NASA

Technical Memorandum 80258

(E84-10153) HEAT CAPACITY MAPPING RADIOMETER (HCMR) DATA PROCESSING ALGORITHM, CALIBRATION, AND FLIGHT PERFORMANCE EVALUATION (NASA) 173 p HC A08/MF A01 CSCL 14B
N84-27245
Unclas
G3/43 00153

HEAT CAPACITY MAPPING RADIOMETER (HCMR) DATA PROCESSING ALGORITHM, CALIBRATION, AND FLIGHT PERFORMANCE EVALUATION

J. R. Bohse, M. Bewtra, and
W. L. Barnes

APRIL 1979

National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland 20771

(+)

TM 80253

HEAT CAPACITY MAPPING RADIOMETER (HCMR) DATA PROCESSING ALGORITHM, CALIBRATION, AND FLIGHT PERFORMANCE EVALUATION

J. R. Bohse
Systems and Applied Sciences Corporation

M. Bewtra
Computer Sciences Corporation

W. L. Barnes
Goddard Space Flight Center

April 1979

National Aeronautics and Space Administration
Goddard Space Flight Center
Greenbelt, Maryland

HEAT CAPACITY MAPPING RADIOMETER (HCMR)
DATA PROCESSING ALGORITHM, CALIBRATION,
AND FLIGHT PERFORMANCE EVALUATION

J. R. Bohse*
Systems and Applied Sciences Corporation

M. Bewtra
Computer Sciences Corporation

W. L. Barnes
Goddard Space Flight Center

ABSTRACT

This document presents the rationale and procedures used in the radiometric calibration and correction of Heat Capacity Mapping Mission (HCMM) data.

Instrument-level testing and calibration of the Heat Capacity Mapping Radiometer (HCMR) were performed by the sensor contractor ITT Aerospace/Optical Division. The principal results are included in this document. From the instrumental characteristics and calibration data obtained during ITT acceptance tests, an algorithm for post-launch processing was developed.

Integrated spacecraft-level sensor calibration was performed at Goddard Space Flight Center (GSFC) approximately 2 months before launch. This calibration provided an opportunity to validate the data calibration algorithm. Instrumental parameters and results of the validation are presented in this document. In addition, the performances of the instrument and the data system after launch are examined with respect to the radiometric results. Anomalies and their consequences are discussed. Flight data indicated a loss in sensor sensitivity with time. The loss was shown to be recoverable by an outgassing procedure performed approximately 65 days after the infrared channel was turned on. It is planned to repeat this procedure periodically.

*This work performed while affiliated with Computer Sciences Corporation.

Results of comparisons between satellite measurements and surface measurements taken at White Sands, New Mexico, are also presented. Surface IR measurements are approximately 6 degrees Kelvin higher than satellite measurements. Due to a lack of alternative solution, the calibrated data were offset to ensure agreement with surface measurements. The validity of this change will be verified by comparing the data with the surface values obtained by various experimenters and from additional White Sands data.

FOREWORD

The algorithm and software development and testing and analysis described in this document were performed by two of the authors (JB and MB) under contract NAS5-24350 Task 403. Portions of the document are taken from the final report of this work (CSC/TM-79/6016).

Instrumental parameters and calibration data were compiled from the HCMR Final Engineering Report (Contract NAS5-20621) of the ITT Aerospace/Optical Division, Fort Wayne, Indiana.

The authors wish to acknowledge the valuable support of Dr. J. C. Price, Heat Capacity Mapping Mission Project Scientist and Mr. H. F. Shaw, Heat Capacity Mapping Radiometer Technical Officer.

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

LIST OF ILLUSTRATIONS

LIST OF TABLES

SECTION 1 - INTRODUCTION

1.1 BACKGROUND

The Heat Capacity Mapping Mission (HCMM) is the first of a series of scheduled missions to support the Applications Explorer Mission (AEM) project and has been designated AEM-A. The AEM-A spacecraft carries a Heat Capacity Mapping Radiometer (HCMR) instrument designed to monitor infrared radiation from the Earth in two spectral bands. The spacecraft is composed of two distinct modules: (1) the base module, which contains the attitude control, power, and data handling equipment (except for science sensor equipment), and (2) the instrument module, which contains the HCMR and its supporting electronics, structure, and thermal control.

In April 1978, the AEM-A spacecraft was launched and injected into a near-Earth, 600-kilometer, circular, Sun-synchronous orbit with a nominal 2 p.m. ascending node and a 97.79-degree inclination. The expected scientific lifetime of the spacecraft is 1 year from launch. HCMM is a real-time-only mission. Science data, consisting of data from two analog radiometer channels, are subcarrier-multiplexed on a real-time S-band link. Housekeeping data, including attitude and some radiometer calibration data, are formatted into biphase pulse code modulation (PCM) and transmitted on a very-high-frequency (VHF) link. These PCM data are also transmitted on a subcarrier of the S-band link. Subcarrier assignments for the link are as follows:

- 800 kilohertz: HCMR thermal channel
- 480 kilohertz: HCMR visible channel
- 70 kilohertz: spacecraft PCM

1.2 HCMR

The HCMR is a two-channel scanning/imaging radiometer. The two channels contain the spectral intervals of 0.55 to 1.1 microns and 10.5 to 12.5 microns and share a common collecting optical system having an instantaneous field of view of 0.83 ± 0.17 milliradian. Table 1-1 describes HCMR system characteristics. Figures 1-1 and 1-2 show the locations of the pertinent features of the HCMR.

Figure 1-3 is a simplified block diagram of the HCMR electronics. The HCMR electronics transmits to the spacecraft two channels of video data synchronized with the spacecraft clock and the rotation of the HCMR scan mirror. The input signals to the HCMR are the spacecraft +28.0-volts-direct-current (VDC) bus; clock signals of 70 kilohertz, 14 kilohertz, and 560 hertz two-phase; and spacecraft commands to the HCMR to implement the available modes of operation. The HCMR electronics provides power conversion, timing and control, signal generation, digital and analog telemetry for verification of operation, and signal amplification for required operation.

The basic blocks of the HCMR electronics are as follows:

1. Infrared data amplifiers
2. Visible data amplifiers
3. Power converter
4. Voltage regulators
5. Timing and control circuits
6. Calibration signal generation circuits
7. Analog telemetry circuits
8. Command and digital telemetry circuits

The HCMR scan sequence, angular representations for various quantitites, and the corresponding times are provided in Figures 1-4 and 1-5. Table 1-2 provides digital and analog telemetry listings.

1.3 DOCUMENT OVERVIEW

Section 2 of this document presents instrumental parameters and calibration data from ITT Aerospace acceptance tests. Only those results that pertain to

Table 1-1. HCMR System Characteristics (1 of 2)

PARAMETER	VALUE/DESCRIPTION
DESIGN PARAMETERS	
WAVELENGTH BAND AT HALF-POWER POINTS	0.55 TO 1.1 MICRONS, 10.5 TO 12.5 MICRONS
FIELD OF VIEW	0.83 MILLIRADIAN
GROUND RESOLUTION (SUBSATELLITE POINT AT 600 KILOMETERS)	0.5 KILOMETER
OPTICAL SPEED	f/0.82
COLLECTING APERTURE DIAMETER	8.0 INCHES
DETECTOR TYPE	HgCdTe–SILICON
OPERATING TEMPERATURE	115 DEGREES KELVIN (K) (AMBIENT)
SCAN RATE	14.0 REVOLUTIONS PER SECOND
INFORMATION BANDWIDTH	53.0 KILOHERTZ
DYNAMIC RANGE	
CHANNEL 2	260 TO 340 DEGREES K
CHANNEL 1	0- TO 100-PERCENT ALBEDO
PERFORMANCE CHARACTERISTICS	
NOISE EQUIVALENT TEMPERATURE DIFFERENCE (NETD) (CHANNEL 2)	0.3 DEGREE K AT 280 DEGREES K
SIGNAL-TO-NOISE RATIO (CHANNEL 1)	10 AT 1.0-PERCENT ALBEDO
PHYSICAL CHARACTERISTICS	
WEIGHT	53.8 POUNDS
SIZE	22 BY 12 BY 17 INCHES
POWER (HIGH–LOW)	24.0 WATTS–21.0 WATTS
OPTICAL PARAMETERS	
INSTANTANEOUS FIELD OF VIEW	SQUARE, 0.83 MILLIRADIAN ON AN EDGE
TELESCOPE	
TYPE	AFOCAL DALL-KIRKAM
CLEAR APERTURE DIAMETER	8.00 INCHES
F-NUMBER (PRIMARY)	0.92
EXIT BEAM DIAMETER	1.00 INCH
MIRROR SUBSTRATE MATERIAL	CERVIT
PRIMARY-SECONDARY SPACER MATERIAL	INVAR
COATING	ALUMINIZED WITH KANIGEN PROCESSING COATING
SYSTEM OPTICAL PARAMETERS, NEAR-INFRARED CHANNEL	
RELAY	AIRSPACE TRIPLET; 32-MILLIMETER FOCAL LENGTH
EFFECTIVE SYSTEM FOCAL LENGTH	256.0 MILLIMETERS

Table 1-1. HCMR System Characteristics (2 of 2)

PARAMETER	VALUE/DESCRIPTION
OPTICAL PARAMETERS (CONT'D)	
F-NUMBER[a]	1.26
FIELD STOP EDGE WIDTH	0.0084 INCH
DIAMETER OF BLUR SPOT, ON AXIS	0.0016 INCH[b]
DIAMETER OF BLUR SPOT, FIELD CORNER	0.0022 INCH[b]
MODULAR TRANSFER FUNCTION (ON AXIS) AT THREE LINE PAIRS PER MILLIMETER	99.3 PERCENT
MODULAR TRANSFER FUNCTION (FIELD CORNER) AT THREE LINE PAIRS PER MILLIMETER	99.2 PERCENT
FOCUS ADJUSTMENT	±0.0326 INCH
CLEAR APERTURE	6.56 INCHES[c]
SYSTEM OPTICAL PARAMETERS, FAR INFRARED CHANNEL	
RELAY	SINGLE GERMANIUM FOCUS LENS WITH GERMANIUM APLANAT LENS; 23.775-MILLIMETER FOCAL LENGTH
EFFECTIVE SYSTEM FOCAL LENGTH	190.2 MILLIMETERS
FIELD STOP EDGE WIDTH	0.0062 INCH
F-NUMBER	0.936
DIAMETER OF BLUR SPOT, ON AXIS	0.0012 INCH[d]
DIAMETER OF BLUR SPOT, FIELD CORNER	0.0042 INCH[d]
MODULAR TRANSFER FUNCTION (ON AXIS) AT 3.6 LINE PAIRS PER MILLIMETER	99.0 PERCENT
MODULAR TRANSFER FUNCTION (FIELD CORNER) AT 3.6 LINE PAIRS PER MILLIMETER	96.5 PERCENT
FOCUS ADJUSTMENT (AIR SPACE BETWEEN FOCUS LENS AND APLANAT)	±0.141 INCH
CLEAR APERATURE	8 INCHES

[a]F-NUMBER DEFINED AS EFFECTIVE FOCAL LENGTH DIVIDED BY CLEAR APERTURE DIAMETER
[b]FOR SPECTRAL BAND FROM 0.80 TO 1.10 MICROMETERS AND 100-PERCENT ENERGY
[c]LIMITED BY SIZE OF RELAY LENS; COULD NOT BE CHANGED WITHOUT EXTENSIVE REDESIGN
[d]FOR 100-PERCENT ENERGY

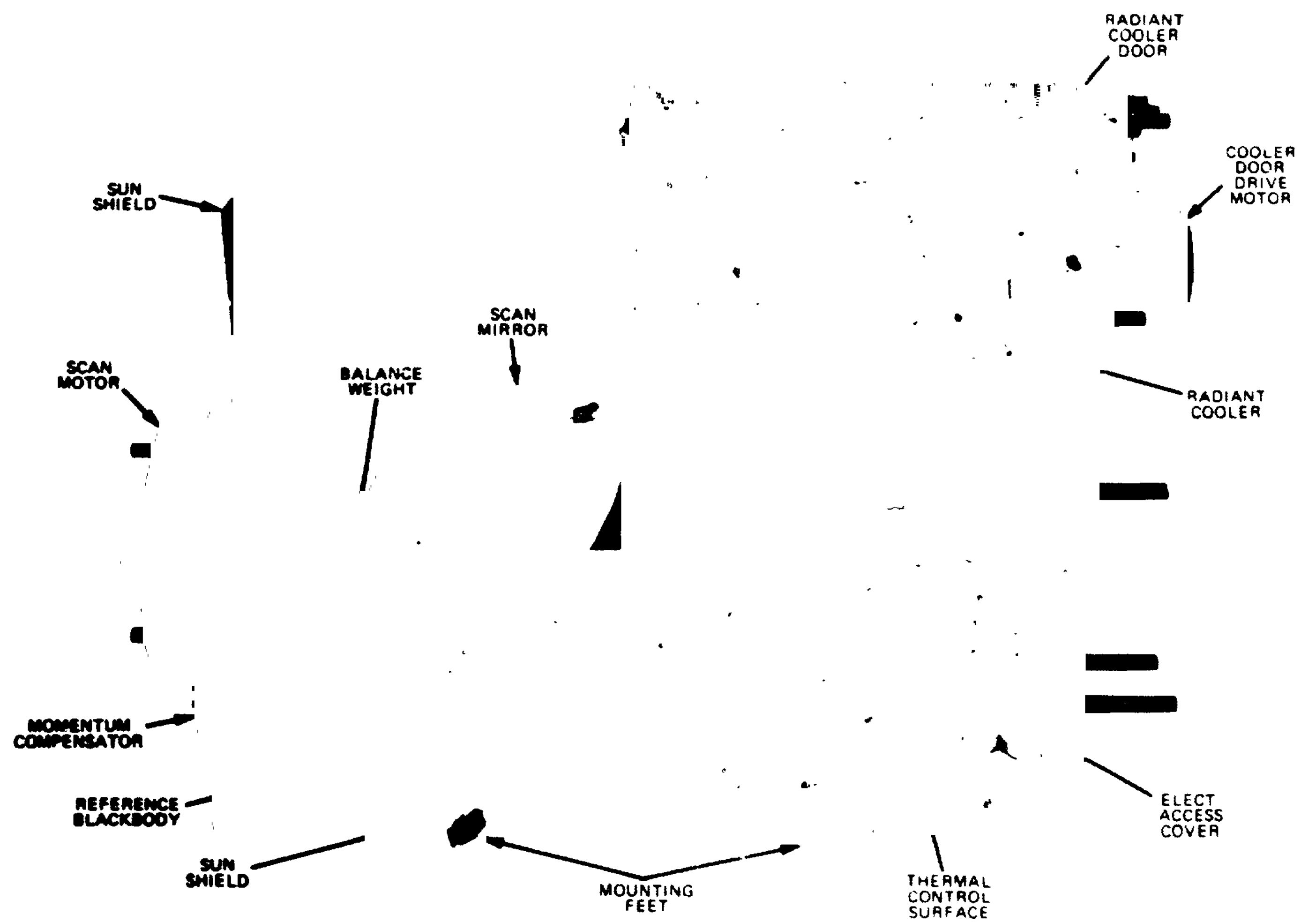


Figure 1-1. HCMR Pertinent Features (Front View)

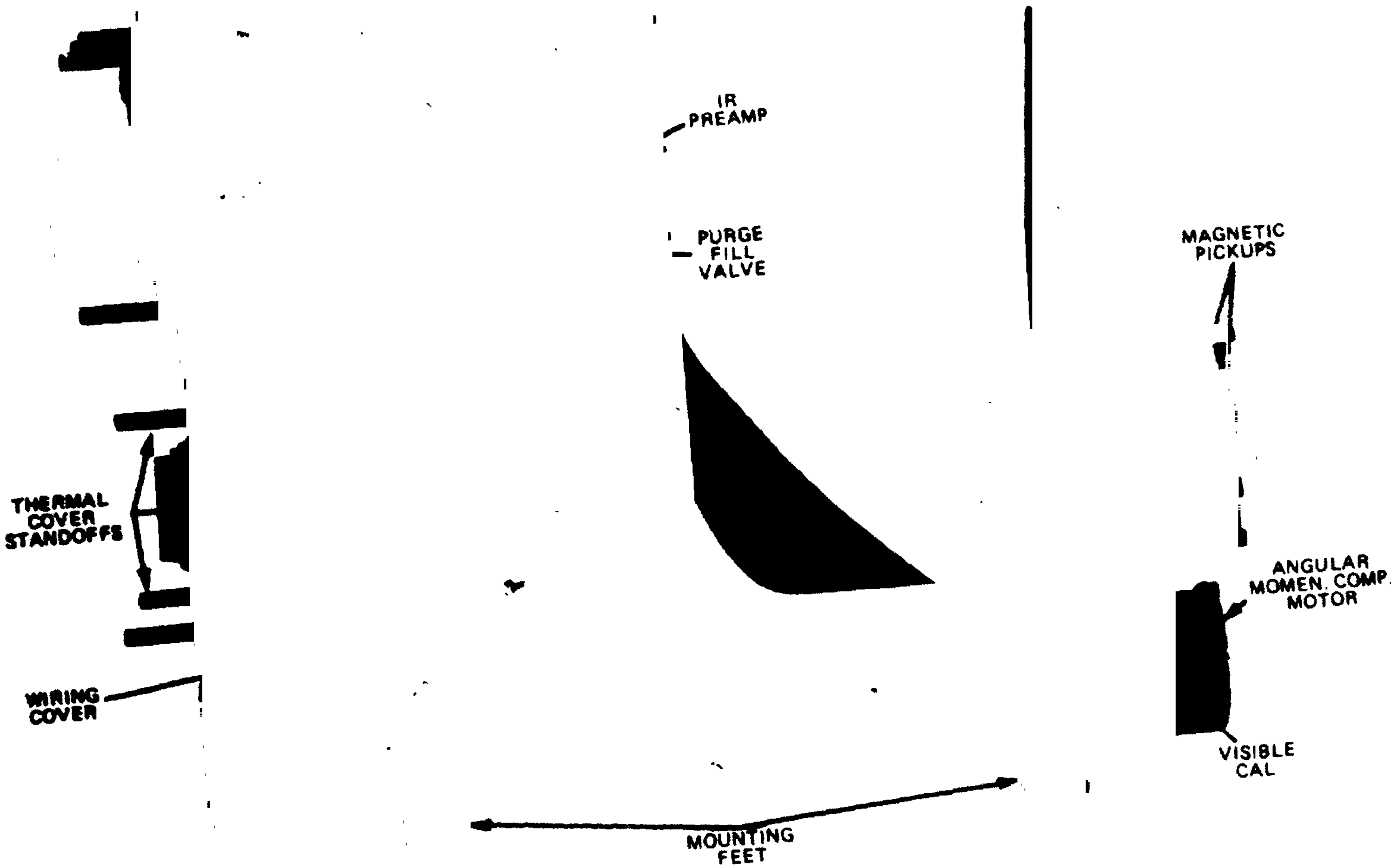


Figure 1-2. HCMR Pertinent Features (Back View)

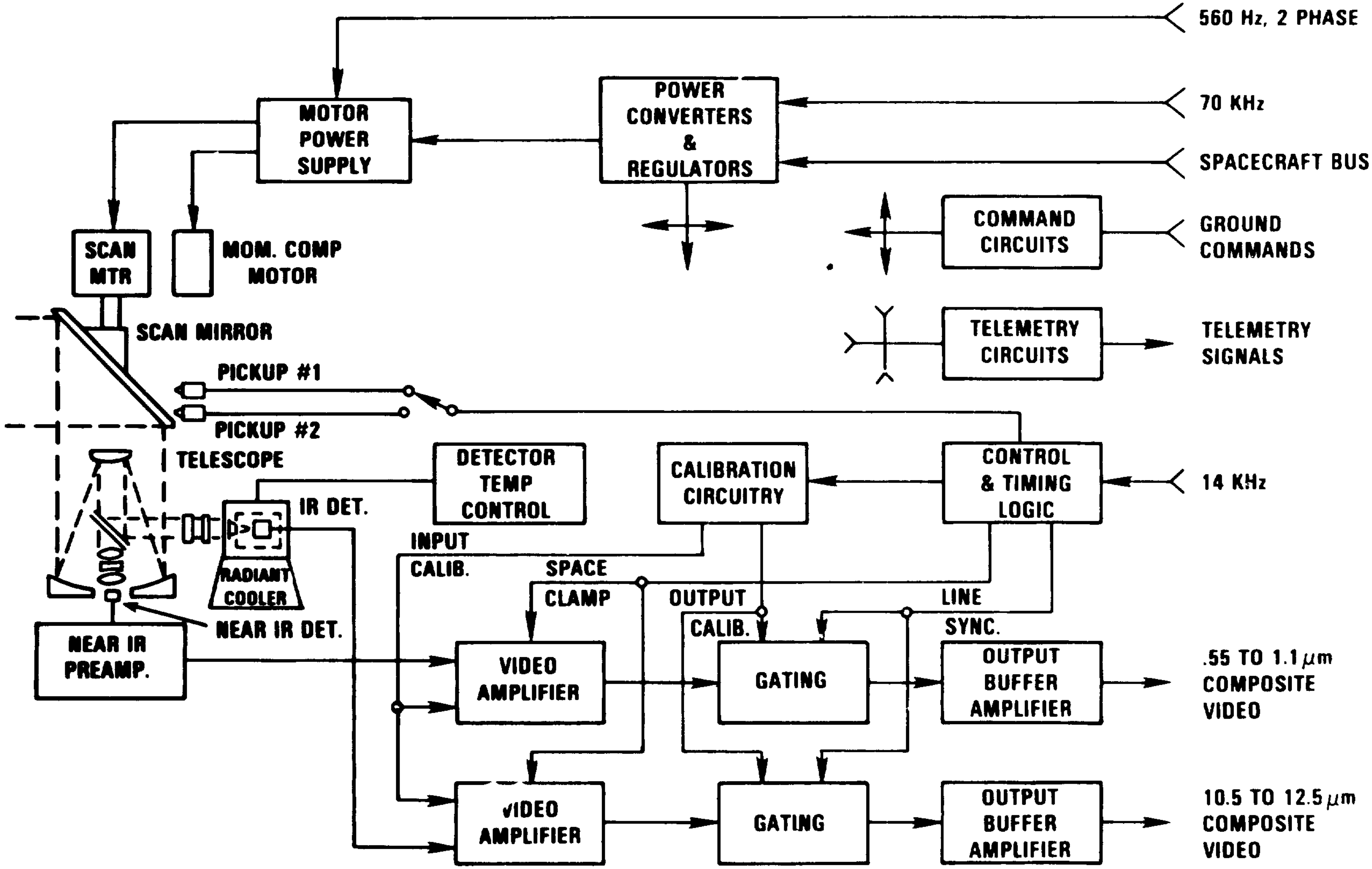
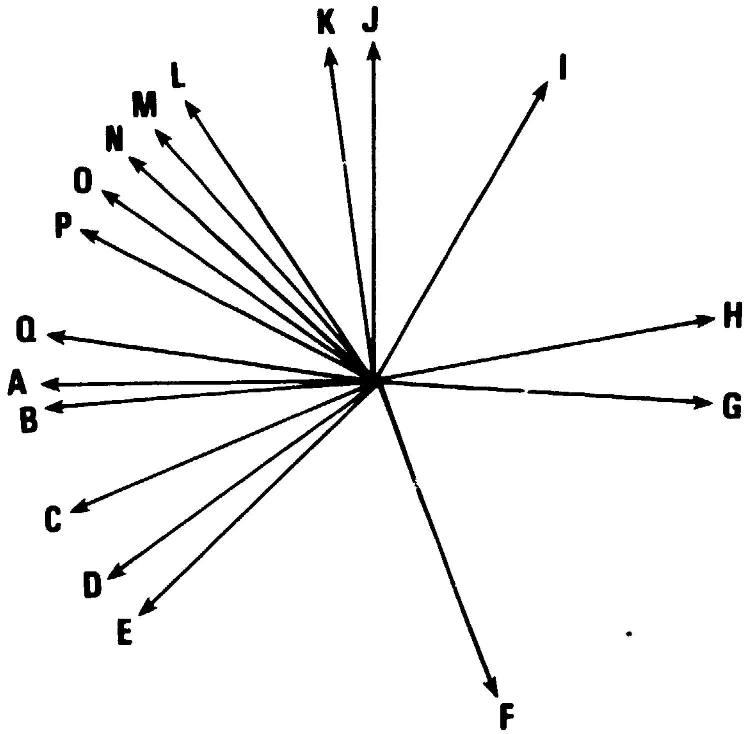


Figure 1-3. HCMR Functional Block Diagram



REFERENCE LETTER	ANGLE (DEGREES)	TIME (ms)	EVENT
A	0	0	BEGIN SYNC PULSE #1
B	3.6	0.714	END SYNC PULSE #1
C	21.6	4.28	BEGIN INPUT CALIBRATION
D	34.2	6.79	END INPUT CALIBRATION
E	42.9	8.51	BEGIN EARTH SCAN
F	109	21.63	NADIR
G	175.1	34.74	END EARTH SCAN
H	189	37.5	BEGIN OUTPUT CALIBRATION
I	239.4	47.5	END OUTPUT CALIBRATION
J	270.4	53.65	BEGIN INTERNAL TARGET VIEW
K	278.3	55.22	COMPLETE INTERNAL TARGET VIEW
L	304.2	60.36	BEGIN INTERNAL TARGET TEMPERATURE TELEMETRY
M	311.4	61.78	END INTERNAL TARGET TEMPERATURE TELEMETRY
N	318.6	63.21	BEGIN SYNC PULSE #2
O	325.8	64.64	END SYNC PULSE #2
P	333.0	66.07	BEGIN PRECURSOR BURST
Q	351.0	69.64	END PRECURSOR BURST

Figure 1-4. HCMR Scan Sequence

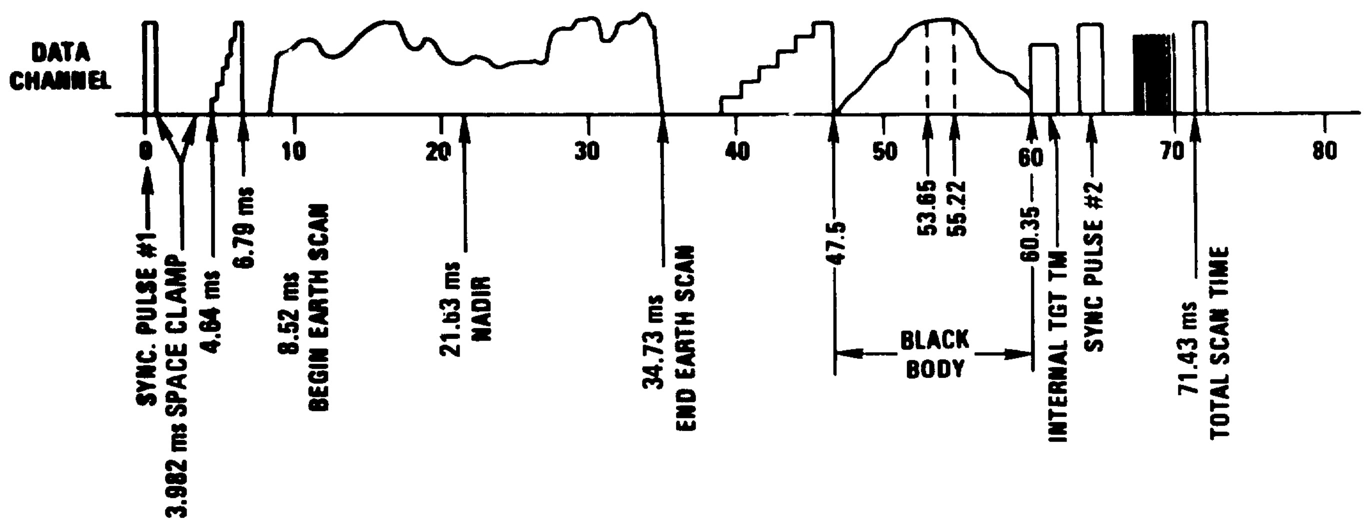


Figure 1-5. HCMR Analog Data Format

Table 1-2. HCMR Telemetry List

FUNCTION	SAMPLE RATE (PER SECOND)
ANALOG TELEMETRY	
+15-VOLT MONITOR	1
+5-VOLT MONITOR	1
-15-VOLT MONITOR	1
TELEMETRY POWER	1
MOTOR DRIVE CURRENT	1
CONE COVER POSITION	1
ELECTRONICS TEMPERATURE	1/8
BASEPLATE TEMPERATURE	1/8
CONE TEMPERATURE	1/8
PATCH TEMPERATURE	1
BLACKBODY TEMPERATURE 1	1
BLACKBODY TEMPERATURE 2	1
PURGE PRESSURE	1
CONE WALL HOUSING TEMPERATURE	1/8
PATCH POWER	1
ELECTRONICS CURRENT	1
OFFSET VOLTAGE	1
MOMENTUM COMPENSATOR SPEED	1
SCAN MOTOR SPEED	1
MOTOR HOUSING TEMPERATURE	1/8
DIGITAL TELEMETRY	
MOTOR STATUS	1
ELECTRONICS STATUS	1
MOTOR POWER STATUS	1
PATCH HEATER STATUS	1
CONE HEATER STATUS 1	1
PURGE VALVE STATUS	1
CONE COVER STATUS 2	1

the radiometric calibration and correction of HCMM data are included. Section 3 contains a review of the entire HCMM primary processing scheme and describes the basis and development of the HCMM radiometric correction algorithm. Section 4 presents the results from the integrated spacecraft calibration performed at Goddard Space Flight Center (GSFC). Data taken during this calibration were used to validate the algorithm developed earlier. Results of this validation are also included in Section 4. Section 5 examines the performance of the instrument and the data system after launch with respect to the radiometric results. Anomalies and their consequences discovered in the performance of the sensor are discussed. Results of comparisons between satellite and ground measurements taken at White Sands, New Mexico, are also presented.

SECTION 2 - INSTRUMENTAL PARAMETERS AND CALIBRATION DATA FROM ITT ACCEPTANCE TESTS

The final performance characteristics of the HCMR were determined by ITT Aerospace, the instrument manufacturer, in a series of tests conducted at the ITT facility as part of the acceptance procedures. The test results and supplemental information on the HCMR were presented in two reports by ITT (References 1 and 2). Because the algorithm developed for interpreting the data was a function of the particular characteristics of the instrument, it is necessary to refer to these data frequently. To facilitate this, many of the results and calibrations presented by ITT are reproduced in this section as a reference source for following sections. Because this document deals primarily with the radiometric calibration, only those results pertinent to a radiometric evaluation of the data are presented. Additional information may be found in the original documents (References 1 and 2).

2.1 TELEMETRY AND ELECTRONIC PERFORMANCE

Table 2-1 lists all of the analog telemetry parameters associated with the HCMR and presents measured values of these parameters as functions of baseplate temperature covering the test range of 5 degrees Celsius (C) to 40 degrees C.

Table 2-2 records the measured voltages for the input and output calibration steps for both channels as functions of baseplate temperature.

Table 2-3 lists the measured values of the noise equivalent temperature (NEΔT) in the infrared channel and the signal-to-noise ratio in the visible channel at selected baseplate temperatures.

2.2 VISIBLE CHANNEL DATA

Table 2-4 lists the measured spectral data for the various optical components of the visible/near-infrared channel.

Table 2-1. Analog Telemetry Data

ANALOG TELEMETRY NUMBER	FUNCTION	BASEPLATE TEMPERATURE (DEGREES C)							
		+5	+10	+15	+20	+25	+30	+35	+40
1	ELECTRONICS TEMPERATURE (DEGREES C)	5.9	9.0	12.2	14.7	17.7	20.3	24.0	27.1
2	CONE TEMPERATURE (DEGREES K)	161.3	161.71	162.05	162.36	162.70	163.1	163.41	164.05
3	BASEPLATE TEMPERATURE (DEGREES C)	+5.5	11.0	15.6	20.0	24.6	29.5	34.1	39.5
4	BLACKBODY TEMPERATURE 1 (DEGREES C)	5.91	10.79	14.93	18.86	23.08	27.15	31.28	35.88
5	BLACKBODY TEMPERATURE 2 (DEGREES C)	5.86	10.79	14.98	18.94	23.18	27.27	31.42	36.05
6	PATCH TEMPERATURE (DEGREES K)	115.49	115.51	115.53	115.55	115.56	115.58	115.61	115.63
7	MOTOR DRIVE CURRENT (AMPERES)	0.297	0.293	0.286	0.282	0.276	0.269	0.264	0.258
8	+15-VOLT MONITOR (+ VOLTS)	+14.67	–	–	–	–	–	–	+14.67
9	−15-VOLT MONITOR (– VOLTS)	−13.56	–	–	–	–	–	–	−13.56
10	+5-VOLT MONITOR (+ VOLTS)	+5.094	5.092	5.092	5.090	5.090	5.088	5.086	5.084
11	SPARE	–	–	–	–	–	–	–	–
12	PREAMP POWER TELEMETRY (+ VOLTS)	10.9	–	–	–	–	–	–	10.09
13	TELEMETRY POWER (+ VOLTS)	14.81	–	–	–	–	–	–	14.81
14	CONE COVER POSITION (DEGREES)	10.4	–	–	–	–	–	–	10.4
15	PATCH POWER (MILLIWATTS)	7.53	7.24	7.00	6.77	6.60	6.28	5.97	5.64
16	COOLER HOUSING TEMPERATURE (DEGREES C)	−6.5	−5.5	−4.5	−4.5	−3.0	−2.5	−0.7	0
17	PURGE PRESSURE (POUNDS PER SQUARE INCH GAGE)	87	–	–	–	–	–	–	87
18	ELECTRONIC CURRENT (+ AMPERES)	0.394	–	–	–	–	–	–	0.394
19	SIGNAL GROUND	–	–	–	–	–	–	–	–
20	SIGNAL GROUND	–	–	–	–	–	–	–	–
21	MOTOR HOUSING TEMPERATURE (DEGREES C)	+6	+11	+15	+19	+23.3	+27.5	+31.5	36.3
22	+28-VOLT RETURN	–	–	–	–	–	–	–	–
23	OFFSET VOLTAGE (VOLTS)	7.54	–	–	–	–	–	–	7.54
24	COMPENSATOR MOTOR SPEED TELEMETRY (REVOLUTIONS PER MINUTE)	4794	4794	4794	4794	4823	4823	4823	4823
25	SCAN MOTOR SPEED TELEMETRY (REVOLUTIONS PER MINUTE)	839.9	–	–	–	–	–	–	839.9

Table 2-2. HCMR Calibration Steps

STEP NUMBER	BASEPLATE TEMPERATURE (DEGREES C)							
	+5	+10	+15	+20	+25	+30	+35	+40
NEAR-INFRARED INPUT (VOLTS)								
1	–	−0.002	−0.002	0.002	−0.002	0.001	0.007	0.003
2	–	1.003	1.004	1.006	0.997	1.001	1.006	1.002
3	–	1.982	1.982	1.986	1.976	1.979	1.986	1.980
4	–	2.989	2.990	2.989	2.980	2.983	2.939	2.984
5	–	3.957	3.968	3.967	3.958	3.961	3.967	3.964
6	–	4.983	4.987	4.983	4.974	4.977	4.984	4.977
7	–	5.957	5.964	5.962	5.952	5.953	5.962	5.953
NEAR-INFRARED OUTPUT (VOLTS)								
1	–	0.011	0.002	0.005	0.005	0.002	0.008	0.008
2	–	0.978	0.969	0.969	0.970	0.969	0.969	0.969
3	–	1.976	1.967	1.972	1.969	1.966	1.970	1.9687
4	–	2.951	2.947	2.948	2.947	2.945	2.947	2.945
5	–	3.958	3.954	3.954	3.956	3.952	3.952	3.954
6	–	4.934	4.929	4.928	4.929	4.926	4.929	4.927
7	–	5.928	5.926	5.924	5.922	5.923	5.925	5.923
INFRARED INPUT (VOLTS)								
1	0.102	0.104	0.102	0.104	0.102	0.102	0.101	0.098
2	1.062	1.062	1.060	1.056	1.058	1.057	1.060	1.053
3	1.987	1.991	1.988	1.986	1.991	1.990	1.991	1.988
4	2.945	2.945	2.942	2.940	2.943	2.944	2.946	2.942
5	3.887	3.883	3.874	3.877	3.875	3.875	3.875	3.873
6	4.855	4.852	4.848	4.842	4.847	4.849	4.852	4.843
7	5.789	5.783	5.778	5.778	5.780	5.783	5.783	5.777
INFRARED OUTPUT (VOLTS)								
1	0.012	0.008	0.007	0.010	0.011	0.008	0.007	0.010
2	0.975	0.970	0.966	0.969	0.969	0.969	0.966	0.968
3	1.966	1.964	1.964	1.962	1.962	1.962	1.961	1.960
4	2.940	2.938	2.936	2.935	2.938	2.936	2.936	2.935
5	3.949	3.947	3.947	3.944	3.944	3.944	3.942	3.942
6	4.926	4.922	4.919	4.921	4.919	4.917	4.919	4.914
7	5.921	5.915	5.915	5.914	5.917	5.912	5.913	5.910

Table 2-3. Measured Values of NEΔT and Signal-to-Noise Ratio

BASEPLATE TEMPERATURE (DEGREES C)	INFRARED SCENE TEMPERATURE				DAYLIGHT	
	67 DEGREES C		−13 DEGREES C		100-PERCENT ALBEDO	
	rms (MILLIVOLTS)	NEΔT (DEGREES K)	rms (MILLIVOLTS)	NEΔT (DEGREES K)	rms (MILLIVOLTS)	SIGNAL-TO-NOISE RATIO AT 1-PERCENT ALBEDO
+45	13.0	0.15	8.3	0.18	8.3	7.2
+40	11.5	0.13	7.0	0.13	8.0	7.5
+35	13.3	0.15	8.3	0.16	8.3	7.2
+30	14.0	0.15	9.0	0.155	8.3	7.2
+25	15.8	0.17	12.5	0.21	8.3	7.2
+20	15.0	0.16	11.5	0.22	7.0	8.6
+15	15.0	0.16	14.0	0.27	8 3	7.2
+10	15.8	0.17	15.0	0.28	8.3	7.2
+ 5	16.6	0.18	13.3	0.25	–	–
0	15.0	0.17	14.0	0.25	–	–

ORIGINAL PAGE IS
OF POOR QUALITY

Table 2-4. Measured Spectral Data

WAVELENGTH (MILLIMETERS)	FOCUS LENS		SCAN MIRROR	GOLD BEAM-SPLITTER	OG 550 SPECTRAL FILTER	TELESCOPE MIRRORS[a]	TOTAL OPTICS TRANSMISSION	SILICON DETECTOR RESPONSE[b]	OPTICS TRANSMISSION DETECTOR RESPONSE	HCMR RELATIVE RESPONSE
	ONE LENS	TRIPLET								
500	0.910	0.754	C 930	0.750	~0	0.907	~0	0.22	~0	~0
525	0.918	0.774	0.930	0.780	0.140	0.920	0.072	0.24	0.0173	0.062
550	0.925	0.791	0.930	0.800	0.845	0.931	0.463	0.26	0.120	0.432
575	0.933	0.812	0.930	0.819	0.920	0.943	0.535	0.28	0.150	0.540
600	0.938	0.825	0.930	0.829	0.929	0.958	0.566	0.29	0.164	0.590
650	0.946	0.844	0.922	0.838	0.930	0.976	0.592	0.32	0.189	0.680
700	0.952	0.863	0.910	0.830	0.930	0.984	0.596	0.42	0.250	0.899
750	0.957	0.876	0.895	0.802	0.930	0.984	0.575	0.44	0.253	0.910
800	0.960	0.882	0.888	0.780	0.930	0.986	0.534	0.46	0.246	0.885
850	0.980	0.885	0.852	0.708	0.930	0.978	0.486	0.57	0.277	0.996
900	0.980	0.886	0.855	0.643	0.930	0.980	0.443	0.62	0.278	1.000
950	0.980	0.886	0.880	0.580	0.930	0.980	0.402	0.57	0.229	0.824
1000	0.980	0.886	0.880	0.537	0.930	0.978	0.372	0.52	0.193	0.694
1050	0.980	0.886	0.858	0.481	0.930	0.974	0.331	0.37	0.122	0.439
1100	0.980	0.886	0.858	0.438	0.930	0.972	0.301	0.10	0.03	0.108
1150	0.960	0.882	0.880	0.401	0.930	0.976	0.276	0.03	0.008	0.029
1200	0.928	0.879	0.862	0.368	0.930	0.972	0.5'	0	0	C

[a] PRODUCT OF PRIMARY AND SECONDARY MIRROR REFLECTANCE
[b] HARSHAW CHEMICAL COMPANY DETECTOR S N 001

Figure 2-1 shows the relative spectral response of the HCMR detector for channel 1.

Table 2-5 presents the results of the visible channel calibration in units of equivalent albedo. The albedo has been adjusted to account for differences in brightness temperature between the calibration target and the solar spectrum by normalizing solar spectrum. Figure 2-2 presents these data in a graphical format.

2.3 INFRARED CHANNEL DATA

Table 2-6 lists the measured spectral data for the various optical components in the spectral range of the infrared channel.

Figure 2-3 is a plot of the relative spectral response of the HgCdTe detector at 115 degrees K. Figure 2-4 is a plot of the transmission characteristics of the germanium band pass filter used with this detector. Figure 2-5 is a plot of the total relative response of the infrared channel.

Table 2-7 lists the calibration results for the infrared channel with 17 scene temperatures and 10 baseplate temperatures. Figure 2-6 shows the family of curves obtained by plotting the calibration values of Table 2-7.

Figure 2-7 is a plot of the difference between the blackbody temperature as indicated by the thermistors in channel 2 and the temperature obtained from the blackbody located in the backscan position of the radiometer. This quantity, ΔT_{BB}, is assumed to be the result of a thermal gradient between the thermal location on the backstructure of the reference blackbody and the radiating surface of this blackbody. It should be noted that this thermal gradient, ΔT_{BB}, will remain as presented in Figure 2-7 unless the thermal environment of the instrument changes. Thus the preflight values will be the proper values for postflight processing if the space environment has been properly simulated in these thermal-vacuum tests.

ORIGINAL PAGE IS
OF POOR QUALITY

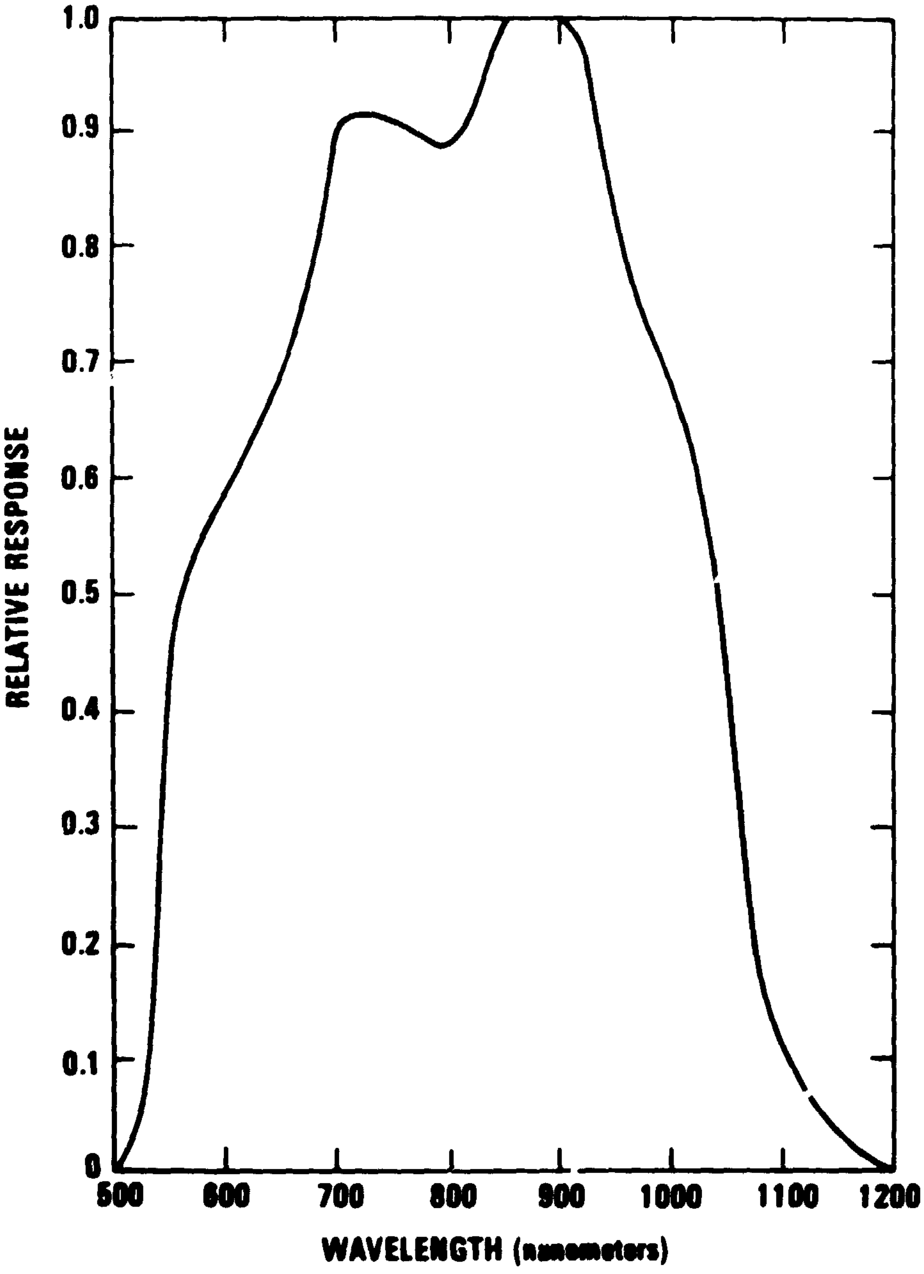


Figure 2-1. HCMR Detector Response for Channel 1

Table 2-5. Near-Infrared Calibration

NUMBER OF LAMPS ON[a]	EQUIVALENT ALBEDO	NEAR-INFRARED OUTPUT (VOLTS)
8	102.3	6.0890
7	89.3	5.3186
6	76.2	4.5534
5	63.6	3.7870
4	51.4	3.0438
3	38.1	2.2546
2	25.1	1.4869
1	12.3	0.7235
0	0	0.0194

[a]GSFC 30-INCH INTEGRATION SPHERE NUMBER 61400-6-7

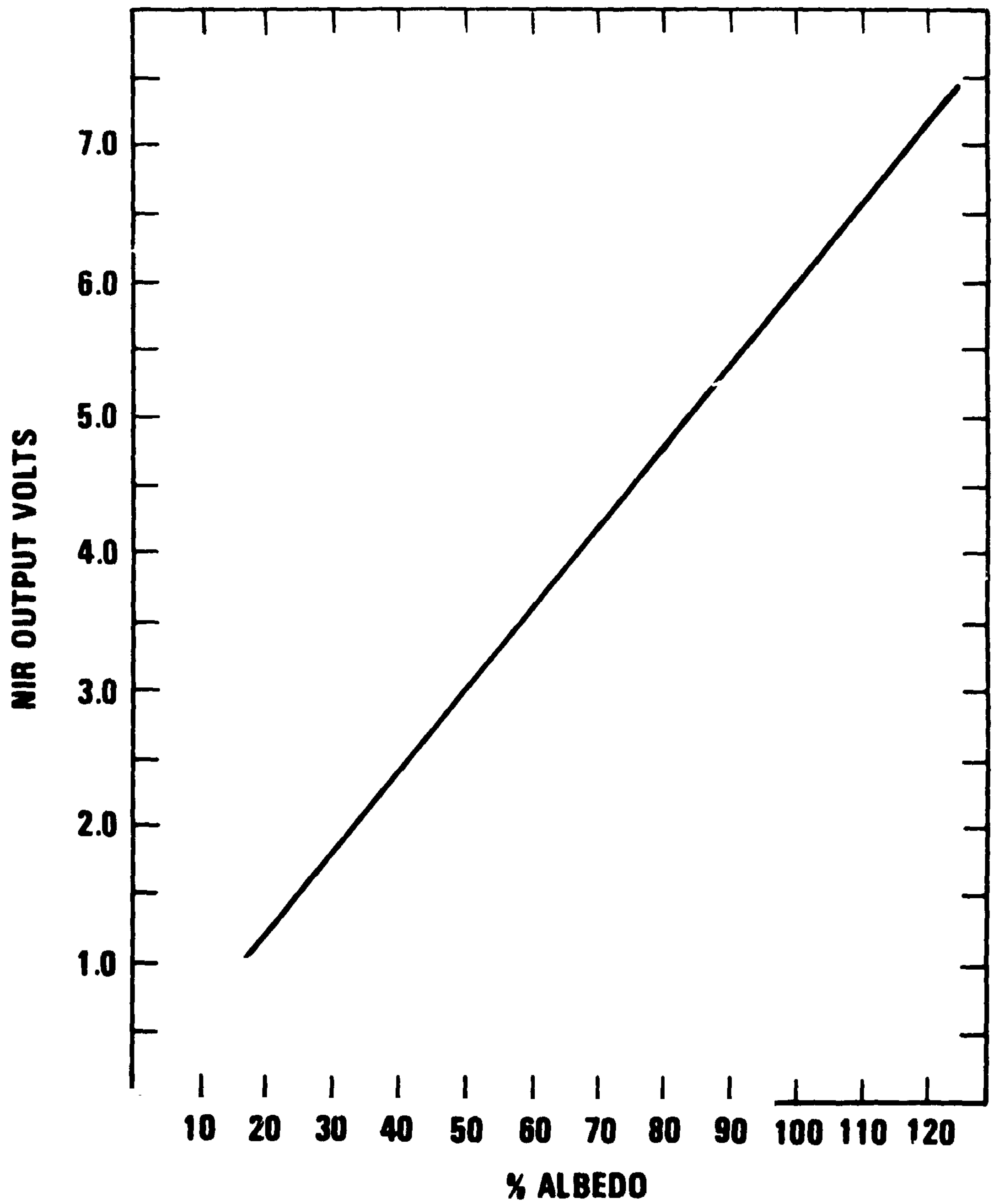


Figure 2-2. Near-Infrared Calibration

ORIGINAL PAGE IS
OF POOR QUALITY

Table 2-6. HCMR Spectral Response Parameters, Infrared Channel

WAVELENGTH (MICROMETERS)	ν (PER CENTIMETER)	BANDPASS FILTER	FOCUS LENS	APLANAT LENS	COOLER WINDOW, HOUSING	COOLER WINDOW, CONE	HgCdTe DETECTOR (115 DEGREES K)	PRODUCT	RELATIVE RESPONSE
10.29	972-1	0.0	–	–	–	–	–	–	0.0
10.4	961	0.11	0.910	0.920	0.902	0.890	0.945	0.070	0.118
10.5	952	0.46	0.915	0.925	0.899	0.889	0.955	0.297	0.500
10.6	943	0.58	0.920	0.930	0.892	0.881	0.968	0.377	0.635
10.7	935	0.74	0.922	0.935	0.885	0.879	0.978	0.485	0.816
10.8	926	0.83	0.923	0.939	0.879	0.875	0.989	0.547	0.921
10.88	919	0.881	0.925	0.941	0.875	0.871	0.992	0.580	0.976
11.01	908	0.842	0.930	0.945	0.870	0.870	1.000	0.560	0.943
11.17	895	0.898	0.932	0.950	0.867	0.870	0.991	0.594	1.000
11.34	882	0.866	0.939	0.950	0.869	0.873	0.958	0.561	0.944
11.47	872	0.895	0.940	0.950	0.872	0.881	0.920	0.565	0.951
11.60	862	0.81	0.940	0.950	0.879	0.879	0.840	0.469	0.790
11.75	851	0.70	0.940	0.948	0.882	0.890	0.748	0.366	0.617
11.90	840	0.81	0.930	0.942	0.880	0.887	0.650	0.360	0.606
12.05	830	0.89	0.931	0.940	0.869	0.880	0.560	0.334	0.561
12.19	820	0.886	0.932	0.939	0.859	0.875	0.490	0.286	0.481
12.34	810	0.80	0.931	0.931	0.848	0.871	0.405	0.207	0.349
12.50	800	0.15	0.921	0.922	0.831	0.870	0.310	0.028	0.048
12.58	795	0.0	–	–	–	–	–	–	0.0

NOTES 1. DICHROIC BEAMSPLITTER, SCAN MIRROR, AND TELESCOPE MIRRORS ALL HAVE UNIFORM TRANSMISSION/REFLECTION OVER THIS SPECTRAL REGION

2. WAVELENGTHS WERE SELECTED IN-BAND AT PEAKS AND VALLEYS OF BANDPASS FILTER TRANSMISSION CURVE. RELATIVE RESPONSE SHAPE (OF HCMR) FOLLOWS SHAPE OF BANDPASS FILTER BETWEEN WAVELENGTHS IN TABLE

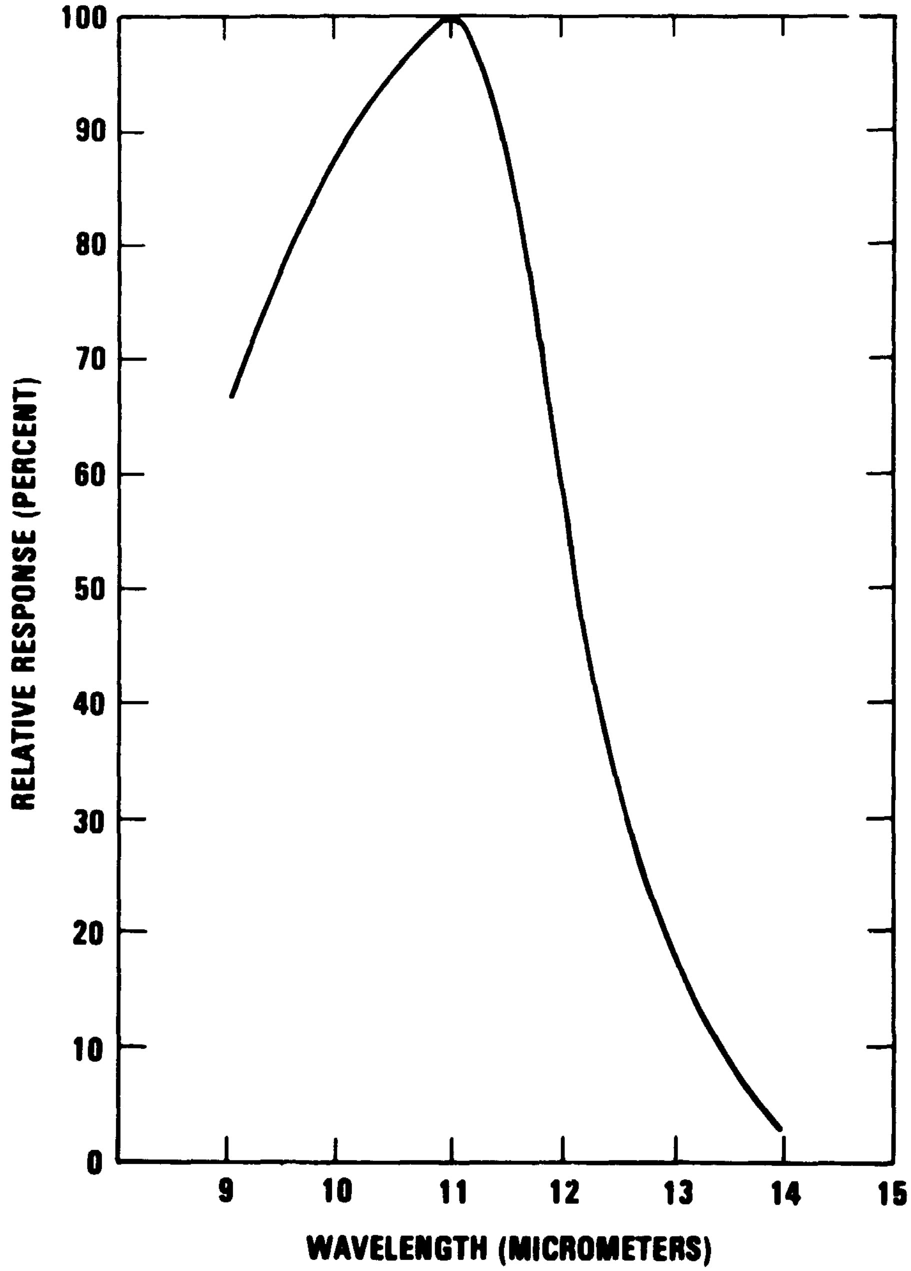


Figure 2-3. Spectral Response of HCMR HgCdTe (Serial Number T-1) at 115 degrees K

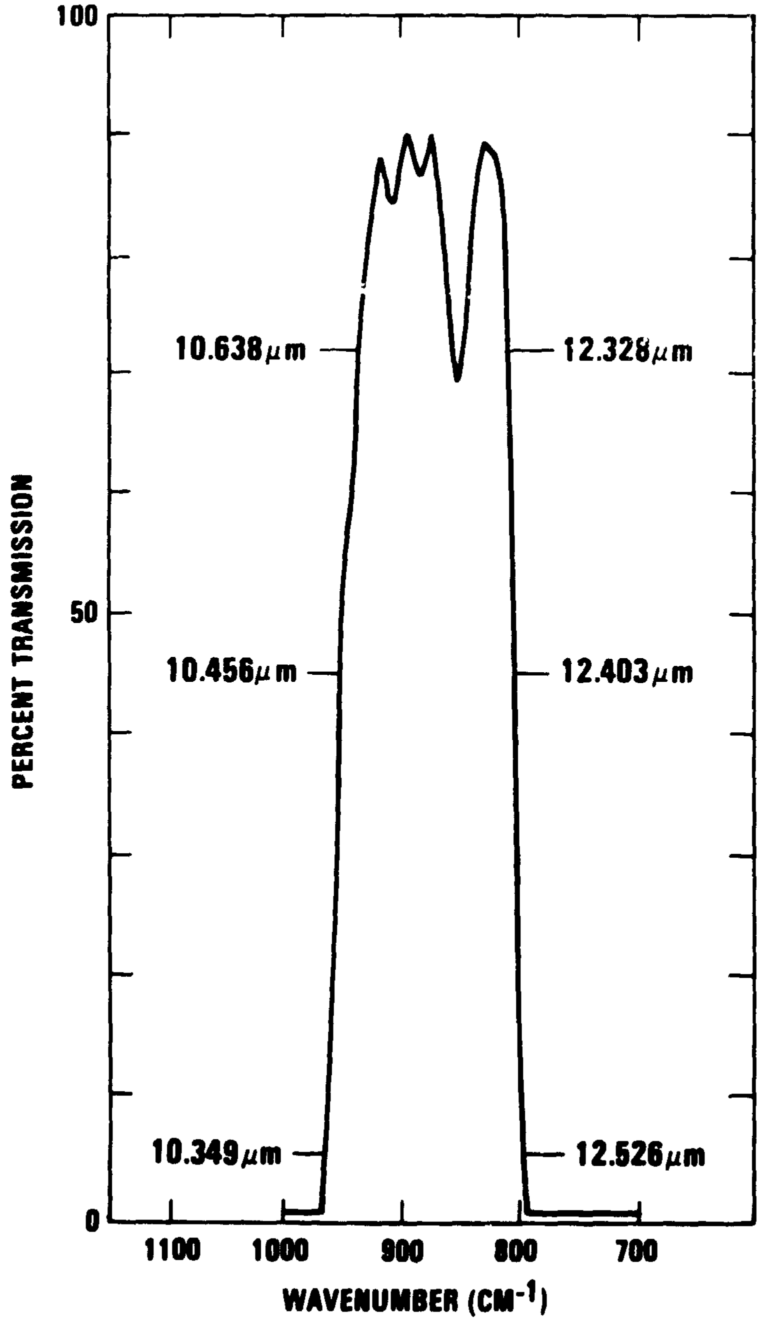


Figure 2-4. Transmission Characteristics of Germanium Band Pass Filter

ORIGINAL PAGE IS
OF POOR QUALITY

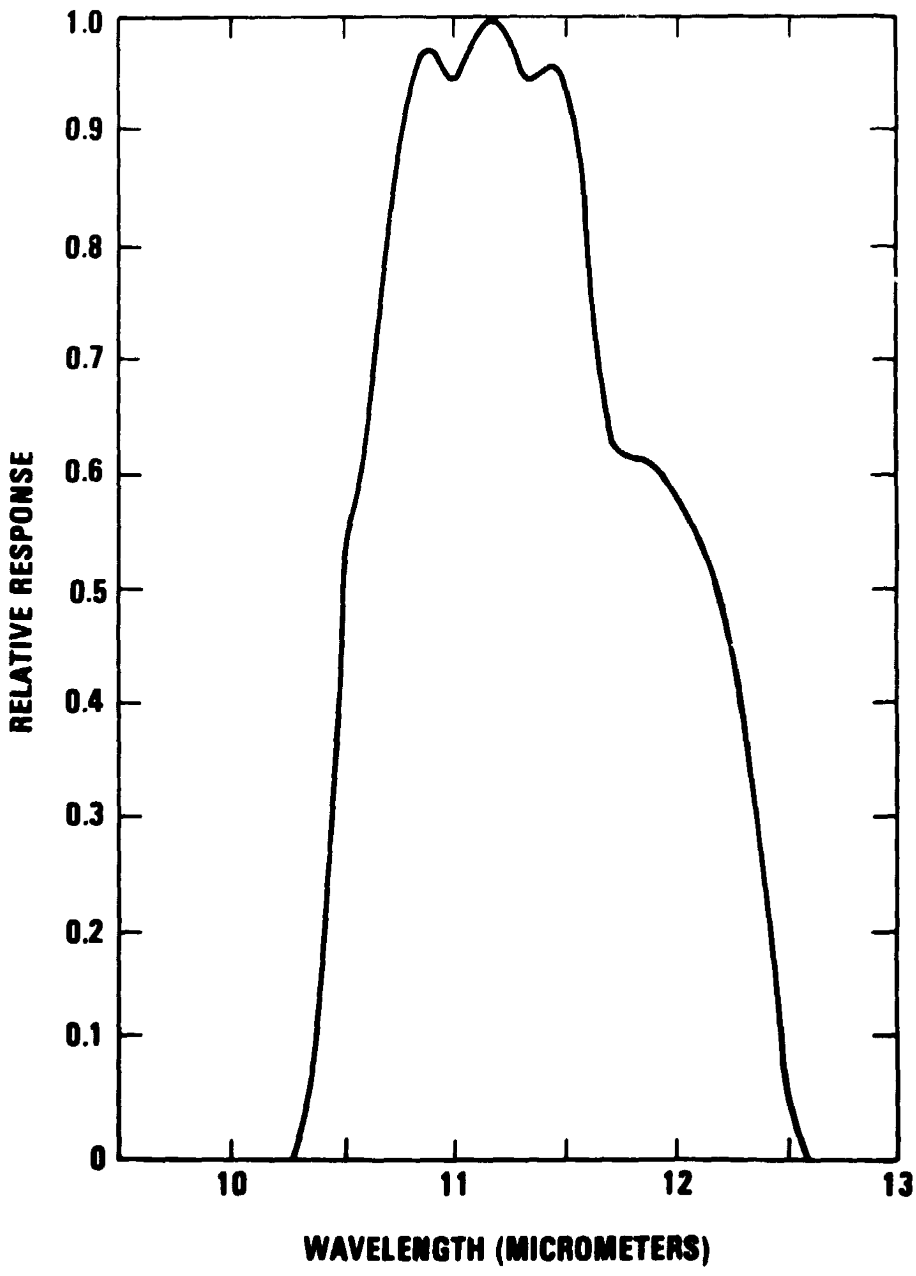


Figure 2-5. HCMR Spectral Response, Infrared Channel

Table 2-7. Infrared Analog Calibration Data (1 of 2)

NOMINAL TARGET TEMPERATURE (DEGREES K)	BASEPLATE TEMPERATURE									
	0 DEGREES C		+5 DEGREES C		+10 DEGREES C		+15 DEGREES C		+20 DEGREES C	
	AVERAGE CALIBRATION TARGET TEMPERATURE	INFRARED SIGNAL (VOLTS)	AVERAGE CALIBRATION TARGET TEMPERATURE	INFRARED SIGNAL (VOLTS)	AVERAGE CALIBRATION TARGET TEMPERATURE	INFRARED SIGNAL (VOLTS)	AVERAGE CALIBRATION TARGET TEMPERATURE	INFRARED SIGNAL (VOLTS)	AVERAGE CALIBRATION TARGET TEMPERATURE	INFRARED SIGNAL (VOLTS)
260	−12.92	0.1240	−13.10	0.1009	−12.95	0.0964	−12.93	0.0879	−13.00	0.0675
265	−8.02	0.3925	−7.94	0.3779	−8.95	0.3590	−8.03	0.3514	−8.01	0.3331
270	−2.91	0.6753	−3.07	0.6534	−2.96	0.6390	−2.97	0.6246	−2.98	0.6085
275	+1.94	0.9657	2.05	0.9496	+2.20	0.9423	+2.12	0.9249	+2.09	0.9046
280	7.85	1.3337	7.06	1.2620	7.18	1.2477	7.04	1.2286	7.17	1.2168
285	12.20	1.6143	12.05	1.5856	12.08	1.5667	12.32	1.5564	12.14	1.5361
290	17.00	1.9482	17.07	1.9264	17.05	1.9019	17.08	1.8904	17.09	1.8640
295	22.04	2.3061	22.06	2.2822	22.05	2.2531	22.10	2.2458	22.17	2.2207
300	27.14	2.6792	27.87	2.7063	27.10	2.6214	26.88	2.5855	27.06	2.5721
305	32.05	3.0451	32.09	3.0275	31.96	2.9913	32.10	2.9815	32.03	2.9481
310	37.04	3.4368	37.00	3.4172	36.97	3.3774	37.00	3.3657	36.98	3.3280
315	42.01	3.8459	42.10	3.8200	42.04	3.7864	42.06	3.7650	42.06	3.7301
320	47.08	4.2723	46.97	4.2357	47.04	4.2054	47.02	4.1778	47.15	4.1601
325	52.01	4.7009	52.03	4.6678	51.96	4.6276	52.05	4.6052	52.05	4.5735
330	56.36	5.1583	57.05	5.1025	57.07	5.0684	57.07	5.0442	57.08	5.0080
335	61.98	5.5881	62.08	5.5672	62.01	5.5194	62.07	5.4921	62.09	5.4616
340	67.14	6.0704	67.03	6.0255	66.97	5.9810	66.95	5.9459	67.02	5.9116

ORIGINAL PAGE IS
OF POOR QUALITY

Table 2-7. Infrared Analog Calibration Data (2 of 2)

NOMINAL TARGET TEMPERATURE (DEGREES K)	BASEPLATE TEMPERATURE									
	+25 DEGREES C		+30 DEGREES C		+35 DEGREES C		+40 DEGREES C		+45 DEGREES C	
	AVERAGE CALIBRATION TARGET TEMPERATURE	INFRARED SIGNAL (VOLTS)	AVERAGE CALIBRATION TARGET TEMPERATURE	INFRARED SIGNAL (VOLTS)	AVERAGE CALIBRATION TARGET TEMPERATURE	INFRARED SIGNAL (VOLTS)	AVERAGE CALIBRATION TARGET TEMPERATURE	INFRARED SIGNAL (VOLTS)	AVERAGE CALIBRATION TARGET TEMPERATURE	INFRARED SIGNAL (VOLTS)
260	−13.01	0.0643	−13.02	0.0357	−12.85	0.0229	−13.14	−0.0006	−11.88	0.0357
265	−8.00	0.3155	−8.01	0.2965	−8.00	0.2818	−7.99	0.2573	−7.99	0.2369
270	−2.80	0.5926	−2.95	0.5752	−2.92	0.5607	−2.97	0.5287	−2.98	0.5084
275	+2.13	0.8927	+2.16	0.8695	+2.27	0.8580	+2.12	0.8201	+2.10	0.7925
280	7.15	1.2008	7.16	1.1762	7.17	1.1575	7.05	1.1138	7.11	1.0906
285	12.16	1.5230	12.14	1.4968	12.15	1.4736	12.12	1.4375	12.17	1.4090
290	17.10	1.8438	17.05	1.8176	17.04	1.7930	17.03	1.7553	17.23	1.7365
295	22.16	2.1968	22.19	2.1673	22.03	2.1382	22.13	2.1051	22.21	2.0730
300	27.03	2.5400	27.18	2.5266	27.11	2.5034	27.15	2.4561	27.15	2.4284
305	31.99	2.9171	32.05	2.8972	31.97	2.8559	32.11	2.8181	32.06	2.7800
310	37.02	3.3016	36.97	3.2690	36.90	3.2375	37.01	3.1917	37.20	3.1687
315	42.08	3.7043	42.08	3.6832	42.02	3.6427	42.08	3.5879	42.07	3.5366
320	47.12	4.1249	47.20	4.0924	47.16	4.0565	47.15	3.9973	47.18	3.9500
325	52.09	4.5471	52.10	4.5002	52.04	4.4629	52.22	4.4196	52.12	4.3617
330	57.08	4.9698	57.04	4.9229	57.12	4.8987	57.10	4.8361	56.93	4.7803
335	62.10	5.4251	62.05	5.3750	62.04	5.3314	62.11	5.2758	62.16	5.2211
340	67.06	5.3765	67.00	5.8231	67.06	5.7887	67.01	5.7119	67.05	5.6535

ORIGINAL PAGE IS
OF POOR QUALITY

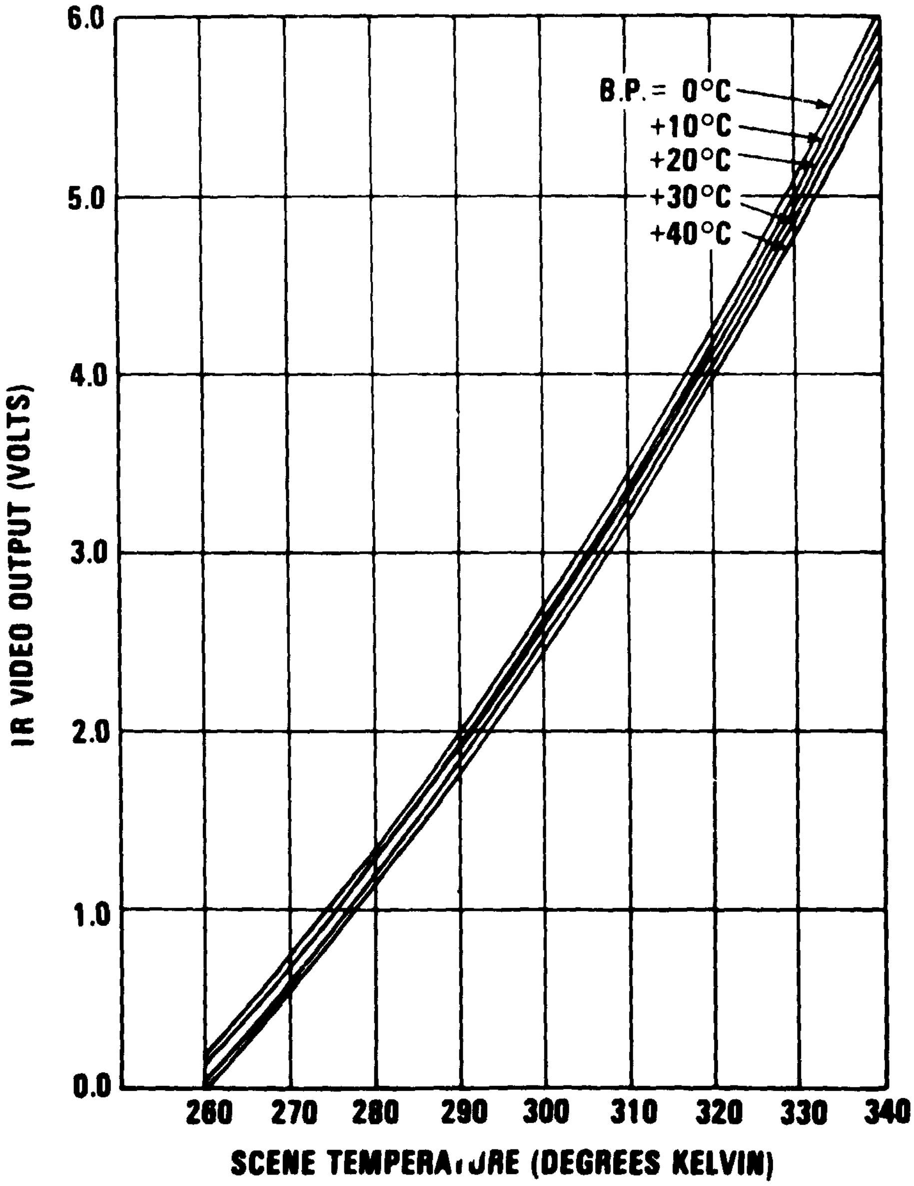


Figure 2-6. Family of Curves Obtained by Plotting Calibration Values of Table 2-7

ORIGINAL PAGE IS
OF POOR QUALITY

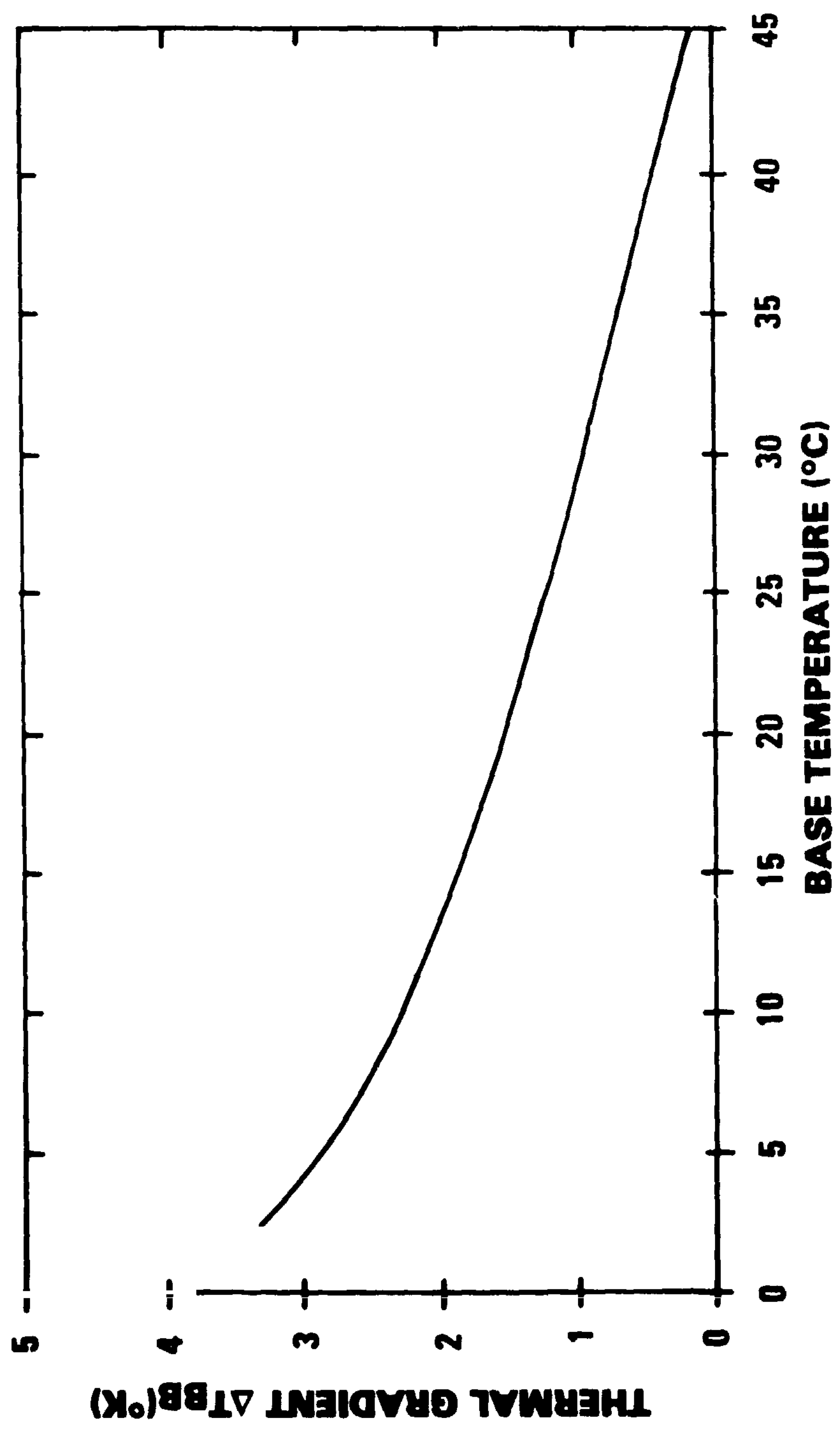


Figure 2-7. Average Difference Between Blackbody Temperature From Signal Line and Blackbody Temperature Read From Signal

2.4 OPTICAL REGISTRATION DATA

Table 2-8 presents the instantaneous field of view (IFOV), the channel registration, and the system modular transfer function (MTF) for both channels for three baseplate temperatures.

ORIGINAL PAGE IS
OF POOR QUALITY

Table 2-8. HCMR IFOV and Registration Data

PARAMETER	BASEPLATE TEMPERATURE					
	0 DEGREES C		25 DEGREES C		45 DEGREES C	
	NEAR-INFRARED CHANNEL	INFRARED CHANNEL	NEAR-INFRARED CHANNEL	INFRARED CHANNEL	NEAR-INFRARED CHANNEL	INFRARED CHANNEL
IFOV						
BENCHTEST						
SCAN DIRECTION (MILLIRADIANS)	ND	ND	0.837	0.99	ND	ND
CROSS-SCAN DIRECTION (MILLIRADIANS)	ND	ND	0.86	0.97	ND	ND
CHAMBER 1 ± FOV TARGET						
SCAN DIRECTION (MILLIRADIANS)	1.16	1.50	1.05	1.27	1.16	1.40
CROSS-SCAN DIRECTION (MILLIRADIANS)	1.075	1.30	1.08	1.36	1.28	1.45
REGISTRATION						
SCAN DIRECTION (MILLIRADIANS)	0.026	–	0.083	–	0.1	–
CROSS-SCAN DIRECTION (MILLIRADIANS)	–	0.063	–	0.032	–	0
MTF AT IFOV TARGET (PERCENT)	55	38	50	35	56	46

NOTE: ND = NO DATA

SECTION 3 - DATA PROCESSING ALGORITHM FOR RADIOMETRIC CALIBRATION AND CORRECTION

3.1 FUNCTIONAL DESCRIPTION OF HCMM PRIMARY DATA PROCESSING

To understand the context in which the radiometric calibration and correction is performed, it is useful to review the entire HCMM primary processing scheme. The two data channels from the experiment are transmitted to the ground as analog signals multiplexed on the 2248.0-megahertz S-band link. The PCM housekeeping telemetry stream is also multiplexed on this data link. To make the data available for the extensive digital processing that it will eventually undergo, a significant amount of preprocessing is required. Apart from the original reception of the data and its recording, most of this preprocessing is performed in a special-purpose system developed to handle the data stream.

The specific functions performed by the preprocessor are the demultiplexing of the composite video that has been received and recorded at the ground station, a scan line synchronization of both the visible and infrared scan lines, and an analog-to-digital conversion of each of the two scan lines at 125 kilohertz. Because not all of the scan line is used in later processing, the preprocessor selectively extracts for digitization only those portions of the scan line that will be later processed. Because the housekeeping telemetry is processed as part of the VHF link, this processing is not duplicated for the S-band link. Several housekeeping parameters do affect the radiometric calibration; these parameters are extracted from the PCM contained on the composite video and are processed and included with the channel 1 and channel 2 digitized output. The primary output of the preprocessor, then, is a high-density tape that will be used as an input to the second step; this tape contains the digitized data from channel 1 and channel 2 as well as selected housekeeping parameters. In addition, this preprocessing phase produces statistics and hardcopies of selected image data for quick-look assessment.

The second phase of the processing, which is performed on the Master Data Processor (MDP), accepts the output high-density tape from the preprocessor, computes radiometric calibration coefficients, and radiometrically corrects the data. The MDP then computes geometric correction coefficients, geometrically corrects the data, frames the input data into approximately 700-kilometer-by-700-kilometer frames, and generates the necessary annotation. Finally the MDP produces a fully corrected archival high-density tape. Further processing of the data (e.g., for night/day registration) is performed on a selected basis by other systems. The radiometric correction discussed in detail in this section is one of the two corrections applied in the main processing cycle.

3.2 BASIS OF HCMR RADIOMETRIC CORRECTION ALGORITHM

The calibration procedure described here has the specific purpose of accepting the digitized radiometer scan data developed by the preprocessor and converting them to values that can be directly interpreted as measurements of scientifically significant parameters such as radiance and brightness temperature.

The input to this processing step received from the preprocessor consists of three separate sets of data:

1. Instrument data from channel 1 (visible/near infrared, 0.5 to 1.1 micrometers)
2. Instrument data from channel 2 (infrared, 10.5 to 12.5 micrometers)
3. Selected housekeeping parameters

The two data channels each produce a full scan every 1/14 second, whereas housekeeping returns instrumental parameters only once every 1 to 8 seconds when in the orbital mode. Housekeeping data used in the reduction of the data channels will be processed on a currently available basis.

The instrument data channels contain two types of information: primary scan data and calibration and performance data. Because the calibration and housekeeping data are relatively stable, an averaging scheme is employed to minimize random noise in these parameters. Because of the possibility of scan-to-scan bounce, however, the averaging scheme will allow averaging over a requested number of scans (N). If N is set to 1, no averaging is performed.

The radiometric calibration of the HCMR is predicated on the following assumptions:

1. The response of the instrument will be as detailed in the system calibration data presented in Reference 1, with the appropriate modifications obtained from the system thermal-vacuum testing and the in-flight calibration data. The system performance during the ITT acceptance testing and calibration will be regarded as nominal, and the calibration values recorded in the supporting documents will be accepted as the nominal values for the mission.

2. The onboard electronic calibration sequence will be used to calibrate current instrument voltages, and the voltage levels of the calibration staircase will be assumed to remain at their nominal values during the mission.

3. A cubic expression may be used to transform current instrument voltages to calibrated values.

4. The near-linear character of the voltage response of the infrared detector with respect to radiant energy input, as indicated in the acceptance calibration, will persist throughout the mission even if the sensitivity of the detector should change.

5. For the visible channel (channel 1), because no in-flight calibration is performed, the preflight calibration will not change during the mission.

6. The space clamp will maintain the output voltage at zero volts for the visible channel and minus the offset bias voltage (V_{OFF}) for the infrared channel when the radiometer has the near-zero radiance input of space. (The $-V_{OFF}$ level will be out of range for the telemetry data and will be represented by the limiting value of zero volts.)

7. For the infrared channel (channel 2), the offset bias voltage (V_{OFF}) applied to the output to maintain the proper range will be proportional to the monitored supply voltage and is not expected to change during the mission.

8. The response of the thermistors and the emissivity of the internal calibration blackbody will not change from nominal during the mission. In addition, the thermal characteristics of the calibration blackbody will not change from nominal unless the instrumental environment changes and independent data confirms that such a change has occurred.

9. The internal calibration blackbody will be used to verify the nominal calibration for the infrared channel (channel 2) as well as to modify the nominal calibration as necessary. Should the blackbody temperature derived from the thermistor measurements be significantly different from that obtained from the radiometer with the nominal calibration, however, an unanticipated system change would be indicated, and the calibration would be subject to reexamination and possible modification using other data such as ground truth measurements.

The validity of these assumptions will be continuously verified to some extent by the calibration program itself so that remedial procedures can be determined and implemented as the need arises.

Preflight constants for HCMM radiometric calibration are presented in Table 3-1.

Table 3-1. Preflight Constants for HCMM Radiometric Calibration

QUANTITY[a]	CONSTANT								
		i = 0	i = 1	i = 2	i = 3	i = 4	i = 5	i = 6	i = 7
N	10								
W_s	0.1								
$VI1_i$			0.001	1.003	1.982	2.986	3.963	4.981	5.958
$VI2_i$			0.102	1.058	1.989	2.943	3.877	4.848	5.781
$VO1_i$			0.006	0.970	1.970	2.947	3.954	4.929	5.924
$VO2_i$			0.009	0.969	1.963	2.937	3.945	4.920	5.915
a_i		−0.312425	43.26225	−0.0728287					
τ_{1i}		332.8817	−15.556	1.772	−0.1917				
W_{BP}	0.2								
τ_{2i}		59.7317	−15.556	1.772	−0.1917				
τ_{3i}		332.8817	−15.556	1.772	−0.1917				
τ_{4i}		333.2296	−15.556	1.772	−0.1917				
W_{Ti}			0.1105	0.1105	0.0790				
σ_i		3.5309	−0.13892	0.26176×10^{-2}	-0.27394×10^{-4}				
ϵ_i		0.71325	1.9×10^{-3}	-3.125×10^{-6}	1.2511591×10^{3}				
W_0	0.1								
ρ_i		5.0096	−0.69922						
b_i		−114.7019	13944.13	14238.17					
V_{Ci}			0.11	2.51	5.01				

[a]THESE QUANTITIES ARE SPECIFIED IN REFERENCE 4.

3.3 MASTER OUTPUT TABLE CONCEPT

Because of system limitations such as instrumental precision and the processing characteristics of the data handling system, both the input and the output of the calibration process will be contained in an eight-bit word. To properly represent the physical quantities that are being sought, master output tables will be used in which appropriate values in radiance units as well as equivalent blackbody temperature and normalized albedo will be listed. These tables are generated so that they include the range of values the instrument is to measure with a maximum increment between successive values that are less than or equal to the system precision. Because these tables need only be updated if profound changes occur in the instrumental characteristics, they are expected to remain fixed during the entire mission. The scan data calibration, then, consists of transforming the counts digitized from the video data stream for both channels 1 and 2 to indices for the master calibration tables, thus eliminating the necessity of several repeated calculations. The eight-bit format dictates that the table will have 256 entries.

For the visible channel (channel 1), one table will give the normalized albedo for each of the 256 outputs covering the range of the instrument. The albedo entries will extend from 0.00 to 1.00 and will represent the ratio of the radiance values measured to the radiance expected from a perfectly reflecting Lambertian surface illuminated by the Sun at vertical incidence. The table entries will be uniformly distributed in albedo. A secondary table will provide the equivalent radiance for each of the albedo values.

For the infrared channel (channel 2), there will be two tables, the first representing the equivalent blackbody temperature and the second giving the radiance values as determined by the Planck function. Because of the channel's near-linearitv, the 256 values will be approximately uniformly distributed in radiance with the corresponding nonuniform distribution for the temperature table. The limits for both tables will be set by the condition that the extreme values for the equivalent blackbody temperature table will be 260 degrees K and 340 degrees K.

Once the master calibration tables are completely defined, they will not be changed during the mission unless profound and currently unexpected changes occur in the system. Expressions for evaluating all table entries for both visible and infrared channels will be presented in a subsequent subsection.

3.4 HOUSEKEEPING DATA EXTRACTION

All of the instrumental housekeeping parameters available are listed in Table 1-2; the nominal values for the analog parameters are summarized in Table 2-1. These data are normally processed with the other housekeeping telemetry. The following four parameters, however, are required for the radiometric calibration procedure and are directly extracted by the preprocessors:

- T_{BP} (baseplate temperature)
- T_{BB1} (blackbody temperature 1)
- T_{BB2} (blackbody temperature 2)
- V_{OFFS} (offset voltage supply)

The first three temperatures (T_{BP}, T_{BB1}, T_{BB2}) are obtained from the corresponding telemetry voltage values (V_{TM}) by the relation

$$T_{TM} = 332.8817 - 15.556\, V_{TM} + 1.772 \left(V_{TM}\right)^2 - 0.1917 \left(V_{TM}\right)^3$$

The offset supply voltage (V_{OFFS}) uses the relation

$$V_{OFFS} = 2V_{TM} - 14.329$$

Because all of these parameters are expected to be quite stable physically, an exponentially decaying averaging process will be applied to eliminate noise from these observations. Any dramatic change in these parameters in flight should be regarded with great concern, because it may significantly affect the processing algorithm.

3.5 SCAN DATA CALIBRATION

The primary instrument data are transmitted from the spacecraft as two analog signals multiplexed on a signal subcarrier. The scan rate is 14 lines per second with both the visible (channel 1) and the infrared (channel 2) synchronized to the scan mirror. The data scan format is nearly identical for both channels and is presented in Figure 3-1. The only difference in format is that for channel 1 the blackbody thermistor measurement is not reported and that portion of the scan is blanked out.

During the preprocessing phase the scan lines are synchronized and digitized, with the two channels being interleaved to provide comparable infrared and visible data. Because not all of the data scan is used in subsequent processing, only six selected intervals are digitized and carried over for further processing. The nominal digitizing intervals are indicated in Figure 3-1. The numbers in parentheses indicate the number of final average values obtained from the scan line. The 6 significant parameters that are digitized are (1) the space view, (2) the input calibration staircase, which consists of 7 levels, (3) the Earth scan measurement, for which 1500 samples cover approximately ±35 degrees from the nadir direction, (4) the 7 values of the output calibration staircase, (5) the blackbody view measurement, and (6) the blackbody thermistor measurement. The preprocessor also extracts the current values of seven parameters from the housekeeping PCM data and includes them with the scan line data. This set of data provides the starting point for the scan line calibration.

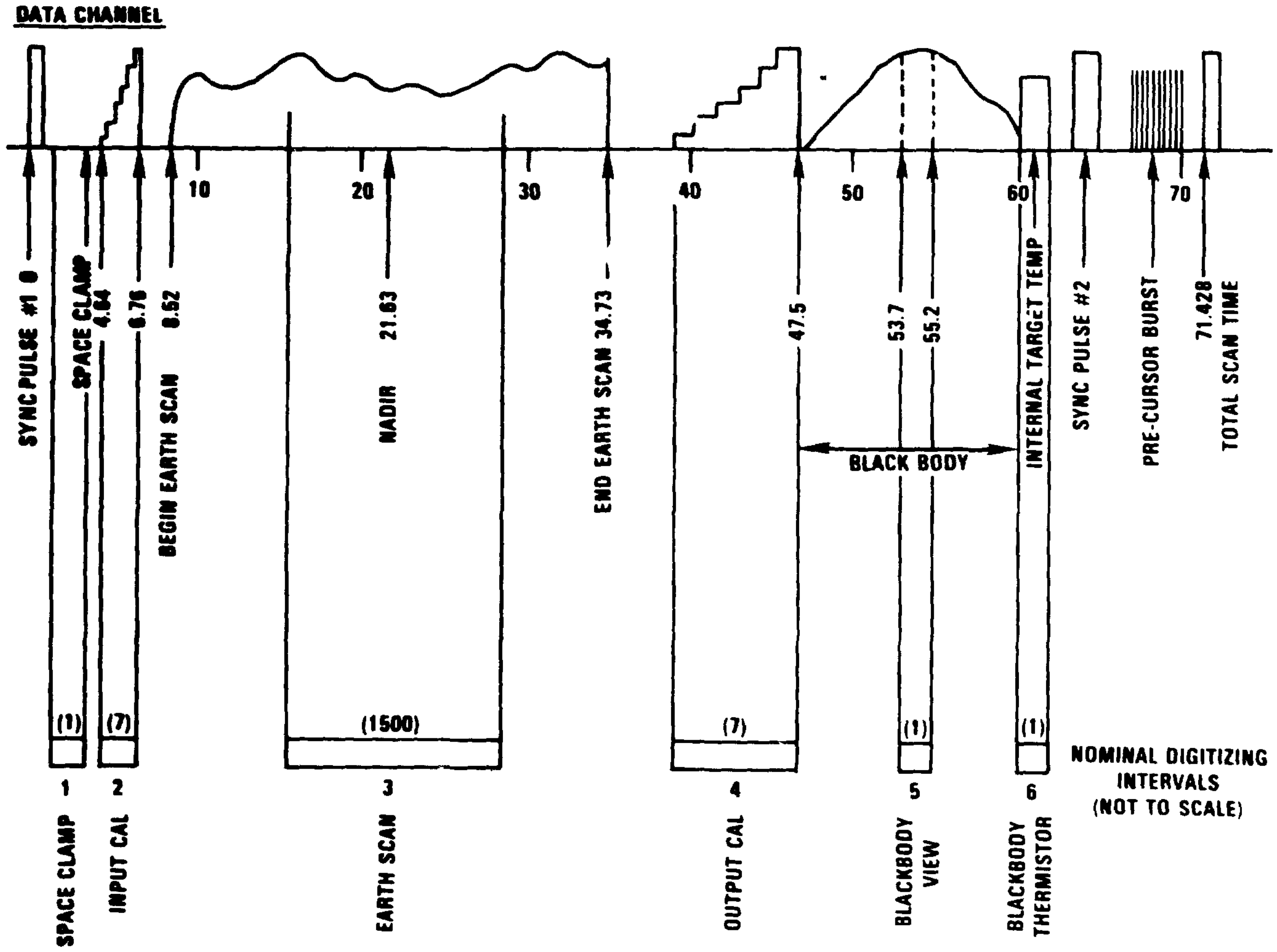


Figure 3-1. HCMR Data Format (not to scale)

An overview of the next processing step is provided in Figure 3-2, which is a schematic representation of the calibration and correction procedure. Starting from the left of that figure, the scan data just described enter the system in a scaled count format (0 to 255). Five of the six digitized measurements are routed to the calibration module; the Earth scan data go directly to the correction module. In addition to the direct scan data, the selected housekeeping data (as well as a number of preflight calibration constants) enter the calibration module. The primary output of this calibration module is the four coefficients that provide the functional transformation of count values to an appropriate radiance or albedo-related index. That transformation function is then transferred to the correction module, where it is applied to each of the Earth scan samples, producing 1500 calibrated indices to the appropriate master output table, which are then output to tape or other processing steps. Ancillary calibration data are also produced for special analysis.

Typically, two levels of conversion are applied to the data in sequence. In the first, a raw voltage count is taken from the data scan and is corrected for instrumental errors using the calibration staircases to obtain a calibrated scan voltage. The second level of conversion transforms the calibrated output voltage to a scaled, physically significant quantity (e.g., temperature, voltage, albedo) using some physical calibration. To clarify the two steps in the following descriptions, the corrected and calibrated voltages are designated by a subscripted V. The second level of conversion uses variable names suggestive of the physical quantities involved.

3.5.1 Count-To-Voltage Conversion

The first level of conversion in which calibrated scan voltages are obtained applies to both channels in exactly the same way. This step is thus discussed here before proceeding to those elements that are unique to each channel. The calibration reference for the count-to-voltage conversion is obtained from the two calibration voltage staircases that are inserted into the signal in each of

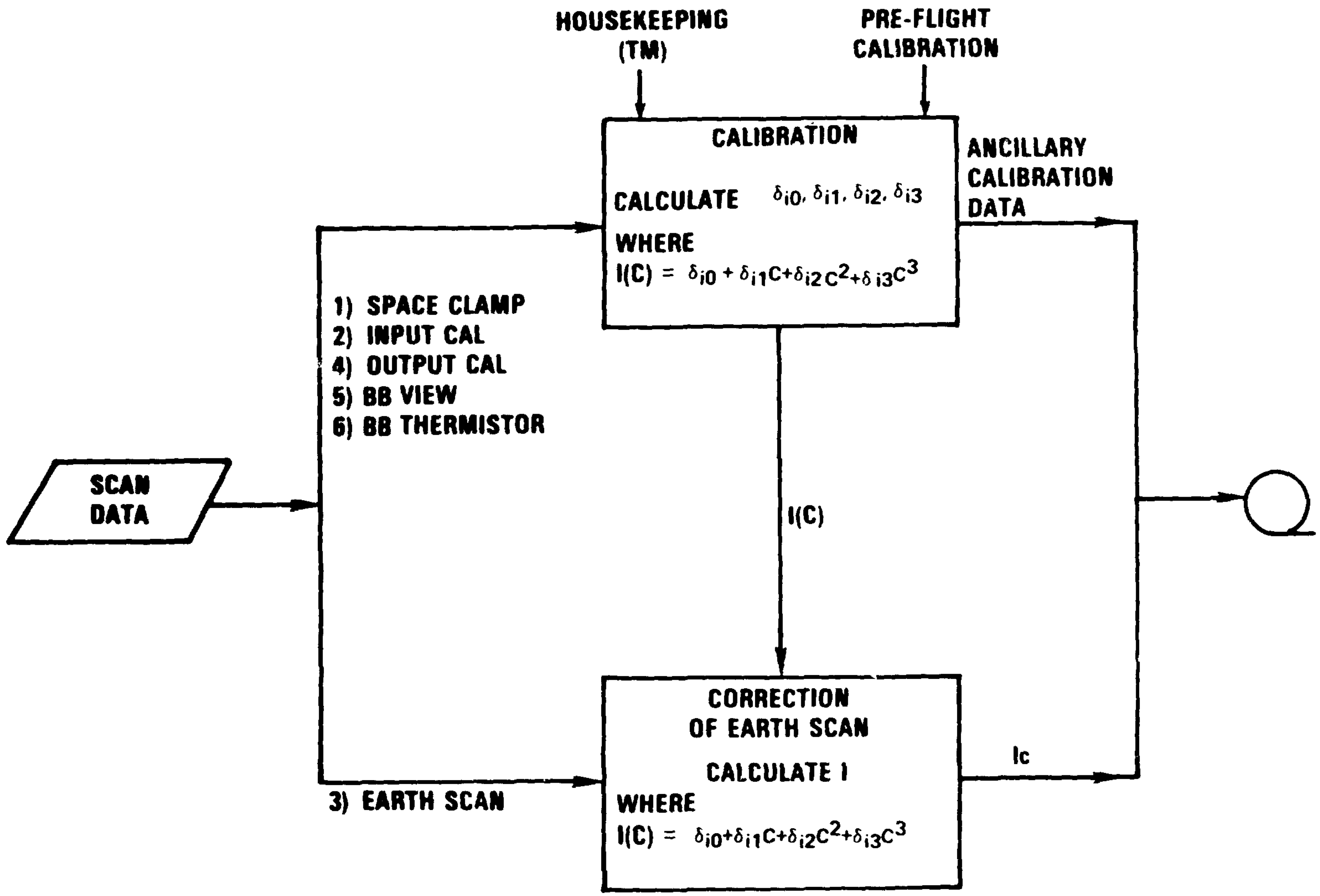


Figure 3-2. HCMR Radiometric Calibration and Correction

the channels. The input calibration sequence is injected into the system immediately after the detector and at the input to the preamplifier. It consists of a set of seven voltage levels, the nominal values of which are 0 to 6 volts in 1-volt steps. The actual values measured by the ITT acceptance test are presented in Reference 1 and are reproduced in Table 2-2. This calibration signal allows for correction of any level of drift or nonlinearities introduced into the system from the preamplifier or through the amplifier, the telemetry system, the downlink, the ground station, or the preprocessor. A second set of seven calibration steps is inserted at the output of the final amplifier and at the input to the telemetry system. This output calibration staircase provides largely redundant information and is used only for amplifier linearity checks and to calibrate the thermistor measurement on the second channel.

Because the voltage levels could not be measured in the spacecraft system configuration, the reference values will be the ITT final acceptance values (as indicated in Section 3.2). These values will be assumed to be unchanged during the mission. Table 2-2 presents these measured values for a range of baseplate temperatures from 5 degrees C to 40 degrees C. Close inspection reveals that the variation of the step values with baseplate temperature is less than or of the order of 0.1 percent of the 6-volt range. For this reason the nominal values for the step voltage can be considered to be independent of baseplate temperature, and the average values for all baseplate temperatures have been used in the calibration processing. These are provided in Table 3-2.

Because of constraints imposed by the processing system, it was determined that a cubic expression would be used to approximate the count-to-voltage relationship for the calibration staircases. This approximation provides an acceptable accuracy level for the preflight data. Unless the system changes dramatically in flight, this approximation is expected to be quite adequate for the life of the mission.

Table 3-2. Nominal Volts for Input and Output Calibration Steps

STEP NUMBER	NEAR-INFRARED INPUT (VOLTS)	NEAR-INFRARED OUTPUT (VOLTS)	INFRARED INPUT (VOLTS)	INFRARED OUTPUT (VOLTS)
1	0.001	0.006	0.102	0.009
2	1.003	0.970	1.059	0.969
3	1.982	1.970	1.989	1.963
4	2.986	2.947	2.943	2.937
5	3.963	3.954	3.877	3.945
6	4.981	4.929	4.849	4.920
7	5.968	5.924	5.781	5.915

3.5.2 Channel 1 Data Calibration (Visible/Near-Infrared Sensor)

As previously indicated, the processing is divided between two modules, one that performs a recalibration and generates functional transformation coefficients and a second that applies that transformation to each sample in the Earth scan. The form of the transformation has been established as a cubic polynomial for both channels, so the correction module need not be discussed further. The module that requires further explanation, however, is the calibration module that develops the transformation coefficients. Figure 3-3 presents a schematic representation of this module for channel 1. In this case the procedure is straightforward, with only two significant elements. The first, a voltage calibration, accepts as input the seven input calibration steps and uses a least-squares procedure to fit these values to the nominal voltage values given in Table 3-2. The resultant cubic expression is passed to the next element, where it is combined with a quadratic expression for the albedo index as a function of calibrated voltage. This last expression was obtained by a least-squares fit to the data in Table 2-5. The final expression gives the albedo as a function of raw count values with all terms beyond cubic discarded. The cubic coefficients are then transferred to the correction module. Reference conversions are performed on several additional data elements in the scan for special analysis on noise and performance. The simplicity of this calibration is attributable to the fact that there is no onboard calibration of the channel 1 sensor, and therefore the sensor performance is assumed to remain fixed during the mission. Only the voltage calibration can be introduced into the processing.

3.5.3 Channel 2 Data Calibration (Infrared Sensor)

Because the infrared detector has onboard calibration capabilities, the calibration module for this channel is significantly more involved than that for the visible channel. Figure 3-4, a schematic representation of this module, illustrates the point. The voltage calibration element functions just as for

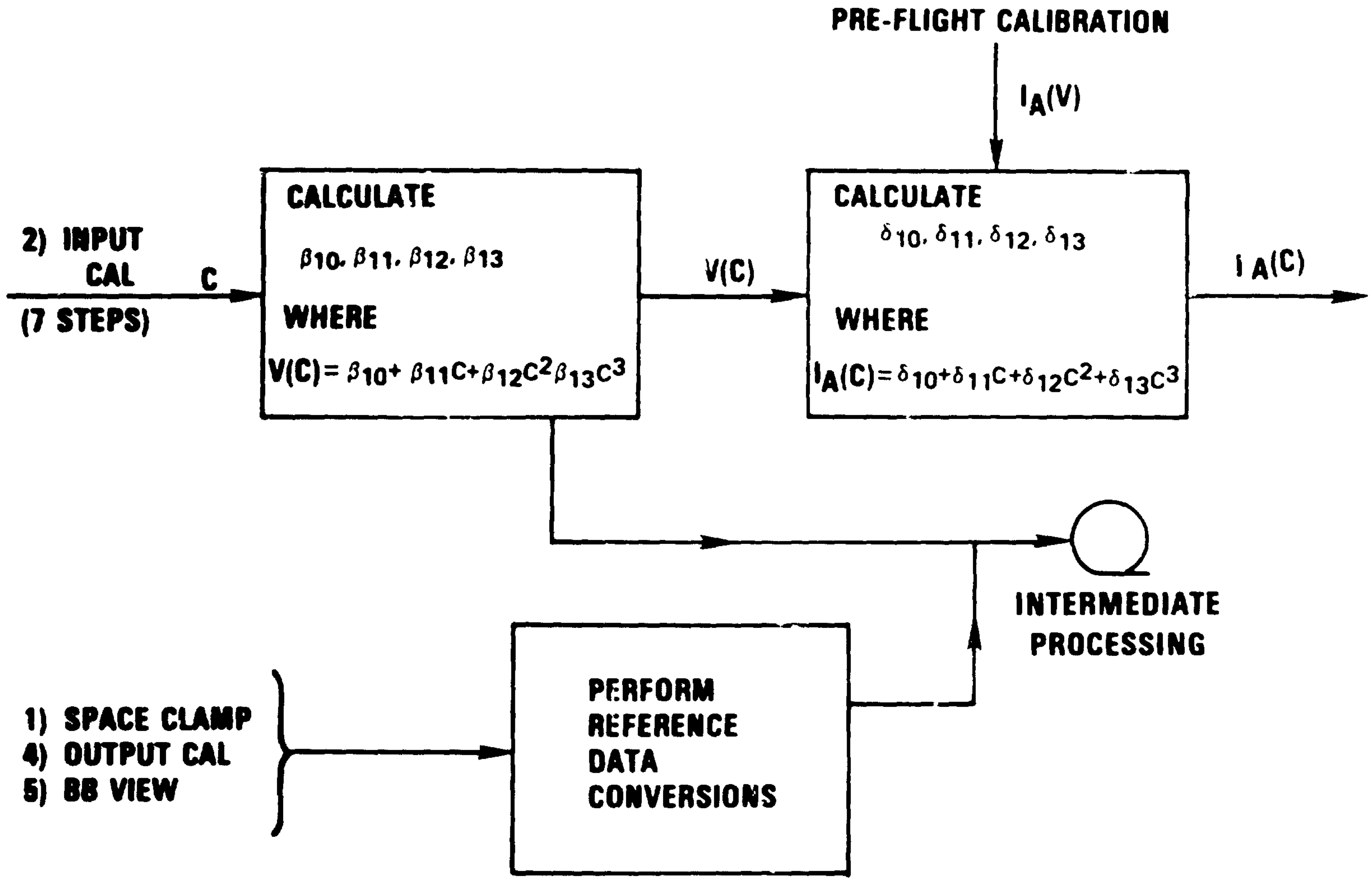


Figure 3-3. Channel 1 Calibration (General)

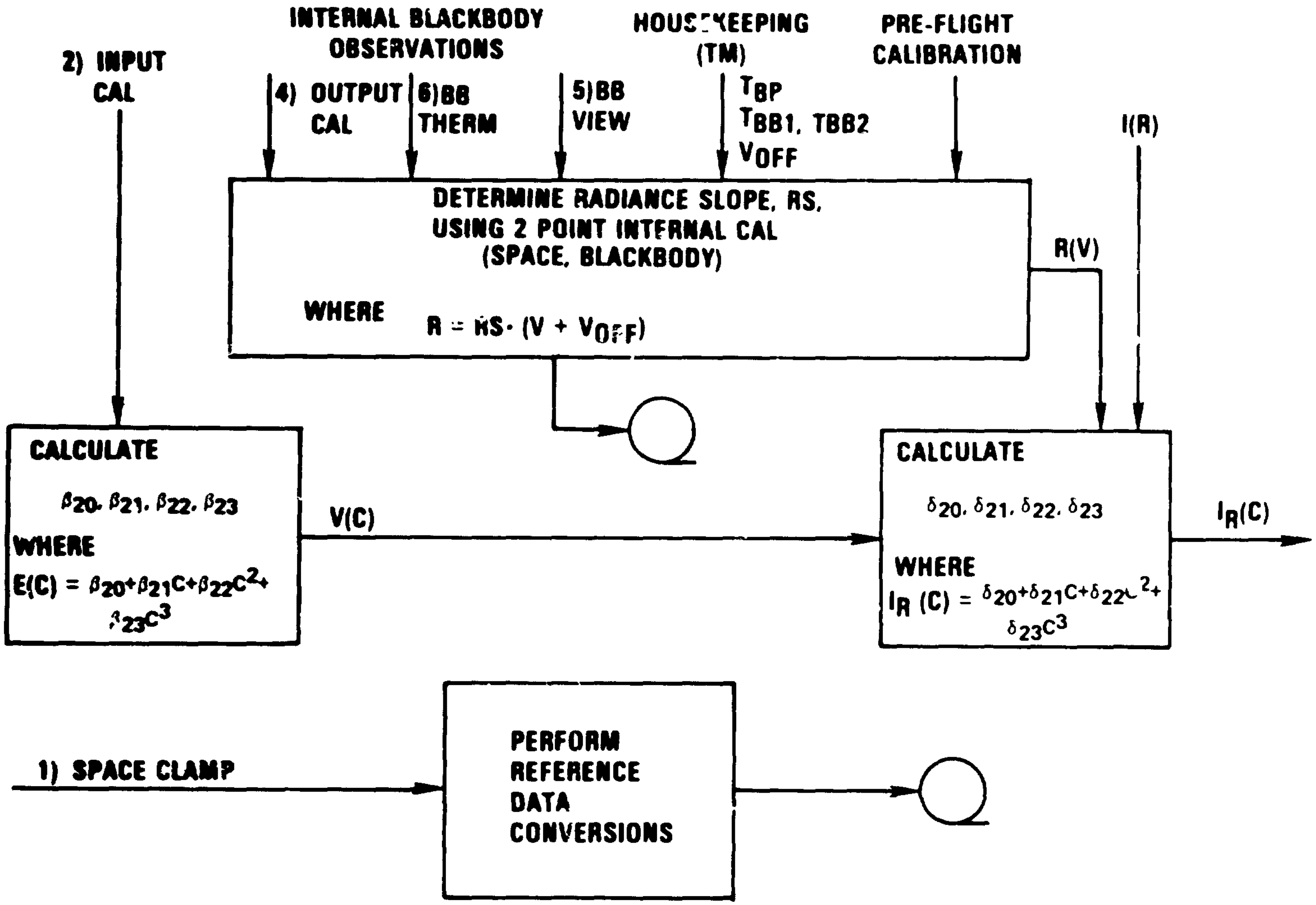


Figure 3-4. Channel 2 Calibration (General)

channel 1, accepting input calibration steps and using at least-squares procedure to fit a cubic polynomial to the preflight data of Table 3-2.

For the second element it is useful to review the relevant features of the instrument as well as some of the assumptions made in Section 3.2. When the calibration data contained in Table 2-7 are reformatted to use radiance rather than temperature as an input parameter, the voltage response is found to be a nearly linear function of radiance. With a slight modification of the Planck function it is possible to obtain a quantity, R, which is more nearly linear with voltage. This function, defined by

$$R = \frac{\epsilon_0 + \epsilon_1 T + \epsilon_2 T^2}{\left(e^{\epsilon_3/T} - 1\right)} \tag{3-1}$$

is used as the basic quantity for recalibrating the data. Assumption 4 of Section 3.2 implies that this quantity will remain linear with respect to voltage throughout the mission even if the gain of the detector changes. It is thus possible to determine the gain by using two known points to locate this line in the R-V plane. The two points that are available are the near-zero temperature of space, which is automatically incorporated into the scan reference, and the internal blackbody, which has a monitored temperature determined by the baseplate temperature. To set the telemetry range to 260 degrees K to 340 degrees K, a bias of magnitude V_{OFF} volts is introduced into the system. This implies that when the instrument is looking at space, the infrared channel has a true output of $-V_{OFF}$ volts. The slope (RS) of the straight line containing the space point ($-V_{OFF}$, 0) and the blackbody with an R value of R(T) with voltage output of V would be

$$RS = \frac{R - 0}{V - (-V_{OFF})}$$

or

$$RS = \frac{R}{V + V_{OFF}} \qquad (3\text{-}2)$$

Given the thermistor-measured temperature of the blackbody and the instrument response to the blackbody, this fundamental relationship is used to recompute the gain of the sensor.

A more detailed diagram of the internal blackbody calibration is presented in Figure 3-5. Starting in the upper-left corner, the first block averages the measurements of the blackbody temperature that are received from the telemetry and from data channel 2 with previously received values using an exponential averaging method. Once a suitably averaged value of the blackbody temperature is obtained, a correction that is a function of baseplate temperature is applied. This correction, determined by ITT and verified in the thermal-vacuum test, is presented in Figure 2-7. It should be noted, however, that flight data suggest that this correction has changed. This is discussed in Section 5.3.2.

The corrected value of the blackbody temperature is used to calculate a value of R . This value, R_{BB} , is then used in Equation (3-2) to obtain a slope, RS . Combining the electronics calibration with the R relationship, a conversion from counts to R is obtained. Finally, an index function can be obtained via this result with a scaling function that also converts the R values to values defined by the Planck function. This last correction is necessary to effect an easily calculated relationship between the master output table and T . After the final set of coefficients has been determined, it is transferred to the correction module for processing of the Earth scan samples.

3.6 MASTER OUTPUT TABLES

This section describes the expressions for evaluating the primary and secondary table entries for both visible and infrared channels. The master output

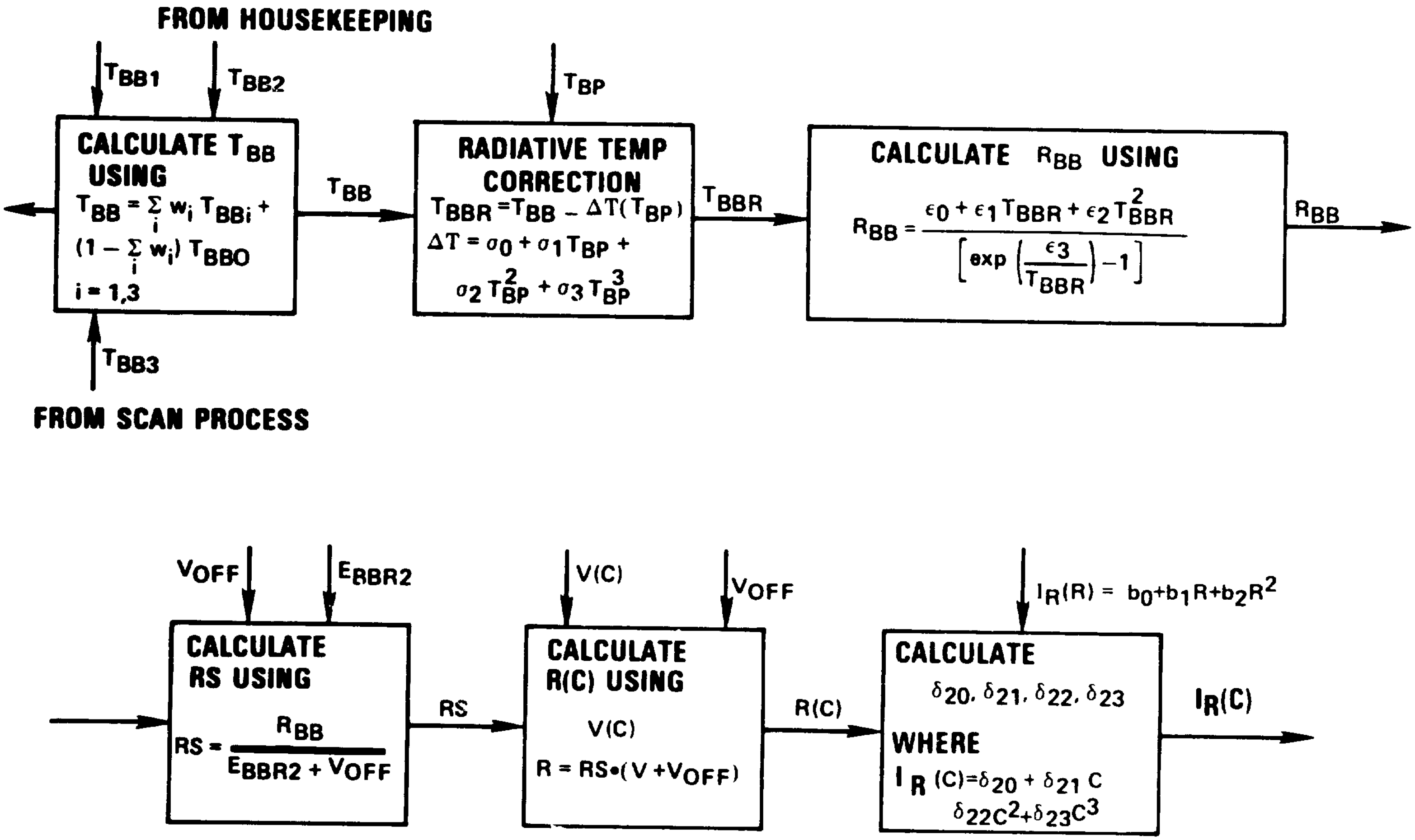


Figure 3-5. Channel 2 Calibration (Internal Blackbody)

table concept was described in Section 3.3. Section 3.6.1 gives the expression for converting output indices to the normalized albedo for the visible channel and to equivalent blackbody temperature for the infrared channel. Section 3.6.2 presents the expression for converting output indices to equivalent radiance values for both channels.

3.6.1 Primary Tables

3.6.1.1 Channel 1 (Visible/Near-Infrared)

The albedo is proportional to the output index

$$A = \alpha I_i$$

where A is the albedo, and I_i is the output index, with limiting conditions

$I_1 = 0$ when $A = 0.00$

$I_1 = 255$ when $A = 1.00$

This gives

$$A = (3.9215686 \times 10^{-3})\, I_1$$

Some sample values are given below:

I_1	A
0	0.0
100	0.392157
200	0.784314
255	1.000000

3.6.1.2 Channel 2 (Infrared)

The Planck function can be written

$$W_\lambda = \frac{C_1' \lambda^{-5}}{[\exp(C_2 | \lambda T) - 1]}$$

where C_1' = 37418.44 watts per centimeter per micrometer^4

C_2 = 14388.33 micrometers per degree K

(These values are from Reference 3.)

If

$$\lambda = 11.5\ \mu m$$

$$\Delta\lambda = 2.0\ \mu m$$

and

$$\Delta W_\lambda(T) = W_\lambda(T)\ \Delta\lambda$$

where T is the temperature, the output index can be defined by

$$I_2 = \Delta W_\lambda(T) + W_o \qquad (3\text{-}3)$$

where W_o is a constant, and I_2 is the output index for the infrared channel. Combining constants, Equation (3-3) can be written as

$$I_2 = \frac{K_1}{\exp(K_2/T) - 1} + K_3 \qquad (3\text{-}4)$$

where K_1 , K_2 and K_3 are constants, with

$$K_2 = \frac{C_2}{11.5} = 1251.1591 \text{ deg K}$$

Using the limiting conditions

$I_2 = 0$ when $T = 260$ degree K

$I_2 = 255$ when $T = 340$ degree K

Equation (3-4) can be solved for K_1 and K_3 as follows:

$$0 = \frac{K_1}{\exp(K_2/260) - 1} + K_3$$

$$K_1 = -K_3[\exp(K_2/260) - 1]$$

$$255 = \frac{K_1}{\exp(K_2/340) - 1} + K_3$$

$$255 = \left\{ - \frac{[\exp(K_2/260) - 1]}{[\exp(K_2/340) - 1]} + 1 \right\} K_3$$

Thus

$$K_3 = -118.21378$$

$$K_1 = 14421.587$$

Solving Equation (3-4) for T ,

$$I_2 - K_3 = \frac{K_1}{\exp(K_2/T) - 1}$$

$$\exp(K_2/T) = \frac{K_1}{I_2 - K_3} + 1$$

$$\frac{K_2}{T} = \ell n \left\{ \frac{K_1}{I_2 - K_3} + 1 \right\}$$

$$T = \frac{K_2}{\ell n \left\{ \frac{K_1}{I_2 - K_3} + 1 \right\}}$$

Thus

$$T = \frac{K_2}{\ell n \left\{ \frac{K_1}{I_2 - K_3} + 1 \right\}}$$

where K_1 **= 14421.587**

K_2 **= 1251.1591 degrees K**

K_3 **= -118.21378**

Some sample values are given below:

I_2	T
0	260.000
100	297.468
200	326.198
255	340.000

3.6.2 Secondary Tables

3.6.2.1 Channel 1 (Visible/Near-Infrared)

The HCMR has been calibrated using a source to simulate the effect of diffusely reflected solar radiation.

The defining expression relating albedo and radiance for a given wavelength as used for this experiment is

$$R(\lambda) = A \frac{H(\lambda)}{\pi}$$

where $R(\lambda)$ = spectral radiance (watts per square centimeter per micrometer per steradian)

A = albedo (dimensionless)

$H(\lambda)$ = spectral irradiance of the Sun outside the atmosphere (watts per square centimeter per micrometer)

To obtain the effective response over the spectral width of the instrument response function ($T_1(\lambda)$), a weighted mean of the radiance is obtained from the expression

$$\bar{R} = \frac{\int_{\lambda_1}^{\lambda_2} T_1(\lambda)\, R(\lambda)\, d\lambda}{\int_{\lambda_1}^{\lambda_2} T_1(\lambda)\, d\lambda}$$

$$= \frac{A}{\pi} \frac{\int_{\lambda_1}^{\lambda_2} T_1(\lambda)\, H(\lambda)\, d\lambda}{\int_{\lambda_1}^{\lambda_2} T_1(\lambda)\, d\lambda}$$

Using the solar spectrum and the response function that was used by ITT in the original calibration, the following is obtained:

$$\bar{R} = \frac{A}{\pi} . 0.112437$$

$$= 3.579 \times 10^{-2} A$$

where $\bar{R}$ is the mean radiance viewed by channel 1 (watts per square centimeter per micrometer per steradian), and A is the albedo (0 to 1.0).

Using the defining relation for the albedo table,

$$A = (I_1/255) = 3.9215686 \times 10^{-3} I_1$$

the following is obtained:

$$\bar{R} = 14.035 \times 10^{-5} I_1 \text{ watts cm}^{-2} \mu\text{m}^{-2} \text{ sr}^{-1}$$

where I_1 is the index value for channel 1.

The effective mean wavelength is

$$\bar{\lambda} = \frac{\int T_1(\lambda)\, \lambda d\lambda}{\int T_1(\lambda)\, d\lambda} = 0.814 \ \mu\text{m}$$

where the half-maximum points of the response function occur at

$$\lambda_1 = 0.560 \ \mu\text{m}$$

and

$$\lambda_2 = 1.040 \ \mu\text{m}$$

and where the instrument response function $T_1(\lambda)$ is given in Table 2-4.

3.6.2.2 Channel 2 (Infrared)

For this channel the radiance values are obtained by assuming a blackbody source at the temperature obtained from the primary calibration table. This expression is of the form

$$T(I_2) = \frac{K_2}{\ell n \left\{ \frac{K_1}{I_2 - K_3} + 1 \right\}}$$

where T is the temperature for an output index value of I_2 from channel 2, and K_1, K_2, and K_3 are as defined in Section 3.6.1.

The mean radiance is then obtained from the expression

$$\bar{W}(T) = \frac{1}{\pi} \frac{\int_{\lambda_1}^{\lambda_2} T_2(\lambda)\, W(\lambda, T)\, d\lambda}{\int_{\lambda_1}^{\lambda_2} T_2(\lambda)\, d\lambda}$$

where $T_2(\lambda)$ is the response function given in Table 2-6 for channel 2, and $W(\lambda, T)$ is the Planck function for temperature T.

The values of $\bar{W}(T)$ or $\bar{W}(I_2)$ can be represented in tabular form.

The relationship between I_2, the output from channel 2, and $\bar{W}(I)$ can be approximated by the following linear expression to better than 0.25 percent:

$$\bar{W}(I) = 4.823047586 \times 10^{-4} + 4.2097918 \times 10^{-6}\, I_2$$

where $\bar{W}$ is the mean radiance in watts per square centimeter per micrometer per steradian.

A better approximation (0.1 percent) can be obtained by using the primary table to obtain T as a function of I_2 and evaluating the following expression:

$$\bar{W}(I_2) = \frac{1}{\pi}\left\{\frac{C_1'(11.33564)^{-5}}{\left[\exp\left(\frac{C_2}{11.33564T}\right) - 1\right]} + 1.09803 \times 10^{-8} I_2 - 7.2 \times 10^{-6}\right\}$$

The effective mean wavelength for channel 2 is given by

$$\bar{\lambda} = \frac{\int T_2(\lambda)\, \lambda d\lambda}{\int T_2(\lambda)\, d\lambda} = 11.3356\ \mu m$$

The half-maximum points for the response function occur at

$$\lambda_1 = 10.50\ \mu m$$

and

$$\lambda_2 = 12.12\ \mu m$$

SECTION 4 - INTEGRATED SPACECRAFT THERMAL-VACUUM CALIBRATION

The integrated AEM-A spacecraft thermal-vacuum test was conducted in February 1978 at GSFC. A detailed description of the procedures may be found in Reference 5. Data for the infrared channel were taken at three baseplate temperatures: hot (33.8 degrees C), ambient (19.7 degrees C), and cold (approximately -2.0 degrees C). During each of the three cycles, data were taken for nine Epply target temperatures in the range from 260 degrees K to 340 degrees K in steps of 10 degrees K. For each target temperature approximately 5 PCM snapshots, 10 full scans, and 50 partial scans were recorded. A full scan sequence is described in Figures 1-4 and 1-5. A partial scan contains the data from the Earth scan region. PCM snapshots contain various housekeeping data. Data was recorded on the Mini-Computer Checkout System (MICOS) developed by the Electronic Systems Branch at GSFC. Processing was performed on the GSFC IBM S/360-91 and S/360-75 computers. Using a GSFC-furnished 30-inch-diameter integrating sphere, calibration data for the visible channel were taken outside the thermal-vacuum environment on January 30, 1978, and March 1, 1978, at GSFC. A description of various processing systems and a summary of results are presented in Sections 4.1 through 4.3.

4.1 NEAR-REAL-TIME DATA PROCESSING SYSTEM

A processing system to be implemented on the IBM S/360-91 and S/360-75 computers was developed to analyze the data recorded on MICOS.

4.1.1 Infrared Channel

4.1.1.1 Full Scans

The following five steps are performed to process a full scan:

1. Raw voltages are averaged over the appropriate number of samples for each of the physically significant quantities. The various quantities and the number of samples used for averaging are as follows:

Quantity	Number of Samples
Seven input calibration steps	14 for each
Seven output calibration steps	74 for each
Space clamp	14
Earth scan (Epply calibration target)	30
Blackbody view	62
Blackbody thermistor	74

The root-mean-square (rms) noise for each of the parameters is also calculated.

2. The offset voltage, the baseplate thermistor voltage, and the two blackbody thermistor voltages are obtained and averaged for all PCM snapshots recorded prior to the first full scan. The baseplate and blackbody thermistor voltages are calibrated and converted to temperatures (degrees K) using the following formulas:

$$CV = \frac{56.6 - RV}{10.81}$$

$$T = \sum_{i=1}^{4} D_i \, (CV)^{i-1}$$

where RV is the raw voltage, CV is the calibrated voltage, and T is the temperature. Coefficients D_i are given in Table 4-1.

Table 4-1. Const nts for Processing Spacecraft Calibration Data

FUNCTION	VALUE OF i						
	1	2	3	4	5	6	7
$VI1_i$	0.001	1.003	1.982	2.986	3.963	4.981	5.958
$VI2_i$	0.102	1.058	1.989	2.943	3.877	4.848	5.781
$VO1_i$	0.006	0.970	1.970	2.947	3.954	4.929	5.924
$VO2_i$	0.009	0.969	1.963	2.937	3.945	4.920	5.915
D_i	332.8817	−15.556	1.772	−0.1917	–	–	–
E_i	0.03121	16.79190	–	–	–	–	–

3. Raw averaged voltages for each of the seven input calibration steps, space clamp, Earth scan, and blackbody view are calibrated using linear interpolation or extrapolation. Specifically,

$$CV = VI2_i + \frac{VI2_{i+1} - VI2_i}{RVI2_{i+1} - RVI2_i} (RV - RVI2_i)$$

where RV and CV are typical raw and calibrated voltages, respectively; $RVI2_i$ and $VI2_i$ are raw and calibrated voltages, respectively, for the seven input calibration steps; and $RVI2_i \leq RV < RVI2_{i+1}$. Raw averaged voltages for the seven output calibration steps and the blackbody thermistor are calibrated in a similar manner using the seven output calibration step values from each scan and the predetermined voltage levels given in Table 4-1. Calibrated rms noise for each of the parameters is determined by the following formula:

$$CRMS = \frac{VI2_{i+1} - VI2_i}{RVI2_{i+1} - RVI2_i} (RRMS)$$

where CRMS and RRMS are calibrated and raw rms noise values, respectively, and the other quantities are as previously described.

4. Calibrated voltages and rms noise from the space clamp, Earth scan, and blackbody views are converted to temperatures (degrees K) and noise equivalent temperature (NEΔT) using the following formulas:

$$T = \sum_{i=1}^{5} C_i (CV)^{i-1}$$

$$NE\Delta T = \left[\sum_{i=2}^{5} (i - 1) C_i (CV)^{i-2} (CRMS) \right]$$

where T is the temperature, and C_i is the appropriate set of coefficients described in Table 4-2.

Coefficients D_i, as presented in Table 4-1, are used for converting blackbody thermistor voltage to temperature.

5. A summary for all full scans processed is generated in two parts. The first part contains the averaged calibrated voltage, the scan-to-scan noise in calibrated voltage, and the calibrated rms noise for each of the parameters. The second part contains the averaged temperature, the scan-to-scan noise, and NEΔT for Earth scan, blackbody view, and blackbody thermistor. The difference between the averaged blackbody thermistor and the blackbody view temperatures (ΔT_{BB}) is also calculated.

4.1.1.2 Partial Scans

Samples in partial scans represent the Epply target region. Steps 1 through 4 of Section 4.1.1.1 are performed for each partial scan for Earth scan data. A summary is prepared for Earth scan data as described in step 5.

4.1.2 Visible Channel

Procedures for processing the near-infrared channel data are very similar to those for the infrared channel. Differences are as follows:

1. There are no blackbody thermistor data.

2. Calibrated voltages and rms noise for space clamp, Earth scan, and blackbody views are converted to albedo and NEΔA (noise-equivalent albedo) using the following formulas:

$$A = E_1 + E_2 \text{ (CV)}$$

$$NE\Delta A = E_2 \text{ (CRMS)}$$

Table 4-2. Coefficients for Converting Infrared Video Output to Temperature

BASEPLATE TEMPERATURE (DEGREES C)	C_1	C_2	C_3	C_4	C_5
0	257.997	18.4691	0.942917	−4.37050E-2	1.07279E-2
	258.920[a]	19.2108	−0.980259	−0.86905E-1	0.15648E-1
5	258.019	19.6024	−1.9052	0.227264	−1.25476E-2
10	258.263	19.7513	−1.97098	0.242068	−1.37652E-2
15	258.479	19.6741	−1.91159	0.228179	−1.26373E-2
20	258.794	19.6036	−1.82114	0.202648	−1.04669E-2
	259.532[a]	21.9840	−3.57012	0.615378	−0.43859E-1
25	259.081	19.7079	−1.89414	0.223598	−1.23276E-2
30	259.382	19.6976	−1.8863	0.226533	−1.28293E-2
35	259.797	19.4749	−1.75711	0.199049	−1.07760E-2
	258.857[a]	19.1720	−1.33345	0.64255E-1	0.46033E-3
40	260.007	20.0119	−1.98857	0.242128	−1.35799E-2
45	260.529	19.73	−1.78309	0.191249	−9.31209E-3

[a] A SECOND SET OF COEFFIC[illegible] WAS CALCULATED USING THE MEASURED TARGET TEMPERATURES.

where CV is the calibrated voltage, A is albedo, E_i is as described in Table 4-1, and CRMS and NEΔA are rms noise in calibrated voltages and albedo, respectively.

3. Signal-to-noise ratio is calculated using Earth scan (visible target) data.

4.2 SUMMARY OF RESULTS

Tables 4-1 and 4-2 describe various predetermined quantities (based on ITT calibration) used for analyzing data taken during the thermal-vacuum test at GSFC.

4.2.1 Infrared Channel

When the infrared signal was converted to scene temperature using the first set of coefficients C_i determined by ITT, discrepancies between the calibrated temperatures and the measured temperatures were observed. Deviations for the hot cycle ranged from 0.01 degree K to 2.05 degrees K; for the ambient cycle, from 0.64 degree K to 1.87 degrees K; and for the cold cycle, from 0.91 degree K to 2.14 degrees K. Measured target temperatures and the infrared signal values were used, and a new set of coefficients C_i was obtained using least-squares fit techniques. Tables 4-2 through 4-5 contain the signal, the measured target temperature, and the calibrated scene temperatures obtained using the old and new sets of coefficients for the three cycles. Tables 4-6 through 4-8 contain the signal, the measured target temperature, the calibrated scene temperature obtained using the new set of coefficients, and various noise values, including NEΔT. Values for ΔT_{BB} (the difference between the blackbody thermistor and the blackbody view) are also included. Table 4-9 represents typical rms noise values for various parameters at all three baseplate temperatures.

The seven input and output calibration voltage levels could not be measured during the spacecraft system configuration. However, the data taken during

Table 4-3. Comparison of Temperatures Using ITT Calibration and Spacecraft Calibration - Hot Cycle

NOMINAL TARGET TEMPERATURE (DEGREES K)	TYPE OF SCAN	SIGNAL (VOLTS)	MEASURED TARGET TEMPERATURE (DEGREES K)	INFRARED TEMPERATURE (OLD CALIBRATION) (DEGREES K)	INFRARED TEMPERATURE (NEW CALIBRATION) (DEGREES K)
260	FULL	0.072	260.18	261.19	260.23
	PARTIAL	0.075	260.18	261.25	260.29
270	FULL	0.606	270.33	270.99	269.99
	PARTIAL[a]	–	–	–	–
280	FULL	1.224	280.41	281.35	280.45
	PARTIAL	1.219	280.41	281.26	280.36
290	FULL	1.877	290.38	291.35	290.58
	PARITAL	1.879	290.41	291.37	290.60
300	FULL	2.540	300.05	300.74	300.02
	PARTIAL	2.540	300.04	300.73	300.02
310	FULL	3.296	310.05	310.75	309.91
	PARITAL	3.295	310.05	310.73	309.90
320	FULL	4.159	320.16	321.49	320.29
	PARTIAL	4.146	320.18	321.34	320.14
330	FULL	5.038	330.04	331.82	330.11
	PARTIAL[a]	–	–	–	–
340	FULL	5.980	340.17	342.20	340.14
	PARTIAL	5.981	340.17	342.22	340.16

[a]DATA NOT AVAILABLE

Table 4-4. Comparison of Temperatures Using ITT Calibration and Spacecraft Calibration - Ambient Cycle

NOMINAL TARGET TEMPERATURE (DEGREES K)	TYPE OF SCAN	SIGNAL (VOLTS)	MEASURED TARGET TEMPERATURE (DEGREES K)	INFRARED TEMPERATURE (OLD CALIBRATION) (DEGREES K)	INFRARED TEMPERATURE (NEW CALIBRATION) (DEGREES K)
260	FULL	0.044	260.59	259.65	260.49
	PARTIAL	0.052	260.62	259.81	260.67
270	FULL	0.534	270.37	268.77	270.34
	PARTIAL	0 541	270.37	268.89	270.46
280	FULL	1.115	280.36	278.66	280.40
	PARTIAL	1.115	280.38	278.65	280.39
290	FULL	1.751	289.94	288.53	290.00
	PARTIAL	1.744	289.96	288.42	289.89
300	FULL	2.504	300 30	299.23	300.25
	PARTIAL	2.492	300.29	299.07	300.09
310	FULL	3.274	310.00	309.36	310.14
	PARTIAL	3.265	310.01	309.25	310.03
320	FULL	4.085	320.27	319 38	320 32
	PARTIAL	4.090	320.28	319.44	320.39
330	FULL	4.821	329.57	328.02	329.41
	PARTIAL	4.831	329.58	328.14	329.53
340	FULL	5.748	340.13	338.36	340 20
	PARTIAL	5.739	340.13	338.26	340.10

Table 4-5. Comparison Temperatures Using ITT Calibration and Spacecraft Calibration - Cold Cycle

NOMINAL TARGET TEMPERATURE (DEGREES K)	TYPE OF SCAN	SIGNAL (VOLTS)	MEASURED TARGET TEMPERATURE (DEGREES K)	INFRARED TEMPERATURE (OLD CALIBRATION) (DEGREES K)	INFRARED TEMPERATURE (NEW CALIBRATION) (DEGREES K)
260	FULL	0.085	260.47	259.56	260.54
	PARTIAL	0.077	260.47	259.41	260.39
270	FULL	0.607	270.24	268.86	270.21
	PARTIAL	0.605	270.23	268.82	270.19
280	FULL	1.186	280.07	278.52	280.21
	PARTIAL	1.191	280.08	278.61	280.30
290	FULL	1.788	289.98	287.87	289.80
	PARTIAL	1.787	289.99	287.85	289.78
300	FULL	2.507	300.19	298.10	300.16
	PARTIAL	2.509	300.18	298.14	300.20
310	FULL	3.285	310.00	308.19	310.20
	PARTIAL	3.277	310.00	308.09	310.09
320	FULL	4.151	320.22	318.47	320.20
	PARTIAL	4.137	320.25	318.31	320.05
330	FULL	5.067	330.01	328.01	330.10
	PARTIAL	5.054	329.98	328.61	329.96
340	FULL	5.968	340.10	338.95	340.03
	PARTIAL	5.982	340.14	339.12	340.20

Table 4-6. Spacecraft Calibration Data (Infrared) - Hot Cycle (Baseplate Temperature: 33.8 Degrees C)

NOMINAL TARGET TEMPERATURE (DEGREES K)	SCAN TYPE	MEASURED TARGET TEMPERATURE (DEGREES K)	INFRARED TEMPERATURE (NEW CALIBRATION) (DEGREES K)	ΔT (CALIBRATION MINUS MEASURED) (DEGREES K)	NEΔT		SIGNAL (VOLTS)	NOISE		ΔT_{BB} (NEW CALIBRATION) (DEGREES K)
					SIGNAL (DEGREES K)	SCAN-TO-SCAN (DEGREES K)		SIGNAL (MILLIVOLTS)	SCAN TO SCAN (MILLIVOLTS)	
260	FULL	260.18	260.23	0.05	0.27	0.07	0.072	14.2	3.5	0.45
	PARTIAL	260.18	260.29	0.11	0.27	0.04	0.075	14.4	1.8	
270	FULL	270.33	269.99	−0.34	0.25	0.09	0.606	14.2	5.1	0.92
	PARTIAL[a]	–	–	–	–	–	–	–	–	
280	FULL	280.41	280.45	0.04	0.28	0.06	1.224	17.4	3.7	0.68
	PARTIAL	280.41	280.36	−0.05	0.29	0.03	1.219	17.7	2.1	
290	FULL	290.38	290.58	0.20	0.24	0.06	1.877	16.3	3.8	0.81
	PARTIAL	290.41	290.60	0.19	0.25	0.04	1.879	16.6	2.4	
300	FULL	300.05	300.02	−0.03	0.17	0.03	2.540	12.6	2.3	1.18
	PARTIAL	300.04	300.02	−0.02	0.19	0.03	2.540	13.8	2.5	
310	FULL	310.05	309.91	−0.14	0.25	0.06	3.296	19.6	5.0	1.16
	PARTIAL	310.05	309.90	−0.15	0.26	0.06	3.295	21.0	4.8	
320	FULL	320.16	320.29	0.13	0.29	0.06	4.159	25.2	4.9	0.77
	PARTIAL	320.18	320.14	−0.04	0.26	0.03	4.146	22.5	3.0	
330	FULL	330.04	330.11	0.07	0.35	0.07	5.038	32.0	6.2	0.50
	PARTIAL[a]	–	–	–	–	–	–	–	–	
340	FULL	340.17	340.14	−0.03	0.34	0.06	5.980	32.4	5.6	0.58
	PARTIAL	340.17	340.16	−0.01	0.35	0.04	5.981	33.6	3.8	

[a]DATA NOT AVAILABLE

Table 4-7. Spacecraft Calibration Data (Infrared) - Ambient Cycle (Baseplate Temperature: 19.7 Degrees C)

NOMINAL TARGET TEMPERATURE (DEGREES K)	SCAN TYPE	MEASURED TARGET TEMPERATURE (DEGREES K)	INFRARED TEMPERATURE (NEW CALIBRATION) (DEGREES K)	ΔT (CALIBRATION MINUS MEASURED) (DEGREES K)	NEΔT		SIGNAL (VOLTS)	NOISE		ΔT_{BB} (NEW CALIBRATION) (DEGREES K)
					SIGNAL (DEGREES K)	SCAN-TO-SCAN (DEGREES K)		SIGNAL (MILLI VOLTS)	SCAN-TO-SCAN (MILLI VOLTS)	
260	FULL	260.59	260.49	−0.10	0.27	0.11	0.044	12.2	5.0	1.34
	PARTIAL	260.62	260.67	0.05	0.27	0.05	0.052	12.4	2.2	
270	FULL	270.37	270.34	−0.03	0.20	0.05	0.534	10.6	2.9	1.89
	PARTIAL	270.37	270.46	0.09	0.19	0.04	0.541	10.1	2.2	
280	FULL	280.36	280.40	0.04	0.16	0.06	1.115	10.2	3.5	1.89
	PARTIAL	280.38	280.39	0.01	0.17	0.03	1.115	10.5	1.7	
290	FULL	289.94	290.00	0.06	0.16	0.04	1.751	11.4	2.8	1.59
	PARTIAL	289.96	289.89	−0.07	0.18	0.03	1.744	12.9	1.9	
300	FULL	300.30	300.25	−0.05	0.20	0.07	2.504	15.1	5.6	1.07
	PARTIAL	300.29	300.09	−0.20	0.19	0.03	2.492	14.4	2.2	
310	FULL	310.00	310.14	0.14	0.18	0.07	3.274	13.9	[illegible]	0.70
	PARTIAL	310.01	310.03	0.02	0.19	0.03	3.265	15.3	2.5	
320	FULL	320.27	320.32	0.05	0.21	0.08	4.085	17.2	6.5	0.83
	PARTIAL	320.28	320.39	0.11	0.23	0.05	4.090	18.7	4.0	
330	FULL	329.57	329.41	−0.16	0.25	0.09	4.821	20.3	7.2	1.31
	PARTIAL	329.58	329.53	−0.05	0.27	0.03	4.831	22.3	2.8	
340	FULL	340.13	340.20	0.07	0.16	0.04	5.748	14.3	3.3	1.53
	PARTIAL	340.13	340.10	−0.03	0.19	0.02	5.739	17.6	2.2	

Table 4-8. Spacecraft Calibration Data (Infrared) - Cold Cycle (Baseplate Temperature: Approximately -2.0 Degrees C)

NOMINAL TARGET TEMPERATURE (DEGREES K)	SCAN TYPE	MEASURED TARGET TEMPERATURE (DEGREES K)	INFRARED TEMPERATURE (NEW CALIBRATION) (DEGREES K)	ΔT (CALIBRATION MINUS MEASURED) (DEGREES K)	NEΔT		SIGNAL (VOLTS)	NOISE		ΔT_{BB} (NEW CALIBRATION) (DEGREES K)
					SIGNAL (DEGREES K)	SCAN-TO SCAN (DEGREES K)		SIGNAL (MILLI-VOLTS)	SCAN-TO-SCAN (MILLI VOLTS)	
260	FULL	260.47	260.54	0.07	0.37	0.43	0.085	19.3	22.4	3.35
	PARTIAL	260.47	260.39	-0.08	0.37	0.31	0.077	19.2	16.4	
270	FULL	270.24	270.21	-0.03	0.45	0.10	0.607	25.0	5.5	3.43
	PARTIAL	270.23	270.19	-0.04	0.47	0.06	0.605	26.5	3.3	
280	FULL	280.07	280.21	0.14	0.21	0.04	1.186	12.6	2.6	3.71
	PARTIAL	280.08	280.30	0.22	0.15	0.02	1.191	8.9	1.3	
290	FULL	289.98	289.80	0.18	0.34	0.09	1.788	22.1	5.8	4.37
	PARTIAL	289.99	289.78	-0.21	0.31	0.04	1.787	20.7	2.9	
300	FULL	300.19	300.16	-0.03	0.22	0.03	2.507	15.9	1.9	4.45
	PARTIAL	300.18	300.20	0.02	0.23	0.02	2.509	16.6	1.8	
310	FULL	310.00	310.20	0.20	0.24	0.04	3.285	20.6	3.5	4.00
	PARTIAL	310.00	310.09	0.09	0.29	0.04	3.277	23.8	3.2	
320	FULL	320.22	320.20	-0.02	0.23	0.07	4.151	20.5	6.0	3.43
	PARTIAL	320.26	320.06	-0.20	0.24	0.03	4.137	22.0	3.2	
330	FULL	330.01	330.10	0.09	0.30	0.06	5.067	28.1	5.5	3.10
	PARTIAL	329.98	329.96	-0.02	0.33	0.03	5.054	31.0	3.2	
340	FULL	340.10	340.03	-0.07	0.28	0.10	5.968	24.2	9.1	3.26
	PARTIAL	340.14	340.20	0.06	0.25	0.03	5.982	21.5	2.7	

Table 4-9. Typical rms Noise Values for Spacecraft Test (Infrared)

PARAMETER	rms NOISE (MILLIVOLTS)		
	HOT CYCLE	AMBIENT CYCLE	COLD CYCLE
SPACE CLAMP	26.3	11.8	9.2
INPUT CALIBRATION 1	8.6	12.4	11.4
INPUT CALIBRATION 2	2.6	12.8	2.9
INPUT CALIBRATION 3	12.4	12.5	25.6
INPUT CALIBRATION 4	27.0	10.9	2.2
INPUT CALIBRATION 5	26.0	13.3	14.8
INPUT CALIBRATION 6	5.5	20.9	20.5
INPUT CALIBRATION 7	17.1	16.0	25.4
EARTH SCAN	32.0	11.4	28.1
OUTPUT CALIBRATION 1	21.7	14.0	23.6
OUTPUT CALIBRATION 2	2.0	9.3	10.9
OUTPUT CALIBRATION 3	22.1	10.1	10.5
OUTPUT CALIBRATION 4	26.6	9.2	0.0
OUTPUT CALIBRATION 5	17.8	13.0	12.9
OUTPUT CALIBRATION 6	3.7	17.8	21.3
OUTPUT CALIBRATION 7	25.9	12.7	15.9
BLACKBODY VIEW	7.6	14.2	26.0
BLACKBODY THERMISTOR	28.1	12.4	27.4

this test was used to determine the change in input calibration steps relative to the output calibration steps. All seven raw input voltages were calibrated using the output calibration voltages as reference. The calibrated voltages were then subtracted from the corresponding input voltage level as determined by ITT; these are provided in Table 3-2. The step number for which maximum difference was observed as well as the difference (referred to as "old minus new" in Tables 4-10 through 4-12) are presented in Tables 4-10 through 4-12. The tables also include the scan-to-scan noise corresponding to that step. This procedure was followed for all three baseplate temperatures. All differences noted are within acceptable limits.

4.2.2 Visible Channel

A summary of the analysis on the two sets of data for the visible channel is presented in Tables 4-13 and 4-14. The tables contain the number of bulbs that were on in the integrating sphere source, the signal, the equivalent albedo, and various noise values. Table 4-15 gives typical rms noise values for various parameters.

Analysis of the data was also performed to determine the change in input calibration steps relative to the output calibration steps. The procedure adopted was similar to the one described in Section 4.2.1. Results are presented in Tables 4-16 and 4-17.

4.3 TESTING OF PREFLIGHT CALIBRATION CONSTANTS

The data taken during the integrated spacecraft thermal-vacuum test were used to verify the calibration algorithm and the preflight constants described in Section 3. The data from 10 full scans for all 9 target temperatures taken at each of the 3 baseplate temperatures were written on 3 disk data sets to be input to a simulation program. Each record of these data sets represents an infrared scan line and contains the channel 2 items 1 through 14 described in Table D.1-1a of Reference 4. Item 16 of the table is represented by 1 Earth

Table 4-10. Comparison of Spacecraft Calibration Data With ITT Data for Infrared Input Calibration Steps - Hot Cycle (Baseplate Temperature: Approximately 33.8 Degrees C)

TARGET TEMPERATURE (DEGREES K)	STEP NUMBER[a]	NOISE (SCAN-TO-SCAN) (MILLIVOLTS)	DIFFERENCE (OLD MINUS NEW) (MILLIVOLTS)	DIFFERENCE WITH RESPECT TO 6 VOLTS (PERCENT)
260	7	2.8	17.0	0.28
270	7	5.7	16.5	0.28
280	7	4.2	16.2	0.27
290	7	3.9	16.9	0.28
300	7	2.8	17.5	0.29
310	4	7.6	24.8	0.41
320	5	4.5	18.9	0.32
330	4	4.9	20.3	0.34
340	4	4.6	20.1	0.34

[a]STEP CORRESPONDING TO MAXIMUM DIFFERENCE

Table 4-11. Comparison of Spacecraft Calibration Data With ITT Data for Infrared Input Calibration Steps - Ambient Cycle (Baseplate Temperature: Approximately 19.7 Degrees C)

TARGET TEMPERATURE (DEGREES K)	STEP NUMBER[a]	NOISE (SCAN-TO-SCAN) (MILLIVOLTS)	DIFFERENCE (OLD MINUS NEW) (MILLIVOLTS)	DIFFERENCE WITH RESPECT TO 6 VOLTS (PERCENT)
260	3	1.9	9.0	0.15
270	3	1.7	9.2	0.15
280	3	2.2	8.5	0.14
290	3	3.0	8.9	0.15
300	7	2.9	9.1	0.15
310	7	3.4	7.8	0.13
320	3	1.9	9.1	0.15
330	3	2.7	9.0	0.15
340	3	2.5	8.4	0.14

[a]STEP CORRESPONDING TO MAXIMUM DIFFERENCE

Table 4-12. Comparison of Spacecraft Calibration Data With ITT Data for Infrared Input C libration Steps - Cold Cycle (Baseplate Temperature: Approximately -2.0 Degrees C)

TARGET TEMPERATURE (DEGREES K)	STEP NUMBER[a]	NOISE (SCAN-TO-SCAN) (MILLIVOLTS)	DIFFERENCE (OLD MINUS NEW) (MILLIVOLTS)	DIFFERENCE WITH RESPECT TO 6 VOLTS (PERCENT)
260	1	8.3	−10.9	−0.18
270	3	6.5	−11.7	−0.20
280	3	4.3	−12.0	−0.20
290	1	8.7	−12.7	−0.21
300	2	1.1	11.5	0.19
310	2	1.7	10.7	0.18
320	2	1.4	11.0	0.18
330	2	0.1	10.1	0.17
340	3	5.7	−10.8	0.18

[a]STEP CORRESPONDING TO MAXIMUM DIFFERENCE

Table 4-13. Visible Calibration Prior to Spacecraft Test (January 30, 1978)

FILE NUMBER	NUMBER OF BULBS	SCAN TYPE	SIGNAL (VOLTS)	NOISE		ALBEDO (PERCENT)	NEΔA		SIGNAL-TO-NOISE RATIO
				SIGNAL (MILLI-VOLTS)	SCAN-TO-SCAN (MILLI-VOLTS)		SIGNAL (PERCENT)	SIGNAL (PERCENT)	
1	8	FULL	5.5572	15.8	6.5	93.35	0.26	0.09	352.68
		PARTIAL	5.5595	15.5	3.7	93.39	0.26	0.06	359.83
2	8	FULL	5.3487	14.5	4.5	89.65	0.24	0.08	367.78
		PARTIAL	5.3401	14.2	5.4	89.70	0.24	0.09	376.89
3	7	FULL	4.6981	12.0	7.5	78.92	0.20	0.12	392.82
		PARTIAL	4.7064	12.4	5.4	79.06	0.21	0.09	378.25
4	6	FULL	3.9976	10.8	12.2	67.16	0.18	0.20	368.76
		PARTIAL	3.9914	10.6	5.3	67.05	0.17	0.09	376.86
5	5	FULL	3.3286	9.3	19.2	55.92	0.16	0.32	341.31
		PARTIAL	3.3096	9.7	5.1	55.61	0.16	0.09	341.06
6	4	FULL	2.6572	9.5	6.8	44.65	0.16	0.11	280.07
		PARTIAL	2.6593	8.9	4.4	44.69	0.15	0.07	297.83
7	3	FULL	1.9891	8.5	3.3	33.43	0.14	0.06	234 23
		PARTIAL	1.9885	8.1	3.7	33.42	0.14	0.06	245.08
8	2	FULL	1.3274	7.8	4.0	22.32	0.13	0.07	171.06
		PARTIAL	1.3259	7.3	3.5	22.29	0.12	0.06	181.04
9	1	FULL	0.6731	9.2	8.0	11.33	0.15	0.13	73.18
		PARTIAL	0.6725	9.2	4.6	11.32	0.16	0.08	72.98
10	C	FULL	0.0085	18.7	3.7	0.17	0.31	0.06	0.55
		PARTIAL	0.0086	20.8	3.4	0.18	0.35	0.06	0.50

Table 4-14. Visible Calibration After Spacecraft Test (March 1, 1978)

FILE NUMBER	NUMBER OF BULBS	SCAN TYPE	SIGNAL (VOLTS)	NOISE		ALBEDO (PERCENT)	NEΔA		SIGNAL-TO-NOISE RATIO
				SIGNAL (MILLI-VOLTS)	SCAN-TO-SCAN (MILLI-VOLTS)		SIGNAL (PERCENT)	SCAN-TO-SCAN (PERCENT)	
1	8	FULL	5.2727	29.9	1.9	88.57	0.50	0.03	177.14
		PARTIAL	5.2879	31.0	3.0	88.82	0.52	0.05	170.81
2	7	FULL	4.6065	26.1	4.8	77.38	0.44	0.08	175.86
		PARTIAL	4.5854	26.7	2.4	77.03	0.45	0.04	171.18
3	6	FULL	3.9334	26.3	18.3	66.08	0.42	0.31	157.33
		PARTIAL	3.9236	27.0	5.4	65.92	0.45	0.09	146.49
4	5	FULL	3.2573	14.7	2.9	54.73	0.25	0.05	218.92
		PARTIAL	3.2279	28.0	4.2	54.23	0.47	0.07	115.38
5	4	FULL	2.6951	6.8	1.8	45.29	0.12	0.03	377.42
		PARTIAL	2.6943	5.9	0.8	45.27	0.10	0.01	452.70
6	3	FULL	2.0130	25.5	0.7	33.83	0.43	0.01	78.67
		PARTIAL	2.0096	23.8	4.0	33.77	0.40	0.07	84.43
7	2	FULL	1.3562	4.4	2.1	22.80	0.07	0.03	325.71
		PARTIAL	1.3584	4.7	1.2	22.84	0.02	0.08	1142.00
8	1	FULL	0.6682	0.8	3.9	11.25	0.01	0.06	1125.00
		PARTIAL	0.6710	3.3	0.3	11.30	0.06	0.01	188.33
9	0	FULL	0.0149	22.0	3.7	0.28	0.37	0.06	0.76
		PARTIAL	0.0176	27.0	2.0	0.33	0.45	0.03	0.73

Table 4-15. Typical rms Noise Values for Visible Channel

PARAMETER	NOISE (SIGNAL) (MILLIVOLTS)
SP CLAMP	27.9
INPUT CALIBRATION 1	28.3
INPUT CALIBRATION 2	16.4
INPUT CALIBRATION 3	9.8
INPUT CALIBRATION 4	7.8
INPUT CALIBRATION 5	7.9
INPUT CALIBRATION 6	11.2
INPUT CALIBRATION 7	12.9
EARTH SCAN	25.9
OUTPUT CALIBRATION 1	26.2
OUTPUT CALIBRATION 2	14.4
OUTPUT CALIBRATION 3	10.7
OUTPUT CALIBRATION 4	10.6
OUTPUT CALIBRATION 5	8.9
OUTPUT CALIBRATION 6	12.4
OUTPUT CALIBRATION 7	9.3
BLACKBODY VIEW	39.6

Table 4-16. Comparison of Spacecraft Data With ITT Data for Visible Input Calibration Steps (January 30, 1978)

NUMBER OF BULBS	STEP NUMBER[a]	NOISE (SCAN-TO-SCAN) (MILLIVOLTS)	DIFFERENCE (OLD MINUS NEW) (MILLIVOLTS)	DIFFERENCE WITH RESPECT TO 6 VOLTS (PERCENT)
8	1	1.9	8.4	0.14
8	6	1.0	−15.5	0.26
7	5	12.7	−14.9	0.25
6	3	4.9	−16.9	0.28
5	3	17.4	−18.3	0.31
4	3	6.0	−11.8	0.20
3	4	4.5	−13.6	0.23
2	3	4.0	−13.1	0.22
1	5	3.6	−17.6	0.29
0	6	4.1	−12.6	0.21

[a]STEP CORRESPONDING TO MAXIMUM DIFFERENCE

Table 4-17. Comparison of Spacecraft Data With ITT Data for Visible Input Calibration Steps (March 1, 1978)

NUMBER OF BULBS	STEP NUMBER[a]	NOISE (SCAN-TO-SCAN) (MILLIVOLTS)	DIFFERENCE (OLD MINUS NEW) (MILLIVOLTS)	DIFFERENCE WITH RESPECT TO 6 VOLTS (PERCENT)
8	4	1.2	20.0	0.33
7	1	1.7	−6.9	0.12
6	2	0.8	−16.7	0.28
5	4	4.0	20.9	0.35
4	4	2.1	19.3	0 32
3	4	3.5	19.3	0.32
2	4	3.9	20.9	0.35
1	4	4.8	18.4	0.31
0	7	7.3	13.1	0.22

[a]STEP CORRESPONDING TO MAXIMUM DIFFERENCE

scan value, which is determined by averaging over 30 samples obtained while viewing the Epply target. The simulation program applies the calibration algorithm described in Section 3 and generates a cubic polynomial for all 10 scan lines representing 1 target temperature. The cubic polynomial is applied to each of the 10 Earth scan values (in counts), and the radiance indices are averaged. The averaged index is converted to a temperature using the formula described in Section 3.6. The procedure is then repeated for the next target temperature. Results are summarized in Tables 4-18 through 4-20. The final column in each table indicates the difference in the platinum resistor values from the Epply calibration target and the calibrated value from the HCMR. Because these differences were minimal, the algorithm and the preflight constants presented in Section 3 appeared to be adequate.

4.4 CONCLUSIONS

Overall, the infrared channel performance was found to be satisfactory and did not change significantly from the performance during ITT calibration. Some differences are noted below:

1. Thermal-vacuum data suggest that the sensitivity of the infrared sensor increased during the hot cycle and decreased during the ambient and cold cycles as compared to the sensitivity during ITT calibration. Because the processing algorithm is designed to adjust for a change in sensitivity, this does not necessitate changing any of the constants presented in Table 3-2.

2. Although for a fixed baseplate temperature variations were observed in ΔT_{BB} as the Epply target temperature varied from 260 degrees K to 340 degrees K, the average values for each of the three baseplate temperatures were not significantly different from the ITT values. The average thermal-vacuum test values were 0.78, 1.35, and 3.68 (degrees K) as compared to ITT values of 0.77, 1.60, and 3.81 (degrees K) for the hot, ambient, and cold temperatures, respectively.

Table 4-18. Comparison of Calibrated Target Temperatures and Measured Target Temperatures - Hot Cycle

NOMINAL TARGET TEMPERATURE (DEGREES K)	MEASURED TARGET TEMPERATURE (DEGREES K)	CALIBRATED TARGET TEMPERATURE (DEGREES K)	DIFFERENCE (DEGREES K)
260	260.18	260.06	–0.12
270	270.33	270.19	–0.14
280	280.41	280.60	0.19
290	290.38	290.36	–0.02
300	300.05	300.06	0.01
310	310.05	310.11	0.06
320	320.16	320.31	0.15
330	330.04	329.98	–0.06
340	340.17	340.00	–0.17

Table 4-19. Comparison of Calibrated Target Temperatures and Measured Target Temperatures - Ambient Cycle

NOMINAL TARGET TEMPERATURE (DEGREES K)	MEASURED TARGET TEMPERATURE (DEGREES K)	CALIBRATED TARGET TEMPERATURE (DEGREES K)	DIFFERENCE (DEGREES K)
260	260.59	260.75	0.16
270	270.37	270.81	0.44
280	280.36	280.55	0.19
290	289.94	290.11	0.17
300	300.30	300.79	0.49
310	310.00	310.50	0.50
320	320.27	320.54	0.27
330	329.57	329.51	−0.06
340	340.13	340.00	−0.13

Table 4-20. Comparison of Calibrated Target Temperatures and Measured Target Temperatures - Cold Cycle

NOMINAL TARGET TEMPERATURE (DEGREES K)	MEASURED TARGET TEMPERATURE (DEGREES K)	CALIBRATED TARGET TEMPERATURE (DEGREES K)	DIFFERENCE (DEGREES K)
260	260.47	260.00	−0.47
270	270.24	269.64	−0.60
280	280.07	279.64	−0.43
290	289.98	289.92	−0.06
300	300.19	299.98	−0.21
310	310.00	310.08	0.08
320	320.22	319.71	−0.51
330	330.01	330.34	0.33
340	340.10	340.00	−0.10

3. The NEΔT values presented in Tables 4-6 and 4-7 were slightly higher than those observed during ITT calibration (as presented in Table 2-3). Most of this increase could have been added by the spacecraft and MICOS. Thus these data suggest no significant increase in the noise coming from the detector.

4. Tables 4-10 through 4-12 indicate that the changes in the input calibration step voltages relative to the output calibration voltages were insignificant.

SECTION 5 - FLIGHT PERFORMANCE EVALUATION

This section describes the results of the analysis performed by processing the computer-compatible tapes (CCTs) generated by the Information Processing Division (IPD) after the launch of AEM-A. Various programs are used to monitor the noise characteristics of the data, determine the sensitivity of the sensor system, provide ground truth comparisons, and test the preflight constants described in Section 3.

5.1 PROCESSING SYSTEM FOR NOISE AND PERFORMANCE ANALYSIS

The processing system for analyzing the data taken during the spacecraft thermal-vacuum test was modified to analyze flight data. Rather than accepting input from MICOS, this program takes input from an HCMM preprocessor CCT (F-tape), the format for which can be found in Reference 6. Each record contains raw sensor data, calibration data, and preprocessor data quality statistics. The system works very much as described in Section 4.1. Major differences are as follows:

1. Housekeeping data are picked from each record rather than from PCM snapshots.
2. There are no partial scans.
3. The number of samples used for averaging various physical parameters is different, as noted below:

Parameter	Samples
Space clamp	12
Input and output calibration steps	12
Blackbody view	30
Blackbody thermistor	30

4. Up to 2000 scan lines can be processed in one run, and a summary is generated.

5.2 SUMMARY OF RESULTS

As each tape is processed, a two-page reporting form, the HCMM Flight Tape Analysis, is prepared. The form contains the rms noise in millivolts for various physical parameters, the noise equivalent temperature (NEΔT), and various other temperatures. Noise values from thermal-vacuum data and a preflight recording are also included for comparison. A sample report is shown in Figure 5-1. Table 5-1, a summary of the analysis performed on the CCTs received from IPD for channel 2, includes tape ID, Julian day, type of pass, NEΔT, $\Delta T'_{BB}$, and minimum and maximum rms noise in the input and output calibration steps. Blackbody view data are used to calculate NEΔT.

$\Delta T'_{BB}$ is the apparent ΔT_{BB} (apparent difference between blackbody thermistor and blackbody view temperature). The blackbody view temperature is obtained by using the prelaunch measured C_i's for a baseplate temperature of 10 degrees C, as taken from Table 4-2. It can be seen that $\Delta T'_{BB}$ changes with time. This change could be due to a change in the sensitivity of the instrument, a change in the thermal gradient (ΔT_{BB}), or both. To separate the contribution from the two conditions, independent ground measurements are needed. This is further discussed in Sections 5.3.2 and 5.4. For the present, the assumption is made that although thermal gradient ΔT_{BB} may have changed from the original value, it remains constant throughout the flight, because once established, onboard thermal environment does not change. Under this assumption, values in column 5 of Table 5-1 can be used to obtain the loss in sensitivity relative to Julian day 131, the day when the infrared channel was operational. Thus by day 193 a loss in sensitivity of approximately 8.7 degrees K (from a range of 80 degrees K) had occurred. A cubic polynomial was fit to represent loss of sensitivity as a function of day. Table 5-2 lists the coefficients obtained as well as actual and calculated losses in sensitivity. For days when more than

11/7/78
Page 1 of 2 Pages

HCMM FLIGHT TAPE ANALYSIS

Tape No: ETC00326-01 (266 day)

Date Received: 11/6/78

THERMAL CHANNEL

Minimum in cal RMS noise (mV): 14.3 @ 2V

Maximum in cal RMS noise (mV): 19.1 @ 5V

Minimum out cal RMS noise (mV): 13.5 @ 2V

Maximum out cal RMS noise (mV): 22.3 @ 5V

Instrument Sensitivity Quotient ($^oK/V$):

Temperature Baseplate (^oK): 284.71

Temperature BB View (^oK): 280.12

Temperature BB Thermistor (^oK): 286.87

$\Delta T'_{BB}$ (^oK): +6.55

NEΔT (BB View) (^oK): 0.24

RMS noise (BB Th) (^oK): 0.17

Comments:

Total saturation in input and output calibration at 6V level (all values 255)

VISIBLE CHANNEL

Minimum in cal RMS noise (mV): 15.0 @ 3V

Maximum in cal RMS noise (mV): 22.8 @ 5V

Minimum out cal RMS noise (mV): 15.4 @ 3V

Maximum out cal RMS noise (mV): 22.0 @ 5V

S/N (BB View - 1% Equivalent): 2.34

Comments:

Total saturation in input and output calibration at 6V level (all values 255)

Figure 5-1. Sample Report (1 of 2)

C-2

THERMAL CHANNEL

RMS noise in MV

VISIBLE CHANNEL

RMS noise in mV

Function	T/V-Micos Ambient	Preflight Recording	Flight Tape	Function	T/V-Micos Ambient	Preflight Recording	Flight Tape
Space Clamp	12.7	1.3[1]	15.5	Space Clamp	27.9	21.8	22.4
INCAL 1	13.7	19.5	16.3	INCAL 1	28.3	25.8	22.5
2	11.9	18.8	14.8	2	16.4	14.4	18.6
3	12.4	18.9	14.3	3	9.8	14.5	16.7
4	10.9	18.9	14.7	4	7.8	13.6	15.0
5	12.8	18.1	16.0	5	7.9	14.3	16.8
6	19.3	20.2	19.1	6	11.2	16.0	22.8
7	16.6	21.0	0.0[2]	7	12.9	17.9	0.0[2]
OUTCAL 1	14.1	6.1[1]	15.5	OUTCAL 1	26.2	22.0	22.0
2	9.7	18.5	13.7	2	14.4	15.6	19.0
3	10.4	19.5	13.5	3	10.7	14.9	16.6
4	9.5	17.0	13.8	4	10.6	13.3	15.4
5	12.7	16.7	15.9	5	8.9	13.0	16.4
6	18.3	20.6	22.3	6	12.4	16.2	21.5
7	12.5	21.8	0.0[2]	7	9.3	17.8	0.0
BB View	11.4	1.7[1]	15.1	BB View	39.6	20.8	26.7
BB Thermistor	10.9	19.5	16.0				

Notes:
1. Anomalous value due to extreme saturation effect.
2. Anomalous value due to total saturation.

Figure 5-1. Sample Report (2 of 2)

Table 5-1. Summary of HCMM Flight Tape Analysis (Infrared Channel)

TAPE ID	JULIAN DAY	PASS	NEΔT (DEGREES K)	$\Delta T'_{BB}$ (DEGREES K)	INPUT CALIBRATION rms NOISE		OUTPUT CALIBRATION rms NOISE	
					MINIMUM (MILLI-VOLTS)	MAXIMUM (MILLI-VOLTS)	MINIMUM (MILLI-VOLTS)	MAXIMUM (MILLI-VOLTS)
AA113181	131	DAY	0.43	-0.74	27.9	44.2	27.4	38.6
MAD00027	131	NIGHT	0.26	+1.19	15.0	18.0	14.6	21.5
MAD00028	131	DAY	0.21	-0.69	14.2	18.1	13.5	17.2
ETC00033	131	DAY	0.28	-0.79	16.4	19.8	15.7	21.3
GDS00072	132	DAY	0.25	-0.81	15.4	19.0	14.2	18.7
MAD00029	132	NIGHT	0.35	-0.73	19.7	27.9	20.7	28.0
MAD00030	132	NIGHT	0.37	-0.59	20.7	27.8	21.2	28.7
GDS00029	132	NIGHT	0.46	-0.54	21.9	31.1	21.5	29.8
GDG00031	132	DAY	0.26	-0.77	15.0	22.0	14.5	20.6
GDS00034	133	DAY	0.47	-0.48	31.6	46.0	30.1	46.5
ETC00048	135	DAY	0.56	-0.21	37.7	50.8	36.6	49.4
GDS00040	136	NIGHT	0.45	+0.29	24.4	30.0	24.4	29.7
GDS00049	138	DAY	0.38	+0.42	20.0	28.5	20.5	27.6
MAD00048	138	DAY	0.64	+0.51	32.1	38.5	32.7	37.8
MAD00052	139	DAY	1.56	+0.52	84.2	120.5	70.2	130.6
MAD00056	140	DAY	0.77	+0.77	42.7	62.5	42.5	61.7
MAD00059	141	DAY	0.83	+0.90	46.8	72.0	47.5	56.3
GDS00056	141	NIGHT	0.40	+1.11	21.1	29.1	21.4	27.0
GDS00065	143	DAY	0.43	+1.26	21.6	30.9	23.4	28.2
ETC00072	143	DAY	0.30	+1.32	19.4	25.6	19.0	25.4
ULA00127	144	DAY	0.39	+1.36	23.6	54.6	23.2	58.6
ULA00133	145	DAY	0.57	+1.61	31.0	42.7	30.3	44.4
GDS00071	146	NIGHT	0.48	+1.89	22.3	33.9	25.6	31.1
ETC00088	148	DAY	0.92	+2.08	50.3	98.5	47.8	110.2
ETC00096	150	DAY	1.36	+2.35	59.9	122.3	55.7	118.3
GDS00091	152	NIGHT	0.41	+2.86	23.0	28.5	22.5	27.0
ORR00085	153	NIGHT	0.66	+2.80	38.5	60.2	36.4	63.4
GDS00100	154	DAY	0.46	+2.96	23.4	28.6	23.7	28.5
ETC00117	157	DAY	0.52	+3.54	17.8	49.0	17.7	50.2
MIL00097	161	DAY	0.33	+4.21	20.4	28.1	19.7	34.5
MIL00099	162	NIGHT	0.34	+4.36	21.5	31.0	21.2	36.8
GDS00146	169	DAY	0.28	+5.34	17.7	23.0	17.4	28.4
ETC00238	193	DAY	0.26	+7.97	15.0	23.3	14.1	28.5
MIL-ISI-32-1	197	DAY	0.30	-0.67	19.9	43.3	19.5	46.5
ETC-ISI-32-2	199	DAY	0.28	-0.37	16.4	30.8	16.6	34.7
GDS00255	207	DAY	0.43	+0.23	26.9	67.8	27.6	89.3
GDS00273	228	DAY	0.31	+2.72	19.5	26.3	18.9	30.5
ORR00269-01	247	NIGHT	0.27	+4.49	16.2	21.2	15.8	24.3
GDS00290-04	250	DAY	0.28	+4.94	17.3	23.1	16.2	25.5
ETC326-01	266	DAY	0.24	+6.56	14.3	19.1	13.5	22.3
ETC356-01	302	NIGHT	0.37	+10.56	20.3	29.6	20.0	36.0

ORIGINAL PAGE IS
OF POOR QUALITY

Table 5-2. Loss in Sensitivity Prior to Undervoltage Condition

DAY (RELATIVE TO 131)	LOSS (DEGREES K)	
	ACTUAL	CALCULATED
1	0.0	–0.04
2	0.05	0.13
3	0.26	0.30
5	0.53	0.65
6	1.03	0.82
8	1.21	1.16
9	1.26	1.33
10	1.51	1.50
11	1.75	1.67
13	2.03	2.01
14	2.10	2.18
15	2.35	2.34
16	2.63	2.51
18	2.82	2.84
20	3.09	3.17
22	3.60	3.50
23	3.54	3.66
24	3.70	3.82
27	4.28	4.29
31	4.95	4.91
32	5.10	5.06
39	6.08	6.06
63	8.71	8.72

NOTE: 0-DEGREE COEFFICIENT = –0.208769
1-DEGREE COEFFICIENT = 0.171133
2-DEGREE COEFFICIENT = 0.616915E–04
3-DEGREE COEFFICIENT = –0.840492E–05

one data point was available, all values were averaged to obtain a single value. The plotted data is shown in Figure 5-2. After the completion of the recovery from an undervoltage condition during which the passive cooler door was closed and the cooler patch warmed to approximately 200 degrees K, the instrument was back to initial sensitivity of day 131. This is suggested by the value -0.67 degree K for $\Delta T'_{BB}$ for day 197. Since then, a loss of approximately 11.2 degrees K has occurred to day 302. Data for this period is described in Table 5-3 and Figure 5-3. A linear fit is made to the data in this case.

Table 5-4, a summary for channel 1, includes tape ID, Julian day, type of pass, signal-to-noise ratio (at 1-percent equivalent albedo), and minimum and maximum rms noise in the input and output calibration steps.

5.3 MASTER DATA PROCESSOR SIMULATION SOFTWARE

A program was developed that accepts input from a preprocessor CCT and applies the data processing algorithm described in Section 3 to generate a cubic polynomial for converting raw counts to radiance indices. This program was used to study the effect of varying N (the number of scans used for averaging calibration data, as described in Section 3.2) on the rms noise in corrected data. It was also used for ground truth comparisons.

5.3.1 Results of Noise Analysis for Calibrated Data

Because very few full scans of thermal-vacuum data were recorded, these data could not be used to study the effect of varying N on the noise in corrected data. Initial flight data were used for this purpose. Approximately 200 scan lines were used. A cubic polynomial was generated for sets of N scan lines, where N varied from 1 to 10. The rms noise in corrected counts for each value in the range 0 to 255 was calculated. Table 5-5 gives rms noise for various values of N for counts 45, 100, 160, 220, and 250 for two tapes; it also includes noise values for N = 10 for two more tapes. The results indicate that value of 10 for N is adequate.

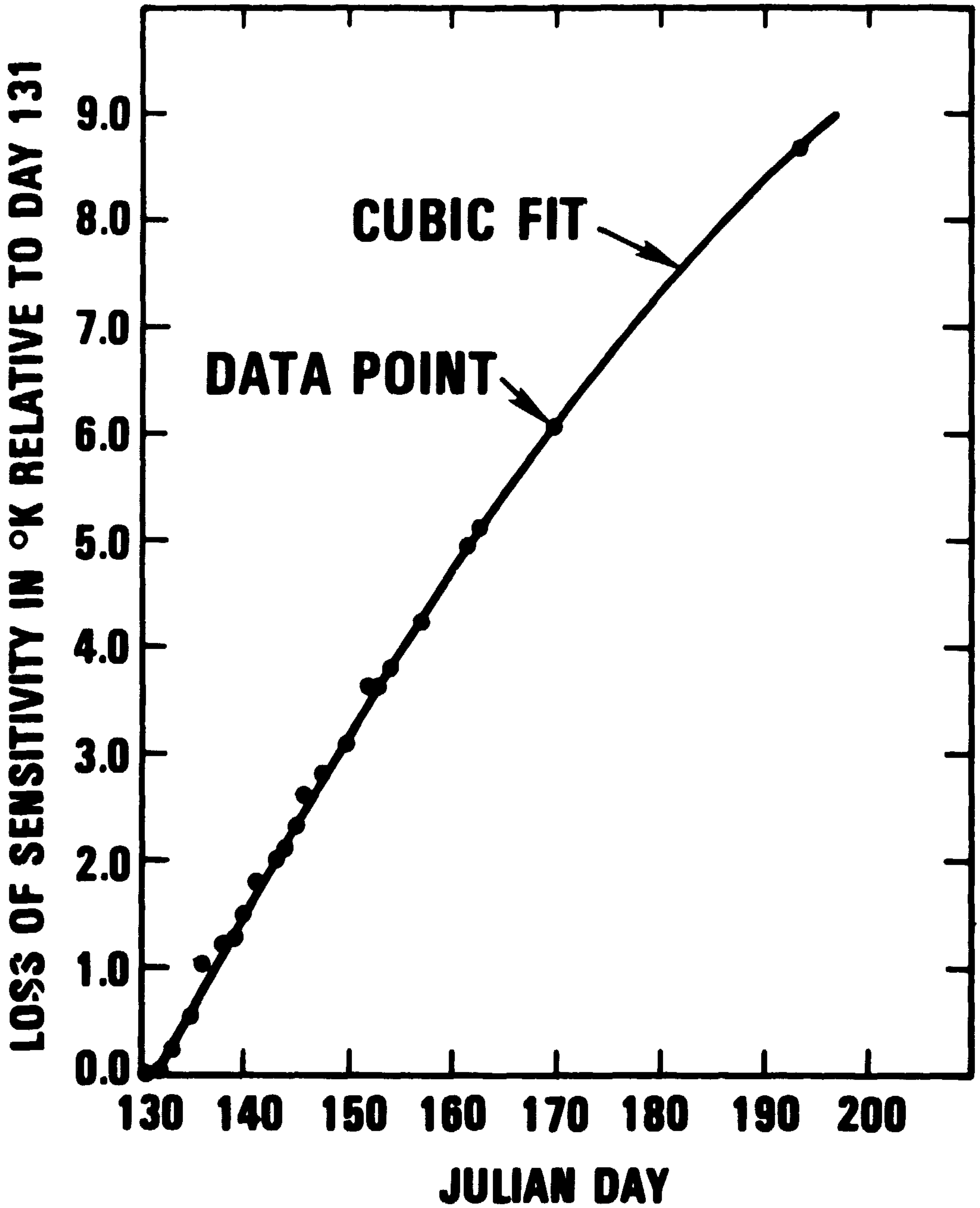


Figure 5-2. Actual and Fitted Loss in Sensitivity Prior to Undervoltage Condition

Table 5-3. Loss in Sensitivity After Recovery From Undervoltage Condition

DAY (RELATIVE TO 197)	LOSS (DEGREES K)	
	ACTUAL	CALCULATED
1	0.0	−0.02
3	0.30	0.19
11	0.90	1.04
32	3.39	3.27
51	5.16	5.29
54	5.61	5.61
70	7.22	7.31
106	11.22	11.13

NOTE: 0-DEGREE COEFFICIENT = −0.130374
1-DEGREE COEFFICIENT = 0.106229

ORIGINAL PAGE IS
OF POOR QUALITY

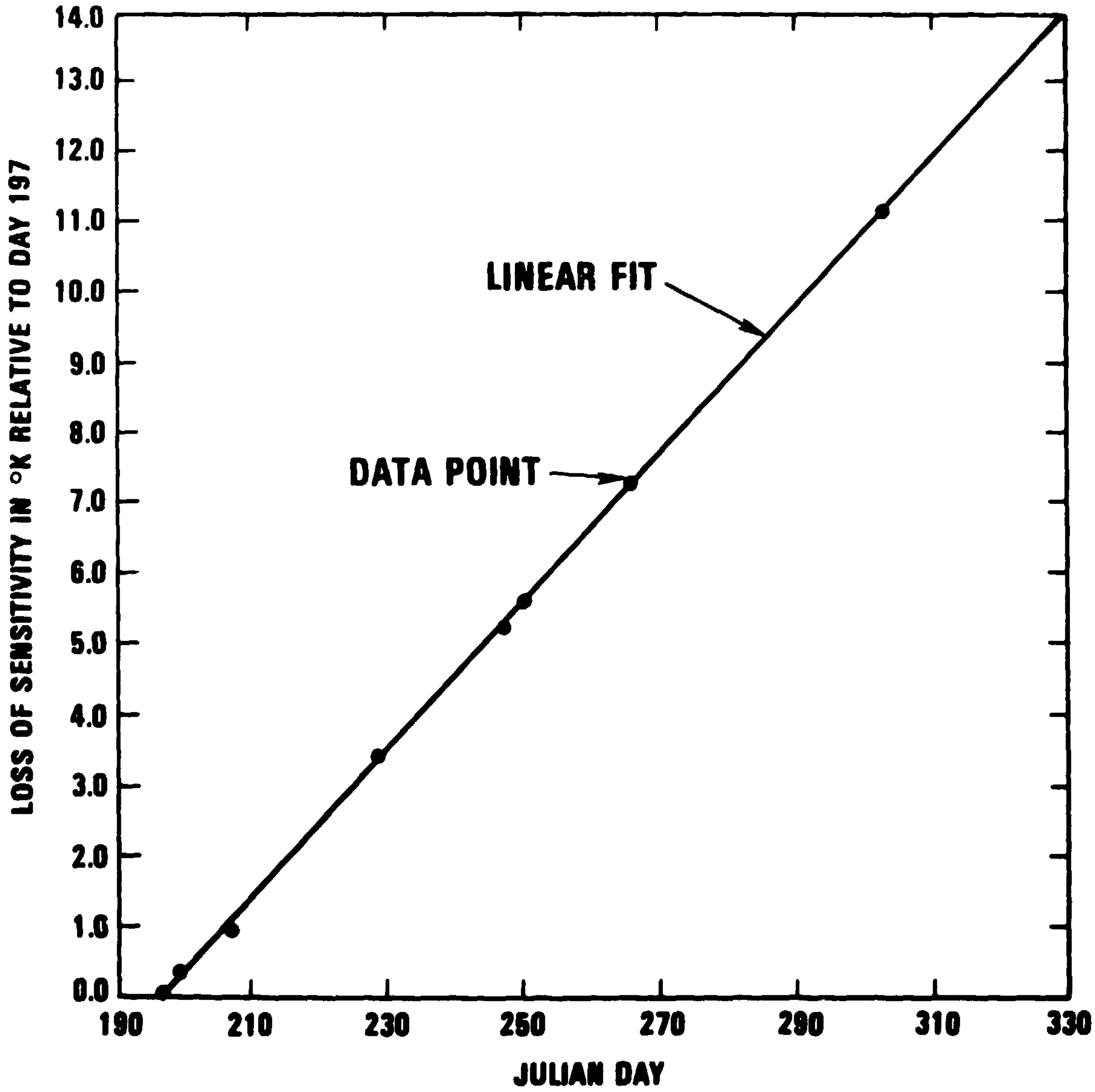


Figure 5-3. Actual and Fitted Loss in Sensitivity After Recovery From Undervoltage Condition

ORIGINAL PAGE IS
OF POOR QUALITY

Table 5-4. Summary of HCMM Flight Tape Analysis Near Infrared Channel

TAPE ID	JULIAN DAY	PASS	SIGNAL-TO-NOISE RATIO (1-PERCENT EQUIVALENT)	INPUT CALIBRATION rms NOISE		OUTPUT CALIBRATION rms NOISE	
				MINIMUM (MILLIVOLTS)	MAXIMUM (MILLIVOLTS)	MINIMUM (MILLIVOLTS)	MAXIMUM (MILLIVOLTS)
AA113181	131	DAY	2.23	17.5	26.3	18.6	25.4
MAD00027	131	NIGHT	2.67	18.6	42.3	17.7	42.2
MAD0028	131	DAY	2.93	16.6	19.5	15.6	19.3
ETC00033	131	DAY	2.96	15.0	22.5	14.8	21.2
GDS00072	132	DAY	2.37	13.8	18.6	14.7	18.8
MAD00029	132	NIGHT	1.40	26.4	40.7	30.0	41.3
MAD00030	132	NIGHT	1.48	26.2	40.5	26.9	40.8
GDS00029	132	NIGHT	2.07	16.6	23.3	16.2	23.4
GDS00031	132	DAY	2.54	17.2	22.1	17.9	22.0
GDS00034	133	DAY	0.96	35.0	50.6	35.0	50.9
ETC00046	135	DAY	1.04	45.7	78.5	46.1	70.6
GDS00040	136	NIGHT	1.86	18.4	24.5	19.5	23.8
GDS00049	138	DAY	1.84	14.8	21.8	16.1	21.2
MAD00046	138	DAY	1.64	24.5	69.2	23.0	66.5
MAD00062	139	DAY	0.17	175.6	332.7	167.0	1539.2
MAD00056	140	DAY	1.16	31.3	46.0	29.5	43.8
MAD00059	141	DAY	1.12	38.4	44.6	37.7	45.2
GDS00066	141	NIGHT	2.00	19.1	23.2	18.3	23.1
GDS00085	143	DAY	1.81	20.0	25.7	19.0	25.2
ETC00072	143	DAY	2.42	20.0	29.3	19.8	30.6
ULA00127	144	DAY	1.85	35.3	122.0	35.7	127.4
ULA00133	145	DAY	1.00	54.9	112.2	54.7	108.3
GDS00071	146	NIGHT	2.01	18.8	25.1	18.1	24.8
ETC00088	148	DAY	0.23	68.9	182.7	69.3	281.1
ETC00096	150	DAY	0.17	86.6	1799.9	83.3	864.5
GDS00091	152	NIGHT	1.82	18.4	23.8	18.9	23.9
ORR00086	153	NIGHT	1.34	44.1	557.0	43.5	710.0
GDS00100	154	DAY	1.95	20.6	25.5	20.9	25.9
ETC00117	157	DAY	0.48	32.9	90.8	33.9	88.8
MIL00087	161	DAY	2.48	18.8	27.4	18.9	26.6
MIL00089	162	NIGHT	2.51	18.6	27.7	18.4	27.0
GDS00146	169	DAY	2.01	20.4	26.7	20.6	30.0
ETC00238	193	DAY	2.73	16.8	21.5	16.9	24.2
MIL-ISI-32-01	197	DAY	2.28	18.2	26.9	18.3	25.9
ETC-ISI-32-02	198	DAY	2.85	16.5	23.3	16.4	22.1
GDS00265	207	DAY	0.99	27.0	89.7	25.2	209.3
GDS00273	228	DAY	1.41	22.9	39.0	23.0	39.0
ORR269-01	247	NIGHT	2.30	16.4	24.5	16.4	23.9
GDS280-04	250	DAY	1.42	18.2	35.9	18.2	34.6
ETC326-01	286	DAY	2.34	15.0	22.8	15.4	22.0
ETC366-01	302	NIGHT	1.78	23.8	39.6	23.7	36.6

Table 5-5. Root-Mean-Square Noise in Calibrated Data

N	rms NOISE (COUNTS)				
	45	100	160	220	250
TAPE ID: MAD00029					
1	0.60	0.70	1.16	1.75	2.06
3	0.21	0.44	0.45	0.68	0.77
5	0.16	0.38	0.27	0.49	0.48
7	0.0	0.36	0.0	0.48	0.53
10	0.0	0.22	0.0	0.48	0.37
TAPE ID: GDS00034					
1	0.26	0.58	0.75	1.08	1.21
3	0.0	0.46	0.47	0.52	0.62
5	0.0	0.42	0.46	0.35	0.55
7	0.0	0.32	0.46	0.36	0.42
10	0.0	0.31	0.37	0.41	0.44
TAPE ID: MAD00059					
10	0.0	0.37	0.0	0.60	0.37
TAPE ID: GDS00146					
10	0.0	0.0	0.45	0.21	0.21

5.3.2 Ground Truth Comparisons

To validate the data processing algorithm described in Section 3, ground measurements made at White Sands, New Mexico, were used. It is planned to continue making these measurements throughout the life of the HCMM mission. These measurements are made in the middle of Elephant Butte Reservoir in White Sands using an infrared radiometer and at the time of an HCMM overpass. Data from radiosondes released at the time coinciding with the HCMM pass are used to derive the atmospheric correction. Work for obtaining the ground measurements and the atmospheric correction was preformed by another contractor. Details of this word are provided in Reference 7.

Master Data Processor (MDP) simulation software was used for converting raw Earth scan pixel values to radiance indices. These indices can be converted to temperatures using the formula given in Section 3.6.1. Satellite-observed temperatures and ground truth temperatures are presented in Table 5-6. As indicated in this table, all ground temperatures obtained at White Sands are considerably lower than the satellite temperatures. Temperatures from Chesapeake Bay and from the Gulf Stream south of Cape Hatteras were also obtained for comparisons. In these two cases ground truth is closer to satellite-observed temperatures.

Satellite temperatures were obtained by using the original thermal gradient ΔT_{BB}, as presented in Table 2-7. It was decided to modify thermal gradient ΔT_{BB} so that the satellite temperatures and ground temperatures would be closer. The last two rows in Table 5-6 were not used because radiosonde data was not adequate. The atmospheric correction was obtained by using the radiosonde data from the shore rather than from the middle of the water body.

For each data point, R_{BB} is calculated using the equation

$$\frac{R_{BB}}{E_{BBR2} + V_{OFF}} = \frac{R_G}{E_G + V_{OFF}}$$

ORIGINAL PAGE IS
OF POOR QUALITY

Table 5-6. HCMR Data Validation

DATE (1978)	SATELLITE OBSERVED RAW COUNT	SATELLITE OBSERVED RADIANCE INDEX	SATELLITE OBSERVED TEMPERATURE (DEGREES K)	ATMOSPHERIC CORRECTION (DEGREES C)	CORRECTED TEMPERATURE (DEGREES K)	OBSERVED TEMPERATURE AT GROUND (DEGREES K)	OBSERVED TEMPERATURE AT GROUND-CORRECTED TEMPERATURE (DEGREES C)	THERMAL GRADIENT ΔT88 DIFFERENCE (DEGREES C)	COMMENTS
ELEPHANT BUTTE RESERVOIR									
MAY 12	117	93	296.2	0.7	295.9	289.5	−6.4	6.14	ON MAY 23, THE RADIOMETER WAS AIMED AT THE LAKE FROM SHORE (DUE TO HIGH WINDS, THE OBSERVER COULD NOT GO OUT ON THE LAKE).
MAY 23	112	90	294.2	0.3	294.5	289.6	−4.9	4.57	
JUNE 1	100	81	291.3	4.5	295.8	291.7	−4.1	4.15	
JUNE 3	116	96	296.8	1.7	298.5	292.5	−6.0	5.57	
JUNE 19	122	106	300.0	2.2	302.2	296.0	−6.2	5.78	
NEAR ENTRANCE TO CHESAPEAKE BAY									
MAY 11	92	68	287.2	0.3	287.5	285.2	−2.3	–	FOR MAY 11, THE GROUND TRUTH WAS EXTRACTED FROM THE GULF STREAM 7-DAY COMPOSITE ISOTHERMAL ANALYSIS
SOUTH OF CAPE HATTERS NEAR GULF STREAM									
MAY 11	117	93	296.2	0.3	295.5	293.2	−2.3	–	

where R_G is the radiance for the ground temperature (observed temperature at the ground-atmospheric connection) obtained from Planck equation

$$R = \frac{\epsilon_0 + \epsilon_1 T + \epsilon_2 T^2}{\left(e^{\epsilon_3/T} - 1\right)} \qquad (\epsilon_i\text{'s are taken from Table 3-1})$$

E_G is the calibrated voltage for the pixel representing ground measurement location, V_{OFF} is the offset voltage, and E_{BBR2} is the calibrated blackbody view voltage. An iterative procedure is used to obtain the temperature corresponding to R_{BB}. This temperature is then subtracted from the corrected blackbody thermistor temperature obtained by using earlier values of σ_i^S (as given in Table 3-1). The average for the five differences is 5.24. It was decided to modify the original thermal gradient ΔT_{BB} by 5.24. The value 5.24 is then added to the constant term of the polynomial (σ_0) for the blackbody temperature correction. Thus the original value of σ_0 (3.5309), as given in Table 3-1, is changed to 8.7709. Other σ_i's remain the same.

5.4 CONCLUSIONS

After launch and a 2-week outgassing period, the HCMR was fully operational on Julian day 131 (May 11, 1978). During the operational checkout period that followed, examination of the telemetry and the results from the software described earlier in this section led to the conclusion that there were several minor anomalies in the performance of the sensor. These discrepancies and their consequences are discussed in the following subsections.

5.4.1 Cooler Temperature Regulation

The passive radiative cooler used on the HCMR to cool the infrared detector uses a feedback network to maintain the detector at a constant 115 degrees K.

After launch the telemetry indicated that the control point was 117.8 degrees K. This value has remained constant for over 200 days, having returned to the same value after the cooler door was closed, the cooler warmed, and the door reopened during a 24-hour period approximately 70 days after initial operation. An increase in the operating temperature of the detector should result in a corresponding decrease in detector response. However, other indications are that the response of the sensor increased after launch.

5.4.2 Postlaunch Sensor Sensitivity

Independent surface measurements are necessary to compare HCMR sensitivity after launch with the sensitivity determined during thermal-vacuum tests at ITT. Such measurements, taken at White Sands, New Mexico, are described in Section 5.3.2 and Table 5-6. Using the values from day 132 (May 12, 1978), the raw count of 117 is first converted to calibrated voltage and then to temperature using the prelaunch measured C_i's for a baseplate temperature of 10 degrees C; the values of C_i, as taken from Table 4-2, were obtained by fitting the calibration data of Table 2-7. After adding 0.7 degree K to this value to account for water-vapor absorption, a value of 299.7 degrees K is obtained; this is 10.2 degrees K higher than the corresponding surface temperature of 289.5 degrees K. Because the sensor-measured temperature was determined by using the prelaunch ITT curves, thereby circumventing the use of the inflight calibration blackbody, the 10.2 degrees K higher value was not due to a change in thermal gradient ΔT_{BB} (the difference in the thermistor-measured and radiatively measured temperature of the inflight blackbody). The difference between the two measurements could be caused by either an increase in the sensitivity of the HCMR after launch or an error in the surface measurements. Both possibilities have been examined, and there is currently no reason to choose one rather than the other.

5.4.3 Postlaunch Value of Thermal Gradient ΔT_{BB}

Using Figure 2-7 and the postlaunch baseplate temperature, thermal gradient ΔT_{BB} should have been approximately 2.3 degrees C. However, as discussed in Section 5.2, the apparent ΔT_{BB}, denoted by $\Delta T'_{BB}$, was found to be approximately -0.7 degree C for Julian day 132, a difference of 3.0 degrees C from the expected value. Assuming the validity of measurements from White Sands, this difference can be attributed to a combination of a change in the sensitivity of the instrument and a change in thermal gradient ΔT_{BB}. Using ground measurement for Julian day 132, the difference in sensitivity (at the blackbody temperature) was 9.0 degrees C, and the difference in thermal gradient ΔT_{BB} was 6.0 degrees C. This is consistent with an overall difference of 3.0 degrees C between the original thermal gradient ΔT_{BB} and the apparent ΔT_{BB} observed on Julian day 132. Details of the calculation of the change in thermal gradient ΔT_{BB} are provided in Section 5.3.2. The average value of the change in thermal gradient ΔT_{BB} for five data points is 5.2 degrees C.

5.4.4 Losses in Optical Transmission

As discussed in Section 5.2, flight data indicate a loss in sensor sensitivity with time. Similar time-dependency is also indicated by the Table 5-7 column representing the differences between the ITT-calibrated temperatures and the surface temperatures. As discussed in Section 5.2 and shown in Figures 5-2 and 5-3, this loss in sensitivity was reversible by a warming cycle of the passive radiative cooler. Therefore, it is believed that this time-dependent loss of sensitivity is, in reality, a loss in optical transmission caused by the deposition of water vapor on the cooled optics of the radiative cooler. This loss is compensated for by the calibration software, but it does result in a gradual increase in the sensor NEΔT and will therefore be reversed periodically.

Table 5-7. Ground Truth Comparison

DATE (1978)	TEMPERATURE, ITT CALIBRATION (DEGREES K)	ATMOSPHERIC CORRECTION (DEGREES C)	CORRECTED TEMPERATURE (DEGREES K)	SURFACE TEMPERATURE (DEGREES K)	DIFFERENCE (DEGREES K)
MAY 12	299.0	0.7	299.7	289.5	10.2
MAY 23	295.6	0.3	295.9	289.6	6.3
JUNE 1	291.3	4.5	295.8	291.7	4.1
JUNE 3	296.3	1.7	298.0	292.5	5.5
JUNE 19	297.2	2.2	299.4	296.0	3.4

5.4.5 Compensation for Changes in Sensor Performance

The preceding discussion indicates that a change in the HCMR probably occurred during launch. That this change manifests itself as an apparent increase in the sensitivity of the sensor is disturbing. However, because no alternative solution was available, it was decided to offset the calibrated data to force them to agree with the surface measurements from White Sands, New Mexico. This was done by increasing σ_0 by the average difference of 5.2 in thermal gradient ΔT_{BB}. The validity of this change will be verified by comparing the data with the surface values obtained by various experimenters and from additional White Sands data.

REFERENCES

1. ITT Aerospace/Optical Division, Heat Capacity Mapping Radiometer for AEM Spacecraft, Final Engineering Report, G. E. Sonnek et al., March 1977

2. --, Acceptance Test Book for Heat Capacity Mapping Radiometer, G. E. Sonnek et al., June 1977

3. B. N. Taylor, W. H. Parker, and D. N. Langenberg, "Determination of e/h, Using Macroscopic Quantum Phase Coherence in Superconductors: Implications for Quantum Electrodynamics and the Fundamental Physical Constants," Reviews of Modern Physics, July 1969, vol. 41, no. 3, pp 375–496

4. International Business Machines Corporation, "HCMM Data Processing Specification," Appendix D. 1, August 1978

5. National Aeronautics and Space Administration, Goddard Space Flight Center, Thermal Vacuum Test Procedures for the AEM-A (HCMM) Spacecraft, N. Witek et al, February 1978

6. --, HCMM Test Computer Compatible Tape Format Description, Information Processing Division, April 1978

7. --, Calibration of the Radiometer on the AEM-A Mission, J. Price and S. Jakkempudi (in preparation)

8. Interface Control Document between the Image Processing Facility and the Master Data Processor System for AEM-A. Partially processed Heat Capacity Mapping Mission partial Output Tape (CCT-RU), May 31, 1978, IBM, Federal Systems Division under Contract NAS5-24285, prepared for GSFC.

APPENDIX A

This appendix contains flowcharts, subprogram inter-relationships, functional descriptions, and source listings for the programs CCTANL, CORECT, and MDPSIM. Each flowchart presents a broad overview of the program. Functional description and major logical steps for each subprogram are explained through inline comment cards. A description of variables in various COMMON blocks and NAMELISTS is also included in this appendix.

Program CCTANL is the processing system for flight data analysis described in Section 5.1. This program was never designed independently for this purpose. Due to unanticipated circumstances, software to monitor the performance of the instrument and ground stations was needed. The processing system developed for analyzing data taken during the integrated spacecraft testing (described in Section 4) was modified and used for testing flight data. Thus, the methods adopted may not be the best possible in certain cases.

Programs CORECT and MDPSIM constitute the Master Data Processor (MDP) simulation software. Program CORECT generates look-up tables for converting raw counts to calibrated indices for master output tables. Program MDPSIM verifies the calibration processing implemented by the MDP. Since many of the functions performed by the two programs are similar, software was coded so that certain subprograms including the COMMON blocks could be shared by the two programs. Common block VALUE is used by both programs, whereas STAT is used only by MDPSIM. There is one block data subprogram for both of these. MDPSIM uses a subprogram BCD5 that converts ASCII characters to EBCDIC characters and is available on SACC (Science and Application Computer Center) computers.

PROGRAM CCTANL

Functional Description and Method

Program CCTANL reads a preprocessor CCT and generates certain quantities that can be used to verify the performance of the instrument in flight and related data handling systems. The program analyzes data in units of blocks of scan lines. The user inputs the size of block, number of first block, and total number of blocks to be analyzed. MAIN first reads through the scan lines to be skipped, and then reads the first scan line to be processed. Data are transferred from the LOGICAL *1 to REAL *4 array so that various arithmetic operations can be performed on them. Counts from the two blackbody and baseplate thermistors are converted to temperatures. Subroutines CCTAVR and CCTBAS are called to calculate averages and standard deviations in counts for various physically significant parameters for each scan line. Subroutine CCTAVR also averages the raw counts for both input and output calibration steps over the requested number of scans to be used later by CCTCNV. An option for no averaging is also available. Subroutine CCTCNV is called to convert raw averages and standard deviations to averages and standard deviations in volts and physical units (temperature for channel 2, albedo for channel 1). When the number of scan lines in a block are processed, a summary for that block is generated. The summary contains averages and standard deviations of the averages and averages of the standard deviations in counts, volts, and physical units. When the requested number of blocks is processed, a summary for all the blocks is generated.

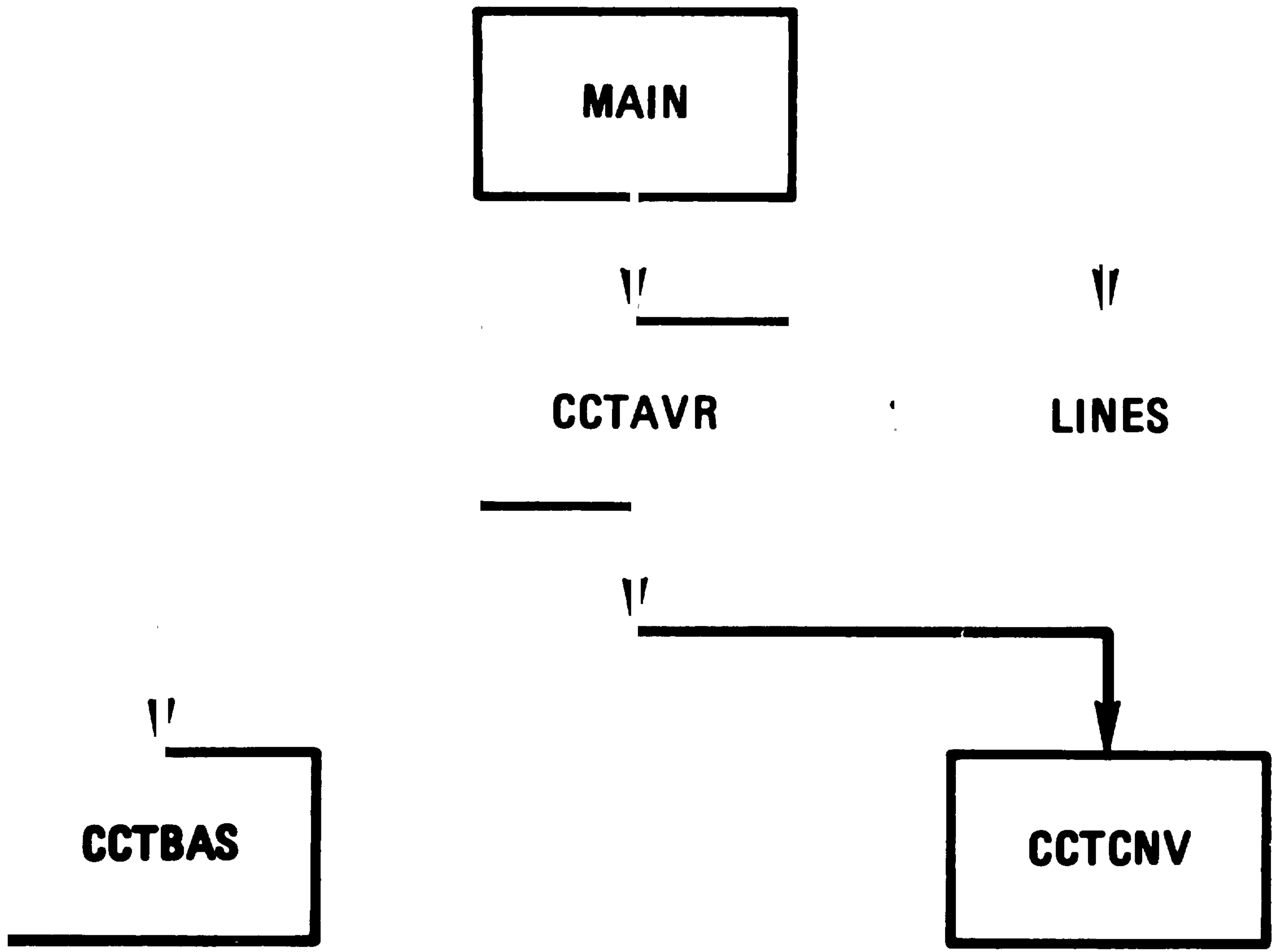


Figure A1 Subprograms For CCTANL

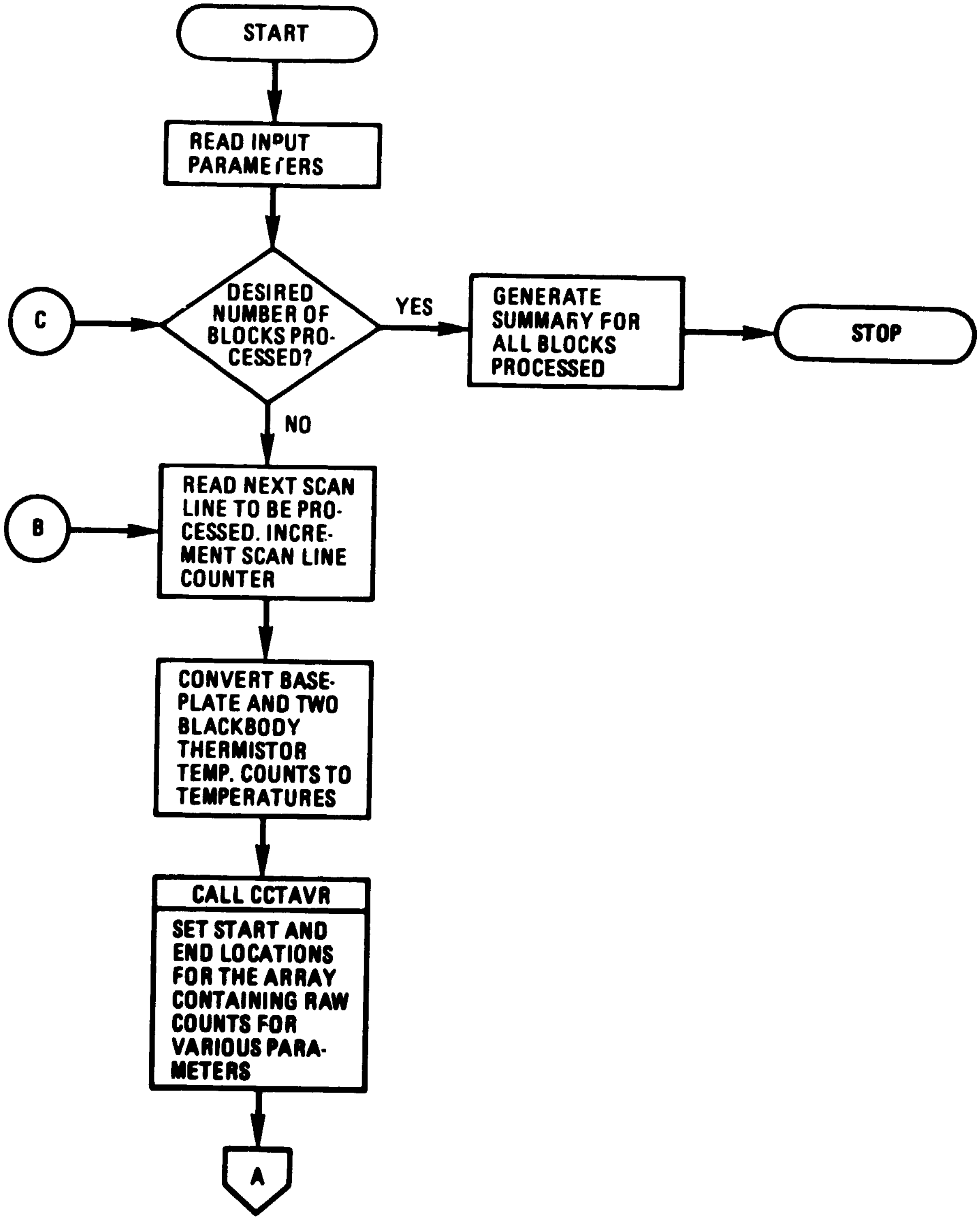


Figure A2 Flowchart For CCTANL (Part 1.)

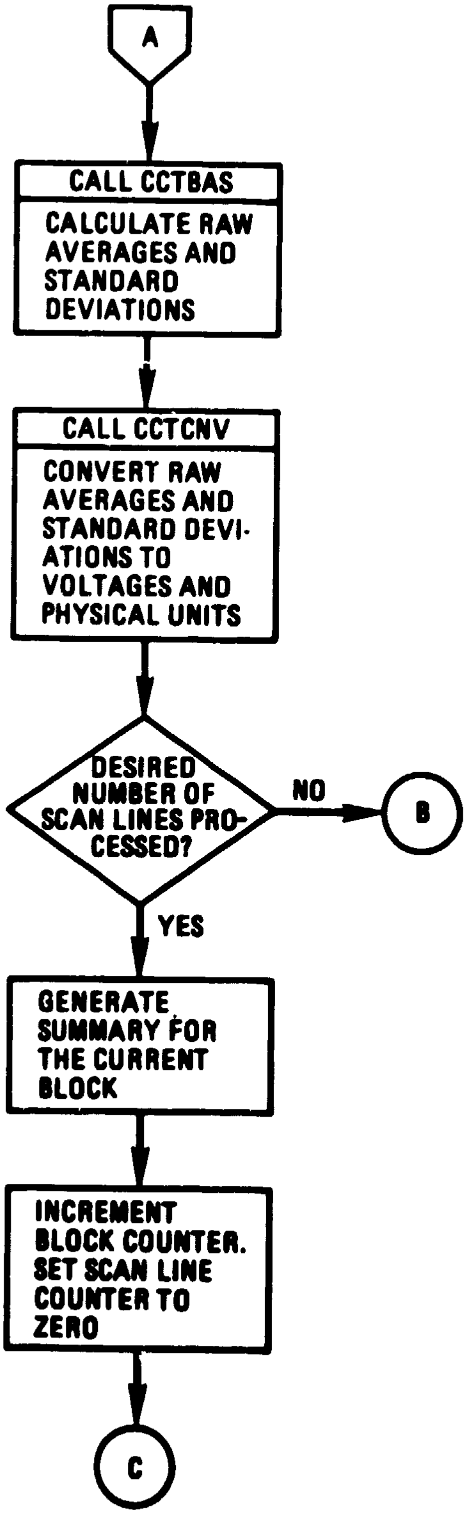


Figure A2 (Cont.) Flowchart For CCTANL (Part 2.)

Table A1 COMMON BLOCK CCINF

Variable	Dimension	Type	Definition
X	2000	R*4	Sensor and calibration data (one location per sample).
ISC	1	I*4	Starting location in array X for space clamp samples.
IES	3	I*4	IES(n) is the starting location in X for the nth set of Earth scan samples.
IOUT	1	I*4	Starting location in array X for output calibration samples.
IBB	1	I*4	Starting location in array X for blackbody view samples.
ITH	1	I*4	Starting location in array X for blackbody thermistor samples.
NSC	1	I*4	Number of samples for space clamp and each of the seven input calibrations steps.
NES	3	I*4	NES(n) is the number of Earth Scan samples in the nth set.
NOUT	1	I*4	Number of samples for each of the seven output calibration steps.
NBB	1	I*4	Number of samples for blackbody view.
NTH	1	I*4	Number of samples for blackbody thermistor.
ITYPE	1	I*4	=1, visible channel =2, thermal channel
NUMES	1	I*4	Number of sets of Earth Scan data to be processed. (Maximum = 3).
QDATA	4500	L*1	Array to hold one CCT record.
QSTR	131	L*1	All elements = character *
FULAV	200,20	R*4	Averages in calibrated volts for various parameters for one scan line. First index is for scan line, Second is for the parameter.
FULSD	200,20	R*4	Standard deviations in calibrated volts.
RFULAV	200,20	R*4	Raw averages.
RFULSD	200,20	R*4	Raw standard deviations.
PUFLAV	200,5	R*4	Averages in physical units.
PUFLSD	200,5	R*4	Standard devistions in physical units.
IFULSC	1	I*4	Scan line counter in a block.
ITMP	1	I*4	Baseplate temperature.
D	4	R*4	Coefficients for converting blackbody thermistor voltage to temperature.
ISCAN	1	I*4	Counter for the scan lines for which raw input and output calibration steps have been averaged.
NSCAN	1	I*4	Number of scan lines over which raw input and output calibration steps have to be averaged prior to calibration (Maximum = 10).
NSET	1	I*4	Counter for sets of NSCAN lines processed.
QTIME	6,10	L*1	STADAN time code.

Table A2 COMMON BLOCK ANALYS

Variable	Dimension	Type	Definition
ZNAME	20	R*8	Names for 20 physically significant parameters.
AVER	20,10	R*4	Raw averages for the parameters for one scan line. First index is for the parameter, second is for scan line.
SD	20,10	R*4	Raw standard deviation (rms).
CV	20,10	R*4	Averages in volts.
CSD	20,10	R*4	Standard deviation in volts.
PU	20,10	R*4	Averages in physical units.
PUSD	20,10	R*4	Standard deviations in physical units.
VIN	7,2	R*4	Raw averages for seven input calibration steps. First index is for step, second for channel.
VOUT	7,2	R*4	Raw averages for seven output calibration steps.
C	5,10	R*4	Coefficients for converting IR volts to temperature. First index is for the coefficient, second for base-plate temperature.
CVIN	7,2	R*4	Predetermined volts for seven input calibration steps.
CVOUT	7,2	R*4	Predetermined volts for seven output calibration steps.
VOFFA	1	R*4	Offset voltage for one scan line.
BPA	1	R*4	Baseplate temperature for one scan line.
BB1A	1	R*4	Blackbody 1 temperature for one scan line.
BB2A	1	R*4	Blackbody 2 temperature for one scan line.

Table A3 NAMELIST SAMPLE

Variables belonging to one of the two COMMON blocks described previously are not included.

Variable	Dimension	Type	Definition
NBLK	1	I*4	Number of blocks to be analyzed (Maximum = 10).
NSTBLK	1	I*4	Starting block to be analyzed.
NSIZE	1	I*4	Number of scan lines in each block (Maximum = 200).
NTYPE	1	I*4	=1, process odd records* =2, process even records

NAMELIST VOLT

All the variables in this NAMELIST have been described in the COMMON BLOCK ANALYS.

*Ordinarily a CCT has all odd records for channel 1, and even records for channel 2. Hence, if the user specifies ITYPE = 1, NTYPE should be 1, and for ITYPE =2, NTYPE should be 2. Occasionally, a CCT has the order reversed. In that case, the combinations to be used are ITYPE = 1, NTYPE = 2, and ITYPE = 2, NTYPE = 1.

PROGRAM MDPSIM

Functional Description and Method

Program MDPSIM verifies the calibration processing implemented by the Master Data Processor (MDP). Data is obtained from a computer compatible tape (CCT-RU) generated by the MDP. This tape contains the input data as well as the output generated by the MDP. The output consists of certain intermediate quantities and the cubic polynomials for converting raw counts to calibrated indices. The user enters input parameters through the NAMELIST INPUT. Subroutine MDPRED is called to read one record at a time, (a single record contains data from both channels unlike a preprocessor CCT), containing input calibration data. Subroutine SMOOTH is called to smooth data. When the data are smoothed over the requested number of scan lines (N), subroutine INTVAL is called to generate certain intermediate quantities and the cubic polynomials referred to above. Subroutine COMPAR then reads the output record from the tape and compares the outputs generated by MDP and MDPSIM. The process described is referred to as processing one calibration set. When the requested number of sets is processed a summary is generated. The format for a CCT-RU tape may be found in Reference 8.

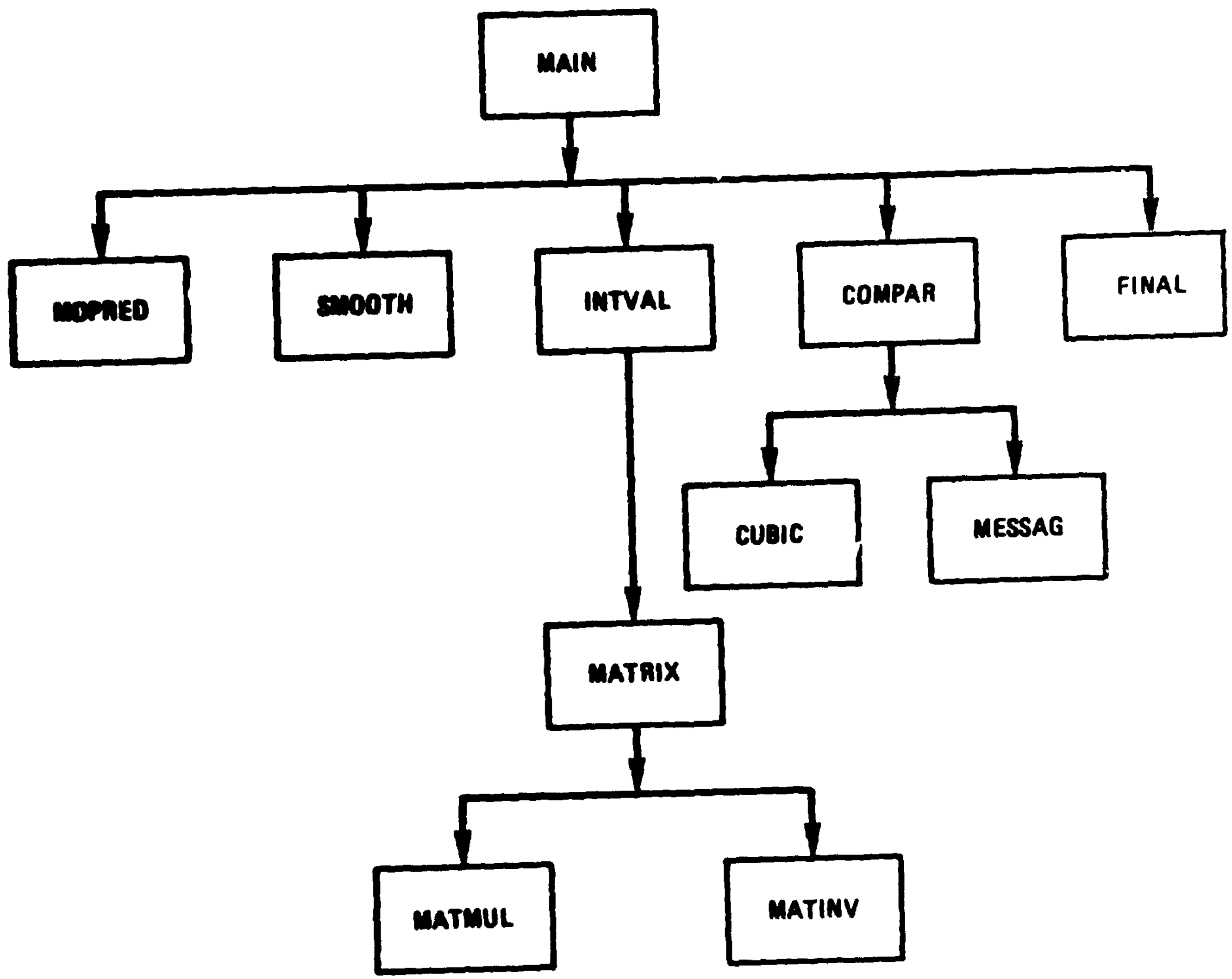


Figure A3 Subprograms For MDPSIM

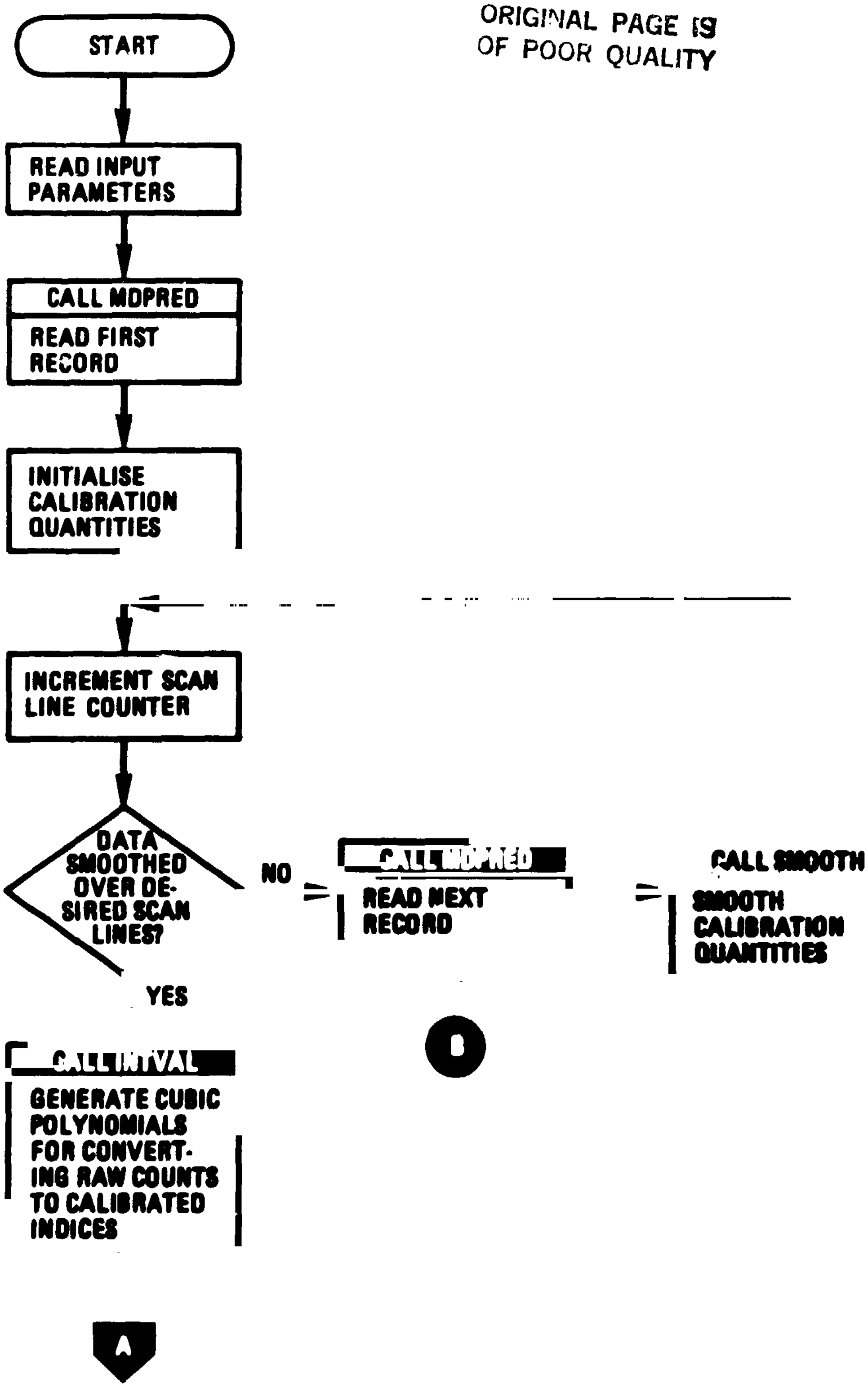


Figure A4 Flowchart for MDPSIM (Part 1.)

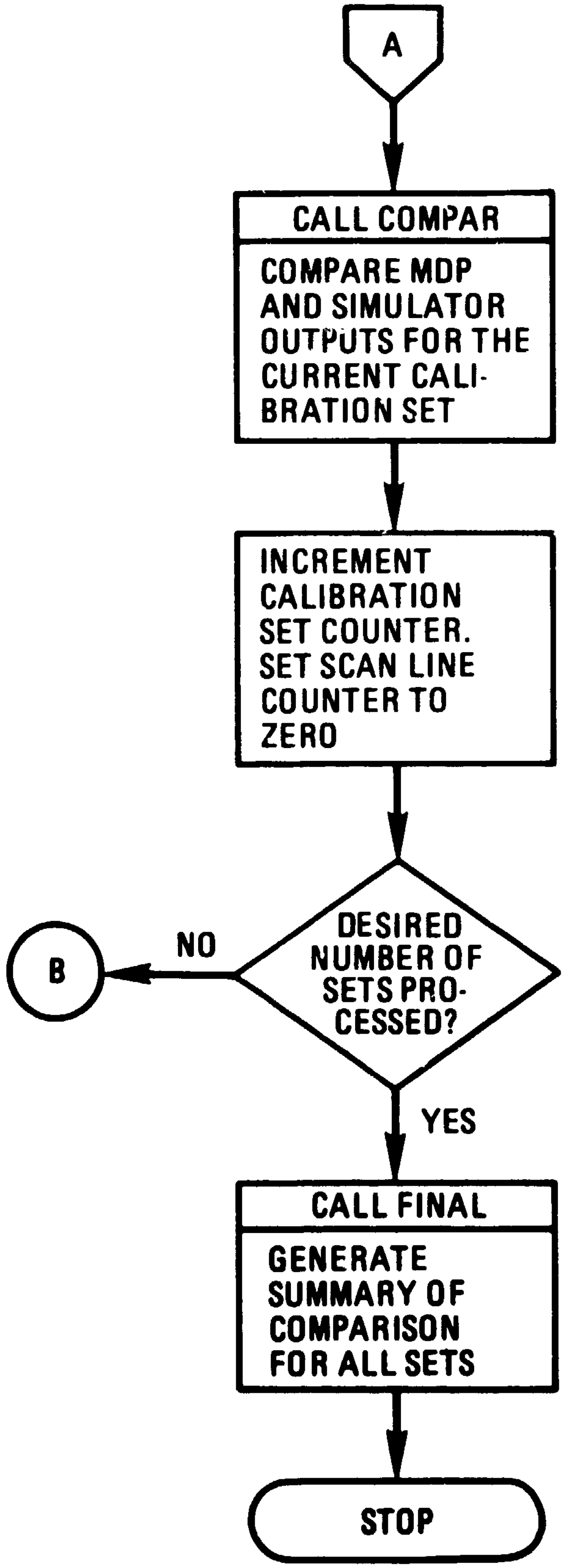


Figure A4 (Cont.) Flowchart for MDPSIM (Part 2.)

Table A4 COMMON BLOCK VALUE

Variable	Dimension	Type	Definition
SCIN1	7	R*8	Smoothed counts from input calibration steps for Channel 1.
SCIN2	7	R*8	Smoothed counts from input calibration steps for Channel 2.
SCOUT1	7	A*8	Smoothed counts from output calibration steps for Channel 1.
SCOUT2	7	R*8	Smoothed counts from output calibration steps for Channel 2.
EC	3	R*8	Telemetry encoder calibration data.
SCBBR1	1	R*8	Smoothed count of blackbody view for Channel 1.
SCSC1	1	R*8	Smoothed space clamp count for Channel 1.
SCBBR2	1	R*8	Smoothed count of blackbody view for Channel 2.
SCSC2	1	R*8	Smoothed count for blackbody thermistor for Channel 2.
EBP	1	R*8	Baseplate voltage.
EBB1	1	R*8	Thermistor 1 blackbody voltage.
EBB2	1	R*8	Thermistor 2 blackbody voltage.
EOFFS	1	R*8	Offset voltage.
WS	1	R*8	Calibration scan filter weight (Default = 0. 1)
PWS	1	R*8	1-WS
ALPHA1	4	R*8	Coefficients of polynomial giving count as a function of voltage at input to amplifier on Channel 1.
ALPHA2	4	R*8	Coefficients of polynomial giving count as a function of voltage at input to Channel 2 amplifier.
ALPHA3	4	R*8	Coefficients of polynomial giving count as a function of voltage at output of Channel 1 amplifier.
ALPHA4	4	R*8	Coefficients of polynomial giving count as a function of voltage at output of Channel 2 amplifier.
DELTA1	4	R*8	Coefficients of polynomial converting raw counts to be calibrated indices for Channel 1.
DELTA2	4	R*8	Coefficients of polynomial converting raw counts to calibrated indices for Channel 2.
C	2	R*8	Telemetry voltage correction coefficients.
EBBR1	1	R*8	Blackbody view voltage on Channel 1.
ESC1	1	R*8	Space clamp voltage on Channel 1.
EBBR2	1	R*8	Blackbody view voltage on Channel 2.
ESC2	1	R*8	Space clamp voltage on Channel 2.
TBB3	1	R*8	Blackbody thermistor temperature from Channel 2 scan.
TBP	1	R*8	Baseplate temperature.
TBB1	1	R*8	Blackbody temperature from thermistor #1.
TBB2	1	R*8	Blackbody temperature from thermistor #2.
VOFF	1	R*8	Offset voltage.
BETA1	4	R*8	Coefficients of polynomial giving voltage at input to Channel 1 amplifier as a function of received count.

Table A4 COMMON BLOCK VALUE (Continued)

Variable	Dimension	Type	Definition
BETA2	1	R*8	Coeffieients of polynomial giving voltage at input to Channel 2 amplifier as a function of received count.
VI1	7	R*8	Predetermined voltages for seven input calibration steps for Channel 1.
VI2	7	R*8	Predetermined voltages for seven input calibration steps for Channel 2.
VO1	7	R*8	Predetermined voltages for seven output calibration steps for Channel 1.
VO2	7	R*8	Predetermined voltages for seven output calibration steps for Channel 2.
A	3	R*8	Albedo intensity function coefficients.
TAU1	4	R*8	Thermistor voltage to temperature polynomial coefficients for SCBB3.
TAU2	4	R*8	Thermistor voltage to temperature polynomial coefficients for baseplate.
TAU3	4	R*8	Thermistor voltage to temperature polynomial coefficients for blackbody thermistor #1.
TAU4	4	R*8	Thermistor voltage to temperature polynomial coefficients for blackbody thermistor #2.
WT	3	R*8	Coefficients used in weighted sum of blackbody temperatures.
SIGMA	4	R*8	Coefficients of polynomial used to correct blackbody temperature for baseplate temperature.
EPSILN	4	R*8	Coefficients in Planck equation used to convert blackbody temperature to radiance.
RHO	2	R*8	Polynomial coefficients used to compute offset voltage.
B	3	R*8	Coefficients for converting radiance to calibrated indices for Channel 2.
VC	3	R*8	A/D conversion levels.
WBP	1	R*8	Filter weight used to smooth baseplate voltage.
WØ	1	R*8	Filter weight used to smooth offset voltage.
NUM	1	I*4	Not used.
N	1	I*4	Number of scan lines to be used for smoothing calibration data (Default = 10).
ICALL	1	I*4	Calibration set being processed.
COUNT	40	I*2	Calibration quantities described in items 1 through 14 in Table D. 1-la, Reference 4 for the current pair of scan lines.
QGOOD	1	L*1	=True, no I/O error in reading the tape =False, I/O error

Table A5 COMMON BLOCK STAT

Variable	Dimension	Type	Definition
AVER1	256	R*8	Average of the differences between the calibrated indices generated by MDP and the program MDPSIM for Channel 1.
AVER2	256	R*8	Same as above for Channel 2.
SD1	256	R*8	Standard deviation of the differences between the calibrated indices generated by MDP and the program MDPSIM for channel 2.
SD2	256	R*8	Same as above for Channel 2.
DFMIN1	256	R*4	Minimum of the differences for Channel 1.
DFMIN2	256	R*4	Minimum of the differences for Channel 2.
DFMAX1	256	R*4	Maximum of the differences for Channel 1.
DFMAX2	256	R*4	Maximum of the differences for Channel 2.
IAV	1	I*4	Number of calibration sets for which MDP and MDPSIM outputs were compared.
QTYPE1	1000	L*1	=1, difference between MDP and MDPSIM outputs exceeded predefined limits for Channel 1. =0, difference within limits for Channel 1.
QTYPE2	1000	L*1	Same as above for Channel 2.

Table A6 NAMELIST INPUT

Variable ISETS is defined below, rest of the variables are described in the COMMON BLOCK VALUE.

Variable	Dimension	Type	Definition
ISETS	1	I*4	Number of calibration sets to be processed (Maximum = 1000).

PROGRAM CORECT

Functional Desc ption and Method

Program CORECT reads calibration data from a preprocessor Computer Compatible Tape (CCT) and generates look-up tables for converting raw counts (0-255) to calibrated indices for master output tables. These indices can then be converted to desired physical units as described in Section 3. The user enters input parameters through the NAMELIST INPUT. Subroutine CCTRED is called to read the records to be skipped before processing and to read the first pair of records (one for each channel). Subroutine SMOOTH is called to smooth the calibration data. When the data are smoothed over the requested number of scan lines (N), subroutine INTVAL is called to generate certain intermediate quantities and the cubic polynomials for converting raw counts to calibrated indices for both channels. Subroutine CONVRT is called to convert counts (0-255) to be calibrated indices using the polynomials generated. Thus, a look-up table is generated for each set of N scan lines referred to as one calibration set. When the requested number of calibration sets are processed, averages and standard deviations for calibrated indices are calculated. Look-up tables, averages, and standard deviations are then printed.

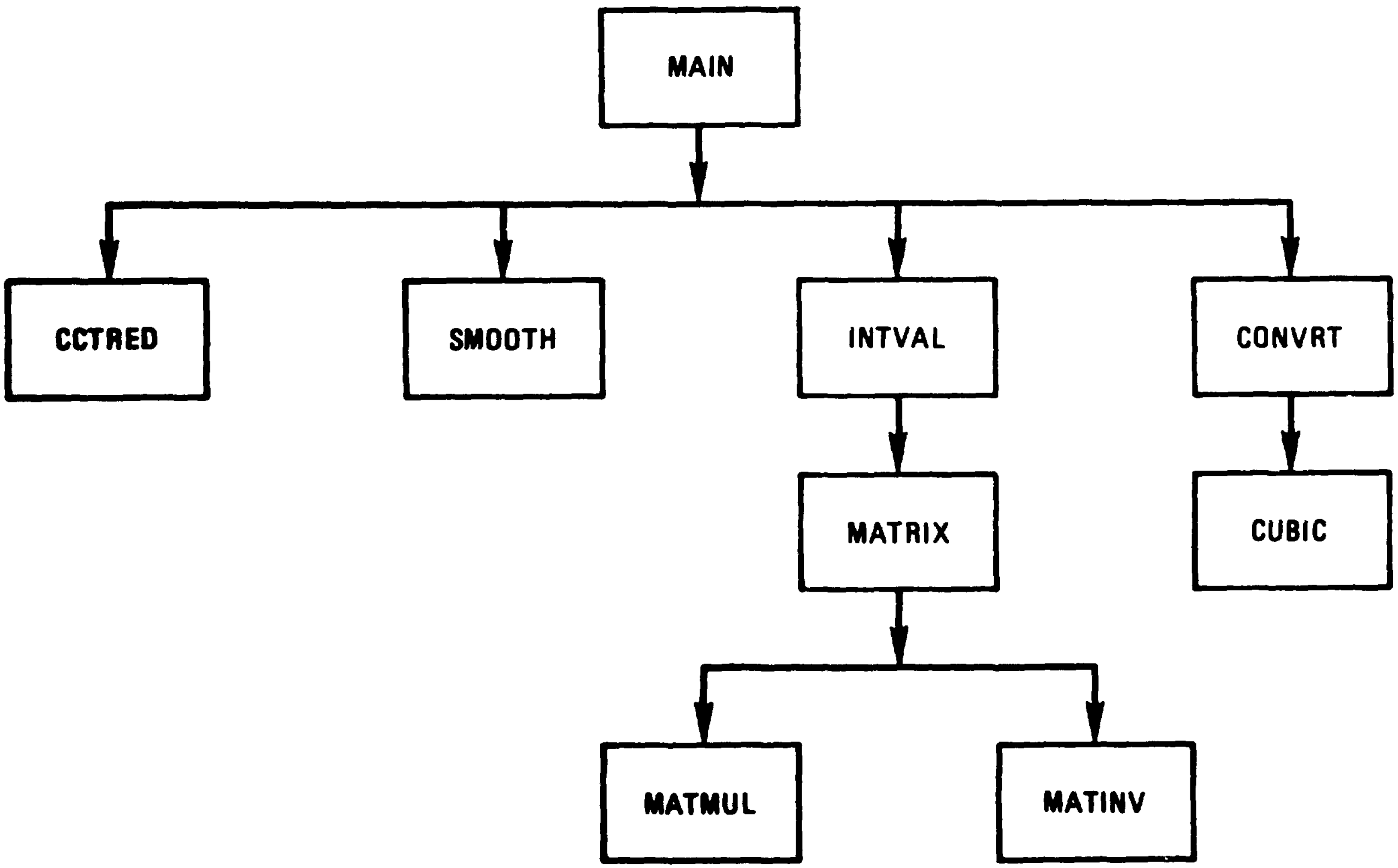


Figure A5 Subprograms for CORECT

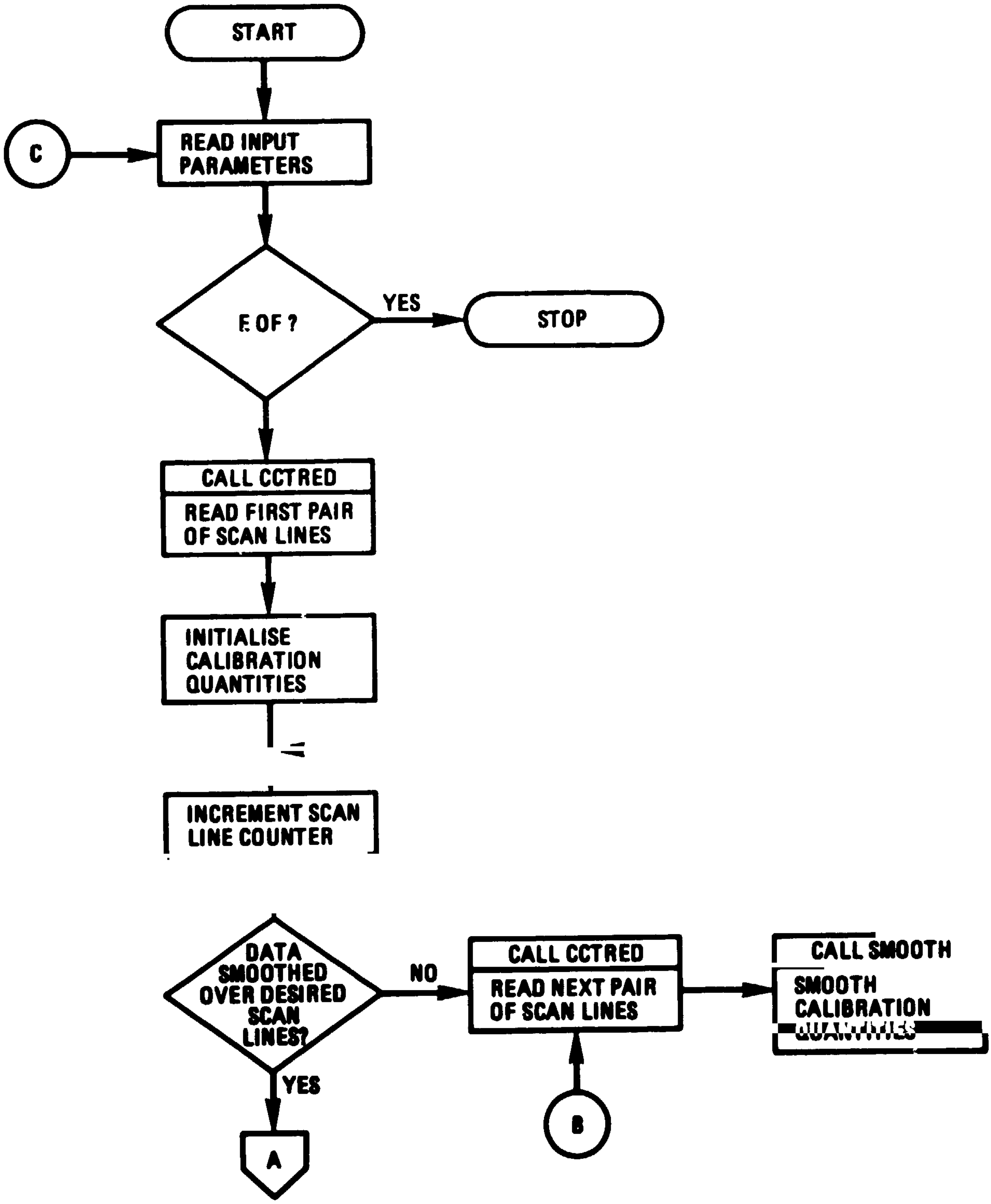


Figure A6 Flowchart for CORECT (Part 1.)

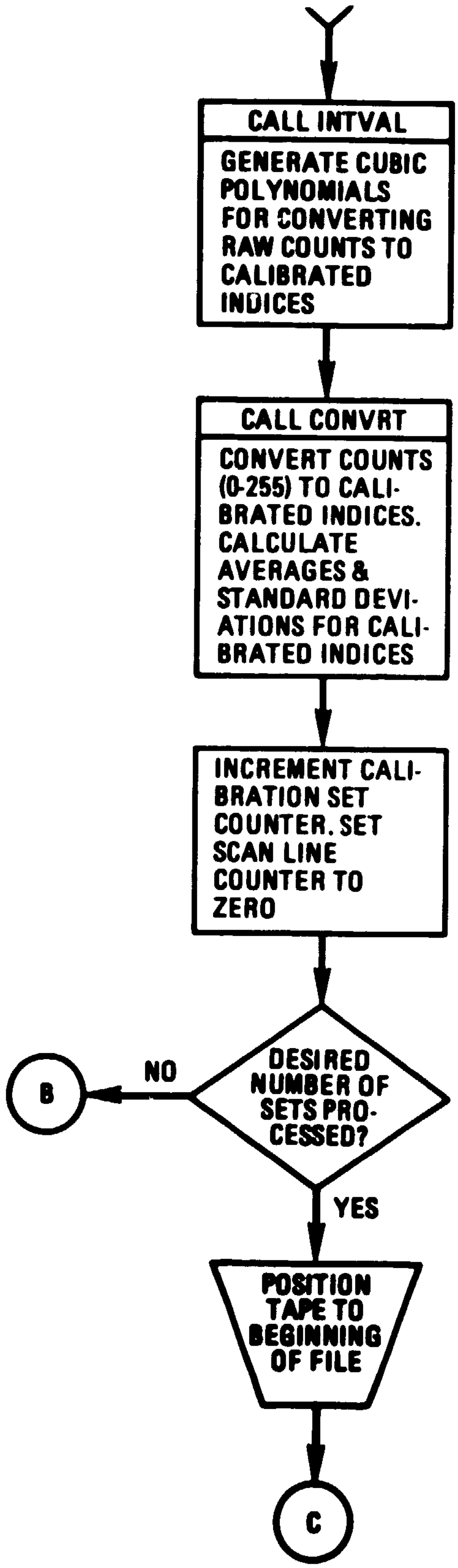


Figure A6 (Cont.) Flowchart for CORECT (Part 2.)

Table A7 NAMELIST INPUT

Variables that belong to the COMMON BLOCK VALUE are not included.

Variable	Dimension	Type	Definition
ISKIP	1	I*4	Number of records to be skipped before processing.
MSETS	1	I*4	Number of calibration sets to be processed (Maximum = 200).
NFILE	1	I*4	Tape file number containing image and calibration data.
MST	1	I*4	First calibration set for which look up tables are to be printed.

```
C++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
C+++++MAIN FOR PROGRAM CCTANL
C+++++       10/16/78
C+++++PROGRAM TO MONITOR PERFORMANCE OF THE RADIOMETER.& NOISE
C+++++IN DATA.
C+++++INPUT FROM PREPROCESSOR CCT
C+++++DEVELOPED BY M.BEWTRA , COMPUTER SCIENCES CORPORATION
C++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
      IMPLICIT LOGICAL*1 (Q)
      INTEGER*2 ICOUNT,C1,C2
      REAL*8 ZNAME,ZNAME2
      COMMON/CCTINF/X(2000)
      COMMON/CCTINF/ISC,IES(3),IOUT,IBB,ITH,NSC,NES(3),NOUT,NBB,NTH,
     1ITYPE,NUMES
      COMMON/CCTINF/QDATA(4500),QSTR(131)
      COMMON/ANALYS/ZNAME(20)
      COMMON/ANALYS/AVER(20,10),SD(20,10),CV(20,10),CSD(20,10),
     *PU(20,10),PUSD(20,10),
     1VIN(7,2),VOUT(7,2),C(5,10),CVIN(7,2),CVOUT(7,2),VOFFA,BPA,BB1A,
     2BB2A,FULAV(200,20),FULSD(200,20),RFULAV(200,20),RFULSD(200,20),
     3PUFLAV(200,5),PUFLSD(200,5),IFULSC,ITMP,D(4),ISCAN,NSCAN,NSET,
     4QTIME(6,10)
      DIMENSION AVFUL(10,20),SDFUL(10,20),AVSDFL(10,20),IND(5)
      DIMENSION SDPUFL(10,5),APUSDF(10,5),AVPUFL(10,5),TPUSDA(5)
      DIMENSION TOTAV(20),TOTSD(20),TOTSDA(20),TPUAV(5),TPUSD(5)
      DIMENSION RAVFUL(10,20),RSDFUL(10,20),RAVSDF(10,20),RTOTAV(20),
     1RTOTSD(20),RTTSDA(20)
      DIMENSION BASEPL(200),BASEAV(10)
      DIMENSION VBBV(10),RBBV(10),PBBV(10)
      DATA IND/9,10,11,19,20/,AVPUFL/50*0.0/,SDPUFL/50*0.0/,
     1AVFUL/200*0.0/,SDFUL/200*0.0/,AVSDFL/200*0.0/,
     2APUSDF/50*0.0/,D1/333.2296/
      DATA RAVFUL/200*0.0/,RSDFUL/200*0.0/,RAVSDF/200*0.0/
      DATA VBBV/10*0.0/,RBBV/10*0.0/,PBBV/10*0.0/
      DATA TVBBV/0.0/,TRBBV/0.0/,TPBBV/0.0/
      DATA ZNAME2/'BASEPLAT'/
      NAMELIST/SAMPLE/ISC,IES,IOUT,IBB,ITH,NSC,NES,NOUT,NBB,NTH,
     1ITYPE,NUMES,NBLK,NSTBLK,NSIZE,NTYPE,NSCAN
     1/VOLT/VIN,VOUT,C,D,CVIN,CVOUT,ITMP
      DIMENSION ISTQ(18),ISTX(18),INUM(18),COUNT(3),VOLTS(3),Y(4)
      DATA ISTQ/12,1670,2222,2246,2270,2294,2318,2342,2366,2774,
     12798,2822,2846,2870,2894,2918,3326,3878/,ISTX/169,1809,29,
     249,69,89,109,129,149,1669,1689,1709,1729,1749,1769,1789,9,
     31859/,INUM/1500,50,15*20,50/,COUNT/5.0,125.0,250.0/,VOLTS/0.11,
     42.51,5.01/,IREC/0/
      DATA VMINI/1.E10/,VMINO/1.E10/,VMAXI/1.E-10/,VMAXO/1.E-10/
C+++++SET START LOCATIONS AND NUMBER OF SAMPLES FOR VARIOUS
C+++++PARAMETERS
      ISCAN=0
      NSET=0
      IBLK=0
      ISC=10
      IOUT=1670
      IES(1)=600
      IBB=1810
      ITH=1860
      NSC=20
      NOUT=20
      NES(1)=300
      NBB=50
      NTH=50
      READ(5,SAMPLE)
      READ(5,VOLT)
      WRITE(8,SAMPLE)
      WRITE(8,VOLT)
      NREC=NSIZE*(NSTBLK-1)*2
      IF(NREC.EQ.0) GO TO 4
C+++++READ RECORDS NOT TO BE PROCESSED
      DO 3 I=1,NREC
      CALL FREAD(QDATA(1),10,LEN,&7,&8)
    3 CONTINUE
      GO TO 4
    7 WRITE(8,9007)
      GO TO 1100
    8 WRITE(8,920)I
      GO TO 3
C+++++TEST IF NUMBER OF DESIRED BLOCKS ARE ANALYSED
```

```
    4 IBLK=IBLK+1
      IF(IBLK.GT.NBLK) GO TO 1000
C+++++READ RECORDS TO BE PROCESSED.DISCARD ALTERNATE RECORDS.
    5 CALL FREAD(QDATA(1),10,LEN,&735,&610)
      IREC=IREC+1
      IF(MOD(IREC-NTYPE,2).NE.0) GO TO 5
      GO TO 10
  610 IREC=IREC+1
      WRITE(8,920)IREC
      GO TO 5
   10 IFULSC=IFULSC+1
      ISCAN=ISCAN+1
      C1=QDATA(7)
      C2=QDATA(8)
      ICOUNT=C1*256+C2
C+++++TRANSFER DATA FROM L*1 ARRAY TO R*4 ARRAY
      DO 25 I=1,18
      IF(I.EQ.1.AND.NUMES.EQ.0) GO TO 25
      K=INUM(I)
      DO 20 J=1,K
      X(ISTX(I)+J)=QDATA(ISTQ(I)+J)
   20 CONTINUE
   25 CONTINUE
C+++++STORE BB1.BB2.BASEPLATE.OFFSET VOLTAGE
      DO 30 I=1,4
      Y(I)=QDATA(3938+I*2)
   30 CONTINUE
C+++++CONVERT BB1,BB2,BASEPLATE  TEMPERATURE  TO VOLTAGES & THEN TO
C+++++TEMPERATURES
C     DO 35 I=1,3
C     COUNT(I)=QDATA(3932+2*I)
C  35 CONTINUE
      DO 60 I=1,4
      IF(Y(I).LT.COUNT(1)) GO TO 42
      IF(Y(I).GE.COUNT(3)) GO TO 44
      DO 40 J=1,2
      IF(Y(I).GE.COUNT(J).AND.Y(I).LT.COUNT(J+1)) GO TO 50
   40 CONTINUE
   42 J=1
      GO TO 50
   44 J=2
   50 FRAC=(VOLTS(J+1)-VOLTS(J))/(COUNT(J+1)-COUNT(J))
      Y(I)=VOLTS(J)+FRAC*(Y(I)-COUNT(J))
   60 CONTINUE
      BB1A=D(1)+D(2)*Y(1)+D(3)*Y(1)*Y(1)+D(4)*Y(1)*Y(1)*Y(1)
      BB2A=D1+D(2)*Y(2)+D(3)*Y(2)*Y(2)+D(4)*Y(2)*Y(2)*Y(2)
      BPA=D(1)+D(2)*Y(4)+D(3)*Y(4)*Y(4)+D(4)*Y(4)*Y(4)*Y(4)
      BASEPL(IFULSC)=BPA
      VOFFA=2.0*Y(3)-14.33
      ITMP=BPA-273.15+2.5
C+++++SAVE SCAN LINE TIME FOR PRINTING LATER
      DO 70 I=1,6
      QTIME(I,ISCAN)=QDATA(1740+I)
   70 CONTINUE
      IF(IFULSC.EQ.1) WRITE(8,944) ICOUNT,(QDATA(J),J=1741,1746)
      CALL LINES(1)
C+++++CALL AVERAGING ROUTINES
      CALL CCTAVR
C+++++HAVE WE PROCESSED ALL SCANS IN A BLOCK
      IF(IFULSC.NE.NSIZE) GO TO 5
  735 WRITE(8,944) ICOUNT,(QDATA(J),J=1741,1746)
      WRITE(8,926) (QSTR(J),J=1,25)
      II=NSTBLK+IBLK-1
      WRITE(8,927) II
      WRITE(8,926) (QSTR(J),J=1,25)
C+++++FIND AVERAGES IN COUNTS & VOLTS FOR EACH BLOCK
      IF(IFULSC.EQ.0) GO TO 780
      K=IFULSC
  737 DO 745 I=1,20
      IF(FULAV(1,I).EQ.-1.0) GO TO 745
      DO 740 J=1,IFULSC
      AVFUL(IBLK,I)=AVFUL(IBLK,I)+FULAV(J,I)
      RAVFUL(IBLK,I)=RAVFUL(IBLK,I)+RFULAV(J,I)
      AVSDFL(IBLK,I)=AVSDFL(IBLK,I)+FULSD(J,I)
      RAVSDF(IBLK,I)=RAVSDF(IBLK,I)+RFULSD(J,I)
  740 CONTINUE
      AVFUL(IBLK,I)=AVFUL(IBLK,I)/IFULSC
      AVSDFL(IBLK,I)=AVSDFL(IBLK,I)/IFULSC
```

```
      RAVFUL(IBLK,I)=RAVFUL(IBLK,I)/IFULSC
      RAVSDF(IBLK,I)=RAVSDF(IBLK,I)/IFULSC
      DO 742 J=1,IFULSC
      SDFUL(IBLK,I)=SDFUL(IBLK,I)+(FULAV(J,I)-AVFUL(IBLK,I))**2
      RSDFUL(IBLK,I)=RSDFUL(IBLK,I)+(RFULAV(J,I)-RAVFUL(IBLK,I))**2
  742 CONTINUE
      RSDFUL(IBLK,I)=SQRT(RSDFUL(IBLK,I)/(K))
      SDFUL(IBLK,I)=SQRT(SDFUL(IBLK,I)/(K))
  745 CONTINUE
      DO 746 I=1,IFULSC
      VBBV(IBLK)=VBBV(IBLK)+FULSD(I,19)*FULSD(I,19)+(FULAV(I,19)-
     1AVFUL(IBLK,19))**2
      RBBV(IBLK)=RBBV(IBLK)+RFULSD(I,19)*RFULSD(I,19)+(RFULAV(I,19)-
     1RAVFUL(IBLK,19))**2
  746 CONTINUE
      VBBV(IBLK)=SQRT(VBBV(IBLK)/IFULSC)
      RBBV(IBLK)=SQRT(RBBV(IBLK)/IFULSC)
C*****PRINT AVERAGES IN COUNTS &VOLTS
      WRITE(8,928) (QSTR(J),J=1,50)
      WRITE(8,934)
      WRITE(8,928)(QSTR(J),J=1,50)
      WRITE(8,930)
      DO 750 I=1,20
      IF(FULAV(1,I).EQ.-1.0) GO TO 750
      WRITE(8,931) ZNAME(I),AVFUL(IBLK,I),SDFUL(IBLK,I),
     1AVSDFL(IBLK,I),ZNAME(I),RAVFUL(IBLK,I),RSDFUL(IBLK,I),RAVSDF(IBLK,
     1I)
  750 CONTINUE
      WRITE(8,933) VBBV(IBLK),RBBV(IBLK)
      CALL LINES(3)
C*****CALCULATE P.U. AVERAGES FOR EACH BLOCK
      DO 758 I=1,5
      IF(PUFLAV(1,I).EQ.-1.0) GO TO 758
      DO 756 J=1,IFULSC
      AVPUFL(IBLK,I)=AVPUFL(IBLK,I)+PUFLAV(J,I)
      APUSDF(IBLK,I)=APUSDF(IBLK,I)+PUFLSD(J,I)
  756 CONTINUE
      AVPUFL(IBLK,I)=AVPUFL(IBLK,I)/IFULSC
      APUSDF(IBLK,I)=APUSDF(IBLK,I)/IFULSC
      DO 757 J=1,IFULSC
      SDPUFL(IBLK,I)=SDPUFL(IBLK,I)+(PUFLAV(J,I)-AVPUFL(IBLK,I))**2
  757 CONTINUE
      SDPUFL(IBLK,I)=SQRT(SDPUFL(IBLK,I)/K)
  758 CONTINUE
      DO 747 I=1,IFULSC
      PBBV(IBLK)=PBBV(IBLK)+PUFLSD(I,4)*PUFLSD(I,4)+(PUFLAV(I,4)-
     1AVPUFL(IBLK,4))**2
  747 CONTINUE
      PBBV(IBLK)=SQRT(PBBV(IBLK)/IFULSC)
      BASEAV(IBLK)=0.0
      DO 760 I=1,IFULSC
      BASEAV(IBLK)=BASEAV(IBLK)+BASEPL(I)
  760 CONTINUE
      BASEAV(IBLK)=BASEAV(IBLK)/IFULSC
      WRITE(8,928) (QSTR(J),J=1,50)
      WRITE(8,938)
      WRITE(8,928) (QSTR(J),J=1,50)
      WRITE(8,930)
C*****WRITE P.U.AVERAGES
      DO 759 I=1,5
      IF(PUFLAV(1,I).EQ.-1.0) GO TO 759
      WRITE(8,931) ZNAME(IND(I)),AVPUFL(IBLK,I),SDPUFL(IBLK,I),
     1APUSDF(IBLK,I)
C*****PRINT S/N FOR VISIBLE CHANNEL
      IF(ITYPE.NE.1.OR.I.GT.3) GO TO 759
      RATIO=AVPUFL(IBLK,I)/APUSDF(IBLK,I)
      WRITE(8,940)RATIO
  759 CONTINUE
      WRITE(8,933) PBBV(IBLK)
      WRITE(8,931) ZNAME2,BASEAV(IBLK)
      CALL LINES(3)
      IF(ITYPE.EQ.1) GO TO 761
C*****PRINT DIFF BETWEEN BB TH &BB VIEW
      DIFF=AVPUFL(IBLK,5)-AVPUFL(IBLK,4)
      WRITE(8,939) DIFF
      RATIO=AVFUL(IBLK,19)/(AVPUFL(IBLK,5)-260.0)
      WRITE(8,947) RATIO
      GO TO 763
```

```
  761 SIGTON=1.0/APUSDF(IBLK,4)
      WRITE(8,948) SIGTON
  763 WRITE(8,925) QSTR
      CALL LINES(20)
C+++++REINITIALISE VARIABLES BEFORE PROCESSING NEXT BLOCK
  762 IFULSC=0
      NSET=0
      GO TO 4
  780 NBLK=IBLK-1
C+++++FIND AVERAGES FOR ALL BLOCKS
C+++++FIRST IN COUNTS & VOLTS
 1000 DO 810 I=1,20
      IF(FULAV(1,I).EQ.-1.0) GO TO 810
      TOTAV(I)=0.0
      TOTSD(I)=0.0
      TOTSDA(I)=0.0
      RTOTAV(I)=0.0
      RTOTSD(I)=0.0
      RTTSDA(I)=0.0
      DO 800 J=1,NBLK
      TOTAV(I)=TOTAV(I)+AVFUL(J,I)
      TOTSDA(I)=TOTSDA(I)+AVSDFL(J,I)
      TOTSD(I)=TOTSD(I)+SDFUL(J,I)*SDFUL(J,I)
      RTOTAV(I)=RTOTAV(I)+RAVFUL(J,I)
      RTTSDA(I)=RTTSDA(I)+RAVSDF(J,I)
      RTOTSD(I)=RTOTSD(I)+RSDFUL(J,I)*RSDFUL(J,I)
  800 CONTINUE
      TOTAV(I)=TOTAV(I)/NBLK
      TOTSDA(I)=TOTSDA(I)/NBLK
      RTOTAV(I)=RTOTAV(I)/NBLK
      RTTSDA(I)=RTTSDA(I)/NBLK
      DO 805 J=1,NBLK
      TOTSD(I)=TOTSD(I)+(AVFUL(J,I)-TOTAV(I))**2
      RTOTSD(I)=RTOTSD(I)+(RAVFUL(J,I)-RTOTAV(I))**2
  805 CONTINUE
      RTOTSD(I)=SQRT(RTOTSD(I)/NBLK)
      TOTSD(I)=SQRT(TOTSD(I)/NBLK)
  810 CONTINUE
      DO 815 J=1,NBLK
      TVBBV=VBBV(J)*VBBV(J)+(AVFUL(J,19)-TOTAV(19))**2+TVBBV
      TRBBV=RBBV(J)*RBBV(J)+(RAVFUL(J,19)-RTOTAV(19))**2+TRBBV
  815 CONTINUE
      TVBBV=SQRT(TVBBV/NBLK)
      TRBBV=SQRT(TRBBV/NBLK)
C+++++WRITE AVERAGES IN COUNTS & VOLTS
      WRITE(8,926) (QSTR(J),J=1,25)
      WRITE(8,946)
      WRITE(8,926) (QSTR(J),J=1,25)
      WRITE(8,928) (QSTR(J),J=1,50)
      WRITE(8,934)
      WRITE(8,928) (QSTR(J),J=1,50)
      WRITE(8,930)
      DO 820 I=1,20
      IF(FULAV(1,I).EQ.-1.0) GO TO 820
      WRITE(8,931) ZNAME(I),TOTAV(I),TOTSD(I),TOTSDA(I)
     1,ZNAME(I),RTOTAV(I),RTOTSD(I),RTTSDA(I)
  820 CONTINUE
      WRITE(8,933) TVBBV,TRBBV
      CALL LINES(2)
C+++++CALCULATE MAX &MIN RMS NOISE IN CAL STEPS IN MV
      DO 825 I=1,7
      IF(TOTSDA(I+1).LT.VMINI) MINI=I-1
      VMINI=AMIN1(VMINI,TOTSDA(I+1))
      IF(TOTSDA(I+1).GT.VMAXI) MAXI=I-1
      VMAXI=AMAX1(VMAXI,TOTSDA(I+1))
      IF(TOTSDA(I+11).LT.VMINO) MINO=I-1
      VMINO=AMIN1(VMINO,TOTSDA(I+11))
      IF(TOTSDA(I+11).GT.VMAXO) MAXO=I-1
      VMAXO=AMAX1(VMAXO,TOTSDA(I+11))
  825 CONTINUE
      VMINI=VMINI*1000
      VMAXI=VMAXI*1000
      VMINO=VMINO*1000
      VMAXO=VMAXO*1000
      WRITE(8,949) VMINI,MINI
      WRITE(8,950) VMAXI,MAXI
      WRITE(8,951) VMINO,MINO
      WRITE(8,952) VMAXO,MAXO
```

09MAR79 14.59.42 - VOL=DISK06, DSN=ZBMMB.LIB.CNTL

```
      CALL LINES(3)
      WRITE(8,928) (OSTR(J),J=1,50)
      WRITE(8,938)
      WRITE(8,928) (OSTR(J),J=1,50)
      WRITE(8,930)
C+++++CALCULATE P.U.AVERAGES
      DO 840 I=1,5
      IF(PUFLAV(1,I).EQ.-1.0) GO TO 840
      TPUAV(I)=0.0
      TPUSDA(I)=0.0
      TPUSD(I)=0.0
      DO 830 J=1,NBLK
      TPUAV(I)=TPUAV(I)+AVPUFL(J,I)
      TPUSDA(I)=TPUSDA(I)+APUSDF(J,I)
      TPUSD(I)=TPUSD(I)+SDPUFL(J,I)*SDPUFL(J,I)
  830 CONTINUE
      TPUAV(I)=TPUAV(I)/NBLK
      TPUSDA(I)=TPUSDA(I)/NBLK
      DO 835 J=1,NBLK
      TPUSD(I)=TPUSD(I)+(AVPUFL(J,I)-TPUAV(I))**2
  835 CONTINUE
      TPUSD(I)=SQRT(TPUSD(I)/NBLK)
  840 CONTINUE
      DO 841 J=1,NBLK
      TPBBV=PBBV(J)*PBBV(J)+(AVPUFL(J,4)-TPUAV(4))**2+TPBBV
  841 CONTINUE
      TPBBV=SQRT(TPBBV/NBLK)
      TBPA=0.0
      DO 842 I=1,NBLK
      TBPA=TBPA+BASEAV(I)
  842 CONTINUE
      TBPA=TBPA/NBLK
C+++++WRITE P.U.AVERAGES
      DO 850 I=1,5
      IF(PUFLAV(1,I).EQ.-1.0) GO TO 850
      WRITE(8,931) ZNAME(IND(I)),TPUAV(I),TPUSD(I),TPUSDA(I)
  850 CONTINUE
       WRITE(8,933) TPBBV
      WRITE(8,931) ZNAME2,TBPA
      IF(ITYPE.EQ.1) GO TO 860
C+++++CALCULATE BB TH-BASEPLATE,BB TH-BB VIEW IN P.U.
      DIFF=TPUAV(5)-TBPA
      WRITE(8,932) DIFF
      DIFF=TPUAV(5)-TPUAV(4)
      WRITE(8,939)DIFF
      RATIO=TOTAV(19)/(TPUAV(5)-260.0)
      WRITE(8,947) RATIO
      GO TO 1100
  860 SIGTON=1.0/TPUSDA(4)
      WRITE(8,948) SIGTON
 1100 STOP
  900 FORMAT(1X,'END OF DATA',I5)
  910 FORMAT(2I3)
  920 FORMAT(1X,'I/O ERROR',I5)
  925 FORMAT(1X,131A1)
  926 FORMAT(54X,25A1)
  927 FORMAT(///54X,'SUMMARY FOR BLOCK',I4)
  928 FORMAT(25X,50A1)
  930 FORMAT(///1X,'FUNCTION',2X,'AVERAGE',5X,'S.D.',7X,'AV S.D.',
     130X,'FUNCTION',2X,'AVERAGE',5X,'S.D.',7X,'AV S.D.')
  931 FORMAT(2X,A8,3F9.4,32X,A8,3F9.2)
  932 FORMAT(1X,'BB THERMISTOR-BASEPLATE=',F9.4)
  933 FORMAT(28X,F9.4,58X,F9.4)
  934 FORMAT(25X,'CALIBRATED & RAW AVERAGES FOR FULL SCANS(VOLTS)')
  938 FORMAT(25X,'P.U. AVERAGES FOR FULL SCANS')
  939 FORMAT(1X,'BB THERMISTOR-BB VIEW=',F8.4)
  940 FORMAT('+',42X,'S/N=',F12.4)
  942 FORMAT(54X,78A1)
  944 FORMAT(54X,'SCAN',I5,2X,'TIME',2X,6Z2)
  946 FORMAT(///54X,'FINAL SUMMARY')
  947 FORMAT(1X,'SENSITIVITY QUOTIENT',F10.4)
  948 FORMAT(1X,'S/N(BB VIEW-1% EQUIVALENT)',F10.4)
  949 FORMAT(1X,'MIN INPUT CAL RMS NOISE=',F8.1,'MV',2X,'@',I1,'V')
  950 FORMAT(1X,'MAX INPUT CAL RMS NOISE=',F8.1,'MV',2X,'@',I1,'V')
  951 FORMAT(1X,'MIN OUTPUT CAL RMS NCISE=',F8.1,'MV',2X,'@',I1,'V')
  952 FORMAT(1X,'MAX OUTPUT CAL RMS NCISE=',F8.1,'MV',2X,'@',I1,'V')
      END
```

09MAR79 14.59.42 - VOL=DISK06, DSN=ZBMMB.LIB.CNTL

*** END OF MEMBER ***   388 RECORDS PROCESSED   **********************************

```
C+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
C+++++SUBROUTINE CCTAVR
C+++++ROUTINE TO SET START & END LOCATIONS FOR X ARRAY FOR
C+++++CALCULATING AVERAGES & STANDARD DEVIATIONS FOR VARIOUS
C+++++TYPES OF SAMPLES.IT ALSO PRINTS RAW,CALIBRATED &P.U.
C+++++AVERAGES &S.D.SAVE AVERAGES &S.D.(CALIBRATED &P.U.&RAW) FOR
C+++++CALCULATING AVERAGES WHEN ALL SCANS ARE PROCESSED
C+++++       11/15/78
C+++++DEVELOPED BY M.BEWTRA , COMPUTER SCIENCES CORPORATION
C+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
      SUBROUTINE CCTAVR
      IMPLICIT LOGICAL*1(Q)
      REAL*8 ZNAME
      COMMON/CCTINF/X(2000)
      COMMON/CCTINF/ISC,IES(3),IOUT,IBB,ITH,NSC,NES(3),NOUT,NBB,NTH,
     1ITYPE,NUMES
      COMMON/CCTINF/QDATA(4500),QSTR(131)
      COMMON/ANALYS/ZNAME(20)
      COMMON/ANALYS/AVER(20,10),SD(20,10),CV(20,10),CSD(20,10),
     *PU(20,10),PUSD(20,10),
     1VIN(7,2),VOUT(7,2),C(5,10),CVIN(7,2),CVOUT(7,2),VOFFA,BPA,BB1A,
     2BB2A,FULAV(200,20),FULSD(200,20),RFULAV(200,20),RFULSD(200,20),
     3PUFLAV(200,5),PUFLSD(200,5),IFULSC,ITMP,D(4),ISCAN,NSCAN,NSET,
     4QTIME(6,10)
      DIMENSION ISMP(7),SN(3,10),IND(5)
      DATA IND/9,10,11,19,20/
C+++++INITIALISE VARIABLES
      IF(ISCAN.NE.1) GO TO 130
      DO 120 I=1,20
      DO 120 J=1,NSCAN
      AVER(I,J)=-1.0
      SD(I,J)=-1.0
      CV(I,J)=-1.0
      CSD(I,J)=-1.0
      PU(I,J)=-1.0
      PUSD(I,J)=-1.0
  120 CONTINUE
      DO 122 I=1,7
      VIN(I,ITYPE)=0.0
      VOUT(I,ITYPE)=0.0
  122 CONTINUE
C+++++CALCULATE RAW AVERAGES CALIBRATED AVERAGES ,CONVERT TO PHYSICAL
C+++++UNITS FOR VARIOUS PARAMETERS
C+++++SPACE CLAMP &INPUT CAL
  130 J=0
      DO 200 I=1,8
      M=NSC-8
      IBEG=ISC+NSC*(I-1)+4
      IEND=IBEG+M-1
      J=J+1
      CALL CCTBAS(IBEG,IEND,J)
      IF(I.EQ.1) GO TO 200
      VIN(I-1,ITYPE)=AVER(I,ISCAN)+VIN(I-1,ITYPE)
  200 CONTINUE
      IF(ISCAN.NE.NSCAN) GO TO 220
      DO 205 I=1,7
      VIN(I,ITYPE)=VIN(I,ITYPE)/NSCAN
  205 CONTINUE
      DO 210 I=1,8
      CALL CCTCNV(I)
  210 CONTINUE
      ISMP(1)=M
C+++++EARTH SCAN
  220 J=8
      IF(NUMES.EQ.0) GO TO 265
      DO 260 L=1,NUMES
      J=J+1
      M=NES(L)-6
      ISMP(L+1)=M
      IBEG=IES(L)+3
      IEND=IBEG+M-1
      CALL CCTBAS(IBEG,IEND,J)
      IF(ISCAN.NE.NSCAN) GO TO 260
      CALL CCTCNV(J)
      DO 230 M=1,NSCAN
      IF(PUSD(J,M).EQ.0.0) PUSD(J,M)=1.0
      SN(L,M)=PU(J,M)/PUSD(J,M)
```

```
  230 CONTINUE
  260 CONTINUE
C+++++OUTPUT CAL
  265 J=11
      DO 300 I=1,7
      M=NOUT-8
      IBEG=IOUT+NOUT*(I-1)+4
      IEND=IBEG+M-1
      J=J+1
      CALL CCTBAS(IBEG,IEND,J)
      VOUT(I,ITYPE)=AVER(11+I,ISCAN)+VOUT(I,ITYPE)
  300 CONTINUE
      IF(ISCAN.NE.NSCAN) GO TO 310
      DO 302 I=1,7
      VOUT(I,ITYPE)=VOUT(I,ITYPE)/NSCAN
  302 CONTINUE
      ISMP(5)=M
      DO 305 I=12,18
      CALL CCTCNV(I)
  305 CONTINUE
C+++++BLACKBODY VIEW
  310 J=19
      M=NBB-20
      IBEG=IBB+10
      IEND=IBEG+M-1
      ISMP(6)=M
      CALL CCTBAS(IBEG,IEND,J)
      IF(ISCAN.NE.NSCAN) GO TO 320
      CALL CCTCNV(J)
C+++++BLACKBODY THERMISTOR
  320 IF(ITYPE.EQ.1) GO TO 330
      J=20
      M=NTH-20
      IBEG=ITH+10
      IEND=IBEG+M-1
      ISMP(7)=M
      CALL CCTBAS(IBEG,IEND,J)
      IF(ISCAN.NE.NSCAN) GO TO 845
      CALL CCTCNV(J)
  330 IF(ISCAN.NE.NSCAN) GO TO 845
      DO 500 M=1,NSCAN
      WRITE(6,942) (QSTR(I),I=1,78)
      II=NSET*NSCAN+M
      WRITE(6,944) II,(QTIME(I,M),I=1,6)
      WRITE(6,942) (QSTR(I),I=1,78)
C+++++PRINT INPUT CALS
      WRITE(6,956) VOFFA,BPA,BB1A,BB2A
      CALL LINES(1)
      WRITE(6,922) (VIN(K,ITYPE),K=1,7)
      WRITE(6,950) ISMP(1)
      WRITE(6,952) (SD(K,M),K=2,8)
      WRITE(6,922) (CV(K,M),K=2,8)
      WRITE(6,952) (CSD(K,M),K=2,8)
      CALL LINES(1)
C+++++PRINT OUTPUT CALS
      WRITE(6,926) (VOUT(K,ITYPE),K=1,7)
      WRITE(6,950) ISMP(5)
      WRITE(6,952) (SD(K,M),K=12,18)
      WRITE(6,926) (CV(K,M),K=12,18)
      WRITE(6,952) (CSD(K,M),K=12,18)
      CALL LINES(1)
      WRITE(6,912)
C+++++PRINT SPACE CLAME
      WRITE(6,920) AVER(1,M),CV(1,M),PU(1,M)
      WRITE(6,950) ISMP(1)
      WRITE(6,951)    SD(1,M),CSD(1,M),PUSD(1,M)
      CALL LINES(1)
C+++++PRINT EARTH SCAN
      IF(NUMES.EQ.0) GO TO 460
      DO 450 L=1,NUMES
      IF(AVER(L+8,M).EQ.-1.0) GO TO 450
      GO TO (420,430,440),L
  420 WRITE(6,923) AVER(9,M),CV(9,M),PU(9,M)
      WRITE(6,950) ISMP(2)
      WRITE(6,951) SD(9,M),CSD(9,M),PUSD(9,M)
      IF(ITYPE.EQ.1) WRITE(6,954) SN(1,M)
      GO TO 450
  430 WRITE(6,924) AVER(10,M),CV(10,M),PU(10,M)
```

ORIGINAL PAGE IS
OF POOR QUALITY


```
      WRITE(6,950) ISMP(3)
      WRITE(6,951) SD(10,M),CSD(10,M),PUSD(10,M)
      IF(ITYPE.EQ.1) WRITE(6,954) SN(2,M)
      GO TO 450
  440 WRITE(6,925) AVER(11,M),CV(11,M),PU(11,M)
      WRITE(6,950) ISMP(4)
      WRITE(6,951) SD(11,M),CSD(11,M),PUSD(11,M)
      IF(ITYPE.EQ.1) WRITE(6,954) SN(3,M)
  450 CONTINUE
      CALL LINES(1)
C+++++PRINT BLACKBODY VIEW
  460 IF(AVER(19,M).EQ.-1.0) GO TO 470
      WRITE(6,928) AVER(19,M),CV(19,M),PU(19,M)
      WRITE(6,950) ISMP(6)
      WRITE(6,951) SD(19,M),CSD(19,M),PUSD(19,M)
      CALL LINES(1)
C+++++PRINT BLACKBODY THERMISTOR
  470 IF(AVER(20,M).EQ.-1.0) GO TO 500
      WRITE(6,930) AVER(20,M),CV(20,M),PU(20,M)
      WRITE(6,950) ISMP(7)
      WRITE(6,951) SD(20,M),CSD(20,M),PUSD(20,M)
      CALL LINES(1)
C+++++CALCULATE AND PRINT DIFF. BETWEEN BB TH & BB VIEW
      IF(ITYPE.EQ.1) GO TO 500
      DIFFT=PU(20,M)-PU(19,M)
      WRITE(6,953) DIFFT
      CALL LINES(1)
  500 CONTINUE
C+++++SAVE AVERAGES &S.D.FOR CALCULATING AVERAGES
C+++++AFTER ALL SCANS ARE PROCESSED
      DO 840 I=1,20
      DO 840 J=1,NSCAN
      FULAV(NSET*NSCAN+J,I)=CV(I,J)
      FULSD(NSET*NSCAN+J,I)=CSD(I,J)
      RFULAV(NSET*NSCAN+J,I)=AVER(I,J)
      RFULSD(NSET*NSCAN+J,I)=SD(I,J)
  840 CONTINUE
      DO 841 I=1,5
      DO 841 J=1,NSCAN
      PUFLAV(NSET*NSCAN   I)=PU(IND(I),J)
      PUFLSD(NSET*NSCAN+ ,I)=PUSD(IND(I),J)
  841 CONTINUE
      NSET=NSET+1
      ISCAN=0
  845 RETURN
C 900 FORMAT(1X,10F10.4)
  912 FORMAT(23X,'RAW',13X,'CALIB',9X,'P.U.')
  920 FORMAT('0','SPACE CLAMP   ',3F16.4)
  922 FORMAT('0','INPUT CAL     ',7F14.4)
  923 FORMAT('0','EARTH SCAN 1 ',3F16.4)
  924 FORMAT('0','EARTH SCAN 2 ',3F16.4)
  925 FORMAT('0','EARTH SCAN 3 ',3F16.4)
  926 FORMAT('0','OUTPUT CAL    ',7F14.4)
  928 FORMAT('0','BB VIEW       ',3F16.4)
  930 FORMAT('0','BB THERMISTOR',3F16.4)
  942 FORMAT(54X,78A1)
  944 FORMAT(54X,'SCAN',I5,2X,'TIME',6Z2)
  950 FORMAT('+',112X,I6)
  951 FORMAT(23X,3('(',F8.4,')',6X))
  952 FORMAT(20X,7('(',F8.4,')',4X))
  953 FORMAT('0','BB THERMISTOR-BB VIEW=',F8.4)
  954 FORMAT('+',70X,'S/N=',F12.4)
  956 FORMAT(1X,'V-OFFSET=',F10.4,'(V)',2X,'BASEPLATE=',F10.4,'(K)',
     12X,'BB1=',F10.4,'(K)',2X,'BB2=',F10.4,'(K)')
      END
```

*** END OF MEMBER ***   220 RECORDS PROCESSED   **********************************

09MAR79 14.59.42 - VOL=DISK06, DSN=ZBMMB.LIB.CNTL

```
C++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
C+++++SUBROUTINE CCTBAS
C+++++     2/22/79/
C+++++ROUTINE TO CALCULATE AVERAGES & STANDARD DEVIATIONS
C+++++OF SAMPLES REPRESENTING VARIOUS PHYSICALLY SIGNIFICANT PARAMETERS
C      IBEG=START LOCATION OF X ARRAY FOR THE PARAMETER BEING PROCESSED
C      IEND=LAST LOCATION OF X ARRAY FOR THE PARAMETER BEING PROCESSED
C      J=INDEX CORRESPONDING TO THE PARAMETER BEING PROCESSED
C
C+++++DEVELOPED BY M.BEWTRA , COMPUTER SCIENCES CORPORATION
C++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
      SUBROUTINE CCTBAS(IBEG,IEND,J)
      IMPLICIT LOGICAL*1 (Q)
      REAL*8 ZNAME
      COMMON/CCTINF/X(2000)
      COMMON/CCTINF/ISC,IES(3),IOUT,IBB,ITH,NSC,NES(3),NOUT,NBB,NTH,
     1ITYPE,NUMES
      COMMON/CCTINF/QDATA(4500),QSTR(131)
      COMMON/ANALYS/ZNAME(20)
      COMMON/ANALYS/AVER(20,10),SD(20,10),CV(20,10),CSD(20,10),
     *PU(20,10),PUSD(20,10),
     1VIN(7,2),VOUT(7,2),C(5,10),CVIN(7,2),CVOUT(7,2),VOFFA,BPA,BB1A,
     2BB2A,FULAV(200,20),FULSD(200,20),RFULAV(200,20),RFULSD(200,20),
     3PUFLAV(200,5),PUFLSD(200,5),IFULSC,ITMP,D(4),ISCAN,NSCAN,NSET,
     *QTIME(6,10)
C     WRITE(6,900) IBEG,IEND,J
C     WRITE(6,910) (X(I),I=IBEG,IEND)
      AVER(J,ISCAN)=0.0
      SD(J,ISCAN)=0.0
      N=IEND-IBEG+1
C+++++CALCULATE AVERAGE
      DO 100 I=IBEG,IEND
      AVER(J,ISCAN)=AVER(J,ISCAN)+X(I)
  100 CONTINUE
C     WRITE(6,910) AVER(J,ISCAN)
      AVER(J,ISCAN)=AVER(J,ISCAN)/N
C     WRITE(6,910) AVER(J,ISCAN)
C     WRITE(6,900) N
C+++++CALCULATE S.D.
      DO 200 I=IBEG,IEND
      SD(J,ISCAN)=SD(J,ISCAN)+(X(I)-AVER(J,ISCAN))**2
  200 CONTINUE
C     WRITE(6,920) SD(J,ISCAN)
      SD(J,ISCAN)=SQRT(SD(J,ISCAN)/(N))
C     WRITE(6,920) SD(J,ISCAN)
      RETURN
C 900 FORMAT(1X,3I6)
C 910 FORMAT(1X,12F10.6)
C 920 FORMAT(1X,2F20.6)
      END
```

*** END OF MEMBER ***   50 RECORDS PROCESSED   **********************************

09MAR79 14.59.42 - VOL=DISK06, DSN=Z8MMB.LIB.CNTL

```
C+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
C+++++SUBROUTINE CCTCNV
C+++++         2/22/79/
C+++++SUBROUTINE TO CONVERT FROM RAW TO CALIBRATED VOLTAGES
C+++++AND THEN TO PHYSICAL UNITS
C     J=INDEX FOR THE PARAMETER BEING PROCESSED
C
C+++++DEVELOPED BY M.BEWTRA , COMPUTER SCIENCES CORPORATION
C+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
      SUBROUTINE CCTCNV(J)
      IMPLICIT LOGICAL*1(Q)
      REAL*8 ZNAME
      COMMON/CCTINF/X(2000)
      COMMON/CCTINF/ISC,IES(3),IOUT,IBB,ITH,NSC,NES(3),NOUT,NBB,NTH,
     1ITYPE,NUMES
      COMMON/CCTINF/QDATA(4500),QSTR(131)
      COMMON/ANALYS/ZNAME(20)
      COMMON/ANALYS/AVER(20,10),SD(20,10),CV(20,10),CSD(20,10),
     *PU(20,10),PUSD(20,10),
     IVIN(7,2),VOUT(7,2),C(5,10),CVIN(7,2),CVOUT(7,2),VOFFA,BPA,BBIA,
     2BB2A,FULAV(200,20),FULSD(200,20),RFULAV(200,20),RFULSD(200,20),
     3PUFLAV(200,5),PUFLSD(200,5),IFULSC,ITMP,D(4),ISCAN,NSCAN,NSET,
     4QTIME(6,10)
C+++++CONVERT FROM RAW TO CALIBRATED VOLTS USING LINEAR INTERPOLATION
C+++++FOR INPUT CAL STEPS,SPACE CLAMP,EARTH SCAN &BB VIEW
      IF(J.EQ.20.OR.(J.GE.12.AND.J.LE.18)) GO TO 180
      DO 175 M=1,NSCAN
      IF(AVER(J,M).LT.VIN(1,ITYPE)) GO TO 105
      IF(AVER(J,M).GE.VIN(7,ITYPE)) GO TO 110
      DO 100 I=1,6
      IF(AVER(J,M).GE.VIN(I,ITYPE).AND.AVER(J,M).LT.VIN(I+1,ITYPE))
     1GO TO 115
  100 CONTINUE
  105 I=1
      GO TO 115
  110 I=6
  115 FRAC=(CVIN(I+1,ITYPE)-CVIN(I,ITYPE))/(VIN(I+1,ITYPE)
     1-VIN(I,ITYPE))
      CV(J,M)=CVIN(I,ITYPE)+FRAC*(AVER(J,M)-VIN(I,ITYPE))
      CSD(J,M)=ABS(SD(J,M)*FRAC)
C+++++CONVERT FROM CALIBRATED VOLTS TO PHYSICAL UNITS FOR SPACE CLAMP,
C+++++EARTH SCAN &BB VIEW.USE FOUR DEGREE POLYNOMIAL FOR THERMAL &
C+++++LINEAR FOR VISIBLE
      IF(J.GE.2.AND.J.LE.8) GO TO 175
      IF(ITYPE.EQ.1) GO TO 170
      II=ITMP/5+1
      PU(J,M)=C(1,II)+C(2,II)*CV(J,M)+C(3,II)*CV(J,M)*CV(J,M)+
     1C(4,II)*CV(J,M)*CV(J,M)*CV(J,M)+C(5,II)*CV(J,M)*CV(J,M)*CV(J,M)*
     1CV(J,M)
      PUSD(J,M)=C(2,II)+2.0*C(3,II)*CV(J,M)+3.0*C(4,II)*CV(J,M)*CV(J,M)+
     14.0*C(5,II)*CV(J,M)*CV(J,M)*CV(J,M)
      PUSD(J,M)=ABS(PUSD(J,M))*CSD(J,M)
      GO TO 175
  170 PU(J,M)=0.03121+16.79190*CV(J,M)
      PUSD(J,M)=16.79190*CSD(J,M)
  175 CONTINUE
      GO TO 300
C+++++CONVERT FROM RAW TO CALIBRATED VOLTAGES FOR OUTPUT CAL STEPS &
C+++++BB THERMISTOR
  180 DO 250 M=1,NSCAN
      IF(AVER(J,M).LT.VOUT(1,ITYPE)) GO TO 205
      IF(AVER(J,M).GE.VOUT(7,ITYPE)) GO TO 210
      DO 200 I=1,6
      IF(AVER(J,M).GE.VOUT(I,ITYPE).AND.AVER(J,M).LT.VOUT(I+1,ITYPE))
     1GO TO 215
  200 CONTINUE
  205 I=1
      GO TO 215
  210 I=6
  215 FRAC=(CVOUT(I+1,ITYPE)-CVOUT(I,ITYPE))/(VOUT(I+1,ITYPE)
     1-VOUT(I,ITYPE))
      CV(J,M)=CVOUT(I,ITYPE)+FRAC*(AVER(J,M)-VOUT(I,ITYPE))
      CSD(J,M)=ABS(SD(J,M)*FRAC)
C+++++CONVERT FROM CALIBRATED VOLTS TO PHYSICAL UNITS FOR BB THERMISTOR
C+++++USING CUBIC POLYNOMIAL
      IF(J.NE.20) GO TO 250
      PU(J,M)=D(1)+D(2)*CV(J,M)+D(3)*CV(J,M)*CV(J,M)+D(4)*CV(J,M)*
```

```
     1CV(J,M)*CV(J,M)                                                00007600
     PUSD(J,M)=D(2)+2.0*D(3)*CV(J,M)+3.0*D(4)*CV(J,M)*CV(J,M)        00007700
     PUSD(J,M)=ABS(PUSD(J,M))*CSD(J,M)                               00007800
 250 CONTINUE                                                        00007900
 300 RETURN                                                          00008000
 900 FORMAT(1X,6F12.5)                                               00008100
     END                                                             00008200

*** END OF MEMBER ***      84 RECORDS PROCESSED    *********************************
```

09MAR79 14.59.42 - VOL=DISK06, DSN=Z8MMB.LIB.CNTL

```
C+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
C+++++BLOCK DATA FOR CCTINF,ANALYS
C+++++       10/16/78/
C+++++DEVELOPED BY M.BEWTRA , COMPUTER SCIENCES CORPORATION
C+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
      BLOCK DATA
      IMPLICIT LOGICAL*1(Q)
      REAL*8 ZNAME
      COMMON/CCTINF/X(2000)
      COMMON/CCTINF/ISC,IES(3),IOUT,IBB,ITH,NSC,NES(3),NOUT,NBB,NTH,
     1ITYPE,NUMES
      COMMON/CCTINF/QDATA(4500),QSTR(131)
      COMMON/ANALYS/ZNAME(20)
      COMMON/ANALYS/AVER(20,10),SD(20,10),CV(20,10),CSD(20,10),
     *PU(20,10),PUSD(20,10),
     1VIN(7,2),VOUT(7,2),C(5,10),CVIN(7,2),CVOUT(7,2),VOFFA,BPA,BBIA,
     2BB2A,FULAV(200,20),FULSD(200,20),RFULAV(200,20),RFULSD(200,20),
     3PUFLAV(200,5),PUFLSD(200,5),IFULSC,ITMP,D(4),ISCAN,NSCAN,NSET,
     4QTIME(6,10)
      DATA ITYPE/2/,NUMES/0/
      DATA IFULSC/0/
      DATA C/258.920,19.2108,-0.980259,-0.86905E-1,0.15648E-1,
     *258.019,19.6024,-1.9052,0.227264,-1.25476E-2,
     *258.263,19.7513,-1.97098,0.242068,-1.37652E-2,
     *258.479,19.6741,-1.91159,0.228179,-1.26373E-2,
     *259.532,21.9840,-3.57012,0.615378,-0.40859E-1,
     *259.081,19.7079,-1.89414,0.223598,-1.23276E-2,
     *259.382,19.6976,-1.8863,0.226533,-1.28293E-2,
     *258.857,19.1720,-1.33345,0.64255E-01,0.46033E-3,
     *260.007,20.0119,-1.98857,0.242128,-1.35799E-2,
     *260.529,19.73,-1.78309,0.191249,-9.31209E-3/,
     3D/332.8817,-15.556,1.772,-0.1917/
      DATA CVIN/0.001,1.005,1.982,2.980,3.963,4.981,5.958,
     1         0.102,1.058,1.989,2.943,3.877,4.848,5.781/
      DATA CVOUT/0.006,0.970,1.970,2.947,3.954,4.929,5.924,
     1          0.009,0.969,1.963,2.937,3.945,4.920,5.915/
      DATA QSTR/131*'*'/
      DATA ZNAME/'SP CLAMP','IN CAL 1','IN CAL 2','IN CAL 3',
     1           'IN CAL 4','IN CAL 5','IN CAL 6','IN CAL 7',
     2           'E SCAN 1','E SCAN 2','E SCAN 3','OUTCAL 1',
     3           'OUTCAL 2','OUTCAL 3','OUTCAL 4','OUTCAL 5',
     4           'OUTCAL 6','OUTCAL 7','BB VIEW ','BB  TH  '/
      END
```

*** END OF MEMBER ***   43 RECORDS PROCESSED   ********************************

ORIGINAL PAGE IS
OF POOR QUALITY

09MAR79 14.59.42 - VOL=DISK06, DSN=Z8MMB.LIB.CNTL

```
C+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
C+++++SUBROUTINE LINES
C+++++      2/22/79/
C+++++SUBROUTINE TO SKIP DESIRED NUMBER OF LINES ON THE LINE PRIMTER
C+++++N=NUMBER OF LINES TO BE SKIPPED
C+
C+++++WRITTEN BY M.BEWTRA,COMPUTER SCIENCES CORPORATION
C+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
      SUBROUTINE LINES(N)
      DO 100 I=1,N
      WRITE(6,900)
  100 CONTINUE
  900 FORMAT(1X)
      RETURN
      END
```

*** END OF MEMBER ***   15 RECORDS PROCESSED   ********************************

09MAR79 14.59.42 - VOL=DISK06, DSN=ZBMMB.LIB.CNTL

```
C+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
C+++++MAIN FOR PROGRAM MDPSIM
C+++++       2/22/79/
C+++++THIS PROGRAM READS CALIBRATION DATA FROM A CCT-RU,PRODUCED BY MDP,
C+++++AND GENERATES CERTAIN INTERMEDIATE QUANTITIES & POLYNOMIALS FOR
C+++++CONVERTING RAW COUNTS TO CALIBRATED INDICES.OUTPUT THUS GENERATED
C+++++IS COMPARED WITH THE OUTPUT FROM MDP FOR EACH CALIBRATION SET.
C+++++A SUMMARY IS GENERATED IN THE END.
C
C+++++WRITTEN BY N.BEWTRA,COMPUTER SCIENCES CORPORATION
C++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
      IMPLICIT REAL*8(A-H,O-Z)
      INTEGER*2 COUNT
      LOGICAL*1 QGOOD,QTYPE1,QTYPE2
      REAL*4 DFMIN1,DFMIN2,DFMAX1,DFMAX2
      COMMON/VALUE/SCIN1(7),SCIN2(7),SCOUT1(7),SCOUT2(7),EC(3),SCBBR1,
     1SCSC1,SCBBR2,SCSC2,SCBB3,EBP,EBB1,EBB2,EOFFS,WS,PWS,
     2ALPHA1(4),ALPHA2(4),ALPHA3(4),ALPHA4(4),DELTA1(4),
     3DELTA2(4),C(2),EBBR1,ESC1,EBBR2,ESC2,TBB3,TBP,TBB1,TBB2,VOFF,
     4BETA1(4),BETA2(4),VI1(7),VI2(7),VO1(7),VO2(7),A(3),TAU1(4),TAU2(4)
     5,TAU3(4),TAU4(4),WT(3),SIGMA(4),EPSILN(4),RHO(2),B(3),VC(3),WBP,W0
     5,NUM,N,ICALL,COUNT(40),QGOOD
      COMMON/STAT/AVER1(256),AVER2(256),SD1(256),SD2(256),
     1DFMIN1(256),DFMIN2(256),DFMAX1(256),DFMAX2(256),IAV,
     2QTYPE1(1000),QTYPE2(1000)
      INTEGER*2 IFILL,ISL
      REAL*4 CONST
      LOGICAL*1 QDATA
      DIMENSION IFILL(4),CONST(176),QDATA(32)
      EQUIVALENCE (IFILL(1),CONST(175))
C
      NAMELIST/INPUT/ISETS,VI1,VI2,VO1,VO2,A,TAU1,TAU2,TAU3,TAU4,WT,
     1SIGMA,EPSILN,RHO,B,VC,W0,WS,PWS,N,WBP
      N=10
      WS=0.1
      PWS=0.9
      READ(5,INPUT)
      WRITE(6,INPUT)
      PWS=1.0-WS
C+++++READ &WRITE HEADER RECORD
      WRITE(6,800)
      CALL FREAD(QDATA(1),10,L,&250,&50)
      WRITE(6,900) (QDATA(J),J=1,32)
      CALL BCD5(QDATA,QDATA,32)
      WRITE(6,901) (QDATA(J),J=1,32)
      GO TO 60
   50 WRITE(6,902)
   60 CALL LINES(2)
C+++++READ & WRITE SYSTEM CONSTANTS
      WRITE(6,805)
      CALL FREAD(CONST(1),10,L,&250,&70)
      WRITE(6,810) IFILL(1),CONST(1),CONST(142),CONST(166)
      WRITE(6,812) (CONST(I),I=58,64)
      WRITE(6,814) (CONST(I),I=135,141)
      WRITE(6,816) (CONST(I),I=96,102)
      WRITE(6,818) (CONST(I),I=65,67)
      WRITE(6,820) (CONST(I),I=103,106)
      WRITE(6,822) (CONST(I),I=143,146)
      WRITE(6,824) (CONST(I),I=147,150)
      WRITE(6,826) (CONST(I),I=151,154)
      WRITE(6,828) (CONST(I),I=155,157)
      WRITE(6,830) (CONST(I),I=158,161)
      WRITE(6,832) (CONST(I),I=162,165)
      WRITE(6,834) (CONST(I),I=167,168)
      WRITE(6,836) (CONST(I),I=169,171)
      WRITE(6,838) (CONST(I),I=172,174)
      WRITE(6,840)
      WRITE(6,842) (CONST(I),I=30,57),(CONST(I),I=107,134),
     1(CONST(I),I=2,29),(CONST(I),I=68,95)
      GO TO 80
   70 WRITE(6,904)
   80 CALL LINES(5)
      ICALL=1
      I=0
C+++++READ FIRST RECORD,INITIALISE CALIBRATION QUANTITIES
   90 CALL MDPRED(I,ISL)
      I=I+1
```

```
      IF(.NOT.QGOOD) GO TO 90
      DO 100 J=1,7
      SCIN1(J)=COUNT(J+1)
      SCIN2(J)=COUNT(J+17)
      SCOUT1(J)=COUNT(J+8)
      SCOUT2(J)=COUNT(J+24)
  100 CONTINUE
      SCBBR1=COUNT(16)
      SCSC1=COUNT(1)
      SCBBR2=COUNT(32)
      SCSC2=COUNT(17)
      SCBB3=COUNT(33)
      IF(N.EQ.1) GO TO 210
  200 CALL MDPRED(I,ICL)
      I=I+1
C*****CALL SMOOTHING ROUTINE
      IF(QGOOD) CALL SMOOTH
C*****CALCULATE INTERMEDIATE QUANTITIES & POLYNOMIALS FOR CONVERSION
C*****IF N RECORDS PROCESSED
      IF(I.NE.N) GO TO 200
  210 WRITE(6,906)TSL
      WRITE(6,908) ICALL
      WRITE(6,909)
      CALL LINES(1)
      WRITE(6,910)SCIN1,SCOUT1,SCIN2,SCOUT2
      WRITE(6,910)SCSC1,SCBBR1,SCSC2,SCBBR2,SCBB3,EC,EEP,EBB1,EBB2,EOFFS
      CALL INTVAL
      I=0
C*****COMPARE SIMULATOR OUTPUT WITH MDF OUTPUT
      CALL COMPAR
      IF(ICALL.EQ.ISETS) GO TO 260
      ICALL=ICALL+1
      GO TO 200
  250 WRITE(6,940)
      GO TO 300
  800 FORMAT(/55X,'****HEADER RECORD****')
  805 FORMAT(/55X,'****MDP SYSTEM CONSTANTS****')
  810 FORMAT(/1X,'N=',I5,5X,'WS=',F8.4,5X,'WBP=',F8.4,5X,'W0=',
     1F8.4)
  812 FORMAT(/1X,'VI1=',7F10.3)
  814 FORMAT(1X,'VI2=',7F10.3)
  816 FORMAT(1X,'VO2=',7F10.3)
  818 FORMAT(/1X,'A=',3F14.7)
  820 FORMAT(/1X,'TAU1=',4F12.4)
  822 FORMAT(1X,'TAU2=',4F12.4)
  824 FORMAT(1X,'TAU3=',4F12.4)
  826 FORMAT(1X,'TAU4=',4F12.4)
  828 FORMAT(/1X,'WT=',3F10.4)
  830 FORMAT(/1X,'SIGMA=',4(1PE15.5))
  832 FORMAT(/1X,'EPSILON=',4(1PE10.6))
  834 FORMAT(/1X,'RHO=',2F10.5)
  836 FORMAT(/1X,'B=',3F12.4)
  838 FORMAT(/1X,'VC=',3F8.2)
  840 FORMAT(/1X,'M1,M2,M3,M4=')
  842 FORMAT(1X,2F15.7)
  900 FORMAT(1X,32Z2)
  901 FORMAT(1X,32A1)
  902 FORMAT(1X,'ERROR IN READING HEADER RECORD')
  904 FORMAT(1X,'ERROR IN READING SYSTEM CONSTANTS RECORD')
  906 FORMAT(/55X,'****SCAN LINE #',I5,'****')
  908 FORMAT(55X,'****CALIBRATION SET #',I5,'****')
  909 FORMAT(1X,'SIMULATOR OUTPUT')
  910 FORMAT(1X,14F9.2)
  920 FORMAT(1X,I5)
  940 FORMAT(1X,'END OF FILE')
  260 CALL FINAL
  300 STOP
      END
*** END OF MEMBER ***     145 RECORDS PROCESSED     **********************************
```

ORIGINAL PAGE IS
OF POOR QUALITY

09MAR79 14.59.42 - VOL=DISK06, DSN=ZEMMB.LIB.CNTL

```
C++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
C+++++SUBROUTINE MDPRED
C+++++        2/22/79
C+++++ROUTINE TO READ CCT-RU GENERATED BY MDP,AND TRANSFER
C+++++CALIBRATION DATA FROM L*1 ARRAY TO I*2 ARRAY.
C       IREC=SCAN LINE COUNTER IN THE CURRECNT CLIBRATION SET
C       ISL=ABSOLUTE SCAN LINE COUNTER
C
C+++++WRITTEN BY M.BEWTRA,COMPUTER SCIENCES CORPORATION
C+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
      SUBROUTINE MDPRED(IREC,ISL)
      IMPLICIT REAL*8(A-H,O-Z)
      INTEGER*2 COUNT
      LOGICAL*1 QGOOD,QTYPE1,QTYPE2
      REAL*4 DFMIN1,DFMIN2,DFMAX1,DFMAX2
      COMMON/VALUE/SCIN1(7),SCIN2(7),SCOUT1(7),SCOUT2(7),EC(3),SCBBR1,
     1SCSC1,SCBBR2,SCSC2,SCBB3,EBP,EBB1,EBB2,EOFFS,WS,PWS,
     2ALPHA1(4),ALPHA2(4),ALPHA3(4),ALPHA4(4),DELTA1(4),
     3DELTA2(4),C(2),EBBR1,ESC1,EBBR2,ESC2,TBB3,TBP,TBB1,TBB2,VOFF,
     4BETA1(4),BETA2(4),VI1(7),VI2(7),VO1(7),VO2(7),A(3),TAU1(4),TAU2(4)
     5,TAU3(4),TAU4(4),WT(3),SIGMA(4),EPSILN(4),RHO(2),B(3),VC(3),WBP,W0
     6,NUM,N,ICALL,COUNT(40),QGOOD
      COMMON/STAT/AVER1(256),AVER2(256),SD1(256),SD2(256),
     1DFMIN1(256),DFMIN2(256),DFMAX1(256),DFMAX2(256),IAV,
     2QTYPE1(1000),QTYPE2(1000)
      LOGICAL*1 QDATA
      INTEGER*2 ISL,NSL
      DIMENSION QDATA(1304)
      EQUIVALENCE (NSL,QDATA(1257))
      QGOOD=.TRUE.
      CALL FREAD(QDATA(1),10,L,&260,&250)
C+++++TRANSFER CALIBRATION QUANTITIES FROM L*1 ARRAY TO I*2 ARRAY
      COUNT(1)=QDATA(442)
      COUNT(16)=QDATA(2)
      COUNT(17)=QDATA(1074)
      COUNT(32)=QDATA(634)
      COUNT(33)=QDATA(1178)
      DO 100 J=1,7
      COUNT(J+1)=QDATA(82+J*24)
      COUNT(J+8)=QDATA(250+J*24)
      COUNT(J+17)=QDATA(714+J*24)
      COUNT(J+24)=QDATA(882+J*24)
  100 CONTINUE
      ISL=NSL
      IF(IREC.GT.0) GO TO 300
C+++++TRANSFER 7 TELEMETRY VALUES
      EBB1=QDATA(1240)
      EBB2=QDATA(1242)
      EOFFS=QDATA(1244)
      EBP=QDATA(1246)
      DO 200 I=1,3
      EC(I)=QDATA(1232+I*2)
  200 CONTINUE
      GO TO 300
C+++++MESSAGE FOR I/O ERROR
  250 JREC=IREC+1
      QGOOD=.FALSE.
      WRITE(6,900) JREC,ICALL
      GO TO 300
C+++++MESSAGE FOR END OF FILE
  260 WRITE(6,902)
      CALL FINAL
      STOP
  300 RETURN
  900 FORMAT(1X,'I/O ERROR IN READING RECORD #',I6,'FOR CALIBRATION
     1SET #',I6)
  902 FORMAT(1X,'END OF FILE')
      END
```

*** END OF MEMBER *** 68 RECORDS PROCESSED ********************************

```
C+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
C+++++SUBROUTINE SMOOTH
C+++++      2/22/79/
C++++^+ROUTINE TO SMOOTH CALIBRATION DATA
C
C+++++WRITTEN BY M.BEWTRA,COMPUTER SCIENCES CORPORATION
C+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
      SUBROUTINE SMOOTH
      IMPLICIT REAL*8(A-H,O-Z)
      INTEGER*2 COUNT
      LOGICAL*1 QGOOD
      COMMON/VALUE/SCIN1(7),SCIN2(7),SCOUT1(7),SCOUT2(7),EC(3),SCBBR1,
     1SCSC1,SCBBR2,SCSC2,SCBB3,EBP,EBE1,EBB2,EOFFS,WS,PWS,
     2ALPHA1(4),ALPHA2(4),ALPHA3(4),ALPHA4(4),DELTA1(4),
     3DELTA2(4),C(2),EBBR1,ESC1,EBBR2,ESC2,TBB3,TBP,TBB1,TBB2,VOFF,
     4BETA1(4),BETA2(4),VI1(7),VI2(7),VO1(7),VO2(7),A(3),TAU1(4),TAU2(4)
     5,TAU3(4),TAU4(4),WT(3),SIGMA(4),EPSILN(4),RHO(2),B([illegible]),VC(3),WBP,W0
     6,NJM,N,ICALL,COUNT(40),QGOOD
      DO 100 J=1,7
      SCIN1(J)=WS*COUNT(J+1)+(PWS)*SCIN1(J)
      SCIN2(J)=WS*COUNT(J+17)+(PWS)*SCIN2(J)
      SCOUT1(J)=WS*COUNT(J+8)+(PWS)*SCOUT1(J)
      SCOUT2(J)=WS*COUNT(J+24)+(PWS)*SCOUT2(J)
  100 CONTINUE
      SCSC1=WS*COUNT(1)+(PWS)*SCSC1
      SCSC2=WS*COUNT(17)+(PWS)*SCSC2
      SCBBR1=WS*COUNT(16)+(PWS)*SCBBR1
      SCBBR2=WS*COUNT(32)+(PWS)*SCBBR2
      SCBB3=WS*COUNT(33)+(PWS)*SCBB3
      RETURN
      END
```

*** END OF MEMBER ***   31 RECORDS PROCESSED   ************************************

ORIGINAL PAGE IS
OF POOR QUALITY

09MAR79 14.59.42 - VOL=DISK06, DSN=ZBMMB.LIB.CNTL

```
C+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
C+++++SUBROUTINE INTVAL
C+++++       2/22/79/
C+++++ROUTINE TO GENERATE VARIOUS INTERMEDIATE QUATITIES & POLYNOMIALS
C+++++FOR CONVERTING RAW COUNTS TO CALIBRATED INDICES.
C
C+++++WRITTEN BY M.BEWTRA,COMPUTER SCIENCES CORPORATION
C++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
      SUBROUTINE INTVAL
      IMPLICIT REAL*8(A-H,O-Z)
      INTEGER*2 COUNT
      LOGICAL*1 QGOOD,QTYPE1,QTYPE2
      REAL*4 DFMIN1,DFMIN2,DFMAX1,DFMAX2
      COMMON/VALUE/SCIN1(7),SCIN2(7),SCOUT1(7),SCOUT2(7),EC(3),  BBR1,
     1SCSC1,SCBBR2,SCSC2,SCBB3,EBP,EBB1,EBB2,EOFFS,WS,PWS,
     2ALPHA1(4),ALPHA2(4),ALPHA3(4),ALPHA4(4),DELTA1(4),
     3DELTA2(4),C(2),EBBR1,ESC1,EBBR2,ESC2,TBB3,TBP,TBB1,TBB2,VOFF,
     4BETA1(4),BETA2(4),VI1(7),VI2(7),VC1(7),VO2(7),A(3),TAU1(4),TAU2(4)
     5,TAU3(4),TAU4(4),WT(3),SIGMA(4),EPSILN(4),RHO(2),B(3),VC(3),WBP,W0
     6,NUM,N,ICALL,COUNT(40),QGOOD
      COMMON/STAT/AVER1(256),AVER2(256),SD1(256),SD2(256),
     1DFMIN1(256),DFMIN2(256),DFMAX1(256),DFMAX2(256),IAV,
     2QTYPE1(1000),QTYPE2(1000)
      DIMENSION VM1(4,7),VM2(4,7),VM3(4,7),VM4(4,7),VM(4,7)
C+++++CHANNEL    1           VISIBLE
C     WRITE(6,900)
C+++++CALCULATE MATRICES FOR OBTAINING COEFFICIENTS OF CUBIC POYNOMIALS
C+++++GIVING COUNT AS A FUNCTION OF VOLTAGE FOR INPUT &OUTPUT CALS
      IF(ICALL.NE.1) GO TO 100
      WT1=1.0-WT(1)-WT(2)-WT(3)
      CALL MATRIX(VI1,VM1)
      CALL MATRIX(VO1,VM3)
C     WRITE(6,902)
C     WRITE(6,904) ((VM1(I,J),J=1,7),I=1,4)
C     WRITE(6,908)
C     WRITE(6,904) ((VM3(I,J),J=1,7),I=1,4)
C+++++CALCULATE COEFFICIENTS
  100 CALL MATMUL(VM1,SCIN1,ALPHA1,4,7,1)
      CALL MATMUL(VM3,SCOUT1,ALPHA3,4,7,1)
C     WRITE(6,906)
C     WRITE(6,904) ALPHA1
C     WRITE(6,910)
C     WRITE(6,904) ALPHA3
C+++++CALCULATE MATRIX & COEFFICIENTS FOR CUBIC POLYNOMIAL GIVING
C+++++VOLTAGE AS A FUNCTION OF COUNTS FOR INPUT CALS
      CALL MATRIX(SCIN1,VM)
      CALL MATMUL(VM,VI1,BETA1,4,7,1)
C     WRITE(6,912)
C     WRITE(6,904) ((VM(I,J),J=1,7),I=1,4)
C+++++COMPUTE SPACE CLAMP &BB VIEW VOLTAGES FROM COUNTS
      ESC1=CUBIC(BETA1,SCSC1)
      EBBR1=CUBIC(BETA1,SCBBR1)
      WRITE(6,916) ESC1,EBBR1
C+++++DETERMINE COEFFICIENTS OF CUBIC POLYNOMIAL TRANSFERRING RAW COUNTS
C+++++TO CALIBRATED INDICES
      DELTA1(1)=A(1)+A(2)*BETA1(1)+A(3)*BETA1(1)*BETA1(1)
      DELTA1(2)=A(2)*BETA1(2)+2.0*A(3)*BETA1(1)*BETA1(2)
      DELTA1(3)=A(2)*BETA1(3)+A(3)*(2.0*BETA1(1)*BETA1(3)+BETA1(2)*
     1BETA1(2))
      DELTA1(4)=A(2)*BETA1(4)+A(3)*(2.0*BETA1(1)*BETA1(4)+2.0*BETA1(2)
     1*BETA1(3))
      WRITE(6,918) BETA1,DELTA1
C+++++CHANNEL    2         THERMAL
C     WRITE(6,920)
C+++++CALCULATE MATRICES FOR OBTAINING COEFFICIENTS OF CUBIC POYNOMIALS
C+++++GIVING COUNT AS A FUNCTION OF VOLTAGE FOR INPUT &OUTPUT CALS
      IF(ICALL.NE.1) GO TO 150
      CALL MATRIX(VI2,VM2)
      CALL MATRIX(VO2,VM4)
C     WRITE(6,902)
C     WRITE(6,904) ((VM2(I,J),J=1,7),I=1,4)
C     WRITE(6,908)
C     WRITE(6,904) ((VM4(I,J),J=1,7),I=1,4)
C+++++CALCULATE COEFFICIENTS
  150 CALL MATMUL(VM2,SCIN2,ALPHA2,4,7,1)
      CALL MATMUL(VM4,SCOUT2,ALPHA4,4,7,1)
C     WRITE(6,906)
```

```
C     WRITE(6,904) ALPHA2
C     WRITE(6,910)
C     WRITE(6,904) ALPHA4
C+++++CALCULATE MATRIX & COEFFICIENTS FOR CUBIC POLYNOMIAL GIVING
C+++++VOLTAGE AS A FUNCTION OF COUNTS FOR INPUT CALS
      CALL MATRIX(SCIN2,VM)
      CALL MATMUL(VM,VI2,BETA2,4,7,1)
C     WRITE(6,912)
C     WRITE(6,904) ((VM(I,J),J=1,7),I=1,4)
C+++++CONVERT BB THERMISTOR FROM COUNTS TO VOLTS USING LINEAR
C+++++INTERPOLATION
      IF(SCBB3.LT.SCOUT2(1)) GO TO 205
      IF(SCBB3.GE.SCOUT2(7)) GO TO 210
      DO 200 I=1,6
      IF(SCBB3.GE.SCOUT2(I).AND.SCBB3.LT.SCOUT2(I+1)) GO TO 215
  200 CONTINUE
  205 I=1
      GO TO 215
  210 I=6
  215 IF(DABS(SCOUT2(I+1)-SCOUT2(I)).LT. .001) GO TO 217
      FRAC=(VO2(I+1)-VO2(I))/(SCOUT2(I+1)-SCOUT2(I))
      EBB3=VO2(I)+FRAC*(SCBB3-SCOUT2(I))
      TBB3=CUBIC(TAU1,EBB3)
      GO TO 216
  217 WRITE(8,942) ICALL
  216 EBBR2=CUBIC(BETA2,SCBBR2)
      ESC2=CUBIC(BETA2,SCSC2)
      WRITE(6,922) EBB3
      WRITE(6,923) ESC2,EBBR2
C+++++COMPUTE  TELEMETRY VOLTAGE CORRECTION COEFFICIENTS AND ADJUST
C+++++TELEMETRY VOLTAGES,SMOOTH BASEPLATE VOLTAGE
      IF(DABS(EC(3)-EC(1)).LT..001) GO TO 218
      C(2)=(VC(3)-VC(1))/(EC(3)-EC(1))
      C(1)=VC(1)-C(2)*EC(1)
      VBP=C(1)+C(2)*EBP
      VBB1=C(1)+C(2)*EBB1
      VBB2=C(1)+C(2)*EBB2
      VOFFS=C(1)+C(2)*EOFFS
      GO TO 219
  218 WRITE(8,940) ICALL
  219 WRITE(6,924) C
      WRITE(6,926) VBP,VBB1,VBB2,VOFFS
      IF(ICALL.EQ.1) PVBP=VBP
      VBP=WBP*VBP+(1-WBP)*PVBP
      PVBP=VBP
C+++++COMPUTE TEMPERATURES FROM THERMISTOR VOLTAGES &SMOOTHED BASEPLATE
C+++++VOLTAGE
      TBP=CUBIC(TAU2,VBP)
      TBB1=CUBIC(TAU3,VBB1)
      TBB2=CUBIC(TAU4,VBB2)
      IF(ICALL.EQ.1) GO TO 240
      TBB=WT(1)*TBB1+WT(2)*TBB2+WT(3)*TBB3+WTT*PTBB
      PTBB=TBB
      GO TO 250
  240 TBB=(TBB1+TBB2+TBB3)/3.0
      PTBB=TBB
  250 CONTINUE
C+++++CORRECT TBB FOR BASEPLATE TEMP
      TBBR=TBB-CUBIC(SIGMA,TBP)
      WRITE(6,928) TBP,TBB1,TBB2,TBB3,TBB,TBBR
C+++++COMPUTE RADIANCE
      RBB=EPSILN(1)+EPSILN(2)*TBBR+EPSILN(3)*TBBR*TBBR
      RBB=RBB/(DEXP(EPSILN(4)/TBBR)-1)
C+++++SMOOTH OFFSET VOLTAGE
      IF(ICALL.EQ.1) PVOFFS=VOFFS
      VOFFS=W0*VOFFS+(1-W0)*PVOFFS
      PVOFFS=VOFFS
      VOFF=RHO(1)+RHO(2)*VOFFS
      RS=RBB/(EBBR2+VOFF)
      WRITE(6,936) VOFFS,VOFF,RS,RBB
C+++++DETERMINE COEFFICIENTS OF POLYNOMIAL TRANSFORMING RAW COUNT TO
C+++++CALIBRATED INDICES
      BETA=BETA2(1)+VOFF
      Z=B(2)+2*B(3)*RS*BETA
      DELTA2(1)=B(1)+RS*BETA*(B(2)+B(3)*RS*BETA)
      DELTA2(2)=BETA2(2)*RS*Z
      DELTA2(3)=BETA2(3)*RS*Z+RS*RS*BETA2(2)*BETA2(2)*B(3)
      DELTA2(4)=BETA2(4)*RS*Z+2.0*RS*RS*BETA2(2)*BETA2(3)*B(3)
```

09MAR79 14.59.42 - VOL=DISKC6, DSN=ZEMMB.LIB.CNTL

```
C     WRITE(6,918)
      WRITE(6,938)BETA2,DELTA2
  900 FORMAT(/1X,'CHANNEL      1        VISIBLE')
  902 FORMAT(//20X,'MATRIX FOR INPUT CALS(GIVES COUNTS FROM VOLTS)')
  904 FORMAT(/7G18.8)
  906 FORMAT(//10X,'COEFFICIENTS OF CUBIC POLYNOMIAL FOR INPUT CALS(
     1GIVES COUNTS FROM VOLTS)')
  908 FORMAT(//20X,'MATRIX FOR OUTPUT CALS(GIVES COUNTS FROM VOLTS)')
  910 FORMAT(//10X,'COEFFICIENTS OF CUBIC POLYNOMIAL FOR OUTPUT CALS
     1(GIVES COUNTS FROM VOLTS)')
  912 FORMAT(//20X,'MATRIX FOR INPUT CALS(GIVES VOLTS FROM COUNTS)')
  913 FORMAT(1X,'BETA1=',4G14.6,2X,'DELTA1=',4G14.6)
  916 FORMAT(/1X,'ESC1=',F11.4,2X,'EBBR1=',F11.4)
  920 FORMAT(/1X,'CHANNEL      2        THERMAL')
  938 FORMAT(/1X,'BETA2=',4G14.6,2X,'DELTA2=',4G14.6)
  922 FORMAT(/1X,'EBB3=',F11.4)
  923 FORMAT('+',19X,'ESC2=',F11.4,2X,'EBBR2=',F11.4)
  924 FORMAT(1X'C=',2F11.4)
  926 FORMAT('+',30X,'VBP=',F9.4,2X,'VBB1=',F9.4,2X,'VBB2=',F9.4,2X,
     1'VBB3=',F9.4)
  928 FORMAT(1X'TBP=',F9.2,2X,'TBB1=',F9.2,2X,'TBB2=',F9.2,2X,'TBB3=',F9
     1.2,2X,'TBB=',F9.2,2X,'TBBR=',F9.2)
  936 FORMAT(1X'VOFFS=',F9.4,2X,'VOFF=',F10.5,2X,'RS=',G18.8,2X,'RBB=',
     1G18.8)
  942 FORMAT(/1X,'DIVIDE CHECK FOR BB THERMISTOR CALCULATION FOR SET #',
     1I8)
  940 FORMAT(/1X,'DIVIDE CHECK FOR TELEMETRY VALUES CALCULATION FOR',
     1' SET #',I8)
      RETURN
      END
```

*** END OF MEMBER ***   185 RECORDS PROCESSED   *********************************

09MAR79 14.59.42 - VOL=DISK06, DSN=ZBMMB.LIB.CNTL

```
C++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
C+++++SUBROUTINE MATRIX
C+++++      2/22/79/
C+++++GIVEN A 7-ELEMENT VECTOR C THIS ROUTINE WILL GENERATE A SPECIAL
C+++++PURPOSE MATRIX D OF SIZE 4X7.FOR A DESCRIPTION OF THE MATRIX
C+++++SEE APPENDIX D.1 OF"HCMM DATA PROCESSING SPECIFICATION",IBM.
C
C+++++WRITTEN BY M.BEWTRA,COMPUTER SCIENCES CORPORATION
C++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
C+++++
      SUBROUTINE MATRIX(C,D)
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION A(4,7),B(7,4),A1(4,4),D(4,7),C(7)
      DO 50 I2=1,7
      A(1,I2)=1.0
   50 CONTINUE
      DO 110 I1=2,4
      DO 100 I2=1,7
      A(I1,I2)=C(I2)**(I1-1)
  100 CONTINUE
  110 CONTINUE
C     WRITE(6,900)A
      DO 130 I1=1,4
      DO 120 I2=1,7
      B(I2,I1)=A(I1,I2)
  120 CONTINUE
  130 CONTINUE
C     WRITE(6,900)B
      CALL MATMUL(A,B,A1,4,7,4)
      CALL MATINV(A1,4,DET)
      CALL MATMUL(A1,A,D,4,4,7)
C     WRITE(6,900) D
C 900 FORMAT(1X,4F12.2)
      RETURN
      END
```

*** END OF MEMBER ***   35 RECORDS PROCESSED   ********************************

```
C++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
C+++++SUBROUTINE MATMUL
C+++++      02/22/79
C+++++SUBROUTINE FOR MATRIX MULTIPLICATION
C      C=AB,WHERE SIZE OF A IS LXM,SIZE OF B IS MXN
C
C+++++WRITTEN BY M.BEWTRA,COMPUTER SCIENCES CORPORATION
C++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
      SUBROUTINE MATMUL(A,B,C,L,M,N)
      REAL*8 A,B,C
      DIMENSION A(L,M),B(M,N),C(L,N)
      DO 110 I=1,L
      DO 100 J=1,N
      C(I,J)=0.0
  100 CONTINUE
  110 CONTINUE
C     WRITE(6,900)A
C     WRITE(6,900)B
C     WRITE(6,900)C
C     WRITE(6,910)L,M,N
C 900 FORMAT(1X,8F12.2)
C 910 FORMAT(1X,3I2)
      DO 130 I=1,L
      DO 125 J=1,N
      DO 120 II=1,M
      C(I,J)=C(I,J)+A(I,II)*B(II,J)
C     WRITE(6,900)C(I,J)
  120 CONTINUE
  125 CONTINUE
  130 CONTINUE
      RETURN
      END
```

*** END OF MEMBER ***   32 RECORDS PROCESSED   ********************************

ORIGINAL PAGE IS
OF POOR QUALITY

09MAR79 14.59.42 - VOL=DISK06, DSN=ZBMMB.LIB.CNTL

```
      SUBROUTINE MATINV(ARRAY,NORDER,DET)
      IMPLICIT REAL*8(A-H,O-Z)
C     SEE PAGES 302-303 OF "DATA REDUCTION & ERROR ANALYSIS FOR THE
C     PHYSICAL SCIENCES",P.H.BEVINGTON FOR COMMENTS
      DIMENSION ARRAY(NORDER,NORDER),IK(10),JK(10)
   10 DET=1.
   11 DO 100 K=1,NORDER
      AMAX=0.
   21 DO 30 I=K,NORDER
      DO 30 J=K,NORDER
   23 IF(DABS(AMAX)-DABS(ARRAY(I,J))) 24,24,30
   24 AMAX=ARRAY(I,J)
      IK(K)=I
      JK(K)=J
   30 CONTINUE
   31 IF(AMAX) 41,32,41
   32 DET=0.
      GO TO 140
   41 I=IK(K)
      IF(I-K) 21,51,43
   43 DO 50 J=1,NORDER
      SAVE=ARRAY(K,J)
      ARRAY(K,J)=ARRAY(I,J)
   50 ARRAY(I,J)=-SAVE
   51 J=JK(K)
      IF(J-K) 21,61,53
   53 DO 60 I=1,NORDER
      SAVE=ARRAY(I,K)
      ARRAY(I,K)=ARRAY(I,J)
   60 ARRAY(I,J)=-SAVE
   61 DO 70 I=1,NORDER
      IF(I-K) 63,70,63
   63 ARRAY(I,K)=-ARRAY(I,K)/AMAX
   70 CONTINUE
   71 DO 80 I=1,NORDER
      DO 80 J=1,NORDER
      IF(I-K) 74,80,74
   74 IF(J-K) 75,80,75
   75 ARRAY(I,J)=ARRAY(I,J) + ARRAY(I,K)*ARRAY(K,J)
   80 CONTINUE
   81 DO 90 J=1,NORDER
      IF(J-K) 83,90,83
   83 ARRAY(K,J)=ARRAY(K,J)/AMAX
   90 CONTINUE
      ARRAY(K,K)=1./AMAX
  100 DET=DET*AMAX
  101 DO 130 L=1,NORDER
      K=NORDER-L+1
      J=IK(K)
      IF(J-K) 111,111,105
  105 DO 110 I=1,NORDER
      SAVE=ARRAY(I,K)
      ARRAY(I,K)=-ARRAY(I,J)
  110 ARRAY(I,J)=SAVE
  111 I=JK(K)
      IF(I-K) 130,130,113
  113 DO 120 J=1,NORDER
      SAVE=ARRAY(K,J)
      ARRAY(K,J)=-ARRAY(I,J)
  120 ARRAY(I,J)=SAVE
  130 CONTINUE
  140 RETURN
      END

*** END OF MEMBER ***    63 RECORDS PROCESSED   ************************************
```

```
C++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
C+++++SUBROUTINE COMPAR
C+++++     2/22/79
C+++++ROUTINE TO COMPARE MDP OUTPUT WITH SIMULATOR'S OUTPUT
C
C+++++WRITTEN BY M.BLWIRA,COMPUTER SCIENCES CORPORATION
C++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
      SUBROUTINE COMPAR
      IMPLICIT REAL*8(A-H,O-Z)
      INTEGER*2 COUNT
      LOGICAL*1 QGOOD,QTYPE1,QTYPE2
      REAL*4 DFMIN1,DFMIN2,DFMAX1,DFMAX2,DIFF
      COMMON/VALUE/SCIN1(7),SCIN2(7),SCOUT1(7),SCOUT2(7),EC(3),SCBBR1,
     1SCSC1,SCBBR2,SCSC2,SCBB3,EBP,EBE1,EBB2,EOFFS,WS,PWS,
     2ALPHA1(4),ALPHA2(4),ALPHA3(4),ALPHA4(4),DELTA1(4),
     3DELTA2(4),C(2),EBBR1,ESC1,EBBR2,ESC2,TBB3,TBP,TBB1,TBB2,VOFF,
     4BETA1(4),BETA2(4),VI1(7),VI2(7),VO1(7),VO2(7),A(3),TAU1(4),TAU2(4)
     5,TAU3(4),TAU4(4),WT(3),SIGMA(4),EPSILN(4),RHO(2),B(3),VC(3),WBP,W0
     6,NUM,N,ICALL,COUNT(40),QGOOD
      COMMON/STAT/AVER1(256),AVER2(256),SD1(256),SD2(256),
     1DFMIN1(256),DFMIN2(256),DFMAX1(256),DFMAX2(256),IAV,
     2QTYPE1(1000),QTYPE2(1000)
      REAL*4 OUT,X1
      DIMENSION OUT(44),D1(4),D2(4)
C+++++READ & WRITE MDP OUPUT RECORD
      CALL FREAD(OUT(1),10,L,&260,&250)
      WRITE(6,901)
      WRITE(6,800) (OUT(I),I=1,8)
      WRITE(6,810) OUT(9),OUT(10)
      WRITE(6,815) (OUT(I),I=36,39),(OUT(I),I=11,14)
      WRITE(6,825) (OUT(I),I=15,18),(OUT(I),I=20,23)
      WRITE(6,835) (OUT(I),I=24,27)
      WRITE(6,840) (OUT(I),I=28,30),OUT(19),OUT(31)
      WRITE(6,845) (OUT(I),I=40,43),(OUT(I),I=32,35)
      INUM=0
      ITYPE=0
C+++++TRANSFER COEFFICIENTS OF FINAL CUBIC FROM R*4 TO R*8 ARRAY
      DO 50 J=1,4
      D1(J)=OUT(10+J)
      D2(J)=OUT(31+J)
   50 CONTINUE
C     WRITE(6,902)
C+++++COMPARE TEMPERATURES & VOLTAGES
      IF(DABS(OUT(9)-EBBR1).GT..01)
     1CALL MESSAG(OUT(9),EBBR1,X,INUM,ITYPE,'EBBR1    ')
      IF(DABS(OUT(10)-ESC1).GT..01)
     1CALL MESSAG(OUT(10),ESC1,X,INUM,ITYPE,'ESC1     ')
      IF(DABS(OUT(24)-EBBR2).GT..01)
     1CALL MESSAG(OUT(24),EBBR2,X,INUM,ITYPE,'EBBR2    ')
      IF(DABS(OUT(25)-ESC2).GT..01)
     1CALL MESSAG(OUT(25),ESC2,X,INUM,ITYPE,'ESC2     ')
      IF(DABS(OUT(19)-TBB3).GT..1)
     1CALL MESSAG(OUT(19),TBB3,X,INUM,ITYPE,'TBB3     ')
      IF(DABS(OUT(28)-TBP).GT..1)
     1CALL MESSAG(OUT(28),TBP,X,INUM,ITYPE,'TBP      ')
      IF(DABS(OUT(29)-TBB1).GT..1)
     1CALL MESSAG(OUT(29),TBB1,X,INUM,ITYPE,'TBB1     ')
      IF(DABS(OUT(30)-TBB2).GT..1)
     1CALL MESSAG(OUT(30),TBB2,X,INUM,ITYPE,'TBB2     ')
      IF(DABS(OUT(31)-VOFF).GT..01)
     1CALL MESSAG(OUT(31),VOFF,X,INUM,ITYPE,'VOFF     ')
      CALL LINES(1)
      IF(INUM.GT.0) QTYPE1(ICALL)=1
C     IF(INUM.EQ.0) WRITE(6,905)
C     CALL LINES(1)
      INUM=0
      ITYPE=1
      WRITE(6,906)
C+++++COMPARE CALIBRATED COUNTS FOR CH 1
      IAV=IAV+1
      DO 100 J=1,256
      X=J-1
      X2=CUBIC(DELTA1,X)
      IF(X2.LT.0.0)X2=0.0
      IF(X2.GT.255.0)X2=255.0
      X1=CUBIC(D1,X)
      IF(X1.LT.0.0)X1=0.0
```

ORIGINAL PAGE IS
OF POOR QUALITY


```
      IF(X1.GT.255.0)X1=255.0
      DIFF=X2-X1
      DFMIN1(J)=AMIN1(DFMIN1(J),DIFF)
      DFMAX1(J)=AMAX1(DFMAX1(J),DIFF)
      AVER1(J)=AVER1(J)+DIFF
      SD1(J)=SD1(J)+DIFF*DIFF
      IF(X1.EQ.0.0) GO TO 100
      IF(DABS(X1-X2).GT..5) CALL MESSAG(X1,X2,X,INUM,ITYPE,' ')
  100 CONTINUE
      IF(INUM.GT.0) QTYPE2(ICALL)=1
      IF(INUM.EQ.0) WRITE(6,907)
      INUM=0
      WRITE(6,910)
C*****COMPARE CALIBRATED COUNTS FOR CH 2
      DO 200 J=1,256
      X=J-1
      X2=CUBIC(DELTA2,X)
      IF(X2.LT.0.0)X2=0.0
      IF(X2.GT.255.0)X2=255.0
      X1=CUBIC(D2,X)
      IF(X1.LT.0.0)X1=0.0
      IF(X1.GT.255.0)X1=255.0
      DIFF=X2-X1
      DFMIN2(J)=AMIN1(DFMIN2(J),DIFF)
      DFMAX2(J)=AMAX1(DFMAX2(J),DIFF)
      AVER2(J)=AVER2(J)+DIFF
      SD2(J)=SD2(J)+DIFF*DIFF
      IF(DABS(X1-X2).GT..5) CALL MESSAG(X1,X2,X,INUM,ITYPE,' ')
C     CALL MESSAG(X1,X2,X,INUM,ITYPE,' ')
  200 CONTINUE
      IF(INUM.GT.0) QTYPE2(ICALL)=1
      IF(INUM.EQ.0) WRITE(6,912)
      GO TO 300
  250 WRITE(6,915) ICALL
      GO TO 300
  260 WRITE(6,920)
  800 FORMAT(/1X,'ALPHA3=',4G14.6,2X,'ALPHA1=',4G14.6)
  810 FORMAT(1X,'EBBR1=',F11.4,2X,'ESC1=',F11.4)
  815 FORMAT(1X,'BETA1=',4G14.6,2X,'DELTA1=',4G14.6)
  825 FORMAT(1X,'ALPHA4=',4G14.6,2X,'ALPHA2=',4G14.6)
  835 FORMAT(1X,'EBBR2=',F11.4,2X,'ESC2=',F11.4,2X,'C=',2F11.4)
  840 FORMAT(1X,'TBP=',F9.2,2X,'TBB1=',F9.2,2X,'TBB2=',F9.2,2X,
     1'TBB3=',F9.2,2X,'VOFF=',F10.5)
  845 FORMAT(1X,'BETA2=',4G14.6,2X,'DELTA2=',4G14.6)
  901 FORMAT(//55X,'****MDP OUTPUT RECORD****')
  902 FORMAT(33X,'****COMPARISON FOR TEMPERATURES & VOLTAGES****')
  905 FORMAT(33X,'****NO TEMPERATURES OR VOLTAGES OUT OF RANGE****')
  906 FORMAT(33X,'****COMPARISON FOR CALIBRATED COUNTS FOR CH 1****')
  907 FORMAT(33X,'****NO CALIBRATED COUNTS OUT OF RANGE FOR CH1****')
  910 FORMAT(33X,'****COMPARISON FOR CALIBRATED COUNTS FOR CH 2****')
  912 FORMAT(33X,'****NO CALIBRATED COUNTS OUT OF RANGE FOR CH 2****')
  915 FORMAT(1X,'ERROR IN READING OUTPUT RECORD FOR CALIBRATION
     1SET #',I6)
  920 FORMAT(1X,'END OF FILE')
  300 RETURN
      END

*** END OF MEMBER ***   133 RECORDS PROCESSED   ***********************************
```

09MAR79 14.59.42 - VOL=DISK06, DSN=ZBMMB.LIB.CNTL

```
C+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
C+++++FUNCTION CUBIC
C+++++          2/22/79
C+++++FUNCTION TO EVALUATE A CUBIC POLYNOMIAL
C       A=COEFFICIENTS OF THE CUBIC POLYNOMIAL
C       X=VALUE AT WHICH POLYNOMIAL IS TO BE EVALUATED
C
C+++++WRITTEN BY M.BEWTRA,COMPUTER SCIENCES CORPORATION
C+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
      REAL FUNCTION CUBIC*8(A,X)
      REAL*8 A(4),X
      CUBIC=A(1)+A(2)*X+A(3)*X*X+A(4)*X*X*X
      RETURN
      END
```

*** END OF MEMBER ***   14 RECORDS PROCESSED   ********************************

```
C++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
C+++++SUBROUTINE MESSAG
C+++++        2/22/79
C+++++ROUTINE TO WRITE MESSAGE IF MDP VALUE DIFFERS FROM SIMULATOR
C+++++VALUE BY MORE THAN SET LIMIT
C      A=MDP VALUE
C      B=MDPSIM VALUE
C      C=RAW COUNT(0-255)
C      I=NUMBER OF QUANTITIES FOR WHICH MDP & MDPSIM OUTPUTS DIFFER BY
C         MORE THAN SET LIMIT
C      J=0,QUANTITY IS A TEMPERATURE OR A VOLTAGE
C      J=1,QUANTITY IS A CALIBRATED INDEX
C      NAME=LOGIACL*1 ARRAY CONTAINING NAME OF THE QUANTITY
C+++++
C+++++WRITTEN BY M.BEWTRA,COMPUTER SCIENCES CORPORATION
C++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
      SUBROUTINE MESSAG(A,B,C,I,J,NAME)
      REAL*8 B,C
      LOGICAL*1 NAME(8)
      DIFF=B-A
      IF(J.EQ.1) GO TO 100
C+++++MESSAGE FOR TEMPERATURES & VOLTAGES
      IF(A.EQ.0.0) GO TO 200
      WRITE(6,900) NAME,A,B,DIFF
      I=I+1
      GO TO 200
C+++++MESSAGE FOR CALIBRATED COUNTS
  100 WRITE(6,910) C,A,B,DIFF
      I=I+1
  200 RETURN
  900 FORMAT(1X,8A1,'MDP VALUE=',F12.4,2X,'SIM VALUE=',F12.4,2X,'DIFF=
     1',F12.4)
  910 FORMAT(1X,'RAW COUNT=',F6.0,2X,'MDP VALUE=',F12.2,2X,'SIM VALUE=',
     1F12.2,2X,'DIFF=',F12.2)
      END
```

*** END OF MEMBER ***   35 RECORDS PROCESSED   ********************************

```
C+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
C+++++SUBROUTINE FINAL
C+++++        10/6/78/
C+++++SUBROUTINE TO GENERATE SUMMARY OF COMPARISON BETWEEN MOP OUTPUT
C+++++& SIMULATOR OUTPUT
C
C+++++WRITTEN BY M.BEWTRA,COMPUTER SCIENCES CORPORATION
C+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
      SUBROUTINE FINAL
      IMPLICIT REAL*8(A-H,O-Z)
      INTEGER*2 COUNT
      LOGICAL*1 QGOOD,QTYPE1,QTYPE2
      REAL*4 DFMIN1,DFMIN2,DFMAX1,DFMAX2
      COMMON/VALUE/SCIN1(7),SCIN2(7),SCOUT1(7),SCOUT2(7),EC(3),SCBBR1,
     1SCSC1,SCBBR2,SCSC2,SCBB3,EBP,EBE1,EBB2,EOFFS,WS,PWS,
     2ALPHA1(4),ALPHA2(4),ALPHA3(4),ALPHA4(4),DELTA1(4),
     3DELTA2(4),C(2),EBBR1,ESC1,EBBR2,ESC2,TBB3,TBP,TBB1,TBB2,VOFF,
     4BETA1(4),BETA2(4),VI1(7),VI2(7),VO1(7),VO2(7),A(3),TAU1(4),TAU2(4)
     5,TAU3(4),TAU4(4),WT(3),SIGMA(4),EPSILN(4),RHO(2),B(3),VC(3),WBP,W0
     6,NUM,N,ICALL,COUNT(40),QGOOD
      COMMON/STAT/AVER1(256),AVER2(256),SD1(256),SD2(256),
     1DFMIN1(256),DFMIN2(256),DFMAX1(256),DFMAX2(256),IAV,
     2QTYPE1(1000),QTYPE2(1000)
C+++++LIST CALIBRATION SETS TO BE CHECKED FOR TEMPERATURES & VOLTAGES
      WRITE(6,900)
      INUM=0
      DO 100 I=1,ICALL
      IF(QTYPE1(I).EQ.0) GO TO 100
      WRITE(6,910) I
      INUM=INUM+1
  100 CONTINUE
      INUM=INUM*100/IAV
      WRITE(6,920) INUM
      INUM=0
      WRITE(6,930)
C+++++LIST CALIBRATION SETS TO BE CHECKED FOR CALIBRATED INDICES
      DO 200 I=    1,ICALL
      IF(QTYPE2(I).EQ.0) GO TO 200
      WRITE(6,910) I
      INUM=INUM+1
  200 CONTINUE
      INUM=INUM*100/IAV
      WRITE(6,920) INUM
      WRITE(6,940)
      WRITE(6,950)
C+++++CALCULATE AVERAGES & S.D. FOR THE DIFFERENCES IN CALIBRATED
C+++++INDICES FOR ALL SETS
      DO 300 I=1,256
      AVER1(I)=AVER1(I)/IAV
      SD1(I)=(SD1(I)-IAV*AVER1(I)*AVER1(I))/(IAV-1)
      SD1(I)=DSQRT(SD1(I))
      K=I-1
      WRITE(6,960) K,DFMIN1(I),DFMAX1(I),AVER1(I),SD1(I)
  300 CONTINUE
      WRITE(6,970)
      WRITE(6,950)
      DO 400 I=1,256
      AVER2(I)=AVER2(I)/IAV
      SD2(I)=(SD2(I)-IAV*AVER2(I)*AVER2(I))/(IAV-1)
      SD2(I)=DSQRT(SD2(I))
      K=I-1
      WRITE(6,960) K,DFMIN2(I),DFMAX2(I),AVER2(I),SD2(I)
  400 CONTINUE
  900 FORMAT(////20X,'****CALIBRATION SETS TO BE CHECKED FOR',
     1' TEMPERATURES AND VOLTAGES****')
  910 FORMAT(1X,I5)
  920 FORMAT(/1X,I5,' % SETS LISTED ABOVE')
  930 FORMAT(////20X,'****CALIBRATION SETS TO BE CHECKED FOR',
     1' CALIBRATED INDICES****')
  940 FORMAT(////20X,'****SUMMARY OF DIFFRENCES BETWEEN SIMULATOR',
     1' AND MOP CALIBRATED INDICES FOR CH 1****')
  950 FORMAT(/1X,'RAW COUNT',4X,'MINIMUM',4X,'MAXIMUM',4X,'AVERAGE',
     14X,'S.D.')
  960 FORMAT(/1X,I3,10X,F7.2,3(4X,F7.2))
  970 FORMAT(////20X,'****SUMMARY OF DIFFRENCES BETWEEN SIMULATOR',
     1' AND MOP CALIBRATED INDICES FOR CH 2****')
      RETURN
```

ORIGINAL PAGE IS
OF POOR QUALITY

09MAR79 14.59.42 - VOL=DISK06, DSN=ZBMMB.LIB.CNTL

END 00006600

*** END OF MEMBER *** 78 RECORDS PROCESSED ***********************************

```
C+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
C+++++BLOCK DATA FOR COMMON BLOCKS VALUE & STAT
C+++++       2/22/79
C
C+++++WRITTEN BY M.BEWTRA, COMPUTER SCIENCES CORPORATION
C++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
      BLOCK DATA
      IMPLICIT REAL*8(A-H,O-Z)
      INTEGER*2 COUNT
      LOGICAL*1 QGOOD,QTYPE1,QTYPE2
      REAL*4 DFMIN1,DFMIN2,DFMAX1,DFMAX2
      COMMON/VALUE/SCIN1(7),SCIN2(7),SCOUT1(7),SCOUT2(7),EC(3),SCBBR1,
     1SCSC1,SCBBR2,SCSC2,SCBB3,EBP,EBE1,EBB2,EOFFS,WS,PWS,
     2ALPHA1(4),ALPHA2(4),ALPHA3(4),ALPHA4(4),DELTA1(4),
     3DELTA2(4),C(2),EBBR1,ESC1,EBBR2,ESC2,TBB3,TBP,TBB1,TBB2,VOFF,
     4BETA1(4),BETA2(4),VI1(7),VI2(7),VO1(7),VO2(7),A(3),TAU1(4),TAU2(4),
     5,TAU3(4),TAU4(4),WT(3),SIGMA(4),EPSILN(4),RHO(2),E(3),VC(3),WBP,W0
     6,NUM,N,ICALL,COUNT(40),QGOOD
      COMMON/STAT/AVER1(256),AVER2(256),SD1(256),SD2(256),
     1DFMIN1(256),DFMIN2(256),DFMAX1(256),DFMAX2(256),IAV,
     2QTYPE1(1000),QTYPE2(1000)
      DATA N/10/,WS/.1/
      DATA VI1,VI2,VO1,VO2/0.001,1.003,1.982,2.986,3.963,4.981,5.958,
     10.102,1.058,1.989,2.943,3.877,4.848,5.781,0.006,0.970,1.970,
     22.947,3.954,4.929,5.924,0.009,0.969,1.963,2.937,3.945,4.920,5.915/
      DATA A/-0.31242500,43.2522500,-0.07282870D/,TAU1,TAU2,TAU3,TAU4/
     1332.8817,-15.556,1.772,-0.1917,59.7317,-15.556,1.772,-0.1917,
     2332.8817,-15.556,1.772,-0.1917,333.2296,-15.556,1.772,-0.1917/
      DATA WT/2*.1105,.0790/,SIGMA/3.5309,-0.13892,.26176D-2,-.27394D-4
     1/,EPSILN/0.71325,1.9D-3,-3.125D-6,1.251159103/,RHO/5.0096,-0.6992
     2/,WBP/0.2/,W0/0.1/,B/-114.7019,13944.13,14238.17/,VC/.11,2.51,5.01
     3/
      DATA QTYPE1/1000*0/,QTYPE2/1000*0/,DFMIN1/256*1.0E10/,
     1DFMIN2/256*1.0E10/,DFMAX1/256*-1.0E10/,DFMAX2/256*-1.0E10/,
     2AVER1/256*0.0/,AVER2/256*0.0/,SD1/256*0.0/,SD2/256*0.0/,
     3IAV/0/
      END
*** END OF MEMBER ***     37 RECORDS PROCESSED     ********************************
```

```
C+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
C+++++           2/22/79/
C++++MAIN FOR PROGRAM CORECT
C+++++MAIN FOR GENERATING CALIBRATION LOOKUP TABLES FOR CONVERTING RAW
C+++++COUNTS(0-255) TO CALIBRATED INDICES FOR MASTER OUTPUT TABLES.
C+++++IT ALSO CALCULATES AVERAGES & S.D. FOR CALIBRATED INDICES.
C
C+++++WRITTEN BY M.BEWTRA,COMPUTER SCIENCES CORPORATION
C++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
      IMPLICIT REAL*8(A-H,O-Z)
      INTEGER*2 COUNT
      LOGICAL*1 QGOOD,QBBV(50)
      COMMON/VALUE/SCIN1(7),SCIN2(7),SCOUT1(7),SCOUT2(7),EC(3),SCBBR1,
     1SCSC1,SCBBR2,SCSC2,SCBB3,EBP,EBB1,EBB2,EOFFS,WS,PWS,
     2ALPHA1(4),ALPHA2(4),ALPHA3(4),ALPHA4(4),DELTA1(4),
     3DELTA2(4),C(2),EBBR1,ESC1,EBBR2,ESC2,TBB3,TBP,TBB1,TBB2,VOFF,
     4BETA1(4),BETA2(4),VI1(7),VI2(7),VO1(7),VO2(7),A(3),TAU1(4),TAU2(4)
     5,TAU3(4),TAU4(4),WT(3),SIGMA(4),EPSILN(4),RHO(2),B(3),VC(3),WBP,W0
     6,NUM,N,ICALL,COUNT(40),QGOOD
C
C
      NAMELIST/INPUT/ISKIP,MSETS,N,WS,NFILE,MST,SIGMA,VI1,VI2,VO1,VO2,A,
     1TAU1,TAU2,TAU3,TAU4,WT,EPSILN,RHO,B,VC,WBP,W0
  100 ICALL=0
      I=0
      READ(5,INPUT,END=1200)
      WRITE(6,INPUT)
      PWS=1.0-WS
C+++++READ FIRST SCAN LINE FOR EACH CHANNEL & INITIALISE CALIBRATION
C+++++QUANTITIES
  105 CALL CCTRED(ISKIP,I)
      I=I+1
      IF(.NOT.QGOOD) GO TO 105
      DO 110 J=1,7
      SCIN1(J)=COUNT(J+1)
      SCIN2(J)=COUNT(17+J)
      SCOUT1(J)=COUNT(J+8)
      SCOUT2(J)=COUNT(J+24)
  110 CONTINUE
      SCBBR1=COUNT(16)
      SCSC1=COUNT(1)
      SCBBR2=COUNT(32)
      SCSC2=COUNT(17)
      SCBB3=COUNT(33)
      QBBV(I)=COUNT(32)
C+++++DO LOOP FOR NUMBER OF SETS OF CALIBRATION DESIRED
      DO 1000 K=1,MSETS
      ICALL=ICALL+1
      IF(N.EQ.1.AND.ICALL.EQ.1) GO TO 300
C+++++READ NEXT SCAN LINE FOR EACH CHANNEL
  200 CALL CCTRED(ISKIP,I)
      I=I+1
      QBBV(I)=COUNT(32)
C+++++SMOOTH DATA IF LINE IS GOOD
      IF(QGOOD) CALL SMOOTH
      IF(I.NE.N) GO TO 200
  300 WRITE(6,910)SCIN1,SCOUT1,SCIN2,SCOUT2
      WRITE(6,910)SCSC1,SCBBR1,SCSC2,SCBBR2,SCBB3,EC,EBP,EBB1,EBB2,EOFFS
C+++++CALCULATE INTERMEDIATE QUANTITIES & POLYNOMIALS FOR CONVERSION
C+++++WHEN N SCAN LINES ARE SMOOTHED
      CALL INTVAL
C+++++CALCULATE CALIBTRATED INDICES,AVERAGES & S.D. FOR THEM
      CALL CONVRT(MSETS,MST,ISKIP,QBBV)
      I=0
 1000 CONTINUE
C+++++POSITION TAPE TO BEGINNING OF FILE WHEN DESIRED NUMBER OF SETS
C+++++ARE CALIBRATED
      CALL REWIND(10)
      CALL POSN(1,10,NFILE)
      GO TO 100
  900 FORMAT(/////)
  910 FORMAT((1X,14F9.2))
  920 FORMAT(/)
 1200 STOP
      END
```

*** END OF MEMBER ***   75 RECORDS PROCESSED   ********************************

09MAR79 14.59.42 - VOL=DISK06, DSN=ZBMMB.LIB.CNTL

```
C++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
C+++++SUBROUTINE CCTRED
C+++++       2/22/79/
C+++++ROUTINE TO READ RECORDS FROM PREPROCESSOR CCT & TRANSFER DATA FROM
C+++++LOGICAL*1 ARRAY TO I*2 ARRAY
C       ISKIP=NUMBER OF RECORDS TO BE SKIPPED BEFORE PROCESSING
C       IREC=SCAN LINE COUNTER IN A CALIBRATION SET
C
C+++++WRITTEN BY M.BEWTRA,COMPUTER SCIENCES CORPORATION
C+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
      SUBROUTINE CCTRED(ISKIP,IREC)
      IMPLICIT REAL*8(A-H,O-Z)
      INTEGER*2 COUNT
      LOGICAL*1 QDATA(4500),QGOOD
      COMMON/VALUE/SCIN1(7),SCIN2(7),SCOUT1(7),SCOUT2(7),EC(3),SCBBR1,
     1SCSC1,SCBBR2,SCSC2,SCBB3,EBP,EBB1,EBB2,EOFFS,WS,PWS,
     2ALPHA1(4),ALPHA2(4),ALPHA3(4),ALPHA4(4),DELTA1(4),
     3DELTA2(4),C(2),EBBR1,ESC1,EBBR2,ESC2,TBB3,TBP,TBB1,TBB2,VOFF,
     4BETA1(4),BETA2(4),VI1(7),VI2(7),VO1(7),VO2(7),A(3),TAU1(4),TAU2(4)
     5,TAU3(4),TAU4(4),WT(3),SIGMA(4),EPSILN(4),RHO(2),B(3),VC(3),WBP,W0
     6,NUM,N,ICALL,CCUNT(40),QGOOD
      QGOOD=.TRUE.
C+++++READ RECORDS TO BE SKIPPED
      IF(ICALL.EQ.0.AND.IREC.EQ.0) GO TO 20
      GO TO 40
   20 DO 30 I=1,ISKIP
      CALL FREAD(QDATA(1),10,LEN,&30,&30)
   30 CONTINUE
C+++++READ A PAIR OF RECORDS ONE FOR EACH CHANNEL
   40 DO 100 K=1,2
      CALL FREAD(QDATA(1),10,LEN,&600,&610)
      IF(MOD(K,2).EQ.0) GO TO 65
C+++++TRANSFER FROM L*1 TO I*2 ARRAY FOR CH 1
      COUNT(1)=QDATA(3326)
      DO 50 J=1,7
      COUNT(J+1)=QDATA(2198+J*24)
      COUNT(J+8)=QDATA(2750+J*24)
   50 CONTINUE
      COUNT(16)=QDATA(1670)
      GO TO 100
   65 IF(.NOT.QGOOD) GO TO 200
C+++++TRANSFER FROM L*1 TO I*2 ARRAY FOR CH 2
      COUNT(17)=QDATA(3326)
      DO 70 J=1,7
      COUNT(17+J)=QDATA(2198+J*24)
      COUNT(24+J)=QDATA(2750+J*24)
   70 CONTINUE
      COUNT(32)=QDATA(1670)
      COUNT(33)=QDATA(3878)
C+++++TRANSFER 7 TELEMETRY VALUES
      DO 80 J=1,7
      COUNT(33+J)=QDATA(3932+J*2)
   80 CONTINUE
  100 CONTINUE
      EBB1=COUNT(37)
      EBB2=COUNT(38)
      EOFFS=COUNT(39)
      EBP=COUNT(40)
      DO 120 I=1,3
      EC(I)=COUNT(33+I)
  120 CONTINUE
      GO TO 200
C+++++MESSAGE FOR END OF FILE
  600 WRITE(6,900)
      GO TO 180
C+++++MESSAGE FOR I/O ERROR
  610 WRITE(6,910)
      QGOOD=.FALSE.
      GO TO 100
  900 FORMAT(1X,'END OF FILE')
  910 FORMAT(1X,'I/O ERROR')
  180 STOP
  200 RETURN
      END
*** END OF MEMBER ***       74 RECORDS PROCESSED    ************************************
```

ORIGINAL PAGE IS
OF POOR QUALITY

09MAR79 14.59.42 - VOL=DISK06, DSN=ZEMMB.LIB.CNTL

```
C+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
C+++++SUBROUTINE CONVRT
C+++++          2/22/79/
C+++++          SUBROUTINE TO CONVERT RAW COUNTS TO CALIBTRATED INDICES.
C+++++ALSO CALCULATES AVERAGES & S.D. FOR CALIBRATED INDICES
C        MSETS=NUMBER OF CALIBRATION SETS TO BE PROCESSED
C        MST=FIRST CALIBRATION SET FOR WHICH LOOKUP TABLES TO BE PRINTED
C        ISKIP=NUMBER OF RECORDS SKIPPED BEFORE PROCESSING
C        QBBV=COUNT OF BLACKBODY VIEW FOR CHANNEL
C
C+++++WRITTEN BY M.BEWTRA,COMPUTER SCIENCES CORPORATION
C+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
      SUBROUTINE CONVRT(MSETS,MST,ISKIP,QBBV)
      IMPLICIT REAL*8(A-H,O-Z)
      INTEGER*2 COUNT
      LOGICAL*1 QINT1(256,200),QINT2(256,200),QGOOD,QBBV(50)
      COMMON/VALUE/SCIN1(7),SCIN2(7),SCOUT1(7),SCOUT2(7),EC(3),SCBBR1,
     1SCSC1,SCBBR2,SCSC2,SCBB3,EBP,EBE1,EBB2,EOFFS,WS,PWS,
     2ALPHA1(4),ALPHA2(4),ALPHA3(4),ALPHA4(4),DELTA1(4),
     3DELTA2(4),C(2),EBBR1,ESC1,EBBR2,ESC2,TBB3,TBP,TBB1,TBB2,VOFF,
     4BETA1(4),BETA2(4),VI1(7),VI2(7),VO1(7),VO2(7),A(3),TAU1(4),TAU2(4)
     5,TAU3(4),TAU4(4),WT(3),SIGMA(4),EPSILN(4),RHO(2),B(3),VC(3),WBP,W0
     6,NUM,N,ICALL,COUNT(40),QGOOD
      DIMENSION AVERV(256),AVERT(256),STDDV(256),STDDT(256)
      DIMENSION INDEX(200)
      DATA AVERV/256*0.0/,AVERT/256*0.0/,STDDV/256*0.0/,STDDT/256*0.0/
      DATA AVRBBV/0.0/,STDBBV/0.0/
C+++++CONVERT COUNTS FOR CH 1
      DO 100 I=1,256
      X=I-1
      X=CUBIC(DELTA1,X)
      IF(X.LE.0.0) X=0.0
      IF(X.GE.255.0) X=255.0
      QINT1(I,ICALL)=X
C+++++RUNNING SUM FOR AVERAGES & S.D.SKIP THE FIRST SET OF CALIBRATION
      IF(ICALL.EQ.1) GO TO 100
      J=X
      X=J
       AVERV(I)=AVERV(I)+N*X
      STDDV(I)=STDDV(I)+N*X*X
  100 CONTINUE
C+++++CONVERT COUNTS FOR CH 2
      DO 200 I=1,256
      X=I-1
      X=CUBIC(DELTA2,X)
      IF(X.LE.0.0) X=0.0
      IF(X.GE.255.0) X=255.0
      QINT2(I,ICALL)=X
C+++++RUNNING SUM FOR AVERAGES & S.D.SKIP THE FIRST SET OF CALIBRATION
      IF(ICALL.EQ.1) GO TO 200
      J=X
      X=J
      AVERT(I)=AVERT(I)+N*X
      STDDT(I)=STDDT(I)+N*X*X
  200 CONTINUE
C+++++CONVERT BLACKBODY VIEW COUNT
      DO 210 I=1,N
      X=QBBV(I)
      X=CUBIC(DELTA2,X)
      J=X
      X=J
      AVRBBV=AVRBBV+X
      STDBBV=STDBBV+X*X
  210 CONTINUE
C+++++CALCULATE AVERAGES & S.D. WHEN DESIRED NUMBER OF SETS ARE
C+++++CALIBRATED
      IF(ICALL.NE.MSETS) GO TO 300
      ISCAN=(MSETS-1)*N
      DO 250 I=1,256
      AVERV(I)=AVERV(I)/ISCAN
      AVERT(I)=AVERT(I)/ISCAN
      STDDV(I)=DSQRT((STDDV(I)-ISCAN*AVERV(I)*AVERV(I))/(ISCAN-1))
      STDDT(I)=DSQRT((STDDT(I)-ISCAN*AVERT(I)*AVERT(I))/(ISCAN-1))
  250 CONTINUE
      JSC=ISCAN+N
      AVRBBV=AVRBBV/JSC
      STDBBV=DSQRT((STDBBV-JSC*AVRBBV*AVRBBV)/(JSC-1))
```

```
C+++++CALCULATE START LINE NUMBER FOR EACH SET OF N LINES CALIBRATED
      KK=MSETS-MST+1
      DO 255 I=1,KK
      INDEX(I)=ISKIP/2+(MST+I-2)*N+1
  255 CONTINUE
C+++++WRITE HEADER CONTAINING LINE NUMBERS
      WRITE(6,960)
      WRITE(6,965) (INDEX(I),I=1,KK)
C+++++WRITE CALIBRATED INDICES,AVERAGES & S.D. FOR CH 1
      DO 260 I=1,256
      K=I-1
      WRITE(6,950) K
      WRITE(6,952) (QINT1(I,J),J=MST,MSETS)
      WRITE(6,955) AVERV(I),STDDV(I)
  260 CONTINUE
C+++++WRITE HEADER CONTAING LINE NUMBERS
      WRITE(6,960)
      WRITE(6,965) (INDEX(I),I=1,KK)
C+++++WRITE CALIBRATED INDICES,AVERAGES & S.D. FOR CH 2
      DO 270 I=1,256
      K=I-1
      WRITE(6,950) K
      WRITE(6,952) (QINT2(I,J),J=MST,MSETS)
      WRITE(6,955) AVERT(I),STDDT(I)
  270 CONTINUE
      WRITE(6,970) AVRBBV,STDBBV
C+++++REINITIALISE VARIABLES
      DO 280 I=1,256
      AVERV(I)=0.0
      AVERT(I)=0.0
      STDDV(I)=0.0
      STDDT(I)=0.0
  280 CONTINUE
      AVRBBV=0.0
      STDBBV=0.0
  900 FORMAT(/1X,'V',25I5)
  910 FORMAT(/1X,'T',25I5)
  920 FORMAT(/2X,25I5)
  930 FORMAT(2X,25F5.1)
  940 FORMAT(2X,25F5.2)
  950 FORMAT(/1X,I5)
  952 FORMAT(8X,20I5)
  955 FORMAT('+',107X,2F8.2)
  960 FORMAT(/////)
  965 FORMAT(8X,20I5)
  970 FORMAT(//1X,'AVERAGE BB VIEW=',F9.2,'S.D.=',F9.2)
  300 RETURN
      END

*** END OF MEMBER ***    125 RECORDS PROCESSED    **********************************
```