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CONTRACT REQUIREMENTS	CONTRACT ITEM	MODEL	CONTRACT NO.	DATE
Exhibit E	Line Item 13.0	LEM	NAS 9-1100	10/31/63

Ref. Para. No. 5.1
Type II

Primary Code 713

REPORT

NO. LED-490-4 DATE: 31 October 1963

PRELIMINARY

LEM MASS PROPERTY REPORT [U]

CODE 26512

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		To UNCLASSIFIED	
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GROUP 4. DOWNGRADED AT 3 YEAR INTERVALS; DECLASSIFIED AFTER 12 YEARS

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Appendix
A. Design Description and Criteria

Enclosures - Structural Arrangement Drawings and Subsystem Functional Diagrams.

INTRODUCTION

This report represents the LEM Mass Properties effective October 31, 1963. It includes all current information available at this time. The current vehicle separation weight (28,442#) is 987# lighter than the Weight Summary Dated 8/29/63 and prepared for the GAEC/NASA Weight Review Meetings held at Bethpage, Sept. 4 thru Sept. 3, 1963.

Pertinent information included herein - either new or in more detail than previously reported - are noted as follows:

1. Mission Weight History vs. Time - This includes Tables and plots of consumables vs. time and the total vehicle weight variation vs. time. Currently these data include:

   a) ECS Consumables vs. Time (Hrs)
   b) EPS " vs. Time (Hrs)
   c) RCS Propellant Weight vs. Time (Hrs)
   d) Total Vehicle Weight vs. Time (Hrs)

2. Pending Changes - This section covers those changes being considered for incorporation into the LEM vehicle, but on which final disposition had not been reached at the time of this report.

3. Government Furnished Equipment - A detailed tabulation is included comparing the official GFE list with a list of items and weights which are indicated to be GFE and total 59# heavier than the official list. The official GFE weight is still reflected in this report.

It should be noted that the major weight reductions reflected in this report are:

1) Elimination of micrometeoroid protection - 278.5#
2) Reduction in wire weight - 375.9#
3) Reduction in number of sensors - 278.8#

The Contractor is continuing efforts to reduce the weight of the LEM Vehicle and is maintaining close liaison with NASA to achieve this goal.

MISSION HISTORY OF WEIGHT AND PERFORMANCE

	29 August 1963		31 Oct. 1963		
Condition	Weight	ΔV	Weight	ΔV	I_{sp}
Earth Launch	29,035		28,039		
Separation	29,429	7311	28,442	7703	305
Touchdown	13,854		12,870		
Lunar Lift-off	10,198	5434	9,460	6025	306
Transfer Orbit	5,592	364	4,830	423	300
Burnout (Docked)	5,374		4,616		

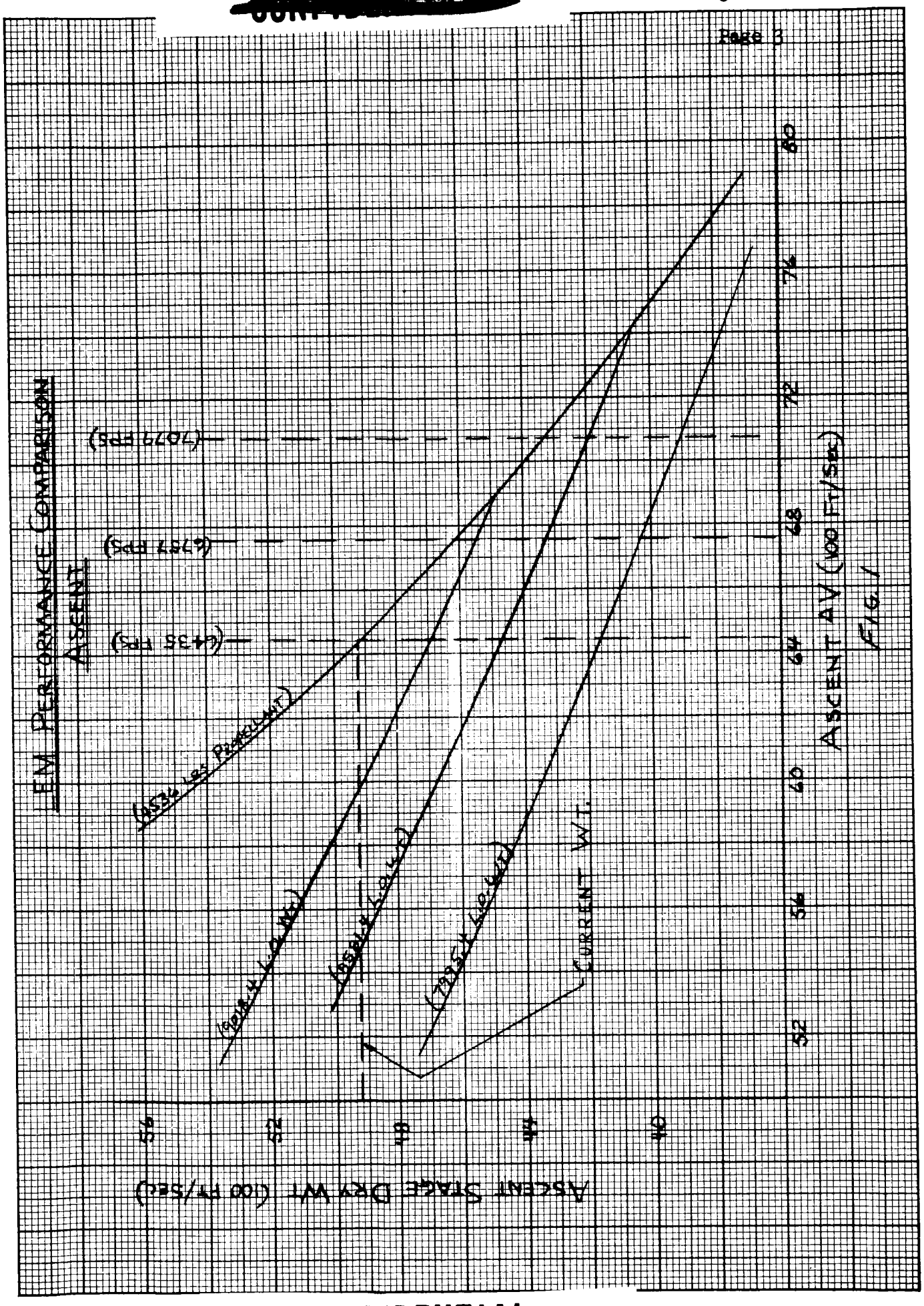

FIG. 1

K&E 10 X 10 TO THE ½ INCH 359T-11 KEUFFEL & ESSER CO. ALBANENE ® MADE IN U.S.A.

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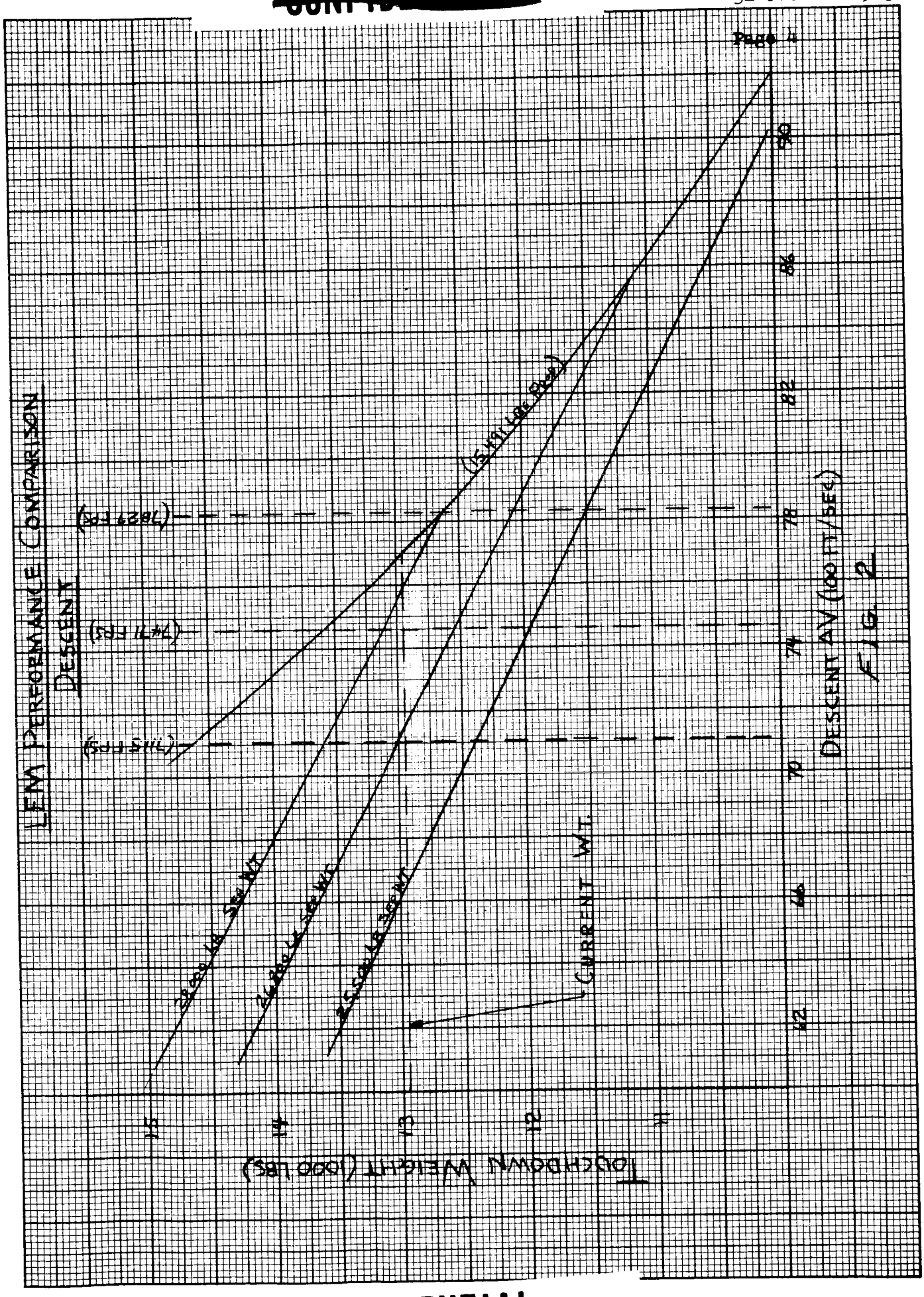

FIG. 2

K+E 10 X 10 TO THE 1/2 INCH 359T-11
KEUFFEL & ESSER CO. MADE IN U.S.A.
ALBANENE ®

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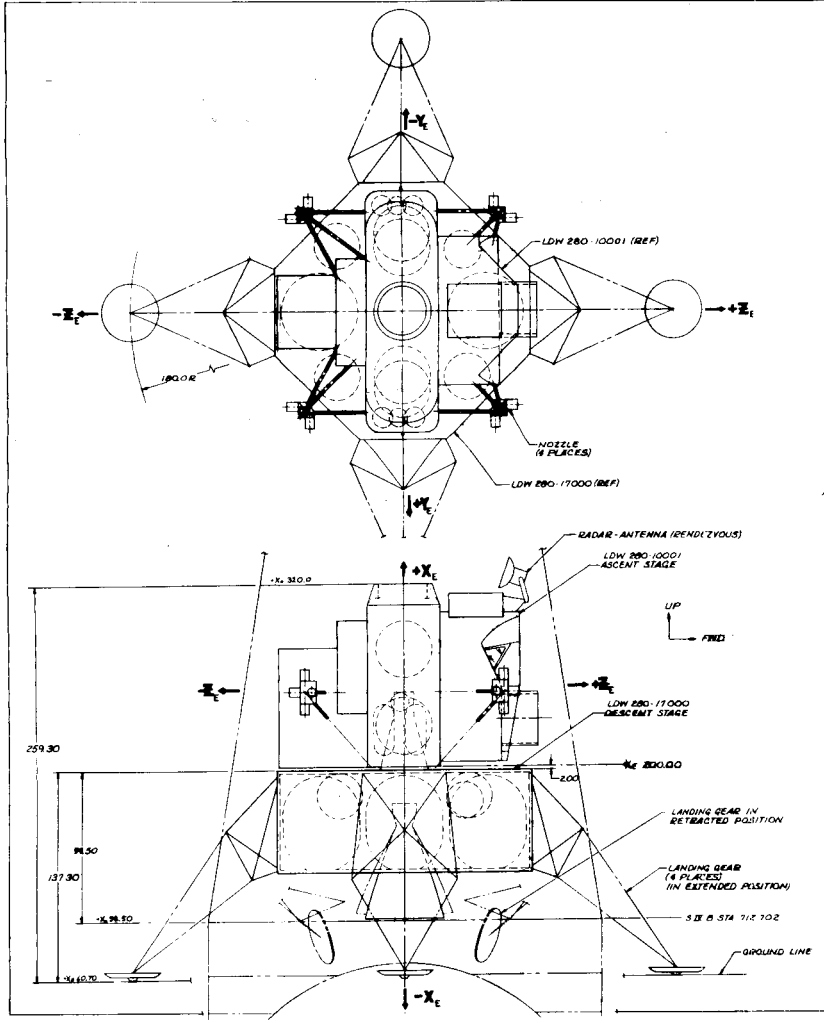

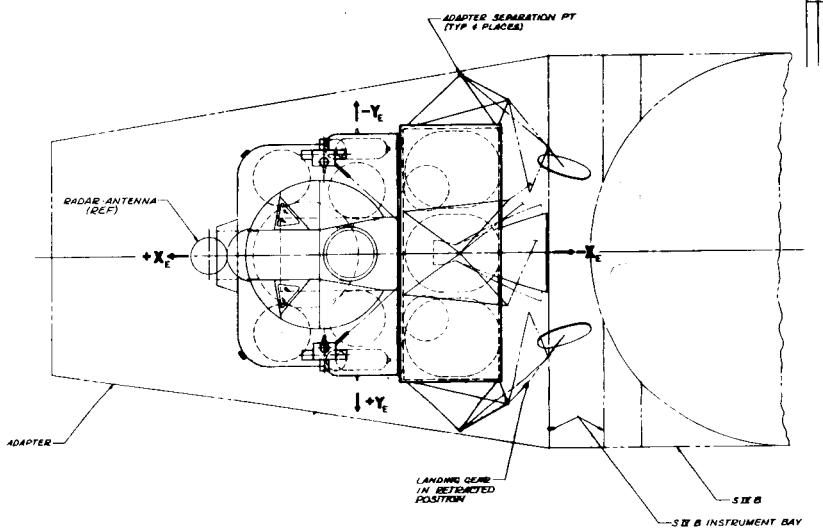

REVISION

LED-490-3
31 OCT 63

LEM AXIS REFERENCE SYSTEM AND SIGN CONVENTION

FIG. 3

THIS DRAWING IS NOT NECESSARILY THE LATEST CONFIGURATION, BUT IS REPRESENTATIVE FOR PURPOSES OF REFERENCE AXIS ORIENTATION.

LDW 280-10000

CONTRACT LINE ITEM NO. 1
PRIMARY CODE NO. 2.0.0
REFERENCE PARAGRAPH NO OF EXHIBIT E.S.S
CATEGORY TYPE III PER EXHIBIT E

[redacted]

[redacted]

Page 5 of 10000 pages

WEIGHT - TIME HISTORY OF LEM

The following section presents a Preliminary Weight Time History of the Lunar Excursion Module. The Basic Design Mission, Table I, defines the time line against which Total Vehicle Weight and various Sub-System Weights are presented. The main purpose has been to develop a usable format for the presentation of vehicle and various sub-systems weight versus time. This data is still undergoing rather frequent and large fluctuations, however, future reports will be based on data of a less tentative nature.

The Summary & Detail Weight Time History, Tables II & III, present the Weight at various critical time periods (i.e. Earth Launch, Separation, Touchdown, Lunar Lift-Off and LEM Jettison) as well as at intermediate phases. A corresponding curve of the Total Weight versus Time is presented in Figure 5.

The three sub-systems which have consumable weight time histories of detailed interest are the Environmental Control System (ECS), the Electrical Power System (EPS), and the Reaction Control System (RCS). Tables IV, V and VI with corresponding curves Figures 6, 7 and 8 present a weight time history for each of these sub-systems. The propellant of the Propulsion Sub-System is consumed during brief periods of thrusting and is shown in Table II. The consumption of large quantities of propellant in relatively brief periods of time predominately shape the Weight Time History Curve as shown in Figure 5 where the comparatively smaller long period weight changes of the other sub-systems are almost completely masked.

Future reports will continually revise and update this Weight Time History Section and will incorporate the latest design information.

LEM
BASIC DESIGN MISSION

TABLE I

MISSION PHASE	DESCRIPTION(1)	Δt (HR.)	CUMULATIVE TIME (HR.)
A	LEM Checkout		
B	Apollo Assembly & Launch Preparation		
C	Countdown (Earth Launch Time = 0)	6.0000	--
D	Launch	.2000	.2000
E	Earth Ascent (included in D)	--	.2000
F	Earth Orbit	3.0000	3.2000
G	Translunar Insertion & Initial Coast	.5833	3.7833
H	Transposition	.5000	4.2833
I	Final Translunar Flight		
	I-1 Jettison S-IV B	.3333	4.6166
	I-2 Translunar Checkout	1.0000	5.6166
	I-3 Continue Translunar Trip	76.6667	82.2833
J	Lunar Orbit		
	J-1 Insertion into 80 n. mile Lunar Orbit	.1000	82.3833
	J-2 Complete One-Half Orbit	1.0167	83.4000
	J-3 LEM Checkout	1.0167	84.4167
	J-4 Continue in 80 n. mile Orbit	.4166	84.8333

TABLE I (Cont.)

MISSION PHASE	DESCRIPTION(1)	Δt (HR.)	CUMULATIVE TIME (HR.)
K	Descent		
	K-1 Separate	.0217	84.8550
	K-2 Orient LEM & Prepare for Descent	.1450	85.0000
	K-3 Insert into Equal Period Descent Transfer Orbit	.0083	85.0083
	K-4 Coast One Complete Equal Period Orbit	2.0434	87.0517
	K-5 Coast to 50,000 ft. Pericynthion	.4900	87.5417
	K-6 Initial Powered Descent	.0633	87.6050
	K-7 Final Powered Descent to 1000 ft.	.0367	87.6417
	K-8 Hover to Touchdown	.0333	87.6750
L	Lunar Stay		
	L-1 Post Landing & Pre-Launch Checkout & Egress Preparation	1.2500	88.9250
	L-2 One-Man Explore	4.0000	92.9250
	L-3 Report and Replenish PLSS	6.0000	98.9250
	L-4 Other Man Explore	4.0000	102.9250
	L-5 Report and Replenish PLSS	6.0583	108.9833
	L-6 Pre-Launch Preparation	1.6667	110.6500
M	Ascent (incl. Contingency)		
	M-1 Powered Ascent	.1000	110.7500
	M-2 Orbit Contingency	17.7000	128.4500
	M-3 Insert into Free-Flight Intercept Transfer Orbit	.0017	128.4517
	M-4 Coast in Free-Flight Intercept Transfer Orbit	.9666	129.4183
	M-5 Rendezvous from 20 n. miles to 500 ft. range of CSM	.4000	129.8183
	M-6 Dock from 500 ft to Contact	.2500	130.0683
	M-7 Transfer Crew	.3333	130.4016
	Jettison LEM		

(1) References: (a) Mission Plan, LPL-540-1 (GAEC), 15 July 1963.

(b) Correction and Amendment of GAEC Mission Plan LPL-540-1 as per NASA Directive, LMO-540-149, 27 September 1963.

LEM BASIC DESIGN MISSION SCHEMATIC

(NO SCALE)

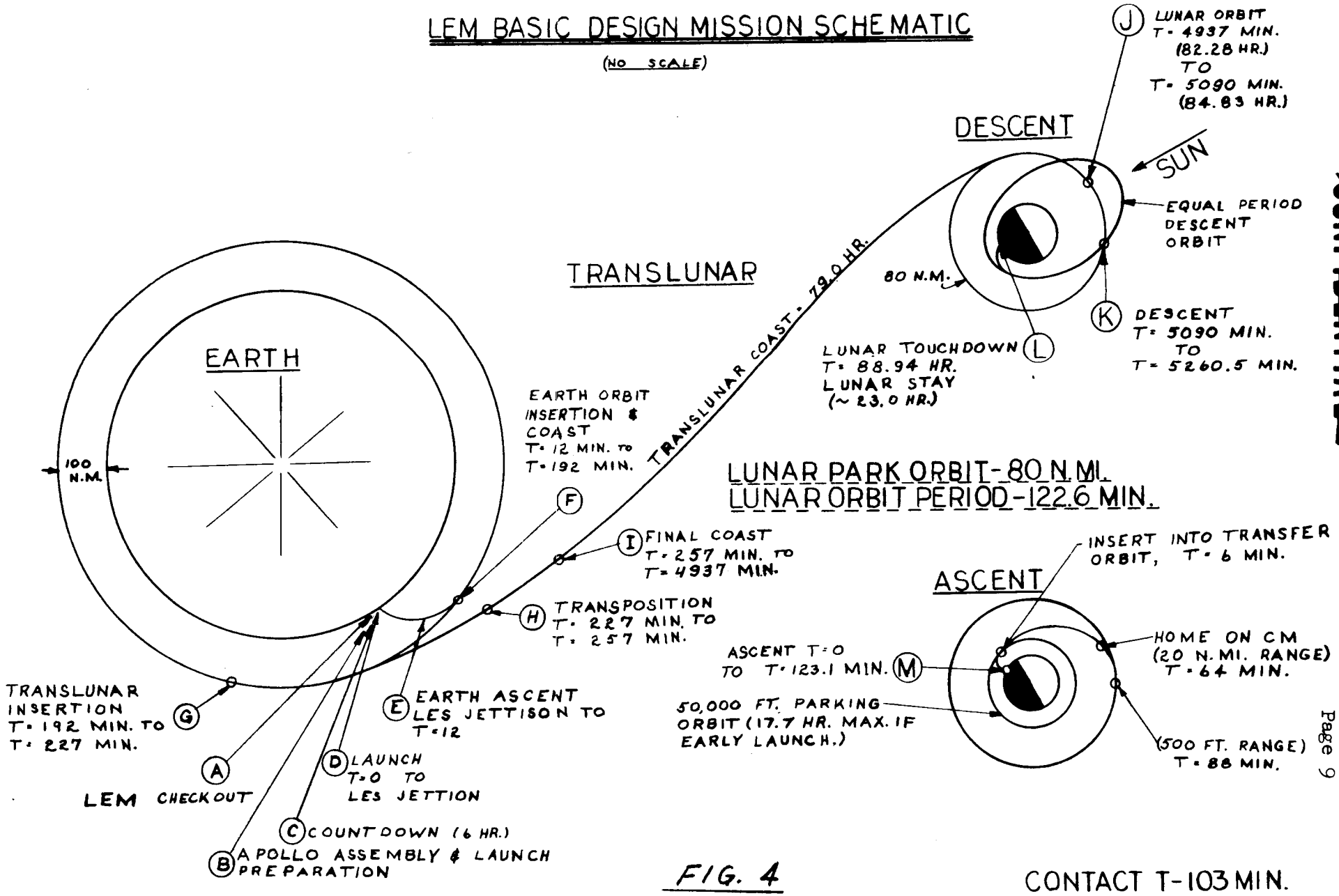

FIG. 4

CONTACT T-103 MIN.
(ALLOW 20 MIN. FOR CREW TRANSFER)

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LEM

SUMMARY - WEIGHT TIME HISTORY

TABLE II

CODE	MISSION PHASE (1)	Δt (HR.)	Cumulative TIME (HR.)	Δ WEIGHT Crew Provisions (LB.)	ECS (LB.)	EPS (LB.)	Propulsion (LB.)	RCS (LB.)	Descent Stage (LB.)	Cumulative Weight (LB.)
A&B	Pre-Launch Preparations									28099.4
C	Countdown (Earth-Launch)	6.000	--			- 1.9				28097.5
D&E	Launch	.200	.200		- .1	- .1				28097.3
F	Earth Parking Orbit	3.000	3.200		-1.5	- .6				28095.2
G	Translunar Orbit Inject.	.583	3.783		- .3	- .1				28094.8
H	LEM Repositioning	.500	4.283		- .2	- .1				28094.5
I	Final Translunar Flight	78.000	82.283		-38.4	-18.9				28037.2
J	Lunar Orbit (Separation)	2.550	84.833	+418.2	- 9.6	- 3.9				28441.9
K	LEM/CM Separation & Descent (Touchdown)	2.842	87.675		-18.8	- 8.3	-15474.0	- 71.0		12869.8
L	Lunar Stay (Lift-Off)	22.975	110.650		-96.9	-73.7			-3238.9	9460.3
M	Ascent (incl. Orbit Contingency)	19.752	130.402		-87.8	-22.1	- 4329.0	-405.0		4616.4

(1) See Page 7

[redacted]

LEM

DETAIL - WEIGHT TIME HISTORY

TABLE III

MISSION PHASE (1)	Δ WEIGHT CREW PROVISIONS (LB.)	ECS (LB.)	EPS (LB.)	PROPULSION (LB.)	RCS (LB.)	DESCENT STAGE (LB.)	CUMULATIVE WEIGHT (LB.)	CUMULATIVE TIME (HR.)
A&B							28099.400	
C			- 1.936				28097.464	-
D&E		- .088	- .044				28097.332	.2000
F		- 1.520	- .657				28095.155	3.2000
G		- .264	- .129				28094.762	3.7833
H		- .220	- .111				28094.431	4.2833
I-1		- .147	- .074				28094.210	4.6166
I-2	+209.1 (2) -209.1	- 6.080	- 2.156				28085.974	5.6166
I-3		- 32.200	-16.644				28037.130	82.2833
J-1		- .042	- .022				28037.066	82.3833
J-2		- .425	- .221				28036.420	83.4000
J-3	+418.2 (3)	- 6.440	- 2.619				28445.561	84.4167
J-4		- 2.690	- .993				28441.878	84.8333
K-1		- .140	- .060		- 7.760		28433.918	84.8550
K-2		- .878	- .429		- 3.372		28429.239	85.0000
K-3		- .052	- .027	-1156.700	- .192		27272.268	85.0083
K-4		- 13.630	- 5.980		- 21.243		27231.415	87.0517
K-5		- 3.050	- 1.338		- 5.084		27221.943	87.5417
K-6		- .466	- .213	-9150.000	- 14.342		18056.922	87.6050
K-7		- .281	- .127	-4097.800	- 8.307		13950.407	87.6417
K-8		- .253	- .117	-1069.500	- 10.700		12869.837	87.6750
L-1		- 7.652	- 3.058				12859.127	88.9250
L-2	-209.1 +209.1	- 17.670	-14.260				12827.197	92.9250
L-3		- 20.608	-15.006				12791.583	98.9250
L-4	-209.1 +209.1	- 18.350	-14.260				12758.973	102.9250
L-5		- 20.900	-15.097				12722.976	108.9833
L-6		- 11.760	-11.996			-3238.9	9460.320	110.6500
M-1		- .828	- .233	-4329.000	-140.251		4990.008	110.7500
M-2		- 72.515	-17.936		- 49.977		4849.580	128.4500
M-3		- .016	- .004		- 2.430		4847.130	128.4517
M-4		- 7.623	- 2.170		- 28.107		4809.230	129.4183
M-5		- 3.210	- .934		-113.319		4691.767	129.8183
M-6		- 2.702	- .773		- 70.916		4617.376	130.0683
M-7		- .967	- .111				4616.293	130.4016

(1) See Page 7

(2) One crew member transfers to LEM for Translunar checkout. At end of checkout he returns to CM.

(3) Both crew members (incl. suits and dosimeters) transfer to LEM.

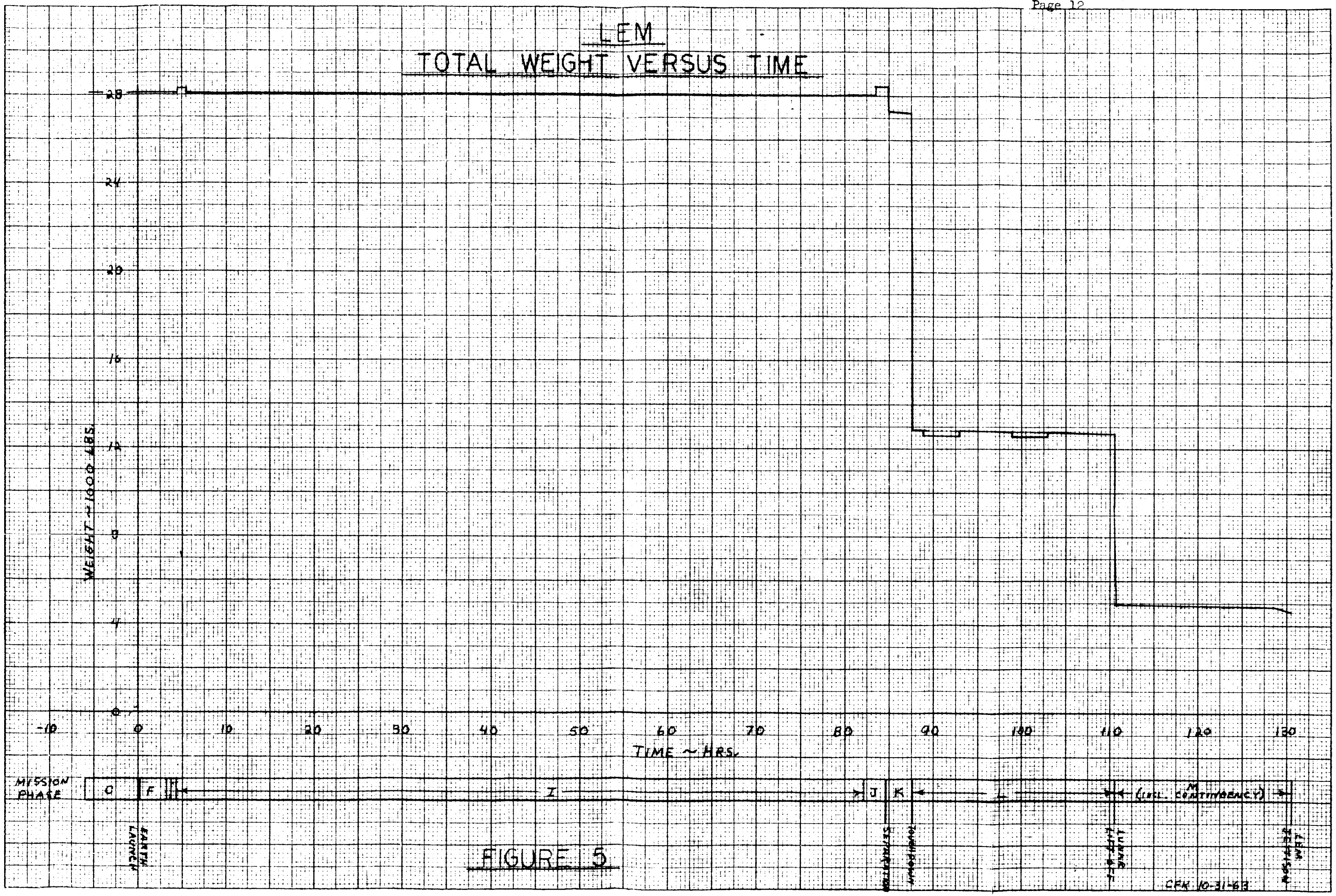

FIGURE 5

K&E 10 X 10 TO THE ½ INCH 359T-11L
KEUFFEL & ESSER CO. MADE IN U.S.A.
ALBANY, N.Y.

LEM

ECS - CONSUMABLE WEIGHT

TABLE IV

MISSION PHASE (1)	WATER CONSUMED HEAT LOAD (LB.)	DRINKING (LB.)	PLSS (LB.)	TOTAL WATER ON BOARD (LB.)	ECS OXYGEN ON BOARD (LB.) (3)	TOTAL ECS CONSUMABLES ON BOARD (LB.)	CUMULATIVE TIME (HR.)
C				311.151 (2)	9.000	320.151	-
D&E	.063			311.063		320.063	.2000
F	1.520			309.543		318.543	3.2000
G	.264			309.279		318.279	3.7833
H	.220			309.059		318.059	4.2833
I-1	.147			308.912		317.912	4.6166
I-2	6.080			302.832		311.832	5.6166
I-3	32.200			270.632		279.632	82.2833
J-1	.042			270.590		279.590	82.3833
J-2	.425			270.165		279.165	83.4000
J-3	6.440			263.725		272.725	84.4167
J-4	2.690			261.035		270.035	84.8333
K-1	.140			260.895		269.895	84.8550
K-2	.878			260.017		269.017	85.0000
K-3	.052			259.965		268.965	85.0083
K-4	13.630			246.335		255.335	87.0517
K-5	3.050			243.285		252.285	87.5417
K-6	.466			242.819		251.819	87.6050
K-7	.281			242.538		251.538	87.6417
K-8	.253			242.285		251.285	87.6750
L-1	7.652			234.633		243.633	88.9250
L-2	9.670	3.000 (4)	5.000 (4)	216.963		225.963	92.9250
L-3	20.608			196.355		205.355	98.9250
L-4	10.350	3.000 (4)	5.000 (4)	178.005		187.005	102.9250
L-5	20.900			157.105		166.105	108.9833
L-6	11.760			145.345	9.000	154.345	110.6500
M-1	.785			144.560	8.957	153.517	110.7500
M-2 (5)	3.950			140.610	8.769	149.379	111.2500
	50.250			90.360	2.866	93.226	126.9500
	11.660			78.700	2.302	81.002	128.4500
M-3	.015			78.685	2.302	80.987	128.4517
M-4	7.260			71.425	1.938	73.363	129.4183
M-5	3.040			68.385	1.768	70.153	129.8183
M-6	2.560			65.825	1.626	67.451	130.0683
M-7	.825			65.000	1.484	66.484	130.4016

(1) See Page 7

(2) Total Water includes drinking water and (6) PLSS Refills.

Water Boiler	230.151
Drinking Water	47.500
PLSS Refills (6)	33.500
Total Water	311.151

(3) In SOX Accumulator.

(4) Vented to Lunar Atmoshpere.

(5) Orbital Contingency.

LEM

ECS-CONSUMABLE WEIGHT VERSUS TIME

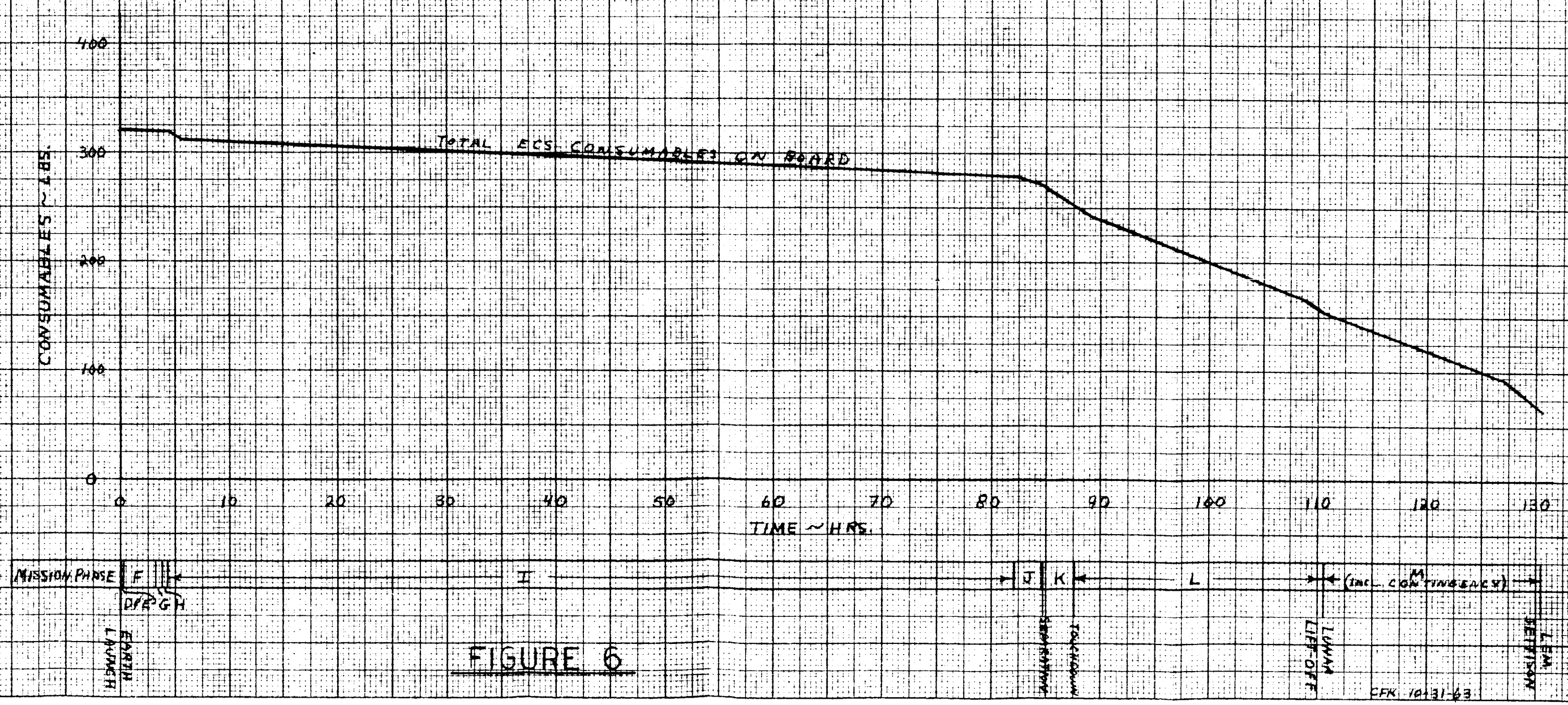

FIGURE 6

K&E 10 X 10 TO THE ½ INCH 359T-11L
KEUFFEL & ESSER CO. MADE IN U.S.A.
ALBANENE ®

LEM

EPS - CONSUMABLE WEIGHT

TABLE V

MISSION PHASE (1)	CONSUMPTION			TOTAL - ON BOARD			TOTAL EPS CONSUMABLES ON BOARD (LB.)	CUMULATIVE TIME (HR.)
	EPS - POWER		CABIN & CREW OXYGEN (LB.)	EPS- POWER		CABIN & CREW OXYGEN (LB.)		
	HYDROGEN (LB.)	OXYGEN (LB.)		HYDROGEN (LB.)	OXYGEN (LB.)			
A&B				31.4349	59.1491	42.1507	132.7347	-
C	.3591	1.5768		31.0758	57.5723	42.1507	130.7988	-
D&E	.0080	.0358		31.0678	57.5365	42.1507	130.7550	.2000
F	.1197	.5376		30.9481	56.9989	42.1507	130.0977	3.2000
G	.0236	.1058		30.9245	56.8931	42.1507	129.9683	3.7833
H	.0202	.0907		30.9043	56.8024	42.1507	129.8574	4.2833
I-1	.0134	.0603		30.8909	56.7421	42.1507	129.7837	4.6166
I-2	.9079	1.1812	.0670	29.9830	55.5609	42.0837	127.6276	5.6166
I-3	3.0590	13.5854		26.9240	41.9755	42.0837	110.9832	82.2833
J-1	.0040	.0177		26.9200	41.9578	42.0837	110.9615	82.3833
J-2	.0406	.1802		26.8794	41.7776	42.0837	110.7407	83.4000
J-3	1.1023	1.3803	.1362	25.7771	40.3973	41.9475	108.1219	84.4167
J-4	.3878	.5492	.0558	25.3893	39.8481	41.8917	107.1291	84.8333
K-1	.0212	.0297	.0090	25.3681	39.8184	41.8827	107.0692	84.8550
K-2	.1566	.2127	.0600	25.2115	39.6057	41.8227	106.6399	85.0000
K-3	.0103	.0135	.0034	25.2012	39.5922	41.8193	106.6127	85.0083
K-4	2.2839	2.8504	.8460	22.9173	36.7418	40.9733	100.6324	87.0517
K-5	.4719	.6630	.2029	22.4454	36.0788	40.7704	99.2946	87.5417
K-6	.0809	.1055	.0262	22.3645	35.9733	40.7442	99.0820	87.6050
K-7	.0482	.0624	.0161	22.3163	35.9109	40.7281	98.9553	87.6417
K-8	.0446	.0576	.0147	22.2717	35.8533	40.7134	98.8384	87.6750
L-1	.8910	1.1526	.4260	21.3807	34.7007	40.2874	96.3688	88.6750
	.2227	.2881	.0775	21.1580	34.4126	40.2099	95.7805	88.9250
L-2	1.1374	1.5966	6.8267	20.0206	32.8160	33.3832	86.2198	90.5917
	1.5902	2.2322	.8773	18.4304	30.5838	32.5059	81.5201	92.9250
L-3	.4530	.6931	4.0960	17.9774	29.8907	28.4099	76.2780	93.9250
	.3010	.4607	2.6884	17.6764	29.4300	25.7215	72.8279	94.5917
	1.9585	2.9965	1.3587	15.7179	26.4335	24.3628	66.5142	98.9250
L-4	1.1374	1.5966	6.8267	14.5805	24.8369	17.5361	56.9535	100.5917
	1.5902	2.2322	.8773	12.9903	22.6047	16.6588	52.2538	102.9250
L-5	.4522	.6920	4.0960	12.5381	21.9127	12.5628	47.0136	103.9250
	.3015	.4613	2.6894	12.2366	21.4514	9.8734	43.5614	104.5917
	1.9872	3.0404	1.3771	10.2494	18.4110	8.4963	37.1567	108.9833
L-6	1.5235	1.9757	.5800	8.7259	16.4353	7.9163	33.0775	110.6500

TABLE V (Cont.)

MISSION PHASE (1)	CONSUMPTION			TOTAL - ON BOARD			TOTAL EPS CONSUMABLES ON BOARD (LB.)	CUMULATIVE TIME (HR.)
	EPS - POWER		CABIN & CREW OXYGEN (LB.)	EPS - POWER		CABIN & CREW OXYGEN (LB.)		
	HYDROGEN (LB.)	OXYGEN (LB.)		HYDROGEN (LB.)	OXYGEN (LB.)			
M-1	.0972	.1362	(2)	8.6287	16.2991	(2)	24.9278	110.7500
M-2 (3)	.4680	.6615		8.1607	15.6376		23.7983	111.2500
	4.9596	8.3084		3.2011	7.3292		10.5303	126.9500
	1.5659	1.9728		1.6352	5.3564		6.9916	128.4500
M-3	.0017	.0023		1.6335	5.3541		6.9876	128.4517
M-4	.8964	1.2735		.7371	4.0806		4.8177	129.4183
M-5	.3888	.5448		.3483	3.5358		3.8841	129.8183
M-6	.3217	.4515		.0266	3.0843		3.1109	130.0683
M-7	.0266	.0843		0	3.0000 (4)		3.0000	130.4016

(1) See Page 7

(2) During the ascent phase, O_2 is used from the O_2 - GOX Accumulator in the ECS.

(3) Orbital Contingency.

(4) 3 lb. Left in SOX- Ascent Tank.

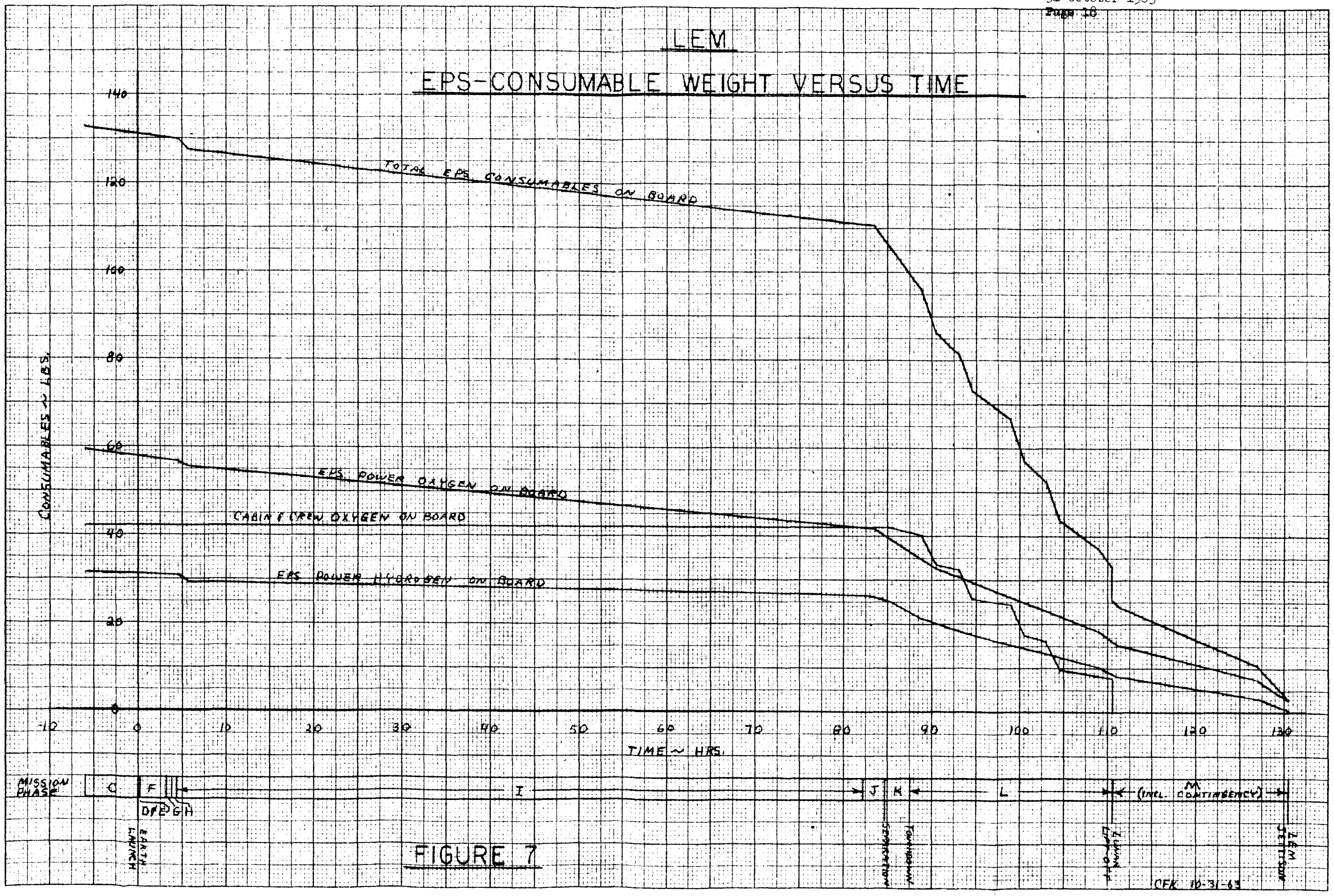

FIGURE 7

K+E 10 X 10 TO THE 1/2 INCH 359T-11L
KEUFFEL & ESSER CO. MADE IN U.S.A.
ALBANENE ®

LEM

RCS CONSUMABLE WEIGHT

TABLE VI

Mission Phase (1)	Propellant Consumption (LB)	Total Propellant On Board (LB)	Cumulative Time (Hr)
C		504.5000	0
D&E ↓ J		↓ 504.5000	↓ 84.8333
K-1	7.7603	496.7397	84.8550
K-2	3.3725	493.3672	85.0000
K-3	.1917	493.1755	85.0083
K-4	21.2432	471.9323	87.0517
K-5	5.0836	466.8487	87.5417
K-6	14.3420	452.5067	87.6050
K-7	8.3070	444.1997	87.6417
K-8	10.6997	433.5000	87.6750
L		433.5000	110.6500
M-1	140.2515	293.2485	110.7500
M-2	49.9770	243.2715	128.4500
M-3	2.4300	240.8415	128.4517
M-4	28.1070	212.7345	129.4183
M-5	113.3190	99.4155	129.8183
M-6	70.9155	28.5000 (2)	130.0683
M-7		~28.5000	130.4016

(1) See Page 7

(2) Residual Propellant

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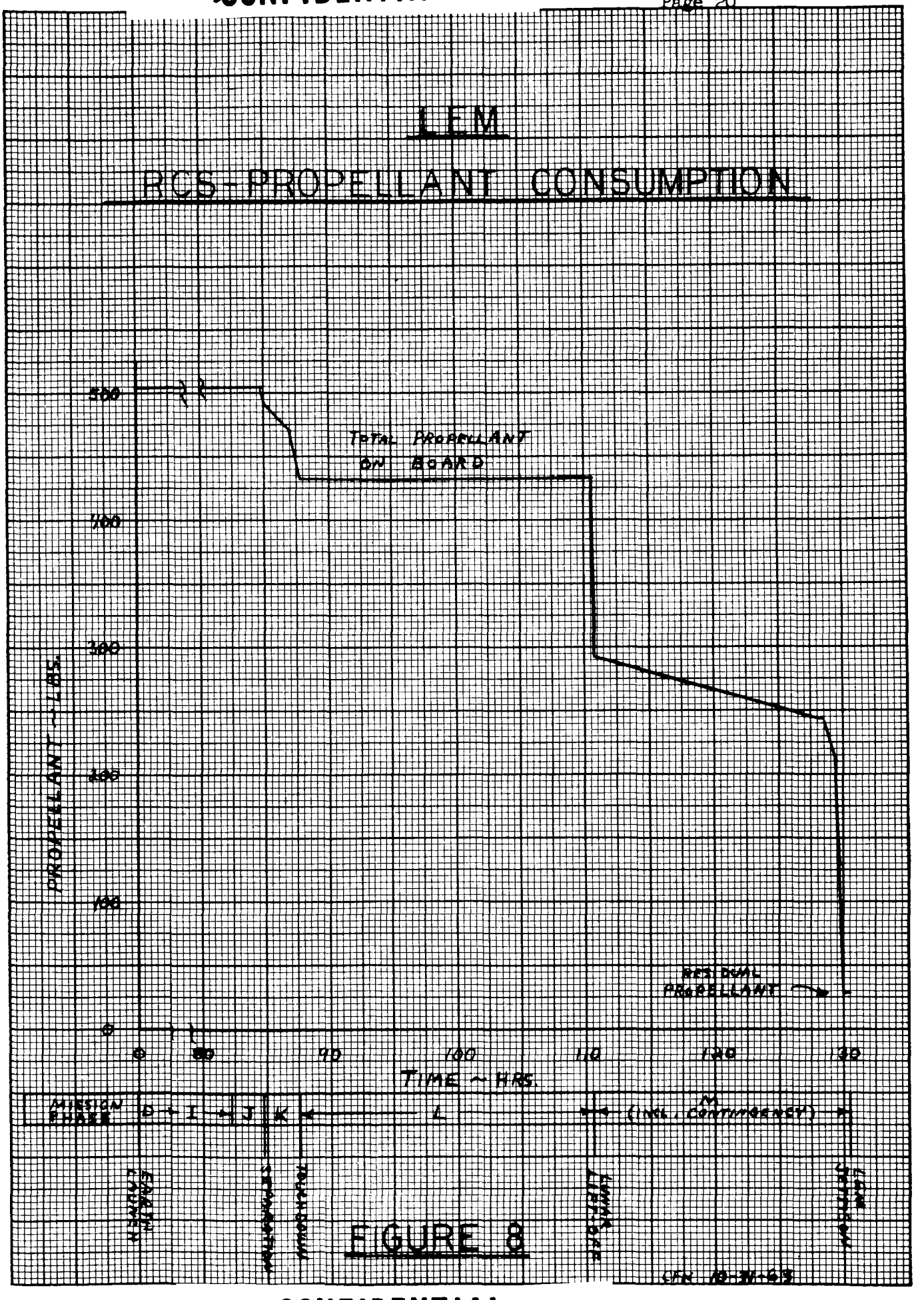

FIGURE 8

CFN 10-30-63

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K+E 10 X 10 TO THE ½ INCH 359T-11
KEUFFEL & ESSER CO. MADE IN U.S.A.
ALBANENE ®

[redacted]

LEM MASS PROPERTY HISTORY

31 October 1963

MISSION PHASE	WEIGHT EARTH POUNDS	CENTER OF GRAVITY			MOMENTS OF INERTIA			PRODUCTS OF INERTIA		
		STATION INCHES	DISTANCE FROM THRUST AXIS		SLUG FT^2			SLUG FT^2		
		X	Y	Z	I_{xx}	I_{yy}	I_{zz}	I_{yz}	I_{xz}	I_{xy}
EARTH LAUNCH	28[illegible]	188.3	-.4	-1.5	18531	22113	21460	-40	-112	82
SEPARATION	28442	189.1	-.4	- .7	20523	23933	23118	-55	170	61
SYNCHRONOUS ORBIT	27597	189.0	-.4	- .7	19957	23580	22873	-55	170	60
HOVER	14454	211.6	-.7	-1.4	11086	14289	15494	-54	268	113
TOUCHDOWN	12870	220.5	-.8	-1.6	10039	11648	13093	-56	304	129
PRE-LIFT OFF	12682	220.9	-.3	-1.4	9969	11517	12952	-74	254	85
LIFT OFF	9460	246.7	-.3	-1.1	5305	3412	4711	-40	234	78
TRANSFER ORBIT 50,000 FEET to 80 MILES	4830	248.8	-.2	-1.8	2808	2664	1637	-29	231	59
BURNOUT (DOCKED)	4616	250.0	-.2	-1.9	2582	2626	1385	-19	233	57
POST-BURNOUT	4058	249.5	.6	-7.6	2260	2309	1256	1	218	63

Mass Properties per drawings LLO-340-121, LDW-280-17000 & LSK-280-10102.

[redacted]

LEM WEIGHT COMPARISON AT SEPARATION BY STAGES

SUBSYSTEM CODE	ITEM	8/29/63 WEIGHT	CURRENT WEIGHT	ΔWEIGHT
A.	Ascent Stage Weight at Separation	10380.9	9624.6	-756.3
1.0	Structure	1044.3	884.8	-159.5
2.0	Stabilization and Control	94.0	104.0	+ 10.0
3.0	Navigation and Guidance	265.0	260.0	+ 5.0
4.0	Crew Provisions	586.4	566.4	- 20.0
5.0	Environmental Control	533.4	529.9	- 3.5
6.0	Landing Gear	---	---	
7.0	Instrumentation - Operational	477.1	307.9	-169.2
	- Scientific	---	---	
8.0	Electrical Power Supply	1340.9	894.8	-446.1
9.0	Propulsion System	(4863.6)	(4903.6)	(+ 40.0)
	Propulsion Inert	488.6	528.6	+ 40.0
	Propellant (includes 46# trapped)	4375.0	4375.0	0
10.0	Reaction Control	(824.6)	(824.6)	0
	Propulsion Inert	320.1	320.1	0
	Propellant (Includes 28.5# trapped)	504.5	504.5	0
11.0	Communications	94.2	94.2	0
12.0	Controls and Displays	257.4	254.4	- 3.0
B.	Descent Stage Weight at Separation	19047.8	18817.3	-230.5
1.0	Structure	921.0	802.0	-119.0
2.0	Stabilization and Control	23.5	13.5	- 10.0
3.0	Navigation and Guidance	5.0	10.0	+ 5.0
4.0	Crew Provisions	10.0	5.0	- 5.0
6.0	Landing Gear - Fixed	468.0	468.0	0
7.0	Instrumentation - Operational	60.1	30.0	- 30.1
	- Scientific	250.0	250.0	0
8.0	Electrical Power Supply	261.3	203.9	- 57.4
9.0	Propulsion System	(17038.8)	(17024.8)	(- 14.0)
	Propulsion Inert	1401.8	1387.8	- 14.0
	Propellant (Includes 163# trapped)	15637.0	15637.0	0
11.0	Communications (Portable)	10.1	10.1	0
	Total Separation Weight (A & B)	29428.7	28441.9	-986.8

[redacted]

LEM
SUMMARY WEIGHT STATEMENT

CODE	ITEM	Weight Status 8/29/63 BURNOUT	CONS'D ON ASCENT	JET ON LURAIN	CONS'D ON DESC.	TOTAL SEP.	Current Weight Status BURNOUT	CONS'D ON ASCENT	JET ON LURAIN	CONS'D ON DESC.	TOTAL SEP.
1.0	Structure	1044.3		921.0		1965.3	884.8		802.0		1686.8
2.0	Stabilization & Control	94.0		23.5		117.5	104.0		13.5		117.5
3.0	Navigation & Guidance	237.0		33.0		270.0	242.0		28.0		270.0
4.0	Crew Provisions	580.8		15.6		596.4	560.8		10.6		571.4
5.0	Environmental Control	300.8	85.2	126.4	21.0	533.4	303.4	87.8	119.9	18.8	529.9
6.0	Landing Gear			468.0		468.0			468.0		468.0
7.0	Instrumentation	557.1		230.1		787.2	387.9		200.0		587.9
8.0	Electrical Power Supply	1335.8	5.1	253.0	8.3	1602.2	872.7	22.1	195.6	8.3	1098.7
9.0	Propulsion	534.6	4329.0	1564.8	15474.0	21902.4	574.6	4329.0	1550.8	15474.0	21928.4
10.0	Reaction Control	348.6	405.0		71.0	824.6	348.6	405.0		71.0	824.6
11.0	Communications	83.2		21.1		104.3	83.2		21.1		104.3
12.0	Controls and Displays	257.4				257.4	254.4				254.4
	Totals	5373.6	4824.3	3656.5	15574.3	29428.7	4616.4	4843.9	3409.5	15572.1	28441.9

Separation Weight	29428.7 lbs.	28441.9 lbs.
Touchdown Weight	13854.4 lbs.	12869.8 lbs.
Lift-Off Weight	10197.9 lbs.	9460.3 lbs.
Burnout Weight	5373.6 lbs.	4616.4 lbs.

[redacted]

LEM
DETAIL WEIGHT STATEMENT

CODE	ITEM	Weight Status 8/29/63 BURNOUT	CONS'D ON ASC.	JET ON LURAIN	CONS'D ON DESC.	TOTAL SEP.	Current Weight Status BURNOUT	CONS'D ON ASC.	JET ON LURAIN	CONS'D ON DESC.	TOTAL SEP.
1.	Structure	1044.3		921.0		1965.3	884.8		802.0		1686.8
1.1	Crew Compartment	(596.6)				(596.6)	(564.3)				(564.3)
1.1.1	Skin	71.9				71.9	71.9				71.9
1.1.2	MM Shielding	32.3				32.3	0				0
1.1.3	Thermal Protection	26.4		[illegible]		26.4	26.4		[illegible]		26.4
1.1.4	Bulkheads	41.0				41.0	41.0				41.0
1.1.5	Beams	16.0				16.0	16.0				16.0
1.1.6	Longerons	20.5		[illegible]		20.5	20.5		[illegible]		20.5
1.1.7	Stiffeners	20.0				20.0	20.0				20.0
1.1.8	Frames	20.0				20.0	20.0				20.0
1.1.9	Windows	43.0				43.0	43.0				43.0
1.1.10	Docking Tube	75.8				75.8	75.8				75.8
1.1.11	Hatches	70.0				70.0	70.0				70.0
1.1.12	Equipment Supports	94.0				94.0	94.0				94.0
1.1.13	Flooring	44.4				44.4	44.4				44.4
1.1.14	Welds & Fasteners	21.3				21.3	21.3				21.3
1.2	Equipment Compartment	(141.9)				(141.9)	(109.7)				(109.7)
1.2.1	Skin	- -				- -	- -				- -
1.2.2	Thermal Protection	18.3				18.3	18.3				18.3
1.2.3	MM Shielding	32.2				32.2	0				0
1.2.4	Vertical Supports	6.3				6.3	6.3				6.3
1.2.5	Stiffeners	7.8				7.8	7.8				7.8
1.2.6	Bulkheads	14.3				14.3	14.3				14.3
1.2.7	Cold Plates	63.0				63.0	63.0				63.0

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LEM
DETAIL WEIGHT STATEMENT

CODE	ITEM	Weight Status 8/29/63 BURNOUT	CONS'D ON ASC.	JET ON LURAIN	CONS'D ON DESC.	TOTAL SEP.	Current Weight Status BURNOUT	CONS'D ON ASC.	JET ON LURAIN	CONS'D ON DESC.	TOTAL SEP.
1.3	Engine/Tank Compt.	(203.4)				(203.4)	(140.4)				(140.4)
1.3.1	Skin	- -				- -	- -				- -
1.3.2	Thermal Protection	34.2				34.2	34.2				34.2
1.3.3	MM Shielding	63.0				63.0	0				0
1.3.4	Bulkheads	73.5				73.5	73.5				73.5
1.3.5	Stiffeners	10.7				10.7	10.7				10.7
1.3.6	Engine Supports	6.0				6.0	6.0				6.0
1.3.7	Tank Supports	16.0				16.0	16.0				16.0
1.4	Bulkhead (Ascent)	(102.4)				(102.4)	(70.4)				(70.4)
1.4.1	Structure	96.0				96.0	64.0				64.0
1.4.11	Insulation	6.4				6.4	6.4				6.4
1.10	Descent Stage Structure			(921.0)		(921.0)			(802.0)		(802.0)
1.10.1	Skin (Closure)			116.0		116.0			116.0		116.0
1.10.2	Beams & Bulkheads			391.0		391.0			391.0		391.0
1.10.3	MM Shielding			119.0		119.0			0		0
1.10.4	Thermal Protection			73.0		73.0			73.0		73.0
1.10.5	Supports			62.0		62.0			62.0		62.0
1.10.6	L.G. Support Truss			107.0		107.0			107.0		107.0
1.10.7	Separation System			29.0		29.0			29.0		29.0
1.10.8	S IV B Attach. Penalty			24.0		24.0			24.0		24.0

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LEM
DETAIL WEIGHT STATEMENT

CODE	ITEM	Weight Status 8/29/63 BURNOUT	CONS'D ON ASC.	JET ON LURAIN	CONS'D ON DESC.	TOTAL SEP.	Current Weight Status BURNOUT	CONS'D ON ASC.	JET ON LURAIN	CONS'D ON DESC.	TOTAL SEP.
2.0	Stabilization & Control	94.0		23.5		117.5	104.0		13.5		117.5
2.1	Guidance Coupler Assy.	6.0				6.0	6.0				6.0
2.2	Attitude Translation Control Assy.	15.0				15.0	22.0				22.0
2.3	Rate Gyro Assy. (2)	3.0				3.0	3.0				3.0
2.4	Inflight Monitor Assy.	10.0				10.0	10.0				10.0
2.5	Descent Engine Control Assy.			23.5		23.5			13.5		13.5
2.6	Back Up Guidance System	(60.0)				(60.0)	(63.0)				(63.0)
2.6.1	Programmer Assy.	20.0				20.0	20.0				20.0
2.6.2	Attitude Reference Assy*	40.0				40.0	43.0				43.0

*Includes Power Supply, Sensors, and Electronics

Inflight Monitor - Monitors performances measured by IFTS.

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LEM
DETAIL WEIGHT STATEMENT

CODE	ITEM	Weight Status 8/29/63 BURNOUT	CONS'D ON ASC.	JET ON LURAIN	CONS'D ON DESC.	TOTAL SEP.	Current Weight Status BURNOUT	CONS'D ON ASC.	JET ON LURAIN	CONS'D ON DESC.	TOTAL SEP.
3.0	Navigation and Guidance	237.0		33.0		270.0	242.0		28.0		270.0
3.1	GFE	(191.0)				(191.0)	(201.0)				(201.0)
3.1.1	IMU	58.0				58.0	59.0				59.0
3.1.2	AOT & Eyepieces	12.0				12.0	24.5				24.5
3.1.3	AGC	60.0				60.0	60.0				60.0
3.1.4	PSA	35.0				35.0	37.5				37.5
3.1.5	NVB	4.0				4.0	3.0				3.0
3.1.6	Cabling	15.0				15.0	10.0				10.0
3.1.7	Star, Maintenance Book	2.0				2.0	2.0				2.0
3.1.8	Cold Plate	5.0				5.0	5.0				5.0
3.2	Rendezvous Radar*	(46.0)				(46.0)	(41.0)				(41.0)
3.2.1	Gimbaled Antenna	10.0				10.0	30.0				30.0
3.2.2	Electronics	26.0				26.0					
3.2.3	Transponder	10.0				10.0	11.0				11.0
3.3	Landing Radar* **			(33.0)		(33.0)			(28.0)		(28.0)
3.3.1	3 Beam Stabilized Antenna			5.0		5.0			10.0		10.0
3.3.2	Electronics ***			28.0		28.0			18.0		18.0

*Includes Encoder functions.
**Including Antenna Electronics.
***Electronics are in the Ascent Stage, but removed and left on lunar surface.

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LEM
DETAIL WEIGHT STATEMENT

CODE	ITEM	Weight Status 8/29/63 BURNOUT	CONS'D ON ASC.	JET ON LURAIN	CONS'D ON DESC.	TOTAL SEP.	Current Weight Status BURNOUT	CONS'D ON ASC.	JET ON LURAIN	CONS'D ON DESC.	TOTAL SEP.
4.0	Crew Provisions	580.8		15.6		596.4	560.8		10.6		571.4
4.1	Crew Accessories	(125.0)				(125.0)	(125.0)				(125.0)
4.1.1	Space Suits (2)	60.0				60.0	60.0				60.0
4.1.2	Portable Life Support System * (2)	60.0				60.0	60.0				60.0
4.1.3	Radiation Dosimeter (2)	5.0				5.0	5.0				5.0
4.2	Crew (2)	353.2				353.2	353.2				353.2
4.3	Seats and Restraints (2)	70.0				70.0	50.0				50.0
4.4	Lighting **	(20.0)		(10.0)		(30.0)	(20.0)		(5.0)		(25.0)
4.4.1	Landing			10.0		10.0			5.0		5.0
4.4.2	Hatchway	4.0				4.0	4.0				4.0
4.4.3	Cabin	8.0				8.0	8.0				8.0
4.4.4	Running (docking)	8.0				8.0	8.0				8.0
4.5	Sustenance & Associated Equipment	(12.6)		(5.6)		(18.2)	(12.6)		(5.6)		(18.2)
4.5.1	Drinking Water					***					***
4.5.2	Food & Storage	10.1		5.6		15.7	10.1		5.6		15.7
4.5.3	First Aid Kit	2.5				2.5	2.5				2.5
4.6	Waste Management					- -					- -

* Weight of 2 LiOH Cartridges is considered part of PLSS dry weight shown.
** Panel lighting (10#) is under controls and displays.
*** Drinking Water is under ECS code.

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LEM
DETAIL WEIGHT STATEMENT

CODE	ITEM	Weight Status 8/29/63 BURNOUT	CONS'D ON ASC.	JET ON LURAIN	CONS'D ON DESC.	TOTAL SEP.	Current Weight Status BURNOUT	CONS'D ON ASC.	JET ON LURAIN	CONS'D ON DESC.	TOTAL SEP.
5.0	Environmental Control	300.8	85.2	126.4	21.0	533.4	303.4	87.8	119.9	18.8	529.9
5.1	Atmosphere Revitalization Section	(88.7)		(26.4)		(115.1)	(82.0)		(23.0)		(105.0)
5.1.1	Suit-Circuit Assy.	30.8				30.8	30.8				30.8
5.1.2	Cabin Recirculation Assy	19.7				19.7	19.7				19.7
5.1.3	CO_2 Removal Cannister	3.3				3.3	3.3				3.3
5.1.4	Plumbing	* 18.4				18.4	18.4				18.4
5.1.5	LiOH Cart. - ECS (5)/[redacted]	16.5				16.5	9.8		9.8		19.6
	- PLSS (8)/(4)			26.4		26.4			13.2		13.2
5.2	Heat Transport Section	(64.4)				(64.4)	(64.4)				(64.4)
5.2.1	Coolant Recirculation Assy	7.0				7.0	7.0				7.0
5.2.2	Valves and Switches	27.4				27.4	27.4				27.4
5.2.3	Cold Plates					**					**
5.2.4	Coolant	30.0				30.0	30.0				30.0
5.3	O_2 Supply and Cabin Pressure Section	(29.7)	(2.2)			(31.9)	(23.7)	(7.5)			(31.2)
5.3.1	GOX Accumulator	15.5				15.5	15.5				15.5
5.3.2	GOX	6.0	2.2			8.2	0	7.5			7.5
5.3.3	Valves and Switches	8.2				8.2	8.2				8.2
5.3.4	SOX and SOX Tank					***					***
5.4	Water Management Section	(88.2)	(83.0)	(100.0)	(21.0)	(292.2)	(103.5)	(80.3)	(96.9)	(18.8)	(299.5)
5.4.1	Water Tank	30.5				30.5	30.5				30.5
5.4.2	Water	55.0	83.0	100.0	21.0	259.0	70.3	80.3	96.9	18.8	266.3
5.4.3	Valves and Switches	2.7				2.7	2.7				2.7

* Included are 4 PLSS replacement cartridges (3.3# ea.) and 4 ECS cartridges (4.9# ea.).
** Included in Structures although ECS expects to purchase 20#.
*** Included in EPS.

[redacted]

LEM
DETAIL WEIGHT STATEMENT

CODE	ITEM	Weight Status 8/29/63 BURNOUT	CONS'D ON ASC.	JET ON LURAIN	CONS'D ON DESC.	TOTAL SEP.	Current Weight Status BURNOUT	CONS'D ON ASC.	JET ON LURAIN	CONS'D ON DESC.	TOTAL SEP.
5.5	Plumbing GAEC	(29.8)				(29.8)	(29.8)				(29.8)
	Heat Transport and H_2O Manage.	8.0				8.0	8.0				8.0
	Atmosphere Revitalization and O_2 Supply	20.0				20.0	20.0				20.0
	Heat Exchangers **** (3)	1.8				1.8	1.8				1.8

**** Includes an additional heat exchanger for O_2 and two heat exchangers for H_2 in EPS.

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LEM
DETAIL WEIGHT STATEMENT

CODE	ITEM	Weight Status 8/29/63 BURNOUT	CONS'D ON ASC.	JET ON LURAIN	CONS'D ON DESC.	TOTAL SEP.	Current Weight Status BURNOUT	CONS'D ON ASC.	JET ON LURAIN	CONS'D ON DESC.	TOTAL SEP.
6.0	Landing Gear*			468.0		468.0					
6.1	Upper Struts			(106.0)		(106.0)					
6.1.1	Tubes			37.0		37.0					
6.1.2	Fittings			49.0		49.0					
6.1.3	Shocks			20.0		20.0		NO CHANGE FROM			
6.2	Lower Struts			(154.0)		(154.0)					
6.2.1	Tubes			64.0		64.0		PREVIOUS REPORT			
6.2.2	Fittings			50.0		50.0					
6.2.3	Shocks			40.0		40.0					
6.3	Mechanism			96.0		96.0					
6.4	Pads & Fittings			(112.0)		(112.0)					
6.4.1	Pads			72.0		72.0					
6.4.2	Fittings			40.0		40.0					

* Note: Landing Gear final configuration and design criteria has not been resolved to date. Combinations of configuration and criteria indicate a landing gear weight range of 400 to 600 pounds.

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DETAIL WEIGHT STATEMENT

CODE	ITEM	Weight Status 8/29/63 BURNOUT	CONS'D ON ASC.	JET ON LURAIN	CONS'D ON DESC.	TOTAL SEP.	Current Weight Status BURNOUT	CONS'D ON ASC.	JET ON LURAIN	CONS'D ON DESC.	TOTAL SEP.
7.0	Instrumentation	557.1		230.1		787.2	387.9		200.0		587.9
7.1	Operational	(156.0)				(156.0)	(121.5)				(121.5)
7.1.1	Signal Conditioner	76.0				76.0	59.0				59.0
7.1.2	PCMTE	50.0				50.0	32.5				32.5
7.1.3	Data Storage Equip. *	30.0				30.0	30.0				30.0
7.2	In Flight Test System **	51.4				51.4	51.4				51.4
7.3	Scientific Equipment	80.0		170.0		250.0	80.0		170.0		250.0
7.4	Sensors	(269.7)		(60.1)		(329.8)	(135.0)		(30.0)		(165.0)
7.4.1	Structure	26.0				26.0	13.0				13.0
7.4.2	Stabilization and Control	28.2				28.2	14.0				14.0
7.4.3	Navigation and Guidance	5.5				5.5	3.0				3.0
7.4.5	Environmental Control System	49.4				49.4	25.0				25.0
7.4.7	Instrumentation	3.3				3.3	2.0				2.0
7.4.8	Electrical Power System	20.3				20.3	10.0				10.0
7.4.9	Propulsion	70.9		60.1		131.0	35.0		30.0		65.0
7.4.10	Reaction Control System	52.4				52.4	26.0				26.0
7.4.11	Communications	13.7				13.7	7.0				7.0

* Weight includes three (3) tapes of which two are spares.
** Has stimuli generator and Inflight comparator functions.

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DETAIL WEIGHT STATEMENT

CODE	ITEM	Weight Status 8/29/63 BURNOUT	CONS'D ON ASC.	JET ON LURAIN	CONS'D ON DESC.	TOTAL SEP.	Current Weight Status BURNOUT	CONS'D ON ASC.	JET ON LURAIN	CONS'D ON DESC.	TOTAL SEP.
8.0	Electrical Power Supply *	1335.8	5.1	253.0	8.3	1602.2	872.7	22.1	195.6	8.3	1098.7
8.1	Power Generation Section	(332.5)	(5.1)	(161.4)	(8.3)	(507.3)	(309.7)	(22.1)	(153.6)	(8.3)	(493.7)
8.1.1	Fuel Cells ** (3)	210.0				210.0	210.0				210.0
8.1.2	Oxygen Tanks (2)	4.8		16.6		21.4	4.8		16.6		21.4
8.1.3	Hydrogen Tanks (3)	23.2		38.8		62.0	23.2		38.8		62.0
8.1.4.1	Oxygen-Ascent	17.9	3.4			21.3	3.0	13.4			16.4
8.1.4.2	-Descent			65.6	5.2	70.8			60.1	5.2	65.3
8.1.5.1	Hydrogen - Ascent	7.9	1.7			9.6		8.7			8.7
8.1.5.2	- Descent			15.8	3.1	18.9			13.5	3.1	16.6
8.1.6	Spiking Battery System	17.0				17.0	17.0				17.0
8.1.7.1	Plumbing-*** O_2 Feed	13.3		9.9		23.2	13.3		9.9		23.2
8.1.7.2	- H_2 Feed	23.4		14.7		38.1	23.4		14.7		38.1
8.1.8	Pyrotechnic Batteries (2)	10.0				10.0	10.0				10.0
8.1.9	Battery Charger (1)	5.0				5.0	5.0				5.0
8.2	Power Conversion Section	(80.0)				(80.0)	(80.0)				(80.0)
8.2.1	Inverters (2)	70.0				70.0	70.0				70.0
[redacted].2	Control Unit	10.0				10.0	10.0				10.0
8.3	Distribution Section	(110.0)				(110.0)	(110.0)				(110.0)
8.3.1	Distribution Boxes (2)	30.0				30.0	30.0				30.0
8.3.2	Circuit Breaker Panels (2)	45.0				45.0	45.0				45.0
8.3.3	Junction Boxes (2)	15.0				15.0	15.0				15.0
8.3.4	Relay Boxes (2)	20.0				20.0	20.0				20.0

* Heat Exchangers and Glycol Plumbing are included under ECS.
** Includes Fuel Cell Control Units.
*** Includes Pressure Regulators.

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DETAIL WEIGHT STATEMENT

CODE	ITEM	Weight Status 8/29/63 BURNOUT	CONS'D ON ASC.	JET ON LURAIN	CONS'D ON DESC.	TOTAL SEP.	Current Weight Status BURNOUT	CONS'D ON ASC.	JET ON LURAIN	CONS'D ON DESC.	TOTAL SEP.
8.4	Electrical Provisions	(813.3)		91.6		(904.9)	(373.0)		(42.0)		(415.0)
8.4.2	Stabilization & Control	24.6				24.6	14.0				14.0
8.4.3	Navigation & Guidance	141.0		5.0		146.0	83.0		2.0		85.0
8.4.4	Crew System	2.8				2.8	2.0				2.0
8.4.5	Environmental Control	7.4				7.4	4.0				4.0
8.4.7	Instrumentation	433.9		53.3		487.2	147.0		24.0		171.0
8.4.8	Electrical Power	117.6		26.3		143.9	71.0		13.0		84.0
8.4.9	Propulsion	27.3		7.0		34.3	17.0		3.0		20.0
8.4.10	Reaction Control	25.7				25.7	15.0				15.0
8.4.11	Communications	26.7				26.7	16.0				16.0
8.4.12	Controls and Displays	6.3				6.3	4.0				4.0

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DETAIL WEIGHT STATEMENT

CODE	ITEM	Weight Status 8/29/63 BURNOUT	CONS'D ON ASC.	JET ON LURAIN	CONS'D ON DESC.	TOTAL SEP.	Current Weight Status BURNOUT	CONS'D ON ASC.	JET ON LURAIN	CONS'D ON DESC.	TOTAL SEP.
9.0	Propulsion System	534.6	4329.0	1564.8	15474.0	21902.4	574.6	4329.0	1550.8	15474.0	21928.4
9.1	Propellant	(46.0)	(4329.0)	(163.0)	(15474.0)	(20012.0)	(46.0)	(4329.0)	(163.0)	(15474.0)	(20012.0)
9.1.1.1	Usable - Ascent		4329.0			4329.0		4329.0			4329.0
9.1.1.2	- Descent				15474.0	15474.0				15474.0	15474.0
9.1.2.1	Trapped- Ascent	46.0				46.0	46.0				46.0
9.1.2.2	- Descent			163.0		163.0			163.0		163.0
9.2	Propellant System	(183.6)		(510.3)		(693.9)	(223.6)		(510.3)		(733.9)
9.2.1	Fuel Tanks -Ascent	80.0				80.0	100.0				100.0
9.2.2	-Descent			242.0		242.0			242.0		242.0
9.2.3	Oxid. Tanks-Ascent	80.0				80.0	100.0				100.0
9.2.4	-Descent			242.0		242.0			242.0		242.0
9.2.5	Plumbing-Ascent	23.6				23.6	23.6				23.6
9.2.6	Plumbing-Descent			26.3		26.3			26.3		26.3
9.3	Pressurization System	(131.0)		(475.4)		(606.4)	(131.0)		(475.4)		(606.4)
9.3.1	Helium Tanks-Ascent	90.0				90.0	90.0				90.0
9.3.2	-Descent			393.0		393.0			393.0		393.0
9.3.3	Helium -Ascent	11.0				11.0	11.0				11.0
9.3.4	-Descent			42.0		42.0			42.0		42.0
9.3.5	Plumbing - Ascent	30.0				30.0	30.0				30.0
9.3.6	Plumbing - Descent			40.4		40.4			40.4		40.4
9.4	Engines	(174.0)		(416.1)		(590.1)	(174.0)		(402.1)		(576.1)
9.4.1	Engine-Ascent	131.0				131.0	131.0				131.0
9.4.2	Engine-Descent			358.5		358.5			358.5		358.5
9.4.3	Shield-Ascent	30.0				30.0	30.0				30.0
	-Descent			14.6		14.6			14.6		14.6
9.4.4	Gimbal Actuators			14.0		14.0			0		0
9.4.5	Eng. Mount - Ascent	5.0				5.0	5.0				5.0
	- Descent			8.0		8.0			8.0		8.0
9.4.6	Misc. - Ascent	8.0				8.0	8.0				8.0
	- Descent			21.0		21.0			21.0		21.0

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DETAIL WEIGHT STATEMENT

CODE	ITEM	Weight Status 8/29/63 BURNOUT	CONS'D ON ASCENT	JET ON LURAIN	CONS'D ON DESCENT	TOTAL SEP.	Current Weight Status BURNOUT	CONS'D ON ASCENT	JET ON LURAIN	CONS'D ON DESCENT	TOTAL SEP.
10.0	Reaction Control System	348.6	405.0		71.0	824.6					
10.1	Propellant	(28.5)	(405.0)		(71.0)	(504.5)					
	Attitude Control		198.0		54.0	252.0					
	For ΔV		207.0		17.0	224.0					
10.1.2	Trapped	28.5				28.5					
10.2.1	Fuel Tanks	16.8				16.8					
10.2.2	Oxid. Tanks	16.8				16.8					
10.2.3	Tank Plumbing	(87.5)				(87.5)		NO CHANGE FROM			
	Ascent Tie In	7.0				7.0					
	Fuel & Oxid. Systems *	56.5				56.5		PREVIOUS REPORT			
	Thruster Isolation Valves	24.0				24.0					
10.3	Pressurization	(54.4)				(54.4)					
10.3.1	Helium Tanks	21.0				21.0					
10.3.2	Helium Gas	2.1				2.1					
10.3.3	Plumbing	31.3				31.3					
10.4	Thruster Installation Assy	(104.6)				(104.6)					
	Thrust Chamber Assy	70.2				70.2					
	Cluster Hardware	26.4				26.4					
	TCA Failure Device	8.0				8.0					
10.5	Quad Support Truss	40.0				40.0					

* It is assumed that these systems have identical components and that each system will weigh 28.25 lbs.

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DETAIL WEIGHT STATEMENT

CODE	ITEM	Weight Status 8/29/63 BURNOUT	CONS'D ON ASCENT	JET ON LURAIN	CONS'D ON DESCENT	TOTAL SEP.	Current Weight Status BURNOUT	CONS'D ON ASCENT	JET ON LURAIN	CONS'D ON DESCENT	TOTAL SEP.
11.0	Communications	83.2		21.1		104.3					
11.1	Intercom (Audio Center)	5.0				5.0					
11.2	VHF LEM/CM	(22.3)				(22.3)					
11.2.1	VHF - Transceiver	4.4				4.4					
11.2.2	- In-Flight Antenna*(2)	3.0				3.0					
11.2.3	- Diplexer	2.5				2.5					
11.2.4	- Lunar Stay Antenna (2)	10.0				10.0					
11.2.5	- Power Dividers (2)	1.0				1.0		NO CHANGE FROM			
11.2.6	- R.F. Switch	1.0				1.0					
11.2.7	- B.H. Flanges (3)	.4				.4					
11.3	Premodulation Processor	10.0				10.0		PREVIOUS REPORT			
11.4	S-Band LEM/Earth	(45.9)		10.1		(56.0)					
11.4.1	S-Band - Transceiver	15.0				15.0					
11.4.2	- Power Amplifier	6.0				6.0					
11.4.3	- Inflight Antenna (2)	2.0				2.0					
11.4.4	- Erectable Antenna			10.0		10.0					
11.4.5	- Steerable Dish Antenna*	8.0				8.0					
11.4.6	- R. F. Switch	1.0				1.0					
11.4.7	- Power Divider	.5				.5					
11.4.8	- B. H. Flanges (4)	.4		.1		.5					
11.4.9	- Diplexer	1.0				1.0					
11.4.10	- Earth Sensor & Drive	12.0				12.0					
11.5	Television**	[illegible]		(11.0)		(11.0)					
11.5.1	Camera, Portable			4.0		4.0					
11.5.2	Lens			2.5		2.5					
11.5.3	Cable and Reel			2.5		2.5					
11.5.4	Camera Thermal Equip.			2.0		2.0					

* Includes Rotary Joint in Antenna Weight.
** Auxiliary Light for television if required is considered part of GFE scientific equipment.

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DETAIL WEIGHT STATEMENT

CODE	ITEM	Weight Status 8/29/63 BURNOUT	CONS'D ON ASC.	JET ON LURAIN	CONS'D ON DESC.	TOTAL SEP.	Current Weight Status BURNOUT	CONS'D ON ASC.	JET ON LURAIN	CONS'D ON DESC.	TOTAL SEP.
12.0	Controls and Displays	257.4				257.4	254.4				254.4
12.1	Structure					--					--
12.2	Stabilization and Control	(65.4)				(65.4)	(65.4)				(65.4)
12.2.1	Flight Controls	49.8				49.8	49.8				49.8
12.2.2	Back-up Guidance	7.8				7.8	7.8				7.8
12.2.3	ΔV Panel	7.8				7.8	7.8				7.8
12.3	Navigation & Guidance	(61.3)				(61.3)	(58.3)				(58.3)
12.3.1	Govt Furnished Equip.	58.0				58.0	56.0				56.0
12.3.2	Rendezvous & Land Radar	3.3				3.3	2.3				2.3
12.4	Crew Provisions	3.3				3.3	3.3				3.3
12.5	Environmental Control	13.1				13.1	13.1				13.1
12.6	Lunar Landing System					--					--
12.7	Instrumentation	9.1				9.1	9.1				9.1
12.8	Electrical Power	23.3				23.3	23.3				23.3
12.8.1	Cryogenic Storage	12.9				12.9	12.9				12.9
12.8.2	D.C. Power Dist.	4.0				4.0	4.0				4.0
12.8.3	A.C. Power Dist.	1.2				1.2	1.2				1.2
12.8.4	Pyrotechnic Subsystem	5.2				5.2	5.2				5.2
12.9	Propulsion	10.0				10.0	10.0				10.0
12.10	Reaction Control	16.0				16.0	16.0				16.0
12.11	Communications	12.9				12.9	12.9				12.9
12.12	Inst. Panel & Side Cons.	43.0				43.0	43.0				43.0

[redacted]

[redacted]

Discussion of Changes Between Current and August 29th Status

		ΔWT_A*	ΔWT_D*	ΔWT_{Sep}*
1.0	Structure			
	Increase meteroid shielding probability of penetration from .01 to .13 by reducing skin thickness requirements to that necessary for thermal protection -(2) .022" t to (1) .015 and (1) .006"	-159.5	-119.0	-278.5
2.0	Stabilization and Control			
	Revised estimate of Attitude Reference Assembly resulted in an increase of 3 pounds per LMO-300-56	+ 3.0		+ 3.0
	NAA increased power rating of holding windings in the RCS jet driver solenoids. This is a change in common usage equipment in which GAEC has no responsibility, hence the increase in weight of the Attitude Translation Control Assembly.	+ 7.0		+ 7.0
	Revised estimate of the four (4) gimbal actuators from 5.5 pounds each to 3 pounds each, reduces weight of the Descent Engine Control Assembly.		- 10.0	- 10.0
3.0	Navigation and Guidance			
	MIT report shows an increase from 191 to 201 pounds since last status.	+ 10.0		+ 10.0
	In recent technical negotiations of the Rendezvous and Landing Radar with the vendor (RCA) a weight of 69 pounds was negotiated as compared to the last status of 79 pounds.	- 5.0	- 5.0	- 10.0
4.0	Crew Provisions			
	Change in crewman attitude results in a 20 pound weight reduction of restraint system	- 20.0		- 20.0
	Reduction of landing flare burning time from 10 minutes to 5 minutes reduces flare weight.		- 5.0	- 5.0
5.0	Environmental Control			
	Change in translunar water coolant requirements which includes a 19 pound water reduction at earth launch and changes the ascent and descent coolant loads.	+ 12.6	- 5.3	+ 7.3
	Quantity of GOX reduced from 8.2# to 7.5#.	- .7		- .7

* ΔWT_A, ΔWT_D & ΔWT_{Sep} are dry weight changes at various events of the LEM Mission (i.e. Ascent, Desc. & Separation)

		ΔWT_A*	ΔWT_D*	$\Delta WT_{Sep.}$*
5.0	Environmental Control (Cont.)			
	The type of cartridges for ECS was changed and the quantity reduced to 4, which is consistent with the Vendor Specification.	- 6.7	- 3.4	- 10.1
7.0	Instrumentation			
	Reduced the quantity of sensors, from 707 to approximately 315. Further reductions may be possible.	-134.7	- 30.1	-164.8
	Revised weight estimate of signal conditioner is based on reduced quantity of sensors.	- 17.0		- 17.0
	Revised estimate of PCMTE based on vendor quotes and GAEC evaluation.	- 17.5		- 17.5
8.0	Electrical Power Supply			
	Reduction in shielding and wire size and use of thin wall insulation.	-339.3	- 36.6	-375.9

Memorandum LMO-390-86, dated 18 Sept. 1963, is a wire comparison report. Eighteen different plans are presented by this report, and the differences are due to variations in the use of 26 guage wire in lieu of 22 guage, shielded vs. unshielded, and/or different types of insulation material.

The wiring or electrical provisions for 29th August LEM vehicle weight was based on a combination of Plan 1 and Plan 2. The current wiring is based on Plan 17. A brief comparison of the three plans mentioned is as follows:

	Plan 1	Plan 2	Plan 17
Shielded Wire	MIL-W-16878 Type E		.005 FEP/.001 ML Insulated
Shield 85%	#36 Ga. Copper		#36 Ga. Copper
Jacket	.010" Teflon		.002"FEP/H-film
Unshielded Wire			
#2 Ga.	MIL-W-7139B	MIL-W-7139B	MIL-W-7139B
#4 Ga. thru #6 Ga.	MIL-W-22759/MS18000	MIL-W-22759/MS18000	MIL-W-22759/ MS18000
#10 Ga. thru #20 Ga.	MIL-W-22759/MS18000	MIL-W-22759/MS18000	MIL-W-16878/ Type E
#22 Ga.	MIL-W-22759/MS18000	MIL-W-22759/MS18000	---
#26 Ga.	---	---	.005 FEP/ML Insulated

* Ibid

		ΔWT_A*	ΔWT_D*	$\Delta WT_{Sep.}$*
8.0	Electrical Power Supply (Cont.)			

A breakdown of the electrical provisions shown herein is as follows:

	29th August Weight	Current Weight
Wire	723	342
Coaxial Cable	(included under wire)	5
Connector and Potting	146	146
Clamps	36	36
Total	905	529

Reduction in sensor wiring due to reduction of instrumentation sensors from 707 to approximately 315.	-101.0	- 13.0	-114.0
Revised estimate of fuel cell reactants.	- 5.8	- 7.8	- 13.6
9.0 Propulsion			
Removed 2 gimbal actuators - descent, error in last report had 6 in lieu of 4		- 14.0	- 14.0
Revised estimate of ascent propellant tank weight based on more detailed layout calculations.	+ 40.0		+ 40.0
12.0 Controls and Displays			
Revised MIT CDU's and displays weight per MIT Report (Rev. 12) from 58 to 56 pounds	- 2.0		- 2.0
Delete 2 indicators which were functionally duplicated	- 1.0		- 1.0
Total Current Changes	-737.6	-249.2	-986.8

* Ibid

PENDING CHANGES

The following list is comprised of those items which are currently being considered and recommended for incorporation into the LEM vehicle.

		Δ Weight* Ascent	Δ Weight* Descent
1.0	Structure		
	a) Reduce the factor of safety in crew compartment from 2.0 to 1.5 and use better quality control to maintain desired reliability.	- 31.0	--
	b) Landing Gear Truss: Going to a 160" cantilevered landing gear results in a 38.6 lb increase in the descent stage truss. (A saving in the Landing Gear weight results in a net weight saving to the vehicle descent stage for these changes see Landing Gear 6.0 a) below.)	+ 38.6	
2.0	Stabilization and Control		
	a) Eliminate descent engine gimbal actuator redundancy as requested by GAEC letter LLR-290-4, dated 23 September 1963.	--	- 6.0
3.0	Navigation and Guidance		
	a) Retention of the MIT system appears to result in a significant weight increase due to an apparent omission of a junction box 10# and the addition of spares to the 15 September 1963 Report E-1142 (Rev. 12).	+ 45.0	--
	b) Rendezvous and Landing Radar weights are increasing based on current vendor quotes of 59.4# and 36.9# respectively.	+ 18.4	+ 8.9
5.0	Environmental Control		
	a) Reduce drinking water to 6.0 lbs/man/day from 13.2 lbs/man/day for the 24 hour period of basic design mission spent in LEM orbit. The 13.2 lbs/man/day is assumed to be required for needs of crew on the lunar surface. Therefore, a weight saving can be realized as indicated herein.	- 2.4	-12.0

* Note: Weights shown are not effective Weights.

PENDING CHANGES

		Δ Weight Ascent	Δ Weight Descent
5.0	Environmental Control (Cont.)		
	b) Acceptance of the new apportionment of metabolic loads could result in a weight decrease of approximately 20 pounds. This change would permit smaller suit fans, which would require about 45 watts less power. The power reduction would decrease the quantity of reactants and the water. Additional reduction in tank weights may be realized.	- 10.0	- 10.0
	c) Stage the water to be used from Earth Launch to Lunar Lift-off and put the remaining water into two equal size tanks. This change reflects a system Dry weight increase but a greater propellant, tankage, etc. decrease. The reliability of the Water Management Section is also improved.	- 16.0	+ 23.0
6.0	Landing Gear		
	a) Replace the 180" semi-tread tripod type of landing gear with 160" semi-tread cantilever type -92.0 lbs. Under Structure the L.G. support truss will decrease and the bulkhead will increase, see Structure code 1.0 b); however the replacement will result in a total decrease of -53.4 lbs. to the reported weight.		- 92.0
7.0	Instrumentation		
	a) Eliminate Data Storage Equipment (recorder) by transmitting data in real time up to lunar lift-off.	- 30.0	--
	b) Reduce returnable scientific instrumentation to 50#.	- 30.0	--
8.0	Electrical Power Supply		
	a) Replace the present three 900 watt fuel cells and two spiking batteries configuration with the two 1250 watt fuel cells and one auxiliary battery configuration. This results in a 38 pound battery increase and a decrease in fuel cell and cable weights of 60 pounds and 5 pounds respectively.	- 27.0	
	b) Reduce twenty hour ascent, which includes 17.7 hour contingency, to five hours and stage the fuel cells. Assume this change is made with the two fuel cell configuration. Stage the fuel cells and battery charger. Eliminate the ascent hydrogen, oxygen and tankage.		

PENDING CHANGES

		Δ Weight Ascent	Δ Weight Descent
8.0	Electrical Power Supply (Cont.)		
	c) Add a 1 KWH battery and a five hour supply of GOX and tank. Reduce ECS water, GOX accumulator, GOX and RCS propellant. Stage and reduce the plumbing and wiring.	-293.0	+193.0
9.0	Propulsion		
	a) Use the controlled pressure decay technique in pressurizing the descent propellant tanks. This results in an 18 pound helium saving and a 180 pound helium tank saving per LMO-271-14, dated 1 August 1963.		-198.0
	b) Fire a single RCS thruster to control moment unbalance during thrusting of main ascent engine in such a manner that ΔV is obtained from the RCS thrusting. This ΔV furnished by the RCS thruster reduces the ΔV required from the main engine and consequently reduces the propellant in main engine tanks.	- 92.0	
10.0	Reaction Control		
	a) Reduce center of gravity limits, during ascent, by .5 inch. This reduces the quantity of RCS propellant needed.	- 50.0	
	b) Eliminate quantity gauging of the RCS propellant. This permits the removal of sensing units and associated equipment (12# RCS), and display indicators (4# in Controls and Displays).	- 16.0	
	c) Reduce the number of helium bottles and propellant tanks to 1 and 2 respectively by doubling the capacity of each container. This reduces propellant tankage weight, trapped propellant, plumbing and gauging. (Configuration V Weight/Reliability Study).	- 59.0	

PENDING CHANGES

10.0 RCS Propellants (Cont.)

A Preliminary RCS Propellant sizing study indicates that total Propellant requirements will be 614.4# for the 28,000 lbs. LEM Separation Weight.

This value is based on the assumptions of RCS duty cycles and thrust vector misalignments and other considerations listed in LMO-310-58, "Criteria used for RCS Tank Sizing". Although this value is currently higher than the reported weight, several evaluations are in progress which will have a significant effect on the RCS Propellant quantity required. These include:

1) Determination of LEM center of gravity location and uncertainties.

2) ΔV provided by the RCS during ullage settling of the propellants in the main tanks.

3) ΔV provided by firing single thrusters during ascent engine burning in lieu of pairs to obtain pure torques to offset main engine thrust vector misalignment moments. (See Propulsion System above)

4) Coasting during the orbital contingency in lieu of maintaining attitude to ±5°. Or reduction of the 17.7 hour orbital contingency.

5) Reduction of ΔV required for "out of plane" changes during ascent.

Although the sizing study may indicate a higher weight than that currently recorded in this report, it is highly probable that this will not become a fact. Rather, preliminary estimates of above items indicate the current recorded value may be reduced by 40 to 90#.

GOVERNMENT FURNISHED EQUIPMENT

The following is a table showing the G.F.E. equipment as originally designated to Grumman by NASA compared with a list of unofficial weights compiled at GAEC.

The reasons for the comparison are:

1) Of the items clearly agreed to be G.F.E., there are weight differences between the original values and those of column 2.

2) There are items indicated as G.F.E. by various sources on which the contractor would like confirmation.

It is very desirable to have the G.F.E. list broken down in the detail shown in column 2.

This will aid the contractor in:

1) Calculation of accurate mass properties (i.e. weight, c.g. and inertias) for the vehicle in various phases of the mission.

2) Evaluating volume and storage considerations.

3) Providing power for those G.F.E. items requiring it.

Code	Item	Qty.	Original Guaranteed Wt. per SSS-LEM-63-20	Presently Indicated Weight	ΔWt.	Remarks
3.1	Navigation & Guidance		(187.0)	(191.0)	(+ 4.0)	
3.1.1	I.M.U.	1	60.0	58.0	- 2.0	
3.1.2	Range Drift Unit	1	20.0	12.0	- 8.0	
3.1.3	A.G.C.	1	60.0	60.0		
3.1.4	P.S.A.	1	25.0	35.0	+10.0	
3.1.5	N.V.B.	1	--	4.0	+ 4.0	
3.1.6	Cabling	1	20.0	15.0	- 5.0	
3.1.7	Star Maintenance Book	1	2.0	2.0		
3.1.8	Cold Plate		--	5.0	+ 5.0	
4.0	Crew Provisions		467.5	527.8	+60.3	
4.1	Crew Accessories		125#	172.1#	+47.1	
4.1.1	Space Suits	2	(60.0)	(68.0)	(+ 8)	
	Torso	2	NO BREAKDOWN AVAILABLE	24.0		
	Helmet + Integ. Comm. & Telem.	2		12.4		Incl. Integral Communication and Telemetry Provisions.
	Boots - Lunar Exploration	2		8.8		
	Gloves	2		2.2		
	Thermal Coveralls	2		13.2		
	Const. Wear Garments	2		2.0		
	Emergency O_2 System	2		5.4		
	Accessories					
	Urine and Fecal Removal	2	NO BREAKDOWN AVAILABLE	NO BREAKDOWN AVAILABLE		GAEC is not clear if these items are an integral part of the suit and, therefore, are assumed to be included in weights noted above.
	Vomitus Removal	2				
	Suit Press. Gage	2				
	" Low Pressure Warning	2				
	High O_2 Flow Warning	2				
	Suit Press. Relief Valve	2				
	Connectors	2				
	Sewing Kit	1 or 2				
	Lubricant	1 or 2				
	Tools and Belt.	2				
	Adhesive	1 or 2				
	Patches	4				
	Gloves	2				
	Disconnect Seals	1 or 2				
	Vomitus Container	6				

Code	Item	Qty.	Original Guaranteed Wt. per SSS-LEM-63-20	Presently Indicated Weight	Δ Wt.	Remarks
4.1.2	PLSS	2	(60.0)	(99.1)	(+39.1)	See Spares under noted under Code 4.1.4.
	Motor - Inverter	2		5.5		
	Fan	2		1.9		
	Battery	2		21.0		
	H_2O Boiler and Separator	2		9.7		
	Slave H_2O	2		2.3		
	Useful H_2O	2		8.0		
	Primary O_2 Regulator	2		3.2		
	Multiple Gas Connector	2		1.8		
	Primary O_2 Tank	2		6.5		
	" O_2	2		1.8		
	Flexible Hose	2		2.4		
	Steam Back Pressure Valve	2		1.6		
	LiOH Cannister	2		2.6		
	LiOH Cartridge	2		7.6		
	Integral Cannister Structure	2		3.3		
	Miscellaneous Sensors	2		.5		
	Support Harness	2		1.3		
	Foamed Cover	2		4.4		
	Miscellaneous Brackets	2		3.1		
	Boiler Mounting Plate	2		1.7		
	Remote O_2 Control	2		.6		
	Electrical Harness	2		.3		
	Communications & Telemetry	2		8.0		
4.1.3	Radiation Dosimeter	2	(5.0)	(5.0)	(0)	
4.1.4	GFE Spares					Undefined
	Seals - Contaminent Container					
	Debris Trap, Sponge					
	Prim. O_2 Qty indicator					
	Antenna					
4.2	Crew	2	(340.0)	(353.2)	(+13.2)	Change from 65 to 75 percentile men.
7.3	Scientific Equipment		(250.0)	(250.0)	(0)	
7.3.1	Lunar Atmosphere Analyzer	1	20.0	20.0		
7.3.2	Gravitometer	1	5.0	5.0		
7.3.3	Magnetometer	1	10.0	10.0		
7.3.4	Radiation Spectrometer	1	20.0	20.0		
7.3.5	Specimen Return Container	1	12.0	12.0		
7.3.6	Geological Equipment		50.0	50.0		
7.3.7	Seismographic Equipment		8.0	8.0		
7.3.8	Soil Temperature Equipment		10.0	10.0		
7.3.9	Miscellaneous		115.0	115.0		Includes: (1) still & (2) motion picture cameras, TV camera & (cont.)

Code	Item	Q_{T_Y}.	Original Guaranted Wt. per SSS-LEM-63-20	Presently Indicated Weight	Δ Wt.	Remarks
7.3.9	Miscellaneous (cont.)					(Cont.) Auxiliary lighting, 1 gimbal mounted telescope.
12.3	Controls & Displays for Navigation and Guidance		(63.0)	(58.0)	(-5)	
12.3.1	CDU		6.0	16.0	+10	
12.3.2	Miscellaneous C & D		50.0	20.0	-30	
12.3.3	A.G.C. C & D		--	15.0	+15	
12.3.4	Eye Register for Reticle		2.0	2.0		
12.3.5	Two- Diget Readout for Reticle		5.0	5.0		
	Total Weight		967.5	1026.8	+59.3	

REFERENCES

1. LMO-271-14 (1 August 1963) - Study of Descent Engine Helium Weight Savings in the Ambient Pressurization System by Controlled Pressure Decay.

2. LMO-300-56 (3 October 1963) - Estimate of Power Dissipation, Size, Dimension and Weight of Stabilization and Control Subsystem.

3. LMO-310-58 (14 October 1963) - Criteria Used for RCS Tank Sizes.

4. LMO-390-86 (18 September 1963) - Servo Section Recommendations for LEM Interconnecting Cabling Components.

5. LMO-540-149 (27 September 1963) - Correction and Amendment of GAEC Mission Plan LPL-540-1 as Per NASA Directive.

6. LLR-290-4 (23 September 1963) - LEM Descent Engine Gimbal Drive Actuator.

7. LPL-540-1 (15 July 1963) - Mission Plan.

8. LPL-540-1 (Amendment) - Mission Plan (27 September 1963).

9. MIT Report E-1142 (Rev. 12) (15 September 1963) - System Status Report.

10. Rocketdyne Report R-5205-4 (1 October 1963)-LEM Monthly Progress Report.

11. STL Report #8438-6022-SC 000 (10 October 1963) - Engineering Reports and Data.

APPENDIX A

DESIGN DESCRIPTION AND CRITERIA

ENCLOSURES - STRUCTURAL ARRANGEMENT DRAWINGS AND SUBSYSTEM FUNCTIONAL DIAGRAMS.

APPENDIX A

SUBSYSTEM DESCRIPTION AND DESIGN CRITERIA

1.0 Structure

Structure design requirements and criteria per report LED-520-1A "Design Criteria and Environments LEM."

2.0 Stabilization and Control

The S & C System function is to accept signals from sources such as the primary Navigation/Guidance System, pilots controller convert this signal to a useable form (by amplification, etc.) and feed it to the correct thruster, or engine. In addition, the S & C System contains a backup guidance system for the purpose of safe crew return in the event of a failure in the primary Navigation/Guidance System. The backup guidance system provides pre-programmed guidance (based on T-1 abort guidance law) for an abort to a clear perycythion of 50,000 ft. This programmer can only be used after initiation of powered descent. The remainder of the ascent trajectory from 50,000 ft. to the 80 mile orbit is flown using the ΔV Display.

The Guidance Coupler Assembly (GCA) includes circuitry for (1) the ullage sequencer for ullage settling of propellants prior to engine ignition (2) signal conversion of engine on-off signals from MIT Navigation Guidance System. The GCA attitude dead band requirements have been set by LEM handling qualities. Two modes are provided ±0.1° and ±5° dead bands. The 0.1° mode is used primarily during thrusting periods and the ±5° is used during coasting periods.

The attitude and translation control assembly weight is based on a Grumman estimate. The driver solenoids are based on the Minneapolis-Honeywell design but repackaged in order to save weight. If GAEC were required to go common usage in this area a weight increase would result.

The current design is based on a constant current load for the RCS thruster solenoid valves.

The ATCA and ARA electronic packages have been sized to meet the cold plate heat transfer requirements of 2 watts/in^2.

2.0 Stabilization and Control (Cont.)

The descent engine control assembly weight includes 1.5 pounds of electronics and 22 pounds for 4 gimbal actuators. The backup programmer as shown in the schematic is obsolete. This unit is a simple preset programmer which lacks data correction capability. This unit would weigh approximately 5 pounds. Further study has indicated that the preset programmer is inadequate and a more versatile programmer will be required. The mechanization of this unit has not been resolved but it is estimated that this unit will weigh 20 lbs. This is one area where the weight statement is more current than the schematic.

3.0 Navigation and Guidance

Discussion of Radar Requirements

The primary function of the LEM Radars is to provide data for the N & G (Navigation & Guidance) Systems in both the primary and backup operational modes. This data will be processed by the AGC (Apollo Guidance Computer) for utilization in the automatic guidance phases or displayed to the crew directly in order to provide them with the capability of completing the mission in the event of a partial N & G system failure. The requirements placed on the radar as regards to accuracy and type of data stem directly from the maneuvers that the LEM executes throughout the mission. In the tabulation which follows those phases of the flight profile which vitally affect the Radar requirements are denoted by upper case type.

1) Separation from CSM
2) Injection into descent transfer orbit
3) COAST TO PERICYNTHION
4) POWERED DESCENT (INITIAL)
5) TERMINAL DESCENT
6) LUNAR STAY AND PRE LAUNCH
7) ASCENT LAUNCH
8) Ascent coast
9) MIDCOURSE CORRECTION
10) RENDEZVOUS - DOCKING

1-2) No requirement for radar data is contemplated in either the first two items. However, immediately after separation it may be expedient to utilize the nearby CSM as a means of checking out as many of the radar functions as practicable.

3.0 Navigation and Guidance (Cont.)

3) In order to establish the orbital parameters of the descent orbit it is required that the LEM Rendezvous Radar be capable of measuring range, range rate angle to the transponder carried aboard the CSM. Although the Landing Radar is not required to furnish precision information during the descent coast phase it is required at an altitude of 70,000 feet and some 10 minutes prior to the initiation of powered descent, to show evidence of its functional status by indicating a received signal when its antenna is oriented (by vehicle rotation) so as to produce vertical incidence of the range measuring beam at the moon's surface.

4) Powered descent is initiated at 50,000 feet. During portions of the descent, data for guidance and control is inertially derived. Because inertial errors arising from initial misalignment and subsequent drift can produce large terminal-descent errors, in both position and velocity, it has been determined that direct sensing of these quantities is a prerequisite to achieving descent and landing within the specified accuracy.

The primary mode of sensor data utilization (altitude, velocity) is in updating the inertial equipment. Altitude updating is performed in the range of 15,000 feet to 20,000 feet altitude. Velocity updating is performed at about 5000 feet altitude. In this manner the optimum use is made of the high frequency content of the inertially derived data which serves to compliment the good low frequency radar-sensed data. Furthermore, subsequent to inertial updating, failure of the radar does not necessarily require a mission abort.

5) If the primary Navigation and Guidance System is working properly the terminal descent from hover can be accomplished without altitude and vertical velocity data from external sensors, provided the IMU was updated at some previous point in the trajectory. Horizontal velocity data from the Landing Radar may, however, be required since:

a) There is a tighter tolerance on horizontal than on vertical at landing and
b) Horizontal velocity changes over a greater range of values during the final portion of the powered descent than does vertical velocity so that even updating early in that phase still leaves the possibility of excessive errors being accumulated by the IMU.

3.0 Navigation and Guidance (Cont.)

In the event of failure in the inertial or computing portions of the primary Navigation and Guidance System occurring during or just prior to the hover phase, there may be increased mission safety if the landing is completed rather than the mission being aborted. Under these conditions non-inertial data must be independently provided and in a form meaningful to the crew and suitable for direct display.

6) Pre-Launch

On the lunar surface, the rendezvous radar tracks the CSM in a 90° sector as it passes over the horizon and comes into view of the LEM. This tracking will be done only long enough to enable the LEM location relative to the CSM orbit to be determined.

7) Launch

Since the ascent is pre-programmed in both the primary and backup modes, non-inertial data is not required. If the launch is made at the proper time, the initial thrust will inject the LEM into the transfer orbit. However, if there is a timing error, the LEM may have to enter a parking orbit and await the proper injection conditions for transfer to the CSM. These conditions can be determined from data obtained by tracking the CSM. If the primary guidance system is functioning properly, the LEM orbit is accurately known and only the phasing or relative selenocentric angle between LEM and the CSM need be known. If the primary guidance system has failed and the LEM is on backup guidance, the errors at thrust termination will generally be larger and angle and range data from the Rendezvous Radar may be needed for the computation of the proper phasing.

8-9) Ascent Coast and Mid-course Correction

The ascent coast phase carries the LEM from burnout altitude of the powered ascent to within homing rendezvous range of the CSM. During this phase, it is anticipated that non-inertial data referring to relative position and velocity of the LEM and the CSM will be required to reduce the effect of burnout errors on the ΔV penalties during homing rendezvous.

For powered ascent and coast phases performed under the direction of the primary Navigation and Guidance System, the errors at burnout will be comparatively small and the problem of performing a mid-course correction relatively easy. Since the AGC is available for computation and data smoothing, the type of data can be restricted, the number of measurements can be fairly large and the mathematical

3.0 Navigation and Guidance (Cont.)

8-9) operations on the data can be extensive and sophisticated.

10) The techniques to achieve successful rendezvous under adverse conditions give rise to a requirement of independently displayed rendezvous radar parameters.

4.0 Crew Systems

Interior Lighting

The panel lighting is an integral lighted system employing electroluminescent lamps (EL) capable of providing up to 1.0 ft. lambert of aviation red (device weight will not vary with color and brightness). The breakdown consists of:

8.85 square feet panels	4.5#
25-2" indicator dials, 9-3" ind. dials, & others	0.5
13 thumbwheels	1.0
15 knobs	1.0
40 pushbuttons	2.0
Total:	9.0#

No hand light (portable) has been included in the lighting breakdown.

The Cabin Lights (8.0#) consists of:

1) A 28-volt redundant backup floodlighting capable of providing up to 1.0 feet lamberts of aviation red. Weighs 2.5#.
2) Hi-ambient white floodlighting to provide up to 40 ft. candles on primary display area. Weighs .5#.
3) Dome light- provides a general white illumination of approximately 15 ft. candles in the crew area to permit movement about area and accomplishment of certain tasks. Weighs .5#.
4) Annunciators, caution lights, mode lights. Weighs 4.5#.

External Lighting

The landing flares (10.0#) are self-oxidizing type. They will provide 10 ft. candles of illumination on the lunar surface at a height of 200 feet in a 30 degree cone for 10 minutes.

The hatchway lights (4.0#) used for docking assumes direct dock rather than probe and drogue. This is still an unresolved area. Two possibilities for lighting are: either four lights at 1# each to illuminate the docking area or a 6 inch illuminated ring at 4# mounted on the docking hatch to facilitate docking. The ring would illuminate to 10 feet lamberts.

4.0 Crew Systems (Cont.)

Running lights (8.0#) consists of six position (formation) lights of approximately 10 candle power each to permit visual recognition of LEM from several miles. The breakdown is: 6 running lights at 1.0# each and 1 recognition light at 2.0#.

Sustenance and associate equipment - Drinking water (53#) is included in the ECS water. Food - was based on 3200 K cal/man/day. The work statement only requires 2800 K cal/man/day, if this requirement was met the weight of the food could be reduced by 1.0#, however, GAEC feels that 2800 K cal/man/day is inadequate. Additional 400 K cal/man/day is for snacks.

First Aid Kit - 2.5 is shown but the contents of the kit is not resolved.

Waste Management - Assumed GFE and it is integral "in space suit" system. Statement of work says very little.

5.0 Environmental Control

ECS Section	Component	Design Parameter or Criteria
I. Atmosphere Revit.		
A) Suit Circuit	1) Suit Fan (-118) and Suit Circuit Heat Exch. (-106)	Peak metabolic load (0.174 lbs.) CO_2/man-hr., 236 Btu sensible/man-hr. 664 Btu latent/man-hr.) suits closed D.C. brushless motors in fans.
	2) Suit Circuit H_2O Evap. (-107)	Mission phase 14 metabolic load (0.134 lbs. CO_2/man-hr., 236 Btu sensible/man-hr., 456 Btu latent/man-hr.) suits closed.
	3) LiOH Cartridge-ECS (-122)	Cartridge good for 24 man-hrs. CO_2 absorption at average CO_2 production rate of 0.10 lbs./man-hr.
B) Cabin Recirc.	1) Cabin Fan (-102)	Mission phase 14, day landing, 75°F±5°F cabin temp., cabin elect. load (non-coldplate) = 1120 Btu/hr., cabin external load = 1000 Btu/hr., window solar load = 0 Btu/hr. (shields assumed), suits open - metabolic load on cabin = 97 Btu sensible/hr. D.C. brushless motor in fan.

5.0 Environmental Control (Cont.)

ECS Section	Component	Design Parameter or Criteria
II. Heat Transport	1) Coolant Recirc. Assy. (-290)	Water-glycol flow = 231 lbs/hr., overall section pressure drop = 30 psi, D.C. brushless motors in pumps.
	2) Coolant Regen. Heat Exch. (-204)	Mission phase 15, night landing, one man outside, 75°F±5°F cabin elect. load (non-cold-plate) = 722 Btu/hr., cabin external load = 1250 Btu/hr., suit open - metabolic load on cabin = -86 Btu sensible/hr., total cold-plate electronic load = 1044 Btu/hr.
	3) Thermal Control Water Evap. (-209A and -209B)	Mission phase 14, day landing, total load on boiler = 7200 Btu/hr., discharge glycol temperature = 40°F, minimum water carryover.
	4) Coolant Accumulator (-210)	Maximum coolant volumetric change = 26 in^3. Bladder spring loaded.
III. O_2 Supply and Cabin Pressure	1) GOX Accumulator (-302)	Contain 7.04 lbs. useable GOX at 850 psia and 160°F.
	2) GOX (7.04 lbs.)	Cabin leakage (0.2 lbs/hr.) and crew metabolic consumption (.088 lbs/man-hr.) during 1.5 hr. ascent and 17.5 hr. orbital contingency.
	3) Cabin Pressure Relief and Dump Valve (-307)	Cabin pressure dump from 5.0 to 0.08 psia in 40 seconds.
IV. H_2O Management	1) Water Tank (-404)	Single tank, contains total of 335 lbs. H_2O at earth launch, bladder is spring and pressure loaded.
	2) Water (259 lbs. at separation)	Day landing mission, full orbital contingency capability, all waste heat rejection to water (no radiators,) 13.2 lbs

5.0 Environmental Control (Cont.)

ECS Section	Component	Design Parameter or Criteria
		H_2O/man-day for drinking and food preparation, 2 PLSS fills at 6.75 lbs. each, 4 PLSS refills at 5.0 lbs. each, all "in-vehicle" latent loads reclaimed, all heat loads on ECS as given in Table II of LSP-330-2A, 1% water carryover across mission.

6.0 Landing Gear

4 Leg Landing Gear
180" Semi-tread
40" Ground Stroke
20" Strut Stroke - Upper
15.4" " " - Lower
Maximum ground load per pad = 18,000 lbs.
24" Ground clearance with L.G. Fully Stroked
(assumed crushable engine)

Positive stability for 10 fps vertical
5 fps horizontal
5° Slopes with a 24" boulder or a 24" hole - or any combination within these limits
12 psi Dynamic Bearing Pressure

No temperature penalty included
Material 7075-T6
Non-Repetitive Life (Crushable honeycomb shock absorber)
Transverse loading due to shock assumed to be 50 g's (shock absorber in pad to absorb energy of unsprung mass)
Ultimate design load on struts is 50% greater than crushing strength of honeycomb

Limit axial load - Upper strut 12.3 Kips
Lower strut 6 Kips
Pad Size = 44.3" Diameter

Assymmetric loading on the Pad-assumed to be approximately 1" off center which results in the following strut end moments

Lower strut - folding - 50,000" lbs
- fixed - 30,000" lbs (based on 37" pad loaded on fwd. half)

7.0 Instrumentation

Requirements for the Instrumentation System are based primarily on a technical approach and are not specifically established in the work statement or subsequent directives. This approach is subject to review and approval by NASA.

Some of the criteria in the current technical approach are listed bellow.

Ground Rules

1. Measurement requirements are based on LEM-10 measurement list dated 7-16-63.

2. Separate sensors are required for each load presented to any single discreet measurand.

3. No spares are allowed.

4. No redundant sensors due to inaccessability.

LEM-10 Sensor Data Flow Configuration

1. Sensor-signal conditioning is done in a central SCU - weight of sensor only is used in sensor unit weight list.

2. Sensor is integrated with sensor-signal conditioning - weight of sensor-signal conditioning is included in sensor unit weight.

3. Sensor and sensor-signal conditioning are physically separate but conditioner is not in SCU - weight listed under unit sensor weight includes signal conditioner.

Signal Conditioning Unit (SCU)

1. Condition sensor output signal.

2. Instrumentation junction box.

3. Furnishes sensor excitation.

4. Supply required GSE connection.

7.0 Instrumentation (Cont.)

Units Contained IN S.C.U.

1. Signal Conditioning Modules

   a. Amplifiers
   b. Attenuators
   c. Demodulators
   d. Freq/DC Converters
   e. AC/DC Converters

2. Module Detail

   a. Cordwood Packaging
   b. E & C 3050 Encapsulant
   c. Wire Wrap
   d. Components - 25% Vol
   e. Module Aug. Wgt. - 7 oz (.43 lbs)

3. Sensor Excitation Power Supplies

4. Certain Temp. Meas. Syst. black boxes

5. Thru wires (preconditioned signals)

6. Mother Board

7. Connectors

8. Misc. electronics association with certain sensors.

Component Circuit Ass'y Distribution

Qty	Modifier units	Unit/Module	Module Qty
125	Amplifiers	2	63
35	Attenuators	5	7
8	Freq./DC Conv.	2	4
14	AC/DC Conv.	2	7
23	Demods	4	6

Total No. Modules = 87
Total Module Wgt =
87 x 0.43 = 37.41 lbs.

7.0 Instrumentation (Cont.)

Reproduction of Flip Charts Design Philosophy of Instrumentation, Not Including Sensors.

DSE
DIGITAL SERIAL DATA

DATA 4 Tracks
TIMING 1 Track

BIT RATE	2.048 KB/SEC.	51.2 KB/SEC.
RECORD	3.75 ips	15 ips
REPRODUCE	93.75 ips	15 ips
REP. SPEED RATIO	25:1	1 : 1

DSE
ANALOG DATA

	RESPONSE	TRACK	S/N
DIRECT	50-25kc.	4	40 db.
FM	DC-2.5kc	4	36 db.
FM COMP.		1	50 db.

INTERCHANGEABLE

RECORD	3.75 ips	15 ips
REPRODUCE	15 ips	15 ips
REP. SPEED RATIO	4:1	1 : 1

DSE
ANALOG

DIRECT

VOICE
SCIENTIFIC
HIGH FREQ. VIB. MEASUREMENTS

FM

SCIENTIFIC
LOW FREQ. VIB. MEASUREMENTS

7.0 Instrumentation (Cont.)

PCMTE DESCRIPTION

1. INPUTS

(a) Analog

Level	0 -5 v						0-40 mv	
Rate (S/S)	100	50	25	10	5	1	25	1
No. of Channels	21	21	48	5	6	281	1	14

(b) Digital

	PARALLEL												SERIAL
Rate (s/s)	200	100	50	50	10	10	5	5	*1	1	1	1	50
No. of Channels	1	1	2	1	7	1	2	1	45	6	2	1	1
Bits/Words	16	16	16	32	16	32	8	16	8	8	16	32	40

* Digital Parallel Event

(c) Input Timing Signal
Sync Signal From N & G

2. OUTPUTS

	Frequency	
(a) PMP (4)	FORMAT 1	FORMAT 2
NRZ (c) Data	51.2Kb/Sec	2.048 Kb/Sec
Sub-carrier Ref.	512Kp/Sec	512 Kp/Sec
Data Rate Timing	51.2Kp/Sec	2.048 Kp/Sec
512 Kc (Emer. Keying)	512Kp/Sec	512 Kp/Sec
(b) GSE (5)		
NRZ (c) Data	51.2Kb/Sec	2.048 Kb/Sec
Sub-carrier Ref.	512Kp/Sec	512 Kp/Sec
Data Rate Timing	51.2Kp/Sec	2.048 Kp/Sec
Prime Frame Sync	50 p/Sec	2 p/Sec
Sub-Frame Sync	1 p/Sec	1 p/Sec
(c) MISC (32)		
IFTS	512Kp/Sec	Same
S & C	512Kp/Sec	Same
EPS (3 lines)	6.4Kp/Sec	Same
Event Time	10 p/Sec	Same
26 Bit Parallel Time		

7.0 Instrumentation (Cont.)

3. CONTROLS (All Remote)

(a)	Format Select	(#1 or #2)
(b)	A-C Power On-Off	(Switched)
(c)	Set	(Real Time into TE)
(d)	Disable	(Time Count)
(e)	Start	(Time Count)
(f)	Advance	(Time Count)
(g)	Retard	(Time Count)

4. POWER

(a) A-C (For PCM Portion)

Voltage	115/200 volts
Frequency	400 C/S
Phases	3

(b) D-C (for TE portion) (Redundant)

Voltage	2o to 32 Volts

(c) Total Power 15 Watts

8.0 Electrical Power Supply

Electrical Power Distribution Section

To best describe design criteria and parameters used for the current PDS Configuration, it is necessary to divide PDS into three separate parts as follows:

A. Power Distribution Circuit Design
B. Electrical Equipment
C. Vehicle Electrical Installation

A. Parameters and Criteria for Power Distribution Circuit Design

Criteria - The criteria for the distribution system is based on the result of the EPS configuration study conducted during January and February, 1963 and subsequently approved by NASA at the March 7th EPS system meeting. The distribution design is based on the use of three fuel cells in conjunction with spiking batteries for Reaction Control. In addition, applicable portions of the LEM Work Statement, dated 20 December, 1962, were utilized.

8.0 Electrical Power Supply (Cont.)

Parameters - The D. C. Distribution system is a nominal 28 volt system with the following characteristics:

- Voltage spread of 25 to 31.5 volts.
- Applicable characteristics defined in MIL-STD-704.
- Equipments and loadings as defined in LEM Load Analysis LDW-390-10000 "A".

The A.C. distribution system is under configuration study at this time. To provide for an eventual system, the following was estimated and is the basis for current A.C. distribution system weight estimates:

- 115/200 volts.
- 3 phase, 400 cycle
- Size estimated at approximately 800 V A.

B. Electrical Equipment

Inverters - Criteria - Based on requirement to supply certain LEM equipment with A.C. power as reflected in Load Analysis. Specific configuration is subject to study at this time.

Inverter - Parameters - Inverter input received from 25 to 31.5 volts D.C. distribution system. Output would be 115/200 volts, 3 phase, 400 cycle. The use of a standby inverter with automatic switchover is provided for in current weight status. Actual parameters are subject to configuration study results.

Spiking Battery - Criteria - Use of spiking battery for reaction control based on assumption that fuel cells would not stay within required voltage regulation (due to reaction control thrusters) and that separate batteries for RCS would not present RFI problems to main D.C. distribution system (use of these batteries being reconsidered).

Spiking Battery - Parameters - Two 28 volt D.C. spiking batteries, each weighing 8.5 pounds with characteristics as defined in LSP-390-3.

PLSS Battery Charger - Criteria - The requirement to electrically recharge the PLSS Back-pack was made known to EPS in January via a Hamilton Standard report numbered HSER2595, dated 15 January 1963. This report was brought to EPS's attention via the Grumman crew systems group. The requirement for battery charger was contained within crew systems' memo L340-M)3-4, dated 31 January 1963, which reported on the results of a space suit interface meeting held with Hamilton Standard on 24 January 1963.

PLSS Battery Charger - Parameters - In light of the above, the EPS stated design effort for the battery charger and its parameters are contained with LSP-390-4.

8.0 Electrical Power Supply (Cont.)

Lighting - The detail requirements are as yet unresolved. The EPS lighting effort to date is shown in memo LMO-390-64, dated 3 September 1963, entitled, "LEM Internal Lighting Study - Power and Control."

C. Vehicle Electrical Installation (Wiring) - The criteria and parameters for this area are generally contained with EPS memo's LMO-390-37 and LMO-390-65. Data contained within these memos is based on best estimates for the various sub-systems affected.

The latest Load Analysis is reflected in LDW-390-10000 "A", dated 3 August 1963 and is based on the LEM Basic Design Mission as presented in LMO-540-59, dated 13 May 1963.

Electrical Power Generation Section

The present EPS design resulted from a series of configuration studies beginning with the EPS Configuration Study, conducted during January and February. An unstaged fuel cell configuration was selected as optimum for the LEM EPS consisting of three 50 per cent fuel cells on the basis of weight and reliability. The basic study criteria and ground rules utilized are contained in LEM report LED-390-2, dated 1 April 1963, "Electrical Power Subsystem Configuration Study. The ECS-EPS Integrated Oxygen Tankage Study resulted in a staged oxygen configuration being recommended to MSC. As a result of the study presentation to NASA-Houston 4 June 1963; the preset oxygen tankage design was approved.

The results of the preliminary hydrogen configuration study were presented at the EPS Systems Meeting No. 3 on 13 June 1963. At that time, with growth factors of 6.68 and 2.82 in effect, GAEC recommended staged hydrogen for the P&WA fuel cells. NASA concurred with the Grumman recommendations. The mission profile utilized for this study, as well as for the fuel cell vendor evaluation, is shown in Table 6 of the "Preliminary Technical Evaluation of Fuel Cell Assembly Vendor Proposals" dated 20 June 1963.

The above information represents the "why and wherefore" of the present three (3) fuel cell, auxiliary battery, and staged oxygen and hydrogen configuration for the EPS Power Generation Section.

The current weight results from using LDW-390-10,000, "A" EPS LEM Electrical Load Analysis as the design criteria for the PGS. (Note that this analysis is based on LEM Engineering Memo LMO-540-59 "LEM Basic Design Mission" dated 13 May 1963.)

8.0 Electrical Power Supply (Cont.)

The cryogenic requirements for the ECS and EPS are shown in Table 1, as well as the tank capacities sized for the H_2 and integrated O_2. A 10 per cent pad was utilized for sizing the tanks to account for fuel cell performance degradation, system leakage and electrical energy growth.

The detailed cryogenic section weights ere determined through the use of parametric tank and insulation data generated by the PGS group. The feed system component weights were obtained through the use of data submitted by the cryogenic manufacturers.

The fuel cell weights are based on the proposed 900 watt P&WA unit which is described by LSP-390-2A, "Design Control Specification for Fuel Cell Assembly."

TABLE 1

Cryogenic Oxygen & Hydrogen Requirements

OXYGEN	HYDROGEN
Requirements ECS = 52.68 pounds EPS = 56.15 pounds	Requirements = 31.43 pounds
Tank Capacities Descent Sox Tank = 90.21 pounds* Ascent Sox Tank = 21.29 pounds	Descent = 24.98 pounds** Ascent = 4.795 pounds ea. (2 required)

* Earth Launch Requirement:
19.44 lbs. expended for EPS during Translunar phase.

** Earth Launch Requirement: 6.04 lbs. expended during Translunar phase.

9.0 Propulsion System

	Section	Design Criteria
1. Descent Stage:	Engine	Chamber pressure thrust, and mission life optimized for pressure fed ablative engine for vehicle gross weight of 28,000 lb. and ΔV requirements of synchronous orbit maneuver to lunar landing. Reliability determines design life.

9.0 Propulsion System (Cont.)

Section	Design Criteria
Feed	Propellant tanks sized for 28,000 lb. G.W. vehicle and ΔV above with operating pressure optimized. Feed section lines and hardware sized to provide propellants to engine at required rate and acceptable pressure drops.
Pressurization	Helium storage bottles sized to provide regulated gas at propellant tank pressure until all propellants are expended. Component size and number chosen for redundancy and reliability. Ambient gas storage work statement requirement.

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2. Ascent Stage:	Engine	Chamber pressure, thrust, and mission life optimized for pressure fed ablative engine for ascent gross weight of 8600 lb. and ΔV requirements for attaining an 80 mmi. lunar orbit and rendezvous with design life of 545 seconds for reliability.
	Feed	Propellant tanks sized for 8837 lb. ascent stage and ΔV above.
	Pressurization	Same as descent stage.

10.0 Reaction Control

1. The basic configuration criterion is that no single component failure shall cause failure of the RCS system. This is considered to be a desirable approach. However, it is not a requirement of the work statement.

10.0 Reaction Control (Cont.)

2. Pressurization System:

a. The nominal pressure for the helium tank is 3000 psi. Provisions were made for 3500 psi with a burst factor of 2.

b. Helium system is designed for 3000 psi upstream of pressure regulators and 250 psi downstream. Stainless steel lines are $\frac{1}{4}$ inch diam., .016 inch wall, except for relief valve path which is 3/8 inch line sized for 250 psi maximum pressure at relief valve full flow.

3. Propellant System:

a. Maximum tank working pressure is 250 psi.

b. Components are designed for 250 psi.

c. The lines are sized for 4 ft/sec flow with 4 engines firing. Line sizes are as follows:

3/4 inch at tank outlet
1/2 inch to clusters
5/8 inch across vehicle

d. This is a bladder type expulsion system.

4. For system analysis the operating temperature range was considered to be 40° to 100°F (70° ± 30°). Heaters may be needed for the injector and for propellant valves. The weight increase would be slight, but there would be a drain on the electric power supply.

5. The reliability figures for the discussed configuration were summed up as follows:

Reliability For	Apportionment	Current Est.
(a) Crew Safety	.999935	.999971
(b) Mission Success	.999804	.999949

The mission associated with crew safety is not defined. It is assumed to end at the 50,000' orbit.

11.0 Communications

General. - The communications subsystem shall:

(a) Provide two-way voice communications.
(b) Provide television information.
(c) Process and transmit telemetry data.
(d) Aid in tracking and ranging.

Voice Communications. - The following capabilities shall be provided:

(a) Voice communications between the LEM and the Command Module (CM) during line-of-sight phase of the mission.

(b) Voice communications between the LEM and the Earth during line-of-sight phases of the mission.

(c) Voice communications between the LEM and crew members external to the LEM to a radial distance of three nautical miles.

(d) Voice communications between the crew members within the LEM.

(e) Voice communications between the LEM and the CM via an umbilical when docked.

(f) A two-way, manually selectable automatic relay of communication between crew members external to the LEM, the Earth and/or the CM.

(g) An alternate voice capability between the LEM and a crew member external to the LEM utilizing the TV cable assembly.

Television. - A capability shall be provided for originating, processing and transmitting television pictures to the Earth while the LEM is on the lunar surface. The television camera shall be portable.

Telemetry Data. - A capability shall be provided to assemble, encode and transmit to the Earth, data from the Operational Instrumentation Subsystem.

Tracking and Ranging. - A capability shall be provided to receive and re-transmit, in phase coherence, a random noise coded signal to enable the GOSS stations to track the LEM during deep space phases.

11.0 Communications (Cont.)

Emergency Keying. - An emergency code keying capability shall be provided for the transfer of priority information in the event of a voice transmission failure.

Equipment. - The Communications System shall consist of the following:

(a) S-Band Section
(b) VHF Section
(c) Portable Television Section
(d) Signal Processing Section

S-Band Section. - The S-Band Section shall consist of those assemblies used to transmit televistion, voice and biomedical data, telemetry; to facilitate tracking; and to receive voice. The S-Band Section, the LEM-Earth Link, shall also be used to extend the range of communications between the LEM and CM by using the Earth as a relay station.

The following assemblies shall constitute the S-Band Section:

(a) S-Band Transceiver
(b) S-Band Power Amplifier
(c) S-Band Diplexer
(d) S-Band R-F Switch
(e) S-Band In-flight Antenna
(f) S-Band Steerable Antenna
(g) S-Band Erectable Antenna
(h) S-Band Cables and Connectors

VHF Section. - The VHF Section shall consist of those assemblies used for duplex communications between the LEM and the Command Module and the LEM and Crew Members outside the LEM. It shall also be used to receive suit and physiological data from the space suit personnel communication systems.

The following assemblies shall constitute the VHF Section:

(a) VHF Transceiver
(b) VHF Diplexer
(c) VHF Switch
(d) VHF In-flight Antenna
(e) VHF Lunar Stay Antenna
(f) VHF Cables and Connectors

11.0 Communications (Cont.)

Portable Television Section - The portable television camera shall be capable of providing pictures as follows:

(a) In the command module from launch to lunar orbit (in conjunction with a 5 foot cable provided by the principal contractor for the CM).

(b) On the lunar surface (using a 62 foot LEM TV cable and reel).

The portable television camera alone (5 foot cable left behind) shall be capable of being transferred from the CM to the LEM in lunar orbit and stowed inoperatively within the LEM crew compartment during lunar descent. The 62 foot cable with reel shall be stowed in the scientific equipment storage cabinet of the LEM.

The following assemblies shall constitute the portable television section:

(a) Camera
(b) Optics
(c) Video Cable and Reel

Signal Processing Section. - The Signal Processing Section shall consist of the audio center and premodulation processor (PMP) and shall be capable of processing the following:

(a) Voice and Biomedical Signals

(1) Voice information shall be hardlined to the PMP from each astronaut within the LEM. The PMP, in conjunction with the Audio Center, shall process the voice information in such a manner that it will provide inputs to the LEM ICS, S-Band modulator and VHF modulator as determined by mode selection.

(2) Biomedical information shall be hardlined to the PMP from each astronaut within the LEM. The biomedical information shall be processed by the PMP for transmission on the S-Band equipment.

(3) The PMP shall provide capability of accepting signals from the VHF receiver. Processing of these signals shall include the routing of voice signals to the ICS as well as the VHF modulator and voice and biomedical information to the S-Band modulator as determined by mode selection.

11.0 Communications (Cont.)

(4) The PMP shall provide capability of accepting voice signals from the S-Band receiver. Processing of this voice information shall include routing to the ICS and VHF modulator as determined by mode selection.

(b) Other Signals - The PMP shall provide the interface between the pulse code modulation and timing equipment, data storage equipment, television camera, and the r-f electronics. The PMP shall perform the switching, gating and mixing associated with the various modes of information transferal.

Associated Equipment. - The communications subsystem shall be capable of operating with the follwoing associated equipment which is not a part of this system:

(a) Pulse Code Modulation and Timing Equipment (PCMTE)
(b) Data Storage Equipment (DSE)
(c) In-flight Test System (IFTS)
(d) Displays and Control Subsystem
(e) Personal Communications System (GFE)

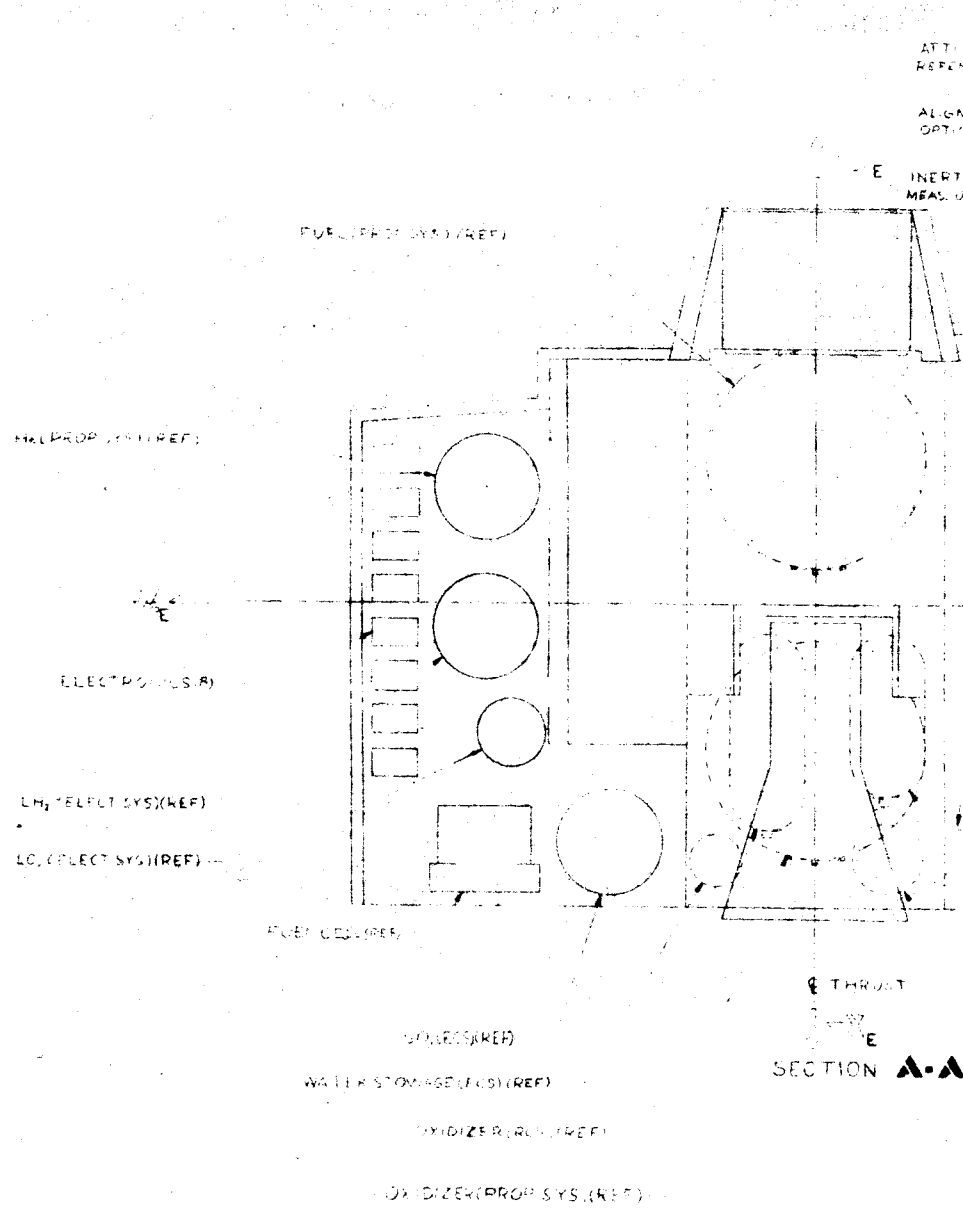
Personal Communication System. - The personal communications system shall be supplied by NASA as part of the Space Suit Assembly. Provision for both Duplex and Simplex operation is provided. On board the LEM, the LEM/Suit hardline capabilities shall be provided as follows:

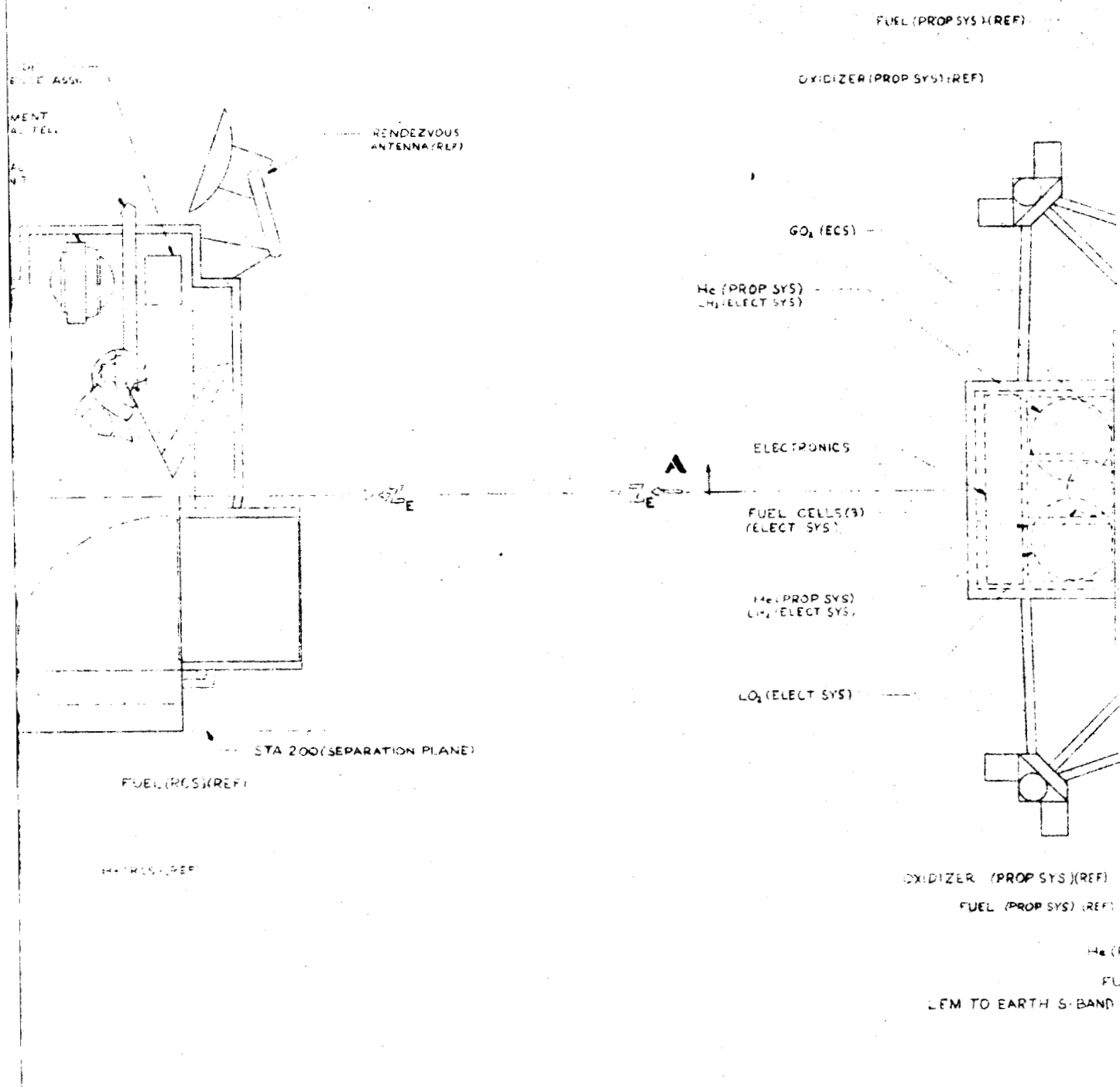
(a) One 30 cps PCMTE measurement for use during descent and ascent, direct from sensor/signal conditioner.

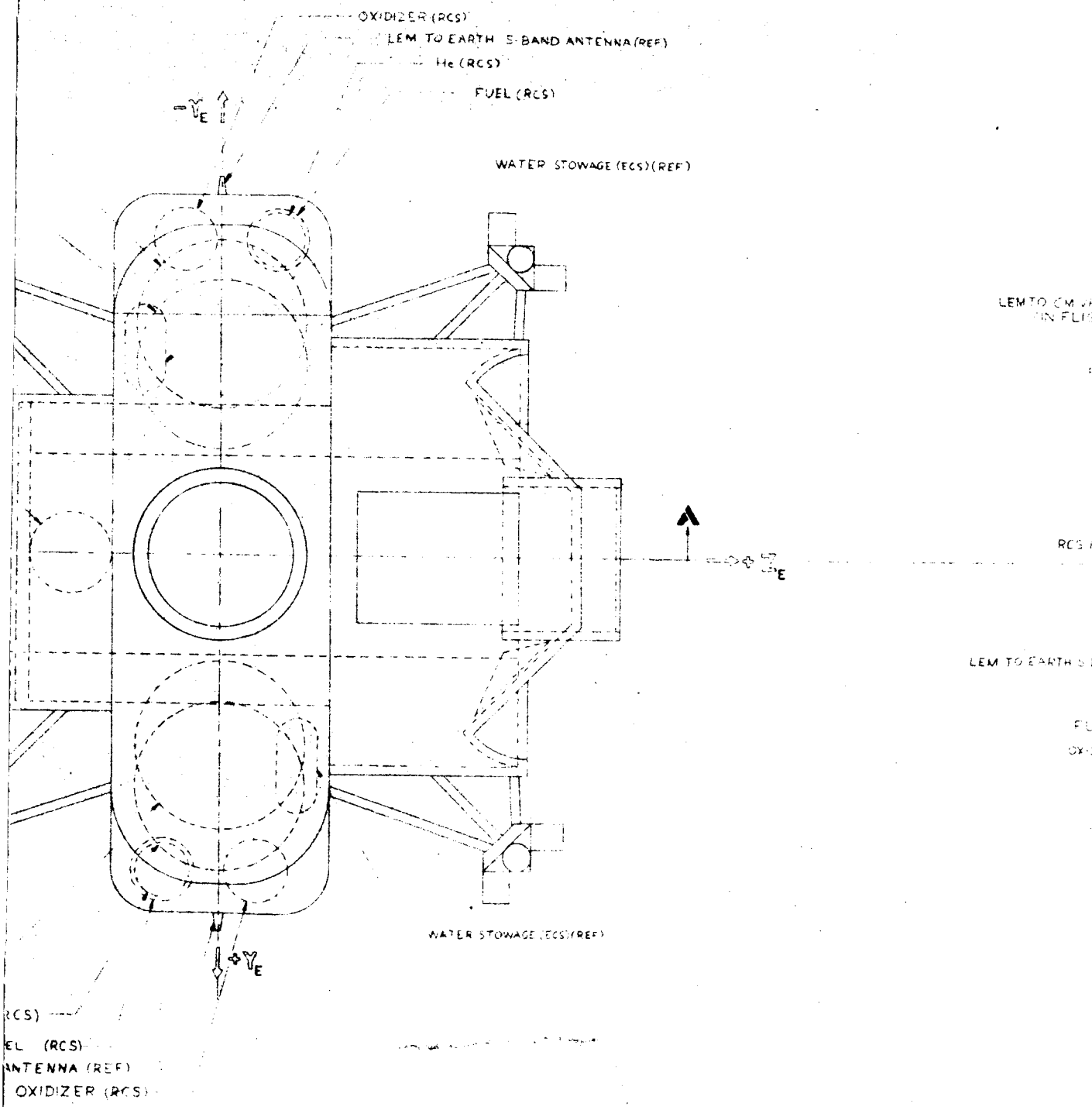
(b) Audio input/output to intercom.

12.0 Controls and Displays

Flight Crew perfromance Specification LED-480-3, defines those criteria the pilot needs to perform the Mission. Only those items are displayed which require action by the pilot.


ATT
REFE
ALIGN
OPT
E
INERT
MEAS.
FUEL (PROP SYS) (REF)
(PROP SYS) (REF)
E
ELECTRO (CS) (R)
LH2 (ELECT SYS) (REF)
LO2 (ELECT SYS) (REF)
FUEL CELL (REF)
℄ THRUST
E
(CS) (REF)
WATER STORAGE (ECS) (REF)
OXIDIZER (R
OXIDIZER (PROP SYS) (REF)
SECTION A-A

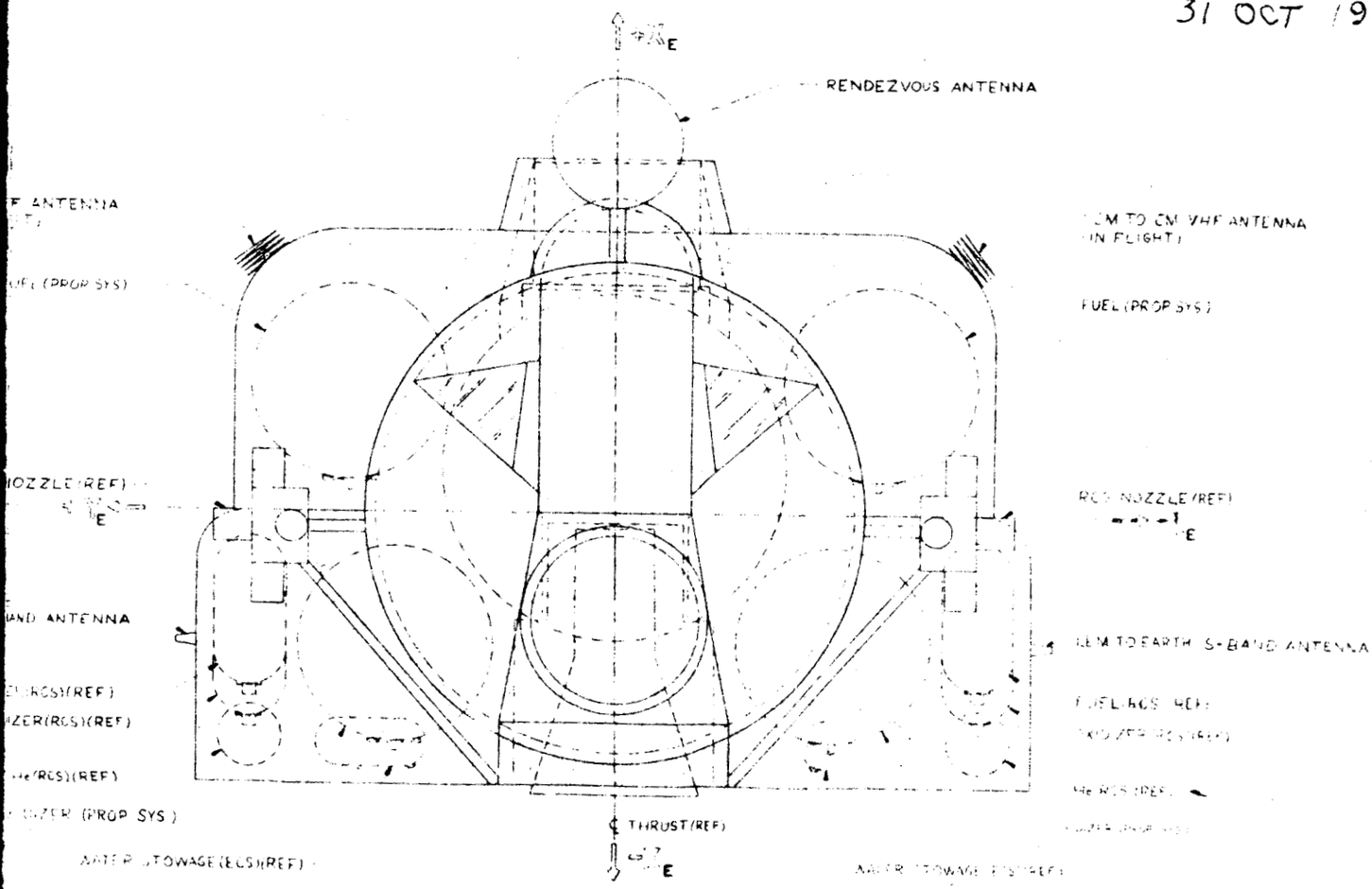

FUEL (PROP SYS)(REF)
OXIDIZER (PROP SYS)(REF)
RENDEZVOUS ANTENNA (REF)
GO_2 (ECS)
He (PROP SYS)
(ELECT SYS)
ELECTRONICS
A
E
E
FUEL CELLS (3)
(ELECT SYS)
He (PROP SYS)
(ELECT SYS)
LO_2 (ELECT SYS)
STA 200 (SEPARATION PLANE)
FUEL (RCS)(REF)
OXIDIZER (PROP SYS)(REF)
FUEL (PROP SYS) (REF)
LEM TO EARTH S-BAND


OXIDIZER (RCS)
LEM TO EARTH S-BAND ANTENNA (REF)
He (RCS)
FUEL (RCS)
$-Y_E$
WATER STOWAGE (ECS)(REF)
LEM TO CM
IN FLI
RCS
$-Z_E$
LEM TO EARTH S
$+Y_E$
WATER STOWAGE (ECS)(REF)
(RCS)
EL (RCS)
ANTENNA (REF)
OXIDIZER (RCS)

LDW 280-10001

REVISION ITEM NO	REVISION	ENGRG. APPR'D	GOVT. APPR.

FIG. 9
LED-490-4
31 OCT 1963



NOTES:

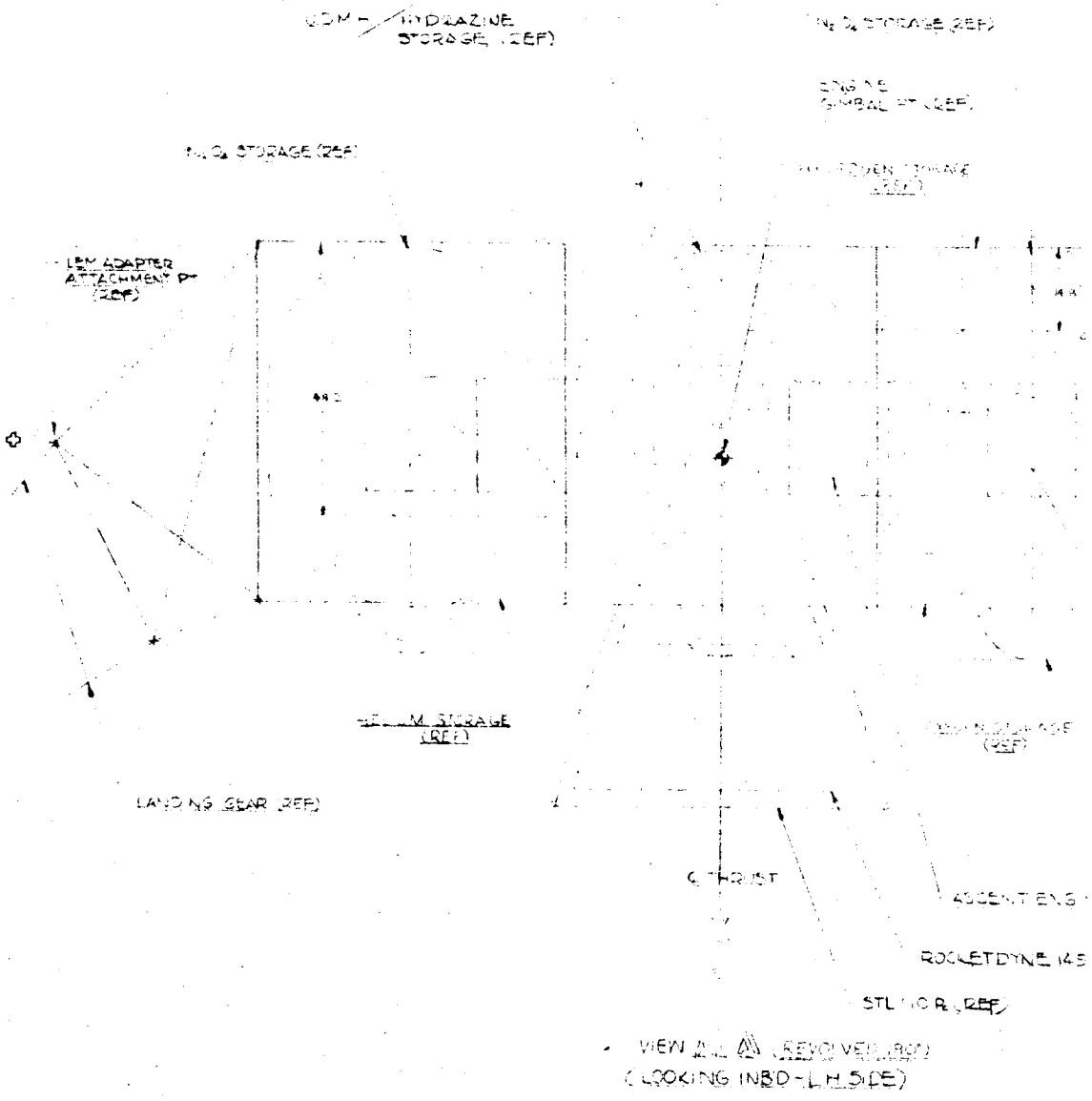
THIS DWG REPLACES & SUPERSEDES DWG LSK 280-1043 DTD 4/10/63.

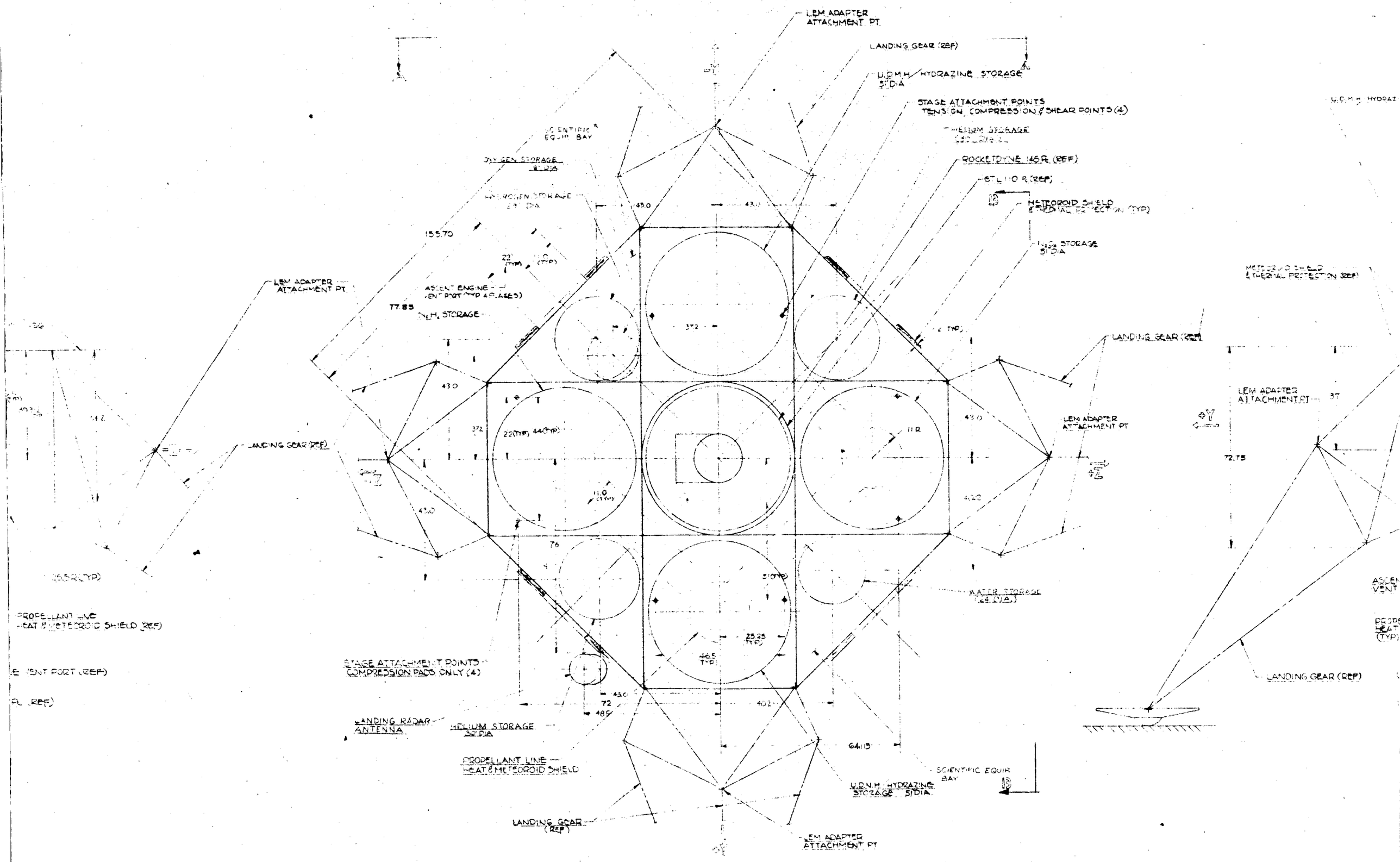
2. FOR NEXT ASSY SEE LDW 280-10000.

CONTRA LINE ITEM NO:
PRIMARY CODE NO: 001
REFERENCE PARAGRAPH NO SPEC EXHIBIT E53
CATEGORY TYPE III PER EXHIBIT E

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCE UNLESS SPECIFIED FRACTIONS · DECIMALS · ANGLES	DRAWN BY / LAYOUT BY	GRUMMAN AIRCRAFT ENGRG CORP BETHPAGE, L.I. N.Y.
ORIG DWG AUTH		GENERAL ARRANGEMENT FM-A CONTSTAGE
CLASS II ENGRG CHANGE / CLASS I ENGRG CHANGE		CONTRACT NO NAS 9-1100
GRUMMAN REL INFO		CODE IDENT NO 26512 — LDW 280-10001
		SCALE 1:1 — SHEET

4


HYDRAZINE
STORAGE (REF)
STORAGE (REF)
STORAGE (REF)
LEM ADAPTER
ATTACHMENT PT
(REF)
STORAGE
(REF)
LANDING GEAR (REF)
THRUST
ROCKETDYNE
VIEW
(REVOLVED)
(LOOKING INBD - L.H. SIDE)



LDW 280-17000 DESCENT STAGE 2
VIEW LOOKING DOWN

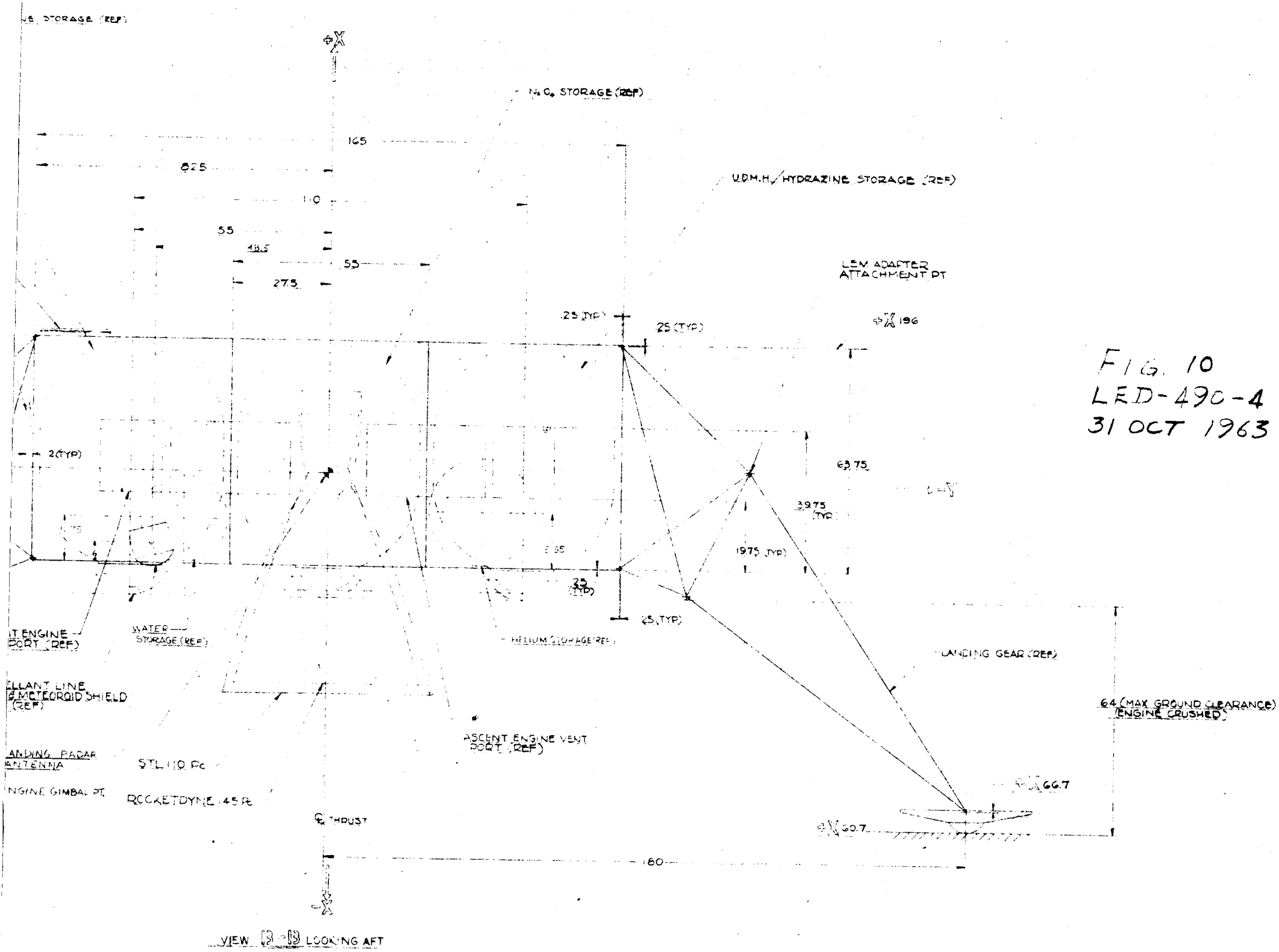
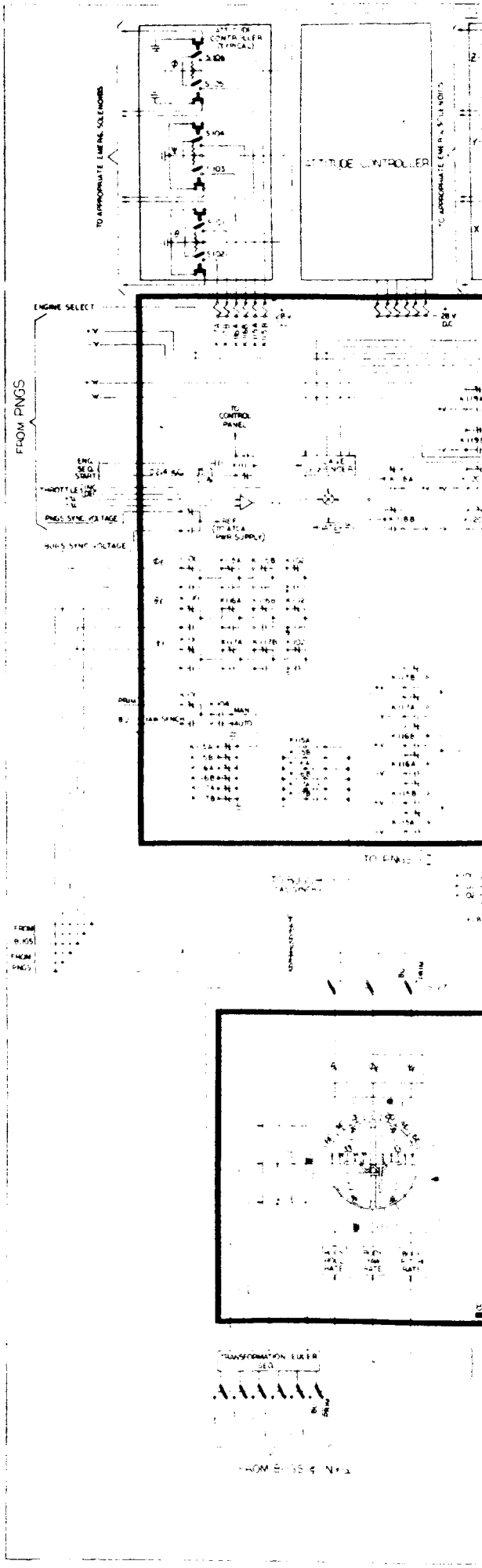
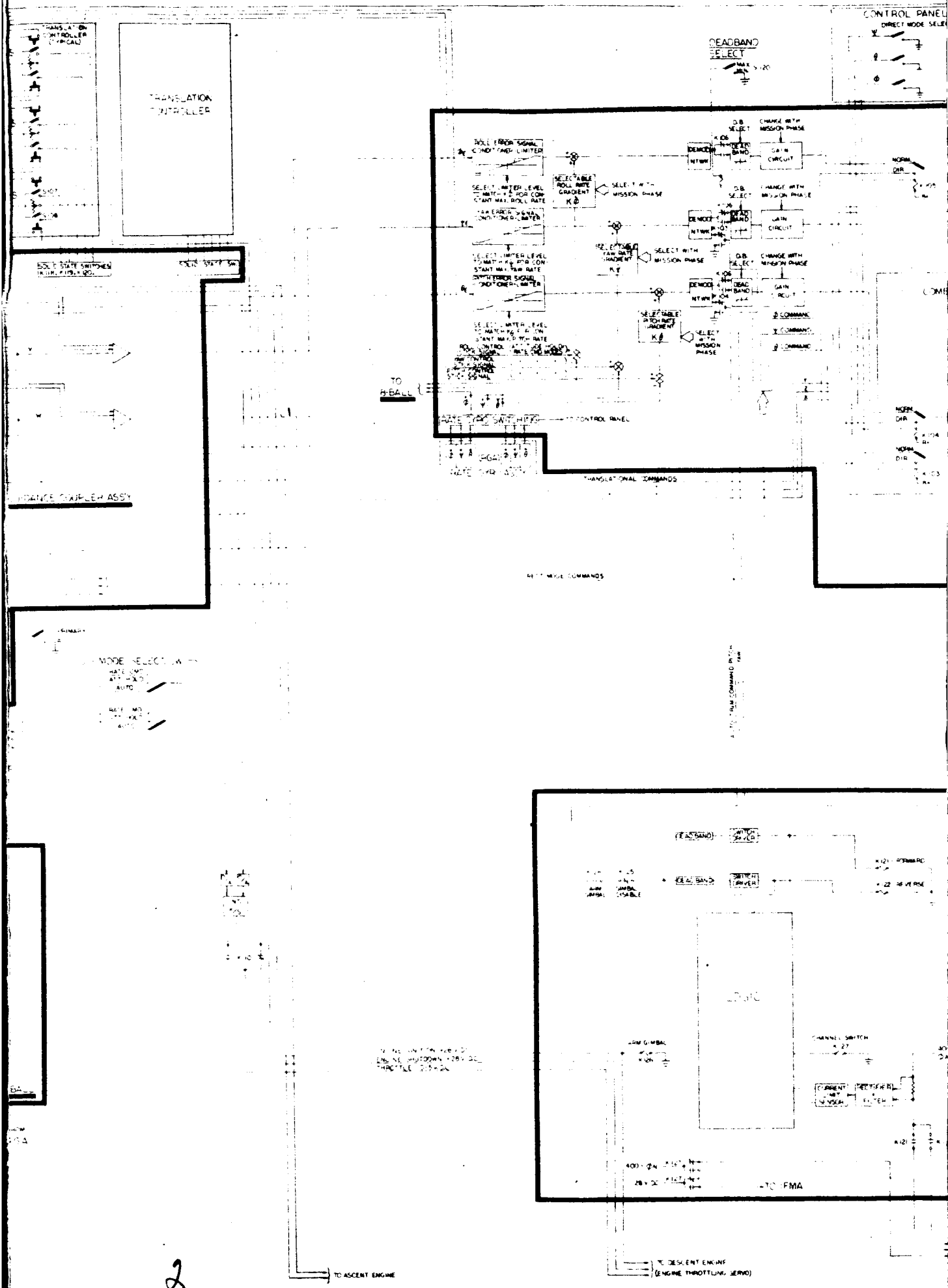


FIG. 10
LED-490-4
31 OCT 1963

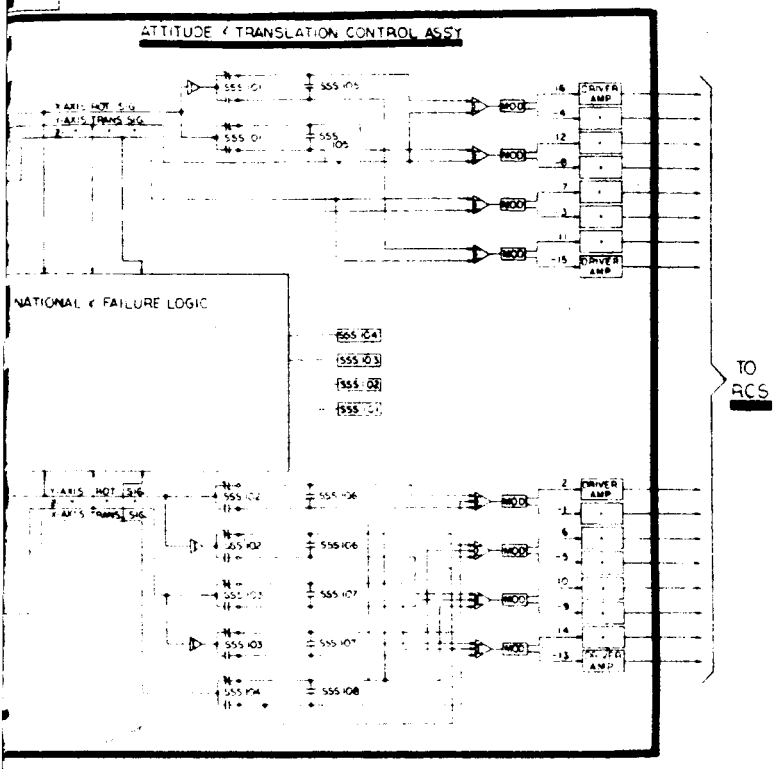

TO APPROPRIATE EMERG. SOLENOIDS
ATTITUDE CONTROLLER
ENGINE SELECT
FROM PNGS
TO CONTROL PANEL
PNGS SYNC VOLTAGE
28 V DC
TRANSFORMATION EULER
FROM PNGS & NAV


TRANSLATION CONTROLLER
CONTROL PANEL
DIRECT MODE SELECT
DEADBAND SELECT
ROLL ERROR SIGNAL CONDITIONER LIMITER
SELECTABLE ROLL RATE GRADIENT
SELECT WITH MISSION PHASE
YAW ERROR SIGNAL CONDITIONER LIMITER
SELECTABLE YAW RATE GRADIENT
PITCH ERROR SIGNAL CONDITIONER LIMITER
SELECTABLE PITCH RATE GRADIENT
DEMOD NTWK
DEAD BAND
GAIN CIRCUIT
D.B. SELECT
CHANGE WITH MISSION PHASE
NORM DIR
TO R-BALL
TO CONTROL PANEL
TRANSLATIONAL COMMANDS
SOLID STATE SWITCHES
GUIDANCE COUPLER ASSY
MODE SELECT SWITCH
TO ASCENT ENGINE
TO DESCENT ENGINE (ENGINE THROTTLING SERVO)
TO FMA
CHANNEL SWITCH
CURRENT SENSOR
RECTIFIER FILTER
SWITCH DRIVER
FORWARD
REVERSE
400 ~ 2φ
28 V DC

2

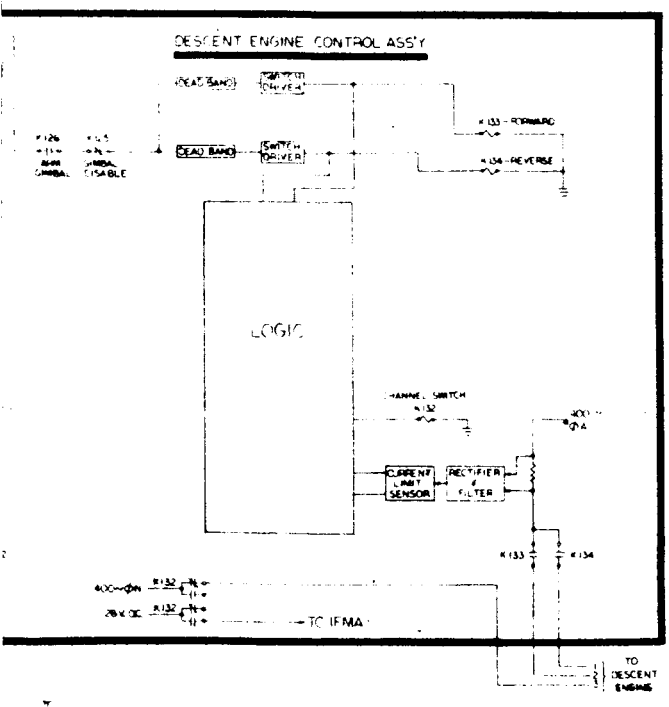
~~CONFIDENTIAL~~

NOTE:
CHANGES REQUIRED FOR SOLID STATE SWITCHING



INFLIGHT MONITOR (IFMA) ASSEMBLY

FIG. 11
LED-490-4
31 OCT 1963



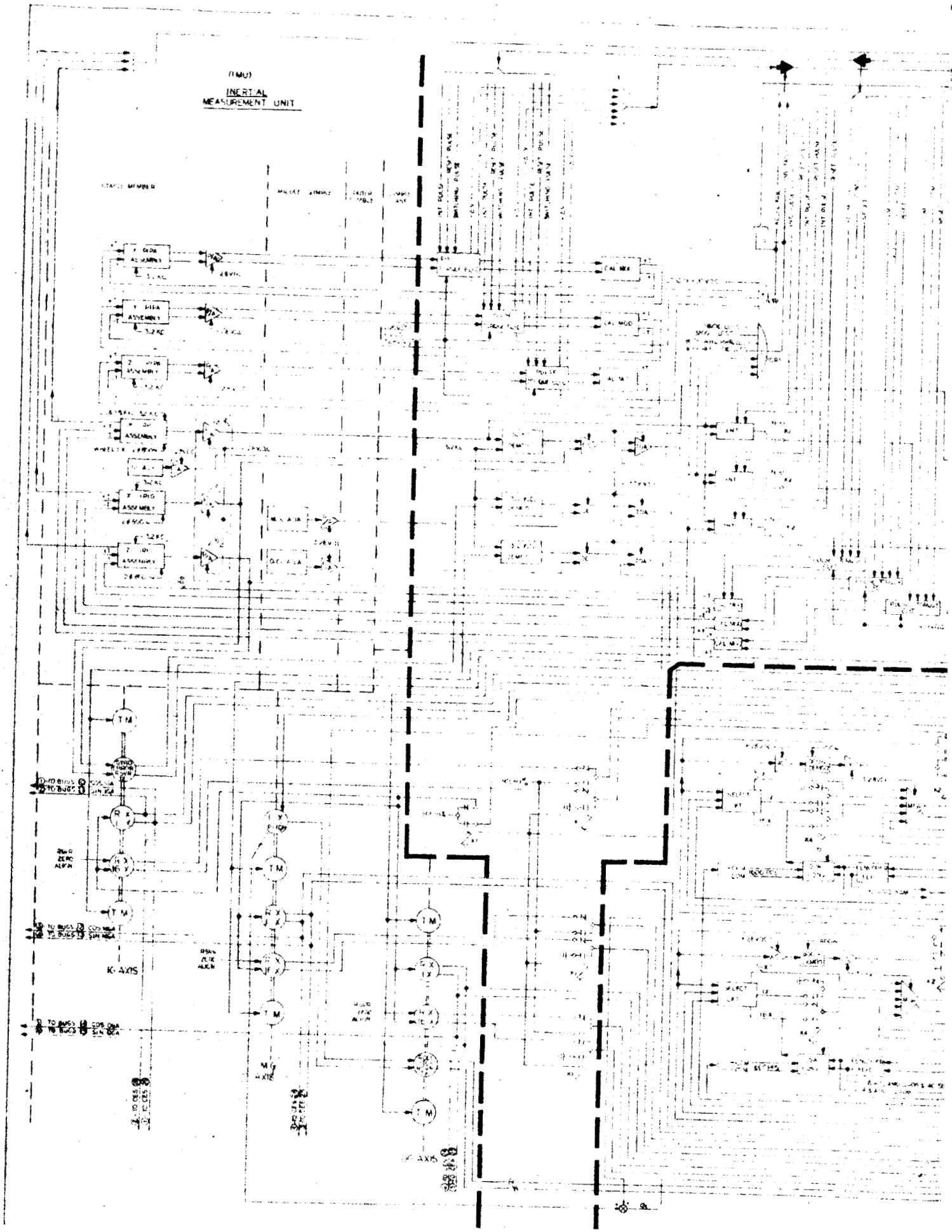
FOR WEIGHTS USE ONLY

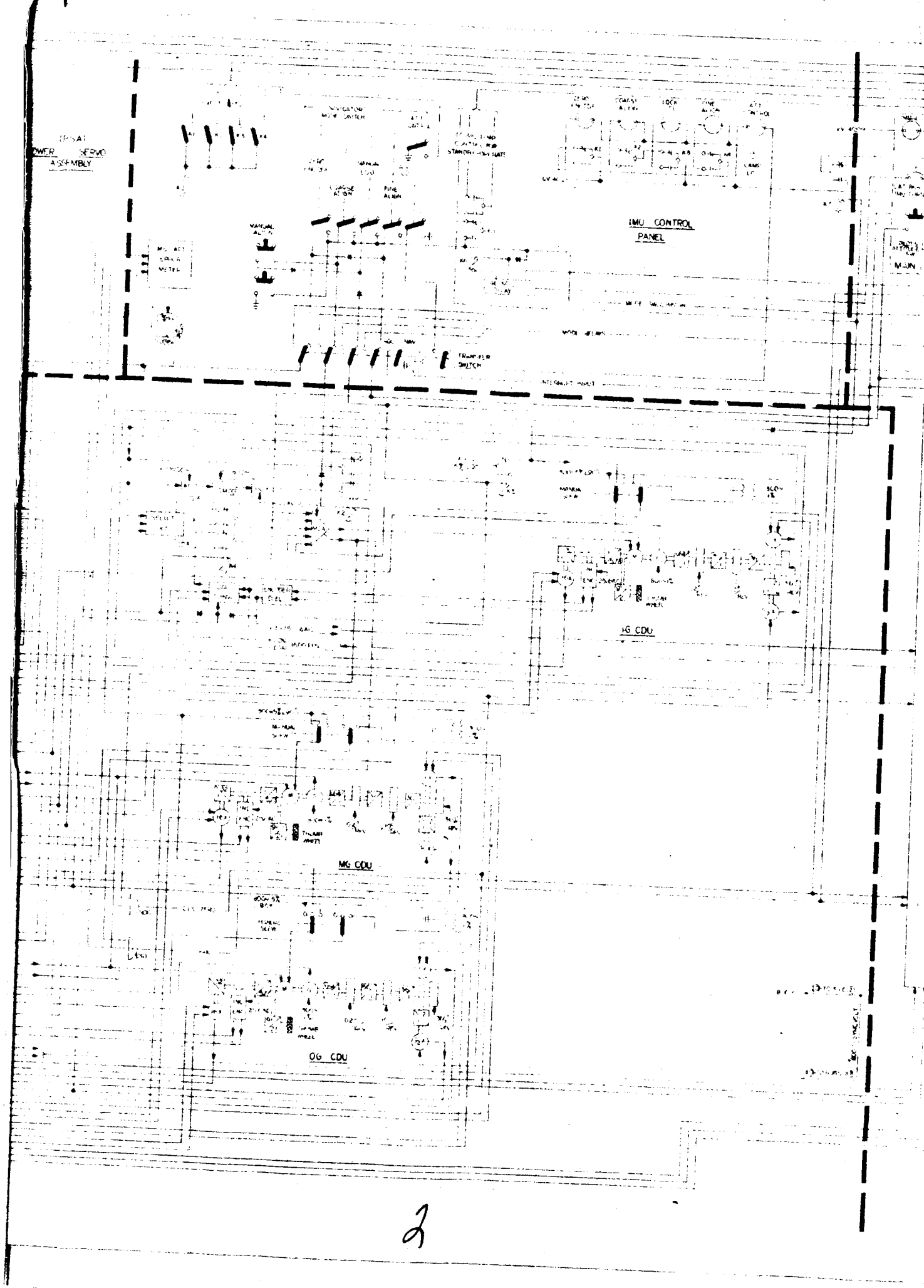
DESCENT ENGINE

3

GRUMMAN AIRCRAFT ENGINE CORP
LEM
CONTROL ELECTRONICS SECTION OF STABILIZATION & CONTROL
LDW-390-14000

~~CONFIDENTIAL~~


(IMU)
INERTIAL
MEASUREMENT UNIT
STATIC MEMBER
K-AXIS
K-AXIS



2

~~CONFIDENTIAL~~

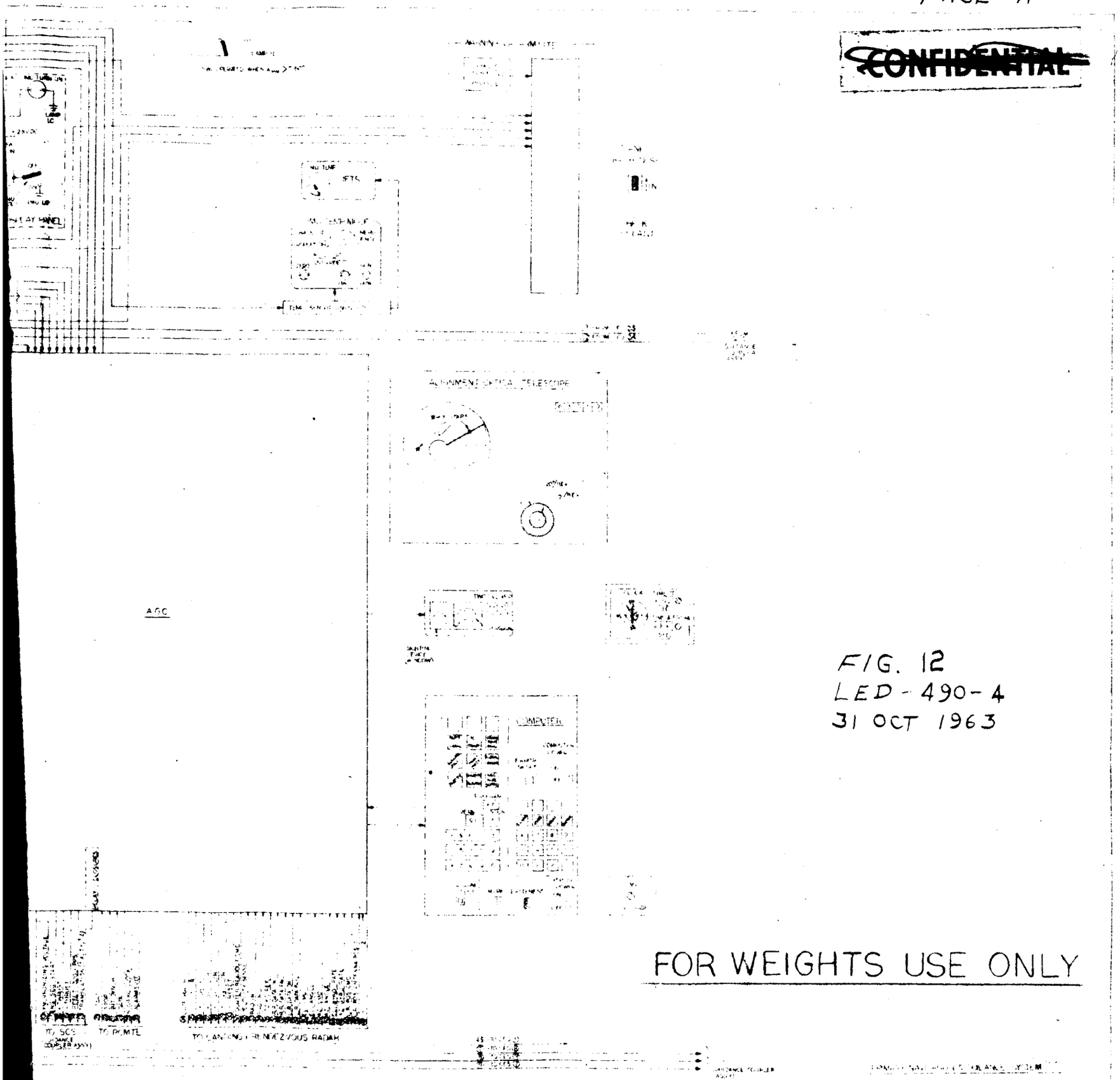


FIG. 12
LED-490-4
31 OCT 1963

FOR WEIGHTS USE ONLY

3

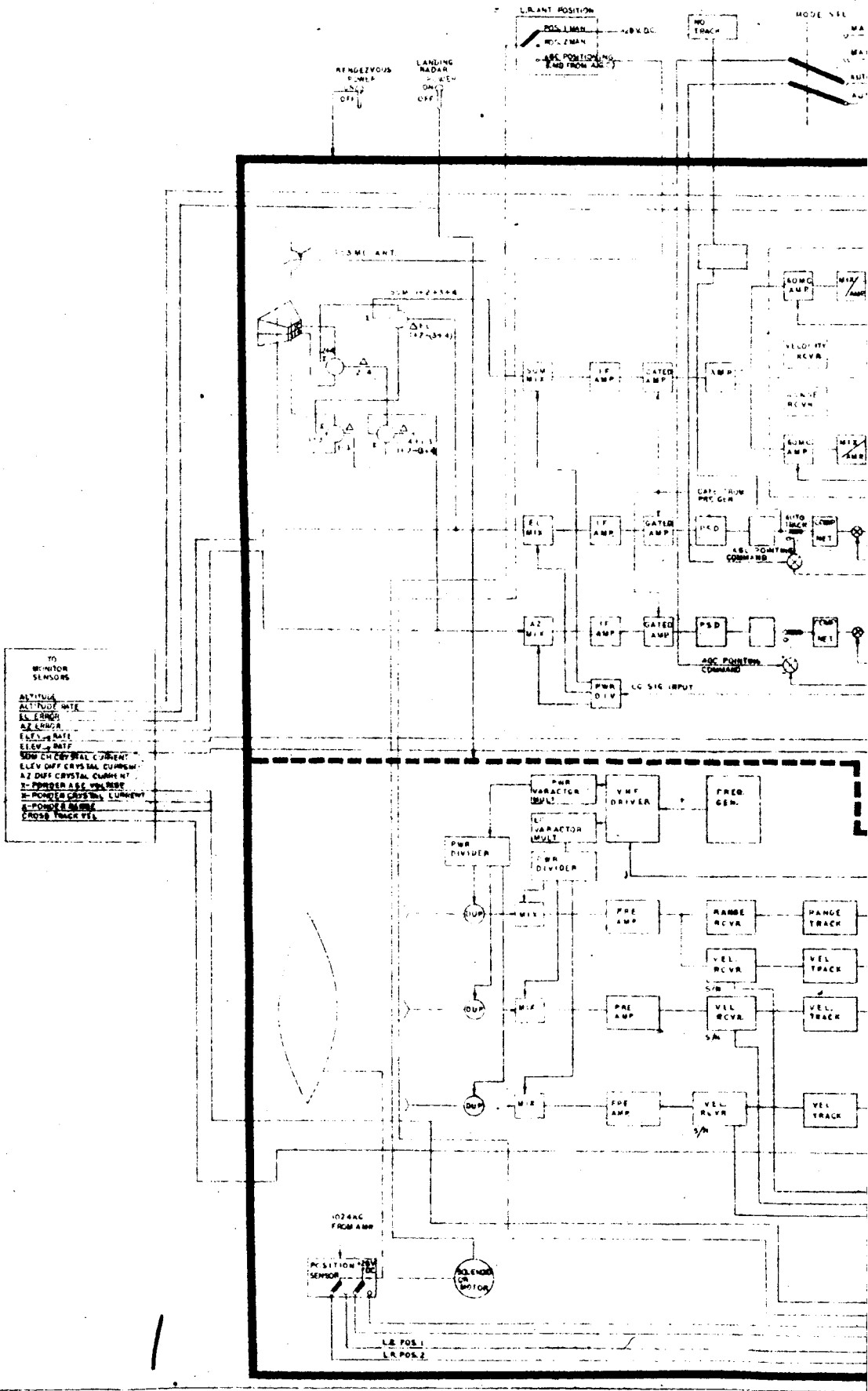
GRUMMAN AIRCRAFT ENGRG CORP

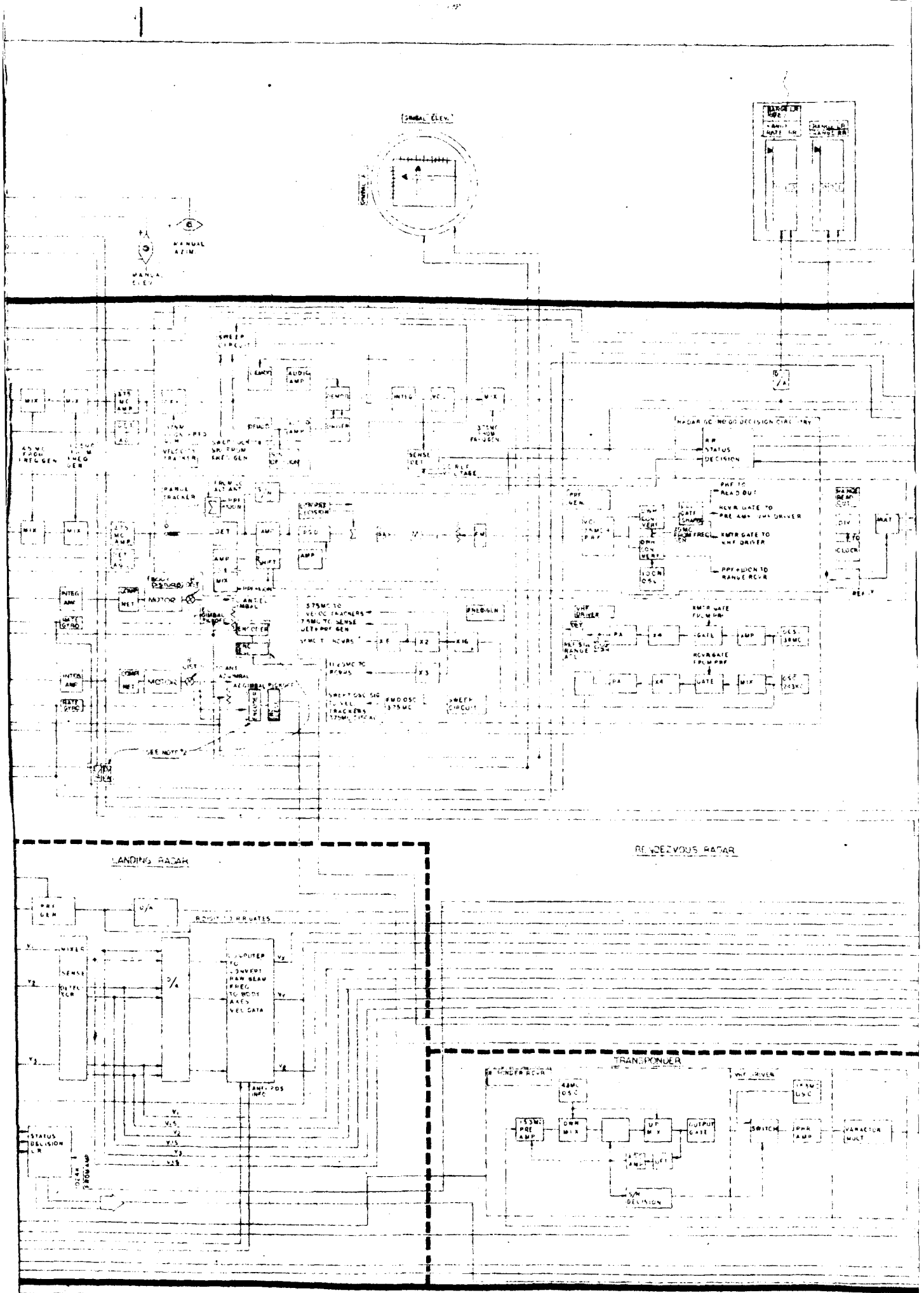
LEM
IMU, PGA, CDU, AGC AND AOT
OF PNGS

26512 LDW 370-10026

SHEET 5 OF 18

~~CONFIDENTIAL~~


L.R. ANT POSITION
POS. 1 MAN
POS. 2 MAN
AGC POSITIONING (AND FROM AGC)
NO TRACK
MODE SEL
RENDEZVOUS POWER
LANDING RADAR POWER
ON
OFF
SUM ANT
SUM MIX
IF AMP
GATED AMP
AMP
SUMC AMP
MIX/AMP
VELOCITY RCVR
RANGE RCVR
EL MIX
PSD
AUTO TRACK
COMP NET
AGC POINTING COMMAND
AZ MIX
PWR DIV
LC SIG INPUT
TO MONITOR SENSORS
ALTITUDE
ALTITUDE RATE
EL ERROR
AZ ERROR
ELEV RATE
ELEV RATE
SUM CH CRYSTAL CURRENT
ELEV DIFF CRYSTAL CURRENT
AZ DIFF CRYSTAL CURRENT
X-POWER A.G.C. VOLTAGE
X-POWER CRYSTAL CURRENT
Y-POWER A.G.C.
CROSS TRACK VEL
PWR VARACTOR MULT
EL VARACTOR MULT
VHF DRIVER
FREQ. GEN.
PWR DIVIDER
DUP
MIX
PRE AMP
RANGE RCVR
RANGE TRACK
VEL RCVR
VEL TRACK
S/B
S/N
1024 AC FROM AMP
POSITION SENSOR
SOLENOID OR MOTOR
L.R. POS. 1
L.R. POS. 2


GIMBAL ELEV.
MANUAL AZIM.
MANUAL ELEV.
SWEEP CIRCUIT
AUDIO AMP
MIX
375 MC AMP
DET
AMP
SHIFT
MOTOR
INTEG AMP
RATE GYRO
375 MC TO VELOCITY TRACKERS
375 MC TO SENSE DET & PRF GEN
X2
X16
X3
SEE NOTE #2
RADAR SCANNING DECISION CIRCUITRY
RF STATUS DECISION
PRF TO READOUT
RCVR GATE TO PRE AMP & VHF DRIVER
XMTR GATE TO VHF DRIVER
PRF & DON TO RANGE RCVR
VHF DRIVER
XMTR GATE FROM PRF
RCVR GATE FROM PRF
GATE
LANDING RADAR
PRF GEN
D/A
A/D
SENSE DETECTOR
STATUS DECISION CKT
RENDEZVOUS RADAR
TRANSPONDER
RENDEZVOUS RCVR
VHF DRIVER
48 MC OSC
153 MC PRE AMP
DWN MIX
UP MIX
OUTPUT GATE
SWITCH
PWR AMP
VARACTOR MULT
S/N DECISION

~~CONFIDENTIAL~~

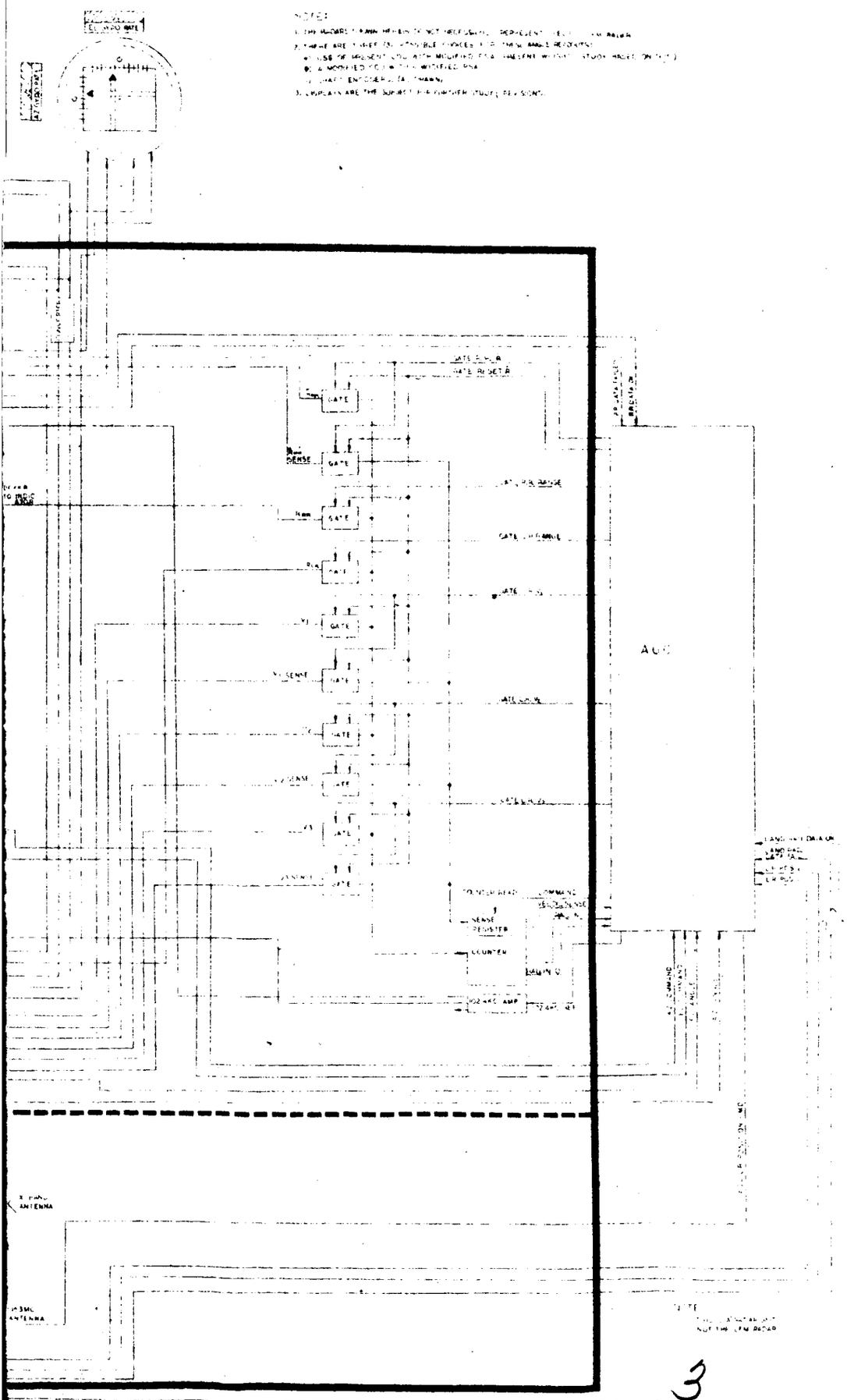
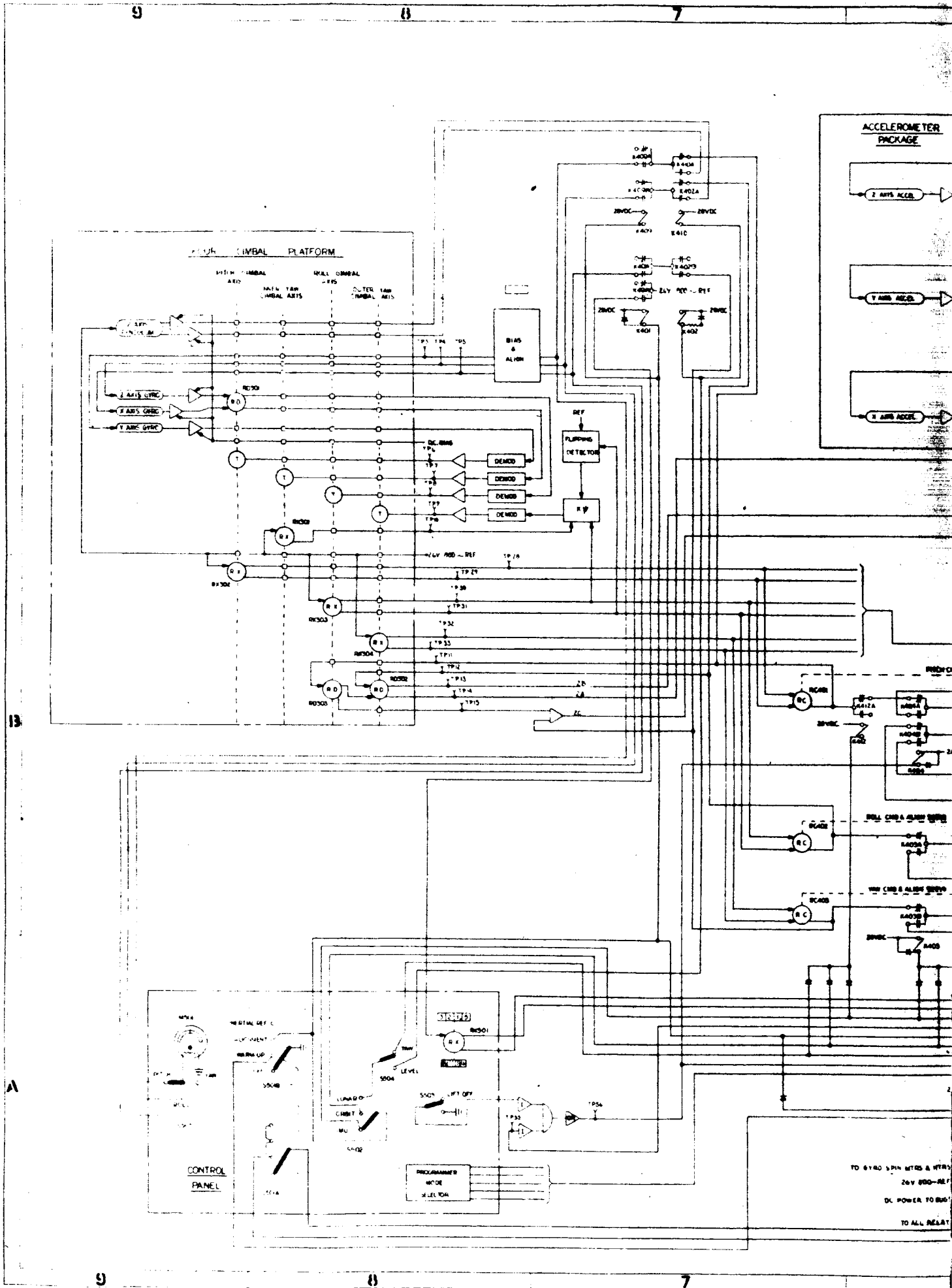


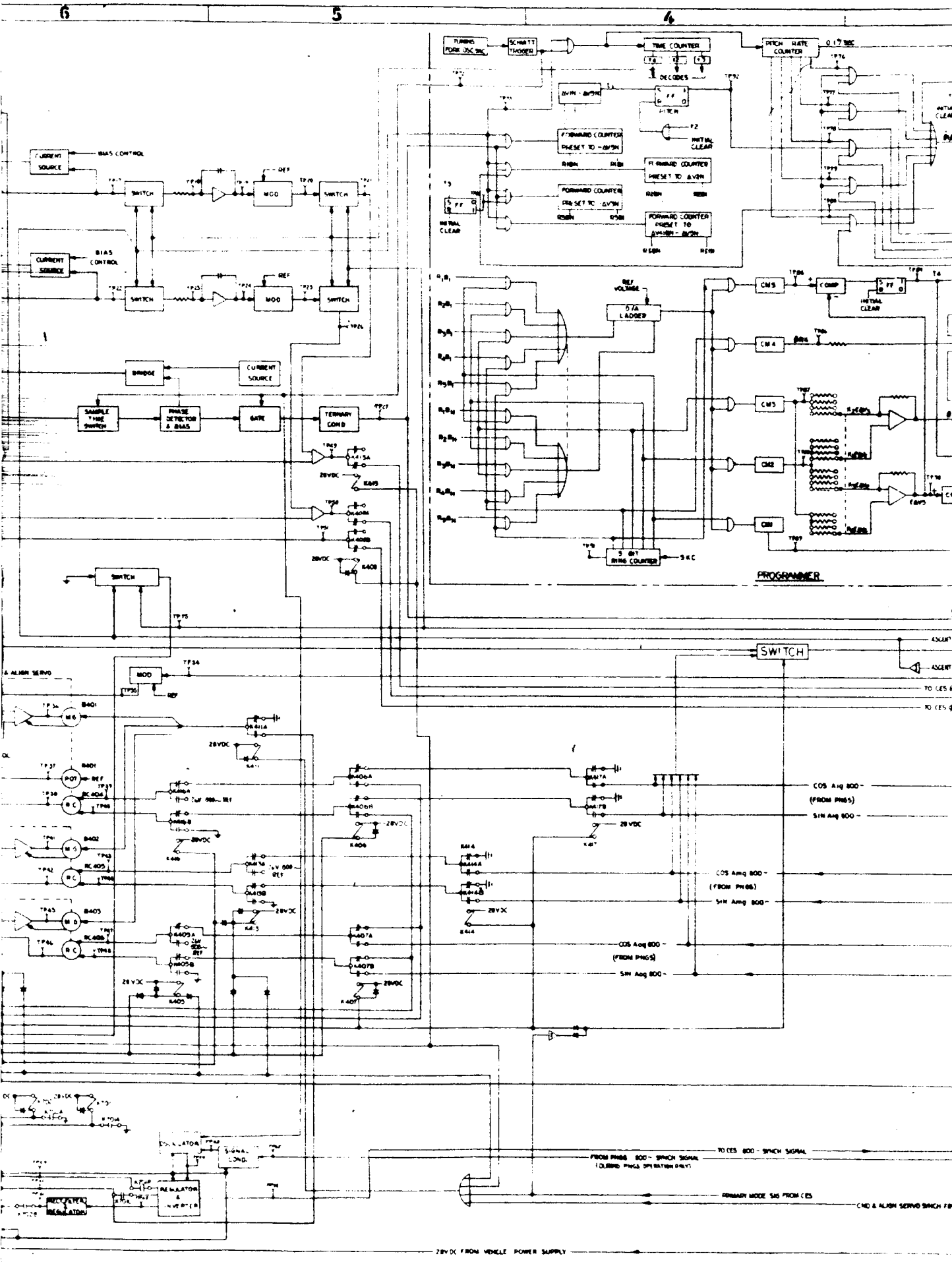
FIG. 13
LED-490-4
31 OCT 1963

FOR WEIGHTS USE ONLY

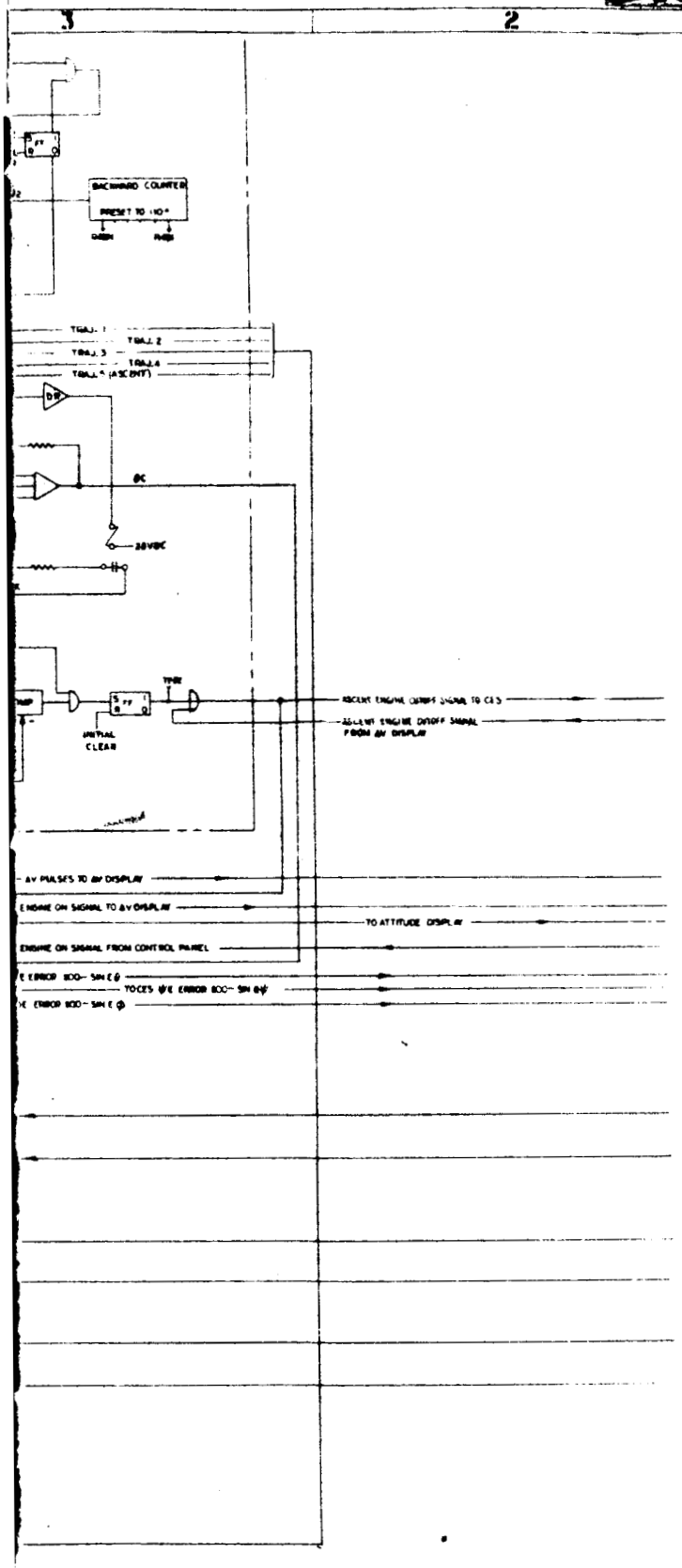
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCE UNLESS SPECIFIED FRACTIONS DECIMALS ANGLES	DRAWN BY / LAYOUT BY / STRUCTURES / SYST. HEAT / SYSTEMS HEAT / SYSTEMS / SYSTEMS ENG / APPROVED	U.S. GRAY	GRUMMAN AIRCRAFT ENGRG CORP BETHPAGE, L.I., N.Y.
ORIG. REQ. AUTH.			LEM RADAR SUB SYSTEM
CLASS I ENGR CHANGE / CLASS II ENGR CHANGE			CONTRACT NO. / SHT. REF. NO. / 20912 / LSW-370-10025
			SCALE / SHEET

~~CONFIDENTIAL~~


ACCELEROMETER PACKAGE
Z AXIS ACCEL
Y AXIS ACCEL
X AXIS ACCEL
GIMBAL PLATFORM
Z AXIS GYRO
X AXIS GYRO
Y AXIS GYRO
BIAS & ALIGN
DEMOD
DEMOD
DEMOD
DEMOD
FLIPPING DETECTOR
REF
CONTROL PANEL
PROGRAMMER MODE SELECTOR
LEVEL
LIFT OFF
TO ALL REALT


CURRENT SOURCE
BIAS CONTROL
SWITCH
MOD
REF
BRIDGE
SAMPLE TIME SWITCH
PHASE DETECTOR & BIAS
GATE
TERNARY COMB
28VDC
TIME COUNTER
DECODES
PITCH RATE COUNTER
SCHMITT TRIGGER
FORWARD COUNTER PRESET TO -ΔV3N
FORWARD COUNTER PRESET TO ΔV2N
FORWARD COUNTER PRESET TO -ΔV1N
FORWARD COUNTER PRESET TO ΔV4N - ΔV3N
INITIAL CLEAR
D/A LADDER
REF VOLTAGE
COMP
5 BIT RING COUNTER
PROGRAMMER
SWITCH
ASCENT
TO CES
COS Aq 800 -
(FROM PH6S)
SIN Aq 800 -
COS Amq 800 -
(FROM PH6S)
SIN Amq 800 -
COS Aaq 800 -
(FROM PH6S)
SIN Aaq 800 -
REGULATOR
SIGNAL COND.
REGULATOR & INVERTER
TO CES 800 - SINCH SIGNAL
FROM PH6S 800 - SINCH SIGNAL
(DURING PH6S OPERATION ONLY)
PRIMARY MODE SIG FROM CES
CMD & ALIGN SERVO SINCH FB
28VDC FROM VEHICLE POWER SUPPLY

2



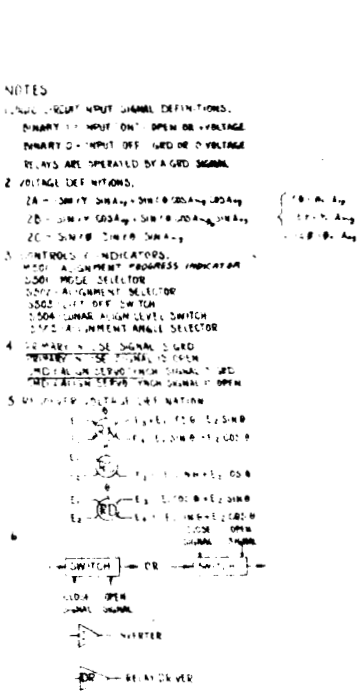
REVISIONS

REV. LTR	ITEM NO	DESCRIPTION	REVISED BY & DATE	ENGINEER APPROVAL
		RETRACED NO CHANGE, LAST CHANGE LETTER "A" RETRACED BY N. ESCALDI DATE RETRACED 4-3-63		
B	1	ADDED TEST POINTS		
	2	DELETED IMU UPDATE SIN 401, 402, & 403		
	3	CORRECTED PINS/S INPUTS TO RE401, 402, 403, 404, 405, & 406		
	4	WIRING CORRECTIONS		
	5	CHG'D OUTPUT OF RE302 TO SIN OR COSINE VARIABLE		
	6	RESOLVER ROTATION IS SHOWN IN NOTE SECTION OF DIAGRAM		
	7	PUT D.C. BIAS VOLTAGE ON PENDULUM PREAMPS & GYRO PREAMPS		
	8	REVISED POWER SUPPLY		

FIG. 14
LED-490-4
31 OCT 1963

NOTES

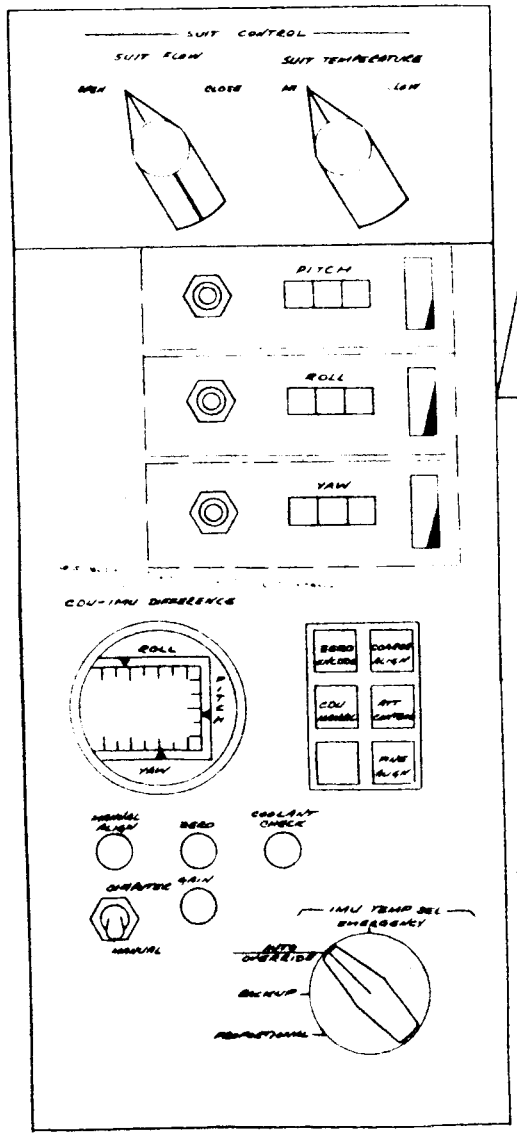
1. LOGIC CIRCUIT INPUT SIGNAL DEFINITIONS.
   - BINARY 1 = INPUT ON = OPEN OR +VOLTAGE
   - BINARY 0 = INPUT OFF = GRD OR 0 VOLTAGE
   - RELAYS ARE OPERATED BY A GRD SIGNAL
2. VOLTAGE DEFINITIONS.
   - 2A = SIN Y SIN Ay + SIN Y COS Ay COS Ay
   - 2B = SIN Y COS Ay + SIN Y COS Ay SIN Ay
   - 2C = SIN Y SIN Y SIN Ay
3. CONTROLS & INDICATORS.
   - MODE ALIGNMENT PROGRESS INDICATOR
   - S501 MODE SELECTOR
   - S502 ALIGNMENT SELECTOR
   - S503 LIFT OFF SWITCH
   - S504 SUNAR ALIGN LEVEL SWITCH
   - S505 ALIGNMENT ANGLE SELECTOR
4. PRIMARY PULSE SIGNAL = GRD
   - PRIMARY PULSE SIGNAL IS OPEN
   - MODE ALIGN DEPRESSED INPUT SIGNAL = GRD
   - MODE ALIGN DEPRESSED INPUT SIGNAL = OPEN
5. [illegible]

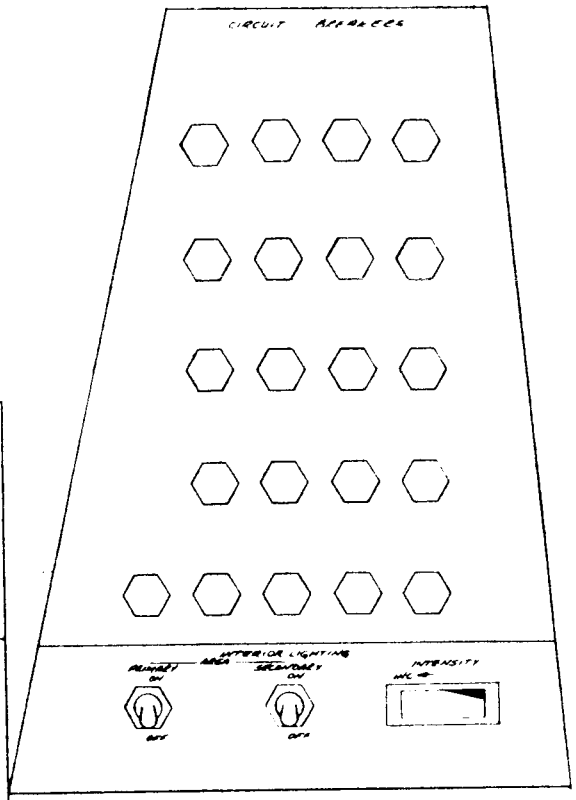


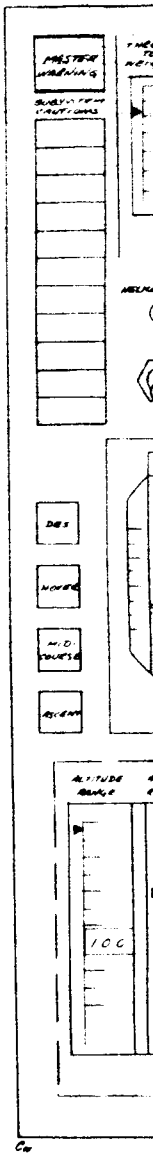
FOR WEIGHTS USE ONLY

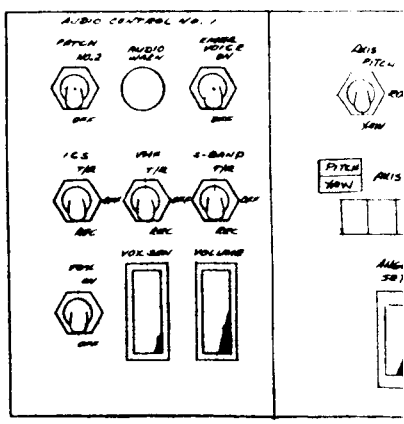
DRAWN BY N. ESCALDI	GRUMMAN AIRCRAFT ENERG CORP BETHPAGE, L.I., N.Y.	
	SCHEMATIC DIAGRAM BACK UP GUIDANCE SYSTEM	
26512	LSK 500-3000	B

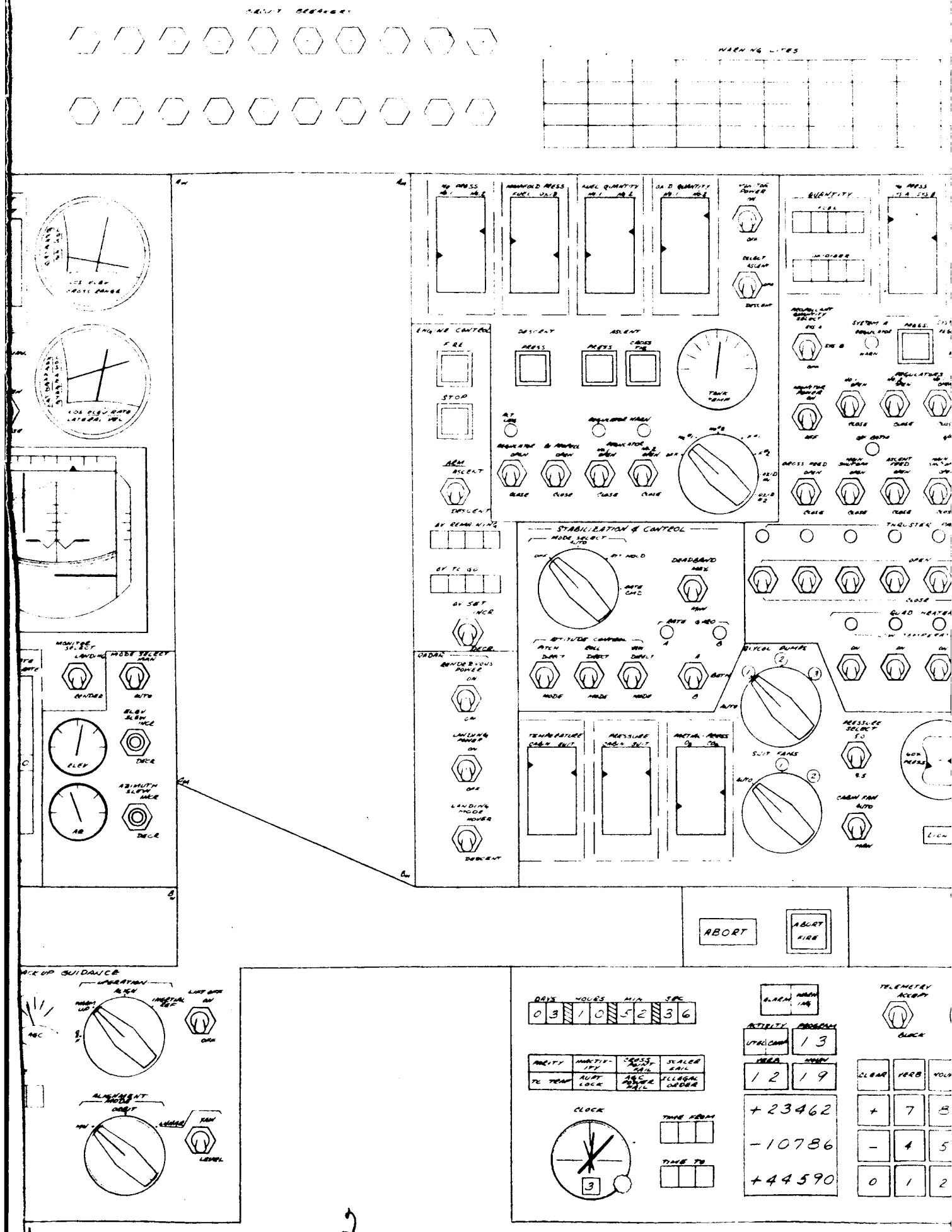
3


SUIT CONTROL
SUIT FLOW
SUIT TEMPERATURE
MAX
CLOSE
HI
LOW
PITCH
ROLL
YAW
CDU-IMU DIFFERENCE
ROLL
PITCH
YAW
ZERO ATTITUDE
COARSE ALIGN
CDU MANUAL
ATT CONTROL
FINE ALIGN
MANUAL ALIGN
ZERO
COOLANT CHECK
GYROSCOPIC
GAIN
MANUAL
IMU TEMP SEL
EMERGENCY
BACKUP

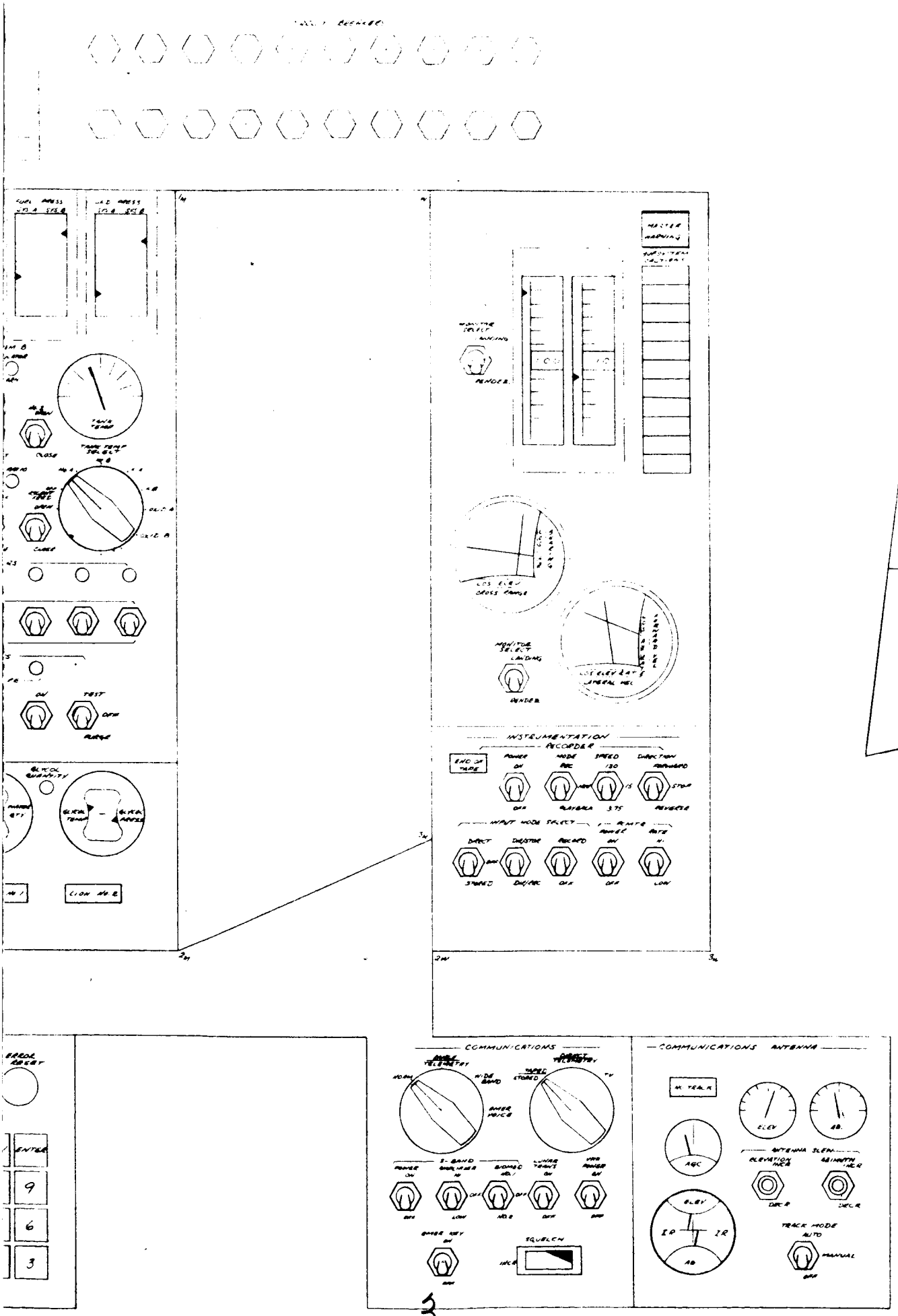

CIRCUIT BREAKERS
INTERIOR LIGHTING
AREA
PRIMARY
SECONDARY
INTENSITY
ON
OFF


MASTER WARNING
DES
HOVER
ASCENT
ALTITUDE RANGE
100

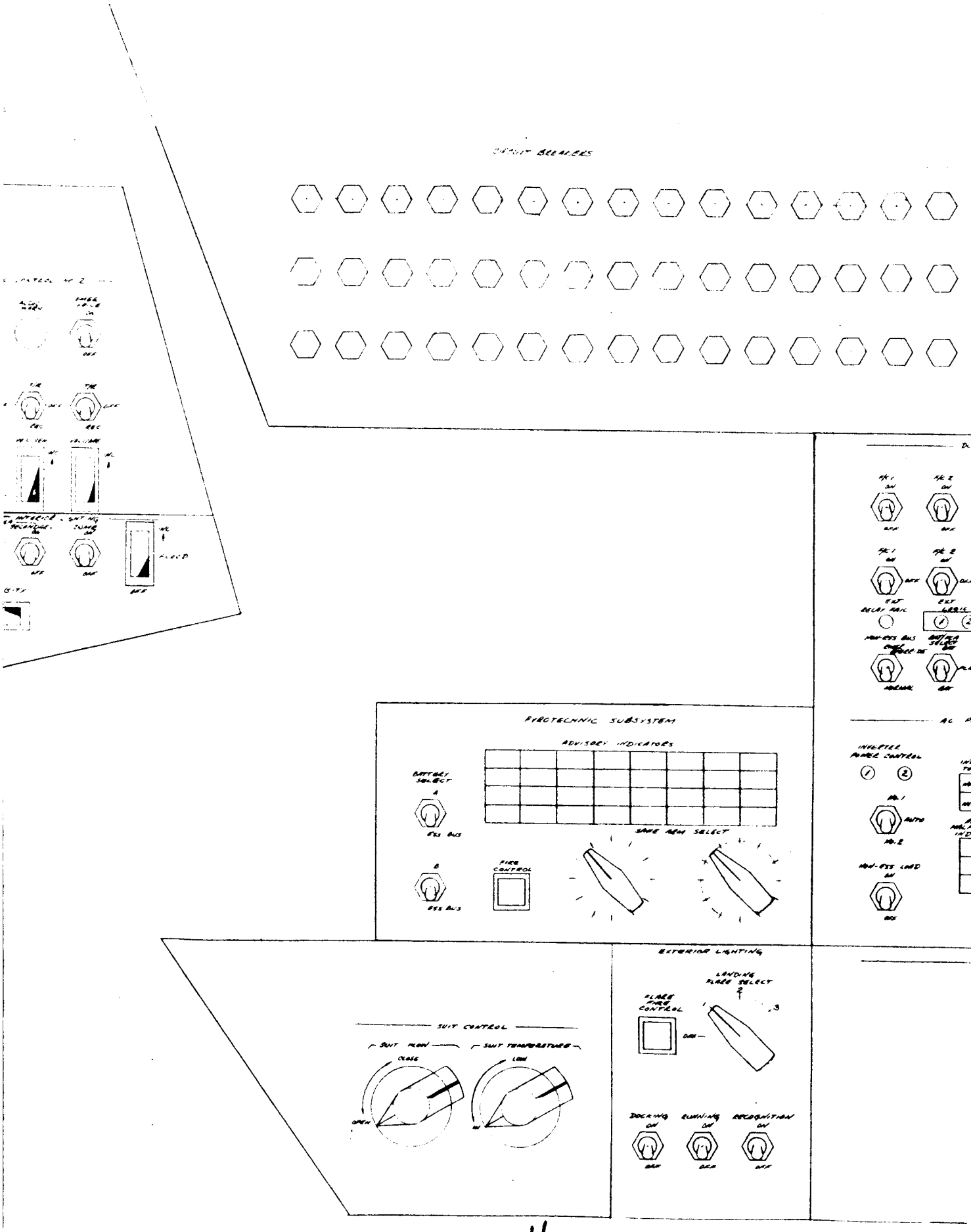

AUDIO CONTROL NO. 1
PITCH NO. 2
AUDIO WARN
EMERG VOICE
ON
OFF
ICS T/R
VHF T/R
S-BAND T/R
REC
VOX SENS
VOLUME
PITCH
YAW


CIRCUIT BREAKERS
WARNING LITES
ENGINE CONTROL
FIRE
STOP
ARM
ASCENT
DESCENT
PRESS
CROSS FEED
TANK TEMP
STABILIZATION & CONTROL
MODE SELECT
DEADBAND
ATTITUDE CONTROL
PITCH
ROLL
YAW
MODE
THRUSTER
OPEN
CLOSE
QUAD HEATER
GLYCOL PUMPS
SUIT FANS
AUTO
CABIN FAN
MONITOR SELECT
LANDING
MODE SELECT
MAN
ENTER
ELEV
AZ
ELEV SLEW
INCR
DECR
AZIMUTH SLEW
INCR
DECR
ABORT
ABORT FIRE
BACK UP GUIDANCE
OPERATION
ALIGN
INERTIAL REF
LIST GYR
ON
OFF
ALIGNMENT MODE
DRIFT
YAW
LEVEL
DAYS
HOURS
MIN
SEC
0 3 1 0 5 2 3 6
ACTIVITY
PROGRAM
1 3
VERB
NOUN
1 2
1 9
+ 23462
- 10786
+ 44590
CLEAR
VERB
CLOCK
TIME FROM
TIME TO
TELEMETRY ACCEPT
CLOCK

2


MASTER WARNING
MONITOR SELECT
LANDING
VENDER
LOS ELEV
CROSS RANGE
INSTRUMENTATION
RECORDER
END OF TAPE
POWER
ON
OFF
MODE
REC
PLAYBACK
SPEED
120
15
3.75
DIRECTION
FORWARD
STOP
REVERSE
INPUT MODE SELECT
DIRECT
STORED
DIR/REC
RECORD
OFF
RATE
POWER
ON
OFF
LOW
TEST
OFF
RANGE
CLOSE
ON
ENTER
9
6
3
COMMUNICATIONS
TELEMETRY
NORM
WIDE BAND
INNER VOICE
TV
S-BAND
POWER
ON
OFF
LOW
MODE
NORM
OFF
LUNAR TRANS
ON
OFF
VHF POWER
ON
OFF
INNER KEY
ON
OFF
SQUELCH
COMMUNICATIONS ANTENNA
AGC
ELEV
AZ.
ANTENNA SLEW
ELEVATION
AZIMUTH
DIR.
TRACK MODE
AUTO
MANUAL
OFF

3


CIRCUIT BREAKERS
PYROTECHNIC SUBSYSTEM
ADVISORY INDICATORS
BATTERY SELECT
A
ESS BUS
B
ESS BUS
FIRE CONTROL
SAME ARM SELECT
EXTERIOR LIGHTING
LANDING FLARE SELECT
FLARE FIRE CONTROL
OFF
DOCKING ON
RUNNING ON
RECOGNITION ON
SUIT CONTROL
SUIT FLOW
CLOSE
OPEN
SUIT TEMPERATURE
COLD
HOT
INVERTER POWER CONTROL
AUTO
NON-ESS LOAD

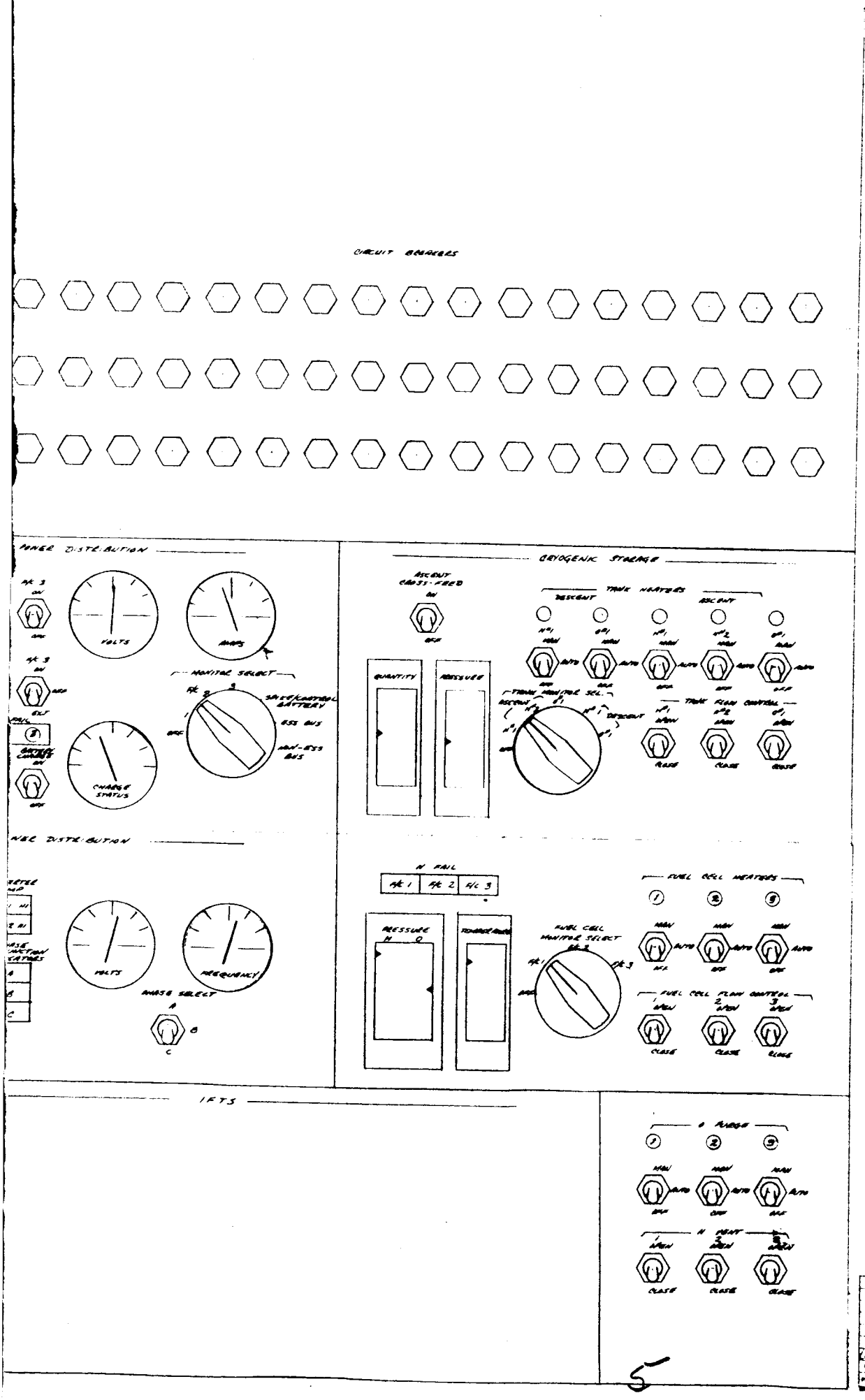


FIG. 15
LED-490-4
31 OCT 1963

REM	LMU-340-10100	M-1	L
PART NO	LLO-340-123		

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCE UNLESS SPECIFIED FRACTIONS - DECIMALS - ANGLES

DRAWN BY
LAYOUT BY
CLASS II ENGRG CHANGE
CLASS I ENGRG CHANGE

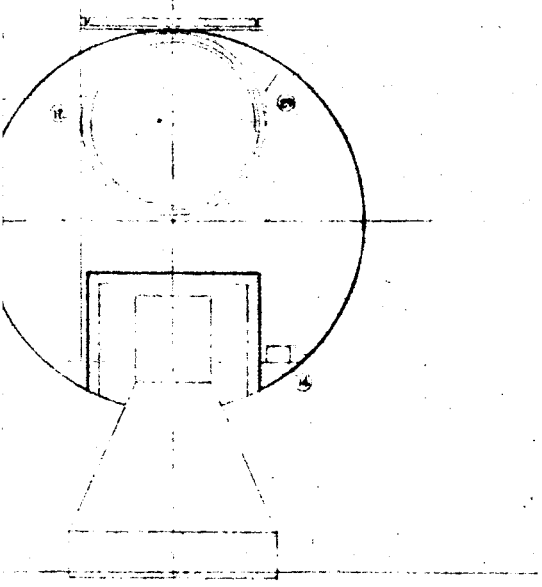
GRUMMAN AIRCRAFT ENGRG CORP
BETHPAGE, L.I., N.Y.

DISPLAY PANEL - ARRANGEMENT
CONFIGURATION D (MOD. E)

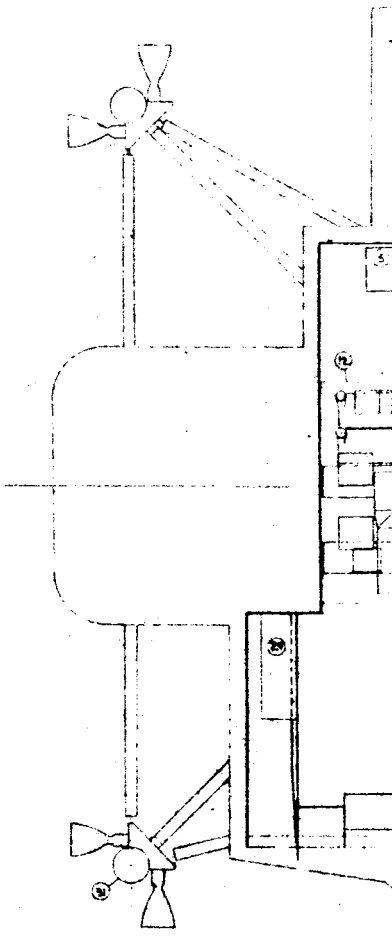
CONTRACT NO
CODE IDENT NO 26512
SIZE
LLO-340-123
SCALE FULL
SHEET 1 OF 1

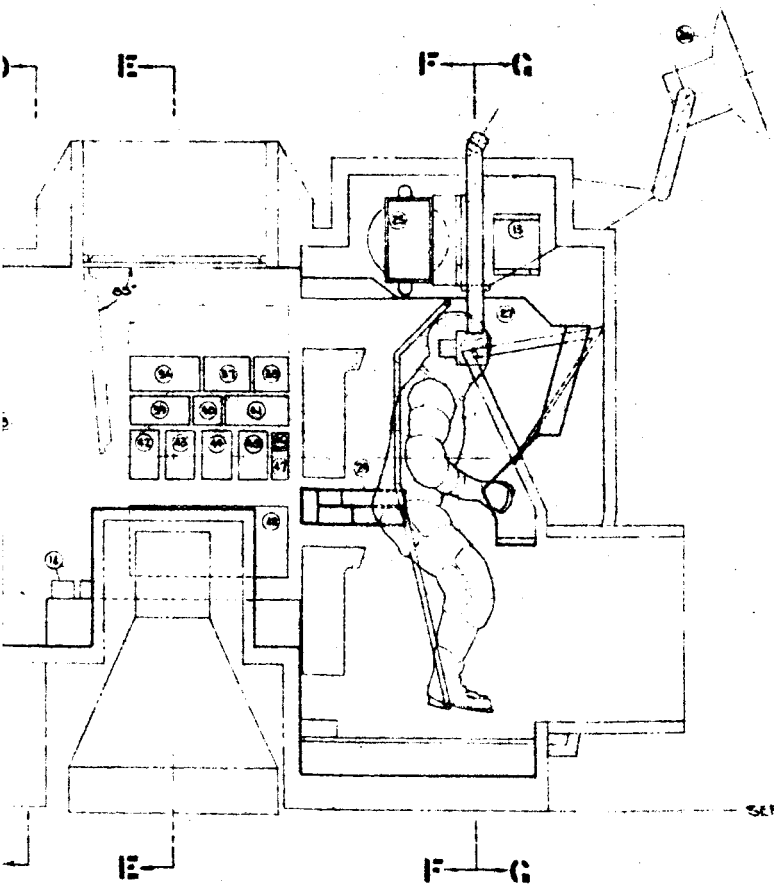
SECT D-D

SECT. H-H

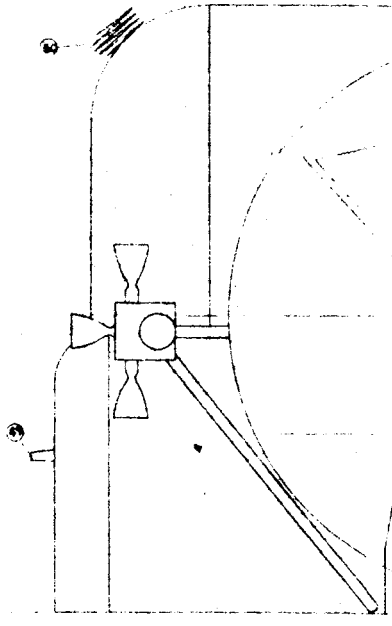


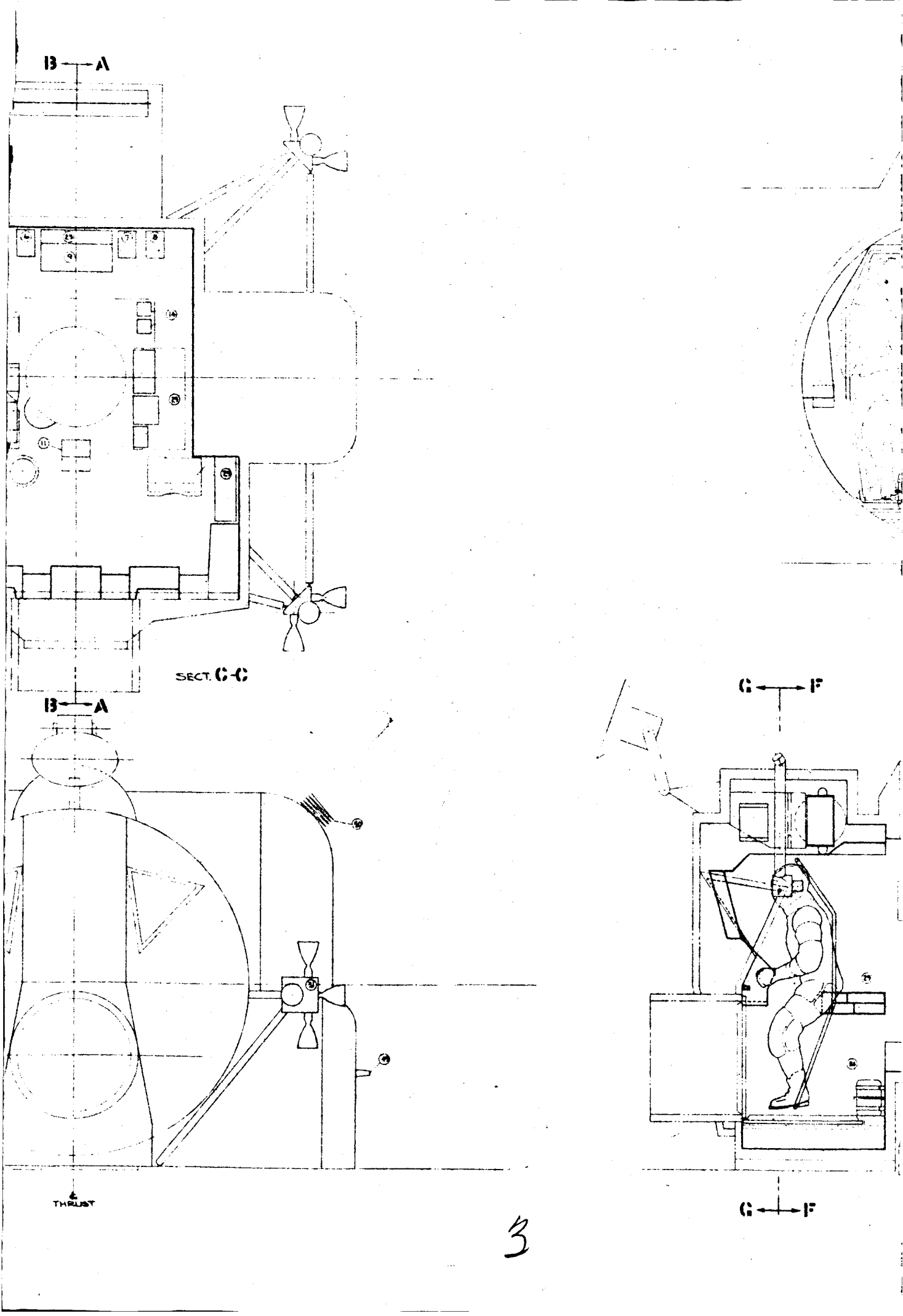
SECT. E-E





SECT. A-A





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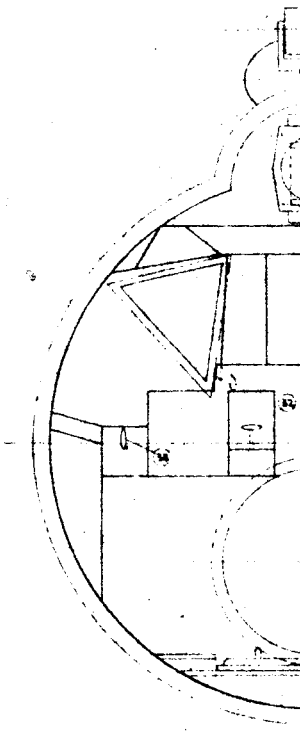
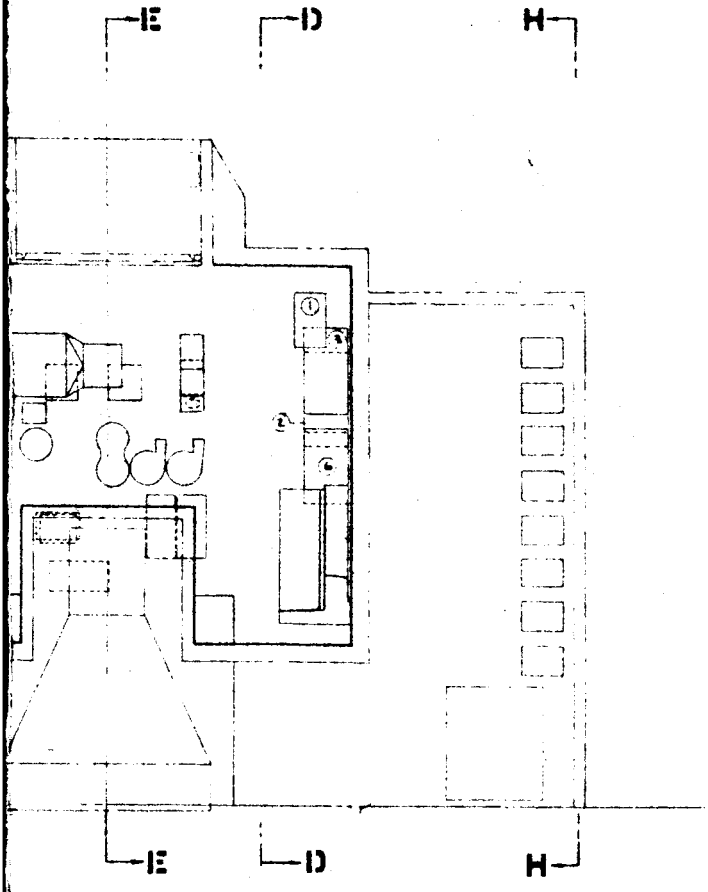


SEPARATION PLANE (REF) X_L 200

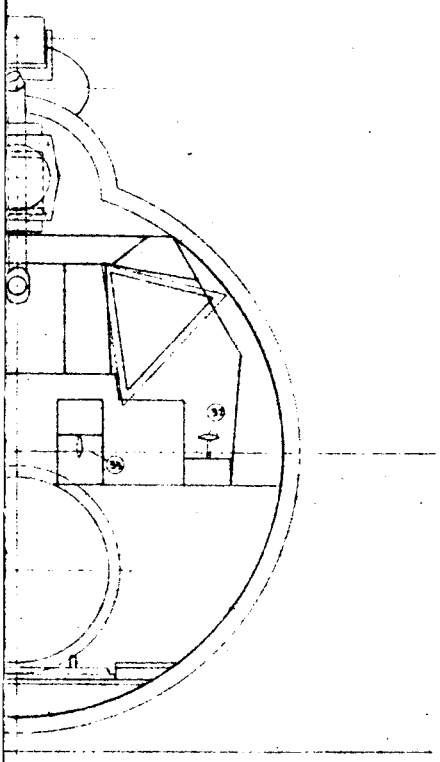
SECT-F-F

SEC



SECT. B-B

4



T-G-G

1. TAPE RECORDER
2. IN-FLIGHT MONITOR ASSY.
3. LANDING RADAR
4. STABILIZATION & CONTROL COMPUTER
5. RENDEZVOUS RADAR XPNDR
6. RENDEZVOUS RADAR
7. COMMUNICATIONS 'A' (S-BAND XPDR, PWR AMP DIPLEXER)
8. ATTITUDE REF. ASSY.
9. APPOLO GUIDANCE COMPUTER
10. VHF & S-BAND ANTENNA SWITCHES
11. STEP
12. ENVIRONMENTAL CONTROL SYSTEM (ECS)
13. BACKUP PLATFORM
14. RATE GYRO ASSY
15. INVERTER
16. INVERTER
17. AUXIXIARY BATTERIES (PEAKING-2EMERGENCY)
18. PYRO BATTERIES & RELAY BOX
19. COMMUNICATIONS 'B' (AUDIO CTR VHF XCVR PMP & ANT. ELECT)
20. ATCA-GCA
21. PCMTE
22. SIGNAL CONDITIONER
23. POWER SERVO ASSY
24. JUNCTION BOX
25. INERTIAL MEASURING UNIT (IMU)
26. RENDEZVOUS RADAR ANTENNA
27. ALIGNING OPTICAL TELESCOPE (AOT)
28. ECS SUIT CONNECTORS
29. CREW PROVISIONS
30. OPTICAL SIGHT
31. REACTION CONTROL UNIT
32. ATTITUDE CONTROLLER
33. TRANSLATION CONTROLLER
34. URINE TANK
35. IPTS (STIM.GEN INFLIGHT COMPAR.)
36. SPACE SUIT REPAIR KIT
37. SRC
38. BATTERY CHARGER
39. PLSS SPARE PARTS
40. CAMERA & SCOPE
41. BOOTS
42. LiOH (2)
43. LiOH (2)
44. LiOH (2)
45. LiOH (2)
46. TOOLS
47. EMERGENCY O_2
48. THERMAL GARMENTS
49. LEM TO EARTH S-BAND ANTENNA
50. LEM TO CM VHF ANTENNA

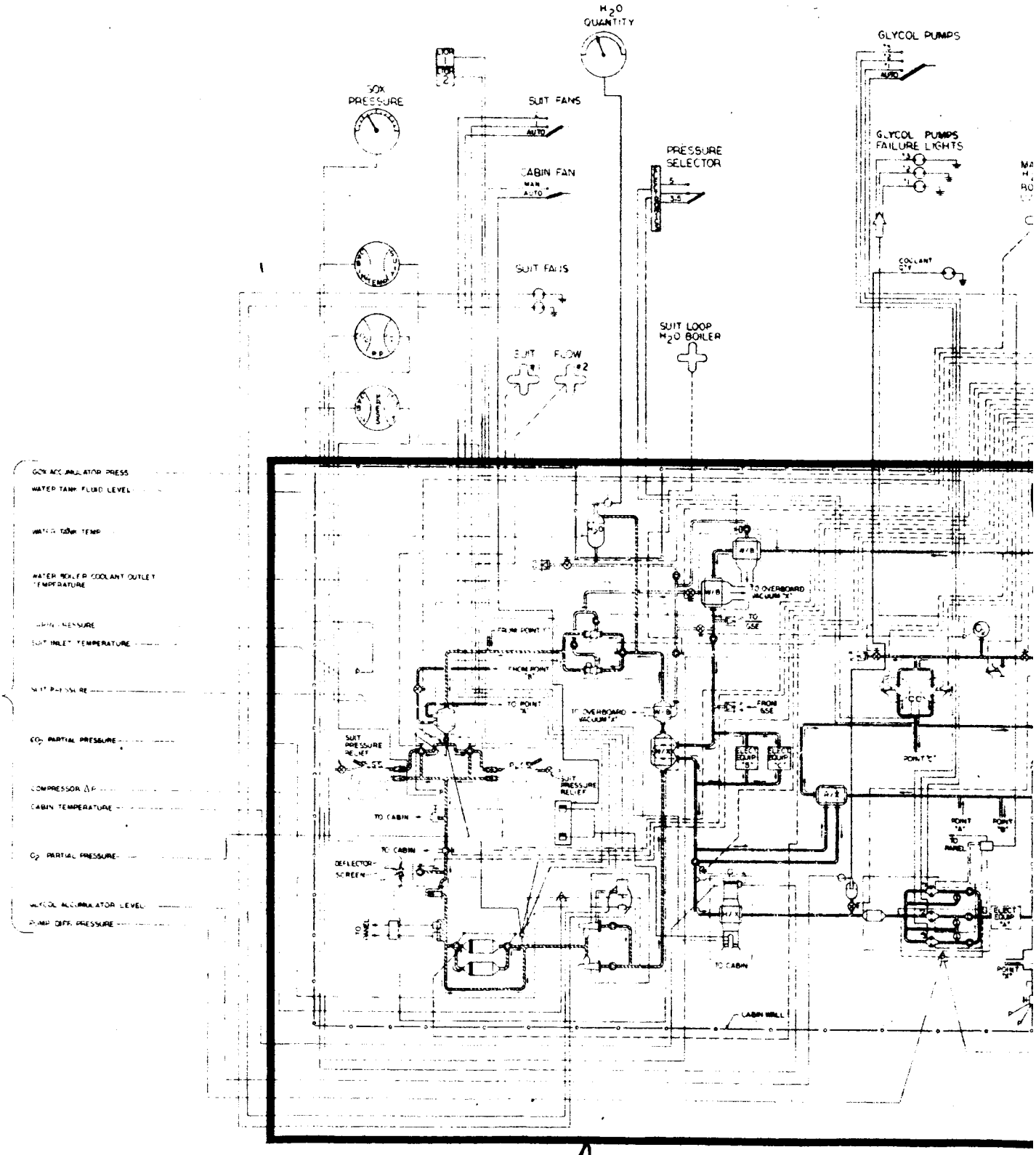
FIG. 16
LED-490-4
31 OCT 1963

GRUMMAN AIRCRAFT ENGRG CORP
BETHPAGE, L. I. N.Y.

INBOARD PROFILE
COCKPIT & EQUIP. BAY CONFIG. P, MOD 1

CONTRACT NO. NAS 9-1100
CODE IDENT NO. 26512
NO. LLO-340-121

TO SIGNAL CONDITIONER
(IN INSTRUMENTATION SYSTEM)


H_2O QUANTITY
GLYCOL PUMPS
SOX PRESSURE
SUIT FANS
AUTO
PRESSURE SELECTOR
GLYCOL PUMPS FAILURE LIGHTS
CABIN FAN
MAN
AUTO
SUIT FANS
SUIT LOOP H_2O BOILER
SUIT FLOW #1
#2
COOLANT
SOX ACCUMULATOR PRESS
WATER TANK FLUID LEVEL
WATER TANK TEMP
WATER BOILER COOLANT OUTLET TEMPERATURE
CABIN PRESSURE
SUIT INLET TEMPERATURE
SUIT PRESSURE
CO_2 PARTIAL PRESSURE
COMPRESSOR ΔP
CABIN TEMPERATURE
O_2 PARTIAL PRESSURE
GLYCOL ACCUMULATOR LEVEL
PUMP DIFF PRESSURE
TO OVERBOARD VACUUM "A"
TO ASE
FROM POINT "A"
FROM POINT "B"
TO POINT "B"
TO OVERBOARD VACUUM "A"
FROM ASE
SUIT PRESSURE RELIEF
SUIT PRESSURE RELIEF
ELECT EQUIP "B"
ELECT EQUIP "C"
POINT "C"
TO CABIN
TO CABIN
DEFLECTOR SCREEN
POINT "A" TO PANEL
POINT "B"
ELECT EQUIP "A"
TO CABIN
CABIN WALL
POINT "A"

2

~~CONFIDENTIAL~~

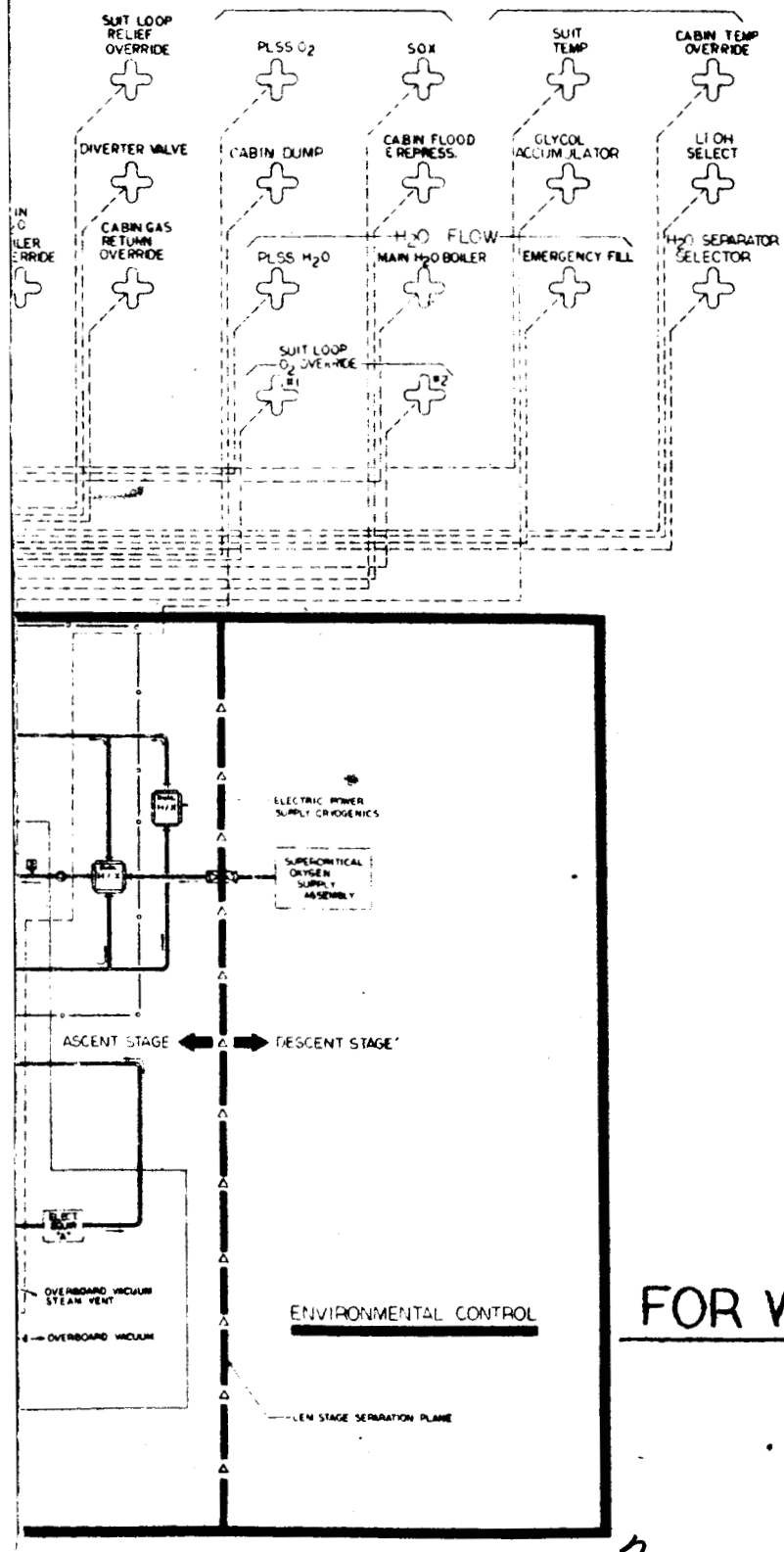


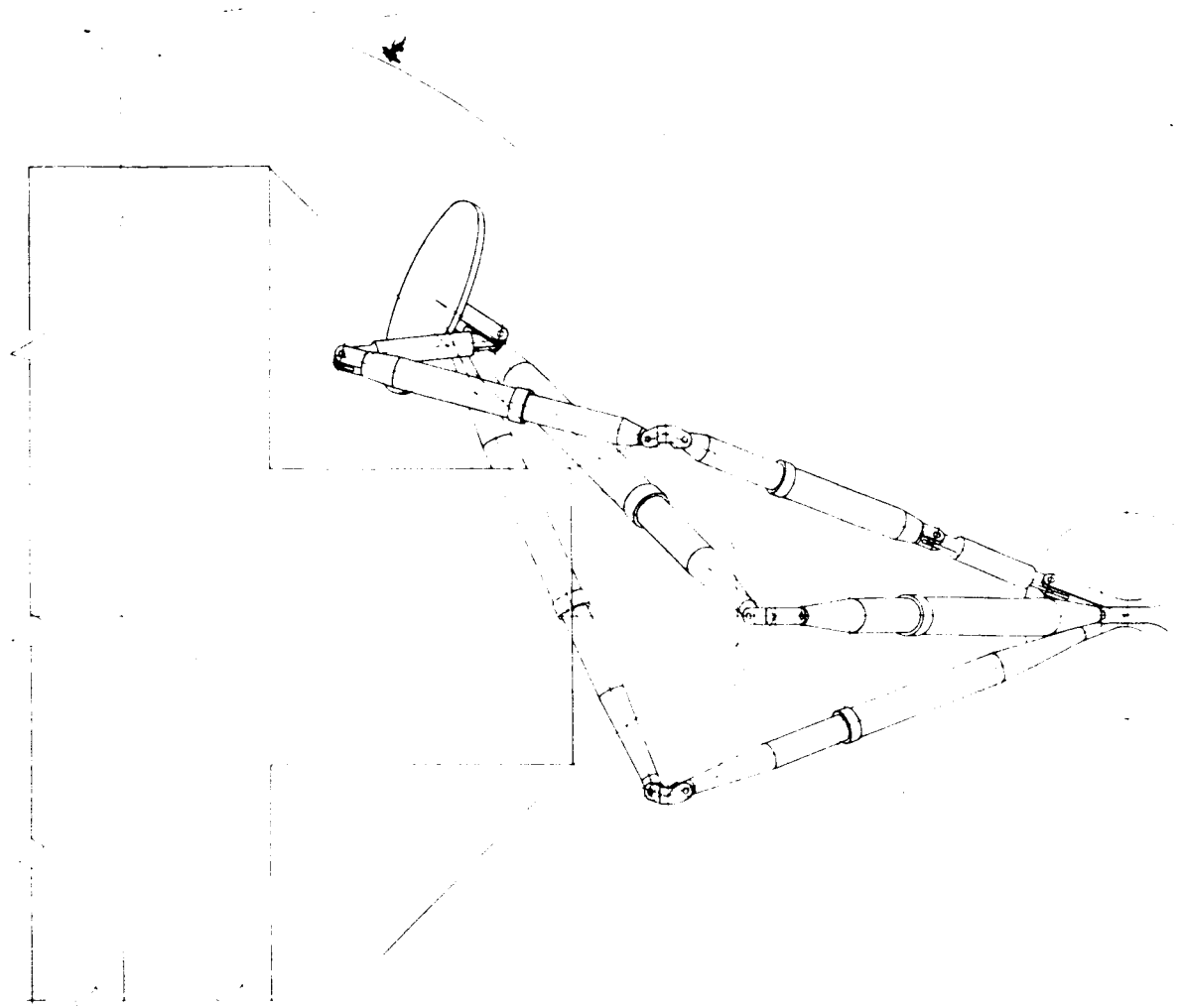
FIG. 17
LED-490-4
31 OCT 1963

FOR WEIGHTS USE ONLY

3

GRUMMAN AIRCRAFT ENGINEERING CORP
LEM
ECS SUB-SYSTEM
LDW-540-10000

~~CONFIDENTIAL~~



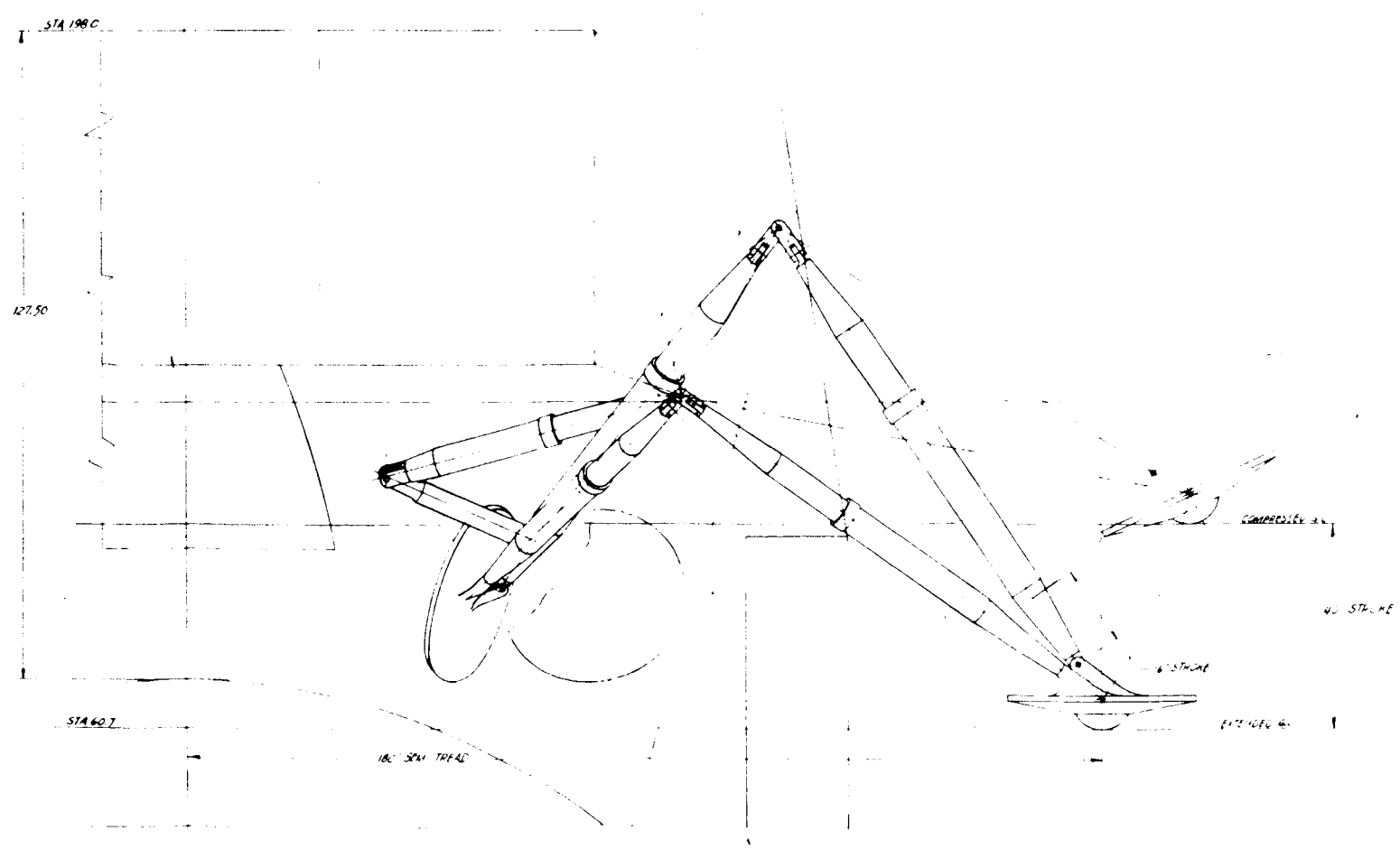


FIG. 18
LED-490-4
31 OCT 1963

180" SEMI-TREAD
LATERAL FOLD
320 LSK 10212

180" SEMI TREAD
LATERAL FOLD
PRELIMINARY
320 LSK 10212

~~CONFIDENTIAL~~

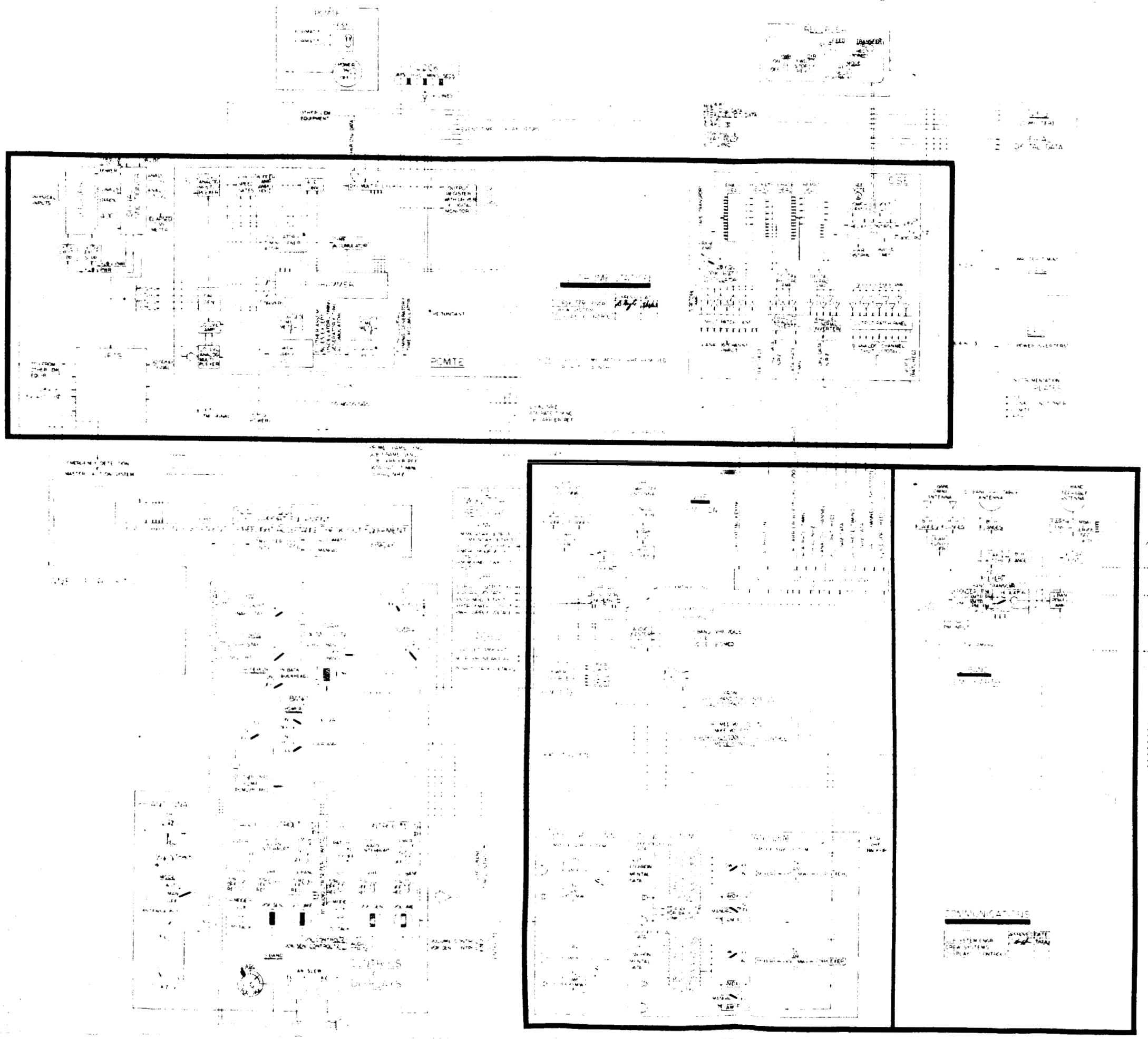
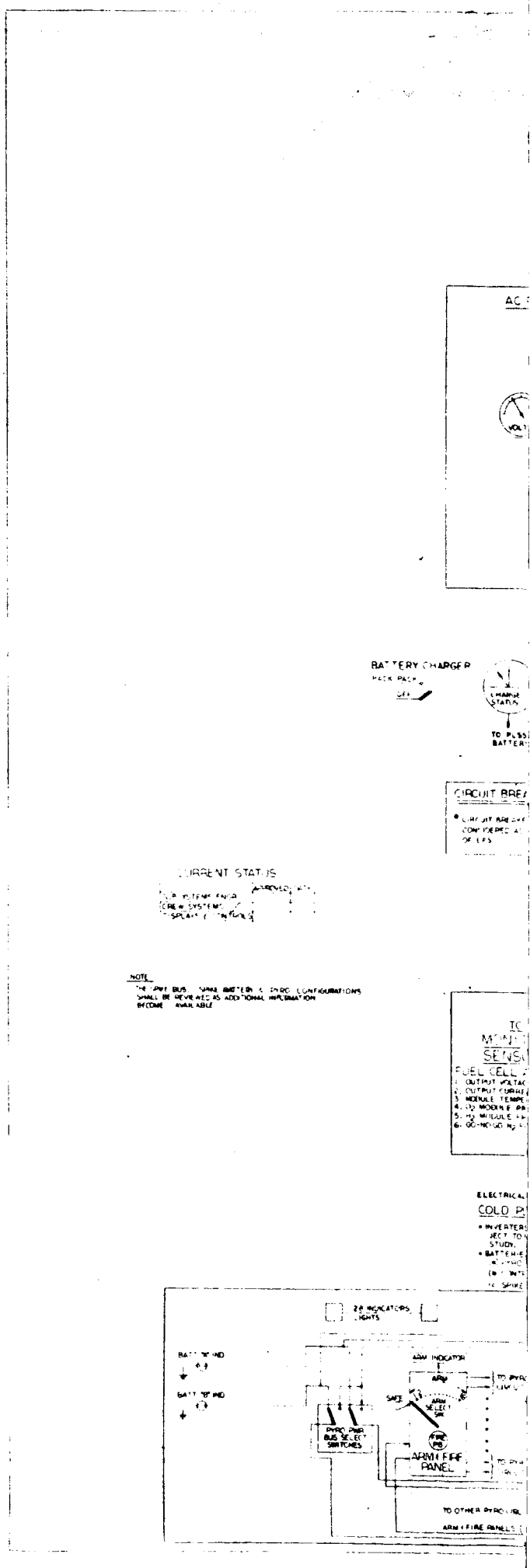


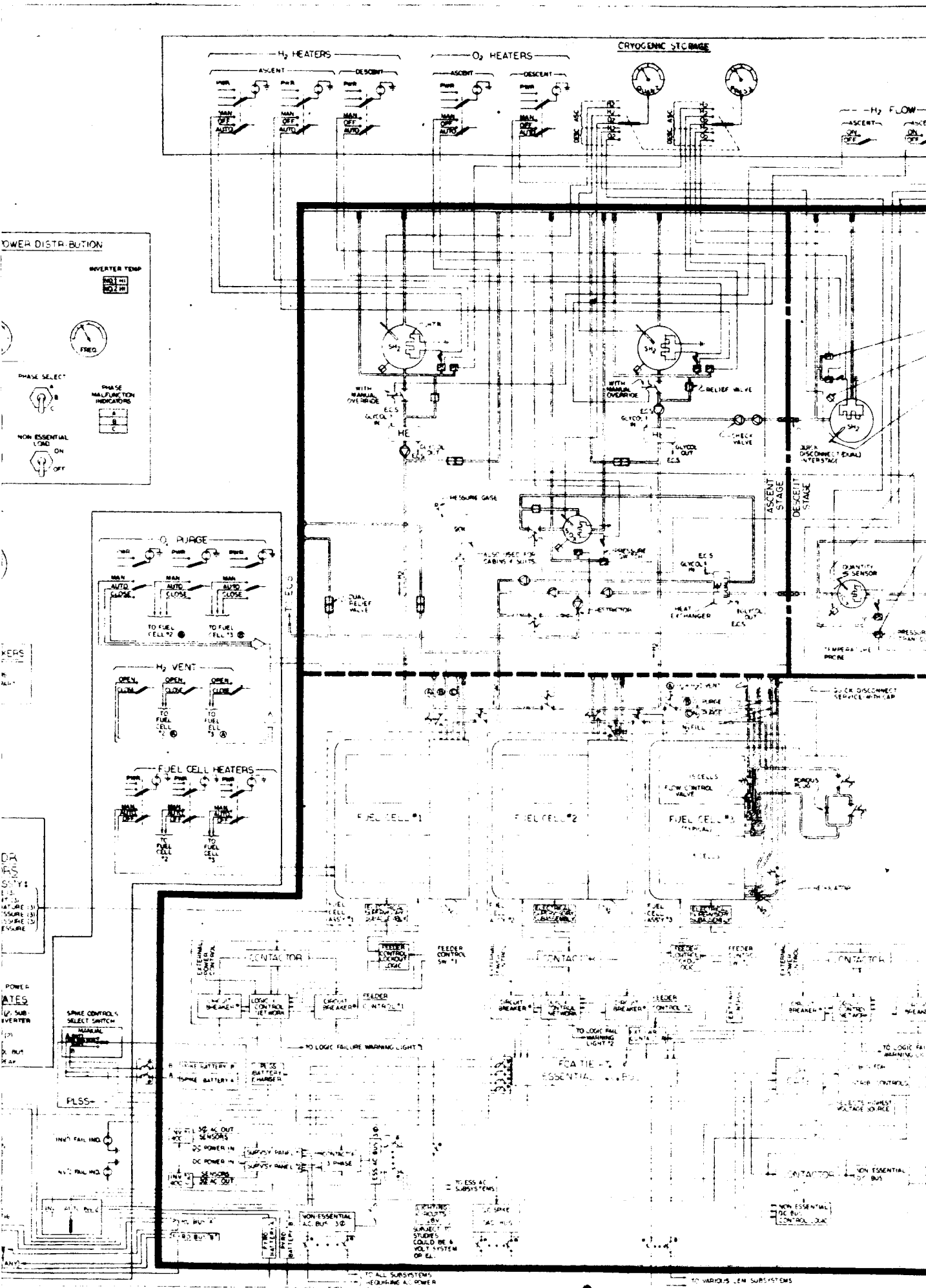
FIG. 19
LED-490-4
31 OCT 1963

FOR WEIGHTS USE ONLY

GRUMMAN AIRCRAFT ENGING CORP
LEM
INSTRECOMM SUBSYSTEM
26512
LWA 540 K0000

~~CONFIDENTIAL~~


AC
BATTERY CHARGER
CHARGER STATUS
CIRCUIT BREA
CURRENT STATUS
NOTE
SENSO
FUEL CELL
ELECTRICAL
COLD P
28 INDICATORS, LIGHTS
BATT "B" IND
BATT "B" IND
ARM INDICATOR
ARM
SAFE
ARM SELECT SW
FIRE PB
PYRO PWR BUS SELECT SWITCHES
ARM / FIRE PANEL
TO OTHER PYRO VAL
ARM / FIRE PANELS


CRYOGENIC STORAGE
H2 HEATERS
O2 HEATERS
ASCENT
DESCENT
H2 FLOW
POWER DISTRIBUTION
INVERTER TEMP
FREQ
PHASE SELECT
PHASE MALFUNCTION INDICATORS
NON ESSENTIAL LOAD
ON
OFF
O2 PURGE
H2 VENT
FUEL CELL HEATERS
TO FUEL CELL #2
TO FUEL CELL #3
WITH MANUAL OVERRIDE
ECS GLYCOL IN
ECS GLYCOL OUT
RELIEF VALVE
CHECK VALVE
QUICK DISCONNECT (DUAL) INTERSTAGE
ASCENT STAGE
DESCENT STAGE
HELIUM GASE
DUAL RELIEF VALVE
HEAT EXCHANGER
QUANTITY SENSOR
PRESSURE TRANSDUCER
TEMPERATURE PROBE
QUICK DISCONNECT SERVICE WITH CAP
FUEL CELL #1
FUEL CELL #2
FUEL CELL #3
FLOW CONTROL VALVE
POROUS PLUG
CONTACTOR
FEEDER CONTROL SW #1
FEEDER CONTROL SW #2
CIRCUIT BREAKER
LOGIC CONTROL NETWORK
TO LOGIC FAILURE WARNING LIGHT #1
TO LOGIC FAIL WARNING LIGHT #2
SPIKE CONTROLS SELECT SWITCH
MANUAL
SPIKE BATTERY #1
SPIKE BATTERY #2
PLSS BATTERY CHARGER
PLSS
ESSENTIAL DC BUS
NON ESSENTIAL DC BUS
NON ESSENTIAL DC BUS CONTROL LOGIC
NON ESSENTIAL A.C. BUS
TO ESS AC SUBSYSTEMS
TO ALL SUBSYSTEMS REQUIRING A.C. POWER
TO VARIOUS LEM SUBSYSTEMS

[redacted]

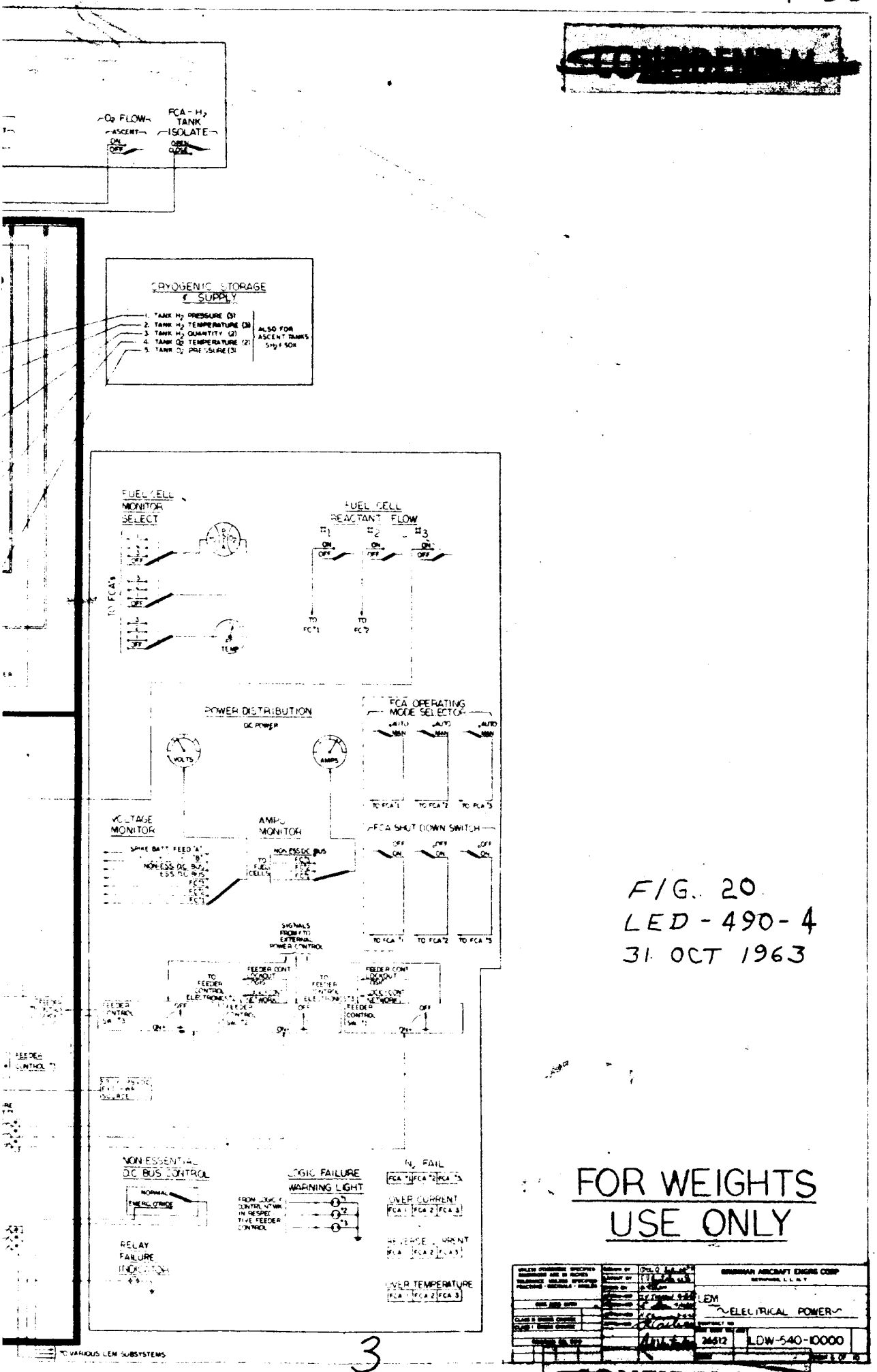


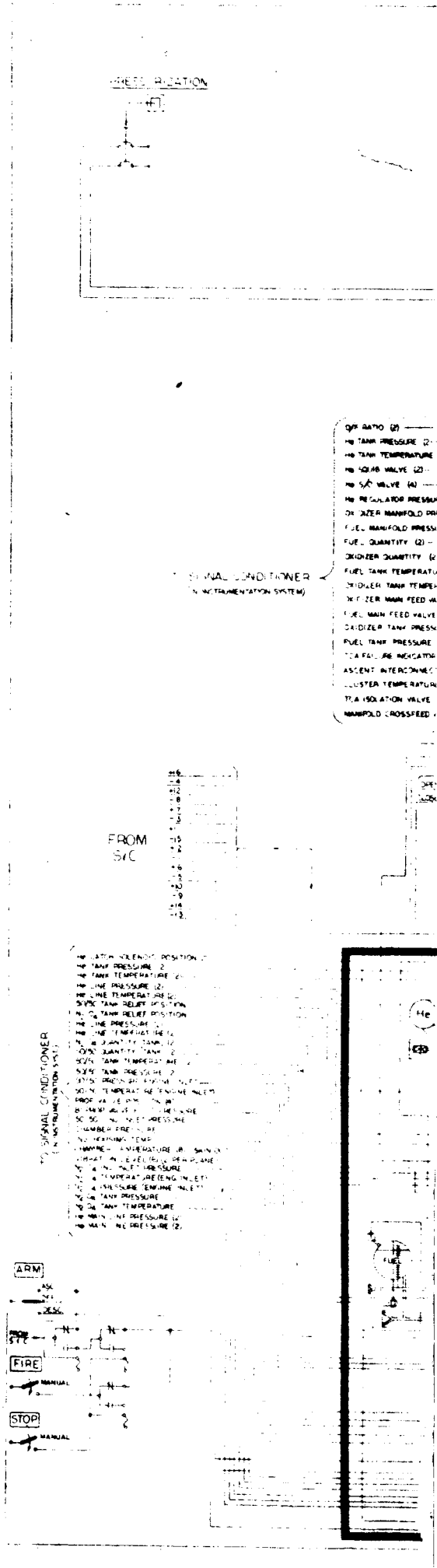
FIG. 20
LED-490-4
31 OCT 1963

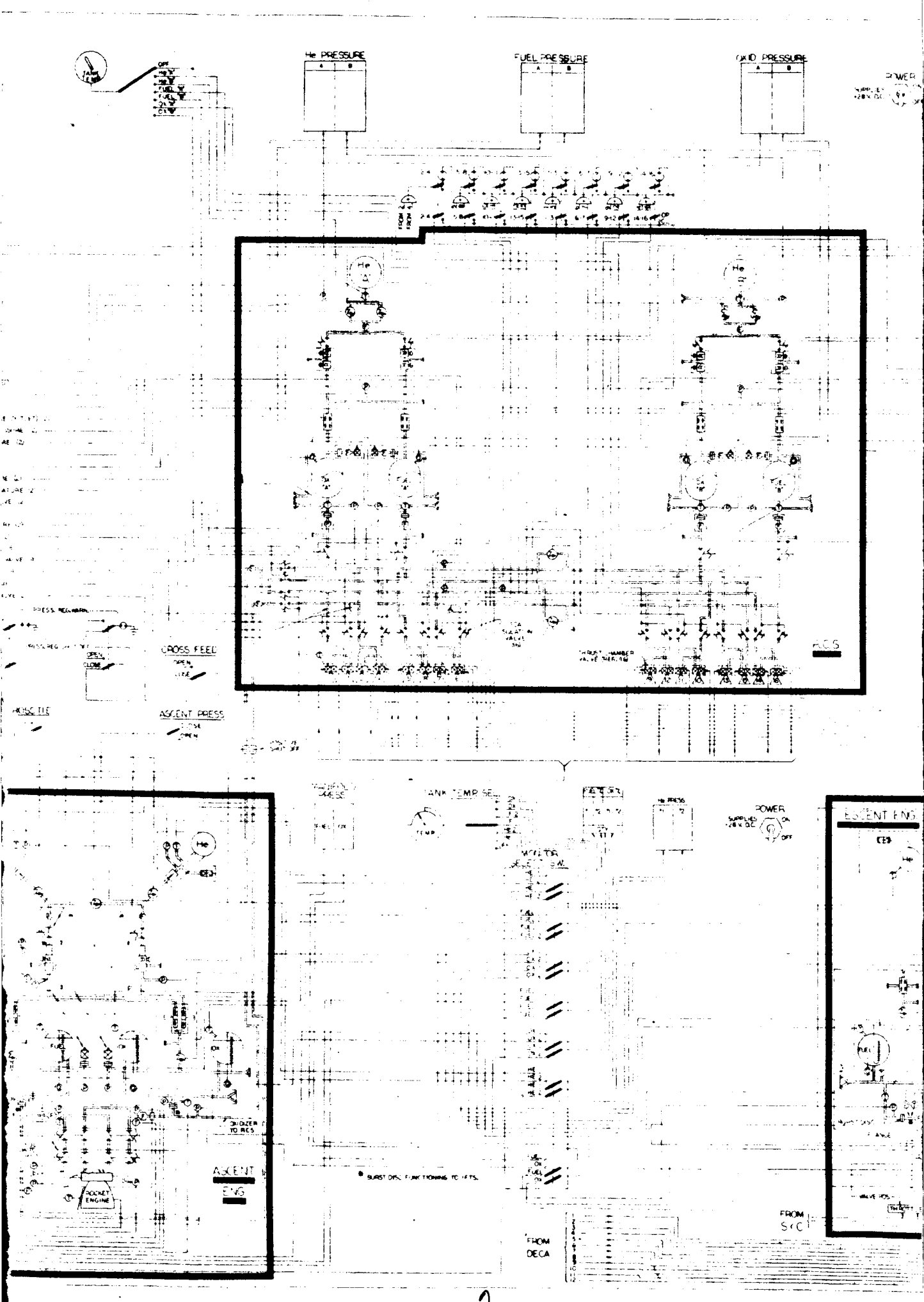
FOR WEIGHTS USE ONLY

		GRUMMAN AIRCRAFT ENGRG CORP BETHPAGE, L.I., N.Y.	
		LEM ELECTRICAL POWER	
		24512	LDW-540-10000

3

[redacted]


FROM
S/C
ARM
FIRE
STOP
MANUAL


He PRESSURE
FUEL PRESSURE
OXID PRESSURE
POWER
CROSS FEED
ASCENT PRESS
RCS
ASCENT ENG
ROCKET ENGINE
TANK TEMP SEL
POWER
FROM DECA
FROM S/C

2

~~CONFIDENTIAL~~

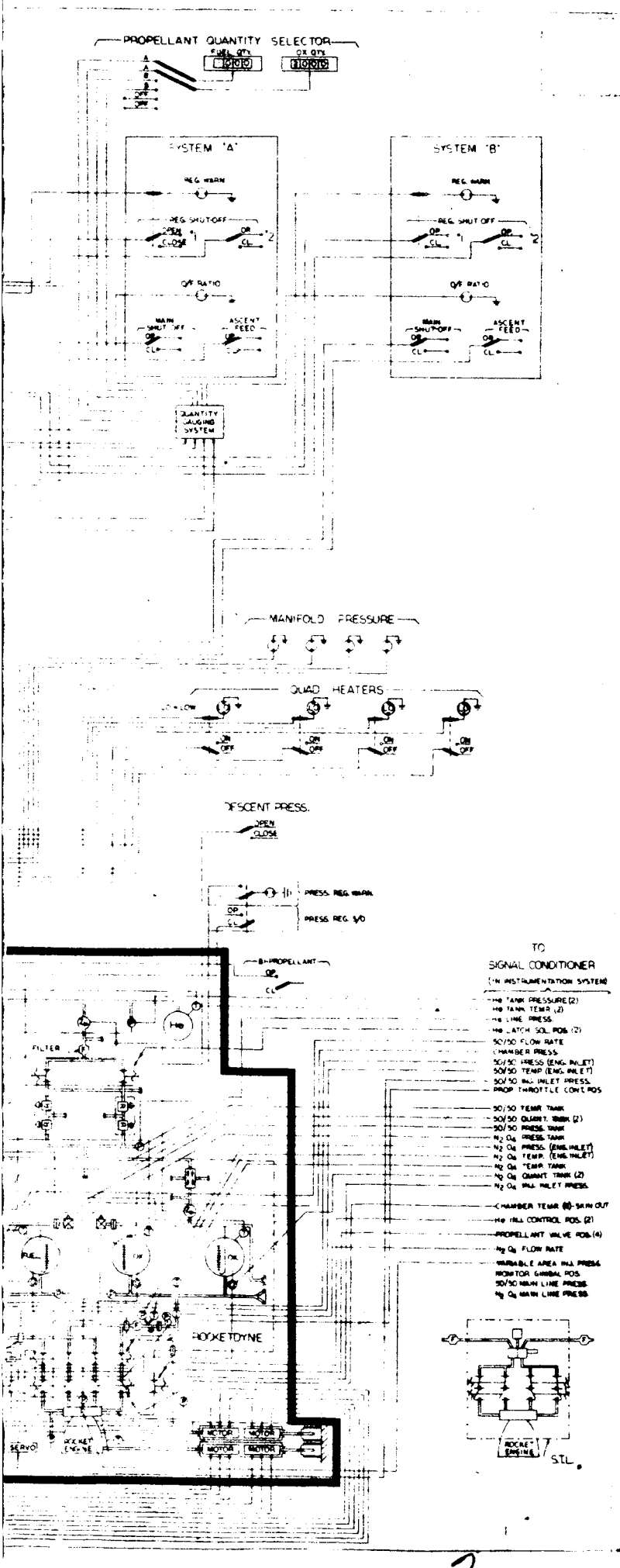


FIG. 21
LED-490-4
31 OCT 1963

FOR WEIGHTS
USE ONLY

DRAWN BY		GRUMMAN AIRCRAFT ENGINE CORP. BETHPAGE, L.I., N.Y.
CHECKED BY		LEM
APPROVED		REACTION CONTROL & PROPULSION
		26612 LDW-540-10000

3

~~CONFIDENTIAL~~