The Antarctic Winter—as Recorded at Dakshin Gangotri

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ABSTRACT

The data tape of the Automatic Weather Recording Station set up by the first expedition was recovered by the second expedition. The station performed well and the entire tape shows valuable and consistent recorded data. The temperature records show progressive cooling with the advance of the Antarctic winter with a minimum recorded temperature of -29° deg C. The wind data is consistent with published results of long term experiments showing winds generally from the South and South East sectors. The maximum wind speed recorded in the 6 months of recording was 85 mph from a southerly direction. Some qualitative explanations are put forward for the observations and the paper concludes with a set of recommendations for future experiments.

INTRODUCTION

On the 15th February 1983 a small team from the Second Indian Expedition Contingent landed at Dakshin Gangotri and surveyed the condition of the Automatic Weather Recording Station left behind by the first expedition.

The team reported that one of the four guy wires holding the mast had worked loose, causing the mast to tilt considerably to one side. The bins containing the electronics, tape unit and the sealed batteries were undamaged, however, as also the underwater connectors, interconnecting cables and "O" ring seals. The mast was reinstalled vertically by the team.

Three of the five external sensors were in good condition. These were the air and surface thermometers and the humidity sensor. The cup anemometer however was missing and the wind vane was partially broken.

The other remaining external units were the heavy duty batteries, which showed no external damage and had a terminal voltage of 12 volts instead of the nominal 24 volts. The secondary external batteries were replaced by new 120 AH, 24 volts batteries.

The bin containing the sealed batteries was opened and checked. These were found in good condition and showed a terminal voltage of 12 volts instead of the nominal 20 volts. They were not replaced. The original cassette tape was replaced and the electronics was checked for proper functioning before resealing the bin.

A photograph taken of the weather station after 13 months at Dakshin Gangotri is shown in Plate I.

RESULTS AND DISCUSSIONS

The format of the recorded data has been discussed in detail elsewhere (Ref. 1) in this report. After a visual scan of the raw replayed data, modifications to the linear equations described in Ref. 1 were made in the processing of the temperature data.

Raw data

The recorded tape was played through a Memodyne tape reader and the data arranged tabularly. A hard copy was obtained on a printer.

A visual check of the data showed that more than 99 % of the recorded data was in a format consistent with the different checks built into the recording system. The remaining 1% of the data showed missed

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characters which can be directly attributed to misprinting or misreading. A typical printout showing an error is given in Table I. The value of the missing character-can be ascertained from the number of characters as well as the trend of the values.

One point of interest was a clock skip which occurred on 28 April 1982. The record numbers had for the previous 103 days showed a monotonic increase. On 28 April however the Random Access Memory chips (RAMs) holding the record number skipped from a record entry of 5168 to 8169. Taking this into account, the total number of interrogations was 1578. At the set interrogation interval of 2 hours 16 minutes 32 seconds, the total working period correspond to 149.6 days. The tape had been loaded on 16 January 1982 and the end of the tape was reached on the "Afternoon" of 13 June 1982. This is consistent with calculations from the number of bytes per interrogation and the capacity of the magnetic tape.

Health monitors

The health of 2 reference voltages was monitored. The 2 reference voltages had nominal values of 1870 and 360 millivolts (mV) and a third check was also made of the ground reference. The ground reference allowed a simple estimation of the drift of the Analog to Digital Converter (ADC) to be made. The record showed that at no stage did the ADC have a drift higher than 1 mV. The checks on the reference voltages allowed the sensor outputs to be corrected.

The minimum, average and maximum values recorded for the high reference of 1870 mV were 1867 mV, 1870 mV and 1873 mV respectively. This was equivalent to ±0.15% drift of full scale.

Winds

The wind sensors were units obtained from M/s. R. M. Young & Co, U. S. A. The cup anemometer gave an output of 4.8 volts for a wind speed of 102 mph and the wind vane direction was read from a constant contact plastic potentiometer. As the range of the ADC was only 2 volts, the anemometer output was divided by a factor of 2.4 to bring it within the ADC operating range. The calibration curve used is shown in Fig. 2.

The excitation voltage for the compass was 360 mV and the output read therefore, directly in degrees.

During the short sojourn of the first expedition at Dakshin Gangotri, the satellite navigator could be used only for establishing one bench mark of Dakshin Gangotri's location. The compass alignment was, therefore, an approximation and this could give rise to some errors in the recorded direction of winds.

Also, the wind vane was aligned as normal for oceanographic current measurements, that is the direction to which currents are flowing. The meteorological convention is the reverse of this, being the point of the compass from which winds originate. The necessary 180 degree factor has been incorporated while plotting the transitional matrix (Fig. 3) as well as on Table 2.

On 8 June, the cup anemometer was blown off from its spindle. The recorded wind speeds showed a previous monotonic increase, with a wind speed of 55 mph as the last record before the loss occurred. The prevailing direction a day earlier and 12 hours after the event was in the southerly direction. The recorded air temperature at the time was only -11 deg C, but coupled with the winds of high velocity this gave an effective wind chill factor equivalent of many degrees below freezing (Ref. 4). The lowest recorded temperature was -29 deg C during the same period (24 hours later). The highest recorded wind speed was 71 knots and occurred on May 11, 1982 in an Easterly direction.

The wind data (both speed and direction) are plotted in Fig. 3 as a transitional matrix. Such a method of presenting the wind data is compact and convenient. It represents a variable in two parts both of which are further quite variable. The matrix can be understood best if the abscissa is considered the "Present" while the ordinate is considered the "Future". Thus if the present winds are 30-40 mph in 90 deg-135 deg direction then the highest probability of the winds in the next observation will be 39% and will be 30-40 mph in a direction 90 deg-135 deg. The probabilities in any vertical column, sum upto 100% giving the resultant of all the recorded readings. Accumulated readings with probabilities lower than 1% have not been included as this would tend to make for a very large graphic display.

Wind direction and speed are given in Table 2 in the format of the Antarctic Pilot. The majority direction of the winds, as seen from both the Tables, is from the E and S-E sectors.

The mean directional speeds from Table II and Table III also compare favourably though in general they tend to show slightly higher values than those of the Russian station. The extreme wind speeds are also higher for *Dakshin Gangotri* than for Novolazarevskaya. This could be accounted for by the fact that the Novolazarevskaya station is at a lower elevation than *Dakshin Gangotri.* The former is also located in a gentle depression at one end of the hilly terrain. *Dakshin Gangotri,* at the other extreme of the rocky range (about 5-10 kms away), is at a higher elevation and is exposed to winds blowing unimpeded for 100 kms across the ice-shelf.

Humidity

The humidity sensor was a humicap from M/s. Vaisala, Finland. This sensor was rated to give 1 mV per humidity percent when excited at 3.60 volts. The calibration of the sensors could not be carried out prior to instailation.The humidity output, as plotted on Table 2 is therefore given directly in mV only and are not converted to percentage humidity. The trend of the output should,however, be a direct indicator of the increasing or decreasing levels of humidity. Table 3 shows the meteorological data of the Soviet station Novolazarevskaya which is fairly close to the Indian station *Dakshin Gangotri. A* comparison of Table 2 with Table 3 indicates that the humidity trends recorded at *Dakshin Gangotri* are a variance with the averages obtained for Novolazarevskaya. From this it can be concluded that this sensor was not functioning as it should have been and the results have been included only for the sake of completing the record.

Air and Surface Temperatures

The thermometers used for air, near surface and bin housing temperature, were all thermistors from M/s. Omega Engineering Inc, U.S.A.

In the short time available for the construction of the weather station, linear low temperature thermometers could not be purchased and readily available ones were used instead. These units had been procured for tropical use and were linear in the range 0 deg C to + 40 deg C.

Since the thermometers were operating outside their linear range, the linear equation relating electrical output to temperature could not be used. However, the thermistor variation with temperature was known (Ref. 2). This was incorporated in the linearising network and a look up curve generated, which is reproduced in Fig. 1.

It can be seen from Fig. 1 that, as the temperature approaches-30 deg C, the thermistor variation with temperature becomes non-linear. The calculated temperature can then be in error by about ± 0.3 deg C for every mV error in reading.

It is also not known what the performance of the thermistor would be when it is exposed to stress conditions of temperatures lower than -30 deg C which is the minimum temperature for which the thermistors were rated.

The values recorded by the air and near surface thermometers were identical throughout the sampling period. As these were distanced only 3 metres apart the station had essentially two air thermometers. The identical recorded values of the 2 thermometers lent greater credence to veracity of the temperature results obtained.

A histogram of the air temperatures for each month are plotted in Fig. 4. The histograms were generated by calculating the percentage of the monthly readings that fell in two degree temperature intervals from +4 deg C to -30 deg C.

The histograms show a clear trend towards lower average temperatures as the Antarctic winter progressed. Also noted along the side of each chart are the maximum, average and minimum temperatures recorded for the month. In order to appreciate the thermal environment of the electronic system, the maximum and the minimum bin temperatures are also noted besides the ambient temperature readings.

Table 2 summarises the data from *Dakshin Gangotri* over a six month period and Table 3 shows the data from the Russian station Novolazarevskaya over a five to seven year period (Ref. 3). The first three columns of the daily mean, the mean daily temperature range and the highest monthly recorded temperature agree well.

The Indian data set for the daily mean is 1 deg C lower in January and 2 deg C in June. This could be attributed to the fact that data was not acquired for the full period of these 2 months. The highest recorded monthly temperatures also show a close agreement, and these are as expected from the thermistor operating range. The largest discrepancies are found in the column of the lowest recorded monthly temperatures.

It would seem at first sight that the limited thermistor operating range could be the main factor in recording higher air temperatures than actual. This logic is, however, invalidated for the June readings which show only 1 deg C difference in the lowest recorded temperatures.

No conclusive explanation can therefore be put forward without obtaining further details regarding the deviation associated with each tabulated value in Table 3. The best approach would be to obtain the actual data from Novalzarevskaya for the 6 month period January to June 1982. However, the overall data sets show a very satisfactory comparison.

The only other point of interest is the recorded bin temperature low of -29 deg C for the month of June, when the lowest recorded air temperature was only -26 deg C. We postulate a qualitative reasoning for such an anomaly. During the initial period of the operation, the secondary batteries had a terminal voltage of 24 volts and were dissipating 24 watts averaged over the 128 sec sampling period.

After 6 months of sampling, the terminal voltage of the batteries would have dropped considerably. Thus if we consider a reduced terminal voltage of 12 volts to the system, then the dissipated power would be half of its original value.

Since the bin was thermally insulated, the high power dissipated during the early part of the year coupled with the relatively warmer ambient temperatures, maintained the electronics at a higher temperature between interrogations. This is clearly seen in Fig. 4 where the bin maximum and minimum temperatures are higher than the ambient temperatures initially. This difference gets slowly reduced to zero by May, by which time the lower dissipated power coupled with lower ambient temperatures does not manage to maintain the electronics at a higher temperature than the ambient.

Recomendations

The weather recording station was our first experience to gain some knowledge of the Antarctic winter. From the recorded data, it seems that it was useful experience. The sensors, their calibrations, their limitations and their drawbacks have been discussed in this communication. The second experience should, therefore, benefit us a great deal as compared to our first try. The following points are noted because they are relevant to future experimentation:

The anomalous behaviour in June can be explained if it is postulated that between the two sampling periods, the ambient dropped to a low of less than -29 deg C and the thermally lagged bin followed this low excursion which showed up in the 2nd sample where the ambient had already increased to -26 deg C, but the thermal insulation gave the bin thermometer a "memory" allowing it to record the recently past colder ambient excursion.

1. Commercially available sensors are easily and readily available for all the parameters to be measured. At *Dakshin Gangotri* no extreme wind or temperature conditions have been recorded.
2. At —35 deg C, the electronic components are generally nearmg their working limits and hence military specifications components are a must. These were used in our *Dakshin Gangotri* station which could be the reason for the success of the weather station. The aspect of heating the electronics is an important one and has to be maintained to ensure the system functioning throughout the winter.
3. Data tapes have limited storage capacity and these have to be regularly serviced. The batteries also need replacement. The sensors and the mechanical structures will have to be periodically checked if uninterrupted data are to be obtained. It would of course, be possible to construct a weather station with low power devices. This should include enough battery back up so as to maintain the collection of data throughout the winter.
4. The obvious next step would be the inclusion of satellite transmitters for a daily Antarctic weather report in India. An extension of this scheme would be a matrix of stations which would allow a comprehensive weather map to be prepared daily for its use by other permanently-stationed teams in the vicinity.

ACKNOWLEDGEMENTS

The authors would like to take this opportunity to thank Dr. S. Z. Qasim, Leader of the First Expedition to Antarctica and Shri K. Saigal for their most encouraging policy, that allowed this station to "get onto its feet" in a matter of a few weeks preparation. Thanks are also due, in large measures, to all our colleagues in the Instrumentation Division and in other Divisions of the Institute who burnt their midnight oil for us in a heartwarming effort of team spirit. Thanks are also due to Prof. G. S. Hobson of the University of Sheffield who assisted us in obtaining the military specifications components used in the station.

Our final thanks go to Drs. A. Sengupta and S. G. Prabhu Matondkar, participants of both expeditions, who carried out the reinstallation of the station during the second expedition and who retrieved the recorded tape,

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Plate 1 : Weather Station after Thirteen Months at Dakshin Gangotri

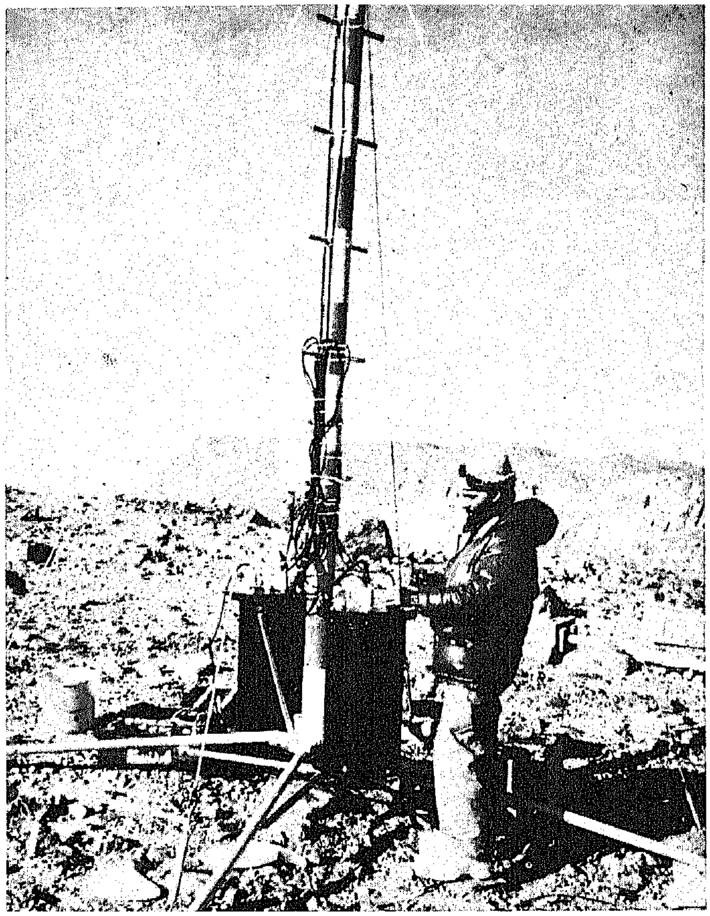

TABLE 1

Plate 2 : Centronics Printer Misprints

SN:5168	Rl :1874	R2:0361	R3:0001	WS:0831	WD:0261	BH:1683
AT:1681	ST:1334	BT:1650	HU:1210	DI :XXXX	D2:YM	D3:ZZZZ
SN:8168	Rl :1873	R2: 0361	RS:0001	WS:0846	WD:0249	BH:1681
AT:1681	ST:1333	BT:1650	HU:1210	D1:XXX	D2 :YYYY	D3:ZZZZ
SN:88169	1:1873	R2:0361	R3: 0001	WS: 0614	WD:0231	BH:1702
AT:1702	S:1377	BT:1652	HU:1170	Dl:XXXX	D2:YYYY	D3:ZZZZ
SN:8170	Rl : 1870	R2: 0360	R3: 0001	WS: 0501	WD:0262	BH:1752
AT:1752	ST: 1316	BT:1757	HU:l218	D1 :XXX	D2 :YYYY	D3:ZZZZ
SN:8171	Rl:1870	R2 :0360	R3 :0001	WS:248	WD:0306	BH :176 0
AT:41760	ST:l323	BT:1761	HU:1210	Dl:XXX	D2:ZZZZ	DS : ZZZZ

TABLE 2
Dakshin Gangotri Data

⊕ = Rare

MONTH	Air Temperature(°C)				ReL Humi-dity	WIND DIRECTION AND SPEED																		Extreme Wind speed
						Percentage of observation from									Mean directional speed from {Knots)									
	Daily Mean	Mean daily range	High-est in each month	Low-est in each month	(mV)	N	NE	E	SE	S	SW	w	NW	Calm	N	NE	E	SE	S	SW	W	NW	Calm	(Knots)
January	- 2	4	+ 2	- 7	157	8	32	33	5	1	3	3	15	0	5	25	26	12	4	6	4	6		84
February	- 4	4	+ 1	-12	113	8	31	37	10	1	2	3	8	1	6	21	22	17	4	17	9	6		63
March	- 9	5	- 1	-17	114	5	20	47	18	1	2	2	5	1	5	17	24	18	10	17	7	4		50
April	-12	5	- 3	-22	107	2	26	38	19	4	5	3	3	3	3	22	29	20	4	10	4	4		57
May	-12	5	- 3	-25	135	0	22	39	39	,0	0	0	0	3	18	31	30	17	⊕	⊕	3	⊕		71
June	-16	5	- 6	-29	98	0	6	73	21	0	0	0	0	1	⊕	21	20	8	⊕	⊕	⊕	⊕		47

TABLE 3

PLACE—NOVOLAZAREVSKAYA (Station), PRINCESSE ASTRID KYST. LAT. 70° 46' S. LONG. 11° 50' E. Height above Mean Sea Level—87 m (285 ft)

WMO. No. 89512 Climatic Table compiled from 5 to 7 Years' Observations, 1961 to 1967

Month	Pressure at M.S.L.	Air temperature				Relative humidity		Mean Cloud Amount		Snowfall and drifting snow		Ø Percentage of observalSons from									Ø Mean directional speed									Extreme wind speed		No. of days with	No. of days with
	Mean	Daily mean	Mean daily range	Highest in each month	Lowest in each month			s	-	Average fall	No. of days with snowfall	N.	N.E.	E.	S.E.	S.	S.W,	W.	N.W.	Calm	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calm				
	mb.	°C.	°C.	°C.	°C.	%	%	Oktas		mm.											Knots									Knots			
January..	988	- 1	5	+ 5	-12	64	—	5		13	2	7	10	34	35	4	3	1	3	3	8	9	16	19	16	18	10	18		57			
February ..	990	- 4	5	+ 3	-15	46		5		4	4	3	4	28	52	7	2	1	2	1	6	10	22	20	13	6		9		52			
March..	985	- 9	6	0	-22	50		5		4	5	1	5	23	52	10	2	1	1	5	Ø	9	22	23	17	12	7	8		60			
April..	985	-13	7	- S	-32	52		4		7	8	1	3	22	46	15	3		3	7	5	9	26	25	18	9		6		58			
May..	986	-13	6	- 6	-31	58		4		13	13	1	4	24	46	9	4		2	7	Ø	10	28	25	20	15	8	6		55			
June...	994	-14	6	- 3.	-30	64		6		75	14	2	2	23	59	7	3		1	2	Ø	22	26	29	26	25	Ø	Ø		63			
July..	989	-18	8	- 5	-33	52		4		29	6	1	3	21	52	10	3		1	7	Ø	10	27	27	23	18	7	6		57			
August..	987	-18	7	- 1	-35	59		5		32	10	1	3	30	48	4	2		1	9	5	8	30	25	18	12	8	9		65			
September..	985	-17	7	- 3	-31	53		5		44	9	1	3	28	49	6	1		1	9	4	9	28	26	.19	11	6	8		61			
October..	983	- 14	7	- 5	-30	54		5		64	10	2	4	25	48	6	3	3	2	7	7	8	27	25	20	10	9	9		64			
November..	987	- 6	6	+ 3	-17	52		5		13	6	2	5	28	52	4	1	1	4	3	Ø	12	21	25	15	Ø	6	16		57			
December .	988	- 1	S	+ 2	- 9	66		5		5	+	6	10	29	37	4	4	1	4	5	6	10	20	19	15	12	11	9		46			
Means .	987	—11	6	_Ø	••	56	—	5	—			2	5	26	48	7	3	2	2	5	6	12	24	24	IS	12	8	10				—	
Totals..	—	—				—		–		303	91																						
Extreme Values .	—	—		—	_35tt	—	—																								I		
No. of years' observations .	5-7											5-																					

•Mean of highest each year,
••Mean of lowest each year.

tHighest recorded, temperature.
tt Lowest recorded temperature.

All observations.
Bars.

Source: Official CLIMATIC data at Met. Office, Bracknell.

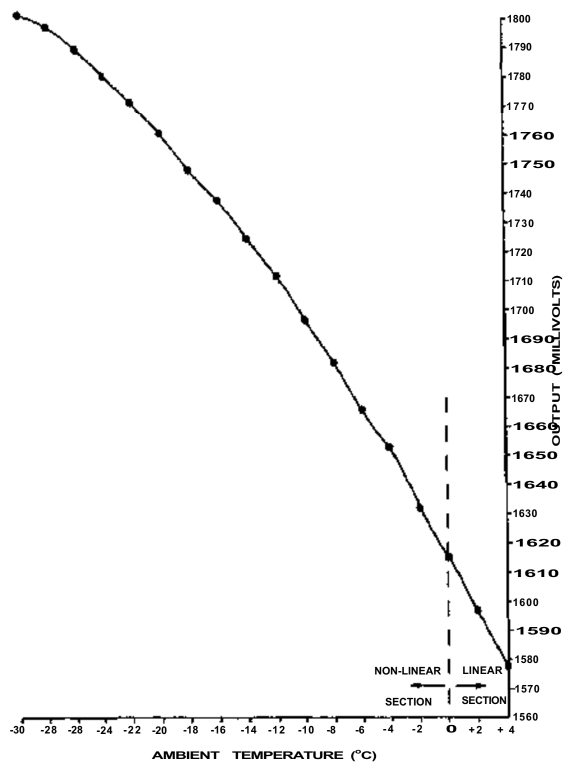

Fig. 1 : **Thermistor calibration curve.**

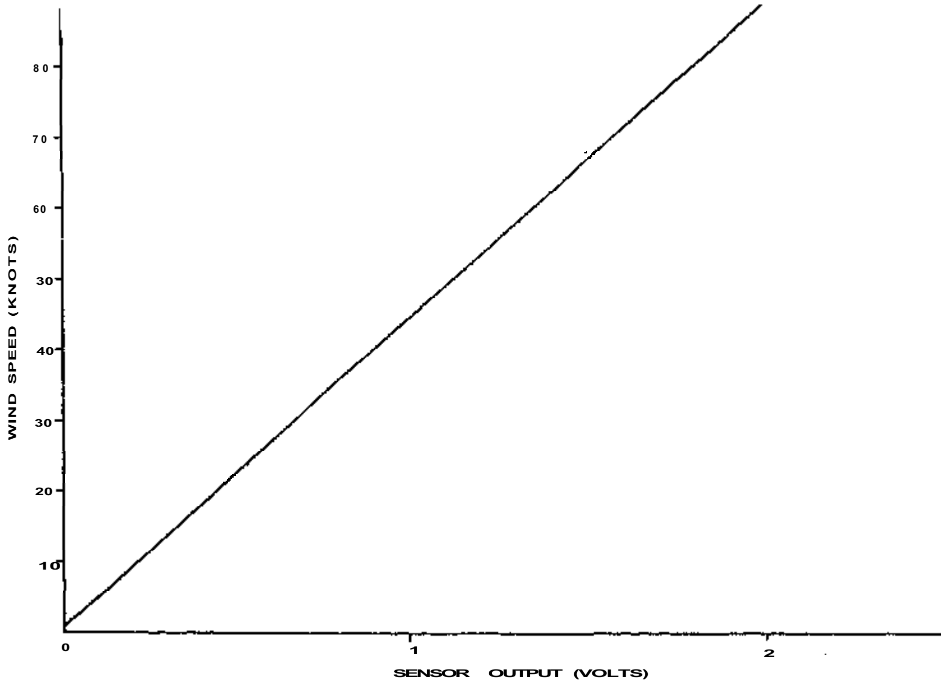

Fig. 2 : **Cup anemometer calibration chart.**

Predicted (Probability) \ Present (%)	0-10mph 0-43°	0-10 mph 45-90°	0-90 mph 90-135°	0-10 mph 135-180°	0-10 mph 180-225°	0-10mph 225-270°	0-10 mph 270-315°	0-10 mph 315-560°	10-20 mph 0-45°	10-20 mph 45-90°	10-25 mph90-135°	10-20mph 225-270	10-20 mph 270-315°	10-20 mph 315-360°	20-30mph 0-45°	20-30 mph 43-90°	20-30 mph 90-135°	30-40mph 45-90°	30-40mph 90-135°	40-50mph 45-90°	40-50 mph 90-135°	50-60 mph 45-90°	50 -60 mph 90-135°	60-70 mph 45-90°
70-80mph 90-135°																							5	5
70-80 mph 45-90°																				5		2		
60-70 mph 135-180°																							5	
60-70 mph 90-135°																						2		5
60-70mph 43-90°		2																		8		8	5	14
50-60mph 90-135°																			3	1	7	6	26	19
50-60 mph 45-90°																		5	1	16	4	35	24	43
40-50 mph 90-135°		2															1	2	14	3	12		5	
40-50 mph 45-90°		2								1						4		14		31		26	5	14
30-40 mph 90-135°			1				2	2	7	1				8		5	17	3	39	3	59	5	10	
30-40 mph 45-90°	3	2								1	2				12	16	4	46	4	28	7	12	5	
20-30 mph 90-135°	5	3	4	3			2			4	27					4	38	2	27		4			
20-30 mph 45-90°	5	7	3			6		5	14	26	7				46	41	15	25	7	3	7	2	10	
20-30 mph 0-45°	3	2				6				1				8	14	4		1		1				
10-20 mph 315-360°	3	3					2	2		1				25	4									
10-20 mph 270-315°							4	2					28		4									
10-20 mph 225-270°							4	5				14	14											
10-20mph 90-135°	8	9	13	3			11	12	7	10	28					4	12		4					
10-20 mph 45-90°	23	9	2	11	7	12	7	6	36	29	11		14			11	3	2	1					
10-20 mph 0-45°	3				3				7	3					8	3								
0-10 mph 315-360°	13	11	2	7	17	12	16	18	14	1	4	28		18	4		2							
0-10 mph 270-315°		4	3	7	7	12	18	19		3	2		44	25										
0-10 mph 225-270°			2	7	3		2			3				16										
0-10 mph 180-225°	5	6	3	7	14	17	5	3		1	3	14												
0-10 mph 135-180°	3	3	2	12	10	17	7	2	8	1	2						2							
0-10 mph 90-135°	13	17	60	22	29	6	4	5		3	14	14				2	6							
0-10 mph 45-90°	3	9	2	14	7	12	9	14		6		16			4	3				1		2		
0-10mph 0-45°	10	9	3	7	3		7	5	7	5		14			4	3								

Present (%)

Predicted (Probability)

Fig. 3 : Wind Data from 16.1.1981 to 13.6.1981

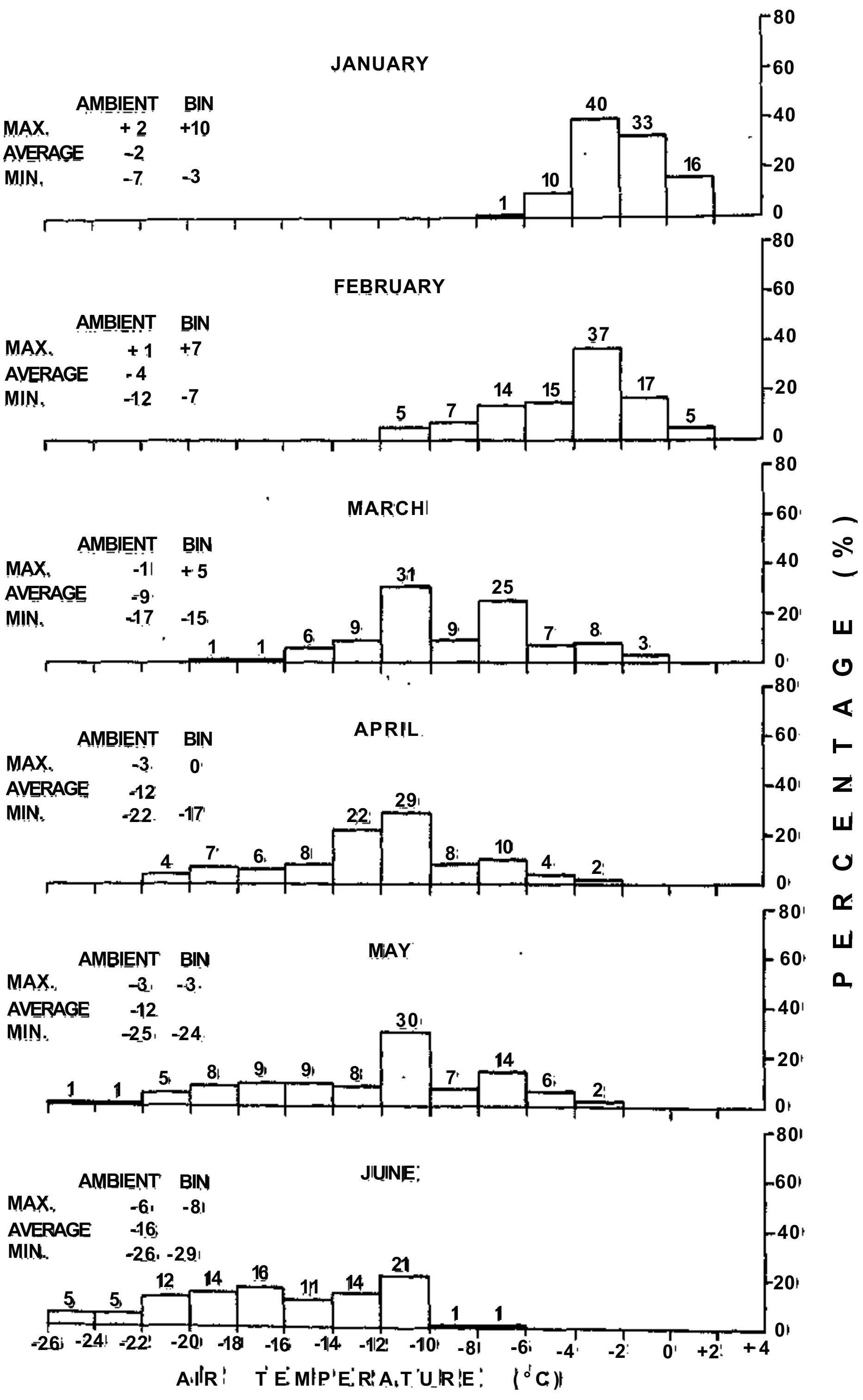

Fig. 4 : Percentage distribution of air temperature.