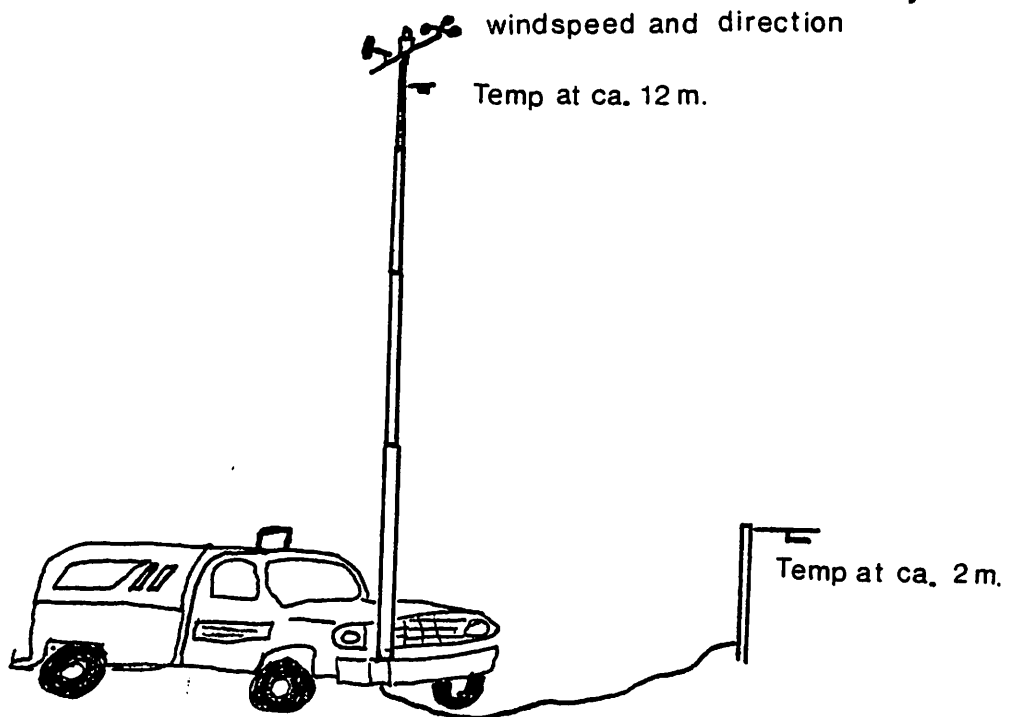


CALIBRATION AND EVALUATION OF THE HEATHKIT

MODEL ID 4001 WEATHER COMPUTER AS AN

INSTRUMENT FOR FIELD USE



by

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## INTRODUCTION

During an experimental spray operation, weather can be a limiting factor in the successful distribution and deposition of spray material on a designated area. Thus, it is of paramount importance that spray weather be measured accurately before, during and immediately after spray emission (Armstrong 1977).

For example, during a small scale experimental spray operation, a great deal of mobility in weather measuring equipment may be required. Equipment commonly used may be cumbersome, erection of a tower may require guying and more than one person may be required for a considerable period of time during the operation. For these reasons, the Heathkit Model ID4001 Weather Computer (Appendix I) was chosen for evaluation and comparison with the standard type of meteorological equipment commonly used during aerial spray experiments (anemometer, wind direction indicator, temperature probes and gauge, psychrometer). The Heathkit Model ID 4001 is a self-contained weather measuring system that is lightweight, relatively inexpensive and portable. This report deals with the calibration and comparison of three of the weather computer features: (a) temperature; (b) windspeed and direction, and (c) barometric pressure.

## MATERIALS AND METHODS

The objective of the experiment was to make a comparison between Environment Canada's Atmospheric Environment Services (A.E.S.) weather measuring equipment, located at the Sault Ste. Marie airport, and a Heathkit weather computer.

The weather computer was mounted behind the front seat of a Dodge Club Cab Powerwagon operated by the Forest Pest Management Institute (FPMI). The AC computer was powered by an inverter connected to the 12 volt DC vehicle power source. After installation of the weather computer calibration and comparison testing began.

Instruments owned and operated by the A.E.S., were used in the comparison - these being: two 12 inch mercury (Zeal) thermometers located inside a Stevenson Screen on the south side of the Airport control tower; a 33 foot steel tower with an anemometer and directional indicator on top, located between runway 29 and taxiway Foxtrot; and a Meteorology Service of Canada barometer located inside the weather office.

### (A) TEMPERATURE

During an experimental spray program, it is very important to determine the stability of the air mass through which the spray droplets must pass. Preferable temperature conditions require stable and inversion profiles. Thus, temperature probes located near ground

level and tree-top height are essential in the determination of a temperature inversion.

Although the weather computer was calibrated at the factory, additional calibration for the temperature probe was required due to the addition of longer leads to the probes. Calibration of each probe required a temperature of 0° Celcius. This temperature was obtained by submerging the temperature probes in a container filled with ice and water. The probes were protected from ice contact by a porous cloth, which, in turn, prevented a false temperature reading. Also, the ice and water were stirred constantly, in order to maintain a 0° celcius reading.

#### (B) WINDSPEED AND DIRECTION

The directional indicator and the anemometer cups were fastened to a piece of ca. 3 cm square tubing and mounted at the top of a 12 m telescopic tower adjacent to the A.E.S. wind measuring equipment. The telescopic tower was mounted on a special bracket attached to the heavy-duty bumper on the FPMI vehicle.

Wind velocity on November 5th was recorded every five minutes from the A.E.S. windspeed and directional panel while simultaneous readings were being made from the Heathkit weather computer.

In addition, on October 18th, wind velocity was recorded at fifteen minute intervals and then compared with the A.E.S. permanent recorder tape for the same time period (Table III).

Velocities for both occasions were recorded in knots for

comparison with the A.E.S. anemometer. Readings in knots are standard within the A.E.S. but miles and kilometers per hour were both available on the weather computer.

Directional indication in the weather office was available in degrees while the weather computer used both degrees and sixteen cardinal points, i.e.: NNE, ENE, etc.

#### (C) BAROMETRIC PRESSURE

Barometric pressure, already preset to sea level pressure at the factory, was checked and it required no further calibration. Two small indicator lights on the face of the weather computer indicated whether the pressure was rising, falling or remaining stable.

Barometric pressure data from the Heathkit unit and the A.E.S. recorder were collected at one hour intervals. This data (Table IV) were accumulated during several different visits to the airport throughout this experiment.

## RESULTS AND DISCUSSION

Temperature data were gathered on several different occasions under variable weather conditions. Temperature data obtained for statistical analysis spanned from 0°C to 14°C. A summary of records is shown in Table (I).

Figures 1 and 2 show the relationship between the A.E.S. and weather computer data as graphed by a Hewlett Packard Calculator Plotter at FPMI. The imperfection in the correlation could have been caused by the lack of decimal intergers in the weather computer figures and/or by human error during the calibration of the temperature probes. However, Table II shows a good correlation between the A.E.S. and weather computer data indicating accuracy of the Heathkit unit.

Windspeed and directional indication functioned well and were accurate up to 12 knots or ca 22 km/hr. Figure 3 shows the "dampened out" effect of the daily wind recorder charts as compared to the direct reading from the indicator needle. However, when the wind averaging button on the weather computer was depressed, the variations between the daily wind recorder and the weather computer were not as great.

The barometric pressure as preset by the factory functioned accurately and no daily calibration was required. The data in Table IV show the weather computer readings as being consistently the same as the A.E.S. observations. The two small lights on the face of the weather computer that indicate a rise or fall in pressure, were sensitive to environmental as well as micro-

environmental pressure changes. Therefore, care was taken when recording pressure tendencies, that overall tendencies and not micro-environmental changes were recorded.

## SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Results of the comparison between the Heathkit Model ID4001 Weather Computer and Environment Canada's Atmospheric Environment Service equipment show that the weather computer can produce reliable measurements/readings and it can be used as a replacement or alternative for present systems of weather measuring equipment. In addition, the Heathkit equipment is rugged and suitable to field uses such as aerial spray weather monitoring.

The accuracy of the experiments at the Sault Airport, as well as preliminary evaluation during an experimental spray operation in New Brunswick, 1979, suggests continued investigation into the further use of the Heathkit Weather Computer. Possible use areas may include: fire research, operational spray programs, pollution control studies or any situation requiring the accurate measurement of weather parameters.

Table I Comparison of Temperature Measurements

Heathkit Temp probe 1	Heathkit Temp probe 2	Zeal Hg Therm	Heathkit Temp probe 1	Heathkit Temp probe 2	Zeal Hg Therm
0	0	0.15	3	3	3.20
0	0	0.50	3	3	3.50
0	0	0.50	3	3	3.85
0	0	0.80	3	3	4.00
0	0	0.90	3	3	4.00
1	0	0.85	3	3	4.05
1	0	0.95	4	3	4.10
1	0	1.00	4	4	4.25
1	1	1.30	4	4	4.30
1	1	1.45	4	4	4.30
1	1	1.50	5	5	5.10
1	1	1.50	5	5	5.10
1	1	1.75	5	5	5.10
1	1	2.00	5	5	5.15
2	1	2.00	5	5	5.20
1	1	2.05	5	5	5.50
2	1	2.05	5	5	5.80
2	2	2.10	6	5	5.80
2	1	2.15	6	5	5.85
2	1	2.20	6	5	5.95
2	1	2.25	6	5	5.95
2	2	2.25	6	6	6.00
2	2	2.65	6	6	6.10
2	2	2.80	6	5	6.25
2	2	3.05	6	6	6.30

Table I con't ... Comparison of Temperature Measurements

Heathkit Temp probe 1	Heathkit Temp probe 2	Zeal Hg Therm	Heathkit Temp probe 1	Heathkit Temp probe 2	Zeal Hg Therm
6	6	6.75	9	9	9.45
7	6	7.00	10	9	9.65
7	6	7.10	10	9	9.75
7	6	7.45	9	9	9.85
7	7	7.45	9	9	9.85
7	7	7.50	10	10	10.00
7	7	7.50	10	10	10.20
7	7	7.65	10	10	10.35
7	7	7.65	10	10	10.50
7	7	7.70	10	10	10.50
7	7	7.70	10	10	10.50
7	7	7.70	10	10	10.50
7	7	7.85	10	10	10.50
7	7	7.85	10	10	10.50
7	7	7.90	10	10	10.65
7	7	7.95	11	10	11.00
8	7	8.05	11	11	11.40
8	7	8.05	11	11	11.50
8	7	8.20	11	11	11.80
8	7	8.30	11	11	12.00
8	8	8.35	12	11	12.05
8	8	8.70	12	11	12.10
8	8	8.85	12	11	12.15
9	8	9.10	11	11	12.20
9	8	9.10	12	12	12.40

Table I can't ... Comparison of Temperature Measurements

Heathkit Temp probe 1	Heathkit Temp probe 2	Zeal Hg Therm	Heathkit Temp probe 1	Heathkit Temp probe 2	Zeal Hg Therm
12	12	12.45	13	13	14.50
12	12	12.50	13	13	14.65
12	12	12.50			
12	12	12.85			
12	12	12.90			
12	12	12.90			
12	12	13.00			
12	12	13.00			
12	12	13.10			
12	12	13.15			
12	12	13.25			
13	12	13.35			
12	12	13.40			
13	12	13.40			
13	13	13.45			
13	12	13.65			
13	13	14.10			
13	13	14.15			
13	13	14.20			
13	13	14.20			
13	13	14.25			
13	13	14.25			
13	13	14.30			
13	13	14.40			

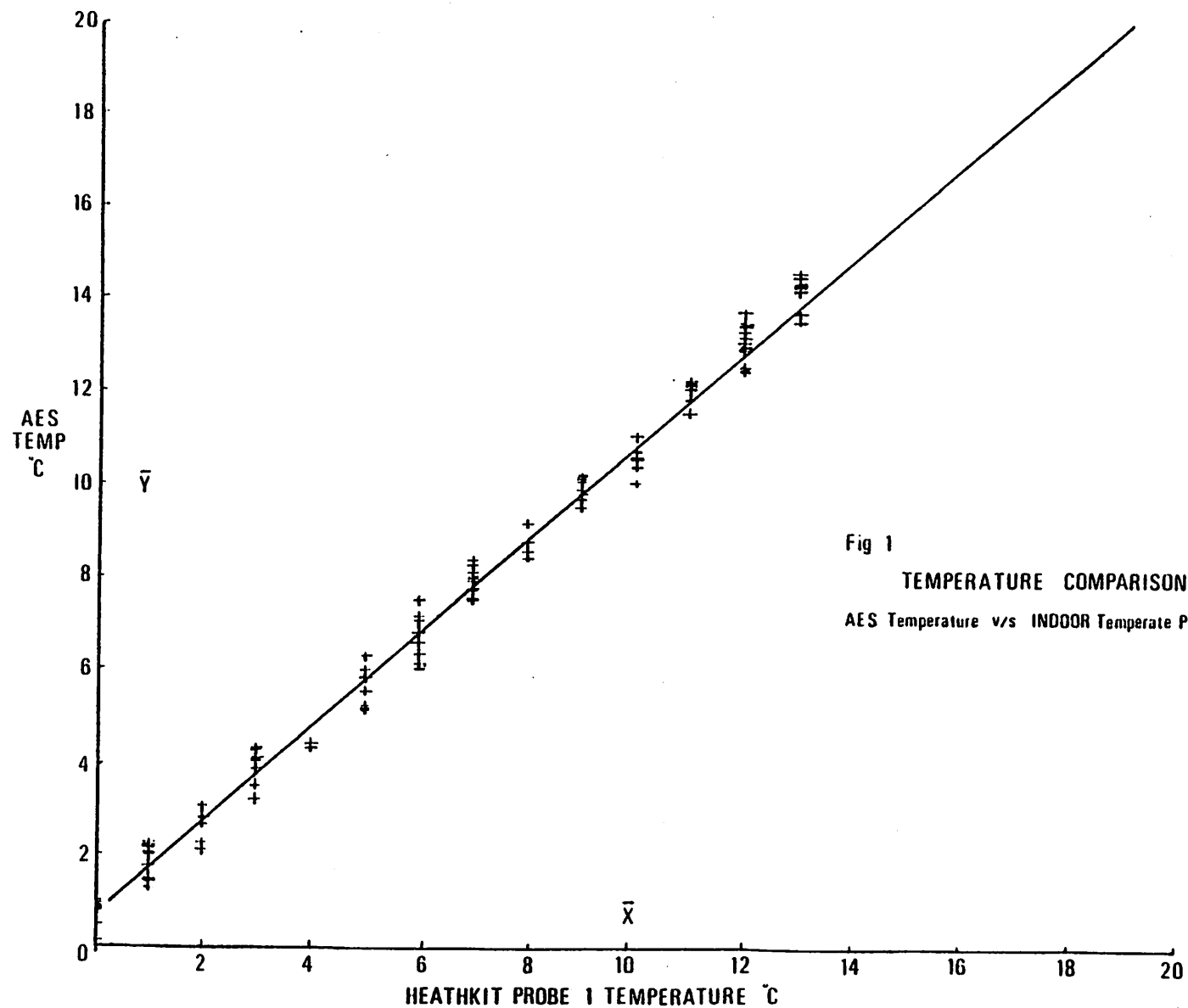


Fig 1  
TEMPERATURE COMPARISON  
AES Temperature v/s INDOOR Temperature Probe 1

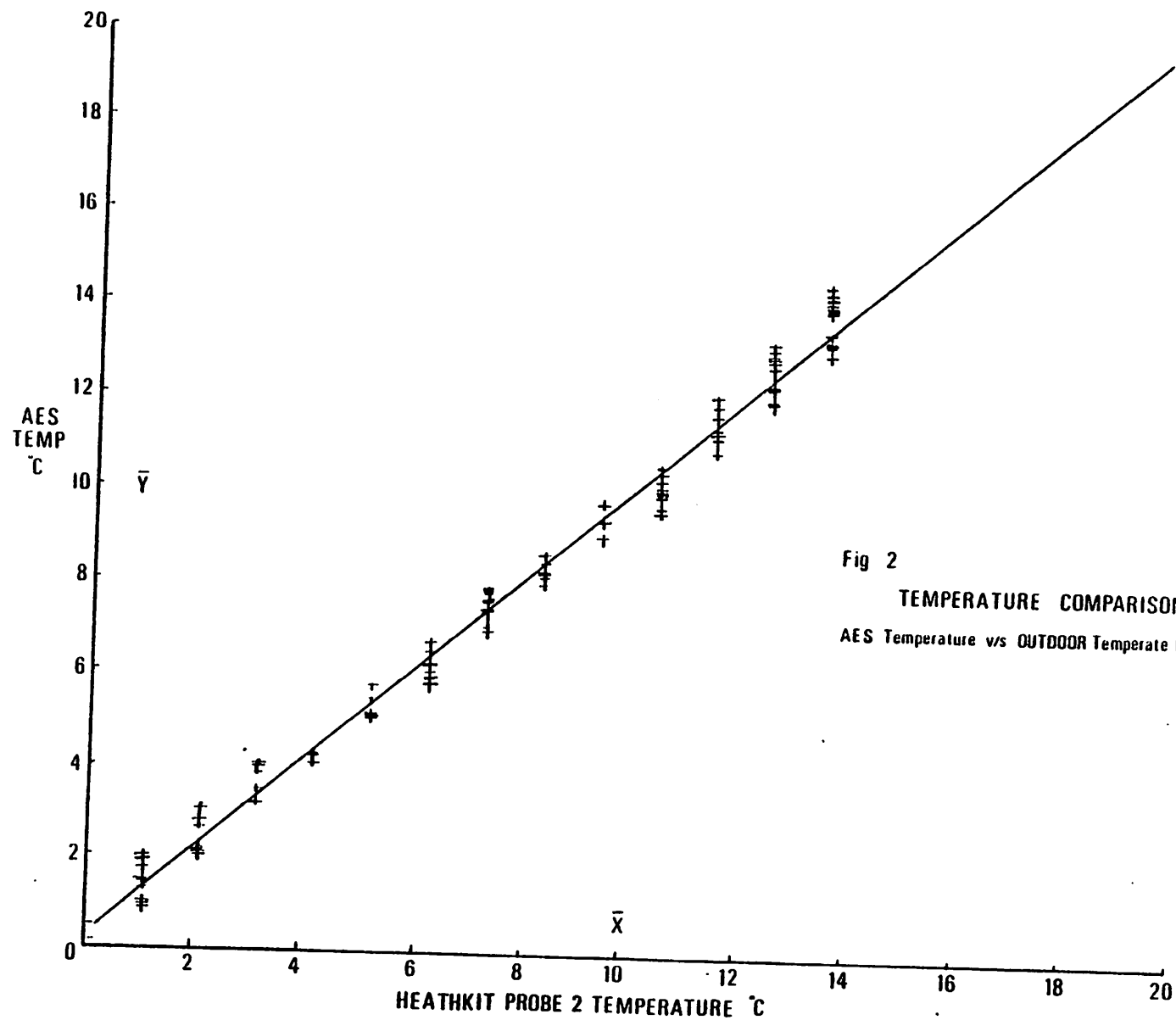


Fig 2  
TEMPERATURE COMPARISON  
AES Temperature v/s OUTDOOR Temperature Probe 2

Table II

# ANALYSIS FOR CORRELATION BETWEEN HEATHKIT TEMPERATURE PROBES 1 & 2 vs. A.E.S. THERMOMETER READINGS

HEATHKIT PROBE 1 vs. A.E.S. THERMOMETER			
Class (C°)			
0 > 4.99	$\bar{X} = 1.54$	$\bar{Y} = 2.31$	$N = 37$
	$S_x = 1.26$	$S_y = 1.29$	$S_{xy} = 1.57$
	Coef of Corr = $9.63 \times 10^{-1}$		
5 > 9.99	$\bar{X} = 6.63$	$\bar{Y} = 7.33$	$N = 46$
	$S_x = 1.28$	$S_y = 1.40$	$S_{xy} = 1.75$
	Coef of Corr = $9.68 \times 10^{-1}$		
10 > 14.99	$\bar{X} = 1.15$	$\bar{Y} = 1.24$	$N = 52$
	$S_x = 1.20$	$S_y = 1.45$	$S_{xy} = 1.78$
	Coef of Corr = $9.72 \times 10^{-1}$		
Summary	$\bar{X} = 7.09$	$\bar{Y} = 7.82$	$N = 135$
	$S_x = 4.19$	$S_y = 4.34$	$S_{xy} = 17.63$
	Coef of Corr = 9.68		
	$R^2 = .938$		
	$A = .708$		
	$B = 1.00$		

HEATHKIT PROBE 2 vs. A.E.S. THERMOMETER			
Class (C°)			
0 > 4.99	$\bar{X} = 1.86$	$\bar{Y} = 2.31$	$N = 37$
	$S_x = 1.25$	$S_y = 1.29$	$S_{xy} = 1.54$
	Coef of Corr = $9.58 \times 10^{-1}$		
5 > 9.99	$\bar{X} = 6.97$	$\bar{Y} = 7.15$	$N = 46$
	$S_x = 1.35$	$S_y = 1.76$	$S_{xy} = 1.65$
	Coef of Corr = $9.68 \times 10^{-1}$		
10 > 14.99	$\bar{X} = 1.17$	$\bar{Y} = 1.21$	$N = 52$
	$S_x = 1.16$	$S_y = 2.24$	$S_{xy} = 1.29$
	Coef of Corr = $9.64 \times 10^{-1}$		
Summary	$\bar{X} = 7.39$	$\bar{Y} = 7.91$	$N = 135$
	$S_x = 4.15$	$S_y = 4.29$	$S_{xy} = 17.77$
	Coef of Corr = $9.96 \times 10^{-1}$		
	$R^2 = .991$		
	$A = .282$		
	$B = 1.03$		

Table III Comparison of Windspeed Measurements

HEATHKIT			ATMOSPHERIC ENVIRONMENT SERVICE	
WINDSPEED	DIRECTION		WINDSPEED	DIRECTION
03	NNE	← SIMULTANEOUS RECORDINGS →	03	NNE
04	NNE		04	NNE
03	NNE		04	NNE
04	NNE		04	NNE
04	NNE		04	NNE
03	NNE		03	NNE
06	NNE		06	NNE
03	NNE		03	NNE
02	NNE		04	NNE
03	NNE		02	NNE
04	NNE	WINDSPEED RECORDED IN KNOTS  1 KNOT = 1.85 kmph = 1.15 mph	04	NNE
06	NNE		06	NNE
06	NNE		04	NNE
04	NNE		05	NNE
05	ESE		06	ESE
05	ESE		05	ESE
05	ESE		07	ESE
09	ESE		05	ESE
12	ESE		10	ESE
08	ESE		10	ESE
08	ESE		10	ESE

# DAMPENING EFFECTS ON ACTUAL WINDSPEED

Fig 3

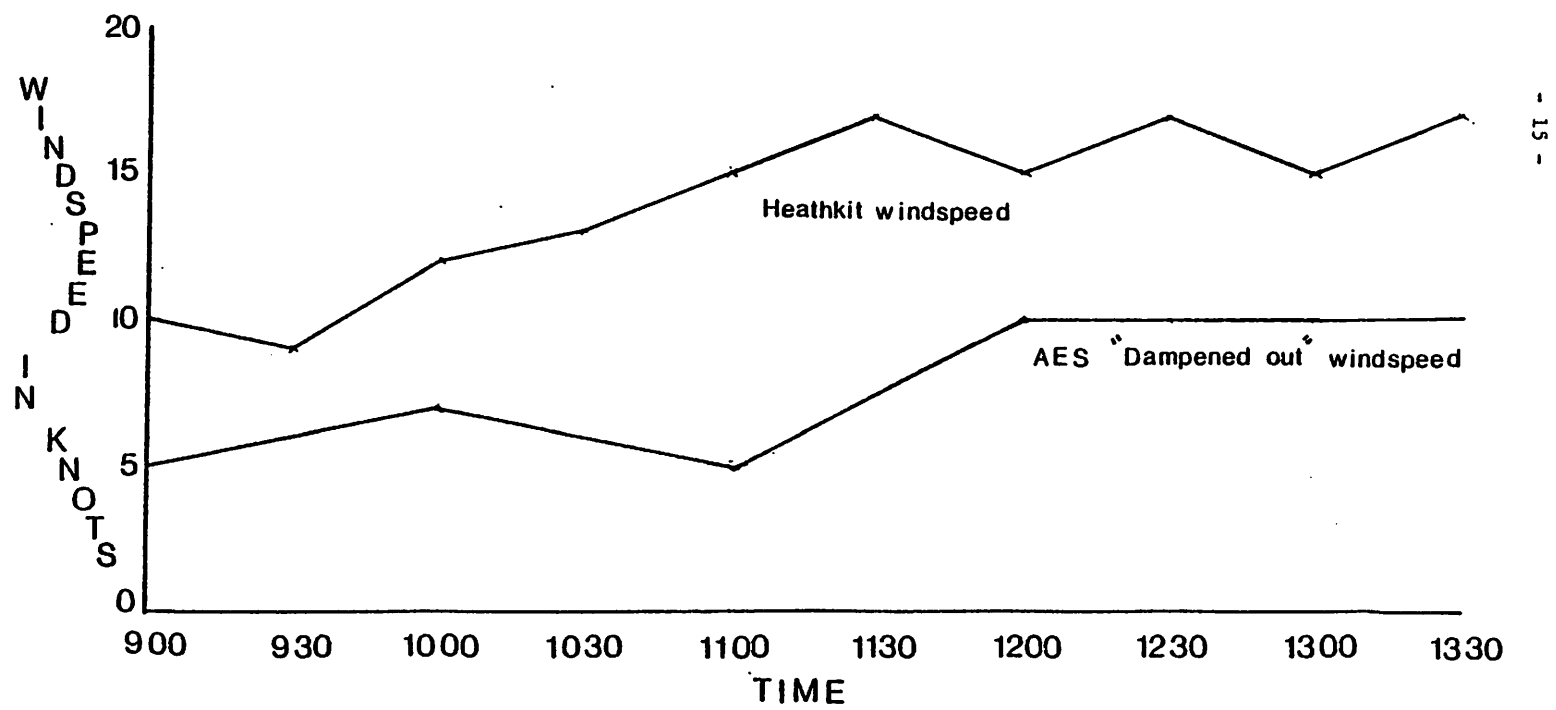


Table IV

BAROMETRIC PRESSURE

HEATHKIT WEATHER COMPUTER		ATMOSPHERIC ENVIRONMENT SERVICE		
BAROMETRIC PRESS.		BAROMETRIC PRESS.		
1021	▲	← SIMULTANEOUS RECORDINGS →	1021	▲
1021	▲		1021	▲
1020	➤		1020	➤
1021	▲		1021	▲
1007	▼	BAROMETRIC PRESSURE TENDENCY ➤ STABLE ➤ ▲ RISING ▲ ▼ FALLING ▼ THE HEATHKIT BAR, PRESS, WAS RECORDED IN MILLIBARS WHILE THE A.E.S. BAR, PRESS, WAS RECORDED IN INCHES OF HG CONVERTED TO MILLIBARS,	1007	▼
1006	▲		1006	▲
1006	▲		1006	▲
1007	▲		1007	▲
1007	▲		1007	▲
1007	▲		1007	▲
1004	▼		1004	▼
1003	➤		1003	➤
995	➤		995	➤
1011	▼		1011	▼
1011	▼		1011	▼
1011	➤		1011	➤
1011	➤		1011	➤
1015	▼		1015	▼
1015	▼		1015	▼
1021	➤		1021	➤
1016	➤		1016	➤

#### LITERATURE CITED

Armstrong, J. A. 1977. Determination of suitable weather conditions for forest aerial spraying. In Pesticide Management and Insecticide Resistance, Academic Press, Inc., New York.

#### ACKNOWLEDGEMENTS

Thanks are extended to Mr. Ron Houghton and staff of the Atmospheric Environment Service and Mr. H. Mingle, Manager of the Sault Ste. Marie Airport for their valuable cooperation in the comparison of meteorological equipment and access to equipment. J.W.G. Beveridge of FPMI built the Heathkit unit; B. F. Zylstra and R. F. DeBoo reviewed the manuscript.

APPENDIX 1

Excerpts from the Heathkit Model ID4001

Weather Computer Manual



## OPERATION

Refer to Pictorial 4-1 (Illustration Booklet, Page 4) for the locations of the displays and switches. These switches and displays are described below. If necessary, again review the "Initial Tests" steps under "Rear Panel Switches" (Page 7) and "Front Panel Pushbuttons" (Page 8).

The numbers at the beginning of the following paragraphs correspond to the numbers on Pictorial 4-1.

## DISPLAY

### TEMPERATURE

1. FAHRENHEIT/CELSIUS indicators — Indicate whether the displayed temperature is in Fahrenheit or Celsius.
2. OUTDOOR/INDOOR indicators — Indicate OUTDOOR when the outdoor temperature is displayed and INDOOR when the indoor temperature is displayed.
3. TEMPERATURE display — Indicates the temperature.

### TIME/DATE

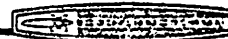
4. AM/PM indicators — Indicate AM or PM while 12-hr time is displayed, but are turned off while the date or 24-hr time is displayed.
5. HOURS/MONTH display — Indicates the hours (1-12 or 0-23) or the month (1-12).
6. MINUTES/DAY display — Indicates the minutes (0-59) or the day (1-31).
7. SECONDS display — Indicates seconds (0-59).

### WIND

8. WIND DIRECTION indicators — Indicate the direction that the wind is coming from.
9. SPEED display — Indicates the speed of the wind.
10. MI/H-KNOTS-KM/H indicators — Indicate the selected wind speed unit-of-measure.

### BAROMETER

11. BAROMETRIC PRESSURE display — Indicates the barometric pressure.
12. RISING/FALLING indicators — Indicate if the barometric pressure is rising or falling.
13. INCHES/MILLIBARS indicators — Indicate whether the barometric pressure is being displayed in inches or millibars.



## FRONT PANEL PUSHBUTTON SWITCHES

14. **CLEAR** — Clears the minimum (MIN) or maximum (MAX) temperature, pressure, or wind PEAK GUST from memory. This switch and another switch (MIN, MAX, PEAK GUST) must be pushed simultaneously. After this switch is released, any future temperature, pressure, or wind peak gust is entered into memory for later comparison. Also, the present time is put into memory.

### TEMPERATURE

15. **MIN** — Causes the minimum temperature that was sensed after the last time this function was "cleared" to be displayed. Also, the time and date that this minimum temperature occurred will be displayed.
16. **MAX** — Causes the maximum temperature that was sensed after the last time this function was "cleared" to be displayed. Also, the time and date that this maximum temperature occurred will be displayed.
17. **WIND CHILL** — Causes the current wind chill temperature to be displayed.

### PRESSURE

18. **MIN** — Causes the minimum pressure that was sensed after the last time this function was "cleared" to be displayed. Also, the time and date that this minimum pressure occurred will be displayed.
19. **MAX** — Causes the maximum pressure that was sensed after the last time this function was "cleared" to be displayed. Also, the time and date that this maximum pressure occurred will be displayed.
20. **RATE CHANGE/HR** — Causes the rate of pressure change within the last hour to be displayed. (The display will be the displayed barometric pressure for the first hour after you plug in the line cord.) There will be no RATE CHANGE/HR indication during the first hour of operation.

### WIND

21. **PEAK GUST** — Causes the peak gust of wind that was sensed after the last time this function was "cleared" to be displayed.
22. **WIND AVG** — Causes the SPEED display to indicate the average wind speed.

## REAR PANEL SWITCHES

### WIND

23. **MI/H-KNOTS-KM/H** — Selects the desired unit-of-measure for measuring wind speed.

### PRES (Barometric Pressure)

24. **INCHES/MILLIBARS** — Determines whether the barometric pressure will be displayed in inches or millibars. It also selects the INCHES or MILLIBARS indicator.

### TEMP (Temperature)

25. **°F/°C** — Selects either the FAHRENHEIT (°F) indicator or the CELSIUS (°C) indicator.

26. **AUTO/HOLD** — In the AUTO position, the TEMPERATURE display alternately displays the outdoor and indoor temperatures. Also, the corresponding OUTDOOR/INDOOR indicators light with the appropriate temperature display. In the HOLD position, either the outdoor or the indoor temperature, and the appropriate OUTDOOR/INDOOR indicator, is displayed continuously, whichever one was being displayed when the switch was placed in the HOLD position.



#### TIME/DATE

27. **START/STOP** — Starts and stops the clock. First, stop the clock. Then use the HR/MO ADVANCE, the MIN/DAY ADVANCE, and the AUTO/HOLD switches to set the date and time. As time reaches the set time, start the clock.
28. **HR/MO ADVANCE** — Advances the HOURS/MONTH display one hour, or one month, each half second.
29. **MIN/DAY ADVANCE** — Advances the MINUTES/DAY display one minute, or one day, each half second.

NOTE: When the two switches (HR/MO ADVANCE and MIN/DAY ADVANCE) are used together, they will advance the MINUTES/DAY display ten minutes each half second.

30. **AUTO/HOLD** — In the AUTO position, the TIME/DATE display alternately displays the time and date. In the HOLD position, either the time or the date is displayed continuously; whichever one was being displayed when the switch was placed in the HOLD position.
31. **12HR/24HR** — Selects either the 12-hour or 24-hour format for displaying time.

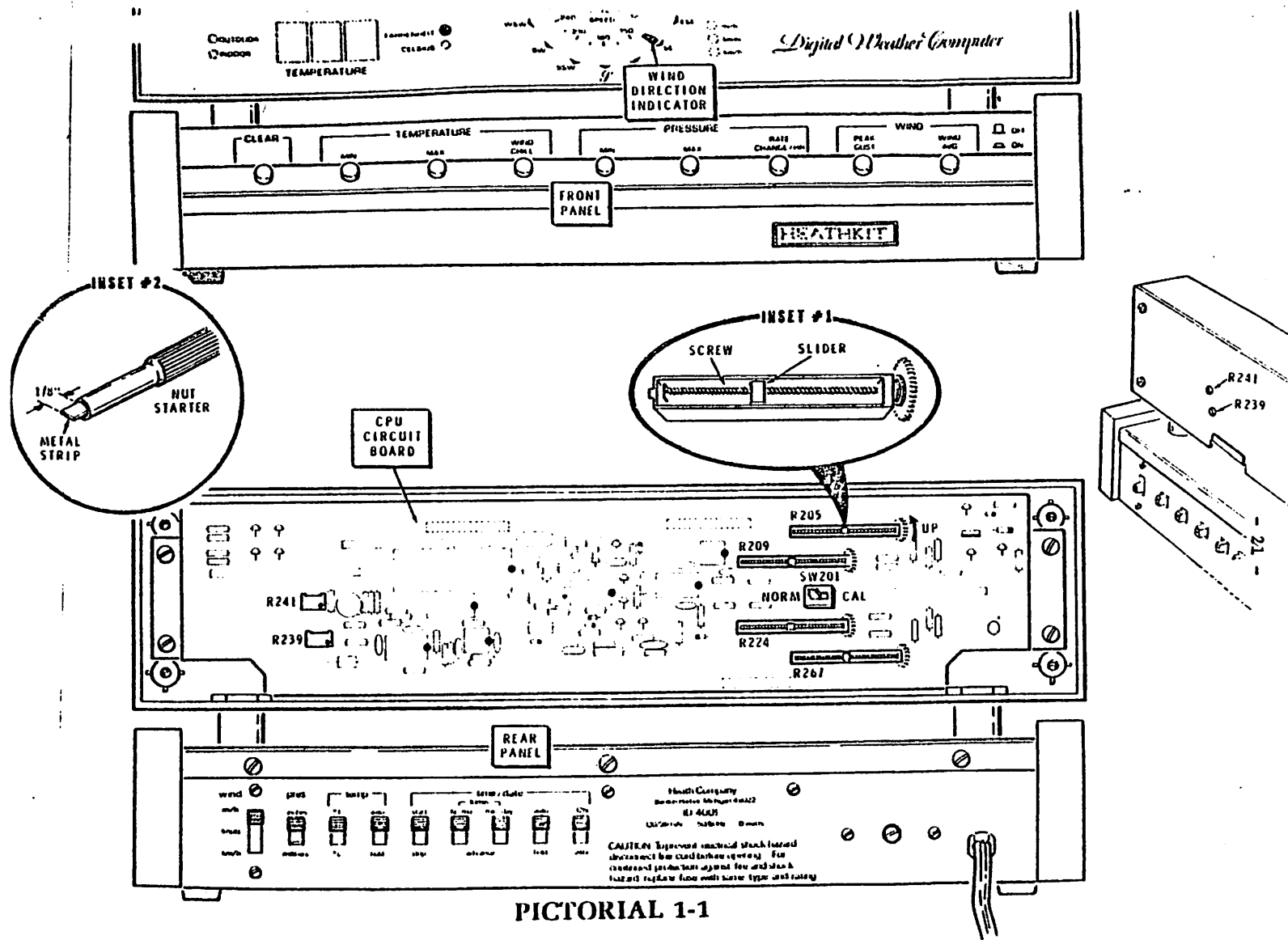
### SETTING THE DATE AND TIME

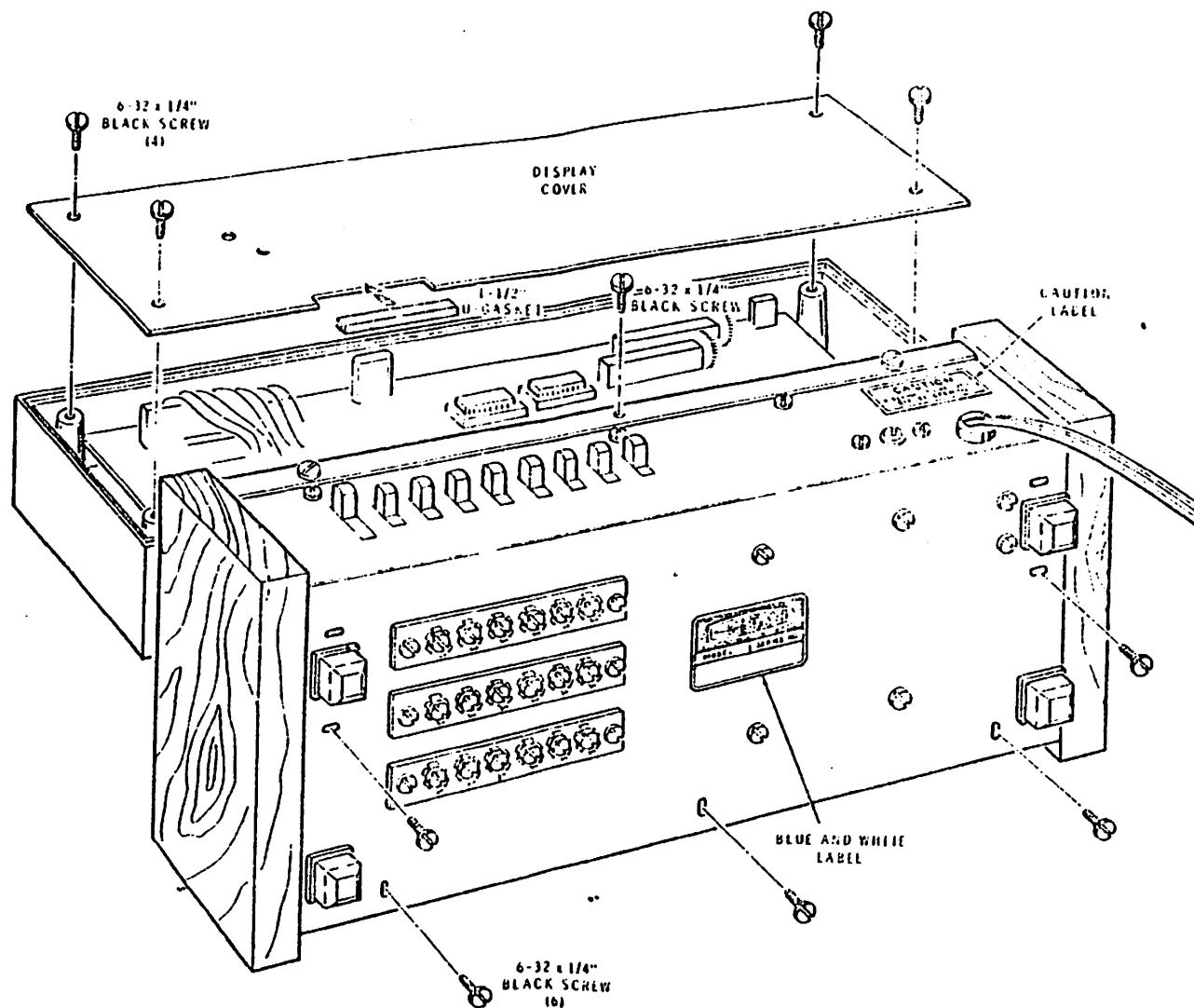
#### DATE

1. When the date is being displayed, place the TIME/DATE AUTO/HOLD switch in the HOLD position.
2. Use the HR/MO and MIN/DAY switches and set the date in the TIME/DATE display.
3. Place the TIME/DATE AUTO/HOLD switch in the AUTO position.

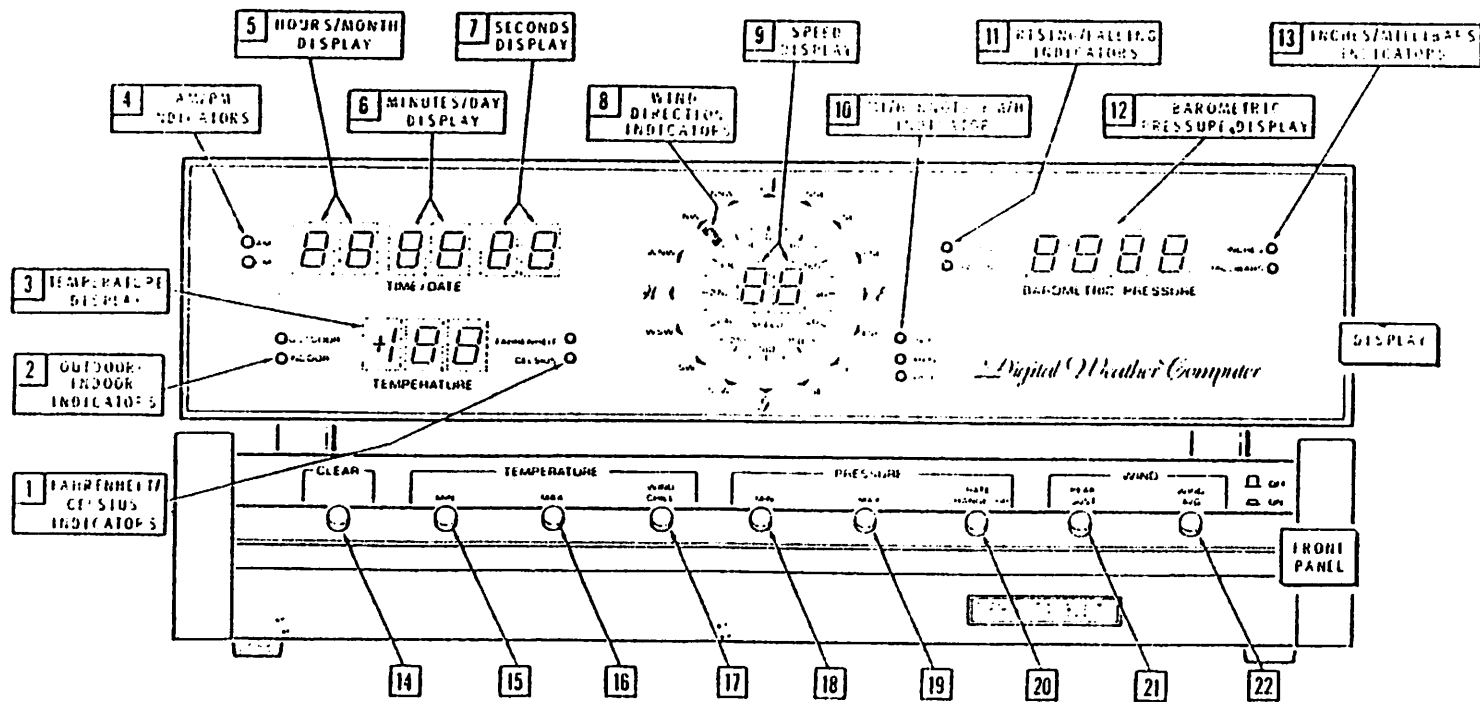
#### TIME

1. When the time is being displayed, place the TIME/DATE START/STOP switch in the STOP position.
2. Use the HR/MO and MIN/DAY switches and set the TIME/DATE display to the desired time.
3. As real time reaches the time set in the display, place the START/STOP switch in the START position.





PICTORIAL 2-1





## SPECIFICATIONS

### DIGITAL CLOCK/4-YEAR CALENDAR

Displays .....	8-digit, 12- or 24-hour format time readout; 4-digit date readout. AM-PM indicator in 12-hour format.
Time Accuracy .....	Determined by the accuracy of the AC line frequency. No accumulative error.
Controls (rear panel) .....	Clock start-stop. Hours/months advance. Minutes/day advance. 10 minutes advance. Time-date hold. 12- or 24-hour time format.

### WIND VECTOR

#### Speed

Displays .....	2 significant digits. Separate indicators show whether display is in miles-per-hour, knots, or kilometers-per-hour.
Memory .....	Date, time, and magnitude of maximum gust.
Accuracy .....	$\pm 5\%$ or better.
Controls	
Front Panel .....	Peak gust, wind average select and clear.
Rear Panel .....	Mi/h-knots-km/h select.

#### Direction

Display .....	One of sixteen indicators arranged in a circular compass configuration. Identified by compass points and radial degrees.
Accuracy .....	$\pm 11.25$ degrees.

## THERMOMETER

Displays .....	2-1/2-digit readout with "+" and "-" signs, indoor-outdoor indicators, and Fahrenheit-Celsius indicators. Display alternately indicates indoor and outdoor temperatures.
Format .....	Switch selected °C (Celsius) or °F (Fahrenheit) readout.
Temperature Range .....	-40°C to +70°C (Celsius). -40°F to +158°F (Fahrenheit).
Accuracy .....	±1° from -40°C to +70°C. ±2° from -40°F to +158°F.
Memory .....	Date, time, and magnitude of maximum and minimum temperatures.
Controls	
Front Panel .....	Wind chill select. Minimum temperature select and clear. Maximum temperature select and clear. Indoor-outdoor display hold. °C (Celsius) -°F (Fahrenheit) select.
Rear Panel .....	

## BAROMETER

Displays .....	4-digit readout. Separate indicators show whether pressure is rising or falling and whether display is in inches of mercury or millibars.
Pressure Range .....	28.00 to 32.00 in. Hg (inches of mercury). 98.1 to 1050 millibars.
Accuracy of Reading .....	29.00 to 31.00 in. Hg (inches of mercury). ±.25% plus ±.033% C.
Memory .....	Date, time, and magnitude of maximum and minimum pressure.
Controls	
Front Panel .....	Minimum pressure select and hold. Maximum pressure select and hold. Rate of change/hour select.
Rear Panel .....	Millibars or inches of mercury select.



## GENERAL

Power Requirements .....	120/240 volts AC, 50/60 Hz; approximately 8 watts. Provision for connection of an external battery, which can supply 6.20 - 14.80 volts DC at 60 mA., to hold memory contents during power interruptions (this feature suspends all functions during the interruption and draws current from the battery only during the interruption).
Operating Temperature	
Outdoor assemblies .....	-40°C to +70°C (-40°F to +158°F).
Unit .....	15°C to 35°C (59°F to 95°F).
Dimensions (overall) .....	16" wide × 6" deep × 7-1/4" high. (40.6 × 15.2 × 18.4 cm).
Weight .....	9 lb. (4.08 kg).

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The Heath Company reserves the right to discontinue products and to change specifications at any time without incurring any obligation to incorporate new features in products previously sold.