APOLLO

GUIDANCE AND NAVIGATION

E-1142 (REV. 16)

(UNCLASSIFIED TITLE)

SYSTEMS STATUS REPORT

January 15, 1964

MIT INSTRUMENTATION LABORATORY

CAMBRIDGE 39, MASSACHUSETTS

CONFIDENTIAL

APOLLO

GUIDANCE AND NAVIGATION

Approved: Milton B. Trageser Date: 1/14/64
MILTON B. TRAGESER, DIRECTOR
APOLLO GUIDANCE AND NAVIGATION PROGRAM

Approved: Roger B. Woodbury Date: 1/27/64
ROGER B. WOODBURY, DEPUTY DIRECTOR
INSTRUMENTATION LABORATORY

E-1142 (REV. 16)

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ABSTRACT

The System Status Report is distributed monthly on the 15th. This month's revision (E-1142, Rev. 16) contains, in general, the following information for the Block I and II Command Module and LEM equipment configurations: weights, centers of gravity, moments of inertia, power requirements, status of computer programs, and reliability figures.

Section 1

INTRODUCTION

1-1 INTRODUCTION

The System Status Reports to this date have applied to the so called Block I G&N configuration. The definition of what constitutes both Block I and Block II Command Module hardware as well as LEM hardware (see Glossary) has reached the stage where monthly reporting on Block II as well as Block I and LEM G&N hardware can be included in the System Status Report.

The following information is included in this month's report:

(1) Command Module, Block I - weights, centers of gravity, moments of inertia, and power requirements.

(2) Command Module, Block II - weights, power requirements, status of computer programs and reliability figures.

(3) LEM - weights, power requirements, and reliability figures.

Weights in this report for both the Block I and Block II Command Module are based upon current Block I design releases. The Lunar Excursion Module weights are based on the best estimate of those expected for the LEM design release which will occur early this year.

1-2 ACCURACY

The accuracy of numerical values reported in this revision should not be considered to be within the tolerances implied by the significant figures quoted. The reported values, although based upon the most current information, are subject to normal changes as design and development phases approach completion.

COMMAND MODULE

Section 2

BLOCK I COMMAND MODULE DATA

2-1 WEIGHTS

Table 2-I presents the weights of all Block I equipment, grouped according to specific location within the Command Module. Weights are reported to the component level and to the nearest tenth of a pound.

Given component weights are identified as estimated, calculated, and measured in the order of increasing accuracy. These terms are defined by North American Aviation as follows.

Estimated weights (E) are based on rough calculations. Calculated weights (C) are based on detailed calculations made from final production drawings that will be used to build flyable equipment. Measured weights (M) are the actual weights of equipment built to the production drawings.

Since most weight values now reported can be classified as only estimated weights, MIT herein affixes a prime to the (E) symbol, i.e., (E'), to denote values which MIT, for various reasons, feels to be more accurate than estimated values, yet which cannot be defined as either calculated or measured weights.

North American Aviation will provide and be responsible for coldplate weights which are not integral with guidance and navigation equipment.

2-1.1 WEIGHTS STATUS REPORTING. Table 2-I also offers a comparison of present component weight values with those listed in System Status Report, E-1142 (Rev. 15), December 15, 1963. All weight changes are explained in paragraph 2-2.

2-1.2 SPEC. WEIGHT. The "Spec. Weight" column in table 2-I contains "proposed MSC weights," that is, goals set forth by MSC in a memo to MIT dated December 5, 1962.

2-1.3 DESIGN LOAD WEIGHT. The "Design Load Weight" column contains worst-estimate design weights assigned to G&N subassemblies attached to the spacecraft structure. These values are included in this report as the result of an S&ID request, at NASA Coordination Meeting No. 8, that one total weight figure for supported G&N load be assigned for structural design use. MIT herein assigns a

Table 2-I. Current Weight Status of Block I Command Module (lbs at 1 g)

Item	Spec. Wt. 12/62 (a)	(b-a)	Status 12/63 (b)	(c-b)	Status 1/64 (c)	Design Load Wt. 1/64 (d)
LOWER EQUIPMENT BAY						
CDU & Frame Assy	6.0	8.5	14.5(M)	0.0	14.5(M)	17.2
Optical Subsystem						
SXT	12.0	0.0	12.0(E)	+ 2.6	14.6(C)	
SCT	9.0	0.0	9.0(E)	+ 4.8	13.8(C)	
Optical Base & Gearing	14.0	+ 7.0	21.0(E)	- 4.3	16.7(E)	
Optical Eyepieces						
SXT	2.0	+ 1.8	1.5(E)	- 0.2	1.3(E)	154.2
SCT			2.3(E)	0.0	2.3(E)	
IMU	40.0	+ 20.2	60.2(M)	0.0	60.2(M)	
NVB & Shock Mounts	16.0	+ 11.2	27.2(E)	0.0	27.2(E)	
Bellows Assy	8.0	+ 4.6	12.6(E)	+ 0.9	13.5(M)	
G&N Interconnection Assy	30.0	+ 13.2	35.2(E)	0.0	35.2(E)	42.8
G&N to S/C Interface Assy			8.0(E)	0.0	8.0(E)	
D&C Nav Station						
IMU Control Panel			2.4(M)	0.0	2.4(M)	6.8
D&C Electronics			2.9(M)	0.0	2.9(M)	7.7
Control Electronics	30.3	- 7.4	2.9(E')	0.0	2.9(E')	
Optical Shroud			5.2(M)	0.0	5.2(M)	4.2
G&N Ind Cont Panel			9.5(M)	0.0	9.5(M)	13.2
D&C/AGC	15.0	+ 4.6	19.6(C)	0.0	19.6(C)	19.4
MDV (including 1 film)	5.0	+ 3.5	8.5(E)	- 0.8	7.7(C)	10.0
AGC (no spares)	80.0	- 10.0	70.0(E)	0.0	70.0(E)	126.4
PSA	25.0	+ 34.4	59.4(E')	0.0	59.4(C)	65.0
Coolant Hoses	0.0	+ 1.0	1.0(E')	0.0	1.0(E')	

(cont)

Table 2-I. Current Weight Status of Block I Command Module (lbs at 1 g) (cont)

Item	Spec. Wt. 12/62 (a)	(b-a)	Status 12/63 (b)	(c-b)	Status 1/64 (c)	Design Load Wt. 1/64 (d)
MAIN PANEL AREA						
D&C/AGC	5.0	+ 14.5	19.5(C)	0.0	19.5(C)	17.2
D&C/NAV	8.0	- 8.0	--	--	--	
LOOSE STORED ITEMS						
Eye Relief Eyepieces	--	+ 1.5	1.5(E)	0.0	1.5(E)	
Film Cartridges (4)	--	+ 3.0	3.0(E)	- 0.6	2.4(E)	
Horizon Photometer	--	+ 3.6	3.6(E)	0.0	3.6(E)	
TOTAL	305.3	+107.2	412.5	+ 2.4	414.9	*484.1
List of Possible Spares for Block I						* Does not include loose stored items
AGC Spare Logic Tray	20.0	+ 58.8	25.0(E)	0.0	25.0(E)	
AGC Spare Memory Tray			34.6(E)	0.0	34.6(E)	
PSA Spare (Unique) Modules			16.7(E)	0.0	16.7(E)	
CDU Spare			2.5(E)	0.0	2.5(M)	
Spare Relay & Diode Module	--	+ 0.3	0.3(E)	0.0	0.3(E)	

total G&N design load weight, in table 2-I, which does not include items termed "loose stored items." The breakdown of this total weight into the individual items of column "d" is typical only.

2-2 REPORTED WEIGHT CHANGES

The Block I weight status summerized in table 2-I this month separates the weight of possible spares from the main body of the table. This was done in recognition of the Development Test Plan activities now under way at S&ID which are defining Block I G&N usage. Since any spacecraft flights involving Block I G&N hardware will be unmanned or of only limited duration, the need for carried spares is doubtful. (Block II G&N will carry no spares in any event.) Because Block I was originally designed to use spares for inflight repair the weight of possible spares is listed separately for information in table 2-I.

Other changes since last month's report, E-1142 (Rev. 15), December 15, 1963 shown in table 2-I are explained below.

2-2.1 SXT, SCT, SXT EYEPIECE, AND OPTICAL BASE AND GEARING. These weight changes are based upon Kollsman's "Apollo Optical Unit Center of Gravity Report" dated 15 December 1963. The weights were arrived at by weighting approximately 70 percent of the parts which were built to production drawings, and mathematically calculating the weights of the remaining parts which were unavailable.

Studs, screws, wire, insulation, cable clamps, grommets, cement, dowel pins, lacing tape, lock rings, etc., were considered individually negligible as far as weight is concerned; however, these parts do constitute approximately 25 percent of the total parts of the unit. Therefore, an estimate of two pounds was made for the weight of these components.

2-2.2 BELLOWS ASSEMBLY. The 0.9-pound increase is due to the weighing of the SXT and SCT bellows, bellows seals, and supporting hardware.

2-2.3 MDV AND FILM CARTRIDGES. These weight decreases are based upon a parts weight breakdown list received from Kollsman Instrument Corporation.

2-3 CENTERS OF GRAVITY

Table 2-II presents the centers of gravity of each weight component or packaged assembly, determined with respect to the basic X, Y, Z axes of the Command Module. Center of gravity values are given to the nearest tenth of an inch.

2-4 MOMENTS OF INERTIA

Table 2-II also presents the moments of the inertia of each weight component or packaged assembly, determined about each of the component axes which (1) run through the center of gravity of the component and (2) are parallel to the basic X, Y, and Z axes of the Command Module.

2-5 COMMAND MODULE POWER REQUIREMENTS

The power requirements of the Command Module G&N equipment on the primary + 28 VDC power supply are shown in figure 2-1, which presents the magnitude and location of dissipated power values on a subassembly level. This chart assumes a 14-day lunar orbit mission as defined by S&ID for power profile computation (Ref: S&ID letter 63 MA 7332).

Table 2-III shows the magnitude and location of power dissipation for the established G&N activities, each of which consists of various power levels of operation.

Table 2-IV shows the energy requirements for each G&N activity on a power level basis. The table is based upon MIT letter AG 679-6, "G&N power Profile Status," dated August 14, 1963. The vertical column to the left indicates the various G&N activities (phases of operation) for the model 14-day mission submitted by S&ID in S&ID letter 63 MA 7332. This column also indicates the power consumption and operating time for each specific activity. The top row indicates the various power levels along with the power consumption and operating time of each power level.

Table 2-II. Block I Command Module Center of Gravity and Moments of Inertia

Item	Weight (lbs)	Centers of Gravity (inches)			Moments of Inertia ($lb-in^2$)		
		X	Y	Z	Ixx	Iyy	Izz
LOWER EQUIPMENT BAY							
CDU & Frame Assy	14.5	63.5	- 14.4	35.8	45	410	410
Optical Subsystem							
SXT	14.6*	70.5	- 3.5	34.7			
SCT	13.8*	70.5	5.5	34.7			
Opt. Base & Gearing	16.7*	67.9	0.0	30.7			
Optical Eyepieces							
SXT	1.3*	65.1	- 3.5	26.2	5	10	5
SCT	2.3	65.1	4.5	26.2	10	10	10
IMU	60.2	56.6	0.0	41.7	1186	1450	1438
NVB & Shock Mounts	27.2	64.3	- 0.1	41.3	3270	4050	5210
Bellows Assy	13.5						
G&N Interconnection Assy	35.2						
G&N to S/C Signal Assy	8.0						
D&C/NAV Station							
IMU Cont Panel	2.4	74.0	- 15.4	30.9	15	22	24
D&C Electronics	2.9	49.5	- 9.6	39.6	20	22	9
Control Electronics Assy	2.9	63.1	10.7	34.9	9	15	8
Optical Shroud	5.2	66.8	0.0	28.9	387	108	413
G&N Ind. Control Panel	9.5	54.1	0.1	33.9	460	120	580
D&C/AGC	19.6						
MDV (includes 1 film)	7.7*	73.5	- 4.5	31.0			
AGC (no spares)	70.0	37.8	1.3	46.1	4980	3990	1710
Spare Tray (logic)	25.0	38.2	- 7.7	45.3	1290	1360	140

(cont)

Table 2-II. Block I Command Module Center of Gravity and Moments of Inertia (cont.)

Item	Weight (lbs)	Centers of Gravity (inches)			Moments of Inertia ($lb\text{-}in^2$)		
		X	Y	Z	Ixx	Iyy	Izz
PSA	59.4	45.0	- 1.1	41.5	3940	1460	2620
Coolant Hoses	1.0						
MAIN PANEL AREA							
D&C/AGC	19.5						
LOOSE STORED ITEMS							
Eye Relief Eyepieces (2)	1.5	(SCT, 4-5/8" x 2-1/2" dia.; SXT 3" x 2-1/4" dia.)					
Film Cartridges (4)	2.4*	(Each cartridge, 1-1/2 x 3 x 6 inches)					
AGC Loose Spares Mem. Tray	34.6						
CDU Spare Gearbox	2.5	(approximately 6.0 x 1-13/16 x 5 1/2 inches)					
Spare Relay & Diode Mod	0.3	(3 x 3 x 2 inches)					
Horizon Photometer	3.6	(6 x 6 x 3 inches)					
PSA Loose Spares	16.7						

*These values represent changes since the last report. E-1142 (Rev. 15), dated December 15, 1963.

COMMAND MODULE

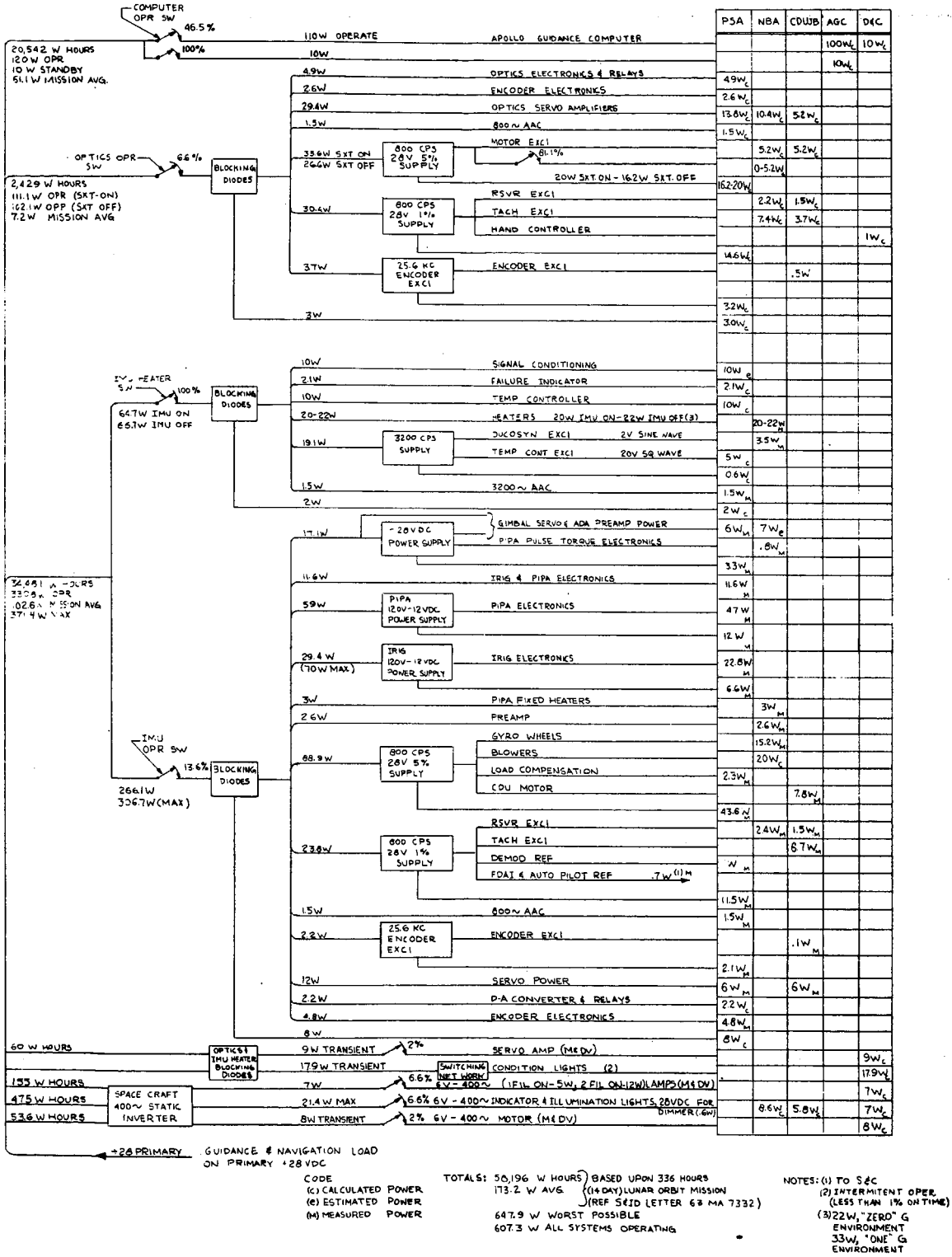

Figure 2-1. Electrical load on primary +28 VDC power supply

Table 2-III. Nominal Power Dissipation (watts) vs G&N Activity

MODE	G&N Activity (power levels)	NBA		CDUJB	PSA		AGC	Thermal Load On S/C Coolant	D&C and S&C	Electrical Load
		IMU	OBA		IMU	OBA				
A	IMU & AGC Operate (1, 4)	74.5	0	22.1	233.5	0	110	440.1	10.7	450.8
B	IMU Alignment (1, 2, 4, 6)	74.5	39	44	233.5	63.6	110	564.6	42.7	607.3
C	Low-Orbit Navigation (1, 3, 4, 6)	74.5	33.8	44	233.5	59.8	110	555.6	42.7	598.3
D	Standby & Computing (1, 5)	25.5	0	0	41.2	0	110	176.7	10	186.7
E	Midcourse Navigation (1, 2, 5, 6)	25.5	39	21.9	41.2	63.6	110	301.2	42	343.2
F	IMU & AGC Standby (5, 7)	25.5	0	0	41.2	0	10	76.7	0	76.7
G	IMU Operate & AGC Standby (4, 7)	74.5	0	22.1	233.5	0	10	340.1	0.7	340.8

1. AGC 120 watts
2. Optics, SXT on 111.1 watts
3. Optics, SXT off 102.1 watts
4. IMU Operate 330.8 watts
5. IMU Standby 66.7 watts
6. Display and Control 45.4 watts
7. AGC Standby 10 watts

Table 2-IV. Block I Command Module Power Profile for 14-Day Lunar Orbit Mission

MODE	G&N Activity	Power Consumption by Levels (kwh)							
		(1) AGC Operate 120 watts 156.09 hrs	(2) Optics, SXT On 111.1 watts 17.99 hrs	(3) Optics, SXT Off 102.1 watts 4.2 hrs	(4) IMU Operate 330.8 watts 45.28 hrs	(5) IMU Standby 66.7 watts 292.46 hrs	(6) Display & Control 45.4 watts 22.19 hrs	(7) AGC Standby 10.0 watts 181.65 hrs	TOTAL
A	IMU & AGC Operate 450.8 watts, 28.00 hrs	3.360	--	--	9.262	--	--	--	12.622
B	IMU Alignment 607.3 watts, 7.33 hrs	0.880	0.814	--	2.425	--	0.333	--	4.452
C	Low-Orbit Navigation 598.3 watts, 4.20 hrs	0.504	--	0.429	1.388	--	0.191	--	2.512
D	Standby & Computing 186.7 watts, 105.9 hrs	12.708	--	--	--	7.063	--	--	19.771
E	Midcourse Navigation 343.2 watts, 10.66 hrs	1.279	1.184	--	--	0.711	0.484	--	3.658
F	IMU & AGC Standby 76.7 watts, 175.9 hrs	--	--	--	--	11.732	--	1.759	13.491
G	IMU Operate & AGC Standby 340.8 watts, 5.75 hrs	--	--	--	1.902	--	--	0.058	1.960
	TOTAL	18.731	1.998	0.429	14.977	19.506	1.008	1.817	58.466

Section 3

BLOCK II COMMAND MODULE DATA

3-1 RELIABILITY

The following numbers do not assume the use of inflight spares or repair. The estimated Command Module G&N reliability is based on the 138-hour mission as defined in the Lunar Landing Mission Design Plan.

Table 3-I. Reliability

Subsystem	Operating Time (hrs) Full Power	Probability of Mission Success
IMU	31	0.99575
AGC (2)	19*	0.999913
DSKY	19	0.999954
PSA	31*	0.994
CDU (5)	31	0.9942
OPTICS	18	0.9985
Total G&N System		0.9824

*Certain assemblies function continuously.

3-2 WEIGHTS

Table 3-II presents the weights of all Block II equipment. Refer to section 2-1 for a general explanation of weight reporting.

Table 3-II. Current Weight Status of Block II Command Module (lbs)

ITEM	Spec. Wt. 12/62 (a)	(b-a)	Status 12/63 (b)	(c-b)	Status 1/64 (c)	Design Load Wt. 1/64 (d)
LOWER EQUIPMENT BAY						
CDU & Frame Assy	6.0				15.0(E)	17.2
Optical Subsystem					14.6(C)	
SXT	12.0				13.8(C)	
SCT	9.0				16.7(E)	
Optical Base & Gearing	14.0					
Optical Eyepieces						
SXT	2.0				1.3(E)	154.2
SCT					2.3(E)	
IMU	40.0				42.0(E)	
NVB & Shock Mounts	16.0				22.0(E)	
Bellows Assy	8.0				13.5(M)	
G&N Interconnection Assy	30.0				35.2(E)	42.8
G&N to S/C Interface Assy					8.0(E)	
D&C Nav Station						
D&C Electronics	30.3				1.5(E)	7.7
Control Electronics					2.9(E)	
Optical Shroud					5.2(M)	4.2
G&N Ind Cont Panel					11.1(E)	13.2
D&C/AGC	15.0				19.6(E)	19.4
M&DV (including 1 film)	5.0				8.3(E)	10.0
AGC (2 complete computers)	80.0				84.0(E)	126.4
AGC Covers (2)					8.5(E)	
PSA	25.0				41.6(E)*	65.0
Coolant Hoses	0.0				1.0(E')	

Table 3-II. Current Weight Status of Block II of Command Module (lbs) (cont)

Item	Spec. Wt. 12/62 (a)	(b-a)	Status 12/63 (b)	(c-b)	Status 1/64 (c)	Design Load Wt. 1/64 (d)
MAIN PANEL AREA						
D&C/AGC	5.0				19.5(E)	17.2
D&C/NAV	8.0				--	
LOOSE STORED ITEMS						
Eye Relief Eyepieces	--				1.5(E)	
Film Cartridges (3)	--				1.8(M)	
Horizon Photometer	--				3.6(E)	
TOTAL	325.3				394.5	**477.3

*See Appendix A for Block II weight breakdown for PSA.

**Minus loose stored items

COMMAND MODULE

3-3 STATUS OF COMMAND MODULE AGC PROGRAMS

Table 3-III lists current Command Module memory estimates and the status of AGC programs. The status of LEM AGC programs is not reported at this time.

A high and low word estimate is given with each program. Each status is defined as follows:

(1) Planning stage
(2) Programming stage
(3) Checkout on AGC simulation
(4) Checkout on G&N simulation
(5) Checkout on AGC

Table 3-III. Current Memory Estimates and the Status of Command Module AGC Programs

Program	Status	Memory Estimate (words)	
		High	Low
List Processing Interpreter	(5)*	1600	1600
AGC Executive	(5)*	250	250
AGC Waitlister	(5)*	150	150
AGC System Exerciser, Checkout, and Error Handler	(3)	1000	750
G&N System Exerciser & Checkout	(2)	1000	750
Display, Keyboard, and Telemetry	(5)*	1500	1500
Input/Output Control	(4)*	850	350
Midcourse and Orbital Navigation	(4)	2000	1500
Midcourse and Orbital Guidance	(2)	500	500
Prelaunch Platform Alignment	(5)*	400	400
In-Flight Platform Alignment	(2)	980	900
Re-entry Control	(2)	1290	1024
Injection and De-Boost	(2)	1000	400
Totals		12520	10074

* These items have changed since the last report, E-1142 (Rev. 15), dated December 15, 1963.

COMMAND MODULE

3-4 POWER REQUIREMENTS

The power requirements of the Block II Command Module G&N equipment on the primary + 28 VDC power supply are shown in figure 3-1, which presents the magnitude and location of dissipated power values on a subassembly level. This chart assumes a 14-day lunar orbit mission as defined by S&ID for power profile computation (Ref: S&ID letter 63 MA 7332).

Major changes to Block II power requirements, as compared to Block I requirements, are due to the use of two computers and electronic CDU's in the Block II system.

COMMAND MODULE

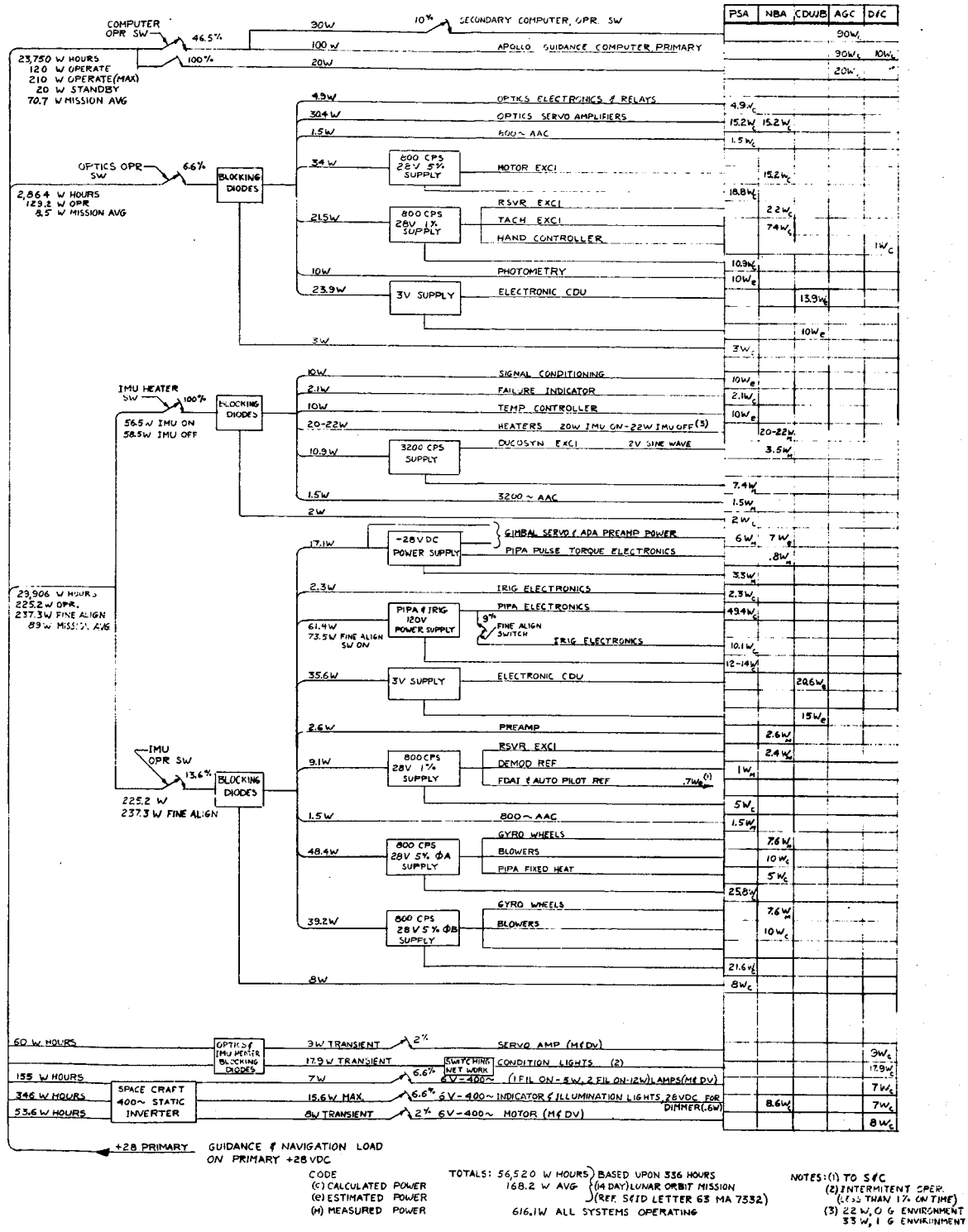

Figure 3-1. Electrical load on primary +28 VDC power supply

LUNAR EXCURSION MODULE

Section 4

LUNAR EXCURSION MODULE DATA

4-1 POWER REQUIREMENTS

The current estimate of LEM G&N power and energy (see table 4-I) is based upon the fixed-telescope concept and the use of the Command Module IMU and computer.

The values shown in table 4-1 are center value estimates and do not include any safety factor for bad estimating.

Transient power peaks, occuring at higher power levels during turn-on and slewing operations, are considered to consume negligible energy. When they become available data on these peaks will be included.

Table 4-I. LEM Power Requirements
(Based upon GAEC Profile, REF: NASA Coord. Meeting L3A)

	Power (watts)	Time (hrs)	Energy (kwh)
IMU Standby	84.7	103.8	8.78
IMU Operate	348.0	26.4	9.19
AGC Standby	10.0	21.3	0.21
AGC Operate	115.0	26.4	3.04
Radar CDU	18.4	23.8	0.44
Optics	Negligible		
Display and Controls	12.2	3.0	0.04
Rendezvous Radar	*	2.0	*
Landing Radar	*	1.0	*
TOTALS	493.6 (peak)		21.70
* Totals do not include radar loads.			

Note that the total energy drawn, 21.70 kwh, is considerably higher than for a "normal" mission since the estimate provides for full operate power for the 18 hours of "orbit contingency" mode. Without this contingency the G&N takes about 13 kwh based upon the GAEC profile.

Separate power turn-on switches are assumed for "IMU operate," "computer standby," "computer operate," and "radar CDU." The LEM G&N uses only the spacecraft + 28 VDC power supply except for operation of condition lights. The condition lights operate from the spacecraft 400-cps power supply.

4-2 RELIABILITY

The numbers in Table 4-II do not assume the use of inflight spares or repair. LEM reliability calculations were based on the guidance and navigation mission profile as directed by MSC for reliability planning.

Table 4-II. Reliability

Subsystem	Operating Time (hrs)	Probability of Mission Success
IMU	7	0.999
AGC	7	0.99769
PSA	7	0.99896
CDU (5)	7	0.998965
OMU	1	0.999957
Total G&N System		0.9946

4-3 WEIGHTS FOR LEM

Lunar Excursion Module weights are presented in table 4-III. In general the data conform to the information contained in paragraphs 2-1 and 2-1.1.

Column (a), Target Weight, was taken from GAEC LMD 490-39, Enclosure 1, submitted to MIT at a weights review meeting on September 10, 1963. GAEC reported that G&N weights associated with D&C will be reported by them as part of the total spacecraft D&C. Therefore, target weights were not given by GAEC to supply the five items denoted by asterisks in column (a).

The row labeled Bare Guidance System is inserted to provide for comparisons with similarly specified systems.

Table 4-III Estimated Weights of LEM G&N Components (lbs at 1g)

Item	Target Wt. 8/63 (a)	(b-a)	Status 12/63 (b)	(c-b)	Status 1/64 (c)	Design Load Wt. (d)
CDU's	*		15.0 (E)	0.0	15.0 (E)	**
Telescope and All Eyepieces	12	+ 12.5	24.5 (E)	0.0	24.5 (E)	
Navigation Base	4	- 4.0	--	--	--	
Eye Register for Reticule	*		2.0 (E)	0.0	2.0 (E)	
Two-Digit Readout for Reticule	*		5.0	0.0	5.0 (E)	
IMU	58	- 16.0	42.0 (E)	0.0	42.0 (E)	
AGC/PSA Interconnection Assy	15	- 5.0	10.0 (E)	0.0	10.0 (E)	
AGC Display and Controls	*		19.5 (E)	0.0	19.5 (E)	
Other Display and Controls	*		15.0 (E)	0.0	15.0 (E)	
Book of Procedures etc	2	0.0	2.0 (E)	0.0	2.0 (E)	
AGC	60	- 18.5	41.5 (E)	0.0	41.5 (E)	
PSA	35	- 8.0	27.0 (E)	0.0	27.0 (E)	
Coldplate	5	- 5.0	--	---	---	
TOTAL	191 Plus * Items not yet given		203.5	0.0	203.5	
Bare Guidance System (IMU, PSA, and computer): ** No design load weight has been assigned			110.5	0.0	110.5	

Section 5

GLOSSARY AND SYSTEM DEFINITION

Apollo Guidance Computer (AGC)

CM BLOCK I A single complete flight computer containing all logic, memory, associated power supplies, and all interface circuits except those identified with the CDU's. Does not contain the associated displays and controls.

Consists of two trays containing replaceable electronic modules, the AGC end connector, and toe plate. Does not include the necessary cold plate or the G&N to CM interface assembly which is located in the adjacent area. Space exists for carrying an extra spare pair of AGC trays. These would not function in this spares location but could interchange with faulty trays in the active position. The spare trays are not included in this accounting.

CM BLOCK II Two complete and active computers each having the same functions as the Block I AGC.

Consists of two wiring matrix headers mounted on each side of the cold plate. This cold plate is not included in this accounting and must be moved up from the Block I configuration location. The modules of the "X" computer mount on one of these headers, the "Y" computer on the other.

Block I and Block II AGC's are not interchangeable.

LEM A single complete flight computer having the same functions as one of the Block II computers. Unless installation constraints yet to be determined prevent it, the LEM computer will be physically identical with one of the Block II computers.

AGC Covers

CM BLOCK I Not required.

CM BLOCK II Two covers, one for each computer, may be required if it becomes necessary to seal the Malco connectors against moisture.

LEM Not defined at this time.

AGC Spares

CM BLOCK I Spare AGC modules or trays as indicated.

CM BLOCK II No spares for AGC in Block II

LEM No spares for AGC in LEM

Alignment Optical Telescope (AOT)

CM BLOCK I AND BLOCK II Not in CM, see Optical Subsystem

LEM A 3-position periscope with single-degree-of-freedom manual read reticule for alignment of the IMU.

Bellows Assembly

CM BLOCK I and CM BLOCK II Flexible pressure seal between CM structure and optical subsystem on NAV BASE for penetration of pressure hull with optics.

LEM Not identified separately in LEM. Is included in LEM as part of the AOT.

Book of Procedures

CM Not in CM; see MDV

LEM Book or other form of maps, charts, procedures, instructions, etc., needed for lunar operations.

CDU and Frame Assembly

The CDU provides the necessary signal interfaces among the IMU gimbal angles, optics gimbal angles, radar gimbal angles, angle registers in the AGC, the spacecraft autopilot attitude error signals, and the tracking radar command error signals.

CM BLOCK I Five interchangeable gear boxes each with necessary motor, tach, resolver synchros, and encoder with mounting framework. Does not include associated electronics which are located in the PSA.

CM BLOCK II Functionally identical to Block I except the instrumentation is all electronic. Includes all support electronics including special power supply and is located in same volume as Block I CDU's.

Changes in resolver synchro characteristics and mode controls make Block I and II CDU's noninterchangeable.

LEM Interchangeable with CM Block II CDU's.

Cold Plate

CM BLOCK I and BLOCK II Cold plates for the IMU are built into the IMU. Necessary cold plates for electronics are part of the equipment supplied by the spacecraft manufacturer.

Control Electronics Assembly

CM BLOCK I Consists of one power transformer, one relay and diode module, and a bracket end connector. Used to support display and control functions.

CM BLOCK II May be relocated with other similar functions.

LEM Not defined in LEM

Coolant Hoses

CM BLOCK I and CM BLOCK II Consists of (1) three aluminum flex coolant hoses between IMU and spacecraft, optics and spacecraft, and optics and IMU, (2) bracket assembly screws and clamp, and (3) entrapped coolant.

LEM Not identified as part of LEM

Display and Control/Apollo Guidance Computer (D&C/AGC)

CM BLOCK I and BLOCK II Number displays and keyboard control associated with the operation of the AGC. Two functionally identical and parallel operation units: one in lower equipment bay and one on main panel between left and center couches.

LEM Identical to CM except only a single unit is required.

D&C Electronics Assembly

CM BLOCK I Consists of a chassis, a relay and diode module, a Demod. Elect.

module, a saturable reactor, a time delay module, a connector, and wiring. Used to support displays and control functions.

CM BLOCK II Similar and probably identical to Block I.

LEM Not defined in LEM at this time.

Eye Register for Reticule

CM Not in CM

LEM Device or equipment not defined yet in detail to position the LEM pilot's eye to use the window marking reticule pattern for landing point observation and selection during the constant flight path phase of landing.

Film Cartridges

CM BLOCK I and BLOCK II Consists of film cartridges and film for map and data viewer.

LEM Does not exist in LEM.

G&N Indicator Control Panel

CM BLOCK I and BLOCK II Consists primarily of controls and displays for the operation of the optics, and the IMU temperature control. Includes display and control elements, panel, panel writing, and supporting hardware.

LEM Not defined at this time for LEM.

G&N Interconnection Assembly

CM BLOCK I Consists of PSA End Connector Assembly and interconnect wiring harness which electrically ties together the assemblies that constitute a completely integrated system. This term does not include the G&N to CM Interface Assembly weight or the weights of harness support brackets which are a NAA responsibility.

CM BLOCK II Similar to Block I but not interchangeable with Block I.

LEM Not clearly defined at present, was called in earlier reports the AGC/PSA Interconnection Assy. Because of the wide separation of G&N components, most interconnection will be accomplished as part of spacecraft wiring.

G&N to CM Interface Assembly

CM BLOCK I Interconnections between the spacecraft wiring channel, the computer end connector, and the PSA end connector. Contains no active electronics.

CM BLOCK II Similar in function to Block I except the configuration is much different and not interchangeable with Block I.

LEM Not identified yet as a separate item in LEM.

Horizon Photometer

CM BLOCK I Not all Block I systems will contain this function, but to support expected early unmanned flights using Block I this will be incorporated into later Block I systems for preflight qualification and flight test. Equipment is defined below. Block I weights assume horizon photometer.

CM BLOCK II An earth horizon brightness photometer and automatic star tracker for navigation measurements against the earth's illuminated limb. The sensors are incorporated into the head of the SXT, the weight of which includes this function. The PSA includes support electronics.

LEM Not part of LEM.

Inertial Measurement Unit (IMU)

CM BLOCK I Size 14 IMU (14-inch case diameter) gimbal assembly including all parts inside hermetic case and including entrapped coolant.

CM BLOCK II Size 12.5 IMU functionally interchangeable with Block I unit, but not physically interchangeable with Block I.

LEM Size 12.5 IMU as described above.

IMU Control Panel

CM BLOCK I Consists of panel, wiring, attitude error meter, CDU transfer switch, manual alignment switch. CDU mode control switches, connector, and supporting hardware.

CM BLOCK II Does not exist in Block II. Moding is done by AGC program and AGC push buttons.

LEM Not defined at this time for LEM.

Indicator Control Panel

CM BLOCK I and BLOCK II Consists primarily of controls and displays for the operation of the optics and the IMU temperature control. Includes display and control elements, panel, panel wiring, and supporting hardware.

LEM Not defined at this time for LEM.

Long-Eye-Relief Eyepieces

CM BLOCK I and BLOCK II Consists of a SXT and a SCT eyepiece to provide eye relief of at least 1.6 inches for closed-visor operation. Used in place of normal eyepieces of SXT and SCT.

LEM Long-eye-relief eyepiece for the AOT is included as part of the AOT in this accounting.

Map and Data Viewer(MDV)

CM BLOCK I and BLOCK II Film viewer for display of maps, charts, procedures, etc. Weight includes one film cartridge for Block I MDV and tentatively two for Block II MDV.

LEM Not in LEM; see Book of Procedures.

NVB and Isolation Mounts

CM BLOCK I Rigid structure supporting the IMU and the optical subsystem with its associated hardware. The NVB is attached to the spacecraft using flexible ISOLATION MOUNTS to prevent spacecraft strains from distorting the NVB and the alignment between the IMU and Optics. These mounts also provide shock and vibration attenuation.

CM BLOCK II Functionally similar to Block I but will be lighter and provide for mounting the size 12.5 IMU.

LEM The need for tieing the AOT and IMU together exists but is accomplished using structure provided by the spacecraft contractor.

Optical Eyepieces

CM BLOCK I Removable SXT eyepiece and removable SCT 1- and 3-power eyepiece combination.

CM BLOCK II Same as Block I for SXT but only a 1-power eyepiece will be used with the SCT.

LEM Included as part of the AOT.

Optical Subsystem

CM BLOCK I Consists of SXT, SCT, Optical base, and associated hardware defined as follows:

SXT: Sextant -- a two-line-of-sight, narrow-field,two-degree-of-freedom sextant and its attached gearing.

SCT: Scanning Telescope -- a single-line-of-sight, wide-field-of view, two-degree-of-freedom articulation optical instrument and its attached gearing.

OPTICAL BASE: Base for SXT and SCT with associated gearing and internal cooling.

CM BLOCK II Similar to Block I except for changes in the sextant to provide line-of-sight velocity control directly without CDU's.

LEM Not in LEM, see AOT.

Optical Shroud & Cover Assembly

CM BLOCK I and BLOCK II Consists of the optical shroud and protective cover.

LEM Does not exist in LEM.

Power Servo Assembly (PSA)

CM BLOCK I Consists of most of the support electronics: power supplies; IMU, Optics, and CDU servos; IMU temperature control; and accelerometer and gyro pulse torquing. Consists of 10 trays with replaceable modules which plug into the PSA end connector assembly. Includes front toe plate but not necessary cold plate.

CM BLOCK II Similar in function to Block I but does not contain the CDU servos needed in Block I. Consists of a single plane matrix header to mount onto the cold plate with the modules plugging onto the top.

LEM (A weight breakdown of the LEM PSA will be in the next report.)

PSA End Connector Assembly

CM BLOCK I Electrical interconnection between the PSA trays, the G&N interconnection Assy, and the G&N to CM interface Assy.

CM BLOCK II Not identified as a separate item; will be part of the PSA matrix header.

LEM Not yet defined. Will probably not exist in LEM.

Two-Digit Readout for Reticule

CM Not in CM.

LEM A 2-digit readout driven by the AGC from 00 to 99 to indicate range component of landing point using fixed numbered scale on window reticule.

Appendix A

VOLUMES AND WEIGHTS FOR BLOCK II PSA MODULES

Table A-I shows weights and volumes for the CM Block II PSA modules.

Table A-I. PSA Weight and Volume

Module	No. of Modules	Total Vol. (cu. in.)	Total Wt. (lbs)
GYRO PULSE TORQUING			
D. C. Diff Amp.	1	4.57	0.173
Ternary Current Switch*	-	-	-
Pulse Torque Gyro Calibr.	1	3.00	0.200
Switching Module	1	7.55	0.242
ACCEL PULSE TORQUING			
D. C. Diff. Amp.	3	13.71	0.517
Binary Current Switch	3	22.65	0.800
A. C. Diff. Amp.	3	17.70	0.710
Interrogator	-	-	-
PIPA Calibr.	3	15.72	0.604
Forward-Backward Ctr.	-	-	-
Back-Up Mode	-	-	-
Lamps, Back-Up Mode	-	-	-
POWER SUPPLIES			
Pulse Torq. Power Supply (120 Volt)	1	18.50	1.200
-28 VDC Power Supply	1	12.55	0.708
25.6 kc Power Supply	-	-	-
3200-cps 1% Amp.	1	6.24	0.281
3200-cps AAC, Filter	1	6.24	0.287
800-cps 1% Amp.	2	18.46	1.408
800-cps 5% Amp.	3	37.65	3.015
800-cps AAC Filter	2	13.12	0.612
Temp. Cont. Power Supply*	-	-	-
G&N Sub-Systems Filter	3	21.00	1.156
800-cps Compensation (Optics)	1	7.32	0.329
IMU-CDU Load Comp.	-	-	-

(cont)

Table A-I. PSA Weight and Volume (cont)

Module	No. of Modules	Total Vol. (cu. in.)	Total Wt. (lbs)
IMU			
Gimbal Servo Amp.	3	31.89	1.749
Gimbal Coarse Align	3	14.76	0.753
IMU Temp. Controller	1	16.51	0.972
IMU Temp. Indicator	-	-	-
Failure Indicator & Warning	1	10.21	0.498
IMU Moding Relays	1	2.64	0.106
CDU			
D to A Converter	-	-	-
Encoder	-	-	-
Motor Drive Amp. & Sel.	-	-	-
CDU Zeroing & Lock Relays	-	-	-
CDU Resolver Loads	-	-	-
CDU Zeroing Trans., Relays	-	-	-
CDU Fixed Resol. Transf. & Entry	-	-	-
OPTICS			
Motor Drive Amp.	4	44.8	2.020
Motor Drive Preamp	-	-	-
2-Speed Switch	2	11.2	0.486
Cosecant Generator	1	5.6	0.257
Resolver Drive Amp.	1	5.6	0.224
Relay Module	2	16.0	0.940
Buffer Circuit	-	-	-
Zero Optics	1	4.0	0.160
Isolation Transformer	1	6.6	0.297
Resistor & Capacitor	1	9.5	0.380
D to A Converter	-	-	-
Encoder	-	-	-
PHOTOMETRY			
Demodulator	1	5.86	0.293
Narrow Band Amplifier.	1	18.76	0.740
Demodulator Signal Amplifier	1	3.36	0.168
Voltage Doubler & Summing Net.	1	4.64	0.234

(cont)

[redacted]

Total Number of Modules	56
Total Module Volume	437.9 cu. in.
Total Module Weight	22.52 lbs.
Toe Cap Weight	0.85
Header Weight	18.19
TOTAL BLOCK II PSA WEIGHT	41.56 lbs.

*The items for which volume and weight are not given are used in Block I only and are eliminated in Block II.

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1560 H Street
Washington, D. C.
Attn: Mr. G. M. Low, MD(P)

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68 Rogers Street
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