field Phase				
	Nitrogen Intake	Foecal Nitrogen (approximately)	Urinary Nitrogen	Total Nitrogen Elimination	Nitrogen Balance	Nitrogen Intake	Foecal Nitrogen (approximate)	Urinary Nitrogen	Total Nitrogen Elimination	Nitrogen Balance	Nitrogen Intake	Foecal Nitrogen (approximate)	Urinary Nitrogen	Total Nitrogen Elimination	Nitrogen Balance
Meat Group:															
Subj. No. 1	15.4	1.5	12.7	14.2	-1.2	19.9	1.0	16.8	17.8	-2.1	19.8	1.0	21.8	22.8	- 3.0
" " 5	14.7	1.5	12.5	14.0	-0.7	19.9	1.0	15.6	16.6	-3.3	19.8	1.0	24.7	25.7	- 5.9
" " 6	11.7	1.5	11.4	12.9	-1.2	19.9	1.0	12.9	13.9	-6.0	19.8	1.0	21.9	22.9	- 3.1
" " 10	8.7	1.5	11.1	12.6	-3.9	19.9	1.0	13.4	14.4	-5.5	19.8	1.0	14.5	15.5	- 4.3
" " 12	16.4	1.5	16.4	17.9	-1.5	19.9	1.0	14.9	15.9	-4.0	19.6	1.0	22.3	23.3	- 3.5
" " 4	16.0	1.5	12.0	13.5	-2.5	19.9	1.0	11.7	12.7	-7.2	-	-	-	-	-
" " 8	16.6	1.5	15.1	16.6	0.0	19.9	1.0	14.5	15.5	4.4	-	-	-	-	-
Mean:	14.2	1.5	13.0	14.5	-0.3	19.9	1.0	14.3	15.3	-4.6	19.8	1.0	21.0	22.0	- 2.2
Carbohydrate Group:															
Subj. No. 2	13.1	1.5	19.7	21.2	-8.7	0.0	0.5	5.9	6.4	-6.4	0.0	0.5	7.7	8.2	- 8.2
" " 3	13.8	1.5	10.3	11.8	-2.0	0.0	0.5	5.2	5.7	-5.7	0.0	0.5	8.8	9.3	- 9.3
" " 7	21.6	1.5	13.3	14.8	-6.8	0.0	0.5	8.3	8.8	-8.8	0.0	0.5	9.6	10.1	-10.1
" " 9	17.9	1.5	12.0	13.5	-4.4	0.0	0.5	5.7	6.2	-6.2	0.0	0.5	7.0	7.5	- 7.5
" " 11	14.4	1.5	10.2	11.7	2.7	0.0	0.5	4.1	4.6	-4.6	0.0	0.5	-	0.5	- 0.5
Mean:	16.2	1.5	13.1	14.6	-1.4	0.0	0.5	5.8	6.3	-6.3	0.0	0.5	6.6	7.1	- 7.1
Meat-Carbohydrate Group:															
Subj. No. 4	16.0	1.5	12.0	13.5	-2.5	-	-	-	-	-	11.8	1.0	15.6	16.6	- 4.8
" " 8	16.6	1.5	15.1	16.6	0.0	-	-	-	-	-	11.8	1.0	17.1	18.1	- 6.3
Mean:	16.3	1.5	13.6	15.1	-1.2	-	-	-	-	-	11.8	1.0	16.4	17.4	- 5.6

TABLE 22. SHOWING THE RESULTS OF URINE EXAMINATION IN SURVIVAL RATION SUBJECTS PRIOR TO TEST.

	Color	Specific Gravity	Reaction	Albumin	Sugar	Acetone	WBC	RBC	Epithelial Cells	Casts	Crystals	Bacteria
Subject No. 1	Clear, yellow	1.021	alk.	0	0	0	few	0	few	0	0	0
" " 2	" "	1.021	"	0	0	0	"	0	"	0	0	0
" " 3	" "	1.015	"	0	0	0	"	0	"	0	0	0
" " 4	" "	1.020	"	0	0	0	"	0	"	0	0	0
" " 5	Cldy, "	1.026	"	0	0	0	"	0	0	0	am. phosph.	0
" " 6	Clear, amber	1.027	acid	0	0	0	"	0	few	0	ca. oxalate.	0
" " 7	Sl. cldy, yel.	1.020	alk.	0	0	0	"	0	"	0	0	0
" " 8	Clear, yellow	1.023	acid	0	0	-	"	0	"	0	0	0
" " 9	" "	1.021	acid	0	0	0	"	0	"	0	am. urates	0
" " 10	" , amber	1.022	alk.	0	0	0	"	0	"	0	0	0
" " 11	" , yellow	1.021	"	0	0	0	"	0	"	0	0	0
" " 12	" , "	1.022	acid	0	0	0	"	0	"	0	0	0

TABLE 23. RESULTS OF URINE EXAMINATION AT VARIOUS STAGES OF THE EXPERIMENT.

Subject	Date	Color	Specific Gravity	Reaction	Albumin	Sugar	Acetone	Microscopic: WBC	RBC	Epithelial Cells	Casts	Crystals	Bacteria
A. Meat Group:													
Subject No. 1													
Phase I	Dec.13'51	Clear,yellow	1.021	alk.	0	0	0	few	-	few	-	-	-
	Jan. 4'52	Clear,amber	1.030	acid	0	0	0	occ.	-	occ.	-	ur.acid	-
Phase II	Jan. 7'52	Clear,straw	1.020	acid	0	0	0	occ.	-	occ.	-	calcium	-
	Jan. 8'52	Clear,yellow	1.014	acid	1+	0	++or +++	occ.	-	occ.	-	-	-
	Jan. 9'52	Clear,yellow	1.019	acid	0	0	+++	2/hpf	-	occ.	-	-	-
	Jan.10'52	Clear,yellow	1.020	acid	0	0	+++	2/hpf	-	occ.	-	-	-
	Jan.11'52	Clear,yellow	1.021	acid	0	0	+++	2/hpf	-	occ.	-	calcium	-
	Jan.12'52	Clear,yellow	1.012	acid	0	0	+++	3/hpf	-	occ.	-	-	-
Phase III	Feb. 1'52	Clear,yellow	1.013	acid	0	0	0	occ.	-	-	-	ca.ox.	-
	Feb. 2'52	Clear,amber	1.016	acid	0	0	++++	occ.	-	occ.	-	-	-
	Feb. 3'52	Cldy,amber	1.026	acid	0	0	+++or ++++	occ.	-	occ.	-	ca.ox.	-
	Feb. 4'52	Clear,amber	1.026	acid	0	0	++++	occ.	-	occ.	-	calc.	-
	Feb. 5'52	Clear,drk am	1.020	acid	0	0	++++	occ.	-	occ.	-	ca.ox.	-
	Feb. 6'52	Clear,amber	1.016	acid	0	0	++++	occ.	-	occ.	-	-	-
	Feb. 7'52	Cldy,amber	1.025	alk.	tr	0	++++	occ.	-	-	-	am.phos	-
	Feb. 8'52	Sl.cldy,amb.	1.026	alk.	tr	0	++++	occ.	-	-	-	am.phos	-
	Feb. 9'52	Sl.cldy,amb.	1.026	sl.alk	tr	0	++++	occ.	-	occ.	-	tr.&am phos.	-
	Feb.10'52	Sl.cldy,amb.	1.026	alk.	0	0	++++	occ.	-	occ.	-	tr & am. phos.	-
Phase IV	Feb.11'52	Clear,amber	1.024	acid	1+	0	tr	occ.	-	occ.	-	ca.ox.	-
	Feb.12'52	Clear,straw	1.022	acid	0	0	0	occ.	-	occ.	-	-	-
Subject No. 5													
	Dec.13'51	Cldy,yellow	1.026	alk.	0	0	0	few	-	-	-	am.phos.	-
Phase I	Jan. 4'52	Clear,amber	1.029	acid	0	0	0	occ.	-	-	-	am.ur.& ca. ox.	-
Phase II	Jan. 7'52	Sl.cldy,yell.	1.027	acid	0	0	tr	occ.	-	-	-	am.ur.	-
	Jan. 8'52	Clear,amber	1.027	acid	0	0	++++	occ.	-	occ.	-	ca.ox.& am. ur.	-

TABLE 23. (Cont'd.)

Subject	Date	Color	Specific Gravity	Reaction	Albumin	Sugar	Acetone	Microscopic: WBC	Microscopic: RBC	Microscopic: Epithelial Cells	Microscopic: Casts	Microscopic: Crystals	Microscopic: Bacteria
	Jan. 9'52	Clear,amber	1.024	acid	0	0	++++	ooo.	-	ooo.	-	-	-
	Jan.10'52	Clear,amber	1.025	acid	0	0	++++	ooo.	-	ooo.	-	-	-
	Jan.11'52	Clear,yell.	1.025	acid	0	0	++++	2/hpf	-	ooo.	-	-	-
	Jan.12'52	Clear,yell.	1.023	acid	0	0	++++	ooo.	-	ooo.	-	-	-
Phase III	Feb. 1'52	Cldy,straw	1.025	alk.	0	0	0	-	-	-	-	tr & am phos.	-
	Feb. 2'52	Sl.cldy,amb	1.021	acid	0	0	+++or ++++	ooo.	-	-	-	ca. ox.	-
	Feb. 3'52	Clear,amber	1.026	acid	0	0	+++or ++++	ooo.	-	ooo.	-	few am. ph,ur.	-
	Feb. 4'52	Clear,straw	1.024	acid	0	0	++++	ooo.	-	ooo.	-	ca. ox.	-
	Feb. 5'52	Cldy,yellow	1.023	alk.	0	0	++++	ooo.	-	-	-	tr.&am. phos.	-
	Feb. 6'52	Clear,yell.	1.020	acid	0	0	++++	ooo.	-	-	-	ca. ox.	-
	Feb. 7'52	Clear,amber	1.022	acid	0	0	++++	ooo.	-	-	-	am. ur.	-
	Feb. 8'52	Clear,amber	1.026	acid	tr	0	++++	ooo.	-	-	-	ca.ex & am.ur.	-
	Feb. 9'52	Sl.cldy,yel.	1.025	acid	0	0	++++	ooo.	-	-	-	am. ur.	-
	Feb.10'52	Cldy,amber	1.025	alk.	1+	0	++++	ooo.	-	-	-	am.& tr. phos.	-
Phase IV	Feb.11'52	Clear,yell.	1.027	acid	2+	0	0	ooo.	-	-	-	ca. ur.	-
	Feb.12'52	Clear,straw	1.027	acid	0	0	0	ooo.	-	ooo.	-	ca.ox.	-
Subject No. 6													
Phase I	Dec.13'51	Clear,amber	1.027	acid	0	0	0	3/hpf	-	few	-	ca.ex.	-
	Jan. 4'52	Clear,yell.	1.017	acid	0	0	0	ooo.	-	ooo.	-	-	-
Phase II	Jan. 7'52	Clear,yell.	1.016	acid	0	0	tr	ooo.	0	-	-	-	-
	Jan. 8'52	Clear,yell.	1.016	alk.	0	0	++or +++	ooo.	-	ooo.	-	-	-
	Jan. 9'52	Clear,amb.	1.022	acid	0	0	+++	ooo.	-	ooo.	-	-	-
	Jan.10'52	Clear,straw	1.012	acid	0	0	+	ooo.	-	ooo.	-	-	-
	Jan.11'52	Clear,yell.	1.022	acid	0	0	++++	2/hpf	-	ooo.	-	-	-
	Jan.12'52	Clear,yell.	1.026	acid	0	0	++++	ooo.	-	ooo.	-	-	-

TABLE 23. (Cont'd.)

TABLE 23. (Cont'd.)

Subject No.	Date	Color	Specific Gravity	Reaction	Albumin	Sugar	Acetone	Microscopic WBC	Microscopic RBC	Microscopic Epithelial Cells	Microscopic Casts	Microscopic Crystals	Microscopic Bacteria
Phase III	Feb. 1'52	Clear,yellow	1.016	alk.	0	0	0	occ.	-	occ.	-	-	-
	Feb. 2'52	Clear,yellow	1.017	acid	0	0	+++or ++++	occ.	-	-	-	ca. ox.	-
	Feb. 3'52	Cldy,straw	1.024	acid	0	0	+++or ++++	occ.	-	occ.	-	-	-
	Feb. 4'52	Clear,yellow	1.021	acid	0	0	++++	occ.	-	occ.	-	ca. ox. & am.ur.	-
	Feb. 5'52	Clear,amber	1.026	acid	0	0	++++	occ.	-	-	-	am. ur.	-
	Feb. 6'52	Clear,yellow	1.021	sl.alk.	0	0	++++	occ.	-	-	-	tr.phos.	-
	Feb. 7'52	Clear,amber	1.023	acid	0	0	++++	occ.	-	occ.	-	ca. ox.	-
	Feb. 8'52	Clear,yellow	1.027	acid	0	0	+++or ++++	2/hpf	-	-	-	ca. ox.	-
	Feb. 9'52	Clear,amber	1.025	sl.alk.	0	0	++++	occ.	-	-	-	tr.& am. phos.	-
	Feb.10'52	Sl.cldy,amb.	1.024	alk.	0	0	++++	occ.	-	-	-	tr.& am. phos.	-
Phase IV	Feb.11'52	Clear,yellow	1.026	acid	0	0	0	occ.	-	-	-	occ.ca. ox.	-
	Feb.12'52	Clear,yellow	1.020	acid	0	0	0	occ.	-	occ.	-	ca. ox.	-
Subject No. 10													
Phase I	Jan. 3'52	Clear,amber	1.022	alk.	0	0	0	few	-	few	-	-	-
	Jan. 4'52	Clear,amber	1.020	alk.	0	0	0	occ.	-	occ.	-	-	-
Phase II	Jan. 7'52	Clear,amber	1.017	acid	0	0	0	occ.	-	1+	-	-	-
	Jan. 8'52	Clear,yellow	1.020	alk.	0	0	tr	occ.	-	1+	-	-	-
	Jan. 9'52	Clear,amber	1.022	acid	0	0	+	occ.	-	occ.	-	-	-
	Jan.10'52	Clear,yellow	1.018	alk.	0	0	tr	occ.	-	occ.	-	am.& tr. phos.	-
	Jan.11'52	Clear,amber	1.024	acid	0	0	+	occ.	-	occ.	-	-	-
	Jan.12'52	Clear,yellow	1.021	acid	0	0	++or +++	occ.	occ.	-	-	-	-
Phase III	Feb. 1'52	Clear,amber	1.025	acid	0	0	0	4/hpf	-	-	-	-	-
	Feb. 2'52	Clear,straw	1.016	acid	0	0	tr or +	occ.	-	occ.	-	-	-

TABLE 23. (Cont'd.)

Subject	Date	Color	Specific Gravity	Reaction	Albumin	Sugar	Acetone	Microscopic: WBC	Microscopic: RBC	Microscopic: Epithelial Cells	Microscopic: Casts	Microscopic: Crystals	Microscopic: Bacteria
Phase III	Feb. 3'52	Clear,amber	1.027	acid	0	0	+++or ++++	ooo.	-	ooo.	-	-	-
	Feb. 4'52	Clear,straw	1.020	acid	0	0	++++	ooo.	-	ooo.	-	ca.ox.	-
	Feb. 5'52	Clear,amber	1.023	acid	0	0	0	ooo.	-	-	-	ca.ox.	-
	Feb. 6'52	Clear,amber	1.025	acid	0	0	++++	ooo.	-	ooo.	-	am.ur.	-
	Feb. 7'52	Cldy,straw	1.021	alk.	tr	0	++++	ooo.	-	-	-	am. ur.	-
	Feb. 8'52	Sl.oldy,yell.	1.025	acid	0	0	++++	ooo.	-	-	-	ca.ox & ur. acid	-
	Feb. 9'52	Sl.oldy,amb.	1.026	acid	0	0	+or ++	ooo.	-	-	-	am.ur.& ca. ox.	-
	Feb.10'52	Sl.oldy,amb.	1.025	alk.	0	0	++++	ooo.	-	ooo.	-	am.& tr. phos.	-
Phase IV	Feb.11'52	Clear,amber	1.030	acid	0	0	0	ooo.	-	-	-	ca.ur.	-
	Feb.12'52	Clear,straw	1.010	alk.	0	0	0	ooo.	-	-	-	am. ph.	-
Subject No. 12													
Phase I	Dec.13'52	Clear,yellow	1.022	acid	0	0	0	few	-	few	-	-	-
Phase II	Jan. 4'52	Clear,yellow	1.022	acid	0	0	0	ooo.	-	ooo.	-	am.ur.	-
	Jan. 7'52	Clear,straw	1.015	acid	0	0	0	ooo.	-	ooo.	-	am.ur.	-
	Jan. 8'52	Clear,straw	1.015	alk.	0	0	0	ooo.	-	ooo.	-	-	-
	Jan. 9'52	Clear,straw	1.013	acid	0	0	0	ooo.	-	ooo.	-	-	-
	Jan.10'52	Clear,straw	1.019	acid	0	0	++	ooo.	-	ooo.	-	-	-
	Jan.11'52	Clear,yellow	1.024	acid	0	0	++++	ooo.	-	1+	-	am.ur.	-
	Jan.12'52	Clear,straw	1.019	acid	0	0	++++	ooo.	-	-	-	am.ur.	-
Phase III	Feb. 1'52	Cldy,straw	1.023	alk.	tr	0	0	ooo.	-	-	-	tr.&am. phos.	-
	Feb. 2'52	Clear,straw	1.014	alk.	0	0	++or +++	ooo.	-	-	-	am.& tr phos.	-
	Feb. 3'52	Clear,straw	1.016	acid	0	0	++or +++	ooo.	-	ooo.	-	ur. ac.	-
	Feb. 4'52	Clear,straw	1.017	alk.	0	0	++++	ooo.	-	ooo.	-	ca.ox.	-
	Feb. 5'52	Cldy,yellow	1.016	alk.	0	0	++++	ooo.	-	-	-	tr.phos.	-
	Feb. 6'52	Clear,yellow	1.019	sl.alk.	0	0	++++	ooo.	-	-	-	ca.ox.	-
	Feb. 7'52	Clear,yellow	1.011	alk.	0	0	++++	ooo.	-	ooo.	-	tr.phos.	-

TABLE 23. (Cont'd.)

	Date	Color	Specific Gravity	Reaction	Albumin	Sugar	Acetone	WBC	Microscopic: RBC	Microscopic: Epithelial Cells	Microscopic: Casts	Microscopic: Crystals	Microscopic: Bacteria
Phase III	Feb. 8'52	Cldy,straw	1.019	alk.	tr	0	++++	occ.	-	-	-	tr-& am Ph.	-
	Feb. 9'52	Cldy,straw	1.015	acid	0	0	++++	occ.	-	occ.	-	am.ur.	-
	Feb.10'52	Cldy,straw	1.020	alk.	tr	0	++++	occ.	-	-	-	tr & am.	-
	Feb.11'52	Clear,straw	1.019	acid	0	0	0	3/hpf	-	occ.	-	am.ur	-
	Feb.12'52	Sl.cldy,yel.	1.021	alk.	0	0	0	occ.	-	-	-	tr.& am. ph.	-
Subject No. 4													
Phase I	Dec.13'51	Clear,yellow	1.020	alk.	0	0	0	few	-	few	-	-	-
	Jan. 4'52	Clear,amber	1.030	acid	0	0	0	5/hpf	-	few	-	ca.ox.& yeast cells	
Phase II	Jan. 7'52	Clear,straw	1.016	acid	0	0	0	occ.	-	occ.	-	-	-
	Jan. 8'52	Clear,yel.	1.014	alk.	0	0	0	occ.	-	1+	-	am. ph.	-
	Jan. 9'52	Clear,amber	1.021	acid	0	0	++[illegible]	3/hpf	-	occ.	-	-	-
	Jan.10'52	Clear,yel.	1.017	acid	0	0	++	2/hpf	-	1+	-	-	-
	Jan.11'52	Clear,yel.	1.017	acid	0	0	++	4/hpf	-	occ.	-	-	-
	Jan.12'52	Clear,yel.	1.020	acid	0	0	++++	occ.	-	-	-	am. ur.	-
Subject No. 8													
Phase I	Jan. 3'52	Clear,yel.	1.023	acid	0	0	+1	2-3/hpf	-	few	-	-	-
	Jan. 4'52	Clear,yel.	1.024	acid	0	0	0	occ.	-	occ.	-	am. ur.	-
Phase II	Jan. 7'52	Clear,straw	1.013	acid	0	0	0	occ.	-	-	-	-	-
	Jan. 8'52	Clear,yel.	1.013	alk.	0	0	0	2/hpf	-	occ.	-	-	-
	Jan. 9'52	Clear,amber	1.015	acid	0	0	+	occ.	-	occ.	-	ca. ox.	-
	Jan.10'52	Clear,yel.	1.022	acid	0	0	++	occ.	-	occ.	-	-	-
	Jan.11'52	Clear,yel.	1.020	acid	0	0	++++	2/hpf	-	occ.	-	am.ur.& ca.ox.	-
	Jan.12'52	Clear,yel.	1.020	acid	0	0	++++	occ.	-	occ.	-	-	-

TABLE 23. (Cont'd.)

	Date	Color	Specific Gravity	Reaction	Albumin	Sugar	Acetone	Microscopic					
								WBC	RBC	Epithelial Cells	Casts	Crystals	Bacteria
B. Carbohydrate Group:													
Subject No. 2													
Phase I	Dec.13'51	Clear,yellow	1.021	alk.	0	0	0	few	-	few	-	-	-
	Jan. 4'52	Clear,straw	1.019	alk.	0	0	0	occ.	-	occ.	-	-	-
Phase II	Jan. 7'52	Clear,amber	1.026	acid	0	0	++	occ.	-	occ.	-	-	-
	Jan. 8'52	Clear,yell.	1.010	acid	0	0	0	occ.	-	+	-	ca.ox.	-
	Jan. 9'52	Clear,yell.	1.015	acid	0	0	0	occ.	-	occ.	-	-	-
	Jan.10'52	Clear,amber	1.021	acid	0	0	tr	3/hpf	-	occ.	-	-	-
	Jan.11'52	Clear,amber	1.020	acid	0	0	0	occ.	-	occ.	-	-	-
	Jan.12'52	Clear,amber	1.029	acid	0	0	0	3/hpf	-	occ.	-	-	-
Phase III	Feb. 1'52	Sl.cldy,yel.	1.020	acid	0	0	0	2/hpf	-	-	-	ca.ox. & am.ur.	-
	Feb. 2'52	Cldy,amber	1.021	acid	0	0	0	occ.	-	-	-	am.& tr. phos.	-
	Feb. 3'52	Cldy,amber	1.029	acid	0	0	++or +++	2/hpf	-	-	-	am. ur.	-
	Feb. 4'52	Cldy,yellow	1.028	acid	0	0	tr	occ.	-	occ.	hyal.	ca.ox.& amorph.	-
	Feb. 5'52	Clear,yell.	1.012	acid	0	0	0	occ.	-	occ.	hyal.	-	-
	Feb. 6'52	Clear,amber	1.025	sl.alk.	0	0	+or ++	2/hpf	-	occ.	-	-	-
	Feb. 7'52	Cldy,amber	1.022	alk.	tr	0	+	3/hpf	-	-	-	am.ph.	-
	Feb. 8'52	Sl.cldy,yel.	1.011	acid	0	0	0	occ.	-	-	-	ca.ox.	-
	Feb. 9'52	Cldy,amber	1.027	alk.	0	0	tr	occ.	-	-	-	tr & am phos.	-
	Feb.10'52	Cldy,amber	1.023	alk.	0	0	++++	occ.	-	-	-	tr.phos.	-
Phase IV	Feb.11'52	Clear,amber	1.030	alk.	0	0	tr	occ.	-	occ.	-	tr.phos.	-
	Feb.12'52	Clear,yell.	1.023	alk.	0	0	0	occ.	-	occ.	-	-	-

TABLE 23. (Cont'd.)

	Date	Color	Specific Gravity	Reaction	Albumin	Sugar	Acetone	WBC	Microscopic: RBC	Microscopic: Epithelial Cells	Microscopic: Casts	Microscopic: Crystals	Microscopic: Bacteria
Subject No. 3													
Phase I	Dec.13'51	Clear,yellow	1.015	alk.	0	0	0	few	-	few	-	-	-
	Jan. 4'52	Clear,yellow	1.012	alk.	0	0	0	occ.	-	occ.	-	-	-
	Jan. 7'52	Clear,amber	1.021	acid	0	0	0	occ.	-	occ.	-	-	-
	Jan. 8'52	Clear,yellow	1.011	acid	0	0	0	occ.	-	occ.	-	-	-
	Jan. 9'52	Clear,amber	1.012	acid	0	0	0	occ.	-	occ.	-	am. ur.	-
	Jan.10'52	Clear,yellow	1.010	acid	0	0	0	3/hpf	-	occ.	-	-	-
	Jan.11'52	Clear,amber	1.014	acid	0	0	0	occ.	-	occ.	-	-	-
	Jan.12'52	Clear,yellow	1.005	acid	0	0	0	occ.	-	occ.	-	-	-
	Feb. 1'52	Clear,straw	1.012	alk.	0	0	0	occ.	-	occ.	-	-	-
	Feb. 2'52	Clear,amber	1.015	acid	0	0	+or ++	occ.	-	occ.	-	-	-
	Feb. 3'52	Cldy,amber	1.027	acid	0	0	0	occ.	-	-	-	am. ur.	-
	Feb. 4'52	Sl.cldy,am.	1.023	acid	0	0	+or ++	occ.	-	occ.	-	ca. ox.	-
	Feb. 5'52	Clear,amber	1.012	acid	0	0	0	3/hpf	-	occ.	-	-	-
	Feb. 6'52	Clear,drk,am	1.019	acid	0	0	0	2/hpf	one	occ.	-	-	-
	Feb. 7'52	Cldy,amber	1.026	acid	0	0	+or	4/hpf	-	occ.	-	am.ur.	-
	Feb. 8'52	Cldy,amber	1.029	acid	0	0	0	occ.	-	-	-	am.ur.	-
	Feb. 9'52	Cldy,amber	1.034	acid	0	0	0	occ.	-	occ.	-	-	-
	Feb.10'52	Clear,amber	1.026	acid	0	0	0	2/hpf	-	occ.	-	-	-
	Feb.11'52	Clear,yellow	1.023	acid	0	0	0	occ.	-	-	-	occ ca. ox.	-
	Feb.12'52	Clear,yellow	1.022	acid	0	0	0	occ.	-	occ.	-	-	-
Subject No. 7													
Phase I	Dec.13'51	Sl.cldy,yel.	1.020	alk.	0	0	0	few	-	occ.	-	-	-
	Jan. 4'52	Clear,yellow	1.024	alk.	0	0	0	5/hpf	-	few	-	-	-
Phase II	Jan. 7'52	Clear,amber	1.021	acid	0	0	tr	occ.	-	occ.	-	-	-
	Jan. 8'52	Clear,yellow	1.013	alk.	0	0	0	2/hpf	-	occ.	-	-	-
	Jan. 9'52	Clear,amber	1.016	acid	0	0	0	3/hpf	-	occ.	-	ca.ox.	-
	Jan.10'52	Clear,drk,am	1.023	acid	0	0	0	5/hpf	-	occ.	-	-	Bile: neg.

TABLE 23. (Cont'd.)

	Date	Color	Specific Gravity	Reaction	Albumin	Sugar	Microscopic: Acetone	WBC	RBC	Epithelial Cells	Casts	Crystals	Bacteria
	Jan.11'52	Clear,drk,am	1.016	acid	0	0	0	3/hpf	-	occ	-	ca.ox.	Bile neg
	Jan.12'52	Clear,drk,am	1.027	acid	0	0	0	occ.	-	-	-	ca.ox.	-
Phase III	Feb. 1'52	Clear,amber	1.020	acid	0	0	0	occ.	-	occ	+	ca.ox.	-
	Feb. 2'52	Sl.cldy,amb.	1.024	acid	0	0	0	2/hpf	-	occ	-	-	-
	Feb. 3'52	Cldy, amber	1.030	alk.	0	0	0	occ.	-	occ	-	-	-
	Feb. 4'52	Cldy,amber	1.021	acid	0	0	tr	occ.	-	-	-	ca.ox. & amor.	-
	Feb. 5'52	Clear,dark,am	1.027	acid	0	0	0	3/hpf	-	occ	-	-	-
	Feb. 6'52	Clear,amber	1.015	alk.	0	0	0	occ.	-	occ	-	ca.ox.	-
	Feb. 7'52	Clear,amber	1.021	acid	0	0	+	3/hpf	-	-	-	ca.ox.	-
	Feb. 8'52	Cldy,amber	1.032	acid	0	0	0	4/hpf	-	occ	-	-	-
	Feb. 9'52	No Specimen											
	Feb.10'52	Cldy,drk,amb.	1.030	alk.	0	0	0	occ.	-	-	-	tr.ph.	-
Phase IV	Feb.11'52	Clear,straw	1.027	sl.alk.	0	0	0	occ.	-	occ	-	-	-
	Feb.12'52	Sl.cldy,yell.	-	acid	0	0	0	2/hpf	-	occ	-	-	-
Subject No. 9													
Phase I	Jan. 3'52	No Specimen											
	Jan. 4'52	Clear, yellow	1.021	acid	0	0	0	10/hpf	-	-	-	am.ur.	-
	Jan. 7'52	Clear,straw	1.019	acid	0	0	0	10/hpf	-	-	-	am.ur.	-
	Jan. 8'52	Clear,yellow	1.011	acid	0	0	0	10/hpf	-	occ	-	-	-
	Jan. 9'52	Clear,amber	1.013	acid	0	0	0	8-10/hpf	-	-	f.gran	-	-
	Jan.10'52	Clear,amber	1.010	alk.	0	0	0	5/hpf	-	one+	-	-	-
	Jan.11'52	Clear,drk,am	1.020	acid	0	0	0	25/hpf	-	occ	-	-	-
	Jan.12'52	Clear,drk,am	1.017	acid	0	0	0	3/hpf	-	occ	-	-	-
	Feb. 1'52	Clear,amber	1.012	acid	0	0	0	12/hpf	-	-	-	ca.ox.	-
	Feb. 2'52	Clear,amber	1.012	acid	0	0	0	10/hpf	-	occ	-	-	-
	Feb. 3'52	Clear,amber	1.017	acid	0	0	++or +++	-	-	occ	-	ca.ox.	-
	Feb. 4'52	Clear, amber	1.018	acid	0	0	++or +++	5/hpf	-	-	hyal.	ca.ox.	-
	Feb. 5'52	Sl.cldy,amber	1.016	acid	0	0	+ or ++	5-8/hpf	-	occ	-	ca.ox.	-
	Feb. 6'52	Clear,amber	1.010	acid	0	0	0	5-8/hpf	-	occ	-	ca.ox.	-

TABLE 23. (Cont'd.)

	Date	Color	Specific Gravity	Reaction	Albumin	Sugar	Acetone	Microscopic: WBC	RBC	Epithelial Cells	Casts	Crystals	Bacteria
	Feb.6'52	Clear,amber	1.010	acid	0	0	0	5-8/hpf	-	occ	-	ca.ox.	-
	Feb.7'52	Clear,amber	1.016	acid	0	0	0	10/hpf	-	-	-	ca.ox.	-
	Feb.8'52	Sl.cldy,amb	1.012	acid	0	0	0	3/hpf	-	occ	-	ca.ox. am.ph.	-
	Feb.9'52	Cldy,yellow	1.010	alk.	one+	0	0	occ	-	-	-	tr.ph.	-
	Feb.10'52	Cldy,amber	1.013	acid	tr	0	0	3/hpf	-	occ	-	-	-
Phase IV	Feb.11'52	Cldy,yellow	1.022	alk.	two+	0	0	3/hpf	-	occ	-	tr.ph.	-
	Feb.12'52	Cldy,straw	1.017	acid	one +	0	0	10/hpf	-	-	-	-	-
Subject No. 11													
Phase I	Dec.13'52	Clear,yellow	1.021	alk.	0	0	0	4/hpf	-	many	-	-	-
	Jan. 4'52	Clear,amber	1.027	acid	0	0	0	occ.	-	-	-	ca. ox.	-
Phase II	Jan. 7'52	Clear,straw	1.020	acid	0	0	0	2/hpf	-	occ	-	-	-
	Jan. 8'52	Clear,yellow	1.010	acid	0	0	0	2/hpf	-	one+	-	occ.ca. cxalate	-
	Jan. 9'52	Clear,amber	1.013	acid	0	0	0	3/hpf	-	one+	-	-	-
	Jan.10'52	Clear,amber	1.016	acid	0	0	0	3/hpf	-	occ	-	-	-
	Jan.11'52	Clear,amber	1.010	alk.	0	0	0	2/hpf	-	one+	-	-	-
	Jan.12'52	Clear,amber	1.023	acid	One+	0	0	occ	-	occ	-	-	-
Phase III	Not available for Field Phase												
C. Meat-Carbohydrate Group.													
Subject No. 4													
Phase III	Feb. 1'52	Clear,amber	1.020	acid	0	0	0	occ.	-	-	-	ca.ox.	-
	Feb. 2'52	Cldy,amber	1.021	acid	0	0	0	occ.	-	occ	-	am.ur.	-
	Feb. 3'52	Clear,amber	1.023	acid	0	0	+++	occ.	-	-	-	ca.ox.	-
	Feb. 4'52	Clear,yell.	1.016	acid	0	0	++++	occ.	-	occ.	-	ca.ox.	-
	Feb. 5'52	Clear,yell.	1.013	acid	0	0	0	occ.	-	occ.	-	ca.ox.	-
	Feb. 6'52	Clear,yell.	1.011	acid	0	0	tr	occ.	-	-	-	ca.ox.	-
	Feb. 7'52	Cldy,amber	1.017	acid	0	0	++	occ.	-	occ.	-	ca.ox. am.ur.	-

TABLE 23. (Cont'd.)

	Date	Color	Specific Gravity	Reaction	Albumin	Sugar	Acetone	Microscopic					
								WBC	RBC	Epithelial Cells	Casts	Crystals	Bacteria
	Feb. 8'52	Cldy,amber	1.022	acid	tr	0	++	occ	-	-	-	ca.ox am.ur.	-
	Feb. 9'52	Cldy,amber	1.020	alk.	0	0	0	occ.	-	-	-	tr & am.ph.	-
	Feb.10'52	Cldy,amber	1.024	alk.	tr	0	tr	occ.	-	-	-	tr.ph.	-
Phase IV	Feb.11'52	Clear,yellow	1.021	acid	0	0	0	-	-	-	-	am.ur.	-
	Feb.12'52	Clear,yellow	1.017	acid	0	0	0	3/hpf	-	occ	-	-	-
Subject No. 8													
Phase III	Feb. 1'52	Clear,amber	1.020	acid	0	0	0	occ	-	-	-	ca.ox.& am. Ur.	-
	Feb. 2'52	Clear,yellow	1.017	acid	0	0	0	occ	-	occ	-	ca.ox.	-
	Feb. 3'52	Cldy,amber	1.025	acid	0	0	+++	occ	-	-	-	ca.ox.& ur. ac.	-
	Feb. 4'52	Cldy,amber	1.021	acid	0	0	++++	occ.	-	occ	-	ca.ox.& am. ph.	-
	Feb. 5'52	Clear,yellow	1.015	acid	0	0	+++	occ.	-	-	-	am.ur.& ur.ac.	-
	Feb. 6'52	Clear,amber	1.020	acid	0	0	++	occ.	-	-	-	tr & am. phos.	-
	Feb. 7'52	Clear,amber	1.022	acid	0	0	++++	2/hpf	-	occ	-	ca.ox.	-
	Feb. 8'52	Cldy,amber	1.022	acid	0	0	++++	occ.	-	occ	-	ca.ox	-
	Feb. 9'52	Cldy,amber	1.024	alk.	tr	0	++++	occ.	-	occ	-	am.phos.	-
	Feb.10'52	Cldy,amber	1.023	alk.	0	0	0	occ.	-	-	-	tr.phos.	-
Phase IV	Feb.11'52	Cldy,straw	1.025	alk.	0	0	0	occ.	-	-	-	tr & am. phos.	-
	Feb.12'52	Clear,yellow	1.021	alk.	0	0	0	occ.	-	-	-	am. phos.	-