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INSTITUTE OF WATER RESOURCES

POLYETHYLENE SHEETING AS A WATER SURFACE COVER IN SUB-ZERO TEMPERATURES

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Report No. IWR-47

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ABSTRACT

The occurrence of temperatures below -20°C in central Alaska produces a situation conducive to the formation of ice fog. By far the largest source of ice fog in the Fairbanks area is the evaporation of water in the cooling ponds of power plants. In an attempt to find methods to reduce this evaporation and subsequent fogging, a study was conducted during the winter of 1973 in order to examine the feasibility of using polyethylene sheeting as a water surface cover.

An uncovered insulated tank of water was placed on the roof of the Engineering Building of the University of Alaska. The water was circulated to prevent stratification and kept from freezing by a thermostatically controlled heater. From January 23 through February 2, the water surface was left uncovered. Evaporation rates were measured daily by maintaining the water surface at a constant level. During the period of February 2 through 11, the water surface was covered with a sheet of clear polyethylene, thereby eliminating evaporation. Throughout the period of study, daily readings were made of the power consumption of the heater and pump. Temperatures within and above the tank were also frequently measured with copper-constantine thermocouples.

From the data collected, a daily energy balance for the tank was calculated. Taken into consideration were the net short-wave and long-wave energy exchange, heat loss due to evaporation and sensible heat transfer, heat loss through the sides of the tank, change in stored energy, and energy input from heater and pump.

Results indicate that polyethylene is an effective water surface cover that could be used to virtually eliminate evaporation from cooling ponds.

INTRODUCTION

The occurrence of temperatures below -20°C in Central Alaska produces a situation conducive to the formation of ice fog. Though not considered a physiologic pollutant, ice fog is a nuisance. It greatly reduces visibility, causes occasional shutdown of airports, increases the number of traffic accidents, and has a psychologically depressing effect on humans. Three factors contribute to the formation of ice fog. These are temperatures below -20°C, a continuous source of water vapor, and particulate matter suspended in the air which act as nuclei for the ice fog particles. The absence of any one of these factors would eliminate ice fog. Since control of winter temperatures is virtually impossible, and a certain amount of particulate matter is always present in the air around urban communities, the only recourse in the prevention of ice fog is to prevent the introduction of water vapor into the atmosphere. The two major sources of water vapor are the combustion of hydrocarbon fuels and evaporation from open water surfaces such as cooling-ponds of power plants and unfrozen streams. Past studies by Benson (1970) indicate that cooling-ponds and/or unfrozen streams are, by far, the largest source of ice fog in the Fairbanks area. In an attempt to find methods to reduce this evaporation, a study was conducted at the University of Alaska during the winter of 1973 examining the feasibility of using polyethylene sheeting as a water surface cover. This report presents the findings from that study.

Due to its exploratory nature, the study was carried out on a small-scale basis with equipment supplied by the various engineering departments of the university and the university's Institute of

Water Resources. The study involved an examination of the evaporation rates and energy losses from both open and covered water surfaces during climatic conditions conducive to ice fog production. The individual modes of heat transfer from both surfaces were considered in order to determine the magnitude of the reduction of heat loss due to the elimination of evaporation from the water surface.

The investigation was conducted in two phases: the first was the physical measurement of evaporation rates and the total of the energy losses from both natural and covered water surfaces. The second phase was the application of the data obtained in Phase I to produce a daily energy balance. With this approach, it was possible to determine the effectiveness of polyethylene sheeting as a water surface cover. Conclusions and recommendations are based on the findings.

METHOD OF EVALUATION

In order to determine the effectiveness of polyethylene sheeting as a water surface cover, it is necessary to determine the rates of evaporation and energy loss from both natural and covered water surfaces under conditions conducive to the formation of ice fog. These values may be obtained by analytical or empirical methods on either a micro- or macro-scale. A combination of the two methods of analysis was used because of the limited scope of the project and the short time available for completion.

In order to obtain physical reality, it was decided to measure evaporation rates and as many heat transfer modes as possible from a small heated tank exposed to January and February climatic conditions in Fairbanks.

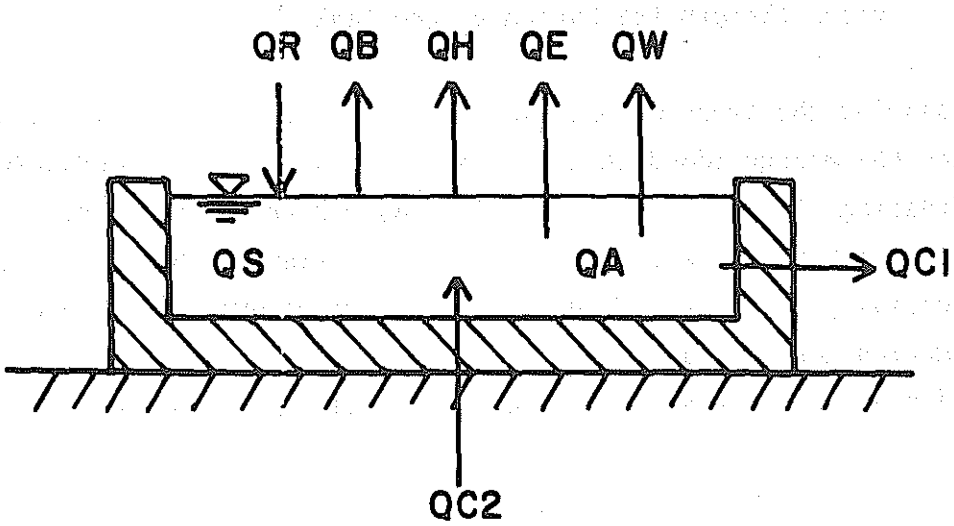

Fig. 1. Energy Budget of a Tank with Open Water Surface

If one considers the total energy balance of the heated tank of water shown in Figure 1, the following equation is arrived at

$$QA - QS = QB + QH + QE + QW + QC1 - QR - QC2 \qquad (1)$$

where

- QA is the energy added to maintain the tank temperature above freezing;
- QS is the change in stored energy;
- QB is the energy loss due to long-wave radiation;
- QH is the energy loss due to sensible heat transfer;
- QE is the heat loss due to evaporation;
- QW is the energy advected from the body of water by the mass of water evaporated;
- $QC1$ is the energy loss due to conduction of heat through the sides of the tank;
- QR is the energy gain due to short-wave radiation;
- $QC2$ is the energy gain due to heat conduction from a warmer surface through the bottom of the tank.

Measuring the evaporation, the water temperature, the air temperature, and the energy added to the water to maintain its temperature above freezing, leaves QE, QH, $QC1$, QR, and $QC2$ to be evaluated. All of these terms, with the exception of QH, the sensible heat transfer, can be reliably calculated from the water temperature and climatological data. Having determined values of QB, $QC1$, and $QC2$, and by applying the condition of conservation of energy, QH can be calculated.

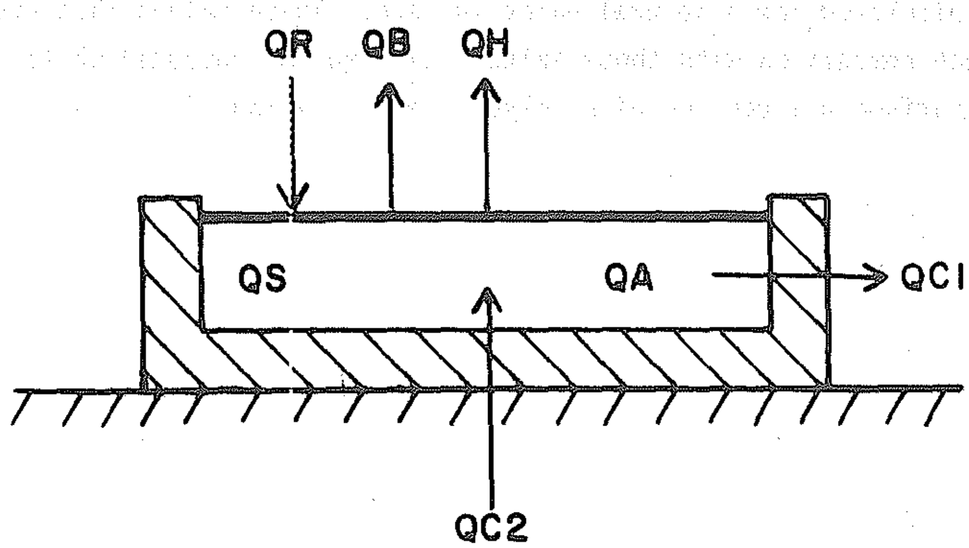

Fig. 2. Energy Budget of a Tank with Covered Water Surface

With the water surface covered, as shown in Figure 2, (1) reduces to

$$QA - QS = QB + QH + QC1 - QR - QC2 \qquad (2)$$

Again, by measuring the temperatures inside and outside the tank and the total energy necessary to maintain the water body above freezing, the terms *QB, QC1, QR*, and *QC2* can be evaluated and *QH* determined.

From examination of (1) and (2), it is evident that the total heat transfer from the covered surface will be different from that of the open water surface. To evaluate this difference, it was necessary to formulate equations based on physical concepts which described the evaporation and sensible heat losses from the open water surface. Using these equations and maintaining the water temperatures and climatological conditions which occurred during the period in which the tank was covered, hypothetical values of the various heat loss components were calculated for a natural water surface. These values then provided a direct comparison with those values measured and computed while the water surface was covered with polyethylene sheeting.

PHYSICAL MEASUREMENTS

Measurements of evaporation rates and total energy losses from both open and covered water surfaces were taken from an insulated tank of water located on the roof of the Duckering Building at the University of Alaska.

The tank, shown in Figure 3, was constructed from 3/8" plywood. Four inches of polystyrene insulation was placed on the inside of the tank in order to minimize any heat conduction through the bottom and sides. The tank was lined with two layers of 4-mil polyethylene sheeting to make it watertight. Inside dimensions were 100.06 cm x 99.70 cm x 29.80 cm deep, resulting in a surface area of 9975 cm^2 and a usable water depth of 25 cm.

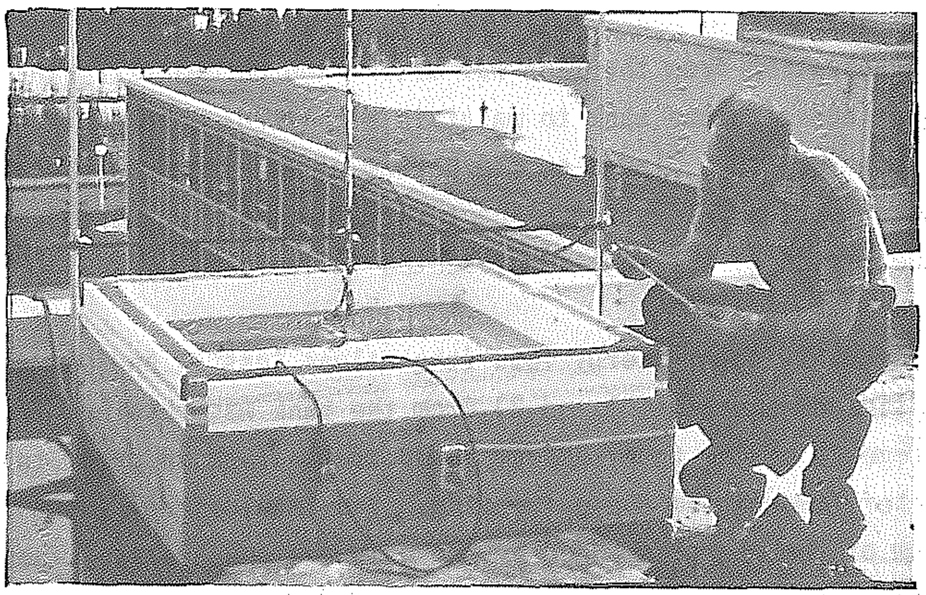

Fig. 3. Test Tank

In order to prevent temperature stratification, the water was continuously circulated within the tank through a pipe network fed by 425-watt submersible pump. Above-freezing water temperatures were maintained by a 755-watt thermostatically controlled hot water heater element.

The testing was conducted from January 23 through February 10, 1973. During the period of January 23 through February 1, the tank was uncovered. From February 2 through February 10, the water surface was covered with a piece of 4-mil clear polyethylene sheeting attached to the sides of the tank.

Whenever possible, measurements of evaporation and total energy loss from the tank were made on a daily basis as close to noon as possible. These measurements were then converted to twenty-four-hour values by assuming a constant rate of evaporation or energy loss between the time of readings. The time measurement under consideration is, therefore, from noon on one day to noon on the following day. For ease of reporting, it is assumed, for example, that January 23 is the period from noon on January 23 to noon on January 24.

Evaporation from the tank was determined by measuring the amount of water added to the tank to maintain a constant water surface level. A 25-cm point gauge placed on the bottom of the tank was used to measure the water surface elevation. The twenty-four-hour values of evaporation for the period of testing are presented in Table 1.

The daily total energy loss (the values less QR and $QC1$ on the right side of equations 1 and 2) from the tank was obtained from measurements of the total energy added to the tank in order to maintain the water temperature above freezing. The total energy input is essentially the sum of the energies added by the pump and the heater. These values were determined by recording their periods of operation and multiplying them by the wattage of the unit. For the pump, which ran continuously, the energy input was a constant. The time of operation of the heater, on the other hand, was not continuous and was measured by placing an electric clock into the circuit controlled by the thermostat. Values are presented in Table 2.

	Date	Daily Evaporation cm^3
OPEN	730123	6240.
	730124	6140.
	730125	5943.
	730126	3719.
	730127	3719.
	730128	3719.
	730129	3711.
	730130	3711.
	730131	3876.
	730201	3975.
COVERED	730202	0.
	730203	0.
	730204	0.
	730205	0.
	730206	0.
	730207	0.
	730208	0.
	730209	0.

Table 1

Daily Evaporation

	Date	Heater Operation Hr
OPEN	730123	12.452
	730124	13.714
	730125	13.559
	730126	10.176
	730127	0.000
	730128	0.000
	730129	3.633
	730130	3.633
	730131	5.336
	730201	5.336
COVERED	730202	1.379
	730203	0.000
	730204	0.000
	730205	0.000
	730206	0.000
	730207	0.000
	730208	0.000
	730209	1.367

Table 2

Daily Heater Operation

Temperature measurements within and above the tank were recorded frequently during the daytime period using copper-constantine thermocouples. Two thermocouples were placed at random within the tank while the remaining thermocouples were located over the center of the tank at elevations of 0, 1, 2, 4, 6, 12, 24, 36, 48 and 60 inches above the gauge point. Readings were taken using a Leeds and Northrup potentiometer. A typical data sheet is shown in Figure 4. Daily averages of the water temperature and the air temperature at 60" are presented in Figure 5. It must be remembered that these values are averages from noon on one day to noon on the following day.

AIR-WATER ENERGY EXCHANGE

University of Alaska
Fairbanks, Alaska

TEMPERATURE DATA

Copper/Constantine Thermocouples — Date 1/20, 1973

Millivolt Readings by: J. McDougall — Day SAT

Temperatures by: J. McDougall — Time 9:00

SWITCH	POSITION	MILLIVOLTS	TEMPERATURE °C
1	60" above gage point	-1.414	-38.56
2	48" above gage point	-1.414	-38.56
3	36" above gage point	-1.410	-38.44
4	24" above gage point	-1.405	-38.30
5	12" above gage point	-1.355	-36.90
6	6" above gage point	-1.305	-35.44
7	4" above gage point	-1.312	-35.64
8	2" above gage point	-1.299	-35.27
9	1" above gage point	-1.258	-34.11
10	0" above gage point	-0.955	-25.61
11	TANK	0.366	9.36
12	TANK	0.366	9.36
13	TANK	0.366	9.36

NOTES:

Fig. 4. Typical Data Sheet

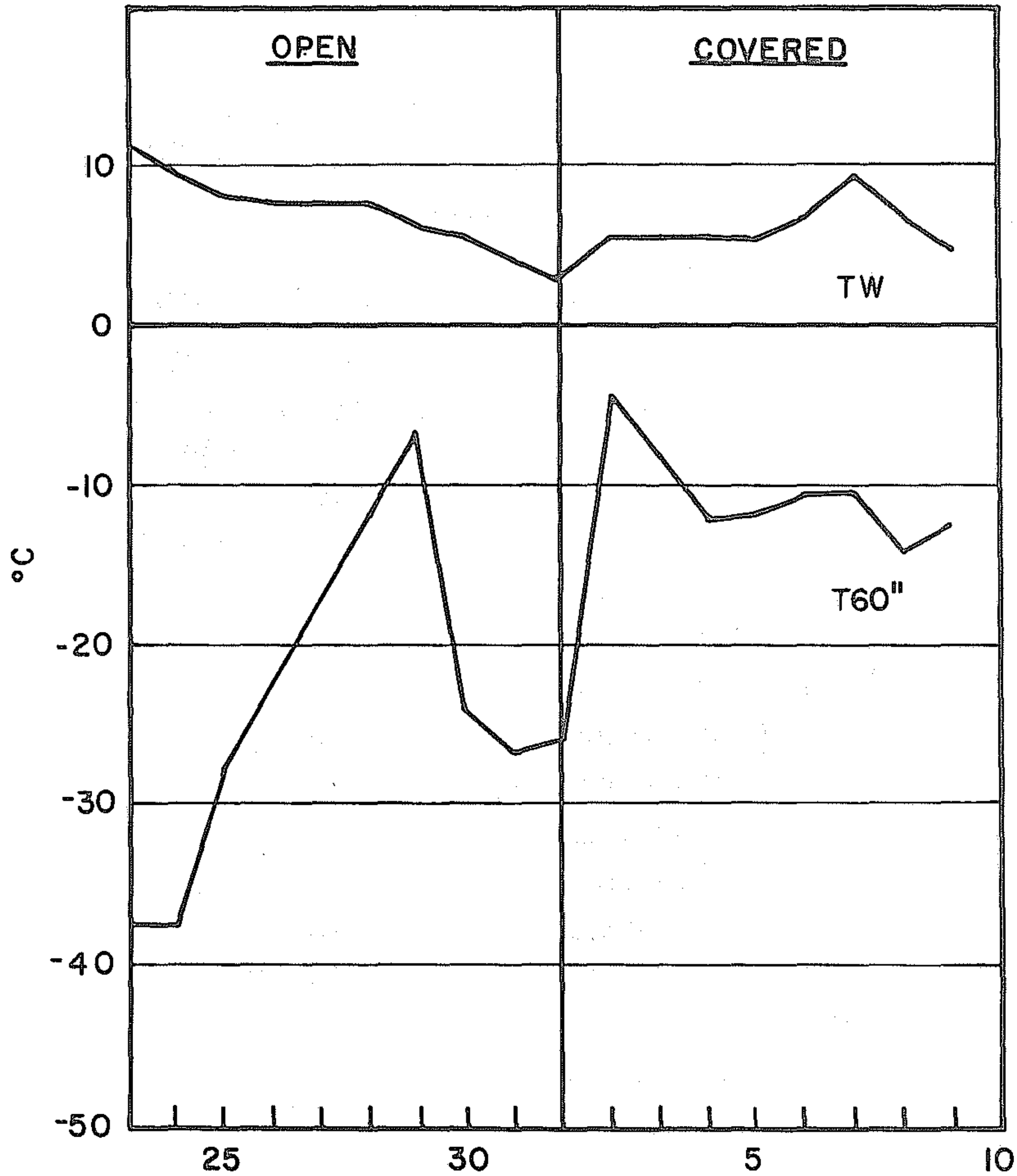

Fig. 5. Water Temperatures and Air Temperatures at 60°

CLIMATOLOGICAL DATA

As mentioned earlier, one can reliably compute values for the heat gain from short-wave radiation, the heat loss to long-wave radiation, and the conduction through the sides and bottom of the tank from water temperatures and climatological data. The necessary climatological data is air temperature, relative humidity, wind speed, cloud cover, and cloud base height. Ideally these values would be measured at the test site. Unfortunately, this was not possible. This data, therefore, was obtained from the monthly summaries of the National Weather Service Office at the Fairbanks International Airport, roughly 2 miles from the test location. Twenty-four-hour averages of the data for the period of testing are presented in Table 3. The monthly summaries appear in Appendix 1.

	Date	TA °C	P mb	RH %	H m	C Tenths	V m/sec
OPEN	730123	-40.76	868.	63.38	3239.	9.00	0.19
	730124	-40.28	877.	65.63	6553.	7.13	0.45
	730125	-40.76	888.	65.50	6682.	5.38	0.45
	730126	-38.57	892.	69.38	6934.	2.63	0.97
	730127	-17.99	877.	53.88	4496.	8.50	0.77
	730128	-4.51	861.	83.00	2621.	8.88	2.51
	730129	-17.22	860.	54.38	4241.	9.25	5.21
	730130	-24.71	871.	49.83	2901.	10.00	0.51
	730131	-32.99	872.	65.25	7620.	2.63	0.58
	730201	-19.77	873.	55.88	4686.	8.88	2.43
COVERED	730202	-18.33	873.	57.63	5296.	5.00	3.73
	730203	-20.35	879.	53.25	6744.	9.00	1.99
	730204	[illegible]	894.	54.25	7239.	4.75	1.54
	730205	-21.8[illegible]	892.	54.88	7315.	1.50	1.73
	730206	-16.94	892.	61.25	6133.	5.25	2.12
	730207	-21.11	897.	55.75	7620.	2.25	1.54
	730208	-23.61	872.	51.00	7620.	0.83	1.22
	730209	-25.39	894	50.25	7620.	0.13	0.00

Table 3

Climatalogical Data

The air temperatures shown in Table 3 were used in the analysis instead of measured values because they represent true 24-hour averages, whereas the measured values are only daytime averages.

ENERGY BALANCE CONSIDERATIONS

In this section, the individual modes of energy exchange between the tank and its surroundings are considered.

QA, ENERGY INPUT FROM HEATER AND PUMP

The energy added to the tank from the 425-watt pump and 755-watt heater is defined by

$$QA = 8,763,676 + 648,683\ t \qquad (3)$$

where

QA = energy input from heater and pump (cal/day),

t = the time of operation of the heater (hours), (Table 2).

Values of QA, determined from the above equation, are presented in Table 4.

	Date	Heater Operation	Q Heater cal/day	Q Pump cal/day	QA cal/day
OPEN	730123	12.452	8077412.	8763677.	16841089.
	730124	13.714	8896051.	8763677.	17659728.
	730125	15.563	10096765.	8763677.	18860442.
	730126	10.196	6613931.	8763677.	15277648.
	730127	0.	0.	8763677.	8763677.
	730128	0.	0.	8763677.	8763677.
	730129	3.623	2356658.	8763677.	11120346.
	730130	3.623	2356658.	8763677.	11120346.
	730131	5.336	3461482.	8763677.	12225159.
	730201	5.336	3461482.	8763677.	12225159.
COVERED	730202	1.379	894535.	8763677.	9658212.
	730203	0.	0.	8763677.	8763677.
	730204	0.	0.	8763677.	8763677.
	730205	0.	0.	8763677.	8763677.
	730206	0.	0.	8763677.	8763677.
	730207	0.	0.	8763677.	8763677.
	730208	0.	0.	8763677.	8763677.
	730209	1.367	886751.	8763677.	9650428.

Table 4

Values of QA

QS, CHANGE IN STORED ENERGY

The basic equation as presented by Gray (1970) for the change in stored energy within the water body is

$$QS = \rho_2 c V_2 (T_2 - T_b) - \rho_1 c V_1 (T_1 - T_b) \tag{4}$$

where

QS = change in stored energy (cal);
ρ_1, ρ_2 = density of water at time t_1, t_2 (cal gm^{-3});
c = specific heat of water (cal $gm^{-1} °C^{-1}$);
V_1, V_2 = volume of the body of water at t_1, t_2 (cm_3);
T_1, T_2 = temperature of the body of water at t_1, t_2 (°C);
T_b = base temperature (°C).

By assuming that the density of the water within the tank remains a constant (1 gm/cm^3), and that the specific heat of water remains a constant (1 cal/gm°C), and by using a base temperature of 0°C, the general equation simplifies to:

$$QS = V_2 T_2 - V_1 T_1 \tag{5}$$

Values of QS resulting from the above equation using daily temperature and volume measurements made before and after filling the tank are presented in Table 5.

	Date	V_1 ml	T_1 °C	V_2 ml	T_2 °C	QS cal/day
OPEN	730123	251370.	14.00	245130.	10.79	-874227.
	730124	251370.	10.91	245230.	7.99	-783059.
	730125	251370.	8.50	245387.	7.40	-320781.
	730126	251370.	7.73	--	--	-34404.
	730127	--	--	--	--	-34404.
	730128	--	--	243370.	7.55	-34404.
	730129	251370.	7.99	--	--	-391914.
	730130	--	--	243948.	5.02	-391914.
	730131	251370.	5.56	--	--	-62966.
	730201	--	--	243618.	5.22	-62956.
COVERED	730202	251370.	5.32	251370.	--	+32678.
	730203	251370.	--	251370.	5.58	+32678.
	730204	251370.	5.58	251370.	5.17	-103062.
	730205	25[illegible]370.	5.17	251370.	5.43	+65356.
	730206	251370.	5.43	251370.	9.49	+1020562.
	730207	251370.	9.49	251370.	8.14	-339350.
	730208	251370.	8.14	251370.	3.24	-1231713.
	730209	251370.	3.24	251370.	5.38	+537[illegible]32.

Table 5

Values of QS

QE, ENERGY LOSS FROM EVAPORATION

The net energy loss from evaporation is defined by

$$QE = E\rho L_e/AREA \tag{6}$$

where

QE = the energy loss (cal cm^{-2});
E = the evaporation (cm^3);
ρ = the density of water (gm cm^{-3});
L_e = the latent heat of evaporation (cal gm^{-3});
= 597.3 - 0.57 (TW - 0°C) where TW is the temperature of the water °C;
$AREA$ = surface area of tank (9975 cm^2).

Values of *QE* calculated from data presented in Table 1 are shown in Table 6.

	Date	TW °C	L_e cal/gm	E gm	QE ly/day
	730123	11.19	590.92	6240.	369.62
	730124	9.51	591.88	6140.	364.29
	730125	8.09	592.69	5983.	355.46
O	730126	7.73	592.89	3719.	221.02
P	730127	7.75	592.88	3719.	221.02
E	730128	7.75	592.88	3719.	221.02
N	730129	6.06	593.85	3711.	220.91
	730130	5.25	594.31	3711.	221.08
	730131	4.00	595.02	3876.	231.19
	730201	2.79	595.71	3876.	231.45

Table 6

Values of QE

QW, ADVECTED ENERGY

The energy advected from the tank by the mass of water evaporated is defined by the equation

$$QW = c\rho E(TW-T_b) \qquad (7)$$

where

QW = advected energy (cal);

c = specific heat of water (cal gm^{-1}°C^{-1});

ρ = density of water (gm cm^{-3});

E = amount of evaporation (cm^3);

TW = water temperature (°C);

T_b = base temperature (°C).

Values of QW calculated from the evaporation data (Table 1) and water temperatures (Figure 5) are presented in Table 7.

	Date	TW °C	E cm^3	QW cal/day
OPEN	730123	11.19	6240.	69826.
	730124	9.51	6140.	58391.
	730125	8.09	5983.	48343.
	730126	7.73	3719.	28748.
	730127	7.75	3719.	28822.
	730128	7.75	3719.	28822.
	730129	6.06	3711.	22489.
	730130	5.25	3711.	19483.
	730131	4.00	3876.	15504.
	730201	2.79	3876.	10814.

Table 7

Values of QW

QB, LONG-WAVE RADIATION

The net heat loss from the natural water surface as long-wave radiation is given by

$$-QB = QA - QAR - QBS \tag{8}$$

where

QA = incoming long-wave atmospheric radiation;
QAR = reflected long-wave atmospheric radiation;
QBS = back radiation from the water surface.

From the Lake Hefner studies, Anderson (1954) has established that the emissivity of the water surface is 0.970 and is independent of the temperature and concentration of dissolved solids. Thus, for the period during which the water surface was not covered

$$QBS = 0.970\ \sigma\ TW^4 \qquad (9)$$

where

σ = the Stefan Boltzman constant
= (1.171×10^{-7} cal cm^{-2} day^{-1} °K^{-4});
TW = water temperature (°K).

When QA is not measured, it can be related empirically to the air temperature, the vapor pressure of the air, and cloud cover conditions (Anderson, 1954). For clear skies the relation initially suggested by Brunt is used with empirical constants determined by Anderson (1954)

$$QA = (0.68 + 0.036\sqrt{e_a})\sigma TA^4 \qquad (10)$$

where

TA = air temperature (°K);
e_a = vapor pressure of the air (mb).

If weather observations are available, the value of e_a can be computed from

$$e_a = \frac{RHe_{sa}}{100} \qquad (11)$$

where

RH = relative humidity (%);
e_{sa} = saturation vapor pressure of the air at TA (mb).

For cloudy skies QA is estimated by

$$QA = (a + b\ e_a)\ \sigma TA^4 \qquad (12)$$

where

a = 0.740 = 0.025 C exp[(-1.92)(10^{-4})H];
b = (4.9)(10^{-3}) - (5.4)(10^{-4})C exp [(-1.97)(10^{-4})H].

In the above equations, C is the cloud cover expressed in tenths and H is the cloud height in meters. For cloud heights less than 500 m, the cloud height is taken as a constant equal to 500 m (Anderson, 1954).

Since the emissivity of water is 0.97, the long-wave reflectivity for the uncovered water surface is therefore 0.03, thus

$$QAR = 0.03\ QA \qquad (13)$$

The above theory with minor modifications applies to the period during which the water surface was covered. Under these conditions, the polyethylene has an emissivity value of approximately 0.95 as compared to a value of 0.97 for water. It can be assumed that because of the thinness of the sheeting, the temperature of the emitting surface is the same as that of the water. With a lower value of emissivity, the reflectivity of the polyethylene sheeting is larger than that of the natural water surface and equal to 0.05.

Application of the above theory, together with the climatological data presented in the previous section, yields the net long-wave radiation loss from the tank surface for both open and covered conditions. These results are presented in Table 8.

	Date	TA °C	TW °C	RH %	C tenths	H m	QB ly/day
OPEN	730123	-40.75	11.19	68.38	9.00	3239.	457.29
	730124	-40.28	9.51	66.63	7.13	6553.	460.92
	730125	-40.76	8.08	65.50	5.38	6602.	452.96
	730126	-38.57	7.73	69.38	2.63	6934.	446.29
	730127	-17.99	7.75	58.80	8.50	4496.	306.33
	730128	-4.51	7.75	93.00	8.88	2621.	135.55
	730129	-17.22	6.06	54.38	9.25	4241.	278.71
	730130	-24.51	5.25	49.88	10.00	2801.	297.47
	730131	-32.99	4.00	65.25	2.63	7620.	384.37
	730201	-19.72	2.79	55.88	8.88	4686.	268.51
COVERED	730202	-18.33	5.32	57.63	5.00	5296.	299.12
	730203	-20.35	5.45	58.25	9.00	6744.	304.30
	730204	-23.05	5.59	54.25	4.75	7239.	335.52
	730205	-21.88	5.	54.88	1.50	7315.	335.51
	730206	-16.94	6.70	61.25	5.25	6153.	306.25
	730207	-21.11	9.25	55.75	2.75	7620.	363.19
	730208	-23.61	6.54	51.00	0.88	7620.	358.39
	730209	-26.39	4.31	50.25	0.13	7620.	342.96

Table 8

Values of QB

QR, SHORTWAVE RADIATION

The method of computation published by S. J. Bolsenga (1964) was adopted to determine the magnitude of the heat gain from short-wave radiation.

The amount of solar radiation received on a horizontal surface outside the atmosphere is given by

$$\frac{dQR}{dt} = \frac{s}{p^2} \cos \Theta \tag{14}$$

where

Θ = the zenith distance to the sun (degrees);
s = the solar constant (1.94 cal cm^{-2} min^{-1});
p = the radius vector of the earth;
t = time (hr).

To determine the extraterrestrial solar radiation (14) is integrated during the period of sunrise to sunset. The zenith distance to the sun may be defined by

$$\cos \Theta = \sin \phi \sin \delta + \cos \phi \cos \delta \cos H \tag{15}$$

where

ϕ = geographic latitude (degrees);
δ = declination of the sun (degrees);
H = hour angles between sunrise and sunset (degrees).

Substitution of the above equation into (14) gives

$$\int dQR = \frac{s}{p^2} \int (\sin \phi \sin \delta + \cos \phi \cos \delta \cos H)dt \tag{16}$$

Figure 6 is the result of the daily integration of the above equation for the latitude of Fairbanks, 65°N, and daily values of the declination of the sun and radius vector of the earth obtained from the K & E 1973 Solar Ephemeris. In the integration of (16) the assumption was made that δ and

p remain constant during the day. Calculations made by Bolsenga (1964) of extreme cases show that the error caused by this calculation does not exceed 2 ly/day.

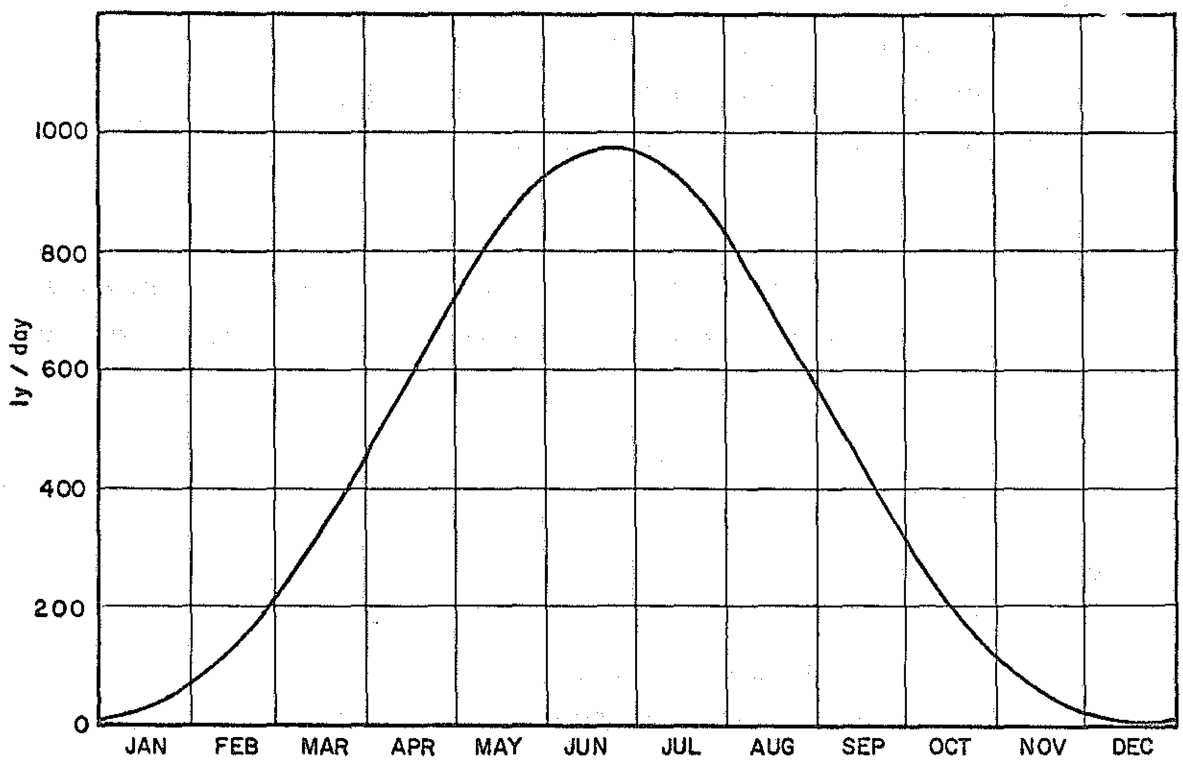

Fig. 6. Extraterrestrial Solar Radiation

From Figure 6 it is seen that a maximum value of extraterrestrial solar radiation of 982 ly/day occurs on July 21 with a minimum value of 7 ly/day occurring on December 21. During the period of study, values ranged from 35 ly/day to 190 ly/day. These values represent the amount of solar radiation reaching a level surface at the top of the atmosphere. They are further reduced to roughly 10 ly/day and 90 ly/day due to the attenuation of the solar radiation by the atmosphere. This attenuation is caused by scattering and absorption of gas molecules of pure dry air, water vapor, and dust particles suspended in the atmosphere.

QC1, QC2, ENERGY LOSS DUE TO CONDUCTION

Typical cross section of the sides and bottom of the tank are shown in Figure 7. The general equation for the heat conduction through the sides and bottom is

$$QC = U\ (TW-T) \tag{17}$$

where

QC = conductive heat flow (cal cm^{-2});
U = coefficient of overall heat transfer (cal day^{-1} cm^{-2} $°C^{-1}$);
TW = water temperature (°C);
T = air temperature for QC1, (°C)
= 20°C for QC2.

Overall heat transfer coefficients of 0.784 and 0.460 cal cm^{-2} day^{-1} $°C^{-1}$ were calculated for the sides and bottom of the tank respectively. Assuming a water temperature of 5°C and an air temperature of -40°C, the heat loss through the sides of the tank, *QC1*, is 35.27 cal cm^{-2} day^{-1}. For the same water temperature and an indoor air temperature of 20°C, the heat gain through the roof of the building and the bottom of the tank, *QC2*, is 6.90 cal cm^{-2} day^{-1}.

Since the area of the sides of the tank in contact with the water was equal to the surface area, the heat conduction through the sides was

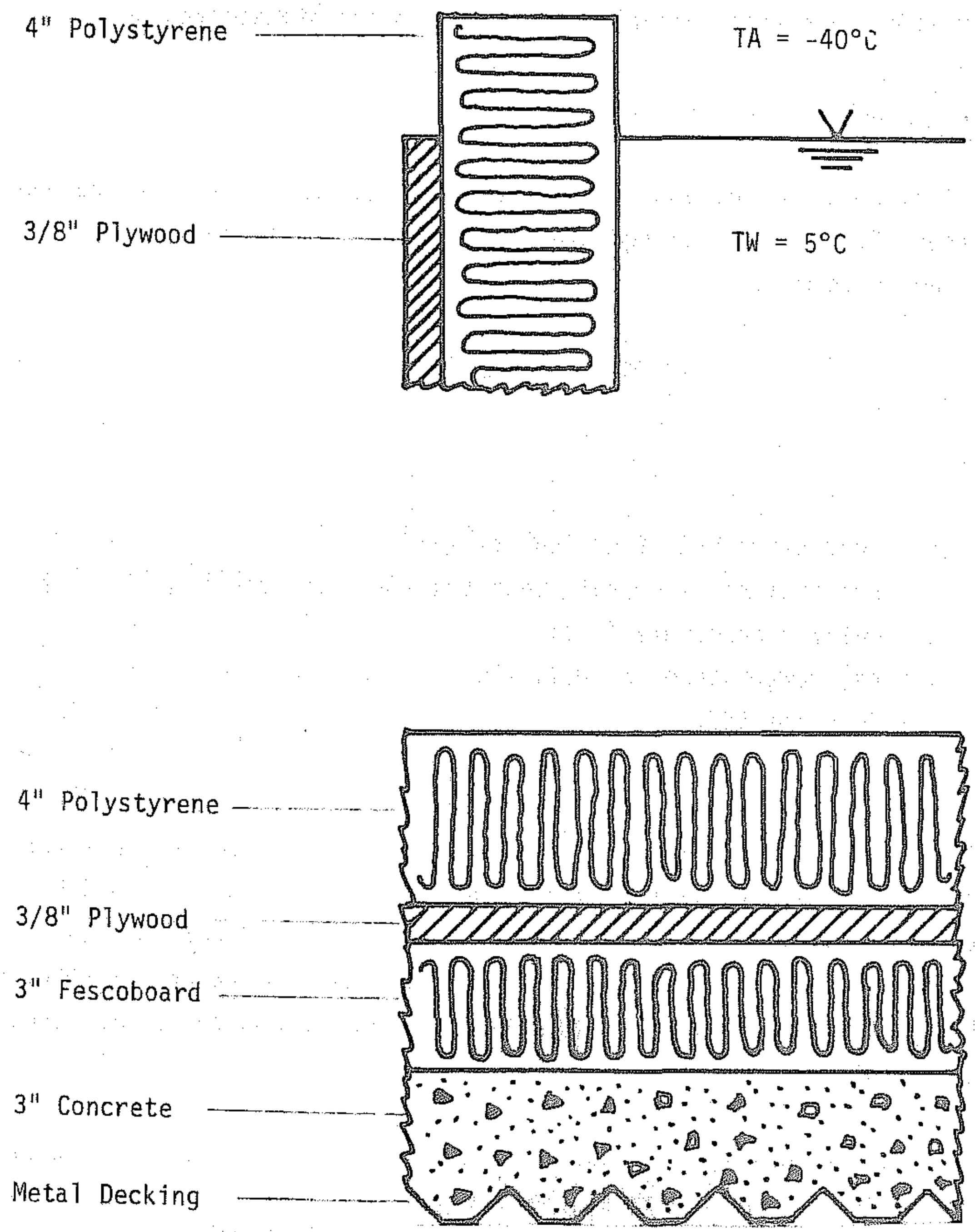

Fig. 7. Cross Sections of Side and Bottom of Tank

of the same magnitude as the energy gain from short-wave radiation, *QR*. It was decided, therefore, to eliminate both terms from the energy balance equations. Because *QC2* was such a small energy gain, it also was neglected.

QH, SENSIBLE HEAT TRANSFER

With values for the previously discussed energy transfer modes, *QH*, the sensible heat transfer can be calculated from the energy balance equ.tions. Neglecting *QR, QC1* and *QC2* and solving for *QH* in (1) and (2) gives, for the open water surface,

$$QH = (QA - QS - QW)/AREA - QB - QE \tag{18}$$

for the covered surface

$$QH = (QA - QS)/AREA - QB \tag{19}$$

Values of *QH* for the open and covered water surface are presented in Table 9 and 10 respectively.

	Date	QA cal/day	QS cal/day	QW cal/day	QB ly/day	QE ly/day	QA ly/day
OPEN	730123	16841089.	-874227.	69926.	457.29	369.62	942.06
	730124	17659728.	-783059.	58391.	460.92	364.29	1017.83
	730125	18860442.	-320791.	48343.	452.96	355.46	1109.66
	730126	15377648.	-34404.	28748.	446.29	221.02	874.87
	730127	8763677.	-34404.	28822.	306.38	221.02	351.12
	730128	8763677.	-34404.	28822.	185.55	221.02	472.55
	730129	11120346.	-391914.	22489.	278.71	220.91	652.24
	730130	11120346.	-391914.	19483.	297.47	221.03	633.61
	730131	12225159.	-62966.	15504.	384.37	231.19	614.78
	730201	12225159.	-62966.	10814.	268.51	231.45	730.85

Table 9

Values of QH (open surface)

	Date	QA cal/day	QS cal/day	QB ly/day	QH ly/day
	730202	9658212.	32678.	499.12	665.85
C	730203	8763677.	32678.	304.80	570.49
O	730204	8763677.	-103062.	335.58	553.32
V E	730205	8763677.	65356.	333.51	538.50
R	730206	8763677.	1020562.	306.25	470.00
E D	730207	8763677.	-339350.	368.19	544.39
	730208	8763677.	-1231713.	358.39	643.65
	730209	9650428.	537932.	353.07	560.46

Table 10

Values of QH (covered surface)

DIFFERENTIAL ENERGY LOSS BETWEEN OPEN AND COVERED SURFACES

From examination of (12) and (2), it is evident that the total heat transfer from the covered surface of the tank will be different from that of the open water surface. To evaluate this difference, it was necessary to determine values for the various energy transfer components from a hypothetical open water surface during the period of time that the water surface was covered. Ignoring the energy gain from short-wave radiation and the heat loss through the bottom and sides of the tank, the terms that must be considered are the energy losses from long-wave radiation and evaporation, the advected energy loss, and the sensible heat loss.

Hypothetical values for the long-wave radiation loss, QB', are easily calculated from the theory presented in the previous section. Values of QB' for the water temperatures and climatological conditions that occurred while the water surface was covered with polyethylene are presented in Table 11.

	Date	QB'
	730202	305.42
	730203	311.21
	730204	342.65
OPEN	730205	342.57
	730206	312.69
	730207	375.95
	730208	365.94
	730209	360.50

Table 11

Values of QB'

In order to determine hypothetical values for the evaporative heat loss, QE', it is necessary to develop an equation that describes the evaporation losses from the open water surface. Dalton's law (1802) suggests a relation of the form

$$QE = (a + b\nu)\ (e_s - e_a) \qquad (20)$$

where

QE = evaporative loss (cal cm^{-2});
ν = average wind speed (m sec^{-1});
e_s = saturation vapor pressure (mb) at the water temperature;
e_a = vapor pressure of air (mb) at the relative humidity and temperature for the elevation at which ν is measured.

Evaluation of the constants a and b in (20) requires controlled measurements, which are difficult on a natural body of water. Average values for these constants have been determined for U.S. Weather Bureau Class A evaporation pans, and are presented in the various texts of hydrology. Because the tank used in this study nowhere resembled a Class A evaporation pan, it was necessary to evaluate these constants.

The objective function used to determine these constants was a comparison between the computed evaporative heat loss using Equation 20 and that measured from the open water surface. It is defined by

$$U = \sum_{i=1}^{n} \left|\ calculated\ QE - measured\ QE\ \right| \qquad (21)$$

where

U = the desired objective function;
i = the day;
n = the number of days for which the function in computed.

By varying the constants a and b in (20), various objective functions were calculated. The minimum value of these objective functions resulted in optimum values for a and b equal to 28.55 and 0.0 respectively. Equation 20 therefore reduces to

$$QE = 28.55\ (e_s - e_a) \qquad (22)$$

Calculated values from (22) and measured values of QE along with the objective function are presented in Table 12. It should be noted that the above constants apply to this study only and should not be used for purposes of engineering design.

	Date	QW Meas ly/day	QW calc ly/day	Diff	| Diff |	% Diff
	730123	369.62	370.82	-1.20	1.20	0.32
	730124	364.29	323.96	40.33	40.33	11.07
	730125	355.46	302.55	52.91	52.91	14.88
	730126	221.02	281.25	-60.23	60.23	27.25
OPEN	730127	221.02	258.64	-37.62	37.62	17.02
	730128	221.02	178.15	42.87	42.87	19.40
	730129	220.91	241.69	-20.78	20.78	9.41
	730130	221.08	236.34	-15.26	15.26	6.90
	730131	231.19	224.24	6.95	6.95	3.01
	730201	231.45	179.60	51.85	51.85	22.40
					U= 330.00	

Table 12

Calculated vs measured values of QW

Hypothetical values for the evaporative heat loss, QE', from an open water surface were calculated using (22) for the conditions that existed while the tank was covered. These values are presented in Table 13.

	Date	$e_s - e_a$ mb	QE' ly/day
	730202	7.862	224.44
	730203	7.989	228.06
O	730204	8.196	233.97
P	730205	8.088	230.90
E	730206	8.268	236.05
N	730207	10.833	309.26
	730208	8.355	252.78
	730209	7.759	221.50

Table 13

Values of QE'

With values of *QE'*, hypothetical values of the advected energy, *QW'*, can be calculated using the theory from the preceding section. The results are shown in Table 14.

	Date	QE' ly/day	TW °C	L_e cal/gm	E gm	QW' cal/day
	730202	224.44	5.32	594.27	3767.	20040.
	730203	228.06	5.45	594.19	3828.	20863.
O	730204	233.97	5.58	594.12	3928.	21918.
P	730205	230.90	5.33	594.26	3875.	20653.
E	730206	236.05	6.70	593.48	3967.	26579.
N	730207	309.26	9.25	592.03	5210.	48193.
	730208	252.78	5.54	593.57	4248.	27782.
	730209	221.50	4.31	594.84	3714.	16007.

Table 14

Values of QW'

Hypothetical values of the sensible heat transfer, *QH'*, were determined using the Bowen (1926) ratio

$$QH/QE = (cp/1000)[(TW-Ta)/(e_s-e_a)] \qquad (23)$$

where

c = constant
p = atmospheric pressure (mb)
TW = water temperature °C
Ta = air temperature °C
e_s = saturation vapor pressure (mb) corresponding to temperature TW
e_a = vapor pressure of the air (mb)

The constant c was evaluated by comparing the calculated values of QH (Table 9) to values determined from (23). The objective function was identifical to that used in the determination of the constants a and b in (20). Here again, the minimum objective function provided an optimum value of c = 0.77. Measured and calculated values with the resulting objective function are presented in Table 15.

Hypothetical values of the sensible heat transfer are presented in Table 16. These values were calculated from hypothetical values of QE' and climatological conditions occurring during the period in which the water surface was covered.

	Date	QH Meas ly/day	QH calc ly/day	Diff	| Diff |	% Diff
	730123	942.06	974.09	-32.03	32.03	3.40
	730124	1017.83	1043.60	-25.77	25.77	2.53
	730125	1109.66	1111.08	-1.42	1.42	0.13
	730126	874.87	678.63	196.24	196.24	22.43
OPEN	730127	351.12	395.89	-44.77	44.77	12.75
	730128	472.55	258.85	213.70	213.70	45.22
	730129	652.24	398.77	253.47	253.47	38.86
	730130	633.31	320.37	-113.24	113.24	17.87
	730131	614.79	728.30	-113.61	113.61	18.48
	730201	733.84	518.29	212.55	212.55	29.08
					U= 1206.79	

Table 15

Calculated vs measured values of QH

	Date	P mb	$e_s - e_a$ mb	TW - TA °C	QE' ly/day	QH' ly/day
OPEN	730202	873.	7.862	23.65	224.44	453.84
	730203	899.	7.989	25.80	226.06	509.83
	730205	892.	8.088	27.21	230.90	533.54
	730204	894.	8.196	28.64	233.97	562.81
	730206	892.	8.268	23.64	236.05	463.56
	730207	897.	10.833	30.36	309.76	598.63
	730208	892.	8.855	30.15	252.78	591.15
	730209	894.	7.759	30.70	221.50	603.30

Table 16

Values of QH'

CONCLUSIONS

For ease of discussion, the results of the previous two sections have been reduced to three tables. Tables 17 and 18 are values of the individual energy loss components from both the open and covered water surfaces. Table 19 represents hypothetical values of energy loss components from an open water surface during the period in which the tank was covered.

	Date	QE ly/day	QW ly/day	QB ly/day	QH ly/day	QT ly/day
	730123	369.62	7.00	457.29	942.06	1775.97
	730124	364.29	5.85	460.92	1017.83	1848.62
	730125	355.46	4.85	452.96	1109.66	1922.93
	730126	221.02	2.88	446.29	874.07	1545.06
OPEN	730127	221.02	2.89	306.38	351.12	831.41
	730128	221.02	2.89	185.55	472.55	882.01
	730129	220.91	2.25	278.71	652.24	1154.11
	730130	221.08	1.95	297.47	633.61	1154.11
	730131	231.19	1.55	384.37	614.78	1231.89
	730201	231.45	1.08	268.51	730.85	1231.89
	TOTAL	2657.06	32.92	3538.45	7399.57	13628.00
	PERCENT	19.50	0.25	25.95	34.30	100.00

Table 17

Heat losses from an open water surface

	Date	QB ly/day	QH ly/day	QT ly/day
COVERED	730202	299.12	665.85	964.97
	730203	304.80	570.49	875.29
	730204	335.58	553.22	888.80
	730205	333.51	538.50	872.01
	730206	306.25	470.00	776.25
	730207	368.19	544.39	912.58
	730208	358.39	643.65	1002.04
	730209	353.07	560.46	913.53
	TOTAL	2658.91	4546.56	7205.47
	PERCENT	36.90	63.10	100.00

Table 18

Heat losses from a covered water surface

	Date	QE' ly/day	QW' ly/day	QB' ly/day	QH' ly/day	QT' ly/day
OPEN	730202	224.44	2.01	305.42	453.84	985.71
	730203	228.06	2.09	311.21	509.83	1051.19
	730204	233.97	2.20	342.55	562.81	1141.73
	730205	230.90	2.07	342.57	533.54	1109.08
	730206	236.05	2.66	312.59	463.56	1014.96
	730207	309.26	4.33	375.95	598.63	1288.67
	730208	252.78	2.79	365.94	591.45	1212.66
	730209	221.50	1.60	360.50	603.30	1186.90
	TOTAL	1936.96	20.25	2716.93	4316.66	8990.80
	PERCENT	21.54	0.23	30.22	48.01	100.00

Table 19

Hypothetical heat losses from an open water surface

From Table 3, it is seen that the major energy loss components from an open water surface are the sensible heat loss, the long-wave loss, the evaporative loss and the advected loss. The average percentage of these individual components to the total energy loss is:

Sensible Heat Loss	54.30%
Longwave Loss	25.95%
Evaporative Loss	19.50%
Advective Loss	0.25%

When the water surface is covered with 4-mil polyethylene sheeting, evaporation, and thus the evaporative heat loss and the advected energy loss, is no longer present. Under this situation, the total energy loss is comprised of long-wave losses and sensible heat losses. The percentage breakdown of these components to the total energy loss is:

Sensible Heat Loss	63.10%
Long-wave Loss	36.90%

From examination of Tables 4 and 5, it is seen that the total energy loss from the open water surface is reduced by approximately 20 per cent when the surface is covered by polyethylene sheeting. This reduction is caused, for the most part, by the nonexistence of evaporative and advective heat losses when the water surface is covered. Covering the water surface produces a slight decrease in long-wave losses and a small increase in the sensible heat losses.

From a heat transfer viewpoint, the above findings clearly indicate that polyethylene sheeting is an effective water surface cover that can, with little decrease in energy loss, virtually eliminate evaporation from cooling ponds and thus reduce a large portion of ice fog. Further developmental research should be centered on appropriate methods of applying and maintaining polyethylene sheeting on water surfaces which create ice fog problems.

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APPENDIX

Climatological Data

LOCAL CLIMATOLOGICAL DATA

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

ENVIRONMENTAL DATA SERVICE

FAIRBANKS, ALASKA
NATIONAL WEATHER SERVICE OFC
INTERNATIONAL AIRPORT
JANUARY 1973

Latitude 64° 49′ N Longitude 147° 52′ W Elevation (ground) 436 ft. Standard time used: ALASKAN WBAN #26411

Date	Temperature °F: Maximum	Minimum	Average	Departure from normal	Average dew point	Degree days Base 65°: Heating	Cooling	Weather types on dates of occurrence (1 Fog, 2 Heavy fog X, 3 Thunderstorm, 4 Ice pellets, 5 Hail, 6 Glaze, 7 Duststorm, 8 Smoke, Haze, 9 Blowing snow)	Snow, ice pellets or ice on ground at 08AM In.	Precipitation: Water equivalent In.	Snow, ice pellets In.	Avg. station pressure In. Elev 454 feet m.s.l.	Wind: Resultant direction	Resultant speed m.p.h.	Average speed m.p.h.	Fastest mile: Speed m.p.h.	Direction	Sunshine: Hours and tenths	Percent of possible	Sky cover Tenths: Sunrise to sunset	Midnight to midnight	Date
1	2	3	4	5	6	7A	7B	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	-15	-35	-25	-14	-37	90	0	1	12	0	0	30.12	10	.6	1.4	6	04			2	4	1
2	7	-17	-5	6	-20	70	0		12	.05	1.7	29.99	24	1.1	2.2	12	23			10	10	2
3	11	6	9	20	- 3	56	0		18	.15	5.8	29.91	36	3.6	3.9	7	02			10	10	3
4	11	-9	1	13	-11	64	0		18	.02	.3	29.76	35	2.1	2.3	7	01			10	9	4
5	22	-10	6	18	- 2	59	0		17	.01	.2	29.31	33	1.0	2.9	7	02			10	9	5
6	23	4	14	26	6	51	0		18	.07	1.6	29.73	03	1.7	2.6	6	36			7	9	6
7	15	5	10	22	5	55	0		17	0	0	29.67	36	1.1	1.9	6	29			10	10	7
8	21	9	15	27	8	50	0		17	0	0	29.89	09	.1	2.3	6	21			10	10	8
9	13	-1	6	18	- 3	59	0		17	0	0	29.84	02	1.1	2.6	4	34			3	8	9
10	15	13	14	26	6	51	0		17	T	T	29.53	02	.4	.4	5	10			10	10	10
11	13	-22	-5	7	-18	70	0	1	17	T	T	29.28	03	1.1	2.3	6	35			2	4	11
12	-20	-40	-30	-18	-37	95	0	1	17	0	0	29.45	24	.6	2.2	7	26			1	3	12
13	-36	-44	-40	-28	-46	105	0	2	17	0	0	29.62	03	.7	1.3	7	03			8	7	13
14	-38	-46	-42	-30	-49	107	0	2	17	0	0	29.60	36	2.3	3.2	6	30			6	8	14
15	-40	-48	-44	-32	-51	109	0	2	17	0	0	29.34	33	1.6	2.5	7	03			8	7	15
16	-45	-51*	-48	-36	-55	113	0	2	17	0	0	29.11	34	.2	.7	5	03			7	8	16
17	-45	-50	-48*	-36	-55	113	0	2	17	0	0	29.13	30	.6	2.6	7	14			4	7	17
18	-31	-45	-38	-26	-42	103	0	2	17	.02	.4	29.09	16	.4	1.3	5	02			10	10	18
19	-31	-41	-36	-24	-43	101	0	2	17	T	T	28.96	00	.0	.0	4	06			4	7	19
20	-31	-40	-36	-25	-41	101	0	2	17	T	T	29.08	00	.0	.0	4	03			10	9	20
21	-35	-43	-39	-28	-47	104	0	2	16	0	0	29.04	22	.4	.4	4	22			7	8	21
22	-30	-43	-37	-26	-43	102	0	2	16	T	T	28.72	00	.0	.0	4	36			9	9	22
23	-31	-40	-36	-25	-43	101	0	2	16	T	T	29.07	02	1.3	1.3	7	01			8	8	23
24	-32	-44	-38	-27	-44	103	0	1	16	T	T	29.39	32	.6	.6	5	32			7	8	24
25	-38	-46	-42	-31	-49	107	0	2	16	0	0	29.73	01	.4	.4	6	36			3	7	25
26	-30	-43	-37	-27	-44	102	0	2	16	0	0	29.86	02	2.0	2.7	6	04			3	3	26
27	5	-36	-16	-6	-27	81	0	1	16	0	0	29.36	31	.8	.9	5	03			10	7	27
28	26	-4	11	21	5	54	0		15	T	T	28.85	35	3.3	3.5	8	34			10	9	28
29	33*	-1	16*	26	11	49	0	1 6 9	16	.12	4.0	28.82	26	8.1	11.4	23	27			10	9	29
30	-1	-13	-7	2	-24	72	0		16	T	T	29.18	25	3.6	3.7	16	24			10	9	30
31	-11	-29	-20	-11	-29	85	0	1	16	T	.2	29.19	14	.4	1.7	7	21			7	7	31
	Sum	Sum				Total	Total			Total	Total	For the month:						Total	% for month	Sum	Sum	
	-325	-804				2582	0	Number of days		.44	14.2	29.41	33	.7	2.1	23	27			226	243	
	Avg.	Avg.	Avg.	Dep.	Avg.	Dep.	Dep.	Precipitation		Dep.						Date:	29	Possible		Avg	Avg.	
	-10.5	-25.9	-18.2	-7.1	-27	223		≥ .01 inch	7	-0.45										7.3	7.8	

Season to date: Total (Heating)	Total (Cooling)
8574	0
Dep.	Dep.
-220	

Number of days: Maximum Temp. ≥ 90° ‡	Maximum Temp. ≤ 32°	Minimum Temp. ≤ 32°	Minimum Temp. ≤ 0°
0	30	31	26

Number of days	
Snow, ice pellets ≥ 1.0 inch	4
Thunderstorms	0
Heavy fog X	13
Clear 6	Partly cloudy 8, Cloudy 17

Greatest in 24 hours and dates: Precipitation	Dates	Snow, ice pellets	Dates	Greatest depth on ground of snow, ice pellets or ice and date	Date
.20	2- 3	7.3	2- 3	19	4+

HOURLY PRECIPITATION (Water equivalent in inches)

Date	A.M. 1	2	3	4	5	6	7	8	9	10	11	12	P.M. 1	2	3	4	5	6	7	8	9	10	11	12	Date
1																									1
2																					T	T	.02	.03	2
3	T	T	.01	.01	.02	.02	.01	.01	T	T	.01	.02	.02	.01	T	T	T	T	T	.01	T	T	T	T	3
4	T	T	T	T	.01	.01	T	T	T																4
5																					T	T	T	.01	5
6	T	.01	.02	.02	.01	.01																			6
7																									7
8																									8
9																									9
10																	T	T	T	T	T	T	T	T	10
11	T	T																							11
12																									12
13																									13
14																									14
15																									15
16																									16
17																									17
18						T	T	T	T	.01	.01	T				T	T						T	T	18
19	T	T	T	T	T																				19
20																T	T	T	T	T	T	T	T		20
21																									21
22										T	T	T	T	T	T		T	T	T	T	T	T	T		22
23									T	T	T								T	T	T	T	T	T	23
24	T						T	T	T	T	T	T	T			T	T	T	T						24
25																									25
26																									26
27																									27
28													T	T	T										28
29						T	.03	.03	.02	.02	.01	T	.01	T	T	T	T	T	T	T	T	T	T	T	29
30																							T	T	30
31	T	T	T	T	T	T	T	T	T	T	T														31

* Extreme temperatures for the month. May be the last of more than one occurrence.
— Below zero temperature or negative departure from normal.
‡ ≥ 70° at Alaskan stations.
\+ Also on an earlier date, or dates.
X Heavy fog restricts visibility to ¼ mile or less.
T In the Hourly Precipitation table and in columns 9, 10, and 11 indicates an amount too small to measure.

The season for degree days begins with July for heating and with January for cooling.
Data in columns 6, 12, 13, 14, and 15 are based on 8 observations per day at 3-hour intervals.
Wind directions are those from which the wind blows. Resultant wind is the vector sum of wind directions and speeds divided by the number of observations. Figures for directions are tens of degrees from true North; i.e., 09 = East, 18 = South, 27 = West, 36 = North, and 00 = Calm. When directions are in tens of degrees in Col. 17, entries in Col. 16 are fastest observed 1-minute speeds. If the / appears in Col. 17, speeds are gusts.
Any errors detected will be corrected and changes in summary data will be annotated in the annual summary.

I certify that this is an official publication of the National Oceanic and Atmospheric Administration, and is compiled from records on file at the National Climatic Center, Asheville, North Carolina 28801.

William H. Haggard
Director, National Climatic Center

SUMMARY BY HOURS

Hour Local time	Averages: Sky cover Tenths	Station pressure In.	Temperature: Air °F	Wet bulb °F	Dew Pt. °F	Relative humidity %	Wind speed m.p.h.	Resultant wind: Direction	Speed m.p.h.
02	8	29.42	-18	-19	-27	66	1.8	35	.7
05	8	29.42	-19	-19	-27	66	2.0	34	.7
08	8	29.42	-20	-20	-28	64	1.6	36	.7
11	7	29.41	-18	-19	-27	64	2.4	33	1.0
14	7	29.40	-16	-17	-24	67	1.7	28	.6
17	8	29.40	-18	-18	-25	67	2.3	33	1.1
20	8	29.39	-19	-19	-27	64	2.4	33	.6
23	8	29.40	-18	-19	-27	65	2.6	30	1.1

OBSERVATIONS AT 3-HOUR INTERVALS

Day	Hour	Sky Cover (Tenths)	Ceiling (Hnds. of ft.)	Visibility: Whole Miles	Visibility: 16ths Mile	Weather	Air °F	Wet Bulb °F	Dew Pt. °F	Rel. Hum. %	Wind Dir.	Wind Speed (Knots)
01	02	1	UNL	2		IF	-34	-34	-40	71	00	0
01	05	1	UNL	1		IF	-33	-33	-39	71	00	0
01	08	0	UNL	1		IF	-35	-35	-41	71	11	3
01	11	1	UNL	0	12	IF	-33	-33	-39	71	00	0
01	14	4	UNL	4		IF	-33	-33	-39	71	00	0
01	17	3	UNL	4		IF	-31	-31	-37	71	11	4
01	20	10	130	15			-20	-20	-35	44	30	3
01	23	10	120	15			-15	-15	-29	45	00	0
02	02	10	110	15			-17	-17	-32	45	00	0
02	05	10	200	15			-14	-14	-30	43	00	0
02	08	10	200	80			-16	-16	-30	46	00	0
02	11	10	200	80			-13	-13	-26	51	25	3
02	14	10	120	40			-04	-05	-16	56	00	0
02	17	10	110	15			03	01	-11	51	02	4
02	20	10	26	10			07	05	-11	43	22	8
02	23	10	15	2	8	S	06	04	-07	55	00	0
03	02	10	20	2		S	07	06	-03	63	32	4
03	05	10	20	2		S	07	05	-06	55	34	5
03	08	10	25	4		S	07	05	-11	43	00	0
03	11	10	10	1	8	S	07	05	-04	60	02	3
03	14	10	15	2	8	S	09	07	-06	50	04	4
03	17	10	8	8		S	10	09	02	70	01	4
03	20	10	9	8		S	09	07	-01	63	34	4
03	23	10	13	10		S	11	10	04	73	36	3
04	02	10	15	10		S	08	07	00	70	00	0
04	05	10	13	2		S	10	09	02	70	00	0
04	08	10	35	10		S	05	03	-10	49	32	3
04	11	10	UNL	80			-01	-02	-12	59	36	3
04	14	10	UNL	80			00	00	-10	62	00	0
04	17	10	UNL	15			-03	-04	-15	56	31	3
04	20	8	UNL	15			-08	-08	-21	52	02	4
04	23	2	UNL	15			-07	-07	-20	52	35	3
05	02	2	UNL	15			-05	-06	-17	35	00	0
05	05	8	180	15			06	04	-08	52	02	6
05	08	10	180	15			01	00	-10	59	00	0
05	11	10	70	80			06	03	-17	33	31	5
05	14	9	70	80			10	09	02	70	18	3
05	17	10	70	15			12	11	05	73	00	0
05	20	10	32	15			17	16	10	74	22	3
05	23	10	18	5		S	21	20	16	81	01	3
06	02	10	20	2	8	S	23	22	17	78	00	0
06	05	10	20	8		S	20	19	15	81	07	3
06	08	9	32	10			18	17	12	77	00	0
06	11	8	UNL	80			18	17	11	74	00	0
06	14	9	40	80			15	14	08	74	05	4
06	17	8	40	15			08	07	00	70	33	4
06	20	10	40	15			04	02	-10	52	07	4
06	23	10	100	15			05	04	-05	63	31	3
07	02	10	100	15			11	10	04	73	01	4
07	05	10	100	15			15	14	09	77	01	3
07	08	10	100	15			08	07	01	73	00	0
07	11	10	120	80			12	11	05	73	00	0
07	14	10	70	80			13	12	06	73	00	0
07	17	10	90	15			14	13	07	74	23	3
07	20	7	200	15			08	07	01	73	03	3
07	23	10	90	15			09	08	04	80	00	0
08	02	10	90	15			11	10	05	77	00	0
08	05	10	90	15			19	18	13	77	10	4
08	08	10	90	15			12	11	05	73	03	4
08	11	10	90	80			20	18	13	74	21	5
08	14	10	UNL	80			15	14	08	74	00	0
08	17	10	160	15			13	12	07	77	00	0
08	20	10	180	15			12	11	05	73	00	0
08	23	10	100	15			11	10	04	73	30	3
09	02	10	90	15			13	12	05	70	00	0
09	05	10	90	15			07	06	-01	69	00	0
09	08	8	180	15			03	01	-11	51	29	3
09	11	2	UNL	80			00	00	-11	59	02	3
09	14	2	UNL	80			00	00	-11	59	06	3
09	17	10	50	15			06	05	-04	63	05	3
09	20	10	40	15			10	09	03	73	36	3
09	23	10	17	15			12	11	08	77	19	3
10	02	10	15	15			14	12	06	70	00	0
10	05	10	19	15			14	13	07	74	00	0
10	08	10	37	15			15	13	07	70	00	0
10	11	10	13	15			15	13	07	70	00	0
10	14	10	33	15			15	13	07	70	00	0
10	17	10	35	10		S	13	12	05	70	00	0
10	20	10	35	15		S	13	12	06	73	00	0
10	23	10	32	15		S	13	12	06	73	02	3
11	02	10	50	15			12	11	04	70	03	3
11	05	8	60	15			06	04	-05	60	00	0
11	08	2	UNL	15			-04	-05	-15	58	01	4
11	11	2	UNL	15			-08	-08	-19	58	00	0
11	14	1	UNL	5		GF	-10	-10	-20	60	18	3
11	17	0	UNL	10			-16	-16	-20	82	07	3
11	20	0	UNL	15			-20	-20	-35	44	00	0
11	23	5	UNL	15			-20	-20	-34	47	33	3
12	02	4	UNL	6			-24	-24	-36	52	00	0
12	05	8	100	4		IF	-25	-25	-31	72	00	0
12	08	4	UNL	2	8	IF	-29	-29	-35	72	03	3
12	11	2	UNL	4		IF	-29	-29	-35	72	22	3
12	14	2	UNL	15			-28	-28	-34	72	00	0
12	17	0	UNL	4		IF	-30	-30	-36	71	31	4
12	20	0	UNL	5		IF	-34	-34	-40	71	00	0
12	23	3	UNL	2		IF	-39	-39	-46	66	18	5
13	02	6	UNL	1		IF	-38	-38	-45	66	35	3
13	05	10	4	0	8	IF	-40	-40	-47	66	01	3
13	08	9	UNL	0	8	IF	-39	-39	-46	66	00	0
13	11	9	UNL	0	2	IF	-38	-38	-46	66	00	0
13	14	9	UNL	0	4	IF	-37	-37	-43	70	00	0
13	17	3	UNL	0	4	IF	-36	-36	-42	71	00	0
13	20	7	UNL	0	4	IF	-40	-40	-47	66	13	3
13	23	10	5	0	4	IF	-42	-42	-49	65	00	0
14	02	9	UNL	0	8	IF	-41	-41	-48	66	35	3
14	05	9	UNL	0	8	IF	-41	-41	-48	66	03	4
14	08	7	UNL	0	8	IF	-43	-43	-50	65	00	0
14	11	3	UNL	0	8	IF	-43	-43	-50	65	04	3
14	14	7	UNL	0	8	IF	-40	-40	-47	66	28	3
14	17	5	UNL	1		IF	-42	-42	-49	65	35	3
14	20	8	UNL	0	4	IF	-43	-43	-50	65	07	3
14	23	9	UNL	0	4	IF	-44	-44	-51	65	33	3
15	02	3	UNL	0	8	IF	-46	-46	-53	65	34	3
15	05	6	UNL	1		IF	-45	-45	-52	65	01	3
15	08	7	UNL	0	4	IF	-45	-45	-52	65	31	2
15	11	6	UNL	0	4	IF	-44	-44	-51	65	33	3
15	14	9	UNL	0	2	IF	-41	-41	-48	66	00	0
15	17	8	UNL	0	4	IF	-42	-42	-49	65	00	0
15	20	7	UNL	0	4	IF	-44	-44	-51	65	36	3
15	23	7	UNL	0	4	IF	-47	-47	-54	64	21	3
16	02	8	UNL	0	4	IF	-46	-46	-53	65	00	0
16	05	7	UNL	0	4	IF	-47	-47	-54	64	00	0
16	08	7	UNL	0	4	IF	-48	-48	-55	64	00	0
16	11	7	UNL	0	2	IF	-47	-47	-54	64	23	2
16	14	8	UNL	0	2	IF	-47	-47	-54	64	00	0
16	17	8	UNL	0	2	IF	-48	-48	-55	64	00	0
16	20	9	UNL	0	4	IF	-50	-50	-57	64	00	0
16	23	8	UNL	0	4	IF	-51	-51	-58	64	02	3
17	02	9	80	0	2	IF	-49	-49	-56	64	36	2
17	05	8	80	0	8	IF	-49	-49	-56	64	19	2
17	08	5	UNL	0	8	IF	-50	-50	-57	64	04	3
17	11	4	UNL	0	1	IF	-49	-49	-56	64	36	4
17	14	5	UNL	0	4	IF	-46	-46	-53	65	21	3
17	17	8	180	0	4	IF	-46	-46	-53	65	00	0
17	20	9	UNL	0	4	IF	-47	-47	-54	64	00	0
17	23	10	180	0	4	IF	-46	-46	-53	65	25	4
18	02	10	170	0	12	IF	-42	-42	-48	70	15	3
18	05	10	170	2	8	IF	-36	-36	-42	71	20	3
18	08	10	90	2	8	S	-34	-34	-45	53	00	0
18	11	10	100	2		S	-31	-31	-44	47	00	0
18	14	10	200	0	12	IF	-32	-32	-38	71	00	0
18	17	9	220	0	12	IF	-32	-32	-38	71	00	0
18	20	9	120	0	8	IF	-33	-33	-39	71	01	3
18	23	10	120	0	12	SIF	-32	-32	-38	71	00	0
19	02	10	220	1	8	SIF	-33	-33	-39	71	00	0
19	05	9	10	0	12	IF	-36	-36	-42	71	00	0
19	08	8	100	0	4	IF	-36	-36	-42	71	00	0
19	11	5	UNL	0	8	IF	-35	-35	-41	71	00	0
19	14	2	UNL	1		IF	-34	-34	-40	71	00	0
19	17	5	UNL	0	8	IF	-38	-38	-45	66	00	0
19	20	8	100	0	2	IF	-41	-41	-48	66	00	0
19	23	8	100	0	4	IF	-40	-40	-47	66	00	0
20	02	7	100	1		IF	-40	-40	-47	66	00	0
20	05	5	UNL	3		IF	-39	-39	-46	66	00	0
20	08	0	100	2	8	IF	-36	-36	-42	71	00	0
20	11	10	210	2		IF	-33	-33	-39	71	00	0
20	14	10	220	1		IF	-32	-32	-38	71	00	0
20	17	10	110	1	8	SIF	-32	-32	-38	71	00	0
20	20	10	110	3		SIF	-34	-34	-40	71	00	0
20	23	10	110	1		IF	-34	-34	-40	71	00	0
21	02	10	100	1		IF	-36	-36	-42	71	00	0
21	05	10	100	0	12	IF	-39	-39	-46	66	00	0
21	08	10	100	0	8	IF	-42	-42	-49	65	00	0
21	11	5	UNL	0	12	IF	-42	-42	-49	65	00	0
21	14	7	UNL	0	4	IF	-39	-39	-46	66	00	0
21	17	9	UNL	0	4	IF	-41	-41	-48	66	00	0
21	20	9	100	0	4	IF	-42	-42	-49	65	00	0
21	23	7	100	0	8	IF	-42	-42	-49	65	22	3
22	02	8	100	0	4	IF	-42	-42	-49	65	00	0
22	05	8	90	0	8	IF	-40	-40	-47	66	00	0
22	08	8	90	0	8	IF	-42	-42	-49	65	00	0
22	11	10	40	0	12	SIF	-37	-37	-43	70	00	0
22	14	9	UNL	3		SIF	-35	-35	-41	71	00	0
22	17	8	80	2		SIF	-34	-34	-40	71	00	0
22	20	10	80	2	8	SIF	-32	-32	-38	71	00	0
22	23	9	80	3		IF	-32	-32	-38	71	00	0
23	02	9	80	2		IF	-36	-36	-42	71	00	0
23	05	7	80	2		IF	-38	-38	-45	66	00	0
23	08	7	80	2		IF	-38	-38	-45	66	00	0
23	11	6	UNL	1		IF	-34	-34	-40	71	01	6
23	14	6	220	0	12	IF	-32	-32	-38	71	00	0
23	17	8	UNL	0	10	IF	-37	-37	-43	70	00	0
23	20	10	40	2		SIF	-40	-40	-47	66	04	3
23	23	10	40	0	8	SIF	-39	-39	-46	66	00	0
24	02	9	40	0	8	IF	-41	-41	-48	66	00	0
24	05	9	40	0	8	IF	-38	-38	-45	66	00	0
24	08	10	40	1		SIF	-36	-36	-42	71	00	0
24	11	10	180	1		SIF	-33	-33	-39	71	00	0
24	14	2	UNL	0	12	IF	-33	-33	-39	71	00	0
24	17	10	UNL	0	12	SIF	-35	-35	-41	71	00	0
24	20	8	180	0	8	IF	-41	-41	-48	66	00	0
24	23	6	UNL	0	12	IF	-42	-42	-49	65	32	4
25	02	0	180	0	12	IF	-42	-42	-49	65	00	0
25	05	10	180	0	8	IF	-42	-42	-49	65	00	0
25	08	10	180	0	4	IF	-45	-45	-52	65	00	0
25	11	3	UNL	0	4	IF	-44	-44	-51	65	01	3
25	14	4	UNL	0	4	IF	-39	-39	-46	66	00	0
25	17	6	UNL	0	4	IF	-41	-41	-48	66	00	0
25	20	8	UNL	0	12	IF	-43	-43	-50	65	00	0
25	23	9	3			IF	-42	-42	-49	65	00	0
26	02	4	UNL	1		IF	-41	-41	-48	66	00	0
26	05	5	UNL	1		IF	-43	-43	-50	65	00	0
26	08	3	UNL	0	12	IF	-42	-42	-49	65	01	3
26	11	4	UNL	0	8	IF	-40	-40	-47	66	01	4
26	14	1	UNL	0	8	IF	-31	-31	-37	71	33	3
26	17	1	UNL	1		IF	-33	-33	-39	71	05	3
26	20	1	UNL	1		IF	-33	-33	-39	71	36	3
26	23	1	UNL	3		IF	-35	-35	-41	71	12	3
27	02	1	UNL	4		IF	-35	-35	-41	71	00	0
27	05	0	UNL	4		IF	-36	-36	-42	71	00	0
27	08	6	190	7			-33	-33	-39	71	00	0
27	11	10	130	20			-22	-22	-32	58	28	3
27	14	10	130	40			-13	-13	-23	60	33	3
27	17	10	120	10			-06	-06	-16	61	00	0
27	20	10	120	8			01	00	-10	59	00	0
27	23	9	120	15			04	02	-14	42	00	0
28	02	10	70	15			08	06	-05	55	00	0
28	05	2	UNL	15			00	00	-11	59	00	0
28	08	7	UNL	15			-02	-02	-09	72	36	6
28	11	10	120	40			05	04	-05	63	36	3
28	14	10	90	20		S	18	17	13	81	30	3
28	17	10	90	15			22	21	17	81	35	4
28	20	10	80	15			23	22	19	85	36	3
28	23	10	90	15			25	23	19	78	36	5
29	02	3	UNL	15			24	23	18	78	02	8
29	05	8	50	15			21	20	17	84	31	7
29	08	10	20	3		S	32	31	30	92	17	4
29	11	10	18	3		S	26	25	22	85	19	5
29	14	10	70	3		ZLSBS	23	21	16	74	26	13
29	17	10	43	8		S	12	10	02	64	26	17
29	20	10	80	6		S	06	04	-06	57	24	12
29	23	10	100	7		S	00	00	-14	51	26	13
30	02	9	190	15			-04	-05	-20	45	24	11
30	05	8	UNL	15			-08	-08	-23	47	27	8
30	08	7	190	15			-10	-10	-25	46	24	4
30	11	10	190	20			-11	-11	-24	51	27	3
30	14	10	110	8			-10	-10	-23	52	00	0
30	17	10	200	10			-11	-11	-25	49	00	0
30	20	10	200	10			-12	-12	-26	49	00	0
30	23	10	90	15		S	-13	-13	-27	48	00	0
31	02	10	12	4		S	-12	-12	-25	51	13	4
31	05	10	8	2		S	-13	-13	-26	51	21	4
31	08	10	50	7		S	-13	-13	-27	48	00	0
31	11	10	65	4		SF	-13	-13	-26	51	00	0
31	14	8	UNL	20			-12	-12	-26	49	00	0
31	17	1	UNL	10			-22	-22	-37	44	01	4
31	20	1	UNL	3		IF	-27	-27	-33	72	00	0
31	23	4	UNL	2		IF	-28	-28	-34	72	00	0

NOTES

CEILING COLUMN

UNL indicates an unlimited ceiling.

WEATHER COLUMN

*	Tornado
T	Thunderstorm
Q	Squall
R	Rain
RW	Rain showers
ZR	Freezing rain
L	Drizzle
ZL	Freezing drizzle
S	Snow
SP	Snow pellets
IC	Ice crystals
SW	Snow showers
SG	Snow grains
IP	Ice pellets
A	Hail
F	Fog
IF	Ice fog
GF	Ground fog
BD	Blowing dust
BN	Blowing sand
BS	Blowing snow
BY	Blowing spray
K	Smoke
H	Haze
D	Dust

WIND COLUMNS

Directions are those from which the wind blows, indicated in tens of degrees from true North; i. e., 09 for East, 18 for South, 27 for West. Entry of 00 in the direction column indicates calm.

Speed is expressed in knots; multiply by 1.15 to convert to miles per hour.

ADDITIONAL DATA
Other observational data contained in records on file can be furnished at cost via microfilm, microfiche, or paper copies of the original records. Inquiries as to availability and costs should be addressed to: Director, National Climatic Center, Federal Building, Asheville, North Carolina 28801.

STATION: FAIRBANKS ALASKA YEAR & MONTH: 73 01

LOCAL CLIMATOLOGICAL DATA

A UNITED STATES DEPARTMENT OF COMMERCE PUBLICATION

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
ENVIRONMENTAL DATA SERVICE

FAIRBANKS, ALASKA
NATIONAL WEATHER SERVICE OFC
INTERNATIONAL AIRPORT
FEBRUARY 1973

Latitude 64° 49′ N Longitude 147° 52′ W Elevation (ground) 436 ft Standard time used: ALASKAN WBAN #26411

Weather types on dates of occurrence: 1 Fog, 2 Heavy fog X, 3 Thunderstorm, 4 Ice pellets, 5 Hail, 6 Glaze, 7 Duststorm, 8 Smoke, Haze, 9 Blowing snow

Date	Temperature °F: Maximum	Minimum	Average	Departure from normal	Average dew point	Degree days Base 65°: Heating	Cooling	Weather types on dates of occurrence	Snow, ice pellets or ice on ground at 08AM In.	Precipitation: Water equivalent In.	Snow, ice pellets In.	Avg. station pressure In. Elev. 454 feet m.s.l.	Wind: Resultant direction	Resultant speed m.p.h.	Average speed m.p.h.	Fastest mile: Speed m.p.h.	Fastest mile: Direction	Sunshine: Hours and tenths	Percent of possible	Sky cover Tenths: Sunrise to sunset	Midnight to midnight	Date
1	2	3	4	5	6	7A	7B	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	-1	-35*	-18*	-10	-32	83	0	1	15	0	0	29.23	03	2.1	2.5	8	03			3	5	1
2	17	-2	8	16	- 3	57	0		15	.01	.2	29.25	27	3.6	8.5	14	27			7	8	2
3	7	-23	-8	0	-18	73	0		15	0	0	30.03	36	4.2	6.0	12	26			9	6	3
4	2	-18	-8	-1	-20	73	0		15	0	0	29.95	03	2.2	4.0	7	01			6	6	4
5	4	-15	-6	1	-21	71	0		15	0	0	29.87	05	1.5	2.6	6	24			7	3	5
6	9	-16	-4	3	-15	69	0		15	0	0	29.88	02	3.6	5.5	9	02			3	4	6
7	10	-10	0	6	-12	65	0		15	0	0	30.03	02	2.1	3.5	6	01			2	3	7
8	10	-15	-3	3	-20	68	0		15	T	T	29.86	01	3.3	4.3	9	01			5	2	8
9	0	-19	-10	-5	-27	75	0		15	T	T	29.93	36	1.7	1.9	6	01			3	1	9
10	11	-25	-7	-2	-29	72	0		15	0	0	29.75	04	3.0	3.6	9	04			0	0	10
11	10	-26	-8	-4	-30	73	0		15	0	0	29.64	02	7.7	8.2	17	01			0	0	11
12	0	-23	-12	-8	-32	77	0		15	0	0	29.71	05	7.4	8.1	16	06			0	0	12
13	0	-23	-12	-8	-33	77	0		15	0	0	29.53	05	5.0	6.3	12	05			0	0	13
14	-1	-27	-14	-11	-33	79	0		15	0	0	29.19	01	2.2	3.0	9	01			0	1	14
15	-3	-20	-12	-9	-27	77	0		15	T	T	29.01	27	1.0	4.0	9	23			7	6	15
16	2	-21	-10	-7	-26	75	0		15	0	0	29.08	20	2.2	3.2	8	20			5	6	16
17	-1	-17	-9	-7	-26	74	0		15	0	0	29.21	00	.0	2.0	5	01			2	3	17
18	11	-20	-5	-3	-21	70	0		15	0	0	29.29	04	1.9	1.9	7	23			4	2	18
19	35*	-8	14	15	3	51	0		15	0	0	29.03	05	3.3	5.0	10	07			8	7	19
20	34	18	26*	27	17	39	0		15	.10	1.6	28.81	33	.7	3.5	9	19			10	10	20
21	28	7	18	19	11	47	0		16	T	T	29.43	01	.5	3.3	7	34			10	8	21
22	29	4	17	17	9	48	0		16	T	T	29.80	01	3.3	3.6	10	02			5	5	22
23	18	-6	6	5	- 7	59	0		16	0	0	29.82	02	1.5	2.3	7	01			1	1	23
24	22	-8	7	6	- 8	58	0		16	0	0	29.84	02	5.8	6.2	10	05			0	0	24
25	21	-15	3	1	-18	62	0		16	0	0	29.80	02	5.3	5.8	9	02			2	1	25
26	21	-17	2	0	-20	63	0		16	0	0	29.47	04	5.0	5.6	13	06			0	0	26
27	13	-20	-4	-6	-20	69	0		16	0	0	29.08	01	6.0	6.6	12	02			4	4	27
28	12	-2	5	2	-11	60	0		16	T	T	29.04	36	4.8	7.2	13	35			10	8	28
	Sum	Sum				Total	Total			Total	Total	For the month:						Total	% for month	Sum	Sum	
	320	-402				1864	0	Number of days		.11	1.8	29.52	02	2.7	4.6	17	01			113	100	
	Avg.	Avg.	Avg.	Dep.	Avg.	Dep.	Dep.	Precipitation		Dep.						Date:	11	Possible		Avg.	Avg.	
	11.4	-14.4	-1.5	1.4	-17	-37		≥ .01 inch	2	-0.41										4.9	3.6	

Number of days: Maximum Temp. ≥ 90° ‡	Maximum Temp. ≤ 32°	Minimum Temp. ≤ 32°	Minimum Temp. ≤ 0°	Season to date: Heating Total	Cooling Total
				10438	0
				Dep.	Dep.
0	26	26	25	-257	

Number of days	
Precipitation ≥ .01 inch	2
Snow, ice pellets ≥ 1.0 inch	1
Thunderstorms	0
Heavy fog X	0
Clear 14	Partly cloudy 9 Cloudy 5

Greatest in 24 hours and dates: Precipitation	Date	Snow, ice pellets	Date	Greatest depth on ground of snow, ice pellets or ice and date	Date
.10	20	1.6	20	16	28+

HOURLY PRECIPITATION (Water equivalent in inches)

Date	A.M. Hour ending at 1	2	3	4	5	6	7	8	9	10	11	12	P.M. Hour ending at 1	2	3	4	5	6	7	8	9	10	11	12	Date
1																									1
2			T	T													T	T	T	.01	T				2
3																									3
4																									4
5																									5
6																									6
7																									7
8																					T	T			8
9										T	T														9
10																									10
11																									11
12																									12
13																									13
14																									14
15																			T	T					15
16																									16
17																									17
18																									18
19																									19
20																			T	T	.04	.06	T	T	20
21		T																							21
22				T	T	T	T																		22
23																									23
24																									24
25																									25
26																									26
27																									27
28										T	T	T	T	T	T	T	T	T	T						28

* Extreme temperatures for the month. May be the last of more than one occurrence.
\- Below zero temperature or negative departure from normal.
‡ ≥ 70° at Alaskan stations.
\+ Also on an earlier date, or dates.
X Heavy fog restricts visibility to ¼ mile or less.
T In the Hourly Precipitation table and in columns 9, 10, and 11 indicates an amount too small to measure.

The season for degree days begins with July for heating and with January for cooling.
Data in columns 6, 12, 13, 14, and 15 are based on 8 observations per day at 3-hour intervals.
Wind directions are those from which the wind blows. Resultant wind is the vector sum of wind directions and speeds divided by the number of observations. Figures for directions are tens of degrees from true North; i.e., 09 = East, 18 = South, 27 = West, 36 = North, and 00 = Calm. When directions are in tens of degrees in Col. 17, entries in Col. 16 are fastest observed 1-minute speeds. If the / appears in Col. 17, speeds are gusts.
Any errors detected will be corrected and changes in summary data will be annotated in the annual summary.

I certify that this is an official publication of the National Oceanic and Atmospheric Administration, and is compiled from records on file at the National Climatic Center, Asheville, North Carolina 28801.

William H. Haggard
Director, National Climatic Center

SUMMARY BY HOURS

Hour Local time	Averages: Sky cover Tenths	Station pressure In.	Temperature: Air °F	Wet bulb °F	Dew Pt. °F	Relative humidity %	Wind speed m.p.h.	Resultant wind: Direction	Speed m.p.h.
02	3	29.53	-8	-8	-20	54	4.3	01	3.1
05	4	29.53	-10	-10	-23	52	4.4	02	3.5
08	4	29.53	-11	-12	-24	53	3.7	02	2.4
11	4	29.53	-1	-2	-14	54	3.3	02	2.4
14	4	29.51	8	6	-7	51	4.2	06	2.2
17	4	29.50	3	2	-11	52	5.7	01	2.3
20	3	29.51	-3	-3	-16	53	5.6	03	3.4
23	3	29.52	-5	-6	-18	54	5.3	01	3.2

OBSERVATIONS AT 3-HOUR INTERVALS

Day	Hour	Sky cover (tenths)	Ceiling (hnds. of ft.)	Visibility whole miles	Visibility 16ths mile	Weather	Air °F	Wet bulb °F	Dew pt. °F	Rel. hum. %	Wind dir.	Wind speed (knots)
01	02	3	UNL	3		IF	-32	-32	-36	71	00	0
01	05	3	UNL	3		IF	-34	-34	-40	71	04	5
01	08	0	UNL	7			-35	-35	-41	71	00	0
01	11	1	UNL	1		IF	-29	-29	-35	72	00	0
01	14	5	UNL	80			-17	-17	-30	50	06	5
01	17	10	230	20			-17	-17	-31	48	00	0
01	20	10	120	15			-12	-12	-23	57	35	4
01	23	10	230	15			-05	-05	-16	58	36	3
02	02	10	100	15			10	09	03	73	35	10
02	05	8	100	15			09	07	-06	50	05	7
02	08	10	100	15			00	00	-10	62	36	5
02	11	8	100	80			04	02	-11	49	31	4
02	14	6	UNL	80			10	08	00	64	24	3
02	17	10	25	2		S	11	10	05	77	22	10
02	20	10	25	5		S	11	10	03	70	24	10
02	23	2	UNL	15			05	03	-07	57	23	10
03	02	0	UNL	15			02	01	-11	54	28	0
03	05	0	UNL	15			-13	-13	-30	41	35	7
03	08	2	UNL	80			-19	-19	-33	47	01	3
03	11	10	90	80			-15	-15	-28	51	35	3
03	14	10	180	80			-01	-02	-12	59	10	4
03	17	10	210	15			00	00	-11	59	01	6
03	20	10	210	15			01	00	-11	56	02	4
03	23	10	220	15			01	00	-09	62	04	3
04	02	10	200	15			-03	-04	-13	62	05	5
04	05	10	UNL	15			-12	-12	-23	57	03	3
04	08	8	UNL	80			-15	-15	-26	56	23	6
04	11	4	UNL	80			-08	-08	-20	55	00	0
04	14	9	200	80			-01	-02	-12	59	00	0
04	17	7	200	40			-04	-05	-15	58	01	6
04	20	4	UNL	15			-11	-11	-23	54	06	5
04	23	0	UNL	15			-14	-14	-25	57	02	3
05	02	0	UNL	15			-13	-13	-28	46	04	4
05	05	0	UNL	15			-13	-13	-27	48	34	3
05	08	8	UNL	80			-14	-14	-26	54	00	0
05	11	10	UNL	80			-06	-06	-17	58	35	3
05	14	4	UNL	80			03	02	-08	60	00	0
05	17	0	UNL	40			-04	-05	-19	48	11	4
05	20	0	UNL	15			-08	-08	-19	58	11	4
05	23	0	UNL	15			-10	-10	-24	49	00	0
06	02	0	UNL	15			-12	-12	-23	57	10	4
06	05	0	UNL	15			-12	-12	-22	60	36	6
06	08	2	UNL	40			-10	-10	-21	57	36	7
06	11	6	170	80			-06	-07	-20	50	07	5
06	14	1	UNL	80			08	06	-05	55	06	5
06	17	7	UNL	15			02	01	-07	66	34	4
06	20	10	180	15			01	00	-09	62	02	4
06	23	7	UNL	15			05	03	-09	52	25	3
07	02	8	100	15			03	02	-08	60	02	5
07	05	9	85	15			-03	-04	-13	62	16	4
07	08	0	UNL	80			-06	-06	-16	61	01	4
07	11	0	UNL	80			02	01	-05	72	05	4
07	14	6	UNL	80			06	04	-05	60	00	0
07	17	1	UNL	80			01	00	-10	59	00	0
07	20	1	UNL	15			-07	-07	-19	55	01	4
07	23	2	UNL	15			-09	-09	-20	58	32	3
08	02	0	UNL	15			-11	-11	-24	51	33	4
08	05	0	UNL	15			-12	-12	-26	49	36	5
08	08	0	UNL	80			-12	-12	-26	49	01	8
08	11	8	UNL	80			-04	-04	-13	65	00	0
08	14	3	UNL	80			06	04	-09	50	36	3
08	17	0	UNL	15			01	00	-10	59	16	3
08	20	0	UNL	15			-10	-10	-22	54	03	4
08	23	0	UNL	15			-15	-15	-29	48	03	3
09	02	0	UNL	15			-16	-16	-31	45	36	3
09	05	0	UNL	15			-19	-19	-34	45	02	3
09	08	1	UNL	15			-18	-18	-30	53	00	0
09	11	3	UNL	80			-13	-13	-25	54	00	0
09	14	1	UNL	80			-02	-03	-14	56	00	0
09	17	0	UNL	80			-11	-11	-22	57	00	0
09	20	0	UNL	15			-16	-16	-30	48	02	3
09	23	0	UNL	15			-17	-17	-29	53	33	4
10	02	0	UNL	15			-20	-20	-32	52	04	3
10	05	0	UNL	15			-21	-21	-34	49	11	4
10	08	0	UNL	80			-24	-24	-40	41	00	0
10	11	0	UNL	80			-13	-13	-28	46	00	0
10	14	0	UNL	80			05	03	-11	47	06	4
10	17	0	UNL	80			-09	-09	-22	52	35	3
10	20	0	UNL	15			-13	-13	-30	41	04	8
10	23	0	UNL	15			-20	-20	-36	42	02	3
11	02	0	UNL	15			-23	-23	-38	44	33	3
11	05	0	UNL	15			-23	-23	-40	39	36	3
11	08	0	UNL	80			-26	-26	-40	46	01	5
11	11	0	UNL	80			-15	-15	-28	51	01	3
11	14	0	UNL	80			-05	-06	-18	53	03	9
11	17	0	UNL	40			04	02	-20	31	01	15
11	20	0	UNL	15			-05	-06	-26	34	05	10
11	23	0	UNL	15			-09	-09	-29	36	03	9
12	02	0	UNL	15			-08	-08	-30	32	36	5
12	05	0	UNL	15			-15	-15	-33	38	05	6
12	08	0	UNL	80			-15	-15	-33	38	06	10
12	11	0	UNL	80			-06	-07	-29	31	02	3
12	14	0	UNL	80			-01	-02	-26	28	07	0
12	17	0	UNL	15			-10	-10	-32	32	02	12
12	20	0	UNL	15			-16	-16	-35	36	07	7
12	23	0	UNL	15			-16	-16	-35	36	06	5
13	02	0	UNL	15			-14	-14	-34	34	04	9
13	05	0	UNL	15			-13	-13	-34	33	04	6
13	08	0	UNL	80			-17	-17	-34	40	03	7
13	11	0	UNL	80			-07	-07	-30	30	06	9
13	14	0	UNL	80			00	-01	-26	27	07	3
13	17	0	UNL	15			-09	-09	-31	32	13	7
13	20	0	UNL	15			-20	-20	-36	42	33	3
13	23	0	UNL	15			-21	-21	-35	47	00	0
14	02	2	UNL	15			-23	-23	-37	46	02	3
14	05	0	UNL	15			-27	-27	-40	48	04	4
14	08	1	UNL	80			-25	-25	-40	43	00	0
14	11	0	UNL	80			-13	-13	-29	43	03	3
14	14	0	UNL	80			-06	-07	-24	40	00	0
14	17	0	UNL	80			-10	-10	-27	42	24	3
14	20	1	UNL	15			-20	-20	-35	44	00	0
14	23	3	UNL	15			-14	-14	-28	48	01	8
15	02	9	100	15			-14	-14	-30	43	03	5
15	05	10	100	15			-05	-06	-23	41	34	6
15	08	6	100	80			-13	-13	-26	51	26	3
15	11	5	UNL	20			-16	-16	-30	48	28	3
15	14	9	65	40			-07	-08	-22	47	20	3
15	17	8	60	20			-05	-06	-20	47	20	3
15	20	7	100	15			-14	-14	-30	43	00	0
15	23	0	UNL	15			-19	-19	-31	53	16	3
16	02	2	UNL	15			-20	-20	-33	50	00	0
16	05	9	UNL	15			-20	-20	-35	44	00	0
16	08	10	220	80			-16	-16	-32	43	20	4
16	11	8	UNL	80			-10	-10	-25	46	23	3
16	14	2	UNL	80			01	00	-16	44	18	3
16	17	2	UNL	40			-03	-04	-18	48	33	3
16	20	6	210	15			-09	-09	-23	49	16	4
16	23	5	UNL	15			-11	-11	-25	49	21	5
17	02	8	UNL	15			-14	-14	-30	43	00	0
17	05	9	UNL	15			-14	-14	-28	48	00	0
17	08	9	UNL	15			-17	-17	-31	48	00	0
17	11	5	UNL	80			-08	-08	-22	49	00	0
17	14	0	UNL	80			-03	-04	-16	48	19	4
17	17	0	UNL	80			-05	-06	-21	45	20	3
17	20	0	UNL	15			-14	-14	-29	46	01	4
17	23	0	UNL	15			-16	-16	-32	43	02	3
18	02	0	UNL	15			-17	-17	-33	42	00	0
18	05	1	UNL	15			-17	-17	-32	45	00	0
18	08	3	UNL	80			-19	-19	-33	47	00	0
18	11	8	UNL	80			-05	-06	-19	50	04	5
18	14	2	UNL	80			09	07	-07	48	05	3
18	17	0	UNL	80			05	03	-10	49	00	0
18	20	0	UNL	15			-04	-05	-15	58	03	5
18	23	0	UNL	15			-07	-07	-19	55	00	0
19	02	5	UNL	15			-04	-05	-15	58	00	0
19	05	2	UNL	15			-05	-06	-19	50	00	0
19	08	2	UNL	80			-08	-08	-21	52	00	0
19	11	10	120	40			22	20	13	68	35	8
19	14	10	120	80			32	28	20	61	07	9
19	17	10	120	40			29	25	15	56	33	5
19	20	10	120	15			30	26	15	54	08	7
19	23	10	50	15			31	26	16	54	10	6
20	02	10	140	15			31	28	22	69	00	0
20	05	10	120	15			25	23	16	69	00	0
20	08	10	100	80			20	19	13	74	00	0
20	11	10	100	80			27	24	18	69	35	4
20	14	10	100	80			32	29	23	69	26	4
20	17	10	90	40			22	19	11	62	19	7
20	20	10	13	3		S	18	18	15	88	04	4
20	23	10	15	4		S	19	19	16	88	01	5
21	02	10	32	15			19	18	14	81	23	4
21	05	9	90	15			15	14	09	77	02	3
21	08	10	100	80			11	10	06	80	00	0
21	11	10	200	40			18	17	12	77	05	4
21	14	9	100	80			24	23	19	81	31	3
21	17	9	100	80			18	17	12	77	00	0
21	20	4	UNL	7			14	13	10	84	18	5
21	23	4	UNL	15			10	09	05	80	03	4
22	02	9	80	15			10	09	06	84	36	3
22	05	10	37	15		S	14	13	10	84	01	3
22	08	10	90	80			14	13	09	80	05	3
22	11	9	90	80			22	21	16	78	00	0
22	14	2	UNL	80			27	24	16	63	02	3
22	17	1	UNL	80			20	19	14	77	33	3
22	20	0	UNL	7			10	09	04	76	35	5
22	23	0	UNL	10			05	04	-02	72	01	5
23	02	0	UNL	15			-02	-03	-13	59	25	3
23	05	5	UNL	10			-06	-06	-17	58	05	4
23	08	7	UNL	40			-06	-06	-18	55	00	0
23	11	0	UNL	80			06	04	-05	60	00	0
23	14	0	UNL	80			18	16	10	71	00	0
23	17	0	UNL	80			13	12	06	73	00	0
23	20	0	UNL	12			04	03	-07	60	03	3
23	23	0	UNL	10			-03	-04	-15	56	01	6
24	02	0	UNL	15			-05	-05	-16	58	36	6
24	05	0	UNL	10			-04	-05	-16	56	36	5
24	08	0	UNL	80			-01	-02	-12	59	04	6
24	11	0	UNL	80			15	13	05	64	04	3
24	14	0	UNL	80			22	18	05	48	02	5
24	17	0	UNL	80			13	10	-02	51	04	8
24	20	0	UNL	15			04	03	-08	57	35	5
24	23	0	UNL	15			-06	-07	-19	52	03	5
25	02	0	UNL	10			-10	-10	-24	49	02	6
25	05	0	UNL	10			-13	-13	-26	51	33	4
25	08	0	UNL	80			-15	-15	-29	48	01	5
25	11	2	UNL	80			09	06	-10	41	04	4
25	14	1	UNL	80			19	14	-07	31	02	4
25	17	3	UNL	[illegible]			15	11	-11	30	05	6
25	20	0	UNL	[illegible]			00	-01	-18	42	04	6
25	23	0	UNL	[illegible]			-08	-08	-22	49	01	5
26	02	0	UNL	10			-14	-14	-27	51	02	4
26	05	0	UNL	10			-16	-16	-30	48	31	3
26	08	0	UNL	80			-17	-17	-31	48	03	5
26	11	0	UNL	80			05	04	-06	60	00	0
26	14	0	UNL	30			19	14	-08	29	06	11
26	17	0	UNL	80			10	07	-15	31	05	7
26	20	0	UNL	15			01	00	-19	38	04	4
26	23	0	UNL	10			-13	-13	-24	57	02	5
27	02	0	UNL	10			-16	-16	-29	50	35	5
27	05	0	UNL	15			-19	-19	-31	53	02	6
27	08	0	UNL	80			-18	-18	-31	50	35	3
27	11	1	UNL	80			06	03	-16	35	01	3
27	14	9	180	80			12	08	-13	[illegible]	09	3
27	17	8	180	80			08	06	-10	43	02	10
27	20	5	UNL	15			05	03	-14	40	34	7
27	23	8	120	10			06	04	-12	43	36	9
28	02	3	UNL	10			00	00	-17	44	04	3
28	05	7	90	10			02	00	-13	49	03	6
28	08	10	80	40			03	01	-14	44	10	4
28	11	9	100	40		S	09	06	-08	45	06	5
28	14	10	100	15		S	10	08	-03	55	23	4
28	17	10	90	15		S	11	08	-05	48	33	9
28	20	7	90	15			05	03	-11	47	35	8
28	23	6	90	10			00	00	-14	51	35	11

NOTES

CEILING COLUMN—

UNL indicates an unlimited ceiling.

WEATHER COLUMN—

- • Tornado
- T Thunderstorm
- Q Squall
- R Rain
- RW Rain showers
- ZR Freezing rain
- L Drizzle
- ZL Freezing drizzle
- S Snow
- SP Snow pellets
- IC Ice crystals
- SW Snow showers
- SG Snow grains
- IP Ice pellets
- A Hail
- F Fog
- IF Ice fog
- GF Ground fog
- BD Blowing dust
- BN Blowing sand
- BS Blowing snow
- BY Blowing spray
- K Smoke
- H Haze
- D Dust

WIND COLUMNS—

Directions are those from which the wind blows, indicated in tens of degrees from true North; i. e., 09 for East, 18 for South, 27 for West. Entry of 00 in the direction column indicates calm.

Speed is expressed in knots; multiply by 1.15 to convert to miles per hour.

ADDITIONAL DATA

Other observational data contained in records on file can be furnished at cost via microfilm, microfiche, or paper copies of the original records. Inquiries as to availability and costs should be addressed to: Director, National Climatic Center, Federal Building, Asheville, North Carolina 28801.

STATION: FAIRBANKS ALASKA YEAR & MONTH: 73 02