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AN/AMT-22 METEOROLOGICAL DROPSONDE AND RDSRU (REFRACTIVE DROPSONDE SIGNAL RECORDING UNIT) PROCESSOR ENGINEERING FIELD TEST RESULTS

John S. Sniscak
Sensors and Avionics Technology Directorate
NAVAL AIR DEVELOPMENT CENTER
Warminster, Pennsylvania 18974

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This technical report documents laboratory and engineering field test results that have been acquired and evaluated in 1978, during the evolutionary development (DT-2) phase of the AN/AMT-22 dropsonde system. This report documents processing data results obtained from the dropsonde RDSRU processor. A system description of the dropsonde and the RDSRU is also provided. Appendix A details the meteorological algorithms utilized for the data processing.

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SUMMARY

1. Introduction/Background

As part of AIRTASK A370370C/001B/9F52-550-000, this command is tasked by NAVAIR to develop the AN/AMT-22 dropsonde system and to evaluate its performance through an extensive TECHEVAL program. The dropsonde sensor, which is capable of measuring meteorological data, is being developed by JMR Systems Corporation, Salem, New Hampshire. The dropsonde program was initiated in June 1976 and TECHEVAL is scheduled to commence in September 1979. The principal use of the dropsonde data at present will be within the IREPS (Index of Refraction Effects Prediction System) for propagation analysis. However, it is also anticipated that the dropsonde will be used by P-3C and S-3A aircraft as a vital aid to their ASW (Antisubmarine Warfare) missions and to their survivability requirements. In addition, potential modifications to the dropsonde, including wind-sensing capability and integration with the AN/SSQ-36 airborne expendable bathythermograph (AXBT) sensor will provide the Navy with a consolidated, improved ASW environmental sensor capability.

The processor function of the dropsonde system, the RDSRU (Refractive Dropsonde Signal Recording Unit) processor, was developed by Bendix Corporation, Baltimore, Maryland, during the period July 1976 to June 1977 and was tested and accepted by NAVAIRDEVCEN. Bendix was also tasked to develop a modified version of the RDSRU, namely the RASP (Refraction

Anomalies Signal Processor), to implement the current dropsonde modification of replacing the baroswitch pressure sensor with the CAPS (Continuous Analog Pressure Sensor). Delivery date of the RASP was slated for 30 September 1979.

This DT-2 (Development Testing) report documents laboratory and field test results that have been acquired and evaluated during the evolutionary development of the dropsonde system design. The ultimate goal of this phase is to demonstrate that design risks have been identified and minimized; that the engineering, design, and development process is complete; and that the performance of the dropsonde system will meet the required specifications.

2. Summary of Results

Four major field tests were conducted in 1978 to verify the overall dropsonde design. Mechanical tests at Warren Grove (New Jersey) in July and at Lakehurst (New Jersey) in September were held to verify the dropsonde deployment mechanism (without any "live" electronics). To prove the adequacy of the transmitted dropsonde signal, field tests were conducted at Key West (Florida) in February and at Cape Hatteras (North Carolina) in September. In addition, laboratory and antenna range tests were performed at NAVAIRDEVCEN in August to improve the tuning procedure of the transmitter board and to refine the antenna design.

a. The received dropsonde signal during the Key West test was noisy, erratic, and marginal in S/N (Signal-to-Noise) ratio. Of the nine sondes launched, four had inoperable thermistors and one generated a very noisy hygristor signal. Due to the poor quality of the incoming signal, the RDSRU processor was unable to process any data during the flights. Only the first launch was capable of being processed subsequently in the laboratory, using a more elaborate processing setup. Mechanically, five of the nine launches had no deployment problems, three experienced premature drogue chute separations from the sonde housing, and the remaining launch encountered a late deployment of the air tab and the drogue chute. Several mechanical and electrical modifications were implemented into the dropsonde design as a result of the failures incurred during this test.

b. At the Warren Grove test, five of the nine launched units experienced no deployment problems. All three of the sondes launched at the maximum aircraft speed (330 kn) encountered failures. Out of the six sondes dropped at velocities of 250 kn or less, only one failure occurred. All of the failures were related to one or more of the following areas: (1) rough finished or improperly polished parts in the timer mechanism, (2) marginal design tolerances in the timer release hardware, and (3) marginal drogue and main parachute shroud line strength at the upper end of the launch envelope. From the results of this test, several design modifications to the timer mechanism were made and the need for another deployment-related drop test was dictated.

c. From the results of the nine sondes launched during the Lakehurst deployment test, it was concluded that the dropsonde design was satisfactory at aircraft speeds up to 300 kn at 1,000 feet of altitude, a severe point on the sonobuoy launch envelope. One failure occurred out of four sondes launched at velocities of 300 kn or less and three failures occurred out of five dropsondes launched at speeds of 325 kn or greater. The two main causes of the deployment failures were in the areas of improper timer mechanism release and fraying of the 500 pound test line. Several design modifications were implemented to the timer mechanism to correct these problems.

d. Laboratory and antenna range tests conducted at NAVAIRDEVCEN indicated deficiencies in the antenna-transmitter subsystem of the dropsonde. An improved simplified transmitter board tuning procedure was developed that utilized a maximum power, rather than minimum current, technique. Refinements in the antenna design, specifically a modification of its actual dimensions and the establishment of an improved grounding point, were also developed.

e. The Cape Hatteras test successfully verified the integrity and RF strength of the transmitted dropsonde signal. The entire five sonde launches were very satisfactory in the areas of deployment and RF and data transmission and reception. However, the RDSRU processor only produced one satisfactory data run during the flight. With the use of the NAVAIRDEVCEN laboratory processing scheme, the data from all five launches were subsequently processed successfully. The data agreed very well with the corresponding National Weather Service rawindsonde data, except for an offset in humidity in several instances. A satisfactory data run of the final drop, utilizing the RDSRU, was also conducted in the laboratory. The resulting atmospheric data outputs matched those generated by the more elaborate NAVAIRDEVCEN processing scheme. However, several shortcomings in the RDSRU processor were identified, specifically the need for data validation, noise rejection, and data averaging capabilities.

3. Conclusions

The engineering, design, and development process for the dropsonde has been satisfactorily completed, except for the current effort of replacing the baroswitch pressure sensor with that of the CAPS sensor. From the results of four major tests conducted during 1978, many mechanical and electrical improvements were implemented into the dropsonde design. The successful results of the final deployment and electrical tests (at Lakehurst and Cape Hatteras, respectively) demonstrate that design risks have been identified and minimized and that the performance of the dropsonde system will meet the required specifications.

4. Recommendations

Based on the successful outcome of the Lakehurst deployment and Cape Hatteras electrical tests, it appears that the dropsonde design problems have been identified, corrected, and minimized. As a result, it is recommended that the dropsonde system advance into the TECHEVAL phase of the program.

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1. INTRODUCTION

The main text of this technical report is divided into six major sections. The first section will present a detailed description of the dropsonde sensor, dropsonde processor, and the processor output data formats, including anticipated users. The next four sections will separately describe each of the four major field tests conducted during FY78; i.e., tests at Key West, Florida; Warren Grove, New Jersey; Lakehurst, New Jersey; and Cape Hatteras, North Carolina. Included in each field test section is a test objective, test setup, test results, conclusions, and recommendations, including corrective design changes. The last major section will relate final conclusions and recommendations based on the results of the four major tests. The intent of this format is to provide a chronological sequence of test results, conclusions, and recommendations.

2. SYSTEM DESCRIPTION

The dropsonde system under development consists of a sensor and a processor. The intent is to utilize the dropsonde system with currently used ASW aircraft receivers, much in the same manner as a sonobuoy and its processor. The dropsonde sensor, processor, and applications for dropsonde-acquired meteorological data will be detailed in the following three sections.

2.1 Dropsonde Sensor

The AN/AMT-22 dropsonde sensor is capable of measuring atmospheric pressure, temperature, and humidity parameters to altitudes of 30,000 feet. The dropsonde is contained within the form factor of an "A"-size sonobuoy (4.875 in. diameter x 36 in. length cylinder). As a result, the sensor can be loaded aboard and CAD (Cartridge Actuated Device) launched from ASW aircraft in the identical manner as sonobuoys. The weight of the dropsonde sensor is 11 pounds.

After launch the dropsonde is retarded in the airstream by a two-stage parachute system that is initiated by a wind flap mechanism. First, a drogue parachute is deployed to decelerate the dropsonde. Within 6 seconds, the timing out of a timer mechanism causes the release of the drogue chute from the sonde and the deployment of the main parachute, a 4-foot diameter ribless guide type. Thus, once deployed into the airstream, the sensor orients and stabilizes within 6 seconds, while descending at a rate of 1700 ft/min. The deployment sequence is illustrated in figures 16 through 21 in section 5 of this report.

The current version of the dropsonde utilizes a baroswitch device that contains resistive pressure contacts for discrete atmospheric pressure measurements. With the baroswitch the data commutation rate is 400 ms/cycle, yielding a data profile resolution of 12 feet. Each cycle consists of four 100 ms parameters in the following order: (1) reference frequency, (2) atmospheric temperature, (3) atmospheric pressure, and (4) atmospheric humidity. The reference signal is approximately 2500 Hz and the other data information ranges in frequency from 225 to 2250 Hz. The commutation signal, a "rounded" square wave of 50 ±5% duty cycle, is generated by a commutator-oscillator network, which converts the individual sensor resistive values to first, corresponding voltages and then, to the proper frequencies. The temperature and humidity sensors utilized are a VIZ rod thermistor (-65° C to + 50° C, ±0.5° C) and a VIZ carbon hygristor (0% to 100%, ±5% relative humidity), respectively. An ongoing development effort will replace the current baroswitch with a Honeywell CAPS sensor, the output of which will vary smoothly and continuously over a range of 1050 to 10 millibars with an accuracy of ±2 mb. This modification in the pressure-measuring device will change the commutation rate from 400 to 800 ms/cycle with eight 100 ms parameters in the following order: (1) reference frequency, (2) atmospheric temperature, (3) pressure, (4) humidity, (5) temperature of the CAPS sensor, which is a parameter used in the pressure algorithm, (6) atmospheric temperature, (7) pressure, and (8) humidity.

The sensor data are multiplexed into the LOFAR (Low Frequency Analysis and Recording) sonobuoy acoustic passband and telemetered to the aircraft on one of three VHF sonobuoy channels (channels 12, 14, and 16) used by the AXBT (Aircraft Expendable Bathythermograph) sonobuoy. This format enables the present avionics aboard ASW aircraft to receive this data and record it on magnetic tape units normally used for acoustic data from sonobuoys. The VHF frequencies are generated by an SSQ-41A transmitter board located within the dropsonde and have a nominal power output of 1 watt. The power source for the transmitter and commutation electronics is a 6-cell, 22.5 volt lithium (SO_2) battery having a nominal operating life of 120 minutes.

2.2 Dropsonde Processor

The current dropsonde processing scheme, which consists of an RDSRU processor and an Axiom EX-800 electrosensitive printer, is capable of near real-time processing of dropsonde meterological data. The processor is designed to condition, decommutate, and digitize dropsonde data that is inputted from the ASW receiver. Through algorithms in its software package, the RDSRU will then convert the digitized data to engineering units as meteorological and refractivity data, select significant values, and display the output on the printer.

Tables XVI, XVII, and XVIII of section 6 are examples of typical RDSRU output data. In table XVI the RDSRU-calculated values of pressure, temperature, humidity, and M and N engineering units are displayed as a function of calculated altitude, along with launch conditions and the estimated surface pressure. In table XVII the period values of reference frequency, temperature, pressure, and humidity are depicted as a function of processor time. Lastly, ducting effects, including pertinent altitudes and engineering units, that are output by the RDSRU are illustrated in table XVIII.

Four PC boards are located within the RDSRU to process the data: (1) input signal conditioning board that contains a data buffer, a 10 Hz decommutation detector and PLL (Phase-Locked Loop), a counter that gates each data parameter for a 10-period window, and a digitizer that converts each data frequency to a 16-bit word, (2) SBC 80/10 board that serves as a CPU (Central Processing Unit), (3) 16 K byte RAM (Random Access Memory) board, and (4) 16 K byte EPROM (Eraseable Programmable Read Only Memory) board that contains the software package with the appropriate meteorological and refractivity algorithms.

The front panel of the RDSRU contains the following items: (1) power off-on switch, (2) power on, system fault, system busy, and data received LED lights, (3) BNC input connections for processing both receiver data and tape recorder data, and (4) a numeric keyboard for prelaunch entering of baroswitch calibration data, thermistor and hygristor lock-in resistance values, and launch conditions, such as drop altitude, latitude, longitude, and date. A reference to table XIX of section 6 will illustrate a typical RDSRU display of prelaunch input data.

The RDSRU can be powered either with a 115 VAC, 60 or 400 Hz external source or a self-contained battery. The weight of the RDSRU is approximately 55 pounds and its dimensions are 18 in. in length, 11 in. in width, and 14 in. in height. The RDSRU is a unique piece of hardware with no production anticipated. An ongoing development effort is being conducted to replace the RDSRU with the RASP processor, which will be an updated version of the RDSRU with the capability of processing continuous pressure data supplied by the CAPS sensor. Figure 22 of section 6 is a block diagram of the proposed P-3C dropsonde processing configuration. The new printer to be utilized with the RASP will be a Miltope TP2000 model, a ruggedized, high-speed, 40 column thermal printer.

2.3 RASP Processor Output Data Formats and Users

A total of four data output formats will be provided by the RASP processor in a 40 character-wide printout. These output formats include: (1) duct report to the aircrew, (2) refractivity profile report, (3) meteorological profile report with mandatory and significant levels, and (4) raw data dump output. An operation manual for utilization of this data will be forthcoming.

The duct report to the aircrew is mandatory and not operator selectable. Basically, the report describes any present real-time refractive layers, including the pressure altitudes (in feet) at the top and the bottom of the duct and the strength of the duct (in M engineering units). The printout will also indicate date, time, latitude, longitude, and sonde type and serial number. The duct report is required by the PPC (Patrol Plane Commander) for avoidance of radar detection of the aircraft and its special ordnance, since the presence of and location of ducts, caused by certain atmospheric conditions, determine the effects on the propagation of electromagnetic radiation. The real-time duct information can be compared on site with the mission environment prediction received prior to flight and adjustments and refinements in the mission plan can be made when required. In addition, a message can be transmitted back to the meteorological center or TSC (Tactical Support Center) indicating differences between the predicted information and the on site measurements, for near-future flight plans.

The second report, the refractivity profile, is also mandatory and not operator selectable. The refractivity information reported is available within minutes after the cessation of sonde telemetered data and includes significant refractivity points (in M-units), the corresponding pressure altitudes (in feet) and geopotential altitudes (in meters), and the pertinent header information described previously. This refractivity information will be used as an input to the IREPS system to develop tactical mission plans through propagation analysis, especially in the generation of radar coverage plots. Further detailed information concerning the IREPS system and basic refractive effects theory can be obtained in reference (a). The number of significant data points generated in this report is limited to 29 for compatibility with the IREPS input format and the altitudes are listed in ascending order. An RS232C interface will be used between the RASP and IREPS units and special precautions are currently being made to modify the IREPS software for compatibility with the RASP output formats.

The meteorological profile report, which is also mandatory (not operator selectable), contains the necessary data for WMO (World Meteorological Organization) format weather reporting. These data collectively form the input to a local weather prediction by the meteorological unit aboard carriers and land-based Naval weather stations. The meteorological data reported by the processor consists of mandatory levels of pressure (mb), altitude (meters), temperature (° C), and dew point depression (° C) and significant levels of pressure (mb), temperature (°C), and dew point depression (° C). This meteorological report can also be utilized to provide FNWC (Fleet Numerical Weather Central) with data to facilitate global weather assessments and to provide the research and development community with archival data. Lastly, this meteorological printout indicates to the aircrew that the processor is functioning properly in the absence of a duct report if no refractive anomalies are present.

The fourth (and last) report is an optional data dump necessary for developmental and debugging purposes. The data printed out consists of period values of the eight parameters (reference frequency, free air temperature, pressure, humidity, CAPS temperature, free air temperature, pressure, and humidity), along with processor time, at each of the mandatory and significant points listed in the meteorological profile report. Thus, this data dump will serve as a backup to check any unusual atmospheric or refractive points listed in the meteorological profile report.

3. KEY WEST DROPSONDE TEST (16-17 February 1978)

3.1 Objective

The objective of this test was of a threefold nature: (1) to verify the deployment operations of the dropsonde, (2) to determine the RF strength and the integrity of the transmitted dropsonde signal, and (3) to employ near real-time data reduction of this signal, utilizing a Bendix RDSRU (Refractive Dropsonde Signal Recording Unit) processor.

3.2 Test Setup

The test consisted of CAD launching nine electrically active dropsondes in sonobuoy launch containers from a Navy P-3C aircraft. All of the sondes that were launched were manufactured by the principal contractor, JMR Systems Inc. However, three of the sondes were modified to include the Honeywell, Inc. CAPS (Continuous Analog Pressure Sensor) and its associated electronics package for design verification purposes. The test format consisted of launching the sondes, one at a time, from the P-3C aircraft at altitudes slightly below 12,500 feet and at aircraft speeds of 250 kn. However, because the drogue chute separated from the sonde on two of the four launches on the first test day, it was decided to reduce the aircraft speed to 190 kn for the final day of testing. Additional information related to the dropsondes and the launches is given in tables I and II.

The tasks onboard the aircraft (P-3C No. 158928) consisted of recording the dropsonde data with a 28-track wideband AQH-( ) tape recorder, monitoring the signal levels with an oscilloscope and an ARR-72 receiver signal strength meter, and taking photographs of the incoming signal from the oscilloscope display. Pressure calibration data and other parameters were also input into the RDSRU processor between drops. The dropsonde deployments were photographed through the utilization of a high-speed (200 frames/s) camera mounted on wing station 13.

Prior to the actual drops at Key West, extensive laboratory tests were conducted at NAVAIRDEVCEN to determine whether all of the sondes met the specification requirements. Tests that were performed included verifying the commutation rate, sensor resistance values, oscillator performance, and RF performance, including frequency, power output, and deviation. Calibration of all of the baroswitches was also accomplished. In addition an arrangement was made with the Key West Weather Service Station to launch a rawindsonde on each test day during the launches for data comparison purposes.

3.3 Laboratory Data Processing

The laboratory data processing scheme is illustrated in block diagram form in figure 1. The aircraft 28-track tape recorded dropsonde data are processed in the following manner: (1) tapes are dubbed to provide compatibility with the laboratory 14-track tape recorder, (2) data are bandpass filtered to eliminate unwanted noise outside of the dropsonde signal frequency band and are displayed on a storage oscilloscope, (3) data are then conditioned by an adjustable trigger circuit in a counter and displayed on an oscilloscope so that a suitable triggering level can be set for the counter and that the data can be viewed to determine its integrity, (4) the conditioned data are synchronously decommutated using a frequency-to-voltage converter and a "flywheel" oscillator, which is adjusted, as necessary, to maintain synchronization, and (5) the average period measurement for each 100 millisecond data sample is input to a Tektronics 4051 microcomputer for storage, processing, and display.

The initial portion of the average period measurement data (which are expressed in hundredths of a microsecond) for the first launch is shown in table III. These data are generated by the counter and transferred to the microcomputer during the rerun of the entire sonde deployment. The data are then output by the microcomputer to a printer, a sample from which is given in table III. These period data are then processed in the microcomputer using the following techniques:

a. First, all of the individual pressure contacts for the entire sonde deployment are manually identified by visual examination of the period data. The pressure contacts are fixed resistors (1% tolerance) switched by the baroswitch as the pressure varies. Table III, which is a sample portion of laboratory-measured period data, identifies pressure contact "makes" (switching from an insulated segment to a pressure contact) and "breaks" (switching from a contact to an insulator). It can be seen from the data that the insulating segments are characterized by much higher period values than those at the pressure contacts. The switch contacts are coded as "l's," "5's," and "15's" types to insure pressure data integrity during the sonde's excursion. In the event the RF signal is interrupted, the pressure data can be redefined once the RF is reacquired. Identifying the "l's," "5's," and "15's" pressure contacts is simplified because they have different fixed resistors, and consequently, different period values.

b. Secondly, the period data of temperature, humidity, and reference frequency is selected by the microcomputer from six cycles at each manually-entered pressure "contact-make" specification: the three data cycles preceding the contact "make," the "make" cycle, and the two data cycles following the contact "make." A six-cycle average of the period data about each pressure contact is then computed for temperature, humidity, and reference frequency. The period data are re-examined by the microcomputer and any value that is not within two standard deviations (2 σ) of the average is discarded. A new average is then calculated from the remaining period data points.

c. A listing of these averaged period values for each entire sonde deployment is then generated and visually inspected to determine if any individual averages vary considerably from their adjacent averages. The occurrence of any such discrepancies may result if two or more period values in a six-cycle segment deviate considerably from the remaining period values. In such a case, the calculated average for the six-cycle segment may be altered sufficiently by the "wild" data points as to maintain them within the 2 σ window, thus precluding their elimination by the program. Consequently, when an "unusual" average is found from a visual inspection of the listings, the individual period values that were used in the calculation of the average are then manually re-examined. If any "wild" period values are detected, then they are manually discarded. A new average is manually calculated from the remaining period values and is reinserted into the microcomputer memory. This manual technique of reinspecting the averages and recalculating any deviating averages could have been executed solely by the microcomputer, but due to time constraints, it was deemed impracticable to implement this technique into a computer program.

d. After the average periods for reference frequency, temperature, and humidity are satisfactorily computed at all of the pressure contact, various algorithms stored in the microcomputer are then used to determine the temperature, humidity, altitude, and refractivity (in M and N units) at each pressure contact. These algorithms are detailed in appendix A. In addition, table IV gives a listing of the absolute pressure levels and the averaged period data that are generated by the microcomputer at the first 25 pressure contacts after the commencement of the launch of sonde No. 1.

3.4 Test Results

A summary of the deployments and of the received audio signal information for all of the nine launched dropsondes is detailed in tables V (a) and (b). This summary is based on real-time data collection and subsequent analysis of both the deployment films and the recorded audio tapes. Mechanically, five of the nine launches had no deployment problems and three experienced premature separations of the drogue chute from the sonde assembly. Of these latter three drops, one launch also had no deployment of its main parachute, as determined by its brief flight time of 1 min, 50 s. The remaining launch had an extremely late deployment of the wind flap (air tab) and of the drogue chute (1 second after the commencement of the launch), as determined by a postflight analysis of the aircraft coverage films of the launches.

The received audio dropsonde signal was not able to be processed in all but two of the launches because the signal, in general, was noisy, erratic, and had a marginal S/N (Signal-to-Noise) ratio. The RF levels were also marginal in most cases and RF dropouts and RFI (Radio Frequency Interference) occurred. The magnitude and severity of these RF problems for each drop is detailed in tables V (a) and (b). In addition, four of the sondes (drop numbers 3, 4, 6 and 7) had inoperable thermistors (temperature sensors) and one had an extremely noisy signal from the hygristor (humidity sensor). An examination of the aircraft films revealed that the expendable plastic plunger disc assembly of the P-3C CAD launching system became a free body after leaving the aircraft. As a result, the disc contacted the sensor end of the dropsonde, causing damage to both the thermistor and the hygristor.

Furthermore, it is also suspected that the CAD launching of the dropsondes might induce a slight offset in the calibration of the baroswitches, as a result of the large shock force created during a launching. Cursory laboratory measurements imply that this force may induce a set (a displacement or "readjustment") in the click-adjustment assembly of the baroswitch, with the possibility of causing an offset of a few millibars. It is suggested that this effect be further investigated, if it is decided to return to the baroswitch method, rather than the CAPS or continuous method, of measuring pressure.

Launch numbers 1 and 4 were the only drops that contained processable data, but only the audio signal of drop No. 1 was processed in the laboratory due to the lack of a thermistor signal during the fourth drop. Furthermore, the Bendix RDSRU processor was incapable of processing any of the incoming dropsonde data during the flights due to the general poor quality of the received signal. Also, an intolerable number of unidentifiable contacts of the pressure sensor baroswitch were reported by the RDSRU. However, with the advent of the CAPS pressure sensor and the current development of the RASP dropsonde processor, any shortcomings of the baroswitch and of the RDSRU processor will be alleviated.

The processed data (M and N units, temperature, and humidity) for sonde No. 1 and for the rawindsonde launched by the National Weather Service are shown in graphical form in figures 2 and 3, respectively. Printouts of the individual data points versus altitude and pressure are given in tables VI and VII. Approximately the first 1,000 feet of dropsonde data can be safely discounted since a brief period of time is required for the dropsonde sensors to stabilize to the outside ambient conditions after being subjected to long periods of warm temperature and low humidity conditions in the launching aircraft. Figures 4 through 8 compare the rawindsonde data listings with those of dropsonde No. 1. It can be seen that the data agree very closely, especially the M units, N units, and temperature comparisons. The fact that the rawindsonde and the first dropsonde were launched about one hour apart may explain the discrepancies in the humidity data, since the cloud cover changed slightly. Also, it is not uncommon that a 5-6% difference in humidity measurements may occur between two different hygristors subjected to identical atmospheric conditions.

Photographs of the dropsonde signal acquired from the tape recorded data are shown in figures 9 through 15. The waveforms in figures 9, 10, and 11 are from sonde No. 1, the only sonde whose data was capable of being processed. In figure 9 an entire 100 millisecond data parameter sample is illustrated, along with the halves of two other data samples. In figure 10, the undistorted feature of the dropsonde signal, which is in the neighborhood of 1,400 Hz in this time period, is captured.

Figure 11 depicts the change in frequency between two successive data parameters. The signal waveform for dropsonde No. 3, which had an inoperable thermistor and a defective, noisy hygristor signal, is shown in figures 12 and 13. In figure 13, the 150 Hz noise spikes generated by the hygristor can be observed prior to the appearance of the reference frequency signal. Lastly, in figures 14 and 15, the lack of a thermistor signal is shown for sonde No. 4. The complete 400 millisecond data cycle is captured in figure 14.

3.5 Conclusions and Recommendations

The following conclusions were drawn from an in-depth evaluation and analysis of on-site data, aircraft films, and laboratory data processing:

a. Five of the nine launches had no deployment problems. Three of the launches experienced premature separations of the drogue chute from the sonde housing (of which one launch had no deployment of the main parachute). An extremely late deployment of the air tab and of the drogue chute were problem areas incurred by the remaining launch, although these are not considered to be operational failures.

b. In general, the received dropsonde signal was noisy, erratic, and had a marginal S/N ratio. RF signal dropouts and RFI also occurred.

c. Four of the sondes had inoperable thermistors and one generated a very noisy hygristor signal.

d. Due to the poor quality of the incoming signal, the RDSRU processor was unable to process any of the dropsonde data during the flights. Only the first launch was able to be processed in the laboratory, using the NAVAIRDEVCEN processing scheme described earlier. The processed dropsonde data agrees very closely with the rawindsonde data, except for a 10% offset in relative humidity in many instances.

e. As a result of cursory laboratory measurements, it is suspected that the CAD launching of the dropsondes may create a shock force of sufficient amplitude to induce a slight offset in the calibration of the baroswitches. It is recommended that this effect be further investigated if it is decided in the future to discard the CAPS sensor and return to the baroswitch.

Several dropsonde design changes were recommended as a result of this test. The main revisions were concentrated in the areas of poor dropsonde signal reception, premature drogue chute and timer mechanism deployment, and inoperable thermistor and hygristor sensors. A complete list of the recommended design changes is given in table VIII. The most important design revisions include: (1) a redesign of the dropsonde antenna by NAVAIRDEVCEN to provide improved signal transmission, specifically, an improved impedance match of the SSQ-41A transmitter to the "hula-hoop" dropsonde antenna, (2) an alteration in the audio modulating signal from a 100 μs pulse to a 50% duty cycle for improved S/N ratio, (3) the use of a stronger parachute cord, (4) a redesign of the release latch lock spring to provide a more positive lock for the timer mechanism, (5) the placing of a knot in the main cord to anchor the drogue chute attachment, (6) the use of grommets in the slots that the nylon cord passes through to reduce the possibility of cord breakage, (7) the changing of the thermistor and hygristor mounts to permit easier installation and replacement of these sensors, and (8) the placing of the thermistor-hygristor mount an additional 1 inch farther inside the sonde housing to preclude any postlaunch damage from the plastic CAD plunger disc.

4. WARREN GROVE DROPSONDE TEST (11 July 1978)

4.1 Objective

The objective of this test was to qualify the dropsonde air deployment mechanism, including the timer release, timer, and the drogue and main parachute components, for aircraft launches within the envelope established for sonobuoys. In addition, a verification was necessary of the recommended corrective mechanical design changes implemented into the dropsonde as a result of the Key West test findings (refer to table VIII).

4.2 Test Setup

The test consisted of CAD launching nine electrically inert dropsondes in sonobuoy launch containers from a Navy P-3C aircraft. Active electronics were not included in the dropsondes since the test objective was to qualify the deployment mechanism. However, the normal weight and center of gravity of the dropsondes were maintained by utilizing ballast.

The test format consisted of launching dropsondes, one at a time, from the aircraft at three distinct points on the launch envelope. The first three dropsondes were dropped with an aircraft velocity of 200 kn, the second three at 250 kn, and the final three at 330 kn, which was maximum velocity. All launches were at an aircraft altitude of 1,000 ft.

The tasks of some of the ground personnel included observation of each launch, with binoculars and with the naked eye, noting any irregularities during a launch, measuring the time between the start of a launch and the initial deployment of the main parachute via a stopwatch, and observing the location of the various deployment parts at ground impact for retrieval and failure analysis purposes. In addition, a communications truck was utilized for coordinating the launches with the aircraft and two handheld cameras, one forward of and one to the port side of the launch point, were used to photograph each launch. Additional film coverage of the launches was provided on the aircraft by a camera pod mounted on the starboard wing. After every third drop, further launches were suspended for approximately 15 minutes so that the various parts of the previously launched dropsonde deployment mechanisms could be recovered and analyzed for damage.

4.3 Test Results

Tables IX (a), (b), and (c) describe the results of the nine launches, including findings made by analyzing the recovered dropsonde parts and by observing the films from the three separate cameras. These tables also include deployment-related timing data, such as timer release and drogue and main chute deployment, all of which were obtained from a "stop-action" analysis of the films. Due to the thick underbrush at the test site and the drifting of a few of the chutes at least a mile away from the launch point, all of the deployment pieces were unable to be recovered. Unfortunately, the main parachute for dropsonde No. 7 and the drogue chutes for units No. 8 and 9 were not found. These hardware items would have aided in the determination of the exact causes for the launch failures evidenced by these units and in determining corrective action necessary.

In summary, five of the nine launches were satisfactory and had no problems with the deployments or landings. Only one failure occurred out of the six dropsondes launched at aircraft speeds of 250 kn or less. This failure (dropsonde No. 3) was caused by the timer mechanism, which failed to release and prevented the main chute from opening. Laboratory analysis determined that a burr on the sear arm of the timer mechanism hindered the operation of the release cam, which releases the timer mechanism. This failure mode of the timer was repeated in the lab, but the burr became more polished with each iteration.

All three of the dropsondes launched at the maximum aircraft velocity (330 kn) experienced failures. Premature deployment of the drogue chute, timer mechanism, and main chute occurred on dropsonde No. 7. The main chute ripped away from the canister only 0.32 second after launch and the chute lines were severed approximately 5 in. from the anchor point. Subsequent lab tests showed that thumb pressure on the lever nearest the sear could force the cam over the sear, causing premature release of the timer. In addition, the tensile strength of the main chute lines may not be capable of handling the shock forces of parachute inflation at this launch envelope point. The failures incurred in dropsonde launches No. 8 and 9 were very similar to No. 7 in that the drogue chute separated from the timer almost immediately after launch. On No. 8, the remainder of the deployment sequence was normal, but on No. 9, the timer mechanism and main chute deployed prematurely, within one second after launch. One noteworthy item is that the timer mechanism sequence (on No. 8) and the main chute deployment (on No. 8 and 9) functioned properly without the drogue chute. It appears highly probable that the drogue chute lines are unable to handle the forces created by the maximum aircraft velocity and may need to be strengthened. In addition, on No. 8, damage was inflicted upon the 500 pound test bridle line, which was cut 10% through at the grommet adjacent to the Rhodes timing unit. This occurrence may have also contributed to the separation of the drogue chute from the timer.

For the six dropsondes in which the timer mechanism functioned properly, the times from air flap release to timer mechanism release were 5.16, 4.98, 5.28, 4.68, 5.28, and 4.50 seconds, respectively, for an average time of 4.98 seconds. This average, as well as all of the individual launch times, is within the specification value of 5 ±1 seconds for main chute deployment.

4.4 Conclusions and Recommendations

In summary, five of the nine launches were satisfactory and had no problems with the deployments or descents. Only one failure occurred out of the six dropsondes launched at aircraft speeds of 250 kn or less. All three of the dropsondes launched at the maximum aircraft velocity (330 kn) experienced failures. All of the test failures can be related to one or more of the following areas: (1) rough finished or improperly polished parts in the timer mechanism, (2) marginal design tolerances in the timer release hardware, and (3) marginal drogue and main parachute shroud line strength at the upper end of the launch envelope. Table X details the dropsonde design revisions recommended as corrective action for these failures. The most important design changes included: (1) deburring and polishing all sears and mating surfaces in the timer mechanism before assembly, (2) enlarging the sear engagement area in the timer mechanism to prevent the cam plate from overriding the sear lever and causing premature timer release, and (3) an improved attachment, including the placement of a grommet, of the drogue chute to the bottom of the timer mechanism.

From the results of this test, another dropsonde flight test to verify the deployment cycle was recommended, with emphasis on the higher aircraft speeds (300 kn or greater). The results of this test are discussed in the next section.

5. LAKEHURST DROPSONDE TEST (6 September 1978)

5.1 Objective

The objective of this test was basically the same as that for the Warren Grove drop test; i.e., to qualify the dropsonde air deployment mechanism for aircraft launches within the envelope established for sonobuoys. In addition, a verification was necessary of the recommended corrective mechanical design changes implemented into the dropsonde as a result of the Warren Grove test results.

5.2 Test Setup

With one exception, the test format, including the launching procedures and the personnel tasks, was identical to that of the Warren

Grove test. The only exception was that the dropsondes were launched at higher aircraft speeds during this test. For this test, dropsondes were launched, one at a time, from the aircraft at four distinct points on the launch envelope. The first two dropsondes were dropped with an aircraft velocity of 275 knots, the second two at 300 knots, the third two at 325 knots, the next one at 345 knots, and the final two at 350 knots, which was the P-3C's maximum velocity. All launches were at an aircraft altitude of 1000 feet. In addition, after the second, fourth, and sixth dropsondes were dropped, further launches were suspended for approximately 15 minutes so that the various parts of the previously launched dropsonde deployment mechanisms could be recovered and analyzed for damage.

5.3 Test Results

In summary, five of the nine launches were satisfactory and had no visible problems with the deployments or landings. The four failures occurred at aircraft speeds of 275, 325, 345, and 350 knots, respectively. The failure at 275 knots (launch No. 2) was caused by the jamming of the timer mechanism in the sonde tube, resulting in the inability of the timer to release and the failure of the main chute to deploy. In the failure at 325 knots (launch No. 6), the main parachute deployed prematurely, within 0.4 second after launch, and the main parachute bag separated from the main chute and was unable to be recovered. However, the main chute deployed successfully and a normal launch resulted. In launch No. 7, at 345 knots, only the drogue chute deployed. It was subsequently found that the timer mechanism timed out, but did not release. In the last failure, at 350 knots (launch No. 8), the tie line snapped, releasing the drogue chute from the timer mechanism. Consequently, the timer mechanism and main parachute did not release from the sonde until moments before ground impact.

A detailed compilation of the deployment results and postlaunch findings is shown in tables XI(a) and (b). A tabulation of deployment related timing events, such as timer release and main parachute deployment, is given in table XII. From the data in table XII, it can be calculated that the average time for timer release (for the five launches that had successful timer releases) was 5.37 s (which is within the specification limit of 5 ± 1 s). This average includes the timer release time for launch No. 8 (6.38 s), which was above the specification limit, but does not include the release time (0.18 s) for launch No. 6, in which the timer mechanism released prematurely. Based on data in table XII, it can also be ascertained that the average time for the main chute to fully open (for the four successful launches that have available data) was 5.8 s (no specification limit exists). Table XII also indicates a late wind flap release and drogue chute deployment for launch No. 8 and 9. All of the dropsonde hardware (the air tab, drogue chute and its bag, main chute and its bag, timer mechanism, and cannister) was recovered, except for the air tab on drop No. 4 and the main parachute bag on drop No. 6.

The various stages of an actual dropsonde deployment are depicted in figures 16 through 21. These photographs were extracted from the aircraft and ground coverage motion picture films and are typical of all normal drops, as substantiated by all previous drop test films. Figure 16 illustrates the release of the air tab and the initial deployment of the drogue chute from the sonde housing as the dropsonde is being launched from the P-3C aircraft. In figure 17 the drogue chute has completely opened. Figure 18 depicts the release of the drogue chute, the timer mechanism, and the main parachute bag from the main parachute and the sonde housing. The full opening of the main chute is captured in figure 19, along with the complete separation of the main chute from the timer mechanism. In figure 20 the vertical descent of the sonde is illustrated. Lastly, figure 21 depicts the sonde moments before ground impact. Special note can be taken of the vertical nature of the sonde's descent. In addition, the absolute sizes of the dropsonde and of the main chute can be easily ascertained.

5.4 Conclusions and Recommendations

From the results of this test, it was concluded that the dropsonde design was satisfactory for launching from aircraft at speeds up to 300 knots at 1000 feet of altitude. Three failures occurred out of the five dropsondes launched at aircraft velocities of 325 knots or greater. At velocities of 300 knots or less, only one of four sondes experienced any failures. The two main causes of the deployment failures were in the areas of improper timer mechanism release and fraying of the 500 pound test line. It was recommended that the design changes to the timer mechanism listed in table XIII be implemented to greatly reduce these problems.

6. CAPE HATTERAS DROPSONDE TEST (8 September 1978)

6.1 Objective

The objective of this test was to verify the RF strength and the integrity of the transmitted dropsonde signal and to employ near real-time data reduction of this signal, utilizing a Bendix RDSRU processor. Successful test results would validate the post-Key West improvements implemented into the antenna-transmitter subsystem, which will be described subsequently.

6.2 Test Setup

The subject dropsonde test consisted of CAD launching five electrically active dropsondes in sonobuoy launch containers from a Navy P-3C aircraft. The test format consisted of launching dropsondes, one at a time, from the aircraft at an altitude of 14,500 feet and an aircraft speed of 200 knots. In addition, the aircraft remained within 25 miles of each launch point so that dropsonde signal reception could be maintained.

The tasks onboard the aircraft consisted of recording the dropsonde data with an AQH-4 tape recorder, monitoring the signal levels with an oscilloscope and an ARR-72 receiver signal strength meter, and taking photographs of the incoming signal from the oscilloscope display. Pressure calibration data and other parameters were also input into the RDSRU processor between drops. These data were evaluated after data collection. In addition, the dropsonde deployments were photographed through the utilization of a high speed (200 frames/s) camera mounted on wing station 13. Table XIV details the launch conditions and the deployment times for the five launches. As an aid to the data collection and processing, a combined test was arranged with the weather station at Cape Hatteras to launch a radiosonde at 1100 and 1300 local time (EDT) for data comparison purposes.

Prior to the actual drops at Cape Hatteras, extensive laboratory tests were conducted at JMR Systems Corporation to determine whether all of the five sondes met the specification requirements. Tests that were performed included verifying the commutation rate, sensor resistance values, oscillator performance, and RF performance, including frequency, power output, and deviation. Calibration of all of the baroswitches was also accomplished on the day prior to the drops.

Furthermore, the antenna-transmitter subsystem of these sondes were subjected to extensive testing at NAVAIRDEVCEN. These five sondes were optimally tuned in the laboratory, using an improved simplified transmitter board tuning procedure that utilized a maximum power, rather than minimum current, technique. More detailed information concerning this tuning procedure can be found in reference (b). In addition, the RF strength of the sondes was measured at the NAVAIRDEVCEN antenna range. Refinements in the antenna design, specifically a modification of its actual dimensions and the establishment of an improved grounding point, were also developed. However, these refinements were not able to be implemented into the five sondes to be tested, since they had already arrived with the former antenna design. The 110 preproduction dropsondes will be implemented with the new antenna design.

6.3 Test Results

All five of the dropsonde launches were successful in the areas of mechanical deployment and RF and data transmission. There were no problems in the deployments of the dropsondes and the transmitted dropsonde signal was received almost immediately after launch. The received dropsonde signal was very clean, had sufficient amplitude, and was judged to be of the highest quality to date during any field test. The RF signal strength was at the maximum level on the ARR-72 receiver indicators and fading of the signal only occurred on the first launch, during which occasional noise bursts and signal dropout occurred. Table XV summarizes the received signal information for each launch and contains additional information pertaining to local atmospheric conditions during the flight and the dropsonde sensor calibration resistances.

The received signal more resembled a sinusoidal wave rather than the usual square wave and did contain occasional ringing. A subsequent investigation showed that these effects were created by the bandpass filters in the aircraft sonobuoy interconnection box, which is preceded by the audio switching assembly and the ARR-72 sonobuoy receivers. To resolve this problem, it has been decided to replace the audio switching assembly and the sonobuoy interconnection box with a presently used tape amplifier box, a RASP switching and systems indication assembly box, and possibly a better designed bandpass filter, all of which will precede the RASP processor. Figure 22 is a block diagram of this proposed aircraft configuration.

Laboratory photographs of the received dropsonde signal taken from a Honeywell 7600 tape recorder output are depicted in figures 23 through 26. The ringing of the signal can be viewed in figures 23 and 24, which represent drop No. 4 and 2, respectively. The sinusoidal nature of the received signal is illustrated in figure 25, which was acquired from the initial launch. The final photograph, figure 26 (drop No. 5), depicts the commutation from one data parameter to another. Even though the integrity and the amplitude of the received dropsonde signal was very good, only one satisfactory data run (drop No. 5) was generated onboard the aircraft utilizing the Bendix RDSRU processor. The remaining four RDSRU data runs were affected by misalignments of the pressure table that led to an excess of unidentifiable contacts. The RDSRU processor was only capable of producing two data cycles of information (800 ms total) for the first launch and could only output reference frequency, temperature, pressure, and humidity period data as a function of time for the middle three launches. A subsequent attempt was made in the laboratory to process the first four launches, using the tape recorded data, an amplifier, bandpass filter, and the RDSRU processor, but no improvement in the processing capability was attained. Since a current development effort is ongoing to improve the capabilities of the RDSRU processor (namely, the RASP processor), the inability of the Bendix RDSRU to properly process this data is considered to have negligible impact on the dropsonde program.

Table XVI illustrates the aircraft processed data output for launch No. 5 (sonde No. 15). It can be seen from the top portion of table XVI that the RDSRU reported five unidentifiable contacts for this launch. The last unidentifiable contact occurred at the bottom end of the data dump, at a pressure of approximately 812 mbar. Since the RDSRU can only calculate and display valid data from the water surface to the location of the last unidentifiable contact, only about half of the total data from this launch was displayed by the RDSRU. Pressure values (in mbar), temperature (in ° c), humidity (in % of relative humidity), and M and N refractivity units are also presented in table XVI as a function of altitude (in meters). The M units are only displayed at the beginning and the end of the data output.

Table XVII represents a portion of the RDSRU data dump of period information for the four parameters (reference frequency R, temperature T, pressure P, and humidity H) as a function of time for sonde No. 15. This period data is used in various algorithms in the RDSRU for computation of temperature, humidity, M and N units, and altitude. The circled data points in tables XVI and XVII are "wild" temperature values that will be explained in section 6.4. In addition, for the last drop (sonde No. 15), the processor displayed and classified abnormal refractivity conditions and listed the M unit values and altitudes at the boundaries of each refractivity gradient, as shown in table XVIII. Lastly, an example of the launch conditions information and the baroswitch calibration data that is input into the RDSRU processor prior to a dropsonde launching is illustrated in table XIX.

An analysis of the films from the aircraft camera on wing station 13 showed a normal deployment for the dropsondes, except for a delay in the release of the air tabs (wind flaps) in launches 2, 3, and 4. It took 0.78, 0.50, 0.22, and 0.04 seconds, respectively, for the air tabs to release from the sonde tube in launches 2 through 5, respectively. The initial launch was unable to be captured on film due to a misunderstanding of the drop sequence. It is believed that the variance in the air tab delays are due to the orientation of the sondes in the sonobuoy launch containers and their orientation in relation to the resultant air stream direction upon launch. These delays should pose no operational problems.

The total drop times (min:s) for each launch from aircraft ejection to splashdown were 6:34, 7:10, 6:12, 6:43, and 7:05, with an average deployment time of 6 minutes and 45 seconds. The initial launch was at an aircraft altitude of 15,000 feet and the remainder of the launches were at 14,500 feet.

6.4 Laboratory Data Processing

The laboratory processing setup of the tape recorded data was identical to that previously mentioned in the Key West dropsonde test section of this report and in appendix A for the algorithms that were used. A compilation of the individual data points for temperature, relative humidity, and M and N refractivity units as a function of altitude is given in tables XX through XXIV for sonde No. 11 to 15 (launch No. 1 to 5), respectively. Figures 27 through 31 are graphs of this same meteorological data versus altitude for sonde No. 11 through 15, respectively. A comparison of these graphs reveals an excellent similarity among all five launches for the four meteorological parameters. In addition, the end points of the processed temperature data agree very well with the surface and launch altitude air temperatures of 27° C and 5° C, respectively, measured during the flight.

The rawindsonde data that was supplied by the National Weather Service and the calculation of M and N units from this data is illustrated in graphical form in figures 32 and 33 and in tabular form in tables XXV and XXVI. Due to the close time proximity of the launches of the first rawindsonde and dropsonde No. 11, and the second rawindsonde and sonde No. 15, respectively, a comparison can be made of the four meteorological parameters (temperature, relative humidity, M units, and N units) for each rawindsonde and its corresponding dropsonde. These data are shown in figures 34 through 43. It can be seen that the dropsonde and rawindsonde data agree very closely, except for an offset in humidity in several instances. A strong correlation exists between the temperature data, although the rawindsonde data is, in general, approximately 1° C higher that the dropsonde data. The humidity and temperature data can be safely discounted for approximately the first 1000 feet of the launch because the sensors need a finite time period to stabilize in the atmospheric environment after being stored in the low humidity, warm temperature environment of the launching aircraft. Lastly, a comparison of the ultimate output, M and N units, demonstrates an extremely close match between the rawindsonde and dropsonde data.

It can be seen from a comparison of the data that, in many cases, the dropsonde relative humidity data is as much as 10% greater than the corresponding rawindsonde data, especially for dropsonde No. 15. However, it can be seen that the relative shape of the humidity curves is very similar. Three possible reasons may account for this 10% offset. First, due to the inherent properties of the hygristor, an offset of as much as 5-6% may exist between two different hygristors measuring identical atmospheric conditions. Secondly, a 13-mile difference in the rawindsonde and dropsonde launch points existed (confirmed by the fact that the P-3C launching aircraft used a visual fix on the

Diamond Shoals east of Cape Hatteras to launch each dropsonde within a 1/4-mile radius of each other). As a result, the humidity conditions measured by the rawindsonde and dropsonde hygristors may have differed enough to account for this offset, considering that relative humidity may be quite inhomogeneous near a land-sea interface. Thirdly, since stratified vapor layers existed during the day of testing (nearly all of the humidity data is less than 80% RH), the presence of wind shears in the atmosphere could cause these vapor layers to change gradually with time. Tables XXVII and XXVIII present the wind information measured by the two rawindsondes. The data shows that wind shears as great as 20-25 knots from 7000 to 18,000 feet occurred during the day of testing. Further substantiation of this wind shear argument is augmented by the temporal variation of humidity when a comparison is made of only the rawindsonde humidity data against itself or of only the dropsonde humidity data against itself. However, the general shape of the humidity curves does not change.

6.5 Bendix RDSRU Data Processing

An analysis of the parameter period data (refer to table XVII) that the RDSRU generated during the flight for the last launch was made using the NAVAIRDEVCEN processing algorithms previously described. This period data was utilized to determine the corresponding pressure contacts and was used in the aforementioned algorithms to generate the graphs of temperature, relative humidity, and M and N units versus altitude depicted in figure 44. A detailed listing of the individual parameter values is given in table XXIX. An inspection of the temperature and M and N units graphs reveals an anomaly at 4000 feet, corresponding to the circled temperature period point in table XVII and the circled temperature values in tables XVI and XXIX. Since this period value is approximately 7% less than the expected value, it is suspected that during the latter portion of the sampling period (10 cycles) for the temperature parameter, a noise spike in the received sonde data generated a false input to the zero crossings detector, resulting in an inaccurate temperature period value (higher frequency -- shorter period). If this explanation is indeed factual, then it should be apparent that the Bendix RDSRU and its replacement, the RASP, should possess a data validation and noise rejection capability.

It can be seen that the graphs (figure 44) of the RDSRU data generated in the aircraft, but processed with the NAVAIRDEVCEN algorithms, agree closely with the corresponding dropsonde No. 15 graphs (figure 31) generated by the NAVAIRDEVCEN processing scheme, except, of course, for the data anomaly at 4000 feet. This RDSRU data also agrees with the RDSRU data dump during the flight (table XVI).

Subsequent to the flight, attempts were made in the laboratory to process the sonde tape recorded data through the Bendix RDSRU processor, utilizing a Hewlett-Packard 467A variable power amplifier and an SKL bandpass filter (20-2000 Hz) between the Honeywell 7600 tape recorder and the processor. Again, the only successful run was with sonde No. 15, which concurs with the aircraft flight processing results, and no unidentifiable contacts were reported by the RDSRU. Tables XXX, XXXI, and XXXII are listings of the actual processor outputs including the parameter values versus altitude, the flagged gradients, and the parameter period data versus processing time, respectively. It should be mentioned that the pressures listed in table XXX are slightly incorrect because the wrong baroswitch calibration data was entered into the processor. An estimated, rather than the actual, surface pressure was actually used by the processor. The rawindsonde data containing the true surface pressure was later received from the Cape Hatteras Weather Station. However, the Bendix processor output data in table XXX agree well, in a large number of cases, with the data in table XXIV for sonde No. 15 that used the NAVAIRDEVCEN processing scheme. A side-by-side comparison of the data in table XXX versus the data in table XXIV is given in table XXXIII.

The period data generated in the laboratory by the Bendix RDSRU for sonde No. 15 (table XXXII) was then input into the NAVAIRDEVCEN processing scheme, the results of which are given in graphical form in figure 45 and in tabular form in table XXXIV. Figures 46 through 50 depict temperature, relative humidity, and M and N units comparison plots of the Bendix RDSRU data (in table XXXIV) as a function of the data generated for dropsonde No. 15 (see figure 31) by exclusive use of the NAVAIRDEVCEN processing setup. It can be seen from the comparison plots that, when subjected to the same algorithms, the period data generated by the RDSRU can produce meteorological data that is almost identical to meteorological data produced from period values that are generated and averaged by the more elaborate NAVAIRDEVCEN processing setup. Slight differences in the humidity graph (figure 47) and consequently, the M and N units graphs (figures 48 through 50), are apparent. These discrepancies are a result of the NAVAIRDEVCEN data being more accurate because an average of six of the parameter values around a pressure contact is performed with the NAVAIRDEVCEN data. Averaging cannot be done with the Bendix RDSRU generated data, since only one period value of each parameter is output by the RDSRU at any pressure contact. As a result, the location of and the M units deficit of the refractivity ducts is slightly different in the comparison plots.

6.6 Conclusions and Recommendations

The following conclusions were drawn from an indepth evaluation and analysis of onsite data, aircraft films, and laboratory data processing:

a. All five of the dropsonde launches were successful in the areas of deployment and RF and data transmission.

b. The received dropsonde signal in all launches was judged to be of the highest quality to date during any field test, specifically in the area of RF signal strength.

c. The received dropsonde signal more resembled a sinusoidal wave rather than the anticipated square wave and did contain some ringing. These problems were subsequently traced to the bandpass filters in the P-3C sonobuoy interconnection box, which will be replaced with an improved system.

d. Only one satisfactory data run was made during the test onboard the P-3C aircraft utilizing the Bendix RDSRU processor. One of the temperature data points generated by the RDSRU was in error by 10° C.

e. Satisfactory data runs of the five launches were subsequently compiled in the laboratory with the use of a sophisticated processing scheme. The data agreed very well with the corresponding rawindsonde data, except for an offset in humidity in several instances.

f. A satisfactory data run was performed in the laboratory with the RDSRU processor, utilizing a power amplifier and a bandpass filter between the tape recorder output and the RDSRU input. The RDSRU-generated period data for each parameter was then input to the algorithms used in the NAVAIRDEVCEN processing scheme and atmospheric data plots were produced. A comparison of these RDSRU plots with the atmospheric data plots for the same launch generated solely by the NAVAIRDEVCEN processing setup demonstrated an excellent matchup of temperature, humidity, and M and N units.

Based on the successful outcome of this test, no major subsystem redesign to the dropsonde sensor is needed. However, as a result of all of the test findings to date, the following design modifications will be incorporated into the dropsonde for the 110 preproduction units:

a. Modification to antenna design

b. Improved transmitter board tuning procedure

c. Honeywell CAPS electronics package to replace the baroswitch and its related components and circuitry

d. Allowance for Honeywell component package to be plugged in as a last assembly procedure

e. Deeper recession of the sensors in the housing package for greater protection during launching conditions

f. Temporary protective cover to be placed over the sensors section for added protection during shipping and handling

The following design changes should be made to future carry-on dropsonde processors:

a. A data validation and noise rejection capability to verify received data and reject unwanted data

b. A data averaging technique to eliminate the adverse effects of any "wild" data points and to ultimately provide a more accurate data output

7. OVERALL PROGRAM CONCLUSIONS AND RECOMMENDATIONS

From a mechanical and an electrical standpoint, the dropsonde is ready to proceed into the preproduction and TECHEVAL phases of the program. It can be concluded, from the results of both the Lakehurst and Warren Grove tests, that the deployment related design problems have been identified and corrected, and the mechanical design risks minimized (up to aircraft velocities of 300 knots). The successful outcome of the Cape Hatteras test demonstrated that the RF and electrical problems identified during the Key West test have been corrected. It can be safely concluded, then, that the RF and electrical problems have been identified and that electrical type design risks have been minimized. Furthermore, deficiencies in the RDSRU processor that were identified during the Cape Hatteras test dictate the need for data validation, noise rejection, and data averaging capabilities to be implemented into future dropsonde processors, specifically the RASP processor.

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(b) NAVAIRDEVCEN Technical Memorandum 3044 of 11 May 1979, "SSQ-41A Transmitter Board Tuning Procedure for Utilization in Preproduction AN/AMT-22 Dropsondes," by John Sniscak

(c) NAVWEPS 50-1D-510 Manual of Barometry, Volume 1, First Edition, 1963

(d) NAVAIRDEVCEN Report 76335-30, "Breadboard Dropsonde-Minirefractionsonde Analyzer, Volume 1," by Mervin Werst, Analytics, Inc., Willow Grove, PA

(e) NAVAIRDEVCEN Report 76129-30-A, "Mini-Refraction Sonde Laboratory Tests," by Curtis Motchenbacher, Honeywell, Inc., Hopkins, MN

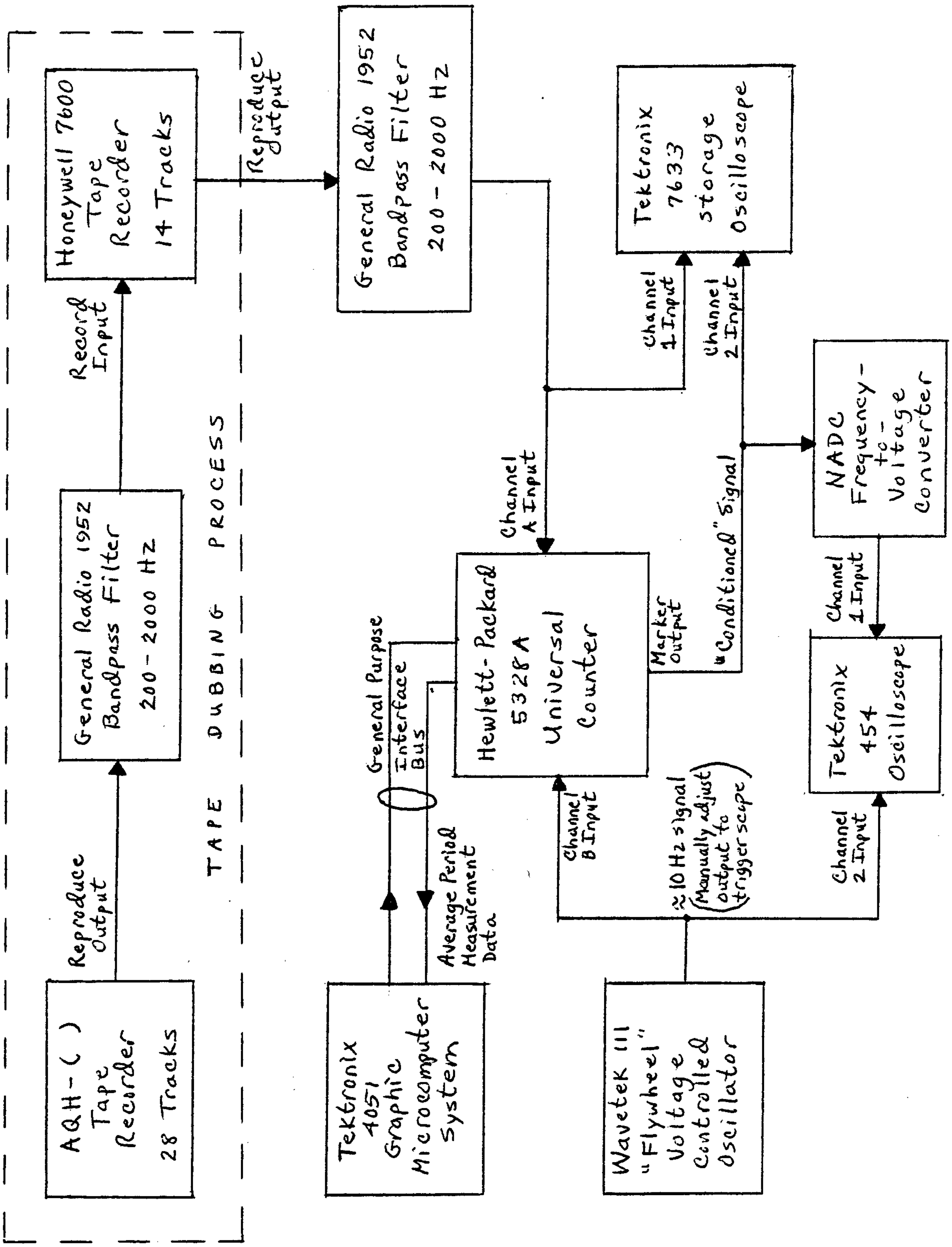


FIGURE 1. NAVAIRDEVCEN Laboratory Data Processing Scheme

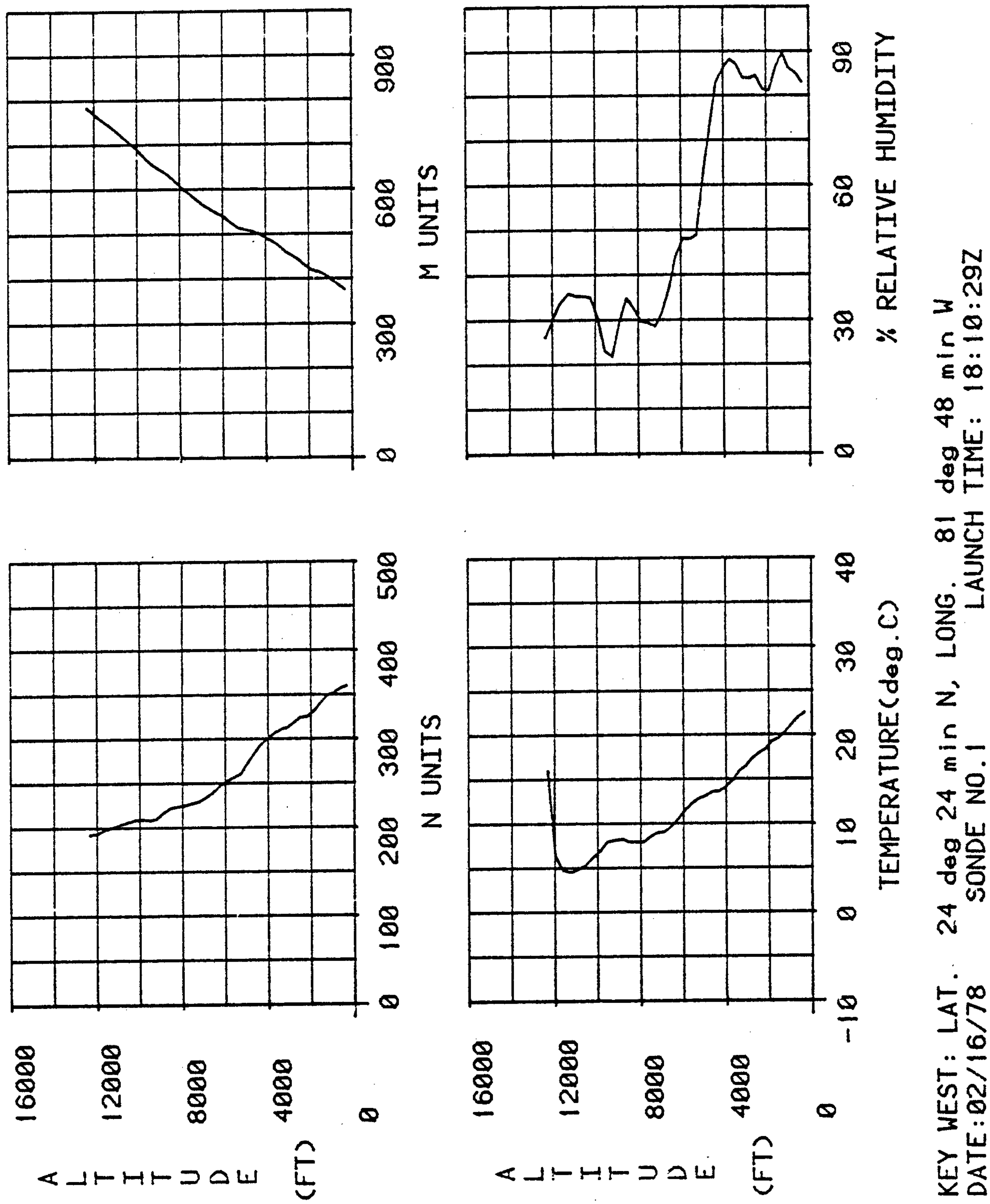


FIGURE 2. NAVAIRDEVCEN Processed Meteorological Data for Sonde No. 1 at Key West

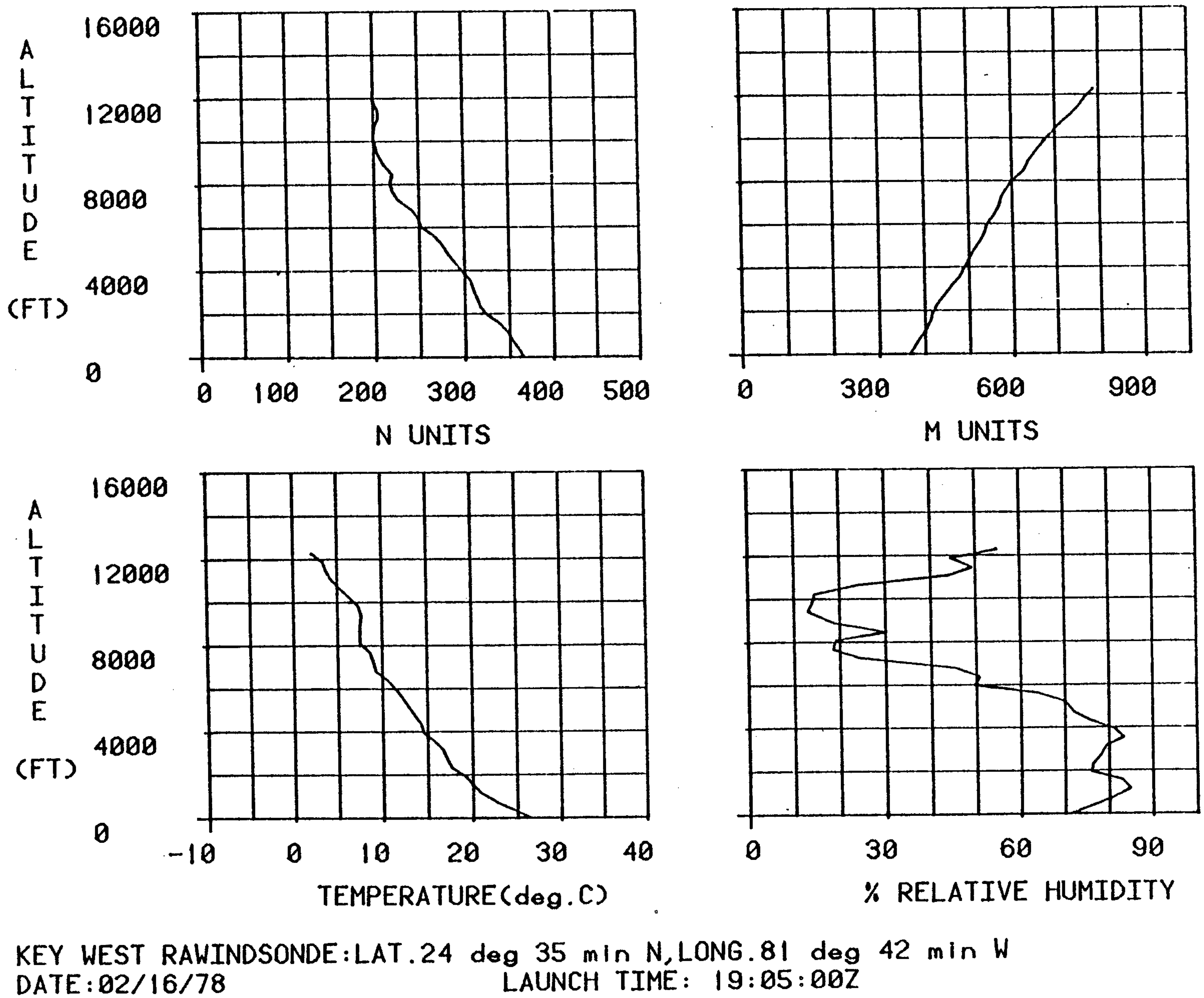
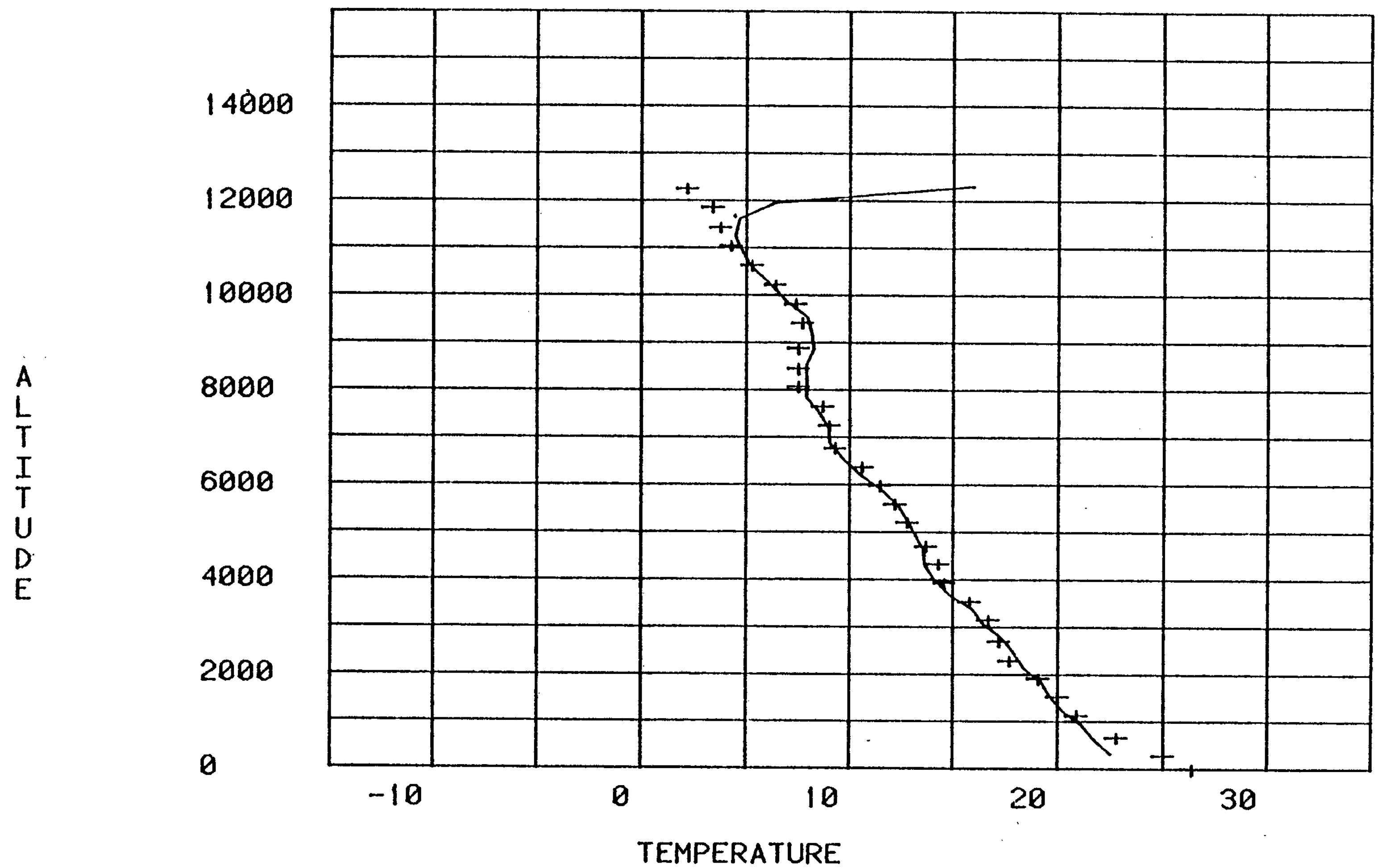


FIGURE 3. Key West Rawindsonde Meteorological Data



KEY WEST

DATE: 02/16/78

+...RAWINDSONDE LAUNCH TIME: 19:05:00Z

-...DROPSONDE No.1 LAUNCH TIME: 18:10:29Z

FIGURE 4. Temperature Data Comparison of Rawindsonde and Sonde No. 1 at Key West

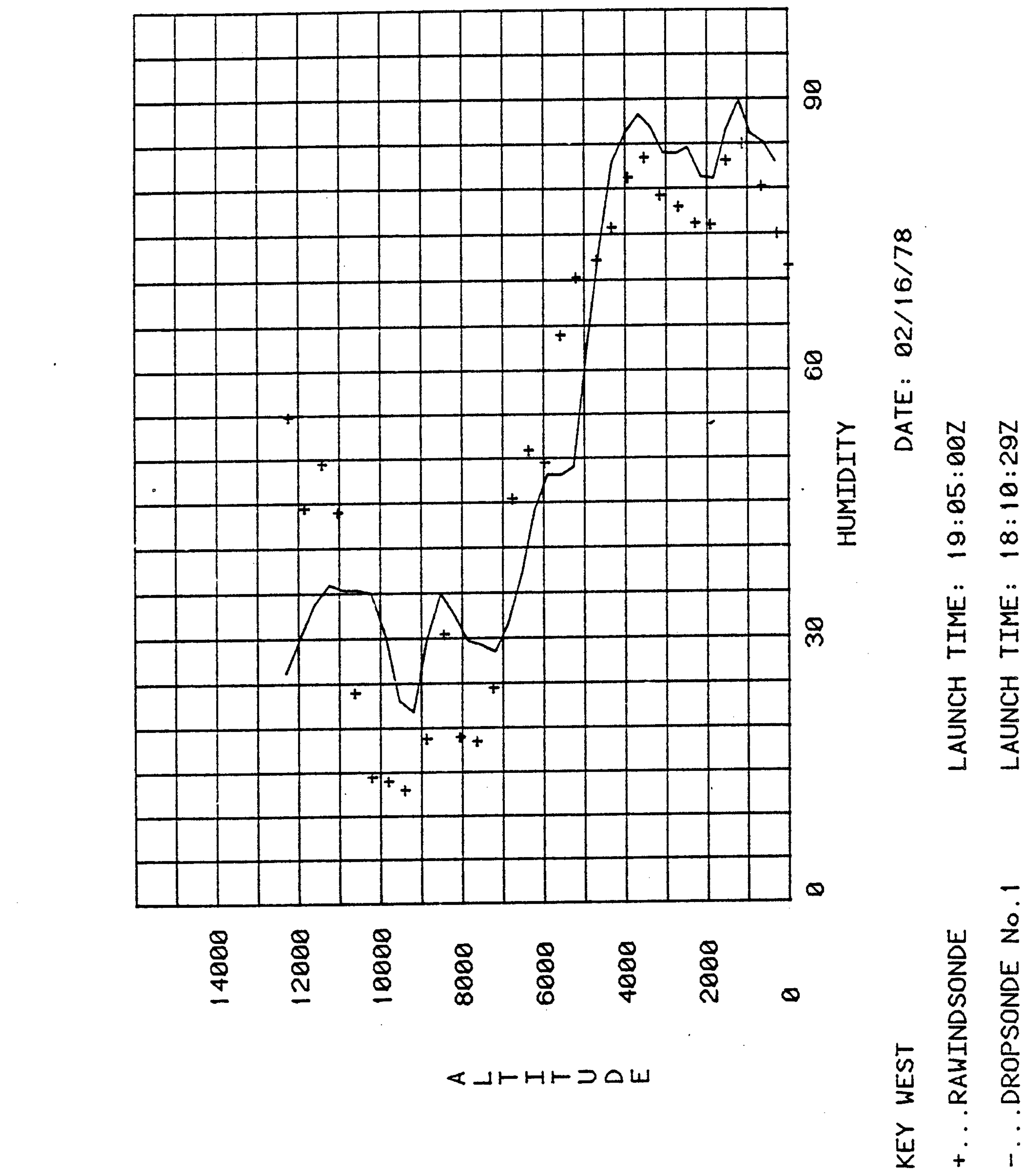
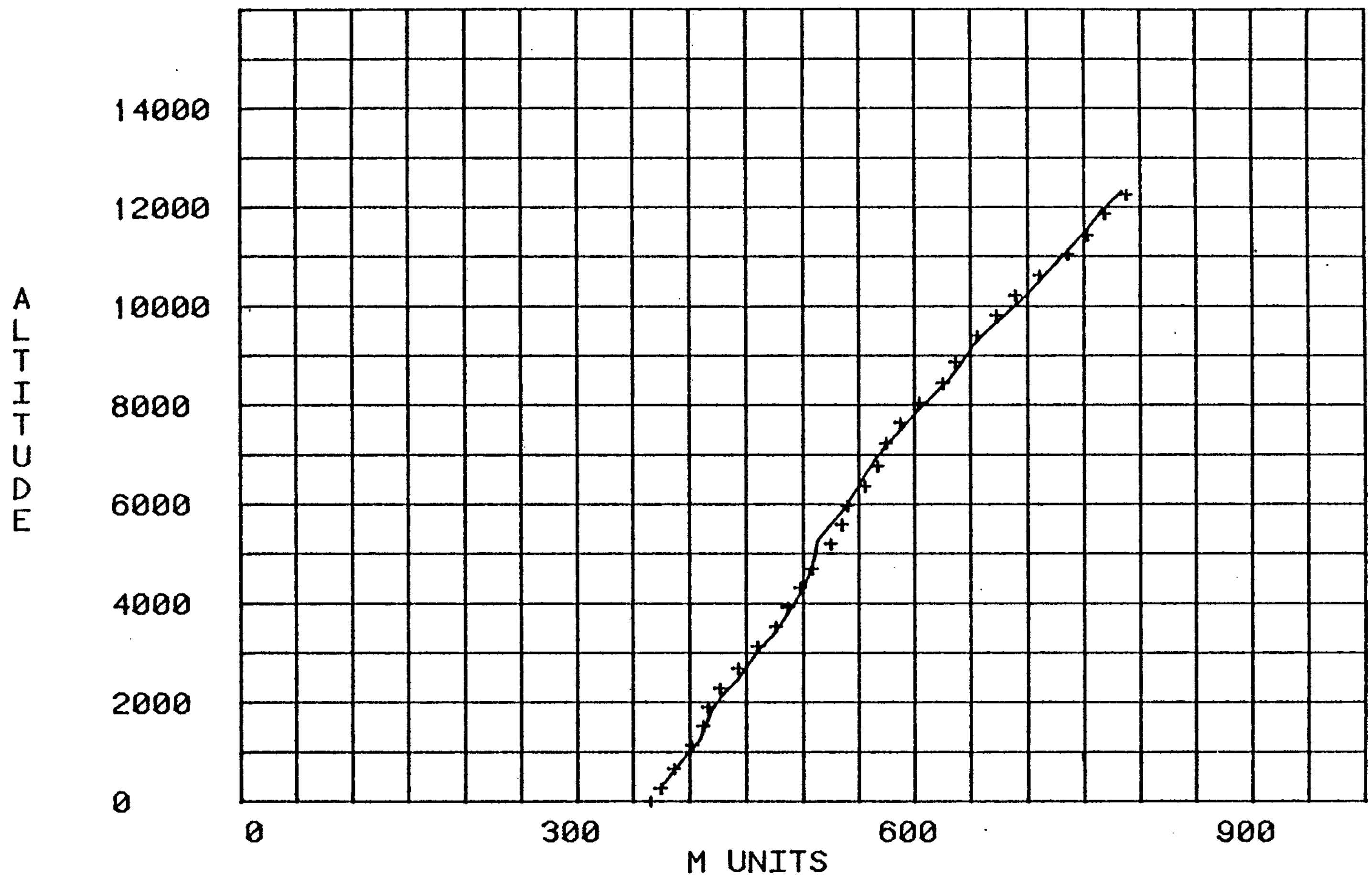


FIGURE 5. Humidity Data Comparison of Rawindsonde and Sonde No. 1 at Key West

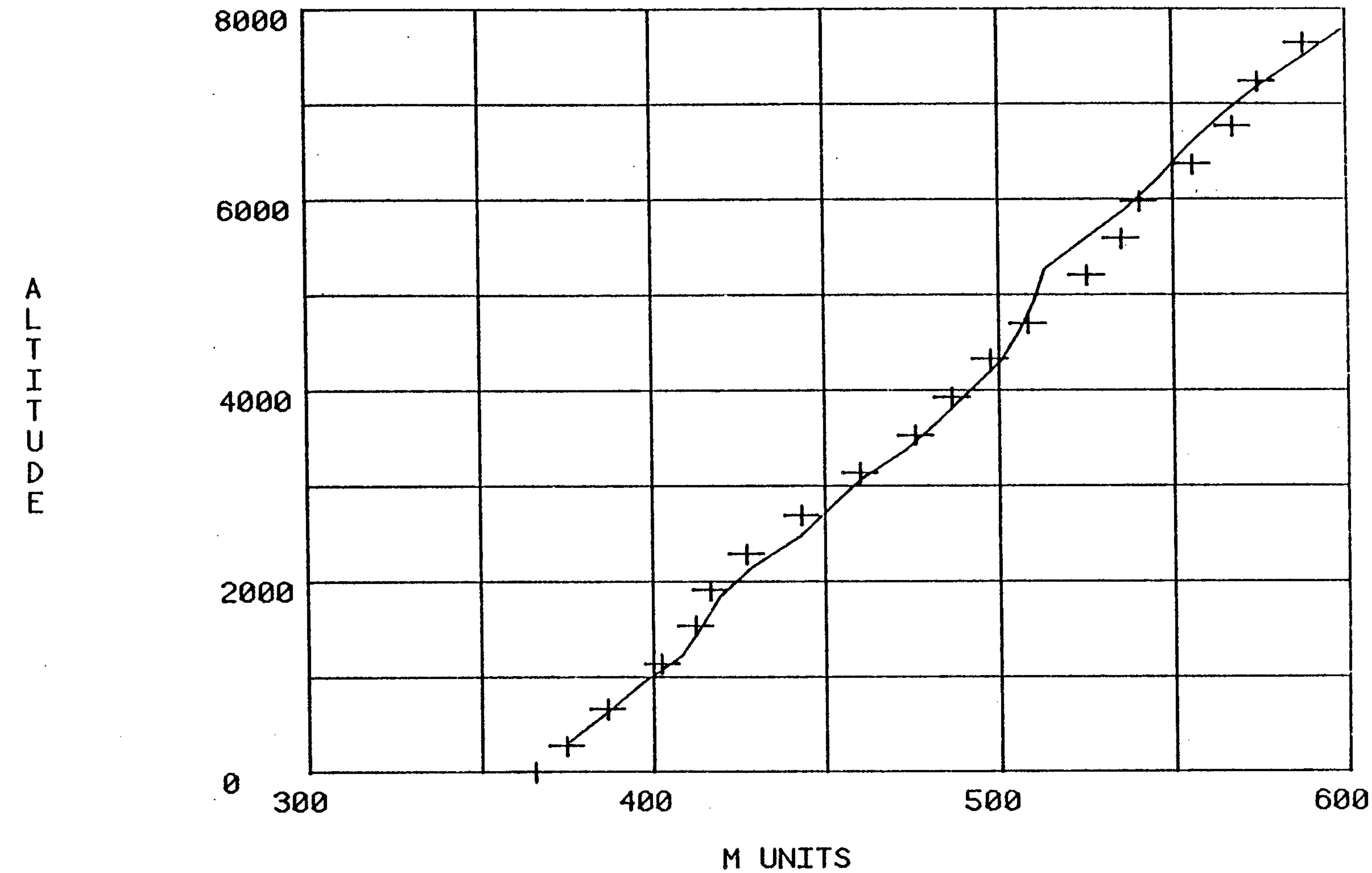


KEY WEST DATE: 02/16/78

+...RAWINDSONDE LAUNCH TIME: 19:05:00Z

-...DROPSONDE No.1 LAUNCH TIME: 18:10:29Z

FIGURE 6. M-Units Data Comparison of Rawindsonde and Sonde No. 1 at Key West



KEY WEST DATE: 02/16/78

+...RAWINDSONDE LAUNCH TIME: 19:05:00Z

-...DROPSONDE No.1 LAUNCH TIME: 18:10:29Z

FIGURE 7. Expanded M-Units Data Comparison of Rawindsonde and Sonde No. 1 at Key West

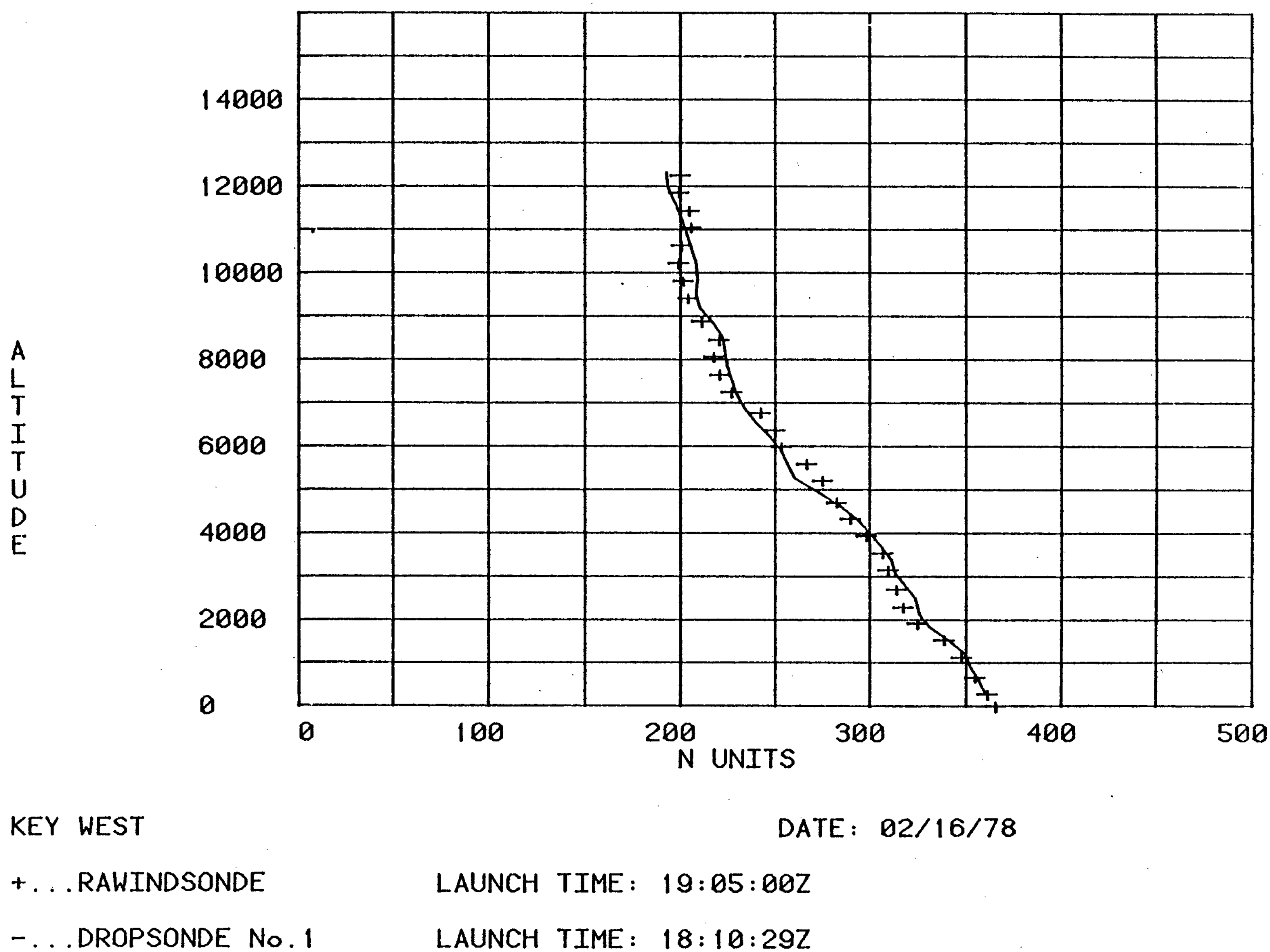


FIGURE 8. N-Units Data Comparison of Rawindsonde and Sonde No. 1 at Key West

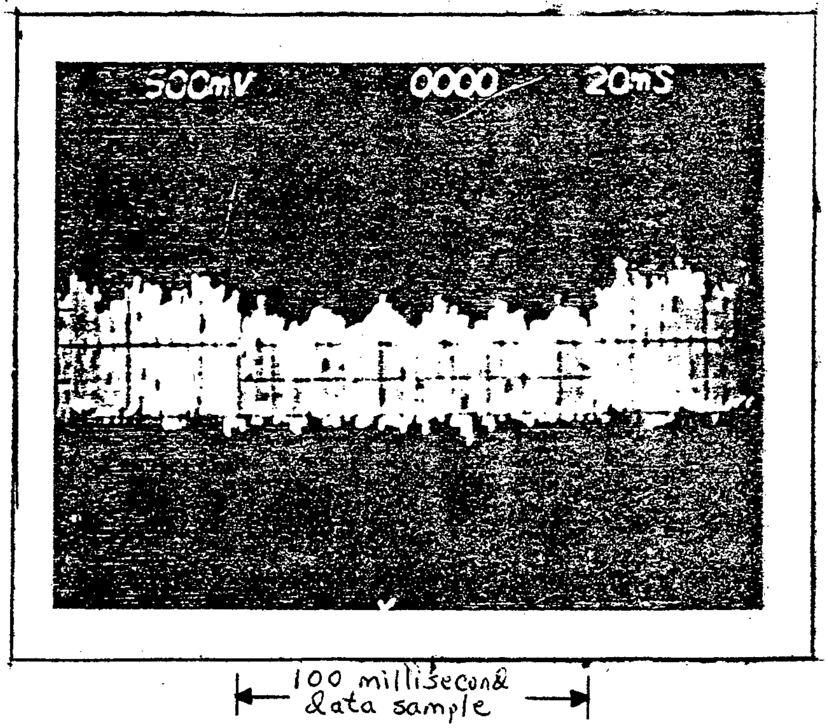


FIGURE 9. Received Audio Signal from Key West Sonde No. 1

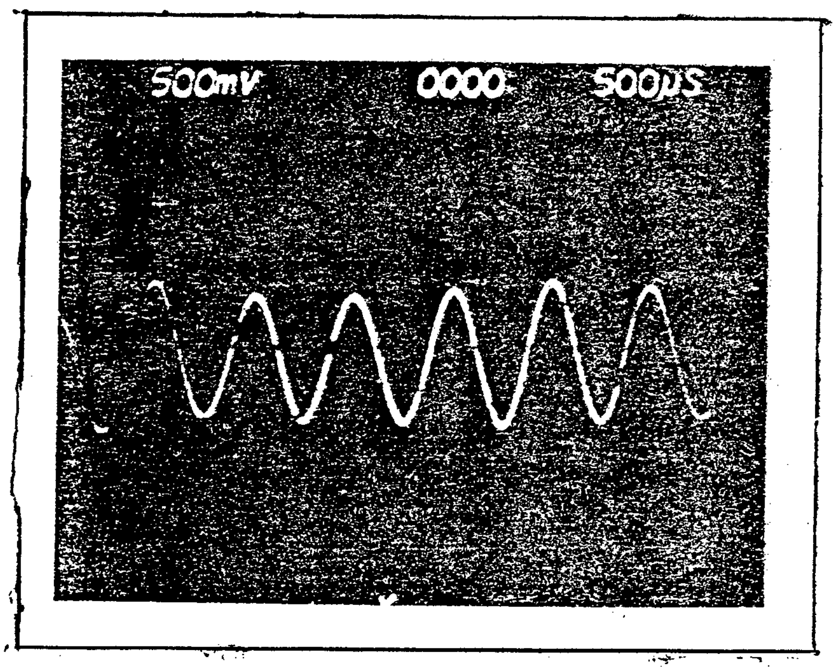


FIGURE 10. Expanded View of Audio Signal from Key West Sonde No. 1

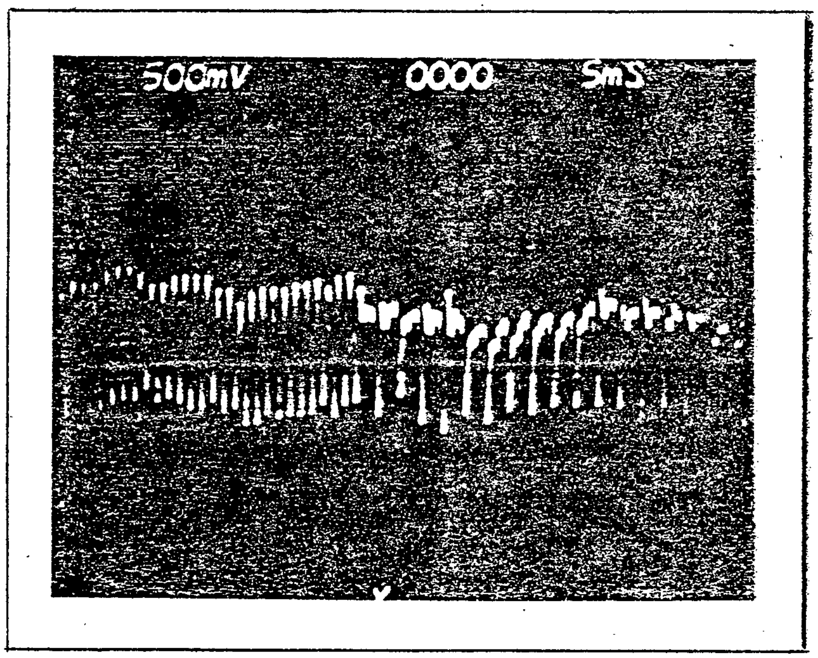


FIGURE 11. Commutation of Two Successive Data Samples from Key West Sonde No. 1

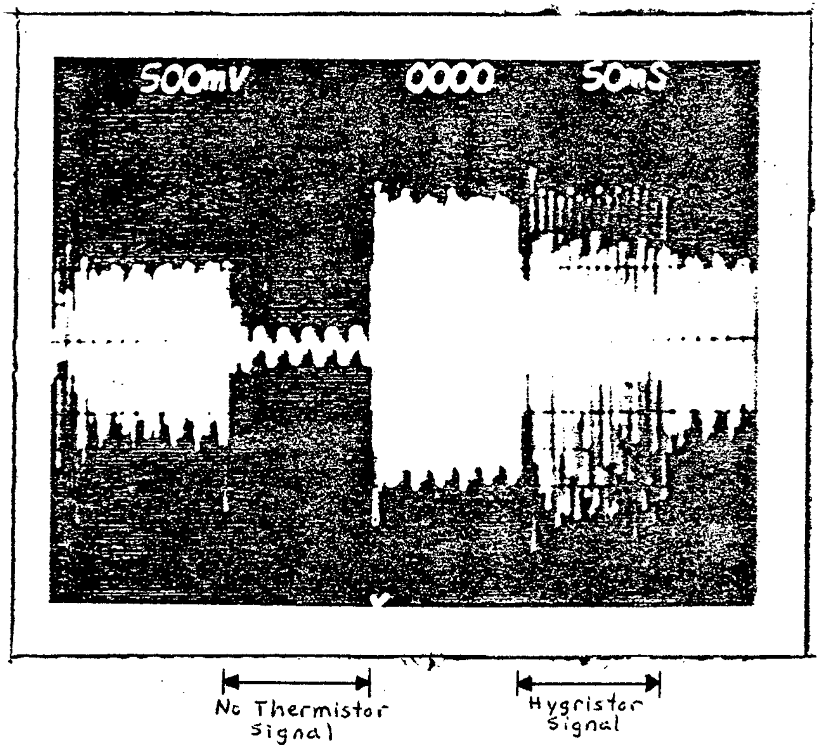


FIGURE 12. Defective Audio Signal from Key West Sonde No. 3

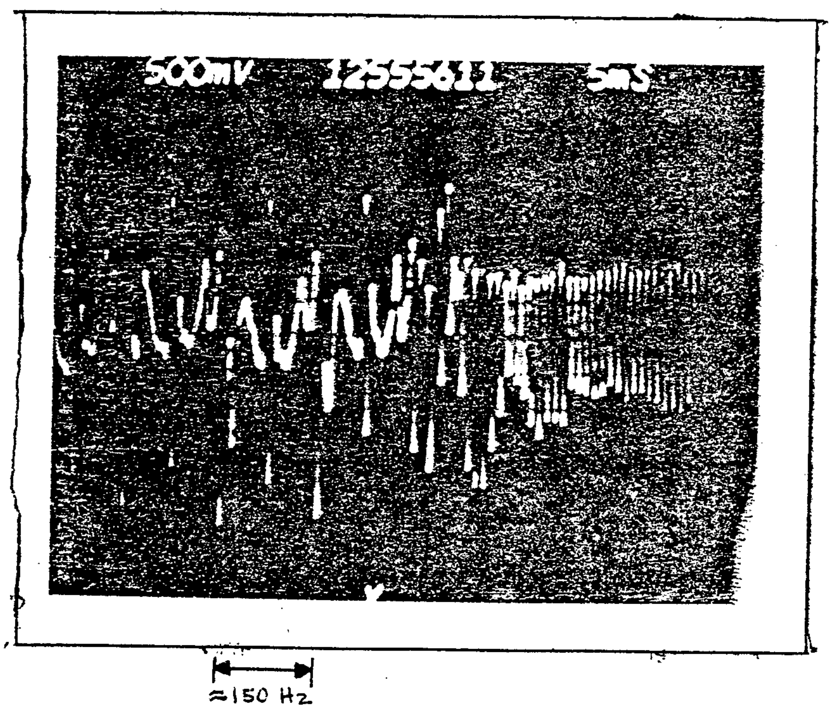


FIGURE 13. Noise Spikes in Hygristor Signal of Key West Sonde No. 3

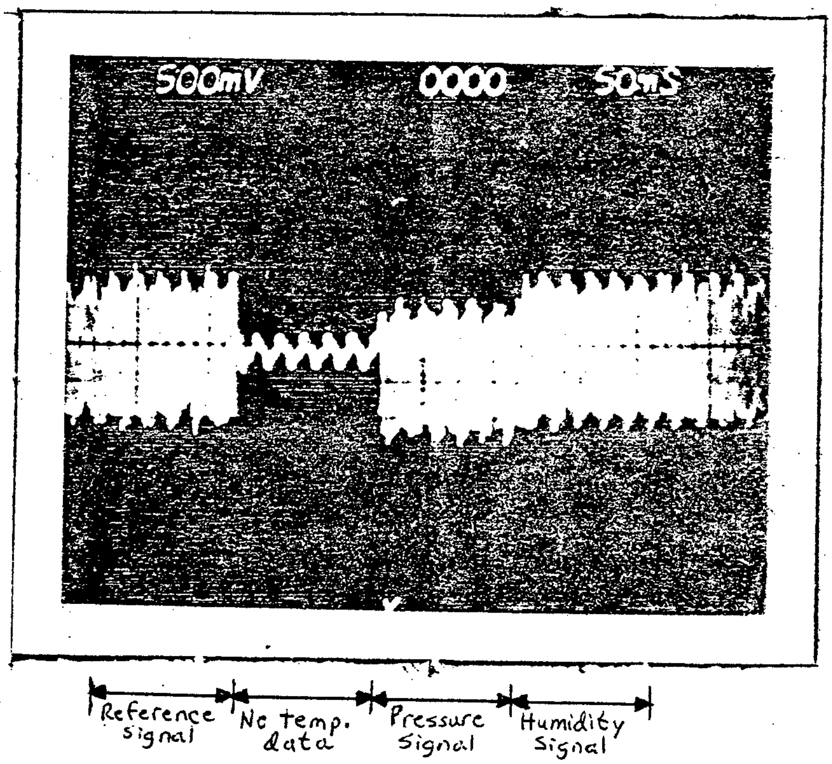


FIGURE 14. Missing Thermistor Signal in Key West Sonde No. 4

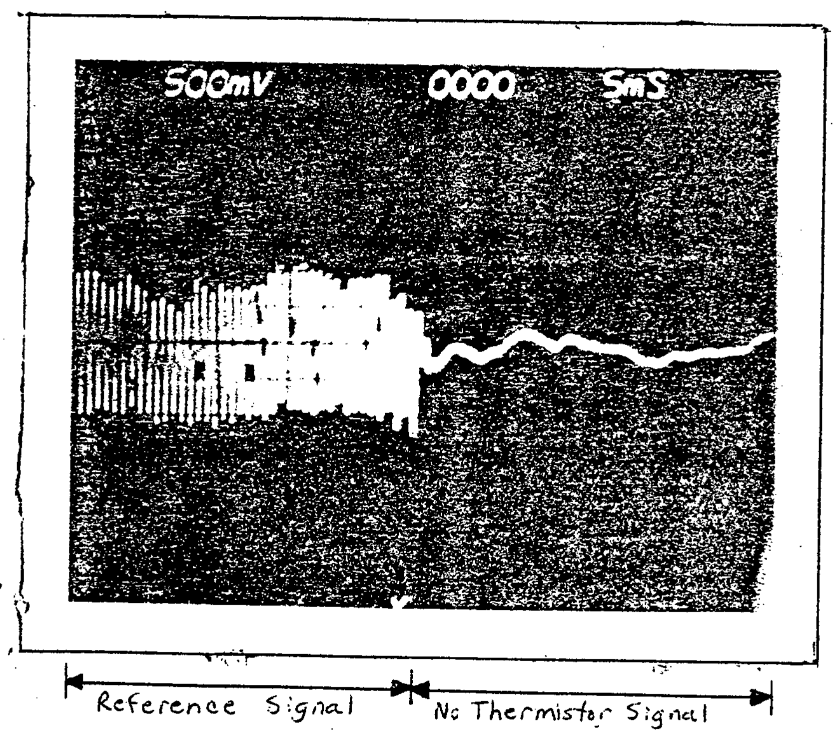


FIGURE 15. Expanded View of Missing Thermistor Signal from Key West Sonde No. 4

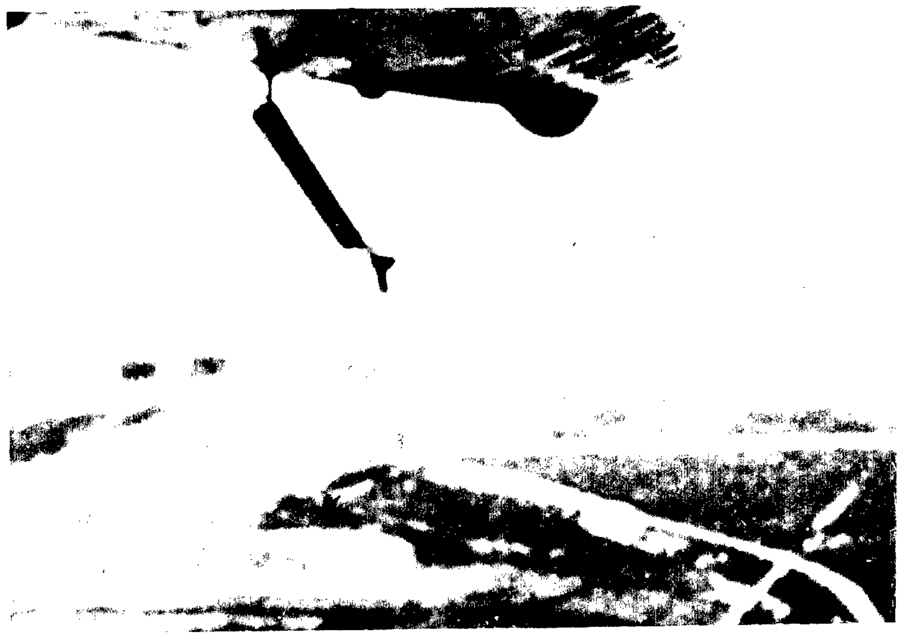


Figure 16 - Air Tab Release from Dropsonde Housing

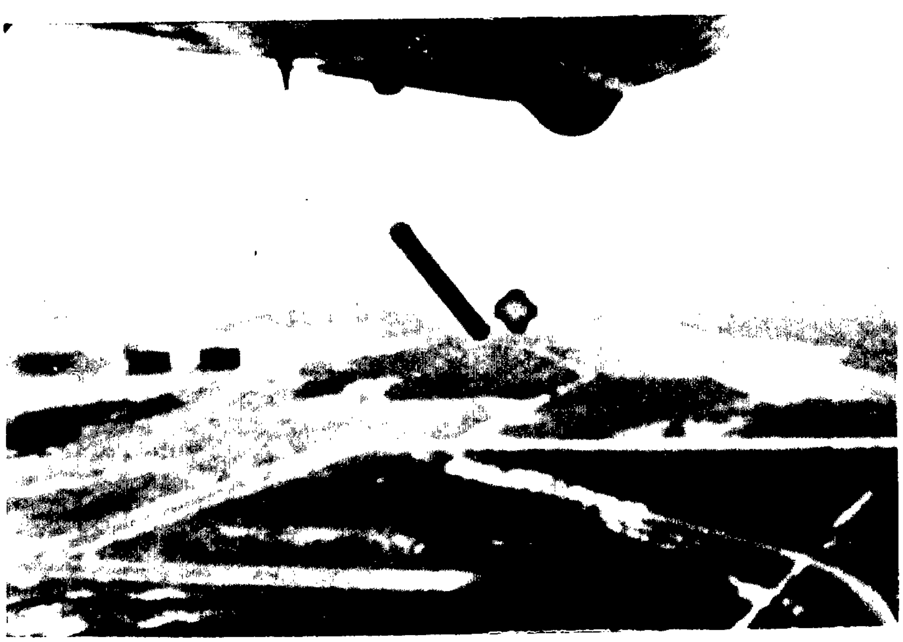


Figure 17 - Full Deployment of Drogue Parachute

Figure 18 - Separation of Main Parachute from Timer Mechanism

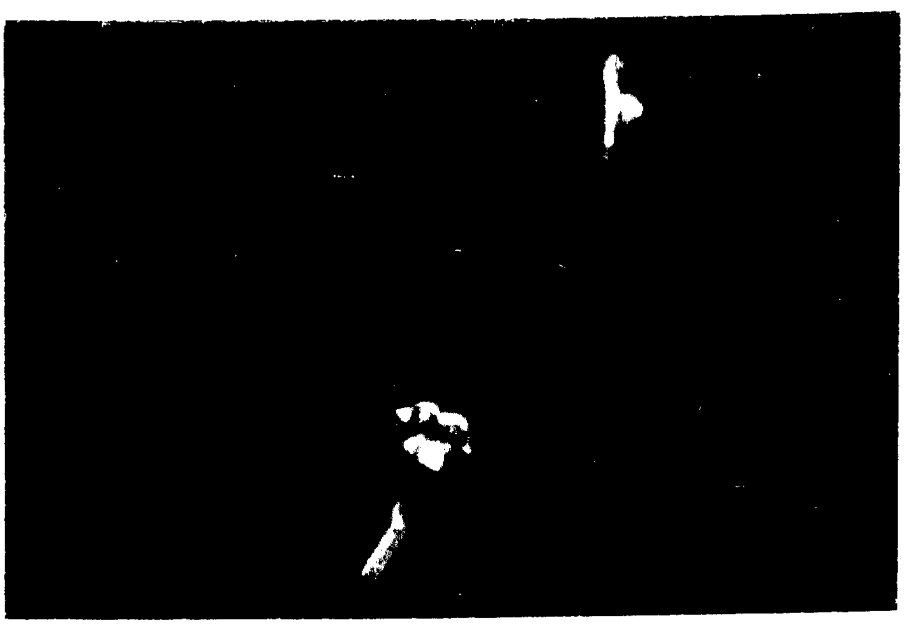


Figure 19 - Full Deployment of Main Parachute

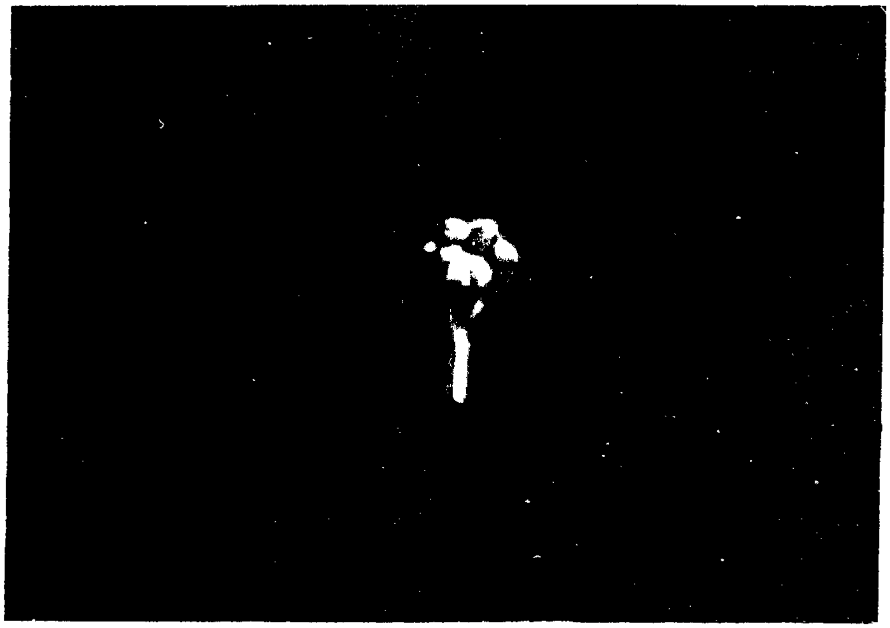


Figure 20 - Vertical Dropsonde Descent

Figure 21 - Dropsonde Descent at Ground Impact

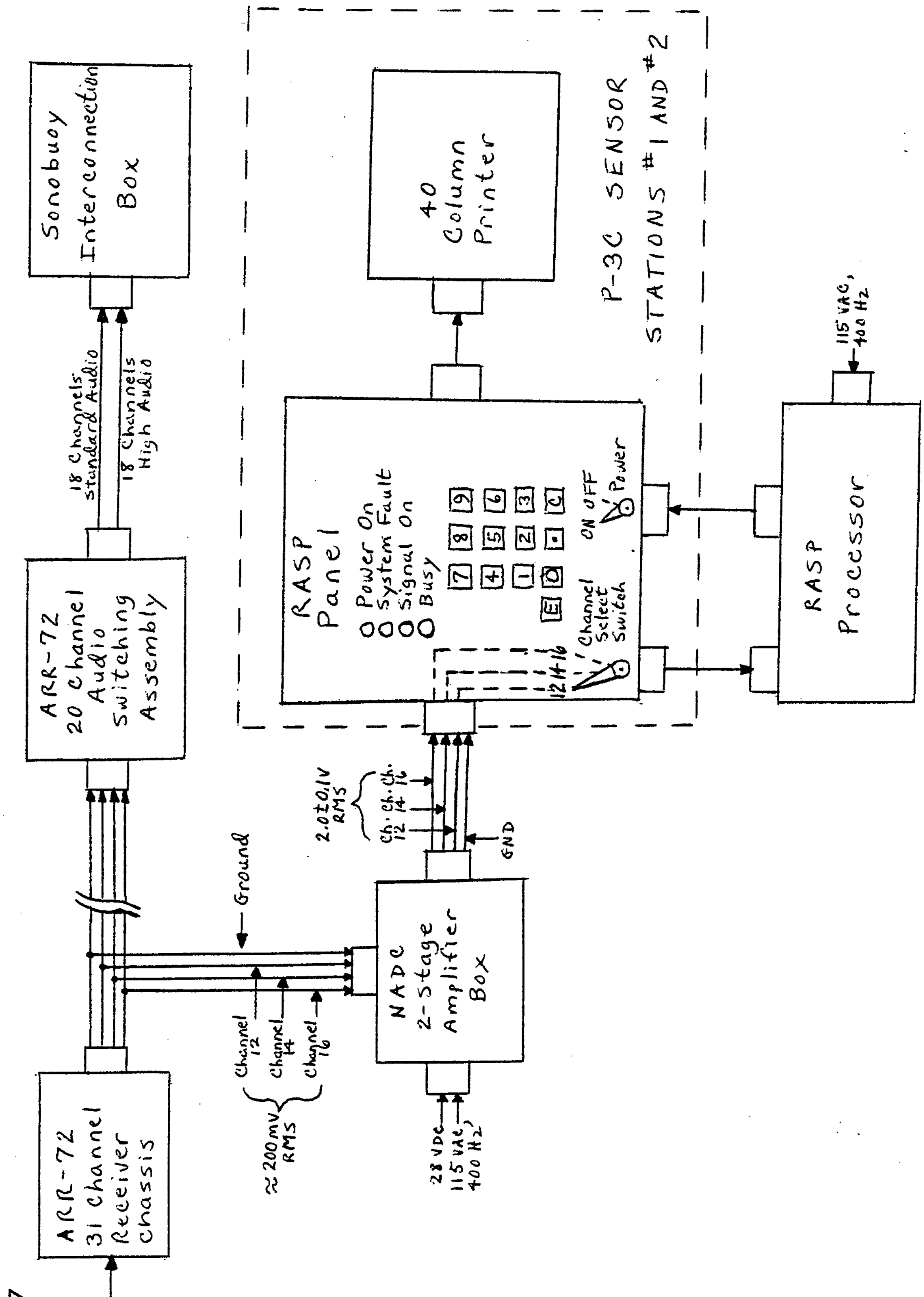


FIGURE 22. Proposed P-3C Dropsonde Processing Configuration

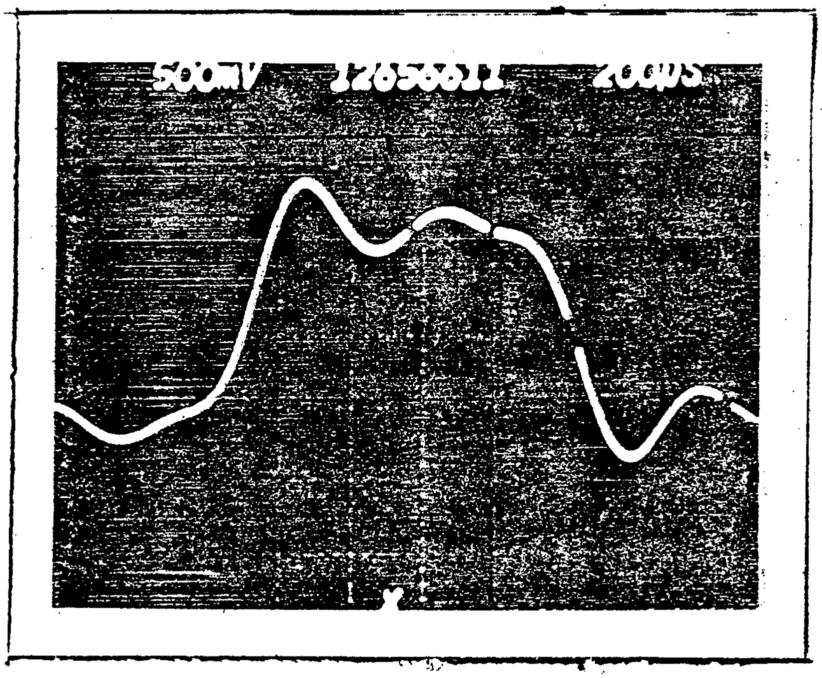


FIGURE 23. Dropsonde Signal Ringing Phenomena at Cape Hatteras

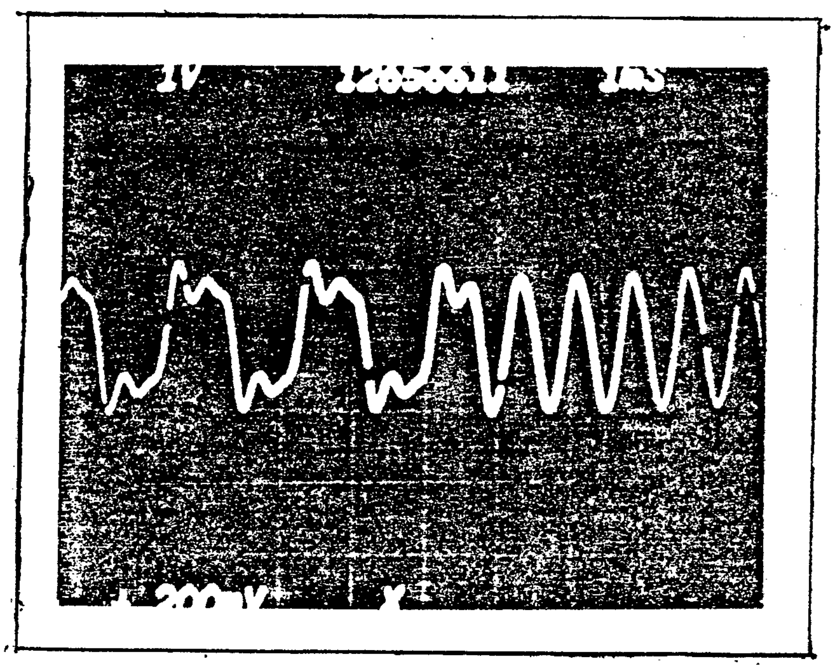


FIGURE 24. Comparative View of Signal Ringing

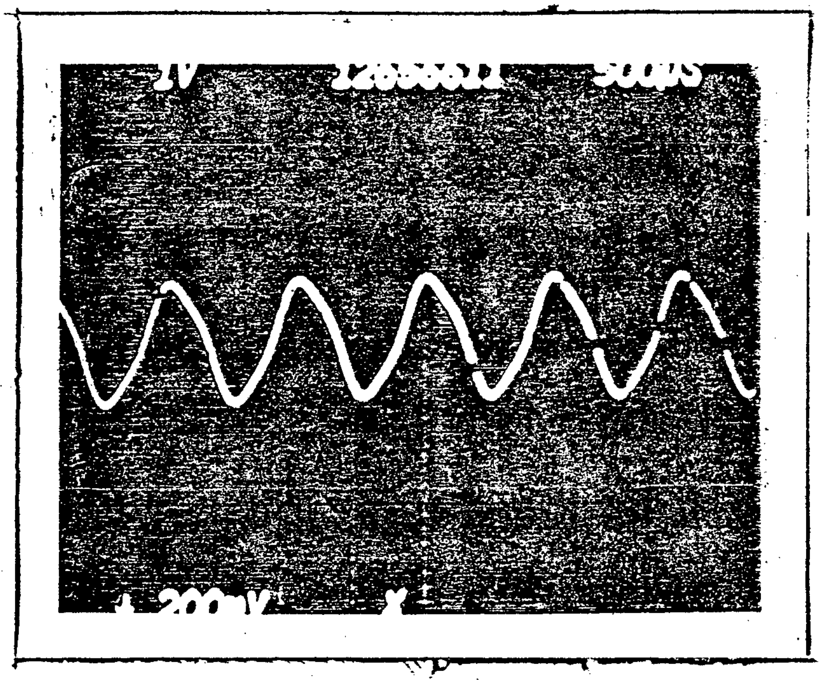


FIGURE 25. Sinusoidal Nature of Received Sonde Signal

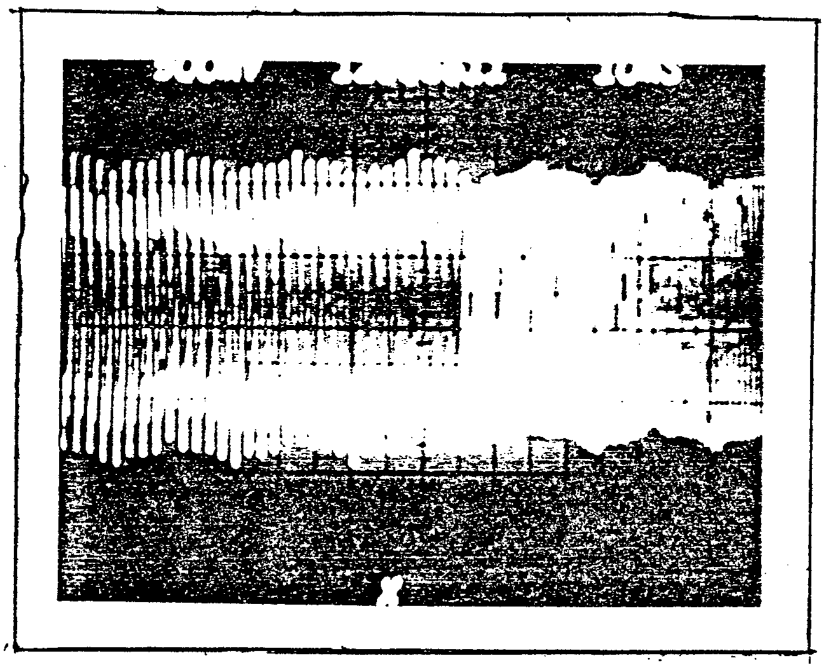
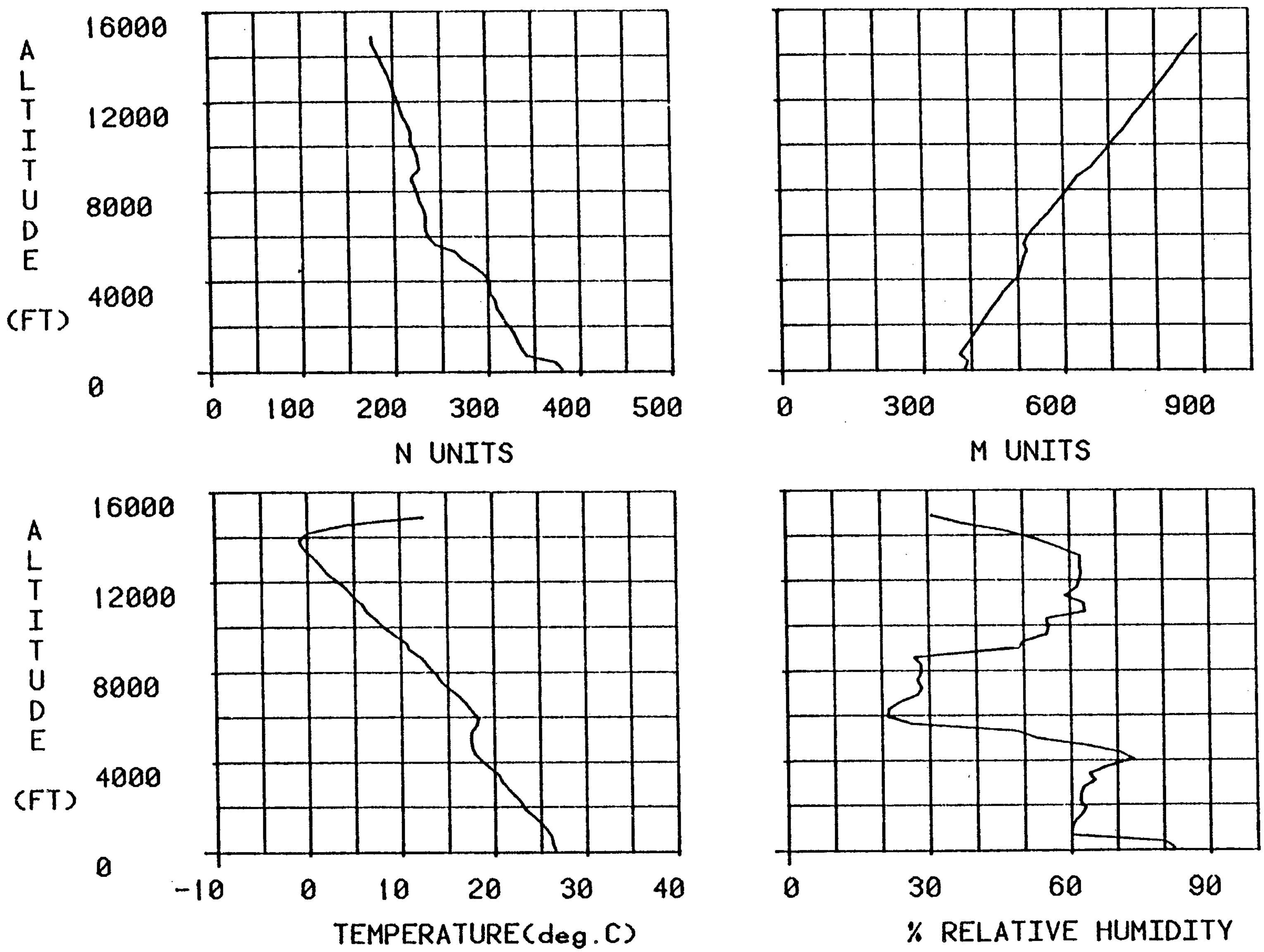


FIGURE 26. Typical Data Parameter Commutation



CAPE HATTERAS: LAT 35 deg 09 min N, LONG 75 deg 18 min W
DATE:09/08/78 SONDE NO.11 LAUNCH TIME: 11:28:42(EDT)

FIGURE 27. NAVAIRDEVCEN Processed Meteorological Data for Sonde No. 11

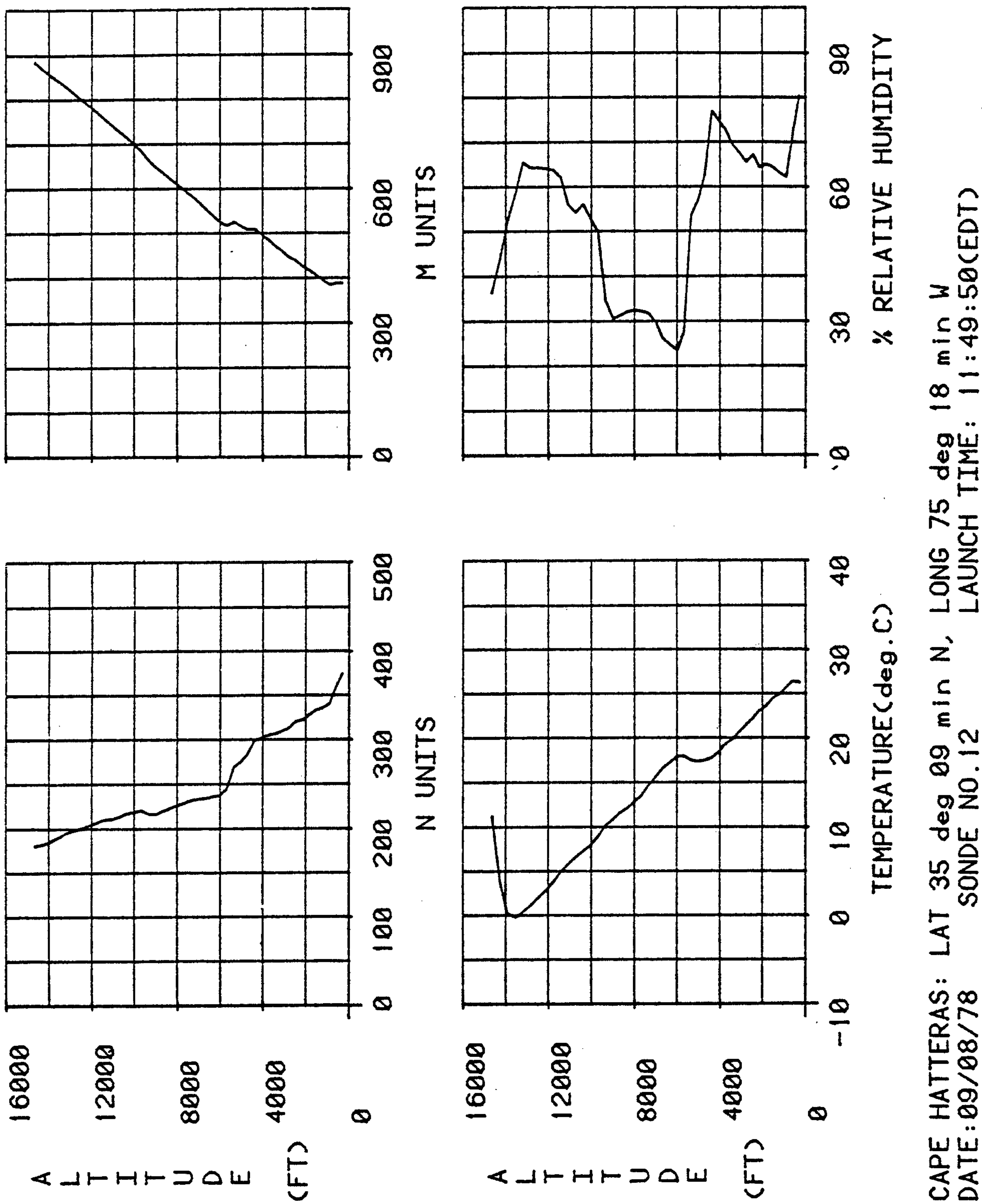
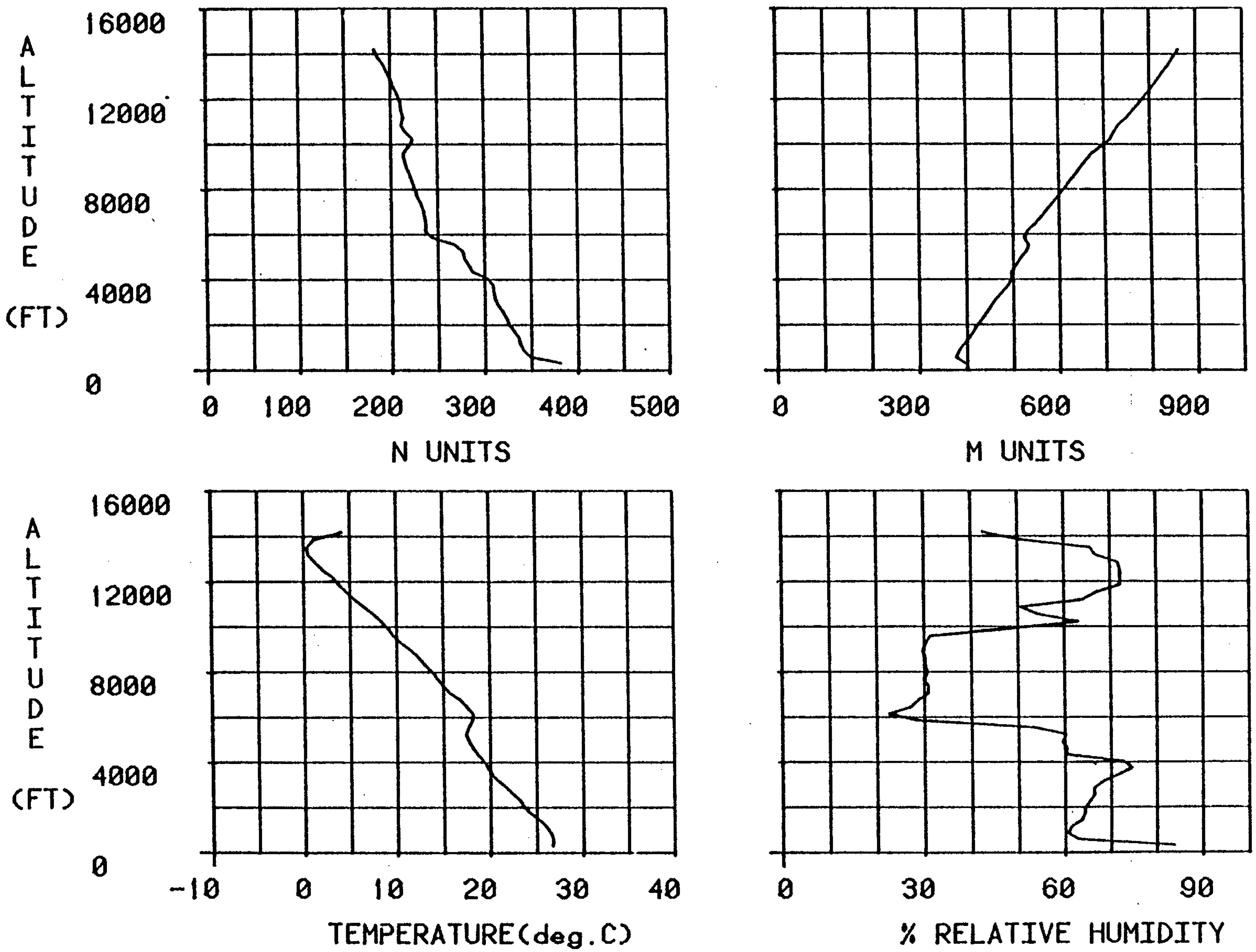
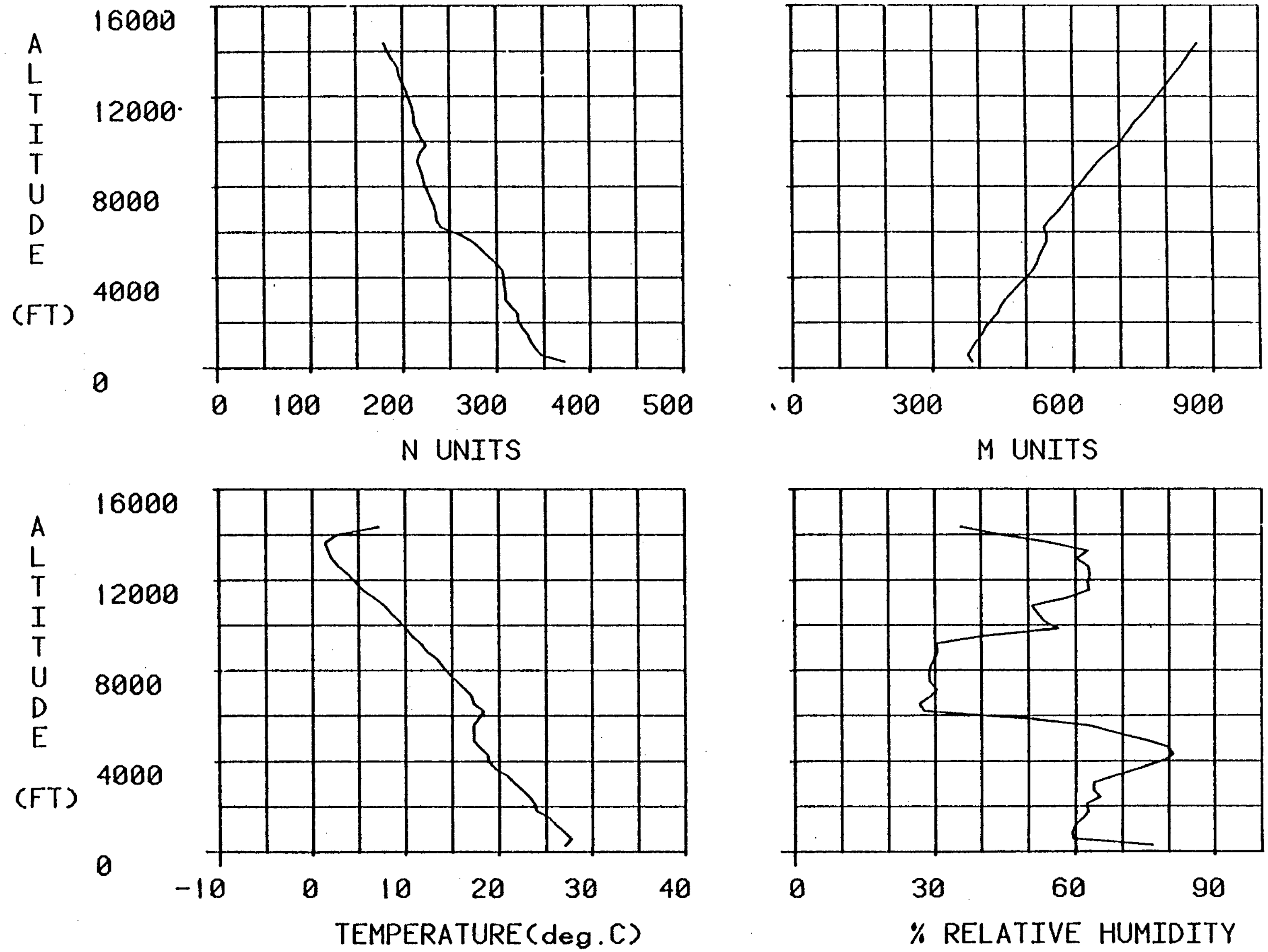


FIGURE 28. NAVAIRDEVCEN Processed Meteorological Data for Sonde No. 12



CAPE HATTERAS: LAT 35 deg 09 min N, LONG 75 deg 18 min W
DATE:09/08/78 SONDE NO.13 LAUNCH TIME: 12:13:31(EDT)

FIGURE 29. NAVAIRDEVCEN Processed Meteorological Data for Sonde No. 13



CAPE HATTERAS: LAT 35 deg 09 min N, LONG 75 deg 18 min W
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FIGURE 30. NAVAIRDEVCEN Processed Meteorological Data for Sonde No. 14

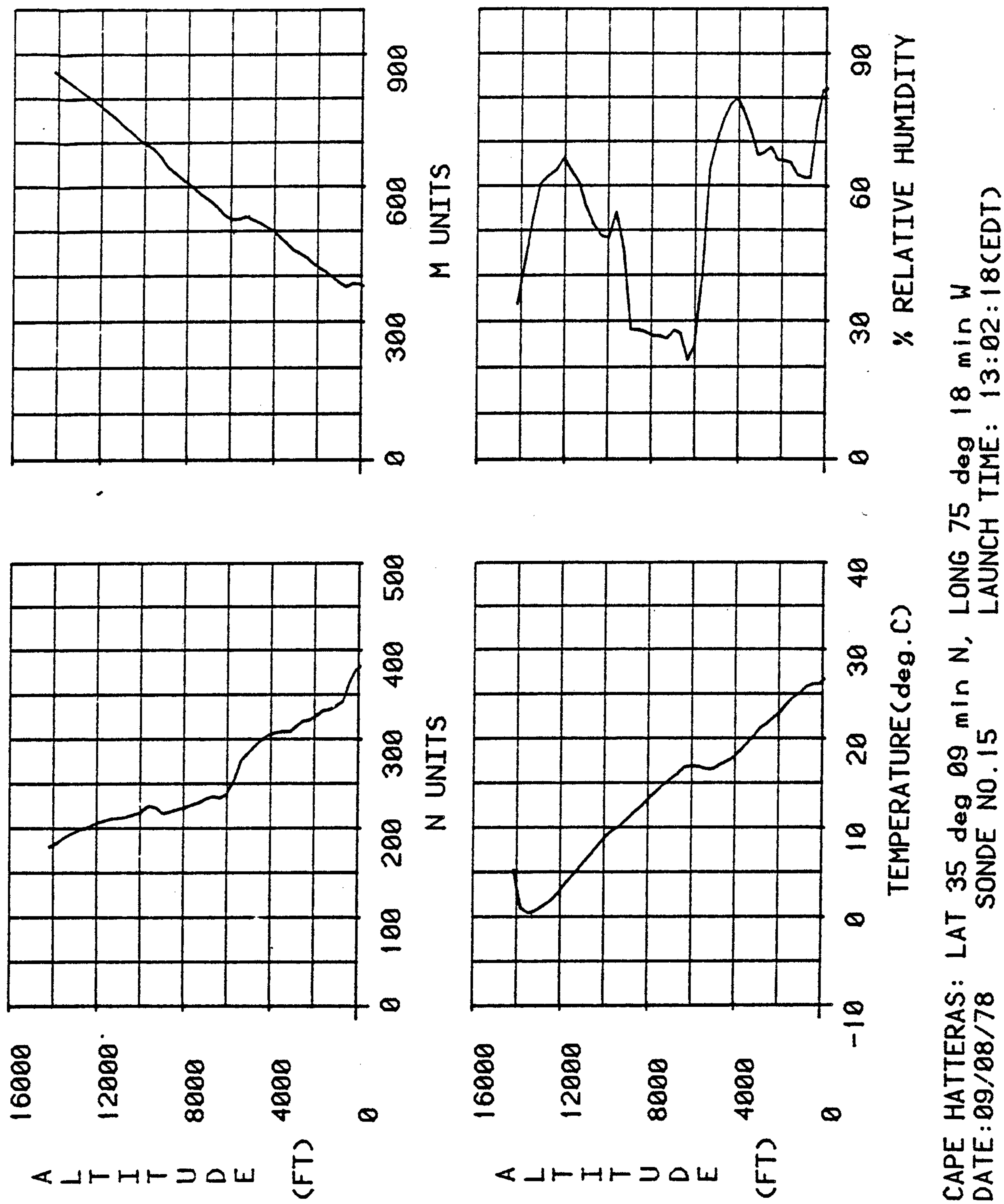


FIGURE 31. NAVAIRDEVCEN Processed Meteorological Data for Sonde No. 15

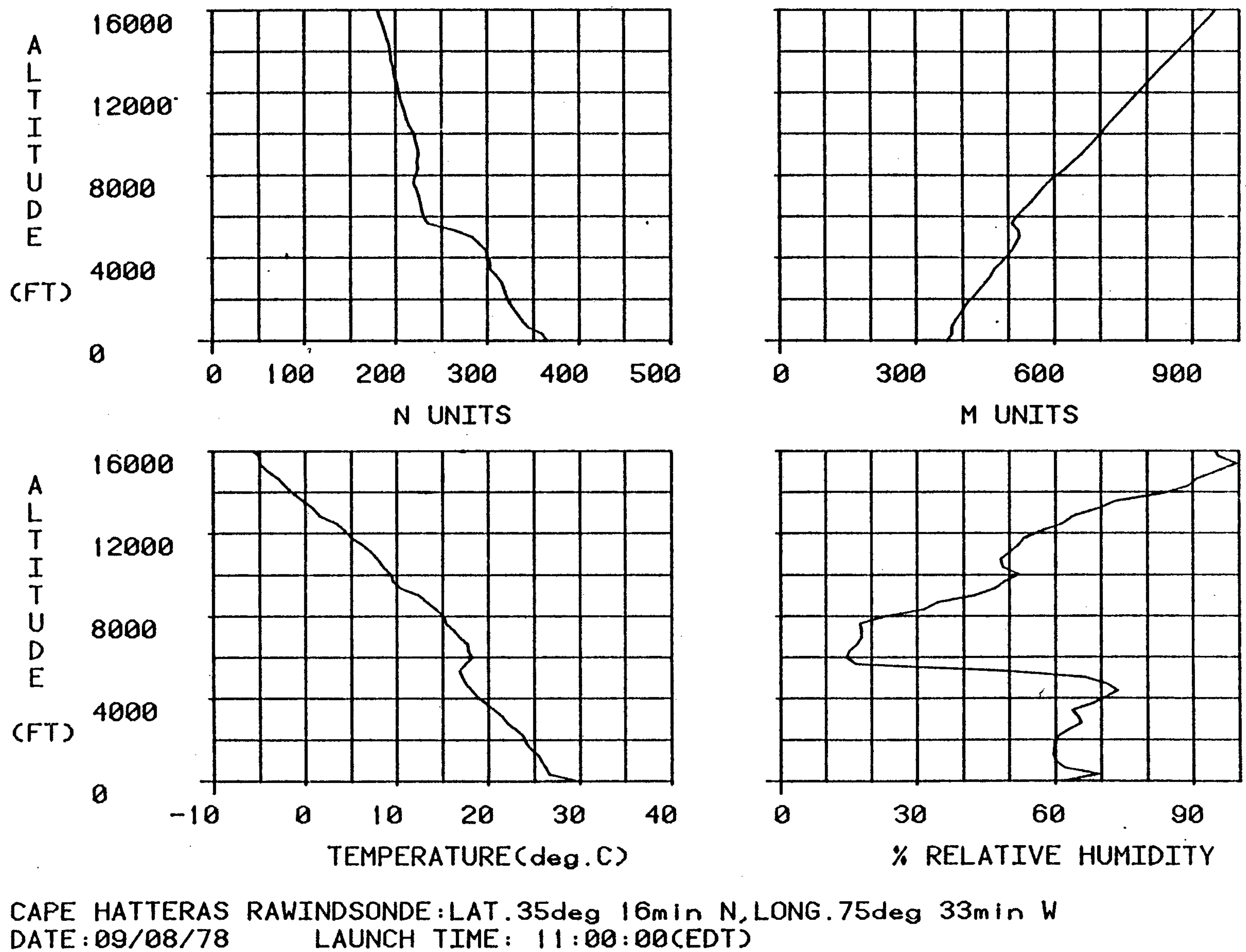


FIGURE 32. Meteorological Data from Rawindsonde No. 1

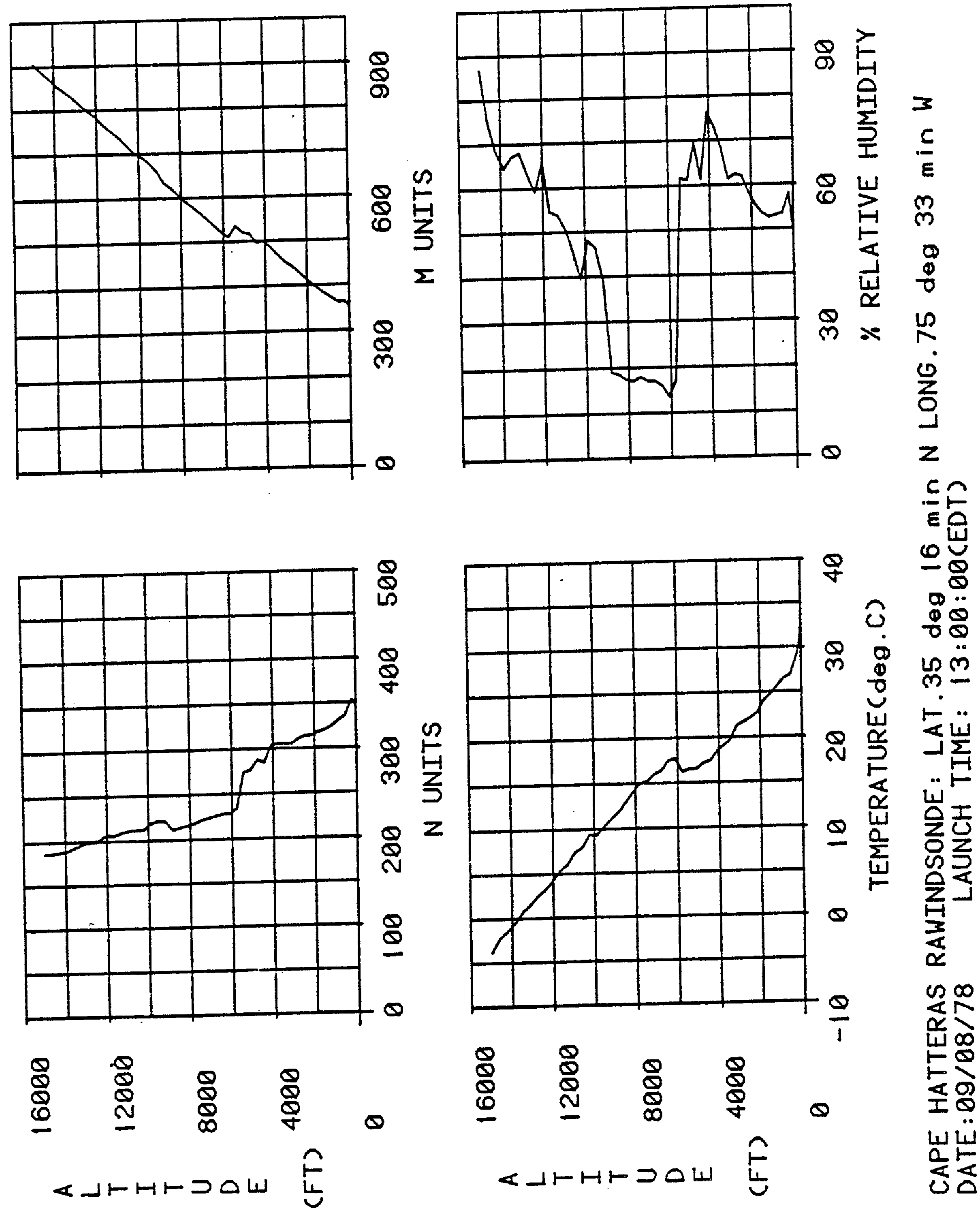


FIGURE 33. Meteorological Data from Rawindsonde No. 2

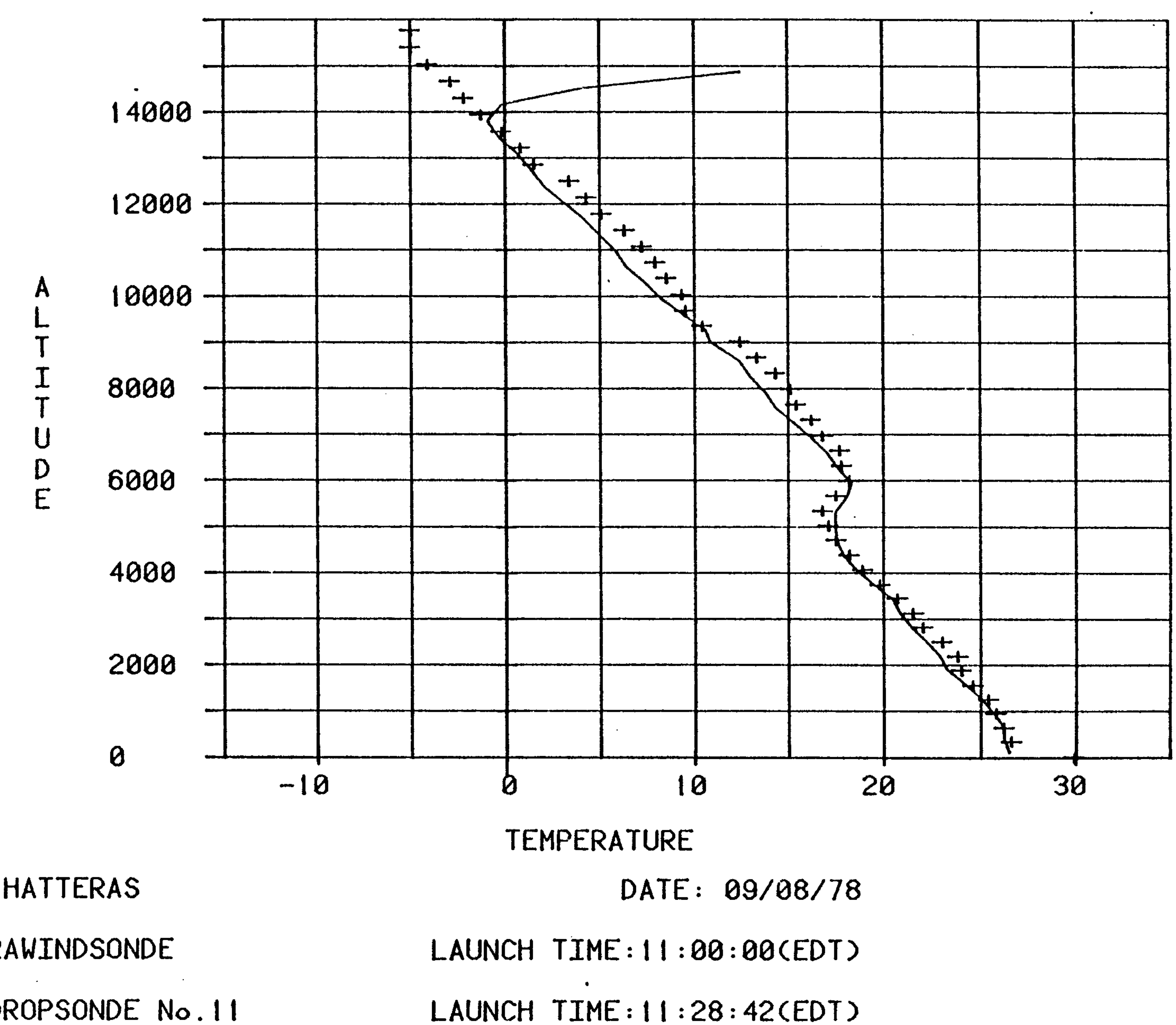


FIGURE 34. Temperature Data Comparison of Rawindsonde No. 1 and Sonde No. 11

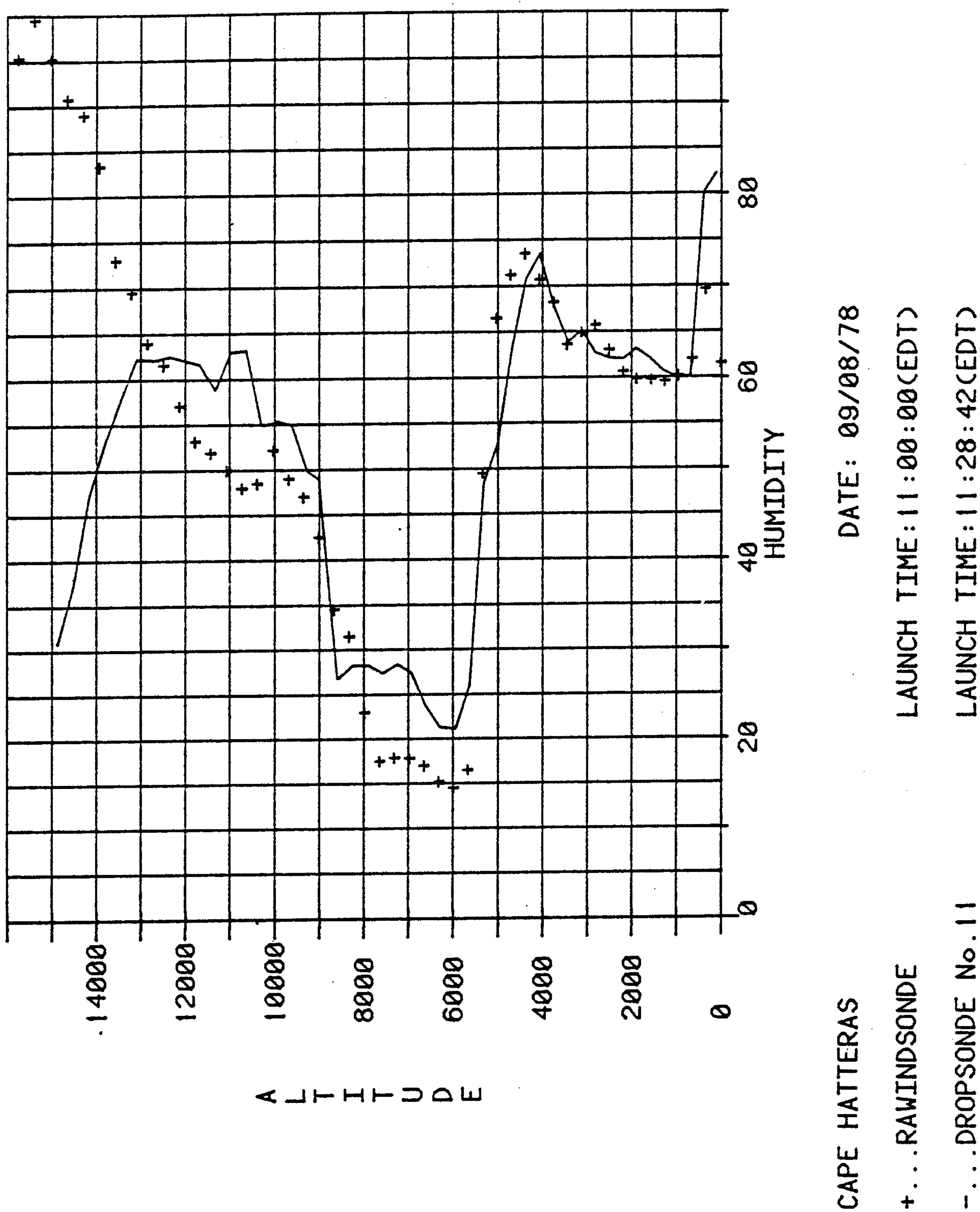


FIGURE 35. Humidity Data Comparison of Rawindsonde No. 1 and Sonde No. 11

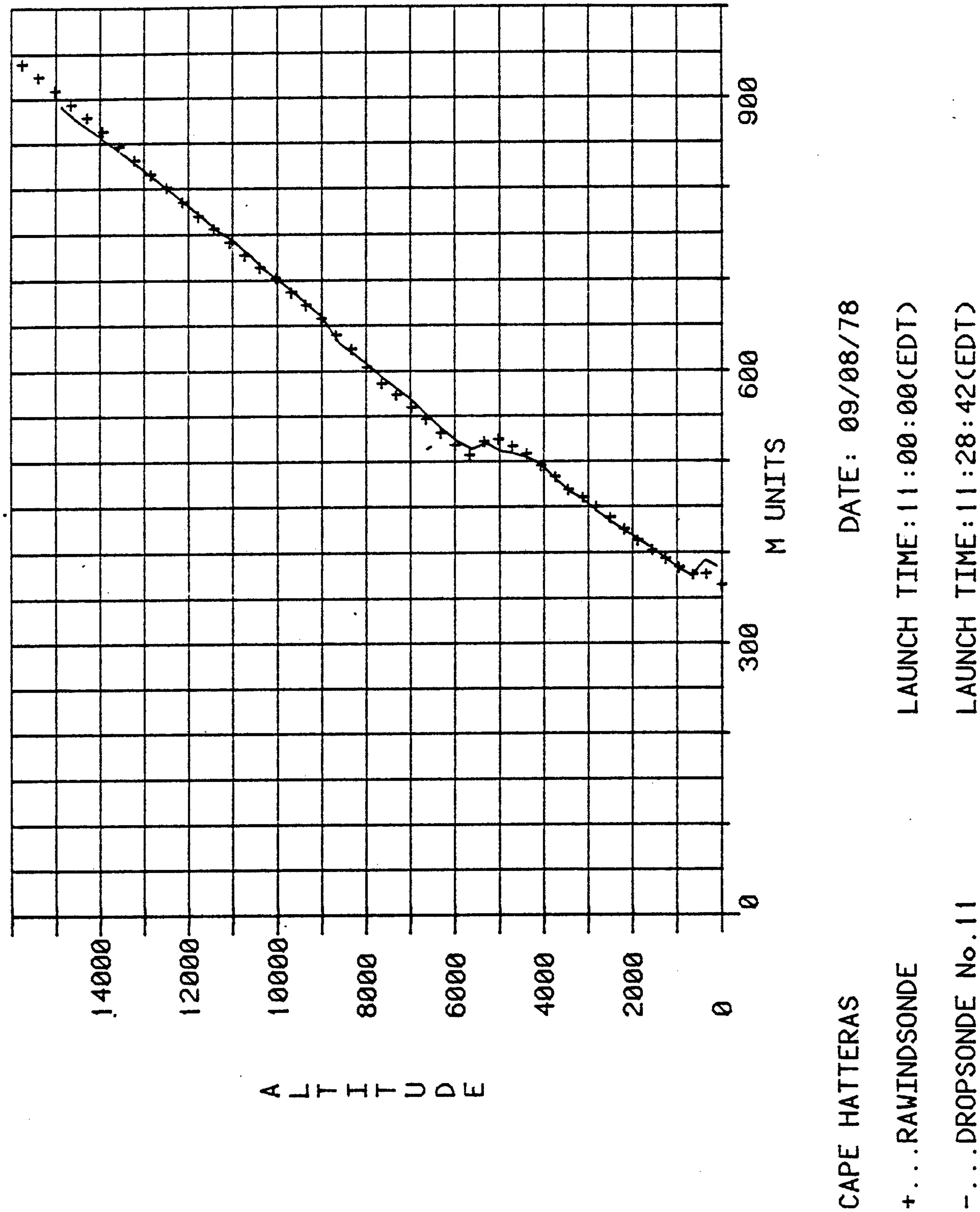


FIGURE 36. M-Units Data Comparison of Rawindsonde No. 1 and Sonde No. 11

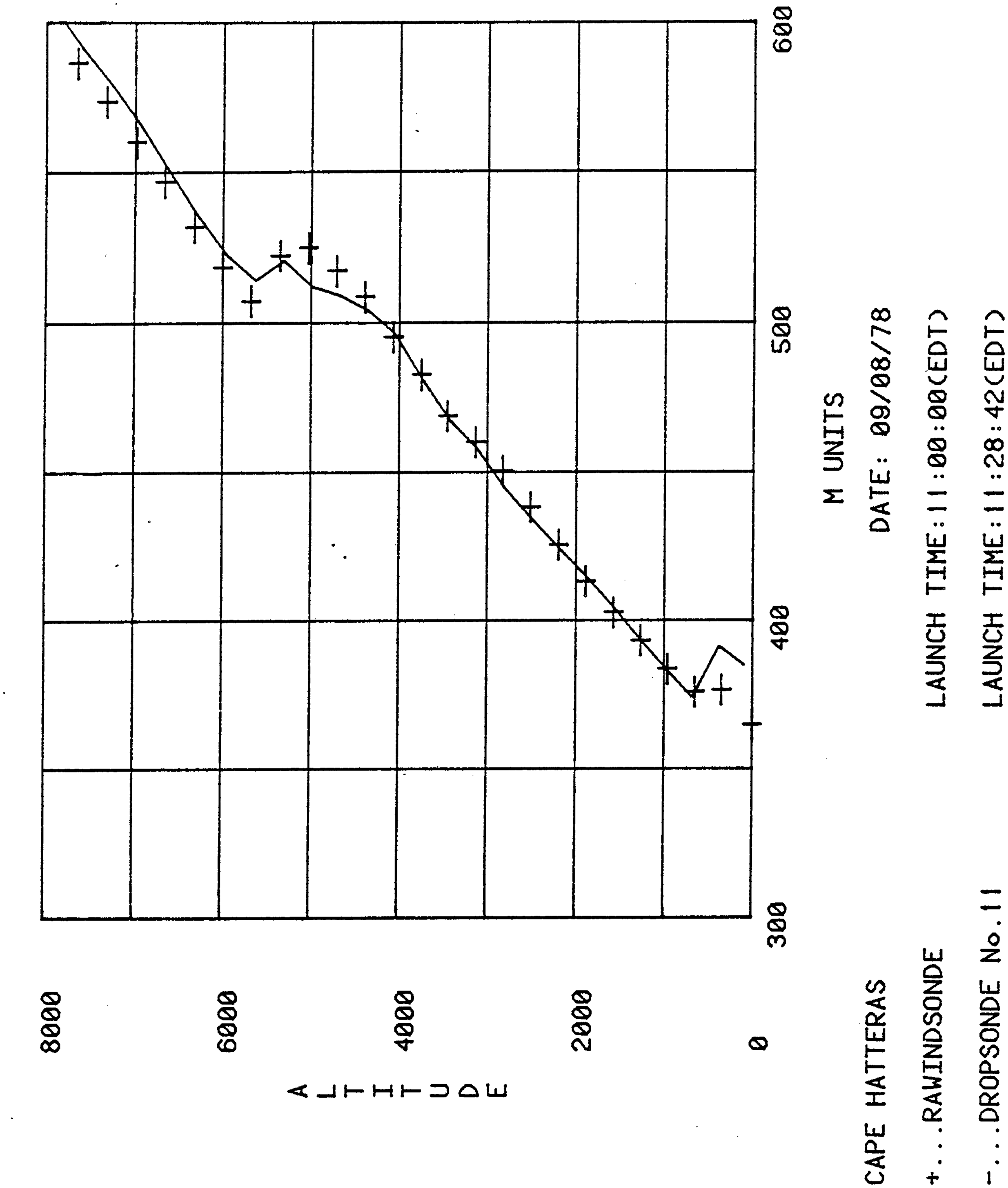


FIGURE 37. Expanded M-Units Data Comparison of Rawindsonde No. 1 and Sonde No. 11

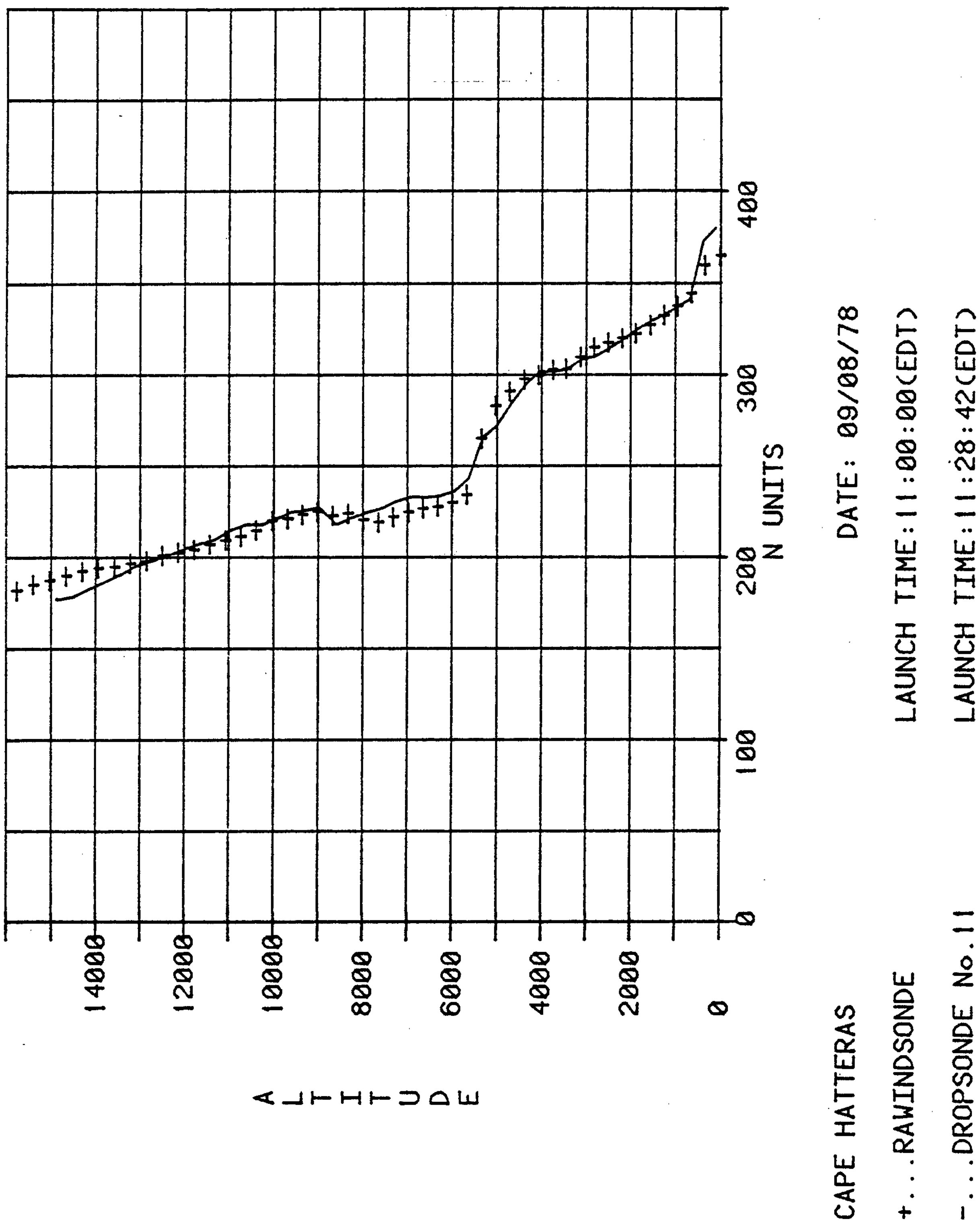


FIGURE 38. N-Units Data Comparison of Rawindsonde No. 1 and Sonde No. 11

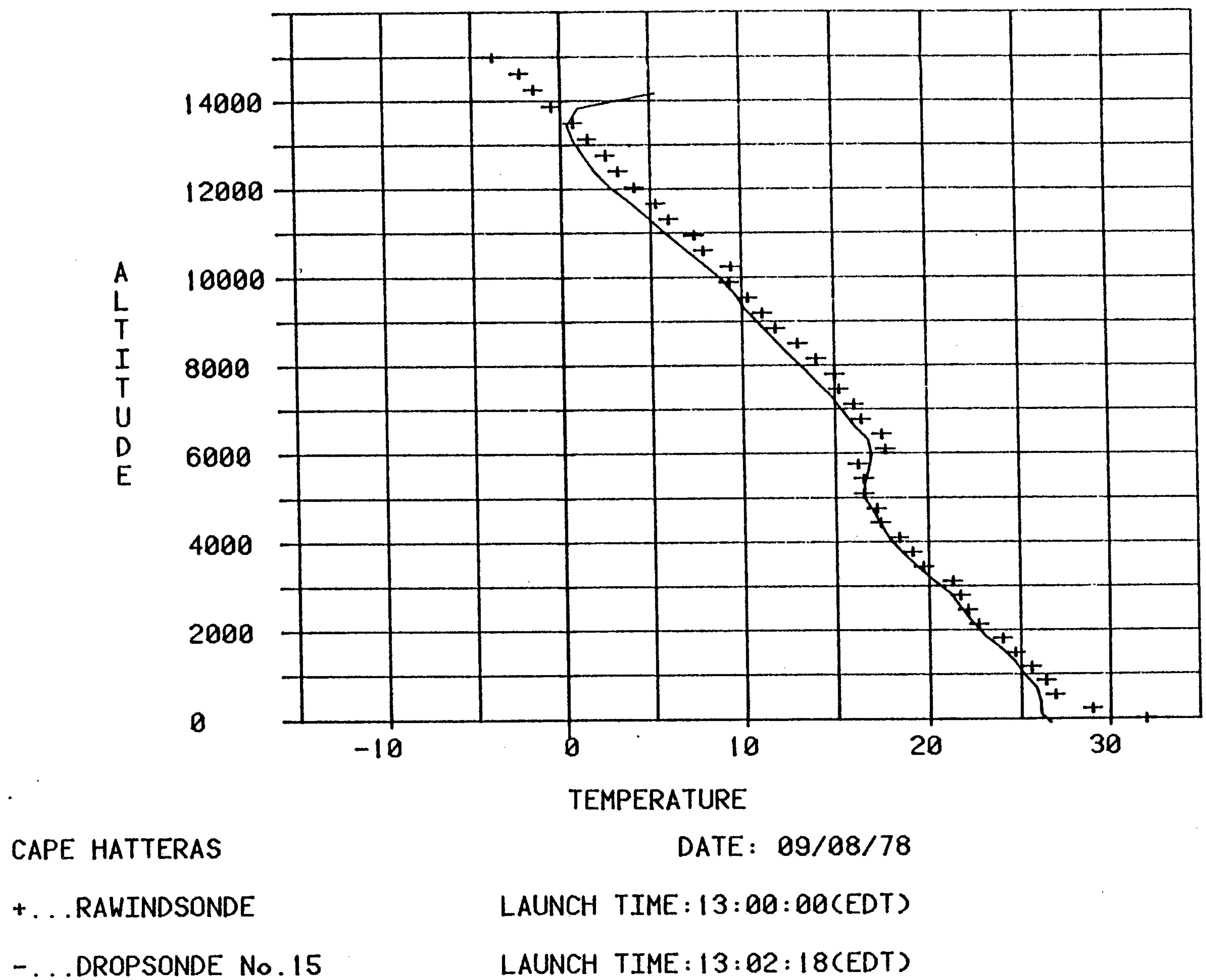


FIGURE 39. Temperature Data Comparison of Rawindsonde No. 2 and Sonde No. 15

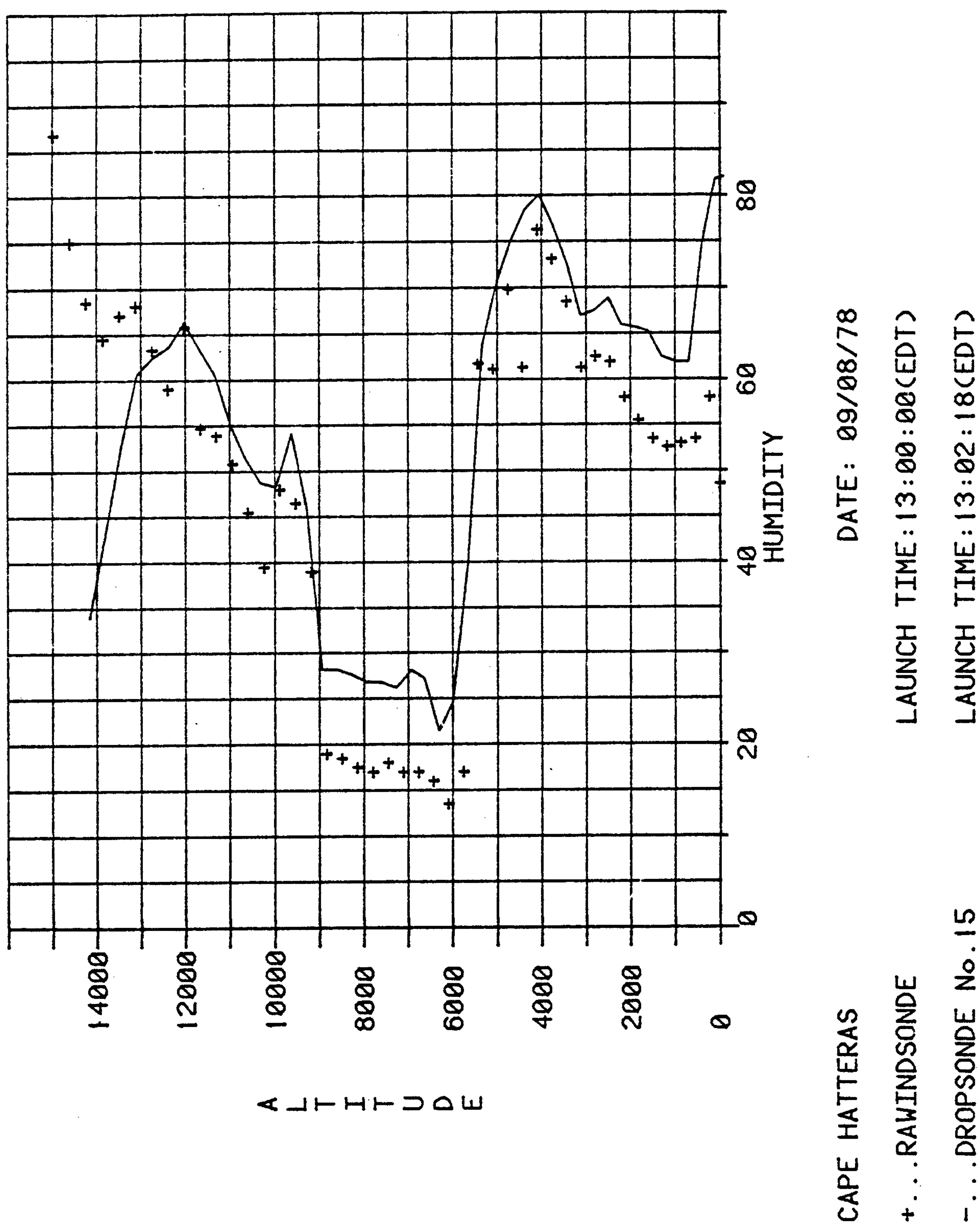


FIGURE 40. Humidity Data Comparison of Rawindsonde No. 2 and Sonde No. 15

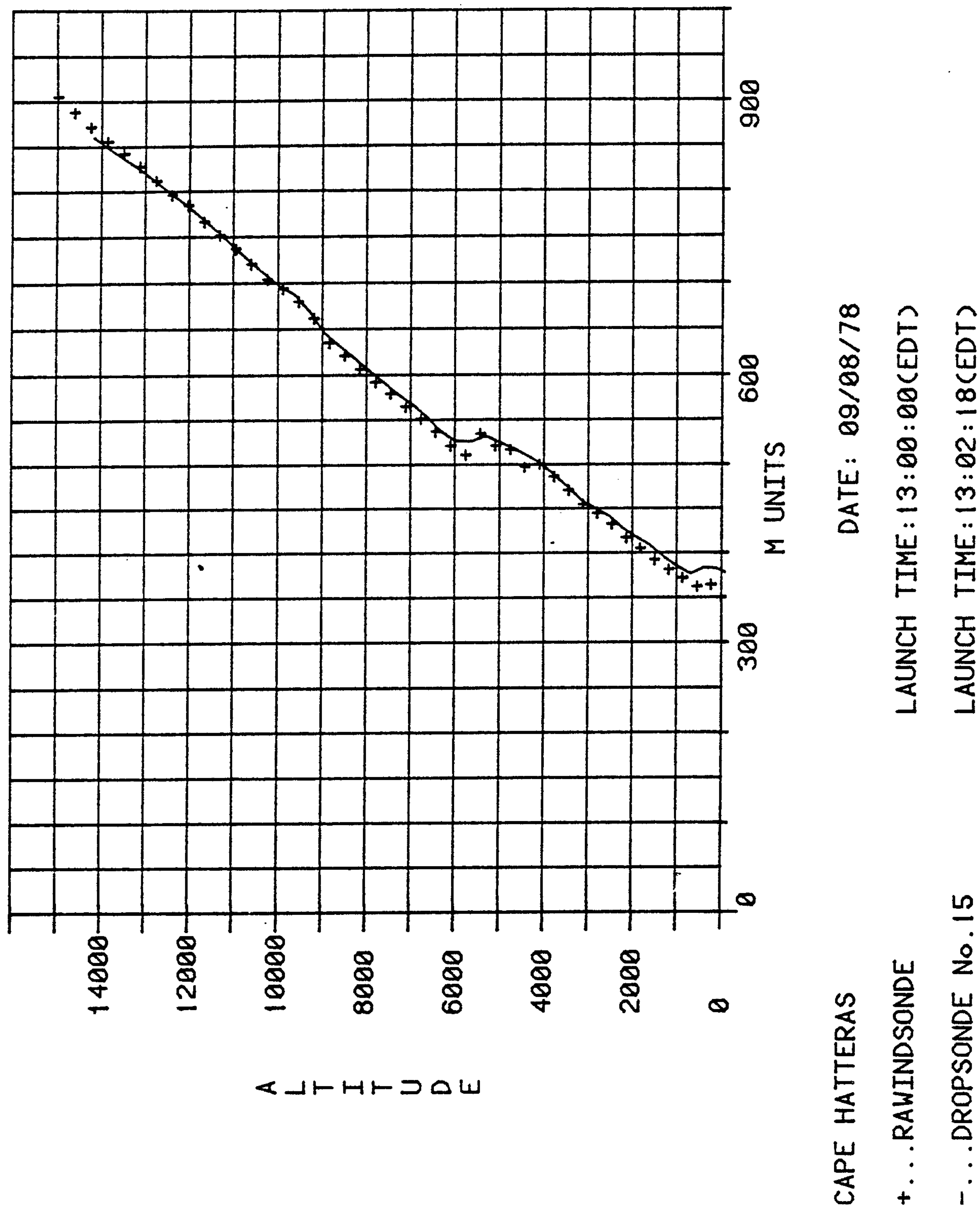


FIGURE 41. M-Units Data Comparison of Rawindsonde No. 2 and Sonde No. 15

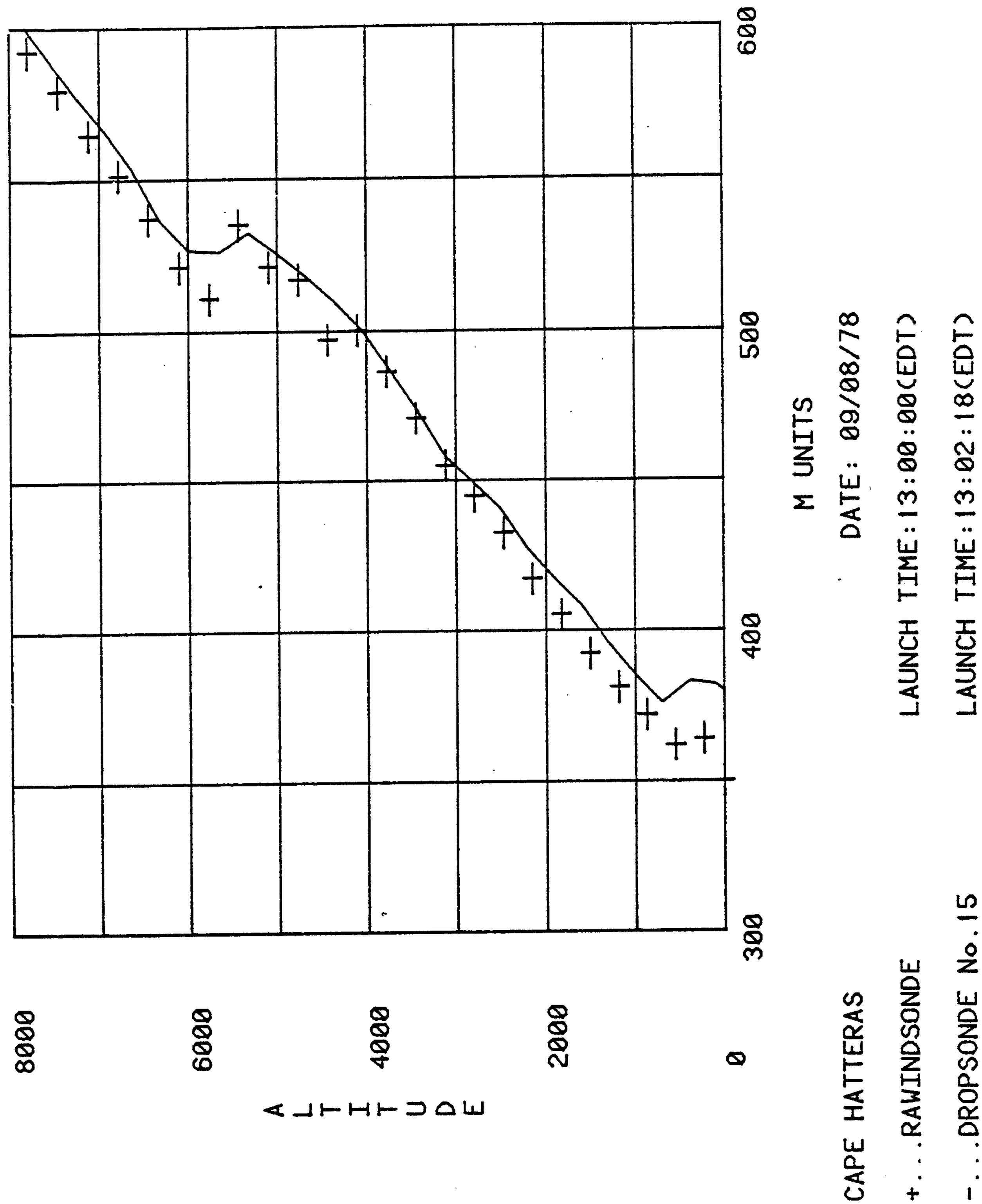


FIGURE 42. Expanded M-Units Data Comparison of Rawindsonde No. 2 and Sonde No. 15

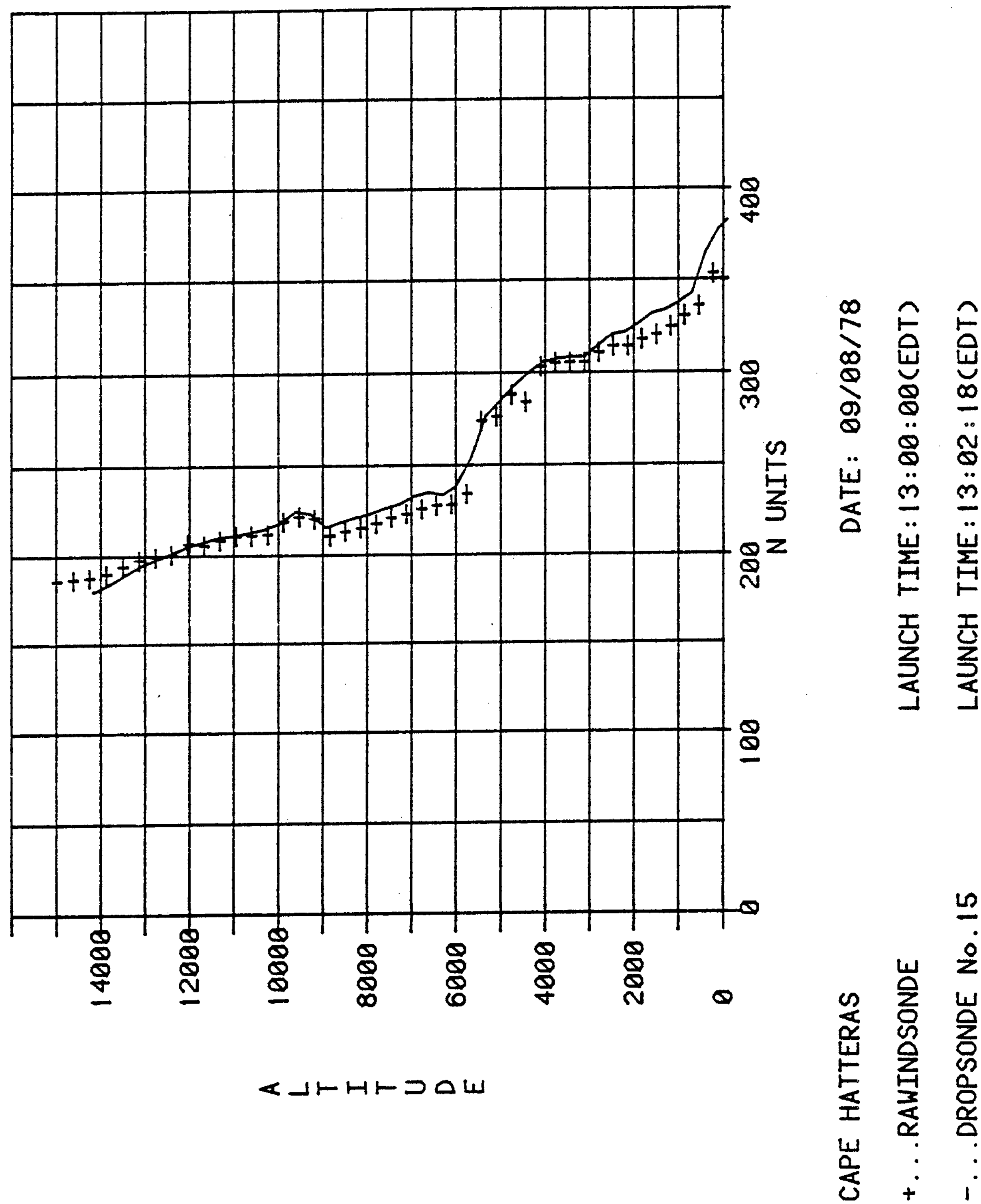
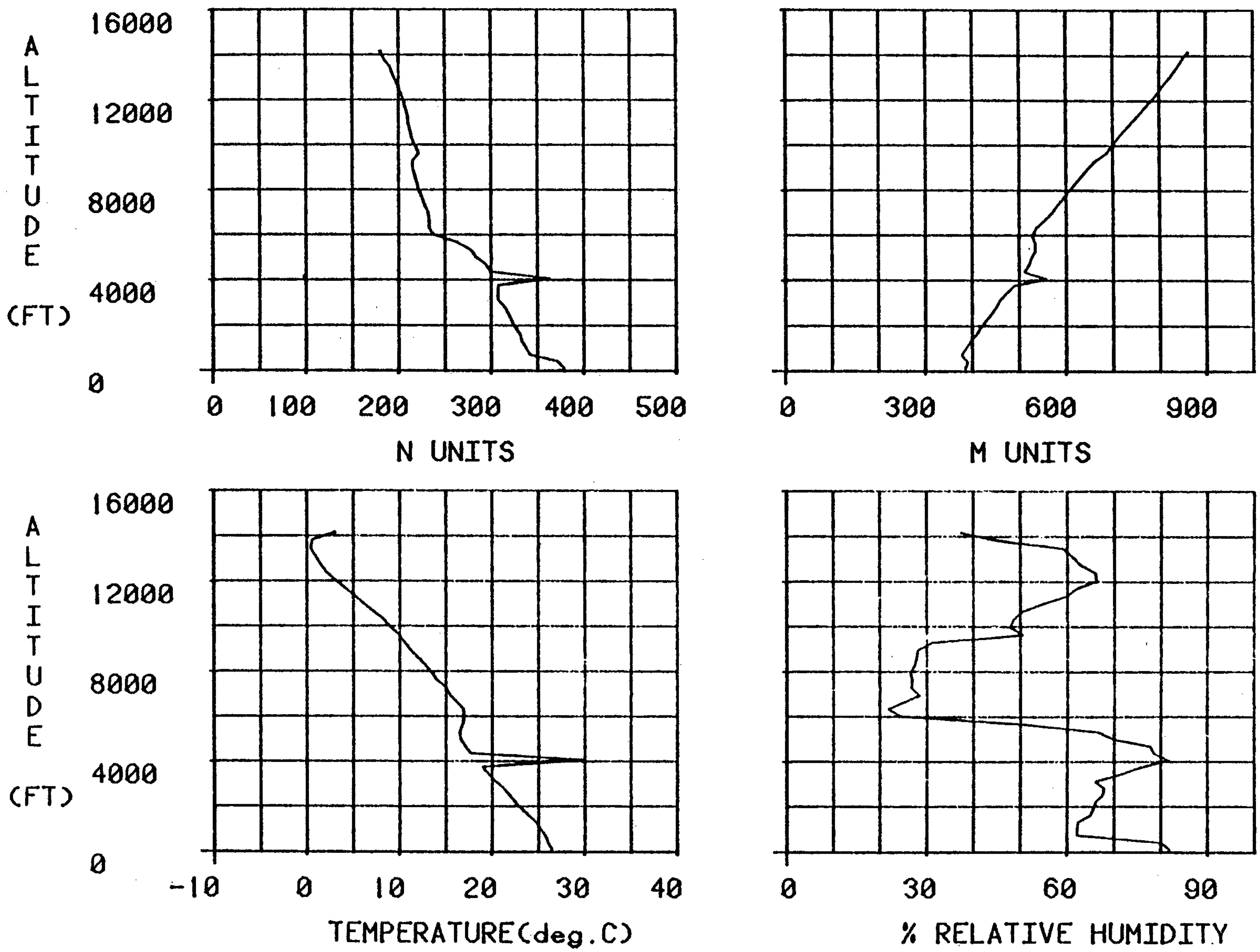
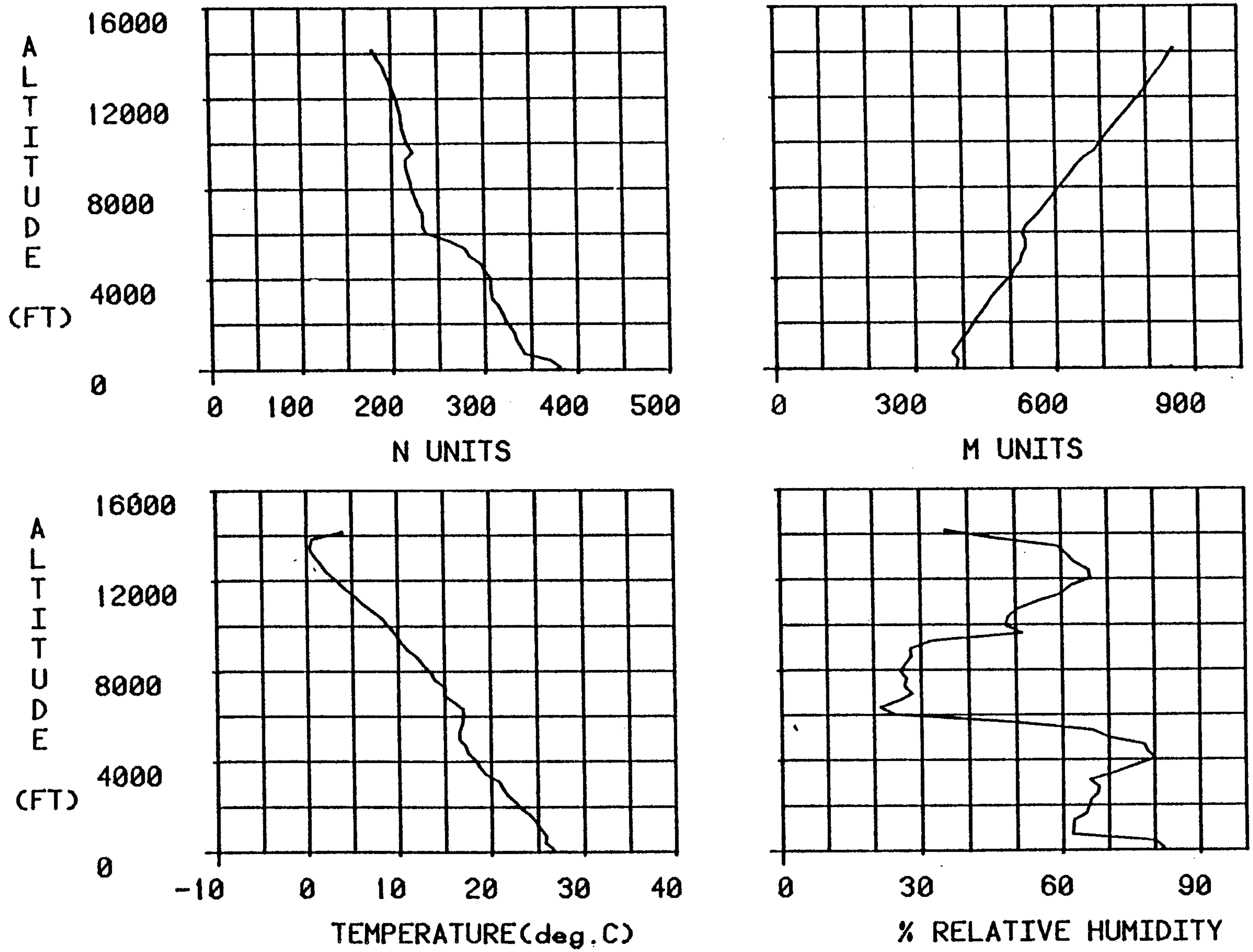


FIGURE 43. N-Units Data Comparison of Rawindsonde No. 2 and Sonde No. 15



BENDIX P-3C CAPE H.: LAT. 35 deg 09 min, LONG. 75 deg 18 min
DATE:09/08/78 SONDE NO.15 LAUNCH TIME: 13:02:18(EDT)

FIGURE 44. Meteorological Data for Sonde No. 15 Using Period Data Generated by Bendix RDSRU in P-3C and NAVAIRDEVCEN Algorithms



BENDIX LAB. CAPE H.: LAT. 35 deg 09 min, LONG. 75 deg 18 min
DATE:09/08/78 SONDE NO.15 LAUNCH TIME: 13:02:18(EDT)

FIGURE 45. Meteorological Data for Sonde No. 15 Using Bendix RDSRU Laboratory Generated Period Data and NAVAIRDEVCEN Algorithms

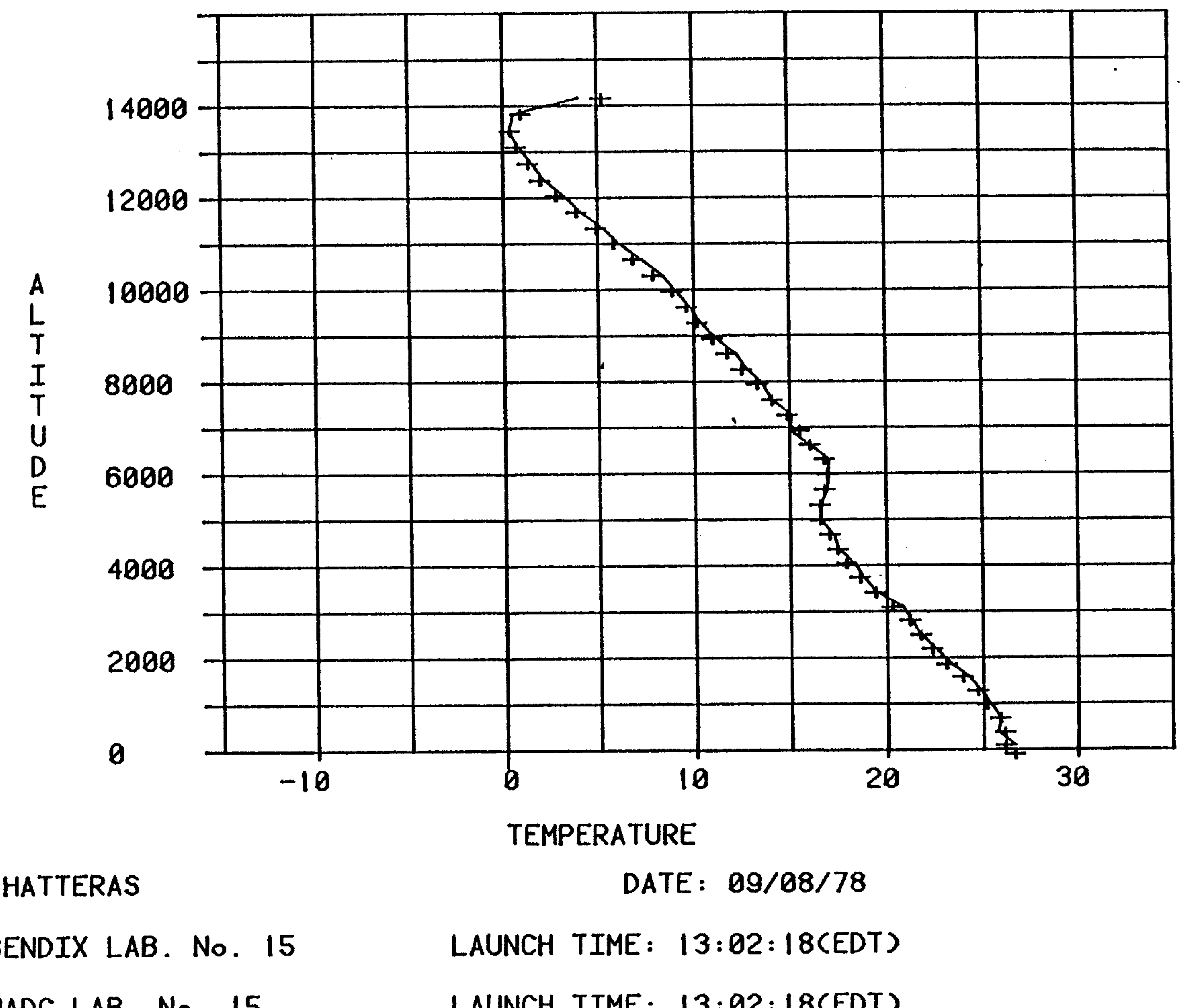
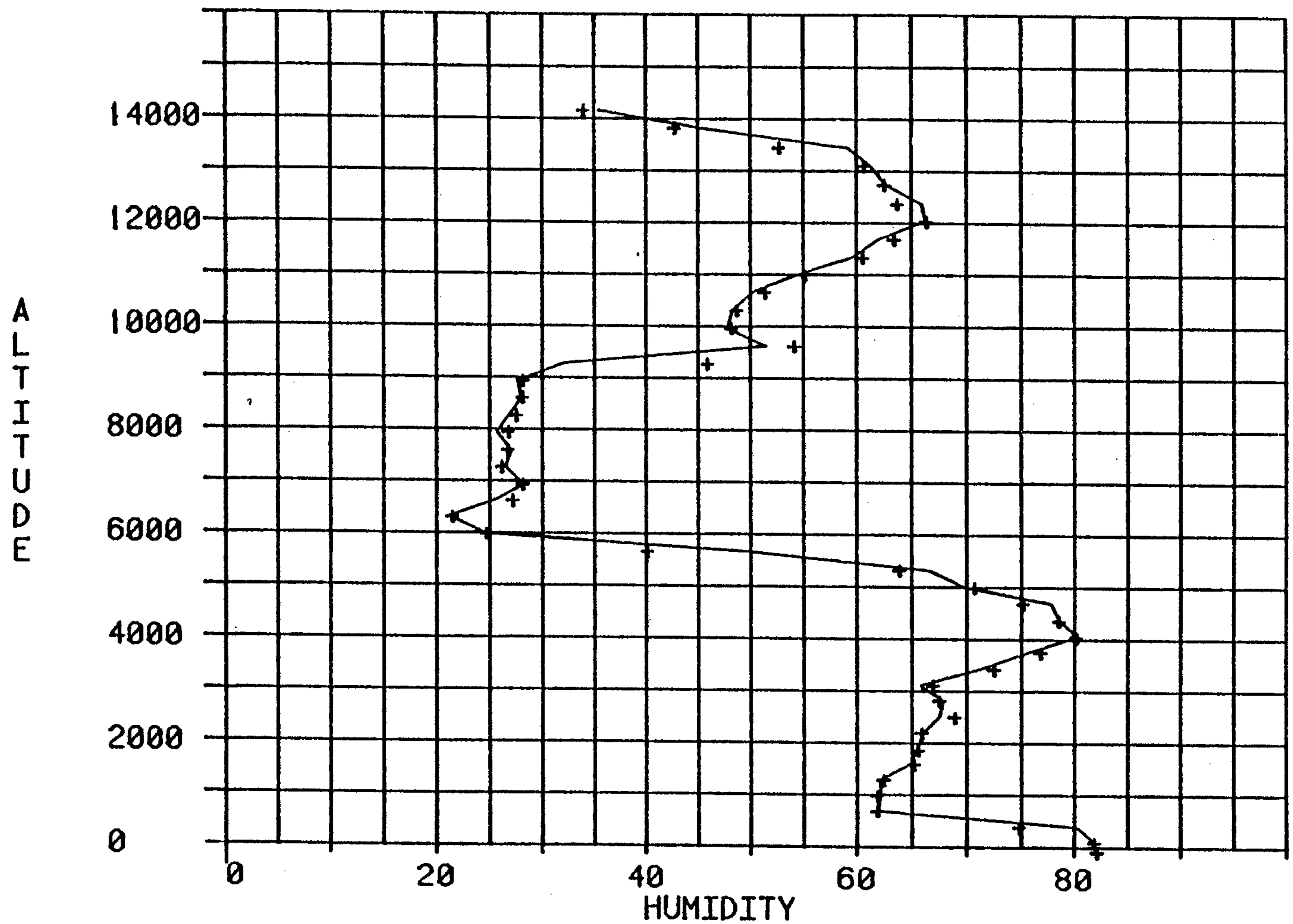


FIGURE 46. Temperature Comparison of Bendix RDSRU Laboratory Data (Figure 45) and NAVAIRDEVCEN Processed Data (Figure 31) for Sonde No. 15



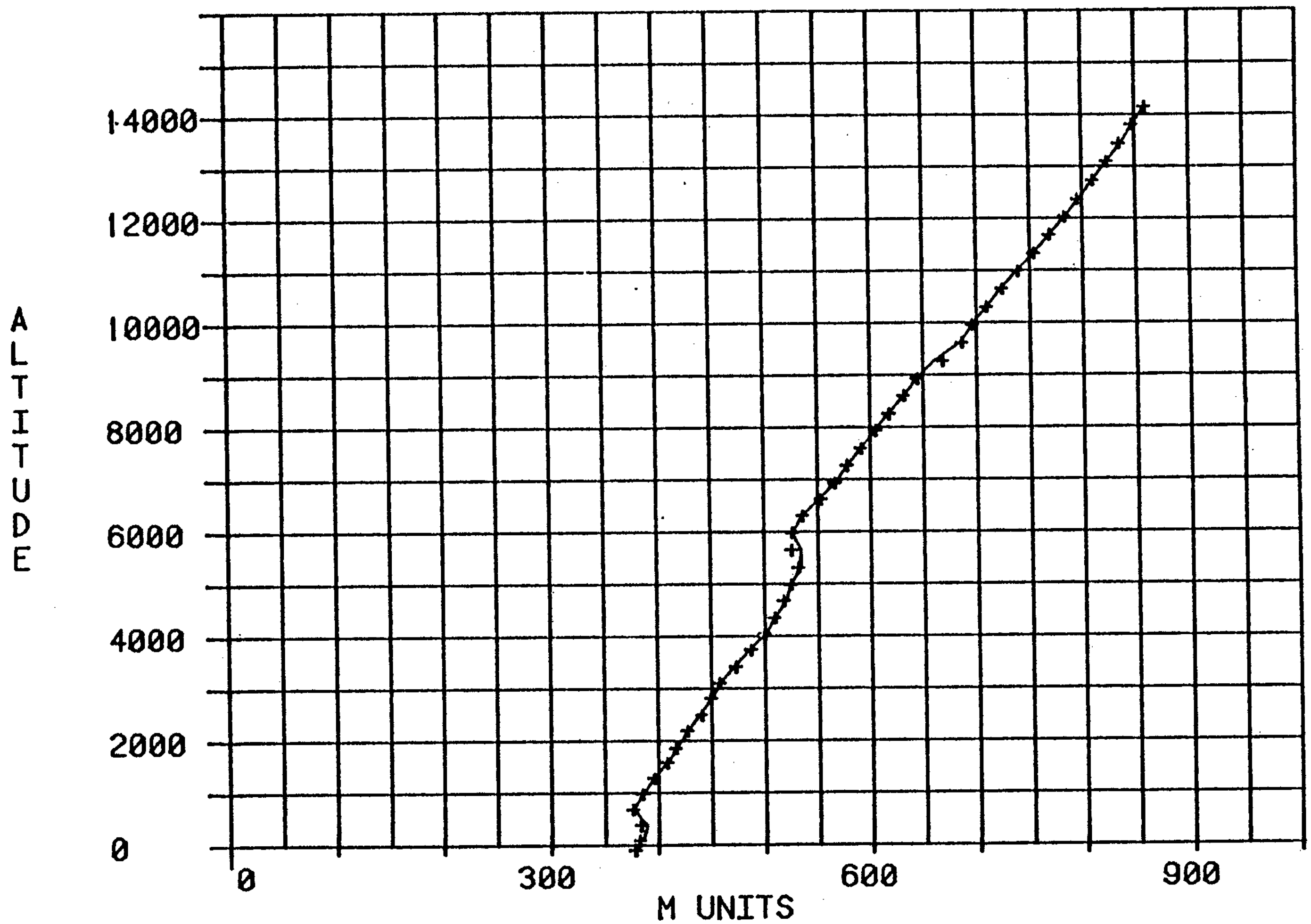
CAPE HATTERAS

DATE: 09/08/78

-...BENDIX LAB. No. 15 LAUNCH TIME: 13:02:18(EDT)

+...NADC LAB. No. 15 LAUNCH TIME: 13:02:18(EDT)

FIGURE 47. Humidity Comparison of Bendix RDSRU Laboratory Data (Figure 45) and NAVAIRDEVCEN Processed Data (Figure 31) for Sonde No. 15



CAPE HATTERAS

DATE: 09/08/78

-...BENDIX LAB. No. 15 LAUNCH TIME: 13:02:18(EDT)

+...NADC LAB. No. 15 LAUNCH TIME: 13:02:18(EDT)

FIGURE 48. M-Units Comparison of Bendix RDSRU Laboratory Data (Figure 45) and NAVAIRDEVCEN Processed Data (Figure 31) for Sonde No. 15

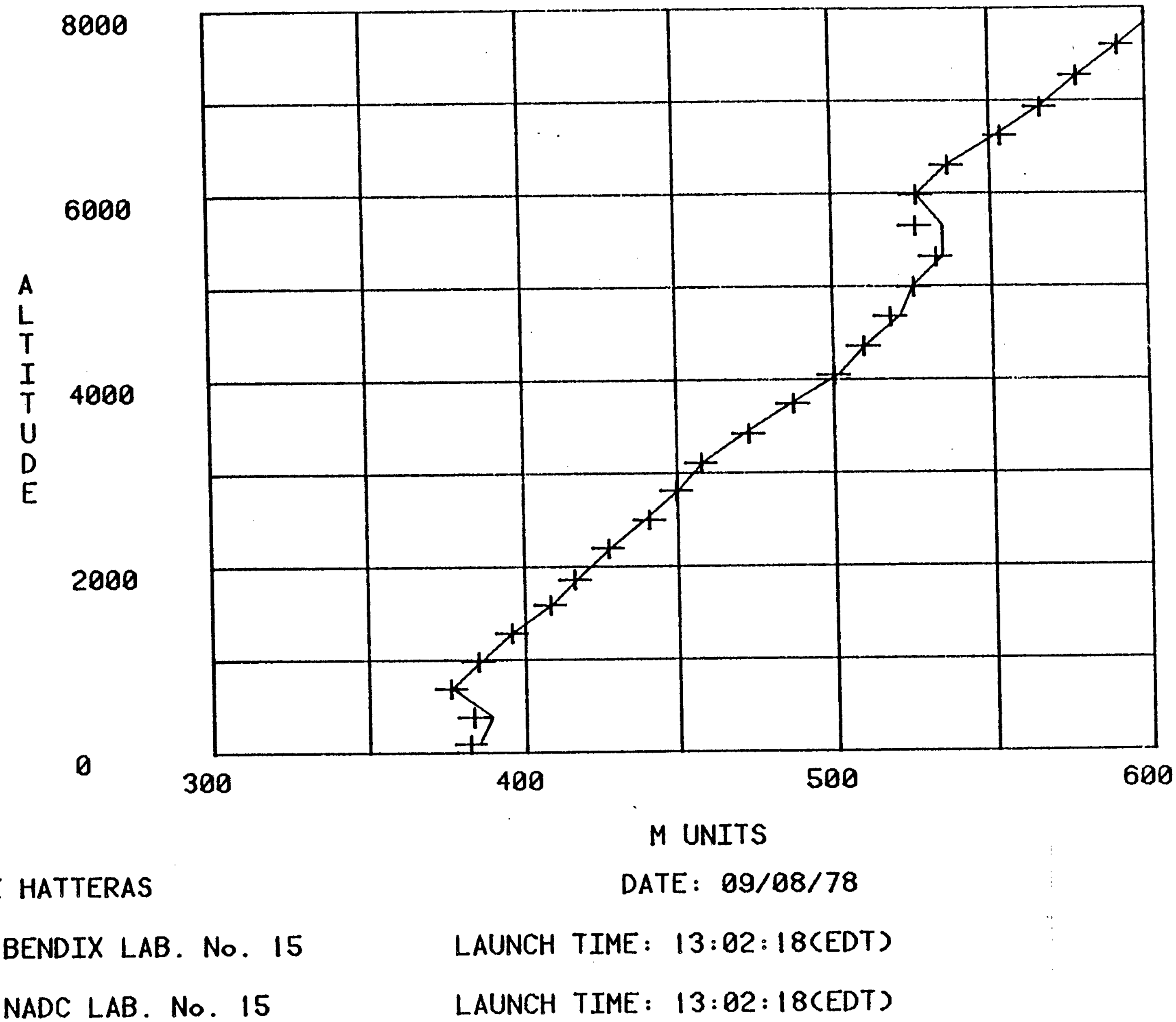
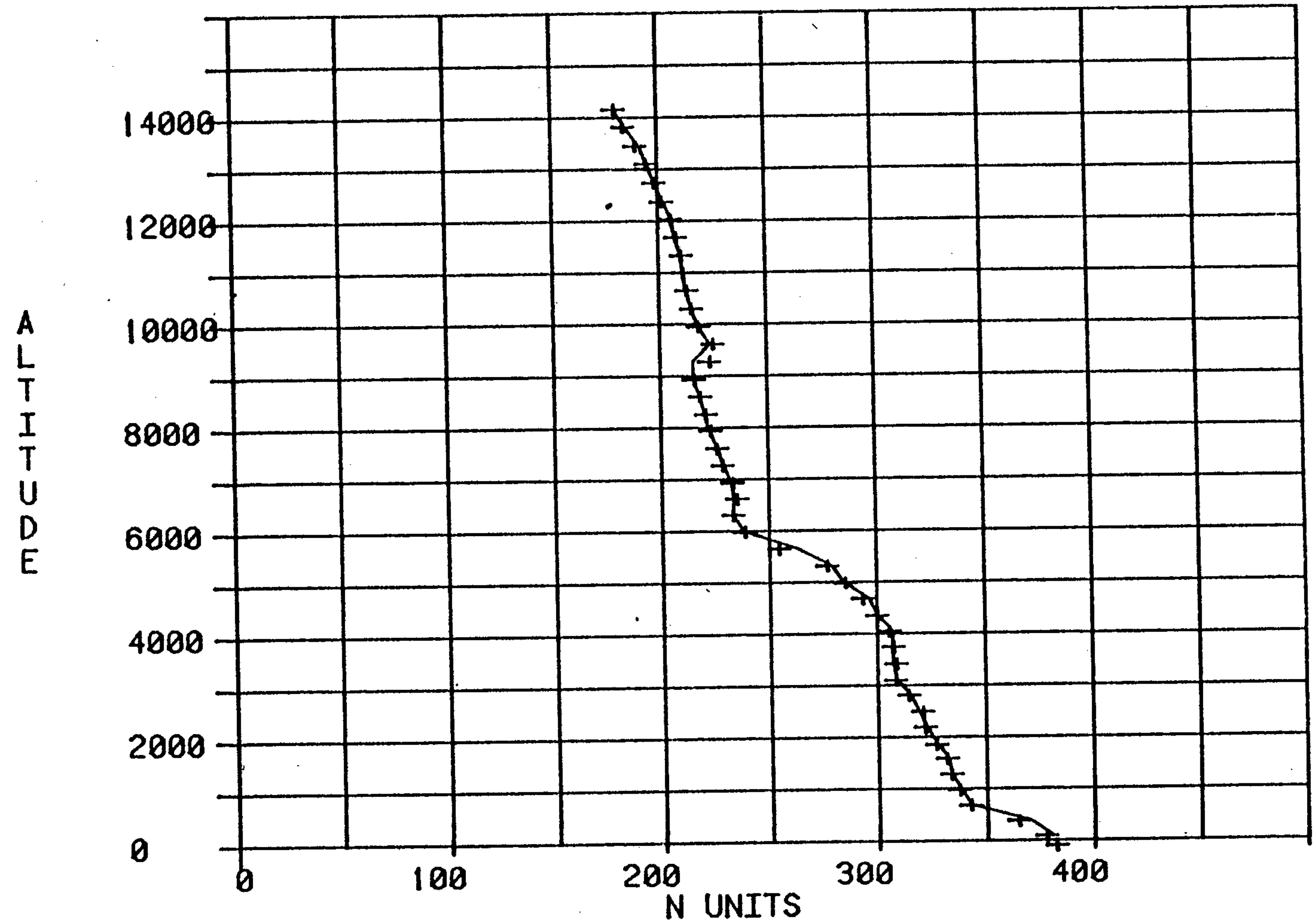


FIGURE 49. Expanded M-Units Comparison of Bendix RDSRU Laboratory Data (Figure 45) and NAVAIRDEVCEN Processed Data (Figure 31) for Sonde No. 15



CAPE HATTERAS

DATE: 09/08/78

-...BENDIX LAB. No. 15 LAUNCH TIME: 13:02:18(EDT)

+...NADC LAB. No. 15 LAUNCH TIME: 13:02:18(EDT)

FIGURE 50. N-Units Comparison of Bendix RDSRU Laboratory Data (Figure 45) and NAVAIRDEVCEN Processed Data (Figure 31) for Sonde No. 15

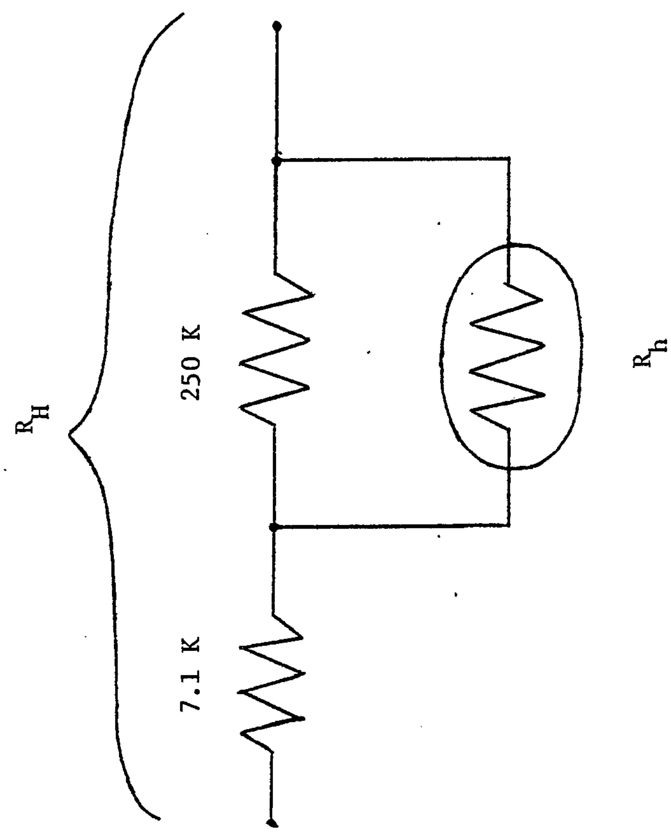


FIGURE 51. Humidity Resistance Network in Dropsonde Electronics

TABLE I

KEY WEST DROPSONDE IDENTIFICATION AND LAUNCH INFORMATION

Drop Number	Date of Launch	Launch Time	Sonde Serial No.	RF Channel Number	Meteorological Electronics Manufacturer	Location at Launch (Lat/Long)	Altitude at Launch (in ft)	Indicated Air Speed (in kt)	Outside Temp. at Launch	Winds Aloft at Launch (Speed/Dir)
1	16 Feb 78	18:10:29Z	01	14	JMR	24°24'24"N 81°48'18"W	12330	250	0°C	24 kt/229°
2	16 Feb 78	18:54:24Z	02	16	JMR	24°25'34"N 81°48'27"W	12344	250	0°C	28 kt/235°
3	16 Feb 78	19:09:40Z	09	14	Honeywell	24°24'43°N 81°48'33"W	12406	250	0°C	25 kt/235°
4	16 Feb 78	19:34:04Z	06	16	JMR	24°24'24"N 81°48'08"W	12419	250	0°C	24 kt/225°
5	17 Feb 78	15:42:04Z	05	16	Honeywell	24°24'18"N 82°05'43"W	12377	192	-1°C	23 kt/192°
6	17 Feb 78	15:56:14Z	07	12	JMR	24°22'07"N 82°05'57"W	12364	192	-1°C	25 kt/220°
7	17 Feb 78	16:14:21Z	04	16	Honeywell	24°22'23"N 82°05'53"W	12326	190	-1°C	24 kt/199°
8	17 Feb 78	16:26:38Z	08	12	JMR	24°22'57"N 82°06'49"W	12344	188	-1°C	24 kt/214°
9	17 Feb 78	16:39:06Z	03	14	JMR	24°23'30"N 82°06'46"W	12326	185	-1°C	24 kt/208°

TABLE II

KEY WEST DROPSONDE DEPLOYMENT INFORMATION

Drop Number	Date of Launch	Launch Time	Surface Pressure (in mb)	Signal Level (in microvolts)	% RFI	Splash Time	Deployment Duration (min:s)
1	16 Feb 78	18:10:29Z	1016.3	30	0	18:16:54Z	6:25
2	16 Feb 78	18:54:24Z	1015.9	30	10	18:56:14Z	1:50
3	16 Feb 78	19:09:40Z	1015.6	28-30	0	19:15:04Z	5:24
4	16 Feb 78	19:34:04Z	1015.2	30	10	19:39:43Z	5:39
5	17 Feb 78	15:42:04Z	1017.9	1	5	15:48:21Z	6:17
6	17 Feb 78	15:56:14Z	1017.9	30+	0	16:02:35Z	6:21
7	17 Feb 78	16:14:21Z	1017.9	18-22	20	16:20:37Z	6:16
8	17 Feb 78	16:26:38Z	1017.7	30+	0	16:32:43Z	6:05
9	17 Feb 78	16:39:16Z	1017.7	1-2	0	16:45:27Z	6:11

KEY WEST DROP 1 OF 16 FEBRUARY 1978

Noise prior to RF Activation

	~~923690.090281~~		~~120274.131209~~	~~104843.099174~~	~~102455.085672~~	
	~~121568.085724~~		~~509329.193578~~	~~282309.222345~~	~~213647.200809~~	
	~~194699.171879~~		~~207388.168438~~	~~177949.185138~~	~~219239.278779~~	
	~~282089.210099~~		~~192819.193128~~	~~138478.180409~~	~~223489.237908~~	
	~~168218.349169~~		~~192221.177438~~	~~371818.219999~~	~~228398.139309~~	
	~~166338.167781~~		~~194505.247778~~	~~281079.336197~~	~~187129.293248~~	
	~~344870.240015~~		~~269189.200699~~	~~289999.265999~~	~~209329.274338~~	
	~~285108.169269~~		~~210038.184048~~	~~239619.228581~~	~~209998.264159~~	
	~~182827.261249~~		~~167701.410009~~	~~176779.289889~~	~~228511.289925~~	
	~~347326.307486~~		~~290344.226708~~	~~65849.~~066314	108867.067918	
	56348.067051		127019.067178	55978.068265	152729.067716	
	56354.069469		152627.067361	56183.069756	142374.067803	
	56211.071118		153138.067593	56068.071229	152788.068009	
Contact #43	56334.072208		62781.067619	73300.072581	61230.068237	
	56500.073308		75827.067707	55893.07378	152957.06844	
	56144.073985		153114.067775	56096.074475	152603.068609	
	56207.074698		152628.067728	56358.075251	152801.068371	
	55923.075185		153008.067988	56279.075858	152867.068281	
	55833.075541		152983.068443	56427.076329	152544.06823	
	55887.075841		153001.068528	56196.077206	152754.068259	
	55974.076269		152916.068617	56207.077006	153190.068304	
	55984.076801	Contact	152458.068888	56473.077001	152857.068156	
	56272.077424	Make	152778.068908	56103.077317	153078.068273	
Contact #42	56058.077604	→	61485.068986	56031.077449	61014.068472	
	56462.077881		67112.068949	56122.077719	60928.068518	
	56387.078074	Contact	61514.076435	55975.077911	61004.068688	
	56291.078138	Break →	152848.090158	56071.077982	152721.068719	
	56388.078359		152677.069468	56128.078248	152896.068732	
	56148.078453	Baro-	152977.06973	56038.078203	153058.068947	
	56045.077849	switch	152681.069558	56528.079131	152686.069148	
	55753.078256	is on	152803.06944	56361.078899	152856.069564	
	55943.078475	the	153030.069161	56008.078379	152718.069829	
	56212.079224	insu-	152557.069523	55949.078323	152668.069507	
	56331.07885	lator	152598.070121	55915.078576	153163.069484	
Contact	56044.078224		153017.069966	56441.078921	152818.069504	
#41	56059.078421		60988.069243	56315.07885	61465.069657	
	56354.078915		61194.069086	55978.078081	61211.069208	
	56367.078899		61507.069258	55956.078521	152778.068717	
	56404.07882		152448.069374	56333.078996	152837.068835	
	55983.078171		153013.069221	56441.078961	153123.069143	
	55841.078355		152914.069138	56325.079012	152579.069433	
	56016.078584		152768.068836	56373.079115	152883.069718	
	56116.078674		153082.069082	56130.078765	152703.069875	
	56449.078748		152969.069269	55992.07859	152466.069804	
	56504.079243		153028.069451	56048.078091	153068.069884	
	56328.079437		152797.069747	55964.078009	152948.07006	
	56547.079198		152698.069818	55838.078428	152884.069944	
	56562.079144		147419.069901	55783.078454	68168.070219	Contact No. 40
	56147.07901		68644.070268	56176.078411	67868.070101	
	56325.078898		68748.070425	56141.078674	68025.070064	
→	56331.07891		68751.070805	55998.078538	71518.070226	

Reference Period — Temperature Period — Pressure Period — Humidity Period

$\underbrace{\hphantom{xxxxxxxxxxxxxxxxxxxx}}_{\text{1 Complete 400 millisecond Data Cycle}}$

TABLE III - Sample of Laboratory-Measured Period Data for Sonde No. 1

56259.2	71700	638.8	Contact #43	67828
56253.1666667	77446	647.8		68624
56188	78651.1666667	656.6		69490
56175.5	78774.1666667	665.8		70041.8333333
56112.6	78390.3333333	674.8		69793
56148.1666667	78109.3333333	684		69836
56253.6666667	77621.6666667	693.2		69860.1666667
56191.3333333	77000.4	702.8		68572.8333333
56203.3333333	76338	711.8		67009.2
56239.8333333	76252.6	721.2		66811.6666667
56276.3333333	76234.2	730.6		68594
56156.8333333	76325.5	740.2		69729.3333333
56144.2	76275	749.4		69101.1666667
56248.1666667	76436.1666667	759.4	Contact #30	68516.1666667
56328.5	76136.5	769		68509.8333333
56242.3	75713	778.6		68239.5
56262.8333333	75704.6666667	788		68985
56349.1666667	75402	798.2		70518
56311	74851.8	807.8		72342.8
56322	74249	817.8		73911.8333333
56458	73945.5	827.8		74031.5
56355.3333333	73535.1666667	837.6		74518.4
56410	73397.8333333	847.6		90134.3333333
56421.6666667	73184.8333333	857.8		116406.5
56436.1666667	73175.8333333	867.8	Contact #19	172064.333333
Averaged Reference Periods (in hundredths of microseconds)	Averaged Temperature Periods	Absolute Pressure Levels (in mbar)		Averaged Humidity Periods

TABLE IV - 4051 MICROCOMPUTER LISTING OF AVERAGED PERIOD VALUES FOR SONDE NO. 1

TABLE V (a)

KEY WEST DROPSONDE DEPLOYMENT AND SIGNAL RECEPTION RESULTS

Drop Number	Total time for Wind Flap to Release (in ms)	Total Time for Drogue Chute to Fully Open (in ms)	Deployment Comments	Dropsonde Signal Comments
1	55	95	Good launch - No deployment problems	Good audio signal - Only launch that was able to be processed in its entirety
2	25	75	Drogue chute separated from sonde 85 ms after start of launch - Main chute did not deploy - Total deployment time to splash was 1 min, 50 s	Signal could not be processed since it was erratic and had too many amplitude variations - Three data gaps existed totalling about 20 s - Signal only lasted for 30 s maximum between gaps
3	20	70	Sonde was tumbling and drogue chute separated from sonde 120 ms after start of launch - Thermistor and hygristor were inoperable	Very poor S/N ratio caused signal to be unprocessable - Signal had many amplitude and frequency variations - Only 2 or 3 tones audible - Thermistor was inoperable and hygristor was probably bad, since its output was very noisy and contained noise spikes at 150 Hz
4	40	85	Good launch - No deployment problems, except for an inoperable thermistor	Good audio signal and commutation was maintained - Data was processable, except for a lack of the temperature sensor - Thus, the humidity equation, which is temperature-dependent, could not be solved - Two short RF dropouts (2-3 s each) occurred
5	45	150	Good launch - No deployment problems	Very poor S/N ratio caused signal to be unprocessable - Signal was noisy and erratic and several data gaps existed - A suitable triggering window for processing purposes was unable to be obtained

TABLE V (b)

KEY WEST DROPSONDE DEPLOYMENT AND SIGNAL RECEPTION RESULTS

Drop Number	Total time for Wind Flap to Release (in ms)	Total Time for Drogue Chute to Fully Open (in ms)	Deployment Comments	Dropsonde Signal Comments
6	55	160	Good launch - No deployment problems, except for a lack of a thermistor	Thermistor was inoperable - Marginal S/N ratio caused signal to be processable only about 50% of the launch - Signal was especially noisy during first half of the launch
7	65	135	Thermistor was lost at beginning of launch - Timer mechanism and drogue chute separated from sonde 175 ms after start of launch - Timer and drogue subsequently separated from each other - Main parachute bag first appeared at the 210 ms mark and the main chute was fully deployed 385 ms after the start of launch	No temperature sensor - Marginal S/N ratio caused signal to be unprocessable - Poor audio - Could not obtain a suitable triggering window for processing
8	900	1000	Extremely late deployment - Wind flap may have hung up as a result of the orientation of the sonde in its sonobuoy launch container and its orientation in relation to the resultant airstream direction upon launch	Signal could not be processed because S/N ratio was marginal, commutation rate was not steady, and synchronization could not be maintained - Signal was very audible, however
9	65	145	Good launch - No deployment problems	Signal could not be processed due to a marginal S/N ratio and due to the absence of a suitable triggering window

KEY WEST: LAT. 24 deg 24 min N, LONG. 81 deg 48 min W

LAUNCH DATE:02/16/78 LAUNCH TIME 18:10:29Z SPLASH TIME 18:16:54Z

SURFACE PRESSURE(mb)=1016.3 SONDE NUMBER 1

PRESS. mb	ALTITUDE feet	TEMP. deg.c	HUMIDITY %rh	N units	M units	GRAD. N/1000 ft.
638.8	12306	15.96	26	193	784	0.00
647.8	11951	6.41	30	194	768	-3.06
656.6	11607	4.66	34	198	755	-10.69
665.8	11252	4.47	36	201	741	-9.49
674.8	10909	4.86	35	203	727	-6.81
684.0	10561	5.32	35	206	713	-7.66
693.2	10218	6.20	35	209	699	-7.60
702.8	9863	6.96	30	209	683	-1.69
711.8	9535	7.96	23	208	666	2.99
721.2	9195	8.16	22	210	652	-5.73
730.6	8858	8.27	30	217	642	-20.03
740.2	8518	7.89	35	222	631	-15.15
749.4	8196	7.94	33	224	617	-4.15
759.4	7849	7.91	30	225	602	-3.62
769.0	7520	8.52	29	227	588	-7.57
778.6	7194	8.99	29	230	575	-7.08
788.0	6877	9.05	32	234	564	-13.40
798.2	6538	9.70	37	240	554	-17.86
807.8	6221	10.50	44	247	546	-22.67
817.8	5895	11.52	48	253	536	-18.33
827.8	5571	12.34	48	257	524	-10.81
837.6	5258	12.82	49	261	513	-12.05
847.6	4941	13.18	62	273	510	-38.71
857.8	4620	13.59	74	284	506	-35.46
867.8	4309	13.64	83	294	501	-30.72
878.2	3989	14.11	86	300	492	-19.77
888.6	3671	14.86	88	307	483	-20.51
898.6	3369	15.98	87	312	473	-16.56
909.0	3057	16.47	84	314	460	-6.03
919.6	2743	17.39	84	319	451	-18.20
928.8	2472	17.91	85	324	443	-17.72
940.4	2134	18.42	81	326	428	-5.19
951.0	1828	19.26	81	331	419	-17.92
961.6	1524	19.66	86	341	414	-31.51
972.4	1218	20.27	90	350	408	-28.21
983.0	920	21.16	86	352	396	-8.76
994.2	608	21.97	85	357	387	-16.72
1004.8	315	22.51	83	360	375	-9.26

TABLE VI - NAVAIRDEVCEN PROCESSED METEOROLOGICAL DATA FOR SONDE NO.1 AT KEY WEST

KEY WEST RAWINDSONDE:LAT.24 deg 35 min N,LONG.81 deg 42 min W

LAUNCH DATE:02/16/78 LAUNCH TIME 19:05:00Z

SURFACE PRESSURE=1016

PRESS. mb	ALTITUDE feet	TEMP. deg.c	HUMIDITY %rh	N units	M units	GRAD. N/1000 ft.
640.0	12250	2.20	55	200	788	0.00
650.0	11856	3.40	44	200	769	1.00
661.0	11429	3.80	49	205	753	-12.11
671.0	11045	4.30	44	206	736	-2.19
682.0	10628	5.30	24	201	711	12.17
693.0	10217	6.40	14	199	690	3.32
704.0	9811	7.40	14	202	673	-6.16
715.0	9410	7.70	13	204	656	-6.08
730.0	8872	7.50	19	211	637	-13.06
742.0	8447	7.50	30	220	626	-21.30
753.0	8063	7.50	19	218	605	6.84
765.0	7648	8.70	18	221	588	-6.81
777.0	7240	9.00	24	227	575	-15.80
791.0	6769	9.30	45	242	567	-32.59
803.0	6371	10.60	51	250	556	-18.75
815.0	5978	11.50	49	253	540	-8.45
827.0	5589	12.20	64	267	535	-34.57
839.0	5205	12.80	70	275	525	-22.12
855.0	4700	13.70	72	283	508	-14.80
867.0	4326	14.30	76	290	498	-19.23
880.0	3925	14.60	81	298	487	-20.80
893.0	3530	15.80	83	307	476	-21.64
906.0	3139	16.70	79	310	460	-6.82
921.0	2693	17.20	78	314	443	-9.76
935.0	2283	17.70	76	318	427	-8.78
948.0	1906	19.10	76	325	417	-20.02
961.0	1533	20.00	83	339	412	-36.45
975.0	1137	20.90	85	348	402	-23.11
992.0	661	22.80	80	355	387	-14.50
1006.0	274	25.00	75	361	375	-16.89
1016.0	0	26.40	71	365	365	-14.30

TABLE VII - KEY WEST RAWINDSONDE METEOROLOGICAL DATA

TABLE VIII

DROPSONDE DESIGN MODIFICATIONS RECOMMENDED FROM KEY WEST TEST RESULTS

TIMER MECHANISM

1. Machined parts. All sharp edges were removed from machined parts in timer mechanism.

2. Grommets placed in slots that nylon rope passes through.

3. Redesigned release latch lock spring to allow more positive lock.

4. Sear redesigned, positively coupled to timer.

5. Knot tied in main cord to anchor drogue parachute attachment at centerpoint of line.

6. Government specification 500# test nylon parachute cord utilized in place of conventional type 500# test cord.

7. Spring (airstream release) was replaced with a heavier spring.

CANNISTER HOUSING

Criss-crossed wax nylon cord attached to end of dropsonde above sensors.

ANTENNA HOUSING

1. Edges of fiberglass antenna housing were rounded to prevent the possibility of parachute line being severed.

2. 1/2 in. water drain holes placed around base diameter of antenna housing.

3. Antenna design changed by NADC revision (1)

ANTENNA PLATFORM

1. Battery plug moisture cover installed. Cam on battery plug redesigned to work w/moisture cover.

2. O-ring seal placed around antenna platform for seal between it and housing cannister.

TABLE VIII (cont)

INSTRUMENT PACKAGE

1. 50% duty cycle incorporated in transmitter.

2. Hygristor mount changed to allow easier installation without distortion.

3. Thermistor mount changed to tubelets with accessible solder points to allow replacement in field.

4. Recess sensor mount 1 inch further into sonde tube.

SAFETY COVER

Design changed to allow easier removal.

TABLE IX(a)

WARREN GROVE DEPLOYMENT AND RECOVERY RESULTS

DROPSONDE NUMBER	LAUNCH CONDITIONS	LAUNCH FINDINGS	POST-LAUNCH FINDINGS
1	1000 feet;200 KT	Good drop - No problems with launch- Sonde was accidentally launched seconds prematurely from aircraft and landed a mile down range from communications truck - calculated 5.16 seconds from air flap release to timer mechanism release (from films)	No damage to dropsonde
2	1000 feet; 200 KT	Good drop - No problems with launch - 4.98 seconds from air flap release to timer release	No damage to dropsonde
3	1000 feet;200 KT	Drogue chute deployed properly, but timer mechanism failed to operate properly and caused main chute to remain undeployed - Timer was dislodged and main chute was released from canister upon ground impact - Elapsed time from launch to ground impact was 12.42 seconds	Damage to tail end of dropsonde canister upon impact - Discovered a burr on the sear arm of the timer mechanism that made it difficult for the release cam to release the timer - The problem of the timer mechanism hanging up was repeated in the lab, although the burr became more polished with each iteration.
4	1000 feet; 250 KT	Good drop- No problems with launch - calculated 5.28 seconds from air flap release to timer release - Total descent time from launch to ground impact for the main chute was 25 seconds (measured during day of test)	No damage to dropsonde

TABLE IX(b)

DROPSONDE NUMBER	LAUNCH CONDITIONS	LAUNCH FINDINGS	POST-LAUNCH FINDINGS
5	1000 feet; 250 KT	Good drop - No problems with launch - Calculated 4.68 seconds from air flap release to timer release	No damage to dropsonde
6	1000 feet; 250 KT	Good drop - No problems with launch- Calculated 5.28 seconds from air flap release to timer release	No damage to dropsonde
7	1000 feet; 330 KT	Premature deployment of drogue chute, timer mechanism, and main chute, which ripped away from the canister at a point 5" from the anchor point and 0.32 seconds after launch - Total descent time from launch to ground impact was 11.34 seconds	One side of the canister was flattened upon ground impact - Damage to timer included bent retention ears, bent roll pins on 2 of the 3 levers, a deformed base plate, and a slight abrasion on the 500 pound test line - Lab tests found that thumb pressure on the lever nearest the sear could force the cam over the sear, causing premature release of the timer - Tensile strength of chute lines may not be capable of handling the forces at this velocity
8	1000 feet; 331 KT	Drogue chute separated from the timer mechanism shortly after launch, but the timer release was normal (4.50 seconds after air flap release) - Main chute deployment was slow, but normal	Damage to the 500 pound bridle line, which was cut 10% at the grommet adjacent to the Rhodes timing unit - This point on the launch envelope may provide pressures too great for the drogue chute lines to withstand

TABLE IX(c)

DROPSONDE NUMBER	LAUNCH CONDITIONS	LAUNCH FINDINGS	POST-LAUNCH FINDINGS
9	1000 feet; 331 KT	Drogue chute separated from timer 0.13 seconds after launch- Main chute deploys prematurely (0.86 seconds after launch)	No damage to dropsonde- Drogue chute and timer not recovered - Deployment functions operated in proper sequence despite failure of drogue chute, as in dropsonde 8 - Main chute bag may not have been tied since it was found separated from the timer

TABLE X

DROPSONDE DESIGN MODIFICATIONS RECOMMENDED FROM WARREN GROVE TEST RESULTS

TIMER MECHANISM

1. Timer - removed raised section of timer cam by stoning to insure smooth operation of timer.

2. Timer - place flat washer under each leg of standoffs to insure stability in baseplate holes, also to increase tolerance between baseplate and timer cam lever pin.

3. Release Plate - removed all rough edges and burrs in notched area.

4. Sear - elongate existing hole, such that it prevents any main spring pressure, transmitting through to timer cam pin. Remove all burrs.

5. Nylon Cord - tie knot in main line on bottom of timer to allow more space for drogue chute and a more positive attachment should line be severed.

6. The use of square knot and a half hitch for more secure joining of two ends of lines.

7. Battery Plug Line - will be tied off to drogue chute and through drogue chute restraining knot in main timer line, in the event of drogue chute separation, battery would be energized by escapement of timer unit.

8. Drogue Chute - a grommet will be placed in loops at attachment point of drogue chute with main timer line being passed through grommet, to cushion shock of Q-force and increase radius of curve around timer line.

TABLE XI (a)

LAKEHURST DEPLOYMENT AND RECOVERY RESULTS

Dropsonde No.	Launch Conditions	Launch Findings	Postlaunch Findings
1	1000 ft, 275 kn	Good drop - No problems with launch	No damage to dropsonde
2	1000 ft, 275 kn	Timer mechanism failed to release, causing main chute to remain undeployed - Drogue chute did not completely open until 0.23 s, 0.1 s later than the other successful drops	Timer mechanism was found to be jammed in the sonde tube
3	1000 ft, 300 kn	Good drop - No problems with launch	Air tab was found bent at a 45° angle - No further damage to dropsonde
4	1000 ft, 300 kn	Good drop - No problems with launch	Air tab was unable to be recovered - No damage to dropsonde
5	1000 ft, 325 kn	Good drop - No problems with launch	One end of the knot that ties the drogue chute to the 500 lb test line was frayed slightly

TABLE XI (b)

Dropsonde No.	Launch Conditions	Launch Findings	Postlaunch Findings
6	1000 ft, 325 kn	Premature deployment of the timer mechanism and the main chute (within 0.4 s after beginning of launch) - Main chute did deploy properly, however, and the rest of the launch was successful	The main parachute bag separated from the main chute and was unable to be recovered - The main chute's tie line was found to be still intact and unbroken, so the main chute bag must have ripped away
7	1000 ft, 345 kn	Drogue chute deployed properly but timer mechanism did not release, causing main chute to remain undeployed	Timer mechanism was discovered to be timed out - Air tab was bent slightly
8	1000 ft, 350 kn	Late release of air tab (0.1 s longer than normal) and late opening of the drogue chute (0.2 s longer than normal) - The drogue chute released from the timer mechanism, which experienced a late release - Main chute did not deploy, but its bag appeared	The bottom of the sonde tube was badly damaged and one side of the tube was crushed - The 500 lb test line was broken in two places under the timer mechanism, but the square knot under the timer was still intact and was pushed toward the Rhodes timer side - The knot by the grommet that connects the drogue chute to the test line was undone and was frayed at the end - Drogue chute bag was badly ripped on one side, starting from the bottom - The dog by the Rhodes timer was sticking and was canted slightly to the right
9	1000 ft, 350 kn	Good drop - No problems with launch, except for late release of air tab (0.2 s later than normal) and late opening of the drogue chute (0.3 s later than normal)	No damage to dropsonde, except for air tab bent inwards about 20°

TABLE XII

LAKEHURST DEPLOYMENT TIMING EVENTS

Dropsonde No.	Total Time for Wind Flap to Release (s)	Total Time for Drogue Chute to Fully Open (s)	Total Time for Timer to Release (s)	Total Time for Main Chute to Fully Open (s)	Total Time from Launch to Ground Impact (s)
1	0.06	0.14	5.32	5.97	N/A
2	0.03	0.23	Timer did not release	Main chute did not open	11.7
3	0.04	0.13	4.87	5.60	N/A
4	0.03	0.12	N/A	N/A	N/A
5	0.04	0.13	5.12	5.64	N/A
6	0.03	0.14	0.18	0.38	13.9
7	0.06	0.17	Timer did not release	Main chute did not open	13.1
8	0.16	0.32	6.38	Main chute did not open	10.7
9	0.24	0.42	5.15	5.99	N/A

N/A: Not available from films

TABLE XIII

TIMER MECHANISM DESIGN MODIFICATIONS RECOMMENDED FROM LAKEHURST TEST RESULTS

a. Release latch fingers extended vertically approximately 1/4 inch. This provides a stop if all dogs are not locked in place.

b. Cover plate slots shape will be changed to allow conformal fit with grommets (to reduce fraying of 500 lb test line).

c. Timer set indicator redesigned for more stable attachment.

d. Flat head screw utilized in top plate to secure latch spring stud in place of present round head.

e. Rivets in place of flat head screws to secure wing to cover plate.

f. Sear mount raised and sear tip lengthened (to prevent premature release of timer mechanism).

TABLE XIV

CAPE HATTERAS LAUNCH CONDITIONS AND DEPLOYMENT TIMES

Launch No.	Dropsonde Serial No.	RF Channel No.	Launch Time (Local EDT)	Splash Time (Local EDT)	Total Deployment Time (Min:s)	Launch Altitude (K ft)	Launch Location (Lat,Long)
1	11	16	11:28:42	11:35:16	6:34	15.0	35°09' N, 75°18' W
2	12	12	11:49:51	11:57:01	7:10	14.5	35°09' N, 75°18' W
3	13	14	12:13:31	12:19:43	6:12	14.5	35°09' N, 75°18' W
4	14	16	12:39:30	12:46:13	6:43	14.5	35°09' N, 75°18' W
5	15	14	13:02:18	13:09:23	7:05	14.5	35°09' N, 75°18' W

TABLE XV

MISCELLANEOUS CAPE HATTERAS DROPSONDE AND LAUNCH INFORMATION

Launch No.	ARR-52 Receiver Signal Level (μv)	Signal Waveform	Surface Pressure (mbar)	Surface Temperature (°C)	Temperature at Launch Altitude (°C)	Thermistor Lock-in Resistance (Kohms)	Hygristor Lock-in Resistance (Kohms)
1	30 (max level) - occasional signal dropout	Good	1014.6	27	5	13.524	10.490
2	30	Good	1014.6	27	5	13.651	10.490
3	30	Good	1014.6	27	5	13.347	10.490
4	30	Good	1014.6	27	5	13.660	10.490
5	30	Good	1014.6	27	5	13.629	10.490

TABLE XVI

P-3C METEOROLOGICAL DATA OUTPUT FROM BENDIX RDSRU FOR SONDE NO. 15

```
05 UNIDENTIFIABLE CONTACTS, ENTER SURFA
CE PRESSURE (XXXX.X)
1015.5?
E   DATE     TIME      LAT.      LONG.
  78:09:08 13:00Z  35:09:00N 075:18:00W

   ALT.  PRESS.  TEMP.   HUM.   N
M
    43  1010.4   26.6     81   384    3
91
   137   999.2   26.2     79   376
   218   989.6   25.8     62   347
   305   979.4   25.4     62   343
   392   969.2   24.9     62   338
   481   959.0   24.2     65   337
   572   948.6   23.4     66   333
   660   938.6   22.8     66   328
   660   938.6   22.7     66   328
   751   928.4   22.1     67   324
   838   918.6   21.4     67   319
   927   908.8   20.6     66   313
  1017   899.0   19.8     70   312
  1107   889.2   19.1     75   312
  1200   879.2   29.9     81   371
  1288   869.8   17.9     77   305
  1381   860.0   17.3     77   301
  1472   850.4   16.8     69   289
  1563   841.0   16.7     66   284
  1656   831.4   17.0     50   268
  1749   822.0   17.2     23   241    5
16
END
```

R	T	P	H	TIME
7353	9299	16610	8837	0
7354	9547	14991	8908	10
7343	10358	9191	9214	56
7338	10610	8077	9541	140
7337	10626	8025	11486	240
7335	10562	11232	11901	342
7335	10505	8024	12240	438
7336	10435	8053	13016	541
7333	10334	8315	13048	649
7337	10236	8031	11933	744
7339	10144	8970	11421	844
7341	10055	8033	10516	948
7342	10000	10118	10089	1019
7342	9971	8057	9928	1051
7350	9949	9904	9891	1070
7343	9874	8030	9685	1154
7340	9807	8035	9621	1254
7348	9745	9200	9937	1365
7348	9693	9017	8992	1464
7344	9637	8040	8894	1560
7348	9580	8038	8896	1660
7343	9515	8868	8880	1766
7349	9474	11330	8861	1854
7352	9470	8853	8857	1897
7348	9431	8100	8876	1949
7348	9365	8247	8865	2052
7347	9332	8036	8917	2144
7348	9285	8037	8826	2243
7344	9235	9198	8735	2341
7343	9230	9227	8775	2375
7343	9229	8786	8793	2397
7348	9234	8037	8817	2433
7348	9247	8069	9885	2529
7347	9266	8137	12562	2632
7346	9257	8036	13421	2723
7346	9225	9577	17830	2822
7345	9187	8074	18384	2925
7345	8551	8406	19596	3016
7345	9115	8482	16198	3105
7345	9070	8030	13542	3197
7339	9014	8965	12221	3297
7341	8971	8101	12650	3397

TABLE XVII

RDSRU GENERATED PERIOD VALUES ABOARD P-3C FOR SONDE NO. 15

TABLE XVIII

RDSRU REFRACTIVITY LAYER DATA OUTPUT ABOARD P-3C FOR SONDE NO.15

```
FLAGGED GRADIENTS (STARTING FROM SEALEVE
L)
    DATE      TIME      LAT.      LONG.
78:09:08 13:00Z 35:09:00N 075:18:00W


   SUPERFRACTIVE:  G=- 0.026
A    43  , A  137
M   391  , M  398
   TRAPPING:  G=- 0.109
A   137  , A  218
M   398  , M  381
   SUBFRACTIVE:  G= 0.193
A  1107  , A  1200
M   486  , M  560
   SUPERFRACTIVE:  G=- 0.040
A  1381  , A  1472
M   518  , M  521
   TRAPPING:  G=- 0.052
A  1563  , A  1656
M   530  , M  529
   TRAPPING:  G=- 0.088
A  1656  , A  1749
M   529  , M  516
   END OF GRADIENT DATA.
```

```
C
PRESS ENTER WHEN READY TO PROCEED
E  ENTER DATE (YY.MMDD)
78.0908?
E  ENTER TIME IN Z (HH.MM)
13.00?
E  ENTER LATITUDE (DD.MMSS)
35.0900?
E  PRESS ENTER IF NORTH, CLEAR IF SOUTH
E  ENTER LONGITUDE (DDD.MMSS)
075.1800?
E  PRESS ENTER IF EAST, CLEAR IF WEST
C  ENTER DROP ALTITUDE (XX.X)
14.5?
E  ENTER TEMP. PARA. (XX.XXX)
13.629?
E  ENTER HUMIDITY PARA. (XX.XXX)
10.490?
E  ENTER PRESS. TAB. (XXXX.XX)  P   1=
1052.6?
E  P   2=
1041.8?
E  P   3=
1031.0?
E  P   4=
1021.2?
E  P   5=
1010.4?
E  P   6=
999.2?
E  P   7=
989.6?
E  P   8=
979.4?
E  P   9=
969.2?
E  P  10=
959.0?
E  P  11=
948.6?
E  P  12=
938.6?
```

TABLE XIX

TYPICAL PRELAUNCH RDSRU INPUT DATA

TABLE XX

NAVAIRDEVCEN PROCESSED METEOROLOGICAL DATA FOR SONDE NO. 11

CAPE HATTERAS: LAT 35 deg 09 min N, LONG 75 deg 18 min W

LAUNCH DATE:09/08/73 LAUNCH TIME 11:28:42(EDT) SPLASH TIME 11:35:16(EDT)

SURFACE PRESSURE(mb)=1014.6 SONDE NUMBER 11

PRESS. mb	ALTITUDE feet	TEMP. deg.c	HUMIDITY %rh	N units	M units	GRAD. N/1000 ft.
575.8	14865	12.42	31	177	891	0.00
584.0	14513	4.11	37	179	875	-4.38
592.4	14157	-0.18	47	183	863	-12.41
600.8	13805	-0.93	53	187	849	-10.86
609.6	13440	-0.30	58	191	836	-11.54
618.2	13088	0.66	62	195	824	-12.18
627.2	12723	1.44	62	198	809	-8.22
636.2	12363	2.13	63	202	795	-8.72
644.8	12022	3.17	62	205	782	-9.01
653.6	11678	4.18	62	208	768	-9.00
662.8	11321	5.02	59	210	753	-6.02
671.8	10976	5.87	63	215	742	-14.86
681.2	10620	6.46	63	218	728	-9.32
690.2	10283	7.42	55	218	712	1.44
699.6	9935	8.30	55	222	699	-10.63
708.8	9597	9.43	55	225	686	-10.27
718.0	9264	10.60	50	226	671	-2.61
725.4	8999	10.87	49	228	660	-6.54
737.0	8585	12.40	27	218	630	23.56
746.6	8247	12.98	28	222	618	-11.30
756.4	7907	13.80	28	225	604	-8.73
766.0	7576	14.34	27	227	591	-6.63
775.6	7249	15.30	28	231	579	-11.53
785.2	6925	16.25	27	233	566	-7.02
794.8	6604	17.04	24	233	550	0.64
804.6	6280	17.63	21	234	535	-2.14
814.8	5946	18.33	21	236	522	-8.34
824.6	5628	18.06	26	244	514	-22.17
834.6	5307	17.47	48	266	520	-68.66
844.6	4989	17.51	53	272	512	-20.61
854.8	4668	17.61	63	285	509	-38.36
865.0	4350	17.97	71	295	504	-32.41
874.8	4047	18.63	74	302	496	-23.06
885.2	3728	19.54	68	302	481	0.26
895.4	3419	20.52	64	303	467	-4.69
905.6	3113	20.88	65	308	458	-16.88
915.8	2809	21.49	63	310	445	-5.54
926.2	2502	22.24	62	314	434	-13.78
936.6	2198	22.92	62	319	425	-15.67
947.2	1891	23.29	63	324	415	-17.30
957.8	1586	24.25	62	329	405	-14.97
968.6	1279	25.03	61	333	394	-11.67
979.0	986	25.64	60	337	384	-13.25
990.0	678	26.20	60	341	374	-15.74
1000.8	379	26.27	80	373	391	-106.19
1011.0	99	26.54	82	380	385	-24.46

TABLE XXI

NAVAIRDEVCEN PROCESSED METEOROLOGICAL DATA FOR SONDE NO. 12

CAPE HATTERAS: LAT 35 deg 09 min N, LONG 75 deg 18 min W

LAUNCH DATE:09/08/78 LAUNCH TIME 11:49:50(EDT) SPLASH TIME 11:57:01(EDT)

SURFACE PRESSURE(mb)=1014.6 SONDE NUMBER 12

PRESS. mb	ALTITUDE feet	TEMP. deg.c	HUMIDITY %rh	N units	M units	GRAD. N/1000 ft.
581.0	14642	11.23	36	181	884	0.00
589.8	14267	3.80	44	183	867	-4.03
598.2	13913	0.21	52	186	854	-10.37
607.0	13547	-0.27	59	191	841	-11.49
616.0	13177	0.38	66	196	828	-13.70
624.6	12828	1.12	64	198	814	-7.21
633.2	12482	1.93	64	201	800	-8.73
642.0	12133	2.81	64	204	787	-8.77
651.4	11763	3.75	64	208	772	-9.08
660.2	11421	4.91	62	211	759	-8.36
669.6	11060	5.82	56	211	742	-2.12
678.6	10718	6.64	54	214	728	-6.94
687.8	10373	7.30	56	218	716	-11.93
697.4	10016	7.96	53	219	700	-4.41
706.6	9678	8.95	50	221	686	-5.71
716.4	9321	10.23	35	216	664	14.13
725.6	8990	10.90	30	217	648	-1.15
735.2	8649	11.66	31	220	635	-10.00
744.6	8318	12.17	32	224	623	-10.10
754.4	7976	12.89	32	227	610	-9.53
763.8	7651	13.60	32	230	597	-8.47
773.8	7310	14.79	32	233	584	-8.88
784.0	6965	15.76	30	234	569	-4.91
793.6	6644	16.68	26	235	553	-0.46
803.8	6306	17.35	25	236	539	-5.55
813.4	5992	18.01	23	238	526	-5.19
823.4	5667	18.01	28	245	517	-20.64
833.8	5333	17.51	54	270	526	-75.83
843.6	5021	17.37	57	275	516	-16.77
854.0	4693	17.56	63	284	509	-25.25
864.6	4362	17.84	77	300	509	-48.98
874.8	4047	18.48	75	303	497	-8.72
885.6	3716	19.36	73	306	485	-10.86
896.0	3401	19.87	69	307	470	-2.82
906.6	3083	20.74	68	311	459	-11.06
917.2	2767	21.49	66	314	446	-9.29
928.0	2449	22.31	67	321	439	-23.43
938.8	2134	23.09	64	323	425	-6.01
949.8	1816	23.66	65	329	416	-17.74
960.6	1507	24.58	64	334	406	-16.76
971.6	1194	25.01	63	337	394	-8.57
982.6	885	25.80	62	341	384	-14.39
993.4	584	26.40	71	359	387	-60.49
1004.6	274	26.22	81	374	388	-48.69

TABLE XXII

NAVAIRDEVCEN PROCESSED METEOROLOGICAL DATA FOR SONDE NO. 13

.CAPE HATTERAS: LAT 35 deg 09 min N, LONG 75 deg 18 min W

LAUNCH DATE:09/08/78 LAUNCH TIME 12:13:31(EDT) SPLASH TIME 12:19:43(EDT)

SURFACE PRESSURE(mb)=1014.6 SONDE NUMBER 13

PRESS. mb	ALTITUDE feet	TEMP. deg.c	HUMIDITY %rh	N units	M units	GRAD. N/1000 ft.
592.2	14166	4.16	43	183	863	0.00
600.4	13822	0.99	50	187	850	-10.63
608.6	13481	0.30	66	194	841	-20.16
616.6	13153	0.53	67	196	828	-8.30
624.8	12820	1.26	72	201	816	-13.55
633.2	12482	2.10	72	204	803	-9.66
641.0	12172	3.14	72	207	792	-10.28
649.8	11826	3.82	72	211	778	-9.37
658.2	11499	4.65	67	212	764	-3.40
666.8	11168	5.55	64	214	750	-6.03
675.4	10840	6.51	51	211	731	8.41
683.8	10523	7.58	54	216	721	-16.17
692.4	10201	8.42	63	224	714	-24.14
701.2	9876	9.16	48	219	693	15.11
710.0	9554	9.70	31	213	671	20.24
718.6	9242	10.59	30	215	658	-6.76
727.6	8919	11.60	30	217	645	-7.52
736.4	8606	12.43	30	220	633	-10.10
745.4	8289	13.09	30	223	621	-8.68
754.6	7969	13.86	31	226	609	-9.95
763.6	7658	14.48	30	228	596	-6.81
772.8	7344	15.04	31	232	584	-11.36
782.0	7033	15.77	31	235	572	-9.08
790.6	6744	16.84	29	236	560	-4.55
800.0	6432	17.56	27	238	546	-4.46
809.2	6129	18.23	23	236	530	4.29
818.6	5822	18.11	28	244	524	-25.58
828.0	5519	17.65	54	269	534	-80.83
837.6	5211	17.40	60	277	527	-26.49
847.0	4913	17.74	59	279	515	-8.07
856.4	4618	18.13	61	284	505	-14.72
866.0	4319	18.68	61	287	495	-12.73
875.4	4028	19.36	73	304	497	-55.78
885.2	3728	19.80	75	309	488	-19.27
894.8	3437	20.21	72	310	475	-2.35
904.4	3149	20.89	68	312	463	-4.79
914.2	2856	21.80	66	315	452	-10.71
924.2	2561	22.50	66	320	443	-17.05
934.0	2274	23.26	65	324	433	-13.20
944.0	1983	23.74	64	327	422	-10.25
953.8	1701	24.41	64	331	413	-16.84
963.8	1415	25.37	64	337	404	-18.18
973.6	1138	26.02	61	338	393	-6.35
984.2	840	26.52	61	342	382	-11.97
994.0	567	26.79	63	349	376	-25.79
1004.4	280	26.69	84	382	395	-114.15

TABLE XXIII

NAVAIRDEVCEN PROCESSED METEOROLOGICAL DATA FOR SONDE NO. 14

CAPE HATTERAS: LAT 35 deg 09 min N, LONG 75 deg 18 min W

LAUNCH DATE:09/08/78 LAUNCH TIME 12:39:30(EDT)   SPLASH TIME 12:46:13(EDT)

SURFACE PRESSURE(mb)=1014.6   SONDE NUMBER 14

PRESS. mb	ALTITUDE feet	TEMP. deg.c	HUMIDITY %rh	N units	M units	GRAD. N/1000 ft.
588.0	14343	7.12	36	180	869	0.00
596.4	13989	2.61	44	184	855	-10.66
605.0	13630	1.43	54	190	844	-15.28
613.6	13276	1.80	63	195	832	-15.55
622.2	12925	2.17	60	197	817	-5.18
630.8	12578	2.90	63	201	805	-11.21
639.4	12236	3.93	63	204	791	-9.79
648.4	11881	4.73	63	207	778	-8.64
657.2	11538	5.49	63	211	764	-9.80
666.0	11198	6.75	58	212	750	-4.44
675.0	10855	7.87	51	212	733	0.21
684.0	10515	8.58	52	216	721	-11.25
693.4	10164	9.49	54	220	708	-12.26
702.4	9832	10.12	56	225	697	-14.42
711.8	9488	10.86	40	219	674	18.67
720.8	9163	11.74	30	216	655	9.19
730.4	8819	12.42	31	219	642	-9.11
739.6	8493	13.50	30	221	629	-7.38
749.2	8157	14.09	29	224	615	-6.92
758.8	7824	14.83	29	226	602	-8.41
768.4	7494	15.63	29	230	589	-9.72
778.0	7168	16.52	30	234	578	-13.00
787.4	6851	17.15	29	236	565	-5.79
797.4	6518	17.44	27	237	549	-2.20
807.2	6195	18.46	28	241	538	-13.32
817.2	5868	17.85	49	262	544	-66.04
827.0	5551	17.30	63	276	542	-42.71
836.8	5237	17.32	69	284	535	-24.41
847.4	4901	17.37	75	292	528	-26.16
857.2	4593	17.99	80	301	522	-28.20
867.4	4275	18.83	81	308	513	-20.40
877.8	3955	18.98	78	308	498	-1.84
888.0	3643	19.68	74	309	484	-1.40
898.2	3335	20.98	68	310	470	-3.96
908.6	3023	21.73	64	310	455	-0.88
919.2	2708	22.58	64	316	446	-17.01
929.4	2408	23.35	65	323	438	-23.57
940.2	2093	23.89	62	324	424	-2.78
950.8	1787	24.02	63	327	413	-12.19
961.4	1484	25.44	62	334	405	-20.59
972.4	1172	26.11	60	336	393	-8.81
982.4	890	27.01	59	341	384	-17.06
994.2	562	27.75	60	348	374	-19.18
1004.6	269	27.02	77	373	386	-85.82

TABLE XXIV

NAVAIRDEVCEN PROCESSED METEOROLOGICAL DATA FOR SONDE NO. 15

CAPE HATTERAS: LONG. 35 deg 09 min N LAT. 75 deg 18 min W

LAUNCH DATE:09/08/78 LAUNCH TIME 13:02:18(EDT) SPLASH TIME 13:09:23(EDT)

SURFACE PRESSURE(mb)=1014.6 SONDE NUMBER 15

PRESS. mb	ALTITUDE feet	TEMP. deg.c	HUMIDITY %rh	N units	M units	GRAD. N/1000 ft.
592.4	14157	5.25	34	180	859	0.00
600.6	13813	0.94	43	184	847	-12.54
609.4	13448	0.36	53	190	835	-14.97
618.0	13096	0.70	61	195	823	-14.51
626.8	12739	1.31	63	198	810	-9.71
636.0	12371	1.95	64	202	796	-9.35
644.6	12030	2.79	66	206	783	-11.84
653.4	11685	3.88	63	208	769	-6.71
662.6	11329	4.91	61	211	754	-6.48
671.4	10992	5.82	55	211	739	-2.75
680.4	10651	6.83	51	213	724	-4.59
689.6	10306	7.87	49	215	710	-6.00
698.8	9964	8.87	48	218	697	-9.04
708.2	9619	9.63	54	225	687	-19.08
717.6	9278	10.17	46	223	669	4.68
727.2	8933	10.96	28	216	645	21.54
736.4	8606	11.71	28	219	632	-8.30
746.2	8261	12.47	28	221	618	-7.33
755.2	7948	13.28	27	223	605	-6.93
765.2	7603	14.07	27	226	591	-8.53
774.8	7276	14.88	26	229	578	-7.48
784.8	6938	15.49	28	233	566	-13.41
794.0	6631	16.04	27	235	554	-6.34
803.6	6313	16.79	21	233	536	6.00
813.4	5992	16.96	25	239	526	-16.89
823.8	5654	16.80	40	255	526	-46.71
834.2	5320	16.56	64	277	532	-67.16
844.4	4995	16.57	71	286	525	-26.08
854.4	4680	17.05	75	293	518	-24.63
864.6	4362	17.47	79	300	510	-21.49
874.6	4053	17.93	80	306	500	-17.93
884.6	3747	18.61	77	308	487	-5.90
895.2	3425	19.43	73	309	473	-3.70
905.6	3113	20.28	67	308	458	0.86
915.6	2815	21.20	68	315	450	-20.21
926.2	2502	21.76	69	321	441	-19.50
936.6	2198	22.35	66	322	427	-4.15
948.2	1862	23.06	66	327	416	-14.95
957.6	1592	23.92	65	332	408	-18.23
968.2	1290	24.70	62	334	396	-6.18
979.0	986	25.20	62	338	385	-12.28
989.4	695	25.88	62	343	376	-17.65
1000.6	385	26.12	75	365	383	-71.29
1011.2	93	26.15	82	378	382	-43.76
1018.1	-95	26.65	82	382	378	-25.26

CAPE HATTERAS RAWINDSONDE:LAT.35deg 16min N,LONG.75deg 33min W

LAUNCH DATE:09/08/78 LAUNCH TIME 11:00:00(EDT)

SURFACE PRESSURE=1014.4

PRESS. mb	ALTITUDE feet	TEMP. deg.c	HUMIDITY %rh	N units	M units	GRAD. N/1000 ft.
522.2	17266	-7.20	32	159	988	0.00
530.4	16885	-6.80	57	166	976	-18.47
538.4	16518	-6.60	77	172	965	-17.15
546.6	16147	-6.10	94	178	953	-16.56
555.0	15771	-5.00	95	182	939	-9.13
563.4	15400	-5.00	99	185	924	-8.97
571.8	15033	-4.10	95	187	909	-6.07
580.4	14662	-2.90	91	190	894	-6.64
588.8	14304	-2.20	89	193	879	-7.18
597.4	13941	-1.30	83	194	863	-4.74
606.2	13575	-0.20	73	195	846	-1.18
614.8	13221	0.80	69	197	831	-6.03
623.6	12863	1.50	64	198	815	-3.35
632.6	12501	3.40	62	201	801	-8.69
641.6	12143	4.30	57	203	786	-4.11
650.6	11789	5.10	53	204	770	-4.23
659.6	11439	6.30	52	207	756	-8.11
668.8	11086	7.20	50	209	742	-6.68
677.8	10743	7.90	48	212	727	-5.97
687.0	10397	8.50	48	215	714	-9.45
696.6	10040	9.30	52	220	702	-14.99
706.0	9694	9.50	49	221	687	-2.88
715.2	9359	10.40	47	223	673	-6.59
724.6	9021	12.40	42	225	658	-4.80
734.2	8679	13.30	34	223	640	6.13
743.8	8340	14.30	31	224	624	-3.21
753.6	7998	15.10	23	221	605	9.98
763.6	7653	15.40	17	219	586	4.49
773.2	7325	16.20	18	222	574	-8.97
783.2	6987	16.80	18	225	560	-7.81
792.8	6665	17.70	17	227	547	-6.06
803.0	6327	17.80	15	228	532	-3.24
812.8	6006	18.20	14	230	518	-6.08
822.8	5681	17.50	16	234	507	-13.69
833.0	5353	16.80	49	265	522	-93.64
843.0	5034	17.10	66	283	525	-55.96
853.2	4713	17.50	71	291	517	-24.39
863.4	4394	18.20	73	298	508	-21.24
873.8	4072	18.90	71	300	495	-6.81
884.2	3753	19.80	68	303	483	-9.24
894.0	3456	20.70	64	303	469	-1.52
904.6	3137	21.50	65	310	460	-20.51
915.0	2827	22.00	66	315	451	-16.70
925.6	2514	23.00	63	318	438	-9.00
936.4	2198	23.80	61	320	426	-7.69
947.0	1891	24.00	60	323	413	-7.76
958.0	1575	24.60	60	327	403	-14.72
968.8	1268	25.40	59	332	393	-16.87
979.6	964	25.80	60	337	384	-16.38
990.6	656	26.20	62	344	376	-22.58
1001.6	352	26.60	70	360	377	-50.31
1014.4	0	29.90	61	365	365	-14.44

TABLE XXV - METEOROLOGICAL DATA FROM CAPE HATTERAS RAWINDSONDE NO. 1

CAPE HATTERAS RAWINDSONDE:LAT.35deg 16min N,LONG.75deg 33min W

LAUNCH DATE:09/08/78 LAUNCH TIME 13:00:00(EDT)

SURFACE PRESSURE=1014.4

PRESS. mb	ALTITUDE feet	TEMP. deg.c	HUMIDITY %rh	N units	M units	GRAD. N/1000 ft.
572.8	14990	-3.80	87	186	905	0.00
581.4	14619	-2.30	75	187	888	-1.63
590.0	14253	-1.50	68	188	872	-3.32
599.2	13866	-0.50	64	190	856	-5.38
608.0	13501	0.70	67	194	842	-11.22
617.0	13131	1.50	68	198	828	-9.45
626.0	12766	2.50	63	199	812	-4.57
635.0	12405	3.20	59	201	796	-4.09
644.2	12040	4.10	66	207	785	-16.37
653.4	11680	5.30	55	206	766	2.67
662.8	11316	6.00	54	209	752	-7.73
672.2	10956	7.40	51	211	737	-6.40
681.4	10607	7.90	45	211	720	-0.82
691.0	10248	9.40	39	212	704	-1.30
700.6	9892	9.30	48	219	694	-20.30
710.2	9541	10.30	46	222	680	-7.59
719.8	9193	11.10	39	220	662	3.49
729.6	8842	11.80	19	211	635	27.23
739.2	8502	13.00	18	213	621	-6.67
749.2	8151	14.00	17	215	606	-5.70
759.2	7804	15.00	17	218	592	-6.69
769.0	7468	15.20	18	221	579	-10.11
779.2	7122	16.00	17	223	565	-5.69
789.2	6785	16.40	17	226	551	-7.98
799.4	6446	17.50	16	228	537	-5.60
809.8	6104	17.70	13	228	521	-1.55
820.2	5765	16.20	17	234	511	-17.18
830.4	5436	16.50	62	274	535	-121.74
841.0	5098	16.50	61	276	521	-6.86
851.6	4763	17.20	70	288	517	-35.45
862.0	4437	17.40	61	284	497	12.85
872.8	4103	18.40	76	303	500	-57.06
883.4	3778	19.10	73	305	487	-6.00
894.2	3450	19.70	68	305	471	-0.43
905.2	3119	21.30	61	305	455	0.07
916.0	2798	21.70	62	311	445	-16.48
927.0	2473	22.10	62	314	433	-10.42
938.0	2152	22.70	58	314	417	-0.28
949.2	1828	24.00	55	318	405	-10.99
960.4	1507	24.70	53	320	392	-7.26
971.8	1183	25.60	53	324	381	-13.39
983.0	868	26.40	53	330	372	-18.57
994.4	551	26.90	53	336	362	-16.47
1006.0	230	29.00	58	353	364	-54.55
1014.4	0	32.00	46	350	350	13.44

TABLE XXVI - METEOROLOGICAL DATA FROM CAPE HATTERAS RAWINDSONDE NO. 2

TABLE XXVII

CAPE HATTERAS WIND INFORMATION FROM RAWINDSONDE NO. 1 (11:00:00 EDT)

Time Elapsed After Launch (min)	Altitude Above Mean Sea Level (ft)	Wind Speed (kn)	Wind Direction (in ° relative to true North)
0	13	6	40
1	935	4	68
2	1838	2	55
3	2648	6	360
4	3419	10	346
5	4381	13	342
6	5143	17	346
7	6066	19	340
8	6933	20	338
9	7897	21	341
10	8721	21	334
11	9662	21	332
12	10498	22	334
13	11426	23	336
14	12284	22	336
15	13276	21	334
16	14139	21	330
17	15179	22	329
18	16047	23	332
19	16921	26	333
20	17884	23	328
21	18790	18	326
22	19752	15	336
23	20679	15	343
24	21654	16	2
25	22612	18	15
26	23576	20	14
27	24510	21	14

TABLE XXVIII

CAPE HATTERAS WIND INFORMATION FROM RAWINDSONDE NO. 2 (13:00:00 EDT)

Time Elapsed After Launch (min)	Altitude Above Mean Sea Level (ft)	Wind Speed (kn)	Wind Direction (in ° relative to true North)
0	13	5	60
1	1012	3	354
2	1864	4	352
3	2846	7	356
4	3826	8	353
5	4763	10	345
6	5741	14	341
7	6614	15	343
8	7514	17	343
9	8328	19	339
10	9312	22	337
11	10212	24	335
12	11208	25	333
13	12137	24	332
14	13088	24	336
15	14046	26	335
16	15030	25	325
17	15998	25	324
18	16993	26	331
19	17900	25	333
20	18985	17	327
21	19904	11	332
22	20960	10	6
23	21887	9	14
24	22843	9	5
25	23840	10	32
26	24845	13	46

BENDIX P-3C CAPE H.: LAT. 35 deg 09 min, LONG. 75 deg 18 min

LAUNCH DATE:09/08/78 LAUNCH TIME 13:02:18(EDT) SPLASH TIME 13:09:23(EDT)

SURFACE PRESSURE(mb)=1014.6 SONDE NUMBER 15

PRESS. mb	ALTITUDE feet	TEMP. deg.c	HUMIDITY %rh	N units	M units	GRAD. N/1000 ft.
592.4	14157	3.03	38	181	860	0.00
600.6	13813	0.56	45	185	848	-12.38
609.4	13448	0.40	59	192	837	-18.62
618.0	13096	0.96	61	195	824	-9.67
626.8	12739	1.50	63	199	810	-9.38
636.0	12371	2.18	66	203	797	-11.38
644.6	12030	3.13	66	206	784	-9.80
653.4	11685	4.18	62	208	769	-4.92
662.6	11329	5.18	60	210	754	-6.99
671.4	10992	6.18	55	211	739	-3.21
680.4	10651	7.14	50	213	724	-3.90
689.6	10306	8.28	48	215	710	-7.16
698.8	9964	9.03	48	218	696	-8.20
708.2	9619	9.93	51	223	685	-14.56
717.6	9278	10.58	31	215	660	24.50
727.2	8933	11.23	28	216	645	-2.74
736.4	8606	12.06	28	218	632	-8.18
746.2	8261	12.85	27	221	618	-7.76
755.2	7948	13.52	26	223	605	-6.38
765.2	7603	14.11	27	227	591	-9.61
774.8	7276	15.07	27	229	578	-8.08
784.8	6938	15.54	28	234	567	-12.97
794.0	6631	16.27	25	234	552	-0.20
803.6	6313	16.96	22	234	537	0.30
813.4	5992	17.05	25	239	526	-16.41
823.8	5654	16.85	51	264	535	-73.96
834.2	5320	16.54	67	279	535	-46.10
844.4	4995	16.66	70	285	525	-18.23
854.4	4680	17.16	78	296	521	-33.96
864.6	4362	17.74	79	301	510	-16.38
874.6	4053	29.91	82	364	558	-202.64
884.6	3747	18.91	76	307	487	184.19
895.2	3425	19.67	71	308	472	-2.11
905.6	3113	20.50	66	308	457	0.45
915.6	2815	21.30	68	315	450	-24.31
926.2	2502	21.94	67	320	440	-14.21
936.6	2198	22.55	66	323	428	-9.69
948.2	1862	23.31	65	328	417	-14.86
957.6	1592	24.07	65	332	408	-15.74
968.2	1290	24.80	62	334	396	-6.35
979.0	986	25.36	62	338	386	-14.87
989.4	695	25.78	62	343	376	-14.26
1000.6	385	26.10	80	372	391	-96.10
1011.2	93	26.52	82	380	384	-24.78

TABLE XXIX - METEOROLOGICAL DATA FOR SONDE NO. 15 USING PERIOD DATA GENERATED BY BENDIX RDSRU IN P-3C AND NAVAIRDEVCEN ALGORITHMS

SURFACE PRESSURE=1012.4?

E DATE TIME LAT. LONG.

78:09:08 13:00Z 35:09:00N 075:18:00W

ALT.	PRESS.	TEMP.	HUM.	N	
M					
0	1012.4	26.9	81	386	3
86					
17	1010.4	26.7	81	385	
111	999.2	25.9	79	375	
192	989.6	26.0	62	348	
279	979.4	25.5	62	343	
366	969.2	25.0	62	339	
455	959.0	24.3	65	338	
546	948.6	23.5	66	333	
634	938.6	22.7	66	328	
725	928.4	21.9	67	323	
812	918.6	21.4	67	319	
901	908.8	21.0	66	314	
991	899.0	19.6	70	312	
1081	889.2	19.0	75	312	
1174	879.2	18.5	79	312	
1262	869.8	17.7	77	304	
1355	860.0	17.4	77	301	
1446	850.4	16.8	69	289	
1537	841.0	16.8	66	284	
1630	831.4	17.1	49	267	
1723	822.0	17.2	23	241	
1820	812.2	17.2	19	234	
1916	802.6	16.2	24	236	
2005	793.8	15.2	28	236	
2096	784.8	15.3	25	232	
2191	775.6	14.2	26	230	
2287	766.4	13.8	24	225	
2381	757.4	13.0	25	223	
2478	748.2	12.4	28	223	
2575	739.2	11.4	27	219	
2672	730.2	10.6	32	220	
2770	721.2	10.0	51	228	
2867	712.4	9.3	46	222	
2965	703.6	8.6	47	220	
3064	694.8	7.5	49	217	
3161	686.2	6.3	54	217	
3260	677.6	5.6	59	216	
3362	668.8	4.4	62	214	
3465	660.0	3.5	66	212	

TABLE XXX - METEOROLOGICAL DATA OUTPUT FOR SONDE NO. 15 GENERATED BY BENDIX RDSRU IN LABORATORY

```
3567   651.4   2.5   66   209
3668   643.0   1.8   63   205
3767   634.8   1.1   61   201
3872   626.2   0.6   59   197
3971   618.2   0.8   45   191
4076   609.8   4.2   35   185   8
27
END
FLAGGED GRADIENTS (STARTING FROM SEALEVE
L)
DATE   TIME   LAT.   LONG.
78:09:08 13:00Z  35:09:00N 075:18:00W


 SUPERFRACTIVE:  G=- 0.032
A  17  , A  111
M  388  , M  392
 TRAPPING:  G=- 0.102
A  111  , A  192
M  392  , M  378
 SUPERFRACTIVE:  G=- 0.028
A  1174  , A  1262
M  497  , M  503
 SUPERFRACTIVE:  G=- 0.040
A  1355  , A  1446
M  514  , M  517
 TRAPPING:  G=- 0.056
A  1537  , A  1630
M  526  , M  524
 TRAPPING:  G=- 0.085
A  1630  , A  1723
M  524  , M  512
 SUBFRACTIVE:  G= 0.006
A  1820  , A  1916
M  521  , M  538
 SUBFRACTIVE:  G= 0.003
A  2575  , A  2672
M  625  , M  641
 SUBFRACTIVE:  G= 0.025
A  2672  , A  2770
M  641  , M  664
 END OF GRADIENT DATA.
```

TABLE XXXI - REFRACTIVITY LAYER DATA OUTPUT FOR SONDE NO. 15
GENERATED BY BENDIX RDSRU IN LABORATORY

E

R	T	P	H	TIME
7309	9088	17053	8770	0
7297	9474	11344	8843	11
7296	10201	7984	9078	51
7283	10532	8026	9474	143
7280	10551	7967	11401	243
7276	10489	11238	11816	347
7286	10431	7959	12143	443
7283	10355	7994	12927	547
7285	10254	8218	12962	655
7284	10168	7967	11858	751
7297	10070	8902	11334	851
7290	9991	7969	10440	955
7300	9900	7986	9852	1059
7296	9799	7977	9610	1163
7289	9733	7980	9557	1263
7289	9674	8976	9969	1371
7289	9630	7985	8952	1471
7293	9576	7981	8825	1571
7297	9503	7981	8841	1671
7294	9454	8099	8804	1767
7301	9406	11267	8781	1867
7290	9361	8036	8806	1963
7294	9292	8121	8797	2067
7300	9306	7984	8853	2159
7287	9224	7981	8763	2259
7293	9166	9151	8662	2359
7292	9166	7986	8751	2455
7296	9176	7975	9722	2551
7294	9195	8079	12464	2655
7293	9194	7968	13318	2747
7291	9148	9418	17698	2847
7284	9121	8028	18253	2947
7296	9090	8253	19456	3043
7291	9054	8414	16078	3135
7286	9008	7970	13460	3227
7303	8948	8899	12123	3327
7286	8904	8001	12565	3427
7286	8877	8158	12464	3523
7281	8830	8122	12094	3623
7290	8798	7956	11958	3715
7288	8750	9055	11820	3815
7290	8720	7963	11285	3907
7281	8684	8195	11259	4007
7289	8668	8426	11230	4103
7269	8651	8284	18688	4203
7287	8629	8964	19874	4299
7286	8618	20564	20135	4317

TABLE XXXII - PERIOD DATA OUTPUT FOR SONDE NO. 15 GENERATED BY BENDIX RDSRU IN LABORATORY

TABLE XXXIII

COMPARISON OF METEOROLOGICAL DATA GENERATED BY RDSRU IN LABORATORY WITH METEOROLOGICAL DATA GENERATED SOLELY BY NAVAIRDEVCEN PROCESSING SCHEME

Bendix RDSRU Calculated Altitude (ft)	NADC Calculated Altitude (ft)	Bendix RDSRU Calculated Temperature (°C)	NADC Calculated Temperature (°C)	Bendix RDSRU Calculated Humidity (%RH)	NADC Calculated Humidity (%RH)	Bendix RDSRU Calculated N Units	NADC Calculated N Units
13373	13448	4.2	0.36	35	53	185	190
13029	13096	0.8	0.70	45	61	191	195
12704	12739	0.6	1.31	59	63	197	198
12360	12371	1.1	1.95	61	64	201	202
12035	12030	1.8	2.79	63	66	205	206
11703	11685	2.5	3.88	66	63	209	208
11369	11329	3.5	4.91	66	61	212	211
11031	10992	4.4	5.82	62	55	214	211
10696	10651	5.6	6.83	59	51	216	213
10371	10306	6.3	7.87	54	49	217	215
10053	9964	7.5	8.87	49	48	217	218
9728	9619	8.6	9.63	47	54	220	225
9407	9278	9.3	10.17	46	46	222	223
9088	8933	10.0	10.96	51	28	228	216
8767	--	10.6	--	32	--	220	--
8449	8606	11.4	11.71	27	28	219	219
8130	8261	12.4	12.47	28	28	223	221
7812	7948	13.0	13.28	25	27	223	223
7504	7603	13.8	14.07	24	27	225	226
7189	7276	14.2	14.88	26	26	230	229
6877	6938	15.3	15.49	25	28	232	233
6578	6631	15.2	16.04	28	27	236	235
6286	6313	16.2	16.79	24	21	236	233
5971	5992	17.2	16.96	19	25	234	239
5653	5654	17.2	16.80	23	40	241	255
5348	5320	17.1	16.56	49	64	267	277

Sonde Number 15

TABLE XXXIII (cont)

Bendix RDSRU Calculated Altitude (ft)	NADC Calculated Altitude (ft)	Bendix RDSRU Calculated Temperature (°C)	NADC Calculated Temperature (°C)	Bendix RDSRU Calculated Humidity (%RH)	NADC Calculated Humidity (%RH)	Bendix RDSRU Calculated N Units	NADC Calculated N Units
5043	4995	16.8	16.57	66	71	284	286
4744	4680	16.8	17.05	69	75	289	293
4446	4362	17.4	17.47	77	79	301	300
4141	4053	17.7	17.93	77	80	304	306
3852	3747	18.5	18.61	79	77	312	308
3547	3425	19.0	19.43	75	73	312	309
3251	3113	19.6	20.28	70	67	312	308
2956	2815	21.0	21.20	66	68	314	315
2664	2502	21.4	21.76	67	69	319	321
2379	--	21.9	--	67	--	323	--
2080	2198	22.7	22.35	66	66	328	322
1791	1862	23.5	23.06	66	66	333	327
1493	1592	24.3	23.92	65	65	338	332
1201	1290	25.0	24.70	62	62	339	334
915	986	25.5	25.20	62	62	343	338
630	695	26.0	25.88	62	62	348	343
364	385	25.9	26.12	79	75	375	365
56	93	26.7	26.15	81	82	385	378
0	-95	26.9	26.65	81	82	386	382

Sonde Number 15

BENDIX LAB, CAPE H.; LAT. 35 deg 09 min, LONG. 75 deg 18 min

LAUNCH DATE:09/08/78 LAUNCH TIME 13:02:18(EDT) SPLASH TIME 13:09:23(EDT)

SURFACE PRESSURE(mb)=1014.6 SONDE NUMBER 15

PRESS. mb	ALTITUDE feet	TEMP. deg.c	HUMIDITY %rh	N units	M units	GRAD. N/1000 ft.
592.4	14157	3.95	35	180	860	0.00
600.6	13813	0.55	45	185	848	-14.03
609.4	13448	0.33	59	192	837	-18.45
618.0	13096	0.85	61	195	824	-9.60
626.8	12739	1.53	63	199	810	-9.57
636.0	12371	2.23	66	203	797	-11.49
644.6	12030	3.26	66	206	784	-10.02
653.4	11685	4.12	62	208	769	-4.45
662.6	11329	5.35	60	210	754	-7.43
671.4	10992	6.11	55	211	739	-2.66
680.4	10651	7.30	50	213	724	-4.27
689.6	10306	8.42	48	215	710	-7.16
698.8	9964	9.10	48	218	696	-8.30
708.2	9619	9.83	52	224	685	-15.48
717.6	9278	10.39	32	215	661	24.14
727.2	8933	11.16	28	216	644	-0.67
736.4	8606	12.20	28	219	632	-9.34
746.2	8261	12.81	27	221	617	-5.96
755.2	7948	13.61	26	223	604	-5.96
765.2	7603	14.05	27	226	591	-11.14
774.8	7276	15.13	26	229	578	-7.98
784.8	6938	15.04	28	233	566	-11.83
794.0	6631	16.02	25	234	552	-2.37
803.6	6313	17.04	21	233	536	2.35
813.4	5992	17.02	25	239	526	-17.81
823.8	5654	16.94	50	263	535	-72.24
834.2	5320	16.60	67	279	535	-48.16
844.4	4995	16.60	70	285	525	-17.26
854.4	4680	17.28	78	296	521	-35.77
864.6	4362	17.57	79	301	510	-13.55
874.6	4053	18.32	80	307	502	-21.08
884.6	3747	18.81	76	307	487	0.35
895.2	3425	19.48	71	308	472	-1.58
905.6	3113	20.89	66	309	458	-4.40
915.6	2815	21.30	68	315	450	-21.02
926.2	2502	21.79	68	319	439	-12.64
936.6	2198	22.55	66	323	428	-11.33
948.2	1862	23.36	65	328	417	-14.97
957.6	1592	24.24	65	333	409	-17.97
968.2	1290	24.88	62	334	396	-4.60
979.0	986	25.39	62	339	386	-15.07
989.4	695	25.92	62	343	376	-14.95
1000.6	385	25.78	80	371	389	-89.59
1011.2	93	26.68	82	380	385	-33.26

TABLE XXXIV - METEOROLOGICAL DATA FOR SONDE NO. 15 USING BENDIX RDSRU LABORATORY GENERATED PERIOD DATA AND NAVAIRDEVCEN ALGORITHMS

APPENDIX A

SUMMARY OF USER ALGORITHMS

The algorithms listed in this section of the report were used by the Tektronics 4051 microcomputer, as part of the NAVAIRDEVCEN processing scheme, to calculate the required meteorological data.

A.1 Altitude

The altitude equation listed below was derived from a tropospheric pressure-altitude equation given in appendix 8.0.1 of reference (c).

$$A_i = (-145445) \left[\left(\frac{1013.246}{P_i}\right)^{-0.190263} - \left(\frac{1013.246}{P_s}\right)^{-0.190263} \right] \qquad \text{(A-1)}$$

where

A_i = Pressure altitude (in feet)

P_i = Pressure (in millibars) at altitude A_i

P_s = Surface pressure (in millibars)

1013.246 = Standard sea level barometric pressure (in millibars)

A.2 Temperature

Two steps are required in the calculation of free air temperature from the telemetered frequency: (1) conversion of the frequency, as developed by the sonde oscillator, to thermistor resistance, and (2) conversion of this resistance value to temperature. It should be noted that the thermistor element itself is directly coupled to the sonde's oscillator.

The following general equation for sensor resistance and sensor frequency was derived by Mr. Sal Grillo of NAVAIRDEVCEN. This equation was formulated by means of a curve-fitting technique of data compiled from the characteristics of oscillators that were incorporated into the dropsonde.

$$F_{SEN} = \frac{90664.788\ F_{HR}}{1719.807\ (R_{SEN} + 47.718)} \qquad \text{(A-2)}$$

where

F_{SEN} = Sensor frequency

R_{SEN} = Sensor resistance

F_{HR} = High reference frequency

The equation for thermistor resistance appears below (see page 3-1 of reference (d)) and can be derived from equation (A-2) by elementary algebraic manipulation. In the data calculations presented previously in this report, the equations that use period values were utilized rather than frequency values. However, either method is valid.

<u>Thermistor Resistance:</u> $$R_T = \frac{52.718\ F_{HR}}{F_T} - 47.718 \qquad \text{(A-3)}$$

or

$$R_T = \frac{52.718\ P_T}{P_{HR}} - 47.718 \qquad \text{(A-4)}$$

where

R_T = Thermistor resistance (in ohms)

F_{HR} = High reference frequency

F_T = Thermistor frequency

$P_T = \frac{1}{F_T}$ = Thermistor period

$P_{HR} = \frac{1}{F_{HR}}$ = Period of the high reference frequency

The ensuing third order polynomial equation, derived empirically by the VIZ Manufacturing Company from test data for its premium temperature sensors (see reference (e)), page 55), converts thermistor resistance to temperature and provides accuracies within $\pm 0.01°$ C to nominal sensor test data.

$$\underline{\text{Temperature}}: \quad T = \frac{1}{\sum_{K=0}^{3} A_K \left[\ln \frac{R_T}{R_{30}}\right]^K} - 273.16 \qquad \text{(A-5)}$$

where

T = Free-air temperature (in ° C)

R_T = Thermistor resistance

R_{30} = Thermistor lock-in resistance at +30° C

A_0 = 3.2987 E-Ø3

A_1 = 4.7764 E-Ø4

A_2 = 3.0029 E-Ø6

A_3 = 1.5108 E-Ø6

A.3 Humidity

There are two steps in the calculation of relative humidity from the telemetered frequency: conversion of the frequency to hygristor resistance and conversion of this resistance value to relative humidity.

The calculation of the hygristor resistance is also a two-step process and begins with the basic sensor resistance equation that was stated previously.

$$R_H = \frac{52.718\ F_{HR}}{F_H} - 47.718 \qquad \text{(A-6)}$$

or

$$R_H = \frac{52.718\ P_H}{P_{HR}} - 47.718 \qquad \text{(A-7)}$$

where

R_H = Resistance of the hygristor resistor network

F_{HR} = High reference frequency

F_H = Hygristor frequency

$P_H = \frac{1}{F_H}$ = Hygristor period

$P_{HR} = \frac{1}{F_{HR}}$ = Period of high reference frequency

The actual total hygristor resistance is derived by determining the total resistance of the resistor network containing the hygristor, which appears in figure 51.

The equation for this resistance network is:

$$R_H = \frac{250\ R_h}{250 + R_h} + 7.1 \qquad \text{(A-8)}$$

and can be converted, via algebraic manipulation, to the following final form for actual hygristor resistance:

<u>Actual Hygristor Resistance</u>: $$R_h = \frac{250\ (R_H - 7.1)}{250 - (R_H - 7.1)} \qquad \text{(A-9)}$$

where

R_h = Actual hygristor resistance (in kohms) and

$R_H = \dfrac{52.718\ P_H}{P_{HR}} - 47.718$, as defined before.

The expressions for calculating the relative humidity were also developed at NAVAIRDEVCEN and are dependent on the free-air temperature and on the ratio of hygristor resistance to the hygristor lock-in resistance. The final equation for calculating relative humidity is given as follows:

<u>Relative Humidity</u>: $H_R = H_1 + \frac{T}{40}(H_2 - H_1)$ (A-10)

where

H_R = Percent relative humidity

T = Free-air temperature at that particular altitude

The variables H_1 and H_2 are determined by the following constraints:

Let $r = \frac{R_h}{R_{LH}}$

where

R_h = Actual hygristor resistance

R_{LH} = Hygristor lock-in resistance at 33% RH and +25° C

If $r \leq 1.46$, then $H_1 = 32.0964 + 38.944 \ln r$

If $1.46 < r \leq 6.2$, then $H_1 = 40.5085 + 16.6907 \ln r$

If $r > 6.2$, then $H_1 = 54.8495 + 9.0138 \ln r$

If $T \leq 0$ and $r \leq 1.4$, then $H_2 = 32.5091 + 36.6271 \ln r$

If $T \leq 0$ and $1.4 < r \leq 3.8$, then $H_2 = 36.372 + 16.4646 \ln r$

If $T \leq 0$ and $r > 3.8$, then $H_2 = 47.2683 + 9.7881 \ln r$

If $T > 0$ and $r \leq 1.2$, then $H_2 = 32.4162 + 50.2485 \ln r$

If $T > 0$ and $1.2 < r \leq 5.0$, then $H_2 = 42.6859 + 20.0476 \ln r$

If $T > 0$ and $5.0 < r \leq 40.0$, then $H_2 = 54.6334 + 11.042 \ln r$

If $T > 0$ and $r > 40.0$, then $H_2 = 78.9251 + 4.3577 \ln r$

A.4 Refractivity: N and M Units

The following equations that were used for the refractivity index (in both N and M units) were taken from pages 3-8 and 3-10 of reference (d).

Refractivity: $$N = \frac{77.6\, P - 0.056\, H_R e_s}{T + 273.16} + \frac{3750\, H_R e_s}{(T + 273.16)^2} \qquad \text{(A-11)}$$

where

N = Refractivity index (in N-units)

P = Barometric pressure (in mbars)

T = Free-air temperature at pressure P (in ° C)

H_R = Percent relative humidity at pressure P

e_s = Saturated water vapor pressure (in mbars)

The saturated water vapor pressure is calculated according to the following equation:

Saturated Water Vapor Pressure:

$$e_s = \frac{1013.246 \times 10^{8.1238 \times 10^{-3}[10^{-3.49149(\frac{1-t}{t})}-1]}}{t^{5.02808} \times 10^{7.90298(\frac{1-t}{t})} \times 10^{1.3816 \times 10^{-7}[10^{11.344(1-t)}-1]}} \quad \text{(A-12)}$$

where

$$t = \frac{T + 273.16}{373.16}$$

T = Free-air temperature (in ° C)

Refractivity in M-units can be determined by the following expression:

Refractivity: $M = N + 0.048\,A$ (A-13)

where

M = Refractivity (in M-units)

N = Refractivity (in N-units)

A - Pressure Altitude (in feet)

The refractivity gradient, $\frac{dN}{dA}$, is calculated for every 1000 feet of altitude as follows:

$$\underline{\text{Refractivity Gradient}}: \quad \frac{dN}{dA} = \frac{N_i - N_{i-1}}{A_i - A_{i-1}} \times 1000 \qquad \text{(A-14)}$$

where

$\frac{dN}{dA}$ = Refractivity gradient/1000 ft

N_i = Refractivity at current altitude A_i

N_{i-1} = Refractivity at previous altitude A_{i-1}

A_i and A_{i-1} are altitudes in feet

$A_i < A_{i-1}$

The refractivity gradient, $\frac{dN}{dA}$, is classified according to the following constraints:

Range	Classification
$\frac{dN}{dA} < -48.0$	Trapping
$-48.0 \leq \frac{dN}{dA} < -24.0$	Superfractive
$-24.0 \leq \frac{dN}{dA} < 0$	Normal
$0 \leq \frac{dN}{dA}$	Subfractive