111 76-H028-R0-00

PROJECT TECHNICAL REPORT

REACTION CONTROL SYSTEM
INTEGRATED SYSTEMS PERFORMANCE ANALYSIS
LM COMPUTER PROGRAM
USER'S MANUAL

NAS 9-8166

30 August 1968

Prepared for
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

TRW SYSTEMS GROUP

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Prepared by: C. C. Garza, Jr.

Approved by: J. C. Preston, Manager
Task E-63A

Approved by: J. P. Aha, Head
Systems Analysis Section

Approved by: D. W. Vernon, Manager
Systems Analysis Department

TRW
SYSTEMS GROUP

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ACKNOWLEDGEMENT

The following individuals have made a significant contribution to this report and RCS ISPALM Program.

Manned Spacecraft Center

L. W. Jenkins

N. R. Schulze

C. A. Vaughan

TRW Systems Group

C. W. Curtis

S. E. Dreiling

A. Gillies

E. Joseph

B. F. LaFleur

C. S. Skillman, Jr.

T. J. Walsh

R. S. West

J. C. Preston

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ABSTRACT

The purpose of the RCS ISPALM Program is to support either inflight or postflight analysis of the performance of the LM-RCS based on the telemetered flight data. This document is the operational user's manual which defines and illustrates the program's usage.

In order for this program to provide meaningful information to the user, it is assumed that basic functional knowledge of the LM-RCS and its associated subsystem interfaces has been acquired. This program's function is to perform those duties of data acquisition and mathematical calculations required for a realistic evaluation of the RCS. The RCS ISPALM Program was designed for ease of operation and modification in order to extend its usefulness as an engineering tool when used in reducing manual effort in the LM flight evaluation process. The program is subdivided functionally into two areas: data acquisition and engineering calculations. The data acquisition portion of the program selects and processes data specified by user input and places the specified processed data values in a data bank for engineering use. The engineering section takes this data, calculates specified results and outputs them. A functional description of the engineering formulation is presented next, and the data acquisition and program operations are described following the formulations.

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INTRODUCTION

Computer processing of the real time telemetered flight data on the Lunar Module Reaction Control System (LM-RCS) described in this document is one of the current methods that will be employed to evaluate overall LM performance.

The RCS Integrated System Performance Analysis-LM (ISPALM) Program, its engineering, and its processing techniques were developed by TRW Systems Analysis Department (SAD), and the Houston Computing Center (HCC), consistent with the technical management and information base of the Auxiliary Propulsion Branch of the Propulsion and Power Division, NASA/MSC. Included in this user's manual is a brief engineering formulation, program operating instructions, and validation sample cases.

Since there will be several LM configurations flown, it will be necessary that the RCS ISPALM Program change. It is intended that as the different LM flights occur, a supplemental specific flight RCS ISPALM Program annex will be published as required for subsequent program modifications. This program document is prepared to accompany the delivery of the RCS ISPALM Program in accordance with the agreements of Task E-63A.

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CONTENTS

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LIST OF TABLES

FIGURES

1. PROBLEM DESCRIPTION

The problem is to develop the analytical formulations and implement them into a computer program which is capable of processing LM-RCS telemetered data to perform overall systems evaluation in the areas of propellant utilization, engine performance and operation, regulator performance, thermal control, and flight mass properties.

1.1 PHYSICAL SYSTEM DESCRIPTION

The LM-RCS is the propulsion subsystem which provides automatic or manual stabilization and control about the three referenced orthogonal axes. In the automatic mode inertial sensors coupled with the LM Guidance computer results in the required maneuver, while in the manual mode, man exercises his capabilities to achieve the desired attitude.

There are 16 thrusters in 4 thrust chamber clusters (TCC) located about the ascent vehicle of LM. Each TCC containing 4 thrusters is provided with pressure-fed liquid propellants by two feeding systems designated A and B respectively. Each system has an oxidizer and fuel tank, a helium pressurant sphere, filters, regulators, check valves, associated relief and isolation valves, propellant tank bladders to isolate and convey system pressurization, and plumbing feed lines. Included on the system are the monitoring devices which provide RCS status through telemetry and recording of the data for evaluation.

1.1.1 RCS Installation Drawing

The installation figure presented shows the general locations of the RCS components relative to each other as installed on the Ascent stage and the thruster numbering designation which will be used by the program (see Figure 1).

1.1.2 RCS Measurement List Table

This table shows the selected telemetered data parameters which will be utilized by the RCS ISPALM Program to evaluate RCS performance (see Table 1).

1.1.3 RCS System and Measurement Device Drawing

The overlay figure presents an integrated view of the physical components making up the RCS Subsystem with the physical locations from which data will be telemetered by monitoring devices (see Figure 2 from Reference 3).

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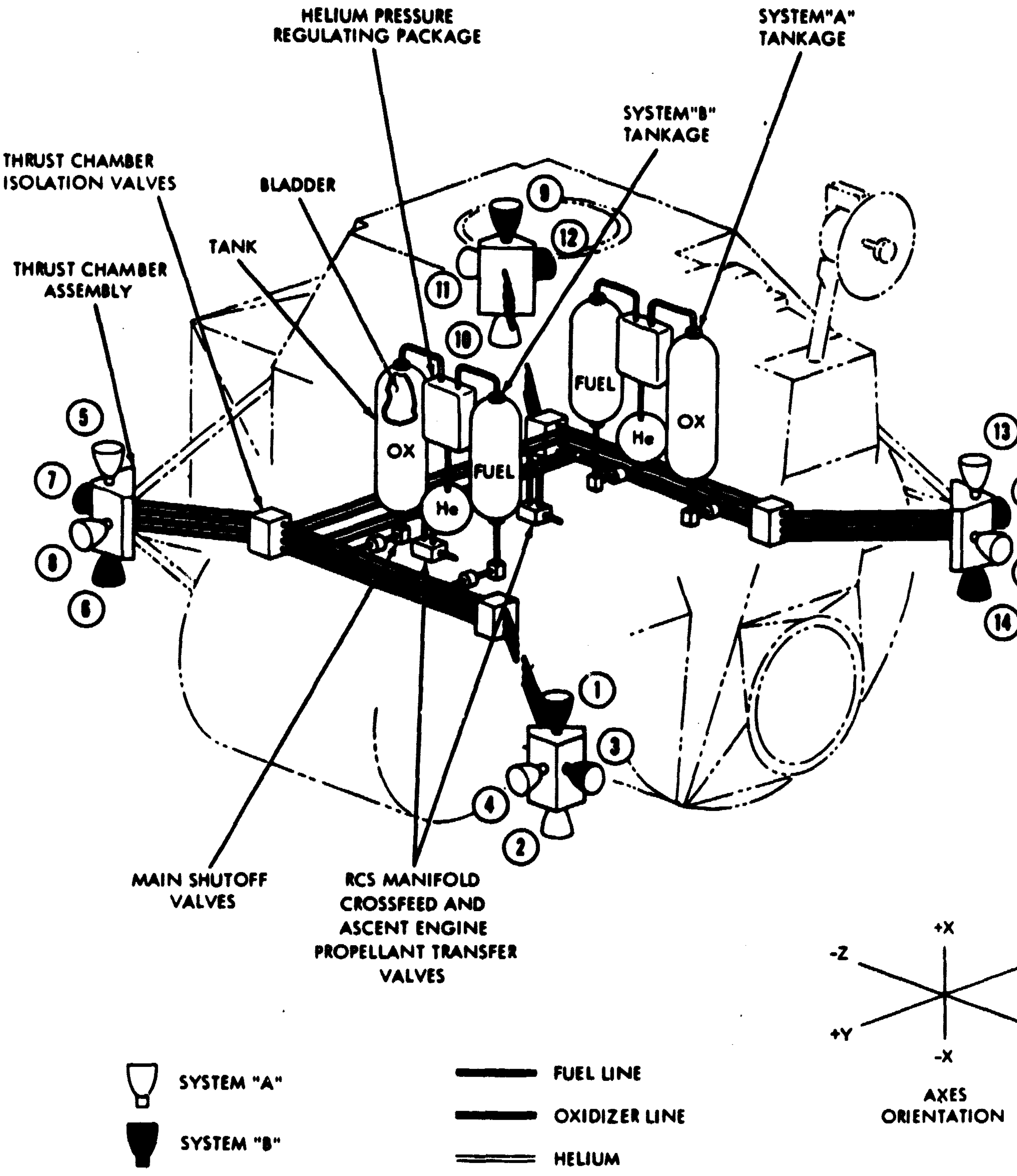

FIGURE 1-1

RCS INSTALLATION

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TABLE 1

CONTENTS OF AUXILLARY PROPULSION ANALYSIS TAPE

MEAS		LOAD NO	MEAS DESCRIPTION	LOW	HIGH	UNITS
GA3001	-	C-10X	ACCEL, X AXIS NO 1			GEES
GA3002	-	C-15X	ACCEL, X AXIS NO 2			RAD/SF
GA3003	-	C-16X/1	ACCEL, Y AXIS NO 1			GEES
GA3003	-	D-10X/23	ACCEL, Y AXIS NO 1			GEES
GA3004	-	D-15X	ACCEL, Y AXIS NO 2			RAD/SF
GA3005	-	D-16X/1	ACCEL, Z AXIS NO 1			GEES
GA3005	-	D-08X/23	ACCEL, Z AXIS NO 1			GEES
GA3006	-	E-14X	ACCEL, Z AXIS NO 2			RAD/SF
GF4582	-S	1015005 15	QUANTITY,ASCENT TANK NO1 WATER	0.0	100.0	PER
GF4583	-S	1014005 15	QUANTITY,ASCENT TANK NO2 WATER	0.0	100.0	PER
GG1523	S	1022098G15E	LGC OPERATE	OFF	ON	BILEVEL
GG2112	AP	1102099 15	VOLTS,IG 1X RES OUTPUT, SIN	-21.2	21.2	VOLTS
GG2113	AP	1102067 15	VOLTS,IG 1X RES OUTPUT, COS	-21.4	21.2	VOLTS
GG2121	-P	1201022 15	VOLT,IG 1X RES SIN (EXPANDED)	-11.3	11.1	DEGS
GG2142	AS	1105036 15	VOLTS,MG 1X RES OUTPUT, SIN	-21.7	21.6	VOLTS
GG2143	AS	1102065 15	VOLTS,MG 1X RES OUTPUT, COS	-21.6	21.5	VOLTS
GG2151	-P	1201018 15	VOLT,MG 1X RES SIN (EXPANDED)	-11.1	11.0	DEGS
GG2172	AP	1103067 15	VOLTS,OG 1X RES OUTPUT, SIN	-21.1	20.9	VOLTS
GG2173	AS	1104033 15	VOLTS,OG 1X RES OUTPUT, COS	-20.9	20.8	VOLTS
GG2181	-P	1201054 15	VOLT,OG 1X RES SIN(EXPANDED)	-11.5	11.3	DEGS
GG2219	-P	1104068 15	VOLT,PITCH CDU DAC OUT	-20.4	20.1	DEGS
GG2249	-P	1102100 15	VOLT,YAW CDU DAC OUT	-20.7	20.3	DEGS
GG2279	-P	1103066 15	VOLT,ROLL CDU DAC OUT	-20.7	20.3	DEGS
GH1214	P	1029098H15E	AUTO ON	NO	YES	BILEVEL
GH1217	P	1037098G15E	AUTO OFF	NO	YES	BILEVEL
GH1240	-P	1101065 15	VOLT,'X' TRANS CMD	-10.0	10.0	VOLTS
GH1260	S	5101032H15E	APS ON	OFF	ON	BILEVEL
GH1283	S	5101032G15E	ABORT STAGE	OFF	ON	BILEVEL
GH1286	P	1037098F15E	ENGINE FIRE OVERRIDE	OFF	ON	BILEVEL
GH1301	P	1029098G15E	DPS ON	OFF	ON	BILEVEL
GH1311	-P	1035005 15	VOLT,MANUAL THRUST CMD	-11.3	108.2	PER
GH1313	-S	1104035 15	VOLT,PITCH GDA POS (RET/EXT)	-2.0	2.0	INCHES
GH1314	-S	1104036 15	VOLT,ROLL GDA POS (EXT/RET)	-2.0	2.0	INCHES
GH1323	P	1029098F15E	PITCH TRIM FAIL	OFF	ON	BILEVEL
GH1330	P	1029098E15E	ROLL TRIM FAIL	NO	YES	BILEVEL
GH1331	-S	1103036 15	VOLT,AUTO THRUST CMD	0.0	98.2	PER
GH1418	P	2201006A15E	JET DRIVER 4U OUTPUT	OFF	ON	BILEVEL
GH1419	P	2201006B15E	JET DRIVER 4D OUTPUT	OFF	ON	BILEVEL
GH1420	P	2201006C15E	JET DRIVER 4F OUTPUT	OFF	ON	BILEVEL
GH1421	P	2201006D15E	JET DRIVER 4S OUTPUT	OFF	ON	BILEVEL
GH1422	P	2201006E15E	JET DRIVER 3U OUTPUT	OFF	ON	BILEVEL
GH1423	P	2201006F15E	JET DRIVER 3D OUTPUT	OFF	ON	BILEVEL
GH1424	P	2201006G15E	JET DRIVER 3F OUTPUT	OFF	ON	BILEVEL
GH1425	P	2201006H15E	JET DRIVER 3S OUTPUT	OFF	ON	BILEVEL
GH1426	P	2201007A15E	JET DRIVER 2U OUTPUT	OFF	ON	BILEVEL
GH1427	P	2201007B15E	JET DRIVER 2D OUTPUT	OFF	ON	BILEVEL
GH1428	P	2201007C15E	JET DRIVER 2F OUTPUT	OFF	ON	BILEVEL
GH1429	P	2201007D15E	JET DRIVER 2S OUTPUT	OFF	ON	BILEVEL

Table 1

CONTENTS OF AUXILLARY PROPULSION ANALYSIS TAPE (CONTINUED)

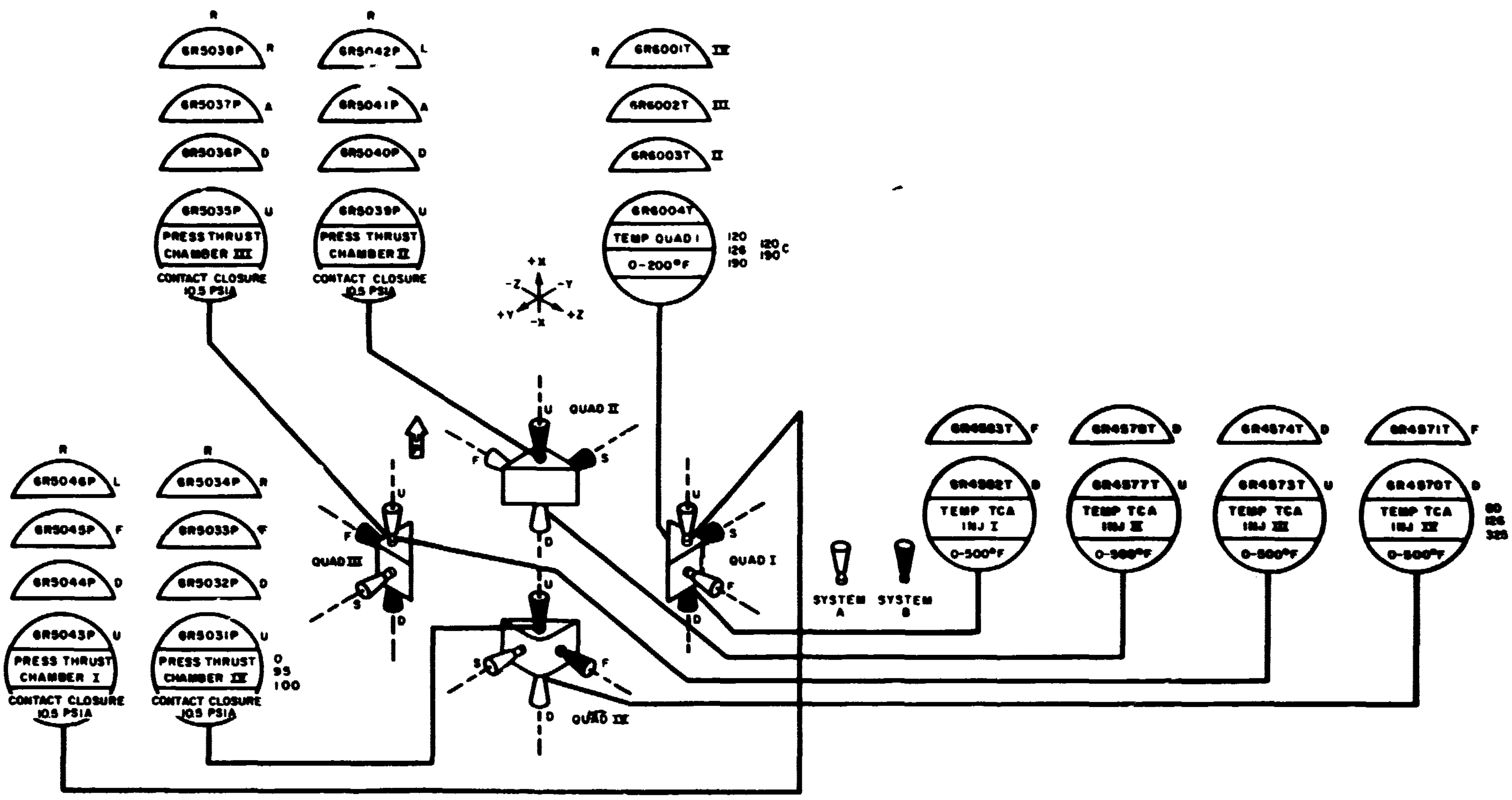
MEAS		LOAD NO	MEAS DESCRIPTION	LOW	HIGH	UNITS
GH1430	P	2201007E15E	JET DRIVER 1U OUTPUT	OFF	ON	BILEVEL
GH1431	P	2201007F15E	JET DRIVER 1D OUTPUT	OFF	ON	BILEVEL
GH1432	P	2201007G15E	JET DRIVER 1F OUTPUT	OFF	ON	BILEVEL
GH1433	P	2201007H15E	JET DRIVER 1S OUTPUT	OFF	ON	BILEVEL
GH1461	-S	1105067 15	VOLT,YAW RG SIG(.8KC)	-3.5	3.5	VOLTS
GH1462	-S	1105099 15	VOLT,PITCH RG SIG(.8KC)	-3.5	3.5	VOLTS
GH1463	-P	1105034 15	VOLT,ROLL RG SIG(.8KC)	-3.5	3.5	VOLTS
GH1603	P	1047098F15E	DEADBAND	NAR	WIDE	BILEVEL
GH1608	P	1037098E15E	AUTO MODE	OFF	ON	BILEVEL
GH1609	P	1037098D15E	ATTITUDE HOLD	OFF	ON	BILEVEL
GH1621	P	1029098D15E	AGS SELECT	OFF	ON	BILEVEL
GH1896	P	1037098C15E	UNBALANCED COUPLES	NO	YES	BILEVEL
GP0001	-S	1046101 15	PRESS,HE SUPPLY TANK NO1	0.0	4000.0	PSIA
GP0002	-S	1027005 15	PRESS,HE SUPPLY TANK NO2	0.0	4000.0	PSIA
GP0025	DP	1010069 15	PRESS,REG OUT MANIFOLD	0.0	300.0	PSIA
GP0201	-S	1044069 15	TEMP,HE SUPPLY TANK NO1	-200.0	200.0	DEGS
GP0202	-S	1008005 15	TEMP,HE SUPPLY TANK NO2	-200.0	200.0	DEGS
GP0501	-	E-EXX-72	PRESS,FUEL TANK ULLAGE			PSIA
GP0718	-S	1044037 15	TEMP,FUEL TANK FUEL BULK	20.0	120.0	DEGS
GP1001	-	E-EXX-12	PRESS,OX TANK ULLAGE			PSIA
GQ3603	-S	1021037 15	QUANTITY,FUEL TANK NO 1	0.0	95.0	PER
GQ3604	-S	1019005 15	QUANTITY,FUEL TANK NO 2	0.0	95.0	PER
GQ4103	-S	1031005 15	QUANTITY,OXID TANK NO 1	0.0	95.0	PER
GQ4104	-S	1046005 15	QUANTITY,OXID TANK NO 2	0.0	95.0	PER
GR1085	-P	1042069 15	QTY,PROPELLANT SYS A	0.0	100.0	PER
GR1089	-S	1037101 15	TEMP,SURFACE HE TANK SYS A	20.0	120.0	DEGS
GR1095	-P	1038069 15	QTY,PROPELLANT SYS B	0.0	100.0	PER
GR1099	-S	1042101 15	TEMP,SURFACE HE TANK SYS B	20.0	120.0	DEGS
GR1101	-S	1042005 15	PRESS,HELIUM TANK A	0.0	3500.0	PSIA
GR1102	-S	1038037 15	PRESS,HELIUM TANK B	0.0	3500.0	PSIA
GR1202	-S	1037005 15	PRESS,HE REGULATOR B OUTPUT	0.0	350.0	PSIA
GR2121	-P	1018037 15	TEMP,FUEL TANK A	20.0	120.0	DEGS
GR2122	-P	1020037 15	TEMP,FUEL TANK B	20.0	120.0	DEGS
GR2201	-F	2201012 15	PRESS,A FUEL MNFLD	0.0	350.0	PSIA
GR2202	-T	2201011 15	PRESS,B FUEL MNFLD	0.0	350.0	PSIA
GR3201	-T	2201014 15	PRESS,A OXID MNFLD	0.0	350.0	PSIA
GR3202	-F	2201013 15	PRESS,B OXID MNFLD	0.0	350.0	PSIA
GR4322	-	C-14X-79	TEMP,TCA FUEL INLET,PR 4R SURF			DEGS
GR4323	-	D-EXX-61	TEMP,TCA FUEL INLET,PR 3A SURF			DEGS
GR4326	-	D-EXX-17	TEMP,TCA FUEL INLET,PR 2R SURF			DEGS
GR4327	-	D-EXX-62	TEMP,TCA FUEL INLET,PR 1A SURF			DEGS
GR4424	-	C-14X-72	TEMP,TCA OXID INLET,PR 3R SURF			DEGS
GR4435	-	C-14X-87	TEMP,TCA OXID VLV NO3S SURF			DEGS
GR4441	-	C-14X-70	TEMP,TCA FUEL VLV NO4D SURF			DEGS
GR4448	-	C-14X-88	TEMP,TCA FUEL VLV NO.1D SURF			DEGS
GR4570	-	D-EXX-56	TEMP,TCA INJECTOR HEAD NO4D			DEGS
GR4571	-	D-EXX-58	TEMP,TCA INJECTOR HEAD NO4F			DEGS
GR4573	-	D-EXX-83	TEMP,TCA INJECTOR HEAD NO3U			DEGS
GR4577	-	D-EXX-77	TEMP,TCA INJECTOR HEAD NO2U			DEGS
GR4578	-	D-EXX-81	TEMP,TCA INJECTOR HEAD NO2D			DEGS
GR4582	-	D-EXX-78	TEMP,TCA INJECTOR HEAD NO1D			DEGS

Table 1

CONTENTS OF AUXILLARY PROPULSION ANALYSIS TAPE (CONTINUED)

MEAS		LOAD NO	MEAS DESCRIPTION	LOW	HIGH	UNITS
GR4583	-	D-EXX-74	TEMP,TCA INJECTOR HEAD NO1F			DEGS
GR5012	-	C-EXX-06	PRESS,TCA FUEL INLET,PR 4B			PSIA
GR5013	-	C-EXX-08	PRESS,TCA FUEL INLET,PR 3A			PSIA
GR5014	-	E-EXX-29	PRESS,TCA FUEL INLET,PR 3B			PSIA
GR5015	-	E-09/23	PRESS,TCA FUEL INLET,PR 2A			PSIA
GR5016	-	C-EXX-26	PRESS,TCA FUEL INLET,PR 2B			PSIA
GR5017	-	C-EXX-28	PRESS,TCA FUEL INLET,PR 1A			PSIA
GR5018	-	D-09X/23	PRESS,TCA FUEL INLET,PR 1B			PSIA
GR5019	-	E-EXX-30	PRESS,TCA OXID INLET,PR 4A			PSIA
GR5020	-	E-EXX-31	PRESS,TCA OXID INLET,PR 4B			PSIA
GR5021	-	E-EXX-32	PRESS,TCA OXID INLET,PR 3A			PSIA
GR5022	-	C-EXX-48	PRESS,TCA OXID INLET,PR 3B			PSIA
GR5023	-	E-15X/3	PRESS,TCA OXID INLET,PR 2A			PSIA
GR5024	-	E-EXX-51	PRESS,TCA OXID INLET,PR 2B			PSIA
GR5025	-	E-EXX-52	PRESS,TCA OXID INLET,PR 1A			PSIA
GR5026	-	C-09X/23	PRESS,TCA OXID INLET,PR 1B			PSIA
GR5031	-	A-06C	PRESS,THRUST CHAMBER NO 4U			PSIA
GR5032	-	A-06C	PRESS,THRUST CHAMBER NO 4D			PSIA
GR5033	-	D-16X/23	PRESS,THRUST CHAMBER NO 4F			PSIA
GR5034	-	E-06X/23	PRESS,THRUST CHAMBER NO 4S			PSIA
GR5035	-	A-01C	PRESS,THRUST CHAMBER NO 3U			PSIA
GR5036	-	A-01C	PRESS,THRUST CHAMBER NO 3D			PSIA
GR5037	-	D-16X/23	PRESS,THRUST CHAMBER OF 3F			PSIA
GR5038	-	E-07X/23	PRESS,THRUST CHEMBER OF 3S			PSIA
GR5039	-	D-12X	PRESS,THRUST CHAMBER NO 2U			PSIA
GR5040	-	D-12X	PRESS,THRUST CHAMBER NO 2D			PSIA
GR5041	-	C-16X/23	PRESS,THRUST CHAMBER OF 2F			PSIA
GR5042	-	E-07X/23	PRESS,THRUST CHAMBER OF 2S			PSIA
GR5043	-	A-07C	PRESS,THRUST CHAMBER NO 1U			PSIA
GR5044	-	A-07C	PRESS,THRUST CHAMBER NO 1D			PSIA
GR5045	-	C-16X/23	PRESS,THRUST CHAMBER NO 1F			PSIA
GR5046	-	E-06X/23	PRESS,THRUST CHAMBER NO 1S			PSIA
GR6001	-P	1003005 15	TEMP,QUAD CLUSTER NO 4	20.0	200.0	DEGS
GR6002	-P	1010005 15	TEMP,QUAD CLUSTER NO 3	20.0	200.0	DEGS
GR6003	-P	1022005 15	TEMP,QUAD CLUSTER NO 2	20.0	200.0	DEGS
GR6004	-P	1023005 15	TEMP,QUAD CLUSTER NO 1	20.0	200.0	DEGS
GR9609	S	1027098F15E	RCS MAIN A CLOSED	OPEN	CLD	BILEVEL
GR9610	S	1027098E15E	RCS MAIN B CLOSED	OPEN	CLD	BILEVEL
GR9611	S	1027098D15E	ASC FEED A OPEN	CLD	OPEN	BILEVEL
GR9612	S	1027098C15E	ASC FEED B OPEN	CLD	OPEN	BILEVEL
GR9613	S	1027098B15E	A/B X FEED OPEN	CLD	OPEN	BILEVEL
GR9661	P	1048098H15E	4A ISOLATION CLOSED	OPEN	CLD	BILEVEL
GR9662	P	1048098G15E	4B ISOLATION CLOSED	OPEN	CLD	BILEVEL
GR9663	P	1048098F15E	3A ISOLATION CLOSED	OPEN	CLD	BILEVEL
GR9664	P	1048098E15E	3B ISOLATION CLOSED	OPEN	CLD	BILEVEL
GR9666	P	1048098C15E	2B ISOLATION CLOSED	OPEN	CLD	BILEVEL
GR9667	P	1048098B15E	1A ISOLATION CLOSED	OPEN	CLD	BILEVEL
GR9665	P	1048098D15E	2A ISOLATION CLOSED	OPEN	CLD	BILEVEL
GR9668	P	1048098A15E	1B ISOLATION CLOSED	OPEN	CLD	BILEVEL

FOLDOUT FRAME 1



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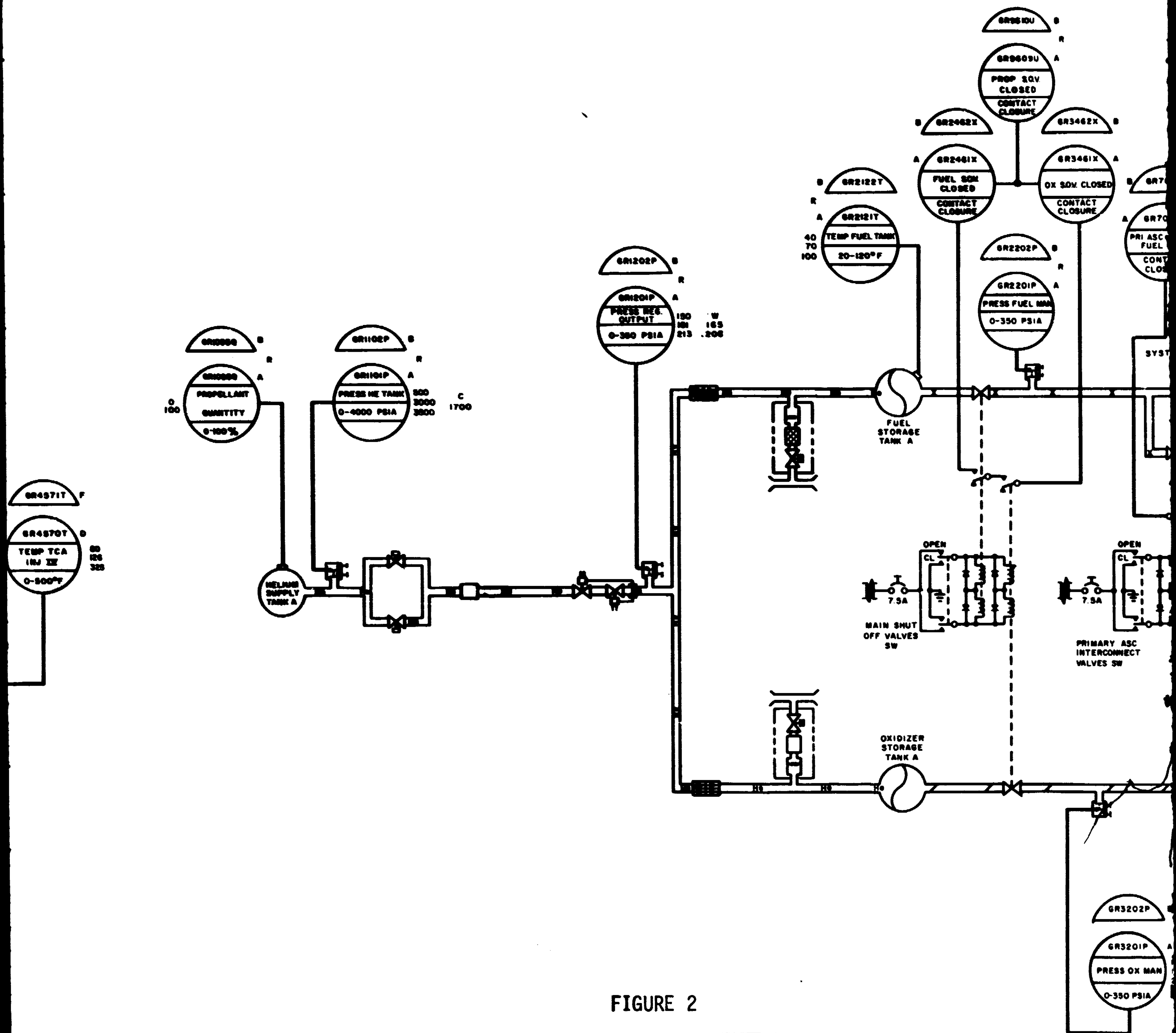
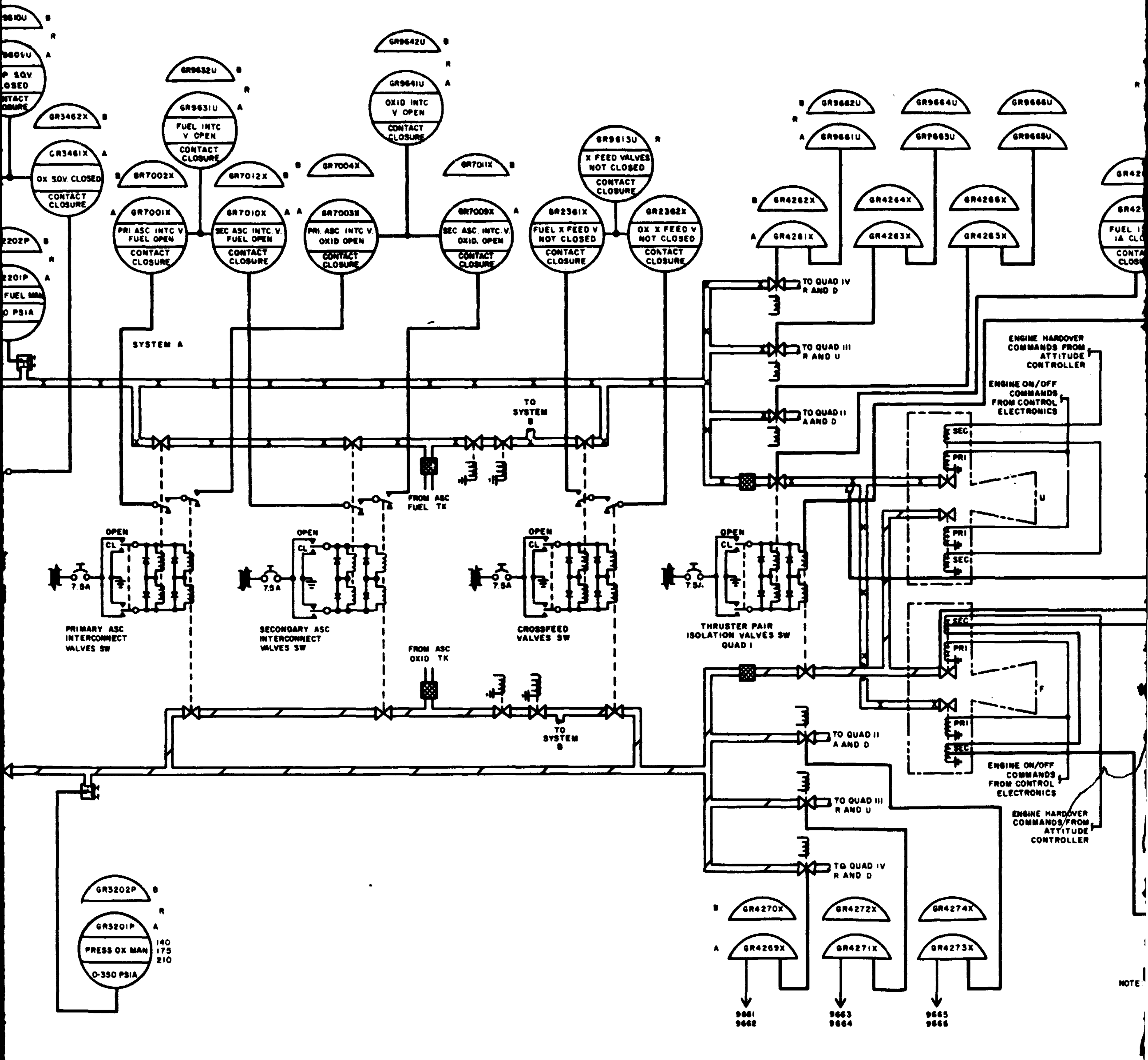


FIGURE 2

RCS MEASUREMENTS

FOLDOUT FRAME 3



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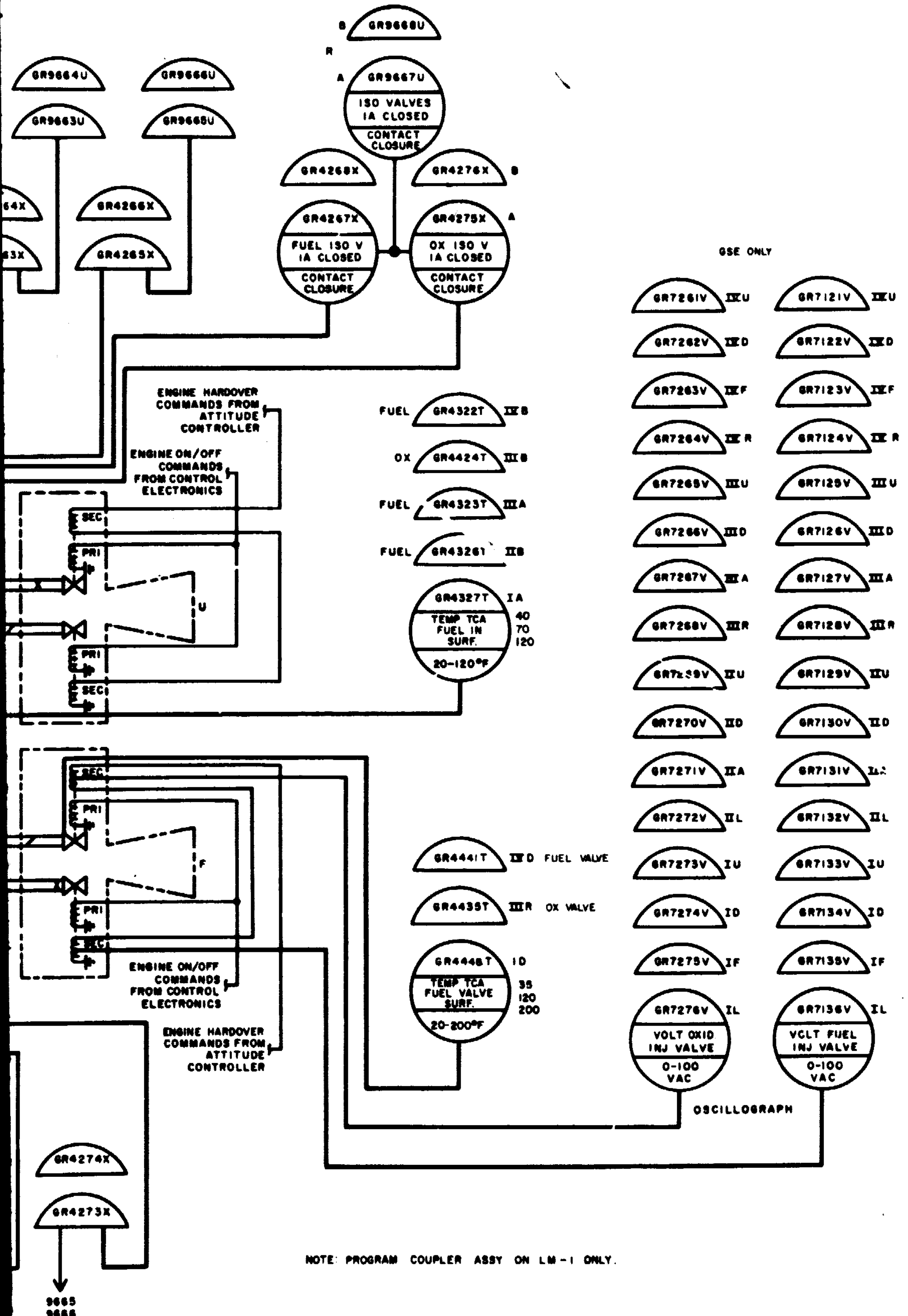

NOTE: PROGRAM COUPLER ASSY ON LM-1 ONLY.

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1.2 METHOD OF SOLUTION

The RCS ISPALM Program has been developed based on the data processing requirements and the desired NASA/MSC evaluations which make up an overall evaluation of the LM-RCS. Because of the nature of an overall performance evaluation, the analytical formulations characterizing the RCS status have been divided into the following general categories:

1.	Propulsion Ascent White Sands Test Series #1 Characterization	(PA-1)
2.	Flowrate, Burn Time	(FRBT)
3.	Pressure, Volume, Temperature	(PVT)
4.	Vehicle Dynamics	(VEDY)
5.	Mass Properties	(MASS PRO)
6.	Helium Leakage	(HELK)
7.	Data Processor	(DP)

These analytical categories comprise the evaluation requirements which for the purpose of terminology will be referred to as "program." The word "processor" will be construed as the software implementation of one or more of the above categories. Development of the ISPALM Program has followed the above general subdivisions and each carries the acronymic designation shown in the parenthesis. The resultant program becomes an integrated multifunctional software tool which can calculate each function separately as a processor or together as a program, depending on a flag selection by the user.

1.2.1 LM-RCS Evaluation Description

The general categories which make up the Reaction Control System evaluation formulations are the following:

PA-1	Formulation to determine RCS engine performance from integrals of the inlet and chamber pressure data over the firing time of each pulse.
FRBT	Ideal performance characterization obtained by regression analysis of the RCS acceptance test data, e.g., Performance Parameter = f (electrical on time of pulse).
PVT	Pressure, Volume, Temperature determination of the propellant quantity remaining in a storage tank.
VEDY	Six-degree of freedom vehicle dynamics formulation to calculate RCS engine performance from body rate data.

MASSPRO	A mass properties formulation that gives the mass properties of the LM from dry mass properties and fluid remaining in the various LM tanks.
HELK	A PVT formulation that calculates initial and final helium mass over a specified time span to determine helium leakage.

The Data Processor formulation is divided into the following categories:

LQF	Least squares curve fitting of data.
STATT	Statistical evaluation of data.
INTEG	Numerical integration of data.
DRIVER	Data tape processing package.
BOLEAN	ISPALM logical control program.

All the expected flight data which the analytical formulations are able to accept will be processed by 1108 computer. The evaluation output is a data bank magnetic tape or a printout. Any variable in any evaluation category can be obtained by the user by specifying the proper variables described in Section 3, Input and Output Procedures.

1.2.2 Analytical Formulations

The engineering formulations of the seven evaluation categories are presented as engineering equations which are used to evaluate the LM RCS Propulsion System Performance. This section does not show all the detail used in programming the separate engineering formulations into a program. The equations give a synopsis of each processor's formulations to show the user the engineering considerations which operate on the data to form the performance evaluation. For the definition of terms used in the equations given in the following sections see the appropriate category of Section 3.1, Input/Output Information For Each Functional Category.

1.2.2.1 PA-1 Formulations

This routine utilizes steady-state propulsion system flow equations as quasi-steady-state solutions of pulse performance (Reference 2). Propellant density equations were added for N_2O_4 and (50/50) UDMH/Hydrazine.

PA-1 Steady State Equations

1) Compute for each pulse and thruster.
   a) $\int PCdt$
   b) $\int PIFdt$
   c) $\int PIOdt$

   Note: Four manifold or eight inlet pressures are available for items (b) and (c).

2) Divide each of the integrals by the electrical on time (t_{eon}) to obtain
   a) $\overline{PC}$ (16 values)
   b) $\overline{PIF}$ (16 values)
   c) $\overline{PIO}$ (16 values) c.f. section 2.2.2

3) Compute 16 flows from:

$$\dot{w}O_i = KO_i(SG)^{1/2} \ (\overline{PIO} - \overline{PC})_i^{1/2} \qquad (i = 1, 16)$$

$$\dot{w}F_i = KF_i(SG)^{1/2} \ (\overline{PIF} - \overline{PC})_i^{1/2} \qquad (i = 1, 16)$$

4) Compute total propellant consumption from:

$$WO_i = \dot{w}O_i \times t_{eon_i} \qquad (i = 1, 16)$$

$$WF_i = \dot{w}F_i \times t_{eon_i} \qquad (i = 1, 16)$$

5) Compute thrust from

$$F_i = CF_i \times \overline{PC}_i \times AT_i \qquad (i = 1, 16)$$

6) Compute

$$C_i^* = \frac{\overline{PC}_i \times AT_i \times g_c}{WT_i} \qquad \begin{bmatrix} WT_i = \dot{W}O_i + \dot{W}F_i \\ g_c = 32.174 \end{bmatrix} \qquad (i = 1, 16)$$

7) Compute total impulse from

$$IT_i = 1.0431260 \int \overline{PC}_i dt + 0.1569234 \qquad (i = 1, 16)$$

Store IT_i, F_i, WO_i, WF_i, PC, C^* in performance matrix. (i = 1, 16)

Note: Specific gravity is given as:

$$\rho = \frac{EXP\ (A + BX + CX^2)}{Y}$$

$$X = \frac{540}{(T + 459.69)}$$

$$Y = \left[\frac{(T + 459.69)}{1.8}\right]^{1/2}$$

	NTO	50/50
A	2.754992	2.778697
B	.90349	.114927
C	-.449924	-.148262

T = propellant temperature, °F (assumed equal for oxidizer and fuel)

= GR 2121 T for thrusters 2, 4, 5, 8, 10, 11, 13, 15

= GR 2122 T for thrusters 1, 3, 6, 7, 9, 12, 14, 16

1.2.2.2 FRBT Formulations

The FRBT formulations are based on the performance parameters mixture ratio, specific impulse, thrust, flow rate, total impulse, and propellant consumed as functions of electrical on-time. These relationships were developed from data generated during the engine qualification tests conducted at the Marquardt Corporation.

The coefficients required for the polynomial curve fits for total impulse (IT), specific impulse (ISP), and mixture ratio were determined using "OMNITAB" routines. The equations are:

1) $IT = -0.176547 + 1.03369 \times 10^{2}\ t_{eon}$ (t_{eon} in seconds)

$\sigma = 0.0192$

2) $ISP = 278.14 - 4.2257\ t + 2.54003 \times 10^{-1}\ t^{2} - 1.08899 \times 10^{-2}\ t^{3} + 1.9704 \times 10^{-4}\ t^{4} - 1.22979 \times 10^{-6}\ t^{5}$

$\sigma = 0.093377$ Where $t = \frac{1}{t_{eon}}$

3) $MR = 2.05232 - 1.063282 \times 10^{-2}\ t + 6.024737 \times 10^{-4}\ t^{2} - 2.067306 \times 10^{-5}\ t^{3} + 2.6910646 \times 10^{-7}\ t^{4} - 1.162644 \times 10^{-9}\ t^{5}$

$\sigma = 0.0171$ Where $t = \frac{1}{t_{eon}}$

The data provided by these polynomial curve fits should be sufficiently accurate for present program execution. The user can change these values by card input of the CD (mnomonic) program array if more accurate curve fits (indicated by the given sigmas) are desired.

4) $IT_i = PN_1\ (t_{eon}) + X_i$

5) $ISP = PN_2 \left(\frac{1}{t_{eon}}\right) + Y_i$

6) $MR_i = PN_3 \left(\frac{1}{t_{eon}}\right) + Z_i$

Ten degree polynomial, whose coefficients are input. X_i, Y_i, and Z_i are correction factors available for each via card input.

IT = Total impulse for pulse

ISP = Specific impulse (avg) for pulse

MR = Pulse average mixture ratio

Compute for each thruster pulse.

7) $WT = \frac{IT}{ISP}$ (Total propellant consumption)

8) $WF = \frac{WT}{(MR + 1)}$ (Total fuel consumption)

9) $WO = (MR)(WF)$ (Total oxidizer consumption)

10) $F = \frac{IT}{t_{eon}}$ (Average thrust)

1.2.2.3 PVT Formulations

The PVT equations were obtained from Reference 1 and modified to incorporate a density equation for the fuel blend comprised of a 50/50 mixture of UDMH and N_2H_4. Provisions can be added for estimating the helium source temperature whenever these measurements are not available. Because the following formulations are based on the pressure-volume-temperature equations of state for a gas and are used in conjunction with the law of conservation of mass (leak free system) to determine propellant quantity, the formulations hold equally for the RCS and the Ascent Propulsion System (APS of the LM).

Propellant Density (lb/in^3)

1) $PFLI = 4.23574 \times 10^{-2} - 1.8426 \times 10^{-5}\ TFI + 2.131532 \times 10^{-7}\ PFI + DFDENS$

2) $POLI = 7.60141 \times 10^{-2} - 4.5.5 \times 10^{-5} TOI + 4.046281 \times 10^{-7} POI + DODENS$

TFI = Measurement ID GR 2121 (or GR 2122) + 459.69

DODENS, DFDENS = Bias correction to density equations, lb/in^3

TOI = TFI

PFI = Measurement ID GR 2201 (or GR 2202)

POI = Measurement ID GR 3201 (or GR 3202)

3) $VOUI = VO - \frac{WOTA}{POLI}$

where VO = oxidizer system volume (in^3)

WOTA = weight of oxidizer tanked

POLI = Equation 2

4) $VUFI = VF - \frac{WFTA}{PFLI}$

where VF = volume of fuel system

WFTA = weight of fuel tanked

PFLI = Equation 1

5) $VHI = VHNOM\ [1 + (PHI - PA)\quad Expan]^3 + VHL$

where VHOM = nominal volume of helium tank, in^3

VHL = volume of helium line from tank to regulator (card input)

Expan = tank expansion factor, psi^{-1}, D/4tE

PHI = initial helium bottle pressure, psia, use measurements GR 1101 or GR 1102

6a) $$PFVI = \frac{\left(\frac{TF}{1.8}\right)^{-7.88} \times 10^{\left(\frac{-5663}{TF} + 31.75\right)}}{51.71}$$

6b) $POVI = e^{\left(16.594 - \frac{7367}{TF}\right)}$

7) $AI = 61.489TSI - 9567.6$

$BI = 21345.1 - 78.803TSI$

$CHI = 16.995 \times TSI - PHI - 11761.6$

$CDFI = 16.995 \times TSI - PFI + PFVI - 11761.6$

$CDOI = 16.995 \times TSI - POI + POVI - 11761.6$

where TSI = measurement TD GR 1089 (or GR 1099) + 459.69

PHI = defined in equation 5

PFI = initial fuel manifold pressure (GR 2201 or GR 2202)

POI = initial oxidizer manifold pressure (GR 3201 or GR 3202)

8) $$ZHI = \frac{-BI + [BI^2 - 4AI\ CHI]^{1/2}}{2AI}$$

$$ZDFI = \frac{-BI + [BI^2 - 4AI\ CDFI]^{1/2}}{2AI}$$

$$ZDOI = \frac{-BI + [BI^2 - 4AI\ CDOI]^{1/2}}{2AI}$$

9) $$GI = \frac{PHI\ VHI}{ZHI} + \frac{PFI - PFVI}{ZDFI} \times VUFI + \frac{POI - POVI}{ZDOI} \times VUOI$$

where PHI = see equation 5

PFI = see equation 7

POI = initial oxidizer manifold pressure (GR 3201 or GR 3202)

Prior equations are solved at t = 0 to determine the boundary conditions using initial values. In the subsequent analysis, these same equations are used, slightly modified, using current values.

10) PFL = use equation 1

11) POL = use equation 2

12) PFV = use equation 6a

13) POV = use equation 6b

14) PHO = PO - POV

PO = GR 3201 or GR 3202

15) PHF = PF - PFV

PF = GR 2201 or GR 2202

16) $ZHF = \frac{-B + [B^2 - 4A\ CHF]^{1/2}}{2A}$ See equation 7

$ZHO = \frac{-B + [B^2 - 4A\ CHO]^{1/2}}{2A}$ See equation 7

$ZH = \frac{-B + [B^2 - 4A\ CN]^{1/2}}{2A}$ See equation 7

17) VHT = use equation 5 with current values

18) WOUT = WOTA - VOTR × POL

where WOTA = tanked oxidizer

VOTR = volume of trapped oxidizer

POL = equation 11

19) WFUT = WFTA - VFTR × PFL

where WFTA = tanked fuel

VFTR = trapped fuel

PFL = equation 10

20) (a) $L = \frac{PHF}{ZHF \times PFL} + \frac{PHO \times MR1}{ZHO \times POL}$

where PHO, PHF = equations 13 and 14

POL, PFL = equations 10 and 11

ZHO, ZHF = equation 16

MR1 = mixture ratio of propellant expended (card input)

(b) VH = VHT (see equation 17)

21) $WFE = \frac{1}{L}\left(\frac{TS}{TSI} \times GI - \frac{PH \times VH}{ZH} - \frac{PHF \times VUFI}{ZHF} - \frac{PHO \times VUOI}{ZHO}\right)$

where L = equation 20a

TS = GR 1089 (or GR 1099) + 459.69

TSI = initial value of TS

GI = equation 9

PH = GR 1101 or GR 1102

VH = equation 20b

ZH, ZHF, ZHO = equation 16

PHO, PHF = equations 13 and 14

VUOI, VUFI = equations 3 and 4

22) WOE = (MR1) × WFE (WFE = equation 21)

23) (a) WPE = WFE + WOE

(b) WOD = WOUT - WOE

(c) WFD = WFUT - WFE

where WFE = equation 21

WOE = equation 22

WOUT = equation 18

WFUT = equation 19

Now determine a value for WFU in the following manner.

24) (a) IF $\frac{WOD}{MR2} \geq WFD$, then WFU = WFD

(b) IF $\frac{WOD}{MR2} < WFD$, then $WFU = \frac{WOD}{MR2}$

where MR2 = expected mixture ratio for the remainder of the flight (card input)

25) (a) WPU = (1 + MR2) × WFU

(b) WOU = MR2 × WFU

Whenever source temperature (GR 1089, 1099) is not available, then the following equation should be used utilizing GR 1085 or GR 1095, respectively.

$$T(°R) = 144P\left[\frac{K_1}{E + K_2} - K_3\right]$$

where P = GR 1085 or GR 1095 in psia

T = Estimation of Tsi in °R

E = Propellant quantity in volts

$K_1 = 1.30167 \times 10^{-2}$

$K_2 = 4.80869$

$K_3 = 1.21022 \times 10^{-4}$

1.2.2.4 VEDY Formulations

The vehicle dynamics formulations described in this section provide a method of deriving the thrust of the individual LM RCS thrusters by analysis of the vehicle dynamics using on-board measurements. The measured linear acceleration rates are combined with rotational acceleration rates to form two sets of simultaneous equations. The first set includes the torque about the vehicle X-axis and the forces normal to the X-axis. The second set includes the torque about the Y and Z-body axes and the force along the X-axis. The first set allows computation of the output of thrusters that are aligned normal to the X-axis; the second set allows computation of the output of thrusters aligned with the X-axis.

The solution allows for any number of jets to be operating. The general logic is set-up for the solution of two (2) sets of three (3) simultaneous equations by matrix methods. Fill-in and redundant formulations are used when 1 or 2 and 4 jets are operating in a given axis system. The fill-in formulations are required to prevent the inverted coefficient matrix from becoming indeterminant. The redundant routine provides for multiple solutions using the current thrust values and for averaging the resultant solutions to provide the calculated thrust values.

The mass properties used in the dynamics equations are derived for each period of RCS activity using inputs from the PVT and DP subroutines which compute the weights of propellants remaining. The position of the propellants in the tanks is based on the load factor for each of the tanks and the resultant acceleration direction. This information is supplied by this subroutine to the mass properties subroutine.

The flow chart of the basic interrelationships of the individual operations that derive the RCS thrusts are shown in Figure 3 at the end of this section.

After the simultaneous equations are divided into two independent systems, the notation of the jets is changed into two sequentially numbered systems to facilitate logic tests in the following routines. The RCS jets are renumbered as follows:

External Notation	P-Axis Notation	Q, R-Axes Notation
T1		T1
T2		T2
T3	T1	
T4	T2	
T5		T3
T6		T4
T7	T3	
T8	T4	
T9		T5
T10		T6
T11	T5	
T12	T6	
T13		T7
T14		T8
T15	T7	
T16	T8	

The jet on-off switches are redesigned as follows:

Jet Switch Notation	P-Axis Notation	Q, R-Axis Notation
SW1		S1
SW2		S2
SW3	S1	
SW4	S2	
SW5		S3
SW6		S4
SW7	S3	
SW8	S4	
SW9		S5
SW10		S6
SW11	S5	
SW12	S6	
SW13		S7
SW14		S8
SW15	S7	
SW16	S8	

The individual terms of the matrices that make up the equation to solve for RCS jet thrust are determined in this routine. The matrix equation is

$$[EFM] = [C][T]$$
$$(3 \times 1) = (3 \times 8)\ (8 \times 1)$$

The [EFM] matrix contains the forces and moments for each axis system. The last calculated values for unknowns in redundant solutions are also included in these terms. The [C] matrix includes the moment arms and thrust direction modifiers for the [T] matrix which contains the unknown thrust terms.

The terms of the matrices are as follows:

<u>P-Axis [EFM]</u>

EFM11 = L + TC1(Y3)(SL1) - TC2(Z4)(SL2) - TC3(Y7)(SL3) - TC4(Z8)(SL4)
- TC5(Y11)(SL5) + TC6(Z12)(SL6) + TC7(Y15)(SL7) + TC8(Z16)(SL8)

EFM21 = TC2(SL2) + TC4(SL4) - TC6(SL6) - TC8(SL8) + FY

EFM31 = FZ + TC1(SL1) - TC3(SL3) - TC5(SL5) + TC7(SL7)

<u>Q, R-Axes [EFM]</u>

EFM11 = M + TC1(Z1)(SL1) - TC2(Z2)(SL2) + TC3(Z5)(SL3) - TC4(Z6)(SL4)
+ TC5(Z9)(SL5) - TC6(Z10)(SL6) + TC7(Z13)(SL7) - TC8(Z14)(SL8)

EFM21 = N - TC1(Y1)(SL1) + TC2(Y2)(SL2) - TC3(Y5)(SL3) + TC4(Y6)(SL4)
- TC5(Y9)(SL5) + TC6(Y10)(SL6) - TC7(Y13)(SL7) + TC8(Y14)(SL8)

EFM31 = TC1(SL1) - TC2(SL2) + TC3(SL3) - TC4(SL4) + TC5(SL5) - TC6(SL6)
+ TC7(SL7) - TC8(SL8) + FX

<u>P-Axis [C]</u>

C11 = -Y3	C21 = 0	C31 = -1
C12 = +Z4	C22 = -1	C32 = 0
C13 = +Y7	C23 = 0	C33 = +1
C14 = +Z8	C24 = -1	C34 = 0
C15 = +Y11	C25 = 0	C35 = +1
C16 = -Z12	C26 = +1	C36 = 0
C17 = -Y15	C27 = 0	C37 = -1
C18 = -Z16	C28 = +1	C38 = 0

Q, R-Axes [C]

C11 = -Z1	C21 = +Y1	C31 = -1
C12 = +Z2	C22 = -Y2	C32 = +1
C13 = -Z5	C23 = +Y5	C33 = -1
C14 = +Z6	C24 = -Y6	C34 = +1
C15 = -Z9	C25 = +Y9	C35 = -1
C16 = +Z10	C26 = -Y10	C36 = +1
C17 = -Z13	C27 = +Y13	C37 = -1
C18 = +Z14	C28 = -Y14	C38 = +1

The 8 × 1 [T] matrix requires no further expansion.

The (SL) terms in the [EFM] matrix are used for redundant solutions. The terms are nulled in the counter routine prior to selection of a solution method. The redundant solution routine sets the value to 1.0 for the assumed thrust value in each of 4 solutions in turn. The EFM matrix represents the measured telemetered data converted to the forces and moments of the LM spacecraft. The following equations show how they are formulated.

1) Compute derivatives of measured P, Q, R (rad/rec) rotation rates to get PDOT, QDOT, RDOT (curve fit option c.g. 3.2.1.1)

$$PDOT = \frac{dP}{dTIME}$$

$$QDOT = \frac{dQ}{dTIME}$$

$$RDOT = \frac{dR}{dTIME}$$

2) Compute the X axis acceleration and find effect of X-c.g. shift of fluid in number of tanks considered for mass properties.

$$ACCTX_j = ACCX - (1/32.174)\ (1/12)\ [(XT_j - XA)\ (Q^2 + R^2)$$

$$+ (YT_j - YA)\ (P(Q)-RDOT) + (ZT_j - ZA)\ (QDOT + P(R))]$$

where

ACCX - Linear "X" acceleration

j - Number of tanks

XT_j, YT_j, ZT_j — Tank Locations

XA, YA, ZA — Accelerometer Locations in LM - Coordinates

3) Compute the linear accelerations of the three axes from measured ACCX, ACCY, ACCZ.

$$XDDOT = ACCX(32.174)-(1./12.)[(XCG-XA)(Q^2+R^2) +(YCG-YA)(P\times Q-RDOT) + (ZCG-ZA)(QDOT+P\times R)]$$

$$YDDOT = ACCY(32.174)-(1./12.)[(YCG-YA)(P^2+R^2) +(XCG-XA)(P\times Q+RDOT) + (ZCG-ZA)(Q\times R+PDOT)]$$

$$ZDDOT = ACCZ(32.174)-(1./12.)[(ZCG-ZA)(P^2+Q^2) +(XCG-XA)(P\times R-QDOT) + (YCG-YA)(Q\times R+PDOT)$$

4) Compute the forces and moments for each axis system which make up the [EFM] matrix

FX = MASS (XDDOT)

FY = MASS (YDDOT)

FZ = MASS (ZDDOT)

L = LCG

M = MCG + (XP-XCG)(FZ)(1./12.)

N = NCG - (XP-XCG)(FY)(1./12.)

where

LCG = IXX(PDOT)-IXY(QDOT-P×R)-IXZ(RDOT+P×Q)

$-IYZ(Q^2-R^2)-(IYY-IZZ)(Q(R))$

MCG = IYY(QDOT)-IXZ(RDOT-P×Q)-IXY(PDOT+Q×R)

$-IXZ(R^2-P^2)-(IZZ-IXX)(P(R))$

NCG = IZZ(RDOT)-IXZ(PDOT-Q×R)-IYZ(QDOT+P×R)

$-IXY(P^2-Q^2)-(ZZ-IYY)(P\times Q)$

5) Compute the moment arms from data input of XP, YJ_j, ZJ_j (j=1-16)

$Y(j)=(YJ_j - YCG)(1./12.)$

$Z(j)=(ZJ_j - ZCG)(1./12.)$

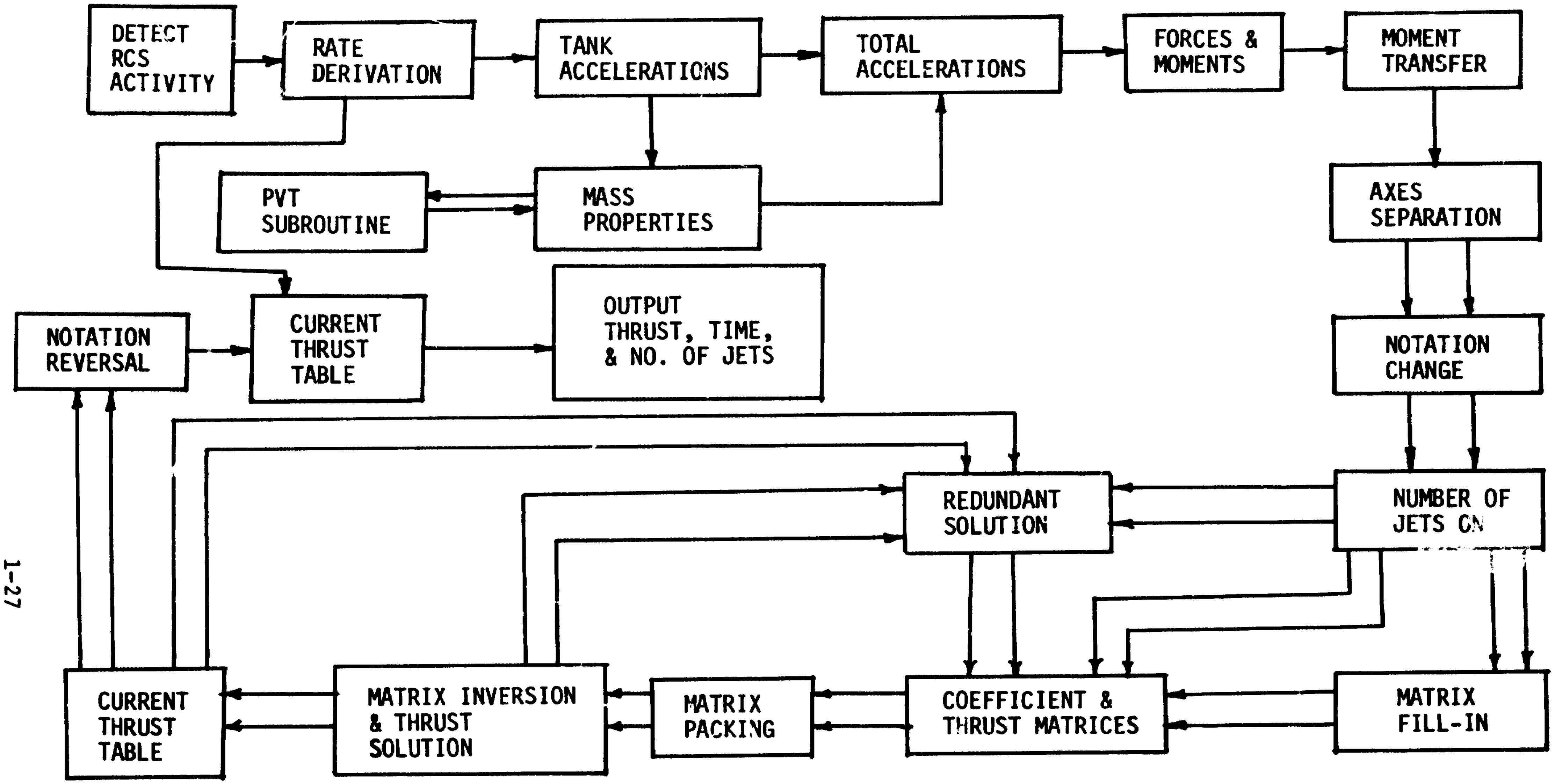

FIGURE 1-3. LM RCS THRUST DERIVATION--SUBROUTINE FLOW CHART

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1.2.2.5 MASS PRO Formulations

The Mass Properties formulations considers the spacecraft as having expendable and non-expendable mass. All non-expendable mass items can be considered collectively as one, and the expendable items separately by a Prop code designated 21 through 31. The user can treat mass property events (such as staging or removal of a crew member from the spacecraft) as negative mass non-expendable items since the LM mass properties are the summation of all the individual expendable and the collective non-expendables. In the expendable category the least X-station formulations place the expendable mass in the most negative X position within the container when an X-axis acceleration causes a shift of the expendable items. All results are in LM-Coordinates.

1.2.2.5.1. Equation Sets - Least X Station

The following equation sets are to be used to calculate the mass properties of the indicated items when the weight is given, and the fluid C.G. is assumed to be at the low end of the tanks. (least X station.)

1) **LM/Ascent Fuel - Prop Code 21**

$$\bar{X} = .20534741\text{E } 03 + .20521777\text{E-01}W - .97024952\text{E-05}W^2 + .24894782\text{E-08}W^3$$

$$\bar{Y} = -71.3$$

$$\bar{Z} = 0$$

$$I_{xx} = -.36310971\text{E-01} + .13338970\text{E-02}W + .19391702\text{E-05}W^2 - .62529461\text{E-09}W^3$$

$$I_{yy} = I_{zz} = -.35499424\text{E-01} + .89666135\text{E-03}W + .78254623\text{E-06}W^2 + .22598471\text{E-10}W^3$$

2) **LM/Ascent Oxidizer - Prop Code 22**

$$\bar{X} = .20535629\text{E } 03 + .12855122\text{E-01}W - .38260466\text{E-05}W^2 + .61744640\text{E-09}W^3$$

$$\bar{Y} = 44.5$$

$$\bar{Z} = 0$$

$$I_{xx} = -.59674799\text{E-01} + .13387123\text{E-02}W + .12089914\text{E-05}W^2 - .24372337\text{E-09}W^3$$

$$I_{yy} = I_{zz} = -.56315809\text{E-01} + .88887222\text{E-03}W + .49824974\text{E-06}W^2 + .65675445\text{E-11}W^3$$

3) **IM/Descent Fuel Positive $\bar{Y}$ Prop Code 23**

$$\bar{X} = .12738810E\ 03 + .19024143E{-}01W - .88853232E{-}05W^2 + .29277965E{-}08W^3 - .34101765E{-}12W^4$$

$$\bar{Y} = 54.0$$

$$\bar{Z} = 0$$

$$Ixx = -.99594951E{-}01 + .19500052E{-}02W + .10704315E{-}05W^2 - .25573546E{-}09W^3 + .13785340E{-}13W^4$$

$$Iyy = Izz = .54411888E{-}02 + .17026676E{-}02W - .45452490E{-}05W^2 + .52687877E{-}08W^3 - .81926266E{-}12W^4$$

4) **IM/Descent Fuel Negative $\bar{Y}$ - Prop Code 24**

$$\bar{X} = .12738810E\ 03 + .19024143E{-}01W - .88853232E{-}05W^2 + .29277965E{-}08W^3 - .34101765E{-}12W^4$$

$$\bar{Y} = 54.0$$

$$\bar{Z} = 0$$

$$Ixx = -.99594951E{-}01 + .19500052E{-}02W + .10704315E{-}05W^2 - .25573546E{-}09W^3 + .13785340E{-}13W^4$$

$$Iyy = Izz = .54411888E{-}02 + .17026676E{-}02W - .45452490E{-}05W^2 + .52687877E{-}08W^3 - .81926266E{-}12W^4$$

5) **IM/Descent Oxidizer Positive $\bar{Z}$ - Prop Code 25**

$$\bar{X} = .12738045E\ 03 + .11928473E{-}01W - .35104368E{-}05W^2 + .72899576E{-}09W^3 - .53568166E{-}13W^4$$

$$\bar{Y} = 0$$

$$\bar{Z} = 54.0$$

$$Ixx = -.15452588E\ 00 + .19224920E{-}02W + .67781895E{-}06W^2 - .10941657E{-}09W^3 + .43359634E{-}14W^4$$

$$Iyy = Izz = -.53731441E{-}01 + .21016984E{-}02W - .32606741E{-}05W^2 + .22014324E{-}08W^3 - .21500729E{-}12W^4$$

6) **IM/Descent Oxidizer Negative $\bar{Z}$ - Prop Code 26**

$$\bar{X} = .12738045E\ 03 + .11928473E{-}01W - .35104368E{-}05W^2 + .72899576E{-}09W^3 - .53568166E{-}13W^4$$

$$\bar{Y} = 0$$

$$\bar{Z} = -54.0$$

$$Ixx = -.15452588E\ 00 + .19224920E{-}02W + .69781895{-}06W^2 - .10941657E{-}09W^3 + .43359634E{-}14W^4$$

$$Iyy = Izz = -.53731441E{-}01 + .21016984E{-}02W - .32606741E{-}05W^2 + .22014324E{-}08W^3 - .21500729E{-}12W^4$$

7) **IM/RCS Propellant System B - Prop Code 27**

W = weight of propellant

Weight of fuel $(W_f) = (.333)\ (W)$

Weight of Oxid. $(W_o) = W{-}W_f$

$$\bar{X}_f = .26506078E\ 03 + .22614669E\ 00W_f - .28328710E{-}02W_f^{\ 2} + .32567607E{-}04W_f^{\ 3} - .13088695E{-}06W_f^{\ 4}$$

$$\bar{Y}_f = 44.6$$

$$\bar{Z}_f = 14.5$$

$$Ixx_f = -.23905386E{-}03 + .16800093E{-}03W_f + .11905717E{-}05W_f^{\ 2} - .12729901E{-}07W_f^{\ 3} + .45305503E{-}10W_f^{\ 4}$$

$$Iyy_f = Izz_f = -.55036172E{-}02 + .16061971E{-}02W_f - .85034118E{-}04W_f^{\ 2} + .17360664E{-}05W_f^{\ 3} - .53912640E{-}08W_f^{\ 4}$$

$$\bar{X}_o = .25856457E\ 03 + .13113119E\ 00W_o - .82350399E{-}03W_o^{\ 2} + .51864054E{-}05W_o^{\ 3} - .11330682E{-}07W_o^{\ 4}$$

$$\bar{Y}_o = 44.6$$

$$\bar{Z}_o = -14.5$$

$$Ixx_o = -.45468262E{-}03 + .17648277E{-}03W_o + .53459723E{-}06W_o^{\ 2} - .32059287E{-}08W_o^{\ 3} + .64977355E{-}11W_o^{\ 4}$$

$$Iyy_o = Izz_o = -.10633841E{-}01 + .15060r11E{-}02W_c - .38169558E{-}04W_o^{\ 2} + .39113826E{-}06W_o^{\ 3} - .28322410E{-}09W_o^{\ 4}$$

8) **LM/RCS Propellant System A - Prop Code 28**

W = weight of propellant

Weight of fuel (W_f) = (.333) (W)

Weight of Oxid (W_o) = $W-W_f$

$\bar{X}_f$ = .26506078E 03 + .22614669E 00W_f - .28328710E-02W_f^2 + .32567607E-04W_f^3 - .13088695E-06W_f^4

$\bar{Y}_f$ = -44.6

$\bar{Z}_f$ = -14.5

Ixx_f = -.23905386E-03 + .16800093E-03W_f + .11905717E-05W_f^2 - .12729901E-07W_f^3 + .45305503E-10W_f^4

Iyy_f = Izz_f = -.55036172E-02 + .16061971E-02W_f - .85034118E-04W_f^2 + .17360664E-05W_f^3 - .53912640E-08W_f^4

$\bar{X}_o$ = .25856457E 03 + .13113119E 00W_o - .82350399E-03W_o^2 + .51864054E-05W_o^3 - .11330682E-07W_o^4

$\bar{Y}_o$ = -44.6

$\bar{Z}_o$ = 14.5

Ixx_o = -.45468262E-03 + .17648277E-03W_o + .53459723E-06W_o^2 - .32059287E-08W_o^3 + .64977355E-11W_o^4

Iyy_o = Izz_o = -.10633841E-01 + .15060411E-02W - .38169558-04W_o^2 + .39113826E-06W_o^3 - .28322410E-09W_o^4

9) **LM/Ascent Water - Prop Code 29 - Positive Y-Z Coord.**

$\bar{X}$ = .29499693E 03 + .31133195E 00W - .13063032E-01W^2 + .35564251E-03W^3 - .35533792E-05W^4

$\bar{Y}$ = 25.0

$\bar{Z}$ = 13.7

Ixx = Iyy = Izz = 0

10) LM/Ascent Water - Prop Code 30 - Negative Y-Z Coord.

$$\bar{X} = .29499693E\ 03 + .31133195E\ 00W - .13063032E\text{-}01W^2 + .35564251E\text{-}03W^3 - .35533792E\text{-}05W^4$$

$$\bar{Y} = -25.0$$

$$\bar{Z} = -13.7$$

$$Ixx = Iyy = Izz = 0$$

11) LM/Descent Water - Prop Code 31

$$\bar{X} = .15548927E\ 03 + .61898149E\text{-}01W - .17837692E\text{-}03W^2 + .26771660E\text{-}06W^3$$

$$\bar{Y} = -43.2$$

$$\bar{Z} = -43.2$$

$$Ixx = -.23038927E\text{-}02 + .42727974E\text{-}03W + .31750165E\text{-}05W^2 -.49695816E\text{-}08W^3$$

$$Iyy = Izz = -.13052020E\text{-}02 + .22579240E\text{-}03W + .18381940E\text{-}05W^2 - .11205275E\text{-}08W^3$$

1.2.2.5.2 The following are the equations which translate the current liquid center of gravity from the lowest to the highest possible position within the tank (greatest X station).

1)	Wt. $\bar{Y}$ $\bar{Z}$	Ixx Iyy Izz	Not affected, use equations for least X station - see paragraphs 3.1 thru 3.11
2)	DPS Fuel Tanks		$\bar{X}_{TF}$ = 322.48 - Least X Station X_F
3)	DPS Oxidizer Tanks		$\bar{X}_{TO}$ = 322.48 - Least X Station X_O
4)	APS Fuel Tank		$\bar{X}_{TF}$ = 458.0 - Least X Station X_F
5)	APS Oxidizer Tank		$\bar{X}_{TO}$ = 458.0 - Least X Station X_O
6)	RCS Fuel Tanks		$\bar{X}_{TF}$ = 560.75 - Least X Station X_F
7)	RCS Oxidizer Tanks		$\bar{X}_{TO}$ = 554.16 - Least X Station X_O

8) Ascent Water Tanks $\bar{X}_{TW}$ = 604.11 - Least X Station X_{WA}

9) Descent Water Tanks $\bar{X}_{TW}$ = 338.2 - Least X Station X_{WO}

1.2.2.5.3 If the liquid center of gravity is assumed to be constant and located at the center of the particular tank, then the following equations are used.

1) Wt., $\bar{Y}$, $\bar{Z}$, Ixx, Iyy, Izz — Not affected, use equations for least X station - see paragraphs 3.1 thru 3.11

2)	DPS Fuel Tanks	X_{MF}	=	159.3
3)	DPS Oxidizer Tanks	X_{MO}	=	159.1
4)	APS Fuel Tanks	X_{MF}	=	227.3
5)	APS Oxidizer Tanks	X_{MO}	=	227.2
6)	RCS Fuel Tanks	X_{MF}	=	279.3
7)	RCS Oxidizer Tanks	X_{MO}	=	275.7
8)	Ascent Water Tanks	X_{MW}	=	300.3
9)	Descent Water Tanks	X_{MW}	=	165.8

1.2.2.5.4 The following equations are to be used for summations of input mass properties.

1) $W^1 = \Sigma \, Wi$

2) $\bar{X}^1 = \Sigma \, W_i \, \bar{X}_i \quad W^1$

3) $\bar{Y}^1 = \Sigma \, W_i \, \bar{Y}_i \quad W^1$

4) $\bar{Z}^1 = \Sigma \, W_i \, \bar{Z}_i \quad W^1$

5) $I^1XX = \left| \Sigma_i \left[W_i \, (\bar{Y}_i^2 + \bar{Z}_i^2) \right] - W^1 \, (\bar{Y}^{1^2} + \bar{Z}^{1^2}) \right| \div 4632.48 + \Sigma_i \, I_{XX_i}$

6) $I^1YY = \left| \Sigma_i \left[W_i \, (\bar{X}_i^2 + \bar{Z}_i^2) \right] - W^1 \, (\bar{X}^{1^2} + \bar{Z}^{1^2}) \right| \div 4632.48 + \Sigma_i \, I_{YY_i}$

7) $I^1ZZ = \left| \Sigma_i \left[W_i \, (\bar{X}_i^2 + \bar{Y}_i^2) \right] - W^1 \, (\bar{X}^{1^2} + \bar{Y}^{1^2}) \right| \div 4632.48 + \Sigma_i \, I_{ZZ_i}$

8) $P^1XY = \left| \Sigma_i \left[W_i \bar{X}_i \bar{Y}_i \right] - W^1 \bar{X}^1 \bar{Y}^1 \right| \div 4632.48 + \Sigma_i P_{XY_i}$

9) $P^1XZ = \left| \Sigma_i \left[W_i \bar{X}_i \bar{Z}_i \right] - W^1 \bar{X}^1 \bar{Z}^1 \right| \div 4632.48 + \Sigma_i P_{XZ_i}$

10) $P^1YZ = \left| \Sigma_i \left[W_i \bar{Y}_i \bar{Z}_i \right] - W^1 \bar{Y}^1 \bar{Z}^1 \right| \div 4632.48 + \Sigma_i P_{YZ_i}$

1.2.2.5.5 Change From Apollo to LM Coordinates

The following equations are to be used to change from Apollo coordinates to LM coordinates, where $\Theta = -60^\circ$.

1) $X_E = 1422.75 - X_A$

2) $Y_E = Y_A \text{ Cos}\Theta - Z_A \text{ Sin}\Theta$

3) $Z_E = -Y_A \text{ Sin}\Theta - Z_A \text{ Cos}\Theta$

4) $I_{xx_E} = I_{xx_A}$

5) $I_{yy_E} = I_{zz_A} \text{ Sin}^2\Theta + I_{yy_A} \text{ Cos}^2\Theta + 2P_{yz_A} \text{ Sin}\Theta \text{ Cos}\Theta$

6) $I_{zz_E} = I_{zz_A} \text{ Cos}^2\Theta + I_{yy_A} \text{ Sin}^2\Theta - 2P_{yz_A} \text{ Sin}\Theta \text{ Cos}\Theta$

7) $P_{xy_E} = -P_{xy_A} \text{ Cos}\Theta + P_{xz_A} \text{ Sin}\Theta$

8) $P_{xz_E} = P_{xy_A} \text{ Sin}\Theta + P_{xz_A} \text{ Cos}\Theta$

9) $P_{yz_E} = 1/2\ (I_{yy_A} - I_{zz_A}) \text{ Sin}2\Theta - P_{yz_A} \text{ Cos}2\Theta$

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1.2.2.6 HELK Formulations

The Helium leakage formulations for computing the rate of leakage are applicable only during quiescent periods.

Tank volume at any time

1) $VH = VNOM[1+ (PH - PA) \times EXPAN]^3 + VH1$

where VHOM = nominal tank volume, in^3

VH1 = volume of helium tank to regulator

PH = helium pressure, psia

VH = volume of helium tank at PH

Helium density (using Akin equation)

2) $$P(lb/ft^3) = \left[\frac{2.6829TSI}{P} + BO\right]^{-1}$$

where TSI(°R) = GR 1089 or GR 1099 + 459.69

P = PH, psia

$$BO = 0.305937\left(\frac{1}{TSI}\right)^{1/4} - 1.845\left(\frac{1}{TSI}\right)^{3/4} - 0.822\left(\frac{1}{TSI}\right)^{5/4}$$

Helium Mass

3) $$MH = \frac{PVH}{1728}$$

Helium Leakage Rate

$\dot{w}H$ = Average leakage rate in storage sphere during quiescent periods, lb/sec.

Then,

4a) $\dot{w}H = 0 \qquad \text{If } \frac{MH(t1) - MH(t2)}{MH(t1)} \leq E1$

Otherwise,

4b) $$\dot{w}H = \frac{MH(t1) - MH(t2)}{t1 - t2}$$

where MH(t1) = mass in tank at beginning of quiescent period for each new period

MH(t2) = mass in tank at end of quiescent period

t1 = time at beginning of quiescent period

t2 = time at print interval or end of quiescent period

E1 = criterion for discerning leakage for errors and noise. Value would normally range from 0 to 1 and is card input.

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1.2.2.7 Data Processor Options

1) Least Squares Fitting gives a polynomial of the type

$$y = \sum_{i=0}^{n} a_i X^i$$

where N is the degree of the polynomial with an optional first derivative, both evaluated at the mid-point of the X variable value limits.

2) Statistical evaluation calculates the estimate of the standard deviation as follows:

$$s^2 = \frac{\Sigma X_i^2 - \frac{(\Sigma X_i)^2}{N}}{N-1}$$

where N is the number of data points in the sample population.

2. PROGRAM DESCRIPTION

The program has three versions to accomplish the calculations of pressure integrals (INTEG), the engine thrust levels using both burn time (FRBT) and pressures (PAI) as basic input data, and thrust levels from the motion of the LM vehicle (VEDY). The input and output for each version is described in more detail in the next section; therefore only the basic operation of each version will be discussed following a description of the functions common to all versions. Processing is based on chronological events.

2.1 GENERAL FUNCTIONS

Initialization, data storage, data identification and event control functions are similar in most respects throughout all versions.

2.1.1 Initialization

Reading of the user's input data deck and a subsequent output report of the input data is accomplished in the main program. Then the first five records of the APB input data tape are read; and the subsequent correlation of the input data from the user and the tape is used in an allocation of storage buffers for the tape input. The allocation is based on the sample rates of the user-selected raw data from the APB tape(s) and the size of the total program data storage area.

2.1.2 Data Storage

The data storage process includes reading APB input data tape records and storing only the user-desired data. This is accomplished by reading single records into alternate input buffers and transferring desired data into the appropriate storage buffer. During the processing of the input record, data end and/or tape end conditions are detected to effect appropriate final processing or additional tape mounting. During the transfer of data, special consideration is given to time data. The actual time of each measurement sample is computed and stored in a parallel time buffer when the data is stored in its data buffer location. After discarding non-specified data, a differentiation between bilevel and non-bilevel measurement data is made, because the storage of bilevel data at a higher density requires a separate process from that used for the non-bilevel measurements.

2.1.3 Data Identification

To identify the data to be used in the processing of a particular engineering function, a single routine is used to search the currently stored data within the appropriate data buffer and to determine the first and last location of applicable data according to the time span of the calculation. Although results continue to be accumulated, completion of the calculations based on time spans which extend beyond currently stored data are automatically suspended until sufficient data is stored.

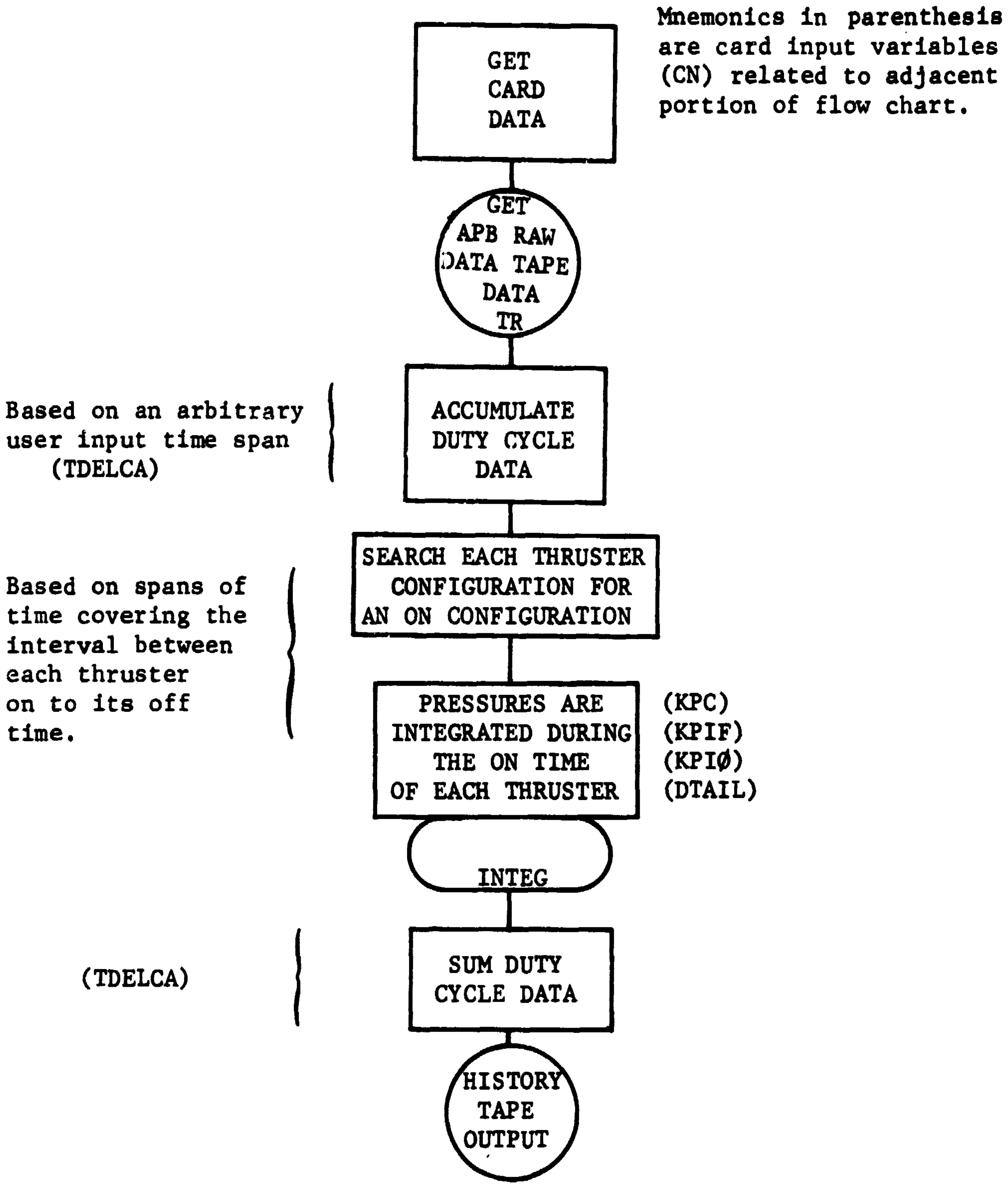
2.1.4 Event Control

The bilevel measurements which indicate the on or off condition of the controlling solenoid drivers, which transmit firing commands, indicate RCS, APS, and DPS events. The storage of a set of bilevel data into its buffer includes storing an associated time which is used to control the processing of events chronologically. As each set of bilevels is examined for change, time is advanced to that value stored at the instant of observation. A search of a set of bilevels to determine which are on and which are off is termed a horizontal search. A search of a particular bilevel measurement to determine its next change (either on or off) is termed a vertical search. The time associated with an event found in a vertical search is not used to control sequential processing; it is used only for event duration purposes. Event control of some calculations is done only by a user determined time span. In the discussion of each version, a functional flow chart indicates the event control for each major engineering calculation.

2.2 INTEGRATOR VERSION

Using a horizontal search, event changes are recorded within a user specified time span framework to accumulate duty cycle data and to calculate the duty cycle for each time span. Whenever an engine is turned off, a vertical search is necessary to determine if there has been normal pressure tail-off before the next firing command. The data accumulated represents the integral of the pressure curve during the firing.

2.2.1 ISPALM Integrator Version



2.2.2 Description of Namelist (CN) input used only for the integrator:

Variables: KPC, KPIF, KPIØ

The same pressure measurement channels are shared by several engines. These arrays give the correspondence between each engine number and the shared measurement channels for chamber pressure, fuel manifold pressure, and oxidizer manifold pressure.

EXAMPLE:

Engine No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
KPC(I)	1	1	2	3	4	4	2	5	6	6	7	5	8	8	7	3
KPIØ(I)	12	11	12	11	11	12	12	11	12	11	11	12	11	12	11	12
KPIF(I)	10	9	10	9	9	10	10	9	10	9	9	10	9	10	9	10

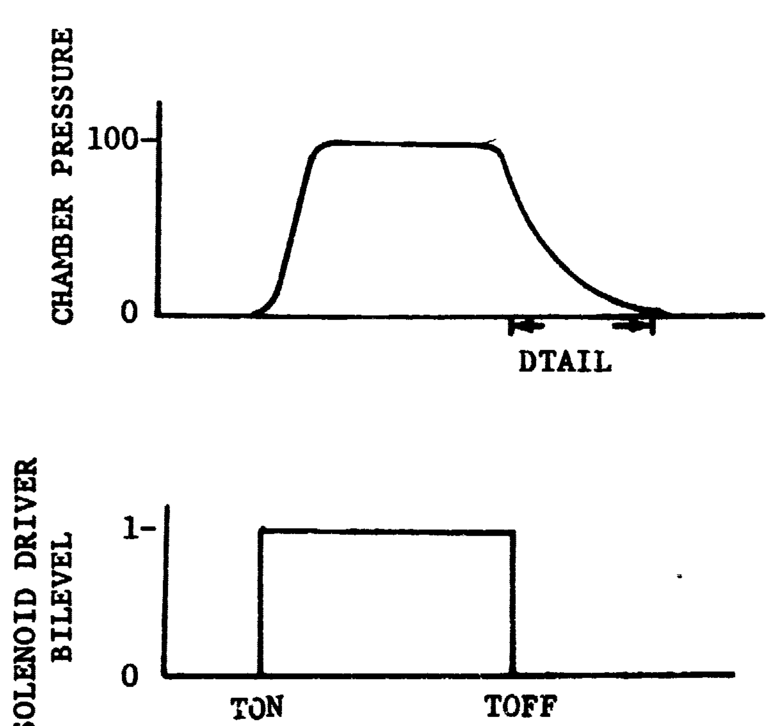
Bilevels in order: GR1418, GR1419, --20, --21, ····, --32, GR1433

Non-Bilevels in order: GR5031, GR5033, GR5046, GR5035, GR5042, GR5039,
GR5041, GR5043, GR2201, GR2202, GR3201, GR3202

E.G., Integrate GR 5042 to get PCI for engines 8 and 12.

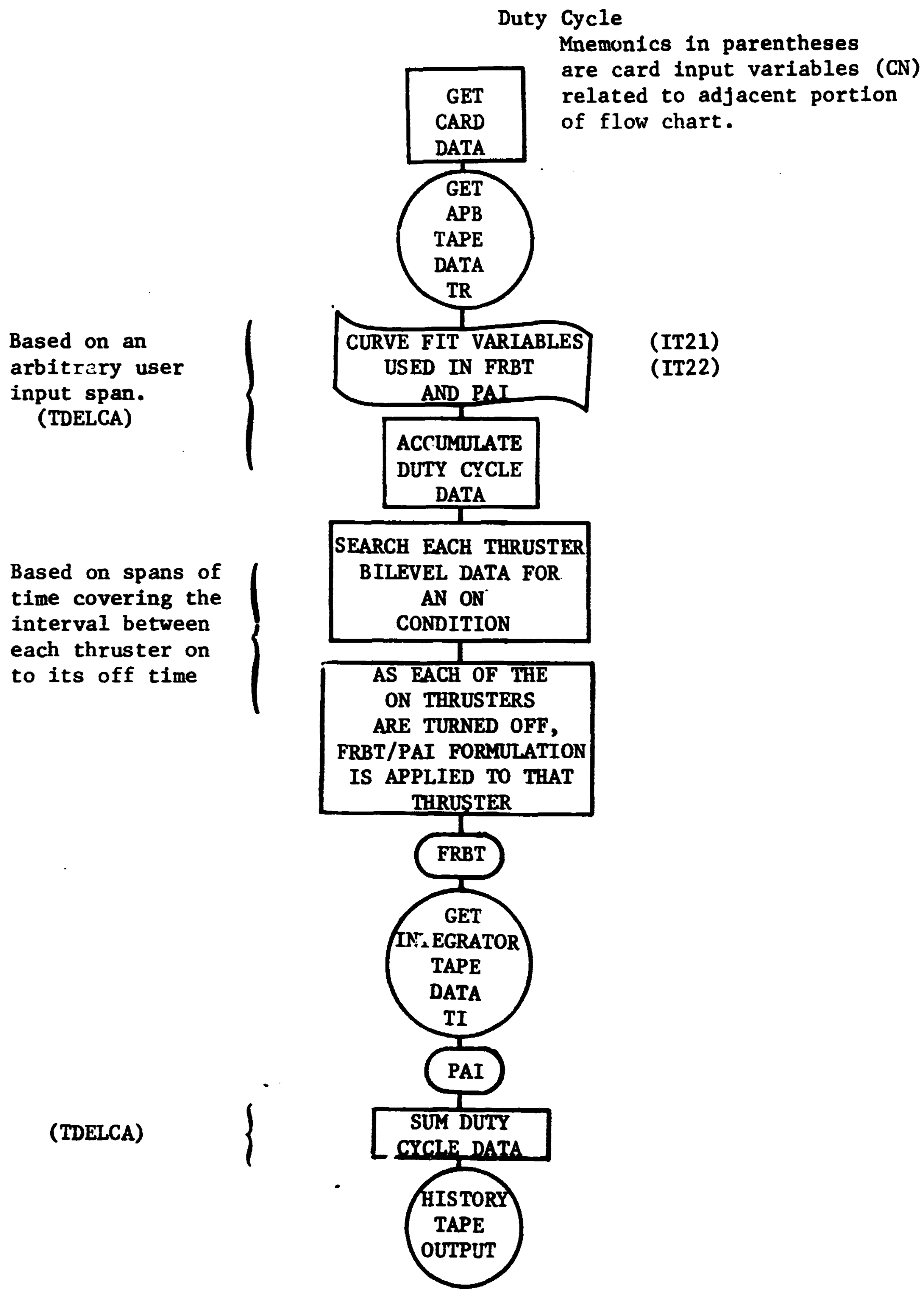
Variables: DTAIL

The integrator integrates the defined pressures over a time span defined by the electrical "on" command and the electrical "off" plus DTAIL. If next on overlaps preceding data, the integral of the first firing is terminated at the start of the second firing.



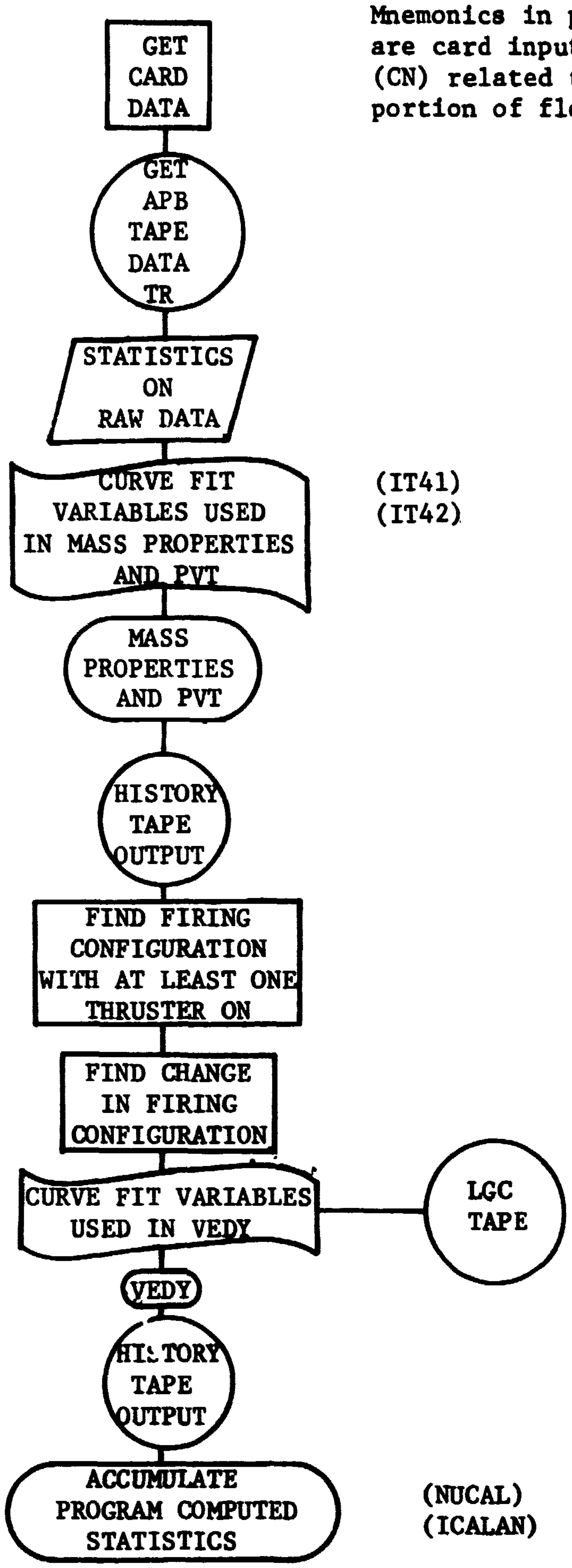
PCI = Area under Pc Curve from TON to TOFF + DTAIL

2.3 ISPALM FRBT/PAI VERSION



2.4 ISPALM VEDY VERSION

Mnemonics in parentheses are card input variables (CN) related to adjacent portion of flow chart.



Based on an arbitrary user input time span. (TDELCA)

(IT41)
(IT42)

Based on a time span covering interval between a thruster configuration with at least one thruster on and a change in the firing configuration.

Note:

Required if firings are greater than two second duration

(NUCAL)
(ICALAN)

3. INPUT AND OUTPUT PROCEDURES

Detailed input requirements for each functional category are shown in section 3.1, "INPUT/OUTPUT Information For Each Functional Category." The explanation of the TAPE/CARD DECK SETUP REQUIREMENTS codes are found in section 3.3, "Tape and Input Card Descriptions."

Section 3.2, "Input/Output Correlation," contains a general user-oriented explanation of the data processor control information.

3.1 INPUT/OUTPUT INFORMATION FOR EACH FUNCTIONAL CATEGORY

The information for each of the seven functional categories is given in tables as follows:

1) PA-1
2) FRBT
3) PVT
4) VEDY
5) MASSPRO
6) HELK
7) STATT

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3.1.1 PA-1

MNEMONIC	DESCRIPTION	TAPE/CARD DECK SETUP REQUIREMENTS CODE	UNITS	DECIMAL ORIGIN IF NEEDED	MEASUREMENT ID
	Card Input (64 Values)				
KO	Oxidizer Conductance (1-16)	CN	lb/(psc -sec)	1632	
KF	Fuel Conductance (1-16)	CN	lb/(psc -sec)	1648	
CF	Average Thrust Coefficient (1-16)	CN		1664	
AT	Throat Area, (1-16)	CN	in^2	1686	
IT21	DP Control	CN			
IT22	DP Control	CN			
KPLO	DP Control	CN			
KPIF	DP Control	CN			
KPC	DP Control	CN			
	Variable Input (64 Values)				
PCI	Integral Pc (1-16)	TI,TR	psia-sec	146	GR 5031-5046
PIOI	Integral PIO (1-16)	TI,TR	psia-sec	1550	GR 5019-5026
PIFI	Integral PIF (1-16)	TI,TR	psia-sec	1566	GR 5011-5018
TEON	Electrical on Time (1-16)	TR	seconds	1614	GR 1418-1433
TF (1)	Fuel Temperature (System A)	TR	°F	1703	GR 2121
TF (2)	Fuel Temperature (System B)	TR	°F	1704	GR 2122
ISS 1	DP Control	CN			
ISS 2	DP Control	CN			
IT21	DP Control	CN			
IT22	DP Control	CN			

3.1.1 PA-1 (continued)

MNEMONIC	DESCRIPTION	TAPE/CARD DECK SETUP REQUIREMENTS CODE	UNITS	DECIMAL ORIGIN IF NEEDED	MEASUREMENT ID
	Output/Pulse (96 Values)				
IT	Total Impulse (1-16)		lb-sec	1518	
F	Average Thrust (1-16)		lbs	1483	
WO (1)	Oxidizer Consumption, (1-16)		lbs	81	
WF (1)	Fuel Consumption, (1-16)		lbs	65	
CSTAR	Characteristic Exhaust Velocity (1-16)		ft/sec	1582	
PCBAR	Average Chamber Pressure (1-16)		psia	1598	
TCAL	Time of Midpoint of Span		sec	1631	

3.1.2 FRBT

MNEMONIC	DESCRIPTION	TAPE/CARD DECK SETUP REQUIREMENTS CODE	UNITS	DECIMAL ORIGIN IF NEEDED	MEASUREMENT ID
	Card Input (78 Values)				
CD(1)-CD(10)	Coefficients for Total Impulse (1-10)	CN			
CD(11)-CD(20)	Coefficients for Specific Impulse (1-10)	CN			
CD(21)-CD(30)	Coefficients for Mixture Ratio (1-10)	CN			
XIM	Correction for Total Impulse (1-16)	CN	lb - sec		
XIS	Correction for Specific Impulse (1-16)	CN	sec		
XM	Correction for Mixture Ratio (1-16)	CN			
	Variable Input/Pulse (16 Values)				
TEON	Electrical On Time (1-16)	TR	sec	1614	GH 1418-1433
	Output/Pulse (64 Values)				
XYB(225) - XYB(240)	Oxidizer Consumption (1-16)		lbs	1451	
XYB(241) - XYN(256)	Fuel Consumption (1-16)		lbs	1467	
FF	Average Thrust (1-16)		lbs	97	
XIMP	Total Impulse (1-16)		lbs	1	
WT	Weight (1-16)		lbs	49	
TCAL	Time of Midpoint of Span		sec	1631	

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3.1.3 PVT

MNEMONIC	DESCRIPTION	TAPE/CARD DECK SETUP REQUIREMENTS CODE	UNITS	DECIMAL ORIGIN IF NEEDED	MEASUREMENT ID
	Card Input/System (19 Values) Subscripts (1) and (2) for A & B Subscripts (3) for (APS)				
TFI	Initial Fuel Temperature,(1-2) (3)	CN	°F		
PFI	Initial Fuel Manifold Pressure, (1-2) (3)	CN	psia		
POI	Initial Oxidizer Manifold Pressure (1-2) (3)	CN	psia		
VO	Volume of Oxidizer System, (1-2) (3)	CN	in^3		
VF	Volume of Fuel System (1-2) (3)	CN	in^3		
VOTR	Volume of Trapped Oxidizer, (1-2) (3)	CN	in^3		
VFTR	Volume of Trapped Fuel, (1-2) (3)	CN	in^3		
WOTA	Weight Tanked Oxidizer, (1-2) (3)	CN	lb		
WFTA	Weight Tanked Fuel (1-2) (3)	CN	lb		
VNOM	Volume of Helium Storage Bottle, (1-2) (3)	CN	in^3		
VHL	Volume of Helium Line (Bottle-Regulator) (1-2) (3)	CN	in^3		
EXPAN	Storage Bottle Expansion Factor, (1-2) (3)	CN	1/psi		
TSI	Initial Storage Bottle Temperature, (1-2) (3)	CN	°F		
PHI	Initial Storage Bottle Pressure, (1-2) (3)	CN	psia		
MRI	Mixture Ratio of Propellant Expended (1-2) (3)	CN	--		
MR2	Mixture Ratio for Remainder of flight (1-2) (3)	CN	--		

3.1.3 PYT (continued)

MNEMONIC	DESCRIPTION	TAPE/CARD DECK SETUP REQUIREMENTS CODE	UNITS	DECIMAL ORIGIN IF NEEDED	MEASUREMENT ID
PA	Ambient Pressure, (1-2) (3)	CN	psia		
DODENS	Bias on Oxidizer Density (1-2) (3)	CN	lb/in^3		
DFDENS	Bias on Fuel Density (1-2) (3)	CN	lb/in^3		
	Card Input Common to A & B Systems and APS (1 Value)				
IT41	DP Control	CN			
IT42	DF Control	CN			
	Variable Input/System (5 Values)				
TF	Fuel Temperature, (1-2) (3)	TR	°F	1703	GR 2121 & 2122
PF	Fuel Manifold Pressure, (1-2) (3)	TR	psia	1706	GR 2201 & 2202
PO	Oxidizer Manifold Pressure, (1-2) (3)	TR	psia	1709	GR 3201 & 3202
TS	Helium Storage Bottle Temperature, (1-2) (3)	TR	°F	1712	GR 1089 & 1099
PH	Helium Storage Bottle Pressure, (1-2) (3)	TR	psia	1715	GR 1101 & 1102
	Output/System (6 Values)				
WOE	Oxidizer Expended, (1-2)		lbs	1721	

3.1.3 PVT (continued)

MNEMONIC	DESCRIPTION	TAPE/CARD DECK SETUP REQUIREMENTS CODE	UNITS	DE 'TMAL ORIGIN IF NEEDED	MEASUREMENT ID
WFE	Fuel Expended, (1-2)		lbs	1724	
WOU	Oxidizer Usable, (1-2)		lbs	1727	
WFU	Fuel Usable, (1-2)		lbs	1730	
WOD	Remaining Oxidizer Deliverable, (1-2) (3)		lbs	1733	
WFD	Remaining Fuel Deliverable (1-2) (3)		lbs	1736	

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3.1.4 VEDY

MNEMONIC	DESCRIPTION	TAPE/CARD DECK SETUP REQUIREMENTS CODE	UNITS	DECIMAL ORIGIN IF NEEDED	MEASUREMENT ID
	Card Input				
XA	X - Axis Accelerometer Location	CN	inches	1773	
YA	Y - Axis Accelerometer Location	CN	inches	1774	
ZA	Z - Axis Accelerometer Location	CN	inches	1775	
XT	X - Axis Tank Location	CN	inches	1779	
YT	Y - Axis Tank Location	CN	inches	1795	
ZT	Z - Axis Tank Location	CN	inches	1811	
XP	X - Location of P-Axis Jets	CN	inches	1827	
YJ	Y - Location of All Jets	CN	inches	1828	
ZJ	Z - Location of All Jets	CN	inches	1844	
DELTIM	Minimum Allowable Firing Configuration Time	CN	sec		
ANG	Angular Data Source	CN			
ACCLMT	Limiting Load Factor	CN	g's		
TCZ	Initial Thrust Value Ground Test	CN			
IT31	DP Control	CN	lb	1757	
IT32	DP Control	CN			
	Variable Input				
ACCX	X - Axis Acceleration	TL	g's	1860	GA 3001
ACCY	Y - Axis Acceleration	TL	g's	1861	GA 3003
ACCZ	Z - Axis Acceleration	TL	g's	1862	GA 3005
P	YAW - Angular Rate	TR	rad/sec	1751	GH 1461
Q	PITCH - Angular Rate	TR	rad/sec	1753	GH 1462
R	ROLL - Angular Rate	TR	rad/sec	1755	GH 1463

3.1.4 VEDY (continued)

MNEMONIC	DESCRIPTION	TAPE/CARD DECK SETUP REQUIREMENTS CODE	UNITS	DECIMAL ORIGIN IF NEEDED	MEASUREMENT ID
	Variable Input (Program Computed)				
ION	Thruster On Switch (1-16)	TR		129	GR 1418-1433
NON	Number of Thrusters On				
MASS	Total Spacecraft Weight		lbs	1750	
IXX	X Axis Moments of Inertia		$Slug\text{-}FT^2$	1510	
IYY	Y Axis Moments of Inertia		$Slug\text{-}FT^2$	1745	
IZZ	Z Axis Moments of Inertia		$Slug\text{-}FT^2$	1746	
IXY	XY Axes Products of Inertia		$Slug\text{-}FT^2$	1747	
IXZ	XZ Axes Products of Inertia		$Slug\text{-}FT^2$	1748	
IYZ	YZ Axes Products of Inertia		$Slug\text{-}FT^2$	1749	
PDOT	YAW Angular Acceleration } Derivative		rad/sec^2	1752	
QDOT	PITCH Angular Acceleration } of		rad/sec^2	1754	
RDOT	ROLL Angular Acceleration } P, Q, R		rad/sec^2	1756	
	Output				
T(1)	Thrust From Body Rate (1-16)		lbs	113	
FNON	Number of Thrusters On			1630	
T11	Bilevel Event Time On		sec	1739	
T22	Bilevel Event Time Off		sec	1740	
TDIF	Bilevel Event Time Difference		sec	1741	
TCAL	Time of Midpoint of Span		sec	1631	

3.1.5 MASS PRO

MNEMONIC	DESCRIPTION	TAPE/CARD DECK SETUP REQUIREMENTS CODE	UNITS	DECIMAL ORIGIN IF NEEDED	MEASUREMENT ID
	Card Input/System				
W (1)	Weight of Fixed Masses (I= 14-25)	CMP	lbs	432	
TAB (I,1)	X-coordinate C.G. of Fixed Mass	CMP	in	162	
TAB (I,2)	Y-coordinate C.G. of Fixed Mass	CMP	in		
TAB (I,3)	Z-coordinate C.G. of Fixed Mass	CMP	in		
TAB (I,4)	X-moment Inertia of Fixed Mass	CMP	$slug\text{-}ft^2$		
TAB (I,5)	Y-moment Inertia of Fixed Mass	CMP	$slug\text{-}ft^2$		
TAB (I,6)	Z-moment Inertia of Fixed Mass	CMP	$slug\text{-}ft^2$		
TAB (I,7)	XY Product Inertia of Fixed Mass	CMP	$slug\text{-}ft^2$		
TAB (I,8)	XZ Product Inertia of Fixed Mass	CMP	$slug\text{-}ft^2$		
TAB (I,9)	YZ Product Inertia of Fixed Mass	CMP	$slug\text{-}ft^2$		
CD (44)	Scale Factor, DPS #1 Ox,	CN	lb/%		
CD (45)	Scale Factor, DPS #2 Ox,	CN	lb/%		
CD (42)	Scale Factor, DPS #1 Fuel,	CN	lb/%		
CD (43)	Scale Factor, DPS #2 Fuel,	CN	lb/%		
CD (31)	Bias Factor, DPS #2 Ox,	CN	lbs		
CD (32)	Bias Factor, DPS #2 Ox,	CN	lbs		
CD (33)	Bias Factor, DPS #1 Fuel,	CN	lbs		
CD (34)	Bias Factor, DPS #2 Fuel	CN	lbs		
CD (48)	Scale Factor, DPS H_2O	CN	lb/%		
CD (46)	Scale Factor, APS #1 H_2O	CN	lb/%		
CD (47)	Scale Factor, APS #2 H_2O,	CN	lb/%		
CD (37)	Bias Factor, DPS H_2O	CN	lbs		
CD (35)	Bias Factor, APS #1 H_2O	CN	lbs		

3.1.5 MASS PRO (continued)

MNEMONIC	DESCRIPTION	TAPE/CARD DECK SETUP REQUIREMENTS CODE	UNITS	DECIMAL ORIGIN IF NEEDED	MEASUREMENT ID
CD (36)	Bias Factor, APS #2 H_2O	CN	lbs		
IT41	DP Control				
IT42	DP Control				
	Variable Input/System				
WFD	Remaining Fuel Deliverable,		lbs		
WOD	Remaining Oxidizer Deliverable		lbs		
XYB (3)	DPS Oxidizer Propellant Quantity #1	TR	%		GQ 4103
XYB (4)	DPS Oxidizer Propellant Quantity #2	TR	%		GQ 4104
XYB (1)	DPS Fuel Propellant Quantity #1	TR	%		GQ 3603
XYB (2)	DPS Fuel Propellant Quantity #2	TR	%		GQ 3604
XYB (7)	DPS H_2O Quantity,	TR	%		NOT TELM
XYB (5)	APS H_2O Quantity, #1	TR	%		GF 4582
XYB (6)	APS H_2O Quantity, #2	TR	%		GF 4583
	Output into Vehicle Dynamics				
IXX	X-moment of Inertia, Vehicle,		$slug\text{-}ft^2$	1510	
IYY	Y-moment of Inertia, Vehicle,		$slug\text{-}ft^2$	1745	
IZZ	Z-moment of Inertia, Vehicle,		$slug\text{-}ft^2$	1746	
IXY	XY Product of Inertia, Vehicle		$slug\text{-}ft^2$	1747	
IXZ	XZ Product of Inertia, Vehicle		$slug\text{-}ft^2$	1748	
IYZ	YZ Product of Inertia, Vehicle		$slug\text{-}ft^2$	1749	
XCG	X Center of Gravity		inch	1776	

3.1.5 MASS PRO (continued)

MNEMONIC	DESCRIPTION	TAPE/CARD DECK SETUP REQUIREMENTS CODE	UNITS	DECIMAL ORIGIN IF NEEDED	MEASUREMENT ID
YCG	Y Center of Gravity		inch	1777	
ZCG	Z Center of Gravity		inch	1778	
MASS	Total Spacecraft Weight		lbs	1750	

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3.1.6 HELK

MNEMONIC	DESCRIPTION	TAPE/CARD DECK SETUP REQUIREMENTS CODE	UNITS	DECIMAL ORIGIN IF NEEDED	MEASUREMENT ID
	TO BE SUPPLIED LATER				

3.1.7 STATT

MNEMONIC	DESCRIPTION	TAPE/CARD DECK SETUP REQUIREMENTS CODE	UNITS	DECIMAL ORIGIN IF NEEDED	MEASUREMENT ID
	Card Input				
NSTPS	Start index in the ISS1 array for Statistical span calculations	CN			
NSTPSP	Final index in the ISS1 array for Statistical span calculations	CN			
NUCAL	Member of program computed variables on which statistical calculations are computed	CN			
	Output				
AVRGS	Statistical Averages			457	
SD	Statistical Standard Deviations			567	
XMIN	Statistical Minimum Values			677	
XMAX	Statistical Maximum Values			787	
XSTPTS	Statistical Number of Value			897	
STSUM	Statistical Summation of Values			1007	
S2	Statistical Summation of Squares of Values			1117	
TMIN	Time of Minimum Value			1866	
TMAX	Time of Maximum Value			1976	

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3.2 INPUT/OUTPUT CORRELATION

The program input media are punch card and magnetic tape. The output media are magnetic tape and printout. These formats are described under Section 3.3.

Input and output at the program interface and between engineering functions are categorically described as a data processor. After familiarization with the information in Sections 2 and 3, this section gives the information and procedures required to set up the program control data to exercise the input/output options.

3.2.1 INPUT

The card data input is explained in Sections 3.1 and 3.3. The Data Processor (DP) control data (referenced in Sections 2.1 and 3.1) and the acquisition of all data from the raw data input tape (TR) are described in the following examples.

3.2.1.1 Instructions and Sample for Extracting Data from the Raw Data Input Tape (TR-APB Format)

Instructions	Sample
1. Determine BCD measurement ID's required for raw $DATAIN input tape (TR) for each functional category requested and for those requiring span statistics.	GR5501, GR5502, GR5503, SR7653, BL1783, BL1783, SR7654, SR7655, SR7656, GS5105, GR5501, GR5501 (Note: These values are general and not a specific match to any standard input/output of Section 3.1)
2. From above, select all non-bilevel BCD measurement ID's to be used from input tape (omitting duplicates).	Integer Reference No.: 1) GR5501 — 1 2) GR5502 — 2 3) GR5503 — 3 4) SR7653 — 4 5) SR7654 — 5 6) SR7655 — 6 7) SR7656 — 7 8) GS5105 — 8
3. The measurement ID's in the input list 2. above are referenced by integer numbers determined from the user input sequence. The only rule of ordering requires the measurement ID's requested for span statistical calculations to be grouped together.	

Instructions (cont.)	Sample (cont.)
4. Generate the ISS1(I) array by combining the integer numbers of all measurements required for each of the functional categories requested in groups by category.	ISS1(I) = 3, 1, 2, 5, 7, 4, 6, 8 3, 1, 2: PVT MASSPRØ 1st functional category 5, 7, 4, 6: VEDY INPUT 2nd functional category 4, 6, 8: SPAN STATISTICS 3rd functional category
5. Generate integer value of the start and stop origins of each category from the ISS1 array subscription.	IT31 = 4 cf name list 3.3.1.1 IT32 = 7 IT41 = 1 IT42 = 3
6. Generate the ISS2(I) array which corresponds one to one with the ISS1(I) array defining the decimal origin in the engineering common where the BCD measurement results should be stored. These decimal origins come from Section 3.1	ISS2(I) = -751, -763, -801, 1535, 1547, 1568, 1589 (Note: These decimal origin values do not match any specific set in Section 3.1)
NOTE 1. Steps 5 and 6 may be omitted in a run to create only span statistical results.	NSTPS = 4 Span statistics would be NSTSP = 8 computed on the last 5 measurements in the list in step 3.
NOTE 2. If the derivative of any measurements in the grouping between IT31-IT32 is desired, the corresponding ISS2 values must be negative. The derivate is stored in the next consecutive common location.	

3.2.1.2 Bilevel Measurement Description

The bilevel BCD measurements are input on the same card format (CM) as the non-bilevels. See deck set up in Section 5 for the relative order of all card input. JIC and NMSM in the namelist (CM) input defines the number of BCD measurements in the bilevel and non-bilevel title card (CM) measurement ID section.

The first 16 bilevels selected must be the thruster switches (thruster solenoid drivers) in the order shown in Figure 1. The 17th and 18th bilevels selected must be the APS and DPS fire switches.

3.2.1.3 Namelist Input Not Related Specifically to Any Option

The following variables are defined in Section 3.3.1.1.2, but some are discussed further here for clarification.

AB(I) - This dimensional variable is equivalent to the engineering data common block. Therefore, any variable in the block may be initialized by the user and that variable will retain the input value until a new value is computed or brought in from the APB tape input and filtering logic. This capability is especially valuable when a telemetered measurement is desired, but was not included on the input APB tape. To obtain the proper subscript for AB, refer to Section 3.1.1.

FNOM - The program uses these values as raw data filter input until the corresponding measurement appears from the APB tape. These values cannot be substituted for a desired measurement which has no BCD identifier or data values on the tape; to accomplish this, the user must use the AB array explained above.

TDELCA - The value of TDELCA must be at least as large as the period of the measurement having the lowest sample rate selected for span calculations. The following variables need no further explanation here:
JIC, NMSM, NOTIN, TIMFN, TIMST, UNIT - Refer to Sections 2. and 3.3.

3.2.2 OUTPUT REPORTS

The first output report is the input data contained in the $DATAIN namelist array, the measurement identification data, and the mass properties data. Next are any output report templates which were input by the user output report correlation. The correspondence between templates and the output report is made by matching the template and the report identifier. After the match is accomplished the variable headings input by the user will correspond on a one-for-one basis with the output report variables by position.

An example of the output report is shown in Section 4, Sample Case.

3.3 TAPE AND INPUT CARD DESCRIPTIONS

This section describes the tape and input card formats and their respective cross reference codes.

3.3.1 CARD INPUT DESCRIPTIONS

Input card data contained in the data deck is sequenced as shown in Figure 5-1. A discussion of each format follows in the order in which it appears in the data deck. For cross referencing with other descriptions, the following codes have been used to indicate under which format a variable will be input:

CN - Namelist and Datain

CM - Measurement Identification

CMP - Mass Properties

CØ - Output Templates

All card input information is output with the calculated information.

3.3.1.1 Namelist

3.3.1.1.1 Formats

The general format for the Namelist card input is as follows:

Header Card Format: $DATAIN (cc 2-8)

Data Card Format:
Card Column 1 must be blank.
Data names are followed by a subscript designation (parenthesis indicates where applicable), an equal sign, one or more numbers in the designated I, F, or E format, each followed by a comma.
Example: FNAME(1) = XXX.X, YY.YY, ZZZ.ZZ, sample indicates that FNAME is an array of at least three members and the first three members are assigned the above values.

End Card Format: $END (cc 2-5)

3.3.1.1.2 Input Variables

Mnemonic	Units	Format	Description
ACCLMT	g	F or E	Limiting load factor. Consumables will be centered in tank if ACCX is less than this value. Used in VEDY.
ACCX	g	F or E	Linear acceleration along the X-axis. Used in VEDY.
ACCY	g	F or E	Linear acceleration along the Y-axis. Used in VEDY.
ACCZ	g	F or E	Linear acceleration along the Z-axis. Used in VEDY.

Mnemonic	Units	Format	Description
AT(I)	in^2	F or E	Throat area. Used in PA1. 1≤I≤16
BIAS(I)	sec	F or E	Time bias used in computing linear accelerations. Used in VEDY routines. 1≤I≤3 (PIPA DATA)
CD(I)		F or E	CD(1) - CD(10) = Coefficients to compute total impulse. CD(11) - CD(20) = Coefficients to compute specific impulse. CD(21) - CD(30) = coefficients to compute mixture ratio. Used in FRBT. Need not be specified unless changes are necessary.
CF(I)		F or E	Average thrust coefficient. Used in PA1. 1≤I≤16
CØN(I)		F or E	Array of constants. Used in PVT. Need not be specified unless changes are necessary. 1≤I≤30
DELTIM	sec	F or E	Minimum time of firing combination. Used in VEDY.
DFDENS(I)	lb/in3	F or E	Bias correction to density equations for fuel. Used in PVT. 1≤I≤3
DØDENS(I)	lb/in^3	F or E	Bias correction to density equations for oxidizer. Used in PVT. 1≤I≤3
DTAIL	sec	F or E	Delta time between span start and stop time.
DTMINF	sec	F or E	Least firing width for non-noise data.
EP	psia	F or E	Propellant leakage criterion for errors and noise. Used in HELK.
EXPAN(I)	1/psi	F or E	Tank expansion factor. Used in PVT. 1≤I≤3
E1	psia	F or E	Helium leakage criterion for errors and noise. Used in HELK.
FH(I)		I	Engineering common subscripts of variables output from HELK and statistical results on program computed variables to be written on history tape. See Engineering Variable Origin Cross Reference, Table 2. 1≤I≤100
FNØM(I)	Variable	F or E	Array of nominal values for all non-bilevel measurements selected in the order in which titles are input. 1≤I≤255
FPH(I)		I	Engineering common subscripts of variables computed in FRBT and PA1 to be written on history tape. See Engineering Variable Origin Cross Reference, Table 2. 1≤I≤100
ICALAN(I)		I	Array of engineering common decimal origins of each of the program calculated variables on which statistical calculations are to be made. There will be as many entries as designated by NUCAL. 1≤I≤20
IFH		I	Total number of engineering common subscripts in the FPH array.

Mnemonics	Units	Format	Description
IFPH		I	Total number of engineering common subscripts in the FPH array.
IFM		I	Tape unit designation for the integrator tape.
IHELK		I	Flag = 0, do not perform helium leakage checks. >0, perform helium leakage checks.
ISH		I	Total number of engineering common subscripts in the SH array.
ISS1(I)		I	Integer position of selected APB non-bilevel measurements. $1 \le I \le 120$
ISS2(I)		I	Engineering common decimal origins designating the location of the filtered measurement. $1 \le I \le 120$. Referenced in the ISS1 array.
IT11			Reserved for future use.
IT12			Reserved for future use.
IT21		I	Start index in the ISS1 array for PA1 and FRBT variables.
IT22		I	Final index in the ISS1 array for PA1 and FRBT variables.
IT31 IT32		I I	Same as IT21, IT22 but for VEDY variables
IT41 IT42		I I	Same as IT21, IT22 but for PVT and mass properties (SPAN) variables.
IVDH		I	Total number of engineering common subscripts in VDH array.
IWTS		I	Tape unit assignment for the mass properties tape.
JIC		I	Total number of bilevels selected.
KF(I)	$\frac{lb}{psi^{\frac{1}{2}}\text{-sec}}$	F or E	Fuel conductance. Used in PA1. $1 \le I \le 16$
KØ(I)	$\frac{lb}{psi^{\frac{1}{2}}\text{-sec}}$	F or E	Oxidizer conductance. Used in PA1. $1 \le I \le 16$
KPC(I)		I	Raw data subscript for PCI. Used in integrator. $1 \le I \le 16$
KPIF(I)		I	Raw data subscript for PIFI. Used in integrator. $1 \le I \le 16$
KPIØ(I)		I	Raw data subscript for PIØI. Used in integrator. $1 \le I \le 16$
M		I	Desired degree of fit. Used in LQF. $1 \le M \le 5$

Mnemonics	Units	Format	Description
MR1(I)		F or E	Mixture ratio of propellant expended. Used in PVT. 1≤I≤3
MR2(I)		F or E	Expected mixture ratio of remainder of flight. Used in PVT. 1≤I≤3
NMSM		I	Total number of measurements (non-bilevel) selected.
NOTIN		I	Number of APB input tapes. Specify if greater than one.
NSTPS		I	Start index in the ISS1 array for statistical span calculations.
NSTPSP		I	Final index in the ISS1 array for statistical span calcuations.
NUCAL		I	Number of different program computed variables on which statistical calculations are to be made. 0≤16*NUCAL + (NSTPSP - NSTPS + 1)≤ 110
PA(I)	psia	F or E	Ambient pressure. Used in PVT. 1≤I≤3
PCI(I)	psia-sec	F or E	Chamber pressure. Used in PA1. 1≤I≤16
PF(I)	psia	F or E	Fuel manifold pressure. Used in PVT. 1≤I≤3
PFI(I)	psia	F or E	Initial fuel manifold pressure. Used in PVT. 1≤I≤3
PH(I)	psia	F or E	Helium storage bottle pressure. Used in PVT. 1≤I≤3
PHI(I)	psia	F or E	Initial helium storage bottle pressure. Used in PVT. 1≤I≤3
PIFI(I)	psia-sec	F or E	Fuel inlet pressure. Used in PA1. 1≤I≤16
PIØI(I)	psia-sec	F or E	Oxidizer inlet pressure. Used in PA1. 1≤I≤16
PØ	psia	F or E	Oxidizer manifold pressure. Used in PVT. 1≤I≤3
PØI(I)	psia	F or E	Initial oxidizer manifold pressure. Used in PVT. 1≤I≤3
SFE(I)		F or E	Scale factor used in computing linear accelerations for VEDY. 1≤I≤3 (PIPA DATA)
SH(I)		I	Engineering common subscripts of variables computed for span calculations to be written on history tape. See Engineering Common Origin cross reference, Table 1≤I≤100
SIG1	psia	F or E	Regulator failure criteria (lower limit). Used in HELK.
SIG2	psia	F or E	Regulator failure criteria (higher limit). Used in HELK.

Mnemonics	Units	Formats	Description
START	sec	F or E	Start time in input LGC data tape.
STØP	sec	F or E	Stop time on input LGC data tape.
TAGO		I	Output flag controlling duty cycle output being written in the output report and/or on the historical tape. Value Meaning 1 Write historical tape only 2 Write output report only 3 Write both
TAG1		I	Same as TAGO but for span calculation variables.
TAG2		I	Same as TAGO but for VEDY output.
TAG3		I	Same as TAGO but for PA1 and FRBT output.
TAG4		I	Same as TAGO but for HELK output and statistics on program computed variables.
TCZ(I)	lbs	F or E	Initial thrust values - ground test data. Used in VEDY. $1 \le I \le 16$
TDELCA	sec	F or E	Size of time span used in span calcuations
TF(I)	°F	F or E	Fuel temperature. Used in PVT or PA1. $1 \le I \le 3$
TFI(I)	°F	F or E	Initial fuel temperature. Used in PVT. $1 \le I \le 3$
TIMST	sec	F or E	Start time of APB tape processing. Processing starts at beginning of tape if not specified.
TIMFN	sec	F or E	Stop time of APB tape processing. Must be specified if TIMST is specified.
TS(I)	°F	F or E	Helium storage bottle temperature. Used in PVT. $1 \le I \le 3$
TSI(I)	°F	F or E	Initial helium storage bottle temperature. Used in PVT. $1 \le I \le 3$
T1HLK	sec	F or E	Beginning of period for which the check for helium leakage is made.
T2HLK	sec	F or E	End of period for which the check for helium leakage is made.
UNIT		I	Tape unit for AP assignment input tape.
VDH(I)		I	Engineering common subscripts of variables computed for VEDY to be written on history tape. See Engineering Common Origin Cross Reference, Table 2. $1 \le I \le 100$
VF(I)	in^3	F or E	Volume of fuel system. Used in PVT. $1 \le I \le 3$
VFTR(I)	in^3	F or E	Volume of trapped fuel. Used in PVT. $1 \le I \le 3$

Mnemonics	Units	Format	Description
VHL(I)	in^3	F or E	Volume of helium line from tank to regulator. Used in PVT. 1≤I≤3
VNØM(I)	in^3	F or E	Nominal volume of helium tank. Used in PVT. 1≤I≤3
VØ(I)	in^3	F or E	Oxidizer system volume. Used in PVT 1≤I≤3
VØTR(I)	in^3	F or E	Volume of trapped oxidizer. Used in PVT. 1≤I<3
WFTA(I)	lbs	F or E	Weight of fuel tanked. Used in PVT. 1≤I≤3
WØTA(I)	lbs	F or E	Weight of oxidizer tanked. Used in PVT. 1≤I≤3
XA	in	F or E	X-axis accelerometer location. Used in VEDY.
XIM(I)	lb-sec	F or E	Correction for total impulse. Used in FRBT. 1≤I≤16
XIS(I)	sec	F or E	Correction for specific impulse. Used in FRBT. 1≤I≤16
XP	in	F or E	X-location of P-axis jets. Used in VEDY.
XT(I)	in	F or E	X-axis tank location. Used in VEDY. 1≤I≤16
YA	in	F or E	Y-axis accelerometer location. Used in VEDY.
YJ(I)	in	F or E	Y-axis lateral location of all jets. Used in VEDY. 1≤I≤16
YT(I)	in	F or E	Y-axis tank location. Used in VEDY. 1≤I≤16
ZA	in	F or E	Z-axis accelerometer location. Used in VEDY. 1≤I≤16
ZJ(I)	in	F or E	Z-axis lateral location of all jets. Used in VEDY. 1≤I≤16
ZT(I)	in	F or E	Z-axis tank locations. Used in VEDY. 1≤I≤16

3.3.1.2 Measurement Identification

The card format, 10(A6, 2X), is the same for both the non-bilevel and the bilevel measurements. With this format the user must put ten items per card with only the last card having all blanks to the right of the last input value. Each measurement identification consists of the first six alphanumeric characters in the total identification as indicated in the engineering formulation descriptions. The first character of each measurement appears in card column 1, 9, 17, 25, 33, 41, 49, 57, 65, or 73.

The non-bilevel group must contain the number of measurements as specified by NMSM contained in $DATAIN namelist; and the group must precede the bilevel group. The number of bilevel measurements must correspond to JIC in the $DATAIN namelist.

3.3.1.3 Mass Properties

A separate card is input for each identifiable, non-expendable item, as follows:

Item	Unit	Format	Card Column	Description
Sequencing information		A	1-10	Up to ten alphanumeric characters for user's identification purposes
Weight	lb	F8.2	11-18	If the input weight is negative, the signs of the moment and product of inertia data will be reversed
XCG	in	F7.2	19-25	Projection of CG on X axis
YCG	in	F5.2	26-30	Projection of CG on Y axis
ZCG	in	F5.2	31-35	Projection of CG on Z axis
X moment	$\frac{\text{lb-in}}{\text{sec}^2}$	F8.2	36-43	Moment of inertia about the X axis
Y moment	$\frac{\text{lb-in}}{\text{sec}^2}$	F8.2	44-51	Moment of inertia about the Y axis
Z moment	$\frac{\text{lb-in}}{\text{sec}^2}$	F8.2	52-59	Moment of inertia about the Z axis
XY product	$\frac{\text{lb-in}}{\text{sec}^2}$	F7.2	60-66	Product of inertia in the XY plane
XZ product	$\frac{\text{lb-in}}{\text{sec}^2}$	F7.2	67-73	Product of inertia in the XZ plane
YZ product	$\frac{\text{lb-in}}{\text{sec}^2}$	F7.2	74-80	Product of inertia in the YZ plane

3.3.1.4 Output Templates

These templates are required input whenever an output report option is requested by inputting the variables, TAG1...2, ...3, or ...4 greater than one. For each report requested, the user completes input cards as follows:

Item	Card Columns	Format	Description
Output ID Card			
Identification	1	I1	Tag variable suffix, i.e., for TAG3, put a 3 in card column 1
Title	5-10	A6	Six alphanumeric characters to identify the title for each record
Variable Cards			One for each output variable in the order specified in the $DATAIN namelist arrays, SH, FPH, VDH, FH, which correspond to TAG1, TAG2, TAG3, and TAG4, respectively.
Output Variable Title	1-12	2A6	Twelve alphanumeric characters to identify each variable

3.3.2 FILES REQUIRED

In addition to the normal I/O, system, and utility files, this program will require a minimum of one input tape and four optional files, including one or two additional input tapes. Following the description of the contents and format of each file is a discussion of the assignment of logical unit numbers used within the program. For correlation with other descriptions, the following symbols have been used when referencing data to a particular tape:

TR - APB data tape (raw data input)

TI - Integrator tape (output from INTEG version; input to the PAI/FRBT version)

TH - Historical tape (output by user option)

TL - LGC (LEM Guidance Computer) Tape (*optional input to the VEDY version)

* Not needed for firings less than 2 seconds. Required for firings of 2 seconds or greater.

1. Identifier (consisting of six alphanumeric characters), which corresponds to a particular set of data being written (see TAG0, TAG1, TAG2, TAG3, and TAG4 in the namelist $DATIN for correspondence). Identifiers are present as follows:

   TAG0 - DCYCLE
   TAG1 - SPAN
   TAG2 - VEDY
   TAG3 - FRBTPA
   TAG4 - HELSTA

2. Integer number giving the total number of data values to be written in the record (see ISH, IVDH, IFPH, and IFH in $DATAIN description). Duty cycle (DCYCLE) will always have 48 values.

3. Up to 100 data values found in the engineering common block (see SH, VDH, FPH, FH in $DATAIN description).

For example: Each record will contain seven items if the user has entered the following values in the namelist $DATAIN:

TAG1 = 1
TAG2 = 2
TAG3 = 2
TAG4 = 2
ISH = 5
SH = 1, 17, 29, 30, 31

The record will have 'SPAN, 5, five data words' in binary format.

3.3.2.1 File Description and Formats

The required input tape is the APB Input Data Tape described in Appendix A. One of the optional input tapes required for vehicle dynamics analysis is the LGC Downlink Input Data Tape described in Appendix B. These tapes are normally provided by the user from flight data in the specified formats described in the appendices. General specifications of the Historical Tape which is an output of the program is found in Appendix C.

The remainder of the file descriptions plus additional specific information on the generation of the Historical tape follow.

3.3.2.1.1 Integrator Data

The second optional input tape contains the data file with the reduced raw data of the fuel, oxidizer, and chamber pressures needed for the engine thrust calculations based on pressure data. Consequently, the integrator data file, which is generated by the INTEG version, must be saved as a tape if the complete analysis is needed but not completed in a single run. In normal circumstances, it would be advisable to save the integrator data file whenever it is generated to reduce the necessity of rerunning the INTEG version in the future. All records have the same 49 binary work format and consist of the following stream of values:

1. Time of measurement (PCTIME)
2. For each of sixteen engines, groups of three values
   a. Chamber pressure (PCI(I))
   b. Oxidizer inlet pressure (PIØI(I))
   c. Fuel inlet pressure (PIFI(I))

3.3.2.1.2 Historical Tape

The format of the historical tape is discussed in Appendix C. The information header record is the same as the flight information header record on the APB input data tape. The program internally computes the number of template records; and, thereafter, each record contains an indicator of the total number of words less two in the second word. The template records and the data records are similar to the corresponding output report records which may be seen in the sample output found in section 4. The integer identifier in the template lable group corresponds to the decimal origin of variables in the Engineering Variable Origin Cross Reference Table 2.

3.3.2.1.3 Mass Properties Scratch File

This file is generated as a single, unformatted thirteen word record during execution of the Mass Properties Subroutine for later use in vehicle dynamics calculations. It is, therefore, necessary for both options; but, since the tape is rewound after each cycle of calculations, saving it as an output tape is impossible inasmuch as only the last set of the mass properties is available.

3.3.2.2 File Assignment

Changing tape units assignments requires some knowledge of 1108 file assignment procedures. The logical unit referred to in the FORTRAN statements within the program must be properly correlated with the ∇ ASG cards and the run request to execute properly. Although the user may change the logical units, if required, within the $DATAIN, the following nominal values are present by the program:

	File	Mnemonic in $DATAIN	Nominal Assignment	ASG Designation
1.	APB DATA	UNIT	14	L
2.	INTEGRATOR DATA	IFM	15	M
3.	LGC DATA	LGCTAP	16	N
4.	HISTORY	HTAPE	10	H
5.	Mass Properties	IWTS	11	I

The appearance of the letter designation by itself on an assign card means the unit will be physically located on a FASTRAN unit, which is unavailable for actual tape manipulations. If the letter is followed by an equal sign and not more than six alphanumeric characters, an instruction to the machine operator is generated to the effect that he should mount said tape. The alphnumeric characters must be the tape number for input tapes, and some identifier also used on the tape save label for output tapes to be saved. In the control cards of the deck setup in Figure 5-1, the use of assign cards is illustrated. The dotted card(s) may be omitted if the history, integrator, and/or LGC data tapes are not input or saved. The absence of an assignment for the mass properties tape, I, means that the file will be physically assigned to the drum.

Great care must be exercised if any of the nominal tape unit assignments are to be changed. First of all, the general restriction: $8 \leq$ tape unit assignment ≤ 26 except 17. Second, no assignment should be duplicated for use by another tape. Third, care must be exercised because of the multiple reel capability in processing data tapes. Because of the limited number of tape drives available to a program, all APB tapes would be handled by no more than two tape drives. The program will alternate between two tape drives according to the following formula, UNIT = 27 - UNIT. Since ISPALM initializes UNIT to 14, the value of UNIT would alternate between 14 and 13 according to the preceeding formula. The alternate for the input value of UNIT must be considered in the tape assignment plan; primary and alternate values of UNIT have the range, $8 \leq$ UNIT ≤ 19 except 10 and 17.

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Table 2. Engineering Variable Origin Cross Reference

Parameter	Word Length	Octal Origin	Decimal Origin	Description
XIMP(1)	16	000001	1	FRBT TOTAL IMPULSE
XISP (1)	16	000021	17	FRBT SPECIFIC IMPULSE
XMR (1)	16	000041	33	FRBT MIXTURE RATIO
WF (1)	16	000061	49	FRBT WEIGHT
WT (1)	16	000101	65	PA-1 FUEL CONSUMPTION
WØ (1)	16	000121	81	PA-1 OX CONSUMPTION
FF (1)	16	000141	97	FRBT - AVERAGE THRUST
T (1)	16	000161	113	VEDY THRUST
IØN (1)	16	000201	129	BOOLEAN - THRUSTER ON IDENTIFICATION
NØN (1)	1	000221	145	BOOLEAN - NUMBER OF THRUSTERS ON
TAB (1)	270	000242	162	MASS PROPERTIES
W(1)	25	000660	432	MASS PROPERTIES - WEIGHTS
AVRGS	110	000711	457*	AVERAGES
SD	110	001067	567*	STANDARD DEVIATIONS
XMIN	110	001245	677*	MINIMUM VALUES
XMAX	110	001423	787*	MAXIMUM VALUES
XSTPTS	110	001601	897*	NUMBER OF VALUES
STSUM	110	001757	1007*	SUMMATION OF VALUES
SZ	110	002135	1117*	SUMMATION OF SQUARES OF VALUES
XYP	256	002313	1227	XYB (1) - (7) = W(3) - W(6); W(11) - W(13) CONVERTED TO LBS XYB (225) - (240) FRBT OX CONSUMPTION XYB (241) - (256) FRBT FUEL CONSUMPTION

* STATISTICAL OUTPUT

Table 2. Program Variable Origin Cross Reference (contd)

Parameter	Word Length	Octal Origin	Decimal Origin	Description
F	16	002713	1483	PA-1 AVERAGE THRUST
WHDOT	2	002733	1499	HELK - LEAKAGE RATE OF QUIESCENT PERIOD #/SEC
E1	1	002735	1501	HELK HELIUM LEAKAGE CRITERIA FOR ERRORS AND NOISE #/SEC
EP	1	002736	1502	HELK-PROPELLANT LEAKAGE CRITERIA FOR ERRORS & NOISE #/SEC
SIG1	1	002737	1503	HELK-REGULATOR FAILURE CRITERIA (LOW LIMTI) PSI. **
SIG2	1	002740	1504	HELK-REGULATOR FAILURE CRITERIA (HIGH LIMIT) PSI. **
T1HLK	1	002741	1505	HELK-START OF QUIESCENT PERIODS - SEC
T2HLK	1	002742	1506	HELK-END OF QUIESCENT PERIODS - SEC
TH	3	002743	1507	NOT USED
IXX	1	002746	1510	MASPRϕ-MOMENT OF INERTIA ABOUT X AXIS
PM	4	002747	1511	HELK-OX MANIFOLD PRESSURE - PSI. **
PREG	3	002753	1515	HELK-REGULATOR PRESSURE - PSI. **
TI	16	002756	1518	PA-1 TOTAL IMPULSE
PCI	16	002776	1534	PA-1 $\int PC\ dt$
PIOI	16	003016	1550	PA-1 $\int PC\phi\ dt$
PIFI	16	003036	1566	PA-1 $\int PI\phi\ dt$
CSTAR	16	003056	1582	PA-1 CHARACTERISTIC EXHAUST VELOCITY
PCBAR	16	003076	1598	PA-1 AVERAGE $Pc = \frac{\int PC\ dt}{TEON}$
TEON	16	003116	1614	ELECTRICAL ON TIME
FNON	1	003156	1630	NUMBER OF THRUSTERS ON
TCAL	1	003137	1631	TIME OF MIDPOINT OF SPAN
KO	16	003140	1632	PA-1 OX CONDUCTANCE

**Reserved for future use.

Table 2. Program Variable Origin Cross Reference (contd)

Parameter	Word Length	Octal Origin	Decimal Origin	Description
KF	16	003160	1648	PA-1 FUEL CONDUCTANCE
CF	16	003200	1664	PA-1 AVERAGE THRUST COEFFICIENT
AT	16	003220	1680	PA-1 THROAT AREA
I1XX	1	003240	1696	MOMENT OF INERTIA ABOUT X AXIS
I1YY	1	003241	1697	MOMENT OF INERTIA ABOUT Y AXIS
I1ZZ	1	003242	1698	MOMENT OF INERTIA ABOUT Z AXIS
X1	1	003243	1699	CG ABOUT X AXIS
Y1	1	003244	1700	CG ABOUT Y AXIS
Z1	1	003245	1701	CG ABOUT Z AXIS
W1	1	003246	1702	SUM-MASS = TOTAL WEIGHT OF TANKS
TF	3	003247	1703	PVT-FUEL TEMP
PF	3	003252	1706	PVT-FUEL MANIFOLD PRESSURE
PO	3	003255	1709	HELK-PVT OX MANIFOLD PRESSURE
TS	3	003260	1712	HELK-PVT HELIUM STORAGE BOTTLE TEMP
PH	3	003263	1715	HELK-PVT HELIUM STORAGE BOTTLE PRESSURE
E	3	003266	1718	NOT USED
WOE	3	003271	1721	PVT-OX EXPENDED
WFE	3	003274	1724	PVT-FUEL EXPENDED
WOU	3	003277	1727	PVT-OX USABLE
WFU	3	003302	1730	PVT-FUEL USABLE
WOD	3	003305	1733	PVT-REMAINING OX DELIVERABLE
WFD	3	003310	1736	PVT-REMAINING FUEL DELIVERABLE
T11	1	003313	1739	BILEVEL EVENT TIME ON
T22	1	003314	1740	BILEVEL EVENT TIME OFF

Table 2. Program Variable Origin Cross Reference (contd)

Parameter	Word Length	Octal Origin	Decimal Origin	Description
TDIF	1	003315	1741	BILEVEL EVENT TIME DIFFERENCE
COSIG	1	003316	1742	NOT USED
COSMG	1	003317	1743	NOT USED
COSOG	1	003320	1744	NOT USED
IYY	1	003321	1745	MASPRO MOMENT OF INERTIA ABOUT Y
IZZ	1	003322	1746	MASPRO MOMENT OF INERTIA ABOUT Z
IXY	1	003323	1747	MASPRO XY PRODUCT OF INERTIA
IXZ	1	003324	1748	MASPRO XZ PRODUCT OF INERTIA
IYZ	1	003325	1749	MASPRO YZ PRODUCT OF INERTIA
MASS	1	003326	1750	MASPRO TOTAL WEIGHT OF TANKS
P	1	003327	1751	VEDY ANGULAR RATE (YAW)
PDOT	1	003330	1752	VEDY ANGULAR ACCELERATION
Q	1	003331	1753	VEDY ANGULAR RATE (PITCH)
QDOT	1	003332	1754	VEDY ANGULAR ACCELERATION
R	1	003333	1755	VEDY ANGULAR RATE (ROLL)
RDOT	1	003334	1756	VEDY ANGULAR ACCELERATION
TCZ	16	003335	1757	VEDY INITIAL THRUST VALUE
XA	1	003355	1773	VEDY X ACCELEROMETER LOCATION
YA	1	003356	1774	VEDY Y ACCELEROMETER LOCATION
ZA	1	003357	1775	VEDY Z ACCELEROMETER LOCATION
XCG	1	003360	1776	MASPRO X CENTER OF GRAVITY
YCG	1	003361	1777	MASPRO Y CENTER OF GRAVITY
ZCG	1	003362	1778	MASPRO Z CENTER OF GRAVITY
XT	16	003363	1779	VEDY X LOCATION OF TANKS
YT	16	003403	1795	VEDY Y LOCATION OF TANKS

Table 2. Program Variable Origin Cross Reference (contd)

Parameter	Word Length	Octal Origin	Decimal Origin	Description
ZT	16	003423	1811	VEDY Z LOCATION OF TANKS
XP	1	003443	1827	VEDY X LOCATION OF P AXIS JETS
YJ	16	003444	1828	VEDY Y LATERAL LOCATIONS OF ALL JETS
ZJ	16	003464	1844	VEDY Z LATERAL LOCATIONS OF ALL JETS
ACCX	1	003504	1860	VEDY X-AXIS ACCELERATION
ACCY	1	003505	1861	VEDY Y-AXIS ACCELERATION
ACCZ	1	003506	1862	VEDY Z-AXIS ACCELERATION
SINIG	1	003507	1863	NOT USED
SINMG	1	003510	1864	NOT USED
SINOG	1	003511	1865	NOT USED
TMIN	110	003512	1866*	TIME OF MINIMUM VALUE
TMAX	110	003670	1976*	TIME OF MAXIMUM VALUE

* STATISTICAL OUTPUT

4. SAMPLE CASE

The sample case is taken from the LM-1 flight. It is a five second period starting at 22922.5 seconds which occurred on the fifth revolution over Antigua. This particular period was selected because there were three RCS on engine configurations of sufficient duration, .2 seconds, to get vehicle dynamics answers. Separate runs were made on the integrator and PA1/FRBT versions to indicate answers for the comparable period. The input data deck listings are followed by the output listings.

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4.1 DECK LISTINGS

There is a data deck listing for each version as follows:

a. Vehicle Dynamics

b. Integrator

c. PA1/FRBT

The actual data deck begins with the card image '$DATAIN'; the first card image was added for identification purposes. The template data for each version is a sample of what might be requested. The user is cautioned to specify time in at least one of the templates, preferably all of them, to aid in correlation of data.

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4.1 VEHICLE DYNAMICS DATA DECK

```
$DATAIN
SFE(1)=-41.0,-59.0,-431.0,
BIAS(1)=96.0,-364.0,19.0,
KF(1)=.01457872,.01449085,.01445768,.01456821,.01459090,.01448282,
KF(7)=.01444325,.01455301,.01445395,.01466685,.01478666,.01429859,
KF(13)=.01447910,.01450425,.01442721,.01433584,
XT(1)=251.9,163.5,266.1,266.1,300.3,300.3,301.5,301.5,189.4,246.2,
XT(11)=246.2,263.,263.,148.3,
YT(1)=9.9,25.,15.1,-15.1,25.,-25.,25.,-25.,-43.2,12.2,-12.2,
YT(12)=46.1,-46.1,47.2,
ZT(1)=-2.4,38.,-53.5,-53.5,13.7,-13.7,13.7,-13.7,-43.2,-48.6,
ZT(11)=-48.6,.6,-.6,-47.8,
DODENS(1)=3*0.,DFDENS=3*0.,PA(1)=3*0.,
TFI(1)=3*70.0,
PFI(1)=2*180.6,183.8,
POI(1)=2*180.6,183.8,
VO(1) =2*4122.52,63042.,
VF(1) =2*3311.35,62773.,
VOTR(1)=2*165.0  ,165.5,
VFTR(1)=2*162.6  ,216.8,
WOTA(1)=2*203.4,3166.7,
WFTA(1)=102.,102.8,1991.3,
VNOM(1)=2*943.1,VNOM(3)=11593.,
VHL(1)=2*16.4,105.6,
EXPAN(1)=2*1.9042E-6,0.22391E-5,
TSI(1)=3*70.0,
PHI(1)=2*3050.,3500.,
PHI(1)=2*2050.,2000.,
MR1(1)=2*2.0,1.6,
MR2(1)=2*2.0,1.6,
XIM(1)=16*0.,XIS(1)=16*0.,XM(1)=16*0.,
E1=5.,EP=5.,
XP=254.0,
YJ(1)= 66.1, 66.1, 61.5, 61.5, 66.1, 66.1, 61.5, 61.5,
YJ(9)=-66.1,-66.1,-61.5,-61.5,-66.1,-66.1,-61.5,-61.5,
ZJ(1)= 66.1, 66.1, 61.5, 61.5,-66.1,-66.1,-61.5,-61.5,
ZJ(9)=-66.1,-66.1,-61.5,-61.5, 66.1, 66.1, 61.5, 61.5,
TCZ(1) =100.7,    CF(1) =1.748,  AT(1) =.5915, KO(1) =.02352640 ,
TCZ(2) =100.2,    CF(2) =1.761,  AT(2) =.5915, KO(2) =.02322354 ,
```

```
TCZ(3) =100.2,    CF(3) =1.768,  AT(3) =.5916, KO(3) =.02320540 ,
TCZ(4) = 99.2,    CF(4) =1.751,  AT(4) =.5914, KO(4) =.02290528 ,
TCZ(5) =100.1,    CF(5) =1.759,  AT(5) =.5916, KO(5) =.02329115 ,
TCZ(6) = 99.7,    CF(6) =1.762,  AT(6) =.5913, KO(6) =.02304897 ,
TCZ(7) =100.6,    CF(7) =1.764,  AT(7) =.5910, KO(7) =.02322524 ,
TCZ(8) =100.1,    CF(8) =1.748,  AT(8) =.5922, KO(8) =.02304709 ,
TCZ(9) =100.0,    CF(9) =1.762,  AT(9) =.5918, KO(9) =.02309698 ,
TCZ(10)= 99.9,    CF(10)=1.748,  AT(10)=.5922, KO(10)=.02341827 ,
TCZ(11)=100.4,    CF(11)=1.748,  AT(11)=.5909, KO(11)=.02327376 ,
TCZ(12)= 99.6,    CF(12)=1.783,  AT(12)=.5917, KO(12)=.02280744 ,
TCZ(13)=100.7,    CF(13)=1.771,  AT(13)=.5917, KO(13)=.02323066 ,
TCZ(14)= 99.7,    CF(14)=1.750,  AT(14)=.5916, KO(14)=.02345456 ,
TCZ(15)=100.5,    CF(15)=1.766,  AT(15)=.5909, KO(15)=.02354279 ,
TCZ(16)= 99.7,    CF(16)=1.766,  AT(16)=.5912, KO(16)=.02291587 ,
XA=309.672,YA=-5.177,ZA=+57.750 ,
ILIMIT=14,
ACCLMT= .001,
     ACCLMT = 1.0
ANG=1.0,DT=2.0,
IT41=1,
IT42=21,
IT31=24,
IT32=26,
ISS2(1)=1227,1228,1229,1230,1231,1232,      1709,1703,1706,1712,1715,
ISS2(12)=1710,1704,1707,1713,1716,      1705,1708,1714,1717,1711,1233,
ISS2(24)=-1751,-1753,-1755,
ISS1(1)=1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20, 21,
ISS1(24)=22,23,24,
CD (1)=-0.176547,1.03369E2,
CD(11) = 278.1413, -4.225769, 0.2540025, -1.0889916E-02, 1.9703564E-04,
CD(16) = -1.2297903E-6,
CD(21) = 2.0523207, -1.063282E-2, 6.0247375E-4, -2.067306E-5,2.6910647E-7,
CD(26) = -1.1626442E-9,
IC(1,2)=1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,
27,28,29,30,31,
DELTIM = .30,
DELTIM = .20,
LF(1) = -100.,100.,-100.,100.,-100., 100.,-100.,100.,-100.,100.,-100.,100.,
-100.,100.,-100.,100.,-100.,100.,-100.,100.,
T1=22287.019,
```

```
 T2=22392.019,
 CD(42)=35.025,35.025,55.425,55.425,0.3,0.3,
 TF(1) = 60., 60., 60.,
 TS(1) = 60., 60., 60.,
 PF(1)=180.0,180.0,180.0,
 PO(1)=180.0,180.0,180.0,
 PH(1)=1800.0,1800.0,1800.0,
 ICALAN(1)=113,1757,
 NUCAL=2,
 ISTBS=30,
 NSTSP=1,NSTPSP=20, TDELCA=02.5,
 TIMST=22922.5,
 START=0,
 STOP=22950.0,
 TIMEN=22927.5,
 ISH= 8,
 SH(1)=433,434,435,436,441,442,443,
 SH(8) = 1631,
 IVDH=9,
 VDH(1)=1757,1758,1759,1760,1761,1762,1763,1764,
 VDH(9)=1631,
 ISH=11,
 IVDH=40,
 SH(1)=1750,1699,1700,1701,1510,1745,1746,1747,1749,1748,1631,
 VDH(1)=1234,129,130,131,132,133,134,135,136,137,138,139,140,141,142,
         143,144,1751,1753,1755,1752,1754,1756,113,114,115,116,117,118,
         119,120,121,122,123,124,125,126,127,128,1631,
 TAG1=3,
 TAG2=3,
 TAG3=0,
 TAG4=0,
 FNOM(1)= 4*0.,100.,100.,180.,70.,180.,70.,1800.,180.,70.,180.,70.,
           1800.,70.,180.,70.,1800.,180.,3*0.
 NMSM  = 24,
 JIC   = 31,
 $END
GQ3603  GQ3604  GQ4103  GQ4104  GF4582  GF4583  GR3201  GR2121  GR2201  GR1089
GP1101  GR3202  GR2122  GR2202  GR1099  GR1102  GP0718  GP0501  GP0201  GP0001
GP1001  GH1461  GH1462  GH1463
GH1418  GH1419  GH1420  GH1421  GH1422  GH1423  GH1424  GH1425  GH1426  GH1427
```

```
GH1428  GH1429  GH1430  GH1431  GH1432  GH1433  GH1260  GH1301  GR9661  GR9662
GR9663  GR9664  GR9665  GR9666  GR9667  GR9668  GR9609  GR9610  GR9611  GR9612
GR9613
 14ALM E    4613.0 257.5   -0.6 0.7   2560.0   2412.0   1494.0   62.0    119.0   -18.0
 15DLM E    3353.0 157.3   12.8 0.7   2359.0   1487.0   1642.0   23.0    58.0    215.0
 16AH20E  -42.5    300.3   -25.0-13.7
 17AH20E  -42.5    300.3   25.0 13.7
 18UMB E  -6.0     209.8   89.0 -29.2
 19RCS E  -22.0    319.7   0.0  6.1    18.0     11.0     11.0    0.0    -2.0  - 2.0
 20ECS E  -2.0     304.8   0.0  0.0    1.0      0.0      1.0
999
1    SPAN
     MASS
    X-CG
    Y-CG
    Z-CG
 MOMENT-XX
 MOMENT-YY
 MOMENT-ZZ
 PRODUCT-XY
 PRODUCT-YZ
 PRODUCT-XZ
     TIME
2    VEDY
 N OF ENG ON
    ENG ON
    ENG ON
    ENG ON
    ENG ON
    ENG ON
    ENG ON
    ENG ON
    ENG ON
    ENG ON
    ENG ON
    ENG ON
    ENG ON
    ENG ON
    ENG ON
    ENG ON
```

```
    ENG ON
      P
      Q
      R
     PDOT
     QDOT
     RDOT
THRUST ENG 1
THRUST ENG 2
THRUST ENG 3
THRUST ENG 4
THRUST ENG 5
THRUST ENG 6
THRUST ENG 7
THRUST ENG 8
THRUST ENG 9
THRUST ENG10
THRUST ENG11
THRUST ENG12
THRUST ENG13
THRUST ENG14
THRUST ENG15
THRUST ENG16
     TIME
```

INTEGRATOR DATA DECK

```
 $DATAIN
  DTMINF = .01,
 DTIN=1.0,
 KPC(1) = 1,1,2,3,4,4,2,5,6,6,7,5,8,8,7,3,
 KPIO(1)=  12,11,12,11,11,12,12,11,12,11,11,12,11,12,11,12,
 KPIF(1)=  10,9,10,9,9,10,10,9,10,9,9,10,9,10,9,10,
 IC(1,2)=1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,
 DTAIL=.05,
  ICHECK = 1,
  TIMST = 22922.5,
 TIMEN=22927.5,
  TAGO   = 3
  TAG3   = 3
  NMSM     = 12
  JIC      = 16,
 FPH(1)=1534,1550,1566,1535,1551,1567,1536,1552,1568,1537,1553,1569,
 1538,1554,1570,1539,1555,1571,1540,1556,1572,1541,1557,573,1542,1558,1574,
 1543,1559,1575,1544,1560,1576,1545,1561,1577,1546,1562,1578,1547,1563,1579,
 1548,1564,1580,1549,1565,1581,1631
 IFPH   = 49,
 $END
GR5031  GR5033  GR5046  GR5035  GR5042  GR5039  GR5041  GR5043  GR2201  GR2202
GR3201  GR3202
GH1418  GH1419  GH1420  GH1421  GH1422  GH1423  GH1424  GH1425  GH1426  GH1427
GH1428  GH1429  GH1430  GH1431  GH1432  GH1433
3    PAFRRT
     PCI( 1)
     PIOI( 1)
     PIFI( 1)
     PCI( 2)
     PIOI( 2)
     PIFI( 2)
     PCI( 3)
     PIOI( 3)
     PIFI( 3)
     PCI( 4)
     PIOI( 4)
     PIFI( 4)
     PCI( 5)
```

```
PIOI( 5)
PIFI( 5)
PCI( 6)
PIOI( 6)
PIFI( 6)
PCI( 7)
PIOI( 7)
PIFI( 7)
PCI( 8)
PIOI( 8)
PIFI( 8)
PCI( 9)
PIOI( 9)
PIFI( 9)
PCI(10)
PIOI(10)
PIFI(10)
PCI(11)
PIOI(11)
PIFI(11)
PCI(12)
PIOI(12)
PIFI(12)
PCI(13)
PIOI(13)
PIFI(13)
PCI(14)
PIOI(14)
PIFI(14)
PCI(15)
PIOI(15)
PIFI(15)
PCI(16)
PIOI(16)
PIFI(16)
 TIME
```

```
     PA1/FRBT DATA DECK
$DATAIN
KF(1)=.01457872,.01449085,.01445768,.01456821,.01459090,.01448282,
KF(7)=.01444325,.01455301,.01445395,.01466685,.01478666,.01429859,
KF(13)=.01447910,.01450425,.01442721,.01433584,
XT(1)=251.9,163.5,266.1,266.1,300.3,300.3,301.5,301.5,189.4,246.2,
XT(11)=246.2,263.,263.,148.3,
YT(1)=9.9,25.,15.1,-15.1,25.,-25.,25.,-25.,-43.2,12.2,-12.2,
YT(12)=46.1,-46.1,47.2,
ZT(1)=-2.4,38.,-53.5,-53.5,13.7,-13.7,13.7,-13.7,-43.2,-48.6,
ZT(11)=-48.6,.6,-.6,-47.8,
DODENS(1)=3*0.,DFDENS=3*0.,PA(1)=3*0.,
TFI(1)=3*70.0,
PFI(1)=2*180.6,183.8,
POI(1)=2*180.6,183.8,
VO(1) =2*4122.52,63042.,
VF(1) =2*3311.35,62773.,
VOTR(1)=2*165.0  ,165.5,
VFTR(1)=2*162.6  ,216.8,
WOTA(1)=2*203.4,3166.7,
WFTA(1)=102.,102.8,1991.3,
VNOM(1)=2*943.1,VNOM(3)=11593.,
VHL(1)=2*16.4,105.6,
EXPAN(1)=2*1.9042E-6,0.03909,
TSI(1)=3*70.0,
PHI(1)=2*3050.,3500.,
MR1(1)=2*2.0,1.6,
MR2(1)=2*2.0,1.6,
XIM(1)=16*0.,XIS(1)=16*0.,XM(1)=16*0.,
E1=5.,EP=5.,
TCZ(1) =100.7,    CF(1) =1.748,  AT(1) =.5915, KO(1) =.02352640 ,
TCZ(2) =100.2,    CF(2) =1.761,  AT(2) =.5915, KO(2) =.02322354 ,
TCZ(3) =100.2,    CF(3) =1.768,  AT(3) =.5916, KO(3) =.02320540 ,
TCZ(4) = 99.2,    CF(4) =1.751,  AT(4) =.5914, KO(4) =.02290528 ,
TCZ(5) =100.1,    CF(5) =1.759,  AT(5) =.5916, KO(5) =.02329115 ,
TCZ(6) = 99.7,    CF(6) =1.762,  AT(6) =.5913, KO(6) =.02304897 ,
TCZ(7) =100.6,    CF(7) =1.764,  AT(7) =.5910, KO(7) =.02322524 ,
TCZ(8) =100.1,    CF(8) =1.748,  AT(8) =.5922, KO(8) =.02304799 ,
TCZ(9) =100.0,    CF(9) =1.762,  AT(9) =.5918, KO(9) =.02309698 ,
TCZ(10)= 99.9,    CF(10)=1.748,  AT(10)=.5922, KO(10)=.02341827 ,
```

```
TCZ(11)=100.4,     CF(11)=1.748,  AT(11)=.5909, KO(11)=.02327376 ,
TCZ(12)= 99.6,     CF(12)=1.783,  AT(12)=.5917, KO(12)=.02280744 ,
TCZ(13)=100.7,     CF(13)=1.771,  AT(13)=.5917, KO(13)=.02323066 ,
TCZ(14)= 99.7,     CF(14)=1.750,  AT(14)=.5916, KO(14)=.02345456 ,
TCZ(15)=100.5,     CF(15)=1.766,  AT(15)=.5909, KO(15)=.02354279 ,
TCZ(16)= 99.7,     CF(16)=1.766,  AT(16)=.5912, KO(16)=.02291587 ,
XA=309.672,YA=-5.177,ZA=+57.750 ,
ILIMIT=14,
ACCLMT= .001,
ANG=1.0,DT=2.0,
IT41=1,
IT42=20,
IT31=24,
IT32=26,
ISS2(1)=1227,1228,1229,1230,1231,1232,      1709,1703,1706,1712,1715,
ISS2(12)=1710,1704,1707,1713,1716,      1705,1708,1714,1717,1233,1711,
ISS2(24)=-1751,-1753,-1755,
ISS1(1)=1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,
ISS1(24)=21,22,23,
CD (1)=-0.176547,1.03369E2,
CD(11) = 278.1413, -4.225769, 0.2540025, -1.0889916E-02, 1.9703564E-04,
CD(16) = -1.2297903E-6,
CD(21) = 2.0523207, -1.063282E-2, 6.0247375E-4, -2.067306E-5,2.6910647E-7,
CD(26) = -1.1626442E-9,
IC(1,2)=1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,
NSTSP=1,NSTPSP=20, TDELCA=005.,
DELTIM = .03,
LF(1) = -100.,100.,-100.,100.,-100., 100.,-100.,100.,-100.,100.,-100.,100.,
-100.,100.,-100.,100.,-100.,100.,-100.,100.,
PF(3)=180.0,
PO(3)=180.0,
DTIN=1.0,
DTIN=3.0,
DTIN=2.5,
 DTIN=2.,
PCI(1)=16*961.0,
PIFI(1)=16*975.0,
PIOI(1)=16*978.0,
TF(1)=2*60.0,
  UNIT = 14,
```

```
  TIMST = 22922.5
 TIMFN=22931.5
  TIMFN = 22927.5
  TIMFN=22924.5
 IFM=8,
 IT31=1,
 IT32=2,
 ISS2(1)=1703,1704,
 ISS1(1)=1,2,
 M=1,
 ICORS(1)=2,7,13,6,12,10,15,16,
 KPIC(1)=3,7,9,4,2,1,3,10,
 KPIF(1)=3,7,9,4,2,1,3,10,
 KPC(1)=3,7,9,4,2,1,3,10,
  TAG1   = 0,
  TAG2   = 0,
  TAG3   = 2,
  TAG4   = 0,
  IFPH   = 6,
 IFPH=7,
 IFPH=17,
 FNOM(1)=65.0,66.0,
  FPH(1) = 97, 1467, 1451, 1483, 65, 81,
 FPH(7)=1631,
 FPH(1)=1483,1484,1485,1486,1487,1488,1489,1490,1491,1492,1493,1494,1495,1496,
 FPH(15)=1497,1498,1631,
  NMSM = 2,
  JIC  = 16,
 $END
GR2121  GR2122
GH1418  GH1419  GH1420  GH1421  GH1422  GH1423  GH1424  GH1425  GH1426  GH1427
GH1428  GH1429  GH1430  GH1431  GH1432  GH1433
3   PAFRBT
  PA1-TH1
  PA1-TH2
  PA1-TH3
  PA1-TH4
  PA1-TH5
  PA1-TH6
  PA1-TH7
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PA1-TH8
PA1-TH9
PA1-TH10
PA1-TH11
PA1-TH12
PA1-TH13
PA1-TH14
PA1-TH15
PA1-TH16
TIME

PRECEDING PAGE BLANK NOT FILMED.

4.2 OUTPUT LISTINGS

The output listings are presented in the same order as the input data decks. Each begins with a listing of the input data under namelist '$DATAIN' and ends with the statement 'PROCESSING IS COMPLETE'.

The second listing which is from the integrator run has special messages to the effect that short firings were encountered. These were not processed inasmuch as the electrical on time was less than .01 second.

The third listing from the PA1/FRBT has a machine diagoni ic pertaining to the occurrence of an attempt to take the square root of a negative number. This happened due to an engine burn analysis when the burn time was less than .006 seconds which is less than can be processed using the current formulation.

PRECEDING PAGE BLANK NOT FILMED.

4.2.1 ISPALM - INTEG

```
$DATAIN
AB      =     .00000000+00,
DATAIL  =     .00000000+00,
DTIN    =     .10000000+01,
DTMINF  =     .10000000-01,
FNOM    =     .00000000+00,   .00000000+00,   .00000000+00,   .00000000+00,
              .00000000+00,   .00000000+00,   .00000000+00,   .00000000+00,
              .00000000+00,   .00000000+00,   .00000000+00,   .00000000+00,
              .00000000+00,   .00000000+00,   .00000000+00,   .00000000+00,
              .00000000+00,   .00000000+00,   .00000000+00,   .00000000+00,
              .00000000+00,   .00000000+00,   .00000000+00,   .00000000+00,
              .00000000+00,   .00000000+00,   .00000000+00,   .00000000+00,
              .00000000+00,   .00000000+00,   .00000000+00,   .00000000+00,
              .00000000+00,   .00000000+00,   .00000000+00,   .00000000+00,
              .00000000+00,   .00000000+00,   .00000000+00,   .00000000+00,
              .00000000+00,   .00000000+00,   .00000000+00,   .00000000+00,
              .00000000+00,   .00000000+00,   .00000000+00,   .00000000+00,
              .00000000+00,   .00000000+00,   .00000000+00,   .00000000+00,
              .00000000+00,   .00000000+00,   .00000000+00,   .00000000+00,
              .00000000+00,   .00000000+00,   .00000000+00,   .00000000+00,
              .00000000+00,   .00000000+00,   .00000000+00,   .00000000+00,
              .00000000+00,   .00000000+00,   .00000000+00,   .00000000+00,
              .00000000+00,   .00000000+00,   .00000000+00,   .00000000+00,
              .00000000+00,   .00000000+00,   .00000000+00,   .00000000+00,
              .00000000+00,   .00000000+00,   .00000000+00,   .00000000+00,
              .00000000+00,   .00000000+00,   .00000000+00,   .00000000+00,
              .00000000+00,   .00000000+00,   .00000000+00,   .00000000+00,
              .00000000+00,   .00000000+00,   .00000000+00,   .00000000+00,
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              .00000000+00,   .00000000+00,   .00000000+00,   .00000000+00,
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              .00000000+00,   .00000000+00,   .00000000+00,   .00000000+00,
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              .00000000+00,   .00000000+00,   .00000000+00,   .00000000+00,
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                  .00000000+00,    .00000000+00,    .00000000+00,    .00000000+00,
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                  .00000000+00,    .00000000+00,    .00000000+00,    .00000000+00,
                  .00000000+00,    .00000000+00,    .00000000+00,    .00000000+00,
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                  .00000000+00,    .00000000+00,    .00000000+00,    .00000000+00,
                  .00000000+00,    .00000000+00,    .00000000+00,    .00000000+00,
HISTRY    =                  6,
HTAPE     =                 10,
IHFLK     =                   ,
SH        =                   ,                ,                ,                ,
                              ,                ,                ,                ,
                              ,                ,
FH        =                   ,                ,                ,                ,
                              ,                ,                ,                ,
                              ,                ,
FPH       =              1534,            1550,            1566,            1535,
                         1551,            1567,            1536,            1552,
                         1568,            1537,            1553,            1569,
                         1538,            1554,            1570,            1539,
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                         1555,          1571,          1540,          1556,
                         1572,          1541,          1557,           573,
                         1542,          1558,          1574,          1543,
                         1559,          1575,          1544,          1560,
                         1576,          1545,          1561,          1577,
                         1546,          1562,          1578,          1547,
                         1563,          1579,          1548,          1564,
                         1580,          1549,          1565,          1581,
                         1631,              ,              ,              ,
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                             ,              ,              ,              ,
                             ,              ,              ,              ,
VDH       =                  ,              ,              ,              ,
                             ,              ,              ,              ,
                             ,              ,
TAG1      =                  ,
TAG2      =                  ,
TAG3      =                 3,
TAG4      =                  ,
ISH       =                 2,
IFPH      =                49,
IFH       =                 6,
IVDH      =                 8,
IC        =                  ,              ,              ,              ,
                             ,              ,              ,              ,
                             ,              ,              ,              ,
                             ,              ,              ,              ,
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1,	2,	3,	4,
5,	6,	7,	8,
9,	10,	11,	12,
13,	14,	15,	16,

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                         ,            ,            ,            ,
ICHECK  =               1,
JIC     =              16,
KPC     =               1,           1,           2,           3,
                        4,           4,           2,           5,
                        6,           6,           7,           5,
                        8,           8,           7,           3,
KPIF    =              10,           9,          10,           9,
                        9,          10,          10,           9,
                       10,           9,           9,          10,
                        9,          10,           9,          10,
KPIO    =              12,          11,          12,          11,
                       11,          12,          12,          11,
                       12,          11,          11,          12,
                       11,          12,          11,          12,
NMSM    =              12,
T1      =     .00000000+00,
T2      =     .00C000C0+00,
TAGO    =               3,
TIMFN   =     .22927500+05,
TIMST   =     .22922500+05,
UNIT    =              14,
$END
  &&&&&G   GR5031   GR5033   GR5046   GR5035   GR5042   GR5039   GR5041   GR5043   GR2201
  GR2202   GR3201   GR3202
  &&&&&K   GH1418   GH1419   GH1420   GH1421   GH1422   GH1423   GH1424   GH1425   GH1426
  GH1427   GH1428   GH1429   GH1430   GH1431   GH1432   GH1433
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APOLLO 5/LM-1 PROPULSICN AND POWER FLIGHT DATA PCM MERGE APCFINAL MERGE REQ. L30 ANT 5

```
DCYCLE DC ENG NO  1-1327   DC ENG NO  2-1328   DC ENG NO  3-1329   DC ENG NO  4-1330   DC ENG NO  5-1331
       DC ENG NO  6-1332   DC ENG NO  7-1333   DC ENG NO  8-1334   DC ENG NO  9-1335   DC ENG NO 10-1336
       DC ENG NO 11-1337   DC ENG NO 12-1338   DC ENG NO 13-1339   DC ENG NO 14-1340   DC ENG NO 15-1341
       DC ENG NO 16-1342      PERIOD   -1323     END TIME  -1325
```

PAFRBT	PCI(1) -1534	PIOI(1) -1550	PIFI(1) -1566	PCI(2) -1535	PIOI(2) -1551
	PIFI(2) -1567	PCI(3) -1536	PIOI(3) -1552	PIFI(3) -1568	PCI(4) -1537
	PIOI(4) -1553	PIFI(4) -1569	PCI(5) -1538	PIOI(5) -1554	PIFI(5) -1570
	PCI(6) -1539	PIOI(6) -1555	PIFI(6) -1571	PCI(7) -1540	PIOI(7) -1556
	PIFI(7) -1572	PCI(8) -1541	PIOI(8) -1557	PIFI(8) - 573	PCI(9) -1542
	PIOI(9) -1558	PIFI(9) -1574	PCI(10) -1543	PIOI(10) -1559	PIFI(10) -1575
	PCI(11) -1544	PIOI(11) -1560	PIFI(11) -1576	PCI(12) -1545	PIOI(12) -1561
	PIFI(12) -1577	PCI(13) -1546	PIOI(13) -1562	PIFI(13) -1578	PCI(14) -1547
	PIOI(14) -1563	PIFI(14) -1579	PCI(15) -1548	PIOI(15) -1564	PIFI(15) -1580
	PCI(16) -1549	PIOI(16) -1565	PIFI(16) -1581	TIME -1631	

PAFERT	.00000000	.00000000	.00000000	.30944804+01	.22061433+01
	.24837689+01	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.12515176+01	.22061433+01	.24837689+01
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.17966221+02
	.44045858+02	.36642849+02	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.22922993+05	
PAFERT	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.22772166+02
	.60012024+02	.49114376+02	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.22923083+05	
PAFERT	.78076771+01	.26566936+02	.21207616+02	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.22923094+05	
PAFERT	.15378138+02	.43395023+02	.35013235+02	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.15866305+02	.43395023+02	.35013235+02	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.15458205+01	.21375813+01	.24185844+01

	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.12668091-00	.21375813+01	.24185844+01	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.22923488+05	
PAFRRT	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.73912461-00	.13425321+01	.15083645+01
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.74250396+01
	.26699332+02	.22088451+02	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.22923894+05	
DCYCLE	.30004883-00	.20581055-00	.00000000	.00000000	.20581055-00
	.19995117-00	.00000000	.00000000	.20581055-00	.19995117-00
	.00000000	.00000000	.19995117-00	.29492188-00	.00000000
	.00000000	.10000000+01	.22923788+05		
PAFRRT	.00000000	.00000000	.00000000	.18748644-00	.21561572+01
	.24185844+01	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.22923988+05	
PAFRRT	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.83416724+01	.26180219+02	.20937082+02	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.26005770+02
	.60744251+02	.49251838+02	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000

	.00000000	.00000000	.00000000	.22924088+05	
PAFRBT	.11346378+02	.34475885+02	.28571446+02	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.12470468+02	.34475885+02	.28571446+02	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.11380835+01	.17461361+01	.15083645+01
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.14191496-00	.17461361+01	.15083645+01	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.22924694+05	
PAFRBT	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.82371859-00	.13259827+01	.15083645+01
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.10082048+01	.13259827+01	.15083645+01
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.22924894+05	
DCYCLE	.10595703+00	.19995117-00	.00000000	.00000000	.10595703+00
	.20581055-00	.00000000	.00000000	.29980469-00	.10595703+00
	.00000000	.00000000	.10595703+00	.10595703+00	.00000000
	.00000000	.10000000+01	.22924788+05		
PAFRBT	.15929263+02	.43931025+02	.35711352+02	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.15558233+02
	.43931025+02	.35711352+02	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.22924988+05	
PAFRBT	.00000000	.00000000	.00000000	.10228116+00	.33044864+01

	.36763428+01	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.29297344+02
	.66257580+02	.54966468+02	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.22925618+05	
PAFRRT	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.11625914+02	.32390316+02	.26611519+02	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.84616153-01	.16019194+01	.17897052+01	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.22925623+05	
DCYCLE	.19995117-00	.32983398-00	.00000000	.00000000	.10595703+00
	.13500977-00	.00000000	.00000000	.32983398-00	.10595703+00
	.00000000	.00000000	.13500977-00	.19995117-00	.00000000
	.00000000	.10000000+01	.22925788+05		

NO. 1 SHORT FIRE ON ENGINE 2 REPORTEDLY TURNED OFF AT, .229259830+05 AFTER COMING ON AT .229259780+05

NO. 2 SHORT FIRE ON ENGINE 3 REPORTEDLY TURNED OFF AT, .229259830+05 AFTER COMING ON AT .229259780+05

NO. 3 SHORT FIRE ON ENGINE 4 REPORTEDLY TURNED OFF AT, .229259830+05 AFTER COMING ON AT .229259780+05

NO. 4 SHORT FIRE ON ENGINE 5 REPORTEDLY TURNED OFF AT, .229259830+05 AFTER COMING ON AT .229259780+05

NO. 5 SHORT FIRE ON ENGINE 6 REPORTEDLY TURNED OFF AT, .229259830+05 AFTER COMING ON AT .229259780+05

NO. 6 SHORT FIRE ON ENGINE 7 REPORTEDLY TURNED OFF AT, .229259830+05 AFTER COMING ON AT .229259780+05

NO. 7 SHORT FIRE ON ENGINE 8 REPORTEDLY TURNED OFF AT, .229259830+05 AFTER COMING ON AT .229259780+05

NO. 8 SHORT FIRE ON ENGINE 9 REPORTEDLY TURNED OFF AT, .229259830+05 AFTER COMING ON AT .229259780+05

NO. 9 SHORT FIRE ON ENGINE 10 REPORTEDLY TURNED OFF AT, .229259830+05 AFTER COMING ON AT .229259780+05

NO. 10 SHORT FIRE ON ENGINE 11 REPORTEDLY TURNED OFF AT, .229259830+05 AFTER COMING ON AT .229259780+05

NO. 11 SHORT FIRE ON ENGINE 12 REPORTEDLY TURNED OFF AT, .229259830+05 AFTER COMING ON AT .229259780+05

NO. 12 SHORT FIRE ON ENGINE 13 REPORTEDLY TURNED OFF AT, .229259830+05 AFTER COMING ON AT .229259780+05

NO. 13 SHORT FIRE ON ENGINE 14 REPORTEDLY TURNED OFF AT, .229259830+05 AFTER COMING ON AT .229259780+05

NO. 14 SHORT FIRE ON ENGINE 15 REPORTEDLY TURNED OFF AT, .229259830+05 AFTER COMING ON AT .229259780+05

NO. 15 SHORT FIRE ON ENGINE 16 REPORTEDLY TURNED OFF AT, .229259830+05 AFTER COMING ON AT .229259780+05

RAFPRT	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.16181846+01	.21696669+01	.24209486+01
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.22926288+05	

PAFRBT	.24607521+02	.61499784+02	.51745404+02	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.78187494+01
	.26075856+02	.21905732+02	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.22926388+05	

USER SPECIFIED STOP TIME, .22927500+05

PAFRBT	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.91936439+01
	.25777967+02	.22389720+02	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.78651694+01
	.25777967+02	.22389720+02	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.22926888+05	
DCYCLE	.30004883-00	.48828125-02	.48828125-02	.48828125-02	.48828125-02
	.48828125-02	.48828125-02	.48828125-02	.48828125-02	.20507813-00
	.48828125-02	.48828125-02	.48828125-02	.10473633+00	.48828125-02
	.48828125-02	.10000000+01	.22926788+05		
PAFRBT	.00000000	.00000000	.00000000	.19599951-00	.13692139+01
	.15083645+01	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.71696077-00	.13692139+01	.15083645+01
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.22926894+05	
PAFRBT	.00000000	.00000000	.00000000	.18819172-00	.12935593+01

	.14492593+01	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.93853910-01	.12735593+01	.14492593+01	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.22927088+05	
PAFPRT	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.18097281+02
	.44186021+02	.36782001+02	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.22927188+05	
PAFPRT	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.17641256+02	.45059426+02	.37654393+02	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.22927193+05	
PAFPRT	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.44739713+01	.18064571+02
	.14687808+02	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.68277893-00	.87847198-00	.96696091-00

	.0000000C	.00000000	.00000000	.22927388+05	
DCYCLE	.00000000	.20581055-00	.00000000	.00000000	.10595703+00
	.20581055-00	.50048828-01	.00000000	.29980469-00	.00000000
	.00000000	.00000000	.99853516-01	.99853516-01	.50048828-01
	.00000000	.10000000+01	.22927788+05		

```
SHORT FIRINGS =   15.  PCI.GT.(PICI.OR.PIFI) =    C

P R O C E S S I N G   I S   C O M P L E T E
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4.2.2 ISPALM PA-1/FRBT

```
$DATAIN
T1       =    .00C00000+00,
T2       =    .COC0000C+00,
TDELCA   =    .5000C000+01,
DELTIM   =    .30000000-C1,
PCDLTM   =    .C000000C+00,
XA       =    .3096720C+03,
YA       =   -.5177000C+01,
ZA       =    .5775CC0C+02,
XT       =    .25190000+03,   .16350000+03,   .2661C00C+03,   .26610000+03,
              .30030000+03,   .30030000+03,   .3015C00C+03,   .30150000+03,
              .18940000+03,   .24620000+03,   .2462C000+03,   .26300000+03,
              .26300000+03,   .14830000+03,   .CCCCC0CC+00,   .00000000+00,
COSMG    =    .CCCC000C+00,
COSOG    =    .COC0000C+C0,
XP       =    .C0000000+C0,
YJ       =    .00000000+00,   .00000C00+00,   .CC0000CC+00,   .00000000+0C,
              .00000000+00,   .00000C00+00,   .CC00C00C+00,   .00000000+00,
              .00000000+00,   .00000C00+00,   .CCCCC0CC+00,   .00000000+00,
              .00C00000+00,   .00000000+00,   .CCC0C000+00,   .00000000+00,
ZJ       =    .00C00000+00,   .00000000+00,   .CCC0C000+00,   .00000000+00,
              .00C00000+00,   .00000000+00,   .C000000C+00,   .00000000+00,
              .0000C000+00,   .00000C00+00,   .C000C00C+00,   .00000000+C0,
              .00000000+00,   .000C0C00+00,   .COC0C0C0+00,   .00000000+00,
ACCX     =    .0000000C+00,
ACCY     =    .0000000C+0C,
ACCZ     =    .C0000000+C0,
ACCLMT   =    .10C0000C-C2,
P        =    .C0000000+00,
Q        =    .C0000000+00,
R        =    .COC00000+00,
ANG      =    .1000000C+01,
ILIMIT   =              14,
CD       =   -.17654700+CC,   .10336899+03,   .CC0C000C+00,   .000C0000+00,
              .00000000+C0,   .00000000+00,   .C000000C+00,   .00000000+00,
              .COC00000+00,   .00000C00+00,   .2781413C+03,  -.42257690+01,
              .2540C250+00,  -.10889916-01,   .19703563-C3,  -.12297903-05,
              .COC0000C+00,   .00000000+00,   .CCC0C00C+00,   .00000000+00,
              .20523207+01,  -.10632820-01,   .60247374-03,  -.20673059-04,
              .26910646-06,  -.11626442-08,   .CCC0C00C+C0,   .00000000+00,
              .C0000000+00,   .00000C00+00,   .CC0000C+00,    .00000000+0C,
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IC =

.00000000+00, 1.	.00000000+00, 2.	.00000000+00, 3.	.00000000+00, 4.
.00000000+00, 5.	.00000000+00, 6.	.00000000+00, 7.	.00000000+00, 8.
.00000000+00, 9.	.00000000+00, 10.	.00000000+00, 11.	.00000000+00, 12.
.00000000+00, 13.	.00000000+00, 14.	.00000000+00, 15.	.00000000+00, 16.

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                          ,          ,          ,          ,
IK       =                ,
IK1      =                ,
TIMST    =     .22922500+05,
TIMFN    =     .22927500+05,
IT11     =                ,
IT12     =                ,
IT21     =                ,
IT22     =                ,
IT31     =               1,
IT32     =               2,
IT41     =               1,
IT42     =              20,
ISS1     =               1,         2,         3,         4,
                         5,         6,         7,         8,
                         9,        10,        11,        12,
                        13,        14,        15,        16,
                        17,        18,        19,        20,
                          ,          ,          ,        21,
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ISS2 =

22,	23,		
1703,	1704,	1229,	1230,
1231,	1232,	1709,	1703,
1706,	1712,	1715,	1710,
1704,	1707,	1713,	1716,
1705,	1708,	1714,	1717,
1233,	1711,		-1751,
-1753,	-1755,		

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                    ,                      ,                      ,                      ,
TOUIS1   =    .00000000+00,
TOUIS2   =    .00000000+00,
LF       =   -.10000000+03,     .10000000+03,    -.10000000+03,     .10000000+03,
             -.10000000+03,     .10000000+03,    -.10000000+03,     .10000000+03,
             -.10000000+03,     .10000000+03,    -.10000000+03,     .10000000+03,
             -.10000000+03,     .10000000+03,    -.10000000+03,     .10000000+03,
             -.10000000+03,     .10000000+03,    -.10000000+03,     .10000000+03,
SIG1     =    .00000000+00,
SIG2     =    .00000000+00,
E1       =    .50000000+01,
EP       =    .50000000+01,
YT       =    .99000000+01,     .25000000+02,     .15100000+02,    -.15100000+02,
              .25000000+02,    -.25000000+02,     .25000000+02,    -.25000000+02,
             -.43200000+02,     .12200000+02,    -.12200000+02,     .46100000+02,
             -.46100000+02,     .47200000+02,     .00000000+00,     .00000000+00,
ZT       =   -.24000000+01,     .38000000+02,    -.53500000+02,    -.53500000+02,
              .13700000+02,    -.13700000+02,     .13700000+02,    -.13700000+02,
             -.43200000+02,    -.48600000+02,    -.48600000+02,     .59999999+00,
             -.59999999+00,    -.47800000+02,     .00000000+00,     .00000000+00,
TCZ      =    .10069999+03,     .10019999+03,     .10019999+03,     .99199999+02,
              .10009999+03,     .99699999+02,     .10059999+03,     .10009999+03,
              .10000000+03,     .99899999+02,     .10039999+03,     .99599999+02,
              .10069999+03,     .99699999+02,     .10050000+03,     .99699999+02,
CF       =    .17480000+01,     .17610000+01,     .17680000+01,     .17510000+01,
              .17590000+01,     .17620000+01,     .17640000+01,     .17[illegible]000+01,
              .17620000+01,     .17480000+01,     .17480000+01,     .17830000+01,
              .17710000+01,     .17500000+01,     .17660000+01,     .17660000+01,
AT       =    .59150000+00,     .59150000+00,     .59159999+00,     .59140000+00,
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		.59159999+00,	.59130000+00,	.59100000+00,	.59220000+00,
		.59180000+00,	.59220000+00,	.55090000+00,	.59170000+00,
		.59170000+00,	.59159999+00,	.55090000+00,	.59119999+00,
KO	=	.23526400-01,	.23223540-01,	.23205400-01,	.22905280-01,
		.23291150-01,	.23048970-01,	.23225240-01,	.23047990-01,
		.23096980-01,	.23418270-01,	.23273760-01,	.22807440-01,
		.23230560-01,	.23454560-01,	.23542790-01,	.22915870-01,
KF	=	.14578720-01,	.14490850-01,	.14457680-01,	.14568210-01,
		.14590900-01,	.14492820-01,	.14443250-01,	.14553010-01,
		.14453950-01,	.14666850-01,	.14786660-01,	.14298590-01,
		.14479100-01,	.14504250-01,	.14427210-01,	.14335840-01,
CODENS	=	.00000000+00,	.00000000+00,	.00000000+00,	
CFDENS	=	.00000000+00,	.00000000+00,	.00000000+00,	
PA	=	.00000000+00,	.00000000+00,	.00000000+00,	
TFI	=	.70000000+02,	.70000000+02,	.70000000+02,	
XPLIM	=	.00000000+00,			
PFI	=	.18060000+03,	.18060000+03,	.18380000+03,	
POI	=	.18060000+03,	.18060000+03,	.18380000+03,	
CCN	=	.00000000+00,	.00000000+00,	.00000000+00,	.00000000+00,
		.00000000+00,	.00000000+00,	.00000000+00,	.00000000+00,
		.00000000+00,	.00000000+00,	.00000000+00,	.00000000+00,
		.00000000+00,	.00000000+00,	.00000000+00,	.00000000+00,
		.00000000+00,	.00000000+00,	.00000000+00,	.00000000+00,
		.00000000+00,	.00000000+00,	.00000000+00,	.00000000+00,
		.00000000+00,	.00000000+00,	.00000000+00,	.00000000+00.
		.00000000+00,	.00000000+00,		
VO	=	.41225200+04,	.41225200+04,	.63042000+05,	
VF	=	.33113500+04,	.33113500+04,	.62773000+05,	
VOTR	=	.16500000+03,	.16500000+03,	.16550000+03,	
VFTR	=	.16260000+03,	.16260000+03,	.21680000+03,	
WOTA	=	.20340000+03,	.20340000+03,	.31667000+04,	
WFTA	=	.10200000+03,	.10279999+03,	.15913000+04,	
VNOM	=	.94309999+03,	.94309999+03,	.11593000+05,	
VHL	=	.16400000+02,	.16400000+02,	.10559999+03,	
EXPAN	=	.19042000-05,	.19042000-05,	.35089999-01,	
TSI	=	.70000000+02,	.70000000+02,	.70000000+02,	
PHI	=	.30500000+04,	.30500000+04,	.35000000+04,	
MR1	=	.20000000+01,	.20000000+01,	.16000000+01,	
MR2	=	.20000000+01,	.20000000+01,	.16000000+01,	
XIM	=	.00000000+00,	.00000000+00,	.00000000+00,	.00000000+00,
		.00000000+00,	.00000000+00,	.00000000+00,	.00000000+00,

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              .00000000+00,  .00000000+00,  .00000000+00,  .00000000+00,
              .00000000+00,  .00000000+00,  .00000000+00,  .00000000+00,
XIS      =    .00000000+00,  .00000000+00,  .00000000+00,  .00000000+00,
              .00000000+00,  .00000000+00,  .00000000+00,  .00000000+00,
              .00000000+00,  .00000000+00,  .00000000+00,  .00000000+00,
              .00000000+00,  .00000000+00,  .00000000+00,  .00000000+00,
XM       =    .00000000+00,  .00000000+00,  .00000000+00,  .00000000+00,
              .00000000+00,  .00000000+00,  .00000000+00,  .00000000+00,
              .00000000+00,  .00000000+00,  .00000000+00,  .00000000+00,
              .00000000+00,  .00000000+00,  .00000000+00,  .00000000+00,
DT       =    .20000000+01,
NSTAC    =                ,
NSTPAC   =                ,
NSTSP    =               1,
NSTPSP   =              20,
M        =               1,
T11      =    .00000000+00,
T22      =    .00000000+00,
NOTIN    =               1,
PCI      =    .96100000+03,  .96100000+03,  .96100000+03,  .96100000+03,
              .96100000+03,  .96100000+03,  .96100000+03,  .96100000+03,
              .96100000+03,  .96100000+03,  .96100000+03,  .96100000+03,
              .96100000+03,  .96100000+03,  .96100000+03,  .96100000+03,
PIFI     =    .97500000+03,  .97500000+03,  .97500000+03,  .97500000+03,
              .97500000+03,  .97500000+03,  .97500000+03,  .97500000+03,
              .97500000+03,  .97500000+03,  .97500000+03,  .97500000+03,
              .97500000+03,  .97500000+03,  .97500000+03,  .97500000+03,
PIOI     =    .97800000+03,  .97800000+03,  .97800000+03,  .97800000+03,
              .97800000+03,  .97800000+03,  .97800000+03,  .97800000+03,
              .97800000+03,  .97800000+03,  .97800000+03,  .97800000+03,
              .97800000+03,  .97800000+03,  .97800000+03,  .97800000+03,
TF       =    .60000000+02,  .60000000+02,  .00000000+00,
DTIN     =    .25000000+01,
KPIO     =               3,              7,              9,              4,
                         2,              1,              3,             10,
                          ,               ,               ,               ,
                          ,               ,               ,               ,
KPIF     =               3,              7,              9,              4,
                         2,              1,              3,             10,
                          ,               ,               ,               ,
                          ,               ,               ,               ,
```

```
ICPES    =            2,            7,           13,            6,
                     12,           10,           15,           16,
                      .             .             .             .
                      .             .             .             .
TSAVT    =  .00000000+00,
KPC      =            3,            7,            9,            4,
                      2,            1,            3,           10,
                      .             .             .             .
                      .             .             .             .
IEM      =            8,
UNIT     =           14,
ENDM     =  .65000000+02, .66000000+02, .00000000+00, .00000000+00,
            .00000000+00, .00000000+00, .00000000+00, .00000000+00,
            .00000000+00, .00000000+00, .00000000+00, .00000000+00,
            .00000000+00, .00000000+00, .00000000+00, .00000000+00,
            .00000000+00, .00000000+00, .00000000+00, .00000000+00,
            .00000000+00, .00000000+00, .00000000+00, .00000000+00,
            .00000000+00, .00000000+00, .00000000+00, .00000000+00,
            .00000000+00, .00000000+00, .00000000+00, .00000000+00,
            .00000000+00, .00000000+00, .00000000+00, .00000000+00,
            .00000000+00, .00000000+00, .00000000+00, .00000000+00,
            .00000000+00, .00000000+00, .00000000+00, .00000000+00,
            .00000000+00, .00000000+00, .00000000+00, .00000000+00,
            .00000000+00, .00000000+00, .00000000+00, .00000000+00,
            .00000000+00, .00000000+00, .00000000+00, .00000000+00,
            .00000000+00, .00000000+00, .00000000+00, .00000000+00,
            .00000000+00, .00000000+00, .00000000+00, .00000000+00,
            .00000000+00, .00000000+00, .00000000+00, .00000000+00,
            .00000000+00, .00000000+00, .00000000+00, .00000000+00,
            .00000000+00, .00000000+00, .00000000+00, .00000000+00,
            .00000000+00, .00000000+00, .00000000+00, .00000000+00,
            .00000000+00, .00000000+00, .00000000+00, .00000000+00,
            .00000000+00, .00000000+00, .00000000+00, .00000000+00,
            .00000000+00, .00000000+00, .00000000+00, .00000000+00,
            .00000000+00, .00000000+00, .00000000+00, .00000000+00,
            .00000000+00, .00000000+00, .00000000+00, .00000000+00,
            .00000000+00, .00000000+00, .00000000+00, .00000000+00,
            .00000000+00, .00000000+00, .00000000+00, .00000000+00,
            .00000000+00, .00000000+00, .00000000+00, .00000000+00,
            .00000000+00, .00000000+00, .00000000+00, .00000000+00,
            .00000000+00, .00000000+00, .00000000+00, .00000000+00,
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         .00000000+00,   .00000000+00,   .00000000+00,   .00000000+00,
         .00000000+00,   .00000000+00,   .00000000+00,   .00000000+00,
         .00000000+00,   .00000000+00,   .00000000+00,   .00000000+00,
         .00000000+00,   .00000000+00,   .00000000+00,   .00000000+00,
         .00000000+00,   .00000000+00,   .00000000+00,   .00000000+00,
         .00000000+00,   .00000000+00,   .00000000+00,   .00000000+00,
         .00000000+00,   .00000000+00,   .00000000+00,   .00000000+00,
         .00000000+00,   .00000000+00,   .00000000+00,   .00000000+00,
         .00000000+00,   .00000000+00,   .00000000+00,   .00000000+00,
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         .00000000+00,   .00000000+00,   .00000000+00,   .00000000+00,
         .00000000+00,   .00000000+00,   .00000000+00,   .00000000+00,
         .00000000+00,   .00000000+00,   .00000000+00,   .00000000+00,
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         .00000000+00,   .00000000+00,   .00000000+00,   .00000000+00,
         .00000000+00,   .00000000+00,   .00000000+00,   .00000000+00,
         .00000000+00,   .00000000+00,   .00000000+00,   .00000000+00,
         .00000000+00,   .00000000+00,   .00000000+00,   .00000000+00,
JIC    =           16,
NMSM   =            2,
TAGO   =            4,
HTAPE  =           10,
DTAIL  = .00000000+00,
CTMINF = .00000000+00,
AB     = .00000000+00,
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IHELK    =          ,
SH       =          ,          ,          ,          ,
                    ,          ,          ,          ,
                    ,          ,
FH       =          ,          ,          ,          ,
                    ,          ,          ,          ,
                    ,          ,
FPH      =      1483,      1484,      1485,      1486,
                1487,      1488,      1489,      1490,
                1491,      1492,      1493,      1494,
                1495,      1496,      1497,      1498,
                1631,          ,          ,          ,
VDH      =          ,          ,          ,          ,
                    ,          ,          ,          ,
                    ,          ,
TAG1     =          ,
TAG2     =          ,
TAG3     =         2,
TAG4     =          ,
ISH      =         2,
IFPH     =        17,
IFH      =         6,
IVDH     =         8,
$END

 MEASUREMENTS SELECTED
  GR2121   GR2122

 BILEVELS SELECTED
  GH1418   GH1419   GH1420   GH1421   GH1422   GH1423   GH1424   GH1425   GH1426   GH1427
  GH1428   GH1429   GH1430   GH1431   GH1432   GH1433
```

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PAFRRT  PA1-TH1    -1483   PA1-TH2    -1484   PA1-TH3    -1485   PA1-TH4    -1486   PA1-TH5    -1487
        PA1-TH6    -1488   PA1-TH7    -1489   PA1-TH8    -1490   PA1-TH9    -1491   PA1-TH10   -1492
        PA1-TH11   -1493   PA1-TH12   -1494   PA1-TH13   -1495   PA1-TH14   -1496   PA1-TH15   -1497
        PA1-TH16   -1498      TIME    -1631

APOLLO 5/LM-1 PROPULSION AND POWER FLIGHT DATA PCM MERGE APDFINAL MERGE REQ. L30 ANT 5

USER SPECIFIED STOP TIME,    .22927500+05

PAFRRT        .00000000        .00000000        .00000000        .00000000        .00000000
              .00000000        .00000000        .00000000        .00000000        .00000000
              .00000000        .00000000        .00000000        .00000000        .00000000
              .00000000        .22922797+05

SQRT(-X) NOT ALLOWED. EVALUATE FOR +X

SQRT  CALLED  AT  SEQUENCE  NUMBER  00174  OF  PA1

PA1   CALLED  AT  SEQUENCE  NUMBER  00475  OF  MAIN PROGRAM

SQRT(-X) NOT ALLOWED. EVALUATE FOR +X

SQRT  CALLED  AT  SEQUENCE  NUMBER  00176  OF  PA1

PA1   CALLED  AT  SEQUENCE  NUMBER  00475  OF  MAIN PROGRAM

PAFRRT        .00000000        .15661531+02     .00000000        .00000000        .63279543+01
              .00000000        .00000000        .00000000        .91026943+02     .00000000
              .00000000        .00000000        .00000000        .00000000        .00000000
              .00000000        .22923002+05

PAFRRT        .00000000        .00000000        .00000000        .00000000        .00000000
              .00000000        .00000000        .00000000        .00000000        .00000000
              .00000000        .00000000        .00000000        .79939894+02     .00000000
              .00000000        .22923092+05

PAFRRT        .80648092+02     .00000000        .00000000        .00000000        .00000000
              .00000000        .00000000        .00000000        .00000000        .00000000
              .00000000        .00000000        .00000000        .00000000        .00000000
              .00000000        .22923103+05
```

PAFRRT	.80648092+02	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.22923297+05			
PAFRRT	.79519927+02	.00000000	.00000000	.00000000	.00000000
	.87883995+02	.00000000	.00000000	.00000000	.85205638+01
	.00000000	.00000000	.66390716-00	.00000000	.00000000
	.00000000	.22923496+05			
PAFRRT	.79519927+02	.00000000	.00000000	.00000000	.00000000
	.87883995+02	.00000000	.00000000	.00000000	.85205638+01
	.00000000	.00000000	.66390716-00	.00000000	.00000000
	.00000000	.22923797+05			
PAFRRT	.00000000	.00000000	.00000000	.00000000	.72590850+01
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.72549628+02	.00000000
	.00000000	.22923902+05			
PAFRRT	.00000000	.97669734-00	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.22923996+05			
PAFRRT	.00000000	.00000000	.00000000	.00000000	.00000000
	.87036925+02	.00000000	.00000000	.90450744+02	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.22924097+05			
PAFRRT	.00000000	.00000000	.00000000	.00000000	.00000000
	.87036925+02	.00000000	.00000000	.90450744+02	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.22924597+05			
PAFRRT	.77413067+02	.00000000	.00000000	.00000000	.00000000
	.86712837+02	.00000000	.00000000	.00000000	.97292288+01
	.00000000	.00000000	.11942888+01	.00000000	.00000000
	.00000000	.22924703+05			
PAFRRT	.77413067+02	.00000000	.00000000	.00000000	.00000000

	.86712837+02	.00000000	.00000000	.00000000	.97292288+01
	.00000000	.00000000	.11942888+01	.00000000	.00000000
	.00000000	.22924796+05			
PAFRRT	.00000000	.00000000	.00000000	.00000000	.80898986+01
	.00000000	.00000000	.00000000	.00000000	.98498317+01
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.22924902+05			
PAFRRT	.82369779+02	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.80556858+02	.00000000
	.00000000	.22924997+05			
PAFRRT	.82369779+02	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.80556858+02	.00000000
	.00000000	.22925296+05			
PAFRRT	.82369779+02	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.80556858+02	.00000000
	.00000000	.22925497+05			
PAFRRT	.00000000	.32300880-00	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.11348105+03	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.22925626+05			
PAFRRT	.00000000	.00000000	.00000000	.00000000	.00000000
	.89717194+02	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.65676230-00	.00000000	.00000000
	.00000000	.22925632+05			
PAFRRT	.00000000	.00000000	.00000000	.00000000	.00000000
	.89717194+02	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.65676230-00	.00000000	.00000000
	.00000000	.22925986+05			
PAFRRT	.00000000	.00000000	.00000000	.00000000	.00000000
	.89717194+02	.00000000	.00000000	.00000000	.00000000

	.00000000	.00000000	.65676230-00	.00000000	.00000000
	.00000000	.22925992+05			
PAFRRT	.00000000	.00000000	.00000000	.00000000	.00000000
	.89717194+02	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.65676230-00	.00000000	.00000000
	.00000000	.22926097+05			
PAFRRT	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.83672736+01
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.22926297+05			
PAFRRT	.94465645+02	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.96368963+02	.00000000
	.00000000	.22926397+05			
PAFRRT	.94465645+02	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.96368963+02	.00000000
	.00000000	.22926797+05			
PAFRRT	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.96007501+02	.00000000
	.00000000	.00000000	.00000000	.81547551+02	.00000000
	.00000000	.22926897+05			
PAFRRT	.00000000	.19268118+01	.00000000	.00000000	.70414095+01
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.22926903+05			
PAFRRT	.00000000	.19268118+01	.00000000	.00000000	.70414095+01
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.22926997+05			
PAFRRT	.00000000	.19631400+01	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.98493852-00	.00000000	.00000000

	.00000000	.22927096+05			
PAFRRT	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.94377881+02	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.22927196+05			
PAFRRT	.00000000	.00000000	.00000000	.00000000	.00000000
	.89304976+02	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.22927202+05			
PAFRRT	.00000000	.00000000	.00000000	.00000000	.00000000
	.89304976+02	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.22927347+05			
PAFRRT	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.93193437+02	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.14236095+02
	.00000000	.22927397+05			

PROCESSING IS COMPLETE

PRECEDING PAGE BLANK NOT FILMED.

4.2.3 ISPALM - VEDY

```
$DATAIN
T1       =    .22287019+05,
T2       =    .22392019+05,
TDELCA   =    .25000000+01,
DELTIM   =    .20000000+00,
PCDLTM   =    .00000000+00,
XA       =    .30967200+03,
YA       =   -.51770000+01,
ZA       =    .57750000+02,
XT       =    .25190000+03,   .16350000+03,   .26610000+03,   .26610000+03,
              .30030000+03,   .30030000+03,   .30150000+03,   .30150000+03,
              .18940000+03,   .24620000+03,   .24620000+03,   .26300000+03,
              .26300000+03,   .14830000+03,   .00000000+00,   .00000000+00,
COSMG    =    .00000000+00,
COSOG    =    .00000000+00,
XP       =    .25400000+03,
YJ       =    .66099999+02,   .66099999+02,   .61500000+02,   .61500000+02,
              .66099999+02,   .66099999+02,   .61500000+02,   .61500000+02,
             -.66099999+02,  -.66099999+02,  -.61500000+02,  -.61500000+02,
             -.66099999+02,  -.66099999+02,  -.61500000+02,  -.61500000+02,
ZJ       =    .66099999+02,   .66099999+02,   .61500000+02,   .61500000+02,
             -.66099999+02,  -.66099999+02,  -.61500000+02,  -.61500000+02,
             -.66099999+02,  -.66099999+02,  -.61500000+02,  -.61500000+02,
              .66099999+02,   .66099999+02,   .61500000+02,   .61500000+02,
ACCX     =    .00000000+00,
ACCY     =    .00000000+00,
ACCZ     =    .00000000+00,
ACCLMT   =    .10000000+01,
P        =    .00000000+00,
Q        =    .00000000+00,
R        =    .00000000+00,
ANG      =    .10000000+01,
ILIMIT   =              14,
CD       =   -.17654700+00,   .10336899+03,   .00000000+00,   .00000000+00,
              .00000000+00,   .00000000+00,   .00000000+00,   .00000000+00,
              .00000000+00,   .00000000+00,   .27814130+03,  -.42257690+01,
              .25400250+00,  -.10889916-01,   .19703563-03,  -.12297903-05,
              .00000000+00,   .00000000+00,   .00000000+00,   .00000000+00,
              .20523207+01,  -.10632820-01,   .60247374-03,  -.20673059-04,
              .26910646-06,  -.11626442-08,   .00000000+00,   .00000000+00,
              .00000000+00,   .00000000+00,   .00000000+00,   .00000000+00,
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                  .00000000+00,    .00000000+00,    .00000000+00,    .00000000+00,
                  .00000000+00,    .00000000+00,    .00000000+00,    .00000000+00,
                  .00000000+00,    .35025000+02,    .35025000+02,    .55425000+02,
                  .55425000+02,    .30000000+00,    .30000000+00,    .00000000+00,
IC      =                     ,                ,                ,                ,
   ...
                              ,                ,                ,                ,
                            1,               2,               3,               4,
                            5,               6,               7,               8,
                            9,              10,              11,              12,
                           13,              14,              15,              16,
                           17,              18,              19,              20,
                           21,              22,              23,              24,
                           25,              26,              27,              28,
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                         29,          30,          31,            ,
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                           ,            ,            ,            ,
                           ,            ,            ,            ,
IK        =                ,
IK1       =                ,
TIMST     =   .22922500+05,
TIMFN     =   .22927500+05,
IT11      =                ,
IT12      =                ,
IT21      =                ,
IT22      =                ,
IT31      =             24,
IT32      =             26,
IT41      =              1,
IT42      =             21,
ISS1      =              1,           2,           3,           4,
                         5,           6,           7,           8,
                         9,          10,          11,          12,
                        13,          14,          15,          16,
                        17,          18,          19,          20,
                        21,            ,            ,          22,
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                         23,     24,      ,      ,
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                           ,       ,      ,      ,
                           ,       ,      ,      ,
ISS2    =                1227,   1228,  1229,  1230,
                         1231,   1232,  1709,  1703,
                         1706,   1712,  1715,  1710,
                         1704,   1707,  1713,  1716,
                         1705,   1708,  1714,  1717,
                         1711,   1233,      , -1751,
                        -1753,  -1755,      ,      ,
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                        ,              ,              ,              ,
TQJIS1  =   .00000000+00,
T3JIS2  =   .00000000+00,
LF      =  -.10000000+03,   .10000000+03,  -.10000000+03,   .10000000+03,
           -.10000000+03,   .10000000+03,  -.10000000+03,   .10000000+03,
           -.10000000+03,   .10000000+03,  -.10000000+03,   .10000000+03,
           -.10000000+03,   .10000000+03,  -.10000000+03,   .10000000+03,
           -.10000000+03,   .10000000+03,  -.10000000+03,   .10000000+03,
SIG1    =   .00000000+00,
SIG2    =   .00000000+00,
E1      =   .50000000+01,
EP      =   .50000000+01,
YT      =   .99000000+01,   .25000000+02,   .15100000+02,  -.15100000+02,
            .25000000+02,  -.25000000+02,   .25000000+02,  -.25000000+02,
           -.43200000+02,   .12200000+02,  -.12200000+02,   .46100000+02,
           -.46100000+02,   .47200000+02,   .00000000+00,   .00000000+00,
7T      =  -.24000000+01,   .38000000+02,  -.53500000+02,  -.53500000+02,
            .13700000+02,  -.13700000+02,   .13700000+02,  -.13700000+02,
           -.43200000+02,  -.48600000+02,  -.48600000+02,   .59999999+00,
           -.59999999+00,  -.47800000+02,   .00000000+00,   .00000000+00,
TCZ     =   .10069999+03,   .10019999+03,   .10019999+03,   .99199999+02,
            .10009999+03,   .99699999+02,   .10059999+03,   .10009999+03,
            .10000000+03,   .99899999+02,   .10039999+03,   .99599999+02,
            .10069999+03,   .99699999+02,   .10050000+03,   .99699999+02,
CF      =   .17480000+01,   .17610000+01,   .17680000+01,   .17510000+01,
            .17590000+01,   .17620000+01,   .17640000+01,   .17480000+01,
            .17620000+01,   .17480000+01,   .17480000+01,   .17830000+01,
            .17710000+01,   .17500000+01,   .17660000+01,   .17660000+01,
AT      =   .59150000+00,   .59150000+00,   .59159999+00,   .59140000+00,
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		.59159999+00,	.59130000+00,	.59100000+00,	.59220000+00,
		.59180000+00,	.59220000+00,	.59090000+00,	.59170000+00,
		.59170000+00,	.59159999+00,	.59090000+00,	.59119999+00,
KD	=	.23526400-01,	.23223540-01,	.23205400-01,	.22905280-01,
		.23291150-01,	.23048970-01,	.23225240-01,	.23047990-01,
		.23096980-01,	.23418270-01,	.23273760-01,	.22807440-01,
		.23230660-01,	.23454560-01,	.23542790-01,	.22915870-01,
KF	=	.14578720-01,	.14490850-01,	.14457680-01,	.14568210-01,
		.14590900-01,	.14482820-01,	.14443250-01,	.14553010-01,
		.14453950-01,	.14665850-01,	.14786660-01,	.14298590-01,
		.14479100-01,	.14504250-01,	.14427210-01,	.14335840-01,
DODENS	=	.00000000+00,	.00000000+00,	.00000000+00,	
DFDENS	=	.00000000+00,	.00000000+00,	.00000000+00,	
PA	=	.00000000+00,	.00000000+00,	.00000000+00,	
TFI	=	.70000000+02,	.70000000+02,	.70000000+02,	
XPLIM	=	.00000000+00,			
PFI	=	.18060000+03,	.18060000+03,	.18380000+03,	
POI	=	.18060000+03,	.18060000+03,	.18380000+03,	
CON	=	.42357399-01,	.18420000-04,	.21315230-06,	.76015099-01,
		.45149999-04,	.40462810-06,	.45969000+03,	.18000000+01,
		.78799999+01,	-.56600000+04,	.31750000+02,	.51710000+02,
		.16594000+02,	.73670000+04,	.61489000+02,	.95676000+04,
		.21345100+05,	.78802999+02,	.16995000+02,	.11761600+05,
		.13016700-01,	.48086900+01,	.12102199-03,	.14700000+02,
		.14400000+03,	.00000000+00,	.00000000+00,	.00000000+00,
		.00000000+00,	.00000000+00,		
VO	=	.41225200+04,	.41225200+04,	.63042000+05,	
VF	=	.33113500+04,	.33113500+04,	.62773000+05,	
VOTR	=	.16500000+03,	.16500000+03,	.16550000+03,	
VFTR	=	.16260000+03,	.16250000+03,	.21680000+03,	
WOTA	=	.20340000+03,	.20340000+03,	.31667000+04,	
WFTA	=	.10200000+03,	.10279999+03,	.19913000+04,	
VNOM	=	.94309999+03,	.94309999+03,	.11593000+05,	
VHL	=	.16400000+02,	.16400000+02,	.10559999+03,	
EXPAN	=	.19042000-05,	.19042000-05,	.22391000-05,	
TSI	=	.70000000+02,	.70000000+02,	.70000000+02,	
PHI	=	.20500000+04,	.20500000+04,	.20000000+04,	
MR1	=	.20000000+01,	.20000000+01,	.16000000+01,	
MR2	=	.20000000+01,	.20000000+01,	.16000000+01,	
XIM	=	.00000000+00,	.00000000+00,	.00000000+00,	.00000000+00,
		.00000000+00,	.00000000+00,	.00000000+00,	.00000000+00,

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XM      =  .00000000+00,   .00000000+00,   .00000000+00,   .00000000+00,
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DT      =  .20000000+01,
NSTAC   =              ,
NSTPAC  =              ,
NSTSP   =             1,
NSTPSP  =            20,
M       =              ,
T11     =  .00000000+00,
T22     =  .00000000+00,
NOTIN   =             1,
PCI     =  .00000000+00,   .00000000+00,   .00000000+00,   .00000000+00,
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PIFI    =  .00000000+00,   .00000000+00,   .00000000+00,   .00000000+00,
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PIOI    =  .00000000+00,   .00000000+00,   .00000000+00,   .00000000+00,
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           .00000000+00,   .00000000+00,   .00000000+00,   .00000000+00,
           .00000000+00,   .00000000+00,   .00000000+00,   .00000000+00,
TF      =  .60000000+02,   .60000000+02,   .60000000+02,
DTIN    =  .49999999-01,
KPIO    =              ,               ,               ,               ,
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                       ,               ,               ,               ,
                       ,               ,               ,               ,
KPIF    =              ,               ,               ,               ,
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ICORS   =                  ,                  ,                  ,                  ,
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                           ,                  ,                  ,                  ,
TSAVT   =    .00000000+00,
KPC     =                  ,                  ,                  ,                  ,
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IFM     =               15,
UNIT    =               14,
TS      =    .60000000+02,    .60000000+02,    .60000000+02,
INTS    =               11,
ICALAN  =              113,            1757,                  ,                  ,
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                           ,                  ,                  ,                  ,
                           ,                  ,                  ,                  ,
NUCAL   =                2,
ISTBS   =               30,
SFE     =   -.41000000+02,   -.59000000+02,   -.43100000+03,
BIAS    =    .96000000+02,   -.36400000+03,    .19000000+02,
START   =    .00000000+00,
STOP    =    .22950000+05,
PH      =    .18000000+04,    .18000000+04,    .18000000+04,
PF      =    .18000000+03,    .18000000+03,    .18000000+03,
PD      =    .18000000+03,    .18000000+03,    .18000000+03,
TCAL    =    .00000000+00,
FNOM    =    .00000000+00,    .00000000+00,    .00000000+00,    .00000000+00,
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JIC       =                  31,
NMSM      =                  24,
TAGO      =                   4,
HTAPE     =                  10,
DTAIL     =         .00000000+00,
DTMINF    =         .00000000+00,
AB        =         .00000000+00,
IHFLK     =                    ,
SH        =                1750,             1699,             1700,             1701,
                           1510,             1745,             1746,             1747,
                           1749,             1748,             1631,                 ,
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FH =

FPH =

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VDH      =                1234,       129,       130,       131,
                           132,       133,       134,       135,
                           136,       137,       138,       139,
                           140,       141,       142,       143,
                           144,      1751,      1753,      1755,
                          1752,      1754,      1756,       113,
                           114,       115,       116,       117,
                           118,       119,       120,       121,
                           122,       123,       124,       125,
                           126,       127,       128,      1631,
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                              ,          ,          ,          ,
                              ,
TAG1     =                   3,
TAG2     =                   3,
TAG3     =                    ,
TAG4     =                    ,
ISH      =                  11,
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IFPH     =               4,
IFH      =               6,
IVDH     =              40,
$END

MEASUREMENTS SELECTED
  GQ3603   GQ3604   GQ4103   GQ4104   GF4582   GF4583   GR3201   GR2121   GR2201   GR1089
  GR1101   GR3202   GR2122   GR2202   GR1099   GR1102   GP0718   GP0501   GP0201   GP0001
  GP1001   GH1461   GH1462   GH1463

BILEVELS SELECTED
  GH1418   GH1419   GH1420   GH1421   GH1422   GH1423   GH1424   GH1425   GH1426   GH1427
  GH1428   GH1429   GH1430   GH1431   GH1432   GH1433   GH1260   GH1301   GR9661   GR9662
  GR9663   GR9664   GR9665   GR9666   GR9667   GR9668   GR9609   GR9610   GR9611   GR9612
  GR9613

MASS PROPERTIES DATA INPUT
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                .00000000+00,
TAB      =      .00000000+00,     .00000000+00,     .00000000+00,     .00000000+00,
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-.00000000+00,    .00000000+00,    .00000000+00,    .00000000+00,
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SPAN	MASS	-1750	X-CG	-1699	Y-CG	-1700	Z-CG	-1701	MOMENT-XX	-1510
	MOMENT-YY	-1745	MOMENT-ZZ	-1746	PRODUCT-XY	-1747	PRODUCT-YZ	-1749	PRODUCT-XZ	-1748
	TIME	-1631								

```
VEDY    N OF ENG ON -1234     ENG ON      - 129     ENG ON      - 130     ENG ON      - 131     ENG ON      - 132
          ENG ON     - 133     ENG ON      - 134     ENG ON      - 135     ENG ON      - 136     ENG ON      - 137
          ENG ON     - 138     ENG ON      - 139     ENG ON      - 140     ENG ON      - 141     ENG ON      - 142
          ENG ON     - 143     ENG ON      - 144     P           -1751     Q           -1753     R           -1755
          PDOT       -1752     QDOT        -1754     RDOT        -1756     THRUST ENG 1- 113     THRUST ENG 2- 114
        THRUST ENG 3- 115     THRUST ENG 4- 116     THRUST ENG 5- 117     THRUST ENG 6- 118     THRUST ENG 7- 119
        THRUST ENG 8- 120     THRUST ENG 9- 121     THRUST ENG10- 122     THRUST ENG11- 123     THRUST ENG12- 124
        THRUST ENG13- 125     THRUST ENG14- 126     THRUST ENG15- 127     THRUST ENG16- 128     TIME        -1631
```

APOLLO 5/LM-1 PRORULSION AND POWER FLIGHT DATA REV.5 ANT APDALL MERGE ALL TIME REQ. 21

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USER SPECIFIED STOP TIME,    .22927500+05

SPAN          .10897717+05     .22043724+03     .15832743+02     .31257220-00     .57057055+04
              .82997284+04     .83230273+04    -.90827251+02     .16966017+03     .13595954+03
              .22924038+05

SPAN          .10898049+05     .22043876+03     .15833620+02     .31212065-00     .57057807+04
              .82999157+04     .83232562+04    -.90724834+02     .16962962+03     .13590679+03
              .22926538+05

SPAN          .10898049+05     .22043876+03     .15833620+02     .31212065-00     .57057807+04
              .82999157+04     .83232562+04    -.90724834+02     .16962962+03     .13590679+03
              .22928144+05

VEDY          .40000000+01     .20000000+01     .50000000+01     .90000000+01     .14000000+02
              .00000000        .00000000        .00000000        .00000000        .00000000
              .00000000        .00000000        .00000000        .00000000        .00000000
              .00000000        .00000000        .00000000       -.45507413-01     .00000000
              .00000000        .31043404-00     .00000000        .10070000+03     .11541053+03
              .10020000+03     .99200000+02     .11541053+03     .99699999+02     .10060000+03
              .10010000+03     .11541053+03     .99899999+02     .10040000+03     .99599999+02
              .10070000+03     .11541053+03     .10050000+03     .99699999+02     .22922891+05

VEDY          .20000000+01     .20000000+01     .90000000+01     .00000000        .00000000
              .00000000        .00000000        .00000000        .00000000        .00000000
              .00000000        .00000000        .00000000        .00000000        .00000000
              .00000000        .00000000        .17246340-02    -.26238336-01     .29194126-01
              .00000000        .17246334-00    -.10347799+00     .10070000+03     .12951536+03
              .10020000+03     .99200000+02     .49667341+02     .99699999+02     .10060000+03
```

	.10010000+03	.11541053+03	.99899999+02	.10040000+03	.99599999+02
	.10070000+03	.11541053+03	.10050000+03	.99699999+02	.22925401+05
VEDY	.20000000+01	.10000000+01	.10000000+02	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.00000000	.00000000	.00000000
	.00000000	.00000000	.17246340-02	.21571398-01	-.23609296-01
	.00000000	-.17246334-00	.10347798+00	.12955821+03	.12951536+03
	.10020000+03	.99200000+02	-.49748817+02	.99699999+02	.10060000+03
	.10010000+03	.11541053+03	.99899999+02	.10040000+03	.99599999+02
	.10070000+03	.11541053+03	.10050000+03	.99699999+02	.22926188+05

PROCESSING IS COMPLETE

5. PRODUCTION COORDINATION INFORMATION

5.1 SYSTEM REQUIREMENTS

The program is in the UNIVAC FORTRAN V language and includes NTRAN capabilities. There are no assembler language routines. The current version(s) will operate under the control of the UNIVAC SGS EXEC II system. There are no special hardware features necessary.

5.2 DECK CONFIGURATION

The control deck configuration is as shown in Figure 5-1. A description of the Input Data Deck Formats is found in paragraph 3.3.1.

5.3 TAPE DRIVES

The required tape drives are dependent on the options and assignments made by the user. The Program Complex File (PCF) and APB data tapes are input tapes for every run. The utility file for transfer of mass properties data during use of the VEDY version is normally assigned to drum. The integrator file and the history files may be assigned to tape drives, fastran units or drum at the user's discretion as described in paragraph 3.3.2.2.

5.4 PRINT AND TIME ESTIMATES

Experience to date indicates that execution time estimates depend not only on the version being run, but also the segment of the APB tape being processed. It takes approximately five minutes to examine an entire tape of 2000 or more data records of 960 words each. Added to the tape search time should be two minutes for operations to mount tapes and a four-to-one ratio of execution time to processed data (real) time. Inasmuch as each APB data tape has varying densities of bandpassed edited data, a short run on each group should be attempted to establish execution to real time.

Print line estimates may be determined approximately by summing the print options times their output intervals times their number of variables divided by five plus 1000 lines for control and input data output reports. Pages of output may be approximated by dividing the above result by 25.

5.5 DIAGNOSTICS AND TROUBLESHOOTING

There are several messages at the end of an incomplete output report which indicate trouble with the data input. The normal clerical input errors usually due to cards being out of place or incorrectly punched data will cause a message to the effect that illegal characters or bad format was encountered to appear. More detailed information concerning these and other input error messages may be found in the UNIVAC FV manual.

5.6 PROGRAM CREATED MESSAGES AND EXPLANATION

1) DPS OR APS IS REPORTED ON

If the DPS or APS is on, the program will report this situation by the above comment along with the boundary times of the firing configuration under consideration for vehicle dynamics.

2) SOME MEASUREMENTS NOT FOUND

If some of the measurements (bilevel or non-bilevel) requested from the APB tape are not found on the tape, the program stops with no output other than the above comment with the array of all measurements on the tape and the user's set of bilevel and non-bilevel arrays.

3) NO UNIQUE SOLUTION EXISTS

If the program least square fit formulation has insufficient data to return a filtered output, the above comment is given and the program will skip that portion of the program which depends on a filtered value and continue.

4) OXIDIZER REGULATOR FAILURE IN SYSTEM --- IN TIME RANGE ---.
OXIDIZER LEAKAGE RATE OF --- IN SYSTEM --- IN TIME RANGE ---.
FUEL REGULATOR FAILURE IN SYSTEM --- IN TIME RANGE ---.
FUEL LEAKAGE RATE OF --- IN SYSTEM --- IN TIME RANGE ---.

The four above self-explanatory comments are the possible statements for the helium leakage subroutine.

5) THE BEGINNING TIME --- IS LESS THAN THE TAPE STARTING TIME ---.
THE END TIME --- IS GREATER THAN THE TAPE END TIME ---.

One of the comments above is given if the LGC tape time limits do not match the burn analysis time limits.

6) SWITCH SETTING FOR LGC DATA COLLECTION CHANGED DURING PROCESSING.

This message indicates that the LGC downlink data list has changed to a mode not suitable for RCS evaluation usage. Program sets accelerations to zero at this time.

7) MEASUREMENT --- IS BAD AT TIME ---.

This comment accompanies the message, NO UNIQUE SOLUTION EXISTS, and identifies the message involved.

8) BAD RECORD ON INPUT TAPE, IGNORE, ATTEMPT TO CONTINUE.
FINAL TIME ON INPUT TAPE ---.
END OF TAPE RECORD ENCOUNTERED ON INPUT TAPE.

The above comments refer to the APB input data tape.

9) TIME = -20000 · ENCOUNTERED ON INPUT TAPE.

Appears when the end-of-tape flag (-20000) is read on the APB tape.

10) PROCESSING IS COMPLETE

This indicates that the problem was completed as specified by the input data.

5.7 LIBRARY SUBROUTINES

The library subroutines referenced are as follows:

SIN(X)	Used to find the trigonometric sine X, where X is in radians.
COS(X)	Used to find the trigonometric cosine of X, where X is in radians.
MOD(I, J)	Used to find the remainder of a fixed point division: I/J.
SQRT(X)	Used to find the square root of X.
EXP(X)	Used to raise e to the X power.

PRECEDING PAGE BLANK NOT FILMED.

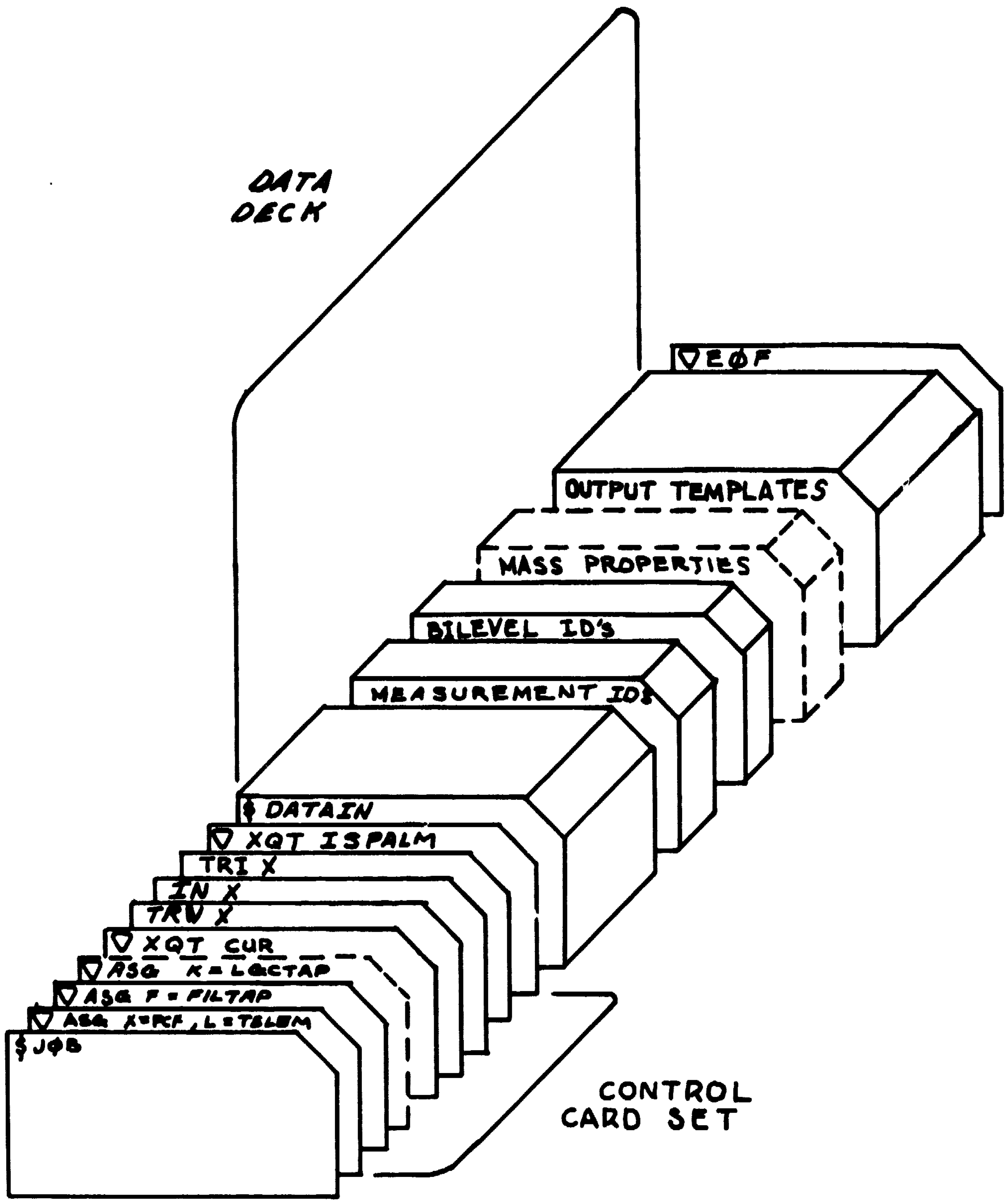

Figure 5-1. Deck Configuration

APPENDIX A

APB Data Tape

Non-Fortran Mixed Mode

Record No. 1 - Binary (8 words)

Word No.	Contents
1	Number of measurements on this tape
2	Number of words in record No. 2
3	Number of words in record No. 3
4	Number of words in record No. 4
5	Number of words in record No. 5
6	Number of words in records No. 6 through last
7-8	Reserved for future use

Record No. 2 - BCD

Information consisting of 96 characters including blanks which are contained in sixteen, six character, BCD words.

Record No. 3 - BCD

The loading numbers of up to 254 measurements which appear in a continuous stream of 6 character BCD words. Each loading number consists of 8 BCD characters; therefore, the length of the record depends on the number of measurements. If the number of characters for all the measurements is not modulo 24, the remaining characters of the last word are filled with blanks.

Record No. 4 - BCD

This record is exactly like No. 3, except the characters pertain to measurement numbers.

Record No. 5 - Binary

Word No.	Contents
1	Index word corresponding to the first loading number in record No. 3 and the first measurement ID in record number 4.
2	Delta time in seconds corresponding to the index word in word number 1.
3	Sample rate in samples/second corresponding to the index word in word number 1.
4	Index word corresponding to the second loading number in record number 3 and the second measurement ID in record number 4.
5	Delta time in seconds corresponding to the index word in word number 4.
6	Sample rate in samples/second corresponding to the index word in word number 4.
.	
.	
.	
n-2	Index word corresponding to the last loading number in record number 3 and the last measurement ID in record number 4.

n-1	Delta time in seconds corresponding to the index word in word number n-2.
n	Sample rate in samples/second corresponding to the index word in word number n.

Record length will normally be three times the number of measurements being processed. Each index word in the above record will be a fixed point quantity. Delta times and sample rates will be floating point quantities.

Record No. 6 - Last

Binary records as follows:

Word No.	Contents
1	Index Word (a) Bits 1-4 Unused (b) Bits 5-12 Index for data in word 2 (c) Bits 13-20 Index for data in word 3 (d) Bits 21-28 Index for data in word 4 (e) Bits 29-36 Index for data in word 5
2	Data
3	Data
4	Data
5	Data
6	Index word (same as described for word number 1 except the indexes apply to data in words 7, 8, 9 and 10)

Word No.	Contents
7	Data
8	Data
9	Data
10	Data
.	
.	
.	
n-4	Index word (same as described for word numbers 1 and 6 except the indexes apply to words n-3, n-2, n-1 and n).
n-3	Data
n-2	Data
n-1	Data
n	Data

Note: In records 6-last as described above, all index words will be fixed point and all data words will be floating point. Bit number 1 of each index word is the most significant (left most) bit of the word. A time word equal to -20000.0 indicates end of data on tape. Time will be in seconds.

APPENDIX B

LM Downlink Tape Format

This appendix contains Table B-1, which presents the LM-1 Downlink Tape format. This tape is generated by the LGC computer program using a Phase I tape as input. As shown in Table B-1, the Downlink Tape has 200 elements. The nomenclature identifies the element data content and the reference word gives the downlink list word number. The LGC output channel, either 34 or 35 or both, is shown for each element. The comments column is self explanatory.

Table B-1 LM Downlink Tape Format*

Element Number	Nomenclature	Reference Word	Channel	Comments
1	Range Time			Time of beginning of revolution of PCM prime frame containing Element No. 2
2	Identification Word	1	34/35	Unique Word: Word Order code is "O". Ch. 34 pattern 000000010011110. Ch. 35 pattern 000000100011111.
3	Major Mode Displayed	50	34	Bits 10-6 First Character Bits 5-1 Second Character (See Note 1)
4	Noun Displayed	49	34	Bits 10-6 First Character Bits 5-1 Second Character (See Note 1)
5	Verb Displayed	49	35	Bits 10-6 First Character Bits 5-1 Second Character (See Note 1)
6	Register R1 Display	48	34	Bit 11 Plus Sign
		47	35	Bit 11 Minus Sign
		48	35	Bits 5-1 First Character
		48	34	Bits 10-6 Second Character
		48	34	Bits 5-1 Third Character
		47	35	Bits 10-6 Fourth Character
		47	35	Bits 5-1 Fifth Character (See Note 1)

* All footnotes for this table appear on Page B29

Table B-1 LM Downlink Tape Format (Continued)*

Element Number	Nomenclature	Reference Word	Channel	Comments
7	Register R2 Display	47	34	Bit 11 Plus sign
		46	35	Bit 11 Minus Sign
		47	34	Bits 10-6 First Character
		47	34	Bits 5-1 Second Character
		46	35	Bits 10-6 Third Character
		46	35	Bits 5-1 Fourth Character
		46	34	Bits 10-6 Fifth Character (See Note 1)
8	Register R3 Display	45	35	Bit 11 Plus Sign
		45	34	Bit 11 Minus Sign
		46	34	Bits 5-1 First Character
		45	35	Bits 10-6 Second Character
		45	35	Bits 5-1 Third Character
		45	34	Bits 10-6 Fourth Character
		45	34	Bits 5-1 Fifth Character (See Note 1)
9	DSPTAB+11	50	35	Bits 15-1 Bilevel (See Note 7)
10	Input Channel 30	43	34	Bits 15-1 Bilevel (See Note 9)
11	Input Channel 31	43	35	Bits 15-1 Bilevel (See Note 9)
12	Input Channel 32	44	34	Bits 15-1 Bilevel (See Note 9)
13	Input Channel 33	44	35	Bits 15-1 Bilevel (See Note 9)
14	Output Channel 11	41	34	Bits 15-1 Bilevel (See Note 7)

* All footnotes for this table appear on Page B29

Table B-1 LM Downlink Tape Format (Continued)*

Element Number	Nomenclature	Reference Word	Channel		Comments
15	Output Channel 12	41	35	Bits 15-1	Bilevel (See Note 7)
16	Output Channel 13	42	34	Bits 15-1	Bilevel (See Note 7)
17	Output Channel 14	42	35	Bits 15-1	Bilevel (See Note 7)
18	FLAGWRD+0	39	34	Bits 15-1	Bilevel (See Note 7)
19	FLAGWRD+1	39	35	Bits 15-1	Bilevel (See Note 7)
20	FLAGWRD+2	40	34	Bits 15-1	Bilevel (See Note 7)
21	DAP BOOLS	40	35	Bits 15-1	Bilevel (See Note 7)
22	DELV X	11	34	Bit 15	Sign
				Bits 14-1	Most significant portion
			35	Bit 15	Sign
				Bits 14-1	Least significant portion of PIPA counts scaled at binary 14
23	DELV Y	12	34	Bit 15	Sign
				Bits 14-1	Most significant portion
			35	Bit 15	Sign
				Bits 14-1	Least significant portion of PIPA counts scaled at binary 14
24	DELV Z	13	34	Bit 15	Sign
				Bits 14-1	Most significant portion
			35	Bit 15	Sign
				Bits 14-1	Least significant portion of PIPA counts scaled at binary 14

* All Footnotes for this table appear on Page B29

Table B-1 LM Downlink Tape Format (Continued)*

Element Number	Nomenclature	Reference Word	Channel		Comments
25	Desired CDU X	9	35	Bits 15-1 (See Note 3)	Fractional quantity scaled at binary 0.
26	Desired CDU Y	10	34	Bits 15-1 (See Note 3)	Fractional quantity scaled at binary 0.
27	Desired CDU Z	10	35	Bits 15-1 (See Note 3)	Fractional quantity scaled at binary 0.
28	R_{N_X}	2	34	Bit 15	Sign
				Bits 14-1	Most significant portion
		2	35	Bit 15	Sign
				Bits 14-1	Least significant portion of X position in meters scaled at binary 24. (See Note 10)
29	R_{N_Y}	3	34	Bit 15	Sign
				Bits 14-1	Most significant portion
		3	35	Bit 15	Sign
				Bits 14-1	Least significant portion of Y position in meters scaled at binary 24. (See Note 10)
30	R_{N_Z}	4	34	Bit 15	Sign
				Bits 14-1	Most significant portion
		4	35	Bit 15	Sign
				Bits 14-1	Least significant portion of Z position in meters scaled at binary 24. (See Note 10)

* All footnotes for this table appear on Page B29

Table B-1 LM Downlink Tape Format (Continued)*

Element Number	Nomenclature	Reference Word	Channel	Comments
31	V_{N_X}	5	34	Bit 15 Sign Bits 14-1 Most significant portion
		5	35	Bit 15 Sign Bits 14-1 Least significant portion of X velocity in meters per centi-second scaled at binary 7 (See Note 4 & 10)
32	V_{N_Y}	6	34	Bit 15 Sign Bits 14-1 Most significant portion
		6	35	Bit 15 Sign Bits 14-1 Least significant portion of Y velocity in meters per centi-second scaled at binary 7 (See Note 4 & 10)
33	V_{N_Z}	7	34	Bit 15 Sign Bits 14-1 Most significant portion
		7	35	Bit 15 Sign Bits 14-1 Least significant portion of Z velocity in meters per centi-second scaled at binary 7 (See Note 4 & 10)
34	PIPTIME	8	34	Bit 15 Sign Bits 14-1 Most significant portion
		8	35	Bit 15 Sign Bits 14-1 Least significant portion of time in centiseconds scaled at binary 28 (See Note 2)
35	TEVENT	30	34	Bit 15 Sign Bits 14-1 Most significant portion
		30	35	Bit 15 Sign Bits 14-1 Least significant portion of time in centiseconds scaled at binary 28 (See Note 2)

*All footnotes for this table appear on Page B29

Table B-1 LM Downlink Tape Format (Continued)*

Element Number	Nomenclature	Reference Word	Channel		Comments
36	REDOCNTR	34	34	Bits 15-1	Number computer restarts scaled at binary 14
37	^ctual CDU X	35	35	Bits 15-1 (See Note 3)	Fractional quantities scaled at binary 0.
38	Actual CDU Y	36	34	Bits 15-1 (See Note 3)	Fractional quantities scaled at binary 0.
39	Actual CDU Z	36	35	Bits 15-1 (See Note 3)	Fractional quantities scaled at binary 0.
40	LMPCMD0	14	34	Bits 15-1 (See Note 7)	Octal code of one of last commands to LMP, scaled at binary 14
41	LMPCMD1	14	35	Bits 15-1 (See Note 7)	Octal code of one of last commands to LMP, scaled at binary 14
42	LMPCMD2	15	34	Bits 15-1 (See Note 7)	Octal code of one of last commands to LMP, scaled at binary 14
43	LMPCMD3	15	35	Bits 15-1 (See Note 7)	Octal code of one of last commands to LMP, scaled at binary 14
44	LMPCMD4	16	34	Bits 15-1 (See Note 7)	Octal code of one of last commands to LMP, scaled at binary 14

* All footnotes for this table appear on Page B29

Table B-1 LM Downlink Tape Format (Continued)*

Element Number	Nomenclature	Reference Word	Channel	Comments
45	LMPCMD5	16	35	Bits 15-1 Octal code of one of last commands to LMP, scaled binary 14. (See Note 7)
46	LMPCMD6	17	34	Bits 15-1 Octal code of one of last commands to LMP, scaled at binary 14. (See Note 7)
47	LMPCMD7	17	35	Bits 15-1 Octal code of one of last commands to LMP, scaled at binary 14. (See Note 7)
48	UPVERB	20	34	Verb used to initiate update. Number in octal scaled at binary 14.
49	COMPNUMB	20	35	Number of register needed for update. Scaled at binary 14.
50	STATE COUNT	21	34	Octal number of next quantity to be loaded during update. Scaled at binary 14.
51	UPOLDMOD	21	35	Octal number of major mode interrupted by update. Scaled at binary 14.
52	$STBUFF_X$	22	34	Bit 15 Sign Bits 14-1 MSP of R_{NX} in kilometers
		22	35	Bit 15 Sign Bits 14-1 LSP of R_{NX} in kilometers Scaled at binary 14
53	$STBUFF_Y$	23	34	Bit 15 Sign Bits 14-1 MSP of R_{NY} in kilometers
		23	35	Bit 15 Sign Bits 14-1 LSP of R_{NY} in kilometers Scaled binary 14

* All footnotes for this table appear on Page B29

Table B-1 LM Downlink Tape Format (Continued)*

Element Number	Nomenclature	Reference Word	Channel	Comments
54	$STBUFF_Z$	24	34	Bit 15 Sign
				Bits 14-1 MSP of R_{NZ} in kilometers
				Bit 15 Sign
				Bits 14-1 LSP of R_{NZ} in kilometers
				Scaled binary 14.
55	$STBUFF_{\dot{X}}$	25	34	Bit 15 Sign
				Bits 14-1 MSP of V_{NX} in kilometers
		25	35	Bit 15 Sign
				Bits 14-1 LSP of V_{NX} in kilometers
				Scaled binary 7
56	$STBUFF_{\dot{Y}}$	26	34	Bit 15 Sign
				Bits 14-1 MSP of V_{NY} in kilometers
		26	35	Bit 15 Sign
				Bits 14-1 LSP of V_{NY} in kilometers
				Scaled binary 7
57	$STBUFF_{\dot{Z}}$	27	34	Bit 15 Sign
				Bits 14-1 MSP of V_{NZ} in kilometers
		27	35	Bit 15 Sign
				Bits 14-1 LSP of V_{NZ} in kilometers
				Scaled binary 7
58	$STBUFF_T$	28	34	Bit 15 Sign
				Bits 14-1 MSP of "fix" time in centisecond
		28	35	Bit 15 Sign
				Bits 14-1 LSP of "fix" time in centiseconds
59	STBUFF+0 (Octal Identifier)	22	34	Octal Identifier, DPS 1 Burn
60	$STBUFF_{RP}$	22	35	Bit 15 Sign
				Bits 14-1 MSP of RP
		23	34	Bit 15 Sign
				Bits 14-1 LSP of RP, desired apogee or perigee
				Scaled at binary 24.

*All footnotes for this table appear on Page B29

Table B-1 LM Downlink Tape Format (Continued)*

Element Number	Nomenclature	Reference Word	Channel	Comments
61	STBUFF+0	22	34	Octal Identifier, DPS 2 Burn
62	$STBUFF_{CPT}$	22	35	Bit 15 Sign Bits 14-1 MSP of CPT
		23	34	Bit 15 Sign Bits 14-1 LSP of CPT, a 1/2 unit vector normal to the desired orbital plane in SM coordinates, scaled at binary zero.
63	$STBUFF_{CPT+2}$	23	35	Bit 15 Sign Bits 14-1 MSP of CPT+2
		24	34	Bit 15 Sign Bits 14-1 LSP of CPT+2, a 1/2 unit vector normal to the desired orbital plane in SM coordinates, scaled at binary zero.
64	$STBUFF_{CPT+4}$	24	35	Bit 15 Sign Bits 14-1 MSP of CPT+4
		25	34	Bit 15 Sign Bits 14-1 LSP of CPT+4, a 1/2 unit vector normal to the desired orbital plane in SM coordinates scaled at binary zero.
65	OLDBT1	9	34	Loaded with the least significant half of the last time that gyro compensation was performed at the halting of average-G computations. When average-G computations are not in progress, the cell will be updated once each 81.93 seconds with the least significant half of the computer clock at that time. Scaled at binary 14 in centiseconds.

*All footnotes for this table appear on Page B29

Table B-1 LM Downlink Tape Format (Continued)*

Element Number	Nomenclature	Reference Word	Channel	Comments
66	VGX	76	34	Bit 15 Sign Bits 14-1 Most significant portion
			35	Bit 15 Sign Bits 14-1 Least significant portion of X-velocity to be gained in meters per centisecond scaled at binary 7. (See Note 4 and 10)
67	VGY	77	34	Bit 15 Sign Bits 14-1 Most significant portion
			35	Bit 15 Sign Bits 14-1 Least significant portion of Y-velocity to be gained in meters per centisecond scaled at binary 7. (See Note 4 & 10)
68	VGZ	78	34	Bit 15 Sign Bits 14-1 Most significant portion Z-velocity to be gained in meters per centisecond scaled at binary 7.
			35	Bits 14-1 Least significant portion (See Note 4 & 10)
69	VDX	79	34	Bit 15 Sign Bits 14-1 Most significant portion X-velocity desired at cutoff in meters per centisecond scaled at binary 7.
			35	Bit 15 Sign Bits 14-1 Least significant portion (See Note 4 & 10)

*All footnotes for this table appear on Page B29

Table B-1 LM Downlink Tape Format (Continued)*

Element Number	Nomenclature	Reference Word	Channel	Comments
70	VDY	80	34	Bit 15 Sign Bits 14-1 Most significant portion Y-velocity desired at cutoff in meters per centisecond scaled at binary 7.
			35	Bit 15 Sign Bits 14-1 Least significant portion (See Note 4 & 10)
71	VDZ	81	34	Bit 15 Sign Bits 14-1 Most significant portion Z-velocity desired at cutoff in meters per centisecond scaled at binary 7
			35	Bit 15 Sign Bits 14-1 Least significant portion (See Note 4 & 10)
72	RBO X	82	34	Bit 15 Sign Bits 14-1 Most significant portion X-position desired at cutoff in meters scaled at binary 25.
			35	Bit 15 Sign Bits 14-1 Least significant portion (See Note 10)
73	RBO Y	83	34	Bit 15 Sign Bits 14-1 Most significant portion Y position desired at cutoff in meters scaled at binary 25
			35	Bit 15 Sign Bits 14-1 Least significant portion (See Note 10)

*All footnotes for this table appear on Page B29

Table B-1 LM Downlink Tape Format (Continued)*

Element Number	Nomenclature	Reference Word	Channel	Comments
74	RBO Z	84	34	Bit 15 Sign Bits 14-1 Most significant portion Z-position desired at cutoff in meters scaled at binary 25
			35	Bit 15 Sign Bits 14-1 Least significant portion (See Note 10)
75	TTGO	75	34	Bit 15 Sign Bits 14-1 Most significant portion. Estimated time to cutoff in centiseconds scaled at binary 28.
			35	Bit 15 Sign Bits 14-1 Least significant portion (See Note 2)
76	TENGINEON	33	34	Bit 15 Sign Bits 14-1 Most significant portion. Predicted time of engine on in centiseconds, scaled at binary 28.
			35	Bit 15 Sign Bits 14-1 Least significant portion (See Note 2)
77	IMODE 30	29	34	Bits 15-1 Bilevel (See Note 7)
78	IMODE 33	29	35	Bits 15-1 Bilevel (See Note 7)
79	THRUSTCMD	31	34	Bit 1t Sign Bits 14-1 Most significant portion. Percent thrust called for by LGC, scaled at binary 14.
			35	Bit 15 Sign Bits 14-1 Least significant portion. (See Note 8)

*All footnotes for this table appear on Page B29

Table B-1 LM Downlink Tape Format (Continued)*

Element Number	Nomenclature	Reference Word	Channel	Comments
80	AOSQ	32	34	Bit 15 Sign Bits 14-1 Angular acceleration due to ascent engine offset. Scaled at binary -2 in revolutions/sec^2. (See Note 5)
81	AOSR	32	35	Bit 15 Sign Bits 14-1 Angular acceleration due to ascent engine offset. Scaled at binary -2 in revolution/sec^2. (See Note 5)
82	OMEGA	37	34	Bit 15 Sign Bits 14-1 Estimate by DAP of vehicle rate. Scaled binary -3 in revolutions/second. (See Note 6)
83	OMEGAR	37	35	Bit 15 Sign Bits 14-1 Estimate by DAP of vehicle rate. Scaled binary -3, in revolutions/second. (See Note 6)
84	OMEGA	38	35	Bit 15 Sign Bits 14-1 Estimate by DAP of vehicle rate. Scaled binary -3 in revolutions/second. (See Note 6)
85	PHASENUM	74	34	The number of the mission phase currently being performed (0,1,2,3,4,6,7,8,9,11, or 13) Scaled at binary 14.

*All footnotes for this table appear on Page B29

Table B-1 LM Downlink Tape Format (Continued)*

Element Number	Nomenclature	Reference Word	Channel	Comments
86	MPHASE4	70	34	Mission Phase Register 4. Initially Set at -0 Set to 8 at the end of mission phase 7. Scaled at binary 14.
87	MPHASE3	70	35	Mission Phase Register 3. Initially set at -0. and will not be reset for this mission.
88	MPHASE2	71	34	Mission Phase Register 2. Initially set at -0. Set to 9 at the end of mission phase 8. Reset to -0 during phase 9 and set to 13 at the end of mission phase 11. Scaled at binary 14.
89	MPHASE1	71	35	Mission Phase Register 1. Initially set at -0. Set to 7 at the end of mission phase y. Reset to -0 during phase 7 and set to 11 at the end of mission phase 9. Scaled at binary 14.
90	MTIMER4	72	34	Mission Timer Register 4. Initially set at -0. Loaded with time interval (a constant loaded into temporary storage during prelaunch) between the end of mission phase 7 and the start of mission phase 8 at the conclusion of phase 7. The register will be counted down to zero during the time interval and reset to -0 at the beginning of phase 8. Scaled at binary 14 in seconds.
91	MTIMER3	72	35	Mission Timer Register 3. Initially set at -0 and will not be reset for this mission.

*All footnotes for this table appear on Page B29

Table B-1 LM Downlink Tape Format (Continued)*

Element Number	Nomenclature	Reference Work	Channel	Comments
92	MTIMER2	73	34	Mission Timer Register 2. Initially set at -0. Loaded with time interval, (a constant loaded into temporary storage during prelaunch) between the end of mission phase 8 and the start of mission phase 9 at the conclusion of phase 8. The register will be counted down to zero during the time interval and reset to -0 at the beginning of phase 9. Scaled at binary 14 in seconds.
93	MTIMER1	73	35	Mission Timer Register 1. Initially set at -0. Loaded with time interval, (a constant loaded into temporary storage during prelaunch) between the end of mission phase 6 and the start of mission phase 7 at the conclusion of phase 6. The register will be counted down to zero during the time interval and reset to -0 at the beginning of phase 7. Scaled at binary 14 in seconds.
94	LMP In	18	34	Index marker in decimal scaled at binary 14.
95	LMP Out	18	35	Index marker in decimal scaled at binary 14.
96	ALPHAR	19	34	Body axis accel. derived by DAP. Scaled at binary -4 in rev/sec^2. (See Note 5)
97	S FAIL	34	35	Return address from error subroutine set during computer self-check. No scaling required. (Binary printout)

*All footnotes for this table appear on Page B29

Table B-1 LM Downlink Tape Format (Continued)*

Element Number	Nomenclature	Reference Word	Channel	Comments
98	TIME 6	35	34	Computer clock register. Scaled at binary 10 in centiseconds. (See Note 2)
99	ALPAQ	38	34	Body axis acceleration. Scaled at binary -4 Rev/sec^2. (See Note 5)
100	1dPIPADT	9	34	Interval of time used for summing ΔV pulses. Scaled at binary 8 in centiseconds. (See Note 2)
101	AGC Time	51	34	Bit 15 Sign Bits 14-1 Most significant portion
			35	Bit 15 Sign Bits 14-1 Least significant portion of computer clock time in centiseconds scaled at binary 28. (See Note 2)
102	Spare			
103	Major Mode Displayed	100	34	Bits 10-6 First Character Bits 5-1 Second Character (See Note 1)
104	Noun Displayed	99	34	Bits 10-6 First Character Bits 5-1 Second Character (See Note 1)

*All footnotes for this table appear on Page B29

Table B-1 LM Downlink Tape Format (Continued)*

Element Number	Nomenclature	Reference Word	Channel	Comments
105	**Verb Displayed**	99	35	Bits 10-6 First character Bits 5-1 Second character (See Note 1)
106	**Register R1 Display**	98	34	Bit 11 Plus sign
		97	35	Bit 11 Minus sign
		98	35	Bits 5-1 First character
		98	34	Bits 10-6 Second character
		98	34	Bits 5-1 Third character
		97	35	Bits 10-6 Fourth character
		97	35	Bits 5-1 Fifth character (See Note 1)
107	**Register R2 Display**	97	34	Bit 11 Plus sign
		96	35	Bit 11 Minus sign
		97	34	Bits 10-6 First character
		97	34	Bits 5-1 Second character
		96	35	Bits 10-6 Third character
		96	35	Bits 5-1 Fourth character
		96	34	Bits 10-6 Fifth character (See Note 1)
108	**Register R3 Display**	95	35	Bit 11 Plus sign
		95	34	Bit 11 Minus sign
		96	34	Bits 5-1 First character
		95	35	Bits 10-6 Second character
		95	35	Bits 5-1 Third character
		95	34	Bits 10-6 Fourth character
		95	34	Bits 5-1 Fifth character (See Note 1)
109	DSPTAB+11	100	35	Bits 11-1 Bilevel (See Note 1)

* All footnotes for this table appear on Page B29

Table B-1 LM Downlink Tape Format (Continued)*

Element Number	Nomenclature	Reference Word	Channel	Comment
110	Input Channel 30	93	34	Bits 15-1 Bilevel (See Note 7)
111	Input Channel 31	93	35	Bits 15-1 Bilevel (See Note 7)
112	Input Channel 32	94	34	Bits 15-1 Bilevel (See Note 7)
113	Input Channel 33	94	35	Bits 15-1 Bilevel (See Note 7)
114	Output Channel 11	91	34	Bits 15-1 Bilevel (See Note 7)
115	Output Channel 12	91	35	Bits 14-1 Bilevel (See Note 7)
116	Output Channel 13	92	34	Bits 15-1 Bilevel (See Note 7)
117	Output Channel 14	92	35	Bits 15-1 Bilevel (See Note 7)
118	FLAGWRD+0	89	34	Bits 15-1 Bilevel (See Note 7)
119	FLAGWRD+1	89	35	Bits 15-1 Bilevel (See Note 7)
120	FLAGWRD+2	90	34	Bits 15-1 Bilevel (See Note 7)
121	DAP BOOLS	90	35	Bits 15-1 Bilevel (See Note 7)
122	COMPTORK+0	52	34	Bit 15 Sign Bits 14-1 Most significant portion
			35	Bit 15 Sign Bits 14-1 Least significant portion of gyro torquing pulses scaled at binary 21 in pulses where each pulse = 0.617 sec.
123	COMPTORK+2	53	34	Bit 15 Sign Bits 14-1 Most significant portion
			35	Bit 15 Sign Bits 14-1 Least significant portion of gyro torquing pulses scaled at binary 21 in pulses where each pulse = 0.617 sec.

*All footnotes for this table appear on Page B29

Table B-1 LM Downlink Tape Format (Continued)*

Element Number	Nomenclature	Reference Word	Channel	Comment
124	COMPTORK+4	54	34	Bit 15 Sign Bits 14-1 Most significant portion
			35	Bit 15 Sign Bits 14-1 Least significant portion of gyro torquing pulses scaled at binary 21 in pulses where each pulse = 0.617 sec.
125	FAILREG	55	34	Binary printout only.
126	FAILREG+1	55	35	Binary printout only.
127	FAILREG+2	56	34	Binary printout only.
128	ALMCADR	56	35	Calling address of "abort" or "alarm" program requested by the computer. Printout in binary.
129	ALMCADR+1	57	34	Address of the cell following the one actually doing the calling. Printout in binary.
130	ERCOUNT	57	35	Count of the number of LGC self-check failures. Scaled at binary 14 as decimal counts.
131	PIPA X	58	34	Accumulated counts at the output of the "X" accelerometer scaled at binary 14 in counts.
132	PIPA Y	58	35	Accumulated counts at the output of the "Y" accelerometer scaled at binary 14 in counts.
133	PIPA Z	59	34	Accumulated counts at the output of the "Z" accelerometer scaled at binary 14 in counts.
134	RHCP	59	35	Computer pitch rate command information. Scaled at binary 14 in counts, where each count = 0.625605 D/S. Not used in flight.

*All footnotes for this table appear on Page B29

Table B-1 LM Downlink Tape Format (Continued)*

Element Number	Nomenclature	Reference Word	Channel	Comment
135	STATE+4	60	34	Bit 15-1 Bilevel (See Note 7)
136	LMPJFAIL	60	35	Monitor of LMP closures to RCS isolation valves. Printout the binary form.
137	Actual CDU X	85	35	Bits 15-1 Fractional quantities scaled at binary 0. (See Note 3)
138	Actual CDU Y	86	34	Bits 15-1 Fractional quantities scaled at binary 0. (See Note 3)
139	Actual CDU Z	86	35	Bits 15-1 Fractional quantities scaled at binary 0. (See Note 3)
140	LMP CMD0	64	34	Bits 15-1 Octal code of one of last commands to LMP, scaled at binary 14. (See Note 7)
141	LMP CMD1	65	34	Bits 15-1 Octal code of one of last commands to LMP, scaled at binary 14. (See Note 7)
142	LMP CMD2	65	34	Bits 15-1 Octal code of one of last commands to LMP, scaled at binary 14. (See Note 7)
143	LMP CMD3	65	35	Bits 15-1 Octal code of one of last commands to LMP, scaled at binary 14. (See Note 7)
144	LMP CMD4	66	34	Bits 15-1 Octal code of one of last commands to LMP, scaled at binary 14. (See Note 7)

*All footnotes for this table appear on Page B29

Table B-1 LM Downlink Tape Format (Continued)*

Element Number	Nomenclature	Reference Word	Channel	Comment
145	LMP CMD5	66	35	Bits 15-1 Octal code of one of last commands to LMP, scaled at binary 14. (See Note 7)
146	LMP CMD6	67	34	Bits 15-1 Octal code of one of last commands to LMP, scaled at binary 14. (See Note 7)
147	LMP CMD7	67	35	Bits 15-1 Octal code of one of last commands to LMP, scaled at binary 14. (See Note 7)
148	EDOTP	19	35	Error in calculated angular rate, scaled at binary -3 in rev/sec. (See Note 6)
149	STBUFF+0 (Octal Identifier)	22	34	Octal Identifier, APS 2 burn.
150	$STBUFF_{R1VEC}$	22	35	Bit 15 Sign Bits 14-1 MSP of R1VEC, a target position vector in meters.
		23	34	Bit 15 Sign Bits 14-1 LSP of R1VEC, a target position vector in meters scaled at binary 25.
151	$STBUFF_{R1VEC+2}$	23	35	Bit 15 Sign Bits 14-1 MSP of R1VEC+2, a target position vector in meters.
		24	34	Bit 15 Sign Bits 14-1 LSP of R1VEC+2, a target position vector in meters scaled at binary 25.

*All footnotes for this table appear on Page B29

Table B-1 LM Downlink Tape Format (Continued)*

Element Number	Nomenclature	Reference Word	Channel	Comment
152	$STBUFF_{R1VEC+4}$	24	35	Bit 15 Sign Bits 14-1 MSP of R1VEC+4, a target position vector in meters
		25	34	Bit 15 Sign Bits 14-1 LSP of R1VEC+4, a target position vector in meters, scaled at binary 25.
153	$STBUFF_{TINT}$	25	35	Bit 15 Sign Bits 14-1 MSP of TINT, time from LGC clock zero to intercept in centiseconds. Bit 15 Sign Bits 14-1 LSP of TINT, time from LGC clock zero to intercept in centiseconds, scaled at binary 28.
154	$STBUFF_{RCO}$	26	35	Bit 15 Sign Bits 14-1 MSP of RCO, desired radius at cutoff in meters.
		27	34	Bit 15 Sign Bits 14-1 LSP of RCO, desired radius at cutoff in meters, scaled at binary 25.
155	$STBUFF_{LMP}$	22	34	Bit 15 Sign Bits 14-1 LMP commands scaled at binary 14 in octal.
156	STBUFF+0 (Index Marker)	22	34	Bit 15 Sign Bits 14-1 Index of times to be updated in decimal scaled at binary 14.
157	$STBUFF_{\Delta T}$	22	35	Bit 15 Sign Bits 14-1 ΔT to be applied to the selected timer in seconds scaled at binary 14.

*All footnotes for this table appear on Page B29

Table B-1 LM Downlink Tape Format (Continued)*

Element Number	Nomenclature	Reference Word	Channel	Comments	
158	STBUFF+0 (Index Marker)	22	34	Bit 15	Sign
				Bits 14-1	Index of Mission Phase register to be changed in decimal, scaled at binary 14.
159	STBUFF+1 (New Phase)	22	35	Bit 15	Sign
				Bits 14-1	Desired new phase in decimal, scaled at binary 14.
160	STBUFF+0 (Index Marker)	22	34	Bit 15	Sign
				Bits 14-1	Index of timer-phase register pairs to be updated in decimal scaled at binary 14.
161	STBUFF+1 (New Phase)	22	35	Bit 15	Sign
				Bits 14-1	Desired new phase in decimal, scaled at binary 14.
162	$STBUFF_{\Delta T}$	23	34	Bit 15	Sign
				Bits 14-1	ΔT to be applied to the selected times in seconds scaled at binary 14.
163	STBUFF+0 (Index Marker)	22	34	Bit 15	Sign
				Bits 14-1	Index of Function Inhibit/Enable to be updated in decimal scaled at binary 14.
164	STBUFF+0 (LGC Clock Align)	22	34	Bit 15	Sign
				Bits 14-1	Incremental time in centiseconds to set into the LGC clock, scaled at binary 28.

*All footnotes for this table appear on Page B29

Table B-1 LM Downlink Tape Format (Continued)*

Element Number	Nomenclature	Reference Word	Channel	Comments
165	OLDBT1	74	35	Same as element number 65.
166	$UNAFC_X$	76	34	Bit 15 Sign Bits 14-1 Most significant portion.
		76	35	Bit 15 Sign Bits 14-1 Least significant portion of required X thrust acceleration in meters/centisecond^2. Scaled at binary 1.
167	$UNAFC_Y$	77	34	Bit 15 Sign Bits 14-1 Most significant portion.
		77	35	Bit 15 Sign Bits 14-1 Least significant portion of required Y thrust acceleration in meters/centisecond^2. Scaled at binary 1.
168	$UNAFC_Z$	78	34	Bit 15 Sign Bits 14-1 Most significant portion.
		78	35	Bit 15 Sign Bits 14-1 Least significant portion of required Z thrust acceleration in meters/centisecond^2. Scaled at binary 1.
169	T_{PIP}	79	34	Bit 15 Sign Bits 14-1 Least significant part of PIP time. Present only during mission phase 11. Scaled at binary 14 in centiseconds.

*All footnotes for this table appear on Page B29

Table B-1 LM Downlink Tape Format (Continued)*

Element Number	Nomenclature	Reference Word	Channel	Comment
170	AVGEXIT	79	35	Octal word used to control computational cycling during targeting for DPS2 burn.
171	MASS	80	34	Bits 15-1 Most significant part of the estimated value of vehicle mass. Scaled at binary 15 in kilograms.
172	TMPHASE	80	35	Bits 14-9 Telemetry index number. Bits 8-1 The address in octal of computations performed when a telemetry interrupt is received.
173	THRUSTMAG	81	34	Bit 15 Sign Bit 14-1 Magnitude of the required thrust acceleration vector. Scaled at binary 6 in meters/centiseconds^2.
174 - 181 Spares				
182	OMEGA (P)	87	34	Bit 15 Sign Bits 14-1 Estimate by DAP of vehicle rate. Scaled binary -3 in revolutions/sec. (See Not 6)
183	OMEGA (Q)	87	35	Bit 15 Sign Bits 14-1 Estimate by DAP of vehicle rate. Scaled binary -3 in revolution/sec. (See Note 6)

*All footnotes for this table appear on Page B29

Table B-1 LM Downlink Tape Format (Continued)*

Element Number	Nomenclature	Reference Word	Channel	Comments
184	OMEGA (R)	88	35	Bit 15 Sign Bits 14-1 Estimate by DAP of vehicle rate. Scaled binary -3, in revolutions/sec. (See Note 6)
185	MASS	61	34	Bit 15 Sign Bits 14-1 Most significant portion
		61	35	Bit 15 Sign Bits 14-1 Least significant portion of mass scaled at binary 15 in kilogrms. (See Note 12)
186	CDUY 1	62	34	Value of CDUY at snapshot time. Fractional quantity scaled at binary zero. (See Note 3)
187	CDUZ 1	62	35	Value of CDUZ at snapshot time. Fractional quantity scaled at binary zero. (See Note 3)
188	CDUY 2	63	34	Value of CDUY at 0.28 ms after element 138. Fractional quantity scaled at binary zero. (See Note 3)

*All footnotes for this table appear on Page B29

Table B-1 LM Downlink Tape Format (Continued)

Element Number	Nomenclature	Reference Word	Channel	Comment
189	CDUZ 2	63	35	Value of CDUZ at 0.28 ms after element 139. Fractional quantity scaled at binary zero. (See Note 3)
190	DELAREA	69	34	Bit 15 Sign Bits 14-1 Most significant portion.
		69	35	Bit 15 Sign Bits 14-1 Least significant portion of D. E. nozzle erosion. Scaled at binary 7 in percent.
191 - 193	Spare			
194	LMP IN	68	34	Index marker in decimal scaled at binary 14.
195	LMP OUT	68	35	Index marker in decimal scaled at binary 14.
196	Spare			
197	Spare			
198	TIME 6	85	34	Computer clock register. Scaled at binary 10 in centiseconds. (See Note 2)
199	ALPA Q	88	34	Body axis acceleration. Scaled at binary -4 in rev/sec^2. (SeeNote 5)
200	1d PIPA DT	74	35	Interval of time used for summing ΔV pulses. Scaled at binary 8 in centiseconds. (See Note 2)

*All footnotes for this table appear on Page B29

Table B-1 LM Downlink Tape Format (Continued)

Notes:

1. If Bits 15-12 are 1110/2, then Bits 10-1 must be complemented. Each character is controlled by a group of 5 latching relays. Once these relays are activated, the character remains until changed. The codes for the characters are as follows:

Character	Code (Octal)	Character	Code (Octal)
Blank	00	5	36
0	25	6	34
1	03	7	23
2	31	8	35
3	33	9	37
4	17		

2. Divide value by 10^2 to provide parameter in seconds.

3. Multiply value by 360 to provide parameter in degrees. Negative values are not complemented.

4. Multiply value by 10^2 to provide parameter in m/sec.

5. Multiply value by 57.29578 to obtain degrees per second^2.

6. Multiply value by 57.29578 to obtain degrees per second^2.

7. Data word should not be complemented if bit 15 is a one.

8. Multiply value by 1/38.82 to convert to percent.

9. Always complement this word. Data is inverted.

10. Multiply all metric position and velocity data by $\frac{1}{0.3048}$ to convert to International feet.

11. For double precision words, modify as follows to shorten word to 27 bits plus sign:
    a. All position and velocity data drop the least significant bit.
    b. All time words drop the most significant bit.
    c. Unit vector data drop the least significant bit.

APPENDIX C

HISTORICAL TAPE FORMAT

This tape is generated by the Integrated System Performance Analysis Program on the UNIVAC 1108 under EXEC II. It has two header records followed by a specified number of template records and a variable number of data records. The last data record is followed by a special terminal record in the same format as the data record. All records are written using Fortran unformated, binary write statements and consist of 36 bit words from a mixed mode source. An explanation of each type of record follows.

Two Header Records:

Number 1. Sixteen words which are the 96 alphanumeric characters of the tape identification.

Number 2. One integer word indicating the number of template records that follow.

Template Record:

Each record has a template identifier, a label count, and a corresponding number of labels.

Word No 1. Six alphanumeric characters which are the template identifier. The tape terminal identifier, 'THEEND', is the only combination of alphanumeric characters which may not be used.

Word No 2. An integer indicating the number of labels which follow in the template.

Label. Each label has a three word group as follows:

Words 1 and 2. Twelve alphanumeric characters which identify a variable in the corresponding position in data records having the matching template identifier.

Word 3. A corresponding integer value identifier.

Data Record:

Each record has its identifier, a data value count, and a corresponding number of data values.

Word No 1. Six alphanumeric characters that match the corresponding template identifier which will be used to identify the data values contained in the data record.

Word No 2. The number (N) of data values which follow.

Word No 3 (N+2). The data values.

Terminal Record.

This record has the same format as the data records. Its identifier is the six letters 'THEEND'; the remaining words in the record are dummy values of no significance to the user.

REFERENCES

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2) LED 320-7, "Integrated RCS/APS PA-1 Series II Test Program - Analysis of RCS Test Data," D. SEDGLEY Et Al.

3) LSG 770-430-LM, "Propulsion & RCS Subsystem Study Guide Lunar Module," William Strasburger, February 1968.

4) MSC-ED-P-67-63, "MSC Internal Technical note D Data Processing Plan for Apollo 5 LM-1," Requirements and Analysis Section of the Computation Branch and LEC Support, Personnel B.

5) 66MA3983 "Definition of CSM-RCS System Performance," G. W. Jeffs, November 10, 1966.