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LM DESCENT/PHASING SUMMARY DOCUMENT

MISSION F

PRELIMINARY

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LM DESCENT/PHASING SUMMARY DOCUMENT

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ABBREVIATIONS

ACA	Attitude Control Assembly (Hand Controller)
AGC	Abort Guidance Computer
AGS	Abort Guidance System
AOT	Alignment Optical Telescope
APS	Ascent Propulsion System
ASC	Ascent
BP	Barber Pole
CB	Circuit Breaker
CDR	Commander
COAS	Crewman Optical Alignment Sight
C&W	Caution and Warning
DAP	Digital Autopilot
DB	Deadband
DEDA	Data Entry and Display Assembly
DES	Descent
DOI	Descent Orbit Injection
DPS	Descent Propulsion System
DSKY	Display and Keyboard
EPS	Electrical Power System
ET	Event Timer
FDAI	Flight Director Attitude Indicator
FOV	Field of View
FPS	Feet Per Second
GET	Ground Elapsed Time
IMU	Inertial Measurement Unit
LGC	LM Guidance Computer
LMP	LM Pilot
LOS	Line of Sight
LR	Landing Radar
LS	Landing Site
MSFN	Manned Spaceflight Network
NM	Nautical Miles
NOR	Normal Operating Range
OHW	Overhead Window
PB	Pushbutton
PGNS	Primary Guidance and Navigation System
PDI	Powered Descent Initiation
RCS	Reaction Control System
ROD	Rate of Descent
RR	Rendezvous Radar
SCHE	Supercritical Helium
SOV	Solenoid Operated Valve
SV	State Vector
SW	Switch
TB	Talkback
TFC	Time From Cutoff

TFI	Time From Ignition
TG	Time to Go
TIG	Time of Ignition
TLM	Telemetry
TM	Tape Meter
TRUN	Trunnion
TTCA	Thrust and Translation Control Assembly
VHF	Very High Frequency
XMTR	Transmitter

1.0 INTRODUCTION

The Descent/Phasing Summary Document has been prepared to document in detail the crew procedures and supporting information to be used in training for the F Mission. The document covers the mission phase from CSM-LM undocking to completion of the phasing burn. The procedures contained herein will become controlled procedures upon final issue.

Comments or questions concerning this document should be directed to C. O. Lewis, Flight Procedures Branch, CF24.

2.0 MISSION SUMMARY

The mission phase within the scope of this document begins with undocking of the LM and CSM approximately three-quarters of a revolution prior to DOI. At the time of undocking, the vehicles are in a 58 nm circular orbit, and LM activation and checkout has been completed except for items which could not be performed while in the docked configuration.

The CSM undocks from the LM and station keeps in close proximity while the LM rotates for a visual inspection by the CSM. Upon completion of the inspection, the LM acquires S-BAND lock-on with MSFN and takes over the station keeping while the CSM prepares for the separation burn. During this period the LGC is updated by MSFN (S/V and DOI targeting) and pad data for DOI and the Phasing Burn is read up.

The CSM performs the separation burn 180° prior to DOI. The burn is 2.5 fps radially down. This burn will put the CSM 11,400 ft in front of the LM at DOI. The LM uses the target ΔV Program to change the CSM S/V in the LGC. After separation, the DOI pre-thrust program is run to verify it is loaded correctly, and a Rendezvous Radar and VHF ranging test is run.

After the LM passes into darkness, the IMU is fine aligned to a landing site REFSMAT. Systems and controls checklists are performed and the AGS is updated, configured to follow the DOI PGNS burn, and aligned to the IMU. The DPS thrust program is called and final preparations for the DOI burn are made.

The DOI burn is a retrograde burn of approximately 70 fps which reduces pericynthian to 50,000 ft. The burn is PGNS controlled, using the external ΔV program. Timing is such that pericynthian will occur 15° prior to reaching the target landing site. The AGS, Rendezvous Radar, and VHF ranging are used to verify that the burn was performed correctly.

The AGS is re-calibrated, Landing Radar turned on and checked out, MSFN reacquired, and pre-burn systems and controls checks made. The powered descent braking program is entered to check the operation of that program in making pre-ignition calculations. It is then exited.

Up to this time, the F Mission has been almost identical to the G Mission profile, but at PDI-10 minutes, the G profile is abandoned and the Phasing Burn targeting is loaded in the LGC. At 3 minutes prior to pericynthian, a pitch rate is established which will have the vehicle 0.0.0 (LV) at pericynthian. Landing

radar readings are taken to assess the radar's high altitude capability, and observations of the landing site are made during the pass.

At 10 minutes prior to the Phasing Burn, the AGS is updated, configured, and aligned to follow-up the burn. The thrust program is entered and final preparations are made. The Phasing Burn occurs 14 minutes past pericynthian and is a posigrade External ΔV burn of approximately 190 fps. The resulting high apogee orbit will put the LM below and behind the CSM on the succeeding revolution so that a lunar landing mission rendezvous can be simulated.

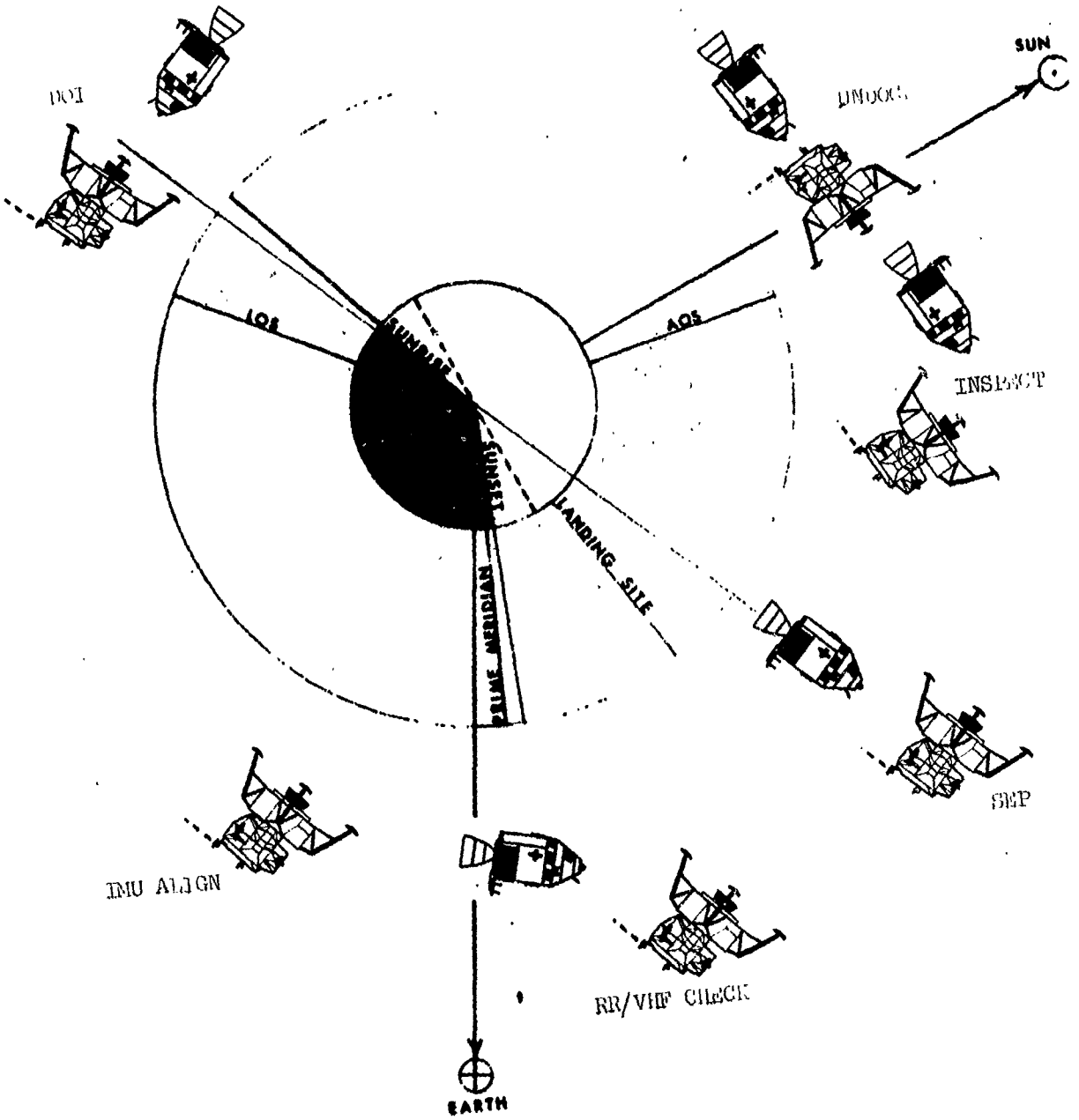
MANEUVER SUMMARY

	UNDOCK	SEPARATION	DOI	PHASING
TIG	98:30	98:55	99:54:12.1	101:06:34.9
PROP SYS	CSM RCS	CSM RCS	LM DPS	LM DPS
CONTROL	MANUAL	PGNS (P41)	PGNS (P40)	PGNS (P40)
ATTITUDE (LV)	POS, HEADS DN	PITCH UP 90°	RET, FACE UP	POS, FACE DN
ΔVX (LV)		0	72.8 AFT	173.1 FWD
ΔVY		0	0	0
ΔVZ		2.5 FPS DN	2.2 DN	86.6 UP
TB		12.5 SEC	27.5 SEC*	42.0 SEC

*ASSUMES THROTTLE UP
TO 40% AT +15 SEC

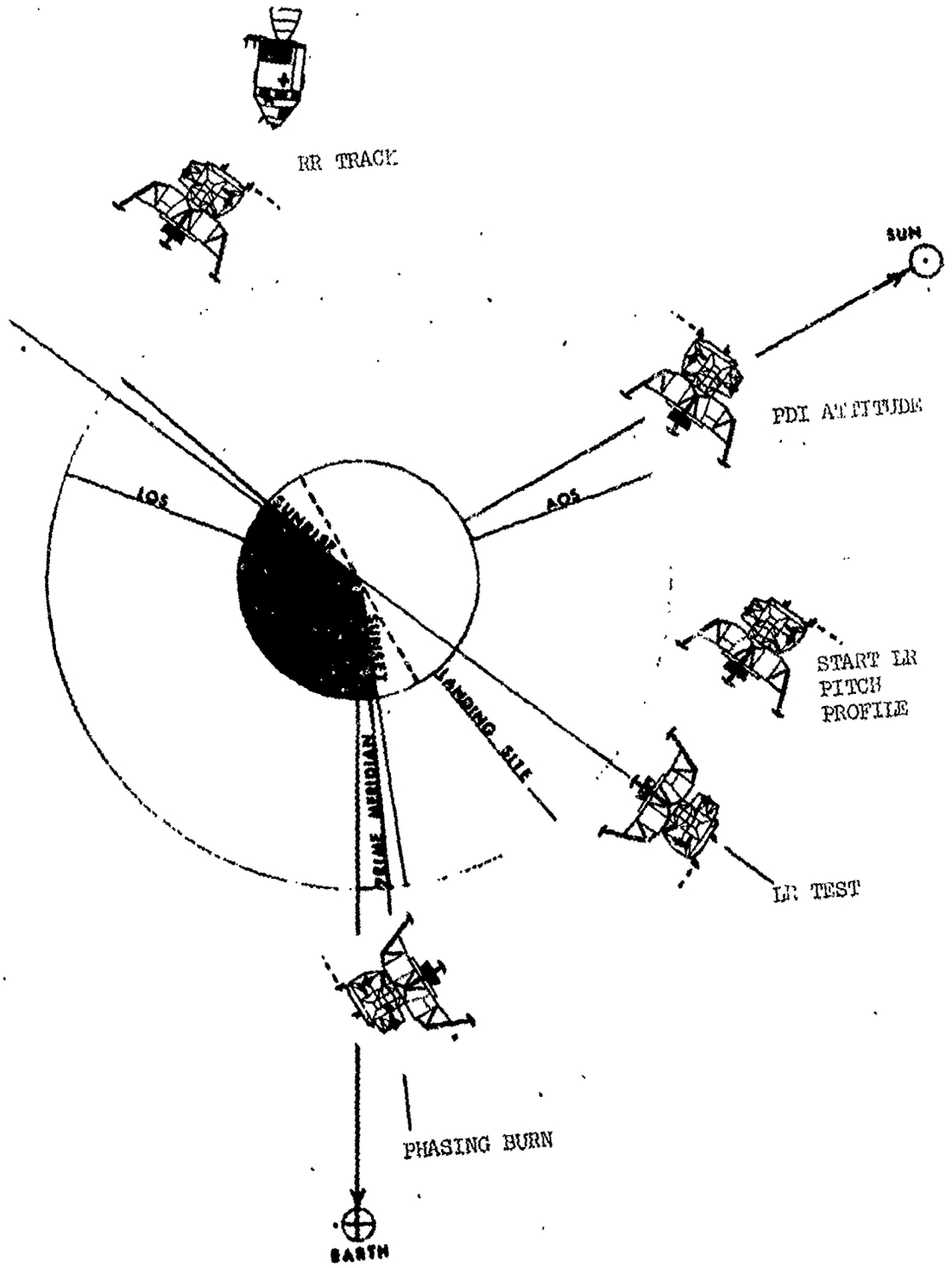
MISSION F

DESCENT/PHASING ATTITUDE PROFILE



MISSION F

DESCENT/PHASING ATTITUDE PROFILE



LM SEQUENCE OF EVENTS

MISSION F

UNDOCKING - PHASING BURN

DOI-85	1.	CSM UNDOCK AND STATION KEEP
	2.	LM YAW RIGHT 120°, PITCH UP 90°, YAW 360° FOR INSPECTION
	3.	ACQUIRE S-BAND WITH MSFN
	4.	LM STATION KEEP UNTIL CSM SEP
	5.	STATE VECTOR AND DOI TARGETING UPDATE (P27)
	6.	COPY DOI AND PHASING BURN PADS
DOI-60	7.	CSM SEP BURN
	8.	UPDATE CSM STATE VECTOR IN LGC (P76)
	9.	VERIFY DOI TARGETING (P30)
	10.	RR/VHF CHECK
	11.	DESIGNATE RR ANTENNA TO CLEAR AOT
DOI-40	12.	ALIGN IMU TO LANDING SITE REFSMMAT (P52)
	13.	CHECK ALIGNMENT
	14.	PERFORM PRE-BURN SYSTEMS CHECK
	15.	SECURE CABIN AND CREW
	16.	CONFIGURE CONTROLS AND DISPLAYS
DOI-10	17.	UPDATE AGS
	18.	CONFIGURE AGS TO FOLLOW DOI BURN
	19.	ALIGN AGS TO IMU
	20.	SWITCH FROM S-BAND TO VHF
	21.	CHECK DAP

DOI-5	22.	ENTER THRUSTING PROGRAM (P40)
DOI	23.	PERFORM DOI BURN
	24.	TRIM RESIDUALS
	25.	POST-BURN SYSTEMS CHECK
	26.	MODE II RR LOCKON (MANUAL)
DOI+10	27.	VERIFY TRAJECTORY WITH RR, VHF
	28.	CALIBRATE AGS GYROS AND ACCELEROMETERS
	29.	POWER UP AND CHECK LANDING RADAR
DOI+30	30.	YAW TO PDI ATTITUDE
	31.	ACQUIRE S-BAND WITH MSFN
	32.	PERFORM PRE-BURN SYSTEMS CHECK
	33.	SECURE CABIN AND CREW
DOI+40	34.	ENTER BRAKING PROGRAM (P63)
	35.	CHECK P63 CALCULATIONS AND EXIT PROGRAM
	36.	CONFIGURE CONTROLS AND DISPLAYS
PDI-10	37.	YAW TO FACE UP
	38.	LOAD PHASING BURN TARGETING (P30)
PDI-3 (PB-17)	39.	START PITCH DOWN PROFILE FOR LR TEST
	40.	LR TEST AND LANDING SITE OBSERVATIONS
PB-10	41.	UPDATE AGS
	42.	CONFIGURE AGS TO FOLLOW PHASING BURN
	43.	ALIGN AGS TO IMU
	44.	CHECK DAP
PB-5	45.	ENTER THRUSTING PROGRAM (P40)
PB	46.	PERFORM PHASING BURN
	47.	TRIM RESIDUALS
	48.	POST-BURN SYSTEMS CHECK

MISSION F LM PROCEDURES (UNDOCKING-PHASING BURN)

ASSUMPTIONS:

A. SYSTEMS CHECKOUT COMPLETE
B. GEAR DOWN
C. LGC IN P00
D. IMU ALIGNED TO L.S. REFSMMAT
E. AGS INITIALIZED, CALIBRATED, ALIGNED TO PGNS
F. RR SELF TESTED
G. LR SELF TESTED, ANTENNA-DESCENT
H. DAP - 21002 GIMBALS TRIMMED
I. CREW SUITED AND RESTRAINED
J. CSM POSIGRADE,-Z VERTICAL DOWN
K. DPS, RCS PRESSURIZED, RCS HOT FIRED
L. CHECKLIST PERFORMED:

MODE CONTROL (PGNS) - ATT HOLD
MODE CONTROL (AGS) - ATT HOLD
ATTITUDE CONTROL (R,P,Y) - PULSE
KEY V77E
DEADBAND - MAX
GUID CONT- AGS
RATE/ERR MON - LDG RDR/CMPTR
RATE SCALE - 5°/SEC
X-TRANSL - 2 JET
BAL CPL - ON
ACA/4 JET (BOTH) - ENABLE
THROTTLE/JETS (BOTH) - JETS
TTCA/TRANSL (BOTH) - ENABLE
CB/HEATERS: AOT - CLOSE

98:45 CSM UNDOCKS

YAW RIGHT 120°
PITCH UP 90° (CSM IN FWD WDW)
YAW 360° FOR INSPECTION
ACA OUT OF DETENT ALL AXIS
ATTITUDE CONTROL (R,P,Y) - MODE CONT

KEY V64E (S-BAND ANT ANGLES)
F 16 51 XXX.XX P XXX.XX Y
ACQUIRE S-BAND LOCK-ON
VERIFY VOICE, TLM

VHF B/XMTR - OFF
TELEMETRY PCM - HI
PRO

DSKY B LM STA KEEP UNTIL SEP

UPDATA LINK - DATA
KEY V21 N01E
KEY 00045E
F 21 01 00000 (Inlink Center Clear)
KEY V37E 00E
P27 (S/V UPDATE, DOI TARGETING)
UPDATA LINK - OFF

COPY PAD

(DOI) TIG ___ : __ : ____
(99: 54:12.1)

ΔVX ____ ΔVY ____ ΔVZ ____
( ) ( ) ( )

R ____ P ____ Y ____
(0) (285) (0)

CHECK STAR _____

ΔTB _____
( )

(PHAS)TIG ___ : __ : ___

ΔVX ___ ΔVY ___ ΔVZ ___
( ) ( ) ( )

R ___ P ___ Y ___
( ) ( ) ( )

ΔTB _____
( )

99:10 CSM SEP (2.5 FPS DOWN)

KEY V37E 76E (TARGET ΔV)
F 06 84 ΔVX ΔVY ΔVZ (SEP ΔV)
PRO
F 06 33 HRS, MIN, SEC (TIG OF SEP)
PRO

KEY V37E 30E (DOI)
F 06 33 TIG (HR,MIN,.01 SEC)
PRO
F 06 81 (-)ΔVX ΔVY ΔVZ (.1 fps)
PRO
F 06 42 60.0 nm APO, 8.3 nm PER, XXXX.X FPS ΔVT
PRO
F 16 45 RR MARKS, TFI, MGA
RESET ET
PRO
POO

-55:00 CSM TRANSPONDER ON, TRACKING ATT
TEMP MON SEL - RNDZ RADAR (10-150°F)
RADAR TEST - OFF
CB/PGNS: SIGN STR DISP - CLOSE
TEST MON - AGC
RR MODE - SLEW
RATE/ERR MON - RNDZ RADAR
RNG/ALT MON - RNG/RNG RT
SLEW RATE - HI
CB/AC BUS A: RNDZ RDR - CLOSE
CB/PGNS: RNDZ RDR - CLOSE
GUID CONT - PGNS
MANEUVER TO POINT +Z AT CSM
SLEW ANT TO 0,0
SLEW RATE - LO
PEAK AGC
RR MODE - AUTO TRACK
NO TRACK LITE - OUT
COMPARE R/R DOT WITH CSM VHF
GUID CONT - AGS

RR MODE - LGC
KEY V41 N72E (RR DESIGNATE)
F 21 73 +00000 TRUN +283.00 SHFT
PRO
04 06 00006 00002 (CONT DESIGNATE)
PRO

41 KEY V16 N72E
16 72 MONITOR TRUN AND SHFT ANGLES
KEY V44E (TERMINATE)
CB/PGNS: RNDZ RDR - OPEN
CB/AC BUS A: RNDZ RDR - OPEN

-40 CB/AC BUS A: AOT LAMP - CLOSE
AOT DETENT -F
KEY V37E 52E (ALIGN IMU)
F 04 06 00001 00003 (REFSMMAT)
PRO
F 50 25 00015 (ACQUIRE STAR #1)
GUID CONT - PGNS
MANEUVER FOR 2 STARS IN FOV
PRO
F 01 70 002XX LOAD STAR #1
PRO
F 50 18 R,P,Y ANGLES (.01°)
MODE CONTROL - AUTO
PRO
06 18
F 50 18 PLEASE TRIM
MODE CONTROL - ATT HOLD
ENTR (TRIM NOT REQ'D)
F 01 71 002XX
PRO
F 54 71 MARK X OR Y
KEY V76E (PULSE)
MARK 5 PAIR X,Y
PRO
F 01 70 002XX LOAD STAR #2
PRO
F 50 18 R,P,Y ANGLES
MODE CONTROL - AUTO
PRO
06 18
50 18 PLEASE TRIM
MODE CONTROL - ATT HOLD
ENTR (TRIM NOT REQ'D)
F 01 71 002XX
PRO
F 54 71 MARK X OR Y
MARK 5 PAIR X,Y
PRO

```
F 06 05   STAR ANGLE DIFF (.01°)
          REJECT: KEY V32E (RECYCLE TO R51)
          ACCEPT: PRO
F 06 93   X,Y,Z GYRO TORQUING ANGLES (.001°)
          PRO
F 50 25   00014 PLEASE FINE ALIGN
          PRO (CHECK ALIGNMENT)
F 50 25   00015 ACQUIRE STAR
          PRO
F 01 70   002XX LOAD CHECK STAR
          PRO
F 50 18   R, P, Y  FDAI ANGLES
          MODE CONTROL-AUTO
          PRO
  06 18
F 50 18
          ENTR
          OBSERVE CHECK STAR IN AOT
          REJECT: REPEAT ALIGNMENT
               ACCEPT: KEY V34E
          MODE CONTROL-ATT HOLD
          POO
          KEY V77E
          GUID CONT - AGS
          CB/AC BUS A: AOT LAMP - OPEN
          AOT DETENT - CL

-20       SYSTEM CHECK:
               PROPULSION SYS: TEMPS/PRESS -NOR
               DES REG: TB's - 1/BP 2/GRAY
               ASC REG: TB's (2) - GRAY
               RCS QUADS: TB's (8) - GRAY
               MAIN SOV: TB's (2) - GRAY
               CRSFD: TB - BP
               ASC FEED: TB's (4) - BP
               ECS SYS: TEMPS/PRESS - NOR
               ASC BATS: NORMAL sw (2) - ON
               CB/EPS: BAL LOADS (2) - OPEN
               CB/INST: CWEA - OPEN THEN CLOSE
               EPS SYS: VOLTS/AMPS - NOR
```

```
          SECURE CABIN AND CREW
          CONTROLS CHECK:
               ATT MON - PGNS (CDR) AGS (LMP)
               HEL MON - SUPCRIT PRESS
               THR CONT - AUTO
               MAN THROT - CDR
               DEAD BAND - MIN
               ACA/4 JET (CDR) - ENABLE
               THROTTLE/JETS (CDR) - THROTTLE (10%)
               TTCA/TRANSL (BOTH) - ENABLE
               DES ENG CMD OVRD - OFF
               ENG STOP PB (BOTH) - RESET
               ABORT/ABORT STAGE PB's - RESET
               RCS TEMP/PRESS MON-HE
               POWER/TEMP MON - CDR BUS
               BAL CPS - ON

-10            KEY V47E (AGS UPDATE)
  F 06 16      90:00:00 AGS CLOCKZERO
               *414+1E
               PRO
               *414 R (00000)
  F 50 16      UPDATE COMPLETE
               PRO
               KEY V83E
  F 06 54      R/R DOT/THETA (.01nm,.1fps,.01°)
               *317 R (RANGE .1 nm) COMPARE
               PRO

               *623+0 E              X-AXIS
               *410+5 E              EXT ΔV
               *411+0 E              DPS
               *407+0 E
               *450-00XX.X E         ΔVX
               *451+00000  E         ΔVY
               *452+00000  E         ΔVZ

               *400+3      E         ALIGN
               *400 R (00000)
               *400+1      E         GUID STEER
               *500 R                VG
```

(AT LOS)
TELEMETRY PCM-LO
VHF B/XMTR - DATA
TRACK MODE - OFF

KEY V48E (DAP)
F 01 46 21002
PRO
F 06 47 LM WT, CSM WT _____ _____
PRO
F 06 48 XXX.XX P XXX.XX R _____ _____
REJECT: ENG GMBL-ENABLE,MODE CONTROL-AUTO
ENG ARM-DES,LOAD AND PRO
ACCEPT: KEY V34E

-5 KEY V37E 40E (DPS THRUSTING)
F 50 18 R,P,Y BURN ATTITUDE (.01°)
MODE CONTROL (PGNS,AGS) - AUTO
PRO
06 18
F 50 18 PLEASE TRIM

ADJUST YAW TO FACE UP
PRO (TRIM)
06 18
F 50 18

OBSERVE CHECK STAR
AGS ATTITUDE ERRORS ZERO
ENTR (NO FURTHER TRIM)
06 40 TFI, VG, ΔVM
-:35 DSKY B
MASTER ARM - ON
PRPLNT QTY MON - DES 1
ENG GMBL - ENABLE
THROTTLE - MIN
ENG ARM - DES
-:07 ULLAGE START (AUTO)
F 99 40 ENABLE IGNITION
PRO
06 40
00:00 ENGINE START, START ET COUNTING UP

+:15 THROTTLE (CDR) - SET TO 40%

ENGINE CUTOFF, ENG STOP PB - PUSH
F 16 40
ENG ARM - OFF
ENG GMBL - OFF
MASTER ARM - OFF
PRPLNT QTY MON - OFF
PRO
F 16 85 VGX VGY VGZ (.1 fps)
NULL VGX
PGNS: _____ VGX _____ VGY _____ VGZ
*AGS: _____ VGX _____ VGY _____ VGZ
500 501 502
TRANSMIT ΔV INFORMATION TO CSM
KEY V82E
F 16 44 APO ALT _____ PER ALT _____ TFF _____
*403 R _____ PER ALT
PRO
POO
*400+0 E (ATT HOLD)
MODE CONTROL (BOTH) - ATT HOLD

SYSTEMS CHECK:
PROPULSION SYS: TEMPS/PRESS-NOR
ASC BATS: NORMAL (2)-OFF/RESET
CB/EPS: CROSS TIE BAL LOADS (2) - CLOSE

EXTERIOR LTG - TRACK (OFF AFTER PITCH)
CSM TRANSPONDER ON, TRACK ATT & LITE
KEY V89E (RNDZ FINAL ATT)
F 04 12 00003 00002 (X-AXIS)
PRO
F 06 18 R,P,Y ANGLES (.01°)
PRO
F 50 18 R,P,Y ANGLES
MODE CONTROL (PGNS) - AUTO
PRO
06 18

F 50 18

ENTR
MODE CONTROL-ATT HOLD
CB/AC BUS A: RNDZ RDR - CLOSE
CB/PGNS: RNDZ RDR - CLOSE
RR MODE - LGC
KEY V41 N72E

F 21 73 +180.00 TRUN +090.00 SHFT
PRO

F 04 06 00006 00002
PRO

41

KEY V16 N72E, MONITOR DRIVE
KEY V44E (TERMINATE DESIG)
PERFORM MANUAL LOCK-ON

+10 TAKE RANGE READINGS:

	RR	CSM	NOM	
DOI +10	_____	_____	50000	FT
15	_____	_____	67000	
20	_____	_____	88000	
25	_____	_____	120000	

+13 GUID CONT - PGNS/PULSE
(MAINTAIN ZERO RATES DURING CALIB)
*400+6 E
*400 R (00000)
GUID CONT -AGS

*540	_____	544	_____
541	_____	545	_____
542	_____	546	_____

+25 CB/PGNS: LDG RDR - CLOSE
TEST MON - VEL XMTR (>2.9v)
TEST MON - ALT XMTR (>2.9v)
RNG ALT MON - ALT/ALT RT
X-POINTER SCALE - HI MULT
MODE SEL - LDG RADAR
RADAR TEST - LDG
H = _____ to _____ FT
HDOT= _____ to _____ FPS

TEST MON - VEL XMTR (X-POINTER UP/RT)
KEY V16 N66E

F 16 66 08300 FT RANGE 00002 ANT POS
REJECT: LDG ANT - AUTO, KEY V61E,
WAIT 22 SEC, KEY V16 N66
ACCEPT: KEY P00
RADAR TEST - OFF

+30 YAW 180° (FACE DOWN)
MAIN RR LOCK
KEY V78E (LR READ)

KEY V64E

F 16 51 S-BAND PITCH, YAW (.01°)
ACQUIRE S-BAND LOCK-ON
VERIFY VOICE, TLM
VHF B/XMTR - OFF
TELEMETRY PCM - HI
PRO

DSKY B

SYSTEMS CHECK:
PROPULSION SYS: TEMPS/PRESS - NOR
DES REG: TB's - 1/BP 2/GRAY
ASC REG: TB's (2) - GRAY
MAIN SOV: TB's (2) - GRAY
CRSFD: TB - BP
ASC FEED: TB's (4) - BP
ECS SYS: TEMPS/PRESS -NOR
ASC BATS: NORMAL sw (2) - ON
CB/EPS: BAL LOADS (2) - OPEN
CB/INST: CWEA - OPEN THEN CLOSE
EPS SYS: VOLTS/AMPS - NOR
SECURE CABIN AND CREW

+40 KEY V37E 63E (BRAKING)

F 06 61 TGO _____, TFI, CR _____ NM
RESET ET
PRO

F 50 25 00014 FINE ALIGN
ENTR (BYPASS ALIGNMENT)

F 50 18 R_____ P_____ Y_____
MANUAL TRIM TO PDI ATTITUDE
KEY V34E
KEY V25 N07E

F 25 07 102,200,0 (RESETS MUNFLAG)

CONTROLS CHECK:
ATT MON - PGNS (CDR) AGS (LMP)
HEL MON - SUPCRIT PRESS
THR CONT - AUTO
MAN THROT - CDR
DEAD BAND -MIN
THROTTLE/JETS (CDR) - THROTTLE (10%)
DES ENG CMD OVRD - OFF
ENG STOP PB (BOTH) - RESET
ABORT/ABORT STAGE PB's - RESET
RCS TEMP/PRESS MON - HE
POWER/TEMP MON - CDR BUS
BAL CPL - ON

PDI-10 YAW RIGHT 180° (FACE UP)
(PB-24)

KEY V37E 30E (PHASING BURN)
F 06 33 : : TIG
PRO
F 06 81 ΔVX ΔVY ΔVZ
PRO
F 06 42 XXXX.XHA XXXX.XHP ΔVT
( ) ( )

PRO
F 16 45 RR MARKS, TFI, MGA
PRO
RESET ET
CB/AC BUS A: RNDZ RDR - OPEN
CB/PGNS: RNDZ RDR - OPEN

GUID CONT - PGNS
KEY V76E

PB-17 BEGIN 0.5°/SEC PITCH DOWN
(PDI-3)

LR DATA
LANDING SITE OBSERVATIONS

PB-10 KEY V77E (STOP PITCH RATE)

KEY V47E (AGS UPDATE)
F 06 16 90:00:00 AGS CLOCK ZERO
*414 +1E
PRO
414 R (00000)
F 50 16 UPDATE COMPLETE
PRO
KEY V83E
F 06 54 R/R DOT/THETA (RANGE .01 nm)
*317 R (RANGE 0.1 nm) COMPARE
PRO

*623+0	E	X-AXIS
*410+5	E	EXT ΔV
*411+0	E	DPS
*407+0	E	
*450+0XXX.X	E	ΔVX
*451+00000	E	ΔVY
*452+00000	E	ΔVZ
*400+3	E	ALIGN
*400 R (00000)		
*400+1	E	GUID STEER
*500 R		VG

KEY V48E (DAP)
F 01 46 21002
PRO
F 06 47 _____LM WT, CSM WT
PRO
F 06 48 XXX.XXP XXX.XXR
KEY V34E (DO NOT TRIM)

PB-5 KEY V37E 40E (DPS THRUST)
F 50 18 XXX.XX R XXX.XX P XXX.XX Y
MODE CONT (PGNS,AGS)-AUTO
PRO
06 18
F 50 18 VERIFY ATT THRU OHW _____°
AGS ATT ERRORS ZERO
ENTR
06 40 TFI, VG, ΔVM

-:35 DSKY B
PRPLNT QTY MON - DES 1
ENG GMBL - ENABLE
THROTTLE - MIN
ENG ARM - DES
-:07 ULLAGE START (AUTO)
F 99 40 ENABLE IGNITION
PRO
06 40
-:00 ENGINE START, START ET COUNTING UP
ENGINE CUTOFF, ENG STOP PB - PUSH
F 16 40
ENG ARM - OFF
ENG GMBL - OFF
PRPLNT QTY MON - OFF
PRO
F 16 85 VGX VGY VGZ (.1 fps)
NULL RESIDUALS
*500 R _____ VGX
*501 R _____ VGY
*502 R _____ VGZ

TRANSMIT ΔV's To CSM
KEY V82E
F 16 44 APO ALT _____ PER ALT _____ TFF _____
PRO
POO
*400+0 E (ATT HOLD)
MODE CONTROL (BOTH) - ATT HOLD

SYSTEMS CHECK:
PROPULSION SYS: TEMPS/PRESS -NOR
ASC BATS: NORMAL (2)- OFF/RESET
CB/EPS: CROSS TIE BAL LOADS (2) - CLOSE
CB/PGNS: LDG RDR - OFF

RENDEZVOUS
PROCEDURES

APPENDIX A - VEHICLE OPERATIONS

A. SWITCH DESCRIPTIONS

GUID CONT sw

This switch selects either PGNS or AGS for guidance and control of the LM.

PGNS - Enables the ACA and TTCA, proportional rate command inputs to the LGC, engine ON-OFF signals and gimbal trim commands, translation ON-OFF commands, the primary preamps of the ATCA, and sends the follow-up signal to the AEA.

AGS - Enables the ACA and TTCA, proportional rate commands to the ATCA, gimbal trim commands, the abort preamps of the ATCA, and removes the follow up signal.

MODE SEL sw

LDG RADAR - Landing radar altitude and altitude rate are displayed on the tapemeter and FWD and LAT velocity is displayed on the X-POINTER.

PGNS - LGC computed altitude and altitude rate are displayed on the tapemeter and FWD and LAT velocity is displayed on the X-POINTER.

AGS - AEA computed altitude, altitude rate, and LAT velocity are displayed.

RNG/ALT MON sw

RNG/RNG RT - RR range and range rate data is displayed on the tapemeter.

ALT/ALT RT - Altitude and altitude rate data, from the system selected by the MODE SEL sw, is displayed on the tapemeter.

RATE/ERR MON sw

This switch selects the input for the X-POINTER and FDAI error needle displays.

RNDZ RADAR	-	RR shaft and trunnion angles are displayed on the error needles and LOS rates are displayed on the X-POINTER.
LDG RDR/CMPTR	-	Attitude errors (PGNS/AGS) are displayed on the error needles and FWD and LAT velocity (PGNS/LR) on the X-POINTER. (When AGS is selected only LAT velocity is displayed).

ATTITUDE MON sw

PGNS	-	PGNS total attitude and attitude errors are displayed on the FDAI.
AGS	-	AGS total attitude and attitude errors are displayed on the FDAI.

SHFT/TRUN $\frac{1}{2}$ sw

This switch selects the scaling for the FDAI error needles when RR shaft and trunnion angles are displayed.

50 DEG	-	Full deflection of the error needles indicates shaft and trunnion angles of 50 DEG.
5 DEG	-	Full deflection indicates angles of 5 DEG.

RATE SCALE sw

25 DEG/SEC	-	Full deflection of the rate needles is 25 DEG/SEC.
5 DEG/SEC	-	Full deflection of the rate needles is 5 DEG/SEC.

ACA PROP sw

This switch allows the crewman to remove power from the ACA transducer primary coils, disabling proportional rate commands. The switch will be used to isolate ACA malfunctions. The direct and hardover modes are still available when disabled.

ENABLE	-	ACA operates normally.
DISABLE	-	Removes 28-volt, 800-cps power from the transducer primary coils.

THR CONT sw

AUTO	-	LGC thrust commands are summed with manual commands from the TTCA for DPS throttle control. Normally the TTCA is in the minimum position (10%) in this mode. LGC commands, plus a 10% bias, are displayed on the CMD side of the thrust indicator.
MAN	-	Manual commands control the DPS throttle and are displayed on the thrust indicator.

MAN THROT sw

This switch selects the TTCA (CDR/SE) which controls the DPS thrust level. (Assuming the THROTTLE-JETS lever is set to THROTTLE)

CDR	-	Enables the CDR's TTCA.
SE	-	Enables the pilots TTCA.

ENG ARM sw

This switch provides arming signals to the APS or DPS while signaling the LGC that the engine is armed. Without the engine arm signal neither engine will fire. The appropriate engine will be armed when the ABORT or ABORT STAGE switches are depressed, regardless of the position of this switch.

ASC	-	The ASC engine is armed.

OFF	-	The arming signals are removed; therefore, this position can be used as a backup means to engine shutdown.
DES	-	The DES engine is armed.

X-TRANSL sw

4 JETS	-	Provides four jets for AGS X-axis translation maneuvers.
2 JETS	-	Provides two jets for AGS X-axis translation maneuvers.

BAL CPL sw

This switch, effective only with AGS, selects either balanced pairs of x-axis RCS jets in a couple or unbalanced x-axis RCS jets for use in maintaining pitch and roll attitude during thrust phases.

ON	-	Enables the four up-firing jets for AGS controlled maneuvers. The switch should be in this position when maximum stabilization and control is required.
OFF	-	Disables the up-firing x-axis jets. The switch will be positioned to OFF to prevent RCS jet firings opposing the direction of motion during powered phases - assuming adequate stability and control can be maintained by the down-firing jets.

ENG GMBL sw

This switch enables or disables pitch and roll DPS gimbal trim commands from the LGC or ATCA. The switch must be placed to ENABLE and the engine must be armed to accomplish the trim function prior to and during a burn. If the ENG GMBL light illuminates during a burn and/or the RCS fuel consumption is excessive the switch should be thrown to OFF.

ENABLE	-	Pitch and roll gimbal trim commands are enabled.

OFF	-	Power is removed from the actuators and the gimbal malfunction logic is reset. The actuators "lock up" in the last commanded position.

DES ENG CMD OVRD sw

The switch applies redundant power to the descent engine bi-propellant valves to prevent inadvertent engine shutdown during a critical mission phase. During powered descent, the switch will be ON immediately after ignition and will remain ON until after the landing. The circuit is interrupted by the ABORT STAGE button and the engine STOP button.

ON	-	Redundant 28 vdc power is applied to the descent engine valves.
OFF	-	Removes 28 vdc from the bi-prop valves.

LDG ANT sw

The switch controls the position of the landing radar antenna.

AUTO	-	The LGC automatically positions the LR antenna as a function of mission phase.
DES	-	The antenna x-axis is driven to a position 24 DEG from the LM body x-axis. The Y and Z antenna axes are 6 DEG from the respective body axes. This is the antenna position during the braking phase of powered descent.
HOVER	-	The antenna x-axis is aligned with the body x-axis and the Y and Z axes are 6 DEG from the respective body axes. This is the antenna position during the approach and landing phases.

DEADBAND sw

MAX	-	A 5 DEG attitude deadband is provided under AGS control. FDAI attitude error needle scaling is 14.4 DEG.
MIN	-	A 0.3 DEG attitude deadband is provided under AGS control. FDAI error needle scaling is 1.7 DEG.

ACA/4 JET sw

The switches allow the crew to disable the hardover mode of the ACA in the event of a short or jammed hand controller. All other ACA modes remain operative.

ENABLE	-	Normal ACA operation.
DISABLE	-	Interrupts the 28 vdc to the secondary RCS coils.

TTCA/TRANSL sw

The switches allow the crew to disable the translation control function of the TTCA in the event of a short or jammed controller. The throttling function of the controller remains operative.

ENABLE	-	Normal TTCA operation.
DISABLE	-	Interrupts $\pm$ 15 vdc to the primary RCS coils.

LUNAR CONTACT LIGHT

The lights are illuminated when the lunar surface sensing probes touch the surface, actuating mechanical switches. If serves as the signal for manual engine shutdown prior to lunar impact. The light is blue and extinguishes when the STOP PB is depressed.

T/W INDICATOR

The indicator displays instantaneous x-axis acceleration in lunar g units. It provides a gross check on engine (APS/DPS) performance.

MASTER ALARM LIGHTS

The lights alert the flight crew to critical subsystem malfunctions. Upon receipt of the signal, the crew should reset the light and refer to the caution and warning panel. Depression of either switch will extinguish both lights and terminate the audible tone.

ABORT PUSH BUTTON sw

The switch should be actuated when an abort from powered descent, using the descent engine is desired. The switch activation arms the descent engine and signals the LGC and AEA to compute and execute the abort trajectory. The AGS will not issue automatic engine ON/OFF commands unless this switch is depressed. It is reset by depressing it a second time.

ABORT STAGE PB sw

The switch should be actuated when an abort staging sequence, with ascent engine ignition is desired. The switch activation will cause the following events to occur:

1. The "Abort Stage" discrete is sent to the LGC and AEA.
2. The "Abort Stage" delay is initiated (500 ms).
3. The DPS is shutdown.
4. The APS is pressurized - should be completed in 400 ms.
5. Power is transferred from descent to ascent batteries.
6. At the termination of the delay, the selected guidance system issues an engine ON command.
7. A "stage" command is sent to the electro-explosive devices.

If the Abort Stage sequence is initiated in coasting flight an ullage burn will be required. This switch interrupts the redundant 28 vdc to the DPS engine valves.

ENGINE STOP sw (2)

The pushbutton switches separately interrupt the "ON" signal to the ascent and descent engines independent of the position of the ENG ARM switch. The STOP PB is the primary means of terminating thrust at lunar landing and should be used to back-up engine shutdown for automatic thrusting maneuvers. When actuated the latching PB illuminates red and is reset

by a second depression. If it cannot be reset the APS can still be started and the Abort Stage function can be utilized with a manual engine start. The switch activation interrupts the redundant 28 vdc to the DPS engine valves.

ENGINE START sw

This PB momentary contact switch provides the crew with the capability to immediately fire the DPS or APS, depending on the position of the ENG ARM sw. The START sw energizes a latching relay which provides a continuous engine ON command and a RED light to indicate the relay is energized. Activation of either STOP sw resets the latching relay, interrupts the ON signal and extinguishes the light.

+ X TRANSL sw

This PB switch applies 28 vdc to the secondary RCS coils providing 4-jet translation in +X direction. It is the primary means of providing ullage for manual APS/DPS burns. The switch is momentary contact and the signal is removed from the coils when the button is released. If the switch fails closed the ATT DIR CONT cb must be opened.

DES RATE sw

This switch can be used to control the rate of descent of the LM, in a semi-manual mode during powered descent. The vehicle must be under PGNS control in the attitude hold mode. Vehicle attitude is controlled by the crewman and the DPS throttle by the LGC. Each switch actuation provides a discrete pulse, changing the rate of descent by 1 fps. Upward deflections of the switch decrease the descent rate and downward deflections increase it.

B. CONTROL MODES/SWITCHES

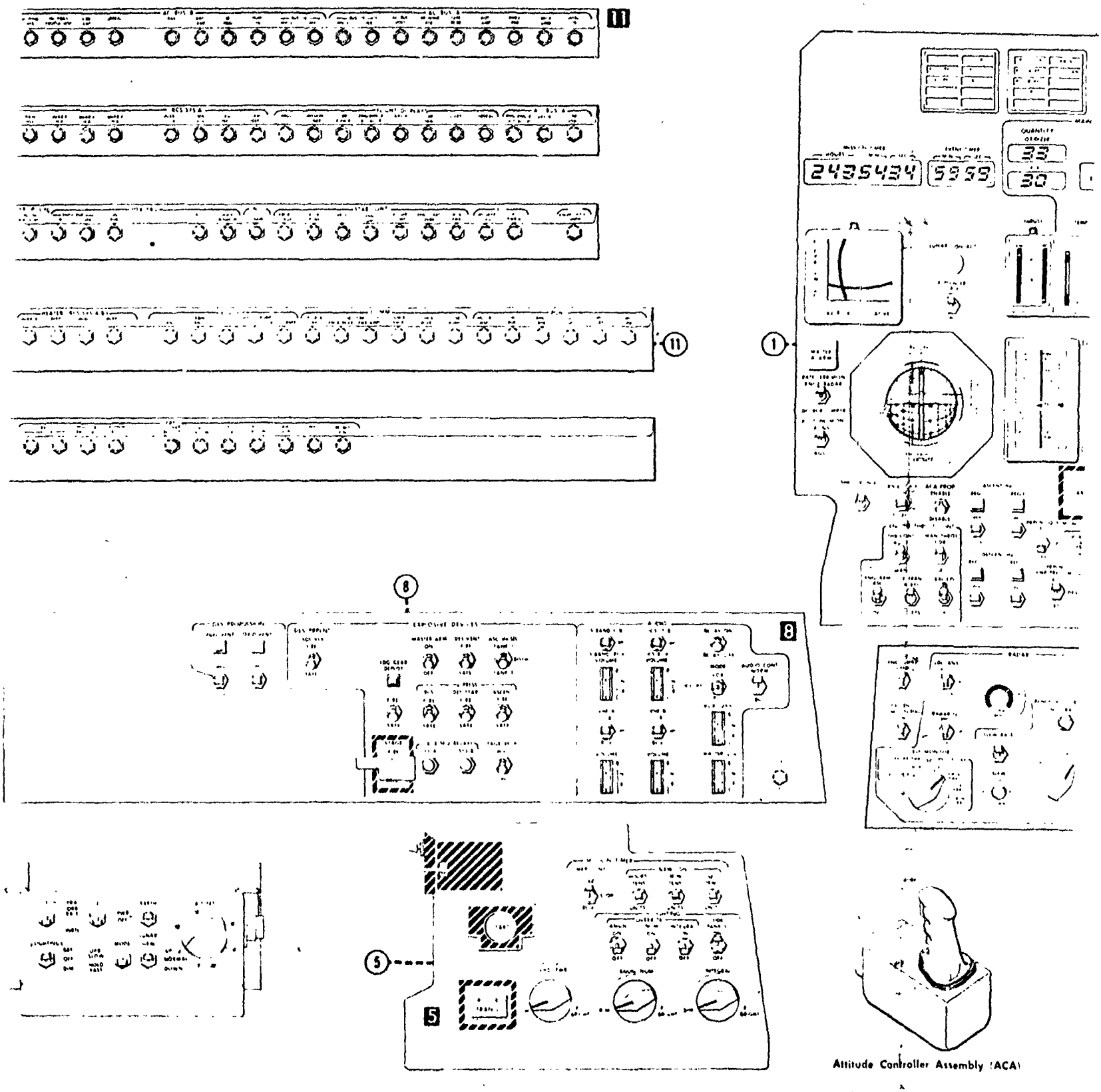
GUID CONT sw	MODE CONT sw's	ATT CONT (selectable per axis)	REMARKS
PGNS	AUTO	MODE CONT	This is the switch configuration for all automatic PGNS maneuvers. Rate compensated steering errors are generated in the DAP and ON/OFF commands are sent to the jet drivers for vehicle control. The crew can

CONTROL MODES/SWITCHES

GUID CONT sw	MODE CONT sw's	ATT CONT (selectable per axis)	REMARKS
			control vehicle yaw attitude in a proportional rate command - attitude hold mode unless there is a program inhibit present.
PGNS	AUTO	PULSE	This position is inoperative. Vehicle control remains automatic.
PGNS	AUTO	DIRECT	A displaced ACA will fire pairs of jets, but since vehicle control is still automatic, the jet firing will conflict with the automatic steering commands.
PGNS	ATT HOLD	MODE CONT	If the extended verb V77 is selected, this is a manual proportional rate command mode. When the hand controller is returned to detent the DAP removes the vehicle rates and reverts to attitude hold. If V76 is selected, this is a minimum impulse mode with a single 14ms jet firing each time the hand controller is moved beyond the pulse/direct switches of the ACA. If no commands, are present the vehicle will drift freely.
PGNS	ATT HOLD	PULSE	Same as AUTO-PULSE.
PGNS	ATT HOLD	DIRECT	Same as AUTO-DIRECT.
PGNS	OFF	MODE CONT, PULSE OR DIRECT	Power is removed from the primary and abort preamps, disabling PGNS control of the RCS jets. The DAP will revert to an idle mode, in which it will not respond to any inputs. The ACA will be operative only in the

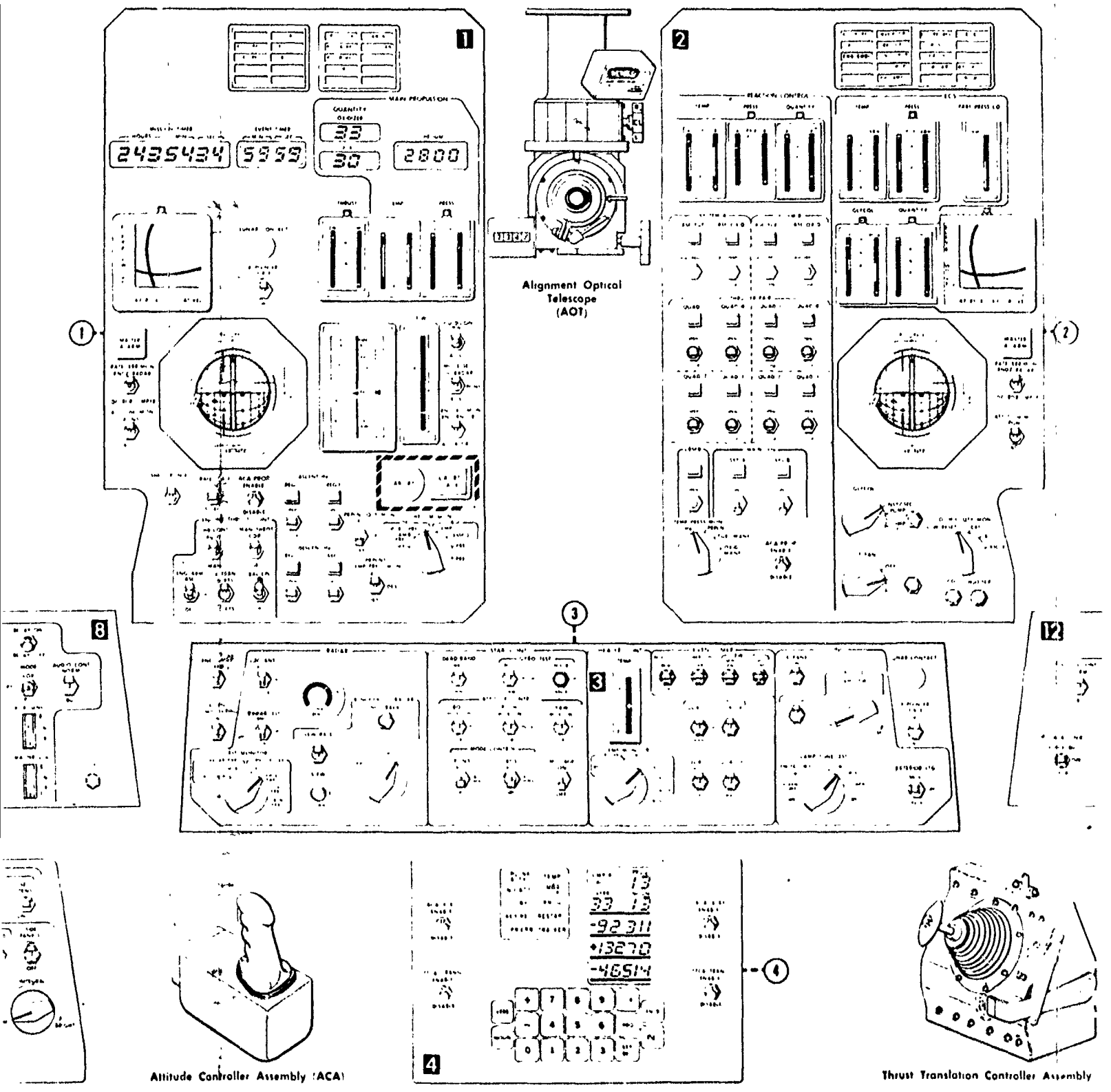
CONTROL MODES/SWITCHES

GUID CONT sw	MODE CONT sw's	ATT CONT (selectable per axis)	REMARKS
			"hardover" position (If DIRECT is selected, 2 jet firing is available in that axis). Automatic engine ON/OFF commands and the TTCA's are disabled.
AGS	AUTO	MODE CONT	This is the switch configuration for automatic AGS maneuvers. Steering signals are generated in the AEA. Rate gyro signals are summed with attitude error signals to provide vehicle rate damping.
AGS	AUTO	PULSE	The crew can command vehicle rotation through low frequency pulsing of the RCS jets (approximately 1.5 pulses/sec). Steering signals are interrupted and there is no rate damping.
AGS	AUTO	DIRECT	The crew can command vehicle rotation through 2 jet operation, direct to the secondary coils. Steering signals are interrupted and there is no rate damping.
AGS	ATT HOLD	MODE CONT	This is a manual proportional rate command mode. The control loop maintains the vehicle attitude when the ACA is returned to detent.
AGS	ATT HOLD	PULSE	Same as AUTO-PULSE.
AGS	ATT HOLD	DIRECT	Same as AUTO-DIRECT.
AGS	OFF	MODE CONT PULSE OR DIRECT	Power is removed from the primary and abort preamps disabling AGS control of the RCS jets. The ACA is operative only in the direct modes using the secondary coils. Automatic engine ON/OFF commands and the TTCA's are disabled.



Attitude Controller Assembly (ACA)

FOLDOUT FRAME 1



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Basi

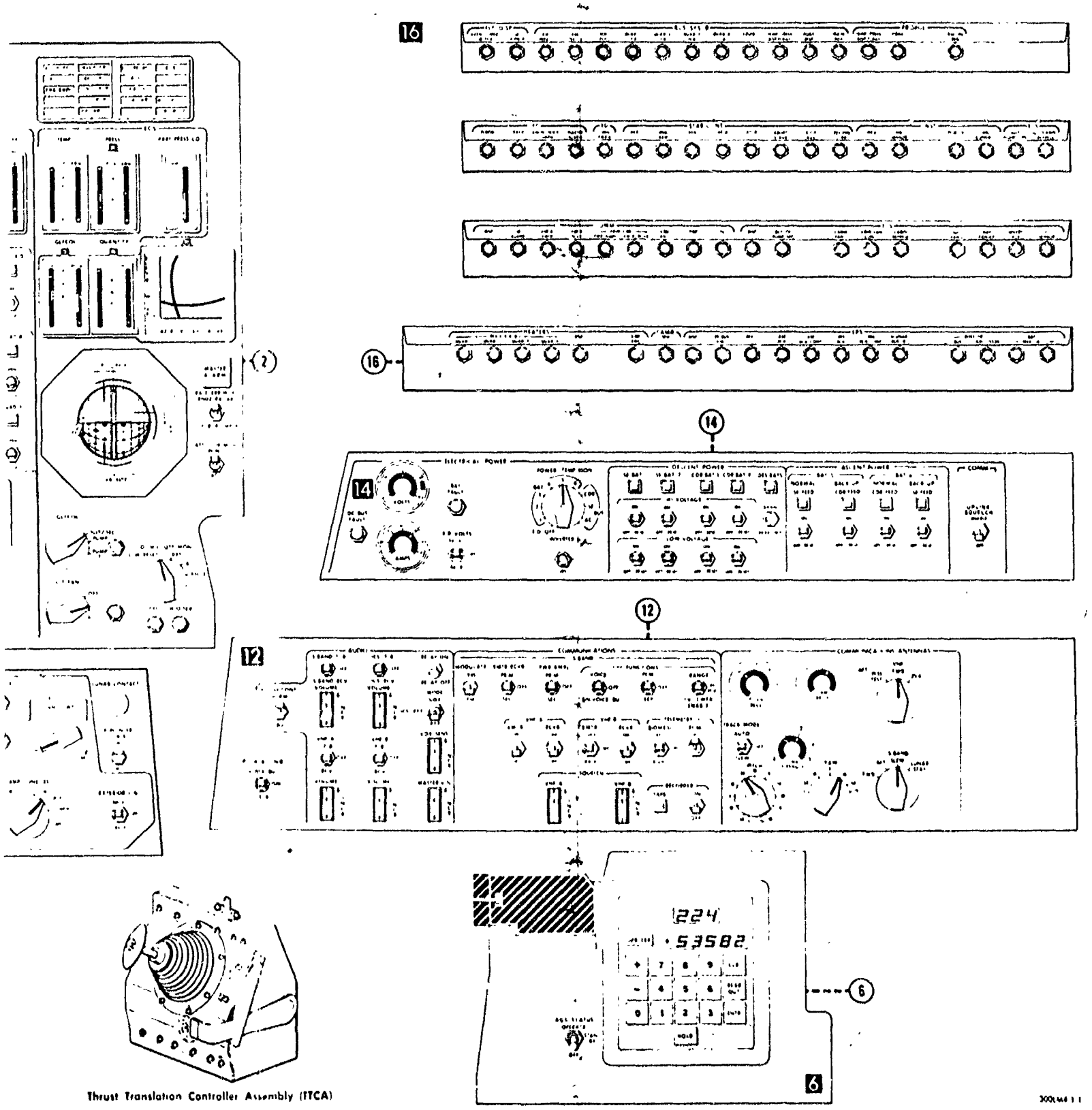

Figure E-1. LM-4 Cabin Controls & Displays

FOLDOUT FRAME 3

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