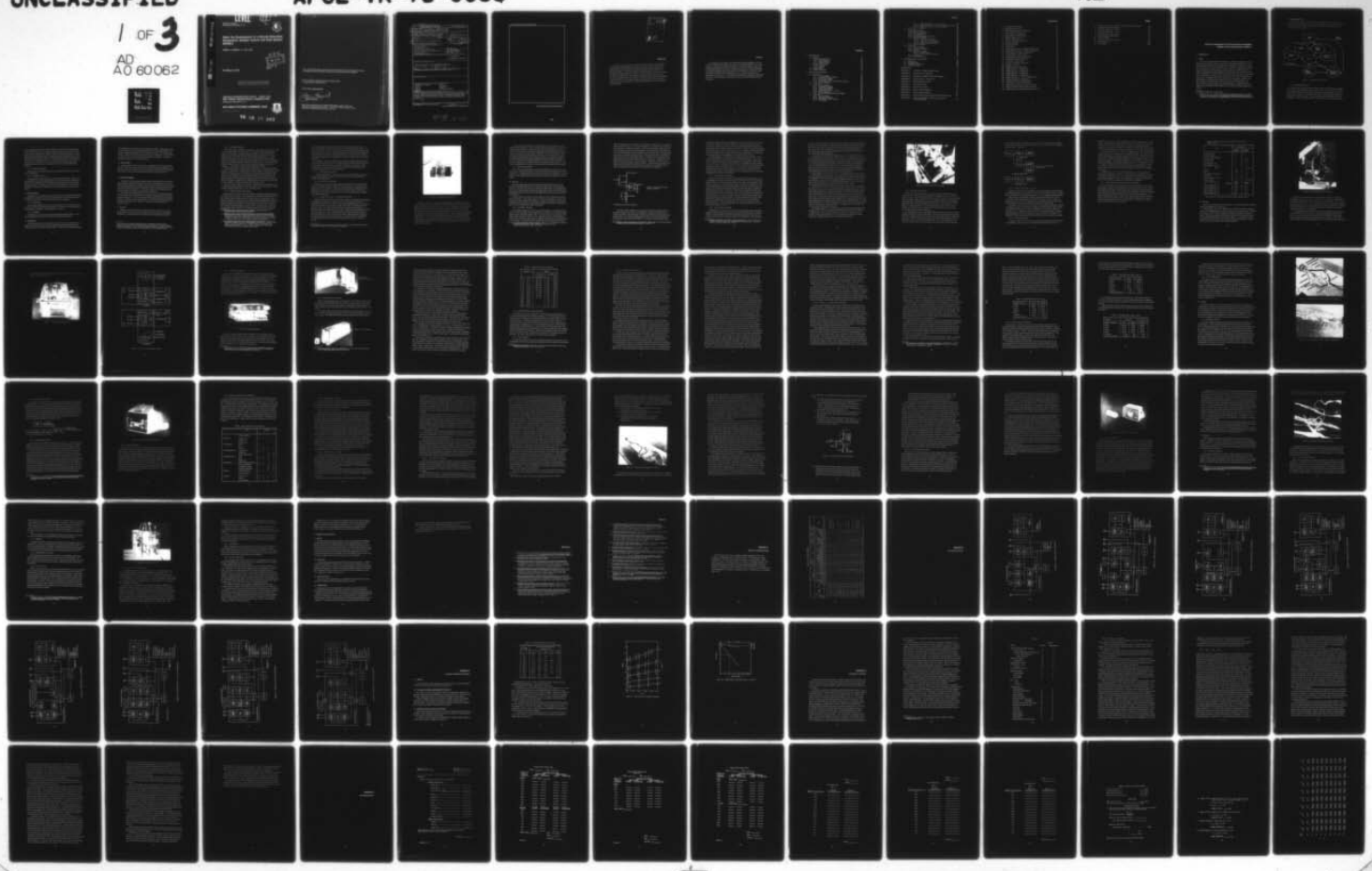
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About the Development of a Second Generation Atmospheric Sampler Control and Data System: SCADS-2

ROBERT H. CORDELLA, Jr., Capt, USAF

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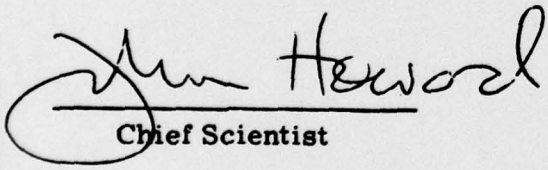
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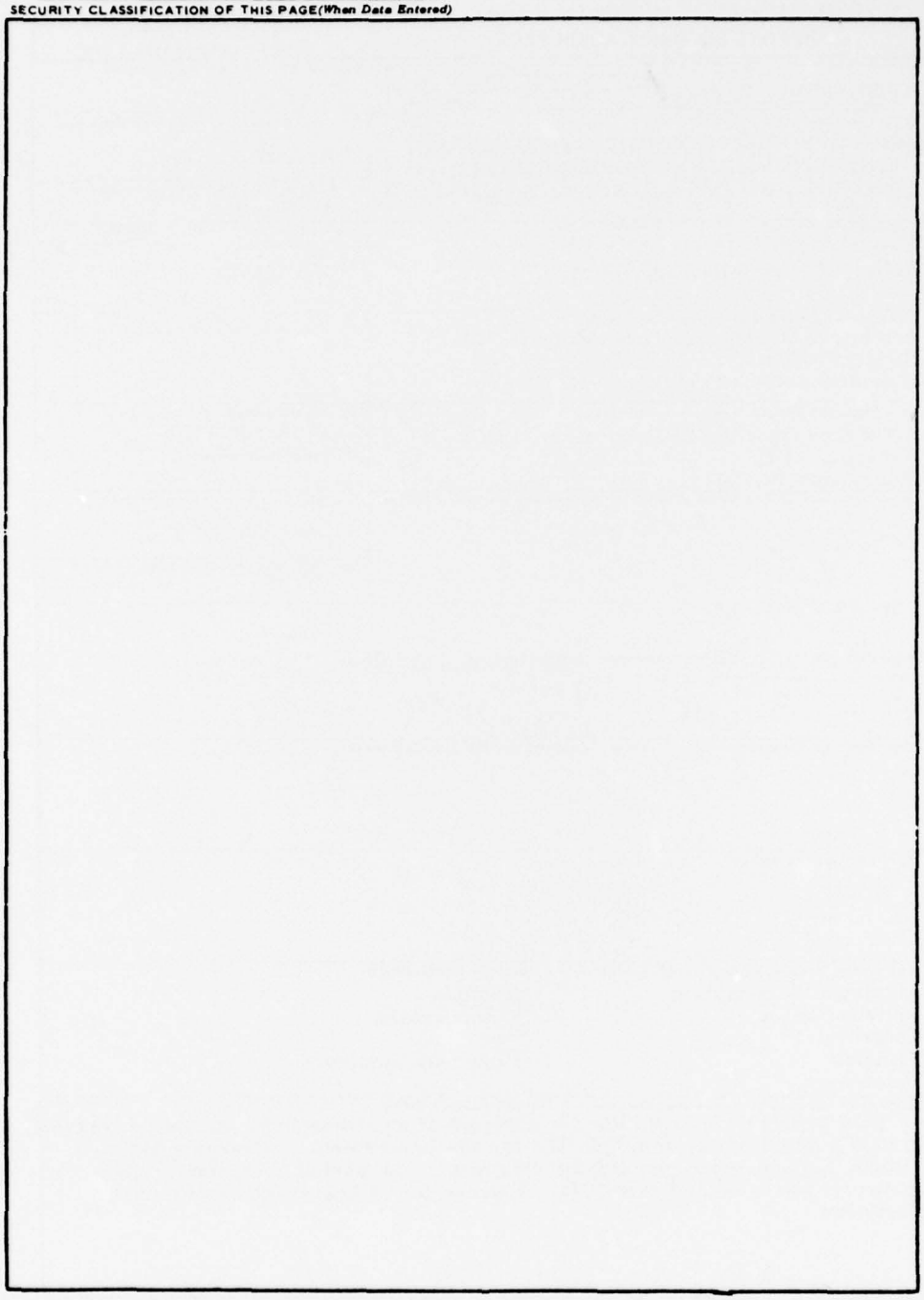
This report documents the development of an atmospheric sampling control and data acquisition system (SCADS) for the Department of Energy's high-altitude, balloon-borne monitoring program. The period documented spans 5 calendar years ending with 1977. Sources for technical information are referenced.

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Foreword

The purpose of this report is to document the development of a second generation atmospheric sampling control and data acquisition system (SCADS) for the Energy Research and Development Administration high-altitude, balloon-borne monitoring program. The instrumentation is documented in Project Ash Can Atmospheric Sampling Handbook, Volume II: Instrumentation, SCADS-2. It should be noted that during system development two agencies involved changed names. Air Force Cambridge Research Laboratories (AFCRL) became Air Force Geophysics Laboratory (AFGL) and the Atomic Energy Commission (AEC) became first the Energy Research and Development Administration (ERDA) and then the Department of Energy (DOE).

Preface

I am indebted to many people who contributed invaluable suggestions, many of which were incorporated into the final system. Specifically thanks go to Mr. Hans Laping for engineering assistance, particularly in the radio frequency spectrum; to SSgt Robert Dumont who supplied a technician's point of view thereby permitting operational stumbling blocks to be eliminated; to Capt Peter L. Miller who wrote the complete programs for the dictionaries, to Mr. Charles Mitropoulos who designed the SAVE-3; to Mr. Alan Griffin who designed the automatic ground station; and to Mrs. Carol McMahon and Ms Margo Cross who typed the original drafts of this report.

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About the Development of a Second Generation Atmospheric Sampler Control and Data System: SCADS-2

1. INTRODUCTION

1.1 History

Air Force Cambridge Research Laboratories, (AFCRL) investigates the interface between geophysical science and Air Force operational requirements. Some upper atmosphere experiments are conducted via balloon-borne platforms. In 1971, AFCRL assumed operational responsibility from the Military Airlift Command (MAC) for the atmospheric sampling program, Project Ash Can. Equipment used in routine sampling missions was transferred from Detachment 31, 6th Weather Wing (MAC) to Detachment 1, AFCRL (AFSC) at Holloman AFB, New Mexico. The equipment was functional, and since key personnel transferred to Det 1, operations continued with an acceptable success rate. However, because project equipment had been designed or fabricated in the 1950's time frame, the funding agency, the Atomic Energy Commission (AEC) and its technical advisor organization, the National Oceanic and Atmospheric Administration (NOAA), requested that AFCRL design a second generation instrumentation system using the existing samplers and sensors.[1]

(Received for publication 14 March 1978)

1. Cordella, R.H., Jr., Capt (1974) A control and telemetry system for a balloon-borne air sampling package, Proceedings, Eighth AFCRL Scientific Balloon Symposium, 30 September to 3 October 1974, AFCRL-TR-74-0393, pp 451-476.

1.2 Theoretical Flight System

The system is depicted in Figure 1. This model benefits from insight gained during system development and includes desirable features not obvious from the beginning. It is a good starting place because it does apply to the original system and all developmental stages.

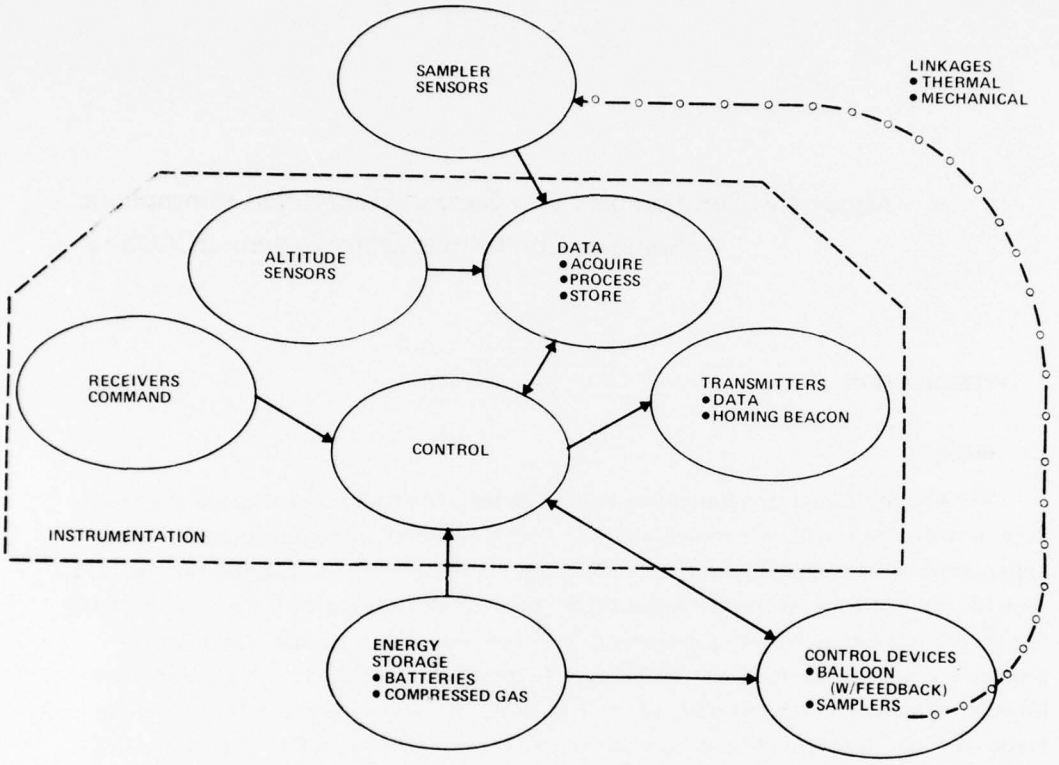


Figure 1. Theoretical Flight System

1.2.1 INSTRUMENTATION

The flight instrumentation is easily segmented into five subsystems associated with control, radio commands, altitude sensors, data, recorders, and transmitters. All controlling functions for the balloon and samplers either originate in the controller from internal time and altitude references, or pass through the controller if originated by a radio command. Some control functions are duplicated to provide flight safety. The command receivers are devices which, upon receipt of the proper

coded radio signal issued from the ground station, generate switch closures that force certain events to occur. Altitude sensors are electro-mechanical pressure sensors that are calibrated for altitude vs standard atmospheric pressure. They generate electrical signals which are transmitted to the ground station and provide information needed for flight control. The data subsystem acquires signals from the sensors, and processes them for recording and transmission. The transmitter radiates UHF or HF energy to move the various data to the ground station; the homing beacon provides a means to help an aircraft locate the instrumentation package.

1.2.2 ENERGY STORAGE

Batteries and compressed nitrogen serve as energy reservoirs for the instruments and samplers.

1.2.3 CONTROL DEVICES

Various devices must be activated to achieve mission objectives, that is, obtain samples and the required support data. These devices include: a helium gas release valve, a ballast valve, and electromechanical devices to activate and deactivate samplers. At the end of a mission, several operations are accomplished in sequence to terminate the flight and to secure the system when it impacts the ground.

1.3 Samplers and Sensors

These devices are the prime movers for the mission. Atmospheric constituents are gathered by various mechanisms; temperatures and flow rates are measured to compute the volume of air from which each sample was obtained.

1.3.1 SAMPLERS

The principal samplers are the air ejector sampler (AE), the Carbon-14 Sampler (C-14), and the Direct Flow Sampler (DFS). The first two are driven by nitrogen aspirators, the latter by a fan coupled to a d-c motor.

1.3.2 SENSORS

Altitude data are derived from primary and backup pressure sensors. Flow rate and temperature data are derived from PR-3 Flowmeter Sensors.

1.4 Original System

This system consists of two subsystems called "Primary" and "Backup" (see Figure B1). However, these terms are misleading because both systems had to operate properly to complete a routine mission. Primary instrumentation functions

are dropping ballast, energizing and deenergizing samplers, deploying the transmitting antenna, and terminating the balloon flight. Backup instrumentation functions are latching open the gas valve, cycling the gas valve, and terminating the mission. Note that only the termination function has redundancy. Timed functions are derived from a d-c chronometric motor driving a gear train. All logical functions are performed by relays and diodes.

1.5 Design Constraints

Succintly stated, the set of functions accomplished by the second generation equipment had to include all those provided by the first generation equipment, but the new system had to do them more accurately while using less power and having less weight. (In fact, other functions were added to improve the system.)

2. SYSTEM DEVELOPMENT

The original (1972) concept of instrumentation modernization was to introduce new equipment in three steps: Replace first, the control equipment, second, the data acquisition equipment, and finally, the equipment for backup control. The data processing ground station would be expanded and automated after the new balloon-borne data system was functional. The program began as described but was redirected because of manpower and operational constraints.*

Previewing the development period in very general terms by year shows that the latter part of 1972 and all 1973 were dedicated to implementing the new system concept in hardware. Year 1974 was spent refining the hardware and introducing software, checklists, and computer programs. Operational flight testing and software updating occupied 1975. Hardware, software, and documentation were finalized in 1976.

2.1 Year 1972

Initially, documentation for the existing system was reviewed. An overall system diagram was produced from drawings of individual cables and equipment. Subsequently, a prototype replacement controller was designed and fabricated.

---

*This report will discuss the developments in chronological order except in instances where describing the final resolution of the topic will result in a much clearer presentation. Also, significant changes necessary to maintain operational integrity of the original system will be documented in chronological order.

2.1.1 CONTROL CHANGES

Primarily, changes took place in two areas; control and control devices. The original "control unit" was replaced with a "controller" designed around digital logic; some redundancy in balloon control was added by modifying the original "backup timer" to facilitate redundant control at the lifting gas valve. A device which became known as the high current switch (HCS) was added to the control devices. This enabled the high motor current required by the Direct Flow Sampler (DFS) to be rerouted, thereby by-passing the control section. (At float altitude the current is between 10 and 27 A, a function of altitude and battery voltage; see Appendix C. The sampler starting current surge is about 100 A).

Comparing Figure B1, Original System Configuration, and Figure B2, Flight Test No. 1 Configuration, will help understand the changes. Two sub-systems which had been necessary for every flight were now joined to enable redundant gas-valve control. To accomplish this, a modification was added to the backup timer, but the basic timer remained an electro-mechanical device as was the control unit. Notice also that the original system dropped slugs (25 lb each) of ballast while the first reconfiguration (Figure B2) used a ballast hopper to permit either incremental pouring of ballast or dropping the entire 300-lb maximum load.

As in the original system, the controller remained the power distribution point for all primary instrumentation. Fuses were added to protect the system if a piece of support equipment should fail in a low resistance mode.

2.1.2 COMMAND RECEIVER CHANGE

Requirements for increased control capability necessitated expanding the command lines from the receiver. The original Raven command receiver/decoder[2] had six command channels (lines) of which five were used for antenna deploy, drop ballast, samplers on, samplers off, and primary flight termination (see Figure B1). Seven command lines are needed for the controller to execute those five plus two additional functions; pour ballast, and valve failsafe (see Figure B2). The Raven six-command receiver/decoder was replaced with a Zenith receiver and decoder which provided nine commands.[3,4] On Figure B2 and others where the Zenith

2. Instruction Book: Command Receiver/Decoder, Raven Industries, Inc., Box 1007, Sioux Falls, South Dakota 57101.

3. Handbook of Instructions for Dual Frequency Command Receiver BCR-4B, Developed for Air Force Cambridge Research Center, Air Research and Development Command, Bedford, MA 01731, under Contract No. F19650-67-0053, 15 March 1967. Manufactured by Military Division, Zenith Radio Corporation, 6501 West Grand Avenue, Chicago, Illinois 60635.

4. Final Engineering Report on Command Selector BCS-2A-3818, Prepared for Electronics Systems Division, AFCRL(AFSC), Laurence G. Hanscom Field, Bedford, MA under Contract No. AF19(628)-3818, 12 December 1964, Government and Special Products Division, Zenith Radio Corporation, 6501 West Grand Avenue, Chicago, Illinois 60635.

receiving equipment is shown with "tone reeds", these external reeds replace older, less reliable reeds that were located in the Zenith command decoder. Also, the Zenith Command receiver system has a feature which the Raven equipment does not possess; that is, prior to a command's being executed a reply code is generated which identifies the command channel selected for use. This code is transmitted to the ground station operator enabling him to verify the selection prior to command execution.

The Zenith receiver used with the backup system is slightly different than that used in the primary system. It has a single frequency front end, and, because it is not used with a command decoder, only three commands are available.[5] These commands do not have the reply confirmation feature because that capability is normally incorporated in the command selector.

2.1.3 TRANSMITTER CHANGE

A Zenith HF transmitter was added to the system to transmit the reply codes.[6] Litton's FM transmitter is modulated directly by the sensor outputs which are analog, audio range signals.[7]

2.1.4 DATA SYSTEM CHANGE

Figure B1 shows that in the original system configuration, data signals from the PR-3 Flowmeter System[8] and the B-60[9] altitude sensor went directly from the sensors to the FM transmitter. When the Zenith transmitter was added to accommodate the command replies, data from the B-34 altitude sensor,[10] which also generates a code in the form of ground closures, was routed through the controller to the Zenith transmitter.

2.1.5 FLIGHT (TEST) NO. 1, MISSION H72-72/H14X

With the modifications described in the preceeding four paragraphs accomplished, a test flight was launched on 2 November 1972 from the operation test site at Holloman AFB, New Mexico. Figure 2 shows the sampling package prior to launch The center equipment is a direct flow sampler (DFS) with a PR-3 flow sensor protected by a cage. Air enters at the bottom and is exhausted at the right side, through the PR-3 flowsensor output. The High Current Switch is mounted on the DFS above the flowsensor. The two insulated thermal packages to the left contain the batteries (bottom box) and the backup system (upper box); the thermal package on the right contains the primary instrumentation. Located between the instrumentation and the batteries is the ballast hopper, behind which is another direct flow sampler.

(Because of the large number of references cited above, they will not be listed here. See Reference Page 61 for References 5 through 11.)

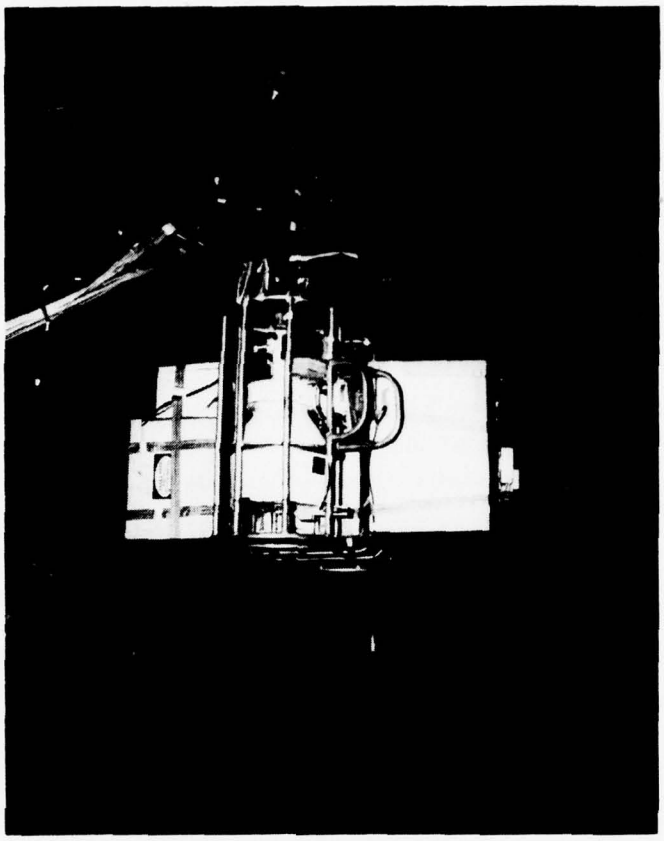


Figure 2. Flight Package, H72-73

Appendix A contains a complete list of the flights and the equipment used on each. The projected float altitude of 21.3 km (70 kft) was not reached because the flight was terminated on ascent at 14.3 km (47 kft). Although certain transmitted signals indicated termination due to balloon trouble, examination of the balloon revealed that certain processes had occurred which take place during a normal termination, and not usually during a balloon burst. Also, the prototype controller (sn 01) functioned correctly during post-flight tests so that a control malfunction could not be proven. However, reviewing the facts and schematics from today's vantage point indicated that the premature flight ending may have been caused by radio frequency interferences from the Litton data transmitter. This will be discussed at a later point.

As a test of the instrumentation, the flight was not a loss, because several important points surfaced. First, the initial High Current Switch, a mechanically latching relay, latched on at impact when the parachute returned the system to earth. No damage was done, but if the flight had been successful to that point, the sample would have been contaminated. Therefore, the relay was replaced with a solid state switch which will be discussed in Section 2.2.1. Second, personnel at the Balloon Operations Test Branch suggested that the controller be designed to de-energize the samplers at flight termination, before the ballast remaining on board is jettisoned, and to logically inhibit the reactivation of the samplers. Both of these suggestions have since been incorporated into the system instrumentation.

2.1.6 IN-USE EQUIPMENT

Since AFGL was responsible for the operational flights, it was deemed necessary to have a relatively complete set of balloon-borne and ground equipment at the laboratory in a configuration similar to that used in the field. Therefore, a portable cabinet was procured and fitted with equipment to duplicate the operational ground station.

2.2 Year 1973

Data acquisition enhancement was stressed during this period and with the exception of the flight-data recorder, prototypes of each piece of new equipment that were to be used in the follow-on system were flight tested. Accomplishments in the major system categories will be discussed below, and actions resulting from knowledge gained from one or more of the flight tests of March, July, and October will be noted.

A letter report was written in July to inform the AEC of the project's status, plans, and options. Parts of this report are included as Appendix D. Figures B2 through B5 cover test flight block diagrams. Detailed explanations of the encoder operation and control theory are included in Appendix D along with a comparison of the in-use and developmental system capabilities.

2.2.1 CONTROL CHANGES

Three major changes were made in the control system. As mentioned in Section 2.1.5, the first high current switch (HCS) was replaced by a solid state design using a silicon controlled rectifier (SCR). The first model was built around a "DC Static Switch" by General Electric Co.[11] Although it worked in the laboratory it failed to turn off reliably under simulated flight conditions; prior to the March flight it was modified. The modified switch configuration was subsequently abandoned

11. G. E. Silicon Controlled Rectifier Manual, edited by F. W. Gutzwiller, prepared for General Electric Company, 3800 North Milwaukee Avenue, Chicago, Illinois 60641, 1967, pp 153-155.

after the July flight, and the switch was reconfigured around the basic circuit shown with solid lines in Figure 3. (Circuit components such as those for gate protection and connectors are omitted for clarity.) The SCR turns the blower motor on, and the relay turns the motor off by interrupting the current, thereby allowing the SCR to turn off when sufficient time has elapsed to let the junction cool. This application of the relay was deemed acceptable based on information available in Reference 12 and discussions with an applications engineer. (Initially this circuit also included another SCR and a 1-Ω series resistor as shown in Figure 3). Terminal ON-1 was pulsed first, then 2 sec later, ON-2 was pulsed. Subsequently, in this way the startup current was limited to about 25 amperes. Calculations showed that the SCR (Motorola type MCR 3935-2) and the relay were capable of sustaining the initial surge current; the components shown by dashed lines were eliminated.

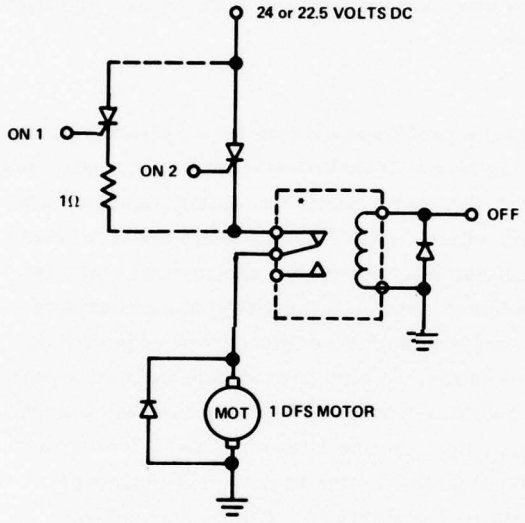


Figure 3. Basic High Current Switch Schematic

The second control change was the inclusion of "impact" switches located on the bottom of the payload system, and having the arming circuit located in the primary controller. This subsystem releases the parachute from the payload upon ground impact. The standard configuration was to fly an in-line switch between the payload and the parachute (see Figure 2). This type of switch depended upon

12. H-G Relay Engineering Manual, Document No. REM-1164, by Hi-G Incorporated, Windsor Locks, CO 06096, 1964, pp 6, 7, and 11.

the tension in the parachute line relaxing before half of the parachute risers could be released. Therefore, in windy conditions, when the circuit action is most needed, the switch is most likely to fail. The replacement impact switch circuit depends only upon momentary pressure at impact to complete a circuit which causes the parachute to be released. This circuit is armed only if the system passes both up and down through a pre-set altitude [usually 3 km (10,000 ft)]. This circuit has functioned properly on each flight since it was included in the system.

The third change was a mechanical reconfiguration of the controller. Serial No. 01 was difficult to work on because of its mechanical makeup. Also, it had several large relays on circuit boards designed to be fabricated in a printed wire mode. Serial No. 02, which was used for the three 1973 flights, had all circuitry on the case "cover." Therefore, when the unit was opened, the chassis and associated wiring were removed from the case. Two circuit boards held the logic and miniature interface relays (TO-5 type enclosure) while the larger relays were mounted on the chassis. This technique was carried through to the final controller configuration (Serial Nos. 03 and above).

2.2.2 TRANSMITTER CHANGES

When the data encoder was added to the prototype system (see Section 2.2.3) it eliminated the need for the Litton SS/T-14 FM transmitter, the four commutated inputs of which were tailored to the PR-3 flowmeter sensor's analog signals. The encoder's output was a closure to ground which, as previously mentioned, worked well with the Zenith Command reply transmitter. However, the natural noise immunity of an FM signal would greatly enhance automatic decoding and printing of data by the ground station. Therefore, a 700-Hz tone oscillator was added to the controller (where it could be interrupted easily, to also provide the indication when radio commands were received) and provisions were made for the encoder output to pulse the tone into an FM transmitter. Because the Litton SS/T-14 data transmitters were nearing the end of their servicable life due to non-availability of replacement parts, a follow-on transmitter, the FMT-1A, was procured from Viable Systems, Inc. The FM transmitter used on Flight (Test) Nos. 3 and 4 was the Viable prototype; the FMT-1.[13]

2.2.3 DATA SYSTEM CHANGES

Flight (Test) No. 1 (Section 2.1.5) in 1972 used basically the original data system. Flights in 1973 introduced and proved the data encoder. Built around a frequency-sensitive analog-to-digital converter, the encoder presented the data words as a serial bit stream which corresponds to Morse Code characters. The eleven data

13. Instruction Manual for Model FMT-1A FM Transmitter, AFCRL Contract No. F19650-74-C-0407, May 1974, Viable Systems, Incorporated, 299 Second Avenue, Needham Heights, MA 02194.

channels, which were buffered for specific inputs, included two for the B-60 altitude sensor (one for high altitude, one for low altitude); one for monitoring housekeeping functions—valve, ballast, burst switch status; and eight for monitoring four PR-3 flow sensors (flow rate and temperature). The three developmental flights described in the following paragraphs used the above encoder format (see Figures B3, B4, and B5) for flight configurations.

The encoder on Flight (Test) No. 2 monitored one PR-3 flow sensor flow rate, and two backup altitude sensors with voltage outputs. The voltages were converted to variable frequences before they were routed into two unused flow sensor channels. These sensors provided data at altitudes from ground to float and were justification for discarding the original altitude sensor/transmitter (B-34). Sensor temperature was not monitored by the encoder but was recorded by the PR-3 flowmeter system as usual. The physical flight configuration was virtually identical to the first flight (see Figure 2). Unfortunately, a battery problem precluded gathering any flow data but the remainder of the system worked properly.

Flight (Test) No. 3 was very similar to No. 2 except that the flow sensor temperature was monitored by the encoder. Also, a PR-3 system was flown in a electrically independent mode to monitor the same outlet port as the PR-3 sensor monitored by the encoder. The volume of air passing through both of these two serially connected sensors (see Figure 4) was calculated independently. The two calculations agreed within 2.6 percent; well within the accuracy of the systems.

Flight (Test) No. 4 (H73-73/H32) was a milestone in this system's development. Because of the success of the previous flight and the attractiveness of saving operational funds, this test was combined with an operational flight requiring two direct flow samplers (DFS) and two Carbon 14 samplers. The two DFS's required three PR-3 flow sensors (two on outlets and one on an inlet); the C-14's required one sensor each. Since encoder sn01 could accommodate four PR-3 sensors and five were required, one was monitored by the standard PR-3 electronics/recorder. This flight configuration necessitated eliminating the back-up altitude sensors; and, since only the sensor part of the PR-3 system was used in five of the flow measurements, onboard recording was virtually eliminated. All flight data were acceptable; this was the prototype system's first success.

This flight configuration was consistent with the instrumentation configuration planned by AFGL, that is, the backup altitude sensors were to be eliminated and a digital recorder was to be added when it was available. However, the AEC advised us that redundant altitude data was mandatory at least at float altitude. Therefore, a backup altitude sensor was subsequently reinstated.

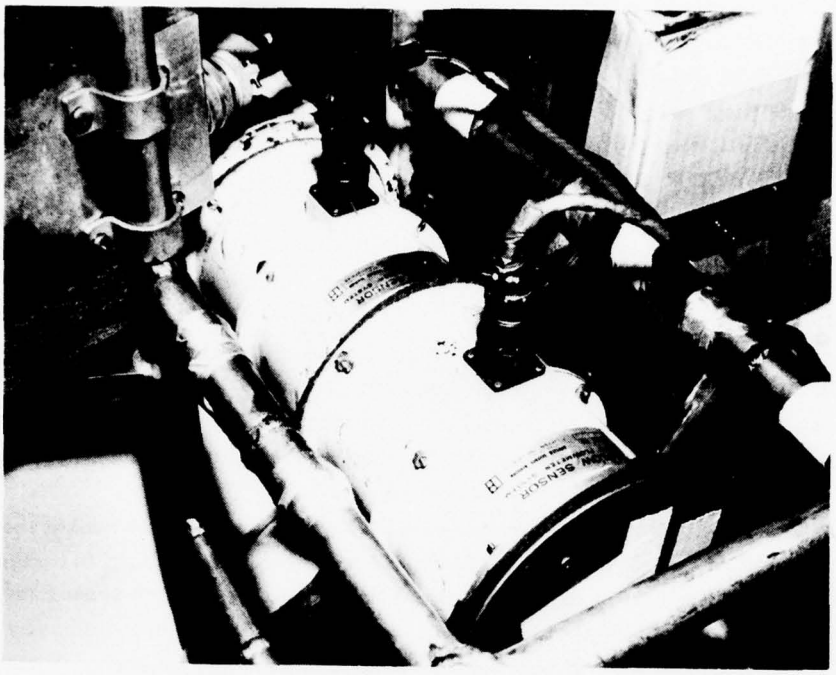


Figure 4. Flow Sensors, H73-50/H-28X

2.2.4 THE GROUND STATION

Originally, at the ground station in the control center, analog signals were retrieved by an analog method and the results were logged by hand. As shown in Figure 5a, the receiver's audio output signal was routed to two areas for processing of two data types; altitude and flow rate. The altitude channel was monitored by a counter through a Schmitt trigger which detected the envelope of a pulsed 3000 Hz signal generated in the B-60 altitude sensor reference. Flow rate data was displayed as a Lissajous figure on an oscilloscope using frequency from an audio oscillator; the frequency which stabilized the Lissajous "circle" was recorded. This method kept the operator rather busy.

The developmental system transmitted digital words which were to be recorded (printed) automatically by the ground station; a forerunner of the automatic ground station was employed with the introduction of the Viable transmitter (see Figure 5b). The receiver 700-Hz audio tone was applied to a phase locked loop filter which reclaimed the dot or dash from the signal envelope. This serial message was recorded by a strip chart recorder providing a permanent record of the flight; reply

codes from the Zenith transmitters were also recorded. This method of obtaining a hard copy of the data was used until the middle of 1975 when the automatic printing ground station was introduced.

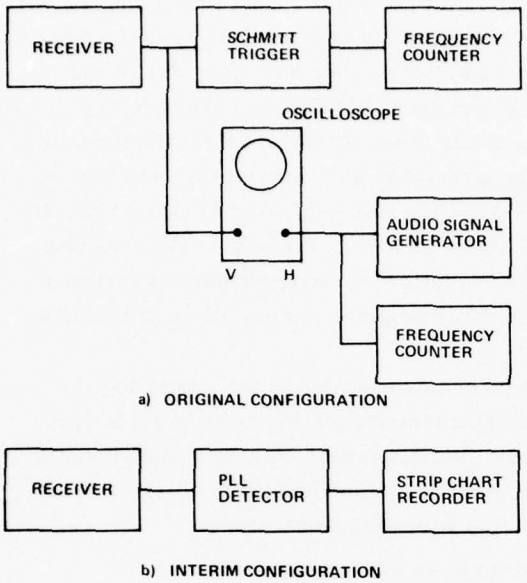


Figure 5. Ground Station Configuration

2.2.5 FLIGHT (TEST) NOS. 2, 3, and 4

Flight No. H73-19/H19, the second test, successfully demonstrated the altitude monitoring capability of the encoder but, because of a bad battery, failed to monitor flow rate when the DFS did not operate properly. The controller performed properly.

The third test, H73-50/H28X, gathered a sample and support data and performed the volume checking experiment described earlier. However, after the sample period was over and the samplers were de-energized, the emergency sampler deactivation circuit failed a test and the sample was contaminated.

Test flight, H73-73/H-32, the fourth test, was successful in gathering a sampler and support data but the samplers de-energized prematurely when a cable carrying current to the DFS's failed. Luckily, the sample was just within the minimum collection time. A spinoff from this accident was a reconfigured battery container providing rigidity to protect the batteries, ample room for air circulation, and a connector so cables would not have to be attached directly to the battery terminals.

2.2.6 IN-USE EQUIPMENT

During the early part of the year, time was spent researching possible sources for an altitude sensor equal to or exceeding the B-60 in range and accuracy. A

proposal by L'Garde, Inc. of Newport Beach, California, initially appeared interesting. Their theoretical sensor used an isotope of americium with a silicon detector but, after detailed calculations by the vendor, the specifications were modified out of our range of interest. A satisfactory replacement was not located but the need was kept in mind as technical literature was read (see Reference 19).

An endeavor begun that year, which was rapidly to bear fruit, was the design and fabrication of a new gondola for the sampling equipment. The author and Mr. Charles Mitropoulos, a mechanical-engineer from AFGL/SU, assembled specifications and Mr. Mitropoulos designed a gondola to accommodate the samplers, instrumentation, battery boxes, ballast hoppers, and gas containers. After several stages of redesign, a dozen gondolas (dubbed the SAVE-3, for SAmpling VEhicle) were procured through the facilities of NOAA in 1976. These gondolas are now used with the original system as well as the follow-on instrumentation systems because they are much more efficient than the original system for assembling a flight system.

As noted earlier, the SS/T-14 FM transmitters were at the end of their economically useful lives. Therefore, replacements were sought and later procured from Viable Systems, Inc. To use the transmitter with both systems, the commutating capability of the T-14 was duplicated in a separate unit (signal conditioner, SC-2) that was supplied by Viable with the transmitters.

2.2.7 INSTRUMENTATION COMPARISON BY WEIGHT

Since every pound of equipment must be buoyed by the helium in the balloon, extra weight is rapidly converted into dollars for larger balloons. Also, interest in atmospheric sampling was increasing and any weight saved could be applied to other experiments as well. Table 1 lists equipment weights and shows in the totals that the new instrumentation was lighter than the in-use instrumentation. The weight advantage grows with the make of PR-3 sensors required because only the sensor is added to the system, whereas the existing system needed an additional recorder/electronics package for each additive PR-3. Therefore, the weight design critera of Section 1.5 has been met.

Table 1. Comparison of Primary Instrumentation Weights Without Cables*

Item	Weight (lb)	
	In-Use System	Proposed system
Thermal Bag	6	
Shock Absorbent	5	
Frame, Instrumentation		7.5
Thermal Box		10.2
Control Unit	9	7.0
Receiving System	6	6.0
Transmitter: T-14	5	---
FMT-1	-	2.0 (max)
B-60	2.7	2.7
B-34	4.0	---
Rosemount & Converter	---	1.5
Encoder	---	2.6
PR-3 Recorder (No. 1)	9.0	---
Data Printer	---	2.0 (max)
PR-3 Sensor (No. 1)	2.0	2.0
Subtotal	48.7	43.5
PR-3 System (No. 2)	59.7	45.5
PR-3 System (No. 3)	70.7	47.5
PR-3 System (No. 4)	81.7	49.5
PR-3 System (No. 5)	92.7	51.5
PR-3 System (No. 6)	103.7	53.5

*In-use system cables weigh more than proposed system cables.

2.3 Year 1974

Tests in 1973 confirmed the model in Figure 1 (from which the final systems in Figures B6 through B8 were derived).

Commencing in 1974, SAVE-3 gondolas were used and evaluated. Figure 6 is a picture of the flight payload for H74-27/H-41X which used this gondola. A direct flow sampler, and a Carbon-14 sampler (at right) are mounted on the gondola exterior; the interior contains (starting at the top) primary instrumentation, batteries, backup instrumentation, and a ballast hopper. To the left of the ballast hopper (the inverted pyramid) is the antenna deploy device (parachute). Impact switches are on four corners of the shock-absorbing pad.

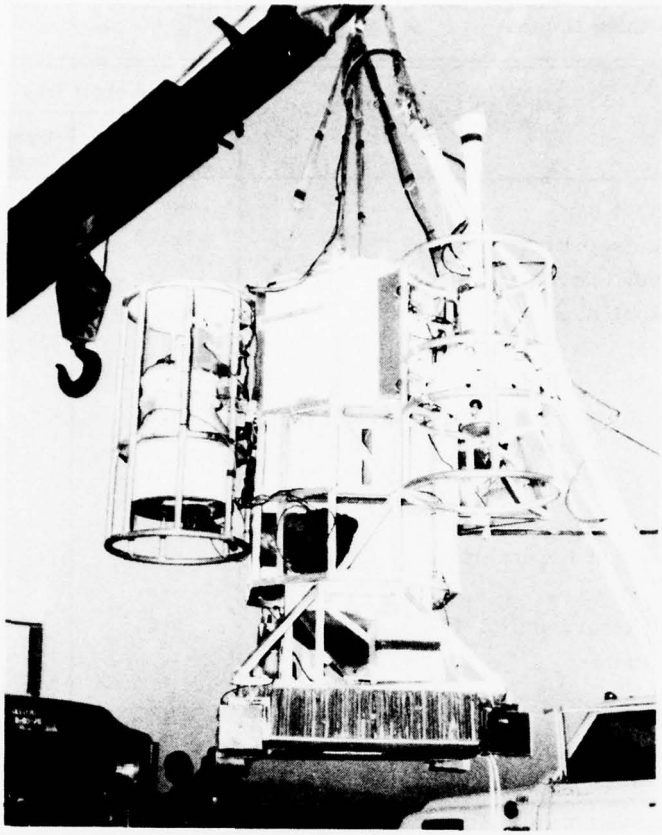


Figure 6. Flight Package, H74-27/H-41X

The primary instrumentation was repackaged to fit the SAVE-3 gondola. Originally in a 58.4 × 56.9 × 35.6 cm (23 × 22 × 14 in.) frame carried outboard in a thermal insulation box with 2-in. walls, the new version used a 41.9 × 41.9 × 39.4 cm (16-1/2 × 16-1/2 × 15-1/2 in.) frame (see Figure 7) in a similar thermal insulation box which was set into the uppermost section of the gondola. When the PR-3 recorder units were discarded for the encoder and central data printer, a reduction in volume was accomplished.

The equipment placement in this primary instrumentation configuration was used for the three tests in July 1974. During that initial flight series for the SAVE-3, it was discovered that the connectors on the exterior of the primary instrumentation fell behind the gondola stanchions or samplers. Thereafter, a mirror-image instrumentation configuration was used which placed the connectors

at sections of the gondola which were always easily accessible. Figure 8b represents the final equipment layout.

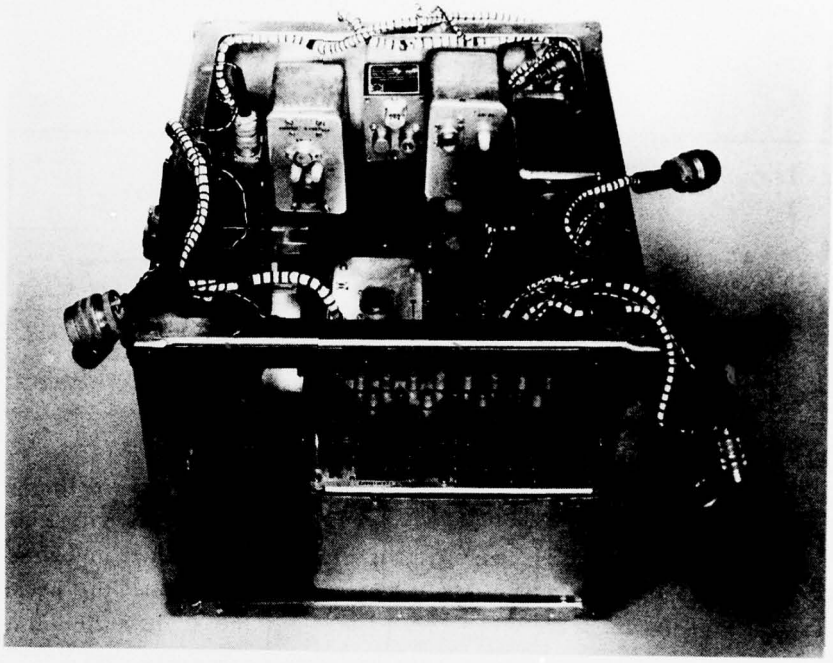


Figure 7. Primary Instrumentation

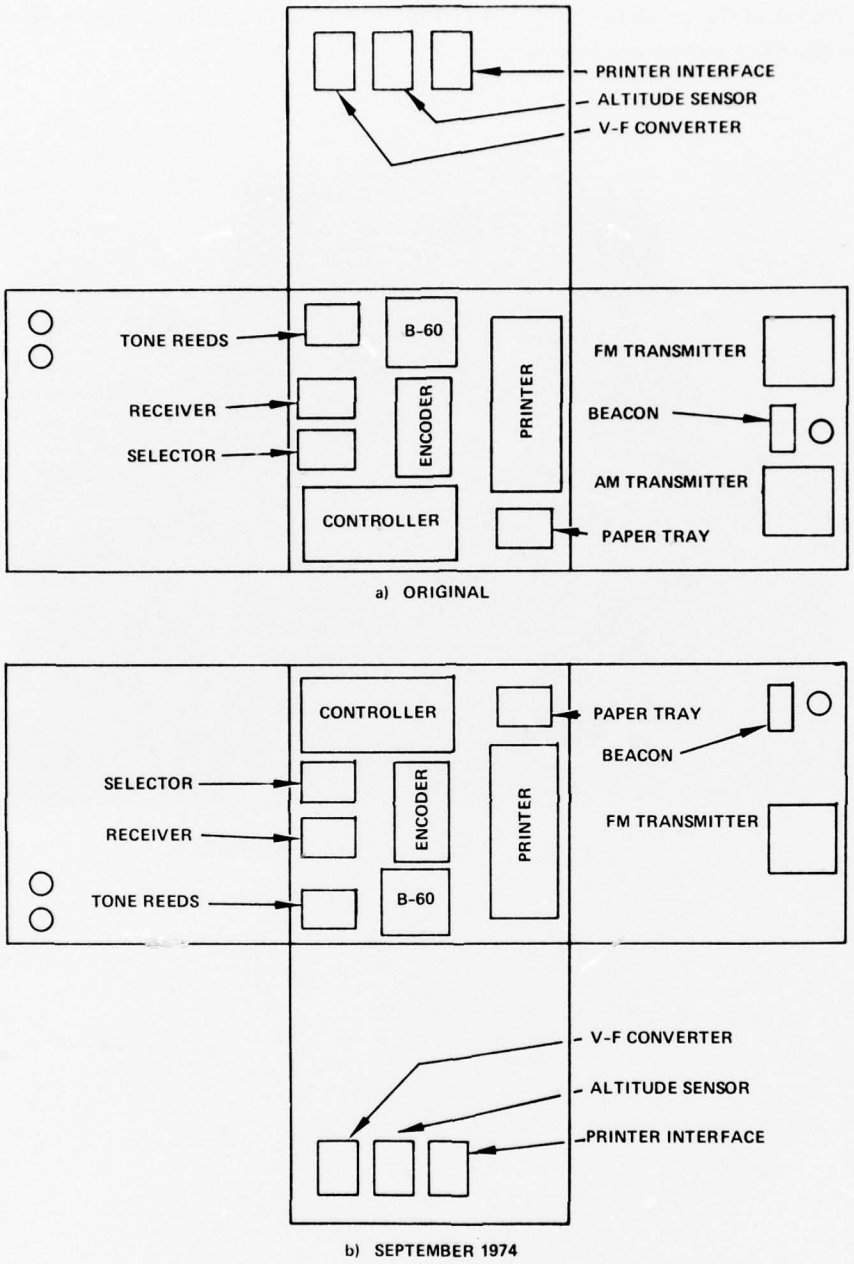


Figure 8. Primary Instrumentation Layout

2.3.1 CONTROL CHANGES

The primary controller was reconfigured into its present package and its connectors were reduced from six to five (see Figure 9). This change simplified construction and testing because the wires were grouped functionally. It also facilitated the implementation of a simple connector-numbering system. Each cable type was assigned a prefix number (0 through 10); 0, RFI filters; 1, primary system power; 2, command receiver; 3, control; 4, data; 5, data transmitter; 6, system interface; 7, backup instrumentation; 8, DFS, DFS cables; 9, DFS battery cable; 10, existing flight equipment. For example, the digit 4 represents data system connectors or cables in or on the primary frame, that is, J40 on the controller to J415; there are 16 connectors. See the project handbook[14] for drawings, parts numbers, etc.

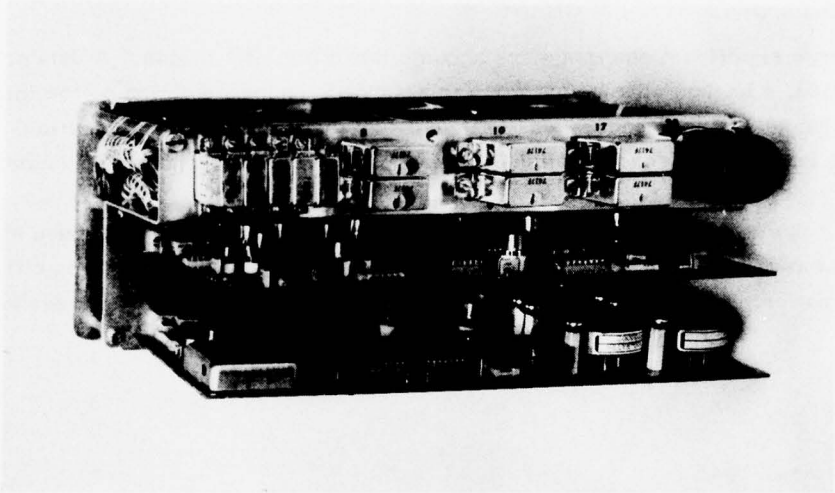


Figure 9. Primary Controller

In July the original backup control unit with gas valve modification was replaced with a solid state crystal clocked controller. Compare figures B6 and B7. Notice that the ballast hopper control functions are now redundant; and the gas valve latch-open function has been dropped because each controller does it automatically at termination. The three backup controller commands are ballast pour, gas valve failsafe, and termination (see Figure 10).

14. Cordella, R.H., Jr., Capt (1977) Project Ash Can Atmospheric Sampling Handbook, Volume II, Instrumentation: SCADS-2, AFGL, Aerospace Instrumentation Division, Hanscom AFB, MA 01731.

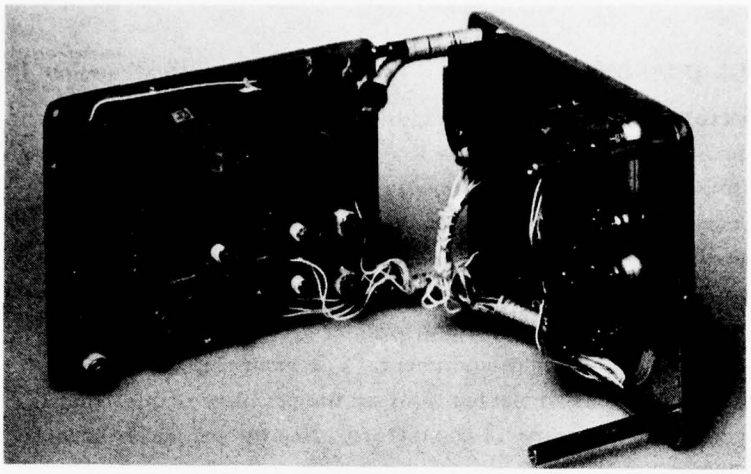


Figure 10.
Backup Controller

2.3.2 DATA SYSTEM CHANGES

Three significant changes were accomplished for 1974 flights. A data printer was added, a backup altitude sensor was returned, and information on the initial three channels of the encoder was changed. To facilitate wiring and testing, the chassis cables were reaccomplished to reduce the external control connector count to one.

The printer (Figure 11) described in Reference 15 was chosen because at that time it was the only lightweight device, less than 746 g (2 lb) operable on either a-c or d-c power. This feature facilitated its use on both ground and flight systems.

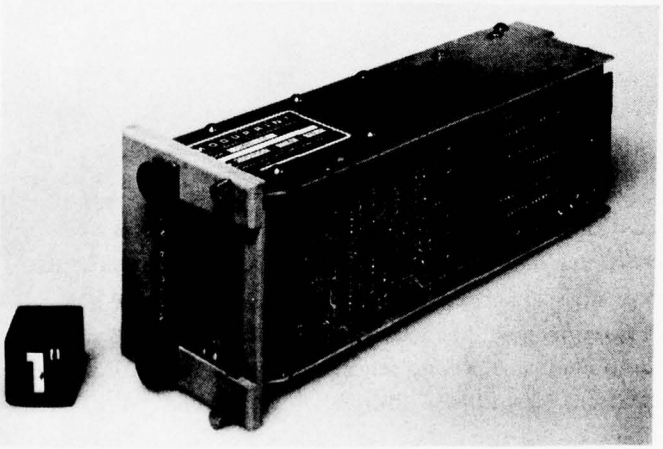


Figure 11. Data Printer

15. Instruction Manual: Model No. CMMP-6A, July 1973, Practical Automation Inc., Trapp Falls Road, Shelton, CO 06484.

The internal printer functions are accomplished by transistor-transistor logic (TTL); an interface provides the regulated voltage and buffers to change voltage levels (CMOS to TTL). At 3-min intervals, a time-code generator produces a 2-digit decimal number which is printed with every data word. This time count is derived from the controller signal which initiates the encoder message, and is referenced to the time when power was applied to the system prior to launch. All data produced by the encoder is hardcopy printed. The word format corresponds to that used by the ground station and the data backup dictionaries. (The dictionaries will be discussed at the end of this section.)

Provision of two methods of obtaining altitude data at the float altitude was a firm requirement. Accordingly, a channel was devoted to monitoring the backup sensor through a voltage-to-frequency converter (see Section 2.2.3). The decision was made to keep the encoder size constant by placing all B-60 altitude data on Channel 1 and maintain the 15 data channel format consistent with the available logic packages. Condensing the B-60 altitude sensor data on one channel necessitated rescaling the constant used in the signal multiplication.[1] Maximum altitude for routine flights was between 18.3 km and 27.4 km (60 to 90 kft) but a requirement exists to reach 36.6 km (120 kft), therefore, an option was included in the encoder to select one of two scaling frequencies based on the float altitude. As in all compromises, you never get something for nothing. Placing all the primary altitude data on one channel cost resolution at the lower altitudes.

Theoretical encoder primary altitude resolution (Table 2) is extracted from unpublished calculations of January 1978. Since the balloon ascends at about 305 m/sec (1 kft/min) this resolution is acceptable. The upper limit of the normal range is about 33 km (106 kft); the extended range is about 42 km (136 kft). This altitude will vary slightly between units because they are not identical.

The encoder format has been finalized as follows: Channel 1, B-60 sensor altitude; 2, housekeeping; 3, backup altitude; 4, 6, 8, 10, 12, 14 flow rate; 5, 7, 9, 11, 13, 15 temperature. The latter 12 channels (channels 4 through 15) are grouped in two's to accommodate six PR-3 flow sensors. A dictionary is used for all channels except channel 2, housekeeping, which has only four possible code options to indicate actuation of the gas valve, ballast hopper, or parachute open indicating switch. See Section 2.2.3.

Data words are based on a twelve bit binary counter; therefore, there are 4096 states or combinations which must be correlated to the actual parameters: flow rate, temperature, and altitude. Dictionaries produced on a CDC 6600 computer accomplish this correlation. These programs were produced in collaboration with Peter L. Miller, Capt, USAF. He wrote the programs after the author presented a rough outline of what they were to do and the sensor characteristics. The programs, their inputs, and their ouputs are explained in Appendices F through I

Table 2. Theoretical Encoder Resolution

Altitude		Range		
		Normal	Extended	
kft	(km)	Resolution:	ft	(m)
10	(3.0)	184 (56)	588	(179)
20	(6.1)	260 (79)	833	(254)
30	(9.1)	260 (79)	833	(254)
40	(12.2)	216 (66)	689	(210)
50	(15.2)	170 (52)	543	(166)
60	(18.3)	125 (38)	403	(123)
70	(21.3)	91 (28)	292	(89)
80	(24.4)	64 (20)	207	(63)
90	(27.4)	45 (14)	145	(44)
100	(30.5)	31 (9)	101	(31)
110	(33.5)		75	(23)
120	(36.6)		54	(16)
130	(39.6)		40	(12)
140	(42.7)		31	(9)

2.3.3 TRANSMITTER SECTION CHANGES

The quality of the received signal from the 40 MHz transmitter had been marginal since the beginning of the equipment updating. Various components in the signal path were analyzed and the transmitting antenna was determined to have the wrong impedance. Although the radiating element was the proper length, the matching transformer and stub dimensions could not be verified. Therefore, the original antenna (designated by an S in the transmitter column of Appendix A) was replaced with a modified dipole (D1). When the FMT-1A transmitters were used, signal strength again became unacceptable so a second modified dipole was designed, tested, and implemented in October. This antenna was used for just over one year when it was replaced with a modified Zepp (Z) antenna[16] to facilitate automatic deployment. Mr. Hans Laping AFGL/LCC designed the Zepp antenna.

2.3.4 TEST FLIGHTS

The eight flight tests in 1974 will be grouped according to the time frame of the experiments for the following discussion. Appendix A lists the equipment for each flight.

16. The ARRL Antenna Book, published by the American Radio Relay League, Inc., Newington, CO, 1974, pp 108, 109, and 116.

2.3.4.1 Tests 5, 6, and 7; June

On test 5, H74-27/H-41X, the HF antenna did not deploy because one squib in the antenna parachute failed to cut the nylon line. At 6.4 km (21 kft), with the balloon ascending at about 305 m (1000 ft) per min, the encoder readout was expanded from 3 to 15 channels. The encoder data format was correct but no temperature data were present on the appropriate odd numbered channels. One hr and 16 min into the flight the samplers were turned on by command and flow data commenced on the appropriate even numbered channels. The received signal was clear but the data were very noise and within 21 min a high noise level obscured all data; the noise produced random counts on the temperature channels. This condition continued for approximately 1 hr at which time the samplers were commanded off; the noise then stopped. The samplers were restarted and the noise did not reappear. Late in the flight there were still no temperature data from the samplers; however, the thermistor located within the encoder did yield apparently valid data. After a 4-hr sample period, the samplers were turned off via command and the flight was then terminated. The termination, descent, and impact were all normal and there was little damage to the SAVE-2 gondola or the samplers.

The noise in the data was initially attributed to, first, the failure of the antenna to deploy from the chute causing a severe mismatch at the transmitter output section. The mismatch resulted in an abnormally high RF field in the vicinity of the instrument system that could easily couple into the system sensor input leads. The noise during the middle of the sample period was most likely due to brush arcing in the motor which was interrupted when the motor was shut off and then failed to return when the motor was restarted.

Although the sensor data was not of sufficient quality to merit processing, a usable sample was obtained and other capabilities of the new system were further tested. The High Current Switch was successfully cycled twice during the mission. The capability to turn the samplers off provides an important option if the balloon should move out of the sampling altitude envelope. The data were clearly received by the receiver and recorded on a strip chart by a phase lock loop (PLL) detector.

An effort was made to duplicate the noise problem on a tethered flight; H74-32. The prototype instrumentation was placed in a standard thermal package and set into the upper section of the flight gondola. The whole gondola and samplers were not flown because of weight restrictions and the necessity to keep the package several wave lengths away from the steel tethering cables. (These cables would have to be brought in closer to the package if a heavier weight were to be suspended.)

The balloon was positioned at an altitude of 600 ft; the instrumentation package was configured with the power and data cables flown on H74-27. The battery box was placed on top of the instrumentation package and DFS flow sensors were positioned

on the gondola to approximate their flight locations. The flight data cable was used. The HF antenna was placed on the gondola as low as possible on the same side it occupied during the free flight. The VHF-FM antenna was placed as it was on the free flight and remained that way throughout the test.

The system was tested in four modes: (1) both transmitters on, with the HF antenna rolled up and in the chute; (2) both transmitters on, and the HF antenna deployed; (3) the HF transmitter off and its antenna removed while the FM transmitter was on; and, (4) the data cable was changed from the flight cable to a cable of identical dimensions but using twisted pairs for each fan or thermistor with the FM transmitter energized. These four test configurations were observed over a period of about 2 hrs; data were recorded on a Gould chart recorder through a phase locked loop (PLL) detector. The data were excellent at all times. The malfunction which occurred during the flight could not be duplicated.

It was decided to refly a configuration similar to that of H74-27. Flight H74-36/H-42X had another DFS with another two PR-3 sensors and only the 40.35 MHz FM transmitter was used. The flight was successfully launched at 1346 Z hr after a flawless checkout and a short hold for surface winds. Altitude data from the B-60 were excellent. At about 14 km (46 kft) the Rosemount back-up altitude data began and was in excellent agreement with the B-50 sensor until the balloon rose out of the range of the back-up sensor. This flight was to 27.4 km (90 kft) and the sensor was chosen and calibrated for the previous flight which was only to 19.5 km (64 kft). At 1406 Z hr the balloon was at about 7.6 km (25 kft) and the encoder message was expanded to 15 channels. The data were excellent, giving a clear indication of the interior and exterior sampler and package temperatures. (The interior package temperature data corresponds very well with the data gathered on the latter portion of flight H74-27.) The gas valve was opened at 1458 Z hr for 4-1/2 min to slow the ascent rate and, although it is not recorded on the Encoder Log, the data was obscured by a steady tone for 63 seconds. This tone was recorded through the PLL onto a strip chart recorder and was discovered during the review of the flight records. It is the warning indication that the flight had been terminated by the burst-pin signal; however, the flight continued. Data were excellent but the samplers could not be started by timer or command. At termination, the package did not respond to the command via the primary system and the backup controller had to be used. The package was returned without power interruption, and the commands were "issued" using the command simulator and test box. The results duplicated the situation in flight; the samplers were unable to be activated, and command 9 (flight termination) was inoperative. Inspection revealed that the squib to release the Carbon-14 sampler gas was detonated as were the squibs for blow ballast. These events along with the 63-sec tone at 1458 Z hr indicated that a signal on the burst line had tried to terminate the flight. However, fuses for the

primary separation squib were blown and had prevented that squib from firing. It is believed that these fuses were not checked prior to launch, and had actually blown during the tethered test. The cause of the activation of the burst circuit was traced to a marginally protected logic gate input which connects directly to the burst switch. The activation of the valve motor caused an electromagnetic field in the parachute cable which coupled into this line and induced more than 100-μA current necessary to trigger the logic. This circuit was desensitized to preclude a reoccurrence of this failure and similar gating equipment schematics were searched for similar oversights to prevent a related failure. This circuit was virtually identical to that used in Flight (Test) No. 1, Mission H72-73.

Besides uncovering a weak point in thehardware, the June flights pointed out the need for an extremely thorough checklist to assure the functional integrity of each unit before and after being integrated into the system. Appendix E is the latest Instrumentation Checklist. I use the term latest because the checklist is constantly evolving and adapting to the people who prepare the system for operational use. However, good testing practice is maintained throughout the sequence by beginning at the simplest level of each piece of equipment, setting the variables (usually times) as they are needed, and not disturbing the subsystem once they are checked.

2.3.4.2 Tests 8, 9, and 10; October/November

Circuits were redesigned to preclude the reoccurrence of the problems encountered in June. A tethered balloon test preceded the next free flight to detect any flaw which had been overlooked. Test 8, Mission H74-55/H47X, placed the flight system in a good approximation of the electromagnetic environment it sees during a routine flight. The system consisted of the primary and back-up instrumentation and their batteries, the samplers and DFS batteries, a parachute cable, a simulated balloon cable, and an EV-13 gas valve. A standard 40.35 MHz antenna was used. This system was assembled in the gondola and suspended from a balloon tethered with non-conductive cables so the transmitting antenna was about 550 ft above the ground to approximate the free space radiation patterns. The pre-flight checklist for operational flights was used during this test.

A most significant piece of information was uncovered during this test. The wire which carries the signal from the burst monitor switch on the parachute is in series with a barometrically operated switch that closes at approximately 3 km (10 kft). Since the tethered system would remain below 1.5 km (5 kft) this switch was by-passed. The encoder and primary controller monitor the switch position and, when the order of applying power before closing the switch was exchanged, an erroneous interaction was noted. The erroneous interaction has been permanently removed by the addition of two steering diodes which permit current to flow only to ground through the burst pin switch and not between the two units. This test fulfilled

its objectives when it uncovered this circuit deficiency. It also demonstrated that radio commands could be utilized during a balloon flight without jeopardizing the sample collection mission, and it developed a data base for comparison of the transmitted and recorded data. In these data, the PR-3 flow sensor temperature was excellent but the flow rate was erratic. A second tethered mission was planned to further examine the system.

Test 9, H74-56/H-48X, equipment was configured as in Test 8. All data were recorded through the phase locked loop (PPL) tone detector and recorded on a strip chart recorder. The valve was cycled numerous times to insure that the current for the motor did not interfere with the burst pin switch circuitry as in flight H74-35/H-42X.

The data revealed that the flow rate sensor monitoring circuitry did not act properly. The complete primary instrumentation with the same data cable used in the flight was set up in the site laboratory and checked using the "Calibration Unit for PR-3 Flowmeter System" manufactured by (Litton) Applied Science.[17] The encoder circuit to eliminate the effect of the PR-3 relay contact bounce was inadequate; it was improved by changing the RC time constants while keeping the same circuit topology. (This check and subsequent correction was accomplished in the field because there were no "Calibration Units" at the headquarters in Massachusetts.)

Since the equipment performed satisfactorily on the two tethered tests and the flow rate monitoring circuit had been improved, a test under operational sampling conditions was in order. Test 10, mission H74-51/H-53X, was launched on 5 November. The equipment was that used on the tethered tests with the exception of the 40.35 MHz antenna which was a new quarter wave dipole. It is noted by D2 in the transmitter column of Appendix A. Changing from the standard antenna to this dipole marks the removal of the last piece of "standard" equipment; with one minor addition in 1976, the system was now SCADS-2.

Prelaunch checks were accomplished according to the Instrumentation Checklist. The actual launch was smooth and the flight continued uneventfully with all equipment functioning properly; the samplers were turned on and off by the system timer. After the data confirmed that all the samplers were off, the valve failsafe and pour ballast commands were issued and verified to confirm that these operations would not adversely affect the balloon flight through an unforeseen interaction. Shortly after these commands were completed, the flight was terminated by command on the primary instrumentation system.

The excellent quality of the recorded and transmitted data resulted in a sizeable data base to examine. Two aspects of the data were checked. First, accuracy;

17. Development and Calibration of the PR-3 Flowmeter, ASD Report No. 2723 by R.C. Wood, L.R. Graf, L.V. Nelson, Applied Science Division of Litton Systems, Inc., August 1965, page 8.

that is, it must be suitably close to the "real" value of the parameter being measured. Second, precision; that is, the datum points should be closely grouped. The requirements were checked using the transmitted data as recorded on the Gould Inc. strip chart recorder through the 720 Hz phase locked loop (PLL) tone decoder. The data were compiled and then processed using a Hewlett-Packard 9810A calculator with Statistics Block 11214A. The results in Hertz for 60 datum points are tabulated in Table 3; they indicated that there was something wrong with the data on the inlet flow channel. At the time it was assumed that the trouble was in the inlet PR-3 reed because both flow data channels were checked with the Litton calibration device and both channels were always within one count of the correct value. However, subsequent flights showed that this was not the case; it will be discussed later. Even though one flow rate channel produced data with an unusually large standard deviation, the flight was a success because it secured a valid sample and support data.

Table 3. Flow Rate Sensor Data: Test 10

Sensor Location	Inlet	Outlet
Units	Hertz	Hertz
Mode	59.75	58.75
Median	59.88	59.00
Mean	64.88	59.00
Variance	136.9	0.6112
Standard Deviation	13.30	0.7818

2.3.4.3 Tests 11 and 12; December

These tests were conducted to assure that the prototype equipment was functioning as expected. Tracing the equipment by serial number in Appendix A shows that the same units were being used; any changes were incorporated into the existing circuit boards or chassis. Test 11, Mission H74-65/H-54X went very smoothly in the command and control sections but the flow rate data was not satisfactory. The spread of each channel's data is a little wide, especially the inlet data. The Hewlett-Packard 9810A with Statistics Block 11214A was used to compile the statistics in Table 4 for over 70 datum points.

The standard deviation of the inlet flow rate data was not too good; yet, the encoder data channels checked out perfectly with the Litton calibration unit (see H74-55/H-45A). It was not logical to assume that all the PR-3 reeds were "bad" yet could be calibrated with the PR-3 recorder systems. So it was decided to set

up the flight system at the environmental chamber at Holloman AFB and examine the circuit with several different reeds operated at a constant flow supplied by the PR Flow Testers (PRFT). This test is documented in Appendix J; the result was an improved flow rate monitoring circuit.

Table 4. Flow Rate Sensor Data: Test 11

Sensor Location	Inlet	Outlet
Units	Hertz	Hertz
Mode	42.5	52.25
Median	44.75	52.25
Mean	45.33	52.29
Variance	7.953	1.868
Standard Deviation	2.820	1.367

Two days after the environmental chamber test, Mission H74-55/H-55X, Test 12 was flown with the encoder circuit modified as documented in Appendix J. Command and control functioned properly and the flow rate data were significantly improved.

Using the Hewlett-Packard 9810A with Statistics Block 11214A and standard data reduction methods, statistics were compiled for the first four flow data sets (see Table 5).

Table 5. Flow Rate Sensor Data: Test 12

Sampler	DFS No. 1		DFS No. 2
Sensor Location	Inlet	Outlet	Outlet
Units	Hertz	Hertz	Hertz
Mode	50.25	57.00	54.25
Median	49.88	56.50	53.50
Mean	49.85	56.18	53.20
Variance	0.7258	1.144	1.788
Standard Deviation	0.8159	1.070	1.337

To further check the quality of this data, the volume (std cu ft) of air passing through the samplers was calculated for each PR-3 for the first 126 min of the flight. This corresponds to the period the balloon was above or at 24.1 km (79.0 kft). For DFS No. 1 the inlet passed 2155 std cu ft and the outlet passed 2202 std cu ft. The outlet of DFS No. 2 showed 2153 std cu ft passing through the sampler. These volumes compare within the accuracy of the system.

2.3.5 IN-USE EQUIPMENT

Two changes were effected in the original sampling equipment. First, the Viable Systems Transmitter and signal conditioner that replaced the Litton transmitter, arrived from the vendor and were tested in a flight configuration, and shipped to the operational field site at Holloman AFB, NM, with appropriate documentation. They were assimilated into the in-use system and precipitated the second change. When the new transmitters were used with the existing 40.35 MHz antenna, the range of acceptable reception was severely decreased. Examination showed that the antenna impedance was much below the specified 50 Ω. A new antenna (designated DZ) was designed by the author and incorporated into the inventory in October 1974.

2.4 Year 1975

The three consecutive successful missions at the end of 1974 completed the "experimental circuitry" phase and allowed 1975 to be a period of operational testing and mechanical fine tuning. The principal objectives were to finalize and document the circuit layouts and to convert as much circuitry as possible to printed wire board while fabricating more equipment to ensure design repeatability. Minor changes which enhanced the workability of a chosen approach will not be discussed but any new approach to deal with an unforeseen problem will be documented.

2.4.1 CONTROL CHANGE

Over several flights there was an intermittent phenomenon involving the separation devices. Two of these squib activated devices, named "Tenney release devices" after the machinist who developed them, are located at the parachute apex; one is activated by the primary controller and the other by the backup controller (see Figure 12). From October 1974, when the backup controller was introduced to April 1975, both devices were activated on four out of the five free balloon missions. An examination of the problem (see Appendix K) disclosed that a ground loop had inadvertently been formed through the metal devices which would cause both to be activated. Keeping the devices electrically isolated solved the problem and became standard practice on all AFGL balloon missions. Figure 13 shows the new arrangement. Notice that each device is secured with a clevis to either the balloon or the parachute to preclude dropping it.

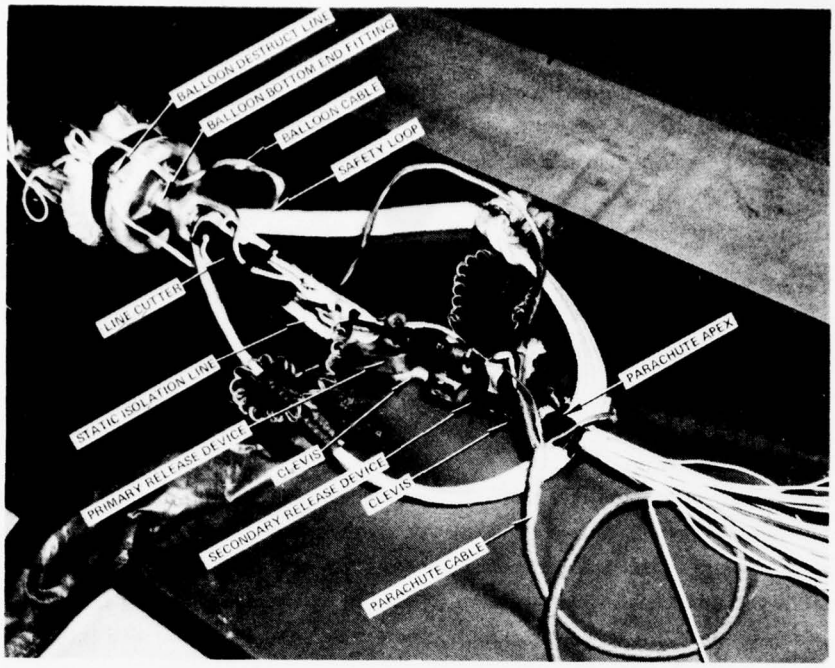


Figure 12. Tenney Release Devices - Original Configuration

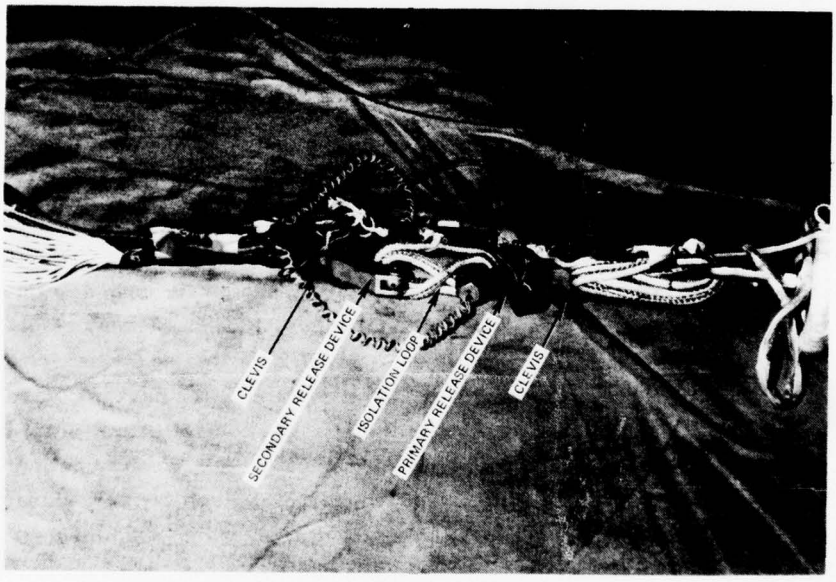


Figure 13. Tenney Release Devices - Present Configuration

2.4.2 DATA SYSTEM CHANGE

Examination of temperature data from both the in-use and new instrumentation showed evidence of a certain amount of almost sinusoidal oscillation of temperature about the average temperature. In an effort to locate a cause of this phenomenon, tests were conducted and it was proven that at the colder temperatures where the thermistor resistance was highest radio frequency (RF) energy would have an effect on the data. Lower resistance thermistors were ordered to eliminate this RF effect on future missions. However, due to the timing of the thermistors' arrival they were not used with the SCADS-2 encoder until 1976. Reference 13 discusses the effect of changing thermistors on the original system.

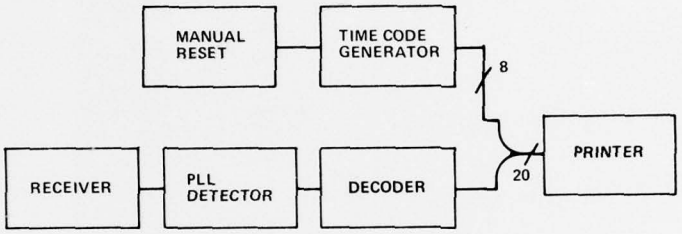


Figure 14.
Ground Station:
Present Configuration

2.4.3 THE GROUND STATION

A new receiver, the TMR-1L by Regency Electronics, Inc., was received and tested early in the year. This small, inexpensive, efficient unit had much better sensitivity than the specifications, and, after operational use in April, several more units were purchased. They have been used very successfully to this date.

In July, the interim ground station mentioned in Section 2.2.4 was replaced with the present automatic ground station diagramed in Figure 14. The design utilizes the same approach as the balloon-borne printer interface but takes advantage of the printer's AC capability. Mr. Alan R. Griffin, AFGL/LCC, accomplished the final electrical and mechanical design and supervised the fabrication of the initial unit (Figure 15). The automatic ground station frees Control Center personnel from the requirement to know Morse Code; the data words are read from the printer and decoded in the dictionaries mentioned in Section 2.3.2. During a normal mission, only channels 1 and 2, primary altitude and housekeeping, are monitored continuously. No difficulties have been experienced since it was introduced into the SCADS-2; so it will not be discussed with the individual flights.

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18. Cordella, R.H., Jr., Capt (1977) An Examination of the Temperature Measuring Accuracy of a Flowmeter System Used with Balloon-Borne Atmospheric Samplers, AFGL-TR-77-0034.

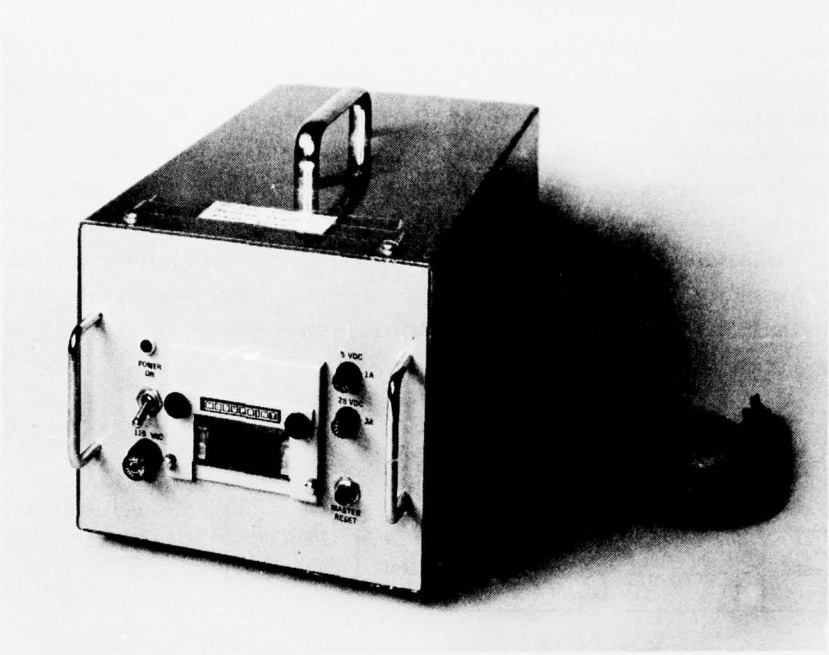


Figure 15. Ground Station (Less Receiver)

2.4.4 TEST EQUIPMENT

Until the middle of 1975 only the control functions had a set of test equipment. Then, with the system undergoing operational testing, assurance was needed that the encoder was functioning properly. An encoder test set was designed to fill this need. Because the encoder monitored signals from so many active devices (primary controller, primary and backup altitude sensors, flow sensors), the test set was built around a signal generator which simulated the signals which these devices produced. The generator is an active device itself and requires a 13-V source to supply about 100 mA. It can test the encoder separately, or, after it has been installed in the instrumentation frame; plus, it can test the data cable. When used in conjunction with the "Model Thermistor UUB31J1" described in Reference 18, it can check the accuracy of the temperature measuring circuit. Complete documentation is available in Reference 14.

2.4.5 SAMPLING EQUIPMENT ACRONYMS

As the developmental equipment was expanded and began to assume part of the operational tests, confusion was generated because there was no terminology for the various equipment and gondolas. They were alternately called old, in-use, new, etc., including various office symbols and surnames. On 12 August 1975 the author published two memos for record which proposed the acronyms SCADS for sampler control and data system, and SAVE for sampler vehicle. These names have been adopted for the project equipment. Table 6 defines the instruments in SCADS-1a, 1b, and 2; SCADS-2a is not yet available. The gondolas were numbered 1 for the original frame, 2 for a gondola developed at the operational detachment, and 3 for the gondola developed by Mr. C. Mitroupoulos of AFGL/SURE. Presently, SAVE-SAVE-3a's are being used. Table 6 lists the equipment designated by the SCADS numbers.

Table 6. Instrumentation and Configuration

	Item	SCADS			
		1a	1b	2	2a
	Primary System				
Receivers	Raven, 6 ch	X	X		
	Zenith, 9 ch			X	
	Raven, 12 ch				X
Transmitters	SST-14	X			
	SC-1		X		
	FMT-1A		X	X	X
Flight Regulators	Control Unit	X	X		
	Controller			X	X
	High Current Switch			X	X
Altitude Sensors	B-60	X	X	X	X
	B-34	X	X		
	Rosemount			X	X
Data Systems	PR-3 Flowmeter System	X	X		
	PR-3 Flow Sensor	X	X	X	X
	Frequency Encoder			X	X
	Printer w/Interface			X	X
Homing	242-MHz Beacon	X	X	X	X
	Back-Up System				
Receiver	Zenith, 3 ch	X	X	X	X
	Timer	X	X		
	b/u Controller			X	X

2.4.6 OPERATIONAL FLIGHTS

At this point SCADS-2 was considered to be out of the developmental state and fit for operational missions; therefore the suffix "X" for experiment was dropped from the mission number. In the interest of clarity, I will continue to refer to the test numbers assigned consecutively in Appendix A.

2.4.6.1 Tests 13 and 14; April

These tests were so similar that except for their altitude one set of comments can suffice for both. The former mission was to 21.3 km (70 kft) and the latter to 24.4 km (80 kft). The primary objective was to obtain atmospheric samples; the secondary objective was to further qualify the new Ash Can electronics systems. Four new instrumentation features were: (1) two high current switches and three 24-V BB405 battery packs were used to power three DFS's; (2) the Air Serve Valve which controls the DFS doors was controlled directly from the primary instrumentaion; (3) both two-wire and three-wire Skinner magnetic latch valves* were controlled simultaneously; and (4) a new telemetry receiver (Regency model TMR-IL)

The extra 24-V pack of BB405's necessitated placing the backup instrumentation on top of the primary instrumentation so its usual position could be used for the extra batteries. This configuration kept the center of gravity as low as possible.

The direct control of the Air Serve Valve, which requires 24 V, enabled the batteries for the DFS to be tapped at 22.5 volts. This reduced the current drain to approximately 17 A which resulted in the battery-voltage remaining at the plateau voltage for over 4.25 hr (reference Eagle-Pitcher data). This was corroborated by the DFS flow rates being very stable over the entire 4-hr sample time.

The data were of excellent quality and the telemetry signal was clear. All flight objectives, primary and secondary, were met.

2.4.6.2 Tests 15, 16, and 17; July

These three flights were successful in that they secured specimens and support data according to the flight plan; and, with the completion of No. 17 there were eight consecutive successful flights. However, none of the three were perfect; each had a slight flaw in the data system function. Rather than try to disregard the insight gained with the passage of time, I will relate the discrepancies, their former interpretation, and their present interpretation. A slight digression into the encoder format will be necessary.

When the encoder format was outlined in Section 2.3.2, it was described how the first three channels were dedicated to flight information and the last 12 channels were dedicated to sampler information. It was not mentioned that a capability exists

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*These valves control the compressed gas which drives the C-14 samplers.

to continuously cycle only the first three channels plus the framing pulse which precedes them. This provides altitude data about every 25 sec and is used at the beginning of each flight to monitor balloon ascent. The encoder is set in this mode automatically when power is applied. After the system is about 3 to 6 km (10-20 kft) in altitude the encoder mode is switched by radio command to the full 15 channel mode which is repeated every 3 min as keyed from the primary controller. This is usually used for the remainder of the flight or until the system is on the recovery parachute. The modes can be switched as often as desired by using the command capability.

On test 15, after the balloon was released from the launch device, the encoder ended up in the full data mode and, for the first 10 min of the flight, the message format (15 twelve-bit words every 3 min) was itself disrupted. After that, the flight was perfect. At that time this erroneous performance was attributed to a C-band transponder which was placed on the gondola to allow White Sands Missile Range to track the balloon. However, even though this interference could not be duplicated, ceramic by-pass capacitors were added on the input which controlled the encoder message length.

Test 16 system did not include a transponder and the flight was virtually perfect. This firmed the opinion that the interference on the previous mission was caused by the transponder. (It is now believed that it was radio frequency interference (RFI) from the 40.35 MHz transmitter.)

Test 17 again had a C-band transponder; some intermittent data transmission was noted during the very early part of the ascent. This was, at that time, attributed to a malfunctioning transmitting antenna because it had become badly twisted just after balloon release but was seen to untangle as the system ascended. This untangling coincided with the resumption of normal telemetry; the remainder of the flight was perfect. Because these deviations from the normal scheme were so minor and could not be attributed to any specific system malfunction, they were documented as being linked to the transponder and largely forgotten. However, the next two attempts at flights using SCADS-2 were to reopen the question.

2.4.6.3 Tests 18 and 19; October

These two tests were catastrophic failures. Since the preceding eight SCADS-2 missions were successful and training of the operational test site personnel was proceeding smoothly, the author was not at the operational site when Test 18 was launched. The following facts are from the "Post Mission Evaluation and Critique for Flight H75-42/H-69" by J. Robert Greenlee, 1/Lt, USAF, the operational project officer.

"Mission Objectives" were to collect atmospheric samples at 21.3 km (70 kft). However, due to a premature termination by the SCADS-2 instrumentation system, the balloon was not successfully launched and mission objectives were not satisfied.

Preparation of the SCADS-2 instrumentation system (Serial No. 01) and SAVE-3 gondola proceeded smoothly and on schedule during the entire week before the launch. At no time during the package checkout were difficulties encountered. In fact, it is noteworthy that the entire pre-launch operation proceeded smoothly and according to schedule. When the package was turned on after balloon inflation, the 40.35 MHz telemetry signal was received loud and clear in the Control Center and in the instrumentation van on the line, and the good signal continued until bubble release. At that time, with the launch vehicle brakes still set, the signal became very garbled and unreadable (only intermittent noise spikes appear on the strip chart recorder). This condition lasted for several seconds and is followed on the strip chart recording by dashing, indicating the primary instrumentation to be in the termination sequence. Personnel monitoring the signal during the launch run, both in the Control Center and in the instrumentation van, heard the dashing and realized its significance, but before anything could be done to notify the crew chief, and before release from the BST* took place, the backup Tenney device fired, separating the parachute and balloon. The parachute fell around the payload (which was still attached to the BST) and was then pulled upwards by the ripline as the balloon ascended. During this process a parachute suspension line became entangled around the radiosonde, ripping it from the payload when the parachute was pulled vertically. The ripline system and ripline cutter worked properly, and the balloon came to rest about 50 ft from the taxiway. An immediate inspection of the system showed that the ballast-blow patch squib fired, the balloon valve was open, and the parachute burst pin was not pulled. The SCADS-2 package continued to transmit until it was turned off, and a post flight inspection of the strip chart recording by Capt. Cordella showed that the package was in "long" cycle after the incident, although primary channel 1 (Encoder Key) had not been issued.

Inspection of the movies also revealed that about 30 sec passed from the moment of bubble release until the backup tenney squib fired. Following the launch attempt the payload and the balloon were returned to the site laboratory. A post mission analysis of the payload malfunction was begun immediately with the payload completely intact and undisturbed. Both the primary and backup packages checked out perfectly and absolutely no discrepancies in performance were noted. Discussions were initiated immediately with Capt. Cordella, and based on his suggestions several additional areas were investigated, but nothing was found which helped to explain the problem. Capt. Cordella arrived on 17 October to take over the investigation, which continued until 20 October.

The facts, when reviewed in the light of the July series which had been conducted with the same instruments, led to the conclusion that this was an isolated

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*BST: The launch vehicle which held the sampling system prior to launch.

failure caused at bubble release by a discharge of static electricity. The failure affected the primary controller by causing it to go into the termination mode, the encoder, by causing it to go into its "long cycle", and the backup controller, by causing it to go into its termination mode. A further conclusion was that the failure was not indicative of a system problem. The decision was made to fly the SCADS-2 sn 02 with the following precautions:

(a) The telemetry receiver would be patched into the magnetic tape recorder to preclude loss of data,

(b) The length of the static isolation strap would be lengthened to approximately 4 ft (see Figure 16),

(c) Procedures were set up to attempt to de-energize the instrumentation if the system went into termination at bubble release.

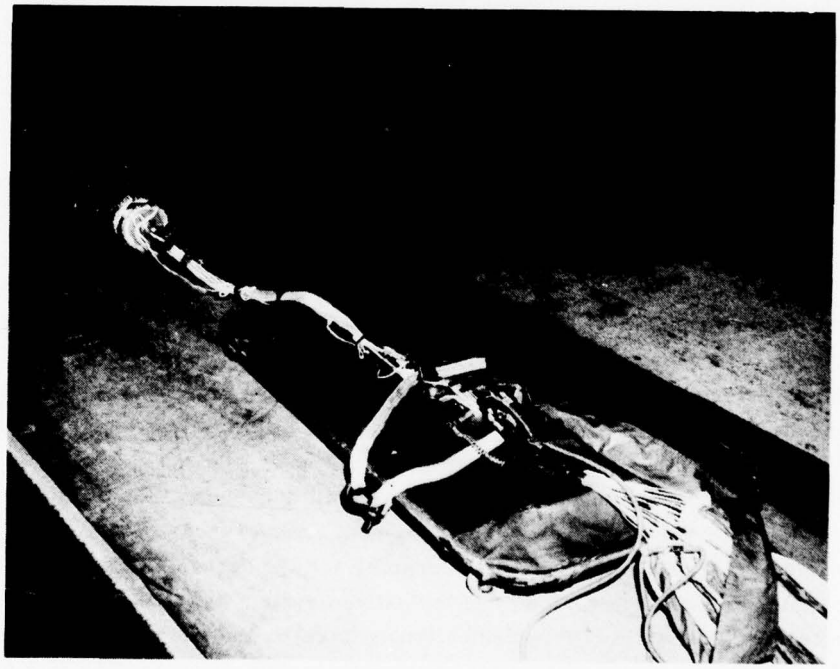


Figure 16. Isolation Strap at BottomEnd Fitting

The objective of Test 19 was to obtain atmospheric samples at 24.4 km (80 kft). Preparation for flight H75-43/H70 proceeded according to the normal instrumentation

check list, albeit very thoroughly. All checks were correct and on 20 October 1975 the system was launched following a perfect preflight checkout. A receiver was positioned on the flight line to facilitate observation of the transmitted data. At bubble release a high frequency tone was noted in the background of the FM transmission. The data could still be clearly heard over this tone and was copied by the phase locked loop filtered recorder in the control center. It was not noticed at the time, but the transmitted format of the last word in thirteenth message was garbled in that some of the bits were run together. The instrumentation initiated a premature termination sequence within moments of system release; separation occurred shortly thereafter. System altitude at the moment of separation was not sufficient to allow proper parachute deployment and the payload impacted several yards north of the runway. Extensive damage was imparted to the system and mission objectives were not satisfied.

The utilization of the same instrumentation packages on the October and July flights with such incompatible results prompted a comparison of the overall configuration in the hope that some differences would be found. The comparison of the five flights was conducted with inputs from as many personnel of all sections as could attend the meeting. Items compared were balloons ripline cutters, gas valves, Tenney device configurations, static isolating strap length, launch arm, gondola type, instrumentation type and serial number, cable configuration, relative humidity, types and numbers of samplers, and presence of C-band transponder. The July and October flight configurations were so similar that the weight of the 24.4 km (80 kft) July flight and 21.3 km (70 kft) October flight were within 4.5 kg (10 lb). Notable differences are balloon type and the direct flow sampler door monitor. The direct flow sampler door monitor switch was first used in October. Its purpose is to report when the sampler doors are not completely closed.

It was determined that the exact cause of the two failures may never be known but that the extensive testing necessary could be more readily accomplished at the home laboratory rather than at the test site facilities.

The information gathered pointed to two possible causes of the premature terminations, static electricity and radio frequency interference. Each cause is virtually impossible to duplicate in the laboratory and the behavior of each is associated with rapid changes in the geometry of the balloon system at bubble release and triplate release. The static charge redistributes itself on the moving balloon system and the electromagnetic field from the transmitting antenna assumes a new shape as the balloon pulls the system upright. The most likely candidate for the problem is the radio frequency interference (RFI) from the 40.35-MHz transmitter. However, static electricity could not be ruled out because of the coincidence of the problem and balloon movement. Since extensive RFI protection in the instruments would protect against static electricity, also this approach was taken in preparation

for a tethered test. Conclusions based on the information on hand in late October were:

(a) The tone in the background of the data transmission was caused by the mismatching of the antenna when it was handled by the instrumentation technician prior to launch. (This proved to be correct.) An attempted fix was to use a different antenna, a modified Zepp antenna, with an antenna chute. (This proved to be a partial fix and will be explained later.)

(b) The "clock" inputs of CMOS chips were more susceptible to RF than the inputs of gates and needed more protection than has been supplied.

(c) The base-emitter junctions of transistors were far more susceptible to RF than the CMOS logic. These junctions could be protected by bypass capacitors and a bias voltage supplied by a Zener diode (see Figure 17).

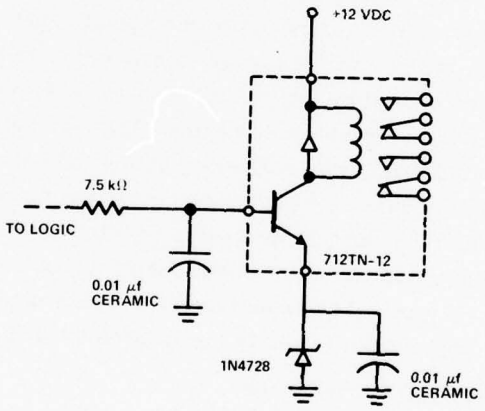


Figure 17. Typical Relay Driver Protection

(d) The direct flow sampler door monitor switch was incorporated in a fashion that left the encoder circuit open. The thermistor was connected to the encoder by a twisted shielded pair of wires, and a normally open switch was inserted in series with the thermistor. Opening the DFS door closed the switch. This was changed so that

the thermistor always terminates the line pair with a normally closed switch in parallel. The switch opens when the DFS door opens. The original method provided an easy path for RF energy to enter the instrumentation. The second method eliminates this hazard.

Instrumentation changes accomplished for RFI protection are the addition of ceramic capacitors to act as RF filters on control lines, addition of a 4-sec delay on the termination command, and lowering the value of the pullup resistors for the control signal lines from the selector. To accomplish the latter, the voltage regulators in the controller and encoder were modified to increase their current capability. Also, to protect the base-emitter junction of the transistors internal to the Teledyne 712TN-12 relays, a Zener diode was placed in series with the emitter lead. It was not possible to incorporate this modification on all the relays prior to the next test because of the difficulty of adding components to printed circuits (PC) boards. The diodes were added only where the relay directly controlled squibs with the understanding that the PC board would be reaccomplished to accommodate a protective diode for each relay. During testing it was noted that the instrumentation could not be affected by coupling RF energy into the cables, or by injecting it directly into connectors for data or control cables with a signal generator. However, by using the output of the FMT-1a transmitter through a capacitor, the transmitted data could be obscured. This was caused by the high RF energy level on the ground plane keeping the transistor in the transmitter keying 712TN-12 relay energized. Checking the CMOS logic revealed that it was unaffected by the RF energy and was performing properly. The controller could not be made to enter the termination mode by using RF energy. The severity of the test necessary to introduce this keying malfunction was interpreted to imply that such a problem during a flight was almost impossible. Also, in the future, TN type relays would have the Zener diode protection. An operational test was now needed to verify the laboratory findings.

2.4.6.4 Tests 20 and 21; December

The purpose of the first flight was to provide a tethered balloon platform for detailed equipment checkout of the SCADS-2 instrumentation system. Non-conductive cables were used to anchor the tethered balloon, because a primary area of instrumentation investigation was RF susceptibility. The new reel-deployable 40.35 MHz Zepp antenna was tested and operated successfully. It was determined that the command method of changing message lengths was well protected but the automatic method of putting the encoder into the complete message mode only afforded minimal protection. The quality of this protection was increased prior to 1976 flights. All mission objectives were satisfied, and based on the positive results of this mission, planning proceeded toward a free balloon test flight.

As can be seen in Appendix A, the same equipment was used on the next Mission, H75-54/H-76X, as was used on the second October flight which failed; only the circuit modification documented in Section 2.4.6.3 and the transmitting antenna were different. This mission was to further test and flight-qualify the SCADS-2 system, to collect DFS samples, and to flight-qualify the newly designed reel-deployable, 40.35 MHz transmitter antenna. All mission objectives were satisfied with the successful collection of a 3-hr sample by both DFS experiments at 18.3 km. Deployment and operation of the antenna was entirely satisfactory. The instrumentation system collected the requisite collateral data via the on-board printer, but a telemetry problem developed which precluded real time data collection.

The loss of transmitted data was caused by RF energy keeping the output relay in the encoder energized after its input signal had returned to ground potential. This relay is of the Teledyne 712TN-12 type discussed in Section 2.4.6.4. There are two theories: first, as the balloon rises into the less dense air, the field of transmitting antenna changes because of the varying properties of the atmosphere such as density or ionization potential; second, as the system goes further from the earth, the field of the transmitting antenna changes because of the system capacitance between the balloon payload and the earth. In either case the results are increased RF energy induced into the instrumentation. The addition of protective Zener diodes eliminated the problem. Realizing that the effects of the radiated RF energy must be minimized, it was decided that the instrumentation would be shielded and have RF filter connectors on the cables entering or leaving the instrumentation frame or the backup controller. However, after researching connector cost, it was decided to use ferrite beads mounted in small boxes to reduce the level of the RF energy (see Figure 18).

In conclusion, problems experienced by SCADS-2 instrumentation to this time were documented, explained and corrected. The next free balloon mission would prove or disprove the effectiveness of the measures taken because, as demonstrated, this type of problem is extremely difficult to duplicate in the laboratory or on tethered balloons.

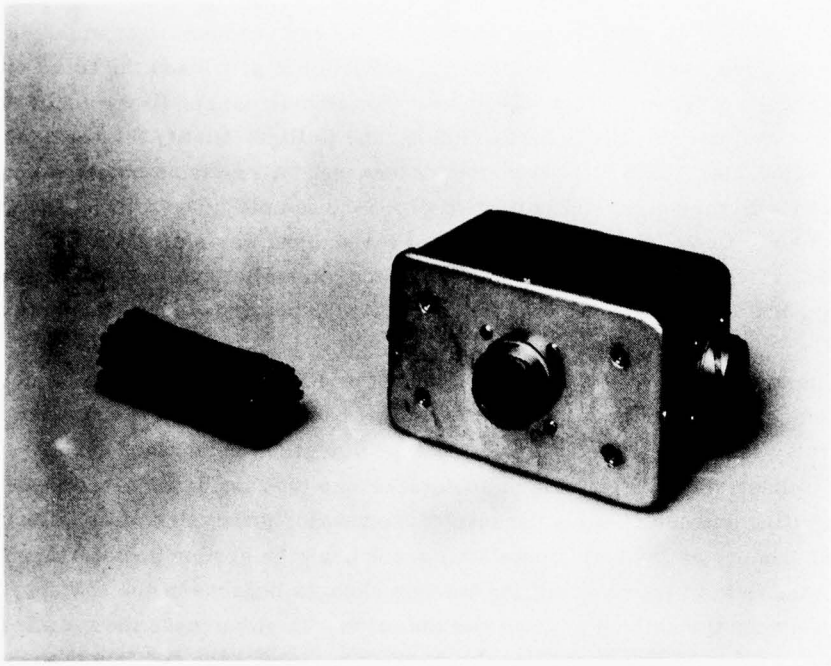


Figure 18. RFI Filter: Ferrite Beads

2.4.7 IN-USE EQUIPMENT

The "high frequency tone" described in Section 2.4.6.3 had occurred briefly at other balloon launchings when the FMT-1a transmitter was used and, on tethered Test 20, the fuse protecting the transmitter was blown during the preflight checkout while the antenna was being handled. This problem was examined at the test site laboratory and at AFGL and the symptoms were duplicated. Tests showed that the cause was a mismatch in the antenna impedance because of a marginal design in the output stages of the transmitter. This problem has been eliminated by the insertion of a 50-MHz low pass filter between the transmitter output and the antenna feed coaxial cable. This filter must be firmly and securely grounded to the same ground plate as the transmitter. The initial flights of this filter with an FMT-1a sn (008) and a reel deployable FM antenna (H76-03 and H76-05) were excellent. The filter solved both problems. The transmitter must now be tuned with the filter in place. Further experimentation at LCC demonstrated that the HF filters flown with the Zenith and Viable receivers must also be securely grounded to be effective. This should be accomplished by physically securing them to the instrumentation frame or using a heavy gauge ground strap.

A problem which did not affect any of the flights directly, but did postpone the launch of Test 21 occurred on 18 November. Receiver/selector performance was noted to be incorrect in that the selector became locked onto the first channel which was energized, and subsequently, issuing the command for any channel resulted in the selection of the channel initially selected. The receiver/selector problem was duplicated in the laboratory by placing the receiver and transmitter antennas in close proximity to each other and then trying to select commands while the transmitter was radiating through its antenna. Radiated RF energy developed a voltage across the diode on the output of the operational amplifier in the reed switch command decoder box. This added voltage would latch the amplifier into its "on" position precluding selection of other commands. This problem was solved by the addition of ceramic 0.01 μm capacitors from both sides of the diode and series resistor to ground on each operational amplifier output. Capacitors were also added to the audio input line and the voltage regulator. All resonant reed decoders were subsequently modified.

A memo on operating power source current requirements for the DFS's (Appendix C) was written in this year and in October a design to modify some SCADS-1a control units to handle three DFS's was formulated from this location.

In September there were extensive discussions about the accuracy and repeatability of the PR-3 flowmeter system. These discussions were instrumental in the decision to change the thermistor and document the results.[18]

2.5 Year 1976

The preceding development and test effort paved the way for defining the system. Therefore, all system documentation was reviewed and reaccomplished where necessary.[14] All of the preceding year's flights fell under the configuration of Figure B7. The addition of the RF filters on the data, control and power cables plus the low pass filter on the Viable 40.35-Mhz transmitter changed the configuration to that shown in Figure B8.

2.5.1 CONTROL CHANGES

There was one addition to the system's control capability; a burst monitor switch was added. This circuit enables the flight director to disable the burst switch circuit by radio command before the system has reached the circuit arming altitude. The need for this capability could arise if the burst pin was inadvertently pulled at launch and was therefore incorrectly indicating that the system was

18. Cordella, R.H., Jr., Capt (1977) An Examination of the Temperature Measuring Accuracy of a Flowmeter System Used with Balloon-Borne Atmospheric Samplers, AFGL-TR-77-0034.

descending. This very rarely happens but a gust of wind can inflate the parachute at launch, causing the pin to be pulled from the switch housing (see Figure 19).



Figure 19. Burst Pin Assembly on Parachute

An important component which does not show up on the schematics but which is essential to the physical configuration of the equipment is the printed circuit (PC) work. With the finalizing of the circuits all PC boards were reviewed and several were reaccomplished to correct component spacing, etc. This is further documented in Section 2.5.4.1.

2.5.2 DATA SYSTEM CHANGES

There was one principal data system change which necessitated several small adjustments. In March, the encoder circuit which monitors the PR-3 flow sensor thermistor was modified to accept a Fenwal bead thermistor—UUB31J1. To fully utilize the potential of the curve-matched thermistor, the temperature measuring circuit was modified so that a set of individual circuits could be adjusted to within an acceptable accuracy envelope. A major benefit is the ability to use one temperature dictionary (Appendix G) for all the encoders. The modification was extremely

simple and left the circuit topology unchanged. Two fixed resistors in the temperature scaling circuit were replaced with variable resistances. Each resistance acts upon the circuit in a basically independent fashion; one changes the warmest indicated temperatures, and the other, the coldest indicated temperatures. Each extreme was adjusted for zero error according to the dictionary. The accuracy envelope for the encoders on-hand was ± 0.7°C over the temperature range +20°C to -80°C.

After these changes were accomplished, tested, and documented, the encoder test set was modified to accommodate the bead thermistor resistances.

2.5.3 SENSORS

As mentioned earlier, the search for a follow-on primary altitude sensor never really ended. Several new digital pressure trandsucers, the Hamilton Standard Model-1D, were ordered for evaluation. Apparently these devices are stable enough to be standards themselves; therefore, if they function over the pressures experienced between sea level and 40 km they may eventually replace the B-60's.[19]

2.5.4 OPERATIONAL FLIGHTS

After the experience gained at the end of 1975, the prognosis was for quick conformation of the "fix" described in the previous year documentation. The SAVE-3 gondola was utilized (see Figure 20). Compare it to Figure 6 and note the lower center of gravity obtained by moving the ballast hopper up on either side of the batteries.

2.5.4.1 Test 22; April

Mission H76-19/H-84X was to be a routine sampling mission to 18.3 km (60 kft). After a smooth checkout, launch and antenna deployment; the primary controller went into the termination mode, ending the flight at 10 kft altitude. At impact the parachute draped over 22-kV lines causing extensive damage to the system cables and instruments. Checking the circuits for the problem disclosed that the impact switch circuit was in error; that is, it was not fabricated in accordance with the documentation. Therefore, all system documentation was inspected and all hardware was checked by at least two people for compliance to the prints. This check included circuit topology and component values. The system was rebuilt and underwent rigorous laboratory testing.

19. Cordella, R.H., Jr., Capt (1978) An Autoranging Balloon Altimeter: A Single Pressure Transducer Monitors Altitude from 0 to 44 Kilometers with 30 Meters Resolution, AFGL-TR-78-0023.

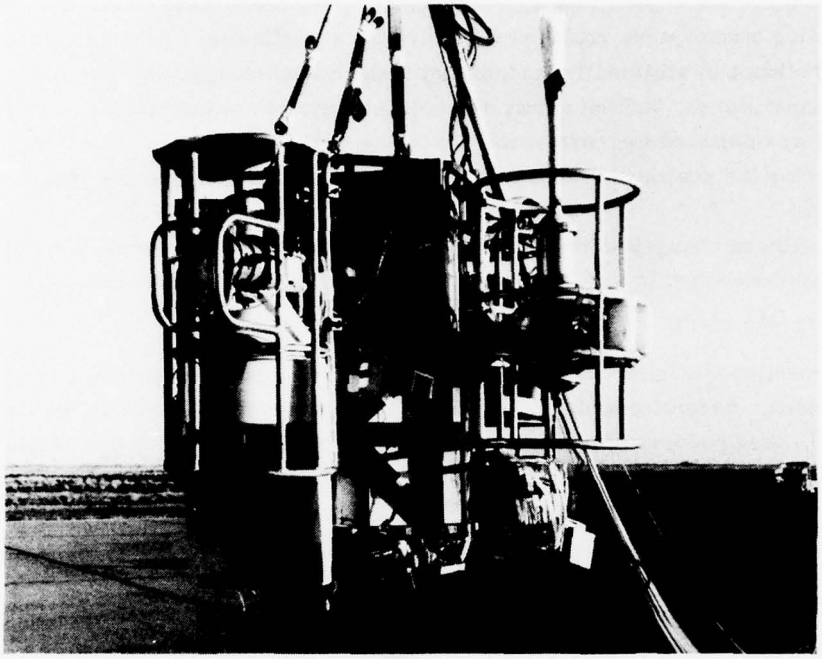


Figure 20. Gondola: SAVE-3

2.5.4.2 Tests 23 and 24; November

A comprehensive RFI test was scheduled before a free-balloon flight. All normal radiators would be operated on the flight system simultaneously. The radiating equipments were a radiosonde, FMT-1a transmitter, homing beacon, FAA transponder, and C-band transponder. The system was prepared as if it were to be a free flight and a condensed sequence of commands and timer initiated events was scheduled to simulate a complete mission. The results of Test 23, Mission H76-65/H-102X were perfect.

The sequence of command and timer activated events were completed as scheduled in a flawless manner. The data tapes for the flight recorder, ground recorder, and a phase locked loop detected strip chart record of the audio were compared on this date. The data on the flight and ground station tapes corresponded within the resolution of a digital system (± 1/2 bit). The data on the ground recorder were interrupted by the replies from the Zenith receiver/selector system. This was confirmed by referring to the strip chart record. There was no hint of RF interference in the data or time code portions of the flight recorder tape. The replies from the FAA and C-band transponders were clearly received by the

appropriate agencies during the test. The previously experienced RFI problems (on flights H-69, H-70, H-75X, H-76X) had either been solved or were such that they could not be explored by this type of test.

Test 24 was ready for launching 3 days after the tethered balloon test. A 4-hr sampling mission was successfully accomplished. Three specimens and support data were gathered; data quality was excellent; the control system performed flawlessly.

The automatic ground station recorded data for the entire mission until the system was below about 6.1 km (20 kft) on the parachute. This loss of signal as the parachute returns the system to earth is normal when the instruments pass below the radio horizon.

2.5.5 COMMENTS

Other sampling missions were planned for the remainder of 1976 but this instrumentation system was virtually destroyed when the parachute contacted a 345-kV power line northeast of Truth or Consequences, New Mexico. After having almost three complete systems in October 1975, we now had no operational equipment left that could be flown without extensive rehabilitation.

2.5.6 IN-USE EQUIPMENT

Several changes to the SCADS-1a system were accomplished; none were foreseen at the beginning of the project but the delay in introducing SCADS-2 in operationally significant numbers required action.

The control units which had been transferred to AFGL (then AFCRL) in the early 1970's were very well worn and required extensive maintenance or replacement. Therefore, new control units were fabricated at the field test site at Holloman AFB, NM. These units were schematically identical to the units being replaced. With two exceptions, first, several of the new control units had the capability to control three DFS's; second, each unit could control a ballast hopper in lieu of the quantized ballast slugs. The control of three DFS's was instituted in 1975 for some of the control units and it was carried forward into the new units. These units have been in use since early 1976 and are functioning properly.

To facilitate calculation of the capacity of BB405 batteries for the DFS, a graphical tool was designed and distributed to the field test site, (see Appendix C).

As mentioned earlier, new FM 40.35-MHz receivers had been procured for the field test site. Prior to shipment to Holloman AFB, an emitter follower amplifier was added to the discriminator output to facilitate the operation of the SCAD-1a ground station. The amplifier precluded the necessity of the data going through the audio amplifier which drives the receiver speaker, resulting in a much cleaner signal. A second benefit is that the receiver volume may be varied without distributing the signal to the ground station.

Between February and August three test flights of the Fenwal bead thermistor in the PR-3 flowmeter system were accomplished. Based on the results of these flights this thermistor was adopted for routine PR-3 use. This will result in improved data now, and will prepare the flow sensors for operation with the SCADS-2 encoder. Results of the tests are documented in Reference 18.

3. COMMENTS AND CONCLUSIONS

3.1 Objectives

The initial objectives stated in Section 1.5 were met and exceeded in both the ground equipment and the flight equipment. In the flight equipment, the control system was tailored to the existing control devices and balloon equipment, and the data system was tailored to the in-use sensors. In both cases the performance of SCADS-2 equipment surpasses SCADS-1a equipment. The SAVE-3 gondola provides a central core on which to assemble repeatable flight configurations. The automatic ground station provides a complete record of the flight, with time codes, and requires no attention after the time code generator is synchronized.

3.2 Documentation

The instrumentation and supporting software are fully documented. Volume 2 of the project handbook[14] contains over two hundred pages of schematics, wiring tables, and parts layouts and lists. The computer programs are documented in the appendices to this report. Also the accuracies of the principal sensors are defined; the B-60 altitude sensor in Table 2, the PR-3 flow sensor in Appendix J and the PR-3 temperature sensors in Section 2.5.2.

3.3 Functional Verification

Nine pieces of test equipment and a comprehensive test procedure have been provided to facilitate extensive inspection before a mission.

3.4 Additional Flights

Beginning in late 1976 arrangements were made to have New Mexico State University, Physical Science Laboratory, fabricate and operate the SCADS-2. Using AFGL documentation[14] plus a physical model, University personnel fabricated a complete SCADS-2 by mid-1977. In this context "complete" means flight hardware exclusive of transmitters and receivers, test equipment, and a ground station. Simultaneously, AFGL personnel fabricated a new set of flight equipment. In early August 1977, an extensive series of bench tests using both AFGL and University

fabricated equipment established the interchangeability of all component modules between the two systems and certified their operational readiness.

During the remainder of 1977 two operational missions were performed with each set of equipment. The results were very gratifying; the SCADS-2 performed perfectly on each mission.

References

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2. Instruction Book: Command Receiver/Decoder, Raven Industries, Inc., Box 1007, Sioux Falls, South Dakota 57101.

3. Handbook of Instructions for Dual Frequency Command Receiver BCR-4B, Developed for Air Force Cambridge Research Center, Air Research and Development Command, Bedford, MA 01731, under Contract No. F19650-67-0053, 15 March 1967. Manufactured by Military Division, Zenith Radio Corporation, 6501 West Grand Avenue, Chicago, Illinois 60635.

4. Final Engineering Report on Command Selector BCS-2A-3818, Prepared for Electronic Systems Division, AFCRL(AFSC), Laurence G. Hanscom Field, Bedford, MA under Contract No. AF19(628)-3818, 12 December 1964. Government and Special Products Division, Zenith Radio Corporation, 6501 West Grand Avenue, Chicago, Illinois 60635.

5. Handbook of Instructions for Command Receiver BCR-3A-477, developed for AF Cambridge Research Center, Air Research and Development Command, Bedford, MA under Contract No. AF19(628)-477, 15 April 1963, Manufactured by Military Division, Zenith Radio Corporation, 6501 West Grand Avenue, Chicago, Illinois 60635.

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7. SS/T14 Telemetry Transmitter Technical Handbook: ASD Document No. 3335, prepared for Department of the Air Force, Detachment 31, 6th Weather Wing (MAC), Goodfellow AFB, Texas 76901 under Contract No. F41614-69-R-0442, July 1969. Applied Science Division, Litton Systems, Inc., 2003 East Hennepin Avenue, Minneapolis, MN 55413.

8. PR-3 Flowmeter System Technical Handbook: ASD Document No. 3330, prepared by Department of the Air Force, Detachment 31, 6th Weather Wing (MAC), Goodfellow AFB, Texas 76901 under Contract No. F41614-69-R-0442, June 1969. Applied Science Division, Litton Systems, Inc., 2003 East Hennepin Avenue, Minneapolis, MN 55413.

9. Model B-60 Balloon Altitude Sensor, Specification No. SK1595, 28 October 1970. Applied Science Division, Litton Systems, Inc.

10. B-34 Baro-Transmitter Technical Handbook: ASD Document No. 3333 prepared for Department of the Air Force, Detachment 31, 6th Weather Wing (MAC); Goodfellow AFB, Texas 76901 under Contract No. F41614-69-R-0442, July 1969. Applied Science Division, Litton Systems, Inc., 2003 West Hennepin Avenue, Minneapolis, Minnesota 55413.

11. G. E. Silicon Controlled Rectifier Manual, edited by F. W. Gutzwiller, prepared for General Electric Company, 3800 North Milwaukee Avenue, Chicago, Illinois 60641, 1967, pp 153-155.

12. Hi-G Relay Engineering Manual, Document No. REM-1164, by Hi-G Incorporated, Windsor Locks, CO 06096, 1964, pp 6, 7, and 11.

13. Instruction Manual for Model FMT-1A FM Transmitter, AFCRL Contract No. F19650-74-C-0407, May 1974. Viable Systems, Incorporated, 299 Second Avenue, Needham Heights, MA 02194.

14. Cordella, R. H., Jr., Capt (1977) Project Ash Can Atmospheric Sampling Handbook, Volume II, Instrumentation: SCADS-2, AFGL, Aerospace Instrumentation Division, Hanscom AFB, MA 01731.

15. Instruction Manual: Model No. CMMP-6A, July 1973, Practical Automation Inc., Trapp Falls Road, Shelton, CO 06484.

16. The ARRL Antenna Book, published by the American Radio Relay League, Inc., Newington, CO, 1974, pp 108, 109, and 116.

17. Development and Calibration of the PR-3 Flowmeter, ASD Report No. 2723 by R. C. Wood, L. R. Graf, L. V. Nelson, Applied Science Division of Litton Systems, Inc., August 1965, page 8.

18. Cordella, R. H., Jr., Capt (1977) An Examination of the Temperature Measuring Accuracy of a Flowmeter System Used with Balloon-Borne Atmospheric Samplers, AFGL-TR-77-0034.

19. Cordella, R. H., Jr., Capt (1978) An Autoranging Balloon Altimeter: A Single Pressure Transducer Monitors Altitude from 0 to 44 Kilometers with 30 Meters Resolution, AFGL-TR-78-0023.

Appendix A

Tabulation of Flight Equipment Usage

This Appendix reviews for each flight the flight equipment and the active samplers. It also proposes two "Figures of Merit" (FOM) to gauge the flights' acceptability. The first FOM, sample acceptability, is strictly binary; sample with data, or fail. The second FOM can vary from 0 to 1 (nothing worked to everything worked) and is an attempt to note the overall instrumentation performance. This numerical indicator is based on 25 points allocated as follows: receiving system 1, controller commands 9 and timer 3, encoder format 5, altitude sensors 2, housekeeping data 1, flow data 1, temperature data 1, recorded data 1, and recorded time code 1.

Table A1. SCADS-2 Flights

TEST NO.	FLIGHT NUMBER	DATE	PRIMARY																									SECONDARY				SAMPLERS			FOM	
			STANDARD								BOTH					LCC													S	B	LCC		BOTH			BOTH	
			TYPE	CONTROL UNIT	B-34	T-14	SC-1	IMPACT SWITCH	PR-3 F/R	PR-3 F/S	FMT-1a	RAVEN RCVR	B-60	BEACON	CONTROLLER	IMPACT SWITCH	ZENITH RCVR	ZENITH XMTR	ENCODER	RECORDER	ROSEMOUNT	HCS-RELAY	HCS	TIMER	ZENITH RCVR	VALVE MOD	BACKUP CNTRLR (ACTIVE)	DFS (ACTIVE)	C14	WAS	AIR EJTR	SAMPLE AC	INSTRUMENTS	COMMENTS
			-	-	-	-	-	-	ea	ea	-	-	-	-	sn	-	-	-	sn	-	-	-	-	-	-	-	sn	ea	ea	ea	ea	-	-	SERIAL NO. OR QUANTITY
1	H72-73/H14X	02 Nov	70		•	S		•	1	2			•	•	01		•	•				1		•	•	•		2				F		
2	H73-17/H-19	22 Mar	80						1	1			•	•	02	•	•	•	01		2		1	•	•	•		1				F		
3	H73-50/H-28X	30 Jul	70						2	2	S		•	•	02	•	•	•	01		2		1	•	•	•		1				F		Serial PR-3 Flow Sensors
4	H73-73/H-32	24 Oct	70						1	5	S		•	•	02	•	•	•	01				1	•	•	•		2	2			S		No Redundant Altitude Sensor
5	H74-27/H-41X	11 Jun	64							2	S		•	•	03	•	•	•	02	•	1		1	•	•	•		1	1			F		Flight recorder added
6	H74-32	14 Jun	T							2	S		•	•	03		•	•	02	•	1			•	•	•		1				-		
7	H74-36/H-42X	19 Jun	90							4	S		•	•	03	•	•		02	•	1		1	•	•	•		2	1			F		
8	H74-55/H-47X	18 Oct	T							2	D1		•	•	03	•	•		02	•	1		1		•		02	1	1			-		Antenna changed, SCADS-2
9	H74-56/H-48X	24 Oct	T							2	D1		•	•	03	•	•		02	•	1		1		•		02	1	1			-		
10	H74-61/H-53X	05 Nov	60							2	D2		•	•	03	•	•		02	•	1		1		•		02	1	1			S	.95	Antenna changed
11	H74-65/H-54X	06 Dec	90							3	D2		•	•	03	•	•		02	•	1		1		•		02	2		1		S	.70	
12	H74-66/H-55X	12 Dec	80							3	D2		•	•	03	•	•		02	•	1		1		•		02	2		1		S	1.0	
13	H75-23/H-57	09 Apr	70							4	D2		•	•	03	•	•		02	•	1		2		•		04	3	1	1		S	1.0	New receiver TMR-11
14	H75-25/H-59	14 Apr	80							4	D2		•	•	03	•	•		02	•	1		2		•		04	3	1	1		S	1.0	
15	H75-35/H-63	16 Jul	80							3	D2		•	•	03	•	•		02	•	1		1		•			2	1			S	.90	Automatic ground station
16	H75-36/H-64	20 Jul	70							3	D2		•	•	03	•	•		02	•	1		1		•		04	2	1			S	1.0	
17	H75-37/H-65	23 Jul	90							3	D2		•	•	04	•	•		03	•	1		1		•		05	2	1			S	.90	
18	H75-42/H-69	15 Oct	70							3	D2		•	•	03	•	•		03	•	1		1		•		05	2	1			F	.40	UTM monitor switch added
19	H75-43/H-70	20 Oct	80							3	D2		•	•	04	•	•		02	•	1		1		•		04	2	1			F	.40	
20	H75-49/H-75X	14 Nov	T							4	Z		•	•	04	•	•		02	•	1		1		•		04	2				-		Antenna changed
21	H75-54/H-76X	02 Dec	60							4	Z		•	•	04	•	•		02	•	1		1		•		04	2				S	.95	Transmitter Relay RF1
22	H76-19/H-84	19 Apr	60							1	Z		•	•	04	•	•		02	•	1		1		•		04	1	1			F	.8	22 KV, PC Error, Beads
23	H76-65/H-102X	15 Nov	T							4	Z		•	•	04	•	•		03	•	1		2		•		03	3	0			-	1	
24	H76-66/H-103X	18 Nov	90							4	Z		•	•	04	•	•		03	•	1		2		•		03	3	0			S	1	345 KV

Appendix B

Flight System Configurations

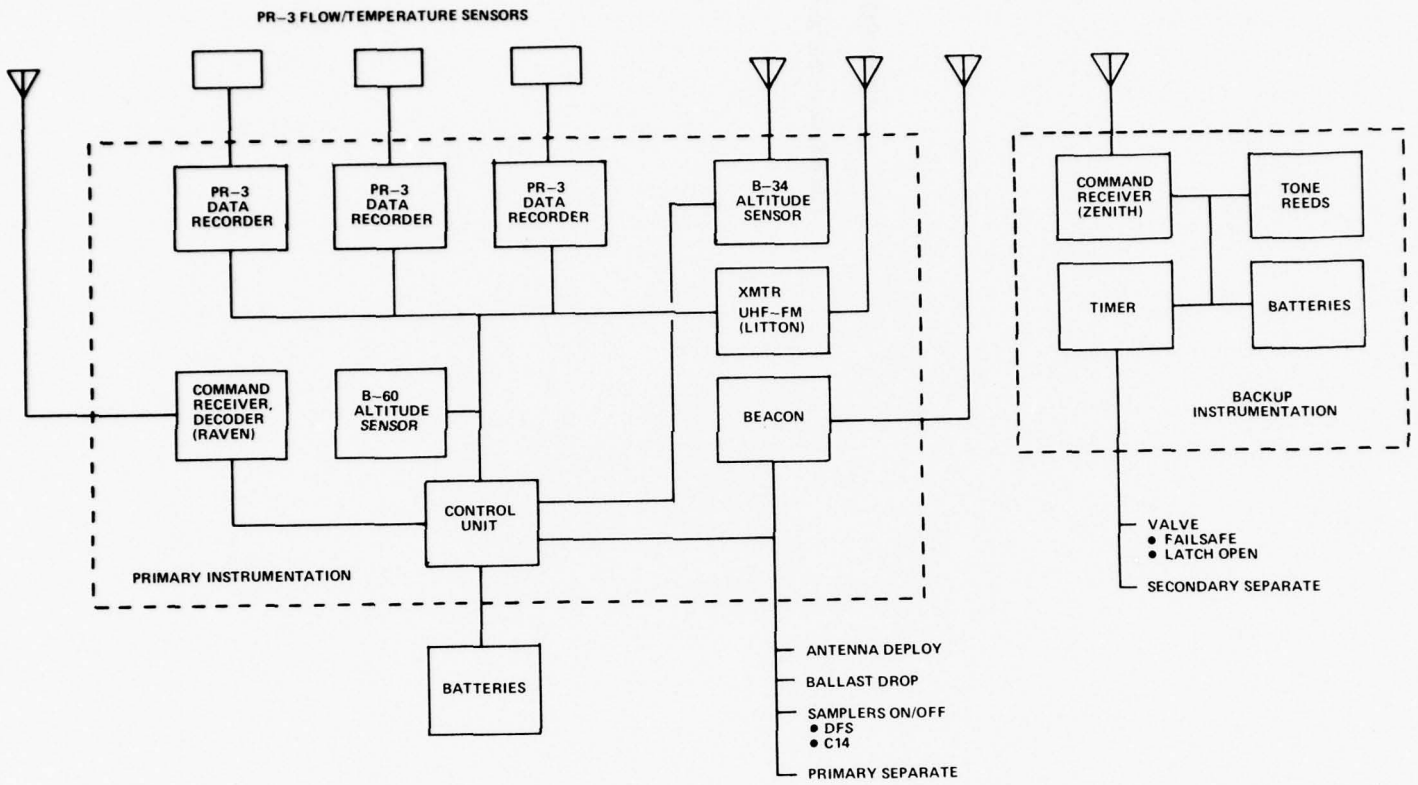


Figure B1. Original System Configuration

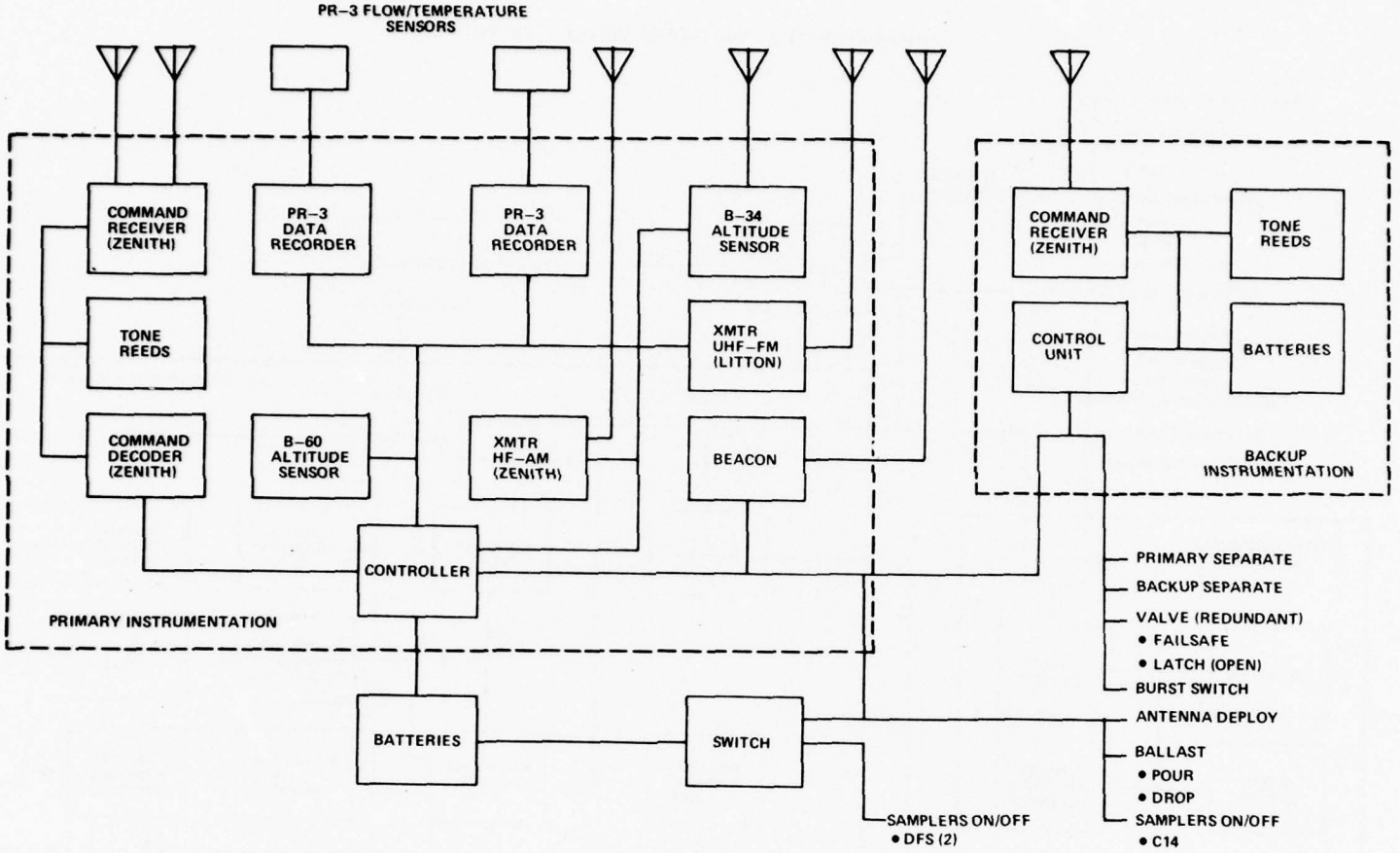


Figure B2. Flight (Test) No. 1 Configuration

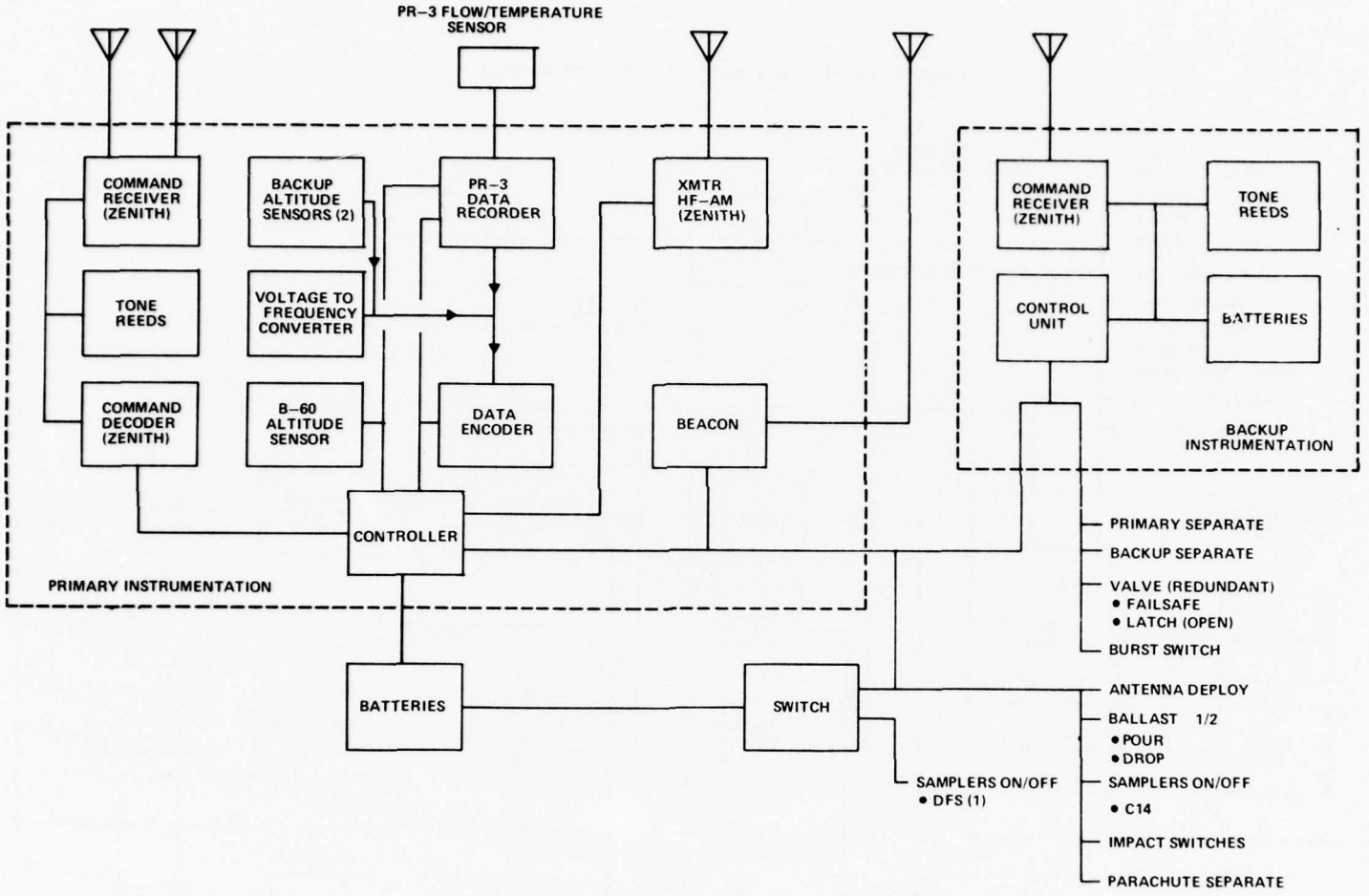


Figure B3. Flight (Test) No. 2 Configuration

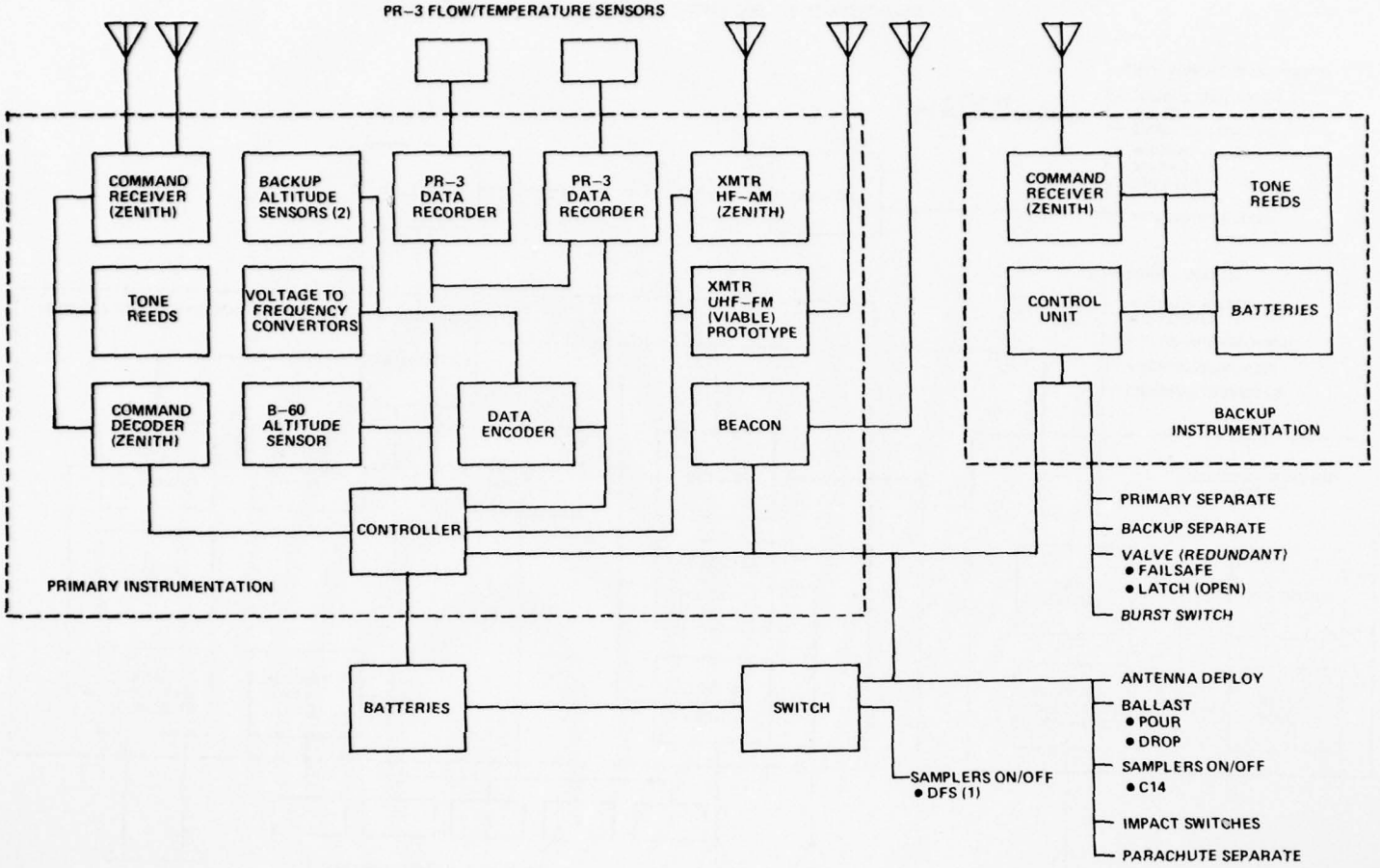


Figure B4. Flight (Test) No. 3 Configuration

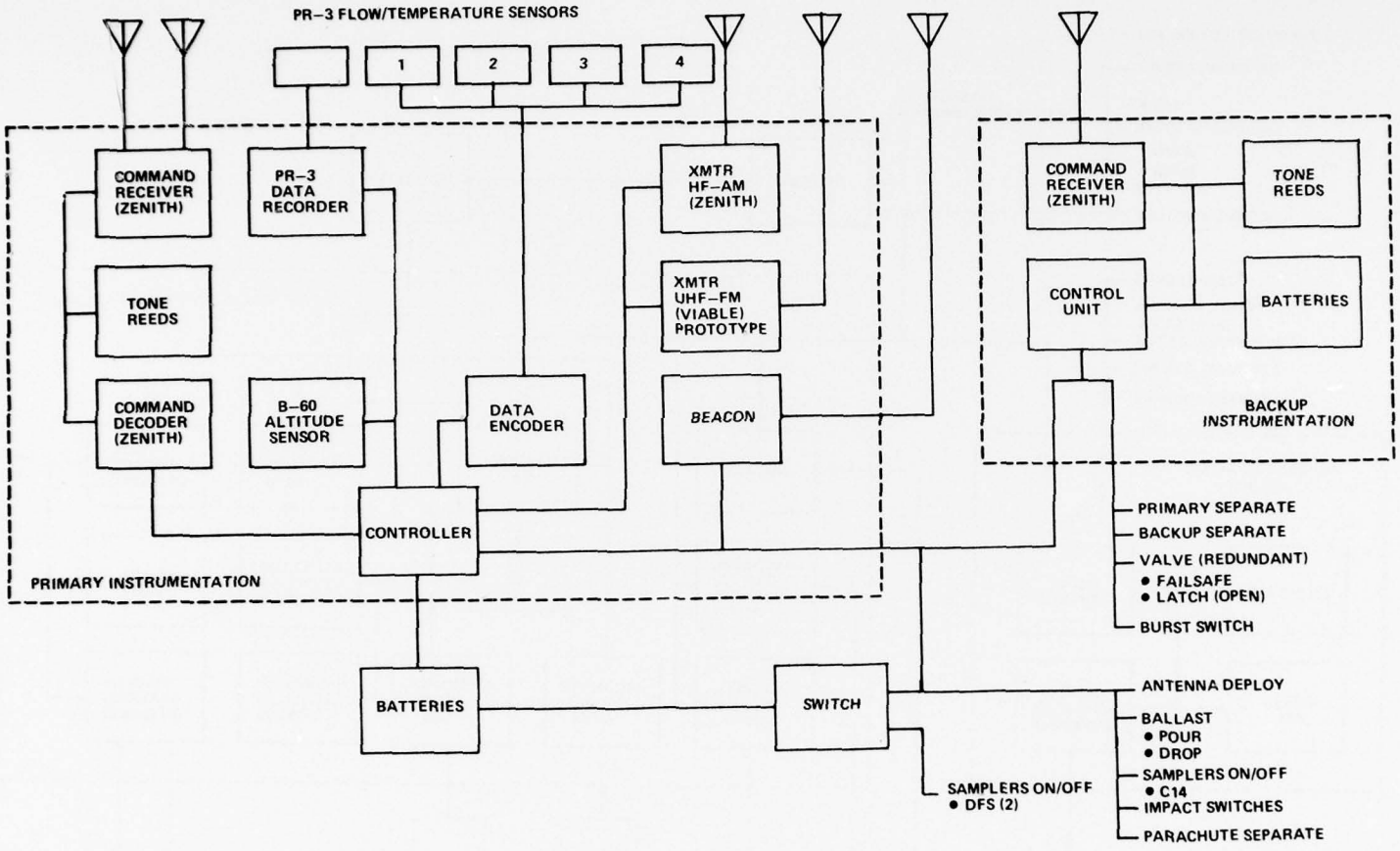


Figure B5. Flight (Test) No. 4 Configuration

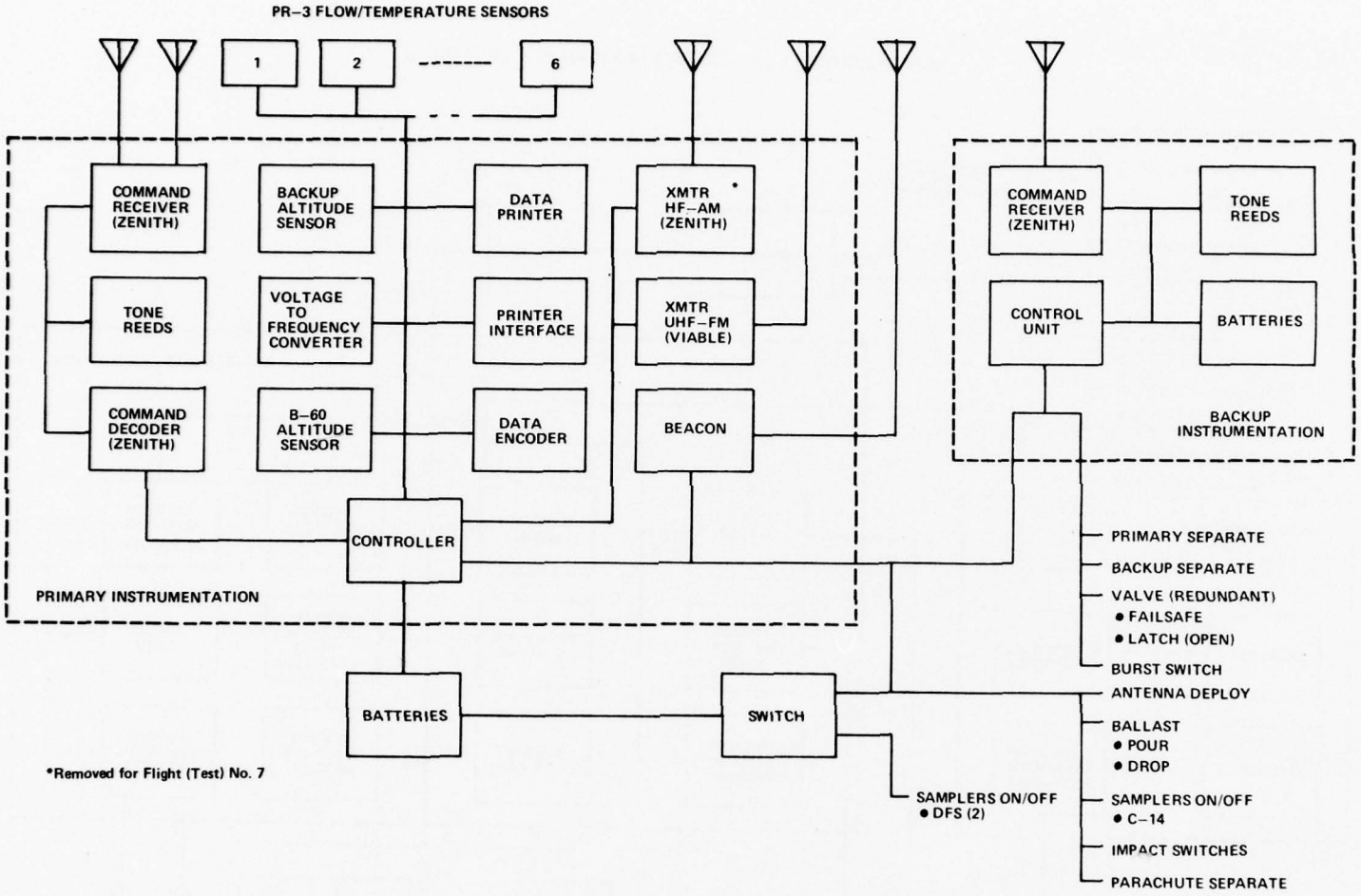


Figure B6. Flight (Test) Nos. 5, 6, and 7 Configurations

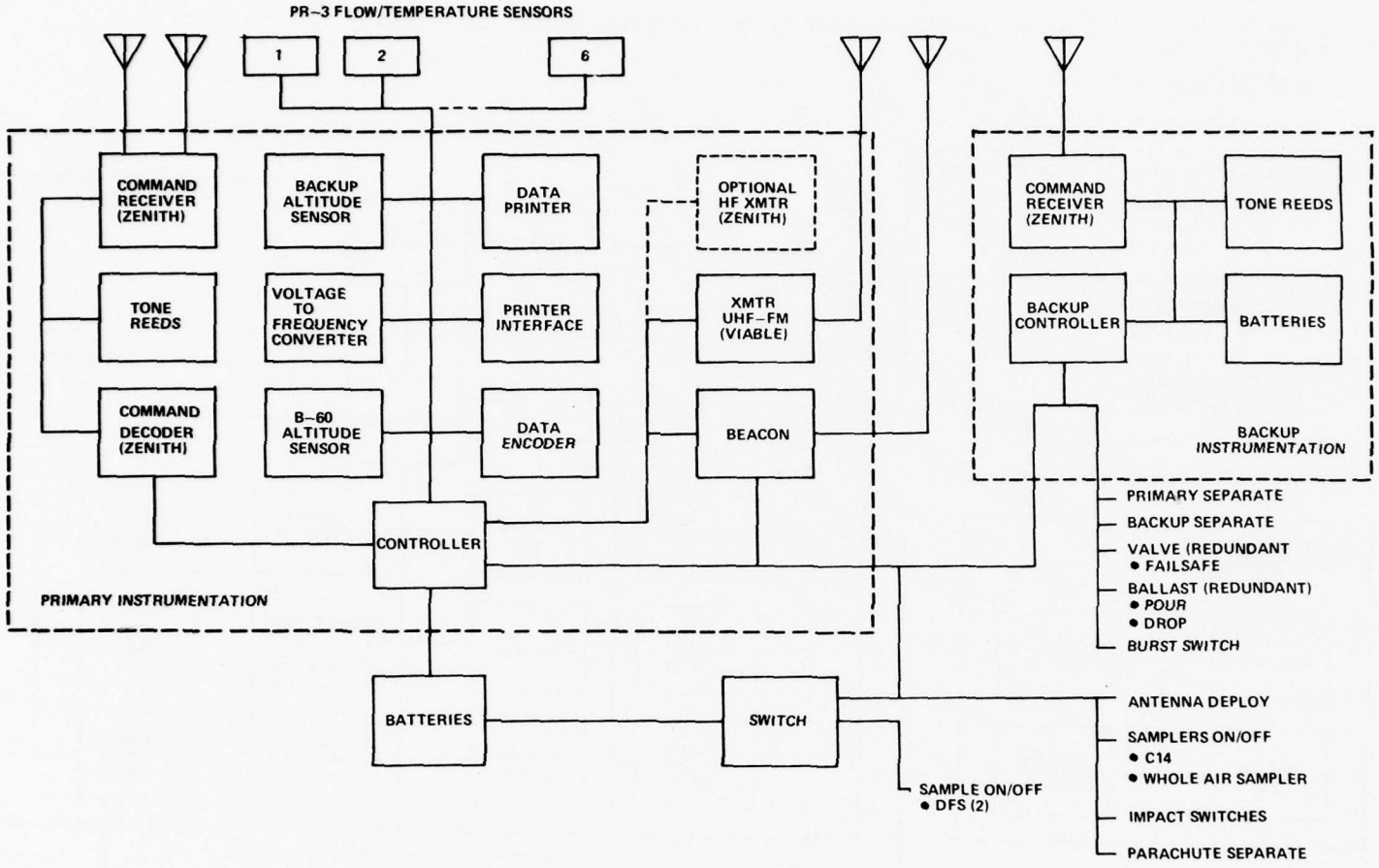


Figure B7. Flights 8 Through 21 Configurations

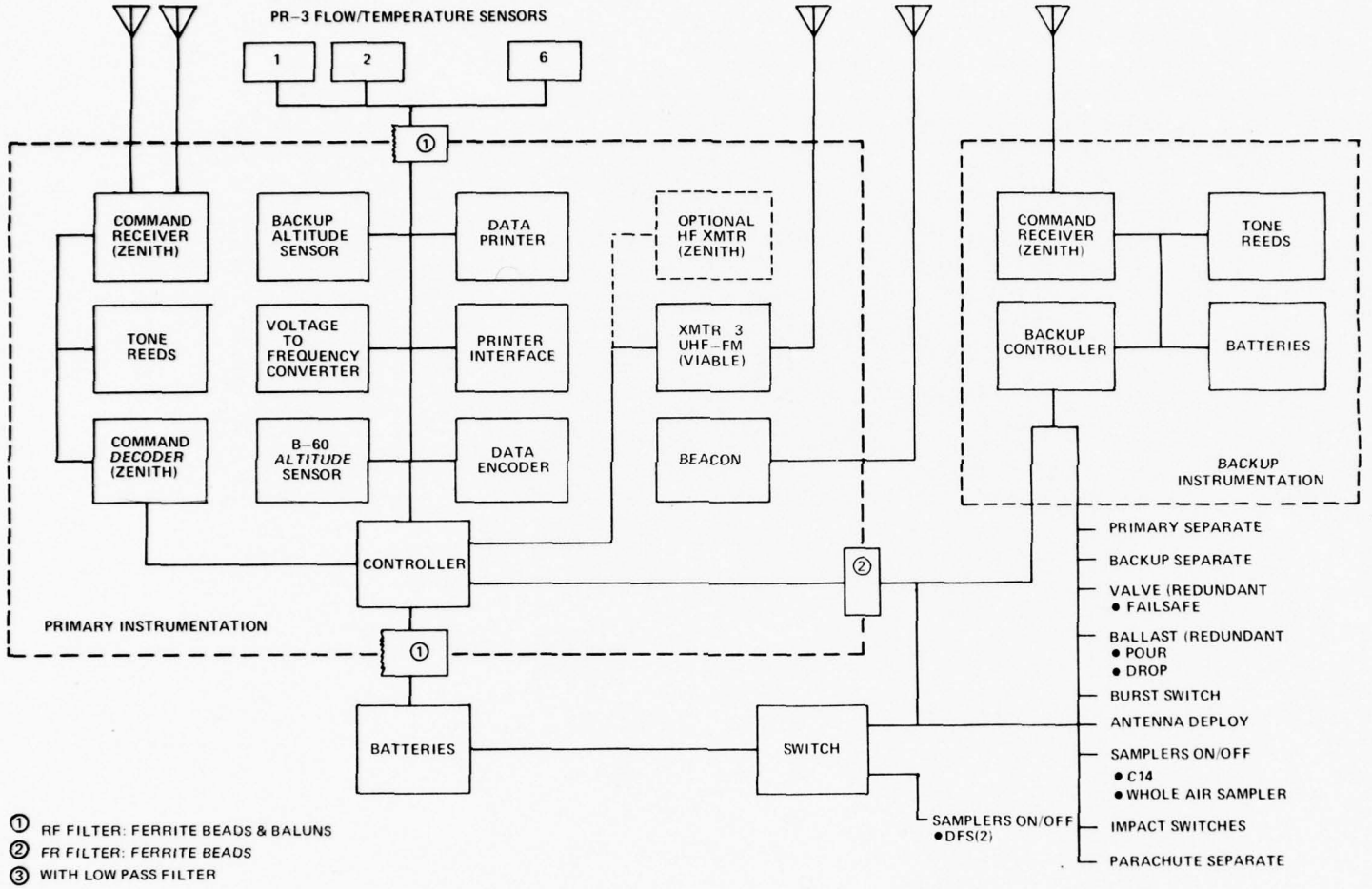


Figure B8. Flights 22, 23, and 24 Configurations

Appendix C

Information to Support Direct Flow Samplers

C1. GENERAL

The following information appeared as memos for record. Section C2 appeared in March 1975 and Section C3 appeared in November 1976.

C2. VOLTAGE AND CURRENT REQUIREMENTS FOR THE DFS

On 10 March a memo containing DFS current vs voltage data collected at the Holloman AFB environmental chamber was received by the author. These data were averaged, retabulated (Table C1) and graphed to facilitate its assimilation.

Figure C1 displays this family of current vs voltage curves for five altitudes. Each curve is the best straight line through the average current points for the various voltages. The vertical lines through the average current points represent the limits of the averaged current data from two DFS's.

C3. DISCHARGE CAPACITY OF BB-405/U BATTERIES

Eagle-Pitcher BB-405/U batteries are nominally rated at 60 Ah at the 6-hr rate. However, graphs transmitted from Eagle-Pitcher on 18 March 1975 further define the Ah rating as a function of current drain.

Pursuing an accurate estimate of available energy I plotted current capacity on various types of paper to establish a usable tool.

Table C1. Average DFS Current vs Voltage

Voltage (dc volts)	Average Current (amperes) (Altitude (k ft)				
	60	70	80	90	100
19.1	17.9	----	----	----	----
19.2	----	----	13.0	----	----
19.3	----	15.1	----	----	----
19.5	18.1	15.3	12.8	10.9	9.3
20.5	18.9	----	----	----	----
20.8	----	15.7	13.4	----	----
21.0	19.1	16.1	13.3	11.3	9.7
22.0	19.6	16.5	13.9	----	----
22.5	20.3	16.9	14.0	----	10.1
23.0	20.7	----	----	12.3	----
23.7	----	17.2	14.2		----
24.0	22.3	17.9	14.6		10.4

Plotting hours and Ah vs current for BB-405 batteries, produced virtually straight lines on log-log paper. The graph is Figure C2.

A 90 k flight of three DFS's will be used as an example.

(a) Current for one DFS at 90 kft altitude with 22.5 Vdc applied is 13 A, worst case. Three samplers powered by two parallel batteries will draw 19.5 A per battery, assuming both batteries are in identical condition. Referring to Figure C2, 19.5 A will be available for 4.1 hr which yields 79.95 Ah. Three DFS's running for 4 hr on two BB-405 packs tapped at a 22.5 Vdc require 156 Ah; the batteries can supply 159.9 Ah. The ratio of required to available Ah is 0.9756 which corresponds to a safety factor of 2.44 percent.

(b) A quicker way to obtain similar information will be demonstrated with the best case current. Under the same conditions as above, best case current is 11 A per sampler or 16.5 A per 22.5 Vdc battery. From the graph, 16.5 A will be available for 5 hours. One hr more than needed corresponds to 20 percent safety factor referenced to the battery capacitor.

(c) Check the answer in (a) using the method of (b). Current is available for 4.1 hr or 0.1 hr extra. The ratio of the extra to the available corresponds to a safety factor of 2.44 percent.

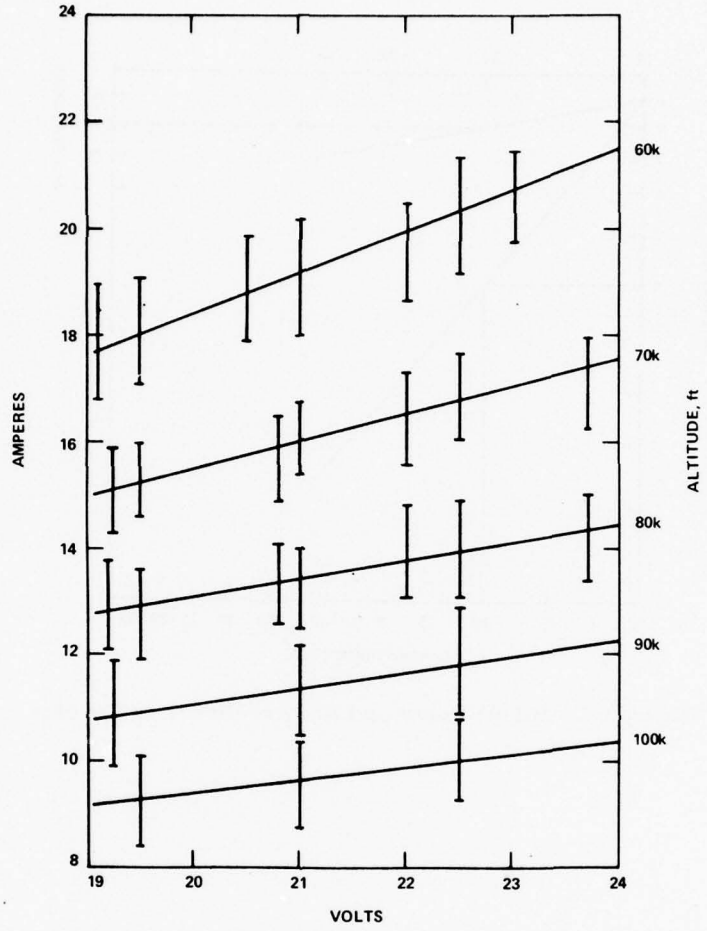


Figure C1. DFS Current vs Voltage and Altitude

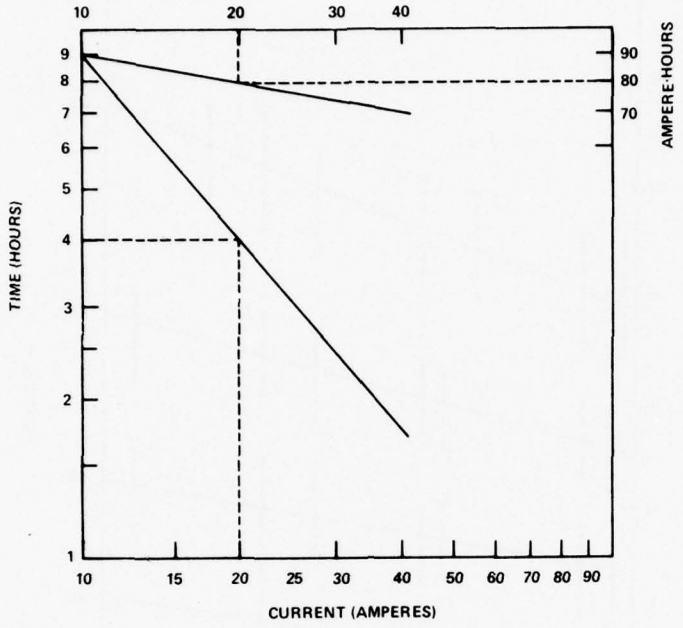


Figure C2. BB405 Hours and Ampere-Hours vs Current

Appendix D

Progress Report: 18 July 1973

The goal of the Ash Can revision is to modify by replacement if necessary the system in such a way as to meet all present and projected aims. This will include a state of the art electronics package or packages and a universal assembly technique built around a common central package. The system electronics will be discussed first.

Studying the manuals for the sampling equipment and support equipment in conjunction with the AEC Sampling Handbook revealed that there was no system diagram of the total system or any of the three major configurations. To facilitate understanding the system, a system schematic was drawn in July 1972. The existing system consists of aMotorola VHF-FM (188.06 MHz) receiver and a six channel selector, a control unit, the B-60 altitude sensor, the SS/T 14 telemetry transmitter VHF-FM (40.35 MHz), the B-34 baro-transmitter, plus the samplers and support equipment for gathering the flow data. This system is backed up by a HF-AM (5-10 MHz) command receiver and a flight termination timer. Five of the six available channels in the primary package are used for ballast, sample on, sample off, termination and antenna drop. The backup package has gas valve failsafe, gas valve latch and termination. Note that the balloon gas valve is not controlled through the primary package. Also, altitude data is transmitted in two modes: first, a course altitude via the B-34, and second, a float altitude from the B-60 through the T-14. Utilizing the now more complete and more easily understood documentation, the system was analyzed with respect to what was wanted and

how it was led to a list of deficiencies which could be corrected through modification or addition.

These deficiencies not only pointed out some inadequacies with the in-use system, but pointed the way for the new system; therefore, a table (D1) is used to compare the two systems. However, a yes/no analysis overlooks some of the fine points involved. For example, look at the interaction of sampling and balloon altitude. The sample can only be collected between certain altitudes, for a given period of time. If the balloon begins to ascend you can valve for control in both systems; but in the in-use system, if the balloon begins to fall, you can't ballast. You can only shut off the samplers as you approach the lower boundary of the sampling zone and terminate the flight. In the new system, you can shut off the samplers, pour ballast from the ballast hopper, restart the samplers after the altitude has been corrected and continue to sample for the full period. Also, at termination by any means (timer, command, balloon burst), should the samplers be on, they will be shut off 20 sec before ballast is blown for the descent.

Once the functions of the new system were identified as outlined in the table (D1), then a choice on how to effect the equipment design was made. The excessive power requirements and weight of the present system spurred the drive for low weight and minimum power consumption which led to the CMOS CD4000A logic family. "The CD4000A series with over 60 standard parts has long passed the critical number of off-the-shelf items required of an established series. It is manufactured by at least seven companies; all have custom capability in addition to standard parts."[1] At this point, the new system will be outlined.

The simplest version of the system must contain several basic components: (1) a receiver for the commands, (2) a control unit to interpret the commands, sense balloon activities, and route information, (3) an encoder to process and multiplex this data, (4) a transmitter, to send data from the encoder to the ground station, (5) the samplers and flow sensors. The UTMT's, gas bottles, etc. are considered part of the sensors. The samplers and flow sensors are, of course, already in the inventory. The receiver is, to the control unit, only a set of contacts which are open or closed (grounded). The transmitter is only a port or a set of ports into which a signal or signals, can be fed. This leaves the control unit and the encoder to think about. Since we still have a choice on the output of the encoder for one or several outputs, let us look at the choices for the overall system by putting receivers and transmitters around the set of remaining units and see what we learn.

---

[1] Computer Design, May 1978, p 105, Kaare Karstad, "CMOS for General Purpose Logic Design".

Table D1

ITEM	SYSTEM IN USE	SYSTEM PROTOTYPE
Balloon Functions (Main Package)	-	-
Valve Failsafe	N	Y
Ballast: Drop Slugs (15-25 lbs each)	Y	N
Pour Dust and Monitor	N	Y
Blow all ballast	N	Y
Burst Pin: Monitor	N	Y
Termination	N	Y
Impact Switch: Switch	Y	I
Termination: Timed	N	Y
Command	Y	Y
Safety Altitude and Time	N	Y
Back-up Package	-	-
Valve Failsafe	Y	I
Valve Latch	Y	Y
Termination	Y	Y
Key: N-No		
Y-Yes		
I-Improved		
Instrumentation		
Altitude Sensor	Y	I
Recorded Float Altitude	N	Y
Valve Monitor	N	Y
Ballast Monitor	N	Y
Burst Pin Monitor	N/A	Y
Homing Section: Terminate	Y	Y
(Beacon) Switchable	N	Y
Sample Protection (at Termination)	N	Y
Altitude Plus Time Turn-On	Y	N
Timed On	N	Y
Timed Off	Y	Y
Command On	Y	Y
Command Off	Y	Y
Rotate Package	Y	Y
Gas Release	Y	Y
Sampler Current in Control Unit	Y	N

Three new systems are possible:

1. HF: Using the HF receiver, selectors, and transmitters on hand at LCC. This requires one output of the encoder.

2. HF-FM: Using the HF receiver and selector as above but directing the output to go to a VHF-FM (40.35 MHz) transmitter. This also would require a single output from the encoder.

3. FM-FM: Using S-band telemetry, all data could be sent real time on up to 13 channels plus data would be received on another set of S-band channels. In this case, the encoder would not be a true analog to digital encoder but a series signal conditioning network.

The latter system (3) requires purchasing the most new equipment and that equipment is more expensive and complex than that needed for the first two systems. On these grounds, it was not considered in competition with the HF and HF-FM systems. The encoder design was now able to be finalized.

The unit labeled encoder serves several functions. As the name implies, its primary function is to serialize or multiplex several pieces of information on to one output. The information sources are analog in form and before they are multiplexed they are buffered and shaped to interface with the CMOS circuitry. After being multiplexed they are encoded to digital form and presented to the output as a stream of dots and dashes time spaced to form Morse Code. At this point a word should be said concerning the digital format of the output.

There are three major signals in the system which must be transmitted. These signals represent altitude, air flow through the PR-3, and air temperature. The altitude and flow signals are binary in form and consist of pulses that vary in frequency in proportion to the measured parameter. The temperature data is a varying voltage derived from a thermistor. Note that two out of three are binary in nature and therefore lend themselves to a digital format. The third signal is easily converted to a binary signal by incorporating the thermistor into an oscillator circuit. Now all three signals are binary where the information is contained in the frequency of the signal. The digital signal to be transmitted is derived from the binary analog signal by counting the number of pulses that occur in a carefully controlled period of time: in this case four minutes. This period was chosen based upon the large frequency variation of the B-60 from ground level to 100 kft pressure altitude. The accuracy of the data channels is always 1 count therefore by keeping the overall count above 100 the resolution can be kept better than 1 percent. As an example; over all sample altitude ranges the frequency of the signal from the PR-3 flow meter will vary from 40 Hz to 150 Hz. Therefore, in H seconds the encoder would count 160 to 600 counts with an accuracy of 1 count so the resolution could be 1 in 160 to 1 in 600, or 0.625 percent to 0.167 percent. The nature of this encoding by counting is such that if the count looks about right and is repeatable, then it most

probably is correct. In any event, it is very easy to verify the accuracy with an oscilloscope and the PR-3 flow sensor or a standard pulse generator.

The count that has been referenced as the end product of the encoder appears at the output as a series of dots and dashes with most significant figures first. Therefore, one count or word of the encoder message would look like

XXX XXX XXX XXX

where each X is a 0 or a 1 represented by a dot or a dash respectively. This twelve bit word is a binary figure with 3 pauses added. If the pauses were eliminated or ignored then the count would be read by summing the decimal equivalent of the powers of two represented by the ones and zeros. But, there is an easier way. With the pauses in place, not only do the dots and dashes form Morse Code letters but they form an octal code where each group of these X's can vary from 0 to 7 therefore 101 001 100 010 can be read as $(5142)_8$ which can be converted to decimal (base ten) by use of an octal to decimal conversion table $(5142)_8 = (2658)_{10}$. This is very easy with a little practice and once the decimal number has been obtained if the data is the flow information it can be divided by four (because the encoder sampled for 4 sec) and the actual count of the flow sensor is obtained. If the above example was valid flow data the flow rate would be proportional to 664.5 Hz. At this point it should be noted that the encoder is now assuming functions presently accomplished by the ground station equipment and personnel. The matching frequencies via Lissajous Patterns will no longer be necessary and an oscilloscope and frequency counter can be eliminated. Data can be copied by hand or recorded on magnetic tape or a strip recorder or both. This will yield permanent records from onboard and ground recording. If the above example was altitude or temperature data a calibration curve or table would convert directly from code to altitude or temperature. Because of the different signal conditioning necessary for the three types of data channels are assigned to specific functions. The first two channels are for flight altitude derived from the B-60. The first channel is used at altitudes greater than 50 kft. The resolution of these channels is at worse ± 1 percent at about 50 kft, and it improves with increasing and decreasing altitude until it is 0.1 percent at ground and 100 kft. The third channel is used to monitor the gas valve, ballast hopper and balloon burst protect circuit. The remaining channels are paired for PR-3 flow and temperature data. Channels 4, 6, 8, and 10 are for flow and channels 5, 7, 9, and 11 are for temperature. During ascent to float altitude, only the first three channels need by observed because there is no data on the remaining channels. Therefore, upon applying power to the encoder the first three channels preceeded by a warning pulse will cycle continuously. As float altitude approached, a command (No. 1) can be given and the encoder message will

expand to all eleven channels (or any preset number) cycling every 3 minutes. The message containing 11 words (channels) will take about 1-1.4 min depending on the ratio of dots to dashes. Issuing command No. 1 a second time will return the encoder message to the three word format. By repeatedly issuing command No. 1, the message length can be changed as often as required. The encoder output is routed to the transmitter by way of the control unit.

The control unit is the focal point of the system. It contains a digital clock and the necessary logic circuitry and aneroid switches to ensure proper sequencing and interaction of system activities. Without issuing commands, the control unit will sequence the package through an entire mission if necessary. It will drop the antenna during ascent, turn the sampler on and off at preset times, blow ballast, terminate the flight, turn on the homing beacon and separate the package from the chute at impact. The setting of times for sample on, sample off, and terminate is accomplished via thumb wheel switches settable for 00.0 hrs to 99.9 hrs. The clock is designed so that disconnecting and reconnecting the power line resets it to 0.0 hrs. Therefore the time elapsed during checkout can be negated from the outside of the flight package simply by interrupting the power to the control unit. In the event of balloon burst, the package will be separated from the balloon and the sampler automatically turned off. When commands are issued through the HF receiver and selector, the return verification code indicating reception of the command by specific channel will be routed to the transmitter, thereby overriding the encoder for these few seconds. At termination by command, clock, or burst, an appropriate signal will be routed to the transmitter. A normal termination will cause a dashing signal to be transmitted and a balloon burst will result in a steady tone. Conspicuous by its absence in the control unit is the heavy duty open frame power relay for the samplers.

The power relay has been replaced with a solid state dc static switch which is mounted on the sampler and is activated by the control unit. This switch does not need power to hold it on. Therefore, three ends are accomplished: (1) the high current is removed from the proximity of the control logic, (2) the high current has a shorter distance to travel (less voltage drop to the blowers), and (3) there is no wasted holding power.

Before proceeding with the description of the test flights conducted to date, a few words should be said about the AR-60 altitude sensor and recorder. As noted earlier, two altitude sensors are used in the existing package. The B-34 sensor is used to follow the balloon's ascent to float altitude and the B-60 section of the AR-60 is used at float altitude. However, the entire range from ground to float altitude is within the operational limits of the B-60. The new instrument package uses the signal from a slightly modified B-60 to feed the encoder in two modes. One mode is very good up to 50 kft and the other mode is very good above 50 kft.

Therefore, one sensor supplies all the altitude data. However, the B-60 works on the ion chamber principle which degrades in quality as the altitude increases, that is, the accuracy is worst at float altitude. Research has been accomplished and procurement started on a sensor using an isotope and detector based on the energy in the particles. This sensor has its poorest accuracy (about 4 percent on the ground and its best accuracy (about 1 percent) at float altitude. The new sensor will interface directly to the new encoder and will replace the B-60 and free one more channel on the encoder. The control unit is unaffected.

The control unit and encoder previously described will function for either of the two systems now under consideration. The HF system has been flown twice and the results of these flights are given below.

The first flight (H72-73, 2 November 1972) was launched successfully; antenna drop was achieved by command the ascent appeared normal. However, at 47.8 kft after 47 min of flight, a burst indication was received by the control center and the package was on the chute. The beacon was activated and the sampler was locked off by the control unit. When the recovery crew reached the package, they noted that the impact switch had fired, and the DPS was running. At this time, the solid state dc static switch was not in use. The high blower current was being switched by a Potter-Brumfield mechanically latching relay. By correlating the times for impact, recovery, and the length of the on time from the PR-3 recorder, it was determined that the relay had latched at impact. The relay was subsequently replaced with the solid state switch designed at LCC. Although float altitude was not reached the control unit did function properly, the mechanical latching relay was proven undependable, and the control equipment was returned in perfect working order and the remaining system checked out favorably. Therefore, the flight did yield useful information. The second flight was more successful.

Launched on 27 March 1973, flight H73-17 was almost a complete success. Immediately after release, antenna drop was issued and properly activated. The system rose at about 1000 ft per min to the float altitude of 81.5 kft and in doing so, provided excellent altitude data for comparing the B-60 to two Rosemont Pressure Sensors which were on two unused encoder channels. Ballast was blown before the sampler was to come on and the expected altitude change was reflected in the B-60 and Rosemont data. When the sampler was to come on, there was no flow data on the encoder channel for the PR-3. The decision was made to assume all was OK in the sampler and continue the flight. Four hours later, prior to termination by command, the beacon (242.0 MHz) was turned on and then off by command and verified by the tracking aircraft. At termination the beacon came on and the package descended without incident. At impact the aircraft witnessed the chute impact release squibs fire. Upon the return of the package, the system was reassembled and the malfunction duplicated. The sampler ran but the UTMT did not open.

Inspection revealed the battery voltage was much lower than at launch indicating that the DFS did run for the sampling period. With a new 24 V battery pack, the sampler ran and the UTMT opened and flow data was transmitted. A cell by cell inspection of the battery pack from the flight revealed that 4 cells were bad. The voltage under the load of the DFS dropped sufficiently to prevent the UTMT from opening. This was duplicated with the new set of batteries. Although no sample was obtained the flight was very successful.

A third test flight is planned for late July 1973. This will be a reflight of the second flight system plus a new 40 MHz FM transmitter will be on board. This will enable the data to be transmitted through two down links: the HF system and the FM system.

After the test flight in late July a comparison will be made between the data available from HF telemetry and VHF-FM telemetry. Based on previous experience it is expected that interference in the VHF-FM range will be much less than that in the HF region. The configuration of the final system would be very similar to the proposed fourth test flight. The command receiver would be a modified Raven receiver/decoder and the data transmitted would be a new VHF-FM transmitter. (See four flight configuration block diagrams.) From the Mechanical point of view, the present system for assembling sampler frames onto the instrument frame is unreliable and time consuming. Because of this, it is necessary to redesign the instrumentation frame. Positive attachment, reproducible alignment and rapid assembly and disassembly is accomplished by the use of a quick disconnect clamp-on device. Also, by relocating the battery system, instrumentation, ballast, etc., the rotational requirement of the original system can be eliminated.

The new instrument storage frame has the capability of supporting one (1) to six (6) sampler frames in any sequence of combinations. The accompanying photographs demonstrate how this can be accomplished. Photo 1, shows the instrument gondola with a DFS frame in the free position. Photo 2, shows the DPS frame attached to the side of the instrument gondola for the two (2) or four (4) or six (6) frame combination. Photo 3 shows the DFS frame attached to the front for the two (2), or four (4) frame version. This prototype frame will be test flown in late July.

Future changes under consideration include choosing a tape recorder as an on board back-up should the telemetry fail, revamping the ground station and up-dating the Handbook to reflect all changes.

Incorporating the new hardware into the existing system will not be a piece by piece job. To avoid duplication of effort and numerous system changes, all new modular equipment will be built and tested. Then the existing flight system equipment will be replaced and the transformation will be complete if AEC/ARL are satisfied with the improved data collection results. Lead time on the active

components for the control unit and encoder is 35 weeks. Components were ordered late April 1973. Assembly time will be about 2 months. Until this time the old system will be used and minor maintenance changes made if necessary.

During the April series at Holloman AFB, NM, several flights were marred by faulty relays in the existing Control Units. These relays No. K 1, K 4, K 5, and K 6 were modified or replaced with sealed relays to preclude trouble from this source on future flights. These control units have been re-flown without incident.

In preparation for the new instrumentation frame interface into the system, twenty DFS frames will be made at AFCRL to replace the distorted frames now in inventory. This will eliminate the need for extensive rework to the old frame plus it will insure proper mating to the new frame attachment devices.

Appendix E

Instrumentation Checklist

PROJECT ASH CAN
INSTRUMENTATION CHECKLIST

ALTITUDE _____
DATE STARTED _____
FLT. NO. _____

PRELIMINARY:

Obtain the following items and note serial numbers:

Primary Instrumentation

Controller ..... _____

242 MH Beacon ..... _____

BCR 4 Receiver: freq ..... _____
S/N ..... _____

Selector ..... _____

Transmitter ..... _____

Reed Box ..... _____

B-60 ..... _____

Rosemount ..... _____

V-F Converter ..... _____

Encoder ..... _____

Printer ..... _____

Printer Interface ..... _____

Backup Instrumentation

Receiver ..... _____

Reed Box ..... _____

Controller ..... _____

Obtain batteries for DFS, Primary and Backup Package. Test each cell under load and record on the following sheets.

Initials _____

Primary System Battery Check

Flight _____ Date _____

nominal cell voltage at + terminal	individual cell voltage after charging		individual cell voltage after despiking	
	no load	0.6 ohm load	no load	0.6 ohm load
25 H's	serial number _____			
27.0				
25.5				
24.0				
22.5				
21.0				
19.5				
18.0				
16.5				
15.0				
13.5				
BB-405's	no load	0.3 ohm load	no load	0.3 ohm load
12.0				
10.5				
9.0				
7.5				
6.0				
4.5				
3.0				
1.5				

serial number _____ date: _____

time: _____

initials: _____

26 Nov 75

Primary System Battery Check
(continued)

Flight _____ Date _____

nominal cell voltage at - terminal	individual cell voltage after charging		individual cell voltage after despiking	
	no load	1.5 ohm load	no load	1.5 ohm load
10 H's				
-12.0	_____	_____	_____	_____
-10.5	_____	_____	_____	_____
-9.0	_____	_____	_____	_____
-7.5	_____	_____	_____	_____
-6.0	_____	_____	_____	_____
-4.5	_____	_____	_____	_____
-3.0	_____	_____	_____	_____
-1.5	_____	_____	_____	_____

serial number _____

date: _____

time: _____

initials: _____

26 Nov 75

Backup System Battery Check

Flight _____ Date _____

nominal cell voltage at - terminal	individual cell voltage after charging		individual cell voltage after despiking	
	no load	2.5 ohm load	no load	2.5 ohm load
6 H's	serial number _____			
-12.0				
-10.5				
-9.0				
-7.5				
-6.0				
-4.5				
-3.0				
-1.5				
+ terminal	serial number _____			
1.5				
3.0				
4.5				
6.0				
7.5				
9.0				
10.5				
12.0				

date: _____

time: _____

initials: _____

26 Nov 75

DATE_____

FLIGHT_____

DFS BATTER CHECK

SET #

NOMINAL CELL VOLTAGE AT +	INDIVIDUAL CELL VOLTS NO LOAD	INDIVIDUAL CELL VOLTS 0.3Ω LOAD
24.0		
22.5		
21.0		
19.5		
18.0		
16.5		
15.0		
13.5		
12.0		
10.5		
9.0		
7.5		
6.0		
4.5		
3.0		
1.5		

Initials_____

DATE_____

FLIGHT_____

DFS BATTER CHECK

SET #

NOMINAL CELL VOLTAGE AT +	INDIVIDUAL CELL VOLTS NO LOAD	INDIVIDUAL CELL VOLTS 0.3Ω LOAD
24.0		
22.5		
21.0		
19.5		
18.0		
16.5		
15.0		
13.5		
12.0		
10.5		
9.0		
7.5		
6.0		
4.5		
3.0		
1.5		

Initials_____

DATE_____

FLIGHT_____

DFS BATTER CHECK

SET #

NOMINAL CELL VOLTAGE AT +	INDIVIDUAL CELL VOLTS NO LOAD	INDIVIDUAL CELL VOLTS 0.3Ω LOAD
24.0		
22.5		
21.0		
19.5		
18.0		
16.5		
15.0		
13.5		
12.0		
10.5		
9.0		
7.5		
6.0		
4.5		
3.0		
1.5		

Initials_____

NOMINAL BAROSWITCH ACTIVATION ALTITUDES

Antenna drop (10K ft)	_____Kft
Burst interlock (15K ft)	_____Kft
Rotate package (26K ft)	_____Kft
Safety time interlock (45K ft)	_____Kft

SAFETY TIME

Timer setting (2 hrs) _____Hours

Use column at right if Project Officer desires a change.

CALCULATIONS FOR TIMERS

A. Time to float altitude is calculated using an ascent rate of 800 feet per minute from ground altitude A_G to float altitude A_F

$$\text{Time to float altitude} = \frac{A_F - A_G}{48 \text{ Kft/hr.}}$$

Where A_F = float altitude (K feet) = _____

A_G = ground altitude (K feet) = _____

Therefore, substituting

Time to float altitude = [( ) - ( )] / 48

= ÷ 48

= _____ hours

Check times with the Project Officer before proceeding.

B. Sample on Time = time before launch (0.2 hrs) + time to float + altitude adjust time (0.4 hrs) + time before sample (0.2 hrs)

= 0.8 hrs + time to float altitude

= 0.8 hrs + _____ hrs

SAMPLE ON TIME = _____ hours

C. Sample Off Time = Sample On time + Sample Time (see form 24)

= _____hrs + _____hrs

SAMPLE OFF TIME = _____hours

D. Primary Termination = Sample off time + 2.0 hrs

= _____hrs + 2.0 hrs

PRIMARY TERMINATION = _____hours

E. Backup Termination = Primary Termination + 1.0 hrs

= _____hrs + 1.0 hrs

BACKUP TERMINATION = _____ hours

HRS	0	1	2	3	4	5	6	7	8	9
0	0.00 -	3.51 -	7.03 -	10.54 -	14.06 -	17.57 -	21.09 -	24.61 -	28.13 -	31.64 -
10	35.16 -	38.68 -	42.19 -	45.71 -	49.22 -	52.74 -	56.26 -	59.77 -	63.29 1'3.3"	66.80 6'6.8"
20	70.32 1'10.3"	73.84 1'13.8"	77.35 1'17.4"	80.87 1'20.9"	84.38 1'24.4"	87.90 1'27.9"	91.42 1'31.4"	94.93 1'34.9"	98.45 1'38.5"	101.96 1'42.0"
30	105.47 1'45.5"	108.99 1'49.0"	112.51 1'52.5"	116.03 1'56.0"	119.54 1'59.5"	123.06 2'3.1"	126.58 2'6.6"	130.09 2'10.1"	133.61 2'13.6"	137.12 2'17.1"
40	140.63 2'20.6"	144.16 2'24.2"	147.67 2'27.7"	151.12 2'31.1"	154.70 2'34.7"	158.22 2'38.2"	161.74 2'41.7"	165.25 2'45.3"	168.77 2'48.8"	172.28 2'52.3"
50	175.78 2'55.8"	179.30 2'59.3	182.81 3'2.8"	186.33 3'6.3"	189.84 3'9.8"	193.36 3'13.4"	196.87 3'16.87"	200.38 3'20.4"	203.90 3'23.9"	207.42 2'27.4"
60	210.94 3'30.9"	214.45 3'34.5"	217.97 3'38.0"	221.48 3'41.5"	225.00 3'45.0"	228.51 3'48.5"	232.03 3'52.0"	235.55 3'55.6"	239.06 3'59.1"	242.58 4'2.6"
70	246.09 4'6.1"	249.61 4'9.6"	253.12 4'13.1"	256.64 4'16.6"	260.15 4'20.2"	263.67 4'23.7"	267.19 4'27.2"	270.70 4'30.7"	274.22 4'34.2"	277.73 4'37.7"
80	281.25 4'41.3"	284.76 4'44.8"	288.28 4'48.3"	291.79 4'51.8"	295.31 4'55.3"	298.83 4'58.8"	302.34 5'2.3"	305.86 5'5.9"	309.37 5'9.4"	312.89 5'12.9"
90	316.41 5'16.4"	319.92 5'19.9"	323.44 5'23.4"	326.95 5'27.0"	330.47 5'30.5"	333.98 5'34.0"	337.50 5'37.5"	341.01 5'41.0"	344.53 5'44.5"	348.04 5'48.0"

AD-A060 062 AIR FORCE GEOPHYSICS LAB HANSCOM AFB MASS F/G 4/1
ABOUT THE DEVELOPMENT OF A SECOND GENERATION ATMOSPHERIC SAMPLE--ETC(U)
MAR 78 R H CORDELLA

UNCLASSIFIED AFGL-TR-78-0065 NL

2 OF 3
AD
A060062



SECTION ONE:

BENCH CHECK OF CONTROLLER

1-1. Remove controller from its case and visually inspect for loose components, broken wires, bent pins etc. Check all fuses. _____

1-2. Set Safety Switch to "5" and set baroswitches.
Actual altitudes: Antenna Drop _____Kft
burst _____Kft
rotate _____Kft
safety _____Kft

1-3. Set all times to 99.9 _____

1-4. Connect Power Cable to J-1
Connect Command Simulator to J-2
Connect Test Box J-31 to J-3
Reset all Test Box Circuit Breakers _____

1-5. Apply power to Controller
Indications:
Valve Closed light-ON
Sample Off Light-ON (≈ 6 Osec.)
Skinner Closed light-ON (≈ 6 Osec.) _____

1-6. Using a VOM do a zero voltage check and then a resistance check on the primary separation squib port. _____

1-7. Depress Command 1
Indications:
No change in indications _____

1-8. Depress Command 2
Indications:
Beacon light-ON (remains on after command released) _____

1-9. Depress Command 3
Indications:
Blow Ballast breaker tripped.
Blow Ballast light-ON (OFF when command released)
Reset breaker _____

1-10. Depress Command 4
Indications:
Antenna drop breaker tripped
Antenna drop light-ON (OFF when command released)
Beacon light-OFF
Reset breaker _____

1-11. Depress Command 5
Indications:
ASV light-ON
2 Wire Skinner light-ON (OFF when command released)
3 Wire Skinner light-ON (OFF when command released)
HCS ON light-ON (OFF when command released) _____

1-12. Depress Command 6
Indications:
ASV light OFF
HCS OFF light ON (for ≈ 70 seconds after released)
Skinner closed lights ON (for ≈ 70 seconds after command released) _____

1-13. Depress Command 7
Indications:
Valve open light ON (when command depressed)
Valve closed light OFF (when command depressed)
Valve open light-OFF (when command released)
Valve closed light-ON (when command released) _____

1-14. Depress Command 8
Indications:
Pour ballast light-ON (OFF when command released) _____

1-15. Depress Command 9 for 5 seconds
Indications:
Valve closed light-OFF
Valve open light-ON
HCS Lock light-ON
HCS OFF light-ON
Skinner closed light-ON
After Approximately 5 seconds:
Beacon light-ON
After Approximately 70 seconds:
Sample OFF light-OFF
Skinner closed light-OFF
After Approximately 32 seconds:
Main Separate breaker-tripped
Main Separate light-ON
Gas Release light-ON
Blow Ballast light-ON
After Approximately 64 seconds:
Main Separate light-OFF
Valve Closed light-ON
Valve Open light-OFF
Sample Lock light-OFF
Gas Release light-OFF
Blow Ballast light-OFF _____

1-16. Depress Command 5
Indication:
Sample should NOT come ON _____

1-17. Remove power from Controller
Reset all test box circuit breakers
Set safety time switch to predetermined hours
and record setting_____hours and elapsed time
for accelerated mode_____seconds. _____

1-18. Apply power to controller and, after the sampler OFF
pulse has passed, connect jumper from V_{DD} to test key.
Indication:
After the number of seconds recorded in 1-16 plus
4 seconds have elapsed the termination sequence begins
and runs as usual. _____

1-19. Remove power from controller. Remove jumper from test key
Reset test box circuit breakers.
Set time switches to previously calculated values
and look up accelerated times.

Sample On_____hrs	:	:	On_____sec.
Sample Off_____hrs	:	:	Off_____sec.
Terminate_____hrs	:	:	T_____sec.

On Board 1:
Set safety switch to 5
Place scope probe on resistor R 31 (200KΩ) to note 0.35
second pulse.
Probe should be on side of R 31 nearest borad connection. _____

1-20. Apply power to controller. After OFF light are
extinguished, connect test key jumper.
Indications:
After approximately ON seconds:
Sample on light ON (momentary)
Skinner open light-ON (momentary)
After approximately OFF seconds:
Sample off light ON (momentary)
Skinner closed light ON (momentary)
After approximately T seconds:
A pulse will be noted on the scope _____

1-21. Remove power from controller. Remove scope probe.
Set all time switches to 99.9 hours
Remove jumper from Vdd to test key
Connect jumper from C to NO on antenna
drop baroswithces (S1) _____

1-22. Place burst switch in OFF (Open) position
Apply power to controller
Indications:
Valve closed light-ON
Sample OFF light-ON (≈ 70 sec.)
Skinner closed light-ON (≈ 70 sec.)
Antenna drop breaker-Tripped
Antenna drop light-ON

1-23. Remove power from controller
Remove jumper from S1

ONLY AT INITIAL CONSTRUCTION: Use the set screw on S1 to simulate ascending and decending past 10K feet to check out the impact circuit.

1-24. Place jumper NC to C of S2
Apply power
Set burst switch on test box to ON position
Indications:
Main Separate breaker-tripped
Main separate light-ON
Valve closed light-OFF
Valve open light-ON
Sample lock light-ON
Sample off light-ON
Skinner closed light-ON
Gas release light-ON
Blow ballast breaker-tripped
Blow ballast light-ON
After Approximately 5 seconds:
Beacon light-ON
After Approximately 70 seconds:
Sample off light-OFF
Skinner closed light-OFF
After Approximately 64 seconds
Valve closed light-ON
Valve open light-OFF
Sample lock light-OFF

1-25. Turn power off for at least 30 seconds. Open the burst switch. Turn power on. Momentarily depress command 10 button. Close burst switch.
Indication:
There should be no change as the burst switch is now latched out of the circuit.

1-26. Using a frequency counter check the output of the oscillator which is used to drive the FM Transmitter. Test point 2, on board 2, is available without removing the board.

Record the frequency_____Hz.
Remove the counter probe _____

1-27. Remove power from controller
Reset all test box circuit breakers
Remove all cables from controller
Remove jumper from baroswitch _____

1-28. Install controller in instrument frame _____

SECTION TWO:

BENCH CHECK OF ENCODER

2-1. Assemble test equipment: encoder test set (signal generator and two cables), power supply and, strip chart recorder. _____

2-2. Remove encoder from its case. Inspect it for loose components, bent pins, foreign matter. _____

2-3. Set power supply for 13V and turn it off. Attach power leads to signal generator. Connect encoder to signal generator using Cable I.
Place all flow channel switches in OFF (down) position.
Set "Hertz" selection dial at 30.
Sonalert may be on or off to suit operator if the chart recorder is used.
If you want to see the messages, monitor the encoder output by connecting a chart recorder on the appropriate binding posts. _____

2-4. Turn on power supply.
Result:
Encoder begins in short cycle: i.e., the first three channels (B-60, housekeeping, Rosemount) are repeated over and over. The codes will be approximately:

channel 1	SWUD	(0314)
2	SSSS	(0000)
4	DSSS	(4000)

Remember that a digital system has a 1 bit resolution; therefore, the code may vary in the least significant letter. _____

2-5. Depress the valve reply button until the second channel code begins.
Result:
Code on channels one and three unaffected. Code on channel 2 changes to DSSS for one message. _____

2-6. Depress ballast reply button until the second channel code begins.
Result:
Code on channel two changes to RSSS for one message. _____

2-7. Depress burst pin reply button until the second channel code begins.
Result:
Code on channel two changes to USSS for one message. _____

2-8. Depress command 1 button momentarily.
Result:
Encoder restarts the message and will continue to long cycle. The words for channels greater than three are sets of flow (even numbered channels) and temperature (odd numbered channels) data. All flow channels will have codes of SSSS or SSSU and the temperature channels will have a code where the first letter of the work, corresponds to the number of the data set' i.e.,

set	channels	temperature code
1	4, 5	U --- (1 ---)
2	6, 7	R --- (2 ---)
3	8, 9	W --- (3 ---)
4	10, 11	D --- (4 ---)
5	12, 13	K --- (5 ---)
6	14, 15	G --- (6 ---)

_____

2-9. Engage the first flow channel (work #4) with flow channel switch #1.
Result:
Code of SUOS (0170) is on channel 4 every message. The least significant letter (on the right) may be a U or an R.
Disengage flow channel #1. _____

2-10. Check remaining channels using same method outlined in 2-9. Use reset button on the encoder to expidite the procedure if desired.
flow channel: 2 _____
3 _____
4 _____
5 _____
6 _____ _____

2-11. If desired 2-9 and 2-10 can be repeated for 60 Hz and/or 90Hz. The codes are SWGS (0360) and SKKS (0550) respectively. _____

2-12. Turn off power supply and disconnect the test set from the encoder. _____

2-13. Install encoder in package _____

SECTION THREE:

CHECKOUT OF PRIMARY PACKAGE

3-1. Install controller in instrumentation frame
Connect J-11 on package to J-1 on controller
Connect Command Simulator to J-2 on controller
Connect J-31 on package to J-3 on controller
Connect J04 to J03 on filter
Connect J-33 on package to J-34 on Test Box
Connect J-12 on package to Power Cable
Connect J01 to J02 on filter
Disconnect power connectors from beacon, FM transmitter, printer interface, B-60 and Rosemount
Connect J-51 to J-50 on controller
Connect beeper box to AM transmitter connector _____

3-2. Reset all circuit breakers
Apply power to package
Indications:
Valve closed light-ON
HCS off light ON (70 sec.)
Skinner closed lights ON (70 sec.) _____

3-3. Depress Command 1
Indications:
No change in indications _____

3-4. Depress Command 2
Indications:
No change in indications _____

3-5. Depress Command 3
Indications:
Blow ballast breaker tripped
Blow ballast light-ON (OFF when command released) _____

3-6. Depress Command 4
Indications:
Antenna drop breaker tripped
Antenna drop light-ON (OFF when command released) _____

3-7. Depress Command 5
Indications:
HCS On light ON (OFF when command released)
Skinner Open light-ON (OFF when command released)
ASV light-ON _____

3-8. Depress Command 6
Indications:
HCS Off light-ON
Skinner Closed lights-ON
For ≈ 70 seconds after command released
ASV light-OFF _____

3-9. Depress Command 7
Indications:
Valve Open light-ON
Valve Closed light OFF when command depressed
Valve Open light-OFF
Valve Closed light-ON when command released _____

3-10. Depress Command 8
Indications:
Pour Ballast light-ON (OFF when command released) _____

3-11. Reset all circuit breakers
Depress Command 9 for 5 seconds
Indications:
Valve Closed light-OFF
Valve Open light-ON
Sample Lock light-ON, dashing for ≈ one minute
Skinner Closed light-ON
After Approximately 70 seconds
Sample OFF light-OFF
Skinner Closed light-OFF
After Approximately 32 seconds
Main Separate breaker-Tripped
Main Separate light-ON
Gas Release light-ON
Blow Ballast breaker-Tripped
Blow Ballast light-ON
After Approximately 64 seconds
Main Separate light-OFF
Valve Closed light-ON
Valve Open light-OFF
Sample Lock light-OFF
Gas Release light-OFF
Blow Ballast light-OFF _____

3-12. Depress Command 5
Indications:
No change in indications _____

3-13. Remove Power from package
Reset all Test Box circuit breakers _____

3-14. Install AM transmitter in package (optional)
Connect J-52 on Package to transmitter
Connect J-41 on package to J-4 on controller
Connect J-414 on package to J-415 on encoder _____

3-15. Apply power to package
Indications:
Beeper Box emits a steady tone for approximately 4 seconds. Then 4 morse code "S", pause, 4 morse code "S", pause, 4 morse code "S", and back to 4 second warning tone to indicate start of cycle. (This is called "short mode"). _____

3-16. Depress Command 1
Indications:
Beeper Box emits a warning tone for as long as the command is depressed.
When command is released, encoder steps through a random number of information channels until encoder key is received from the control unit. When encoder key is received, encoder will cycle back to warning tone, then step through 15 information channels. (This is called "Long mode"). _____

3-17. Depress the Reset Button on top of the Encoder
Indications:
Encoder will cycle to the warning tone. _____

3-18. Disconnect J-414 from Encoder for one minute
Indications:
When Power is restored Encoder will be in short mode _____

3-19. Depress Command 1
Indications:
Encoder will go into long mode _____

3-20. Depress Command 1
Indications:
Encoder will go into short cycle _____

3-21. Remove power from the package
Connect J-42 to the B-60. Energize package.
Indications:
The code on Encoder channel one will change from SSSS to a combination representative of the altitude at which the check is being performed. Check altitude in the dictionary. No other channel will change. _____

3-22. Connect J-46 to the Rosemount altitude sensor and J-44 to the voltage to frequency converter.
Indications:
If the Rosemount sensor is of the range 0-16 PSIA. A code other than SSSS will appear on Encoder channel three. Check this in the dictionary. _____

3-23. Remove power from the package and connect J-412 to the data printer interface box. Reapply power. While the transmitter gives the 4 second tone the printer will skip a line. The printer will record each data word plus a time code as the transmitter begins to transmit. _____

3-24. Press and hold command 7 until indication is confirmed.
Indications:
Test Box will indicate valve open voltage is applied and will return a reply signal to the controller and encoder so that "DSSS" is transmitted on channel two and "DSSS" is printed by the data recorder. _____

3-25. Press and hold Command 8 until indication is confirmed.
Indication:
Test Box will indicate pour ballast and will return a reply signal to the Encoder so that "RSS" is transmitted on channel two and "RSSS" is printed. _____

3-26. Place burst switch simulator on Test Box in the set (continuity) position.
Indication:
The Encoder will signal "USSS" on channel two via the transmitter and the data recorder will print "USSS" _____

3-27. Reset the Burst Switch Simulator. _____

3-28. Remove Power. Remove command simulator. Connect J-21 to J-2. Connect J-26 to the receiver, J-25 to the reed box and J-22, J-23, J-24 to the selector. Connect an antenna to the receiver. _____

3-29. Reapply power and using the command test set issue commands 1 through 9, verify replys and verify indications as in steps 3-3 through 3-12. _____

Frequency	_____ KHz		_____ KHz
1	_____	6	_____
2	_____	7	_____
3	_____	8	_____
4	_____	9	_____
5	_____		

_____

3-30. Remove power. Connect Wattmeter to FMT-1A feed through on Package. Connect J-53 to the transmitter. Turn on FM receiver. _____

3-31. Reapply power to the instrumentation. Tune the FM receiver to the FM transmitter frequency. The FM and AM transmissions should be identical. The Wattmeter should indicate about 10 watts. _____

3-32. Remove Power. _____

3-33. Disconnect J-53 from the FM transmitter. Remove Wattmeter. Attach data cable to J-48 and using the encoder signal generator check the continuity of the cable and numbering of the J-42X connectors. _____

3-34. Remove power. _____

SECTION FOUR:

BENCH CHECK BACKUP CONTROLLER AND BACKUP PACKAGE

4-1. Attach battery/receiver cable to power supplies or batteries.

WHT	-12v
BLK	GND
RED	+12v
GRN	+12v if S-68 SQUIBS are used.

_____

4-2. Attach command simulator (CS-2) to the battery/receiver cable. _____

4-3. Connect the battery/receiver cable to the backup controller. _____

4-4. With the start plug out, connect the system interface cable to the backup controller and to the test box J-61, J-100 and J-101. J-62 is not connected at this time. _____

4-5. Set the time to termination to 99.9 hours and connect the start plug.
Indication:
No lamp will come on because J-62 is not connected. _____

4-6. Using a VOM do a zero voltage check and then a resistance check on the secondary separation squib port. _____

4-7. Press command three on the command simulator. Release command three.
Indication:
While the button is depressed the lamp indicating pour Ballast will be lit. _____

4-8. Press command two on the command simulator. Release command two.
Indication:
When the button is depressed the lamp indicating the application of valve opening voltage will be lit. When the button is released the lamp indicating what valve closing voltage is applied will be lit for about 30 seconds. This gives the valve time to close using the batteries in the backup package. The extinquishing of the lamp indicates that control of the valve has switched back to the primary controller but J-62 is not connected. So the lamp which would normally be lit (indicating closing voltage) is not lit. _____

4-9. Press command one for 5 seconds on the command simulator.
Release command one.
Indication:
The lamp indicating application of the valve opening voltage will come on immediately.
At about 32 seconds the secondary termination light comes on and ballast blow lamp will illuminate.
At about 64 seconds the ballast and separation lamps will extinguish and the lamp indicating valve closing voltage will light.
At about 95 seconds the valve light will go out. _____

4-10. Remove power from the backup controller. Set the time select switch for the hours from launch that backup time will terminate the flight. TIME _____HRS _____

4-11. Open the backup controller and place a jumper from Vdd to the clock accelerate test point. Look up the elapsed time corresponding to the time set in. TIME_____MIN____SEC _____

4-12. Place scope probe on resistor R1 (200KΩ)
Using a stop watch time the accelerated clock from the application of power to the positive pulse on the scope
MIN_____SEC _____

4-13. Remove power _____

4-14. Remove jumper between Vdd and clock accelerate of backup controller. Remove scope probe. _____

4-15. Check receiver/selector with BCTS 3A. _____

SECTION FIVE:

CHECKOUT OF INTEGRATED SYSTEM

5-1. Check receiver and reeds using BCTS-3A
Install components in back-up package
Connect back-up package components _____

5-2. Insure all primary instrumentation components are connected. _____

5-3. Connect system interface cable between primary instrumentation and back-up package
Connect Test Box into system interface cable.
Connect Beeper Box to AM Output of primary instrumentation.
Connect Wattmeter to FM Output of primary instrumentation _____

5-4. Connect power cable between primary instrumentation and instrumentation and battery box.
Install back-up package start plug. _____

5-5. Using BCTS-3A, Command7
Indications:
Valve open light ON (When Command Depressed).
Valve closed light OFF (When Command Depressed).
Valve open light-OFF (When Command Released).
Valve closed light-ON (When Command Released). _____

5-6. Using BCTS-3A, Command 8
Indications:
Pour ballast light-ON (OFF when Command Released). _____

5-7. Using BCTS-3A, Command 9
Indications:
Valve open light-ON
Valve closed light-OFF
After Approximately 32 seconds:
Main separate breaker Tripped
Main separate light-ON
Blow ballast breaker-Tripped
Blow ballast light-ON
After Approximately 64 seconds:
Main separate light-OFF
Valve closed light ON
Valve open light OFF
Blow ballast light-OFF _____

5-8. Remove power from primary and back-up package.
Connect high current switch to control cable.
Connect high current switch to test motor
Connect high current switch to DFS batteries.
Connect CS-1 to J-2 on Controller _____
Apply power to primary and back-up packages.

---------- NOTE ----------

In the following step the motor must not run for more than 2 minutes to prevent damage to equipment. Also, each section of each high current switch must be checked.

5-9. Using CS-1, command 5 and hold until motor comes on. As soon as motor reaches speed command 6 to shut down. (Note: In event motor will not respond to command 6, disconnect DFS battery pack to prevent damage). _____

5-10. Using CS-1, command 5
ommand 9 and insure termination sequence shuts down motor.
ommand 5 and insure motor cannot be re-started after initiation of termination sequence. _____

5-11. Disconnect high current switch from DFS battery package.
Disconnect high current switch from control cable.
Reset all est ox circuit breakers.
Apply Power to primary and back-up packages. _____

5-12. Using BCTS-3A non-sequenced, Command 2
Indications:
Valve open light-ON
Valve closed light-OFF when dommand depressed
Valve open light-OFF
Valve closed light-ON when command released _____

5-13. Using BCTS-3A non-sequenced, command 3
Indications:
Pour ballast light-ON (OFF when CMD released) _____

5-14. Using BCTS-3A, non-sequenced command 1
Indications:
Valve open light-ON
Valve closed light-OFF
After Approximately 32 seconds:
Backup separate breaker-tripped
Backup separate light-ON
Blow ballast breaker-Tripped
Blow ballast light-ON
After Approximately 64 seconds:
Backup separate light-OFF
Valve open light-OFF
Valve closed light-ON
Blow ballast light-OFF _____

5-15. Remove power from primary and back-up packages. _____

5-16. If time permits repeat Steps 5-3 thru 5-7 using control center transmitter. _____

5-17. Connect impact circuit test box between J-39 and J-310 after connecting J-34 to primary package. Apply power to packages.
Indication:
Green lamp lights indicating squib is grounded. _____

5-18. Depress switches 1 through 4 (simulating impact switches).
Indication:
Should have no effect. _____

WARNING

This next step simulates ascent past antenna drop aneroid altitude and it will energize the antenna drop squib circuit.

5-19. Depress arm button (momentarily)
Indication:
Amber light ON momentarily (Circuit now Armed)
Green light remains ON _____

5-20. Depress any switch 1 through 4 (simulating impact switches)
Indication:
Will trip the circuit breaker simulating the squib.
Red light-ON
Green light-OFF _____

5-21. Remove power from primary and back-up packages.
Disconnect impact circuit test box. _____

5-22. Conduct a valve check through the balloon. Code_____.

5-23. Check burst pin and code_____.

5-24. At the parachute apex perform zero voltage and zero resistance checks on the primary separation squib port _____
and on the secondary separation squib port _____.

SECTION SIX

FINAL PREPARATIONS

6-1. Set or verify the following flight data:

Primary package:
SAMPLE ON: _____
SAMPLE OFF: _____
TERMINATE: _____
SAFETY SWITCH: _____
Back-up package:
TERMINATE: _____ _____

6-2. Check all cable connections in primary and back-up packages.
Verify all components secure in primary and back-up packages.
Verify back-up batteries securely connected and held in place.
Verify system batteries securely connected and held in place.
Check all cable connections and associated hardware for security on complete rack.
Insure rack is prepared for movement to flight line. _____

6-3. Put a new paper refill in the printer _____

6-4. Verify all items on this checklist have been completed and initialed to indicate completeness. _____

6-5. Attach ground strap between instrumentation frame and gondola. _____

Appendix F

Flow Rate Program

F1. GENERAL

This program produces a dictionary to relate flow rates to every code combination available from the encoder. It has no input per se because the relationship between the flow rate and the events counted by the data counter is purely mathematical and is generated in the program.

F1.1 The Algorithm

The counts are four times the frequency output by the PR-3 flow sensor because the frequency is doubled and sampled for two seconds. Therefore

$$\text{Count} = \text{frequency } \left(\frac{\text{events}}{\text{second}}\right) \times 2 \times 2 \text{ sec} = \text{events} \times 4 \ .$$

See Reference 1, Section 6.4 for a block diagram and Reference 14 for its implementation.

F1.2 The Output

Sixteen pages of tables, 256 words per page, comprise the computer output. Both data printers (flight and ground) record the twelve bit data word in a four letter code where each letter represents three bits. Therefore, should the flow rate be represented by SRKG, the speed of the flow sensor is 43.50 Hz. This figure is used with the sensor calibration to ascertain the flow rate as cubic feet per minute.

A complete copy of the computer program follows. The dictionary is printed in an 8 × 10-1/2 in. format to facilitate placement in a ring binder. It is valid until the sensor or encoder is changed.

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```
PROGRAM CPS        74/74   OPT=1                    FTN 4.8+414        03/11/77
```

```
      PROGRAM CPS(OUTPUT,TAPE6=OUTPUT)
      DIMENSION LETTR(8),X(8)
      DATA LETTR/1HS,1HU,1HR,1HW,1HD,1HK,1HG,1HO/
      N=0
      DO 500 J1=1,16
      WRITE(6,101) J1
  101 FORMAT(1H1,6X,"COUNTS VS CPS",48X,"PAGE",I3)
      WRITE(6,102)
  102 FORMAT(1H0,38X,"CPS")
      WRITE(6,103) LETTR
  103 FORMAT(1H0,8X,8(7X,A1))
      K1= (J1+1)/2
      DO 400 J2=1,4
      WRITE(6,104)
  104 FORMAT(1H )
      DO 300 J3=1,8
      DO 200 J4= 1,8
      X(J4)= 0.25*FLOAT(N)
  200 N= N+1
      K2= MOD((J1-1)*4+J2-1,8)+1
  300 WRITE(6,301) LETTR(K1),LETTR(K2),LETTR(J3),X
  301 FORMAT(1H ,6X,3A1,1X,8F8.2)
  400 CONTINUE
  500 CONTINUE
      STOP
      END
```


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LOAD MAP - CPS CYBER LOADER 1.1-420 03/12/77 15.47.43 PAGE 1

FWA OF THE LOAD 111
LWA+1 OF THE LOAD 13465

TRANSFER ADDRESS -- CPS 2157

PROGRAM AND BLOCK ASSIGNMENTS.

BLOCK	ADDRESS	LENGTH	FILE	DATE	PROCSSR	VER	LEVEL	HARDWARE	COMMENTS
CPS	111	2220	LGO	03/11/77	FTN	3.	3-414	6600 I	OPTS.
/PCL.C./	2331	23							
/Q8.IO./	2354	131							
CENTRY=	2505	0	SL-FORTRAN	08/11/76	COMPASS	3.	3-414		FCL INITIALIZATION ROUTINE
COMIO=	2505	64	SL-FORTRAN	08/11/76	COMPASS	3.	3-414		COMMON BLK FOR I/O ROUTINES AND BUFFERS
FCHSK=	2971	41	SL-FORTRAN	08/11/76	COMPASS	3.	3-414		INITIALIZE CONSTANTS.
FLTOUT=	2632	310	SL-FORTRAN	08/11/76	COMPASS	3.	3-414		COMMON FLD FOR OUTPUT SUB
FORSYS=	3142	601	SL-FORTRAN	08/11/76	COMPASS	3.	3-414		FORTRAN OBJECT LIB ANY UTILITY S
OUTCOM=	3743	154	SL-FORTRAN	08/11/76	COMPASS	3.	3-414		COMMON OUT UT
SYSAID=	4117	1	SL-FORTRAN	08/11/76	COMPASS	3.	3-414		LINK BETWEEN SYSAID SUB ENTRY & LAST
FMTAP=	4120	352	SL-FORTRAN	08/11/76	COMPASS	3.	3-414		STACK APPL I/O FOR
FORUTL=	4472	16	SL-FORTRAN	08/11/76	COMPASS	3.	3-414		FCL MISC UTILITIES
GETFIT=	4510	42	SL-FORTRAN	08/11/76	COMPASS	3.	3-414		LOCAT AN FIT
KOMPR=	4552	456	SL-FORTRAN	08/11/76	COMPASS	3.	3-414		OUTPUT FORM
OUTC=	5230	172	SL-FORTRAN	08/11/76	COMPASS	3.	3-414		FORMATTED WAIT
/CON.RM/	5422	6							
CIO.RM	5430	40	SL-SYSIO	05/26/76	COMPASS	3.	75125		
/A8P.RM/	5470	10							
MOVE.RM	5500	64	SL-SYSIO	05/26/76	COMPASS	3.	75125		
PCT.RM	5564	233	SL-SYSIO	05/26/76	COMPASS	3.	75125		
/JMPS.RM/	6017	11							
/MEMC.RM/	6030	3							
/OPSS.FO/	6033	1							
/OPEN.FO/	6034	7							
OPEN.RM	6043	235	SL-SYSIO	05/26/76	COMPASS	3.	75125		
/TERM.RM/	6300	1							
/PUT.FO/	6301	7							
PUT.SQ	6310	1362	SL-SYSIO	05/26/76	COMPASS	3.	75125		
WAP.SQ	7672	260	SL-SYSIO	05/26/76	COMPASS	3.	75125		
/CLSF.FO/	10152	7							
CLSF.RM	10161	23	SL-SYSIO	05/26/76	COMPASS	3.	75125		
/GET.BT/	10204	5							
RTRT.SQ	10211	114	SL-SYSIO	05/26/76	COMPASS	3.	75125		
NEOV.SQ	10325	142	SL-SYSIO	05/26/76	COMPASS	3.	75125		
/SKFL.FO/	10467	7							
SKFL.SQ	10476	47	SL-SYSIO	05/26/76	COMPASS	3.	75125		
ERR.RM	10545	404	SL-SYSIO	05/26/76	COMPASS	3.	75125		
CHWR.SQ	11151	7	SL-SYSIO	05/26/76	COMPASS	3.	75125		
CSUR.RM	11160	65	SL-SYSIO	05/26/76	COMPASS	3.	75125		
OPEN.SQ	11245	262	SL-SYSIO	05/26/76	COMPASS	3.	75125		
OPEX.SQ	11527	14	SL-SYSIO	05/26/76	COMPASS	3.	75125		
/PUT.RT/	11543	11							
RLEO.RM	11554	42	SL-SYSIO	05/26/76	COMPASS	3.	75125		
CLSF.SQ	11616	132	SL-SYSIO	05/26/76	COMPASS	3.	75125		
/CLSV.FO/	11750	7							

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LOAD MAP - CPS CYBER LOADER 1.3+42 [illegible]

CLSV.SQ	11757	123	SL-SYSIO	08/28/76	COMPASS 3. 7512[illegible]
/REW.FO/	12102	7			
REW.SQ	12111	31	SL-SYSIO	08/28/76	COMPASS 3. 7512[illegible]
/GET.FO/	12142	7			
/GET.RT/	12151	11			
GET.SQ	12162	1035	SL-SYSIO	08/28/76	COMPASS 3. 7512[illegible]
Z.SQ	13217	101	SL-SYSIO	08/28/76	COMPASS 3. 7512[illegible]
FSU.SQ	13320	106	SL-SYSIO	08/28/76	COMPASS 3. 7512[illegible]
SYS.PM	13426	37	SL-NUCLEUS	08/29/76	COMPASS 3. 7512[illegible] PROC SL SYST[illegible]

.407 CP SECONDS 25[illegible] CM STORAGE USED [illegible] TABL[illegible] 10V 5

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COUNTS VS CPS

PAGE 1

	S	U	R	W	P	K	G	O
				CPS				
SSS	0.00	.25	.50	.75	1.00	1.25	1.5	1.75
SSU	2.00	2.25	2.50	2.75	3.00	3.25	3.50	3.75
SSR	4.00	4.25	4.50	4.75	5.00	5.25	5.50	5.75
SSW	6.00	6.25	6.50	6.75	7.00	7.25	7.50	7.75
SSD	8.00	8.25	8.50	8.75	9.00	9.25	9.50	9.75
SSK	10.00	10.25	10.50	10.75	11.00	11.25	11.50	11.75
SSG	12.00	12.25	12.50	12.75	13.00	13.25	13.50	13.75
SSO	14.00	14.25	14.50	14.75	15.00	15.25	15.50	15.75
SUS	16.00	16.25	16.50	16.75	17.00	17.25	17.50	17.75
SUU	18.00	18.25	18.50	18.75	19.00	19.25	19.50	19.75
SUR	20.00	20.25	20.50	20.75	21.00	21.25	21.50	21.75
SUW	22.00	22.25	22.50	22.75	23.00	23.25	23.50	23.75
SUD	24.00	24.25	24.50	24.75	25.00	25.25	25.50	25.75
SUK	26.00	26.25	26.50	26.75	27.00	27.25	27.50	27.75
SUG	28.00	28.25	28.50	28.75	29.00	29.25	29.50	29.75
SUO	30.00	30.25	30.50	30.75	31.00	31.25	31.50	31.75
SRS	32.00	32.25	32.50	32.75	33.00	33.25	33.50	33.75
SRU	34.00	34.25	34.50	34.75	35.00	35.25	35.50	35.75
SRR	36.00	36.25	36.50	36.75	37.00	37.25	37.50	37.75
SRW	38.00	38.25	38.50	38.75	39.00	39.25	39.50	39.75
SRD	40.00	40.25	40.50	40.75	41.00	41.25	41.50	41.75
SRK	42.00	42.25	42.50	42.75	43.00	43.25	43.50	43.75
SRG	44.00	44.25	44.50	44.75	45.00	45.25	45.50	45.75
SRO	46.00	46.25	46.50	46.75	47.00	47.25	47.50	47.75
SWS	48.00	48.25	48.50	48.75	49.00	49.25	49.50	49.75
SWU	50.00	50.25	50.50	50.75	51.00	51.25	51.50	51.75
SWR	52.00	52.25	52.50	52.75	53.00	53.25	53.50	53.75
SWW	54.00	54.25	54.50	54.75	55.00	55.25	55.50	55.75
SWD	56.00	56.25	56.50	56.75	57.00	57.25	57.50	57.75
SWK	58.00	58.25	58.50	58.75	59.00	59.25	59.50	59.75
SWG	60.00	60.25	60.50	60.75	61.00	61.25	61.50	61.75
SWO	62.00	62.25	62.50	62.75	63.00	63.25	63.50	63.75

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COUNTS VS CPS

	S	U	W	K	G
		CPS			
SDS	64.00	64.25	64.75	63.25	63.75
SDU	66.00	66.25	66.75	67.25	67.75
SDR	68.00	68.25	68.75	69.25	69.75
SDW	70.00	70.25	70.75	71.25	71.75
SDD	72.00	72.25	72.75	73.25	73.75
SDK	74.00	74.25	74.75	75.25	75.75
SDG	76.00	76.25	76.75	77.25	77.75
SDO	78.00	78.25	78.75	79.25	79.75
SKS	80.00	80.25	80.75	81.25	81.75
SKU	82.00	82.25	82.75	83.25	83.75
SKR	84.00	84.25	84.75	85.25	85.75
SKW	86.00	86.25	86.75	87.25	87.75
SKD	88.00	88.25	88.75	89.25	89.75
SKK	90.00	90.25	90.75	91.25	91.75
SKG	92.00	92.25	92.75	93.25	93.75
SKO	94.00	94.25	94.75	95.25	95.75
SGS	96.00	96.25	96.75	97.25	97.75
SGU	98.00	98.25	98.75	99.25	99.75
SGR	100.00	100.25	100.75	101.25	101.75
SGW	102.00	102.25	102.75	103.25	103.75
SGD	104.00	104.25	104.75	105.25	105.75
SGK	106.00	106.25	106.75	107.25	107.75
SGG	108.00	108.25	108.75	109.25	109.75
SGO	110.00	110.25	110.75	111.25	111.75
SOS	112.00	112.25	112.75	113.25	113.75
SOU	114.00	114.25	114.75	115.25	115.75
SOR	116.00	116.25	116.75	117.25	117.75
SOW	118.00	118.25	118.75	119.25	119.75
SOD	120.00	120.25	120.75	121.25	121.75
SOK	122.00	122.25	122.75	123.25	123.75
SOG	124.00	124.25	124.75	125.25	125.75
SOO	126.00	126.25	126.75	127.25	127.75

COUNTS VS CPS PAGE 3

	CPS							
	S	U	R	W	D	K	G	O
USS	128.00	128.25	128.50	128.75	129.00	129.25	129.50	129.75
USU	130.00	130.25	130.50	130.75	131.00	131.25	131.50	131.75
USR	132.00	132.25	132.50	132.75	133.00	133.25	133.50	133.75
USW	134.00	134.25	134.50	134.75	135.00	135.25	135.50	135.75
USD	136.00	136.25	136.50	136.75	137.00	137.25	137.50	137.75
USK	138.00	138.25	138.50	138.75	139.00	139.25	139.50	139.75
USG	140.00	140.25	140.50	140.75	141.00	141.25	141.50	141.75
USO	142.00	142.25	142.50	142.75	143.00	143.25	143.50	143.75
UUS	144.00	144.25	144.50	144.75	145.00	145.25	145.50	145.75
UUU	146.00	146.25	146.50	146.75	147.00	147.25	147.50	147.75
UUR	148.00	148.25	148.50	148.75	149.00	149.25	149.50	149.75
UUW	150.00	150.25	150.50	150.75	151.00	151.25	151.50	151.75
UUD	152.00	152.25	152.50	152.75	153.00	153.25	153.50	153.75
UUK	154.00	154.25	154.50	154.75	155.00	155.25	155.50	155.75
UUG	156.00	156.25	156.50	156.75	157.00	157.25	157.50	157.75
UUO	158.00	158.25	158.50	158.75	159.00	159.25	159.50	159.75
URS	160.00	160.25	160.50	160.75	161.00	161.25	161.50	161.75
URU	162.00	162.25	162.50	162.75	163.00	163.25	163.50	163.75
URR	164.00	164.25	164.50	164.75	165.00	165.25	165.50	165.75
URW	166.00	166.25	166.50	166.75	167.00	167.25	167.50	167.75
URD	168.00	168.25	168.50	168.75	169.00	169.25	169.50	169.75
URK	170.00	170.25	170.50	170.75	171.00	171.25	171.50	171.75
URG	172.00	172.25	172.50	172.75	173.00	173.25	173.50	173.75
URO	174.00	174.25	174.50	174.75	175.00	175.25	175.50	175.75
UWS	176.00	176.25	176.50	176.75	177.00	177.25	177.50	177.75
UWU	178.00	178.25	178.50	178.75	179.00	179.25	179.50	179.75
UWR	180.00	180.25	180.50	180.75	181.00	181.25	181.50	181.75
UWW	182.00	182.25	182.50	182.75	183.00	183.25	183.50	183.75
UWD	184.00	184.25	184.50	184.75	185.00	185.25	185.50	185.75
UWK	186.00	186.25	186.50	186.75	187.00	187.25	187.50	187.75
UWG	188.00	188.25	188.50	188.75	189.00	189.25	189.50	189.75
UWO	190.00	190.25	190.50	190.75	191.00	191.25	191.50	191.75

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COUNTS VS CPS

CPS

	S	U	P	W	D	K	G	O
UDS	192.00	192.25	192.50	192.75	193.00	193.25	193.50	193.75
UDU	194.00	194.25	194.50	194.75	195.00	195.25	195.50	195.75
UDR	196.00	196.25	196.50	196.75	197.00	197.25	197.50	197.75
UDW	198.00	198.25	198.50	198.75	199.00	199.25	199.50	199.75
UDD	200.00	200.25	200.50	200.75	201.00	201.25	201.50	201.75
UDK	202.00	202.25	202.50	202.75	203.00	203.25	203.50	203.75
UDG	204.00	204.25	204.50	204.75	205.00	205.25	205.50	205.75
UDO	206.00	206.25	206.50	206.75	207.00	207.25	207.50	207.75
UKS	208.00	208.25	208.50	208.75	209.00	209.25	209.50	209.75
UKU	210.00	210.25	210.50	210.75	211.00	211.25	211.50	211.75
UKR	212.00	212.25	212.50	212.75	213.00	213.25	213.50	213.75
UKW	214.00	214.25	214.50	214.75	215.00	215.25	215.50	215.75
UKD	216.00	216.25	216.50	216.75	217.00	217.25	217.50	217.75
UKK	218.00	218.25	218.50	218.75	219.00	219.25	219.50	219.75
UKG	220.00	220.25	220.50	220.75	221.00	221.25	221.50	221.75
UKO	222.00	222.25	222.50	222.75	223.00	223.25	223.50	223.75
UGS	224.00	224.25	224.50	224.75	225.00	225.25	225.50	225.75
UGU	226.00	226.25	226.50	226.75	227.00	227.25	227.50	227.75
UGR	228.00	228.25	228.50	228.75	229.00	229.25	229.50	229.75
UGW	230.00	230.25	230.50	230.75	231.00	231.25	231.50	231.75
UGD	232.00	232.25	232.50	232.75	233.00	233.25	233.50	233.75
UGK	234.00	234.25	234.50	234.75	235.00	235.25	235.50	235.75
UGG	236.00	236.25	236.50	236.75	237.00	237.25	237.50	237.75
UGO	238.00	238.25	238.50	238.75	239.00	239.25	239.50	239.75
UCS	240.00	240.25	240.50	240.75	241.00	241.25	241.50	241.75
UCU	242.00	242.25	242.50	242.75	243.00	243.25	243.50	243.75
UCR	244.00	244.25	244.50	244.75	245.00	245.25	245.50	245.75
UCW	246.00	246.25	246.50	246.75	247.00	247.25	247.50	247.75
UCD	248.00	248.25	248.50	248.75	249.00	249.25	249.50	249.75
UCK	250.00	250.25	250.50	250.75	251.00	251.25	251.50	251.75
UCG	252.00	252.25	252.50	252.75	253.00	253.25	253.50	253.75
UCO	254.00	254.25	254.50	254.75	255.00	255.25	255.50	255.75

COUNTS VS CPS

	CPS							
	S	U	P	W	D	K	G	C
RSS	256.00	256.25	256.50	256.75	257.00	257.25	257.50	257.75
RSU	258.00	258.25	258.50	258.75	259.00	259.25	259.50	259.75
RSR	260.00	260.25	260.50	260.75	261.00	261.25	261.50	261.75
RSW	262.00	262.25	262.50	262.75	263.00	263.25	263.50	263.75
RSD	264.00	264.25	264.50	264.75	265.00	265.25	265.50	265.75
RSK	266.00	266.25	266.50	266.75	267.00	267.25	267.50	267.75
RSG	268.00	268.25	268.50	268.75	269.00	269.25	269.50	269.75
RSO	270.00	270.25	270.50	270.75	271.00	271.25	271.50	271.75
RUS	272.00	272.25	272.50	272.75	273.00	273.25	273.50	273.75
RUU	274.00	274.25	274.50	274.75	275.00	275.25	275.50	275.75
RUR	276.00	276.25	276.50	276.75	277.00	277.25	277.50	277.75
RUW	278.00	278.25	278.50	278.75	279.00	279.25	279.50	279.75
RUD	280.00	280.25	280.50	280.75	281.00	281.25	281.50	281.75
RUK	282.00	282.25	282.50	282.75	283.00	283.25	283.50	283.75
RUG	284.00	284.25	284.50	284.75	285.00	285.25	285.50	285.75
RUO	286.00	286.25	286.50	286.75	287.00	287.25	287.50	287.75
RRS	288.00	288.25	288.50	288.75	289.00	289.25	289.50	289.75
RRU	290.00	290.25	290.50	290.75	291.00	291.25	291.50	291.75
RRR	292.00	292.25	292.50	292.75	293.00	293.25	293.50	293.75
RRW	294.00	294.25	294.50	294.75	295.00	295.25	295.50	295.75
RRD	296.00	296.25	296.50	296.75	297.00	297.25	297.50	297.75
RRK	298.00	298.25	298.50	298.75	299.00	299.25	299.50	299.75
RRG	300.00	300.25	300.50	300.75	301.00	301.25	301.50	301.75
RRO	302.00	302.25	302.50	302.75	303.00	303.25	303.50	303.75
RWS	304.00	304.25	304.50	304.75	305.00	305.25	305.50	305.75
RWU	306.00	306.25	306.50	306.75	307.00	307.25	307.50	307.75
RWR	308.00	308.25	308.50	308.75	309.00	309.25	309.50	309.75
RWW	310.00	310.25	310.50	310.75	311.00	311.25	311.50	311.75
RWD	312.00	312.25	312.50	312.75	313.00	313.25	313.50	313.75
RWK	314.00	314.25	314.50	314.75	315.00	315.25	315.50	315.75
RWG	316.00	316.25	316.50	316.75	317.00	317.25	317.50	317.75
RWO	318.00	318.25	318.50	318.75	319.00	319.25	319.50	319.75

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COUNTS VS CPS

	CPS							
	S	U	P	W	Q	K	G	O
ROS	320.00	320.25	320.50	320.75	321.00	321.25	321.50	321.75
ROU	322.00	322.25	322.50	322.75	323.00	323.25	323.50	323.75
ROR	324.00	324.25	324.50	324.75	325.00	325.25	325.50	325.75
ROW	326.00	326.25	326.50	326.75	327.00	327.25	327.50	327.75
ROD	328.00	328.25	328.50	328.75	329.00	329.25	329.50	329.75
ROK	330.00	330.25	330.50	330.75	331.00	331.25	331.50	331.75
ROG	332.00	332.25	332.50	332.75	333.00	333.25	333.50	333.75
ROO	334.00	334.25	334.50	334.75	335.00	335.25	335.50	335.75
RKS	336.00	336.25	336.50	336.75	337.00	337.25	337.50	337.75
RKU	338.00	338.25	338.50	338.75	339.00	339.25	339.50	339.75
RKR	340.00	340.25	340.50	340.75	341.00	341.25	341.50	341.75
RKW	342.00	342.25	342.50	342.75	343.00	343.25	343.50	343.75
RKD	344.00	344.25	344.50	344.75	345.00	345.25	345.50	345.75
RKK	346.00	346.25	346.50	346.75	347.00	347.25	347.50	347.75
RKG	348.00	348.25	348.50	348.75	349.00	349.25	349.50	349.75
RKO	350.00	350.25	350.50	350.75	351.00	351.25	351.50	351.75
RGS	352.00	352.25	352.50	352.75	353.00	353.25	353.50	353.75
RGU	354.00	354.25	354.50	354.75	355.00	355.25	355.50	355.75
RGR	356.00	356.25	356.50	356.75	357.00	357.25	357.50	357.75
RGW	358.00	358.25	358.50	358.75	359.00	359.25	359.50	359.75
RGD	360.00	360.25	360.50	360.75	361.00	361.25	361.50	361.75
RGK	362.00	362.25	362.50	362.75	363.00	363.25	363.50	363.75
RGG	364.00	364.25	364.50	364.75	365.00	365.25	365.50	365.75
RGO	366.00	366.25	366.50	366.75	367.00	367.25	367.50	367.75
ROS	368.00	368.25	368.50	368.75	369.00	369.25	369.50	369.75
ROU	370.00	370.25	370.50	370.75	371.00	371.25	371.50	371.75
ROR	372.00	372.25	372.50	372.75	373.00	373.25	373.50	373.75
ROW	374.00	374.25	374.50	374.75	375.00	375.25	375.50	375.75
ROD	376.00	376.25	376.50	376.75	377.00	377.25	377.50	377.75
ROK	378.00	378.25	378.50	378.75	379.00	379.25	379.50	379.75
ROG	380.00	380.25	380.50	380.75	381.00	381.25	381.50	381.75
ROO	382.00	382.25	382.50	382.75	383.00	383.25	383.50	383.75

COUNTS VS CPS PAGE 7

CPS

	S	U	R	W	D	K	G	C
WSS	384.00	384.25	384.50	384.75	385.00	385.25	385.50	385.75
WSU	386.00	386.25	386.50	386.75	387.00	387.25	387.50	387.75
WSR	388.00	388.25	388.50	388.75	389.00	389.25	389.50	389.75
WSW	390.00	390.25	390.50	390.75	391.00	391.25	391.50	391.75
WSO	392.00	392.25	392.50	392.75	393.00	393.25	393.50	393.75
WSK	394.00	394.25	394.50	394.75	395.00	395.25	395.50	395.75
WSG	396.00	396.25	396.50	396.75	397.00	397.25	397.50	397.75
WSO	398.00	398.25	398.50	398.75	399.00	399.25	399.50	399.75
WUS	400.00	400.25	400.50	400.75	401.00	401.25	401.50	401.75
WUU	402.00	402.25	402.50	402.75	403.00	403.25	403.50	403.75
WUR	404.00	404.25	404.50	404.75	405.00	405.25	405.50	405.75
WUW	406.00	406.25	406.50	406.75	407.00	407.25	407.50	407.75
WUO	408.00	408.25	408.50	408.75	409.00	409.25	409.50	409.75
WUK	410.00	410.25	410.50	410.75	411.00	411.25	411.50	411.75
WUG	412.00	412.25	412.50	412.75	413.00	413.25	413.50	413.75
WUO	414.00	414.25	414.50	414.75	415.00	415.25	415.50	415.75
WRS	416.00	416.25	416.50	416.75	417.00	417.25	417.50	417.75
WRU	418.00	418.25	418.50	418.75	419.00	419.25	419.50	419.75
WRR	420.00	420.25	420.50	420.75	421.00	421.25	421.50	421.75
WRW	422.00	422.25	422.50	422.75	423.00	423.25	423.50	423.75
WRO	424.00	424.25	424.50	424.75	425.00	425.25	425.50	425.75
WRK	426.00	426.25	426.50	426.75	427.00	427.25	427.50	427.75
WRG	428.00	428.25	428.50	428.75	429.00	429.25	429.50	429.75
WRO	430.00	430.25	430.50	430.75	431.00	431.25	431.50	431.75
WWS	432.00	432.25	432.50	432.75	433.00	433.25	433.50	433.75
WWU	434.00	434.25	434.50	434.75	435.00	435.25	435.50	435.75
WWR	436.00	436.25	436.50	436.75	437.00	437.25	437.50	437.75
WWW	438.00	438.25	438.50	438.75	439.00	439.25	439.50	439.75
WWO	440.00	440.25	440.50	440.75	441.00	441.25	441.50	441.75
WWK	442.00	442.25	442.50	442.75	443.00	443.25	443.50	443.75
WWG	444.00	444.25	444.50	444.75	445.00	445.25	445.50	445.75
WWO	446.00	446.25	446.50	446.75	447.00	447.25	447.50	447.75

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COUNTS VS CPS

	S	U	P	W	D	K	G	O
	CPS							
WDS	448.00	448.25	448.50	448.75	449.00	449.25	449.50	449.75
WDU	450.00	450.25	450.50	450.75	451.00	451.25	451.50	451.75
WDR	452.00	452.25	452.50	452.75	453.00	453.25	453.50	453.75
WDW	454.00	454.25	454.50	454.75	455.00	455.25	455.50	455.75
WDD	456.00	456.25	456.50	456.75	457.00	457.25	457.50	457.75
WDK	458.00	458.25	458.50	458.75	459.00	459.25	459.50	459.75
WDG	460.00	460.25	460.50	460.75	461.00	461.25	461.50	461.75
WDO	462.00	462.25	462.50	462.75	463.00	463.25	463.50	463.75
WKS	464.00	464.25	464.50	464.75	465.00	465.25	465.50	465.75
WKU	466.00	466.25	466.50	466.75	467.00	467.25	467.50	467.75
WKR	468.00	468.25	468.50	468.75	469.00	469.25	469.50	469.75
WKW	470.00	470.25	470.50	470.75	471.00	471.25	471.50	471.75
WKD	472.00	472.25	472.50	472.75	473.00	473.25	473.50	473.75
WKK	474.00	474.25	474.50	474.75	475.00	475.25	475.50	475.75
WKG	476.00	476.25	476.50	476.75	477.00	477.25	477.50	477.75
WKO	478.00	478.25	478.50	478.75	479.00	479.25	479.50	479.75
WGS	480.00	480.25	480.50	480.75	481.00	481.25	481.50	481.75
WGU	482.00	482.25	482.50	482.75	483.00	483.25	483.50	483.75
WGR	484.00	484.25	484.50	484.75	485.00	485.25	485.50	485.75
WGW	486.00	486.25	486.50	486.75	487.00	487.25	487.50	487.75
WGD	488.00	488.25	488.50	488.75	489.00	489.25	489.50	489.75
WGK	490.00	490.25	490.50	490.75	491.00	491.25	491.50	491.75
WGG	492.00	492.25	492.50	492.75	493.00	493.25	493.50	493.75
WGO	494.00	494.25	494.50	494.75	495.00	495.25	495.50	495.75
WOS	496.00	496.25	496.50	496.75	497.00	497.25	497.50	497.75
WOU	498.00	498.25	498.50	498.75	499.00	499.25	499.50	499.75
WOR	500.00	500.25	500.50	500.75	501.00	501.25	501.50	501.75
WOW	502.00	502.25	502.50	502.75	503.00	503.25	503.50	503.75
WOD	504.00	504.25	504.50	504.75	505.00	505.25	505.50	505.75
WOK	506.00	506.25	506.50	506.75	507.00	507.25	507.50	507.75
WOG	508.00	508.25	508.50	508.75	509.00	509.25	509.50	509.75
WOO	510.00	510.25	510.50	510.75	511.00	511.25	511.50	511.75

COUNTS VS CPS

	CPS							
	S	U	R	W	D	K	G	O
DSS	512.00	512.25	512.50	512.75	513.00	513.25	513.50	513.75
DSU	514.00	514.25	514.50	514.75	515.00	515.25	515.50	515.75
DSR	516.00	516.25	516.50	516.75	517.00	517.25	517.50	517.75
DSW	518.00	518.25	518.50	518.75	519.00	519.25	519.50	519.75
DSD	520.00	520.25	520.50	520.75	521.00	521.25	521.50	521.75
DSK	522.00	522.25	522.50	522.75	523.00	523.25	523.50	523.75
DSG	524.00	524.25	524.50	524.75	525.00	525.25	525.50	525.75
DSO	526.00	526.25	526.50	526.75	527.00	527.25	527.50	527.75
DUS	528.00	528.25	528.50	528.75	529.00	529.25	529.50	529.75
DUU	530.00	530.25	530.50	530.75	531.00	531.25	531.50	531.75
DUR	532.00	532.25	532.50	532.75	533.00	533.25	533.50	533.75
DUW	534.00	534.25	534.50	534.75	535.00	535.25	535.50	535.75
DUD	536.00	536.25	536.50	536.75	537.00	537.25	537.50	537.75
DUK	538.00	538.25	538.50	538.75	539.00	539.25	539.50	539.75
DUG	540.00	540.25	540.50	540.75	541.00	541.25	541.50	541.75
DUO	542.00	542.25	542.50	542.75	543.00	543.25	543.50	543.75
DRS	544.00	544.25	544.50	544.75	545.00	545.25	545.50	545.75
DRU	546.00	546.25	546.50	546.75	547.00	547.25	547.50	547.75
DRR	548.00	548.25	548.50	548.75	549.00	549.25	549.50	549.75
DRW	550.00	550.25	550.50	550.75	551.00	551.25	551.50	551.75
DRD	552.00	552.25	552.50	552.75	553.00	553.25	553.50	553.75
DRK	554.00	554.25	554.50	554.75	555.00	555.25	555.50	555.75
DRG	556.00	556.25	556.50	556.75	557.00	557.25	557.50	557.75
DRO	558.00	558.25	558.50	558.75	559.00	559.25	559.50	559.75
DWS	560.00	560.25	560.50	560.75	561.00	561.25	561.50	561.75
DWU	562.00	562.25	562.50	562.75	563.00	563.25	563.50	563.75
DWR	564.00	564.25	564.50	564.75	565.00	565.25	565.50	565.75
DWW	566.00	566.25	566.50	566.75	567.00	567.25	567.50	567.75
DWD	568.00	568.25	568.50	568.75	569.00	569.25	569.50	569.75
DWK	570.00	570.25	570.50	570.75	571.00	571.25	571.50	571.75
DWG	572.00	572.25	572.50	572.75	573.00	573.25	573.50	573.75
DWO	574.00	574.25	574.50	574.75	575.00	575.25	575.50	575.75

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	CPS							
	S	U	R	W	D	K	G	O
DDS	576.00	576.25	576.50	576.75	577.00	577.25	577.50	[illegible]
DDU	578.00	578.25	578.50	578.75	579.00	579.25	579.50	[illegible]
DDR	580.00	580.25	580.50	580.75	581.00	581.25	581.50	[illegible]
DDW	582.00	582.25	582.50	582.75	583.00	583.25	583.50	[illegible]
DDD	584.00	584.25	584.50	584.75	585.00	585.25	585.50	[illegible]
DDK	586.00	586.25	586.50	586.75	587.00	587.25	587.50	[illegible]
DDG	588.00	588.25	588.50	588.75	589.00	589.25	589.50	[illegible]
DDO	590.00	590.25	590.50	590.75	591.00	591.25	591.50	[illegible]
DKS	592.00	592.25	592.50	592.75	593.00	593.25	593.50	[illegible]
DKU	594.00	594.25	594.50	594.75	595.00	595.25	595.50	[illegible]
DKR	596.00	596.25	596.50	596.75	597.00	597.25	597.50	[illegible]
DKW	598.00	598.25	598.50	598.75	599.00	599.25	599.50	[illegible]
DKD	600.00	600.25	600.50	600.75	601.00	601.25	601.50	[illegible]
DKK	602.00	602.25	602.50	602.75	603.00	603.25	603.50	[illegible]
DKG	604.00	604.25	604.50	604.75	605.00	605.25	605.50	[illegible]
DKO	606.00	606.25	606.50	606.75	607.00	607.25	607.50	[illegible]
DGS	608.00	608.25	608.50	608.75	609.00	609.25	609.50	[illegible]
DGU	610.00	610.25	610.50	610.75	611.00	611.25	611.50	[illegible]
DGR	612.00	612.25	612.50	612.75	613.00	613.25	613.50	[illegible]
DGW	614.00	614.25	614.50	614.75	615.00	615.25	615.50	[illegible]
DGD	616.00	616.25	616.50	616.75	617.00	617.25	617.50	[illegible]
DGK	618.00	618.25	618.50	618.75	619.00	619.25	619.50	[illegible]
DGG	620.00	620.25	620.50	620.75	621.00	621.25	621.50	[illegible]
DGO	622.00	622.25	622.50	622.75	623.00	623.25	623.50	[illegible]
DOS	624.00	624.25	624.50	624.75	625.00	625.25	625.50	[illegible]
DOU	626.00	626.25	626.50	626.75	627.00	627.25	627.50	[illegible]
DOR	628.00	628.25	628.50	628.75	629.00	629.25	629.50	[illegible]
DOW	630.00	630.25	630.50	630.75	631.00	631.25	631.50	[illegible]
DOD	632.00	632.25	632.50	632.75	633.00	633.25	633.50	[illegible]
DOK	634.00	634.25	634.50	634.75	635.00	635.25	635.50	[illegible]
DOG	636.00	636.25	636.50	636.75	637.00	637.25	637.50	[illegible]
DOO	638.00	638.25	638.50	638.75	639.00	639.25	639.50	[illegible]

CPS

	S	U	R	W	D	K	G	O
KSS	641.00	640.25	640.50	640.75	641.00	641.25	641.50	641.75
KSU	642.00	642.25	642.50	642.75	643.00	643.25	643.50	643.75
KSR	644.00	644.25	644.50	644.75	645.00	645.25	645.50	645.75
KSW	646.00	646.25	646.50	646.75	647.00	647.25	647.50	647.75
KSD	648.00	648.25	648.50	648.75	649.00	649.25	649.50	649.75
KSK	650.00	650.25	650.50	650.75	651.00	651.25	651.50	651.75
KSG	652.00	652.25	652.50	652.75	653.00	653.25	653.50	653.75
KSO	654.00	654.25	654.50	654.75	655.00	655.25	655.50	655.75
KUS	656.00	656.25	656.50	656.75	657.00	657.25	657.50	657.75
KUU	658.00	658.25	658.50	658.75	659.00	659.25	659.50	659.75
KUR	660.00	660.25	660.50	660.75	661.00	661.25	661.50	661.75
KUW	662.00	662.25	662.50	662.75	663.00	663.25	663.50	663.75
KUD	664.00	664.25	664.50	664.75	665.00	665.25	665.50	665.75
KUK	666.00	666.25	666.50	666.75	667.00	667.25	667.50	667.75
KUG	668.00	668.25	668.50	668.75	669.00	669.25	669.50	669.75
KUO	670.00	670.25	670.50	670.75	671.00	671.25	671.50	671.75
KPS	672.00	672.25	672.50	672.75	673.00	673.25	673.50	673.75
KRU	674.00	674.25	674.50	674.75	675.00	675.25	675.50	675.75
KRR	676.00	676.25	676.50	676.75	677.00	677.25	677.50	677.75
KRW	678.00	678.25	678.50	678.75	679.00	679.25	679.50	679.75
KRD	680.00	680.25	680.50	680.75	681.00	681.25	681.50	681.75
KRK	682.00	682.25	682.50	682.75	683.00	683.25	683.50	683.75
KRG	684.00	684.25	684.50	684.75	685.00	685.25	685.50	685.75
KRO	686.00	686.25	686.50	686.75	687.00	687.25	687.50	687.75
KWS	688.00	688.25	688.50	688.75	689.00	689.25	689.50	689.75
KWU	690.00	690.25	690.50	690.75	691.00	691.25	691.50	691.75
KWR	692.00	692.25	692.50	692.75	693.00	693.25	693.50	693.75
KWW	694.00	694.25	694.50	694.75	695.00	695.25	695.50	695.75
KWD	696.00	696.25	696.50	696.75	697.00	697.25	697.50	697.75
KWK	698.00	698.25	698.50	698.75	699.00	699.25	699.50	699.75
KWG	700.00	700.25	700.50	700.75	701.00	701.25	701.50	701.75
KWO	702.00	702.25	702.50	702.75	703.00	703.25	703.50	703.75

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COUNTS VS CPS

CPS

	S	U	R	W	D	K	G	O
KDS	704.00	704.25	704.50	704.75	705.00	705.25	705.50	705.75
KDU	706.00	706.25	706.50	706.75	707.00	707.25	707.50	707.75
KDR	708.00	708.25	708.50	708.75	709.00	709.25	709.50	709.75
KDW	710.00	710.25	710.50	710.75	711.00	711.25	711.50	711.75
KDD	712.00	712.25	712.50	712.75	713.00	713.25	713.50	713.75
KDK	714.00	714.25	714.50	714.75	715.00	715.25	715.50	715.75
KDG	716.00	716.25	716.50	716.75	717.00	717.25	717.50	717.75
KDO	718.00	718.25	718.50	718.75	719.00	719.25	719.50	719.75
KKS	720.00	720.25	720.50	720.75	721.00	721.25	721.50	721.75
KKU	722.00	722.25	722.50	722.75	723.00	723.25	723.50	723.75
KKR	724.00	724.25	724.50	724.75	725.00	725.25	725.50	725.75
KKW	726.00	726.25	726.50	726.75	727.00	727.25	727.50	727.75
KKD	728.00	728.25	728.50	728.75	729.00	729.25	729.50	729.75
KKK	730.00	730.25	730.50	730.75	731.00	731.25	731.50	731.75
KKG	732.00	732.25	732.50	732.75	733.00	733.25	733.50	733.75
KKO	734.00	734.25	734.50	734.75	735.00	735.25	735.50	735.75
KGS	736.00	736.25	736.50	736.75	737.00	737.25	737.50	737.75
KGU	738.00	738.25	738.50	738.75	739.00	739.25	739.50	739.75
KGR	740.00	740.25	740.50	740.75	741.00	741.25	741.50	741.75
KGW	742.00	742.25	742.50	742.75	743.00	743.25	743.50	743.75
KGD	744.00	744.25	744.50	744.75	745.00	745.25	745.50	745.75
KGK	746.00	746.25	746.50	746.75	747.00	747.25	747.50	747.75
KGG	748.00	748.25	748.50	748.75	749.00	749.25	749.50	749.75
KGO	750.00	750.25	750.50	750.75	751.00	751.25	751.50	751.75
KOS	752.00	752.25	752.50	752.75	753.00	753.25	753.50	753.75
KOU	754.00	754.25	754.50	754.75	755.00	755.25	755.50	755.75
KOR	756.00	756.25	756.50	756.75	757.00	757.25	757.50	757.75
KOW	758.00	758.25	758.50	758.75	759.00	759.25	759.50	759.75
KOD	760.00	760.25	760.50	760.75	761.00	761.25	761.50	761.75
KOK	762.00	762.25	762.50	762.75	763.00	763.25	763.50	763.75
KOG	764.00	764.25	764.50	764.75	765.00	765.25	765.50	765.75
KOO	766.00	766.25	766.50	766.75	767.00	767.25	767.50	767.75

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CPS

	S	U	R	W	O	K	G	O
GSS	768.00	768.25	768.50	768.75	769.00	769.25	769.50	[illegible]
GSU	770.00	770.25	770.50	770.75	771.00	771.25	771.50	[illegible]
GSR	772.00	772.25	772.50	772.75	773.00	773.25	773.50	[illegible]
GSW	774.00	774.25	774.50	774.75	775.00	775.25	775.50	[illegible]
GSO	776.00	776.25	776.50	776.75	777.00	777.25	777.50	[illegible]
GSK	778.00	778.25	778.50	778.75	779.00	779.25	779.50	[illegible]
GSG	780.00	780.25	780.50	780.75	781.00	781.25	781.50	[illegible]
GSO	782.00	782.25	782.50	782.75	783.00	783.25	783.50	[illegible]
GUS	784.00	784.25	784.50	784.75	785.00	785.25	785.50	[illegible]
GUU	786.00	786.25	786.50	786.75	787.00	787.25	787.50	[illegible]
GUR	788.00	788.25	788.50	788.75	789.00	789.25	789.50	[illegible]
GUW	790.00	790.25	790.50	790.75	791.00	791.25	791.50	[illegible]
GUO	792.00	792.25	792.50	792.75	793.00	793.25	793.50	[illegible]
GUK	794.00	794.25	794.50	794.75	795.00	795.25	795.50	[illegible]
GUG	796.00	796.25	796.50	796.75	797.00	797.25	797.50	[illegible]
GUO	798.00	798.25	798.50	798.75	799.00	799.25	799.50	[illegible]
GRS	800.00	800.25	800.50	800.75	801.00	801.25	801.50	[illegible]
GRU	802.00	802.25	802.50	802.75	803.00	803.25	803.50	[illegible]
GRR	804.00	804.25	804.50	804.75	805.00	805.25	805.50	[illegible]
GRW	806.00	806.25	806.50	806.75	807.00	807.25	807.50	[illegible]
GRO	808.00	808.25	808.50	808.75	809.00	809.25	809.50	[illegible]
GRK	810.00	810.25	810.50	810.75	811.00	811.25	811.50	[illegible]
GRG	812.00	812.25	812.50	812.75	813.00	813.25	813.50	[illegible]
GRO	814.00	814.25	814.50	814.75	815.00	815.25	815.50	[illegible]
GWS	816.00	816.25	816.50	816.75	817.00	817.25	817.50	[illegible]
GWU	818.00	818.25	818.50	818.75	819.00	819.25	819.50	[illegible]
GWR	820.00	820.25	820.50	820.75	821.00	821.25	821.50	[illegible]
GWW	822.00	822.25	822.50	822.75	823.00	823.25	823.50	[illegible]
GWO	824.00	824.25	824.50	824.75	825.00	825.25	825.50	[illegible]
GWK	826.00	826.25	826.50	826.75	827.00	827.25	827.50	[illegible]
GWG	828.00	828.25	828.50	828.75	829.00	829.25	829.50	[illegible]
GWO	830.00	830.25	830.50	830.75	831.00	831.25	831.50	[illegible]

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COUNTS VS CPS

	CPS							
	S	U	E	W	P	K	G	O
GDS	832.00	832.25	832.50	832.75	833.00	833.25	833.50	833.75
GDU	834.00	834.25	834.50	834.75	835.00	835.25	835.50	835.75
GDR	836.00	836.25	836.50	836.75	837.00	837.25	837.50	837.75
GDW	838.00	838.25	838.50	838.75	839.00	839.25	839.50	839.75
GDD	840.00	840.25	840.50	840.75	841.00	841.25	841.50	841.75
GDK	842.00	842.25	842.50	842.75	843.00	843.25	843.50	843.75
GDG	844.00	844.25	844.50	844.75	845.00	845.25	845.50	845.75
GDO	846.00	846.25	846.50	846.75	847.00	847.25	847.50	847.75
GKS	848.00	848.25	848.50	848.75	849.00	849.25	849.50	849.75
GKU	850.00	850.25	850.50	850.75	851.00	851.25	851.50	851.75
GKR	852.00	852.25	852.50	852.75	853.00	853.25	853.50	853.75
GKW	854.00	854.25	854.50	854.75	855.00	855.25	855.50	855.75
GKD	856.00	856.25	856.50	856.75	857.00	857.25	857.50	857.75
GKK	858.00	858.25	858.50	858.75	859.00	859.25	859.50	859.75
GKG	860.00	860.25	860.50	860.75	861.00	861.25	861.50	861.75
GKO	862.00	862.25	862.50	862.75	863.00	863.25	863.50	863.75
GGS	864.00	864.25	864.50	864.75	865.00	865.25	865.50	865.75
GGU	866.00	866.25	866.50	866.75	867.00	867.25	867.50	867.75
GGR	868.00	868.25	868.50	868.75	869.00	869.25	869.50	869.75
GGW	870.00	870.25	870.50	870.75	871.00	871.25	871.50	871.75
GGD	872.00	872.25	872.50	872.75	873.00	873.25	873.50	873.75
GGK	874.00	874.25	874.50	874.75	875.00	875.25	875.50	875.75
GGG	876.00	876.25	876.50	876.75	877.00	877.25	877.50	877.75
GGO	878.00	878.25	878.50	878.75	879.00	879.25	879.50	879.75
GOS	880.00	880.25	880.50	880.75	881.00	881.25	881.50	881.75
GOU	882.00	882.25	882.50	882.75	883.00	883.25	883.50	883.75
GOR	884.00	884.25	884.50	884.75	885.00	885.25	885.50	885.75
GOW	886.00	886.25	886.50	886.75	887.00	887.25	887.50	887.75
GOD	888.00	888.25	888.50	888.75	889.00	889.25	889.50	889.75
GOK	890.00	890.25	890.50	890.75	891.00	891.25	891.50	891.75
GOG	892.00	892.25	892.50	892.75	893.00	893.25	893.50	893.75
GOO	894.00	894.25	894.50	894.75	895.00	895.25	895.50	895.75

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CPS

	S	U	R	W	T	K	G	O
OSS	896.00	896.25	896.50	896.75	897.00	897.25	897.50	897.75
OSU	898.00	898.25	898.50	898.75	899.00	899.25	899.50	899.75
OSR	900.00	900.25	900.50	900.75	901.00	901.25	901.50	901.75
OSW	902.00	902.25	902.50	902.75	903.00	903.25	903.50	903.75
OSD	904.00	904.25	904.50	904.75	905.00	905.25	905.50	905.75
OSK	906.00	906.25	906.50	906.75	907.00	907.25	907.50	907.75
OSG	908.00	908.25	908.50	908.75	909.00	909.25	909.50	909.75
OSO	910.00	910.25	910.50	910.75	911.00	911.25	911.50	911.75
OUS	912.00	912.25	912.50	912.75	913.00	913.25	913.50	913.75
OUU	914.00	914.25	914.50	914.75	915.00	915.25	915.50	915.75
OUR	916.00	916.25	916.50	916.75	917.00	917.25	917.50	917.75
OUW	918.00	918.25	918.50	918.75	919.00	919.25	919.50	919.75
OUD	920.00	920.25	920.50	920.75	921.00	921.25	921.50	921.75
OUK	922.00	922.25	922.50	922.75	923.00	923.25	923.50	923.75
OUG	924.00	924.25	924.50	924.75	925.00	925.25	925.50	925.75
OUO	926.00	926.25	926.50	926.75	927.00	927.25	927.50	927.75
ORS	928.00	928.25	928.50	928.75	929.00	929.25	929.50	929.75
ORU	930.00	930.25	930.50	930.75	931.00	931.25	931.50	931.75
ORR	932.00	932.25	932.50	932.75	933.00	933.25	933.50	933.75
ORW	934.00	934.25	934.50	934.75	935.00	935.25	935.50	935.75
ORD	936.00	936.25	936.50	936.75	937.00	937.25	937.50	937.75
ORK	938.00	938.25	938.50	938.75	939.00	939.25	939.50	939.75
ORG	940.00	940.25	940.50	940.75	941.00	941.25	941.50	941.75
ORO	942.00	942.25	942.50	942.75	943.00	943.25	943.50	943.75
OWS	944.00	944.25	944.50	944.75	945.00	945.25	945.50	945.75
OWU	946.00	946.25	946.50	946.75	947.00	947.25	947.50	947.75
OWR	948.00	948.25	948.50	948.75	949.00	949.25	949.50	949.75
OWW	950.00	950.25	950.50	950.75	951.00	951.25	951.50	951.75
OWD	952.00	952.25	952.50	952.75	953.00	953.25	953.50	953.75
OWK	954.00	954.25	954.50	954.75	955.00	955.25	955.50	955.75
OWG	956.00	956.25	956.50	956.75	957.00	957.25	957.50	957.75
OWO	958.00	958.25	958.50	958.75	959.00	959.25	959.50	959.75

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COUNTS VS CPS

CPS

	S	U	P	W	T	K	G	O
CDS	960.00	960.25	960.50	960.75	961.00	961.25	961.50	961.75
CDU	962.00	962.25	962.50	962.75	963.00	963.25	963.50	963.75
CDR	964.00	964.25	964.50	964.75	965.00	965.25	965.50	965.75
CDW	966.00	966.25	966.50	966.75	967.00	967.25	967.50	967.75
CDD	968.00	968.25	968.50	968.75	969.00	969.25	969.50	969.75
CDK	970.00	970.25	970.50	970.75	971.00	971.25	971.50	971.75
CDG	972.00	972.25	972.50	972.75	973.00	973.25	973.50	973.75
CDO	974.00	974.25	974.50	974.75	975.00	975.25	975.50	975.75
OKS	976.00	976.25	976.50	976.75	977.00	977.25	977.50	977.75
CKU	978.00	978.25	978.50	978.75	979.00	979.25	979.50	979.75
CKR	980.00	980.25	980.50	980.75	981.00	981.25	981.50	981.75
CKW	982.00	982.25	982.50	982.75	983.00	983.25	983.50	983.75
CKD	984.00	984.25	984.50	984.75	985.00	985.25	985.50	985.75
CKK	986.00	986.25	986.50	986.75	987.00	987.25	987.50	987.75
CKG	988.00	988.25	988.50	988.75	989.00	989.25	989.50	989.75
CKO	990.00	990.25	990.50	990.75	991.00	991.25	991.50	991.75
OGS	992.00	992.25	992.50	992.75	993.00	993.25	993.50	993.75
CGU	994.00	994.25	994.50	994.75	995.00	995.25	995.50	995.75
CGR	996.00	996.25	996.50	996.75	997.00	997.25	997.50	997.75
CGW	998.00	998.25	998.50	998.75	999.00	999.25	999.50	999.75
CGD	1000.00	1000.25	1000.50	1000.75	1001.00	1001.25	1001.50	1001.75
CGK	1002.00	1002.25	1002.50	1002.75	1003.00	1003.25	1003.50	1003.75
CGG	1004.00	1004.25	1004.50	1004.75	1005.00	1005.25	1005.50	1005.75
CGO	1006.00	1006.25	1006.50	1006.75	1007.00	1007.25	1007.50	1007.75
OOS	1008.00	1008.25	1008.50	1008.75	1009.00	1009.25	1009.50	1009.75
OOU	1010.00	1010.25	1010.50	1010.75	1011.00	1011.25	1011.50	1011.75
OOR	1012.00	1012.25	1012.50	1012.75	1013.00	1013.25	1013.50	1013.75
COW	1014.00	1014.25	1014.50	1014.75	1015.00	1015.25	1015.50	1015.75
OOD	1016.00	1016.25	1016.50	1016.75	1017.00	1017.25	1017.50	1017.75
OOK	1018.00	1018.25	1018.50	1018.75	1019.00	1019.25	1019.50	1019.75
OOG	1020.00	1020.25	1020.50	1020.75	1021.00	1021.25	1021.50	1021.75
COO	1022.00	1022.25	1022.50	1022.75	1023.00	1023.25	1023.50	1023.75

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```
 03/11/77  SCOPE 3.4.4        * CDC466A  A.F.G.L.
08.30.22.CORD02J  FROM MFA
08.30.22.IP  00000256 WORDS - FILE INPUT  , DC 80
08.30.23.CORD.
08.30.23.          2036    CORDELLA
08.30.25.FTN.SL.
08.30.32.       .159 CP SECONDS COMPILATION TIME
08.30.32.LGO.
08.30.41.    STOP
08.30.41.      1.159 CP SECONDS EXECUTION TIME
08.30.41.CP  00005312 WORDS - FILE OUTPUT , DC 40
08.30.41.MS     7168  WORDS  (   10752 MAX USED)
08.30.41.CPA       1.826 SEC.          .037 COST
08.30.41.IO         .923 SEC.          .036 COST
08.30.41.CM       31.869 KWS.          .034 COST
08.30.41.SS      COST OF JOB           .078
08.30.41.PP        8.217 SEC.      DATE 03/11/77
08.30.41.EJ  END OF JOB, **

**********          CORD02J  //// END OF LIST ////
**********          CORD02J  //// END OF LIST ////
```


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Appendix G

Temperature Program

G1. GENERAL

This program produces a dictionary to convert coded data to degrees Celsius. It operates on the number of counts produced in two sec by an oscillator whose frequency is a function of temperature.

G1.1 The Algorithm

Since the thermistor resistance vs temperature is a nonlinear function, an nth order polynomial is fit to the data over a specified interval of datum points. It was determined emperically that a fourth-order equation fit over four points works very well. The order and interval are entered on data card 1 which preceeds the temperature data.

G1.2 The Output

This discussion is keyed to a typical printout which is photo reduced and printed in its entirety at the end of this appendix. Following the identifier cover sheet are five pages of computer program. The comment cards explain the details of data entry. After the memory map is the data exactly as on the data cards. The 8 in column 1 of the last card is a flag which says there are no more data sets to follow. This flag works because the counts are entered as octal numbers; eights and nines do not exist in that number field. The next page is the program documenting how

you told it to process the data and how many datum points were read. Thirteen pages of dictionary, formulated to fit an 8 × 10-1/2 in. binder, follow. The program prints full pages extrapolated from the data. Therefore, this dictionary begins at -80.0°C to +20.0°C. An error table showing deviations from the entered datum points concludes the requested printout. Negative zeros indicate that zero was being approached from the negative side and the error is smaller than -0.1°C. Date, various computer times, and cost are documented on the last page. This dictionary is valid until changes are made in the encoder or thermistor.

G1.3 The Input

The count of events occurring during the two sec encoder sample period which, is the program input, was obtained by terminating the encoder with a simulated thermistor and recording the code vs temperature. The simulated thermistor was an 11 position resistance box which was set to the thermistor resistance ± 0.1 percent for each of the 11 temperatures -80°C, -70°C,.... +20°C. The count was derived from the code. This technique was used to check the accuracy of the PR-3 flowmeter system temperatures and is documented in Reference 18.

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```
      PROGRAM THERM      74/74   OPT=1                                FTN 4.8+.1+
 1              PROGRAM THERM(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
               C PROGRAM TO PRODUCE A THERMISTOR CALIBRATION DICTIONARY
               C INT= INTERVAL(NUMBER OF CALIBRATION POINTS) OVER WHICH BEST LINE IS
               C      TO BE FIT.  MUST BE AN EVEN NUMBER
 5             C IORDR= ORDER OF POLYNOMIAL TO BE FIT
               C T= TEMPERATURE
               C TSTAR= BEST ESTIMATE OF T
               C NC= COUNTS
               C INPUT DATA--
10             C CARD 1
               C      CC 1 INPUT TEMPERATURE SCALE, F OR C (A1)
               C      CC 2 OUTPUT TEMPERATURE SCALE, F OR C (A1)
               C      CC 3-5 INTERVAL (I3)
               C      CC 6-8 IORDR (I3)
15             C      CC 9-16 SERIAL NUMBER
               C      CC 17-26 DATE
               C CARD 2 THRU N+1
               C      CC 1-5 FIVE OCTAL DIGITS REPRESENTING COUNTS, RIGHT JUSTIFIED
               C      CC 6-15 TEMPERATURE (F10.0)
20             C      CARDS MUST BE IN ASCENDING ORDER BY TEMPERATURE
               C LAST CARD
               C      CC 1 =8 LAST THERMISTOR,  =9 MORE THERMISTORS TO FOLLOW
                      COMMON INT,INT2,IORDR,JORDR,N,NC,NCEND,X0,Y0,
                     1 T(201),COUNTS(201),TSTAR(200),C(21)
25                    DIMENSION LETTR(8),X(8),TEMP(2),ITEMP(2),JTEMP(2),IOCT(5)
                      DATA LETTR/1HS,1HU,1HC,1HW,1HD,1HK,1HG,1HO/
                      DATA TEMP/10HFAHRENHEIT,10HCENTIGRADE/
                      DATA JTEMP/1HF,1HC/
                   10 READ(5,20) ITEMP,INT,IORDR,SN,DATE
30                 20 FORMAT(2A1,2I3,A8,A10)
                      WRITE(6,21) ITEMP,INT,IORDR,SN,DATE
                   21 FORMAT(1H1,2A1,2I3,A8,A10)
                      DO 24 I=1,2
                      DO 23 J= 1,2
35                    IF(ITEMP(I).EQ.JTEMP(J)) GO TO 24
                   23 CONTINUE
                   24 ITEMP(I)= J
                      K= 2*(ITEMP(1)-1)+ITEMP(2)
                      N= 0
40                 25 N= N+1
                      READ(5,26) IOCT,T(N)
                   26 FORMAT(5I1,F10.0)
                      WRITE(6,1026) IOCT,T(N)
                 1026 FORMAT(1H ,5I1,F10.5)
45                    IF(IOCT(1).GT.7) GO TO 30
                      COUNTS(N)= 0.0
                      DO 27 I= 1,5
                   27 COUNTS(N)= COUNTS(N)+IOCT(I)*8**(5-I)
                      GO TO (25,28,29,25),K
50             C      CONVERT FAHRENHEIT TO CENTIGRADE
                   28 T(N)= (T(N)-32.0)*5.0/9.0
                      GO TO 25
               C      CONVERT CENTIGRADE TO FAHRENHEIT
                   29 T(N)= 1.8*T(N)+32.0
55                    GO TO 25
                   30 N= N-1
                      WRITE(6,31) TEMP(ITEMP(1))
```


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```
      31 FORMAT("1TEMPERATURE INPUT AS DEGREES ",A10)
         WRITE(6,32) TEMP(ITEMP(2))
      32 FORMAT(" TEMPERATURE OUTPUT AS DEGREES ",A10)
         WRITE(6,35) IORDR
      35 FORMAT(" ORDER READ AS",I4)
         WRITE(6,40) INT
      40 FORMAT(" INTERVAL READ AS",I4)
         WRITE(6,45) N
      45 FORMAT(" N IS",I4)
         INT= (INT/2)*2
         IF(INT.GT.N) INT=(N/2)*2
         INT2= INT/2
         WRITE(6,50) INT
      50 FORMAT(" INTERVAL USED IS",I4)
         J= INT2
         CALL COEF(J)
         NLAST= IFIX(COUNTS(N)+0.5)
         NC= IFIX(COUNTS(1)/256.0)*256
         DO 60 I= 1,INT2
      60 CALL GNPS(TSTAR(I),COUNTS(I)*X0+X0,C,JORDR)
         IPAGE= 0
      70 IPAGE= IPAGE+1
         WRITE(6,80) SN,DATE,IPAGE
      80 FORMAT(1H1,6X,"THERMISTOR CALIBRATION RESULTS",2X,"S/N ",A4,
        1 " DATE ",A10," PAGE",I3)
         WRITE(6,81) TEMP(ITEMP(2))
      81 FORMAT(1HO,23X,"TEMPERATURE IN DEGREES ",A10)
         WRITE(6,82) LETTR
      82 FORMAT(1HO,9X,8(7X,A1))
         DO 400 J2= 1,4
         WRITE(6,83)
      83 FORMAT(1H )
         DO 300 J3= 1,8
         K=NC/8
         K3= MOD(K,8)+1
         K=K/8
         K2= MOD(K,8)+1
         K= K/8
         K1= MOD(K,8)+1
         DO 200 J4= 1,8
         IF(NC.GT.NCEND) CALL COEF(J)
         CALL GNPS(X(J4),FLOAT(NC)*X0+X0,C,JORDR)
     200 NC= NC+1
     300 WRITE(6,301) LETTR(K1),LETTR(K2),LETTR(K3),X
     301 FORMAT(1H ,6X,3A1,1X,6F8.1)
     400 CONTINUE
         IF(NC.LT.NLAST) GO TO 70
         J= J+1
         DO 440 I=J,N
     440 CALL GNPS(TSTAR(I),COUNTS(I)*X0+X0,C,JORDR)
         WRITE(6,451)
     451 FORMAT(1H1,3X,"I",4X,"COUNTS",4X,"T*",5X,"T-T*")
         DO 500 I= 1,N
         ERR= T(I)-TSTAR(I)
     500 WRITE(6,501) T(I),COUNTS(I),TSTAR(I),ERR
     501 FORMAT(1H ,F6.1,3F8.1)
         IF(IOCT(1).EQ.9) GO TO 10
```


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```
      PROGRAM THERM     74/74  OPT=1
  115       STOP
            END
```

```
SUBROUTINE COEF       74/74   OPT=1                    FTN 4.8+1[illegible]

      SUBROUTINE COEF(J)
      COMMON INT,INT2,IORDR,JORDR,N,NC,NCEND,XD,XB,
     1 T(201),COUNTS(201),TSTAR(201),C(201)
      DIMENSION DATI(100),WORK(259)
      IF(J+INT2.GT.N) RETURN
      J= J+1
      K1= J-INT2
      K2= J+INT2-1
      CALL RMOVE(COUNTS,K1,K2,DATI,1)
      CALL RMOVE(T,K1,K2,DATI,INT+1)
      DATI(2*INT+1)= -1
      JORDR= IORDR
      CALL APCH(DATI,INT,JORDR,XD,XB,WORK,IER)
      CALL APFS(WORK,JORDR,IPES,*,0.0001,0.0001,IER)
      I= JORDR*(JORDR-1)/2+1
      CALL RMOVE (WORK,I,I+JORDR-1,C,1)
      CALL CNPS(TSTAR(J),COUNTS(J)*XD+XB,C,JORDR)
      NCEND= IFIX(COUNTS(J))
      RETURN
      END
```


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```
SUBROUTINE RMOVE    74/74   OPT=1                FTN 4.5+414    03/22/77  03.56.37    PAG    1

 1              SUBROUTINE RMOVE(X,N1,N2,Y,M1)
                DIMENSION X(1),Y(1)
                L1= M1
                DO 5 I= N1,N2
                Y(L1)= X(I)
 5              L1= L1+1
                RETURN
                END
```

LOAD MAP - CNPS CYBER LOADER 1 1-420 05/11/77 [illegible] PAGE 1

FWA OF THE LOAD 111
LWA+1 OF THE LOAD 22534

TRANSFER ADDRESS -- THERM 5035

PROGRAM AND BLOCK ASSIGNMENTS.

BLOCK	ADDRESS	LENGTH	FILE	DATE	PROCESSR	VER LEVEL	HARDWARE	COMMENTS
CNPS	111	70	INPUT	04/26/74	FTN	4.1 P374	6600 I	OPT=1
APFS	201	252	INPUT	04/26/74	FTN	4.1 P374	6600 I	OPT=1
APCH	453	251	INPUT	04/26/74	FTN	4.1 P374	6600 I	OPT=1
THERM	724	4735	LGO	05/11/77	FTN	4.8 414	6600 I	OPT=1
COEF	5661	665	LGO	05/11/77	FTN	4.8 414	6600 I	OPT=1
RMOVE	6546	23	LGO	05/11/77	FTN	4.8 414	6600 I	OPT=1
/FCL.C./	6571	23						
/OS.IO./	6614	131						
COMIO=	6745	64	SL-FORTRAN	05/11/76	COMPASS	3. 2+414		COMMON SUB D I/O ROUTINES AND CERTAIN
OSNTRY=	6745	0	SL-FORTRAN	05/11/76	COMPASS	3. 2+414		FCL INITIALIZATION ROUTIN
FECMSK=	7031	41	SL-FORTRAN	05/11/76	COMPASS	3. 2+414		INITIALIZ CONSTANTS
FLTOUT=	7072	310	SL-FORTRAN	05/11/76	COMPASS	3. 2+414		COMMON FLOATING OUTPUT SUB
FORSYS=	7402	601	SL-FORTRAN	05/11/76	COMPASS	3. 2+414		FORTRAN OBJECT LIBRARY UTILITIES
INCOM=	10203	277	SL-FORTRAN	05/11/76	COMPASS	3. 2+414		COMMON INPUT FORMATTING SUB
INPC=	10502	160	SL-FORTRAN	05/11/76	COMPASS	3. 2+414		FORMATTED READ FORTRAN RECORD
KOOFR=	10662	456	SL-FORTRAN	05/11/76	COMPASS	3. 2+414		OUTPUT FORMAT INTERPRETER
OUTCOM=	11340	154	SL-FORTRAN	05/11/76	COMPASS	3. 2+414		COMMON OUTPUT SUBR
COTOER=	11514	14	SL-FORTRAN	05/11/76	COMPASS	3. 2+414		COMPUTED GO TO TRACE BACK PROCESSR
ITOJ=	11530	16	SL-FORTRAN	05/11/76	COMPASS	3. 2+414		INTEGER TO INT SUB SUBROUTINE
SQRT	11546	43	SL-FORTRAN	05/11/76	COMPASS	3. 2+414		COMPUTE THE SQUARE ROOT OF X (REAL)
SYS=1ST	11611	62	SL-FORTRAN	05/11/76	COMPASS	3. 2+414		MATH LIBRARY LINK TO CYBER BUSINESS PROCESSOR
FLTIN=	11673	154	SL-FORTRAN	05/11/76	COMPASS	3. 2+414		COMMON FLOATING INPUT CONVERT
FMTAP=	12047	352	SL-FORTRAN	05/11/76	COMPASS	3. 2+414		CHECK SPLIT AND FORMAT FOR NOUNKNOWN
FORUTL=	12421	16	SL-FORTRAN	05/11/76	COMPASS	3. 2+414		FCL MISC UTILITIES
GETFIT=	12437	42	SL-FORTRAN	05/11/76	COMPASS	3. 2+414		LOCATE AN FIT GIVEN A FILE NAME
KRAKER=	12501	406	SL-FORTRAN	05/11/76	COMPASS	3. 2+414		PROCESS FORMATTED FORTRAN INPUT
OUTC=	13107	172	SL-FORTRAN	05/11/76	COMPASS	3. 2+414		FORMATTED WRITE, FORTRAN RECORD
SYSAID=	13301	1	SL-FORTRAN	05/11/76	COMPASS	3. 2+414		LINK BETWEEN SYSAID AND INITIALIZATION CODE.
/CON.RM/	13302	6						
OIO.RM	13310	40	SL-SYSIO	05/28/76	COMPASS	3. 75125		
/ADR.RM/	13350	10						
MOVE.RM	13360	64	SL-SYSIO	05/28/76	COMPASS	3. 75125		
MCT.RM	13444	233	SL-SYSIO	05/28/76	COMPASS	3. 75125		
/JMPS.RM/	13677	11						
/MEMC.RM/	13710	3						
/OPES.FO/	13713	1						
/OPEN.FO/	13714	7						
OPEN.RM	13723	235	SL-SYSIO	05/28/76	COMPASS	3. 75125		
/TERM.RM/	14160	1						
/PUT.FO/	14161	7						
PUT.SQ	14170	1362	SL-SYSIO	05/28/76	COMPASS	3. 75125		
VAR.SQ	15552	260	SL-SYSIO	05/28/76	COMPASS	3. 75125		
/CLSF.FO/	16032	7						
CLSF.RM	16041	23	SL-SYSIO	05/28/76	COMPASS	3. 75125		
/GET.BT/	16064	5						

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LOAD MAP - CNPS — CYBER LOADER 1.1-42* — 05/11/77 — PAGE 4

BTRT.SQ	16071	114	SL-SYSIO	05/28/76	COMPASS	3. 75125
WEOW.SQ	16205	142	SL-SYSIO	05/28/76	COMPASS	3. 75125
/SKFL.FO/	16347	7				
SKFL.SQ	16356	47	SL-SYSIO	05/28/76	COMPASS	3. 75125
ERR.RM	16425	404	SL-SYSIO	05/28/76	COMPASS	3. 75125
CHWR.SQ	17031	7	SL-SYSIO	05/28/76	COMPASS	3. 75125
OSUB.RM	17045	65	SL-SYSIO	05/28/76	COMPASS	3. 75125
CPEN.SQ	17125	262	SL-SYSIO	05/28/76	COMPASS	3. 75125
CPEX.SQ	17407	14	SL-SYSIO	05/28/76	COMPASS	3. 75125
/PUT.RT/	17423	11				
FLED.RM	17434	42	SL-SYSIO	05/28/76	COMPASS	3. 75125
CLSF.SQ	17476	132	SL-SYSIO	05/28/76	COMPASS	3. 75125
/CLSV.FO/	17630	7				
CLSV.SQ	17637	123	SL-SYSIO	05/28/76	COMPASS	3. 75125
/REW.FO/	17762	7				
RFM.SQ	17771	31	SL-SYSIO	05/28/76	COMPASS	3. 75125
/GET.FO/	20022	7				
/GET.RT/	20031	11				
GET.SQ	20042	1035	SL-SYSIO	05/26/76	COMPASS	3. 75125
Z.SQ	21077	101	SL-SYSIO	05/26/76	COMPASS	3. 75125
FSU.SQ	21200	106	SL-SYSIO	05/26/76	COMPASS	3. 75125
SYS.RM	21306	37	SL-NUCLEUS	03/29/76	COMPASS	3. 75125
//	21345	1167				

PROCESS SYSTEM REQUEST

•569 CP SECONDS — 340008 CM STORAGE USED — 31 TABLE ENTRIES

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```
GG  4  4 W831J1 27 MAR 76
00451  -60.00000
00627  -70.00000
01115  -60.00000
01536  -50.00000
02315  -40.00000
03171  -30.00000
04074  -20.00000
04735  -10.00000
05506    0.00000
06151   10.00000
06503   20.00000
*****   -0.00000
```

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TEMPERATURE INPUT AS DEGREES CENTIGRADE
TEMPERATURE OUTPUT AS DEGREES CENTIGRADE
ORDER READ AS  4
INTERVAL READ AS  4
N IS  11
INTERVAL USED IS  4
```

THERMISTOR CALIBRATION RESULTS S/N UUB31J1 DATE 27 MAR 76 PAGE 1

TEMPERATURE IN DEGREES CENTIGRADE

	S	U	R	M	O	K	G	O
SDS	-84.8	-84.7	-84.5	-84.4	-84.3	-84.2	-84.1	-83.9
SDU	-83.8	-83.7	-83.6	-83.4	-83.3	-83.2	-83.1	-83.0
SDR	-82.8	-82.7	-82.6	-82.5	-82.4	-82.3	-82.1	-82.0
SDW	-81.9	-81.8	-81.7	-81.6	-81.5	-81.3	-81.2	-81.1
SDO	-81.0	-80.9	-80.8	-80.7	-80.6	-80.4	-80.3	-80.2
SDK	-80.1	-80.0	-79.9	-79.8	-79.7	-79.6	-79.5	-79.4
SDG	-79.2	-79.1	-79.0	-78.9	-78.8	-78.7	-78.6	-78.5
SDO	-78.4	-78.3	-78.2	-78.1	-78.0	-77.9	-77.8	-77.7
SKS	-77.6	-77.5	-77.4	-77.3	-77.2	-77.1	-77.0	-76.9
SKU	-76.8	-76.7	-76.6	-76.5	-76.4	-76.3	-76.2	-76.1
SKR	-76.0	-75.9	-75.8	-75.7	-75.6	-75.5	-75.4	-75.3
SKW	-75.3	-75.2	-75.1	-75.0	-74.9	-74.8	-74.7	-74.6
SKO	-74.5	-74.4	-74.3	-74.3	-74.2	-74.1	-74.0	-73.9
SKK	-73.8	-73.7	-73.6	-73.5	-73.5	-73.4	-73.3	-73.2
SKG	-73.1	-73.0	-72.9	-72.9	-72.8	-72.7	-72.6	-72.5
SKO	-72.4	-72.4	-72.3	-72.2	-72.1	-72.0	-71.9	-71.9
SGS	-71.8	-71.7	-71.6	-71.5	-71.5	-71.4	-71.3	-71.2
SGU	-71.1	-71.1	-71.0	-70.9	-70.8	-70.7	-70.6	-70.6
SGR	-70.5	-70.5	-70.4	-70.3	-70.2	-70.1	-70.1	-70.0
SGW	-69.9	-69.9	-69.8	-69.7	-69.6	-69.6	-69.5	-69.4
SGO	-69.3	-69.3	-69.2	-69.1	-69.1	-69.0	-68.9	-68.8
SGK	-68.8	-68.7	-68.6	-68.6	-68.5	-68.4	-68.4	-68.3
SGG	-68.2	-68.2	-68.1	-68.0	-68.0	-67.9	-67.8	-67.8
SGO	-67.7	-67.6	-67.6	-67.5	-67.4	-67.4	-67.3	-67.2
SOS	-67.2	-67.1	-67.0	-67.0	-66.9	-66.8	-66.8	-66.7
SOU	-66.7	-66.6	-66.5	-66.5	-66.4	-66.3	-66.3	-66.2
SOR	-66.2	-66.1	-66.0	-66.0	-65.9	-65.9	-65.8	-65.7
SOW	-65.7	-65.6	-65.6	-65.5	-65.5	-65.4	-65.3	-65.3
SOO	-65.2	-65.2	-65.1	-65.1	-65.0	-64.9	-64.9	-64.8
SOK	-64.8	-64.7	-64.7	-64.6	-64.6	-64.5	-64.4	-64.4
SOG	-64.3	-64.3	-64.2	-64.2	-64.1	-64.1	-64.0	-64.0
SOO	-63.9	-63.9	-63.8	-63.7	-63.7	-63.6	-63.6	-63.5

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THERMISTOR CALIBRATION RESULTS S/N UU831J1 DATE 27 MAR 7o PAGE 2

TEMPERATURE IN DEGREES CENTIGRADE

	S	U	R	W	O	K	G	O
USS	-63.5	-63.4	-63.4	-63.3	-63.3	-63.2	-63.2	-63.1
USU	-63.1	-63.0	-63.0	-62.9	-62.9	-62.8	-62.8	-62.7
USR	-62.7	-62.6	-62.6	-62.5	-62.5	-62.5	-62.4	-62.4
USW	-62.3	-62.3	-62.2	-62.2	-62.1	-62.1	-62.0	-62.0
USO	-61.9	-61.9	-61.8	-61.8	-61.8	-61.7	-61.7	-61.6
USK	-61.6	-61.5	-61.5	-61.4	-61.4	-61.4	-61.3	-61.3
USG	-61.2	-61.2	-61.1	-61.1	-61.0	-61.0	-61.0	-60.9
USO	-60.9	-60.8	-60.8	-60.7	-60.7	-60.7	-60.6	-60.6
UUS	-60.5	-60.5	-60.5	-60.4	-60.4	-60.3	-60.3	-60.2
UUU	-60.2	-60.2	-60.1	-60.1	-60.0	-60.0	-60.0	-59.9
UUR	-59.9	-59.8	-59.8	-59.7	-59.7	-59.6	-59.6	-59.5
UUW	-59.5	-59.5	-59.4	-59.4	-59.3	-59.3	-59.2	-59.2
UUO	-59.1	-59.1	-59.1	-59.0	-59.0	-58.9	-58.9	-58.8
UUK	-58.8	-58.7	-58.7	-58.7	-58.6	-58.6	-58.5	-58.5
UUG	-58.4	-58.4	-58.4	-58.3	-58.3	-58.2	-58.2	-58.1
UUO	-58.1	-58.1	-58.0	-58.0	-57.9	-57.9	-57.8	-57.8
URS	-57.8	-57.7	-57.7	-57.6	-57.6	-57.5	-57.5	-57.5
URU	-57.4	-57.4	-57.3	-57.3	-57.3	-57.2	-57.2	-57.1
URR	-57.1	-57.1	-57.0	-57.0	-56.9	-56.9	-56.9	-56.9
URW	-56.8	-56.7	-56.7	-56.7	-56.6	-56.6	-56.6	-56.5
URO	-56.5	-56.4	-56.4	-56.3	-56.3	-56.3	-56.2	-56.2
URK	-56.1	-56.1	-56.1	-56.0	-56.0	-55.9	-55.9	-55.9
URG	-55.8	-55.8	-55.8	-55.7	-55.7	-55.6	-55.6	-55.6
URO	-55.5	-55.5	-55.4	-55.4	-55.4	-55.3	-55.3	-55.3
UWS	-55.2	-55.2	-55.1	-55.1	-55.1	-55.0	-55.0	-55.0
UWU	-54.9	-54.9	-54.9	-54.8	-54.8	-54.7	-54.7	-54.7
UWR	-54.6	-54.6	-54.6	-54.5	-54.5	-54.5	-54.4	-54.4
UWW	-54.3	-54.3	-54.3	-54.2	-54.2	-54.2	-54.1	-54.1
UWO	-54.1	-54.0	-54.0	-54.0	-53.9	-53.9	-53.8	-53.8
UWK	-53.8	-53.7	-53.7	-53.7	-53.6	-53.6	-53.6	-53.5
UWG	-53.5	-53.5	-53.4	-53.4	-53.4	-53.3	-53.3	-53.3
UWO	-53.2	-53.2	-53.2	-53.1	-53.1	-53.1	-53.0	-53.0

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THERMISTOR CALIBRATION RESULTS S/N UU831J1 DATE 27 MAR 75 PAGE 3

TEMPERATURE IN DEGREES CENTIGRADE

	S	U	R	W	D	K	G	O
UDS	-53.0	-52.9	-52.9	-52.9	-52.8	-52.8	-52.8	-52.7
UDU	-52.7	-52.7	-52.6	-52.6	-52.6	-52.5	-52.5	-52.5
UDR	-52.4	-52.4	-52.4	-52.3	-52.3	-52.3	-52.2	-52.2
UDW	-52.2	-52.1	-52.1	-52.1	-52.0	-52.0	-52.1	-51.9
UDD	-51.9	-51.9	-51.8	-51.8	-51.8	-51.7	-51.7	-51.7
UDK	-51.6	-51.6	-51.6	-51.6	-51.5	-51.5	-51.5	-51.4
UD6	-51.4	-51.4	-51.3	-51.3	-51.3	-51.2	-51.2	-51.2
UDO	-51.1	-51.1	-51.1	-51.1	-51.0	-51.0	-51.1	-51.0
UKS	-50.9	-50.9	-50.8	-50.8	-50.8	-50.7	-50.7	-50.7
UKU	-50.7	-50.6	-50.6	-50.6	-50.6	-50.5	-50.5	-50.4
UKR	-50.4	-50.4	-50.4	-50.3	-50.3	-50.3	-50.2	-50.2
UKW	-50.2	-50.1	-50.1	-50.1	-50.1	-50.0	-50.1	-50.0
UKD	-49.9	-49.9	-49.9	-49.8	-49.8	-49.8	-49.7	-49.7
UKK	-49.7	-49.7	-49.6	-49.6	-49.6	-49.5	-49.5	-49.5
UKG	-49.4	-49.4	-49.4	-49.3	-49.3	-49.3	-49.2	-49.2
UK0	-49.2	-49.2	-49.1	-49.1	-49.1	-49.1	-49.0	-49.0
UGS	-48.9	-48.9	-48.9	-48.8	-48.8	-48.8	-48.8	-48.7
UGU	-48.7	-48.7	-48.6	-48.6	-48.6	-48.5	-48.5	-48.5
UGR	-48.5	-48.4	-48.4	-48.4	-48.3	-48.3	-48.3	-48.2
UGW	-48.2	-48.2	-48.2	-48.1	-48.1	-48.1	-48.1	-48.0
UG0	-48.0	-47.9	-47.9	-47.9	-47.9	-47.8	-47.8	-47.8
UGK	-47.7	-47.7	-47.7	-47.6	-47.6	-47.6	-47.6	-47.5
UG6	-47.5	-47.5	-47.4	-47.4	-47.4	-47.4	-47.3	-47.3
UGO	-47.3	-47.2	-47.2	-47.2	-47.1	-47.1	-47.1	-47.1
UOS	-47.0	-47.0	-47.0	-46.9	-46.9	-46.9	-46.9	-46.8
UOU	-46.8	-46.8	-46.7	-46.7	-46.7	-46.7	-46.6	-46.6
UOR	-46.6	-46.5	-46.5	-46.5	-46.5	-46.4	-46.4	-46.4
UOW	-46.3	-46.3	-46.3	-46.3	-46.2	-46.2	-46.2	-46.1
UOD	-46.1	-46.1	-46.1	-46.0	-46.0	-46.0	-46.1	-45.9
UOK	-45.9	-45.9	-45.8	-45.8	-45.8	-45.8	-45.7	-45.7
UO6	-45.7	-45.6	-45.6	-45.6	-45.6	-45.5	-45.5	-45.5
UOO	-45.5	-45.4	-45.4	-45.4	-45.3	-45.3	-45.3	-45.3

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THERMISTOR CALIBRATION RESULTS S/N UU831J1 DATE 27 MAR 76 PAGE 4

TEMPERATURE IN DEGREES CENTIGRADE

	S	U	R	W	D	K	G	O
RSS	-45.2	-45.2	-45.2	-45.1	-45.1	-45.1	-45.1	-45.1
RSU	-45.0	-45.0	-45.0	-44.9	-44.9	-44.9	-44.8	-44.8
RSR	-44.8	-44.8	-44.7	-44.7	-44.7	-44.7	-44.6	-44.6
RSW	-44.6	-44.6	-44.5	-44.5	-44.5	-44.4	-44.4	-44.4
RSD	-44.4	-44.3	-44.3	-44.3	-44.3	-44.2	-44.2	-44.2
RSK	-44.2	-44.1	-44.1	-44.1	-44.0	-44.0	-44.0	-44.0
RSG	-43.9	-43.9	-43.9	-43.9	-43.8	-43.8	-43.8	-43.8
RSO	-43.7	-43.7	-43.7	-43.7	-43.6	-43.6	-43.6	-43.5
RUS	-43.5	-43.5	-43.5	-43.4	-43.4	-43.4	-43.4	-43.3
RUU	-43.3	-43.3	-43.3	-43.2	-43.2	-43.2	-43.2	-43.1
RUR	-43.1	-43.1	-43.1	-43.0	-43.0	-43.0	-43.0	-42.9
RUW	-42.9	-42.9	-42.8	-42.8	-42.8	-42.8	-42.7	-42.7
RUD	-42.7	-42.7	-42.6	-42.6	-42.6	-42.6	-42.5	-42.5
RUK	-42.5	-42.5	-42.4	-42.4	-42.4	-42.4	-42.3	-42.3
RUG	-42.3	-42.3	-42.2	-42.2	-42.2	-42.2	-42.1	-42.1
RUO	-42.1	-42.1	-42.0	-42.0	-42.0	-42.0	-41.9	-41.9
RRS	-41.9	-41.9	-41.8	-41.8	-41.8	-41.8	-41.7	-41.7
RRU	-41.7	-41.7	-41.6	-41.6	-41.6	-41.6	-41.5	-41.5
RRR	-41.5	-41.5	-41.4	-41.4	-41.4	-41.4	-41.3	-41.3
RRW	-41.3	-41.3	-41.2	-41.2	-41.2	-41.2	-41.1	-41.1
RRD	-41.1	-41.1	-41.0	-41.0	-41.0	-41.0	-40.9	-40.9
RRK	-40.9	-40.9	-40.8	-40.8	-40.8	-40.8	-40.8	-40.7
RRG	-40.7	-40.7	-40.7	-40.6	-40.6	-40.6	-40.5	-40.5
RRO	-40.5	-40.5	-40.5	-40.4	-40.4	-40.4	-40.4	-40.3
RWS	-40.3	-40.3	-40.3	-40.2	-40.2	-40.2	-40.2	-40.1
RWU	-40.1	-40.1	-40.1	-40.0	-40.0	-40.0	-40.0	-39.9
RWR	-39.9	-39.9	-39.9	-39.9	-39.8	-39.8	-39.8	-39.8
RWW	-39.7	-39.7	-39.7	-39.7	-39.6	-39.6	-39.6	-39.6
RWD	-39.5	-39.5	-39.5	-39.5	-39.4	-39.4	-39.4	-39.4
RWK	-39.3	-39.3	-39.3	-39.3	-39.2	-39.2	-39.2	-39.2
RWG	-39.1	-39.1	-39.1	-39.1	-39.0	-39.0	-39.0	-39.0
RWO	-38.9	-38.9	-38.9	-38.9	-38.8	-38.8	-38.8	-38.8

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THERMISTOR CALIBRATION RESULTS S/N 00831J1 DATE 27 MAR 76 PAGE 5

TEMPERATURE IN DEGREES CENTIGRADE

	S	U	R	M	D	K	G	O
RDS	-38.7	-38.7	-38.7	-38.7	-38.6	-38.6	-38.5	-38.5
RDU	-38.5	-38.5	-38.5	-38.5	-38.4	-38.4	-38.4	-38.4
RDR	-38.3	-38.3	-38.3	-38.3	-38.2	-38.2	-38.2	-38.2
RDW	-38.2	-38.1	-38.1	-38.1	-38.1	-38.1	-38.1	-38.
RDB	-38.0	-37.9	-37.9	-37.9	-37.9	-37.8	-37.8	-37.8
RDK	-37.8	-37.7	-37.7	-37.7	-37.7	-37.6	-37.6	-37.6
RDG	-37.6	-37.5	-37.5	-37.5	-37.5	-37.5	-37.4	-37.4
RDO	-37.4	-37.4	-37.3	-37.3	-37.3	-37.3	-37.2	-37.2
RKS	-37.2	-37.2	-37.1	-37.1	-37.1	-37.1	-37.1	-37.0
RKU	-37.0	-37.0	-36.9	-36.9	-36.9	-36.9	-36.9	-36.8
RKR	-36.8	-36.8	-36.8	-36.7	-36.7	-36.7	-36.7	-36.6
RKW	-36.6	-36.6	-36.6	-36.5	-36.5	-36.5	-36.5	-36.4
RKB	-36.4	-36.4	-36.4	-36.4	-36.3	-36.3	-36.3	-36.3
RKK	-36.2	-36.2	-36.2	-36.2	-36.1	-36.1	-36.1	-36.1
RKG	-36.0	-36.0	-36.0	-36.0	-36.0	-35.9	-35.9	-35.9
RKO	-35.9	-35.8	-35.9	-35.8	-35.8	-35.7	-35.7	-35.7
RGS	-35.7	-35.6	-35.6	-35.6	-35.6	-35.6	-35.5	-35.5
RGU	-35.5	-35.5	-35.4	-35.4	-35.4	-35.4	-35.3	-35.3
RGR	-35.3	-35.3	-35.2	-35.2	-35.2	-35.2	-35.2	-35.1
RGW	-35.1	-35.1	-35.1	-35.0	-35.0	-35.0	-35.0	-34.9
RGB	-34.9	-34.9	-34.9	-34.9	-34.8	-34.8	-34.8	-34.8
RGK	-34.7	-34.7	-34.7	-34.7	-34.6	-34.6	-34.6	-34.6
RGG	-34.6	-34.5	-34.5	-34.5	-34.5	-34.4	-34.4	-34.4
RGO	-34.4	-34.3	-34.3	-34.3	-34.3	-34.2	-34.2	-34.2
ROS	-34.2	-34.2	-34.1	-34.1	-34.1	-34.1	-34.0	-34.0
ROU	-34.0	-34.0	-34.0	-33.9	-33.9	-33.9	-33.9	-33.8
ROR	-33.8	-33.8	-33.8	-33.7	-33.7	-33.7	-33.7	-33.7
ROW	-33.6	-33.6	-33.6	-33.6	-33.5	-33.5	-33.5	-33.5
ROB	-33.4	-33.4	-33.4	-33.4	-33.4	-33.3	-33.3	-33.3
ROK	-33.3	-33.2	-33.2	-33.2	-33.2	-33.1	-33.1	-33.1
ROG	-33.1	-33.1	-33.0	-33.0	-33.0	-33.0	-32.9	-32.9
ROO	-32.9	-32.9	-32.9	-32.8	-32.8	-32.8	-32.8	-32.7

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THERMISTOR CALIBRATION RESULTS S/N UUB31J1 DATE 27 MAR 76 PAGE 5

TEMPERATURE IN DEGREES CENTIGRADE

	S	U	R	W	D	K	G	O
WSS	-32.7	-32.7	-32.7	-32.6	-32.6	-32.6	-32.6	-32.6
WSU	-32.5	-32.5	-32.5	-32.5	-32.4	-32.4	-32.4	-32.4
WSR	-32.4	-32.3	-32.3	-32.3	-32.3	-32.2	-32.2	-32.2
WSW	-32.2	-32.2	-32.1	-32.1	-32.1	-32.1	-32.1	-32.0
WSD	-32.0	-32.0	-31.9	-31.9	-31.9	-31.9	-31.9	-31.9
WSK	-31.8	-31.8	-31.8	-31.7	-31.7	-31.7	-31.7	-31.7
WSG	-31.6	-31.6	-31.6	-31.6	-31.5	-31.5	-31.5	-31.5
WSO	-31.5	-31.4	-31.4	-31.4	-31.4	-31.3	-31.3	-31.3
WUS	-31.3	-31.3	-31.2	-31.2	-31.2	-31.2	-31.1	-31.1
WUU	-31.1	-31.1	-31.0	-31.0	-31.0	-31.0	-31.0	-31.0
WUR	-30.9	-30.9	-30.9	-30.8	-30.8	-30.8	-30.8	-30.8
WUW	-30.7	-30.7	-30.7	-30.7	-30.6	-30.6	-30.6	-30.6
WUD	-30.6	-30.5	-30.5	-30.5	-30.5	-30.4	-30.4	-30.4
WUK	-30.4	-30.4	-30.3	-30.3	-30.3	-30.3	-30.2	-30.2
WUG	-30.2	-30.2	-30.2	-30.1	-30.1	-30.1	-30.1	-30.1
WUO	-30.0	-30.0	-30.0	-30.0	-29.9	-29.9	-29.9	-29.9
WRS	-29.8	-29.8	-29.8	-29.8	-29.8	-29.7	-29.7	-29.7
WRU	-29.7	-29.6	-29.6	-29.6	-29.6	-29.6	-29.6	-29.6
WRR	-29.5	-29.5	-29.4	-29.4	-29.4	-29.4	-29.4	-29.3
WRW	-29.3	-29.3	-29.3	-29.2	-29.2	-29.2	-29.2	-29.2
WRD	-29.1	-29.1	-29.1	-29.1	-29.0	-29.0	-29.0	-29.0
WRK	-29.0	-28.9	-28.9	-28.9	-28.9	-28.8	-28.8	-28.8
WRG	-28.8	-28.8	-28.7	-28.7	-28.7	-28.7	-28.6	-28.6
WRO	-28.6	-28.6	-28.6	-28.5	-28.5	-28.5	-28.5	-28.4
WWS	-28.4	-28.4	-28.4	-28.4	-28.3	-28.3	-28.3	-28.3
WWU	-28.2	-28.2	-28.2	-28.2	-28.2	-28.1	-28.1	-28.1
WWR	-28.1	-28.0	-28.0	-28.0	-28.0	-28.0	-27.9	-27.9
WWW	-27.9	-27.9	-27.9	-27.8	-27.8	-27.8	-27.8	-27.7
WWD	-27.7	-27.7	-27.7	-27.7	-27.6	-27.6	-27.6	-27.6
WWK	-27.5	-27.5	-27.5	-27.5	-27.5	-27.4	-27.4	-27.4
WWG	-27.4	-27.3	-27.3	-27.3	-27.3	-27.3	-27.2	-27.2
WWO	-27.2	-27.2	-27.1	-27.1	-27.1	-27.1	-27.1	-27.

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THERMISTOR CALIBRATION RESULTS S/N UUB31J1 DATE 27 MAR 76 PAGE 7

TEMPERATURE IN DEGREES CENTIGRADE

	S	U	R	W	D	K	G	O
WDS	-27.0	-27.0	-27.0	-26.9	-26.9	-26.9	-26.9	-26.9
WDU	-26.8	-26.8	-26.8	-26.8	-26.7	-26.7	-26.7	-26.7
WDR	-26.7	-26.6	-26.6	-26.6	-26.6	-26.5	-26.5	-26.5
WDW	-26.5	-26.5	-26.4	-26.4	-26.4	-26.4	-26.4	-26.3
WDD	-26.3	-26.3	-26.3	-26.2	-26.2	-26.2	-26.2	-26.2
WDK	-26.1	-26.1	-26.1	-26.1	-26.0	-26.0	-26.1	-26.0
WDG	-26.0	-25.9	-25.9	-25.9	-25.9	-25.9	-25.9	-25.8
WDO	-25.8	-25.8	-25.7	-25.7	-25.7	-25.7	-25.6	-25.6
WKS	-25.6	-25.6	-25.6	-25.5	-25.5	-25.5	-25.5	-25.4
WKU	-25.4	-25.4	-25.4	-25.4	-25.3	-25.3	-25.3	-25.3
WKR	-25.3	-25.2	-25.2	-25.2	-25.2	-25.1	-25.1	-25.1
WKW	-25.1	-25.1	-25.0	-25.0	-25.0	-25.0	-24.9	-24.9
WKD	-24.9	-24.9	-24.9	-24.9	-24.8	-24.8	-24.8	-24.7
WKK	-24.7	-24.7	-24.7	-24.7	-24.6	-24.6	-24.5	-24.5
WKG	-24.5	-24.5	-24.5	-24.5	-24.5	-24.4	-24.4	-24.4
WKO	-24.4	-24.3	-24.3	-24.3	-24.3	-24.3	-24.2	-24.2
WGS	-24.2	-24.2	-24.1	-24.1	-24.1	-24.1	-24.1	-24.0
WGU	-24.0	-24.0	-24.0	-23.9	-23.9	-23.9	-23.9	-23.9
WGR	-23.8	-23.8	-23.8	-23.8	-23.8	-23.7	-23.7	-23.7
WGW	-23.7	-23.6	-23.6	-23.6	-23.6	-23.6	-23.5	-23.5
WGD	-23.5	-23.5	-23.4	-23.4	-23.4	-23.4	-23.4	-23.3
WGK	-23.3	-23.3	-23.3	-23.2	-23.2	-23.2	-23.2	-23.2
WGG	-23.1	-23.1	-23.1	-23.1	-23.0	-23.0	-23.0	-23.0
WGO	-23.0	-22.9	-22.9	-22.9	-22.9	-22.8	-22.8	-22.8
WOS	-22.8	-22.8	-22.7	-22.7	-22.7	-22.7	-22.6	-22.6
WOU	-22.6	-22.6	-22.6	-22.5	-22.5	-22.5	-22.5	-22.4
WOR	-22.4	-22.4	-22.4	-22.4	-22.3	-22.3	-22.3	-22.3
WOW	-22.2	-22.2	-22.2	-22.2	-22.2	-22.1	-22.1	-22.1
WOD	-22.1	-22.0	-22.0	-22.0	-22.0	-22.0	-21.9	-21.9
WOK	-21.9	-21.9	-21.8	-21.8	-21.9	-21.8	-21.8	-21.7
WOG	-21.7	-21.7	-21.7	-21.6	-21.6	-21.6	-21.6	-21.6
WOO	-21.5	-21.5	-21.5	-21.5	-21.4	-21.4	-21.4	-21.4

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THERMISTOR CALIBRATION RESULTS S/N 0083101 DATE 27 MAR 76 PAGE 8

TEMPERATURE IN DEGREES CENTIGRADE

	S	U	R	W	O	K	G	O
OSS	-21.3	-21.3	-21.3	-21.3	-21.3	-21.2	-21.2	-21.2
OSU	-21.2	-21.1	-21.1	-21.1	-21.1	-21.1	-21.0	-21.0
OSR	-21.0	-21.0	-20.9	-20.9	-20.9	-20.9	-20.9	-20.8
OSW	-20.8	-20.8	-20.8	-20.7	-20.7	-20.7	-20.7	-20.7
OSO	-20.6	-20.6	-20.6	-20.6	-20.5	-20.5	-20.5	-20.5
OSK	-20.5	-20.4	-20.4	-20.4	-20.4	-20.3	-20.3	-20.3
OSG	-20.3	-20.2	-20.2	-20.2	-20.2	-20.2	-20.1	-20.1
OSO	-20.1	-20.1	-20.0	-20.0	-20.0	-20.0	-20.0	-19.9
OUS	-19.9	-19.9	-19.9	-19.8	-19.8	-19.8	-19.8	-19.8
OUU	-19.7	-19.7	-19.7	-19.7	-19.6	-19.6	-19.6	-19.6
OUR	-19.5	-19.5	-19.5	-19.5	-19.5	-19.4	-19.4	-19.4
OUW	-19.4	-19.3	-19.3	-19.3	-19.3	-19.2	-19.2	-19.2
OUO	-19.2	-19.2	-19.1	-19.1	-19.1	-19.1	-19.1	-19.1
OUK	-19.0	-19.0	-19.0	-18.9	-18.9	-18.9	-18.9	-18.8
OUG	-18.8	-18.8	-18.8	-18.7	-18.7	-18.7	-18.7	-18.7
OUO	-18.6	-18.6	-18.6	-18.6	-18.5	-18.5	-18.5	-18.5
ORS	-18.4	-18.4	-18.4	-18.4	-18.4	-18.3	-18.3	-18.3
ORU	-18.3	-18.2	-18.2	-18.2	-18.2	-18.1	-18.1	-18.1
ORR	-18.1	-18.1	-18.0	-18.0	-18.0	-18.0	-17.9	-17.9
ORW	-17.9	-17.9	-17.8	-17.8	-17.8	-17.8	-17.8	-17.7
ORO	-17.7	-17.7	-17.7	-17.6	-17.6	-17.6	-17.6	-17.5
ORK	-17.5	-17.5	-17.5	-17.5	-17.4	-17.4	-17.4	-17.4
ORG	-17.3	-17.3	-17.3	-17.3	-17.2	-17.2	-17.2	-17.2
ORO	-17.1	-17.1	-17.1	-17.1	-17.1	-17.0	-17.0	-17.0
OWS	-17.0	-16.9	-16.9	-16.9	-16.9	-16.8	-16.8	-16.8
OWU	-16.8	-16.8	-16.7	-16.7	-16.7	-16.7	-16.6	-16.6
OWR	-16.6	-16.6	-16.5	-16.5	-16.5	-16.5	-16.4	-16.4
OWW	-16.4	-16.4	-16.4	-16.3	-16.3	-16.3	-16.3	-16.2
OWO	-16.2	-16.2	-16.2	-16.1	-16.1	-16.1	-16.1	-16.0
OWK	-16.0	-16.0	-16.0	-15.9	-15.9	-15.9	-15.9	-15.9
OWG	-15.8	-15.8	-15.8	-15.8	-15.7	-15.7	-15.7	-15.7
OWO	-15.6	-15.6	-15.6	-15.6	-15.5	-15.5	-15.5	-15.5

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THERMISTOR CALIBRATION RESULTS S/N UUB31J1 DATE 27 MAR 76 PAGE 9

TEMPERATURE IN DEGREES CENTIGRADE

	S	U	R	W	D	K	G	J
CDS	-15.5	-15.4	-15.4	-15.4	-15.4	-15.3	-15.3	-15.3
CDU	-15.3	-15.2	-15.2	-15.2	-15.2	-15.1	-15.1	-15.1
CDR	-15.1	-15.0	-15.0	-15.0	-15.0	-14.9	-14.9	-14.9
CDW	-14.9	-14.9	-14.8	-14.8	-14.8	-14.8	-14.7	-14.7
CDD	-14.7	-14.7	-14.6	-14.6	-14.6	-14.5	-14.5	-14.5
CDK	-14.5	-14.5	-14.4	-14.4	-14.4	-14.4	-14.3	-14.3
CDG	-14.3	-14.3	-14.3	-14.2	-14.2	-14.2	-14.2	-14.1
CDO	-14.1	-14.1	-14.1	-14.0	-14.0	-14.0	-14.0	-13.9
DKS	-13.9	-13.9	-13.9	-13.8	-13.8	-13.8	-13.8	-13.7
DKU	-13.7	-13.7	-13.7	-13.6	-13.6	-13.6	-13.6	-13.5
DKR	-13.5	-13.5	-13.5	-13.5	-13.4	-13.4	-13.4	-13.4
DKW	-13.3	-13.3	-13.3	-13.3	-13.2	-13.2	-13.2	-13.2
DKD	-13.1	-13.1	-13.1	-13.1	-13.0	-13.0	-13.0	-13.0
DKK	-12.9	-12.9	-12.9	-12.9	-12.8	-12.8	-12.8	-12.8
DKG	-12.7	-12.7	-12.7	-12.7	-12.6	-12.6	-12.6	-12.6
DKO	-12.5	-12.5	-12.5	-12.5	-12.4	-12.4	-12.4	-12.4
DGS	-12.3	-12.3	-12.3	-12.3	-12.2	-12.2	-12.2	-12.2
DGU	-12.1	-12.1	-12.1	-12.1	-12.0	-12.0	-12.0	-12.
DGR	-11.9	-11.9	-11.9	-11.9	-11.8	-11.8	-11.8	-11.8
DGW	-11.7	-11.7	-11.7	-11.7	-11.6	-11.6	-11.6	-11.6
DGD	-11.5	-11.5	-11.5	-11.5	-11.4	-11.4	-11.4	-11.4
DGK	-11.3	-11.3	-11.3	-11.3	-11.2	-11.2	-11.2	-11.2
DGG	-11.1	-11.1	-11.1	-11.1	-11.0	-11.0	-11.0	-11.0
DGO	-10.9	-10.9	-10.9	-10.9	-10.8	-10.8	-10.8	-10.8
DOS	-10.7	-10.7	-10.7	-10.7	-10.6	-10.6	-10.6	-10.6
DOU	-10.5	-10.5	-10.5	-10.5	-10.4	-10.4	-10.4	-10.4
DOR	-10.3	-10.3	-10.3	-10.3	-10.2	-10.2	-10.2	-10.2
DOW	-10.1	-10.1	-10.1	-10.1	-10.0	-10.0	-10.0	-9.9
DOD	-9.9	-9.9	-9.9	-9.8	-9.8	-9.8	-9.8	-9.7
DOK	-9.7	-9.7	-9.7	-9.6	-9.6	-9.6	-9.6	-9.5
DOG	-9.5	-9.5	-9.5	-9.4	-9.4	-9.4	-9.4	-9.3
DOO	-9.3	-9.3	-9.3	-9.2	-9.2	-9.2	-9.2	-9.1

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THERMISTOR CALIBRATION RESULTS S/N UU831J1 DATE 27 MAR 76 PAGE 1

TEMPERATURE IN DEGREES CENTIGRADE

	S	U	R	W	O	K	G	O
KSS	-9.1	-9.1	-9.1	-9.0	-9.0	-9.0	-9.0	-8.9
KSU	-8.9	-8.9	-8.9	-8.8	-8.8	-8.8	-8.8	-8.7
KSR	-8.7	-8.7	-8.6	-8.6	-8.6	-8.6	-8.5	-8.5
KSW	-8.5	-8.5	-8.4	-8.4	-8.4	-8.4	-8.3	-8.3
KSO	-8.3	-8.3	-8.2	-8.2	-8.2	-8.2	-8.1	-8.1
KSK	-8.1	-8.1	-8.0	-8.0	-8.0	-7.9	-7.9	-7.9
KSG	-7.9	-7.8	-7.9	-7.8	-7.8	-7.8	-7.7	-7.7
KSO	-7.7	-7.6	-7.6	-7.6	-7.6	-7.6	-7.5	-7.5
KUS	-7.4	-7.4	-7.4	-7.4	-7.3	-7.3	-7.3	-7.3
KUU	-7.2	-7.2	-7.2	-7.2	-7.1	-7.1	-7.1	-7.1
KUR	-7.0	-7.0	-7.0	-6.9	-6.9	-6.9	-6.9	-6.8
KUW	-6.8	-6.8	-6.8	-6.7	-6.7	-6.7	-6.7	-6.6
KUO	-6.6	-6.6	-6.5	-6.5	-6.5	-6.5	-6.4	-6.4
KUK	-6.4	-6.4	-6.3	-6.3	-6.3	-6.2	-6.2	-6.2
KUG	-6.2	-6.1	-6.1	-6.1	-6.1	-6.1	-6.0	-6.0
KUO	-6.0	-5.9	-5.9	-5.9	-5.8	-5.8	-5.8	-5.8
KRS	-5.7	-5.7	-5.7	-5.7	-5.6	-5.6	-5.6	-5.5
KRU	-5.5	-5.5	-5.5	-5.4	-5.4	-5.4	-5.4	-5.3
KRR	-5.3	-5.3	-5.2	-5.2	-5.2	-5.2	-5.1	-5.1
KRW	-5.1	-5.0	-5.0	-5.0	-5.0	-4.9	-4.9	-4.9
KRO	-4.9	-4.8	-4.8	-4.8	-4.7	-4.7	-4.7	-4.7
KRK	-4.6	-4.6	-4.6	-4.5	-4.5	-4.5	-4.5	-4.4
KRG	-4.4	-4.4	-4.4	-4.3	-4.3	-4.3	-4.2	-4.2
KRO	-4.2	-4.2	-4.1	-4.1	-4.1	-4.0	-4.0	-4.0
KWS	-4.0	-3.9	-3.9	-3.9	-3.8	-3.8	-3.8	-3.8
KWU	-3.7	-3.7	-3.7	-3.6	-3.6	-3.6	-3.6	-3.5
KWR	-3.5	-3.5	-3.4	-3.4	-3.4	-3.4	-3.3	-3.3
KWW	-3.3	-3.2	-3.2	-3.2	-3.2	-3.1	-3.1	-3.1
KWO	-3.0	-3.0	-3.0	-3.0	-2.9	-2.9	-2.9	-2.8
KWK	-2.8	-2.8	-2.8	-2.7	-2.7	-2.7	-2.6	-2.6
KWG	-2.6	-2.5	-2.5	-2.5	-2.5	-2.4	-2.4	-2.4
KWO	-2.3	-2.3	-2.3	-2.3	-2.2	-2.2	-2.2	-2.1

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THERMISTOR CALIBRATION RESULTS S/N UUB31J1 DATE 27 MAR 76 PAGE 11

TEMPERATURE IN DEGREES CENTIGRADE

	S	U	R	W	D	K	G	O
KDS	-2.1	-2.1	-2.1	-2.0	-2.0	-2.0	-1.9	-1.9
KDU	-1.9	-1.8	-1.8	-1.8	-1.8	-1.7	-1.7	-1.7
KDR	-1.6	-1.6	-1.6	-1.5	-1.5	-1.5	-1.5	-1.4
KDW	-1.4	-1.4	-1.3	-1.3	-1.3	-1.2	-1.2	-1.2
KDO	-1.2	-1.1	-1.1	-1.1	-1.0	-1.0	-1.0	-.9
KDK	-.9	-.9	-.9	-.8	-.8	-.8	-.7	-.7
KDG	-.7	-.6	-.6	-.6	-.6	-.5	-.5	-.5
KDO	-.4	-.4	-.4	-.3	-.3	-.3	-.2	-.2
KKS	-.2	-.2	-.1	-.1	-.1	-.1	-.0	.0
KKU	.1	.1	.1	.1	.2	.2	.2	.3
KKR	.3	.3	.4	.4	.4	.5	.5	.5
KKW	.5	.6	.6	.6	.7	.7	.7	.8
KKO	.8	.8	.8	.9	.9	.9	1.0	1.0
KKK	1.0	1.1	1.1	1.1	1.2	1.2	1.2	1.2
KKG	1.3	1.3	1.3	1.4	1.4	1.4	1.5	1.5
KKO	1.5	1.6	1.6	1.6	1.6	1.7	1.7	1.7
KGS	1.8	1.8	1.8	1.9	1.9	1.9	2.0	2.0
KGU	2.0	2.1	2.1	2.1	2.2	2.2	2.2	2.2
KGR	2.3	2.3	2.3	2.4	2.4	2.4	2.5	2.5
KGW	2.5	2.6	2.6	2.6	2.7	2.7	2.7	2.8
KGO	2.8	2.8	2.9	2.9	2.9	3.0	3.0	3.0
KGK	3.1	3.1	3.1	3.1	3.2	3.2	3.2	3.3
KGG	3.3	3.3	3.4	3.4	3.4	3.5	3.5	3.5
KGO	3.6	3.6	3.6	3.7	3.7	3.7	3.8	3.8
KOS	3.8	3.9	3.9	3.9	4.0	4.0	4.0	4.1
KOU	4.1	4.1	4.2	4.2	4.2	4.3	4.3	4.3
KOR	4.4	4.4	4.4	4.5	4.5	4.5	4.6	4.6
KOW	4.6	4.7	4.7	4.8	4.8	4.8	4.9	4.9
KOO	4.9	5.0	5.0	5.0	5.1	5.1	5.1	5.2
KOK	5.2	5.2	5.3	5.3	5.3	5.4	5.4	5.4
KOG	5.5	5.5	5.5	5.6	5.6	5.7	5.7	5.7
KOO	5.8	5.8	5.8	5.9	5.9	5.9	6.0	6.0

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THERMISTOR CALIBRATION RESULTS S/N UU831J1 DATE 27 MAR 76 PAGE 12

TEMPERATURE IN DEGREES CENTIGRADE

	S	U	R	W	O	K	G	O
GSS	6.0	6.1	6.1	6.1	6.2	6.2	6.3	6.3
GSU	6.3	6.4	6.4	6.4	6.5	6.5	6.5	6.6
GSR	6.6	6.6	6.7	6.7	6.8	6.8	6.8	6.9
GSW	6.9	6.9	7.0	7.0	7.1	7.1	7.1	7.2
GSO	7.2	7.2	7.3	7.3	7.3	7.4	7.4	7.5
GSK	7.5	7.5	7.6	7.6	7.6	7.7	7.7	7.8
GSG	7.8	7.8	7.9	7.9	7.9	8.0	8.0	8.1
GSO	8.1	8.1	8.2	8.2	8.2	8.3	8.3	8.4
GUS	8.4	8.4	8.5	8.5	8.6	8.6	8.6	8.7
GUU	8.7	8.7	8.8	8.8	8.9	8.9	8.9	9.0
GUR	9.0	9.1	9.1	9.1	9.2	9.2	9.2	9.3
GUW	9.3	9.4	9.4	9.4	9.5	9.5	9.6	9.6
GUO	9.6	9.7	9.7	9.8	9.8	9.8	9.9	9.9
GUK	10.0	10.0	10.0	10.1	10.1	10.2	10.2	10.2
GUG	10.3	10.3	10.4	10.4	10.4	10.5	10.5	10.6
GUO	10.6	10.6	10.7	10.7	10.8	10.8	10.9	10.9
GRS	10.9	11.0	11.0	11.1	11.1	11.1	11.2	11.2
GRU	11.3	11.3	11.3	11.4	11.4	11.5	11.5	11.6
GRR	11.6	11.6	11.7	11.7	11.8	11.8	11.9	11.9
GRW	11.9	12.0	12.0	12.1	12.1	12.1	12.2	12.2
GRO	12.3	12.3	12.4	12.4	12.4	12.5	12.5	12.6
GRK	12.6	12.7	12.7	12.7	12.8	12.8	12.9	12.9
GRG	13.0	13.0	13.1	13.1	13.1	13.2	13.2	13.3
GRO	13.3	13.4	13.4	13.5	13.5	13.5	13.6	13.6
GWS	13.7	13.7	13.8	13.8	13.9	13.9	13.9	14.0
GWU	14.0	14.1	14.1	14.2	14.2	14.3	14.3	14.3
GWR	14.4	14.4	14.5	14.5	14.6	14.6	14.7	14.7
GWW	14.8	14.8	14.8	14.9	14.9	15.0	15.0	15.1
GWO	15.1	15.2	15.2	15.3	15.3	15.4	15.4	15.4
GWK	15.5	15.5	15.6	15.6	15.7	15.7	15.8	15.8
GWG	15.9	15.9	16.0	16.0	16.1	16.1	16.2	16.2
GWO	16.3	16.3	16.3	16.4	16.4	16.5	16.5	16.6

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THERMISTOR CALIBRATION RESULTS S/N UUB31J1 DATE 27 MAR 76 PAGE 13

TEMPERATURE IN DEGREES CENTIGRADE

	S	U	R	W	D	K	G	O
GDS	16.6	16.7	16.7	16.8	16.8	16.9	16.9	17.0
GDU	17.0	17.1	17.1	17.2	17.2	17.3	17.3	17.4
GDR	17.4	17.5	17.5	17.6	17.6	17.7	17.7	17.8
GDW	17.8	17.9	17.9	18.0	18.0	18.1	18.1	18.2
GDD	18.2	18.3	18.3	18.4	18.4	18.5	18.5	18.6
GDK	18.6	18.7	18.7	18.8	18.8	18.9	18.9	19.0
GDG	19.0	19.1	19.1	19.2	19.2	19.3	19.3	19.4
GDO	19.4	19.5	19.5	19.6	19.6	19.7	19.7	19.8
GKS	19.8	19.9	19.9	20.0	20.1	20.1	20.2	20.2
GKU	20.3	20.3	20.4	20.4	20.5	20.5	20.6	20.6
GKR	20.7	20.7	20.8	20.8	20.9	21.0	21.0	21.1
GKW	21.1	21.2	21.2	21.3	21.3	21.4	21.4	21.5
GKD	21.5	21.6	21.7	21.7	21.8	21.8	21.9	21.9
GKK	22.0	22.0	22.1	22.1	22.2	22.3	22.3	22.4
GKG	22.4	22.5	22.5	22.6	22.6	22.7	22.8	22.8
GKO	22.9	22.9	23.0	23.0	23.1	23.2	23.2	23.3
GGS	23.3	23.4	23.4	23.5	23.5	23.6	23.7	23.7
GGU	23.8	23.8	23.9	23.9	24.0	24.1	24.1	24.2
GGR	24.2	24.3	24.4	24.4	24.5	24.5	24.6	24.6
GGW	24.7	24.8	24.8	24.9	24.9	25.0	25.1	25.1
GGD	25.2	25.2	25.3	25.3	25.4	25.5	25.5	25.6
GGK	25.6	25.7	25.8	25.8	25.9	25.9	26.0	26.1
GGG	26.1	26.2	26.2	26.3	26.4	26.4	26.5	26.5
GGO	26.6	26.7	26.7	26.8	26.8	26.9	27.0	27.0
GOS	27.1	27.2	27.2	27.3	27.3	27.4	27.5	27.5
GOU	27.6	27.6	27.7	27.8	27.8	27.9	28.0	28.0
GOR	28.1	28.1	28.2	28.3	28.3	28.4	28.5	28.5
GOW	28.6	28.6	28.7	28.8	28.8	28.9	29.0	29.0
GOD	29.1	29.2	29.2	29.3	29.3	29.4	29.5	29.5
GOK	29.6	29.7	29.7	29.8	29.9	29.9	30.0	30.1
GOG	30.1	30.2	30.3	30.3	30.4	30.4	30.5	30.6
GOO	30.6	30.7	30.8	30.8	30.9	31.0	31.0	31.1

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T	COUNTS	T*	T-T*
-80.0	297.0	-80.0	.0
-70.0	487.0	-70.0	.0
-60.0	589.0	-60.0	.0
-50.0	662.0	-50.0	.0
-40.0	1129.0	-40.0	.0
-30.0	1657.0	-30.0	.0
-20.0	2100.0	-20.0	.0
-10.0	2525.0	-10.0	.0
0.0	2186.0	-.0	.0
10.0	3177.0	10.0	.0
20.0	3395.0	20.0	.0

```
 03/11/77   SCOPE 3.4.4        * CDC466A  A.F.6.L.
08.36.34.CORD02Q  FROM MFA
08.36.35.IP  00001400 WORDS - FILE INPUT  , OC 66
08.36.35.(CORD01,T120,CM600CJ.
08.36.35.          2036    CORDELLA
08.36.36.FTN,SL.
08.36.44.       .781 CP SECONDS COMPILATION TIME
08.36.44.LOAD(INPUT)
08.36.44.LOAD(LGO)
08.36.44.EXECUTE.
08.36.50.     STOP
08.36.50.      1.271 CP SECONDS EXECUTION TIME
08.36.50.CP  00005504 WORDS - FILE OUTPUT , OC 46
08.36.51.MS     7168  WORDS  (   14336 MAX USED)
08.36.51.CPA       2.727 SEC.          .055 COST
08.36.51.IO        1.944 SEC.          .012 COST
08.36.51.CM       75.535 KWS.          .083 COST
08.36.51.SS      COST OF JOB           .151
08.36.51.PP       11.250 SEC.      DATE 03/11/77
08.36.51.EJ  END OF JOB, **

************          CORD02Q  //// END OF LIST ////
************          CORD02Q  //// END OF LIST ////
```


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Appendix H

Primary Altitude Program

H1. GENERAL

This program is keyed to a B-60 altitude sensor (Reference 9) when used through the SCADS-2 encoder. The end product is a dictionary converting an alpha-code to altitude in thousands of feet which is valid for at least 18 months if no changes are made in the B-60 sensor. A dictionary is needed for each sensor; changing encoders will not affect the validity of the program.

H1.1 The Algorithm

The physics of the sensor is such that the period of the output is directly proportional to pressure which decreases exponentially with altitude. Since the period is multiplied by a frequency in the encoder, the sensor-encoder interaction is defined by the equation

$$\text{count} = A\epsilon^{B \cdot \text{altitude}},$$

where count is the number of events registered in the encoder data counter; A and B are constants; and altitude is in feet. The signal processing is covered in detail in Reference 1 pages 468 and 469.

H1.2 *The Input*

Each B-60 sensor is calibrated in a vacuum chamber for period (msec) vs altitude (thousands of ft). This data, the frequency with which the period will be multiplied, and the number of points over which the curve is to be fit are the required input. The period under discussion is that of the sensor core which is a blocking oscillator not that available at the output of the B-60 which is twice the basic period. A flip flop doubles the period to facilitate protecting the signal while moving it from the B-60 to the encoder. The base period is recovered by calibrating the B-60 in ascending and descending modes then dividing by four. The two multiplying frequencies are obtained from Reference 14.

H1.3 The Output

This discussion is keyed to the computer printout which follows. After the cover sheet, program list, and memory map is the frequency, curve fitting interval, and number of data points. The next page starts the list of data as read from the cards. It is preceeded by the calculated code word. Sixteen pages of dictionary, suitable to be entered into a $8 \times 10\text{-}1/2$ in. ring binder follow the data. Note that the unneeded space at the right of each page has been utilized to display the calculated constants used to calculate that row of code. Cost and time data close the printout.

Since the program calculates an altitude for every code, the initial codes are filled with "altitudes" which are below sea level. These negative altitudes are ignored; the dictionary effectively begins at code SSKG for 590 feet.

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```
      PROGRAM B60        74/74   OPT=1                              FTN 4.[illegible]
      1                PROGRAM B60 (INPUT,OUTPUT,TAPE5=INPUT, TAPE6=OUTPUT)
                     C
                     C PROGRAM TO PRODUCE B-60 CALIBRATION DICTIONARY
                     C
      5              C CLOCK= CLOCK FREQUENCY
                     C T= PULSE WIDTH IN UNITS OF TIME
                     C NC= COUNTS
                     C H= ALTITUDE
                     C A,B= CONSTANTS IN ALTITUDE-COUNTS EQUATION  NC= A*EXP(B*H)
     10              C INT= INTERVAL(NUMBER OF POINTS) OVER WHICH BEST LINE IS TO BE FIT
                     C    MUST BE AN EVEN NUMBER
                     C INPUT DATA--EACH SET
                     C   CARD 1
                     C     CC 1-3 INTERVAL (I3)
     15              C     CC 4-10 CLOCK (F7.1)
                     C     CC 11-18 S/N (A8)
                     C     CC 19-30 DATE OF CALIBRATION (3A4)
                     C   CARD 2 TO N+1
                     C    CC 1-10 ALTITUDE IN FEET (F10.0)
     20              C     CC 11-20 PULSE WIDTH IN MSEC (F10.0)
                     C   LAST CARD
                     C     CC 1-10 -1.0 IF MORE DATA SETS FOLLOW
                     C             -2.0 IF IT IS THE LAST DATA SET
                     C
     25                COMMON INT2,N,NC,NCENC,H(200),T(200),A,B,SN,SN2,ST,SNT,AINT
                      1,NLBL
                       DIMENSION SN(2),DATE(3),LETTR(9),X(8)
                       DATA LETTR/1HS,1HU,1HR,1HW,1HD,1HK,1HG,1HO/
                    10 READ(5,20) INT,CLOCK,SN,DATE
     30             20 FORMAT(I3,F7.1,2A4,3A4)
                       N=0
                    25 N=N+1
                       READ(5,30) H(N),T(N)
                    30 FORMAT(2F10.0)
     35                IF(H(N).GE.0) GO TO 25
                       NLBL=N
                       N=N-1
                       WRITE(6,31) CLOCK
                    31 FORMAT(1H1,"CLOCK READ AS",F7.1)
     40                WRITE(6,32) INT
                    32 FORMAT(" INTERVAL READ AS",I4)
                       INT= (INT/2)*2
                       IF(INT.GT.N) INT= (N/2)*2
                       WRITE(6,33) N
     45                WRITE(6,34) INT
                    34 FORMAT(" INTERVAL USED IS",I4)
                       DO 39 I= 1,N
                       IF(MOD(I,50).EQ.1) WRITE(6,35)
     50                35 FORMAT("1CODE   H(FT)  T(MSEC)")
                       J= IFIX(0.0010*T(I)*CLOCK+0.5)
                       J4= MOD(J,8)+1
                       J=J/8
                       J3= MOD(J,8)+1
     55                J= J/8
                       J2= MOD(J,8)+1
                       J1= J/8+1
```


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```
      PROGRAM B60        74/74   OPT=1                    FTN 4.8+414     05/11/7  0.  7.5s      PAGE  2

                  J= IFIX(H(I)+0.5)
                  A= T(I)+0.0005
                  WRITE(6,36) LETTR(J1),LETTR(J2),LETTR(J3),LETTR(J4),J,A
           60     FORMAT(1H ,4A1,I8,F9.3)
                  T(I)= .0010*T(I)*CLOCK
                  INT2= INT/2
                  NCEND= IFIX(T(INT2+1))
           65     NC=0
                  J= INT2+1
                  SH=0.0
                  SH2= 0.0
                  ST= 0.0
           70     SHT= 0.0
                  AINT= FLOAT(INT)
                  DO 50 I= 1,INT
                  SH= SH+H(I)
                  SH2= SH2+H(I)**2
           75     ST= ST+ALOG(T(I))
           50     SHT= SHT+H(I)*ALOG(T(I))
                  B=(ST*SH-AINT*SHT)/(SH*SH-AINT*SH2)
                  A= (ST-B*SH)/AINT
                  DO 500 J1= 1,16
           80     WRITE(6,70) SN,DATE,J1
           70     FORMAT(1H1,6X,"B-66 CALIBRATION RESULTS",3X,"S/N ",A4,3X,"DATE ",
                 1A4,"  PAGE",I3,22X,"A=",1PE7.1,"B=")
                  WRITE(6,71)
           71     FORMAT(1HC,25X,"ALTITUDE IN THOUSANDS OF FEET")
           85     WRITE(6,75) LETTR
           75     FORMAT(1H0,8X,9(7X,A1))
                  K1= (J1+1)/2
                  DO 400 J2= 1,4
                  WRITE(6,76)
           90     FORMAT(1H )
                  DO 300 J3= 1,8
                  DO 200 J4= 1,8
                  IF(NC.GT.NCEND) CALL AH(J)
                  IF(NC.GT.0) GO TO 19
           95     X(J4)=0.0
                  GO TO 199
          190     X(J4)= 0.0010*(ALOG(FLOAT(NC))-A)/B+3.095
          199     NC= NC+1
          200     CONTINUE
          100     K2= MOD((J1-1)*4+J2-1,8)+1
                  WRITE(6,301) LETTR(K1),LETTR(K2),LETTR(J3),X,A,B
          301     FORMAT(1H ,6X,3A1,1X,8F8.2,14X,2E15.8)
          400     CONTINUE
          500     CONTINUE
          105     N=NLBL
                  IF(H(N).EQ.-1.0) GO TO 10
                  STOP
                  END
```

```
SUBROUTINE AB        74/74   OPT=1                    FTN 4.2+414        ??/???/??  ??.??.??      PAGE    1

      1              SUBROUTINE AB(J)
                     COMMON INT2,N,NC,NCEND,H(2?1),T(2?1),A,B,SH,SH2,ST,SHT,AINT
                     IF(J+INT2.GT.N) RETURN
                     K1=J-INT2
      5              K2= J+INT2
                     J= J+1
                     SH= SH-H(K1)+H(K2)
                     SH2= SH2-H(K1)**2+H(K2)**2
                     ST= ST-ALOG(T(K1))+ALOG(T(K2))
     10              SHT= SHT-H(K1)*ALOG(T(K1))+H(K2)*ALOG(T(K2))
                     B=(ST*SH-AINT*SHT)/(SH*SH-AINT*SH2)
                     A= (ST-B*SH)/AINT
                     NCEND= IFIX(T(J))
                     RETURN
     15              END
```


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LOAD MAP - 860 CYBER LOADER 1.[illegible] [illegible] PAGE 1

FWA OF THE LOAD 111
LWA+1 OF THE LOAD 20372

TRANSFER ADDRESS -- 860 4222

PROGRAM AND BLOCK ASSIGNMENTS.

BLOCK	ADDRESS	LENGTH	FILE	DATE	PROCSSR	VER	LEVEL	HARDWAR	COMMENTS
860	111	4577	LGO	03/11/77	FTN	4.5	414	865X I	OPT=.
AB	4710	52	LGO	03/11/77	FTN	4.5	414	865X I	OPT=1
/FCL.C./	4762	23							
/08.IO./	5005	131							
CONTRY=	5136	0	SL-FORTRAN	08/11/76	COMPASS	3.	2-414		FCL INITIALIZATION ROUTINE.
COMIO=	5136	64	SL-FORTRAN	08/11/76	COMPASS	3.	2-414		COMMON CODE FOR I/O ROUTINES AND CONSTANTS.
FECMSK=	5222	41	SL-FORTRAN	08/11/76	COMPASS	3.	2-414		INITIALIZE CONSTANTS.
FLTOUT=	5263	310	SL-FORTRAN	08/11/76	COMPASS	3.	2-414		COMMON FLOATING OUTPUT CODE
FORSYS=	5573	601	SL-FORTRAN	08/11/76	COMPASS	3.	2-414		FORTRAN OBJECT LIBRARY UTILITIES
INCOM=	6374	277	SL-FORTRAN	08/11/76	COMPASS	3.	2-414		COMMON INPUT FORMATTING CODE
INPC=	6673	160	SL-FORTRAN	08/11/76	COMPASS	3.	2-414		FORMATTED [illegible] FORMAT ROUTINE
KODER=	7053	456	SL-FORTRAN	08/11/76	COMPASS	3.	2-414		OUTPUT FORMA. INTERPRETER.
CUTCOM=	7531	154	SL-FORTRAN	08/11/76	COMPASS	3.	2-414		COMMON OUTPUT CODE
ALOG	7705	73	SL-FORTRAN	08/11/76	COMPASS	3.	2-414		COMPUTE COMMON AND NATURAL LOGARITHMS. OPTIONAL.
SYSAID=	10000	1	SL-FORTRAN	08/11/76	COMPASS	3.	2-414		LINK WITH SYSTEM AND INITIALIZATION CODE
FLTIN=	10001	154	SL-FORTRAN	08/11/76	COMPASS	3.	2-414		COMMON FLOATING INPUT CONVERSION.
FMTAP=	10155	352	SL-FORTRAN	08/11/76	COMPASS	3.	2-414		CRACK APPLI AND FORMAT FOR KRAKER.
FORUTL=	10527	16	SL-FORTRAN	08/11/76	COMPASS	3.	2-414		FCL MISC. UTILITIES
CETFIT=	10545	42	SL-FORTRAN	08/11/76	COMPASS	3.	2-414		LOCATE AN FI. ELEM. A FCL NAME
KRAKER=	10607	406	SL-FORTRAN	08/11/76	COMPASS	3.	2-414		PROCESS FORMATTED FORTRAN INPUT.
CUTC=	11215	172	SL-FORTRAN	08/11/76	COMPASS	3.	2-414		FORMATTED OUT. FORTRAN PROCSR
SYS=1ST	11407	62	SL-FORTRAN	08/11/76	COMPASS	3.	2-414		MATH LIBRARY LINK TO CYBER 865 AR. PROCESSOR
/CON.RM/	11471	6							
CIO.RM	11477	48	SL-SYSIO	05/26/76	COMPASS	3.	75126		
/ABR.RM/	11537	10							
MOVE.RM	11547	64	SL-SYSIO	05/26/76	COMPASS	3.	75126		
RCT.RM	11633	233	SL-SYSIO	05/26/76	COMPASS	3.	75126		
/JMPS.RM/	12066	11							
/MEMC.RM/	12077	3							
/OPES.FO/	12102	1							
/OPEN.FO/	12103	7							
OPEN.RM	12112	235	SL-SYSIO	05/26/76	COMPASS	3.	75126		
/TERM.RM/	12347	1							
/PUT.FO/	12350	7							
PUT.SQ	12357	1362	SL-SYSIO	05/26/76	COMPASS	3.	75126		
WAR.SQ	13741	268	SL-SYSIO	05/26/76	COMPASS	3.	75126		
/CLSF.FO/	14221	7							
CLSF.RM	14230	23	SL-SYSIO	05/26/76	COMPASS	3.	75126		
/GET.BT/	14253	5							
STRT.SQ	14260	114	SL-SYSIO	05/26/76	COMPASS	3.	75126		
WEOX.SQ	14374	142	SL-SYSIO	05/26/76	COMPASS	3.	75126		
/SKFL.FO/	14536	7							
SKFL.SQ	14545	47	SL-SYSIO	05/26/76	COMPASS	3.	75126		
ERR.RM	14614	404	SL-SYSIO	05/26/76	COMPASS	3.	75126		
CHWP.SQ	15220	7	SL-SYSIO	05/26/76	COMPASS	3.	75126		

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LOAD MAP - 860 CYBER LOADER 1.1-48 08/11/77 PAG 2

CSUR.RM	15227	65	SL-SYSIO	08/28/76 COMPASS	3. 7b12
OPEN.SQ	15314	262	SL-SYSIO	08/28/76 COMPASS	3. 7b12
OPEX.SQ	15576	14	SL-SYSIO	08/28/76 COMPASS	3. 7b12
/PUT.RT/	15612	11			
FLEO.RM	15623	42	SL-SYSIO	08/28/76 COMPASS	3. 7b12
CLSF.SQ	15665	132	SL-SYSIO	08/28/76 COMPASS	3. 7b12
/CLSV.FO/	16017	7			
CLSV.SQ	16026	123	SL-SYSIO	08/28/76 COMPASS	3. 7b12
/REW.FO/	16151	7			
REW.SQ	16160	31	SL-SYSIO	08/28/76 COMPASS	3. 7b12
/GET.FO/	16211	7			
/GET.RT/	16220	11			
GET.SQ	16231	1035	SL-SYSIO	08/28/76 COMPASS	3. 7b12
Z.SQ	17266	101	SL-SYSIO	08/28/76 COMPASS	3. 7b12
FSU.SQ	17367	106	SL-SYSIO	08/28/76 COMPASS	3. 7b12
SYS.RM	17475	37	SL-NUCLEUS	04/29/76 COMPASS	3. 7b12 PROCESS SYSTEM MODULE.
//	17534	636			

.514 CP SECONDS 321008 CM STORAGE USED 13 TABLE MOVES

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CLOCK READ AS 6553.6
INTERVAL READ AS  10
N IS 136
INTERVAL USED IS  10
```

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CODE	H(FT)	T(MSEC)
SSKG	0	7.021
SSKG	1000	7.071
SSKC	2000	7.171
SSGS	3000	7.281
SSGS	4000	7.401
SSGU	5000	7.551
SSGR	6000	7.681
SSGW	7000	7.831
SSGD	8000	7.991
SSGK	9000	8.151
SSGO	10000	8.371
SSOS	11000	8.611
SSOR	12000	8.861
SSOD	13000	9.111
SSOG	14000	9.401
SSOO	15000	9.671
SUSU	16000	9.951
SUSD	17000	10.381
SUSO	18000	10.771
SUUU	19000	11.131
SUUD	20000	11.551
SUUO	21000	11.981
SURR	22000	12.481
SURK	23000	13.041
SUWU	24000	13.581
SUWK	25000	14.161
SUDU	26000	14.801
SUDK	27000	15.411
SUKU	28000	16.031
SUKG	29000	16.781
SUGW	30000	17.511
SUGO	31000	18.231
SUOK	32000	19.131
SRSD	33000	20.121
SRUU	34000	20.881
SRUO	35000	21.801
SRRG	36000	22.891
SRWK	37000	23.961
SRDC	38000	24.991
SRKK	39000	26.411
SRGD	40000	27.451
SROR	41000	28.451
SWSK	42000	30.021
SWUG	43000	31.361
SWWR	44000	33.201
SWKU	45000	35.561
SWGD	46000	37.241
SOSS	47000	39.891
SOUD	48000	40.921
SOWU	49000	42.921

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CODE	H(FT)	T(MSEC)
SDDG	50000	44.821
S06K	51000	47.081
SKSN	52000	49.291
SKRW	53000	51.671
SKOW	54000	54.101
SKGD	55000	56.751
SGSO	56000	59.651
S6WD	57000	62.351
SGKC	58000	65.331
SOSS	59000	68.431
SORK	60700	71.551
SOKD	61000	75.031
USSW	62000	78.651
USWD	63000	82.301
USGG	64000	86.331
UUPU	65000	90.481
UUKK	66000	94.830
URUW	67000	99.359
URKW	68000	104.101
UWUR	69000	108.881
UWKD	70000	114.151
UOUO	71000	119.531
UOGK	72000	125.301
UKWR	73000	130.981
UGSS	74000	136.731
UGRU	75000	143.031
UORO	76000	149.601
U006	77000	156.801
RSOU	78000	164.901
RUWK	79000	170.431
RRUG	80000	177.931
RWSR	81000	185.781
RWOR	82000	194.331
RO6R	83000	202.881
RKRW	84000	211.601
R6RU	85000	221.051
ROKU	86000	230.881
WSRW	87000	240.931
WUKO	88000	251.381
WR6U	89000	262.601
WDSD	90000	274.081
WKUG	91000	285.281
WGWR	92000	296.881
W0W0	93000	309.981
DUSK	94000	323.031
RRRS	95000	334.481
DWGW	96000	349.551
BWRD	97000	364.451
DGKO	98000	377.751
KSWW	99000	394.664

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CODE	M(FT)	T(MSEC)
KUOW	100000	409.451
KWKO	101000	427.031
KKPW	102000	442.381
KOUO	103000	461.231
GUSU	104000	478.701
GWSK	105000	496.851
GDCG	106000	517.251
666U	107000	536.001
OUUW	108000	558.251
OWSO	109000	577.251
OKSR	110000	596.001
OOKG	111000	622.251
5UDO	112000	640.251
5WKU	113000	660.501
5GOC	114000	689.501
5SOO	115000	712.251
5WSO	116000	733.001
5KOG	117000	757.751
5OKO	118000	778.251
5RKO	119000	807.501
5DCU	120000	827.751
5ORG	121000	853.001
5UOW	122000	874.501
5OSS	123000	898.500
5WRO	124000	892.250
5ROR	125000	962.250
5OKO	126000	983.750
5ROO	127000	962.500
5ROU	128000	1040.251
5OKO	129000	1057.751
5SUS	130000	1095.001
5WRW	131000	1126.001
5GOC	132000	1162.001
5RRW	133000	1194.251
5ORU	134000	1213.501
5ORS	135000	1242.751

B-60 CALIBRATION RESULTS S/N 020 DATE 21 OCT 75 PAGE 1

ALTITUDE IN THOUSANDS OF FEET

	S	U	R	W	O	K	G	O
SSS	0.00	-223.39	-182.84	-159.12	-142.23	-129.24	-118.57	-1 9.55
SSU	-101.74	-94.85	-88.69	-83.11	-78.02	-73.34	-69.0	-64.97
SSR	-61.19	-57.64	-54.30	-51.14	-48.14	-45.28	-42.55	-39.96
SSW	-37.47	-35.08	-32.79	-30.58	-28.45	-26.4	-24.42	-22.5
SSO	-20.64	-18.84	-17.09	-15.40	-13.75	-12.15	-10.59	-9.07
SSK	-7.59	-6.14	-4.73	-3.36	-2.01	-.72	.59	1.8
SSG	3.08	4.29	5.44	6.45	7.38	8.24	9.04	9.8
SSO	10.51	11.21	11.85	12.45	13.02	13.56	14.08	14.5
SUS	15.09	15.56	16.04	16.48	16.92	17.36	17.78	18.1
SUU	18.53	18.92	19.28	19.64	19.99	20.33	20.65	20.98
SUR	21.30	21.61	21.93	22.24	22.57	22.83	23.14	23.42
SUW	23.70	23.98	24.25	24.51	24.77	25.04	25.29	25.55
SUO	25.79	26.04	26.29	26.53	26.77	26.99	27.22	27.49
SUK	27.68	27.91	28.12	28.33	28.55	28.76	28.98	29.19
SUG	29.40	29.60	29.81	30.01	30.21	30.41	30.61	30.81
SUO	30.99	31.18	31.37	31.55	31 74	31.92	32.10	32.2
SRS	32.46	32.63	32.81	32.98	33.15	33.32	33.49	33.66
SRU	33.82	33.98	34.14	34.30	34.46	34 61	34.77	34.93
SRR	35.09	35.24	35.39	35.54	35.69	35.84	35.99	36.15
SRW	36.29	36.44	36.59	36.73	36.87	37.02	37.16	37.3
SRO	37.43	37.57	37.71	37.85	38.00	38.13	38.27	38.4
SRK	38.53	38.66	38.79	38.92	39.05	39 18	39.28	39.41
SRG	39.53	39.66	39.78	39.90	39.97	40 09	40.21	40.3
SRO	40.44	40.55	40.67	40.77	40.88	40.99	41.1	41.21
SWS	41.31	41.42	41.53	41.63	41.74	41.85	41.96	42.06
SWU	42.16	42.26	42.36	42.45	42.55	42.65	42.77	42.85
SWR	42.96	43.05	43.15	43.24	43.34	43.43	43.52	43.62
SWW	43.71	43.80	43.94	44.03	44.12	44.2	44.29	44.38
SWO	44.47	44.55	44.64	44.73	44.81	44.90	44.98	45.07
SWK	45.15	45.23	45.36	45.45	45.53	45.61	45.69	45.77
SWG	45.86	45.94	46.02	46.1	46.18	46.27	46.35	46.43
SWO	46.51	46.59	46.67	46.75	46.83	46.91	46.99	47.07

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B-60 CALIBRATION RESULTS S/N 029 DATE 21 OCT 76 PAGE 2

ALTITUDE IN THOUSANDS OF FEET

	S	U	R	W	D	K	G	O		
SDS	47.14	47.23	47.31	47.39	47.47	47.54	47.62	[illegible]	[illegible]	[illegible]
SDU	47.78	47.85	47.93	48.05	48.18	48.13	48.21	48.29	[illegible]	[illegible]
SDR	48.36	48.44	48.52	48.59	48.67	48.75	48.82	48.90	[illegible]	[illegible]
SDW	48.97	49.04	49.09	49.16	49.24	49.31	49.39	[illegible]	[illegible]	[illegible]
SDD	49.54	49.61	49.69	49.75	49.84	49.91	49.98	[illegible]	[illegible]	[illegible]
SDK	50.12	50.20	50.27	50.34	50.41	50.48	50.56	[illegible]	[illegible]	[illegible]
SDG	50.79	50.77	50.84	50.91	50.98	51.04	51.11	[illegible]	[illegible]	[illegible]
SDO	51.24	51.31	51.38	51.45	51.52	51.56	51.65	[illegible]	[illegible]	[illegible]
SKS	51.79	51.85	51.92	51.98	52.05	52.12	52.18	[illegible]	[illegible]	[illegible]
SKU	52.32	52.38	52.45	52.51	52.57	52.64	52.71	[illegible]	[illegible]	[illegible]
SKR	52.83	52.89	52.96	53.02	53.08	53.15	53.21	[illegible]	[illegible]	[illegible]
SKW	53.33	53.40	53.46	53.52	53.58	53.64	53.71	[illegible]	[illegible]	[illegible]
SKD	53.82	53.88	53.94	54.01	54.07	54.13	54.19	[illegible]	[illegible]	[illegible]
SKK	54.31	54.37	54.43	54.49	54.54	54.60	54.66	[illegible]	[illegible]	[illegible]
SKG	54.78	54.83	54.89	54.95	55.01	55.07	55.12	[illegible]	[illegible]	[illegible]
SKO	55.24	55.29	55.35	55.41	55.46	55.52	55.58	[illegible]	[illegible]	[illegible]
SGS	55.69	55.74	55.80	55.85	55.91	55.96	56.02	[illegible]	[illegible]	[illegible]
SGU	56.13	56.19	56.24	56.29	56.35	56.40	56.46	[illegible]	[illegible]	[illegible]
SGR	56.56	56.62	56.67	56.72	56.79	56.83	56.88	[illegible]	[illegible]	[illegible]
SGW	56.99	57.04	57.09	57.14	57.20	57.25	57.31	[illegible]	[illegible]	[illegible]
SGD	57.40	57.45	57.51	57.56	57.61	57.66	57.71	[illegible]	[illegible]	[illegible]
SGK	57.81	57.86	57.91	57.96	58.01	58.06	58.11	[illegible]	[illegible]	[illegible]
SGG	58.21	58.26	58.31	58.36	58.41	58.46	58.51	[illegible]	[illegible]	[illegible]
SGO	58.61	58.65	58.71	58.75	58.81	58.85	58.90	[illegible]	[illegible]	[illegible]
SOS	58.99	59.04	59.08	59.13	59.18	59.23	59.27	[illegible]	[illegible]	[illegible]
SOU	59.37	59.42	59.46	59.51	59.56	59.61	59.65	[illegible]	[illegible]	[illegible]
SOR	59.74	59.79	59.84	59.88	59.93	59.97	60.01	[illegible]	[illegible]	[illegible]
SOW	60.11	60.15	60.20	60.24	60.29	60.33	60.38	[illegible]	[illegible]	[illegible]
SOD	60.47	60.51	60.56	60.60	60.65	60.69	60.74	[illegible]	[illegible]	[illegible]
SOK	60.83	60.87	60.91	60.96	61.00	61.05	61.09	61.13	[illegible]	[illegible]
SOG	61.18	61.22	61.26	61.31	61.35	61.39	61.44	[illegible]	[illegible]	[illegible]
SOO	61.52	61.56	61.61	61.65	61.69	61.73	61.78	[illegible]	[illegible]	[illegible]

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[illegible] CALIBRATION RESULTS S/N 020 DATE 21 OCT 76 PAGE 3

ALTITUDE IN THOUSANDS OF FEET

	S	U	P	W	D	K	G	J	A	B
[illegible]	61.86	61.90	61.94	61.98	62.03	62.07	62.11	[illegible]	[illegible]	[illegible]
[illegible]	62.19	62.23	62.27	62.32	62.36	62.40	62.44	[illegible]	[illegible]	[illegible]
[illegible]	62.52	62.56	62.60	62.64	62.68	62.72	62.76	[illegible]	[illegible]	[illegible]
[illegible]	62.84	62.88	62.92	62.96	63.00	63.04	63.08	[illegible]	[illegible]	[illegible]
[illegible]	63.16	63.20	63.24	63.28	63.32	63.36	63.39	[illegible]	[illegible]	[illegible]
[illegible]	63.47	63.51	63.55	63.59	63.63	63.67	63.71	[illegible]	[illegible]	[illegible]
[illegible]	63.78	63.82	63.86	63.89	63.93	63.97	64.01	[illegible]	[illegible]	[illegible]
[illegible]	64.09	64.13	64.17	64.21	64.24	64.28	64.31	[illegible]	[illegible]	[illegible]
[illegible]	64.39	64.43	64.46	64.50	64.54	64.57	64.61	[illegible]	[illegible]	[illegible]
[illegible]	64.68	64.72	64.76	64.79	64.83	64.87	64.90	[illegible]	[illegible]	[illegible]
[illegible]	64.98	65.01	65.05	65.08	65.12	65.16	65.19	[illegible]	[illegible]	[illegible]
[illegible]	65.26	65.30	65.33	65.37	65.41	65.44	65.48	[illegible]	[illegible]	[illegible]
[illegible]	65.55	65.58	65.62	65.66	65.69	65.72	65.76	[illegible]	[illegible]	[illegible]
[illegible]	65.83	65.86	65.90	65.93	65.97	66.00	66.04	[illegible]	[illegible]	[illegible]
[illegible]	66.10	66.14	66.17	66.21	66.24	66.28	66.31	[illegible]	[illegible]	[illegible]
[illegible]	66.38	66.41	66.45	66.48	66.51	66.55	66.58	[illegible]	[illegible]	[illegible]
[illegible]	66.65	66.68	66.72	66.75	66.78	66.82	66.85	[illegible]	[illegible]	[illegible]
[illegible]	66.92	66.95	66.98	67.01	67.05	67.08	67.11	[illegible]	[illegible]	[illegible]
[illegible]	67.18	67.21	67.24	67.28	67.31	67.34	67.37	[illegible]	[illegible]	[illegible]
[illegible]	67.44	67.47	67.50	67.54	67.57	67.60	67.63	[illegible]	[illegible]	[illegible]
[illegible]	67.70	67.73	67.76	67.79	67.82	67.86	67.89	[illegible]	[illegible]	[illegible]
[illegible]	67.95	67.98	68.01	68.05	68.08	68.11	68.14	[illegible]	[illegible]	[illegible]
[illegible]	68.20	68.24	68.27	68.30	68.33	68.36	68.39	[illegible]	[illegible]	[illegible]
[illegible]	68.45	68.48	68.52	68.55	68.58	68.61	68.64	[illegible]	[illegible]	[illegible]
[illegible]	68.70	68.73	68.76	68.79	68.82	68.86	68.89	[illegible]	[illegible]	[illegible]
[illegible]	68.94	68.97	69.01	69.04	69.07	69.10	69.13	[illegible]	[illegible]	[illegible]
[illegible]	69.19	69.22	69.25	69.28	69.31	69.34	69.37	[illegible]	[illegible]	[illegible]
[illegible]	69.43	69.46	69.49	69.52	69.55	69.58	69.61	[illegible]	[illegible]	[illegible]
[illegible]	69.67	69.70	69.73	69.76	69.79	69.82	69.84	[illegible]	[illegible]	[illegible]
[illegible]	69.90	69.93	69.96	69.99	70.02	70.05	70.08	[illegible]	[illegible]	[illegible]
[illegible]	70.14	70.17	70.20	70.23	70.25	70.28	70.31	[illegible]	[illegible]	[illegible]
[illegible]	70.37	70.40	70.43	70.46	70.48	70.51	70.54	[illegible]	[illegible]	[illegible]

B-60 CALIBRATION RESULTS S/N 020 DATE 21 OCT 76 PAGE 6

ALTITUDE IN THOUSANDS OF FEET

	S	U	P	W	D	K	G	U	A	B
UDS	70.60	70.63	70.66	70.68	70.71	70.74	70.77	[illegible]	[illegible]	[illegible]
UDU	70.83	70.85	70.88	70.91	70.94	70.97	70.99	[illegible]	[illegible]	[illegible]
UDR	71.05	71.08	71.11	71.13	71.16	71.19	71.22	[illegible]	[illegible]	[illegible]
UDW	71.27	71.30	71.33	71.36	71.38	71.41	71.44	[illegible]	[illegible]	[illegible]
UDC	71.49	71.52	71.55	71.58	71.60	71.63	71.66	[illegible]	[illegible]	[illegible]
UDK	71.71	71.74	71.77	71.79	71.82	71.85	71.88	[illegible]	[illegible]	[illegible]
UDG	71.93	71.96	71.98	72.01	72.04	72.06	72.09	[illegible]	[illegible]	[illegible]
UDO	72.15	72.18	72.20	72.23	72.26	72.28	72.31	[illegible]	[illegible]	[illegible]
UKS	72.36	72.39	72.42	72.44	72.47	72.50	72.52	[illegible]	[illegible]	[illegible]
UKU	72.58	72.60	72.63	72.65	72.68	72.71	72.73	[illegible]	[illegible]	[illegible]
UKR	72.79	72.81	72.84	72.86	72.89	72.92	72.94	[illegible]	[illegible]	[illegible]
UKW	72.99	73.02	73.05	73.06	73.08	73.11	73.13	[illegible]	[illegible]	[illegible]
UKC	73.18	73.21	73.23	73.26	73.29	73.31	73.34	[illegible]	[illegible]	[illegible]
UKK	73.39	73.41	73.44	73.46	73.49	73.51	73.54	73.56	[illegible]	[illegible]
UKG	73.59	73.61	73.64	73.66	73.69	73.71	73.74	[illegible]	[illegible]	[illegible]
UKO	73.79	73.81	73.84	73.86	73.89	73.91	73.94	[illegible]	[illegible]	[illegible]
UGS	73.99	74.02	74.04	74.07	74.09	74.12	74.14	[illegible]	[illegible]	[illegible]
UGU	74.19	74.21	74.24	74.26	74.29	74.31	74.34	[illegible]	[illegible]	[illegible]
UGR	74.39	74.41	74.44	74.46	74.49	74.51	74.53	[illegible]	[illegible]	[illegible]
UGW	74.58	74.61	74.63	74.65	74.69	74.70	74.73	[illegible]	[illegible]	[illegible]
UGC	74.77	74.80	74.82	74.85	74.87	74.89	74.92	[illegible]	[illegible]	[illegible]
UGK	74.97	74.99	75.02	75.04	75.07	75.09	75.11	[illegible]	[illegible]	[illegible]
UGG	75.16	75.19	75.21	75.23	75.26	75.28	75.31	[illegible]	[illegible]	[illegible]
UGO	75.35	75.38	75.40	75.42	75.45	75.47	75.49	[illegible]	[illegible]	[illegible]
UOS	75.54	75.56	75.59	75.61	75.63	75.66	75.68	[illegible]	[illegible]	[illegible]
UOU	75.73	75.75	75.77	75.80	75.82	75.84	75.87	[illegible]	[illegible]	[illegible]
UOR	75.91	75.94	75.96	75.99	76.01	76.03	76.05	[illegible]	[illegible]	[illegible]
UOW	76.10	76.12	76.15	76.17	76.19	76.22	76.24	[illegible]	[illegible]	[illegible]
UOC	76.28	76.31	76.33	76.35	76.38	76.40	76.42	[illegible]	[illegible]	[illegible]
UOK	76.47	76.49	76.51	76.53	76.56	76.58	76.61	[illegible]	[illegible]	[illegible]
UOG	76.65	76.67	76.69	76.72	76.74	76.76	76.79	[illegible]	[illegible]	[illegible]
UOO	76.83	76.85	76.87	76.89	76.92	76.94	76.96	[illegible]	[illegible]	[illegible]

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ALTITUDE IN THOUSANDS OF FEET

	S	U	C	W	D	K	G	O
RSS	77.01	77.03	77.05	77.07	77.10	77.12	77.14	77.16
RSU	77.18	77.21	77.23	77.25	77.27	77.29	77.32	77.34
RSR	77.36	77.38	77.40	77.43	77.45	77.47	77.49	77.51
RSW	77.53	77.56	77.58	77.60	77.62	77.64	77.67	77.69
RSD	77.71	77.73	77.75	77.77	77.79	77.82	77.84	77.86
RSK	77.88	77.90	77.92	77.94	77.97	77.99	78.01	78.03
RSG	78.05	78.07	78.09	78.12	78.14	78.16	78.18	78.20
RSO	78.22	78.24	78.26	78.29	78.31	78.33	78.35	78.37
RUS	78.39	78.41	78.43	78.45	78.47	78.50	78.52	78.54
RUU	78.56	78.58	78.60	78.62	78.64	78.66	78.69	78.71
RUR	78.73	78.75	78.77	78.79	78.81	78.83	78.85	78.87
RUW	78.89	78.91	78.93	78.95	78.97	78.99	79.01	79.03
RUD	79.05	79.07	79.09	79.11	79.13	79.15	79.17	79.20
RUK	79.22	79.24	79.26	79.28	79.30	79.32	79.34	79.36
RUG	79.38	79.40	79.42	79.44	79.46	79.48	79.50	79.52
RUO	79.54	79.56	79.58	79.60	79.62	79.64	79.66	79.68
RRS	79.70	79.72	79.74	79.76	79.78	79.80	79.82	79.84
RRU	79.86	79.88	79.90	79.92	79.94	79.96	79.98	80.00
RRR	80.01	80.03	80.05	80.07	80.09	80.11	80.13	80.15
RRW	80.17	80.19	80.21	80.23	80.25	80.27	80.29	80.31
RRD	80.33	80.35	80.37	80.39	80.41	80.43	80.45	80.46
RRK	80.48	80.50	80.52	80.54	80.56	80.58	80.60	80.62
RRG	80.64	80.66	80.68	80.70	80.72	80.74	80.75	80.77
RRO	80.79	80.81	80.83	80.85	80.87	80.89	80.91	80.93
RWS	80.95	80.97	80.98	81.00	81.02	81.03	81.05	81.07
RWU	81.09	81.11	81.13	81.15	81.17	81.19	81.21	81.23
RWR	81.24	81.26	81.28	81.30	81.32	81.34	81.36	81.37
RWW	81.39	81.41	81.43	81.45	81.47	81.49	81.51	81.52
RWD	81.54	81.56	81.58	81.60	81.62	81.64	81.65	81.67
RWK	81.69	81.71	81.73	81.75	81.77	81.78	81.80	81.82
RWG	81.84	81.86	81.88	81.89	81.91	81.93	81.95	81.97
RWO	81.99	82.00	82.01	82.03	82.05	82.06	82.08	82.10

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B-60 CALIBRATION RESULTS S/N 020 DATE 21 OCT 76 PAGE 6

ALTITUDE IN THOUSANDS OF FEET

	S	U	P	W	D	K	G	O	A	B
RDS	82.12	82.14	82.16	82.17	82.19	82.21	82.23	82.25		
RDU	82.26	82.28	82.30	82.32	82.34	82.35	82.37	82.39		
RDR	82.41	82.43	82.45	82.46	82.48	82.50	82.52	82.53		
RDW	82.55	82.57	82.59	82.61	82.62	82.64	82.66	82.68		
RDD	82.70	82.71	82.73	82.75	82.77	82.78	82.80	82.82		
RDK	82.84	82.86	82.87	82.89	82.91	82.93	82.94	82.96		
RDG	82.98	83.00	83.03	83.05	83.07	83.09	83.10	83.12		
RDO	83.14	83.16	83.17	83.19	83.21	83.22	83.24	83.26		
RKS	83.28	83.29	83.31	83.33	83.34	83.36	83.38	83.40		
RKU	83.41	83.43	83.45	83.46	83.48	83.50	83.52	83.53		
RKR	83.55	83.57	83.58	83.60	83.62	83.63	83.65	83.67		
RKW	83.69	83.70	83.72	83.74	83.75	83.77	83.79	83.80		
RKD	83.82	83.84	83.85	83.87	83.89	83.90	83.92	83.94		
RKK	83.95	83.97	83.99	84.00	84.02	84.04	84.05	84.07		
RKG	84.09	84.10	84.12	84.14	84.15	84.17	84.19	84.20		
RKO	84.22	84.24	84.25	84.27	84.29	84.30	84.32	84.34		
RGS	84.35	84.37	84.38	84.40	84.42	84.43	84.45	84.47		
RGU	84.48	84.50	84.52	84.53	84.55	84.56	84.58	84.60		
RGR	84.61	84.63	84.65	84.66	84.68	84.69	84.71	84.73		
RGW	84.74	84.76	84.77	84.79	84.81	84.82	84.84	84.86		
RGD	84.87	84.89	84.90	84.92	84.94	84.95	84.97	84.98		
RGK	85.00	85.01	85.03	85.05	85.06	85.08	85.09	85.11		
RGG	85.13	85.14	85.16	85.17	85.19	85.21	85.22	85.24		
RGO	85.25	85.27	85.29	85.30	85.32	85.33	85.35	85.36		
ROS	85.38	85.40	85.41	85.43	85.44	85.46	85.47	85.49		
ROU	85.51	85.52	85.54	85.55	85.57	85.58	85.60	85.62		
ROR	85.63	85.65	85.66	85.68	85.69	85.71	85.72	85.74		
ROW	85.76	85.77	85.79	85.80	85.82	85.83	85.85	85.86		
ROD	85.88	85.89	85.91	85.92	85.94	85.96	85.97	85.99		
ROK	86.00	86.02	86.03	86.05	86.07	86.08	86.10	86.11		
ROG	86.13	86.14	86.16	86.17	86.19	86.20	86.22	86.23		
ROO	86.25	86.26	86.28	86.30	86.31	86.33	86.34	86.36		

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ALTITUDE IN THOUSANDS OF FEET

	S	U	R	W	D	K	G	O
WSS	86.37	86.39	86.40	86.42	86.43	86.45	86.46	86.48
WSU	86.49	86.51	86.52	86.54	86.55	86.57	86.58	86.60
WSR	86.61	86.63	86.64	86.66	86.67	86.69	86.70	86.72
WSW	86.73	86.75	86.76	86.78	86.79	86.81	86.82	86.84
WSD	86.85	86.87	86.88	86.90	86.91	86.93	86.94	86.96
WSK	86.97	86.99	87.00	87.02	87.04	87.05	87.07	87.08
WSG	87.10	87.11	87.13	87.14	87.16	87.17	87.19	87.20
WSO	87.22	87.23	87.25	87.26	87.28	87.29	87.31	87.32
WUS	87.33	87.35	87.36	87.38	87.39	87.41	87.42	87.44
WUU	87.45	87.47	87.48	87.49	87.51	87.52	87.54	87.55
WUR	87.57	87.58	87.60	87.61	87.63	87.64	87.66	87.67
WUW	87.68	87.70	87.71	87.73	87.74	87.76	87.77	87.79
WUD	87.80	87.81	87.83	87.84	87.86	87.87	87.89	87.90
WUK	87.91	87.93	87.94	87.96	87.97	87.99	88.00	88.01
WUG	88.03	88.05	88.06	88.07	88.09	88.10	88.12	88.13
WUO	88.15	88.16	88.17	88.19	88.20	88.22	88.23	88.24
WRS	88.26	88.27	88.29	88.30	88.32	88.33	88.34	88.36
WRU	88.37	88.39	88.40	88.41	88.43	88.44	88.46	88.47
WRR	88.48	88.50	88.51	88.53	88.54	88.56	88.57	88.58
WRW	88.60	88.61	88.63	88.64	88.65	88.67	88.68	88.70
WRD	88.71	88.72	88.74	88.75	88.76	88.78	88.79	88.81
WRK	88.82	88.83	88.85	88.86	88.88	88.89	88.91	88.92
WRG	88.93	88.94	88.96	88.97	88.99	89.00	89.01	89.03
WRO	89.04	89.05	89.07	89.08	89.09	89.11	89.12	89.13
WWS	89.15	89.16	89.18	89.19	89.20	89.22	89.23	89.24
WWU	89.26	89.27	89.29	89.30	89.31	89.33	89.34	89.35
WWR	89.37	89.38	89.40	89.41	89.42	89.44	89.45	89.46
WWW	89.48	89.49	89.50	89.52	89.53	89.54	89.56	89.57
WWD	89.58	89.60	89.61	89.62	89.64	89.65	89.67	89.68
WWK	89.69	89.71	89.72	89.73	89.75	89.76	89.77	89.79
WWG	89.80	89.81	89.83	89.84	89.85	89.87	89.88	89.89
WWO	89.91	89.92	89.93	89.95	89.96	89.97	89.99	90.00

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ALTITUDE IN THOUSANDS OF FEET

	S	U	R	W	D	K	G	O	A	B
WDS	90.01	90.03	90.04	90.05	90.07	90.09	90.10	90.12		
WDU	90.13	90.14	90.16	90.17	90.18	90.20	90.21	90.22		
WDR	90.24	90.25	90.26	90.28	90.29	90.30	90.32	90.33		
WDW	90.34	90.36	90.37	90.38	90.41	90.41	90.42	90.44		
WDD	90.45	90.46	90.48	90.49	90.50	90.52	90.53	90.54		
WDK	90.55	90.57	90.58	90.59	90.61	90.62	90.63	90.65		
WDG	90.66	90.67	90.69	90.70	90.71	90.73	90.74	90.75		
WDO	90.76	90.78	90.79	90.80	90.82	90.83	90.84	90.86		
WKS	90.87	90.88	90.89	90.91	90.92	90.93	90.95	90.96		
WKU	90.97	90.99	91.00	91.01	91.02	91.04	91.05	91.06		
WKR	91.07	91.09	91.10	91.11	91.12	91.14	91.15	91.16		
WKW	91.18	91.19	91.20	91.21	91.23	91.24	91.25	91.27		
WKD	91.28	91.29	91.30	91.32	91.33	91.34	91.36	91.37		
WKK	91.38	91.39	91.41	91.42	91.43	91.45	91.46	91.47		
WKG	91.48	91.50	91.51	91.52	91.54	91.55	91.56	91.57		
WKO	91.59	91.60	91.61	91.62	91.64	91.65	91.66	91.67		
WGS	91.69	91.70	91.71	91.73	91.74	91.75	91.76	91.78		
WGU	91.79	91.80	91.81	91.83	91.84	91.85	91.86	91.88		
WGR	91.89	91.90	91.91	91.93	91.94	91.95	91.96	91.98		
WGW	91.99	92.00	92.01	92.02	92.03	92.04	92.06	92.07		
WGD	92.08	92.09	92.11	92.12	92.13	92.14	92.16	92.17		
WGK	92.18	92.19	92.21	92.22	92.23	92.24	92.26	92.27		
WGG	92.28	92.29	92.31	92.32	92.33	92.34	92.36	92.37		
WGO	92.38	92.39	92.40	92.42	92.43	92.44	92.45	92.47		
WOS	92.48	92.49	92.50	92.52	92.53	92.54	92.55	92.56		
WOU	92.58	92.59	92.60	92.61	92.63	92.64	92.65	92.66		
WOR	92.67	92.69	92.70	92.71	92.72	92.74	92.75	92.76		
WOW	92.77	92.78	92.80	92.81	92.82	92.83	92.84	92.86		
WOD	92.87	92.88	92.89	92.91	92.92	92.93	92.94	92.96		
WOK	92.97	92.98	92.99	93.00	93.01	93.03	93.04	93.05		
WOG	93.06	93.07	93.09	93.10	93.11	93.12	93.14	93.15		
WOO	93.16	93.17	93.18	93.20	93.21	93.22	93.23	93.24		

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ALTITUDE IN THOUSANDS OF FEET

	S	U	R	W	O	K	G	O	A	B
CSS	93.26	93.27	93.28	93.29	93.30	93.32	93.33	93.34	.3[illegible]	.[illegible]
DSU	93.35	93.36	93.38	93.39	93.40	93.41	93.42	93.44	.3[illegible]	.[illegible]
CSR	93.45	93.46	93.47	93.48	93.50	93.51	93.52	93.53	.3[illegible]	.[illegible]
DSW	93.54	93.56	93.57	93.58	93.59	93.60	93.62	93.63	.3[illegible]	.[illegible]
CSO	93.64	93.65	93.66	93.67	93.69	93.70	93.71	93.72	.3[illegible]	.[illegible]
DSK	93.73	93.75	93.76	93.77	93.78	93.79	93.80	93.82	.3[illegible]	.[illegible]
CSG	93.83	93.84	93.85	93.86	93.88	93.89	93.90	93.91	.3[illegible]	.[illegible]
DSO	93.92	93.93	93.95	93.96	93.97	93.98	93.99	94.[illegible]	.3[illegible]	.[illegible]
CUS	94.02	94.03	94.04	94.05	94.06	94.07	94.08	94.09	.3[illegible]	.[illegible]
CUU	94.10	94.12	94.13	94.14	94.15	94.16	94.17	94.18	.3[illegible]	.[illegible]
CUR	94.20	94.21	94.22	94.23	94.24	94.25	94.27	94.28	.3[illegible]	.[illegible]
CUW	94.29	94.30	94.31	94.32	94.34	94.35	94.36	94.37	.3[illegible]	.[illegible]
CUO	94.38	94.39	94.40	94.42	94.43	94.44	94.45	94.46	.3[illegible]	.[illegible]
CUK	94.47	94.49	94.50	94.51	94.52	94.53	94.54	94.55	.3[illegible]	.[illegible]
CUG	94.57	94.58	94.59	94.60	94.61	94.62	94.63	94.65	.3[illegible]	.[illegible]
CUO	94.66	94.67	94.68	94.69	94.70	94.71	94.73	94.74	.3[illegible]	.[illegible]
CRS	94.75	94.76	94.77	94.78	94.79	94.81	94.82	94.82	.3[illegible]	.[illegible]
CRU	94.84	94.85	94.86	94.87	94.88	94.91	94.91	94.92	.3[illegible]	.[illegible]
CRR	94.93	94.95	94.96	94.97	94.98	94.99	95.01	95.01	.3[illegible]	.[illegible]
CRW	95.02	95.04	95.05	95.06	95.07	95.08	95.09	95.10	.3[illegible]	.[illegible]
CRO	95.11	95.13	95.14	95.15	95.16	95.17	95.18	95.19	.3[illegible]	.[illegible]
CRK	95.20	95.22	95.23	95.24	95.25	95.26	95.27	95.28	.3[illegible]	.[illegible]
CR6	95.29	95.31	95.32	95.33	95.34	95.35	95.36	95.37	.3[illegible]	.[illegible]
CRO	95.38	95.39	95.41	95.42	95.43	95.44	95.45	95.46	.3[illegible]	.[illegible]
CWS	95.47	95.48	95.49	95.51	95.52	95.53	95.54	95.55	.3[illegible]	.[illegible]
CWU	95.56	95.57	95.58	95.59	95.61	95.62	95.63	95.64	.3[illegible]	.[illegible]
CWR	95.65	95.66	95.67	95.69	95.69	95.70	95.72	95.73	.3[illegible]	.[illegible]
CWW	95.74	95.75	95.76	95.77	95.78	95.79	95.80	95.81	.3[illegible]	.[illegible]
CWO	95.82	95.84	95.85	95.86	95.87	95.88	95.89	95.9[illegible]	.3[illegible]	.[illegible]
CWK	95.91	95.92	95.93	95.94	95.96	95.97	95.98	95.99	.3[illegible]	.[illegible]
CWG	96.00	96.01	96.02	96.03	96.04	96.05	96.06	96.07	.3[illegible]	.[illegible]
CWO	96.08	96.09	96.10	96.12	96.13	96.14	96.15	96.16	.3[illegible]	.[illegible]

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B-60 CALIBRATION RESULTS S/N 020 DATE 21 OCT 76 PAGE 10

ALTITUDE IN THOUSANDS OF FEET

	S	U	P	W	D	K	G	O	A	B
DDS	96.17	96.18	96.19	96.20	96.21	96.22	96.23	96.25	.3877	
DDU	96.26	96.27	96.28	96.29	96.30	96.31	96.32	96.33	.3877	
DDR	96.34	96.35	96.36	96.37	96.38	96.40	96.41	96.42	.3877	
DDW	96.43	96.44	96.45	96.46	96.47	96.48	96.49	96.50	.3877	
DDD	96.51	96.52	96.53	96.54	96.56	96.57	96.58	96.59	.3877	
DDK	96.60	96.61	96.62	96.63	96.64	96.65	96.66	96.67	.3877	
DDG	96.68	96.69	96.70	96.71	96.72	96.74	96.75	96.75	.3877	
DDO	96.77	96.78	96.79	96.80	96.81	96.82	96.83	96.84	.3877	
DKS	96.85	96.86	96.87	96.88	96.89	96.90	96.91	96.92	.3877	
DKU	96.94	96.95	96.96	96.97	96.98	96.99	97.00	97.01	.3877	
DKR	97.02	97.03	97.04	97.05	97.06	97.07	97.09	97.11	.3877	
DKW	97.11	97.12	97.13	97.14	97.15	97.16	97.17	97.18	.3877	
DKD	97.19	97.20	97.21	97.22	97.23	97.24	97.25	97.26	.3877	
DKK	97.27	97.28	97.29	97.30	97.32	97.33	97.34	97.35	.3877	
DKG	97.36	97.37	97.38	97.39	97.40	97.41	97.42	97.43	.3877	
DKO	97.44	97.45	97.46	97.47	97.48	97.49	97.50	97.51	.3877	
DGS	97.52	97.53	97.54	97.55	97.56	97.57	97.58	97.59	.3877	
DGU	97.61	97.62	97.63	97.64	97.65	97.66	97.67	97.68	.3877	
DGR	97.69	97.70	97.71	97.72	97.73	97.74	97.75	97.76	.3877	
DGW	97.77	97.78	97.79	97.80	97.81	97.82	97.83	97.84	.3877	
DGD	97.85	97.86	97.87	97.88	97.89	97.90	97.91	97.92	.3877	
DGK	97.93	97.94	97.95	97.96	97.97	97.98	97.99	98.00	.3877	
DGG	98.01	98.02	98.03	98.04	98.05	98.06	98.07	98.08	.3877	
DGO	98.10	98.11	98.12	98.13	98.14	98.15	98.16	98.17	.3877	
DOS	98.18	98.19	98.20	98.21	98.22	98.23	98.24	98.25	.3877	
DOU	98.26	98.27	98.28	98.29	98.30	98.31	98.32	98.33	.3877	
DOR	98.34	98.35	98.36	98.37	98.38	98.39	98.41	98.42	.3877	
DOW	98.42	98.43	98.44	98.45	98.46	98.47	98.48	98.49	.3877	
DOD	98.50	98.51	98.52	98.53	98.54	98.55	98.56	98.57	.3877	
DOK	98.58	98.59	98.60	98.61	98.62	98.63	98.64	98.65	.3877	
DOG	98.66	98.66	98.67	98.68	98.69	98.70	98.71	98.72	.3877	
DOO	98.73	98.74	98.75	98.76	98.77	98.78	98.79	98.80	.3877	

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ALTITUDE IN THOUSANDS OF FEET

	S	U	R	W	D	K	G	O	A	B
KSS	98.81	98.82	98.83	98.84	98.85	98.86	98.87	98.88		
KSU	98.89	98.90	98.91	98.92	98.93	98.94	98.95	98.96		
KSR	98.97	98.98	98.99	99.00	99.01	99.02	99.03	99.04		
KSW	99.05	99.06	99.07	99.09	99.10	99.11	99.12	99.13		
KSD	99.13	99.14	99.15	99.16	99.17	99.18	99.19	99.2		
KSK	99.21	99.22	99.23	99.24	99.25	99.26	99.27	99.28		
KSG	99.29	99.30	99.31	99.32	99.33	99.34	99.35	99.36		
KSO	99.37	99.38	99.39	99.40	99.41	99.42	99.43	99.44		
KUS	99.44	99.45	99.46	99.47	99.48	99.49	99.50	99.51		
KUU	99.52	99.53	99.54	99.55	99.56	99.57	99.58	99.59		
KUR	99.60	99.61	99.62	99.63	99.64	99.65	99.65	99.66		
KUW	99.67	99.68	99.69	99.70	99.71	99.72	99.73	99.74		
KUD	99.75	99.76	99.77	99.78	99.79	99.80	99.81	99.82		
KUK	99.83	99.84	99.84	99.85	99.86	99.87	99.88	99.89		
KUG	99.90	99.91	99.92	99.93	99.94	99.95	99.96	99.97		
KUO	99.98	99.99	100.00	100.01	100.00	100.01	100.02	100.03		
KRS	100.04	100.05	100.06	100.07	100.08	100.09	100.10	100.11		
KRU	100.12	100.12	100.13	100.14	100.15	100.16	100.17	100.18		
KRR	100.19	100.20	100.21	100.22	100.23	100.24	100.25	100.26		
KRW	100.27	100.27	100.28	100.29	100.30	100.31	100.32	100.33		
KRD	100.34	100.35	100.36	100.37	100.38	100.39	100.40	100.41		
KRK	100.42	100.42	100.43	100.44	100.45	100.46	100.47	100.48		
KRG	100.49	100.50	100.51	100.52	100.53	100.54	100.55	100.55		
KRO	100.56	100.57	100.58	100.59	100.60	100.61	100.62	100.63		
KWS	100.64	100.65	100.66	100.67	100.67	100.68	100.69	100.70		
KWU	100.71	100.72	100.73	100.74	100.75	100.76	100.77	100.78		
KWR	100.79	100.79	100.80	100.81	100.82	100.83	100.84	100.85		
KWW	100.86	100.87	100.88	100.89	100.90	100.90	100.91	100.92		
KWD	100.93	100.94	100.95	100.96	100.97	100.98	100.99	101.00		
KWK	101.00	101.01	101.02	101.03	101.04	101.05	101.06	101.07		
KWG	101.08	101.09	101.10	101.11	101.12	101.12	101.13	101.14		
KWO	101.15	101.16	101.17	101.18	101.19	101.20	101.21	101.22		

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B-60 CALIBRATION RESULTS S/N 020 DATE 21 OCT 76 PAGE 12

ALTITUDE IN THOUSANDS OF FEET

	S	U	R	W	D	K	G	O	A	B
KOS	101.22	101.23	101.24	101.25	101.26	101.27	101.28	101.29	.3983[illegible]E+01	.39[illegible]E-1
KOU	101.30	101.31	101.32	101.32	101.33	101.34	101.35	101.36	.3983[illegible]E+01	.39[illegible]E-1
KOR	101.37	101.38	101.39	101.40	101.41	101.41	101.42	101.43	.3983[illegible]E+01	.39[illegible]E-1
KOW	101.44	101.45	101.46	101.47	101.48	101.49	101.50	101.51	.3983[illegible]E+01	.39[illegible]E-1
KOD	101.51	101.52	101.53	101.54	101.55	101.56	101.57	101.58	.3983[illegible]E+01	.39[illegible]E-1
KOK	101.58	101.59	101.60	101.61	101.62	101.63	101.64	101.65	.3983[illegible]E+01	.39[illegible]E-1
KOG	101.66	101.67	101.67	101.68	101.69	101.70	101.71	101.72	.3983[illegible]E+01	.39[illegible]E-1
KOO	101.73	101.74	101.75	101.75	101.76	101.77	101.78	101.79	.3983[illegible]E+01	.39[illegible]E-1
KKS	101.80	101.81	101.82	101.83	101.83	101.84	101.85	101.86	.3983[illegible]E+01	.39[illegible]E-1
KKU	101.87	101.88	101.89	101.90	101.91	101.91	101.92	101.93	.3983[illegible]E+01	.39[illegible]E-1
KKR	101.94	101.95	101.96	101.97	101.99	102.00	102.00	102.01	.3983[illegible]E+01	.39[illegible]E-1
KKW	102.02	102.03	102.04	102.05	102.06	102.07	102.08	102.08	.3983[illegible]E+01	.39[illegible]E-1
KKD	102.09	102.10	102.11	102.12	102.13	102.14	102.15	102.15	.3983[illegible]E+01	.39[illegible]E-1
KKK	102.16	102.17	102.18	102.19	102.20	102.21	102.22	102.22	.3983[illegible]E+01	.39[illegible]E-1
KKG	102.23	102.24	102.25	102.26	102.27	102.28	102.29	102.30	.3983[illegible]E+01	.39[illegible]E-1
KKO	102.30	102.31	102.32	102.33	102.34	102.35	102.36	102.37	.3983[illegible]E+01	.39[illegible]E-1
KGS	102.37	102.38	102.39	102.40	102.41	102.42	102.43	102.43	.3983[illegible]E+01	.39[illegible]E-1
KGU	102.44	102.45	102.46	102.47	102.48	102.49	102.50	102.50	.3983[illegible]E+01	.39[illegible]E-1
KGR	102.51	102.52	102.53	102.54	102.55	102.56	102.57	102.57	.3983[illegible]E+01	.39[illegible]E-1
KGW	102.58	102.59	102.60	102.61	102.62	102.63	102.63	102.64	.3983[illegible]E+01	.39[illegible]E-1
KGD	102.65	102.66	102.67	102.68	102.69	102.70	102.71	102.71	.3983[illegible]E+01	.39[illegible]E-1
KGK	102.72	102.73	102.74	102.75	102.76	102.76	102.77	102.78	.3983[illegible]E+01	.39[illegible]E-1
KGG	102.79	102.80	102.81	102.82	102.82	102.83	102.84	102.85	.3983[illegible]E+01	.39[illegible]E-1
KGO	102.86	102.87	102.88	102.88	102.89	102.90	102.91	102.92	.3983[illegible]E+01	.39[illegible]E-1
KOS	102.93	102.94	102.94	102.95	102.96	102.97	102.98	102.99	.3983[illegible]E+01	.39[illegible]E-1
KOU	103.00	103.00	103.01	103.02	103.03	103.04	103.05	103.05	.3983[illegible]E+01	.39[illegible]E-1
KOR	103.06	103.06	103.07	103.08	103.09	103.10	103.11	103.12	.3983[illegible]E+01	.39[illegible]E-1
KOW	103.12	103.13	103.14	103.15	103.16	103.17	103.17	103.18	.3983[illegible]E+01	.39[illegible]E-1
KOD	103.19	103.20	103.21	103.22	103.23	103.23	103.24	103.25	.3983[illegible]E+01	.39[illegible]E-1
KOK	103.26	103.27	103.28	103.29	103.29	103.30	103.31	103.32	.3983[illegible]E+01	.39[illegible]E-1
KOG	103.33	103.34	103.35	103.35	103.36	103.37	103.38	103.39	.3983[illegible]E+01	.39[illegible]E-1
KOO	103.40	103.40	103.41	103.42	103.43	103.44	103.45	103.46	.3983[illegible]E+01	.39[illegible]E-1

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B-60 CALIBRATION RESULTS S/N 020 DATE 21 OCT 76 PAGE 13

ALTITUDE IN THOUSANDS OF FEET

	S	U	R	W	D	K	G	O	A	B
GSS	103.46	103.47	103.48	103.49	103.50	103.51	103.51	103.52		
GSU	103.53	103.54	103.55	103.56	103.56	103.57	103.58	103.59		
GSR	103.60	103.61	103.62	103.62	103.63	103.64	103.65	103.66		
GSW	103.67	103.67	103.68	103.69	103.70	103.71	103.72	103.72		
GSD	103.73	103.74	103.75	103.76	103.77	103.77	103.78	103.79		
GSK	103.80	103.81	103.82	103.82	103.83	103.84	103.85	103.86		
GSG	103.87	103.87	103.88	103.89	103.90	103.91	103.92	103.92		
GSO	103.93	103.94	103.95	103.96	103.97	103.97	103.98	103.99		
GUS	104.00	104.01	104.03	104.03	104.04	104.05	104.06	104.07		
GUU	104.07	104.08	104.09	104.10	104.11	104.12	104.12	104.13		
GUR	104.14	104.15	104.16	104.17	104.17	104.18	104.19	104.20		
GUW	104.21	104.22	104.22	104.23	104.24	104.25	104.26	104.27		
GUD	104.27	104.28	104.29	104.30	104.31	104.32	104.32	104.33		
GUK	104.34	104.35	104.36	104.36	104.37	104.38	104.39	104.40		
GUG	104.41	104.41	104.42	104.43	104.44	104.45	104.45	104.46		
GUO	104.47	104.48	104.49	104.50	104.50	104.51	104.52	104.53		
GRS	104.54	104.54	104.55	104.56	104.57	104.58	104.58	104.59		
GRU	104.60	104.61	104.62	104.63	104.63	104.64	104.65	104.66		
GRR	104.67	104.68	104.68	104.69	104.70	104.71	104.72	104.72		
GRW	104.73	104.74	104.75	104.76	104.76	104.77	104.78	104.79		
GRD	104.80	104.80	104.81	104.82	104.83	104.84	104.85	104.85		
GRK	104.86	104.87	104.88	104.89	104.89	104.90	104.91	104.92		
GRG	104.93	104.93	104.94	104.95	104.96	104.97	104.97	104.98		
GRO	104.99	105.00	105.01	105.01	105.02	105.03	105.04	105.05		
GWS	105.05	105.06	105.07	105.08	105.09	105.09	105.10	105.11		
GWU	105.13	105.14	105.15	105.15	105.16	105.17	105.18	105.19		
GWR	105.19	105.20	105.21	105.22	105.23	105.24	105.24	105.25		
GWW	105.26	105.27	105.28	105.28	105.29	105.30	105.31	105.32		
GWD	105.32	105.33	105.34	105.35	105.35	105.36	105.37	105.38		
GWK	105.39	105.40	105.41	105.41	105.42	105.43	105.44	105.45		
GWG	105.45	105.46	105.47	105.48	105.49	105.49	105.50	105.51		
GWO	105.52	105.53	105.53	105.54	105.55	105.56	105.57	105.57		

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B-60 CALIBRATION RESULTS S/N 026 DATE 21 OCT 76 PAGE 14

ALTITUDE IN THOUSANDS OF FEET

	S	U	R	W	O	K	G	O
GOS	105.58	105.59	105.60	105.61	105.61	105.62	105.63	105.6-
GOU	105.65	105.65	105.66	105.67	105.68	105.69	105.69	105.7[illegible]
GOR	105.71	105.72	105.73	105.73	105.74	105.75	105.76	105.77
GOW	105.77	105.78	105.79	105.80	105.81	105.81	105.82	1[illegible]
GOO	105.84	105.84	105.85	105.86	105.87	105.88	105.88	105.89
GOK	105.90	105.91	105.92	105.92	105.93	105.94	105.95	1[illegible]
GOG	105.96	105.97	105.98	105.99	105.99	106.00	106.01	106.[illegible]
GOO	106.03	106.03	106.04	106.05	106.06	106.07	106.[illegible]	[illegible]
GKS	106.08	106.09	106.10	106.11	106.12	106.12	106.13	1[illegible]
GKU	106.15	106.16	106.16	106.17	106.18	106.19	106.20	1[illegible]
GKR	106.21	106.22	106.23	106.23	106.24	106.25	106.26	106.27
GKW	106.27	106.28	106.29	106.30	106.30	106.31	106.32	1[illegible]
GKO	106.34	106.34	106.35	106.36	106.37	106.37	106.38	1[illegible]
GKK	106.40	106.41	106.41	106.42	106.43	106.44	106.44	1[illegible]
GKG	106.46	106.47	106.48	106.48	106.49	106.50	106.51	1[illegible]
GKO	106.52	106.53	106.54	106.55	106.55	106.56	106.57	1[illegible]
GGS	106.58	106.59	106.60	106.61	106.62	106.62	106.63	1[illegible]
GGU	106.65	106.65	106.66	106.67	106.68	106.68	106.69	1[illegible]
GGR	106.71	106.72	106.72	106.73	106.74	106.75	106.75	1[illegible]
GGW	106.77	106.78	106.78	106.79	106.80	106.81	106.82	106.82
GGO	106.83	106.84	106.85	106.85	106.86	106.87	106.88	1[illegible]
GGK	106.89	106.90	106.91	106.91	106.92	106.93	106.94	1[illegible]
GGG	106.95	106.96	106.97	106.98	106.98	106.99	107.00	1[illegible]
GGO	107.01	107.02	107.03	107.04	107.05	107.05	107.06	1[illegible]
GOS	107.08	107.09	107.09	107.10	107.11	107.12	107.12	1[illegible]
GOU	107.14	107.15	107.16	107.16	107.17	107.18	107.19	1[illegible]
GOR	107.20	107.21	107.22	107.23	107.23	107.24	107.25	1[illegible]
GOW	107.26	107.27	107.28	107.29	107.29	107.30	107.31	1[illegible]
GOO	107.33	107.33	107.34	107.35	107.36	107.35	107.37	1[illegible]
GOK	107.39	107.39	107.40	107.41	107.42	107.42	107.43	1[illegible]
GOG	107.45	107.46	107.46	107.47	107.47	107.48	107.49	107.[illegible]
GOO	107.51	107.52	107.52	107.53	107.54	107.55	107.55	1[illegible]

A	B
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
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B-60 CALIBRATION RESULTS S/N 020 DATE 21 OCT 76 PAGE 15

ALTITUDE IN THOUSANDS OF FEET

	S	U	O	W	D	K	G	Q
OSS	107.57	107.58	107.59	107.59	107.60	107.51	107.62	107.56
OSU	107.63	107.64	107.65	107.65	107.66	107.57	107.68	107.58
OSR	107.69	107.70	107.71	107.71	107.72	107.73	107.74	107.74
OSW	107.75	107.76	107.77	107.77	107.78	107.79	107.80	107.79
OSO	107.81	107.82	107.83	107.83	107.84	107.85	107.86	107.85
OSK	107.87	107.88	107.89	107.89	107.9	107.91	107.92	107.92
OSG	107.93	107.94	107.95	107.96	107.96	107.97	107.98	107.98
OSO	107.99	108.00	108.01	108.02	108.02	108.03	108.04	108.04
OUS	108.05	108.06	108.07	108.08	108.08	108.09	108.10	108.10
OUU	108.11	108.12	108.13	108.14	108.15	108.16	108.17	108.16
OUR	108.19	108.19	108.19	108.20	108.21	108.22	108.22	108.23
OUW	108.25	108.25	108.25	108.26	108.27	108.28	108.29	108.29
OUO	108.31	108.31	108.32	108.33	108.34	108.34	108.35	108.35
OUK	108.37	108.37	108.38	108.39	108.39	108.40	108.41	108.41
OUG	108.43	108.43	108.44	108.45	108.45	108.46	108.47	108.47
OUO	108.49	108.49	108.50	108.51	108.52	108.52	108.53	108.53
ORS	108.55	108.55	108.56	108.57	108.57	108.58	108.59	108.59
ORU	108.61	108.61	108.62	108.62	108.63	108.64	108.65	108.65
ORR	108.67	108.67	108.68	108.68	108.69	108.70	108.71	108.71
ORW	108.73	108.73	108.74	108.74	108.75	108.76	108.77	108.77
ORO	108.79	108.79	108.80	108.80	108.81	108.82	108.82	108.83
ORK	108.85	108.85	108.85	108.86	108.87	108.88	108.88	108.89
ORG	108.91	108.91	108.92	108.92	108.93	108.94	108.94	108.95
ORO	108.97	108.97	108.98	108.98	108.99	109.00	109.01	109.01
OWS	109.02	109.02	109.03	109.04	109.05	109.06	109.06	109.07
OWU	109.08	109.07	109.08	109.09	109.09	109.10	109.11	109.11
OWR	109.12	109.12	109.13	109.14	109.14	109.15	109.16	109.16
OWW	109.18	109.18	109.19	109.20	109.20	109.21	109.22	109.22
OWO	109.24	109.24	109.25	109.25	109.26	109.27	109.28	109.29
OWK	109.30	109.30	109.31	109.31	109.32	109.33	109.34	109.34
OWG	109.36	109.36	109.37	109.37	109.38	109.39	109.40	109.40
OWO	109.42	109.42	109.42	109.43	109.44	109.45	109.45	109.46

C-60 CALIBRATION RESULTS S/N 020 DATE 21 OCT 76 PAGE 15

ALTITUDE IN THOUSANDS OF FEET

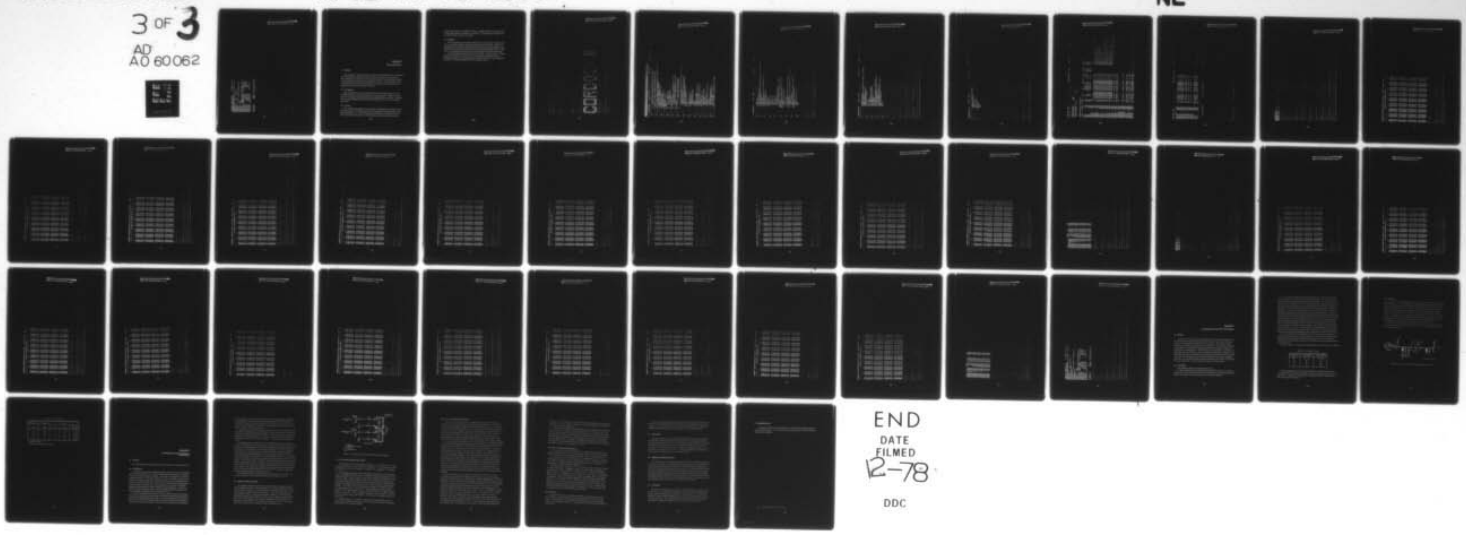
	S	U	R	M	D	K	G	O
ODS	109.48	109.48	109.49	109.50	109.51	109.51	109.52	109.53
ODU	109.53	109.54	109.55	109.56	109.56	109.57	109.58	109.59
ODR	109.59	109.60	109.61	109.61	109.62	109.63	109.64	109.64
ODW	109.65	109.66	109.67	109.67	109.68	109.69	109.69	109.70
ODD	109.71	109.72	109.72	109.73	109.74	109.75	109.75	109.76
ODK	109.77	109.77	109.78	109.79	109.80	109.80	109.81	109.82
ODG	109.83	109.83	109.84	109.85	109.85	109.86	109.87	109.88
ODO	109.88	109.89	109.90	109.90	109.91	109.92	109.93	109.93
OKS	109.94	109.95	109.95	109.96	109.97	109.97	109.98	109.99
OKU	109.99	110.00	110.01	110.02	110.02	110.03	110.04	110.04
OKR	110.05	110.06	110.07	110.07	110.08	110.09	110.10	110.10
OKW	110.11	110.12	110.12	110.13	110.14	110.15	110.15	110.16
OKD	110.17	110.17	110.18	110.19	110.20	110.20	110.21	110.22
OKK	110.22	110.23	110.24	110.25	110.25	110.26	110.27	110.28
OKG	110.28	110.29	110.30	110.30	110.31	110.32	110.32	110.33
OKO	110.34	110.35	110.35	110.36	110.37	110.37	110.38	110.39
OGS	110.40	110.40	110.41	110.42	110.42	110.43	110.44	110.45
OGU	110.45	110.46	110.47	110.47	110.48	110.49	110.50	110.50
OGR	110.51	110.52	110.52	110.53	110.54	110.55	110.55	110.56
OGW	110.57	110.57	110.58	110.59	110.59	110.60	110.61	110.62
OGD	110.62	110.63	110.64	110.64	110.65	110.66	110.67	110.67
OGK	110.68	110.69	110.69	110.70	110.71	110.71	110.72	110.73
OGG	110.74	110.74	110.75	110.76	110.76	110.77	110.78	110.79
OGO	110.79	110.80	110.81	110.81	110.82	110.83	110.83	110.84
OOS	110.85	110.86	110.86	110.87	110.88	110.88	110.89	110.90
OOU	110.90	110.91	110.92	110.93	110.93	110.94	110.95	110.95
OOR	110.96	110.97	110.97	110.98	110.99	111.00	111.00	111.01
OOW	111.02	111.02	111.03	111.04	111.04	111.05	111.06	111.06
OOD	111.07	111.08	111.09	111.09	111.10	111.11	111.11	111.12
OOK	111.13	111.13	111.14	111.15	111.16	111.16	111.18	111.19
OOG	111.19	111.20	111.21	111.21	111.22	111.23	111.23	111.24
OOO	111.25	111.26	111.26	111.27	111.28	111.28	111.29	111.30

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AD-A060 062 AIR FORCE GEOPHYSICS LAB HANSCOM AFB MASS F/G 4/1
ABOUT THE DEVELOPMENT OF A SECOND GENERATION ATMOSPHERIC SAMPLE--ETC(U)
MAR 78 R H CORDELLA

UNCLASSIFIED AFGL-TR-78-0065 NL

3 OF 3
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```
 03/11/77  SCOPE 3.4.4      * COC466A  A.F.G.L.
08.59.56.CORD03C  FROM MFA
08.59.56.IP  0000096 WORDS - FILE INPUT  , DC CE
08.59.56.CORD.      2836    CORDELLA
08.59.56.
08.59.57.FTN.SL.
09.00.03.      .692 CP SECONDS COMPILATION TIME
09.00.31.LGO.
09.00.43.      STOP
09.00.43.      1.039 CP SECONDS EXECUTION TIME
09.00.43.CP  0000008 WORDS - FILE OUTPUT , DC CO
09.00.43.MS    10752  WORDS  (  14336 MAX USED)
09.00.43.CPA          3.155 SEC.      .064 COST
09.00.43.IO           1.527 SEC.      .010 COST
09.00.43.CM          66.093 KWS.      .072 COST
09.00.43.SS     COST OF JOB           .147
09.00.43.PP          40.599 SEC.    DATE 03/11/77
09.00.43.EJ  END OF JOB, **

**********      CORD03C  //// END OF LIST ////
**********      CORD03C  //// END OF LIST ////
```

Appendix I

Backup Altitude Program

I1. GENERAL

This program is written to produce a code vs altitude dictionary for a Rosemount type altitude sensor calibrated through a voltage to frequency (V-F) converter. This combination will be used as a set with any encoder; the serial number position on the dictionary contains the serial number of each unit. Usually this data covers an envelope about the projected float altitude or about several float altitudes, depending upon the pressure range of the sensor.

I1.1 The Algorithm

Rosemount type sensors are non-linear with respect to pressure so it is not possible to fit them to a simple exponential as the B-60 was fit. Instead, the data is fit to a general nth order equation over a selectable number of points. Numerous data runs have established that a fourth order equation fit over four to six points works well.

I1.2 The Input

The first data card contains n for the order of the equation, the interval, serial numbers and data. Remaining cards hold one data point each; period msec vs altitude in thousands of ft. Like the preceeding two programs, more than one set of data can be entered at one time. The last data card in a set is used as a flag to

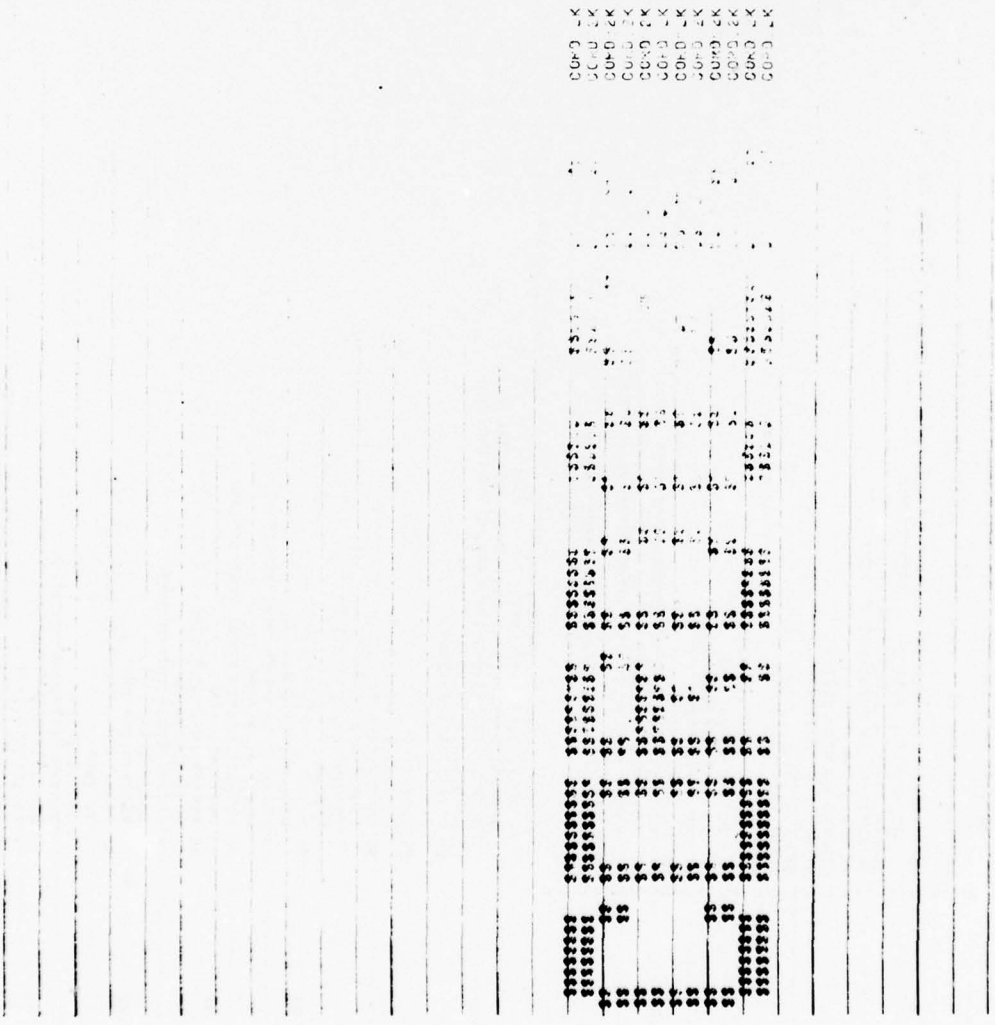
inform the program if more data sets follow. Negative numbers are used as flags because they cannot be mistaken for an altitude. The program which follows was run with two sets of data as an example.

II.3 The Output

After the identifying cover sheet, program, and memory map; contents of data card 1 are printed plus the count of the remaining cards in that set. Next is the dictionary 52 kft to 105 kft followed by the input data and error calculations. Note that the data covered 60 kft to 100 kft for the nominal float altitudes of 70, 80, and 90 kft. The program automatically fills the pages begun to cover the input data.

A second dictionary follows; the format is similar. Data covering 60 to 100 kft produced a dictionary for 50 to 106 kft. Comparing the headings for the two dictionaries shows that two sensors (serial numbers 148 and 149) were calibrated through V-F converter (serial No. 03) on 2 November 1976.

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```
      PROGRAM ROSE       76/76   OPT=1                    FTN 4.54414      03/11/77  [illegible]     PAGE  1

 1                PROGRAM ROSE(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
                  C
                  C PROGRAM TO PRODUCE A ROSEMOUNT CALIBRATION DICTIONARY
                  C
 5                C INT= INTERVAL(NUMBER OF CALIBRATION POINTS) OVER WHICH BEST LINE IS
                  C      TO BE FIT.  MUST BE AN EVEN NUMBER
                  C IORDR= ORDER OF POLYNOMIAL TO BE FIT
                  C H= ALTITUDE IN THOUSANDS OF FEET
                  C P= PERIOD IN MSEC
10                C COUNTS= COUNTS= 2000/P
                  C HSTAR= BEST ESTIMATE OF H
                  C NC= COUNTS
                  C INPUT DATA--EACH SET
                  C CARD 1
15                C      CC 1-4 INTERVAL (I4)
                  C      CC 5-8 IORDR (I4)
                  C      CC 9-16 SERIAL NUMBER
                  C      CC 17-26 DATE
                  C CARD 2 THRU N+1
20                C      CC 1-10 ALTITUDE IN THOUSANDS OF FEET (F10.0)
                  C      CC 11-20 PERIOD IN MSEC (F10.0)
                  C      CARDS MUST BE IN ASCENDING ORDER BY ALTITUDE
                  C LAST CARD
                  C      CC 1-10 =1.0 IF MORE DATA SETS FOLLOW
25                C              -2.0 IF IT IS THE LAST DATA SET
                  C
                        COMMON INT,INT2,IORDR,N,NC,NCEND,H(201),COUNTS(201),HSTAR(  )
                       1,JORDR,XD,XC,C(21),NLBL
                        DIMENSION LETTR(8),P(201),SN(2),DATE(3),X(8)
30                      DATA LETTR/1HS,1HU,1HF,1HW,1HO,1HK,1HG,1HO/
                     10 READ(5,20) INT,IORDR,SN,DATE
                     20 FORMAT(2I4,2A4,3A4)
                        N=0
                     25 N= N+1
35                      READ(5,30) H(N),P(N)
                     30 FORMAT(2F10.0)
                        COUNTS(N)= 2000./P(N)
                        IF(H(N).GE.0) GO TO 25
                        NLBL=N
40                   31 N=N-1
                        WRITE(6,35) IORDR
                     35 FORMAT(1H1,"ORDER READ AS",I5)
                        WRITE(6,40) INT
                     40 FORMAT(1H ,"INTERVAL READ AS",I5)
45                      WRITE(6,45) N
                     45 FORMAT(1H ,"N IS",I4)
                        INT= (INT/2)*2
                        IF(INT.GT.N) INT=(N/2)*2
                        INT2= INT/2
50                      WRITE(6,50) INT
                     50 FORMAT(1H ,"INTERVAL USED IS",I5)
                        J= INT2
                        CALL COEF(J)
                        NLAST= IFIX(COUNTS(N)+0.5)
55                      NC= IFIX(COUNTS(1)/256.0)*256
                        DO 60 I= 1,INT2
                     60 CALL CNPS(HSTAR(I),COUNTS(I)*XD+XC,C,JORDR)
```


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```
      PROGRAM ROSE      74/74   OPT=1                    FTN 4.5+419
      IPAGE= 0
   70 IPAGE= IPAGE+1
   60 WRITE(6,80) SN,DATE,IPAGE
   80 FORMAT(1H1,6X,"ROSEMOUNT CALIBRATION RESULTS"," S/N ",2A4," DATE "
     1,3A4," PAGE",I3)
      WRITE(6,81)
   81 FORMAT(1H0,25X,"ALTITUDE IN THOUSANDS OF FEET")
   65 WRITE(6,82) LETTR
   82 FORMAT(1H ,8X,8(7X,A1))
      DO 400 J2= 1,4
      WRITE(6,83)
   83 FORMAT(1H )
   70 DO 390 J3= 1,8
      K=NC/8
      K3= MOD(K,8)+1
      K=K/8
      K2= MOD(K,8)+1
   75 K1= K/8+1
      DO 200 J4= 1,8
      IF(NC.GT.NCEND) CALL COEF(J)
      CALL CNPS(X(J4),FLOAT(NC)*X0+X1,C,JORDR)
  200 NC= NC+1
   80 300 WRITE(6,301) LETTR(K1),LETTR(K2),LETTR(K3),X
  301 FORMAT(1H ,6X,3A1,1X,8F8.2)
  400 CONTINUE
      IF(NC.LT.NLAST) GO TO 70
      J= J+1
   85 DO 440 I=J,N
  440 CALL CNPS(HSTAR(I),COUNTS(I)*X0+X1,C,JORDR)
      WRITE(6,451)
  451 FORMAT(1H1,4X,"H",8X,"P",4X,"COUNTS",4X,"H*",6X,"H-H*")
      DO 500 I= 1,N
   90 ERR= H(I)-HSTAR(I)
  500 WRITE(6,501) H(I),P(I),COUNTS(I),HSTAR(I),ERR
  501 FORMAT(1H ,2F8.3,F8.1,2F8.3)
      N=NLBL
      IF(H(N).EQ.-1.0) GO TO 10
   95 STOP
      END
```


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```
SUBROUTINE COEF      74/74  OPT=1                    FTN 4.[illegible]      [illegible]  PAG
      SUBROUTINE COEF(J)
      COMMON INT,INT2,IORDR,N,NC,NCEND,H(2[illegible]),COUNTS(2[illegible]),HSTAR([illegible])
     1,JORDR,XD,X0,C(20)
      DIMENSION DATI(100),WORK(2[illegible])
      IF(J+INT2.GT.N) RETURN
      J= J+1
      K1= J-INT2
      K2= J+INT2-1
      CALL RMOVE(COUNTS,K1,K2,DATI,1)
      CALL RMOVE(H,K1,K2,DATI,INT+1)
      DATI(2*INT+1)= -1
      JORDR= IORDR
      CALL APCH(DATI,INT,JORDR,XD,X0,WORK,IER)
      CALL APFS(WORK,JORDR,IRES,I,0.[illegible],0.[illegible],I[illegible])
      I= JORDR*(JORDR-1)/2+1
      CALL RMOVE (WORK,I,I+JORDR-1,C,1)
      CALL CNPS(HSTAR(J),COUNTS(J)*X0+X[illegible],C,JORDR)
      NCEND= IFIX(COUNTS(J))
      RETURN
      END
```


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```
SUBROUTINE RMOVE    74/74   OPT=1                FTN 4.5+415    12/21/7?  ??.?.?5    PAGE  1

 1        SUBROUTINE RMOVE(X,N1,N2,Y,M1)
          DIMENSION X(1),Y(1)
          L1= M1
          DO 5 I= N1,N2
          Y(L1)= X(I)
 5        L1= L1+1
          RETURN
          END
```

LOAD MAP = CNPS CYBER LOADER 1 1-42? 03/11/?? ?:??:?? PAGE 1

FWA OF THE LOAD 111
LWA+1 OF THE LOAD 22644

TRANSFER ADDRESS -- ROSE 5C35

PROGRAM AND BLOCK ASSIGNMENTS.

BLOCK	ADDRESS	LENGTH	FILE	DATE	PROCSSR	VER	LEVEL	HARDWARE	COMMENTS
CNPS	111	70	XX	04/30/74	FTN	4.1	P37.	865X I	OPT=1
APPS	201	252	XX	04/30/74	FTN	4.1	P37	865X I	OPT=1
APCH	453	251	XX	04/30/74	FTN	4.1	P37.	865X I	OPT=1
ROSE	724	5376	LGO	03/11/77	FTN	4.?	1+	865X I	OPT=1
COEF	6022	665	LGO	03/11/77	FTN	4.?	41+	865X I	OPT=1
RMOVE	6707	23	LGO	03/11/77	FTN	4.?	41+	865X I	OPT=1
/FCL.C./	6732	23							
/08.IO./	6755	131							
COMIO=	7106	64	SL-FORTRAN	08/11/76	COMPASS	3	2-41-		COMMON CIO & I/O ROUTINES AND CONSTANTS
CONTRY=	7106	0	SL-FORTRAN	08/11/76	COMPASS	3.	2-41-		FCL INITIALIZATION ROUTINE
FECMSK=	7172	41	SL-FORTRAN	08/11/76	COMPASS	3	2-41-		INITIALIZE CONSTANTS
FLTOUT=	7233	310	SL-FORTRAN	08/11/76	COMPASS	3.	2-41-		COMMON FLOATING OUTPUT CODE
FORSYS=	7543	601	SL-FORTRAN	08/11/76	COMPASS	3	2-41-		FORTRAN OBJECT LIBRARY UTILITIES
INCOM=	10144	277	SL-FORTRAN	08/11/76	COMPASS	3.	2-414		COMMON INPUT FORMATTING CODE
INPC=	10643	160	SL-FORTRAN	08/11/76	COMPASS	3	2-41-		FORMATTED (AND FORTRAN A) INPUT
KODEP=	11023	456	SL-FORTRAN	08/11/76	COMPASS	3.	2-414		OUTPUT FORMAT INTERPRETER
OUTCOM=	11501	154	SL-FORTRAN	08/11/76	COMPASS	3.	2-41-		COMMON OUTPUT CODE
SQRT	11655	43	SL-FORTRAN	08/11/76	COMPASS	3.	2-414		COMPUTE INTEGER SQUARE ROOT OF X (OPT=ALL
SYS=1ST	11720	62	SL-FORTRAN	08/11/76	COMPASS	3	2-41-		MATH LIBRARY LINK TO LOAD MAP AND PROCESSOR
FLTIN=	12002	154	SL-FORTRAN	08/11/76	COMPASS	3.	2-414		COMMON FLOATING INPUT CONVERT
FMTAP=	12156	352	SL-FORTRAN	08/11/76	COMPASS	3.	2-41-		CHECK APLIST AND FORMAT FOR KOSER/KRAKER
FORUTL=	12530	16	SL-FORTRAN	08/11/76	COMPASS	3.	2-41-		FCL MISC. UTILITIES
GETFIT=	12546	42	SL-FORTRAN	08/11/76	COMPASS	3	2-41-		LOCATE AN FIT GIVEN A FILE NAME
KRAKER=	12610	406	SL-FORTRAN	08/11/76	COMPASS	3.	2-41-		PROCESS FORMATTED FORTRAN INPU
OUTC=	13216	172	SL-FORTRAN	08/11/76	COMPASS	3	2-414		FORMATTED WRIT. FORTRAN RECORD
SYSAID=	13410	1	SL-FORTRAN	08/11/76	COMPASS	3.	2-414		LINK BETWEEN SYSAID AND INITIALIZATION CODE
/CON.RM/	13411	6							
CIO.RM	13417	40	SL-SYSIO	05/28/76	COMPASS	3	75125		
/A09.RM/	13457	10							
MOVE.RM	13467	64	SL-SYSIO	05/28/76	COMPASS	3.	75125		
PCT.RM	13553	233	SL-SYSIO	05/28/76	COMPASS	3.	75125		
/JMPS.RM/	14006	11							
/MEMC.RM/	14017	3							
/OPES.FO/	14022	1							
/OPEN.FO/	14023	7							
OPEN.RM	14032	235	SL-SYSIO	05/28/76	COMPASS	3.	75125		
/TERM.RM/	14267	1							
/PUT.FO/	14270	7							
PUT.SQ	14277	1362	SL-SYSIO	05/28/76	COMPASS	3.	75125		
WAR.SQ	15661	260	SL-SYSIO	05/28/76	COMPASS	3.	75125		
/CLSF.FO/	16141	7							
CLSF.RM	16150	23	SL-SYSIO	05/28/76	COMPASS	3.	75125		
/GET.BT/	16173	5							
BTRT.SQ	16200	114	SL-SYSIO	05/28/76	COMPASS	3.	75125		
WEOX.SQ	16314	142	SL-SYSIO	05/28/76	COMPASS	3.	75125		

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/SKFL.FO/	16456	7				
SKFL.SQ	16465	47	SL-SYSIO	05/28/76	COMPASS 3	78125
ERR.RM	16534	404	SL-SYSIO	05/28/76	COMPASS 3	78125
CHWR.SQ	17140	7	SL-SYSIO	05/28/76	COMPASS 3	78125
OSUB.RM	17147	65	SL-SYSIO	05/28/76	COMPASS 3.	78125
OPEN.SQ	17234	262	SL-SYSIO	05/28/76	COMPASS 3	78125
OPEX.SQ	17516	14	SL-SYSIO	05/28/76	COMPASS 3.	78125
/PUT.RT/	17532	11				
RLEQ.RM	17543	42	SL-SYSIO	05/28/76	COMPASS 3.	78125
CLSF.SQ	17605	132	SL-SYSIO	05/28/76	COMPASS 3	78125
/CLSV.FO/	17737	7				
CLSV.SQ	17746	123	SL-SYSIO	05/28/76	COMPASS 3.	78125
/REW.FO/	20071	7				
REW.SQ	20100	31	SL-SYSIO	05/28/76	COMPASS 3.	78125
/GET.FO/	20131	7				
/GET.RT/	20140	11				
GET.SQ	20151	1035	SL-SYSIO	05/28/76	COMPASS 3.	78125
Z.SQ	21206	101	SL-SYSIO	05/28/76	COMPASS 3.	78125
FSU.SQ	21307	106	SL-SYSIO	05/28/76	COMPASS 3	78125
SYS.RM	21415	37	SL-NUCLEUS	03/29/76	COMPASS 3.	78125
//	21454	1170				

PROCESS SYSTEM MODULE

.546 CP SECONDS 341009 CM STORAGE USED [illegible] TABLE MOVES

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ROSEMOUNT CALIBRATION RESULTS S/N 148-03 DATE 02 NOV 76 PAGE 1

ALTITUDE IN THOUSANDS OF FEET

	S	U	R	W	D	K	G	O
SSS	52.19	53.81	53.79	54.53	55.24	55.92	56.56	57.16
SSU	57.74	58.28	58.80	59.28	59.74	60.17	60.58	60.96
SSR	61.31	61.64	61.96	62.25	62.51	62.77	63.00	63.21
SSW	63.41	63.60	63.77	63.92	64.08	64.25	64.40	64.55
SSD	64.69	64.83	64.95	65.07	65.18	65.28	65.38	65.47
SSK	65.55	65.63	65.70	65.76	65.81	65.86	65.91	65.94
SSG	65.98	66.01	66.09	66.16	66.24	66.32	66.39	66.46
SSO	66.54	66.61	66.68	66.75	66.81	66.88	66.94	67.01
SUS	67.07	67.13	67.19	67.25	67.31	67.37	67.43	67.46
SUU	67.53	67.59	67.64	67.69	67.74	67.79	67.84	67.89
SUR	67.93	67.97	68.02	68.06	68.10	68.14	68.18	68.22
SUW	68.26	68.29	68.33	68.36	68.40	68.43	68.46	68.49
SUD	68.52	68.55	68.58	68.61	68.63	68.66	68.68	68.71
SUK	68.73	68.75	68.77	68.79	68.81	68.83	68.84	68.86
SUG	68.88	68.89	68.91	68.92	68.93	68.94	68.95	68.96
SUO	68.97	68.98	68.99	69.00	69.00	69.01	69.01	69.02
SRS	69.02	69.02	69.02	69.02	69.02	69.02	69.02	69.02
SRU	69.02	69.01	69.01	69.01	69.00	68.99	68.99	68.98
SRR	68.97	68.96	68.95	68.95	68.93	68.92	68.91	68.9
SRW	68.89	68.87	68.86	68.84	68.83	68.81	68.80	68.78
SRD	68.76	68.75	68.73	68.71	68.69	68.67	68.65	68.63
SRK	68.61	68.58	68.56	68.54	68.52	68.49	68.47	68.44
SRG	68.42	68.39	68.37	68.34	68.31	68.28	68.26	68.23
SRO	68.20	68.17	68.14	68.11	68.08	68.05	68.02	67.99
SWS	68.01	68.02	68.04	68.05	68.06	68.07	68.08	68.09
SWU	68.10	68.11	68.12	68.13	68.14	68.15	68.16	68.17
SWR	68.18	68.19	68.20	68.21	68.22	68.23	68.24	68.25
SWW	68.26	68.27	68.28	68.29	68.30	68.31	68.32	68.32
SWD	68.33	68.34	68.35	68.36	68.37	68.38	68.39	68.40
SWK	68.41	68.42	68.43	68.44	68.44	68.45	68.46	68.47
SWG	68.48	68.49	68.50	68.51	68.51	68.52	68.53	68.54
SWO	68.55	68.56	68.57	68.57	68.58	68.59	68.60	68.61

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ALTITUDE IN THOUSANDS OF FEET

	S	U	R	W	D	K	G	O
SOS	68.62	68.63	68.63	68.64	68.65	68.65	68.67	68.67
SOU	68.68	68.69	68.70	68.71	68.71	68.72	68.73	68.74
SOR	68.75	68.75	68.76	68.77	68.78	68.78	68.79	68.80
SOW	68.81	68.81	68.82	68.83	68.84	68.84	68.85	68.86
SOD	68.87	68.87	68.88	68.89	68.90	68.90	68.91	68.92
SOK	68.93	68.93	68.94	68.95	68.95	68.96	68.97	68.97
SOG	68.98	68.99	69.00	69.01	69.01	69.02	69.02	69.03
SOO	69.04	69.04	69.05	69.06	69.06	69.07	69.08	69.08
SKS	69.09	69.10	69.10	69.11	69.12	69.12	69.13	69.14
SKU	69.14	69.15	69.15	69.15	69.17	69.17	69.18	69.19
SKR	69.19	69.20	69.21	69.21	69.22	69.22	69.23	69.24
SKW	69.24	69.25	69.25	69.26	69.27	69.27	69.28	69.28
SKD	69.29	69.30	69.30	69.31	69.31	69.32	69.33	69.33
SKK	69.34	69.34	69.35	69.36	69.36	69.37	69.37	69.38
SKG	69.38	69.39	69.40	69.41	69.41	69.41	69.42	69.42
SKO	69.43	69.43	69.44	69.45	69.45	69.46	69.46	69.47
SGS	69.47	69.48	69.48	69.49	69.50	69.50	69.51	69.51
SGU	69.52	69.52	69.53	69.53	69.54	69.54	69.55	69.55
SGR	69.56	69.57	69.57	69.58	69.58	69.59	69.59	69.60
SGW	69.60	69.60	69.61	69.61	69.62	69.62	69.63	69.63
SGD	69.64	69.65	69.65	69.65	69.66	69.66	69.67	69.67
SGK	69.68	69.69	69.69	69.70	69.70	69.71	69.72	69.72
SGG	69.73	69.73	69.74	69.74	69.75	69.75	69.76	69.76
SGO	69.77	69.77	69.78	69.78	69.79	69.79	69.80	69.80
SOS	69.81	69.81	69.82	69.82	69.83	69.83	69.84	69.85
SOU	69.85	69.85	69.86	69.86	69.87	69.87	69.88	69.88
SOR	69.89	69.89	69.90	69.90	69.91	69.91	69.92	69.92
SOW	69.93	69.93	69.94	69.94	69.95	69.95	69.96	69.96
SOD	69.97	69.97	69.98	69.98	69.99	69.99	70.00	70.00
SOK	70.01	70.01	70.02	70.03	70.04	70.04	70.05	70.05
SOG	70.06	70.07	70.08	70.08	70.09	70.10	70.11	70.11
SOO	70.12	70.13	70.13	70.14	70.15	70.15	70.16	70.17

ROSEMOUNT CALIBRATION RESULTS S/N 148-03 DATE 02 NOV 76 PAGE 3

ALTITUDE IN THOUSANDS OF FEET

	S	U	R	W	D	K	G	O
USS	70.18	70.18	70.19	70.20	70.20	70.21	70.22	70.22
USU	70.23	70.24	70.25	70.25	70.26	70.27	70.27	70.28
USR	70.29	70.29	70.30	70.31	70.32	70.32	70.33	70.34
USW	70.34	70.35	70.36	70.36	70.37	70.38	70.39	70.39
USD	70.40	70.41	70.41	70.42	70.43	70.44	70.44	70.45
USK	70.46	70.46	70.47	70.48	70.48	70.49	70.50	70.51
USG	70.51	70.52	70.53	70.53	70.54	70.55	70.56	70.56
USO	70.57	70.58	70.58	70.59	70.60	70.61	70.61	70.62
UUS	70.63	70.63	70.64	70.65	70.66	70.66	70.67	70.68
UUU	70.68	70.69	70.70	70.71	70.71	70.72	70.73	70.73
UUR	70.74	70.75	70.76	70.76	70.77	70.78	70.79	70.79
UUW	70.80	70.81	70.81	70.82	70.83	70.84	70.84	70.85
UUD	70.86	70.86	70.87	70.88	70.89	70.89	70.90	70.91
UUK	70.92	70.92	70.93	70.94	70.94	70.95	70.96	70.97
UUG	70.97	70.98	70.99	71.00	71.00	71.01	71.02	71.02
UUO	71.03	71.04	71.05	71.05	71.06	71.07	71.08	71.08
URS	71.09	71.10	71.10	71.11	71.12	71.13	71.13	71.14
URU	71.15	71.16	71.16	71.17	71.18	71.19	71.19	71.20
URR	71.21	71.21	71.22	71.23	71.24	71.24	71.25	71.26
URW	71.27	71.27	71.28	71.29	71.30	71.30	71.31	71.32
URD	71.33	71.33	71.34	71.35	71.36	71.36	71.37	71.38
URK	71.39	71.39	71.40	71.41	71.42	71.42	71.43	71.44
URG	71.44	71.45	71.46	71.47	71.47	71.48	71.49	71.50
URO	71.50	71.51	71.52	71.53	71.53	71.54	71.55	71.56
UWS	71.56	71.57	71.58	71.59	71.60	71.60	71.61	71.62
UWU	71.63	71.63	71.64	71.65	71.66	71.66	71.67	71.68
UWR	71.69	71.69	71.70	71.71	71.72	71.72	71.73	71.74
UWW	71.75	71.75	71.76	71.77	71.78	71.78	71.79	71.80
UWD	71.81	71.82	71.82	71.83	71.84	71.85	71.85	71.86
UWK	71.87	71.88	71.88	71.89	71.90	71.91	71.91	71.92
UWG	71.93	71.94	71.95	71.95	71.96	71.97	71.98	71.98
UWO	71.99	72.00	72.01	72.02	72.02	72.03	72.04	72.05

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ROSEMOUNT CALIBRATION RESULTS S/N 148-03 DATE 12 NOV 76 PAGE 4

ALTITUDE IN THOUSANDS OF FEET

	S	U	R	W	D	K	G	O
UDS	72.05	72.06	72.07	72.08	72.09	72.09	72.10	72.11
UDU	72.12	72.12	72.13	72.14	72.15	72.16	72.16	72.17
UDR	72.18	72.19	72.20	72.20	72.21	72.22	72.23	72.24
UDW	72.24	72.25	72.26	72.27	72.27	72.28	72.29	72.30
UDD	72.31	72.31	72.32	72.33	72.34	72.35	72.35	72.36
UDK	72.37	72.38	72.39	72.39	72.40	72.41	72.42	72.43
UDG	72.43	72.44	72.45	72.45	72.47	72.47	72.48	72.49
UDO	72.50	72.51	72.51	72.52	72.53	72.54	72.55	72.55
UKS	72.56	72.57	72.58	72.59	72.59	72.60	72.61	72.62
UKU	72.63	72.64	72.64	72.65	72.66	72.67	72.68	72.68
UKR	72.69	72.70	72.71	72.72	72.72	72.73	72.74	72.75
UKW	72.76	72.77	72.77	72.78	72.79	72.80	72.81	72.81
UKD	72.82	72.83	72.84	72.85	72.86	72.86	72.87	72.88
UKK	72.89	72.90	72.90	72.91	72.92	72.93	72.94	72.95
UKG	72.95	72.96	72.97	72.98	72.99	73.00	73.00	73.01
UKO	73.02	73.03	73.04	73.04	73.05	73.06	73.07	73.08
UGS	73.09	73.09	73.10	73.11	73.12	73.13	73.14	73.15
UGU	73.15	73.16	73.17	73.18	73.19	73.19	73.20	73.21
UGR	73.22	73.23	73.24	73.25	73.25	73.26	73.27	73.28
UGW	73.29	73.30	73.30	73.31	73.32	73.33	73.34	73.35
UGD	73.35	73.36	73.37	73.38	73.39	73.40	73.41	73.41
UGK	73.42	73.43	73.44	73.45	73.46	73.46	73.47	73.48
UGG	73.49	73.50	73.51	73.52	73.52	73.53	73.54	73.55
UGO	73.56	73.57	73.58	73.58	73.59	73.60	73.61	73.62
UOS	73.63	73.64	73.64	73.65	73.66	73.67	73.68	73.69
UOU	73.70	73.70	73.71	73.72	73.73	73.74	73.75	73.76
UOR	73.76	73.77	73.78	73.79	73.80	73.81	73.82	73.83
UOW	73.83	73.84	73.85	73.86	73.87	73.88	73.89	73.90
UOD	73.90	73.91	73.92	73.93	73.94	73.95	73.96	73.96
UOK	73.97	73.98	73.99	74.00	74.01	74.02	74.03	74.04
UOG	74.04	74.05	74.06	74.07	74.08	74.09	74.10	74.11
UOO	74.11	74.12	74.13	74.14	74.15	74.16	74.17	74.18

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ROSEMOUNT CALIBRATION RESULTS S/N 148-03 DATE 02 NOV 78 PAGE 5

ALTITUDE IN THOUSANDS OF FEET

	S	U	R	W	D	K	G	O
RSS	74.19	74.19	74.20	74.21	74.22	74.23	74.24	74.25
RSU	74.26	74.27	74.27	74.28	74.29	74.30	74.31	74.32
RSR	74.33	74.34	74.35	74.36	74.36	74.37	74.38	74.39
RSW	74.40	74.41	74.42	74.43	74.44	74.45	74.45	74.46
RSD	74.47	74.48	74.49	74.50	74.51	74.52	74.53	74.54
RSK	74.54	74.55	74.56	74.57	74.58	74.59	74.60	74.61
RSG	74.62	74.63	74.64	74.64	74.65	74.66	74.67	74.68
RSO	74.69	74.70	74.71	74.72	74.73	74.74	74.74	74.75
RUS	74.76	74.77	74.78	74.79	74.80	74.81	74.82	74.83
RUU	74.84	74.85	74.85	74.86	74.87	74.88	74.89	74.90
RUR	74.91	74.92	74.93	74.94	74.95	74.96	74.97	74.97
RUW	74.98	74.99	75.00	75.01	75.02	75.03	75.04	75.05
RUD	75.06	75.07	75.08	75.09	75.09	75.10	75.11	75.12
RUK	75.13	75.14	75.15	75.16	75.17	75.18	75.19	75.20
RUG	75.21	75.22	75.23	75.23	75.24	75.25	75.26	75.27
RUO	75.28	75.29	75.30	75.31	75.32	75.33	75.34	75.35
RRS	75.36	75.37	75.38	75.38	75.39	75.40	75.41	75.42
RRU	75.43	75.44	75.45	75.46	75.47	75.48	75.49	75.5
RRR	75.51	75.52	75.53	75.54	75.55	75.55	75.56	75.57
RRW	75.58	75.59	75.60	75.61	75.62	75.63	75.64	75.65
RRD	75.66	75.67	75.68	75.69	75.70	75.71	75.72	75.73
RRK	75.74	75.75	75.75	75.76	75.77	75.78	75.79	75.8
RRG	75.81	75.82	75.83	75.84	75.85	75.86	75.87	75.88
RRO	75.89	75.90	75.91	75.92	75.93	75.94	75.95	75.96
RWS	75.97	75.98	75.99	76.00	76.00	76.01	76.02	76.03
RWU	76.04	76.05	76.06	76.07	76.08	76.09	76.10	76.11
RWR	76.12	76.13	76.14	76.15	76.16	76.17	76.17	76.18
RWW	76.19	76.20	76.21	76.22	76.23	76.24	76.25	76.26
RWD	76.27	76.28	76.29	76.30	76.31	76.32	76.33	76.34
RWK	76.35	76.36	76.37	76.38	76.39	76.39	76.40	76.41
RWG	76.42	76.43	76.44	76.45	76.46	76.47	76.48	76.49
RWO	76.50	76.51	76.52	76.53	76.54	76.55	76.56	76.57

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ROSEMOUNT CALIBRATION RESULTS S/N 148-03 DATE 02 NOV 76 PAGE 6

ALTITUDE IN THOUSANDS OF FEET

	S	U	R	W	D	K	G	O
ROS	76.58	76.59	76.60	76.61	76.62	76.63	76.64	76.65
ROU	76.66	76.67	76.68	76.69	76.70	76.70	76.71	76.72
ROR	76.73	76.74	76.75	76.76	76.77	76.78	76.79	76.80
ROW	76.81	76.82	76.83	76.84	76.85	76.86	76.87	76.88
ROD	76.89	76.90	76.91	76.92	76.93	76.94	76.95	76.96
ROK	76.97	76.98	76.99	77.00	77.01	77.02	77.03	77.04
ROG	77.05	77.06	77.07	77.08	77.09	77.10	77.11	77.12
ROO	77.13	77.14	77.15	77.16	77.17	77.18	77.19	77.20
RKS	77.21	77.22	77.23	77.24	77.25	77.26	77.27	77.28
RKU	77.29	77.30	77.31	77.32	77.33	77.34	77.36	77.37
RKR	77.38	77.39	77.40	77.41	77.42	77.43	77.44	77.45
RKW	77.46	77.47	77.48	77.49	77.50	77.51	77.52	77.53
RKD	77.54	77.55	77.56	77.57	77.58	77.59	77.60	77.61
RKK	77.62	77.63	77.64	77.66	77.67	77.68	77.69	77.70
RKG	77.71	77.72	77.73	77.74	77.75	77.76	77.77	77.78
RKO	77.79	77.80	77.81	77.82	77.83	77.85	77.86	77.87
RGS	77.88	77.89	77.90	77.91	77.92	77.93	77.94	77.95
RGU	77.96	77.97	77.98	78.00	78.01	78.02	78.03	78.04
RGR	78.05	78.06	78.07	78.08	78.10	78.11	78.12	78.13
RGW	78.14	78.15	78.16	78.17	78.18	78.20	78.21	78.22
RGD	78.23	78.24	78.25	78.26	78.28	78.29	78.30	78.31
RGK	78.32	78.33	78.34	78.35	78.37	78.38	78.39	78.40
RGG	78.41	78.42	78.43	78.45	78.46	78.47	78.48	78.49
RGO	78.50	78.51	78.53	78.54	78.55	78.56	78.57	78.58
ROS	78.59	78.61	78.62	78.63	78.64	78.65	78.66	78.68
ROU	78.69	78.70	78.71	78.72	78.73	78.75	78.76	78.77
ROR	78.78	78.79	78.80	78.82	78.83	78.84	78.85	78.86
ROW	78.87	78.89	78.90	78.91	78.92	78.93	78.94	78.96
ROD	78.97	78.98	78.99	79.00	79.01	79.03	79.04	79.05
ROK	79.06	79.07	79.09	79.10	79.11	79.12	79.13	79.15
ROG	79.16	79.17	79.18	79.19	79.20	79.22	79.23	79.24
ROO	79.25	79.26	79.28	79.29	79.30	79.31	79.32	79.34

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ROSEMOUNT CALIBRATION RESULTS S/N 148-03 DATE 02 NOV 78 PAG ?

ALTITUDE IN THOUSANDS OF FEET

	S	U	P	W	D	K	G	O
WSS	79.35	79.36	79.37	79.38	79.40	79.41	79.42	79.43
WSU	79.44	79.46	79.47	79.48	79.49	79.50	79.52	79.53
WSR	79.54	79.55	79.56	79.58	79.59	79.60	79.61	79.62
WSW	79.64	79.65	79.66	79.67	79.69	79.70	79.71	79.72
WSD	79.73	79.75	79.76	79.77	79.78	79.73	79.81	79.82
WSK	79.83	79.84	79.86	79.87	79.88	79.89	79.90	79.92
WSG	79.93	79.94	79.95	79.97	79.98	79.99	80.00	80.01
WSO	80.03	80.04	80.05	80.06	80.07	80.09	80.10	80.11
WUS	80.12	80.13	80.15	80.16	80.17	80.18	80.19	80.21
WUU	80.22	80.23	80.24	80.25	80.27	80.28	80.29	80.30
WUR	80.31	80.33	80.34	80.35	80.36	80.37	80.39	80.40
WUW	80.41	80.42	80.44	80.45	80.46	80.47	80.48	80.50
WUD	80.51	80.52	80.53	80.54	80.56	80.57	80.58	80.59
WUK	80.61	80.62	80.63	80.64	80.65	80.67	80.68	80.69
WUG	80.70	80.72	80.73	80.74	80.75	80.77	80.78	80.79
WUO	80.80	80.81	80.83	80.84	80.85	80.86	80.88	80.89
WRS	80.90	80.91	80.93	80.94	80.95	80.96	80.98	80.99
WRU	81.00	81.01	81.03	81.04	81.05	81.06	81.08	81.09
WRR	81.10	81.11	81.13	81.14	81.15	81.16	81.18	81.19
WRW	81.20	81.21	81.23	81.24	81.25	81.26	81.28	81.29
WRD	81.30	81.32	81.33	81.34	81.35	81.37	81.38	81.39
WRK	81.40	81.42	81.43	81.44	81.46	81.47	81.48	81.49
WRG	81.51	81.52	81.53	81.55	81.56	81.57	81.58	81.59
WRO	81.61	81.62	81.64	81.65	81.66	81.67	81.69	81.70
WWS	81.71	81.73	81.74	81.75	81.77	81.78	81.79	81.81
WWU	81.82	81.83	81.84	81.86	81.87	81.88	81.90	81.91
WWR	81.92	81.94	81.95	81.96	81.98	81.99	82.00	82.02
WWW	82.03	82.04	82.06	82.07	82.09	82.10	82.11	82.12
WWD	82.14	82.15	82.17	82.18	82.19	82.21	82.22	82.23
WWK	82.25	82.26	82.28	82.29	82.30	82.32	82.33	82.34
WWG	82.36	82.37	82.39	82.40	82.41	82.43	82.44	82.45
WWO	82.47	82.48	82.50	82.51	82.52	82.54	82.55	82.57

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ROSEMOUNT CALIBRATION RESULTS S/N 148-03 DATE 02 NOV 76 PAGE 8

ALTITUDE IN THOUSANDS OF FEET

	S	U	R	W	D	K	G	O
WOS	82.58	82.59	82.61	82.62	82.64	82.65	82.66	82.68
WOU	82.69	82.71	82.72	82.73	82.75	82.76	82.78	82.79
WOR	82.80	82.82	82.83	82.85	82.86	82.87	82.89	82.90
WON	82.92	82.93	82.95	82.96	82.97	82.99	83.00	83.02
WOD	83.03	83.05	83.06	83.07	83.09	83.10	83.12	83.13
WOK	83.15	83.16	83.17	83.19	83.20	83.22	83.23	83.25
WOG	83.26	83.28	83.29	83.30	83.32	83.33	83.35	83.36
WOO	83.38	83.39	83.41	83.42	83.44	83.45	83.46	83.48
WKS	83.49	83.51	83.52	83.54	83.55	83.57	83.58	83.60
WKU	83.61	83.63	83.64	83.65	83.67	83.68	83.70	83.71
WKR	83.73	83.74	83.76	83.77	83.79	83.80	83.82	83.83
WKW	83.85	83.86	83.88	83.89	83.91	83.92	83.94	83.95
WKD	83.96	83.98	83.99	84.01	84.02	84.04	84.05	84.07
WKK	84.08	84.10	84.11	84.13	84.14	84.16	84.17	84.19
WKG	84.20	84.22	84.23	84.25	84.26	84.28	84.29	84.31
WKO	84.32	84.34	84.35	84.37	84.38	84.40	84.41	84.43
WGS	84.44	84.46	84.47	84.49	84.50	84.52	84.53	84.55
WGU	84.56	84.58	84.59	84.61	84.62	84.64	84.65	84.67
WGR	84.68	84.70	84.71	84.73	84.74	84.76	84.77	84.79
WGW	84.81	84.82	84.84	84.85	84.87	84.88	84.90	84.91
WGD	84.93	84.94	84.96	84.97	84.99	85.01	85.02	85.04
WGK	85.05	85.07	85.08	85.10	85.11	85.13	85.14	85.16
WGG	85.18	85.19	85.21	85.22	85.24	85.25	85.27	85.28
WGO	85.30	85.32	85.33	85.35	85.36	85.38	85.39	85.41
WOS	85.42	85.44	85.46	85.47	85.49	85.50	85.52	85.53
WOU	85.55	85.57	85.59	85.60	85.61	85.63	85.64	85.66
WOR	85.68	85.69	85.71	85.72	85.74	85.75	85.77	85.79
WON	85.80	85.82	85.84	85.85	85.87	85.88	85.90	85.92
WOD	85.93	85.95	85.96	85.98	86.00	86.01	86.03	86.04
WOK	86.06	86.08	86.09	86.11	86.13	86.14	86.16	86.17
WOG	86.19	86.21	86.22	86.24	86.25	86.27	86.29	86.30
WOO	86.32	86.34	86.35	86.37	86.38	86.40	86.42	86.43

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ROSEMOUNT CALIBRATION RESULTS S/N 148-03 DATE 02 NOV 76 PAGE 9

ALTITUDE IN THOUSANDS OF FEET

	S	U	R	W	D	K	G	O
DSS	86.45	86.47	86.48	86.50	86.51	86.53	86.55	86.56
DSU	86.58	86.60	86.61	86.63	86.65	86.66	86.68	86.70
DSR	86.71	86.73	86.75	86.76	86.78	86.80	86.81	86.83
DSW	86.85	86.86	86.88	86.90	86.91	86.93	86.95	86.96
DSD	86.98	87.00	87.01	87.03	87.05	87.06	87.08	87.10
DSK	87.11	87.13	87.15	87.17	87.18	87.20	87.22	87.23
DSG	87.25	87.27	87.28	87.30	87.32	87.34	87.35	87.37
DSO	87.39	87.40	87.42	87.44	87.46	87.47	87.49	87.51
DUS	87.53	87.54	87.56	87.58	87.59	87.61	87.63	87.65
DUU	87.66	87.68	87.70	87.72	87.73	87.75	87.77	87.79
DUR	87.80	87.82	87.84	87.86	87.86	87.89	87.91	87.93
DUW	87.95	87.96	87.98	88.00	88.02	88.03	88.05	88.07
DUD	88.09	88.11	88.12	88.14	88.16	88.18	88.20	88.21
DUK	88.23	88.25	88.27	88.29	88.30	88.32	88.34	88.36
DUG	88.38	88.39	88.41	88.43	88.45	88.47	88.48	88.50
DUO	88.52	88.54	88.56	88.58	88.60	88.61	88.63	88.65
DRS	88.67	88.69	88.71	88.73	88.74	88.76	88.78	88.80
DRU	88.82	88.84	88.86	88.87	88.89	88.91	88.93	88.95
DRR	88.97	88.99	89.01	89.03	89.04	89.06	89.08	89.10
DRW	89.12	89.14	89.16	89.18	89.20	89.22	89.24	89.26
DRD	89.27	89.29	89.31	89.33	89.35	89.37	89.39	89.41
DRK	89.43	89.45	89.47	89.49	89.51	89.53	89.55	89.57
DRG	89.59	89.61	89.63	89.65	89.67	89.69	89.71	89.73
DRO	89.75	89.77	89.79	89.81	89.83	89.85	89.87	89.89
DWS	89.91	89.93	89.95	89.97	89.99	90.01	90.03	90.05
DWU	90.07	90.09	90.11	90.13	90.15	90.18	90.20	90.22
DWR	90.24	90.26	90.28	90.30	90.32	90.34	90.37	90.39
DWW	90.41	90.43	90.45	90.47	90.49	90.52	90.54	90.56
DWD	90.58	90.60	90.62	90.65	90.67	90.69	90.71	90.73
DWK	90.75	90.78	90.80	90.82	90.84	90.86	90.89	90.91
DWG	90.93	90.95	90.97	90.99	91.02	91.04	91.06	91.08
DWO	91.10	91.13	91.15	91.17	91.19	91.21	91.24	91.26

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ROSEMOUNT CALIBRATION RESULTS S/N 148-03 DATE 02 NOV 76 PAGE 1

ALTITUDE IN THOUSANDS OF FEET

	S	U	R	W	P	K	G	D
DDS	91.28	91.30	91.32	91.35	91.37	91.39	91.41	91.43
DDU	91.46	91.48	91.50	91.52	91.55	91.57	91.59	91.61
DDR	91.63	91.66	91.68	91.70	91.72	91.74	91.77	91.79
DDW	91.81	91.83	91.86	91.88	91.90	91.92	91.95	91.97
DDD	91.99	92.01	92.03	92.05	92.08	92.10	92.12	92.14
DDK	92.16	92.18	92.20	92.23	92.25	92.27	92.29	92.31
DDG	92.33	92.35	92.38	92.40	92.42	92.44	92.46	92.48
DDO	92.50	92.53	92.55	92.57	92.59	92.61	92.63	92.66
DKS	92.68	92.70	92.72	92.74	92.76	92.79	92.81	92.83
DKU	92.85	92.87	92.89	92.92	92.94	92.96	92.98	93.00
DKR	93.03	93.05	93.07	93.09	93.11	93.14	93.16	93.18
DKW	93.20	93.22	93.25	93.27	93.29	93.31	93.34	93.36
DKD	93.38	93.40	93.42	93.45	93.47	93.49	93.51	93.53
DKK	93.56	93.58	93.61	93.63	93.65	93.67	93.70	93.72
DKG	93.74	93.76	93.79	93.81	93.83	93.86	93.88	93.90
DKO	93.93	93.95	93.97	94.00	94.02	94.04	94.07	94.09
DGS	94.11	94.14	94.16	94.19	94.21	94.24	94.26	94.28
DGU	94.31	94.33	94.36	94.38	94.41	94.43	94.45	94.48
DGR	94.50	94.53	94.55	94.58	94.60	94.63	94.65	94.68
DGW	94.70	94.73	94.75	94.78	94.80	94.83	94.85	94.88
DGD	94.90	94.93	94.95	94.98	95.00	95.03	95.05	95.08
DGK	95.10	95.13	95.16	95.18	95.21	95.23	95.26	95.28
DGG	95.31	95.34	95.36	95.39	95.41	95.44	95.46	95.49
DGO	95.52	95.54	95.57	95.60	95.62	95.65	95.67	95.70
DOS	95.73	95.75	95.78	95.81	95.83	95.86	95.89	95.91
DOU	95.94	95.97	95.99	96.02	96.05	96.07	96.10	96.13
DOR	96.16	96.18	96.21	96.24	96.27	96.29	96.32	96.35
DOW	96.38	96.40	96.43	96.46	96.49	96.51	96.54	96.57
DOD	96.60	96.62	96.65	96.68	96.71	96.74	96.76	96.79
DOK	96.82	96.85	96.88	96.90	96.93	96.96	96.99	97.02
DOG	97.05	97.07	97.10	97.13	97.16	97.19	97.22	97.24
DOO	97.27	97.30	97.33	97.36	97.39	97.41	97.44	97.47

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ROSEMOUNT CALIBRATION RESULTS S/N 148-03 DATE 02 NOV 76 PAGE 1

ALTITUDE IN THOUSANDS OF FEET

	S	U	R	W	C	K	G	O
KSS	97.50	97.53	97.56	97.59	97.62	97.64	97.67	97.70
KSU	97.73	97.76	97.79	97.82	97.85	97.87	97.90	97.93
KSR	97.96	97.99	98.02	98.05	98.08	98.11	98.14	98.16
KSW	98.19	98.22	98.25	98.28	98.31	98.34	98.37	98.40
KSD	98.43	98.46	98.49	98.51	98.54	98.57	98.60	98.63
KSK	98.66	98.69	98.72	98.75	98.78	98.81	98.84	98.87
KSG	98.90	98.93	98.95	98.98	99.01	99.04	99.07	99.10
KSO	99.13	99.16	99.19	99.22	99.25	99.28	99.31	99.34
KUS	99.37	99.40	99.43	99.45	99.48	99.51	99.54	99.57
KUU	99.60	99.63	99.66	99.69	99.72	99.75	99.78	99.81
KUR	99.84	99.87	99.90	99.93	99.96	99.99	100.01	100.04
KUW	100.07	100.10	100.13	100.16	100.19	100.22	100.25	100.28
KUD	100.31	100.34	100.37	100.40	100.43	100.46	100.49	100.51
KUK	100.54	100.57	100.60	100.63	100.66	100.69	100.72	100.75
KUG	100.78	100.81	100.84	100.87	100.90	100.92	100.95	100.98
KUO	101.01	101.04	101.07	101.10	101.13	101.16	101.19	101.22
KRS	101.25	101.27	101.30	101.33	101.36	101.39	101.42	101.45
KRU	101.48	101.51	101.54	101.56	101.59	101.62	101.65	101.68
KRR	101.71	101.74	101.77	101.79	101.82	101.85	101.88	101.91
KRW	101.94	101.97	102.00	102.02	102.05	102.08	102.11	102.14
KRD	102.17	102.19	102.22	102.25	102.28	102.31	102.34	102.36
KRK	102.39	102.42	102.45	102.48	102.51	102.53	102.56	102.59
KRG	102.62	102.65	102.67	102.70	102.73	102.76	102.79	102.81
KRO	102.84	102.87	102.90	102.92	102.95	102.98	103.01	103.03
KWS	103.06	103.09	103.12	103.14	103.17	103.20	103.23	103.25
KWU	103.28	103.31	103.34	103.36	103.39	103.42	103.44	103.47
KWR	103.50	103.52	103.55	103.58	103.60	103.63	103.66	103.68
KWW	103.71	103.74	103.76	103.79	103.82	103.84	103.87	103.9
KWD	103.92	103.95	103.98	104.00	104.03	104.05	104.08	104.11
KWK	104.13	104.16	104.18	104.21	104.24	104.26	104.29	104.31
KWG	104.34	104.36	104.39	104.41	104.44	104.46	104.49	104.52
KWO	104.54	104.57	104.59	104.62	104.64	104.67	104.69	104.72

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W	P	COUNTS	M*	M-M*
60.000	150.000	12.6	60.000	.000
62.000	110.200	16.1	62.000	-.000
64.000	72.668	27.5	64.000	.000
66.000	48.898	48.9	66.000	.000
68.000	10.498	190.7	68.000	.000
70.000	4.178	486.9	70.000	.000
72.000	2.628	761.0	72.000	.000
74.000	1.994	1003.9	74.000	.000
76.000	1.648	1219.5	76.000	.000
78.000	1.409	1419.4	78.000	.000
80.000	1.258	1549.8	80.000	.000
82.000	1.143	1749.8	82.000	.000
84.000	1.058	1893.4	84.000	.000
86.000	.990	2020.2	86.000	.000
88.000	.935	2139.8	88.000	.000
90.000	.891	2244.7	90.000	.000
92.000	.856	2336.4	92.000	.000
94.000	.824	2427.2	94.000	.000
96.000	.798	2506.3	96.000	.000
98.000	.776	2577.3	98.000	.000
100.000	.756	2645.5	100.000	.000

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ROSEMOUNT CALIBRATION RESULTS S/N 149-03 DATE 02 NOV '6 PAGE 1

ALTITUDE IN THOUSANDS OF FEET

	S	U	R	W	D	K	G	O
SSS	49.63	50.70	50.95	51.57	52.18	52.77	53.34	[illegible]
SSU	54.42	54.94	55.44	55.92	56.38	56.83	57.26	[illegible]
SSR	58.08	58.47	58.84	59.20	59.55	59.88	60.20	[illegible]
SSW	60.80	61.08	61.35	61.61	61.85	62.09	62.32	[illegible]
SSD	62.74	62.94	63.13	63.31	63.48	63.65	63.81	[illegible]
SSK	64.11	64.25	64.39	64.53	64.66	64.78	64.91	[illegible]
SSG	65.13	65.23	65.33	65.43	65.52	65.60	65.69	[illegible]
SSO	65.84	65.91	65.97	66.05	66.13	66.21	66.29	[illegible]
SUS	66.45	66.52	66.59	66.66	66.73	66.80	66.86	[illegible]
SUU	66.99	67.05	67.11	67.16	67.22	67.27	67.32	[illegible]
SUR	67.42	67.47	67.51	67.56	67.60	67.64	67.68	[illegible]
SUW	67.75	67.78	67.82	67.85	67.88	67.90	67.93	[illegible]
SUD	67.98	68.00	68.02	68.04	68.06	68.08	68.10	[illegible]
SUK	68.12	68.13	68.14	68.15	68.15	68.16	68.17	[illegible]
SUG	68.17	68.17	68.17	68.17	68.17	68.16	68.16	[illegible]
SUO	68.15	68.14	68.13	68.12	68.11	68.09	68.08	[illegible]
SRS	68.05	68.03	68.02	68.00	68.07	68.05	68.07	[illegible]
SRU	68.11	68.13	68.15	68.17	68.19	68.21	68.23	[illegible]
SRR	68.27	68.29	68.31	68.33	68.35	68.37	68.39	[illegible]
SRW	68.42	68.44	68.46	68.48	68.50	68.51	68.53	[illegible]
SRD	68.57	68.58	68.60	68.62	68.63	68.65	68.67	[illegible]
SRK	68.70	68.72	68.73	68.75	68.76	68.78	68.79	[illegible]
SRG	68.82	68.84	68.85	68.87	68.88	68.90	68.91	[illegible]
SRO	68.94	68.96	68.97	68.98	69.00	69.01	69.02	[illegible]
SWS	69.05	69.06	69.08	69.09	69.10	69.11	69.13	[illegible]
SWU	69.15	69.16	69.18	69.19	69.20	69.21	69.22	[illegible]
SWR	69.25	69.26	69.27	69.28	69.29	69.31	69.31	[illegible]
SWW	69.33	69.34	69.35	69.36	69.37	69.38	69.39	[illegible]
SWD	69.41	69.42	69.43	69.44	69.45	69.46	69.47	[illegible]
SWK	69.49	69.49	69.50	69.51	69.52	69.53	69.54	[illegible]
SWG	69.55	69.56	69.57	69.58	69.58	69.59	69.60	[illegible]
SWO	69.61	69.62	69.63	69.63	69.64	69.65	69.65	[illegible]

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ROSEMOUNT CALIBRATION RESULTS S/N 149-C3 DATE 02 NOV 76 PAGE 2

ALTITUDE IN THOUSANDS OF FEET

	S	U	R	W	D	K	G	O
SOS	69.67	69.67	69.68	69.69	69.69	69.71	69.71	69.71
SOU	69.72	69.72	69.73	69.73	69.74	69.75	69.75	69.76
SOR	69.76	69.77	69.77	69.78	69.78	69.79	69.79	69.80
SOW	69.80	69.81	69.81	69.81	69.82	69.82	69.83	69.83
SOD	69.84	69.84	69.84	69.85	69.85	69.86	69.86	69.86
SOK	69.87	69.87	69.87	69.88	69.88	69.88	69.89	69.89
SOG	69.89	69.90	69.90	69.90	69.91	69.91	69.91	69.91
SOO	69.92	69.92	69.92	69.92	69.93	69.93	69.93	69.93
SKS	69.94	69.94	69.94	69.94	69.94	69.95	69.95	69.95
SKU	69.95	69.95	69.96	69.96	69.96	69.96	69.96	69.96
SKR	69.96	69.97	69.97	69.97	69.97	69.97	69.97	69.97
SKW	69.98	69.98	69.98	69.98	69.98	69.98	69.98	69.98
SKD	69.98	69.98	69.99	69.99	69.99	69.99	69.99	69.99
SKK	69.99	69.99	69.99	69.99	69.99	69.99	69.99	69.99
SKG	69.99	69.99	70.00	70.00	70.00	70.00	70.00	70.00
SKO	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00
SGS	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00
SGU	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00
SGR	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00
SGW	70.00	70.00	70.01	70.01	70.02	70.03	70.03	70.04
SGD	70.05	70.05	70.06	70.07	70.08	70.08	70.09	70.10
SGK	70.10	70.11	70.12	70.12	70.13	70.14	70.15	70.15
SGG	70.16	70.17	70.17	70.18	70.19	70.19	70.20	70.21
SGO	70.22	70.22	70.23	70.24	70.24	70.25	70.26	70.26
SCS	70.27	70.28	70.29	70.29	70.30	70.31	70.31	70.32
SCU	70.33	70.33	70.34	70.35	70.35	70.36	70.37	70.38
SCR	70.38	70.39	70.40	70.40	70.41	70.42	70.42	70.43
SCW	70.44	70.45	70.45	70.46	70.47	70.47	70.48	70.49
SCD	70.49	70.50	70.51	70.52	70.52	70.53	70.54	70.54
SCK	70.55	70.56	70.57	70.57	70.58	70.59	70.59	70.60
SCG	70.61	70.61	70.62	70.63	70.64	70.64	70.65	70.66
SCO	70.66	70.67	70.68	70.68	70.69	70.70	70.71	70.71

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ROSEMOUNT CALIBRATION RESULTS S/N 149-03 DATE 02 NOV 76 PAGE 3

ALTITUDE IN THOUSANDS OF FEET

	S	U	R	W	D	K	G	O
USS	70.72	70.73	70.73	70.74	70.75	70.75	70.76	70.77
USU	70.78	70.78	70.79	70.80	70.80	70.81	70.82	70.83
USR	70.83	70.84	70.85	70.85	70.86	70.87	70.88	70.88
USW	70.89	70.90	70.90	70.91	70.92	70.92	70.93	70.94
USD	70.95	70.95	70.96	70.97	70.97	70.98	70.99	71.00
USK	71.00	71.01	71.02	71.02	71.03	71.04	71.05	71.06
USG	71.06	71.07	71.07	71.08	71.09	71.10	71.10	71.11
USO	71.12	71.12	71.13	71.14	71.15	71.15	71.16	71.17
UUS	71.17	71.18	71.19	71.20	71.20	71.21	71.22	71.22
UUU	71.23	71.24	71.25	71.25	71.26	71.27	71.27	71.28
UUR	71.29	71.30	71.30	71.31	71.32	71.33	71.33	71.34
UUW	71.35	71.35	71.36	71.37	71.38	71.38	71.39	71.40
UUD	71.40	71.41	71.42	71.43	71.43	71.44	71.45	71.46
UUK	71.46	71.47	71.48	71.48	71.49	71.50	71.51	71.51
UUG	71.52	71.53	71.54	71.54	71.55	71.56	71.56	71.57
UUO	71.58	71.59	71.59	71.60	71.61	71.62	71.62	71.63
URS	71.64	71.65	71.65	71.66	71.67	71.67	71.68	71.68
URU	71.70	71.70	71.71	71.72	71.73	71.73	71.74	71.75
URR	71.76	71.76	71.77	71.78	71.79	71.79	71.80	71.81
URW	71.82	71.82	71.83	71.84	71.85	71.85	71.86	71.87
URD	71.87	71.88	71.89	71.90	71.90	71.91	71.92	71.93
URK	71.93	71.94	71.95	71.96	71.96	71.97	71.98	71.99
URG	71.99	72.00	72.01	72.02	72.03	72.03	72.04	72.05
URO	72.06	72.06	72.07	72.08	72.09	72.10	72.10	72.11
UWS	72.12	72.13	72.13	72.14	72.15	72.16	72.17	72.17
UWU	72.18	72.19	72.20	72.21	72.21	72.22	72.23	72.24
UWR	72.24	72.25	72.26	72.27	72.28	72.28	72.29	72.30
UWW	72.31	72.32	72.32	72.33	72.34	72.35	72.36	72.36
UWD	72.37	72.38	72.39	72.39	72.40	72.41	72.42	72.43
UWK	72.43	72.44	72.45	72.46	72.47	72.47	72.48	72.49
UWG	72.50	72.51	72.51	72.52	72.53	72.54	72.55	72.55
UWO	72.56	72.57	72.58	72.59	72.59	72.60	72.61	72.62

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ROSEMOUNT CALIBRATION RESULTS S/N 149-93 DATE 02 NOV 76 PAGE 4

ALTITUDE IN THOUSANDS OF FEET

	S	U	R	W	D	K	G	O
UOS	72.63	72.63	72.64	72.65	72.66	72.67	72.67	72.68
UOU	72.69	72.70	72.71	72.72	72.72	72.73	72.74	72.75
UOR	72.76	72.76	72.77	72.78	72.79	72.80	72.80	72.81
UOW	72.82	72.83	72.84	72.84	72.85	72.86	72.87	72.88
UOD	72.89	72.89	72.90	72.91	72.92	72.93	72.93	72.94
UOK	72.95	72.96	72.97	72.98	72.98	72.99	73.00	73.01
UOG	73.02	73.02	73.03	73.04	73.05	73.06	73.07	73.07
UOO	73.08	73.09	73.10	73.11	73.11	73.12	73.13	73.14
UKS	73.15	73.16	73.16	73.17	73.18	73.19	73.20	73.21
UKU	73.21	73.22	73.23	73.24	73.25	73.26	73.26	73.27
UKR	73.28	73.29	73.30	73.30	73 31	73 32	73.33	73.34
UKW	73.35	73.35	73.36	73.37	73.38	73 39	73.40	73.40
UKD	73.41	73.42	73.43	73.44	73.45	73.45	73.46	73.47
UKK	73.48	73.49	73.50	73.50	73.51	73.52	73.53	73.54
UKG	73.55	73.55	73.56	73.57	73.58	73 59	73.60	73.61
UKO	73.61	73.62	73.63	73.64	73.65	73.66	73.66	73.67
UGS	73.68	73.69	73.70	73.71	73.71	73.72	73.73	73.74
UGU	73.75	73.76	73.77	73.77	73.78	73.79	73.80	73.81
UGR	73.82	73.82	73.83	73.84	73 85	73 86	73.87	73.88
UGW	73.88	73.89	73.90	73.91	73.92	73 93	73.93	73.94
UGD	73.95	73.96	73.97	73.98	73 99	73.99	74.00	74.01
UGK	74.02	74.03	74.04	74.04	74.05	74.06	74.07	74.08
UGG	74.09	74.09	74.10	74.11	74 12	74 13	74.14	74.15
UGO	74.15	74.16	74.17	74.18	74.19	74.19	74.20	74.21
UOS	74.22	74.23	74.24	74.24	74.25	74.26	74.27	74.28
UOU	74.29	74.30	74.30	74.31	74.32	74.33	74.34	74.35
UOR	74.35	74.36	74.37	74.38	74.39	74.40	74.40	74.41
UOW	74.42	74.43	74.44	74.45	74.46	74 46	74.47	74.48
UOD	74.49	74.50	74.51	74.51	74.52	74.53	74.54	74.55
UOK	74.56	74.57	74.57	74.58	74.59	74.60	74.61	74.62
UOG	74.63	74.63	74.64	74.65	74 66	74 67	74.68	74.69
UOO	74.69	74.70	74.71	74.72	74.73	74.74	74.75	74.75

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ROSEMOUNT CALIBRATION RESULTS S/N 149-03 DATE 02 NOV 76 PAGE 1

ALTITUDE IN THOUSANDS OF FEET

	S	U	R	W	D	K	G	O
RSS	74.76	74.77	74.78	74.79	74.80	74.81	74.81	74.82
RSU	74.83	74.84	74.85	74.86	74.87	74.87	74.88	74.89
RSR	74.90	74.91	74.92	74.93	74.94	74.94	74.95	74.96
RSW	74.97	74.98	74.99	75.00	75.01	75.01	75.02	75.03
RSD	75.04	75.05	75.06	75.07	75.07	75.08	75.09	75.10
RSK	75.11	75.12	75.13	75.14	75.15	75.15	75.16	75.17
RSG	75.18	75.19	75.20	75.21	75.22	75.22	75.23	75.24
RSO	75.25	75.26	75.27	75.28	75.29	75.30	75.31	75.31
RUS	75.32	75.33	75.34	75.35	75.36	75.37	75.37	75.38
RUU	75.39	75.40	75.41	75.42	75.43	75.44	75.45	75.46
RUR	75.46	75.47	75.48	75.49	75.50	75.51	75.52	75.53
RUW	75.54	75.55	75.55	75.56	75.57	75.58	75.59	75.60
RUD	75.61	75.62	75.63	75.64	75.64	75.65	75.66	75.67
RUK	75.68	75.69	75.70	75.71	75.72	75.73	75.74	75.74
RUG	75.75	75.76	75.77	75.78	75.79	75.80	75.81	75.82
RUO	75.83	75.84	75.85	75.85	75.86	75.87	75.88	75.89
RRS	75.90	75.91	75.92	75.93	75.94	75.95	75.96	75.97
RRU	75.97	75.98	75.99	76.00	76.01	76.02	76.03	76.04
RRR	76.05	76.06	76.07	76.08	76.09	76.10	76.11	76.11
RRW	76.12	76.13	76.14	76.15	76.16	76.17	76.18	76.19
RRD	76.20	76.21	76.22	76.23	76.24	76.25	76.26	76.27
RRK	76.27	76.28	76.29	76.30	76.31	76.32	76.33	76.34
RRG	76.35	76.36	76.37	76.38	76.39	76.40	76.41	76.42
RRO	76.43	76.44	76.45	76.46	76.47	76.48	76.49	76.49
RWS	76.50	76.51	76.52	76.53	76.54	76.55	76.56	76.57
RWU	76.58	76.59	76.60	76.61	76.62	76.63	76.64	76.65
RWR	76.66	76.67	76.68	76.69	76.70	76.71	76.72	76.73
RWW	76.74	76.75	76.76	76.77	76.78	76.79	76.80	76.81
RWD	76.82	76.83	76.84	76.85	76.86	76.87	76.88	76.89
RWK	76.90	76.91	76.92	76.93	76.94	76.95	76.96	76.97
RWG	76.98	76.99	76.99	77.00	77.01	77.02	77.03	77.04
RWO	77.05	77.07	77.08	77.09	77.10	77.11	77.12	77.13

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ROSEMOUNT CALIBRATION RESULTS S/N 149-83 DATE 02 NOV 76 PAGE 5

ALTITUDE IN THOUSANDS OF FEET

	S	U	O	W	D	K	G	O
ROS	77.14	77.15	77.16	77.17	77.18	77.19	77.2[illegible]	77.21
ROU	77.22	77.23	77.24	77.25	77.26	77.27	77.28	77.29
ROR	77.30	77.31	77.32	77.33	77.34	77.35	77.36	77.3[illegible]
ROW	77.38	77.39	77.40	77.41	77.42	77.43	77.44	77.45
ROD	77.46	77.47	77.48	77.49	77.50	77.51	77.52	77.5[illegible]
ROK	77.54	77.55	77.56	77.58	77.59	77.60	77.61	77.62
ROG	77.63	77.64	77.65	77.66	77.67	77.68	77.69	77.7[illegible]
ROO	77.71	77.72	77.73	77.74	77.75	77.76	77.77	77.78
RKS	77.79	77.81	77.82	77.83	77.84	77.85	77.86	77.87
RKU	77.88	77.89	77.90	77.91	77.92	77.93	77.94	77.9[illegible]
RKR	77.96	77.98	77.99	78.00	78.01	78.02	78.03	78.0[illegible]
RKW	78.05	78.06	78.07	78.08	78.09	78.11	78.12	78.13
RKD	78.14	78.15	78.16	78.17	78.18	78.19	78.21	78.22
RKK	78.23	78.24	78.25	78.26	78.27	78.28	78.29	78.3[illegible]
RKG	78.31	78.33	78.34	78.35	78.36	78.37	78.38	78.39
RKO	78.40	78.41	78.43	78.44	78.45	78.46	78.47	78.48
RGS	78.49	78.50	78.51	78.53	78.54	78.55	78.56	78.57
RGU	78.58	78.59	78.60	78.62	78.63	78.64	78.65	78.66
RGR	78.67	78.68	78.69	78.71	78.72	78.73	78.74	78.75
RGW	78.76	78.77	78.79	78.80	78.81	78.82	78.83	78.84
RGD	78.85	78.86	78.88	78.89	78.90	78.91	78.92	78.93
RGK	78.94	78.96	78.97	78.98	78.99	79.00	79.01	79.02
RGG	79.04	79.05	79.06	79.07	79.08	79.09	79.11	79.12
RGO	79.13	79.14	79.15	79.16	79.17	79.19	79.20	79.21
ROS	79.22	79.23	79.24	79.26	79.27	79.28	79.29	79.3[illegible]
ROU	79.31	79.32	79.34	79.35	79.36	79.37	79.38	79.39
ROR	79.41	79.42	79.43	79.44	79.45	79.46	79.48	79.49
ROW	79.50	79.51	79.52	79.53	79.55	79.56	79.57	79.58
ROD	79.59	79.61	79.62	79.63	79.64	79.65	79.66	79.68
ROK	79.69	79.70	79.71	79.72	79.73	79.74	79.75	79.77
ROG	79.78	79.79	79.81	79.82	79.83	79.84	79.85	79.86
ROO	79.88	79.89	79.90	79.91	79.92	79.94	79.95	79.96

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ROSEMOUNT CALIBRATION RESULTS S/N 149-03 DATE 02 NOV 76 PAGE 7

ALTITUDE IN THOUSANDS OF FEET

	S	U	R	W	O	K	G	O
WSS	79.97	79.98	79.99	80.01	80.02	80.03	80.04	80.05
WSU	80.06	80.08	80.09	80.10	80.11	80.12	80.13	80.15
WSR	80.16	80.17	80.18	80.19	80.20	80.22	80.23	80.24
WSW	80.25	80.26	80.28	80.29	80.30	80.31	80.32	80.33
WSO	80.35	80.36	80.37	80.38	80.39	80.40	80.42	80.43
WSK	80.44	80.45	80.46	80.48	80.49	80.50	80.51	80.52
WSG	80.53	80.55	80.56	80.57	80.58	80.59	80.61	80.62
WSO	80.63	80.64	80.65	80.67	80.68	80.69	80.70	80.71
WUS	80.73	80.74	80.75	80.76	80.77	80.78	80.80	80.81
WUU	80.82	80.83	80.84	80.86	80.87	80.88	80.89	80.91
WUR	80.92	80.93	80.94	80.95	80.97	80.98	80.99	81.00
WUW	81.01	81.03	81.04	81.05	81.06	81.07	81.09	81.10
WUO	81.11	81.12	81.14	81.15	81.16	81.17	81.18	81.20
WUK	81.21	81.22	81.23	81.24	81.26	81.27	81.28	81.29
WUG	81.31	81.32	81.33	81.34	81.36	81.37	81.38	81.39
WUO	81.40	81.42	81.43	81.44	81.45	81.47	81.48	81.49
WRS	81.50	81.52	81.53	81.54	81.55	81.57	81.58	81.59
WRU	81.60	81.62	81.63	81.64	81.65	81.67	81.68	81.69
WRR	81.70	81.72	81.73	81.74	81.75	81.77	81.78	81.79
WRW	81.80	81.82	81.83	81.84	81.85	81.87	81.88	81.89
WRO	81.90	81.92	81.93	81.94	81.95	81.97	81.98	81.99
WRK	82.01	82.02	82.03	82.04	82.06	82.07	82.08	82.09
WRG	82.11	82.12	82.13	82.15	82.16	82.17	82.18	82.20
WRO	82.21	82.22	82.24	82.25	82.26	82.28	82.29	82.3
WWS	82.31	82.33	82.34	82.35	82.37	82.38	82.39	82.41
WWU	82.42	82.43	82.44	82.46	82.47	82.48	82.50	82.51
WWR	82.52	82.54	82.55	82.56	82.58	82.59	82.60	82.62
WWW	82.63	82.64	82.66	82.67	82.68	82.69	82.71	82.72
WWO	82.73	82.75	82.76	82.77	82.79	82.80	82.81	82.82
WWK	82.84	82.85	82.87	82.88	82.89	82.91	82.92	82.94
WWG	82.95	82.96	82.98	82.99	83.00	83.02	83.03	83.04
WWO	83.06	83.07	83.08	83.10	83.11	83.12	83.14	83.15

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ROSEMOUNT CALIBRATION RESULTS S/N 149-03 DATE 02 NOV 76 PAGE 8

ALTITUDE IN THOUSANDS OF FEET

	S	U	R	W	D	K	G	O
WDS	83.17	83.18	83.19	83.21	83.22	83.23	83.25	83.26
WDU	83.27	83.29	83.30	83.32	83.33	83.34	83.36	83.37
WDR	83.38	83.40	83.41	83.43	83.44	83.45	83.47	83.48
WDW	83.50	83.51	83.52	83.54	83.55	83.56	83.58	83.59
WDD	83.61	83.62	83.63	83.65	83.66	83.68	83.69	83.70
WDK	83.72	83.73	83.75	83.76	83.77	83.79	83.80	83.82
WDG	83.83	83.85	83.86	83.87	83.89	83.90	83.92	83.93
WDO	83.95	83.96	83.97	83.99	84.00	84.02	84.03	84.05
WKS	84.06	84.07	84.09	84.10	84.12	84.13	84.15	84.16
WKU	84.18	84.19	84.21	84.22	84.23	84.25	84.26	84.28
WKR	84.29	84.31	84.32	84.34	84.35	84.37	84.38	84.40
WKW	84.41	84.43	84.44	84.45	84.47	84.48	84.50	84.51
WKD	84.53	84.54	84.56	84.57	84.59	84.60	84.62	84.63
WKK	84.65	84.66	84.68	84.69	84.71	84.72	84.74	84.75
WKG	84.77	84.78	84.80	84.81	84.83	84.84	84.86	84.87
WKO	84.89	84.90	84.92	84.93	84.95	84.96	84.98	84.99
WGS	85.01	85.02	85.04	85.05	85.07	85.08	85.10	85.11
WGU	85.13	85.15	85.16	85.18	85.19	85.21	85.22	85.24
WGR	85.25	85.27	85.28	85.30	85.31	85.33	85.34	85.36
WGW	85.38	85.39	85.41	85.42	85.44	85.45	85.47	85.48
WGD	85.50	85.51	85.53	85.55	85.56	85.58	85.59	85.61
WGK	85.62	85.64	85.65	85.67	85.68	85.70	85.72	85.73
WGG	85.75	85.76	85.78	85.79	85.81	85.83	85.84	85.86
WGO	85.87	85.89	85.90	85.92	85.94	85.95	85.97	85.98
WOS	86.00	86.01	86.03	86.04	86.06	86.08	86.09	86.11
WOU	86.12	86.14	86.15	86.17	86.19	86.20	86.21	86.23
WOR	86.25	86.26	86.28	86.29	86.31	86.32	86.34	86.35
WOW	86.37	86.39	86.40	86.42	86.43	86.45	86.46	86.48
WOD	86.50	86.51	86.53	86.54	86.56	86.57	86.59	86.60
WOK	86.62	86.64	86.65	86.67	86.69	86.70	86.72	86.73
WOG	86.75	86.77	86.78	86.80	86.81	86.83	86.85	86.86
WOO	86.88	86.89	86.91	86.93	86.94	86.96	86.97	86.99

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ROSEMOUNT CALIBRATION RESULTS S/N 149-03 DATE 02 NOV 76 PAGE 9

ALTITUDE IN THOUSANDS OF FEET

	S	U	R	W	P	K	G	O
DSS	87.01	87.02	87.04	87.06	87.07	87.09	87.10	87.12
DSU	87.14	87.15	87.17	87.19	87.20	87.22	87.23	87.25
DSR	87.27	87.28	87.30	87.32	87.33	87.35	87.37	87.38
DSW	87.40	87.42	87.43	87.45	87.47	87.48	87.5	87.52
DSD	87.53	87.55	87.57	87.58	87.60	87.62	87.63	87.65
DSK	87.67	87.68	87.70	87.72	87.74	87.75	87.77	87.79
DSG	87.80	87.82	87.84	87.85	87.87	87.89	87.91	87.92
DSO	87.94	87.96	87.97	87.99	88.01	88.03	88.04	88.06
DUS	88.08	88.10	88.11	88.13	88.15	88.17	88.18	88.20
DUU	88.22	88.24	88.26	88.27	88.29	88.31	88.33	88.34
DUR	88.36	88.38	88.40	88.42	88.43	88.45	88.47	88.48
DUW	88.51	88.52	88.54	88.56	88.58	88.60	88.61	88.63
DUD	88.65	88.67	88.69	88.71	88.72	88.74	88.76	88.78
DUK	88.80	88.82	88.83	88.85	88.87	88.89	88.91	88.93
DUG	88.95	88.96	88.98	89.00	89.02	89.04	89.06	89.07
DUO	89.09	89.11	89.13	89.15	89.17	89.19	89.21	89.23
DRS	89.25	89.26	89.28	89.30	89.32	89.34	89.36	89.38
DRU	89.40	89.42	89.44	89.46	89.47	89.49	89.51	89.53
DRR	89.55	89.57	89.59	89.61	89.63	89.65	89.67	89.69
DRW	89.71	89.73	89.75	89.77	89.79	89.81	89.83	89.84
DRD	89.86	89.88	89.90	89.92	89.94	89.96	89.98	90.00
DRK	90.02	90.04	90.06	90.08	90.10	90.13	90.15	90.17
DRG	90.19	90.21	90.23	90.25	90.27	90.29	90.31	90.33
DRO	91.35	90.37	90.39	90.41	90.43	90.45	90.48	90.50
DWS	90.52	90.54	90.56	90.58	90.60	90.62	90.64	90.66
DWU	90.68	90.70	90.72	90.75	90.77	90.79	90.81	90.83
DWR	90.85	90.87	90.89	90.92	90.94	90.96	90.98	91.00
DWW	91.02	91.04	91.06	91.09	91.11	91.13	91.15	91.17
DWD	91.19	91.21	91.23	91.26	91.28	91.30	91.32	91.34
DWK	91.36	91.38	91.41	91.43	91.45	91.47	91.49	91.51
DWG	91.53	91.56	91.58	91.60	91.62	91.64	91.66	91.68
DWO	91.71	91.73	91.75	91.77	91.79	91.82	91.84	91.86

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ROSEMOUNT CALIBRATION RESULTS S/N 149-03 DATE 12 NOV 76 PAGE 10

ALTITUDE IN THOUSANDS OF FEET

	S	U	Q	W	D	K	G	O
DDS	91.88	91.90	91.92	91.95	91.97	91.99	92.01	92.03
DDU	92.05	92.07	92.11	92.12	92.14	92.16	92.18	92.20
DDR	92.22	92.24	92.26	92.29	92.31	92.33	92.35	92.37
DDW	92.39	92.41	92.43	92.46	92.48	92.50	92.52	92.54
DDO	92.56	92.58	92.61	92.63	92.65	92.67	92.69	92.71
DDK	92.73	92.76	92.78	92.80	92.82	92.84	92.86	92.89
DDG	92.91	92.93	92.95	92.97	92.99	93.02	93.04	93.06
DDO	93.08	93.10	93.12	93.15	93.17	93.19	93.21	93.23
DKS	93.26	93.28	93.30	93.32	93.35	93.37	93.39	93.41
DKU	93.43	93.46	93.48	93.50	93.52	93.55	93.57	93.59
DKR	93.61	93.64	93.66	93.68	93.70	93.73	93.75	93.77
DKW	93.79	93.82	93.84	93.86	93.89	93.91	93.93	93.95
DKO	93.98	94.00	94.02	94.05	94.07	94.09	94.12	94.14
DKK	94.16	94.19	94.21	94.23	94.26	94.28	94.30	94.33
DKG	94.35	94.37	94.40	94.42	94.44	94.47	94.49	94.51
DKO	94.54	94.56	94.59	94.61	94.63	94.66	94.68	94.71
DGS	94.73	94.75	94.78	94.80	94.83	94.85	94.88	94.90
DGU	94.93	94.95	94.98	95.00	95.02	95.05	95.07	95.10
DGR	95.12	95.15	95.18	95.20	95.23	95.25	95.28	95.30
DGW	95.33	95.35	95.38	95.41	95.43	95.46	95.48	95.51
DGO	95.54	95.56	95.59	95.61	95.64	95.67	95.69	95.72
DGK	95.75	95.77	95.80	95.82	95.85	95.88	95.91	95.93
DGG	95.96	95.99	96.02	96.05	96.07	96.10	96.13	96.15
DGO	96.19	96.22	96.25	96.28	96.30	96.33	96.36	96.39
DOS	96.42	96.45	96.48	96.51	96.54	96.57	96.60	96.63
DOU	96.66	96.69	96.72	96.75	96.78	96.81	96.84	96.87
DOR	96.90	96.93	96.96	96.99	97.02	97.05	97.09	97.11
DOW	97.14	97.17	97.20	97.23	97.26	97.29	97.32	97.35
DOO	97.38	97.42	97.45	97.48	97.51	97.54	97.57	97.60
DOK	97.63	97.66	97.69	97.73	97.76	97.79	97.82	97.85
DOG	97.88	97.91	97.94	97.98	98.01	98.04	98.07	98.10
DOO	98.13	98.16	98.20	98.23	98.26	98.29	98.32	98.35

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ALTITUDE IN THOUSANDS OF FEET

	S	U	R	W	D	K	G	O
KSS	98.39	98.42	98.45	98.48	98.51	98.54	98.58	98.61
KSU	98.64	98.67	98.70	98.73	98.77	98.80	98.83	98.86
KSR	98.89	98.92	98.96	98.99	99.02	99.05	99.08	99.11
KSW	99.15	99.18	99.21	99.24	99.27	99.31	99.34	99.37
KSD	99.40	99.43	99.46	99.50	99.53	99.56	99.59	99.62
KSK	99.65	99.69	99.72	99.75	99.78	99.81	99.84	99.87
KSG	99.91	99.94	99.97	100.00	100.03	100.06	100.10	100.13
KSO	100.16	100.19	100.22	100.25	100.28	100.31	100.35	100.38
KUS	100.41	100.44	100.47	100.50	100.53	100.56	100.59	100.62
KUU	100.66	100.69	100.72	100.75	100.78	100.81	100.84	100.87
KUR	100.90	100.93	100.96	100.99	101.02	101.05	101.08	101.11
KUW	101.14	101.17	101.20	101.23	101.26	101.29	101.32	101.35
KUD	101.38	101.41	101.44	101.47	101.50	101.53	101.56	101.59
KUK	101.62	101.65	101.68	101.71	101.74	101.77	101.80	101.83
KUG	101.85	101.88	101.91	101.94	101.97	102.00	102.03	102.06
KUO	102.08	102.11	102.14	102.17	102.20	102.23	102.26	102.29
KRS	102.31	102.34	102.35	102.39	102.42	102.45	102.47	102.50
KRU	102.53	102.56	102.58	102.61	102.64	102.66	102.69	102.72
KRR	102.74	102.77	102.80	102.82	102.85	102.87	102.90	102.93
KRW	102.95	102.98	103.00	103.03	103.06	103.08	103.11	103.13
KRD	103.16	103.18	103.21	103.23	103.26	103.28	103.31	103.33
KRK	103.35	103.38	103.40	103.43	103.45	103.47	103.50	103.52
KRG	103.54	103.57	103.59	103.61	103.64	103.66	103.68	103.71
KRO	103.73	103.75	103.77	103.80	103.82	103.84	103.86	103.88
KWS	103.91	103.93	103.95	103.97	103.99	104.01	104.03	104.05
KWU	104.08	104.10	104.12	104.14	104.16	104.18	104.20	104.22
KWR	104.24	104.26	104.28	104.30	104.31	104.33	104.35	104.37
KWW	104.39	104.41	104.43	104.45	104.46	104.48	104.50	104.52
KWD	104.53	104.55	104.57	104.59	104.60	104.62	104.64	104.65
KWK	104.67	104.69	104.70	104.72	104.73	104.75	104.77	104.78
KWG	104.80	104.81	104.83	104.84	104.86	104.87	104.89	104.90
KWO	104.91	104.93	104.94	104.95	104.97	104.98	104.99	105.01

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M	P	COUNTS	M*	M-M*
60.000	93.560	21.4	60.000	.000
62.000	89.890	26.6	62.000	.000
64.000	50.890	39.3	64.000	.000
66.000	36.220	58.4	66.000	.000
68.000	15.290	130.8	68.000	.000
70.000	4.888	489.2	70.000	.000
72.000	2.904	688.7	72.000	.000
74.000	2.142	933.7	74.000	.000
76.000	1.720	1162.8	76.000	.000
78.000	1.467	1363.3	78.000	.000
80.000	1.308	1538.5	80.000	.000
82.000	1.174	1703.6	82.000	.000
84.000	1.080	1851.9	84.000	.000
86.000	1.008	1954.1	86.000	.000
88.000	.949	2107.5	88.000	.000
90.000	.903	2214.8	90.000	.000
92.000	.866	2309.5	92.000	.000
94.000	.833	2401.0	94.000	.000
96.000	.806	2481.4	96.000	.000
98.000	.785	2547.8	98.000	.000
100.000	.766	2611.0	100.000	.000

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03/11/77.  SCOPE 3.4.4      * CDC6600 A.F.G.L.
08.30.35.CORD02K  FROM MFA
08.30.35.IP  0001344 WORDS = FILE INPUT  , DC 30
08.30.35.CORD.      2036    CORDELLA
08.30.35.
08.30.36.COPYBR,INPUT,XX,3.
08.30.37.FTN,SL.
08.30.45.      .659 CP SECONDS COMPILATION TIME
08.30.45.LGO,XX.
08.30.46.LGO.
08.30.53.      STOP
08.30.53.      2.261 CP SECONDS EXECUTION TIME
08.30.53.OP  0000800# WORDS - FILE OUTPUT , DC -C
08.30.53.MS   10752  WORDS  (   1792# MAX USED)
08.30.53.CPU        3.578 SEC.      .073 COST
08.30.53.IO         1.980 SEC.      .013 COST
08.30.54.CM        82.337 KWS.      .090 COST
08.30.54.SS     COST OF JOB         .177
08.30.54.PP        12.001 SEC.    DATE 03/11/77
08.30.54.EJ  END OF JOB, **

**********      CORD02K  //// END OF LIST ////
**********      CORD02K  //// END OF LIST ////
```

Appendix J

Environmental Chamber Tests of PR-3 Flow Rate Sensors

J1. THE TEST

As noted in the text, this test was conducted to examine the interaction of the PR-3 flow sensor when used with the encoder designed to replace the PR-3 electronics. The usual PR-3 calibration system was set up. This system utilizes a Perkin 0-50 V, 0-20 A power supply to run the PRFTs. The magnetic tachometer in each PRFT was monitored by a General Radio 1192-B frequency counter and occasionally an oscilloscope. A PR-3 flow sensor was attached to each PRFT. The procedure used was as follows. First, the PR-3 flow sensor was connected to the PR-3 data recorder and calibrated at the proper pressure altitude. Next the PR-3 flow sensor was connected to the new instrumentation and its indicated frequency recorded. The information about the reed characteristic and the flow data channels was very informative. The test results are listed in the next section.

J1.1 Test Findings

Three separate points were surfaced by the test:

(1) Both data encoder flow channels tested reacted the same way to any individual reed. This should have been the case because all the circuits were built with similar components: 5 percent resistors and 10 percent capacitors.

(2) The amount of contact bounce varied greatly from reed to reed. Of four PR-3 flow sensors checked, one (SN35) interfaced perfectly with the data encoder and produced accurate data with the PRFT turning at 60 Hz. However, the other three PR-3 flow sensors (SN's 58, 65, and 86) all produced data that was well above the correct value of frequency. The recorded frequency exceeded the control frequency by 23.7 percent, 35.2 percent, and 42.0 percent respectively at 60 Hz on the PRFT. It is logical for the data to be in error by having too high a value because if the effects of reed contact bounce are not eliminated prior to counting the data pulses, the pulses caused by the contact bounce will be counted as data pulses. The varying error for each reed demonstrates that the reeds have different amounts of contact bounce at the same frequency. Also, two of the four sensors produced data with standard deviations less than 1.00 while two (SN's 58 and 86) produced data with standard deviations greater than 4.00. All these sensors were checked on two identical circuits with the same results. This further demonstrates that, at the same frequency, there is a wide range of bounce characteristics for the reeds and, that the reed which was chosen by Litton Industries for use in the PR-3 Calibration Unit is not truly representative of the reeds used in the PR-3 flow sensors.

(3) The contact bounce characteristic of each reed varies with frequency. Two reeds were each checked at three flow rates (60, 75, and 90 Hz) and although both reeds produced high frequency readings when working into the data encoder the percentage of error between the reeds and the PRFT was very significantly different for each flow rate.

Even the direction of change in the percentage error was different. See Table J1.

Table J1. Flow Rate Errors

Frequency	Error (SN58)	Error (SN65)
(Hz)	Percent	Percent
60	23.7	35.2
75	18.7	41.0
90	38.9	46.0

This characteristic does not effect the PR-3 data recorders because of the circuit they use to monitor the reeds and, it does not now effect the new data encoder either. However, it is important to document the bounce characteristics of this critical part of the system.

J1.2 A Solution

The solution to the variation in reed characteristics was achieved at the environmental chamber. Using the previously described test set up the encoder flow data channel was examined with an oscilloscope while a particularly "bouncy" reed was being driven in the chamber. It was noted that when the flow data channel (see Figure J1) was switched into the main part of the encoder the current drawn by the transistor in the level shifting amplifier loaded the contact bounce smoothing circuit. This allowed the contact bounce to be amplified and enter the data counting circuit. The addition of a current limiting resistor into the transistor's base circuit reduced the loading of the preceeding stage and eliminated the effect of the contact bounce on the flow data. Corroborative data is in Table J2.

Note that two of the units (SN's 58 and 86) used in the test previously produced data with a standard deviation greater than 4.0 but now produced data with a much more acceptable spread.

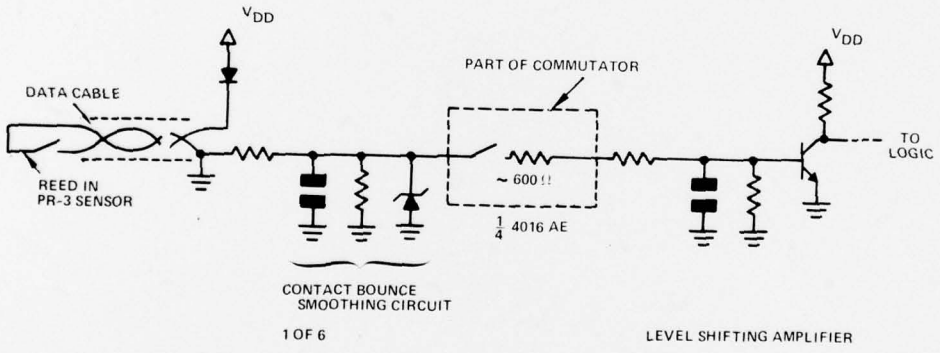


Figure J1. Typical Flow Rate Sensor Monitoring Circuit

Table J2. Test Results

Flow Sensor	Control*	*Data		
SN	PRFT	PR-3**	Encoder	Standard Deviation
35	60	---	57.0	0.524
86	60	---	54.7	0.285
65	60	54	54.1	0.300
58	61	55	56.3	0.409
58	90	88	89.1	0.401

*Units are Hertz.

**This is the PR-3 data recorder

Appendix K

Electrical Detonation of Primary and Secondary Separation Squibs

K1. GENERAL

The following information appeared as a Memo for Record, dated 1 May 1975.

K2. BACKGROUND

The primary and secondary separation squibs activated the primary and backup tenney release devices which are used to separate the parachute and its suspended load from the balloon bottom end fitting. Each squib is controlled by a completely independent system. Each system contains the wires to the squib, radio command or timer activated controller and, batteries. The only common point between the squibs is the electrical "ground". This "ground" is obviously not earth ground but a common point of reference arrived at by definition and utilized for batteries supplying either positive or negative voltage to various equipment. In this case (the Project Ash Can System), the primary separation squib is activated by +24 V and the secondary separation squib is activated by +12 V.

On several past flights the recovery crews have noted that only the secondary tenney device remained on the parachute apex with its squib detonated resulting in the loss of the primary separation tenney. On 3 April 1975 after the instrumentation checks for H75-23/H57 were completed I decided to examine this situation by setting up the system on the ground. The primary and secondary instrumentation

was set up with all their interconnecting cables. Power supplies were substituted for the batteries. A 63-ft diam parachute (SN 2022) with its control cable was connected to the primary control cable which is equivalent to what is commonly referred to as a "bar cable." Two tenney separation devices were attached to the proper connectors at the parachute apex.

These tenney devices were secured from LCD C&I. They were requested with the instructions that the preparation should be the same as that for an active flight except that one squib per device was adequate. Prior to attaching the devices to the parachute cable it was noted that on each device the dark blue wire was attached to the body of the device for a "ground" connection. This is the normal procedure at LCD.

The parachute and its cable were run out of the building and the two tenney devices were covered with a heavy steel can to avoid injury or damage and to deaden the noise. Power was applied to the instrumentation and primary termination was commanded. Both squibs, one in each device, detonated. When the connectors on the tenney devices were opened and the wiring inspected, it was determined that each connector was wired backwards. Pin A is normally "ground" and pin B is normally "grounded" then switched to a positive potential via a relay. Pin A should receive the dark blue wires and pin B should receive the light green wires from the squibs. These were reversed. Therefore, when power was applied to the wires at the instrumentation there was a "short-circuit" at the tenney where it was connected to the "ground" side of the cable. When the tenney release devices were rearmed with properly wired squibs and the experiment rerun the results were as expected; that is, the primary squib detonated and did not effect the secondary squib which was then detonated through the backup controller.

On flight H75-25/H-59, when both tenney devices were wired correctly, the primary tenney was not found with the parachute and the backup was fired.

K3. MODEL OF SQUIBS AND CABLES

The preceding events precipitated an investigation into the paths available for current supplied by either of the control systems. The squib detonating arrangement is shown in Figure K1. The left side of the drawing represents the end of the cable where it terminates in the two controllers. The right side of the drawing contains the two tenney release devices and their squibs: R_s. The resistors R_d represent the distributed resistance of all the wires and cables between the squib firing relay and the squibs plus the contact resistance of all the connector pins between the various cables. The resistor R_c represents the contact resistance of the surfaces of the two tenney devices and their connecting clevis.

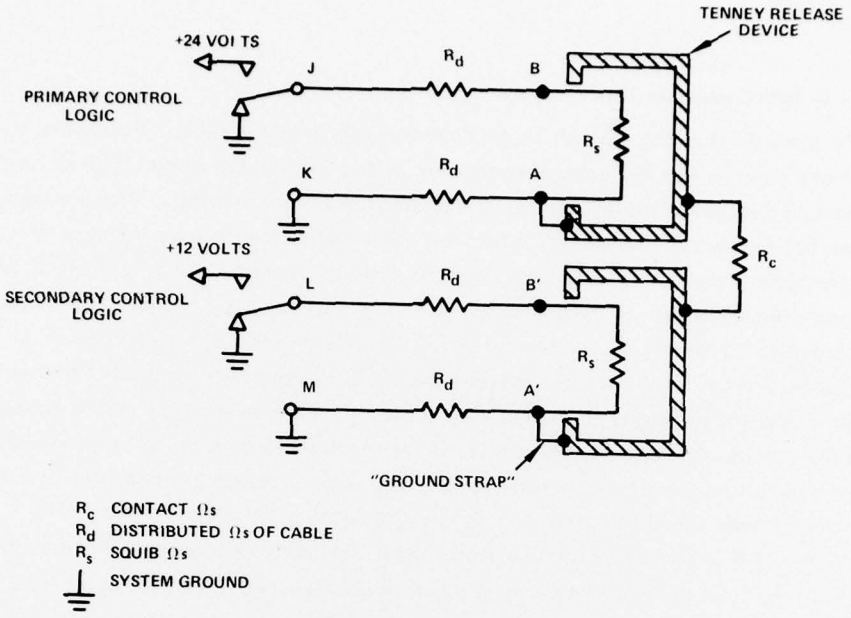


Figure K1. Model of Primary and Secondary Release Devices

K4. CALCULATION OF RESISTANCE VALUES

The resistance of one DuPont S-68 squib is 1.37 Ω. Usually two are used in parallel which reduced the resistance to 0.685 Ω. For the purposes of this analysis these values were averaged to facilitate the computations. Therefore $R_s \simeq 1.0\ \Omega$.

The distributed resistance of the cables (R_d), was based on a 63-ft diam parachute. The handbook notes that 15 in. of cable will be snaked into each 12 in. of parachute length. This is a ratio of 1.25:1 but my experience indicates that a ratio of 1.5:1 is closer to what is actually used. Since this parachute is 90 ft long it would require about 135 ft of cable to reach from the apex to the confluence point. The 135 ft of parachute cable is A.W.G. No. 16 which results in a resistance of 0.553 Ω. The cables in the instrumentation packages are about 15 ft long and are constructed of A.W.G. No. 20 wire. Their resistance is therefore about 0.155 Ω. The contact resistance of the connectors used in the cables is about 0.003 Ω per pin pair. Their combined resistance is about 0.015 Ω. Therefore R_d sum of 0.553, 0.155, and 0.015 Ω. To simplify the calculations let's say $R_d \simeq 3/4\ \Omega$.

The resistance R_c is an unknown. Depending on the cleanliness of the two tenney devices and their connecting clevis, it can vary from about 0 Ω to numbers large enough to be considered infinite.

K4.1 Case 1: Both Connectors Wired Correctly

Let's assume that the circuit is as represented in the sketch. Points A, A', B and B' are pins in the MS series connector at the parachute apex. The primed set is used to designate the connector to the backup tenney device. The connectors are wired the same and correctly: pin A on each connector is connected to the side of the wire pair which is always connected to system ground. This is point K for the primary tenney squib and point M for the secondary tenney squib. Also, each pin A is used to "ground" its tenney device. Each wire which is switched to a positive potential to detonate the appropriate squib is normally grounded through the relay's normally closed contact. This is for protection against static charges.

Let's examine the case where R_c is so large that there is no interaction between the two circuits and the primary termination mode is activated. The three resistors around the circuit JBAK run to 2.5 Ω so when the wire attached to point J is switched to +24 V a current of 9.6 A flows until the squib detonates. A current of this magnitude flowing from J to K will cause a voltage 7.2 V to appear across the R_d between A and K. Therefore point A and the primary tenney device are at +7.2 V until the squib detonates. At that time the point A returns to ground potential because no current if flowing. And, point B is a +24 V until the primary termination sequencer returns the relay to which point J is connected to its relaxed state. Then, point B is returned to ground potential. Two points must be noted. First, R_c was assumed to be so large that the secondary termination circuit did not enter into the analysis. Second, point A which is commonly referred to as "ground" is obviously not "ground" and when there is a current in the circuit the "ground" strap surely does not keep the primary tenney device at (system) ground potential.

Now let's examine the case where R_c approaches 0 Ω and the primary termination mode is activated. Starting at joint J, R_d and R_s are still in series, but these two resistances are in series with the parallel combination of (1) the return R_d between A and K; (2) the return R_d between A' and M and; (3) the series combination of R_s and R_d between A' and L. (Don't forget that T_c = 0 Ω.) This parallel combination results in an effective resistance of 0.31 Ω from point A (or A') to ground. The series resistance from point J to ground is now the R_d between J and B plus R_s plus the effective resistance of 0.31 Ω. This is a resistance of 2.06 Ω which will result in a current of 11.65 A when J is switched to +24 V. This current will cause a potential of about 3.6 V (= 11.65 A × 0.31 Ω) at point A. When the current which is producing this voltage splits in the current divider formed by the parallel resistance, 2.06 A (= 3.6 V/1.75 Ω) will flow through the leg containing the R_s and R_d between A' and L. The backup squib represented by R_s will definitely fire. Several points must be noted. First, for these calculations

R_c is 0 Ω. Second, depending on the speed of the squib detonations the instrumentation fuses may or may not blow. Third, even though everything was "correct" the primary tenney device will be lost.

In real life, the probability of R_c being either 0 Ω or infinite ohms is just about zero. However, it probably could get very close to 0 Ω. The point is that if the results of the two extremes are known, then it stands to reason that some value of R_c exists which is the exact point where the "approximate all fire current" for the backup squib(s) represented by R_s will be present. If R_c is larger, the squib(s) will not detonate; if R_c is smaller, the squib(s) will detonate. To get a feel for this value of R_c let all resistances be 1 Ω and let the "approximate all fire current" be 0.6 A for one S-68 squib. Then, R_c = 3-1/9 Ω.

K4.2 Case 2: Both Connectors Wired Incorrectly

It is of academic interest to examine the case of both tenney release device squibs wired backwards. The only change in the sketch is to remove the "ground" strap from point A to the tenney device and place it from point B to the device.

Let's assume that R_c is extremely large. As before the current is 9.6 A and point B attains a potential of 16.8 V but the tenney device is attached to point B so it is at 16.8 V, then 24 V until the squib detonates and the relay returns to its relaxed state. The backup squib if unaffected.

The next example is when R_c is 0 Ω. Using the same reasoning as before, the total resistance is R_d between J and B plus the parallel combination of the three legs. This is (0.75 Ω + 0.40 Ω =) 1.15 Ω . The current through point J when it is switched to +24 V is then (24 V / 1.15 Ω =) 20.9 A. This current results in 8.3 V on point B and 4.8 A through the backup squib. Both squibs will detonate. The circuit path then changes to a loop comprising points JBB'L. Each R_d is 3/4 Ω and R_c is 0 Ω. The loop current is therefore 16 A. If the initial 20.9 A surge did not blow the fuse in series with the 24 V supply, then the 16 A steady state current will surely blow the fuse. This was verified by the experiment which was recorded above. The value of R_c for which the exact value of "approximate all fire current" is present is 7.56 Ω.

K4.3 Other Cases

Since the circuit used to model the two methods of separating the parachute from the balloon is symmetrical, the analysis presented above is valid for the similar case of backup termination being enacted while the primary termination system is not operating. However, all current and voltage values will be half those stated above.

Also, it could be assumed that the primary device was wired correctly as the backup device was wired incorrectly or that the reverse situation was applicable. However, I don't feel that these cases would occur because the same person will probably wire both tenney devices. Therefore, they will not be examined.

K5. CONCLUSION

The above analysis was undertaken with the belief that incorrectly wiring both tenney device connectors would result in the detonation of the squibs in both the primary and backup tenney devices. It has been shown that both devices will usually be activated upon activation of primary termination regardless of how they are wired if R_c is of sufficiently low value. The larger currents and higher value for the limiting case of R_c noted in Case 2, increase the probability of detonating the backup squib if the tenney devices are incorrectly wired.

K6. CORRELATION WITH FLIGHT DATA

The system on which this analysis is based is the new LCC backup controller and primary controller. This combination has been flown five times (H74-61/H-53X, H74-65/H-54X, H74-66/H-55X, H75-23/H-57, and H75-25/H-59). Both tenney devices had been activated on four of the five flights. Only on H75-23/H-57 did the recovery crew find the primary tenney device near the parachute. This simultaneous firing of squibs did not occur on earlier flights because the Ash Can Backup Package (see Ash Can Handbook Part II Attachment 10) does not keep the "hot" line to the squib normally grounded. Also, the Range Package II (See handbook page 41) does not keep the backup tenney device squib normally grounded.

K7. A SOLUTION

The interaction between the two circuits can be eliminated by making value of R_c very large. This can be accomplished in real life by inserting a standard 10K pound test nylon loop between the two tenneys. Another clevis may be used with the loop to keep the angular relationships of the two sets of squib leads the same as that flown at present. This additional loop will necessitate moving the parachute cable upward to enable the connector to reach the primary tenney device.

8. RECOMMENDATIONS

The above solution should be implemented on future Ash Can flights using the new electronics system. A copy of this memo should be placed in flight folders for the above listed flights.

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