MASSACHUSETTS INSTITUTE OF TECHNOLOGY

APOLLO

GUIDANCE, NAVIGATION AND CONTROL

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R-567

GUIDANCE SYSTEM OPERATIONS PLAN FOR MANNED LM EARTH ORBITAL AND LUNAR MISSIONS USING PROGRAM LUMINARY 1E

SECTION 4 OPERATIONAL MODES (Rev. 10)

DECEMBER 1971

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R-567

GUIDANCE SYSTEM OPERATIONS PLAN FOR MANNED LM EARTH ORBITAL AND LUNAR MISSIONS USING PROGRAM LUMINARY 1E

SECTION 4 OPERATIONAL MODES

REVISION 10

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FOREWORD

Section 4 Revision 10

The Guidance System Operations Plan (GSOP) for program LUMINARY 1E is published in six sections as separate volumes:

1. Prelaunch
2. Data Links
3. Digital Autopilot
4. Operational Modes
5. Guidance Equations
7. Erasable Memory Programs

With this issue, Section 4 is revised from the previous issue of LUMINARY GSOP (Revision 9 for program LUMINARY 1E Rev. 210) in order to reflect the NASA/MSC approved changes listed on the "Revision Index Cover Sheet" at the beginning of this volume.

Although the GSOP specifies an earth-orbital capability—and this capability has been provided—verification testing shall not be accomplished for earth-orbit rendezvous.

This volume is published as a control document for LUMINARY 1E, governing operational modes, including PGNCS interfaces with the flight crew and MCC. Revisions constituting changes to the LUMINARY program require NASA approval.

Russell A. Larson
LUMINARY PROJECT MANAGER

REVISION INDEX COVER SHEET

GUIDANCE SYSTEM OPERATIONS PLAN

GSOP No. R-567 Title: For Manned LM Earth Orbital and Lunar Missions Using Program LUMINARY (Rev 069)

Section No. 4 Title: Operational Modes (Revision 1)

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9	SIMPLIFY CREW PROCEDURES IN R60 (ATTITUDE MANEUVER ROUTINE)
13	MODE II RENDEZVOUS RADAR DESIGNATE
15	S-BAND ANTENNA
30	DPS TRIMMING TIME
31	LGC REQUIREMENTS DURING AGC SWITCHOVER
39	Z AXIS TRACK (ONLY)
70	CHANGES TO P12, P70, P71
79	FLAGBIT UPDATE VERB
80	STATE VECTOR SYNCHRONIZATION
85	RATE COMMAND/ATTITUDE HOLD DURING X-AXIS OVERRIDE
86	DEADBAND SELECTION CHANGES
95	SIGN CHANGE TO NOUN 72
96	CHANGE TO RR COARSE ALIGN EXTENDED VERB
97	RR MONITOR ROUTINE CHANGE

PCR	TITLE
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106	DELETION OF DIRECT TRANSFER ASCENT TARGETING
114	DELETE MINIMUM DEADBAND SETTING DURING MINIMUM IMPULSE BURN
118	REDEFINITION OF R12 PROCEED AND INHIBIT
121	NEW ENGINE FAIL ROUTINE
124	ATTITUDE MANEUVER DURING RR SEARCH ROUTINE
134	PULSE TORQUING TO ACHIEVE IMU REALIGNMENT
137	R12 FLAG CHANGE
138	DELETION OF PREDICTED LAUNCH TIME PROGRAM
144	REDUCTION OF ULLAGE DURATION AND DELTA V THRESHOLD
146	EMERGENCY TERMINATION OF INTEGRATION FUNCTION
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186	ELIMINATION OF ULLAGE FOLLOWING AN ENTER OR TERMINATE
190	CLARIFICATION OF R31'S OPERATION
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PCR	TITLE
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234	UPDATE LUMINARY GSOP SECTION 4 (NASA COMMENTS)
244	DELAY
246	IMPLEMENTATION OF ONE-PHASE DESCENT GUIDANCE LOGIC
248	LR REASONABILITY TEST
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254	MODIFICATION OF CDH TIME COMPUTATION LOGIC
258	REDEFINITION OF VERTICAL RISE VELOCITY CUTOFF
259	OMIT ZONE 1 FROM DESCENT LOGIC
400	PROVIDE RR DOWNLINK DATA ON LUNAR SURFACE IN P22
401	CORRECTION OF IMU WARM UP TIME
405	GSOP UPDATE SECTION 4
406	CORRECTION TO RC4 IN GSOP SECTION 4
407	GSOP CHANGE TO NOUN 90 R1 SCALE
408	R47 CHANGES TO SECTION 4
409	TRANSFER OF RR FROM AUTO TRACK TO LGC MODE
410	PREVENT PROBLEMS ARISING FROM RR CONTROL MODE CHANGES
413	GSOP SECTION 4 R02 IMUSE FLAG
415	PREVENT DISPLAY CONFLICTS WHEN RR GOES OUT OF AUTO MODE
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445	USE OF N34 IN P39
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468	CHANGE R32 INTO PROGRAM P76
469	NOUN CHANGE IN P57
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475	EXTENSION OF RTC CAPABILITY
476	FINDCDUW - GIMBAL DRIVE
489	BYPASS R54 AND NOUN 93 DURING INITIAL ALIGNMENT
490	NEW NOUN FOR OPTION CODE IN EXTENDED VERBS
496	INCORPORATION OF EXTENDED VERBS
497	DO NOT DELAY P63 THROTTLE-UP TIME
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PCR	TITLE
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502	CLARIFY FIRST TFI DISPLAY IN P35/P75
507	TERMINATION OF INTEGRATION
513	CORRECT EXIT OF R33
514	F12 GSOP CHANGE
518	CORRECTION TO R30
527	MARK VERB FOR R59
531	ADD 1 MINUTE IN R63 EXTRAPOLATION
536	P70, P71 SELECTION VIA V37
537	SURFACE NAVIGATION FLAG CHECK IN P20 AND P22
539	PROVIDE OPTION TO DISABLE THE PITCH-ROLL RCS AUTOPILOT
540	ACTIVE VEHICLE CENTRAL ANGLE IN CSI-CDH
541	DECREASE FREQUENCY OF MARKS IN P22
542	ASSURE RATE COMMAND/ATTITUDE HOLD MODE DURING P66 AND P67
545	P38/P78 UPDATE INHIBIT FOR T(FINAL) CALCULATION
546	P68 DELETION OF PLEASE PERFORM ATTITUDE STORAGE DISPLAY
547	P68 TERMINATES IN GOTOPOOH
549	RR SHAFT/TRUNNION BIAS MODIFICATION BY CREW
559	R29 HINDRANCE BY MID-TO-AVE TIG SLIP IN P12
561	RESET OF RENDWFLAG IN P12
562	SELECTION AND TERMINATION OF P20/22/25
568	DELETE USE OF R29 DURING P63

PCR	TITLE
593	MODIFY ARCSIN-ARCCOS ALARM (01301) ACTION TO AVOID HARDWARE RESTART
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607	UPDATE ALARM CODE LIST
608	SIMPLIFICATION OF PREFERRED ORIENTATION SELECTION (P57)
609	PREFERRED IMU ORIENTATION WHEN THRUST IS ALONG LOCAL VERTICAL
612	RAISE THRESHOLDS FOR DELTA V MONITOR
613	AUTOMATIC 4-JET TRANSLATION CAPABILITY IN P12,70,71
614	ADD NOUN 38 FOR TIME OF STATE VECTOR
615	REDUCE RESTRICTIONS ON RUNNING R04 TO A MINIMUM
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618	MAKE THE DAP RATE COMMAND A NON-LINEAR FUNCTION OF LM HAND CONTROLLER DEFLECTION
622	CORRECTION TO V83, R DOT, THETA, ON LUNAR SURFACE
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634	CORRECT DESIGN FLAW IN R61,R65 FOR HIGH LOS RATES
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GUIDANCE SYSTEM OPERATIONS PLAN

GSOP No. R-567 Title: For Manned LM Earth Orbital and Lunar Missions Using Program LUMINARY 1A

Section No. 4 Title: Operational Modes (Revision 2, 3, 4)

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270	PLACEMENT OF DESIRED INSERTION RADIAL VELOCITY COMPONENT INTO ERASABLE FOR P70/P71/P12
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647	REPLACE LAMBERT WITH "A" STEER IN P40,P41, AND P42
648	MODIFY P42 TO PERMIT STAGING BETWEEN TIG-30 AND TIG
654	LESSEN DELAYS IN R31
670	SIMPLIFICATION OF LANDING PROGRAMS
695	PROVIDE OPTION FOR CSI PROGRAM TO COMPUTE T(APOAPSIS)
696	V06N22 DISPLAY IN P57
697	LIMITATION OF LM ABORT ORBIT INSERTION TO 1/2 DEGREE PLANE CHANGE
698	ADD LM POSITION DETERMINATION CAPABILITY TO P57
699	PAD LOAD ACT BACK DETENT AZ AND EL ANGLES
700	IMPROVE THE RATE-OF-DESCENT MODE (P66) PERFORMANCE
702	ADD COAS CALIBRATION OPTION TO R52

PCR	TITLE
708	PROVIDE CONTINUOUSLY VARIABLE ABORT ORBIT INSERTION TARGETING
716	ASCENT POWERED FLIGHT RCS CONTROL
720	ABORT COASTING INTEGRATION WHEN IN INFINITE ACCELERATION OVERFLOW LOOP
721	TIME-THETA AND TIME-RADIUS ALARM ABORT
722	IMPROVE PERFORMANCE OF RR DESIGNATE PROCEDURE ON LUNAR SURFACE
732	PERMIT THE CREW TO MODIFY W-MATRIX BIAS ERROR IN V67 ROUTINE
736	ADD SOURCE CODE TO NOUN 49 IN P20/P22
737	PERMIT ATT HOLD MODE IN P63, P64, P65
738	H, V, GAMMA DISPLAY WITH P21
740	DISPLAY TLAND IN P52, OPTION 4
744	CHANGE EPSILON TO 1.5 SECONDS IN R24
751	MAKE 1406 ALARM NON-ABORTIVE
752	CLARIFY DESCRIPTION OF TCDH-TCSI AND TTPI-TCDH DISPLAYS
754	PROVIDE IMU ORIENTATION SELECTION OPTION CODE IN P57
755	CHANGE IMU GIMBAL ANGLES IN GRAVITY VECTOR DETERMINATION
757	INITIALIZE RADMODES FOR P20, P22 AND R29
758	ALLOW 15 SECONDS FOR AN INTEGRATION TIME STEP IN R41
761.1	R-2 LUNAR POTENTIAL MODEL
762	DELETE V68

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GUIDANCE SYSTEM OPERATIONS PLAN

GSOP No. R-567 Title: For Manned LM Earth Orbital and Lunar Missions Using Program LUMINARY 1B

Section No. 4 Title: Operational Modes (Revision 5, 6)

PCR	TITLE
277	A FIXED CUMPCNT
279	VARIABLE INSERTICN CCMPUTATION
779	LEAVE TRACK ENABLE SET WHEN R29 IS TERMINATED
780	PRCVIDE PURE RR RANGE, RANGE RATE, ANC TIME TAG CURING P20, P22, AND P25
791.2	DC NCT ALLCW A PRCCEEC RESPCNSE TO A V21, V22, OR V23
798.2	RESET CLCKFAIL IN ROC
801.2	MAKE BAILCUT ALARMS START WITH 3XXXX ANC PCCDOC ALARMS START WITH 2XXXX
802.2	SAVE ALARM CATA AFTER "ERRCR RESET"
805	DCN'T ALLCW V66 CN THE SURFACE
807.2	ACC PRESENT TIME CPTICN TC P21
812.2	RESETTING AND SETTING CF THE EXTERNAL DELTA V FLAG
814	REDUCE KEYSTRCKES REQUIRED TO CHECK ANC APPRCVE LR CATA
816	MCDIFY R03 TC PERMIT ASTRONAUT SETTING OF 1 DEGREE DEADBAND
817	ELIMINATE UNDESIRABLE LR PCSITICN ALARMS FRCM R12
818	PERMIT REJECTICN CF INCIVICUAL MEASUREMENT INCCRPCRATIONS IN P20

PCR	TITLE
820	ELIMINATE LIGHTING OF ALT LIGHT WHEN LOW SCALE DISCRETE IS ABSENT
823	DELETE P31(LAMBERT AIM POINT GUIDANCE PROGRAM)
825.2	DISPLAY OPTION 3 IN P52/P54
826.2	REVERSE P76 DISPLAY
832.2	REMOVE RESTRICTION OF RUNNING R05 ONLY IN PCO
838	PREVENT RCS JET FIRINGS ON LUNAR SURFACE
839	R12 AND LR RE-POSITION ROUTINE IMPROVEMENTS
840	REDUCE ATTITUDE OSCILLATIONS IN P64 AND P65
841	PGNCS DERIVED VEHICLE ATTITUDE RATES ON FDAI ERROR NEEDLES
*845	DO NOT TURN ON R29 DURING P70/P71
847	ELIMINATE POSSIBLE LOCK-OUT OF PITCH-OVER FROM P12,P70,P71
848	PREVENT RR ECDLS FROM STEALING LGC MEMORY CYCLES
853	RESTRICT V35 TO PCC
854	PROVIDE A FLEXIBLE METHOD FOR CREW TO MODIFY RLS
855	BEGIN READING LR VELOCITY AS SOON AS VELOCITY DATA GOOD APPEARS
856	CHANGE 1502/1206 FROM POODOO'S TO BAILOUTS
844	DELETION OF P38/P78 and P39/P79

* ALSO REFER TO PCR 279

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GUIDANCE SYSTEM OPERATIONS PLAN

GSOP No. R567 Title: For Manned LM Earth Orbital and Lunar Missions Using Program LUMINARY 1C

Section No. 4 Title: Operational Modes (Revision 7)

PCR	TITLE
285(REV 1)	REMOVE CHECK OF AUTO THROTTLE DISCRETE
806.2	ALLOW NOUN TO ACCESS OUTPUT CHANNELS
863.2	MAKE P76 SET NODC FLAG
882	REPLACE VHORIZ WITH SOMETHING BETTER
893	ABORT TARGETING FLAGBIT
895	LR REPOSITION BY V59E IN P63
936.2	INITIALIZE V90 TIME TO TIG
943	VELOCITY REASONABILITY TEST
968	LPD BIAS CORRECTION
972	DISPLAY POLARITY OF SIGHTING ANGLE DIFFERENCE IN R-54

Date: November 1970

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GUIDANCE SYSTEM OPERATIONS PLAN

GSOP No. R-567 Title: For Manned LM Earth Orbital and Lunar Missions Using Program LUMINARY 1D

Section No. 4 Title: Operational Modes (Revision 8)

Revision 8 incorporates the following NASA/MSC approved changes and becomes the control document for LUMINARY 1D (Rev. 178).

PCR (PCN*)	TITLE	PAGES/PROGRAMS AFFECTED
287	Removal of 526 Alarm in P22 and P20	Nouns, Flags, P20, P22
296	Set "G" Vector Parallel to Landing Site Radius Vector	P57, P68
298	Decrease Time to Call Alarm Code 523	R12, V59
302.2/ 315.2	Channel 77	Nouns, P27, R01, V36
310	Time to Call 511 Alarms	R12, Flags
872.2/ *1040	Initiate TFI in P30/Only P41 has Early TFI Countdown	Nouns, P41
874.2	Change Decimal Load Technique	pp. 4-9, 4-11, 4-15, 4-16
892	Delete R29	R12, Index, Flags, P12, P63, R00, V40 N72, V41 N72, V59, R04, R41, R77, V36, R20
896	LR Velocity Read Centered at PIP TIME	R12
898	LR Velocity Read	R12, R00, Flags
†942	LR Update Cutoff	Flags, R12, P66
979	Delete 521 Alarm	Alarms, Flags, P20, P22, R20
982	Extend Capability of Lunar Surface Star Acquisition Routine R59	R59
983	Unit Vector Capability for N88	Nouns, R58
†988	AUTO P66	R12, R10, P63, P64, P66, R09, R13, Flags
*990	V44 RR Remode Check	Flags
996/ *1036	Liftoff Check in P07/PCR 996 (Liftoff Check in P07) Improvments	Alarms, V36

PCR (PCN*)	TITLE	PAGES/PROGRAMS AFFECTED
*1009	Luminary 1D Editorial Changes to Section 4	4-1, 2, 9, 10, 23, 24, P12, P20, P22, P25, P32, P34, P35, P40, P41, P42, P52, P57, P63, P64, P68, P70, P71, P73, P74, P75, P76, R00, R01, R03, R04, R12, R13, R22, R30, R31, R41, R51, R52, R53, R57, R58, R59, R65, V36, V59, P66, Nouns, Alarms, Flags
†1013	Multiple Servicers Avoidance in P66	P63, P64, P66
1015	Check for AVEGON at Start of R36	Flags, R36
1021	Fixed Memory Landing Radar Transformation Matrices	R12, Flags
1022	Landing Radar Position Alarms	R12
1025	Remove Gravity Computation After Landing Radar Altitude Update	R12, R20
1027/ *1039	A-PRIORI TERRAIN MODELS/ TERRAIN Model Improvements (PCR 1027)	R12
1028	Two-Segment Altitude Weighting Functions for Landing Maneuver	P64
*1035	V68 and P66 Terminate the Terrain Model	P63, V68, R13, Flags, Verbs
*1037	P66 Corrections	P66, R13, Flags
1038	Keep 526 Alarm in P20 (PCR 287)	Alarms, P20, P22
*1040	Only P41 has Early TFI Countdown (PCR 872.2)	P41
1048	Initialize Elevation Angle in P34/P74	P34, P74
1056 Rev 1	Improvements for Impulse and Ullage Logic	P40, P42
1058	New Landing Analog Displays (R10)	R10, P12, P20, P63, P71
1069.2	Delete Rendezvous Test for Earth Orbit	Foreword

†PCR change also applicable to the LUM 1C program (LM 131, Rev 1) although not included in Rev 7 of Section 4 GSOP.

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GUIDANCE SYSTEM OPERATIONS PLAN

GSOP No. R-567 Title: For Manned LM Earth Orbital and Lunar Missions Using Program LUMINARY 1E

Section No. 4 Title: Operational Modes (Revision 9)

Revision 9 incorporates the following NASA/MSC approved changes and becomes the control document for LUMINARY 1E (Rev. 210).

PCR (PCN*)	TITLE	PAGES/PROGRAMS AFFECTED
317.2	Rescaling Nouns Containing Range and Range Rate	Nouns, R04, R22
319	A Priori Terrain	R12
324	PGNCS/AGS RR Data Transfer	R22, R56, R65, V36
333	Change recognition of ROD inputs	R57, Flags
334 Rev. 1	Change DSKY Descent/Ascent Nouns	Nouns, Flags, P12, P63, P64, P70, P71, R40, V57
335	Remove Alignment Option from P63	V50N25, P63, R51
336 Rev. 1	Allow Extended Verbs During P20 Maneuvers (Delete R60 0618 Display)	P20, R60
338	Change LPD Scaling to 1.0^{o} in all Directions	P64
339	Have P20 F50 72 Display Update	P20, NOUNS
341	Landing Radar Reasonability Test	R12
347	Modification to Code Word Configuration for PGNCS/AGS Data Transfer	R22
348	New Target-ΔV Program for LGC	P77, Index
1044	Redesign of R53 and R57	4-17, Verbs, V50 N25, Alarms, Flags, R51, R52, R53, NOUNS, R58, R57, R59, V52, V53, V54, indexes
*1059	Have Major Modes Changes Set Up a 1/ACCS Job	V36
1066	Display N81 on all passes in P34/74/35/75	Nouns, P34, P35, P74, P75

PCR (PCN*)	TITLE	PAGES/PROGRAMS AFFECTED
1088	Inhibit Program Change During Critical 10.56 sec after IMU zero	V40 N20
1091	Priority Display Light on DSKY	xxiii, 4-6, 4-16, P20
1097.2 Rev. 1	V30/31 Operator Error Lockout	4-15, 4-16
1100	Delete Setting of NODOFLAG in R47	Flags, R47
1107	Back up of Abort Bits Channel 30 Bits 1 and 4 for on (0)	Nouns, P66, R03, R11
1109	Back up of OFF (1) Failures of Auto Throttle Channel 30 Bit 5	Nouns, P40, P63, P66, P70, P71, R03
1110	Back up for Failures of the display Inertial Data Bit Channel 30 Bit 6	R10
1117.2	Addition to POODOO logic; add Abort GSOP description	4-23, 4-24
*1126	Set NOTHROTL for DPS Impulse burns	P40
*1132	Correction to PCR 1117.2	4-23, 4-24
1134	Revision of PCR 1111: Back up of Guid Select and Mode Control Switches	4-6, V76
*1137	Correct Constant for Ascent Guidance	P12
*1141	Initialize FLRCS in P12	P12
*1145 Rev. 1	Section 4 Revision 9 GSOP Changes	Index, Alarms, Flags, P12, P20, P21, P22, P27, P40, P42, P57, P63, P64, P66, P68, P70, P71, P72, R00, R01, R03, R04, R09, R10, R12, R13, R20, R22, R25, R26, R30, R31, R47, R51, R56, R60, R61, V36, V40N20, V41N20, V41N72, V42, V43, V44, V55, V59, V67, V74, V76, 4-10, 4-16, NOUNS
*1147	Clarification of the Implementation of PCR 334 Rev 1 "Change DSKY Descent/Ascent Nouns"	P12, P70, P71

Date: December 1971

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GUIDANCE SYSTEM OPERATIONS PLAN

GSOP No. R-567 Title: For Manned LM Earth Orbital and Lunar Missions Using Program LUMINARY 1E

Section No. 4 Title: Operational Modes (Revision 10)

Revision 10 incorporates the following NASA/MSC approved changes and becomes the control document for LUMINARY 1E (Rev. 210).

PCR (PCN*)	TITLE	PAGES/PROGRAMS AFFECTED
1180*	Editorial and Technical Changes to Rev 9 LUM 1E Section 4 GSOP	4-4, 4-6, 4-7, 4-8, 4-9, 4-14, 4-16, 4-17, 4-18, 4-22, 4-23, 4-24, Index, Verbs, Nouns, Flags, P00, P06, P12, P20, P22, P25, P27, P30, P33, P34, P35, P40, P41, P42, P57, P63, P64, P66, P70, P71, P73, P74, P75, P77, R00, R03, R04, R09, R10, R11, R12, R13, R20, R21, R22, R23, R24, R26, R40, R41, R47, R51, R53, R56, R57, R59, R60, R61, R65, R76, V36, V40N20, V40N72, V41N20, V41N72, V42, V43, V44, V55, V59, V67, V85

NOTE: For the computer printed pages, all changes are indicated in the "PROG CONT" column by + signs bracketing the affected area and by the authorizing PCR/PCN number.

For the numbered front pages, a series of dots in the margin indicates a change in specification authorized by the PCR/PCN listed at the bottom of the page.

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SECTION 4

OPERATIONAL MODES

4.0 Introduction

Preparation of the PGNCS for any mission involves the generation of computer programs, flight and ground crew procedures, and the provision of hardware to meet interface, accuracy, and instrumentation requirements. All of these mission-related items are specified in the Guidance System Operations Plan.

The guidance operational concept is designed to comprise a set of manually-initiated programs and functions which may be arranged by the flight crew to implement a large class of flight plans. This concept of operation will permit both a late flight-plan definition and a capability for real-time flight-plan changes.

The PGNC System is designed to perform the LM guidance and navigation functions required on lunar landing missions in a self-contained mode within specified accuracy and maneuver propellant constraints. The System is also designed to accept navigation data from earth-based facilities whenever required to improve accuracy, to reduce maneuver propellant requirements, or to gain some other operational advantage.

4.1 LGC Program Control

To efficiently coordinate the design of the LGC* Programs, as well as define the astronaut and ground control procedures with respect to the PGNC System, it is necessary to define the operating inter-relationships between the PGNC System, other S/C Systems, the astronauts and the ground.

In primary PGNCS control modes the LGC can automatically compute required mission parameters and automatically command both PGNCS and LM subsystems. Complete automation of this control throughout a mission is neither feasible nor desirable. For primary as well as secondary PGNCS control modes the astronauts and/or the ground must be capable of initiation or termination of LGC Programs. These procedures must be thoroughly defined for use in the design of the LGC Program logic for astronaut/ground participation.

4.1.1 LGC Program Initiation

4.1.1.1 LGC Programs

Because of the random time sequencing of many of the LGC tasks, the design of Programs which are capable of being utilized at varied times and in varied circumstances offers the best method of accomplishing these tasks. These Programs must incorporate sufficient logic to clearly define the particular time and/or application for which they are used. They must also standardize astronaut/LGC communication procedures, ground/LGC communication procedures,and PGNCS and SCS Mode determination.

A logical sequence of these Programs has been prepared, supplemented by simpler Routines which do not require identification as Programs. The Programs, their associated Routines and the crew interfaces are outlined in Section 4.4.

Programs in process in the LGC are identified by the Program light on the keyboard and display panel with three exceptions, P20, P25, and P00 with P27 in foreground. These Programs may be in process simultaneously with another Program whose number is displayed.

The LGC is programmed to initiate a Program only in response to the start of a specific mission task and will continue the programmed sequence of computations and displays for the specific task until Program completion or termination.

Programs are generally initiated by manual keyboard entry (astronaut) or by LGC UPLINK command (ground). In certain cases Program initiation is automatically performed by a previous Program.

4.1.1.2 Special LGC Routines

In addition to the LGC Programs there are many Routines and subroutines not specifically identified with a Program. The majority of these are automatically

*AGC is an acronym for Apollo Guidance Computer. In the LM, this computer is officially designated as the LGC (LM Guidance Computer).

performed in a particular computation or control sequence and involve no notification to the "outside world" that they are in process. While they may occasionally be referred to in this document their large number requires that detailed descriptions be restricted to special LGC program documents.

Several special Routines are described in detail herein because of one or more of the following characteristics:

(a) The Routine involves LGC communication with the astronaut.
(b) The Routine is of importance in understanding the Programs.
(c) The Routine involves significant sequences of LGC/astronaut action but might be performed while certain programs are in process.

These Routines include those automatically called by the LGC as well as those manually called. If the Routine requires LGC/astronaut communication, it will start with a particular display which acts as a key to the astronaut that the LGC has automatically entered the Routine.

4.1.2 LGC Program Termination

Normally there are three ways by which an LGC Program in process is terminated:

1. At nominal completion, the program in process will transfer control to the Final Automatic Request Terminate Routine (R00).
2. At nominal completion the program in process will select a subsequent program.
3. Via a terminate response by the astronaut to an LGC-generated flashing display on the DSKY (usually results in transferring control to R00).

In addition to the above the astronaut may terminate a particular LGC program as follows:

1. Use the DSKY to select a new Program to operate.
2. Use the DSKY to select a Routine which has been specifically designed to terminate a particular Program or activity (e.g.: state vector integration).
3. Select the FRESH START routine, which essentially initializes the LGC.

4.2 LGC/Astronaut/Ground Communications

4.2.1 LGC/Ground Communications

The LGC/Ground Communications are via the LGC UPLINK and LGC DOWNLINK and are described in detail in Section 2 of the GSOP.

4.2.2 LGC/Astronaut Communications

The display and keyboard logic in the LGC processes information exchanged between the LGC and the computer operator. This information is exchanged via the display and keyboard (DSKY).

The modes of operation are basically:

(a) Display of internal data - This includes simple displays and periodically updated displays of data; and displays of requests for operator action required by the LGC.

(b) Loading of external data -The process of inserting data into the LGC via the DSKY.

(c) Program or Routine calling - Initiated by operator action via the DSKY.

The following paragraphs and Table 4-1 (page 4-17) provide a limited description of the DSKY, and the crew/DSKY operating procedures. They are included herein to facilitate understanding of the Program logic in Section 4.4 and do not comprise a complete instruction manual for the use of the DSKY.

4.2.2.1 The DSKY (refer to Fig. 4-1, page 4-18).

1. UPLINK ACTY Light - is energized by the first character of a digital UPLINK message received by the LGC. If the light is not extinguished by the UPLINK transmission it should be extinguished by crew use of the RSET or KEY REL buttons when the UPLINK transmission is complete.

2. NO ATT Light - is energized when the LGC is in the Operate Mode and there is no inertial reference; i.e.: the ISS is caged or in the Coarse Align Mode.

3. STBY Light - is energized when the LGC is in the Standby Mode and de-energized when the LGC is in the Operate Mode.

4. KEY REL Light

   A. Energized when:

      (a) An internal display comes up while the astronaut has the DSKY.

      (b) An astronaut keystroke is made when an internal flashing display is currently on the DSKY. (Note three exceptions: PRO (proceed), RSET (reset) and ENTR (enter) if ENTR is a single button response).

(c) The astronaut makes a keystroke on top of (his own) Monitor Verb display. This is the so-called "suspended monitor" case. (Monitor Verbs display data updated every one second.)

B. De-energized when:

(a) Astronaut relinquishes the DSKY by operating the KEY REL button.

(b) Astronaut terminates his current sequence normally, e.g.:

i) with final ENTR of a load sequence.

ii) the ENTR of a response to a flashing display.

iii) the ENTR of an extended verb request.

C. Some special DSKY cases are:

(a) The astronaut may select a non-Monitor Verb display on top of his own previously selected Monitor Verb. This will cause KEY REL light to flash (See (4)(A.)(c) above). Hitting the KEY REL button will bring back (unsuspend) the monitor and extinguish the light. However, if these sequences are selected on top of an internal display, the KEY REL light will not go out as the monitor is unsuspended. It requires one more KEY REL button operation to extinguish the light and bring back the internal display.

(b) If the astronaut selects another verb-noun combination (e.g.: a V16 monitor) on top of an internal flashing display, that internal display can still be answered with PRO or VERB 34 ENTR (terminate), which wipes everything from the DSKY till the next internal display. Therefore, an astronaut selected monitor should, as a rule, never be terminated with VERB 34 ENTR, because that may not be the desired response to the flashing display. The KEY REL button should be used instead.

5. TEMP Light - the LGC receives a signal from the IMU when the stable member temperature is in the range 126.3° F to 134.3° F. In the absence of this signal, the TEMP lamp on the DSKY is actuated.

6. GIMBAL LOCK Light - is energized when the middle gimbal angle exceeds $\pm 70^{\circ}$ from its zero position. When the middle gimbal angle exceeds $\pm 85^{\circ}$ from its zero position the LGC automatically commands the coarse align mode in the ISS to prevent gimbal oscillation. The NO ATT light will then be energized (see (2.) above).

7. PROG Light - under a variety of situations a program alarm is generated. The program alarm actuates the PROG lamp on the DSKY. For further information see section 4.3.3, and 4.3.4.
8. TRACKER Light - when the rendezvous radar is on, the light is energized when:
   A. An RR CDU fine error signal greater than 1.0 vrms occurs.*
   B. An RR CDU coarse error signal greater than 2.5 vrms occurs.*
   C. The RR read counter limit-cycles at a rate greater than 160 cps.*
   D. An RR CDU analog-to-digital conversion fails, i.e.: cos $(\Theta - \phi)$ signal is less than 2 volts.
   E. The RR CDU +14 VDC supply decreases to 50% of nominal.*
   F. When the RR Data Good bar discrete occurs during an LGC data read sequence.
9. OPR ERR Light - is energized when the DSKY operator performs an improper sequence of key depressions. The light is de-energized by pressing the RSET button.
10. COMP ACTY Light - is energized when the LGC is occupied with an internal sequence. It is not an indication that the operator may or may not use the DSKY or that the LGC is incapable of handling further computation.
11. RESTART Light - in the event of a Restart during operation of a Program a latch is set in the LGC which illuminates the RESTART lamp on the DSKY until the latch is manually reset by RSET (see section 4.3.3).
12. ALT Light - when the landing radar is on, the light is energized (on steady or flashing) when:
    A. LR range data good discrete was not present before and after LR altitude sampling (STEADY).
    B. LR altitude reasonability test was failed (FLASHING).
13. VEL Light - when the landing radar is on, the light is energized (on steady or flashing) when:
    A. LR velocity data good discrete was not present before and after LR velocity sampling (STEADY).
    B. LR velocity reasonability test was failed (FLASHING).
14. NO DAP Light - (Placarded NO DAP - opposite VEL light)
    Energized when PGNS DAP is not controlling attitude (minimum impulse mode or idling mode).
15. PRIORITY Light - (Placarded PRIO DISP - opposite ALT light)
    Energized when LGC attempts to display a priority display (see 4.2.2.14)

*And RR is in auto mode and RR CDU's are not being zeroed.

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[ ] Added GSOP # R-567 PCR # _____ Rev. 10

16. Display Panel - consists of 24 electroluminescent sections arranged as in Fig. 4-1, page 4-18. Each section is capable of displaying a decimal character or remaining blank, except the 3 sign sections (R1S, R2S, R3S). These display a plus sign, a minus sign, or a blank. The numerical sections are grouped to form 3 data display registers, each of 5 numerical characters; and 3 control display registers, each of 2 numerical characters. The data display registers are referred to as R1,R2,R3. The control display registers are known as VERB, NOUN, and PROGRAM.

    At maximum activity, the complete display panel may be updated in 0.50 second.

17. Keyboard - contains the following buttons:

    VERB - pushing the button indicates that the next two numerical characters keyed are to be interpreted as the Verb Code.

    NOUN - pushing the button indicates that the next two numerical characters keyed are to be interpreted as the Noun Code.

    + and − - sign keys used for sign convention and to identify decimal data.

    0 - 9 - numerical keys.

    CLR - used during a data loading sequence to blank the data display register (R1, R2, R3) being used. It allows the operator to reload the data word.

    PRO - this pushbutton performs two functions:

    1. When the LGC is in the Standby Mode, pressing this button will put the LGC in the Operate Mode, turn off the STBY light (see 3.) and automatically select Routine 00 in the LGC, after restoring the clock.

    2a. When the LGC is in the Operate Mode but Program 06 is not selected, pressing the button will provide the "Proceed" function. "Proceed" directs the LGC to continue to the next programmed event. In response to an LGC request it further indicates crew compliance with the request. If the PRO button is pressed when the VERB lights contain verb 21, 22 or 23, the button is rejected and the OPR ERR light is energized.

    b. When the LGC is in the Operate Mode and Program 06 is selected, pressing the button will put the LGC in the Standby Mode and turn on the STBY light (see 3.).

    KEY REL - releases the DSKY displays initiated by key board action so that the DSKY is available for displays generated by the LGC program.

ENTR - is used in three ways:

1. To direct the LGC to execute the Verb/Noun now appearing on the Verb/Noun lights.
2. To direct the LGC to accept a data word just loaded.
3. In response to a "Please Perform" request (see section 4.2.2.7).

RSET - Turns off PROG light, RESTART light, and OPR ERR light; also clears R1 and R2 of the noun 09 registers containing the alarm code (FAILREG's).

4.2.2.2 Verbs and Nouns

The basic language of communication between the astronaut and the DSKY consists of the Verb and Noun. The Verb Code indicates what action is to be taken. The Noun Code indicates to what this action is applied.

Verb Noun codes may be originated either by manual operation or by the LGC Program in process.

The standard procedure for a manual keyboard operation consists of a sequence of 7 key depressions:

VERB V_1 V_2 NOUN N_1 N_2 ENTR

The VERB key depression blanks the Verb lights on the display panel and clears the Verb Code register within the computer. The next two numerical characters punched are interpreted as the Verb Code. Each of these characters is displayed in the Verb lights on the display panel as it is keyed in. The NOUN key operates similarly for the Noun lights and Noun Code register.

The depression of the ENTR key causes the performance of the Verb-Noun combination appearing in the lights at the time of depression. Thus it is not necessary to follow any order in punching in the Verb or Noun Code. They may be done in reverse order, or an old Verb or old Noun may be used without repunching it.

No action is ever taken in performing the Verb-Noun combination until ENTR is pressed. If an error is noticed in either the Verb Code or the Noun Code before the ENTR is pressed, correction is simple. Merely press the VERB or NOUN key and repunch the originally intended code, without necessarily changing the other. Only when the astronaut has verified that the desired Verb and Noun Codes are shown in the lights, should he press the ENTR key to execute the Verb-Noun combination.

A Noun Code can refer to a group of computer erasable registers, a group of counter registers, or may serve merely as a label. A label Noun refers to no particular computer register, but conveys information by its Noun Code number only. The group of registers to which a Noun Code refers may be a group of 1, 2 or 3 members. These are generally referred to as 1, 2, or 3 component Nouns. The component is understood as a component member of the register group to which the Noun refers. The machine addresses for the registers to which a Noun refers are stored within the computer in Noun tables.

A single Noun Code refers to a group of 1, 2, or 3 component members. It is the Verb Code that determines which component member of the Noun group is operated on. Thus, for instance, there are five different Load Verbs. Verb 21 is required for loading the first component of whatever Noun is used therewith; Verb 22 loads the second component of the Noun; Verb 23, the third component; Verb 24, the first and second components of the Noun; and Verb 25 loads all three components of the Noun. A similar component format is used in the Display and Monitor Verbs.

When the decimal Display Verb is employed, all the component members of the Noun being used are scaled as appropriate, converted to decimal, and displayed in the data display registers.

Decimal data is identified by a + or - sign preceding the numerical characters. If decimal is used for loading data of any component members of a multi-component Load Verb, it must be used for all components of the Verb. Thus no mixture of decimal and octal data is permitted for different components of the same Load Verb. (If this is violated, the OPR ERR alarm is turned on.)

There is a class of verbs called Monitor Verbs which display data every one second. Once a Monitor Verb is executed, the data on the display panel continues to be updated until the Monitor is turned off.

The Monitor is turned off by: PRO, VERB 34 ENTR (terminate), and internal program initiation of the Keyboard and Display System Program, (if the DSKY is not busy) or by a Fresh Start of the LGC, or by a re-cycle verb, or a Restart.

Monitor action is suspended (but not ended) by the depression of any key, except RSET, KEY REL, and ENTR. This turns on the KEY REL light immediately. Monitor action continues after the Keyboard and Display System is released. Thus it is possible to suspend a monitor while the astronaut loads some data (or requests another display) and to return to the original monitor when his intervention is concluded.

After any use of the DSKY, the numerical characters (verb, noun and data words) remain visible until the next use of the DSKY. If a particular use of the DSKY involves fewer than 3 data words, the data display registers (R1, R2, R3) not used remain unchanged unless blanked by deliberate program action.

The DSKY procedures above were described for manual operation; however, the principles described remain the same for DSKY operation by the LGC Programs and Routines.

As outlined in the Mission Programs (sec. 4.4.9) the majority of DSKY operations are of the following categories:

a) Display - to display data to the operator. Display Verbs present data computed by the mission program.

b) Load - to request a data load as described in detail below.

c) Please Perform - to request an action from the astronaut. (see section 4.2.2.7)

d) Please Mark - to request the astronaut to push a "MARK" button for an optics sighting.

LGC initiated Verb/Noun combinations are either statically displayed or flashed. If static they identify data displayed only for astronaut information requiring no response from him. If the Verb/Noun is flashing, appropriate astronaut response is required as dictated by the Verb/Noun combination. In this case the LGC Program or Routine is interrupted until the astronaut responds appropriately, (although the program may continue to update the display) then the Verb/Noun flash is terminated and the Program or Routine is resumed.

An appropriate astronaut response to a flashing Verb/Noun should be a data load and ENTR, VERB 32 ENTR (recycle), PRO, or VERB 34 ENTR (terminate). The internal program response to any one of these astronaut responses varies according to the Verb/Noun flashing and the Program in process as described below and in Section 4.4.9.

4.2.2.3 Acceptance of Keys

The numerical keys, the CLR key, and the sign keys are rejected if struck after completion (final ENTR) of a data display or data load Verb. At such time, only the VERB, NOUN, ENTR, RSET, or KEY REL are accepted. Thus the data keys are accepted only after the control keys have instructed the program to accept them.

Similarly the plus (+) and minus (-) keys are accepted just before the first numerical character of R1, R2, R3 is punched in, and at no other time.

The 8 or 9 key is accepted only while defining a verb, noun, or program number, or when loading a data word into R1, R2, or R3 which was preceded by a plus or minus sign. (If this is violated, the OPR ERR alarm is turned on.)

If more than two numerical characters are punched in while loading the Verb, Noun, or Program code, or more than five numerical characters while loading a data word, the excess characters are not accepted.

4.2.2.4 Release of Keyboard and Display System

The Keyboard and Display System Program can be used by internal computer programs. However, any operator keyboard action (except RSET) makes the Keyboard and Display System Program busy to internal routines. The operator has control of the Keyboard and Display System until he wishes to release it. Thus he is assured that data he wishes to observe will not be replaced by internally initiated data displays. There are 6 cases in which the operator initiated normal displays will be replaced by internally initiated action. These are: in P12, P40, P41, P42 and P63, when the DSKY is blanked at T-35 seconds and also P22 in certain cases, may blank the DSKY. In general, it is recommended that the operator release the Keyboard and Display System for internal use when he has temporarily finished with it. This is done by pressing the KEY REL button.

If an internal program attempts to use the Keyboard and Display System, but finds that the astronaut has used it and not yet released it, the KEY REL light is turned on. When the astronaut finds it convenient, he should strike the KEY REL button to allow the internal program to use the keyboard and display panel.

4.2.2.5 Display - Verb/Noun Flashing

This is an internally initiated action. The appropriate astronaut response to a flashing display Verb/Noun combination is:

(a) Correct the data (see Section 4.2.2.6 below). Perform the appropriate Load Verb sequence. Upon the final ENTR, the program proceeds normally.

(b) VERB 32 ENTR (recycle). This causes the program to return to a previous location.

(c) PRO. This indicates acceptance of the displayed data, and a desire for the internal sequence to continue normally.

(d) VERB 34 ENTR (terminate). The astronaut wishes to terminate the operation.

NOTE: Uncommon responses are defined in the program logic of Section 4.4.9.

4.2.2.6 Load - Verb/Noun Flashing

Whenever any data is to be loaded the Verb/Noun flashes. The flash occurs whether the data load is initiated by the LGC or by the astronaut. The appropriate data display register (R1, R2, or R3) is blanked in anticipation of the data load. Data is loaded in 5-character words and is displayed character-by-character in one of the 5-position data display registers as it is keyed in.

Numerical data is considered decimal if the data word is preceded by a plus or minus sign; if no sign is supplied it is considered octal. The plus and minus keys are accepted only when they precede the first numerical character of the data word; they are ignored at any other time. Both decimal and octal data may be loaded with high order zeros suppressed. If decimal is used for any component of a multicomponent Load Verb, it must be used for all components of that Verb. No mixing of octal and decimal data is permitted for different components of the same Load Verb. (If this principle is violated, the OPR ERR alarm is turned on.)

The ENTR key must be pressed after each data word. This tells the program that the numerical word punched in is complete. The flash is turned off after the last ENTR of a loading sequence.

As data is loaded, it is temporarily stored in buffers. It is not placed into its final destination, as specified by the Noun Code, until the final ENTR of the load sequence.

If an attempt is made to key in more than five numerical characters in sequence, the sixth and subsequent characters are simply rejected. If the 8 or 9 key is punched during octal load (as identified by lack of a sign entry), it is rejected and the OPR ERR light is turned on.

In multi-component load situations, the appropriate single component Load Verbs are flashed one at a time. The computer always instructs the astronaut through a loading sequence. The astronaut (or the internal program) initiates the sequence by selecting VERB 25, "load 3 components of:"(any 3-component noun will do). The Verb Code is changed to 21, "load first component of:" and the flash is turned on. VERB 21 continues to be flashed as the astronaut punches in the first word of data. When the ENTR is pressed, the Verb Code is changed to 22. Flashing continues while the astronaut punches the second data word. When ENTR is pressed, the Verb Code is changed to 23, "load third component," and again the flash continues while the third data word is punched in. When ENTR is pressed, the flash is turned off, and all three data words are placed in the locations specified by the Noun. Throughout the changing of the Verb Codes, the Noun Code is left unchanged.

The CLR button is used during data loading to remove errors in R1, R2, or R3. It allows the astronaut to begin loading the data word again. It does not clear the Program, Noun, or Verb lights. (The Noun lights are blanked by the NOUN key; the Verb lights, by the VERB key.) In the following discussions, the term Clearing Function will be used to mean blanking the data display register.

For single component Load Verbs, the CLR button depression performs the Clearing Function on whichever register is being loaded, provided that the CLR is punched before the data ENTR. Once the ENTR is depressed, the CLR does nothing. The only way to correct an error after the data ENTR for a single component Load Verb is to begin the Load Verb again.

For the 2- or 3- component Load Verbs, there is a backing-up feature of CLR. The first depression of the CLR key performs the Clearing Function on whichever register is being loaded. (The CLR may be pressed after any character, but before its ENTR.) Consecutive depressions of CLR perform the Clearing Function on the data display register above the current one, and also changes the VERB light to indicate the register being acted upon until R1 is cleared. Any attempts to back up beyond R1 are simply ignored.

The backing-up of CLR operates only on whatever data is pertinent to the Load Verb which initiated the loading sequence. For example, if the initiating Load Verb was a load second component only, no backing-up action is possible.

4.2.2.7 Please Perform - Verb/Noun Flashing

This is always an internally initiated action, as astronaut response is always required to the "please perform" request; the Verb-Noun is always flashed, and the Program is interrupted. The "please perform" verb (50) is usually used with the "Checklist" noun (25) with an appropriate "checklist code" number in R1. The appropriate response is:

(a) PRO to indicate an affirmative response to the request.

(b) ENTR to indicate a negative response to the request.

4.2.2.8 Please Mark

The "please mark" verbs (52, 53, or 54) are flashed when the LGC is prepared to accept optical sighting data upon the pushing of a "MARK" button. The logic associated with the "please mark" function is completely described in Section 4.4.9.

4.2.2.9 Machine Address to be Specified

There is a class of noun available to allow any machine address to be used. These are called "Machine Address to be Specified" nouns. When the ENTR which causes the Verb-Noun combination to be executed senses a noun of this type, R3 is blanked and the flash is immediately turned on. The Verb Code is left unchanged. The astronaut should load the 5-octal-character complete machine address of interest. It is displayed in R3 as it is punched in. If an error is made in loading the address, the CLR may be used to remove it. Pressing ENTR causes the verb to be executed.

4.2.2.10 Program Selection

VERB 37 ENTR is used to select a Program. This causes the Noun display register to be blanked and the Verb Code to be flashed. The 2-character Program Code would then be loaded. For verification purposes, it is displayed as it is loaded in the Noun display register. The ENTR causes 1) the flash to be turned off, 2) the Noun register to be blanked, 3) a request for the new Program to be entered, and 4) the new Program Code to be displayed (if allowed) in the Program display register.

4.2.2.11 Illegal Verbs, Nouns and Combinations

The simplest alarm situation is an attempt to use an undefined (or spare) Verb Code or Noun Code. The OPR ERR light is turned on when the ENTR that attempts to execute the Verb/Noun combination is pressed. No further action is taken.

It is possible to choose a Verb that is defined and a Noun that is defined, but have the combination of Verb and Noun be illegal (for example, the "decimal display" Verb used with a Noun which is restricted to be "octal only"). The OPR ERR light is turned on at the ENTR that attempts to execute the Verb/Noun combination for display verbs and at the ENTR following the final data load for load verbs. No further action is taken.

Violation of the following principles causes the OPR ERR light to be turned on. No further action is taken.

(a) An undefined (or spare) verb must not be used.

(b) An undefined (or spare) noun must not be used.

(c) In octal Display and Monitor Verbs and all Load verbs, the components number of the verb must not exceed the number of components in the noun. (Note, all "machine address to be specified" nouns are considered 3-component.)

(d) The octal Display and Monitor Verbs must not be used with a "decimal only" noun.

(e) The decimal Display and Monitor Verbs must not be used with an "octal only" noun.

(f) The double precision decimal Display and Monitor Verbs (07,17) must not be used with mixed nouns (codes 40-99).

(g) No Load Verb may be used with a noun restricted to be "no load". All nouns having split MIN/SEC scale or .2 integers for any component are "no load" for the entire noun. (This does not apply to V21,V22, or V23 except for the specific components.)

(h) No input code other than those which are defined may be punched into the keyboard.

4.2.2.12 Illegal Data and Recycle

Many legal Verb/Noun combinations require the loading of additional data (either numerical or machine address). It is possible that the data supplied may itself be improper for the Noun selected. Examples are: (1) the numerical data exceeds the maximum value allowed by the scale factor associated with the Noun, and (2) decimal data is loaded into an "octal only" noun.

In general the offense is detected at the final ENTR of the loading sequence. The alarm is turned on and a recycle is performed back to the beginning of the loading sequence. The flash is left on, and the data display register associated with the first data word in the sequence is blanked again. It is necessary for the operator

only to supply the data again; he need not attempt to re-execute the Verb/Noun combination. (Note, if decimal data is supplied for the address of a "machine address to be specified" noun, the alarm and recycle are performed at the ENTR immediately following the address keyed in.)

Violation of the following principles causes the OPR ERR light to be turned on, and a recycle to be performed:

(a) The address keyed in for a "machine address to be specified" noun must be octal.

(b) In multicomponent load verbs, no mixing of octal and decimal data is permitted. All the data words loaded for a given noun must either be all octal or all decimal.

(c) Octal data must not be loaded into a "decimal only" noun.

(d) Decimal data must not be loaded into an "octal only" noun.

(e) Decimal data loaded must not numerically exceed the maximum permitted by the scale factor associated with the appropriate component of the noun.

(f) All 3 words must loaded for the Hours, Minutes, Seconds scale.

(g) When loading with the Hours, Minutes, Seconds scale, the minutes must not exceed 59; the seconds must not exceed 59.99; and the total magnitude must not exceed 745 hours, 39 minutes, 14.55 seconds.

(h) Two numerical characters must be supplied for the Program Code under V37.

4.2.2.13 Operator Error and Key Rejection

There are five situations which cause the OPR ERR light to be turned on and the offending key depression to be simply rejected. These are:

(a) An 8 or 9 is punched while loading a word which was not preceded by a plus or minus sign. The 8 or 9 is simply rejected. The remaining characters may then be supplied or the offending word removed and its loading begun again.

(b) Certain program controlled cases (see Section 4.4.9).

(c) The PRO button may not be pressed when the VERB lights contain verb 21, 22 or 23.

(d) An attempt to call one extended verb on top of another without allowing proper termination of the first.

(e) Neither V30E or V31E can be called if R1 of N26 is zero.

4.2.2.14 Priority Displays

When the LGC attempts to display a Priority display the PRIO DISP light is turned ON. The LGC will accept a response of PRO, V33E, V32E, or V34E after 2 sec. which will reset the light. A response of V37EXXE, V56E or V36E will also reset the light, no delay required. The PRIO DISP light is also set and subsequently reset by the DSKY light test routine (V35E).

TABLE 4-1 Astronaut Response to DSKY Displays and LGC Resultant Action.

	DISPLAY OF INFORMATION		REQUEST FOR ASTRO ACTION	REQUEST FOR DATA LOAD	REQUEST FOR OPTICS MARK
	Type of information identified by V__N__ followed by up to three available registers of information, R1, R2, R3		Request identified by V99 (please enable engine on), V97 (perform engine fail procedure), V37 (please select program) or V50 (please perform checklist)identifying a function to be performed or a checklist, one register R1 identifying function on that checklist.	Request identified by V__ and type of data by N__. Loaded data appears in registers R1, R2, R3. At completion key in "ENTR".	Request identified by V52, V53 or V54.
	LGC Awaiting ASTRO Response	LGC Not Awaiting ASTRO	LGC Always Awaiting ASTRO Response	LGC Always Awaiting ASTRO Response	LGC Always Awaiting ASTRO Response
ASTRONAUT RESPONSE	V__N__ Flashing	V__N__ Static	VXXN__ Flashing	V__N__ Flashing	V52, V53, or V54 Flashing
Key in "ENTR"	No LGC Action	No LGC Action	LGC assumes ASTRO did not comply, terminates flashing Verb-Noun, and continues.	AGC takes loaded data, terminates flashing Verb-Noun and continues.	1. Change MARK REJECT option 2. For V52/V53 change MARK option.
Key in "PRO"	LGC assumes displayed data is correct, terminates flashing Verb-Noun, and continues.	No LGC Action	LGC assumes ASTRO complied, terminates flashing Verb-Noun, and continues.	Varies with program in process	Marking sequence is terminated
Key in VERB 34 ENTR (terminate)	Varies with program in progress.	No LGC Action	Varies with program in process.	Varies with program in process.	Program in progress is terminated.
Key in VERB 32 ENTR (recycle)	LGC returns to earlier point in sequence.	No LGC Action	Incorrect Response.	Incorrect Response	Discard mark data on present target and return to earlier point in sequence
Press appropriate "MARK X" button or "MARK Y" button for FL54. For FL52/53 press either button or actuate ROD control when requested sighting is made.					For V54 LGC reads CDU angles and time and redisplays mark request V54. For V52/V53 LGC reads 3 CDU angles and time and displays V21/22N79 requesting cursor/spiral angle key in.

☒ Revised ☐ Added LUMINARY 1E GSOP # R567 PCN # 1180 PCR # Rev. 10

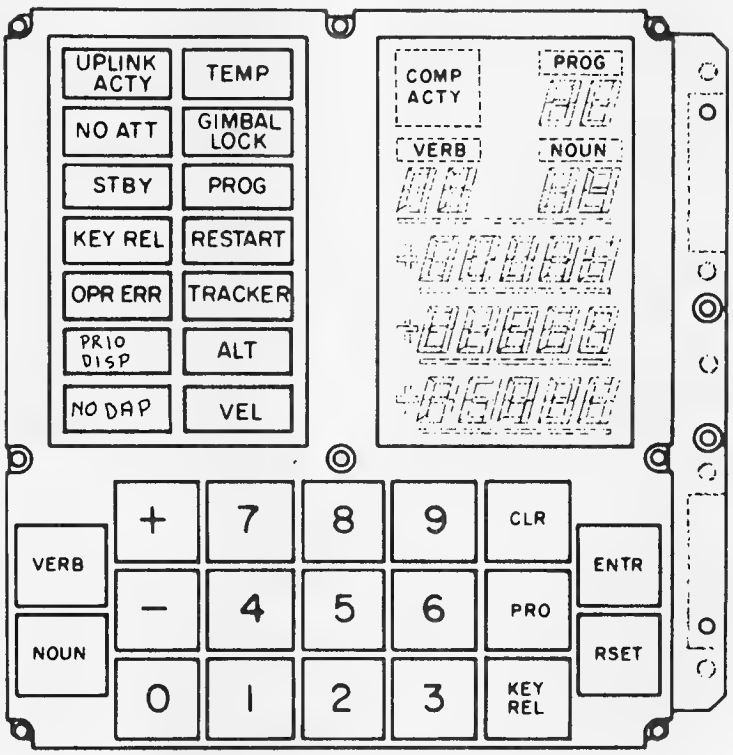

Fig. 4-1 Display and Control Panel

4.3 PGNCS Failure Monitor

The PGNCS performance and operational readiness are self-monitored and caution and warning information are displayed to the crew. Two warning (red) lamps are actuated by the PGNCS on the Caution/Warning Panel: LGC Warning indicates computer failure; ISS warning indicates failure of the inertial subsystem. Further detail regarding the caution items is displayed by means of the DSKY event lamps and the DSKY data registers (in the event of a program alarm.)

4.3.1 LGC Warning

An LGC warning alarm is generated in the event of LGC power failure, scaler failure of either of two types, restart or counter fail during LGC operate, or in response to an alarm test program. A scaler fail or prime power fail result in an immediate alarm indication whereas the other inputs are buffered by a filter so as to prevent momentary transient disturbances from causing a warning alarm. In this subsection the various inputs and conditions associated with LGC warning are defined.

(a) SCAFAL - Occurs if scaler stage 17 (1.28-sec period) fails to produce pulses. This provides a check on the timing for all logic alarms.

(b) COUNTER FAIL - Occurs if counter increments happen too frequently or else fail to happen following an increment request. "Too frequently" means continuous counter requests and/or incrementing for from 0.625 to 1.875 ms.

(c) SCADBL - Occurs if the 100 pps scaler stage operates at a pulse rate of 200 pps or more.

(d) PARITY FAIL - Occurs if any accessed word in fixed or erasable memory whose address is octal 10 or greater contains an even number of "ones".

(e) RUPT LOCK - Occurs if interrupt is either too long or too infrequent. The criterion for "too long" is phase dependent, varying from 140 ms to 300 ms. Likewise the criterion for "too infrequent" varies from 140 ms to 300 ms.

(f) TC TRAP - Occurs if too many consecutive TC or TCF instructions are run, or TC or TCF instructions are too infrequent. The criterion for "too many" varies from 5 ms to 15 ms duration. The criterion for "too infrequent" varies from 5 ms to 15 ms absence.

(g) NIGHT WATCHMAN - Occurs if the computer should fail to access address octal 67 within a period whose duration varies from 0.64 sec to 1.92 sec.

(h) V FAIL - Occurs if the LGC voltages (28, 14, 4)are out of limits. This signal produces STRT1 if it stays on for a period of between 157 and 470 μsec. If the computer is in the STANDBY mode, an input to the LGC WARNING FILTER is generated simultaneously with STRT1. The following criteria apply for V FAIL:

4 V Supply > 4.4 V	14 V Supply > 16 V
4 V Supply < 3.65 V	14 V Supply < 12.5 V
	28 V Supply < ~22.6V

(i) STANDBY - This is a signal which turns on RESTART and turns off the switchable +4 and +14 voltage, thus putting the LGC into a low power mode where only the scaler, timing signal, and a few auxiliary signals are operative. STANDBY is initiated by first setting the ENABLE STANDBY outbit (CH13 B11), and then pressing the PRO button on the DSKY for a time which varies from 0.64 sec to 1.92 sec. at the end of which time the STANDBY light is turned on.. (All LGC alarms are inhibited during the Standby mode with the exception of LGC WARNING, which can be caused by VOLTAGE FAIL or SCALER FAIL; and TEMPERATURE CAUTION, which can be caused by TEMP ALARM.) Normal operation is resumed by pressing the PRO Button on the DSKY again, time of depression same as above.

(j) RESTART - RESTART occurs after any of the following: RUPT LOCK, TC TRAP, NIGHT WATCHMAN, PARITY FAIL, STANDBY, VOLTAGE FAIL.

RESTART causes the computer to transfer control to address octal 4000 as soon as it disappears. It lights the RESTART lamp in the DSKY.

The RESTART lamp is turned off either by the ALARM RESET (RSET) key, or by setting outbit CH11 B10.

(k) WARNING FILTER - This circuit is used to operate the LGC WARNING output following repeated or prolonged occurrences of any of certain failure parameters. All occurrences of these signals are stretched so that no more than one input to the filter is generated in each 160 - millisecond period. Approximately six consecutive stretched pulses cause LGC WARNING to turn on for

about 5 seconds. Non-consecutive stretched pulses may also cause LGC WARNING after an interval dependent on the frequency of the pulses. The output will not occur if input pulses occur at a frequency of less than 0.9 pps; and the output will remain on if pulses occur at a frequency of 0.6 pps or more. The threshold of the filter resumes its normal level with a time constant of many seconds after the filter has received inputs. An immediate reset of the LGC FAIL due to a WARNING FILTER output is therefore not possible.

(1) OSCILLATOR FAIL - Occurs if the oscillator stops. Has nominal 250-millisecond delay to keep signal present after the oscillator starts. Also occurs when LGC is in STANDBY because of loss of power to front end of circuit. This results in a 250-millisecond delay in starting when LGC comes out of STANDBY into OPERATE. Causes immediate restart without waiting for time pulse 12.

4.3.2 ISS Warning

The ISS Warning signal is the logical "OR" of the following parameters, any one of which will cause an ISS Warning under the following conditions:

(a) IMU Fail

(1) IG Servo Error - greater than 2.9 mr for 2 sec

(2) MG Servo Error - greater than 2.9 mr for 2 sec

(3) OG Servo Error - greater than 2.9 mr for 2 sec

(4) 3200 cps - decrease to 50% of normal voltage level

(5) 800 cps wheel supply - decrease to 50% of normal voltage level

These parameters are generated in the Inertial Subsystem. However, the "FAIL" signal itself is under LGC program control. The "FAIL" signal is inhibited by the LGC program when the PGNCS is in the Coarse Align Mode and during the 5-second interval following Coarse Align. During this mode the servo errors normally exceed the above criteria.

(b) PIPA FAIL

Occurs if no pulses arrive from a PIPA during a 312.5 μsec period, or else if both plus and minus pulses occur, or if a "long time" elapses without at least one plus pulse and at least one minus pulse arriving. By "long time" is meant a period of between 1.28 sec and 3.84 sec.

This FAIL signal is generated totally within the LGC and thus is completely under LGC program control. Its generation is enabled by the LGC only during LGC controlled translation or thrusting maneuvers.

(c) ISS CDU FAIL (Monitored for each of 3 CDUs). Set if any or all of the following conditions exist for approximately 2-10 seconds.

(1) CDU fine error - in excess of 1.0 V rms

(2) CDU coarse error - in excess of 2.5 V rms

(3) READ COUNTER limit cycle - in excess of 160 cps

(4) Cos ($\theta - \phi$) - below 2.0 V

(5) +14 VDC Supply - decrease to 50% of normal level

These parameters are generated in the Inertial Subsystem. However, the response to the "FAIL" signal itself is under LGC program control. The "FAIL" signal is ignored by the LGC program for about 8 seconds after the CDU ZERO mode has been commanded. During this Mode the CDU errors normally exceed some of the above criteria.

4.3.3 PGNCS Caution

The PGNCS Caution lamp is actuated by the following undesirable but non-critical events:

(a) LGC Restart during Operation. In the event of Restart during operate a latch is set in the LGC which maintains the PGNCS Caution alarm and the RESTART lamp on the DSKY until the latch is reset by the program or until the latch is manually reset by ALARM RESET. For further detail see section 4.3.4.

(b) Temperature out of Limits. The LGC receives a signal from the IMU when the stable member temperature is in the range 126.3° F to 134.3°F. In the absence of this signal, the Caution alarm and the TEMP lamp on the DSKY are actuated.

(c) Gimbal Lock. When the LGC determines that the middle gimbal angle (MGA) of the IMU is greater than 70°, the Caution alarm and the Gimbal Lock lamp on the DSKY are actuated. When MGA exceeds 85° the ISS is downmoded to Coarse Align and the No Attitude lamp on the DSKY is actuated.

(d) Program Alarm. Under a variety of situations a program alarm is generated. One example is that of a PIPA fail when the vehicle is not in a thrusting mode. Under program control the LGC inhibits this alarm for 10 sec after system turn-on. The program alarm actuates

the Caution alarm and the Program lamp on the DSKY. For further information see section 4.3.4.

(e) Tracker Alarm indicates Rendezvous Radar CDU failures or loss of DATA GOOD discrete (see paragraph 4.2.2.1-8).

4.3.4 Restart and Program Alarms

(a) Alarm conditions are indicated by lighting the PROG ALARM light and storing the appropriate alarm code so that it may be examined by keying V05N09E. In some special cases V05N09 is automatically displayed. The light is turned off and R1, R2 of N09 are cleared by the ERROR RESET key. For non-ABORT alarm conditions the normal program flow is not interrupted.

(b) The ABORT type of alarm conditions preclude continuation of normal program flow; in these special cases recovery from the condition is accomplished by the software by means of a "software restart". These ABORT conditions are divided into two classes:

1. "BAILOUT" alarms, designated by a five-digit alarm code with 3 as the first digit, e.g. 31201.
   These alarms cause suspension of non-restartable program activity and continuation of only that program activity which is restartable. This type of alarm condition is generally due to temporary overloading of the system; the BAILOUT procedure will relieve the situation and allow continuation of the program.
2. "POODOO" alarms, designated by a five-digit alarm code with 2 as the first digit, e.g., 21302.
   These alarms are caused by conditions which are less likely to be correctable than the "BAILOUT" alarm conditions, e.g. inconsistencies in mathematical calculations. Software recovery terminates current program flow and a flashing V37 is displayed, requesting the astronaut to exit the current program.
   If an Extended Verb is active, the "BAILOUT" recovery procedure is followed to prevent Extended Verb Routines from terminating mission programs. In this instance, the POODOO alarm code is retained.

If "Average G" is active, POODOO alarms will retain the basic "Average G" cycle (without guidance functions). During the Powered Descent, the Abort monitor is also retained, but the LR navigation (R12) is terminated.

(c) Exit from a continuous "BAILOUT" loop can be accomplished by simultaneous depression of the ERROR RESET and MARK REJECT buttons, as in the case of a hardware restart loop. Exit from either a hardware or a software restart loop by means of the above will cause reinitialization of the software by a Fresh Start. The listing of program alarms is included in section 4.4.7.

4.3.5 Restart Protection

With the exception of P06 and the pulse torquing option of P52 all programs are restart protected. All routines which are called by a program are restart protected. The restart logic is designed so that as much significant information as possible is not lost due to a restart. Extended verb routines and manually called displays are not restart protected.

4.4 LGC Logic/Ground/Crew Interface Diagrams

These diagrams outline the detailed logic of the inter-relationship between the LGC/Crew/Ground. For ease of correction and reproduction the diagrams have been incorporated in a computer memory and are presented as a computer printout.

The diagrams contain the following:

1) Program Control - Indication of sequence interruptions and the following display notation:
   a) PRIO (Priority) - denotes a priority display
   b) HOLD - denotes that the verb-noun and data will continue to be displayed until the astronaut takes DSKY action.
   c) TEMP HOLD (Temporary HOLD) - denotes that the duration of the display on the DSKY (non-flashing) is controlled by the LGC.
   d) POSS HOLD (Possible HOLD) - denotes that the display is a possible path taken by the LGC.
   e) MON (Monitor) - denotes that the displayed data is automatically updated and displayed by the LGC.
   f) SNAP - denotes that the displayed data is not automatically updated (monitored) by the LGC.

2) LGC
3) Ground
4) Crew

   } The sequence logic and interface relationships of the LGC logic, ground operations and crew activities.

5) A line count is provided on the right hand side of the page.
6) The LGC Program (or Routine) number is printed on the lower right hand corner of each page eg.: P40/LUMINARY.

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************************************************************************************************************************
************************************************************************************************************************
************************************************************************************************************************

LL            UU         UU   MM          MM   II   NN          NN    AAAAAAAAAA    RRRRRRRRRR     YY          YY
LL            UU         UU   MM         MMM   II   NN          NN   AAAAAAAAAAAA   RRRRRRRRRRR     YY        YY
LL            UU         UU   MMMM      MMMM   II   NNNN        NN   AA        AA   RR         RR    YY      YY
LL            UU         UU   MM MM    MM MM   II   NN NN       NN   AA        AA   RR         RR     YY    YY
LL            UU         UU   MM  MMMM   MM    II   NN   NN     NN   AA        AA   RR         RR       YYYY
LL            UU         UU   MM    MM     MM  II   NN    NN    NN   A LUMINARY A   RRRRRRRRRRR          YY
LL            UU         UU   MM           MM  II   NN      NN  NN   A LUMINARY A   RRRRRRRRRR           YY
LL            UU         UU   MM           MM  II   NN       NN NN   AA        AA   RR     RR            YY
LL            UU         UU   MM           MM  II   NN        NNNN   AA        AA   RR      RR           YY
LL            UU         UU   MM           MM  II   NN         NNN   AA        AA   RR       RR          YY
LLLLLLLLLLLL   UUUUUUUUUUU    MM           MM  II   NN          NN   AA        AA   RR        RR         YY
LLLLLLLLLLLL     UUUUUUUUU    MM           MM  II   NN          NN   AA        AA   RR         RR        YY

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4.4.1 PROGRAMS AND ROUTINES DIAGRAMMED IN SECTIONS 4.4.9 AND 4.4.10 FOR PROGRAM LUMINARY

REV 05 12/01/71

PHASE	PROGRAM NUMBER	PROGRAM TITLE	PCR
SERVICE	00	LGC IDLING	
	01	-----*	
	02	-----*	
	03	-----*	
	04	-----*	

	05	-----*
	06	LGC PJWER DOWN
	07	IMU PERFORMANCE TEST (PRELAUNCH CNLY) **
	08	-----*
	09	-----*
ASCENT	10	-----*
	11	-----*
	12	POWERED ASCENT
	13	-----*
	14	-----*
	15	-----*
	16	-----*
	17	-----*
	18	-----*
	19	-----*
COAST	20	RENDEZVOUS NAVIGATION
	21	GROUND TRACK DETERMINATION
	22	LUNAR SURFACE NAVIGATION
	23	-----*
	24	-----*
	25	PREFERRED TRACKING ATTITUDE
	26	-----*
	27	LGC UPDATE
	28	-----*
	29	-----*

PRE-THRUSTING	30	EXTERNAL DELTA V
	31	-----*
	32	CO-ELLIPTIC SEQUENCE INITIATION (CSI)
	33	CONSTANT DELTA ALTITUDE (CDH)
	34	TRANSFER PHASE INITIATION (TPI)
	35	TRANSFER PHASE MIDCOURSE (TPM)
	36	-----*
	37	-----*
	38	-----*
	39	-----*
THRUST-ING	40	DPS
	41	RCS
	42	APS
	43	-----*
	44	-----*
	45	-----*
	46	-----*
	47	THRUST MONITOR
	48	-----*
	49	-----*
ALIGN-MENTS	50	-----*
	51	IMU ORIENTATION DETERMINATION
	52	IMU REALIGN
	53	-----*
	54	-----*
	55	-----*

	56	-----*	
	57	LUNAR SURFACE ALIGN	
	58	-----*	
	59	-----*	
DES-CENT	60	-----*	
	61	-----*	
	62	-----*	
	63	BRAKING PHASE	
	64	APPROACH PHASE	
	65	-----*	
	66	LANDING PHASE	
	67	-----*	
	68	LANDING CONFIRMATION	
	69	-----*	
ABORTS AND BACKUPS	70	DPS ABORT	
	71	APS ABORT	
	72	CSM CO-ELLIPTIC SEQUENCE INITIATION (CSI) TARGETING	
	73	CSM CONSTANT DELTA ALTITUDE (CDH) TARGETING	
	74	CSM TRANSFER PHASE INITIATION (TPI) TARGETING	
	75	CSM TRANSFER PHASE MIDCOURSE(TPM) TARGETING	
	76	TARGET DELTA V	
	77	IMPULSIVE DELTA V	1180
	78	-----*	
	79	-----*	

ROUTINE	ROUTINE TITLE
00	FINAL AUTOMATIC REQUEST TERMINATE
01	ERASABLE AND CHANNEL MODIFICATION
02	IMU STATUS CHECK
03	DAP DATA LOAD
04	RR/LR SELF TEST
05	S-BAND ANTENNA
06	-----*
07	-----*
08	-----*
09	R10/R11/R12 SERVICE
10	LANDING ANALOG DISPLAYS
11	ABORT DISCRETES MONITOR
12	DESCENT STATE VECTOR UPDATE
13	LANDING AUTO MODES MONITOR
14	-----*
15	-----*
16	-----*
17	-----*
18	-----*
19	-----*
20	LR/RR READ
21	RR DESIGNATE
22	RR DATA READ
23	RR MANUAL ACQUISITION
24	RR SEARCH

25	RR MONITOR	
26	LUNAR SURFACE RR PRE-DESIGNATE	
27	-----*	
28	-----*	
29	-----*	
30	ORBITAL PARAMETERS DISPLAY	
31	RENDEZVOUS PARAMETER DISPLAY	
32	-----*	
33	LGC/CMC CLOCK SYNCHRONIZATION	
34	-----*	
35	-----*	
36	RENDEZVOUS OUT-OF-PLANE DISPLAY	
37	-----*	
38	-----*	
39	-----*	
40	DPS/APS THRUST FAIL	
41	STATE VECTOR INTEGRATION (MID TC AVE)	
42	-----*	
43	-----*	
44	-----*	
45	-----*	
46	-----*	
47	AGS INITIALIZATION	
48	-----*	
49	-----*	
50	COARSE ALIGN	
51	INFLIGHT FINE ALIGN	
52	AUTOMATIC OPTICS (LM) POSITIONING	1180
53	AOT MARK	

54	SIGHTING DATA DISPLAY	
55	GYRO TORQUING	
56	TERMINATE TRACKING	
57	MARKRUPT	
58	CELESTIAL BODY DEFINITION	
59	LUNAR SURFACE SIGHTING MARK	1180
60	ATTITUDE MANEUVER	
61	PREFERRED TRACKING ATTITUDE	
62	CREW-DEFINED MANEUVER	
63	RENDEZVOUS FINAL ATTITUDE	
64	-----*	
65	FINE PREFERRED TRACKING ATTITUDE	
66	-----*	
67	-----*	
68	-----*	
69	-----*	
70	-----*	
71	-----*	
72	-----*	
73	-----*	
74	-----*	
75	-----*	
76	EXTENDED VERB INTERLOCK	
77	LR SPURIOUS TEST	

* THIS PROGRAM OR ROUTINE DOES NOT EXIST FOR ASSEMBLY LUMINARY
** THIS PROGRAM IS DOCUMENTED IN SECTION 1 OF R557

ANGE CONTROL NOTES

REV 00 PCR 39
REV 01 PCR 79,105,106,138,229,468,470,562
REV 00(LUM 1A) PCR 722
REV 01(LUM 1B) PCR 279,823
REV 02(LUM 1C) PCR 285,806.2
REV 03(LUM 1D) PCR 892,988
REV 04(LUM 1E) PCR 348,1044, PCN 1145
REV 05(LUM 1E) PCN 1180

4.4.3 VERBS USED IN PROGRAM LUMINARY

4.4.3.1 REGULAR VERBS

REV C5 12/01/71

PCR

00 NOT IN USE
01 DISPLAY OCTAL COMP 1 IN R1
02 DISPLAY OCTAL COMP 2 IN R1
03 DISPLAY OCTAL COMP 3 IN R1
04 DISPLAY OCTAL COMP 1,2 IN R1,R2
05 DISPLAY OCTAL COMP 1,2,3 IN R1,R2,R3
06 DISPLAY DECIMAL IN R1 OR R1,R2 OR R1,R2,R3
07 DISPLAY DP DECIMAL IN R1,R2
08 SPARE
09 SPARE
10 SPARE
11 MONITOR OCTAL COMP 1 IN R1
12 MONITOR OCTAL COMP 2 IN R1
13 MONITOR OCTAL COMP 3 IN R1
14 MONITOR OCTAL COMP 1,2 IN R1,R2
15 MONITOR OCTAL COMP 1,2,3 IN R1,R2,R3
16 MONITOR DECIMAL IN R1 OR R1,R2 OR R1,R2,R3
17 MONITOR DP DECIMAL IN R1,R2
18 SPARE

19 SPARE

20 SPARE

21 LOAD COMPONENT 1 INTO R1

22 LOAD COMPONENT 2 INTO R2

23 LOAD COMPONENT 3 INTO R3

24 LOAD COMPONENT 1,2 INTO R1,R2

25 LOAD COMPONENT 1,2,3 INTO R1,R2,R3

26 SPARE

27 DISPLAY FIXED MEMORY

28 SPARE

29 SPARE

30 REQUEST EXECUTIVE

31 REQUEST WAITLIST

32 RECYCLE

33 PROCEED

34 TERMINATE

35 TEST LIGHTS (USAGE RESTRICTED TO P00)

36 REQUEST FRESH START (#)

37 CHANGE PROGRAM

38 SPARE

39 SPARE

# DENOTES THAT LOGIC FLOW IS DESCRIBED IN SEC 4.4.11

4.4.3.2 EXTENDED VERBS

		WHEN USED	PCR

40	ZERO CDUS (SPECIFY N20 OR N72)	#	(N20 AND N72)	
41	COARSE ALIGN CDUS (SPECIFY N20 OR N72)	#	(N20 AND N72)	
42	FINE ALIGN IMU	#		
43	LOAD FCAI ERROR NEEDLES (TEST ONLY)	#		
44	TERMINATE RR CONTINUOUS DESIGNATE	#		
45	SPARE			
46	SPARE			
47	INITIALIZE AGS (R47)			
48	START DAP DATA LOAD (R03)			
49	START CREW DEFINED MANEUVER (R62)		P00	
50	PLEASE PERFORM			
51	SPARE			
52	MARK CURSOR		R53	
53	MARK SPIRAL		R53	
54	MARK X OR Y RETICLE		R53	
55	INCREMENT LGC TIME (DECIMAL)	#	R33	
56	REQUEST TERMINATE TRACKING ROUTINE (R56)		P20,P22,P25	
57	PERMIT LANDING RADAR UPDATE	#	P63	
58	INHIBIT LANDING RADAR UPDATE	#		
59	COMMAND LR TO POSITION 2	#		
60	DISPLAY VEHICLE RATES	#		
61	DISPLAY DAP ATTITUDE ERROR	#		
62	DISPLAY TOTAL ATTITUDE ERROR	#		
63	START RR/LR SELF TEST ROUTINE (R04)			
64	START S-BAND ANTENNA ROUTINE(R05)			
65	DISABLE U,V JETS DURING DPS BURNS	#		
66	VEHICLES ATTACHED. MOVE THIS VEHICLE STATE VECTOR TO OTHER VEHICLE STATE VECTOR	#		
67	W MATRIX RSS ERROR DISPLAY	#	P20,P22	1180

68	INHIBIT TERRAIN MODEL COMPUTATIONS	#		
69	RESTART	#		
70	START LGC UPDATE; LIFTOFF TIME		P27	
71	START LGC UPDATE; BLOCK ADDRESS		P27	
72	START LGC UPDATE; SINGLE ADDRESS		P27	
73	START LGC UPDATE: LGC TIME (OCTAL)		P27	
74	INITIALIZE ERASABLE DUMP VIA DOWNLINK	#		
75	ENABLE U,V JETS DURING DPS BURNS	#		
76	MINIMUM IMPULSE COMMAND MODE	#		
77	RATE COMMAND AND ATTITUDE HOLD MODE	#		
78	START LR SPURIOUS TEST (R77)			
79	STOP LR SPURIOUS TEST (R77)			
80	ENABLE LM STATE VECTOR UPDATE	#	P20	
81	ENABLE CSM STATE VECTOR UPDATE	#	P20,P22	
82	REQUEST ORBITAL PARAMETERS DISPLAY (R30)		ANYTIME(P12, P40,P41,P42,P47)	
83	REQUEST RENDEZVOUS PARAMETER DISPLAY (R31)		ANYTIME(P47)	
84	SPARE			
85	DISPLAY RR LOS AZIMUTH AND ELEVATION	#	P12,P22,P57,P68	1180
86	SPARE			
87	SPARE			
88	SPARE			
89	START RENDEZVOUS FINAL ATTITUDE MANEUVER (R63)		P00	
90	REQUEST RENDEZVOUS OUT-OF-PLANE DISPLAY (R36)		P32,P33,P34,P35, P72,P73,P74,P75	
91	DISPLAY BANKSUM	#		
92	START IMU PERFORMANCE TESTS (GROUND USE)			
93	ENABLE W MATRIX INITIALIZATION	#	P20,P22	
94	SPARE			

95	NO UPDATE OF EITHER STATE VECTOR	#	P20,P22
96	INTERRUPT INTEGRATION AND GO TO P00	#	ANYTIME
97	PERFORM ENGINE FAIL PROCEDURE		R40
98	SPARE		
99	ENABLE ENGINE IGNITION		P12,P40,P42 P63,R40

DESIGNATES THOSE EXTENDED VERBS FOR WHICH
LOGIC FLOW IS DESCRIBED IN SECTION 4.4.11

CHANGE CONTROL NOTES

REV 01 PCR 8,99,118,164,173,229,246,420,468,470,539,623
REV 00(LUM 1A) PCR 762
REVS 01,02(LUM 1B) PCR 841,853
REV 03(LUM 1D) PCN 1035
REV 04(LUM 1E) PCR 1044
REV 05(LUM 1E) PCN 1180

4.4.4 NOUNS USED IN PROGRAM LUMINARY.

REV 06 12/01/71

NOUNS SPECIFIED AS BEING LOADABLE IN THIS DOCUMENT ARE MARKED (L). ALTHOUGH OTHER NOUNS MAY BE LOADABLE, WHETHER NEWLY LOADED DATA IS USED BY THE PROGRAM IS SUBJECT TO THE PARTICULAR CODING ASSOCIATED WITH THE USE OF THE NOUN.

NOUNS				WHEN USED	PCR
00	NOT IN USE				
01	SPECIFY ADDRESS (FRAC)	(L)	.XXXXX FRAC .XXXXX FRAC .XXXXX FRAC	P27,V91	
02	SPECIFY ADDRESS (WHOLE)	(L)	XXXXX. INTEG XXXXX. INTEG XXXXX. INTEG	P27	
03	SPECIFY ADDRESS (DEGREE)	(L)	XXX.XX DEG XXX.XX DEG XXX.XX DEG		
04	GRAVITY ERROR ANGLE		XXX.XX DEG	P57	
05	SIGHTING ANGLE DIFFERENCE		XXX.XX DEG	R22, R54	
06	OPTION CODE ID OPTION CODE CATCODE (P57)	(L,R2 ONLY)	OCT OCT OCT		
07	CHANNEL/FLAGWORD/ERASABLE OPERATOR	ECADR OR CHANNEL NO. BIT ID ACTION	(L, SEE R01 FOR USE AND RESTRICTIONS) OCT OCT OCT	ANYTIME WITH V25	1180
08	ALARM DATA	ADRES BBCON ERCOUNT	OCT OCT OCT	ANYTIME WITH V05	
09	ALARM CODES	FIRST SECOND LAST	OCT OCT OCT	ANYTIME WITH V05	
10	CHANNEL TO BE SPECIFIED (L,EXCEPT CHANNEL 7)		OCT	ANYTIME WITH V01,V11, OR V21	
11	TIG(CSI)	(L)	00XXX. HRS	P32,P72	

			OOOXX. MIN OXX.XX SEC		
12	OPTION CODE ID(USED BY EXT VERBS ONLY) OPTION CODE (L,R2 ONLY)		OCT OCT	R04,R30,R63,V41N72	1187
13	TIG(CDH)	(L)	OOXXX. HRS OOOXX. MIN OXX.XX SEC	P33,P73	
14	CHECKLIST (USED INTERNALLY BY EXTENDED VERBS ONLY) (N25 IS PASTED AFTER DISPLAY. N14 IS NEVER VISIBLE TO THE CREW.)		XXXXX. XXXXX. XXXXX.		
15	INCREMENT ADDRESS	(L,WITH NO1,02,03)	OCT		
16	TIME OF EVENT (USED BY EXTENDED VERBS ONLY)	(L)	OOXXX. HRS OOOXX. MIN OXX.XX SEC	R36,R47	
17	SPARE				
18	DESIRED AUTO MANEUVER FDAI BALL ANGLES		R XXX.XX DEG P XXX.XX DEG Y XXX.XX DEG	R60,R63	
19	SPARE				
20	PRESENT ICDU ANGLES		OG XXX.XX DEG IG XXX.XX DEG MG XXX.XX DEG	ANYTIME WITH V06	
21	PIPAS		X XXXXX. PULSES Y XXXXX. PULSES Z XXXXX. PULSES	ANYTIME WITH V06	
22	DESIRED ICDU ANGLES	(L)	OG XXX.XX DEG IG XXX.XX DEG MG XXX.XX DEG	P51,P52,P57,R62,V41N20,V43	
23	SPARE				
24	DELTA TIME FOR LGC CLOCK	(L)	OOXXX. HRS OOOXX. MIN OXX.XX SEC	V55	
25	CHECKLIST (USED WITH V50)		XXXXX.		
26	PRIO/DELAY,ADRES,BBCON	(L,WITH V30,31)	OCT OCT OCT		
27	SELF TEST ON/OFF SWITCH	(L)	XXXXX.		
28	SPARE				

29	SPARE				
30	SPARE				
31	SPARE				
32	TIME FROM PERIGEE		00XXX. HRS 000XX. MIN 0XX.XX SEC	R30	
33	TIG	(L)	00XXX. HRS 000XX. MIN 0XX.XX SEC	P12,P22,P30,P76,P77	I180
34	TIME OF EVENT	(L)	00XXX. HRS 000XX. MIN 0XX.XX SEC	P21,P52,P57	
35	TFI		00XXX. HRS 000XX. MIN 0XX.XX SEC		
36	TIME OF LGC CLOCK		00XXX. HRS 000XX. MIN 0XX.XX SEC		
37	TIG (TPI)	(L)	00XXX. HRS 000XX. MIN 0XX.XX SEC	P32,P34,P72,P74	
38	SV INTEGRATION TIME (TET)		00XXX. HRS 000XX. MIN 0XX.XX SEC	ANYTIME	
39	SPARE				
40	TIME FROM IGNITION/CUTOFF VG DELTA V (MEASURED)		XXBXX MIN/SEC XXXX.X FPS XXXX.X FPS	P40,P41,P42	
41	NAV BASE AZIMUTH NAV BASE LATITUDE	(L)	XXX.XX DEG XX.XXX DEG	SYSTEM TEST	
42	APO ALT PER ALT DELTA V		XXXX.X NM XXXX.X NM XXXX.X FPS	P30	
43	LATITUDE LONGITUDE ALTITUDE		XXX.XX DEG (+ NORTH) XXX.XX DEG (+ EAST) XXXX.X NM	P21,P68	
44	APO ALT PER ALT TFF		XXXX.X NM XXXX.X NM XXBXX MIN/SEC	R30	
45	MARKS (M)		XXXXX.	P30,P32,P33,P34,P35	

	TFI		XXBXX MIN/SEC	P72,P73,P74,P75	
	YSA		XXX.XX DEG		
46	DAP CONFIG	(L)	OCT	R03,R11,P66,P40,P63,P70,P71	
	CHANBKUP		OCT		
47	THIS VEHICLE WT	(L)	XXXXX. LBS	R03	
	OTHER VEHICLE WT		XXXXX. LBS		
48	GIMBAL PITCH TRIM	(L)	XXX.XX DEG	R03 (LOAD POSITIVE NON-ZERO ONLY)	
	GIMBAL ROLL TRIM		XXX.XX DEG		
49	DELTA R		XXX.XX NM	R22	
	DELTA V		XXXX.X FPS		
	SOURCE CODE		XXXXX.		
50	SPARE				
51	S BAND ANT PITCH (ALPHA)		XXX.XX DEG	R05	
	S BAND ANT YAW (BETA)		XXX.XX DEG		
52	CENTRAL ANGLE OF ACTIVE VEHICLE		XXX.XX DEG	P34,P35,P74,P75	
53	SPARE				
54	RANGE		XXX.XX NM	P20,P22,R31	
	RANGE RATE		XXXX.X FPS		
	THETA		XXX.XX DEG		
55	NO OF APSIDAL CROSSINGS (N)	(L)	XXXXX.	P32,P34,P72,P74	
	ELEVATION ANGLE (E)		XXX.XX DEG		
	CENTRAL ANGLE (CENTANG)		XXX.XX DEG		
56	RR LOS AZIMUTH		XXX.XX DEG	P12,P22,P57,P68,V85	
	RR LOS ELEVATION		XXX.XX DEG		
57	SPARE				
58	PERIGEE ALTITUDE (POST TPI)		XXXX.X NM	P34,P74	
	DELTA V (TPI)		XXXX.X FPS		
	DELTA V (TPF)		XXXX.X FPS		
59	DELTA V LOS		XXXX.X FPS	P34,P35,P74,P75	
			XXXX.X FPS	WITH V06 OR V16	1180
			XXXX.X FPS		
60	FORVEL		XXXX.X FPS	P66	
	H DOT		XXXX.X FPS		
	H		XXXXX. FT		
61	TG		XXBXX MIN/SEC	P63	
	TFI		XXBXX MIN/SEC		
	CROSSRANGE		XXXX.X NM		
62	VI		XXXX.X FPS	P63	
	TFI		XXBXX MIN/SEC		
	DELTA V (MEASURED)		XXXX.X FPS		

63	DELTA H	XXXXX. FT	P63	
	H DOT	XXXX.X FPS		
	H	XXXXX. FT		
64	TIME LEFT FOR REDESIGNATIONS (TR)/LPD	XXBXX SEC/DEG	P64	
	H DOT	XXXX.X FPS		
	H	XXXXX. FT		
65	SAMPLED LGC TIME	00XXX. HRS	R33, ANYTIME WITH V16 OR V06	
	(FETCHED IN INTERRUPT)	000XX. MIN		
		0XX.XX SEC		
66	LR SLANT RANGE	XXXXX. FT	R04 (LR POSITION ANYTIME WITH V06 OR V16)	
	LR POSITION	0000X.		
67	LR VX	XXXXX. FPS	R04	
	LR VY	XXXXX. FPS		
	LR VZ	XXXXX. FPS		
68	HOR RANGE TO LS	XXXX.X NM	P63,P64,P66 WITH V06 OR V16	
	TG	XXBXX MIN/SEC		
	VI	XXXX.X FPS		
69	LAND DELTA Z COMPONENT (L)	XXXXX. FT	P63	
	LAND DELTA Y COMPONENT	XXXXX. FT		
	LAND DELTA X COMPONENT	XXXXX. FT		
70	AOT DETENT CODE/STAR CODE (L)	OCT	R52,R59	
71	AOT DETENT CODE/STAR CODE (L)	OCT	R53,R59	1180
	X(OR CURSOR) MARK COUNTER AND REJECT POINTER	OCT		
	Y(OR SPIRAL) MARK COUNTER AND REJECT POINTER	OCT		
72	RR TRUNNION ANGLE	XXX.XX DEG	P20,R04, ANYTIME WITH	1180
	RR SHAFT ANGLE	XXX.XX DEG	V06 OR V16 (IF RR IN LGC MODE)	
73	DESIRED RR TRUNNION ANGLE (L)	XXX.XX DEG	V41N72	
	DESIRED RR SHAFT ANGLE	XXX.XX DEG		
74	TFI	XXBXX MIN/SEC	P12	
	YAW	XXX.XX DEG		
	PITCH	XXX.XX DEG		
75	DELTA ALTITUDE CDH	XXXX.X NM	P32,P33,P72,P73	1180
	DELTA TIME (CDH-CSI OR TPI-CDH)	XXBXX MIN/SEC		
	DELTA TIME (TPI-CDH OR TPI-NOMTPI)	XXBXX MIN/SEC		
	(NOTE: R2 AND R3 ARE MODULARIZED TO THE HOUR; I.E. 63 MINS 22 SECS IS DISPLAYED AS 03B22 EXCEPT THAT IF R2 IS NEGATIVE IN P33 OR P73 IT IS LIMITED INSTEAD, I.E. -63 MIN. 22 SEC. IS DISPLAYED AS -59B59.)			
76	DOWNRANGE VELOCITY (VHF) (L)	XXXX.X FPS	P12,P70,P71	
	RADIAL VELOCITY (H DOT F)	XXXX.X FPS		

	CROSSRANGE			XXXX.X NM		
77	TG			XXBXX MIN/SEC	P12,P70,P71	
	VGY(LM)			XXXX.X FPS	ANYTIME WITH V66 OR V16	
	VI			XXXX.X FPS		
78	RR RANGE			XXX.XX NM	R04,R65	1180
	RR RANGE RATE			XXXX.X FPS		
	TFI			XXBXX MIN/SEC.		
79	CURSOR ANGLE	(L)		XXX.XX DEG	R57,R59	
	SPIRAL ANGLE			XXX.XX DEG		
	POSITION CODE			XXXXX.		
80	DATA INDICATOR			XXXXX.	R24	
	OMEGA			XXX.XX DEG		
81	DELTA VX(LV)	(L)		XXXX.X FPS	P30,P32,P33,P34,P35,P40,P41,P42,	
	DELTA VY(LV)			XXXX.X FPS	P72,P73,P74,P75,P77	1180
	DELTA VZ(LV)			XXXX.X FPS		
82	DELTA VX(LV)			XXXX.X FPS	P32,P72	
	DELTA VY(LV)			XXXX.X FPS		
	DELTA VZ(LV)			XXXX.X FPS		
83	DELTA VX(LM)			XXXX.X FPS	P47	
	DELTA VY(LM)			XXXX.X FPS		
	DELTA VZ(LM)			XXXX.X FPS		
84	DELTA VX(DV)	(L)		XXXX.X FPS	P76	
	DELTA VY(DV)			XXXX.X FPS		
	DELTA VZ(DV)			XXXX.X FPS		
85	VGX(LM)			XXXX.X FPS	P12,P40,P41,P42,P70,P71	
	VGY(LM)			XXXX.X FPS		
	VGZ(LM)			XXXX.X FPS		
86	VGX(LV)			XXXX.X FPS	P40,P41,P42	
	VGY(LV)			XXXX.X FPS		
	VGZ(LV)			XXXX.X FPS		
87	BACKUP OPTICS LOS AZIMUTH	(L)		XXX.XX DEG	R52,R53,R59	
	BACKUP OPTICS LOS ELEVATION			XXX.XX DEG		
88	CELESTIAL BODY UNIT POSITION VECTOR	(L)	X	.XXXXX	R58	
			Y	.XXXXX		
			Z	.XXXXX		
89	LATITUDE	(L)		XX.XXX DEG	P52,P57	
	LONG/2			XX.XXX DEG		
	ALTITUDE			XXX.XX NM		
90	REND CUT OF PLANE PARAMETERS		Y	XXX.XX NM	R36	
			Y DOT	XXXX.X FPS		
			PSI	XXX.XX DEG		
91	ALTITUDE			XXXXX. NMX10	P21	1180

	VELOCITY		XXXXX. FPS		
	FLIGHT PATH ANGLE		XXX.XX DEG		
92	THRCMC		XXXXX. PCT	P63,P64,P66	
	H DOT		XXXX.X FPS		
	H		XXXXX. FT		
93	DELTA GYRO ANGLES	IL FOR V42 ONLY)	X XX.XXX DEG Y XX.XXX DEG Z XX.XXX DEG	P57,R55,V42	1180
94	VGX(LM)		XXXX.X FPS	P12,P70,P71	
	H DOT		XXXX.X FPS		
	H		XXXXX. FT		
95	SPARE				
96	SPARE				
97	SYSTEM TEST INPUTS	(L)	XXXXX. XXXXX. XXXXX.		
98	SYSTEM TEST RESULTS AND INPUT	(L)	XXXXX. .XXXXX XXXXX.		
99	RSS IN POSITION	(L)	XXXXX. FT	V67	1180
	RSS IN VELOCITY		XXXX.X FPS		
	RSS IN BIAS		XXXXX. MILLIRADIANS		

CHANGE CONTROL NOTES

REV 00 PCR 79
REV 01 PCR 9,99,106,138,173,254,407,469,472,490,540,614,623
REV 00(LUM 1A) PCR 268,270,695,732,736,738
REVS 01,02(LUM 1B) PCR 279,752,780,823,854,EDITORIAL
REV 03(LUM 1C) PCR 285,806.2,882, EDITORIAL
REV 04(LUM 1D) PCR 287,302.2,872.2,983, PCN 1009
REV 05(LUM 1E) PCR 317.2,334,339,1044,1066,1107,1109, PCN 1145
REV 06(LUM 1E) PCN 1180

4.4.5 CHECKLIST REFERENCE CODES USED WITH THE "PLEASE PERFORM CHECKLIST" REQUEST (VERB 50 NOUN 25) REV 03 02/17/71

R1 CODE	ACTION TO BE EFFECTED	WHEN USED	PCR
00013	KEY IN NORMAL OR GYRO TORQUE COARSE ALIGN	P52	
00014	KEY IN FINE ALIGNMENT OPTION	P57,R51	335
00015	PERFORM CELESTIAL BODY ACQUISITION	P51,R51,R59	
00016	PERFORM SIGHTING DATA REJECT OPTION	R53	1044
00062	SWITCH LGC POWER DOWN	P06	
00200	-	-	
00201	SWITCH RR MODE TO AUTOMATIC	P20,P22,R04	
00203	SWITCH GUIDANCE CONT TO PGNS, MODE TO AUTO, THR CONT TO AUTO	P12,P40,P42,P63,P70,P71	
00205	PERFORM MANUAL ACQUISITION OF CSM WITH RR	R23	
00500	SWITCH LR ANTENNA TO POSITION 1	P63	
00501	-	-	

SWITCH-DENOTES CHANGE POSITION OF A CONSOLE SWITCH

PERFORM-DENOTES START OR END OF A TASK

KEY IN-DENOTES KEY IN OF DATA THRU THE DSKY

CHANGE CONTROL NOTES

REV 01 PCR 134,470
REV 02 EDITORIAL
REV 03(LUM 1E) PCR 335,1044

REV C3 12/03/69

OPTION CODES/LUM

4.4.6 THIS LIST STATES THE OPTION CODES DISPLAYED IN R1 IN CONJUNCTION WITH VERB 04 NOUN 06 (OR V04N12 FOR EXTENDED VERBS OR V05 FOR P57) TO REQUEST THE ASTRONAUT TO LOAD INTO R2 THE OPTION HE DESIRES FOR PROGRAM LUMINARY. THE SPECIFIED OPTION CODES WILL BE DISPLAYED IN R1 IN CONJUNCTION WITH FLASHING V04-N06 (OR V04N12 FOR EXTENDED VERBS OR V05 FOR P57) TO REQUEST THE ASTRONAUT TO LOAD INTO R2 THE OPTION HE DESIRES.

R1

OPTION CODE	PURPOSE	INPUT FOR R2	WHEN USED	PCR
00001	SPECIFY IMU ORIENTATION	1=PREF, 2=NUM, 3=REFSMMAT, 4=LAND SITE	P52,P57	
00002	SPECIFY VEHICLE	1=THIS, 2=OTHER	P21,R30	
00003	SPECIFY TRACKING ATTITUDE	1=PREFERRED, 2=OTHER	R63	
00004	SPECIFY RADAR	1=RR, 2=LR	R04	
00006	SPECIFY RR COARSE ALIGN OPTION	1=LOCKON, 2=CONTINUOUS DESIG	V41N72	
00010	SPECIFY ALIGNMENT MODE	0=ANYTIME, 1=REFSMMAT +G, 2=TWO BODIES, 3=ONE BODY +G	P57	
00012	SPECIFY CSM ORBIT OPTION	1=NO ORBIT CHANGE, 2=CHANGE ORBIT TO PASS OVER LM	P22	

CHANGE CONTROL NOTES

REV C1 PCR 105,490
REV 02(LUM 18) PCR 279
REV 03 EDITORIAL

4.4.7 ALARM CODES USED WITH VERB 05 NOUN 09

REV 05 02/17/71

R1 CODE		PURPOSE	SET BY	PCR
00111		MARK MISSING	R53	
00112		MARK OR MARK REJECT NOT BEING ACCEPTED	R57	
00113		NO INBITS	R57	
00115		NO MARKS TO REJECT	R57	1044
00206		ZERO ENCODE NOT ALLOWED WITH COARSE ALIGN + GIMBAL LOCK	IMU MODE SWITCH V40N20	
00207		ISS TURN-ON REQUEST NOT PRESENT FOR 90 SEC	# T4RUPT	
00210		IMU NOT OPERATING	IMU MODE SWITCH, R02 P51,P57	1145
00211		COARSE ALIGN ERROR	IMU MODE SWITCH, P51, P57,R50	
00212		PIPA FAIL BUT PIPA IS NOT BEING USED	# IMU MODE SWITCH, T4RUPT	
00213		IMU NOT OPERATING WITH TURN-ON REQUEST	# T4RUPT	
00214		PROGRAM USING IMU WHEN TURNED OFF	# T4RUPT	
00217		BAD RETURN FROM IMUSTALL	P51,P57,R50	
00220		BAD REFSMMAT	R02,R47	
00401		DESIRED GIMBAL ANGLES GREATER THAN "X" DEG	INF ALIGN ("X"=60), FINDCDUW ("X"=70) KALCMANU	
00402		FINDCDUW ROUTINE NOT CONTROLLING ATTITUDE BECAUSE OF INADEQUATE POINTING VECTORS.	FINDCDUW	
00404	M	SPECIFIED STAR NOT AVAILABLE IN ANY DETENT	R59	
00405	M	TWO STARS NOT AVAILABLE	R51	
00421		W-MATRIX OVER FLOW	INTEGRV	
20430	**	ACCELERATION OVERFLOW IN INTEGRATION	# ORBITAL INTEGRATION	

00501	MP	RADAR ANTENNA OUT OF LIMITS	R23	
00502		BAD RADAR GIMBAL ANGLE INPUT	V41N72	
00503	MP	RADAR ANTENNA DESIGNATE FAIL	R21,V41N72(NON MP)	
00510		RADAR AUTO DISCRETE NOT PRESENT	R25,V4CN72	
00511		LR POSITION INDETERMINABLE	R12	1145
00514	MP	RR GOES OUT OF AUTO MODE WHILE IN USE	P20,P22	
00515		RR CDU FAIL DISCRETE PRESENT	R25	
00520		RADARUPT NOT EXPECTED AT THIS TIME	P20,P22,R12	
00522		LR POSITION CHANGE	RC4	
00523		LR DID NOT ACHIEVE POSITION 2	V59	1145
00525	MP	DELTA THETA GREATER THAN 3 DEG	R22	
00526		RANGE GREATER THAN 400 MILES	P20	1145
00527		LOS NOT IN MODE 2 COVERAGE WHILE ON LUNAR SURFACE OR VEHICLE MANEUVER REQUIRED	R24	
00530	MP	LOS NOT IN MODE 2 COVERAGE ON LUNAR SURFACE AFTER 600 SEC	R26	1145
00600	M	IMAGINARY ROOTS ON FIRST ITERATION	P32,P72	
00601	M	PERIGEE ALTITUDE CSI LESS THAN 35K FT (LUNAR ORBIT) OR 85 NM (EARTH ORBIT).	P32,P72	
00602	M	PERIGEE ALTITUDE CDH LESS THAN 35K FT (LUNAR ORBIT) OR 85NM (EARTH ORBIT).	P32,P72	
00603	M	CSI TO CDH TIME LESS THAN 10 MIN	P32,P72	
00604	M	CDH TO TPI TIME LESS THAN 10 MIN OR COMPUTED CDH TIME IS GREATER THAN INPUT TPI TIME.	P32,P72	
00605	M	NUMBER OF ITERATIONS EXCEEDS P32/72 LOOP MAXIMUM	P32,P72	
00606	M	DELTA V EXCEEDS MAXIMUM	P32,P72	
20607	**	NO SOLUTION FROM TIME-THETA OR TIME-RADIUS	# TIMETHET, TIMERAD	
00611	M	NO TIG FOR GIVEN ELEV ANGLE	P33,P34,P73,P74	
00701	M	ILLEGAL ALIGNMENT TECHNIQUE SELECTED	P57	1145

00777	PIPA FAIL CAUSED ISS WARNING	# T4RUPT	
01102	LGC SELF TEST ERROR	# SELF CHECK	
21103	** UNUSED CCS BRANCH EXECUTED	# ABORT	
31104	* DELAY ROUTINE BUSY	# EXECUTIVE	
01105	DOWNLINK TOO FAST	# T4RUPT	
01106	UPLINK TOO FAST	# T4RUPT	
01107	PHASE TABLE FAILURE. ASSUME ERASABLE MEMORY IS DESTROYED	# RESTART	
31201	* EXECUTIVE OVERFLOW - NO VAC AREAS	# EXECUTIVE	
31202	* EXECUTIVE OVERFLOW-NO CORE SETS	# EXECUTIVE	
31203	* WAITLIST OVERFLOW - TOO MANY TASKS	# WAITLIST	
21204	** WAITLIST, VARDELAY, FIXDELAY, LONGCALL OR DELAYJOB CALLED WITH ZERO OR NEGATIVE DELTA TIME	# WAITLIST	
31206	* SECOND JOB ATTEMPTS TO GO TO SLEEP VIA KEYBOARD AND DISPLAY PROGRAM	# PINBALL	
31207	* NO VAC AREA FOR MARKS	R53	
31210	* TWO PROGRAMS USING DEVICE AT THE SAME TIME	# IMU MODE SWITCH	
31211	* ILLEGAL INTERRUPT OF EXTENDED VERB	R53	
01301	ARCSIN-ARCCOS ARGUMENT TOO LARGE	# INTERPRETER	
21302	** SQRT CALLED WITH NEGATIVE ARGUMENT	# INTERPRETER	
21406	** BAD RETURN FROM ROOTPSRS (DURING IGNITION ALGORITHM)	# P63	
01406	BAD RETURN FROM ROOTPSRS (DURING POWERED FLIGHT)	# P63,P64	
01407	VG INCREASING (DELTA-V ACCUMULATED AT 90 DEGREES FROM DESIRED THRUST VECTOR).	P40,P42	
01410	UNINTENTIONAL OVERFLOW IN GUIDANCE	# P63,P64,P66	1145
01412	DESCENT IGNITION ALGORITHM NOT CONVERGING	# P63	
01466	TOO FEW THROTTLINGS SINCE LAST OMISSION OF P66	# P66	
21501	** KEYBOARD AND DISPLAY ALARM DURING INTERNAL	# PINBALL	

		USE (NVSUB). ABORT	
31502		* ILLEGAL FLASHING DISPLAY	# GOPLAY
01520		V37 REQUEST NOT PERMITTED AT THIS TIME	R00
01600		OVERFLOW IN DRIFT TEST	# GROUND TEST
01601		BAD IMU TORQUE	# GROUND TEST
01703		TOO CLOSE TO IGNITION, SLIP TIG	R41
01706	M	INCORRECT PROGRAM SELECTED FOR VEH CONFIG	P40,P42
32000		* DAP STILL IN PROCESS AT NEXT TIME 5 RUPT	# DAP
02001		JET FAILURES HAVE DISABLED Y-Z TRANS-LATION	# DAP
02002		JET FAILURES HAVE DISABLED X TRANS-LATION	# DAP
02003		JET FAILURES HAVE DISABLED P ROTAT-IONS	# DAP
02004		JET FAILURES HAVE DISABLED U-V ROTA-TIONS	# DAP
03777		ICDU FAIL CAUSED THE ISS WARNING	# T4RUPT
04777		ICDU, PIPA FAILS CAUSED THE ISS WARNING	# T4RUPT
07777		IMU FAIL CAUSED THE ISS WARNING	# T4RUPT
10777		IMU, PIPA FAILS CAUSED THE ISS WARNING	# T4RUPT
13777		IMU, ICDU FAILS CAUSED THE ISS WARNING	# T4RUPT
14777		IMU, ICDU, PIPA FAILS CAUSED THE ISS WARNING	# T4RUPT

SECTION 4 OF THE GSOP DOES NOT DESCRIBE LOGIC OF ALARM GENERATION. CONSULT PROGRAM LISTING

* GENERATES SOFTWARE RESTART (BAILOUT ALARM)
** RESULTS IN PROGRAM GOING TO R00 (PCODOO ALARM)
M INDICATES MAIN ALARM
P INDICATES PRIORITY ALARM

NOTE: FOR VC5 NC9 DISPLAYS:
R1-XXXXX (FIRST ALARM FOLLOWING ERROR RESET).
R2-XXXXX (SECOND ALARM FOLLOWING ERROR RESET).
R3-XXXXX (MOST RECENT ALARM).

ERROR RESET WILL SET R1 AND R2 TO
ZERO, BUT NOT AFFECT R3.

CHANGE CONTROL NOTES

LOGIC REV 01 PCR 105,106,138,437,536,593
LOGIC REV 00(LUM 1A) PCR 720,721,722,751
REVS 01,02(LUM 1B) PCR 801.2,802.2,817,856,EDITORIAL
REV 03 EDITORIAL
REV 04(LUM 1D) PCR 979,1013, PCN 1009
REV 05(LUM 1E) PCR 1044, PCN 1145

4.4.8 FLAGS REFERENCED IN SECTION 4 OF R567 REV 07 12/01/71

FLAG	PCR	IF FLAG SET	IF FLAG RESET	TESTED	SET	RESET *
ABORT ENABLE FLAG		ABORT PROGRAMS ENABLED	ABORT PROGRAMS NOT ENABLED	P70,P71,R11	P63	P12,P68,P70,P71
ABORT TARGETING FLAG		J2,K2 PARAMETERS USED FOR ABORT TARGETING	J1,K1 PARAMETERS USED FOR ABORT TARGETING		P70,P71	R00
ACTIVE VEHICLE FLAG		LM IS ACTIVE VEHICLE	CSM IS ACTIVE VEHICLE	TARGETING COMPUTATIONS	P32,P33,P34,P35	P72,P73,P74, P75
APS ABORT CONTINUATION FLAG	1180	APS CONTINUED ABORT AFTER DPS ABORT	APS ABORT NOT A CONTINUATION OF DPS ABORT	P71	P70,P71	
APS FLAG		CREW HAS SPECIFIED THAT DPS HAS BEEN STAGED	CREW HAS SPECIFIED THAT DPS HAS NOT BEEN STAGED	P12,P40,P42,P63 P70,P71,R03,R40	P42,P68,P71,R03	R03
ASTRONAUT FLAG		CREW HAS APPROVED IGNITION	CREW HAS NOT APPROVED IGNITION	P12,P40,P41,P42,P63, R40	P12,P40,P42,P63,R40	P12,P40,P41,P42, P63,R40
ATTITUDE FLAG	1180	LGC HAS STORED LM ATTITUDE IN MOON-FIXED CO-ORD	LGC HAS NOT STORED LM ATTITUDE IN MOON-FIXED CO-ORD	P57	P57,P68	
AUX FLAG		IF IDLE FLAG RESET SERVICER WILL EXERCISE DVMON	IF IDLE FLAG RESET SERVICER WILL SKIP DVMON AND SET AUX FLAG	R40	R40	R40
AVERAGE G FLAG	1180	AVERAGE G (SERVICER) DESIRED	AVERAGE G (SERVICER) NOT DESIRED	P70,P71,R25,R30,R31, AVERAGE G, R57,V59	AVERAGE G	R00
COMP E FLAG		ELEV. ANGLE SUPPLIED FOR P34/74	ELEV. ANGLE NOT SUPPLIED FOR P34/74	P34,P74	P34,P74	P34,P74
CONTINUOUS DESIGNATE FLAG	1180	LGC COMMANDS RR WITHOUT LOCK ON	LGC CHECKS FOR LOCK ON	V41N72,V44	V41N72,R26	P20,P22,R00,R24, R25,R26,R56, V41N72,V44
DESIGNATE FLAG	1180	RR DESIGNATE	RR DESIGNATE NOT	V41N72	V41N72	P20,P22,R00,R24,

		REQUESTED OR IN PROGRESS	REQUESTED OR IN PROGRESS.			R26,R56,V41N72, V44
DID FLAG		INERTIAL DATA AVAIL-ABLE	PERFORM DATA DISPLAY INITIAL-IZATION	R10	R10	R10
DRIFT FLAG		GYRO COM-PENSATION	NO GYRO COMPEN-SATION	T3RUPT	P51,P52,P57,R00,R50	P06,P51,P52,P57, R50,V41N20
ENGINE ON FLAG	1180	ENGINE TURNED ON	ENGINE NOT TURNED ON		P12,P40,P42, P63,P70,P71,R40	P12,P40,P42,P63, P70,P71,R00,R40
EXTENDED VERB ACTIVE FLAG	1180	EXTENDED VERB IN PROGRESS	NO EXTENDED VERB IN PROGRESS	R05,R30,R31,R76,V85	R76	P27,R03,R04,R05, R30,R31,R36,R47, R62,R63,V41N20, V41N72,V42,V43, V55,V67,V85,V91, P07
EXTERNAL DELTA V FLAG		EXTERNAL DELTA V VG COMP	LAMBERT VG COMP	TVC COMPUTATIONS	P30,P32,P33,P72,P73	P34,P35,P74,P75
FINAL FLAG		LAST PASS THROUGH REND. COMP.	INTERIM PASS THROUGH REN-DEZVOUS COMP	P32,P33,P34,P35,P72, P73,P74,P75	P30,P32,P33,P34,P35, P72,P73,P74,P75	P32,P33,P34, P35,P72,P73, P74,P75
FIRST PASS FLAG		FIRST PASS	SUCCEEDING PASS	P20,P22	P20,P22	P20,P22
FIRST TIME FLAG		FIRST TIME THRU LUNAR SURFACE RR PRE-DESIGNATE ROUTINE (R26)	NOT FIRST TIME THRU LUNAR SURFACE RR PRE-DESIGNATE ROUTINE (R26)	R26	R26	R26
FLIGHT 59 FLAG	1180	LUNAR SURFACE MARK PRO-CEDURE (CURSOR/SPIRAL) USED DURING P52	NORMAL MARKING (X,Y PAIRS) USED DURING P52	R52,R53,R59	R51	P57,R51,R00
GIMBAL LOCK FLAG		GIMBAL LOCK	NOT GIMBAL LOCK			R00
H FAIL FLAG	1180	LANDING RADAR ALT FAILED REASONABILITY TEST	LANDING RADAR ALT PASSED REASONABILITY TEST		R12	P70,P71,R00,R12
H FLASH FLAG	1180	FLASH LR ALTITUDE FAIL LAMP	DO NOT FLASH LR ALTITUDE FAIL LAMP	R09	R12	P70,P71,R00,R12
HIGATE FLAG	1180	AFTER HIGATE	BEFORE HIGATE	R12	R12	P70,P71,R00
IDLE FLAG		NO DV MONITOR	CONNECT DV MONITOR	R40	P12,P40,P42,P70,P71, R00,R40, FRESH START	P12,P40,P42,P63, P70,P71,R40

					(V36E)	
IGNITION FLAG		TIG HAS ARRIVED	TIG HAS NOT ARRIVED	P12,P40,P42,P63,R40	P12,P40,P41,P42,P63, R40	P12,P40,P41,P42, P63,R40
IMPULSE FLAG		MINIMUM IMPULSE BURN (C/O SET)	STEERING BURN (C/O NOT SET)	P40,P42,P63,R40	P40,P42	P40,P42
IMUSE FLAG		IMU IN USE	IMU NOT IN USE	R47	P51,P57,R02	P06,P00,R56
INERTIAL DATA DISCRETE FLAG		RR CDUS IN USE FOR INERTIAL DATA DISPLAY	RR CDUS NOT IN USE FOR INERTIAL DATA DISPLAY	R10	R10	R10
INITIAL ALIGN FLAG		INITIAL PASS	SECOND PASS OF P57	P57	P57	P57
LANDING ANALOG DISPLAYS FLAG	1180	LANDING ANALOG DISPLAYS ENABLED	LANDING ANALOG DISPLAYS NOT ENABLED	R10	AVERAGE-G	R00
LOCK-ON FLAG		RADAR LOCK-ON DESIRED	RADAR LOCK-ON NOT DESIRED	V41N72	R21,V41N72	R21,R26,V41N72
LOSCM		LOS BEING COMPUTED	LOS NOT BEING COMPUTED	R21	R21	P20,P22,R21,R24, V41N72
LR BYPASS FLAG		BYPASS LR UPDATES	DO NOT BYPASS LR UPDATES	R04,R12,R77,V59, V40N72,V41N72	P70,P71,R00,FRESH START (V36E)	P63
LR PERMIT FLAG	1180	LR UPDATES PERMITTED BY ASTRONAUT	LR UPDATES NOT PERMITTED BY ASTRONAUT	P63,R12	V57	P70,P71,R00,R12, V58
LR POSITION DATA FAIL FLAG		LR ALTITUDE DATA FAIL	NO LR ALTITUDE DATA FAIL	R20	R20	R20
LR POSITION FLAG	1180	LR POSITION #2 DESIRED	LR POSITION #1 DESIRED	R04	R04,R12,R77,V59	R04,R77
LR VELOCITY DATA FAIL FLAG		LR VELOCITY DATA FAIL	NO LR VELOCITY DATA FAIL	R20	P20	R20
MANUAL ACQUIRE FLAG		MANUAL ACQUIRE BY REND. RADAR	AUTO ACQUIRE BY REND. RADAR	P20,P22	P20	P20,P22
MARK IN PROGRESS FLAG		MARK IN PROGRESS	NO MARK IN PROGRESS	R53,R76	R53	R53
MARK INPUT INHIBIT FLAG		MARK PROCESSING INHIBITED	MARK PROCESSING ALLOWED	R57	R53,R57	R53
MID 1 FLAG		INTEGRATE STATE TO TDEC1	INTEGRATE STATE TO PRESENT TIME	R41	R41	R41
MUNFLAG	1180	SERVICER CALLS MUNRVG	SERVICER CALLS CALC RVG	R25,R31	P12,P63	R00
NEEDLE FLAG	1180	TOTAL ATTITUDE	A/P FOLLOWING	DAP	P60,V62	V61

		ERROR DISPLAYED	ERROR DISPLAYED			
NEED2FLG	1180	VEHICLE ATTITUDE RATES DISPLAYED	VEHICLE ATTITUDE RATES NOT DISPLAYED	DAP	V60	R60,V61,V62
NEW TARGET FLAG		ASTRONAUT OVER-WROTE DELTA V AT TPI OR TPM	ASTRONAUT DID NOT OVERWRITE DELTA V	P34,P35,P74,P75	P34,P35,P74,P75	P34,P35,P74,P75
NO DO VERB 37 FLAG	1180	V37 NOT ALLOWED	V37 ALLOWED	ROC	P06,P76,P77	P06,P76,P77,ROC
NO LR READ FLAG	1180	LR REPOSI-TIONING	LR NOT REPOSI-TIONING	R12	R12	P70,P71,RCO,R12
NO MARKS ALLOWED FLAG	1180	MARKS NOT ALLOWED (EXTENDED VERB ACTIVE)	MARKS ALLOWED	R53,R76	R76	P27,R03,RC4,R05, R30,R31,R36,R47, R53,R62,R63, V41N20,V41N72, V42,V43,V55,V67, V85,V91,PC7
NO RR MONITOR FLAG	1180	BYPASS RR MONITOR	PERFORM RR MONITOR	R25	R23,R26,V41N72	P20,P22,R21,R23, V44
NO THROTTLE FLAG		INHIBIT FULL THROTTLE	ALLOW FULL THROTTLE	P40	P40	P40,P63
NO UPDATE FLAG		NEITHER VEHICLE MAY BE UPDATED	EITHER VEHICLE MAY BE UPDATED	R22	V95	V80,V81
POOHFLAG	1180	P00 SELECTED (BYPASS BACKWARDS INTEGRATION)	P00 NOT SELECTED	ORBITAL INTEGRATION	P00	R00
PREFERRED-ATTITUDE-COMPUTED FLAG		PREFERRED ATTI-TUDE COMPUTED	PREFERRED ATTITUDE NOT COMPUTED	P52	P40,P41,P42	P52
PRIORITY DISPLAY AWAITING KEY RELEASE FLAG		ASTRONAUT USING KEYBOARD WHEN PRIORITY DISPLAY INITIATED	ASTRONAUT NOT USING (KEYBOARD FREE)	R76	OSKY DISPLAY PROGRAM	OSKY DISPLAY PROGRAM
PRIORITY DISPLAY FLAG	1180	PRIORITY DISPLAY IN ENDIDLE	NO PRIORITY DISPLAY IN ENDIDLE	R76,DSKY DISPLAY PROGRAM	DSKY DISPLAY PROGRAM	DSKY DISPLAY PROGRAM
PRIORITY IDLE FLAG		PRIORITY DISPLAY AWAITING ASTRO-NAUT RESPONSE	PRIORITY DISPLAY NOT WAITING (KEYBOARD FREE)	R76	DSKY DISPLAY PROGRAM	DSKY DISPLAY PROGRAM
PULSES FLAG	1180	MINIMUM IMPULSE COMMAND MODE	NOT IN MINIMUM IMPULSE COMMAND MODE	DAP	P68,V76	P12,P40,P41,P42, P63,P70,P71,R4C, V77,FRESH START (V36E)
P20 PRIORITY DISPLAY FLAG	1180	P20/P25 PRIORITY DISPLAY	P20/P25 NORMAL DISPLAY	R6C	R61,R65	R61,R65

P25 FLAG	1180	P25 RUNNING	P25 NOT RUNNING	P25,R00,R56	P25	P63,R00,R56
P70?1 FLAG		P70 OR P71 USING ASCENT GUIDANCE EQUATIONS	PI2 USING ASCENT GUIDANCE EQUATIONS	ASCENT GUIDANCE	P70,P71	
QUIT FLAG		STOP INTE-GRATION	CONTINUE INTE-GRATION	P00	V96	P00
RANGE DATA FLAG	1180	LR ALTITUDE MEASUREMENT MADE	NO LR ALTITUDE MEASUREMENT MADE	R12	R20	P70,P71,R00,R12
RANGE SCALE FLAG		SCALE CHANGE DURING RR/LR READ	NO SCALE CHANGE DURING RR/LR READ	R22	R20	R22
RCS FLAG	1180	RCS INJECTION MODE	MAIN ENGINE MODE	ASCENT GUIDANCE	PI2,P70,P71	PI2,P70,P71
REDESIGNATION FLAG		LANDING SITE REDESIGNATION ALLOWED	LANDING SITE REDESIGNATION PROHIBITED	P64	P64	P63,P64
REFSMMAT FLAG	1180	REFSMMAT GOOD	REFSMMAT BAD	P30,P32,P33,P34, P35,P57,R02,R47,R59	P51,P52,P57	P06,P51,P52,P57, R50,V41N20
REMODE FLAG	1180	CHANGE IN ANTENNA MODE REQUESTED	NO CHANGE IN ANTENNA MODE REQUESTED	R24,R25, V41N72,V44	R21,V41N72	R21,R25, V41N72
RENDEZVOUS FLAG	1180	P20 OR P22 RUNNING	NEITHER P20 NOR P22 RUNNING	P20,P22,R00,R22, R24,R25,R56	P20,P22	P06,PI2,P63,R00, R56,P25
REND W FLAG		W MATRIX VALID	W MATRIX INVALID	NAVIGATION COMPUTATIONS	NAVIGATION COMPUTATIONS	PI2,V67,V93
REPOSITION FLAG	1180	REPOSITION IN PROGRESS	NO REPOSITION IN PROGRESS	R20,R21,R25, V40N72,V41N72,V44	R25	R25,V41N72
ROTATION FLAG	1180	FORCE VEHICLE ROTATION IN PRE-FERRED DIRECTION	DO NOT FORCE VEHICLE ROTATION	PI2,P70,P71	P70,P71	PI2,P70,P71
RR ANTENNA MODE FLAG		RR IN MODE #2	RR IN MODE #1	R21	R25,V40N72	R25,V40N72
RR AUTO MODE FLAG		RR NOT IN AUTO MODE	RR IN AUTO MODE	V40N72	R25, FRESH START (V36E)	R25
RR CDU NOT FAILED FLAG		NO RR CDU FAIL	RR CDU FAILED	R20,R25	R25, FRESH START (V36E)	R25
RR CDU ZERO FLAG	1180	RR CDUS BEING ZEROED	RR CDUS NOT BEING ZEROED	P20,P22,R22,R25	R25,V40N72	R25,V40N72

RR DATA FAIL FLAG		RR DATA FAIL	NO RR DATA FAIL	R25	R20	R20
RR TURN ON FLAG	1180	RR TURN ON SEQUENCE IN PROGRESS	NO RR TURN ON SEQUENCE	V40N72	R25	R25
R04 FLAG		R04 RUNNING	R04 NOT RUNNING	R77	R04	P20,P22,R00,R04
R10 FLAG	1180	R10 OUTPUTS INERTIAL CROSS AXIS VELOCITY AND ZEROS FORWARD VELOCITY	R10 OUTPUTS TO H AND HDOT METERS AND FORWARD AND LATERAL CROSSPOINTERS	R10	P12,P70,P71	
R12 X-AXIS OVERRIDE FLAG	1180	INHIBIT OVERRIDE	DO NOT INHIBIT OVERRIDE	R12	R12	P70,P71,R00
R12 DELAY FLAG	1180	INHIBIT R12 PROCESSING OF VELOCITY DATA	ALLOW R12 PROCESSING OF VELOCITY DATA	R12		P70,P71,R00,R20
R61 FLAG		RUN R61 LM	RUN R65 LM	R61,R65	R61	R65
R77 FLAG	1180	R77 ON (SUPPRESS RADAR ALARMS AND TRACKER FAILS)	R77 OFF	R04,R20,R77,V59, V40N72,V41N72	R77	R77(V79)
SEARCH FLAG	1180	RADAR IN AUTO SEARCH OPTION	RADAR NOT IN AUTO SEARCH OPTION	P20,P22,R24	R24	P20,P22,R56
SNUFFER FLAG	1180	U, V JETS DISABLED DURING DPS BURN	U, V JETS ENABLED DURING DPS BURN	DAP	V65	V75
STEER FLAG		SUFFICIENT THRUST	NOT SUFFICIENT THRUST	TVC	R40	R40
SURFACE FLAG		LM ON MOON	LM NOT ON MOON	P20,P22,R21,R22,R24, R31,R53,V66,V67	P68	P12
TERRAIN MODEL INHIBIT FLAG	1180	TERRAIN MODEL INHIBITED	TERRAIN MODEL ALLOWED	R12	R13,V68	P63
TRACK FLAG	1180	TRACKING ALLOWED	TRACKING NOT ALLOWED	P20,P22,P25,R04,R22, R56,R61,R65,R77,V59, V40N72,V41N72	P20,P22,P25,P30, P32,P33,P34,P35, P72,P73,P74,P75,P76, P77,R00	P06,P51,P57,R00, R50,R56,V41N20
ULLAGE FLAG	1180	ULLAGE REQUEST	NO ULLAGE REQUEST	DAP	P40,P42,P63,R40	P12,P40,P42,P63, P70,P71,R00,R40
UPDATE FLAG		SV UPDATING BY RR MARKS ALLOWED	SV UPDATING BY RR MARKS NOT ALLOWED	R22	P20,P22,P30,P32, P33,P34,P35, P72,P73,P74,P75,	P30,P32, P33,P34,P35, P72,

					R00	P73,P74,P75, R00,R56
USE-QR-JETS FLAG	1180	TRIM GIMBAL UN-USABLE-USE JETS ONLY	TRIM GIMBAL MAY BE USED	DAP	P40,P70,R00,R40, FRESH START (V36E)	R40
VEHICLE UPDATE FLAG		CSM BEING UPDATED	LM BEING UPDATED	NAVIGATION COMPUTATIONS	P22,V81	P20,V80
VELOCITY DATA FLAG	1180	LR VELOCITY MEASUREMENT MADE	LR VELOCITY MEASUREMENT NOT MADE	R12	R20	P70,P71,R00,R12
VERIFLAG		INVERTED BY V33 AT	END OF P27	GROUND CONTROLLERS	P27	P27
VERTICAL RISE FLAG		VERTICAL RISE	NON VERTICAL RISE	P12,P70,P71	P12,P70,P71	P12,P70,P71
V FAIL FLAG	1180	LANDING RADAR VELOCITY FAILED REASONABILITY TEST	LANDING RADAR VELOCITY PASSED REASONABILITY TEST		R12	P70,P71,R00,R12
V FLASH FLAG	1180	LR VELOCITY LAMP FLASHING	LR VELOCITY LAMP NOT FLASHING	R09	R12	P70,P71,R00,R12
VX INHIBIT FLAG	1180	SINCE Z-VELOCITY BAD, BYPASS X-VELOCITY UPDATE	UPDATE X-VELOCITY	R12	R12	P70,P71,R00,R12
V37 FLAG	1180	SERVICER IS RUNNING	SERVICER IS NOT RUNNING	R00,R04,R36,R77, V59,V40N72,V41N72	AVERAGE G	R00
V67 FLAG		ASTRONAUT OVER-WROTE INITIAL W-MATRIX	ASTRONAUT HAS NOT OVERWRITTEN W-MATRIX	V67	V67	V67
X-AXIS OVERRIDE INHIBIT FLAG		BELOW LIMIT-IN-HIBIT OVERRIDE	ABOVE LIMIT-DO NOT INHIBIT	DAP	P12,P70,P71,R12	P12,P70,P71,R00, R13
3-AXIS FLAG		3-AXIS MANEUVER	1-AXIS MANEUVER (VECPOINT)	R60	R62	P40,P41,P42,R00, R52,R60,R61,R63, R65
4-JET TRANSLATION FLAG	1180	4-JET X-AXIS TRANSLATION	2-JET X-AXIS TRANSLATION	DAP	P12,P70,P71,CREW OPTION IN R03	CREW OPTION IN R03

* A FRESH START (V36E) RESETS ALL OF THE ABOVE FLAGS EXCEPT FOR THE FOLLOWING:
APS FLAG
IDLE FLAG
LR BYPASS FLAG
LR POSITION FLAG (SET TO VALUE OF BIT 6 OF CHANNEL 33.)
REFSMMAT FLAG
RR AUTO MODE FLAG

RR CDU NOT FAILED FLAG
SURFACE FLAG
USE-QR-JETS FLAG

CHANGE CONTROL NOTES

REV 01 EDITORIAL
REVS 00,01 (LUM 1A) PCR 260,648,670,722,EDITORIAL
REVS 02,03 (LUM 1B) PCR 279,780,798,814,820,823,838,
839,841,845,EDITORIAL
REV 04(LUM 1C) PCR 285,863.2,893,895,EDITORIAL
REV 05(LUM 1D) PCR 287,310,892,898,942,979,988,
990,1015,1021, PCN 1009,1035,1037
REV 06(LUM 1E) PCR 333,334,1044,1100,PCN 1145
REV 07(LUM 1E) PCN 1180

041

4.4.9 LUMINARY PROGRAMS

LGC IDLING PROGRAM (P00) REV 04 12/01/71

PURPOSE: (1) TO PROVIDE A PROGRAM TO FULFILL THE FOLLOWING REQUIREMENTS:

++
+04
+
+
+1180
++

(A) PROVIDE AN INDICATION TO THE CREW THAT THE LGC IS ENGAGED IN NO CONTROL OR COMPUTATIONAL OPERATIONS WHICH MIGHT REQUIRE CONSIDERATION FOR COORDINATION WITH OTHER CREW TASKS IN PROGRESS.

(B) MAINTAIN THE LGC IN A CONDITION OF READINESS FOR ENTRY INTO OTHER PROGRAMS EXCEPT DURING STATE VECTOR EXTRAPOLATION.

(2) TO UPDATE THE LM AND CSM STATE VECTORS EVERY FOUR TIME STEPS.

ASSUMPTIONS: (1) THE IMU MAY OR MAY NOT BE ON. IF ON, THE IMU IS INERTIALLY STABILIZED BUT NOT NECESSARILY ALIGNED TO AN ORIENTATION WHICH IS KNOWN TO THE LGC.

(2) THE DAP IS AVAILABLE FOR MANUALLY CONTROLLED ATTITUDE MANEUVERS IF THE IMU IS ON. IF ATTITUDE MANEUVERS ARE MADE BY THE CREW CARE MUST BE TAKEN TO AVOID IMU GIMBAL LOCK BY OBSERVING THE ICDUS (V16 N20) OR BY MONITORING THE FDAI BALL.

(3) DURING THIS PROGRAM THE COASTING INTEGRATION ROUTINE WILL PERIODICALLY UPDATE THE LM STATE VECTOR (IF NOT ON THE LUNAR SURFACE) AND THE CSM STATE VECTOR TO APPROXIMATELY THE CURRENT TIME AS DESCRIBED IN SECTION 5.6 OF R567. THE CAPABILITY TO SELECT AN LGC PROGRAM (V37E--E) IS INHIBITED BY THE LGC DURING THIS INTEGRATION. V37 USE AT THIS TIME WILL RESULT IN A PROGRAM ALARM (01520).

(4) TO MONITOR THE PROGRESS OF STATE VECTOR INTEGRATION, THE TIME ASSOCIATED WITH THE ADVANCING (REGRESSING) STATE IS AVAILABLE BY KEYING IN V06N38E:

V06N38
R1-TET-HRS
R2-TET-MINS
R3-TET-SECS

TET-THE TIME (GET) TO WHICH THE STATE VECTOR INTEGRATION PROCESS HAS PRESENTLY CALCULATED THE STATE VECTOR. IN HRS, MINS, SECS TO NEAREST .01 SEC.

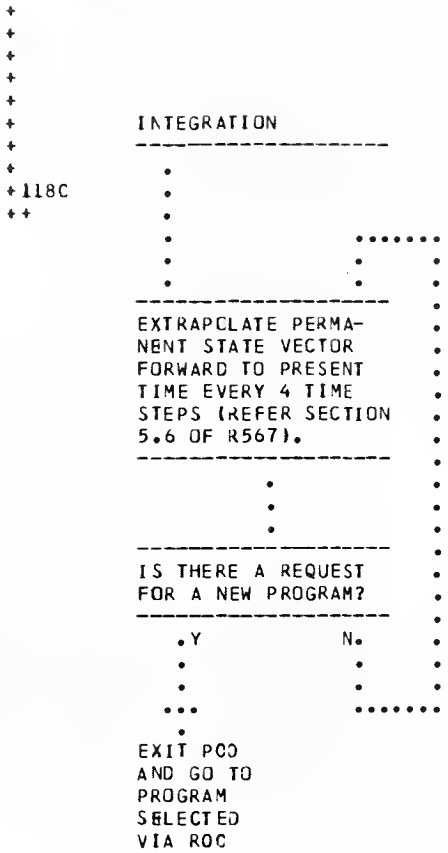
(5) THIS PROGRAM IS AUTOMATICALLY SELECTED BY V96E, WHICH MAY BE DONE DURING ANY PROGRAM. STATE VECTOR INTEGRATION IS PERMANENTLY INHIBITED FOLLOWING V96E. NORMAL INTEGRATION FUNCTIONS WILL RESUME AFTER SELECTION OF ANY PROGRAM. USE OF V96 CAN CAUSE INCORRECT W-MATRIX EXTRAPOLATION SINCE STATE VECTOR SYNCHRONIZATION IS NOT MAINTAINED.

(6) THE PROGRAM IS SELECTED BY THE ASTRONAUT BY OSKY ENTRY.

PROG	LGC	GROUND	CREW

CONT


CREW
PROGRAM
SELECTION
START LGC IDLING
PROGRAM (P00)
DISPLAY P00
KEY IN LGC IDLING
PROGRAM (P00)
V37E 00E
#10
MONITOR OSKY:
OBSERVE DISPLAY OF
P00
#20
IS QUIT FLAG SET?
N
Y
#30
RESET QUIT FLAG.
WAIT FOR
SELECTION OF
ANY PROGRAM
#40
SET POOHFLAG TO
INHIBIT BACKWARD
+04



#5C

#6C

#7C

#8C

CHANGE CONTROL NOTES

REV 01 PCR 80,146,234,507,614
REV 02 EDITORIAL
REV 03 EDITORIAL
REV 04 PCN 1180

LGC POWER DOWN PROGRAM (P06) REV 03 12/01/71

PURPOSE: (1) TO TRANSFER THE LGC FROM THE OPERATE TO THE STANDBY CONDITION.

ASSUMPTIONS: (1) THE NORMAL CONDITION OF READINESS OF THE PGNCS WHEN NOT IN USE IS STANDBY. IN THIS CONDITION THE IMU STANDBY CIRCUIT BREAKER IS ON, THE IMU OPERATE CIRCUIT BREAKER IS OFF, THE LGC/DSKY CIRCUIT BREAKER IS ON AND THE STANDBY LIGHT ON THE DSKY IS ON. IN THIS CONFIGURATION BOTH THE IMU AND LGC ARE OFF, WITH POWER APPLIED ONLY TO THE IMU HEAT CONTROL CIRCUITRY AND THE LGC TIMING CIRCUITRY.

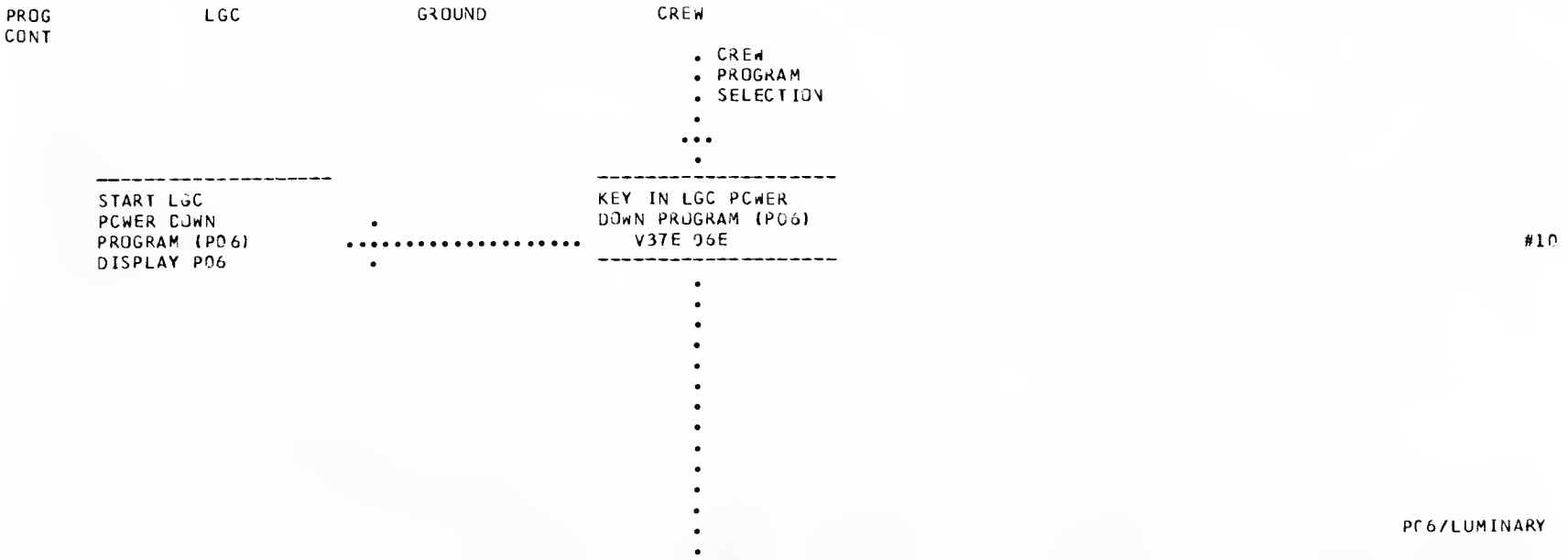
(2) A POSSIBLE CONDITION OF READINESS OF THE PGNCS WHEN NOT COMPLETELY ON IS THE SAME AS STANDBY (1) ABOVE, EXCEPT THAT THE STANDBY LIGHT ON THE DSKY IS OFF. IN THIS CONFIGURATION THE LGC IS RUNNING FOR COMPUTATIONAL PURPOSES THAT DO NOT REQUIRE THE IMU.

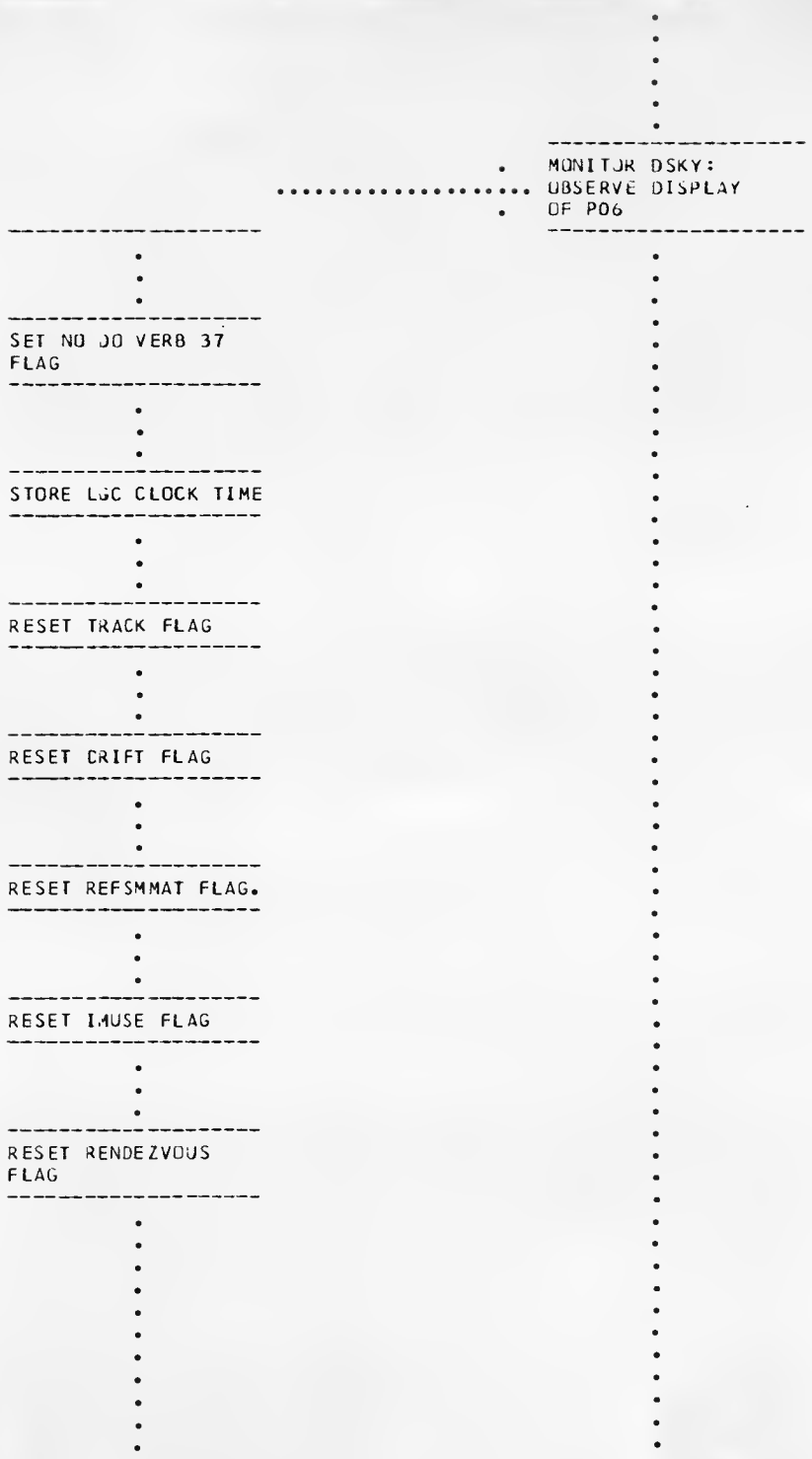
(3) IF THE COMPUTER POWER IS SWITCHED OFF IT WILL BE NECESSARY TO PERFORM A COMPUTER FRESH START (V36E) TO INITIALIZE THE ERASABLE STORAGE. THE LGC UPDATE PROGRAM (P27) WOULD HAVE TO BE DONE TO UPDATE THE LM AND CSM STATE VECTORS AND COMPUTER CLOCK TIME.

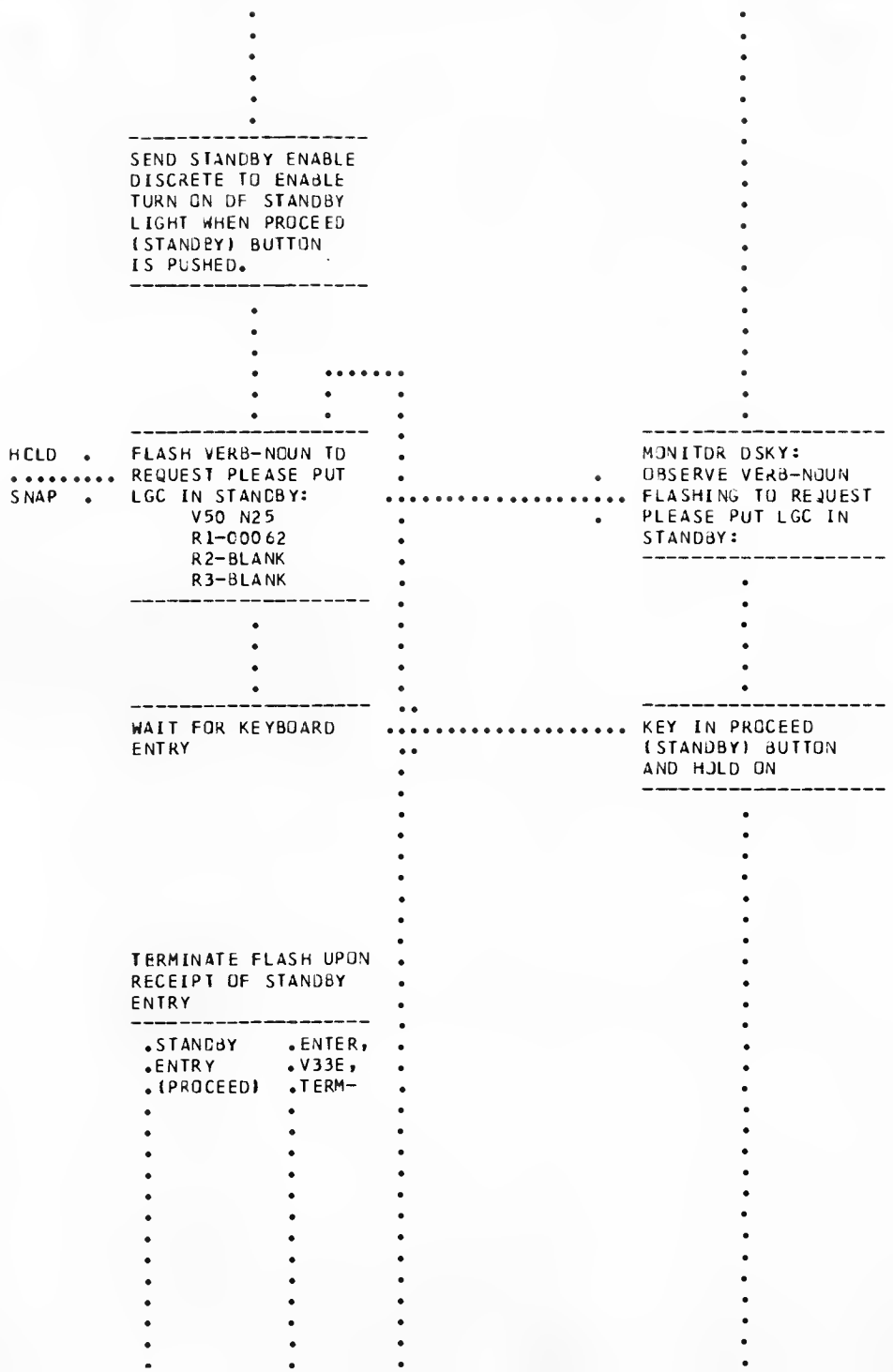
(4) THE LGC IS CAPABLE OF MAINTAINING AN ACCURATE VALUE OF GROUND ELAPSED TIME (GET) FOR ONLY 23 HRS WHEN IN THE STANDBY MODE. IF THE LGC IS NOT BROUGHT OUT OF THE STANDBY CONDITION TO THE RUNNING CONDITION (SEE (2) ABOVE) AT LEAST ONCE WITHIN 23 HOURS THE LGC VALUE OF GET MUST BE UPDATED.

(5) ONCE THE PROGRAM HAS BEEN SELECTED THE LGC MUST BE SHUT DOWN UNLESS V69E IS PERFORMED BEFORE A PROCEED (STANDBY) RESPONSE IS MADE TO THE V50N25 (00062) DISPLAY. AFTER P06 SELECTION THE LGC WILL NOT HONOR A NEW PROGRAM REQUEST (V37EXXE, EXCEPT XX=00), A TERMINATE (V34E), A V33E, OR AN ENTER IN RESPONSE TO THE LGC REQUEST FOR LGC STANDBY.

(6) THE PROGRAM IS SELECTED BY THE ASTRONAUT BY DSKY ENTRY.




MONITOR DSKY:
OBSERVE DISPLAY
OF P06
#20
SET NO GO VERB 37
FLAG
#30
STORE LGC CLOCK TIME
RESET TRACK FLAG
#40
RESET DRIFT FLAG
RESET REFSMMAT FLAG.
#50
RESET IMUSE FLAG
#60
RESET RENDEZVOUS
FLAG



#70

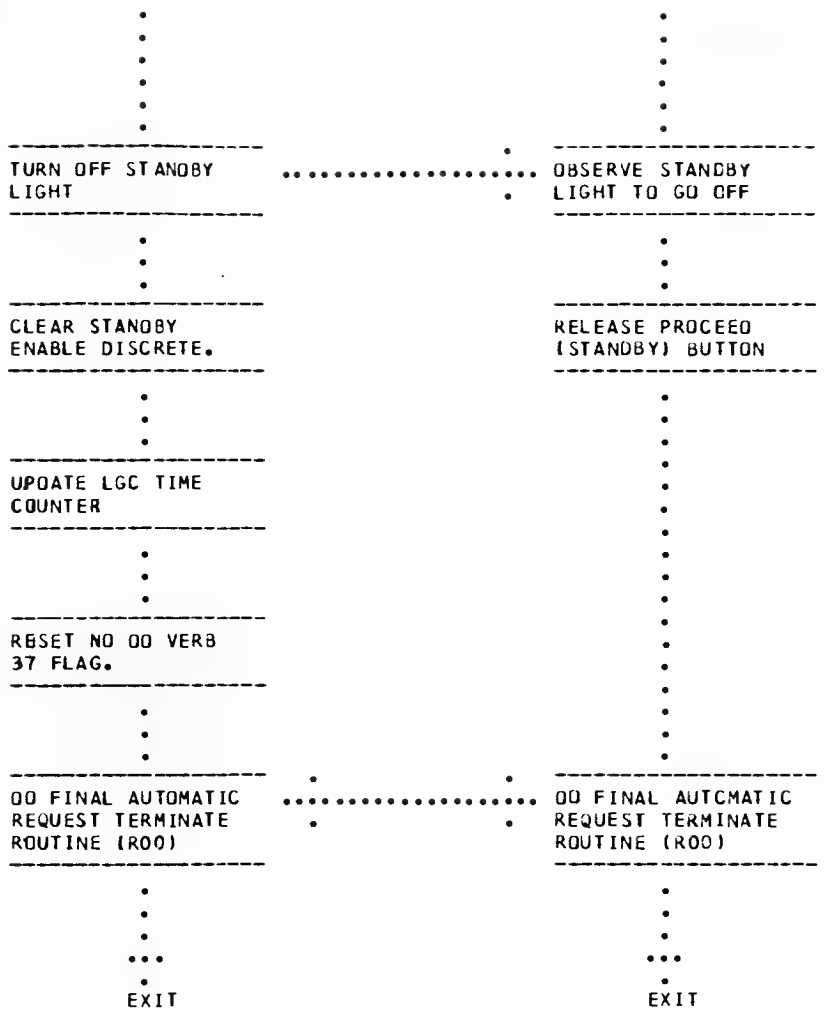
#80

#90

#100

#110


INATE
TURN ON STANDBY LIGHT
OBSERVE STANDBY LIGHT TO COME ON.
#120
RELEASE PROCEED (STANDBY) BUTTON
#130
PUT LGC IN STANDBY. BLANK ALL DSKY LIGHTS
MONITOR DSKY: OBSERVE ALL DSKY LIGHTS TO GO BLANK.
#140
EXIT P06
EXIT PC6
NOTE: WHEN IT IS DESIRED TO BRING THE LGC FROM STANDBY TO OPERATE THE FOLLOWING PRO-CEDURES APPLY.
#150
WAIT FOR STANDBY ENTRY
KEY IN PROCEED (STANDBY) BUTTON AND HOLD ON
#160



CHANGE CONTROL NOTES

REV 01 PCR 444
REV 02 EDITORIAL
REV 03 PCN 1180

POWERED ASCENT PROGRAM (P12) REV 15 12/01/71

PURPOSE: (1) TO DISPLAY TO THE CREW, PRIOR TO ASCENT ENGINE IGNITION, CERTAIN LGC-STORED PARAMETERS ASSOCIATED WITH THE POWERED ASCENT, FOR POSSIBLE MODIFICATION BY THE CREW.

(2) TO DISPLAY TO THE CREW, PRIOR TO ASCENT ENGINE IGNITION, CERTAIN FDAI BALL READINGS ASSOCIATED WITH THE EARLY PHASES OF THE ASCENT MANEUVER.

(3) TO CONTROL THE PGNCS DURING COUNTDOWN, IGNITION, THRUSTING AND THRUST TERMINATION OF A PGNCS-CONTROLLED APS POWERED ASCENT MANEUVER FROM THE LUNAR SURFACE.

ASSUMPTIONS: (1) THE LGC HAS STORED INJECTION VALUES WHICH DEFINE AN ASCENT TRAJECTORY. THESE VALUES ARE ALTITUDE OF INJECTION, THE DISTANCE AT INJECTION BETWEEN THE LM AND THE CSM ORBITAL PLANE, AND THE LM VERTICAL (V(R)) AND HORIZONTAL (V(Y)) AND (V(Z)) VELOCITIES AT INJECTION. THIS TRAJECTORY IS DESIGNED TO BE COPLANAR WITH THAT OF THE CSM AND TO RESULT IN AN APOLUNE OF 30 NM. ALL ALTITUDES ARE MEASURED WITH RESPECT TO THE MAGNITUDE OF THE LANDING SITE POSITION VECTOR WHICH IS AN LGC INITIALIZATION PARAMETER.

THIS PREDEFINED ASCENT TRAJECTORY MAY BE PARTIALLY MODIFIED DURING THIS PROGRAM BY ASTRONAUT INPUT (SEE ASSUMPTION (2) AND LOGIC BELOW FOR DOWNRANGE VELOCITY, RADIAL VELOCITY, AND CROSSRANGE DISPLAY).

(2) THE PGNCS WILL CONTROL THE LM ASCENT MANEUVER SUCH THAT THE LM VELOCITY AT INJECTION IS PARALLEL TO THE CSM ORBITAL PLANE, EITHER IN THAT PLANE, OR AT A SPECIFIED DISTANCE FROM THAT PLANE AS CONTROLLED BY ASTRONAUT DEFINITION OF CROSSRANGE. THE ASTRONAUT CAN ALSO CHANGE THE REQUIRED INJECTION CONDITIONS BY MODIFYING THE NOMINAL INITIAL DOWNRANGE AND RADIAL VELOCITY DISPLAY VALUES. (SEE DISPLAY OF V06N76 IN LOGIC BELOW). CROSSRANGE SHOULD NOT BE SPECIFIED SUCH AS TO CAUSE THE ASCENT TRAJECTORY TO CRUSS THRDUGH THE CSM ORBITAL PLANE.

(3) THE INITIAL PERIOD OF THE ASCENT TRAJECTORY WILL CONSIST OF TWO PHASES:

(A) VERTICAL RISE PHASE-FROM TIG UNTIL THE RADIAL VELOCITY (V(R)) OF THE LM EXCEEDS 40 FT/SEC, THE LM WILL BE HELD BY THE PGNCS TO AN ATTITUDE SUCH THAT THE LM +X AXIS IS PARALLEL TO THE LM POSITION VECTOR AT TIG. AT TIG THE PGNCS WILL COMMAND THE LM AROUND ITS X AXIS (YAW) UNTIL THE LM +Z AXIS POINTS DOWNRANGE.

(B) PITCHOVER PHASE-WHEN V(R) EXCEEDS 40 FT/SEC, THE PGNCS WILL COMMAND THE LM TO PITCH DOWN AN AMOUNT DEFINED BY THE GUIDANCE EQUATIONS.

THE LM ATTITUDE WILL SUBSEQUENTLY BE CONTROLLED BY THE GUIDANCE EQUATIONS.

(4) THE X-AXIS OVERRIDE OPTION PROVIDES THE CREW WITH THE ABILITY TO EXERCISE MANUAL CONTROL ABOUT THE LM X AXIS WITH THE ATTITUDE CONTROLLER EVEN THOUGH THE PGNCS ATTITUDE CONTROL MODE IS AUTO. WHEN THE CONTROLLER IS RETURNED TO DETENT THE PGNCS DAMPS THE YAW RATE, STORES THE YAW ATTITUDE WHEN THE YAW RATE IS DAMPED, AND THEN MAINTAINS THAT ATTITUDE.

THE X-AXIS OVERRIDE OPTION IS ALWAYS AVAILABLE TO THE CREW EXCEPT WHEN THE LGC IS SPECIFYING A DESIRED YAW ATTITUDE. THUS THE OPTION IS INHIBITED BY THIS PROGRAM FROM TIG(AS) UNTIL APPROXIMATELY 12 SECONDS AFTER V(R) EQUALS +40 FT/SEC.

(5) THE IMU IS ON AND MUST BE AT A KNOWN ORIENTATION BEFORE THIS PROGRAM MAY BE COMPLETED. NORMALLY, THE LUNAR SURFACE ALIGN PROGRAM (P57) HAS BEEN COMPLETED BEFORE SELECTION OF THIS PROGRAM. IT IS NORMALLY REQUIRED THAT THE ISS BE ON FOR A MINIMUM OF 15 MINUTES PRIOR TO A THRUSTING MANEUVER.

(6) ENGINE IGNITION MAY BE SLIPPED BEYOND TIG(AS) IF DESIRED BY THE CREW OR IF STATE VECTOR INTEGRATION CANNOT BE COMPLETED IN TIME. VARIATION OF THE TIME OF ASCENT IGNITION (TIG(AS)) EITHER BY DESIGN OR INADVERTANT SLIPPAGE WILL CHANGE THE RELATIVE PHASING WITH RESPECT TO THE CSM OF THE ASCENT TRAJECTORY AND THE RESULTANT LM ORBIT.

(7) IF A THRUSTING MANEUVER IS PERFORMED WITH THE GUIDANCE CONTROL SWITCH IN PGNS AND THE MODE CONTROL SWITCH IN AUTO THE PGNCS WILL CONTROL THE TOTAL VEHICLE ATTITUDE AND GENERATE EITHER MODE I OR MODE II ATTITUDE ERRORS AND VEHICLE ATTITUDE RATES (SEE ASSUMPTION (9)) FOR DISPLAY ON THE EDAI. THE CREW MAY EXERCISE CONTROL AROUND THE YAW AXIS ONLY WITH THE ACA (X-AXIS OVERRIDE) IF THE X-AXIS OVERRIDE CAPABILITY IS PERMITTED BY THE PROGRAM IN PROCESS. THIS MANUAL CONTROL WILL BE IN THE RATE COMMAND/ATTITUDE HOLD MODE.

IF A THRUSTING MANEUVER IS PERFORMED WITH THE GUIDANCE CONTROL SWITCH IN PGNS AND THE MODE CONTROL SWITCH IN ATTITUDE HOLD THE PGNCS WILL HOLD THE VEHICLE ATTITUDE AND WILL GENERATE EITHER MODE I OR MODE II ATTITUDE ERRORS FOR DISPLAY ON THE EDAI. THE CREW MAY EXERCISE MANUAL ATTITUDE CONTROL ABOUT ALL VEHICLE AXES WITH THE ACA IN EITHER THE RATE COMMAND OR MINIMUM IMPULSE MODE DEPENDING UPON THE STATUS OF THE PULSES FLAG. HOWEVER IT IS STRONGLY RECOMMENDED THAT POWERED FLIGHT NOT BE ATTEMPTED IN THE MINIMUM IMPULSE MODE. THE PULSES FLAG IS SET OR RESET BY EXTENDED VERBS 76 (MINIMUM IMPULSE) AND 77 (RATE COMMAND) RESPECTIVELY. THE PULSES FLAG IS ALSO RESET BY P12, P40, P41, P42, P63, P70, P71, AND R40 AT MAIN ENGINE IGNITION; WITH THE EXCEPTION OF THESE CASES, MODE SELECTION IS ALWAYS BASED UPON THE LAST ENTRY MADE IN THE DSKY. DURING A THRUSTING MANEUVER IN THE PGNS/ATTITUDE HOLD MODE THE PGNCS WILL NOT BE RESPONSIBLE IF REGISTER OVERFLOWS OCCUR WITHIN THE LGC.

(8) CONTROL OF THE LM RCS AND APS IS TRANSFERRED FROM THE PGNCS TO THE ABORT GUIDANCE SYSTEM (AGS) BY PLACING THE GUID CONT SWITCH FROM PGNS TO AGS.

THE AGS WILL BE CAPABLE OF TAKING OVER CONTROL OF THE LM DURING ANY PORTION OF THE LUNAR ASCENT, THE AGS WILL GUIDE THE LM TO A SAFE ORBIT.

++ THE AGS MAY BE INITIALIZED BY THE LGC AT ANY TIME BY MANUAL SELECTION OF THE AGS INITIALIZATION ROUTINE
+05 (R47), AND SHOULD HAVE BEEN PERFORMED PRIOR TO SELECTION OF P12.
+ IN THE EVENT THAT THE GUIDANCE CONTROL SWITCH IS CHANGED FROM PGNS TO AGS DURING A THRUSTING MANEUVER, THE LGC
+ WILL CONTINUE COMPUTATION OF POSITION AND VELOCITY, THE DESIRED THRUST VECTOR AND THE EDAI ATTITUDE ERROR NEEDLE
+1180 DISPLAY, HOWEVER THE PGNCS WILL NOT BE RESPONSIBLE IF REGISTER OVERFLOWS OCCUR WITHIN THE LGC.
++

(9) THE PGNCS CAN GENERATE TWO TYPES OF ATTITUDE ERRORS FOR DISPLAY ON THE EDAI;
MODE I - SELECTED BY EXTENDED VERB 61. AUTOPILOT FOLLOWING ERRORS USED AS A MONITOR OF THE DAP'S ABILITY TO TRACK AUTOMATIC STEERING COMMANDS.
MODE II- SELECTED BY EXTENDED VERB 62. TOTAL ATTITUDE ERRORS USED TO ASSIST CREW IN MANUALLY MANEUVERING
++ THE VEHICLE.
+C5 PGNCS-DERIVED VEHICLE ATTITUDE RATES MAY ALSO BE DISPLAYED VIA SELECTION BY EXTENDED VERB 60.
+ DISPLAY SELECTION IS ALWAYS BASED UPON THE LAST ENTRY MADE IN THE DSKY, WITH THE EXCEPTION THAT MODE II ATTITUDE
+ ERROR DISPLAYS ARE AUTOMATICALLY SELECTED AT THE BEGINNING OF R60. FOR A MORE DETAILED DESCRIPTION OF THESE DISPLAYS
+1180 REFER TO SECTION 3 OF R567, PARA. 3.2.
++

(10) THE LANDING ANALOG DISPLAYS ROUTINE (R10) IS ENABLED WHEN AVERAGE G IS TURNED ON.
R10 IS TERMINATED UPON TERMINATION OF AVERAGE G. DURING THIS MODE ALTITUDE-RATE AND ALTITUDE ARE DISPLAYED ON THE TAPE METERS AND INERTIAL CROSSRANGE VELOCITY ON THE CROSS POINTERS.

(11) EITHER THE DAP DATA LOAD ROUTINE (R03) OR THE LANDING CONFIRMATION PROGRAM (P68) HAS BEEN PERFORMED PRIOR TO SELECTION OF THIS PROGRAM.

(12) FOR EACH BURN AN IGNITION TOTAL ALLOWABLE TIME DELAY WILL BE SPECIFIED IN THE MISSION RULES. THIS DELAY TIME IS THE TOTAL TIME WHICH THE THRUSTING MANEUVER MAY BE DELAYED BEYOND THE LGC CALCULATED TIME OF IGNITION. IF ENGINE RESTARTS ARE INVOLVED, THE ACCOUNTING OF THIS TOTAL TIME DELAY IS UP TO THE CREW.

(13) THE ASTRONAUT MAY MONITOR THE FOLLOWING ADDITIONAL PARAMETERS DURING THIS PROGRAM BY KEYING IN V16N77E:

V16N77
R1-TG
R2-VGY(LM)
R3-VI

WHERE:

TG-THE ESTIMATED TIME OF FLIGHT FROM THE PRESENT TIME TO THE ACCOMPLISHMENT OF THE ASCENT

INJECTION CONDITIONS. POLARITY IS -. IN MINS AND SECS TO NEAREST SEC. MAX READING IS 5°B5°. IF AN RCS INJECTION DECISION IS MADE AFTER AN LGC ASSUMED APS THRUST FAILURE (SEE R40), THE UPDATE OF TG IS NOT MEANINGFUL.

VGY(LM) - THE COMPONENT OF THE PRESENT VG VECTOR ALONG LM Y AXIS. IN FPS TO NEAREST .1 FPS.

VI - THE MAGNITUDE OF THE LM INERTIAL VELOCITY WITH RESPECT TO THE REFERENCE COORDINATE SYSTEM. IN FPS TO THE NEAREST .1 FPS.

(14) THE ASTRONAUT MAY MONITOR THE FOLLOWING ADDITIONAL PARAMETERS AT ANY TIME DURING THIS PROGRAM AFTER TIG, BY KEYING IN V16N85E:

V16N85
R1-VGX(LM)
R2-VGY(LM)
R3-VGZ(LM)

FOR DEFINITION, SEE LOGIC BELOW.

(15) THE DAP WILL BE ENERGIZED WHENEVER THE PGNS CONTROL MODE AND THE AUTO ATTITUDE OR ATTITUDE HOLD CONTROL MODE HAVE BEEN SELECTED. IF THIS OCCURS PRIOR TO THE PGNS AUTO CHECK IN THIS PROGRAM, THE ATTITUDE ERRORS WILL BE ZEROED AND THE ATTITUDE DEADBAND WILL BE SET TO THE LAST VALUE SPECIFIED BY R03 (ASTRONAUT DEFINED). IMMEDIATELY PRIOR TO THE PGNS AUTO CHECK, THIS PROGRAM WILL SET THE ATTITUDE DEADBAND TO 1 DEGREE.

(16) THE FOLLOWING DISPLAY IS AVAILABLE DURING THIS PROGRAM PRIOR TO TIG BY KEYING IN V85E (SEE EXTENDED VERBS).

V16N56
R1 - RR LOS AZIMUTH
R2 - RR LOS ELEVATION
R3 - BLANK

WHERE:

RR LOS AZIMUTH - THE ANGLE BETWEEN THE LM X/Z PLANE AND THE RR LOS VECTOR. POSITIVE ROTATION IS FROM THE LM +Z AXIS TO THE LM +Y AXIS. IN DEGREES TO THE NEAREST 0.01 DEGREE.

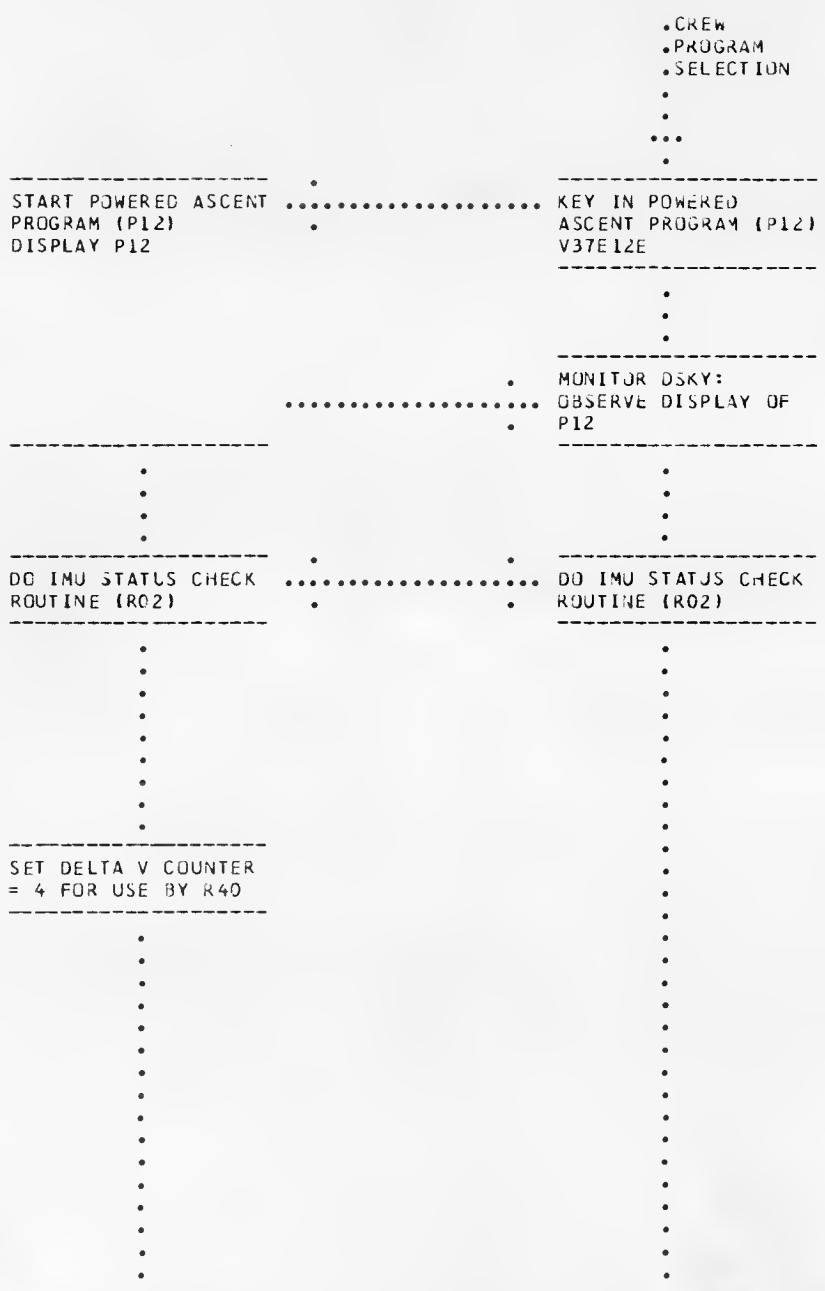
RR LOS ELEVATION - THE ANGLE BETWEEN THE LM +Z AXIS AND THE PROJECTION OF THE RR LOS VECTOR ON THE LM X/Z PLANE. POSITIVE ROTATION IS POSITIVE ROTATION ABOUT THE LM +Y AXIS.

(17) LGC AND CREW PROCEDURES IN CASES OF LGC-ASSUMED THRUST FAILURE ARE DEFINED BY THE DPS/APS THRUST FAIL ROUTINE (R40). THIS ROUTINE IS CALLED AT APS IGNITION BY THIS PROGRAM.

(18) THIS PROGRAM IS SELECTED BY THE ASTRONAUT BY DSKY ENTRY AT LEAST 5 MINUTES BEFORE THE ESTIMATED TIME OF ASCENT IGNITION TIG(AS).

PROG	LGC	GROUND	CREW

CONT

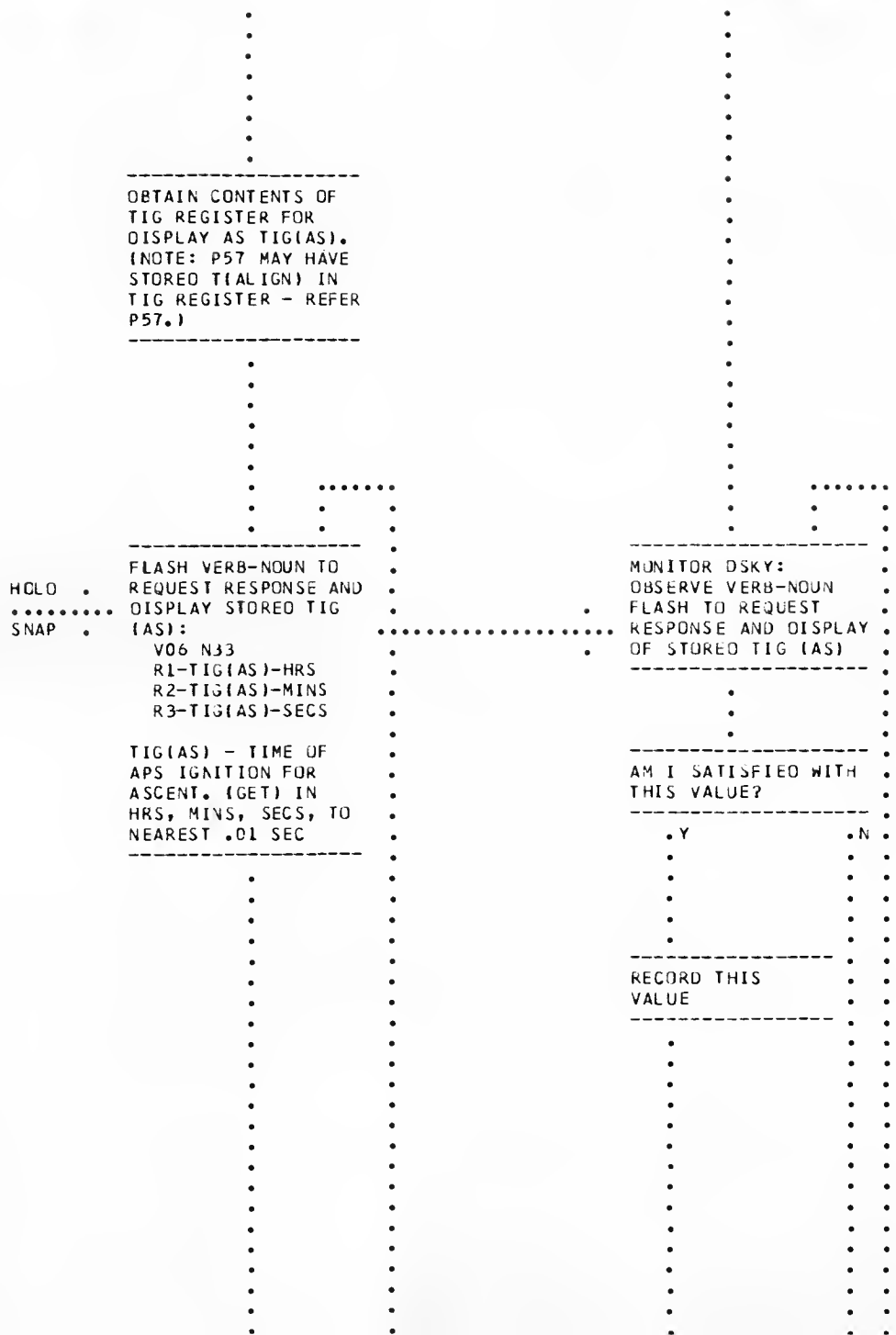


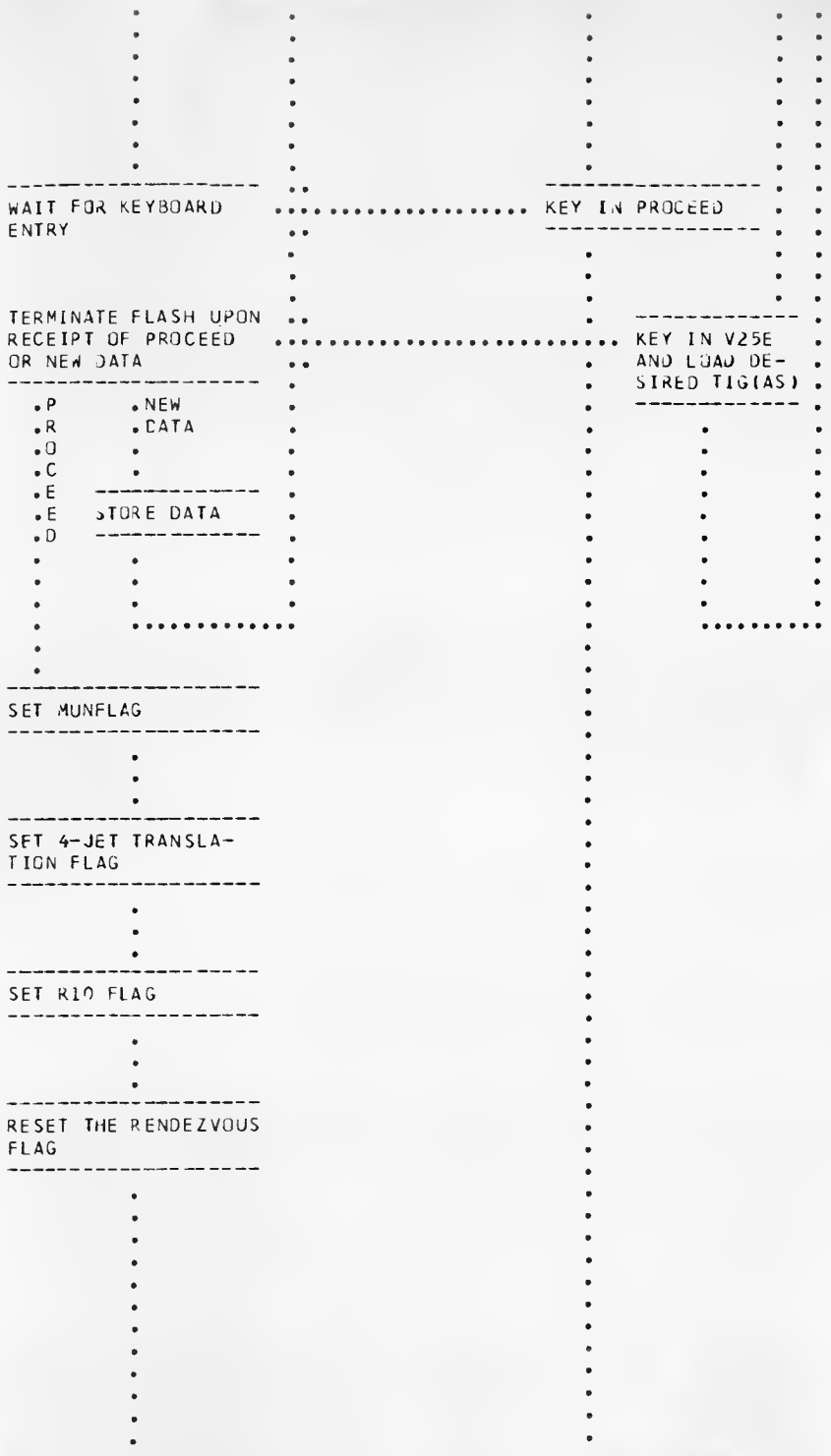
#1C

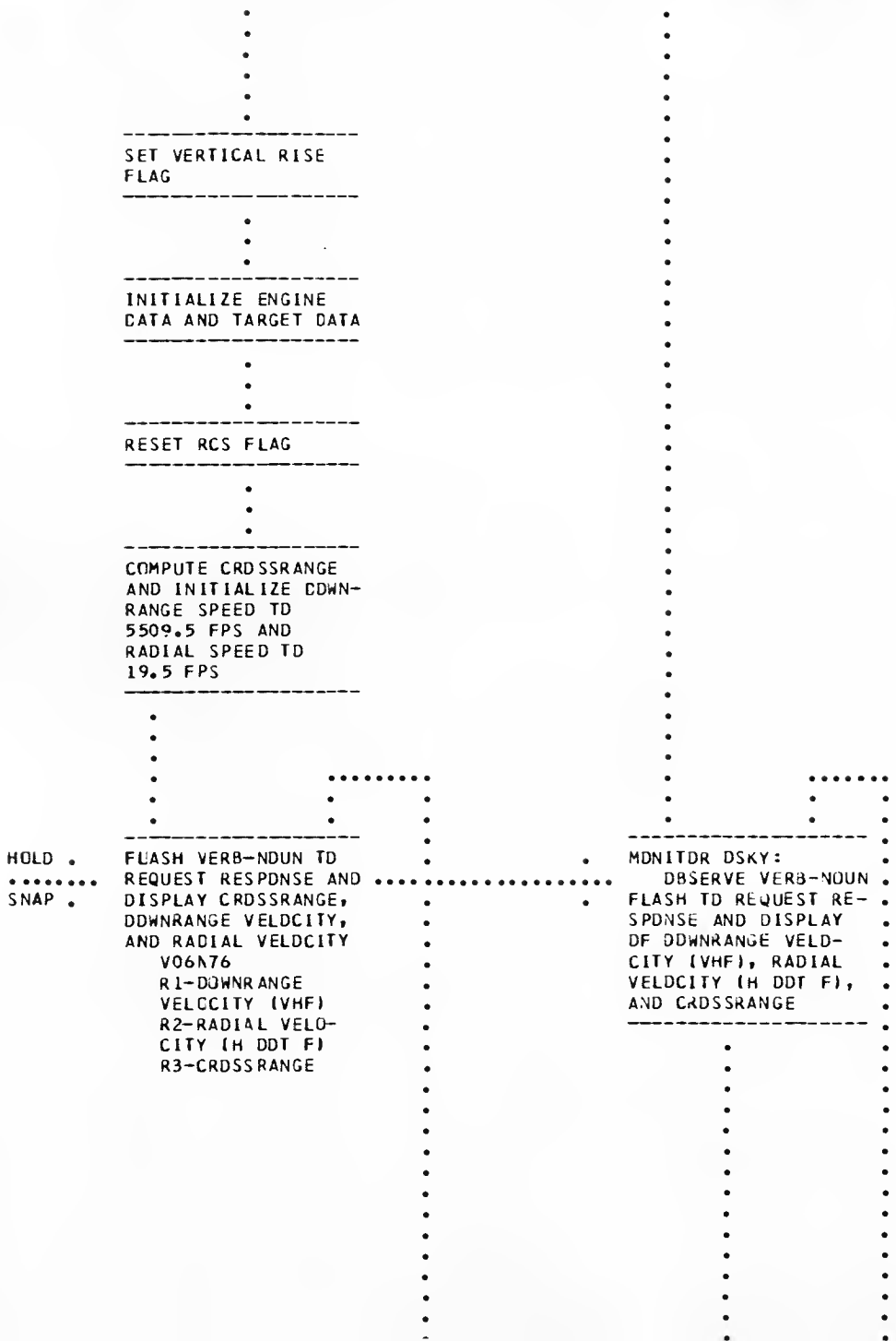
#2C

#3C

#4C


OBTAIN CONTENTS OF TIG REGISTER FOR DISPLAY AS TIG(AS). (NOTE: P57 MAY HAVE STORED T(ALIGN) IN TIG REGISTER - REFER P57.)
HOLD SNAP
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY STORED TIG (AS):
V06 N33
R1-TIG(AS)-HRS
R2-TIG(AS)-MINS
R3-TIG(AS)-SECS
TIG(AS) - TIME OF APS IGNITION FOR ASCENT. (GET) IN HRS, MINS, SECS, TO NEAREST .01 SEC
MONITOR DSKY: OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY OF STORED TIG (AS)
AM I SATISFIED WITH THIS VALUE?
Y
N
RECORD THIS VALUE
#50
#60
#70
#80
#90


WAIT FOR KEYBOARD ENTRY
KEY IN PROCEED
#100
TERMINATE FLASH UPON RECEIPT OF PROCEED OR NEW DATA
KEY IN V25E AND LOAD DESIRED TIG(AS)
.P .R .O .C .E .E .D
.NEW .DATA
STORE DATA
#110
#120
SET MUNFLAG
SET 4-JET TRANSLATION FLAG
#130
SET R10 FLAG
#140
RESET THE RENDEZVOUS FLAG



#150

#160

#170

#180

#190

DOWNRANGE VELOCITY-
THE VELOCITY ALONG
THE LM LOCAL HORIZ-
ONTAL DOWNRANGE AXIS
AT ASCENT INJECTION,
I.E: UNIT(R X UNIT
-L
(V X R)). THIS VALUE
-C -C
WILL ALWAYS BE POS-
ITIVE. IN FT/SEC TO
THE NEAREST 0.1
FT/SEC.

(NOTE: THE INITIAL
VALUES OF DOWNRANGE
VELOCITY = 5509.5
FT/SEC AND RADIAL
VELOCITY =
19.5 FT/SEC WILL
SATISFY AN ORBIT
WITH AN APOLUNE
OF 30 N.M. (REFER
ASSUMPTION 1)
THE CREW SHOULD
CONFER WITH THE
GROUND TO DETERMINE
OVERLOAD VALUES IF
SUCH PROCEDURE IS
DESIRED.)

RADIAL VELOCITY-THE
VELOCITY (UP) ALONG
THE LM LOCAL VERT-
ICAL AXIS AT ASCENT
INJECTION, I.E.;
ALONG UNIT R . THIS
-L
VALUE WILL ALWAYS BE
POSITIVE. IN FT/SEC
TO THE NEAREST
0.1 FT/SEC.

CROSSRANGE-THE DIS-
TANCE BETWEEN THE LM
ORBITAL PLANE AFTER

IS THE ANTICIPATED
TOTAL DELTA V EXPEN-
DITURE FOR THE
ASCENT AND RENDEZV-
OUS MANEUVERS SUCH
THAT I WISH TO RE-
DUCE THE AMOUNT OF
CROSSRANGE FOR THE
ASCENT MANEUVER?

.N .Y

#200

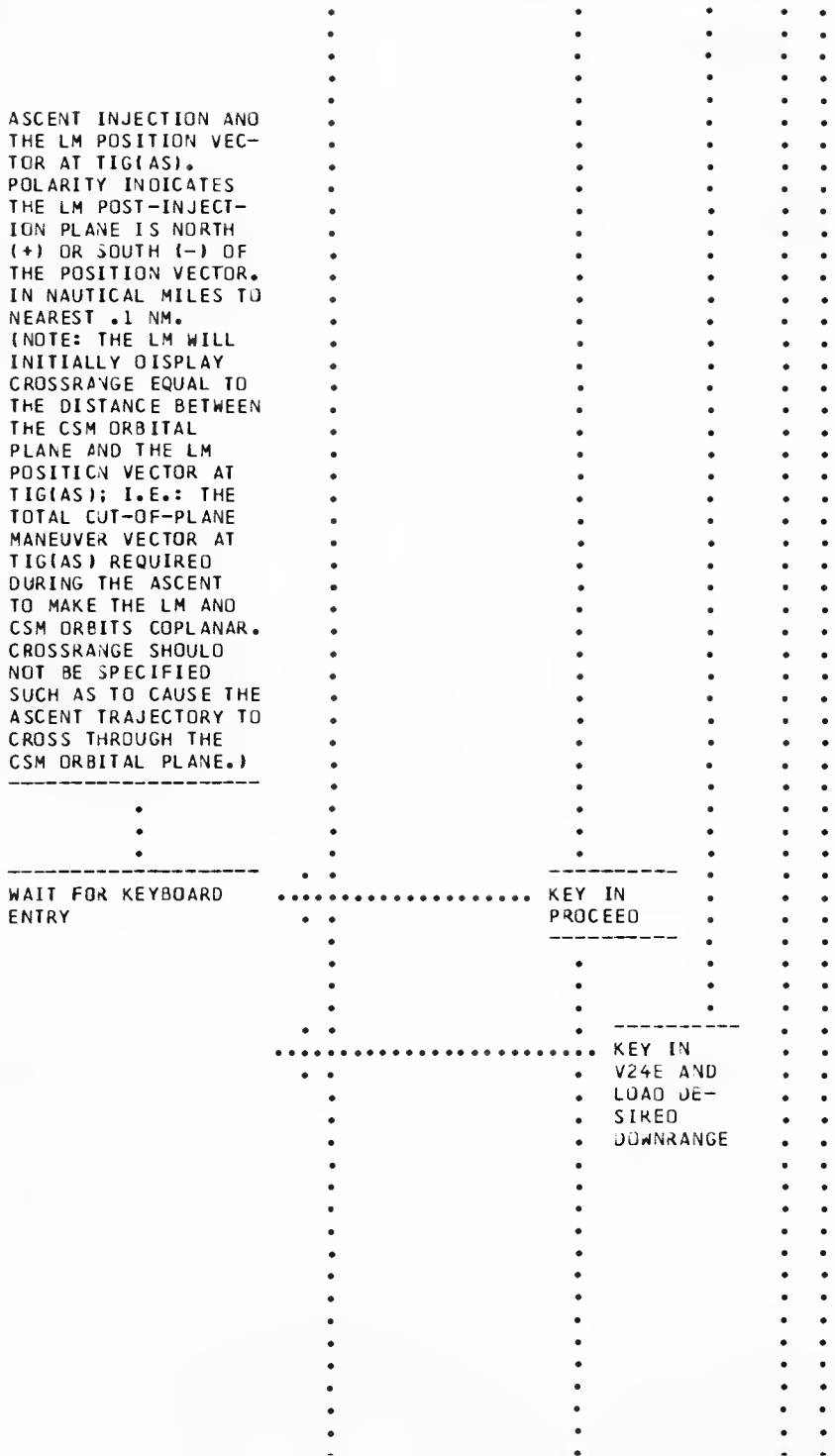
#210

#220

DO I WISH TO
CHANGE THE
PRESENTLY DE-
FINED DOWN-
RANGE VELOCITY
OR RADIAL
VELOCITY FOR
THE ASCENT
TRAJECTORY?

.N .Y

#230



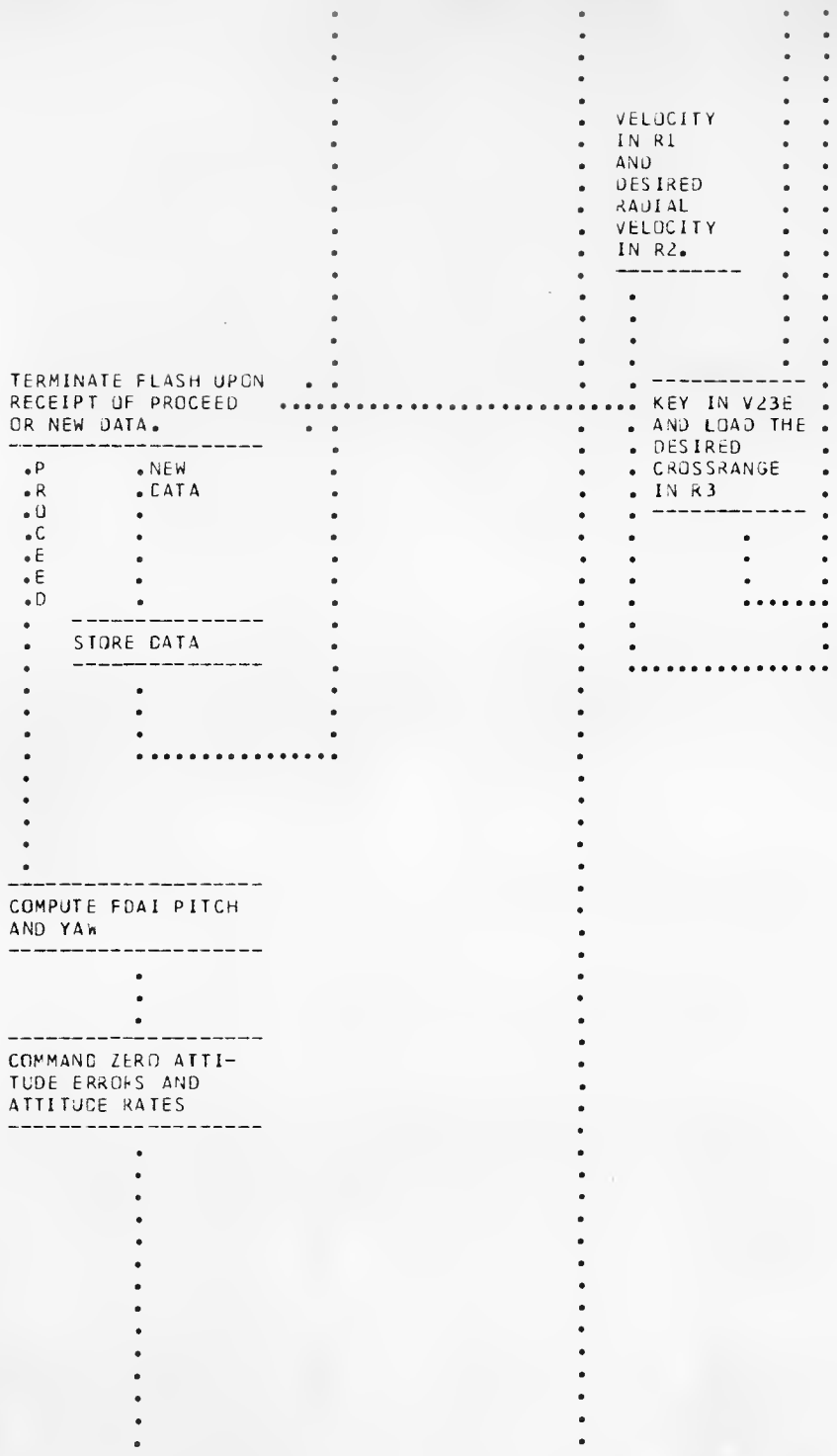
#240

#250

#260

#270

#280



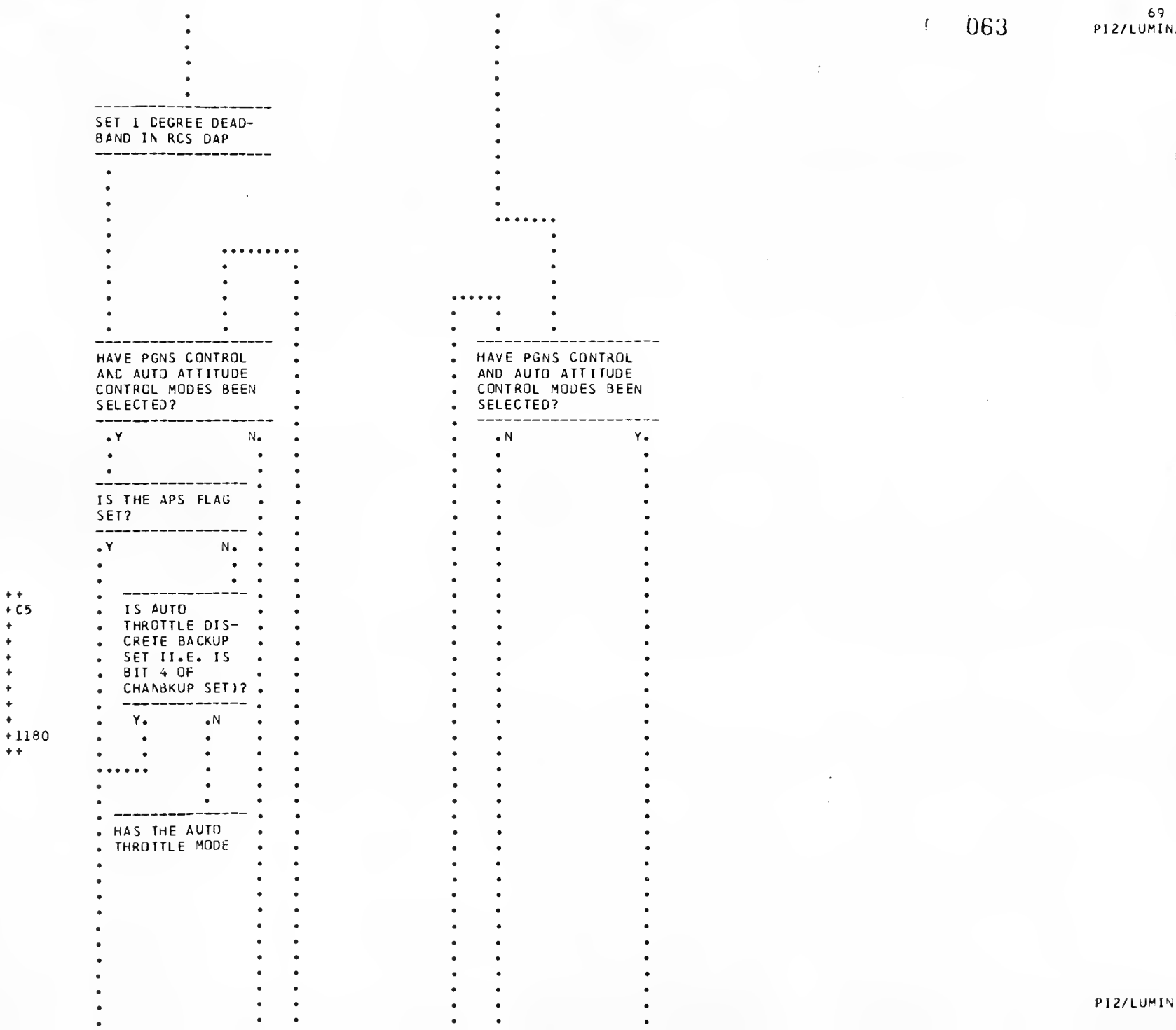
#290

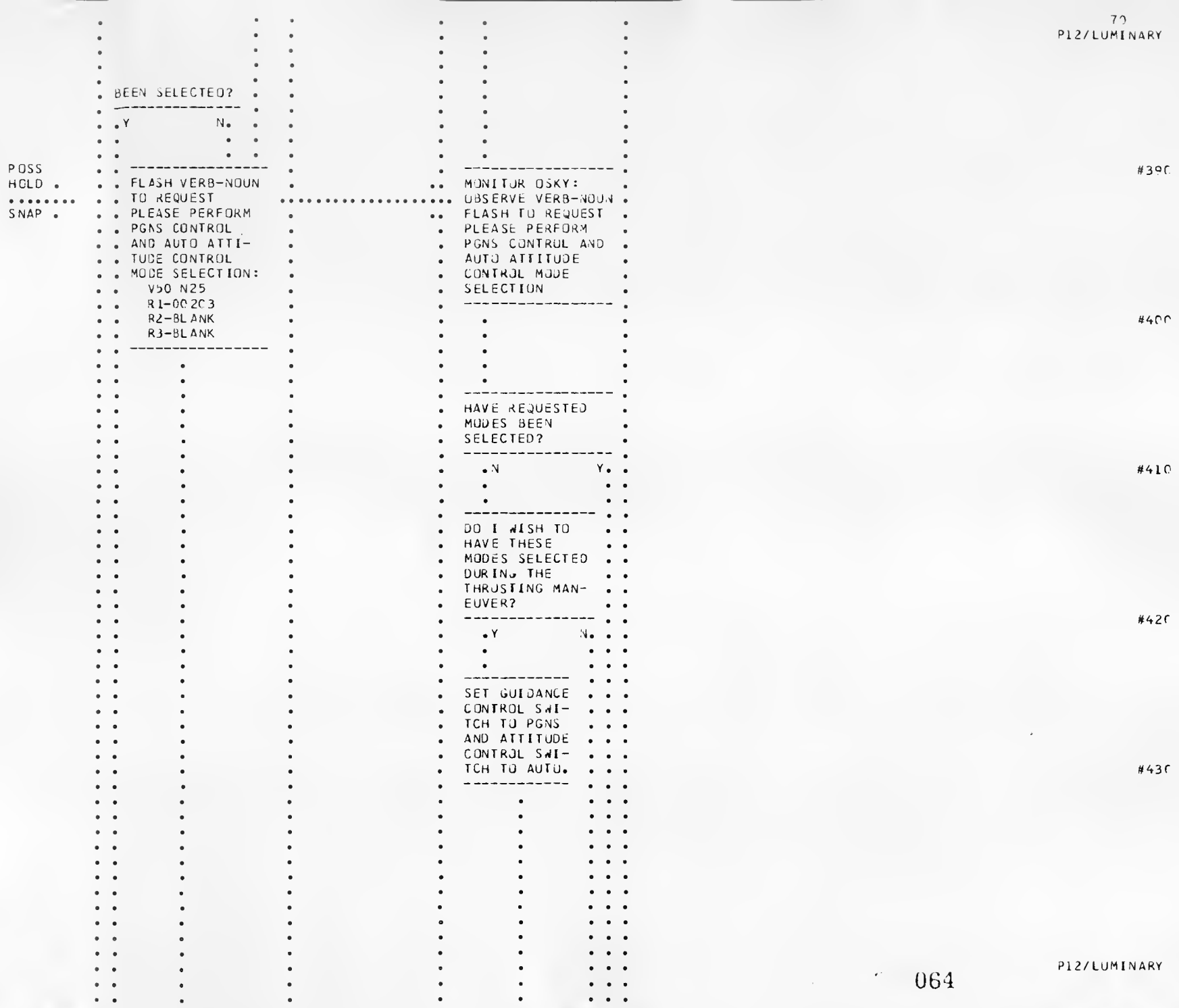
#300

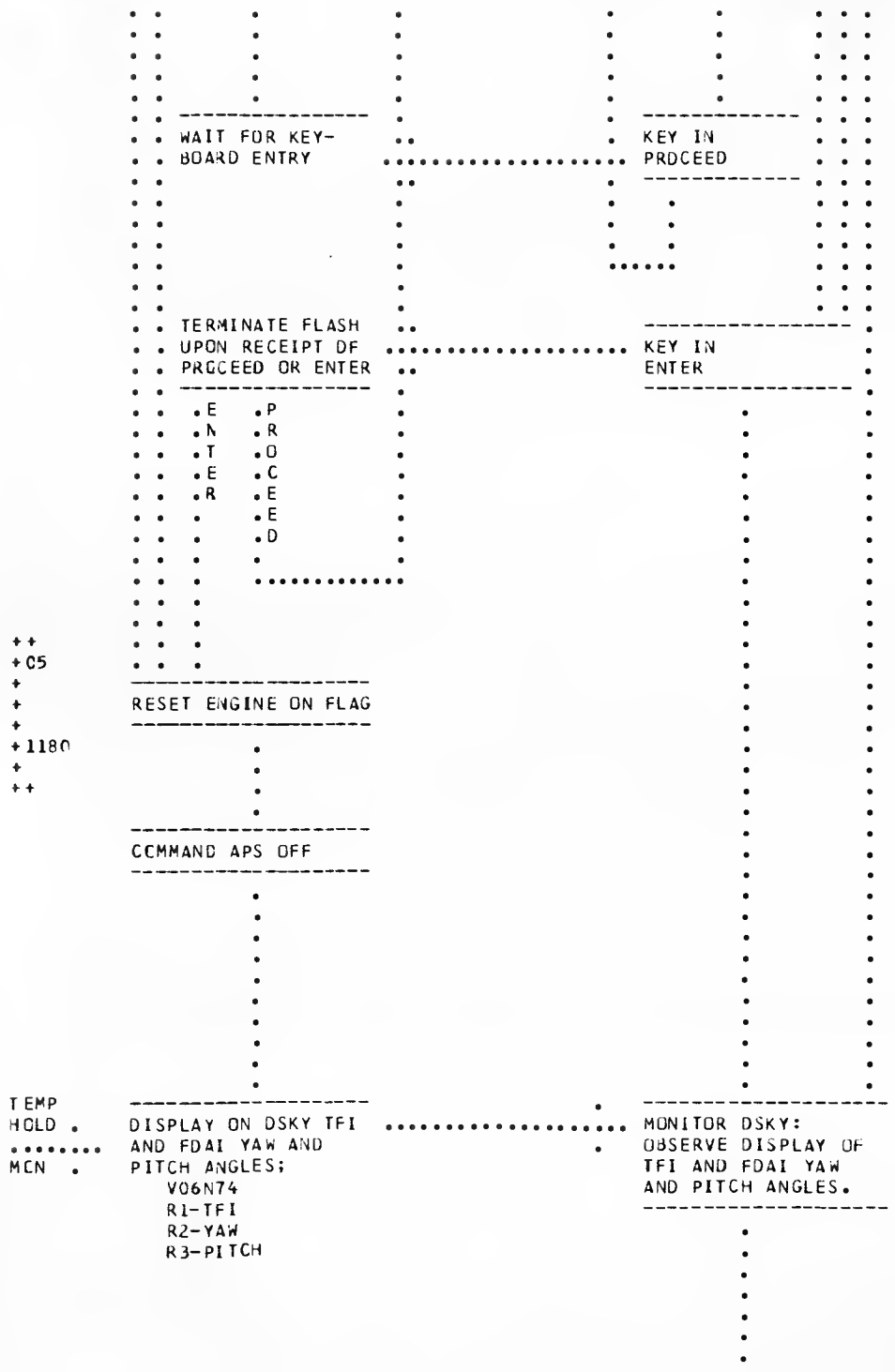
#310

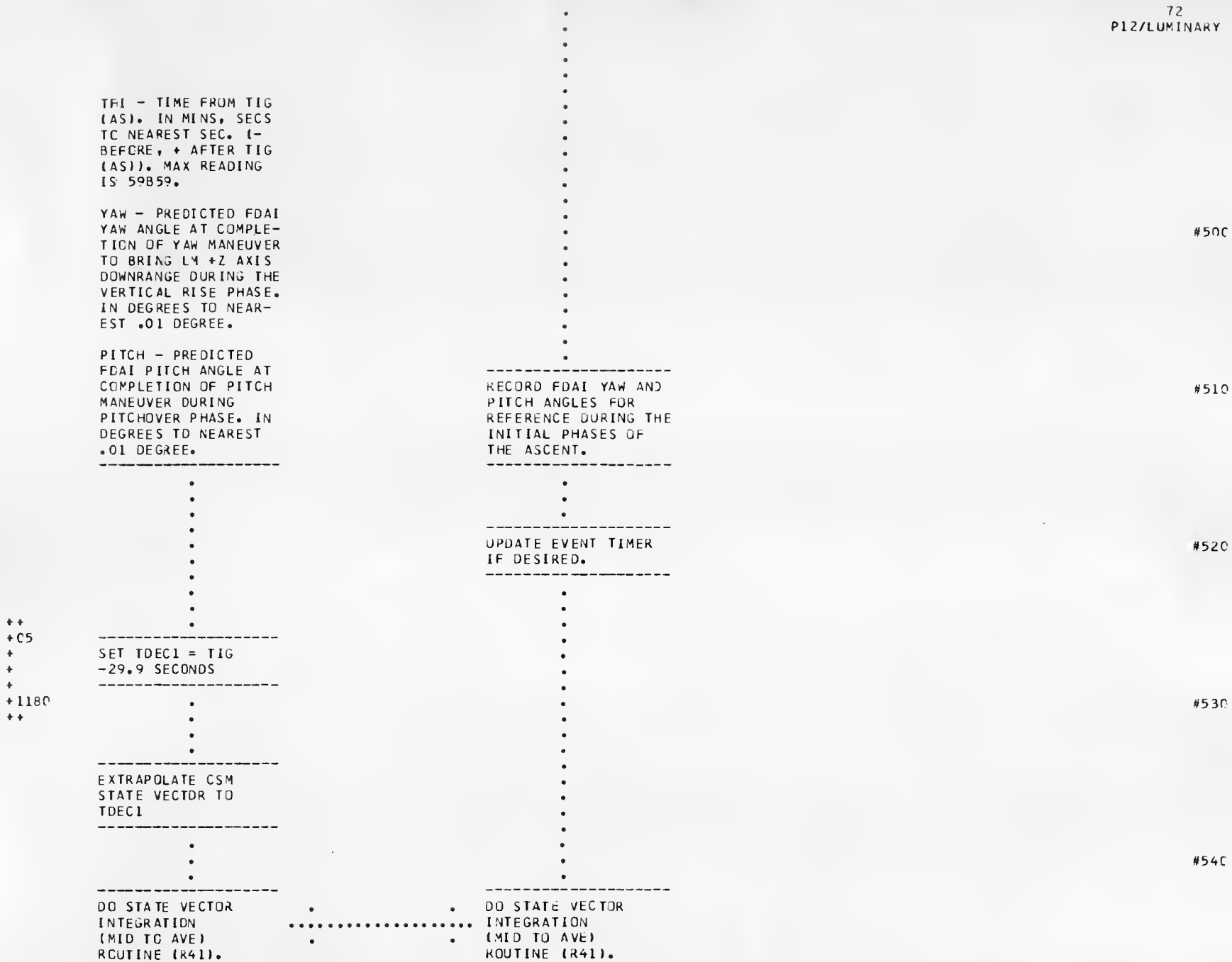
#320

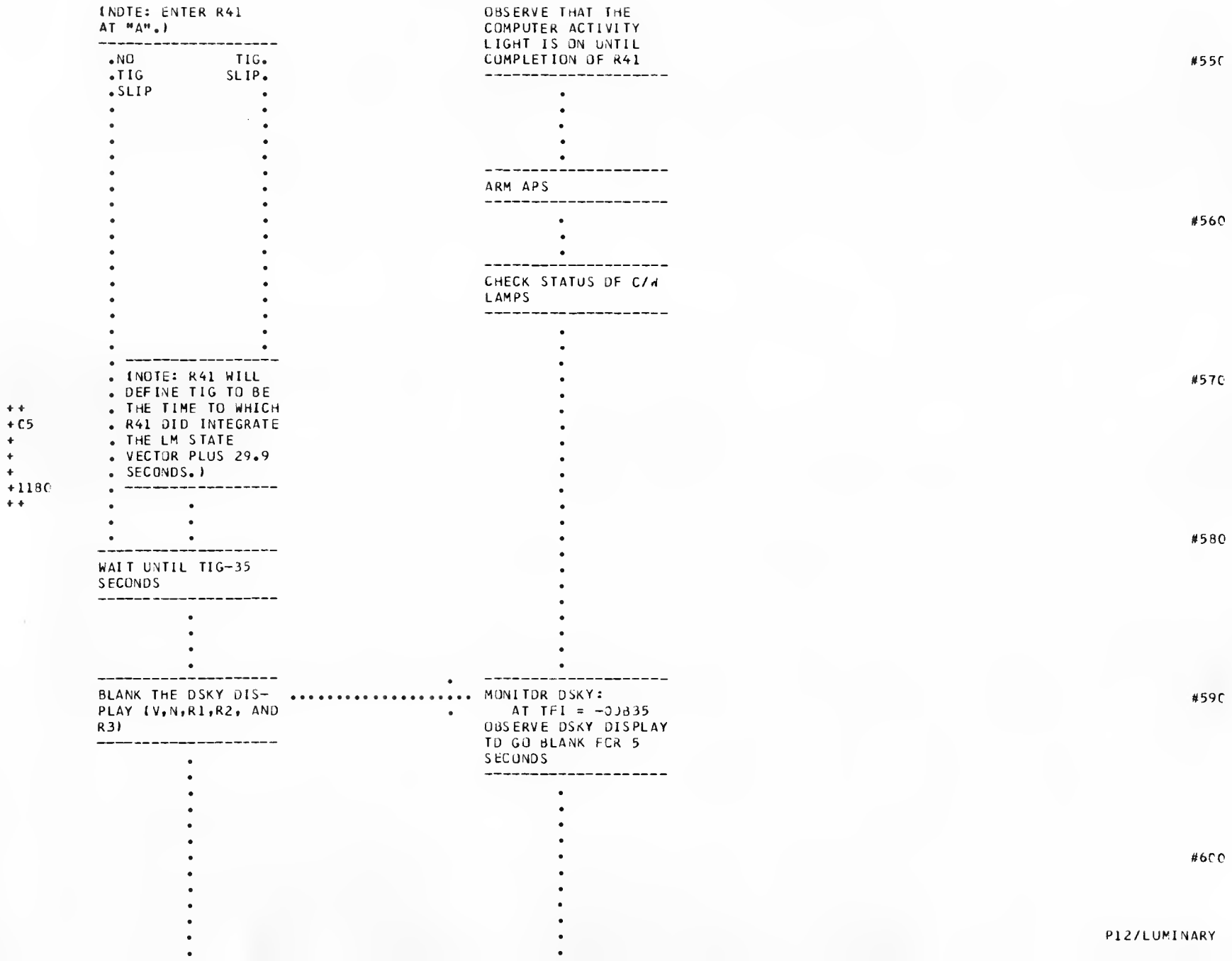
#330


SET 1 DEGREE DEAD-
BAND IN RCS DAP
#34C
HAVE PGNS CONTROL
AND AUTO ATTITUDE
CONTROL MODES BEEN
SELECTED?
.Y
N.
#35C
IS THE APS FLAG
SET?
.Y
N.
#36D
IS AUTO
THROTTLE DIS-
CRETE BACKUP
SET II.E. IS
BIT 4 OF
CHANBKUP SET)?
Y.
.N
+C5
+1180
#37C
HAS THE AUTO
THROTTLE MODE
#38D
HAVE PGNS CONTROL
AND AUTO ATTITUDE
CONTROL MODES BEEN
SELECTED?
.N
Y.
#36D


BEEN SELECTED?
Y
N.
POSS HOLD
SNAP
FLASH VERB-NOUN TO REQUEST PLEASE PERFORM PGNS CONTROL AND AUTO ATTI-TUDE CONTROL MODE SELECTION: V50 N25 R1-00203 R2-BLANK R3-BLANK
MONITOR OSKY: OBSERVE VERB-NOUN FLASH TO REQUEST PLEASE PERFORM PGNS CONTROL AND AUTO ATTITUDE CONTROL MODE SELECTION
#390
#400
HAVE REQUESTED MODES BEEN SELECTED?
N
Y
#410
DO I WISH TO HAVE THESE MODES SELECTED DURING THE THRUSTING MAN-EUVER?
Y
N.
#420
SET GUIDANCE CONTROL SWI-TCH TO PGNS AND ATTITUDE CONTROL SWI-TCH TO AUTO.
#430


WAIT FOR KEY-
BOARD ENTRY
KEY IN
PROCEED
#440
TERMINATE FLASH
UPON RECEIPT OF
PROCEED OR ENTER
KEY IN
ENTER
.ENTER
.PROCEED
#450
#460
++
+05
+
+
+
+1180
+
++
RESET ENGINE ON FLAG
COMMAND APS OFF
#470
#480
TEMP
HOLD .
.....
MCN .
DISPLAY ON DSKY TFI
AND FDAI YAW AND
PITCH ANGLES;
V06N74
R1-TFI
R2-YAW
R3-PITCH
MONITOR DSKY:
OBSERVE DISPLAY OF
TFI AND FDAI YAW
AND PITCH ANGLES.
#490


TFI - TIME FROM TIG (AS). IN MINS, SECS TO NEAREST SEC. (- BEFORE, + AFTER TIG (AS)). MAX READING IS 59B59.
YAW - PREDICTED FDAI YAW ANGLE AT COMPLETION OF YAW MANEUVER TO BRING LM +Z AXIS DOWNRANGE DURING THE VERTICAL RISE PHASE. IN DEGREES TO NEAREST .01 DEGREE.
PITCH - PREDICTED FDAI PITCH ANGLE AT COMPLETION OF PITCH MANEUVER DURING PITCHOVER PHASE. IN DEGREES TO NEAREST .01 DEGREE.
RECORD FDAI YAW AND PITCH ANGLES FOR REFERENCE DURING THE INITIAL PHASES OF THE ASCENT.
UPDATE EVENT TIMER IF DESIRED.
#500
#510
#520
+C5
SET TDEC1 = TIG -29.9 SECONDS
+1180
#530
EXTRAPOLATE CSM STATE VECTOR TO TDEC1
#540
DO STATE VECTOR INTEGRATION (MID TO AVE) ROUTINE (R41).
DO STATE VECTOR INTEGRATION (MID TO AVE) ROUTINE (R41).


(NOTE: ENTER R41 AT "A".)
.NO TIG. .TIG SLIP. .SLIP
(NOTE: R41 WILL DEFINE TIG TO BE THE TIME TO WHICH R41 DID INTEGRATE THE LM STATE VECTOR PLUS 29.9 SECONDS.)
WAIT UNTIL TIG-35 SECONDS
BLANK THE DSKY DISPLAY (V,N,R1,R2, AND R3)
OBSERVE THAT THE COMPUTER ACTIVITY LIGHT IS ON UNTIL COMPLETION OF R41
ARM APS
CHECK STATUS OF C/W LAMPS
MONITOR DSKY: AT TFI = -00835
OBSERVE DSKY DISPLAY TO GO BLANK FOR 5 SECONDS
#550
#560
#570
#580
#590
#600
++
+C5
+
+
+
+1180
++

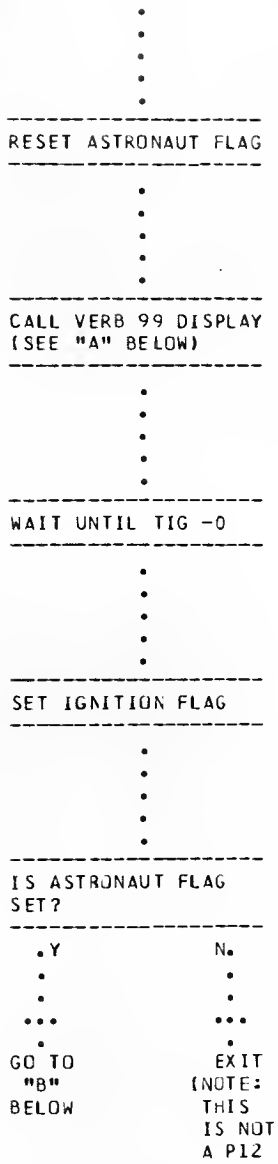
#610

#620

#630

#640

#650



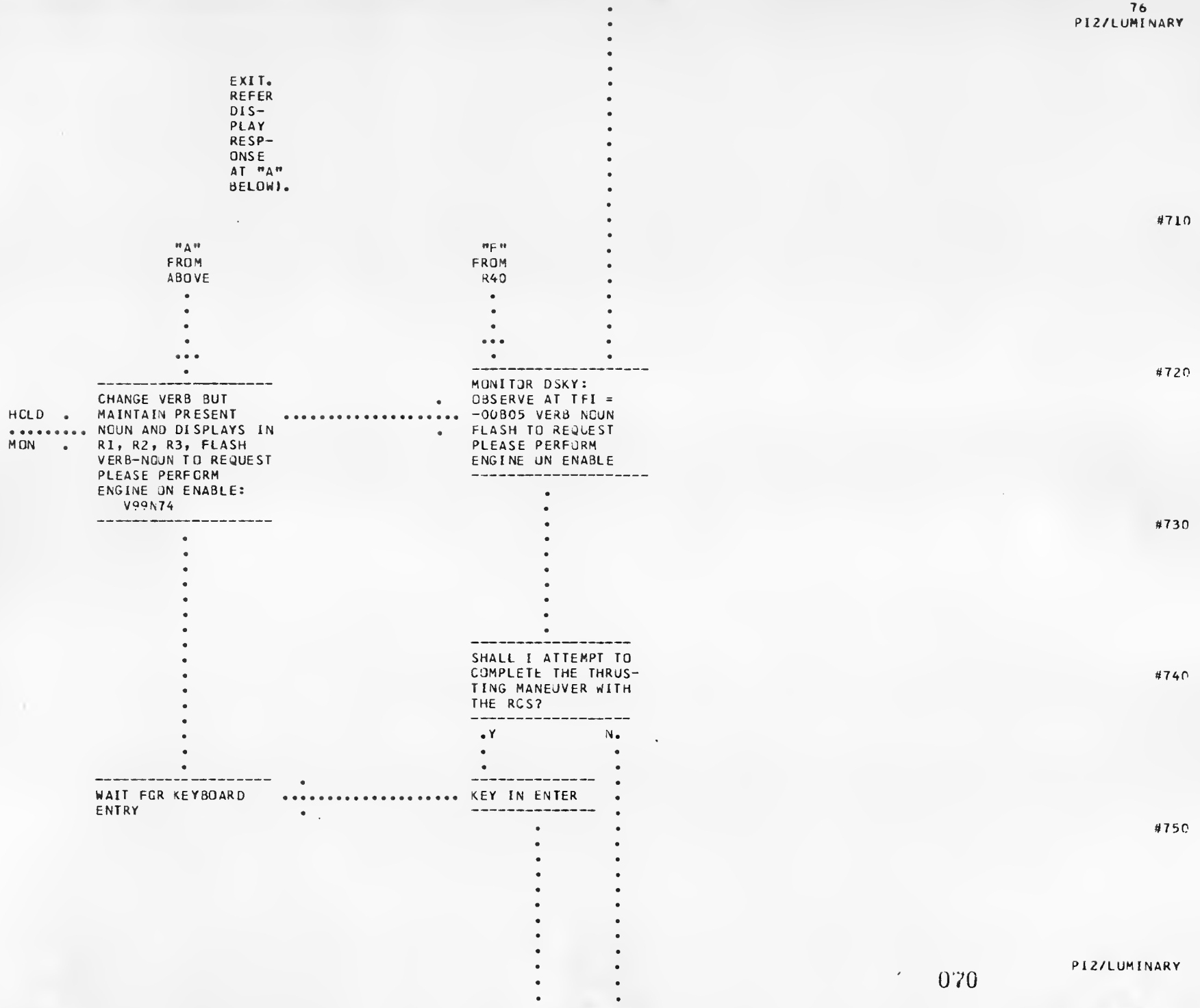
#660

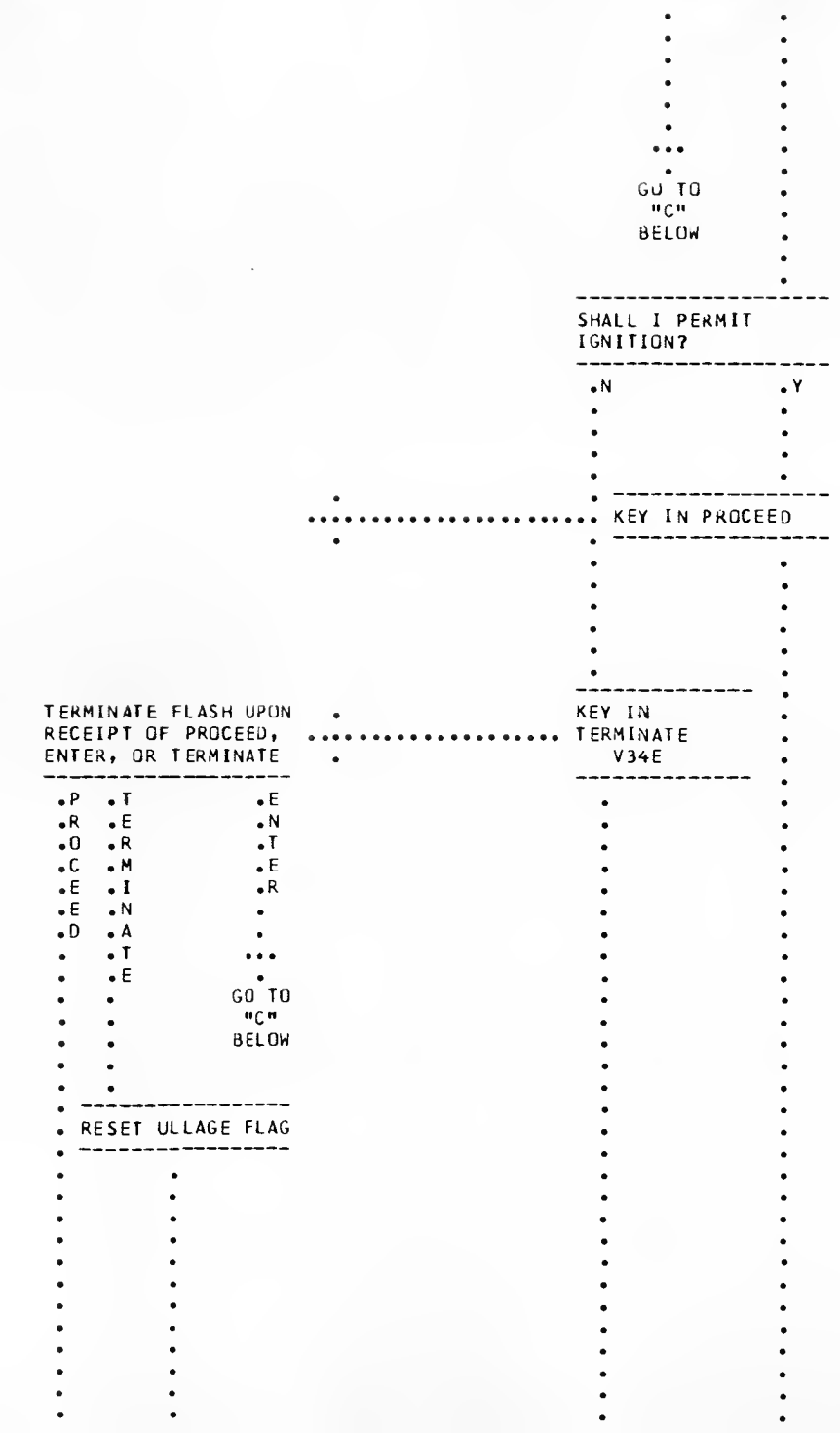
#670

#680

#690

#700


EXIT.
REFER
DIS-
PLAY
RESP-
ONSE
AT "A"
BELOW).
#710
"A"
FROM
ABOVE
"F"
FROM
R40
#720
HOLD
MON
CHANGE VERB BUT
MAINTAIN PRESENT
NOUN AND DISPLAYS IN
R1, R2, R3, FLASH
VERB-NOUN TO REQUEST
PLEASE PERFORM
ENGINE ON ENABLE:
V99N74
MONITOR DSKY:
OBSERVE AT TFI =
-00805 VERB NOUN
FLASH TO REQUEST
PLEASE PERFORM
ENGINE ON ENABLE
#730
SHALL I ATTEMPT TO
COMPLETE THE THRUS-
TING MANEUVER WITH
THE RCS?
#740
Y
N
WAIT FOR KEYBOARD
ENTRY
KEY IN ENTER
#750



#760

#770

#780

#790

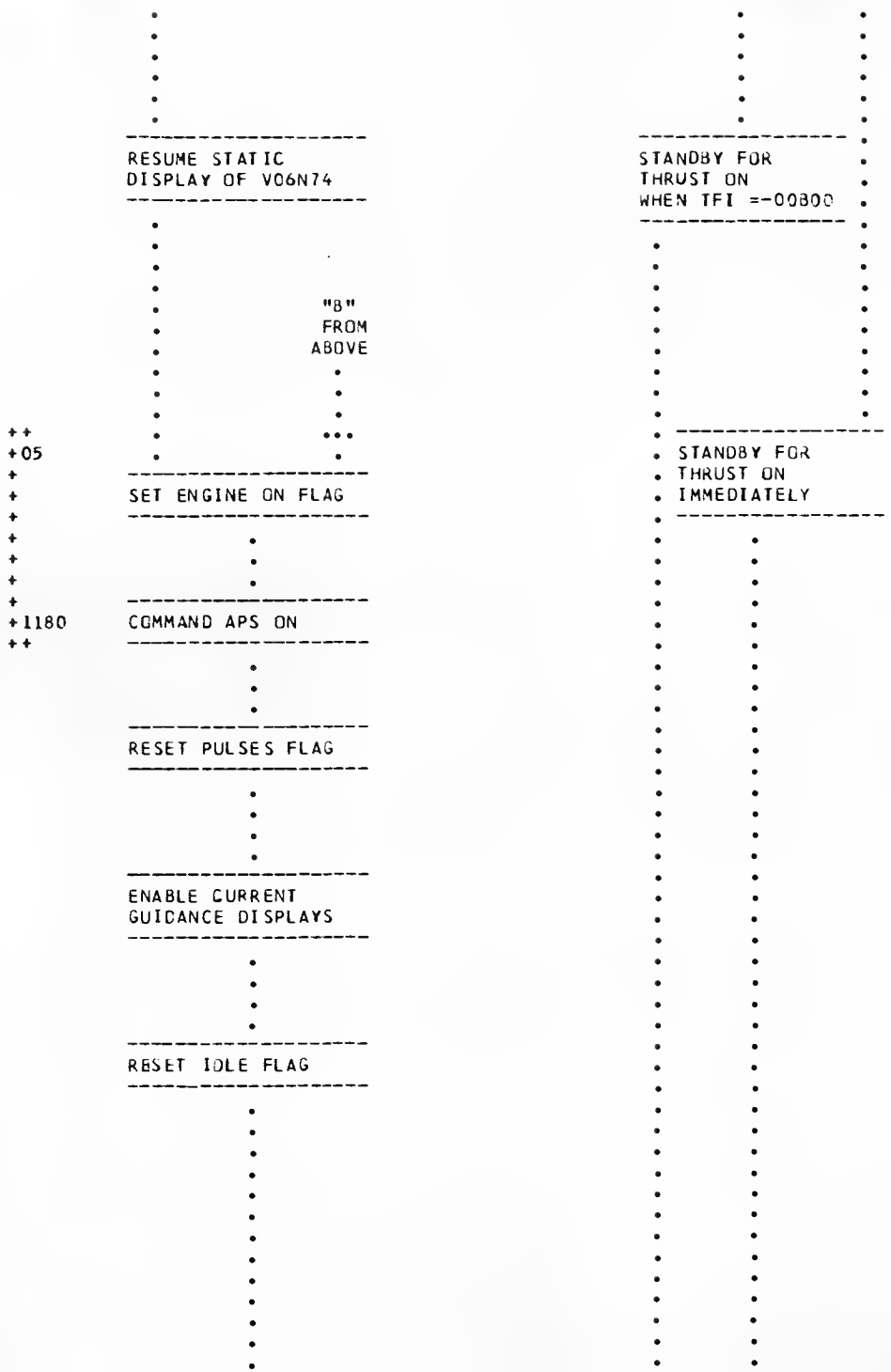
#800

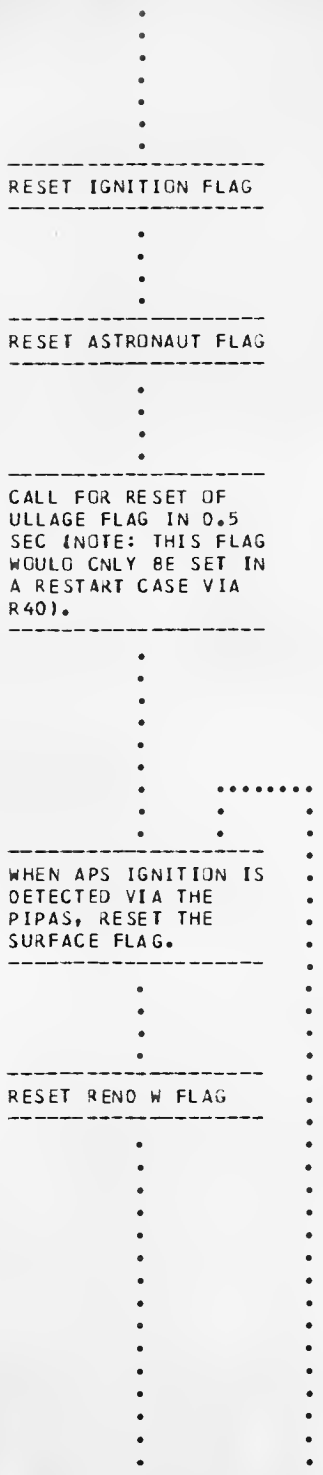
#810

#820

#830

#840


RESUME STATIC DISPLAY OF V06N74
"8" FROM ABOVE
+05
SET ENGINE ON FLAG
+1180
COMMAND APS ON
RESET PULSES FLAG
ENABLE CURRENT GUIDANCE DISPLAYS
RESET IDLE FLAG
STANDBY FOR THRUST ON WHEN TFI =-00800
STANDBY FOR THRUST ON IMMEDIATELY
#850
#860
#870
#880
#890



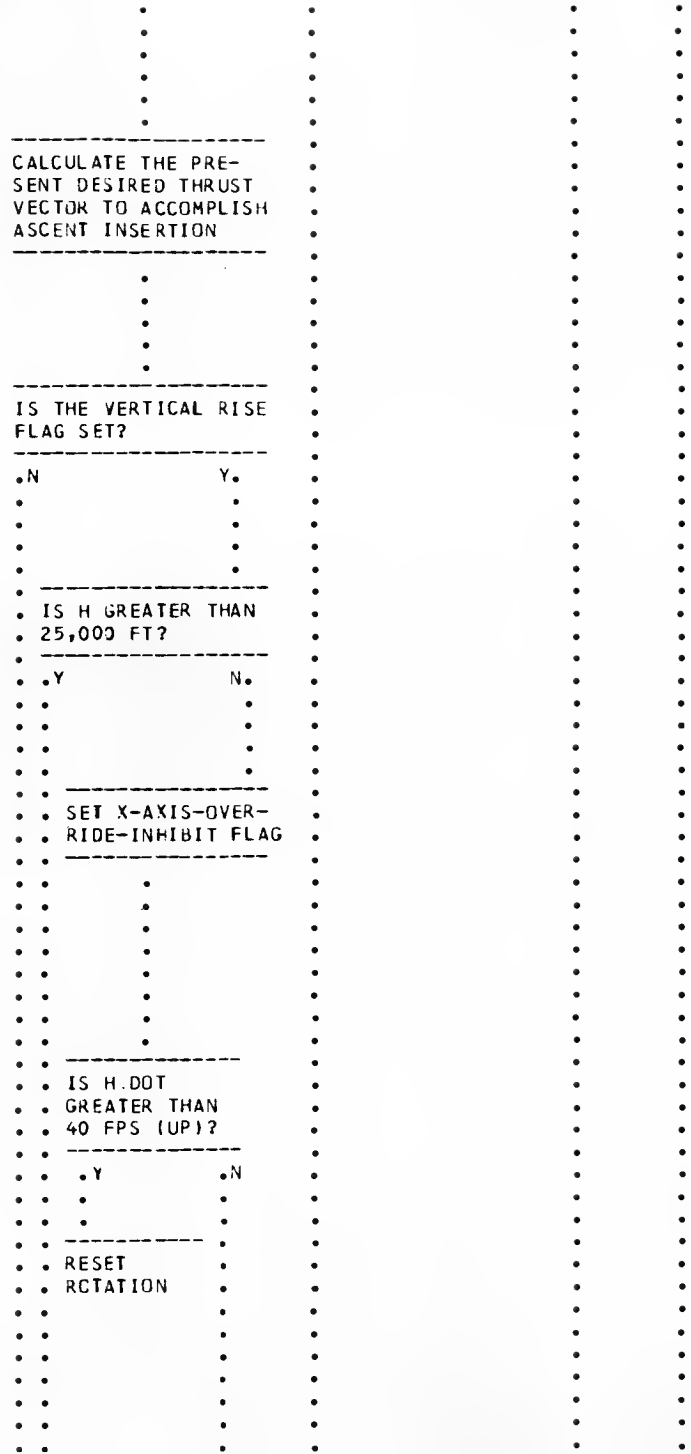
#900

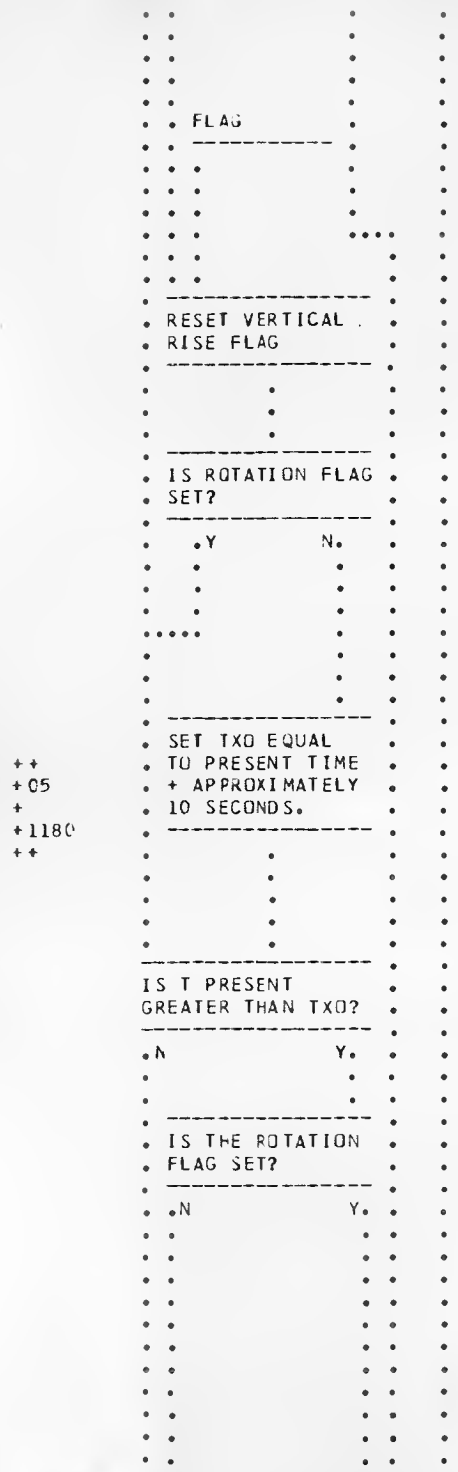
#910

#920

#930

#940


CALCULATE THE PRE-
SENT DESIRED THRUST
VECTOR TO ACCOMPLISH
ASCENT INSERTION
#950
IS THE VERTICAL RISE
FLAG SET?
#960
N
Y
IS H GREATER THAN
25,000 FT?
#970
Y
N
SET X-AXIS-OVER-
RIDE-INHIBIT FLAG
#980
IS H.DOT
GREATER THAN
40 FPS (UP)?
#990
Y
N
RESET
ROTATION




```
++
+05
+
+1180
++
```

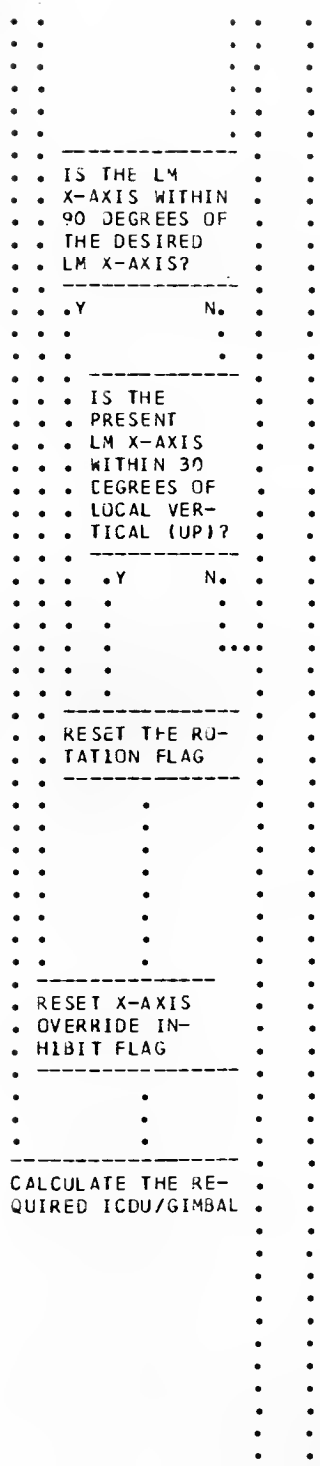
#1000

#1010

#1020

#1030

#1040



#1050

#1060

#1070

#1080

#1090

ANGLES AND DRIVE THE ICDUS (USING FINDCDUW) TO ALIGN THE LM +X AXIS WITH THE DESIRED THRUST VECTOR TO ACCOMPLISH THE ASCENT, THE LM +Y AXIS HORIZONTAL, AND THE LM +Z AXIS DOWN.

#1100

#1110

CALCULATE THE REQUIRED ICDU/GIMBAL ANGLES AND DRIVE THE ICDUS (USING FINDCDUW) TO ALIGN THE LM +X AXIS WITH THE PRESENT LOCAL VERTICAL (UP), THE LM +Y AXIS NORMAL TO THE ANTICIPATED PITCH MANEUVER PLANE FOR THE ASCENT, AND THE LM +Z AXIS DOWNRANGE.

#1120

#1130

TEMP HOLD MON

DISPLAY ON DSKY:
V06N94
R1-VGX(LM)
R2-H DOT
R3-H

VGX(LM) - COMPONENT

MONITOR DSKY:
OBSERVE DISPLAY OF VGX(LM), H DOT, AND H

#1140

OF THE PRESENT VG VECTOR ALONG LM X AXIS. IN FPS TO NEAREST .1 FPS. UPDATED BY STEERING LOOPS DURING EACH COMPUTATIONAL CYCLE.

H DOT - THE PRESENT RATE OF CHANGE OF ALTITUDE(H). POLARITY INDICATES DESCENT (-) OR ASCENT (+). IN FT/SEC TO NEAREST .1 FT/SEC.

H - THE PRESENT ALTITUDE OF THE LM ABOVE THE LM POSITION VECTOR AT TIG (AS). POLARITY IS + FOR ALTITUDES GREATER THAN THE ABOVE RADIUS. IN FEET TO NEAREST FOOT.

MONITOR FDAI BALL, LM WINDOW, AND OSKY:

(A) OBSERVE LM X AXIS TO COME TO LOCAL VERTICAL.

(B) OBSERVE LM YAW MANEUVER TO FDAI BALL YAW ANGLE PREVIOUSLY DISPLAYED AND RECORDED.

(C) OBSERVE LM

#I15C

#I16C

#I17C

#I18C

#I19C

PITCH MANEUVER TO FDAI BALL PITCH ANGLE PREVIOUSLY DISPLAYED AND RECORDED.

.Y .N

GO TO BACKUP PROCEDURES

#1200

THE X-AXIS OVERRIDE OPTION IS RESTORED APPROXIMATELY 12 SECONDS AFTER H DOT REACHES +00400

#1210

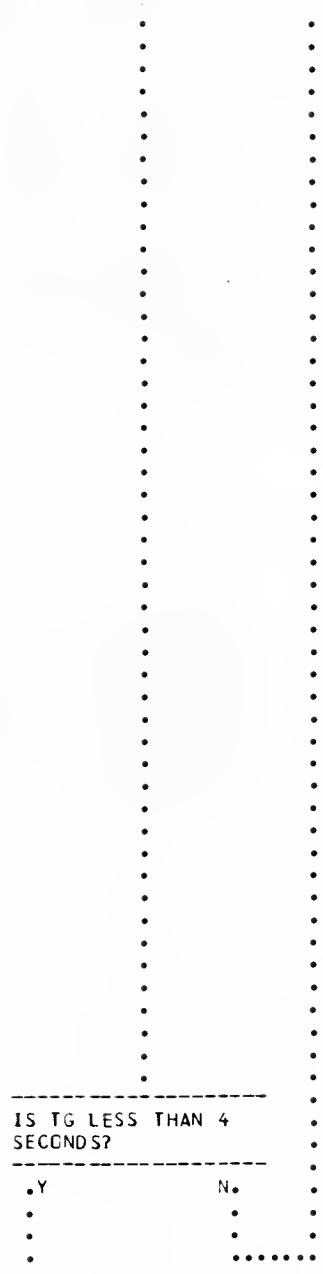
CONTINUE MONITOR OF APS THRUSTING:

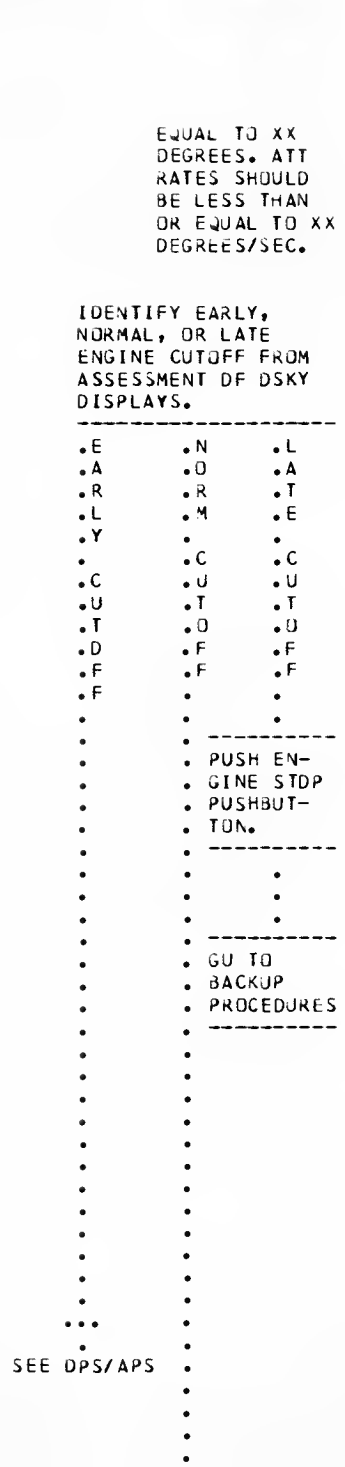
1. DSKY:
   R1-VGX SHOULD BE DECREASING
   R2-H DOT SHOULD BE INCREASING AND THEN DECREASE
   R3-H SHOULD BE INCREASING.

#1220

#1230

2. FDAI-ATT ERRORS SHOULD BE LESS THAN OR





#1240

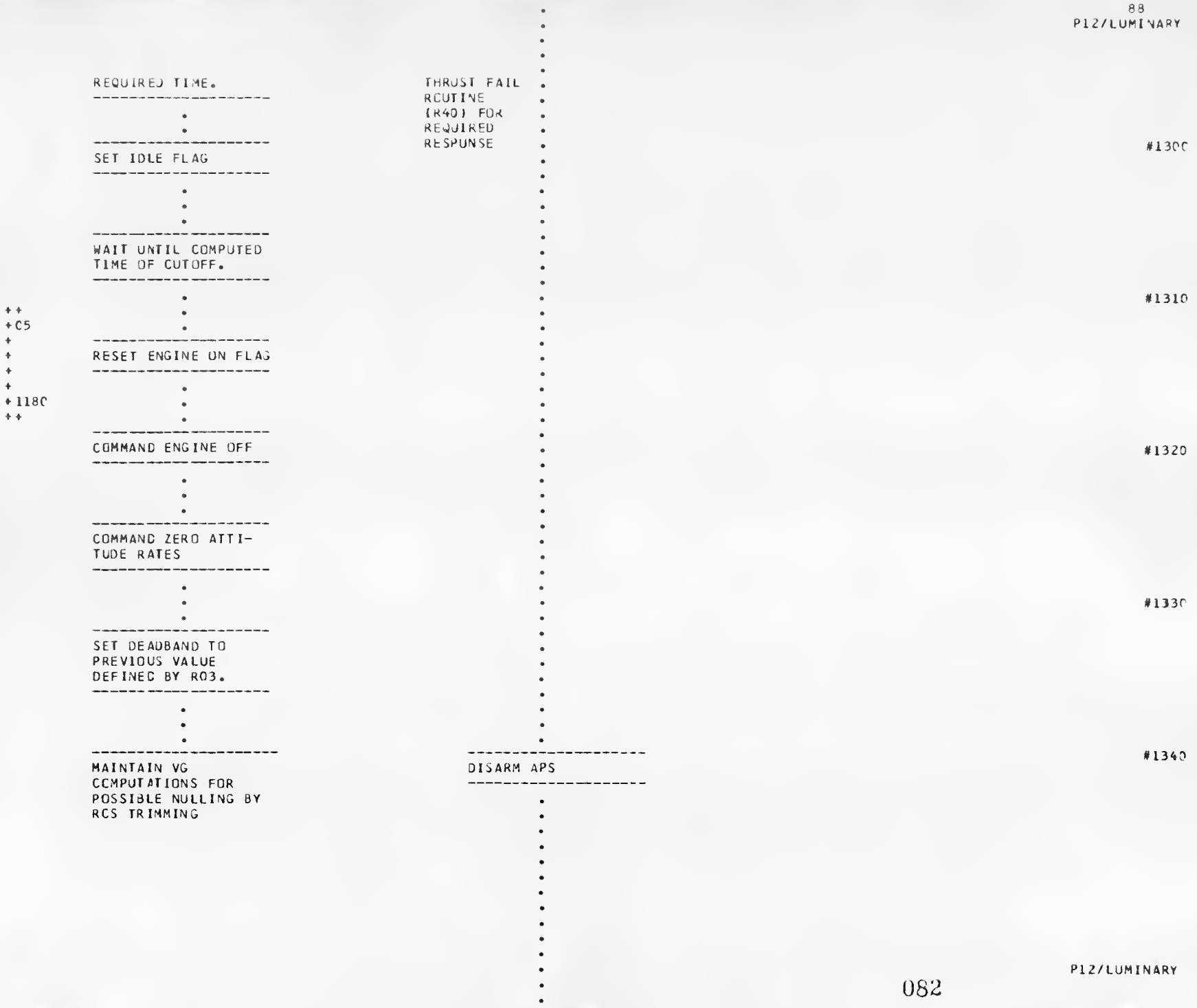
#1250

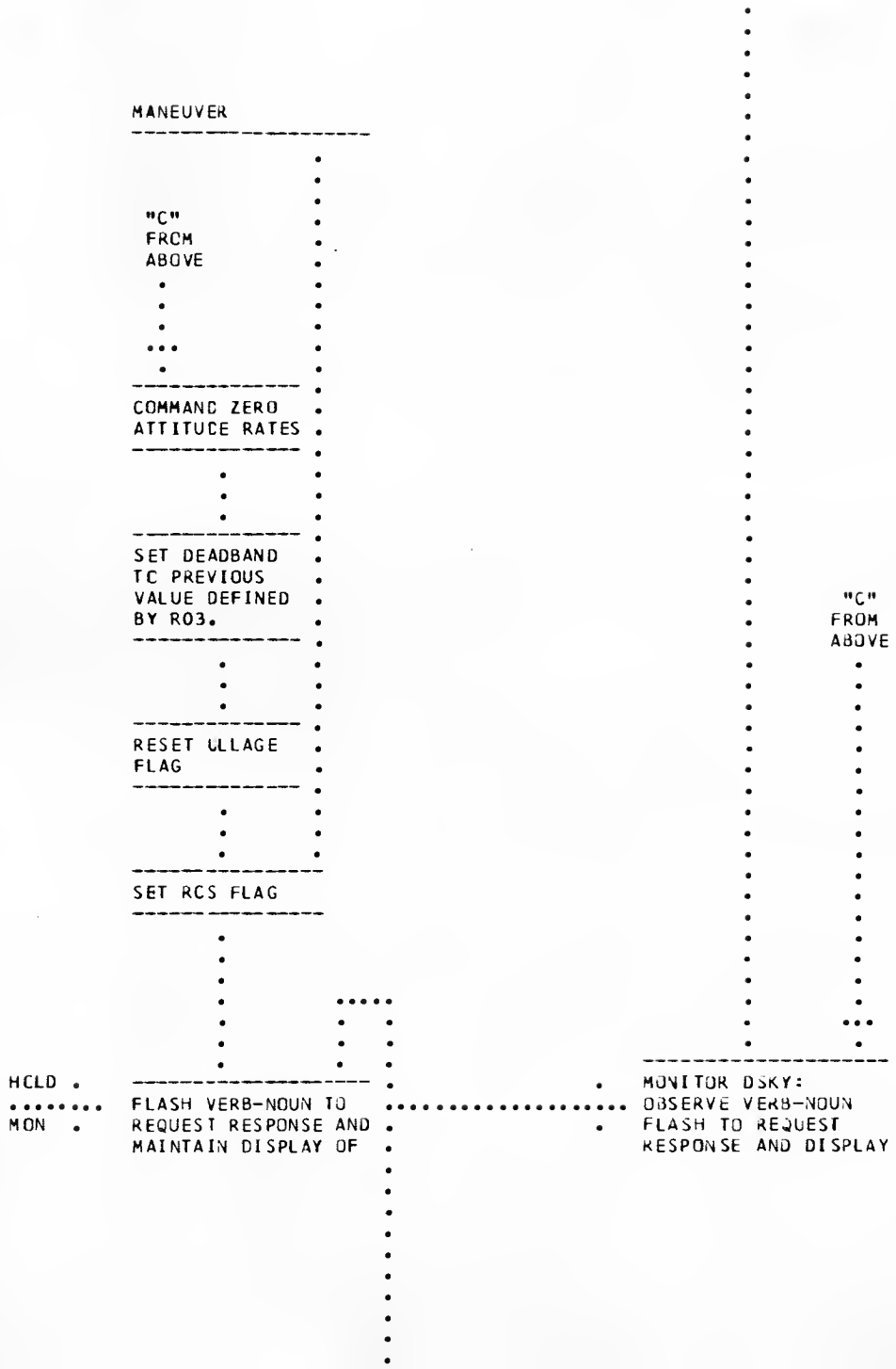
#1260

#1270

#1280

#1290


REQUIRED TIME.
SET IDLE FLAG
WAIT UNTIL COMPUTED TIME OF CUTOFF.
C5
RESET ENGINE ON FLAG
1180
COMMAND ENGINE OFF
COMMAND ZERO ATTITUDE RATES
SET DEADBAND TO PREVIOUS VALUE DEFINED BY R03.
MAINTAIN VG COMPUTATIONS FOR POSSIBLE NULLING BY RCS TRIMMING
THRUST FAIL ROUTINE (R40) FOR REQUIRED RESPONSE
DISARM APS
#1300
#1310
#1320
#1330
#1340



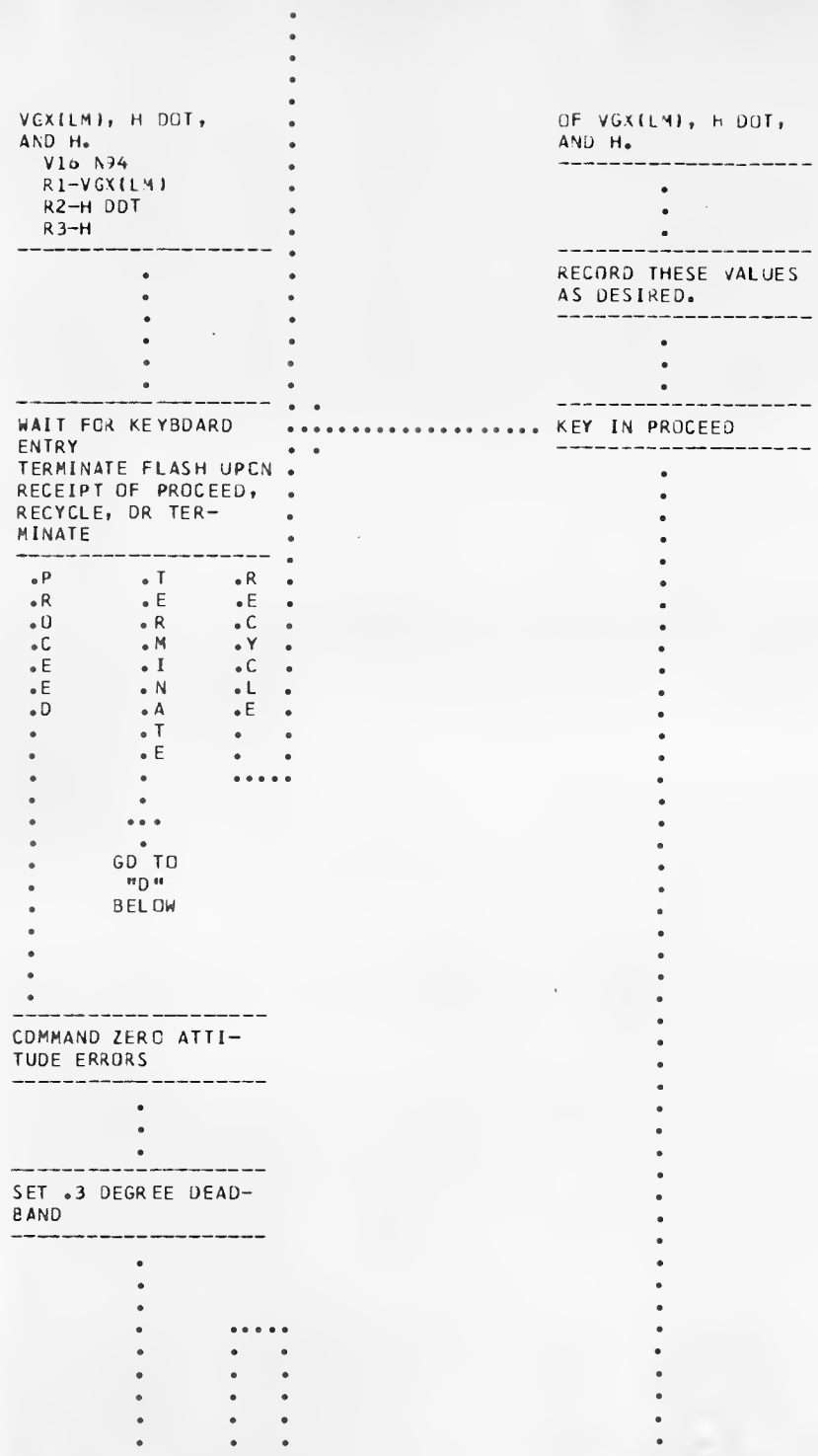
#1350

#1360

#1370

#1380

#1390



#1400

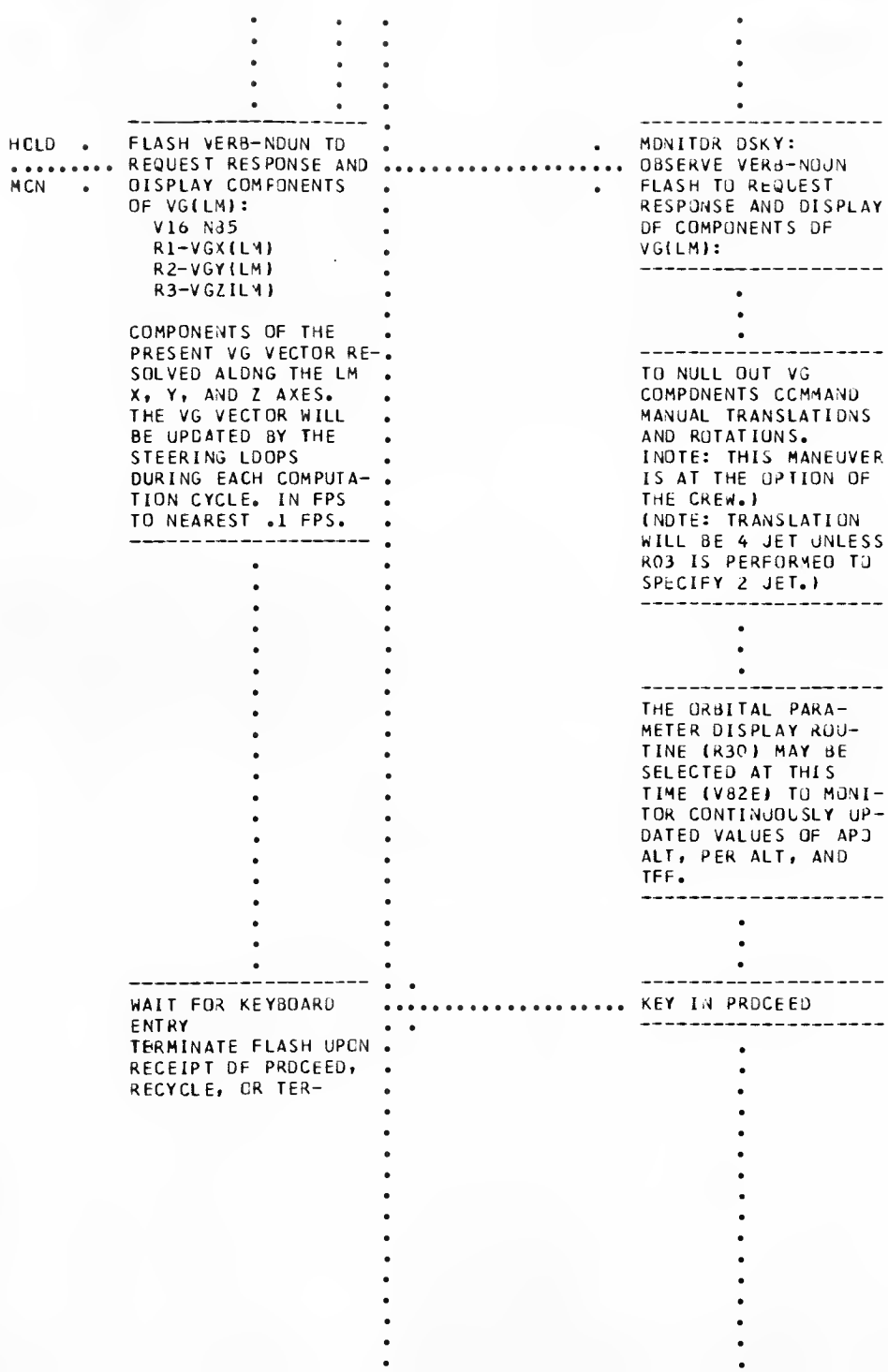
#1410

#1420

#1430

#1440

#1450


HOLD
MCN
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY COMPONENTS OF VG(LM):
V16 N85
R1-VGX(LM)
R2-VGY(LM)
R3-VGZ(LM)
COMPONENTS OF THE PRESENT VG VECTOR RESOLVED ALONG THE LM X, Y, AND Z AXES. THE VG VECTOR WILL BE UPDATED BY THE STEERING LOOPS DURING EACH COMPUTATION CYCLE. IN FPS TO NEAREST .1 FPS.
WAIT FOR KEYBOARD ENTRY
TERMINATE FLASH UPON RECEIPT OF PROCEED, RECYCLE, OR TER-
MONITOR DSKY:
OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY OF COMPONENTS OF VG(LM):
#1460
TO NULL OUT VG COMPONENTS COMMAND MANUAL TRANSLATIONS AND ROTATIONS.
(NOTE: THIS MANEUVER IS AT THE OPTION OF THE CREW.)
#1470
(NOTE: TRANSLATION WILL BE 4 JET UNLESS R03 IS PERFORMED TO SPECIFY 2 JET.)
THE ORBITAL PARAMETER DISPLAY ROUTINE (R30) MAY BE SELECTED AT THIS TIME (V82E) TO MONITOR CONTINUOUSLY UPDATED VALUES OF APO ALT, PER ALT, AND TFF.
#1480
#1490
KEY IN PROCEED

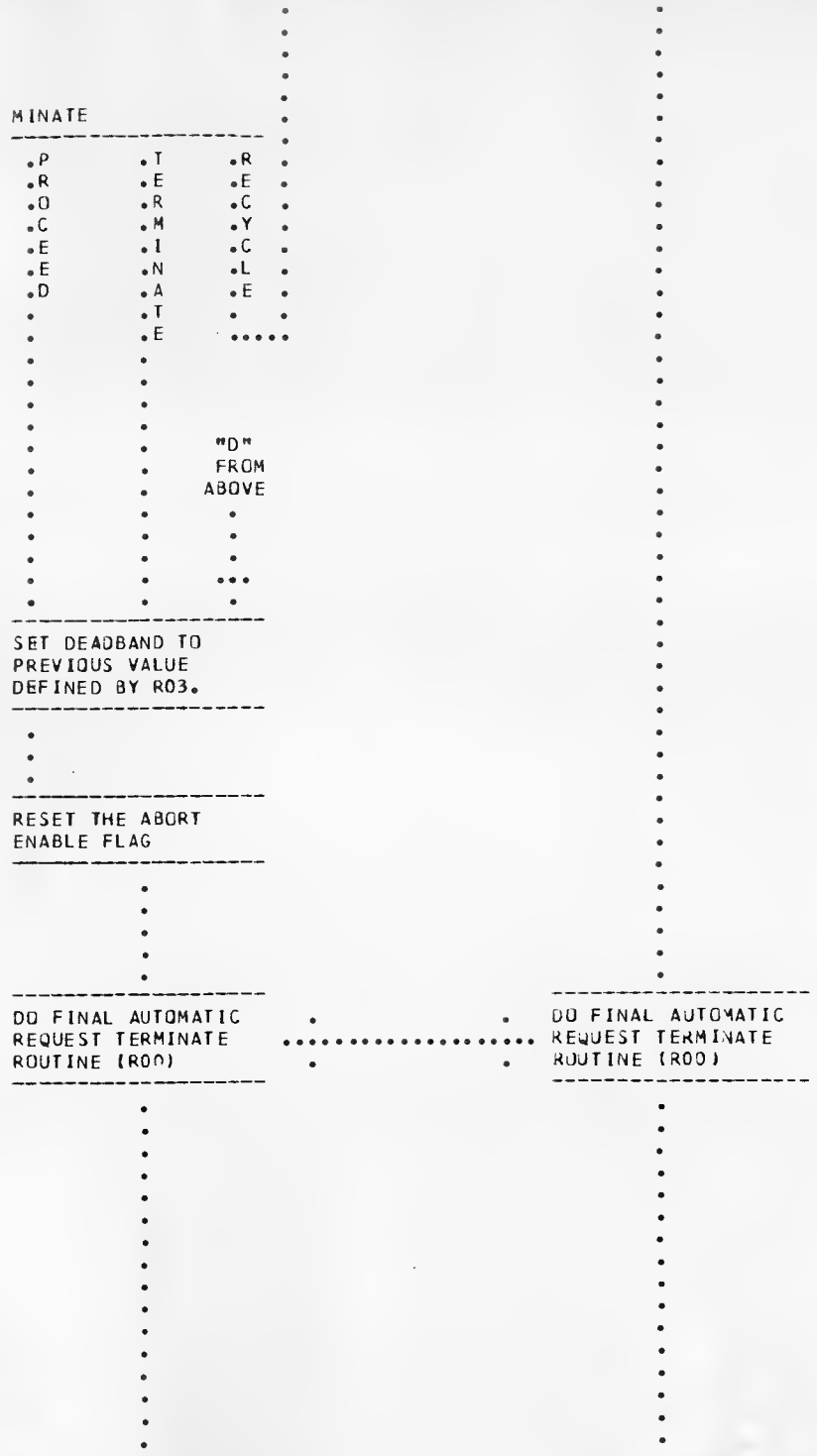
#1500

#1510

#1520

#1530

#1540



#1550

CHANGE CONTROL NOTES

REV 00 PCR 13,31
REV 01 PCR 85,86,99,106,138,144,164,234,258,401,
419,437,475,476,514,548,561,613,617,623
REV 00(LUM 1A) PCR 260,270,708,757
REV 01(LUM 1B) PCR 838,841,847, EDITORIAL
REV 02 EDITORIAL
REV 03(LUM 1D) PCR 892,1058, PCN 1009
REV 04(LUM 1E) PCR 334,1141, PCN 1137,1145,1147
REV 05(LUM 1E) PCN 1180

RENDEZVOUS NAVIGATION PROGRAM (P20) REV 06 12/01/71

PURPOSE: (1) TO CONTROL THE LM ATTITUDE AND THE RENDEZVOUS RADAR (RR) TO ACQUIRE AND TRACK THE CSM WITH THE RR WHILE THE LM IS IN FLIGHT.

(2) TO UPDATE EITHER THE LM OR CSM STATE VECTOR (AS SPECIFIED BY THE ASTRONAUT BY DSKY ENTRY) ON THE BASIS OF RR TRACKING DATA OR TO TRACK THE CSM WITHOUT UPDATING EITHER VEHICLE STATE VECTOR.

(3) TO POINT THE LM OPTICAL BEACON AT THE CSM.

ASSUMPTIONS: (1) THE ISS MAY BE IN STANDBY OR OPERATE. THE IMU WOULD NORMALLY BE ON AND THE IMU ORIENTATION DETERMINATION PROGRAM (P51) OR THE LUNAR SURFACE ALIGN PROGRAM (P57) COMPLETED BEFORE THE SELECTION OF THIS PROGRAM. NO PREFERRED ORIENTATION IS SPECIFIED OR REQUIRED FOR THIS PROGRAM AS THE ATTITUDE MANEUVER ROUTINE (R60) CAN ALWAYS CALCULATE A VEHICLE ORIENTATION ABOUT THE LM +Z AXIS THAT CAN AVOID GIMBAL LOCK FOR ANY IMU INERTIAL ORIENTATION.
THE ISS THUS MAY BE:

(A) OFF (STANDBY).

(B) ON, AND NOT ALIGNED SINCE TURN ON.

(C) ON AND AT AN INERTIAL ORIENTATION KNOWN ONLY INACCURATELY BY THE LGC, I.E.: HAVING BEEN ALIGNED AT LEAST ONCE SINCE TURN ON BUT HAVING DRIFTED FROM THE STORED ALIGNMENT.

(D) ON AND AT AN INERTIAL ORIENTATION KNOWN ACCURATELY BY THE LGC.

IF (A) IS TRUE A PROGRAM ALARM WILL BE MADE BY THIS PROGRAM.
IF (B) IS TRUE A PROGRAM ALARM WILL BE MADE BY THIS PROGRAM.
IF (C) IS TRUE THE LGC MAY OR MAY NOT HAVE A SATISFACTORY INERTIAL REFERENCE TO ACCURATELY COMPLETE THE PROGRAM.
IF (D) IS TRUE THE LGC HAS A SATISFACTORY INERTIAL REFERENCE TO ACCURATELY COMPLETE THE PROGRAM.

(2) THE CSM IS MAINTAINING A PREFERRED TRACKING ATTITUDE FOR RR TRACKING BY THE LM. THIS PREFERRED ATTITUDE CORRECTLY ORIENTS THE CSM RADAR TRANSPONDER.

(3) AT THE BEGINNING OF THE PROGRAM THE STATE VECTOR UPDATE OPTION IS AUTOMATICALLY SET TO THE LM. THIS OPTION MAY BE CHANGED AT ANY TIME LATER BY ONE OF THE FOLLOWING MANUAL ENTRIES;

V80E UPDATE LM STATE VECTOR
V81E UPDATE CSM STATE VECTOR
V95E NO STATE VECTOR UPDATE

NOTE: IF V95E IS ENTERED BEFORE P20 IS SELECTED, EITHER V80E OR V81E MUST BE PERFORMED TO ALLOW STATE VECTOR UPDATING.

(4) THE RENDEZVOUS RADAR IS ON, AND PRELIMINARY CHECKOUT HAS BEEN COMPLETED.

(5) THE INITIALIZATION OF THE W MATRIX (SEE SECTION 5.2 OF R567) IS ENABLED BY:

(A) A MANUAL DSKY ENTRY (V93E).

(B) COMPUTER FRESH START (V36E).

(C) LM OR CSM IN-FLIGHT STATE VECTOR UPDATE FROM THE GROUND (P27) (EXCEPT FOR UPDATE OF LANDING SITE VECTOR WHEN THE LM IS ON THE LUNAR SURFACE).

(D) THE POWERED ASCENT PROGRAM (P12) INVALIDATES THE W-MATRIX USED BY P22 AND CAUSES P20 TO RE-INITIALIZE

THE W-MATRIX WHEN SELECTED.

++ (6) THE RR TRACKING MARK COUNTER COUNTS THE NUMBER OF RR MARKS PROCESSED BY THE LGC. THIS COUNTER IS ZEROED BY:
+C6
+ (A) MANUAL SELECTION OF P20/22 (V37E20/22E).
+
+ (B) COMPLETION OF THE TARGET DELTA V PROGRAM (P76), OR THE IMPULSIVE DELTA V PROGRAM, P77.
+1180
++ (C) SELECTION OF A NEW PROGRAM FROM A PROGRAM WHICH HAD TURNED ON AVERAGE G.

(D) INITIALIZATION OF THE W MATRIX (SEE (5) ABOVE).

(E) COMPLETION OF RR SEARCH ROUTINE (R24) IN P20.

(7) THE CREW MAY MANUALLY ADJUST THE LGC-STORED VALUES OF RR SHAFT AND TRUNNION BIAS BY A DIRECT LOAD OF FOUR REGISTERS TO BE SPECIFIED. HOWEVER, UNLESS THE RR HAS BEEN JARRED, THE LGC BIAS ESTIMATE SHOULD BE MORE ACCURATE THAN THAT FROM ANOTHER SOURCE.

(8) THE SELECTION AND TERMINATION OF P20,P22, AND P25 ARE SUBJECT TO SPECIAL OPERATING PROCEDURES DIFFERENT FROM ALL OTHER PROGRAMS;

(A) SELECTION

(1) ALWAYS BY V37EXXE.

++ (2) IF ANY OTHER PROGRAM IS RUNNING AT THE TIME OF P20/22/25 SELECTION THE NEW PROGRAM WILL REPLACE THE
+06 OLD. THIS INCLUDES P20/22/25 SELECTION WHENEVER EITHER P20,22, OR 25 IS RUNNING.
+ (3) IF P20 OR P25 IS RUNNING, SELECTION OF ANY PROGRAM OTHER THAN P00, P22, OR P25 WILL RESULT IN P20
+ OR P25 CONTINUING AND THE NEW PROGRAM ALSO OPERATING WITH ITS NUMBER IN THE DSKY PROG LIGHTS.
+ (4) IF P20 OR P25 IS RUNNING, SELECTION OF P00 OR P22 OR P25 WILL RESULT IN THE TERMINATION OF THE OLD
+1180 PROGRAM AND OPERATION OF THE NEW.

++ (B) TERMINATION

(1) BY SELECTION OF P00, V56E OR BY V34E.

(2) P00 SELECTION WILL TERMINATE P20,22, AND 25 AND ANY OTHER PROGRAM IN PROCESS, AND ESTABLISH P00.

(3) V56E SELECTION WILL SELECT THE TERMINATE TRACKING ROUTINE (R56) WHICH WILL TERMINATE ONLY P20 OR P25 IF EITHER OF THESE PROGRAMS IS RUNNING IN CONJUNCTION WITH ANOTHER PROGRAM. IN ALL OTHER CASES R56 WILL SELECT R00. V56E MAY BE PERFORMED ANY TIME DURING P20,22, OR 25 OPERATION.

(4) THE LGC WILL ACT UPON V34E ONLY IN RESPONSE TO A FLASHING VERB-NOUN. IF THIS DISPLAY WAS ORIGINATED BY P20,22, OR 25, V34E WILL RESULT IN AN IDENTICAL LGC RESPONSE TO THAT OF V56E, THAT IS, SELECTION OF R56 EXCEPT IN THE CASE OF A V06N49 DISPLAY. IF THIS DISPLAY WAS NOT ORIGINATED BY P20,22, OR 25 (SUCH AS P32, WHILE RUNNING WITH P20) THE LGC WILL GO TO R00, HOWEVER THE PROGRAM IN THE BACKGROUND WILL CONTINUE. THE NEW PROGRAM SELECTED FOLLOWS THE SELECTION RULES ABOVE, (A).

(5) ALTHOUGH IT IS NOT CLEARLY SHOWN IN THE LOGIC BELOW, A V34E RESPONSE TO A PRIORITY DISPLAY MUST BE DELAYED 2 SECONDS FROM DISPLAY INITIATION WHEREAS THE DELAY IS NOT NECESSARY FOR A V56E RESPONSE. A LAMP IS LIGHTED ON THE DSKY TO INDICATE A PRIORITY DISPLAY.

(9) THE RR MANUAL ACQUISITION ROUTINE (R23) MAY ONLY BE SELECTED IF P20 IS NOT RUNNING IN CONJUNCTION WITH ANOTHER PROGRAM.

(10) WHEN P20 IS SELECTED ANYTIME PRIOR TO THE LANDING PHASE IN THE LUNAR MISSION, THIS PROGRAM MUST BE OPERATED IN
++ THE NO UPDATE MODE.
+06
+
(11) THE RSS POSITION AND VELOCITY ERRORS AND ANGLE BIAS ERRORS COMPUTED FROM THE W MATRIX ARE AVAILABLE BY EXTENDED
+1180 VERB (V67E). BASED UPON VALUES IN THIS DISPLAY AND THE DETAILS OF THE MISSION, THE ASTRONAUT CAN ELECT TO STOP OR
++ CONTINUE THE CURRENT NAVIGATION PROCEDURE OR TO RE-INITIALIZE THE W MATRIX AND CONTINUE NAVIGATING. THE CAPABILITY TO REINITIALIZE THE W MATRIX IS ALSO PROVIDED VIA V67E.

(12) TO MONITOR THE PROGRESS OF STATE VECTOR INTEGRATION, THE TIME ASSOCIATED WITH THE ADVANCING (REGRESSING) STATE IS AVAILABLE BY KEYING IN V06N38E:

V06N38
R1-TET-HRS
R2-TET-MINS
R3-TET-SECS

TET-THE TIME (GET) TO WHICH THE STATE VECTOR INTEGRATION PROCESS HAS PRESENTLY CALCULATED THE STATE VECTOR. IN HRS, MINS, AND SECS TO NEAREST .01 SEC.

(13) STATE VECTOR INTEGRATION MAY BE PERMANENTLY INHIBITED BY V96E. THIS ENTRY WILL TERMINATE ALL PRESENT PROGRAMS AND SELECT THE LGC IDLING PROGRAM (P00) WITH THE P00 AUTOMATIC STATE VECTOR INTEGRATION PERMANENTLY INHIBITED UNTIL SELECTION OF ANOTHER PROGRAM. USE OF V96 CAN CAUSE INCORRECT W-MATRIX EXTRAPOLATION SINCE STATE VECTOR SYNCHRONIZATION IS NOT MAINTAINED.

(14) EXTENDED VERBS, E.G., V82/V83, MAY BE CALLED WHILE P20 IS MANEUVERING THE VEHICLE.

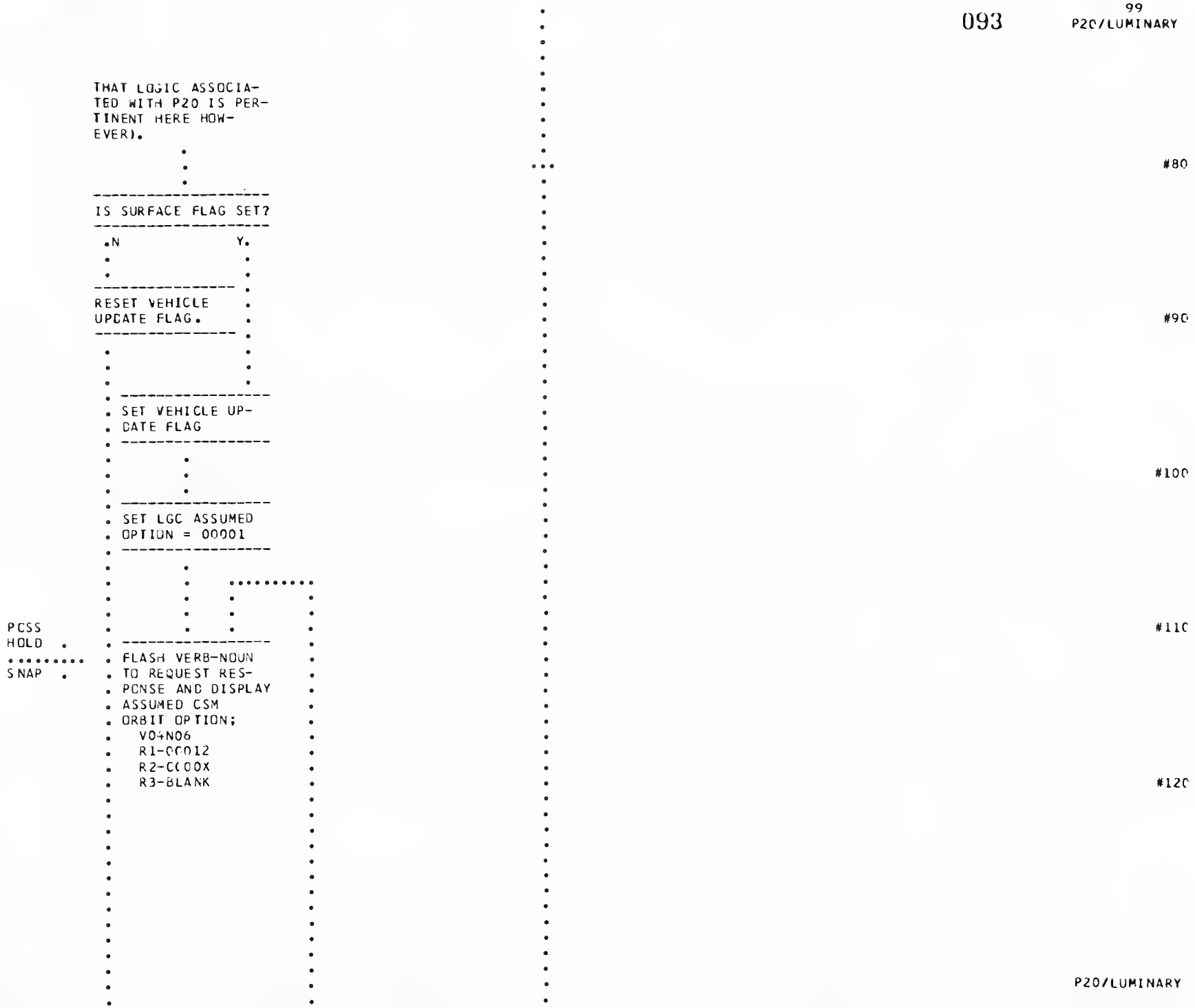
PROG CONT	LGC	GROUND	CREW

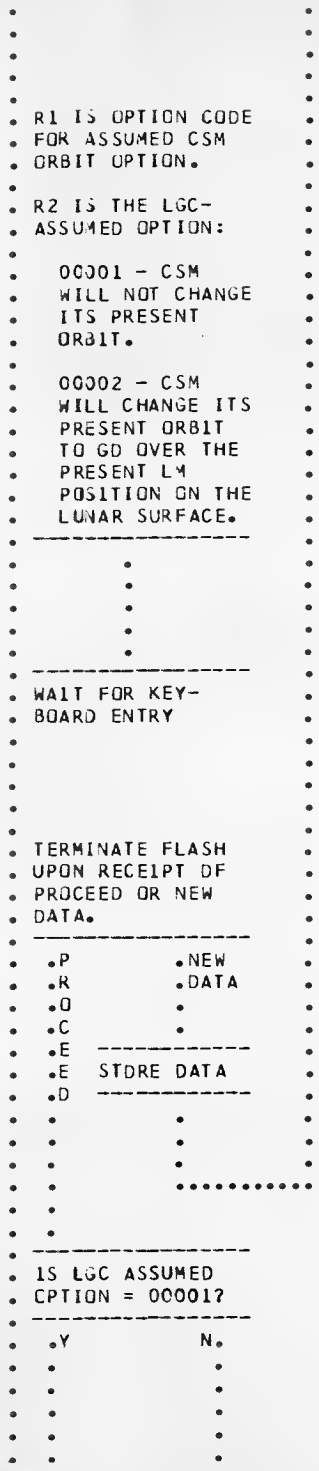
#10

#20

.CREW
.PROGRAM
.
.
.
.
.
.
.
.
.
.
.
.
.
.
.
.


SELECTION
#30
START RENDEZVOUS NAVIGATION PROGRAM (P20). DISPLAY P20
KEY IN RENDEZVOUS NAVIGATION PROGRAM (P20) V37E20E NOTE: WHENEVER P20 IS SELECTED PRIOR TO THE LANDING OPERATION IN THE LUNAR MISSION, IT MUST BE ENTERED AND OPERATED IN THE NO UPDATE MODE (I.E.: - V95E MUST BE EXECUTED BEFORE ENTRY INTO P20.)
#40
#50
MONITOR DSKY: OBSERVE DISPLAY OF P20
#60
(NOTE: FROM THIS POINT ON THE LGC LOGIC DESCRIBES BOTH THE RENDEZVOUS NAVIGATION PROGRAM (P20) AND THE LUNAR SURFACE NAVIGATION PROGRAM (P22). ONLY
(NOTE: ALL LOGIC IN THE CREW COLUMN IS ONLY THAT ASSOCIATED WITH THE RENDEZVOUS NAVIGATION PROGRAM (P20)).
#70


THAT LOGIC ASSOCIA-
TED WITH P20 IS PER-
TINENT HERE HOW-
EVER).
IS SURFACE FLAG SET?
N
Y
RESET VEHICLE
UPDATE FLAG.
SET VEHICLE UP-
DATE FLAG
SET LGC ASSUMED
OPTION = 00001
PCSS
HOLD
SNAP
FLASH VERB-NOUN
TO REQUEST RES-
PONSE AND DISPLAY
ASSUMED CSM
ORBIT OPTION;
V04N06
R1-00012
R2-C0O0X
R3-BLANK
#80
#90
#100
#110
#120



#130

#140

#150

#160

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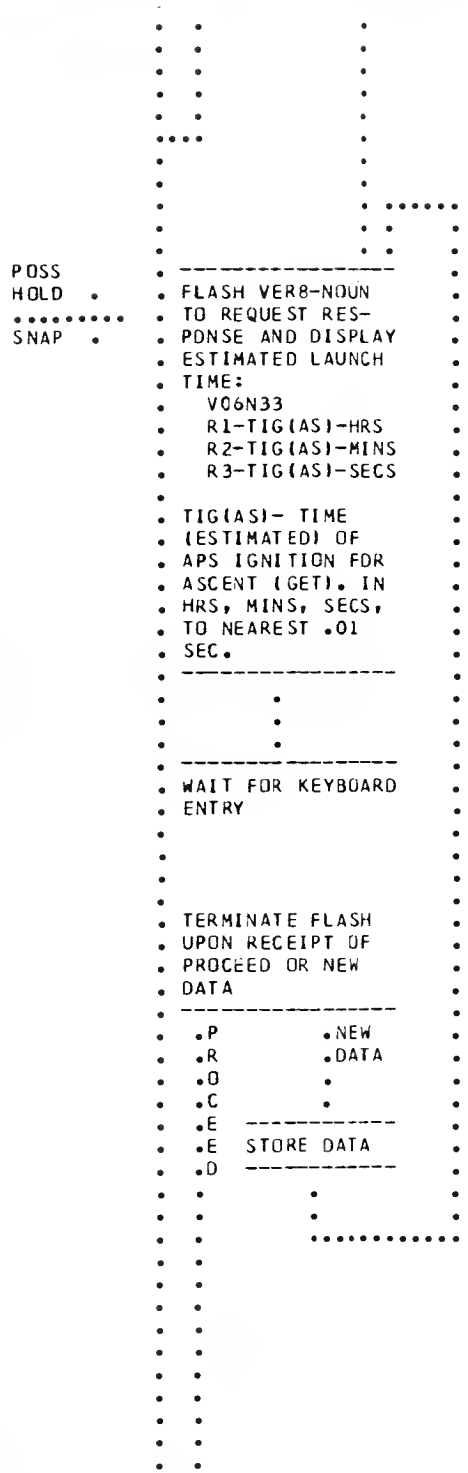


#180

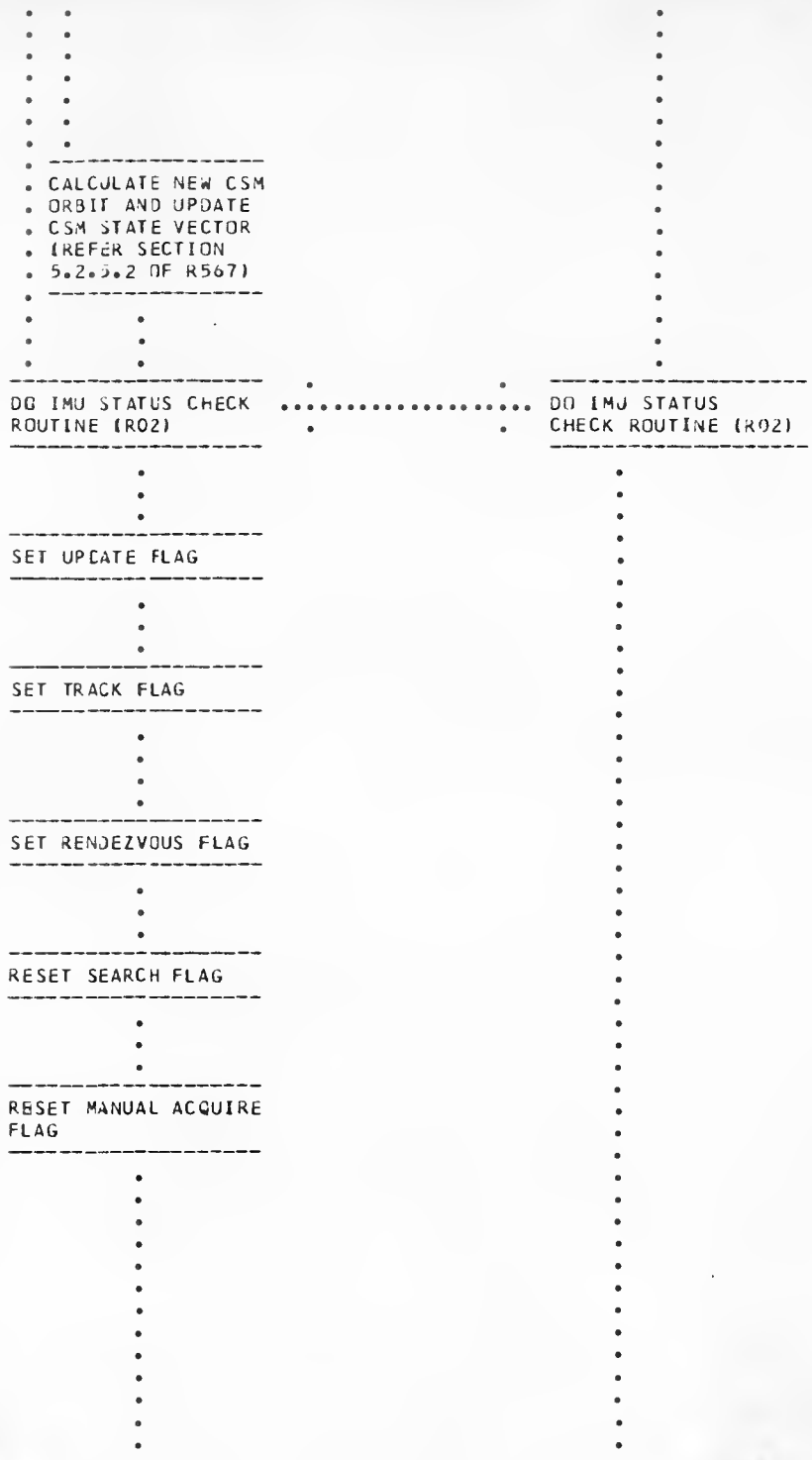
#190

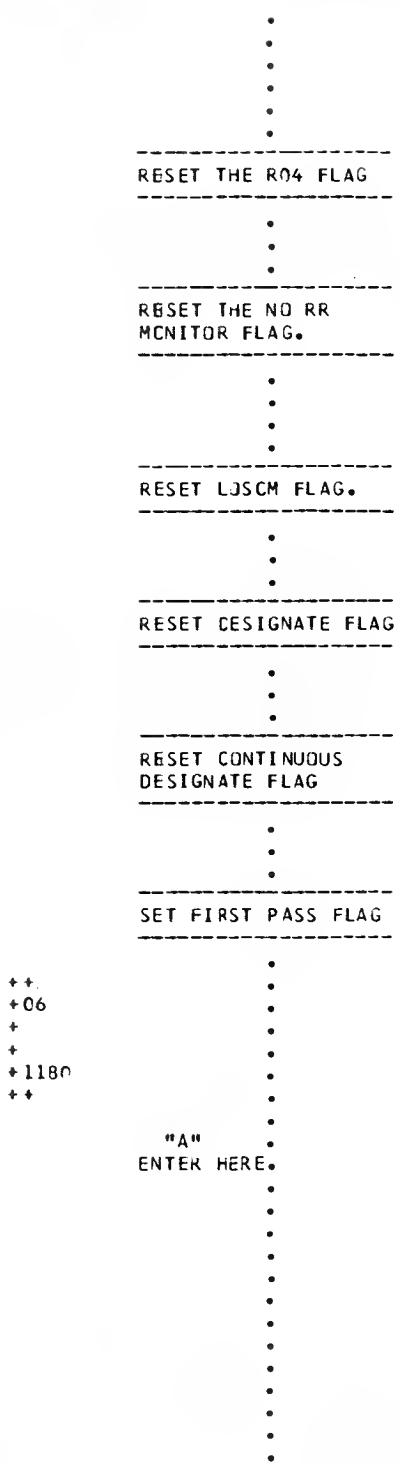
#200

#210

#220

#230


CALCULATE NEW CSM ORBIT AND UPDATE CSM STATE VECTOR (REFER SECTION 5.2.5.2 OF R567)
#240
DO IMU STATUS CHECK ROUTINE (R02)
DO IMU STATUS CHECK ROUTINE (R02)
SET UPDATE FLAG
#250
SET TRACK FLAG
#260
SET RENDEZVOUS FLAG
RESET SEARCH FLAG
#270
RESET MANUAL ACQUIRE FLAG
#280

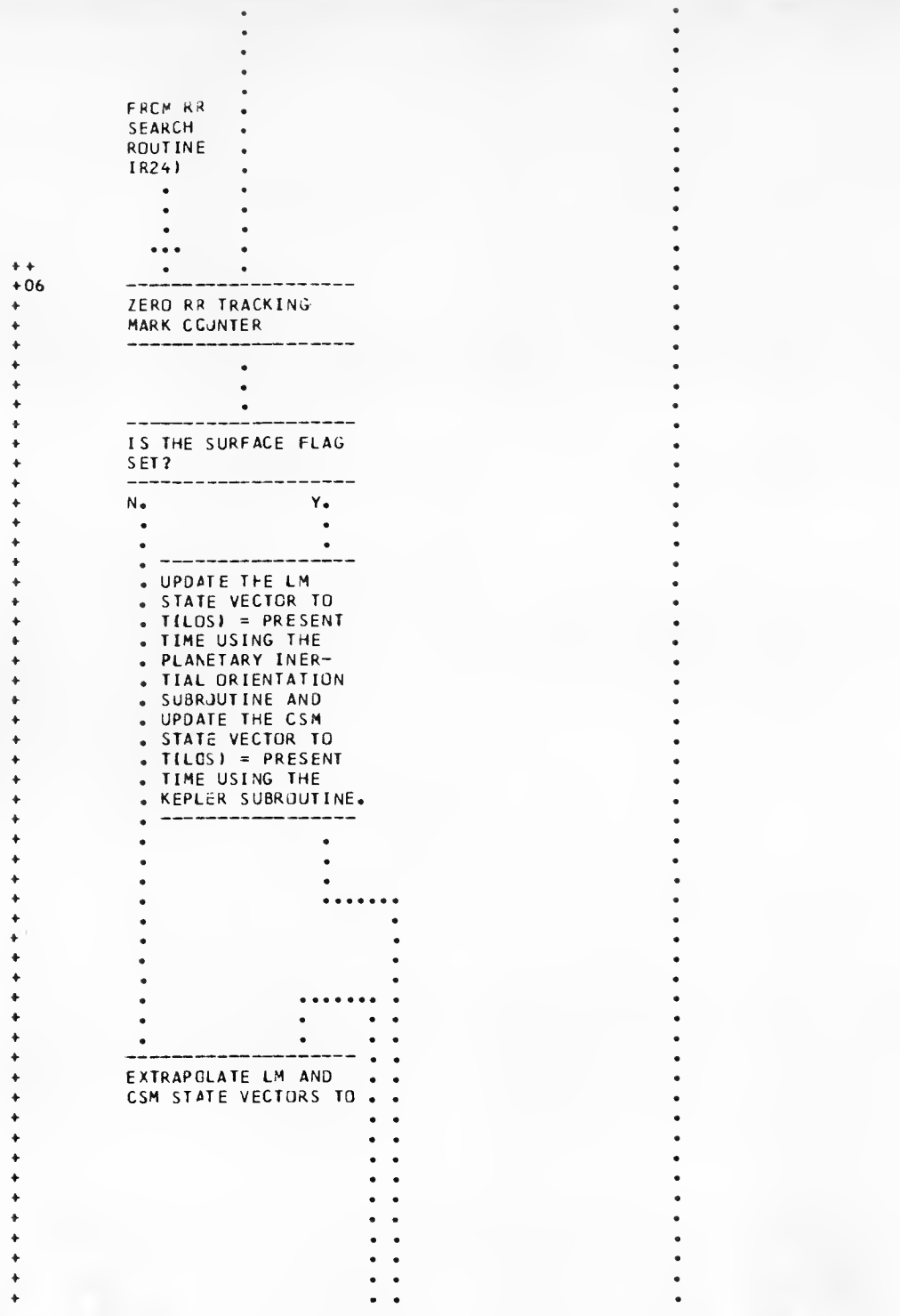


#290

#300

#310

#320



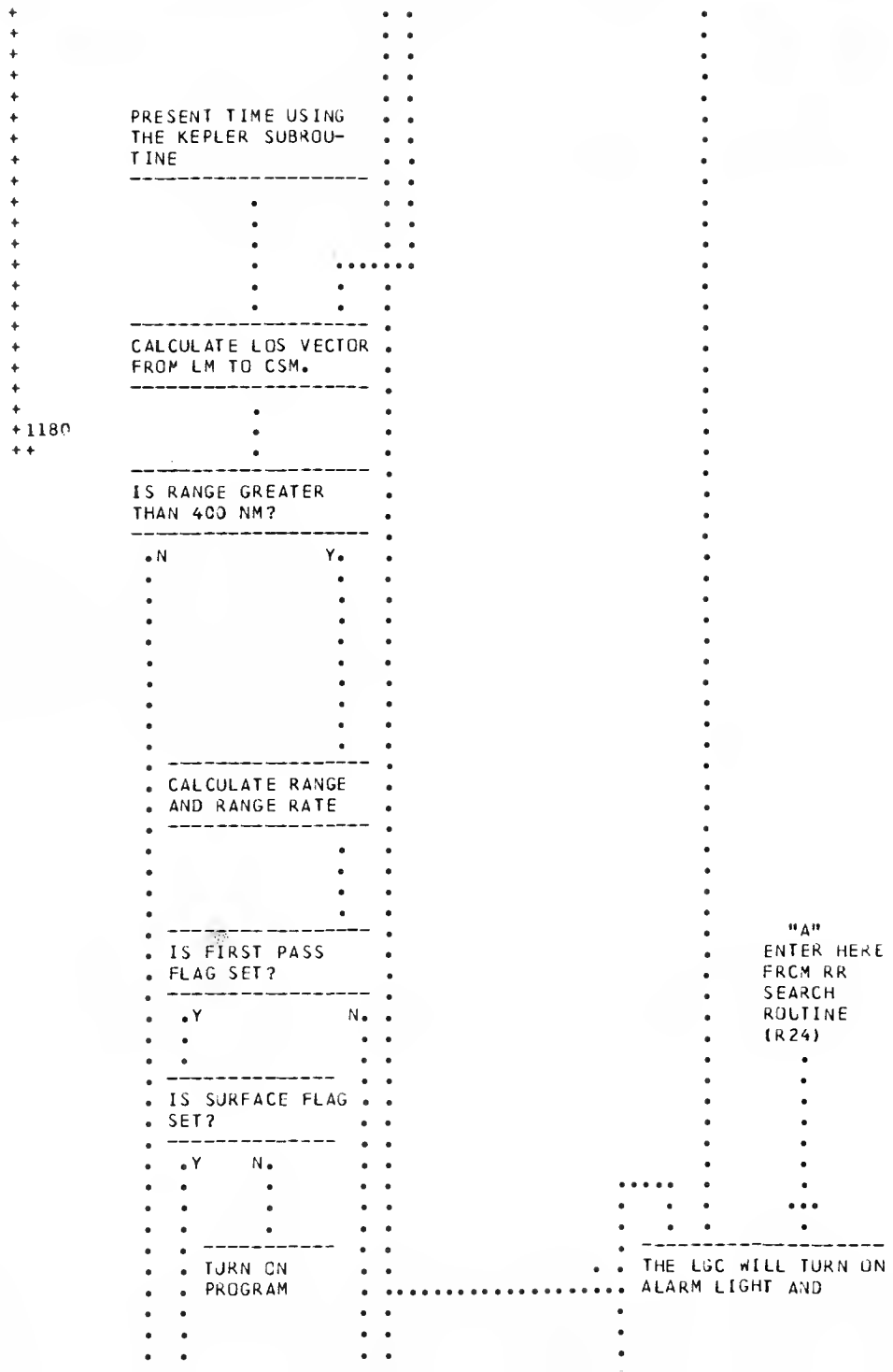
#330

#340

#350

#360

#370


PRESENT TIME USING THE KEPLER SUBROUTINE
#380
CALCULATE LOS VECTOR FROM LM TO CSM.
#390
1180
IS RANGE GREATER THAN 400 NM?
#400
N
Y
CALCULATE RANGE AND RANGE RATE
#410
IS FIRST PASS FLAG SET?
"A" ENTER HERE FROM RR SEARCH ROUTINE (R24)
#420
Y
N
IS SURFACE FLAG SET?
Y
N
TURN ON PROGRAM
#430
THE LGC WILL TURN ON ALARM LIGHT AND

ALARM AND
STORE ALARM
CODE 00526

RESET FIRST
PASS FLAG

WAIT 5
SECONDS

IS RANGE RATE A
POSITIVE VALUE?

N / Y

GO TO
"I"
BELOW

++
+06
+1180
++

POSS
TEMP
HOLD
MON

DISPLAY ON DSKY:
V16N54
R1-RANGE
R2-RANGE RATE

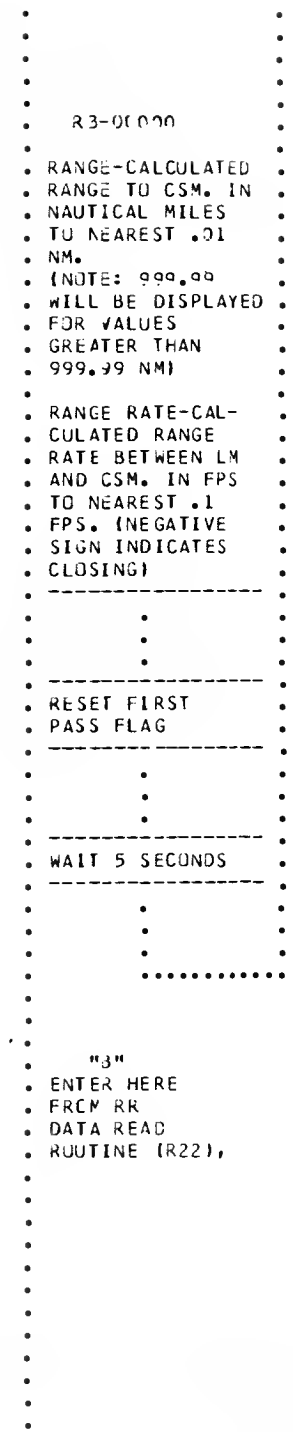
STORE ALARM CODE
00526 INDICATING
THAT RANGE IS GREAT-
ER THAN 400 N.M.
(NOTE: AT THE OPTION
OF THE CREW, THE
RANGE AND RANGE RATE
DISPLAY MAY BE
SELECTED AT THIS
TIME BY KEYING
IN V16N54E. IF THE
RANGE IS INCREASING,
THE CREW MAY TERM-
INATE P20 BY KEYING
IN V56E).
(NOTE: ALARM GENE-
RATED ON FIRST PASS
ONLY).

IS RANGE TO CSM LESS
THAN 400 NM?

N / Y

WAIT 5 SECONDS

#440
#450
#460
#470
#480



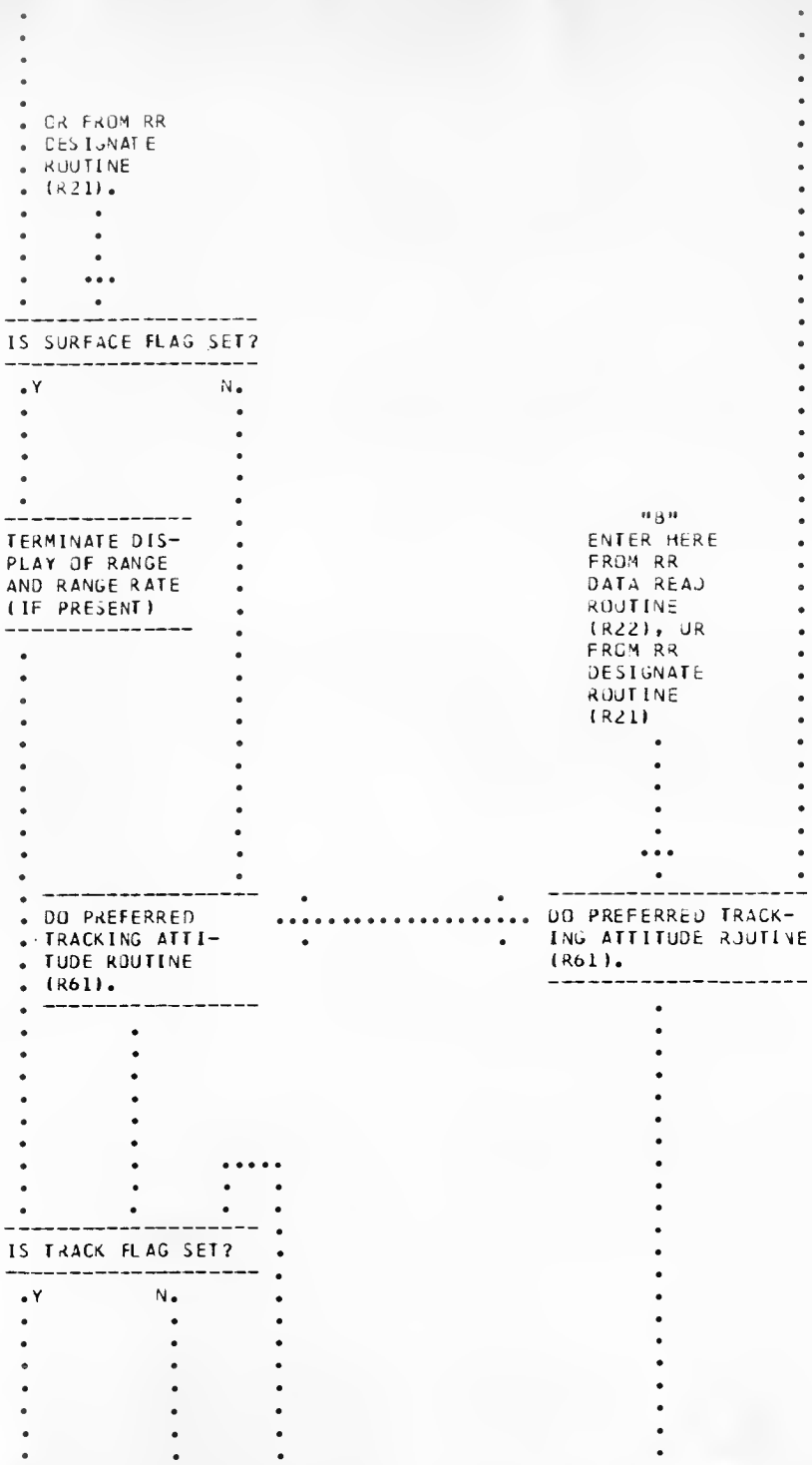
#490

#500

#510

#520

#530



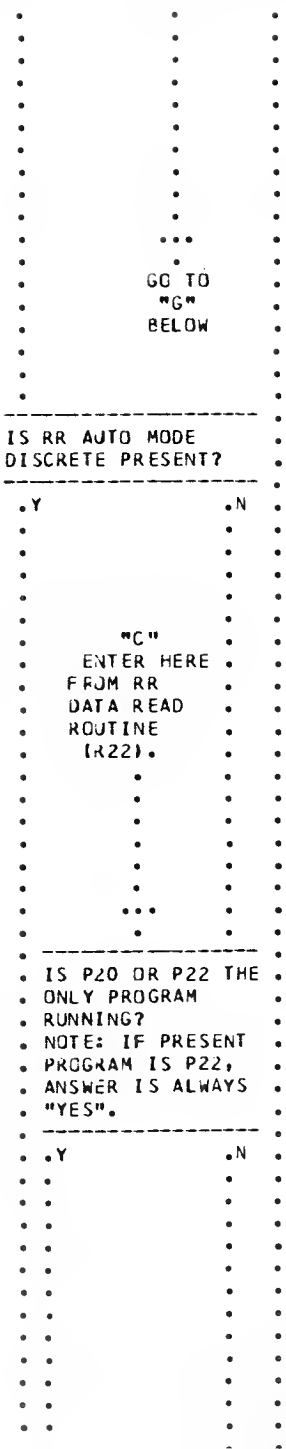
#54C

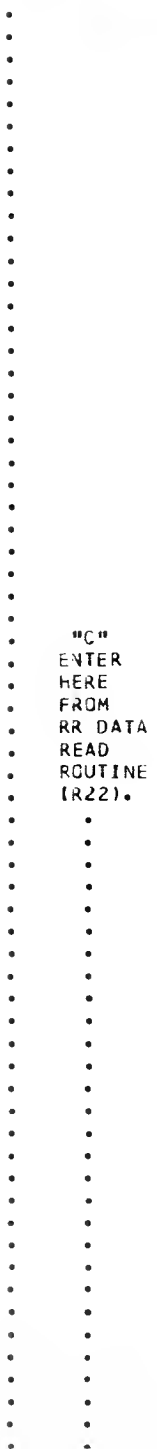
#55C

#56C

#57C

#58C





#590

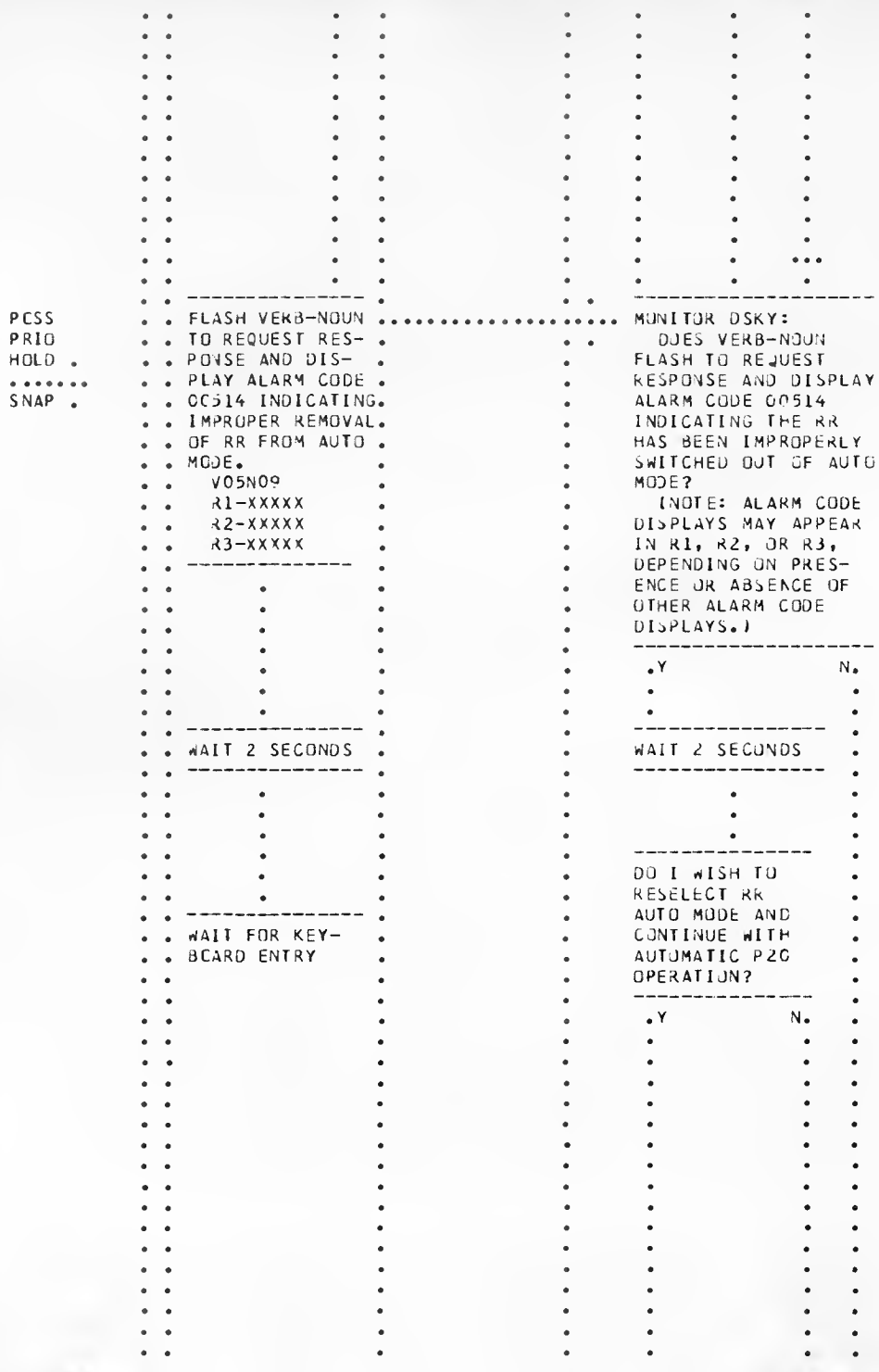
#600

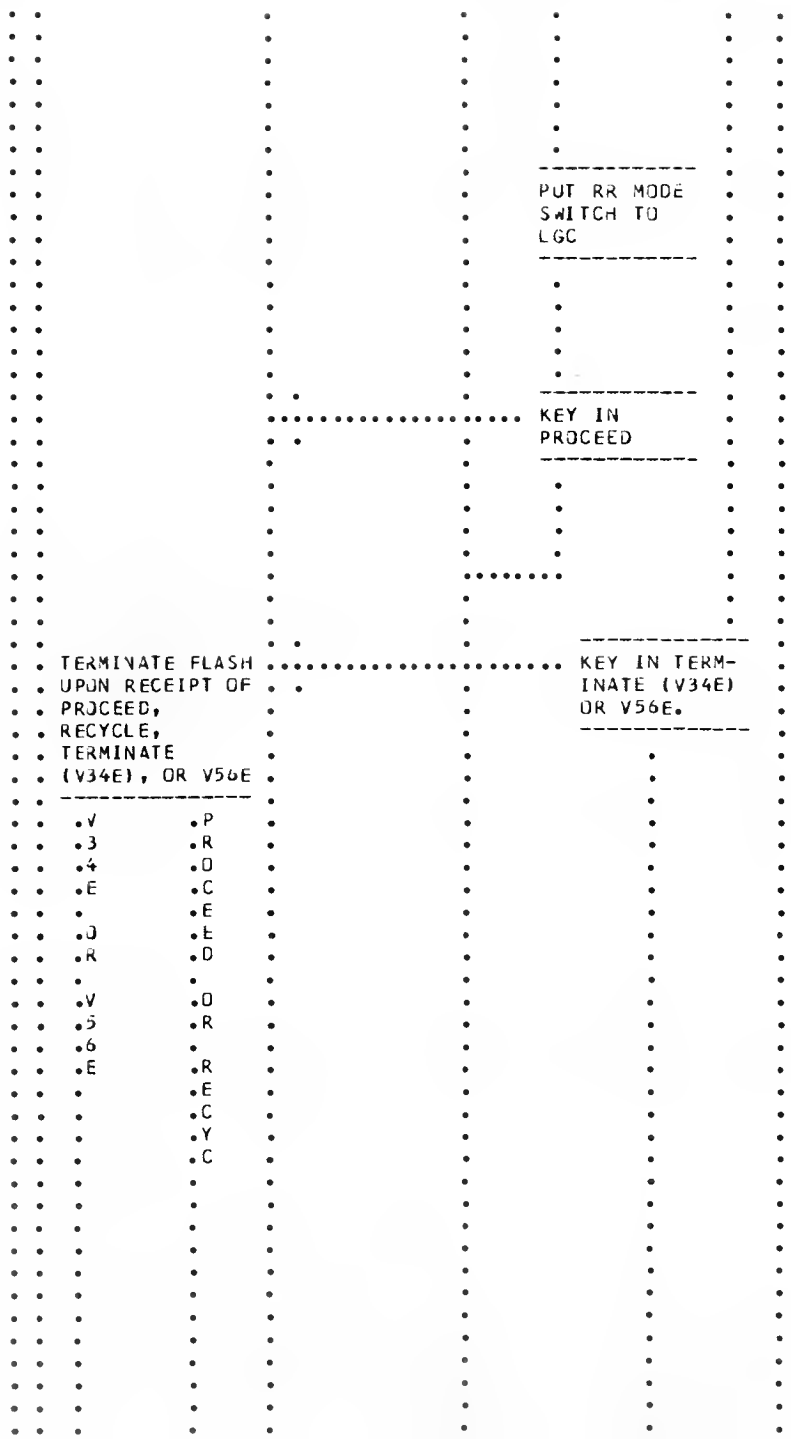
#610

#620

#630

#640


PCSS
PRIO
HOLD .
.....
SNAP .
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY ALARM CODE 00514 INDICATING IMPROPER REMOVAL OF RR FROM AUTO MODE.
V05N09
R1-XXXXX
R2-XXXXX
R3-XXXXX
WAIT 2 SECONDS
WAIT FOR KEYBOARD ENTRY
MONITOR DSKY:
DOES VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY ALARM CODE 00514 INDICATING THE RR HAS BEEN IMPROPERLY SWITCHED OUT OF AUTO MODE?
(NOTE: ALARM CODE DISPLAYS MAY APPEAR IN R1, R2, OR R3, DEPENDING ON PRESENCE OR ABSENCE OF OTHER ALARM CODE DISPLAYS.)
.Y
N.
WAIT 2 SECONDS
DO I WISH TO RESELECT RR AUTO MODE AND CONTINUE WITH AUTOMATIC P20 OPERATION?
.Y
N.
#65C
#66C
#67C
#68C



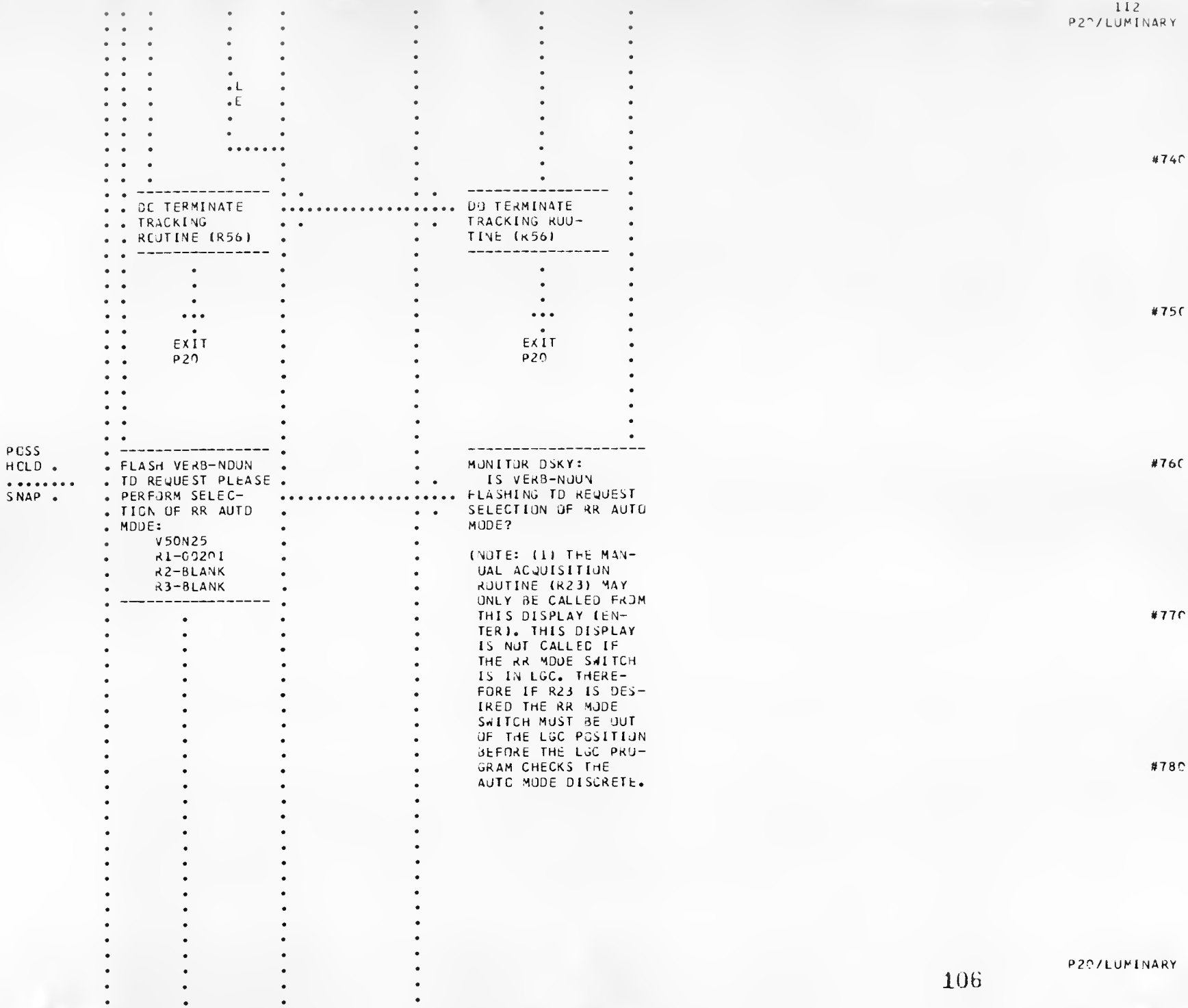
#690

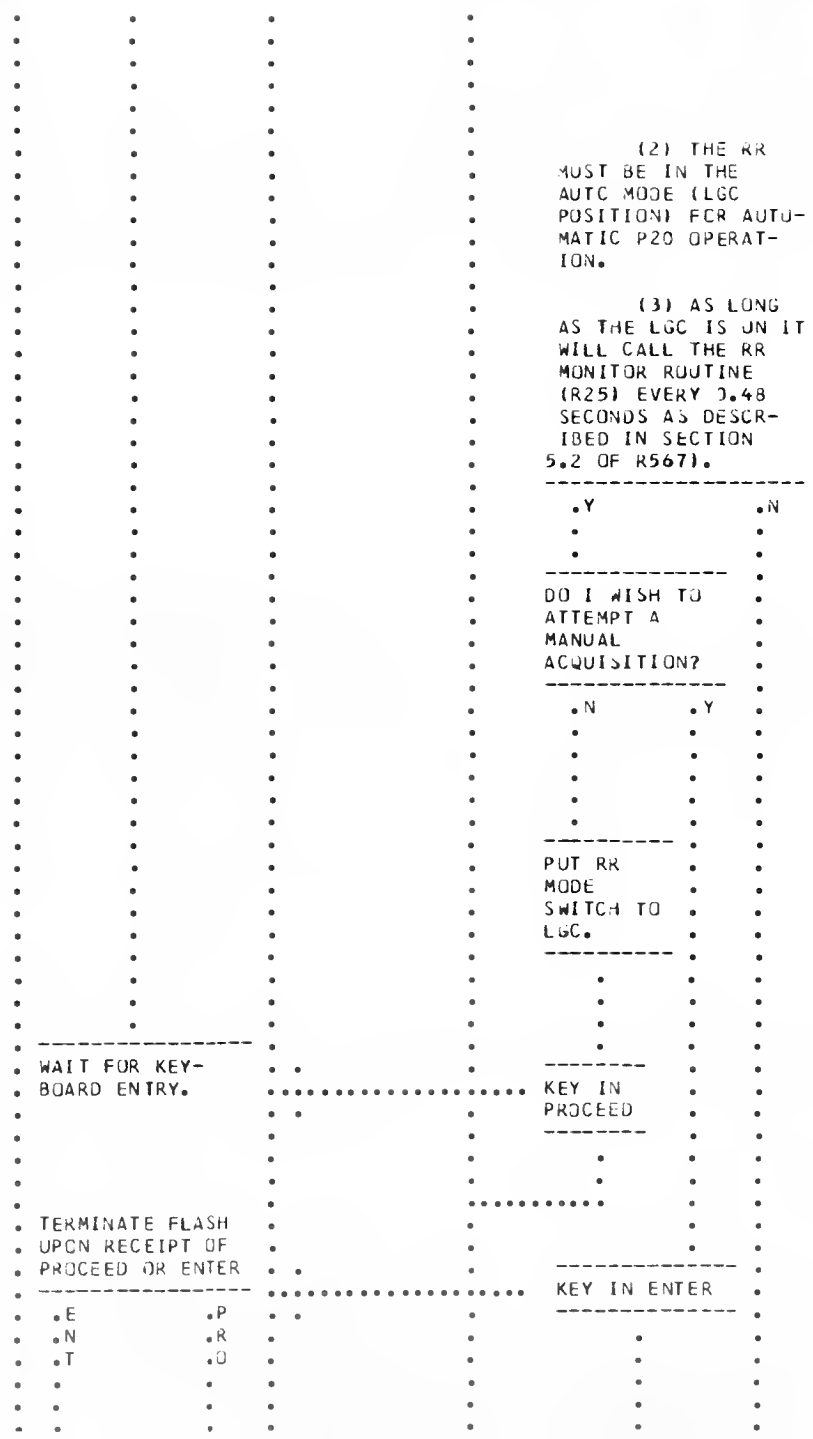
#700

#710

#720

#730


.L
.E
DC TERMINATE TRACKING ROUTINE (R56)
EXIT P20
DD TERMINATE TRACKING ROUTINE (R56)
EXIT P20
POSS HOLD . SNAP .
FLASH VERB-NOUN TO REQUEST PLEASE PERFORM SELECTION OF RR AUTO MODE:
V50N25
R1-00201
R2-BLANK
R3-BLANK
MONITOR DSKY: IS VERB-NOUN FLASHING TO REQUEST SELECTION OF RR AUTO MODE?
(NOTE: (1) THE MANUAL ACQUISITION ROUTINE (R23) MAY ONLY BE CALLED FROM THIS DISPLAY (ENTER). THIS DISPLAY IS NOT CALLED IF THE RR MODE SWITCH IS IN LGC. THEREFORE IF R23 IS DESIRED THE RR MODE SWITCH MUST BE OUT OF THE LGC POSITION BEFORE THE LGC PROGRAM CHECKS THE AUTO MODE DISCRETE.
#740
#750
#760
#770
#780



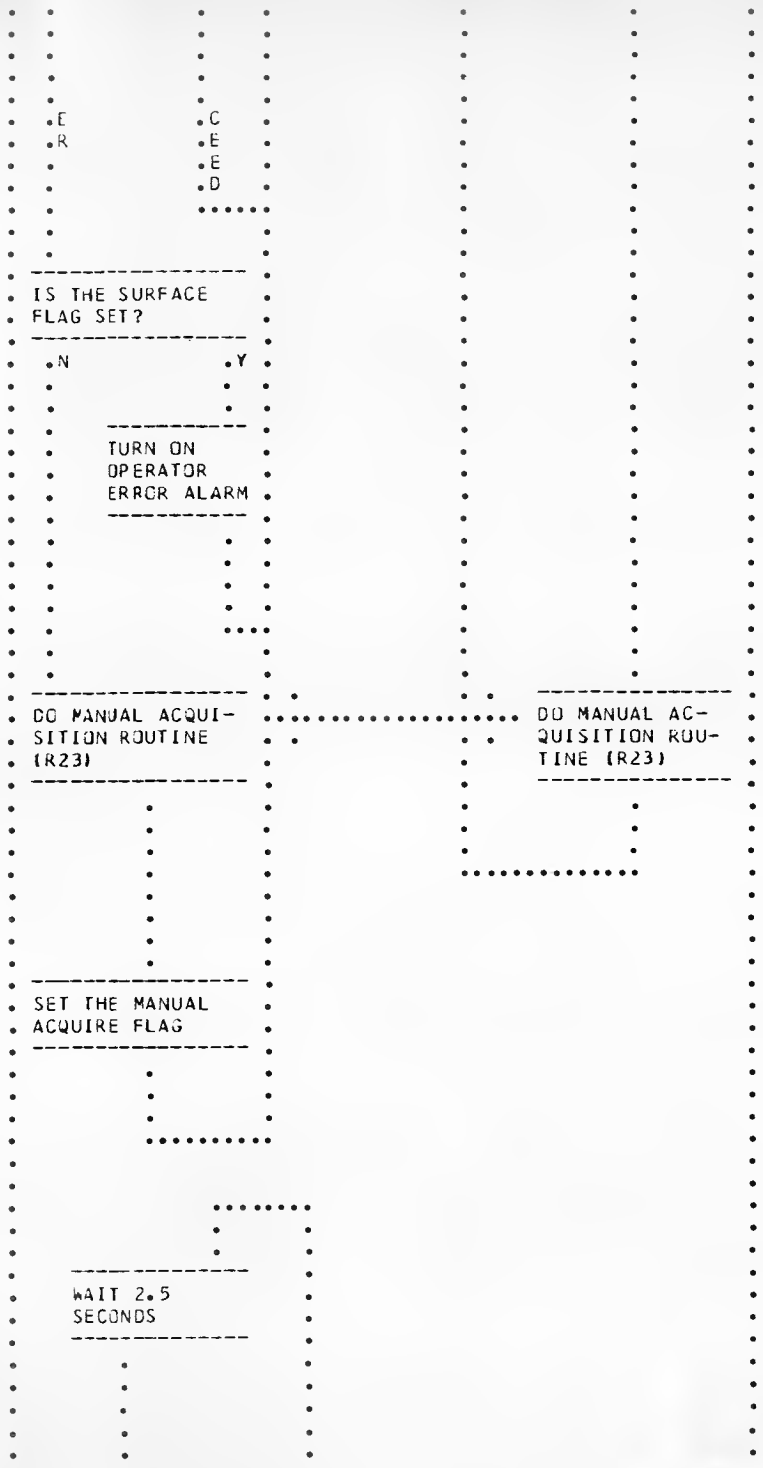
#790

#800

#810

#820

#830



#840

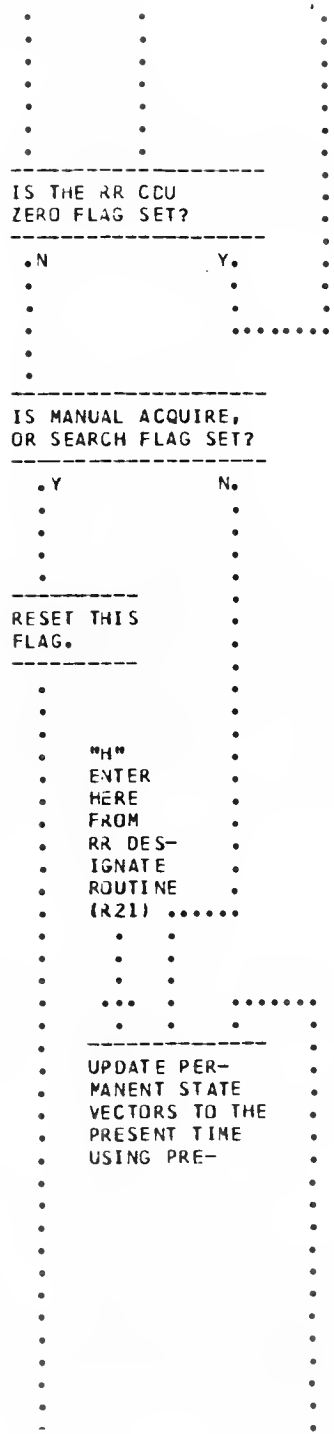
#850

#860

#870

#880

#890



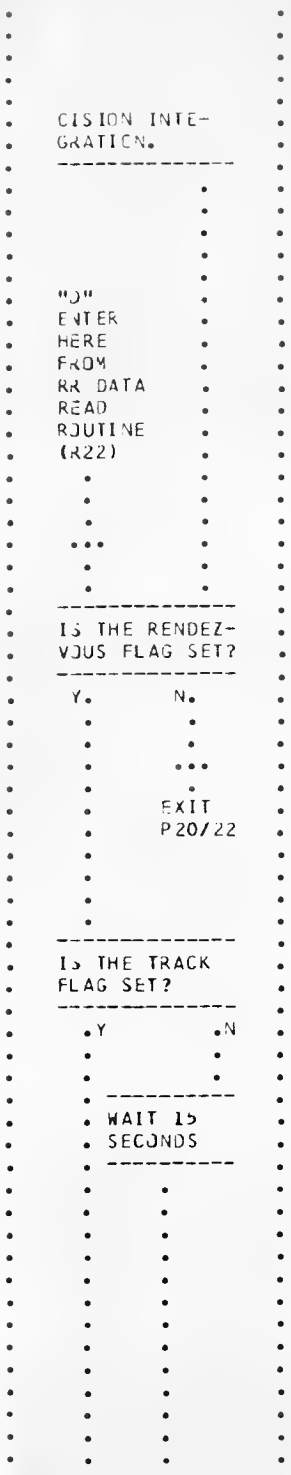
#90C

#91C

#92C

#93C

#94C



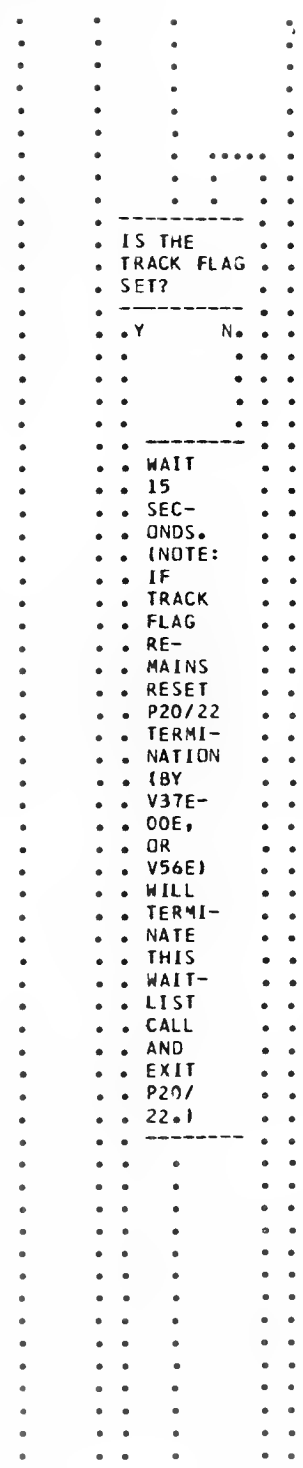
#950

#960

#970

#980

#990



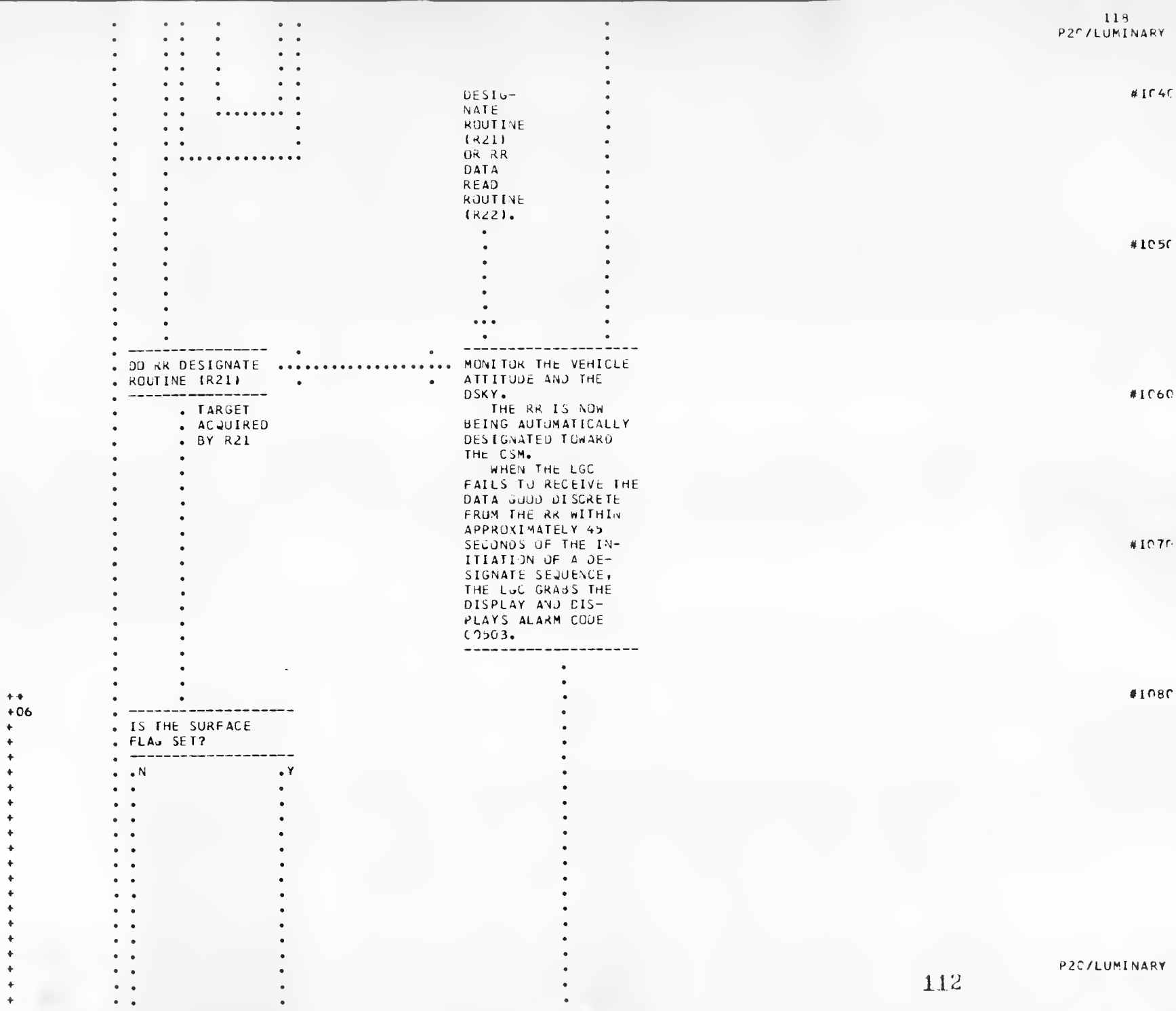
"D"
"H"
ENTER
HERE
FROM RR

#1000

#1010

#1020

#1030



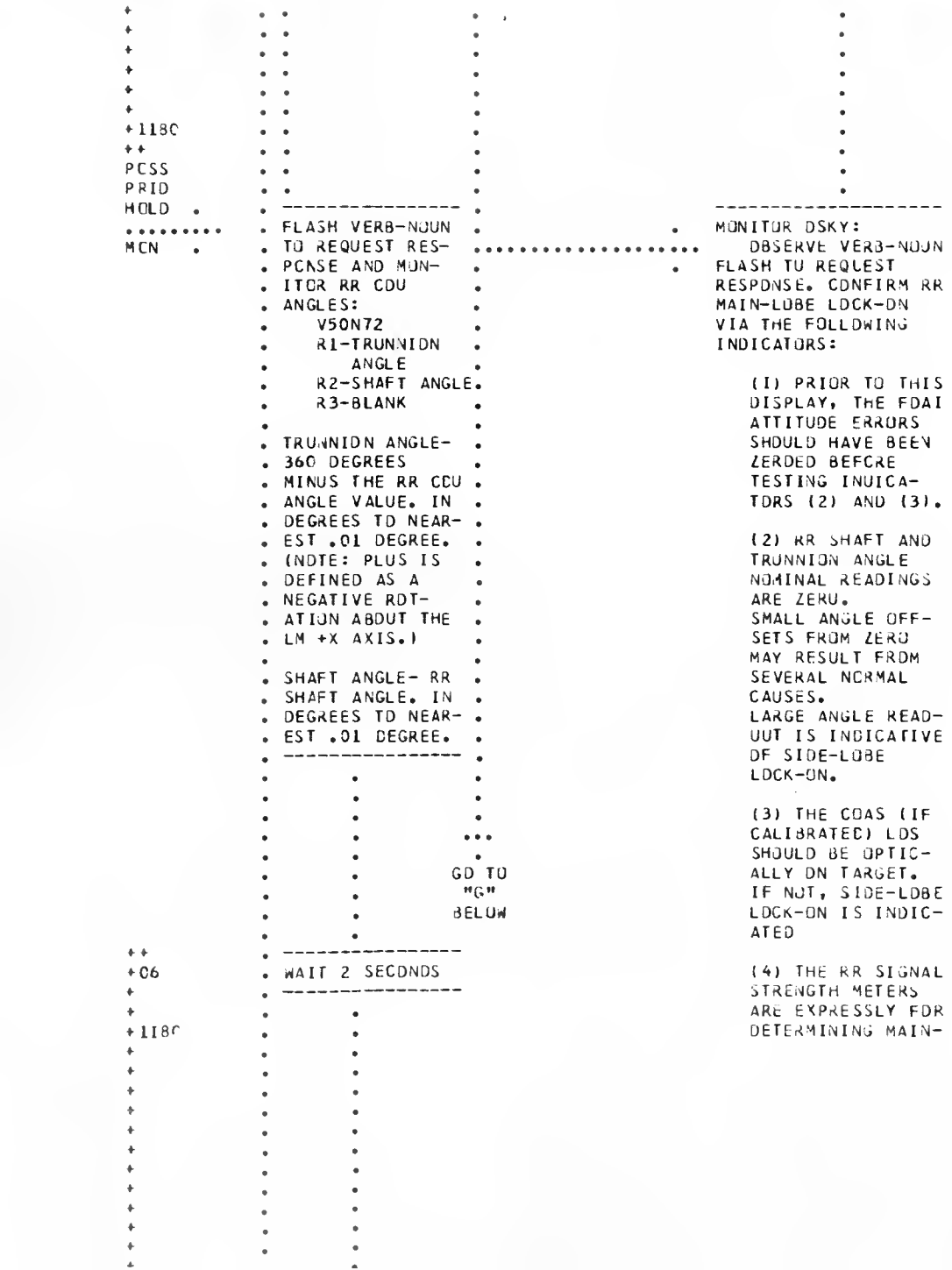
#1040

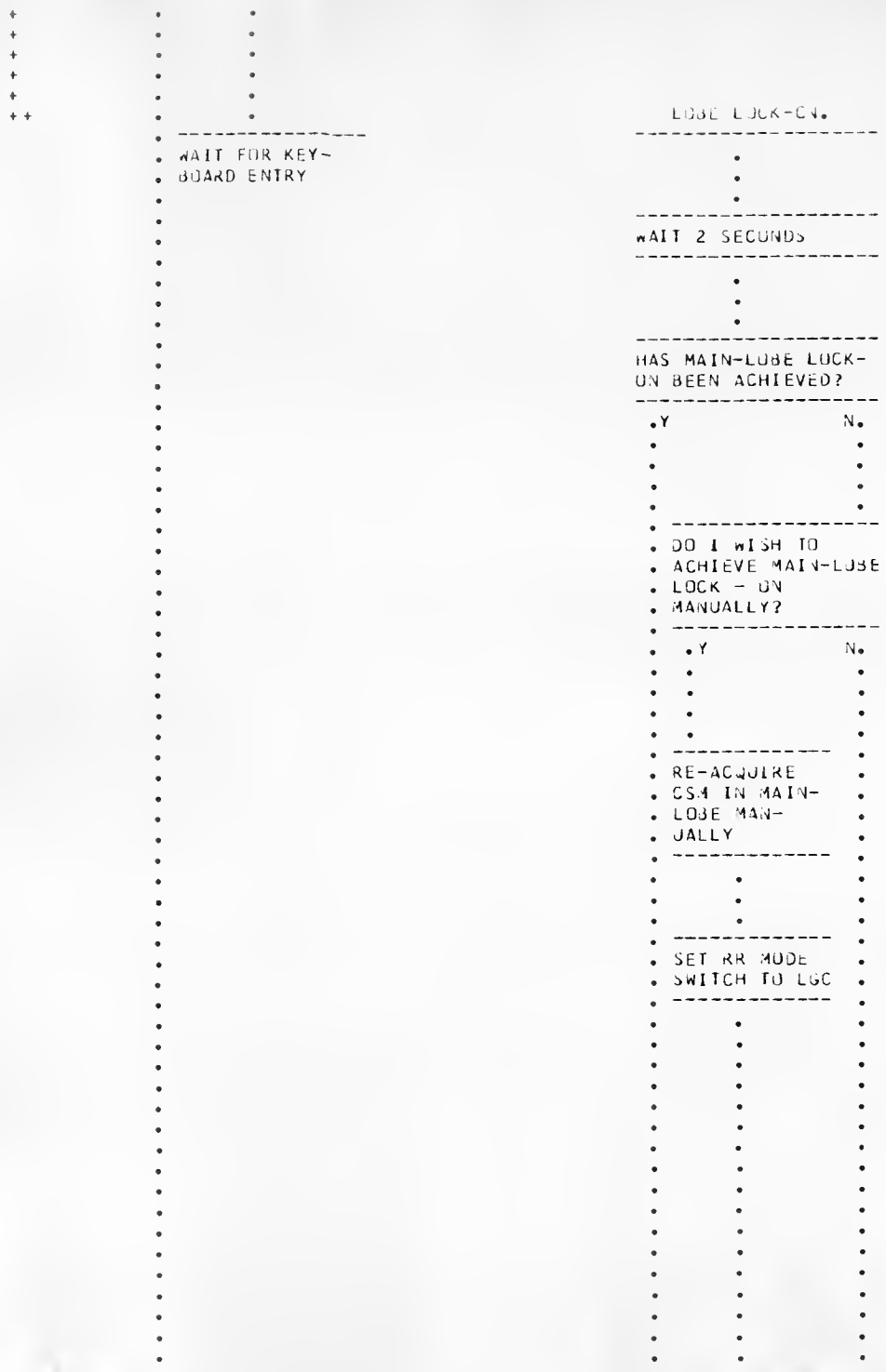
#1050

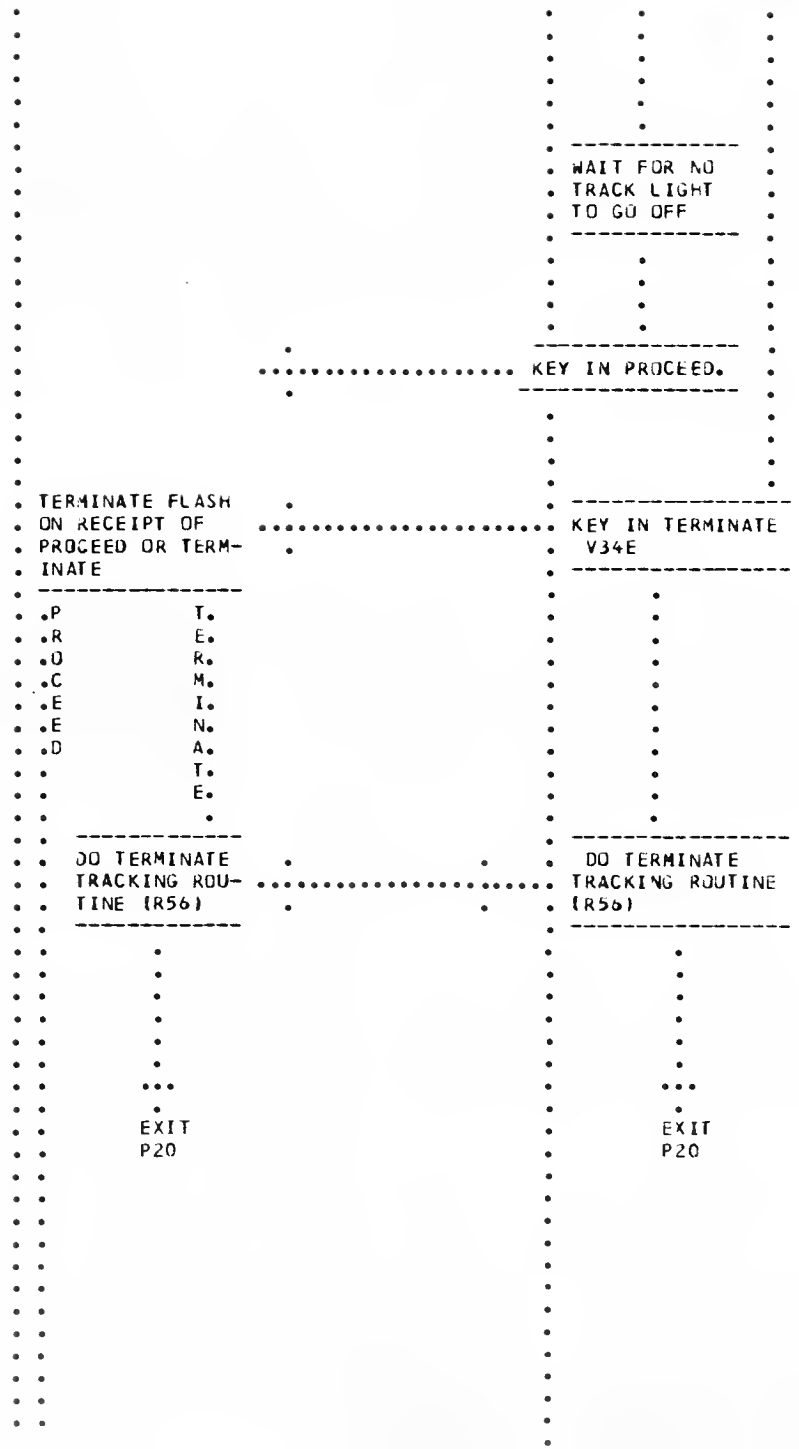
#1060

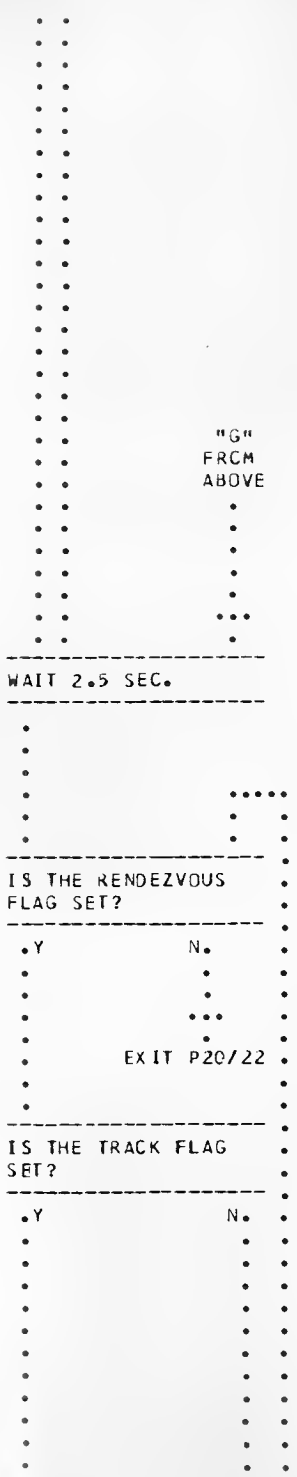
#1070

#1080


+1180
++
PCSS
PRID
HOLD
MCN
FLASH VERB-NOUN TO REQUEST RESPONSE AND MONITOR RR CDU ANGLES:
V50N72
R1-TRUNNION ANGLE
R2-SHAFT ANGLE
R3-BLANK
TRUNNION ANGLE- 360 DEGREES MINUS THE RR CDU ANGLE VALUE. IN DEGREES TO NEAREST .01 DEGREE. (NOTE: PLUS IS DEFINED AS A NEGATIVE ROTATION ABOUT THE LM +X AXIS.)
SHAFT ANGLE- RR SHAFT ANGLE. IN DEGREES TO NEAREST .01 DEGREE.
GO TO "G" BELOW
++
+06
WAIT 2 SECONDS
+1180
MONITOR DSKY:
OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE. CONFIRM RR MAIN-LOBE LOCK-ON VIA THE FOLLOWING INDICATORS:
(1) PRIOR TO THIS DISPLAY, THE FDAI ATTITUDE ERRORS SHOULD HAVE BEEN ZERODED BEFORE TESTING INDICATORS (2) AND (3).
(2) RR SHAFT AND TRUNNION ANGLE NOMINAL READINGS ARE ZERO. SMALL ANGLE OFFSETS FROM ZERO MAY RESULT FROM SEVERAL NORMAL CAUSES. LARGE ANGLE READOUT IS INDICATIVE OF SIDE-LOBE LOCK-ON.
(3) THE COAS (IF CALIBRATED) LOS SHOULD BE OPTICALLY ON TARGET. IF NOT, SIDE-LOBE LOCK-ON IS INDICATED
(4) THE RR SIGNAL STRENGTH METERS ARE EXPRESSLY FOR DETERMINING MAIN-


WAIT FOR KEY-
BOARD ENTRY
LOSE LOCK-ON.
WAIT 2 SECONDS
#1140
HAS MAIN-LOBE LOCK-
ON BEEN ACHIEVED?
#1150
Y
N.
DO I WISH TO
ACHIEVE MAIN-LOBE
LOCK - ON
MANUALLY?
#1160
Y
N.
RE-ACQUIRE
CSM IN MAIN-
LOBE MAN-
UALLY
#1170
SET RR MODE
SWITCH TO LGC
#1180


WAIT FOR NO TRACK LIGHT TO GO OFF
#1190
KEY IN PROCEED.
TERMINATE FLASH ON RECEIPT OF PROCEED OR TERMINATE
KEY IN TERMINATE V34E
#1200
PROCEED
TERMINATE
#1210
DO TERMINATE TRACKING ROUTINE (R56)
DO TERMINATE TRACKING ROUTINE (R56)
#1220
EXIT P20
EXIT P20



#1230

#1240

MONITOR THE VEHICLE ATTITUDE AND THE DSKY:

THE ATTITUDE MANEUVER/RR TRACK/RR MARK/STATE VECTOR UPDATE PROCESS IS NOW AUTOMATIC. THE LGC WILL ONLY COMMUNICATE WITH THE ASTRONAUT DURING THIS PROGRAM:

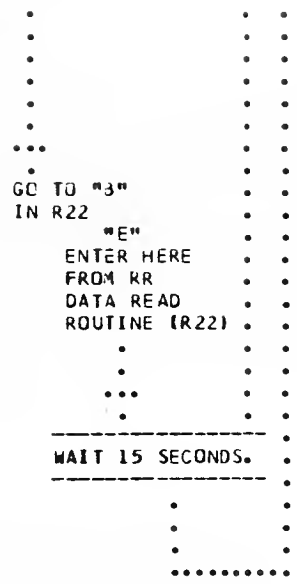
#1250

(1) WHEN A DSKY ENTRY OF V16N45E IS MADE TO REQUEST A DISPLAY OF THE NUMBER OF MARKS (M), THIS DISPLAY WILL CONTAIN M IN R1. THIS DISPLAY MAY

#1260

ALSO BE USED TO OBTAIN THE MIDDLE GIMBAL ANGLE WHEN THE IMU IS ON AND THE LM +X AXIS IS ALIGNED WITH THE INITIAL THRUST VECTOR (R3 -MGA). IF NO BURN HAS BEEN DEFINED R3 WILL BE MEANINGLESS. THE INFORMATION IN R2 AT THIS TIME IS NOT RELIABLE. CONTROL OF THE DSKY DISPLAY IS RETURNED TO THE

#1270



++
+06
+
+
+
+
+
+
+
+
+
+
+
+
+
+1180
++

LGC BY PUSHING
KEY RELEASE.

(2) WHEN THE DATA
GOOD DISCRETE
LAPSES DURING THE
DATA READ ROUTINE
(R22), A TRACKER
FAIL ALARM RE-
SULTS. NO DISPLAY
INTERRUPTION OCC-
URS.

(3) WHEN THE RR
AUTO MODE DIS-
CRETE IS NOT PRE-
SENT IMMEDIATELY
PRIOR TO A DATA
READ SEQUENCE
DURING THE DATA
READ ROUTINE
(R22) THE LGC
GRABS THE DISPLAY
AND REQUESTS THIS
DISCRETE.

(4) WHEN THE LGC
DETERMINES THAT
THE ACTUAL RR LOS
DIFFERS FROM THE
LGC CALCULATED
LOS BY MORE THAN
3 DEGREES AFTER
A DATA READ SE-
QUENCE THE LGC
GRABS THE DISPLAY
AND DISPLAYS AN
ALARM CODE
(00525).

(5) WHEN THE
MAGNITUDE OF A
STATE VECTOR COR-
RECTION IS GREAT-
ER THAN THE ALLO-

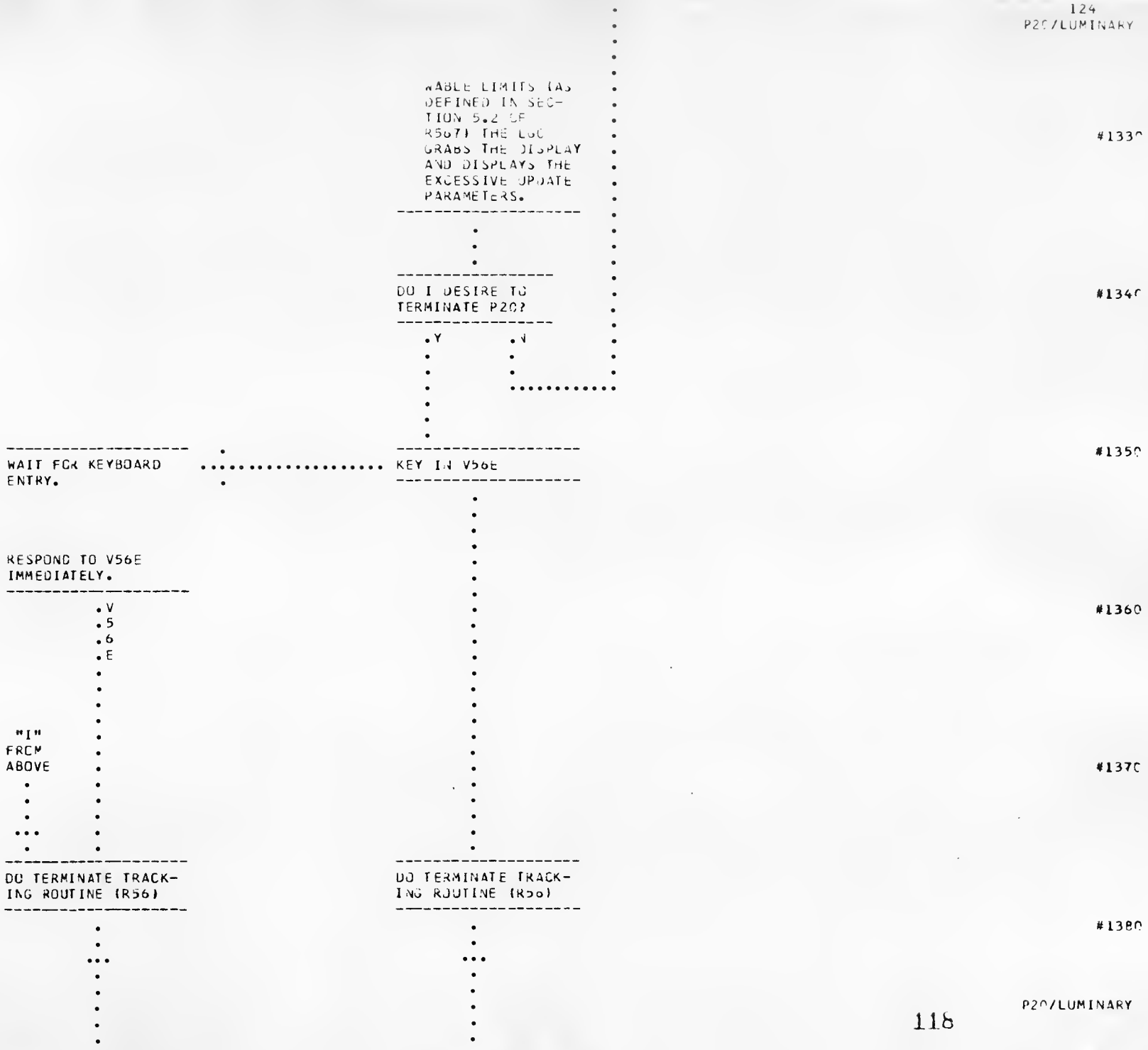
#1280

#1290

#1300

#1310

#1320


#ABLE LIMITS (AS
DEFINED IN SEC-
TION 5.2 OF
R567) THE LGC
GRABS THE DISPLAY
AND DISPLAYS THE
EXCESSIVE UPDATE
PARAMETERS.
DO I DESIRE TO
TERMINATE P20?
#1340
.Y
.N
#1330
WAIT FOR KEYBOARD
ENTRY.
KEY IN V56E
#1350
RESPOND TO V56E
IMMEDIATELY.
.V
.5
.6
.E
#1360
"I"
FROM
ABOVE
#1370
DO TERMINATE TRACK-
ING ROUTINE (R56)
DO TERMINATE TRACK-
ING ROUTINE (R56)
#1380

```
        .
        .
        .
        .
        .
      EXIT
    P20/P22
```

```
        .
        .
        .
        .
        .
      EXIT
       P20
```

CHANGE CONTROL NOTES

```
REV 01  PCR 146,173,226,415,451,468,537,541,549,562,614,640
REVS 00,01(LUM 1A)  PCR 646,732,757
REV 02  EDITORIAL
REV 03  EDITORIAL
REV 04(LUM 1D) PCR 287,979,1038, PCN 1009
REV 05(LUM 1E) PCR 336,339,1091, PCN 1145
REV 06(LUM 1E) PCN 1180
```

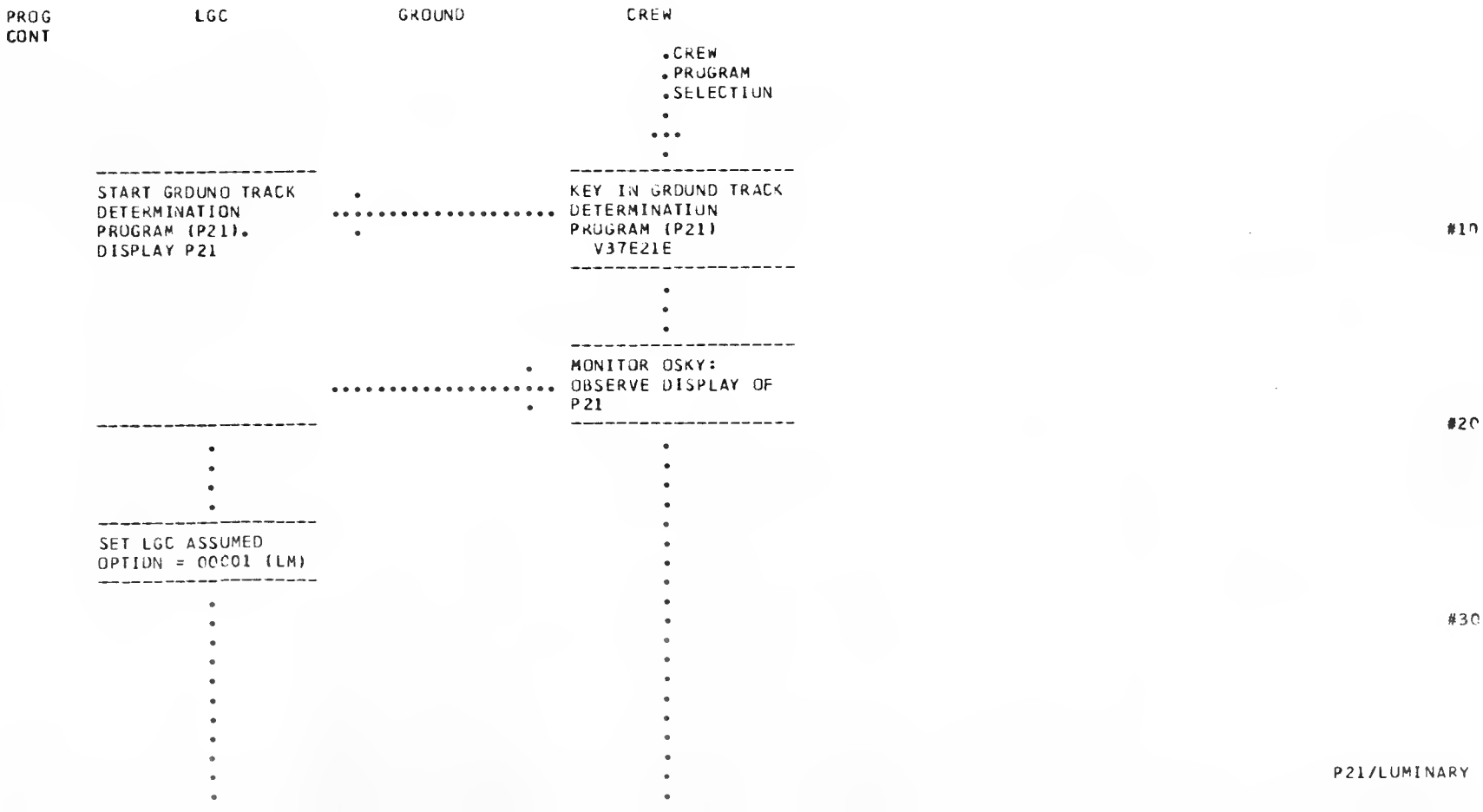
GROUND TRACK DETERMINATION PROGRAM (P21) REV 03 02/17/71

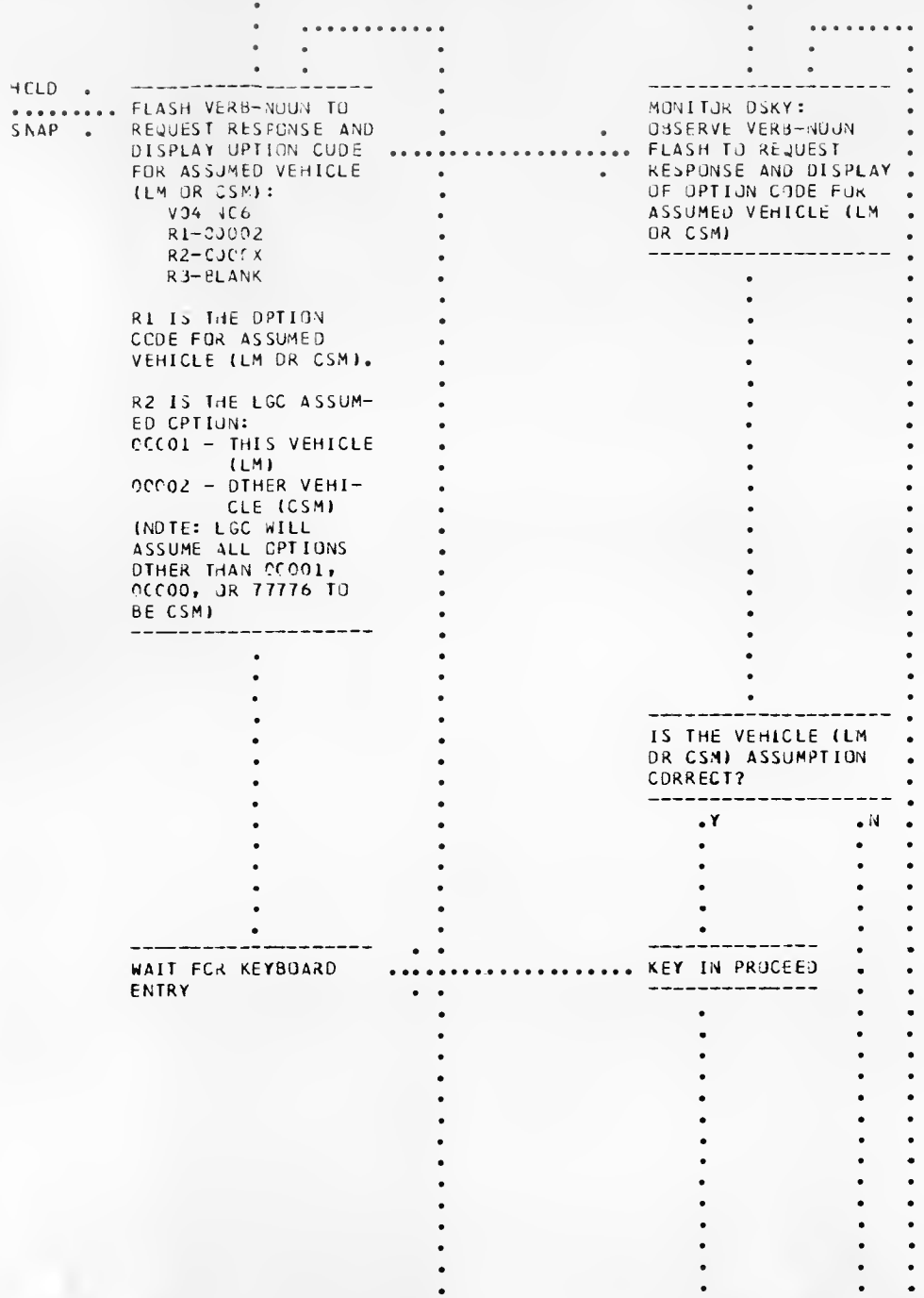
PURPOSE: (1) TO PROVIDE THE ASTRONAUT DETAILS OF HIS GROUND TRACK WITHOUT THE NEED FOR GROUND COMMUNICATION.

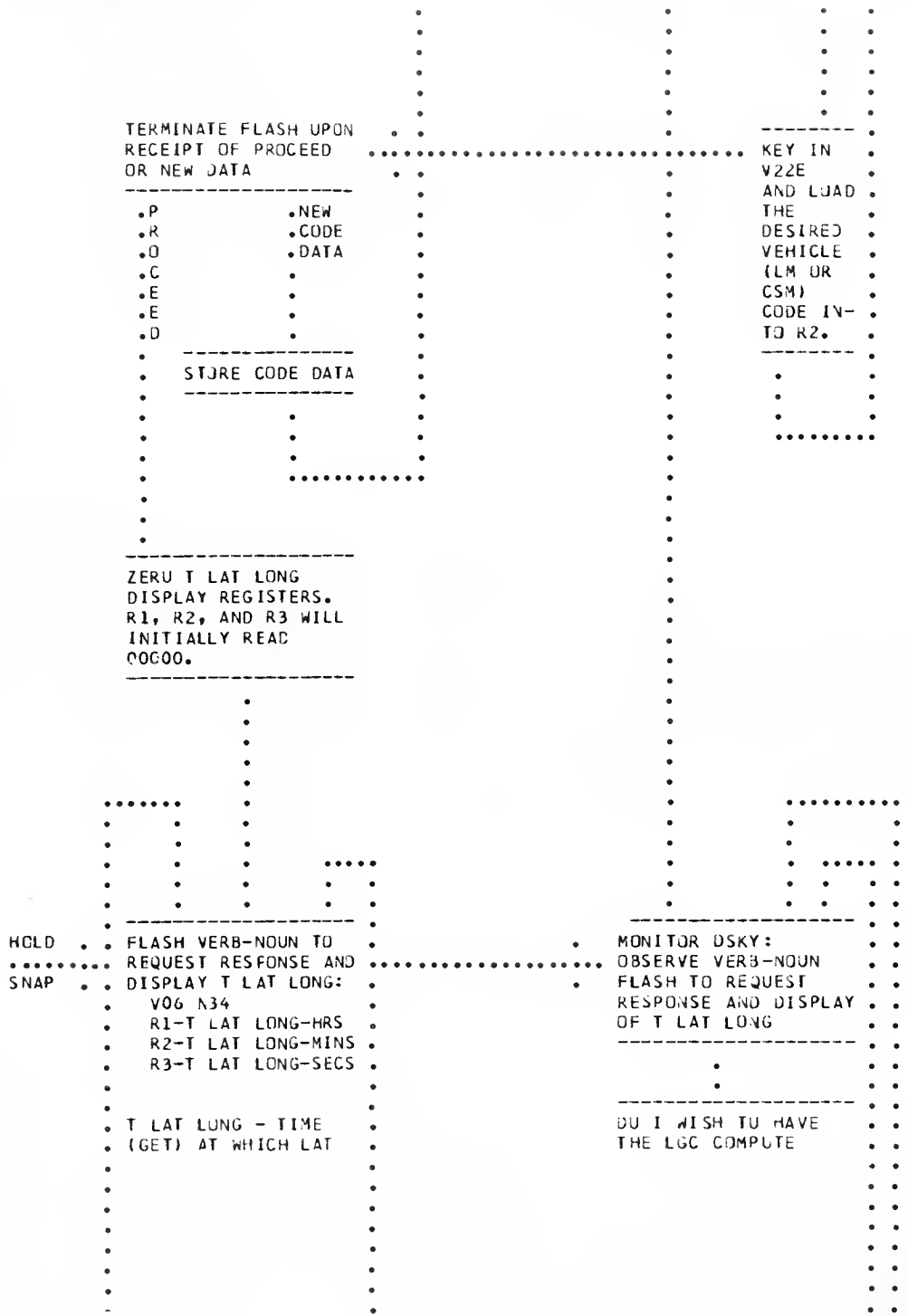
ASSUMPTIONS: (1) THIS PROGRAM MAY BE SELECTED WHILE THE LM IS EITHER IN EARTH OR LUNAR ORBIT, TO DEFINE THE GROUND TRACK OF EITHER THE LM OR THE CSM.

(2) THIS PROGRAM ASSUMES THE VEHICLE WHOSE GROUND TRACK PARAMETERS ARE CALCULATED TO REMAIN IN FREE FALL FROM THE PRESENT TIME UNTIL T LAT LONG.

(3) THE PROGRAM IS SELECTED BY THE ASTRONAUT BY DSKY ENTRY.




HOLD
SNAP
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY OPTION CODE FOR ASSUMED VEHICLE (LM OR CSM):
V04 N06
R1-00002
R2-CCCXX
R3-BLANK
R1 IS THE OPTION CODE FOR ASSUMED VEHICLE (LM OR CSM).
R2 IS THE LGC ASSUMED OPTION:
00001 - THIS VEHICLE (LM)
00002 - OTHER VEHICLE (CSM)
(NOTE: LGC WILL ASSUME ALL OPTIONS OTHER THAN 00001, 00000, OR 77776 TO BE CSM)
WAIT FOR KEYBOARD ENTRY
MONITOR DSKY: OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY OF OPTION CODE FOR ASSUMED VEHICLE (LM OR CSM)
IS THE VEHICLE (LM OR CSM) ASSUMPTION CORRECT?
Y
N
KEY IN PROCEED
#40
#50
#60
#70
#80



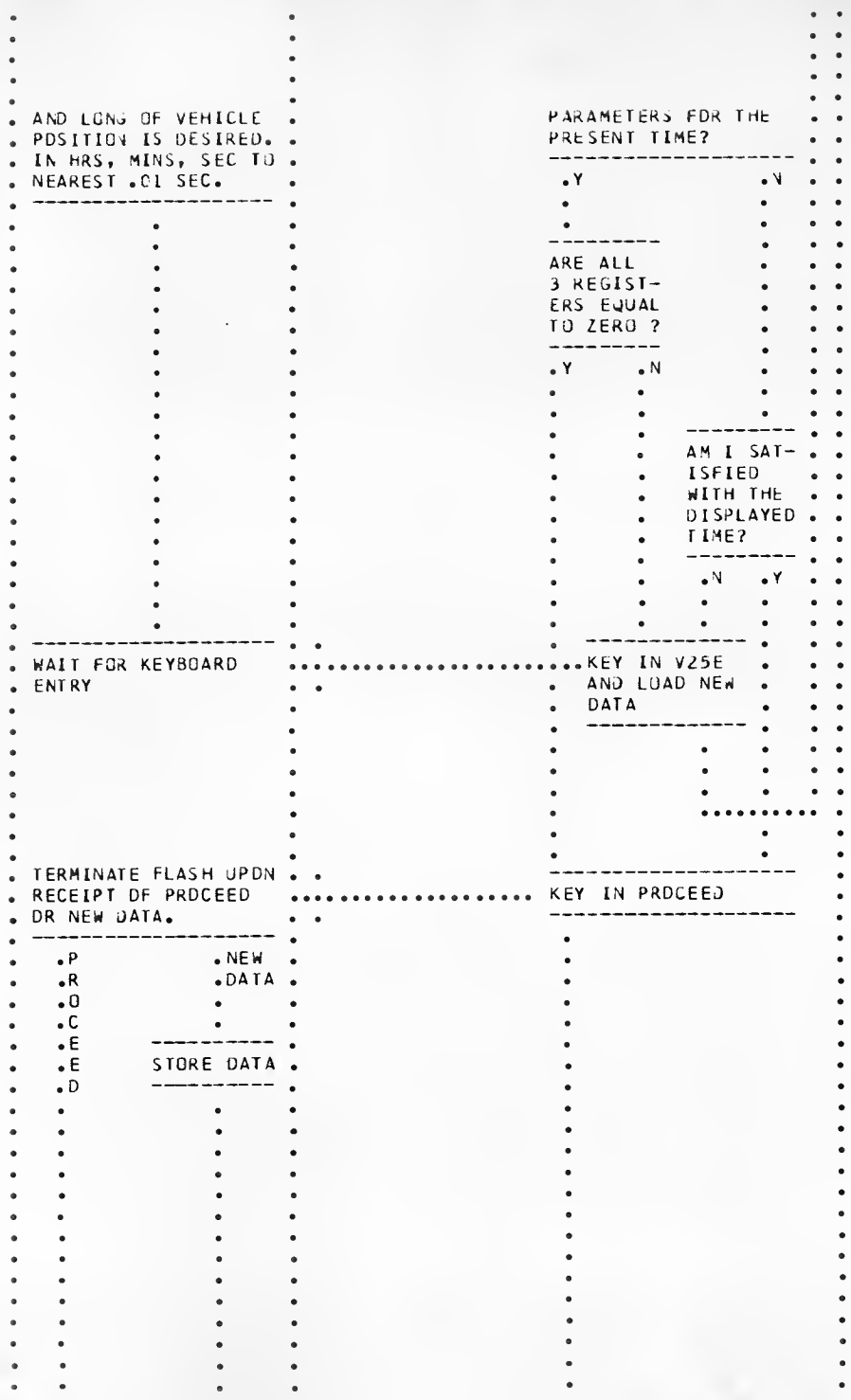
#90

#100

#110

#120

#130



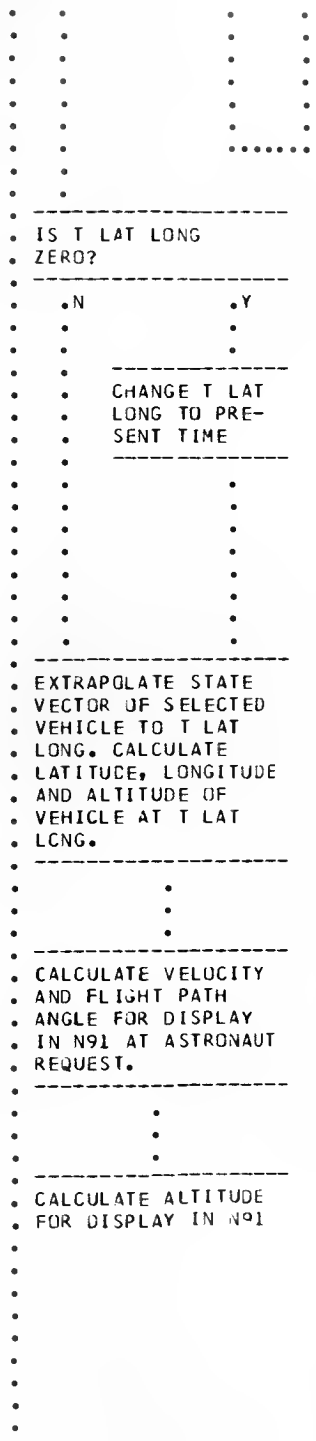
#140

#150

#160

#170

#180



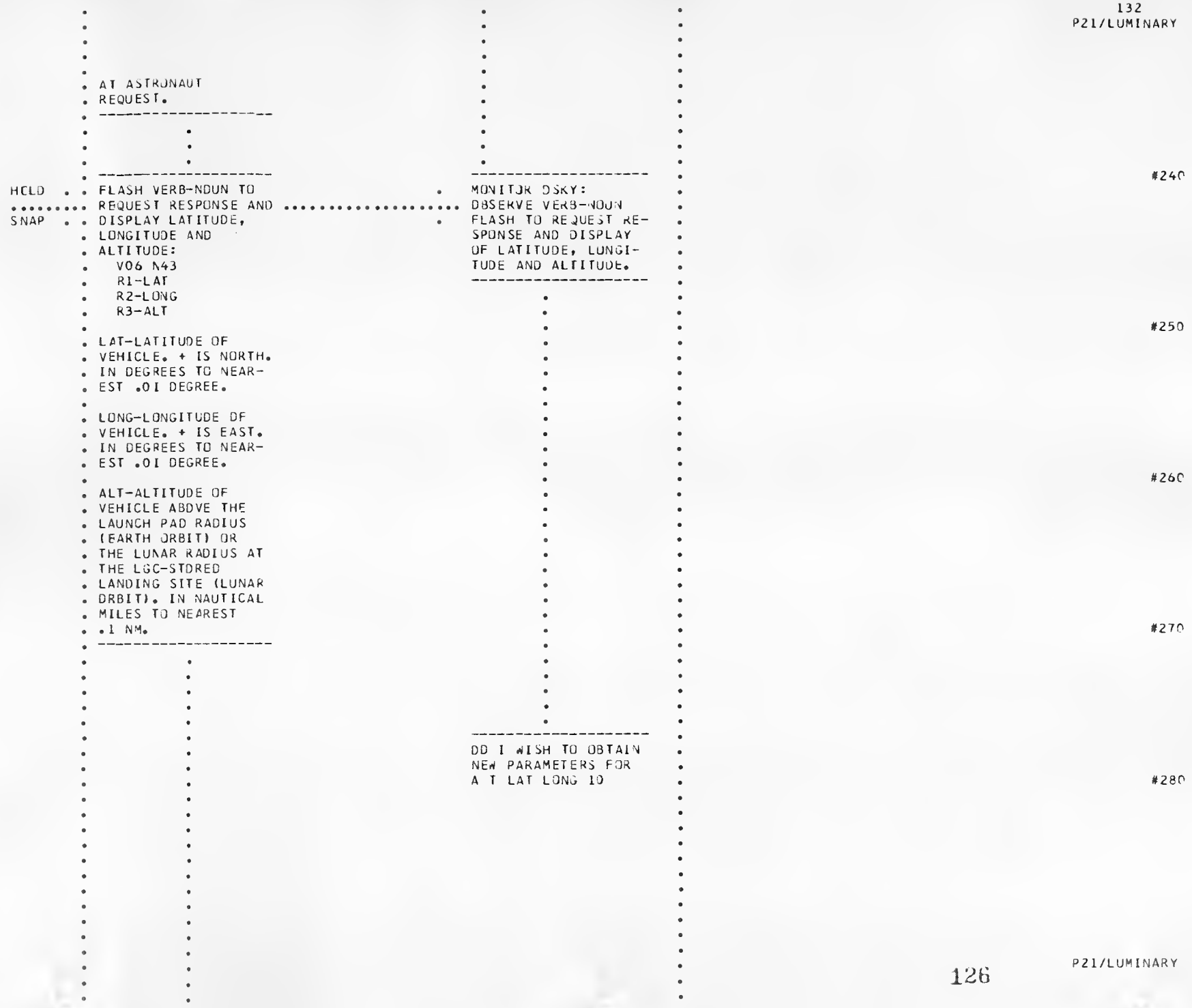
#190

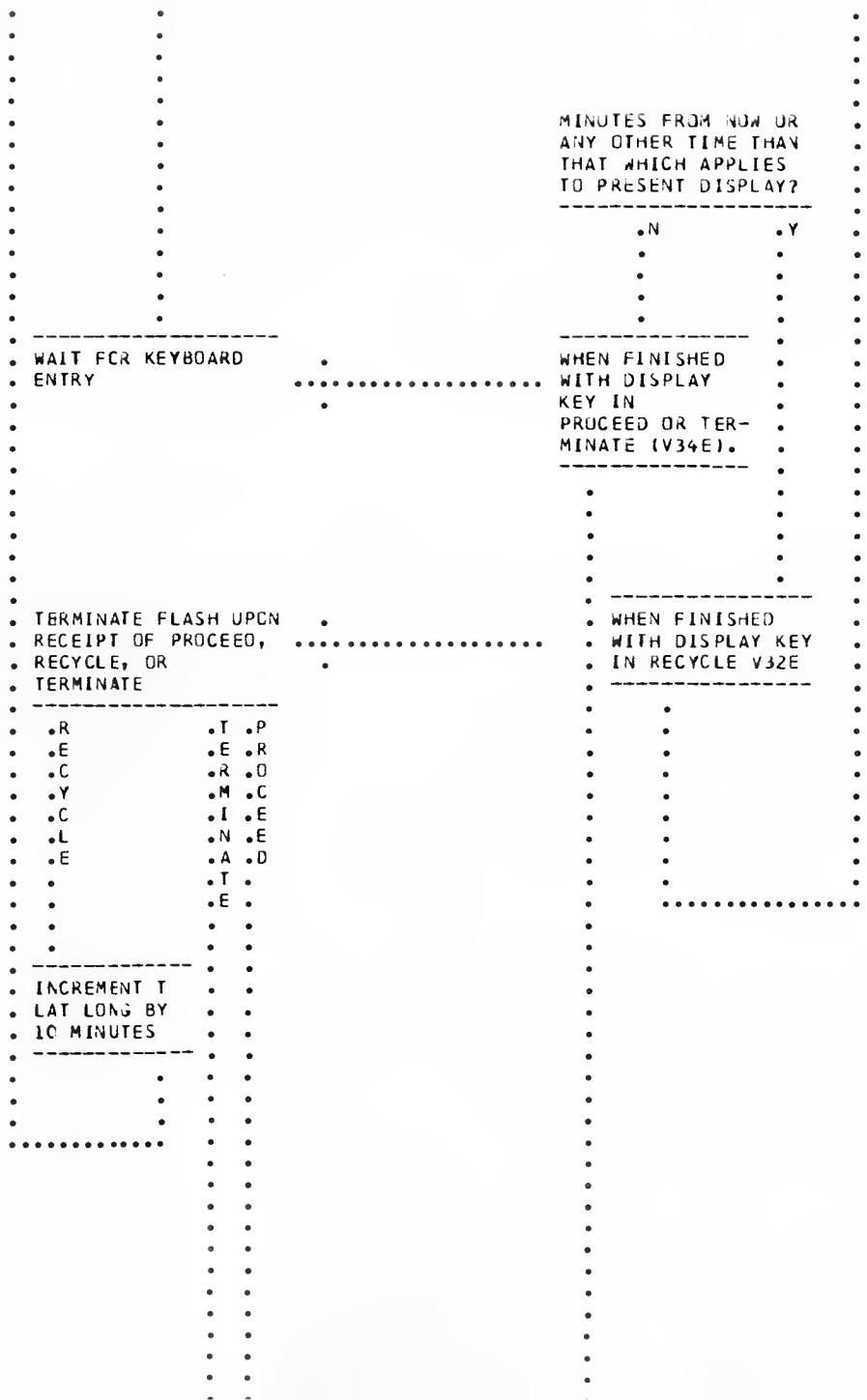
#200

#210

#220

#230


AT ASTRONAUT REQUEST.
HOLD
SNAP
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY LATITUDE, LONGITUDE AND ALTITUDE:
V06 N43
R1-LAT
R2-LONG
R3-ALT
LAT-LATITUDE OF VEHICLE. + IS NORTH. IN DEGREES TO NEAREST .01 DEGREE.
LONG-LONGITUDE OF VEHICLE. + IS EAST. IN DEGREES TO NEAREST .01 DEGREE.
ALT-ALTITUDE OF VEHICLE ABOVE THE LAUNCH PAD RADIUS (EARTH ORBIT) OR THE LUNAR RADIUS AT THE LGC-STORED LANDING SITE (LUNAR ORBIT). IN NAUTICAL MILES TO NEAREST .1 NM.
MONITOR DSKY: OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY OF LATITUDE, LONGITUDE AND ALTITUDE.
DO I WISH TO OBTAIN NEW PARAMETERS FOR A T LAT LONG 10
#240
#250
#260
#270
#280



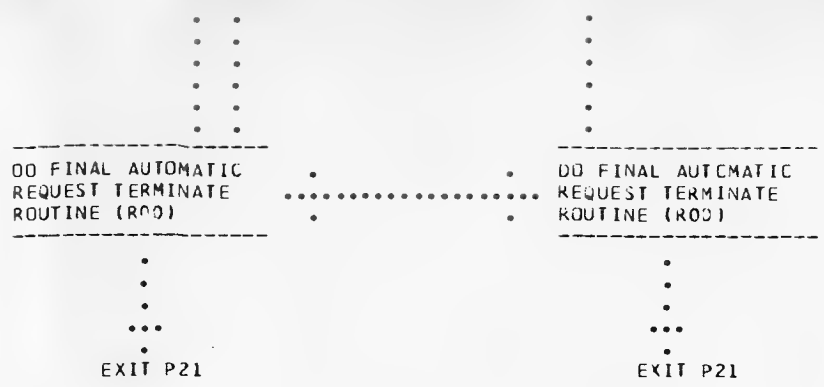
#290

#300

#310

#320

#330



#340

CHANGE CONTROL NOTES

REV 01 EDITORIAL
REV 00(LUM 1A) PCR 738
REV 01(LUM 1B) PCR 807.2
REV C2 EDITORIAL
REV C3(LUM 1E) PCN 1145

LUNAR SURFACE NAVIGATION PROGRAM (P22) REV 06 12/01/71

PURPOSE: (1) TO CONTROL THE RENDEZVOUS RADAR(RR) TO ACQUIRE AND TRACK THE CSM WHILE THE LM IS ON THE LUNAR SURFACE.

(2) TO UPDATE THE CSM STATE VECTOR ON THE BASIS OF RR TRACKING DATA.

(3) TO TRACK THE CSM WITHOUT UPDATING EITHER VEHICLE STATE VECTOR.

ASSUMPTIONS: (1) THE ISS MAY BE IN STANDBY OR OPERATE. THE IMU WOULD NORMALLY BE ON AND THE LUNAR SURFACE ALIGN PROGRAM (P57) COMPLETED BEFORE THE SELECTION OF THIS PROGRAM.
THE ISS THUS MAY BE:

(A) OFF (STANDBY).

(B) ON, AND NOT ALIGNED SINCE TURN ON.

(C) ON AND AT AN INERTIAL ORIENTATION KNOWN ONLY INACCURATELY BY THE LGC, I.E. HAVING BEEN ALIGNED AT LEAST ONCE SINCE TURN ON BUT EITHER HAVING BEEN INACCURATELY ALIGNED OR HAVING DRIFTED FROM THE STORED ALIGNMENT.

(D) ON AND AT AN INERTIAL ORIENTATION KNOWN ACCURATELY BY THE LGC.

IF (A) IS TRUE A PROGRAM ALARM WILL BE MADE BY THIS PROGRAM.
IF (B) IS TRUE A PROGRAM ALARM WILL BE MADE BY THIS PROGRAM.
IF (C) IS TRUE THE LGC MAY OR MAY NOT HAVE A SATISFACTORY INERTIAL REFERENCE TO ACCURATELY COMPLETE THE PROGRAM.
IF (D) IS TRUE THE LGC HAS A SATISFACTORY INERTIAL REFERENCE TO ACCURATELY COMPLETE THE PROGRAM.

(2) THE CSM MAY OR MAY NOT BE BELOW THE LUNAR HORIZON. ALTHOUGH ABOVE THE HORIZON IT MAY STILL BE OUTSIDE OF THE AVAILABLE RR COVERAGE SECTOR. ALTHOUGH WITHIN THE AVAILABLE RR COVERAGE SECTOR IT MAY BE OUTSIDE THE ALLOWABLE RR COVERAGE SECTOR (SEE RR MONITOR ROUTINE (R25)).
THIS PROGRAM WILL ALWAYS TRACK THE CSM WITH THE RADAR IN MODE 2 (SEE FIGURE 2.4-3 OF SECTION 5 OF P567). IN MODE 2 THE AVAILABLE COVERAGE IS ALWAYS LESS THAN HORIZON TO HORIZON.

(3) THE CSM IS MAINTAINING A PREFERRED TRACKING ATTITUDE FOR RR TRACKING BY THE LM. THIS PREFERRED ATTITUDE CORRECTLY ORIENTS THE CSM RADAR TRANSPONDER.

(4) AT THE BEGINNING OF THE PROGRAM THE STATE VECTOR UPDATE OPTION IS AUTOMATICALLY SET TO THE CSM. THIS OPTION MAY BE INHIBITED AT ANY TIME AND LATER RESTORED BY THE FOLLOWING MANUAL ENTRIES:
V81E UPDATE CSM STATE VECTOR
V95E NO STATE VECTOR UPDATE

NOTE: IF V95E IS ENTERED BEFORE P22 IS SELECTED, V81E MUST BE PERFORMED TO ALLOW STATE VECTOR UPDATING.

(5) THE RENDEZVOUS RADAR IS ON, PRELIMINARY CHECKOUT HAS BEEN COMPLETED.

(6) THE FOLLOWING DISPLAY IS AVAILABLE DURING THIS PROGRAM UPON CREW REQUEST BY KEYING IN V85E (SEE EXTENDED VERBS):

V16N56
R1-RR LOS AZIMUTH
R2-RR LOS ELEVATION
R3-BLANK

WHERE: RR LOS AZIMUTH-THE ANGLE BETWEEN THE LM X/Z PLANE AND THE RR LOS VECTOR. POSITIVE ROTATION IS FROM THE

LM +Z AXIS TO THE LM +Y AXIS. IN DEGREES TO NEAREST .01 DEGREE.

RR LOS ELEVATION-THE ANGLE BETWEEN THE LM +Z AXIS AND THE PROJECTION OF THE RR LOS VECTOR ON THE LM X/Z PLANE. POSITIVE ROTATION IS POSITIVE ROTATION ABOUT THE LM +Y AXIS.

(7) THE INITIALIZATION OF THE W MATRIX (SEE SECTION 5.2.4.2 OF R567) IS ENABLED BY:

(A) A MANUAL OSKY ENTRY (V93E).

(B) COMPUTER FRESH START (V36E).

(C) LM OR CSM IN-FLIGHT STATE VECTOR UPDATE FROM THE GROUND (P27) (EXCEPT FOR UPDATE OF LANDING SITE VECTOR WHEN THE LM IS ON THE LUNAR SURFACE).

++ (8) THE RR TRACKING MARK COUNTER COUNTS THE NUMBER OF RR MARKS PROCESSED BY THE LGC. THIS COUNTER IS ZEROED BY:

+C6

+ (A) MANUAL SELECTION OF P20/P22 (V37E20/22E).

+

+ (B) COMPLETION OF THE TARGET DELTA V PROGRAM (P76), OR THE IMPULSIVE DELTA V PROGRAM (P77).

+1180

++ (C) SELECTION OF A NEW PROGRAM FROM A PROGRAM WHICH HAD TURNED ON AVERAGE G.

(D) INITIALIZATION OF THE W MATRIX (SEE 7) ABOVE).

(E) COMPLETION OF RR SEARCH ROUTINE (R24).

++

+06 (9) THE RSS POSITION AND VELOCITY ERRORS COMPUTED FROM THE W MATRIX ARE AVAILABLE BY EXTENDED VERB (V67E). BASED

+ UPON VALUES IN THIS DISPLAY AND THE DETAILS OF THE MISSION, THE ASTRONAUT CAN ELECT TO STOP OR CONTINUE THE

+1180 CURRENT NAVIGATION PROCEDURE OR TO RE-INITIALIZE THE W MATRIX AND CONTINUE NAVIGATING. THE CAPABILITY TO REINITIALIZE

++ THE W MATRIX IS ALSO PROVIDED VIA V67E.

(10) THE SELECTION AND TERMINATION OF P20, P22, AND P25 ARE SUBJECT TO SPECIAL OPERATING PROCEDURES DIFFERENT FROM ALL OTHER PROGRAMS;

(A) SELECTION

(1) ALWAYS BY V37EXXE.

(2) IF ANY OTHER PROGRAM IS RUNNING AT THE TIME OF P20/22/25 SELECTION THE NEW PROGRAM WILL REPLACE THE

++ OLD. THIS INCLUDES P20/22/25 SELECTION WHENEVER EITHER P20, 22, OR 25 IS RUNNING.

+06 (3) IF P20 OR P25 IS RUNNING, SELECTION OF ANY PROGRAM OTHER THAN P00, P22, OR P25 WILL RESULT IN P20 OR

+ P25 CONTINUING AND THE NEW PROGRAM ALSO OPERATING WITH ITS NUMBER IN THE OSKY PROG LIGHTS.

+1180 (4) IF P20 OR P25 IS RUNNING, SELECTION OF P00, P22, OR P25 WILL RESULT IN THE TERMINATION OF THE OLD

++ PROGRAM AND OPERATION OF THE NEW.

(B) TERMINATION

(1) BY SELECTION OF P00, V56E, OR BY V34E.

(2) P00 SELECTION WILL TERMINATE P20, 22, AND 25 AND ANY OTHER PROGRAM IN PROCESS AND ESTABLISH P00.

(3) V56E SELECTION WILL SELECT THE TERMINATE TRACKING ROUTINE (R56) WHICH WILL TERMINATE ONLY P20 OR P25 IF EITHER OF THESE PROGRAMS IS RUNNING IN CONJUNCTION WITH ANOTHER PROGRAM. IN ALL OTHER CASES R56 WILL SELECT R00. V56E MAY BE PERFORMED ANY TIME DURING P20, 22, OR 25 OPERATION.

(4) THE LGC WILL ACT UPON V34E ONLY IN RESPONSE TO A FLASHING VERB-NOUN. IF THIS DISPLAY WAS ORIGINATED BY

++ P20, 22, OR 25, V34E WILL RESULT IN AN IDENTICAL LGC RESPONSE TO THAT OF V56E, THAT IS SELECTION OF

+C6 R56 EXCEPT IN THE CASE OF A V06 N49 DISPLAY.

+1180 IF THIS DISPLAY WAS NOT ORIGINATED BY P20, 22, OR 25 (SUCH AS P32, WHILE RUNNING WITH P20) THE LGC

++ WILL GO TO R00, HOWEVER THE PROGRAM IN THE BACKGROUND WILL CONTINUE. THE NEW PROGRAM SELECTED FOLLOWS THE SELECTION RULES ABOVE, (A).

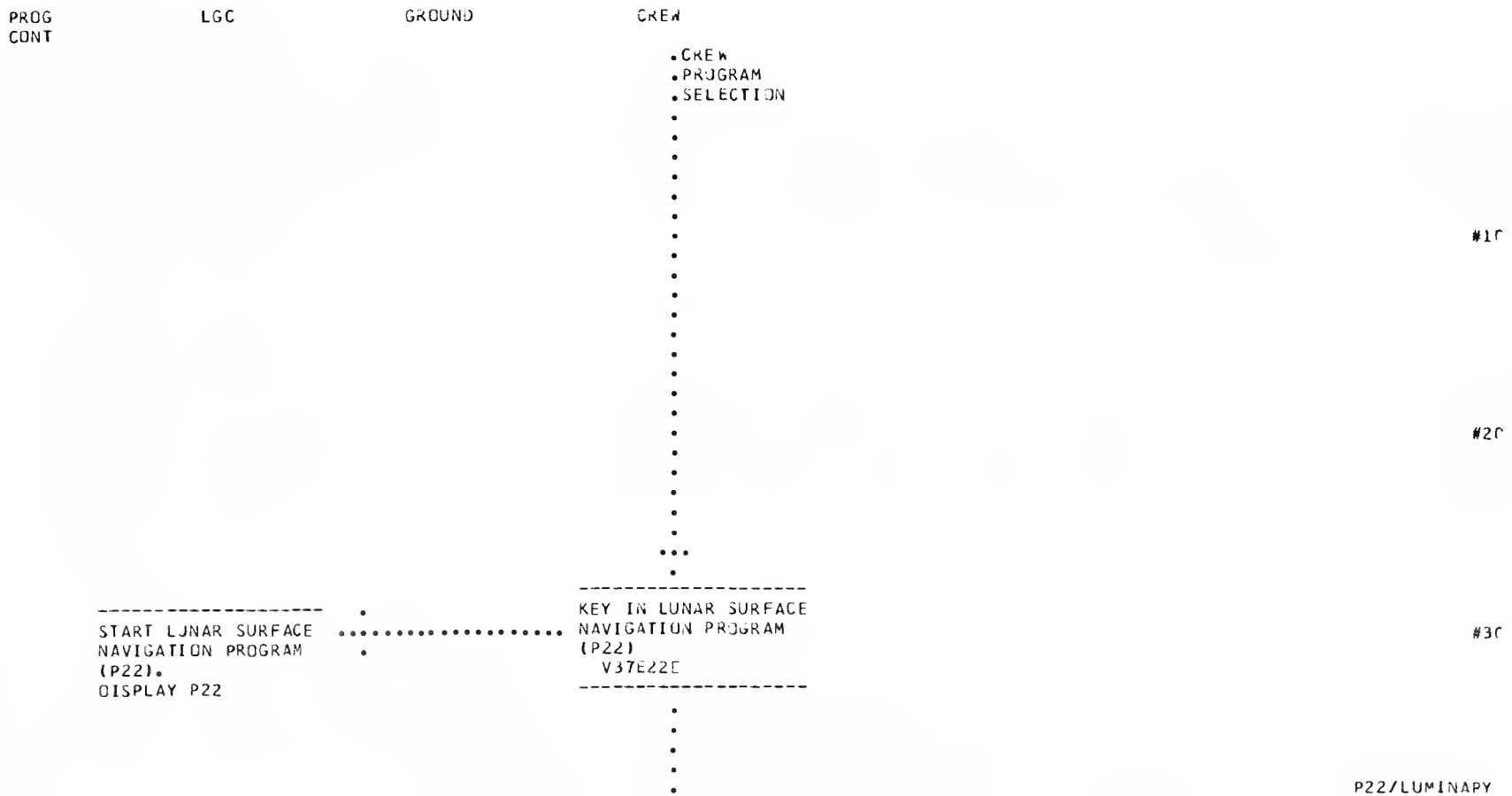
(5) ALTHOUGH IT IS NOT CLEARLY SHOWN IN THE LOGIC BELOW, A V34E RESPONSE TO A PRIORITY DISPLAY MUST BE DELAYED 2 SECONDS FROM DISPLAY INITIATION WHEREAS THE DELAY IS NOT NECESSARY FOR A V56E RESPONSE.

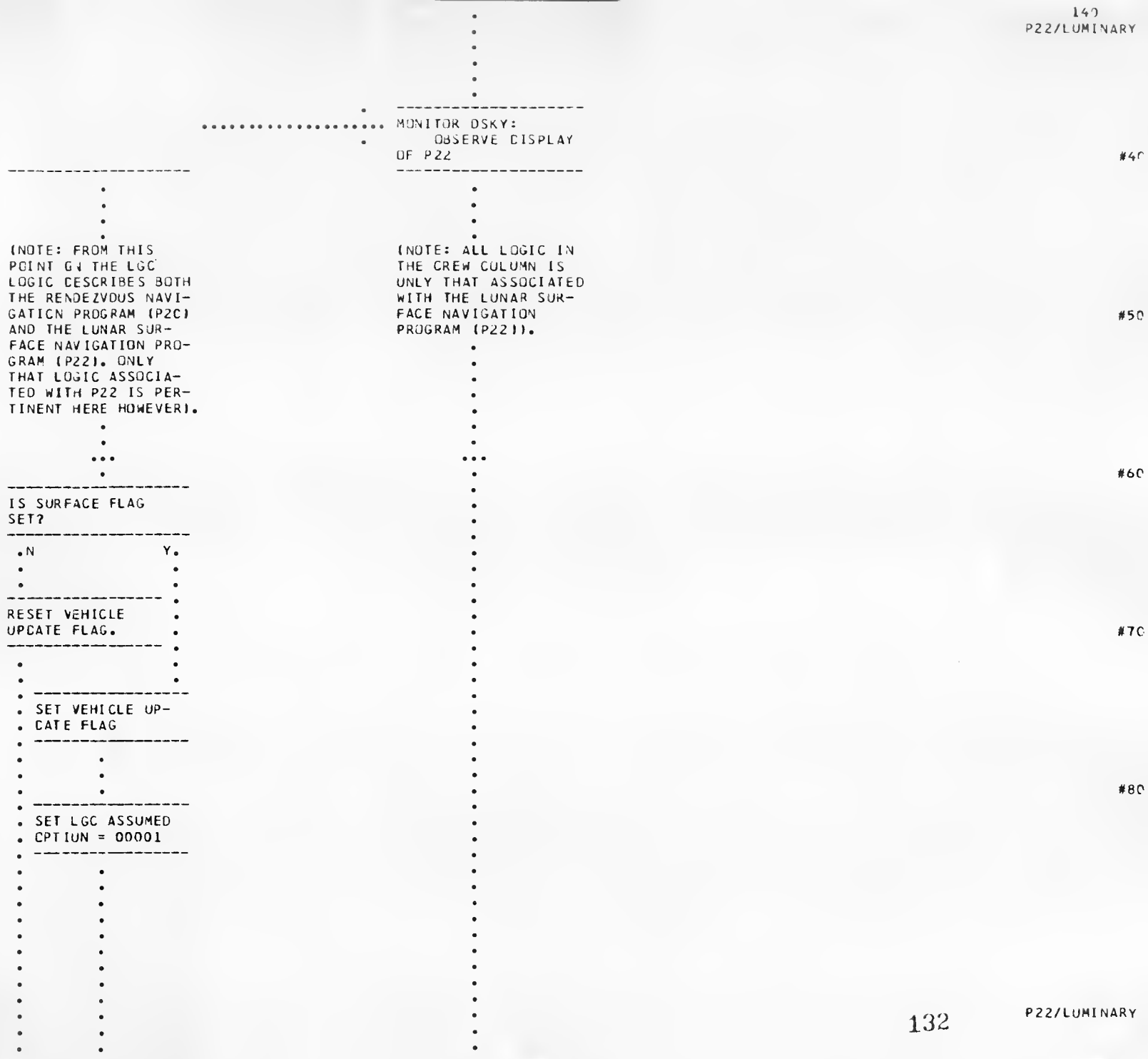
(11) TO MONITOR THE PROGRESS OF STATE VECTOR INTEGRATION, THE TIME ASSOCIATED WITH THE ADVANCING (REGRESSING) STATE IS AVAILABLE BY KEYING IN V06N38E:

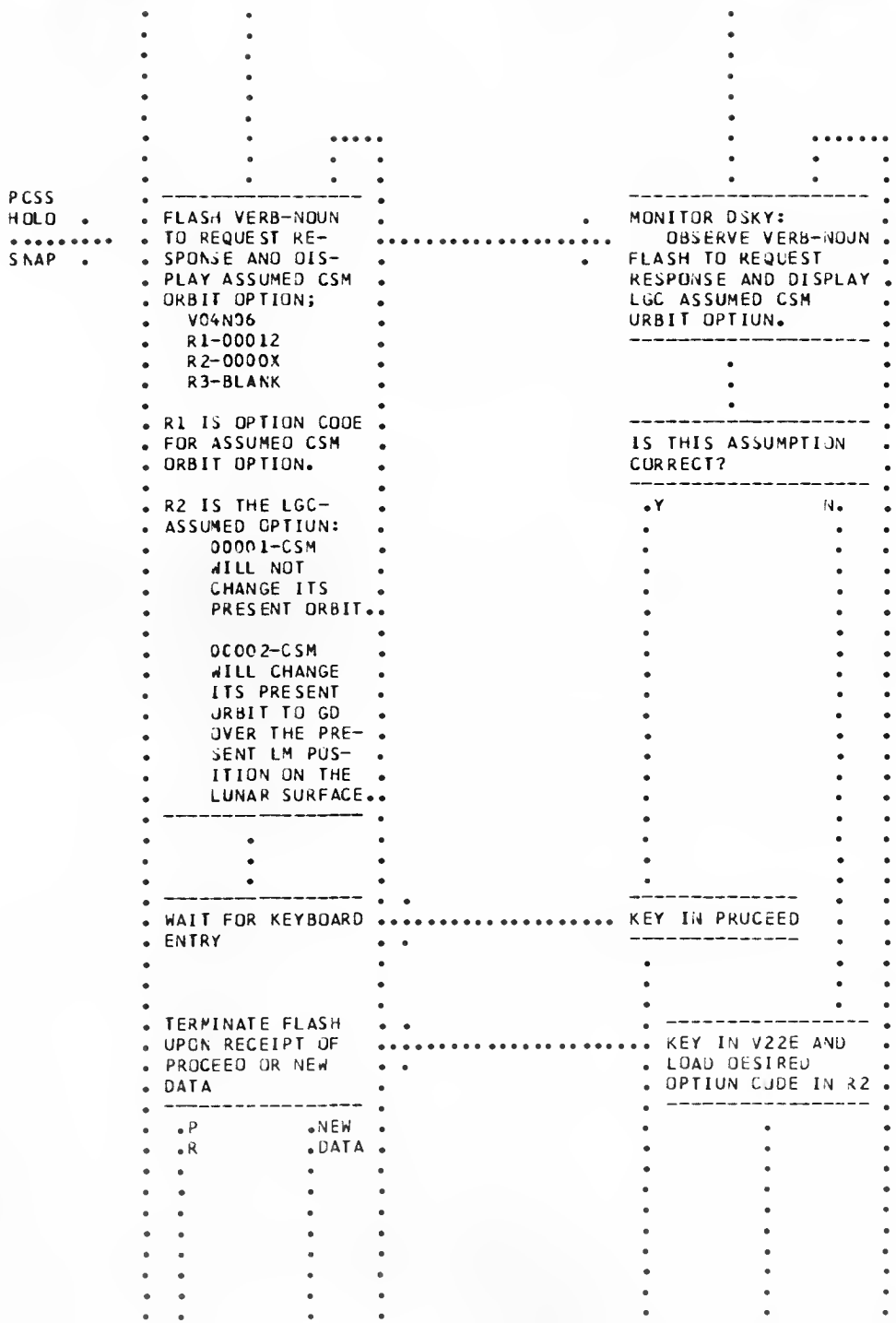
V06N38
R1-TET-HRS
R2-TET-MINS
R3-TET-SECS

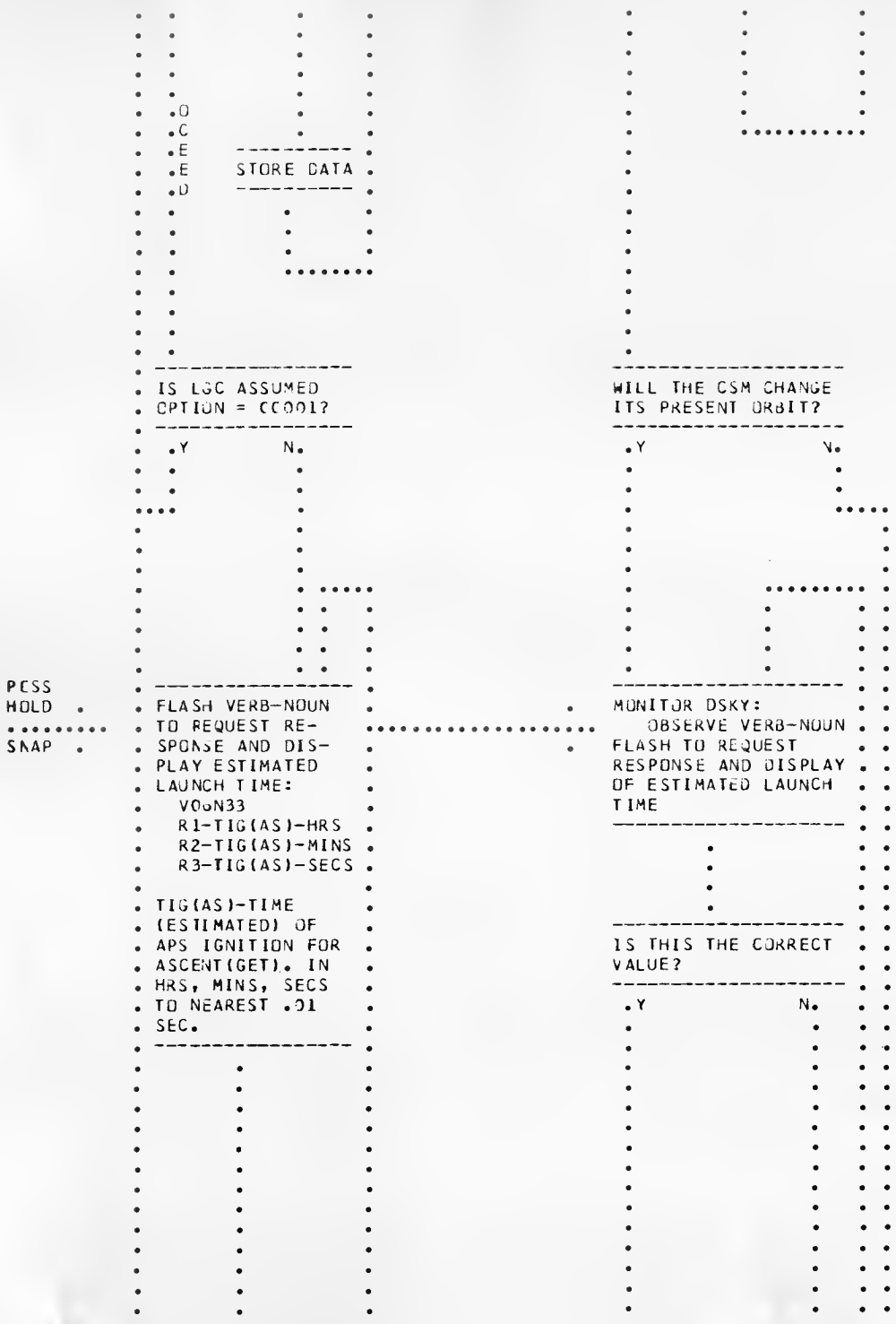
TET - THE TIME (GET) TO WHICH THE STATE VECTOR INTEGRATION PROCESS HAS PRESENTLY CALCULATED THE STATE VECTOR. IN HRS, MINS, AND SECS TO NEAREST .01 SEC.

(12) STATE VECTOR INTEGRATION MAY BE PERMANENTLY INHIBITED BY V96E. THIS ENTRY WILL TERMINATE ALL PRESENT PROGRAMS AND SELECT THE LGC IDLING PROGRAM (P00) WITH THE P00 AUTOMATIC STATE VECTOR INTEGRATION PERMANENTLY INHIBITED UNTIL SELECTION OF ANOTHER PROGRAM. USE OF V96 CAN CAUSE INCORRECT W-MATRIX EXTRAPOLATION SINCE STATE VECTOR SYNCHRONIZATION IS NOT MAINTAINED.




MONITOR DSKY:
OBSERVE DISPLAY
OF P22
(NOTE: ALL LOGIC IN THE CREW COLUMN IS ONLY THAT ASSOCIATED WITH THE LUNAR SURFACE NAVIGATION PROGRAM (P22)).
(NOTE: FROM THIS POINT ON THE LGC LOGIC DESCRIBES BOTH THE RENDEZVOUS NAVIGATION PROGRAM (P20) AND THE LUNAR SURFACE NAVIGATION PROGRAM (P22). ONLY THAT LOGIC ASSOCIATED WITH P22 IS PERTINENT HERE HOWEVER).
IS SURFACE FLAG SET?
N
Y
RESET VEHICLE UPDATE FLAG.
SET VEHICLE UPDATE FLAG
SET LGC ASSUMED OPTION = 00001
#40
#50
#60
#70
#80


PCSS
HOLD
SNAP
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY ASSUMED CSM ORBIT OPTION;
V04N06
R1-00012
R2-0000X
R3-BLANK
R1 IS OPTION CODE FOR ASSUMED CSM ORBIT OPTION.
R2 IS THE LGC-ASSUMED OPTION:
00001-CSM WILL NOT CHANGE ITS PRESENT ORBIT
00002-CSM WILL CHANGE ITS PRESENT ORBIT TO GO OVER THE PRESENT LM POSITION ON THE LUNAR SURFACE
WAIT FOR KEYBOARD ENTRY
TERMINATE FLASH UPON RECEIPT OF PROCEED OR NEW DATA
.P
.R
.NEW DATA
MONITOR DSKY: OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY LGC ASSUMED CSM URBIT OPTION.
IS THIS ASSUMPTION CORRECT?
.Y
N.
KEY IN PROCEED
KEY IN V22E AND LOAD DESIRED OPTION CODE IN R2
#9C
#10C
#11C
#12C
#13C



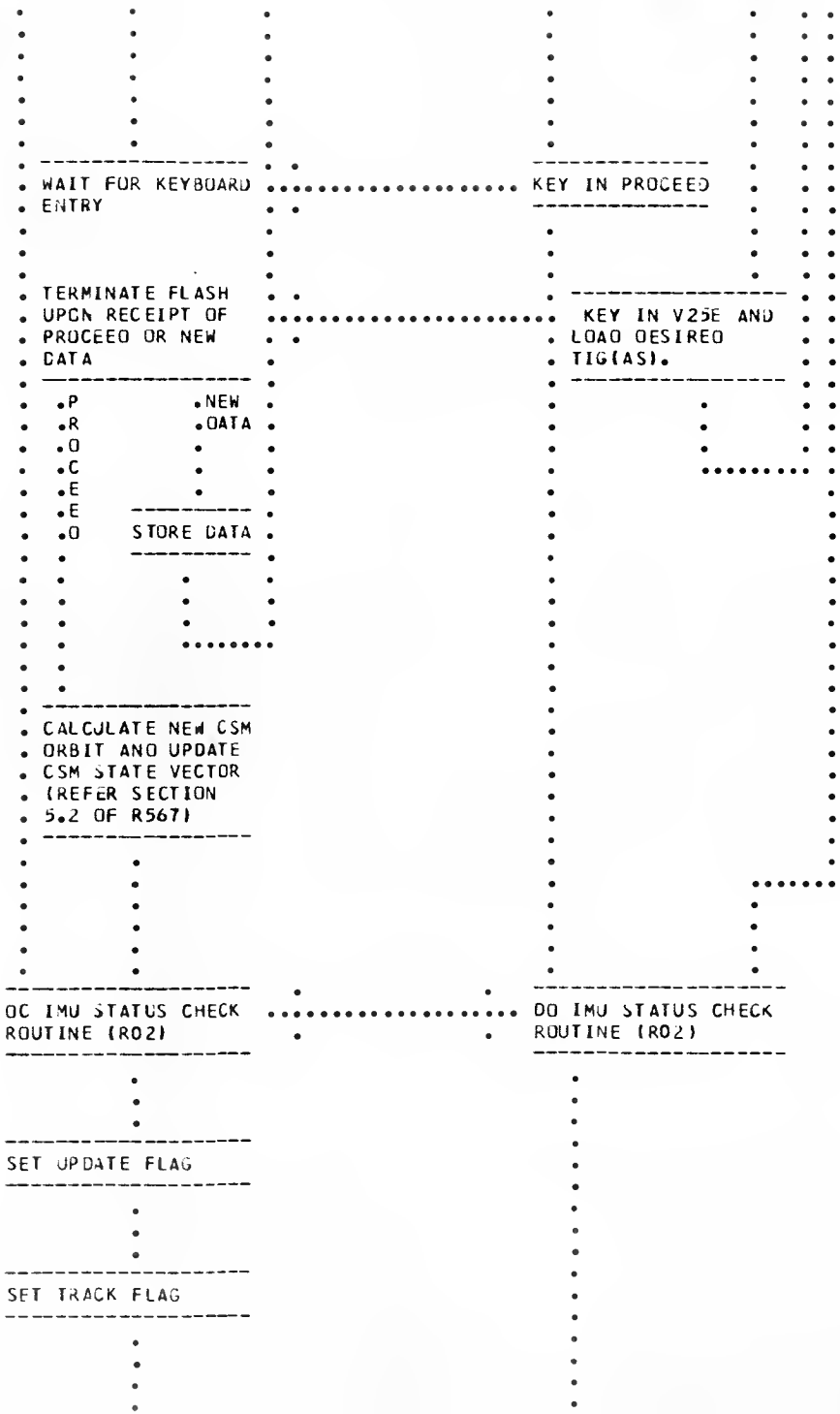
#140

#150

#160

#170

#180



#190

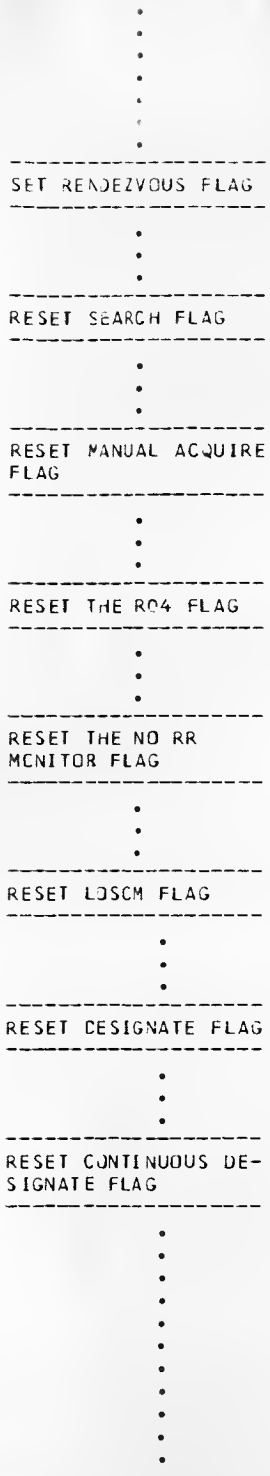
#200

#210

#220

#230

#240



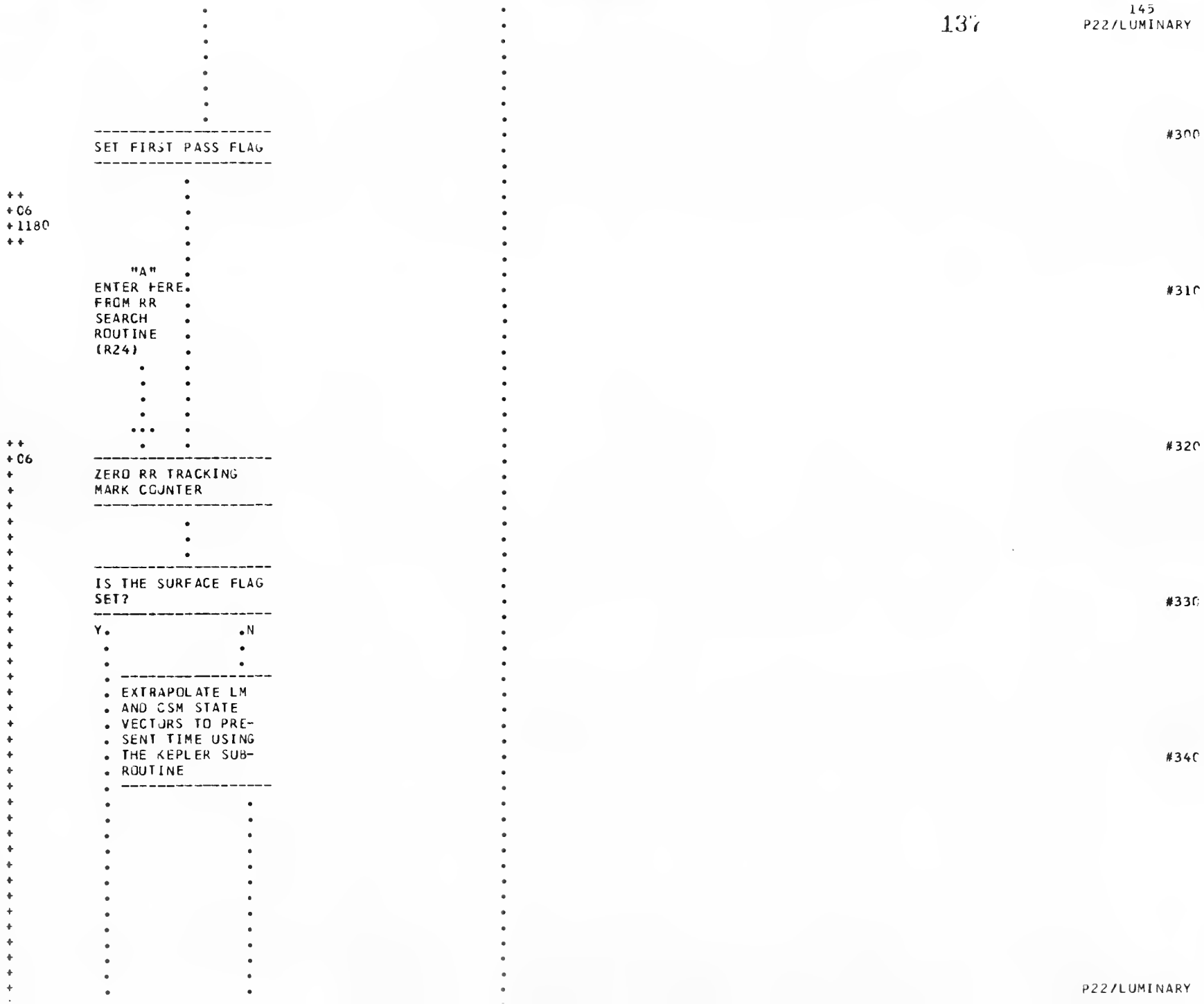
#250

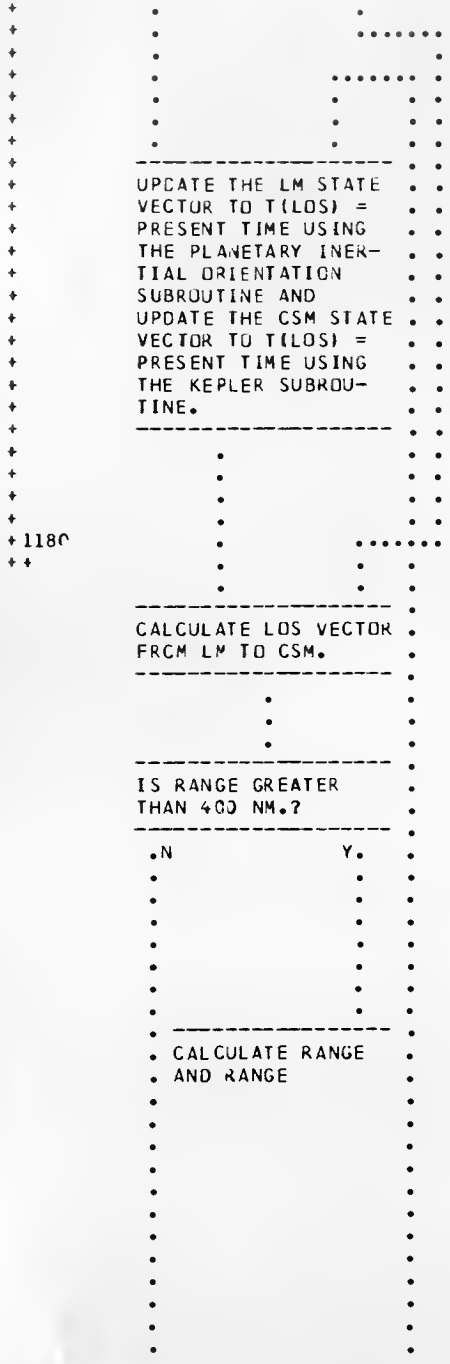
#260

#270

#280

#290


SET FIRST PASS FLAG
"A" ENTER HERE FROM RR SEARCH ROUTINE (R24)
ZERO RR TRACKING MARK COUNTER
IS THE SURFACE FLAG SET?
Y.
.N
EXTRAPOLATE LM AND CSM STATE VECTORS TO PRESENT TIME USING THE KEPLER SUBROUTINE
#300
#310
#320
#330
#340



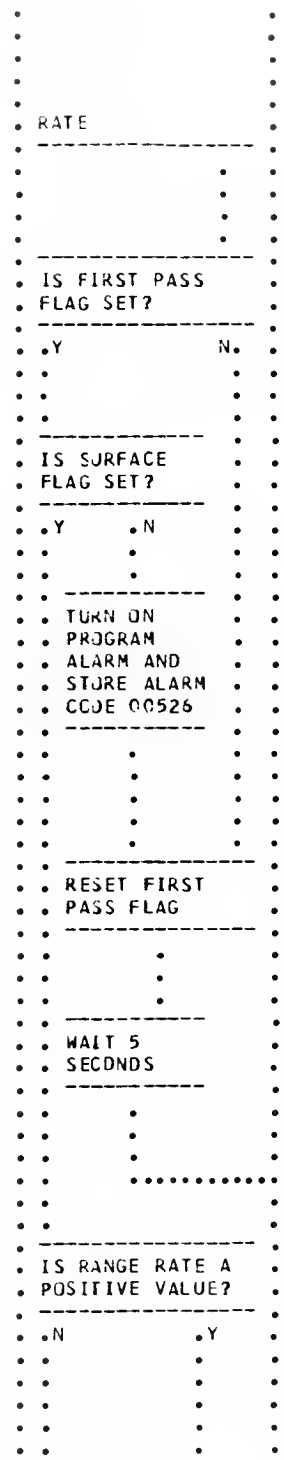
#350

#360

#370

#380

#390



#400

#410

#420

#430

"A"
ENTER
HERE FROM
RR SEARCH
ROUTINE
(R24)

#440

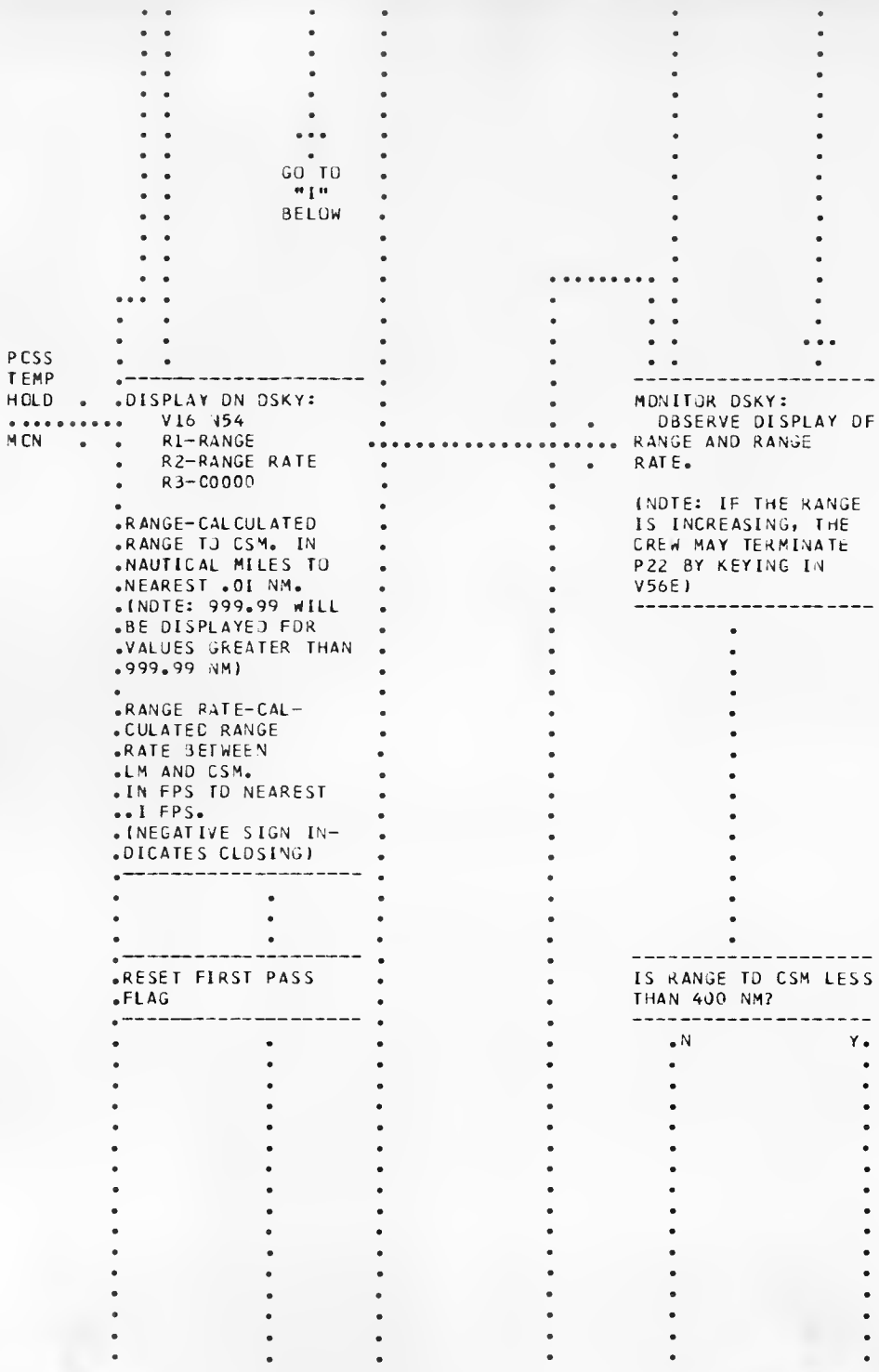
#450

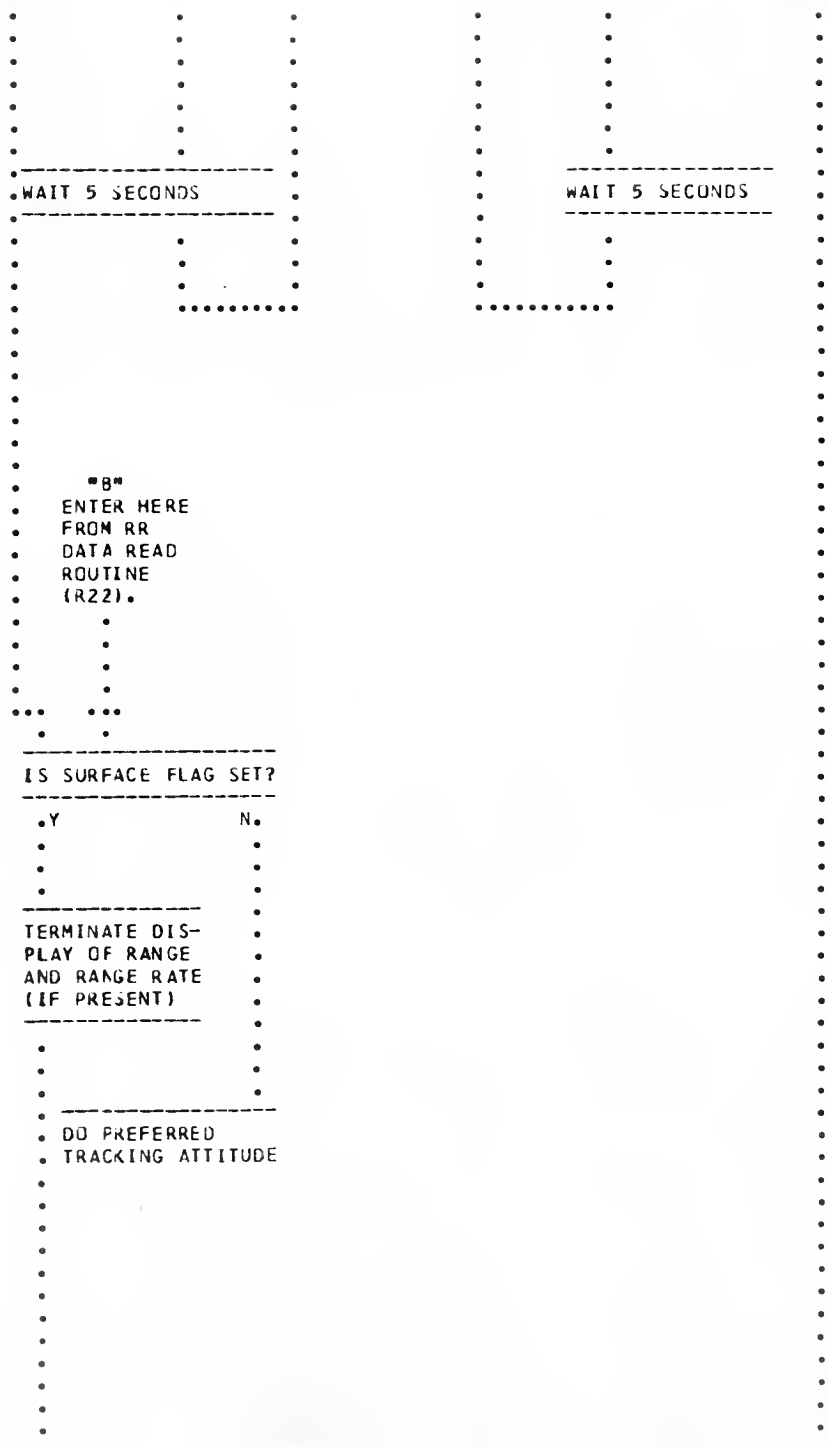
#460

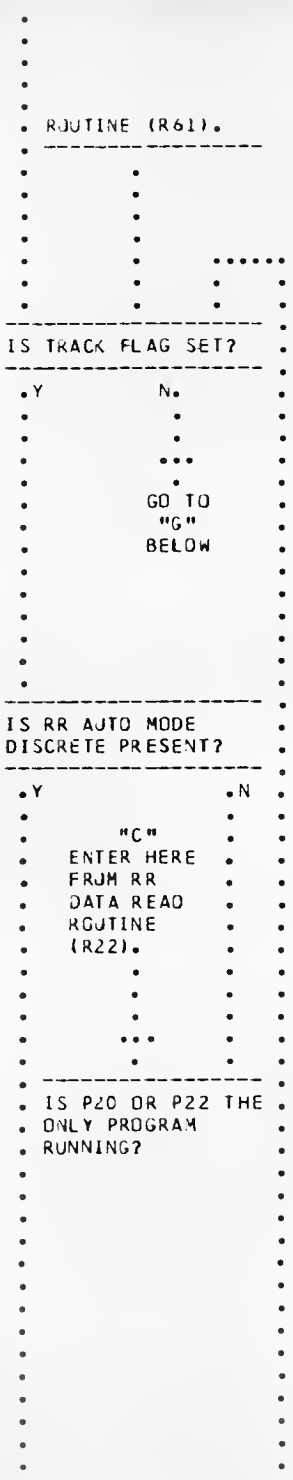
#470

#480

#490




WAIT 5 SECONDS
WAIT 5 SECONDS
#500
#510
"B"
ENTER HERE
FROM RR
DATA READ
ROUTINE
(R22).
#520
IS SURFACE FLAG SET?
Y
N
#530
TERMINATE DIS-
PLAY OF RANGE
AND RANGE RATE
(IF PRESENT)
#540
DO PREFERRED
TRACKING ATTITUDE



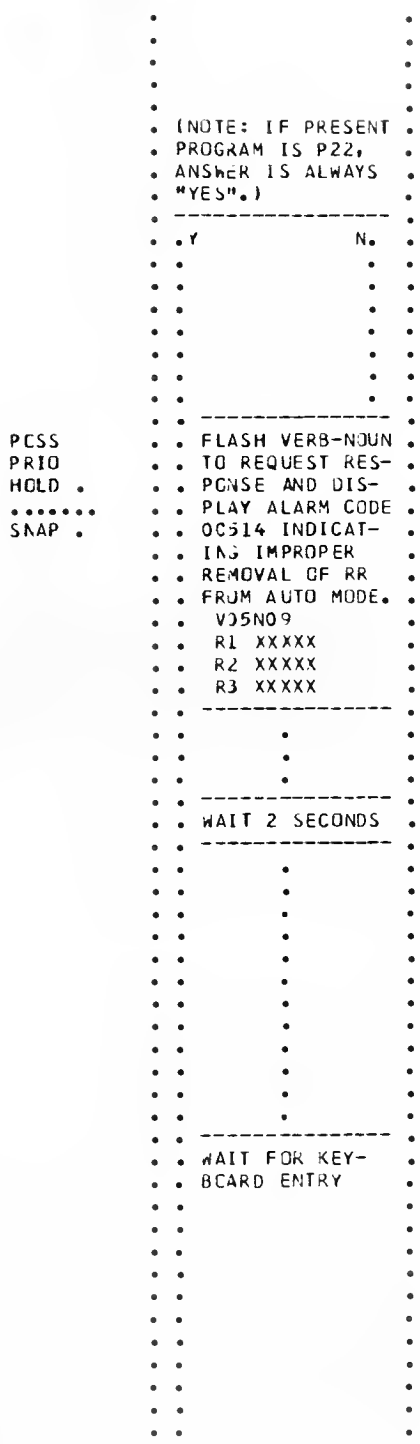
#550

#560

#570

#580

#590



PCSS
PRIO
HOLD .
.....
SNAP .

#600

#610

#620

#630

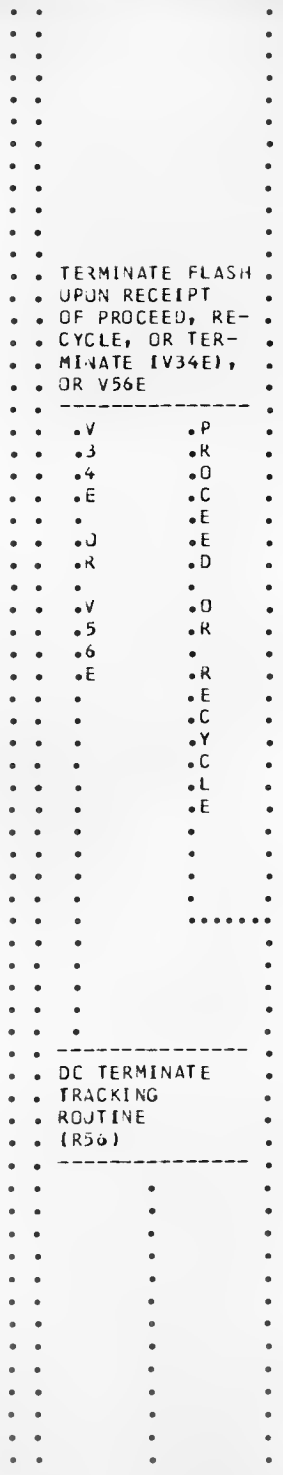
#640

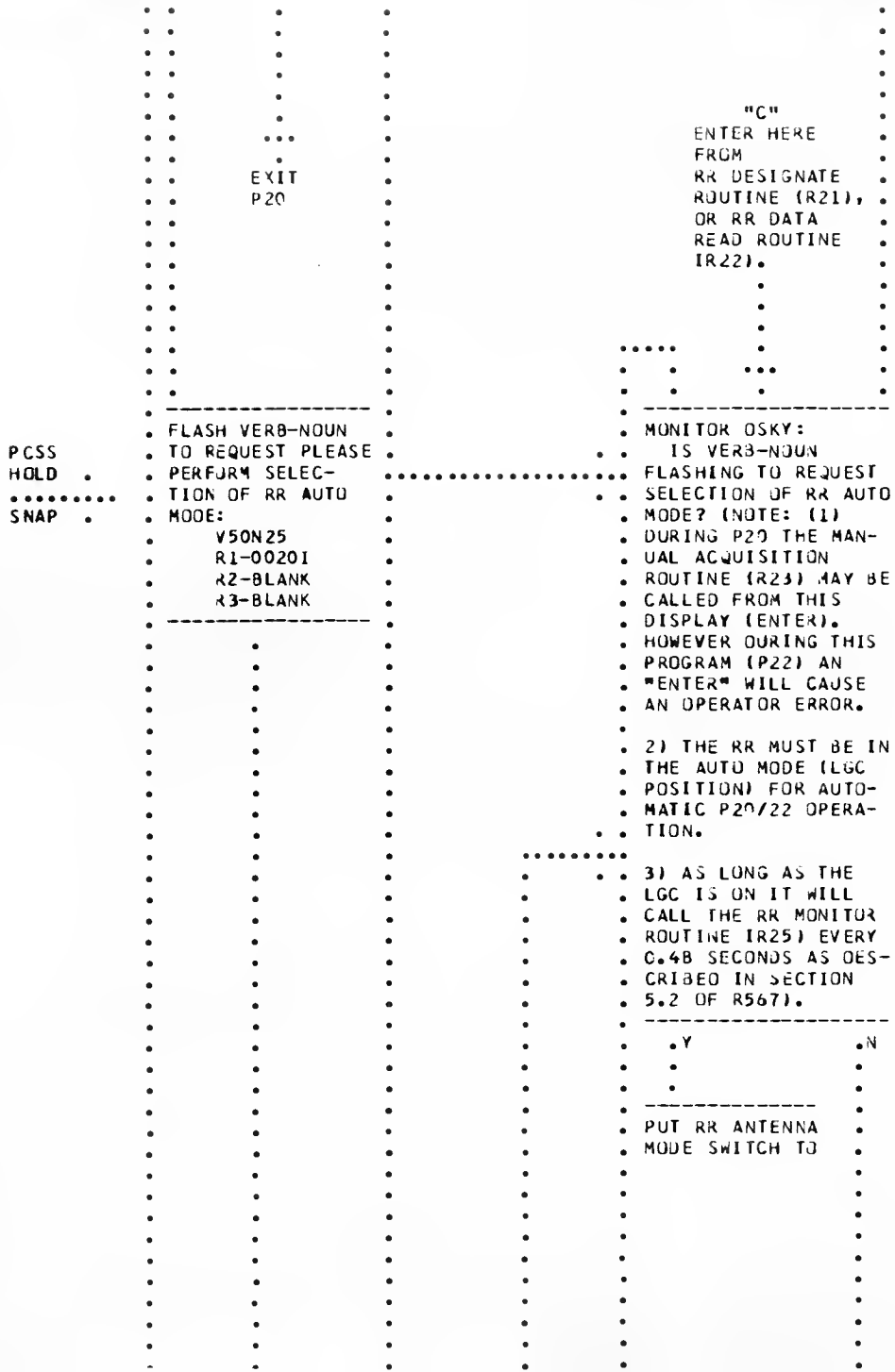
#650

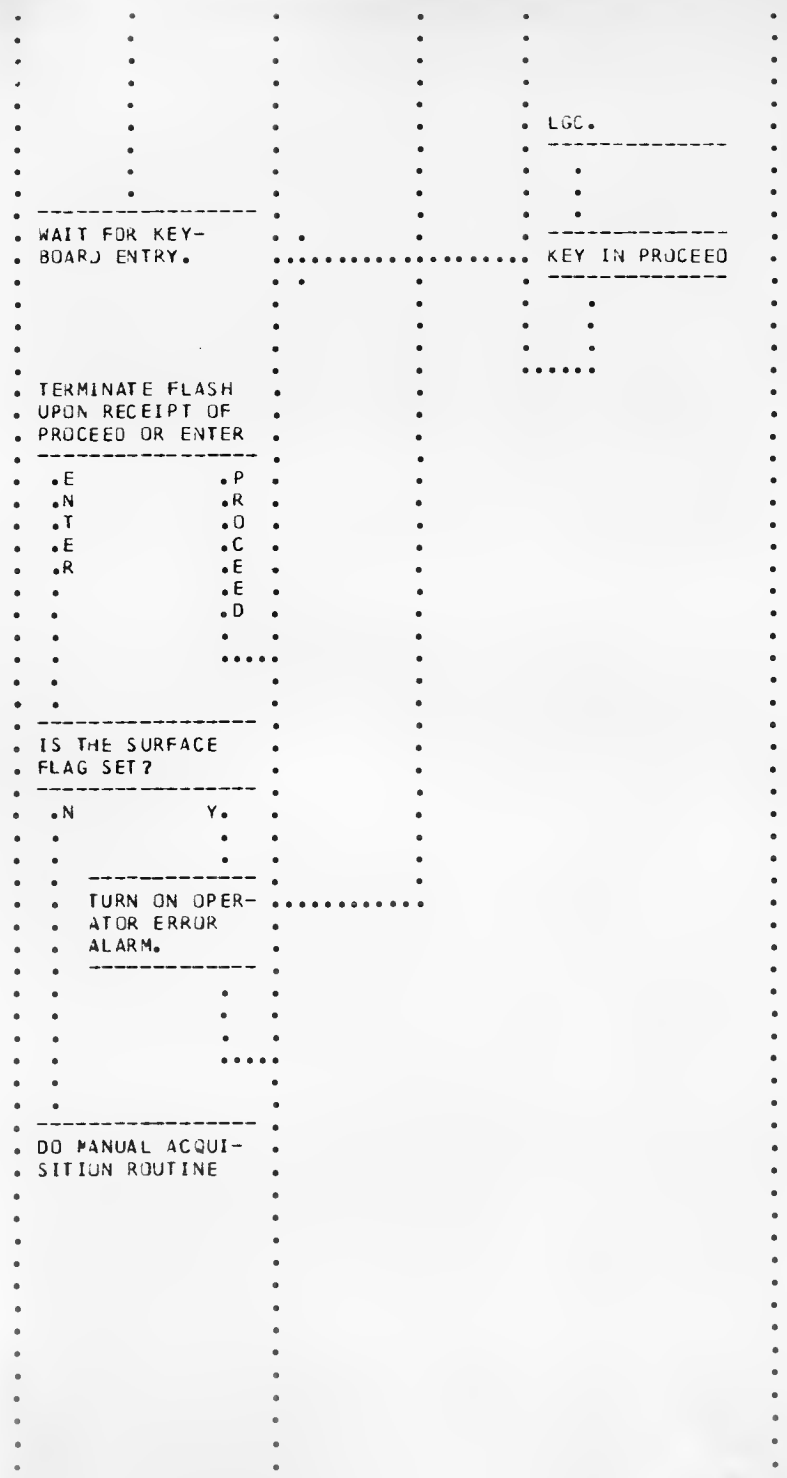
#660

#670

#680




"C"
ENTER HERE
FROM
RR DESIGNATE
ROUTINE (R21),
OR RR DATA
READ ROUTINE
(R22).
EXIT
P20
#690
#700
#710
#720
#730
PCSS
HOLD
SNAP
FLASH VERB-NOUN
TO REQUEST PLEASE
PERFORM SELEC-
TION OF RR AUTO
MODE:
V50N25
R1-00201
R2-BLANK
R3-BLANK
MONITOR OSKY:
IS VERB-NOUN
FLASHING TO REQUEST
SELECTION OF RR AUTO
MODE? (NOTE: (1)
DURING P20 THE MAN-
UAL ACQUISITION
ROUTINE (R23) MAY BE
CALLED FROM THIS
DISPLAY (ENTER).
HOWEVER DURING THIS
PROGRAM (P22) AN
"ENTER" WILL CAUSE
AN OPERATOR ERROR.
2) THE RR MUST BE IN
THE AUTO MODE (LGC
POSITION) FOR AUTO-
MATIC P20/22 OPERA-
TION.
3) AS LONG AS THE
LGC IS ON IT WILL
CALL THE RR MONITOR
ROUTINE (R25) EVERY
0.48 SECONDS AS DES-
CRIBED IN SECTION
5.2 OF R567).
.Y
.N
PUT RR ANTENNA
MODE SWITCH TO



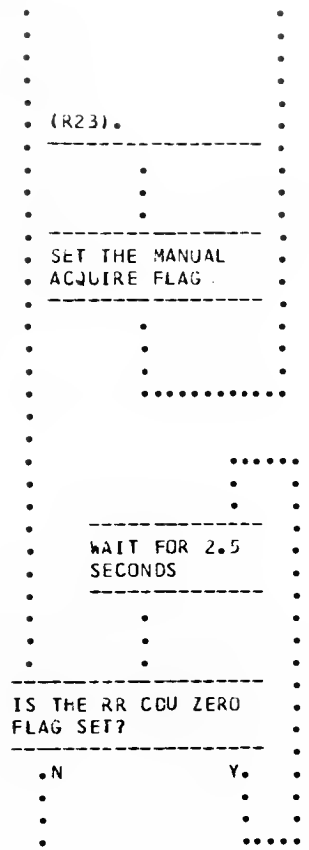
#740

#750

#760

#770

#780



#790

#800

#810

#820

#830

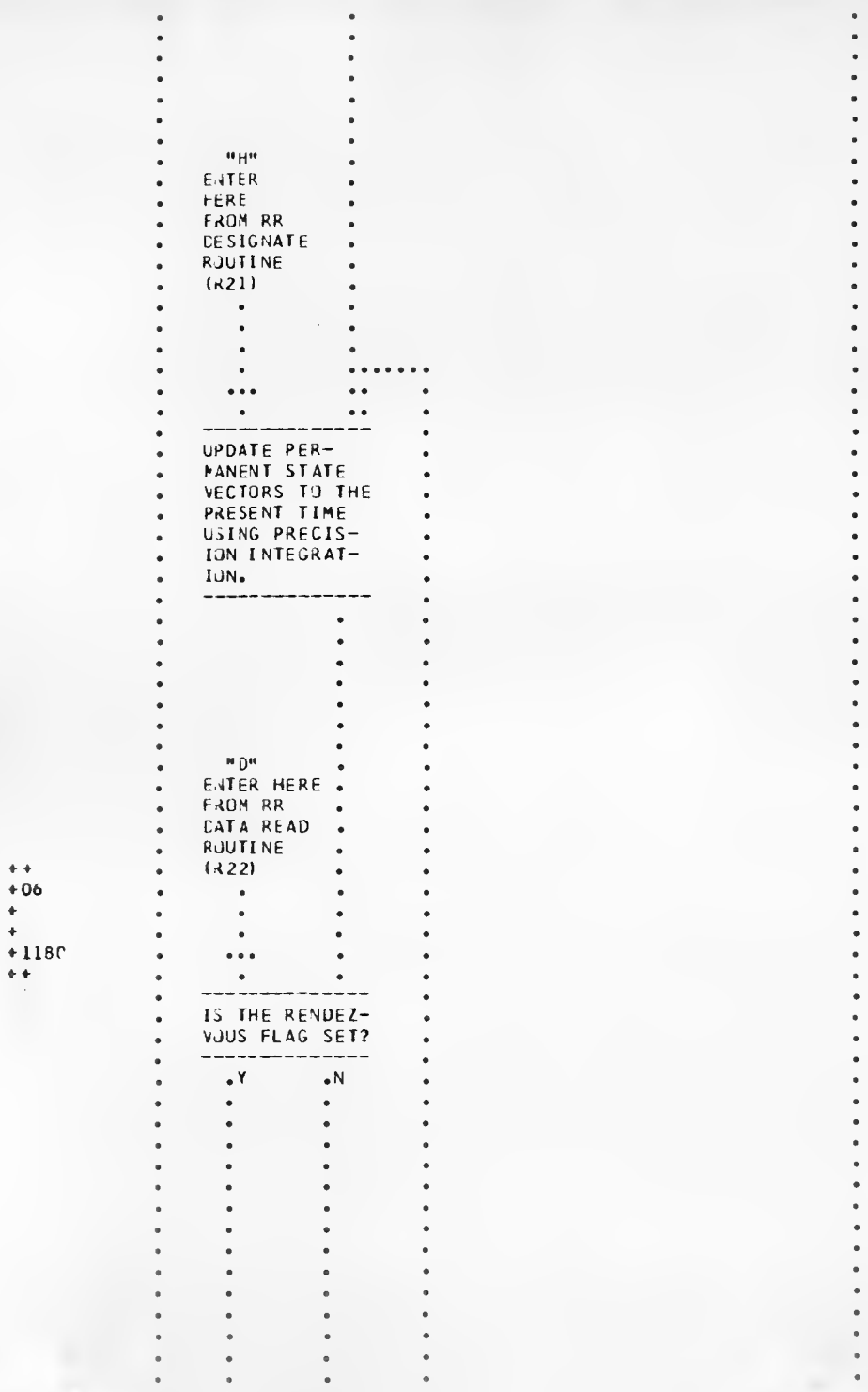
#84C

#85C

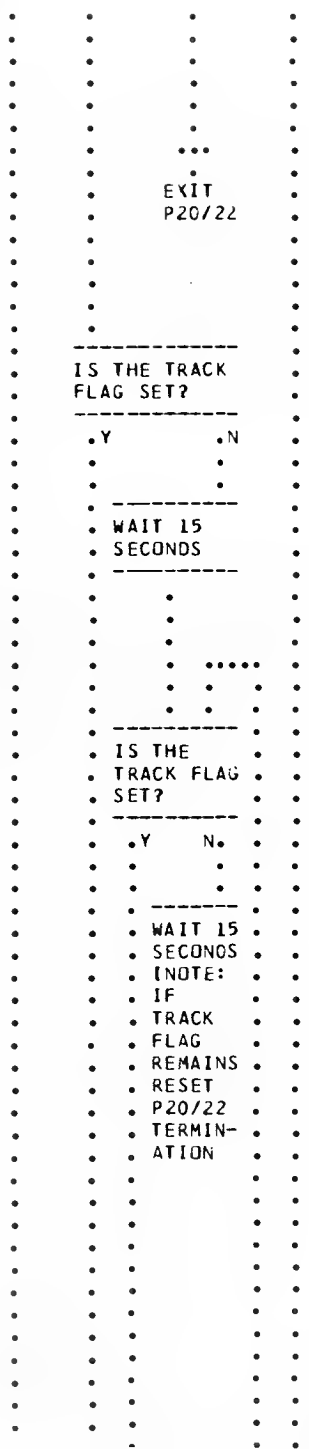
#86C

#87C

#88C



++
+06
+
+
+118C
++



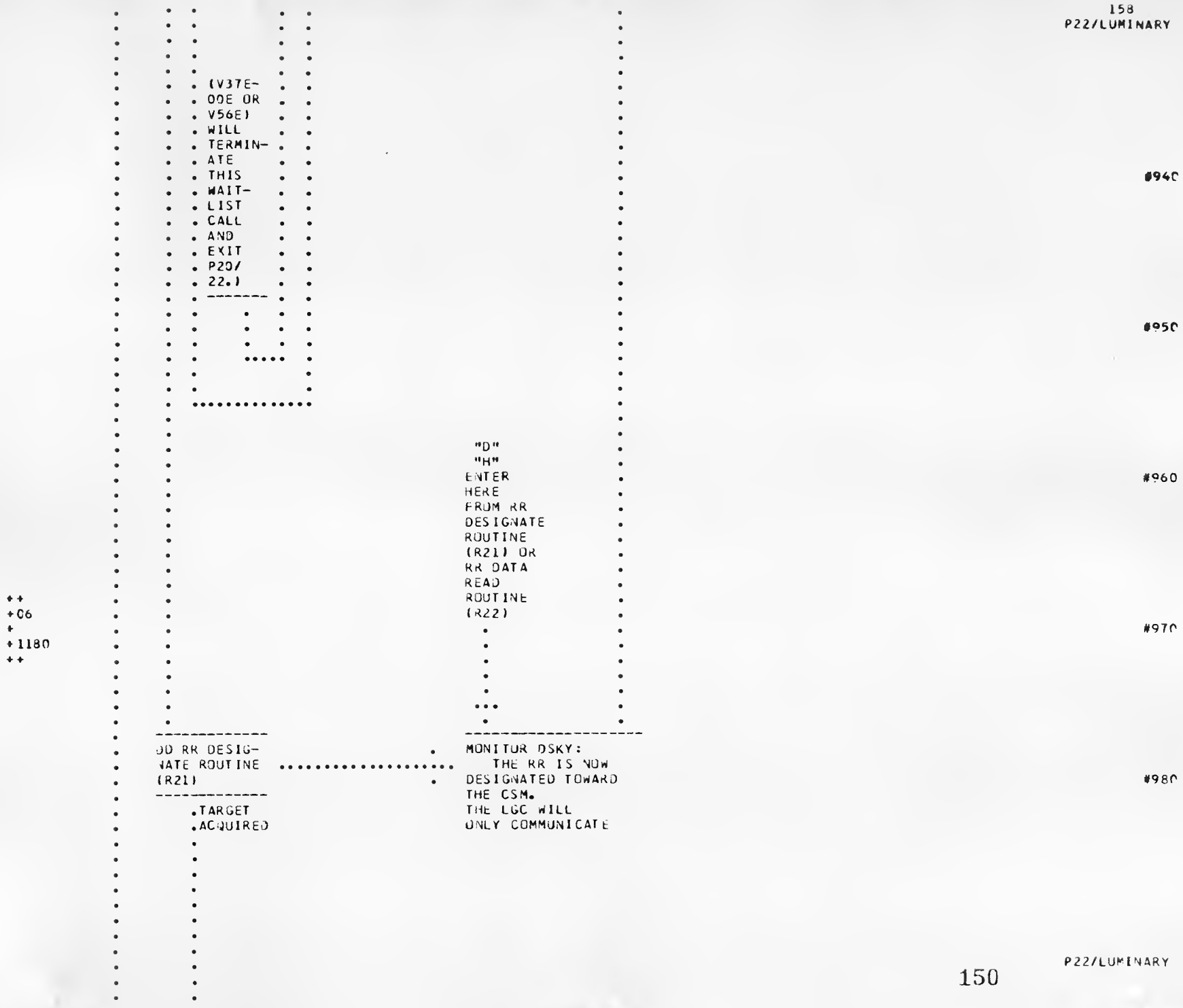
#89C

#90C

#91C

#92C

#93C



#940

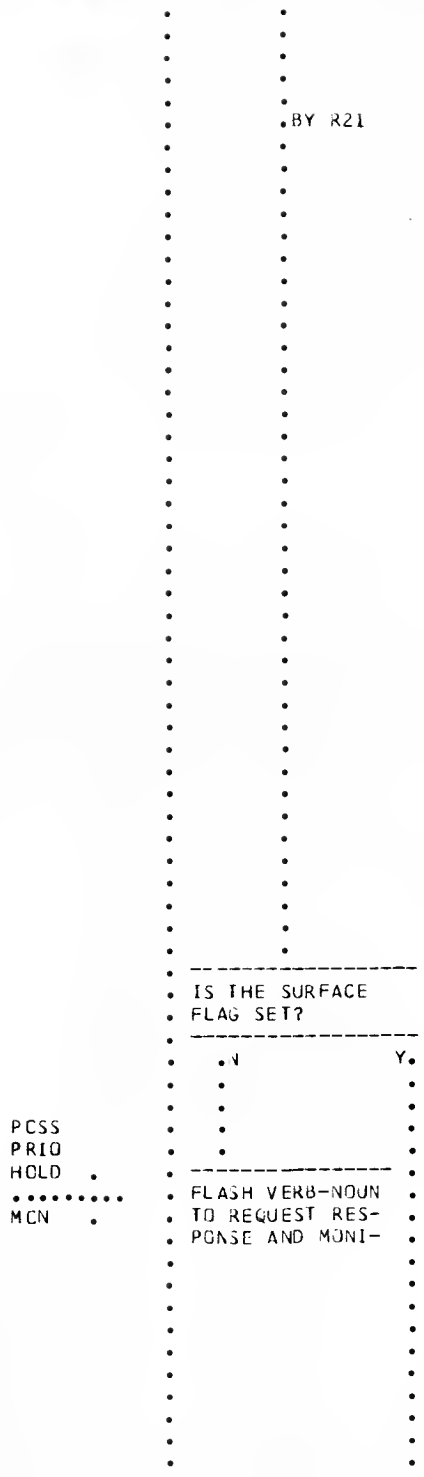
#950

#960

#970

#980

++
+06
+
+1180
++



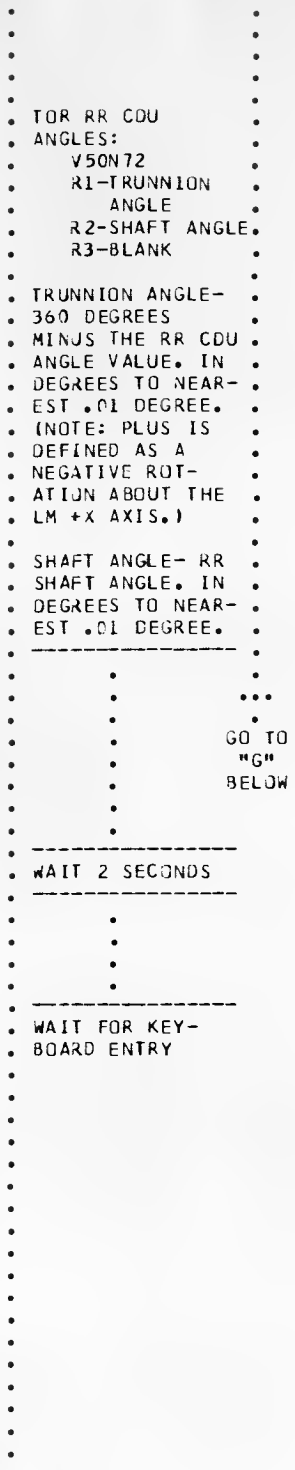
WITH THE ASTRONAUT DURING THIS ROUTINE:

(1) WHEN THE LGC FAILS TO RECEIVE THE DATA GOOD DISCRETE FROM THE RR WITHIN APPROX-IMATELY 45 SEC-ONDS OF THE IN-ITIATION OF A DE-SIGNATE SEQUENCE, THE LGC GRABS THE DISPLAY AND DIS-PLAYS ALARM CODE 00503. #990

(2) WHEN THE LGC CALCULATES THAT THE LOS TO THE CSM IS OUTSIDE THE ALLOWABLE LIMITS FOR THE RR DURING A PRE-DESIGNATE ON THE LUNAR SUR-FACE, THE LGC GRABS THE DISPLAY AND DISPLAYS ALARM CODE 00530. #1000 #1010

#1020

#1030




```
++
+06
+
+118C
++
```

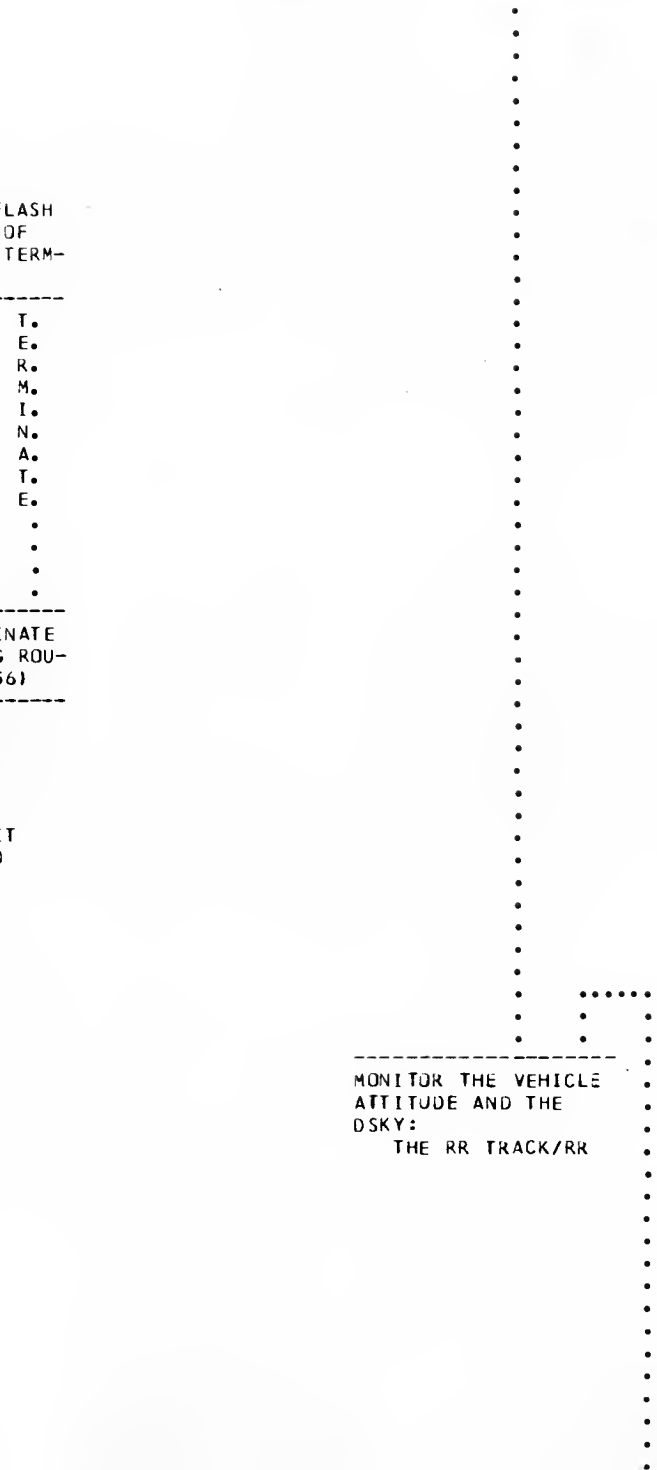
#1040

#1050

#1060

#1070

#1080



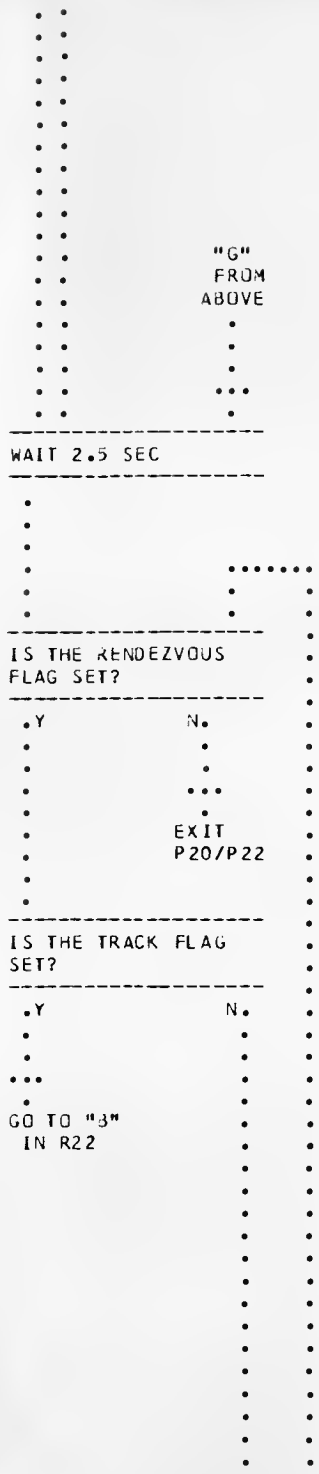
#1090

#1100

#1110

#1120

#1130



MARK/STATE VECTOR UPDATE PROCESS IS NOW AUTOMATIC.

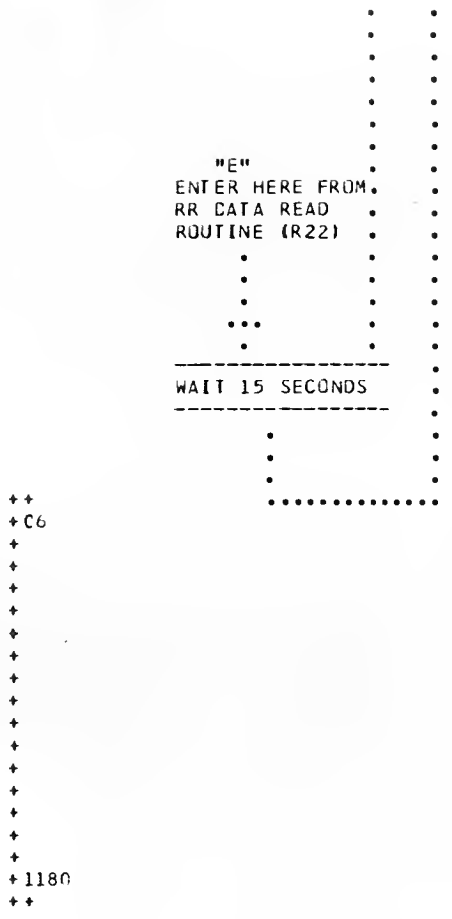
THE LGC WILL ONLY COMMUNICATE WITH THE ASTRONAUT DURING THIS PROGRAM:

(1) WHEN A DSKY ENTRY OF V16N45E IS MADE TO REQUEST A DISPLAY OF THE NUMBER OF MARKS (M), THIS DISPLAY WILL CONTAIN M IN R1. THIS DISPLAY MAY ALSO BE USED TO OBTAIN THE MIDDLE GIMBAL ANGLE WHEN THE IMU IS ON AND THE +X LM AXIS IS ALIGNED WITH THE INITIAL THRUST VECTOR (R3-MGA). IF NO BURN HAS BEEN DEFINED R3 WILL BE MEANINGLESS. THE INFORMATION IN R2 AT THIS TIME IS NOT RELIABLE. CONTROL OF THE DSKY DISPLAY IS RETURNED TO THE LGC BY PUSHING KEY RELEASE. #1140

(2) WHEN THE DATA GOOD DISCRETE LAPSES DURING THE DATA READ ROUTINE (R22), A TRACKER FAIL ALARM RESULTS. NO DISPLAY INTERRUPTION OCCURS. #1150

#1160

#1170



(3) WHEN THE RR AUTO MODE DISCRETE IS NOT PRESENT IMMEDIATELY PRIOR TO A DATA READ SEQUENCE DURING THE DATA READ ROUTINE (R22) THE LGC GRABS THE DISPLAY AND REQUESTS THIS DISCRETE. #1180 #1190

(4) WHEN THE LGC DETERMINES THAT THE ACTUAL RR LOS DIFFERS FROM THE LGC CALCULATED LOS BY MORE THAN 3 DEGREES AFTER A DATA READ SEQUENCE THE LGC GRABS THE DISPLAY AND DISPLAYS AN ALARM CODE (00525). #1200

(5) WHEN THE MAGNITUDE OF A STATE VECTOR CORRECTION IS GREATER THAN THE ALLOWABLE LIMITS (AS DEFINED IN PARAGRAPH 5.2 OF R567) THE LGC GRABS THE DISPLAY AND DISPLAYS THE EXCESSIVE UPDATE PARAMETERS. #1210 #1220

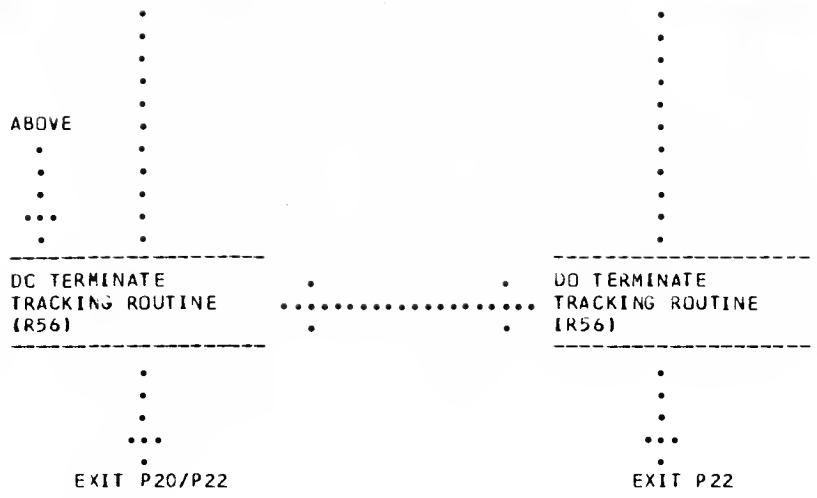
#1230

#1240

#1250

#1260

#1270



#1280

#1290

CHANGE CONTROL NOTES

REV 01 PCR 99,146,173,226,415,451,468,537,541,549,562,614,623
640
REVS 00, 01 (LUM 1A) PCR 646, 757
REV 02 EDITORIAL
REV 03 EDITORIAL
REV 04(LUM 1D) PCR 287,979,1038, PCN 1009
REV 05(LUM 1E) PCN 1145
REV 06(LUM 1E) PCN 1180

PREFERRED TRACKING ATTITUDE PROGRAM (P25) REV 05 12/01/71

PURPOSE: (1) TO COMPUTE THE PREFERRED TRACKING ATTITUDE OF THE LM WHICH ENABLES CSM TRACKING OF THE LM BEACON.

(2) TO PERFORM THE MANEUVER TO THE PREFERRED TRACKING ATTITUDE.

ASSUMPTIONS: (1) DURING THE RENDEZVOUS NAVIGATION PROGRAM (P20) THE LM ATTITUDE CONTROL IS INTIMATELY ASSOCIATED WITH THE RENDEZ-VOUS RADAR (RR). SHOULD RR MALFUNCTION PRECLUDE CORRECT OPERATION OF P20, THIS PROGRAM (P25) SHOULD BE SELECTED TO PROVIDE A LM PREFERRED TRACKING ATTITUDE.

(2) THE PREFERRED TRACKING ATTITUDE IS DEFINED AS FOLLOWS:

(A) THE LM +Z AXIS IS ALIGNED ALONG THE LOS TO THE CSM.

(B) THE ROLL ATTITUDE (ABOUT LM +Z AXIS) IS UNCONSTRAINED AND IS DEFINED AS NECESSARY TO AVOID GIMBAL LOCK.

(3) THE ISS MAY BE IN STANDBY OR OPERATE. THE IMU WOULD NORMALLY BE ON AND THE IMU ORIENTATION DETERMINATION PROGRAM (P51) OR THE LUNAR SURFACE ALIGN PROGRAM (P57) COMPLETED BEFORE THE SELECTION OF THIS PROGRAM. NO PREFERRED ORIENTATION IS SPECIFIED OR REQUIRED FOR THIS PROGRAM AS THE FINE PREFERRED TRACKING ATTITUDE ROUTINE (R65) CAN ALWAYS CALCULATE A VEHICLE ORIENTATION ABOUT A SPECIFIED LM +Z VECTOR THAT CAN AVOID GIMBAL LOCK FOR ANY INERTIAL IMU ORIENTATION.
THE ISS THUS MAY BE:

(A) OFF (STANDBY).

(B) ON, AND NOT ALIGNED SINCE TURN ON.

(C) ON AND AT AN INERTIAL ORIENTATION KNOWN ONLY INACCURATELY BY THE LGC, I.E.: HAVING BEEN ALIGNED AT LEAST ONCE SINCE TURN-ON BUT HAVING DRIFTED FROM THE STORED ALIGNMENT.

(D) ON AND AT AN INERTIAL ORIENTATION KNOWN ACCURATELY BY THE LGC.

IF (A) IS TRUE A PROGRAM ALARM WILL BE MADE BY THIS PROGRAM.
IF (B) IS TRUE A PROGRAM ALARM WILL BE MADE BY THIS PROGRAM.
IF (C) IS TRUE THE LGC MAY OR MAY NOT HAVE A SATISFACTORY INERTIAL REFERENCE TO ACCURATELY COMPLETE THE PROGRAM.
IF (D) IS TRUE THE LGC HAS A SATISFACTORY INERTIAL REFERENCE TO ACCURATELY COMPLETE THE PROGRAM.

(4) THE LM TRACKING BEACON FIELD OF VIEW IS A 30 DEGREE HALF ANGLE CONE WITH THE CONE AXIS PARALLEL TO THE LM +Z AXIS.

(5) THE SELECTION AND TERMINATION OF P20, P22, AND P25 ARE SUBJECT TO SPECIAL OPERATING PROCEDURES DIFFERENT FROM ALL OTHER PROGRAMS;

(A) SELECTION

(1) ALWAYS BY V37EXXE.

(2) IF ANY OTHER PROGRAM IS RUNNING AT THE TIME OF P20/22/25 SELECTION THE NEW PROGRAM WILL REPLACE THE OLD. THIS INCLUDES P20/22/25 SELECTION WHENEVER EITHER P20,22, OR 25 IS RUNNING.

(3) IF P20 OR P25 IS RUNNING, SELECTION OF ANY PROGRAM OTHER THAN P00, P22, OR P25 WILL RESULT IN P20 OR P25 CONTINUING AND THE NEW PROGRAM ALSO OPERATING WITH ITS NUMBER IN THE DSKY PROG LIGHTS.

(4) IF P20 OR P25 IS RUNNING, SELECTION OF P00, P22, OR P25 WILL RESULT IN THE TERMINATION OF THE OLD PROGRAM AND OPERATION OF THE NEW.

(B) TERMINATION

(1) BY SELECTION OF P00, V56E OR BY V34E.

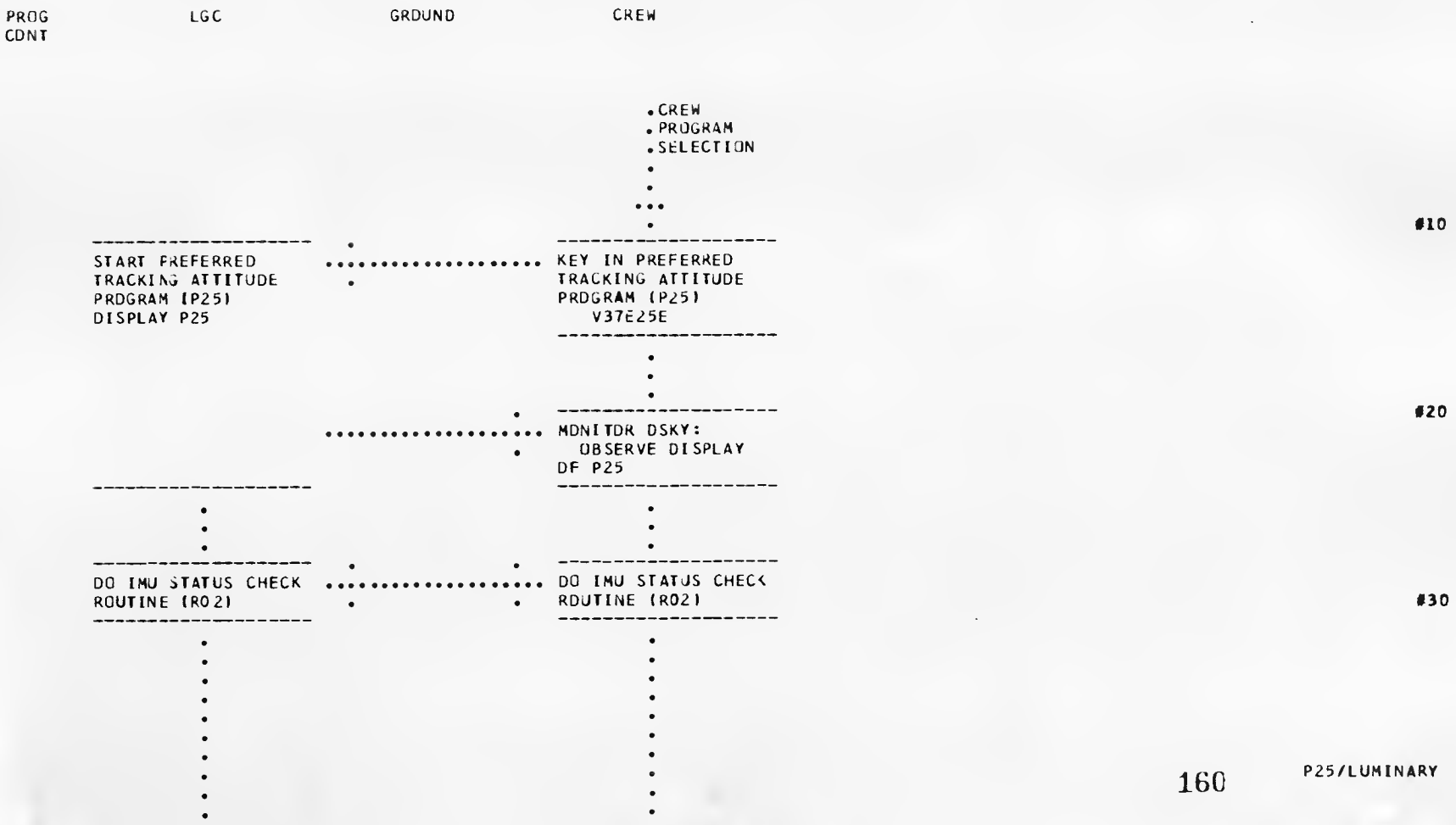
(2) P00 SELECTION WILL TERMINATE P20,22, AND 25 AND ANY OTHER PROGRAM IN PROCESS AND ESTABLISH P00.

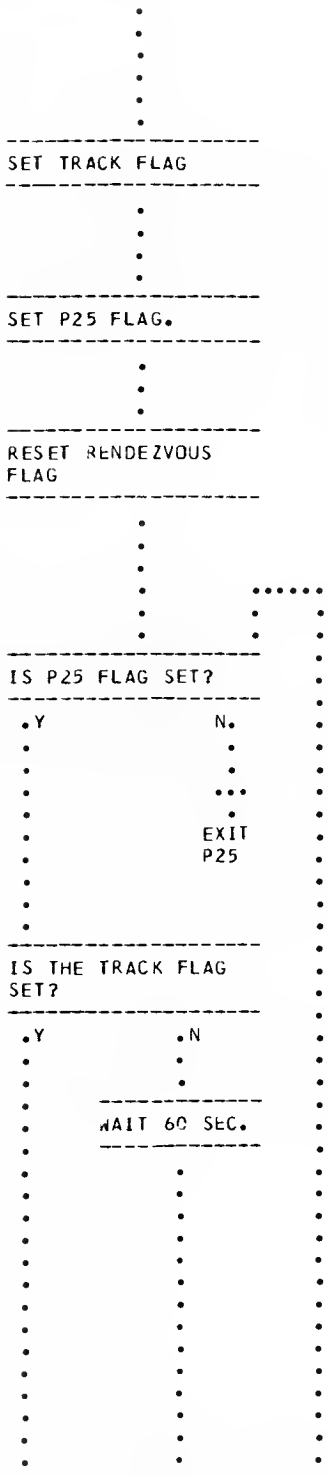
(3) V56E SELECTION WILL SELECT THE TERMINATE TRACKING ROUTINE (R56) WHICH WILL TERMINATE ONLY P20 OR P25 IF EITHER OF THESE PROGRAMS IS RUNNING IN CONJUNCTION WITH ANOTHER PROGRAM. IN ALL OTHER CASES R56 WILL SELECT R00. V56E MAY BE PERFORMED ANY TIME DURING P20,22, OR 25 OPERATION.

++
+C5
+
+1180
++

(4) THE LGC WILL ACT UPON V34E ONLY IN RESPONSE TO A FLASHING VERB-NOUN. IF THIS DISPLAY WAS ORIGINATED BY P20,22, OR 25, V34E WILL RESULT IN AN IDENTICAL LGC RESPONSE TO THAT OF V56E, THAT IS, SELECTION OF R56 EXCEPT IN THE CASE OF A V06 N49 DISPLAY. IF THIS DISPLAY WAS NOT ORIGINATED BY P20,22, OR 25 (SUCH AS P32, WHILE RUNNING WITH P20) THE LGC WILL GO TO R00. HOWEVER THE PROGRAM IN THE BACKGROUND WILL CONTINUE. THE NEW PROGRAM SELECTED FOLLOWS THE SELECTION RULES ABOVE, (A).

(5) ALTHOUGH IT IS NOT CLEARLY SHOWN IN THE LOGIC BELOW A V34E RESPONSE TO A PRIORITY DISPLAY MUST BE DELAYED 2 SECONDS FROM DISPLAY INITIATION WHEREAS THE DELAY IS NOT NECESSARY FOR A V56E RESPONSE.




SET TRACK FLAG
SET P25 FLAG.
RESET RENDEZVOUS FLAG
IS P25 FLAG SET?
.Y
N.
EXIT P25
IS THE TRACK FLAG SET?
.Y
.N
WAIT 60 SEC.

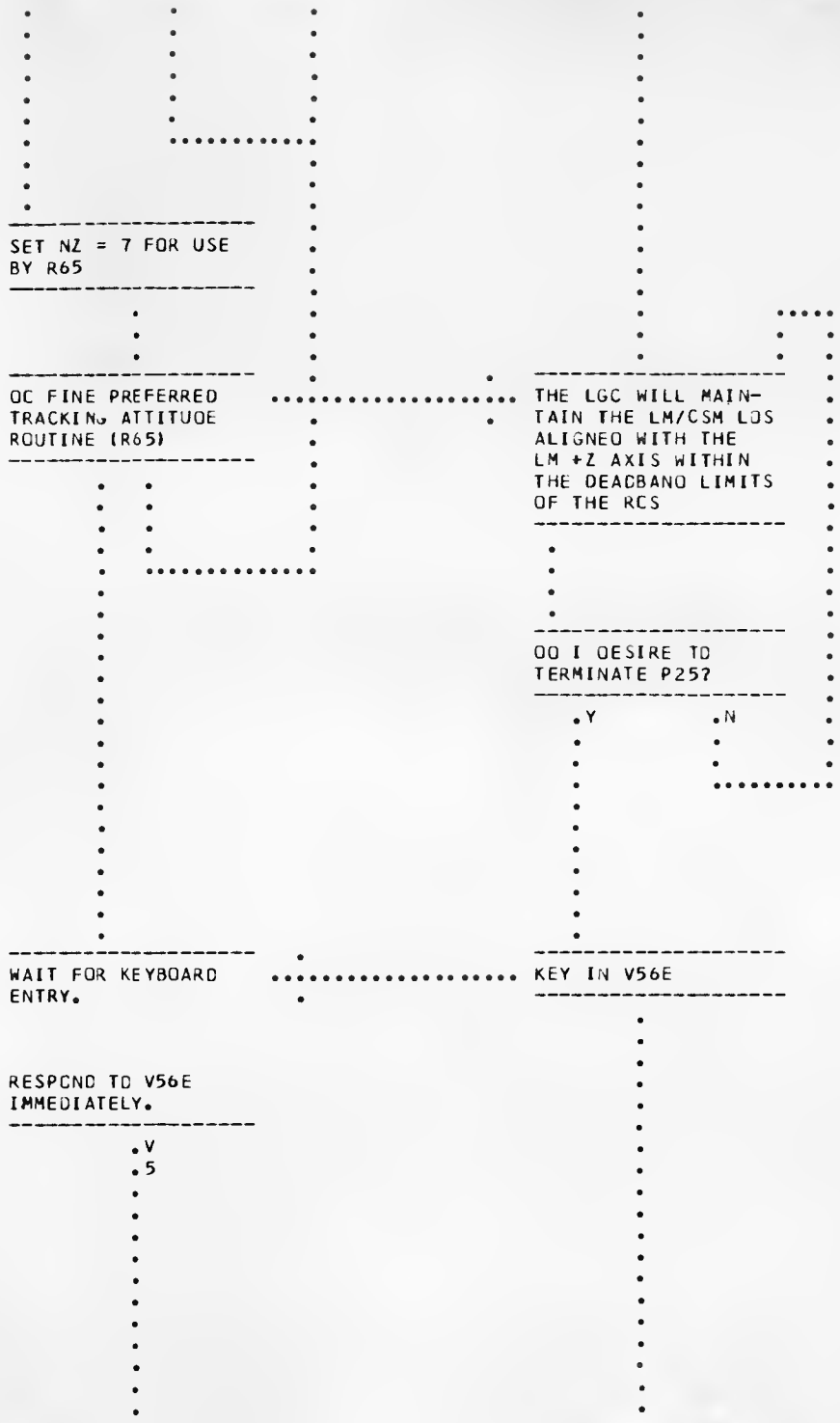
#40

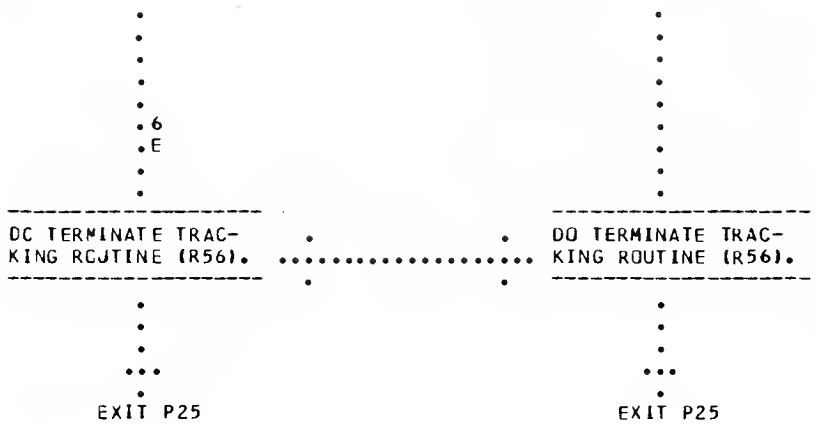
#50

#60

#70

#80


SET NZ = 7 FOR USE BY R65
#90
OC FINE PREFERRED TRACKING ATTITUDE ROUTINE (R65)
THE LGC WILL MAINTAIN THE LM/CSM LOS ALIGNED WITH THE LM +Z AXIS WITHIN THE DEADBAND LIMITS OF THE RCS
#100
DO I DESIRE TO TERMINATE P25?
#110
Y
N
#120
WAIT FOR KEYBOARD ENTRY.
KEY IN V56E
RESPOND TO V56E IMMEDIATELY.
#130
V
5



#140

CHANGE CONTROL NOTES

REV 00 PCR 39
REV 01 PCR 451,562
REV 02 EDITORIAL
REV 03 EDITORIAL
REV 04 PCN 1009
REV 05 PCN 1180

LGC UPDATE PROGRAM (P27) REV 16 12/01/71

PURPOSE: (1) TO INSERT INFORMATION INTO THE LGC VIA THE DIGITAL UPLINK BY TRANSMISSION FROM THE GROUND OR VIA THE DSKY KEYBOARD BY CREW MANUAL INPUT.

ASSUMPTIONS: (1) THE LGC MUST BE IN THE OPERATE CONDITION. THE ISS MAY BE IN STANDBY OR OPERATE CONDITION.

(2) LGC UPDATES ARE OF FOUR CATEGORIES:

(A) PROVIDE AN UPDATE FOR LGC LIFTOFF TIME (V70).

(B) PROVIDE LOAD CAPABILITY FOR A BLOCK OF SEQUENTIAL ERASABLE LOCATIONS (1-18 INCLUSIVE LOCATIONS WHOSE ADDRESS IS SPECIFIED) (V71).

(C) PROVIDE LOAD CAPABILITY FOR 1-9 INCLUSIVE INDIVIDUALLY SPECIFIED ERASABLE LOCATIONS (V72).

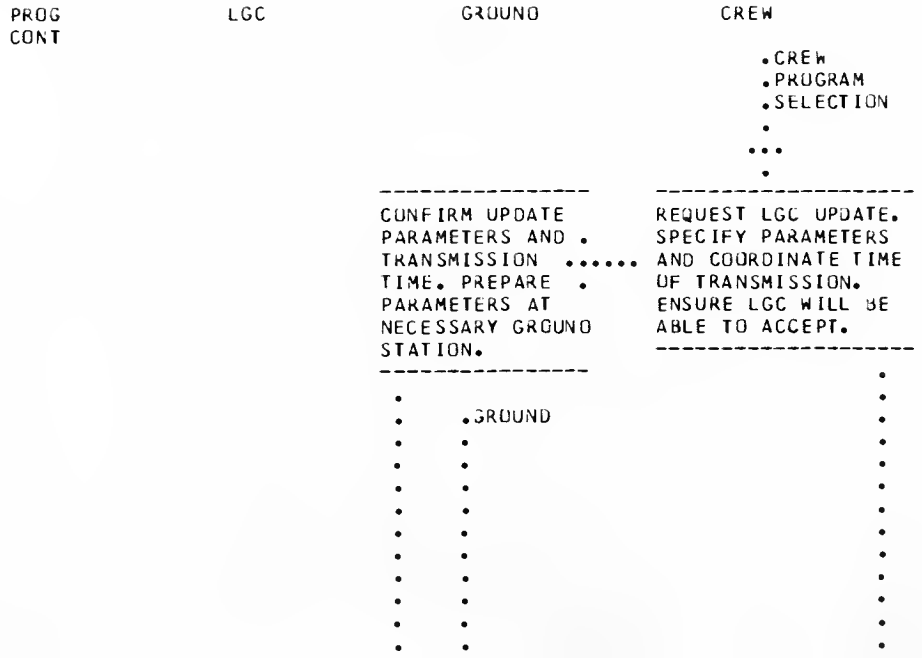
(D) PROVIDE AN OCTAL INCREMENT FOR THE LGC CLOCK ONLY (V73).

(3) A COMPLETE DESCRIPTION OF THE LGC UPLINK FORMAT IS INCLUDED IN SECTION 2 OF R567.

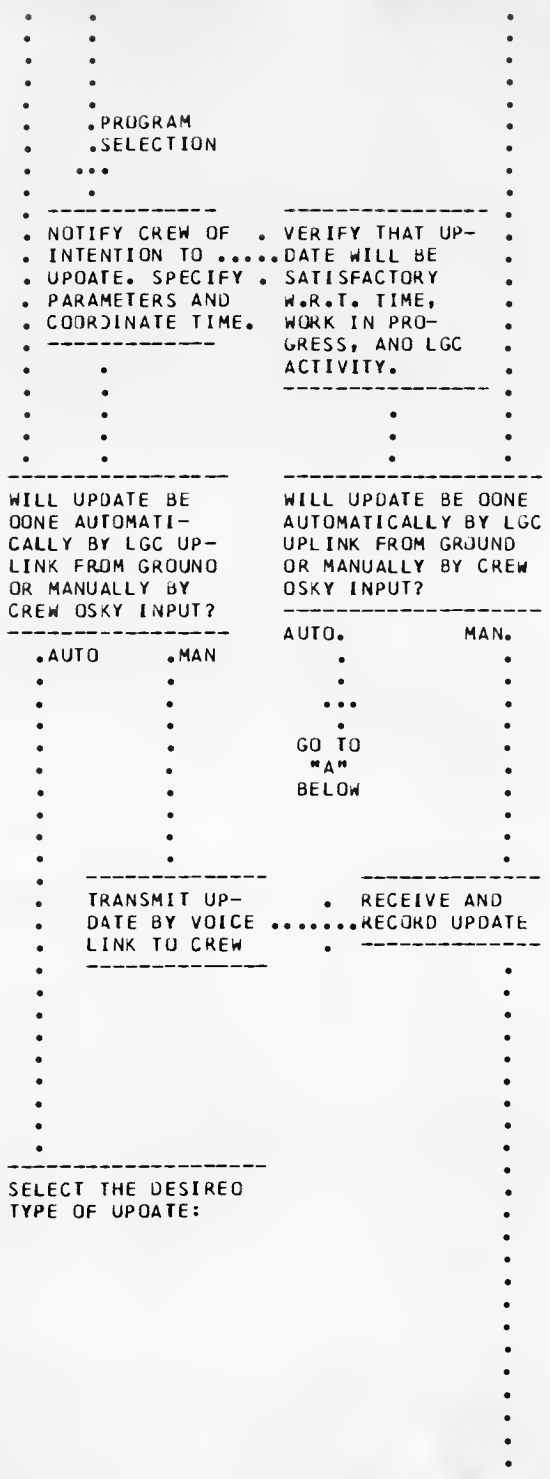
(4) THE UPLINK MAY BE BLOCKED BY PLACING THE VOICE/CFF/VOICE BU SWITCH TO VOICE BU.

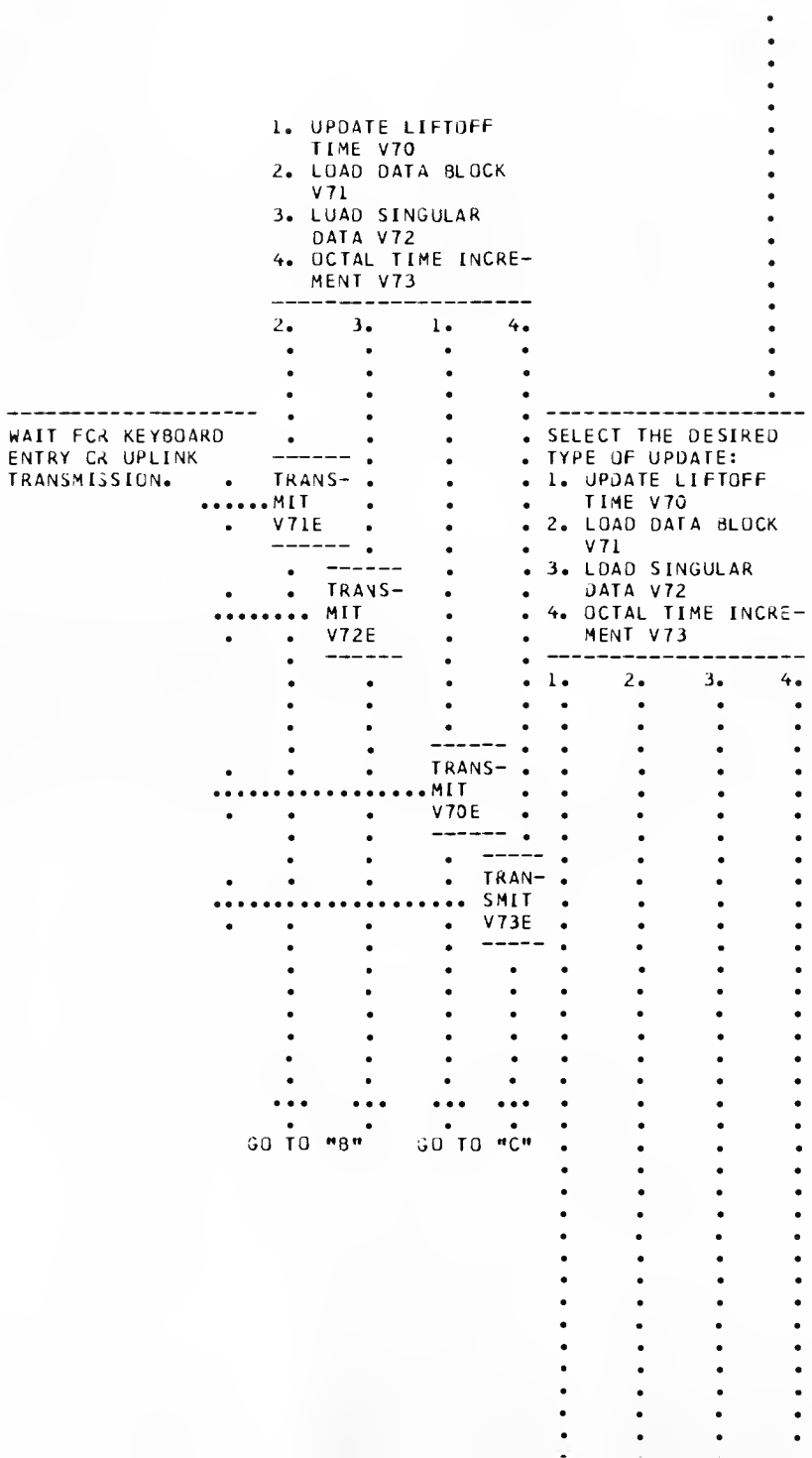
(5) UPDATE IS ALLOWED IN THE LM ONLY WHEN THE LGC IS IN THE LGC IDLING PROGRAM (P00). P27 EXIT IS ALWAYS TO P00.

(6) THE PROGRAM IS MANUALLY SELECTED BY THE ASTRONAUT BY DSKY ENTRY OR BY THE GROUND BY UPLINK TRANSMISSION.



#10


PROGRAM SELECTION
#20
NOTIFY CREW OF INTENTION TO UPDATE. SPECIFY PARAMETERS AND COORDINATE TIME.
VERIFY THAT UPDATE WILL BE SATISFACTORY W.R.T. TIME, WORK IN PROGRESS, AND LGC ACTIVITY.
#30
WILL UPDATE BE DONE AUTOMATICALLY BY LGC UPLINK FROM GROUND OR MANUALLY BY CREW OSKY INPUT?
WILL UPDATE BE DONE AUTOMATICALLY BY LGC UPLINK FROM GROUND OR MANUALLY BY CREW OSKY INPUT?
#40
AUTO.
MAN.
AUTO
MAN
GO TO "A" BELOW
#50
TRANSMIT UPDATE BY VOICE LINK TO CREW
RECEIVE AND RECORD UPDATE
#60
SELECT THE DESIRED TYPE OF UPDATE:



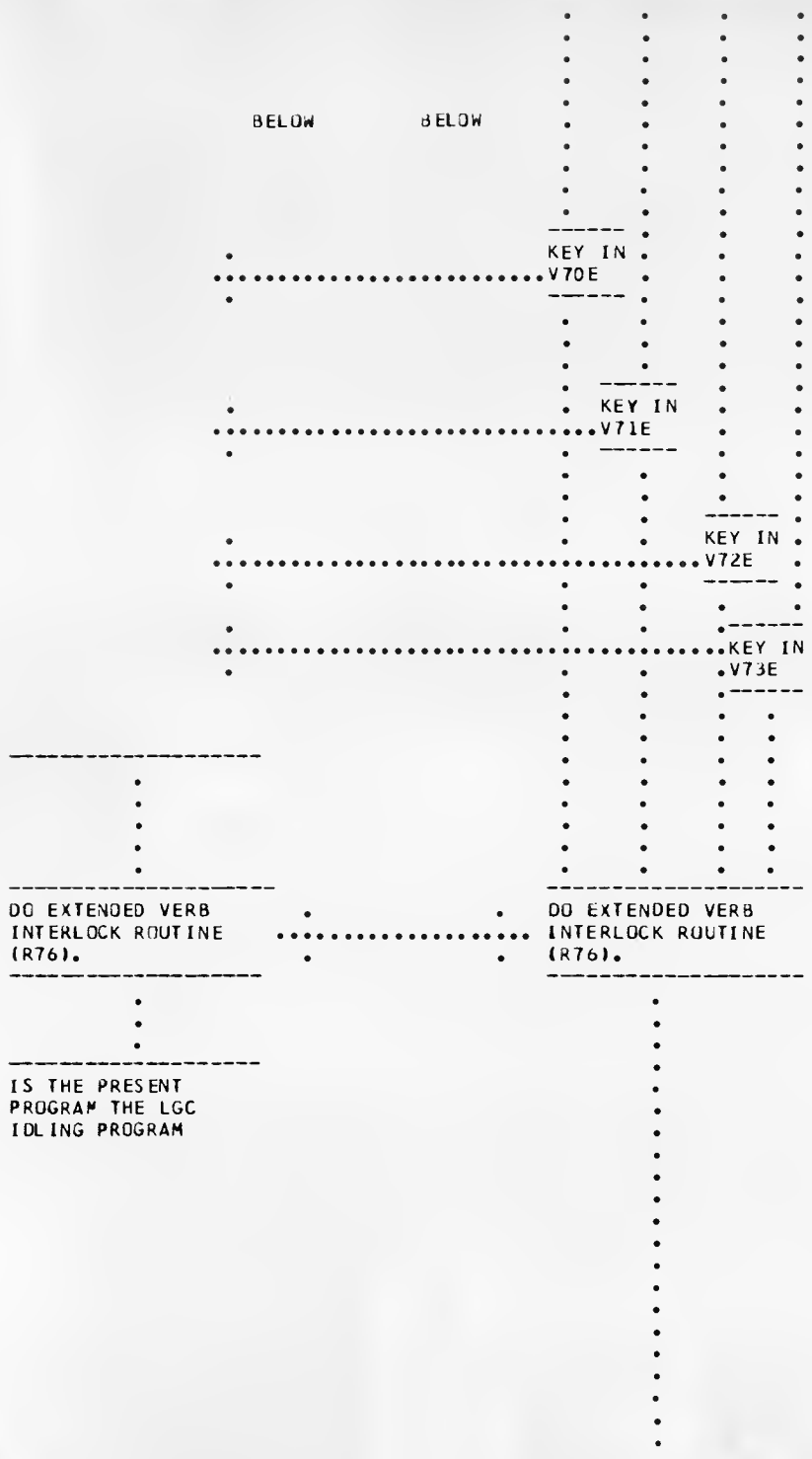
#70

#80

#90

#100

#110



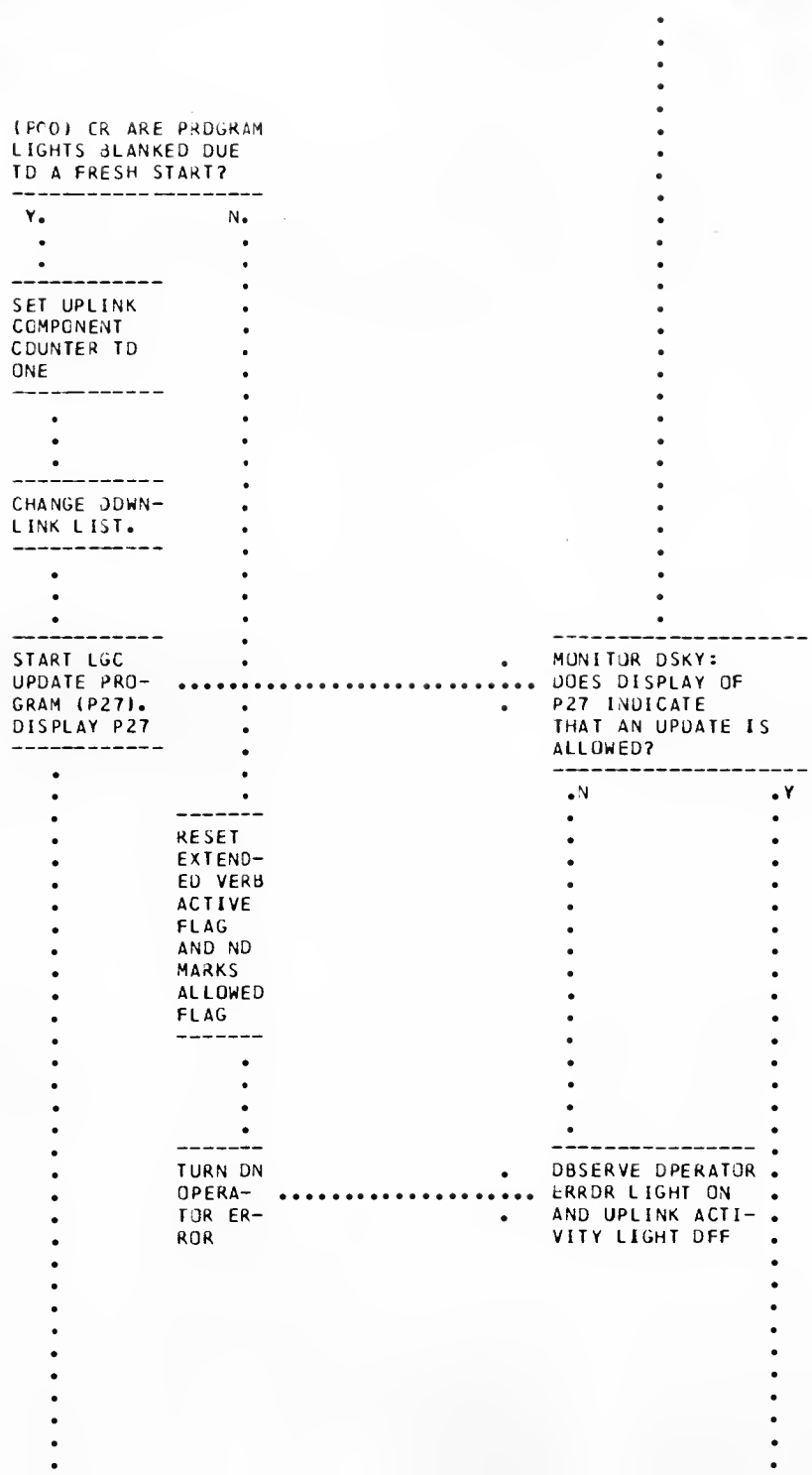
#120

#130

#140

#150

#160



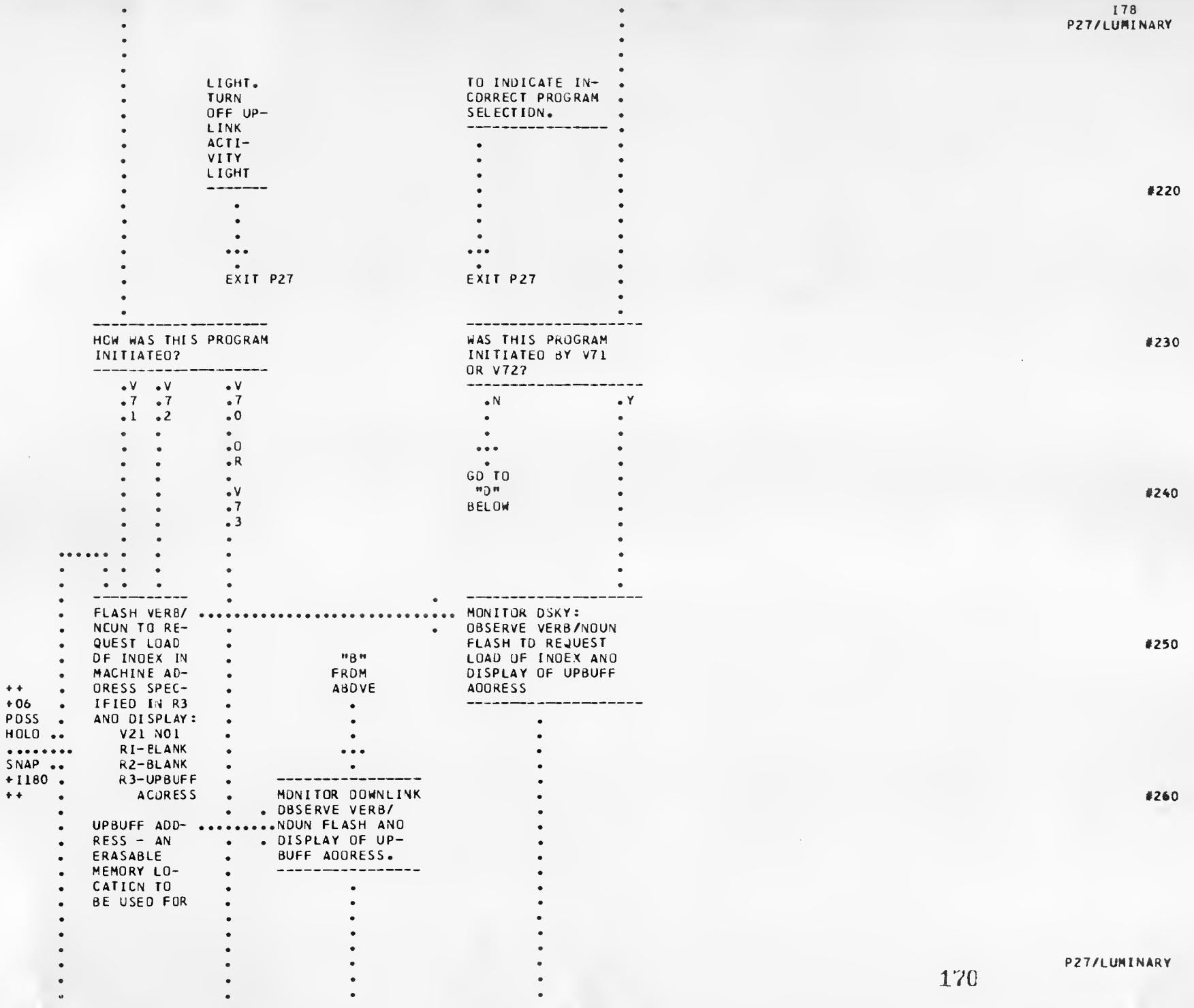
#170

#180

#190

#200

#210



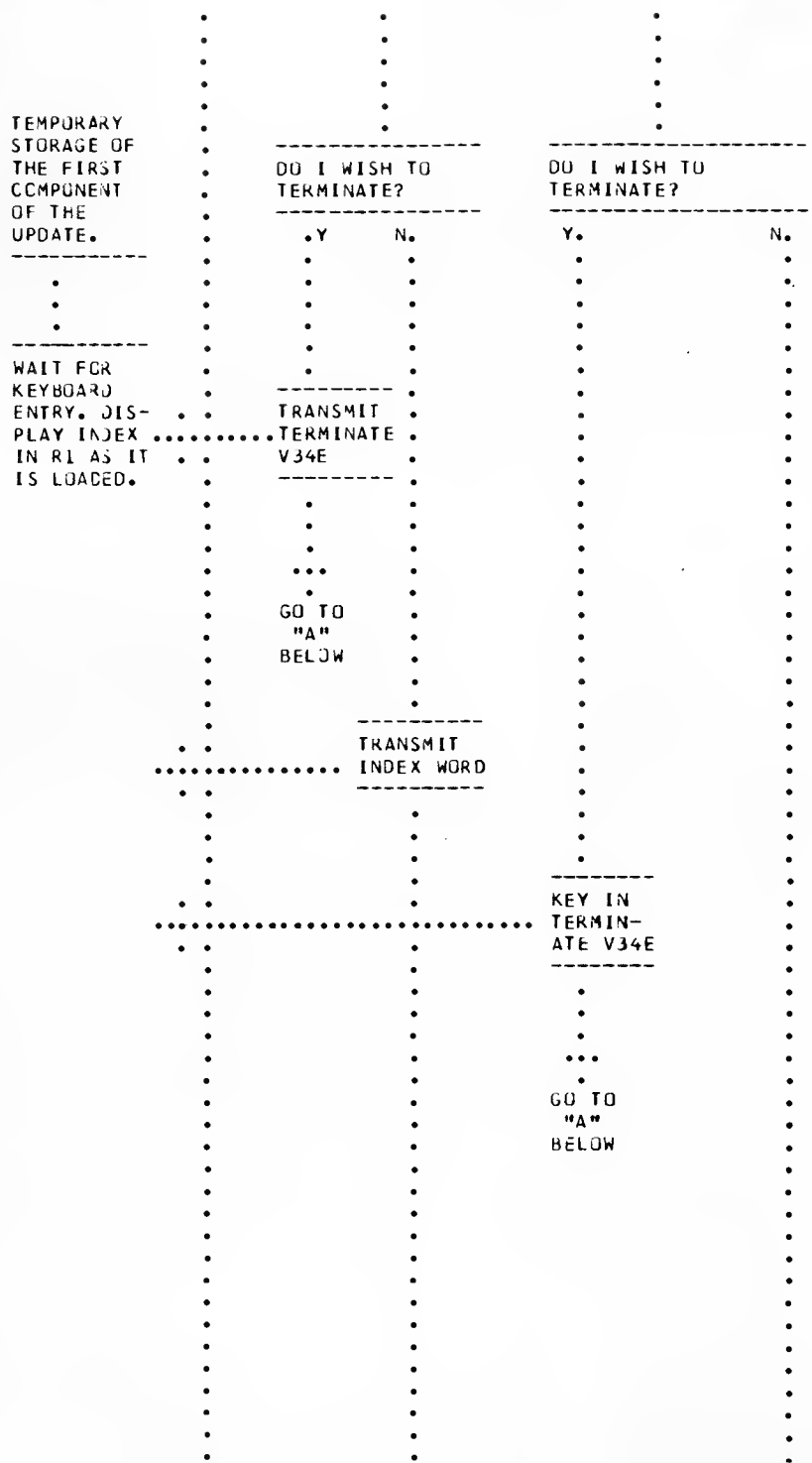
#220

#230

#240

#250

#260



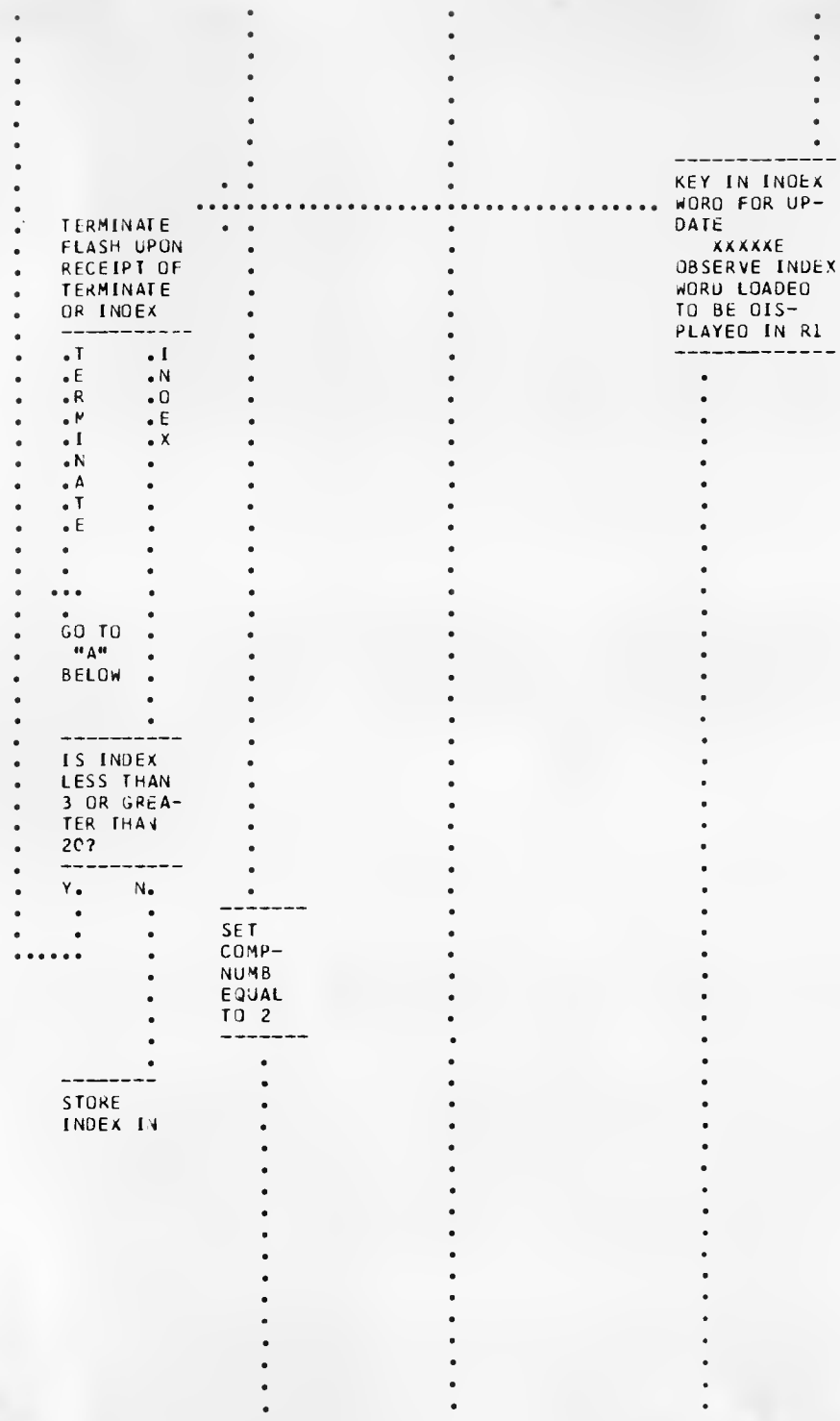
#270

#280

#290

#300

#310



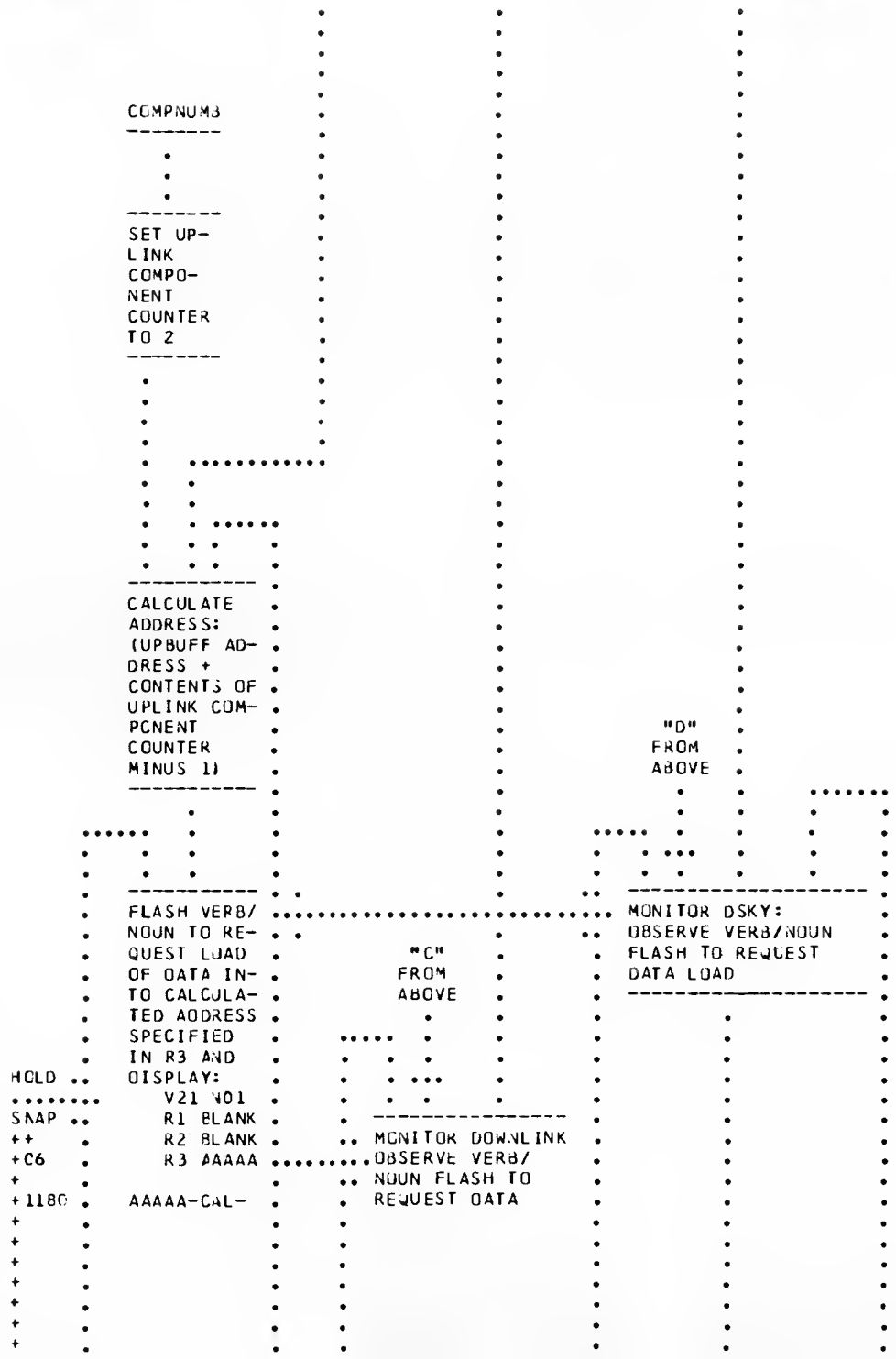
#320

#330

#340

#350

#360



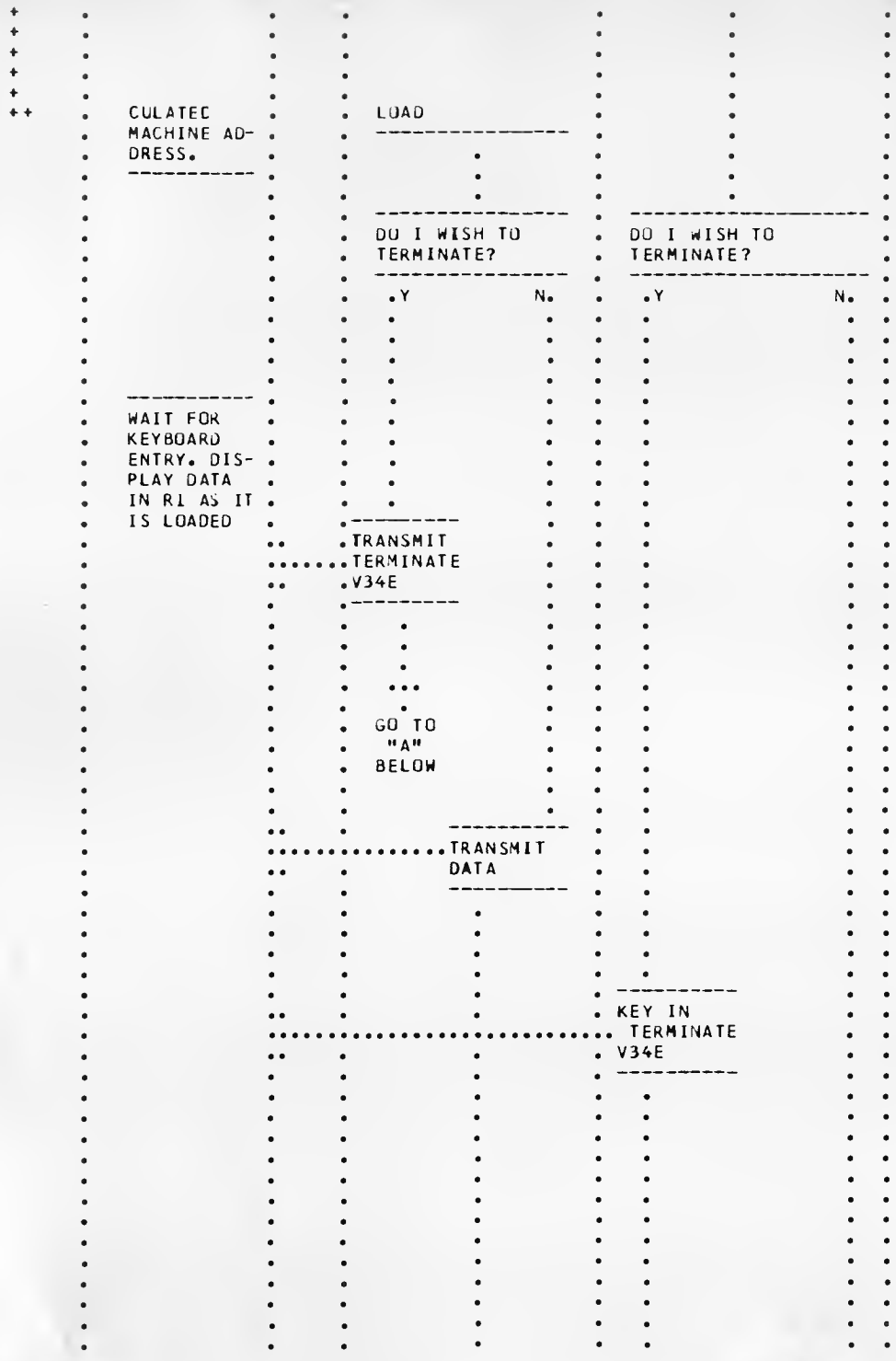
#370

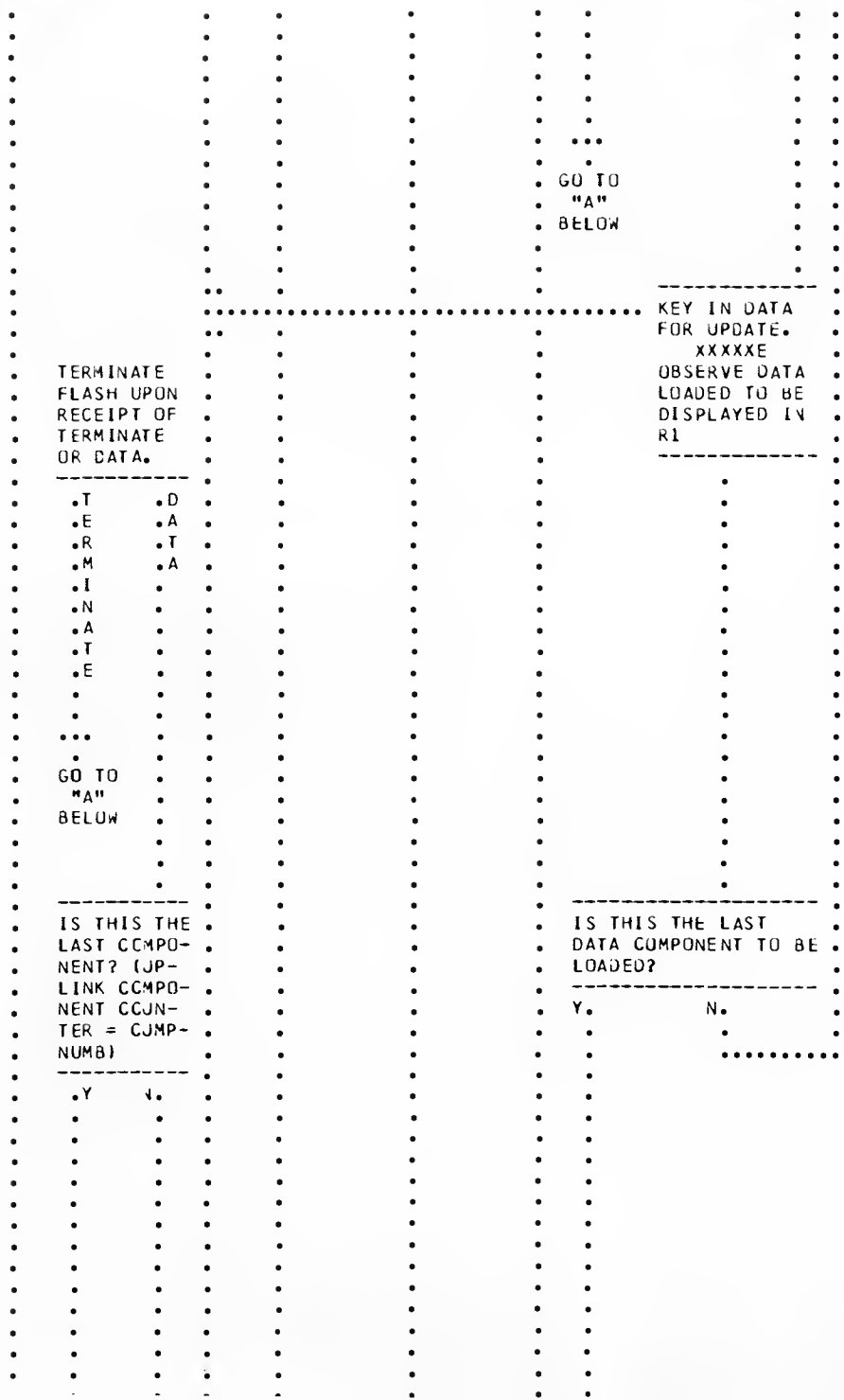
#380

#390

#400

#410


CULATED MACHINE ADDRESS.
LOAD
DO I WISH TO TERMINATE?
Y
N.
DO I WISH TO TERMINATE?
Y
N.
#420
#430
WAIT FOR KEYBOARD ENTRY. DISPLAY DATA IN R1 AS IT IS LOADED
TRANSMIT TERMINATE V34E
#440
GO TO "A" BELOW
#450
TRANSMIT DATA
#460
KEY IN TERMINATE V34E



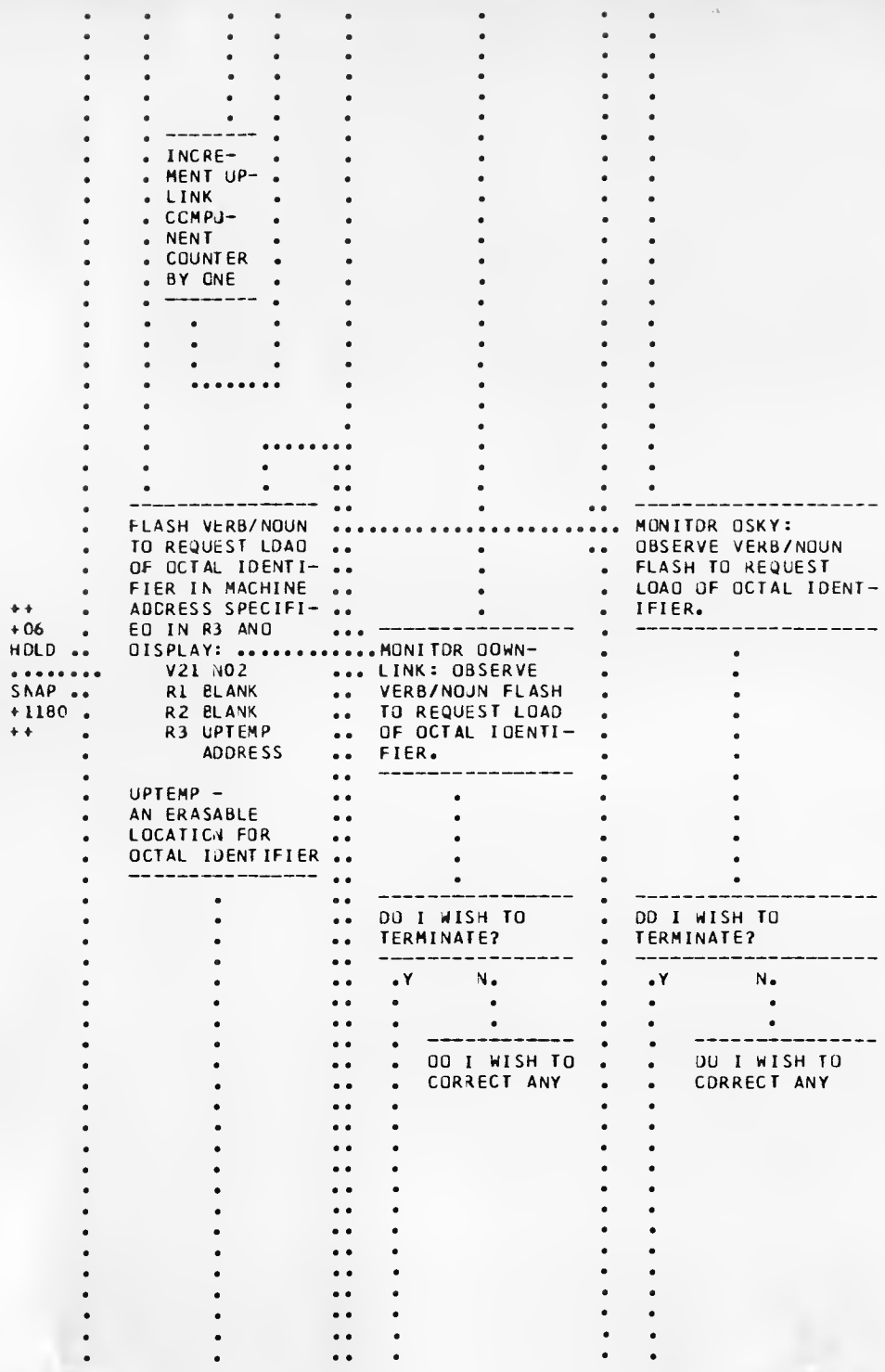
#470

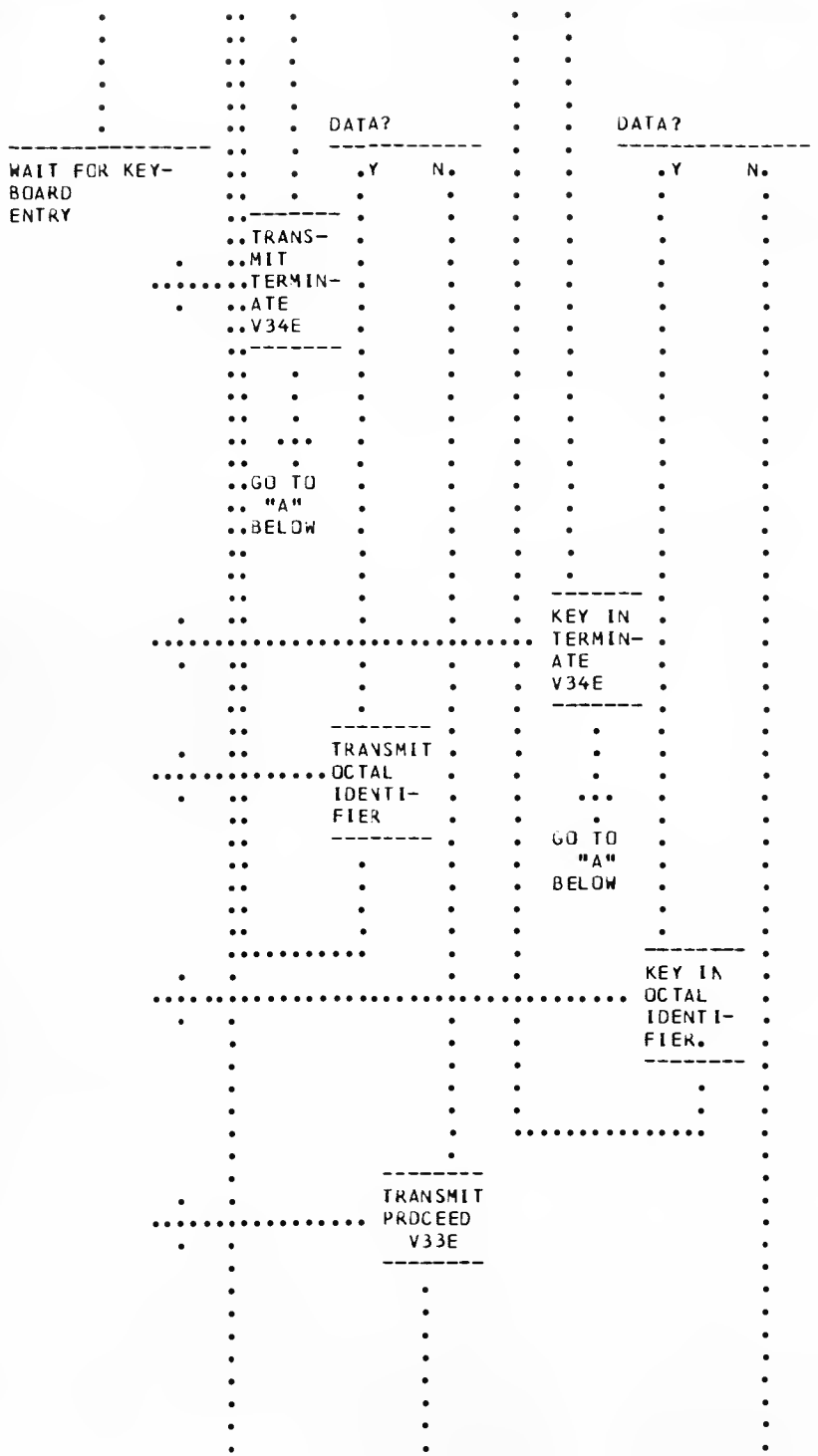
#480

#490

#500

#510


INCRE-
MENT UP-
LINK
COMPU-
NENT
COUNTER
BY ONE
FLASH VERB/NOUN
TO REQUEST LOAD
OF OCTAL IDENTI-
FIER IN MACHINE
ADDRESS SPECIFI-
ED IN R3 AND
DISPLAY:
V21 N02
R1 BLANK
R2 BLANK
R3 UPTEMP
ADDRESS
UPTEMP -
AN ERASABLE
LOCATION FOR
OCTAL IDENTIFIER
MONITOR DOWN-
LINK: OBSERVE
VERB/NOUN FLASH
TO REQUEST LOAD
OF OCTAL IDENTI-
FIER.
DO I WISH TO
TERMINATE?
.Y
N.
DO I WISH TO
CORRECT ANY
MONITOR OSKY:
OBSERVE VERB/NOUN
FLASH TO REQUEST
LOAD OF OCTAL IDENT-
IFIER.
DO I WISH TO
TERMINATE?
.Y
N.
DO I WISH TO
CORRECT ANY
++
+06
HOLD
SNAP
+1180
++
#520
#530
#540
#550
#560



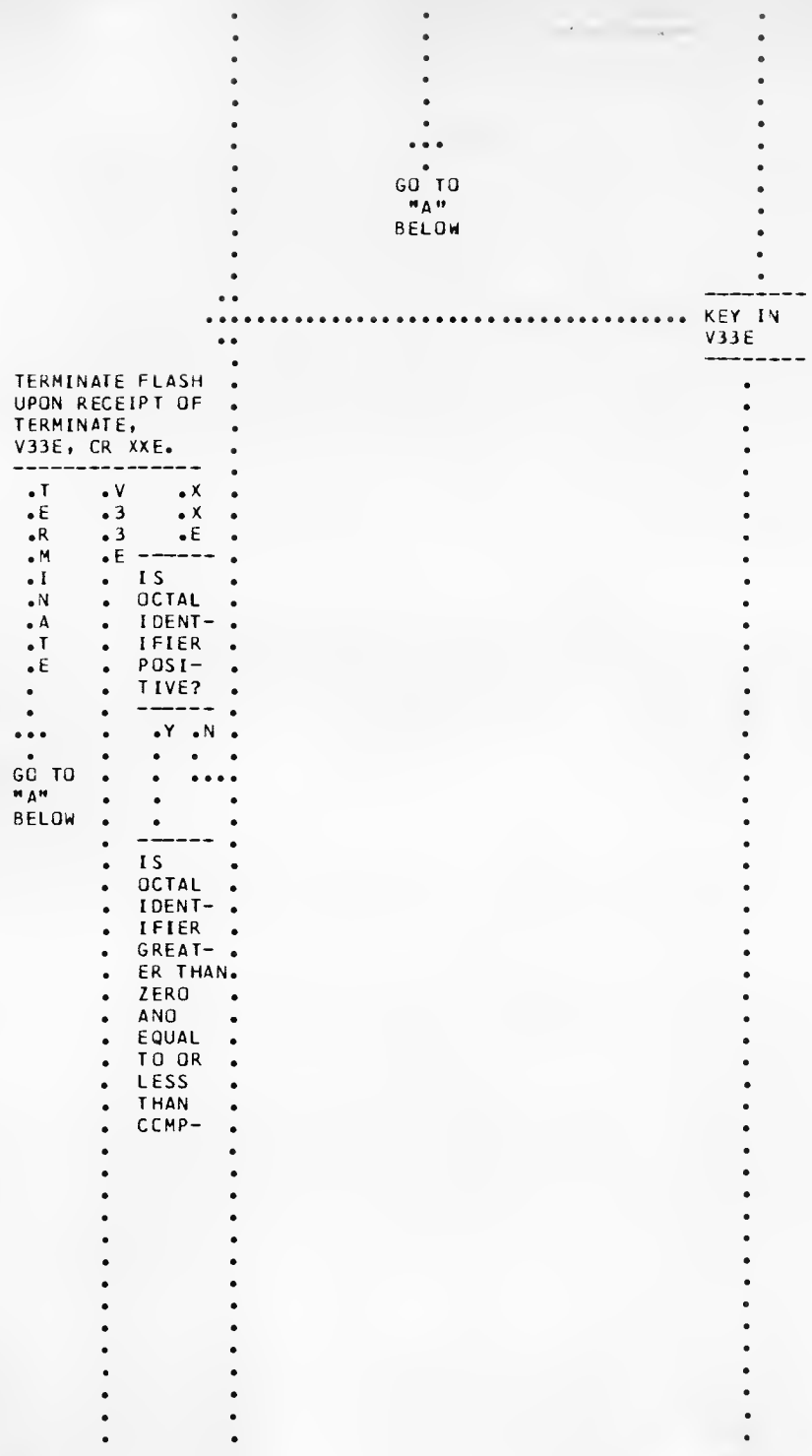
#570

#580

#590

#600

#610



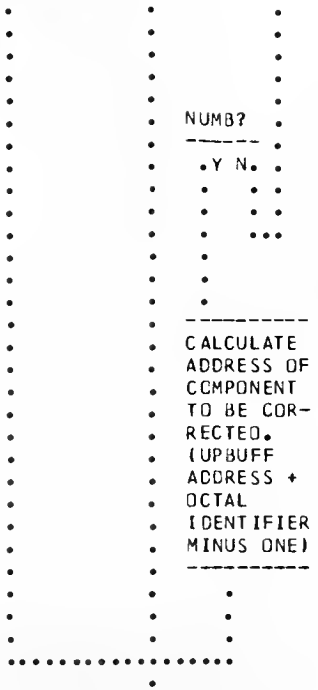
#620

#630

#640

#650

#660



#670

#680

#690

INVERT VERIFLAG

#700

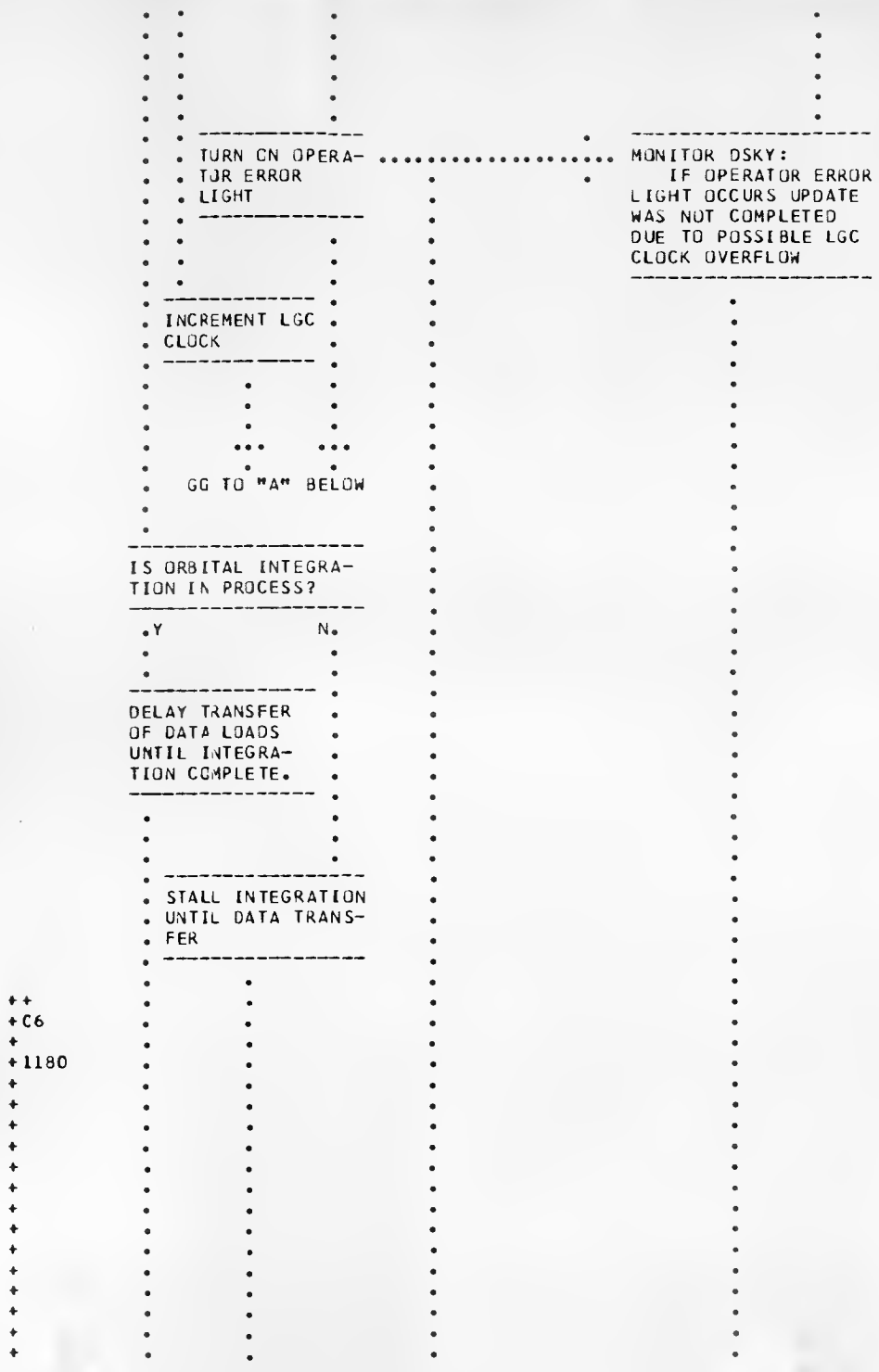
IS THIS AN OCTAL TIME INCREMENT (V73)?

#710

N Y

WOULD THE INCREMENT CAUSE THE LGC CLOCK TO OVERFLOW?

N Y



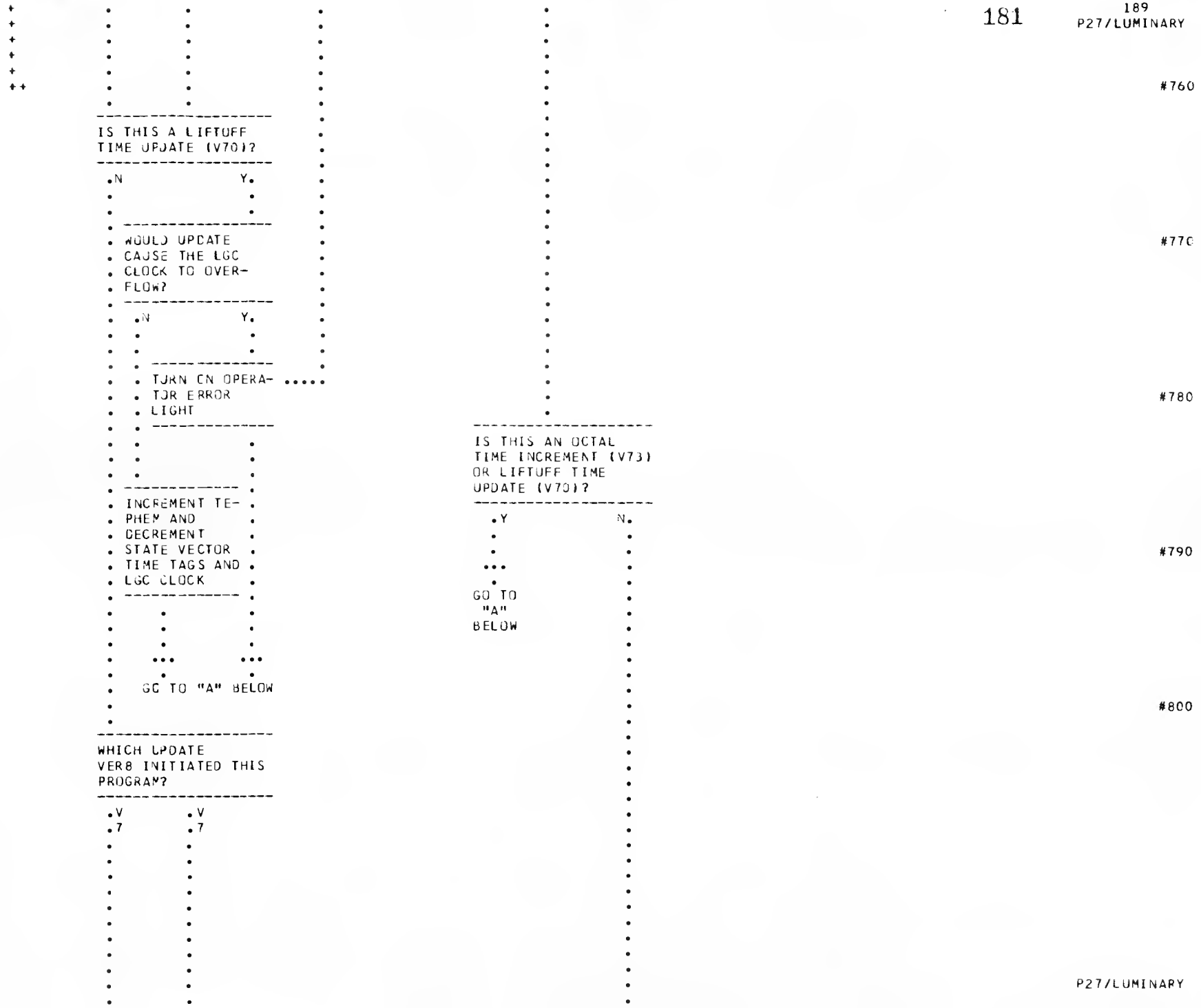
#720

#730

#740

#750

++
+C6
+
+1180
+
+
+
+
+
+
+
+
+
+
+
+
+
+
+



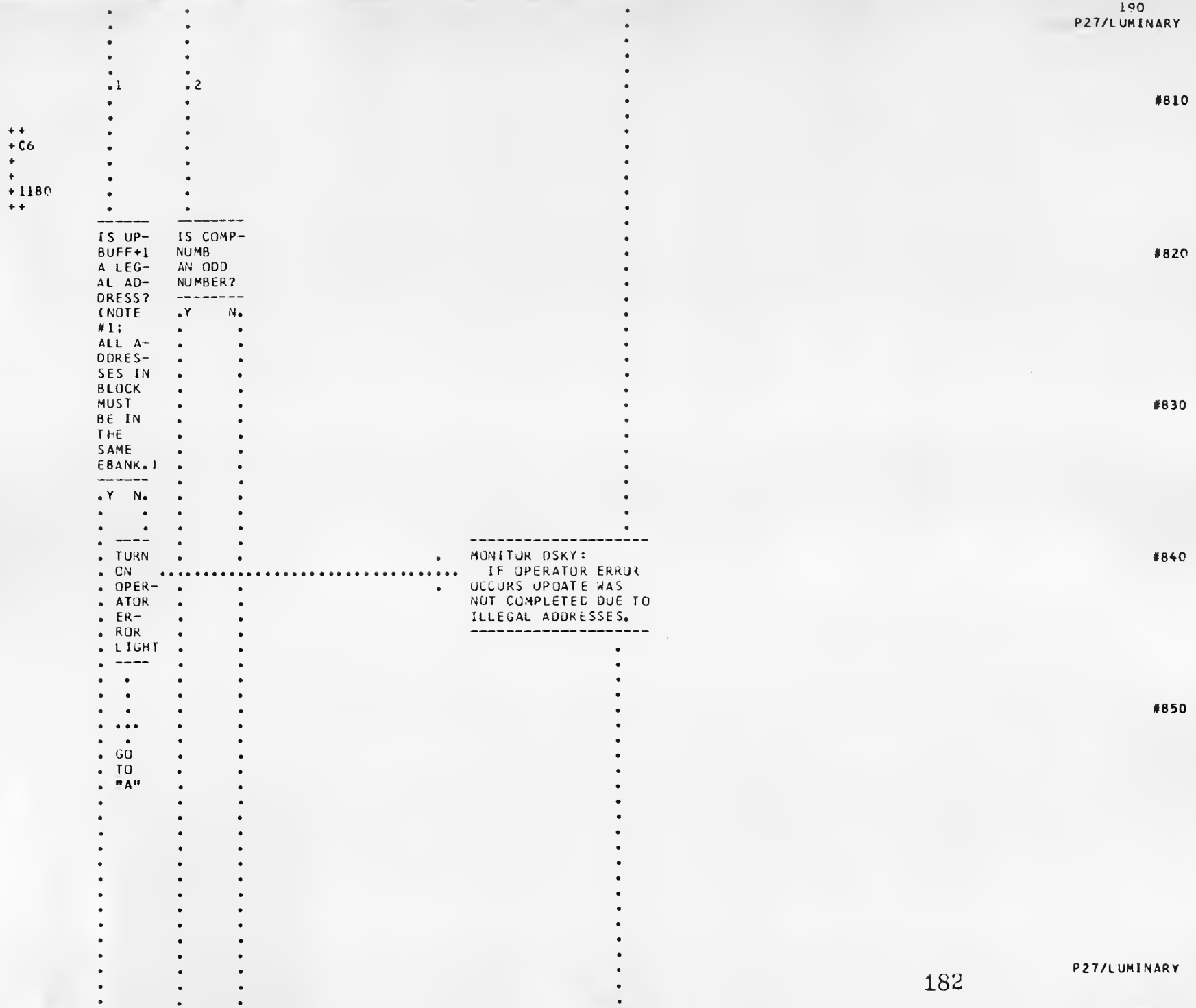
#760

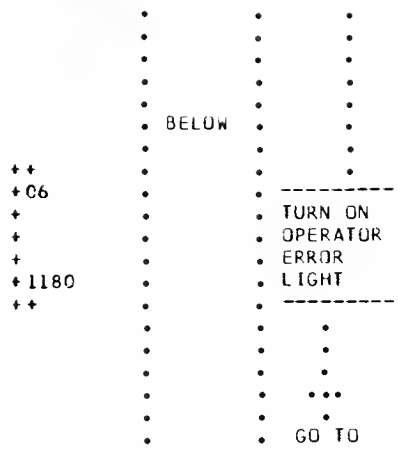
#770

#780

#790

#800


.1
.2
++
+C6
+
+
+1180
++
IS UP-
BUFF+1
A LEG-
AL AD-
DRESS?
(NOTE
#1;
ALL A-
DDRES-
SES IN
BLOCK
MUST
BE IN
THE
SAME
EBANK.)
.Y N.
TURN
ON
OPER-
ATOR
ER-
ROR
LIGHT
GO
TO
"A"
IS COMP-
NUMB
AN ODD
NUMBER?
.Y N.
MONITOR DSKY:
IF OPERATOR ERROR
OCCURS UPDATE WAS
NOT COMPLETED DUE TO
ILLEGAL ADDRESSES.
#810
#820
#830
#840
#850



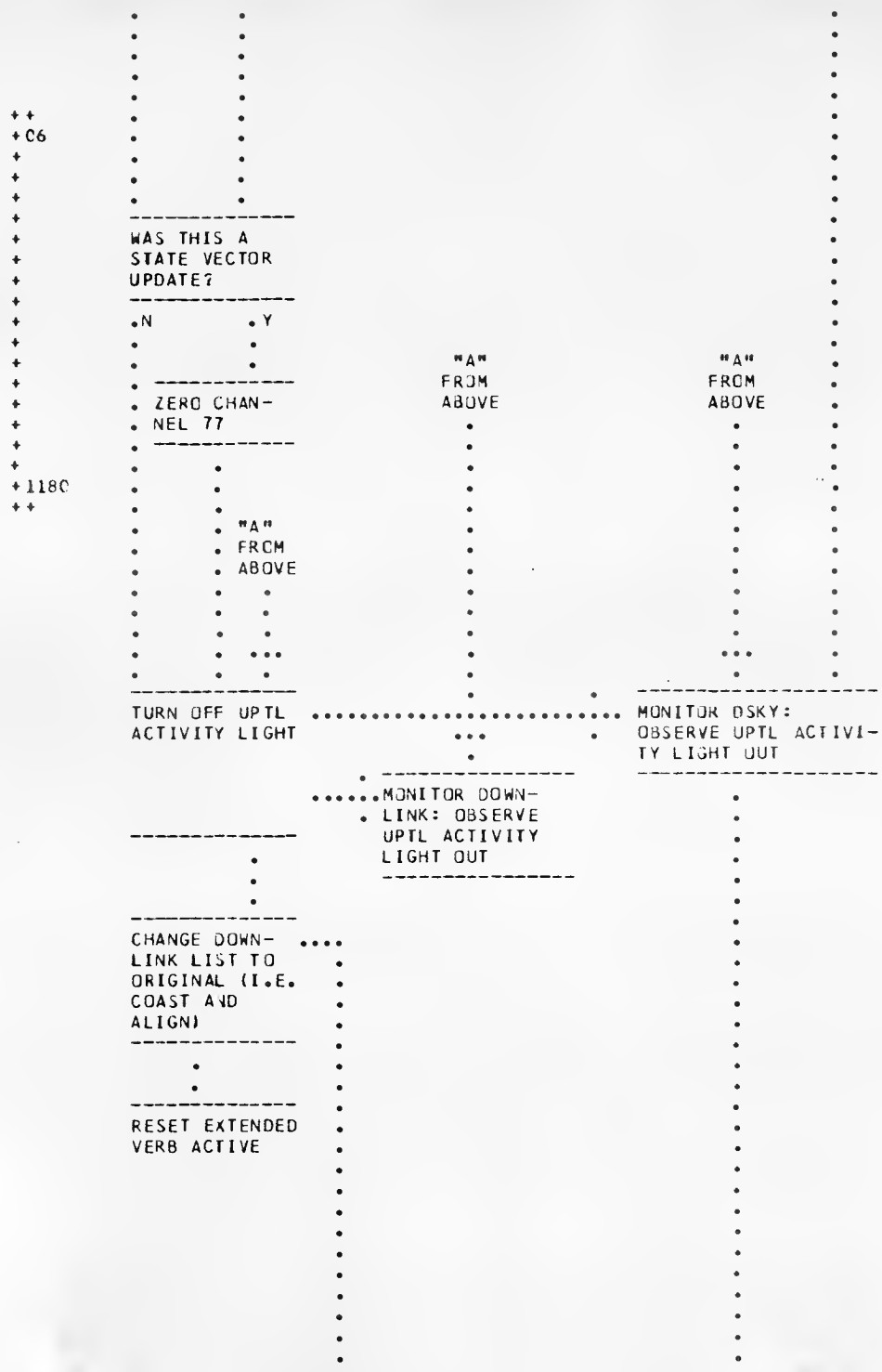
#860

#870

#880

#890

#900



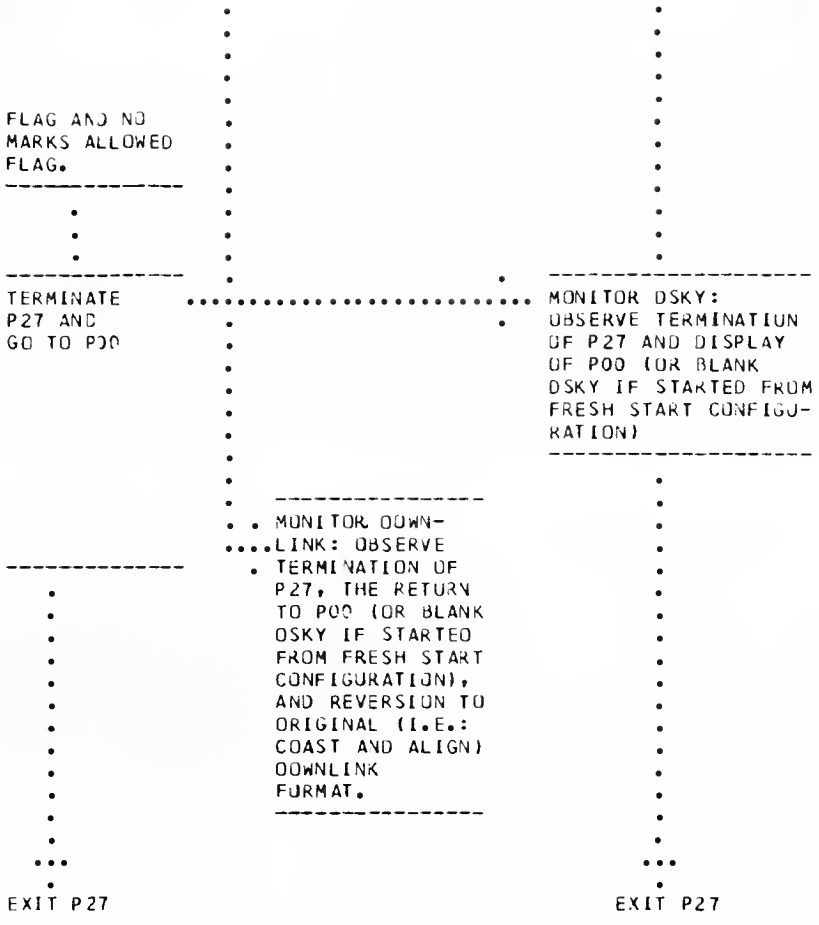
#910

#920

#930

#940

#950



#960

#970

#980

#990

CHANGE CONTROL NOTES

REV 01 PCR 417
REV 02 EDITORIAL
REV 03 EDITORIAL
REV 04(LUM 1D) PCR 302.2
REV 05(LUM 1E) PCN 1145
REV 06 PCN 1180

EXTERNAL DELTA V PROGRAM (P30) REV 04 12/01/71

PURPOSE: (1) TO ACCEPT TARGETING PARAMETERS OBTAINED FROM A SOURCE(S) EXTERNAL TO THE LGC AND COMPUTE THEREFROM THE REQUIRED VELOCITY AND OTHER INITIAL CONDITIONS REQUIRED BY THE LGC FOR EXECUTION OF THE DESIRED MANEUVER. THE TARGETING PARAMETERS INSERTED INTO THE LGC ARE THE TIME OF IGNITION (TIG) AND THE IMPULSIVE DELTA V ALONG LM LOCAL VERTICAL AXES AT TIG.

(2) TO DISPLAY TO THE ASTRONAUT AND THE GROUND CERTAIN SPECIFIC DEPENDENT VARIABLES ASSOCIATED WITH THE DESIRED MANEUVER FOR APPROVAL BY THE ASTRONAUT/GROUND.

ASSUMPTIONS: (1) THE TARGET PARAMETERS (TIG AND DELTA V(LV)) MAY HAVE BEEN LOADED FROM THE GROUND DURING A PRIOR EXECUTION OF P27.

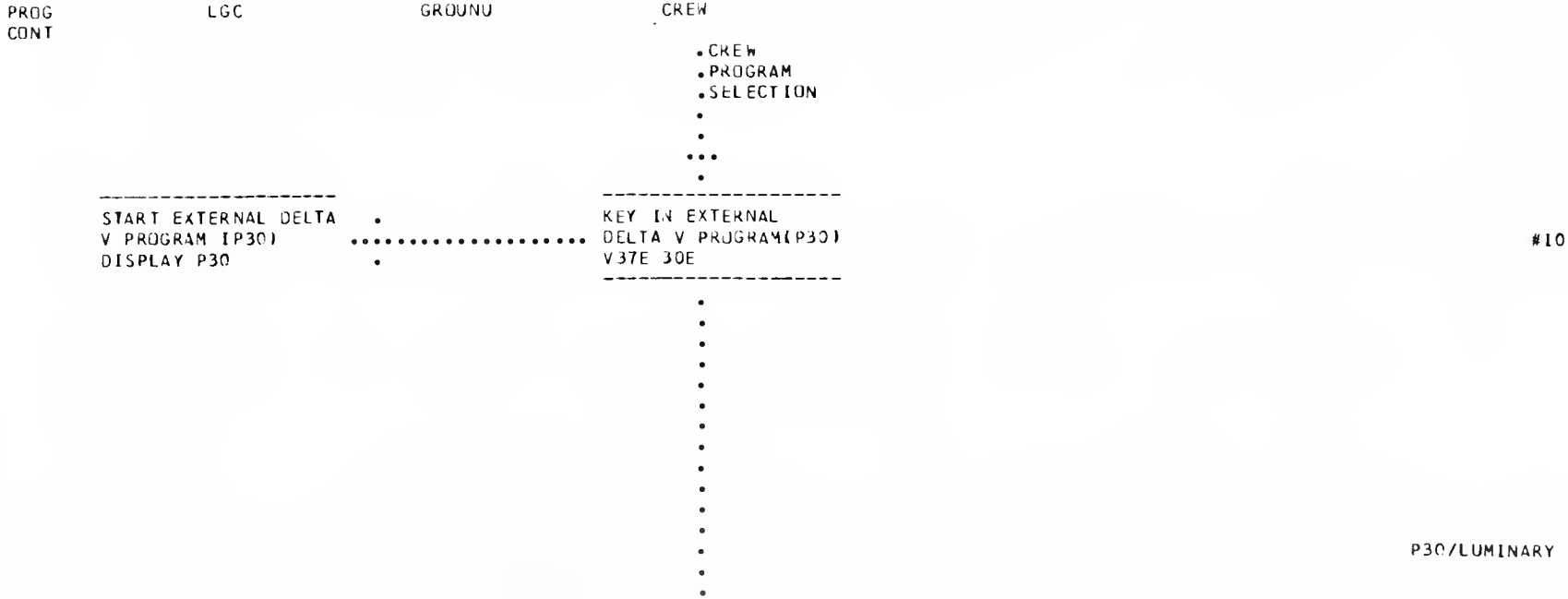
(2) THE EXTERNAL DELTA V FLAG IS SET DURING THIS PROGRAM TO DESIGNATE TO THE THRUSTING PROGRAM THAT EXTERNAL DELTA V STEERING IS TO BE USED.

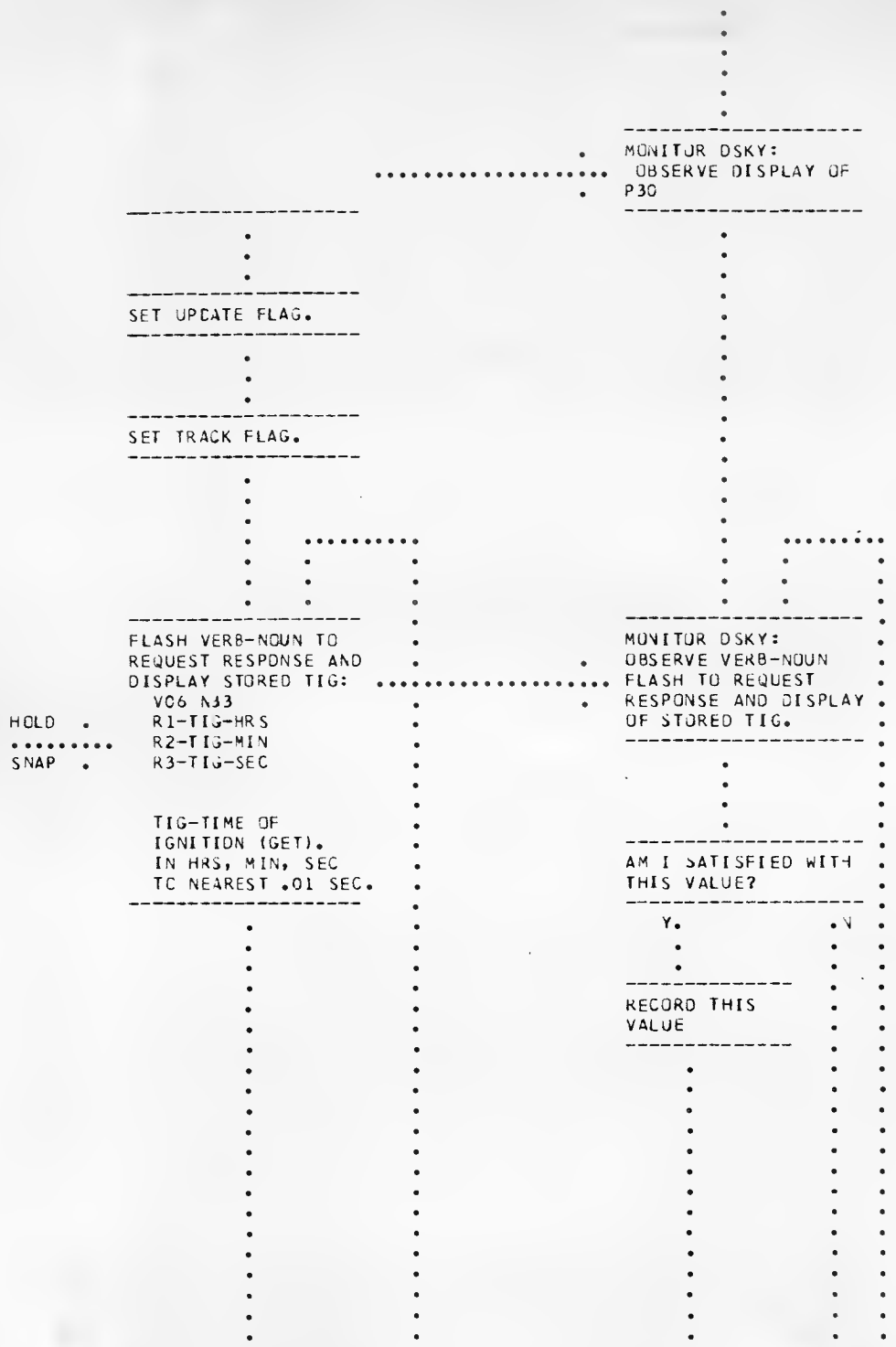
(3) THE ISS NEED NOT BE ON.

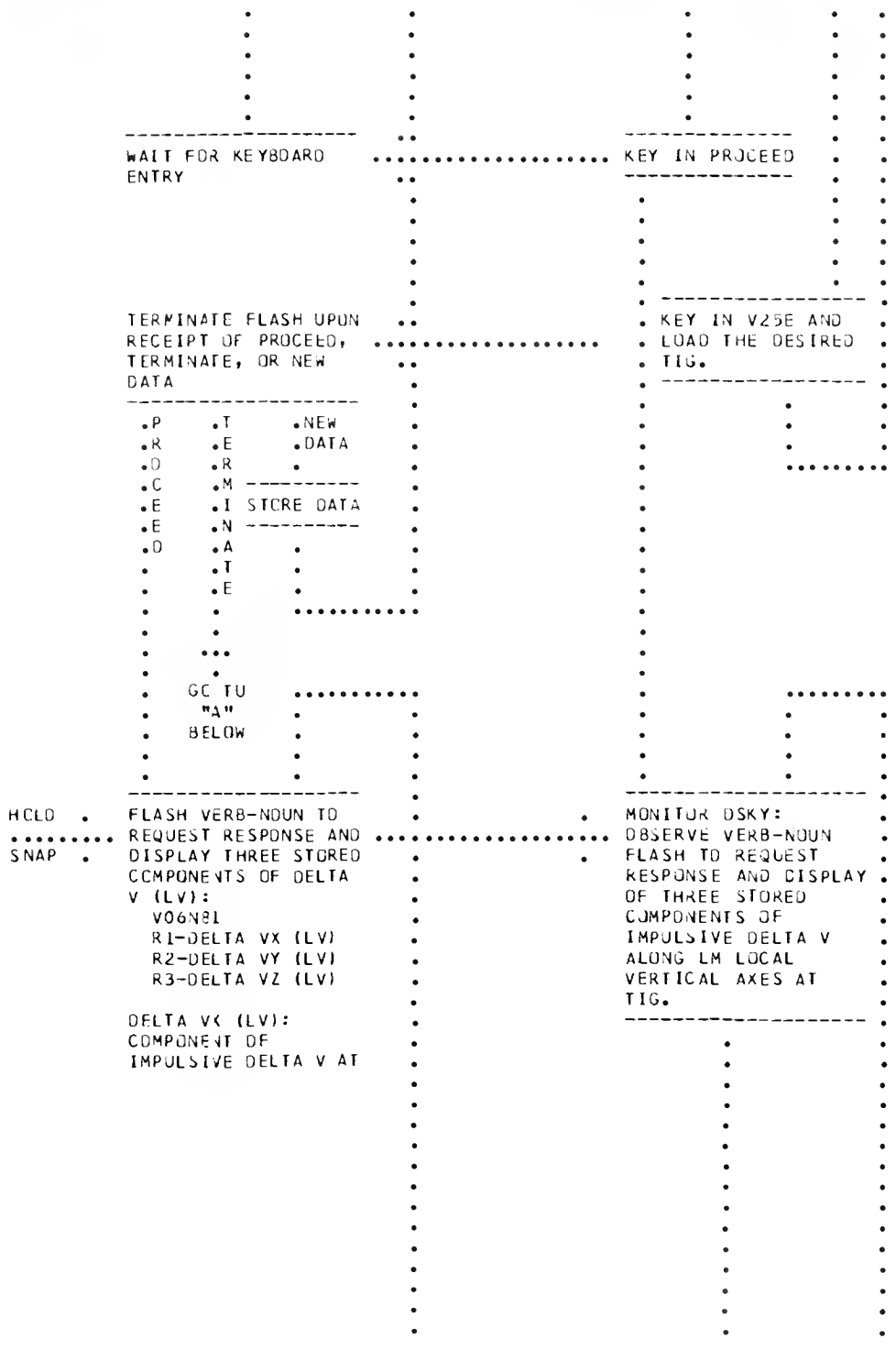
(4) THE RENDEZVOUS RADAR MAY OR MAY NOT BE USED TO UPDATE THE LM OR CSM STATE VECTORS FOR THIS PROGRAM. IF RADAR USE IS DESIRED, THE ISS SHOULD BE IN OPERATION AND THE RADAR SHOULD HAVE BEEN TURNED ON AND LOCKED ON THE CSM BY PREVIOUS SELECTION OF P20. RADAR SIGHTING MARKS WILL BE MADE AUTOMATICALLY APPROXIMATELY ONCE A MINUTE WHEN ENABLED BY THE TRACK AND UPDATE FLAGS.

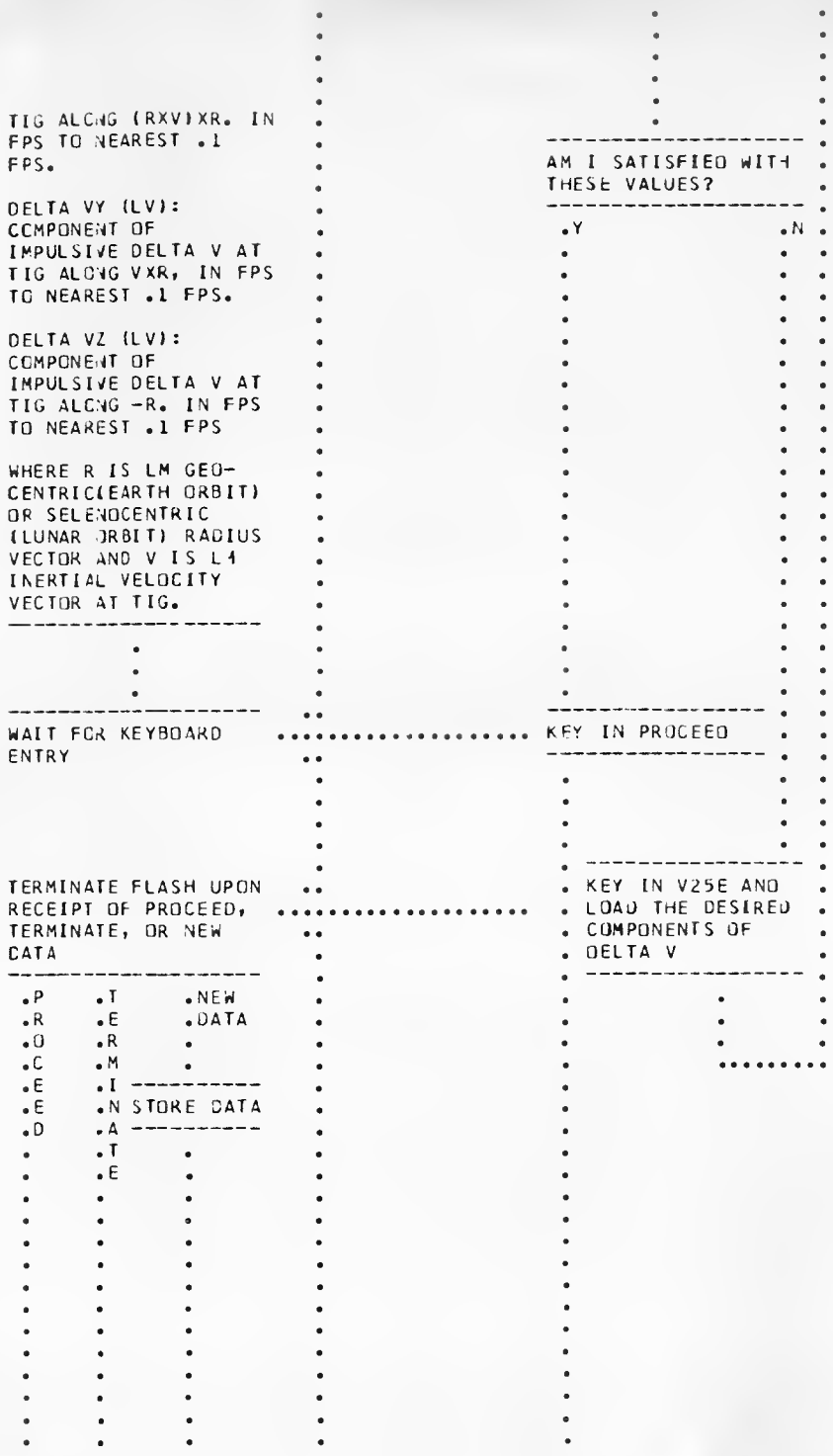
(5) THIS PROGRAM IS APPLICABLE IN EITHER EARTH OR LUNAR ORBIT.

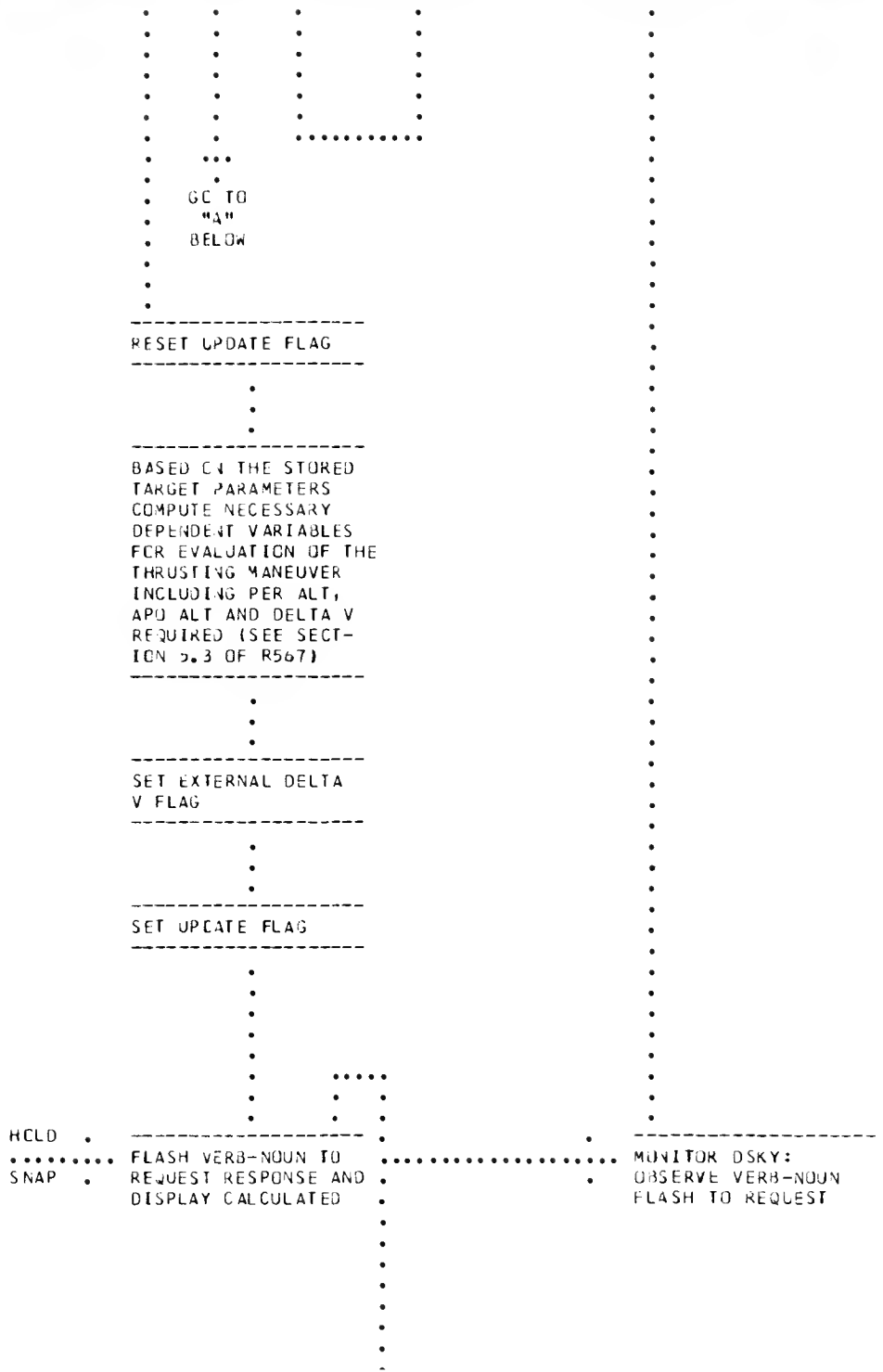
(6) THIS PROGRAM IS SELECTED BY THE ASTRONAUT BY DSKY ENTRY.




MONITOR DSKY:
OBSERVE DISPLAY OF
P30
#20
SET UPDATE FLAG.
SET TRACK FLAG.
#30
FLASH VERB-NOUN TO
REQUEST RESPONSE AND
DISPLAY STORED TIG:
V06 N33
R1-TIG-HRS
R2-TIG-MIN
R3-TIG-SEC
HOLD
SNAP
MONITOR DSKY:
OBSERVE VERB-NOUN
FLASH TO REQUEST
RESPONSE AND DISPLAY
OF STORED TIG.
#40
TIG-TIME OF
IGNITION (GET).
IN HRS, MIN, SEC
TO NEAREST .01 SEC.
#50
AM I SATISFIED WITH
THIS VALUE?
Y.
.N
RECORD THIS
VALUE
#60


WAIT FOR KEYBOARD ENTRY
KEY IN PROCEED
#70
TERMINATE FLASH UPON RECEIPT OF PROCEED, TERMINATE, OR NEW DATA
KEY IN V25E AND LOAD THE DESIRED TIG.
PROCEED
TERMINATE
NEW DATA
#80
STORE DATA
#90
GO TO "A" BELOW
HOLD
SNAP
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY THREE STORED COMPONENTS OF DELTA V (LV):
V06N81
R1-DELTA VX (LV)
R2-DELTA VY (LV)
R3-DELTA VZ (LV)
DELTA VX (LV): COMPONENT OF IMPULSIVE DELTA V AT
MONITOR DSKY: OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY OF THREE STORED COMPONENTS OF IMPULSIVE DELTA V ALONG LM LOCAL VERTICAL AXES AT TIG.
#100
#110


TIG ALONG (RXV)XR. IN FPS TO NEAREST .1 FPS.
DELTA VY (LV): COMPONENT OF IMPULSIVE DELTA V AT TIG ALONG VXR, IN FPS TO NEAREST .1 FPS.
DELTA VZ (LV): COMPONENT OF IMPULSIVE DELTA V AT TIG ALONG -R. IN FPS TO NEAREST .1 FPS
WHERE R IS LM GEO-CENTRIC(EARTH ORBIT) OR SELENOCENTRIC (LUNAR ORBIT) RADIUS VECTOR AND V IS L4 INERTIAL VELOCITY VECTOR AT TIG.
AM I SATISFIED WITH THESE VALUES?
.Y
.N
#120
#130
WAIT FOR KEYBOARD ENTRY
KEY IN PROCEED
#140
TERMINATE FLASH UPON RECEIPT OF PROCEED, TERMINATE, OR NEW DATA
KEY IN V25E AND LOAD THE DESIRED COMPONENTS OF DELTA V
#150
.PROCEED
.TERMINATE
.NEW DATA
STORE DATA



#160

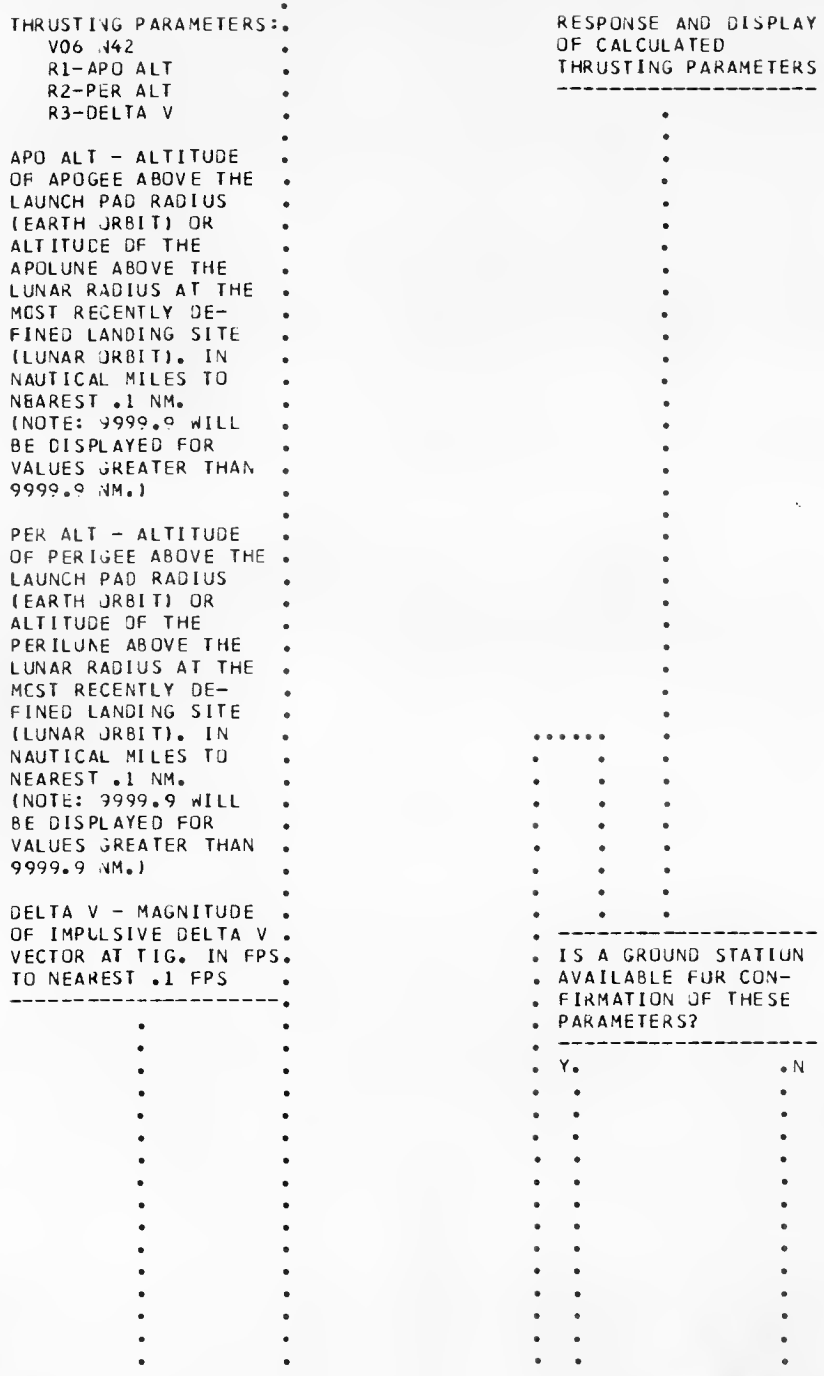
#170

#180

#190

#200

#210



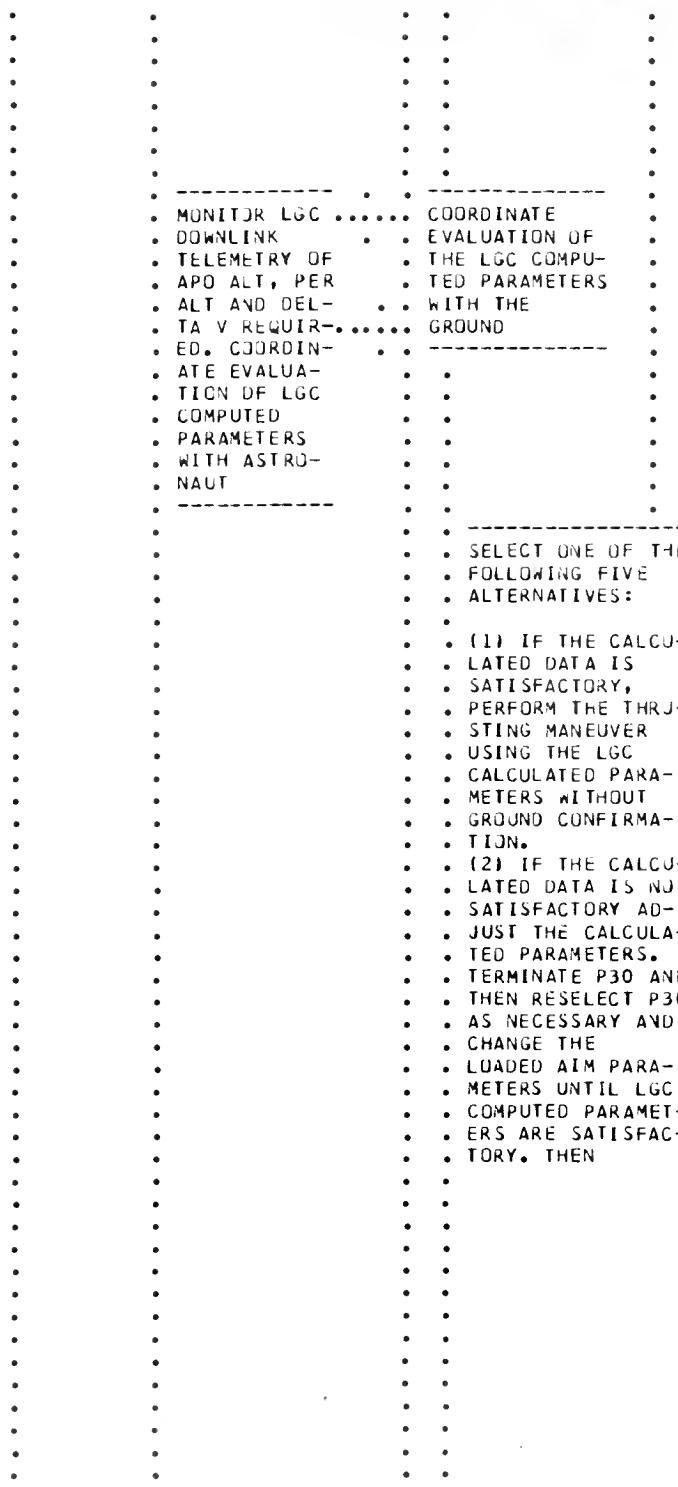
#220

#230

#240

#250

#260

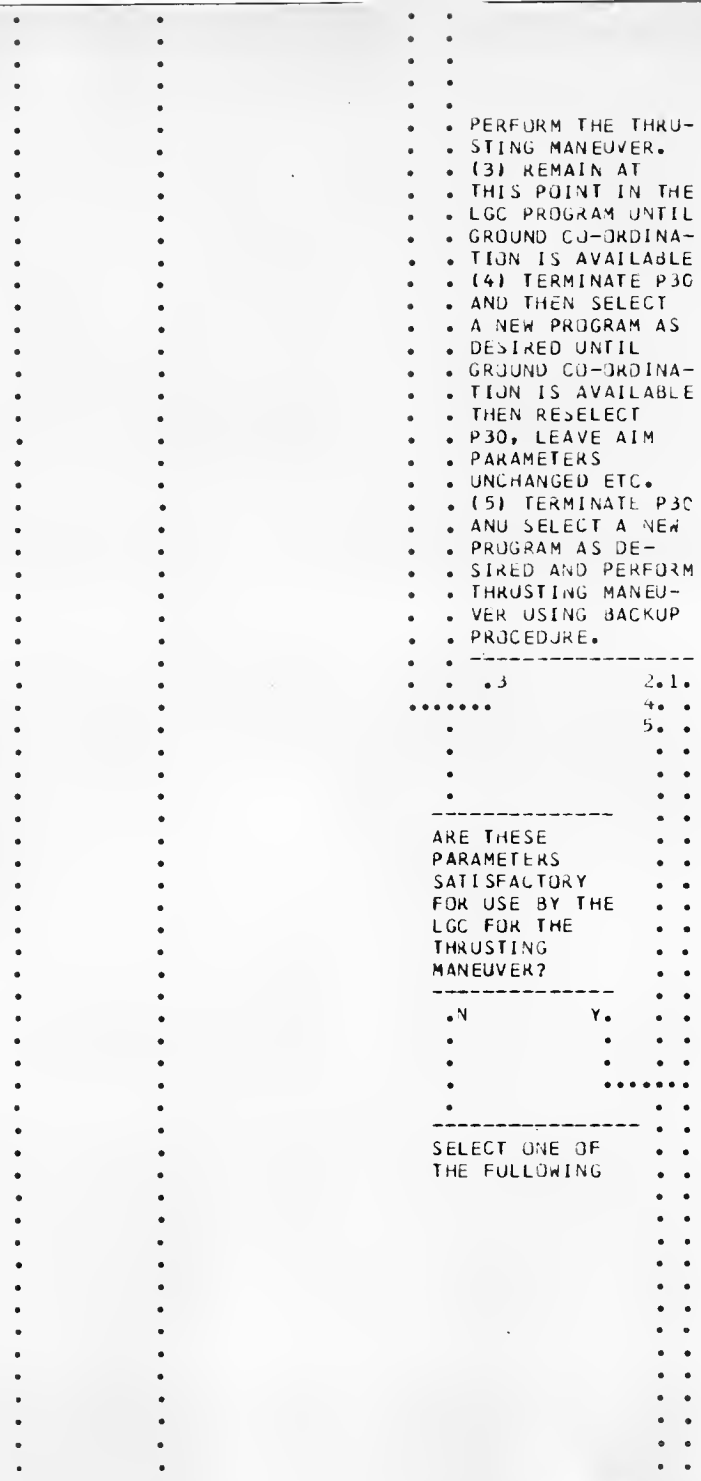


#270

#280

#290

#300



#310

#320

#330

#340

#350

FOUR ALTERNATIVES:

(1) ADJUST THE CALCULATED PARAMETERS. TERMINATE P30 AND THEN RESELECT P30 AS NECESSARY AND CHANGE THE LOADED AIM PARAMETERS UNTIL LGC COMPUTED PARAMETERS ARE SATISFACTORY. #360

(2) TERMINATE P30 AND OBTAIN NEW AIM PARAMETERS FROM THE GROUND BY VOICE LINK, RESELECT P 30, KEY IN NEW DATA, ETC. #370

(3) TERMINATE P30 AND SELECT THE LGC UPDATE PROGRAM (P27). LOAD NEW AIM PARAMETERS FROM THE GROUND VIA THE LGC UPLINK, OR BY CREW DSKY INPUT. OBSERVE NEW AIM PARAMETERS,ETC. #380

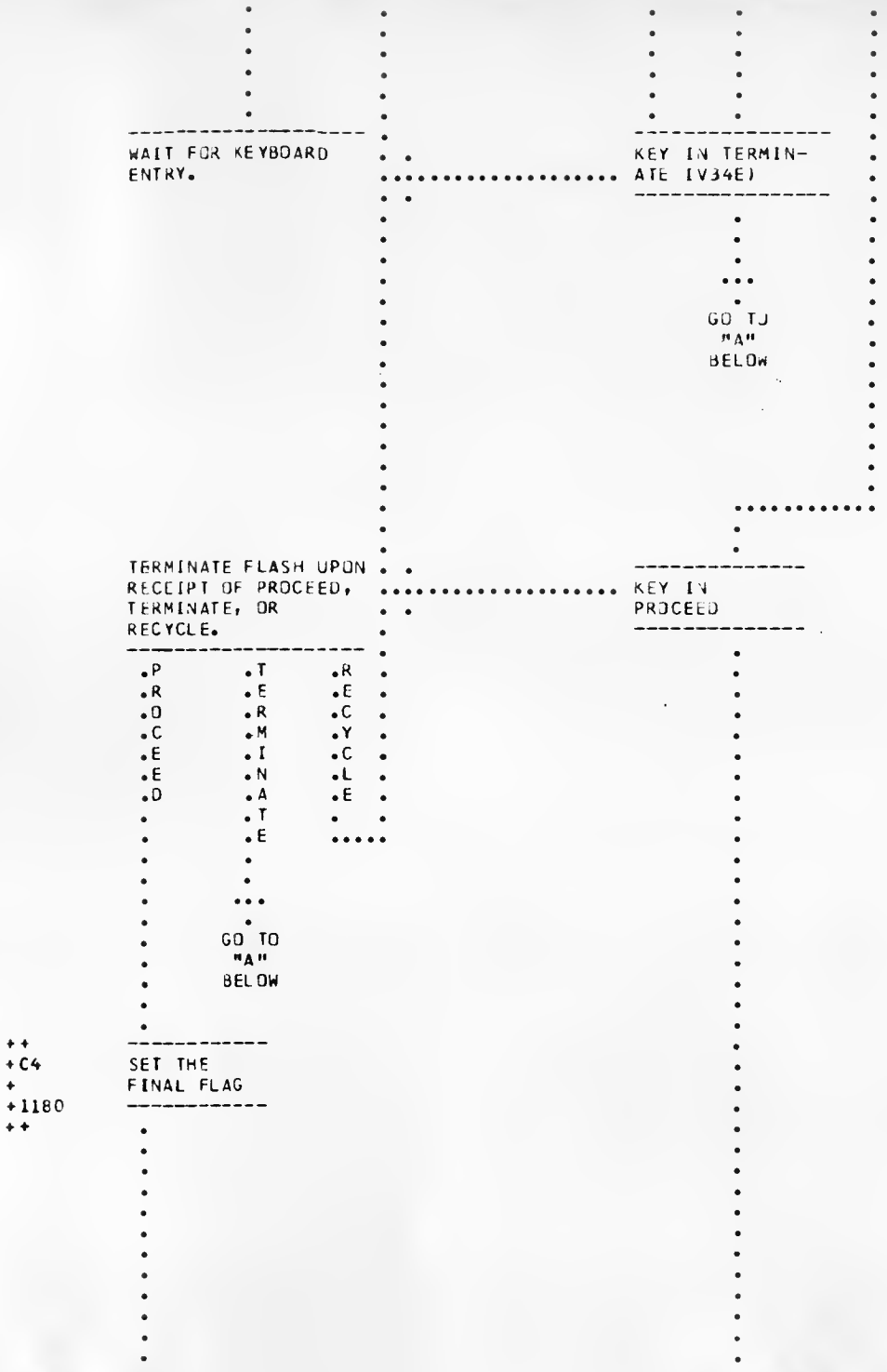
(4) TERMINATE P30 AND PERFORM THRUSTING MANEUVER USING BACKUP PROCEDURES. #390

1.

2.

3.

4. #400


WAIT FOR KEYBOARD ENTRY.
KEY IN TERMIN-ATE (V34E)
GO TO "A" BELOW
#410
#420
#430
TERMINATE FLASH UPON RECEIPT OF PROCEED, TERMINATE, OR RECYCLE.
KEY IN PROCEED
.P .R .O .C .E .E .D
.T .E .R .M .I .N .A .T .E
.R .E .C .Y .C .L .E
GO TO "A" BELOW
#440
#450
++
+C4
+
+1180
++
SET THE FINAL FLAG

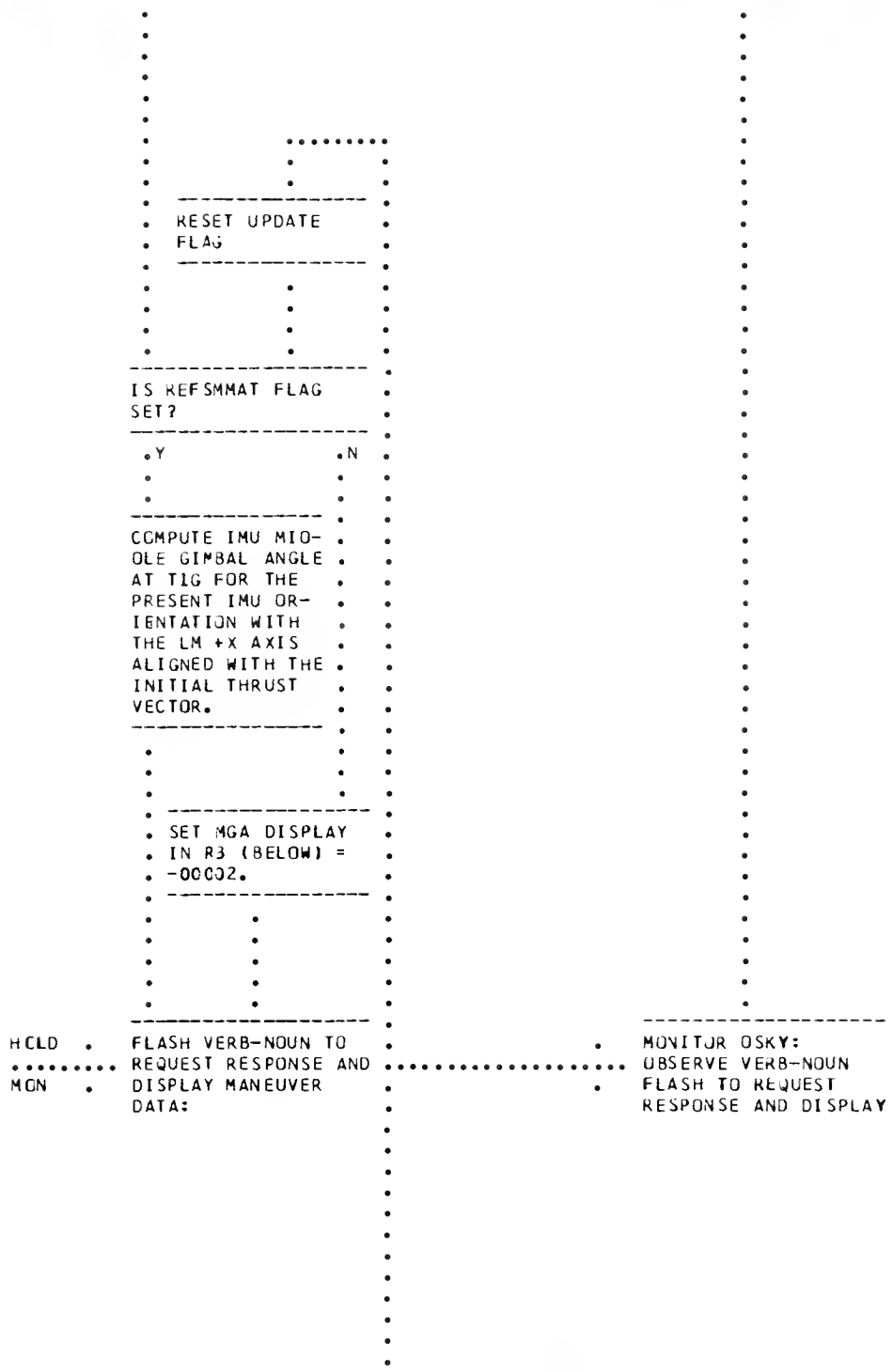
#460

#470

#480

#490

#500



V16 N45
R1-M
R2-TFI
R3-MGA

M-THE NUMBER OF
MARKS MADE SINCE
THE RR TRACKING MARK
COUNTER WAS ZEROED
(SEE ASSUMPTION 6
OF P20).

TFI - TIME FROM
TIG. IN MIN AND SEC
TO NEAREST SEC.
MAXIMUM READING IS
59B59. (- BEFORE
+ AFTER TIG.)

MGA-MIDDLE GIMBAL
ANGLE AT TIG IF
+X LM AXIS IS
ALIGNED WITH INITIAL
THRUST DIRECTION.
SIGN IS ALWAYS +
EXCEPT WHEN THE IMU
IS NOT ALIGNED THE
VALUE IS -00002. IN
DEGREES TO NEAREST
.01 DEGREE

OF MANEUVER DATA

#510

#520

#530

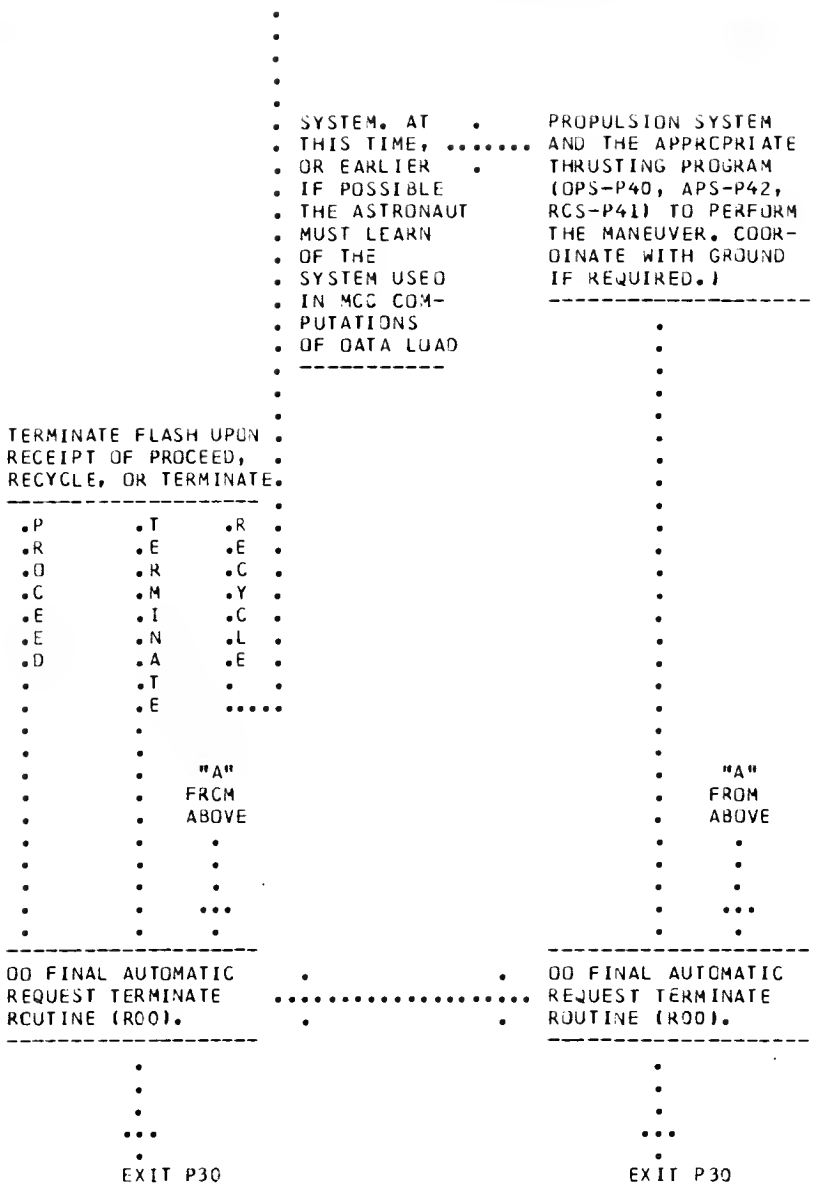
#540

WAIT FOR KEYBOARD
ENTRY

IF TIME AND
LOCATION
PERMIT
ASSIST
ASTRONAUT IN
SELECTION OF
PROPULSION

KEY IN PROCEED
(NOTE: CONSIDERING
VALUE OF DELTA V,
FUEL AVAILABLE,
STATUS OF PROPULSION
HARDWARE, AND TIME
AVAILABLE TO RE-AL-
IGN THE IMU TO AVOID
GIMBAL LOCK SELECT A

#550



#560

#570

#580

#590

#600

CHANGE CONTROL NOTES

REV 01 PCR 604
REV 02(LUM 18) PCR 812.2, EDITORIAL
REV 03 EDITORIAL
REV 04 PCN 1180

CO-ELLIPTIC SEQUEN E INITIATION (CSI) PROGRAM (P32) REV (4 09/03/70

PURPOSE: (1) TO CALCULATE PARAMETERS ASSOCIATED WITH THE FOLLOWING CONCENTRIC FLIGHT PLAN MANEUVERS; THE CO-ELLIPTIC SEQUENCE INITIATION (CSI) AND THE CONSTANT DELTA ALTITUDE MANEUVER (CDH), FOR DELTA V BURNS.

(2) TO CALCULATE THESE PARAMETERS BASED UPON MANEUVER DATA APPROVED AND KEYED INTO THE LGC BY THE ASTRONAUT.

(3) TO DISPLAY TO THE ASTRONAUT AND THE GROUND DEPENDENT VARIABLES ASSOCIATED WITH THE CONCENTRIC FLIGHT PLAN MANEUVERS FOR APPROVAL BY THE ASTRONAUT/GROUND.

(4) TO STORE THE CSI TARGET PARAMETERS FOR USE BY THE DESIRED THRUSTING PROGRAM.

ASSUMPTIONS: (1) AT A SELECTED TPI TIME THE LINE OF SIGHT BETWEEN THE LM AND THE CSM IS SELECTED TO BE A PRESCRIBED ANGLE (E) FROM THE HORIZONTAL PLANE DEFINED AT THE ACTIVE POSITION.

(2) THE TIME BETWEEN CSI IGNITION AND CDH IGNITION MUST BE COMPUTED TO BE GREATER THAN 1[illegible] MINUTES FOR SUCCESSFUL COMPLETION OF THE PROGRAM.

(3) THE TIME BETWEEN CDH IGNITION AND TPI IGNITION MUST BE COMPUTED TO BE GREATER THAN 10 MINUTES FOR SUCCESSFUL COMPLETION OF THE PROGRAM.

(4) CDH DELTA V IS SELECTED TO MINIMIZE THE VARIATION OF THE ALTITUDE DIFFERENCE BETWEEN THE ORBITS.

(5) CSI BURN IS DEFINED SUCH THAT THE IMPULSIVE DELTA V IS IN THE LM HORIZONTAL PLANE AT CSI IGNITION.

(6) THE PERICENTER ALTITUDE OF THE ORBIT FOLLOWING CSI AND CDH MUST BE GREATER THAN 35,000 FT (LUNAR ORBIT) OR 85 NM (EARTH ORBIT) FOR SUCCESSFUL COMPLETION OF THIS PROGRAM.

(7) THE CSI AND CDH MANEUVERS ARE ORIGINALLY ASSUMED TO BE PARALLEL TO THE PLANE OF THE CSM ORBIT. HOWEVER CREW MODIFICATION OF DELTA V (LV) COMPONENTS MAY RESULT IN AN OUT-OF-PLANE CSI MANEUVER.

(8) LGC COMPUTED VARIABLES MAY BE STORED FOR LATER VERIFICATION BY THE GROUND. THESE STORAGE CAPABILITIES ARE NORMALLY LIMITED ONLY TO THE PARAMETERS FOR ONE THRUSTING MANEUVER AT A TIME EXCEPT FOR CONCENTRIC FLIGHT PLAN MANEUVER SEQUENCES.

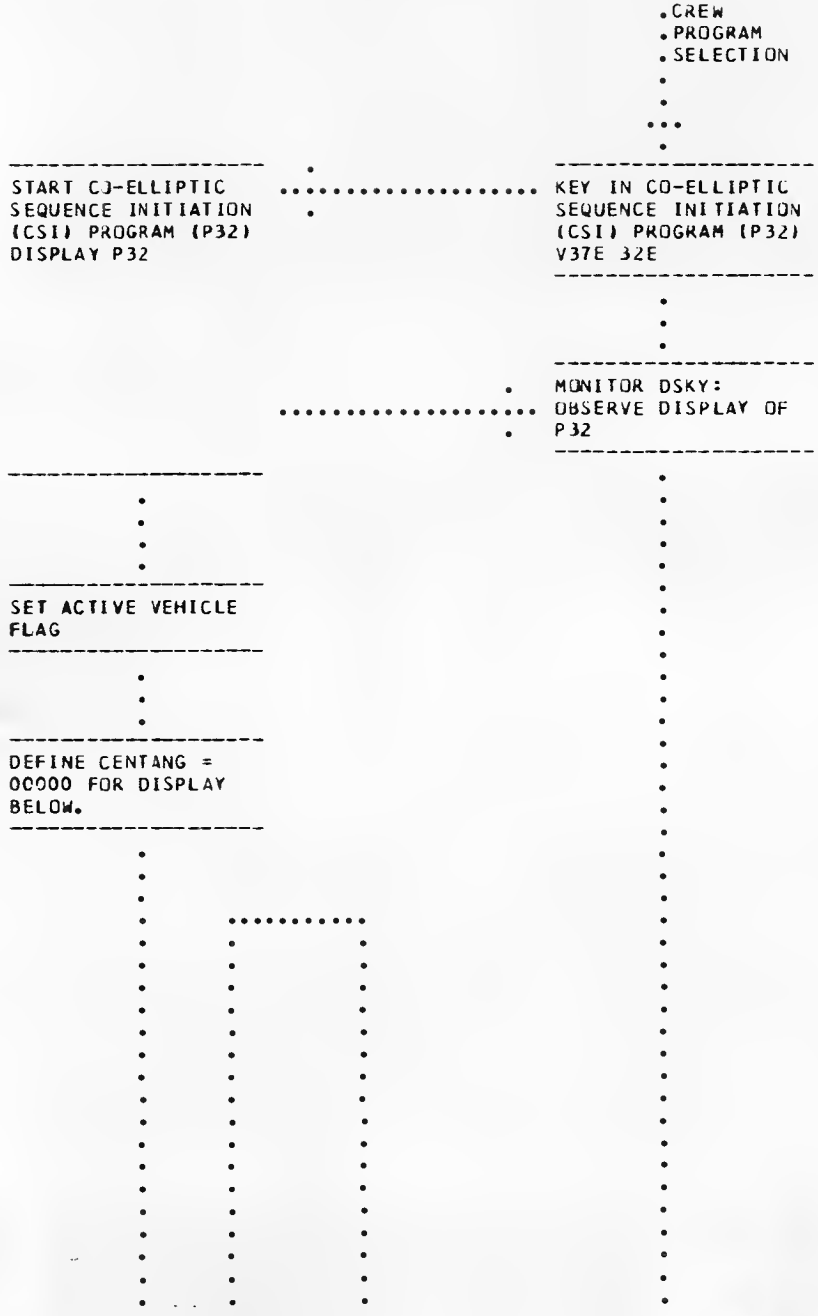
(9) THE RENDEZVOUS RADAR MAY OR MAY NOT BE USED TO UPDATE THE LM OR CSM STATE VECTORS FOR THIS PROGRAM. IF RADAR USE IS DESIRED THE RADAR SHOULD BE TURNED ON AND LOCKED ON THE CSM BY PREVIOUS SELECTION OF P20. RADAR SIGHTING MARKS WILL BE MADE AUTOMATICALLY APPROXIMATELY ONCE A MINUTE WHEN ENABLED BY THE TRACK AND UPDATE FLAGS. THE RENDEZVOUS TRACKING MARK COUNTER IS ZEROED BY THE SELECTION OF P20 AND AFTER EACH THRUSTING MANEUVER.

(10) THE ISS NEED NOT BE ON TO COMPLETE THIS PROGRAM UNLESS THE RENDEZVOUS RADAR IS TO BE USED FOR AUTOMATIC STATE VECTOR UPDATING BY THE RENDEZVOUS NAVIGATION PROGRAM (P20). P20 WILL DEFINE THE STATUS OF THE ISS.

(11) THIS PROGRAM IS SELECTED BY THE ASTRONAUT BY DSKY ENTRY.

PROG	LGC	GROUND	CREW

CONT

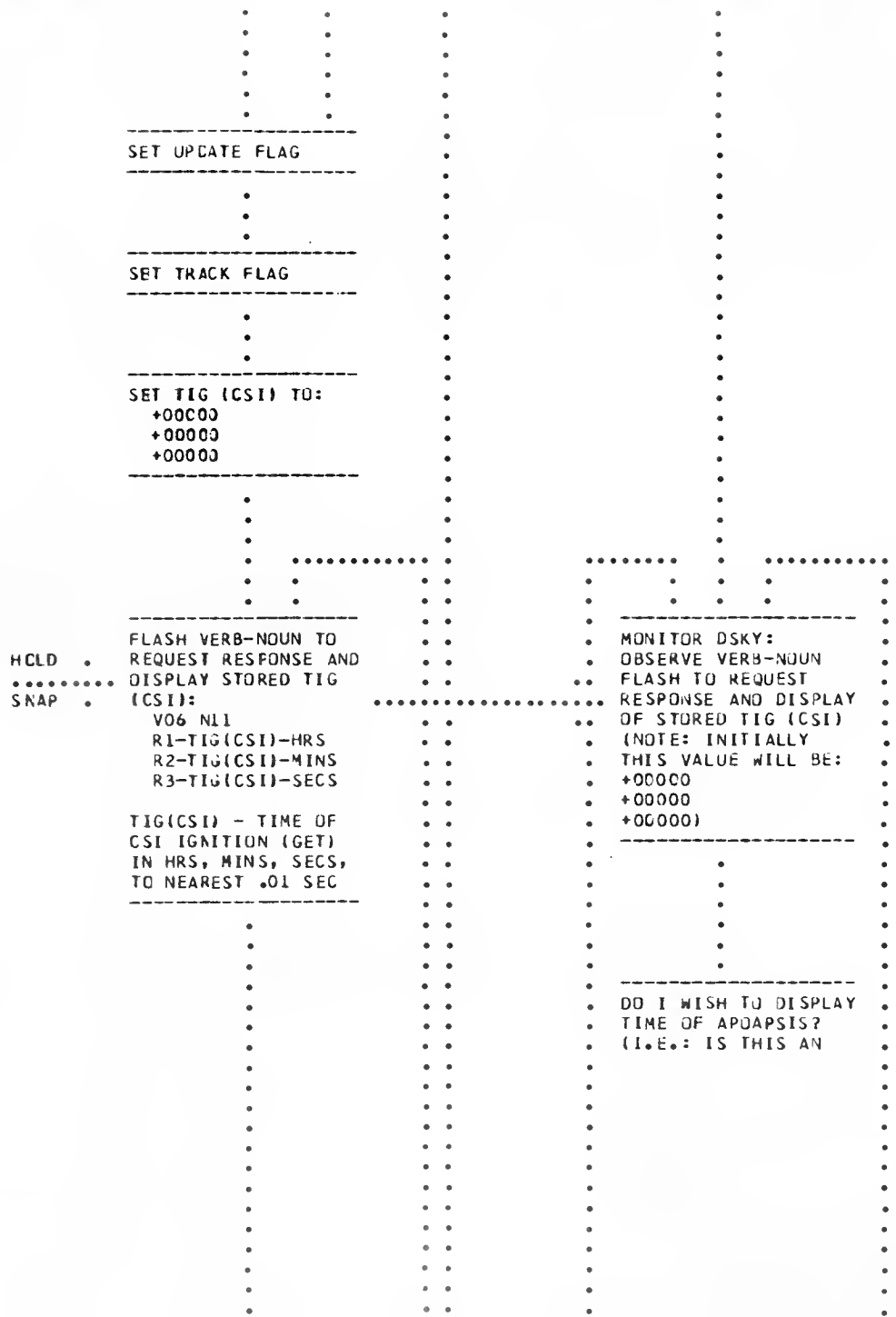


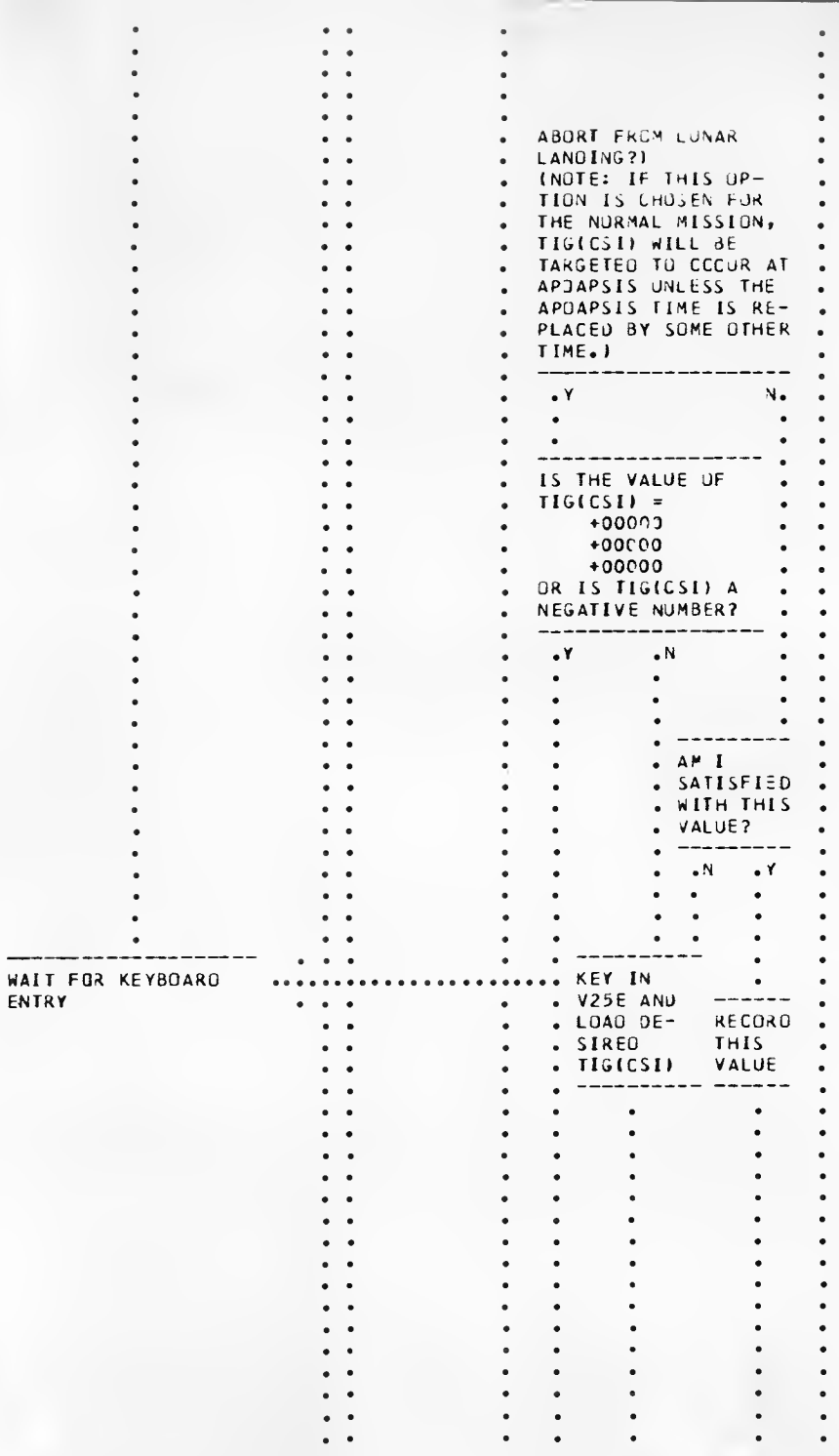
#10

#20

#30

#40


SET UPDATE FLAG
SET TRACK FLAG
SET TIG (CSI) TO:
+00000
+00000
+00000
FLASH VERB-NOUN TO
REQUEST RESPONSE AND
DISPLAY STORED TIG
(CSI):
V06 N11
R1-TIG(CSI)-HRS
R2-TIG(CSI)-MINS
R3-TIG(CSI)-SECS
TIG(CSI) - TIME OF
CSI IGNITION (GET)
IN HRS, MINS, SECS,
TO NEAREST .01 SEC
HOLD
SNAP
MONITOR DSKY:
OBSERVE VERB-NOUN
FLASH TO REQUEST
RESPONSE AND DISPLAY
OF STORED TIG (CSI)
(NOTE: INITIALLY
THIS VALUE WILL BE:
+00000
+00000
+00000)
DO I WISH TO DISPLAY
TIME OF APOAPSIS?
(I.E.: IS THIS AN
#50
#60
#70
#80
#90



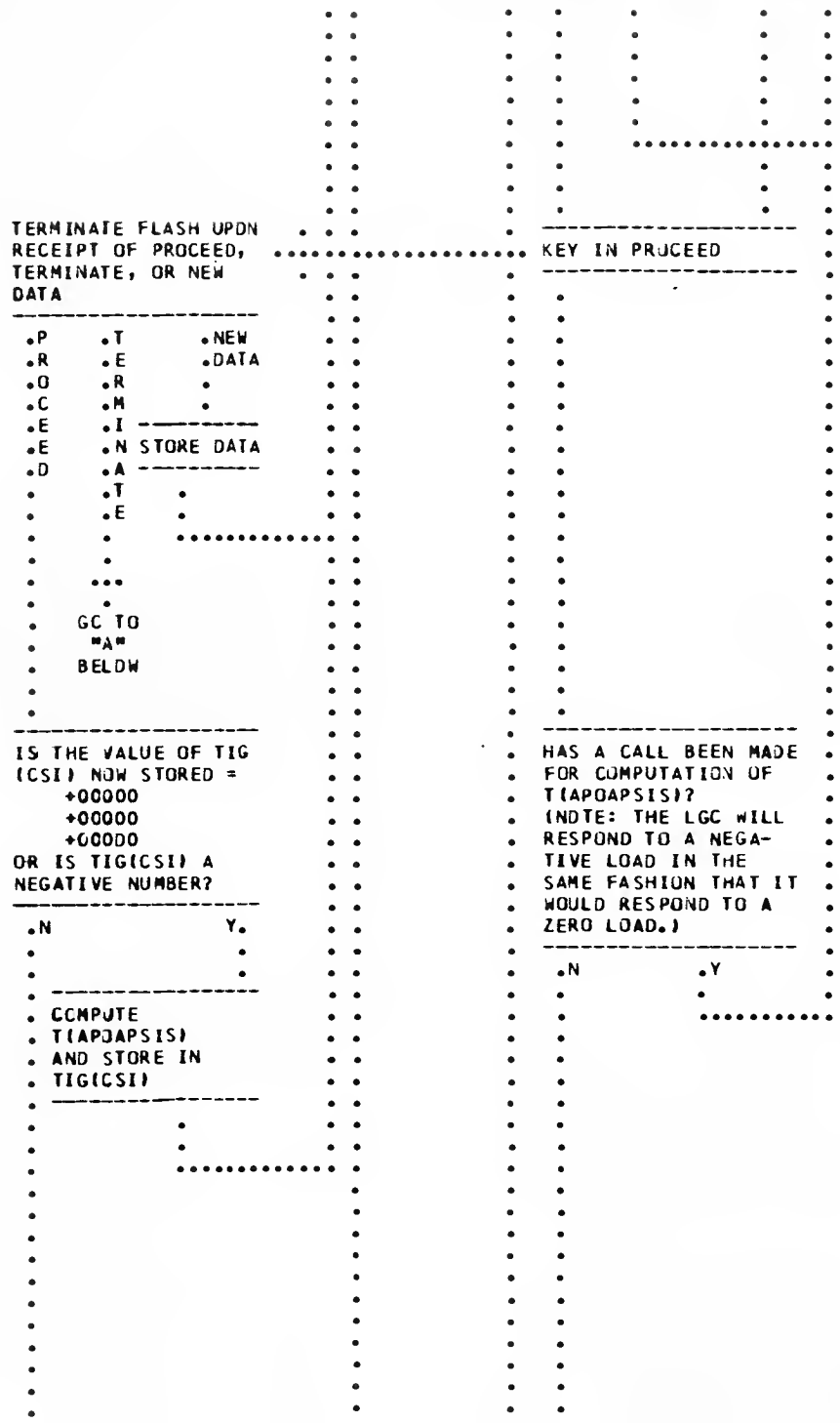
#100

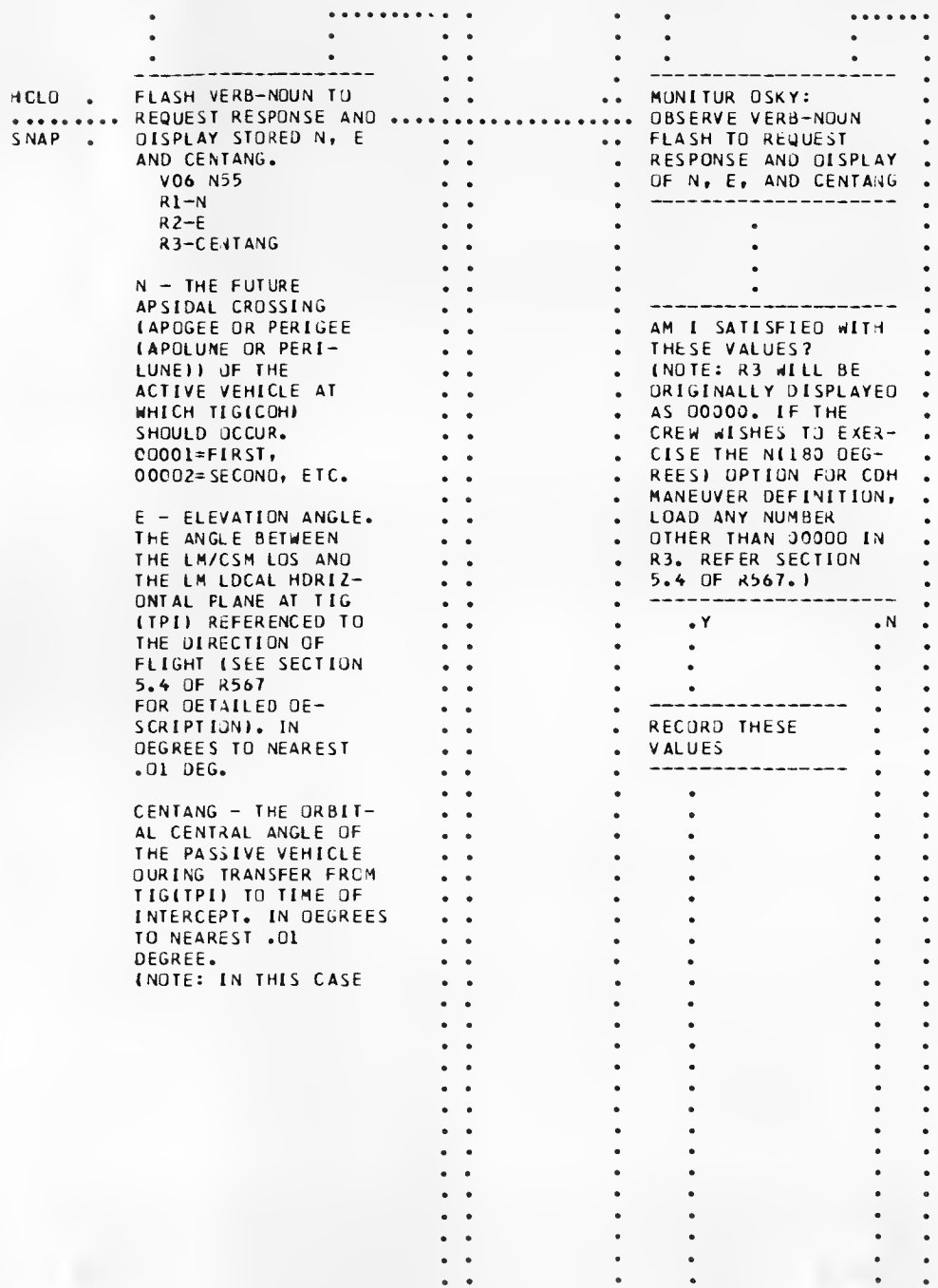
#110

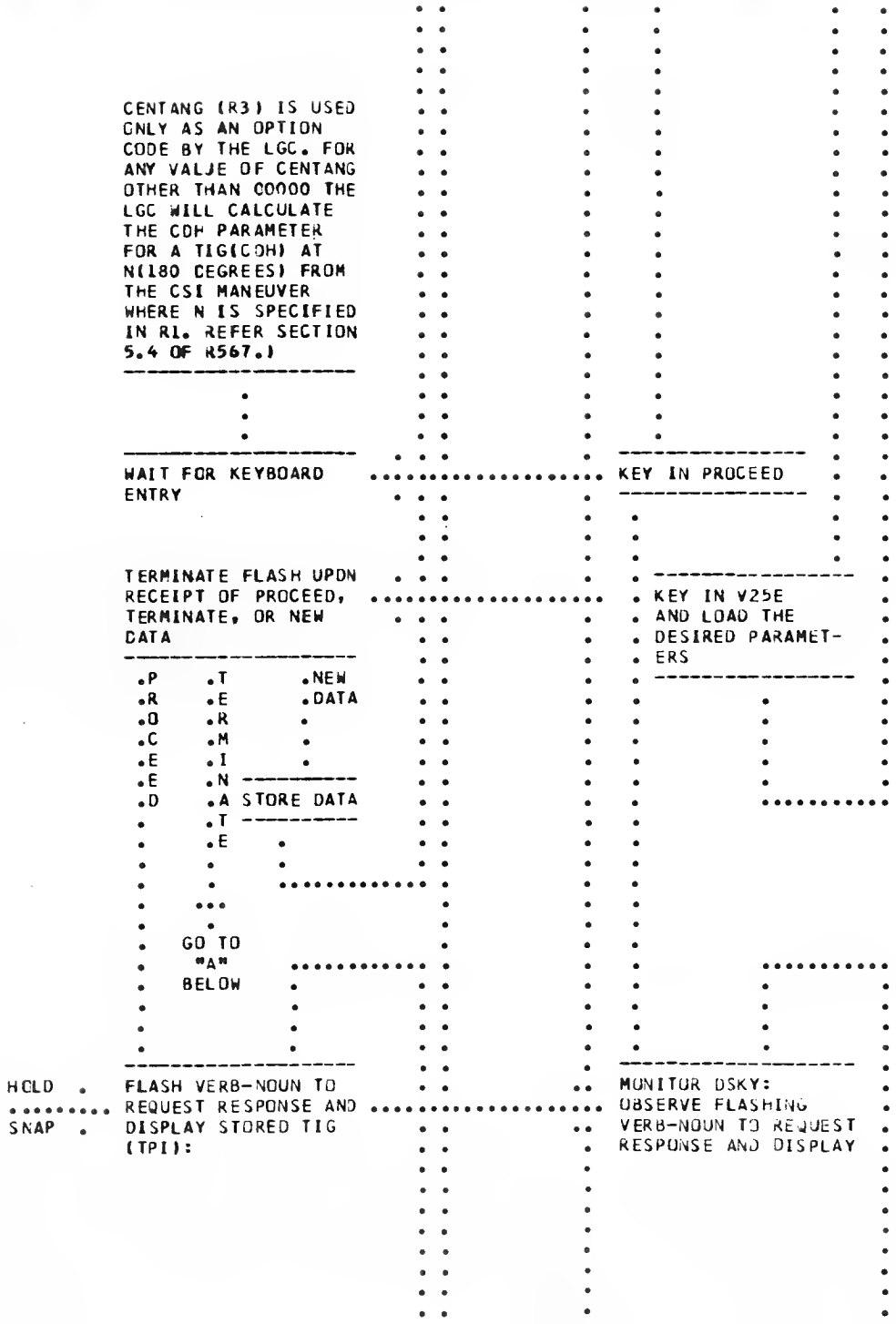
#120

#130

#140


TERMINATE FLASH UPON RECEIPT OF PROCEED, TERMINATE, OR NEW DATA
PROCEED
TERMINATE
NEW DATA
STORE DATA
GO TO "A" BELOW
KEY IN PROCEED
#150
#160
IS THE VALUE OF TIG (CSI) NOW STORED = +00000 +00000 +00000 OR IS TIG(CSI) A NEGATIVE NUMBER?
HAS A CALL BEEN MADE FOR COMPUTATION OF T(APOAPSIS)? (NOTE: THE LGC WILL RESPOND TO A NEGATIVE LOAD IN THE SAME FASHION THAT IT WOULD RESPOND TO A ZERO LOAD.)
#170
N
Y
N
Y
#180
COMPUTE T(APOAPSIS) AND STORE IN TIG(CSI)
#190


HOLD
SNAP
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY STORED N, E AND CENTANG.
V06 N55
R1-N
R2-E
R3-CENTANG
N - THE FUTURE APSIDAL CROSSING (APOGEE OR PERIGEE (APOLUNE OR PERILUNE)) OF THE ACTIVE VEHICLE AT WHICH TIG(COH) SHOULD OCCUR. 00001=FIRST, 00002=SECOND, ETC.
E - ELEVATION ANGLE. THE ANGLE BETWEEN THE LM/CSM LOS AND THE LM LOCAL HORIZONTAL PLANE AT TIG (TPI) REFERENCED TO THE DIRECTION OF FLIGHT (SEE SECTION 5.4 OF R567 FOR DETAILED DESCRIPTION). IN DEGREES TO NEAREST .01 DEG.
CENTANG - THE ORBITAL CENTRAL ANGLE OF THE PASSIVE VEHICLE DURING TRANSFER FROM TIG(TPI) TO TIME OF INTERCEPT. IN DEGREES TO NEAREST .01 DEGREE.
(NOTE: IN THIS CASE
MONITOR OSKY: OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY OF N, E, AND CENTANG
#200
AM I SATISFIED WITH THESE VALUES?
(NOTE: R3 WILL BE ORIGINALLY DISPLAYED AS 00000. IF THE CREW WISHES TO EXERCISE THE N(180 DEGREES) OPTION FOR CDH MANEUVER DEFINITION, LOAD ANY NUMBER OTHER THAN 00000 IN R3. REFER SECTION 5.4 OF R567.)
#210
.Y
.N
RECORD THESE VALUES
#220
#230



#240

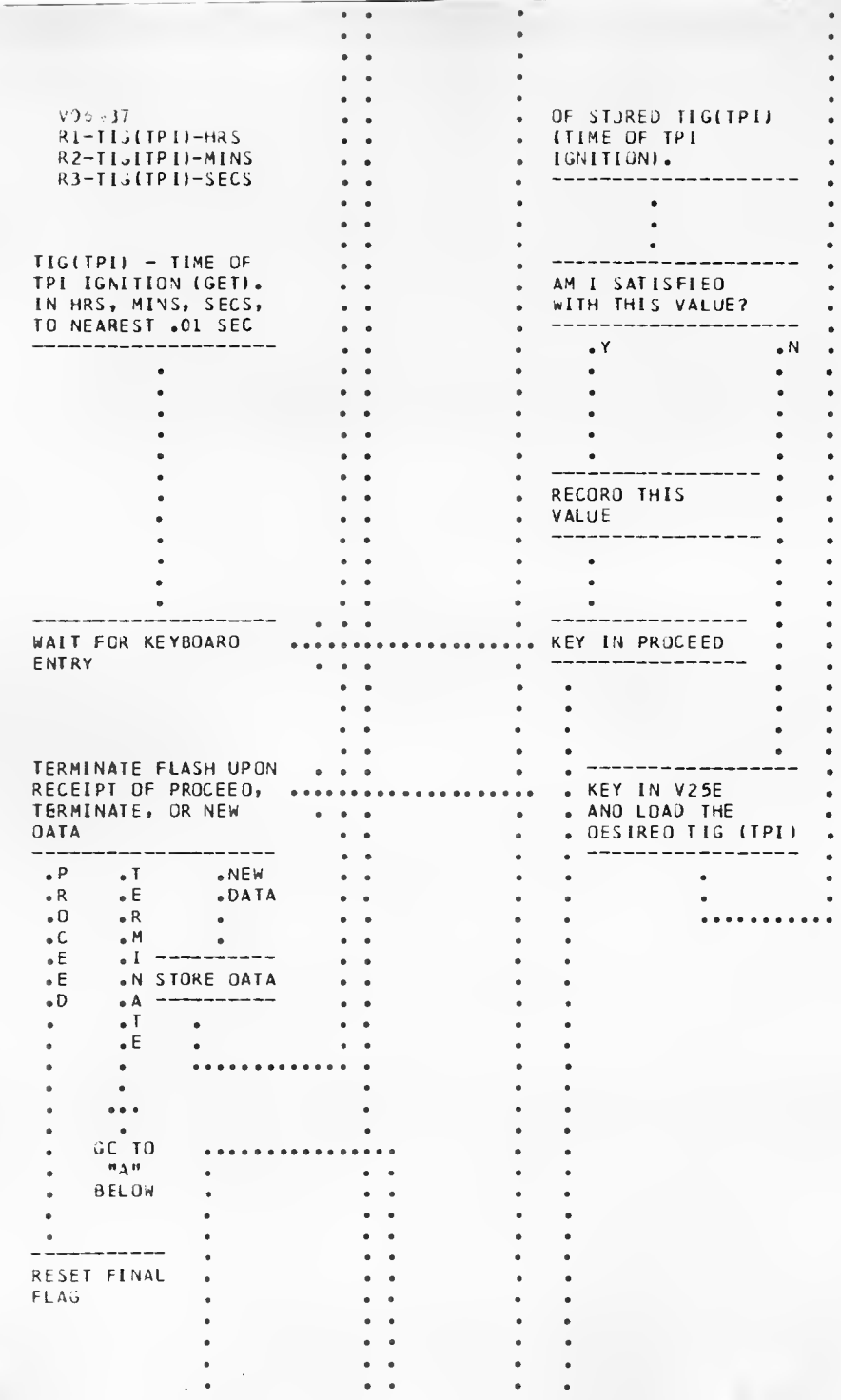
#250

#260

#270

#280

#290



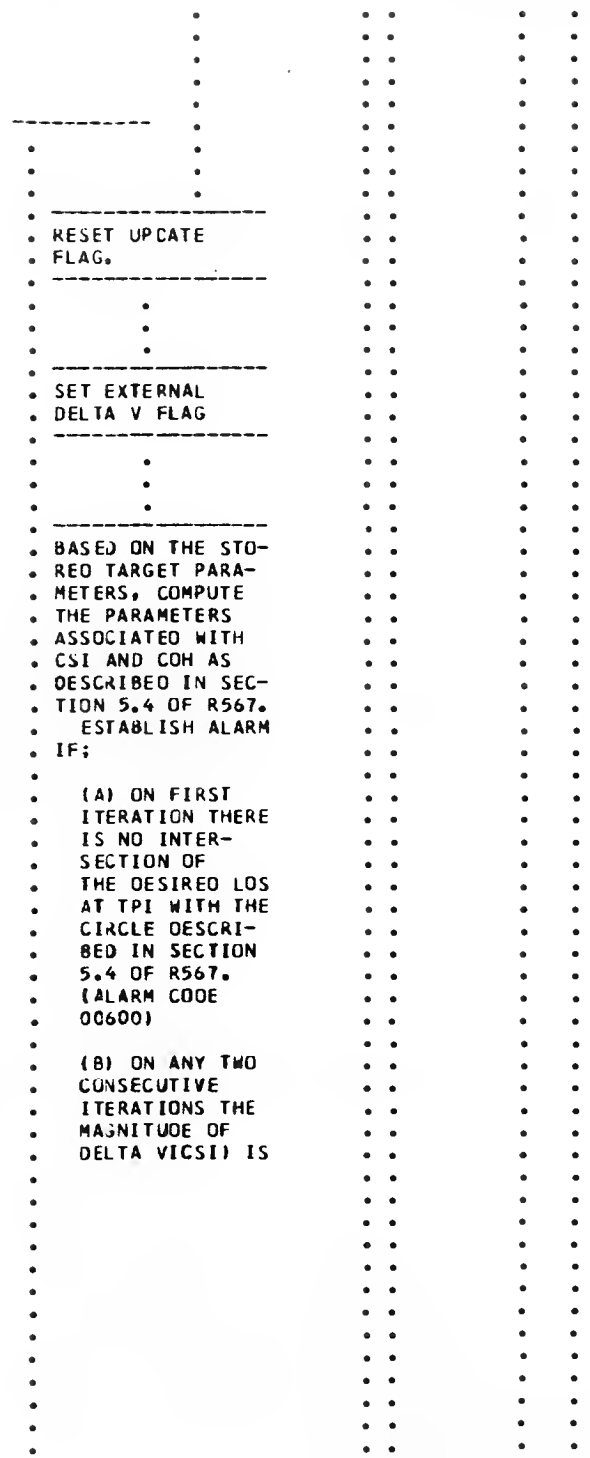
#300

#310

#320

#330

#340



#350

#360

#370

#380

#390

GREATER THAN
1000 FPS.
(ALARM CODE
00606)

#400

(C) THE ITERA-
TION COUNTER
EXCEEDS 15
WITHOUT ARRI-
VING AT A PRO-
BLEM SOLUTION.
(ALARM CODE
00605)

(D) PERICENTER
ALT (POST CSI)
IS LESS THAN
35,000 FT.
(LUNAR ORBIT)
OR 85 NM (EARTH
ORBIT).
(ALARM CODE
00601)

#410

(E) PERICENTER
ALT (POST CDH)
IS LESS THAN
35,000 FT
(LUNAR ORBIT)
OR 85 NM (EARTH
ORBIT) (ALARM
CODE 00602)

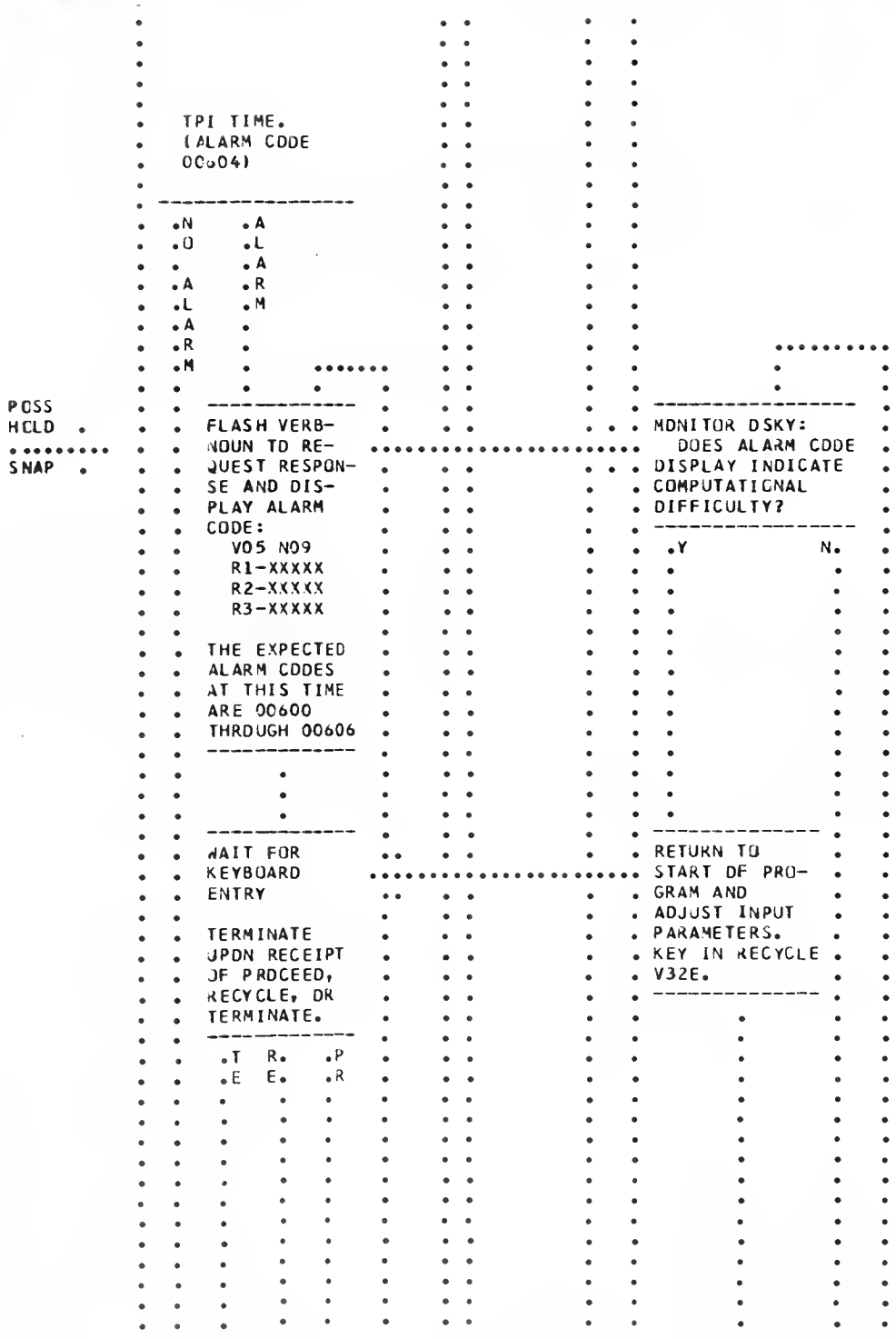
#420

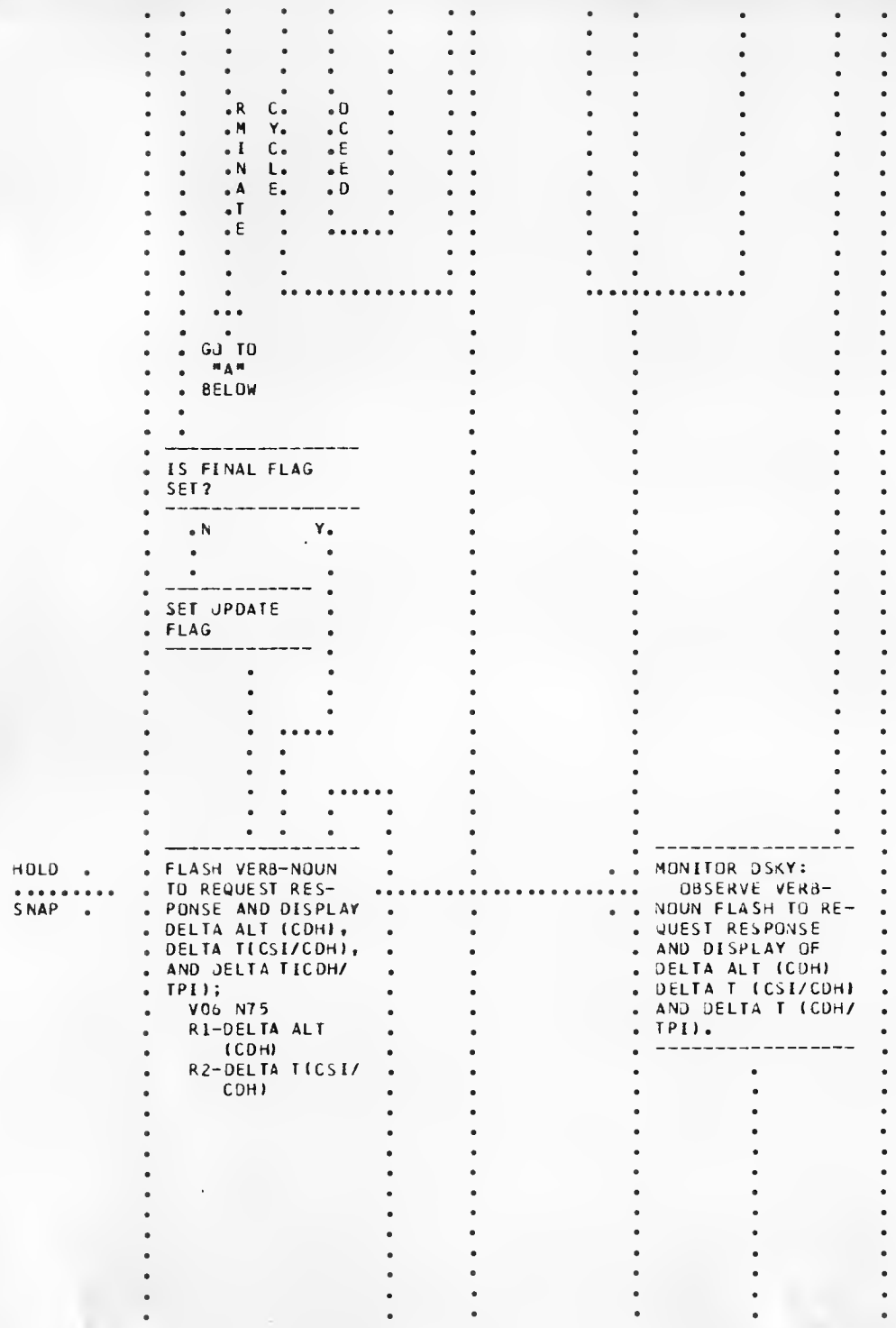
(F) TIG(CDH) -
TIG(CSI) IS
LESS THAN 10
MIN. (ALARM
CODE 00603)

#430

(G) TIG(TPI) -
TIG(CDH) IS
LESS THAN 10
MIN OR COM-
PUTED CDH
TIME IS
GREATER
THAN INPUT

#440


TPI TIME.
(ALARM CODE
00604)
NO ALARM
FLASH VERB-
NOUN TO RE-
QUEST RESPON-
SE AND DIS-
PLAY ALARM
CODE:
V05 N09
R1-XXXXX
R2-XXXXX
R3-XXXXX
THE EXPECTED
ALARM CODES
AT THIS TIME
ARE 00600
THRDUGH 00606
WAIT FOR
KEYBOARD
ENTRY
TERMINATE
UPDN RECEIPT
OF PROCEED,
RECYCLE, OR
TERMINATE.
TER
PRO
MONITOR DSKY:
DOES ALARM CODE
DISPLAY INDICATE
COMPUTATIONAL
DIFFICULTY?
Y
N
RETURN TO
START OF PRO-
GRAM AND
ADJUST INPUT
PARAMETERS.
KEY IN RECYCLE
V32E.
POSS
HOLD
SNAP
#450
#460
#470
#480
#490



#500

#510

#520

#530

#540

R3-DELTA T(CDH/TPI)

DELTA ALT(CDH) - THE ALTITUDE BETWEEN THE ACTIVE AND PASSIVE VEHICLE ORBITS AT TIG(CDH). SIGN IS + WHEN THE ACTIVE VEHICLE IS BELOW THE PASSIVE VEHICLE. IN NAUTICAL MILES TO NEAREST .1 NM.

DELTA T(CSI/CDH)- TIG(CDH) MINUS TIG (CSI). COMPUTED IN HRS, MINS, SECS OF WHICH ONLY THE MINS AND SECS ARE DISPLAYED. TO NEAREST SEC.

DELTA T(CDH/TPI)- TIG(TPI) MINUS TIG (CDH). COMPUTED IN HRS, MINS, SECS, OF WHICH ONLY THE MINS AND SECS ARE DISPLAYED. TO NEAREST SEC. (NOTE: R2 AND R3 ARE MODULARIZED TO THE HOUR, I.E., 63 MINS 22 SECS IS DISPLAYED AS 03B22)

(NOTE: TIG(CDH) IS AVAILABLE BY KEYING IN V06N13.)

RECORD THESE VALUES

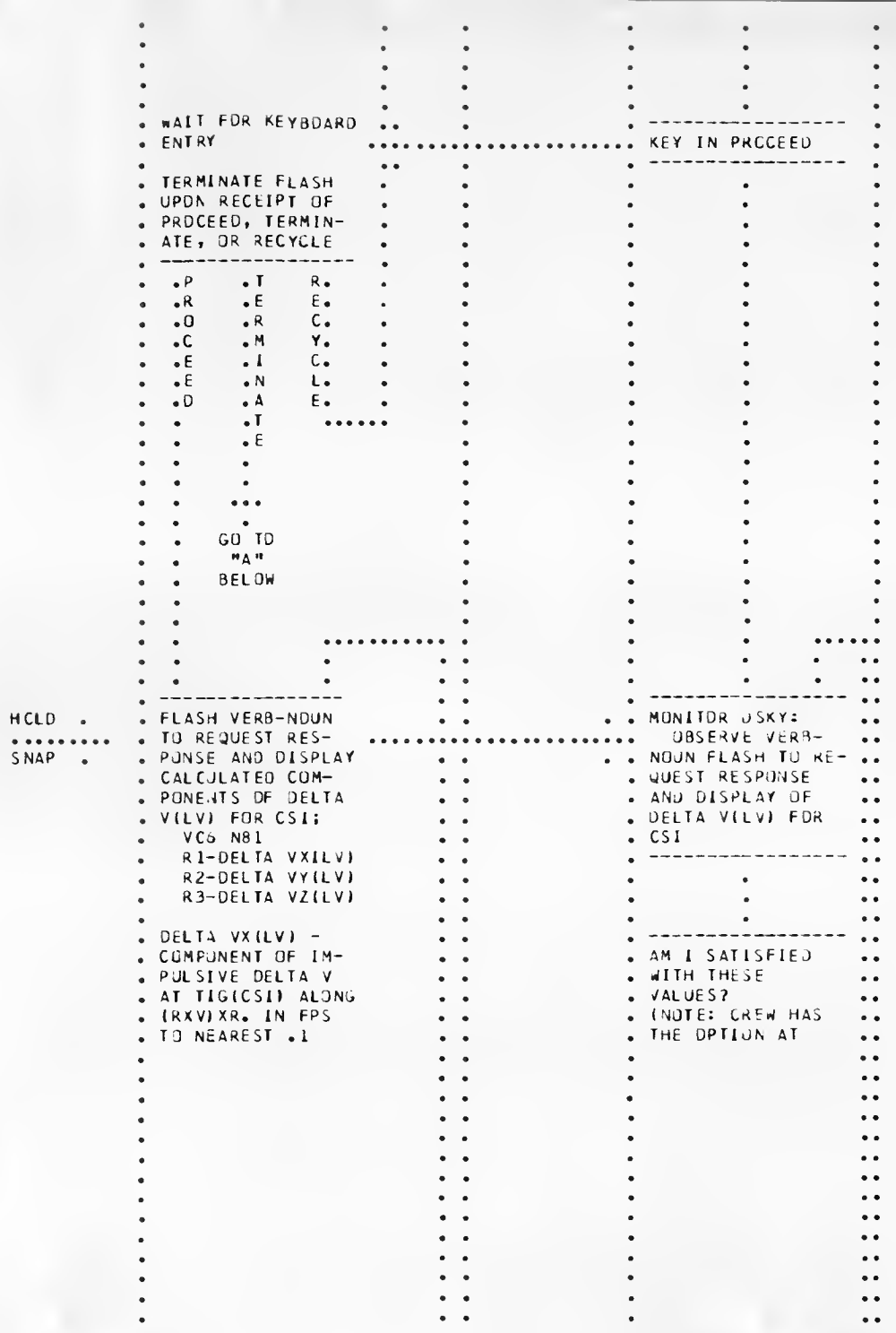
#550

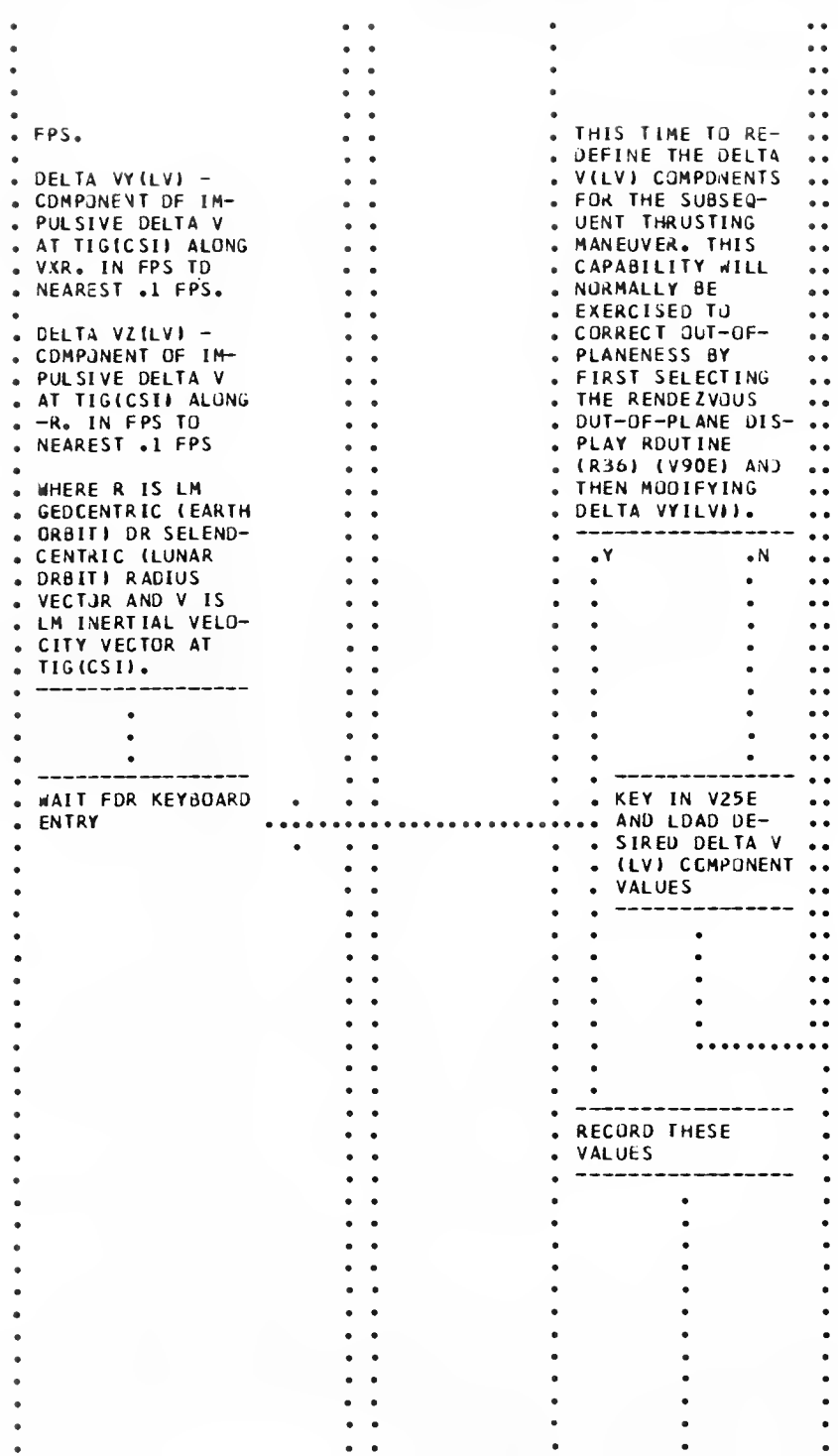
#560

#570

#580

#590


WAIT FOR KEYBOARD ENTRY
TERMINATE FLASH UPON RECEIPT OF PROCEED, TERMINATE, OR RECYCLE
PROCEED
TERMINATE
RECYCLE
GO TO "A" BELOW
KEY IN PROCEED
#600
#610
#620
HOLD
SNAP
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY CALCULATED COMPONENTS OF DELTA V(LV) FOR CSI:
VC6 N81
R1-DELTA VX(LV)
R2-DELTA VY(LV)
R3-DELTA VZ(LV)
DELTA VX(LV) - COMPONENT OF IMPULSIVE DELTA V AT TIG(CSI) ALONG (RXV)XR. IN FPS TO NEAREST .1
MONITOR OSKY: OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY OF DELTA V(LV) FOR CSI
#630
AM I SATISFIED WITH THESE VALUES? (NOTE: CREW HAS THE OPTION AT
#640



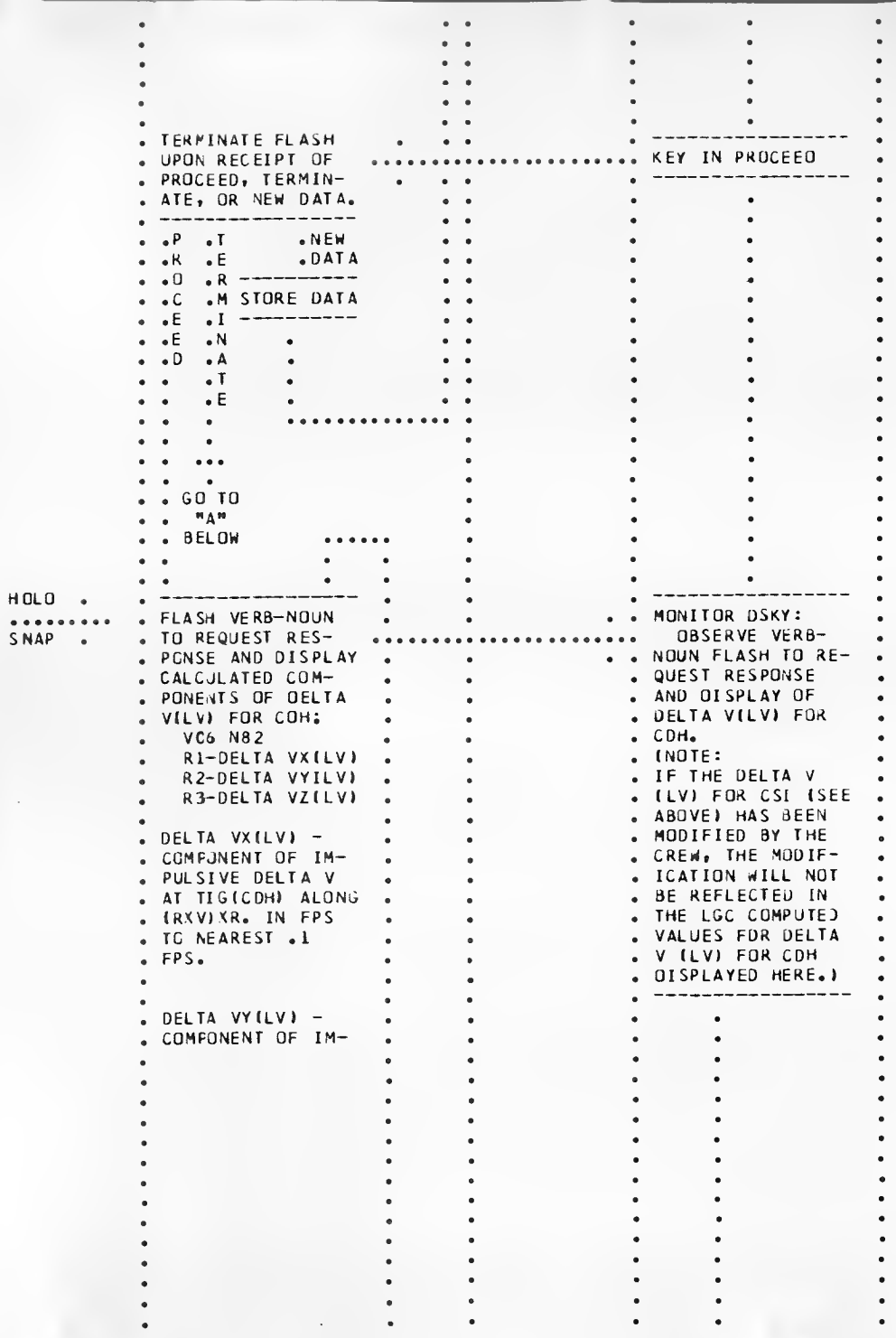
#650

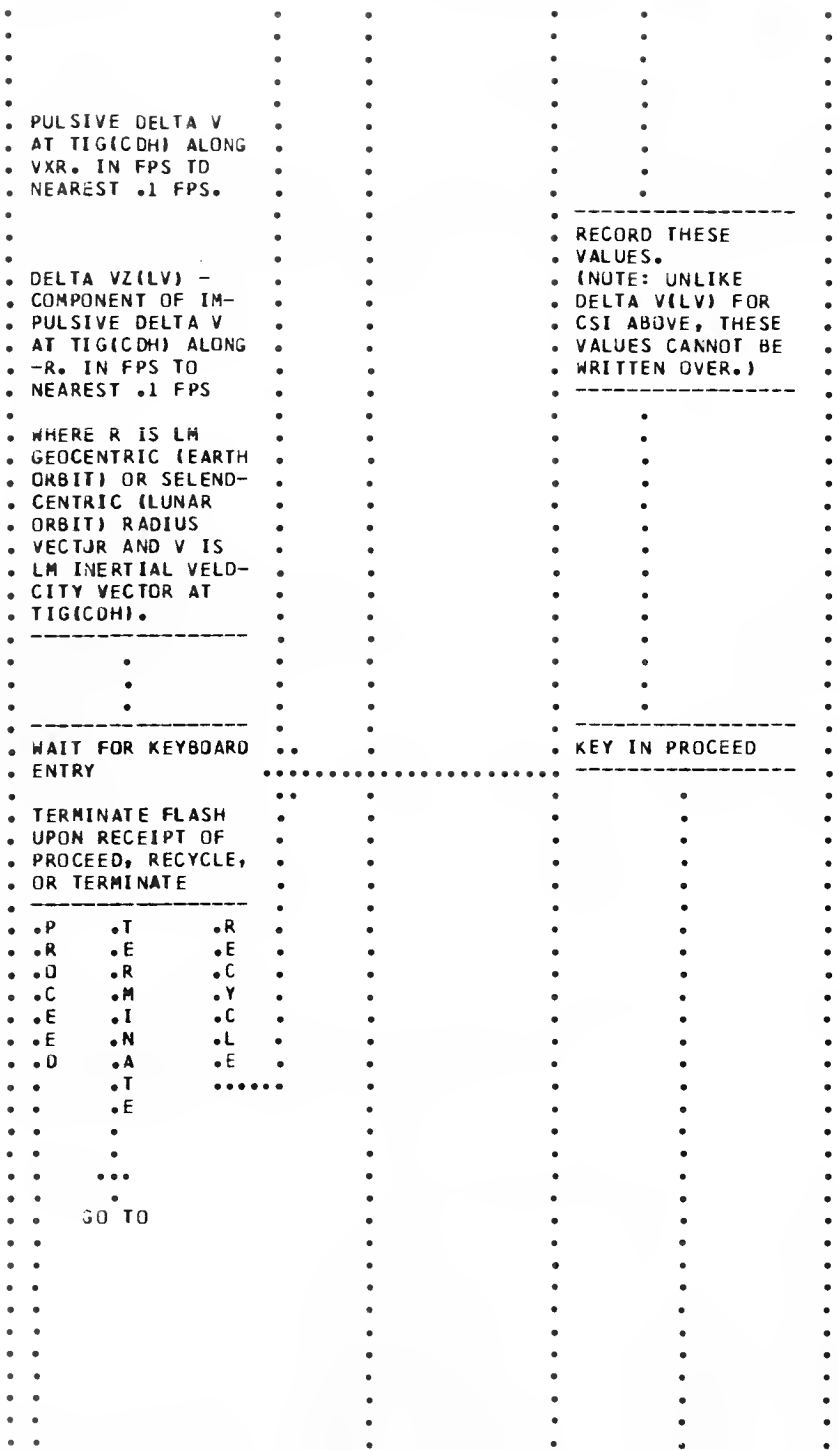
#660

#670

#680

#690


TERMINATE FLASH
UPON RECEIPT OF
PROCEED, TERMIN-
ATE, OR NEW DATA.
PROCEED
TERMINATE
NEW DATA
STORE DATA
GO TO
"A"
BELOW
KEY IN PROCEED
HOLO
SNAP
FLASH VERB-NOUN
TO REQUEST RES-
PONSE AND DISPLAY
CALCULATED COM-
PONENTS OF DELTA
V(LV) FOR COH:
VC6 N82
R1-DELTA VX(LV)
R2-DELTA VY(LV)
R3-DELTA VZ(LV)
DELTA VX(LV) -
COMPONENT OF IM-
PULSIVE DELTA V
AT TIG(CDH) ALONG
(RXV)XR. IN FPS
TO NEAREST .1
FPS.
DELTA VY(LV) -
COMPONENT OF IM-
MONITOR DSKY:
OBSERVE VERB-
NOUN FLASH TO RE-
QUEST RESPONSE
AND DISPLAY OF
DELTA V(LV) FOR
CDH.
(NOTE:
IF THE DELTA V
(LV) FOR CSI (SEE
ABOVE) HAS BEEN
MODIFIED BY THE
CREW, THE MODIF-
ICATION WILL NOT
BE REFLECTED IN
THE LGC COMPUTED
VALUES FOR DELTA
V (LV) FOR CDH
DISPLAYED HERE.)
#700
#710
#720
#730
#740



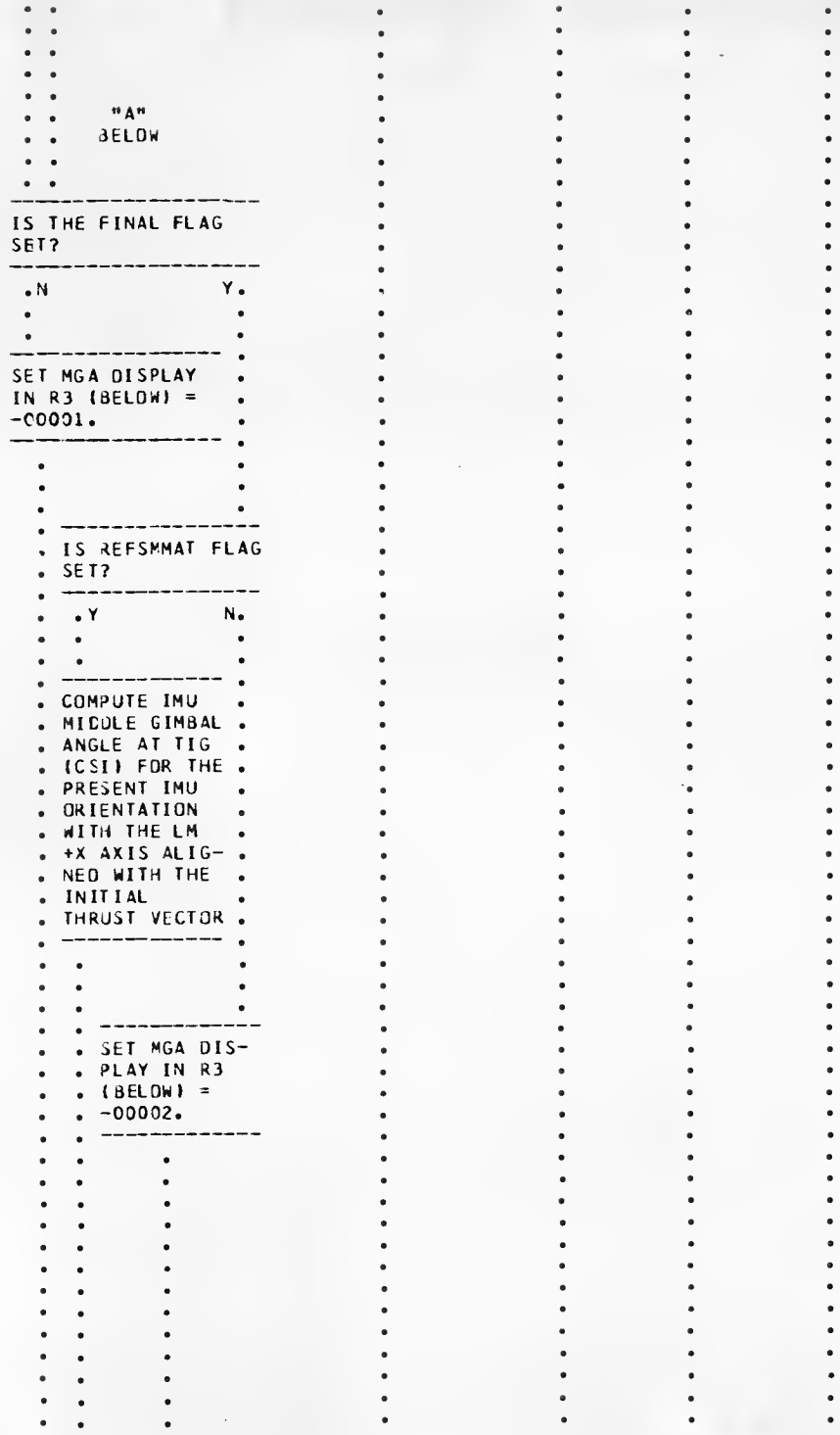
#750

#760

#770

#780

#790



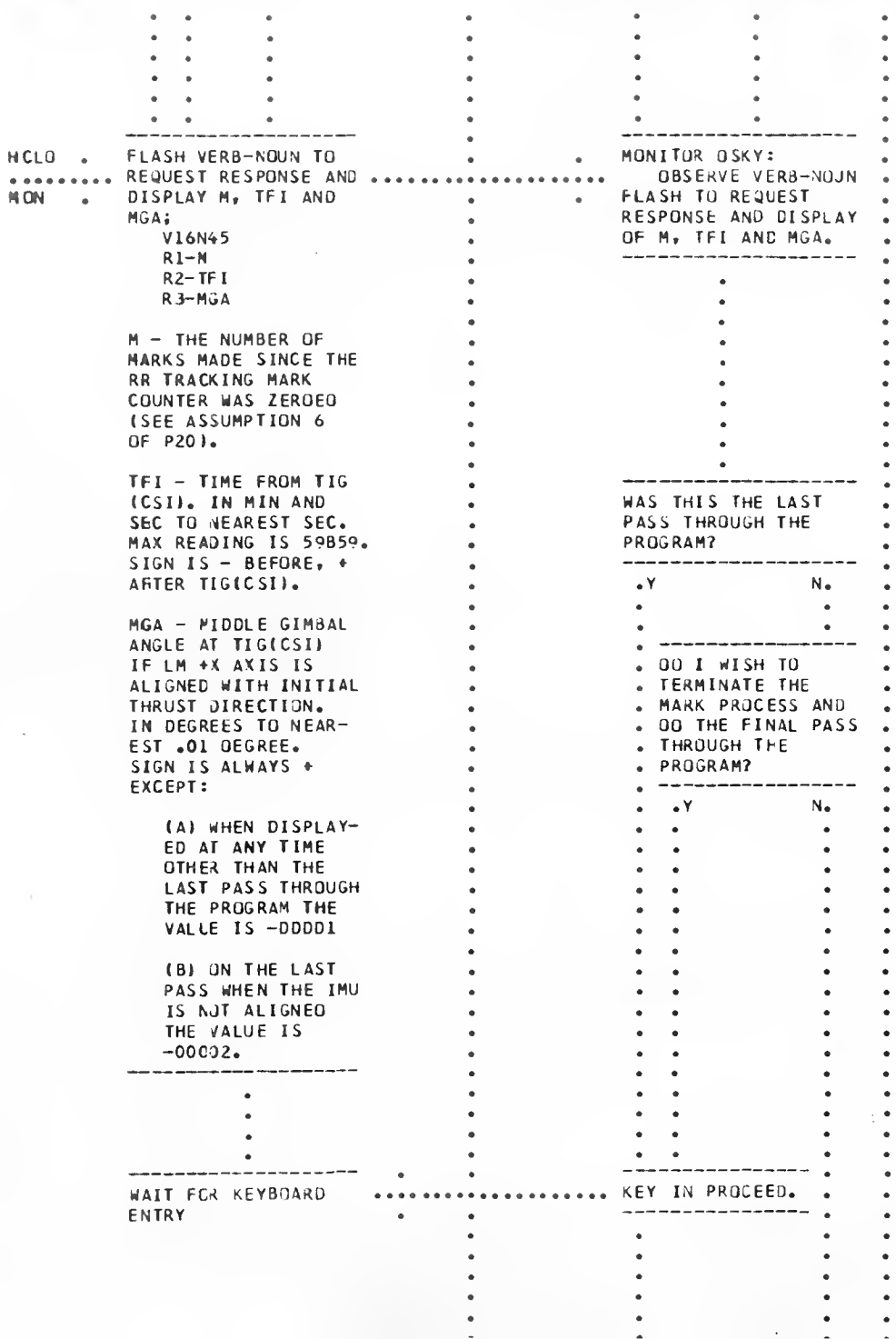
#800

#810

#820

#830

#840



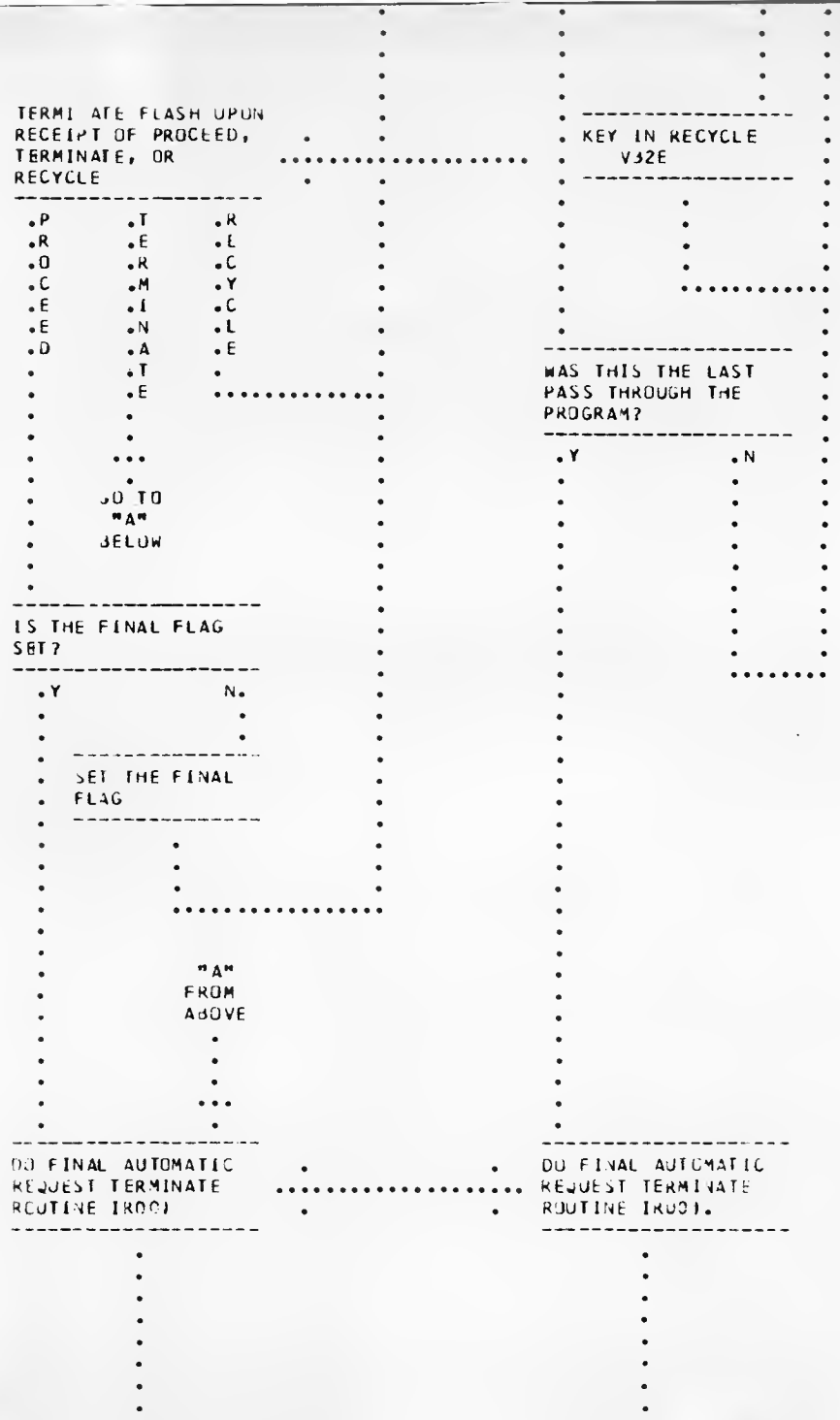
#850

#860

#870

#880

#890



#900

#910

#920

#930

#940

#950

EXIT P32

EXIT P32

221

CHANGE CONTROL NOTES

REV 01 PCR 254,540,623
REV OCILUM 1A) PCR 695, 752
REV 02 EDITORIAL
REV 03 EDITORIAL
REV 04 PCN 1009

CONSTANT DELTA ALTITUDE (CDH) PROGRAM (P33) REV 04 12/01/71

PURPOSE: (1) TO CALCULATE PARAMETERS ASSOCIATED WITH THE CONSTANT DELTA ALTITUDE MANEUVER (CDH), FOR DELTA V BURNS.

(2) TO CALCULATE THESE PARAMETERS BASED UPON MANEUVER DATA APPROVED AND KEYED INTO THE LGC BY THE ASTRONAUT.

(3) TO DISPLAY TO THE ASTRONAUT AND THE GROUND DEPENDENT VARIABLES ASSOCIATED WITH THE CDH MANEUVER FOR APPROVAL BY THE ASTRONAUT/GROUND.

(4) TO STORE THE CDH TARGET PARAMETERS FOR USE BY THE DESIRED THRUSTING PROGRAM.

ASSUMPTIONS: (1) THIS PROGRAM IS BASED UPON PREVIOUS COMPLETION OF THE CO-ELLIPTIC SEQUENCE INITIATION (CSI) PROGRAM (P32). THEREFORE:

(A) AT A SELECTED TPI TIME (NOW IN STORAGE) THE LINE OF SIGHT BETWEEN THE LM AND THE CSM WAS SELECTED TO BE A PRESCRIBED ANGLE (E) (NOW IN STORAGE) FROM THE HORIZONTAL PLANE DEFINED AT THE ACTIVE VEHICLE POSITION.

(B) THE TIME BETWEEN CSI IGNITION AND CDH IGNITION WAS COMPUTED TO BE GREATER THAN 10 MINUTES.

(C) THE TIME BETWEEN CDH IGNITION AND TPI IGNITION WAS COMPUTED TO BE GREATER THAN 10 MINUTES.

(D) THE VARIATION OF THE ALTITUDE DIFFERENCE BETWEEN THE ORBITS WAS MINIMIZED.

(E) CSI BURN WAS DEFINED SUCH THAT THE IMPULSIVE DELTA V WAS IN THE LM HORIZONTAL PLANE AT CSI IGNITION.

(F) THE PERICENTER ALTITUDES OF THE ORBITS FOLLOWING CSI AND CDH WERE COMPUTED TO BE GREATER THAN 35,000 FT (LUNAR ORBIT) OR 85 NM FOR EARTH ORBIT.

(G) THE CSI AND CDH MANEUVERS WERE ASSUMED TO BE PARALLEL TO THE PLANE OF THE CSM ORBIT. HOWEVER, CREW MODIFICATION OF DELTA V (LV) COMPONENTS MAY HAVE RESULTED IN AN OUT-OF-PLANE CSI MANEUVER.

(2) LGC COMPUTED VARIABLES MAY BE STORED FOR LATER VERIFICATION BY THE GROUND. THESE STORAGE CAPABILITIES ARE NORMALLY LIMITED ONLY TO THE PARAMETERS FOR ONE THRUSTING MANEUVER AT A TIME EXCEPT FOR CONCENTRIC FLIGHT PLAN MANEUVER SEQUENCES.

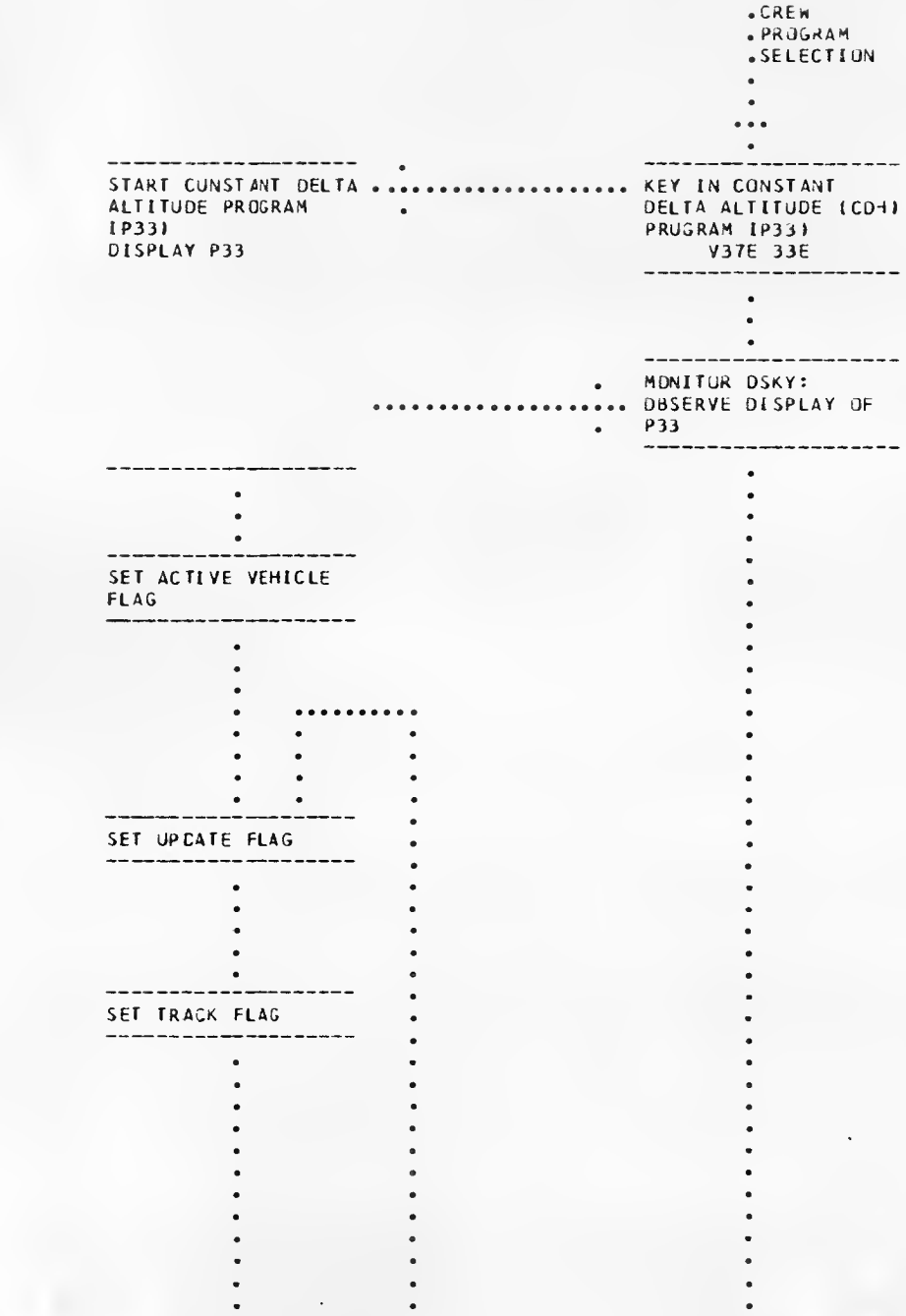
(3) THE RENDEZVOUS RADAR MAY OR MAY NOT BE USED TO UPDATE THE LM OR CSM STATE VECTORS FOR THIS PROGRAM. IF RADAR USE IS DESIRED THE RADAR WAS TURNED ON AND LOCKED ON THE CSM BY PREVIOUS SELECTION OF P20. RADAR SIGHTING MARKS WILL BE MADE AUTOMATICALLY APPROXIMATELY ONCE A MINUTE WHEN ENABLED BY THE TRACK AND UPDATE FLAGS (SEE P20). THE RENDEZVOUS TRACKING MARK COUNTER IS ZEROED BY THE SELECTION OF P20 AND AFTER EACH THRUSTING MANEUVER.

(4) THERE IS NO REQUIREMENT FOR ISS OPERATION DURING THIS PROGRAM UNLESS AUTOMATIC STATE VECTOR UPDATING IS DESIRED BY THE RENDEZVOUS NAVIGATION PROGRAM (P20). IF SELECTED, P20 WILL DEFINE THE STATUS OF THE ISS.

(5) THIS PROGRAM IS SELECTED BY THE ASTRONAUT BY DSKY ENTRY.

PROG	LGC	GROUND	CREW

CONT



#10

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#30

#40

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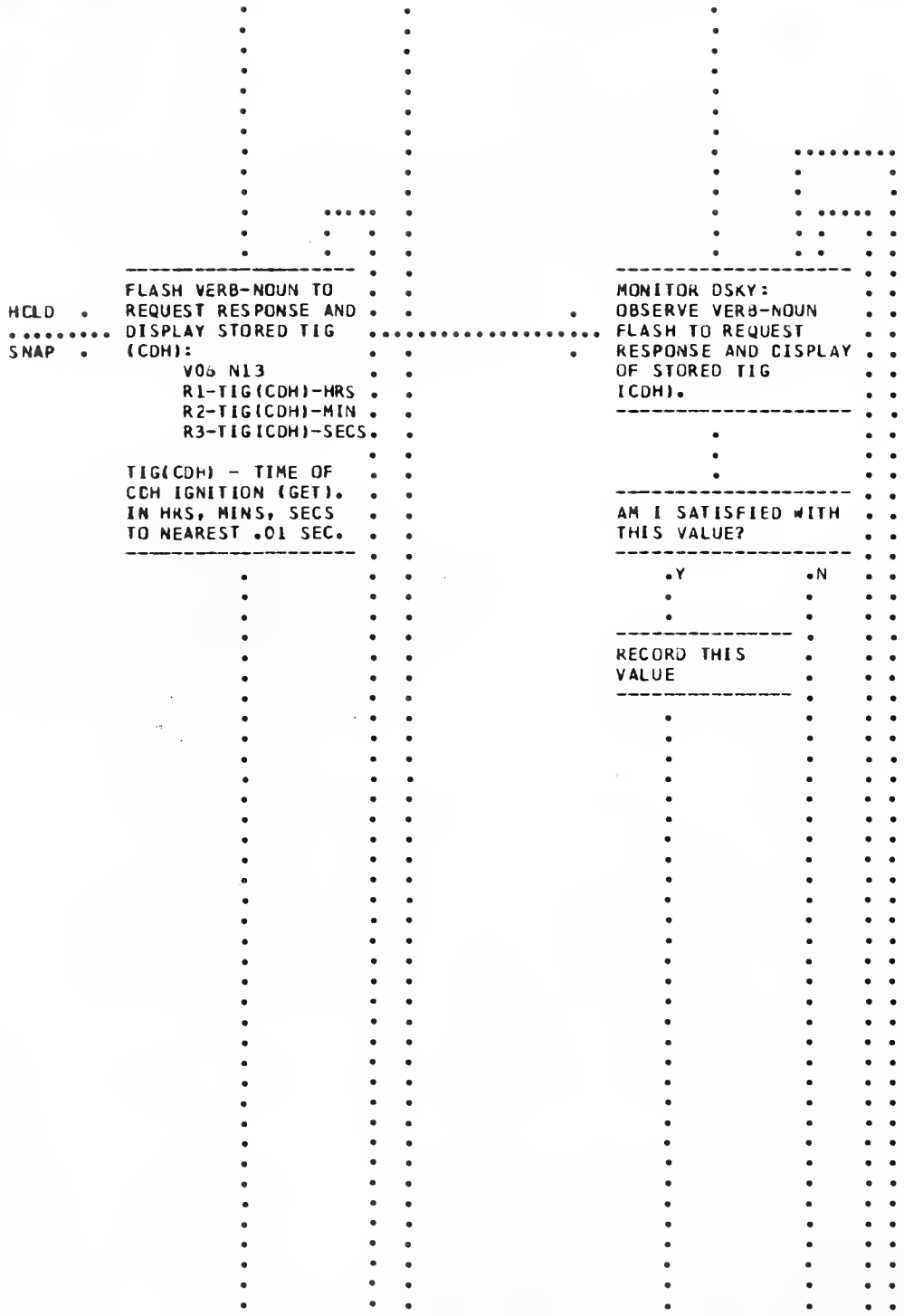

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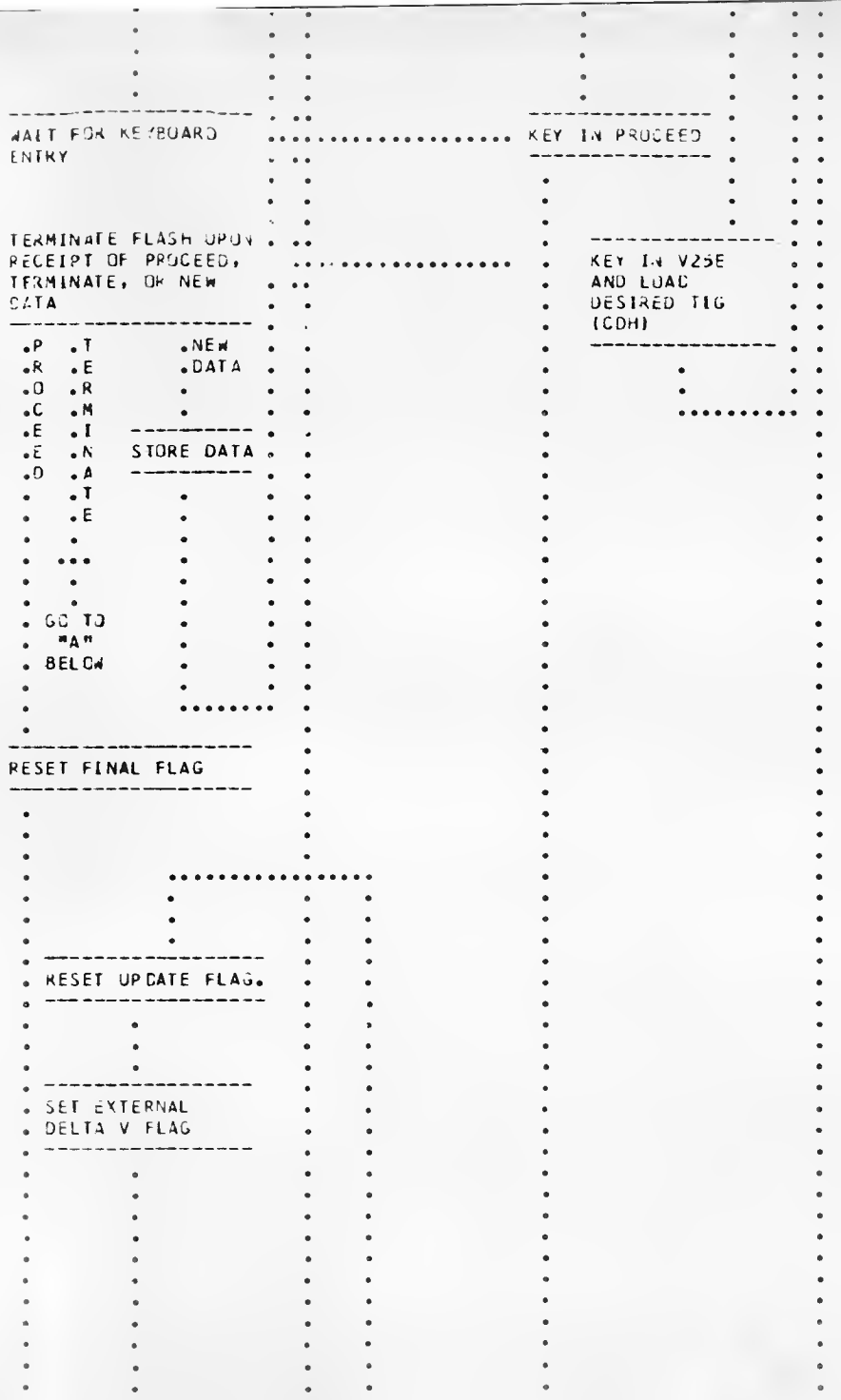

#110

#120

#130

#140

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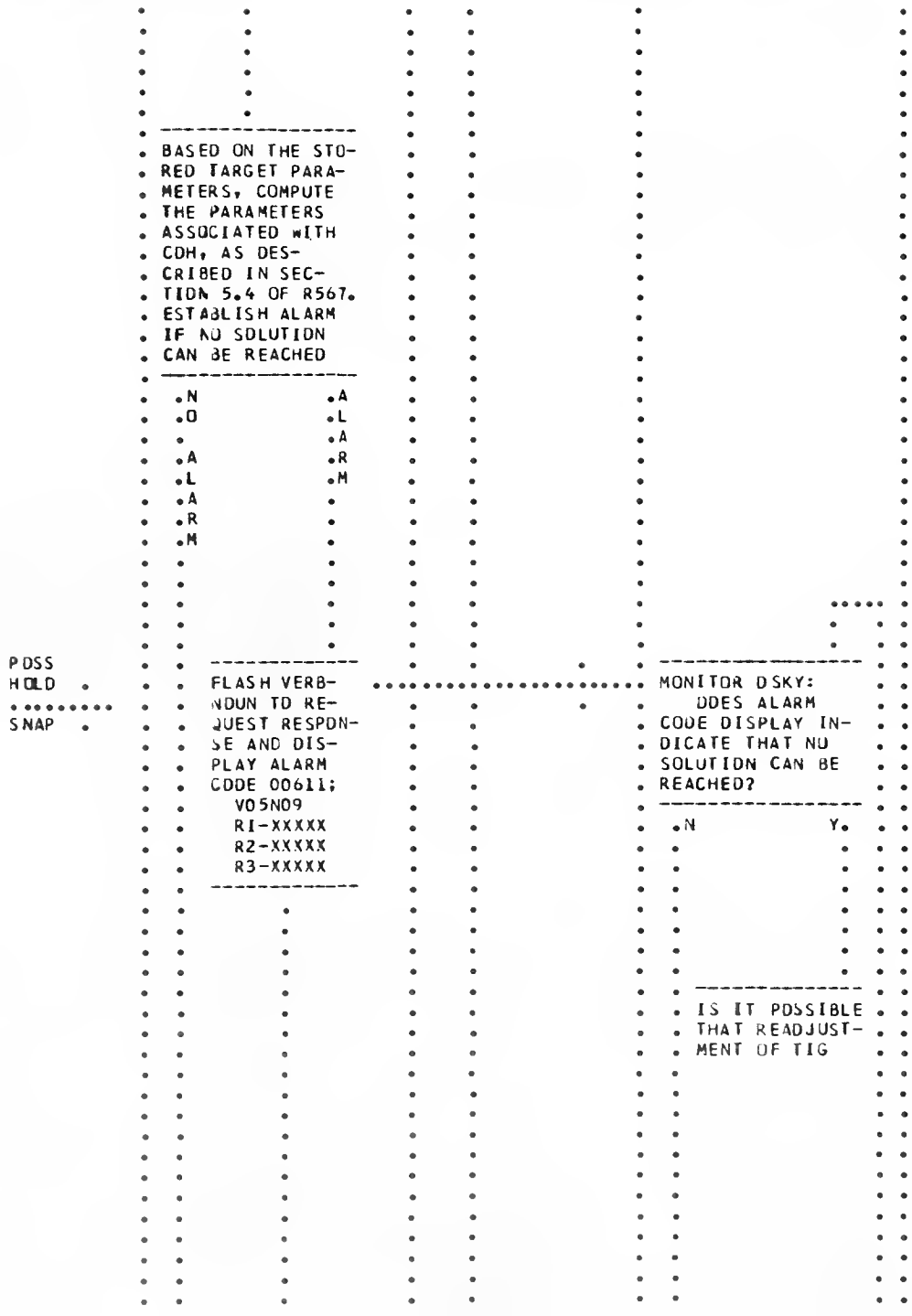
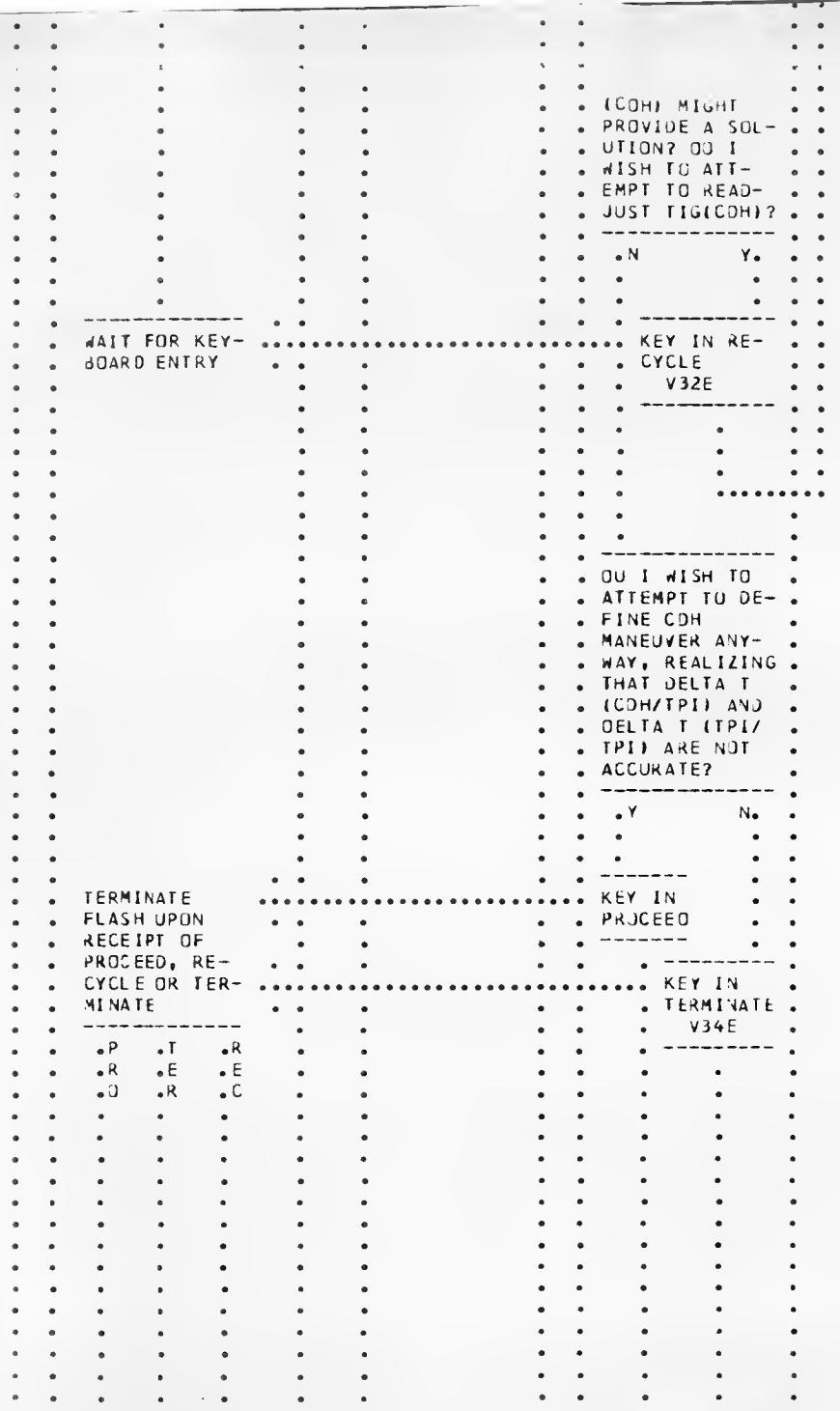


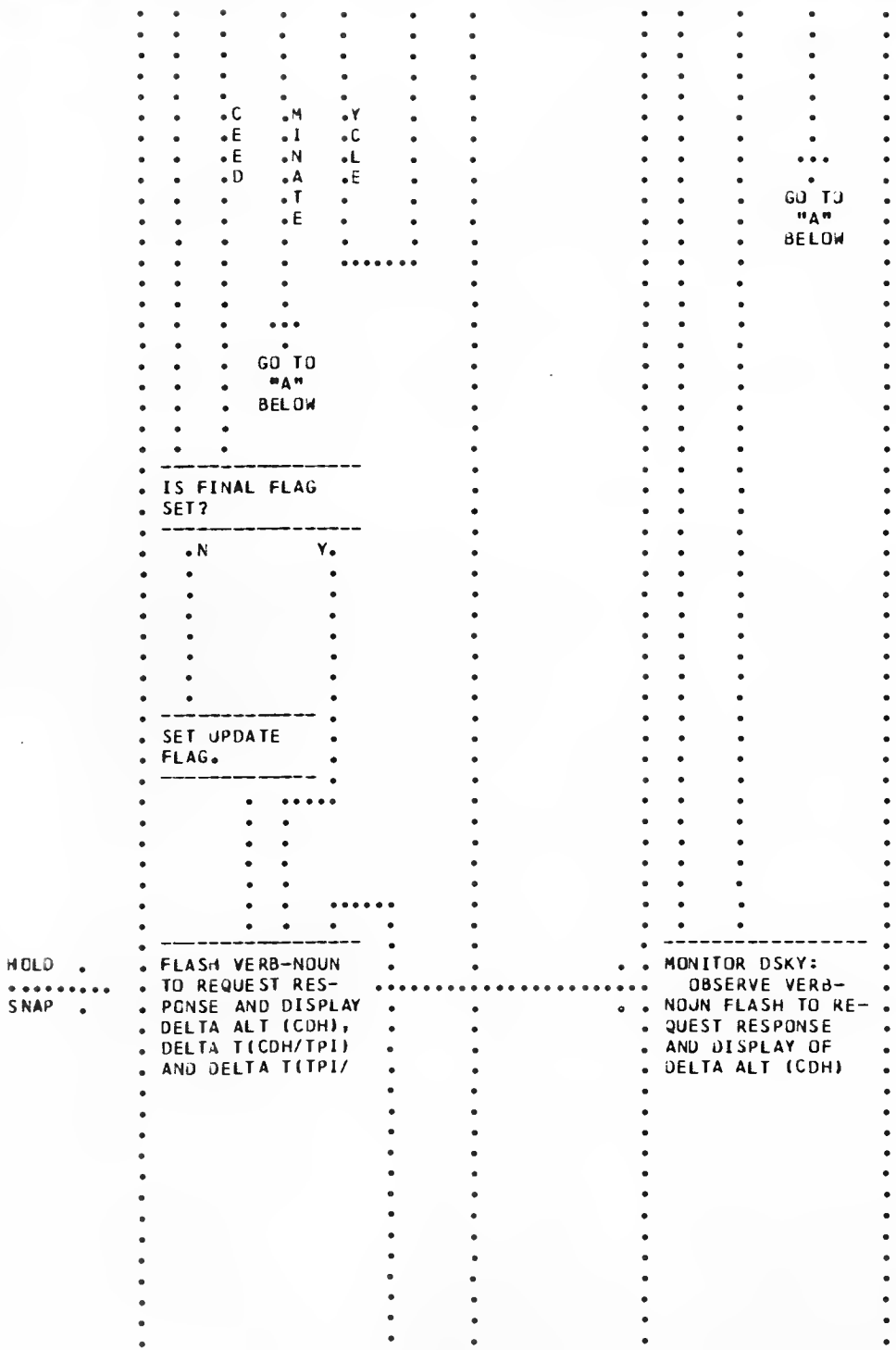
#160

#170

#180

#190


(COH) MIGHT PROVIDE A SOL- UTION? DO I WISH TO ATT- EMPT TO READ- JUST TIG(COH)?
.N Y.
#200
WAIT FOR KEY- BOARD ENTRY
KEY IN RE- CYCLE V32E
#210
#220
DO I WISH TO ATTEMPT TO DE- FINE COH MANEUVER ANY- WAY, REALIZING THAT DELTA T (COH/TPI) AND DELTA T (TPI/ TPI) ARE NOT ACCURATE?
.Y N.
#230
TERMINATE FLASH UPON RECEIPT OF PROCEED, RE- CYCLE OR TER- MINATE
.P .T .R .R .E .E .O .R .C
PROCEED
KEY IN PROCEED
#240
KEY IN TERMINATE V34E



#250

#260

#270

#280

#290

TPI);
VC6 N75
R1-DELTA ALT (CDH)
R2-DELTA T(CDH/TPI)
R3-DELTA T(TPI/TPI)

DELTA ALT(CDH) - THE ALTITUDE BETWEEN THE ACTIVE AND PASSIVE VEHICLE ORBITS AT TIG(CDH). SIGN IS + WHEN THE ACTIVE VEHICLE IS BELOW THE PASSIVE VEHICLE. IN NAUTICAL MILES TO THE NEAREST .1 NM

DELTA T(CDH/TPI)-TIG(TPI) AS DEFINED BY THIS PROGRAM MINUS TIG(CDH). COMPUTED IN HRS, MINS, AND SECS OF WHICH ONLY THE MINS AND SECS ARE DISPLAYED.

DELTA T(TPI/TPI)-TIG(TPI) AS DEFINED BY THIS PROGRAM MINUS TIG(TPI) AS DEFINED EARLIER BY P32. COMPUTED IN HRS, MINS, AND SECS OF WHICH ONLY THE MINS AND SECS ARE DISPLAYED.

++
+04 NOTE: R2 IS COMPUTED [DOUBLE]

DELTA T (CDH/TPI) AND DELTA T (TPI/TPI).

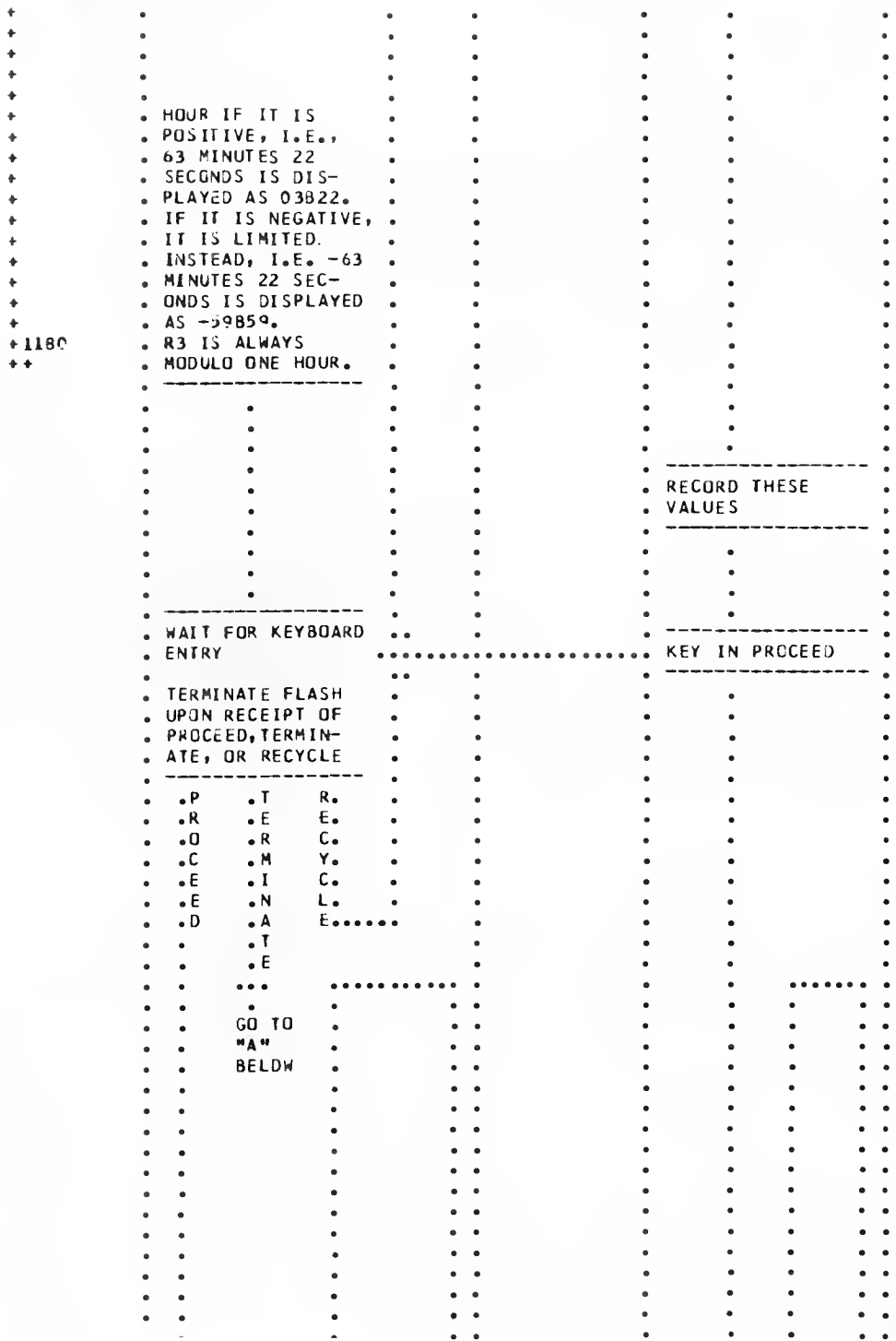
#300

#310

#320

#330

#340

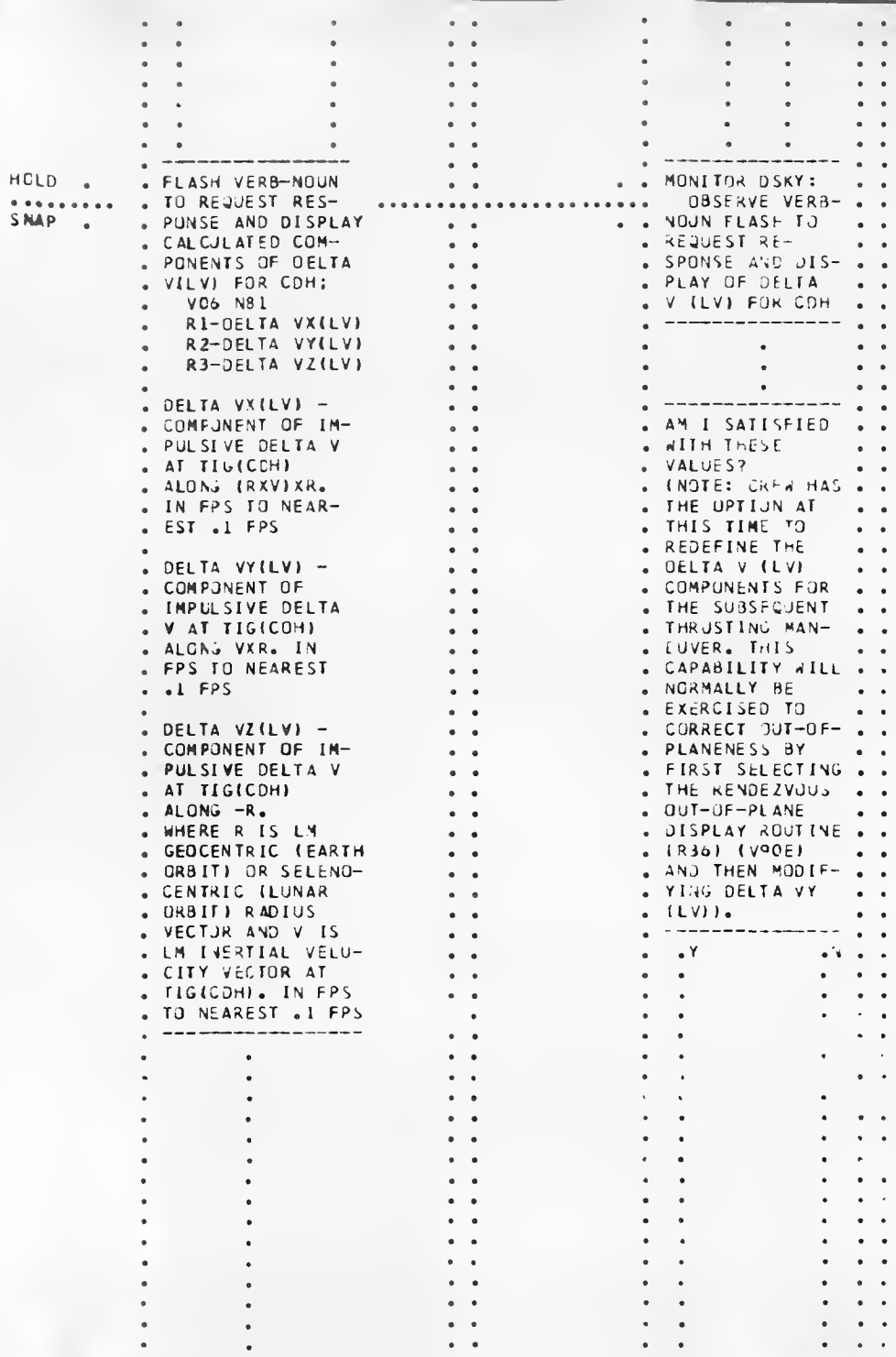


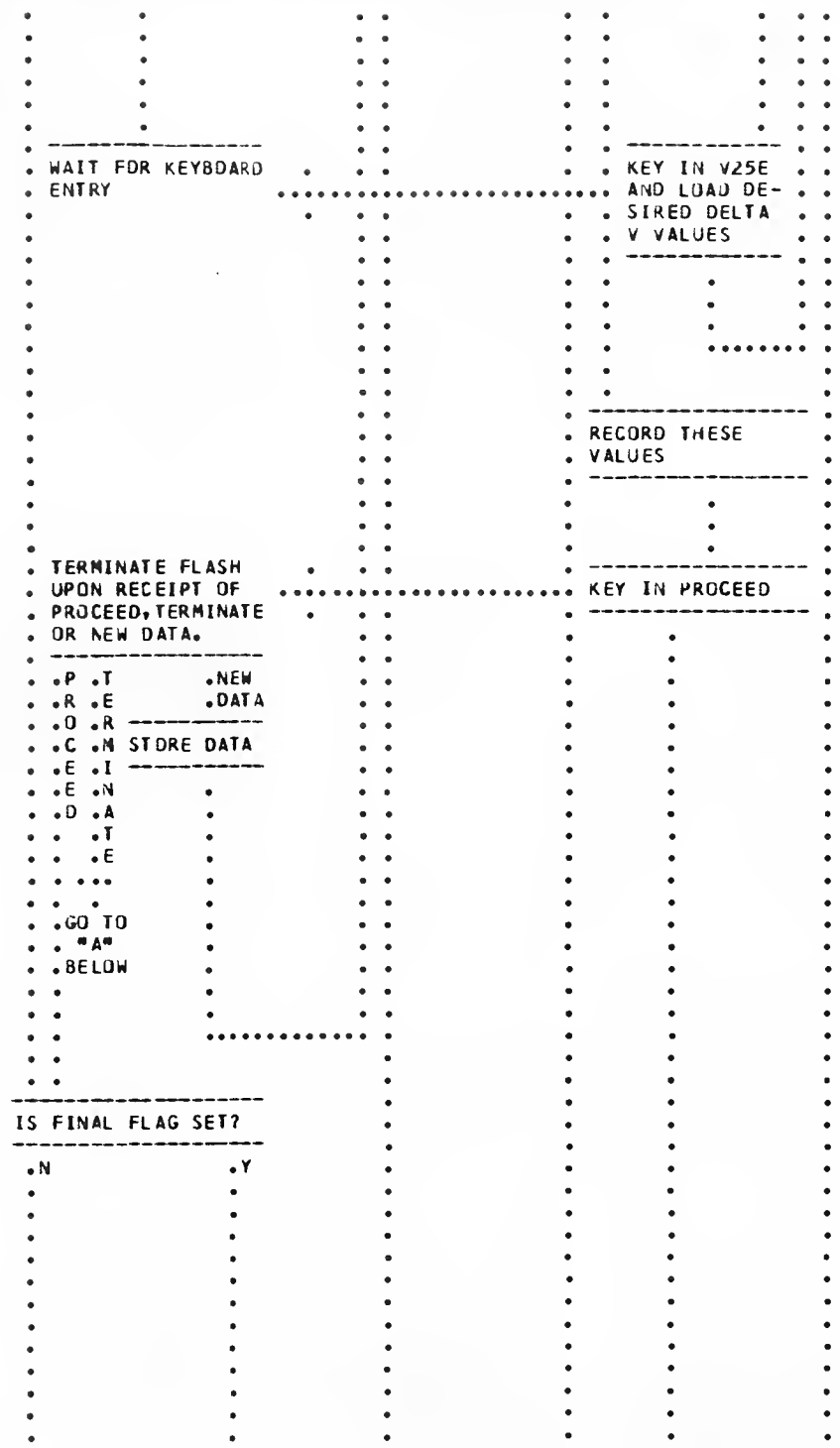
#350

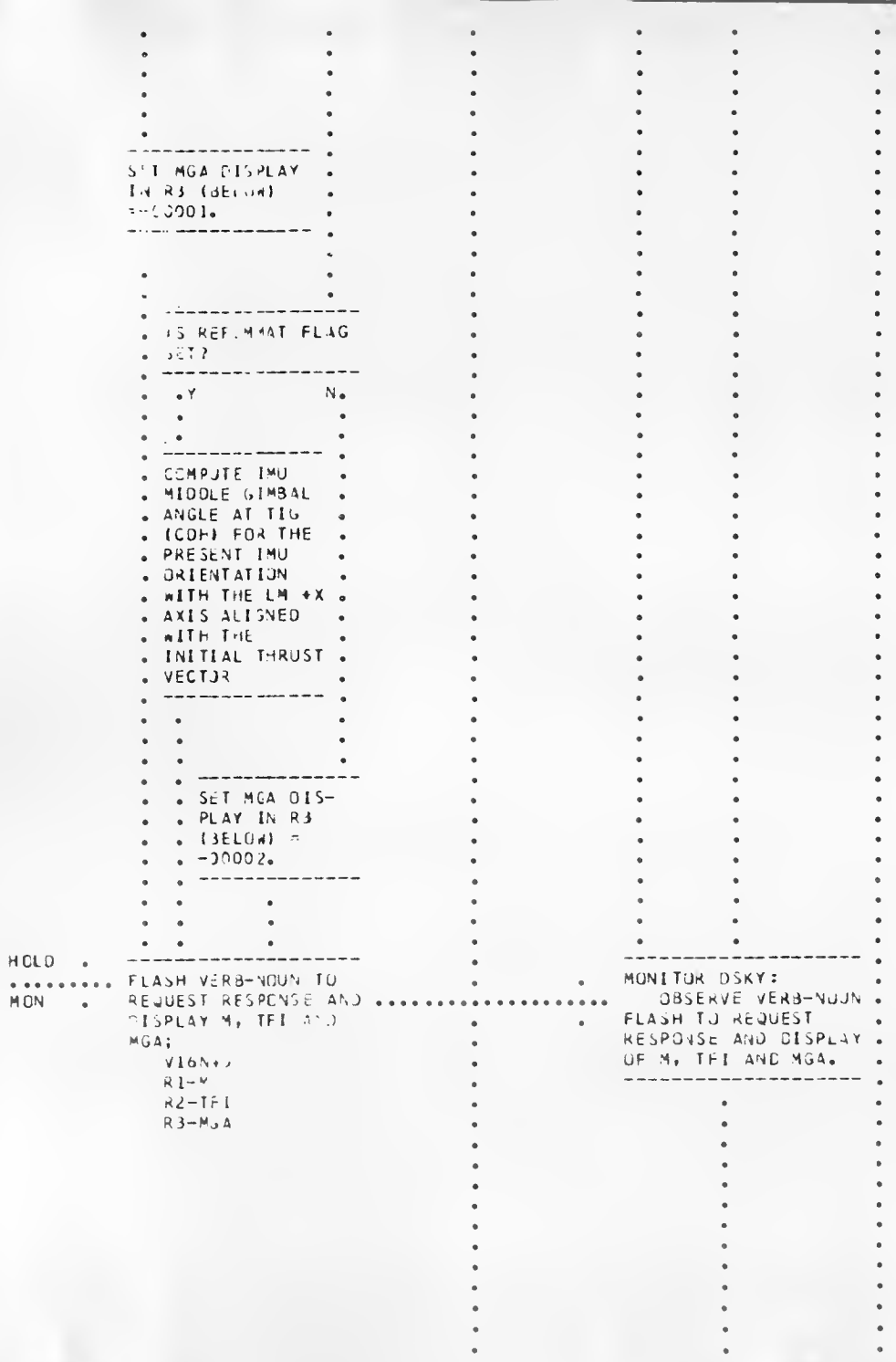
#360

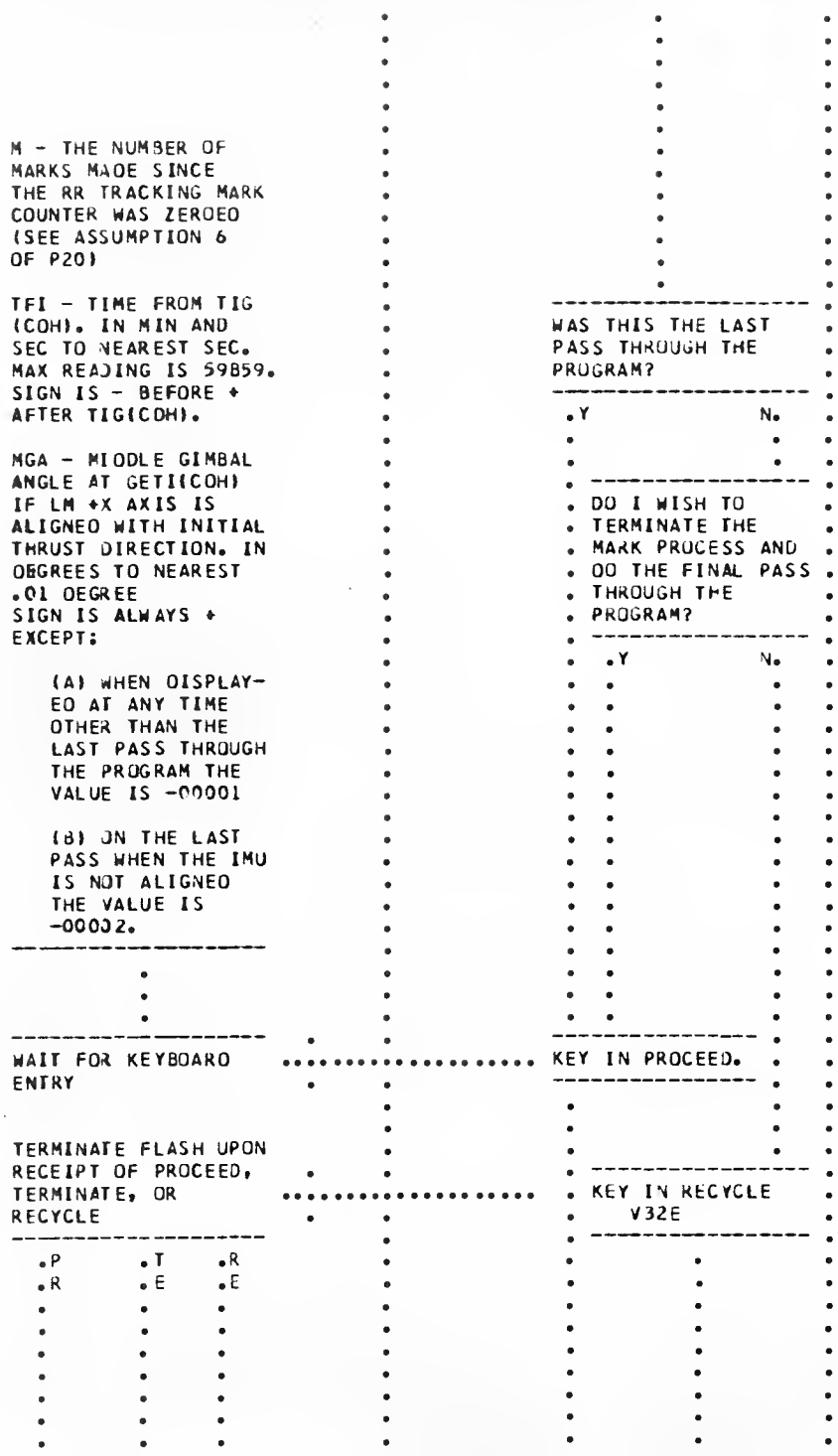
#370

#380


HOLD
SNAP
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY CALCULATED COMPONENTS OF DELTA V(LV) FOR CDH;
V06 N81
R1-DELTA VX(LV)
R2-DELTA VY(LV)
R3-DELTA VZ(LV)
DELTA VX(LV) - COMPONENT OF IMPULSIVE DELTA V AT TIG(CDH) ALONG (RXV)XR. IN FPS TO NEAREST .1 FPS
DELTA VY(LV) - COMPONENT OF IMPULSIVE DELTA V AT TIG(CDH) ALONG VXR. IN FPS TO NEAREST .1 FPS
DELTA VZ(LV) - COMPONENT OF IMPULSIVE DELTA V AT TIG(CDH) ALONG -R. WHERE R IS LM GEOCENTRIC (EARTH ORBIT) OR SELENOCENTRIC (LUNAR ORBIT) RADIUS VECTOR AND V IS LM INERTIAL VELOCITY VECTOR AT TIG(CDH). IN FPS TO NEAREST .1 FPS
MONITOR DSKY: OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY OF DELTA V (LV) FOR CDH
AM I SATISFIED WITH THESE VALUES? (NOTE: CREW HAS THE OPTION AT THIS TIME TO REDEFINE THE DELTA V (LV) COMPONENTS FOR THE SUBSEQUENT THRUSTING MANEUVER. THIS CAPABILITY WILL NORMALLY BE EXERCISED TO CORRECT OUT-OF-PLANENESS BY FIRST SELECTING THE RENDEZVOUS OUT-OF-PLANE DISPLAY ROUTINE (R36) (V06E) AND THEN MODIFYING DELTA VY (LV)).
#300
#400
#410
#420
#430


WAIT FOR KEYBOARD ENTRY
KEY IN V25E AND LOAD DESIRED DELTA V VALUES
#440
RECORD THESE VALUES
#450
TERMINATE FLASH UPON RECEIPT OF PROCEED, TERMINATE OR NEW DATA.
KEY IN PROCEED
#460
PROCEED
TERMINATE
NEW DATA
STORE DATA
#470
GO TO "A" BELOW
IS FINAL FLAG SET?
#480
N
Y


SET MGA DISPLAY IN R3 (BELOW) =-00001.
#490
IS REFSMMAT FLAG SET?
Y
N
#500
COMPUTE IMU MIDDLE GIMBAL ANGLE AT TIG (COAS) FOR THE PRESENT IMU ORIENTATION WITH THE LM +X AXIS ALIGNED WITH THE INITIAL THRUST VECTOR
#510
SET MGA DISPLAY IN R3 (BELOW) = -00002.
#520
HOLD MON
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY M, TFI AND MGA;
V16N22
R1-M
R2-TFI
R3-MGA
MONITOR DSKY: OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY OF M, TFI AND MGA.
#530



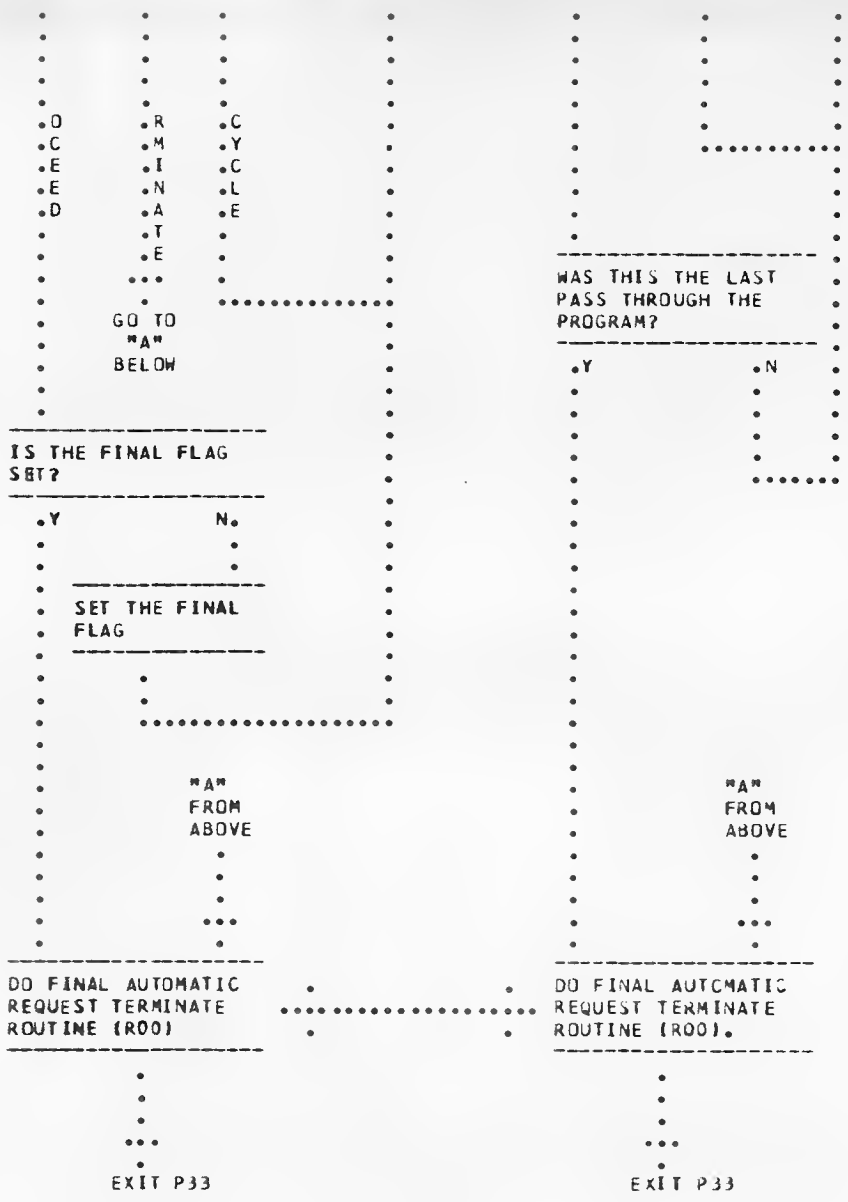
#540

#550

#560

#570

#580



#590

#600

#610

#620

#630

CHANGE CONTROL NOTES

REV 01 PCR 540,623
REV 02 PCR 752, EDITORIAL
REV 03 EDITORIAL
REV 04 PCN 1180

TRANSFER PHASE INITIATION (TPI) PROGRAM (P34) REV 05 12/01/71

PURPOSE: (1) TO CALCULATE THE REQUIRED DELTA V AND OTHER INITIAL CONDITIONS REQUIRED BY THE LGC FOR LM EXECUTION OF THE TRANSFER PHASE INITIATION (TPI) MANEUVER, GIVEN:

(A) TIME OF IGNITION TIG(TPI) OR THE ELEVATION ANGLE (E) OF THE LM/CSM LOS AT TIG(TPI)

(B) CENTRAL ANGLE OF TRANSFER (CENTANG) FROM TIG(TPI) TO INTERCEPT TIME (TIG(TPF)).

(2) TO CALCULATE TIG(TPI) GIVEN E OR E GIVEN TIG(TPI).

(3) TO CALCULATE THESE PARAMETERS BASED UPON MANEUVER DATA APPROVED AND KEYED INTO THE LGC BY THE ASTRONAUT.

(4) TO DISPLAY TO THE ASTRONAUT AND THE GROUND CERTAIN DEPENDENT VARIABLES ASSOCIATED WITH THE MANEUVER FOR APPROVAL BY THE ASTRONAUT/GROUND.

(5) TO STORE THE TPI TARGET PARAMETERS FOR USE BY THE DESIRED THRUSTING PROGRAM.

ASSUMPTIONS: (1) LGC COMPUTED VARIABLES MAY BE STORED FOR LATER VERIFICATION BY THE GROUND. THESE STORAGE CAPABILITIES ARE LIMITED ONLY TO THE PARAMETERS FOR ONE THRUSTING MANEUVER AT A TIME, EXCEPT FOR CONCENTRIC FLIGHT PLAN MANEUVER SEQUENCES.

(2) THE RENDEZVOUS RADAR MAY OR MAY NOT BE USED TO UPDATE THE LM OR CSM STATE VECTORS FOR THIS PROGRAM. IF RADAR USE IS DESIRED THE RADAR SHOULD BE TURNED ON AND LOCKED ON THE CSM BY PREVIOUS SELECTION OF P20. RADAR SIGHTING MARKS WILL BE MADE AUTOMATICALLY APPROXIMATELY ONCE A MINUTE WHEN ENABLED BY THE TRACK AND UPDATE FLAGS. THE RENDEZVOUS TRACKING MARK COUNTER IS ZEROED BY THE SELECTION OF P20 AND AFTER EACH THRUSTING MANEUVER.

(3) THERE IS NO REQUIREMENT FOR ISS OPERATION DURING THIS PROGRAM UNLESS AUTOMATIC STATE VECTOR UPDATING IS DESIRED BY THE RENDEZVOUS NAVIGATION PROGRAM (P20). IF SELECTED, P20 WILL DEFINE THE STATUS OF THE ISS.

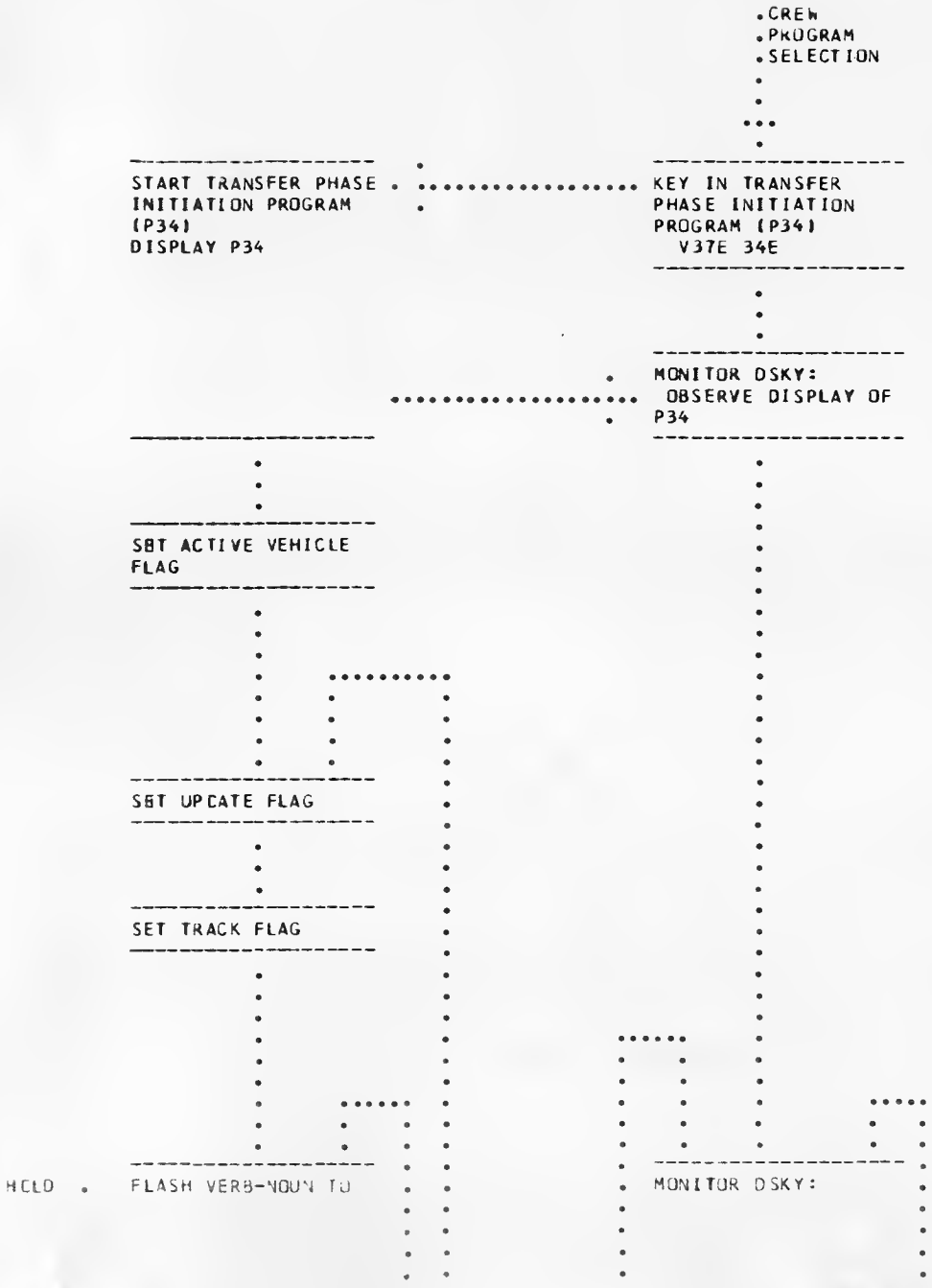
(4) ONCE THE PARAMETERS REQUIRED FOR COMPUTATION OF THE MANEUVER HAVE BEEN COMPLETELY SPECIFIED, THE VALUE OF THE ACTIVE VEHICLE CENTRAL ANGLE OF TRANSFER IS COMPUTED AND STORED. THIS NUMBER WILL BE AVAILABLE FOR DISPLAY TO THE ASTRONAUT THROUGH THE USE OF V06N52.

THE ASTRONAUT WOULD CALL THIS DISPLAY TO VERIFY THAT THE CENTRAL ANGLE OF TRANSFER OF THE ACTIVE VEHICLE IS NOT WITHIN 170 TO 190 DEGREES. IF THE ANGLE IS WITHIN THIS ZONE THE ASTRONAUT SHOULD REASSESS THE INPUT TARGETING PARAMETERS BASED UPON DELTA V AND EXPECTED MANEUVER TIME.

++ (5) THIS PROGRAM IS SELECTED BY THE ASTRONAUT BY DSKY ENTRY.
+05
+1180 (6) THE DELTA V IN LOS COORDINATES (N59) IS AVAILABLE AT FL V16 N45 AFTER EACH COMPUTATION CYCLE.
++

PROG	LGC	GROUND	CREW

CONT



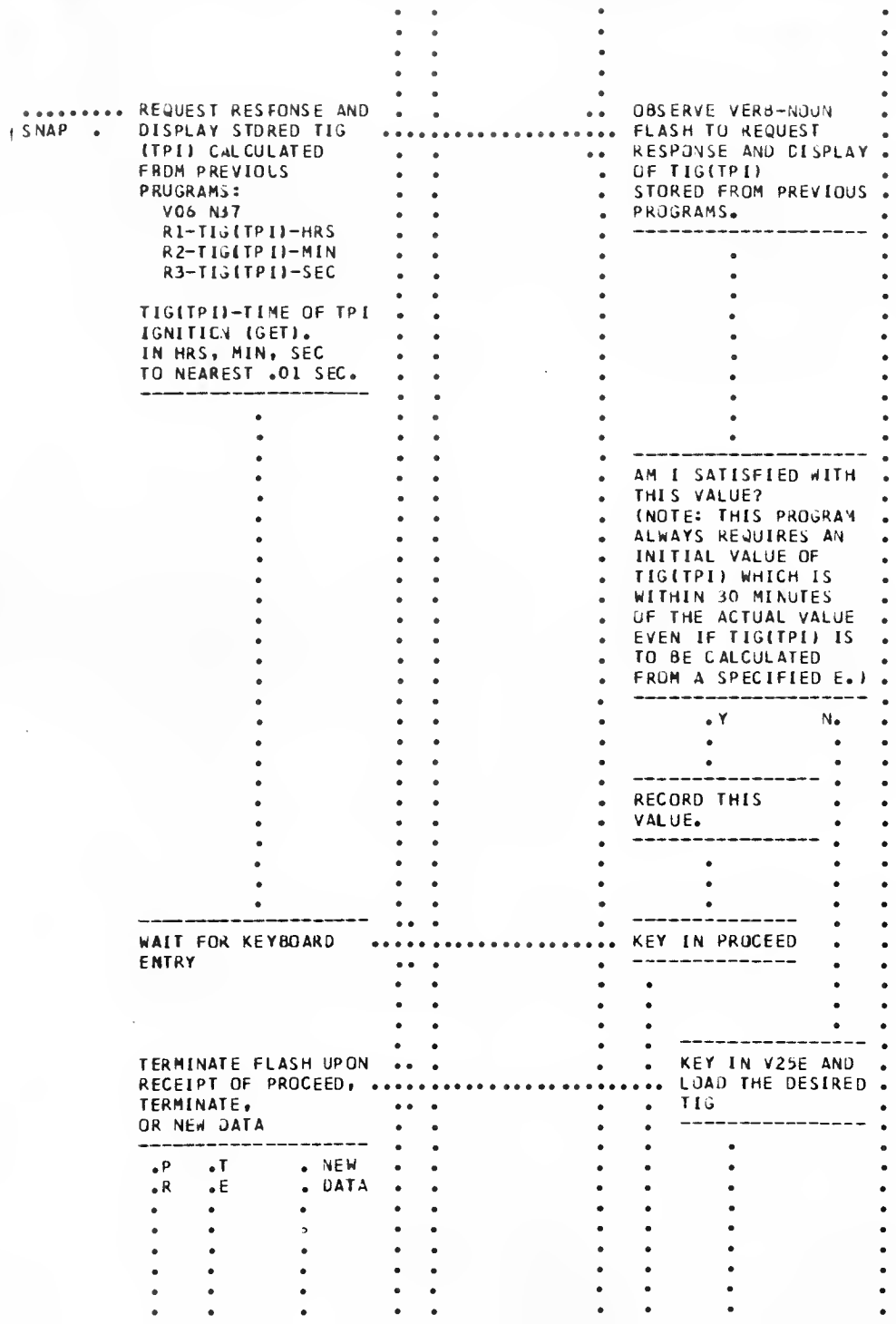
#10

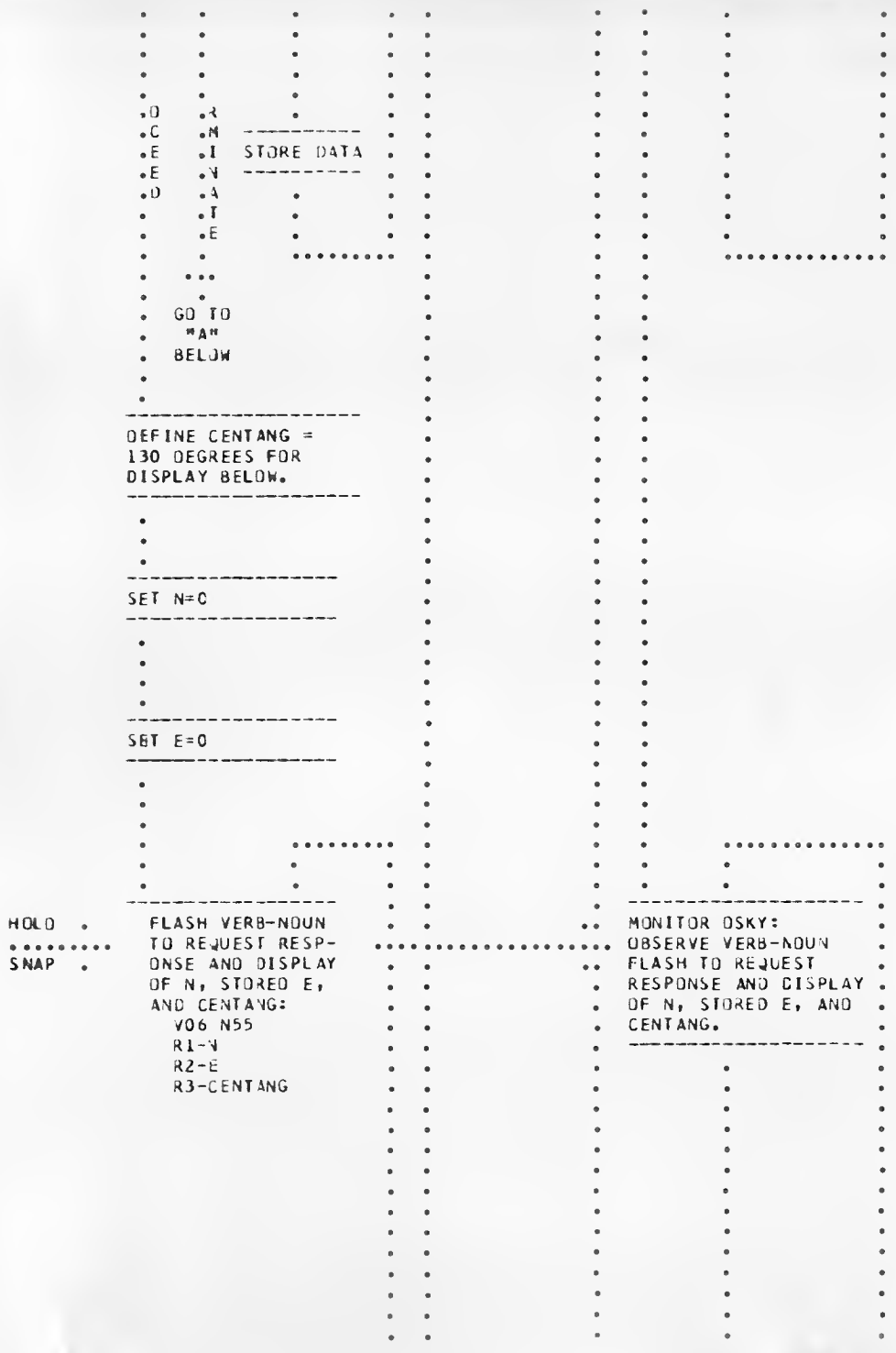
#20

#30

#40

#50


SNAP
REQUEST RESPONSE AND DISPLAY STORED TIG (TPI) CALCULATED FROM PREVIOUS PROGRAMS:
V06 N37
R1-TIG(TPI)-HRS
R2-TIG(TPI)-MIN
R3-TIG(TPI)-SEC
TIG(TPI)-TIME OF TPI IGNITION (GET). IN HRS, MIN, SEC TO NEAREST .01 SEC.
OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY OF TIG(TPI) STORED FROM PREVIOUS PROGRAMS.
AM I SATISFIED WITH THIS VALUE? (NOTE: THIS PROGRAM ALWAYS REQUIRES AN INITIAL VALUE OF TIG(TPI) WHICH IS WITHIN 30 MINUTES OF THE ACTUAL VALUE EVEN IF TIG(TPI) IS TO BE CALCULATED FROM A SPECIFIED E.)
Y
N
RECORD THIS VALUE.
WAIT FOR KEYBOARD ENTRY
KEY IN PROCEED
TERMINATE FLASH UPON RECEIPT OF PROCEED, TERMINATE, OR NEW DATA
KEY IN V25E AND LOAD THE DESIRED TIG
P
R
T
E
NEW DATA
#60
#70
#80
#90
#100
#110


DOCMAN
STORE DATA
#120
GO TO "AM" BELOW
DEFINE CENTANG = 130 DEGREES FOR DISPLAY BELOW.
#130
SET N=0
#140
SET E=0
#150
HOLD
SNAP
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY OF N, STORED E, AND CENTANG:
V06 N55
R1-N
R2-E
R3-CENTANG
MONITOR OSKY: OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY OF N, STORED E, AND CENTANG.

#160

N-THE FUTURE AP-
SIDAL CROSSING
(APOCENTER OR
PERICENTER) OF
THE ACTIVE
VEHICLE AT
WHICH TIG (CDH)
SHOULD OCCUR.

#170

00001=FIRST
00002=SECOND
ETC.

(NOTE:
IN THIS CASE, N IS
THE NUMBER OF TAR-
GET OFFSETS. WHEN
N IS ZERO, USE CO-
NIC INTEGRATION TO
DETERMINE THE IN-
ITIAL POSITION AND
VELOCITY OF THE
TARGET AT INTER-
CEPT TIME. WHEN N
IS NON-ZERO, USE
PRECISION INTEGRA-
TION AND THE INDI-
CATED NUMBER OF
OFFSETS.

#180

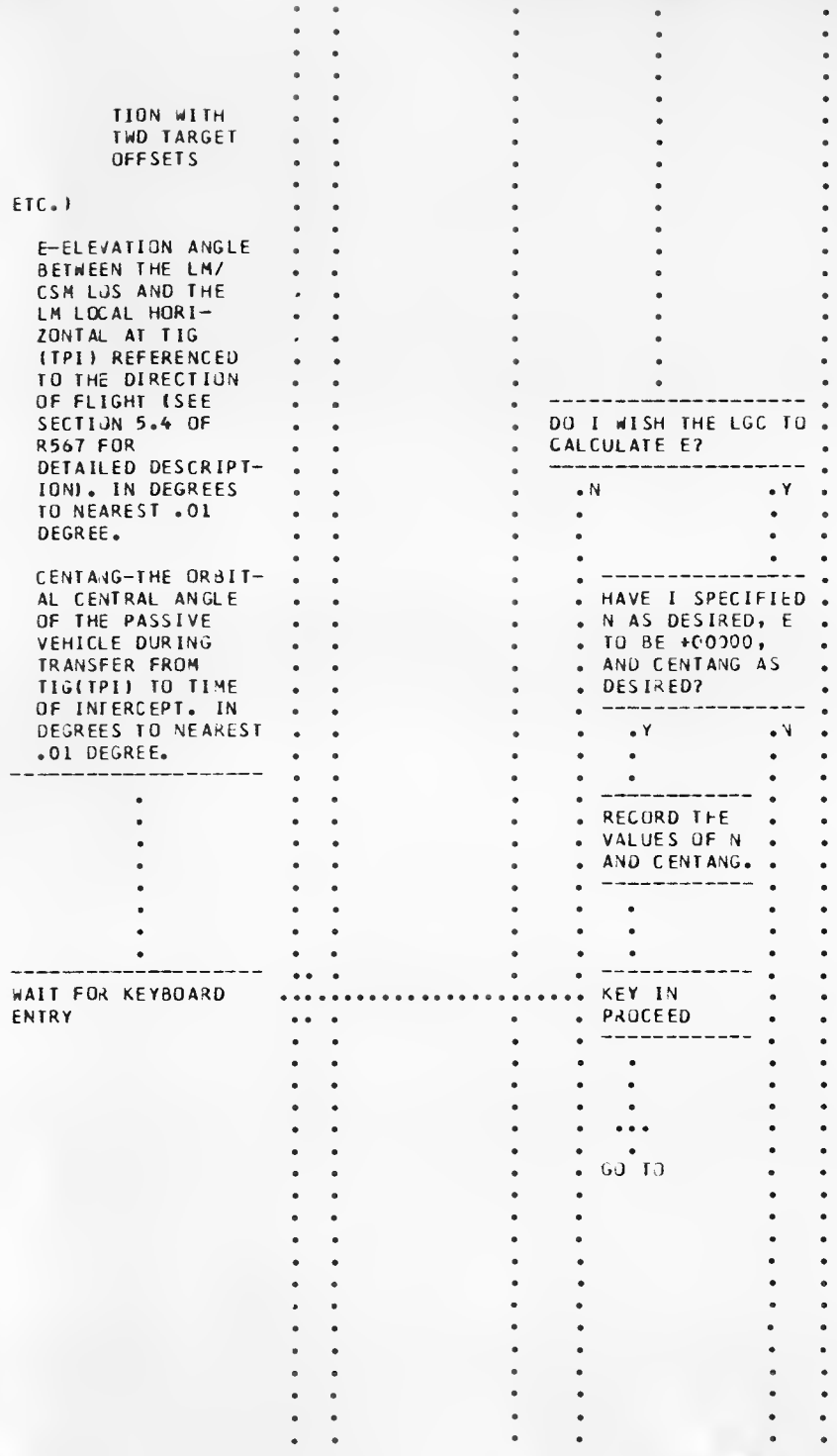
#190

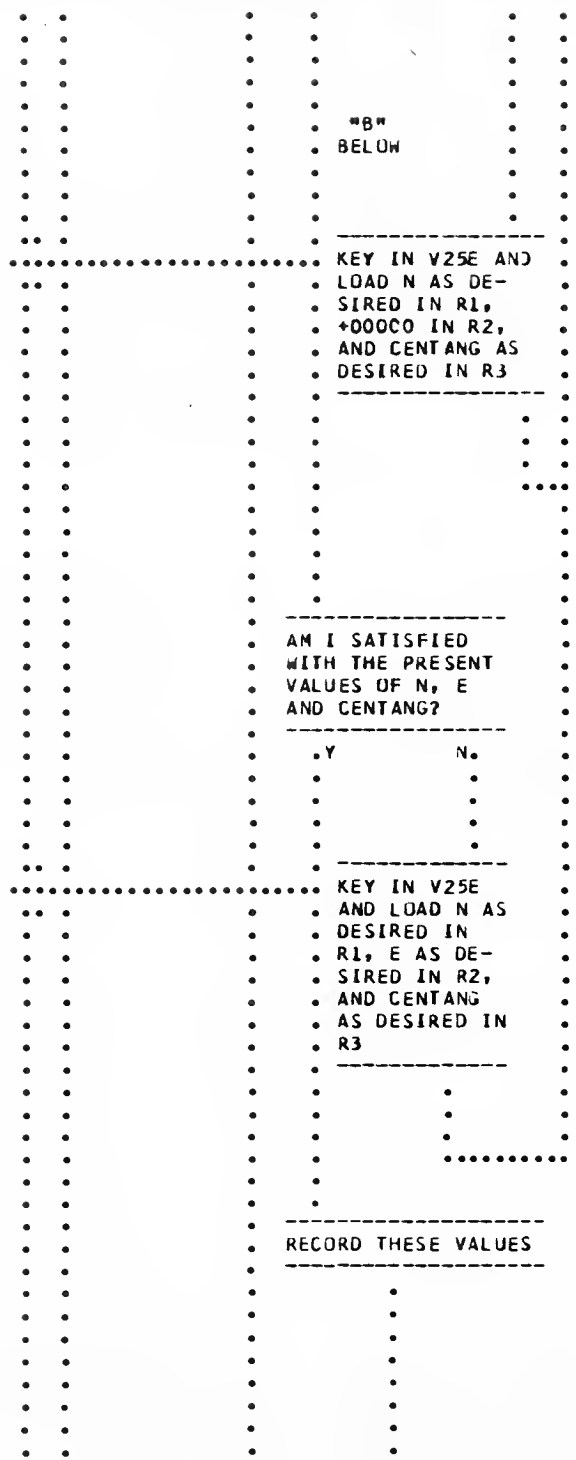
00000-KEPLER CO-
NIC INTE-
GRATION
WITH NO
TARGET
OFFSET

00001-PRECISION
INTEGRA-
TION WITH
ONE TARGET
OFFSET

#200

00002-PRECISION
INTEGRA-


TION WITH
TWO TARGET
OFFSETS
ETC.)
E-ELEVATION ANGLE BETWEEN THE LM/CSM LOS AND THE LM LOCAL HORIZONTAL AT TIG (TPI) REFERENCED TO THE DIRECTION OF FLIGHT (SEE SECTION 5.4 OF R567 FOR DETAILED DESCRIPTION). IN DEGREES TO NEAREST .01 DEGREE.
CENTANG-THE ORBITAL CENTRAL ANGLE OF THE PASSIVE VEHICLE DURING TRANSFER FROM TIG(TPI) TO TIME OF INTERCEPT. IN DEGREES TO NEAREST .01 DEGREE.
WAIT FOR KEYBOARD ENTRY
#210
#220
DO I WISH THE LGC TO CALCULATE E?
.N
.Y
#230
HAVE I SPECIFIED N AS DESIRED, E TO BE +00000, AND CENTANG AS DESIRED?
.Y
.N
#240
RECORD THE VALUES OF N AND CENTANG.
KEY IN PROCEED
#250
GO TO



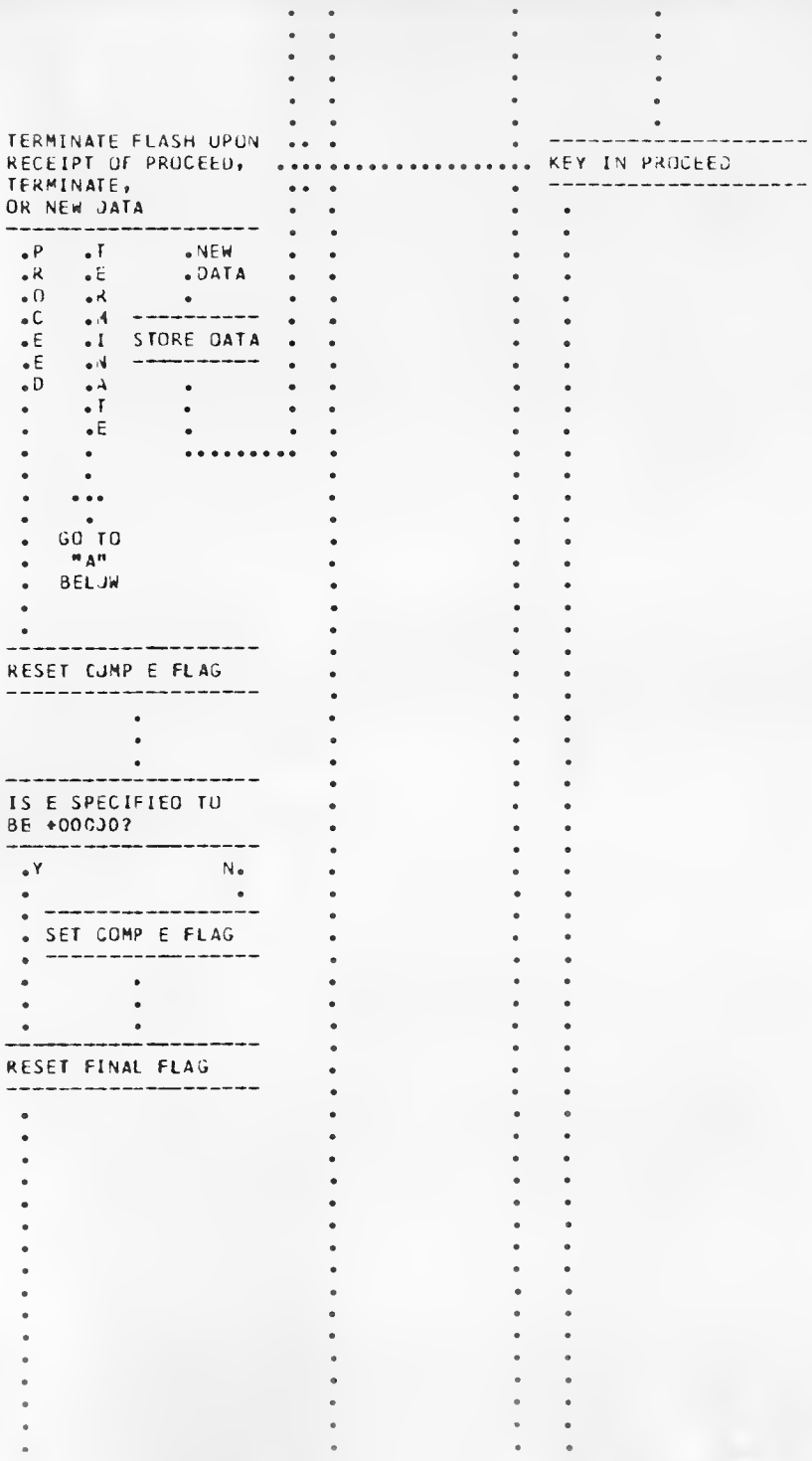
#260

#270

#280

#290

#300



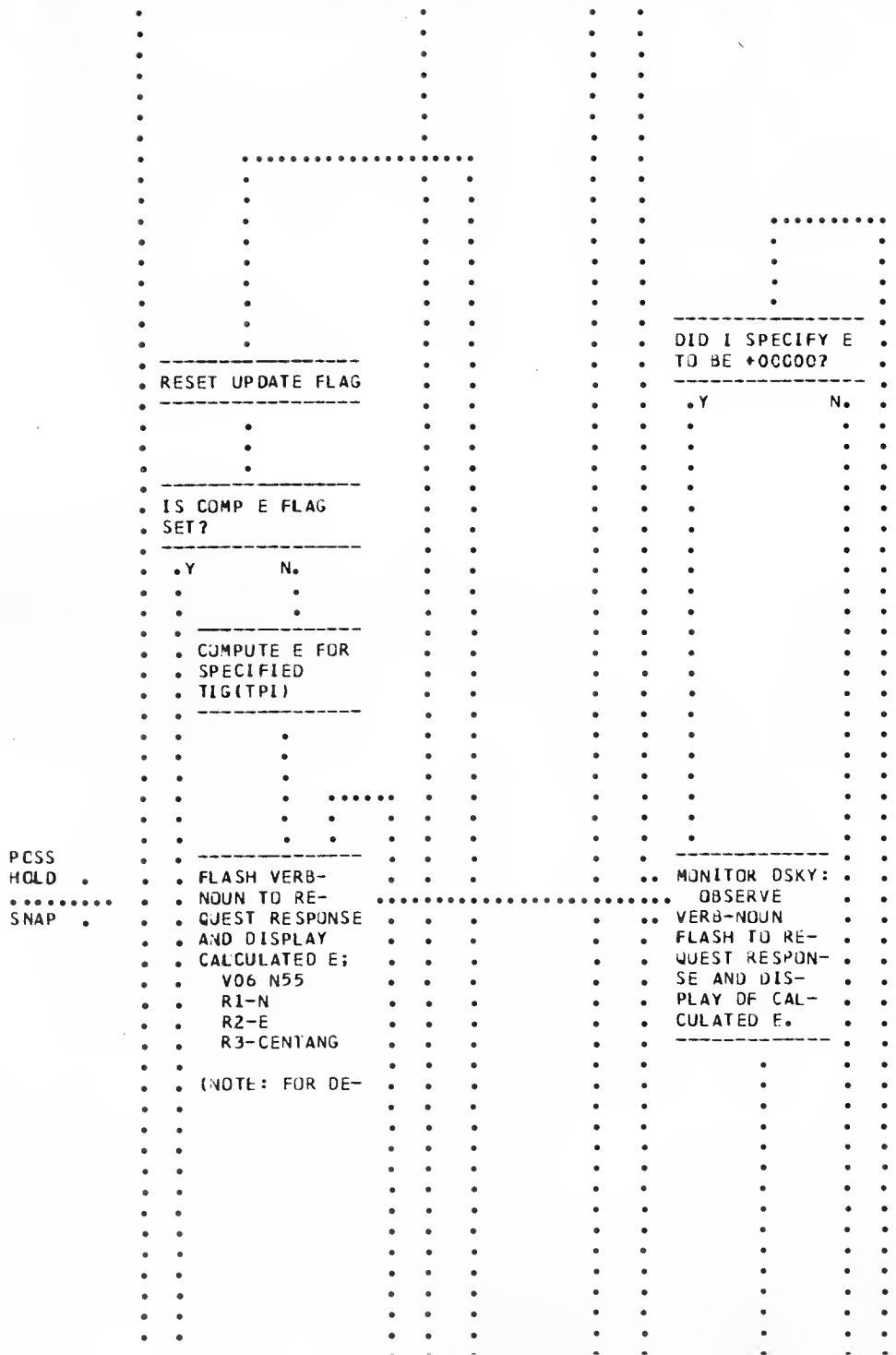
#310

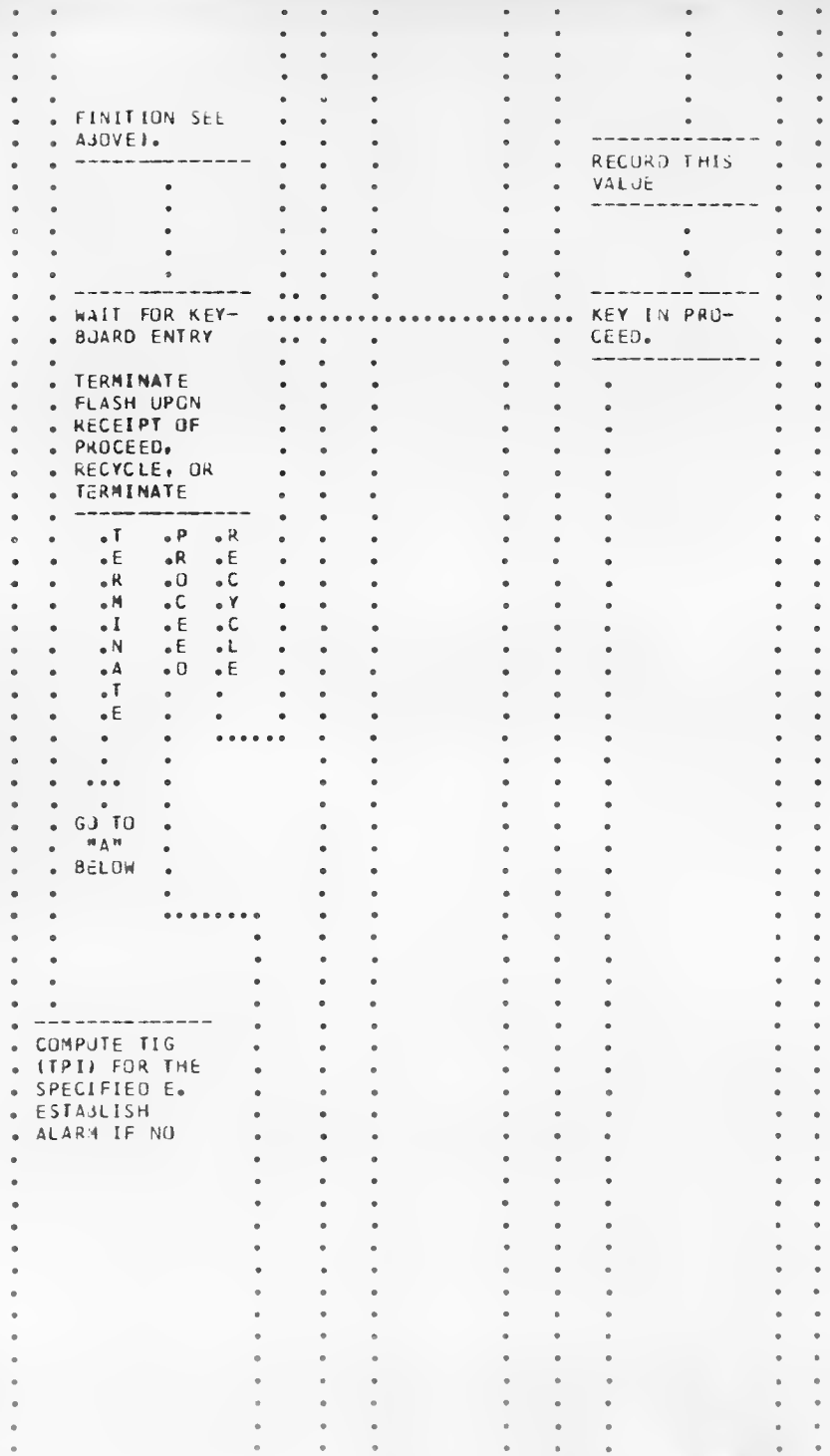
#320

#330

#340

#350


#360
DID I SPECIFY E TO BE +00000?
Y
N.
#370
RESET UPDATE FLAG
IS COMP E FLAG SET?
Y
N.
#380
COMPUTE E FOR SPECIFIED TIG(TPI)
#390
PCSS HOLD
SNAP
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY CALCULATED E;
V06 N55
R1-N
R2-E
R3-CENTANG
(NOTE: FOR DE-
MONITOR DSKY: OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY OF CALCULATED E.
#400



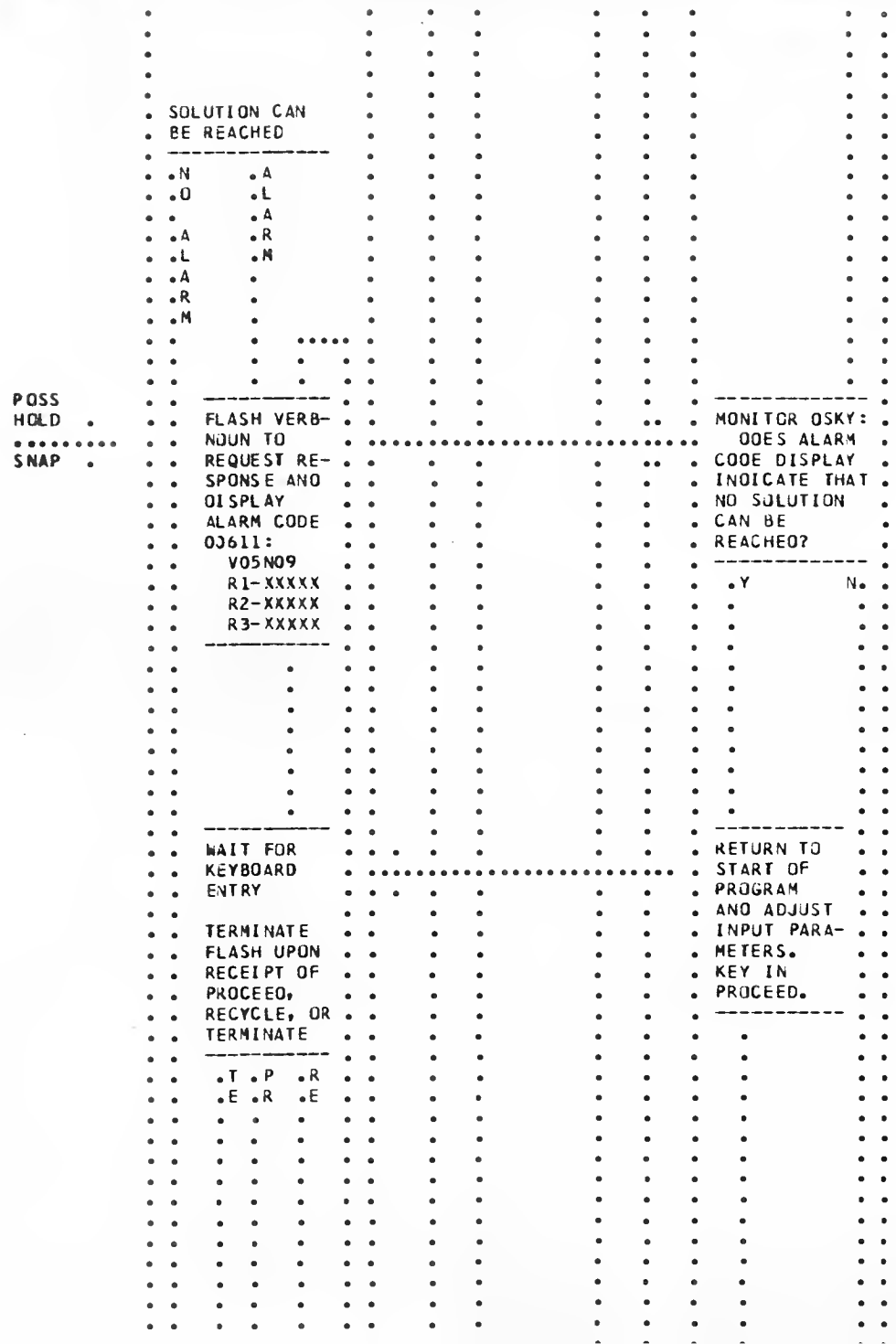
#410

#420

#430

#440

#450



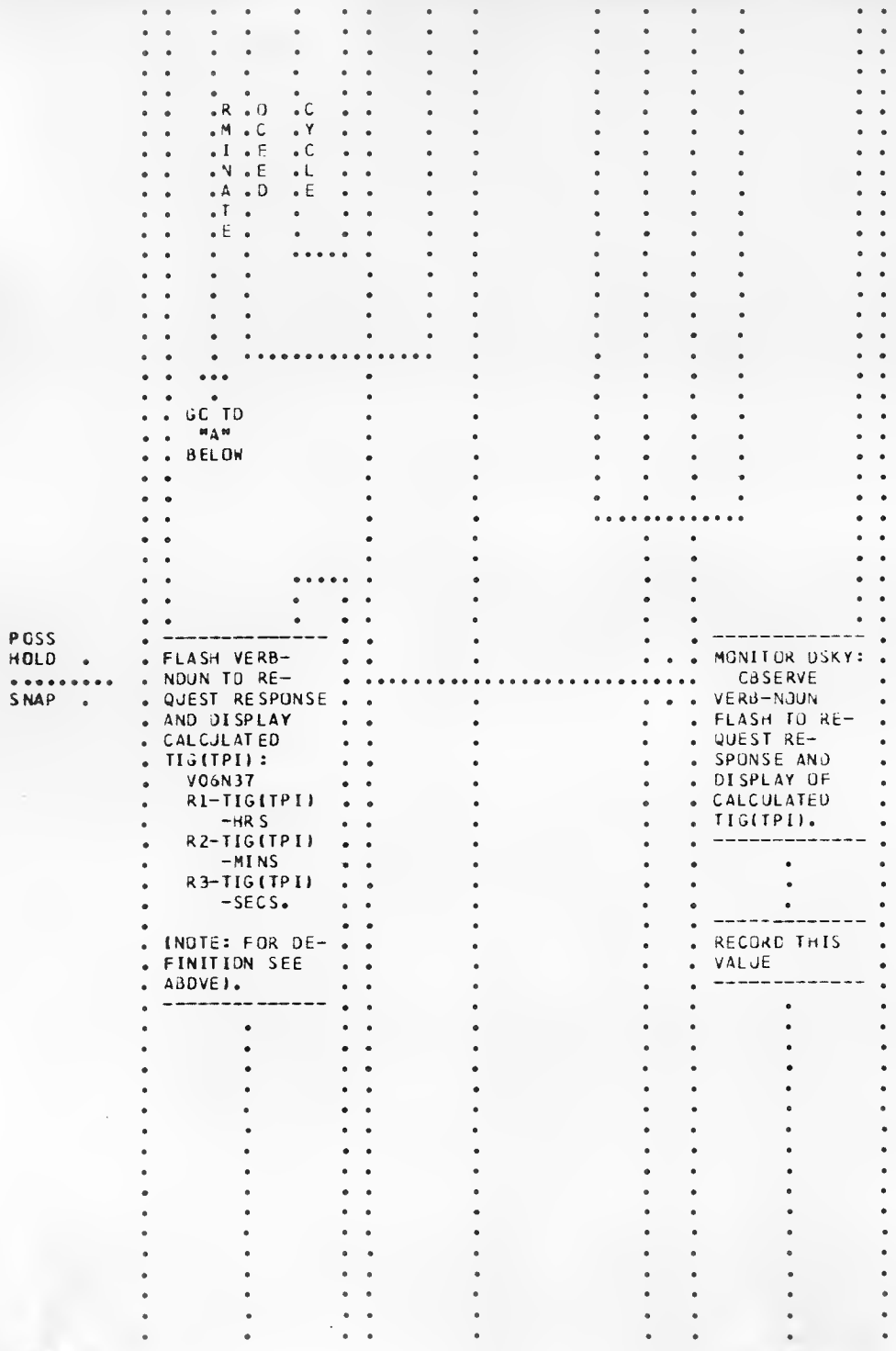
#460

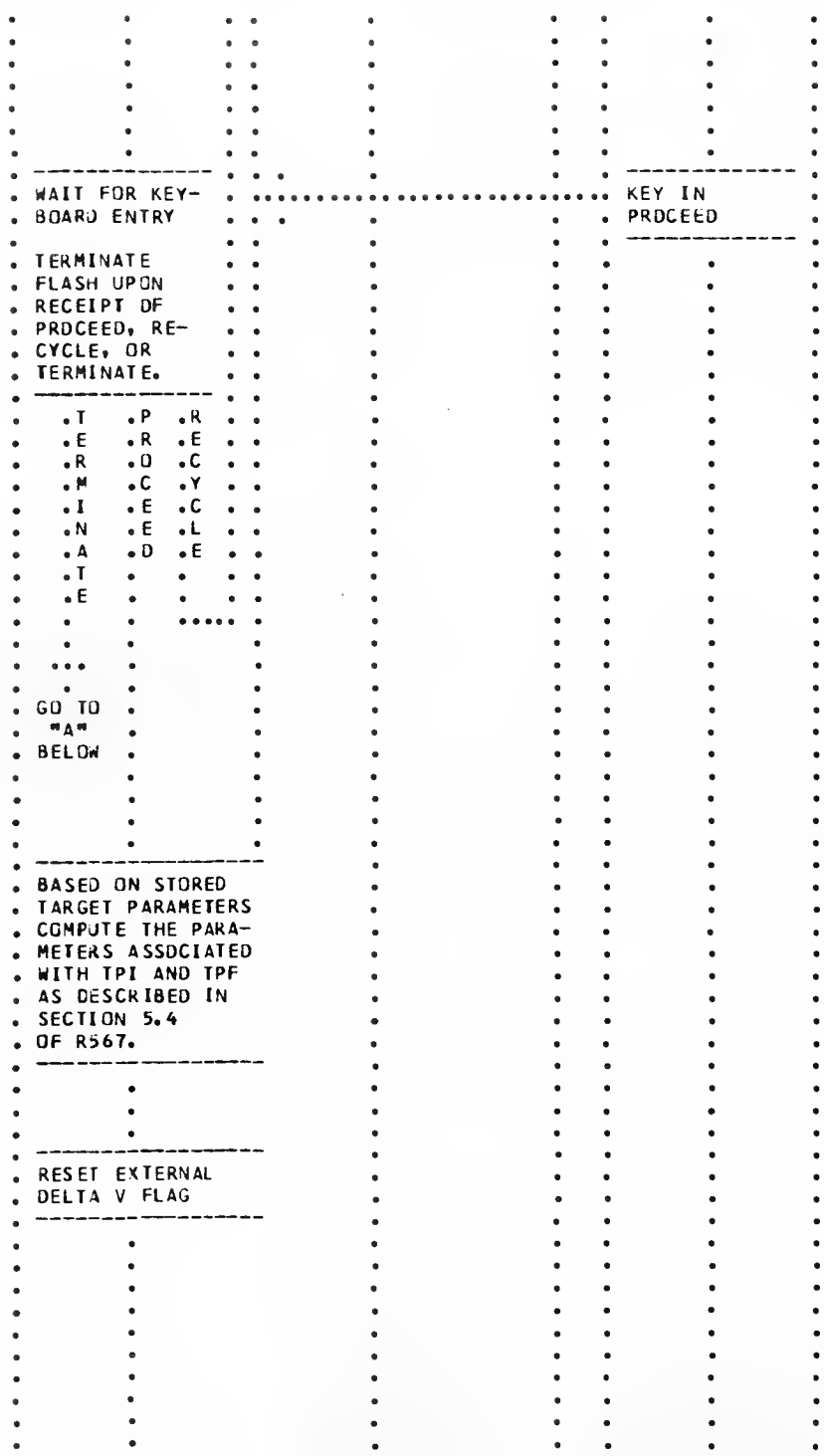
#470

#480

#490

#500


READ CYCLE
GO TO "A" BELOW
#510
#520
POSS HOLD
SNAP
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY CALCULATED TIG(TPI):
V06N37
R1-TIG(TPI) -HRS
R2-TIG(TPI) -MINS
R3-TIG(TPI) -SECS.
(NOTE: FOR DEFINITION SEE ABOVE).
MONITOR DSKY: OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY OF CALCULATED TIG(TPI).
#530
#540
RECORD THIS VALUE
#550



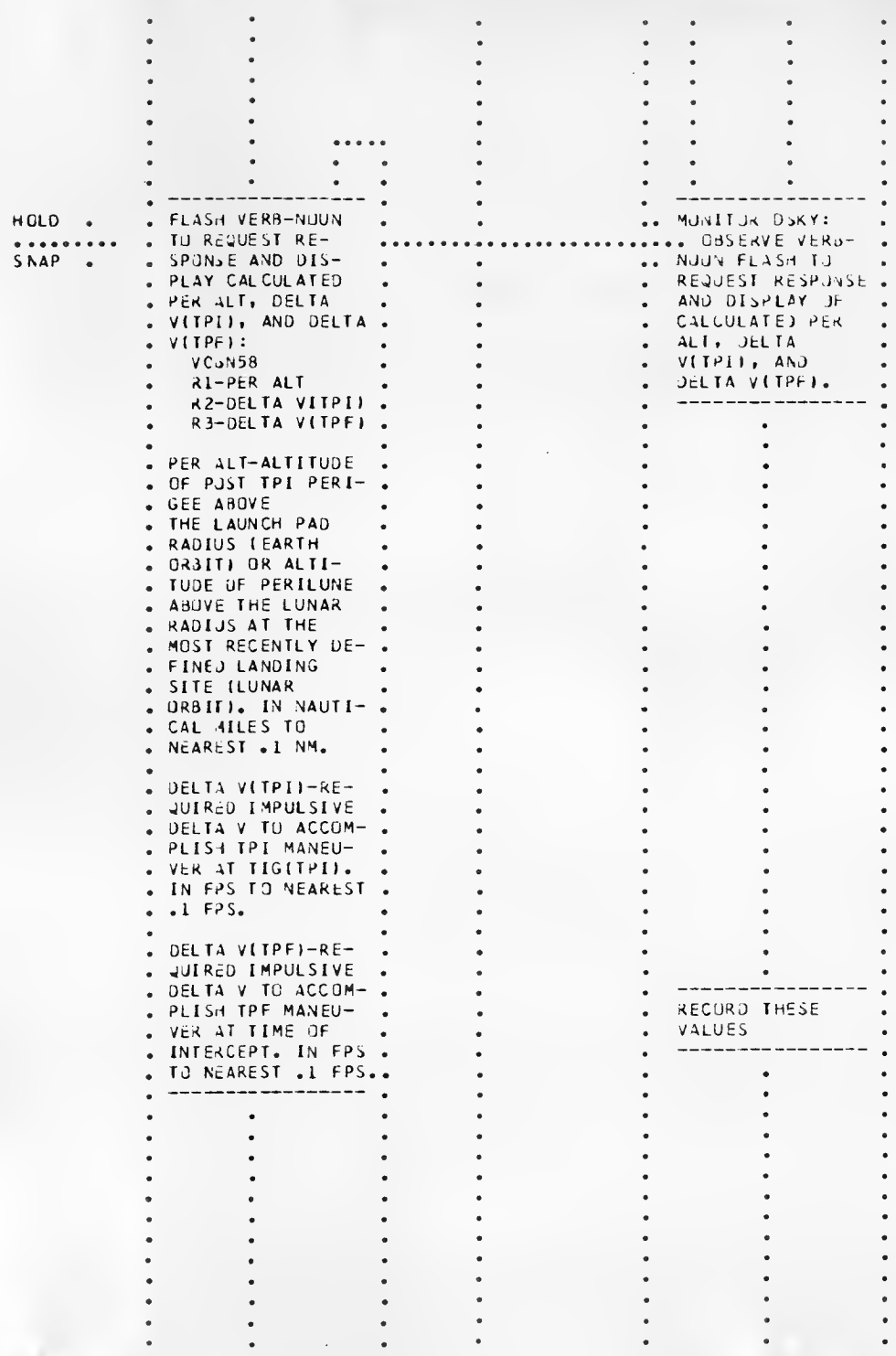
#560

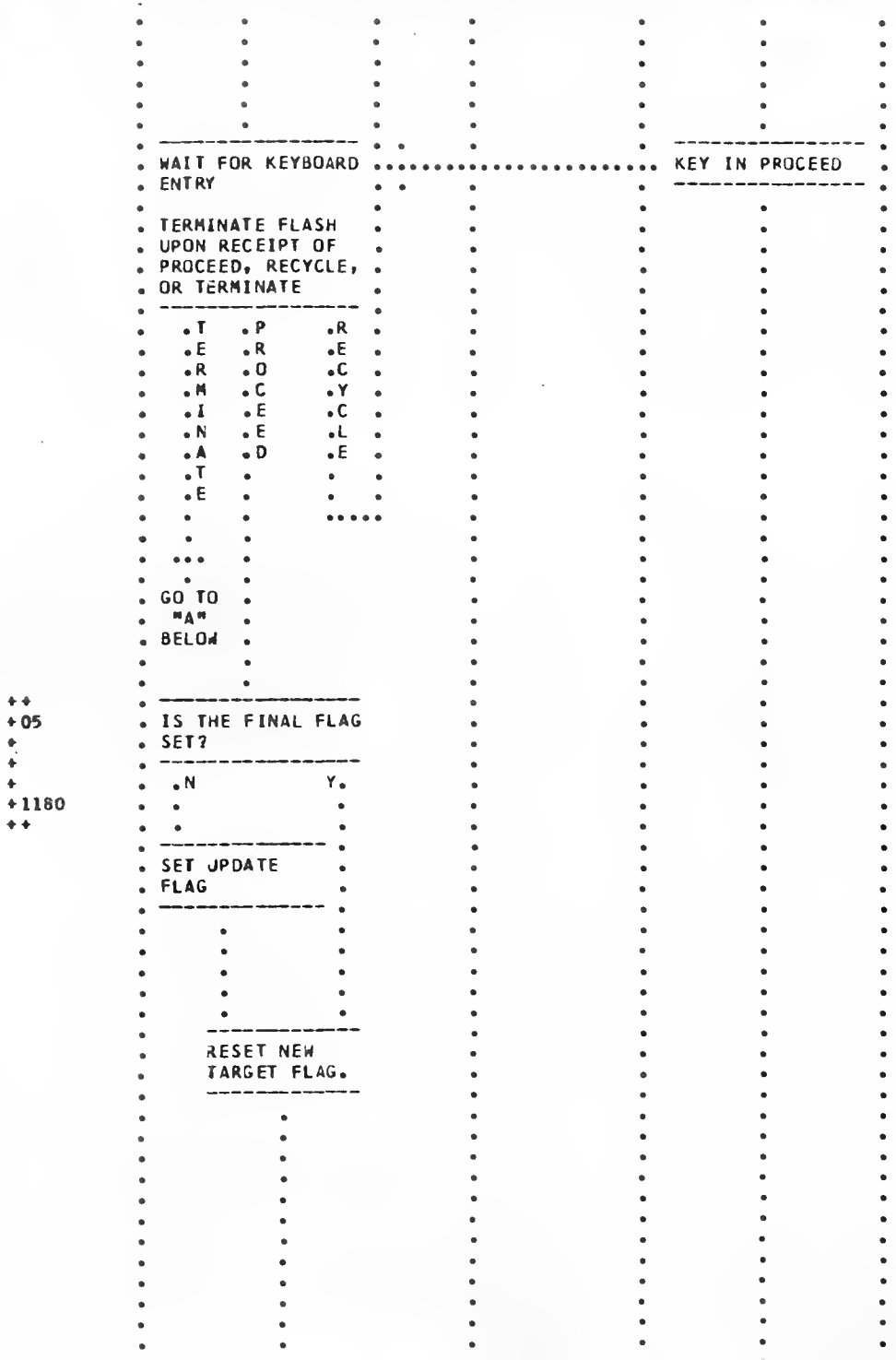
#570

#580

#590

#600


HOLD
SNAP
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY CALCULATED PER ALT, DELTA V(TPI), AND DELTA V(TPF):
VC&N58
R1-PER ALT
R2-DELTA V(TPI)
R3-DELTA V(TPF)
PER ALT-ALTITUDE OF POST TPI PERIGEE ABOVE THE LAUNCH PAD RADIUS (EARTH ORBIT) OR ALTITUDE OF PERILUNE ABOVE THE LUNAR RADIUS AT THE MOST RECENTLY DEFINED LANDING SITE (LUNAR ORBIT). IN NAUTICAL MILES TO NEAREST .1 NM.
DELTA V(TPI)-REQUIRED IMPULSIVE DELTA V TO ACCOMPLISH TPI MANEUVER AT TIG(TPI). IN FPS TO NEAREST .1 FPS.
DELTA V(TPF)-REQUIRED IMPULSIVE DELTA V TO ACCOMPLISH TPF MANEUVER AT TIME OF INTERCEPT. IN FPS TO NEAREST .1 FPS.
MONITOR DSKY: OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY OF CALCULATED PER ALT, DELTA V(TPI), AND DELTA V(TPF).
RECORD THESE VALUES
#610
#620
#630
#640
#650



#660

#670

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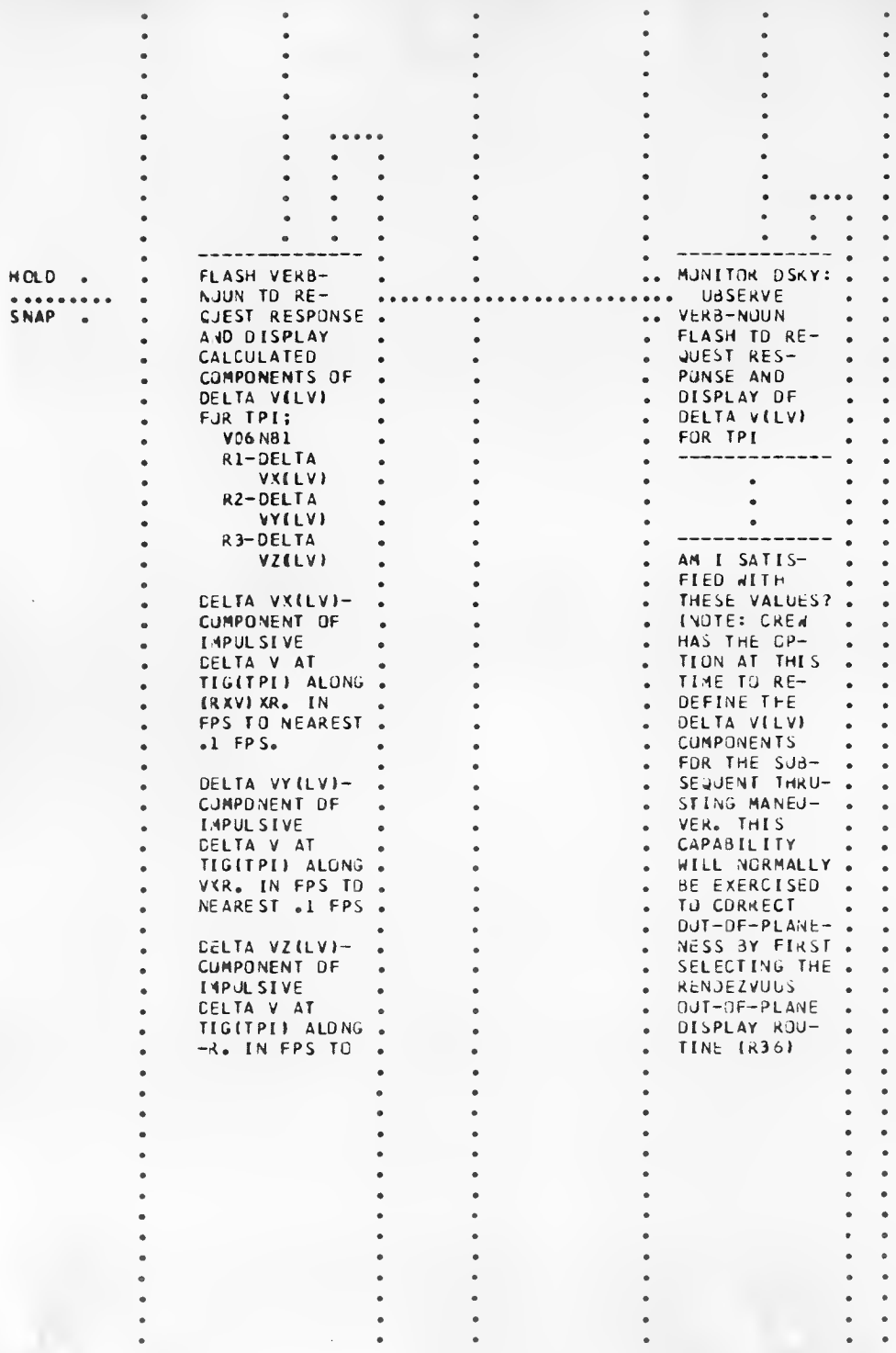
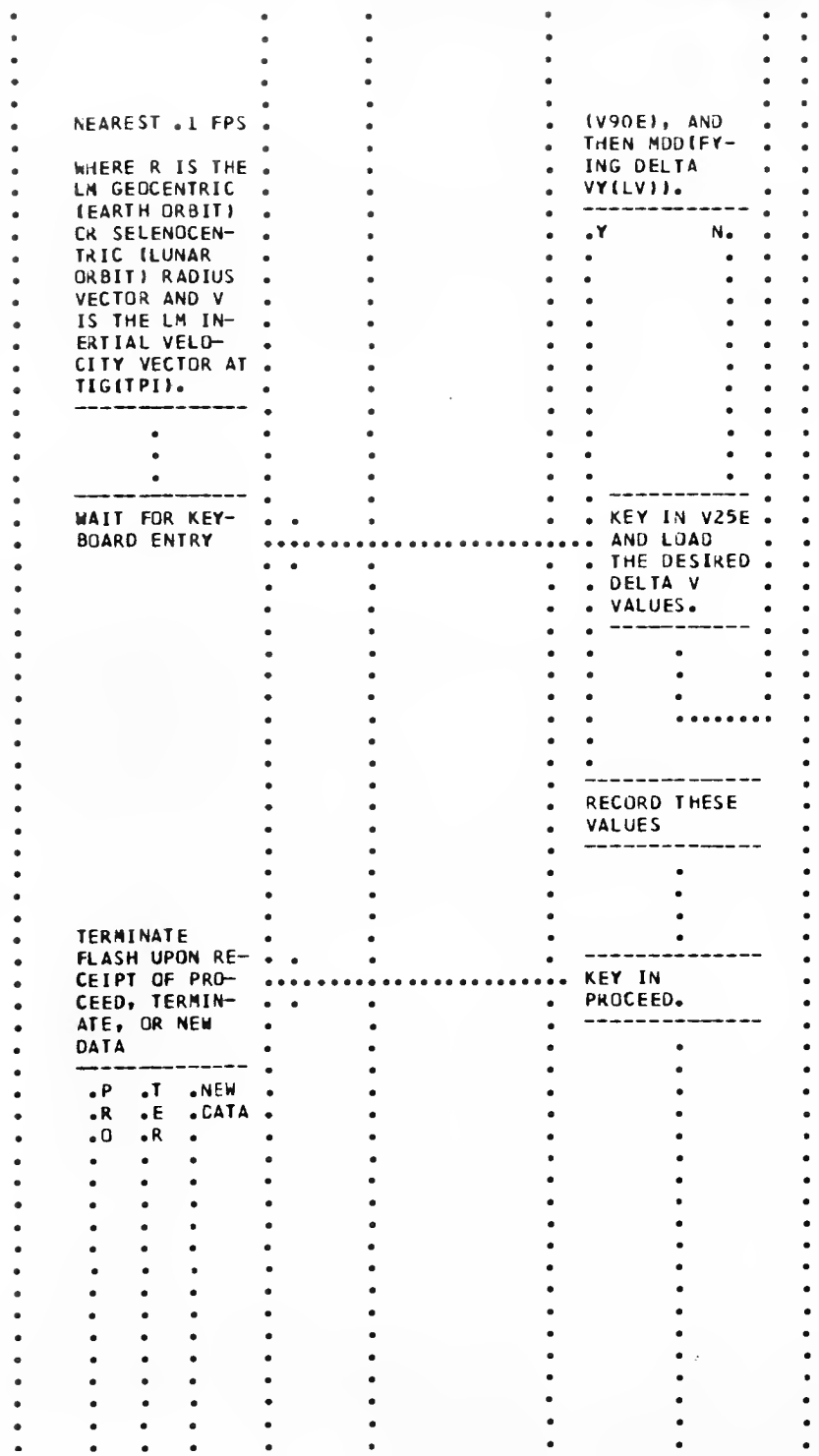

HOLD
SNAP
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY CALCULATED COMPONENTS OF DELTA V(LV) FOR TPI;
V06N81
R1-DELTA VX(LV)
R2-DELTA VY(LV)
R3-DELTA VZ(LV)
DELTA VX(LV)- COMPONENT OF IMPULSIVE DELTA V AT TIG(TPI) ALONG (RXV)XR. IN FPS TO NEAREST .1 FPS.
DELTA VY(LV)- COMPONENT OF IMPULSIVE DELTA V AT TIG(TPI) ALONG VXR. IN FPS TO NEAREST .1 FPS
DELTA VZ(LV)- COMPONENT OF IMPULSIVE DELTA V AT TIG(TPI) ALONG -R. IN FPS TO
MONITOR DSKY: OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY OF DELTA V(LV) FOR TPI
AM I SATISFIED WITH THESE VALUES? (NOTE: CREW HAS THE OPTION AT THIS TIME TO REDEFINE THE DELTA V(LV) COMPONENTS FOR THE SUBSEQUENT THRUSTING MANEUVER. THIS CAPABILITY WILL NORMALLY BE EXERCISED TO CORRECT OUT-OF-PLANENESS BY FIRST SELECTING THE RENDEZVOUS OUT-OF-PLANE DISPLAY ROUTINE (R36)
#710
#720
#730
#740
#750

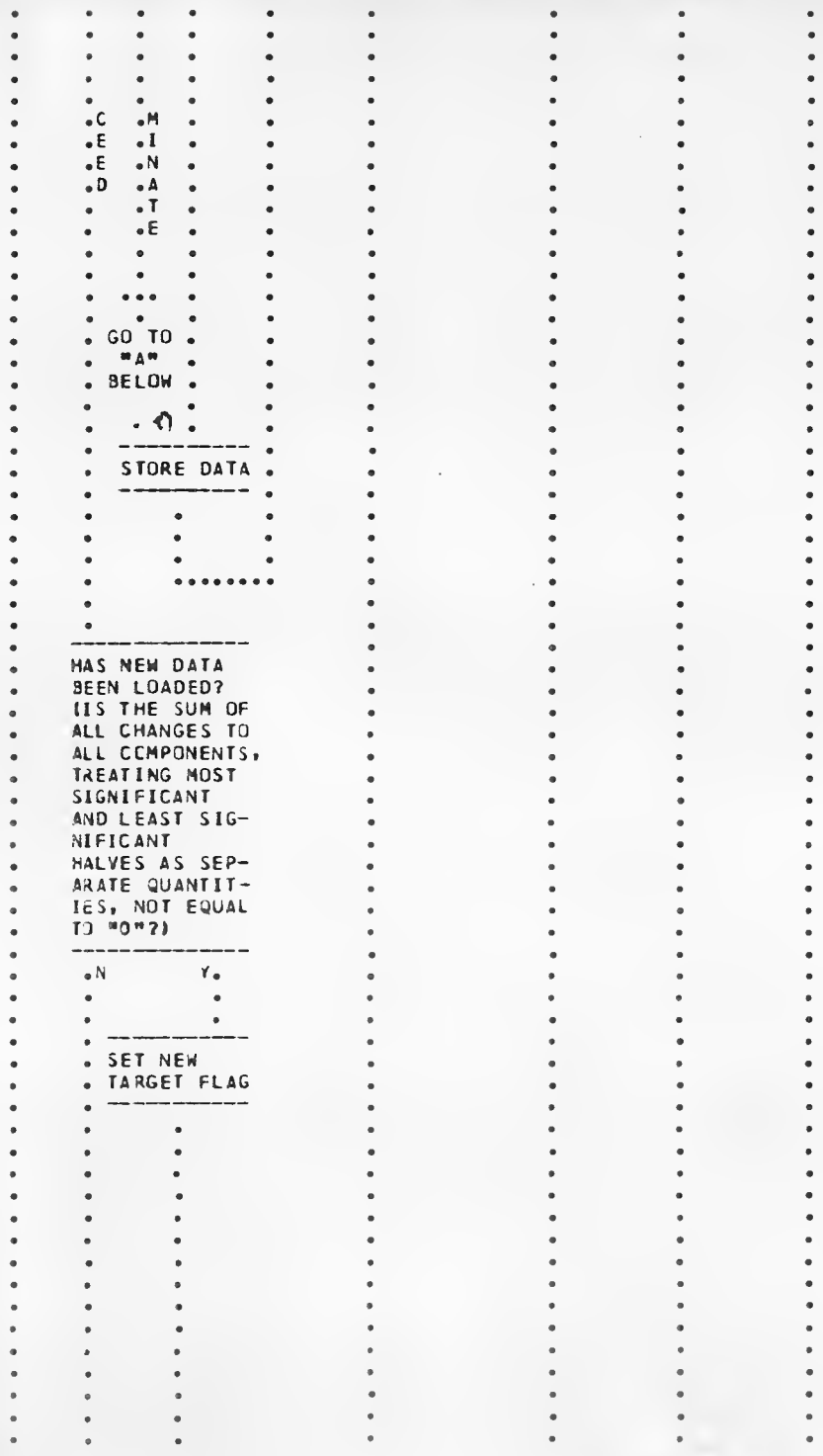


#760

#770

#780

#790



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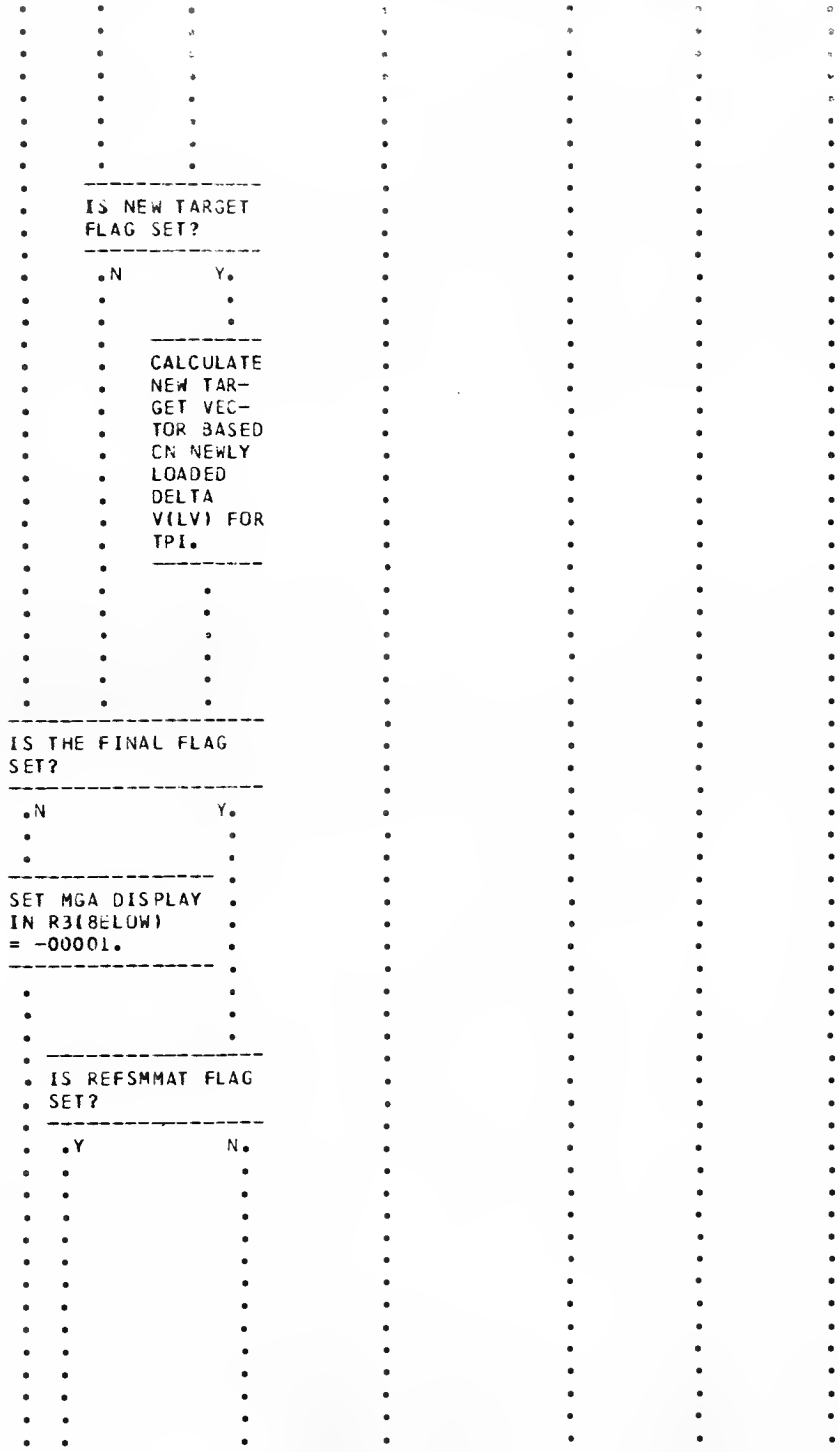

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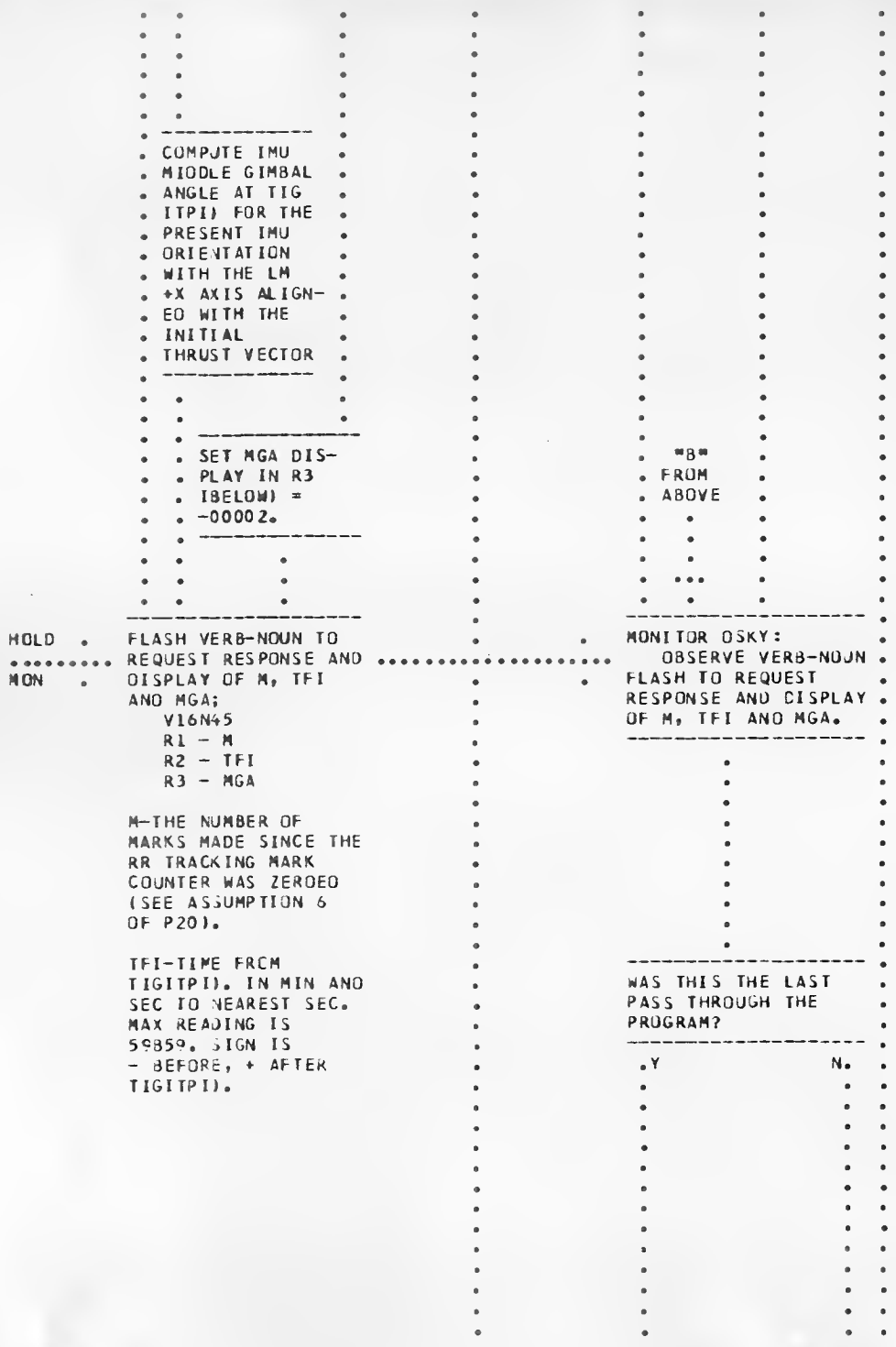
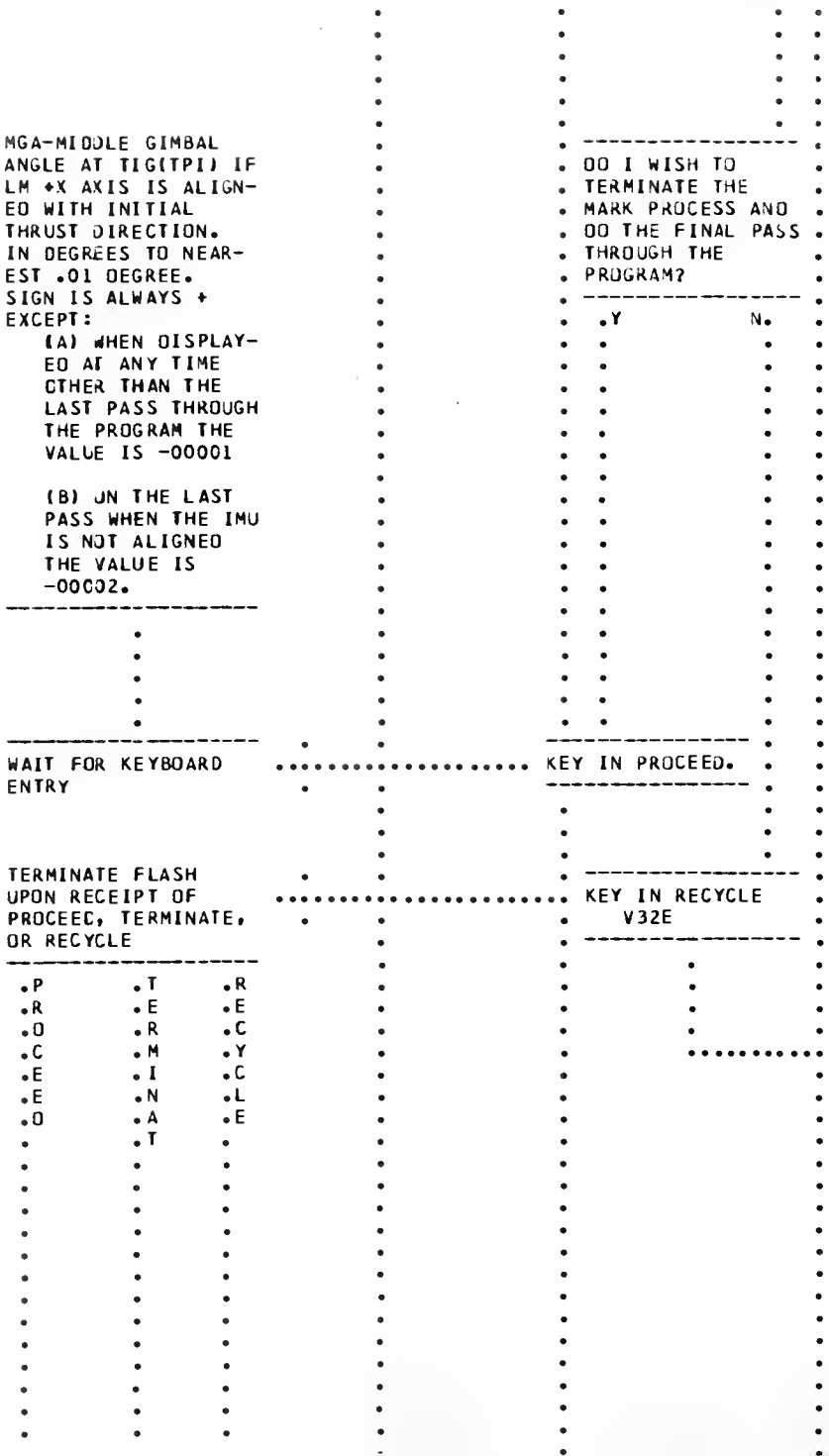
#860

#870

#880

#890


COMPUTE IMU MIDDLE GIMBAL ANGLE AT TIG (TPI) FOR THE PRESENT IMU ORIENTATION WITH THE LM +X AXIS ALIGNED WITH THE INITIAL THRUST VECTOR
SET MGA DISPLAY IN R3 (BELOW) = -00002.
"B" FROM ABOVE
HOLD MON
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY OF M, TFI AND MGA;
V16N45
R1 - M
R2 - TFI
R3 - MGA
M-THE NUMBER OF MARKS MADE SINCE THE RR TRACKING MARK COUNTER WAS ZEROED (SEE ASSUMPTION 6 OF P20).
TFI-TIME FROM TIGITPI). IN MIN AND SEC TO NEAREST SEC. MAX READING IS 59859. SIGN IS - BEFORE, + AFTER TIGITPI).
MONITOR OSKY: OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY OF M, TFI AND MGA.
WAS THIS THE LAST PASS THROUGH THE PROGRAM?
Y
N.
#900
#910
#920
#930
#940



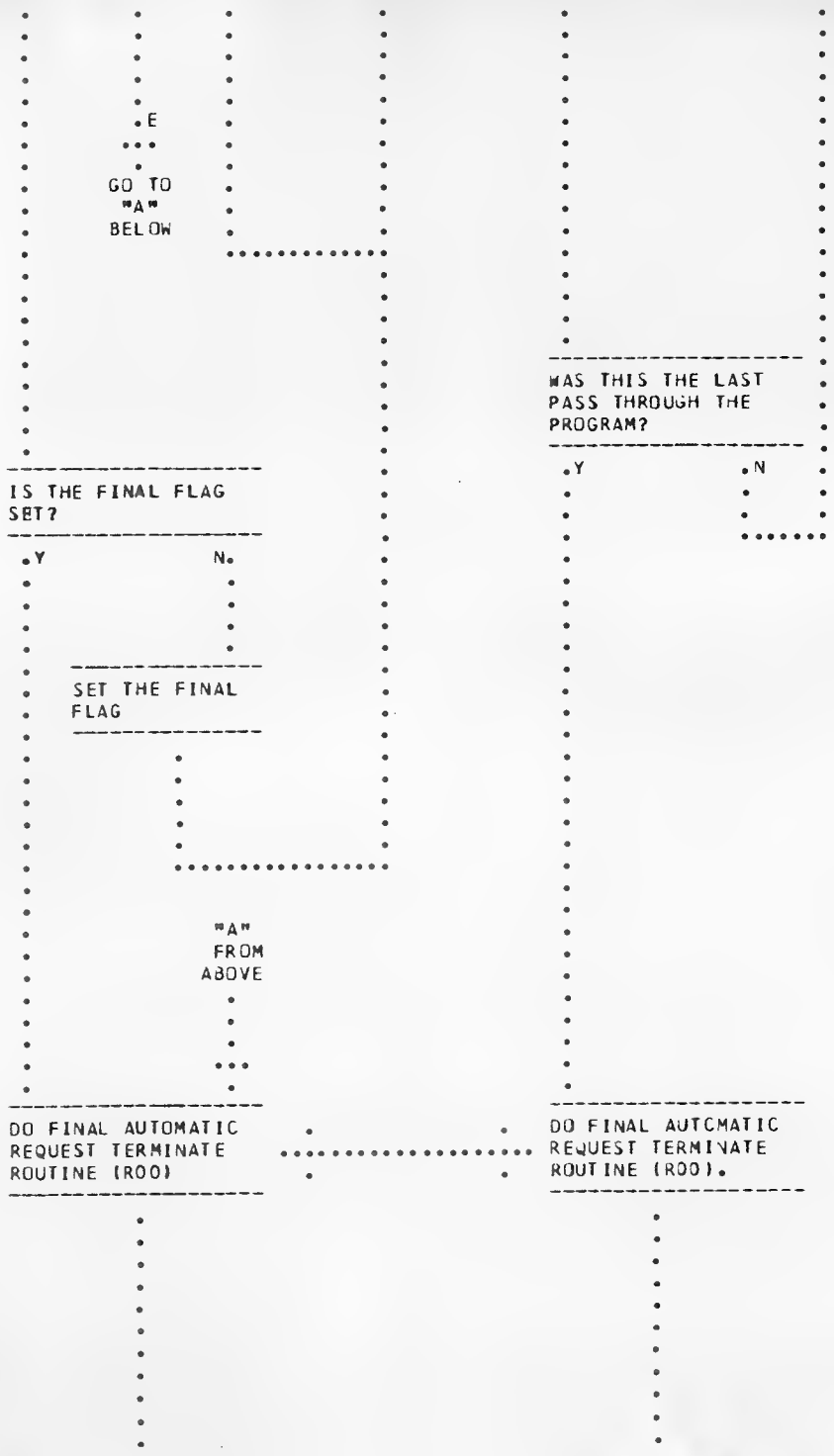
#950

#960

#970

#980

#990



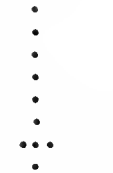
#1000

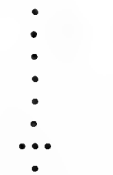
#1010

#1020

#1030

#1040





CHANGE CONTROL NOTES

REV 01 PCR 627
REV 00(LUM 1A) PCR 268.2
REV 01(LUM 1B) PCR 812.2
REV 02 EDITORIAL
REV 03(LUM 1D) PCR 1048, PCN 1009
REV 04(LUM 1E) PCR 1066
REV 05 PCN 1180

TRANSFER PHASE MIDCOURSE (TPM) PROGRAM (P35) REV 06 12/01/71

PURPOSE: (1) TO CALCULATE THE REQUIRED DELTA V AND OTHER INITIAL CONDITIONS REQUIRED BY THE LGC FOR LM EXECUTION OF THE NEXT MIDCOURSE CORRECTION OF THE TRANSFER PHASE OF AN ACTIVE LM RENDEZVOUS.

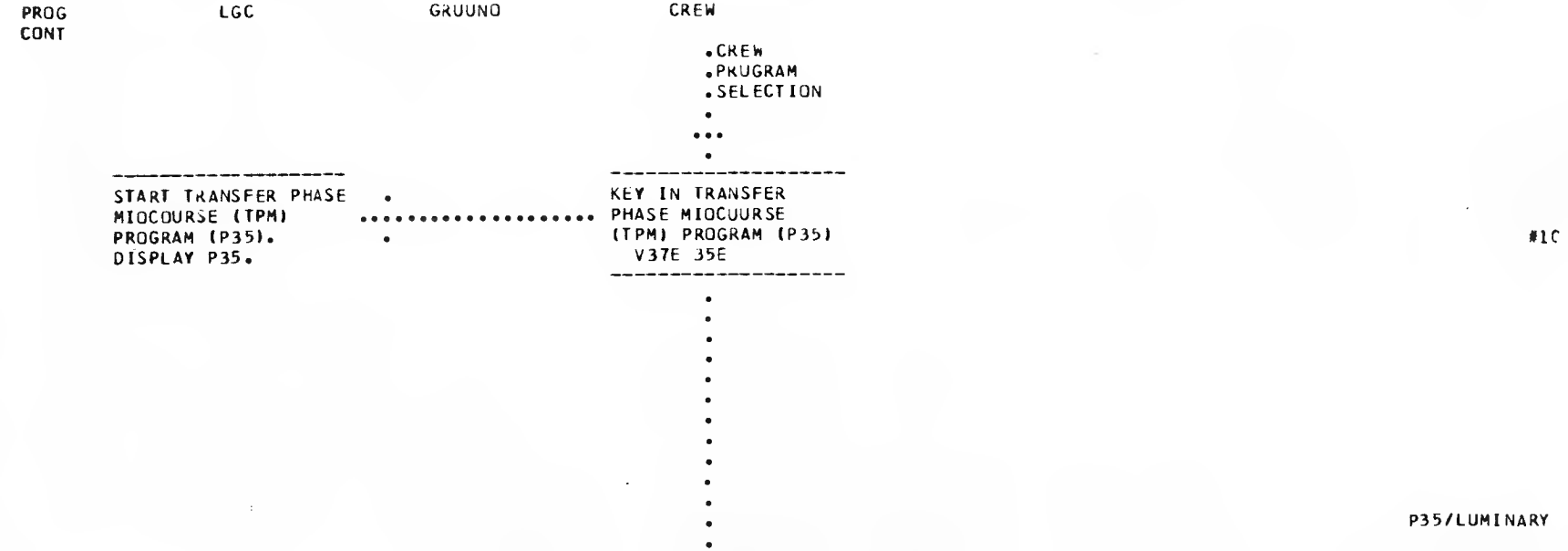
ASSUMPTIONS: (1) THERE IS NO REQUIREMENT FOR ISS OPERATION DURING THIS PROGRAM UNLESS AUTOMATIC STATE VECTOR UPDATING IS DESIRED BY THE RENDEZVOUS NAVIGATION PROGRAM (P20). IF SELECTED, P20 WILL DEFINE THE STATUS OF THE ISS.

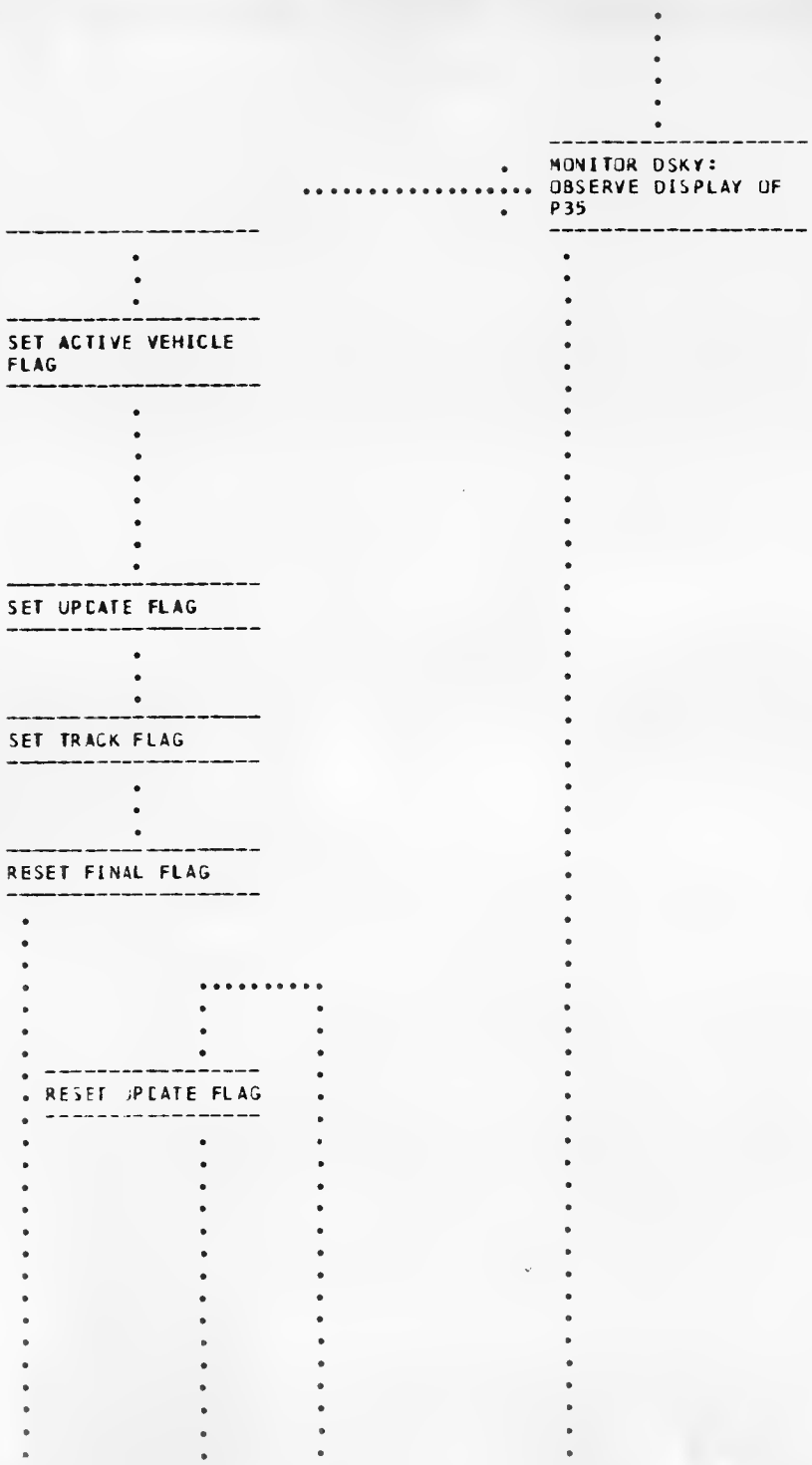
(2) THE RENDEZVOUS RADAR IS ON AND IS LOCKED ON THE CSM. THIS WAS DONE DURING PREVIOUS SELECTION OF P20. RADAR SIGHTING MARKS WILL BE MADE AUTOMATICALLY APPROXIMATELY ONCE A MINUTE WHEN ENABLED BY THE TRACK AND UPDATE FLAGS. THE RENDEZVOUS TRACKING MARK COUNTER IS ZEROED BY THE SELECTION OF P20 AND AFTER EACH THRUSTING MANEUVER.

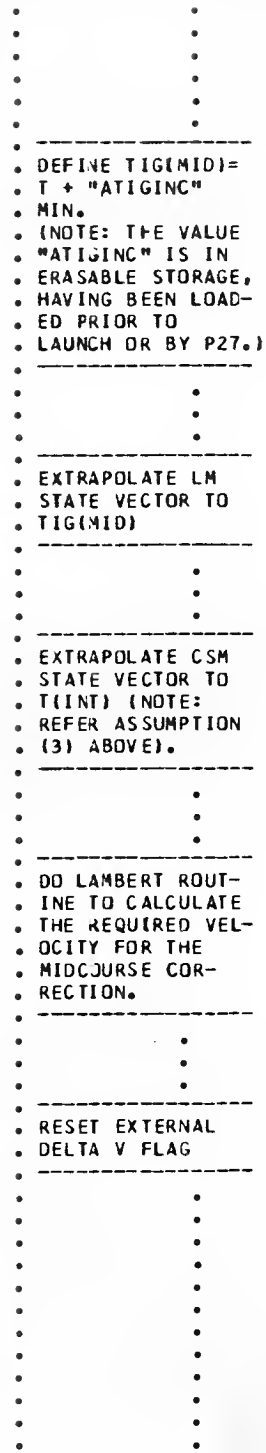
(3) THE TIME OF INTERCEPT (T(INT)) WAS DEFINED BY PREVIOUS COMPLETION OF THE TRANSFER PHASE INITIATION (TPI) PROGRAM (P34) AND IS PRESENTLY AVAILABLE IN LGC STORAGE.

(4) ONCE THE PARAMETERS REQUIRED FOR COMPUTATION OF THE MANEUVER HAVE BEEN COMPLETELY SPECIFIED, THE VALUE OF THE ACTIVE VEHICLE CENTRAL ANGLE OF TRANSFER IS COMPUTED AND STORED. THIS NUMBER WILL BE AVAILABLE FOR DISPLAY TO THE ASTRONAUT THROUGH THE USE OF V06N52.
THE ASTRONAUT WOULD CALL THIS DISPLAY TO VERIFY THAT THE CENTRAL ANGLE OF TRANSFER OF THE ACTIVE VEHICLE IS NOT WITHIN 170 TO 190 DEGREES. IF THE ANGLE IS WITHIN THIS ZONE THE ASTRONAUT SHOULD REASSESS THE INPUT TARGETING PARAMETERS BASED UPON DELTA V AND EXPECTED MANEUVER TIME.

++ (5) THE PROGRAM IS SELECTED BY THE ASTRONAUT BY DSKY ENTRY PRIOR TO ANY ANTICIPATED RENDEZVOUS MIDCOURSE CORRECTION.
+06
+1180 (6) THE DELTA V IN LOS COORDINATES (N59) IS AVAILABLE AT FL V16 N45 AFTER EACH COMPUTATION CYCLE.
++




MONITOR DSKY:
OBSERVE DISPLAY OF
P35
#20
SET ACTIVE VEHICLE
FLAG
#30
SET UPDATE FLAG
#40
SET TRACK FLAG
RESET FINAL FLAG
#50
RESET UPDATE FLAG
#60



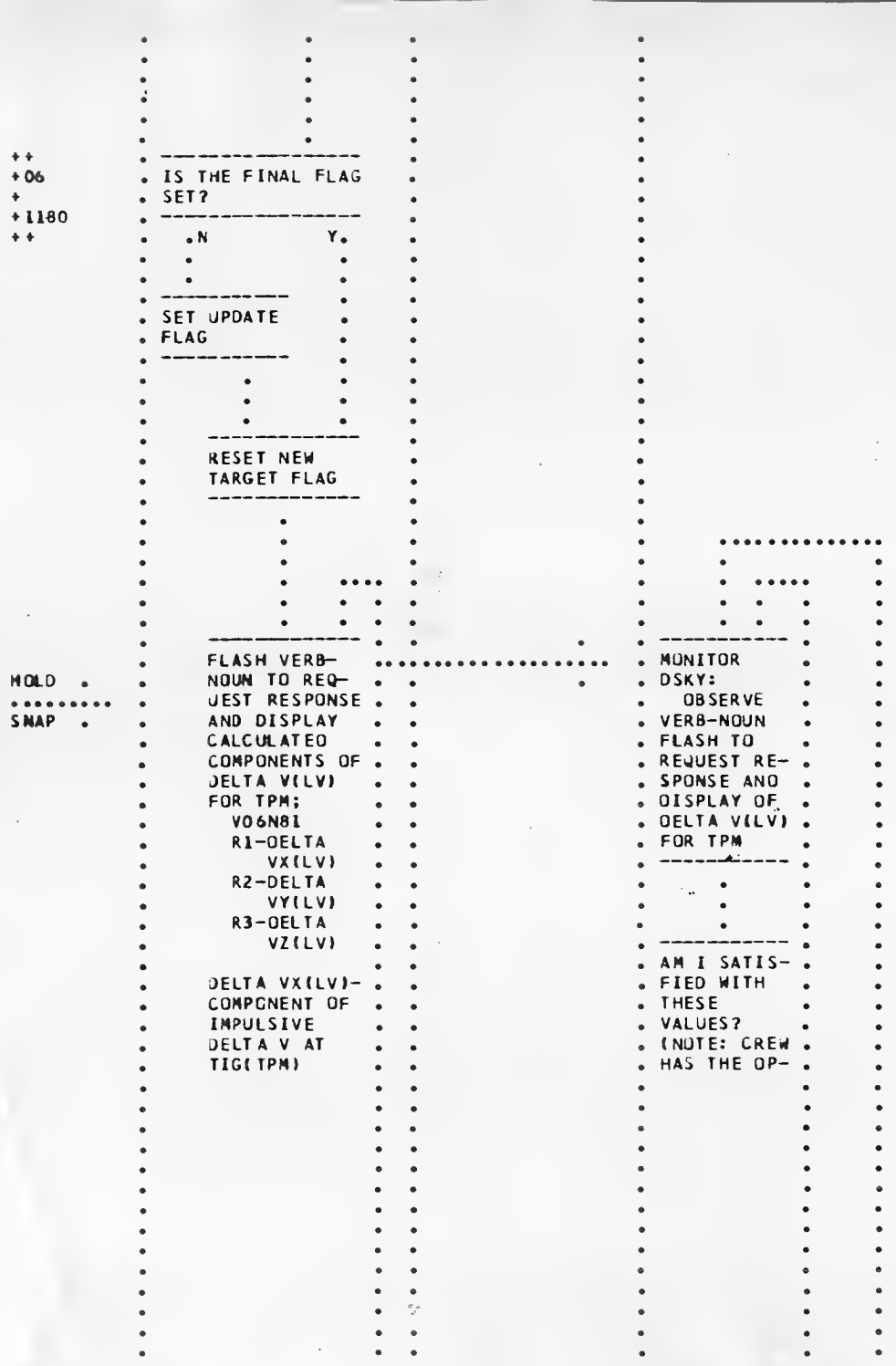
#70

#80

#90

#100

#110



#120

#130

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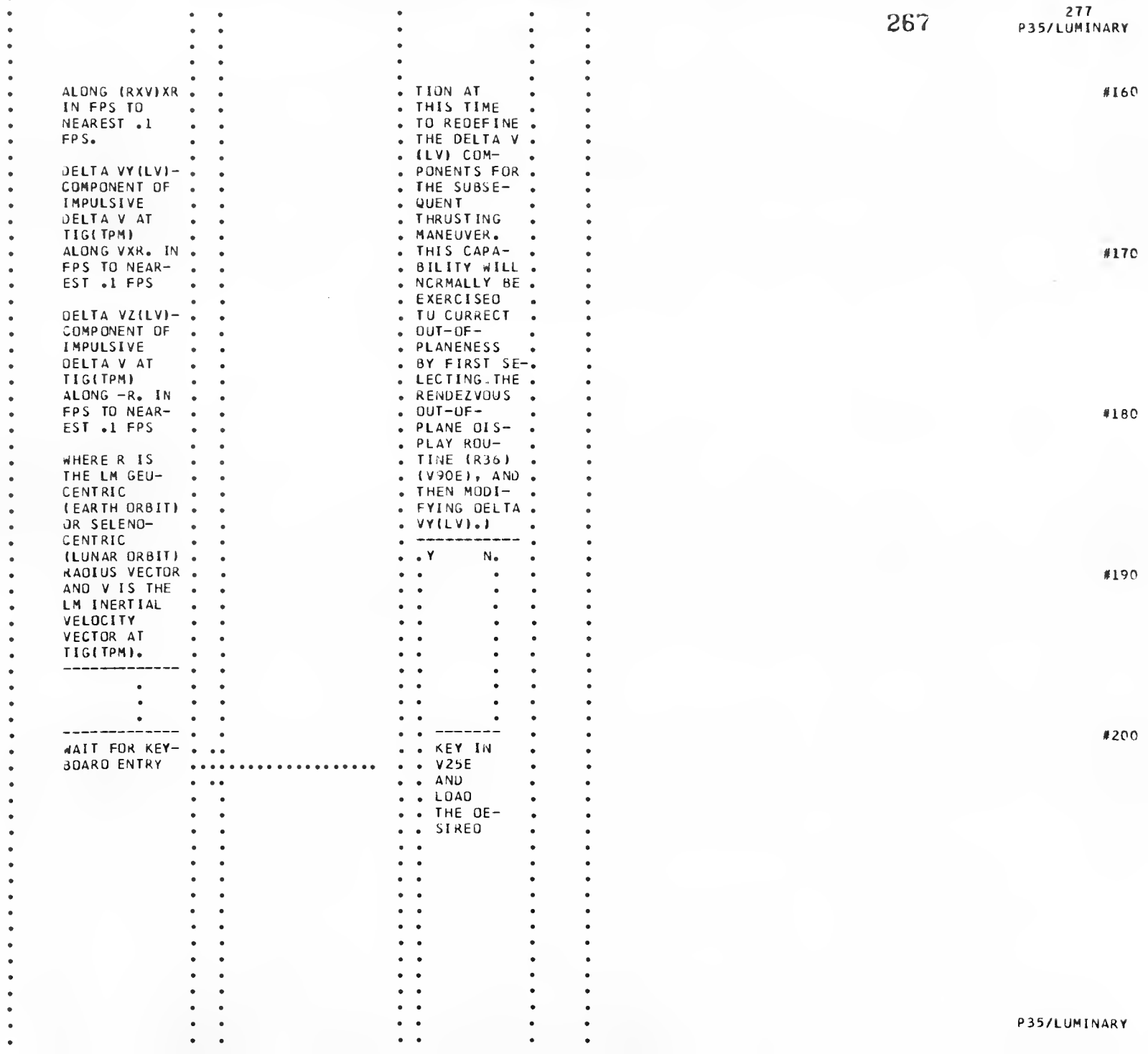


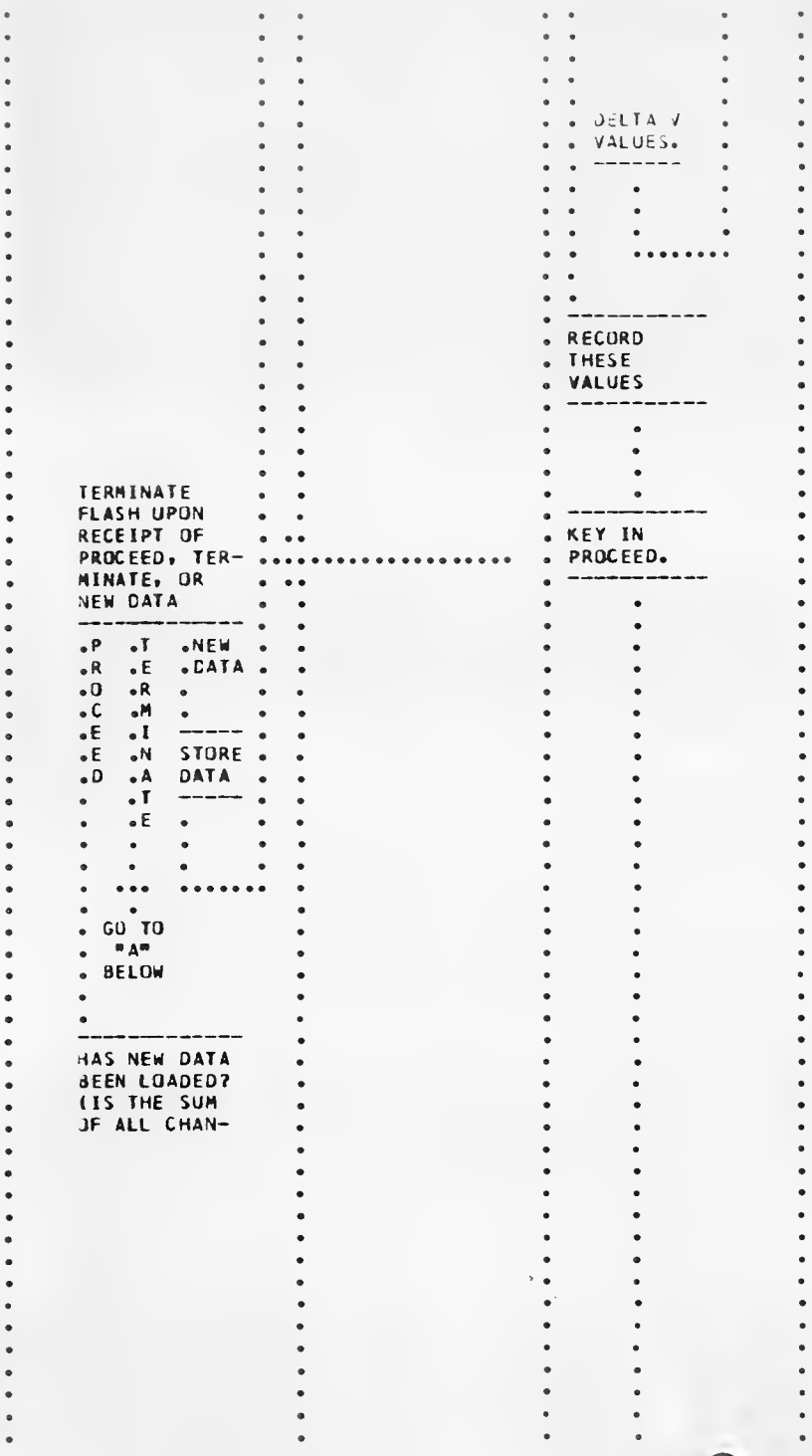
#160

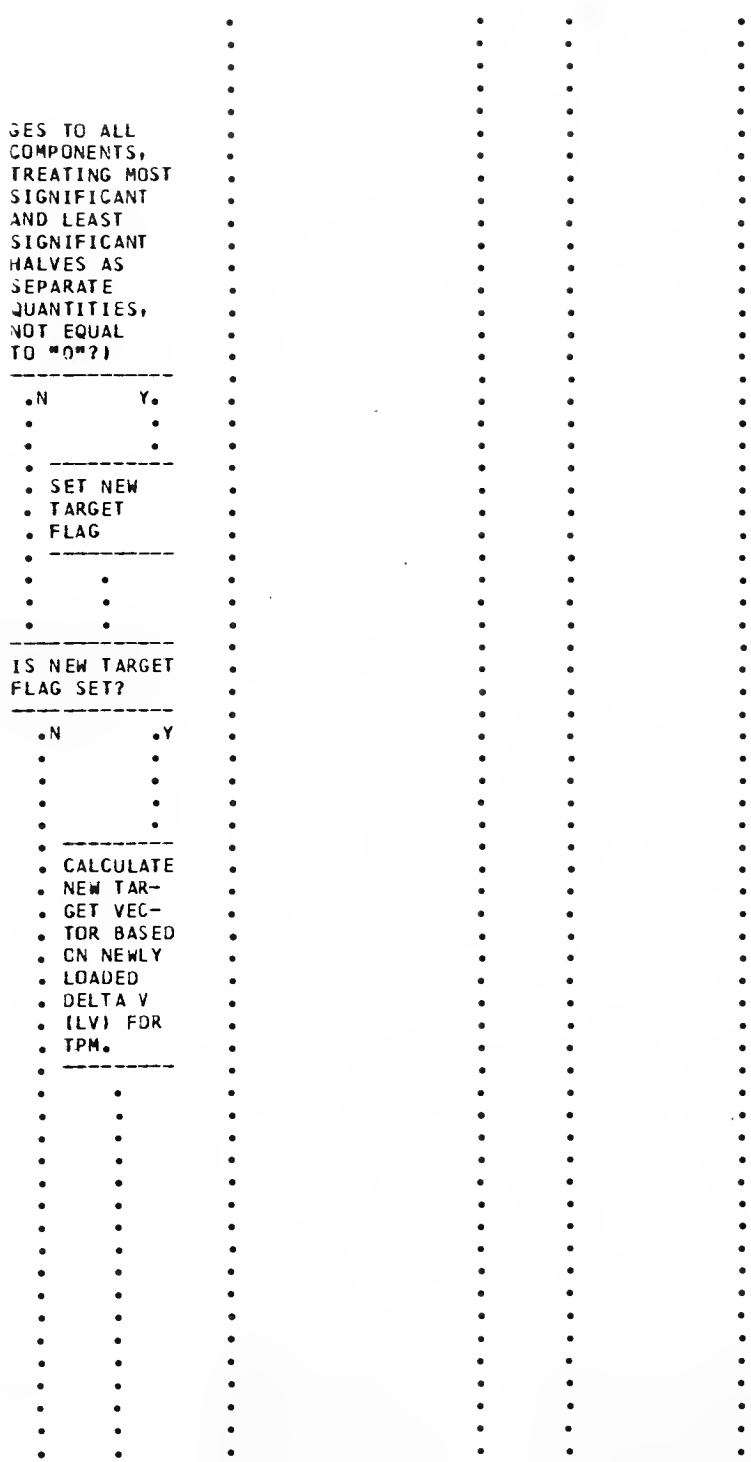
#170

#180

#190

#200


DELTA V
VALUES.
#210
RECORD
THESE
VALUES
#220
KEY IN
PROCEED.
#230
TERMINATE
FLASH UPON
RECEIPT OF
PROCEED, TER-
MINATE, OR
NEW DATA
.P .T .NEW
.R .E .DATA
.O .R .
.C .M .
.E .I -----
.E .N STORE
.D .A DATA
. .T -----
. .E .
. . .
. ...
#240
GO TO
"A"
BELOW
HAS NEW DATA
BEEN LOADED?
(IS THE SUM
OF ALL CHAN-
#250



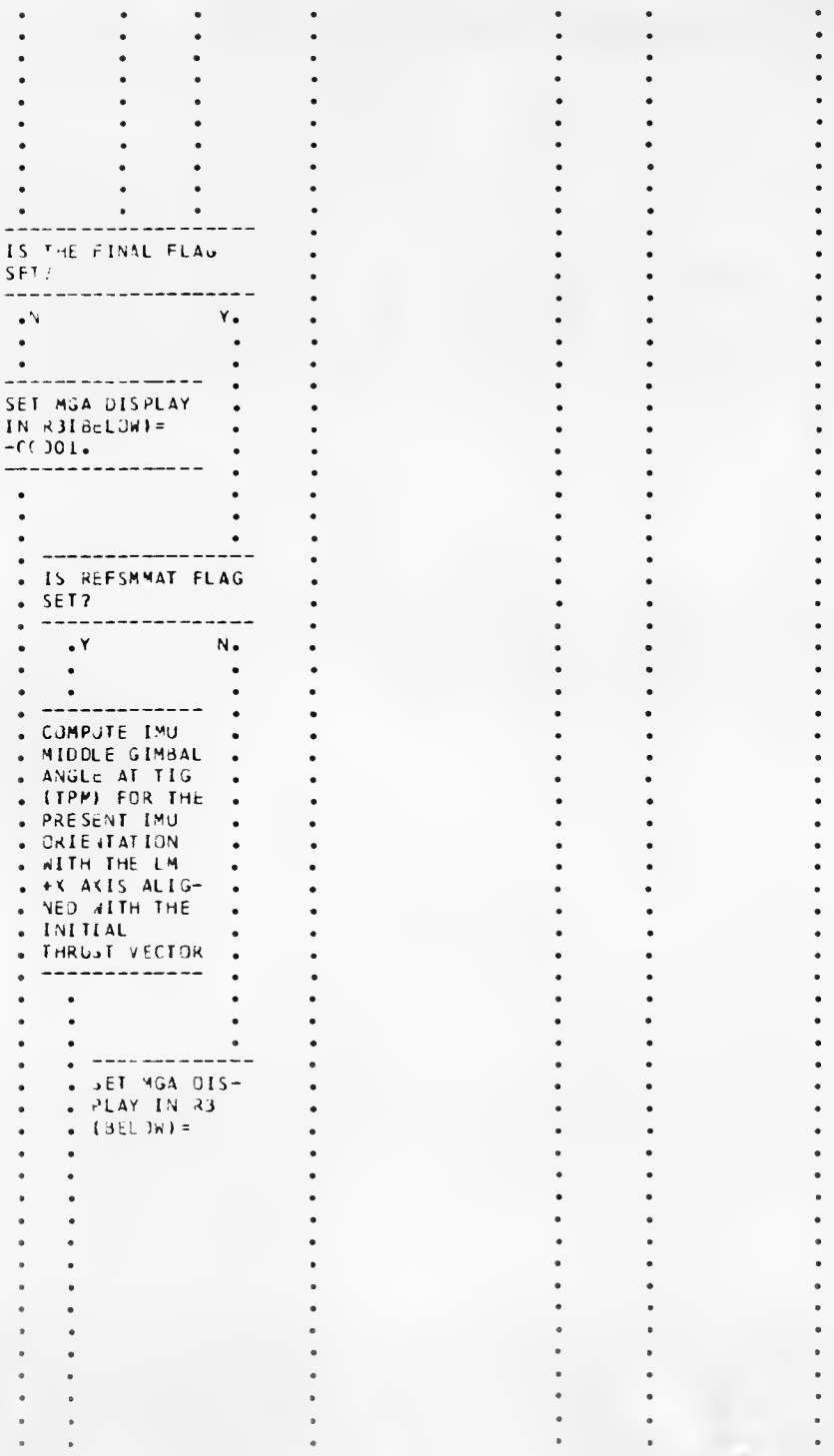
#260

#270

#280

#290

#300



#310

#320

#330

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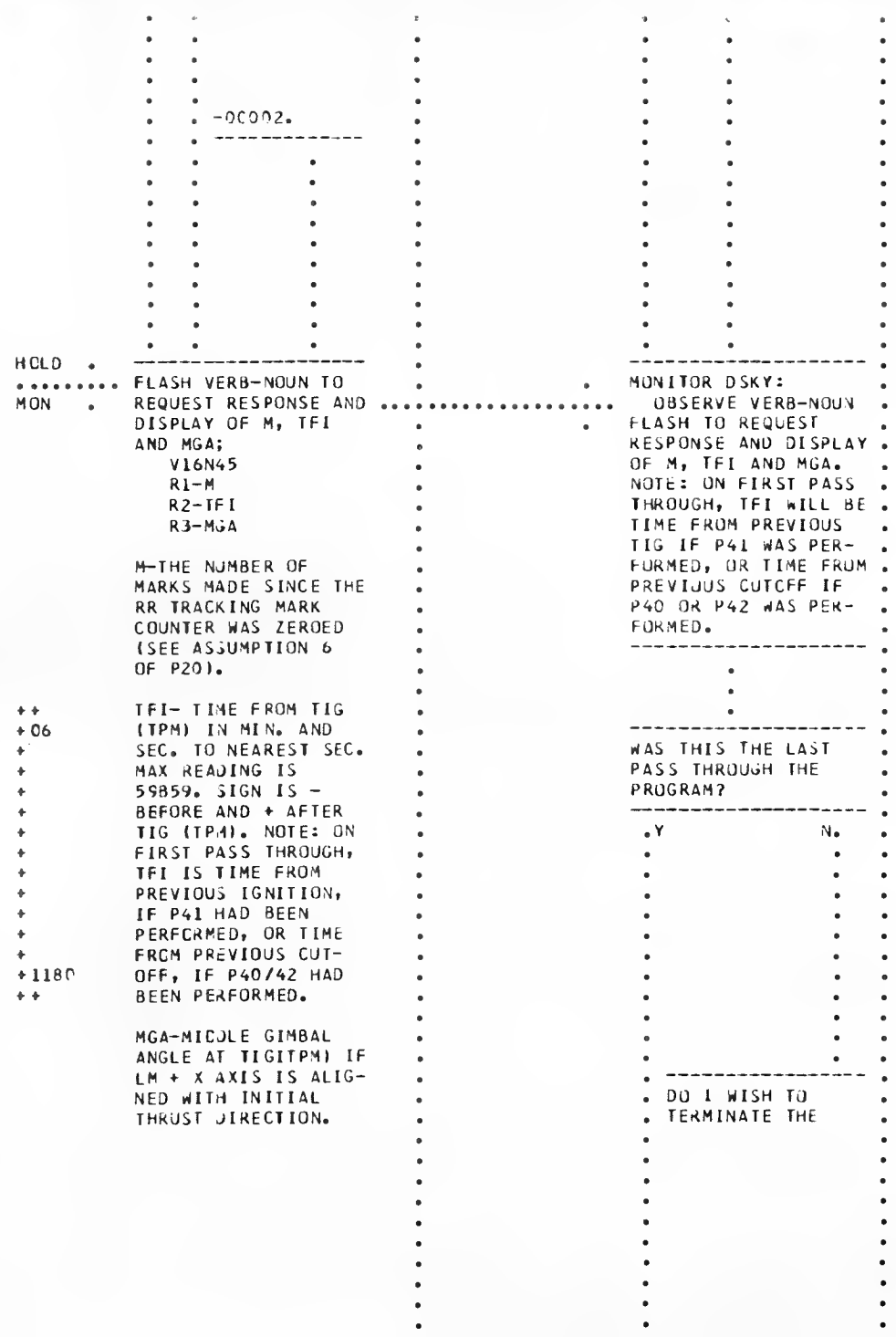
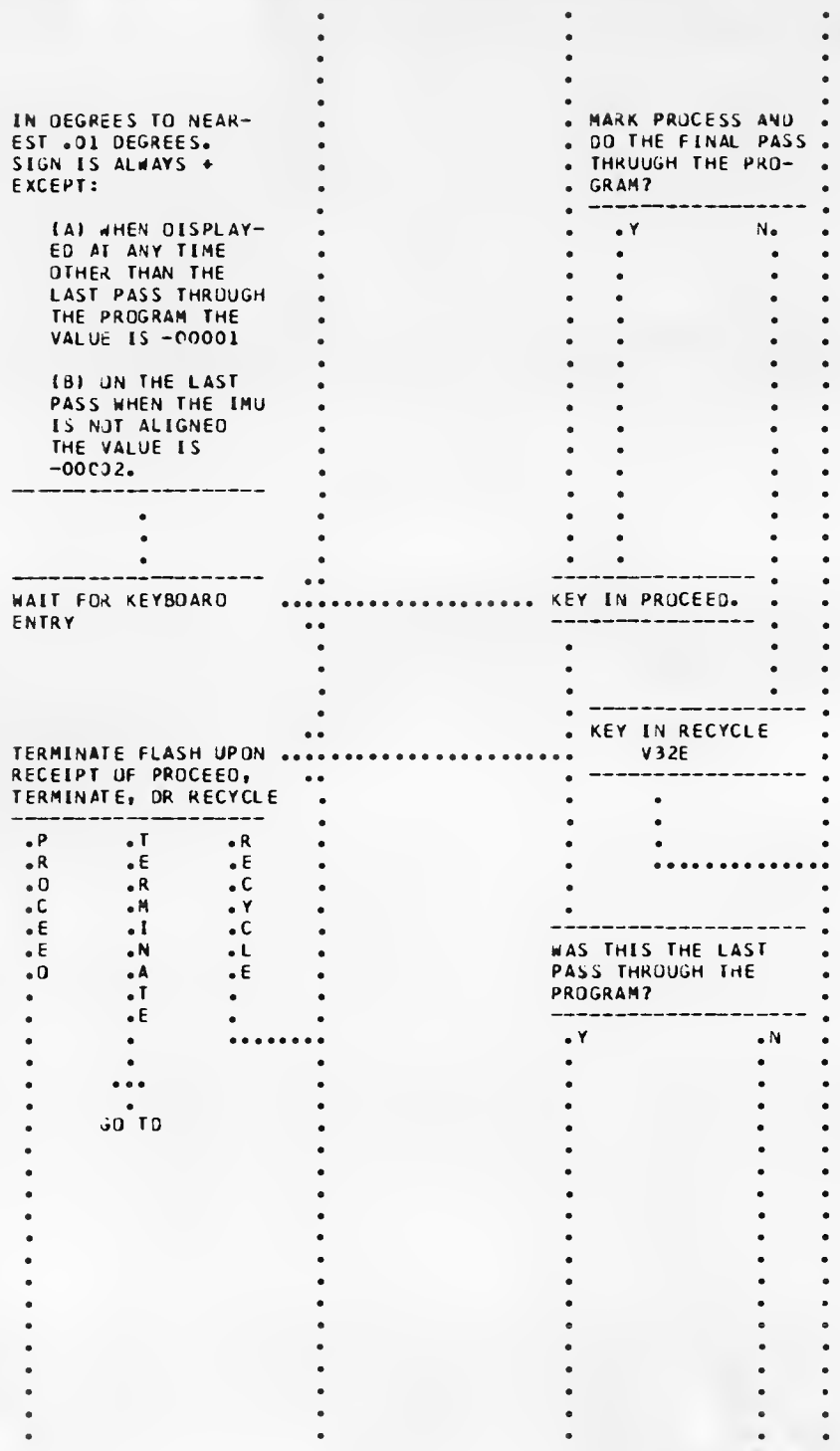

-00002.
HOLD
MON
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY OF M, TFI AND MGA;
V16N45
R1-M
R2-TFI
R3-MGA
M-THE NUMBER OF MARKS MADE SINCE THE RR TRACKING MARK COUNTER WAS ZEROED (SEE ASSUMPTION 6 OF P20).
++
+06
+1180
++
TFI- TIME FROM TIG (TPM) IN MIN. AND SEC. TO NEAREST SEC. MAX READING IS 59859. SIGN IS - BEFORE AND + AFTER TIG (TPM). NOTE: ON FIRST PASS THROUGH, TFI IS TIME FROM PREVIOUS IGNITION, IF P41 HAD BEEN PERFORMED, OR TIME FROM PREVIOUS CUT-OFF, IF P40/42 HAD BEEN PERFORMED.
MGA-MIDDLE GIMBAL ANGLE AT TIG(TPM) IF LM + X AXIS IS ALIGNED WITH INITIAL THRUST DIRECTION.
MONITOR DSKY:
OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY OF M, TFI AND MGA.
NOTE: ON FIRST PASS THROUGH, TFI WILL BE TIME FROM PREVIOUS TIG IF P41 WAS PERFORMED, OR TIME FROM PREVIOUS CUTOFF IF P40 OR P42 WAS PERFORMED.
WAS THIS THE LAST PASS THROUGH THE PROGRAM?
.Y
N.
DO I WISH TO TERMINATE THE
#350
#360
#370
#380
#390



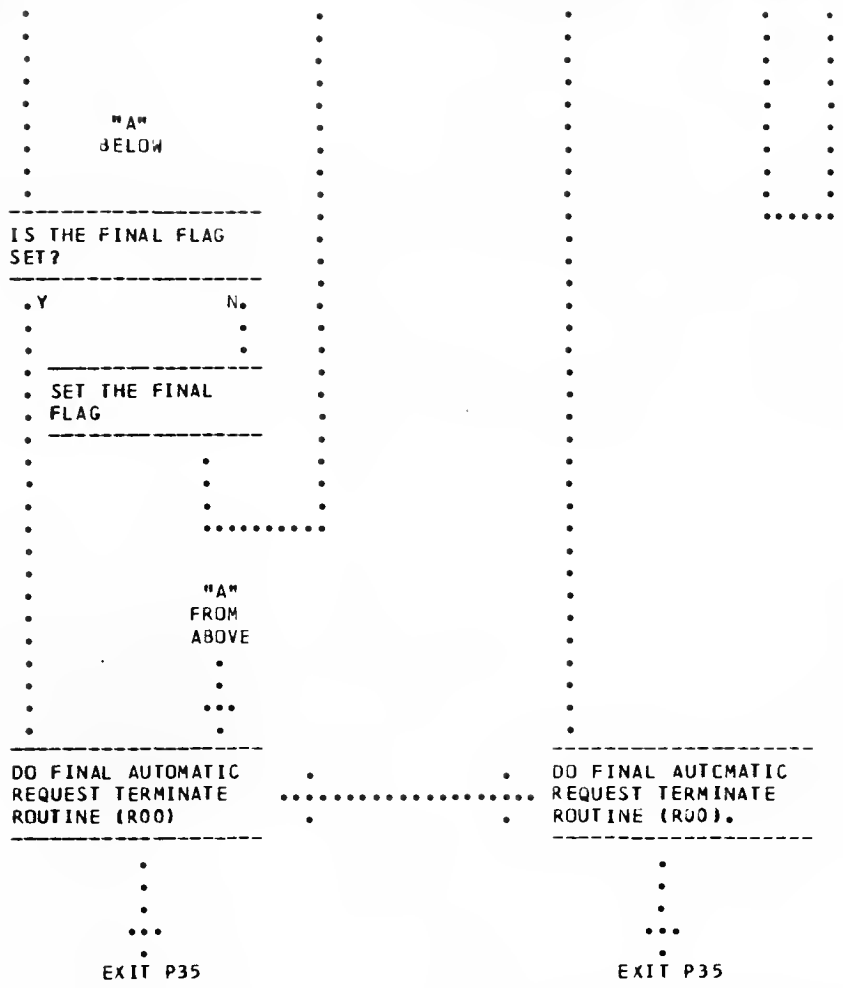
#400

#410

#420

#430

#440



#450

#460

#470

#480

CHANGE CONTROL NOTES

REV 01 PCR 502,627
REV 02(LUM1B) PCR 812.2
REV 03 EDITORIAL
REV 04 PCN 1009
REV 05(LUM 1E) PCR 1066
REV 06 PCN 1180

OPS PROGRAM (P40) REV 05 12/01/71

PURPOSE: (1) TO COMPUTE A PREFERRED IMU ORIENTATION AND A VEHICLE ATTITUDE FOR A LM DPS THRUSTING MANEUVER.

(2) TO DO THE VEHICLE MANEUVER TO THE THRUSTING ATTITUDE.

(3) TO CONTROL THE PGNCS DURING COUNTDOWN, IGNITION, THRUSTING, AND THRUST TERMINATION OF A PGNCS CONTROLLED DPS MANEUVER.

ASSUMPTIONS: (1) THE TARGET PARAMETERS HAVE BEEN CALCULATED AND STORED IN THE LGC BY PRIOR EXECUTION OF A PRE-THRUSTING PROGRAM.

(2) THE REQUIRED STEERING EQUATIONS ARE IDENTIFIED BY THE PRIOR PRE-THRUST PROGRAM, WHICH EITHER RESET ("ASTEER") OR SET (EXT DELTA V) THE EXTERNAL DELTA V FLAG. FOR EXTERNAL DELTA V STEERING, VG IS CALCULATED ONCE FOR THE SPECIFIED TIME OF IGNITION. THEREAFTER BOTH DURING DPS THRUSTING AND UNTIL THE CREW NOTIFIES THE LGC THAT RCS TRIM THRUSTING HAS BEEN COMPLETED, THE LGC UPDATES VG ONLY AS A RESULT OF ACCELEROMETER INPUTS.
FOR STEERING CONTROL WHEN USING "ASTEER", THE VELOCITY REQUIRED IS CALCULATED FROM FIGURE 3.3-13A IN SECTION 5 OF R-567. THE LAMBERT ROUTINE PERIODICALLY RE-COMPUTES THE INTERCEPT TRAJECTORY SEMI-MAJOR AXIS FOR THE "ASTEER" CALCULATIONS. THE INTERVAL BETWEEN LAMBERT SOLUTIONS IS CONTROLLED BY AN ERASABLE LOADED VALUE (UT).

(3) THE IMU IS ON AND MUST BE AT A KNOWN ORIENTATION BEFORE THIS PROGRAM MAY BE COMPLETED. IT IS NORMALLY REQUIRED THAT THE ISS BE ON FOR A MINIMUM OF 15 MINUTES PRIOR TO A THRUSTING MANEUVER.

(4) THE EVENT TIMER IS SET TO COUNT TO ZERO AT TIG.

(5) ENGINE IGNITION MAY BE SLIPPED BEYOND THE ESTABLISHED TIG IF DESIRED BY THE CREW, OR IF STATE VECTOR INTEGRATION CANNOT BE COMPLETED IN TIME.

(6) IF A THRUSTING MANEUVER IS PERFORMED WITH THE GUIDANCE CONTROL SWITCH IN PGNS AND THE MODE CONTROL SWITCH IN AUTO, THE PGNCS WILL CONTROL THE TOTAL VEHICLE ATTITUDE AND GENERATE EITHER MODE I OR MODE II ATTITUDE ERRORS AND VEHICLE ATTITUDE RATES (SEE ASSUMPTION (7)) FOR DISPLAY ON THE FDAI. THE CREW MAY EXERCISE CONTROL AROUND THE YAW AXIS ONLY WITH THE ACA (X-AXIS OVERRIDE) IF THE X-AXIS OVERRIDE CAPABILITY IS PERMITTED BY THE PROGRAM IN PROCESS. THIS MANUAL CONTROL WILL BE IN THE RATE COMMAND/ATTITUDE HOLD MODE.
IF A THRUSTING MANEUVER IS PERFORMED WITH THE GUIDANCE CONTROL SWITCH IN PGNS AND THE MODE CONTROL SWITCH IN ATTITUDE HOLD THE PGNCS WILL HOLD THE VEHICLE ATTITUDE AND WILL GENERATE EITHER MODE I OR MODE II ATTITUDE ERRORS FOR DISPLAY ON THE FDAI. THE CREW MAY EXERCISE MANUAL ATTITUDE CONTROL ABOUT ALL VEHICLE AXES WITH THE ACA IN EITHER THE RATE COMMAND OR MINIMUM IMPULSE MODE DEPENDING UPON THE STATUS OF THE PULSES FLAG. HOWEVER, IT IS STRONGLY RECOMMENDED THAT POWERED FLIGHT NOT BE ATTEMPTED IN THE MINIMUM IMPULSE MODE. THE PULSES FLAG IS SET OR RESET BY EXTENDED VERBS 76 (MINIMUM IMPULSE) AND 77 (RATE COMMAND) RESPECTIVELY. THE PULSES FLAG IS ALSO RESET BY P12,P40,P41,P42,P63,P70,P71, AND R40 AT MAIN ENGINE IGNITION; WITH THE EXCEPTION OF THESE CASES, MODE SELECTION IS ALWAYS BASED UPON THE LAST ENTRY MADE IN THE DSKY. DURING A THRUSTING MANEUVER IN THE PGNS/ATTITUDE HOLD MODE THE PGNCS WILL NOT BE RESPONSIBLE IF REGISTER OVERFLOWS OCCUR WITHIN THE LGC. IN THE EVENT THAT THE GUIDANCE CONTROL SWITCH IS CHANGED FROM PGNS TO AGS DURING A THRUSTING MANEUVER, THE LGC WILL CONTINUE COMPUTATION OF POSITION, VELOCITY, THE DESIRED THRUST VECTOR, AND THE FDAI ATTITUDE ERROR NEEDLE DISPLAY. HOWEVER, THE PGNCS WILL NOT BE RESPONSIBLE IF REGISTER OVERFLOWS OCCUR WITHIN THE LGC.

(7) THE PGNCS CAN GENERATE TWO TYPES OF ATTITUDE ERRORS FOR DISPLAY ON THE FDAI;
MODE I - SELECTED BY EXTENDED VERB 61. AUTOPILOT FOLLOWING ERRORS USED AS A MONITOR OF THE DAP'S ABILITY TO TRACK AUTOMATIC STEERING COMMANDS.
MODE II - SELECTED BY EXTENDED VERB 62. TOTAL ATTITUDE ERRORS USED TO ASSIST CREW IN MANUALLY MANEUVERING THE VEHICLE.
PGNCS-DERIVED VEHICLE ATTITUDE RATES MAY ALSO BE DISPLAYED VIA SELECTION BY EXTENDED VERB 60.
DISPLAY SELECTION IS ALWAYS BASED UPON THE LAST ENTRY MADE IN THE DSKY, WITH THE EXCEPTION THAT MODE II ATTITUDE

+D5 ERRUR DISPLAYS ARE AUTOMATICALLY SELECTED AT THE BEGINNING OF R60.
+1180 FOR A MORE DETAILED DESCRIPTION UF THESE DISPLAYS REFER TO SECTICN 3 OF R557, PARA. 3.2.6
++

(8) THE X-AXIS OVERRIDE OPTION PRCVIDES THE CREW WITH THE ABILITY TJ EXERCISE MANUAL CONTROL ABOUT THE LM X AXIS WITH THE ATTITUDE CONTROLLER EVEN THOUGH THE PGNCS ATTITUDE CONTRDL MODE IS AUTO. WHEN THE CONTROLLER IS RETURNED TO DETENT THE PGNCS DAMPS THE YAW RATE, STORES THE YAW ATTITUDE WHEN THE YAW RATE IS DAMPED, AND THEN MAINTAINS THAT ATTITUDE.
THE X-AXIS OVERRIDE OPTION IS ALWAYS AVAILABLE TO THE CREW, HOWEVER IT SHOULD NOT BE EXERCISED WHEN THE LGC IS SPECIFYING A DESIRED YAW ATTITUDE, I.E.: DURING THE ATTITUDE MANEUVER TO THE THRUSTING ATTITUDE (SEE R6C).

(9) WHEN THE THRUST/TRANSLATION CONTRDLLER IS SET TO MINIMUM THRUST POSITION AND THE LGC THRDTTLE COMMAND IS ZERO THE DPS WILL START AT 10 PER CENT THRUST.

(10) THE DAP DATA LOAD ROUTINE (R03) HAS BEEN PERFORMED PRIOR TO SELECTION OF THIS PROGRAM AND THE DPS ENGINE GIMBAL HAS BEEN PREVIOUSLY DRIVEN TJ THE CORRECT TRIM POSITION.IF THIS BURN IS OF SUFFICIENT DURATION THAT VEHICLE TRANSIENTS AT IGNITION DJE TO CG/THRUST DOES NOT AFFECT ACCOMPLISHMENT OF MANEUVER AIM CONDITIONS, THEN GIMBAL DRIVE TO TRIM POSITION NEED NOT BE DONE BEFORE TIG. GIMBAL DRIVE TO TRIM PDSITION IN WORST CASE COULD REQUIRE 2 MINUTES.

(11) DURING DPS BURNS ONLY, THE PITCH-ROLL RCS JET AUTOPILOT (U AND V JETS) MAY BE DISABLED (V65) OR ENABLED (V75) BY EXTENDED VERB AS SHOWN. THIS CAPABILITY IS INTENDED TO BE USED TO PREVENT LM AND DESCENT STAGE THERMAL CONSTRAINT VIOLATICNS DURING CSM-DOCKED DPS BURNS (P40). THE CAPABILITY EXISTS DURING P63 AND P70 ALSO. PERFORMANCE OF FRESH START (V36E) WILL ALWAYS ENABLE THE PITCH-ROLL JETS.

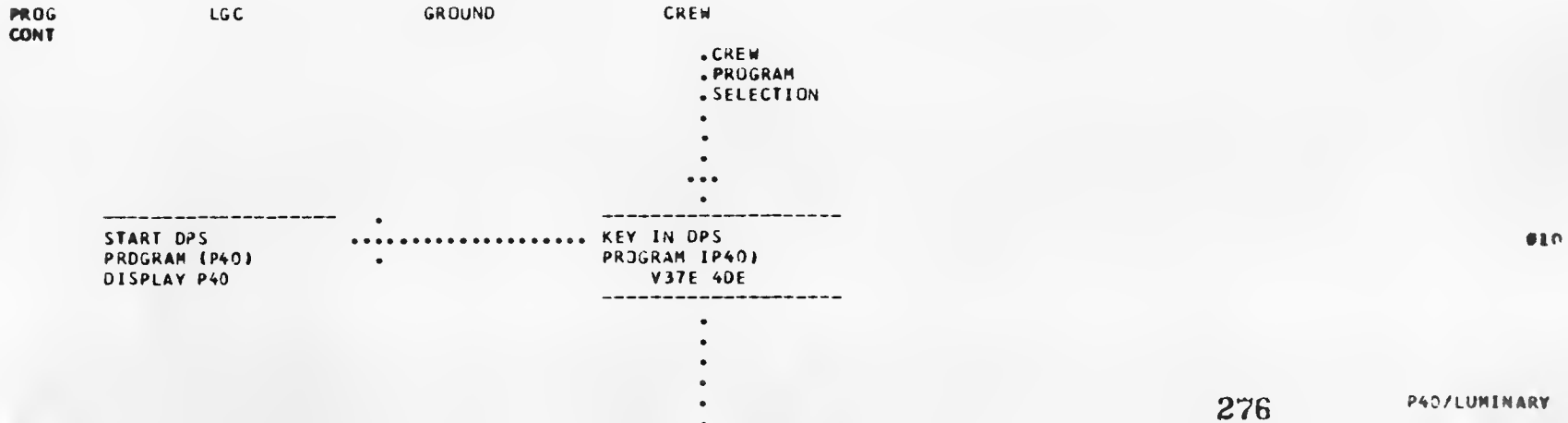
(12) FOR EACH BURN AN IGNITION TOTAL ALLOWABLE TIME DELAY WILL BE SPECIFIED IN THE MISSION RULES. THIS DELAY TIME IS THE TOTAL TIME WHICH THE THRUSTING MANEUVER MAY BE DELAYED BEYOND THE LGC CALCULATED TIME OF IGNITION. IF ENGINE RESTARTS ARE INVOLVED, THE ACCOUNTING OF THIS TOTAL TIME DELAY IS UP TO THE CREW.

(13) LGC AND CREW PROCEDURES IN CASES OF LGC-ASSUMED THRUST FAILURE ARE DEFINED BY THE DPS/APS THRUST FAIL ROUTINE (R40). THIS ROUTINE IS CALLED AT DPS IGNITION BY THIS PROGRAM.

(14) THE LGC WILL NEITHER DESIGNATE NOR READ THE RENDEZVOUS RADAR (RR) DURING THIS PROGRAM.

(15) THIS PROGRAM SHOULD BE SELECTED BY THE ASTRONAUT BY DSKY ENTRY AT LEAST 5 MIN. BEFORE THE ESTIMATED TIME OF IGNITION.

(16) THIS PROGRAM IS SELECTED MANUALLY BY DSKY ENTRY.



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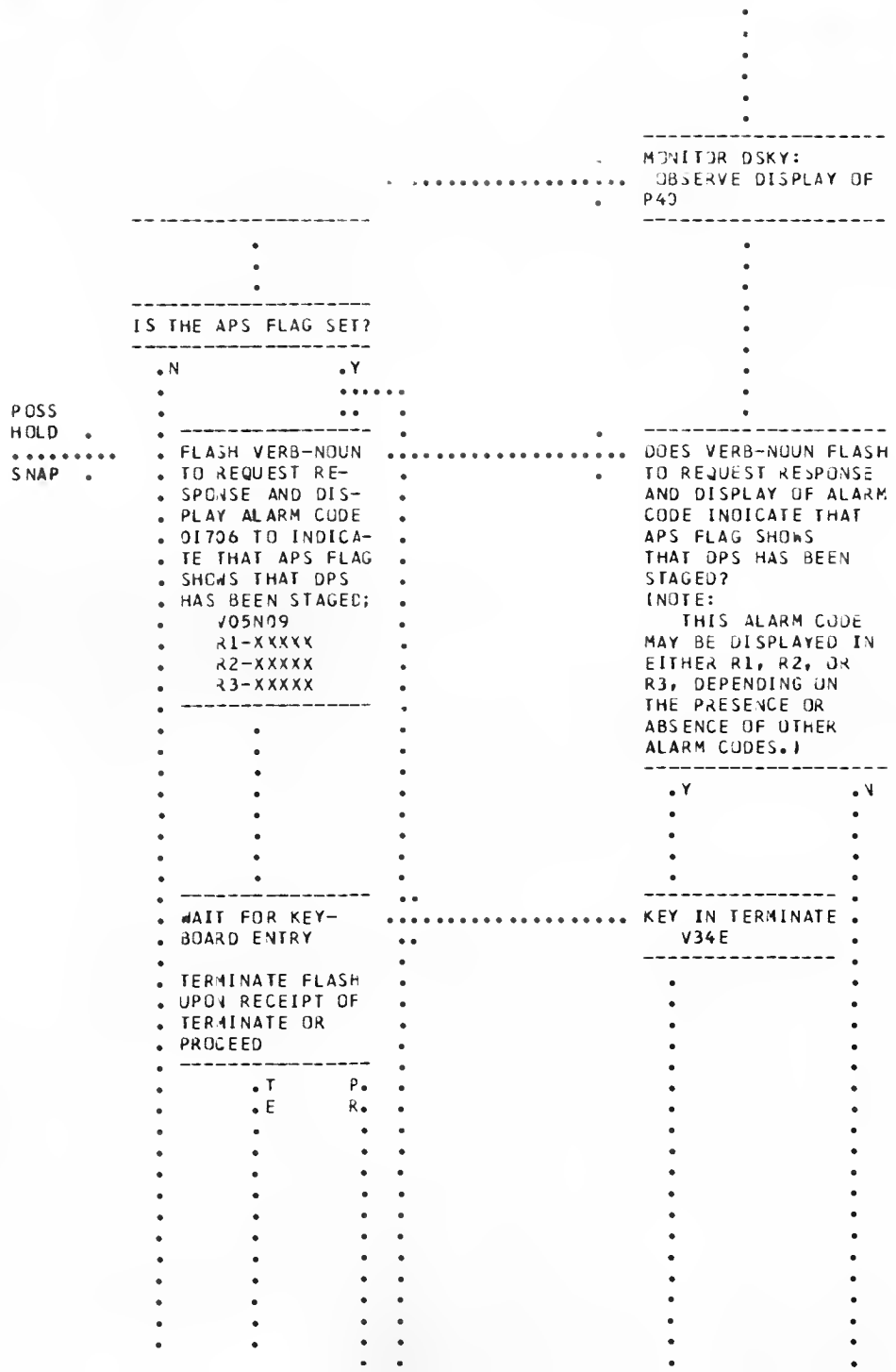
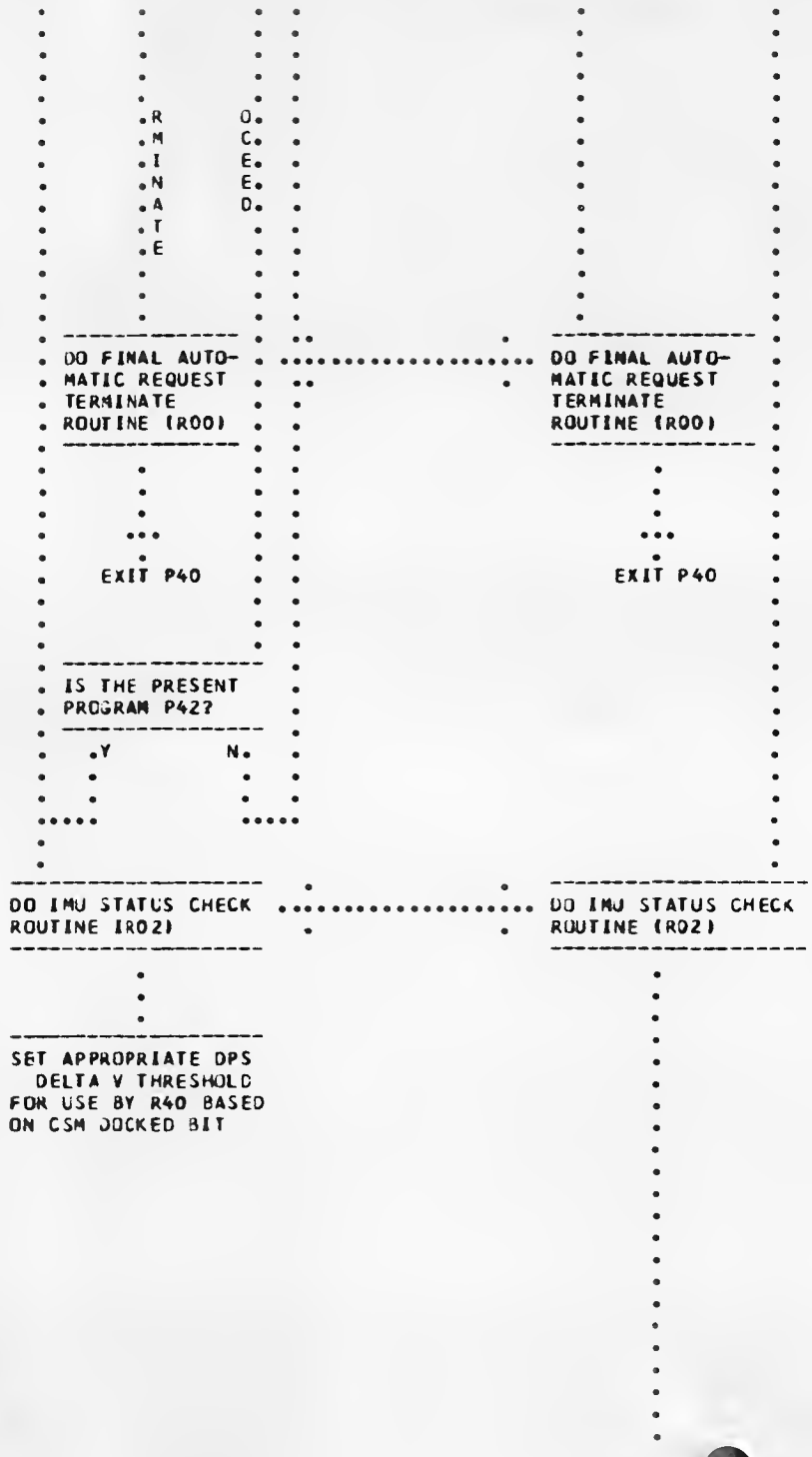

MONITOR DSKY:
OBSERVE DISPLAY OF P40
#20
IS THE APS FLAG SET?
N
Y
POSS HOLD
SNAP
#30
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY ALARM CODE 01706 TO INDICATE THAT APS FLAG SHOWS THAT DPS HAS BEEN STAGED;
V05N09
R1-XXXXX
R2-XXXXX
R3-XXXXX
DOES VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY OF ALARM CODE INDICATE THAT APS FLAG SHOWS THAT DPS HAS BEEN STAGED?
(NOTE:
THIS ALARM CODE MAY BE DISPLAYED IN EITHER R1, R2, OR R3, DEPENDING ON THE PRESENCE OR ABSENCE OF OTHER ALARM CODES.)
#40
Y
N
#50
WAIT FOR KEYBOARD ENTRY
TERMINATE FLASH UPON RECEIPT OF TERMINATE OR PROCEED
KEY IN TERMINATE
V34E
#60
T
E
P
R



0070

0080

0090

0100

0110

IN OAP.

```
          .
          .
          .
```

SET DELTA V COUNTER=4 FOR USE BY R40

```
          .
          .
          .
```

RESET NO THROTTLE FLAG

```
          .
          .
          .
```

COMPUTE INITIAL THRUST DIRECTION AND INITIAL VALUE OF VG VECTOR AND STORE VG(LV) IN N81 AND N86 FOR POSSIBLE MANUAL SELECTION:

  R1-VGX(LV)
  R2-VGY(LV)
  R3-VGZ(LV)

VGX(LV)-COMPONENT OF VG AT TIG ALONG (RXV)XR. IN FPS TO NEAREST .1 FPS.

VGY(LV)-COMPONENT OF VG AT TIG ALONG VXR. IN FPS TO NEAREST .1 FPS.

VGZ(LV)-COMPONENT OF VG AT TIG ALONG -R. IN FPS TO NEAREST .1 FPS.

#120

#130

#140

#150

WHERE R IS GEO-
CENTRIC (EARTH
ORBIT) OR SELENO-
CENTRIC (LUNAR
ORBIT) RADIUS VECTOR
AND V IS VEHICLE
INERTIAL VELOCITY
VECTOR AT TIG.
(NOTE: N81 WILL NOW
DIFFER FROM N81 DIS-
PLAY OF P30, P32,
AND P33 BECAUSE OF
ROTATION OF VG
VECTOR).

.
.
.

COMPUTE PREFERRED
IMU ORIENTATION:

$$\underset{-SM}{X} = \text{UNIT}(\underset{-}{T})$$

$$\underset{-SM}{Y} = \text{UNIT}(\underset{-}{T} \times \underset{-}{R})$$

$$\underset{-SM}{Z} = \text{UNIT}(\underset{-SM}{X} \times \underset{-SM}{Y})$$

WHERE:

T = THE INITIAL
- THRUST VECTOR
AT TIG

R = THE GEOCENTRIC
- (EARTH ORBIT)
OR SELENO-
CENTRIC (LUNAR
ORBIT) RADIUS
VECTOR AT TIG.
(NOTE: IF $\underset{-}{T} \times \underset{-}{R}$ IS
SMALL (REFER SECTION

#160

#170

#180

#190

#200

5.3 OF R567),
THEN Y = - SM
UNIT (T X V)
WHERE V = VEHICLE INERTIAL VELOCITY VECTOR AT TIG.)

#210

#220

STORE DESIRED ATTITUDE SPECIFICATION FOR USE BY ATTITUDE MANEUVER ROUTINE (R60). THE FINAL ATTITUDE WILL BE COMPUTED DURING R60 AND WILL POINT THE LM +X AXIS IN THE INITIAL THRUST DIRECTION. HOWEVER, IN ORDER TO CONSERVE RCS FUEL AND NOT CONSTRAIN THE NON-CRITICAL ATTITUDE ABOUT THE THRUST VECTOR, WINGS MAY NOT BE LEVEL IN THE COMPUTED FINAL ATTITUDE.

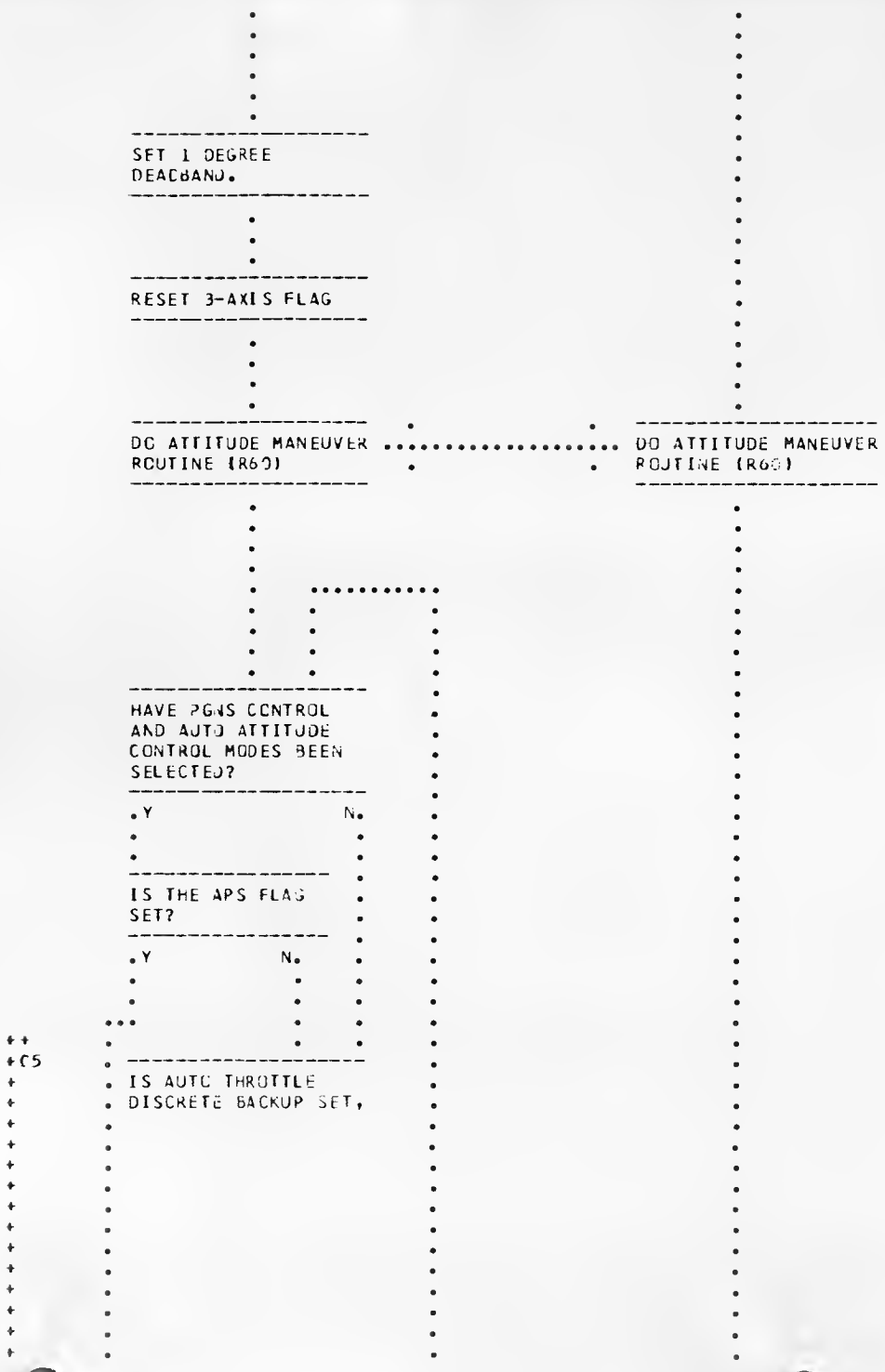
#230

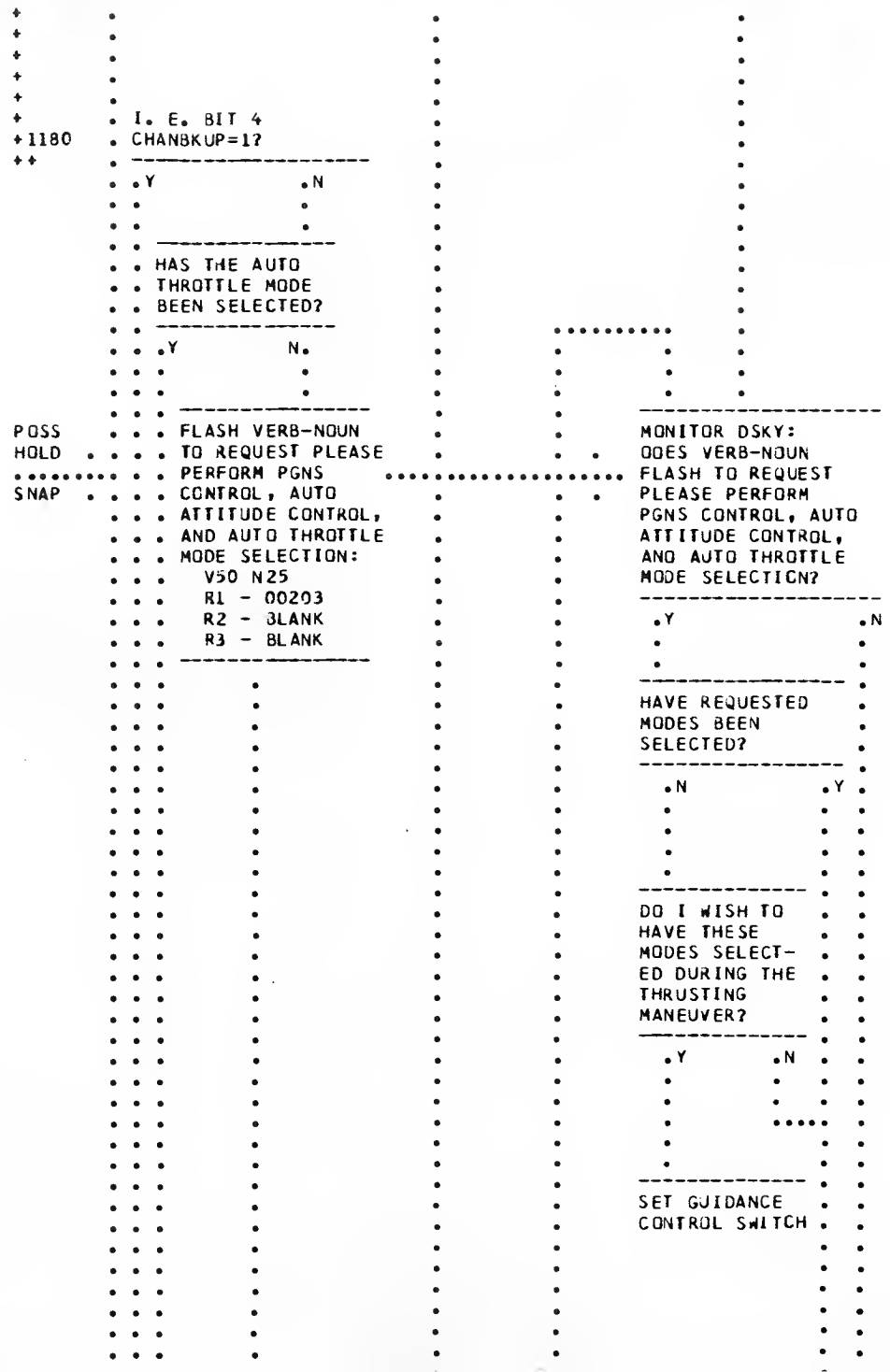
#240

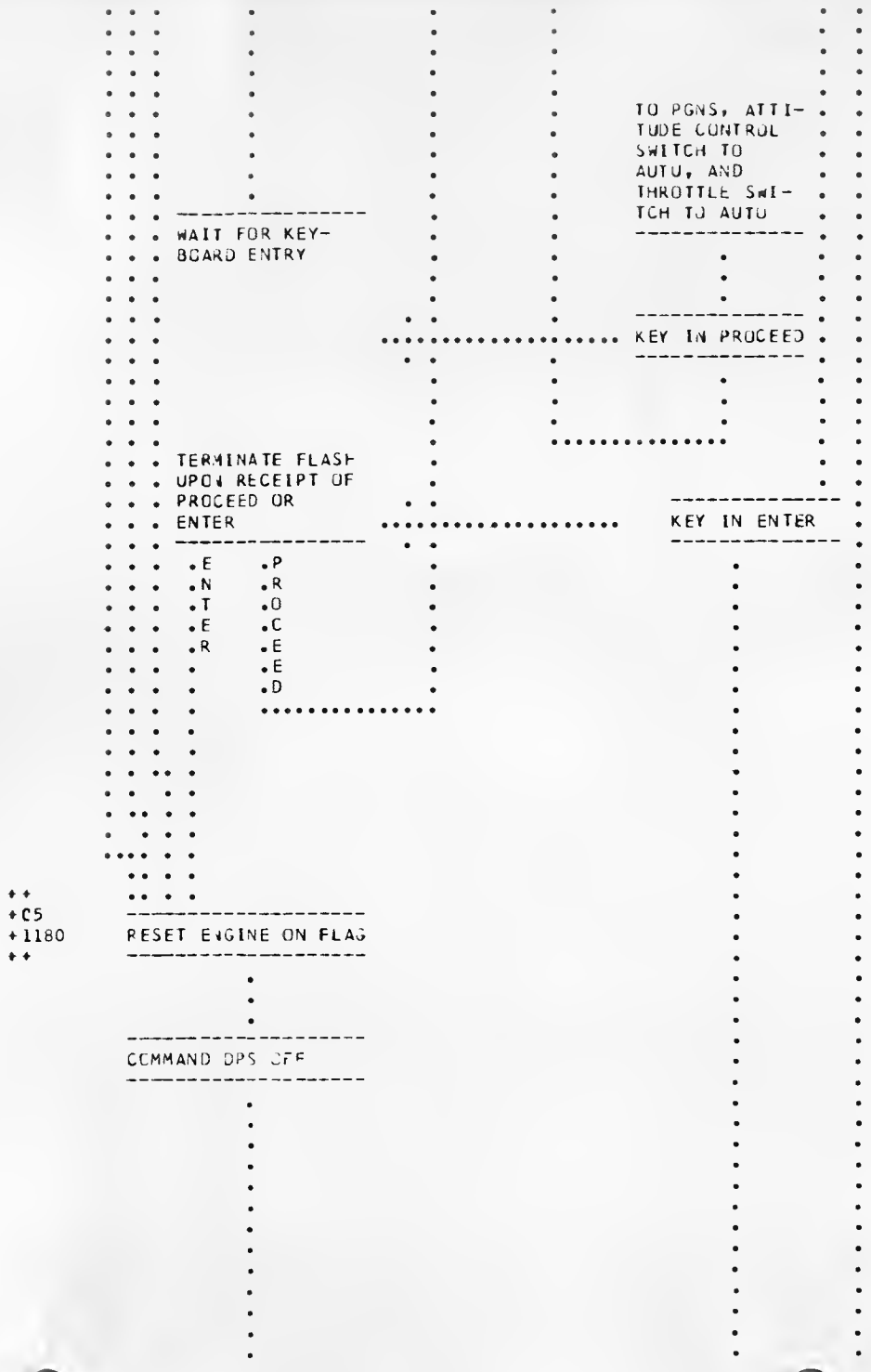
SET PREFERRED-ATTITUDE-COMPUTED FLAG

#250

COMMAND ZERO ATTITUDE ERRORS


SET 1 DEGREE DEADBAND.
#260
RESET 3-AXIS FLAG
#270
DO ATTITUDE MANEUVER ROUTINE (R60)
DO ATTITUDE MANEUVER ROUTINE (R60)
#280
HAVE PGNS CONTROL AND AUTO ATTITUDE CONTROL MODES BEEN SELECTED?
#290
Y
N.
IS THE APS FLAG SET?
Y
N.
#300
IS AUTO THROTTLE DISCRETE BACKUP SET,


I. E. BIT 4
CHANBKUP=1?
Y
N
HAS THE AUTO THROTTLE MODE BEEN SELECTED?
Y
N.
FLASH VERB-NOUN TO REQUEST PLEASE PERFORM PGNS CONTROL, AUTO ATTITUDE CONTROL, AND AUTO THROTTLE MODE SELECTION:
V50 N25
R1 - 00203
R2 - BLANK
R3 - BLANK
POSS HOLD
SNAP
MONITOR DSKY: DOES VERB-NOUN FLASH TO REQUEST PLEASE PERFORM PGNS CONTROL, AUTO ATTITUDE CONTROL, AND AUTO THROTTLE MODE SELECTION?
Y
N
HAVE REQUESTED MODES BEEN SELECTED?
N
Y
DO I WISH TO HAVE THESE MODES SELECTED DURING THE THRUSTING MANEUVER?
Y
N
SET GUIDANCE CONTROL SWITCH
#310
#320
#330
#340
#350
#360



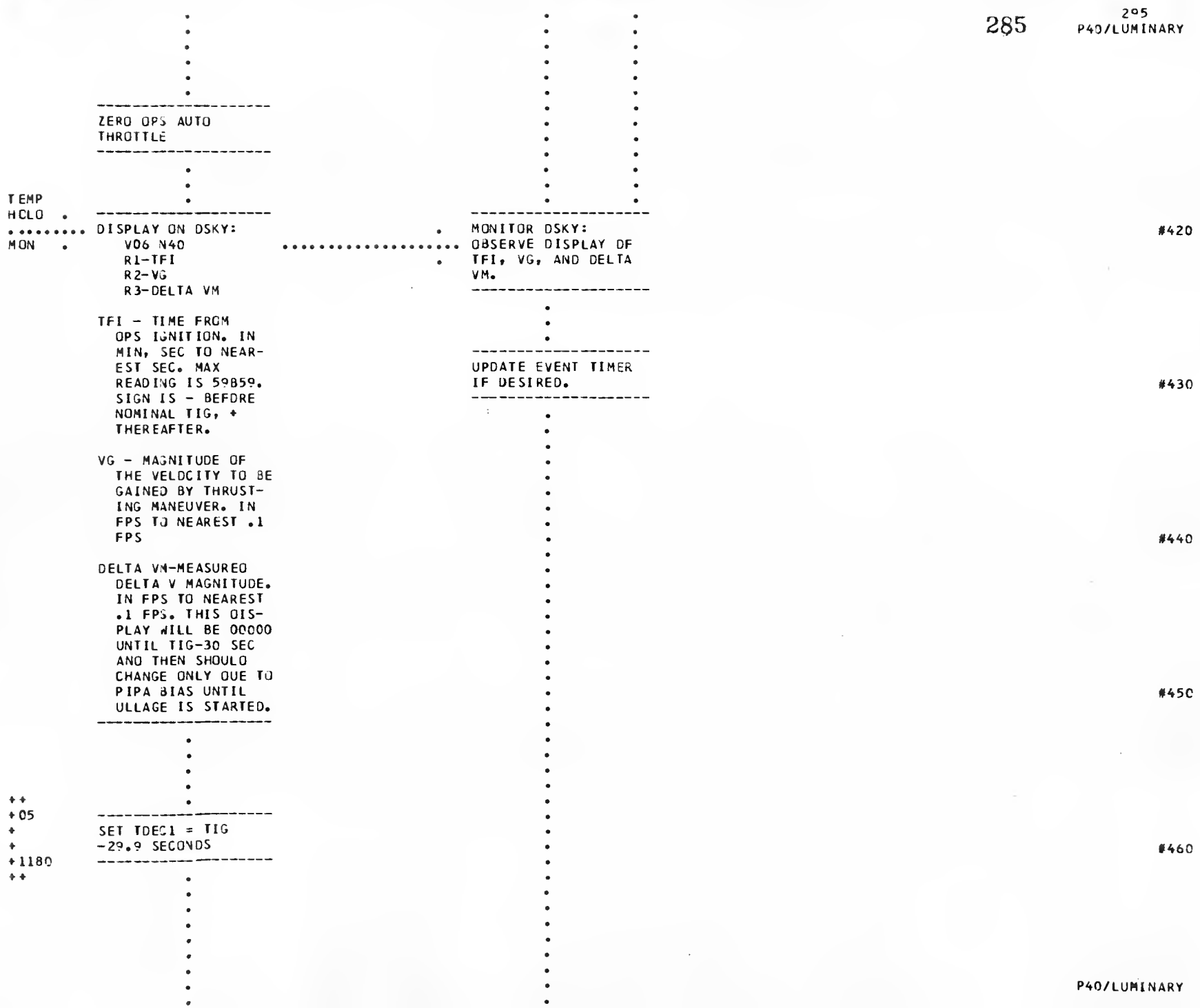
#370

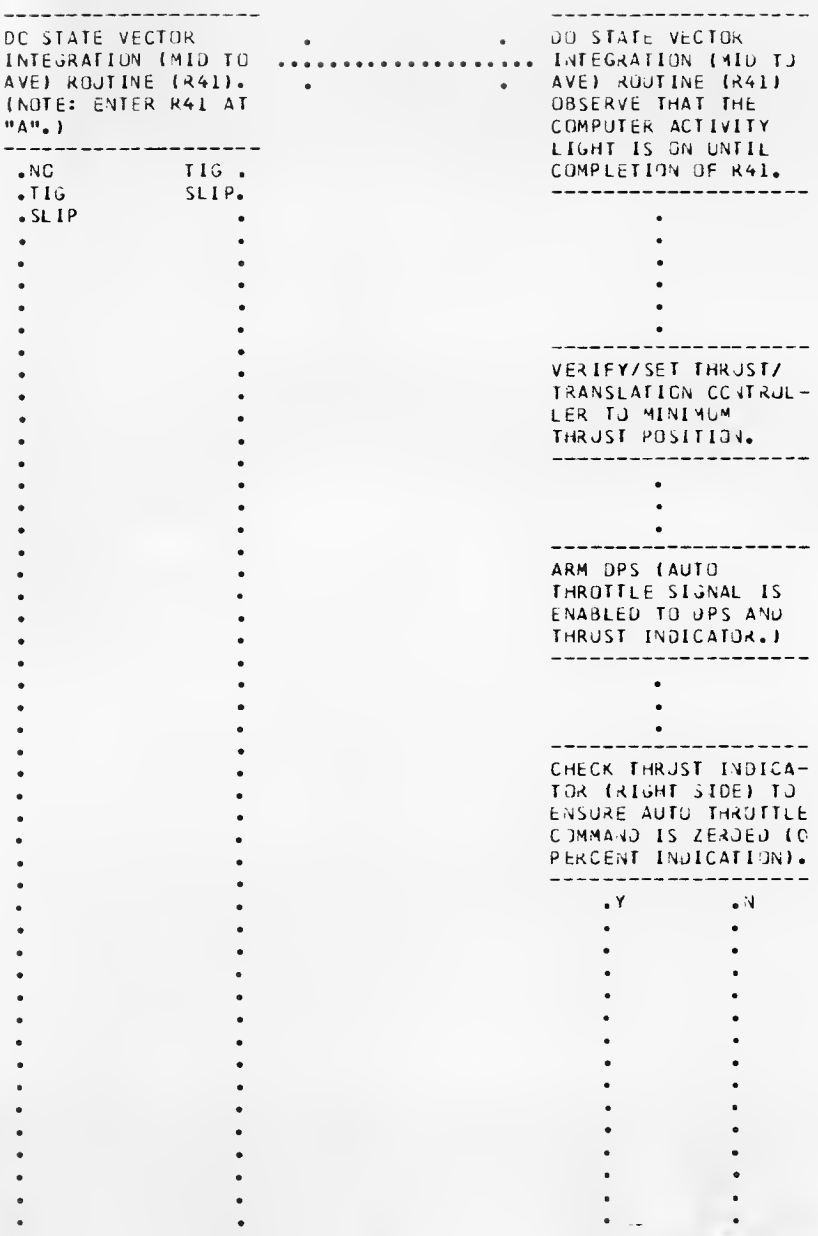
#380

#390

#400

#410


ZERO OPS AUTO THROTTLE
TEMP HCLO MON
DISPLAY ON DSKY:
V06 N40
R1-TFI
R2-VG
R3-DELTA VM
TFI - TIME FROM OPS IGNITION. IN MIN, SEC TO NEAREST SEC. MAX READING IS 59859. SIGN IS - BEFORE NOMINAL TIG, + THEREAFTER.
VG - MAGNITUDE OF THE VELOCITY TO BE GAINED BY THRUSTING MANEUVER. IN FPS TO NEAREST .1 FPS
DELTA VM-MEASURED DELTA V MAGNITUDE. IN FPS TO NEAREST .1 FPS. THIS DISPLAY WILL BE 00000 UNTIL TIG-30 SEC AND THEN SHOULD CHANGE ONLY DUE TO PIPA BIAS UNTIL ULLAGE IS STARTED.
++
+05
+1180
++
SET TDEC1 = TIG -29.9 SECONDS
MONITOR DSKY:
OBSERVE DISPLAY OF TFI, VG, AND DELTA VM.
#420
UPDATE EVENT TIMER IF DESIRED.
#430
#440
#450
#460



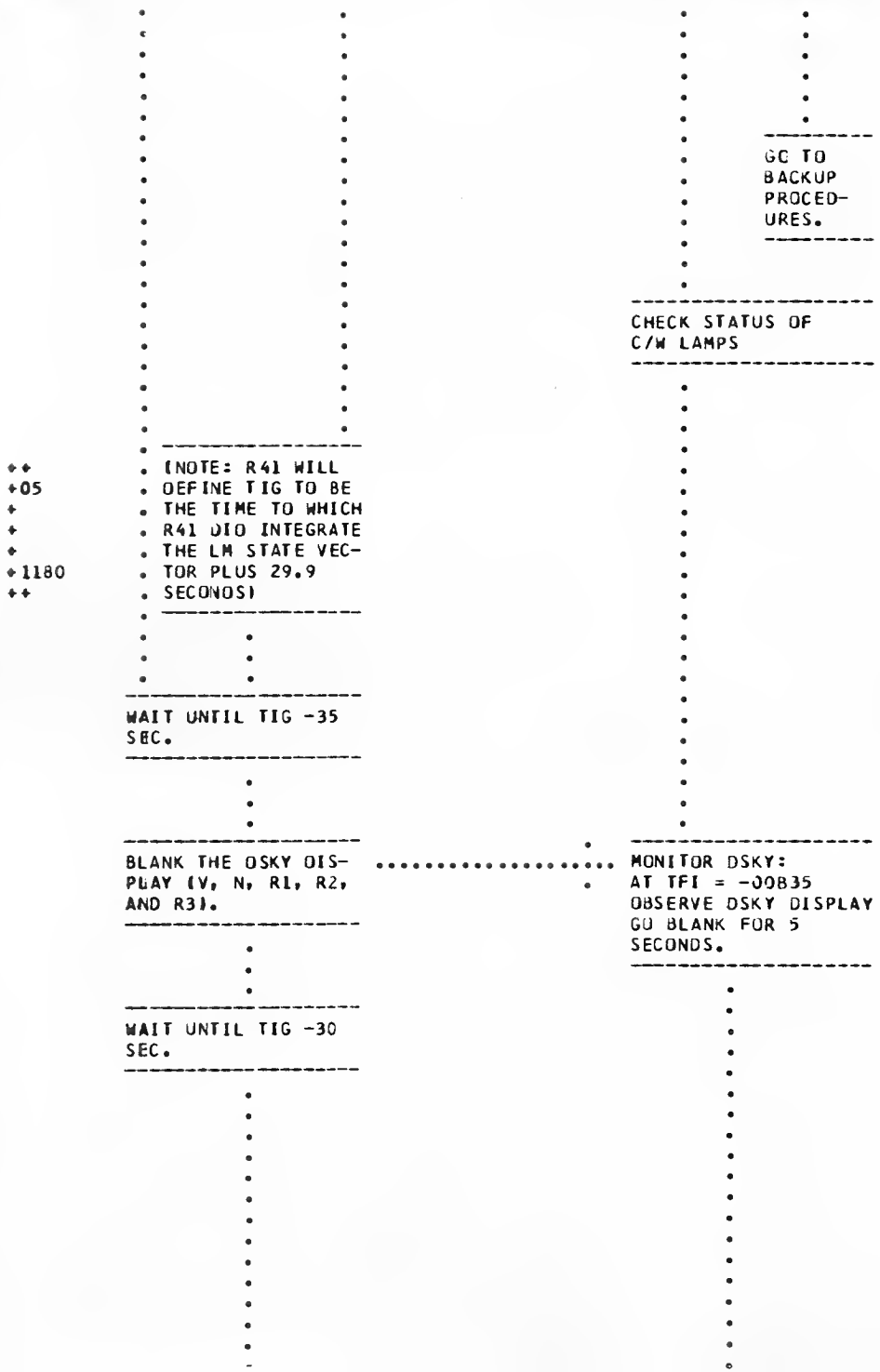
#470

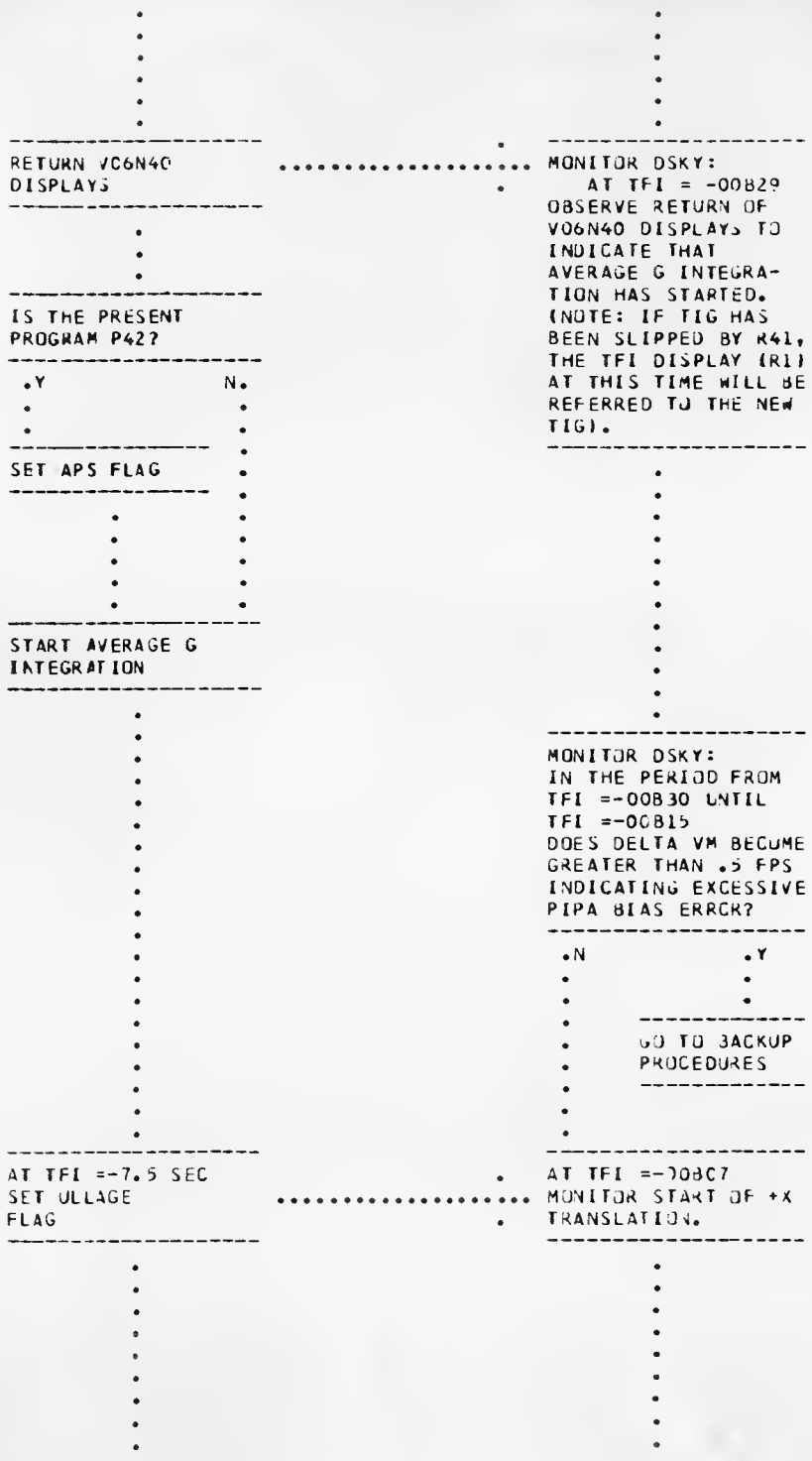
#480

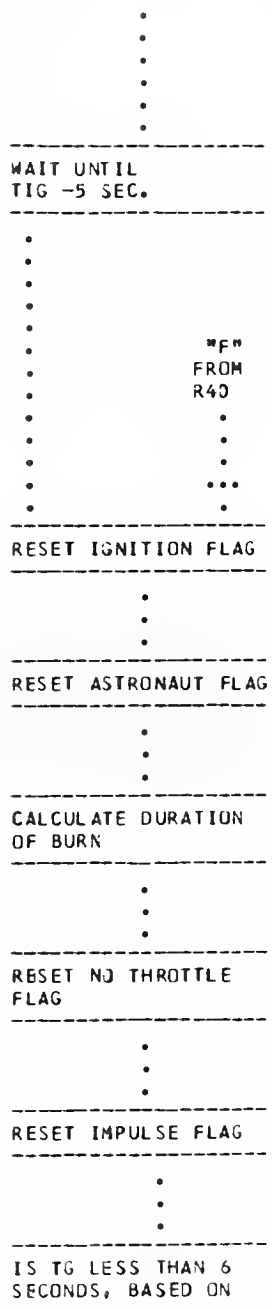
#490

#500

#510


GC TO BACKUP PROCEDURES.
#520
CHECK STATUS OF C/W LAMPS
++
+05
+
+
+
+1180
++
(NOTE: R41 WILL DEFINE TIG TO BE THE TIME TO WHICH R41 DIO INTEGRATE THE LM STATE VECTOR PLUS 29.9 SECONDS)
#530
#540
WAIT UNTIL TIG -35 SEC.
BLANK THE DSKY DISPLAY (V, N, R1, R2, AND R3).
MONITOR DSKY: AT TFI = -00835 OBSERVE DSKY DISPLAY GO BLANK FOR 5 SECONDS.
#550
WAIT UNTIL TIG -30 SEC.
#560


RETURN VC6N40 DISPLAYS
MONITOR DSKY:
AT TFI = -00829
OBSERVE RETURN OF VO6N40 DISPLAYS TO INDICATE THAT AVERAGE G INTEGRATION HAS STARTED.
(NOTE: IF TIG HAS BEEN SLIPPED BY R41, THE TFI DISPLAY (R1) AT THIS TIME WILL BE REFERRED TO THE NEW TIG).
#570
IS THE PRESENT PROGRAM P42?
.Y
N.
SET APS FLAG
#580
START AVERAGE G INTEGRATION
MONITOR DSKY:
IN THE PERIOD FROM TFI =-00830 UNTIL TFI =-00815
DOES DELTA VM BECOME GREATER THAN .5 FPS INDICATING EXCESSIVE PIPA BIAS ERROR?
#590
.N
.Y
GO TO BACKUP PROCEDURES
#600
AT TFI =-7.5 SEC
SET ULLAGE FLAG
AT TFI =-00807
MONITOR START OF +X TRANSLATION.
#610



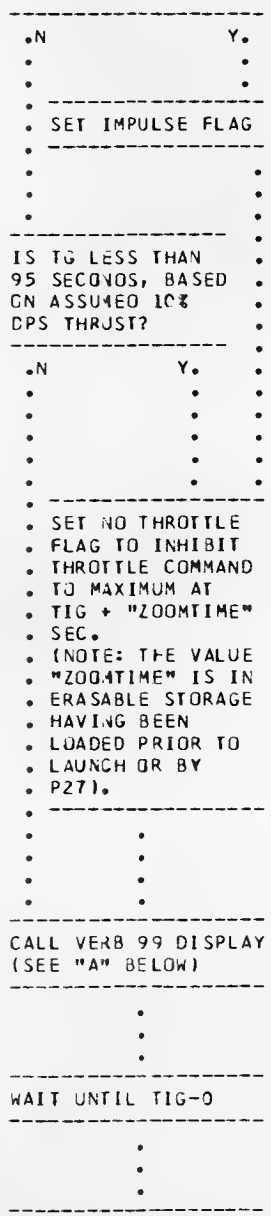
#620

#630

#640

#650

#660



#670

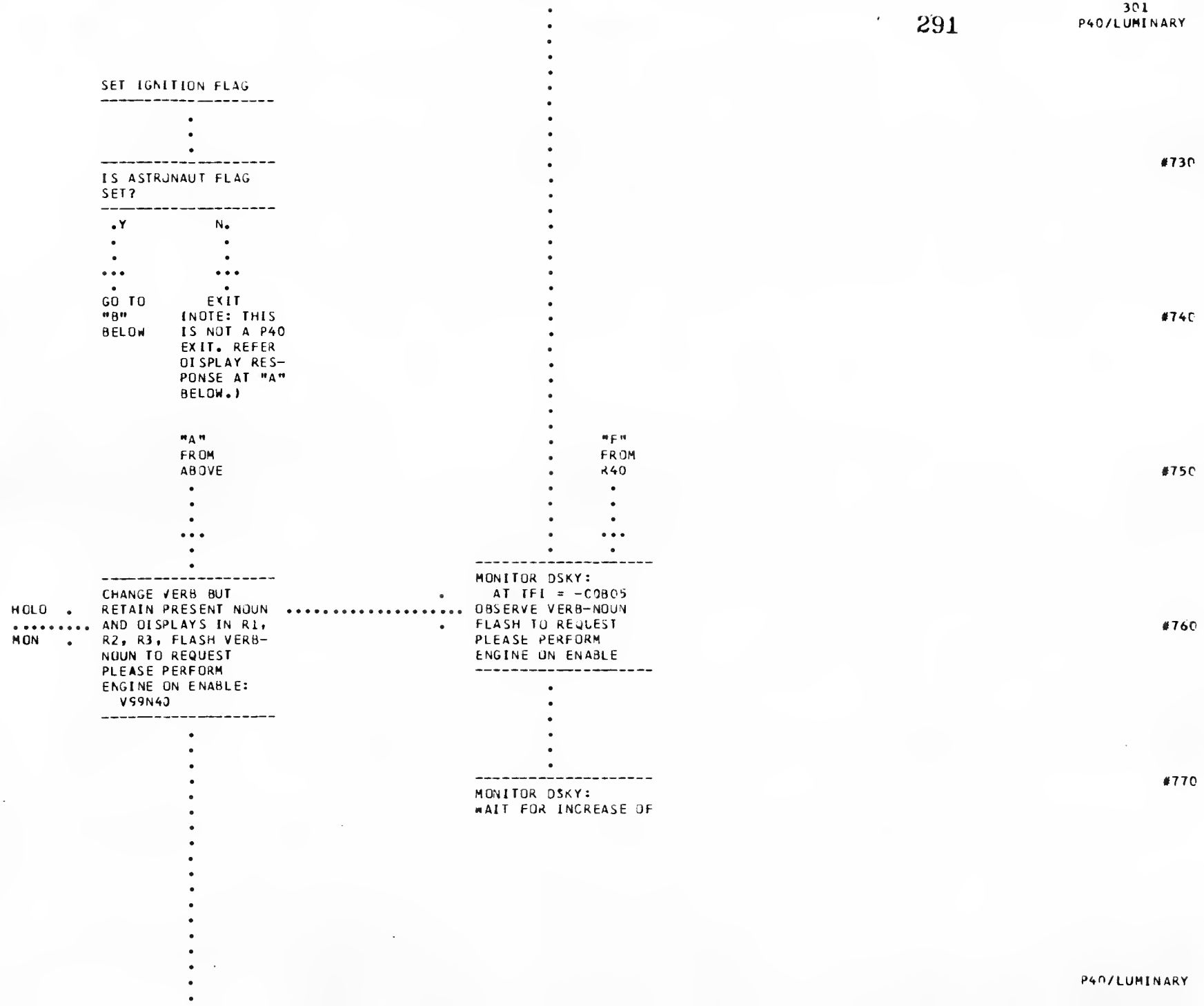
#680

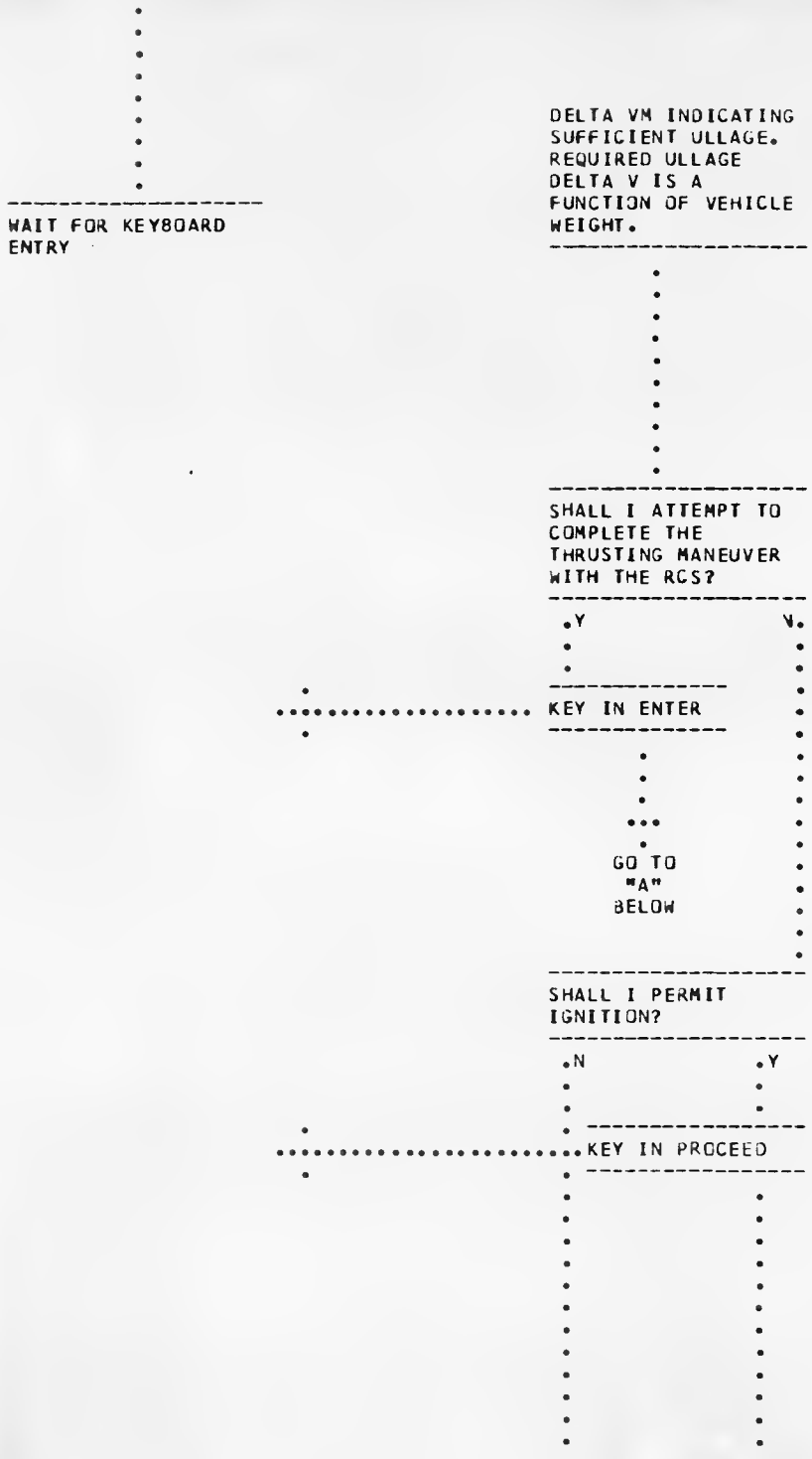
#690

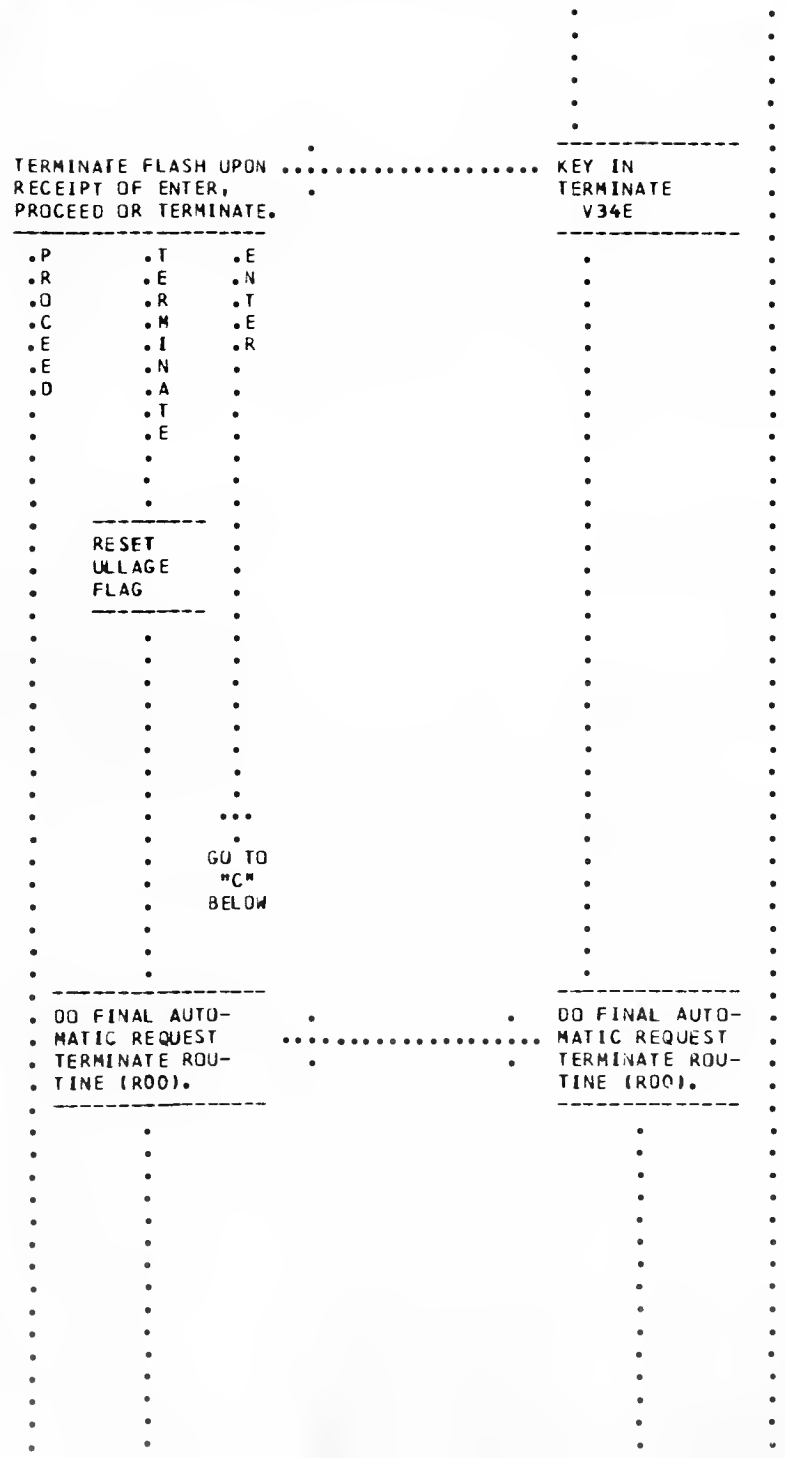
#700

#710

#720


SET IGNITION FLAG
IS ASTRONAUT FLAG SET?
.Y
N.
GO TO "B" BELOW
EXIT (NOTE: THIS IS NOT A P40 EXIT. REFER DISPLAY RESPONSE AT "A" BELOW.)
"A" FROM ABOVE
"F" FROM R40
CHANGE VERB BUT RETAIN PRESENT NOUN AND DISPLAYS IN R1, R2, R3, FLASH VERB-NOUN TO REQUEST PLEASE PERFORM ENGINE ON ENABLE: V99N40
HOLD MON
MONITOR DSKY: AT TFI = -C0805 OBSERVE VERB-NOUN FLASH TO REQUEST PLEASE PERFORM ENGINE ON ENABLE
MONITOR DSKY: WAIT FOR INCREASE OF
#730
#740
#750
#760
#770


WAIT FOR KEYBOARD ENTRY
DELTA VM INDICATING SUFFICIENT ULLAGE. REQUIRED ULLAGE DELTA V IS A FUNCTION OF VEHICLE WEIGHT.
#780
SHALL I ATTEMPT TO COMPLETE THE THRUSTING MANEUVER WITH THE RCS?
#790
Y
N
KEY IN ENTER
#800
GO TO "A" BELOW
#810
SHALL I PERMIT IGNITION?
N
Y
KEY IN PROCEED
#820



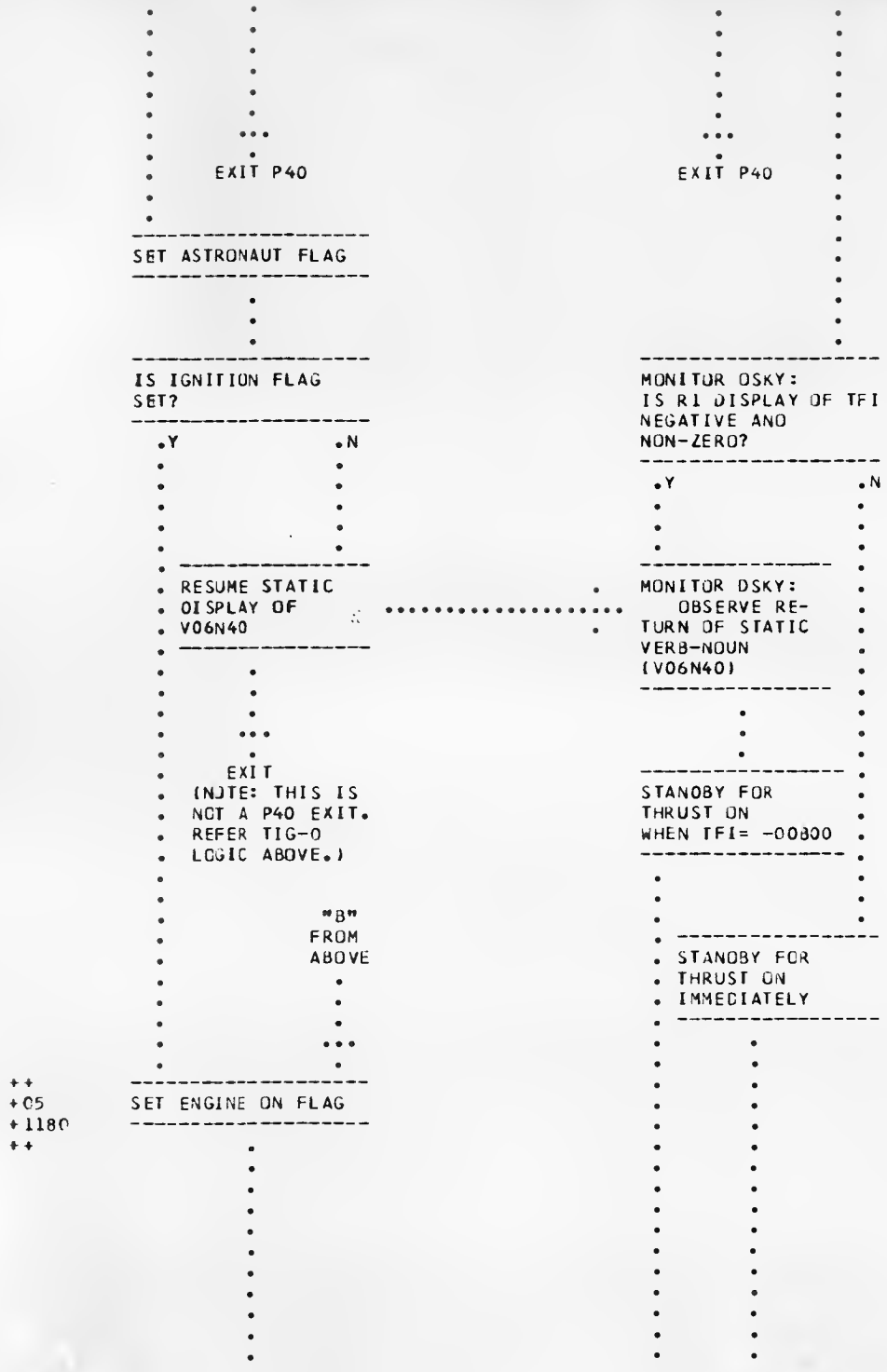
#830

#840

#850

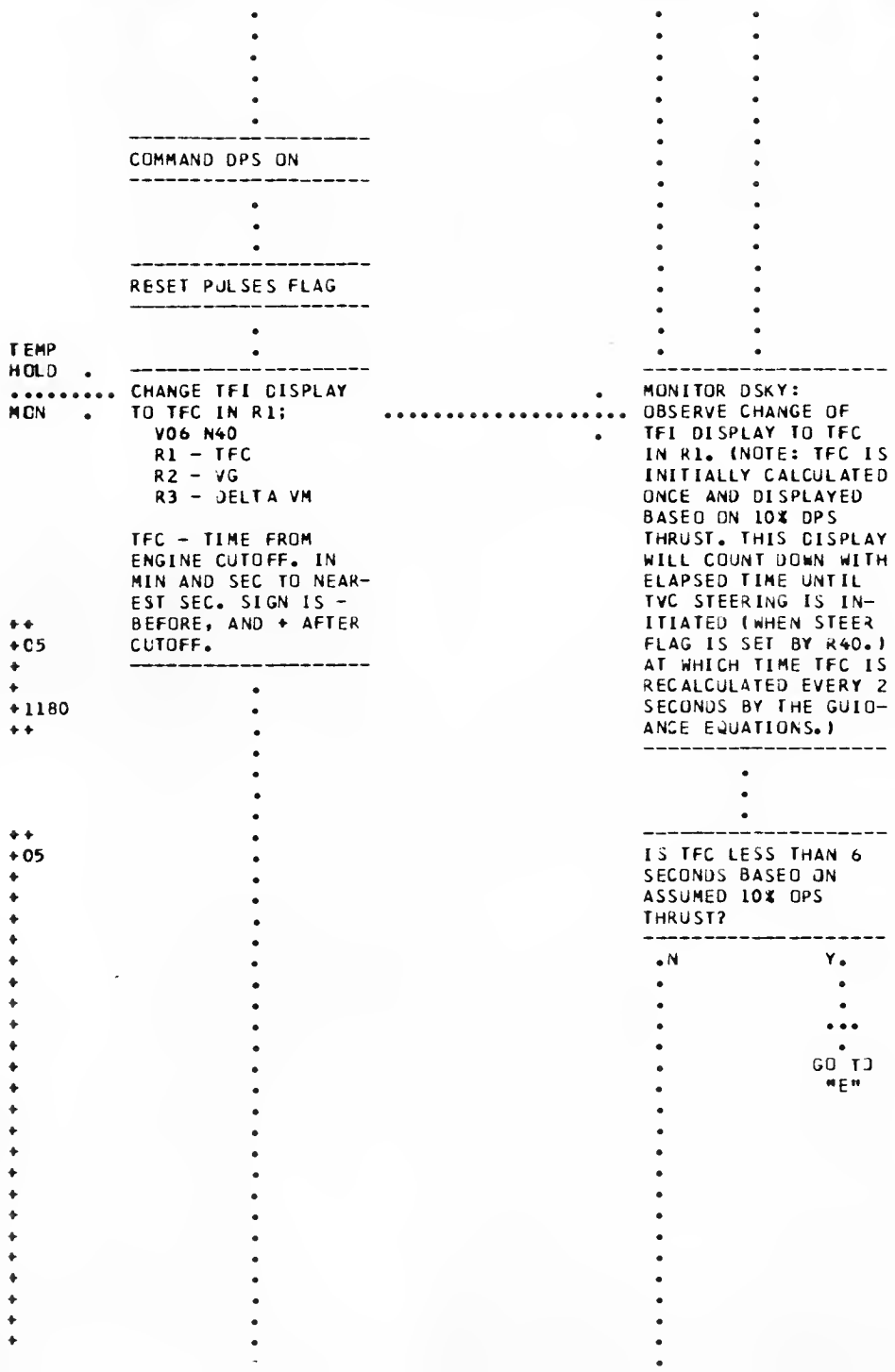
#860

#870



++
+05
+1180
++

#880
#890
#900
#910
#920



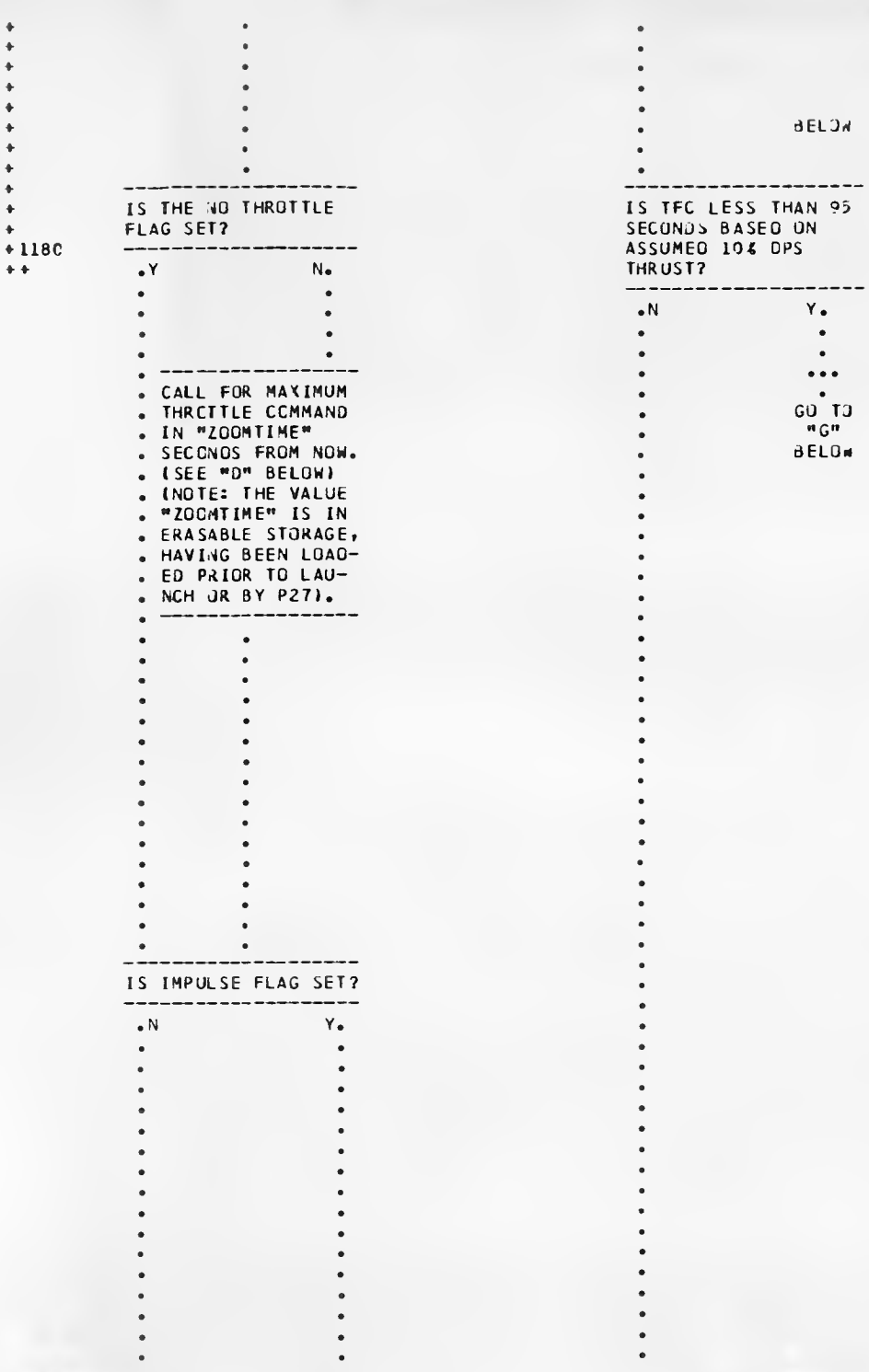
#930

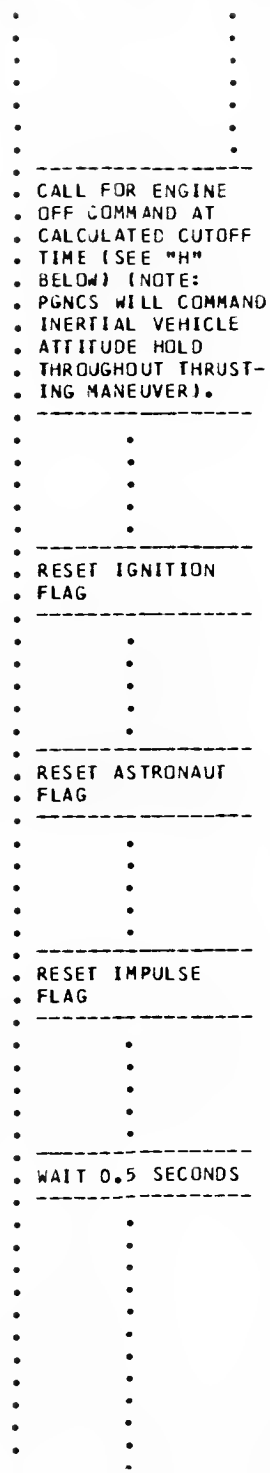
#940

#950

#960

#970


#1180
IS THE NO THROTTLE FLAG SET?
Y
N
CALL FOR MAXIMUM THRCTTLE CCMMAND IN "ZOOMTIME" SECONDS FROM NOW. (SEE "D" BELOW) (NOTE: THE VALUE "ZOOMTIME" IS IN ERASABLE STORAGE, HAVING BEEN LOAD-ED PRIOR TO LAU-NCH OR BY P27).
IS IMPULSE FLAG SET?
N
Y
BELOW
IS TFC LESS THAN 95 SECONDS BASED ON ASSUMED 10% DPS THRUST?
N
Y
GO TO "G" BELOW
#980
#990
#1000
#1010



#1020

#1030

#1040

#1050

#1060

#1070

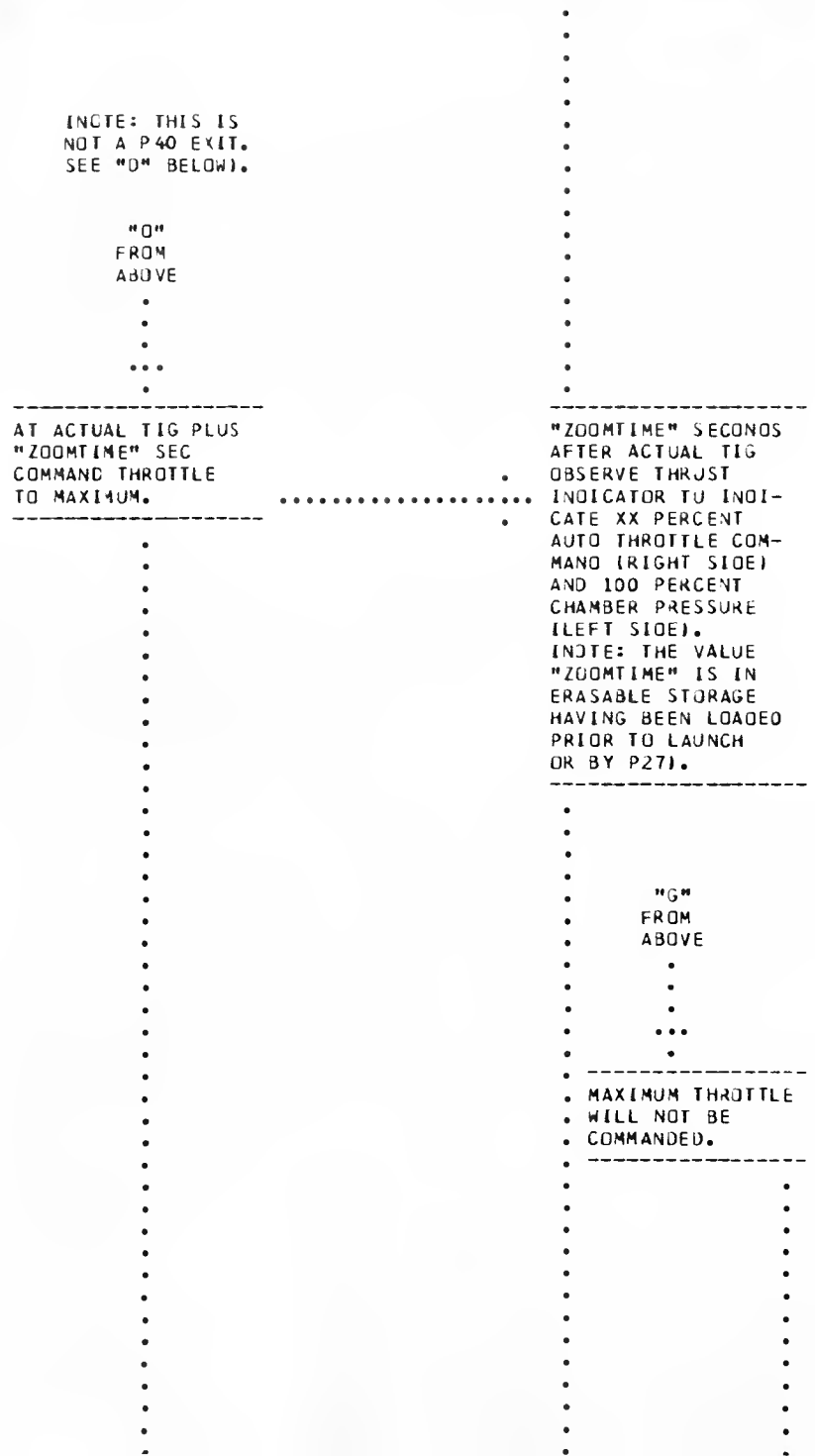
#1080

#1090

#1100

#1110

#1120



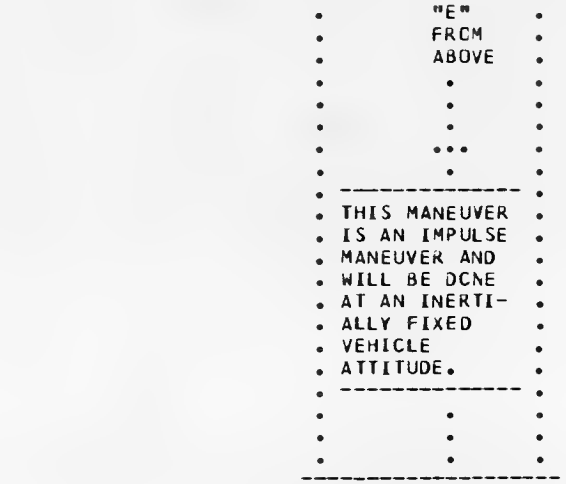
#1130

#1140

#1150

#1160

#1170



#1180

#1190

MONITOR DPS
THRUSTING:

1. DSKY:
   R1-TFC
   SHOULD BE
   DECREASING

   R2-VG SHOULD BE
   DECREASING

   R3-DELTA VM
   SHOULD INCREASE

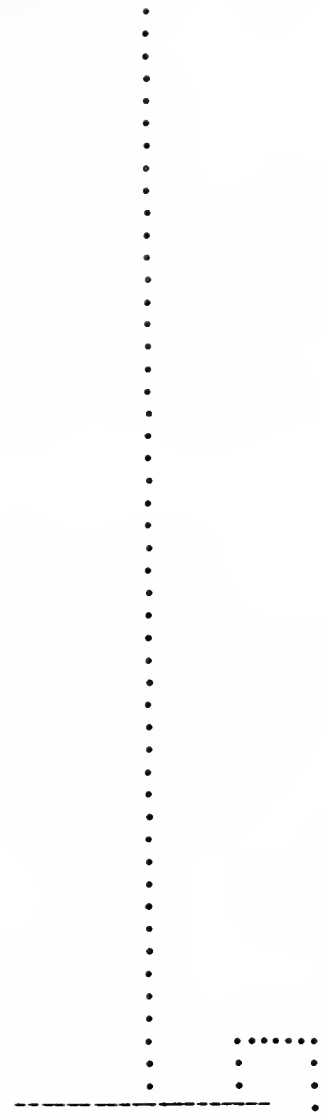
#1200

#1210

2. FDAI-ATT. ERRORS
SHOULD BE LESS THAN
OR EQUAL TO XX
DEGREE.

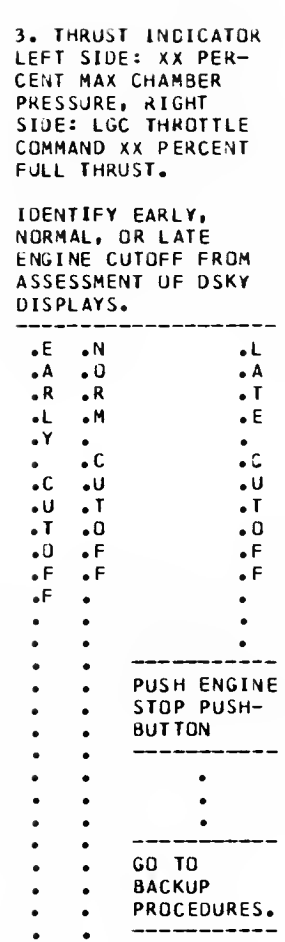
ATT RATES SHOULD BE
LESS THAN OR EQUAL
TO XX DEGREE/SEC.

#1220



3. THRUST INDICATOR LEFT SIDE: XX PERCENT MAX CHAMBER PRESSURE, RIGHT SIDE: LGC THROTTLE COMMAND XX PERCENT FULL THRUST.

IDENTIFY EARLY, NORMAL, OR LATE ENGINE CUTOFF FROM ASSESSMENT OF DSKY DISPLAYS.



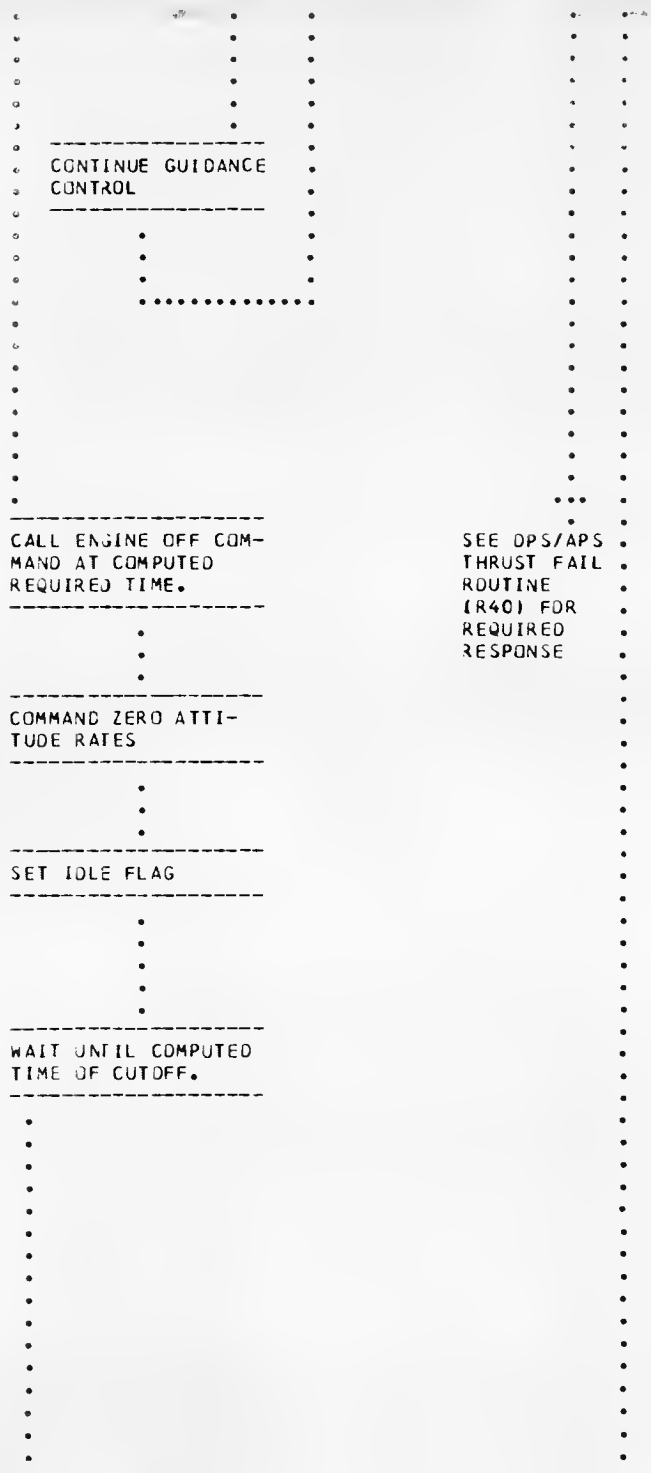
#1230

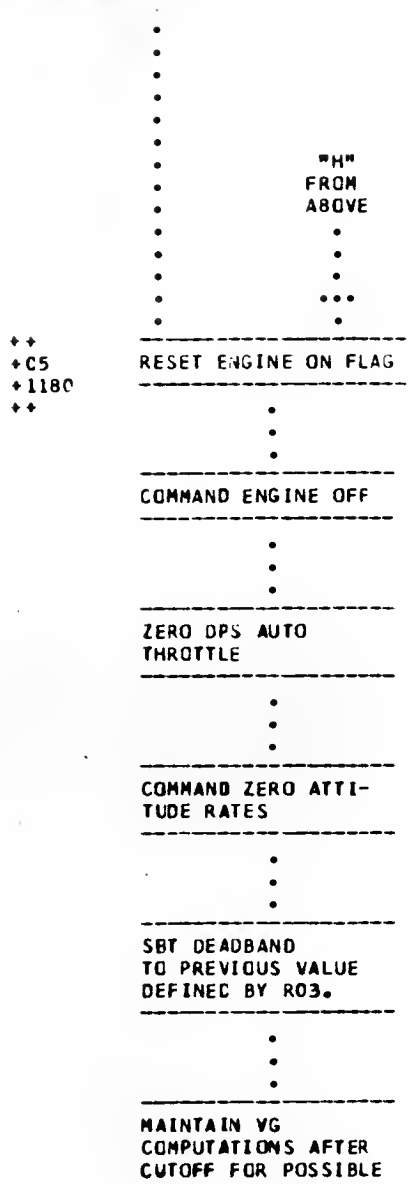
#1240

#1250

#1260

#1270


CONTINUE GUIDANCE CONTROL
#1280
CALL ENGINE OFF COMMAND AT COMPUTED REQUIRED TIME.
SEE DPS/APS THRUST FAIL ROUTINE (R40) FOR REQUIRED RESPONSE
#1290
COMMAND ZERO ATTITUDE RATES
#1300
SET IDLE FLAG
#1310
WAIT UNTIL COMPUTED TIME OF CUTOFF.



++
+C5
+1180
++

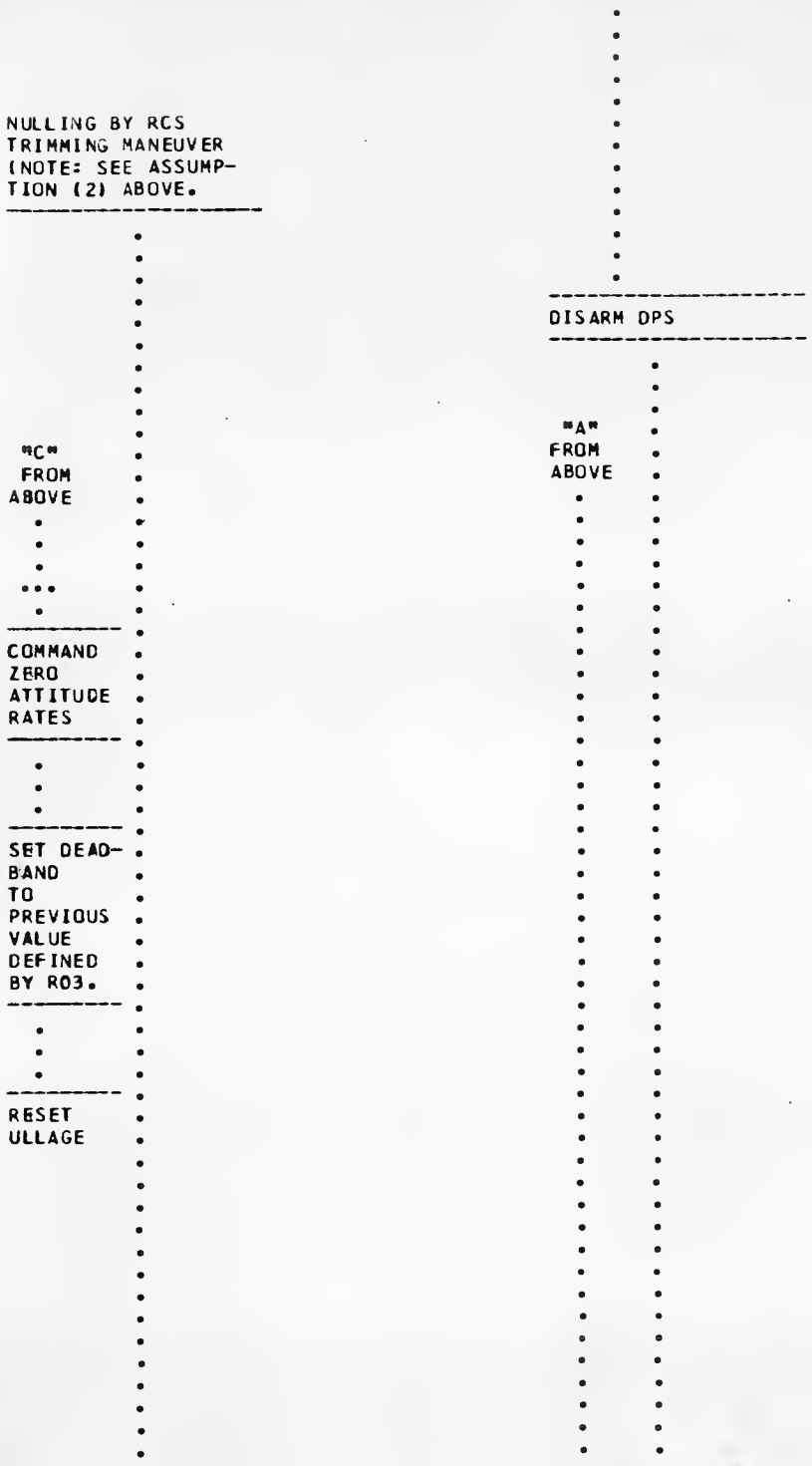
#1320

#1330

#1340

#1350

#1360



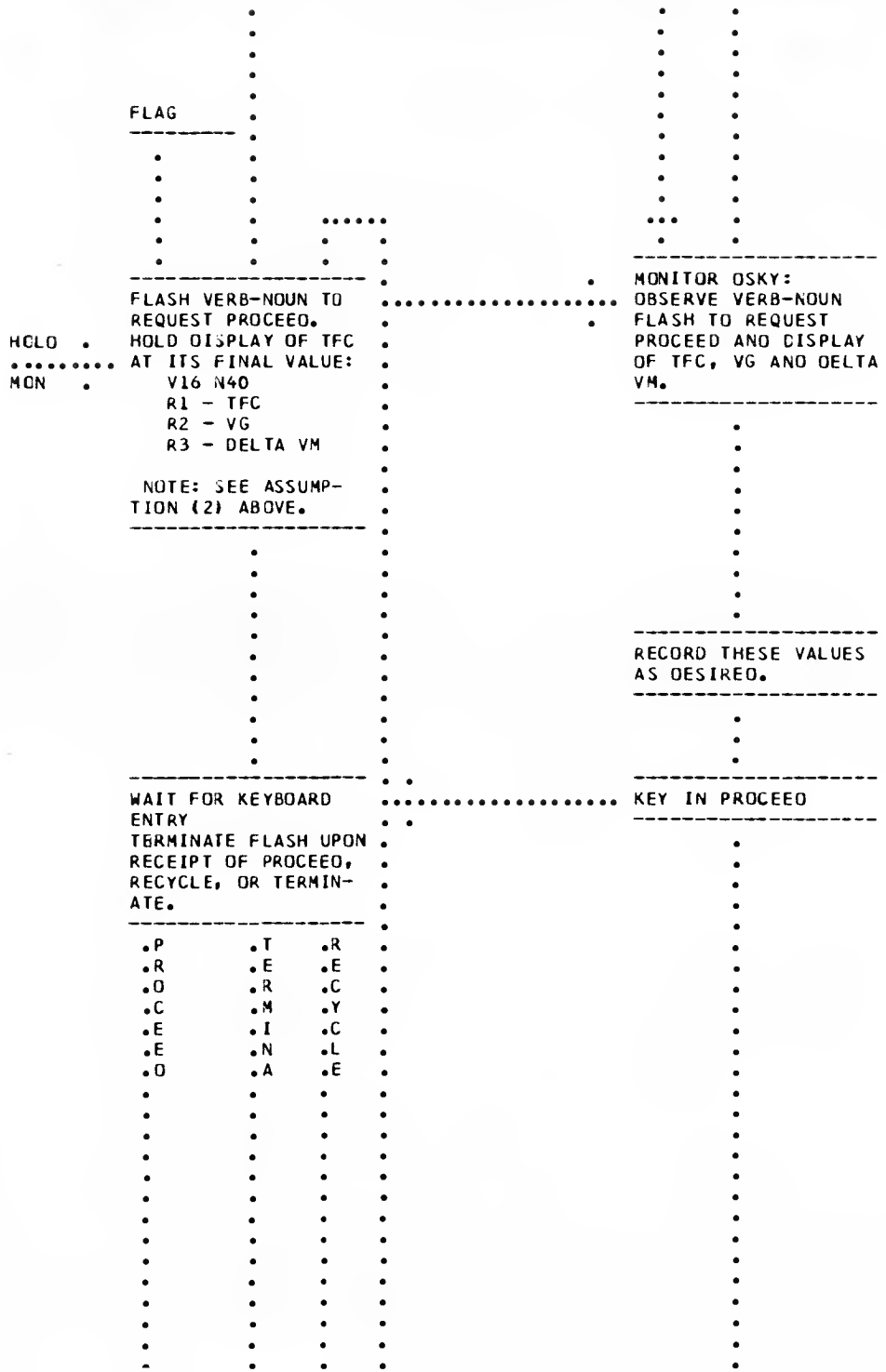
#1370

#1380

#1390

#1400

#1410



#1420

#1430

#1440

#1450

#1460

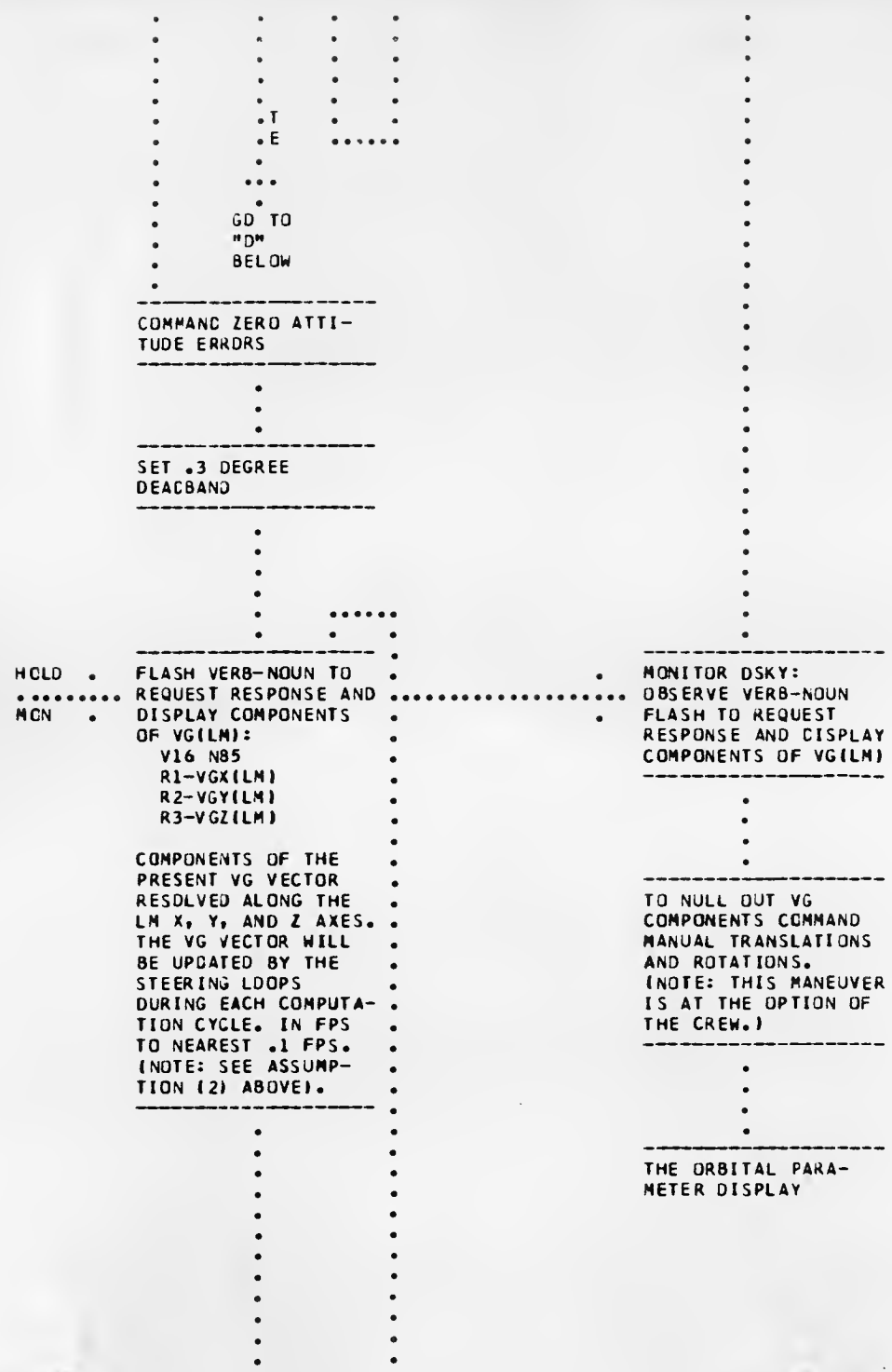
#1470

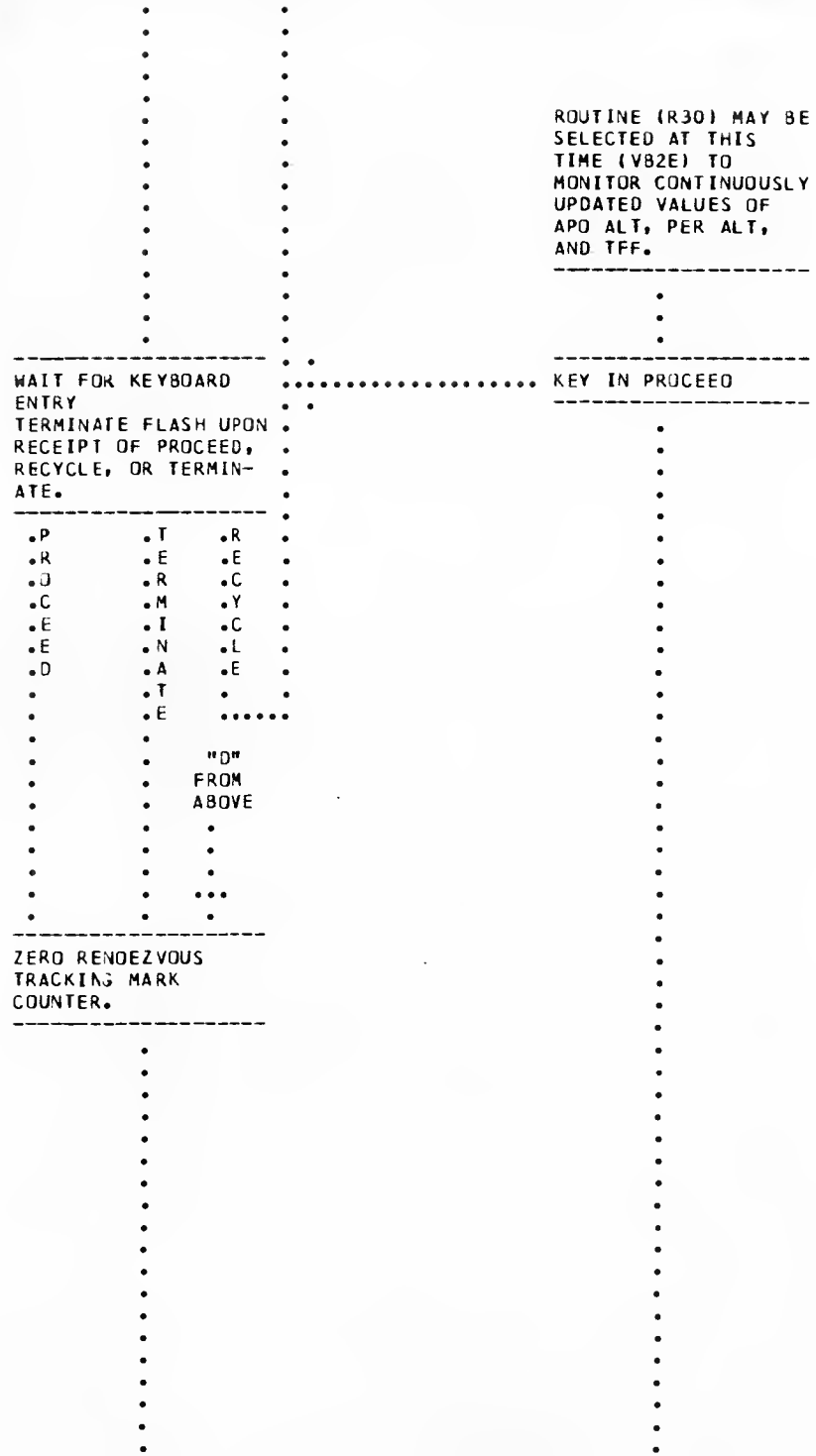
#1480

#1490

#1500

#1510

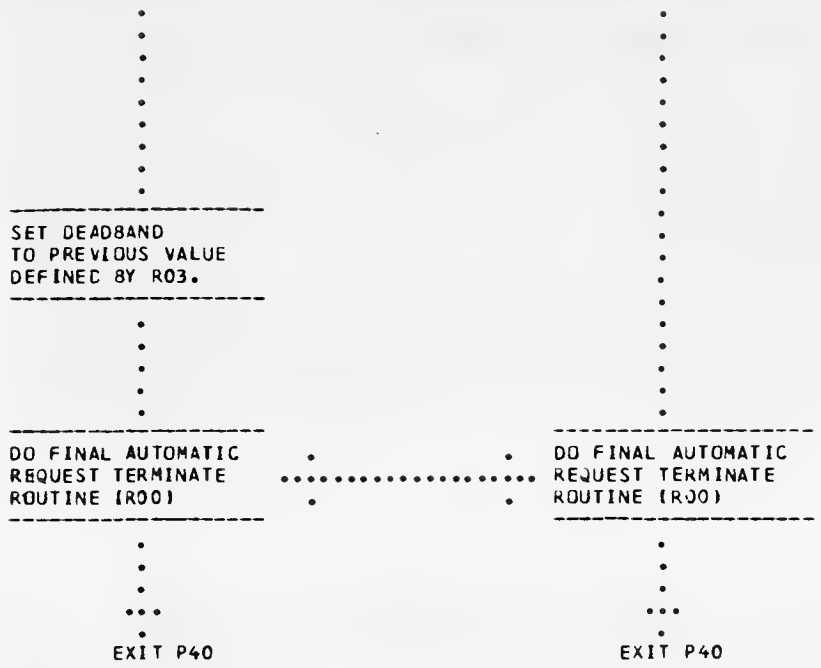



ROUTINE (R30) MAY BE SELECTED AT THIS TIME (V82E) TO MONITOR CONTINUOUSLY UPDATED VALUES OF APO ALT, PER ALT, AND TFF.
#1520
KEY IN PROCEED
WAIT FOR KEYBOARD ENTRY
TERMINATE FLASH UPON RECEIPT OF PROCEED, RECYCLE, OR TERMINATE.
#1530
PROCEED
TERMINATE
RECYCLE
"D" FROM ABOVE
#1540
ZERO RENDEZVOUS TRACKING MARK COUNTER.
#1550

#1560

#1570

#1580



CHANGE CONTROL NOTES

REV 00 PCR 30,31
REV 01 PCR 85,86,144,164,186,401,419,539,609,637
REV 00(LUM 1A) PCR 647,648
REV 01(LUM 1B) PCR 838,841,EDITORIAL
REV 02 EDITORIAL
REV 03 PCN 1009
REV 04(LUM 1E) PCR 1109, PCN 1126,1145
REV 05 PCN 1180

RCS PROGRAM (P41) REV 04 12/01/71

PURPOSE: (1) TO COMPUTE A PREFERRED IMU ORIENTATION AND A VEHICLE ATTITUDE FOR AN RCS THRUSTING MANEUVER.

(2) TO PERFORM THE VEHICLE MANEUVER TO THE THRUSTING ATTITUDE.

(3) TO PROVIDE SUITABLE DISPLAYS FOR MANUAL EXECUTION OF THE THRUSTING MANEUVER IN THE ATTITUDE HOLD MODE.

ASSUMPTIONS: (1) THE TARGET PARAMETERS HAVE BEEN CALCULATED AND STORED IN THE LGC BY PRIOR EXECUTION OF A PRE-THRUSTING PROGRAM.

(2) THE REQUIRED STEERING EQUATIONS ARE IDENTIFIED BY THE PRIOR PRE-THRUST PROGRAM, WHICH EITHER RESET ("ASTEER") OR SET (EXT DELTA V) THE EXTERNAL DELTA V FLAG. FOR EXTERNAL DELTA V STEERING, VG IS CALCULATED ONCE FOR THE SPECIFIED TIME OF IGNITION. THEREAFTER UNTIL THE CREW NOTIFIES THE LGC THAT RCS THRUSTING HAS BEEN COMPLETED, THE LGC UPDATES VG ONLY AS A RESULT OF ACCELEROMETER INPUTS.

FOR STEERING CONTROL WHEN USING "ASTEER", THE VELOCITY REQUIRED IS CALCULATED FROM FIGURE 3.3-13A IN SECTION 5 OF R-567. THE LAMBERT ROUTINE PERIODICALLY RE-COMPUTES THE INTERCEPT TRAJECTORY SEMI-MAJOR AXIS FOR THE "ASTEER" CALCULATIONS. THE INTERVAL BETWEEN LAMBERT SOLUTIONS IS CONTROLLED BY AN ERASABLE LOADED VALUE (UT).

(3) WITH THE GUIDANCE CONTROL SWITCH IN PGNS AND THE MODE CONTROL SWITCH IN ATTITUDE HOLD THE PGNCS WILL HOLD THE VEHICLE ATTITUDE AND WILL GENERATE EITHER MODE I OR MODE II ATTITUDE ERRORS AND VEHICLE ATTITUDE RATES (SEE ASSUMPTION (4)) FOR DISPLAY ON THE FDAI. THE CREW MAY EXERCISE MANUAL ATTITUDE CONTROL ABOUT ALL VEHICLE AXES WITH THE ACA IN EITHER THE RATE COMMAND OR MINIMUM IMPULSE MODE DEPENDING UPON THE STATUS OF THE PULSES FLAG. HOWEVER, IT IS STRONGLY RECOMMENDED THAT POWERED FLIGHT NOT BE ATTEMPTED IN THE MINIMUM IMPULSE MODE. THE PULSES FLAG IS SET OR RESET BY EXTENDED VERBS 76 (MINIMUM IMPULSE) AND 77 (RATE COMMAND) RESPECTIVELY. THE PULSES FLAG IS ALSO RESET BY P12, P40, P41, P42, P63, P70, P71, AND R40 AT MAIN ENGINE IGNITION; WITH THE EXCEPTION OF THESE CASES, MODE SELECTION IS ALWAYS BASED UPON THE LAST ENTRY MADE IN THE DSKY. DURING A THRUSTING MANEUVER IN THE PGNS/ATTITUDE HOLD MODE THE PGNCS WILL NOT BE RESPONSIBLE IF REGISTER OVERFLOWS OCCUR WITHIN THE LGC.

(4) THE PGNCS CAN GENERATE TWO TYPES OF ATTITUDE ERRORS FOR DISPLAY ON THE FDAI;

++
+C4
+
+
+
+
+
+
+
+1180
++

MODE I - SELECTED BY EXTENDED VERB 61. AUTOPILOT FOLLOWING ERRORS USED AS A MONITOR OF THE DAP'S ABILITY TO TRACK AUTOMATIC STEERING COMMANDS.

MODE II - SELECTED BY EXTENDED VERB 62. TOTAL ATTITUDE ERRORS USED TO ASSIST CREW IN MANUALLY MANEUVERING THE VEHICLE.

PGNCS-DERIVED VEHICLE ATTITUDE RATES MAY ALSO BE DISPLAYED VIA SELECTION BY EXTENDED VERB 60. DISPLAY SELECTION IS ALWAYS BASED UPON THE LAST ENTRY MADE IN THE DSKY, WITH THE EXCEPTION THAT MODE II ATTITUDE ERROR DISPLAYS ARE AUTOMATICALLY SELECTED AT THE BEGINNING OF R60. FOR A MORE DETAILED DESCRIPTION OF THESE DISPLAYS REFER TO SECTION 3 OF R-567, PARA 3.2.6.

(5) THE IMU IS ON AND MUST BE AT A KNOWN ORIENTATION BEFORE THIS PROGRAM MAY BE COMPLETED. IT IS NORMALLY REQUIRED THAT THE ISS BE ON FOR A MINIMUM OF 15 MINUTES PRIOR TO A THRUSTING MANEUVER.

(6) THE EVENT TIMER IS SET TO COUNT TO ZERO AT TIG.

(7) RCS IGNITION MAY BE SLIPPED BEYOND THE ESTABLISHED TIG IF DESIRED BY THE CREW, OR IF STATE VECTOR INTEGRATION CANNOT BE COMPLETED ON TIME.

(8) THE X - AXIS OVERRIDE OPTION PROVIDES THE CREW WITH THE ABILITY TO EXERCISE MANUAL CONTROL ABOUT THE LM X AXIS WITH THE ATTITUDE CONTROLLER EVEN THOUGH THE PGNCS ATTITUDE CONTROL MODE IS AUTO. WHEN THE CONTROLLER IS RETURNED TO DETENT THE PGNCS DAMPS THE YAW RATE, STORES THE YAW ATTITUDE WHEN THE YAW RATE IS DAMPED, AND THEN MAINTAINS THAT ATTITUDE.

THE X - AXIS OVERRIDE OPTION IS ALWAYS AVAILABLE TO THE CREW, HOWEVER IT SHOULD NOT BE EXERCISED WHEN THE LGC IS SPECIFYING A DESIRED YAW ATTITUDE, I.E.: DURING THE ATTITUDE MANEUVER TO THE THRUSTING ATTITUDE (SEE R60).

(9) THE DAP DATA LOAD ROUTINE (R03) HAS BEEN PERFORMED PRIOR TO SELECTION OF THIS PROGRAM.

(10) THE LGC WILL NEITHER DESIGNATE NOR READ THE RENDEZVOUS RADAR (RR) DURING THIS PROGRAM.

(11) THE ASTRONAUT MAY OBSERVE THE FOLLOWING ADDITIONAL PARAMETERS DURING THIS PROGRAM (AFTER THE IMU STATUS CHECK ROUTINE (R02) AND PRIOR TO TIG-35 SECONDS) BY KEYING IN V06 N40:

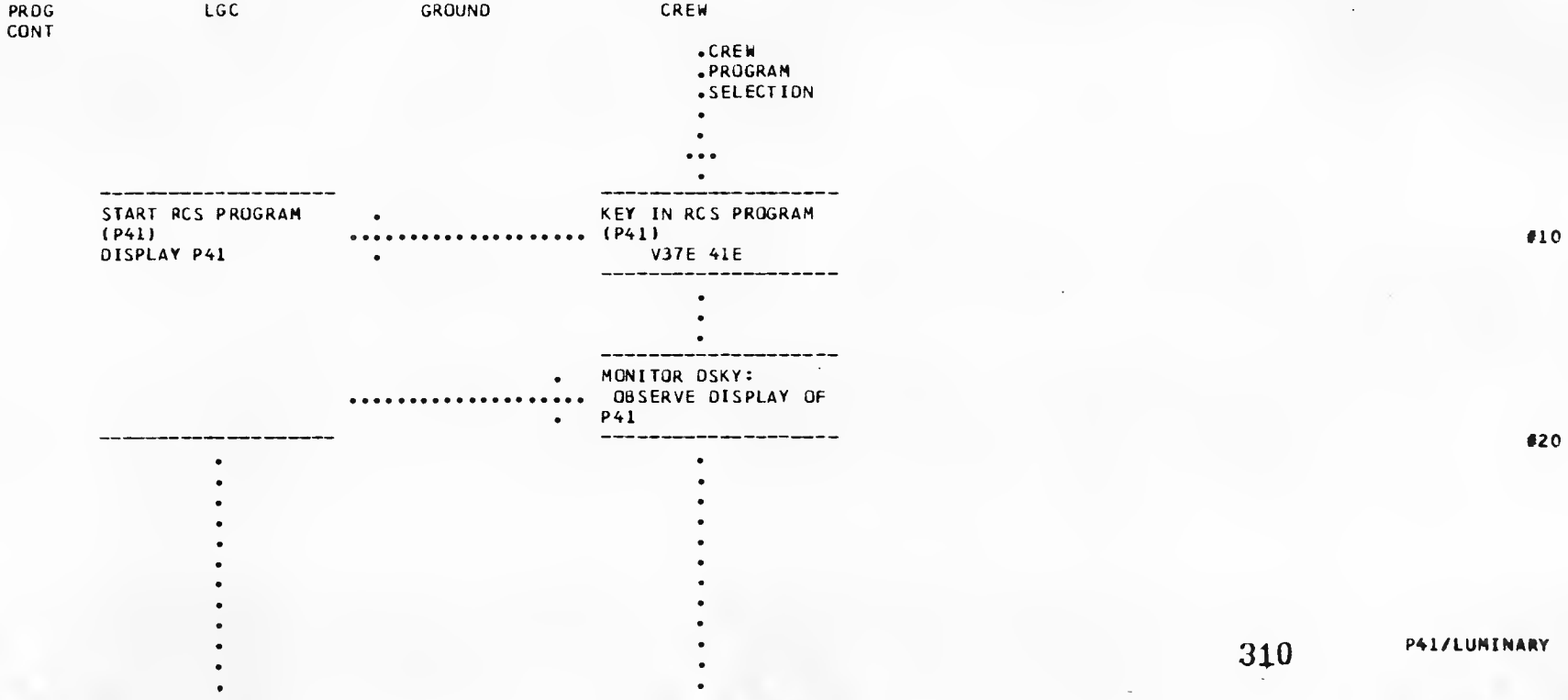
(A) V06 N40
R1 - TFI
R2 - VG
R3 - DELTA VM

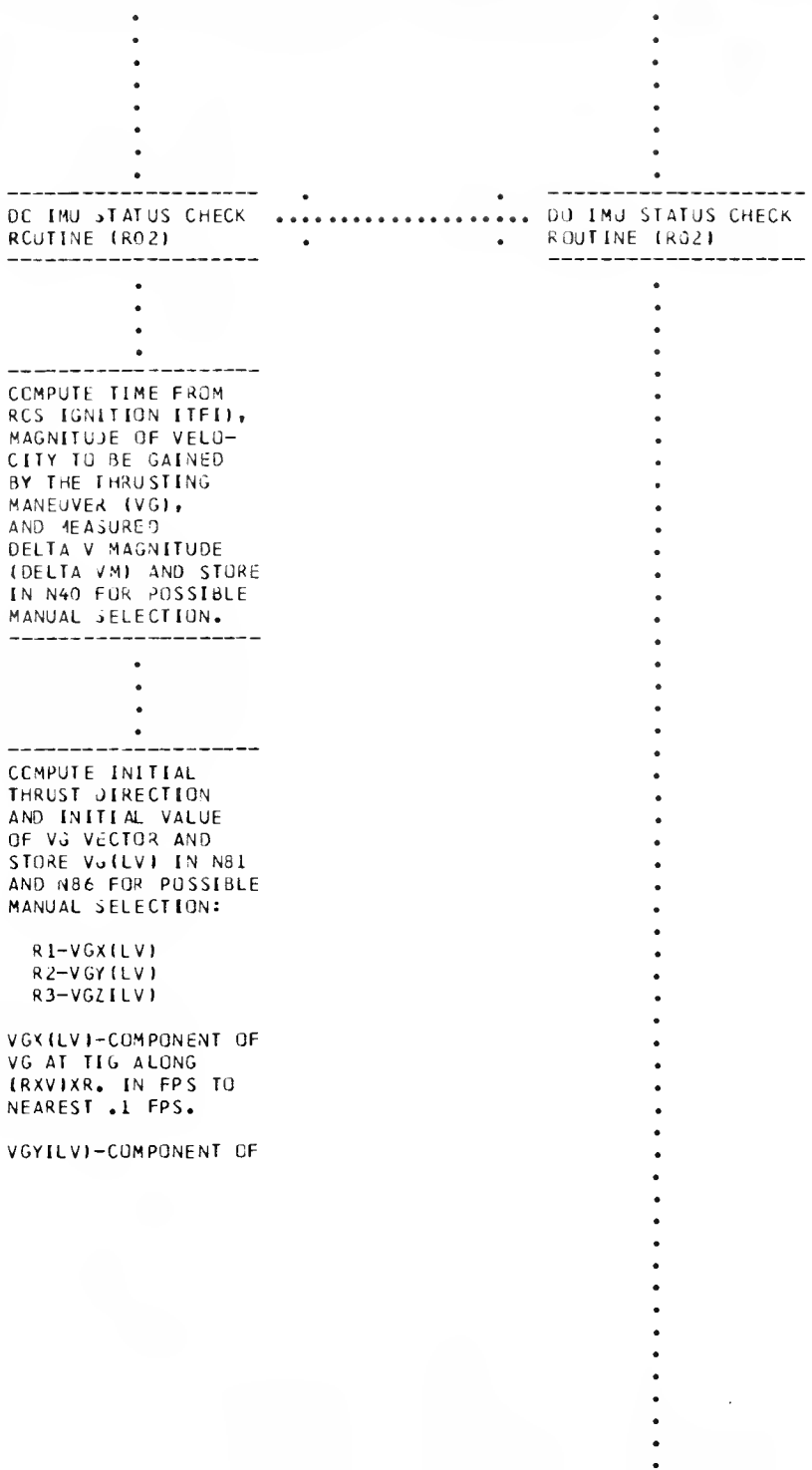
TFI - TIME FROM DPS IGNITION. IN MIN, SEC TO NEAREST SEC. MAXIMUM READING IS 59B59. SIGN IS - BEFORE NOMINAL TIG, + THEREAFTER.

VG - MAGNITUDE OF THE VELOCITY TO BE GAINED BY THRUSTING MANEUVER. IN FPS TO NEAREST .1 FPS.

DELTA VM - MEASURED DELTA V MAGNITUDE. IN FPS TO NEAREST .1 FPS. (THIS DISPLAY WILL BE 00000 UNTIL TIG-30 SECONDS AND THEN SHOULD CHANGE ONLY DUE TO PIPA BIAS UNTIL ULLAGE IS STARTED).

(12) THIS PROGRAM IS SELECTED MANUALLY BY DSKY ENTRY.




DC IMU STATUS CHECK ROUTINE (R02)
DO IMU STATUS CHECK ROUTINE (R02)
COMPUTE TIME FROM RCS IGNITION (TFI), MAGNITUDE OF VELO-CITY TO BE GAINED BY THE THRUSTING MANEUVER (VG), AND MEASURED DELTA V MAGNITUDE (DELTA VM) AND STORE IN N40 FOR POSSIBLE MANUAL SELECTION.
COMPUTE INITIAL THRUST DIRECTION AND INITIAL VALUE OF VG VECTOR AND STORE VG(LV) IN N81 AND N86 FOR POSSIBLE MANUAL SELECTION:
R1-VGX(LV)
R2-VGY(LV)
R3-VGZ(LV)
VGX(LV)-COMPONENT OF VG AT TIG ALONG (RXV)XR. IN FPS TO NEAREST .1 FPS.
VGY(LV)-COMPONENT OF

#30

#40

#50

#60

VG AT TIG ALONG VXR.
IN FPS TO NEAREST
.1 FPS.

VGZ(LV)-COMPONENT OF
VG AT TIG ALONG -R.
IN FPS TO NEAREST
.1 FPS.

WHERE R IS GEOCENT-
RIC (EARTH ORBIT) OR
SELENOCENTRIC (LUNAR
ORBIT) RADIUS VECTOR
AND V IS VEHICLE
INERTIAL VELOCITY
VECTOR AT TIG.
(NOTE: N81 WILL NOW
DIFFER FROM N81 DIS-
PLAY OF P30, P32,
AND P33 BECAUSE OF
ROTATION OF VG
VECTOR).

•
•
•

COMPUTE PREFERRED
IMU ORIENTATION:

$X_{-SM} = UNIT(T)$

$Y_{-SM} = UNIT(T \times R)$

$Z_{-SM} = UNIT(X_{-SM} \times Y_{-SM})$

WHERE:

T = THE INITIAL
THRUST VECTOR.

R = THE GEOCENTRIC

#70

#80

#90

#100

#110

```
-
(EARTH ORBIT) OR
SELENOCENTRIC
(LUNAR ORBIT)
RADIUS VECTOR AT
TIG.
(NOTE: IF T X R IS
          - -
SMALL (REFER SECTION
5.3 OF R567),
THEN Y   =
     -SM
UNIT (T X V)
      - -
WHERE V = VEHICLE
      -
INERTIAL VELOCITY
VECTOR AT TIG.)
--------------------
          .
          .
          .
          .
--------------------
STORE DESIRED ATTI-
TUDE SPECIFICATION
FOR USE BY ATTITUDE
MANEUVER ROUTINE
(R60). THE FINAL
ATTITUDE WILL BE
COMPUTED DURING R60
AND WILL POINT THE
LM +X AXIS IN THE
INITIAL THRUST DI-
RECTION.
HOWEVER, IN ORDER TO
CONSERVE RCS FUEL
AND NOT CONSTRAIN
THE NON-CRITICAL
ATTITUDE ABOUT THE
THRUST VECTOR, WINGS
MAY NOT BE LEVEL IN
THE COMPUTED FINAL
ATTITUDE.
--------------------
          .
          .
          .
--------------------
SET PREFERRED-ATT-
ITUDE-COMPUTED FLAG.
--------------------
          .
          .
          .
          .
          .
          .
          .
          .
          .
```

#120

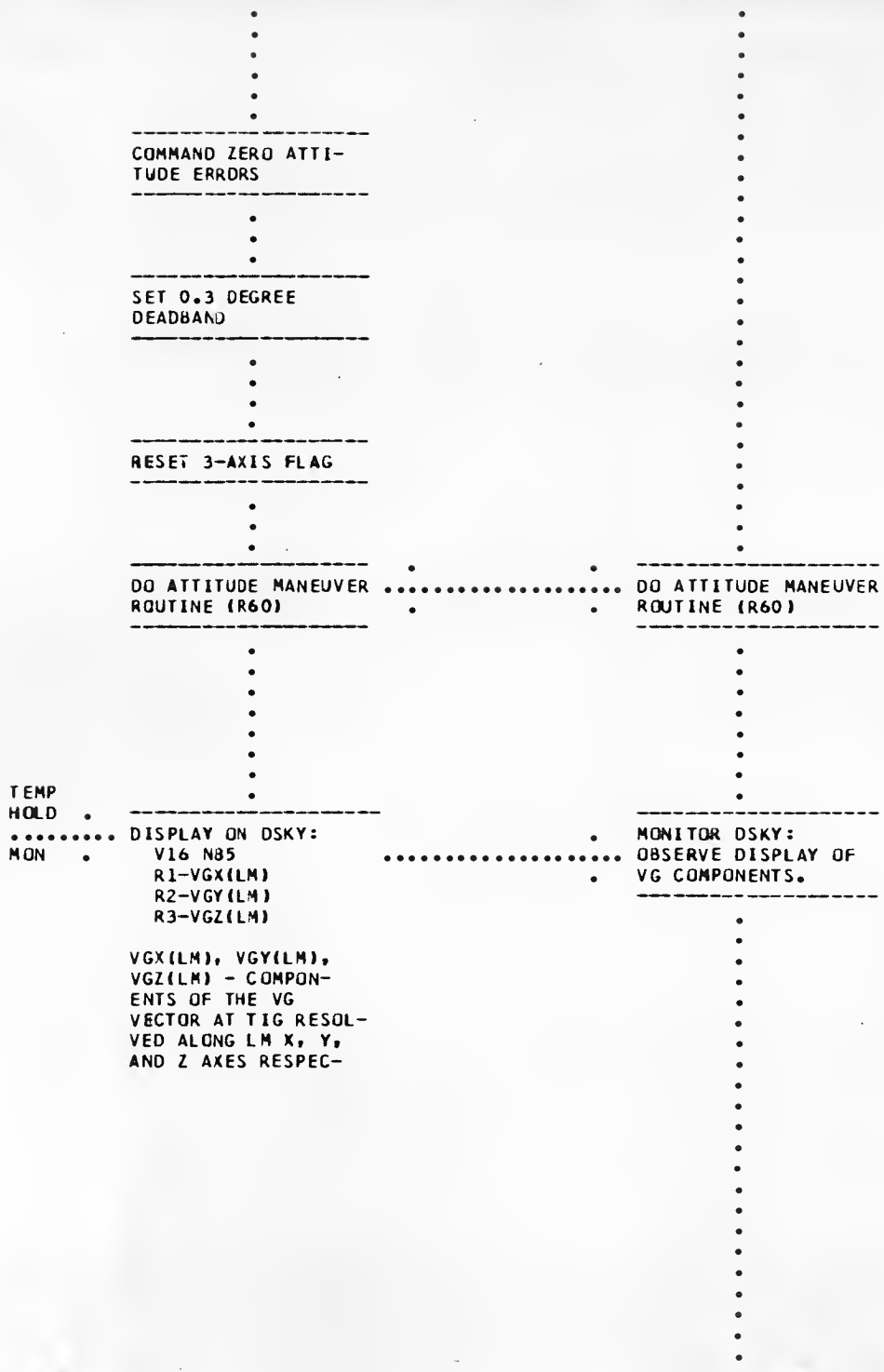
#130

#140

#150

#160

#170

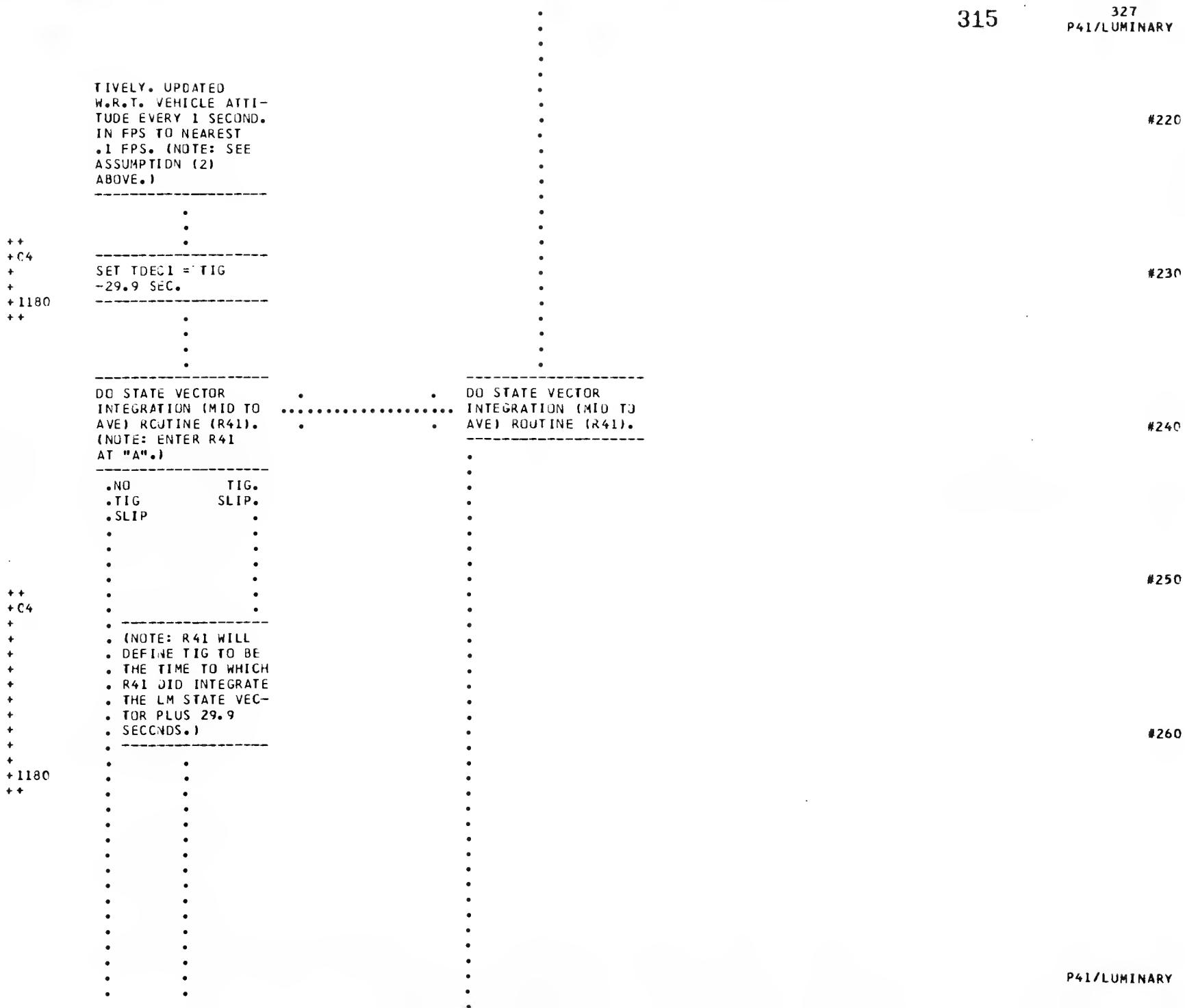


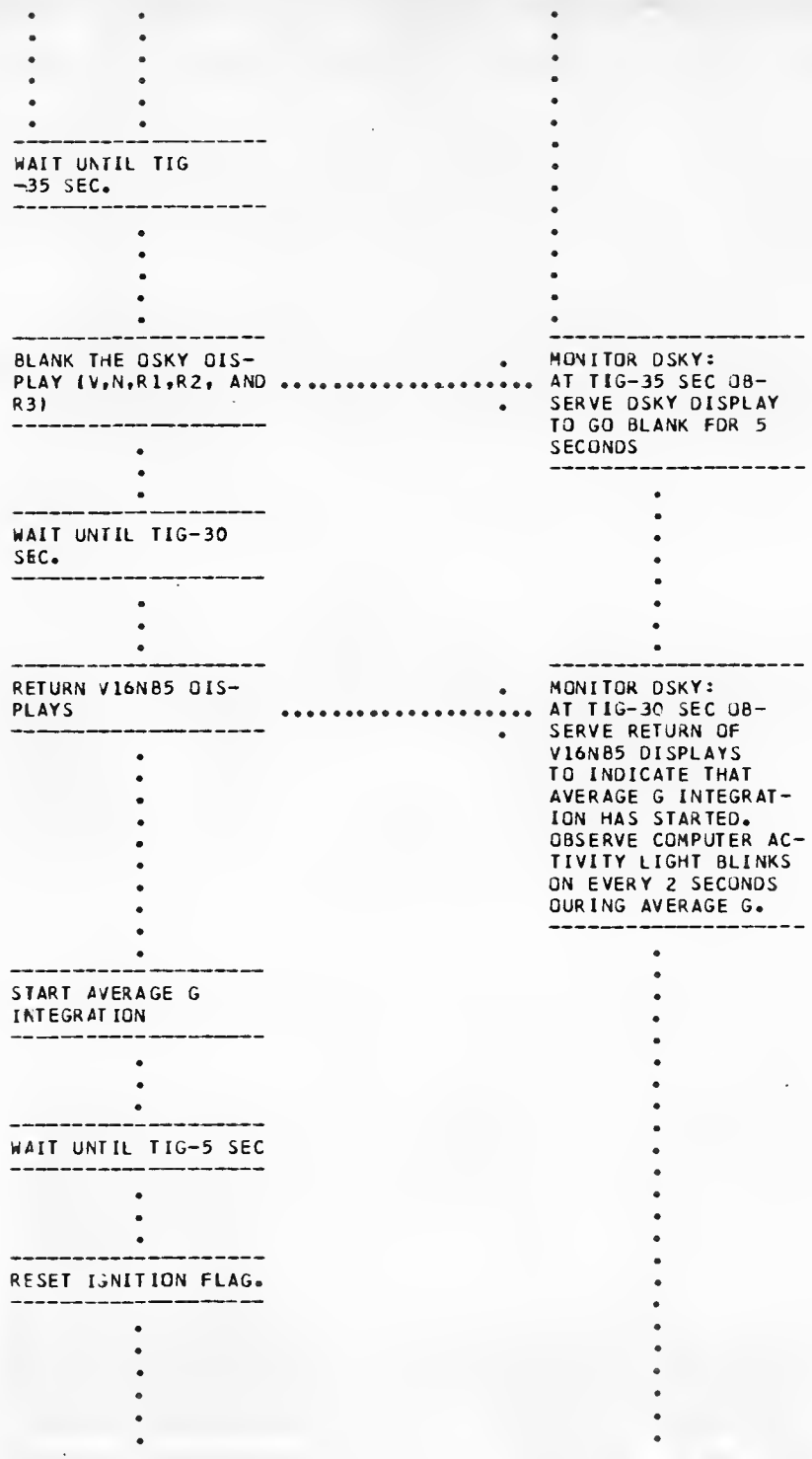
#180

#190

#200

#210


TIVELY. UPDATED W.R.T. VEHICLE ATTI-TUDE EVERY 1 SECOND. IN FPS TO NEAREST .1 FPS. (NOTE: SEE ASSUMPTION (2) ABOVE.)
SET TDEC1 = TIG -29.9 SEC.
DO STATE VECTOR INTEGRATION (MID TO AVE) ROUTINE (R41). (NOTE: ENTER R41 AT "A".)
.NO TIG. .TIG SLIP.
(NOTE: R41 WILL DEFINE TIG TO BE THE TIME TO WHICH R41 DID INTEGRATE THE LM STATE VEC-TOR PLUS 29.9 SECONDS.)
DO STATE VECTOR INTEGRATION (MID TO AVE) ROUTINE (R41).
#220
#230
#240
#250
#260



#270

#280

#290

#300

#310

#320

RESET ASTRONAUT FLAG

WAIT UNTIL TIG-0 SEC

SET IGNITION FLAG

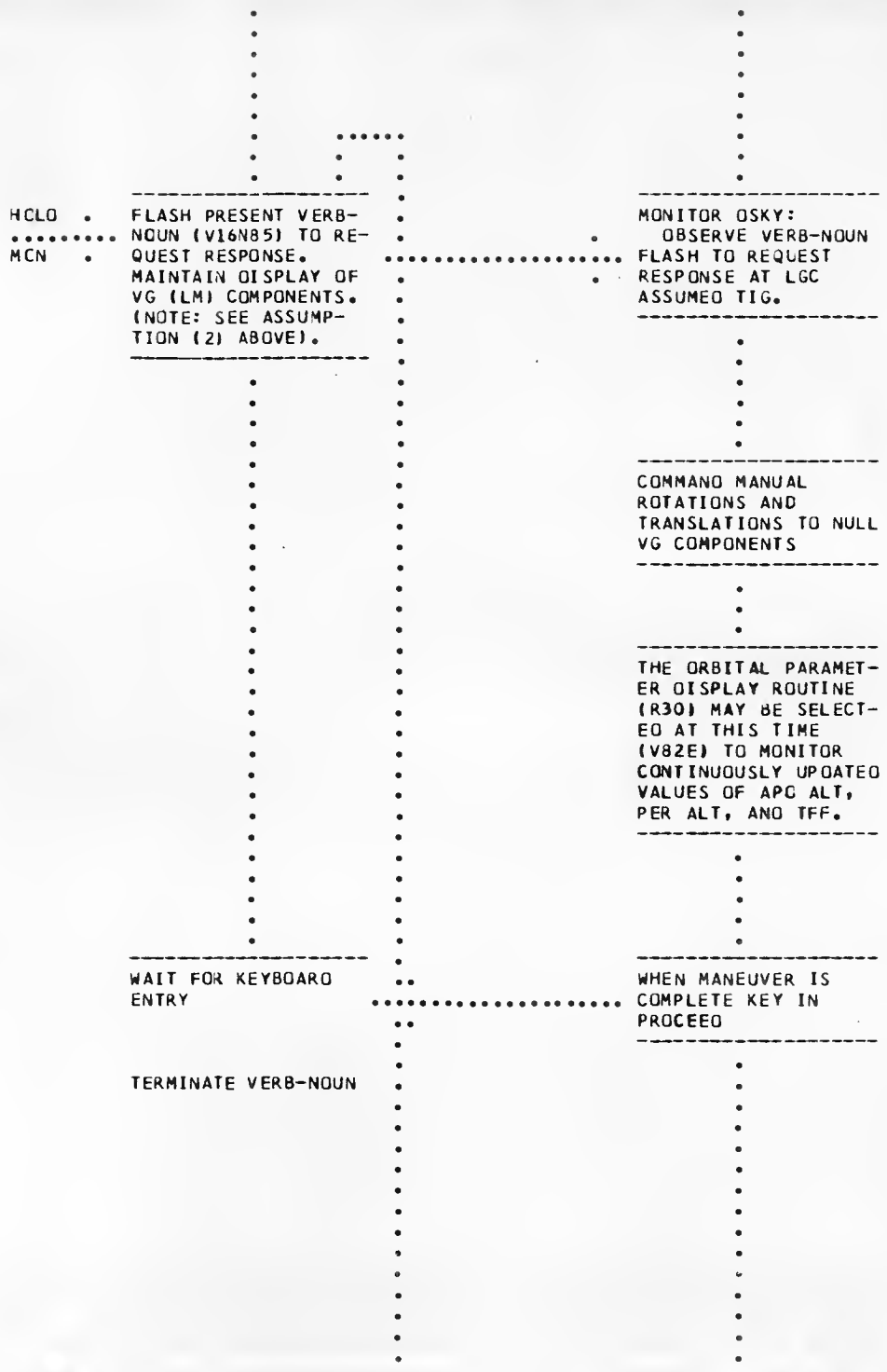
IS ASTRONAUT FLAG SET?
(NOTE: IN P41 THE ANSWER IS ALWAYS NO BECAUSE ASTRONAUT HAS NO V99 TO RESPOND TO).

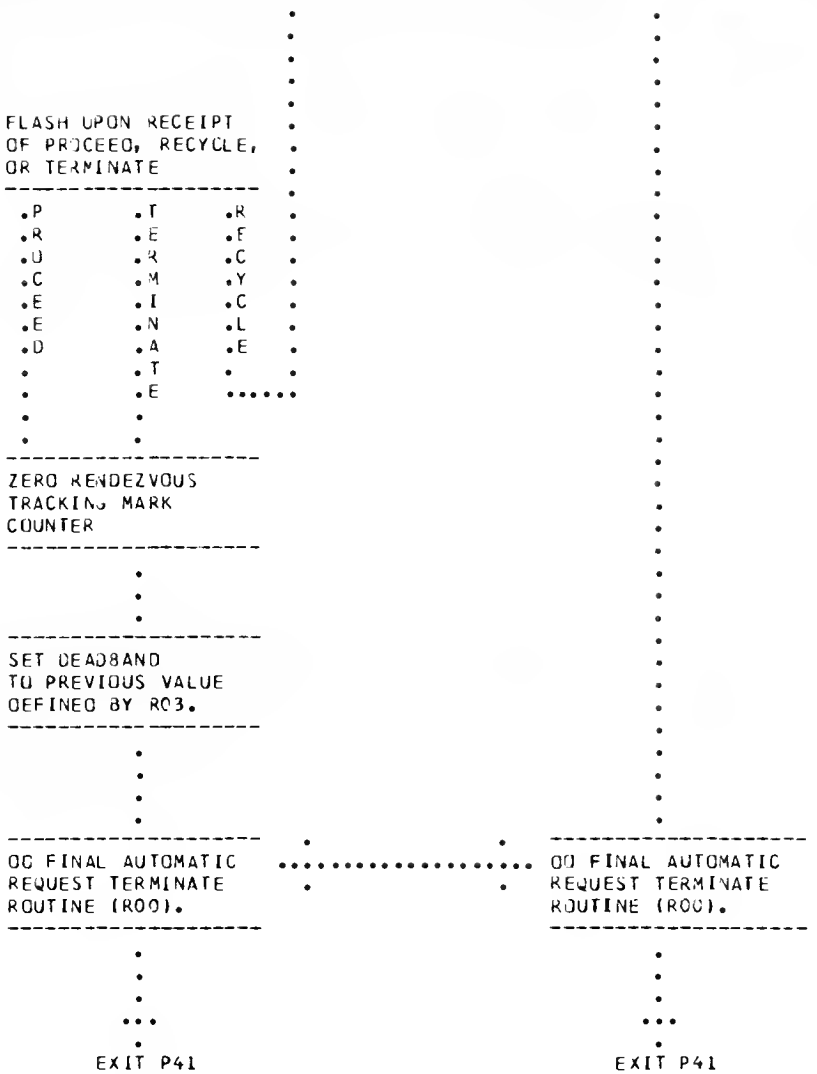
N.

RESET PULSES FLAG

COMMAND ZERO ATTITUDE ERRORS

SET .3 DEGREE DEADBAND


HCLO
MCN
FLASH PRESENT VERB-NOUN (V16N85) TO REQUEST RESPONSE. MAINTAIN DISPLAY OF VG (LM) COMPONENTS. (NOTE: SEE ASSUMPTION (2) ABOVE).
MONITOR OSKY: OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AT LGC ASSUMED TIG.
#380
COMMAND MANUAL ROTATIONS AND TRANSLATIONS TO NULL VG COMPONENTS
#390
THE ORBITAL PARAMETER DISPLAY ROUTINE (R30) MAY BE SELECTED AT THIS TIME (V82E) TO MONITOR CONTINUOUSLY UPDATED VALUES OF APO ALT, PER ALT, AND TFF.
#400
#410
WAIT FOR KEYBOARD ENTRY
WHEN MANEUVER IS COMPLETE KEY IN PROCEED
TERMINATE VERB-NOUN



#420

#430

#440

#450

#460

CHANGE CONTROL NOTES

REV 01 PCR 85,86,164,401,609,637
REV 00(LUM 1A) PCR 647
REV 01(LUM 1B) PCR 838,841,EDITORIAL
REV 02 EDITORIAL
REV 03(LUM 1D) PCR 872.2, PCN 1009,1040
REV 04 PCN 1180

APS PROGRAM (P42) REV C5 12/01/71

PURPOSE: (1) TO COMPUTE A PREFERRED IMU ORIENTATION AND A VEHICLE ATTITUDE FOR A LM APS THRUSTING MANEUVER.

(2) TO DO THE VEHICLE MANEUVER TO THE THRUSTING ATTITUDE.

(3) TO CONTROL THE PGNCS DURING COUNTDOWN, IGNITION, THRUSTING, AND THRUST TERMINATION OF A PGNCS CONTROLLED APS MANEUVER.

ASSUMPTIONS: (1) THE TARGET PARAMETERS HAVE BEEN CALCULATED AND STORED IN THE LGC BY PRIOR EXECUTION OF A PRE-THRUSTING PROGRAM.

(2) THE REQUIRED STEERING EQUATIONS ARE IDENTIFIED BY THE PRIOR PRE-THRUST PROGRAM, WHICH EITHER RESET ("ASTEER") OR SET (EXT DELTA V) THE EXTERNAL DELTA V FLAG. FOR EXTERNAL DELTA V STEERING, VG IS CALCULATED ONCE FOR THE SPECIFIED TIME OF IGNITION. THEREAFTER BOTH DURING APS THRUSTING AND UNTIL THE CREW NOTIFIES THE LGC THAT RCS TRIM THRUSTING HAS BEEN COMPLETED, THE LGC UPDATES VG ONLY AS A RESULT OF ACCELEROMETER INPUTS.
FOR STEERING CONTROL WHEN USING "ASTEER", THE VELOCITY REQUIRED IS CALCULATED FROM FIGURE 3.3-13A IN SECTION 5 OF R-567. THE LAMBERT ROUTINE PERIODICALLY RE-COMPUTES THE INTERCEPT TRAJECTORY SEMI-MAJOR AXIS FOR THE "ASTEER" CALCULATIONS. THE INTERVAL BETWEEN LAMBERT SOLUTIONS IS CONTROLLED BY AN ERASABLE LOADED VALUE (DT).

(3) THE IMU IS ON AND MUST BE AT A KNOWN ORIENTATION BEFORE THIS PROGRAM MAY BE COMPLETED. IT IS NORMALLY REQUIRED THAT THE ISS BE ON FOR A MINIMUM OF 15 MINUTES PRIOR TO A THRUSTING MANEUVER.

(4) THE EVENT TIMER IS SET TO COUNT TO ZERO AT TIG.

(5) ENGINE IGNITION MAY BE SLIPPED BEYOND THE ESTABLISHED TIG IF DESIRED BY THE CREW OR IF STATE VECTOR INTEGRATION CANNOT BE COMPLETED IN TIME.

(6) IF A THRUSTING MANEUVER IS PERFORMED WITH THE GUIDANCE CONTROL SWITCH IN PGNS AND THE MODE CONTROL SWITCH IN AUTO, THE PGNCS WILL CONTROL THE TOTAL VEHICLE ATTITUDE AND GENERATE EITHER MODE I OR MODE II ATTITUDE ERRORS AND VEHICLE ATTITUDE RATES (SEE ASSUMPTION (7)) FOR DISPLAY ON THE FDAI. THE CREW MAY EXERCISE CONTROL AROUND THE YAW AXIS ONLY WITH THE ACA (X-AXIS OVERRIDE) IF THE X-AXIS OVERRIDE CAPABILITY IS PERMITTED BY THE PROGRAM IN PROCESS. THIS MANUAL CONTROL WILL BE IN THE RATE COMMAND/ATTITUDE HOLD MODE.
IF A THRUSTING MANEUVER IS PERFORMED WITH THE GUIDANCE CONTROL SWITCH IN PGNS AND THE MODE CONTROL SWITCH IN ATTITUDE HOLD THE PGNCS WILL HOLD THE VEHICLE ATTITUDE AND WILL GENERATE EITHER MODE I OR MODE II ATTITUDE ERRORS FOR DISPLAY ON THE FDAI. THE CREW MAY EXERCISE MANUAL ATTITUDE CONTROL ABOUT ALL VEHICLE AXES WITH THE ACA IN EITHER THE RATE COMMAND OR MINIMUM IMPULSE MODE DEPENDING UPON THE STATUS OF THE PULSES FLAG. HOWEVER IT IS STRONGLY RECOMMENDED THAT POWERED FLIGHT NOT BE ATTEMPTED IN THE MINIMUM IMPULSE MODE. THE PULSES FLAG IS SET OR RESET BY EXTENDED VERBS 76 (MINIMUM IMPULSE) AND 77 (RATE COMMAND) RESPECTIVELY. THE PULSES FLAG IS ALSO RESET BY P12, P40, P41, P42, P63, P70, P71, AND R40 AT MAIN ENGINE IGNITION. WITH THE EXCEPTION OF THESE CASES, MODE SELECTION IS ALWAYS BASED UPON THE LAST ENTRY MADE IN THE DSKY. DURING A THRUSTING MANEUVER IN THE PGNS/ATTITUDE HOLD MODE THE PGNCS WILL NOT BE RESPONSIBLE IF REGISTER OVERFLOWS OCCUR WITHIN THE LGC.
++ IN THE EVENT THAT THE GUIDANCE CONTROL SWITCH IS CHANGED FROM PGNS TO AGS DURING A THRUSTING MANEUVER, THE
+05 LGC WILL CONTINUE COMPUTATION OF POSITION AND VELOCITY, THE DESIRED THRUST VECTOR, AND THE FDAI ATTITUDE ERROR NEEDLE
+1180 DISPLAY. HOWEVER, THE PGNCS WILL NOT BE RESPONSIBLE IF REGISTER OVERFLOWS OCCUR WITHIN THE LGC.
++

(7) THE PGNCS CAN GENERATE TWO TYPES OF ATTITUDE ERRORS FOR DISPLAY ON THE FDAI;

MODE I - SELECTED BY EXTENDED VERB 61. AUTOPILOT FOLLOWING ERRORS USED AS A MONITOR OF THE DAP'S ABILITY TO TRACK AUTOMATIC STEERING COMMANDS.
MODE II - SELECTED BY EXTENDED VERB 62. TOTAL ATTITUDE ERRORS USED TO ASSIST CREW IN MANUALLY MANEUVERING THE VEHICLE.

PGNCS-DERIVED VEHICLE ATTITUDE RATES MAY ALSO BE DISPLAYED VIA SELECTION BY EXTENDED VERB 60.

++ DISPLAY SELECTION IS ALWAYS BASED UPON THE LAST ENTRY MADE IN THE DSKY, WITH THE EXCEPTION THAT MODE II ATTITUDE
+05 ERROR DISPLAYS ARE AUTOMATICALLY SELECTED AT THE BEGINNING OF R60. FOR A MORE DETAILED DESCRIPTION OF THESE DISPLAYS
+1180 REFER TO SECTION 3 OF R57, PARA. 3.2.6.
++

(8) THE X-AXIS OVERRIDE OPTION PROVIDES THE CREW WITH THE ABILITY TO EXERCISE MANUAL CONTROL ABOUT THE LM X AXIS WITH THE ATTITUDE CONTROLLER EVEN THOUGH THE PGNCS ATTITUDE CONTROL MODE IS AUTO. WHEN THE CONTROLLER IS RETURNED TO DETENT THE PGNCS DAMPS THE YAW RATE, STORES THE YAW ATTITUDE WHEN THE YAW RATE IS DAMPED, AND THEN MAINTAINS THAT ATTITUDE.

THE X-AXIS OVERRIDE OPTION IS ALWAYS AVAILABLE TO THE CREW, HOWEVER IT SHOULD NOT BE EXERCISED WHEN THE LGC IS SPECIFYING A DESIRED YAW ATTITUDE, I.E.: DURING THE ATTITUDE MANEUVER TO THE THRUSTING ATTITUDE (SEE R60).

(9) FOR EACH BURN AN IGNITION TOTAL ALLOWABLE TIME DELAY WILL BE SPECIFIED IN THE MISSION RULES. THIS DELAY TIME IS THE TOTAL TIME WHICH THE THRUSTING MANEUVER MAY BE DELAYED BEYOND THE LGC CALCULATED TIME OF IGNITION. IF ENGINE RESTARTS ARE INVOLVED, THE ACCOUNTING OF THIS TOTAL TIME DELAY IS UP TO THE CREW.

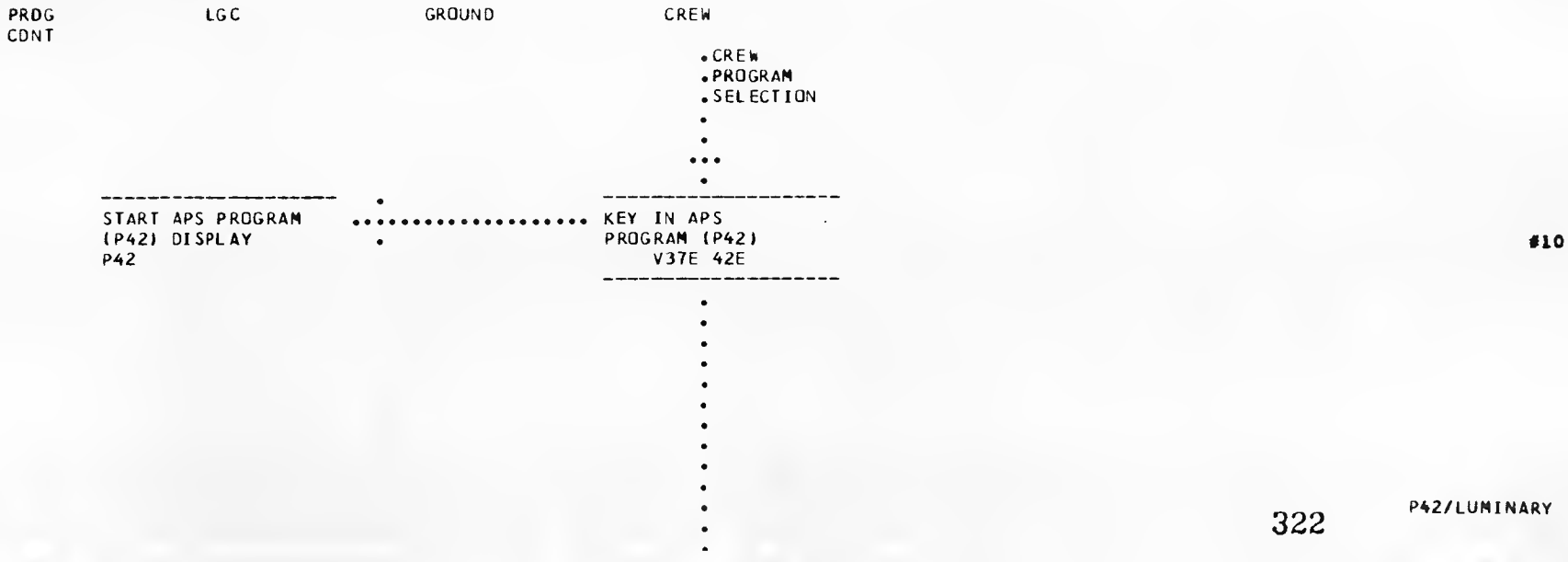
++ (10) THE DAP DATA LOAD ROUTINE (R03) MAY HAVE BEEN PERFORMED PRIOR TO SELECTION OF THIS PROGRAM. 4JET X-TRANSLATION
+05 FOR ULLAGE IS ASSUMED. 2 JET OR 4 JET ULLAGE IS INITIALIZED BY DAP DATA LOAD ROUTINE (R03). PRIME FLIGHT CREW WILL
+1180 BE USING 4 JET X-TRANSLATION FOR ULLAGE IN CASE (1) APS DOESN'T SHUTDOWN OR (2) APS DOESN'T IGNITE AT ALL, THE DELTA
++ V WILL BE EASIER TO NULL THAN WITH 2 JETS.

(11) LGC AND CREW PROCEDURES IN CASES OF LGC-ASSUMED THRUST FAILURE ARE DEFINED BY THE DPS/APS THRUST FAIL ROUTINE (R40). THIS ROUTINE IS CALLED AT APS IGNITION BY THIS PROGRAM.

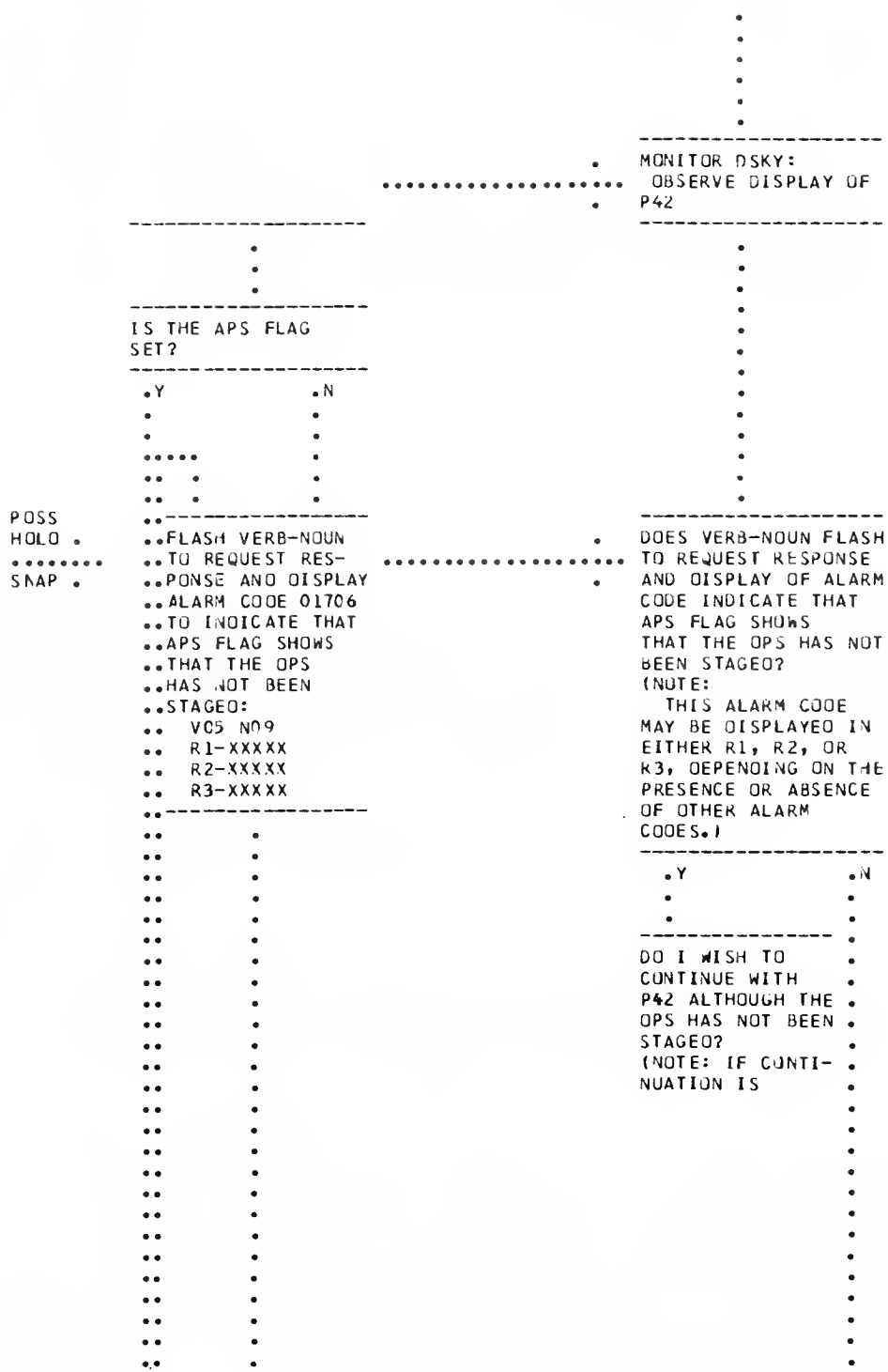
(12) THE LGC WILL NEITHER DESIGNATE NOR READ THE RENDEZVOUS RADAR IRR) DURING THIS PROGRAM.

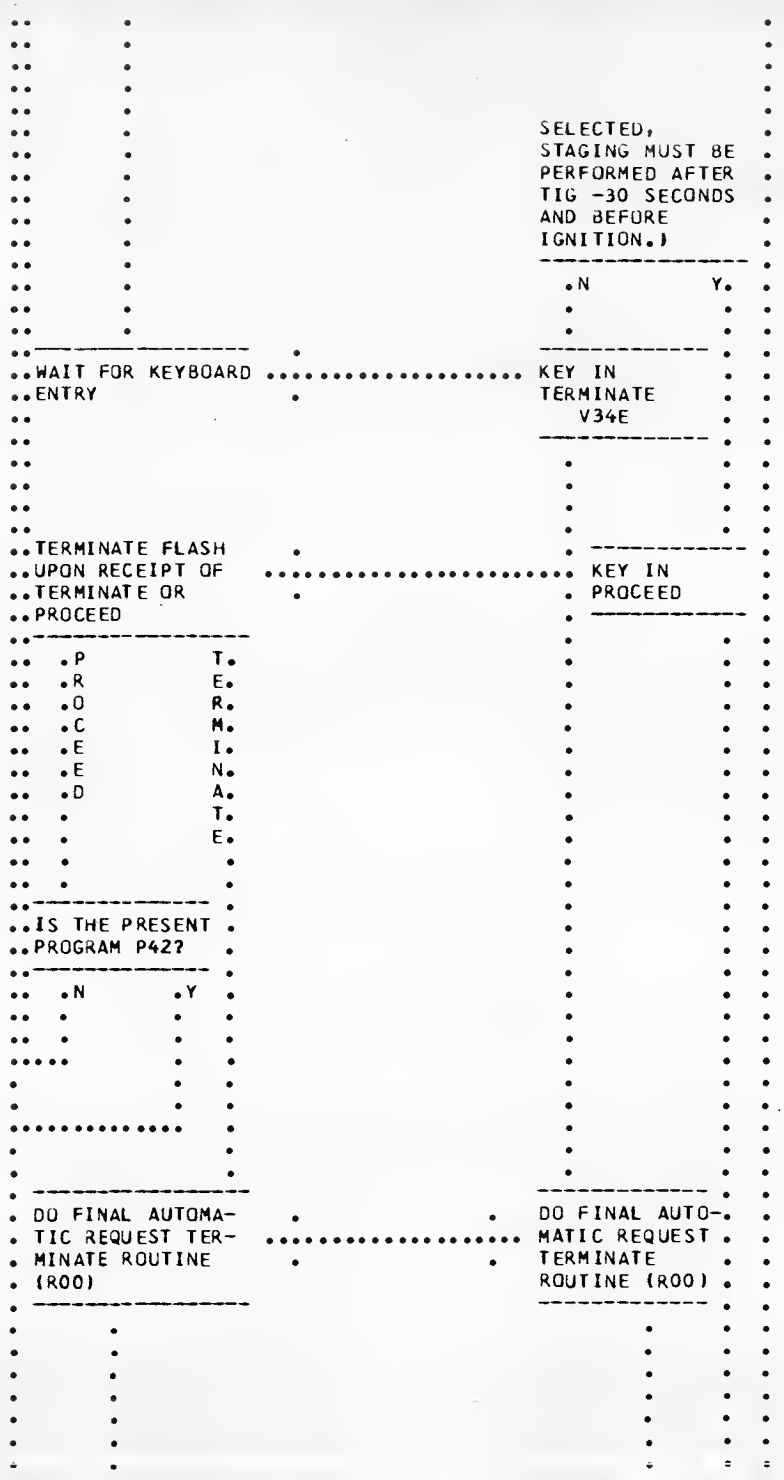
(13) THIS PROGRAM SHOULD BE SELECTED BY THE ASTRONAUT BY DSKY ENTRY AT LEAST 5 MINUTES BEFORE THE ESTIMATED TIME OF IGNITION.

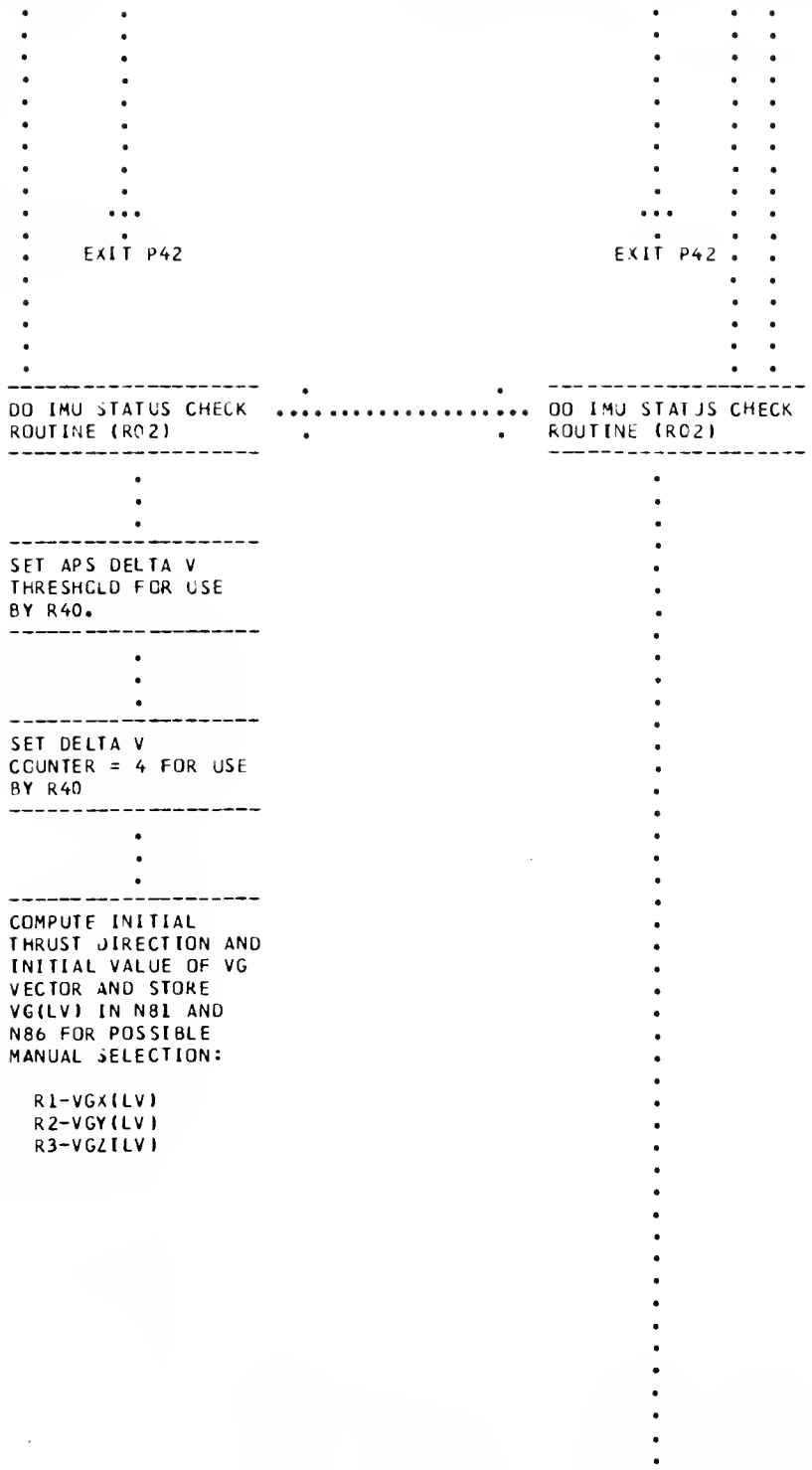
(14) THIS PROGRAM IS SELECTED MANUALLY BY DSKY ENTRY.



#10


MONITOR DSKY:
OBSERVE DISPLAY OF
P42
#20
IS THE APS FLAG
SET?
.Y
.N
#30
POSS
HOLO
SNAP
FLASH VERB-NOUN
TO REQUEST RES-
PONSE AND DISPLAY
ALARM CODE 01706
TO INDICATE THAT
APS FLAG SHOWS
THAT THE OPS
HAS NOT BEEN
STAGED:
V05 N09
R1-XXXXX
R2-XXXXX
R3-XXXXX
DOES VERB-NOUN FLASH
TO REQUEST RESPONSE
AND DISPLAY OF ALARM
CODE INDICATE THAT
APS FLAG SHOWS
THAT THE OPS HAS NOT
BEEN STAGED?
(NOTE:
THIS ALARM CODE
MAY BE DISPLAYED IN
EITHER R1, R2, OR
R3, DEPENDING ON THE
PRESENCE OR ABSENCE
OF OTHER ALARM
CODES.)
#40
#50
.Y
.N
DO I WISH TO
CONTINUE WITH
P42 ALTHOUGH THE
OPS HAS NOT BEEN
STAGED?
(NOTE: IF CONTI-
NUATION IS
#60


SELECTED,
STAGING MUST BE
PERFORMED AFTER
TIG -30 SECONDS
AND BEFORE
IGNITION.)
.N
Y.
#70
WAIT FOR KEYBOARD
ENTRY
KEY IN
TERMINATE
V34E
#80
TERMINATE FLASH
UPON RECEIPT OF
TERMINATE OR
PROCEED
KEY IN
PROCEED
.P
T.
.R
E.
.O
R.
.C
M.
.E
I.
#90
.E
N.
.D
A.
T.
E.
IS THE PRESENT
PROGRAM P42?
#100
.N
.Y
#110
DO FINAL AUTOMA-
TIC REQUEST TER-
MINATE ROUTINE
(R00)
DO FINAL AUTO-
MATIC REQUEST
TERMINATE
ROUTINE (R00)



#120

#130

#140

#150

#160

VGX(LV)-COMPONENT OF
VG AT TIG ALONG
IRXV)XR. IN FPS TO
NEAREST .1 FPS.

#170

VGY(LV)-COMPONENT OF
VG AT TIG ALONG VXR.
IN FPS TO NEAREST
.1 FPS.

VGZ(LV)-COMPONENT OF
VG AT TIG ALONG -R.
IN FPS TO NEAREST
.1 FPS.

#180

WHERE R IS GEOCENT-
RIC (EARTH ORBIT)
OR SELENOCENTRIC
(LUNAR ORBIT) RADIUS
VECTOR, AND V IS
VEHICLE INERTIAL
VELOCITY VECTOR AT
TIG.
(NOTE: N81 WILL NOW
DIFFER FROM N81
DISPLAY OF P30, P32,
AND P33 BECAUSE OF
ROTATION OF VG
VECTOR).

#190

.
.
.

#200

COMPUTE PREFERRED
IMU ORIENTATION:

$$\underline{X}_{SM} = UNIT(\underline{T})$$

$$\underline{Y}_{SM} = UNIT(\underline{T} \times \underline{R})$$

$$\underline{Z} = UNIT(\underline{X} \times \underline{Y})$$

#210

-SM -SM -SM

WHERE:

T = THE INITIAL
- THRUST VECTOR
AT IGNITION

R = THE GEOCENTRIC
- (EARTH ORBIT)
OR SELENOCENT-
RIC (LUNAR
ORBIT) RADIUS
VECTOR AT TIG.
(NOTE: IF T X R IS
- -
SMALL (REFER SECTION
5.3 OF R567),
THEN Y =
-SM
UNIT (T X V).
- -
WHERE V = VEHICLE
-
INERTIAL VELOCITY AT
TIG.)

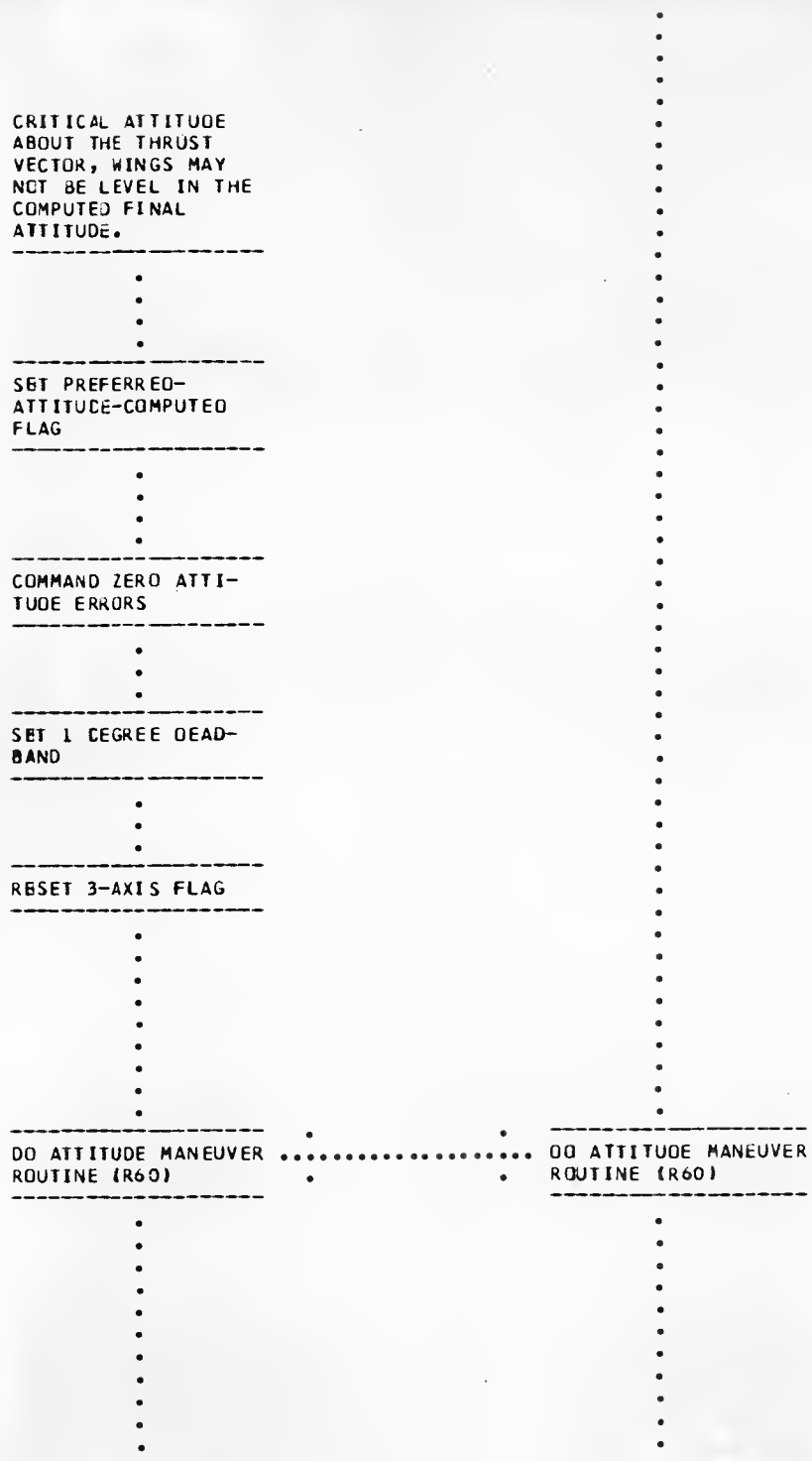
#220

#230

#240

#250

STORE DESIRED ATTI-
TUDE SPECIFICATION
FOR USE BY ATTITUDE
MANEUVER ROUTINE
(R60). THE FINAL
ATTITUDE WILL BE
COMPUTED DURING R60
AND WILL POINT THE
LM +X AXIS IN THE
INITIAL THRUST
DIRECTION. HOWEVER,
IN ORDER TO CONSERVE
RCS FUEL AND NOT
CONSTRAIN THE NON-



#260

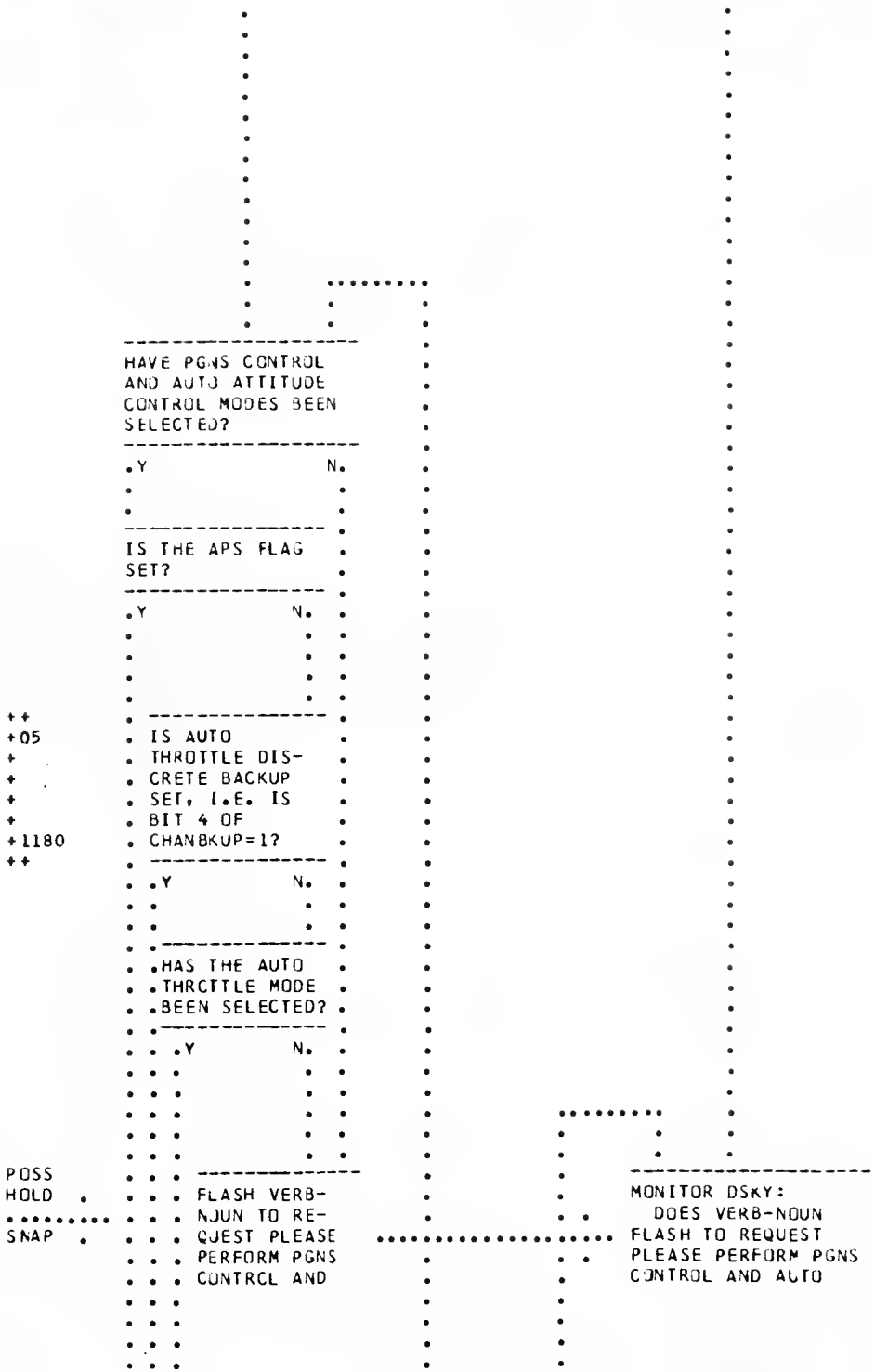
#270

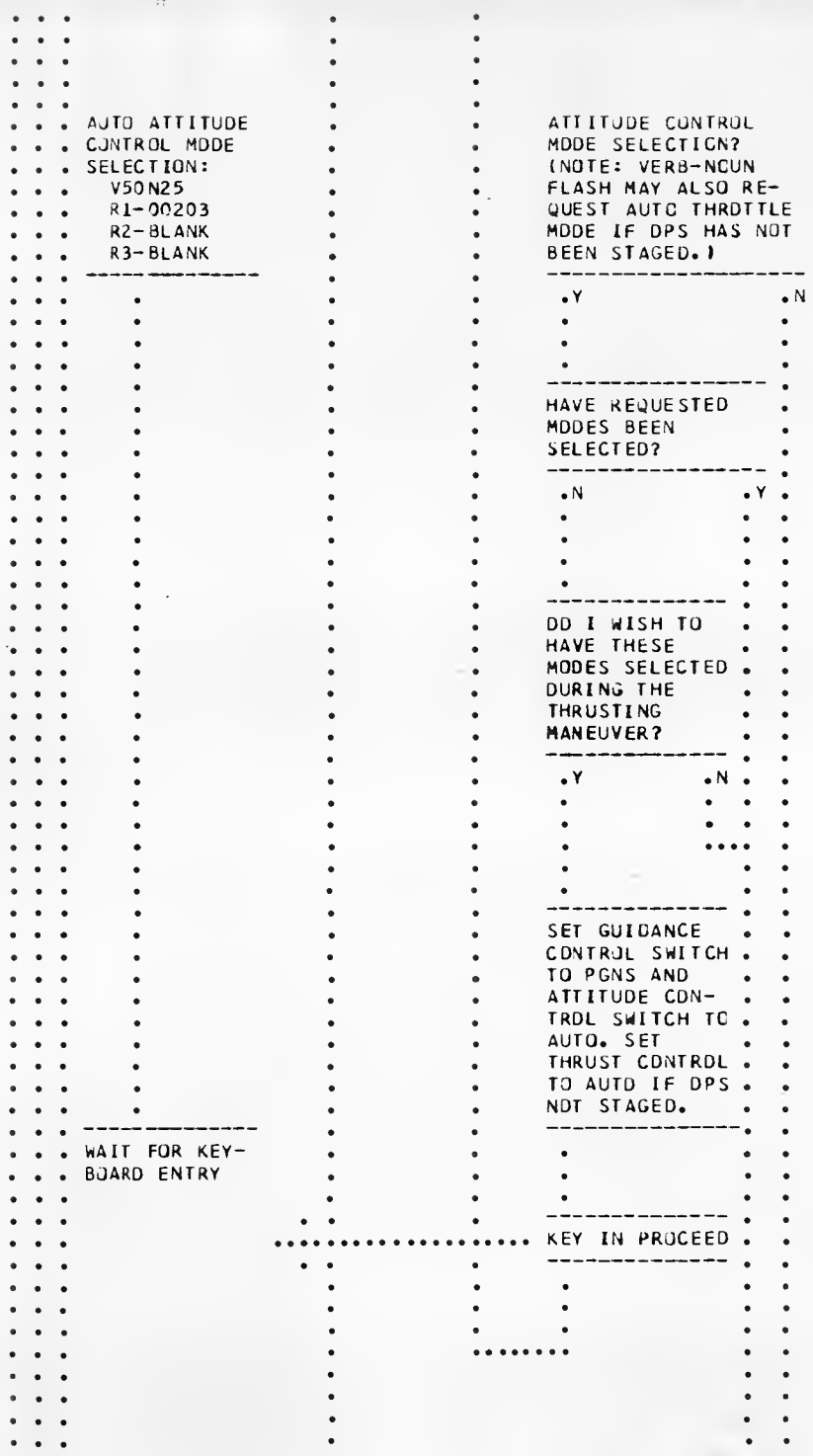
#280

#290

#300

#310


HAVE PGNS CONTROL AND AUTO ATTITUDE CONTROL MODES BEEN SELECTED?
.Y
N.
#320
IS THE APS FLAG SET?
.Y
N.
#330
++
+05
+
+
+
+1180
++
IS AUTO THROTTLE DIS-CRETE BACKUP SET, I.E. IS BIT 4 OF CHANBKUP=1?
.Y
N.
#340
.HAS THE AUTO .THRCTTLE MODE .BEEN SELECTED?
.Y
N.
#350
POSS HOLD
SNAP
FLASH VERB-NOUN TO RE-QUEST PLEASE PERFORM PGNS CONTRCL AND
MONITOR DSKY: DOES VERB-NOUN FLASH TO REQUEST PLEASE PERFORM PGNS CONTROL AND AUTO
#360



#370

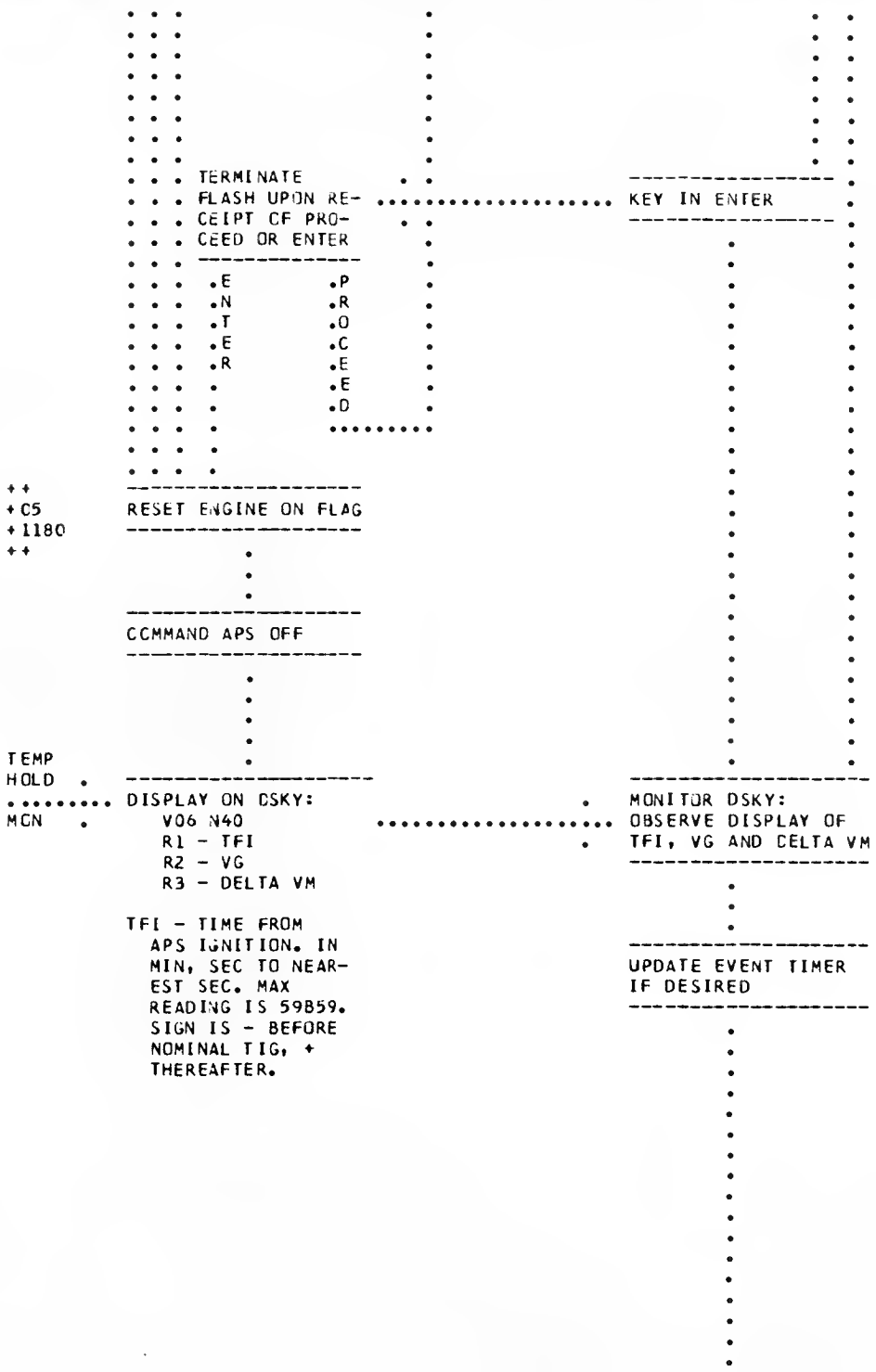
#380

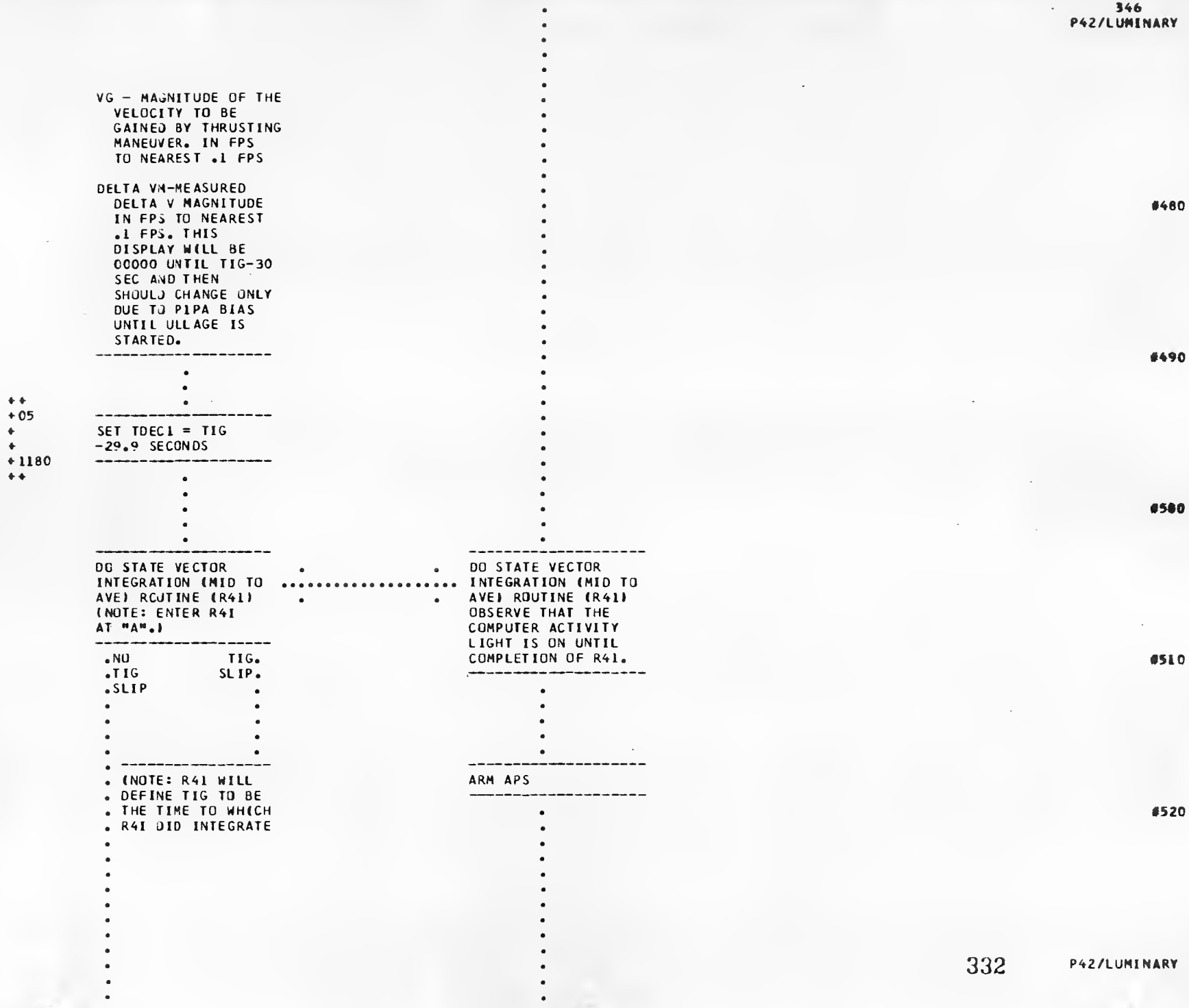
#390

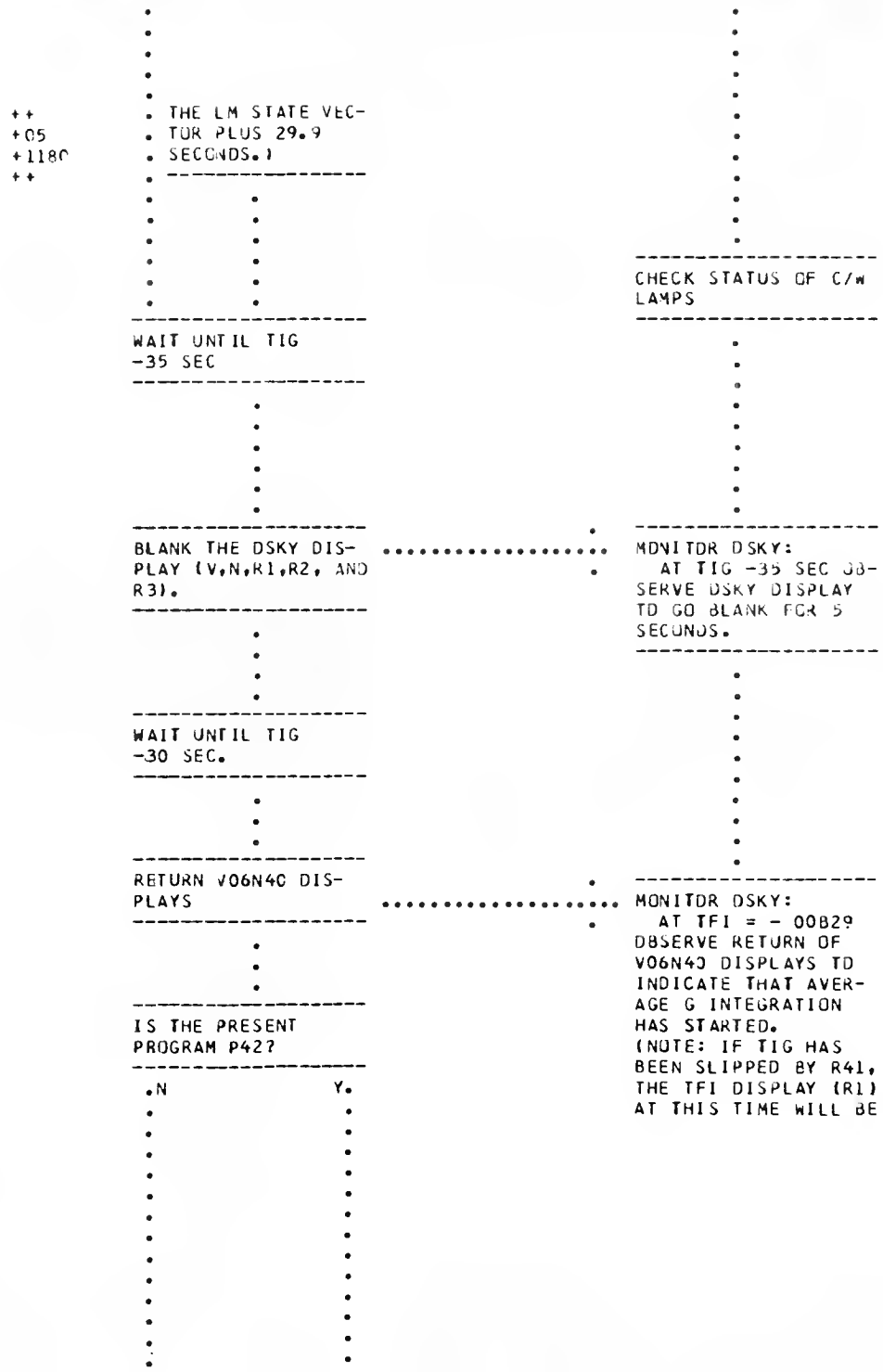
#400

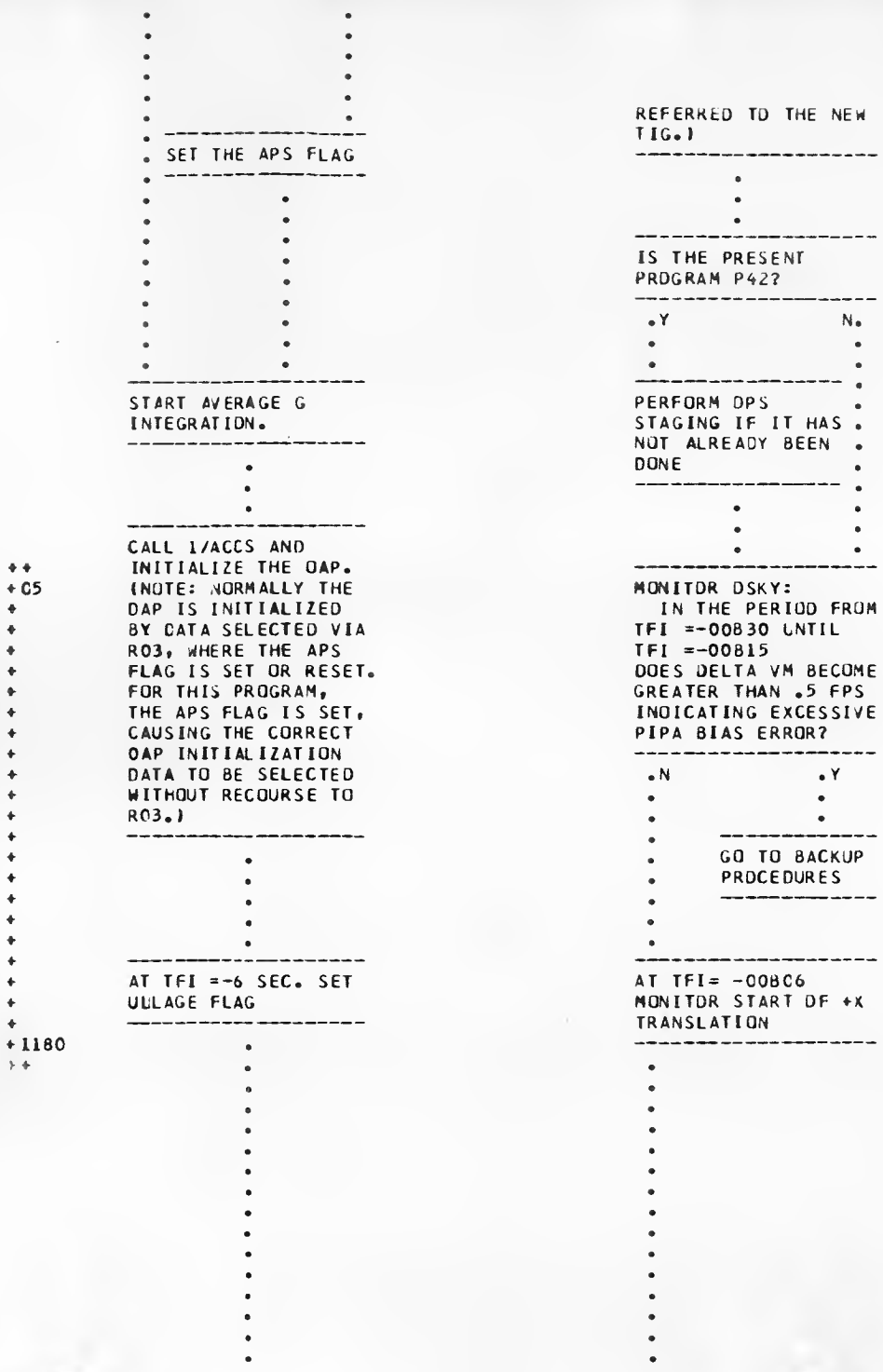
#410

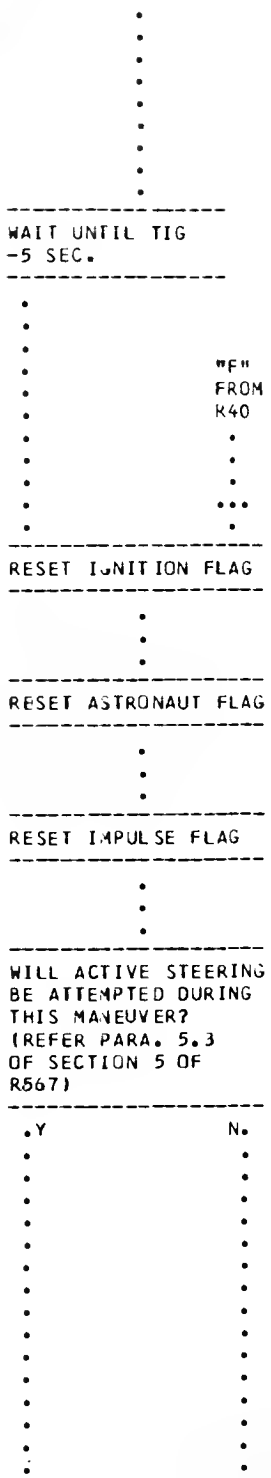
#420


TERMINATE FLASH UPON RECEIPT OF PROCEED OR ENTER
.ENTER
.PROCEED
KEY IN ENTER
#430
++
+C5
+1180
++
RESET ENGINE ON FLAG
COMMAND APS OFF
#440
#450
TEMP HOLD
MCN
DISPLAY ON DSKY:
V06 N40
R1 - TFI
R2 - VG
R3 - DELTA VM
TFI - TIME FROM APS IGNITION. IN MIN, SEC TO NEAREST SEC. MAX READING IS 59B59. SIGN IS - BEFORE NOMINAL TIG, + THEREAFTER.
MONITOR DSKY:
OBSERVE DISPLAY OF TFI, VG AND DELTA VM
#460
UPDATE EVENT TIMER IF DESIRED
#470


VG - MAGNITUDE OF THE VELOCITY TO BE GAINED BY THRUSTING MANEUVER. IN FPS TO NEAREST .1 FPS
DELTA VM-MEASURED DELTA V MAGNITUDE IN FPS TO NEAREST .1 FPS. THIS DISPLAY WILL BE 00000 UNTIL TIG-30 SEC AND THEN SHOULD CHANGE ONLY DUE TO PIPA BIAS UNTIL ULLAGE IS STARTED.
#480
#490
++
+05
+
+
+1180
++
SET TDEC1 = TIG -29.9 SECONDS
#500
DO STATE VECTOR INTEGRATION (MID TO AVE) ROUTINE (R41) (NOTE: ENTER R41 AT "A".)
.NO TIG. .TIG SLIP. .SLIP
(NOTE: R41 WILL DEFINE TIG TO BE THE TIME TO WHICH R41 DID INTEGRATE
DO STATE VECTOR INTEGRATION (MID TO AVE) ROUTINE (R41) OBSERVE THAT THE COMPUTER ACTIVITY LIGHT IS ON UNTIL COMPLETION OF R41.
#510
ARM APS
#520


++
+05
+1180
++
THE LM STATE VEC-
TOR PLUS 29.9
SECONDS.)
WAIT UNTIL TIG
-35 SEC
BLANK THE DSKY DIS-
PLAY (V,N,R1,R2, AND
R3).
WAIT UNTIL TIG
-30 SEC.
RETURN V06N40 DIS-
PLAYS
IS THE PRESENT
PROGRAM P42?
.N
Y.
CHECK STATUS OF C/W
LAMPS
MONITOR DSKY:
AT TIG -35 SEC OB-
SERVE DSKY DISPLAY
TO GO BLANK FOR 5
SECONDS.
MONITOR DSKY:
AT TFI = - 00829
OBSERVE RETURN OF
V06N40 DISPLAYS TO
INDICATE THAT AVER-
AGE G INTEGRATION
HAS STARTED.
(NOTE: IF TIG HAS
BEEN SLIPPED BY R41,
THE TFI DISPLAY (R1)
AT THIS TIME WILL BE
#530
#540
#550
#560
#570


SET THE APS FLAG
START AVERAGE G INTEGRATION.
CALL 1/ACCS AND INITIALIZE THE DAP. (NOTE: NORMALLY THE DAP IS INITIALIZED BY DATA SELECTED VIA R03, WHERE THE APS FLAG IS SET OR RESET. FOR THIS PROGRAM, THE APS FLAG IS SET, CAUSING THE CORRECT DAP INITIALIZATION DATA TO BE SELECTED WITHOUT RECOURSE TO R03.)
AT TFI =-6 SEC. SET ULLAGE FLAG
REFERRED TO THE NEW TIG.)
IS THE PRESENT PROGRAM P42?
Y
N.
PERFORM DPS STAGING IF IT HAS NOT ALREADY BEEN DONE
MONITOR DSKY: IN THE PERIOD FROM TFI =-00830 UNTIL TFI =-00815 DOES DELTA VM BECOME GREATER THAN .5 FPS INDICATING EXCESSIVE PIPA BIAS ERROR?
N
Y
GO TO BACKUP PROCEDURES
AT TFI= -00806 MONITOR START OF +X TRANSLATION
#580
#590
#600
#610



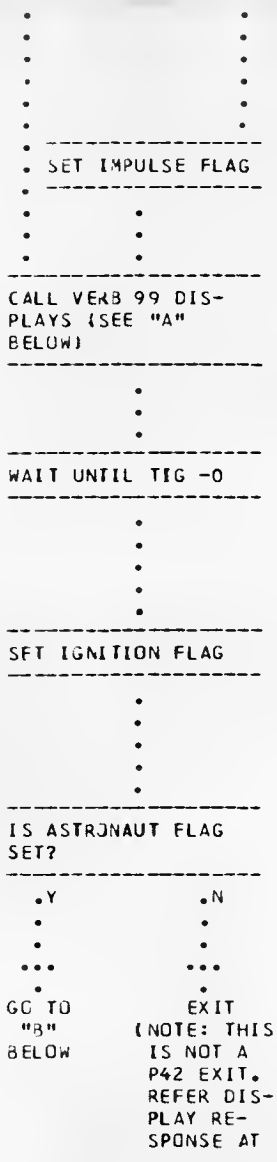
#620

#630

#640

#650

#660



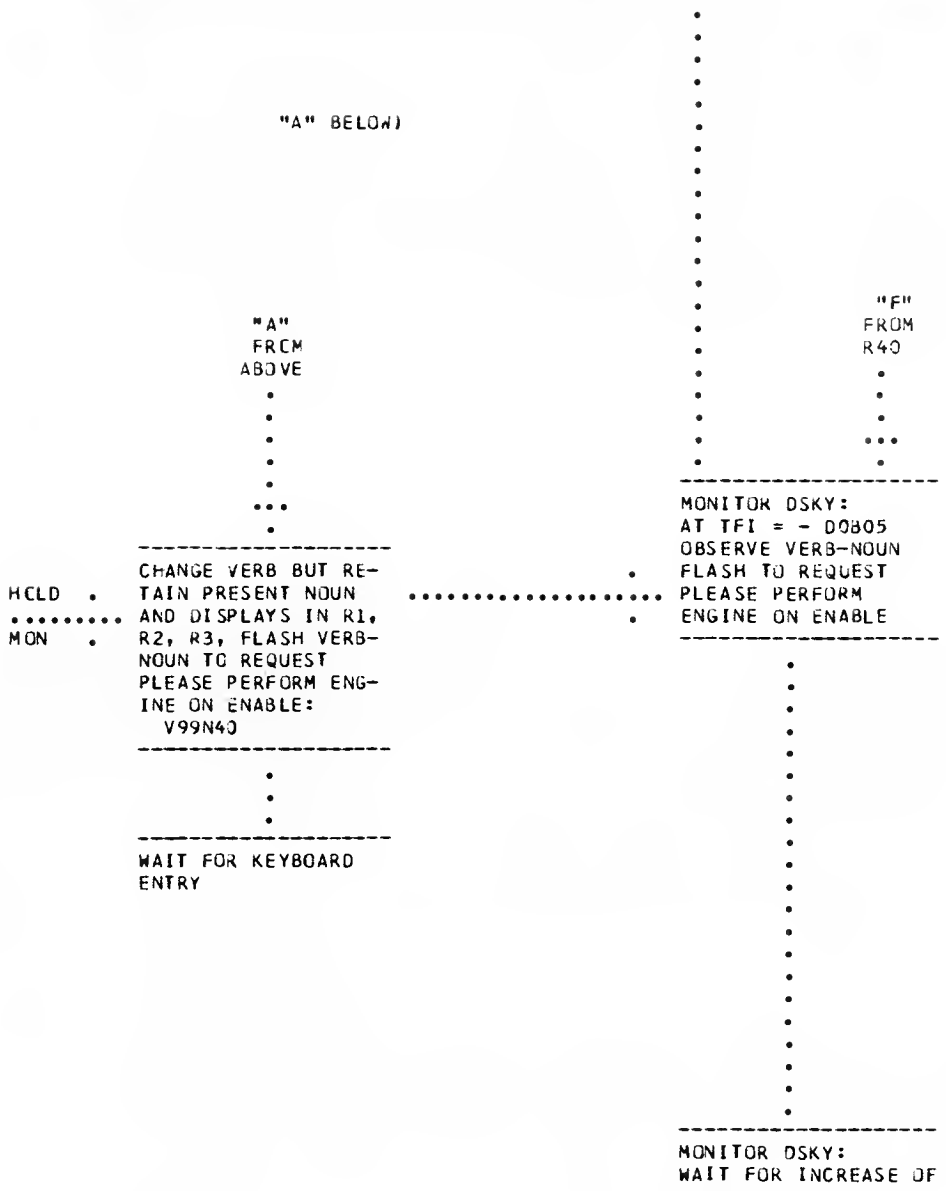
#670

#680

#690

#700

#710



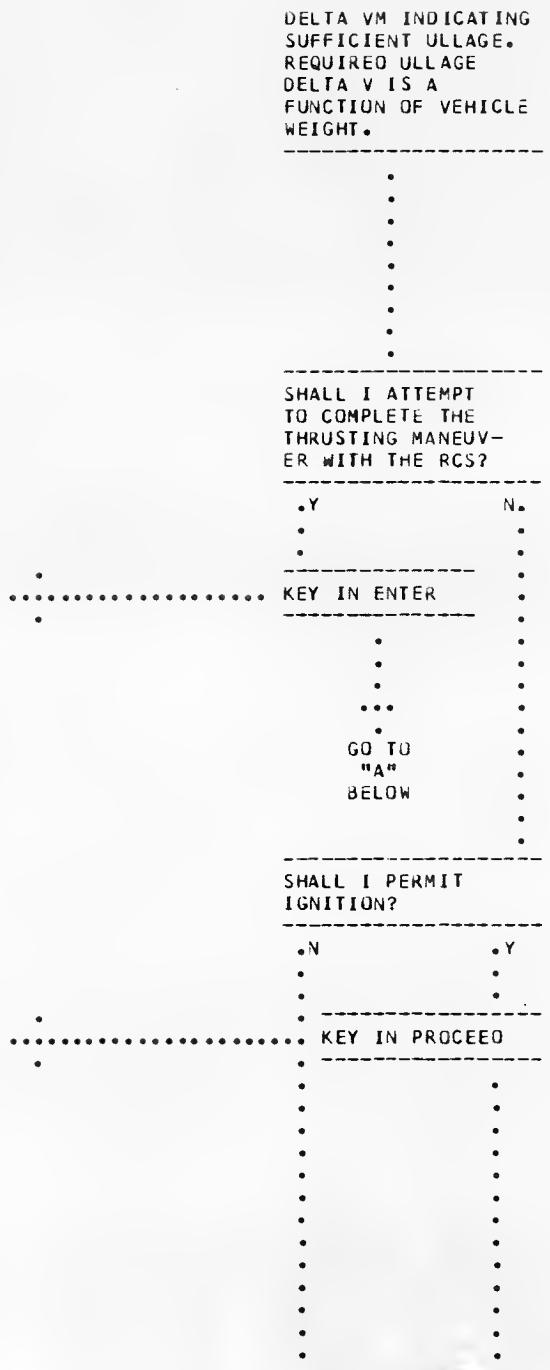
#720

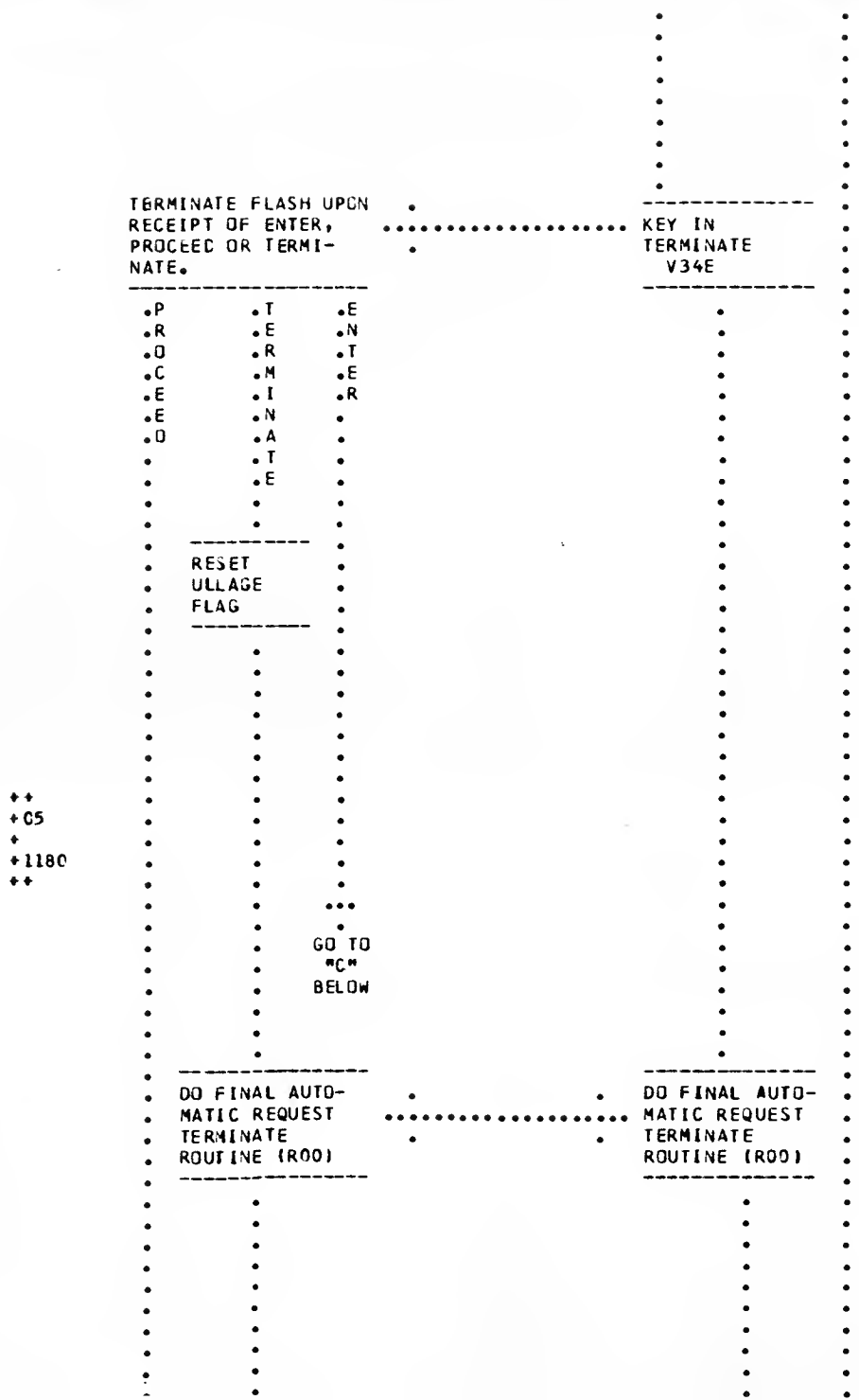
#730

#740

#750

#760


DELTA VM INDICATING SUFFICIENT ULLAGE. REQUIRED ULLAGE DELTA V IS A FUNCTION OF VEHICLE WEIGHT.
#770
SHALL I ATTEMPT TO COMPLETE THE THRUSTING MANEUV- ER WITH THE RCS?
#780
Y
N
KEY IN ENTER
#790
GO TO "A" BELOW
SHALL I PERMIT IGNITION?
#800
N
Y
KEY IN PROCEED
#810



#820

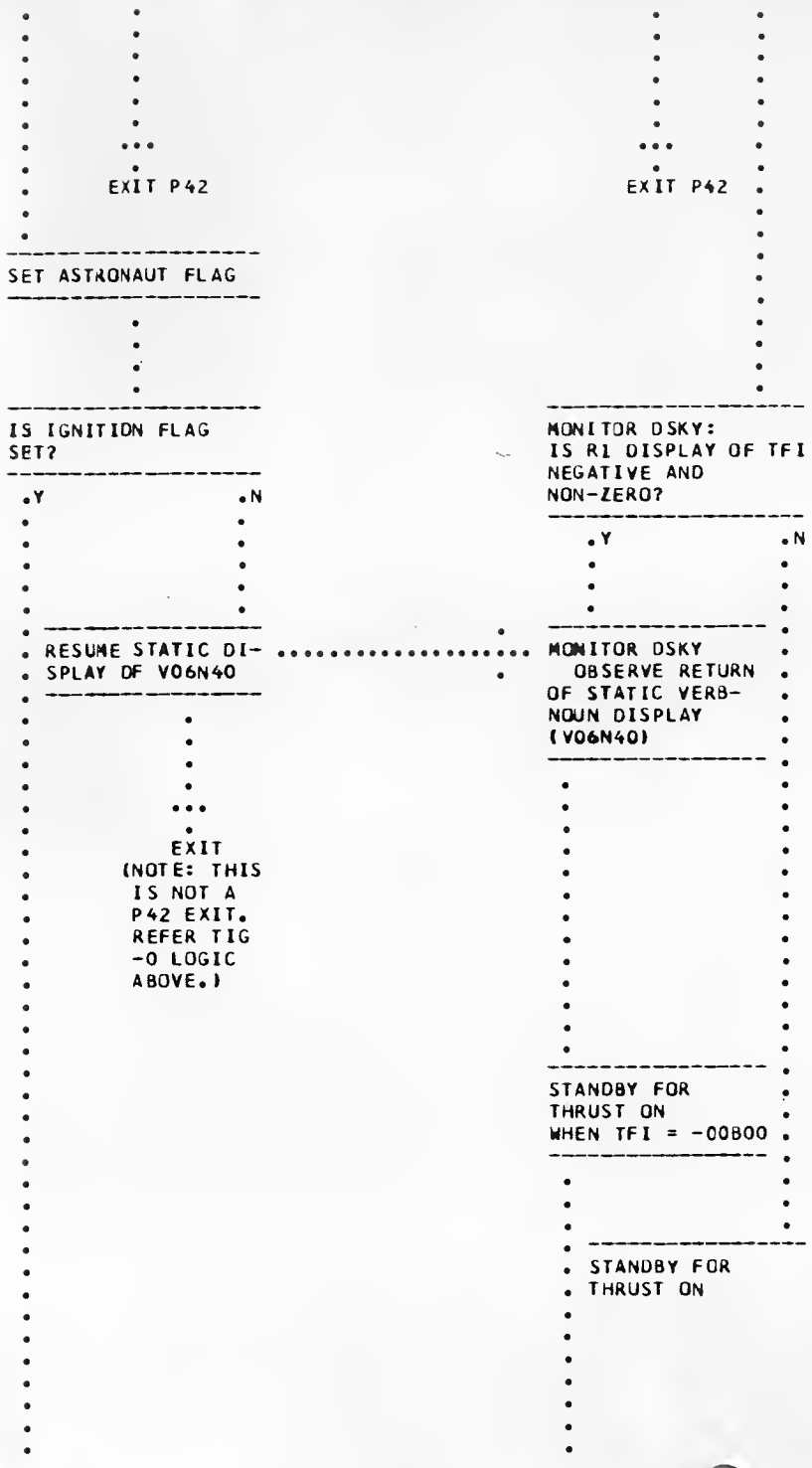
#830

#840

++
+05
+
+1180
++

#850

#860



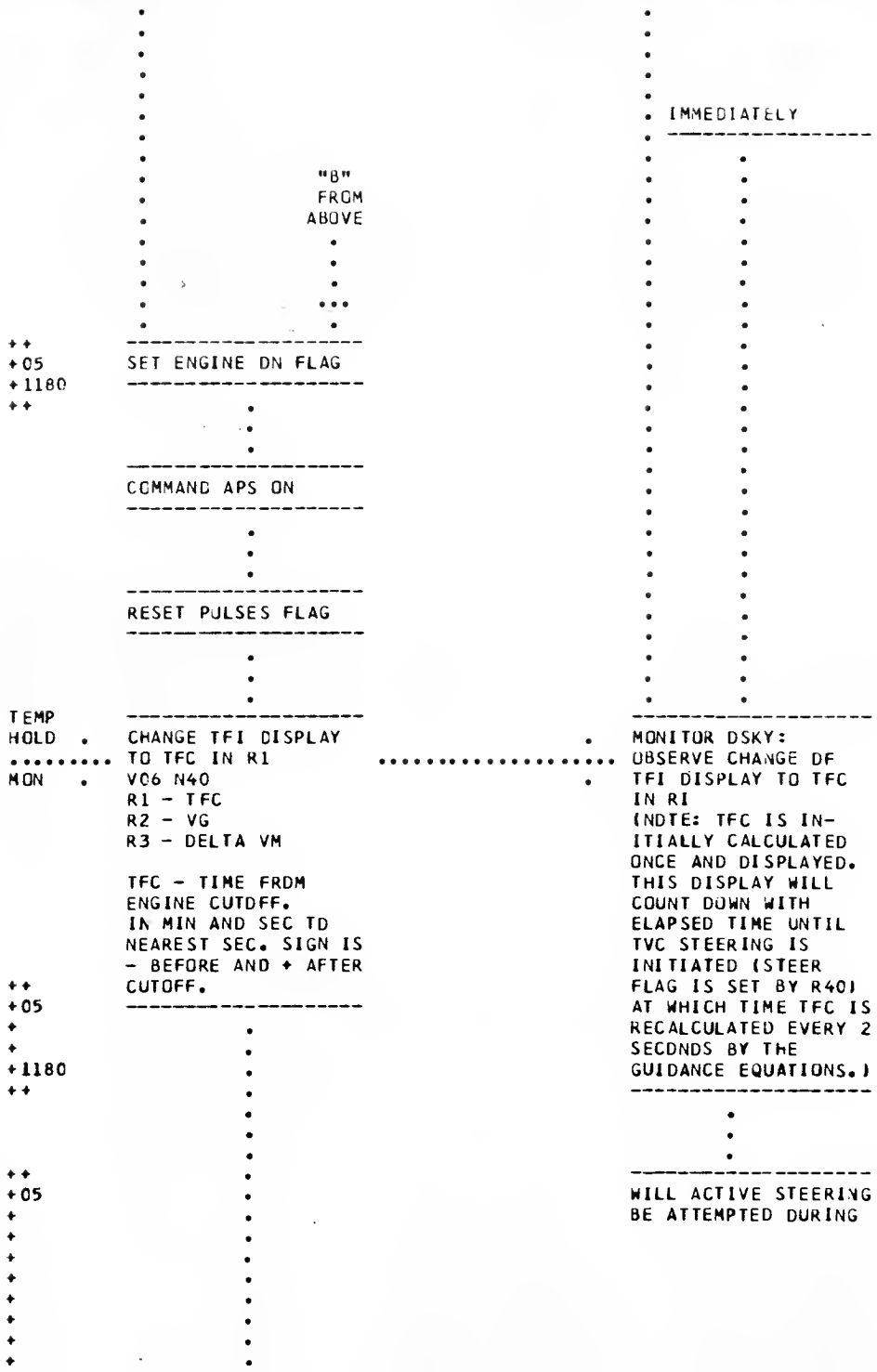
#870

#880

#890

#900

#910



#920

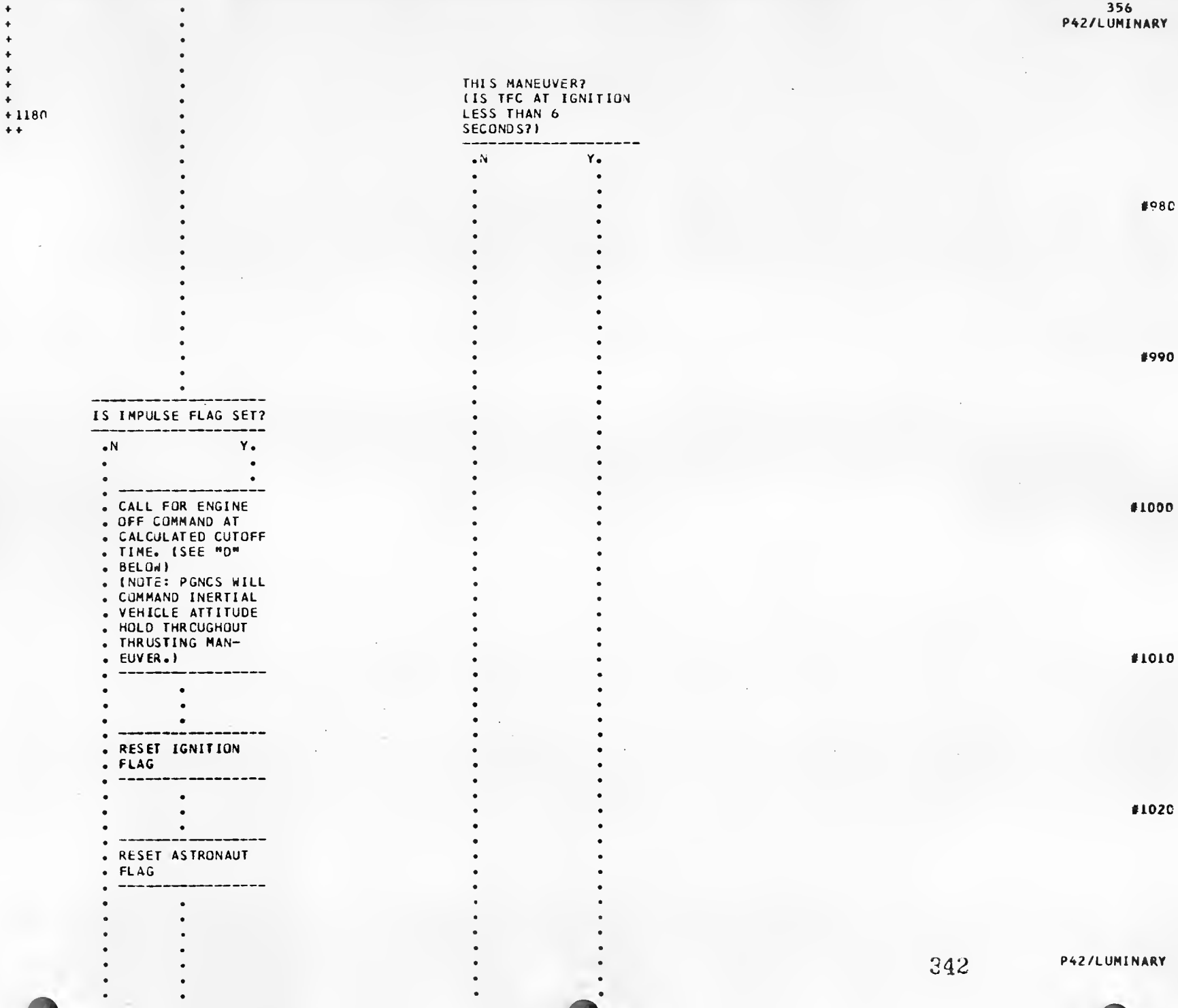
#930

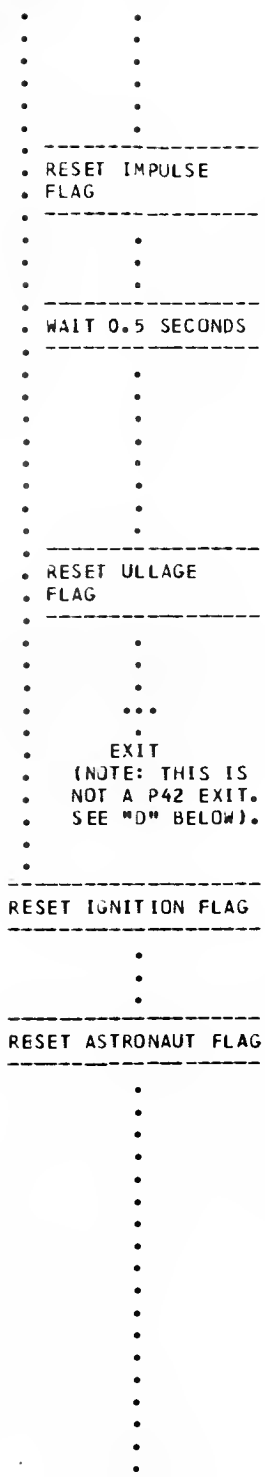
#940

#950

#960

#970


+1180
++
IS IMPULSE FLAG SET?
.N
Y.
CALL FOR ENGINE OFF COMMAND AT CALCULATED CUTOFF TIME. (SEE "D" BELOW) (NOTE: PGNCS WILL COMMAND INERTIAL VEHICLE ATTITUDE HOLD THRCUGHOUT THRUSTING MAN-EUVER.)
RESET IGNITION FLAG
RESET ASTRONAUT FLAG
THIS MANEUVER? (IS TFC AT IGNITION LESS THAN 6 SECONDS?)
.N
Y.
#980
#990
#1000
#1010
#1020



#1030

#1040

#1050

#1060

#1070

RESET IDLE FLAG

CALL FCR RESET OF ULLAGE FLAG IN 0.5 SEC.

THIS BURN IS A MINIMUM IMPULSE MANEUVER AND WILL BE DONE AT AN INERTIALLY FIXED VEHICLE ATTITUDE

MONITOR APS THRUSTING:
1. DSKY:
   R1-TFC SHOULD BE DECREASING.

   R2-VG SHOULD BE DECREASING.

   R3-DELTA VM SHOULD INCREASE.

2. FDAI-ATT. ERROR SHOULD BE LESS THAN OR EQUAL TO XX DEGREE.

ATT RATES SHOULD BE LESS THAN OR EQUAL TO XX DEGREE/SEC.

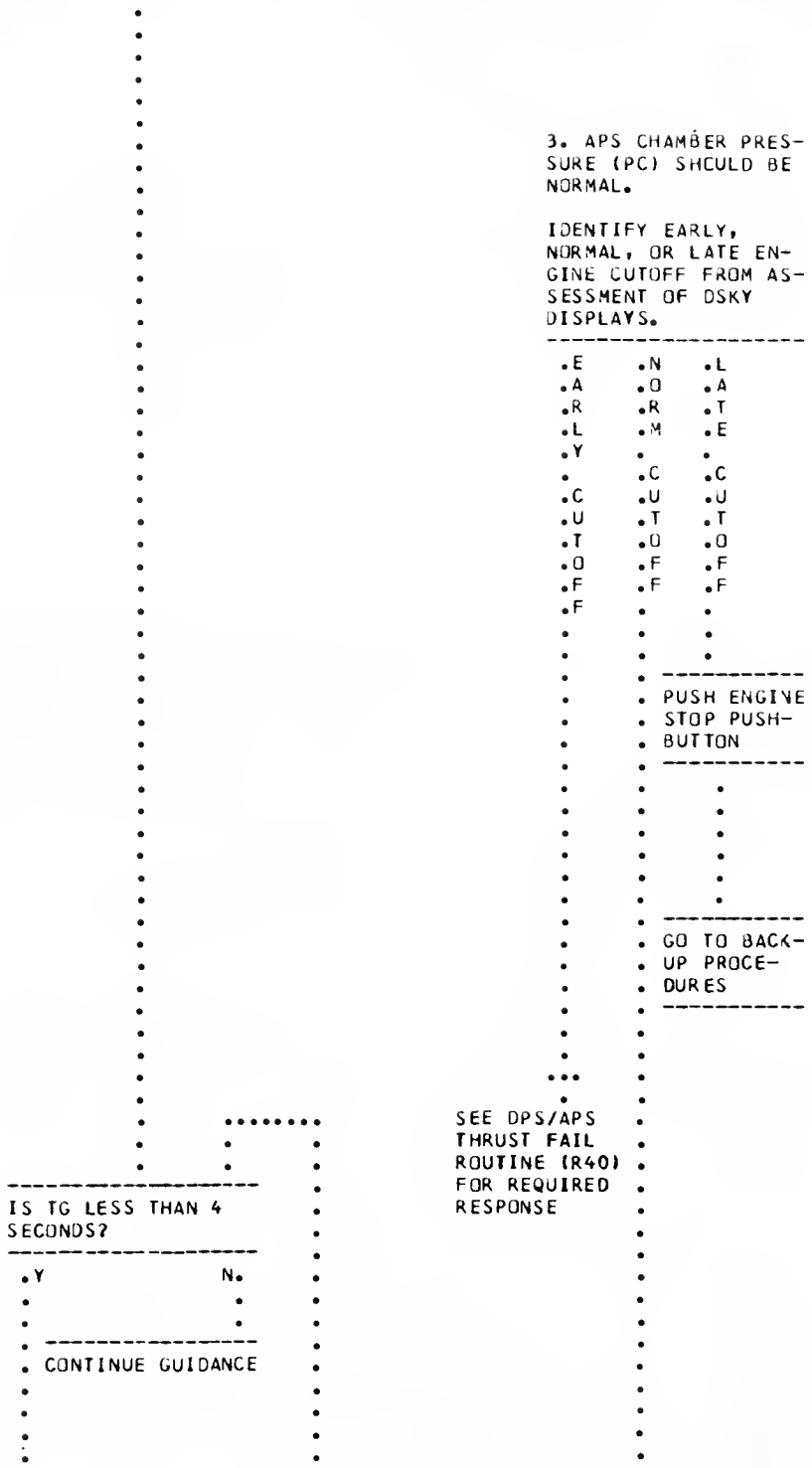
#1080

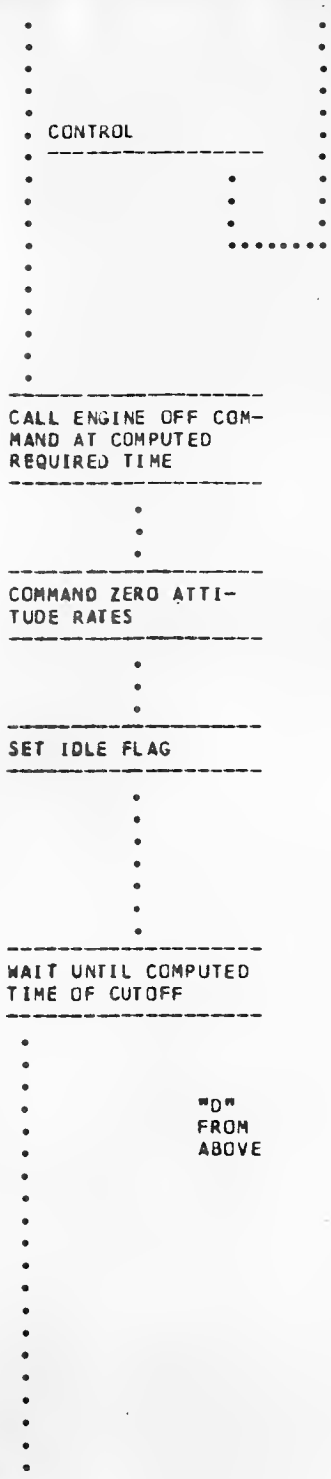
#1090

#1100

#1110

#1120


3. APS CHAMBER PRESSURE (PC) SHOULD BE NORMAL.
IDENTIFY EARLY, NORMAL, OR LATE ENGINE CUTOFF FROM ASSESSMENT OF DSKY DISPLAYS.
#1130
EARLY
NORMAL
LATE
CUTOFF
CUTOFF
CUTOFF
#1140
PUSH ENGINE STOP PUSHBUTTON
#1150
GO TO BACKUP PROCEDURES
#1160
SEE DPS/APS THRUST FAIL ROUTINE (R40) FOR REQUIRED RESPONSE
#1170
IS TG LESS THAN 4 SECONDS?
Y
N
CONTINUE GUIDANCE



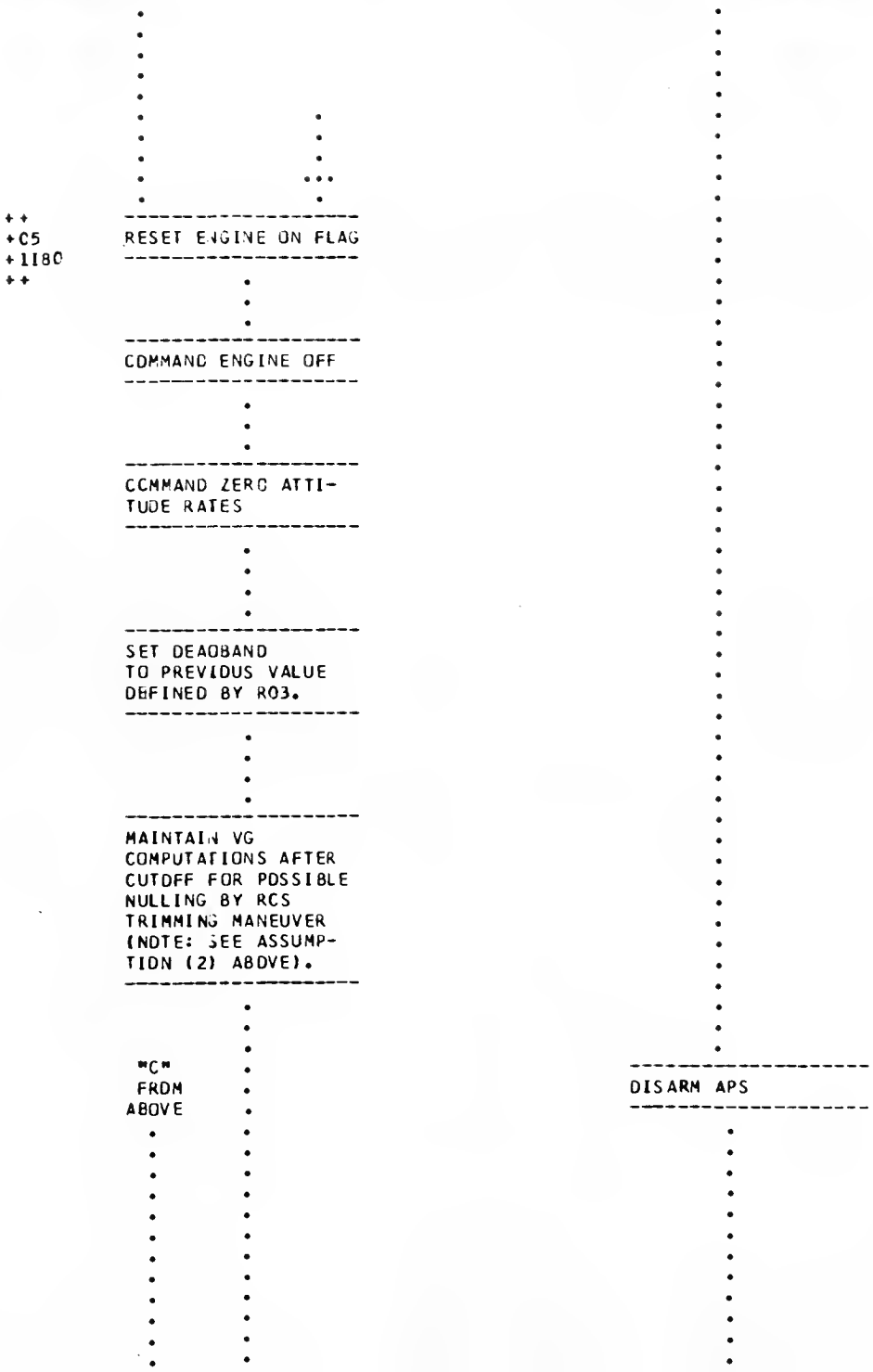
#1180

#1190

#1200

#1210

#1220


++
+C5
+1180
++
RESET ENGINE ON FLAG
COMMAND ENGINE OFF
COMMAND ZERO ATTI-
TUDE RATES
SET DEADBAND
TO PREVIOUS VALUE
DEFINED BY R03.
MAINTAIN VG
COMPUTATIONS AFTER
CUTOFF FOR POSSIBLE
NULLING BY RCS
TRIMMING MANEUVER
(NOTE: SEE ASSUMP-
TION (2) ABOVE).
"C"
FROM
ABOVE
DISARM APS
#1230
#1240
#1250
#1260
#1270

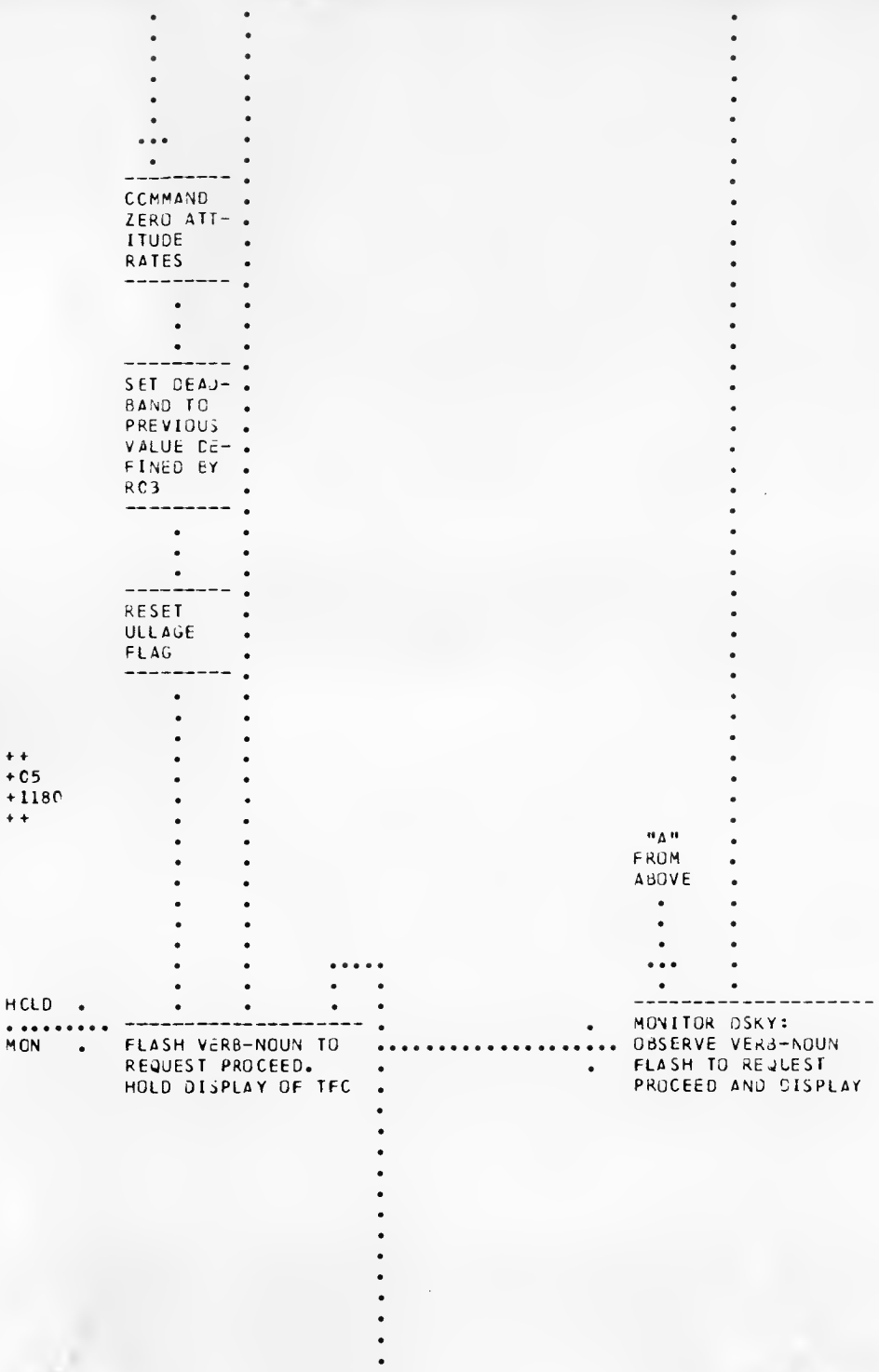
#1280

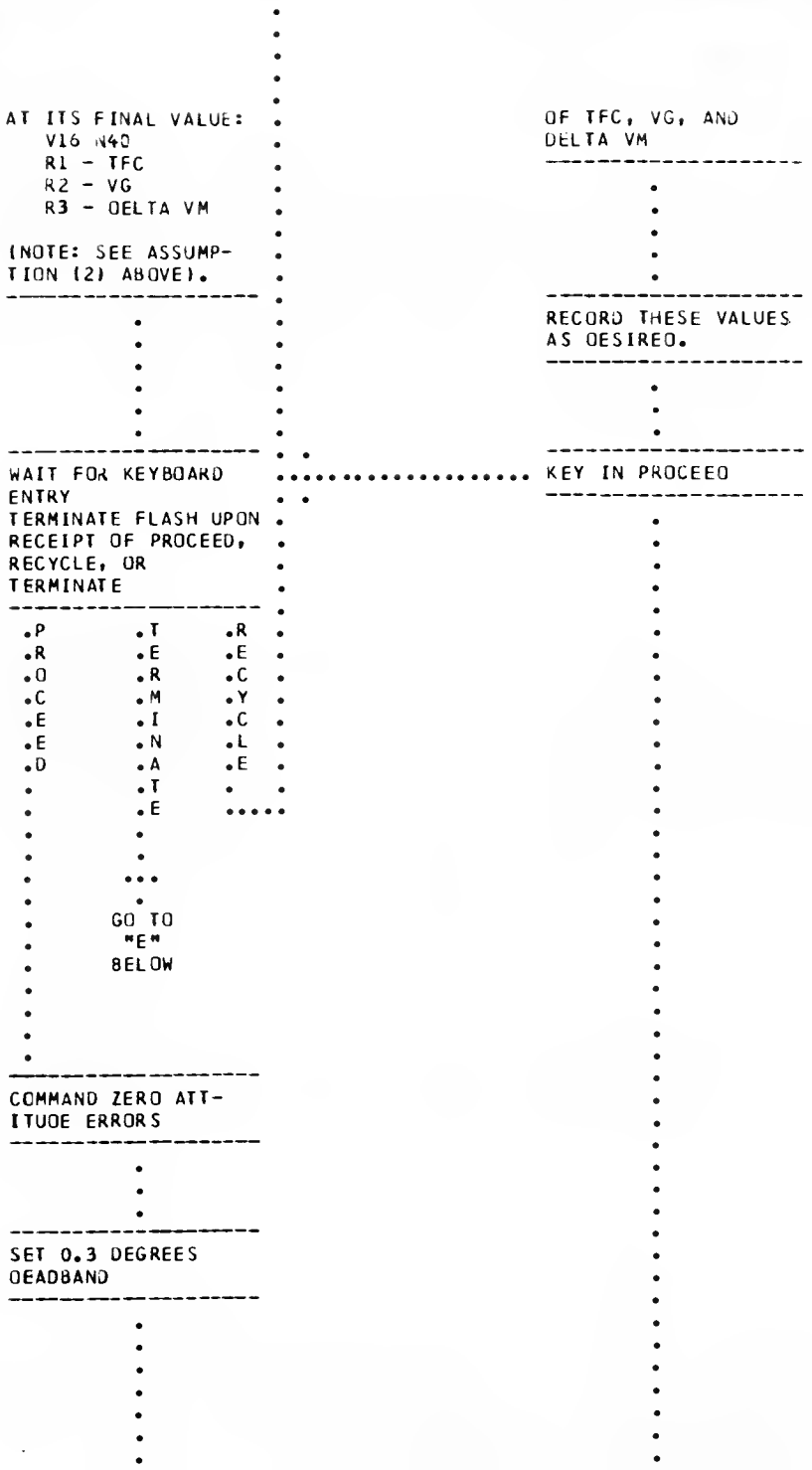
#1290

#1300

#1310

#1320





#1330

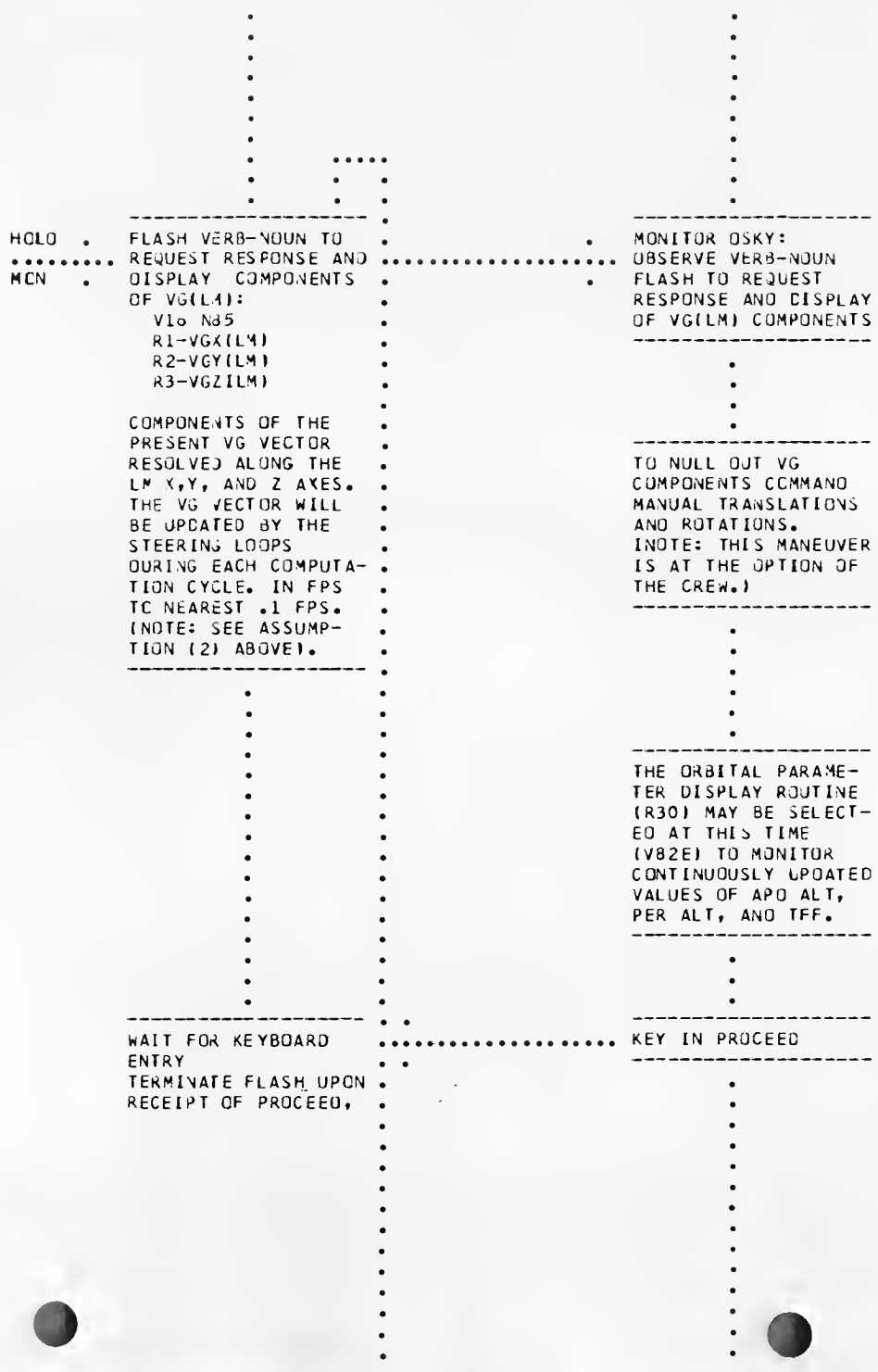
#1340

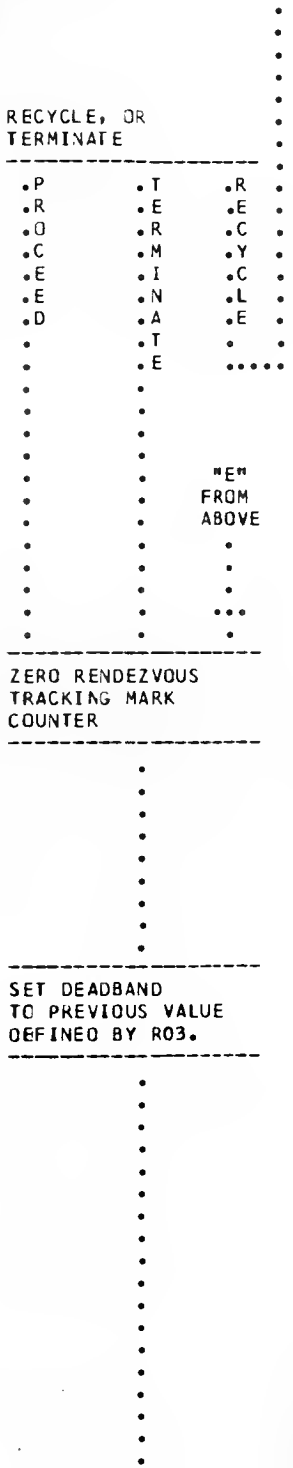
#1350

#1360

#1370

#1380


HOLD
MCN
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY COMPONENTS OF VG(LM):
V16 N85
R1-VGX(LM)
R2-VGY(LM)
R3-VGZ(LM)
COMPONENTS OF THE PRESENT VG VECTOR RESOLVED ALONG THE LM X,Y, AND Z AXES. THE VG VECTOR WILL BE UPDATED BY THE STEERING LOOPS DURING EACH COMPUTATION CYCLE. IN FPS TO NEAREST .1 FPS. (NOTE: SEE ASSUMPTION (2) ABOVE).
WAIT FOR KEYBOARD ENTRY
TERMINATE FLASH UPON RECEIPT OF PROCEED.
MONITOR OSKY: OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY OF VG(LM) COMPONENTS
TO NULL OUT VG COMPONENTS COMMAND MANUAL TRANSLATIONS AND ROTATIONS. (NOTE: THIS MANEUVER IS AT THE OPTION OF THE CREW.)
THE ORBITAL PARAMETER DISPLAY ROUTINE (R30) MAY BE SELECTED AT THIS TIME (V82E) TO MONITOR CONTINUOUSLY UPDATED VALUES OF APO ALT, PER ALT, AND TFF.
KEY IN PROCEED
#1390
#1400
#1410
#1420
#1430



#1440

#1450

#1460

#1470

#1480

#1490

CHANGE CONTROL NOTES

REV 00 PCR 31
REV 01 PCR 85,86,114,144,164,186,401,419,609,637
REV 00(LUM 1A) PCR 647,648
REV 01(LUM 1B) PCR 838,841, EDITORIAL
REV 02 EDITORIAL
REV 03 PCN 1009
REV 04(LUM 1E) PCN 1145
REV 05 PCN 1180

THRUST MONITOR PROGRAM (P47) REV 02 08/07/69

PURPOSE: (1) TO MONITOR VEHICLE ACCELERATION DURING A NON-PGNCS CONTROLLED THRUSTING MANEUVER.

(2) TO DISPLAY THE DELTA V APPLIED TO THE VEHICLE BY THIS THRUSTING MANEUVER.

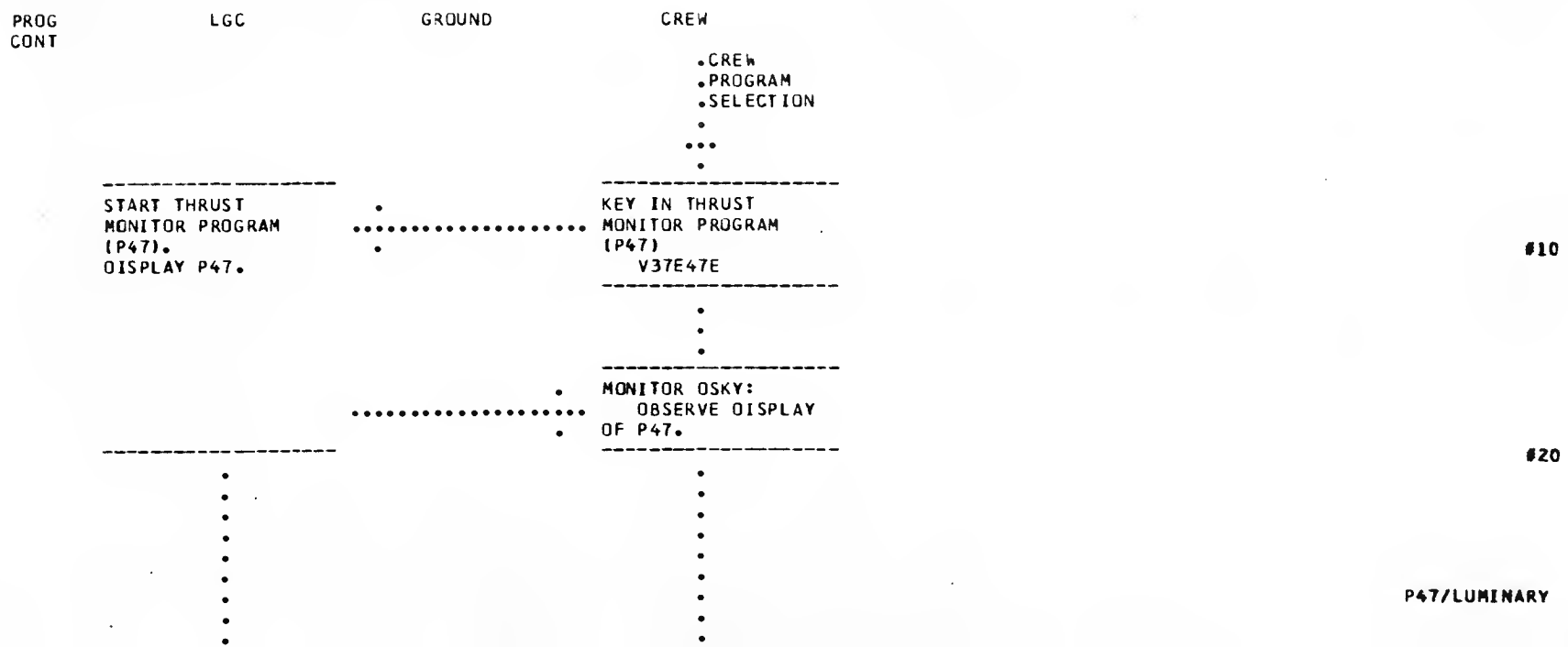
ASSUMPTIONS: (1) THE IMU IS ON AND MUST BE AT A KNOWN ORIENTATION BEFORE THIS PROGRAM MAY BE COMPLETED. IT IS NORMALLY REQUIRED THAT THE ISS BE ON FOR A MINIMUM OF 15 MINUTES PRIOR TO A THRUSTING MANEUVER.

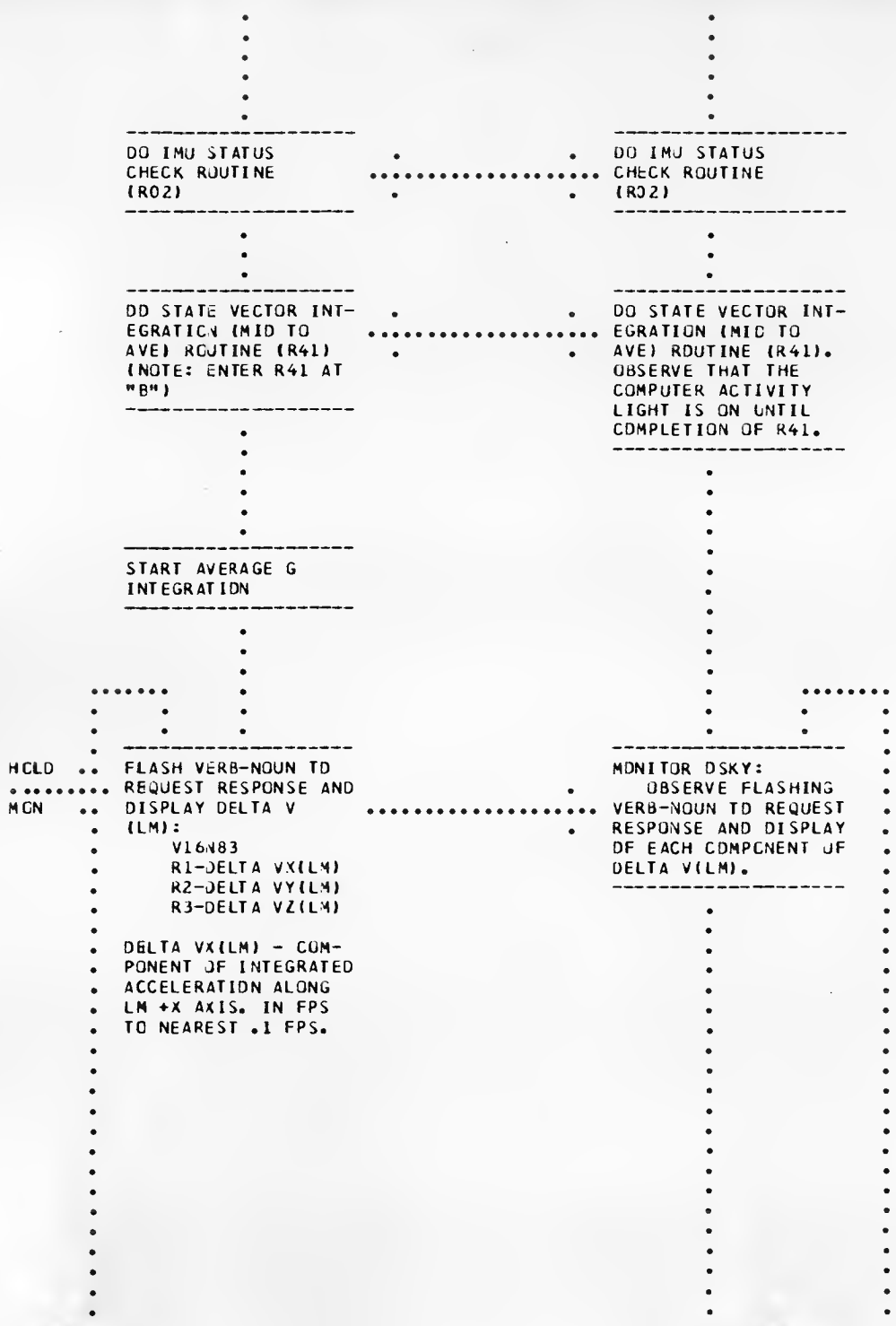
(2) THE RESPONSIBILITY OF AVOIDING GIMBAL LOCK DURING EXECUTION OF THIS PROGRAM IS UPON THE ASTRONAUT.

(3) THIS PROGRAM IS NORMALLY USED DURING RENDEZVOUS FINAL PHASE. IF THE CREW DESIRES TO DO ANY FINAL PHASE THRUSTING MANEUVERS AUTOMATICALLY UNDER PGNCS CONTROL THEY MUST BE ACCOMPLISHED VIA SELECTION OF TRANSFER PHASE INITIATION (TPI) PROGRAM (P34) AND THEN THE DPS THRUSTING PROGRAM (P40) OR THE APS THRUSTING PROGRAM (P42).

(4) RANGE, RANGE RATE, AND THETA MAY BE DISPLAYED DURING THIS PROGRAM BY CALLING THE RENDEZVOUS PARAMETER DISPLAY ROUTINE (R31).

(5) THIS PROGRAM IS SELECTED BY THE ASTRONAUT BY DSKY ENTRY. THE PROGRAM SHOULD BE TURNED ON JUST PRIOR TO THE PLANNED THRUSTING MANEUVER AND TERMINATED AS SOON AS POSSIBLE AFTER THE MANEUVER IN ORDER TO KEEP ERRORS ASSOCIATED WITH AVERAGE G INTEGRATION AT A MINIMUM.



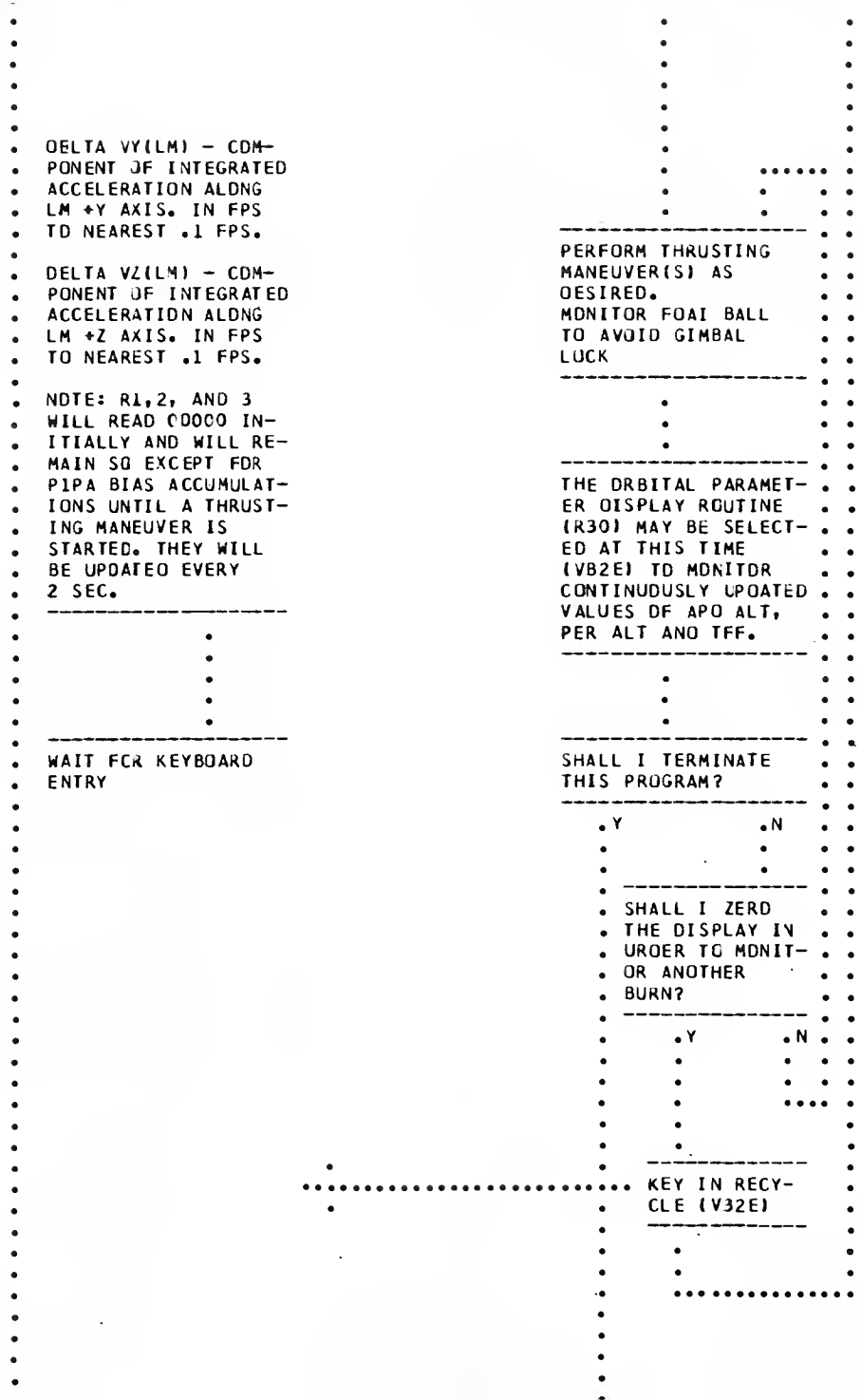

DO IMU STATUS CHECK ROUTINE (R02)
DO STATE VECTOR INTEGRATION (MID TO AVE) ROUTINE (R41) (NOTE: ENTER R41 AT "B")
START AVERAGE G INTEGRATION
HOLD
MON
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY DELTA V (LM):
V16N83
R1-DELTA VX(LM)
R2-DELTA VY(LM)
R3-DELTA VZ(LM)
DELTA VX(LM) - COMPONENT OF INTEGRATED ACCELERATION ALONG LM +X AXIS. IN FPS TO NEAREST .1 FPS.
DO IMU STATUS CHECK ROUTINE (R02)
DO STATE VECTOR INTEGRATION (MID TO AVE) ROUTINE (R41). OBSERVE THAT THE COMPUTER ACTIVITY LIGHT IS ON UNTIL COMPLETION OF R41.
MONITOR DSKY:
OBSERVE FLASHING VERB-NOUN TO REQUEST RESPONSE AND DISPLAY OF EACH COMPONENT OF DELTA V(LM).

#30

#40

#50

#60



#70

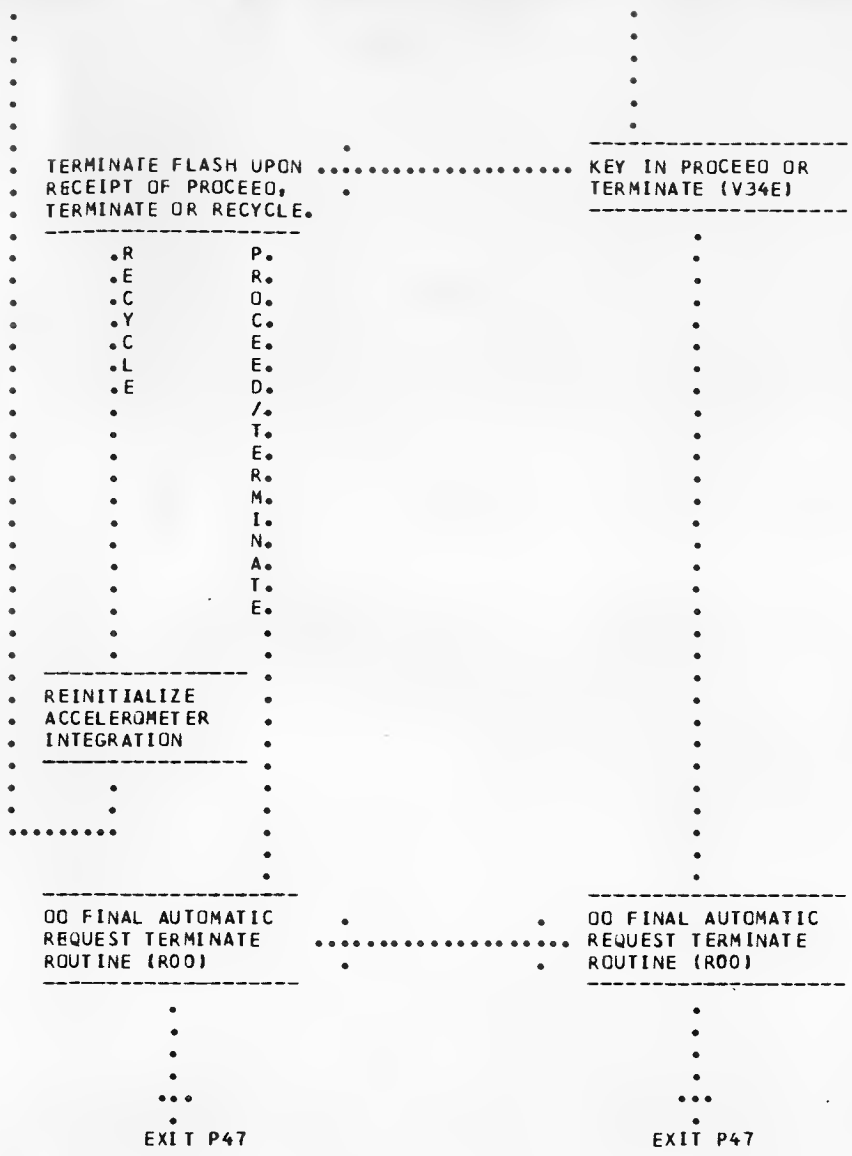
#80

#90

#100

#110

#120



#130

#140

#150

#160

#170

CHANGE CONTROL NOTES

LOGIC REV 01 PCR 401,437
      REV 02 EDITORIAL

IMU ORIENTATION DETERMINATION PROGRAM (P51) REV 02 08/07/69

PURPOSE: (1) TO DETERMINE THE INERTIAL ORIENTATION OF THE IMU USING SIGHTINGS ON TWO CELESTIAL BODIES WITH THE AOT OR A BACKUP OPTICAL SYSTEM.

ASSUMPTIONS: (1) THIS PROGRAM MAY ONLY BE PERFORMED WHILE THE LM IS IN FLIGHT.

(2) THE ISS MAY BE:

(A) OFF (STANDBY)

(B) ON, AND ALIGNED OR NOT ALIGNED SINCE TURN ON.

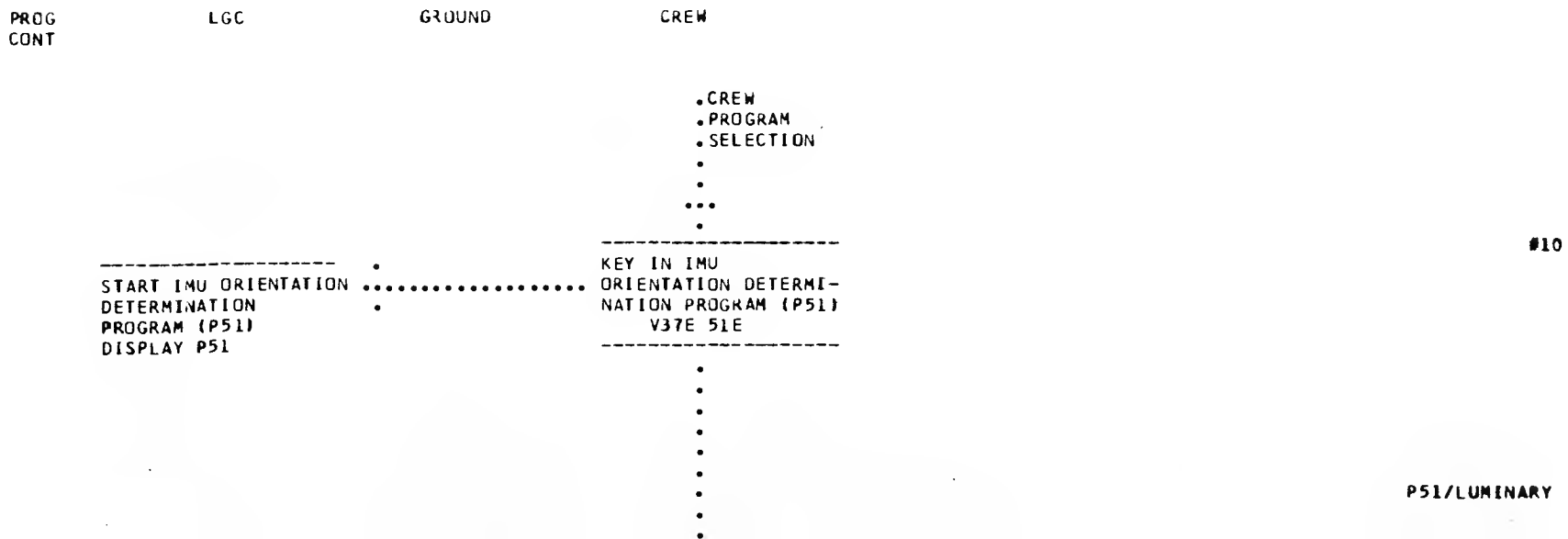
IF (A) IS TRUE, THE IMU MUST BE TURNED ON BEFORE THIS PROGRAM CAN BE PERFORMED.
IF (B) IS TRUE THIS PROGRAM CAN BE COMPLETED.

(3) THERE ARE NO RESTRAINTS UPON THE LM ATTITUDE CONTROL MODES UNTIL THE CREW WISHES TO MANUALLY MANEUVER THE VEHICLE.

(4) TIME AND RCS FUEL MAY BE SAVED, AND SUBSEQUENT IMU ALIGNMENT DECISIONS GREATLY SIMPLIFIED IF THIS PROGRAM IS PERFORMED IN SUCH A WAY AS TO LEAVE THE IMU INERTIALLY STABILIZED AT AN ORIENTATION AS CLOSE AS POSSIBLE TO THE OPTIMUM ORIENTATION REQUIRED BY FUTURE LGC PROGRAMS.

(5) EXTENDED VERBS SHOULD NOT BE EXERCISED DURING THIS PROGRAM BECAUSE OF POSSIBLE INTERFERENCE WITH R53.

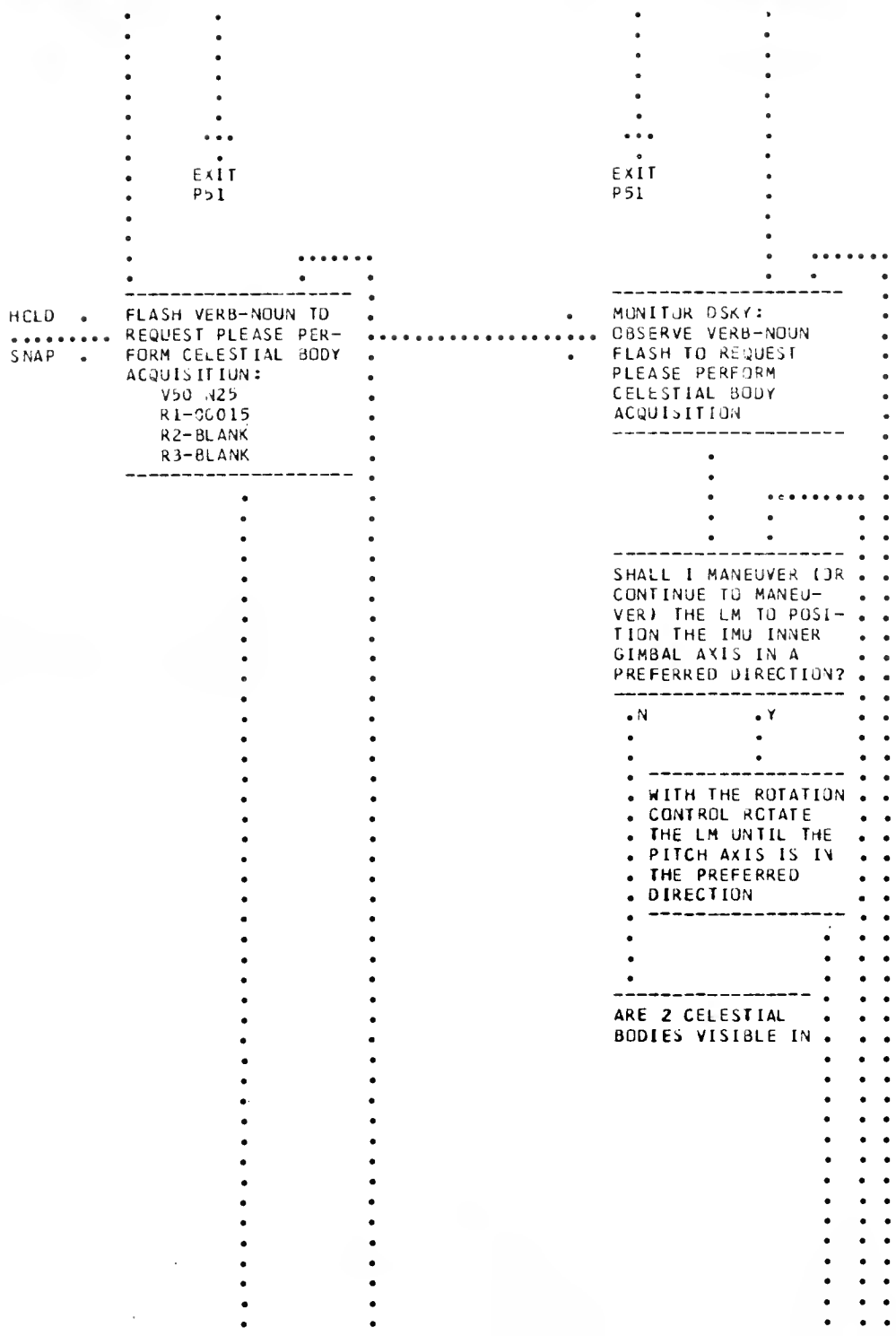
(6) THE PROGRAM IS SELECTED BY THE ASTRONAUT BY DSKY ENTRY.



#10

P51/LUMINARY


MONITOR DSKY:
OBSERVE DISPLAY OF
P51
#20
IS THE ISS ON?
.Y
.N
#30
SET IMUSE FLAG
TURN ON PROGRAM
ALARM LIGHT AND
STORE ALARM CODE.
(NOTE: IF CALLED,
ALARM CODE WILL
BE 00210.)
MONITOR DSKY:
DOES PROGRAM ALARM
LIGHT COME ON INDIC-
ATING THAT THE IMU
IS NOT ON?
#40
.Y
.N
TURN ON IMU
AND RESELECT
P51 VIA R00
#50
DO FINAL AUTOMATIC
REQUEST TERMINATE
ROUTINE (R00).
DO FINAL
AUTOMATIC
REQUEST TER-
MINATE ROU-
TINE (R00).
#60



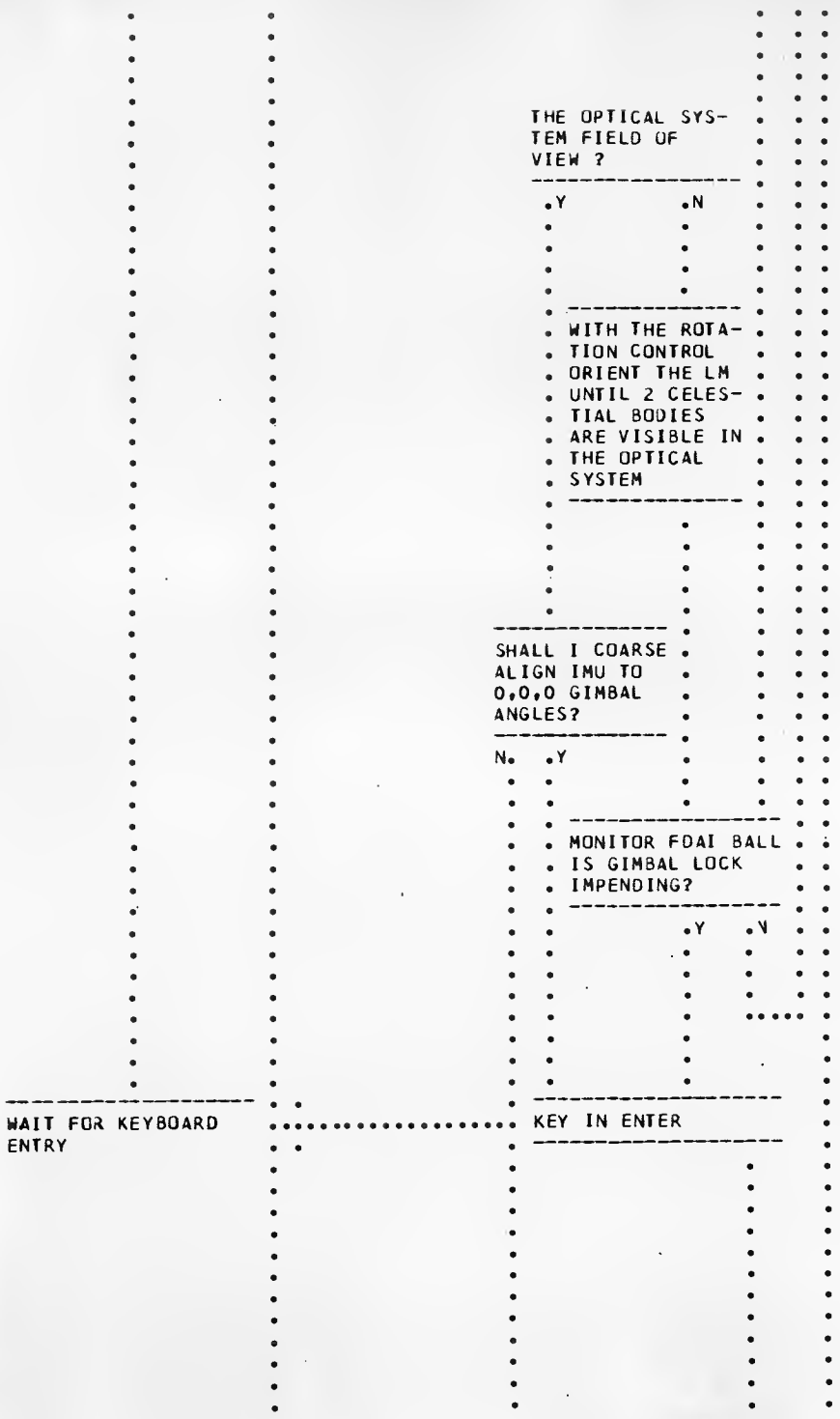
#70

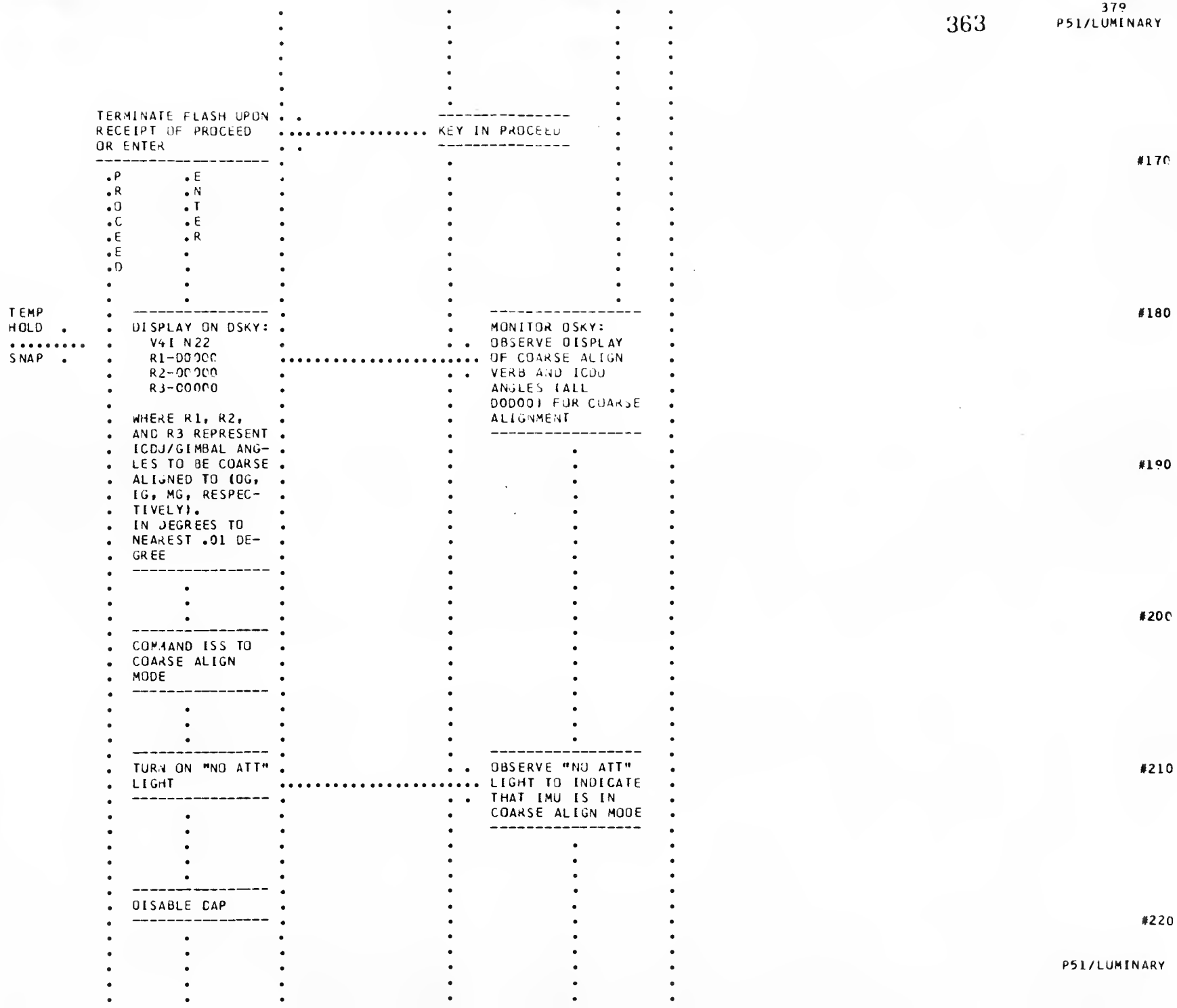
#80

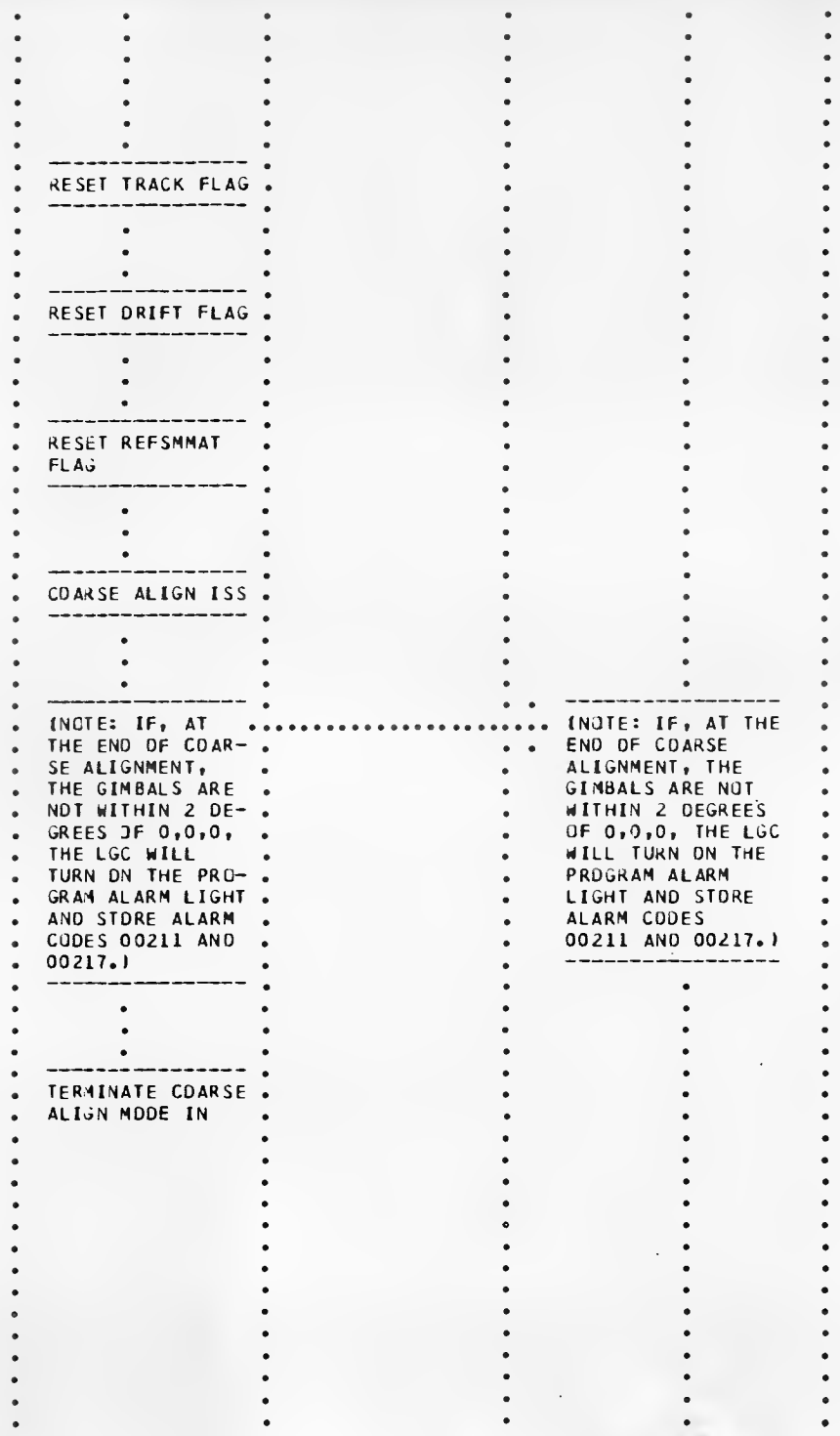
#90

#100

#110


THE OPTICAL SYS-
TEM FIELD OF
VIEW ?
.Y
.N
#120
WITH THE ROTA-
TION CONTROL
ORIENT THE LM
UNTIL 2 CELES-
TIAL BODIES
ARE VISIBLE IN
THE OPTICAL
SYSTEM
#130
SHALL I COARSE
ALIGN IMU TO
0,0,0 GIMBAL
ANGLES?
#140
N.
.Y
MONITOR FDAI BALL
IS GIMBAL LOCK
IMPENDING?
#150
.Y
.N
#160
WAIT FOR KEYBOARD
ENTRY
KEY IN ENTER


TERMINATE FLASH UPON RECEIPT OF PROCEED OR ENTER
KEY IN PROCEED
PROCEED
ENTER
#170
TEMP HOLD SNAP
DISPLAY ON DSKY:
V41 N22
R1-00000
R2-00000
R3-00000
WHERE R1, R2, AND R3 REPRESENT ICDU/GIMBAL ANGLES TO BE COARSE ALIGNED TO (OG, IG, MG, RESPECTIVELY).
IN DEGREES TO NEAREST .01 DEGREE
MONITOR DSKY:
OBSERVE DISPLAY OF COARSE ALIGN VERB AND ICDU ANGLES (ALL 00000) FOR COARSE ALIGNMENT
#180
#190
COMMAND ISS TO COARSE ALIGN MODE
#200
TURN ON "NO ATT" LIGHT
OBSERVE "NO ATT" LIGHT TO INDICATE THAT IMU IS IN COARSE ALIGN MODE
#210
DISABLE CAP
#220

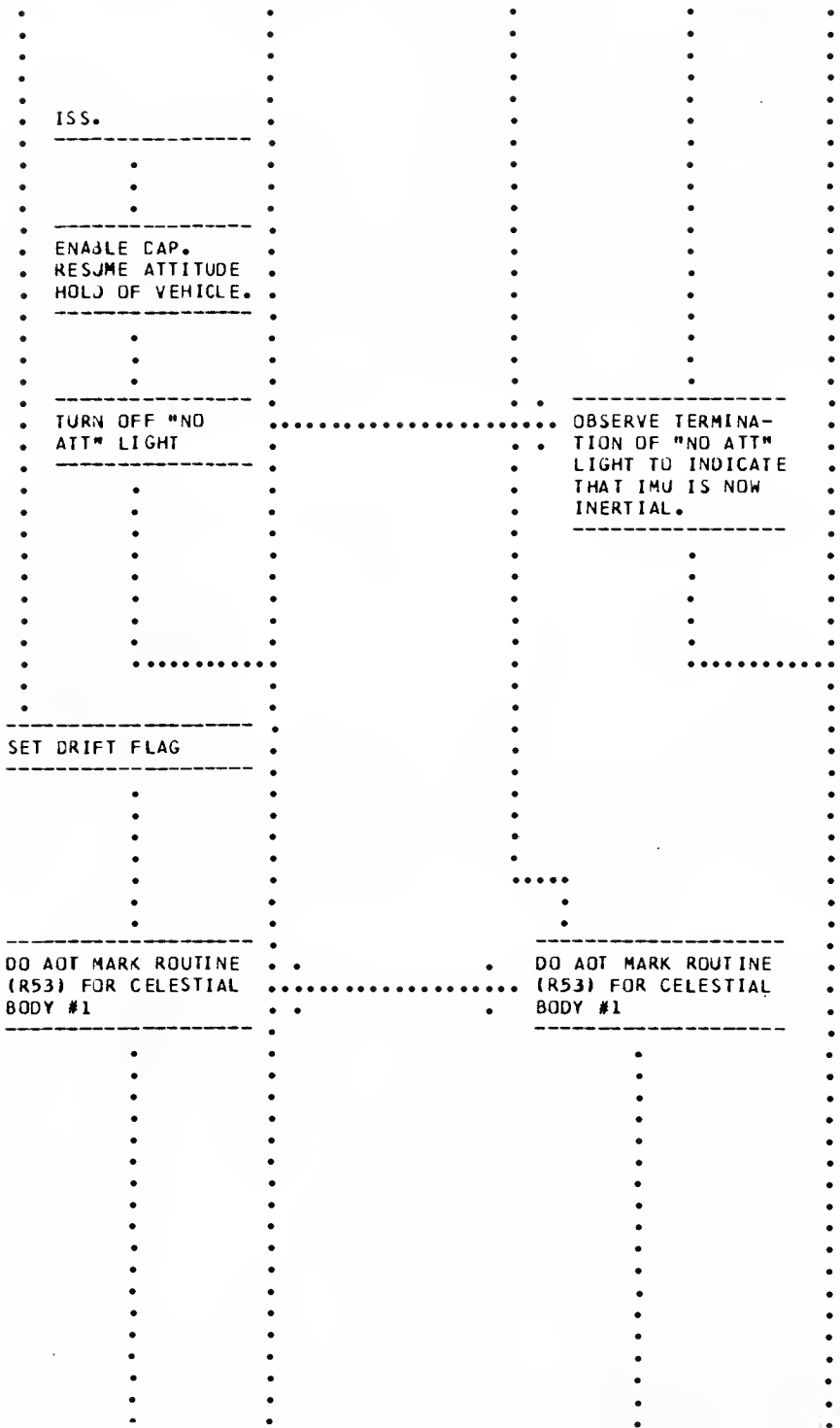


#230

#240

#250

#260



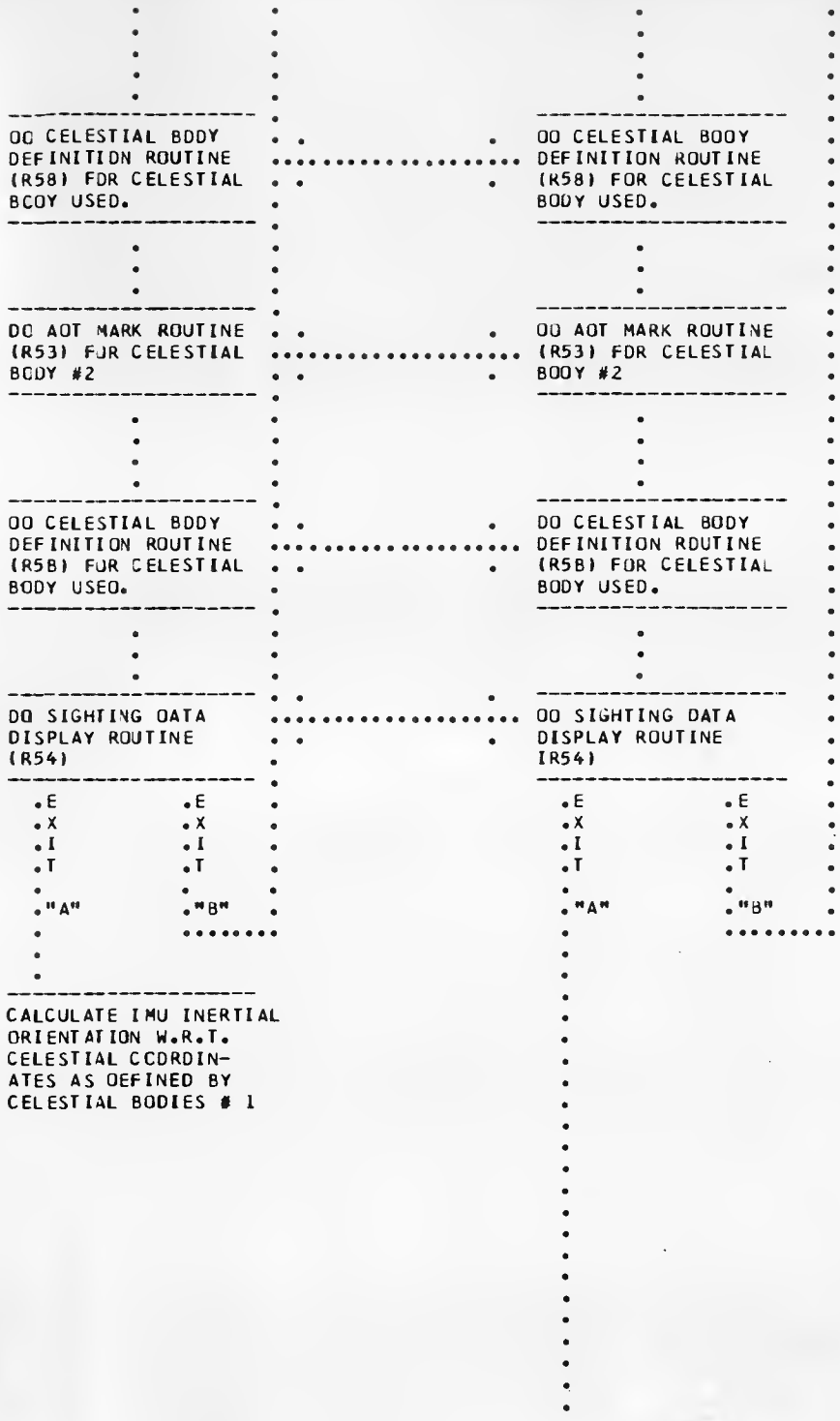
#270

#280

#290

#300

#310



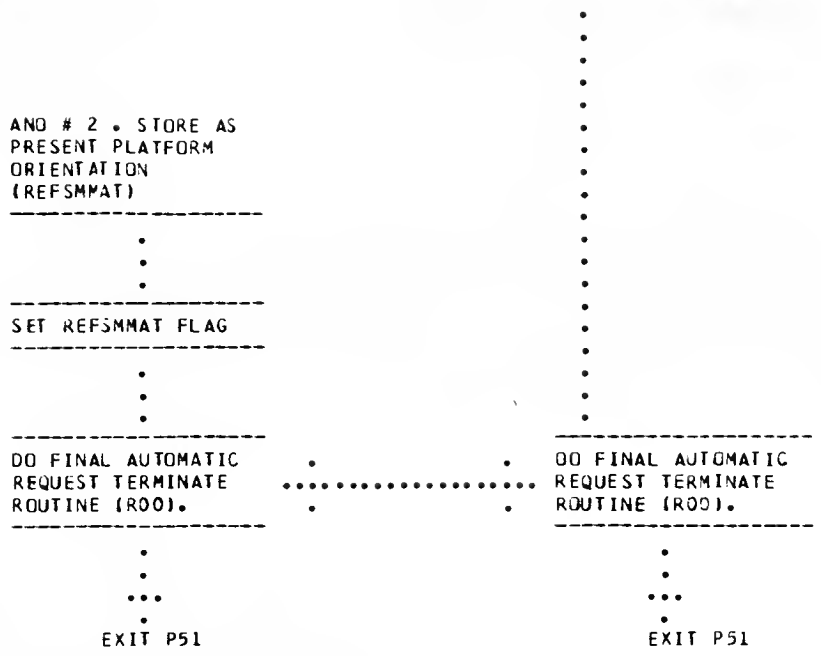
#320

#330

#340

#350

#360



#370

#380

CHANGE CONTROL NOTES

LOGIC REV 00 PCR 7
REV 01 EDITORIAL
REV 02 EDITORIAL

IMU REALIGN PROGRAM (P52) REV 03 09/03/70

PURPOSE: (1) TO ALIGN THE IMU FROM A "KNOWN" (SEE ASSUMPTION 5) ORIENTATION TO ONE OF FOUR ORIENTATIONS SELECTED BY THE ASTRONAUT USING SIGHTINGS ON TWO CELESTIAL BODIES WITH THE AOT OR A BACKUP OPTICAL SYSTEM.

(A) PREFERRED ORIENTATION (OPTION 00001)

AN OPTIMUM ORIENTATION FOR A PREVIOUSLY CALCULATED MANEUVER. THIS ORIENTATION MUST BE CALCULATED AND STORED BY A PREVIOUSLY SELECTED PROGRAM.

(B) LANDING SITE ORIENTATION (OPTION 00004)

$$X_{-SM} = UNIT(R_{-LS})$$

$$Y_{-SM} = UNIT(Z_{-SM} \times X_{-SM})$$

$$Z_{-SM} = UNIT(H_{-CSM} \times X_{-SM})$$

WHERE:

THE ORIGIN IS THE CENTER OF THE MOON.

R_{-LS} = THE POSITION VECTOR OF THE LM ON THE LUNAR SURFACE AT A LANDING SITE AND A TIME T(ALIGN) SELECTED BY THE CREW.

H_{-CSM} = THE ANGULAR MOMENTUM VECTOR OF THE CSM ($R_{-CSM} \times V_{-CSM}$).

A SPECIAL CASE OF THE LANDING SITE ORIENTATION OCCURS WHEN T(ALIGN) IS DEFINED AS THE TIME OF LUNAR LANDING T(LAND). THIS CASE OCCURS ONLY IF T(LAND) HAS BEEN DEFINED BY THE MSFN, TRANSMITTED TO THE CREW, AND THE CREW HAS THEN DEFINED T(ALIGN) TO BE T(LAND) IN THIS PROGRAM.

(C) NOMINAL ORIENTATION (OPTION 00002)

$$X_{-SM} = UNIT(R)$$

$$Y_{-SM} = UNIT(V \times R)$$

$$Z_{-SM} = UNIT(X_{-SM} \times Y_{-SM})$$

WHERE:

R = THE GEOCENTRIC (EARTH ORBIT) OR SELENOCENTRIC (LUNAR ORBIT) RADIUS VECTOR AT TIME T(ALIGN) SELECTED BY THE ASTRONAUT.

V = THE INERTIAL VELOCITY VECTOR AT TIME TIALIGN) SELECTED BY THE ASTRONAUT.

(D) REFSMMAT (OPTION 00003)

SEE ASSUMPTION (5)

ASSUMPTIONS: (1) THIS PROGRAM MAY ONLY BE PERFORMED WHILE THE LM IS IN FLIGHT.

(2) THE CONFIGURATION MAY BE DOCKED (LM/CSM) OR UNDOCKED (LM ALONE). THE PRESENT CONFIGURATION SHOULD HAVE BEEN ENTERED INTO THE LGC BY COMPLETION OF THE DAP DATA LOAD ROUTINE (R03).

(3) THERE ARE NO RESTRAINTS UPON THE LM ATTITUDE CONTROL MODES UNTIL A PGNCS CONTROLLED MANEUVER IS CALLED BY A PROGRAM OR THE CREW WISHES TO MANUALLY MANEUVER THE VEHICLE. THE GUIDANCE CONTROL SWITCH MAY BE AT PGNS OR AGS AND IF AT PGNS, THE MODE MAY BE AUTO OR ATTITUDE HOLD. PRIOR TO PGNCS CONTROLLED MANEUVERS THE LGC WILL REQUEST THE CORRECT MODE IF IT IS NOT IN EFFECT. FOR MANUALLY CONTROLLED MANEUVERS THE CREW MUST SELECT THE CORRECT MODES.

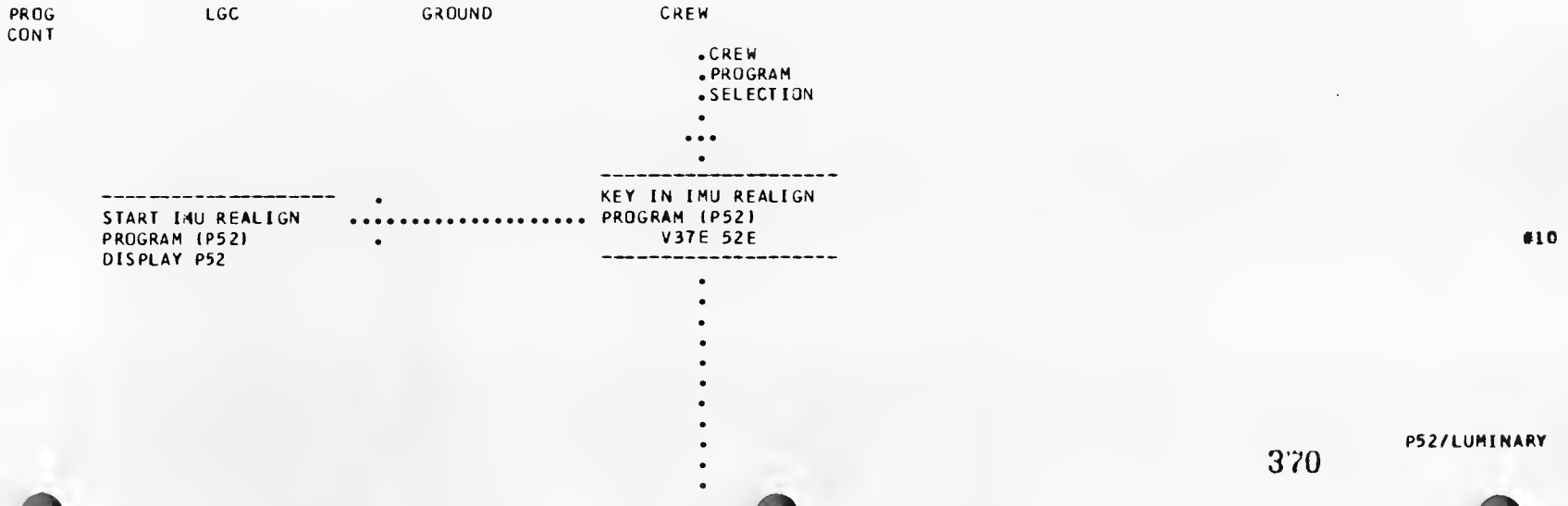
(4) THIS PROGRAM MAKES NO PROVISION FOR AN ATTITUDE MANEUVER TO RETURN THE VEHICLE TO A SPECIFIC ATTITUDE. SUCH A MANEUVER, IF DESIRED, MUST BE DONE MANUALLY. AN OPTION IS PROVIDED HOWEVER TO ALLOW POINTING OF THE AOT AT ASTRONAUT OR LGC SELECTED STARS EITHER MANUALLY BY THE CREW OR AUTOMATICALLY BY AN LGC CONTROLLED ATTITUDE MANEUVER.

(5) THE ISS IS ON AND HAS BEEN ALIGNED TO A "KNOWN" ORIENTATION WHICH IS STORED IN THE LGC (REFSMMAT). THE PRESENT IMU ORIENTATION DIFFERS FROM THAT TO WHICH IT WAS LAST ALIGNED ONLY DUE TO GYRO DRIFT (I.E. NEITHER GIMBAL LOCK NOR IMU POWER INTERRUPTION HAS OCCURRED SINCE THE LAST ALIGNMENT).

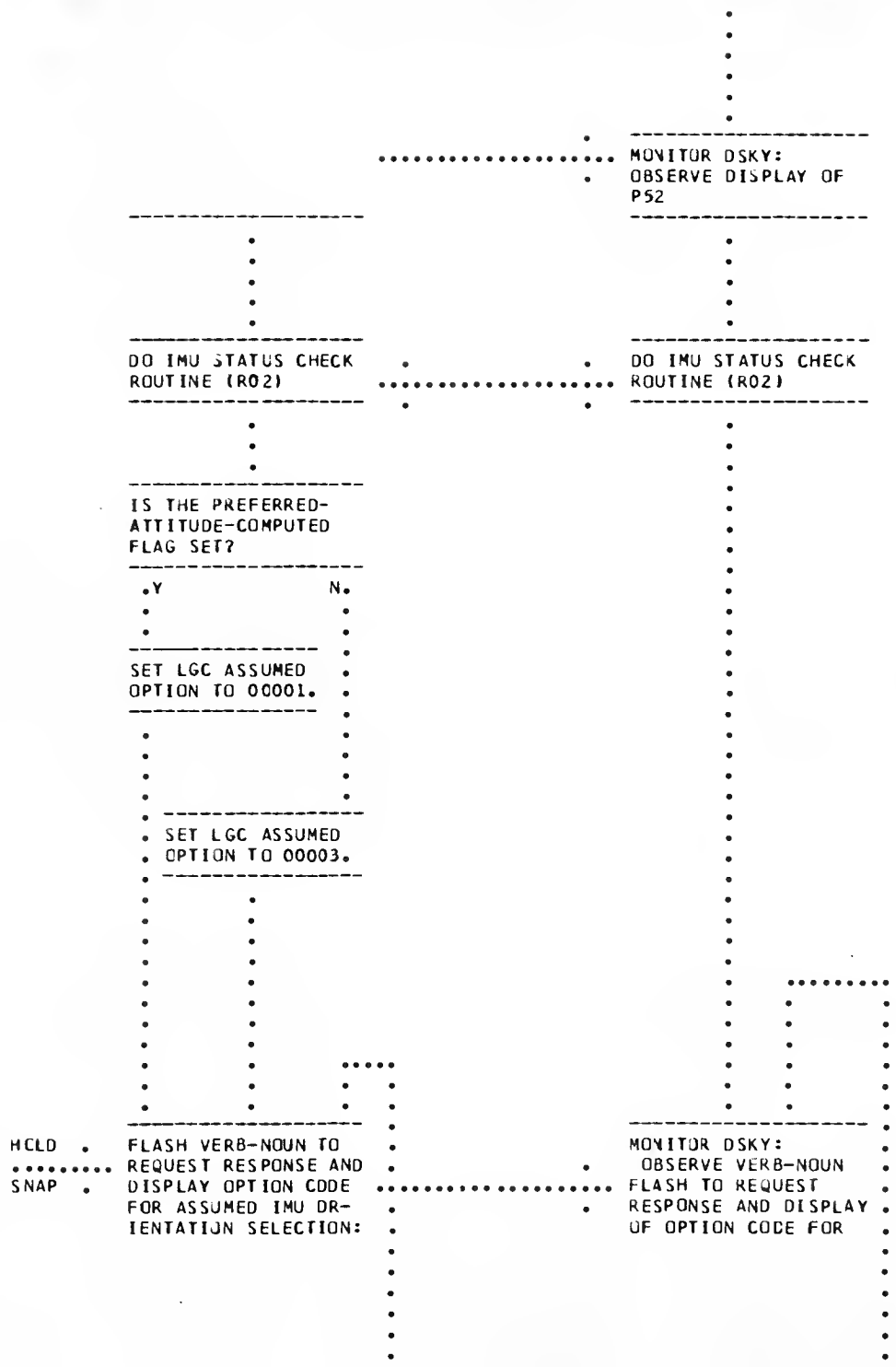
(6) AN OPTION IS PROVIDED TO REALIGN THE IMU TO THE PREFERRED, NOMINAL, OR LANDING SITE ORIENTATIONS WITHOUT MAKING CELESTIAL BODY SIGHTINGS (SEE LOGIC FLOW).

(7) EXTENDED VERBS SHOULD NOT BE EXERCISED DURING THIS PROGRAM BECAUSE OF POSSIBLE INTERFERENCE WITH R53.

(8) THE PROGRAM IS SELECTED BY THE ASTRONAUT BY DSKY ENTRY.



#10


MONITOR DSKY:
OBSERVE DISPLAY OF
P52
DO IMU STATUS CHECK
ROUTINE (R02)
DO IMU STATUS CHECK
ROUTINE (R02)
IS THE PREFERRED-
ATTITUDE-COMPUTED
FLAG SET?
Y
N
SET LGC ASSUMED
OPTION TO 00001.
SET LGC ASSUMED
OPTION TO 00003.
HOLD
SNAP
FLASH VERB-NOUN TO
REQUEST RESPONSE AND
DISPLAY OPTION CODE
FOR ASSUMED IMU OR-
IENTATION SELECTION:
MONITOR DSKY:
OBSERVE VERB-NOUN
FLASH TO REQUEST
RESPONSE AND DISPLAY
OF OPTION CODE FOR

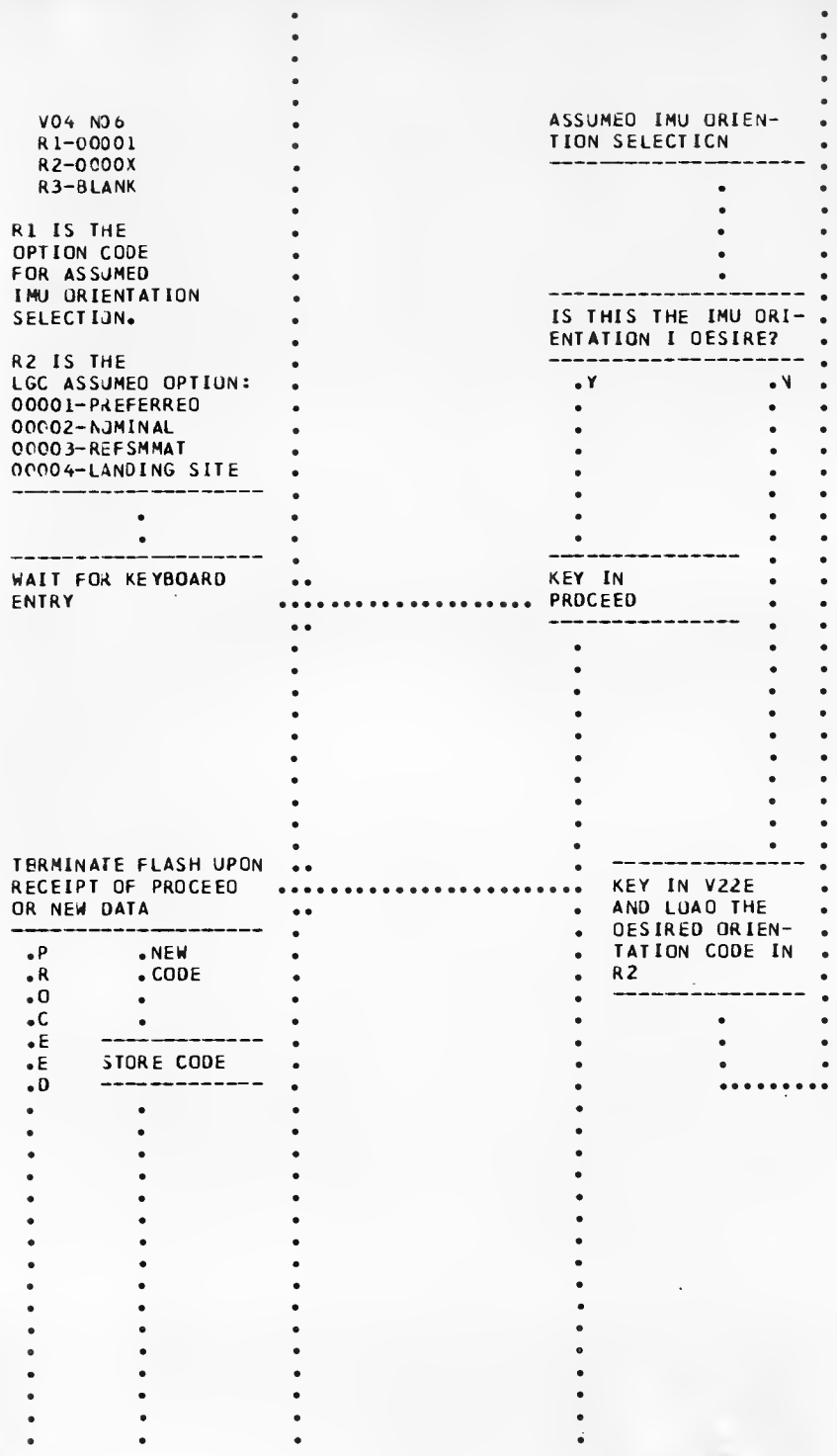
#20

#30

#40

#50

#60



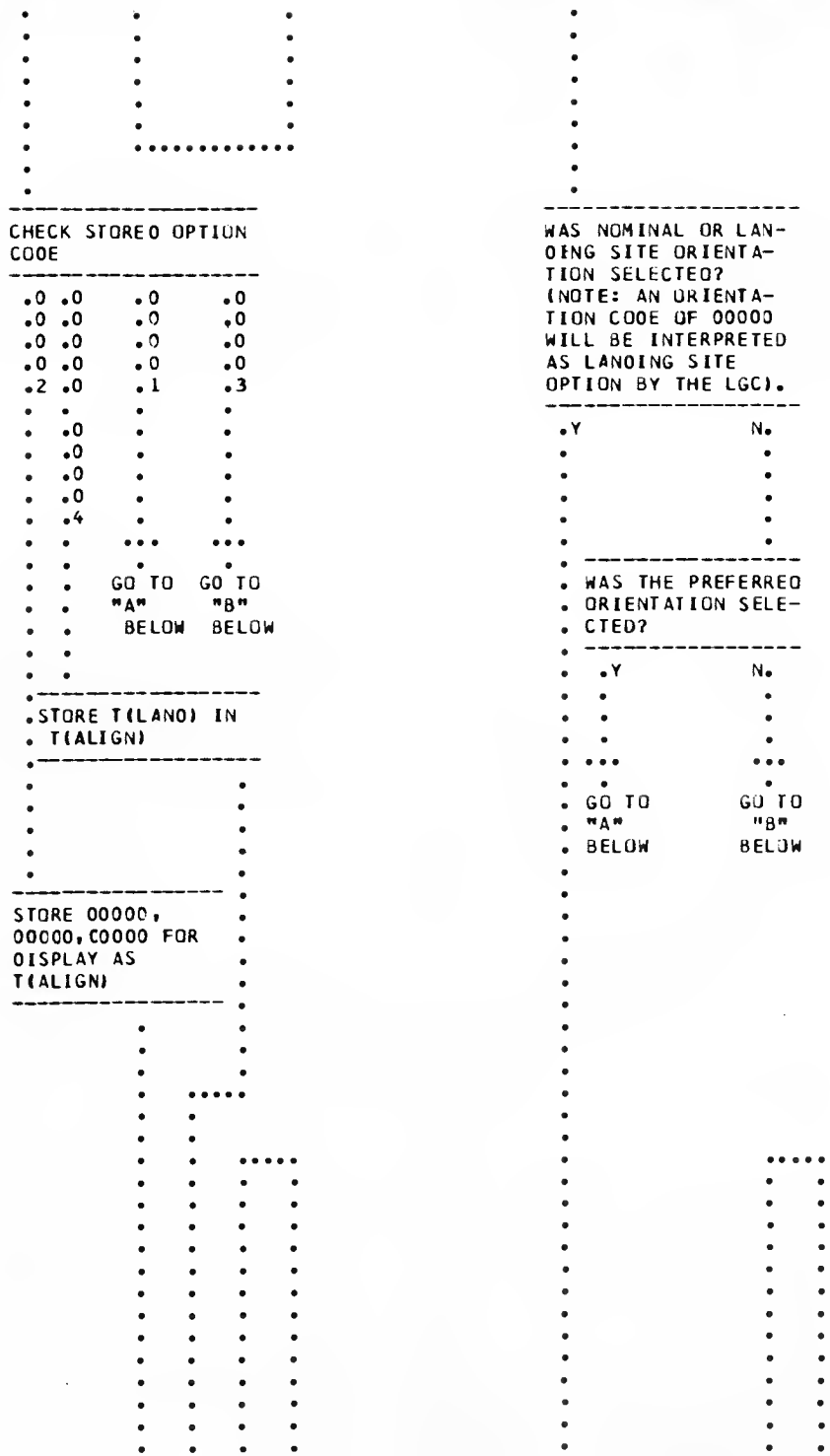
#70

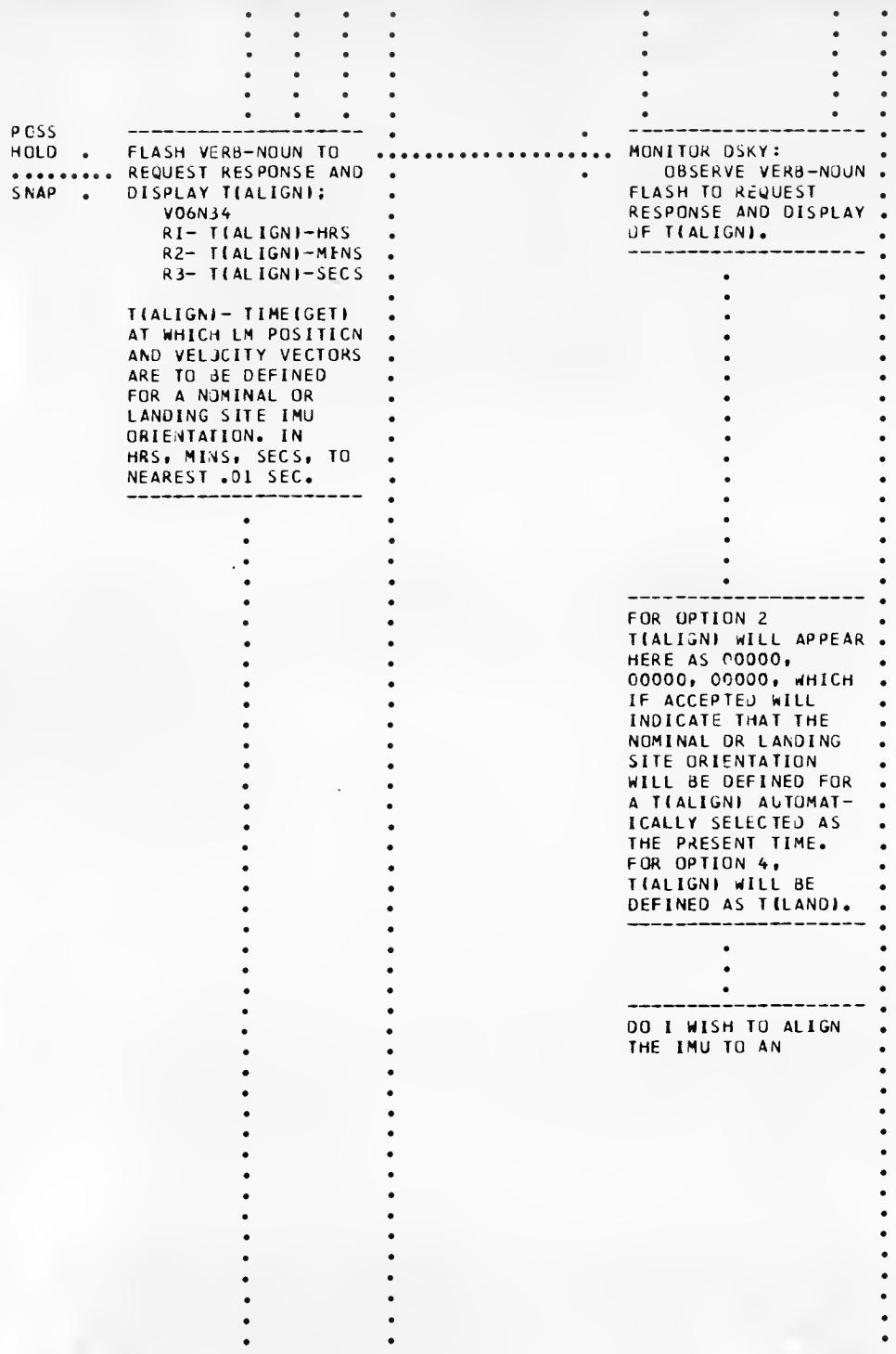
#80

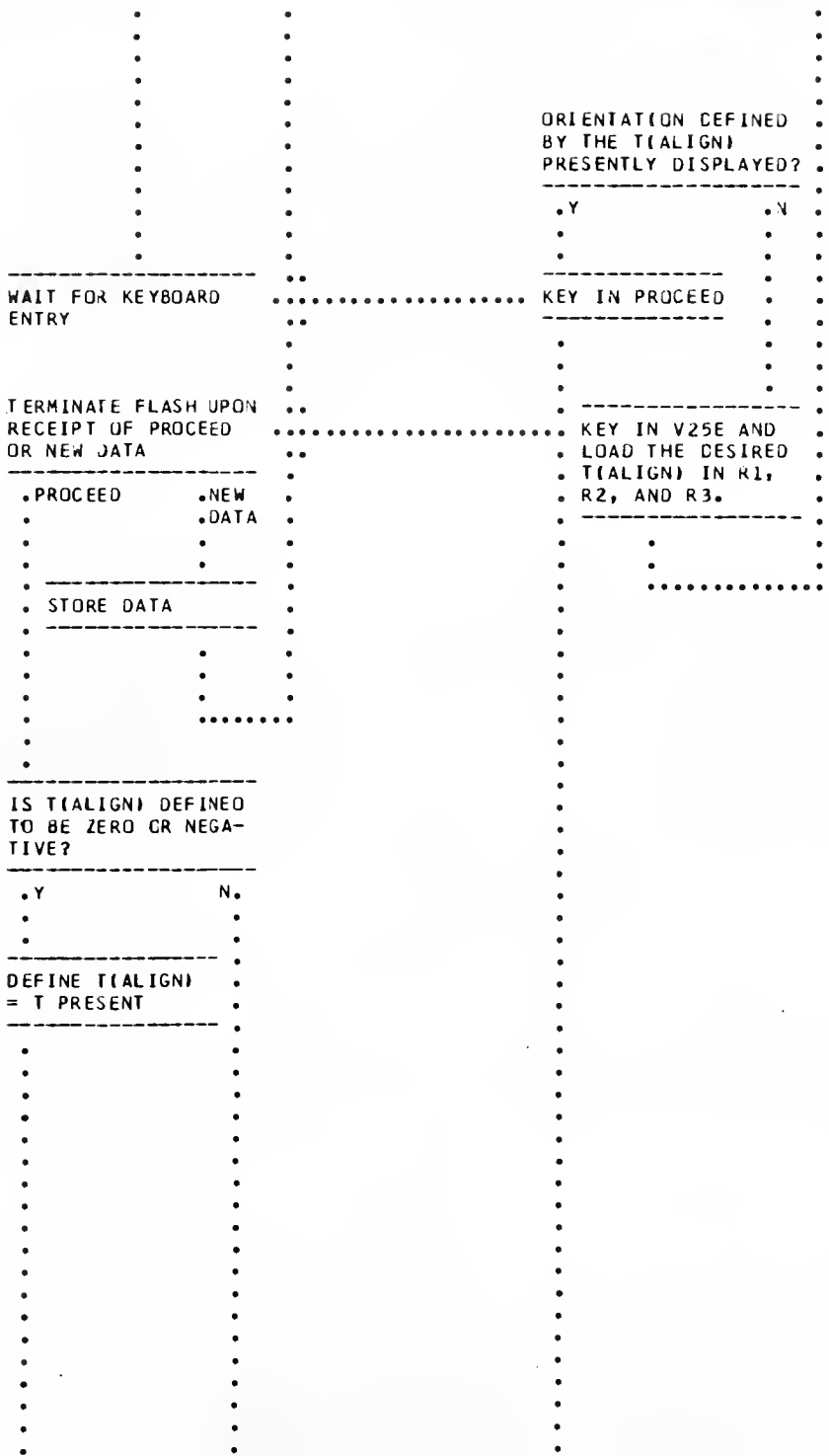
#90

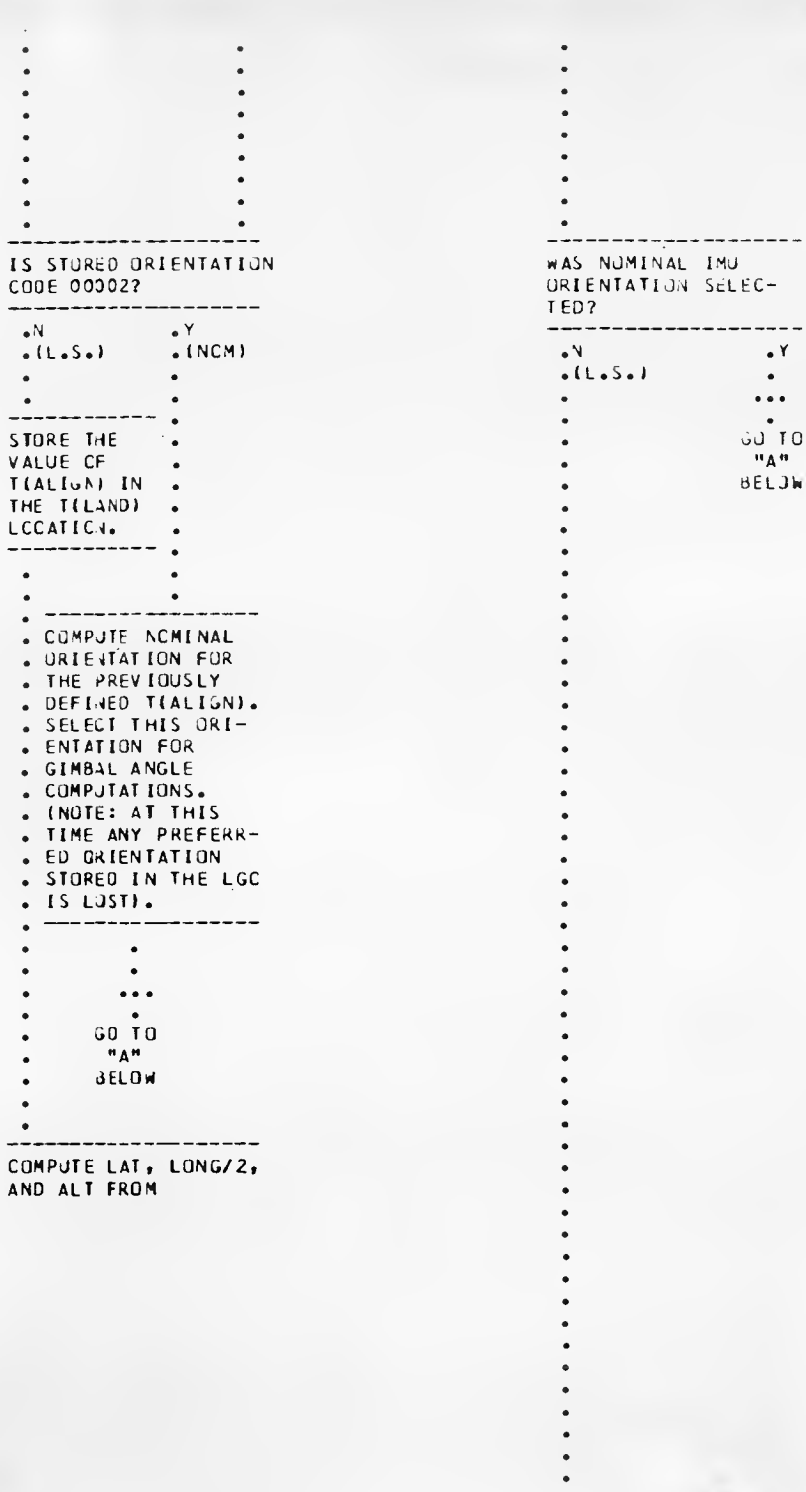
#100

#110


CHECK STOREO OPTION CODE
.0 .0 .0 .0
.0 .0 .0 .0
.0 .0 .0 .0
.0 .0 .0 .0
.2 .0 .1 .3
.0
.0
.0
.0
.4
GO TO "A" BELOW
GO TO "B" BELOW
.STORE T(LANO) IN T(ALIGN)
STORE 00000, 00000, C0000 FOR DISPLAY AS T(ALIGN)
WAS NOMINAL OR LANDING SITE ORIENTATION SELECTED? (NOTE: AN ORIENTATION CODE OF 00000 WILL BE INTERPRETED AS LANDING SITE OPTION BY THE LGC).
.Y
N.
WAS THE PREFERRED ORIENTATION SELECTED?
.Y
N.
GO TO "A" BELOW
GO TO "B" BELOW
#120
#130
#140
#150
#160


POSS
HOLD
SNAP
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY T(ALIGN):
V06N34
R1- T(ALIGN)-HRS
R2- T(ALIGN)-MINS
R3- T(ALIGN)-SECS
T(ALIGN)- TIME(GET) AT WHICH LM POSITION AND VELOCITY VECTORS ARE TO BE DEFINED FOR A NOMINAL OR LANDING SITE IMU ORIENTATION. IN HRS, MINS, SECS, TO NEAREST .01 SEC.
MONITOR DSKY:
OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY OF T(ALIGN).
FOR OPTION 2 T(ALIGN) WILL APPEAR HERE AS 00000, 00000, 00000, WHICH IF ACCEPTED WILL INDICATE THAT THE NOMINAL OR LANDING SITE ORIENTATION WILL BE DEFINED FOR A T(ALIGN) AUTOMATICALLY SELECTED AS THE PRESENT TIME. FOR OPTION 4, T(ALIGN) WILL BE DEFINED AS T(LAND).
DO I WISH TO ALIGN THE IMU TO AN
#170
#180
#190
#200
#210


ORIENTATION DEFINED BY THE T(ALIGN) PRESENTLY DISPLAYED?
Y
N
WAIT FOR KEYBOARD ENTRY
KEY IN PROCEED
#220
TERMINATE FLASH UPON RECEIPT OF PROCEED OR NEW DATA
KEY IN V25E AND LOAD THE DESIRED T(ALIGN) IN R1, R2, AND R3.
#230
PROCEED
NEW DATA
STORE DATA
#240
IS T(ALIGN) DEFINED TO BE ZERO OR NEGATIVE?
Y
N
#250
DEFINE T(ALIGN) = T PRESENT



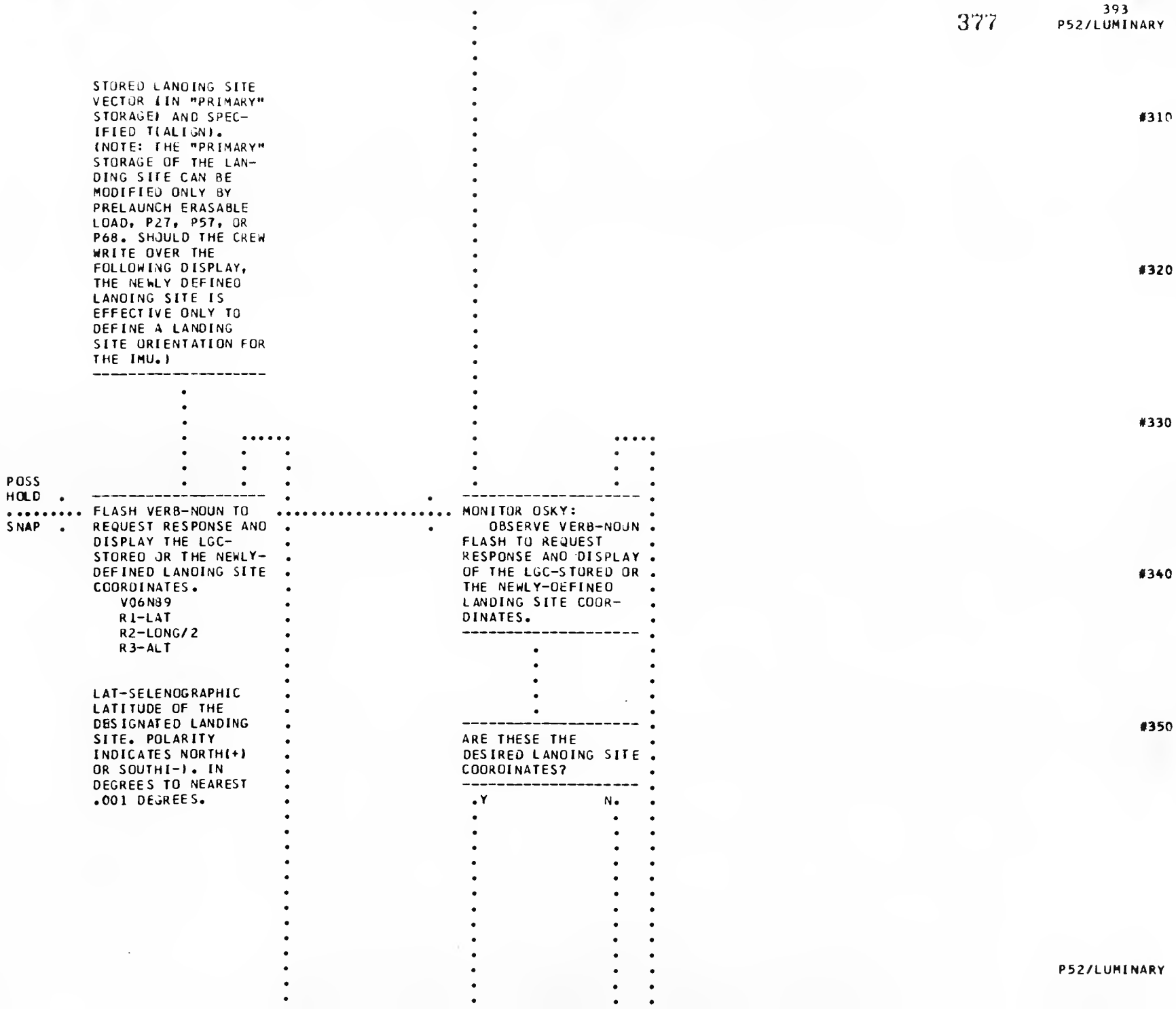
#260

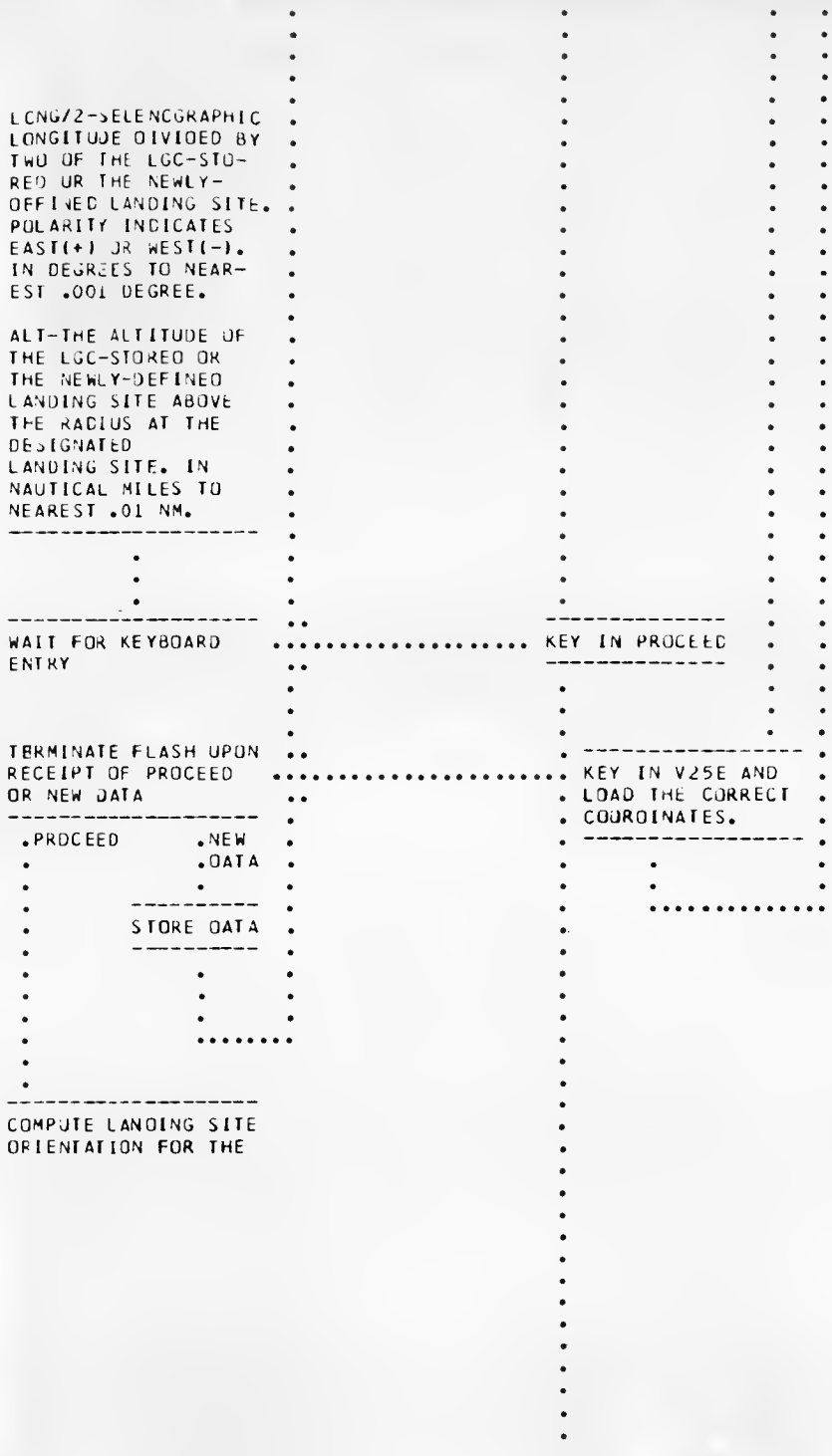
#270

#280

#290

#300


STORED LANDING SITE VECTOR (IN "PRIMARY" STORAGE) AND SPECIFIED T(ALIGN). (NOTE: THE "PRIMARY" STORAGE OF THE LANDING SITE CAN BE MODIFIED ONLY BY PRELAUNCH ERASABLE LOAD, P27, P57, OR P68. SHOULD THE CREW WRITE OVER THE FOLLOWING DISPLAY, THE NEWLY DEFINED LANDING SITE IS EFFECTIVE ONLY TO DEFINE A LANDING SITE ORIENTATION FOR THE IMU.)
#310
#320
#330
POSS HOLD
SNAP
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY THE LGC-STORED OR THE NEWLY-DEFINED LANDING SITE COORDINATES.
V06N89
R1-LAT
R2-LONG/2
R3-ALT
LAT-SELENOGRAPHIC LATITUDE OF THE DESIGNATED LANDING SITE. POLARITY INDICATES NORTH(+) OR SOUTH(-). IN DEGREES TO NEAREST .001 DEGREES.
MONITOR OSKY:
OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY OF THE LGC-STORED OR THE NEWLY-DEFINED LANDING SITE COORDINATES.
#340
#350
ARE THESE THE DESIRED LANDING SITE COORDINATES?
.Y
N.



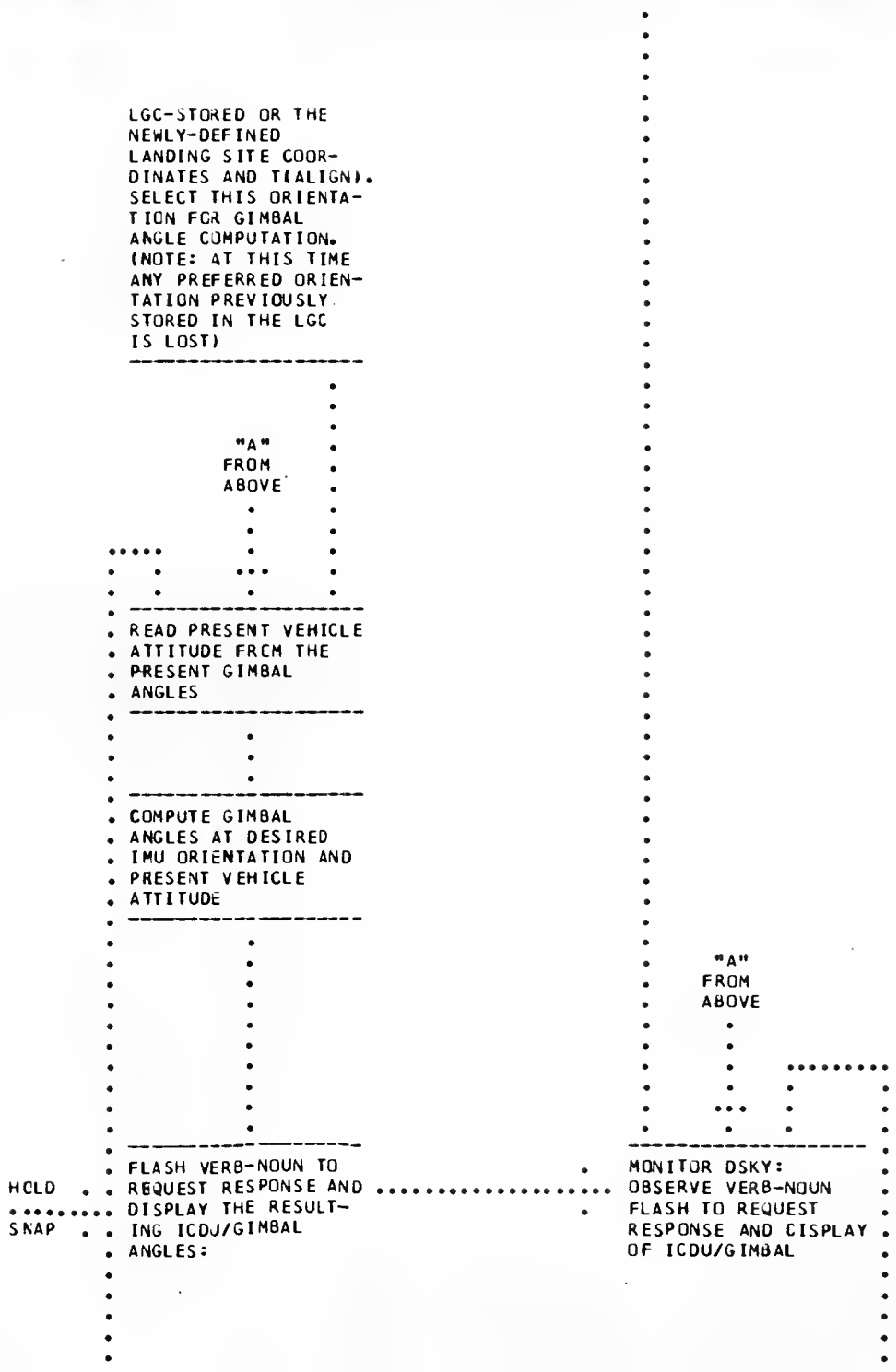
#360

#370

#380

#390

#400



#410

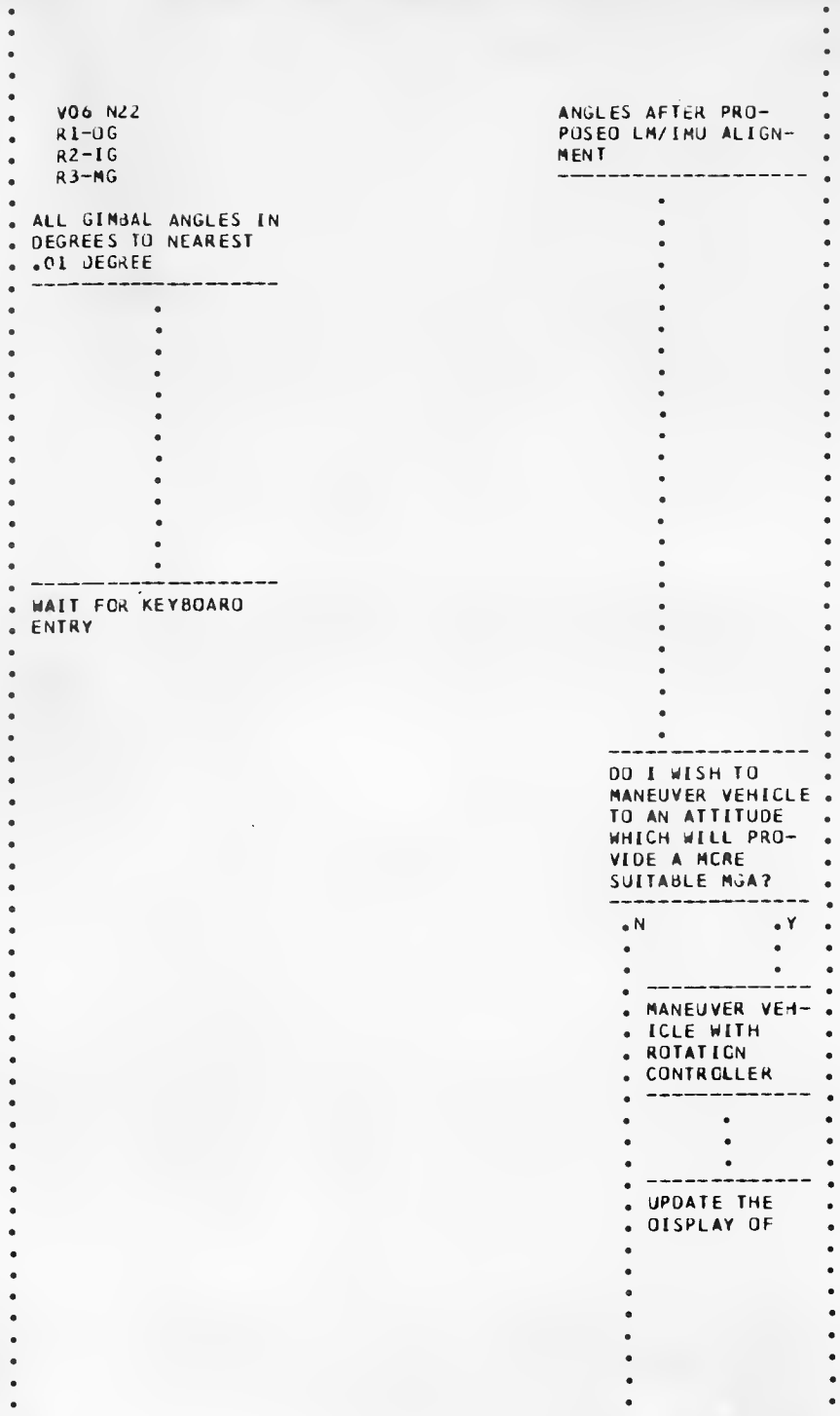
#420

#430

#440

#450

#460



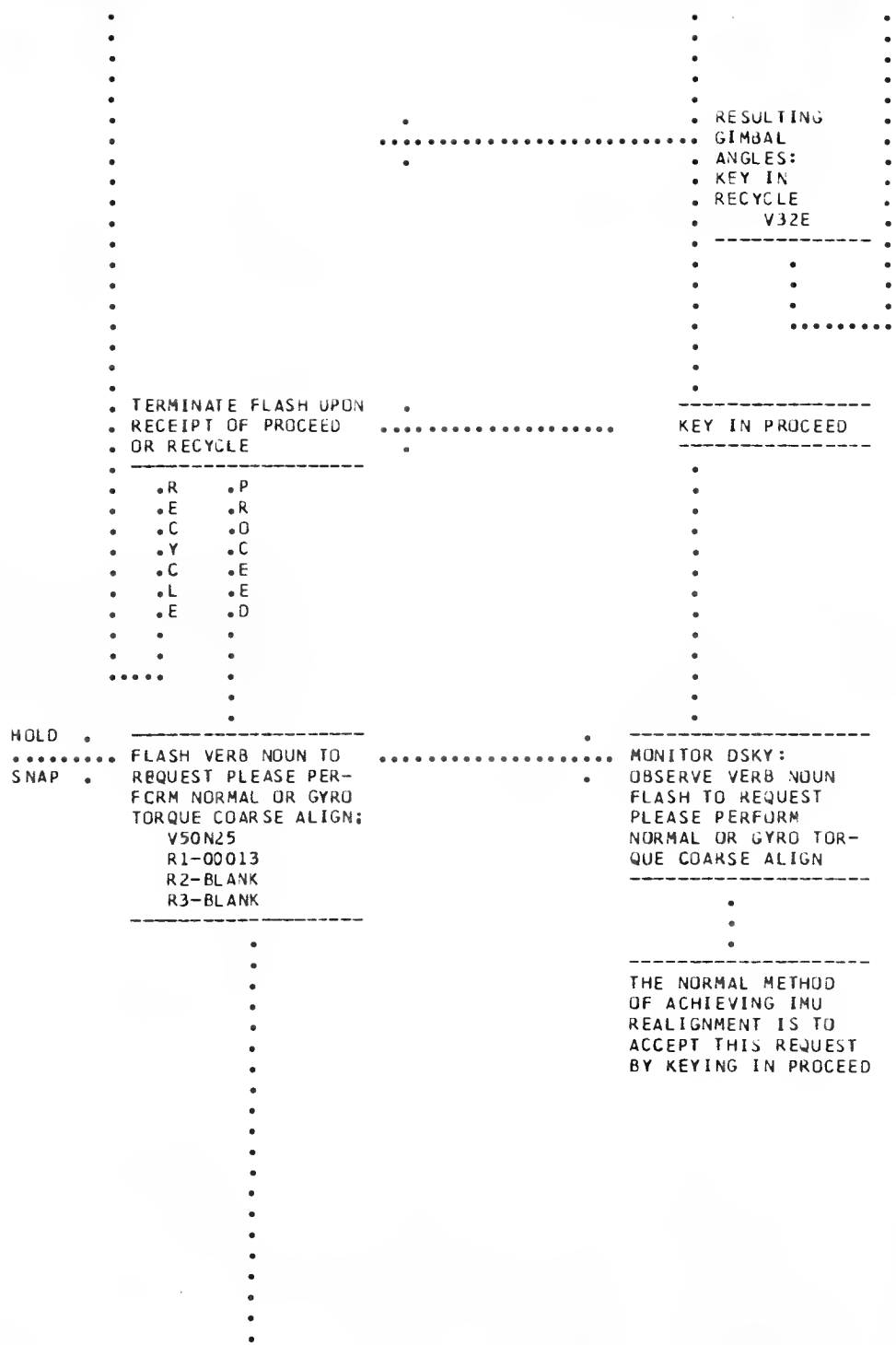
#470

#480

#490

#500

#510


RESULTING GIMBAL ANGLES: KEY IN RECYCLE V32E
#520
TERMINATE FLASH UPON RECEIPT OF PROCEED OR RECYCLE
KEY IN PROCEED
#530
.R .E .C .Y .C .L .E
.P .R .O .C .E .E .D
#540
HOLD SNAP
FLASH VERB NOUN TO REQUEST PLEASE PERFORM NORMAL OR GYRO TORQUE COARSE ALIGN; V50N25 R1-00013 R2-BLANK R3-BLANK
MONITOR DSKY: OBSERVE VERB NOUN FLASH TO REQUEST PLEASE PERFORM NORMAL OR GYRO TORQUE COARSE ALIGN
#550
THE NORMAL METHOD OF ACHIEVING IMU REALIGNMENT IS TO ACCEPT THIS REQUEST BY KEYING IN PROCEED
#560

WHICH WILL CAUSE THE
LGC TO COARSE ALIGN
THE STABLE MEMBER TO
THE GIMBAL ANGLES
APPROXIMATING THE
NEW ORIENTATION AND
THEN TO PROCEED
THROUGH OPTICAL
SIGHTINGS AND PULSE
TORQUING TO ACHIEVE
PRECISE ALIGNMENT.
AN ALTERNATE METHOD
OF ACHIEVING IMU
REALIGNMENT IS TO
KEY IN ENTER WHICH
WILL CAUSE THE LGC
TO COMPUTE THE NUM-
BER OF TORQUING
PULSES REQUIRED BY
EACH IRIG (X,Y,Z)
IN ORDER TO ACHIEVE
PRECISE ALIGNMENT,
AND ISSUE THESE
PULSES. THIS ALTER-
NATE METHOD INTRO-
DUCES A PREDICTABLE
ERROR INTO THE LGC'S
KNOWLEDGE OF THE
STABLE MEMBER ORIEN-
TATION AND TAKES A
PREDICTABLE PERIOD
OF TIME FOR COMPLET-
ION.
AN APPROXIMATION OF
THIS ERROR AND THE
TIME TO TORQUE CAN
BE MADE BY CALCULA-
TING THE SUM OF THE
GIMBAL ANGLE CHAN-
GES, MULTIPLYING BY
2 FOR TIME TO TORQUE
IN SECONDS, AND MUL-
TIPLYING BY .002 FOR
ERROR IN DEGREES.
SHALL I REALIGN IN
THE NORMAL WAY?

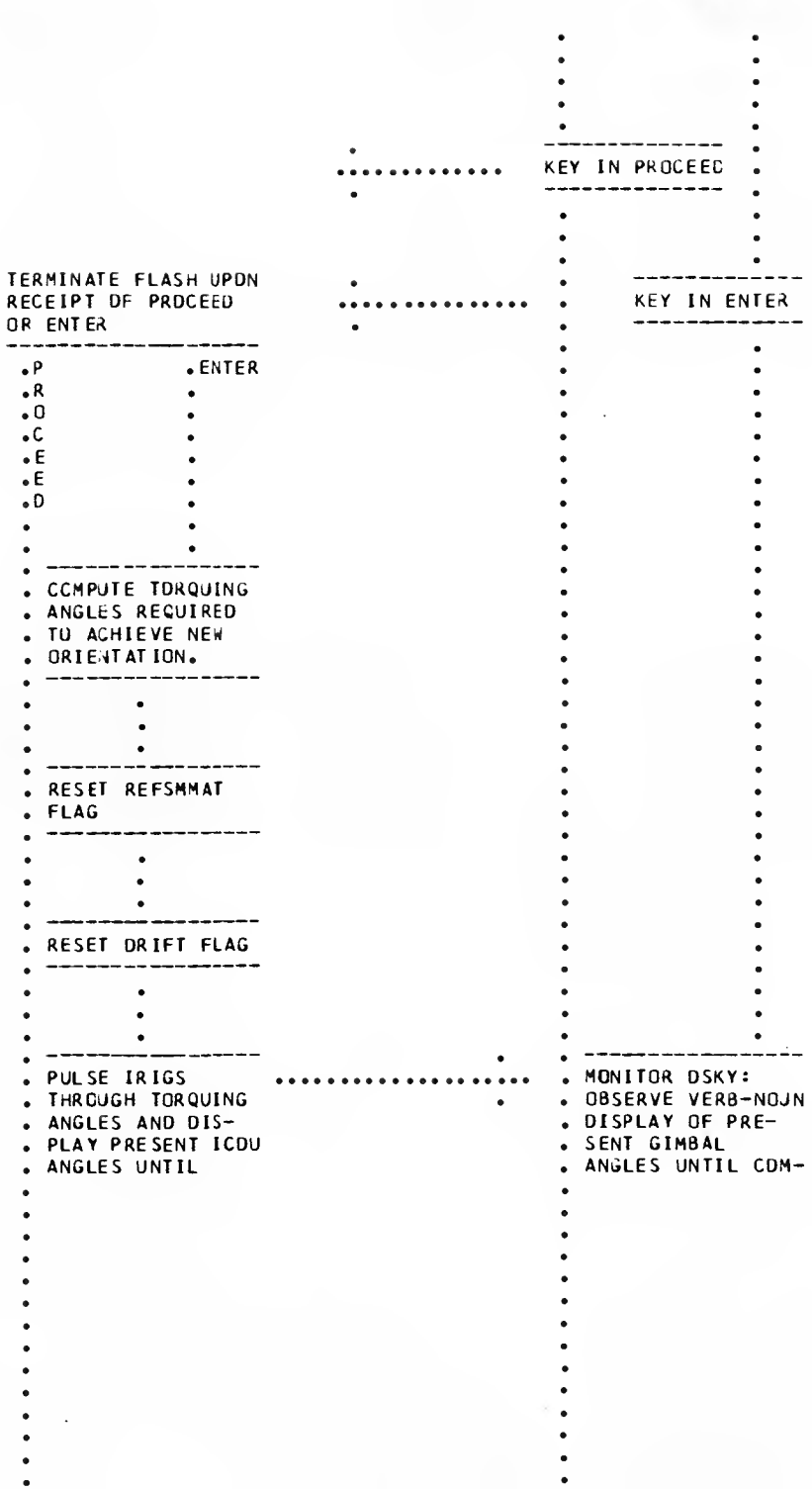
#570

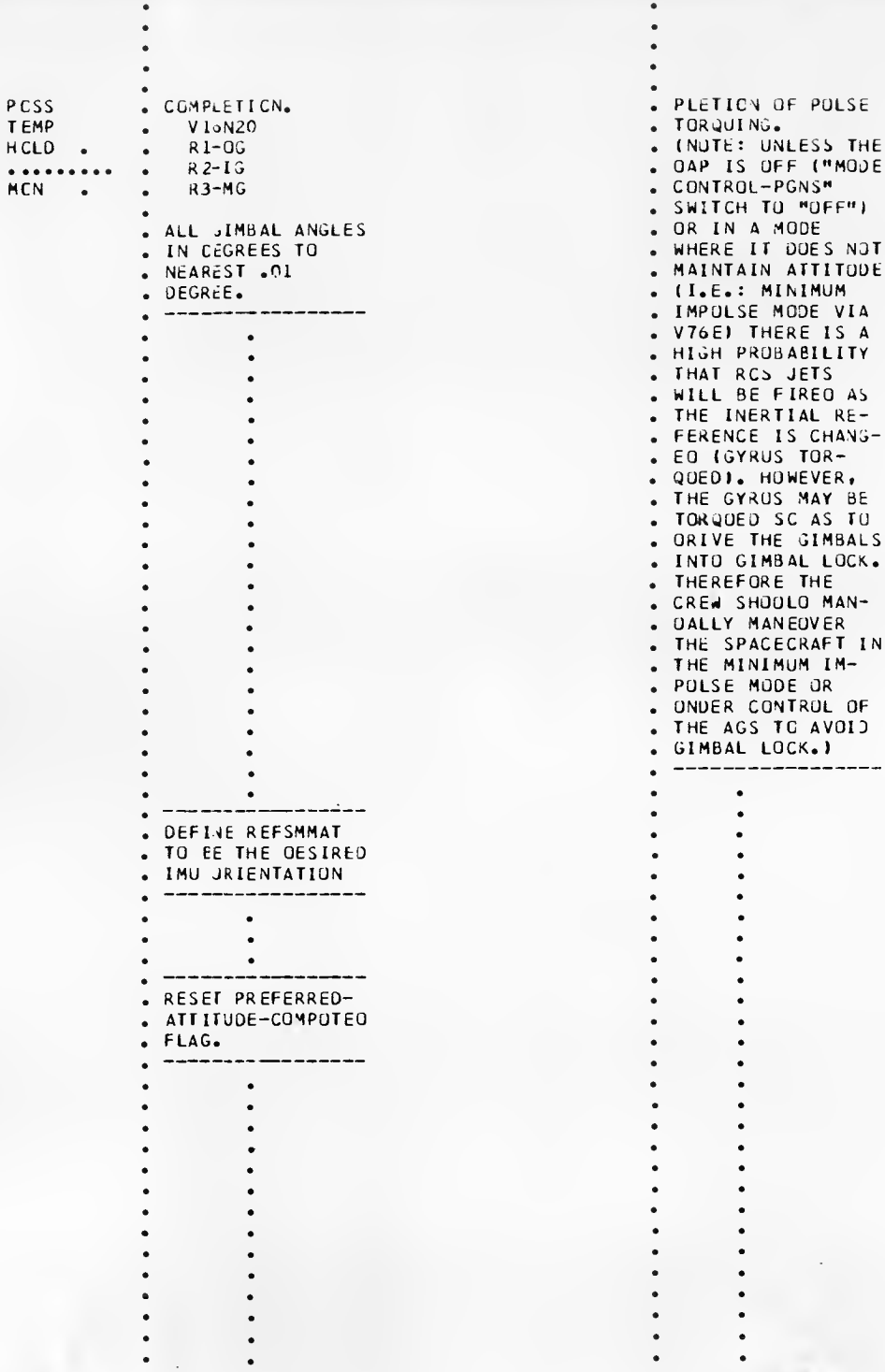
#580

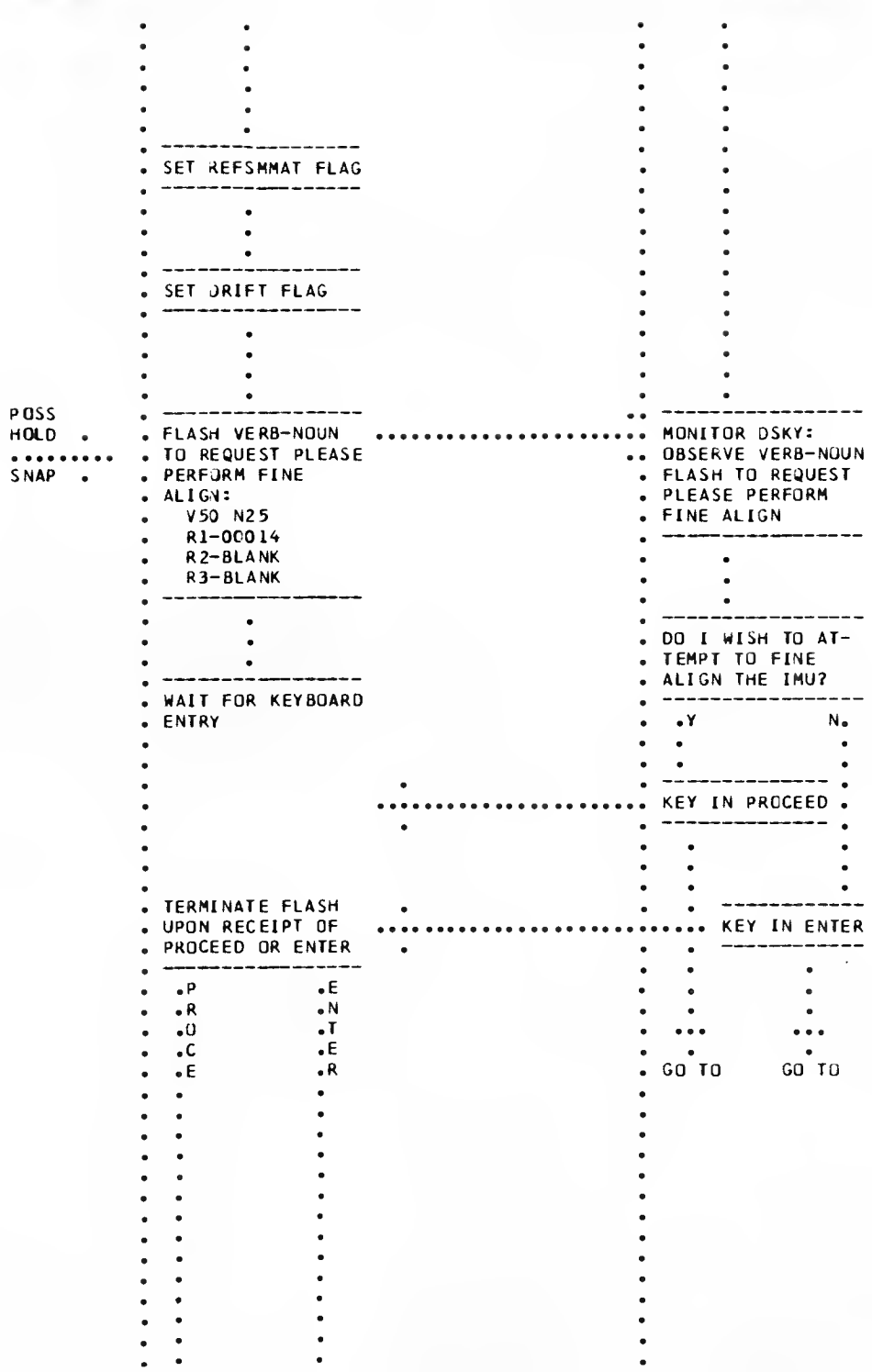
#590

#600

#610


KEY IN PROCEED
TERMINATE FLASH UPON RECEIPT OF PROCEED OR ENTER
KEY IN ENTER
PROCEED
ENTER
#620
#630
COMPUTE TORQUING ANGLES REQUIRED TO ACHIEVE NEW ORIENTATION.
#640
RESET REFSMMAT FLAG
RESET DRIFT FLAG
#650
PULSE IRIGS THROUGH TORQUING ANGLES AND DISPLAY PRESENT ICDU ANGLES UNTIL
MONITOR DSKY: OBSERVE VERB-NOUN DISPLAY OF PRESENT GIMBAL ANGLES UNTIL COM-


PCSS
TEMP
HCLD
MCN
COMPLETION.
V16N20
R1-OG
R2-IG
R3-MG
ALL GIMBAL ANGLES IN DEGREES TO NEAREST .01 DEGREE.
DEFINE REFSMMAT TO BE THE DESIRED IMU ORIENTATION
RESET PREFERRED-ATTITUDE-COMPUTED FLAG.
PLETION OF POLSE TORQUING.
(NOTE: UNLESS THE OAP IS OFF ("MODE CONTROL-PGNS" SWITCH TO "OFF") OR IN A MODE WHERE IT DOES NOT MAINTAIN ATTITUDE (I.E.: MINIMUM IMPULSE MODE VIA V76E) THERE IS A HIGH PROBABILITY THAT RCS JETS WILL BE FIRED AS THE INERTIAL REFERENCE IS CHANGED (GYRUS TORQUED). HOWEVER, THE GYROS MAY BE TORQUED SO AS TO DRIVE THE GIMBALS INTO GIMBAL LOCK. THEREFORE THE CREW SHOULD MANUALLY MANEUVER THE SPACECRAFT IN THE MINIMUM IMPULSE MODE OR UNDER CONTROL OF THE AGS TO AVOID GIMBAL LOCK.)
#660
#670
#680
#690
#700



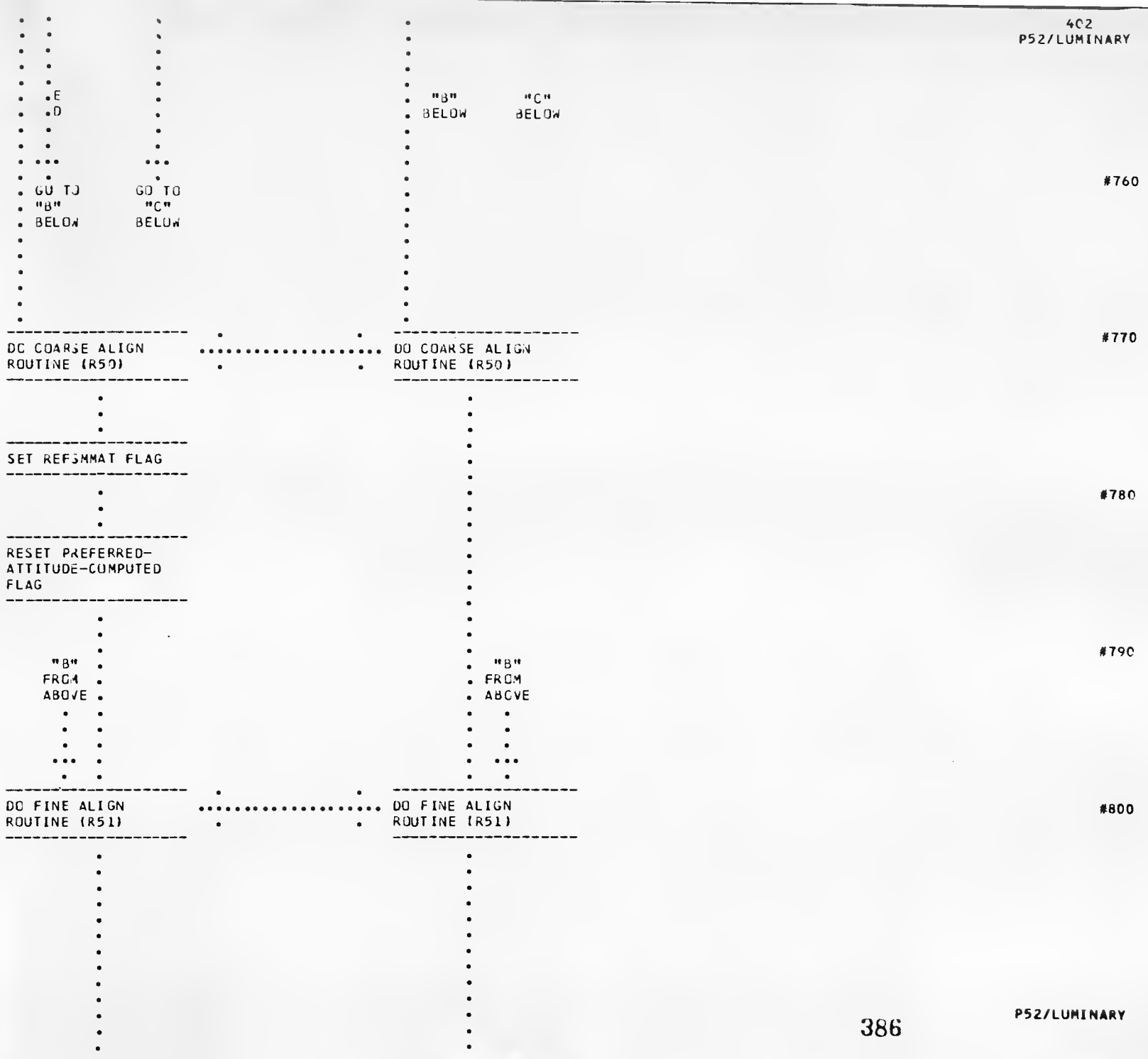
#710

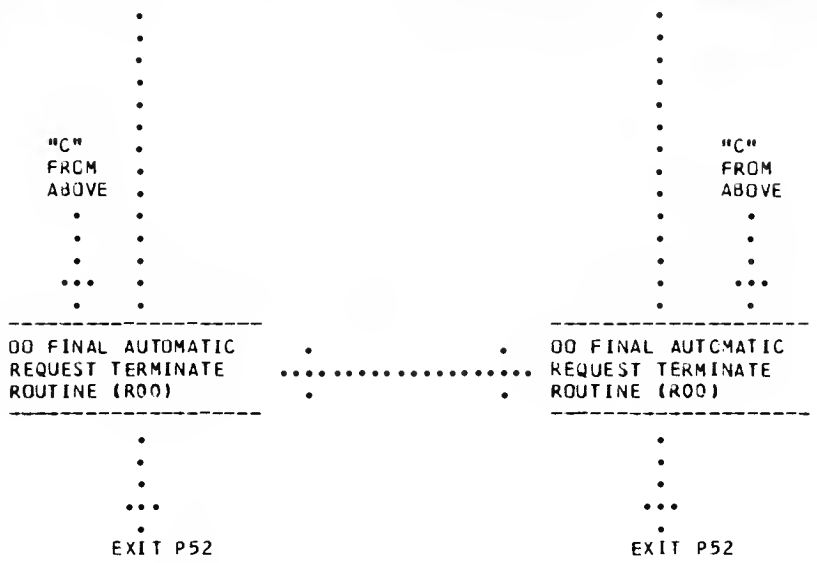
#720

#730

#740

#750


.E
.D
GO TO "B" BELOW
GO TO "C" BELOW
"B" BELOW
"C" BELOW
#760
DO COARSE ALIGN ROUTINE (R50)
DO COARSE ALIGN ROUTINE (R50)
#770
SET REFSMMAT FLAG
#780
RESET PREFERRED-ATTITUDE-COMPUTED FLAG
"B" FROM ABOVE
"B" FROM ABOVE
#790
DO FINE ALIGN ROUTINE (R51)
DO FINE ALIGN ROUTINE (R51)
#800



#810

#820

CHANGE CONTROL NOTES

REV 01 PCR 134,439
REV 00(LUM 1A) PCR 740
REV 01(LUM 1B) PCR 825.2
REV 02 EDITORIAL
REV 03 PCN 1009

LUNAR SURFACE ALIGN PROGRAM (P57) REV C6 12/01/71

PURPOSE: (1) WHILE ON THE SURFACE OF THE MOON TO ALIGN OR REALIGN THE IMU TO ONE OF THREE TYPES OF ORIENTATIONS:

(A) LANDING SITE ORIENTATION

$$X_{-SM} = UNIT(R_{-LS})$$

$$Y_{-SM} = UNIT(Z_{-SM} \times X_{-SM})$$

$$Z_{-SM} = UNIT(H_{-CSM} \times X_{-SM})$$

WHERE:

(1) THE ORIGIN IS THE CENTER OF THE MOON

(2) R_{-LS} = THE POSITION VECTOR OF THE LM ON THE LUNAR SURFACE AT THE MOST RECENTLY DESIGNATED LANDING SITE AND A TIME T(ALIGN) SELECTED BY THE CREW.

(3) H_{-CSM} = THE ANGULAR MOMENTUM VECTOR OF THE CSM ($R_{-CSM} \times V_{-CSM}$).

(B) PREFERRED ORIENTATION

AN IMU ORIENTATION SPECIFIED BY THE GROUND AND LOADED INTO THE LGC BY THE LGC UPDATE PROGRAM (P27).

(C) PRESENT REFSMMAT

ASSUMPTIONS: (1) THERE ARE SEVERAL TECHNIQUES AVAILABLE TO THE CREW FOR COMPLETING AN IMU ALIGNMENT. THE RESULTANT ACCURACY OF THE IMU TO THE SPECIFIED DESIRED ORIENTATION (I.E. THAT ORIENTATION DEFINED BY THE FINAL REFSMMAT) IS DEPENDENT UPON THE ALIGNMENT TECHNIQUE WHICH THE CREW SELECTS. THIS SELECTION WILL BE DICTATED BY THE CIRCUMSTANCES AT THE TIME OF ALIGNMENT.

(2) THE LM HAS LANDED ON THE LUNAR SURFACE. THE LM YAW ANGLE WITH RESPECT TO THE INERTIAL ORIENTATION OF THE IMU AT LANDING WAS NOT CONSTRAINED DURING LANDING.

(3) ALL POSSIBLE EFFORTS HAVE BEEN MADE BY THE CREW TO ENSURE THAT THE LM WILL NOT SHIFT ITS POSITION WITH RESPECT TO THE LUNAR SURFACE. NO PROVISION HAS BEEN MADE TO INCORPORATE IN THE LGC ANY MEASUREMENT OF LM SETTLING ON THE LUNAR SURFACE. HOWEVER A SHIFTING OF THE LM WILL RESULT IN A MISALIGNED IMU ONLY IN THE CASE WHERE AN ALIGNMENT IS MADE FROM A STORED LM ATTITUDE WITH RESPECT TO THE LUNAR SURFACE (OPTION CODES 00000 AND 00001; SEE LOGIC BELOW), AND THE IMU IS NOT SUBSEQUENTLY ALIGNED BY REFERENCE TO CELESTIAL BODIES AND/OR LUNAR GRAVITY.

(4) THE ISS IS ON AND MAY BE:

(A) AT AN INERTIAL ORIENTATION "UNKNOWN" TO THE LGC; I.E.: IT MAY HAVE BEEN SHUT DOWN AND RESTARTED SINCE

LANDING WITHOUT SUBSEQUENT ORIENTATION DETERMINATION.

(8) AT AN INERTIAL ORIENTATION "KNOWN" BY THE LGC; I.E.: NEITHER GIMBAL LOCK NOR IMU POWER INTERRUPTION HAS OCCURRED SINCE THE LAST IMU ALIGNMENT OR ORIENTATION DETERMINATION. THEREFORE THE PRESENT ORIENTATION DIFFERS FROM THAT STORED IN REFSMMAT ONLY BECAUSE OF GYRO DRIFT AND/OR THE INITIAL MISALIGNMENT OF THE IMU TO THE STORED REFSMMAT.

(5) NO MONITOR OR CONTROL OF THE RENDEZVOUS RADAR (RR) WILL BE EXERCISED BY THE LGC DURING THIS PROGRAM EXCEPT AS DEFINED BY THE RR MONITOR ROUTINE (R25).

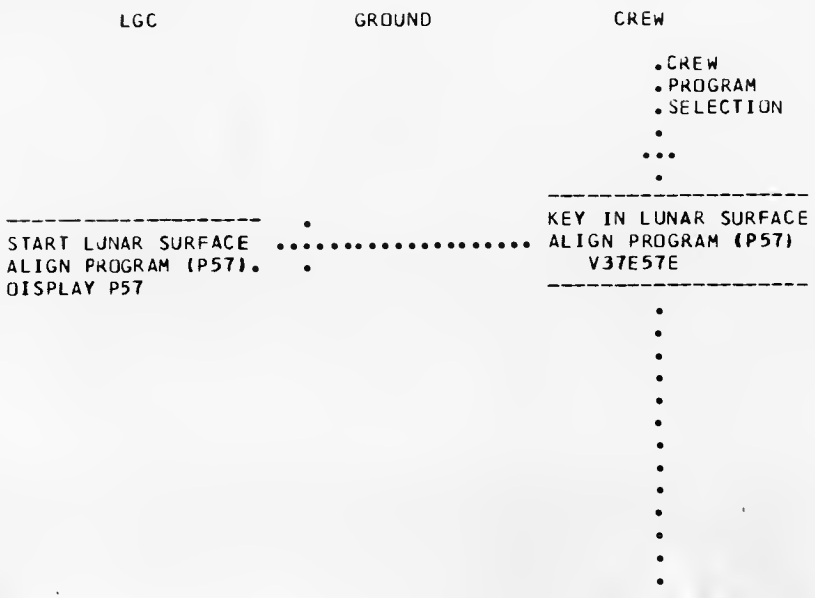
(6) THE LM ATTITUDE WITH RESPECT TO THE LUNAR SURFACE IS AVAILABLE IN LGC STORAGE, I.E.: IT WILL HAVE BEEN STORED BY THE LANDING CONFIRMATION PROGRAM (P68). ONCE THIS ATTITUDE HAS BEEN STORED IT WILL BE PRESERVED BY THE LGC UNTIL IT IS REPLACED BY A MORE RECENT VALUE.

(7) EXTENDED VERBS SHOULD NOT BE EXERCISED DURING THE R59 PORTION OF THIS PROGRAM BECAUSE OF POSSIBLE INTERFERENCE WITH R53.

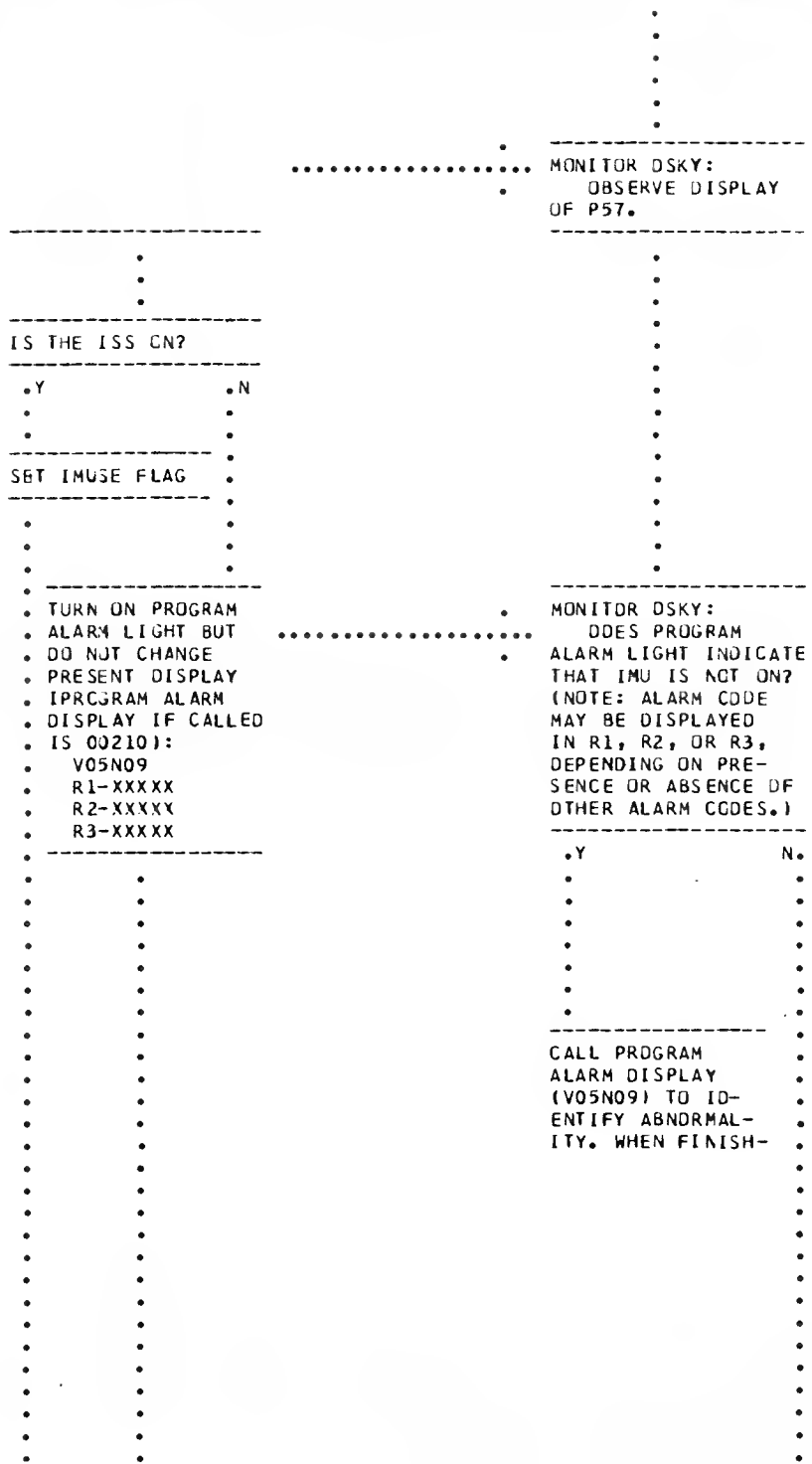
(8) THE DAP SHOULD BE OFF OR IN MINIMUM IMPULSE ("MODE CONTROL-PGNS" SWITCH TO "OFF" OR "ATT HOLD" WITH V76E) DURING GYRO TORQUING BY THIS PROGRAM TO PRECLUDE RCS JET FIRINGS DUE TO REALIGNMENT OF THE IMU CAUSING ATTITUDE ERRORS EXCEEDING THE ATTITUDE DEADBAND.

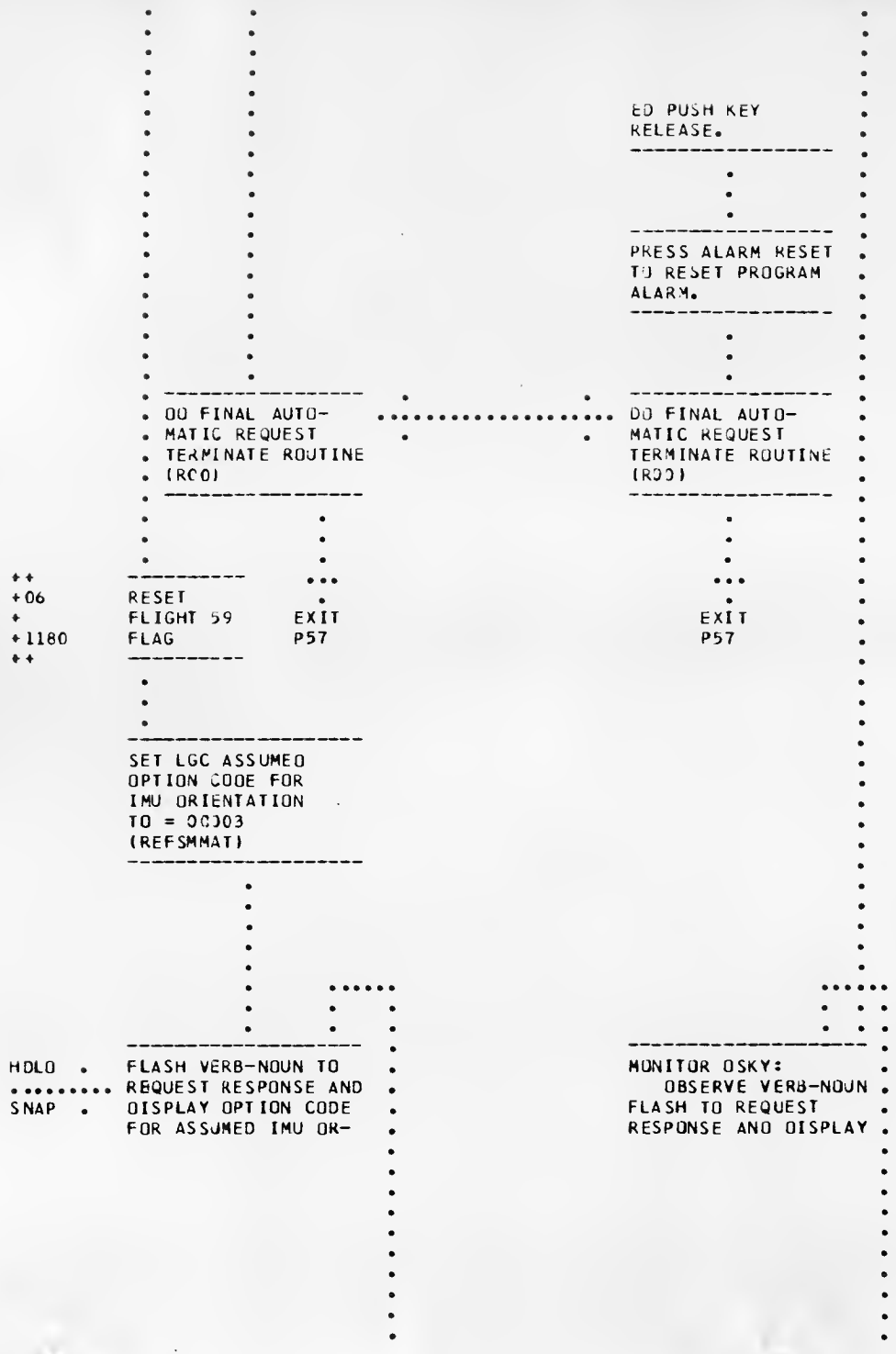
(9) THIS PROGRAM IS SELECTED BY THE ASTRONAUT BY DSKY ENTRY. IT WILL NORMALLY BE SELECTED TO PERFORM AN ALIGNMENT OF THE IMU IMMEDIATELY AFTER LANDING ON THE LUNAR SURFACE, PRIOR TO SELECTION OF THE RR LUNAR SURFACE NAVIGATION PROGRAM (P22), PRIOR TO AGS INITIALIZATION AND APPROXIMATELY 15 MINUTES PRIOR TO ASCENT. THIS PROGRAM MAY ALSO BE USED TO PROVIDE AN IMU ALIGNMENT IN TIME-CRITICAL EMERGENCIES PRIOR TO ASCENT.

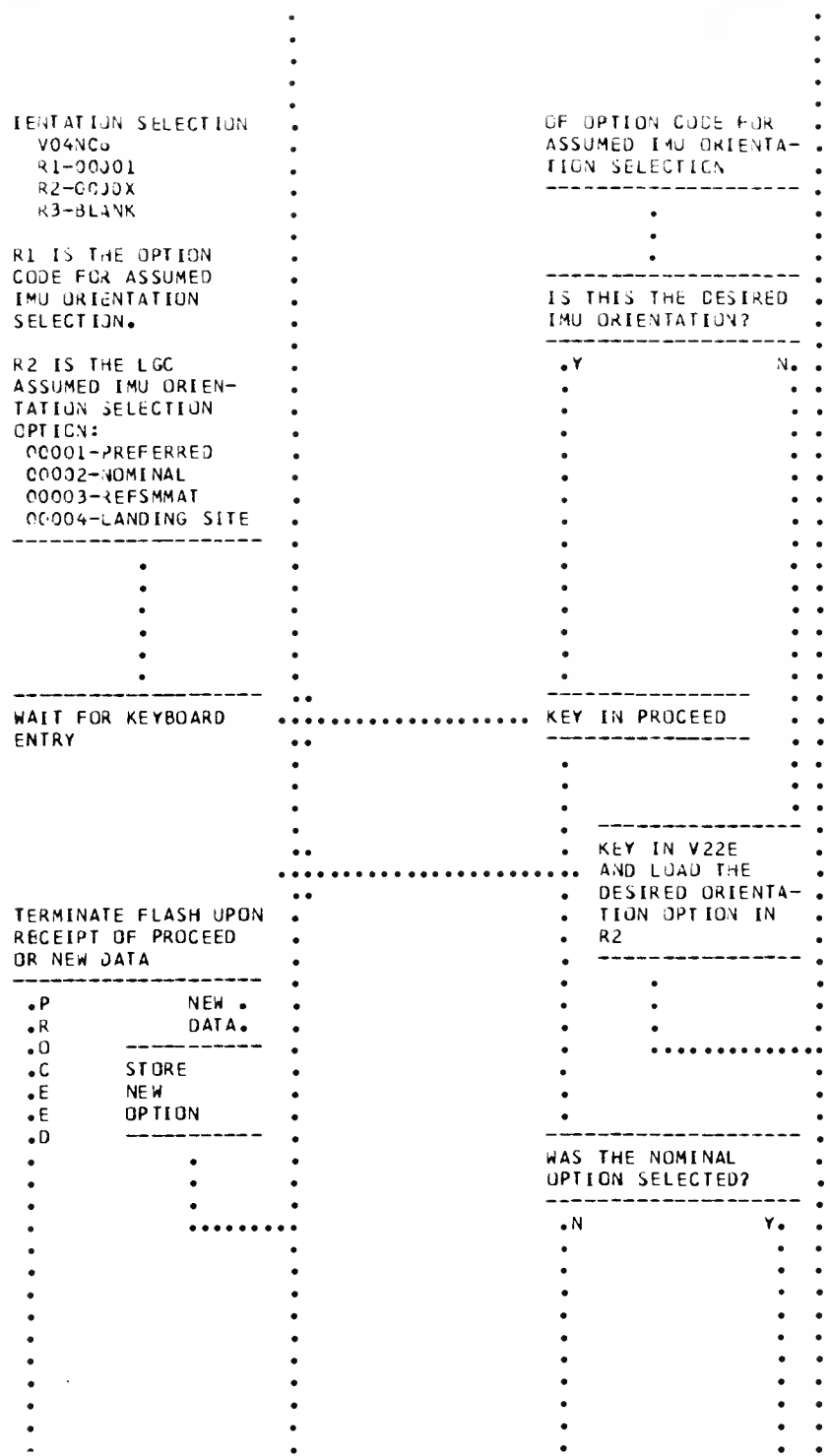
(10) A DETERMINATION OF THE LM POSITION VECTOR WHILE ON THE LUNAR SURFACE IR $_{-LS}$) CAN BE ACCOMPLISHED ONLY IN CONJUNCTION WITH IMU ALIGNMENT TECHNIQUE OPTION #2 (USING AOT SIGHTINGS TO TWO CELESTIAL BODIES). IT IS VALID ONLY IF THE LUNAR GRAVITY VECTOR HAS BEEN PREVIOUSLY DEFINED, DURING P57, USING IMU ALIGNMENT TECHNIQUE OPTION #1 (USING REFSMMAT OR STORED LM ATTITUDE AND DETERMINATION OF LUNAR GRAVITY VECTOR) OR OPTION #3 (USING SINGLE CELESTIAL BODY SIGHTING AND DETERMINATION OF LUNAR GRAVITY VECTOR).



#10


MONITOR DSKY:
OBSERVE DISPLAY
OF P57.
#20
IS THE ISS ON?
Y
N
SET IMUSE FLAG
#30
TURN ON PROGRAM
ALARM LIGHT BUT
DO NOT CHANGE
PRESENT DISPLAY
(PROGRAM ALARM
DISPLAY IF CALLED
IS 00210):
V05N09
R1-XXXXX
R2-XXXXX
R3-XXXXX
MONITOR DSKY:
DOES PROGRAM
ALARM LIGHT INDICATE
THAT IMU IS NOT ON?
(NOTE: ALARM CODE
MAY BE DISPLAYED
IN R1, R2, OR R3,
DEPENDING ON PRE-
SENCE OR ABSENCE OF
OTHER ALARM CODES.)
#40
Y
N
#50
CALL PROGRAM
ALARM DISPLAY
(V05N09) TO ID-
ENTIFY ABNORMAL-
ITY. WHEN FINISH-
#60


ED PUSH KEY RELEASE.
PRESS ALARM RESET TO RESET PROGRAM ALARM.
#70
DO FINAL AUTO-MATIC REQUEST TERMINATE ROUTINE (RCO)
DO FINAL AUTO-MATIC REQUEST TERMINATE ROUTINE (ROD)
#80
++
+06
+
+1180
++
RESET FLIGHT 59 FLAG
EXIT P57
EXIT P57
#90
SET LGC ASSUMED OPTION CODE FOR IMU ORIENTATION TO = 00003 (REFSMMAT)
#100
HDLO
SNAP
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY OPTION CODE FOR ASSUMED IMU OR-
MONITOR OSKY: OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY
#110



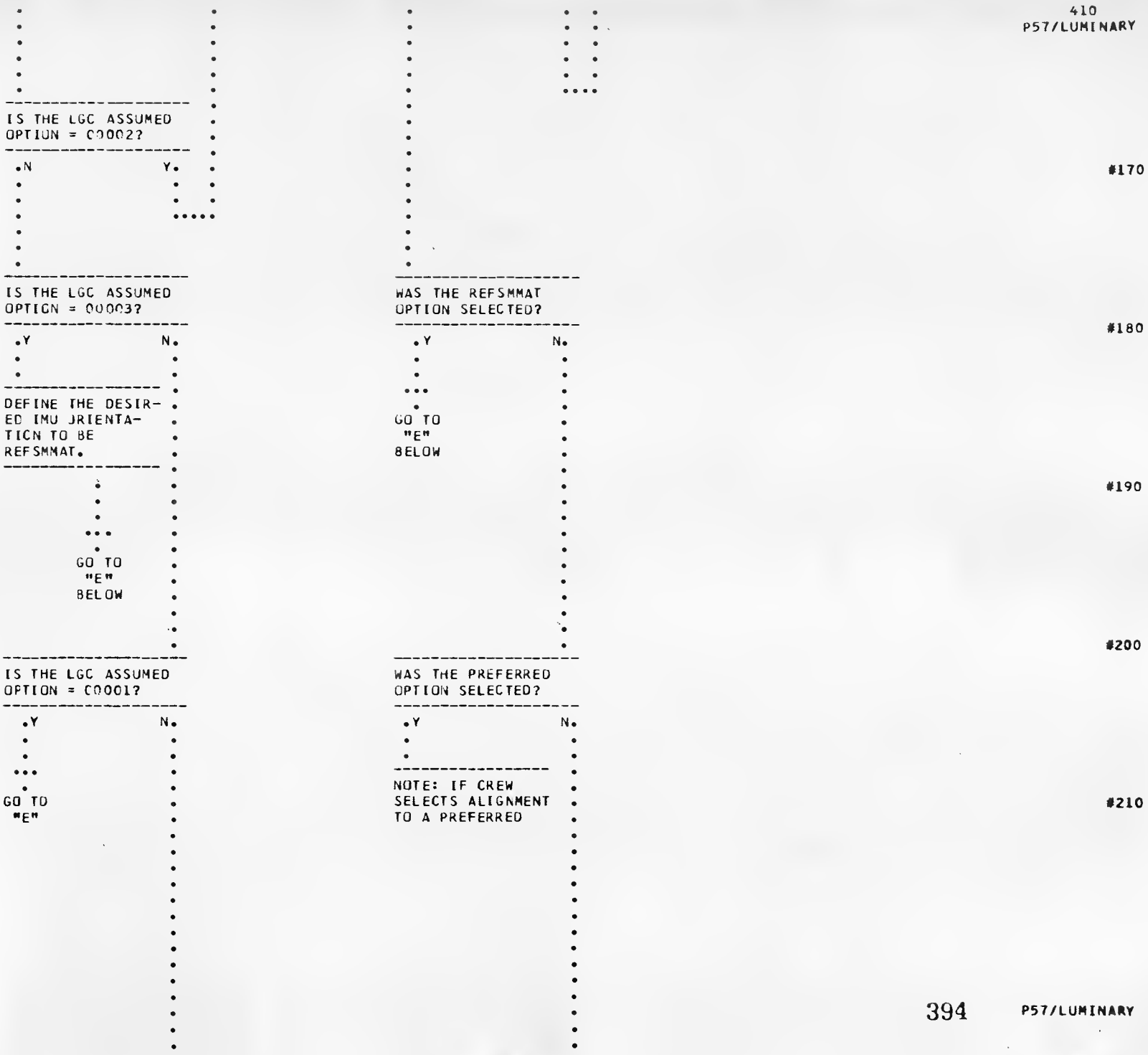
#120

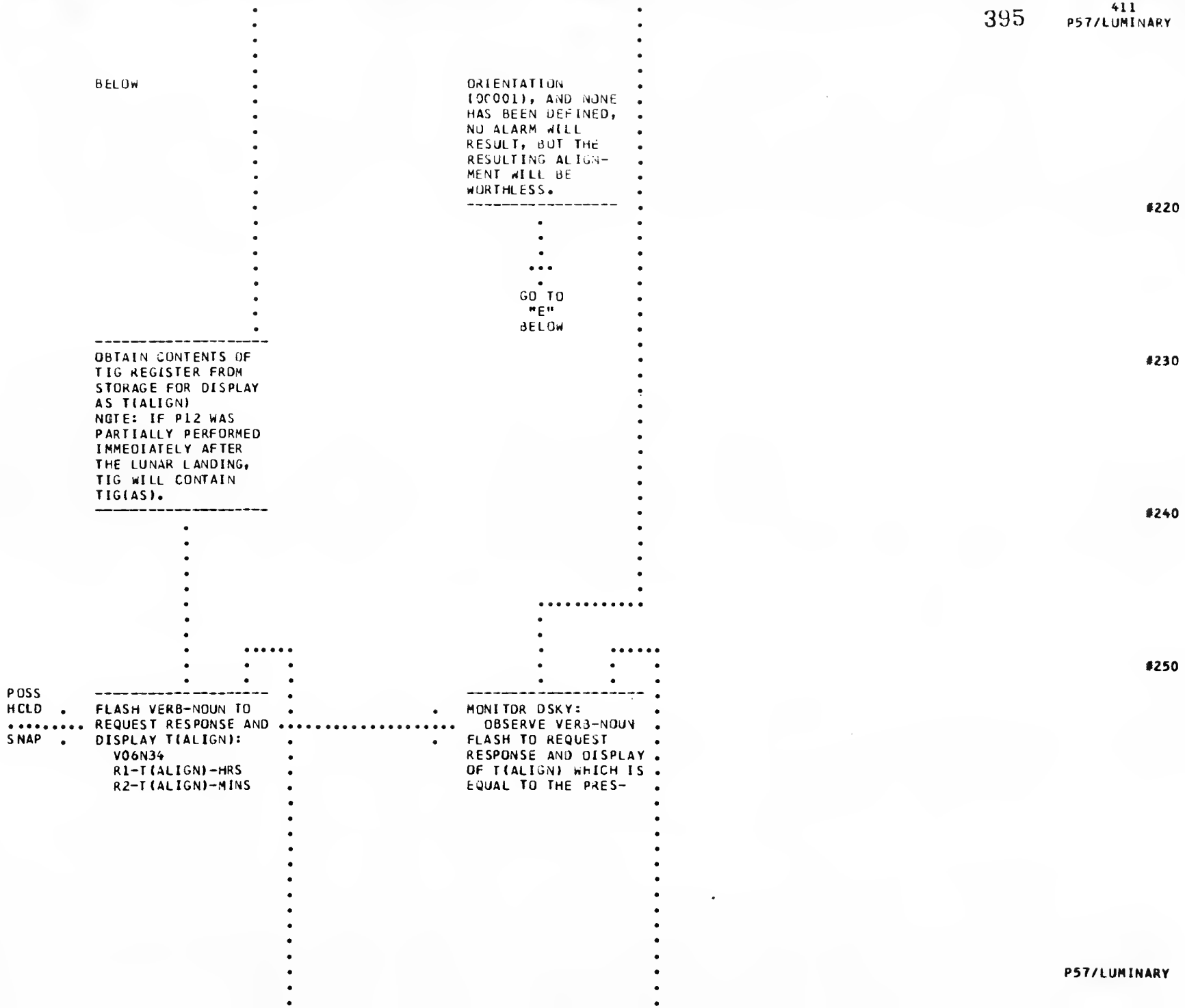
#130

#140

#150

#160


IS THE LGC ASSUMED OPTION = 00002?
N
Y
#170
IS THE LGC ASSUMED OPTION = 00003?
Y
N
DEFINE THE DESIRED IMU ORIENTATION TO BE REFSMMAT.
GO TO "E" BELOW
#180
IS THE LGC ASSUMED OPTION = 00001?
Y
N
GO TO "E"
#190
WAS THE REFSMMAT OPTION SELECTED?
Y
N
GO TO "E" BELOW
#200
WAS THE PREFERRED OPTION SELECTED?
Y
N
NOTE: IF CREW SELECTS ALIGNMENT TO A PREFERRED
#210


BELOW
ORIENTATION (OCOO1), AND NONE HAS BEEN DEFINED, NO ALARM WILL RESULT, BUT THE RESULTING ALIGN-MENT WILL BE WORTHLESS.
GO TO "E" BELOW
#220
OBTAIN CONTENTS OF TIG REGISTER FROM STORAGE FOR DISPLAY AS T(ALIGN)
NOTE: IF P12 WAS PARTIALLY PERFORMED IMMEDIATELY AFTER THE LUNAR LANDING, TIG WILL CONTAIN TIG(AS).
#230
#240
#250
POSS HOLD
SNAP
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY T(ALIGN):
V06N34
R1-T(ALIGN)-HRS
R2-T(ALIGN)-MINS
MONITOR DSKY:
OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY OF T(ALIGN) WHICH IS EQUAL TO THE PRES-

R3-T(ALIGN)-SECS

T(ALIGN)-TIME(GET) AT WHICH LM POSITION VECTOR IS DEFINED FOR A LANDING SITE ORIENTATION. IN HRS MINS AND SECS TO NEAREST .01 SEC.

WAIT FOR KEYBOARD ENTRY

ENTLY DEFINED TIG (AS).
(NOTE: IT IS ASSUMED THAT P12 WAS PARTIALLY PERFORMED IMMEDIATELY AFTER THE LUNAR LANDING. AT THAT TIME TIG(AS) WAS DEFINED.)

IF T(ALIGN) IS DEFINED TO BE 00000, C0000, 00000, THE LANDING SITE ORIENTATION WILL BE DEFINED FOR A

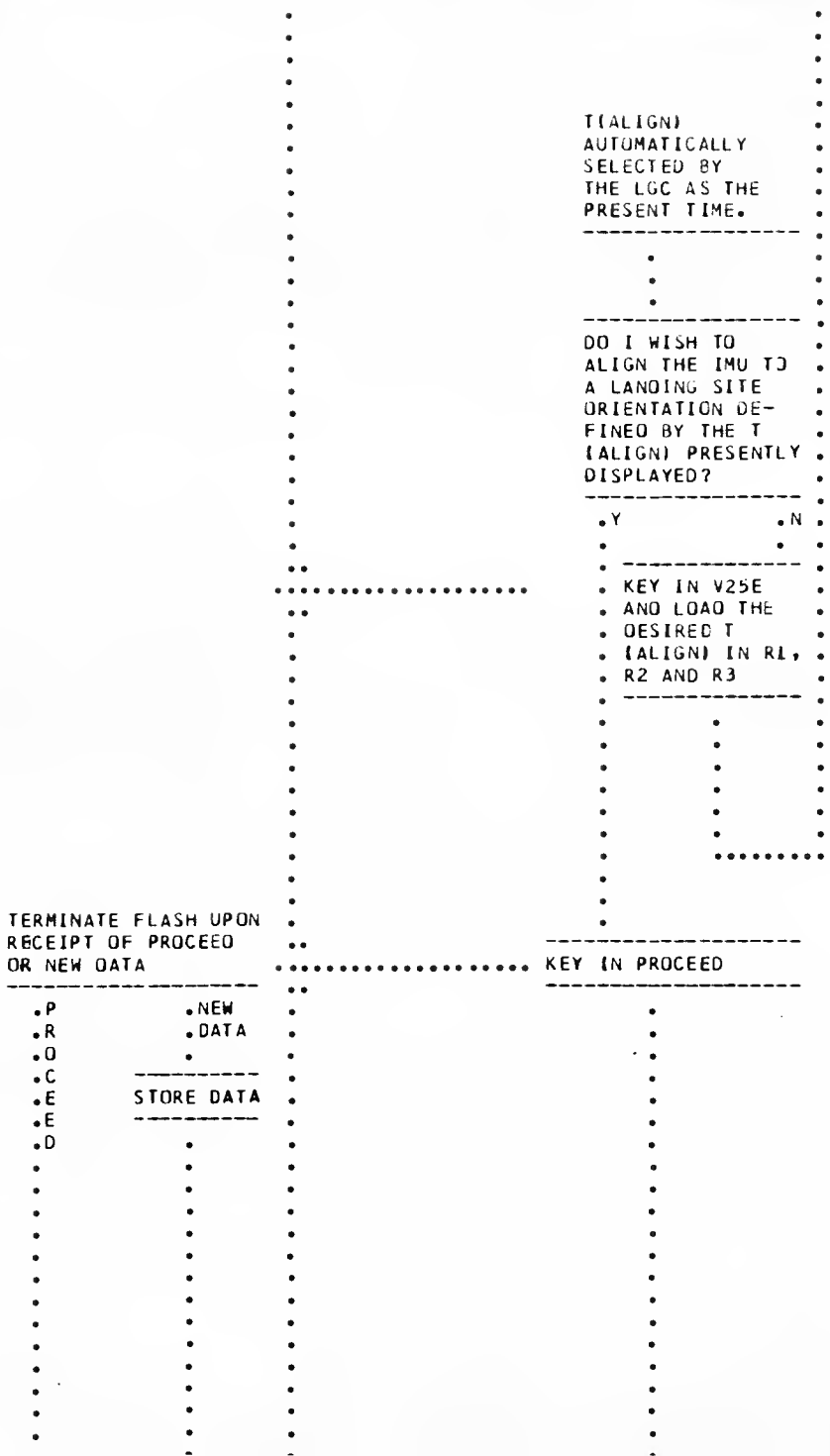
#260

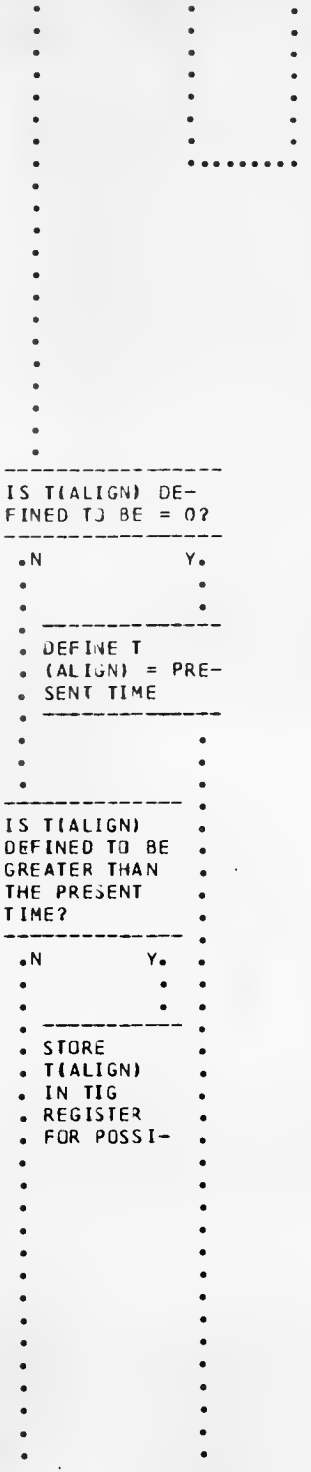
#270

#280

#290

#300


T(ALIGN) AUTOMATICALLY SELECTED BY THE LGC AS THE PRESENT TIME.
#310
DO I WISH TO ALIGN THE IMU TO A LANDING SITE ORIENTATION DE-FINED BY THE T (ALIGN) PRESENTLY DISPLAYED?
#320
Y
N
KEY IN V25E AND LOAD THE DESIRED T (ALIGN) IN R1, R2 AND R3
#330
#340
TERMINATE FLASH UPON RECEIPT OF PROCEED OR NEW DATA
KEY IN PROCEED
P
R
O
C
E
E
D
NEW DATA
STORE DATA
#350



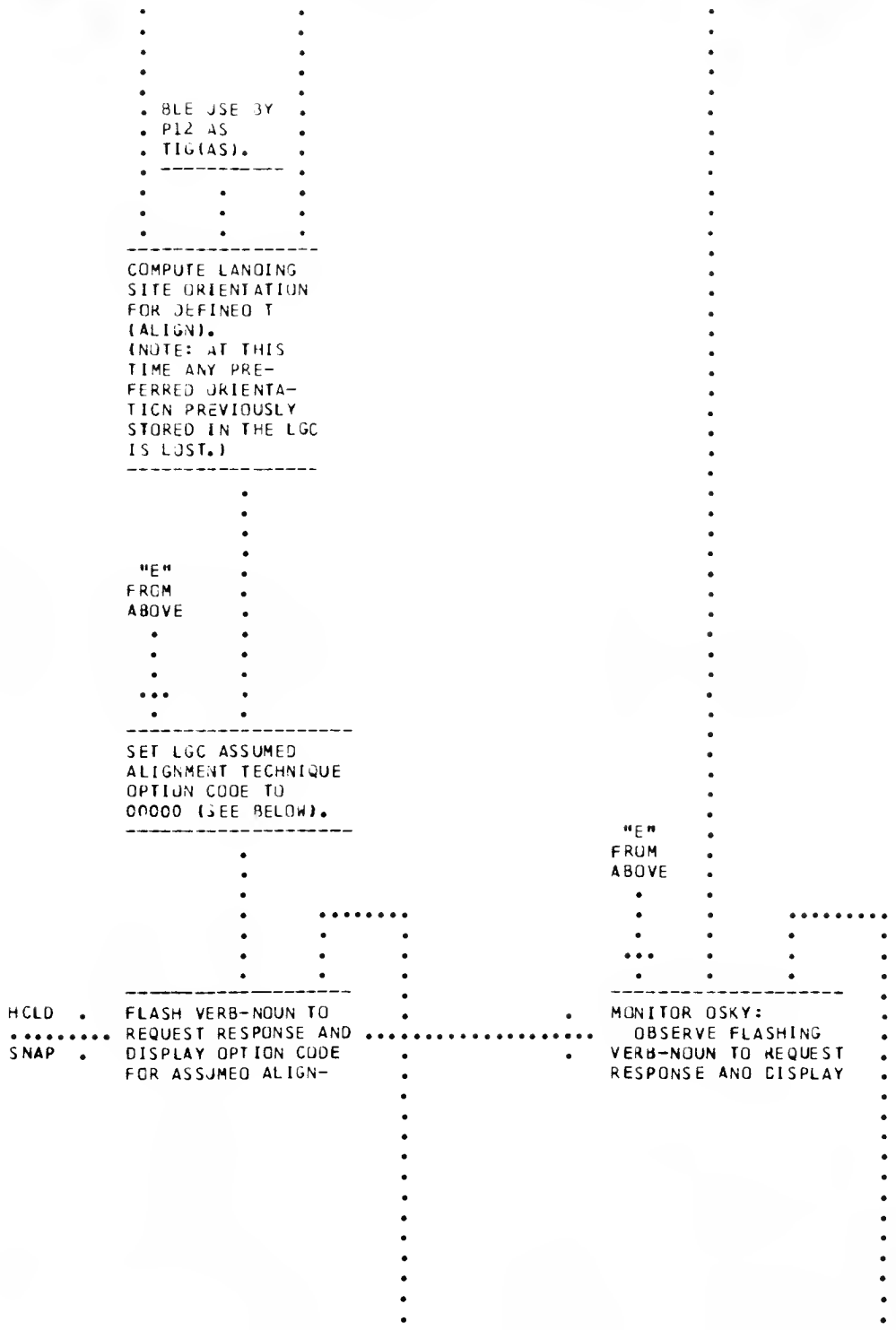
#360

#370

#380

#390

#400


BLE USE BY P12 AS TIG(AS).
COMPUTE LANDING SITE ORIENTATION FOR DEFINED T (ALIGN). (NOTE: AT THIS TIME ANY PREFERRED ORIENTATION PREVIOUSLY STORED IN THE LGC IS LOST.)
#410
#420
"E" FROM ABOVE
SET LGC ASSUMED ALIGNMENT TECHNIQUE OPTION CODE TO 00000 (SEE BELOW).
#430
"E" FROM ABOVE
#440
HOLD
SNAP
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY OPTION CODE FOR ASSUMED ALIGN-
MONITOR OSKY: OBSERVE FLASHING VERB-NOUN TO REQUEST RESPONSE AND DISPLAY

MENT TECHNIQUE TO BE EMPLOYED, AND STORED DATCODE:
V05N06
R1-00010
R2-00000
R3-00000

R1 IS THE OPTION CODE FOR ASSUMED ALIGNMENT TECHNIQUE TO BE EMPLOYED.

R2 IS THE LGC-ASSUMED ALIGNMENT TECHNIQUE OPTION CODE:

00000: TIME CRITICAL ANYTIME ALIGN TO THE DESIRED ORIENTATION PREVIOUSLY SELECTED USING STORED LM ATTITUDE WITH RESPECT TO THE LUNAR SURFACE OR PRESENT REFSMMAT.

00001-ALIGN TO THE DESIRED ORIENTATION PREVIOUSLY SELECTED USING PRESENT REFSMMAT (OR A STORED LM ATTITUDE WITH RESPECT TO THE LUNAR SURFACE) AND DETERMINATION OF THE LUNAR GRAVITY VECTOR.

00002-ALIGN TO THE DESIRED ORIENTATION PREVIOUSLY SEL-

OF OPTION CODE FOR ASSUMED ALIGNMENT TECHNIQUE TO BE EMPLOYED, AND STORED DATCODE.

THE PREREQUISITES FOR SELECTION OF AN ALIGNMENT TECHNIQUE OPTION CODE (R2) ARE AS FOLLOWS:

00000-(A)
00001-(A)
00002-(B)
00003-(C)

WHERE:

(A) A LM ATTITUDE WITH RESPECT TO THE LUNAR SURFACE OR REFSMMAT IS DEFINED. (REFER TO ASSUMPTION (4)(B) ABOVE.)

(B) TWO CELESTIAL BODIES ARE VISIBLE FOR SIGHTING (TWO NAV STARS/PLANETS, OR ONE NAV STAR/PLANET AND THE SUN).

(C) ONE CELESTIAL BODY IS VISIBLE FOR SIGHTING (NAV STAR/PLANET OR SUN).

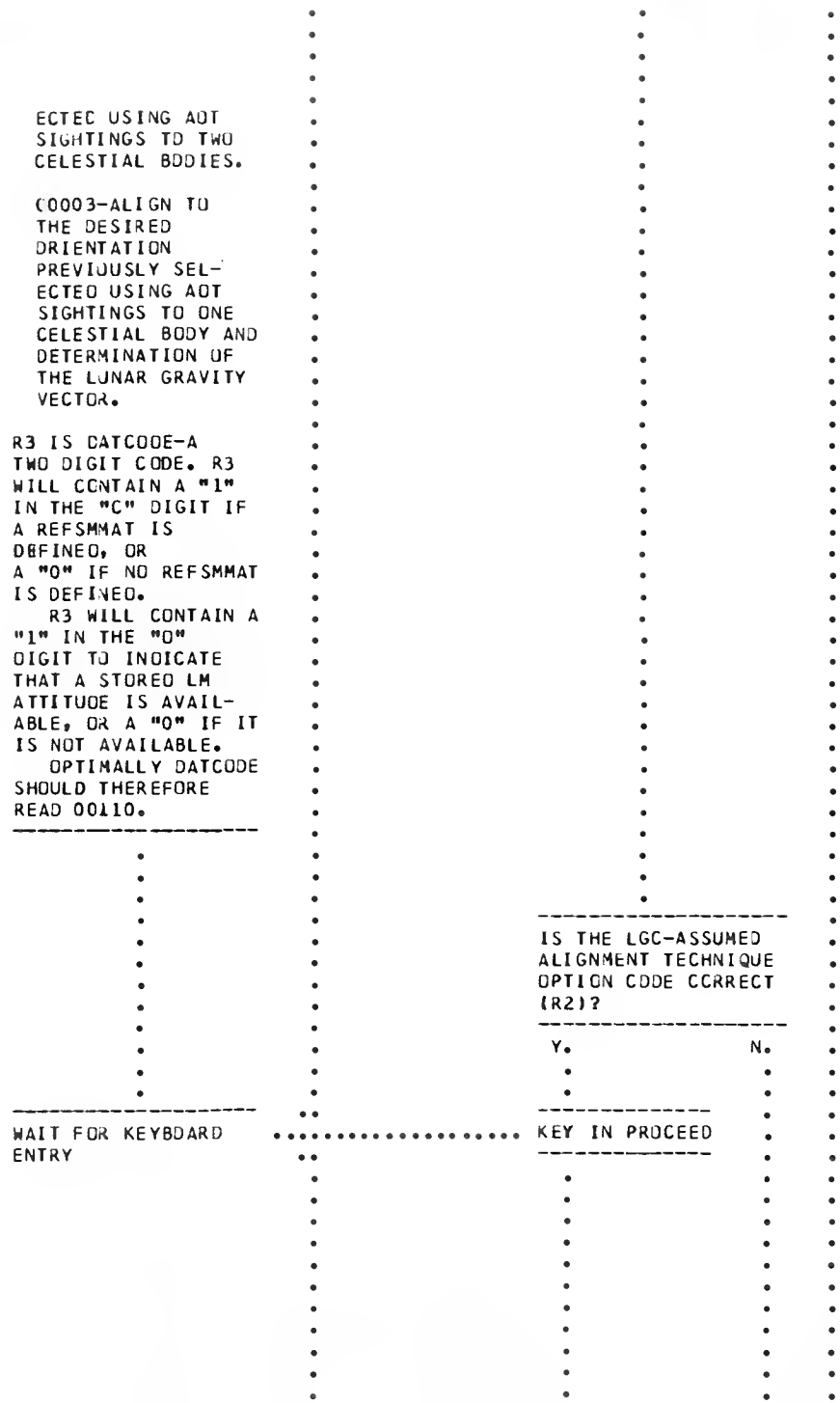
#450

#460

#470

#480

#490



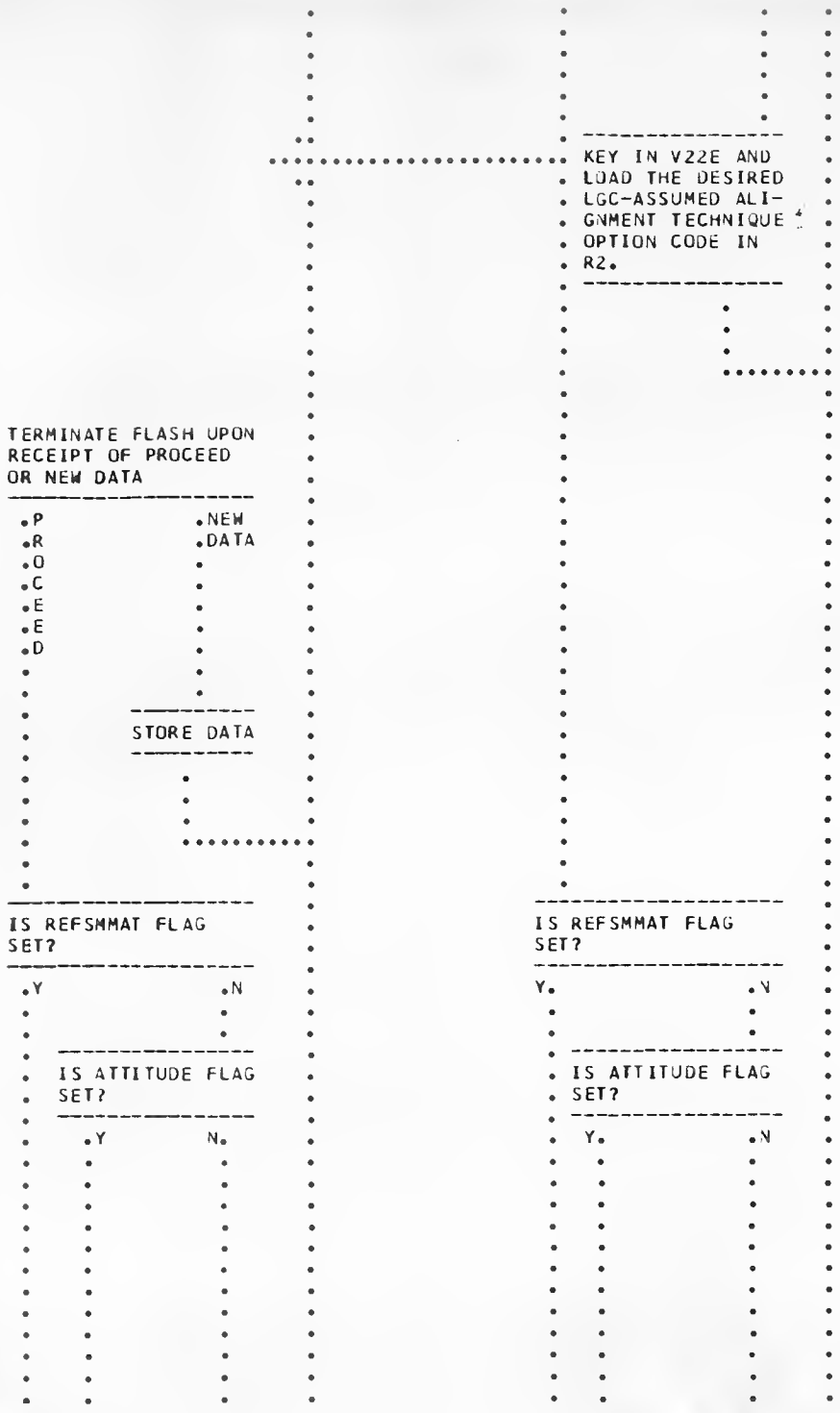
#500

#510

#520

#530

#540



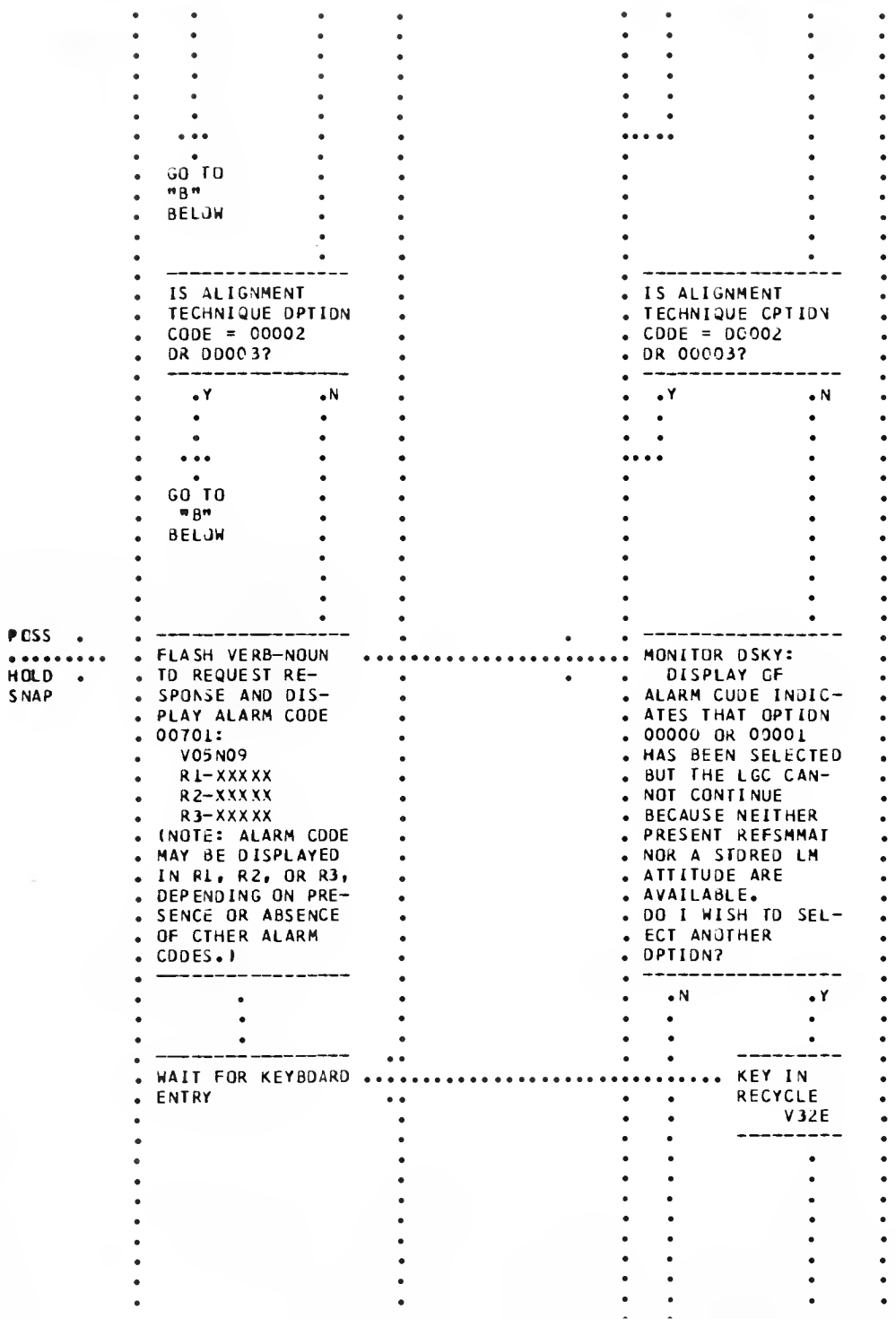
#550

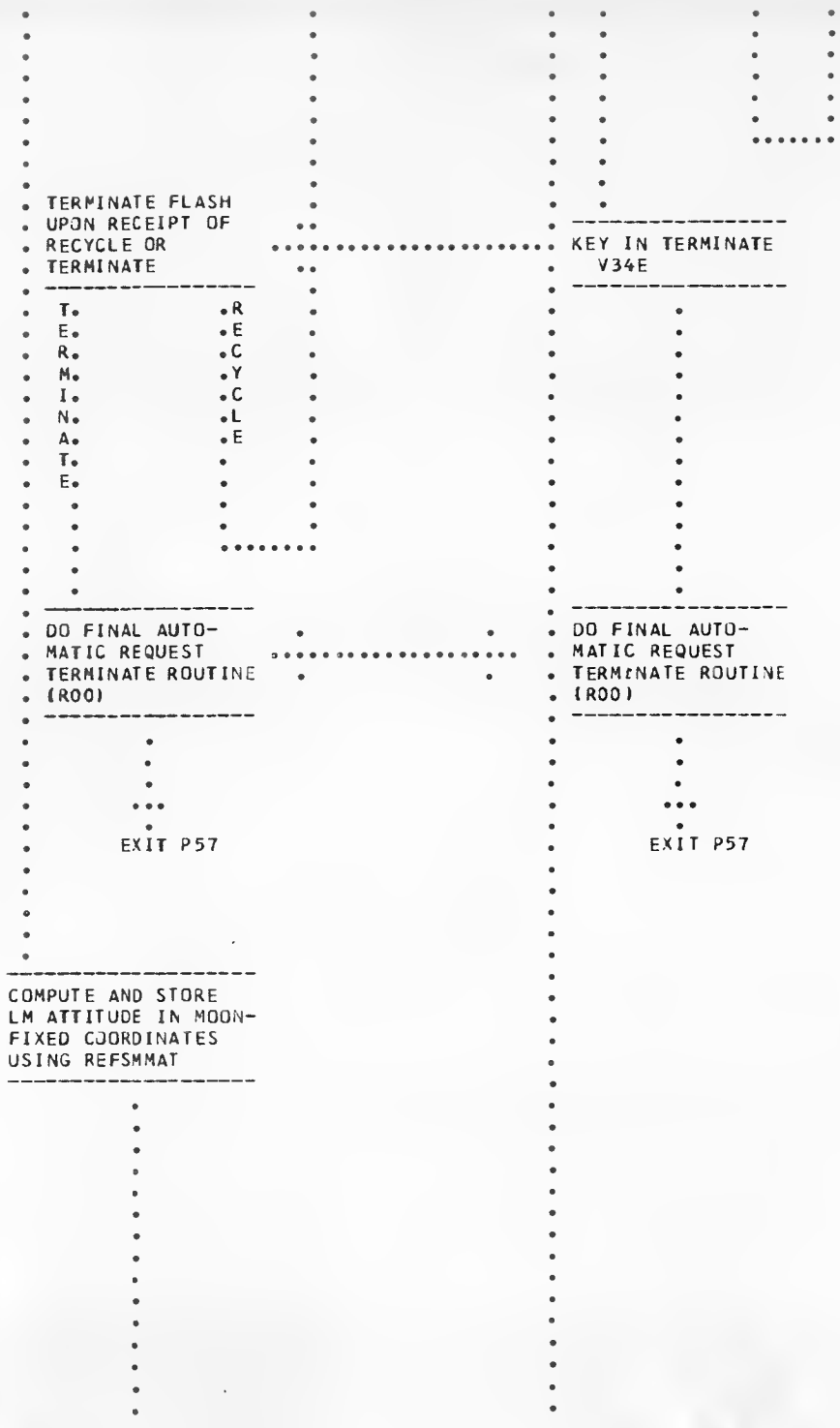
#560

#570

#580

#590


GO TO "B" BELOW
IS ALIGNMENT TECHNIQUE OPTION CODE = 00002 OR 00003?
.Y
.N
GO TO "B" BELOW
IS ALIGNMENT TECHNIQUE OPTION CODE = 00002 OR 00003?
.Y
.N
#600
#610
#620
POSS HOLD SNAP
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY ALARM CODE 00701:
V05N09
R1-XXXXX
R2-XXXXX
R3-XXXXX
(NOTE: ALARM CODE MAY BE DISPLAYED IN R1, R2, OR R3, DEPENDING ON PRESENCE OR ABSENCE OF OTHER ALARM CODES.)
MONITOR DSKY: DISPLAY OF ALARM CODE INDICATES THAT OPTION 00000 OR 00001 HAS BEEN SELECTED BUT THE LGC CANNOT CONTINUE BECAUSE NEITHER PRESENT REFSMMAT NOR A STORED LM ATTITUDE ARE AVAILABLE. DO I WISH TO SELECT ANOTHER OPTION?
.N
.Y
#630
#640
WAIT FOR KEYBOARD ENTRY
KEY IN RECYCLE V32E
#650

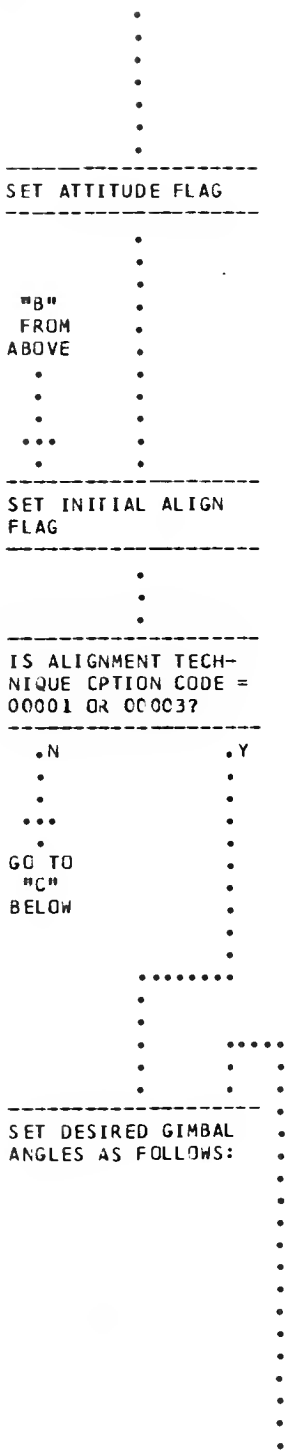


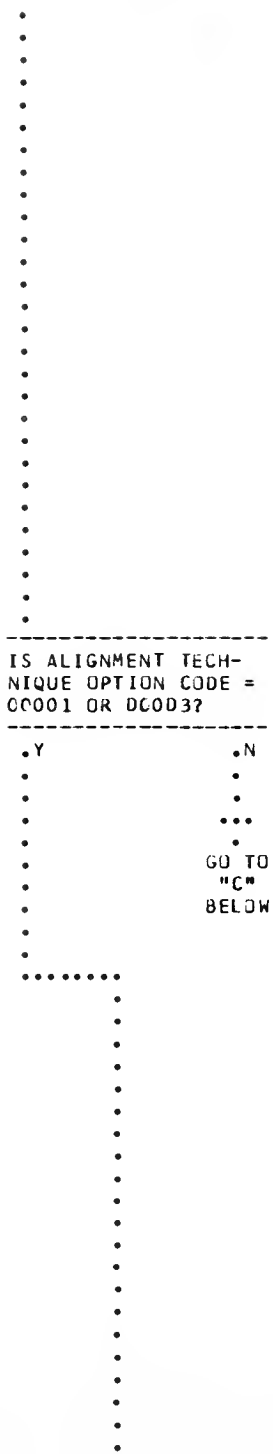
#660

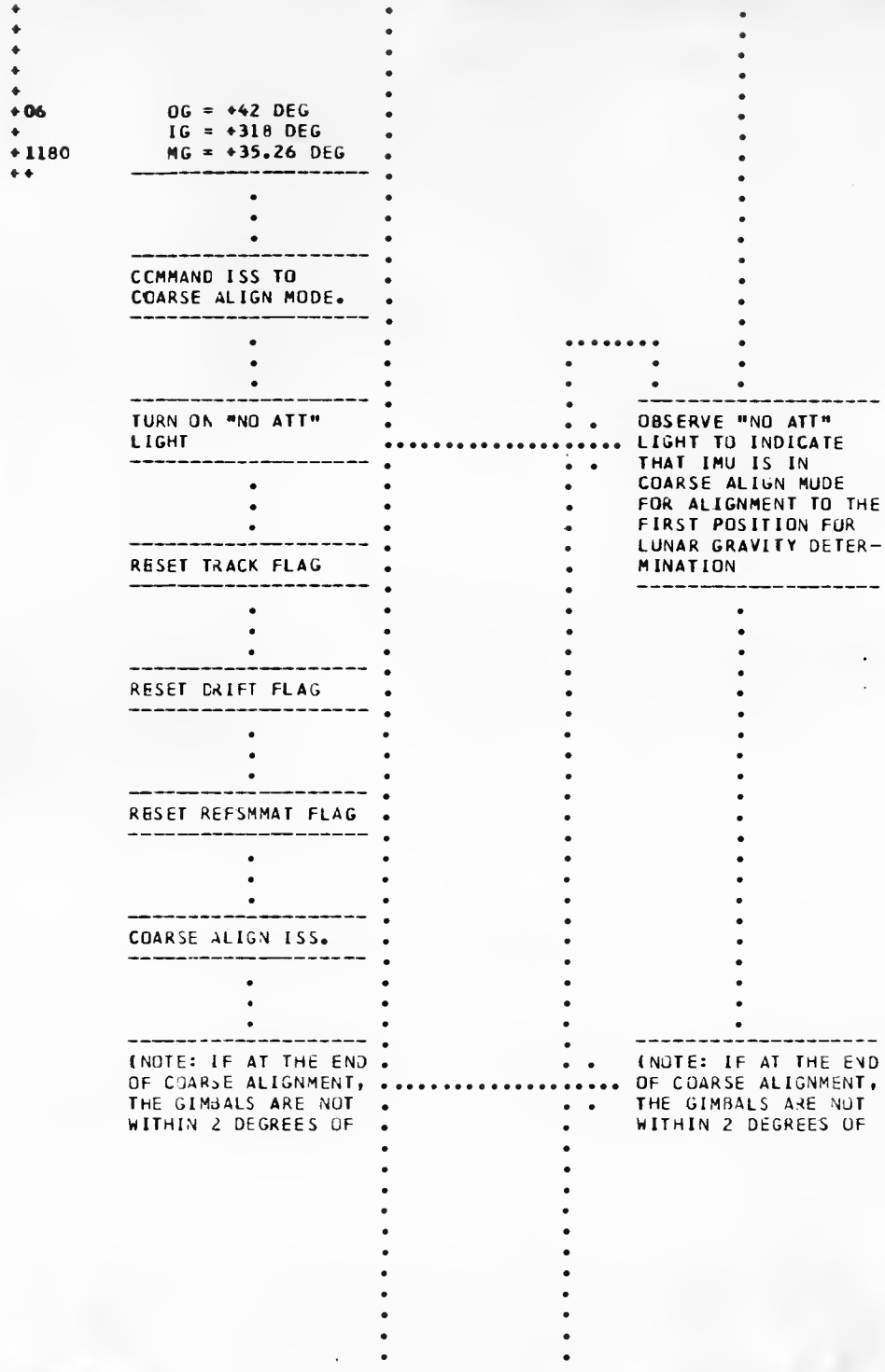
#670

#680

#690


SET ATTITUDE FLAG
"B" FROM ABOVE
SET INITIAL ALIGN FLAG
IS ALIGNMENT TECH-NIQUE OPTION CODE = 00001 OR 00003?
N
Y
GO TO "C" BELOW
SET DESIRED GIMBAL ANGLES AS FOLLOWS:


#70C
#710
#720
IS ALIGNMENT TECH-NIQUE OPTION CODE = 00001 OR 00003?
Y
N
#730
GO TO "C" BELOW
#740



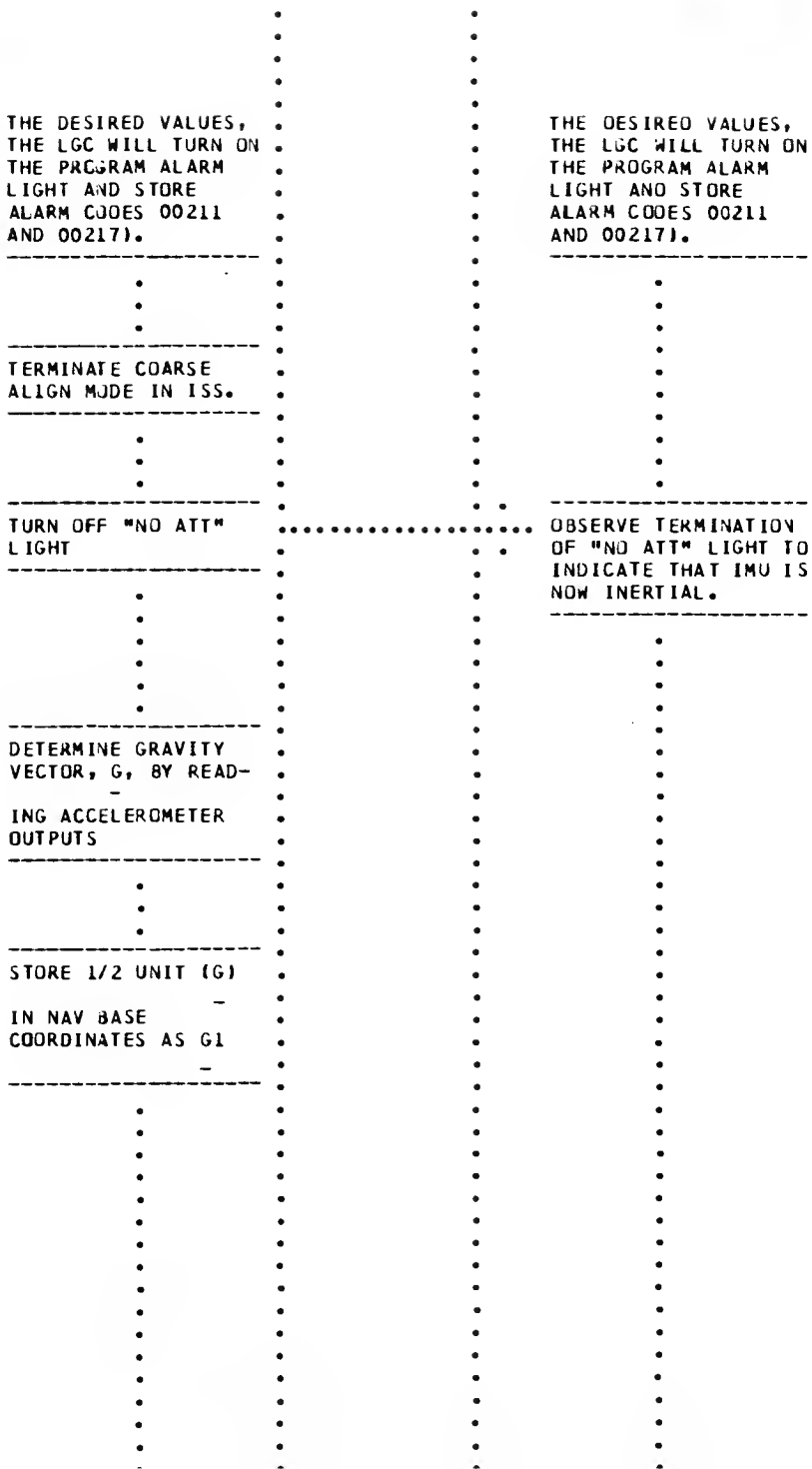
#750

#760

#770

#780

#790



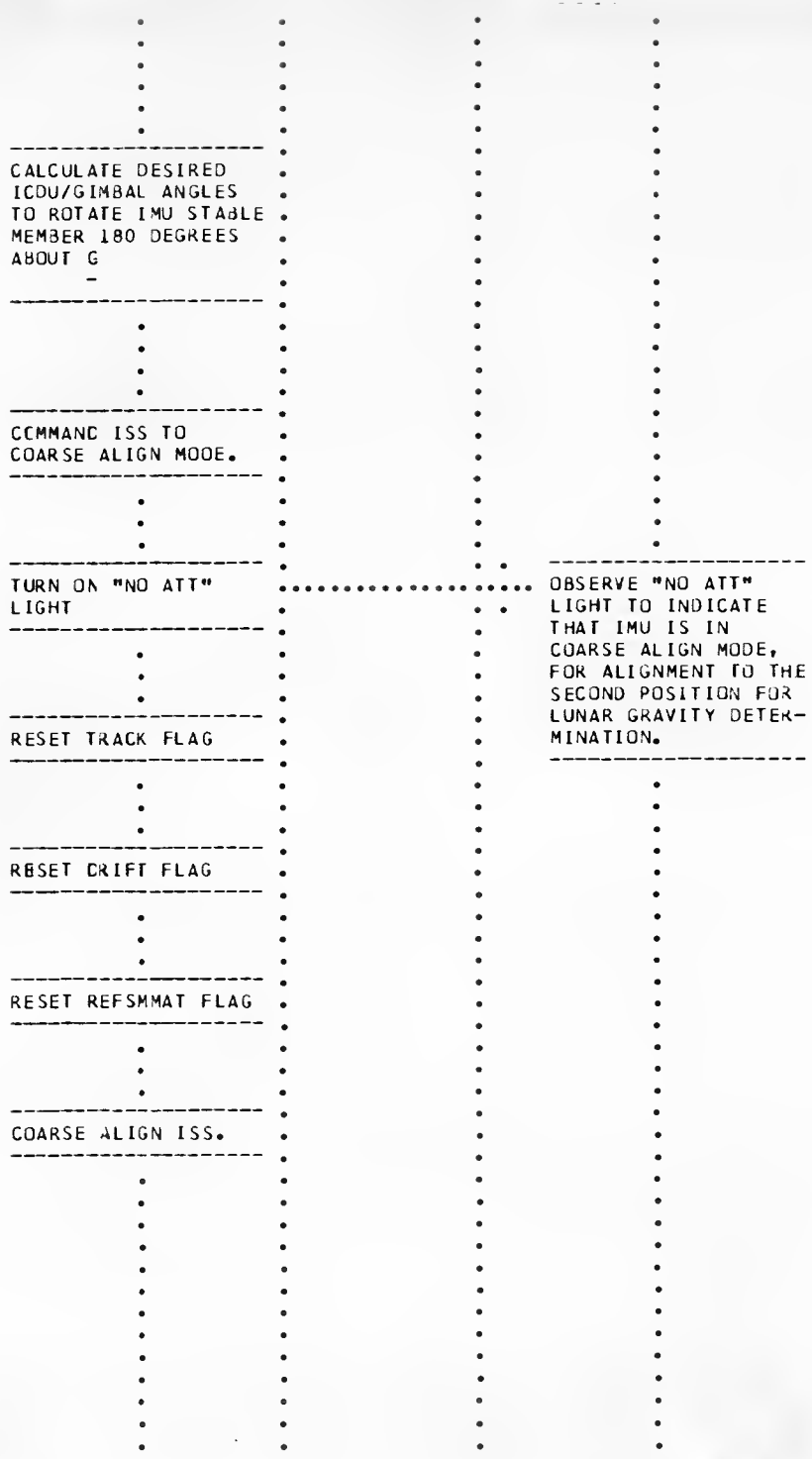
#800

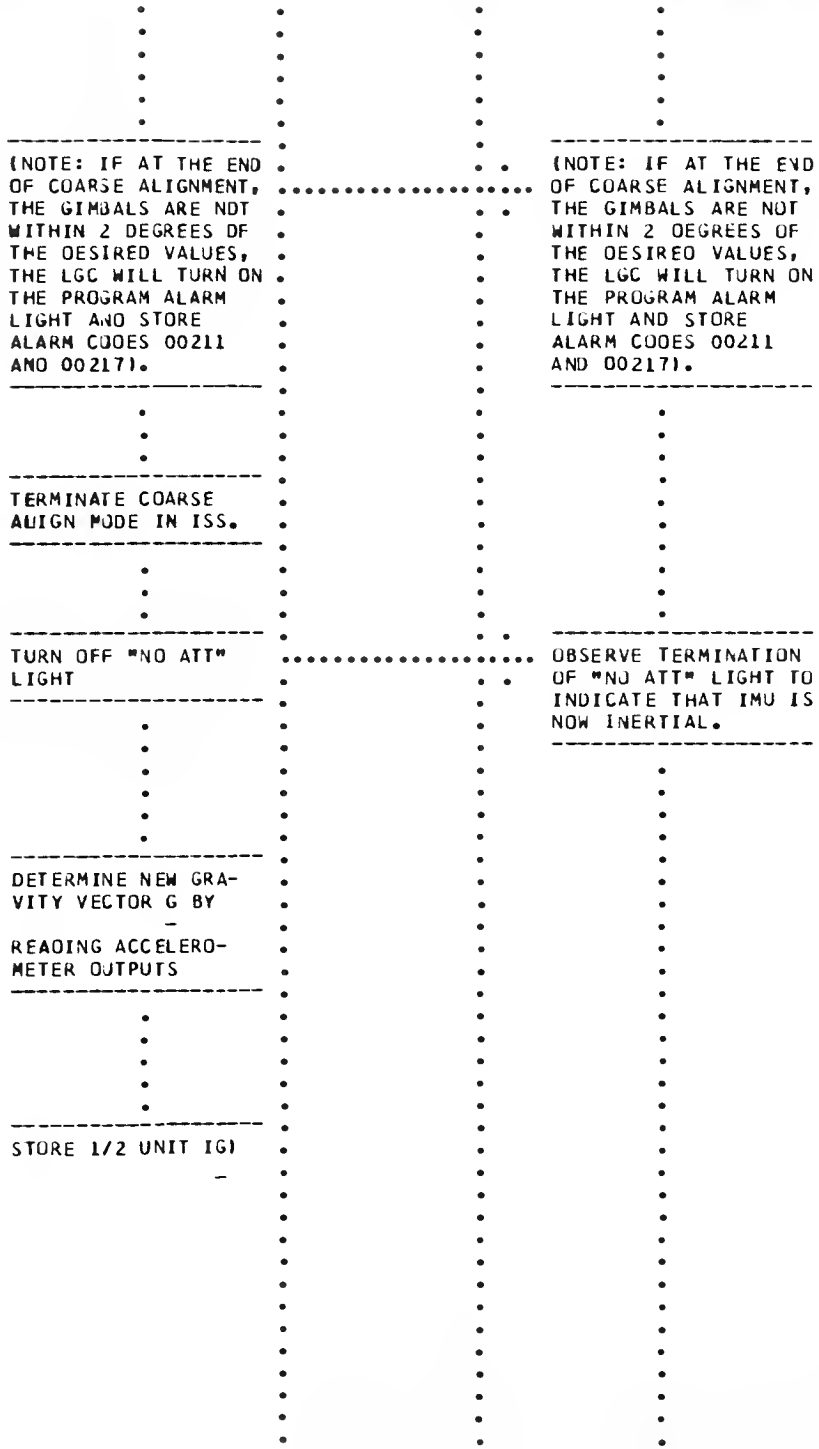
#810

#820

#830

#840


CALCULATE DESIRED ICDU/GIMBAL ANGLES TO ROTATE IMU STABLE MEMBER 180 DEGREES ABOUT G
#850
COMMAND ISS TO COARSE ALIGN MODE.
#860
TURN ON "NO ATT" LIGHT
OBSERVE "NO ATT" LIGHT TO INDICATE THAT IMU IS IN COARSE ALIGN MODE, FOR ALIGNMENT TO THE SECOND POSITION FOR LUNAR GRAVITY DETERMINATION.
#870
RESET TRACK FLAG
RESET DRIFT FLAG
#880
RESET REFSMMAT FLAG
COARSE ALIGN ISS.
#890



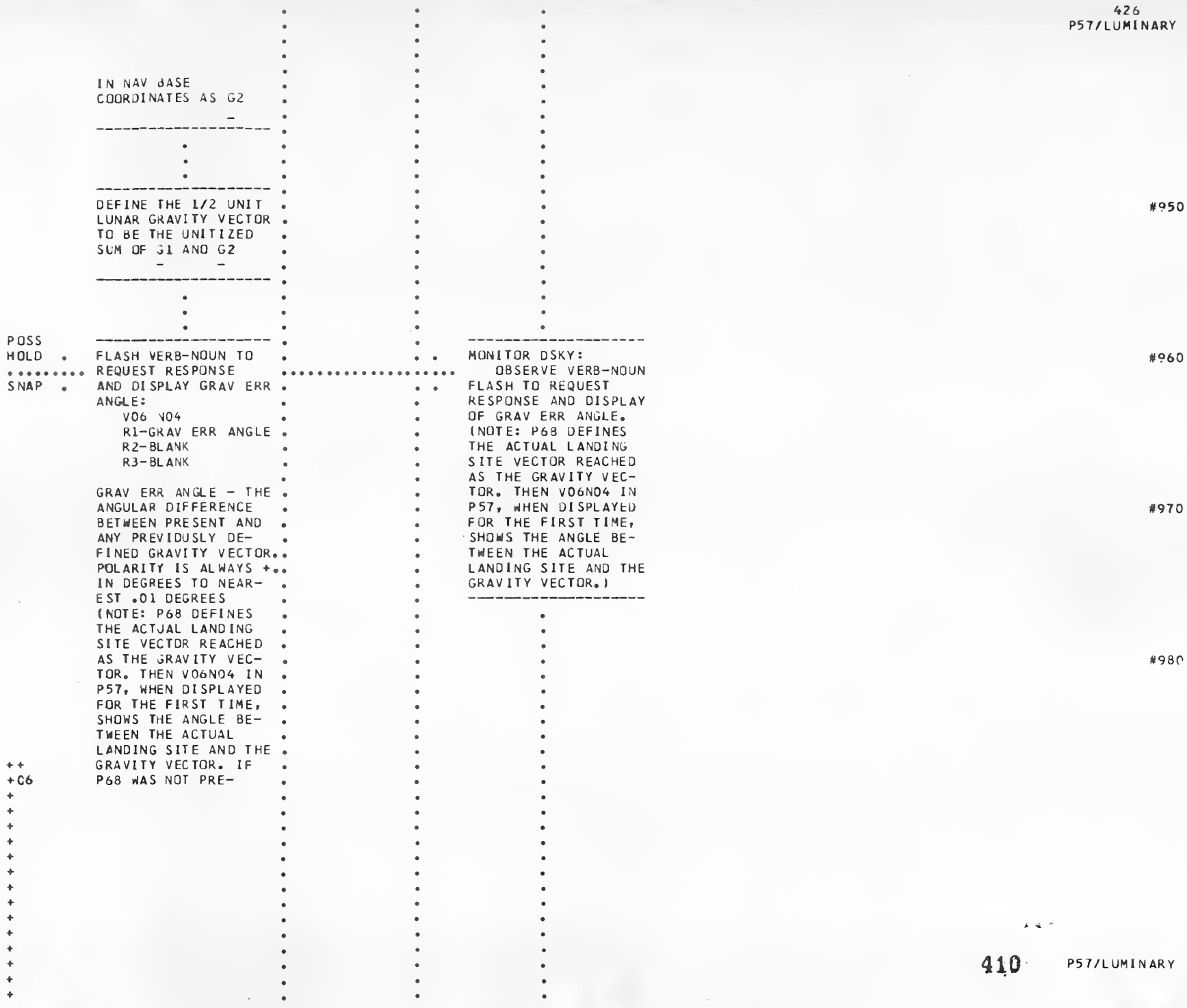
#900

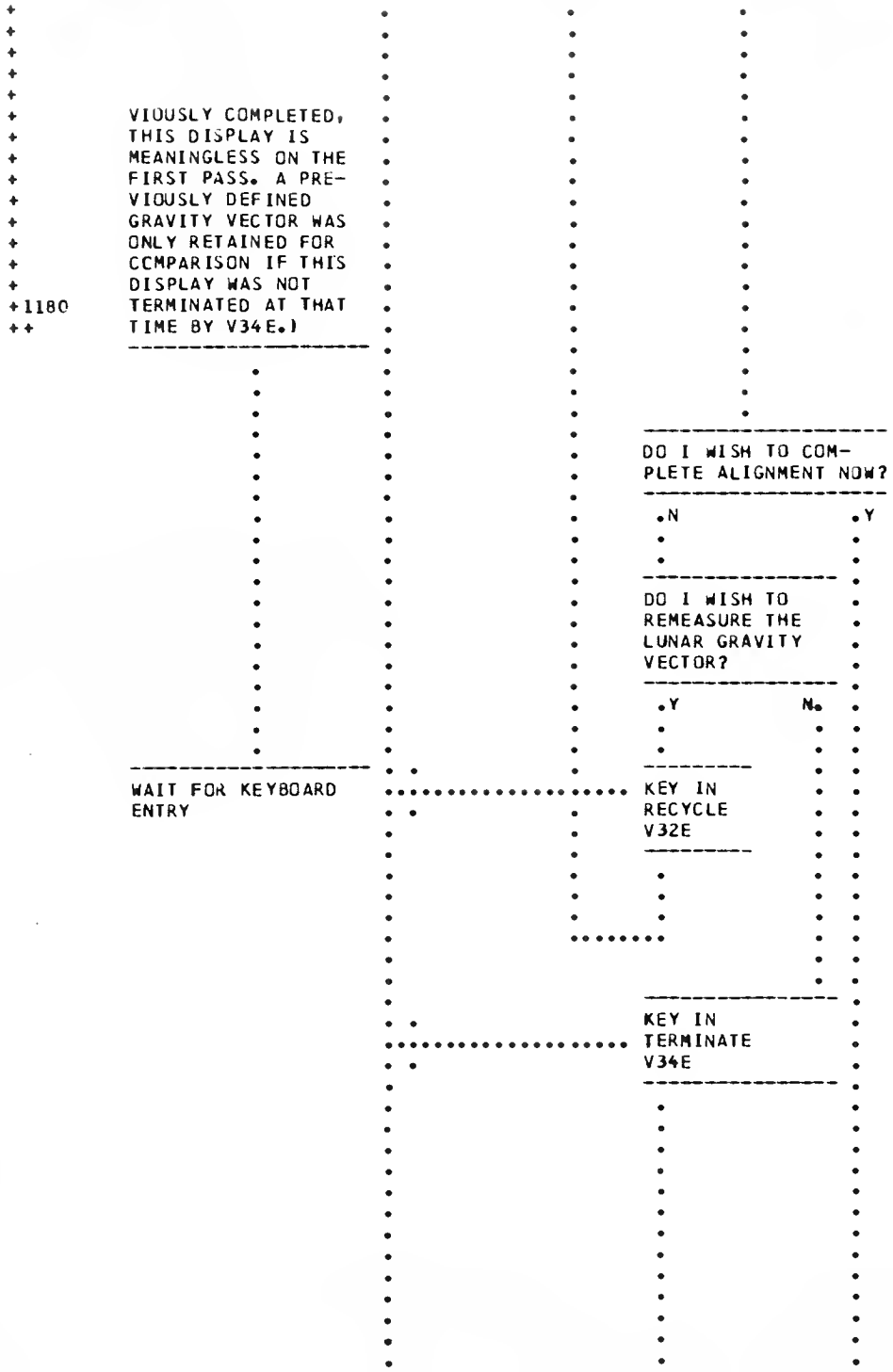
#910

#920

#930

#940


IN NAV BASE
COORDINATES AS G2
DEFINE THE 1/2 UNIT
LUNAR GRAVITY VECTOR
TO BE THE UNITIZED
SUM OF G1 AND G2
POSS
HOLD
SNAP
FLASH VERB-NOUN TO
REQUEST RESPONSE
AND DISPLAY GRAV ERR
ANGLE:
V06 N04
R1-GRAV ERR ANGLE
R2-BLANK
R3-BLANK
GRAV ERR ANGLE - THE
ANGULAR DIFFERENCE
BETWEEN PRESENT AND
ANY PREVIOUSLY DE-
FINED GRAVITY VECTOR.
POLARITY IS ALWAYS +
IN DEGREES TO NEAR-
EST .01 DEGREES
(NOTE: P68 DEFINES
THE ACTUAL LANDING
SITE VECTOR REACHED
AS THE GRAVITY VEC-
TOR. THEN V06N04 IN
P57, WHEN DISPLAYED
FOR THE FIRST TIME,
SHOWS THE ANGLE BE-
TWEEN THE ACTUAL
LANDING SITE AND THE
GRAVITY VECTOR. IF
P68 WAS NOT PRE-
MONITOR DSKY:
OBSERVE VERB-NOUN
FLASH TO REQUEST
RESPONSE AND DISPLAY
OF GRAV ERR ANGLE.
(NOTE: P68 DEFINES
THE ACTUAL LANDING
SITE VECTOR REACHED
AS THE GRAVITY VEC-
TOR. THEN V06N04 IN
P57, WHEN DISPLAYED
FOR THE FIRST TIME,
SHOWS THE ANGLE BE-
TWEEN THE ACTUAL
LANDING SITE AND THE
GRAVITY VECTOR.)
#950
#960
#970
#980



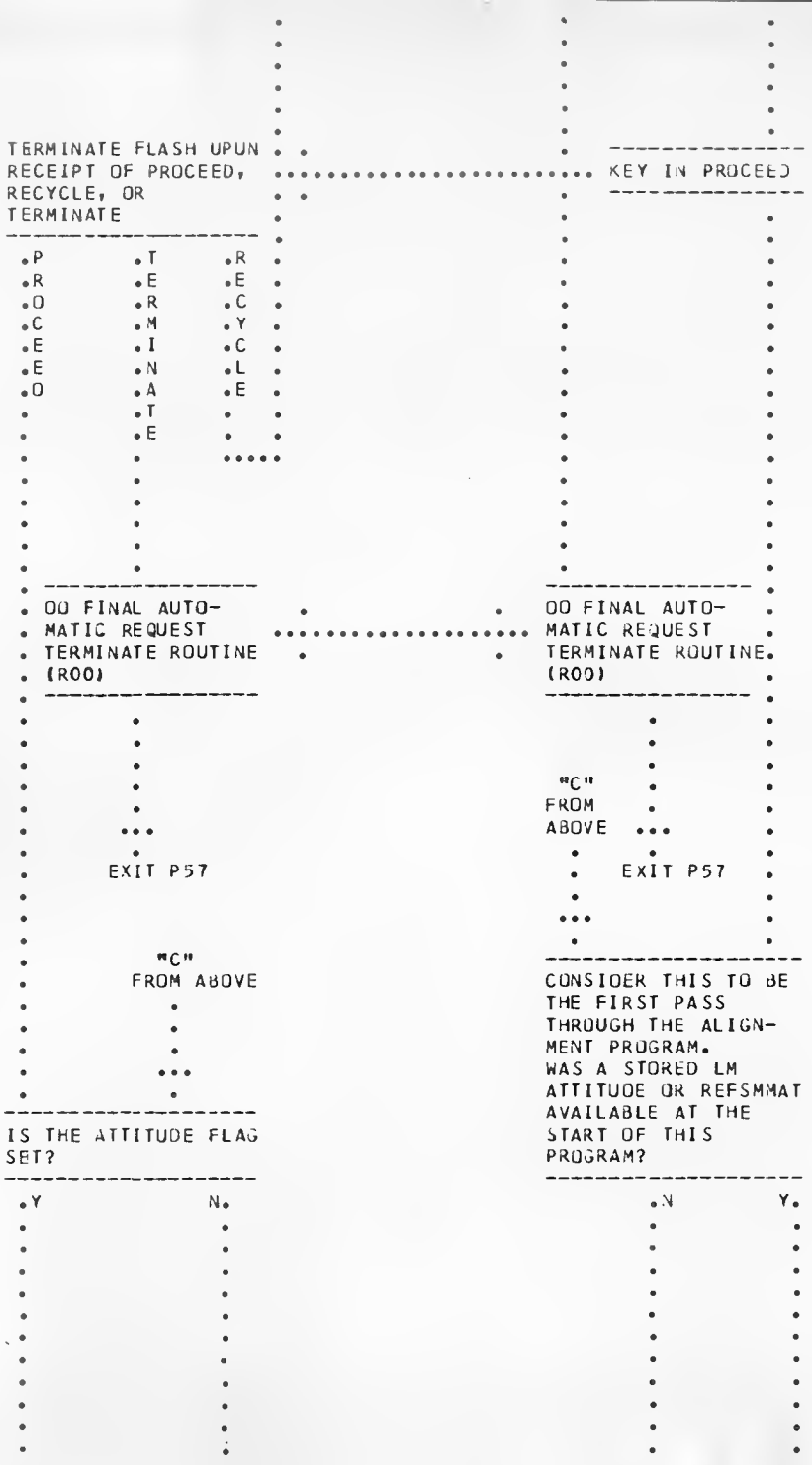
#990

#1000

#1010

#1020

#1030



#1040

#1050

#1060

#1070

#1080

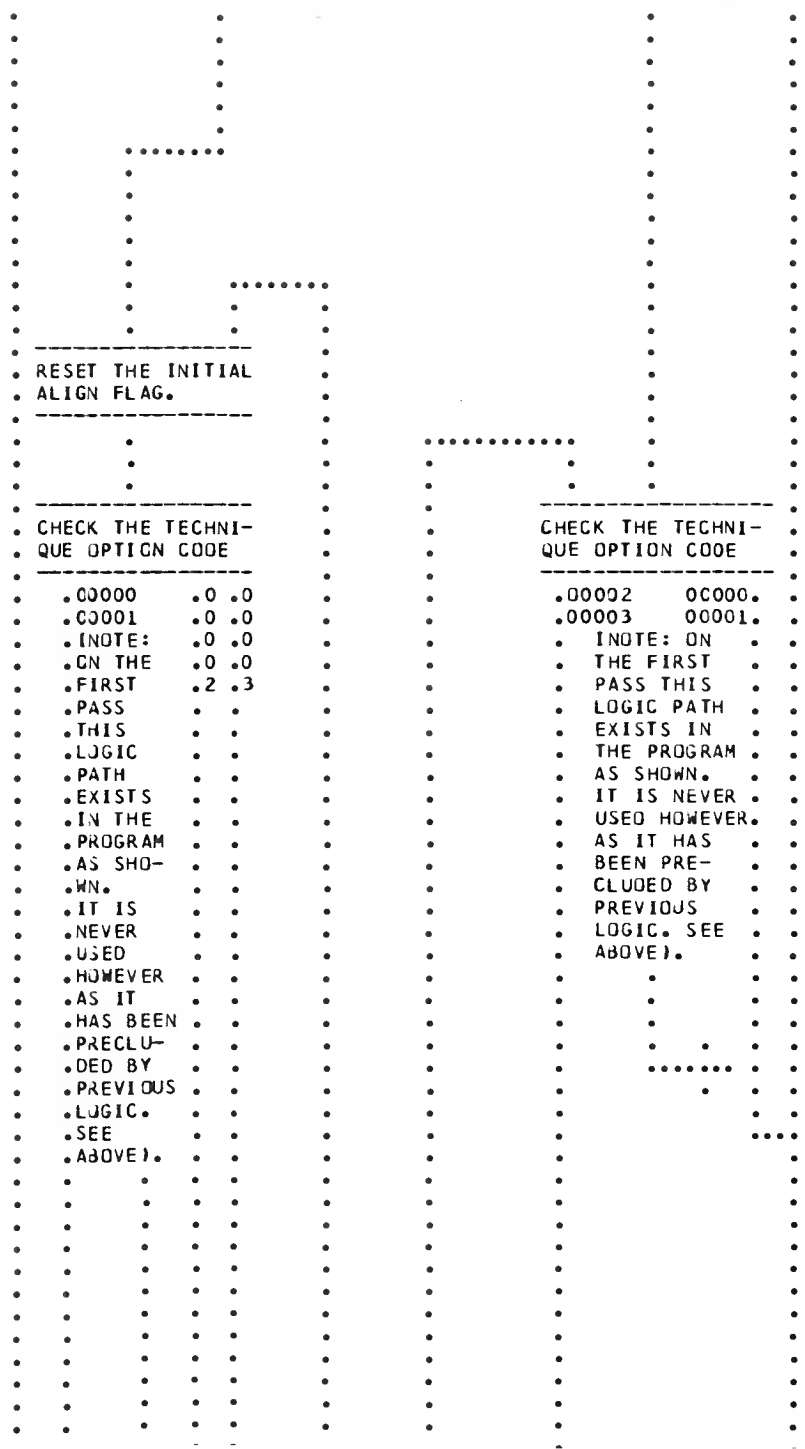
#1090

#1100

#1110

#1120

#1130



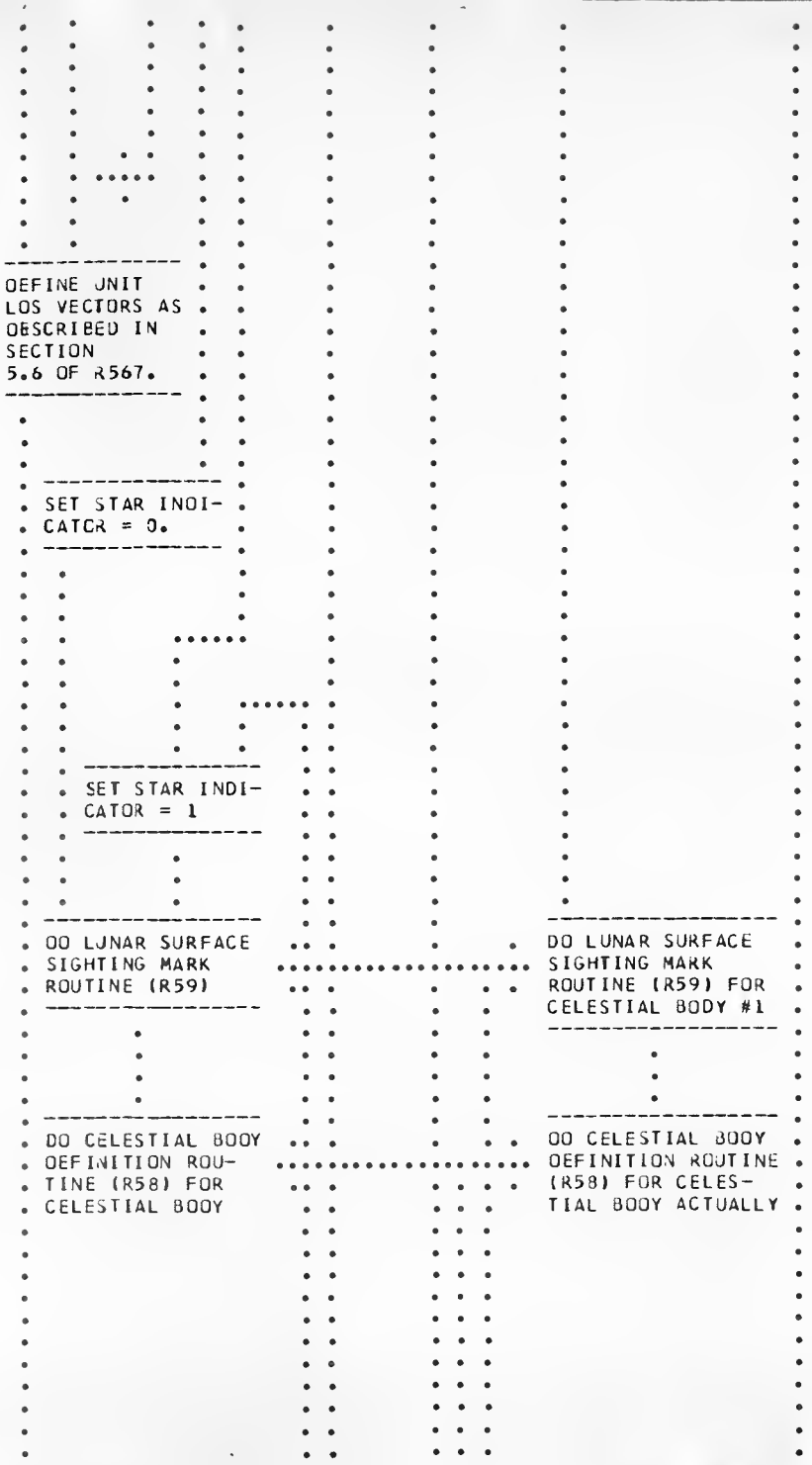
#1140

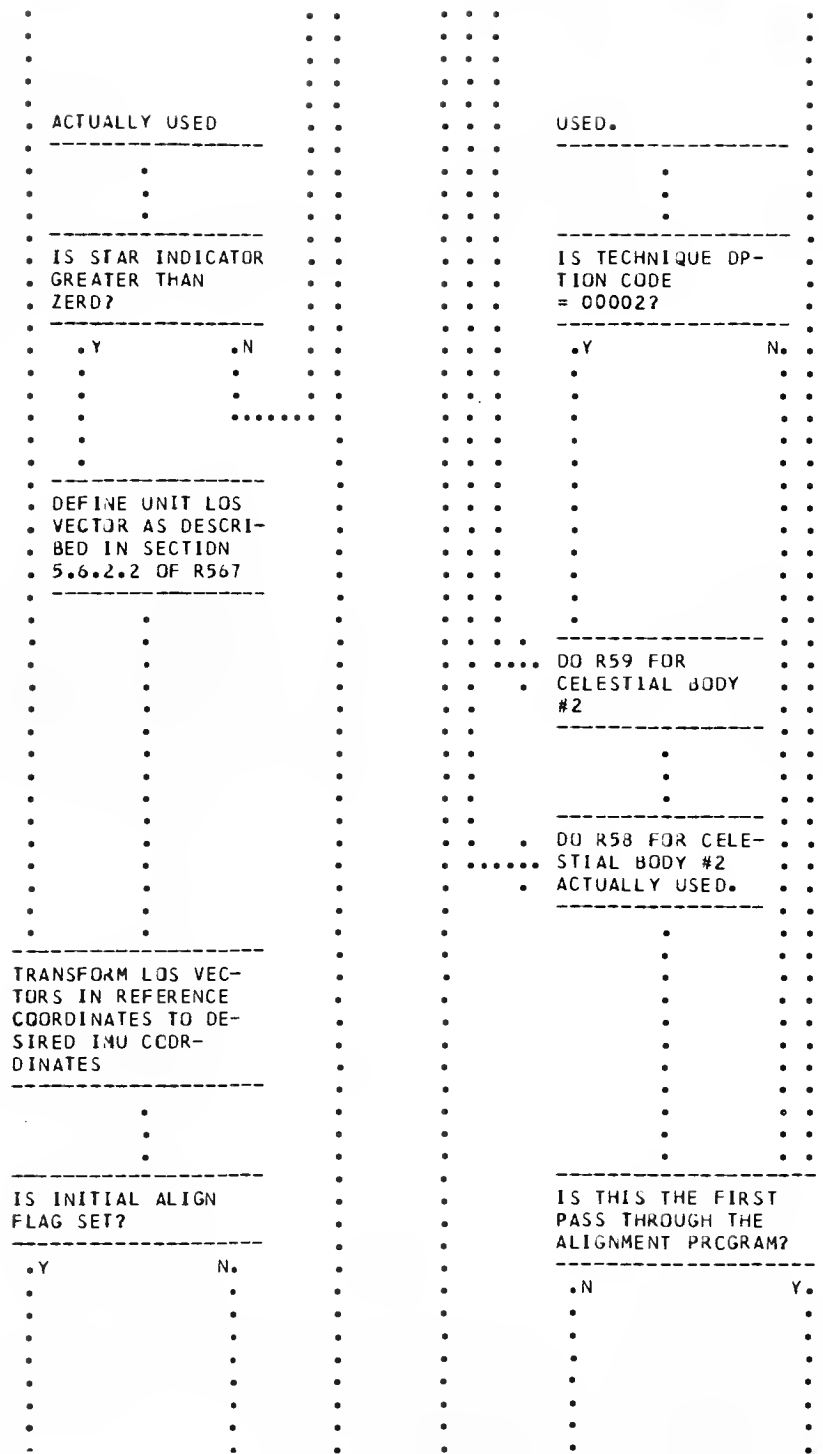
#1150

#1160

#1170

#1180





#1190

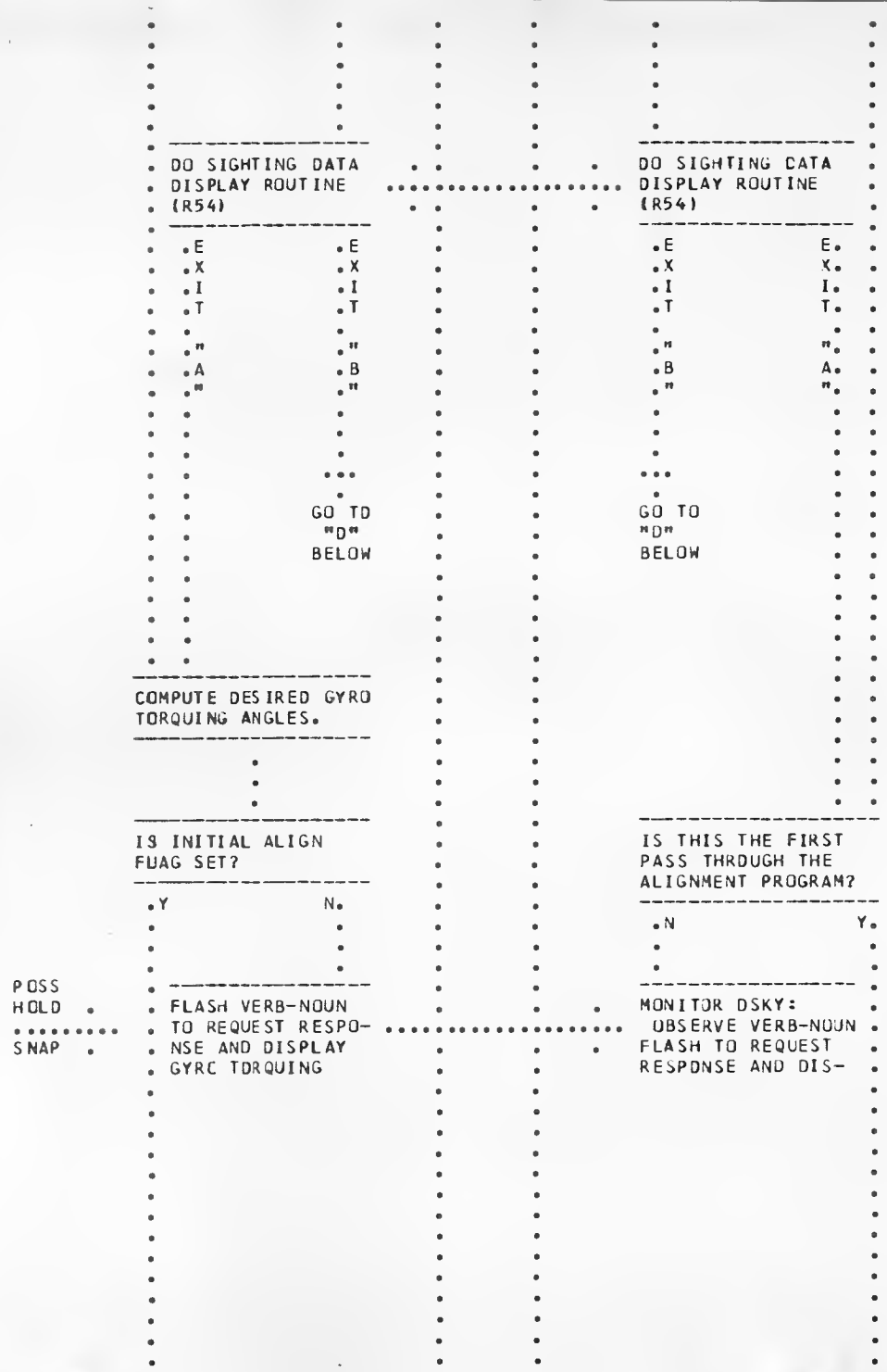
#1200

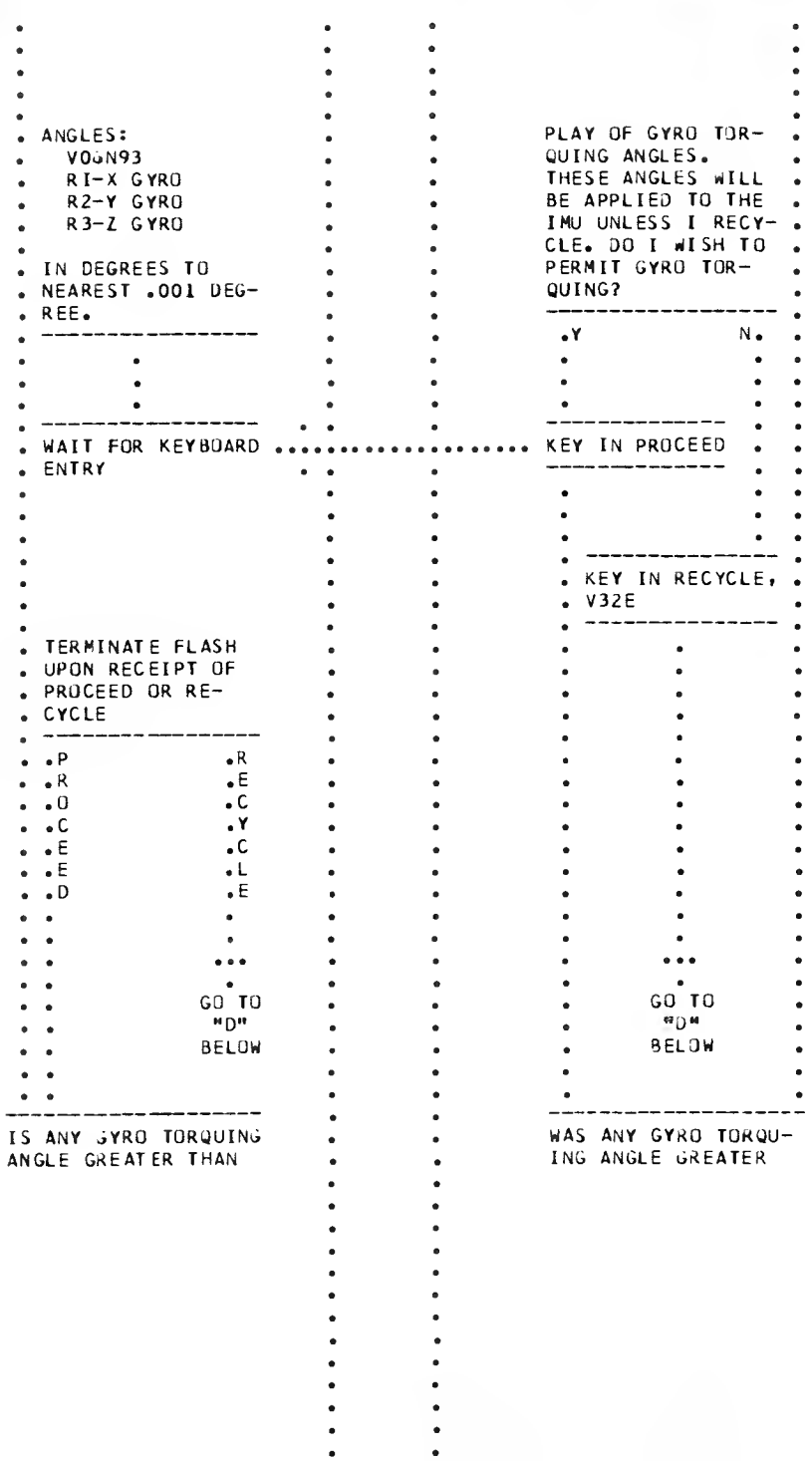
#1210

#1220

#1230

#1240


DO SIGHTING DATA DISPLAY ROUTINE (R54)
.E .X .I .T . ." A ."
GO TO "D" BELOW
DO SIGHTING DATA DISPLAY ROUTINE (R54)
.E .X .I .T . ." B ."
GO TO "D" BELOW
#1250
#1260
COMPUTE DESIRED GYRO TORQUING ANGLES.
#1270
IS INITIAL ALIGN FLAG SET?
.Y N.
IS THIS THE FIRST PASS THROUGH THE ALIGNMENT PROGRAM?
.N Y.
#1280
POSS HOLD . SNAP .
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY GYRO TORQUING
MONITOR DSKY: OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DIS-



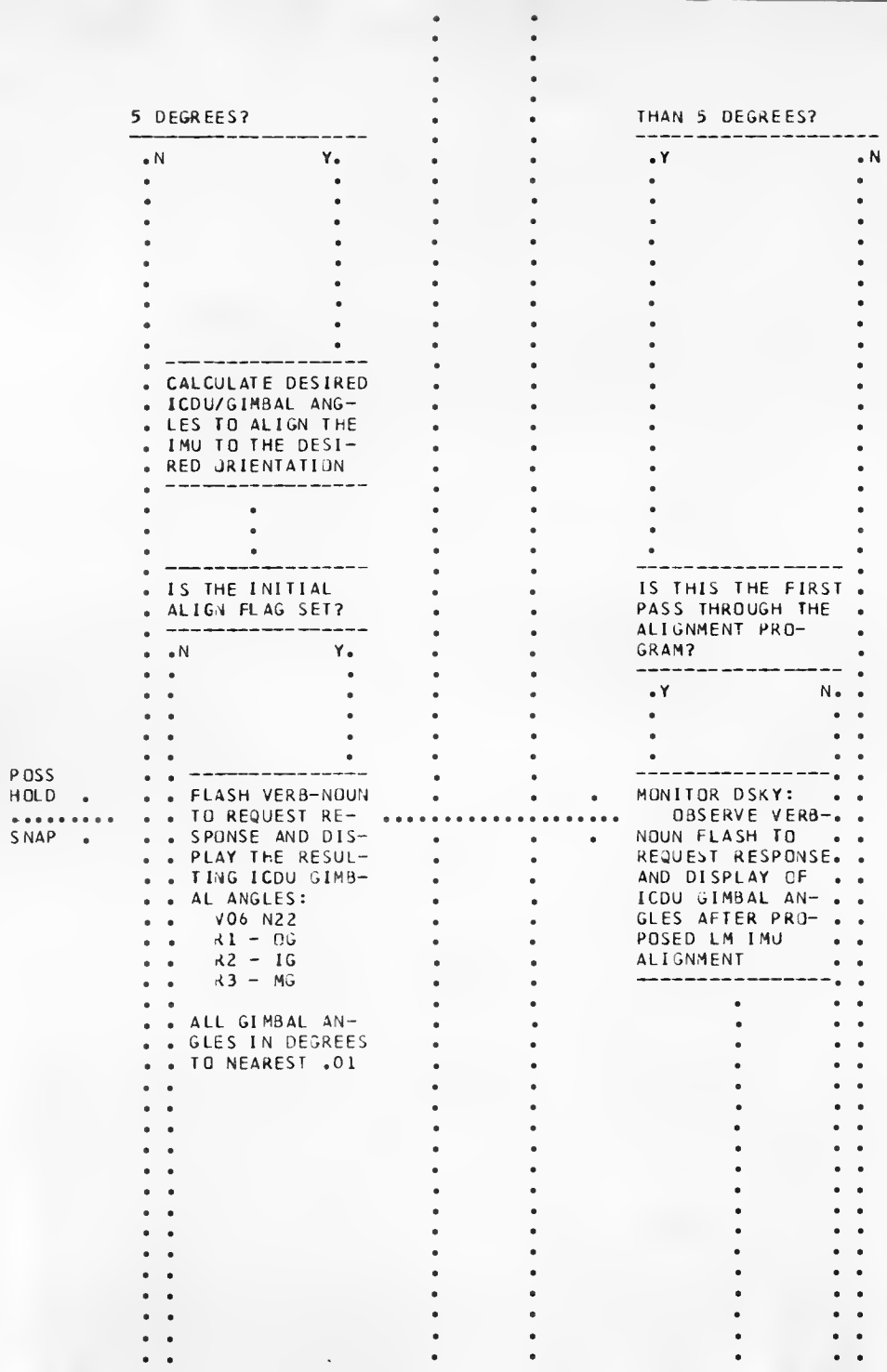
#1290

#1300

#1310

#1320

#1330



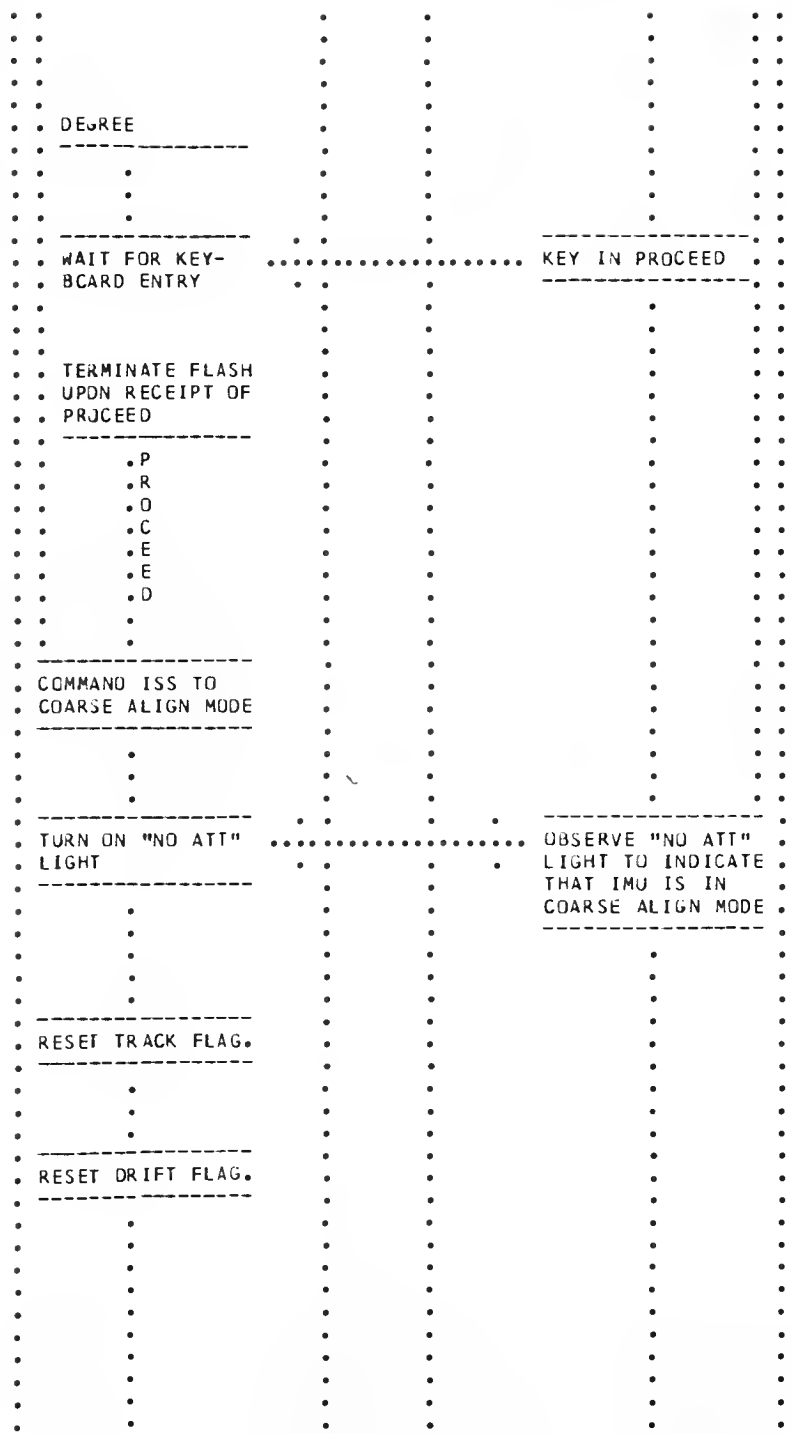
#1340

#1350

#1360

#1370

#1380



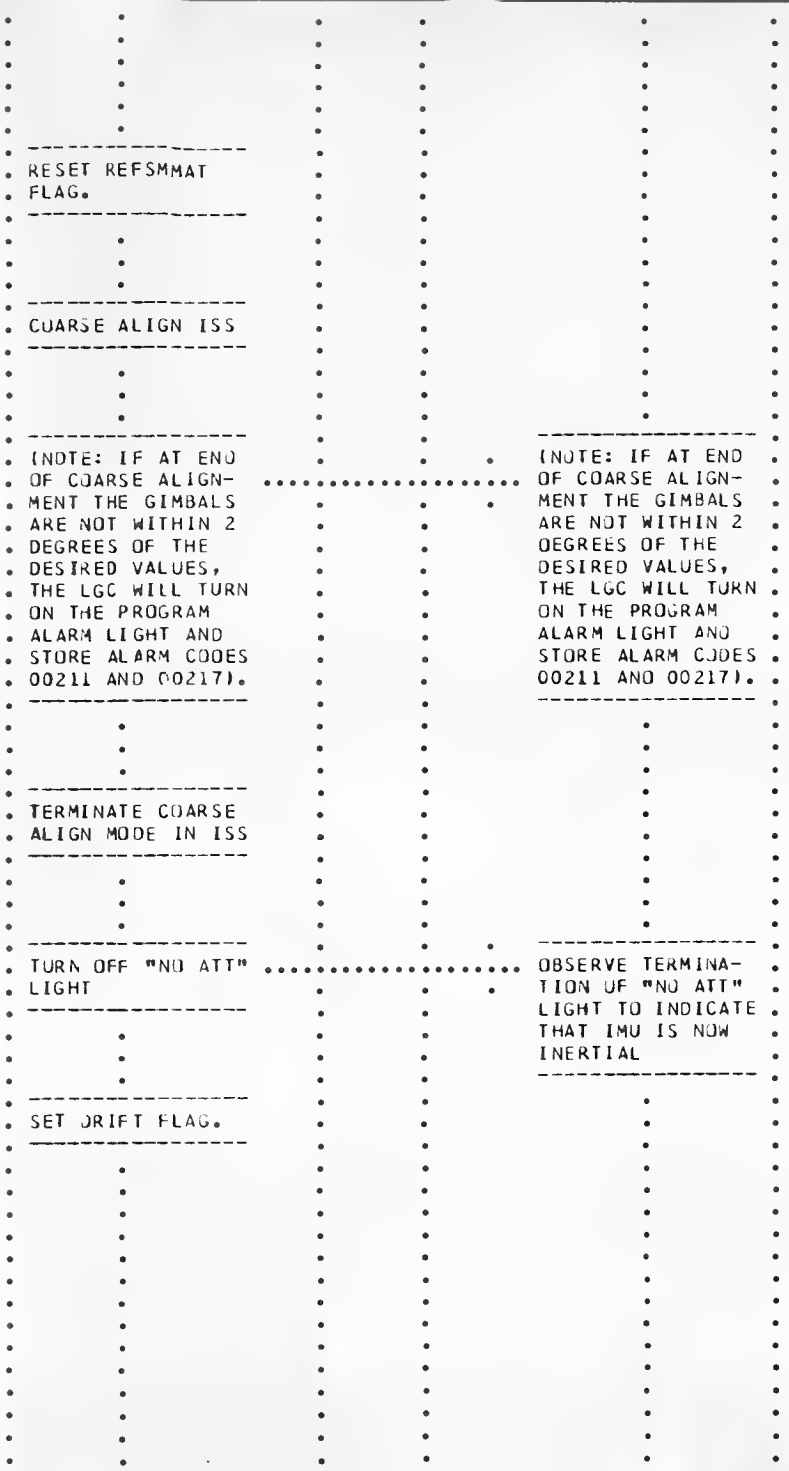
#1390

#1400

#1410

#1420

#1430



#1440

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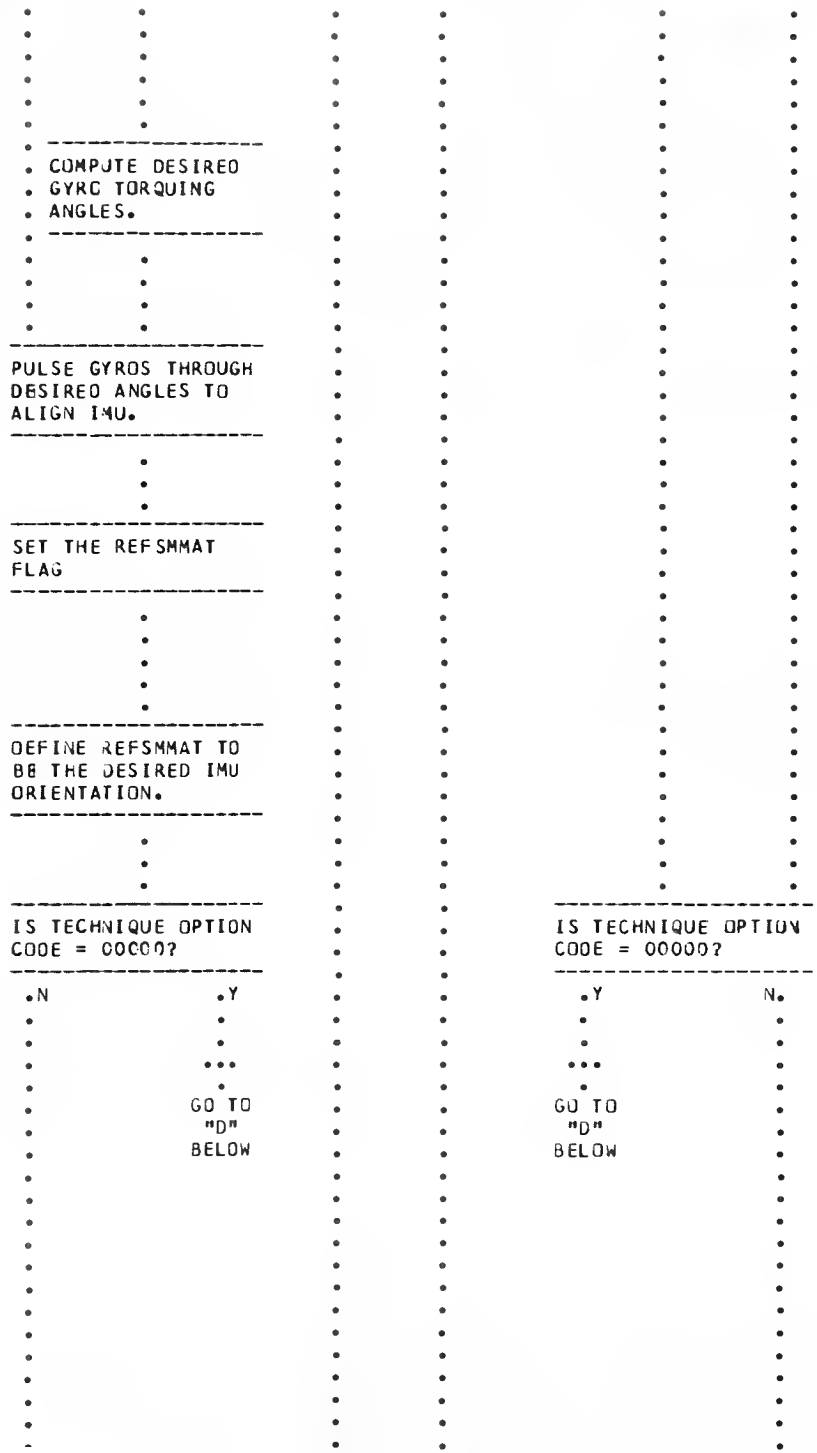
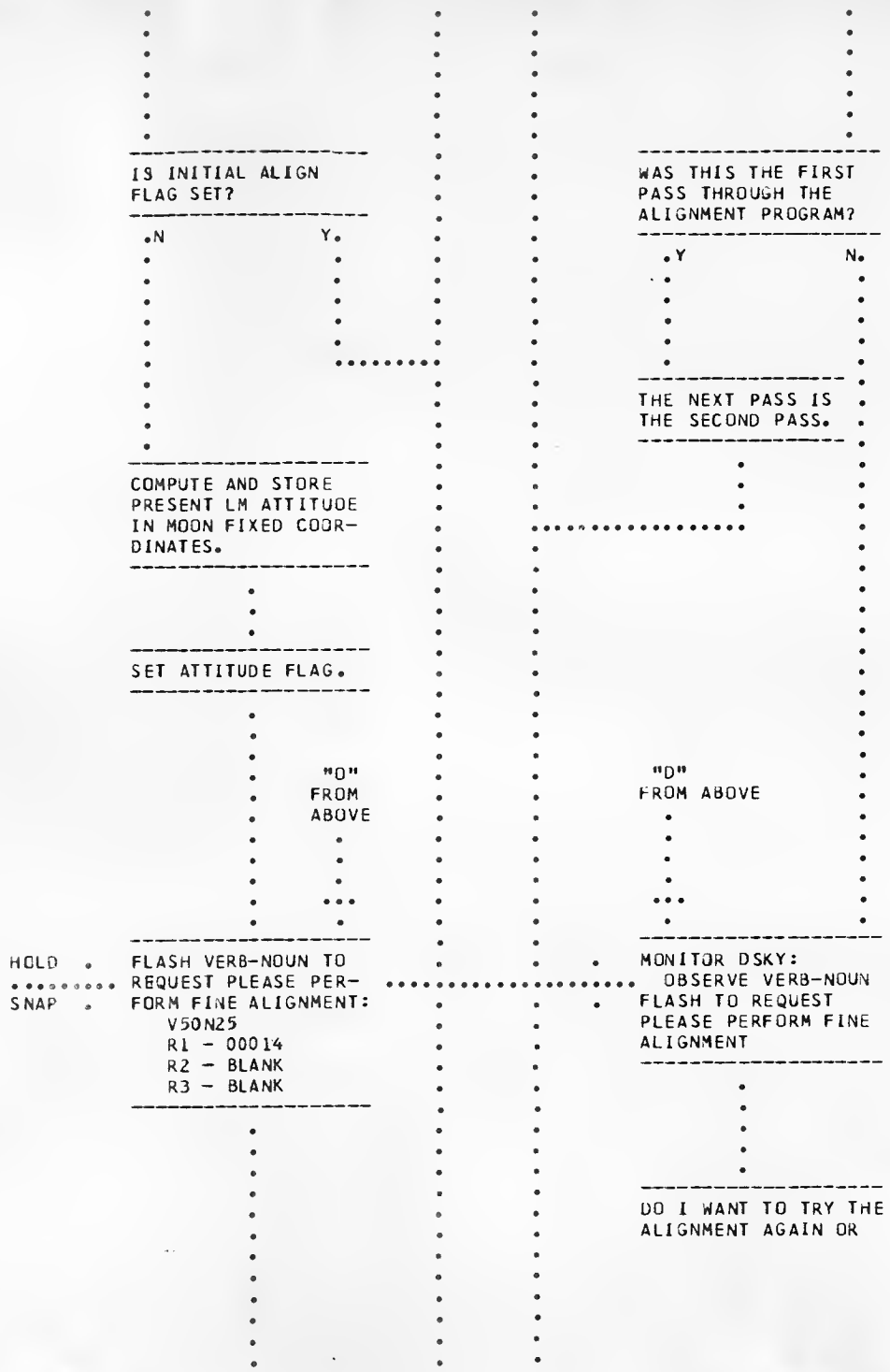


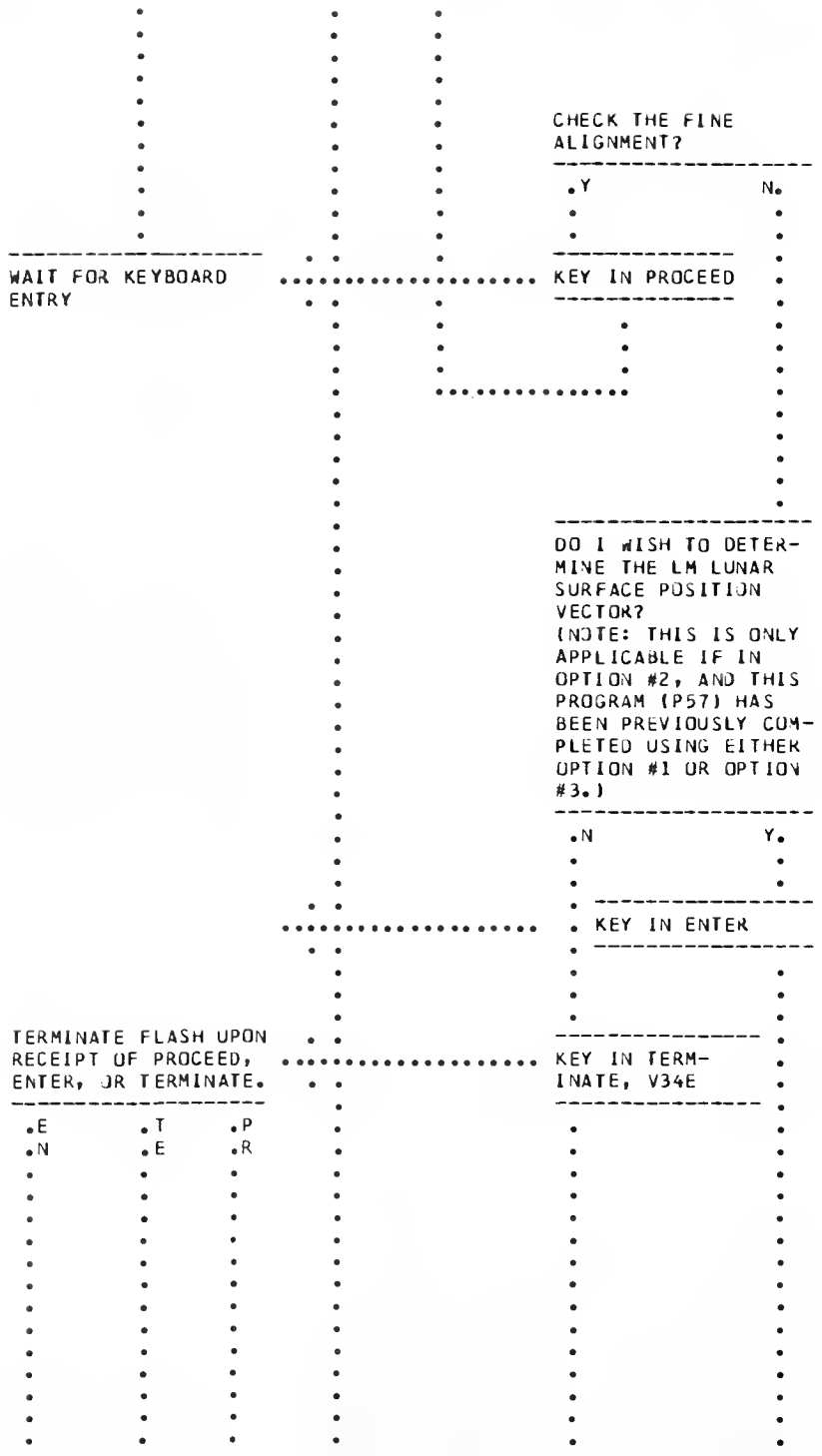
#1490

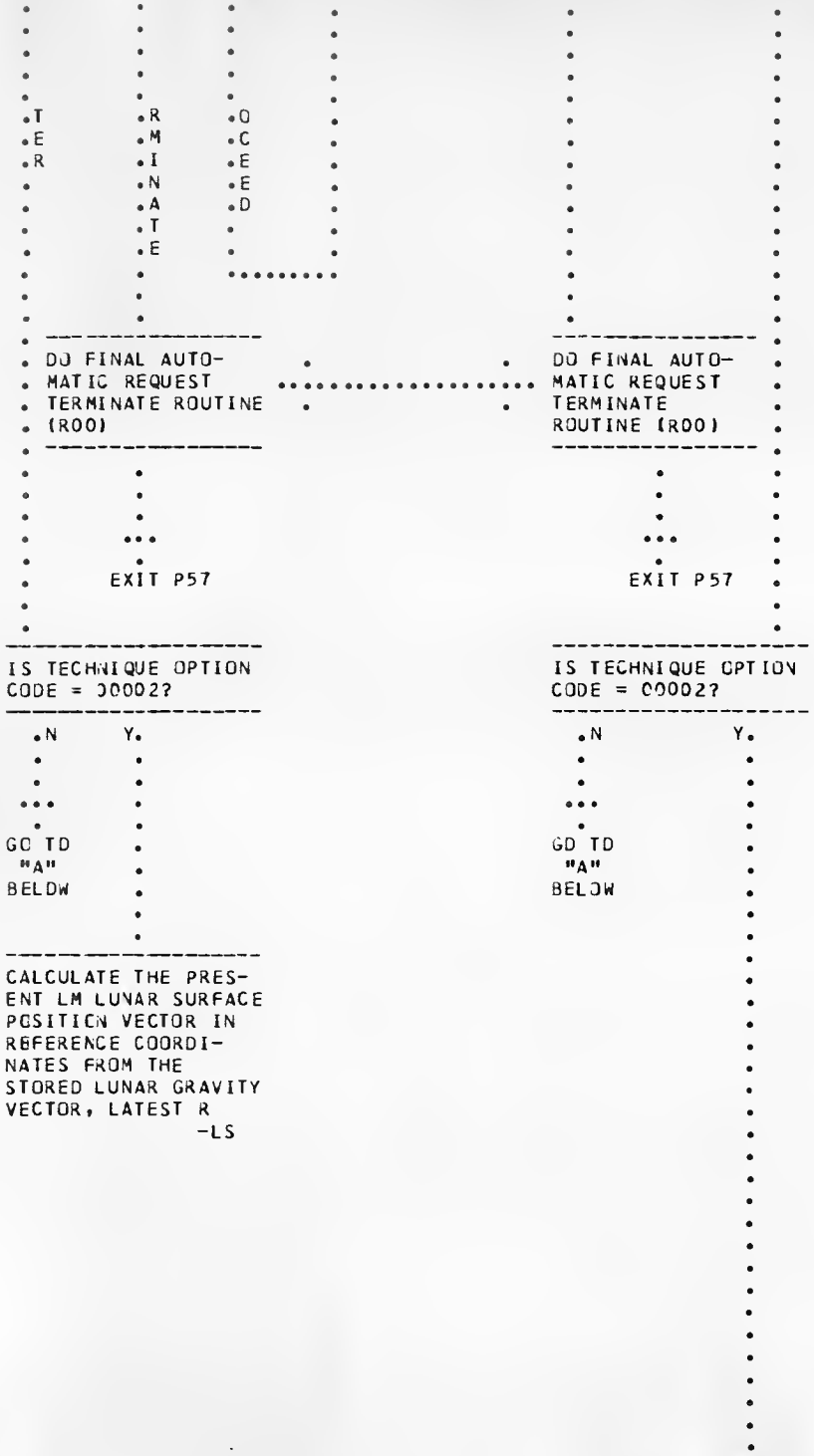
#1500

#1510

#1520


#1530
IS INITIAL ALIGN FLAG SET?
.N
Y.
WAS THIS THE FIRST PASS THROUGH THE ALIGNMENT PROGRAM?
.Y
N.
#1540
THE NEXT PASS IS THE SECOND PASS.
COMPUTE AND STORE PRESENT LM ATTITUDE IN MOON FIXED COORDINATES.
#1550
SET ATTITUDE FLAG.
#1560
"D" FROM ABOVE
"D" FROM ABOVE
HOLD .
SNAP .
FLASH VERB-NOUN TO REQUEST PLEASE PERFORM FINE ALIGNMENT:
V50N25
R1 - 00014
R2 - BLANK
R3 - BLANK
MONITOR DSKY: OBSERVE VERB-NOUN FLASH TO REQUEST PLEASE PERFORM FINE ALIGNMENT
#1570
#1580
DO I WANT TO TRY THE ALIGNMENT AGAIN OR


CHECK THE FINE ALIGNMENT?
.Y
N.
WAIT FOR KEYBOARD ENTRY
KEY IN PROCEED
#1590
#1600
DO I WISH TO DETERMINE THE LM LUNAR SURFACE POSITION VECTOR? (NOTE: THIS IS ONLY APPLICABLE IF IN OPTION #2, AND THIS PROGRAM (P57) HAS BEEN PREVIOUSLY COMPLETED USING EITHER OPTION #1 OR OPTION #3.)
#1610
.N
Y.
KEY IN ENTER
#1620
TERMINATE FLASH UPON RECEIPT OF PROCEED, ENTER, OR TERMINATE.
KEY IN TERMINATE, V34E
.E
.N
.T
.E
.P
.R
#1630

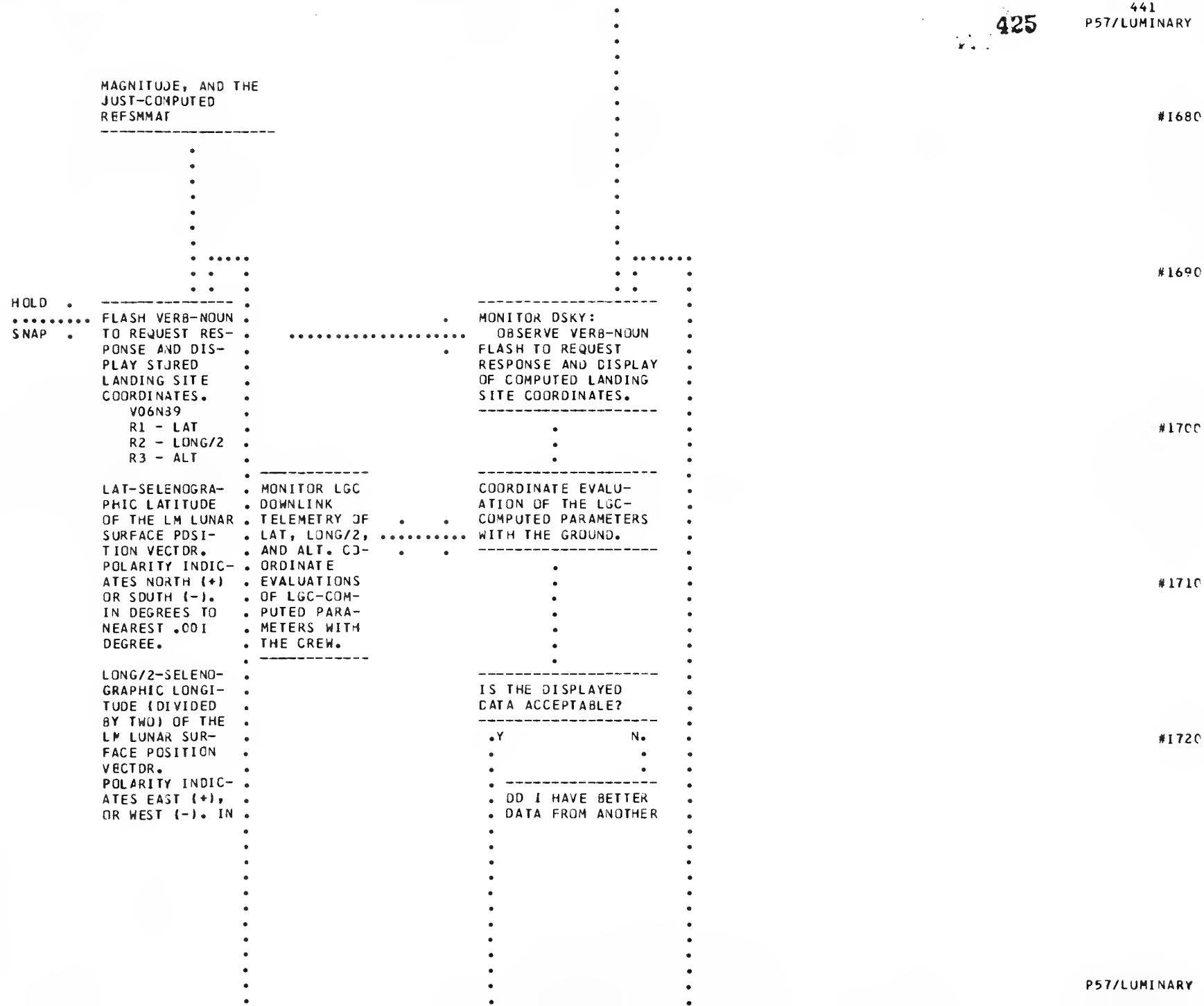


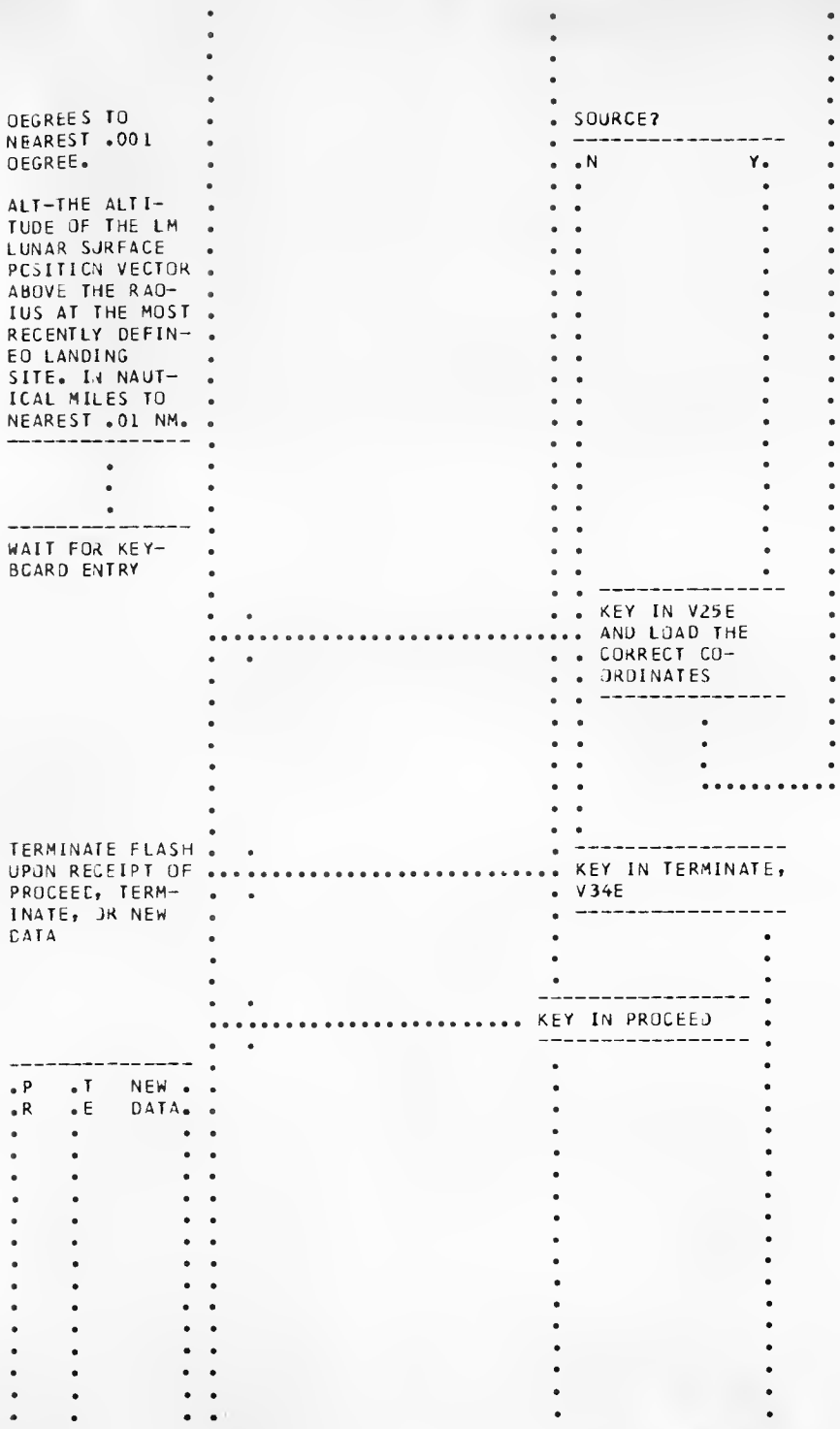
#1640

#1650

#1660

#1670


MAGNITUDE, AND THE JUST-COMPUTED REFSMMAT
#1680
#1690
HOLD
SNAP
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY STORED LANDING SITE COORDINATES. V06N39 R1 - LAT R2 - LONG/2 R3 - ALT
MONITOR DSKY: OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY OF COMPUTED LANDING SITE COORDINATES.
#1700
LAT-SELENOGRAPHIC LATITUDE OF THE LM LUNAR SURFACE POSITION VECTOR. POLARITY INDICATES NORTH (+) OR SOUTH (-). IN DEGREES TO NEAREST .001 DEGREE.
MONITOR LGC DOWNLINK TELEMETRY OF LAT, LONG/2, AND ALT. COORDINATE EVALUATIONS OF LGC-COMPUTED PARAMETERS WITH THE CREW.
COORDINATE EVALUATION OF THE LGC-COMPUTED PARAMETERS WITH THE GROUND.
#1710
LONG/2-SELENOGRAPHIC LONGITUDE (DIVIDED BY TWO) OF THE LM LUNAR SURFACE POSITION VECTOR. POLARITY INDICATES EAST (+), OR WEST (-). IN
IS THE DISPLAYED DATA ACCEPTABLE?
Y
N.
#1720
DO I HAVE BETTER DATA FROM ANOTHER



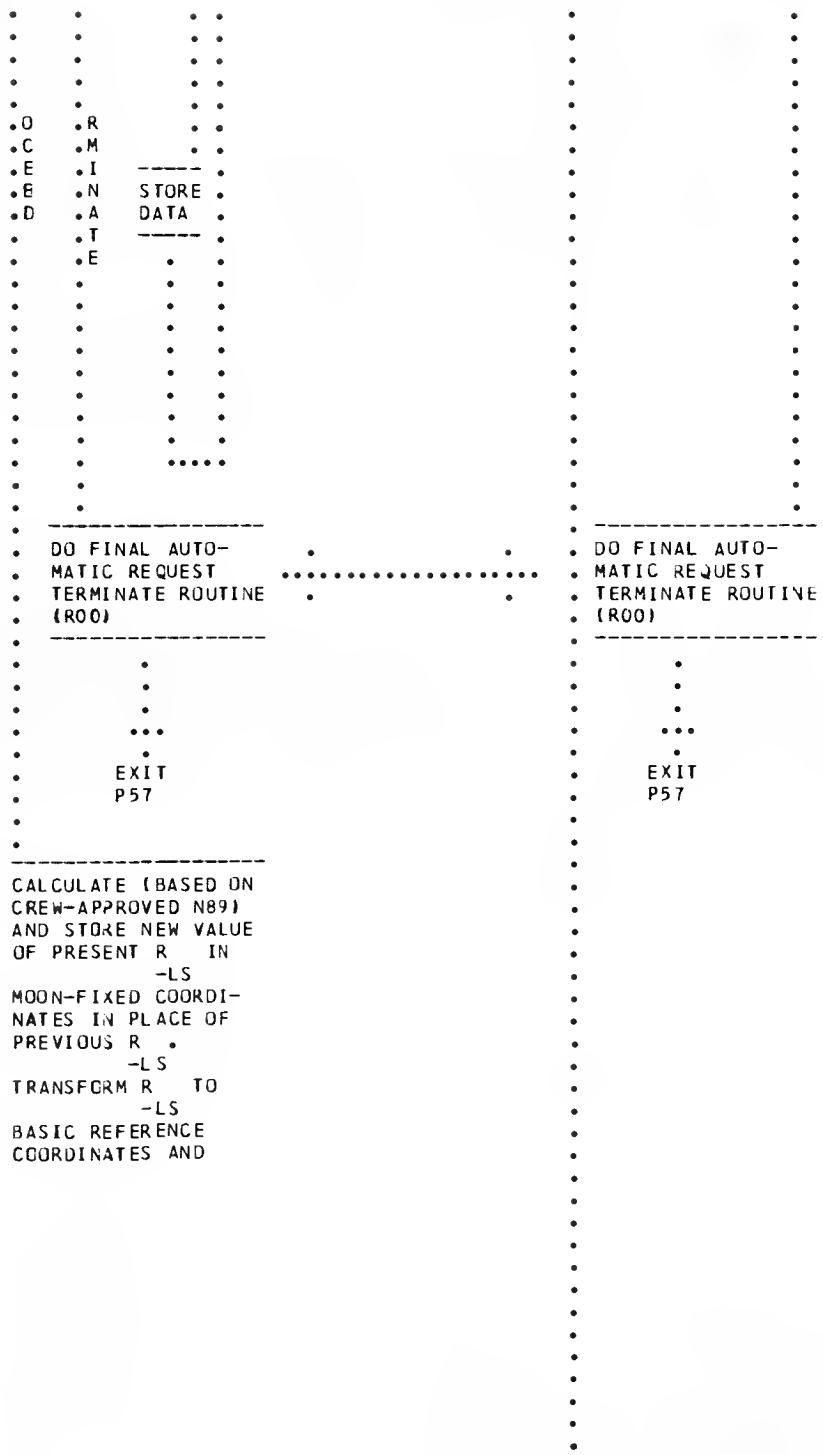
#1730

#1740

#1750

#1760

#1770

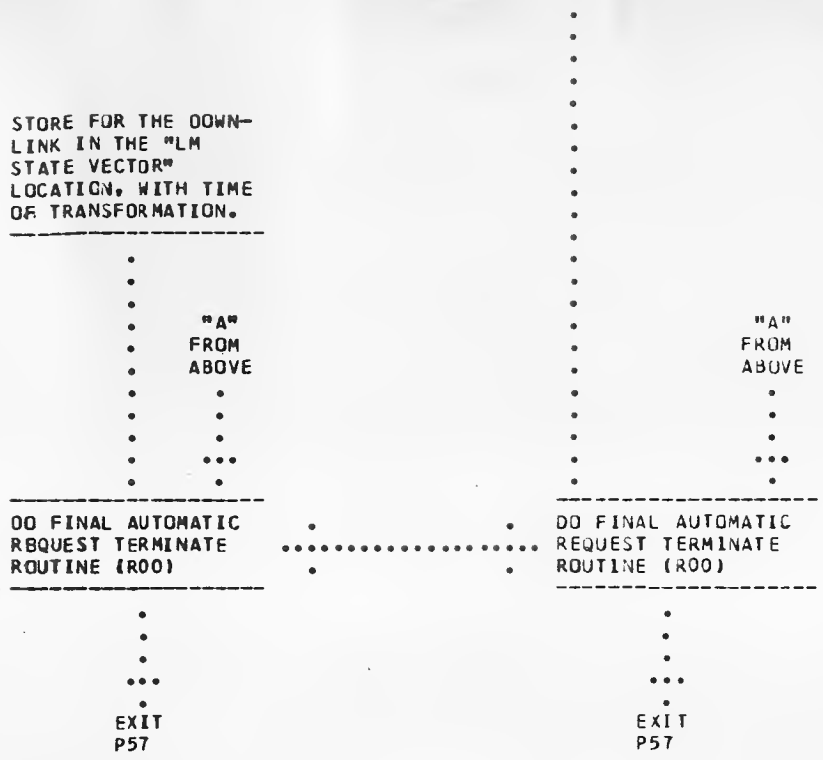


#1780

#1790

#1800

#1810



#1820

#1830

#1840

#1850

CHANGE CONTROL NOTES

REV 01 PCR 106,138,234,439,469,489,608
REV 00(LUM 1A) PCR 696, 698
REV 01(LUM 1A) PCR 754, 755
REV 02 EDITORIAL
REV 03 EDITORIAL
REV 04(LUM 1D) PCR 296, PCN 1009
REV 05(LUM 1E) PCN 1145
REV 06 PCN 1180

BRAKING PHASE PROGRAM (P63) REV 06 12/01/71

PURPOSE: (1) TO CALCULATE THE REQUIRED TIME OF DPS IGNITION (TIG) AND OTHER INITIAL CONDITIONS REQUIRED BY THE LGC FOR A PGNCS-CONTROLLED, DPS-EXECUTED, BRAKING PHASE OF THE POWERED LANDING MANEUVER.

(2) TO ALIGN THE LM TO THE THRUSTING IGNITION ATTITUDE.

(3) TO CONTROL THE PGNCS DURING COUNTDOWN, IGNITION, AND THRUSTING OF THE POWERED LANDING MANEUVER UNTIL HI GATE.

(4) TO INDICATE THAT HI GATE HAS BEEN REACHED ITGO LESS THAN TENDBRAK) BY AUTOMATIC SELECTION OF THE APPROACH PHASE PROGRAM (P64).

ASSUMPTIONS: (1) THE LM IS ON A DESCENT COAST ORBIT (HOHMANN TRANSFER) APPROACHING THE BRAKING IGNITION POINT WHICH IS NOMINALLY 50,000 FT. ABOVE THE LUNAR RADIUS AT THE DESIGNATED LANDING SITE. THE DESCENT COAST ORBIT IS APPROXIMATELY COPLANAR WITH THE CSM ORBITAL PLANE. IF THE DESIGNATED LANDING SITE IS NOT IN THE DESCENT COAST PLANE AT THE NOMINAL TIME OF LANDING THE PLANE CHANGE WILL BE ACCOMPLISHED BY THE POWERED LANDING MANEUVER (BRAKING PROGRAM (P63) AND APPROACH
++ PROGRAM (P64)).
+06
+
+1180 PREFERRED TRACKING ATTITUDE FOR OPTICAL TRACKING OF THE LM.
++

(2) IF CIRCULARIZATION HAS NOT OCCURRED, THE CSM IS IN A 9X60 (NM) ORBIT AROUND THE MOON. THE CSM IS MAINTAINING A

(3) THE IMU IS ON AND ALIGNED TO A LANDING SITE ORIENTATION DEFINED FOR THE DESIGNATED LANDING SITE AND THE NOMINAL TIME OF LANDING IT(LAND)). THE LM HAS NOT YET BEEN ALIGNED TO THE CORRECT ATTITUDE FOR IGNITION FOR THE POWERED LANDING MANEUVER.

(4) THE LANDING RADAR (LR) WAS ENERGIZED AND CHECKED OUT, AND MADE READY AT LR POSITION #1 PRIOR TO SELECTION OF THIS PROGRAM. RADAR DATA WILL NOT BE INCORPORATED INTO THE LM STATE VECTOR UNTIL THE ASTRONAUT SETS THE LR PERMIT FLAG VIA V57E INDICATING HE IS SATISFIED WITH THE QUALITY OF THE DATA (THE LR PERMIT FLAG IS RESET BY R00, OR BY EXTENDED VERB V58).

(5) THE LGC WILL NEITHER DESIGNATE NOR READ THE RENDEZVOUS RADAR (RR) DURING THIS PROGRAM.

(6) THE LANDING ANALOG DISPLAYS ROUTINE IR10) IS ENABLED AT THE START OF AVERAGE G AND IS TERMINATED UPON TERMINATION OF AVERAGE G.

I7) THE ENTIRE POWERED LANDING MANEUVER (BRAKING, APPROACH, AND LANDING) WILL BE ACCOMPLISHED USING THE DPS ENGINE.

(8) THE AIM CONDITIONS FOR THE BRAKING PHASE ARE STORED IN THE LGC.

I9) THE FOLLOWING PARAMETERS REQUIRED BY THIS PROGRAM HAVE BEEN STORED BY THE LGC SINCE LGC INITIALIZATION BY ERASABLE REGISTER LOAD.

(A) THE LM AND CSM STATE VECTORS. THE LGC HAS UPDATED THESE AS REQUIRED. NO FURTHER STATE VECTOR UPDATES FROM ANY EXTERNAL SOURCE OTHER THAN THE LR WILL BE ACCEPTED BY THIS PROGRAM.

(B) THE NOMINAL LANDING TIME AT THE DESIGNATED LANDING SITE IT(LAND)) AND THE POSITION IRLS)

(10) THE DPS IS NOT THROTTLABLE OVER THE WHOLE RANGE FROM 0 TO MAXIMUM. IT MUST BE OPERATED EITHER AT MAXIMUM THROTTLE OR OVER A SPECIFIC THROTTLE RANGE OF LOWER SETTINGS. THESE THROTTLE SETTINGS ARE SPECIFIED IN SECTION 5.3 OF R567 AND ARE TOTAL THROTTLE SETTINGS, I.E.: THE SUM OF THE MANUAL SETTING (WHOSE MINIMUM IS ABOUT 10 PERCENT) AND THE PGNCS COMMANDED SETTING.
THIS PROGRAM ASSUMES THE THROTTLE CONTROL TO BE IN "AUTO" ITHE DPS RECEIVES THE SUM OF THE MANUAL AND PGNCS

COMMANDED SETTINGS) AND THE MANUAL THROTTLE TO BE SET AT MINIMUM FOR "ZOOMTIME" SECONDS OF THRUSTING, AND THEREAFTER AT A LEVEL LESS THAN THAT REQUIRED BY THE LGC. THE VALUE "ZOOMTIME" IS IN ERASABLE STORAGE, HAVING BEEN LOADED PRIOR TO LAUNCH OR BY P27.

DUE TO THE REGION OF FORBIDDEN THROTTLING, THRUST COMMAND LOGIC IN CONJUNCTION WITH THE INTERIM TERMINAL CONDITIONS (SEE ASSUMPTION 18)) ASSURE THAT THE COMMANDED THROTTLE REMAINS AT MAXIMUM UNTIL THE GUIDANCE EQUATIONS FIRST REQUIRE IT TO BE WITHIN THE ALLOWABLE THROTTLE RANGE. THEREAFTER IT SHOULD REMAIN WITHIN THE ALLOWABLE THROTTLE RANGE. THIS PRINCIPLE IS DESCRIBED IN MORE DETAIL IN SECTION 5.3.4 OF R567. THE RESULT IS A SMOOTH AND EFFICIENT THRUST ATTITUDE PROFILE THROUGHOUT THE BRAKING PHASE.

++
+06
+1180
++

FURTHERMORE THE DPS MUST BE STARTED IN THE FOLLOWING SEQUENCE: +X AXIS ULLAGE FOR 7.5 SEC; IGNITION AT MINIMUM THROTTLE; ULLAGE OFF 0.5 SECONDS AFTER IGNITION: MINIMUM THRUST UNTIL TIG(AS DEFINED BY R41) + "ZOOMTIME"; AND THEN MAXIMUM THROTTLE. THE THROTTLE SETTING THEN BECOMES CONTROLLED BY THE GUIDANCE EQUATIONS.

(11) DURING THE POWERED LANDING MANEUVER, THE LGC WILL MONITOR THE PRESENCE OR ABSENCE OF THE "NON-ATTITUDE HOLD" DISCRETE. THIS DISCRETE IS ISSUED TO THE LGC WHEN THE ATTITUDE MODE CONTROL SWITCH IS IN THE AUTO POSITION.

SHOULD THIS DISCRETE APPEAR DURING THE POWERED LANDING MANEUVER, THE LGC ASSUMES THAT IT NO LONGER HAS COMPLETE AUTOMATIC CONTROL OF THE S/C ATTITUDE.

THE MONITOR AND THE ASSOCIATED LGC LOGIC IS INCLUDED IN THE LANDING AUTO MODES MONITOR ROUTINE (R13) WHICH WILL BE CALLED BY THIS PROGRAM.

(12) THE X-AXIS OVERRIDE OPTION PROVIDES THE CREW WITH THE ABILITY TO EXERCISE MANUAL CONTROL ABOUT THE LM X AXIS WITH THE ATTITUDE CONTROLLER EVEN THOUGH THE PGNCS ATTITUDE CONTROL MODE IS AUTO. WHEN THE CONTROLLER IS RETURNED TO DETENT THE PGNCS DAMPS THE YAW RATE, STORES THE YAW ATTITUDE WHEN THE YAW RATE IS DAMPED, AND THEN MAINTAINS THAT ATTITUDE.

THE X-AXIS OVERRIDE OPTION IS AVAILABLE TO THE CREW (UNTIL THE ESTIMATED ALTITUDE IS BELOW 30,000 FEET), HOWEVER IT SHOULD NOT BE EXERCISED WHEN THE LGC IS SPECIFYING A DESIRED YAW ATTITUDE, I.E.: DURING THE ATTITUDE MANEUVER TO THE THRUSTING ATTITUDE (SEE R60). THE OPTION IS INHIBITED BY THIS PROGRAM FROM MIDWAY IN THE PROGRAM (SEE ASSUMPTION (13) BELOW) TO THE END.

(13) THE LGC SPECIFIES LM ATTITUDE DURING THE POWERED LANDING MANEUVER BASED UPON THE REQUIREMENTS OF THRUST VECTOR CONTROL, LANDING SITE VISIBILITY, AND LR ORIENTATION. AFTER OPS IGNITION, THRUST VECTOR CONTROL IS REQUIRED THROUGH THE REMAINDER OF THIS PROGRAM. THE LANDING SITE BECOMES VISIBLE AT THE BEGINNING OF THE APPROACH PHASE.

THRUST VECTOR CONTROL DOES NOT CONSTRAIN THE LM ORIENTATION ABOUT THE THRUST AXIS (YAW ATTITUDE). ROTATION ABOUT THE LM Y AND LM Z AXES IS USED TO POINT THE MEASURED THRUST VECTOR ALONG THE DESIRED THRUST VECTOR.

THE FIRST RESTRAINT UPON THE LM YAW ATTITUDE TO OCCUR IS THAT OF LR ORIENTATION. AUTOMATIC X-AXIS OVERRIDE LOCKOUT (DONE BY R12) AND YAW ATTITUDE SPECIFICATION BY THE LGC WILL NOT OCCUR UNTIL THE LGC ESTIMATED ALTITUDE IS 30,000 FT. BEFORE THIS TIME, THE ASTRONAUT MUST MANEUVER TO A ROUGHLY-WINDOW-UP YAW ORIENTATION TO PREVENT SUBSEQUENT LOSS OF S-BAND LOCK ON. THE LGC WILL THEN COMMAND THE VEHICLE TO THE LGC-SPECIFIED YAW ATTITUDE.

SUBSEQUENT TO X-AXIS OVERRIDE LOCKOUT, CONTROL OF THE VEHICLE ABOUT THE LM X AXIS IS GOVERNED BY LR ORIENTATION REQUIREMENTS DURING THIS PROGRAM. THE LANDING SITE BECOMES VISIBLE TO THE COMMAND PILOT IF THE LOOK ANGLE (THE ANGLE BETWEEN THE LM -X AXIS AND THE LOS TO THE LANDING SITE) IS GREATER THAN 25 DEGREES AND THE LOS IS IN OR NEAR THE LM X/Z PLANE.

AT ANY TIME DURING P63 OR P64, THE MAGNITUDE OF THE LOOK ANGLE AND THE ORIENTATION OF THE LOOK ANGLE PLANE (THAT PLANE CONTAINING THE LOS AND THE LM X AXIS) ARE DEFINED BY THE INERTIAL ORIENTATION OF THE LM X AXIS AND THE POSITION OF THE LM WITH RESPECT TO THE LANDING SITE.

(14) THE CREW HAS THE CAPABILITY TO DISPLAY LGC CALCULATED VALUES OF FORWARD VELOCITY, LATERAL VELOCITY, ALTITUDE AND ALTITUDE RATE ON CERTAIN LM METERS DURING THIS PROGRAM. THE CALCULATION OF THESE PARAMETERS IS UNDER THE CONTROL OF THE LANDING ANALOG DISPLAYS ROUTINE (R10).

(15) THE RATE OF DESCENT (ROD) MODE IS NOT ENABLED DURING THIS PROGRAM (SEE LANDING PHASE PROGRAM (P66), ASSUMPTION 12 FOR DEFINITION OF ROD MODE).

(16) AN ABORT FROM THE LUNAR DESCENT MAY BE REQUIRED AT ANY TIME DURING THE DESCENT ORBIT INJECTION, THE DESCENT COAST, OR THE POWERED DESCENT (P63), (P64), OR (P66).

FOR ABORTS FROM THE DESCENT ORBIT INJECTION OR THE DESCENT COAST IT IS ASSUMED THAT SUFFICIENT TIME EXISTS TO PERFORM A TPI MANEUVER (SEE TRANSFER PHASE INITIATION (TPI) PROGRAM (P34)) TO INTERCEPT THE CSM DIRECTLY.

FOR ABORTS AFTER OPS IGNITION FOR THE POWERED LANDING MANEUVER, TIME IS CRITICAL. DURING THIS PERIOD AN ABORT IS

NOMINALLY COMMANDED BY PUSHING ONE OF TWO BUTTONS IN THE LM. THE ABORT MAY BE COMMANDED TO USE THE DESCENT STAGE (ABORT BUTTON) OR THE ASCENT STAGE (ABORT STAGE BUTTON). IF THE DESCENT STAGE IS SELECTED, AND THE DPS PROPELLANT APPROACHES EXHAUSTION, CONTROL MUST BE SWITCHED TO THE ASCENT STAGE BY THE CREW BY ASCENT STAGE SELECTION (ABORT STAGE BUTTON).

++ +06 +1180 ++ DURING THE POWERED LANDING MANEUVER THE LGC WILL CONTINUOUSLY MONITOR THE ABORT AND ABORT STAGE DISCRETES, AND UPON RECEIPT OF EITHER WILL TERMINATE THE PROGRAM IN PROCESS AND CALL THE APPROPRIATE ABORT PROGRAM (DPS ABORT PROGRAM (P70) OR APS ABORT PROGRAM (P71)) UNLESS DIRECTED TO IGNORE THESE DISCRETES BY THE DAP DATA LOAD ROUTINE (R03). BOTH ABORT PROGRAMS WILL GUIDE THE LM TO AN ORBIT AS SPECIFIED IN SECTION 5.4 OF R567.

THE MONITOR OF THE ABORT AND ABORT STAGE PUSHBUTTONS IS CONTROLLED BY THE ABORT DISCRETES MONITOR ROUTINE (R11) WHICH WILL BE ENABLED BY THIS PROGRAM.

(17) IF A THRUSTING MANEUVER IS PERFORMED WITH THE GUIDANCE CONTROL SWITCH IN PGNS AND THE MODE CONTROL SWITCH IN AUTO, THE PGNCS WILL CONTROL THE TOTAL VEHICLE ATTITUDE AND GENERATE EITHER MODE I OR MODE II ATTITUDE ERRORS AND VEHICLE ATTITUDE RATES (SEE ASSUMPTION (19)) FOR DISPLAY ON THE FDAI. THE CREW MAY EXERCISE CONTROL AROUND THE YAW AXIS ONLY WITH THE ACA (X-AXIS OVERRIDE) IF THE X-AXIS OVERRIDE CAPABILITY IS PERMITTED BY THE PROGRAM IN PROCESS. THIS MANUAL CONTROL WILL BE IN RATE COMMAND/ATTITUDE HOLD MODE.

IF A THRUSTING MANEUVER IS PERFORMED WITH THE GUIDANCE CONTROL SWITCH IN PGNS AND THE MODE CONTROL SWITCH IN ATTITUDE HOLD THE PGNCS WILL HOLD THE VEHICLE ATTITUDE AND WILL GENERATE EITHER MODE I OR MODE II ATTITUDE ERRORS FOR DISPLAY ON THE FDAI. THE CREW MAY EXERCISE MANUAL ATTITUDE CONTROL ABOUT ALL VEHICLE AXES WITH THE ACA IN EITHER THE RATE COMMAND OR MINIMUM IMPULSE MODE DEPENDING UPON THE STATUS OF THE PULSES FLAG. THIS FLAG IS RESET BY P12, P40,P41,P42,P63,P70,P71 AND R40 AT MAIN ENGINE IGNITION. IT IS STRONGLY RECOMMENDED THAT POWERED FLIGHT NOT BE ATTEMPTED IN THE MINIMUM IMPULSE MODE. THE PULSES FLAG IS ALSO SET OR RESET BY EXTENDED VERBS 76 (MINIMUM IMPULSE) AND 77 (RATE COMMAND) RESPECTIVELY. DURING A THRUSTING MANEUVER IN THE PGNS/ATTITUDE HOLD MODE THE ASTRONAUT IS RESPONSIBLE FOR MAINTAINING SMALL ENOUGH ATTITUDE ERRORS TO ACHIEVE GUIDANCE OBJECTIVES.

(18) CONTROL OF THE LM DPS, RCS AND APS IS TRANSFERRED FROM THE PGNCS TO THE ABORT GUIDANCE SYSTEM (AGS) BY PLACING THE GUID CONT SWITCH FROM PGNS TO AGS.

THE AGS WILL BE CAPABLE OF TAKING OVER CONTROL OF THE LM DURING ANY PORTION OF THE LUNAR DESCENT OR ASCENT OR DURING EITHER OF THE ABORT PROGRAMS (P70 OR P71). THE AGS WILL GUIDE THE LM TO A SAFE ORBIT.

++ +06 + + +1180 ++ THE AGS MAY BE INITIALIZED BY THE LGC AT ANY TIME BY MANUAL SELECTION OF THE AGS INITIALIZATION ROUTINE (R47).

IN THE EVENT THAT THE GUIDANCE CONTROL SWITCH IS CHANGED FROM PGNS TO AGS DURING A THRUSTING MANEUVER, THE LGC WILL CONTINUE COMPUTATION OF POSITION AND VELOCITY, THE DESIRED THRUST VECTOR, AND THE FDAI ATTITUDE ERROR NEEDLE DISPLAY.

HOWEVER THE PGNCS WILL NOT BE RESPONSIBLE IF REGISTER OVERFLOWS OCCUR WITHIN THE LGC.

(19) THE PGNCS CAN GENERATE TWO TYPES OF ATTITUDE ERRORS FOR DISPLAY ON THE FDAI;

MODE I - SELECTED BY EXTENDED VERB 61. AUTOPILOT FOLLOWING ERRORS USED AS A MONITOR OF THE DAP'S ABILITY TO TRACK AUTOMATIC STEERING COMMANDS.

MODE II - SELECTED BY EXTENDED VERB 62. TOTAL ATTITUDE ERRORS USED TO ASSIST CREW IN MANUALLY MANEUVERING THE VEHICLE.

PGNCS - DERIVED VEHICLE ATTITUDE RATES MAY ALSO BE DISPLAYED VIA SELECTION BY EXTENDED VERB 63.
DISPLAY SELECTION IS ALWAYS BASED UPON THE LAST ENTRY MADE IN THE DSKY, WITH THE EXCEPTION THAT MODE II ATTITUDE ERRORS ARE AUTOMATICALLY SELECTED AT THE BEGINNING OF R60.

FOR A MORE DETAILED DESCRIPTION OF THESE DISPLAYS REFER TO SECTION 3 OF R567, PARA. 3.2.6

(20) THE EVENT TIMER WAS SET PRIOR TO SELECTION OF THIS PROGRAM TO COUNT TO ZERO AT T BRAK BASED ON A TIME FROM IGNITION PROVIDED BY THE GROUND.

(21) THE DAP DATA LOAD ROUTINE (R03) HAS BEEN PERFORMED PRIOR TO SELECTION OF THIS PROGRAM. AT THAT TIME THE DPS ENGINE GIMBAL SHOULD HAVE BEEN DRIVEN TO THE CORRECT TRIM POSITION.

(22) DURING DPS BURNS ONLY, THE PITCH-ROLL RCS JET AUTOPILOT (U AND V JETS) MAY BE DISABLED (V65) OR ENABLED (V75) BY EXTENDED VERB AS SHOWN. THIS CAPABILITY IS INTENDED TO BE USED TO PREVENT LM AND DESCENT STAGE THERMAL CONSTRAINT VIOLATIONS DURING CSM-DOCKED DPS BURNS (P40). THE CAPABILITY EXISTS DURING P63 AND P70 ALSO. PERFORMANCE OF FRESH START (V36E) WILL ALWAYS ENABLE THE PITCH-ROLL JETS.

(23) THE ASTRONAUT MAY MONITOR THE FOLLOWING ADDITIONAL PARAMETERS DURING THIS PROGRAM (AFTER COMPLETION OF THE IGNITION ALGORITHM) BY KEYING IN V16N68E:

V16 N68
R1-HOR RANGE
R2-TG
R3-VI

HOR RANGE - HOR RANGE FWD FROM THE LM TO THE DESIGNATED LANDING SITE. IN NAUTICAL MILES TO NEAREST .1 NM.

TG - THE ESTIMATED TIME OF FLIGHT FROM THE PRESENT TIME TO THE ACCOMPLISHMENT OF THE CURRENT AIM CONDITIONS. IN MINS AND SECS TO NEAREST SEC. MAX READING IS 59859. SIGN IS -.

VI - MAGNITUDE OF LM INERTIAL VELOCITY WITH RESPECT TO THE REFERENCE COORDINATE SYSTEM. IN FPS TO NEAREST .1 FPS.

(24) LGC AND CREW PROCEDURES IN CASES OF LGC-ASSUMED THRUST FAILURE ARE DEFINED BY THE DPS/APS THRUST FAIL ROUTINE (R40). THIS ROUTINE IS ENABLED AT DPS IGNITION BY THIS PROGRAM.

(25) THIS PROGRAM IS SELECTED BY THE ASTRONAUT BY DSKY ENTRY. IT SHOULD BE SELECTED AT LEAST 20 MINUTES BEFORE THE NOMINAL TIME OF IGNITION FOR THE POWERED LANDING MANEUVER (T BRAK).

(26) IT IS NORMALLY REQUIRED THAT THE ISS BE ON FOR A MINIMUM OF 15 MINUTES PRIOR TO A THRUSTING MANEUVER.

(27) ENGINE IGNITION MAY BE SLIPPED BEYOND THE ESTABLISHED TIG IF DESIRED BY THE CREW OR IF STATE VECTOR INTEGRATION CANNOT BE COMPLETED IN TIME. FOR A SUCCESSFUL LANDING, NO SLIP SHOULD BE PERMITTED.

(28) THREE ALARM CONDITIONS MAY BE ORIGINATED BY THE PGNCS POWERED LANDING EQUATIONS:

(A) IF SUBROUTINE ROOTPSRS IN THE RG/VG CALCULATION FAILS TO CONVERGE IN 8 PASSES THE LGC WILL TURN ON THE PROGRAM ALARM LIGHT, STORE PROGRAM ALARM 01406, STOP ALL VEHICLE ATTITUDE RATES, AND CONTINUE. THIS ALARM COULD ONLY OCCUR IN P63 OR P64. (NOTE: IF THIS CONDITION OCCURS BEFORE IGNITION DURING THE IGNITION ALGORITHM, THE RESULT WILL BE A PODDDO ALARM, 21406).

(B) IF AN OVERFLOW OCCURS ANYWHERE IN THE LANDING GUIDANCE EQUATIONS THE LGC WILL TURN ON THE PROGRAM ALARM LIGHT, STORE ALARM CODE 01410, STOP ALL VEHICLE ATTITUDE RATES AND CONTINUE. THIS ALARM COULD OCCUR IN P63,P64, OR P66.

(C) IF THERE ARE TOO FEW THROTTLINGS SINCE THE LAST P66 OMISSION, THE LGC WILL TURN ON THE PROGRAM ALARM LIGHT, STORE ALARM CODE 01466, AND BRANCH TO THE V06 N6C DISPLAY. THIS ALARM COULD ONLY OCCUR IN P66.

(29) THIS PROGRAM ALLOWS MANUAL CONTROL OF LM ATTITUDE AND THE SELECTION OF P66.
DURING P63 (AND P64) THE ASTRONAUT CAN DISPLAY THE PGNCS TOTAL GUIDANCE ERROR ON THE FDAI ERROR NEEDLES (ATTITUDE MON SWITCH IN PGNCS) BY HAVING KEYED IN V62 THRU THE DSKY. HE CAN THEN STEER OUT THE PGNCS P63 ATTITUDE ERRORS WITH THE AGS MANUALLY (GUID CONT IN AGS AND AGS MODE CONTROL IN ATT HOLD); OR WITH THE PGNCS MANUALLY (GUID CONT IN PGNCS AND PGNCS MODE CONTROL IN ATT HOLD) OR AUTOMATICALLY (PGNCS MODE CONTROL IN AUTO). THUS THERE ARE THREE ATTITUDE CONTROL SUBMODES IN P63 (AND P64): AGS MANUAL; PGNCS MANUAL; OR PGNCS AUTO.
A CAUTIONARY NOTE: IF THE ASTRONAUT HITS THE RDD (RATE-OF-DESCENT) SWITCH WHILE HE IS IN PGNCS ATT HOLD, THE LGC WILL IRREVOCABLY TRANSFER HIM INTO THE LANDING PHASE PROGRAM, P66.

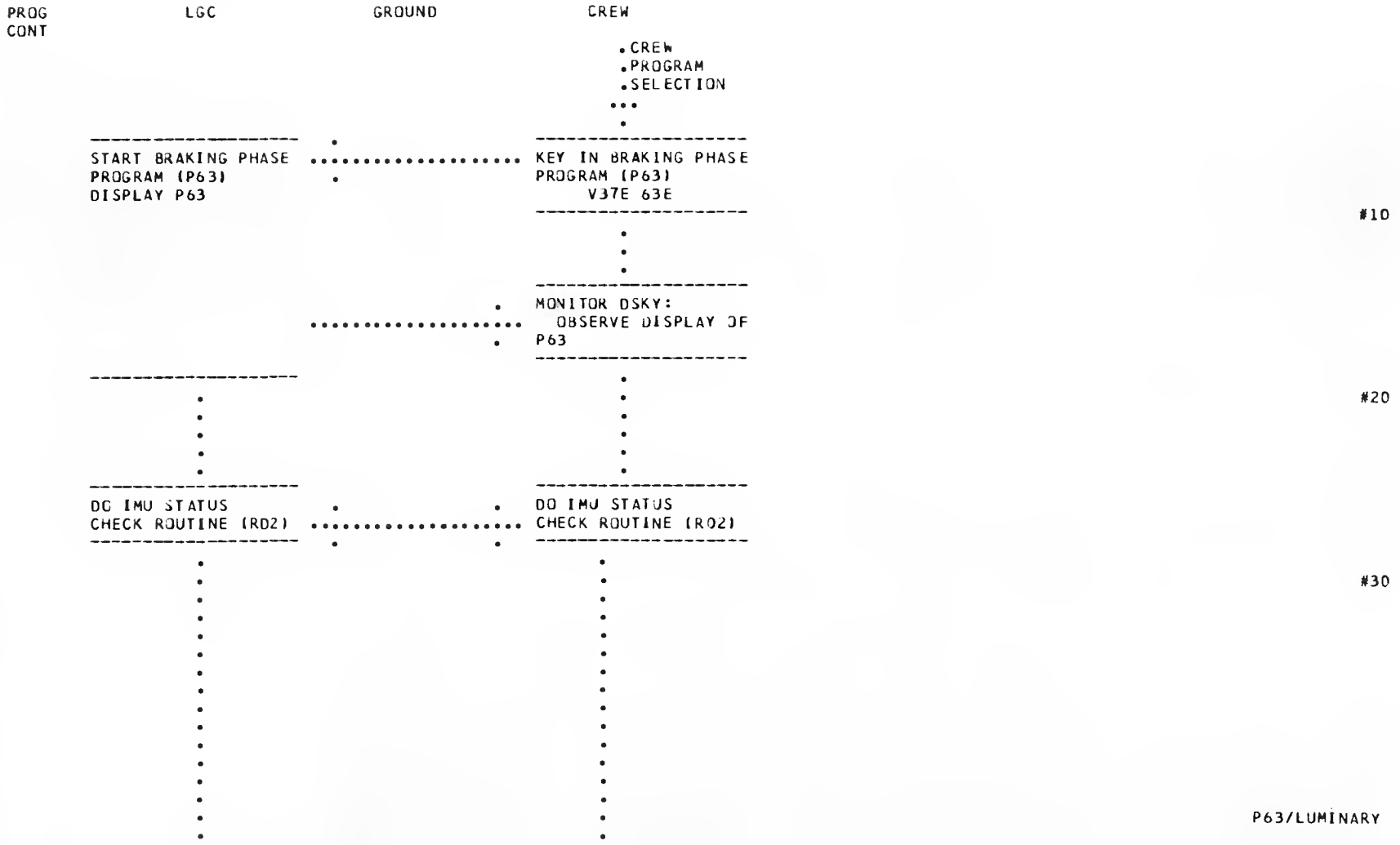
(30) THE ASTRONAUT MAY MONITOR THE FOLLOWING PARAMETERS BY KEYING IN V16 N92E:

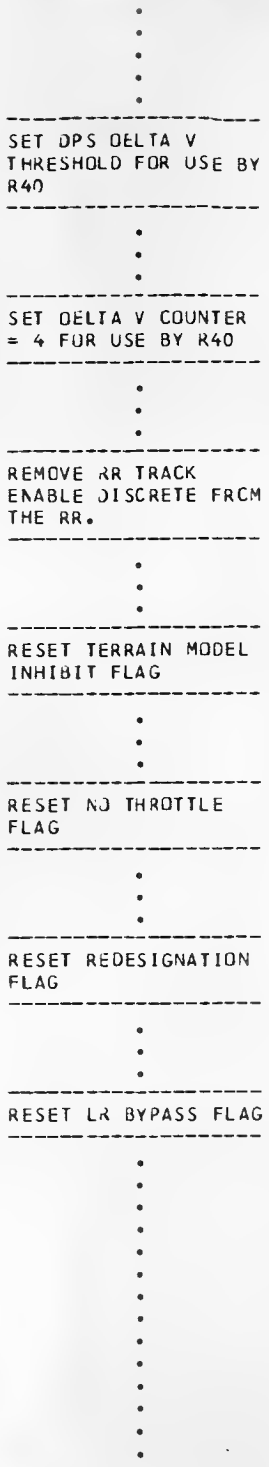
(A) V16 N92
R1- THRCMD
R2- HDOT
R3- H

THRCMD- THE PERCENT THROTTLE DESIRED BY THE LGC, BASED ON THE DPS RATED THRUST OF 10,500 POUNDS. IN PERCENT TO NEAREST PERCENT. (NOTE: IN P63 MORE THRUST IS DESIRED THAN CAN BE DELIVERED BY THE DPS; THEREFORE, R1 MAY SHOW MORE THAN 100 PERCENT (WHILE THROTTLE IS AT 100 PERCENT DELIVERED). AT THROTTLE RECOVERY (THROTTLE DOWN) R1 WILL DISPLAY +00057; AT HALF-THROTTLE, R1 WILL DISPLAY +00050).

HDOT - THE PRESENT RATE OF CHANGE OF ALTITUDE (H). IN FPS TO NEAREST .1 FPS.

H- THE PRESENT ALTITUDE OF THE LM ABOVE THE LUNAR RADIUS AT THE DESIGNATED LANDING SITE. IN FEET TO NEAREST FOOT.




SET DPS DELTA V THRESHOLD FOR USE BY R40
SET DELTA V COUNTER = 4 FOR USE BY R40
REMOVE RR TRACK ENABLE DISCRETE FROM THE RR.
RESET TERRAIN MODEL INHIBIT FLAG
RESET NO THROTTLE FLAG
RESET REDESIGNATION FLAG
RESET LR BYPASS FLAG

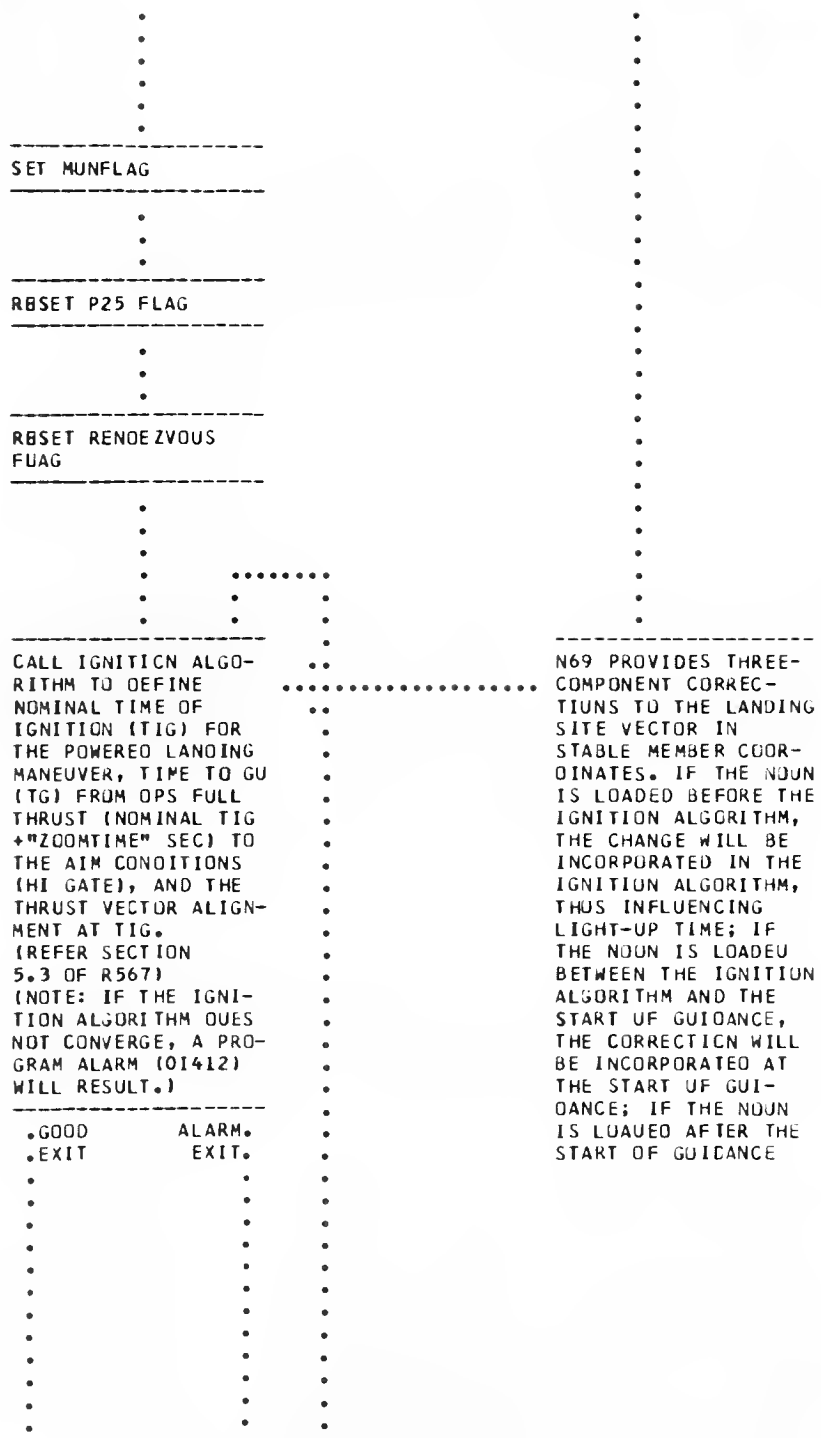
#40

#50

#60

#70

#80



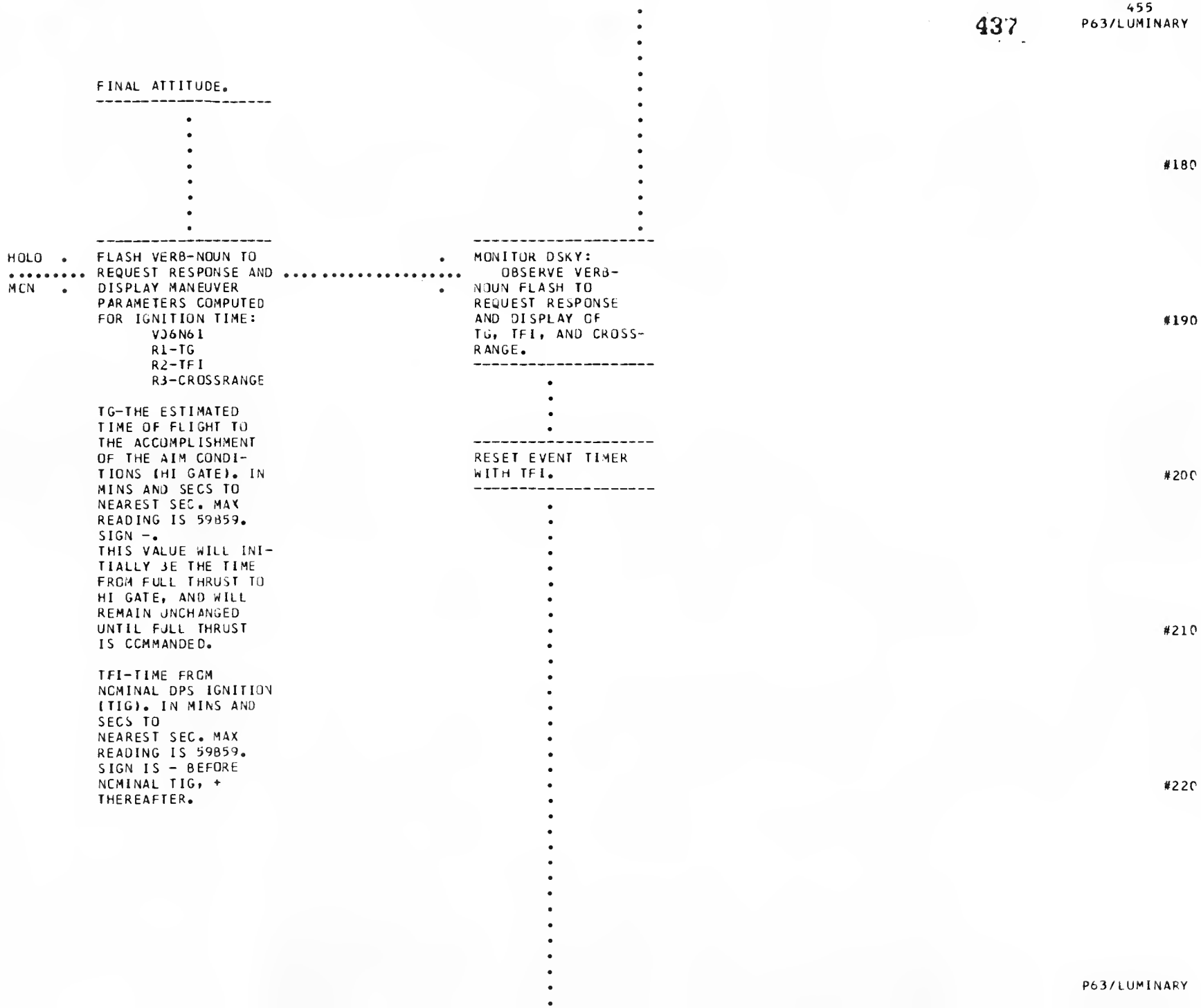
#90

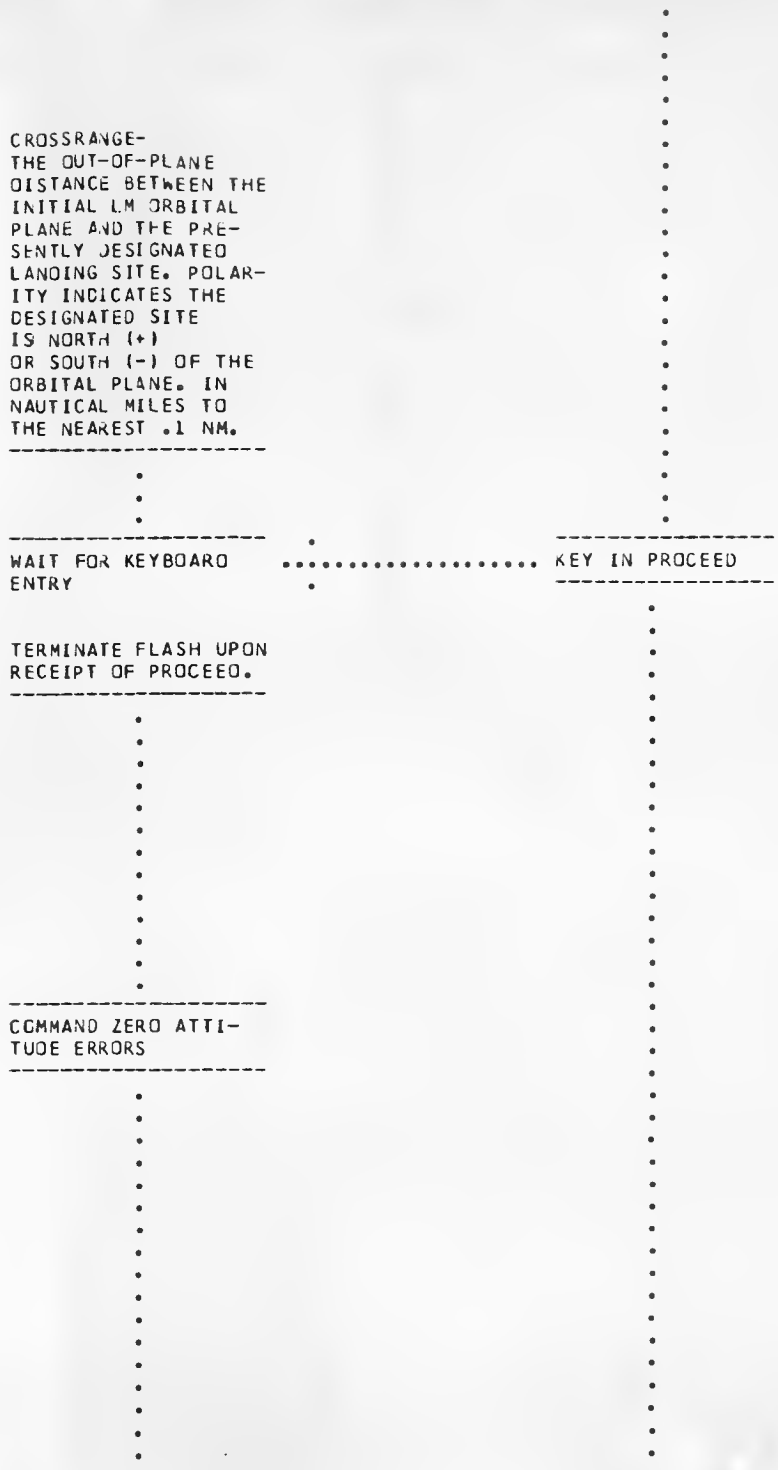
#100

#110

#120


(AT THROTTLE-UP), THE CORRECTION WILL BE INCORPORATED IMMEDIATELY. (NOTE: SINCE RLS IS NOT CHANGED, RESELECTION OF P63 WILL DESTROY ANY CHANGES MADE USING THIS TECHNIQUE.)
#130
#140
TURN ON PROGRAM ALARM LIGHT AND STORE ALARM CODE 01412
DOES PROGRAM ALARM LIGHT INDICATE PROGRAM ABNORMALITY?
.Y
N.
#150
STORE THE DESIRED ATTITUDE SPECIFICATION FOR USE BY THE ATTITUDE MANEUVER ROUTINE (R60). THE FINAL ATTITUDE WILL BE COMPUTED TO POINT THE LM +X AXIS IN THE INITIAL THRUST DIRECTION. HOWEVER, IN ORDER TO CONSERVE RCS FUEL AND NOT CONSTRAIN THE NON-CRITICAL ATTITUDE ABOUT THE THRUST VECTOR, WINGS MAY NOT BE LEVEL IN THE COMPUTED
KEY IN V05N09 AND IDENTIFY ALARM CODE. CODE 01412 INDICATES THAT THE IGNITION ALGORITHM WILL NOT CONVERGE. CREW MUST RESPOND WITH V96E OR NEW PROGRAM SELECTION (V37EXXE). CONSULT BACKUP PROCEDURES.
#160
#170


FINAL ATTITUDE.
HOLD MCN
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY MANEUVER PARAMETERS COMPUTED FOR IGNITION TIME:
VD6N61
R1-TG
R2-TFI
R3-CROSSRANGE
TG-THE ESTIMATED TIME OF FLIGHT TO THE ACCOMPLISHMENT OF THE AIM CONDITIONS (HI GATE). IN MINS AND SECS TO NEAREST SEC. MAX READING IS 59859. SIGN -.
THIS VALUE WILL INITIALLY BE THE TIME FROM FULL THRUST TO HI GATE, AND WILL REMAIN UNCHANGED UNTIL FULL THRUST IS COMMANDED.
TFI-TIME FROM NOMINAL DPS IGNITION (TIG). IN MINS AND SECS TO NEAREST SEC. MAX READING IS 59859. SIGN IS - BEFORE NOMINAL TIG, + THEREAFTER.
MONITOR DSKY:
OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY OF TG, TFI, AND CROSS-RANGE.
RESET EVENT TIMER WITH TFI.
#180
#190
#200
#210
#220

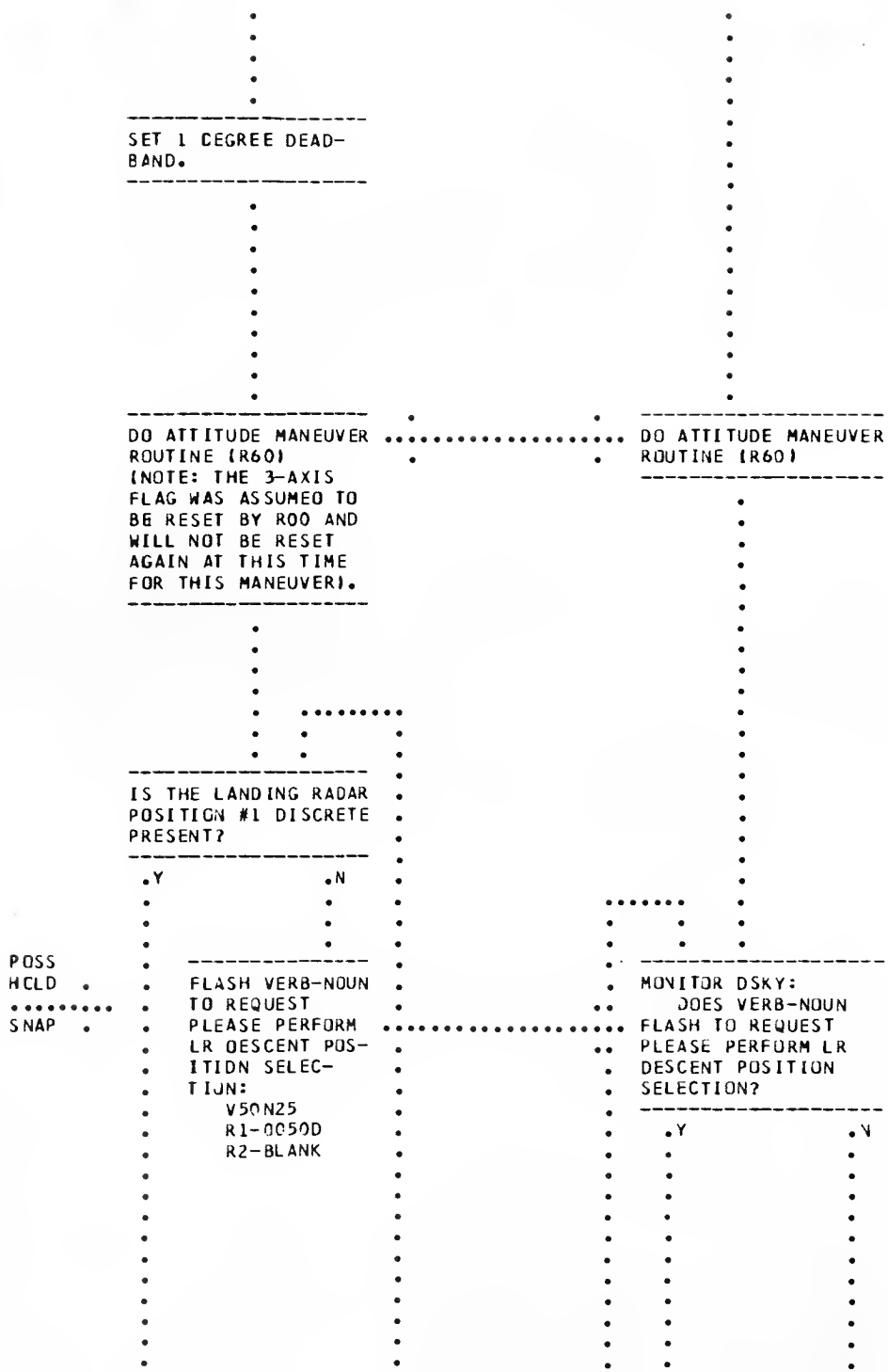


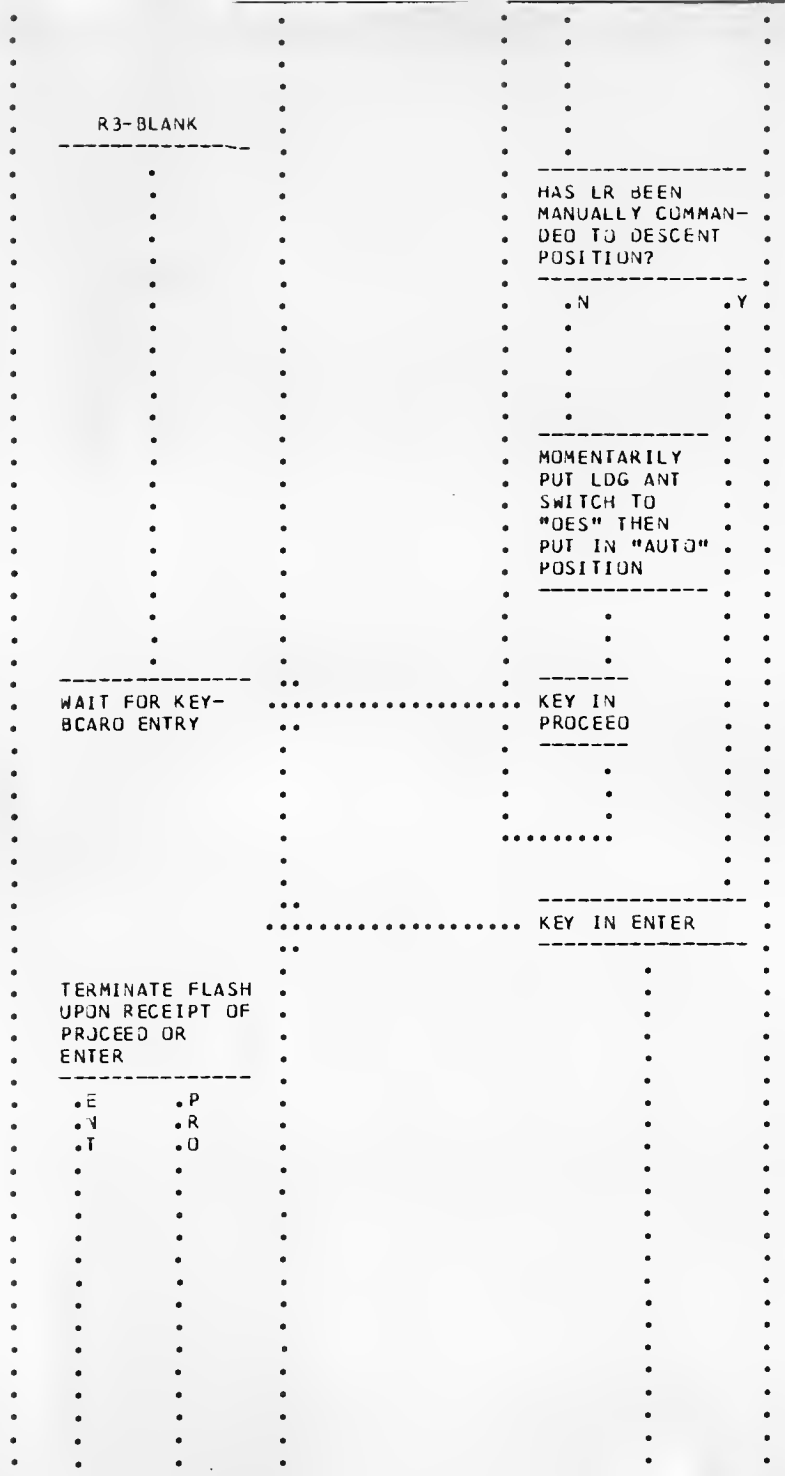
#230

#240

#250

#260


SET 1 DEGREE DEAD-
BAND.
#270
#280
DO ATTITUDE MANEUVER
ROUTINE (R60)
(NOTE: THE 3-AXIS
FLAG WAS ASSUMED TO
BE RESET BY R00 AND
WILL NOT BE RESET
AGAIN AT THIS TIME
FOR THIS MANEUVER).
DO ATTITUDE MANEUVER
ROUTINE (R60)
#290
#300
IS THE LANDING RADAR
POSITION #1 DISCRETE
PRESENT?
.Y
.N
POSS
HOLD
SNAP
FLASH VERB-NOUN
TO REQUEST
PLEASE PERFORM
LR DESCENT POS-
ITION SELEC-
TION:
V50N25
R1-00500
R2-BLANK
MONITOR DSKY:
DOES VERB-NOUN
FLASH TO REQUEST
PLEASE PERFORM LR
DESCENT POSITION
SELECTION?
#310
.Y
.N



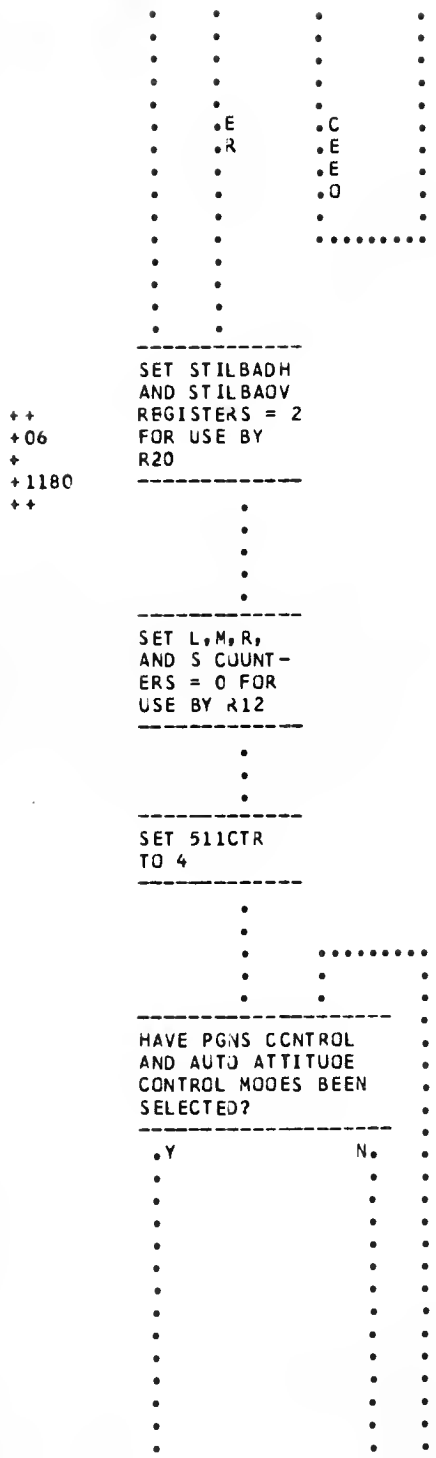
#320

#330

#340

#350

#360



++
+06
+
+1180
++

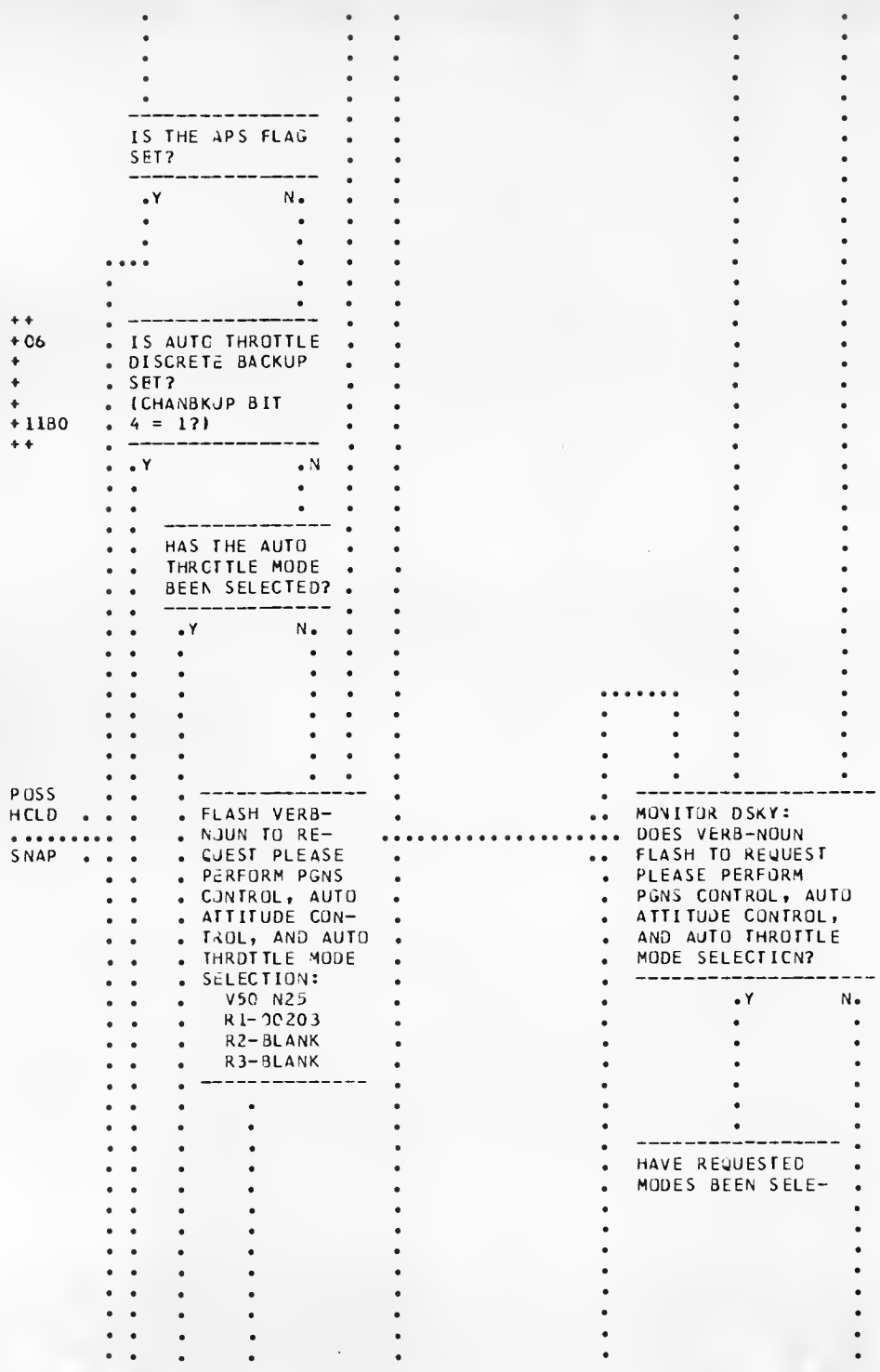
#370

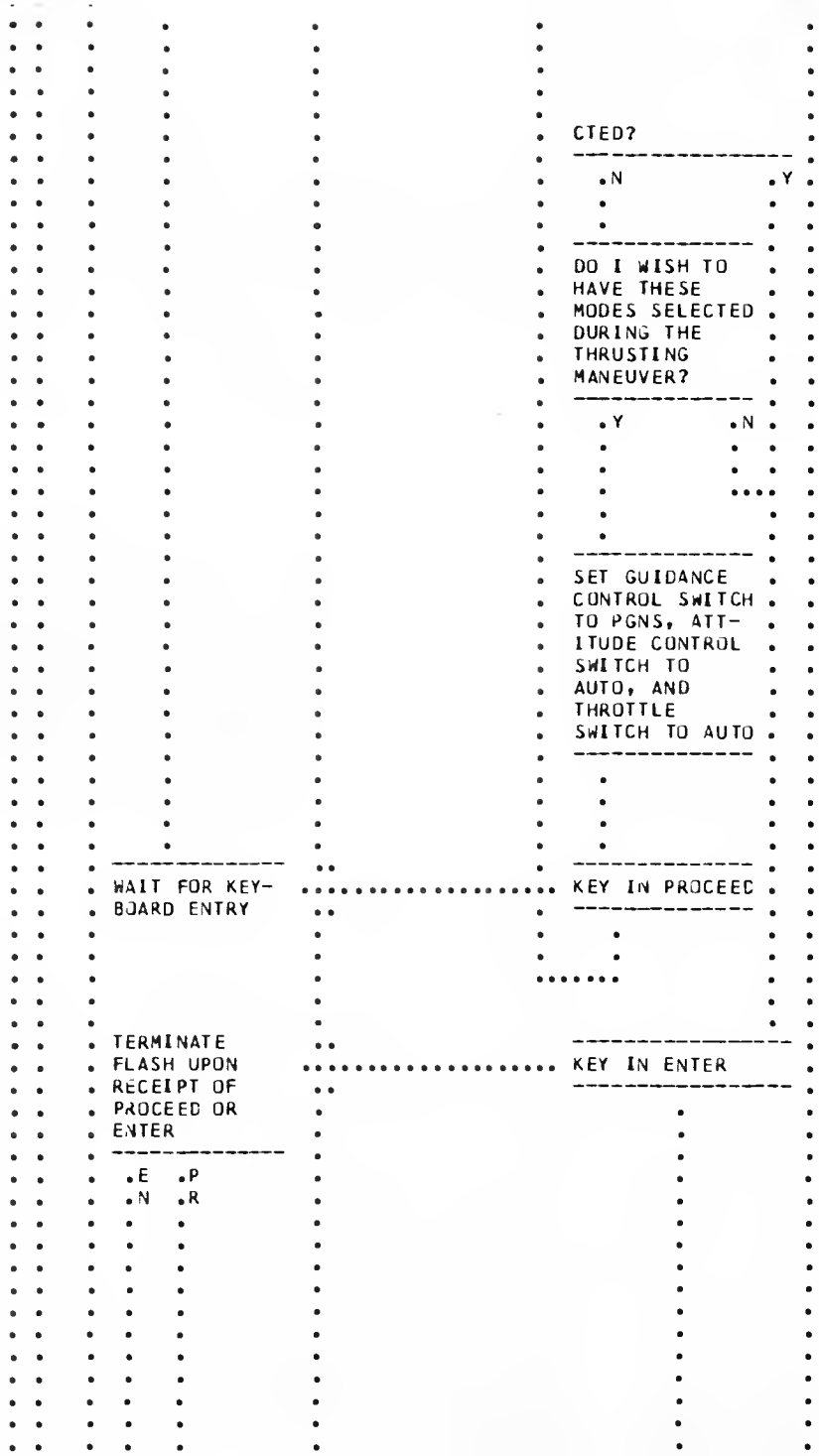
#380

#390

#400

#410


IS THE APS FLAG SET?
.Y
N.
#420
++
+06
+
+
+1180
++
IS AUTO THROTTLE DISCRETE BACKUP SET? (CHANBKUP BIT 4 = 1?)
.Y
.N
#430
HAS THE AUTO THROTTLE MODE BEEN SELECTED?
.Y
N.
#440
POSS HOLD
SNAP
FLASH VERB-NOUN TO REQUEST PLEASE PERFORM PGNS CONTROL, AUTO ATTITUDE CONTROL, AND AUTO THROTTLE MODE SELECTION:
V50 N25
R1-00203
R2-BLANK
R3-BLANK
MONITOR DSKY: DOES VERB-NOUN FLASH TO REQUEST PLEASE PERFORM PGNS CONTROL, AUTO ATTITUDE CONTROL, AND AUTO THROTTLE MODE SELECTION?
#450
.Y
N.
#460
HAVE REQUESTED MODES BEEN SELE-



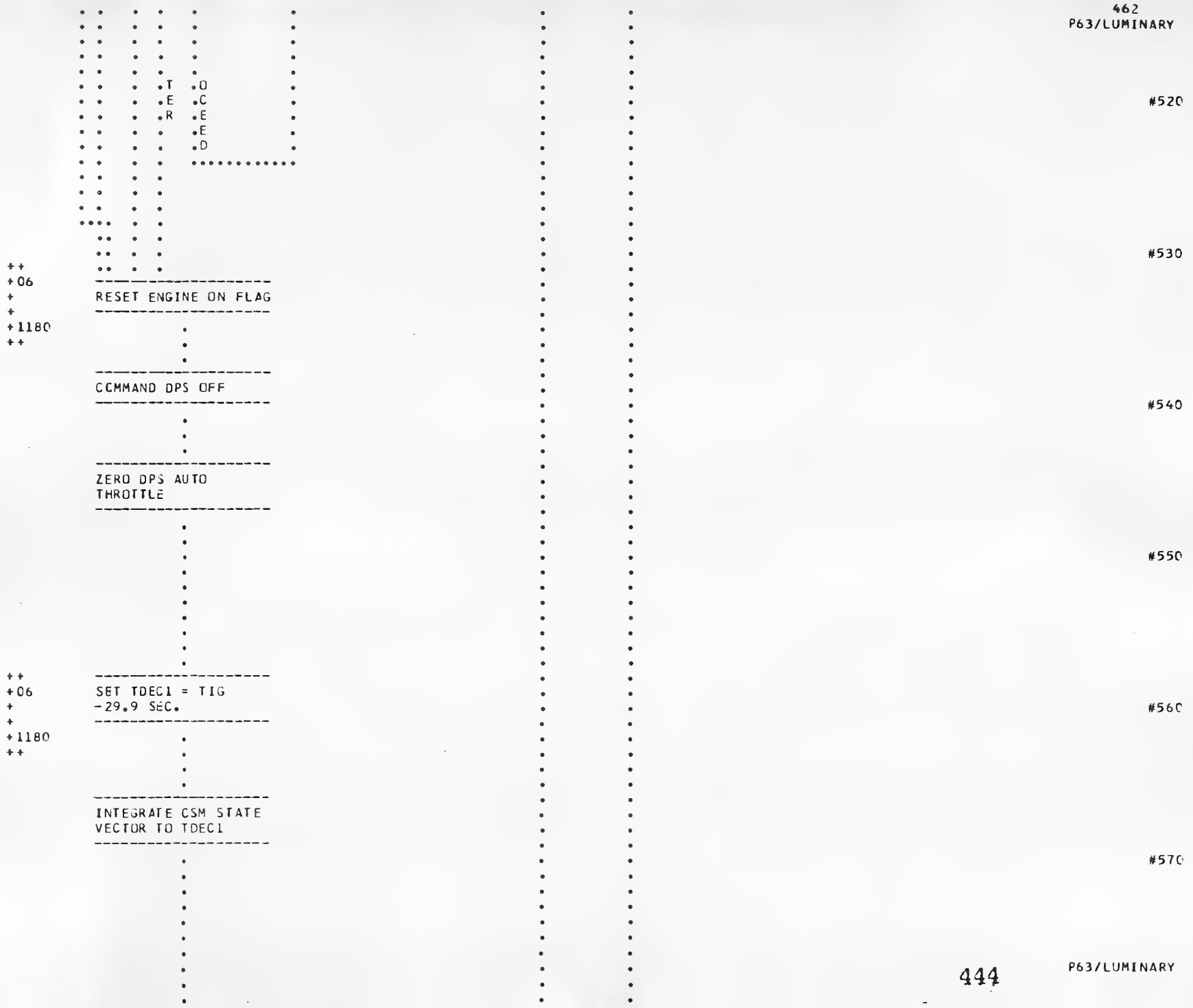
#470

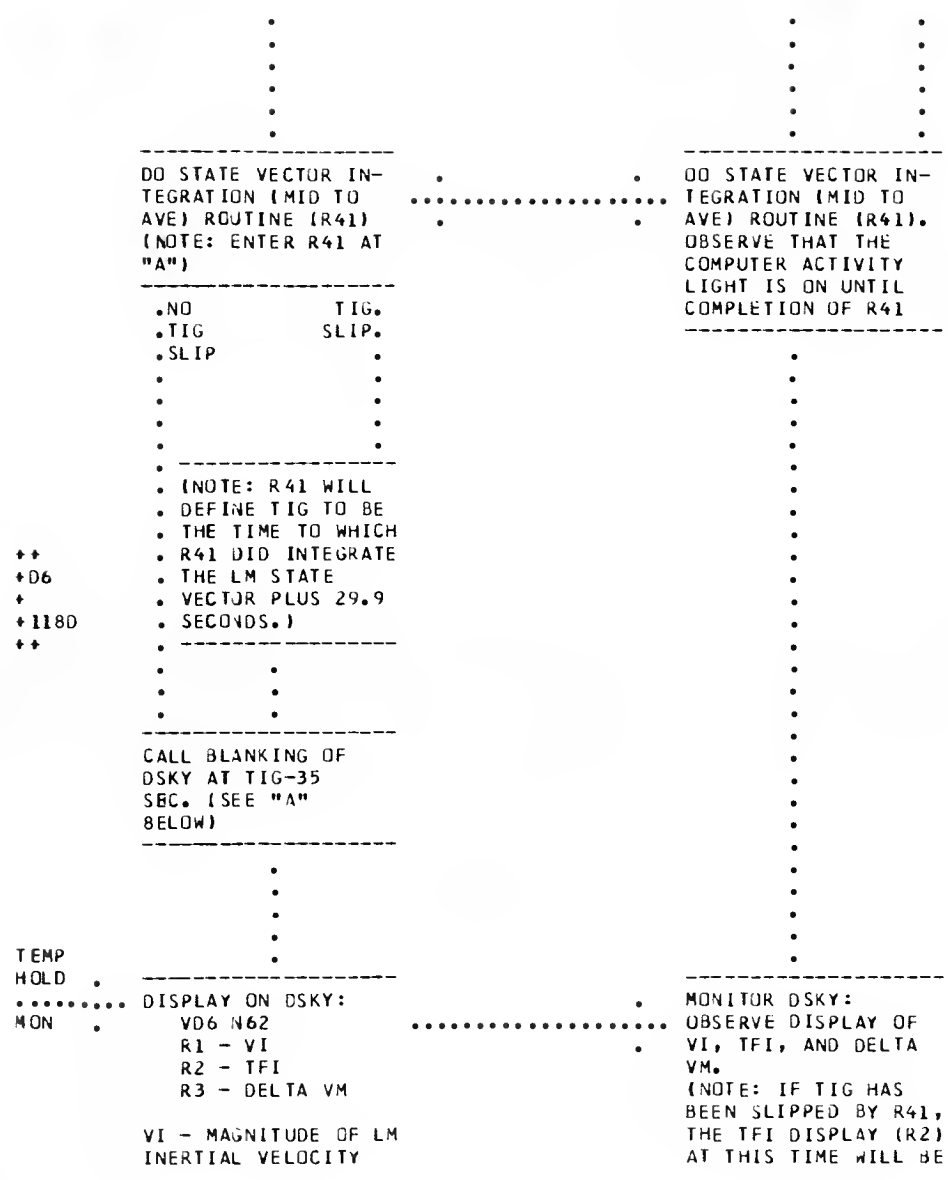
#480

#490

#500

#510


T
E
R
O
C
E
E
D
#520
#530
++
+06
+
+
+1180
++
RESET ENGINE ON FLAG
COMMAND DPS OFF
#540
ZERO DPS AUTO
THROTTLE
#550
++
+06
+
+
+1180
++
SET TDEC1 = TIG
-29.9 SEC.
#560
INTEGRATE CSM STATE
VECTOR TO TDEC1
#570



++
+D6
+
+1180
++

TEMP
HOLD
MON

#580
#590
#600
#610

WITH RESPECT TO THE
REFERENCE COORDINATE
SYSTEM. IN FPS TO
NEAREST .1 FPS.
(NOTE: THIS DISPLAY
(R1) REMAINS CON-
STANT AT THE VALUE
APPROPRIATE TO AVER-
AGE-G INITIATION,
UNTIL TIG-30 THE
VALUE IS AN EXTRA-
POLATED VALUE GOOD
AT TIG-30.)

TFI-SEE DEFINITION
ABOVE

DELTA VM-MEASURED
DELTA V MAGNITUDE.
IN FPS TO NEAREST
.1 FPS. THIS DIS-
PLAY WILL BE 00000
UNTIL TIG-30 SEC AND
THEN SHOULD CHANGE
ONLY DUE TO PIPA
BIAS UNTIL ULLAGE IS
STARTED.

EXIT
(NOTE: THIS IS
NOT A P63 EXIT.
SEE "A" BELOW.)

REFERRED TO THE NEW
TIG.) #620

UPDATE EVENT TIMER
IF DESIRED.

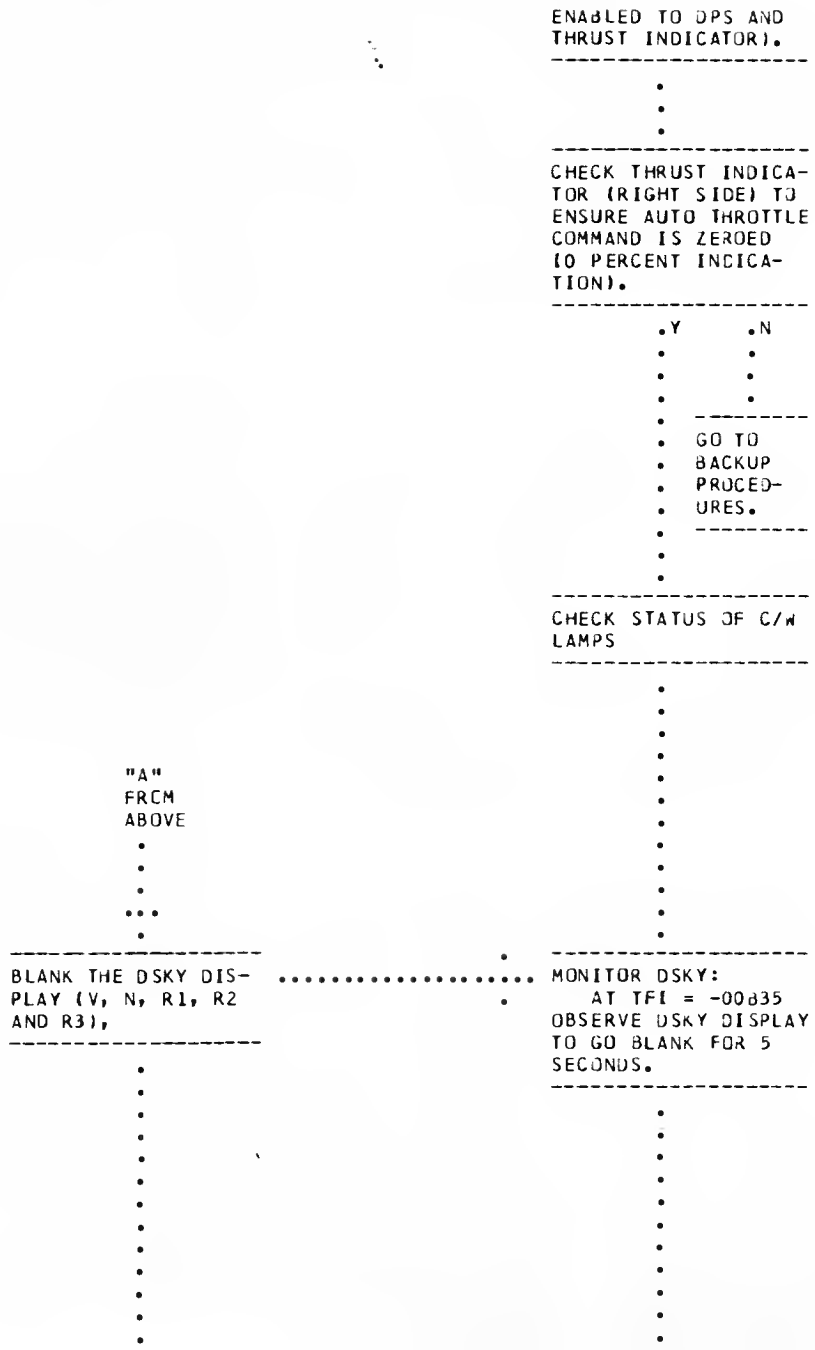
#630

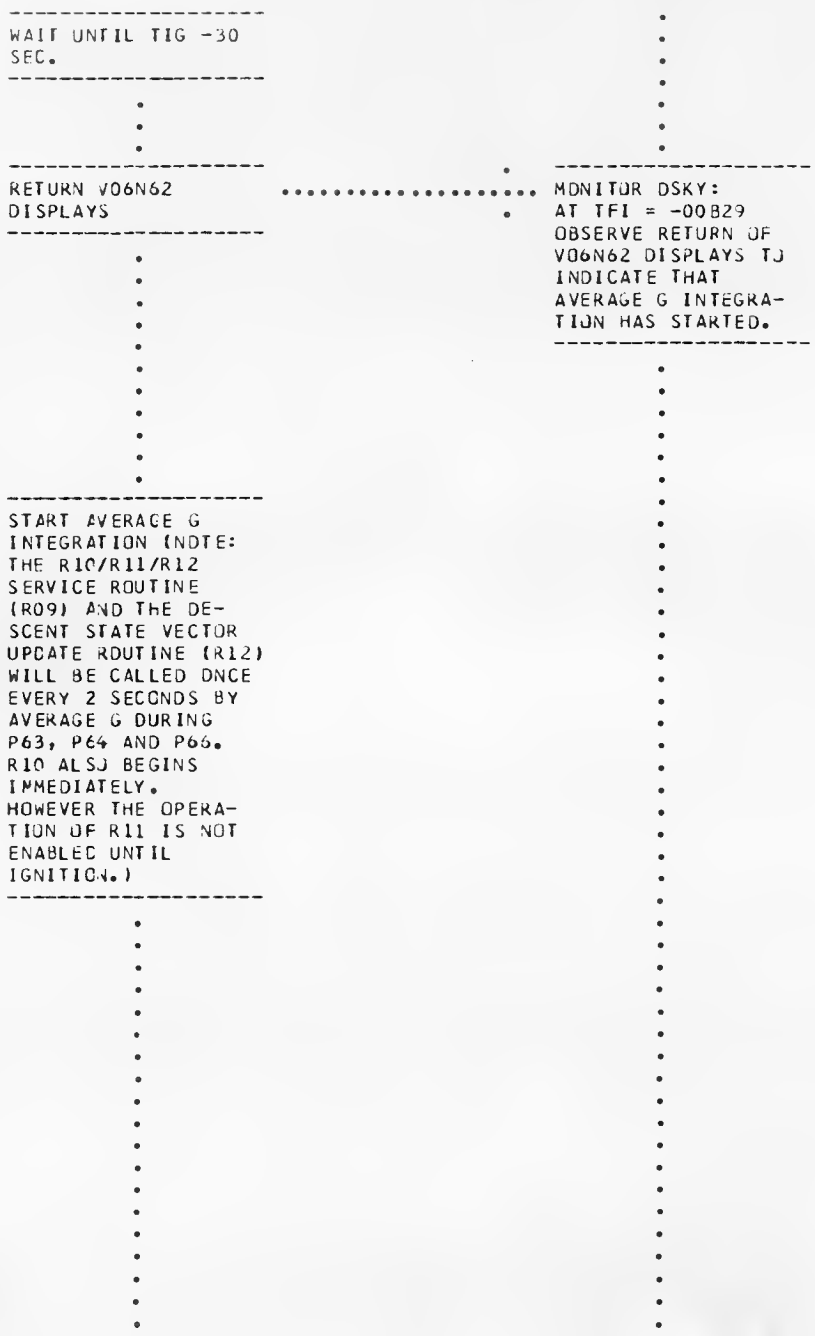
#640

#650

VERIFY/SET THRUST/
TRANSLATION CONTROL-
LER TO MINIMUM
THRUST POSITION. #660

ARM DPS. (AUTO
THROTTLE SIGNAL IS


ENABLED TO DPS AND THRUST INDICATOR).
#670
CHECK THRUST INDICATOR (RIGHT SIDE) TO ENSURE AUTO THROTTLE COMMAND IS ZEROED (0 PERCENT INDICATION).
#680
Y
N
GO TO BACKUP PROCEDURES.
#690
CHECK STATUS OF C/W LAMPS
#700
"A" FROM ABOVE
MONITOR DSKY: AT TFI = -00835 OBSERVE DSKY DISPLAY TO GO BLANK FOR 5 SECONDS.
#710
BLANK THE DSKY DISPLAY (V, N, R1, R2 AND R3),



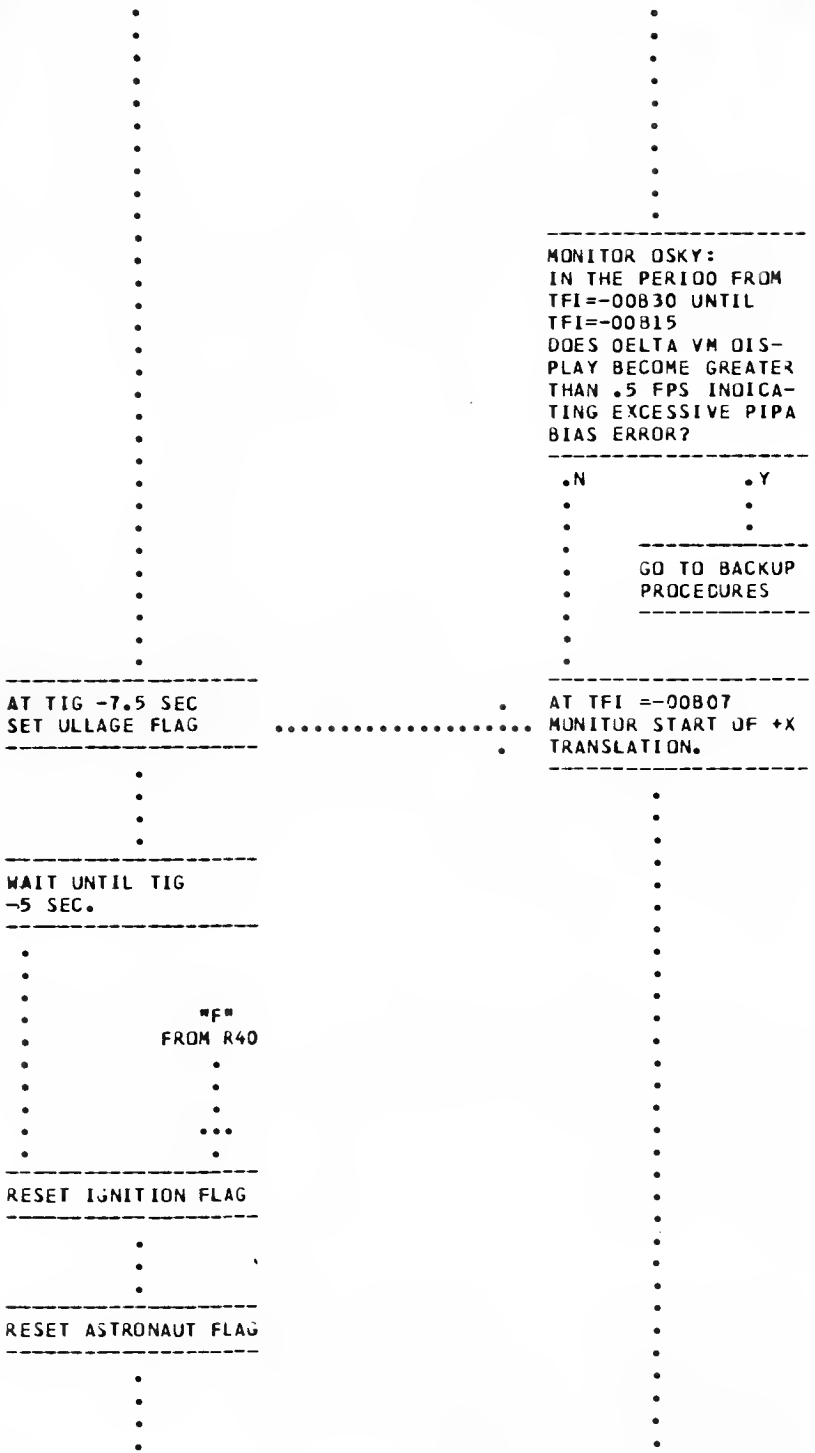
#720

#730

#740

#750

#760



#770

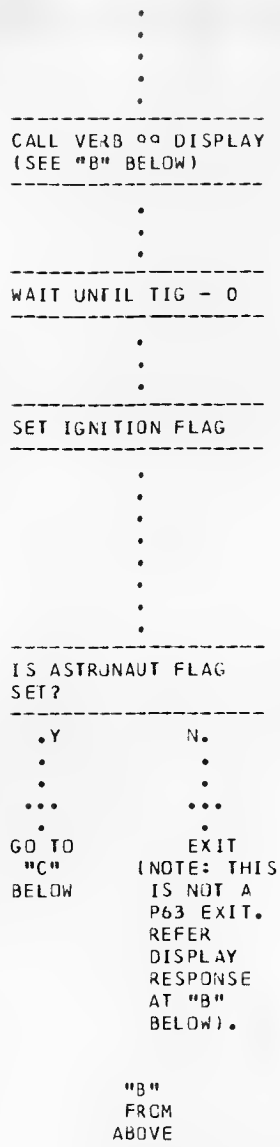
#780

#790

#800

#810

#820



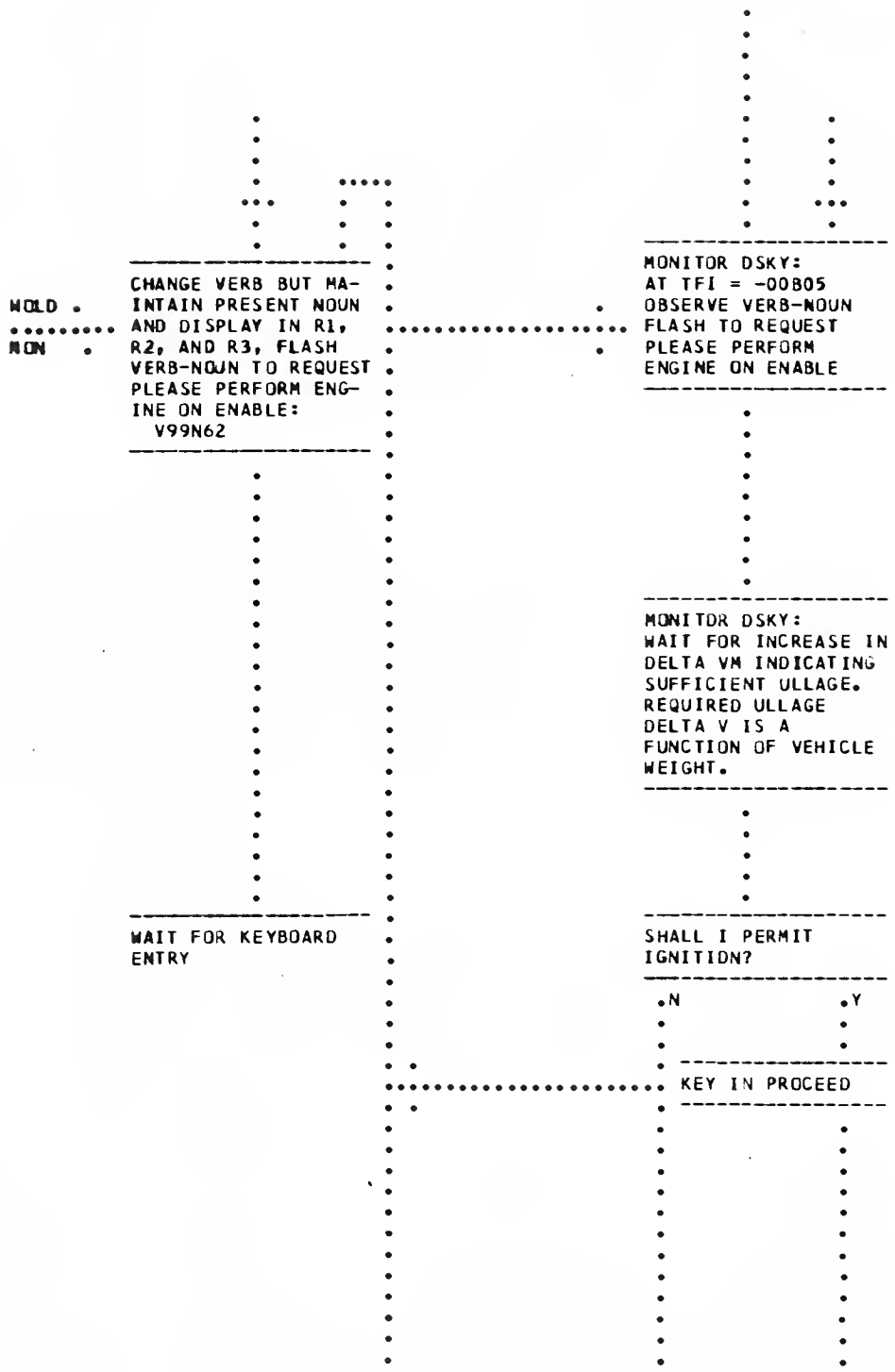
#830

#840

#850

#860

"F"
FROM R40


#870
#880
#890
#900
#910
MONITOR DSKY:
AT TFI = -00805
OBSERVE VERB-NOUN
FLASH TO REQUEST
PLEASE PERFORM
ENGINE ON ENABLE
MONITOR DSKY:
WAIT FOR INCREASE IN
DELTA VM INDICATING
SUFFICIENT ULLAGE.
REQUIRED ULLAGE
DELTA V IS A
FUNCTION OF VEHICLE
WEIGHT.
SHALL I PERMIT
IGNITION?
.N
.Y
KEY IN PROCEED
HOLD .
NON .
CHANGE VERB BUT MA-
INTAIN PRESENT NOUN
AND DISPLAY IN R1,
R2, AND R3, FLASH
VERB-NOUN TO REQUEST
PLEASE PERFORM ENG-
INE ON ENABLE:
V99N62
WAIT FOR KEYBOARD
ENTRY

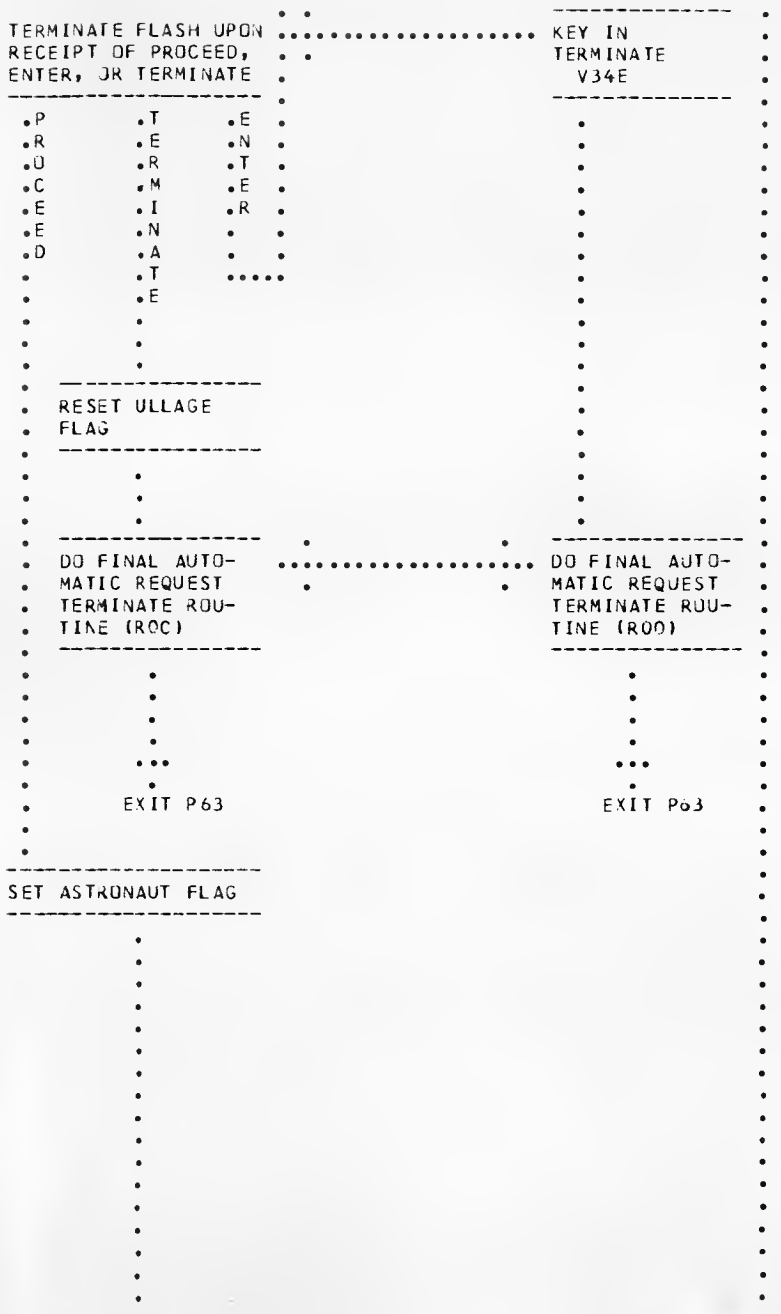
#920

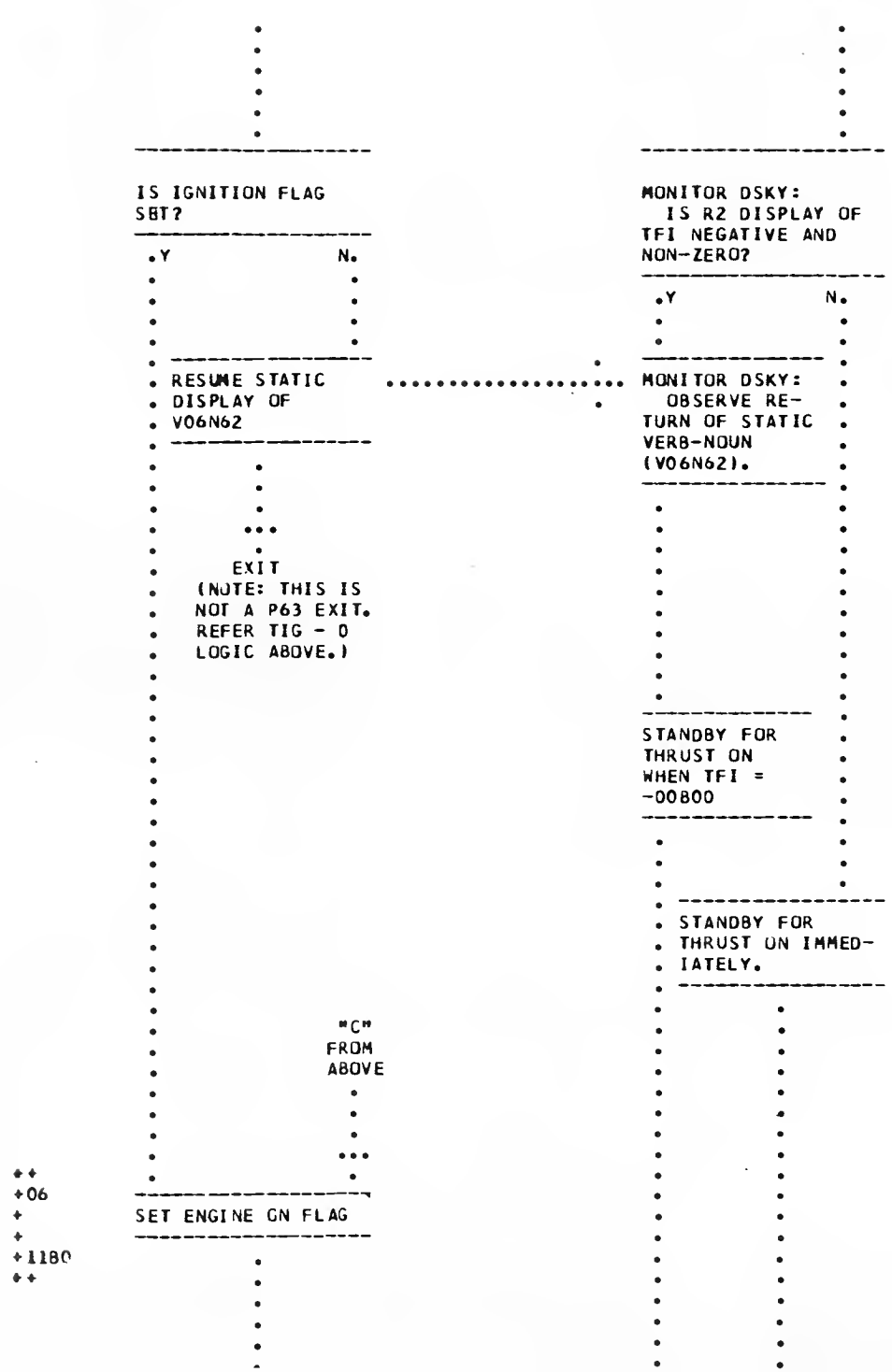
#930

#940

#950

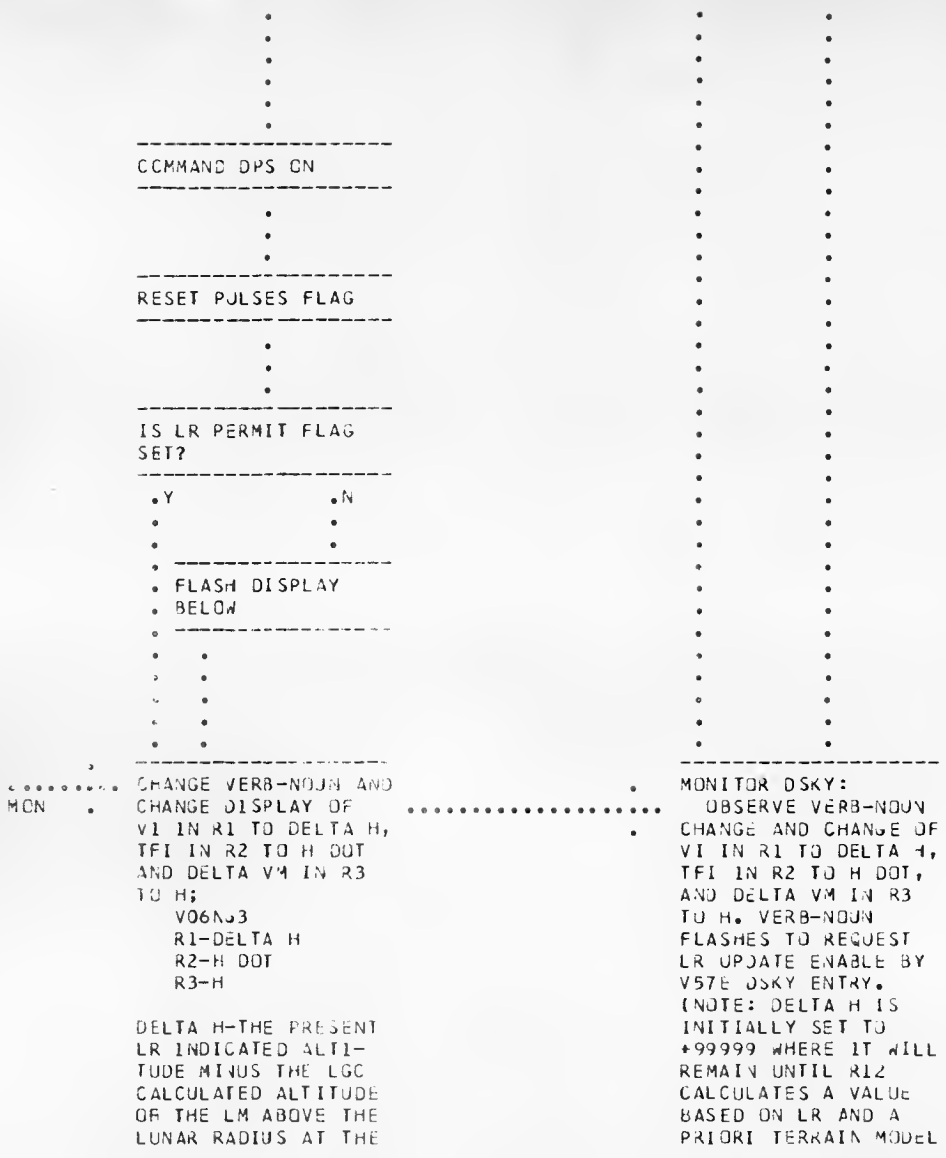
#960





#970
#980
#990
#1000
#1010
#1020

++
+06
+
+
+1180
++


COMMAND DPS ON
RESET PULSES FLAG
#1030
IS LR PERMIT FLAG SET?
#1040
Y
N
FLASH DISPLAY BELOW
#1050
CHANGE VERB-NOUN AND CHANGE DISPLAY OF V1 IN R1 TO DELTA H, TFI IN R2 TO H DOT AND DELTA VM IN R3 TO H;
V06N63
R1-DELTA H
R2-H DOT
R3-H
MON
MONITOR DSKY:
OBSERVE VERB-NOUN CHANGE AND CHANGE OF V1 IN R1 TO DELTA H, TFI IN R2 TO H DOT, AND DELTA VM IN R3 TO H. VERB-NOUN FLASHES TO REQUEST LR UPDATE ENABLE BY V57E DSKY ENTRY.
#1060
DELTA H-THE PRESENT LR INDICATED ALTITUDE MINUS THE LGC CALCULATED ALTITUDE OF THE LM ABOVE THE LUNAR RADIUS AT THE
(NOTE: DELTA H IS INITIALLY SET TO +99999 WHERE IT WILL REMAIN UNTIL R12 CALCULATES A VALUE BASED ON LR AND A PRIORI TERRAIN MODEL

DESIGNATED LANDING SITE. IN FEET TO NEAREST FOOT.

H DOT-THE PRESENT RATE OF CHANGE OF ALTITUDE (H). POLARITY INDICATES DESCENT (-) OR ASCENT (+). IN FPS TO NEAREST .1 FPS.

H - THE PRESENT ALTITUDE OF THE LM ABOVE THE LUNAR RADIUS AT THE DESIGNATED LANDING SITE. POLARITY IS + FOR ALTITUDES GREATER THAN THE ABOVE RADIUS. IN FEET TO NEAREST FOOT.

SET ABORT ENABLE FLAG

RESET IDLE FLAG

IS IMPULSE FLAG SET? (NOTE: ANSWER WILL

DATA. V57E WILL SET THE LR PERMIT FLAG AND VERB-NOUN WILL NO LONGER FLASH. V58E RESETS THE LR PERMIT FLAG AND WILL CAUSE VERB-NOUN TO FLASH AGAIN.)

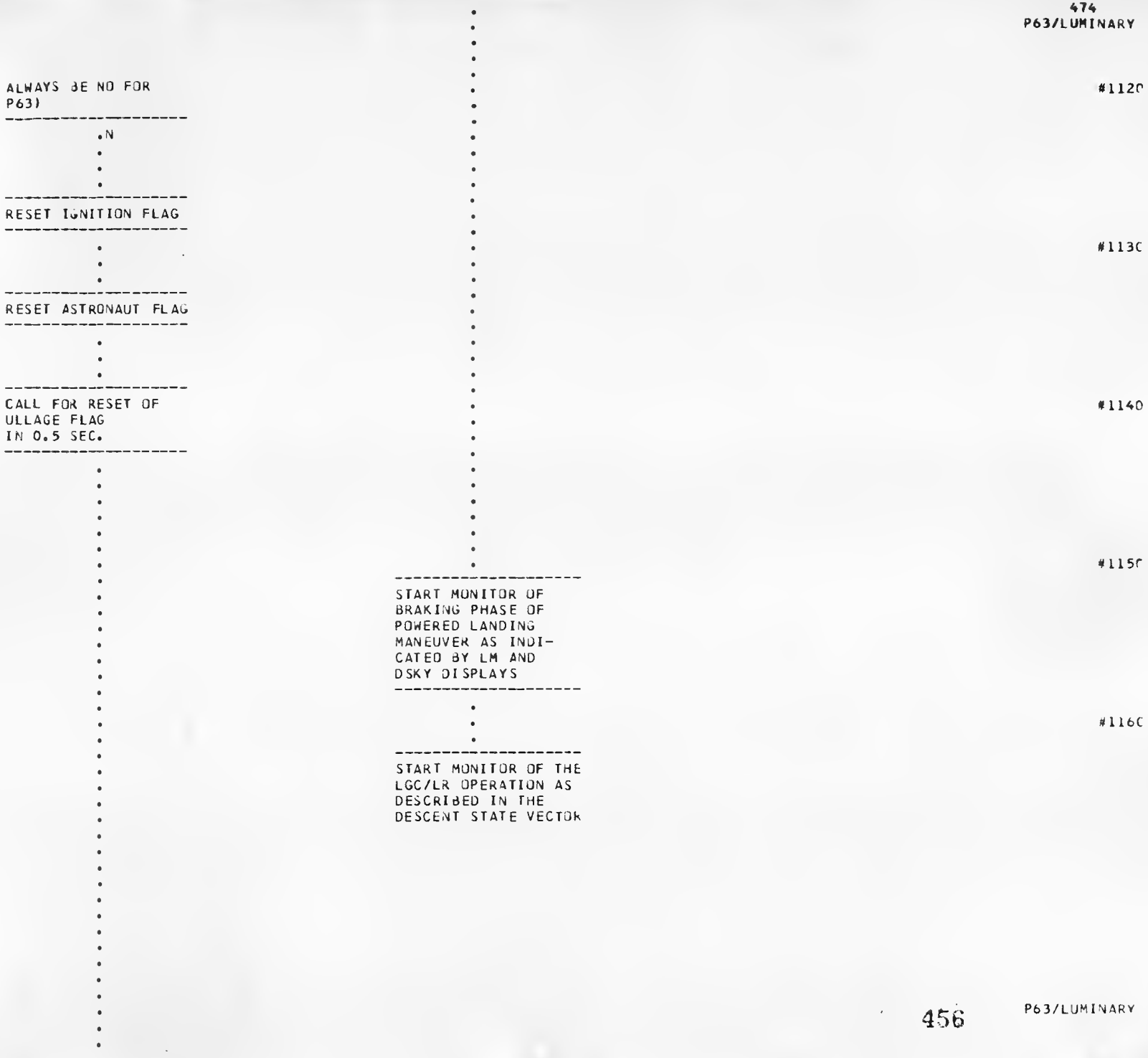
#1070

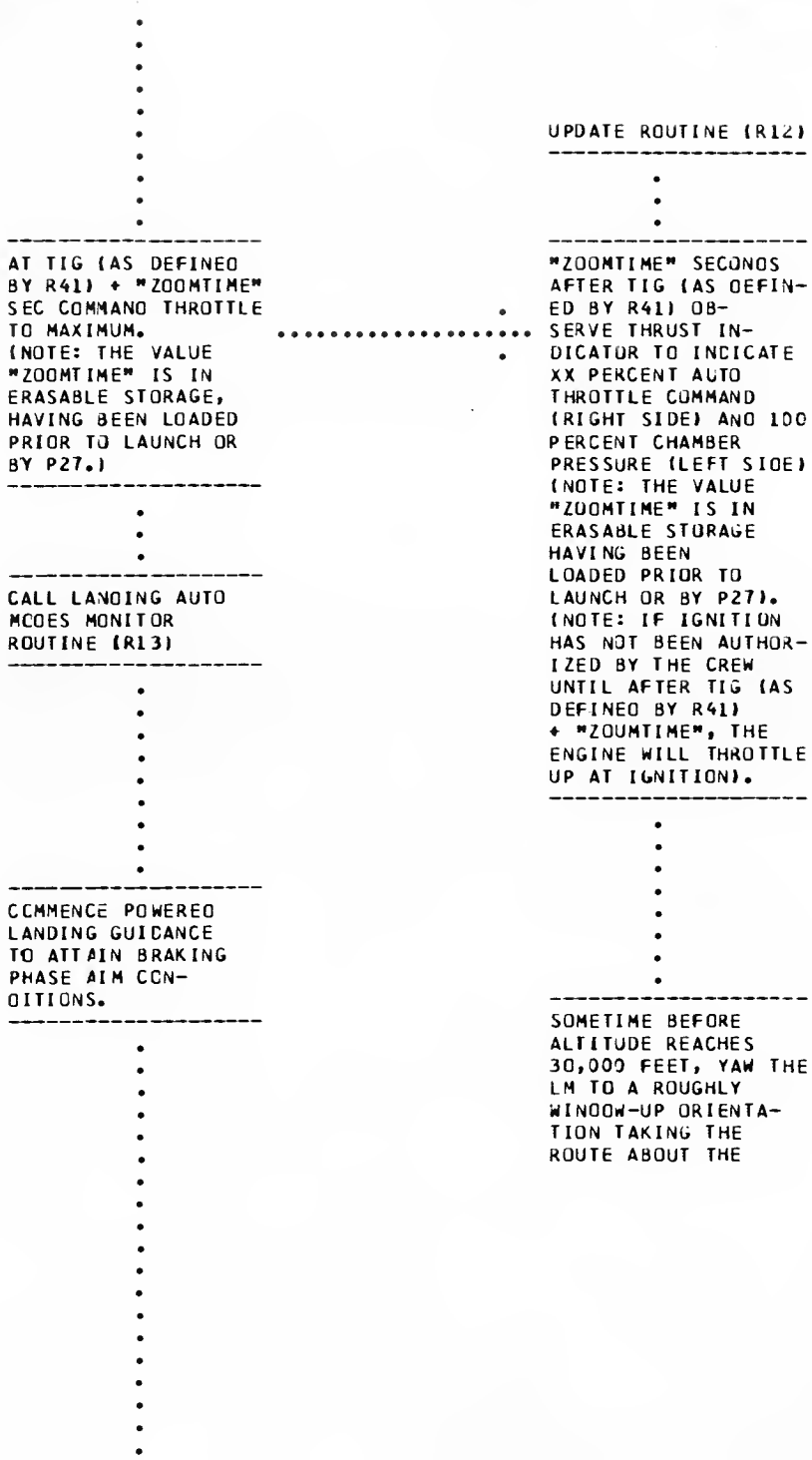
#1080

#1090

#1100

#1110


ALWAYS BE NO FOR P63)
N
RESET IGNITION FLAG
RESET ASTRONAUT FLAG
CALL FOR RESET OF ULLAGE FLAG IN 0.5 SEC.
START MONITOR OF BRAKING PHASE OF POWERED LANDING MANEUVER AS INDICATED BY LM AND DSKY DISPLAYS
START MONITOR OF THE LGC/LR OPERATION AS DESCRIBED IN THE DESCENT STATE VECTOR
#1120
#1130
#1140
#1150
#1160



#1170

#1180

#1190

#1200

#1210

X-AXIS THAT DOES NOT RESULT IN LOSS OF S-BAND LOCK-ON

#1220

WHEN H IS EQUAL TO + 30000 THE X-AXIS OVERRIDE OPTION IS REMOVED BY R12. THE LGC WILL AUTOMATICALLY COMMAND THE LM TO AN ATTITUDE AROUND THE LM X AXIS AS SPECIFIED BY THE GUIDANCE EQUATIONS. THE CREW NO LONGER HAS ANY MANUAL ATTITUDE CONTROL OF THE LM WHILE IN THE AUTO ATTITUDE CONTROL MODE.

#1230

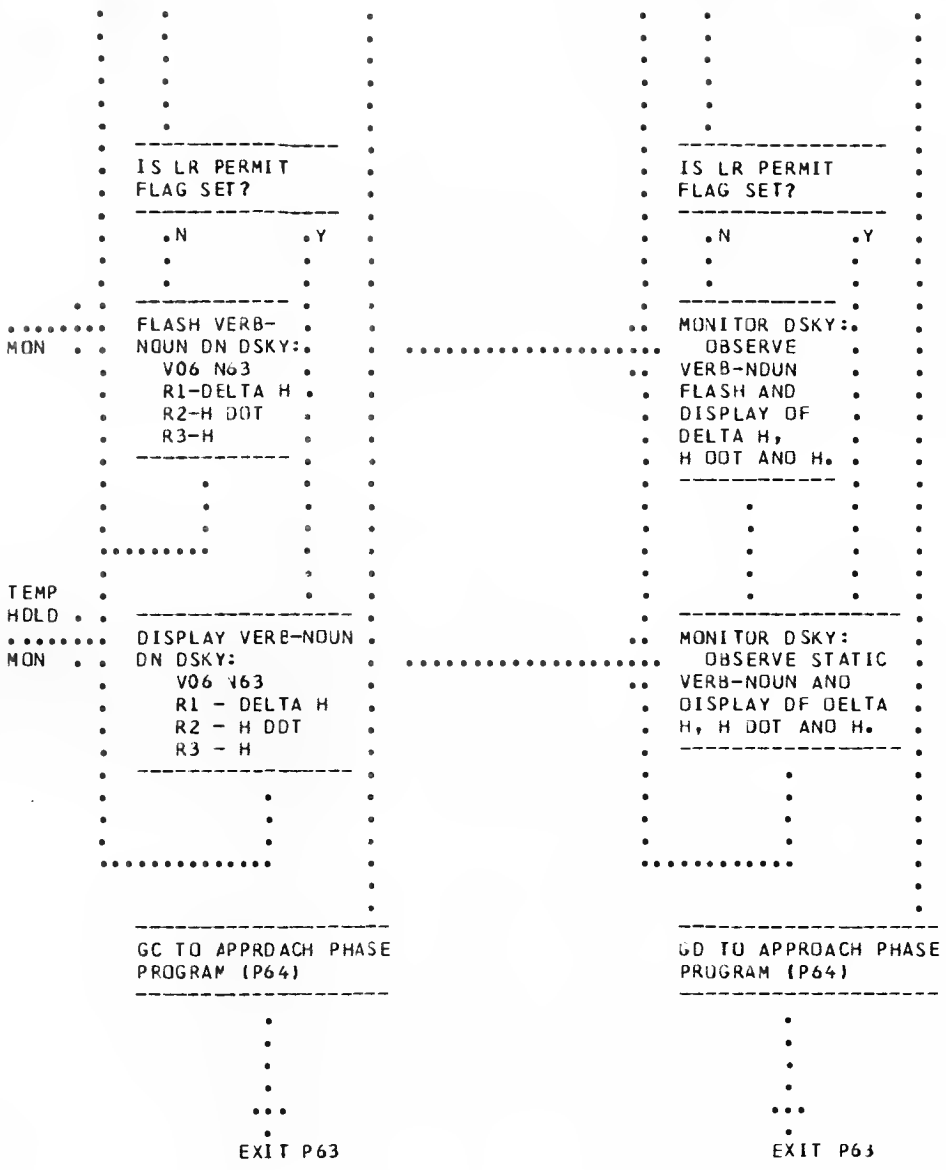
#1240

IS TG LESS THAN "TENDBRAK"? (NOTE: THE VALUE "TENDBRAK" IS IN ERASABLE STORAGE HAVING BEEN LOADED PRIOR TO LAUNCH OR BY P27).

#1250

.N .Y

#1260



#1270

#1280

#1290

#1300

#1310

CHANGE CONTROL NOTES

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REV 00   PCR 13,30,31
REV 01   PCR 85,86,118,144,164,186,234,246,253,401,419,437,
             497,539,542,568,637
REV 00(LUM 1A)    PCR 670,737,751
REVS 01,02(LUM 1B) PCR 814,838,841,854, EDITORIAL
REV 03(LUM 1C)    PCR 285, EDITORIAL
REV 04(LUM 1D)    PCR 892,988,1013, PCN 1009,1035
REV 05(LUM 1E)    PCR 334,335,1109, PCN 1145
REV 06   PCN 1180
```

APPROACH PHASE PROGRAM (P64) REV 05 12/01/71

PURPOSE: (1) TO CONTROL THE PGNCS DURING THE THRUSTING OF THE POWERED LANDING MANEUVER BETWEEN HI GATE AND LO GATE.

(2) TO CONTROL THE DPS THRUST AND ATTITUDE BETWEEN HI GATE AND LO GATE.

(3) TO PROVIDE THE CREW WITH THE CAPABILITY OF REDESIGNATING THE LANDING SITE TO WHICH THE PGNCS IS GUIDING THE LM.

(4) TO SELECT P66 AUTOMATICALLY WHEN TG IS LESS THAN TENDAPPR (TIME-TO-END-APPROACH-PHASE).

ASSUMPTIONS: (1) THE LM IS ON THE POWERED LANDING DESCENT BETWEN HI GATE AND LO GATE (SEE BRAKING PHASE PROGRAM (P63), AND SECTION 5.3.4 OF R567).

(2) IF CIRCULARIZATION HAS NOT OCCURRED, THE CSM IS IN A 9X60 (MILES) ORBIT AROUND THE MOON. THE CSM IS MAINTAINING A PREFERRED TRACKING ATTITUDE FOR OPTICAL TRACKING OF THE LM.

(3) THE IMU IS ON AND ACCURATELY ALIGNED TO A LANDING SITE ORIENTATION DEFINED FOR THE DESIGNATED LANDING SITE AND THE NOMINAL TIME OF LANDING IT(LAND)).

(4) THE LANDING RADAR (LR) IS ON, CHECKED OUT, AND SHOULD HAVE BEEN PROVIDING TO THE LGC VELOCITY AND RANGE INFORMATION WITH RESPECT TO THE MOON. THIS INFORMATION SHOULD HAVE BEEN INCORPORATED INTO THE LM STATE VECTOR. THE LGC/LR OPERATION IS UNDER THE CONTROL OF THE DESCENT STATE VECTOR UPDATE ROUTINE (R12) WHICH IS ALREADY IN PROCESS.

(5) THE LGC WILL NEITHER DESIGNATE NOR READ THE RENDEZVOUS RADAR (RR) DURING THIS PROGRAM.

(6) THE ENTIRE POWERED LANDING MANEUVER (BRAKING, APPROACH AND LANDING) WILL BE ACCOMPLISHED USING THE DPS ENGINE.

(7) THE AIM CONDITIONS (LO GATE) FOR THE APPROACH PHASE ARE STORED IN THE LGC.

(8) THE FOLLOWING PARAMETERS REQUIRED BY THIS PROGRAM HAVE BEEN STORED IN THE LGC SINCE LGC INITIALIZATION BY ERASABLE REGISTER LOAD.

(A) THE LM STATE VECTOR. THE LGC HAS UPDATED THIS AS REQUIRED DURING THRUSTING. NO FURTHER STATE VECTOR UPDATES FROM ANY SOURCE OTHER THAN THE LR WILL BE ACCEPTED BY THIS PROGRAM.

(9) THE DPS IS NOT THROTTLABLE OVER THE WHOLE RANGE FROM 0 TO MAXIMUM. IT MUST BE OPERATED EITHER AT MAXIMUM THROTTLE OR OVER A SPECIFIC THROTTLE RANGE OF LOWER SETTINGS. THESE THROTTLE SETTINGS ARE SPECIFIED IN SECTION 5.3.4 OF R567 AND ARE TOTAL THROTTLE SETTINGS, I.E.: THE SUM OF THE MANUAL SETTING (WHOSE MINIMUM IS ABOUT 10 PERCENT) AND THE PGNCS COMMANDED SETTING.

THE THROTTLE CONTROL MAY BE SET TO AUTO (THE DPS RECEIVES THE SUM OF THE MANUAL AND PGNCS COMMANDED SETTINGS) OR MANUAL.

NOMINALLY, IF THE APPROACH PHASE PROGRAM IS COMPLETED WITHOUT ANY REDESIGNATION OF THE LANDING SITE (SEE ASSUMPTION (12)), THE THROTTLE WILL REMAIN WITHIN THE ALLOWABLE THROTTLE RANGE THROUGHOUT THE PHASE. EXCESSIVE TARGET REDESIGNATIONS DURING THIS PROGRAM HOWEVER MAY RESULT IN REQUIRED THROTTLE EXCURSIONS OUTSIDE THE ALLOWABLE RANGE. IN SUCH CASES THE LGC WILL COMMAND MAXIMUM THROTTLE FOR AT LEAST 2 SEC, AND UNTIL THE REQUIRED THROTTLE SETTING RETURNS TO THE PERMITTED THROTTLE REGION.

(10) DURING THE POWERED LANDING MANEUVER, THE LGC WILL MONITOR THE PRESENCE OR ABSENCE OF THE "NON-ATTITUDE HOLD" DISCRETE. THIS DISCRETE IS ISSUED TO THE LGC WHEN THE ATTITUDE MODE CONTROL SWITCH IS IN THE AUTO POSITION.

SHOULD THIS DISCRETE APPEAR DURING THE POWERED LANDING MANEUVER, THE LGC ASSUMES THAT IT NO LONGER HAS COMPLETE AUTOMATIC CONTROL OF THE ATTITUDE OF THE SPACECRAFT.

THE MONITOR AND THE ASSOCIATED LGC LOGIC IS INCLUDED IN THE LANDING AUTO MODES MONITOR ROUTINE (R13) WHICH IS

ALREADY IN PROCESS.

(11) THE X-AXIS OVERRIDE OPTION IS NOT PROVIDED THE CREW WHENEVER THE LGC-ESTIMATED ALTITUDE IS LESS THAN 30,000 FT. (REFER R12 AND ASSUMPTION 13 OF P63).

(12) DURING MOST OF THE APPROACH PHASE, THE LGC PROVIDES THE CREW THE OPTION TO REDESIGNATE THE LANDING SITE TO WHICH THE PGNCS IS GUIDING THE LM. THIS OPTION IS CALLED THE LANDING POINT DESIGNATOR (LPD) MODE. IT IS WORTH NOTING THAT THE PGNCS MODE CONTROL SWITCH MUST BE IN AUTO FOR THE ACA TO FUNCTION AS A LANDING SITE RE-DESIGNATOR. IF THIS SWITCH IS IN ATT HOLD THE ACA FUNCTIONS AS A RATE COMMAND/ATTITUDE HOLD STICK.

THE LANDING POINT REDESIGNATION, IF EXERCISED, IS BASED UPON VISUAL ASSESSMENT OF THE LUNAR TERRAIN WITH RESPECT TO THE PRESENTLY DESIGNATED LANDING SITE. DURING THE LPD MODE THE PRESENT LANDING SITE IS DISPLAYED ON THE DSKY IN TERMS OF COORDINATES ON THE LPD SIGHTING GRID ON THE LEFT HAND LM WINDOW (LPD ANGLE). LANDING SITE REDESIGNATIONS ARE MANUALLY PUT INTO THE COMPUTER VIA THE ATTITUDE CONTROLLER ON AN INCREMENTAL BASIS, I.E.: A LIMIT SWITCH ACTUATION IN THE ATTITUDE CONTROLLER CAUSES THE LGC TO REDESIGNATE THE LANDING SITE A FIXED ANGULAR INCREMENT (1 DEGREE IN ELEVATION, 1 DEGREE IN AZIMUTH) FROM THE PRESENT LM/LANDING SITE LOS. THE APPLICABLE ATTITUDE CONTROLLER POLARITIES ARE:

(A) - PITCH ROTATION GIVES - LPD ELEVATION (NEW SITE BEYOND PRESENT SITE)
(B) + PITCH ROTATION GIVES + LPD ELEVATION (NEW SITE SHORT OF PRESENT SITE)
(C) + ROLL ROTATION GIVES + LPD AZIMUTH (NEW SITE TO RIGHT OF PRESENT SITE)
(D) - ROLL ROTATION GIVES - LPD AZIMUTH (NEW SITE TO LEFT OF PRESENT SITE)

THE LPD MODE IS MORE COMPLETELY DESCRIBED IN SECTION 5.3.4 OF R567.

(13) THE INITIAL MANEUVER OF THE APPROACH PHASE IS THE LM ATTITUDE TRANSITION FROM THE LM ATTITUDE AT THE START OF P64 TO A SATISFACTORY ATTITUDE FOR LANDING SITE VISIBILITY. AFTER THE COMPLETION OF THIS MANEUVER THE LM ATTITUDE IS CONSTRAINED BY THRUST POINTING REQUIREMENTS AND IS CONTROLLED ABOUT THE THRUST AXIS SO AS TO MAINTAIN THE CURRENT LANDING SITE IN THE LM X/Z PLANE. THE CONDITIONS ACHIEVED BY THE START OF P64 SHOULD BE SUCH THAT THE THRUST POINTING REQUIREMENTS OF THE APPROACH PHASE WILL YIELD SATISFACTORY VISIBILITY AND RADAR ORIENTATIONS.

THE LANDING SITE BECOMES VISIBLE TO THE COMMAND PILOT IF THE LOOK ANGLE (THE ANGLE BETWEEN THE LM -X AXIS AND THE LOS TO THE LANDING SITE) IS GREATER THAN 25 DEGREES AND THE LOS IS IN OR NEAR THE LM X/Z PLANE.

AT ANYTIME DURING P63 OR P64, THE MAGNITUDE OF THE LOOK ANGLE AND THE ORIENTATION OF THE LOOK ANGLE PLANE (THAT PLANE CONTAINING THE LOS AND THE LM X AXIS) ARE DEFINED BY THE INERTIAL ORIENTATION OF THE LM X AXIS AND THE POSITION OF THE LM WITH RESPECT TO THE LANDING SITE.

THE INERTIAL ORIENTATION OF THE LM X AXIS IS CONTROLLED BY REQUIREMENTS OF THRUST VECTOR CONTROL. THE ORIENTATION OF THE LM WINDOWS WITH RESPECT TO THE LOOK ANGLE PLANE IS CONTROLLED BY ROTATION OF THE VEHICLE ABOUT THE LM X AXIS. THIS CONTROL IS EXERCISED AS SHOWN IN SECTION 5.3.4 OF R567.

(14) THE CREW HAS THE CAPABILITY TO DISPLAY LGC CALCULATED VALUES OF FORWARD VELOCITY, LATERAL VELOCITY, ALTITUDE AND ALTITUDE RATE ON CERTAIN LM METERS DURING THIS PROGRAM. THE CALCULATION OF THESE PARAMETERS IS UNDER THE CONTROL OF THE LANDING ANALOG DISPLAYS ROUTINE (R10) WHICH IS ALREADY IN PROCESS.

(15) THE RATE OF DESCENT (ROD) MODE IS NOT ENABLED DURING THIS PROGRAM (SEE LANDING PHASE PROGRAM (P66), ASSUMPTION (12) FOR DEFINITION OF ROD MODE).

(16) AN ABORT FROM THE LUNAR DESCENT MAY BE REQUIRED AT ANY TIME DURING THE DESCENT ORBIT INJECTION, THE DESCENT COAST, OR THE POWERED DESCENT (P63),(P64), OR (P66).

FOR ABORTS FROM THE DESCENT ORBIT INJECTION OR THE DESCENT COAST IT IS ASSUMED THAT SUFFICIENT TIME EXISTS TO PERFORM A TPI MANEUVER (SEE TRANSFER PHASE INITIATION (TPI) PROGRAM (P34)) TO INTERCEPT THE CSM DIRECTLY.

FOR ABORTS AFTER DPS IGNITION FOR THE POWERED LANDING MANEUVER, TIME IS CRITICAL. DURING THIS PERIOD AN ABORT IS NOMINALLY COMMANDED BY PUSHING ONE OF TWO BUTTONS IN THE LM. THE ABORT MAY BE COMMANDED TO USE THE DESCENT STAGE (ABORT BUTTON) OR THE ASCENT STAGE (ABORT STAGE BUTTON). IF THE DESCENT STAGE IS SELECTED, AND THE DPS PROPELLANT APPROACHES EXHAUSTION, CONTROL MUST BE SWITCHED TO THE ASCENT STAGE BY THE CREW BY ASCENT STAGE SELECTION (ABORT STAGE BUTTON).

++
+05
+1180
+
+
+
+

DURING THE POWERED LANDING MANEUVER THE LGC WILL CONTINUOUSLY MONITOR THE ABORT AND THE ABORT STAGE DISCRETES, AND UPON RECEIPT OF EITHER WILL TERMINATE THE PROGRAM IN PROCESS AND CALL THE APPROPRIATE ABORT PROGRAM (DPS ABORT PROGRAM (P70) OR APS ABORT PROGRAM (P71)), UNLESS DIRECTED TO IGNORE THESE DISCRETES BY THE DAP DATA LOAD ROUTINE

(R03). BOTH ABORT PROGRAMS WILL GUIDE THE LM TO AN ORBIT AS SPECIFIED IN SECTION 5.4.3 OF R567.

THE MONITOR OF THE ABORT AND ABORT STAGE PUSHBUTTONS IS CONTROLLED BY THE ABORT DISCRETES MONITOR ROUTINE (R11) WHICH IS ALREADY IN PROCESS.

(17) IF A THRUSTING MANEUVER IS PERFORMED WITH THE GUIDANCE CONTROL SWITCH IN PGNS AND THE MODE CONTROL SWITCH IN AUTO, THE PGNCS WILL CONTROL THE TOTAL VEHICLE ATTITUDE AND GENERATE EITHER MODE I OR MODE II ATTITUDE ERRORS AND VEHICLE ATTITUDE RATES (SEE ASSUMPTION (19)) FOR DISPLAY ON THE FDAI. THE CREW MAY EXERCISE CONTROL AROUND THE YAW AXIS ONLY WITH THE ACA (X-AXIS OVERRIDE) IF THE X-AXIS OVERRIDE CAPABILITY IS PERMITTED BY THE PROGRAM IN PROCESS. THIS MANUAL CONTROL WILL BE IN THE RATE COMMAND/ATTITUDE HOLD MODE.

IF A THRUSTING MANEUVER IS PERFORMED WITH THE GUIDANCE CONTROL SWITCH IN PGNS AND THE MODE CONTROL SWITCH IN ATTITUDE HOLD THE PGNCS WILL HOLD THE VEHICLE ATTITUDE AND WILL GENERATE EITHER MODE I OR MODE II ATTITUDE ERRORS FOR DISPLAY ON THE FDAI. THE CREW MAY EXERCISE MANUAL ATTITUDE CONTROL ABOUT ALL VEHICLE AXES WITH THE ACA IN EITHER THE RATE COMMAND OR MINIMUM IMPULSE MODE DEPENDING UPON THE STATUS OF THE PULSES FLAG. IT IS STRONGLY RECOMMENDED THAT POWERED FLIGHT NOT BE ATTEMPTED IN THE MINIMUM IMPULSE MODE. THE PULSES FLAG IS SET OR RESET BY EXTENDED VERBS 76 (MINIMUM IMPULSE) AND 77 (RATE COMMAND) RESPECTIVELY. THE PULSES FLAG IS ALSO RESET BY PI2,P40,P41,P42,P63,P70,P71 AND R40 AT MAIN ENGINE IGNITION. WITH THE EXCEPTION OF THESE CASES, MODE SELECTION IS ALWAYS BASED UPON THE LAST ENTRY MADE IN THE DSKY. DURING A THRUSTING MANEUVER IN THE PGNS/ATTITUDE HOLD MODE THE PGNCS WILL NOT BE RESPONSIBLE IF REGISTER OVERFLOWS OCCUR WITHIN THE LGC EXCEPT DURING THE DESCENT THRUSTING MANEUVER. IN THIS MANEUVER, WHEN OVERFLOW IS DETECTED, CALCULATIONS ARE HALTED AND THE NEXT CALCULATION CYCLE IS BEGUN WITH UPDATED DATA.

(18) CONTROL OF THE LM DPS, RCS, AND APS IS TRANSFERRED FROM THE PGNCS TO THE ABORT GUIDANCE SYSTEM (AGS) BY PLACING THE GUID CONT SWITCH FROM PGNS TO AGS.

THE AGS WILL BE CAPABLE OF TAKING OVER CONTROL OF THE LM DURING ANY PORTION OF THE LUNAR DESCENT OR ASCENT OR DURING EITHER OF THE ABORT PROGRAMS (P70 OR P71). THE AGS WILL GUIDE THE LM TO A SAFE ORBIT.

THE AGS MAY BE INITIALIZED BY THE LGC AT ANY TIME DURING THIS PROGRAM BY MANUAL SELECTION OF THE AGS INITIALIZATION ROUTINE (R47).

++ IN THE EVENT THAT THE GUIDANCE CONTROL SWITCH IS CHANGED FROM PGNS TO AGS DURING A THRUSTING MANEUVER, THE LGC
+05 WILL CONTINUE COMPUTATION OF POSITION AND VELOCITY, THE DESIRED THRUST VECTOR AND THE FDAI ATTITUDE ERROR NEEDLE
+11B0 DISPLAY, HOWEVER THE PGNCS WILL NOT BE RESPONSIBLE IF REGISTER OVERFLOWS OCCUR WITHIN THE LGC.
++

(19) THE PGNCS CAN GENERATE TWO TYPES OF ATTITUDE ERRORS FOR DISPLAY ON THE FDAI;

MODE I - SELECTED BY EXTENDED VERB 61. AUTOPILOT FOLLOWING ERRORS USED AS A MONITOR OF THE DAP'S ABILITY TO TRACK AUTOMATIC STEERING COMMANDS.

MODE II - SELECTED BY EXTENDED VERB 62. TOTAL ATTITUDE ERRORS USED TO ASSIST CREW IN MANUALLY MANEUVERING THE VEHICLE.

PGNCS-DERIVED VEHICLE ATTITUDE RATES MAY ALSO BE DISPLAYED VIA SELECTION BY EXTENDED VERB 60.

++ DISPLAY SELECTION IS ALWAYS BASED UPON THE LAST ENTRY MADE IN THE DSKY, WITH THE EXCEPTION THAT MODE II ATTITUDE
+05 ERROR DISPLAYS ARE AUTOMATICALLY SELECTED AT THE BEGINNING OF R60. FOR A MORE DETAILED DESCRIPTION OF THESE
+11B0 DISPLAYS REFER TO SECTION 3 OF R567, PARA. 3.2.6.
++

(20) THE DAP DATA LOAD ROUTINE (R03) HAS BEEN PERFORMED PRIOR TO THE START OF THE POWERED LANDING MANEUVER AND SHOULD NOT BE REQUIRED DURING THIS PROGRAM.

(21) LGC AND CREW PROCEDURES IN CASES OF LGC-ASSUMED THRUST FAILURE ARE DEFINED BY THE DPS/APS THRUST FAIL ROUTINE (R40). THIS ROUTINE IS IN EFFECT DURING THIS PROGRAM, HAVING BEEN ENABLED BY P63.

(22) THIS PROGRAM IS AUTOMATICALLY SELECTED BY THE BRAKING PHASE PROGRAM (P63) WHEN TG DURING THE PHASE BECOMES LESS THAN TENDBRAK (TIME-TO-END-BRAKING-PHASE).

(23) THREE ALARM CONDITIONS MAY BE ORIGINATED BY THE PGNCS POWERED LANDING EQUATIONS:

(A) IF SUBROUTINE ROOTPSRS IN THE TIME-TO-GO CALCULATION FAILS TO CONVERGE IN 8 PASSES THE LGC WILL TURN ON

THE PROGRAM ALARM LIGHT, STORE PROGRAM ALARM 01406, STOP ALL VEHICLE ATTITUDE RATES, AND CONTINUE. THIS ALARM COULD OCCUR ONLY IN P63 AND P64.

(B) IF AN OVERFLOW OCCURS ANYWHERE IN THE LANDING GUIDANCE EQUATIONS THE LGC WILL TURN ON THE PROGRAM ALARM LIGHT, STORE ALARM CODE 01410, STOP ALL VEHICLE RATES AND CONTINUE. THIS ALARM COULD OCCUR IN P63, P64, OR P66.

(C) IF THERE ARE TOO FEW THROTTLINGS SINCE THE LAST P66 OMISSION, THE LGC WILL TURN ON THE PROGRAM ALARM LIGHT, STORE ALARM CODE 01466, AND BRANCH TO THE V06 N60 DISPLAY. THIS ALARM COULD ONLY OCCUR IN P66.

(24) THIS PROGRAM ALLOWS MANUAL CONTROL OF THE LM ATTITUDE. IF MANUAL CONTROL IS DESIRED, PUT THE MODE CONTROL SWITCH IN ATT HOLD AND USE THE ACA TO CONTROL THE LM ATTITUDE.

IF P66 IS DESIRED, CLICK THE ROD SWITCH WHILE THE MODE CONTROL SWITCH IS IN ATT HOLD. THE ACA DOES NOT RE-DESIGNATE THE LANDING SITE WHILE THE MODE CONTROL SWITCH IS IN ATT HOLD. TO USE THE ACA TO RE-DESIGNATE THE LANDING SITE, PUT THE MODE CONTROL SWITCH IN AUTO AND ROTATE THE ACA IN THE DESIRED DIRECTION. ONCE CONTROL IS TRANSFERRED FROM P64 TO P66, P64 CANNOT BE RE-ENTERED.

(25) THE ASTRONAUT MAY MONITOR THE FOLLOWING ADDITIONAL PARAMETERS DURING THIS PROGRAM BY KEYING IN V16 N68E OR V16 N92E:

(A) V16 N68
R1-HOR RANGE
R2-TG
R3-VI

HOR RANGE - HOR RANGE FROM THE LM TO THE DESIGNATED LANDING SITE. IN NAUTICAL MILES TO NEAREST .1 NM.

TG - THE ESTIMATED TIME OF FLIGHT FROM THE PRESENT TIME TO THE ACCOMPLISHMENT OF THE CURRENT AIM CONDITIONS. IN MINS AND SECS TO NEAREST SEC. MAX READING IS 59B59. SIGN IS -.

VI - MAGNITUDE OF LM INERTIAL VELOCITY WITH RESPECT TO THE REFERENCE COORDINATE SYSTEM. IN FPS TO NEAREST .1 FPS.

(B) V16 N92
R1 - THRCMD
R2 - HDOT
R3 - H

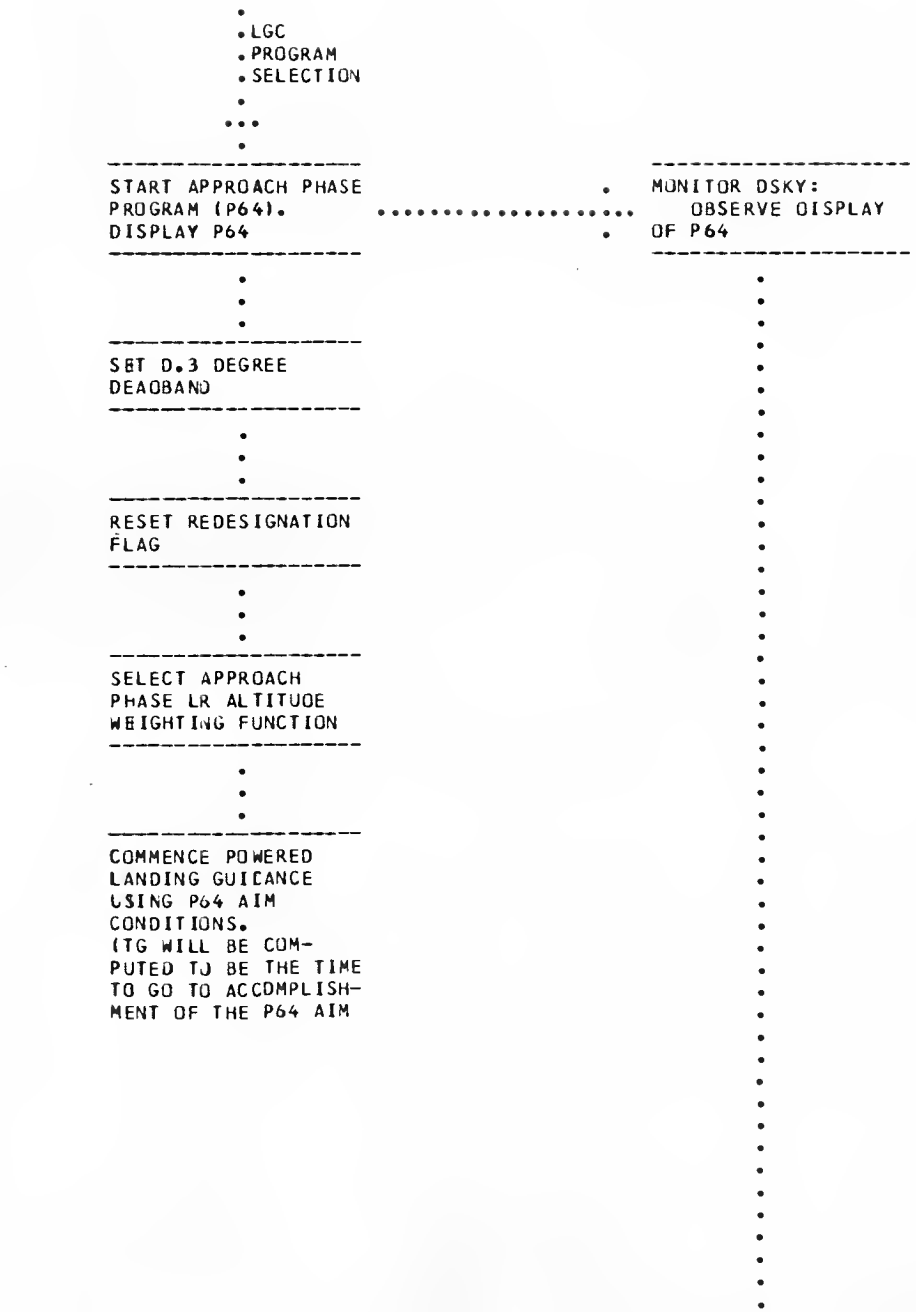
THRCMD - THE PERCENT THROTTLE DESIRED BY THE LGC, BASED ON THE DPS RATED THRUST OF 10,500 POUNDS. IN PERCENT TO NEAREST PERCENT.

HDOT - THE PRESENT RATE OF CHANGE OF ALTITUDE (H). IN FPS TO NEAREST .1 FPS.

H - THE PRESENT ALTITUDE OF THE LM ABOVE THE LUNAR RADIUS AT THE DESIGNATED LANDING SITE. IN FEET TO NEAREST FOOT.

PROG	LGC	GROUND	CREW

CONT



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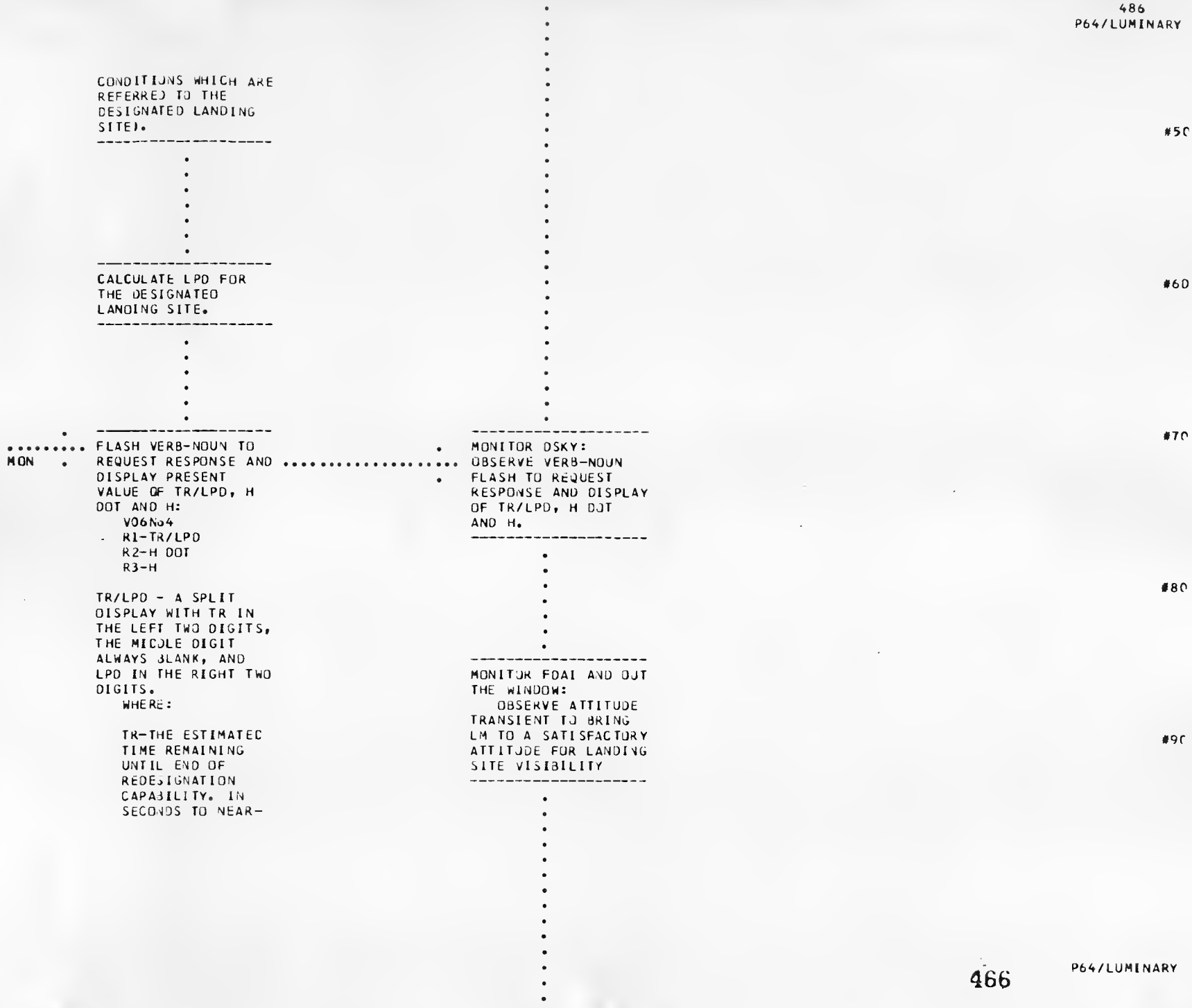

CONDITIONS WHICH ARE REFERRED TO THE DESIGNATED LANDING SITE).
#50
CALCULATE LPD FOR THE DESIGNATED LANDING SITE.
#60
MON
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY PRESENT VALUE OF TR/LPD, H DOT AND H:
V06N64
R1-TR/LPD
R2-H DOT
R3-H
MONITOR OSKY: OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY OF TR/LPD, H DOT AND H.
#70
#80
TR/LPD - A SPLIT DISPLAY WITH TR IN THE LEFT TWO DIGITS, THE MIDDLE DIGIT ALWAYS BLANK, AND LPD IN THE RIGHT TWO DIGITS.
WHERE:
TR-THE ESTIMATED TIME REMAINING UNTIL END OF REDESIGNATION CAPABILITY. IN SECONDS TO NEAR-
MONITOR FDAI AND OUT THE WINDOW:
OBSERVE ATTITUDE TRANSIENT TO BRING LM TO A SATISFACTORY ATTITUDE FOR LANDING SITE VISIBILITY
#90

EST SECOND. POLARITY IS ALWAYS +. MAXIMUM READING IS 99, FOR EXAMPLE: 130 SECONDS IS DISPLAYED AS 99. (NOTE: TR IS A POSITIVE NUMBER EQUAL TO: -TG-(TCGFAPPR+4), WHERE TCGFAPPR IS THE TIME-TO-GO AT WHICH ERECTION OF THE GUIDANCE COORDINATE FRAME IS SUSPENDED.)

LPD-THE ANGLE BELOW THE LM +Z AXIS TO THE LOS TO THE PRESENTLY DESIGNATED LANDING SITE. IN DEGREES TO NEAREST DEGREE.

(NOTE: THE DISPLAY IN R1 APPEARS AS XXBYY WHERE: XX IS TR AND YY IS LPD).

H DOT - THE PRESENT RATE OF CHANGE OF ALTITUDE (H). POLARITY INDICATES DESCENT (-) OR ASCENT (+). IN FT/SEC TO NEAREST .1 FT/SEC.

H - THE PRESENT ALTITUDE OF THE LM ABOVE THE LUNAR RADIUS AT THE DESIGNATED LANDING SITE. POLARITY IS + FOR ALTITUDES

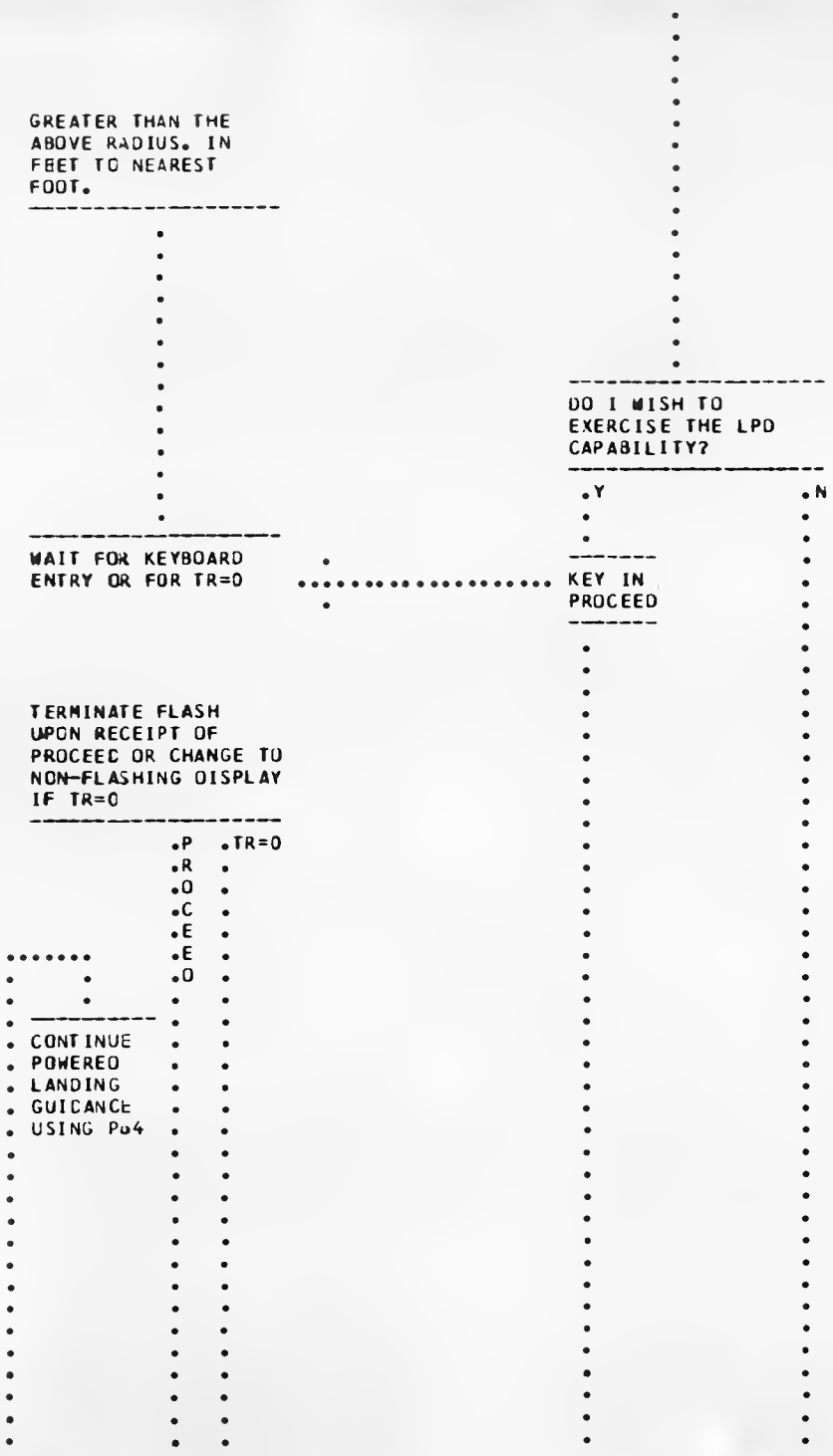
#100

#110

#120

#130

#140



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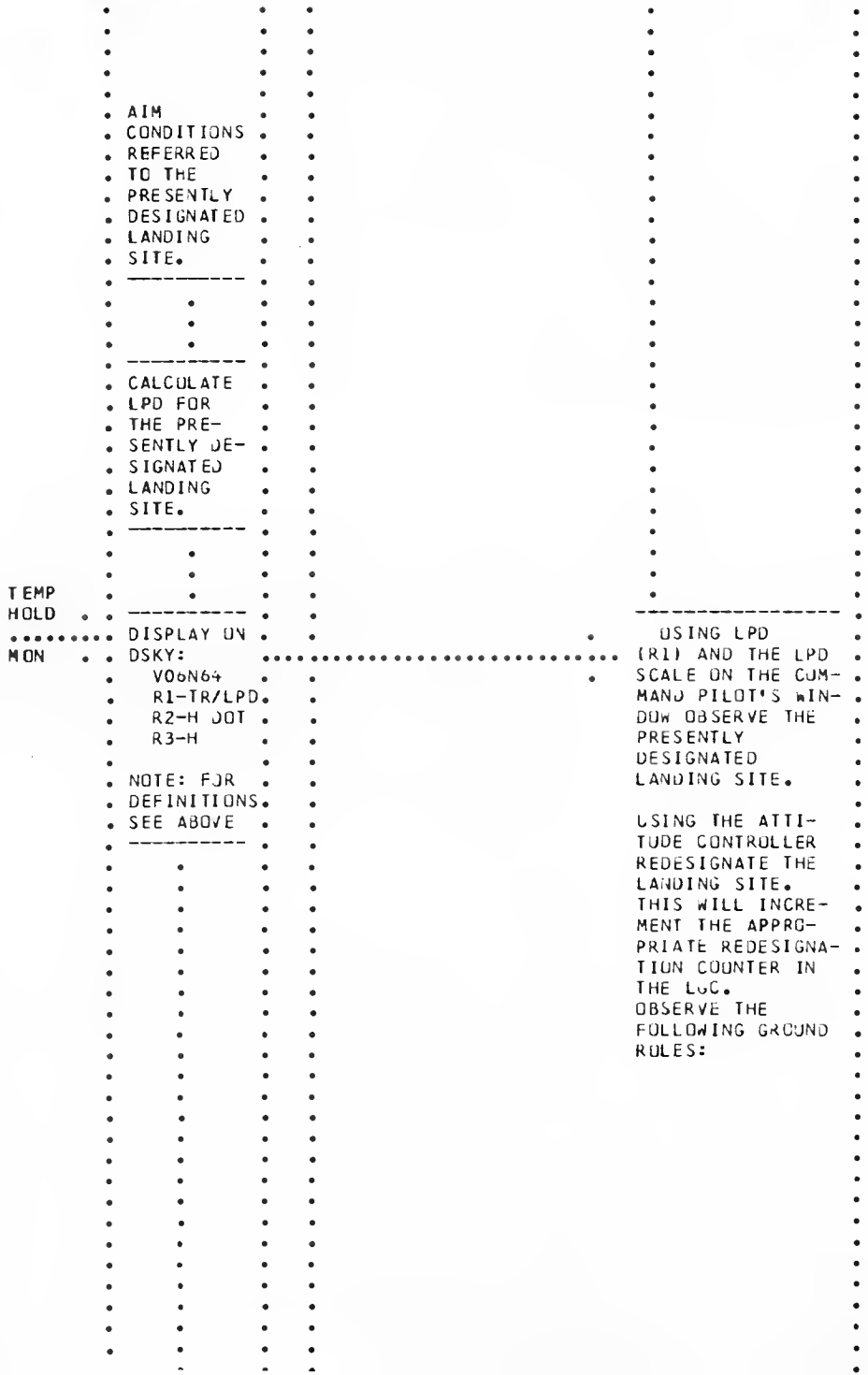

(A) SITE REDESIG-
NATION TOWARDS
THE LM (+ PITCH
ROTATION) WILL
REDUCE THIS SITE
VISIBILITY CLEAR-
ANCE WHICH IS
ORIGINALLY ONLY
10 DEGREES.

(B) LARGE REDES-
IGNATIONS SHOULD
BE MADE AS EARLY
IN THE APPROACH
PHASE AS POSS-
IBLE TO CONSERVE
FUEL AND MINIMIZE
ATTITUDE TRANS-
IENTS.

(C) WHEN TR IS
EQUAL TO 0
SEC THE LGC
WILL NO LONGER
RESPOND TO LPD
REDESIGNATIONS.

(NOTE: DISPLAYED
LPD ANGLES AND
VEHICLE YAW MAY BE
BIASED TO MAKE UP
FOR ERRORS IN THE
ALIGNMENT OF
THE LPD RETICLE
AND FOR WINDOW
BENDING WHEN THE
LM IS PRESSURIZED.
THAT PART OF
WINDOW ERROR
WHICH CANNOT BE
RESOLVED INTO
ROTATIONS ABOUT
THE BODY Y AND X
AXES WILL REMAIN
UNCOMPENSATED,
EXCEPT AT A CHOSEN
SPOT ALONG THE

#240

#250

#260

#270

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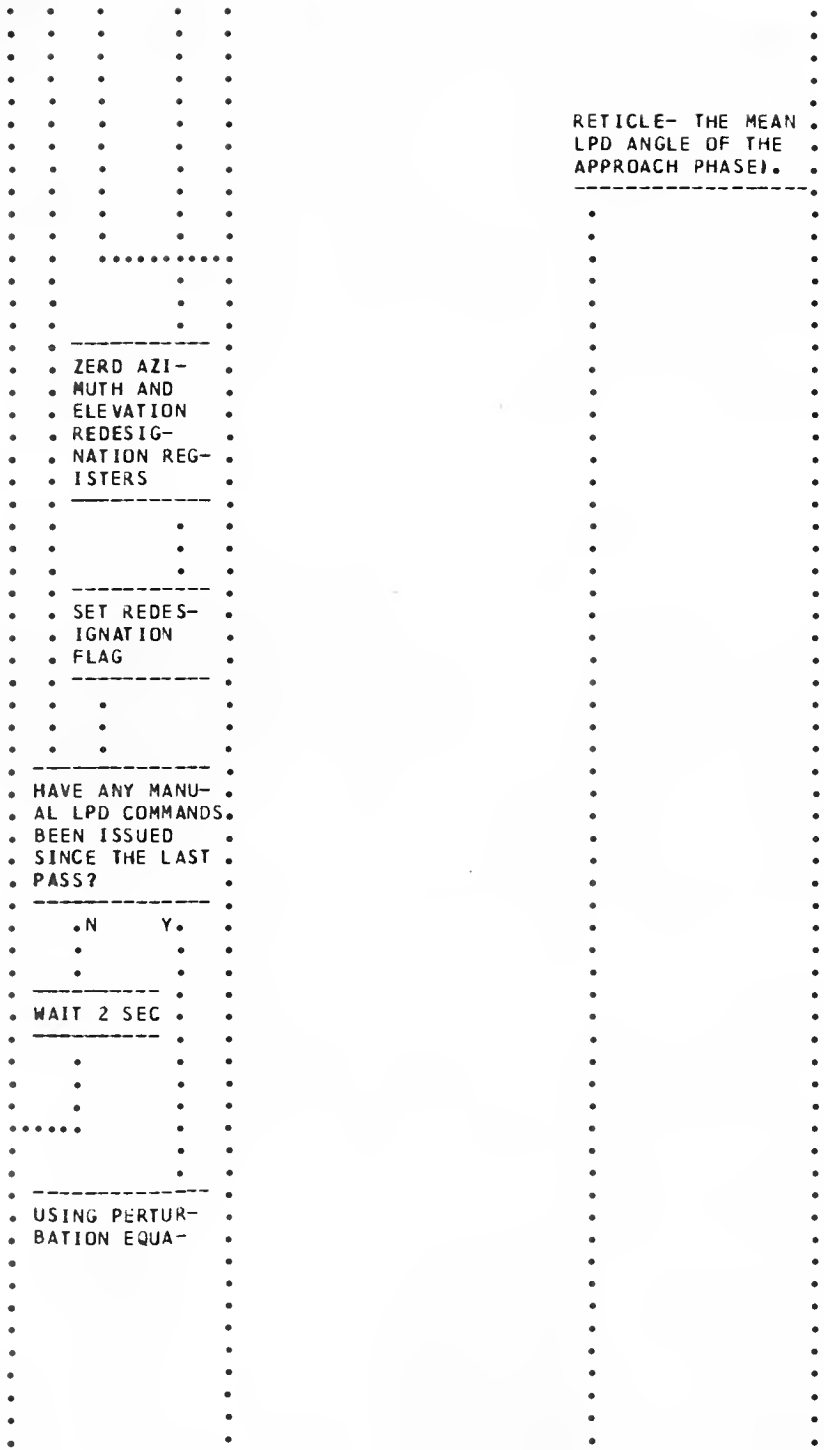

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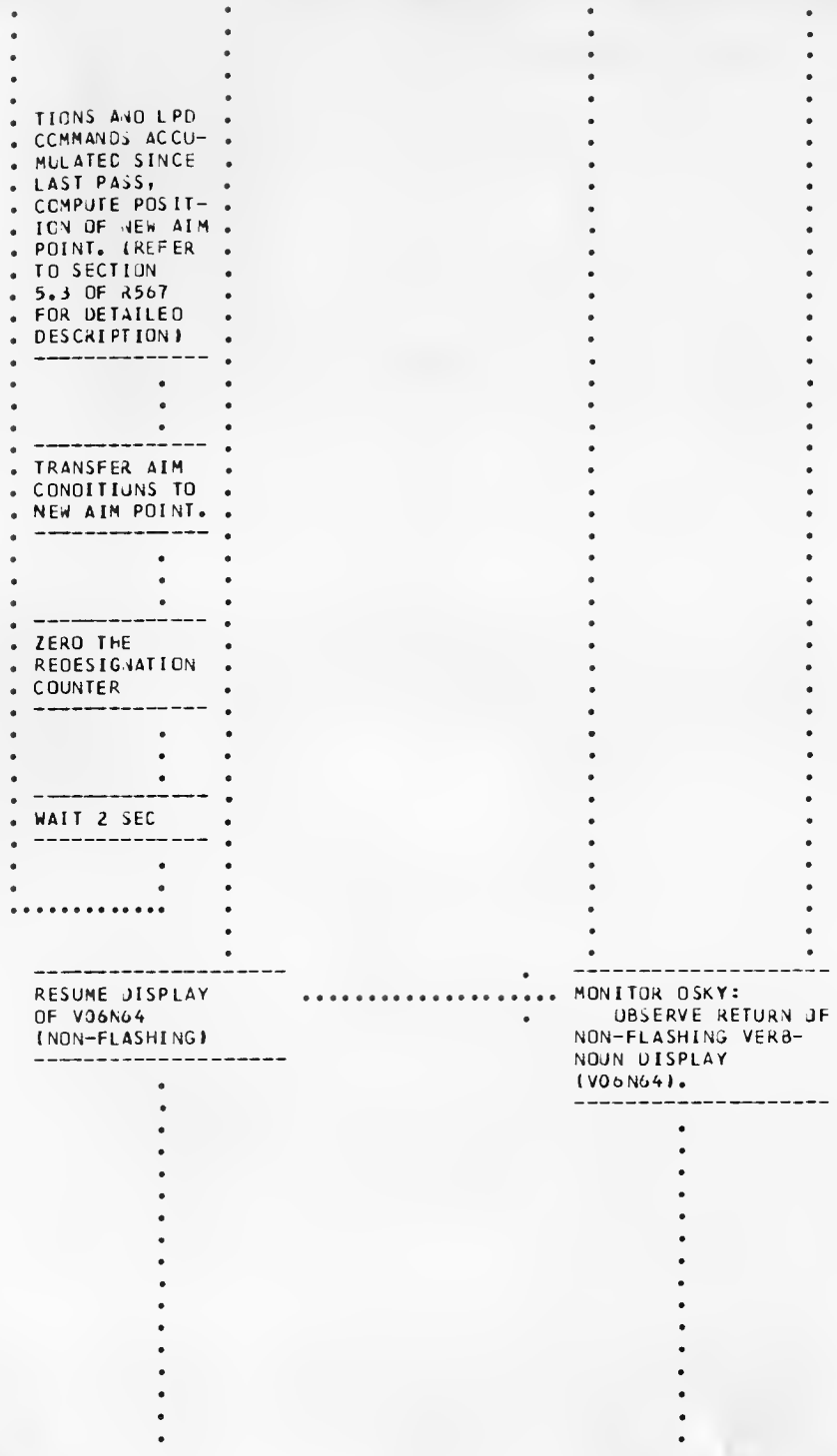

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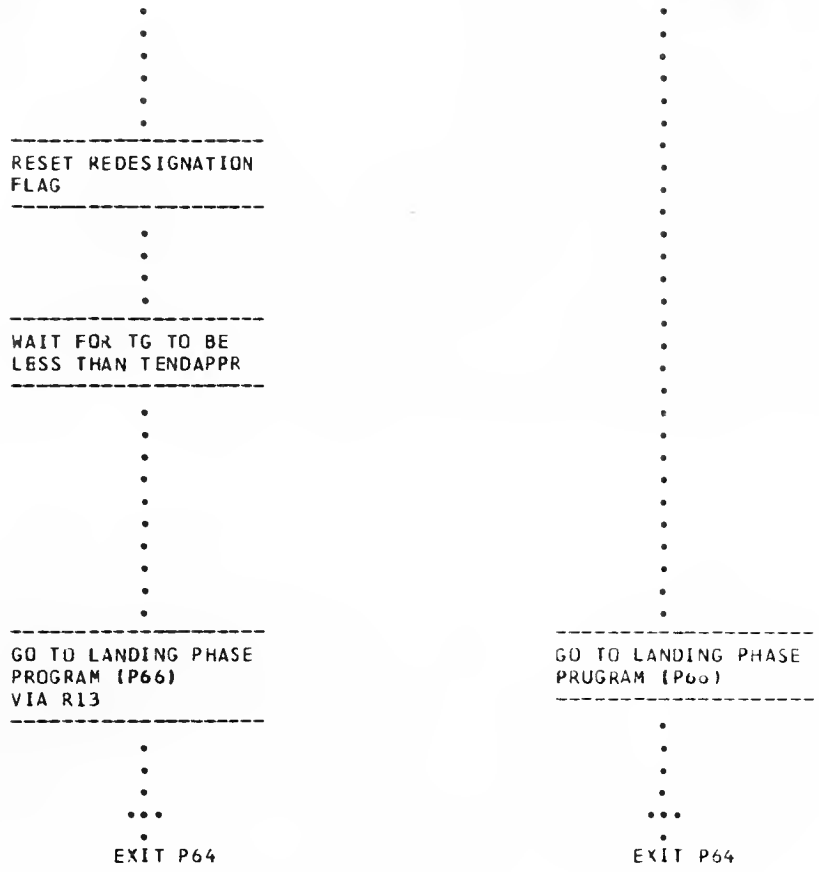

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CHANGE CONTROL NOTES

REV CO PCR 31
REV 01 PCR 85,164,246,542
REV 00(LUM 1A) PCR 670,737,751
REV 01(LUM 1B) PCR 838,840,841, EDITORIAL
REV 02(LUM 1C) PCR 285,968, EDITORIAL
REV 03(LUM 1D) PCR 988,1013,1028, PCN 1009
REV 04(LUM 1E) PCR 334,338, PCN 1145
REV 05 (LUM1E) PCN 1180

LANDING PHASE PROGRAM (P66) REV 05 12/01/71

PURPOSE: (1) TO MODIFY THE RATE OF DESCENT OF THE LM (WITH RESPECT TO THE LUNAR SURFACE) IN RESPONSE TO ASTRONAUT ORIGINATED INPUTS TO THE LGC VIA THE LM RATE OF DESCENT SWITCH.

(2) TO MODIFY THE INERTIAL ATTITUDE OF THE LM IN RESPONSE TO ASTRONAUT ORIGINATED INPUTS VIA THE ATTITUDE CONTROLLER ONLY IF THE ATTITUDE CONTROL SWITCH IS IN ATTITUDE HOLD, AND TO CONTROL ATTITUDE SO AS TO NULL LM VELOCITY RELATIVE TO THE SURFACE WHEN THE ATTITUDE CONTROL SWITCH IS IN AUTO.

(3) TO MAINTAIN A CONSTANT RATE OF DESCENT AND L4 INERTIAL ATTITUDE IN THE ABSENCE OF MANUAL CONTROL INPUTS.

(4) TO UPDATE THE LM STATE VECTOR WITH VEHICLE ACCELERATION AND LANDING RADAR (LR) DATA.

ASSUMPTIONS: (1) THE LM IS IN THE LATE STAGES OF LANDING, WITH A RELATIVELY LOW INERTIAL VELOCITY.

(2) THE IMU IS ON AND ACCURATELY ALIGNED TO A LANDING SITE ORIENTATION DEFINED FOR THE DESIGNATED LANDING SITE AND THE NOMINAL TIME OF LANDING (T(LAND)).

(3) THE LANDING RADAR (LR) IS ON, CHECKED OUT, AND SHOULD HAVE BEEN PROVIDING TO THE LGC VELOCITY AND RANGE INFORMATION WITH RESPECT TO THE MOON. THIS INFORMATION SHOULD HAVE BEEN INCORPORATED INTO THE LM STATE VECTOR. THE LGC/LR OPERATION IS UNDER THE CONTROL OF THE DESCENT STATE VECTOR UPDATE ROUTINE (R12) WHICH IS ALREADY IN PROCESS.

(4) THE LGC WILL NEITHER DESIGNATE NOR READ THE RENDEZVOUS RADAR (RR) DURING THIS PROGRAM.

(5) THE ENTIRE POWERED LANDING MANEUVER (BRAKING, APPROACH AND LANDING) WILL BE ACCOMPLISHED USING THE DPS ENGINE.

(6) THE FOLLOWING PARAMETERS REQUIRED BY THIS PROGRAM HAVE BEEN STORED IN THE LGC SINCE LGC INITIALIZATION BY ERASABLE REGISTER LOAD.

(A) THE LM STATE VECTOR. THE LGC HAS UPDATED THIS AS REQUIRED DURING THRUSTING. NO FURTHER STATE VECTOR UPDATES FROM ANY SOURCE OTHER THAN THE LR WILL BE ACCEPTED BY THIS PROGRAM.

(7) THE DPS IS NOT THROTTLABLE OVER THE WHOLE RANGE FROM 0 PERCENT TO MAXIMUM. IT MUST BE OPERATED EITHER AT MAXIMUM THROTTLE OR OVER A SPECIFIC THROTTLE RANGE OF LOWER SETTINGS. THESE THROTTLE SETTINGS ARE SPECIFIED IN SECTION 5.3.4 OF R567 AND ARE TOTAL THROTTLE SETTINGS, I.E.: THE SUM OF THE MANUAL SETTING (WHOSE MINIMUM IS 10 PERCENT), AND THE PGNCS COMMANDED SETTING.
THE THROTTLE CONTROL MAY BE SET TO AUTO (THE DPS RECEIVES THE SUM OF THE MANUAL AND PGNCS COMMANDED SETTINGS) OR MANUAL.
NOMINALLY THE THROTTLE WILL REMAIN WITHIN THE ALLOWABLE THROTTLE RANGE THROUGHOUT THIS PROGRAM.

(8) DURING THE POWERED LANDING MANEUVER, THE LGC WILL MONITOR THE PRESENCE OR ABSENCE OF THE "NON-ATTITUDE HOLD" DISCRETE. THIS DISCRETE IS ISSUED TO THE LGC WHEN THE ATTITUDE MODE CONTROL SWITCH IS IN THE AUTO POSITION.
SHOULD THIS DISCRETE APPEAR DURING THE POWERED LANDING MANEUVER, THE LGC ASSUMES THAT IT NO LONGER HAS COMPLETE AUTOMATIC CONTROL OF THE ATTITUDE OF THE SPACECRAFT.
THE MONITOR AND THE ASSOCIATED LGC LOGIC IS INCLUDED IN THE LANDING AUTO MODES MONITOR ROUTINE (R13) WHICH IS ALREADY IN PROCESS.

(9) THE LPD OPTION IS NOT PROVIDED THE CREW DURING THIS PROGRAM.

(10) THE ATTITUDE HOLD MODE OR THE AUTO MODE IS RECOGNIZED BY THE LGC THROUGHOUT THIS PROGRAM. IN ATTITUDE HOLD THE LGC WILL HOLD INERTIAL ATTITUDE UNLESS IT IS CHANGED BY MANUAL CONTROL VIA THE ATTITUDE CONTROL ASSEMBLY. THE ATTITUDE ERRORS ARE DISPLAYED ON THE FDAI NEEDLES WHEN THE LGC IS IN THE ATTITUDE HOLD MODE. IN AUTO MODE THE LGC

CONTROLS HORIZONTAL VELOCITY NULLING VIA THE ISSUANCE OF COMMANDS TO THE DIGITAL AUTOPILOT.

(11) THE CREW HAS THE CAPABILITY TO DISPLAY LGC CALCULATED VALUES OF FORWARD VELOCITY, LATERAL VELOCITY, ALTITUDE AND ALTITUDE RATE ON CERTAIN LM METERS DURING THIS PROGRAM. THE CALCULATION OF THESE PARAMETERS IS UNDER THE CONTROL OF THE LANDING ANALOG DISPLAYS ROUTINE (R10) WHICH IS ALREADY IN PROCESS.

(12) DURING THIS PROGRAM THE LGC MONITORS THE OUTPUT OF THE RATE OF DESCENT (ROD) SWITCH IN THE LM. THIS SWITCH IS OPERATED BY THE ASTRONAUT IN RESPONSE TO HIS ASSESSMENT OF THE PRESENT LM RATE OF DESCENT BASED ON OUT-THE-WINDOW REFERENCES AND LM/DSKY DISPLAYS.
SWITCH OPERATION IS ON AN INCREMENTAL BASIS, EITHER - (INCREASE ROD) OR + (DECREASE ROD). EACH COMMAND RESULTS IN AN LGC-COMMANDED CHANGE OF "RODSCALE" FT/SEC IN THE LM RATE OF DESCENT. ("RODSCALE" IS A VALUE LOADED INTO ERASABLE STORAGE PRIOR TO FLIGHT)

(13) AN ABORT FROM THE LUNAR DESCENT MAY BE REQUIRED AT ANY TIME DURING THE POWERED DESCENT (P63), (P64), OR (P66).
FOR ABORTS AFTER DPS IGNITION FOR THE POWERED LANDING MANEUVER, TIME IS CRITICAL. DURING THIS PERIOD AN ABORT IS COMMANDED BY PUSHING ONE OF TWO BUTTONS IN THE LM. THE ABORT MAY BE COMMANDED TO USE THE DESCENT STAGE (ABORT BUTTON) OR THE ASCENT STAGE (ABORT STAGE BUTTON). IF THE DESCENT STAGE IS SELECTED, AND THE DPS PROPELLANT APPROACHES EXHAUSTION, CONTROL MUST BE SWITCHED TO THE ASCENT STAGE BY THE CREW BY ASCENT STAGE SELECTION (ABORT STAGE BUTTON).
DURING THE POWERED LANDING MANEUVER, THE LGC WILL CONTINUOUSLY MONITOR THE ABORT AND ABORT STAGE DISCRETES, AND UPON RECEIPT OF EITHER WILL TERMINATE THE PROGRAM IN PROCESS AND CALL THE APPROPRIATE ABORT PROGRAM (DPS ABORT PROGRAM (P70) OR APS ABORT PROGRAM (P71)) UNLESS DIRECTED TO IGNORE THESE DISCRETES BY THE DAP DATA LOAD ROUTINE (R03). BOTH ABORT PROGRAMS WILL GUIDE THE LM TO AN ORBIT AS SPECIFIED IN SECTION 5.4 OF R567.
THE MONITOR OF THE ABORT AND ABORT STAGE PUSHBUTTONS IS CONTROLLED BY THE ABORT DISCRETES MONITOR ROUTINE (R11) WHICH IS ALREADY IN PROCESS.

(14) IF A THRUSTING MANEUVER IS PERFORMED WITH THE GUIDANCE CONTROL SWITCH AT PGNS AND THE MODE CONTROL SWITCH AT ATTITUDE HOLD THE PGNCS WILL HOLD THE VEHICLE ATTITUDE AND WILL GENERATE EITHER MODE I OR MODE II ATTITUDE ERRORS AND VEHICLE ATTITUDE RATES FOR DISPLAY ON THE FDAI. THE CREW MAY EXERCISE MANUAL ATTITUDE CONTROL ABOUT ALL VEHICLE AXES WITH THE ACA IN EITHER THE RATE COMMAND OR MINIMUM IMPULSE MODE DEPENDING UPON THE STATUS OF THE PULSES FLAG. IT IS STRONGLY RECOMMENDED THAT POWERED FLIGHT NOT BE ATTEMPTED IN THE MINIMUM IMPULSE MODE. THE PULSES FLAG IS SET OR RESET BY EXTENDED VERBS 76 (MINIMUM IMPULSE) AND 77 (RATE COMMAND) RESPECTIVELY. THE PULSES FLAG IS ALSO RESET BY P12,P40,P41,P42,P63,P70,P71 AND R40 AT MAIN ENGINE IGNITION. WITH THE EXCEPTION OF THESE CASES, MODE SELECTION IS ALWAYS BASED UPON THE LAST ENTRY MADE IN THE DSKY. DURING A THRUSTING MANEUVER IN THE PGNS/ATTITUDE HOLD MODE, THE PGNCS WILL NOT BE RESPONSIBLE IF REGISTER OVERFLOWS OCCUR WITHIN THE LGC, EXCEPT DURING THE DESCENT THRUSTING MANUEVER. IN THIS MANEUVER, WHEN OVERFLOW IS DETECTED, CALCULATIONS ARE HALTED AND THE NEXT CALCULATION CYCLE IS BEGUN WITH UPDATED DATA.

++
+05 (15) CONTROL OF THE LM DPS, RCS, AND APS IS TRANSFERRED FROM THE PGNCS TO THE ABORT GUIDANCE SYSTEM (AGS) BY
+ PLACING THE GUID CONT SWITCH FROM PGNS TO AGS.
+ THE AGS WILL BE CAPABLE OF TAKING OVER CONTROL OF THE LM DURING ANY PORTION OF THE LUNAR DESCENT OR ASCENT OR
+ DURING EITHER OF THE ABORT PROGRAMS (P70 OR P71). THE AGS WILL GUIDE THE LM TO A SAFE ORBIT.
+ THE AGS MAY BE INITIALIZED BY THE LGC AT ANY TIME BY MANUAL SELECTION OF THE AGS INITIALIZATION ROUTINE (R47).
+ IN THE EVENT THAT THE GUIDANCE CONTROL SWITCH IS CHANGED FROM PGNS TO AGS DURING A THRUSTING MANEUVER, THE LGC
+ WILL CONTINUE COMPUTATION OF POSITION AND VELOCITY, THE DESIRED THRUST VECTOR, AND THE FDAI ATTITUDE ERROR NEEDLE DIS-
+1180 PLAY; HOWEVER THE PGNCS WILL NOT BE RESPONSIBLE IF REGISTER OVERFLOWS OCCUR WITHIN THE LGC BECAUSE THE AGS IS NOT
++ MAINTAINING REASONABLE ATTITUDE CONTROL.

(16) THE DAP DATA LOAD ROUTINE (R03) HAS BEEN PERFORMED PRIOR TO THE START OF THE POWERED LANDING MANEUVER AND SHOULD NOT BE REQUIRED DURING THIS PROGRAM.

(17) LGC AND CREW PROCEDURES IN CASES OF LGC-ASSUMED THRUST FAILURE ARE DEFINED BY THE DPS/APS THRUST FAIL ROUTINE (R40). THIS ROUTINE IS IN EFFECT DURING THIS PROGRAM UNTIL SELECTION (VIA RCC) OF THE LANDING CONFIRMATION PROGRAM (P68), HAVING BEEN ENABLED BY P63.

(18) THIS PROGRAM IS AUTOMATICALLY SELECTED BY THE LANDING AUTO MODES MONITOR ROUTINE (R13) DURING THE POWERED LANDING MANEUVER WHEN:

(A) ATTITUDE CONTROL IS FIRST TRANSFERRED TO MANUAL (ATTITUDE CONTROL SWITCH TO ATTITUDE HOLD) AND THE ASTRONAUT COMMANDS A NET CHANGE IN THE RATE OF DESCENT BY MEANS OF THE ROD SWITCH.

(B) LGC TARGETED LOGATE CONDITIONS WARRANT CHANGE FROM APPROACH PHASE TO VERTICAL LANDING PHASE.

(19) THE ASTRONAUT MAY MONITOR THE FOLLOWING PARAMETERS BY KEYING IN V16 N92E:

(A) V16 N92
R1-THRCMD
R2-HDOT
R3-H

THRCMD-THE PERCENT THROTTLE DESIRED BY THE LGC BASED ON THE DPS RATED THRUST OF 10,500 POUNDS. IN PERCENT TO NEAREST PERCENT.

HDOT-THE PRESENT RATE OF CHANGE OF ALTITUDE (H). IN FPS TO NEAREST .1 FPS.

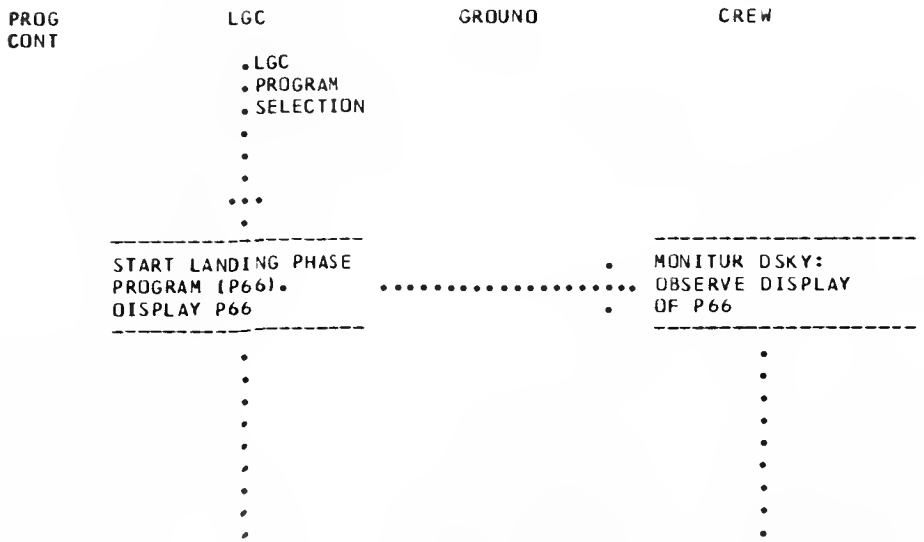
H-THE PRESENT ALTITUDE OF THE LM ABOVE THE LUNAR RADIUS AT THE DESIGNATED LANDING SITE. IN FEET TO NEAREST FOOT.

(20) THREE ALARM CONDITIONS MAY BE ORIGINATED BY THE PGNCS POWERED LANDING EQUATIONS:

(A) IF SUBROUTINE ROOTPSRS IN THE RG/VG CALCULATION FAILS TO CONVERGE IN 8 PASSES THE LGC WILL TURN ON THE PROGRAM ALARM LIGHT, STORE PROGRAM ALARM 01406, STOP ALL VEHICLE ATTITUDE RATES, AND CONTINUE. THIS ALARM COULD ONLY OCCUR IN P63 OR P64. (NOTE: IF THIS CONDITION OCCURS BEFORE IGNITION DURING THE IGNITION ALGORITHM, THE RESULT WILL BE A POODDD ALARM, 21406).

(B) IF AN OVERFLOW OCCURS IN THE LANDING GUIDANCE AND CONTROL EQUATIONS THE LGC WILL TURN ON THE PROGRAM ALARM LIGHT, STORE ALARM CODE 01410, STOP ALL VEHICLE ATTITUDE RATES AND CONTINUE. THIS ALARM COULD OCCUR IN P63, P64, OR P66.

(C) IF THERE ARE TOO FEW THROTTLINGS SINCE THE LAST P66 OMISSION, THE LGC WILL TURN ON THE PROGRAM ALARM LIGHT, STORE ALARM CODE 01466, AND BRANCH TO THE V06 N60 DISPLAY. THIS ALARM COULD ONLY OCCUR IN P66.



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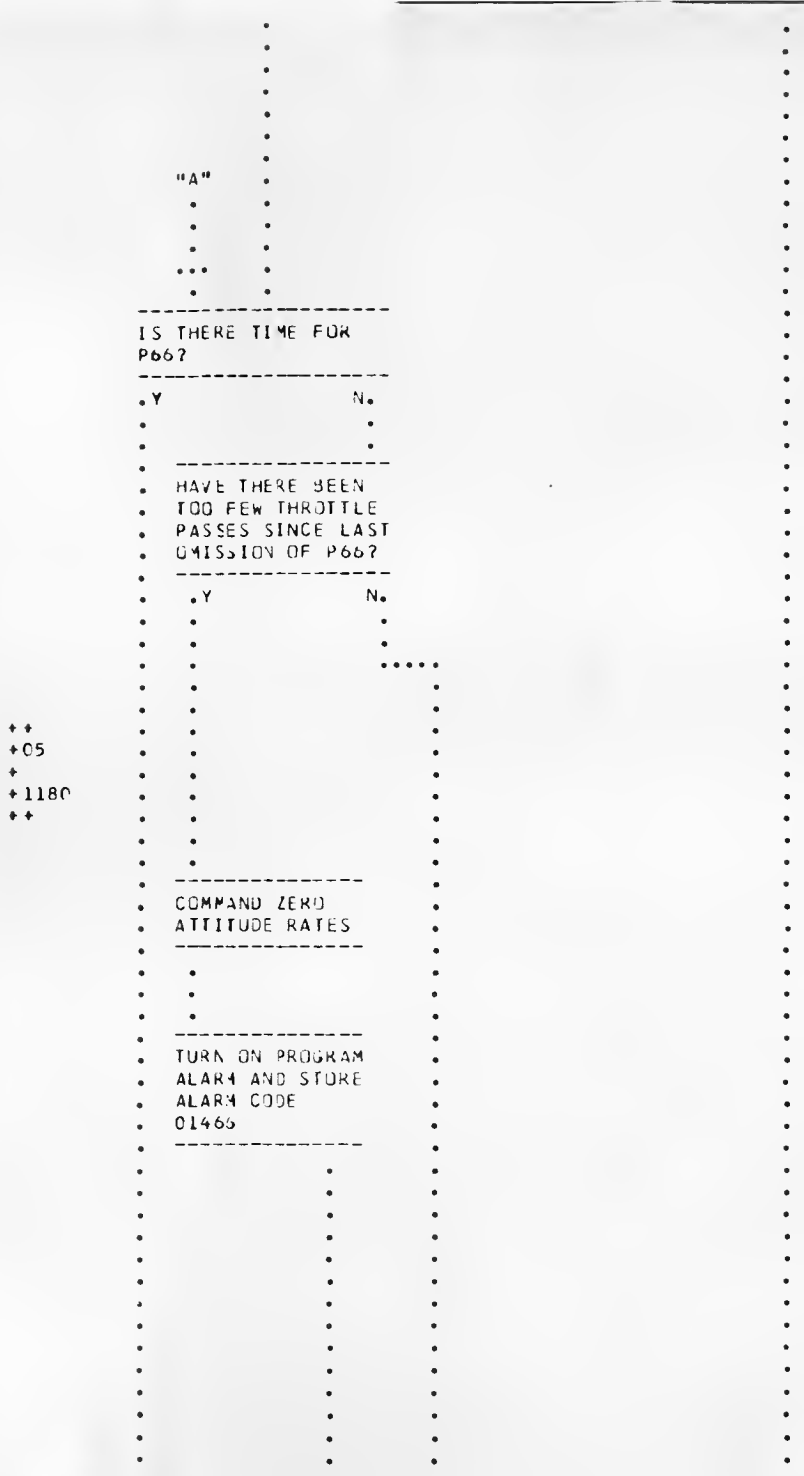

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+05
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+1180
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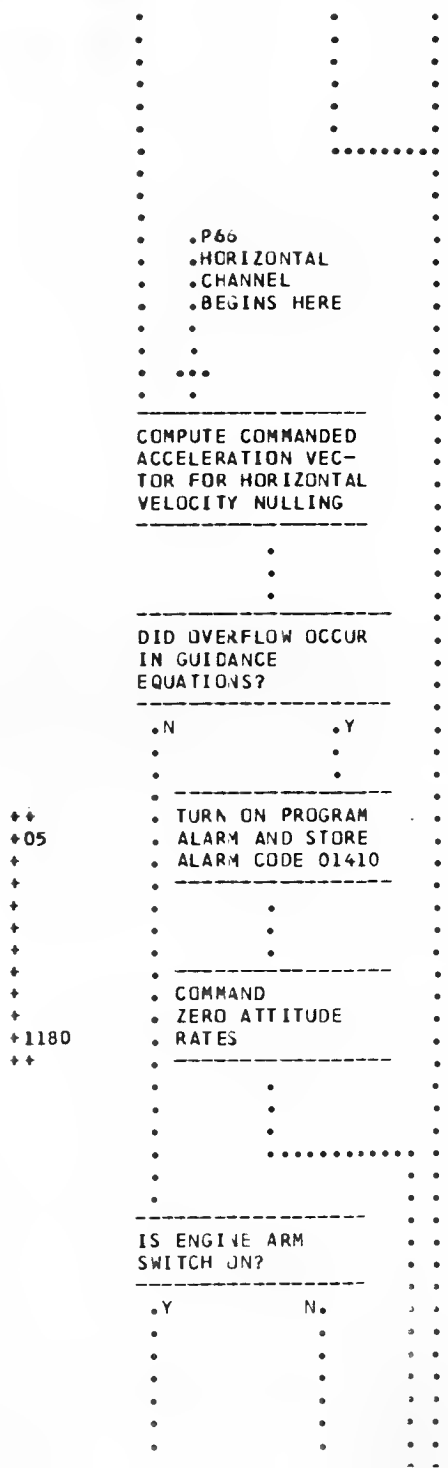

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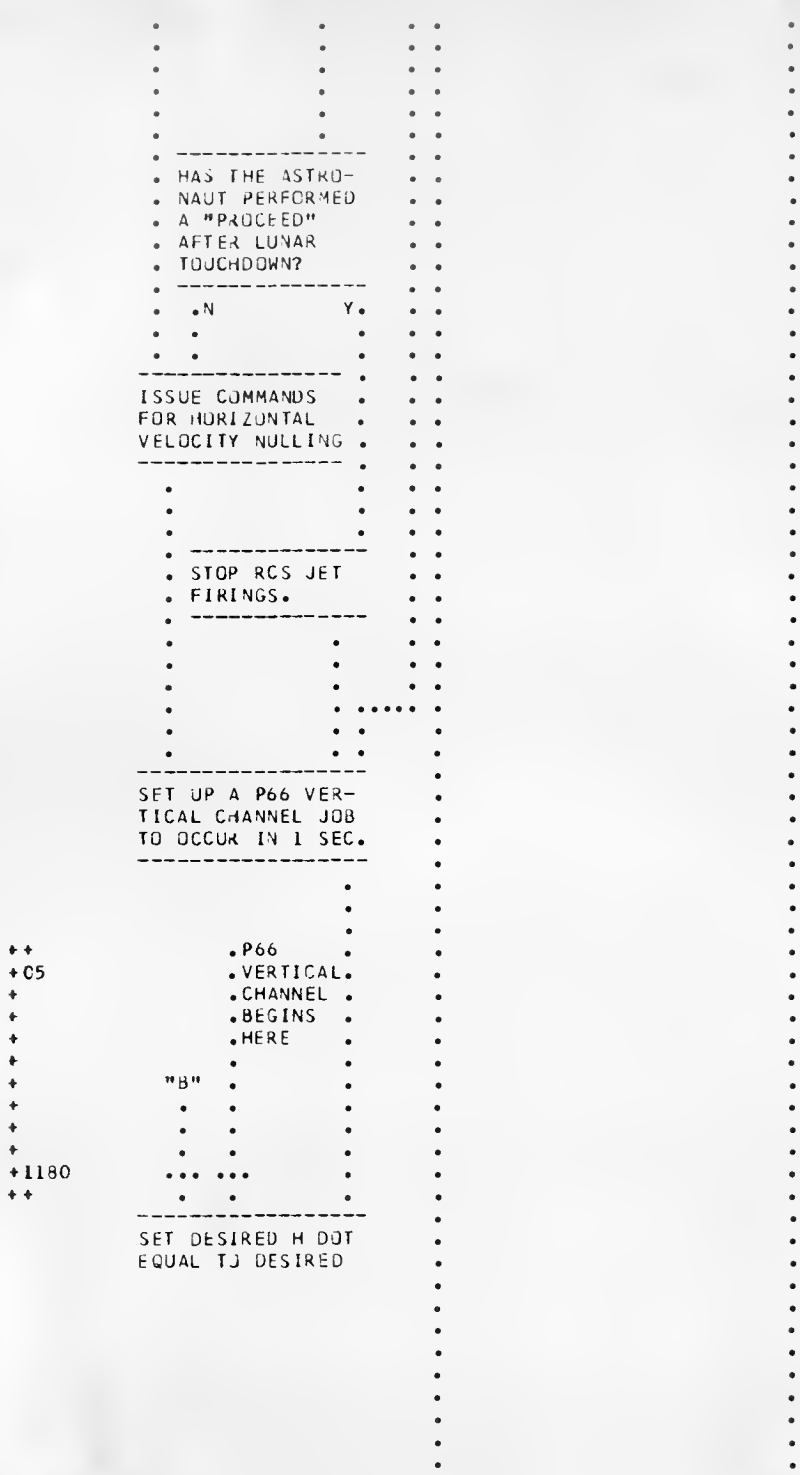

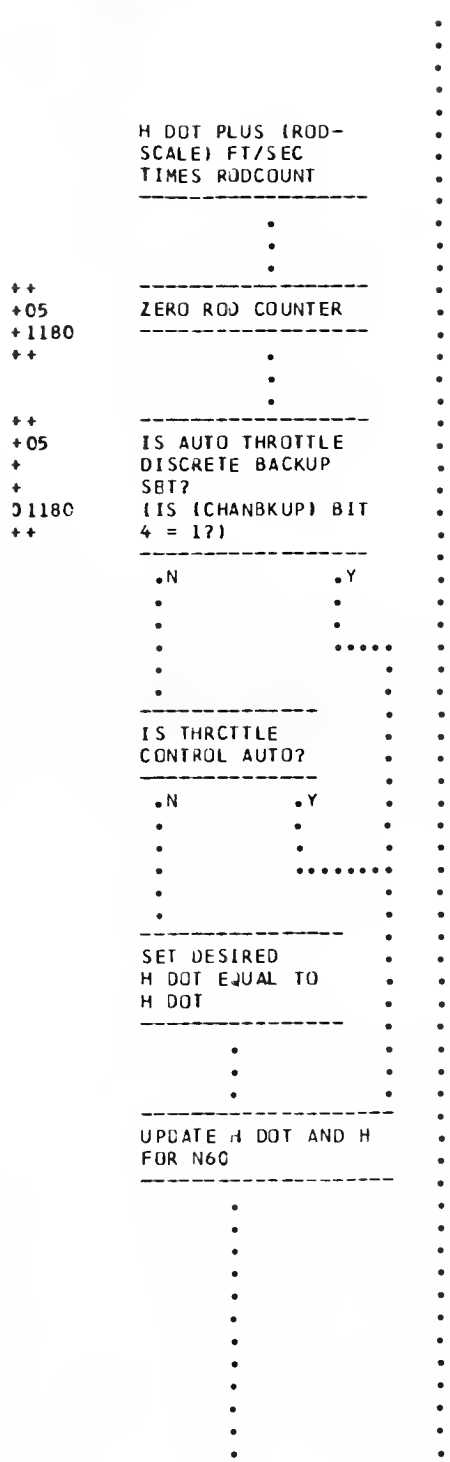

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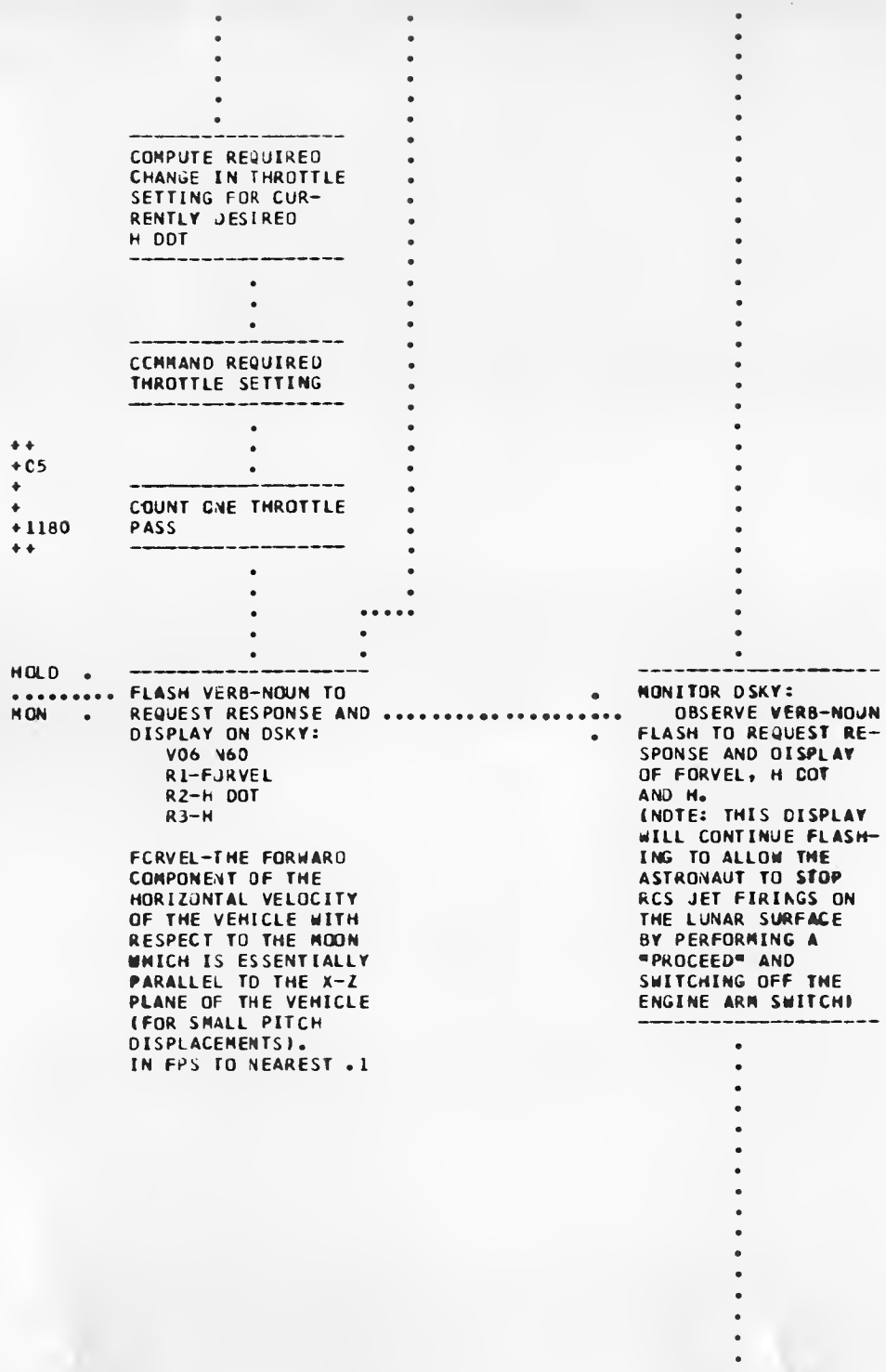

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#250

#260

FPS

H DOT-THE PRESENT RATE OF CHANGE OF ALTITUDE (H). POLARITY INDICATES DESCENT (-), OR ASCENT (+). POLARITY IS NOMINALLY - DURING THIS PROGRAM. IN FPS TO NEAREST .1 FPS

H-THE PRESENT RADAR UPDATED ALTITUDE OF THE LM ABOVE THE LUNAR SURFACE. POLARITY IS + FOR ALTITUDES GREATER THAN THE ABOVE RADIUS. IN FEET TO NEAREST FOOT.

++ NOTE: THE N60 DIS-
+05 PLAY IS PERIODICALLY
+ UPDATED, AND P66
+ CHANNELS ARE BEGUN
+ AT DIFFERENT TIME
+ INTERVALS. THESE
+ ARE:
+ A) DIRECT GUIDANCE
+ FLOW FROM SERVICER
+ TO "A" ABOVE.
+
+ B) SCHEDULED GUID-
+ ANCE FLOW FROM FIRST
+ P66 PASS TO "B"
+1180 ABOVE.
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#270

#280

#290

#300

#310

MONITOR PROGRESS OF POWERED LANDING MANEUVER USING LM DISPLAYS, DSKY DIS-

PLAYS AND WINDOW.
USING RATE OF DESCENT SWITCH, COMMAND DESIRED RATE OF DESCENT.
IF MANUAL ATTITUDE CONTROL IS DESIRED USE ATTITUDE CONTROLLER.
MONITOR THRUST INDICATOR (RIGHT SIDE) TO ENSURE THAT LGC THROTTLE COMMAND DOES NOT EXCEED XX PERCENT. (NOTE: THE LGC WILL NOT INTENTIONALLY COMMAND A THRUST LEVEL LARGER THAN THAT SPECIFIED BY A PAD-LOADED LIMIT (NOMINALLY 60 PERCENT) NO MATTER WHAT THE CIRCUMSTANCES ARE.)
IF MANUAL THROTTLE CONTROL IS DESIRED, ADVANCE THRUST/TRANSLATION CONTROLLER UNTIL LGC CONTRIBUTION TO TOTAL THRUST IS ZERO (THRUST INDICATOR-RIGHT SIDE), AND PUT THROTTLE SWITCH TO MANUAL. THE LGC WILL MAINTAIN THE PRESENT LM INERTIAL ATTITUDE. THROTTLE CONTROL WILL REVERT TO THE LEVEL COMMANDED BY THE THRUST/TRANSLATION CONTROLLER.
RATE OF DESCENT MAY THEN BE MODIFIED BY MANUAL THROTTLE CONTROL. LM ATTITUDE WILL REMAIN INER-

#320

#330

#340

#350

#360

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++
+05
+
+1180
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TIALLY FIXED UNLESS
MANUAL ATTITUDE CON-
TROL IS EXERCISED,
HOWEVER MANUAL
ATTITUDE CONTROL
CANNOT BE EXERCISED
UNLESS THE ATTITUDE
CONTROL MODE SWITCH                                  #370
IS IN ATTITUOE HOLD.
IN EVENT OF AUTO
THROTTLE DISCRETE
FAILURE:
  KEY V04 N46E
      R2 0000X
      V22E 1XE
      V04 N46E
      R2 0001X
--------------------                                 #380
        .
        .
        .
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MONITOR DSKY:
   WHEN H IS
APPROXIMATELY 50 FT
OBSERVE THAT LR UP-
DATING HAS BEEN
TURNED OFF AUTO-                                     #390
MATICALLY.
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        .
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MONITOR DSKY:
   WHEN ACTUAL ALTI-
TUDE IS APPROXI-
MATELY 4.4 FT,                                       #400
OBSERVE LUNAR
CONTACT LIGHT TO
COME ON INDICATING
THAT THE PROBE(S) ON
THE LM LANDING GEAR
HAVE MADE CONTACT
WITH THE LUNAR SUR-
FACE.
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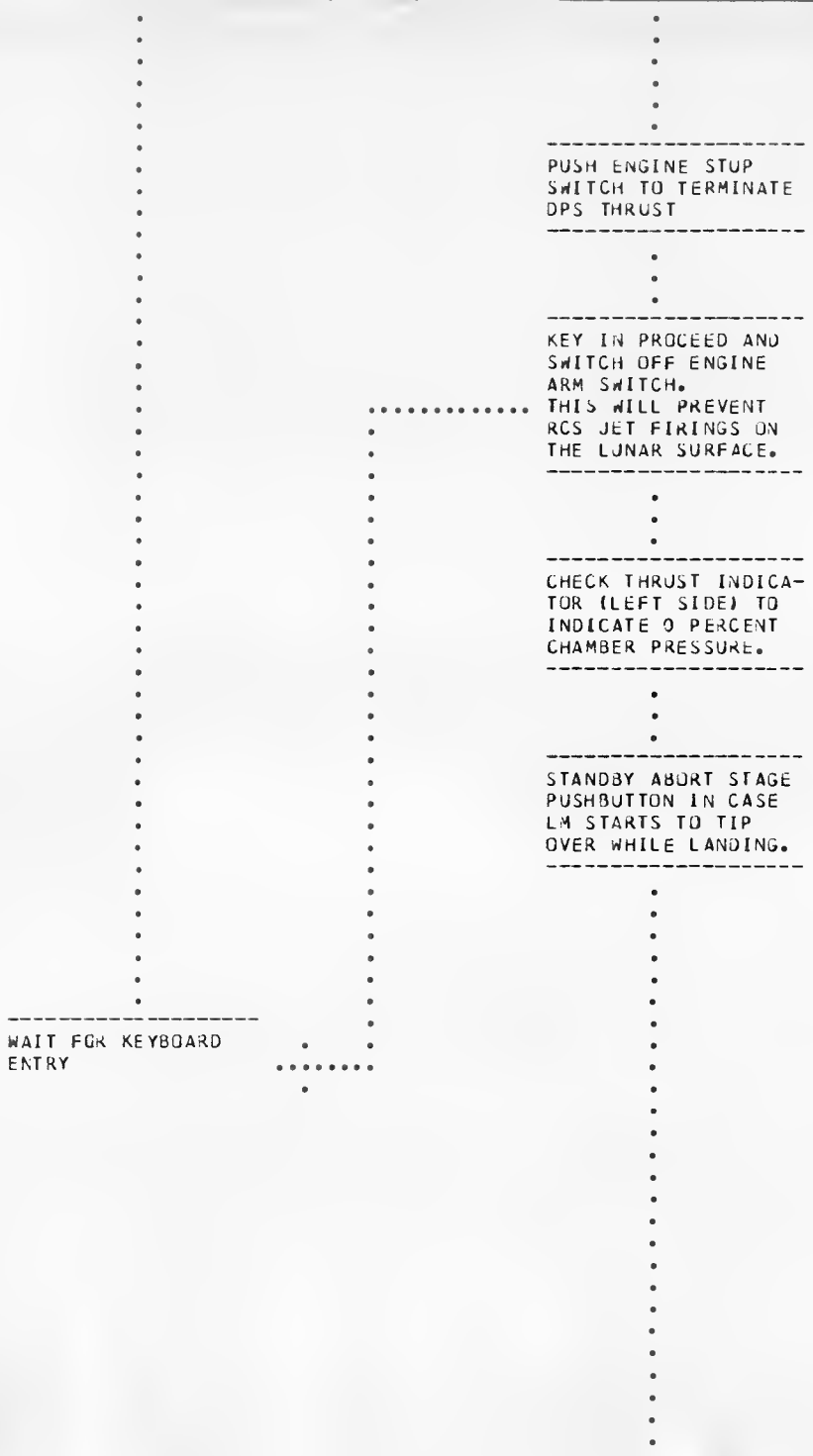
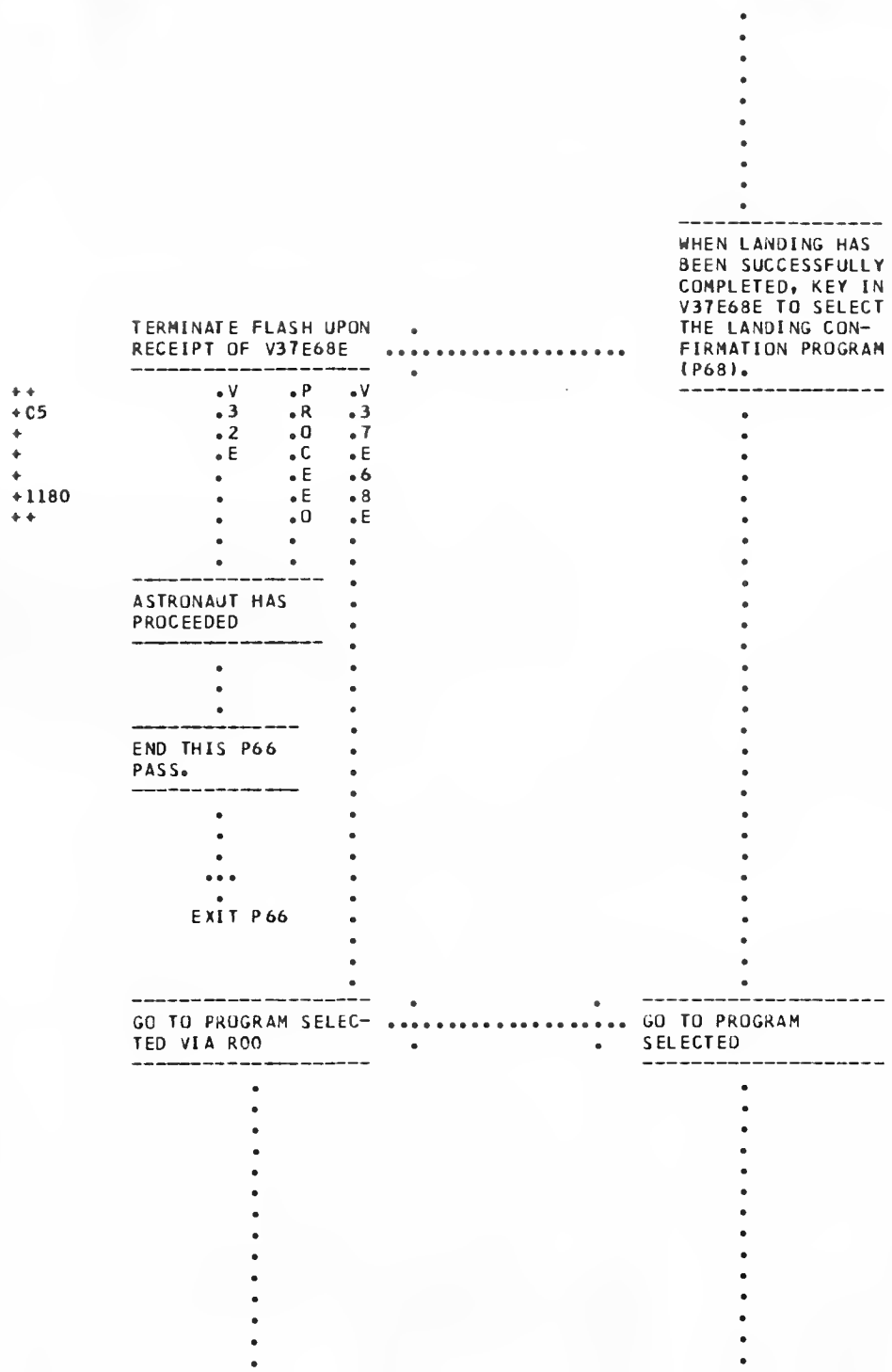

PUSH ENGINE STUP SWITCH TO TERMINATE DPS THRUST
#420
KEY IN PROCEED AND SWITCH OFF ENGINE ARM SWITCH. THIS WILL PREVENT RCS JET FIRINGS ON THE LUNAR SURFACE.
#430
CHECK THRUST INDICATOR (LEFT SIDE) TO INDICATE 0 PERCENT CHAMBER PRESSURE.
#440
STANDBY ABORT STAGE PUSHBUTTON IN CASE LM STARTS TO TIP OVER WHILE LANDING.
#450
WAIT FOR KEYBOARD ENTRY



#460

#470

#480

#490

#500

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     ...
      .
   EXIT P66
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      .
     ...
      .
   EXIT P66
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#510

CHANGE CONTROL NOTES

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REV 00    PCR 31
REV 01    PCR 85,210,470,542
REV C0(LUM 1A)    PCR 700,737
REV 01(LUM 1B)    PCR 838,841, EDITORIAL
REV C2(LUM 1C)    PCR 285,882,EDITORIAL
REV 03(LUM 1D)    PCR 942,988,1013, PCN 1037,1009
REV C4(LUM 1E)    PCR 1107,1109, PCN 1145
REV C5    PCN 1180
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LANDING CONFIRMATION PROGRAM (P68) REV 05 02/17/71

PURPOSE: (1) TO TERMINATE LANDING PROGRAM AND DAP FUNCTIONS.

(2) TO INITIALIZE THE LGC FOR LUNAR SURFACE OPERATION.

(3) TO PERMIT THE ASTRONAUT TO PREVENT RCS JET FIRINGS ON THE LUNAR SURFACE.

ASSUMPTIONS: (1) THE FOLLOWING DISPLAY IS AVAILABLE DURING THE PROGRAM BY KEYING IN V85E (SEE EXTENDED VERBS).

V16N56
R1 - RR LOS AZIMUTH
R2 - RR LOS ELEVATION
R3 - BLANK

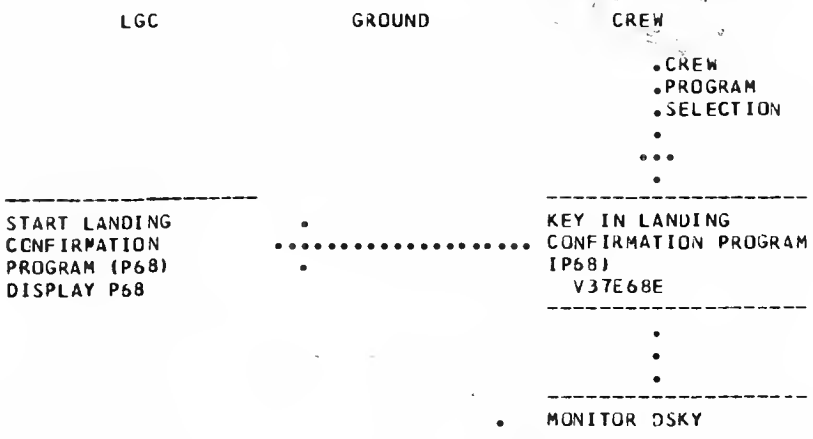
WHERE: RR LOS AZIMUTH - THE ANGLE BETWEEN THE LM X/Z PLANE AND THE RR LOS VECTOR. POSITIVE ROTATION IS FROM THE LM +Z AXIS TO THE LM +Y AXIS. IN DEGREES TO THE NEAREST .01 DEGREE.

RR LOS ELEVATION - THE ANGLE BETWEEN THE LM +Z AXIS AND THE PROJECTION OF THE RR LOS VECTOR ON THE LM X/Z PLANE. POSITIVE ROTATION IS POSITIVE ROTATION ABOUT THE LM +Y AXIS.

(2) THIS PROGRAM IS SELECTED BY THE ASTRONAUT BY DSKY ENTRY. IT IS TO BE SELECTED ONLY AFTER THE LM HAS LANDED ON THE LUNAR SURFACE.

(3) V37E68E SELECTION OF P68 WILL TERMINATE AVERAGE G AND COMMAND THE ENGINE OFF (REFER TO R00).

(4) THE SELECTION OF THIS PROGRAM PLACES THE DAP IN THE MINIMUM IMPULSE COMMAND MODE. AS LONG AS THE ASTRONAUT KEEPS THE MODE CONT SWITCH IN ATT HOLD, RCS JET FIRINGS WILL NOT OCCUR, EVEN WHILE THE PLATFORM IS BEING GYRO TORQUED (IN P57).



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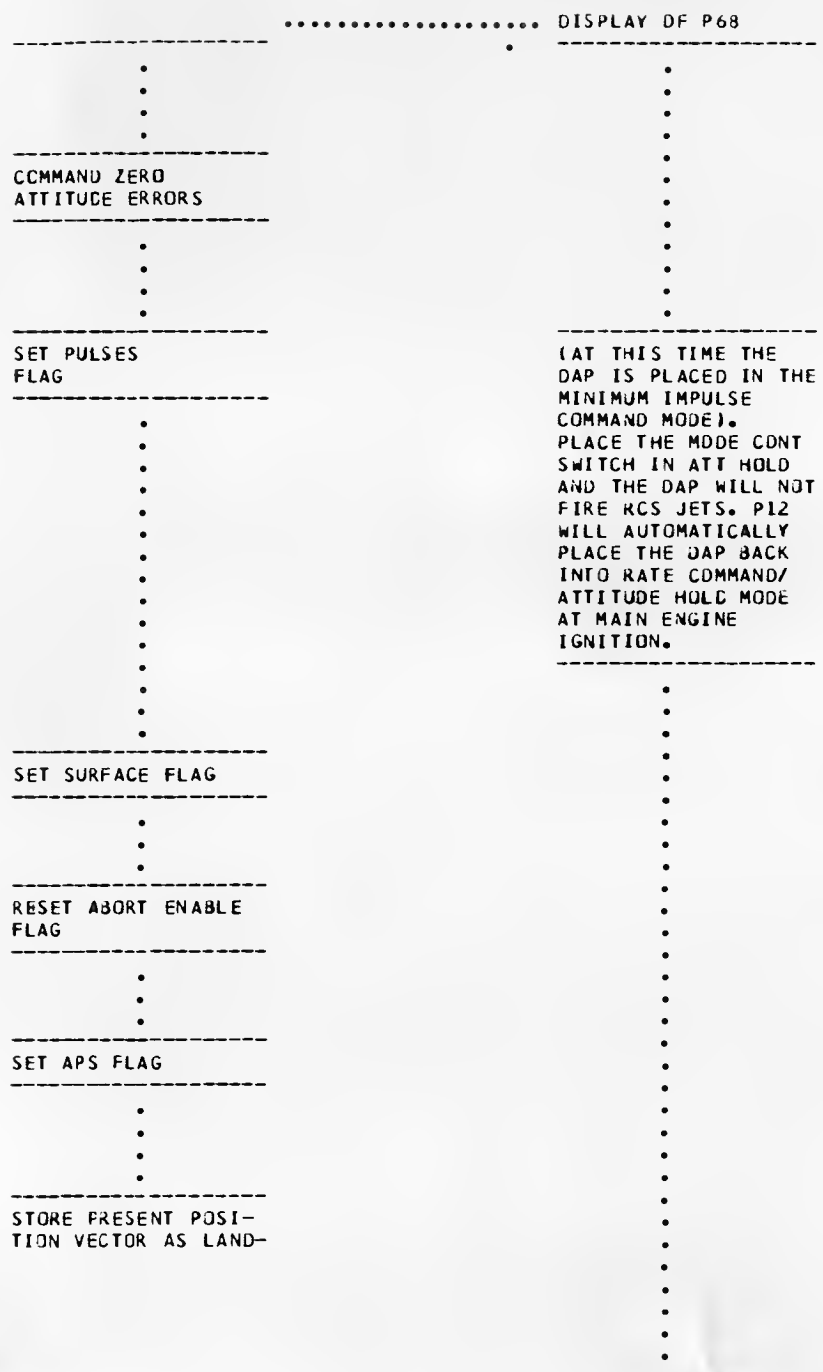

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#70

ING SITE IN LUNAR FIXED COORDINATES (REFER TO SECTION 5.3 OF R567).

HOLD . SNAP . FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY LGC CALCULATED LANDING SITE COORDINATES:
V06N43
R1-LAT
R2-LONG
R3-ALT

OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY OF LGC CALCULATED LANDING SITE COORDINATES.

RECORD THESE VALUES.

LAT-SELENOGRAPHIC LATITUDE OF THE LGC-ASSUMED PRESENT LANDING SITE. POLARITY INDICATES NORTH (+) OR SOUTH (-). IN DEGREES TO NEAREST .01 DEGREES.

LONG-SELENOGRAPHIC LONGITUDE OF THE LGC-ASSUMED PRESENT LANDING SITE. POLARITY INDICATES EAST (+) OR WEST (-). IN DEGREES TO NEAREST .01 DEGREES.

ALT-THE PRESENT ALTITUDE OF THE L/M ABOVE THE LUNAR RADIUS AT THE DESIGNATED LANDING SITE (IF RESTART OCCURS-ABOVE THE LUNAR RADIUS AT THE LGC-ASSUMED PRESENT LANDING

#80

#90

#100

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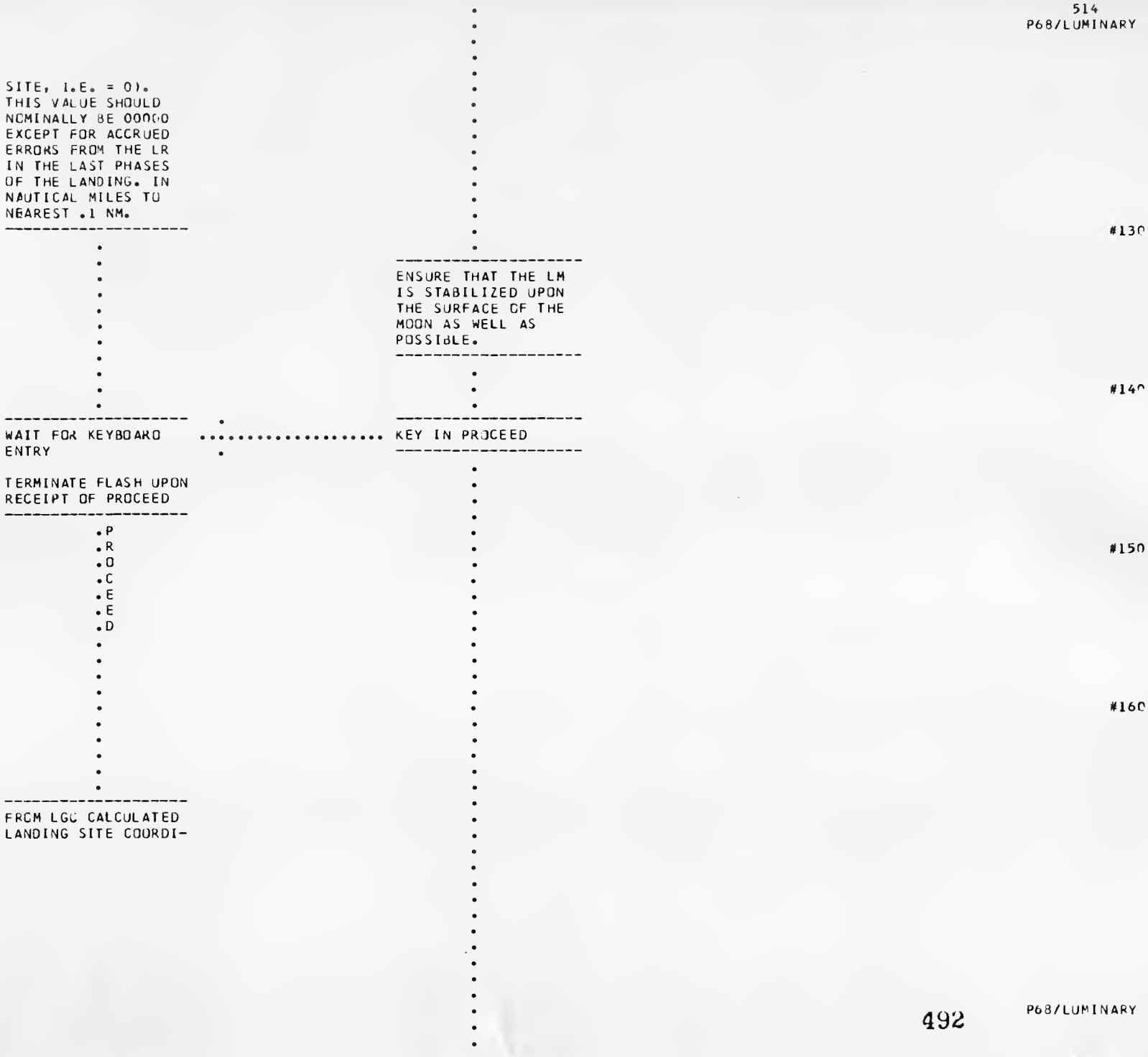
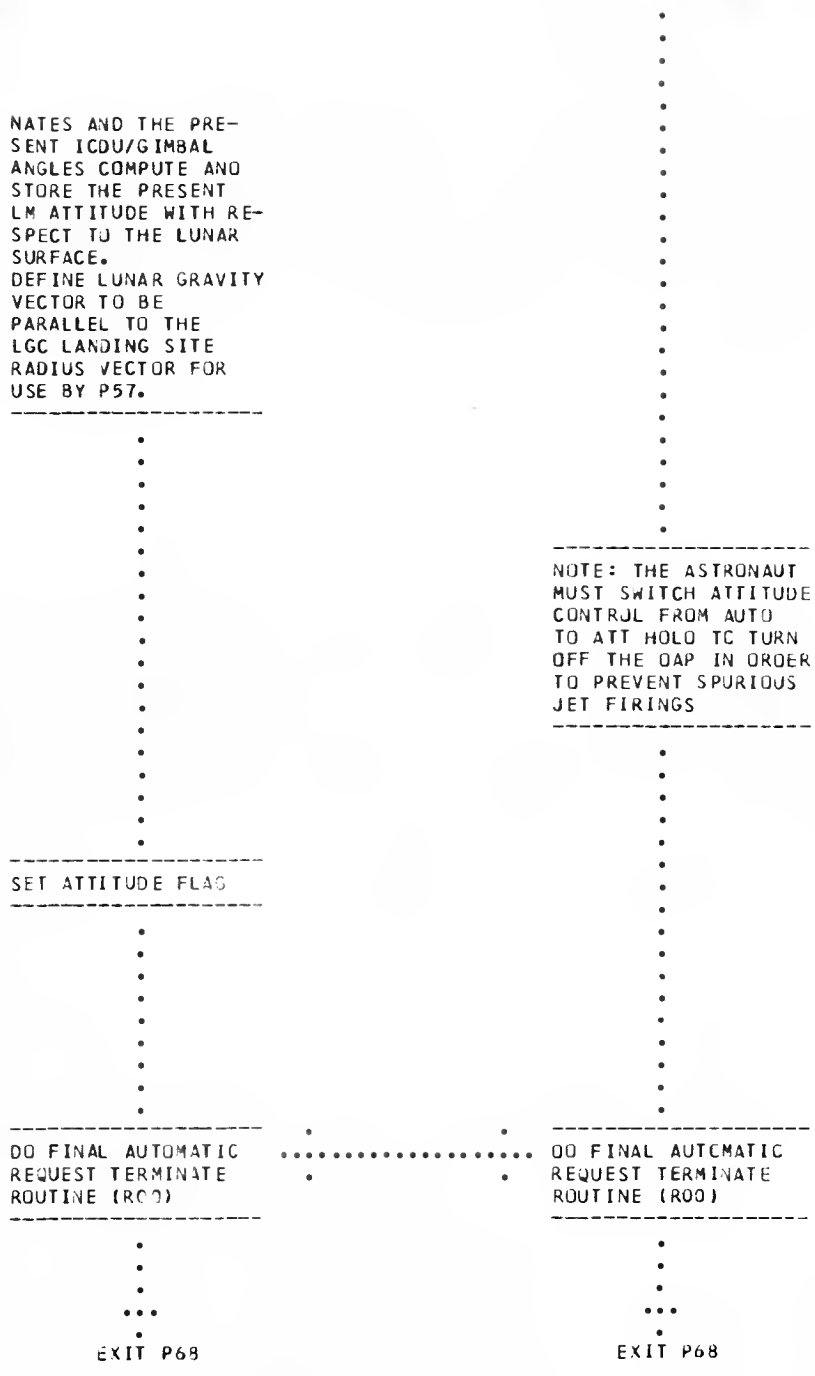
#120


SITE, I.E. = 0).
THIS VALUE SHOULD
NOMINALLY BE 00000
EXCEPT FOR ACCRUED
ERRORS FROM THE LR
IN THE LAST PHASES
OF THE LANDING. IN
NAUTICAL MILES TO
NEAREST .1 NM.
#130
ENSURE THAT THE LM
IS STABILIZED UPON
THE SURFACE OF THE
MOON AS WELL AS
POSSIBLE.
#140
WAIT FOR KEYBOARD
ENTRY
KEY IN PROCEED
TERMINATE FLASH UPON
RECEIPT OF PROCEED
.P
.R
.O
.C
.E
.E
.D
#150
#160
FROM LGC CALCULATED
LANDING SITE COORDI-



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#190

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#210

#220

CHANGE CONTROL NOTES

LOGIC REV 00 PCR 470
REV 01 PCR 99,419,546,547,623
REV 02(LUM 18) PCR 838, EDITORIAL
REV 03(LUM 1C) PCR 285, EDITORIAL
REV 04(LUM 1D) PCR 296, PCN 1039
REV 05(LUM 1E) PCN 1145

OPS ABORT PROGRAM (P70) REV 06 12/01/71

PURPOSE: (1) TO CONTROL A PGNCS CONTROLLED OPS ABORT FROM THE POWERED LANDING MANEUVER (P63,64, OR 66) WHEN REQUIRED. (SEE ASSUMPTION (1)).

ASSUMPTIONS: (1) THIS PROGRAM WILL CONTROL A DPS ABORT IN ONE OF TWO WAYS:

(A) IF THE ALTITUDE IS GREATER THAN 25,000 FT, THIS PROGRAM WILL COMMAND MAXIMUM OPS THROTTLE, CONTINUE DPS THRUSTING, PERFORM AN ATTITUDE MANEUVER (USING THE RCS) TO THE CORRECT ATTITUDE TO CONTINUE THE ABORT ASCENT, AND COMPLETE THE ABORT ASCENT TO INSERT THE LM ON AN ABORT ORBIT.

(B) IF THE ALTITUDE IS LESS THAN 25,000 FT, THIS PROGRAM WILL COMMAND MAXIMUM DPS THROTTLE AND ENTER A VERTICAL RISE PHASE WHICH WILL TERMINATE EITHER WHEN THE LM ALTITUDE EXCEEDS 25,000 FT. OR WHEN THE LM VERTICAL VELOCITY IS GREATER THAN 40 FT/SEC.
DURING THE VERTICAL RISE PHASE, THE VEHICLE IS MANEUVERED TO ALIGN THE LM +X AXIS WITH THE LOCAL VERTICAL (USING THE RCS), AND THE LM +Y AXIS NORMAL TO THE ANTICIPATED PITCH MANEUVER PLANE. THE PROGRAM WILL THEN PITCH THE LM TO THE CORRECT ATTITUDE FOR ASCENT, AND COMPLETE THE ABORT ASCENT TO INSERT THE LM ON AN ABORT ORBIT.

(2) THE ABORT ORBIT IS DEFINED IN SECTION 5.4.3 OF R567.

(3) THE LM IS ON THE POWERED LANDING DESCENT SOMEWHERE BETWEEN OPS IGNITION FOR THE MANEUVER (P63) AND DPS SHUTDOWN ON THE LUNAR SURFACE (P66).

(4) IF CIRCULARIZATION HAS NOT OCCURRED, THE CSM IS IN A 9X60 (NM) ORBIT AROUND THE MOON. THE CSM IS MAINTAINING A PREFERRED TRACKING ATTITUDE FOR OPTICAL TRACKING OF THE LM.

(5) THE IMU IS ON AND ACCURATELY ALIGNED TO THE LANDING SITE ORIENTATION.

(6) THE LANDING RADAR (LR) IS ON AND WAS CHECKED OUT WHEN IN POSITION #1. THE LGC/LR OPERATION IS UNDER THE CONTROL OF THE DESCENT STATE VECTOR UPDATE ROUTINE (R12).

++ (7) THE LANDING ANALOG DISPLAYS ROUTINE (R1D) IS ENABLED UPON ENTRY TO THIS PROGRAM, HAVING BEEN ENABLED BY P63.
+06 R1D IS TERMINATED UPON TERMINATION OF AVERAGE G. DURING THIS MODE ALTITUDE AND ALTITUDE-RATE ARE DISPLAYED ON THE
+1180 TAPE METERS AND INERTIAL CROSS-RANGE VELOCITY ON THE CROSS POINTERS.
++

(8) THE DPS IS NOT THROTTLABLE OVER THE WHOLE RANGE FROM ZERO TO MAXIMUM. IT MUST BE OPERATED EITHER AT MAXIMUM THROTTLE OR OVER A SPECIFIC THROTTLE RANGE OF LOWER SETTINGS. THESE THROTTLE SETTINGS ARE SPECIFIED IN SECTION 5 OF R567 AND ARE TOTAL THROTTLE SETTINGS, I.E.: THE SUM OF THE MANUAL SETTING (WHOSE MINIMUM IS 10 PERCENT) AND THE PGNCS COMMANDED SETTING.
THIS PROGRAM ASSUMES THE THROTTLE CONTROL TO BE IN AUTO (THE OPS RECEIVES THE SUM OF THE MANUAL AND PGNCS COMMANDED SETTINGS) AND THE MANUAL THROTTLE TO BE SET AT A LEVEL LESS THAN THAT REQUIRED BY THE LGC. THE LGC WILL COMMAND MAXIMUM THROTTLE FOR ALL DPS THRUSTING CONTROLLED BY THIS PROGRAM.

(9) THE X-AXIS OVERRIDE OPTION PROVIDES THE CREW WITH THE ABILITY TO EXERCISE MANUAL CONTROL ABOUT THE LM X AXIS WITH THE ATTITUDE CONTROLLER EVEN THOUGH THE PGNCS ATTITUDE CONTROL MODE IS AUTO. WHEN THE CONTROLLER IS RETURNED TO DETENT THE PGNCS DAMPS THE YAW RATE, STORES THE YAW ATTITUDE WHEN THE YAW RATE IS DAMPED, AND THEN MAINTAINS THAT ATTITUDE.
THE X-AXIS OVERRIDE OPTION IS ALWAYS AVAILABLE TO THE CREW EXCEPT WHEN THE LGC IS SPECIFYING A DESIRED YAW ATTITUDE. THUS THE OPTION IS INHIBITED BY THIS PROGRAM ONLY IN THE CASE OF ASSUMPTION (1)(B) ABOVE, UNTIL THE COMPLETION OF THE PITCH MANEUVER TO THE ATTITUDE FOR THE ASCENT MANEUVER.

(10) IF A THRUSTING MANEUVER IS PERFORMED WITH THE GUIDANCE CONTROL SWITCH IN PGNS AND THE MODE CONTROL SWITCH IN AUTO, THE PGNCS WILL CONTROL THE TOTAL VEHICLE ATTITUDE AND GENERATE EITHER MODE I OR MODE II ATTITUDE ERRORS AND VEHICLE ATTITUDE RATES (SEE ASSUMPTION (12)) FOR DISPLAY ON THE FDAI. THE CREW MAY EXERCISE CONTROL AROUND THE YAW AXIS ONLY WITH THE ACA (X-AXIS OVERRIDE) IF THE X-AXIS OVERRIDE CAPABILITY IS PERMITTED BY THE PROGRAM IN PROCESS. THIS MANUAL CONTROL WILL BE IN THE RATE COMMAND/ATTITUDE HOLD MODE.

IF A THRUSTING MANEUVER IS PERFORMED WITH THE GUIDANCE CONTROL SWITCH IN PGNS AND THE MODE CONTROL SWITCH IN ATTITUDE HOLD THE PGNCS WILL HOLD THE VEHICLE ATTITUDE AND WILL GENERATE EITHER MODE I OR MODE II ATTITUDE ERRORS FOR DISPLAY ON THE FDAI. THE CREW MAY EXERCISE MANUAL ATTITUDE CONTROL ABOUT ALL VEHICLE AXES WITH THE ACA IN EITHER THE RATE COMMAND OR MINIMUM IMPULSE MODE DEPENDING UPON THE STATUS OF THE PULSES FLAG. IT IS STRONGLY RECOMMENDED THAT POWERED FLIGHT NOT BE ATTEMPTED IN THE MINIMUM IMPULSE MODE. THE PULSES FLAG IS SET OR RESET BY EXTENDED VERBS 76 (MINIMUM IMPULSE) AND 77 (RATE COMMAND) RESPECTIVELY. THE PULSES FLAG IS ALSO RESET BY P12, P40, P41, P42, P63, P70, P71 AND R40 AT MAIN ENGINE IGNITION. WITH THE EXCEPTION OF THESE CASES, MODE SELECTION IS ALWAYS BASED UPON THE LAST ENTRY MADE IN THE DSKY. DURING A THRUSTING MANEUVER IN PGNS/ATTITUDE HOLD MODE THE PGNCS WILL NOT BE RESPONSIBLE IF REGISTER OVERFLOWS OCCUR WITHIN THE LGC.

(11) CONTROL OF THE LM DPS, RCS, AND APS IS TRANSFERRED FROM THE PGNCS TO THE ABORT GUIDANCE SYSTEM (AGS) BY PLACING THE GUID CONT SWITCH FROM PGNS TO AGS.

THE AGS WILL BE CAPABLE OF TAKING OVER CONTROL OF THE LM DURING ANY PORTION OF THE LUNAR DESCENT OR ASCENT OR DURING EITHER OF THE ABORT PROGRAMS (P70 OR P71). THE AGS WILL GUIDE THE LM TO A SAFE ORBIT.

THE AGS MAY BE INITIALIZED BY THE LGC AT ANY TIME BY MANUAL SELECTION OF THE AGS INITIALIZATION ROUTINE (R47).

++ IN THE EVENT THAT THE GUIDANCE CONTROL SWITCH IS CHANGED FROM PGNS TO AGS DURING A THRUSTING MANEUVER, THE LGC
+06 WILL CONTINUE COMPUTATION OF POSITION AND VELOCITY, THE DESIRED THRUST VECTOR, AND THE FDAI ATTITUDE ERROR NEEDLE DIS-
+1180 PLAY; HOWEVER THE PGNCS WILL NOT BE RESPONSIBLE IF REGISTER OVERFLOWS OCCUR WITHIN THE LGC.
++

(12) THE PGNCS CAN GENERATE TWO TYPES OF ATTITUDE ERRORS FOR DISPLAY ON THE FDAI:

MODE I - SELECTED BY EXTENDED VERB 61. AUTOPILOT FOLLOWING ERRORS USED AS A MONITOR OF THE DAP'S ABILITY TO TRACK AUTOMATIC STEERING COMMANDS.

MODE II- SELECTED BY EXTENDED VERB 62. TOTAL ATTITUDE ERRORS USED TO ASSIST CREW IN MANUALLY MANEUVERING THE VEHICLE.

PGNCS-DERIVED VEHICLE ATTITUDE RATES MAY ALSO BE DISPLAYED VIA SELECTION BY EXTENDED VERB 60.

++ DISPLAY SELECTION IS ALWAYS BASED UPON THE LAST ENTRY MADE IN THE DSKY, WITH THE EXCEPTION THAT MODE II ATTITUDE
+06 ERROR DISPLAYS ARE AUTOMATICALLY SELECTED AT THE BEGINNING OF R60. FOR A MORE DETAILED DESCRIPTION OF THESE
+1180 DISPLAYS REFER TO SECTION 3 OF R567 (PARA. 3.2.6.).
++

(13) THE DAP DATA LOAD ROUTINE (R03) WAS COMPLETED PRIOR TO DPS IGNITION FOR THE POWERED LANDING MANEUVER AND SHOULD NOT BE SELECTED DURING THIS MANEUVER.

(14) DURING DPS BURNS ONLY, THE PITCH-ROLL RCS JET AUTOPILOT (U AND V JETS) MAY BE DISABLED (V65) OR ENABLED (V75) BY EXTENDED VERB AS SHOWN. THIS CAPABILITY IS INTENDED TO BE USED TO PREVENT LM AND DESCENT STAGE THERMAL CONSTRAINT VIOLATIONS DURING CSM-DOCKED OPS BURNS (P40). THE CAPABILITY EXISTS DURING P63 AND P70 ALSO. PERFORMANCE OF FRESH START (V36E) WILL ALWAYS ENABLE THE PITCH-ROLL JETS.

++ (15) THIS PROGRAM MAY BE CALLED IN TWO WAYS:
+06
+
(A) ABORT PUSHBUTTON - IF THE ABORT PUSHBUTTON IS USED DURING THE POWERED DESCENT IT WILL BE DETECTED BY
+1180 THE ABORT DISCRETES MONITOR ROUTINE (R11), UNLESS DIRECTED TO IGNORE THIS DISCRETE BY THE DAP DATA LOAD ROUTINE (R03).
++ R11 WILL THEN CALL THIS PROGRAM.

(B) V37E70E - THIS PROGRAM MAY BE CALLED BY THE SAME PROCEDURE AS OTHER PROGRAMS ARE MANUALLY CALLED.

(16) THE LGC WILL NOT AUTOMATICALLY SELECT THE APS ABORT PROGRAM (P71) IF DPS FUEL EXHAUSTION OCCURS DURING EXECUTION OF P70. THE CREW MUST ANTICIPATE DPS FUEL EXHAUSTION AND SELECT P71 BY THE ABORT STAGE PUSHBUTTON OR BY V37E71E.

(17) THE ASTRONAUT MAY MONITOR THE FOLLOWING ADDITIONAL PARAMETERS DURING THIS PROGRAM BY KEYING IN V16N77E:

V16N77
R1-TG
R2-VGY(LM)
R3-VI

WHERE:
TG - THE ESTIMATED TIME OF FLIGHT FROM THE PRESENT TIME TO THE ACCOMPLISHMENT OF THE ASCENT INJECTION CONDITIONS. POLARITY IS -. IN MINS AND SECS TO NEAREST SEC. MAX READING IS 59859.

VGY(LM) - COMPONENT OF THE PRESENT VG VECTOR ALONG LM Y AXIS. IN FPS TO NEAREST .1 FPS.

VI - THE MAGNITUDE OF THE LM INERTIAL VELOCITY WITH RESPECT TO THE REFERENCE COORDINATE SYSTEM. IN FPS TO THE NEAREST .1 FPS.

(18) THE ASTRONAUT MAY MONITOR THE FOLLOWING ADDITIONAL PARAMETERS AT ANY TIME DURING THIS PROGRAM AFTER TIG BY KEYING IN V16N85E:

V16N85
R1-VGX(LM)
R2-VGY(LM)
R3-VGZ(LM)

FOR DEFINITIONS, SEE LOGIC BELOW.

(19) THE ASTRONAUT MAY OBSERVE THE FOLLOWING ADDITIONAL PARAMETERS DURING THIS PROGRAM BY KEYING IN V06N76E:

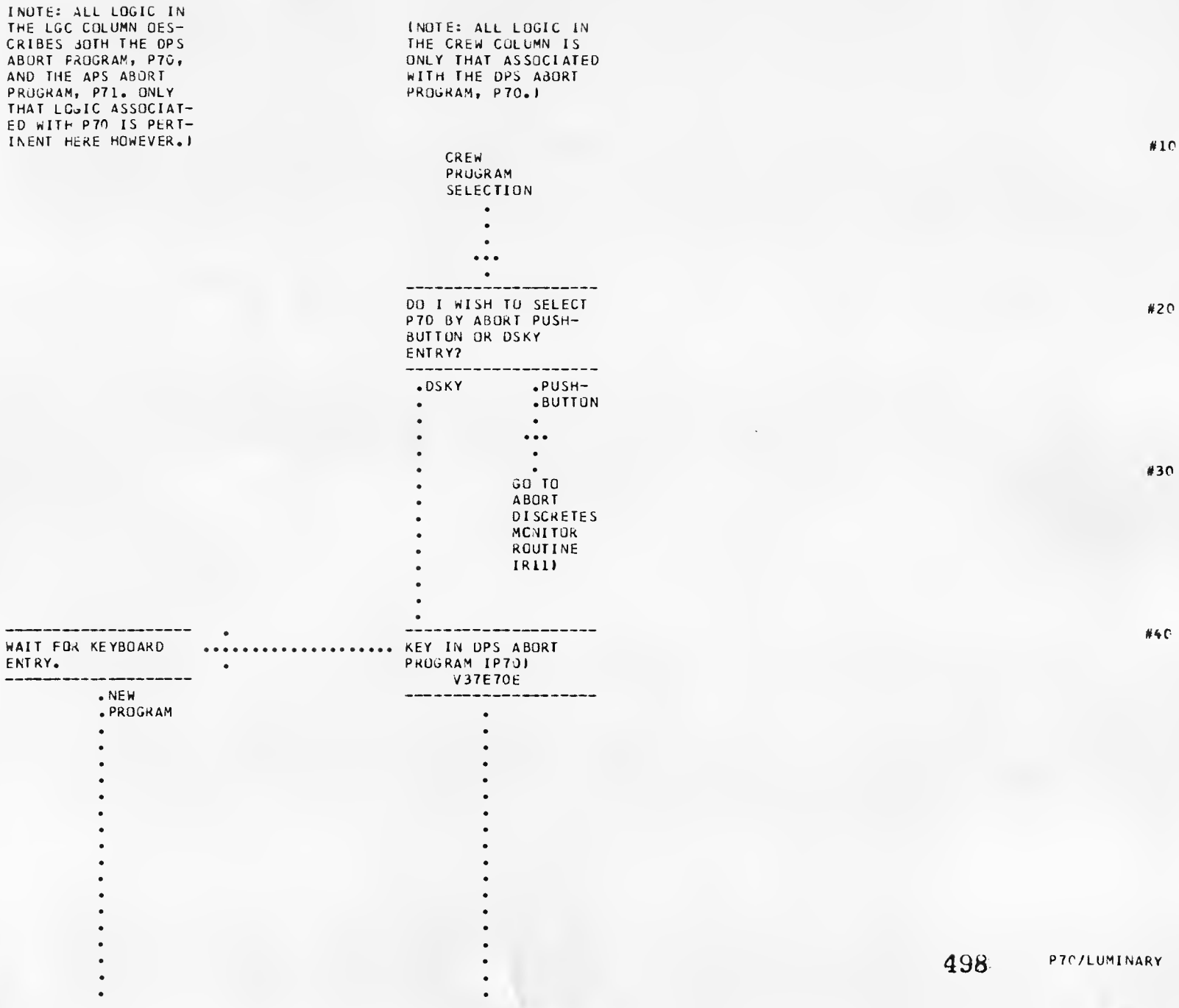
V06N76
R1-DOWNRANGE VELOCITY (VHF)
R2-RADIAL VELOCITY (H OOT F)
R3-CROSSRANGE

WHERE: DOWNRANGE VELOCITY - THE HORIZONTAL DOWNRANGE VELOCITY AT INJECTION IN FPS TO NEAREST .1 FPS.

RADIAL VELOCITY - THE RADIAL VELOCITY AT INJECTION (THIS VALUE WILL BE DRAWN FROM PAD-LOADED ERASABLE STORAGE LOCATION) IN FPS TO NEAREST .1 FPS.

CROSSRANGE - THE DISTANCE BETWEEN THE LM ORBITAL PLANE AFTER INJECTION AND THE LM POSITION VECTOR AT TIG. (FOR THIS PROGRAM, THE CROSSRANGE VALUE IS RESTRICTED IN MAGNITUDE TO PAD-LOADED VALUE. PRESENTLY THE MAXIMUM ALLOWABLE VALUE IS CONSTRAINED TO BE 0.5 DEGREE (APPROXIMATELY 8 N.M.)) IN NM TO NEAREST .1 NM.

PROG CONT | LGC | GROUND | CREW


(NOTE: ALL LOGIC IN THE LGC COLUMN DES-CRIBES BOTH THE DPS ABORT PROGRAM, P70, AND THE APS ABORT PROGRAM, P71. ONLY THAT LOGIC ASSOCIAT-ED WITH P70 IS PERT-INENT HERE HOWEVER.)
(NOTE: ALL LOGIC IN THE CREW COLUMN IS ONLY THAT ASSOCIATED WITH THE DPS ABORT PROGRAM, P70.)
#10
CREW PROGRAM SELECTION
#20
DO I WISH TO SELECT P70 BY ABORT PUSH-BUTTON OR DSKY ENTRY?
.DSKY
.PUSH-BUTTON
#30
GO TO ABORT DISCRETES MONITOR ROUTINE (R11)
#40
WAIT FOR KEYBOARD ENTRY.
KEY IN DPS ABORT PROGRAM (P70) V37E70E
.NEW PROGRAM

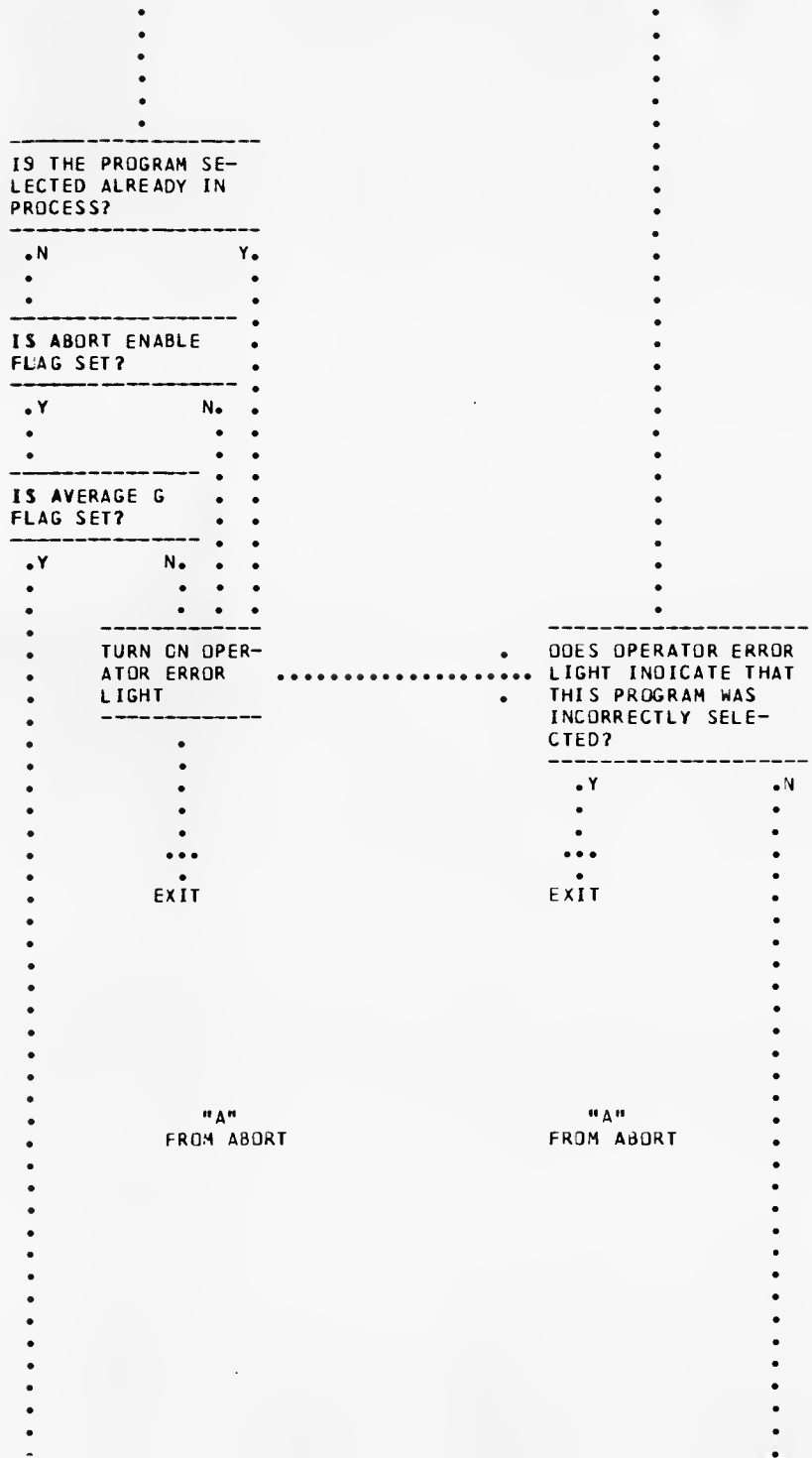
#50

#60

#70

#80

#90


IS THE PROGRAM SELECTED ALREADY IN PROCESS?
N
Y
IS ABORT ENABLE FLAG SET?
Y
N
IS AVERAGE G FLAG SET?
Y
N
TURN ON OPERATOR ERROR LIGHT
EXIT
"A" FROM ABORT
DOES OPERATOR ERROR LIGHT INDICATE THAT THIS PROGRAM WAS INCORRECTLY SELECTED?
Y
N
EXIT
"A" FROM ABORT


DISCRETES MONITOR ROUTINE (R11)
DISCRETES MONITOR ROUTINE (R11)
#100
START DPS ABORT PROGRAM (P70) OR APS ABORT PROGRAM (P71) AS DEFINED BY V37 OR R11 SELECTION. DISPLAY P70 OR P71 AS APPROPRIATE.
MONITOR DSKY: OBSERVE DISPLAY OF P70.
#110
IS THE PRESENT PROGRAM P71?
#120
N
Y
SET APS FLAG
#130
RESET ULLAGE FLAG
#140
RESET X-AXIS OVERRIDE INHIBIT FLAG

RESET PULSES FLAG #150

SET 1.0 DEGREE DEADBAND

#160

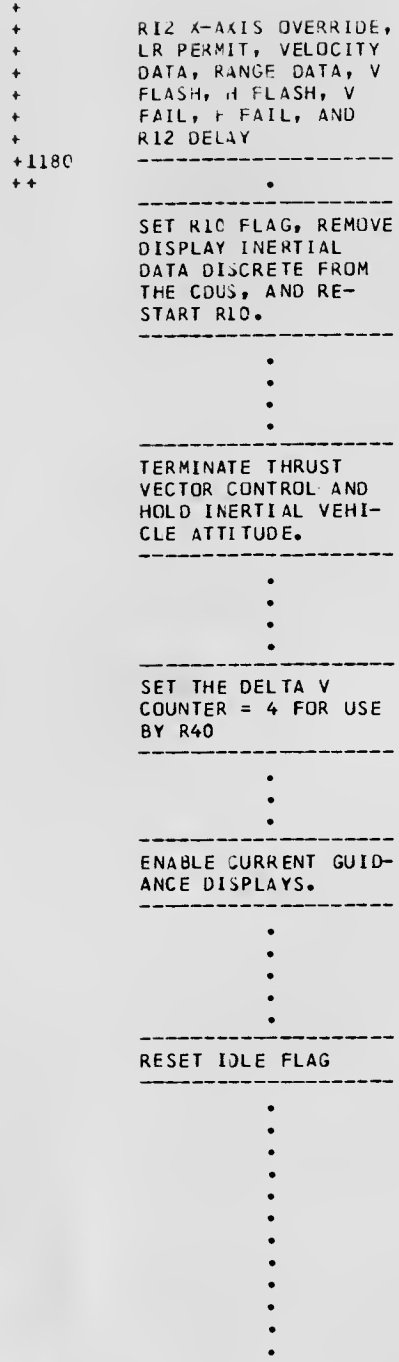
++
+06 SET ENGINE ON FLAG
+1180
++

COMMAND ENGINE ON. #170
(NOTE: IF TOTAL
THRUST FAILURE HAS
OCCURRED, MANUAL
TRANSLATION MUST BE
APPLIED PRIOR TO
P70/71 SELECTION
UNTIL P70/71 AUTOMA-
TICALLY COMMANDS
ENGINE ON.)

#180

SET LR BYPASS FLAG

++
+06 RESET FOLLOWING #190
+ FLAGS ASSOCIATED
+ WITH R12: VX INHIBIT,
+ HIGATE, NO LR READ,



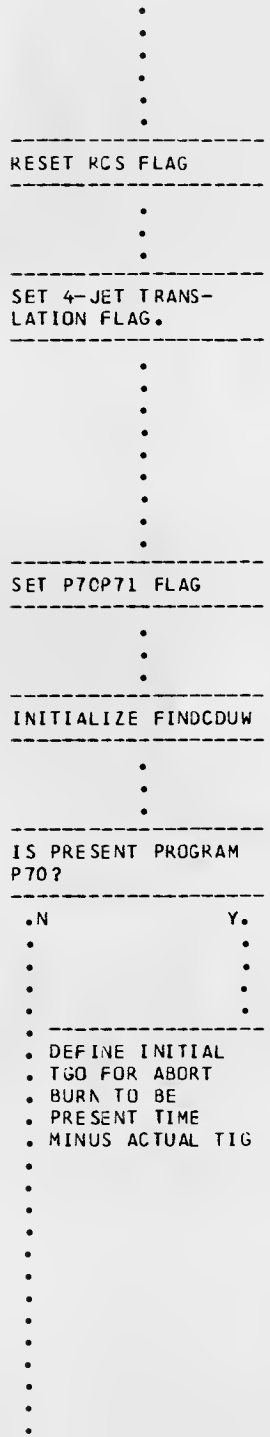
#200

#210

#220

#230

#240



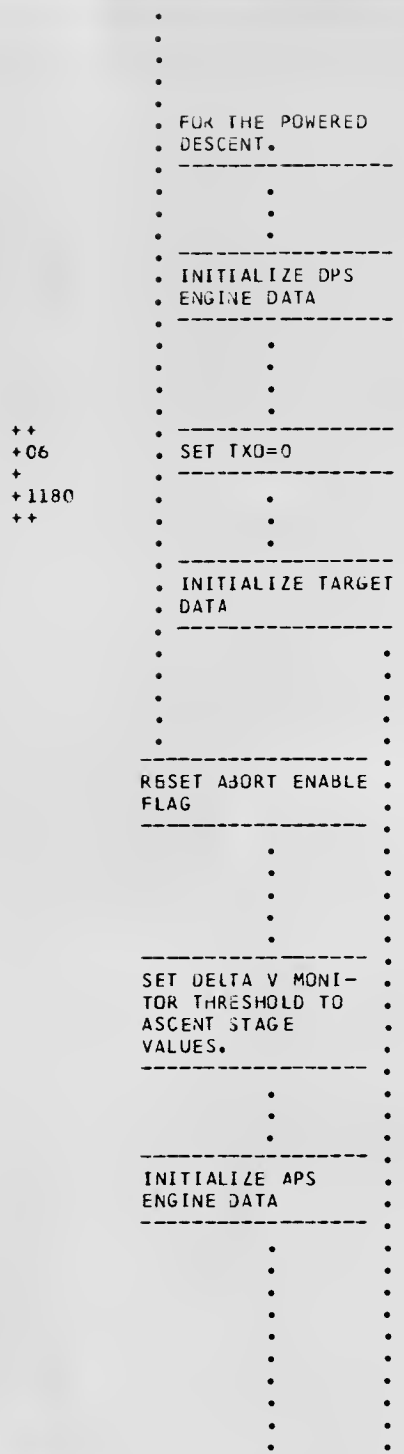
#250

#260

#270

#280

#290



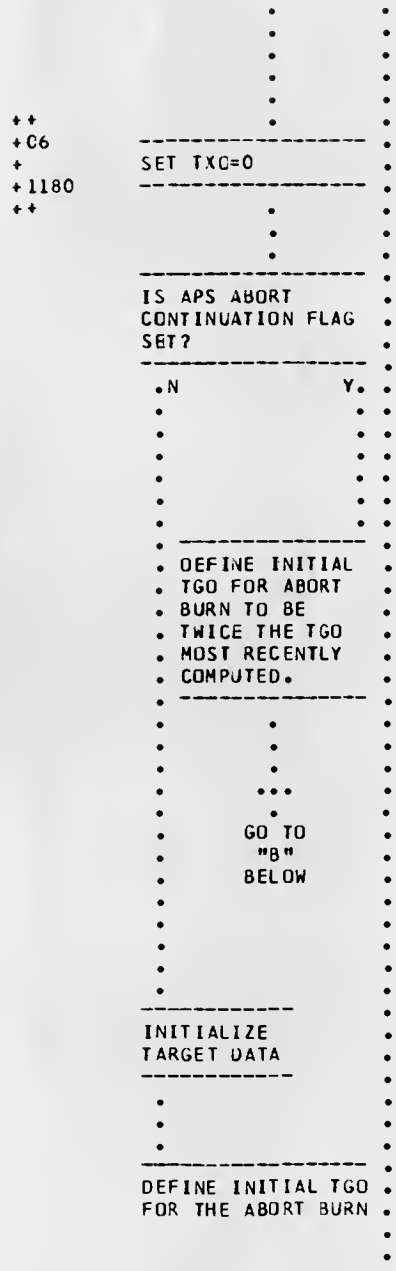
#300

#310

#320

#330

#340



#350

#360

#370

#380

#390

TO BE PRESENT TIME
MINUS ACTUAL TIG
FOR POWERED DES-
CENT.

#400

SET THE DESIRED
RADIAL VELOCITY
EQUAL TO
PAD-LOADED VALUE

#410

COMPUTE CROSSRANGE
DISTANCE USING
PAD-LOADED VALUE
RESTRICTION. I.E.:
COMPUTE
OUT-OF-PLANE (Y)
IF |Y| <0.5 DEG.,
XRANGE = -Y
IF |Y| >0.5 DEG.,
XRANGE = 0.5 DEG.
SGN (-Y)

#420

SET VERTICAL RISE
FLAG

#430

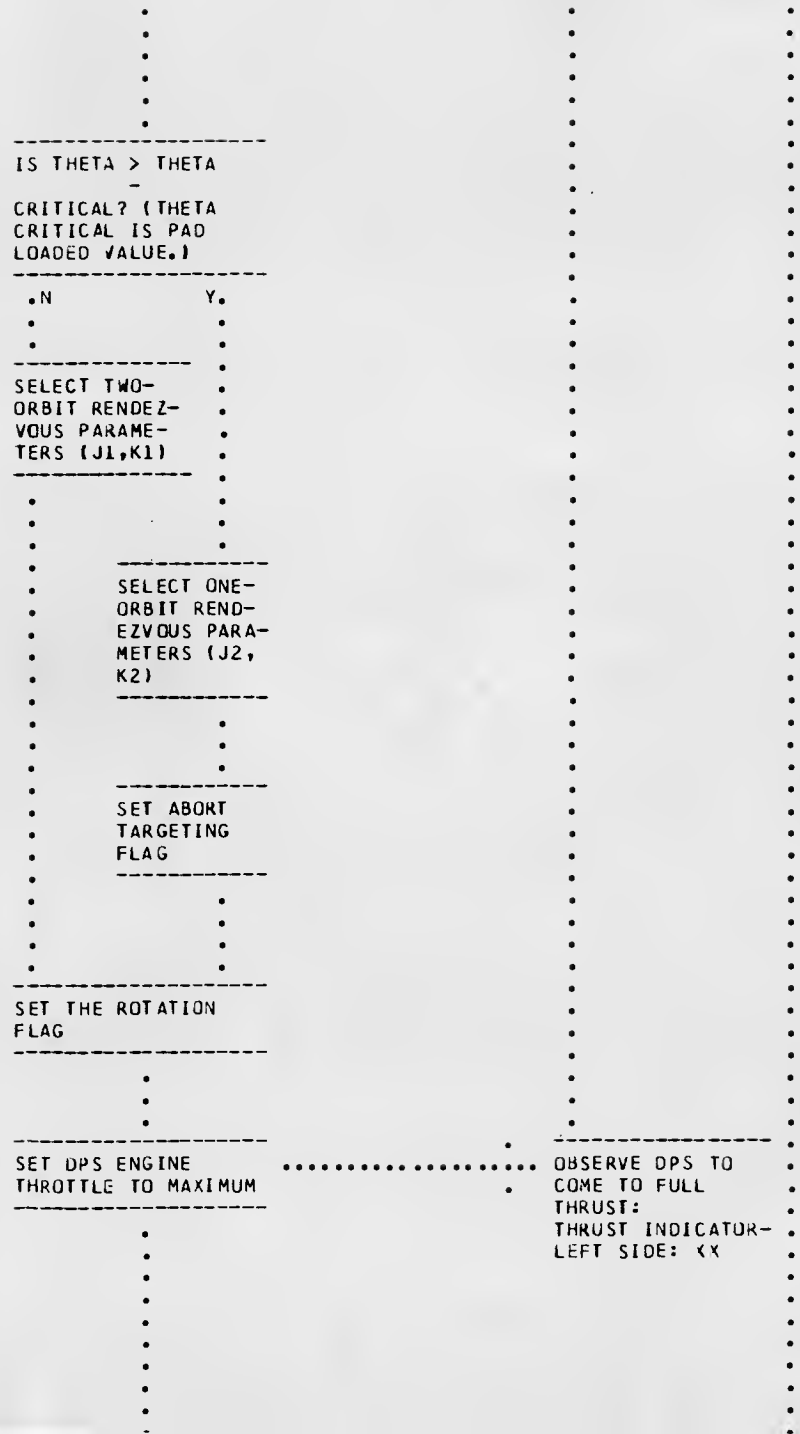
COMPUTE THETA (LM TO
CSM PHASE ANGLE)

#440

HAVE PGNS CONTROL
AND AUTO THRCTTLE
MODES BEEN SELECTED?

Y

N.



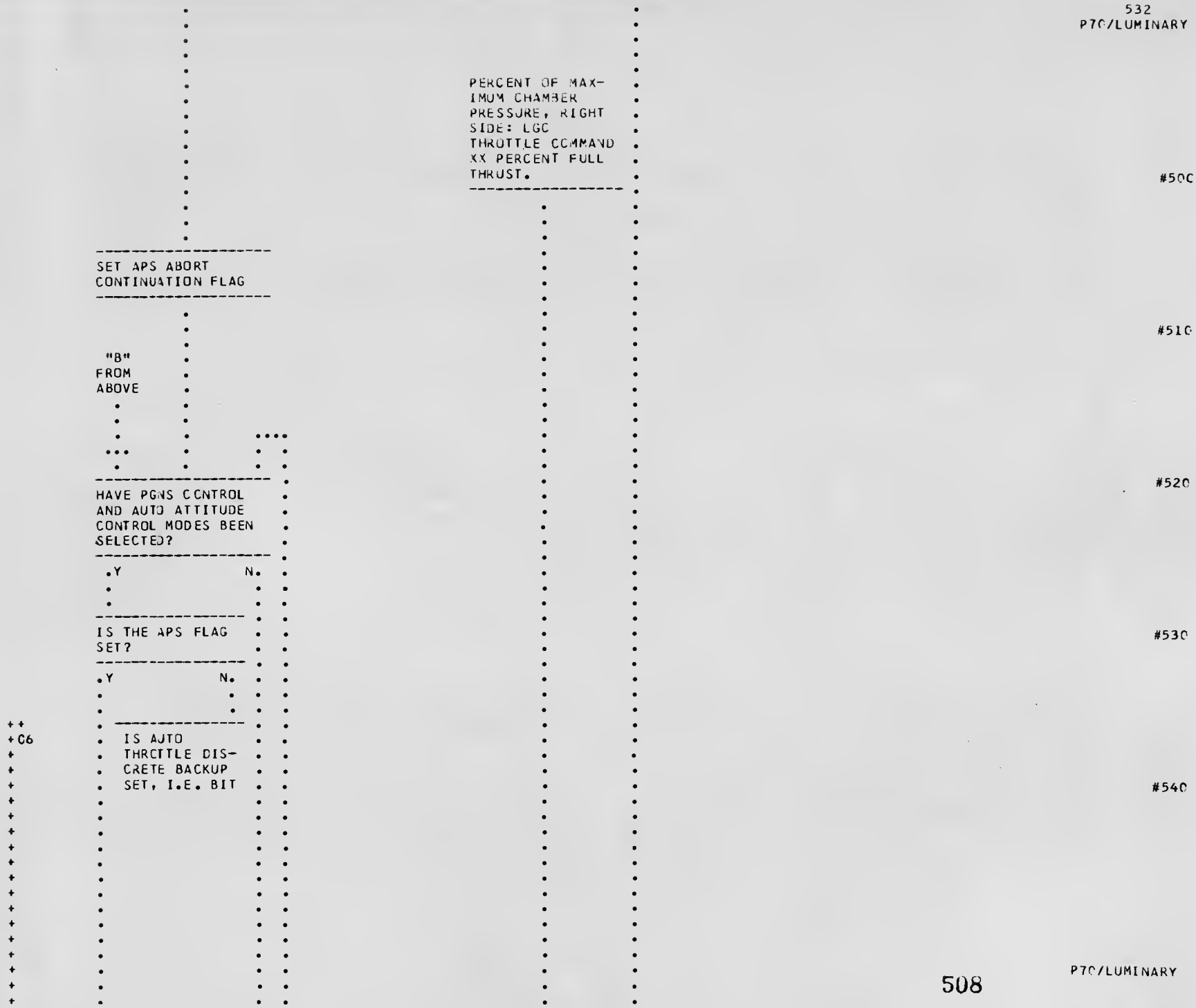
#450

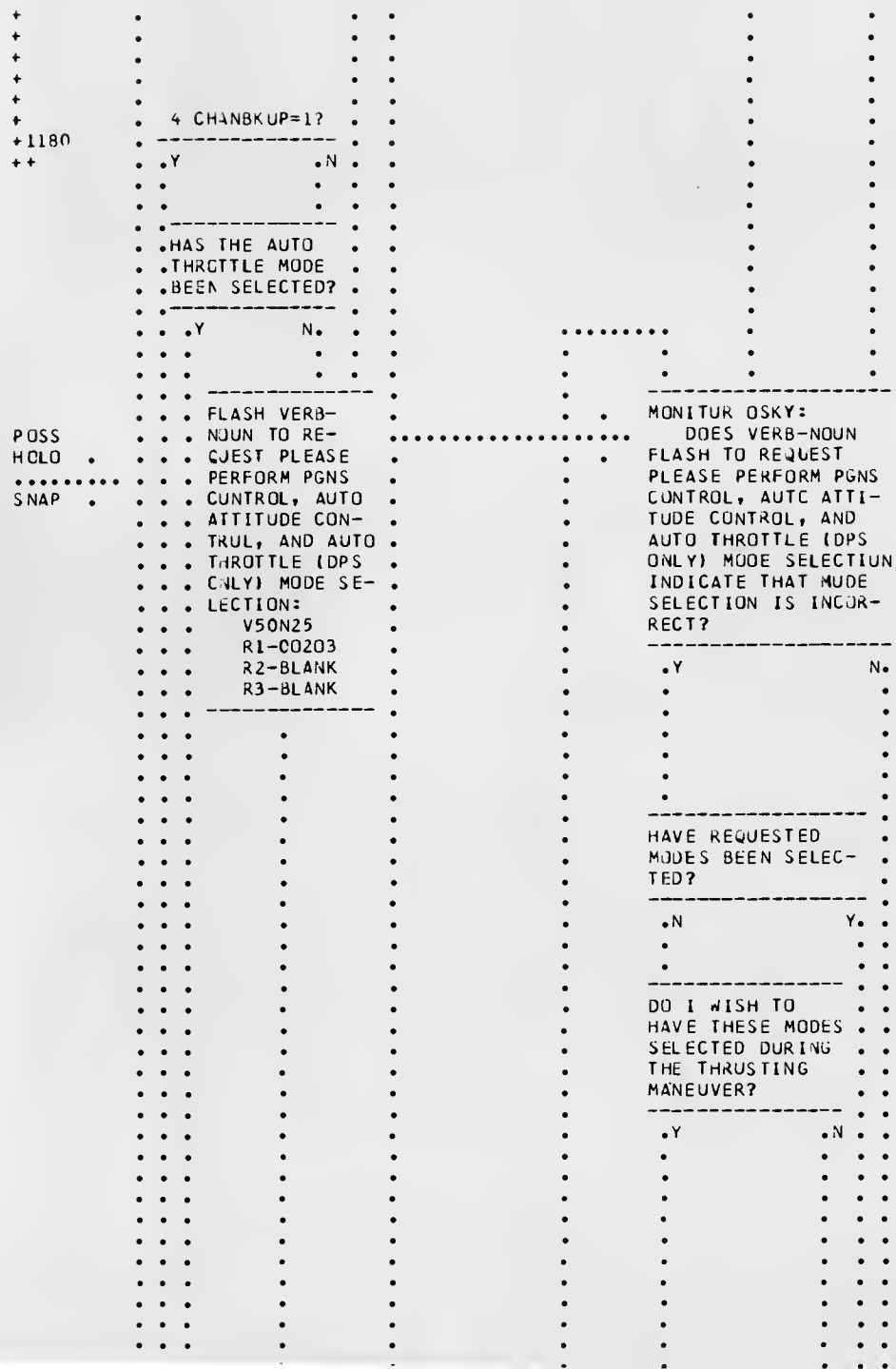
#460

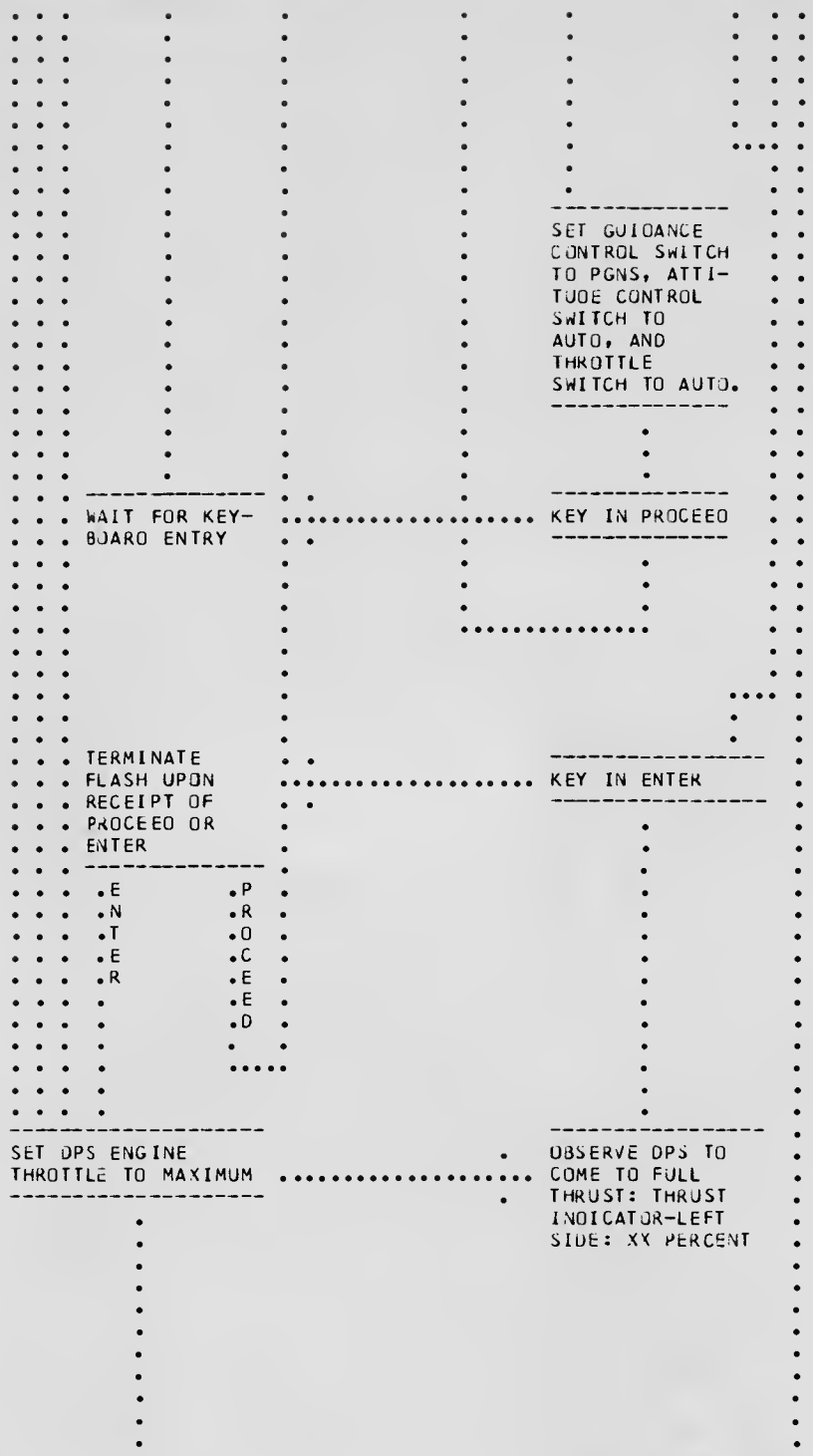
#470

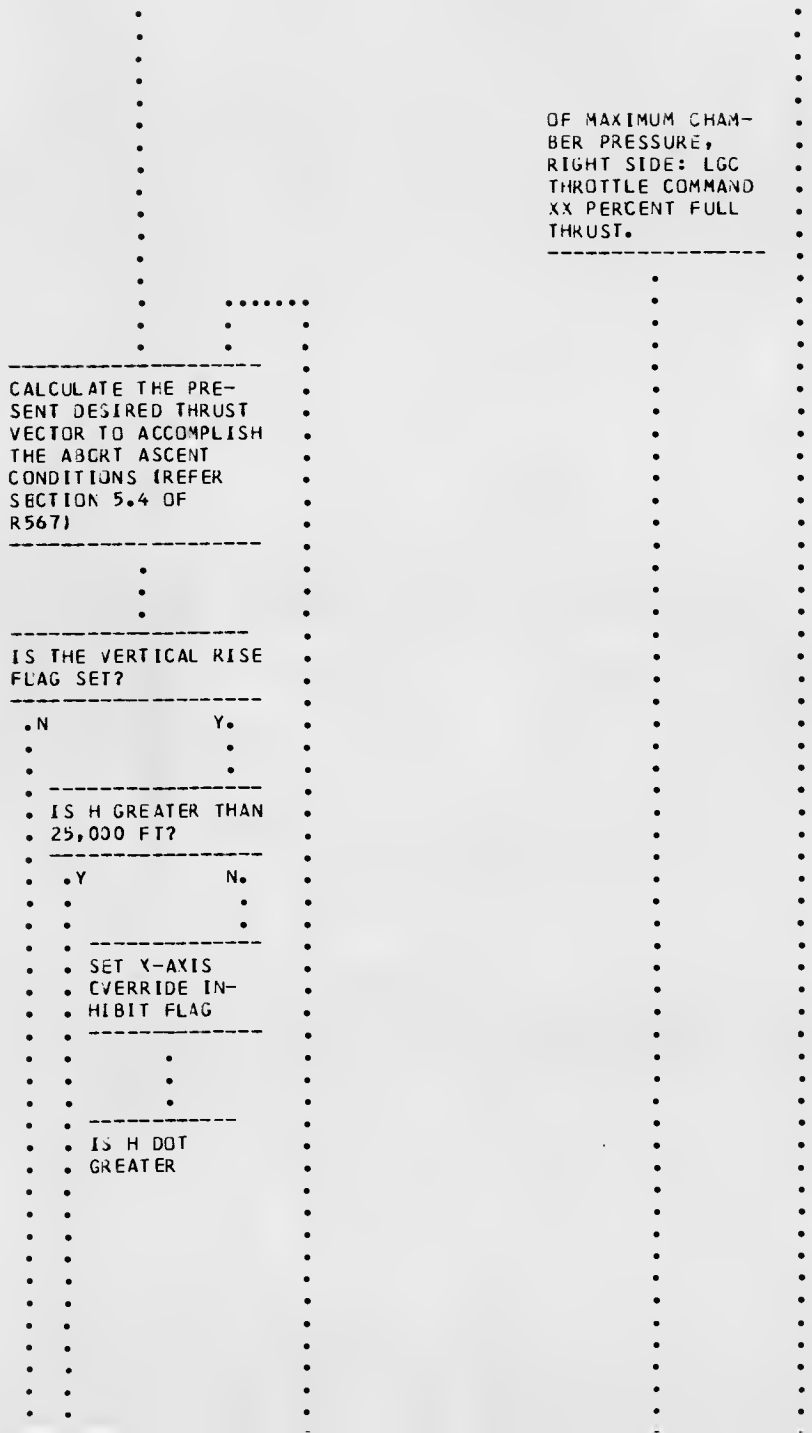
#480

#490


SET APS ABORT CONTINUATION FLAG
"B" FROM ABOVE
HAVE PGNS CONTROL AND AUTO ATTITUDE CONTROL MODES BEEN SELECTED?
Y
N.
IS THE APS FLAG SET?
Y
N.
IS AUTO THROTTLE DISCRETE BACKUP SET, I.E. BIT
C6
PERCENT OF MAXIMUM CHAMBER PRESSURE, RIGHT SIDE: LGC THROTTLE COMMAND XX PERCENT FULL THRUST.
#500
#510
#520
#530
#540


4 CHANBKUP=1?
Y
N
HAS THE AUTO THROTTLE MODE BEEN SELECTED?
Y
N
FLASH VERB-NOUN TO REQUEST PLEASE PERFORM PGNS CONTROL, AUTO ATTITUDE CONTROL, AND AUTO THROTTLE (DPS ONLY) MODE SELECTION:
V50N25
R1-C02O3
R2-BLANK
R3-BLANK
MONITUR OSKY:
DOES VERB-NOUN FLASH TO REQUEST PLEASE PERFORM PGNS CONTROL, AUTC ATTITUDE CONTROL, AND AUTO THROTTLE (DPS ONLY) MODE SELECTIUN INDICATE THAT MUDE SELECTION IS INCORRECT?
Y
N
HAVE REQUESTED MODES BEEN SELECTED?
N
Y
DO I WISH TO HAVE THESE MODES SELECTED DURING THE THRUSTING MANEUVER?
Y
N
+1180
++
POSS HOLO
SNAP
#55C
#560
#57C
#58C
#59C


SET GUIDANCE CONTROL SWITCH TO PGNS, ATTITUDE CONTROL SWITCH TO AUTO, AND THROTTLE SWITCH TO AUTO.
#600
WAIT FOR KEYBOARD ENTRY
KEY IN PROCEED
#610
TERMINATE FLASH UPON RECEIPT OF PROCEED OR ENTER
KEY IN ENTER
#620
.E .N .T .E .R
.P .R .O .C .E .E .D
#630
SET DPS ENGINE THROTTLE TO MAXIMUM
OBSERVE DPS TO COME TO FULL THRUST: THRUST INDICATOR-LEFT SIDE: XX PERCENT
#640



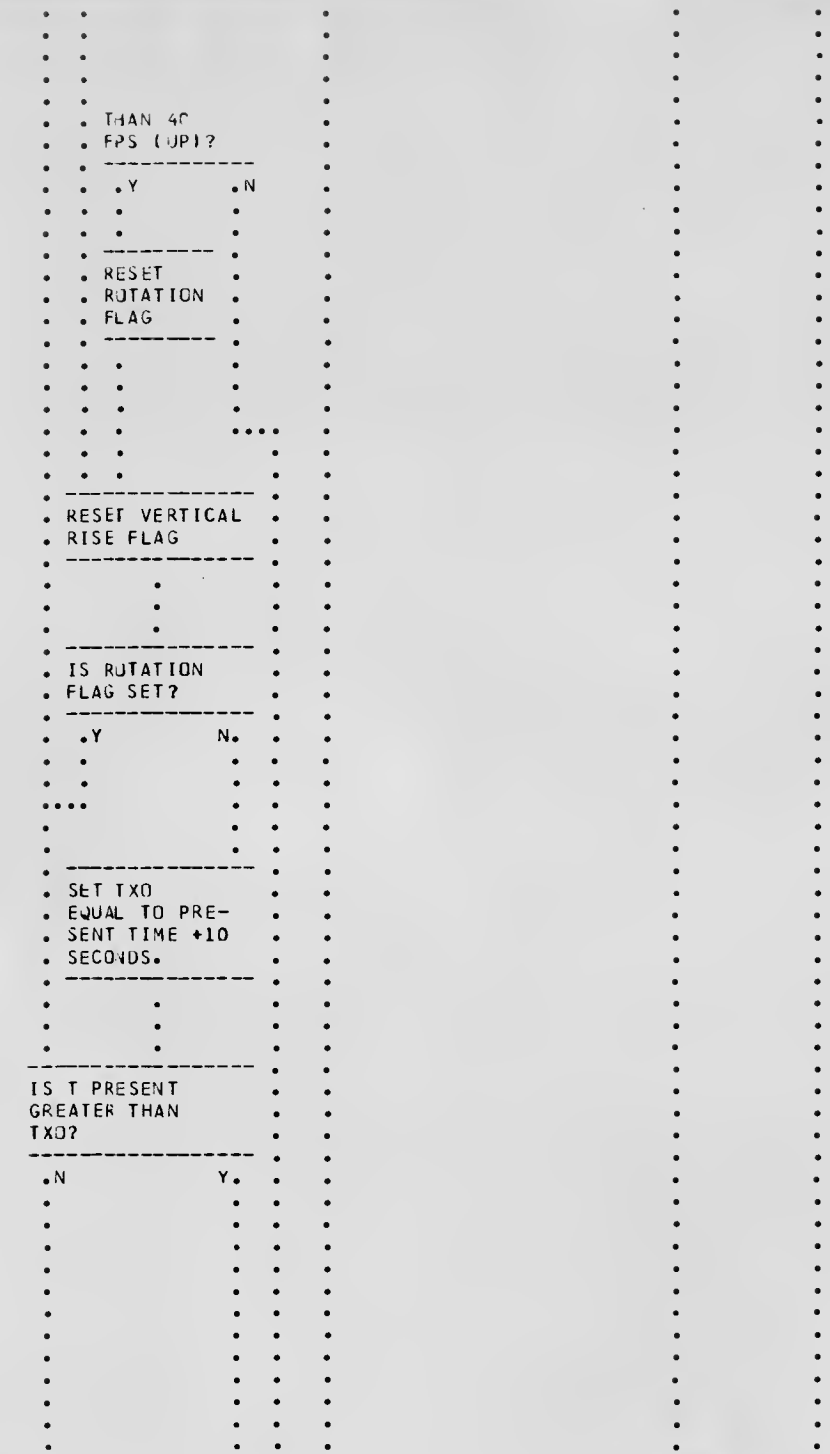
#650

#660

#670

#680

#690



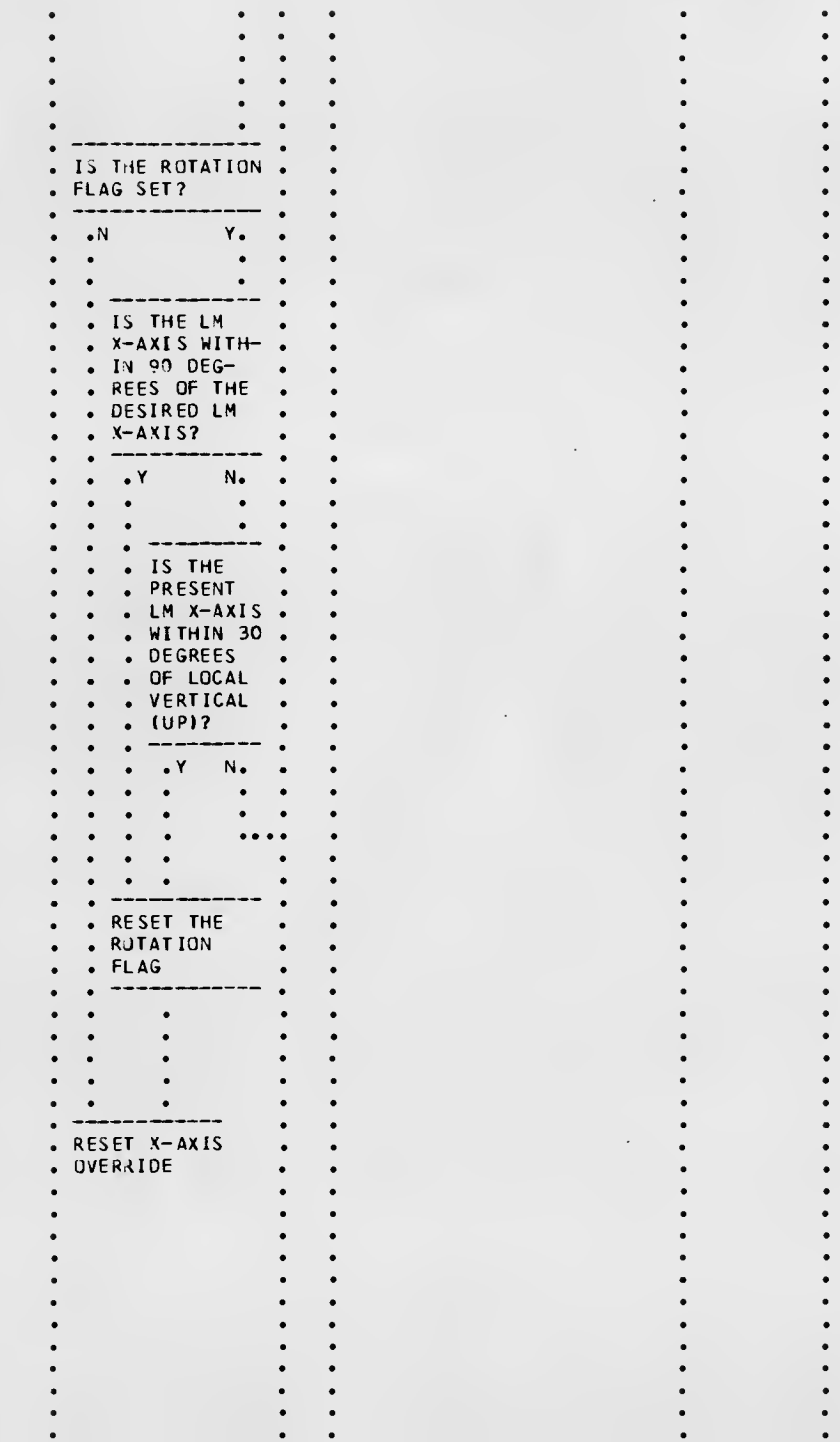
#700

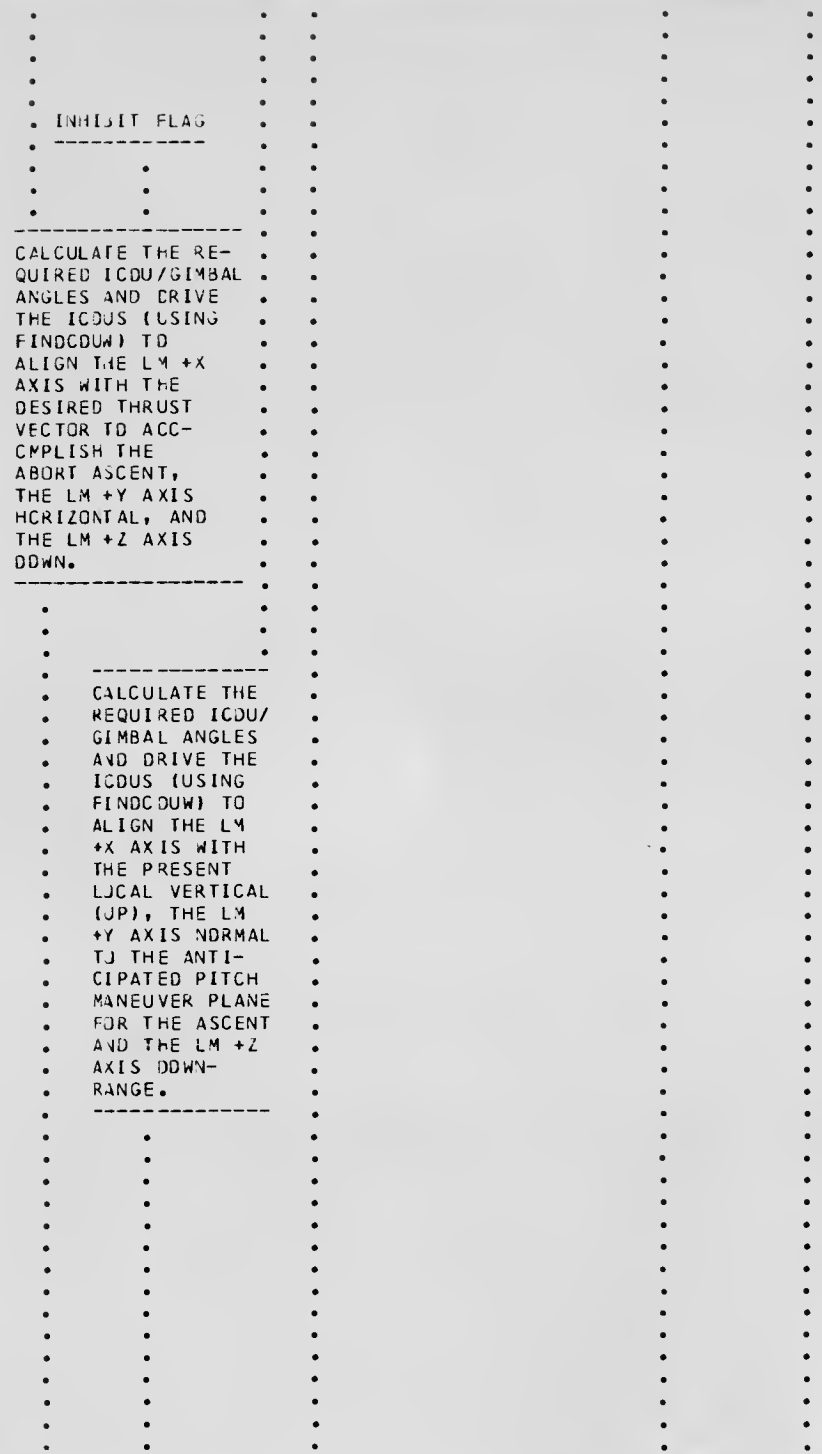
#710

#720

#730

#740


IS THE ROTATION FLAG SET?
N
Y
IS THE LM X-AXIS WITHIN 90 DEGREES OF THE DESIRED LM X-AXIS?
Y
N
IS THE PRESENT LM X-AXIS WITHIN 30 DEGREES OF LOCAL VERTICAL (UP)?
Y
N
RESET THE ROTATION FLAG
RESET X-AXIS OVERRIDE
#750
#760
#770
#780



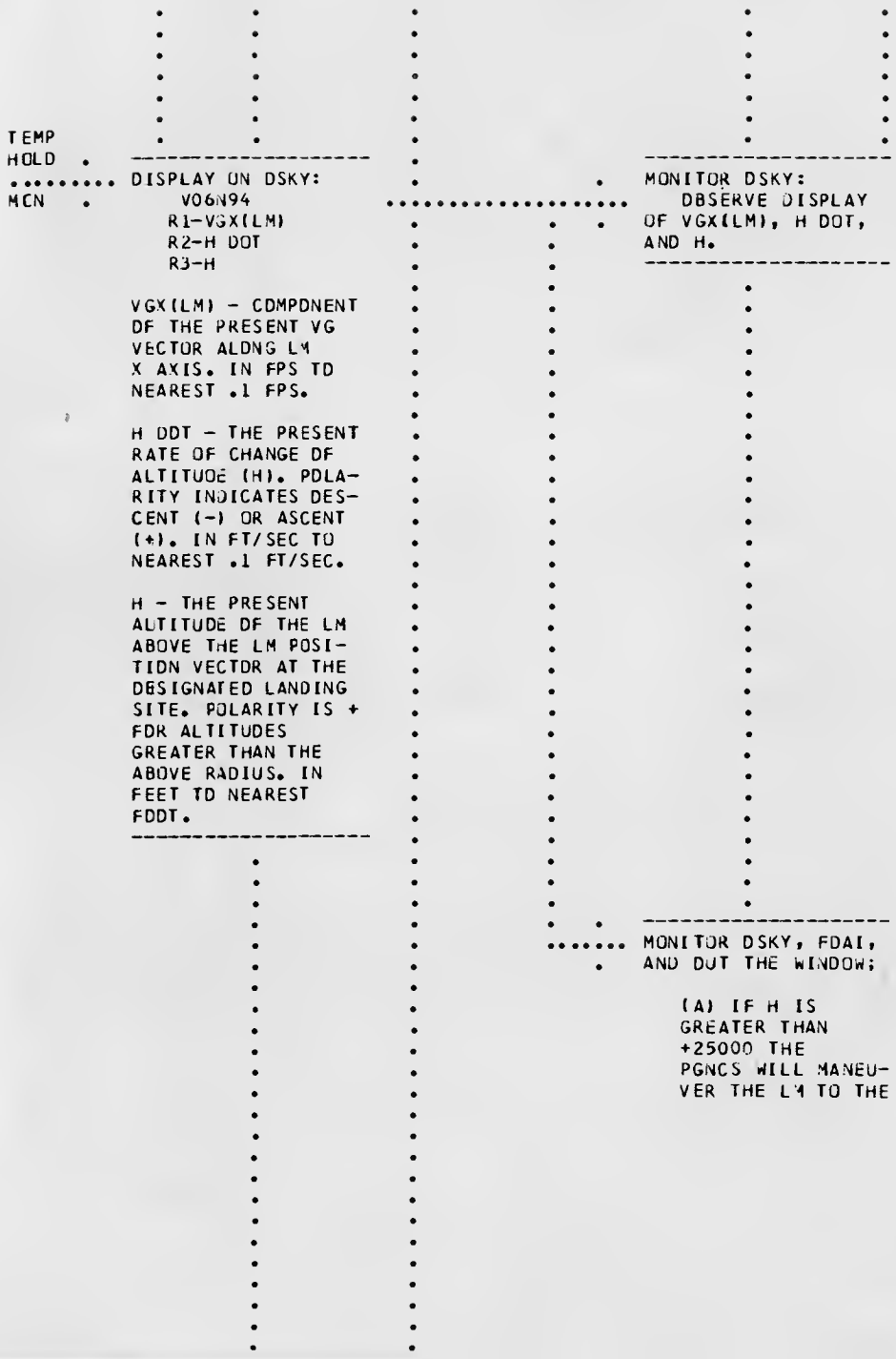
#790

#800

#810

#820

#830


TEMP HOLD
MCN
DISPLAY ON DSKY:
V06N94
R1-VGX(LM)
R2-H DOT
R3-H
VGX(LM) - COMPONENT OF THE PRESENT VG VECTOR ALONG LM X AXIS. IN FPS TO NEAREST .1 FPS.
H DOT - THE PRESENT RATE OF CHANGE OF ALTITUDE (H). POLARITY INDICATES DESCENT (-) OR ASCENT (+). IN FT/SEC TO NEAREST .1 FT/SEC.
H - THE PRESENT ALTITUDE OF THE LM ABOVE THE LM POSITION VECTOR AT THE DESIGNATED LANDING SITE. POLARITY IS + FOR ALTITUDES GREATER THAN THE ABOVE RADIUS. IN FEET TO NEAREST FOOT.
MONITOR DSKY:
OBSERVE DISPLAY OF VGX(LM), H DOT, AND H.
MONITOR DSKY, FDAI, AND OUT THE WINDOW;
(A) IF H IS GREATER THAN +25000 THE PGNCS WILL MANEUVER THE LM TO THE
#840
#850
#860
#870
#880

CORRECT ATTITUDE
TO PERFORM THE
ASCENT ABORT.

(B). IF H IS LESS
THAN +25000 THE
X-AXIS OVERRIDE
OPTION IS INHI-
BITED. THE PGNCS
WILL MANEUVER THE
LM TO LOCAL VER-
TICAL (LM +X AXIS
UP) AND YAW THE
LM SO WINDOWS ARE
DOWNRANGE. THE
LOCAL VERTICAL
ATTITUDE WILL BE
MAINTAINED UNTIL
H IS GREATER THAN
+25000 OR H DOT
IS GREATER THAN
+00400 AT WHICH
TIME THE PGNCS
WILL MANEUVER
(PITCH) THE LM TO
THE CORRECT ATTI-
TUDE TO PERFORM
THE ASCENT ABORT
AND THEN THE
X-AXIS OVERRIDE
OPTION IS
RESTORED.

THE ABOVE MANEUVERS
WILL BE DONE WITH
THE RCS WITH THE DPS
AT FULL THRUST.

.
.
.
.

MONITOR DPS
THRUSTING:
1. DSKY:
R1-VGX

#890
#900
#910
#920
#930

SHOULD BE
DECREASING

R2- H DOT
SHOULD REMAIN +.

R3-H SHOULD
INCREASE

2. FDAI-ATT. ERRORS
SHOULD BE LESS THAN
OR EQUAL TO XX
DEGREE

ATT RATES SHOULD BE
LESS THAN OR EQUAL
TO XX DEGREE/SEC.

3. THRUST INDICATOR
LEFT SIDE: XX PER-
CENT MAX CHAMBER
PRESSURE,
RIGHT SIDE: LGC
THROTTLE COMMAND XX
PERCENT FULL THRUST.

IDENTIFY EARLY,
NORMAL, OR LATE
ENGINE CUTOFF FROM
ASSESSMENT OF DSKY
DISPLAYS.

.E	.L	.N
.A	.A	.O
.R	.T	.R
.L	.E	.M
.Y	.	.
.	.C	.C
.C	.U	.U
.U	.T	.T
.T	.O	.O
.O	.F	.F
.F	.F	.F
.F	.	.
.	.	.
.	.	.
...	.	.
.	.	.

SEE DPS/APS

#940

#950

#960

#970

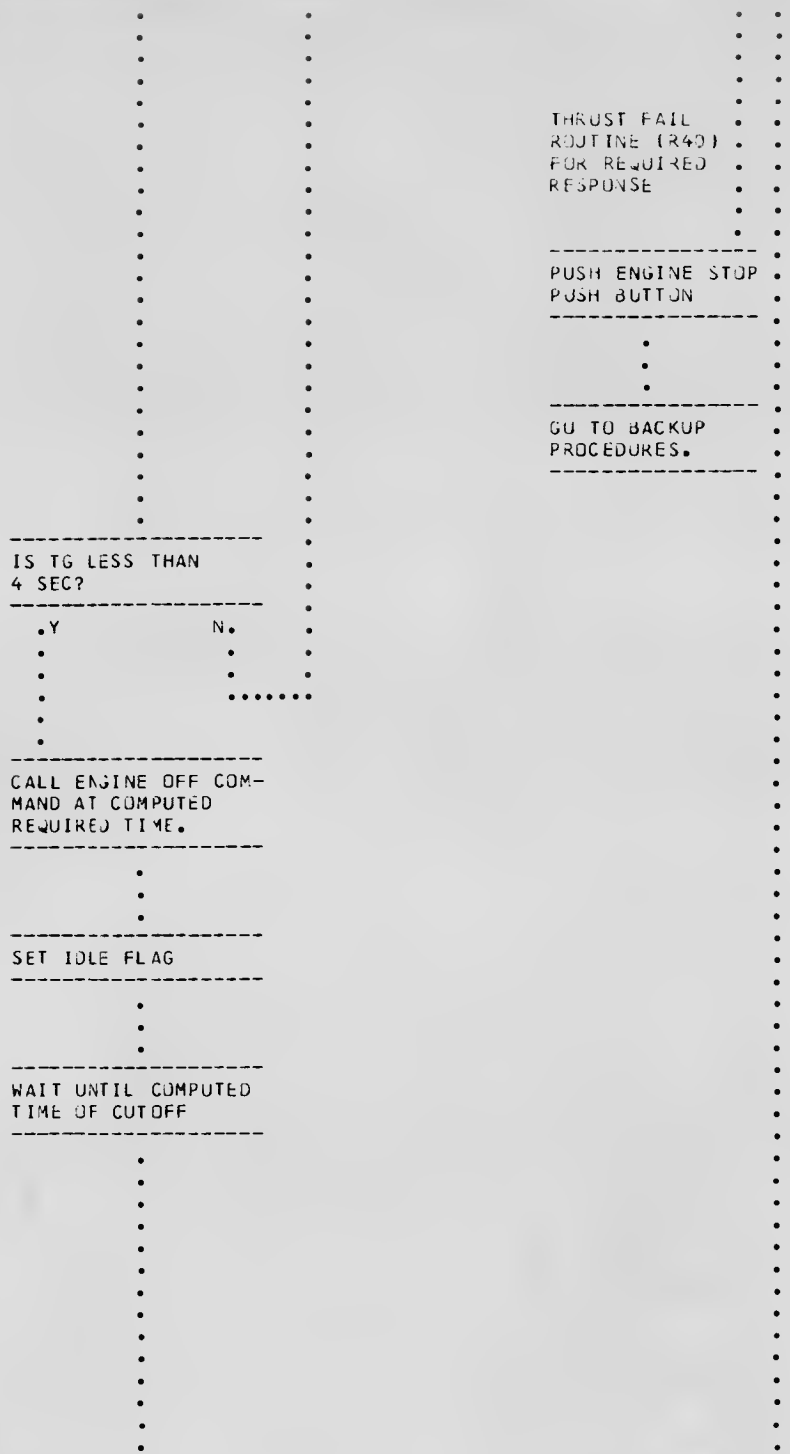
#980

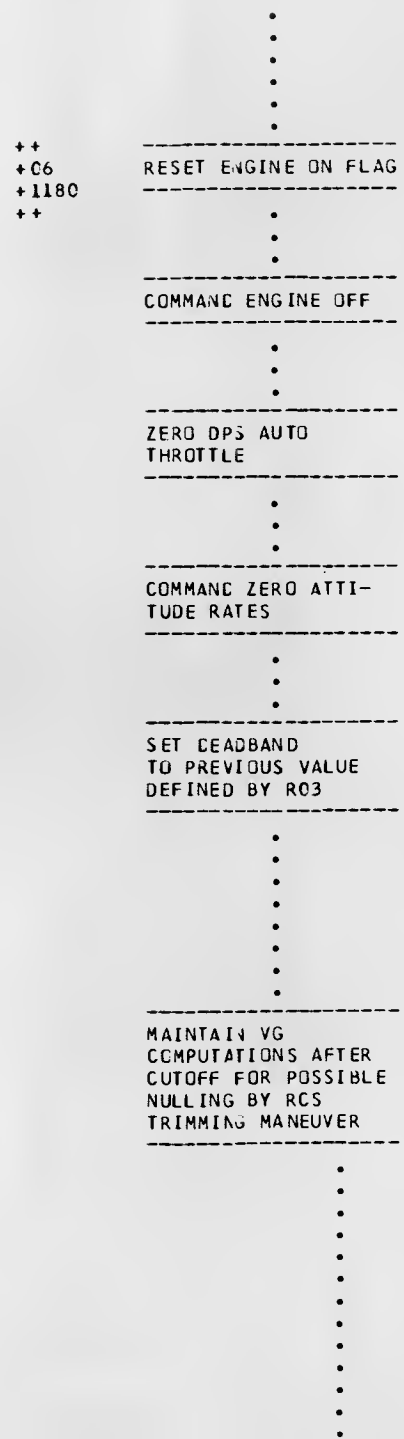
#990

#1000

#1010

#1020





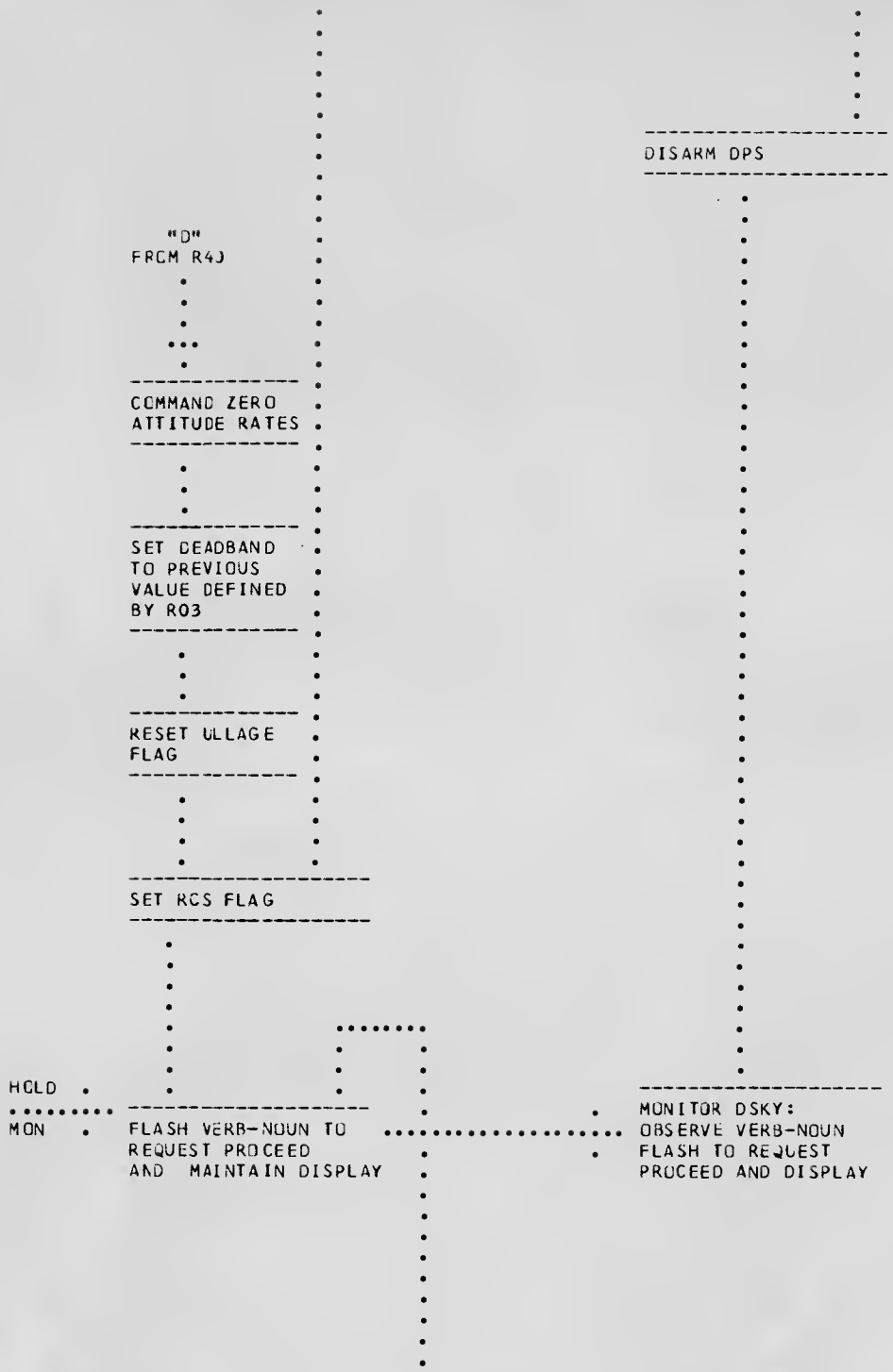
#1030

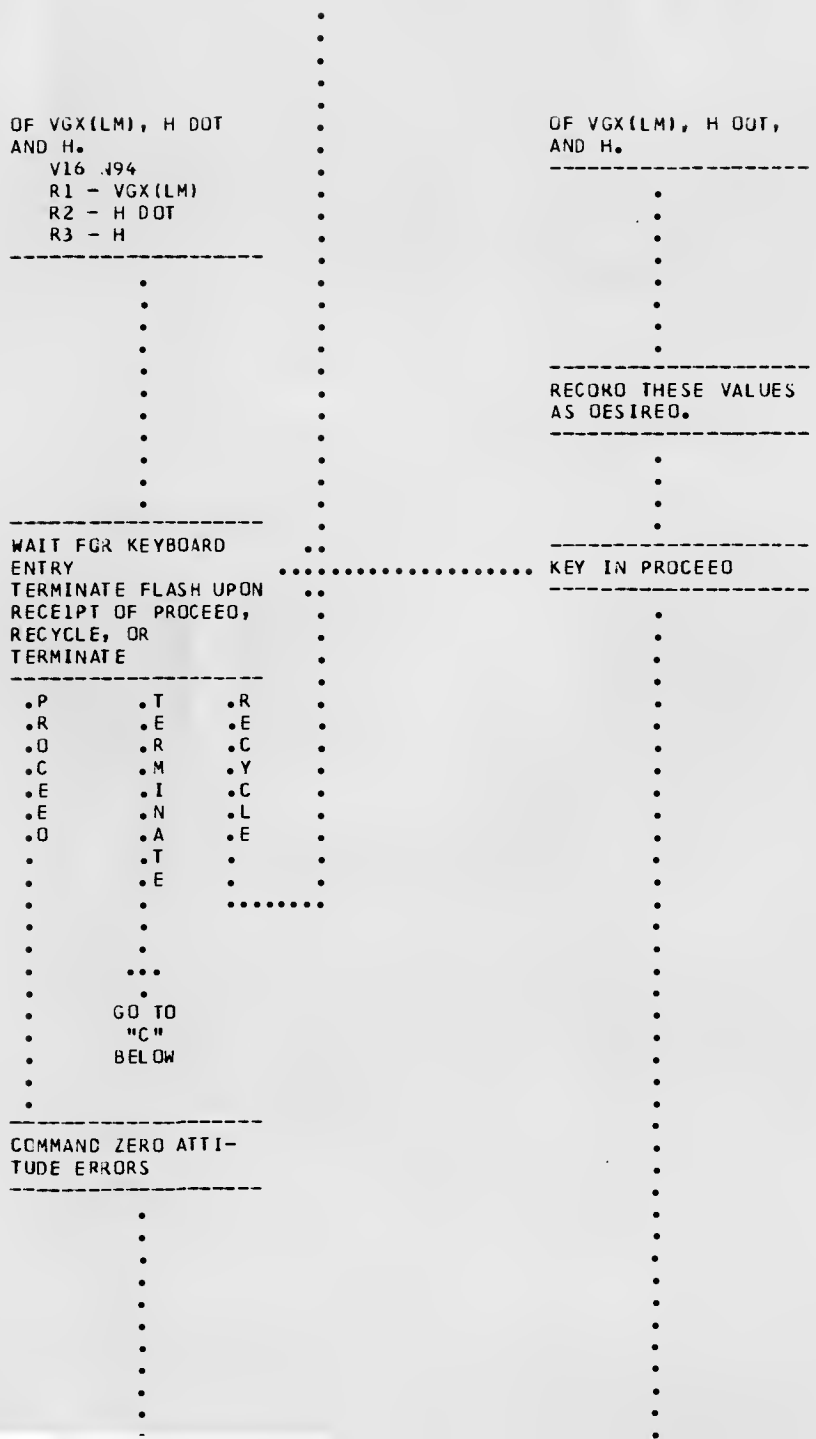
#1040

#1050

#1060

#1070


DISARM DPS
#1080
"D"
FROM R40
#1090
COMMAND ZERO
ATTITUDE RATES
SET DEADBAND
TO PREVIOUS
VALUE DEFINED
BY R03
#1100
RESET ULLAGE
FLAG
#1110
SET RCS FLAG
#1120
HOLD
MON
FLASH VERB-NOUN TO
REQUEST PROCEED
AND MAINTAIN DISPLAY
MONITOR DSKY:
OBSERVE VERB-NOUN
FLASH TO REQUEST
PROCEED AND DISPLAY



#1130

#1140

#1150

#1160

#1170

#1180

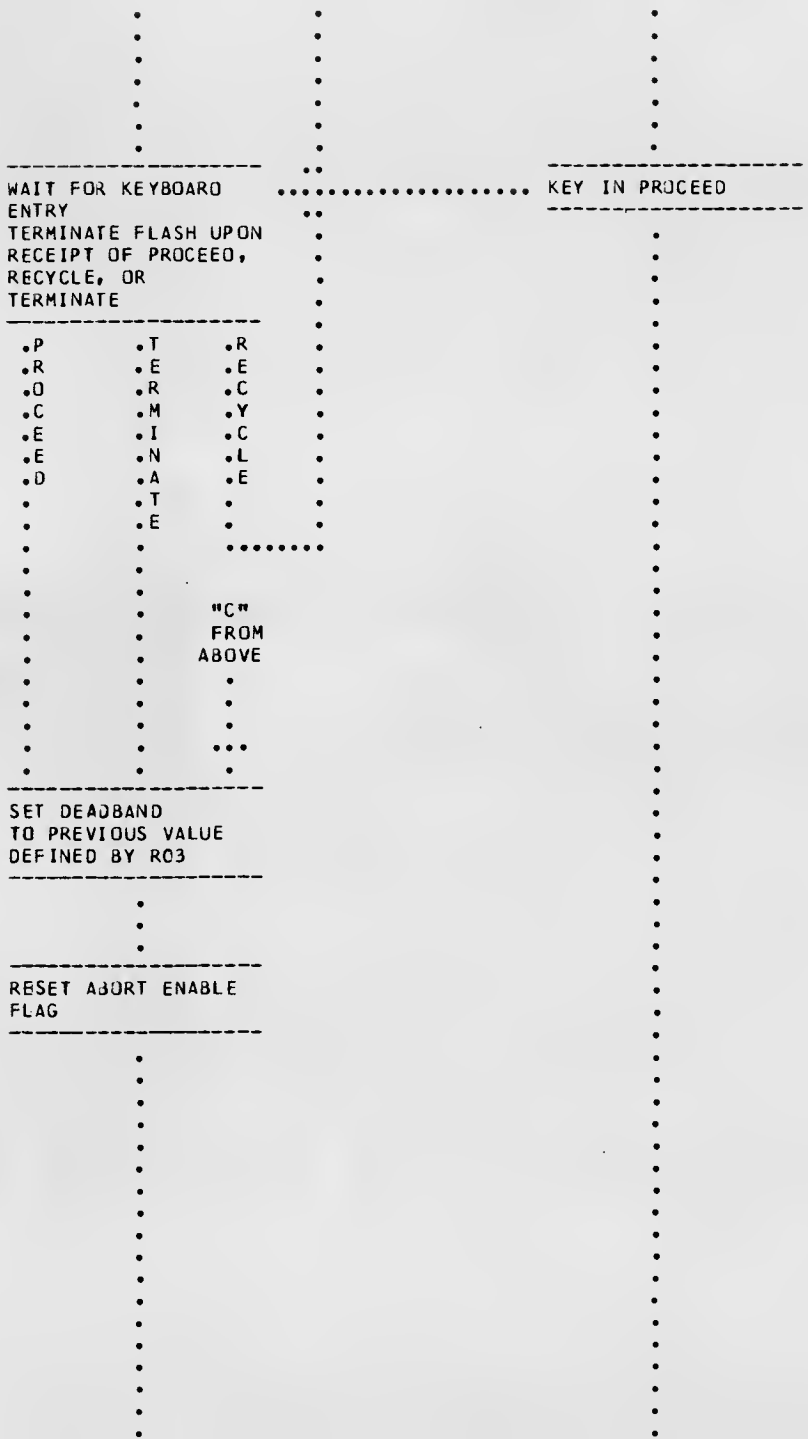
#1190

#1200

#1210

#1220

#1230


WAIT FOR KEYBOARD ENTRY
TERMINATE FLASH UPON RECEIPT OF PROCEED, RECYCLE, OR TERMINATE
KEY IN PROCEED
PROCEED
TERMINATE
RECYCLE
#1240
#1250
"C" FROM ABOVE
#1260
SET DEADBAND TO PREVIOUS VALUE DEFINED BY R03
RESET ABORT ENABLE FLAG
#1270

CHANGE CONTROL NOTES

REV 00 PCR 13,31
REV 01 PCR 70,85,86,164,234,258,259,419,472,475,476,536,539,542,568,613,617
REV 00(LUM 1A) PCR 260,270,697,708,757
REV 01(LUM 1B) PCR 279,838,840,841,845,847,EDITORIAL
REV 02(LUM 1C) PCR 285,893, EDITORIAL
REV 03 PCN 1009
REV 04(LUM 1D) PCR 1058, PCN 1009
REV 05(LUM 1E) PCR 334,1109, PCN 1145,1147
REV 06 PCN 1180

APS ABORT PROGRAM (P71) REV 05 12/01/71

PURPOSE: (1) TO CONTROL A PGNCS CONTROLLED APS ABORT FROM THE POWERED LANDING MANEUVER (P63, 64, OR 66) OR A DPS ABORT (P70) WHEN REQUIRED (SEE ASSUMPTION (1)).

ASSUMPTIONS: (1) THE PROGRAM WILL CONTROL AN APS ABORT IN ONE OF TWO WAYS:

(A) IF THE ALTITUDE IS GREATER THAN 25,000 FT, THIS PROGRAM WILL IGNITE THE APS, CONTINUE APS THRUSTING, PERFORM AN ATTITUDE MANEUVER (USING THE RCS) TO THE CORRECT ATTITUDE TO CONTINUE THE ABORT ASCENT, AND COMPLETE THE ABORT ASCENT TO INSERT THE LM ON AN ABORT ORBIT.

(B) IF THE ALTITUDE IS LESS THAN 25,000 FT, THIS PROGRAM WILL IGNITE THE APS, CONTINUE APS THRUSTING, ENTER A VERTICAL RISE PHASE WHICH WILL TERMINATE EITHER WHEN THE LM ALTITUDE EXCEEDS 25,000 FT. OR WHEN THE LM VERTICAL VELOCITY IS GREATER THAN 40 FT/SEC.
DURING THE VERTICAL RISE PHASE THE VEHICLE IS MANEUVERED IN ORDER TO ALIGN THE LM +X AXIS WITH THE LOCAL VERTICAL (USING THE RCS) AND THE LM +Y AXIS NORMAL TO THE ANTICIPATED PITCH MANEUVER PLANE. THE PROGRAM WILL THEN PITCH THE LM TO THE CORRECT ATTITUDE FOR ASCENT, AND THEN COMPLETE THE ABORT ASCENT TO INSERT THE LM ON AN ABORT ORBIT.

(2) THIS PROGRAM DOES NOT CHECK TO SEE IF THE DPS HAS BEEN STAGED. THUS IF P71 IS SELECTED VIA V37 AND THE DESCENT STAGE HAS NOT BEEN MANUALLY STAGED THIS PROGRAM MAY COMMAND ENGINE ON (ASSUMPTION 1A OR 1B ABOVE). IN SUCH CASES THE COMMAND WILL GO TO THE DPS.

(3) THE ABORT ORBIT IS DEFINED IN SECTION 5.4 OF R567.

(4) IF CIRCULARIZATION HAS NOT OCCURRED, THE CSM IS IN A 9X60 (MILES) ORBIT AROUND THE MOON. THE CSM IS MAINTAINING A PREFERRED TRACKING ATTITUDE FOR OPTICAL TRACKING OF THE LM.

(5) THE IMU IS ON AND ACCURATELY ALIGNED TO THE LANDING SITE ORIENTATION.

(6) THE LANDING RADAR (LR) IS ON AND WAS CHECKED OUT WHEN IN POSITION #1. THE LGC/LR OPERATION IS UNDER THE CONTROL OF THE DESCENT STATE VECTOR UPDATE ROUTINE (R12).

++ (7) THE LANDING ANALOG DISPLAYS ROUTINE (R1D) IS ENABLED UPON ENTRY TO THIS PROGRAM, HAVING BEEN ENABLED BY P63.
+C5 R1D IS TERMINATED UPON TERMINATION OF AVERAGE G. DURING THIS MODE ALTITUDE AND ALTITUDE-RATE ARE DISPLAYED ON THE
+1180 TAPE METERS AND INERTIAL CROSS-RANGE VELOCITY ON THE CROSS POINTERS.
++

(8) THE X-AXIS OVERRIDE OPTION PROVIDES THE CREW WITH THE ABILITY TO EXERCISE MANUAL CONTROL ABOUT THE LM X AXIS WITH THE ATTITUDE CONTROLLER EVEN THOUGH THE PGNCS ATTITUDE CONTROL MODE IS AUTO. WHEN THE CONTROLLER IS RETURNED TO DETENT THE PGNCS DAMPS THE YAW RATE, STORES THE YAW ATTITUDE WHEN THE YAW IS DAMPED, AND THEN MAINTAINS THAT ATTITUDE.
THE X-AXIS OVERRIDE OPTION IS ALWAYS AVAILABLE TO THE CREW EXCEPT WHEN THE LGC IS SPECIFYING A DESIRED YAW ATTITUDE. THUS THE OPTION IS INHIBITED BY THIS PROGRAM ONLY IN THE CASE OF ASSUMPTION (1) (B) ABOVE, UNTIL THE COMPLETION OF THE PITCH MANEUVER TO THE ATTITUDE FOR THE ASCENT MANEUVER.

(9) IF A THRUSTING MANEUVER IS PERFORMED WITH THE GUIDANCE CONTROL SWITCH IN PGNS AND THE MODE CONTROL SWITCH IN AUTO, THE PGNCS WILL CONTROL THE TOTAL VEHICLE ATTITUDE AND GENERATE EITHER MODE I OR MODE II ATTITUDE ERRORS AND VEHICLE ATTITUDE RATES (SEE ASSUMPTION (11)) FOR DISPLAY ON THE FDAI. THE CREW MAY EXERCISE CONTROL AROUND THE YAW AXIS ONLY WITH THE ACA (X-AXIS OVERRIDE) IF THE X-AXIS OVERRIDE CAPABILITY IS PERMITTED BY THE PROGRAM IN PROCESS.

THIS MANUAL CONTROL WILL BE IN THE RATE COMMAND/ATTITUDE HOLD MODE.
IF A THRUSTING MANEUVER IS PERFORMED WITH THE GUIDANCE CONTROL SWITCH SET AT PGNS AND THE MODE CONTROL SWITCH IN ATTITUDE HOLD THE PGNCS WILL HOLD THE VEHICLE ATTITUDE AND WILL GENERATE EITHER MODE I OR MODE II ATTITUDE ERRORS FOR DISPLAY ON THE FDAI. THE CREW MAY EXERCISE MANUAL ATTITUDE CONTROL ABOUT ALL VEHICLE AXES WITH THE ACA IN EITHER THE RATE COMMAND OR MINIMUM IMPULSE MODE DEPENDING UPON THE STATUS OF THE PULSES FLAG. IT IS STRONGLY RECOMMENDED THAT POWERED FLIGHT NOT BE ATTEMPTED IN THE MINIMUM IMPULSE MODE. THE PULSES FLAG IS SET OR RESET BY EXTENDED VERBS 76 (MINIMUM IMPULSE) AND 77 (RATE COMMAND) RESPECTIVELY. THE PULSES FLAG IS ALSO RESET BY P12, P40, P41, P42, P63, P70, P71, AND R40 AT MAIN ENGINE IGNITION. WITH THE EXCEPTION OF THESE CASES, MODE SELECTION IS ALWAYS BASED UPON THE LAST ENTRY MADE IN THE DSKY. DURING A THRUSTING MANEUVER IN THE PGNS/ATTITUDE HOLD MODE THE PGNCS WILL NOT BE RESPONSIBLE IF REGISTER OVERFLOWS OCCUR WITHIN THE LGC.

(10) CONTROL OF THE LM UPS, RCS, AND APS IS TRANSFERRED FROM THE PGNCS TO THE ABORT GUIDANCE SYSTEM (AGS) BY PLACING THE GUID CONT SWITCH FROM PGNS TO AGS.
THE AGS WILL BE CAPABLE OF TAKING OVER CONTROL OF THE LM DURING ANY PORTION OF THE LUNAR DESCENT OR ASCENT OR DURING EITHER OF THE ABORT PROGRAMS (P70 OR P71). THE AGS WILL GUIDE THE LM TO A SAFE ORBIT.
THE AGS MAY BE INITIALIZED BY THE LGC AT ANY TIME BY MANUAL SELECTION OF THE AGS INITIALIZATION ROUTINE (R47).
IN THE EVENT THAT THE GUIDANCE CONTROL SWITCH IS CHANGED FROM PGNS TO AGS DURING A THRUSTING MANEUVER, THE LGC
++ WILL CONTINUE COMPUTATION OF POSITION AND VELOCITY, THE DESIRED THRUST VECTOR, AND THE FDAI ATTITUDE ERROR NEEDLE DIS-
+05 PLAY, HOWEVER THE PGNCS WILL NOT BE RESPONSIBLE IF REGISTER OVERFLOWS OCCUR WITHIN THE LGC.
+1180
++

(11) THE PGNCS CAN GENERATE TWO TYPES OF ATTITUDE ERRORS FOR DISPLAY ON THE FDAI;
MODE I - SELECTED BY EXTENDED VERB 61. AUTOPILOT FOLLOWING ERRORS USED AS A MONITOR OF THE DAP'S ABILITY TO TRACK AUTOMATIC STEERING COMMANDS.
MODE II - SELECTED BY EXTENDED VERB 62. TOTAL ATTITUDE ERRORS USED TO ASSIST CREW IN MANUALLY MANEUVERING THE VEHICLE.

PGNCS-DERIVED VEHICLE ATTITUDE RATES MAY ALSO BE DISPLAYED VIA SELECTION BY EXTENDED VERB 60.
++ DISPLAY SELECTION IS ALWAYS BASED UPON THE LAST ENTRY MADE IN THE DSKY, WITH THE EXCEPTION THAT MODE II ATTITUDE
+05 ERROR DISPLAYS ARE AUTOMATICALLY SELECTED AT THE BEGINNING OF R60.
+1180 FOR A MORE DETAILED DESCRIPTION OF THESE DISPLAYS REFER TO SECTION 3 OF R567, PARA. 3.2.6.
++

(12) THE DAP DATA LOAD ROUTINE (R03) WAS COMPLETED PRIOR TO DPS IGNITION FOR THE POWERED LANDING MANEUVER AND SHOULD NOT BE SELECTED DURING THIS MANEUVER.

(13) THIS PROGRAM MAY BE CALLED IN TWO WAYS:

(A) ABORT STAGE PUSHBUTTON - IF THE ABORT STAGE PUSHBUTTON IS USED DURING THE POWERED DESCENT OR THE DPS
++ ABORT PROGRAM (P70), IT WILL BE DETECTED BY THE ABORT DISCRETES MONITOR ROUTINE (R11) UNLESS DIRECTED
+05 TO IGNORE THIS DISCRETE BY THE DAP DATA LOAD ROUTINE (R03). R11 WILL THEN CALL THIS PROGRAM.
+1180
++

(B) V37E71E - THIS PROGRAM MAY BE CALLED BY THE SAME PROCEDURE AS OTHER PROGRAMS ARE MANUALLY CALLED.

(14) THE ASTRONAUT MAY MONITOR THE FOLLOWING ADDITIONAL PARAMETERS DURING THIS PROGRAM BY KEYING IN V16N77E:

(A) V16N77
R1-TG
R2-VGY(LM)
R3-VI

WHERE: TG - THE ESTIMATED TIME OF FLIGHT FROM THE PRESENT TIME TO THE ACCOMPLISHMENT OF THE ASCENT INJECTION CONDITIONS. POLARITY IS -. IN MINS AND SECS TO NEAREST SEC. MAX READING IS 59859.

VGY(LM) - COMPONENT OF THE PRESENT VG VECTOR ALONG LM Y AXIS. IN FPS TO NEAREST 0.1 FPS.

VI - THE MAGNITUDE OF THE LM INERTIAL VELOCITY WITH RESPECT TO THE REFERENCE COORDINATE SYSTEM. IN FPS TO THE NEAREST .1 FPS.

(15) THE ASTRONAUT MAY MONITOR THE FOLLOWING ADDITIONAL PARAMETERS AT ANY TIME DURING THIS PROGRAM AFTER TIG BY KEYING IN V16N85E;

V16N85
R1-VGX(LM)
R2-VGY(LM)
R3-VGZ(LM)

FOR DEFINITION SEE LOGIC BELOW.

(16) THE ASTRONAUT MAY OBSERVE THE FOLLOWING ADDITIONAL PARAMETERS DURING THIS PROGRAM BY KEYING IN V06N76E:

V06N76
R1-DOWNRANGE VELOCITY (VHF)
R2-RADIAL VELOCITY (H OOT F)
R3-CROSSRANGE

WHERE:

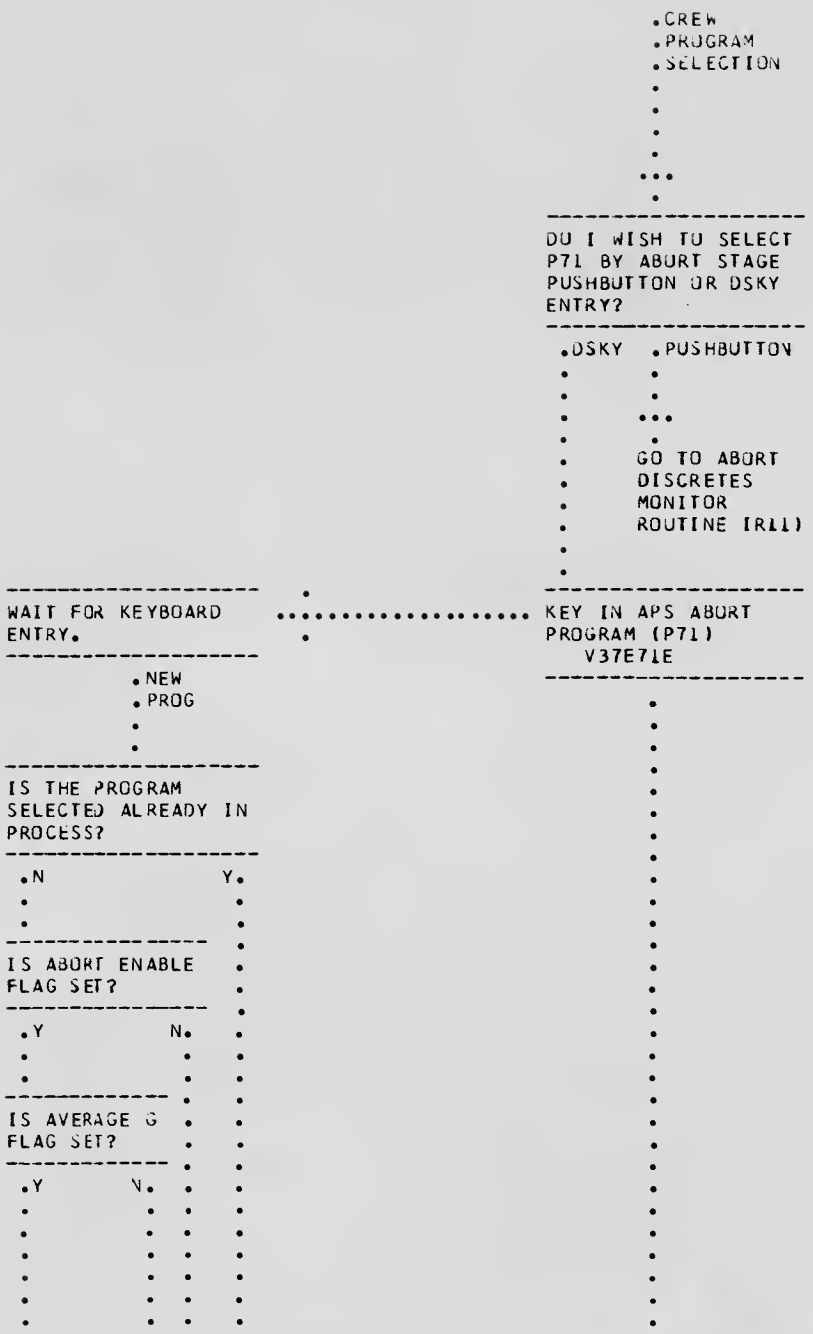
DOWNRANGE VELOCITY - THE HORIZONTAL DOWNRANGE VELOCITY AT INJECTION IN FPS TO NEAREST .1 FPS.

RADIAL VELOCITY - THE RADIAL VELOCITY AT INJECTION (THIS VALUE WILL BE STORED IN A PAD-LOADED ERASABLE LOCATION) IN FPS TO NEAREST .1 FPS.

CROSSRANGE - THE DISTANCE BETWEEN THE LM ORBITAL PLANE AFTER INJECTION AND THE LM POSITION VECTOR AT TIG. (FOR THIS PROGRAM, THE CROSSRANGE VALUE IS RESTRICTED IN MAGNITUDE TO PAD-LOADED VALUE. PRESENTLY THE MAXIMUM ALLOWABLE VALUE IS CONSTRAINED TO BE 0.5 DEGREE (APPROXIMATELY 8 N.M.)) IN NM TO NEAREST .1 NM.

PROG CONT	LGC	GROUND	CREW
	(NOTE: ALL LOGIC IN THE LGC COLUMN DESCRIBES BOTH THE DPS ABORT PROGRAM, P70, AND THE APS ABORT PROGRAM, P71. ONLY THAT LOGIC ASSOCIATED WITH P71 IS PERTINENT HERE HOWEVER.)		(NOTE: ALL LOGIC IN THE CREW COLUMN IS ONLY THAT ASSOCIATED WITH THE APS ABORT PROGRAM, P71.)

#1C


.CREW
.PROGRAM
.SELECTION
DO I WISH TO SELECT P71 BY ABORT STAGE PUSHBUTTON OR DSKY ENTRY?
.DSKY
.PUSHBUTTON
GO TO ABORT DISCRETES MONITOR ROUTINE (R11)
WAIT FOR KEYBOARD ENTRY.
KEY IN APS ABORT PROGRAM (P71) V37E71E
.NEW PROG
IS THE PROGRAM SELECTED ALREADY IN PROCESS?
.N
Y.
IS ABORT ENABLE FLAG SET?
.Y
N.
IS AVERAGE G FLAG SET?
.Y
N.

#20

#30

#40

#50

#60

#70

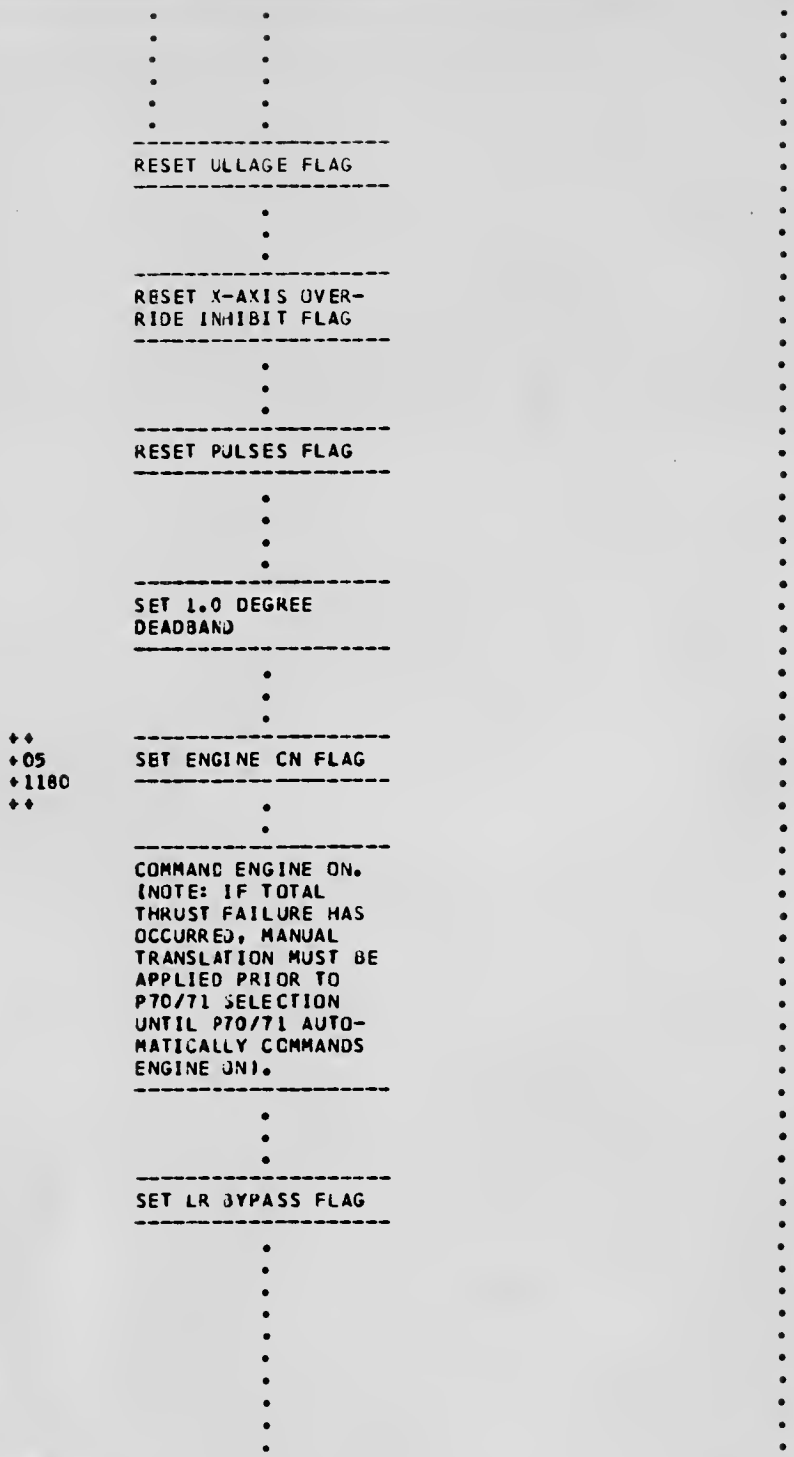
#80

#90

#100

#110

#120



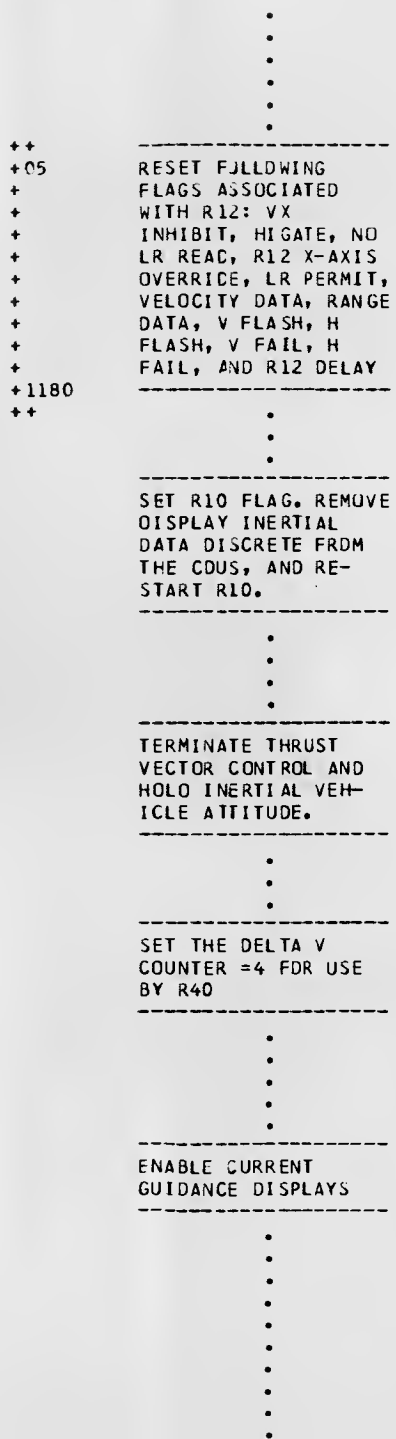
#130

#140

#150

#160

#170



#180

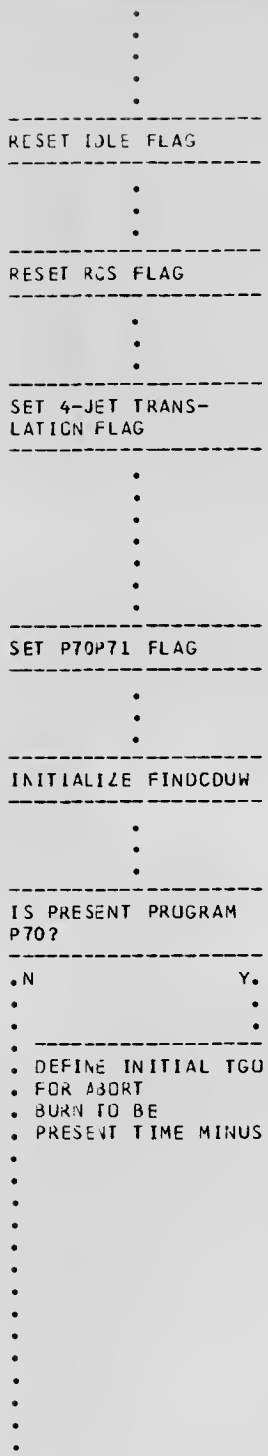
#190

#200

#210

#220

#230

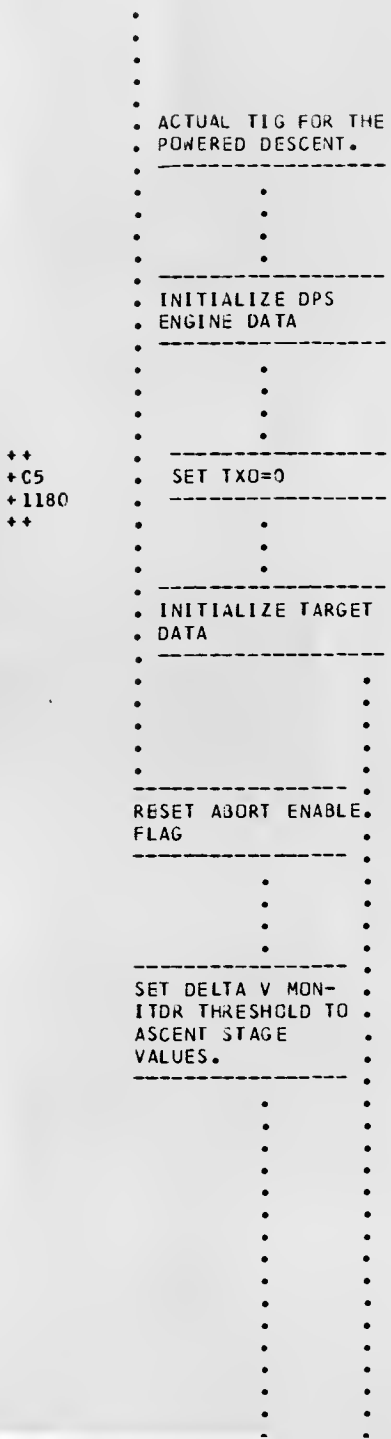


#240

#250

#260

#270



++
+C5
+1180
++

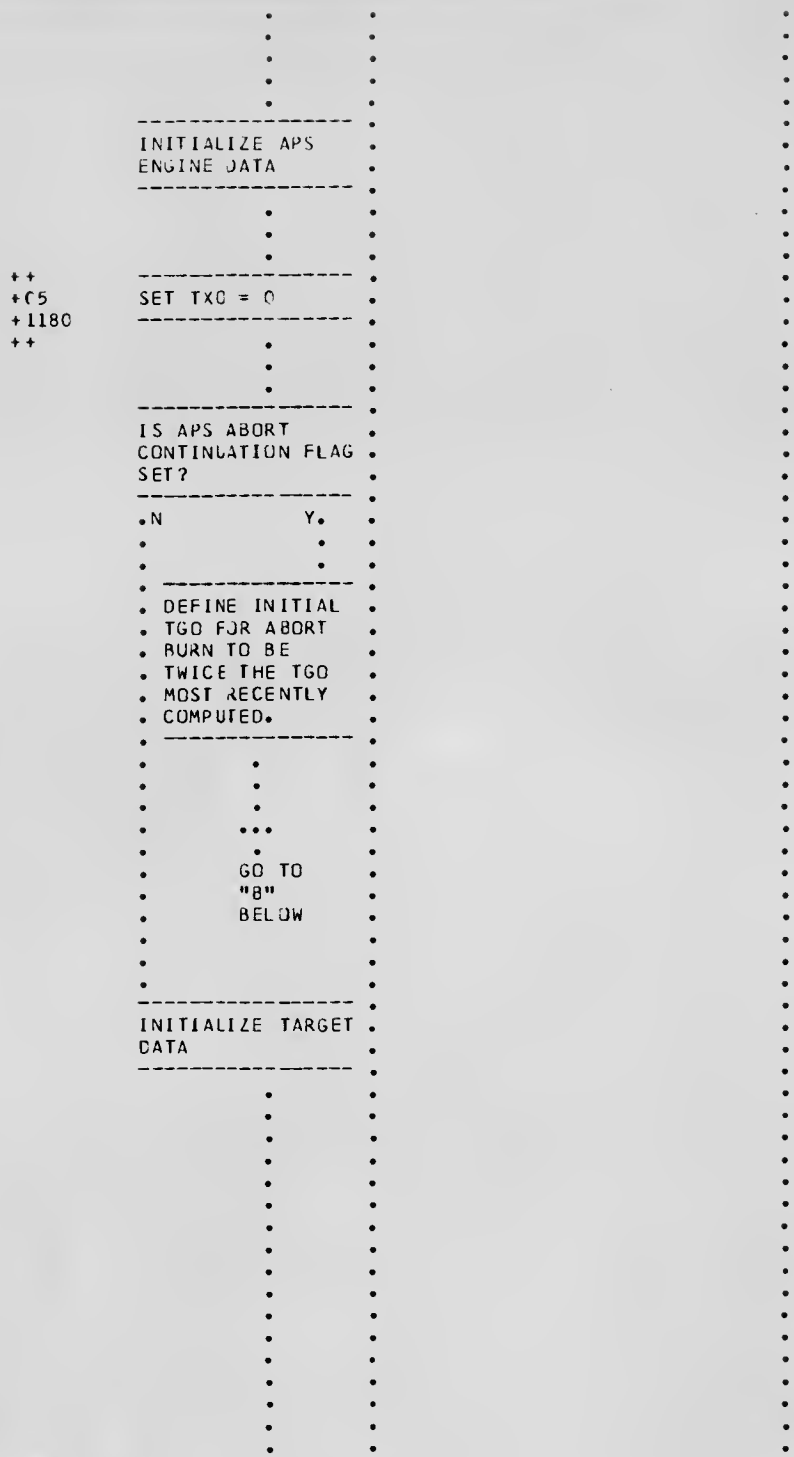
#280

#290

#300

#310

#320



#330

#340

#350

#360

#370

```
DEFINE INITIAL
TGO FOR THE ABORT
BURN TO BE PRES-
ENT TIME MINUS
ACTUAL TIG FOR
POWERED DESCENT.
```

#380

```
SET THE DESIRED
RADIAL VELOCITY
EQUAL TO PAD-LOADED
VALUE
```

#390

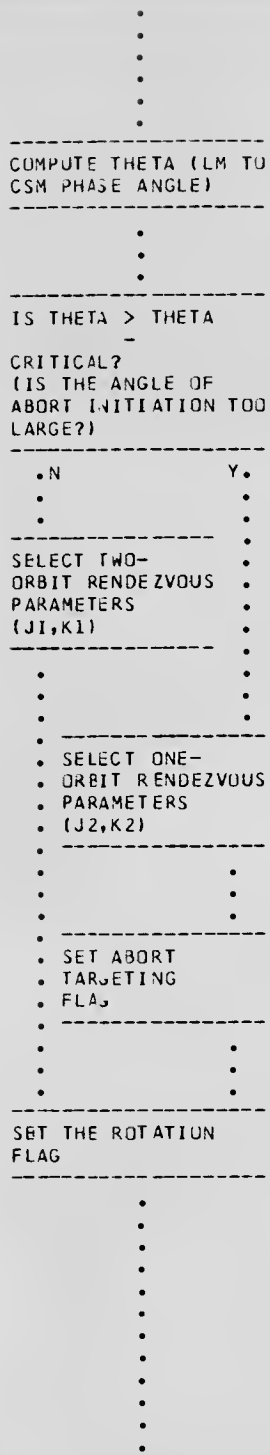
```
COMPUTE CROSS-RANGE
DISTANCE USING
PAD-LOADED VALUE
RESTRICTION.
I.E.:
COMPUTE
OUT-OF-PLANE (Y)
IF |Y| < 0.5 DEG.,
XRANGE = -Y
IF |Y| > 0.5 DEG.,
XRANGE = 0.5 DEG.
SGN (-Y)
```

#400

#410

```
SET VERTICAL RISE
FLAG
```

#420



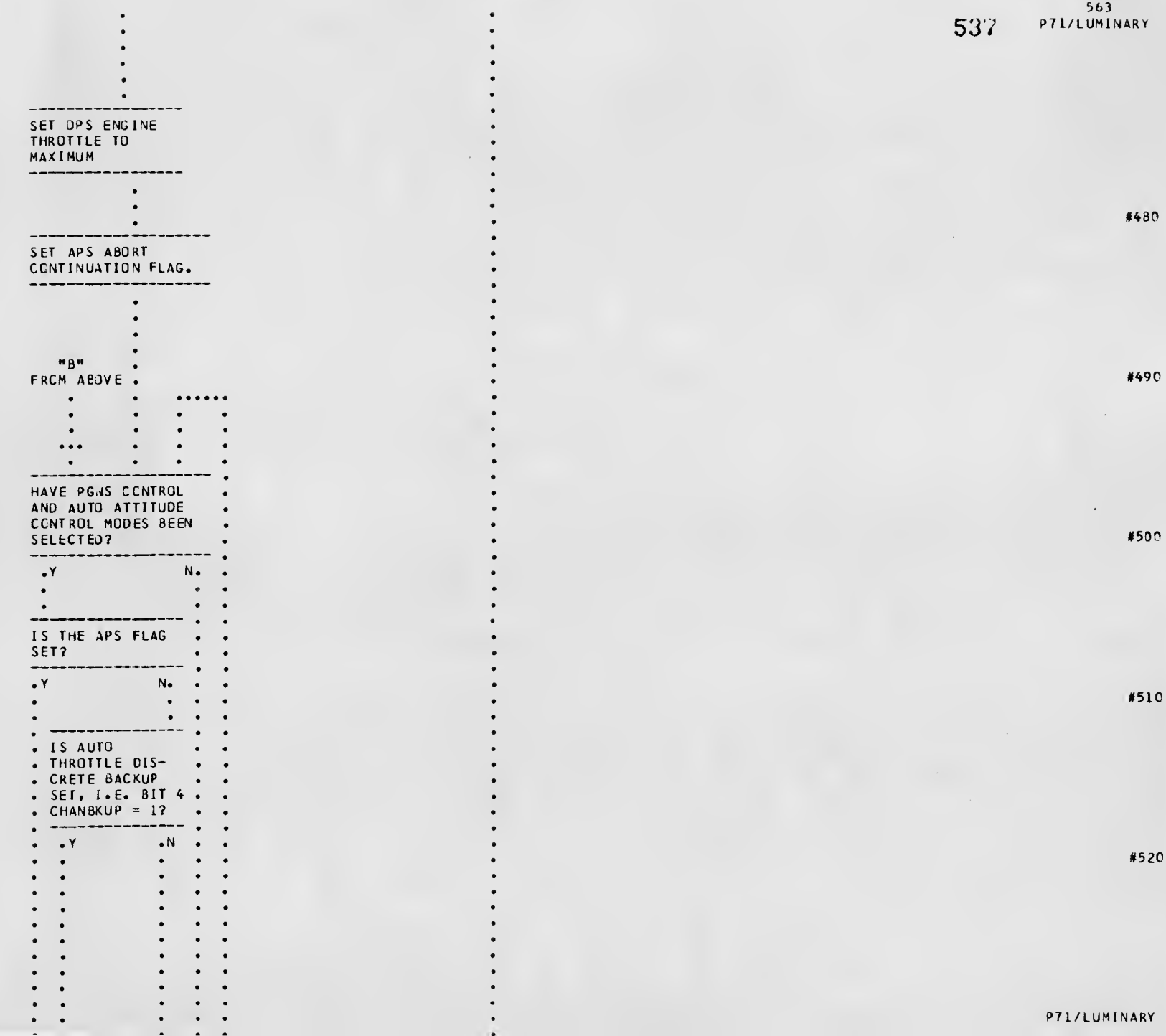
#430

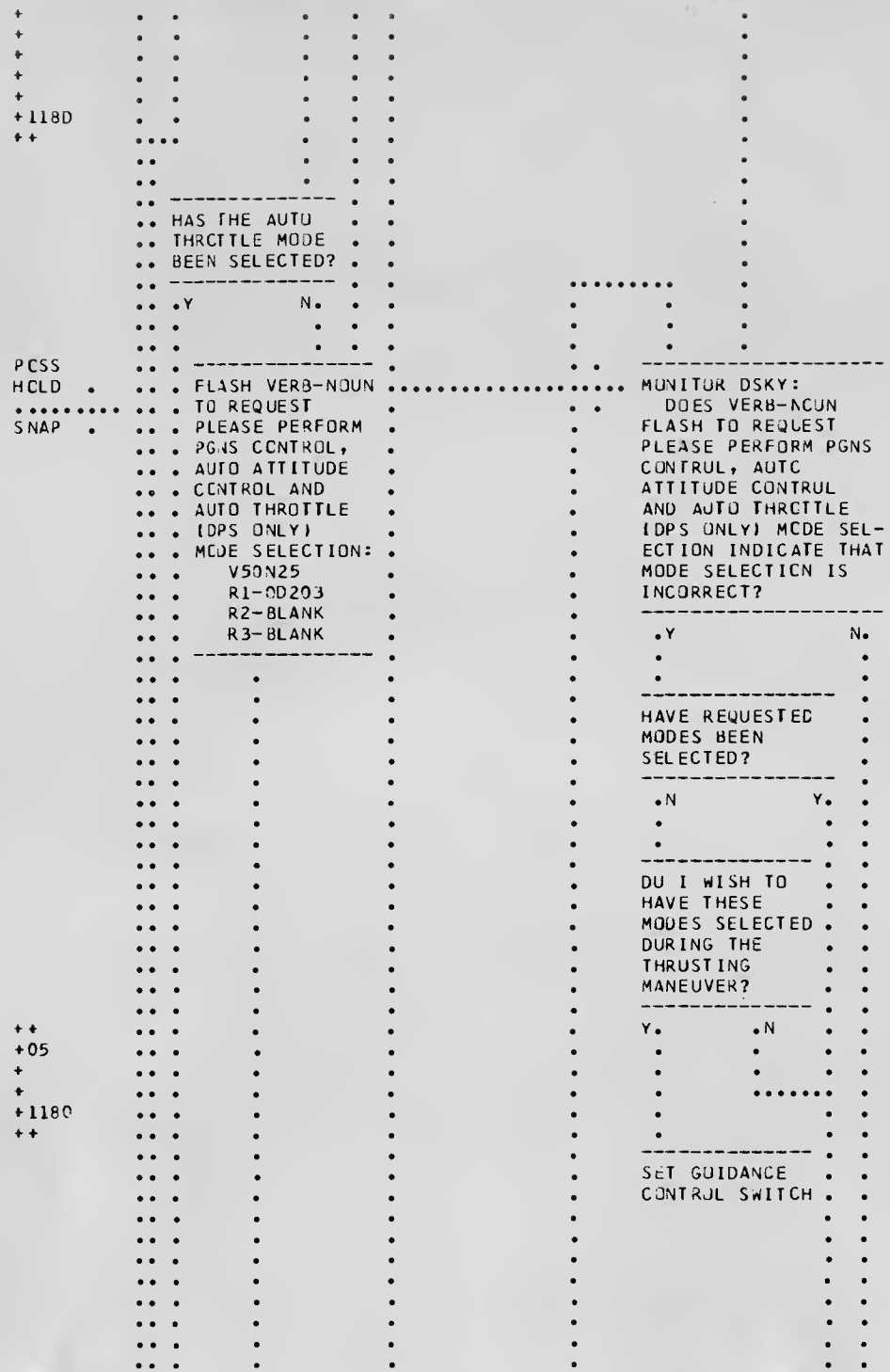
#440

#450

#460

#470


SET DPS ENGINE THROTTLE TO MAXIMUM
SET APS ABORT CONTINUATION FLAG.
"B" FROM ABOVE
HAVE PGNS CONTROL AND AUTO ATTITUDE CONTROL MODES BEEN SELECTED?
Y
N
IS THE APS FLAG SET?
Y
N
IS AUTO THROTTLE DIS-CRETE BACKUP SET, I.E. BIT 4 CHANBKUP = 1?
Y
N
#480
#490
#500
#510
#520



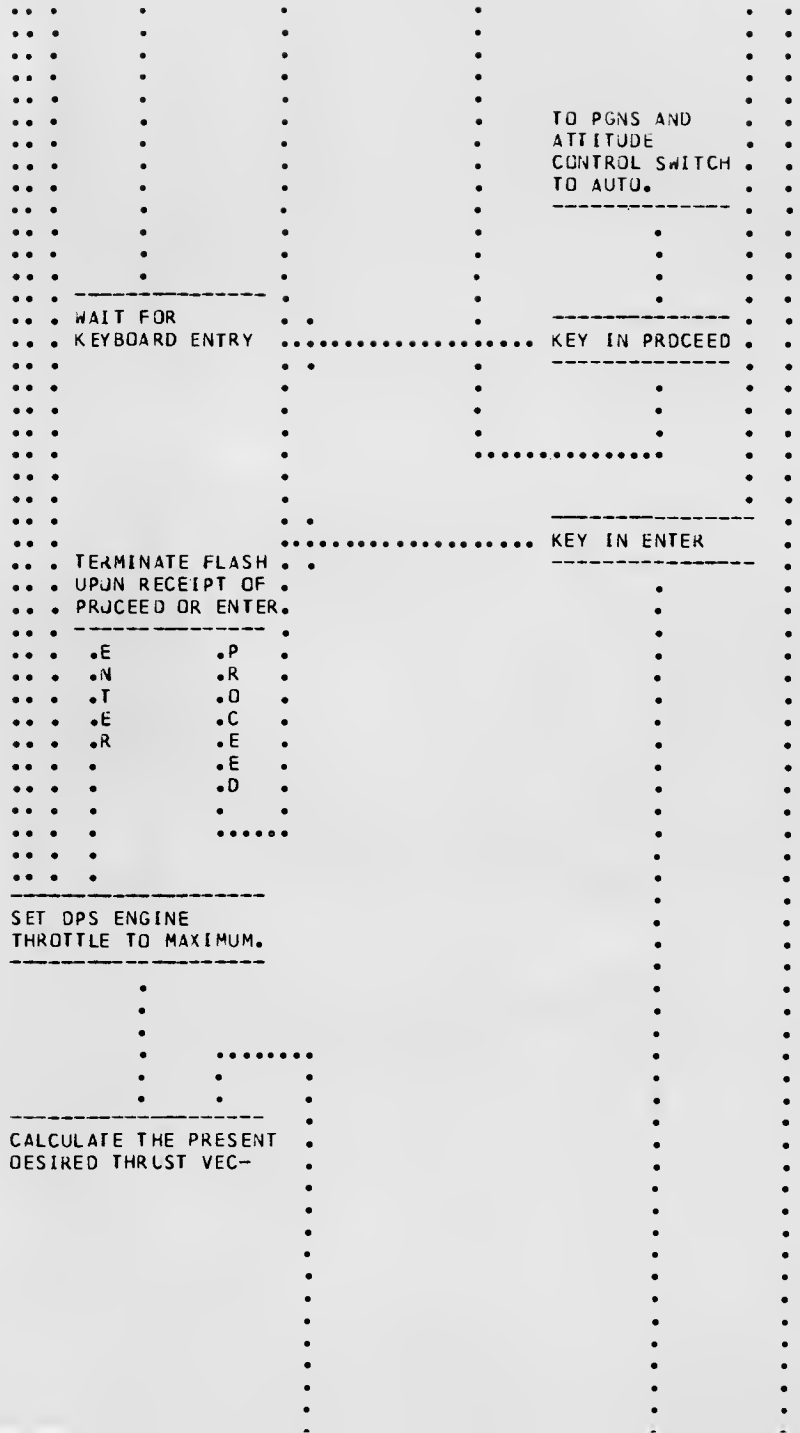
#530

#540

#550

#560

#570



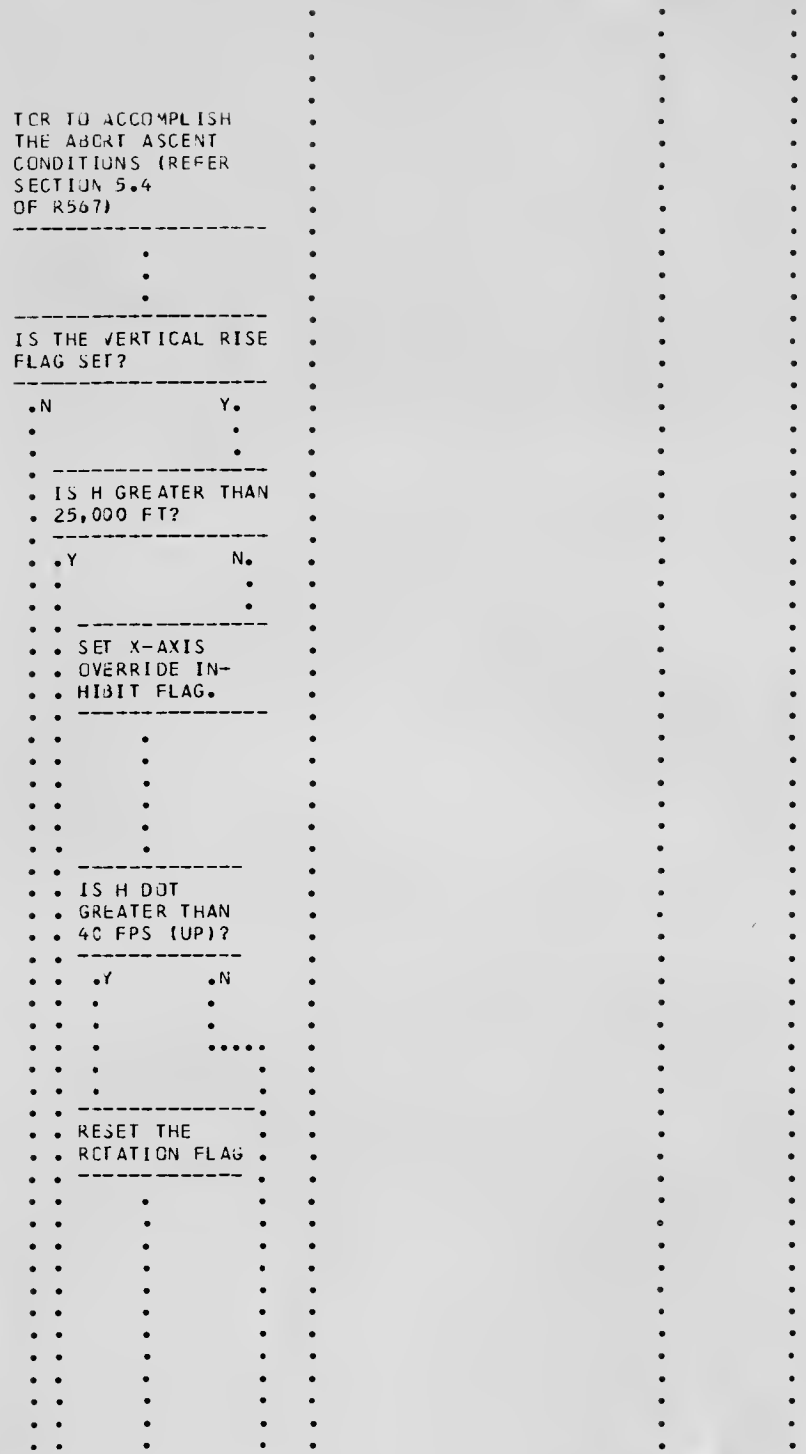
#580

#590

#600

#610

#620



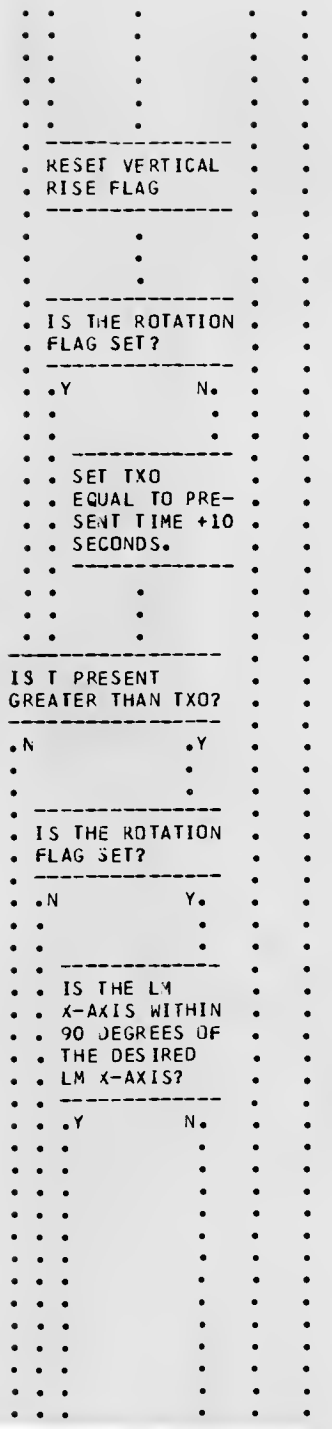
#630

#640

#650

#660

#670

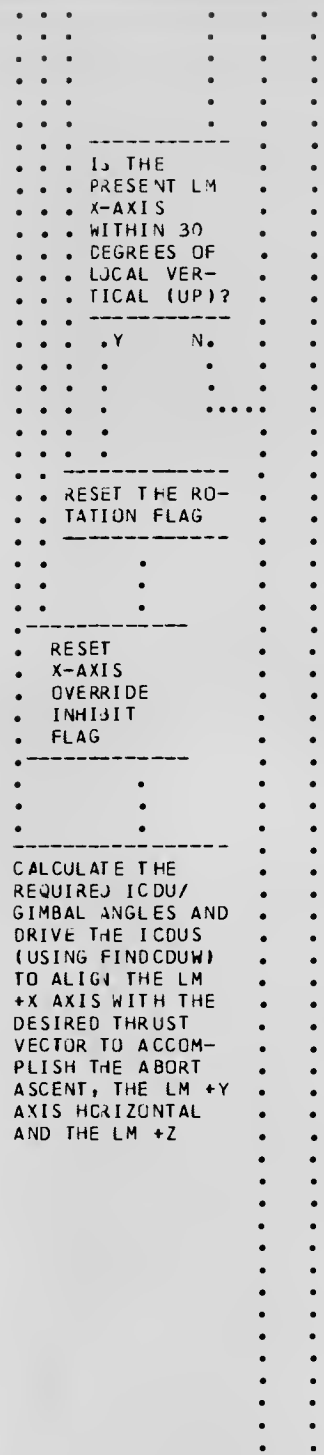


#680

#690

#700

#710



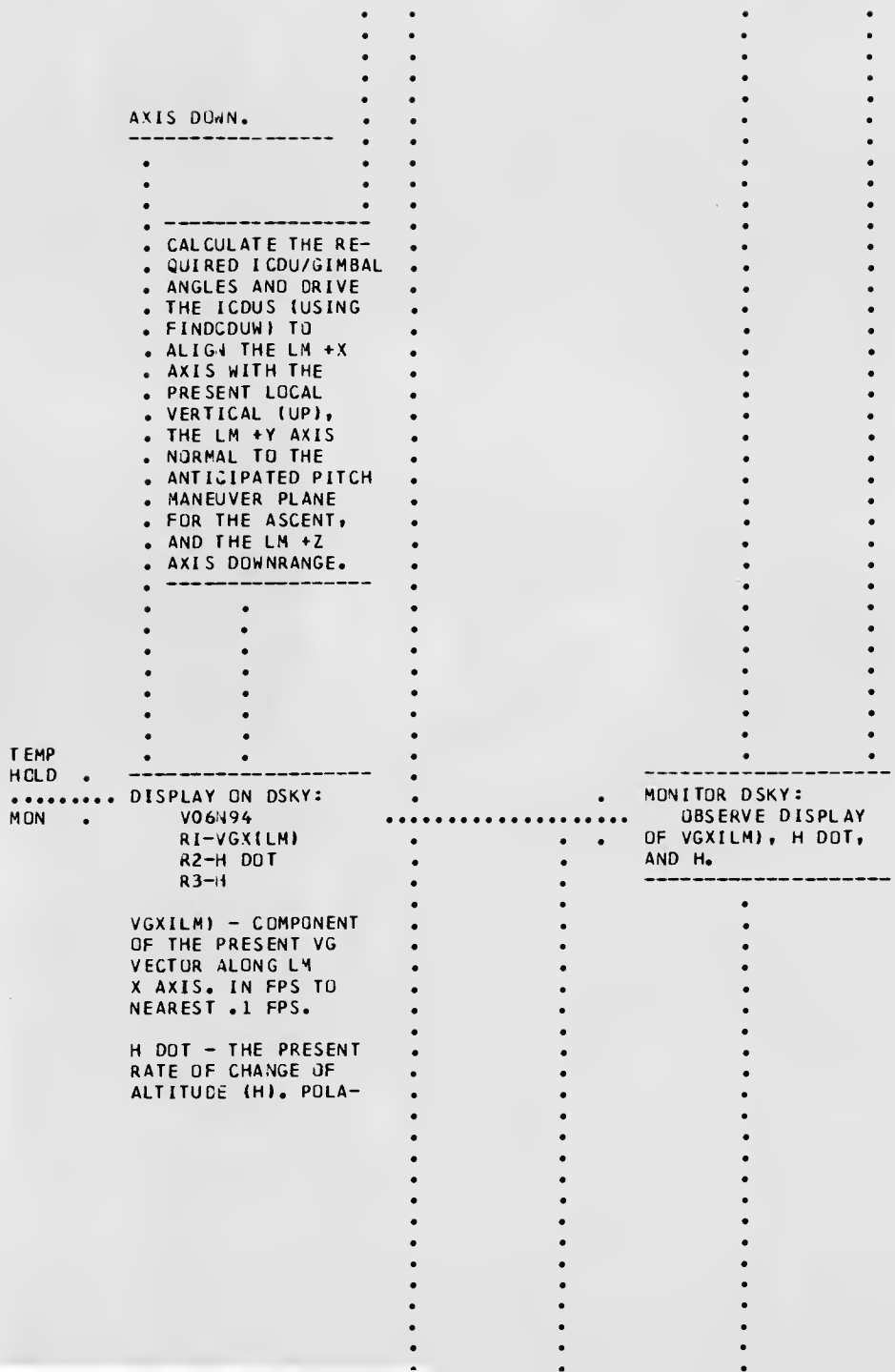
#720

#730

#740

#750

#760


AXIS DOWN.
CALCULATE THE REQUIRED ICDU/GIMBAL ANGLES AND DRIVE THE ICDUS (USING FINDCDUW) TO ALIGN THE LM +X AXIS WITH THE PRESENT LOCAL VERTICAL (UP), THE LM +Y AXIS NORMAL TO THE ANTICIPATED PITCH MANEUVER PLANE FOR THE ASCENT, AND THE LM +Z AXIS DOWNRANGE.
#770
#780
#790
TEMP HOLD
MON
DISPLAY ON DSKY:
V06N94
R1-VGX(LM)
R2-H DOT
R3-H
MONITOR DSKY:
OBSERVE DISPLAY OF VGXILM), H DOT, AND H.
#800
VGXILM) - COMPONENT OF THE PRESENT VG VECTOR ALONG LM X AXIS. IN FPS TO NEAREST .1 FPS.
H DOT - THE PRESENT RATE OF CHANGE OF ALTITUDE (H). POLA-
#810

RITY INDICATES DES-
CENT (-) OR ASCENT
(+). IN FT/SEC TO
NEAREST .1 FT/SEC.

H - THE PRESENT
ALTITUDE OF THE LM
ABOVE THE LM POSI-
TION VECTOR AT THE
DESIGNATED LANDING
SITE. POLARITY IS +
FOR ALTITUDES
GREATER THAN THE
ABOVE RADIUS. IN
FEET TO NEAREST
FOOT.

#820

#830

MONITOR OSKY, FDAI
AND OUT THE WINDOW;

(A) IF H IS
GREATER THAN
+25000 THE
PGNCS WILL MANEU-
VER THE LM TO THE
CORRECT ATTITUDE
TO PERFORM THE
ASCENT ABORT.

#840

(B) IF H IS
LESS THAN
+25000, THE
X-AXIS OVERRIDE
OPTION IS INHI-
BITED. THE PGNCS
WILL MANEUVER THE
LM TO LOCAL VER-
TICAL (LM +X AXIS
UP) AND YAW THE
LM SO WINDOWS ARE
DOWNRANGE. THE
LOCAL VERTICAL
ATTITUDE WILL BE

#850

#860

MAINTAINED UNTIL
H IS GREATER THAN
+25000 OR H DOT
IS GREATER THAN
+00400 AT WHICH
TIME THE PGNCS
WILL MANEUVER
(PITCH) THE LM TO
THE CORRECT ATTI-
TUDE TO PERFORM
THE ASCENT ABORT
AND THEN THE
X-AXIS OVERRIDE
OPTION IS
RESTORED.

THE ABOVE MANEUVERS
WILL BE DONE WITH
THE RCS.

#870

#880

#890

MONITOR APS
THRUSTING:
1. OSKY:
R1-VGX
SHOULD BE
DECREASING

#900

R2- H DOT
SHOULD REMAIN +.

R3-H SHOULD
INCREASE

2. FDAI-ATT. ERRORS SHOULD BE LESS THAN OR EQUAL TO XX DEGREE.

ATT RATES SHOULD BE LESS THAN OR EQUAL TO XX DEGREE/SEC.

3. APS CHAMBER PRESSURE, PC, SHOULD BE NORMAL.

IDENTIFY EARLY, NORMAL, OR LATE ENGINE CUTOFF FROM ASSESSMENT OF DSKY DISPLAYS.

.E .A .R .L .Y	.L .A .T .E .	.N .O .R .M .
.C .U .T .O .F .F	.C .U .T .O .F .F	.C .U .T .O .F .F
SEE DPS/APS THRUST FAIL ROUTINE (R40) FOR REQUIRED RESPONSE		
PUSH ENGINE STOP PUSH BUTTON		

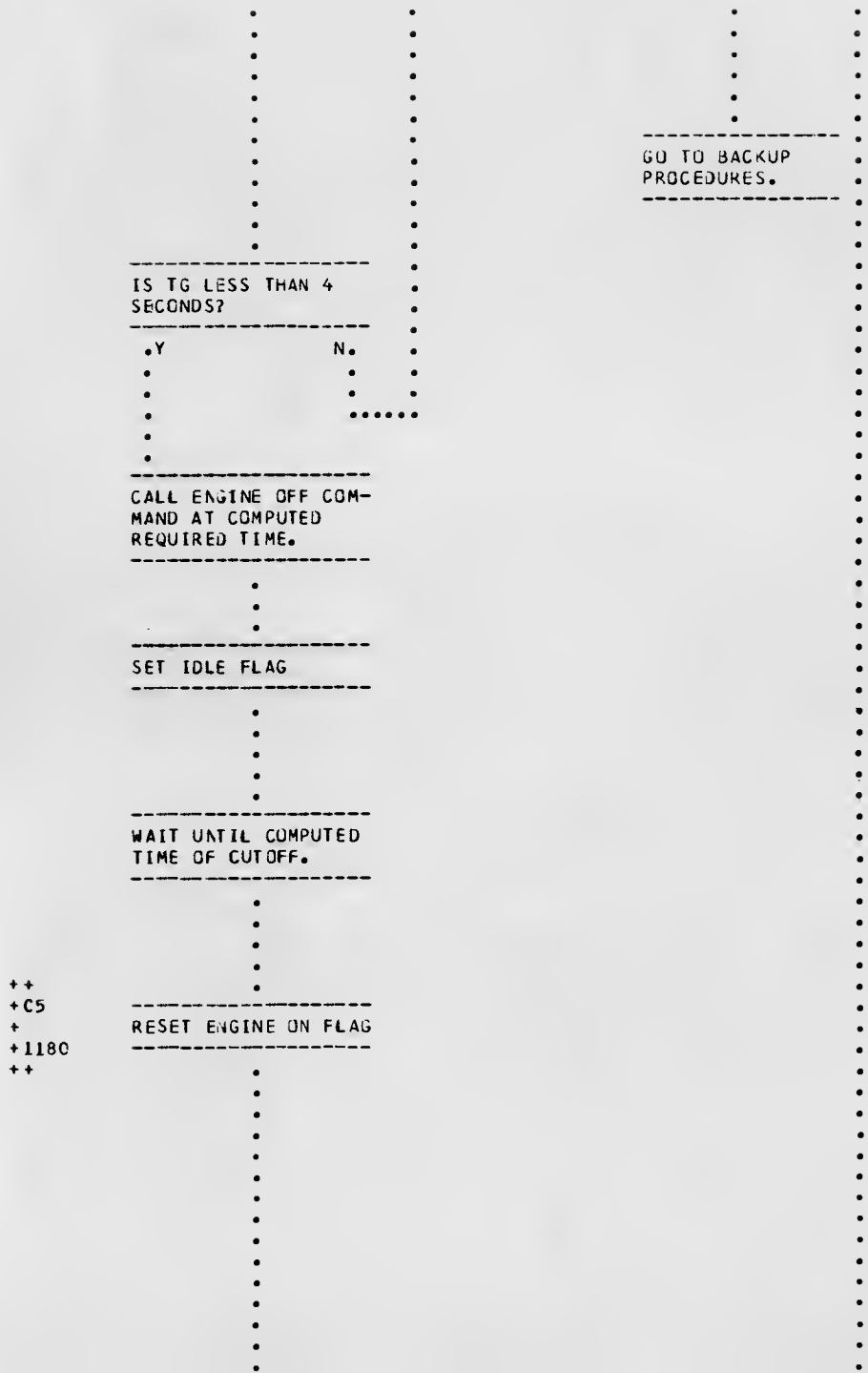
#910

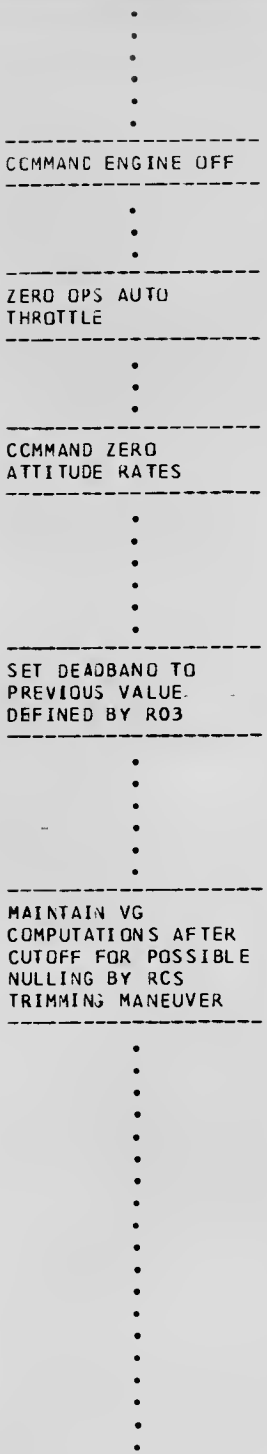
#920

#930

#940

#950


GO TO BACKUP PROCEDURES.
#960
IS TG LESS THAN 4 SECONDS?
.Y
N.
#970
CALL ENGINE OFF COMMAND AT COMPUTED REQUIRED TIME.
#980
SET IDLE FLAG
#990
WAIT UNTIL COMPUTED TIME OF CUTOFF.
++
+C5
+
+1180
++
RESET ENGINE ON FLAG
#1000



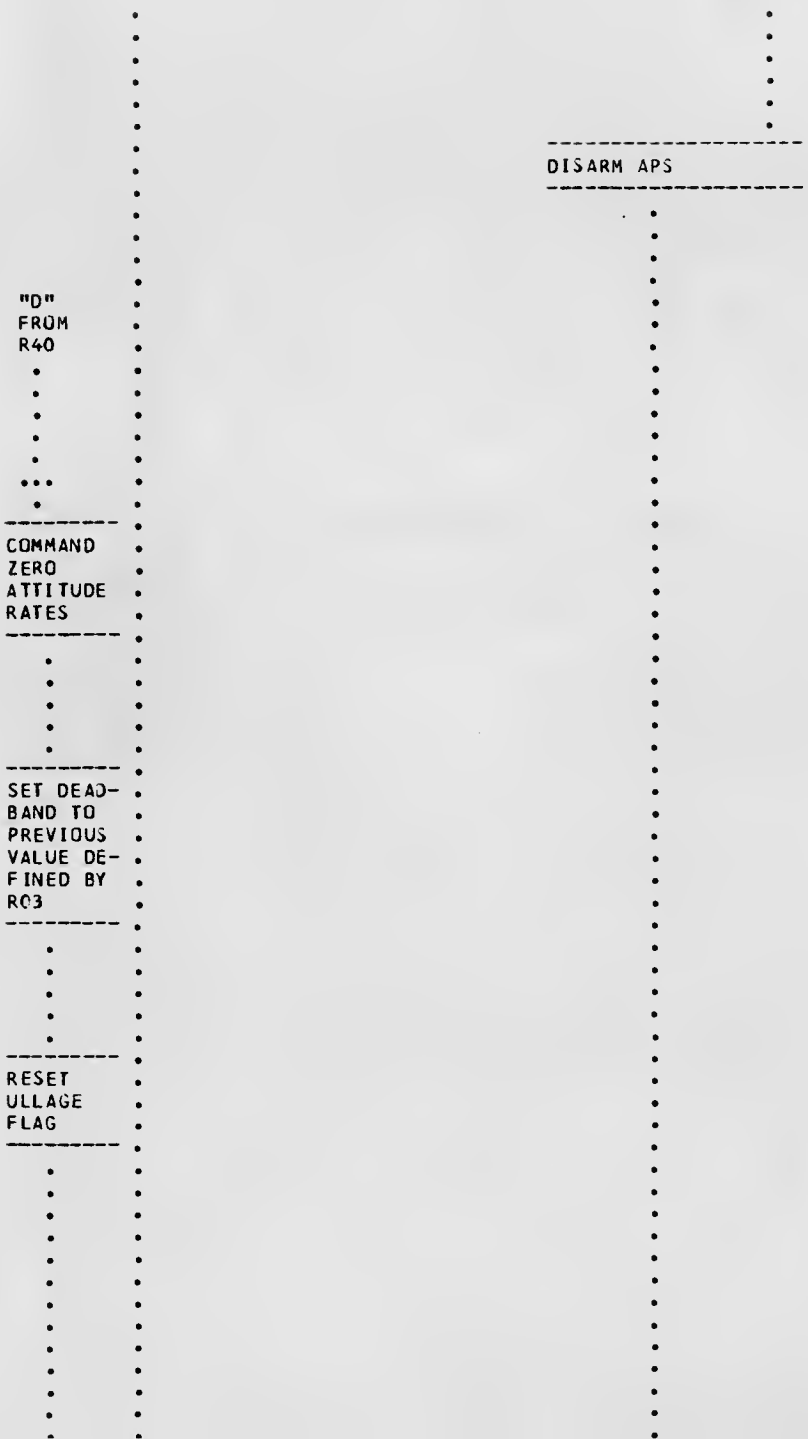
#1010

#1020

#1030

#1040

#1050

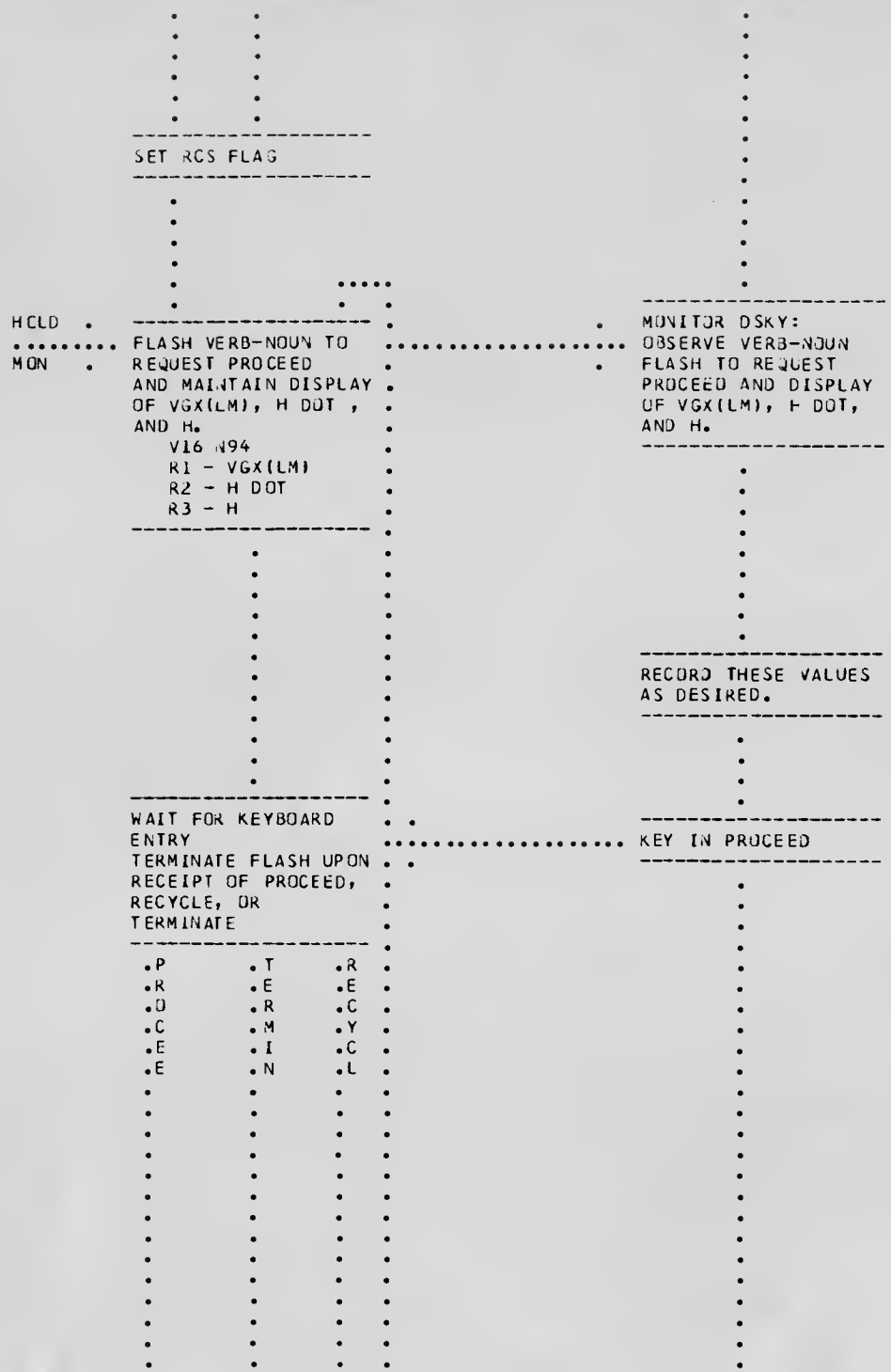


#1060

#1070

#1080

#1090



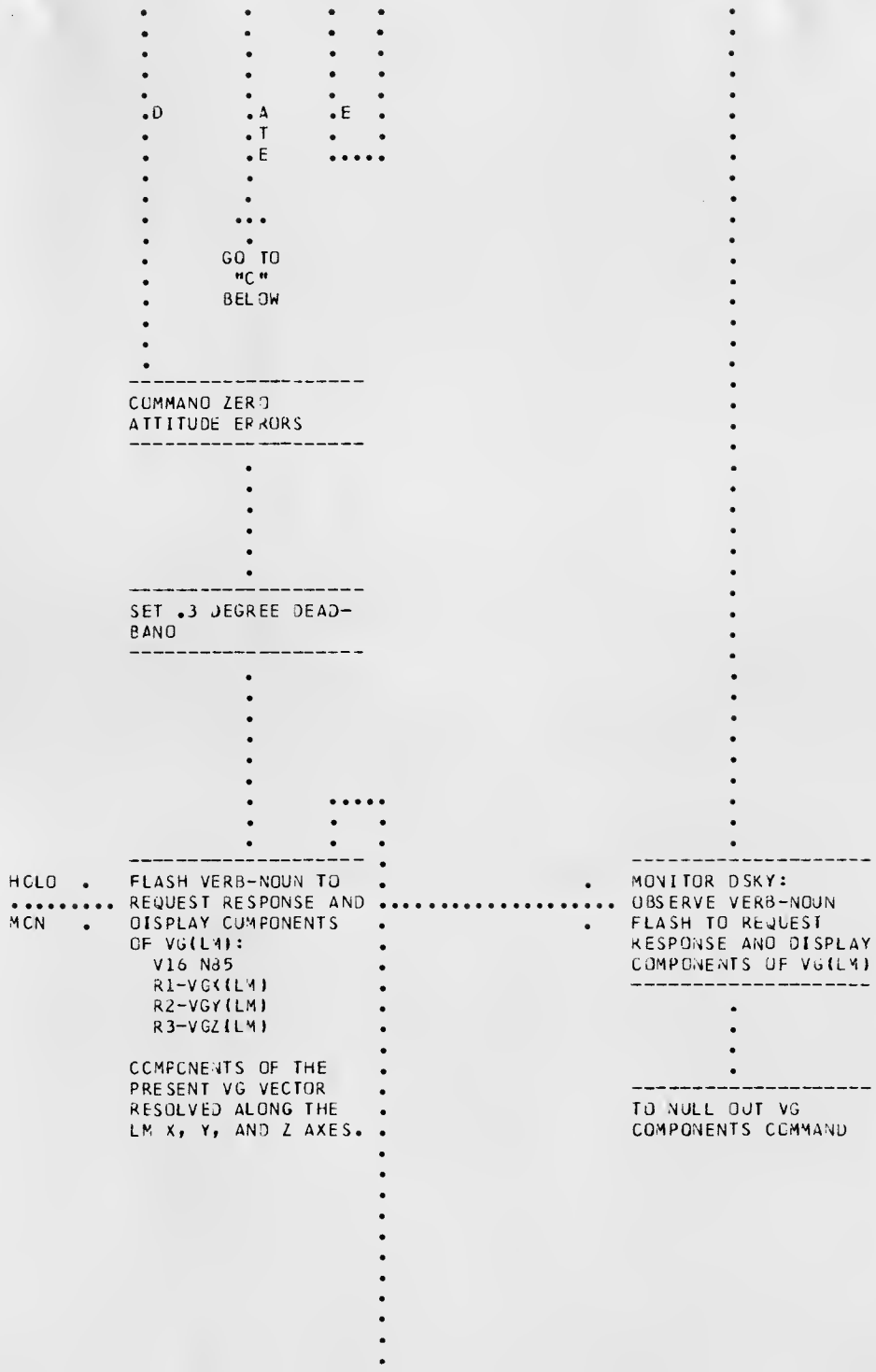
#1100

#1110

#1120

#1130

#1140



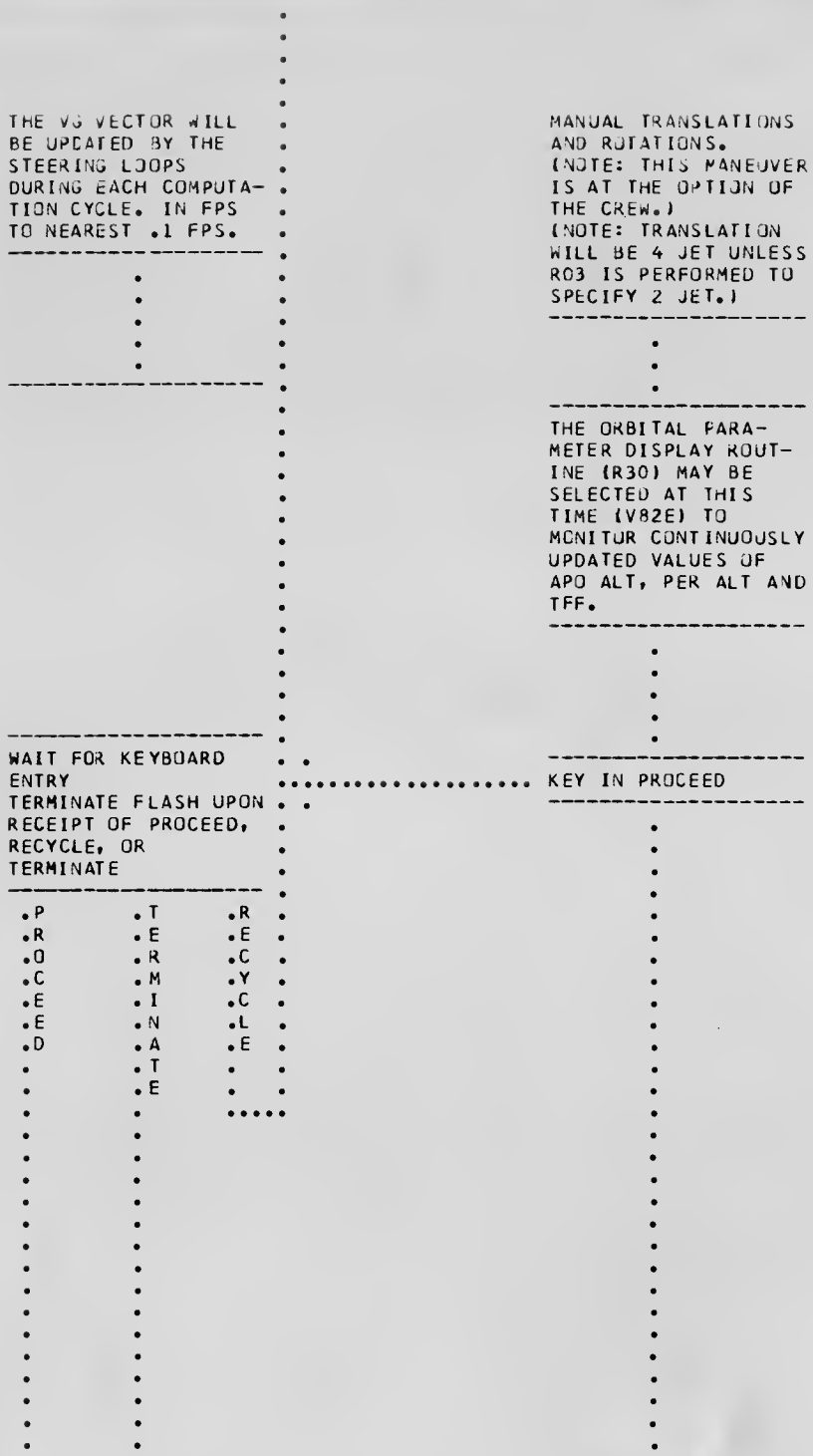
#1150

#1160

#1170

#1180

#1190


THE VG VECTOR WILL BE UPDATED BY THE STEERING LOOPS DURING EACH COMPUTATION CYCLE. IN FPS TO NEAREST .1 FPS.
MANUAL TRANSLATIONS AND ROTATIONS. (NOTE: THIS MANEUVER IS AT THE OPTION OF THE CREW.) (NOTE: TRANSLATION WILL BE 4 JET UNLESS R03 IS PERFORMED TO SPECIFY 2 JET.)
#1200
#1210
THE ORBITAL PARAMETER DISPLAY ROUTINE (R30) MAY BE SELECTED AT THIS TIME (V82E) TO MONITOR CONTINUOUSLY UPDATED VALUES OF APO ALT, PER ALT AND TFF.
#1220
WAIT FOR KEYBOARD ENTRY TERMINATE FLASH UPON RECEIPT OF PROCEED, RECYCLE, OR TERMINATE
KEY IN PROCEED
#1230
.PROCEED
.TERMINATE
.RECYCLE
#1240

#1250

#1260

#1270

#1280

#1290

CHANGE CONTROL NOTES

REV 00 PCR 13,31
REV 01 PCR 70,85,86,164,234,253,259,419,472,475,
+76,536,542,568,613,617
REV 00(LUM 1A) PCR 260,270,697,708,757
REV 01(LUM 1B) PCR 279,838,840,841,845,847,EDITORIAL
REV 02(LUM 1C) PCR 285,893, EDITORIAL
REV 03(LUM 1D) PCR 1058, PCN 1039
REV 04(LUM 1E) PCR 334,1109, PCN 1145,1147
REV 05(LUM 1E) PCN 1180

CSM CO-ELLIPTIC SEQUENCE INITIATION (CSI) TARGETING PROGRAM (P72) REV 03 02/17/71

PURPOSE: (1) TO CALCULATE PARAMETERS ASSOCIATED WITH THE FOLLOWING CONCENTRIC FLIGHT PLAN MANEUVERS FOR CSM EXECUTION OF THE MANEUVERS UNDER THE CONTROL OF THE CMC; THE CO-ELLIPTIC SEQUENCE INITIATION (CSI) AND THE CONSTANT DELTA ALTITUDE MANEUVER (CDH).

(2) TO CALCULATE THESE PARAMETERS BASED UPON MANEUVER DATA APPROVED AND KEYED INTO THE LGC BY THE ASTRONAUT.

(3) TO DISPLAY TO THE ASTRONAUT AND THE GROUND DEPENDENT VARIABLES ASSOCIATED WITH THE CONCENTRIC FLIGHT PLAN MANEUVERS FOR APPROVAL BY THE ASTRONAUT/GROUND.

ASSUMPTIONS: (1) AT A SELECTED TPI TIME THE LINE OF SIGHT BETWEEN THE CSM AND THE LM IS SELECTED TO BE A PRESCRIBED ANGLE (E) FROM THE HORIZONTAL PLANE DEFINED AT THE CSM POSITION.

(2) THE TIME BETWEEN CSI IGNITION AND CDH IGNITION MUST BE COMPUTED TO BE GREATER THAN 10 MINUTES FOR SUCCESSFUL COMPLETION OF THE PROGRAM.

(3) THE TIME BETWEEN CDH IGNITION AND TPI IGNITION MUST BE COMPUTED TO BE GREATER THAN 10 MINUTES FOR SUCCESSFUL COMPLETION OF THE PROGRAM.

(4) CDH DELTA V IS SELECTED TO MINIMIZE THE VARIATION OF THE ALTITUDE DIFFERENCE BETWEEN THE ORBITS.

(5) CSI BURN IS DEFINED SUCH THAT THE IMPULSIVE DELTA V IS IN THE CSM HORIZONTAL PLANE AT CSI IGNITION.

(6) THE PERICENTER ALTITUDE OF THE ORBIT FOLLOWING CSI AND CDH MUST BE GREATER THAN 35,000 FT (LUNAR ORBIT) OR 85 NM (EARTH ORBIT) FOR SUCCESSFUL COMPLETION OF THIS PROGRAM.

(7) THE CSI AND CDH MANEUVERS ARE ASSUMED TO BE PARALLEL TO THE PLANE OF THE LM ORBIT, HOWEVER CREW MODIFICATION OF DELTA V(LV) COMPONENTS MAY RESULT IN AN OUT-OF-PLANE CSI MANEUVER.

(8) LGC COMPUTED VARIABLES MAY BE STORED FOR LATER VERIFICATION BY THE GROUND. THESE STORAGE CAPABILITIES ARE NORMALLY LIMITED ONLY TO THE PARAMETERS FOR ONE THRUSTING MANEUVER AT A TIME EXCEPT FOR CONCENTRIC FLIGHT PLAN MANEUVER SEQUENCES.

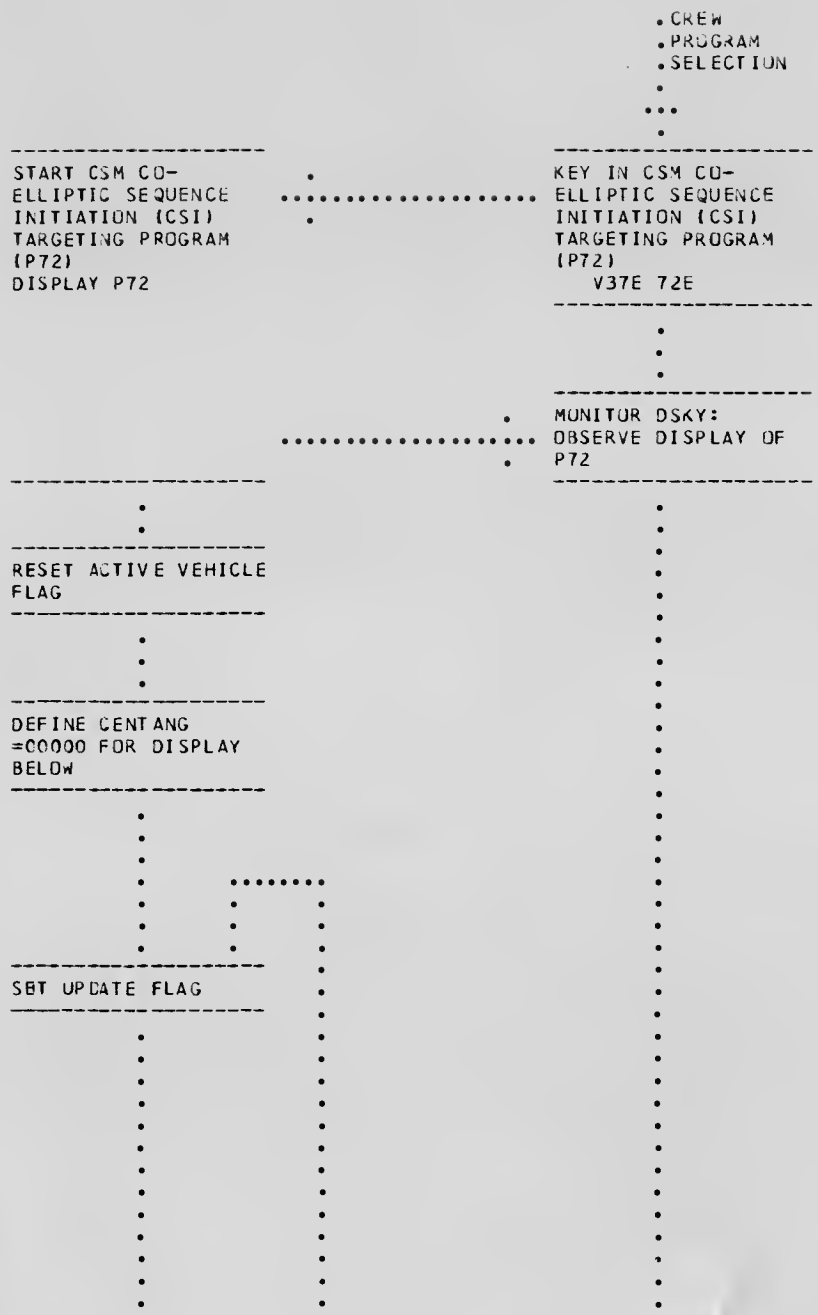
(9) THE RENDEZVOUS RADAR MAY OR MAY NOT BE USED TO UPDATE THE LM OR CSM STATE VECTORS FOR THIS PROGRAM. IF RADAR USE IS DESIRED THE RADAR WAS TURNED ON AND LOCKED ON THE CSM BY PREVIOUS SELECTION OF P20. RADAR SIGHTING MARKS WILL BE MADE AUTOMATICALLY APPROXIMATELY ONCE A MINUTE WHEN ENABLED BY THE TRACK AND UPDATE FLAGS. THE RENDEZVOUS TRACKING MARK COUNTER IS ZEROED BY THE SELECTION OF P20 AND AFTER EACH THRUSTING MANEUVER.

(10) THERE IS NO REQUIREMENT FOR ISS OPERATION DURING THIS PROGRAM UNLESS AUTOMATIC STATE VECTOR UPDATING IS DESIRED BY THE RENDEZVOUS NAVIGATION PROGRAM (P20). IF SELECTED, P20 WILL DEFINE THE STATUS OF THE ISS.

(11) THIS PROGRAM IS SELECTED BY THE ASTRONAUT BY OSKY ENTRY.

PROG	LGC	GROUND	CREW

CONT

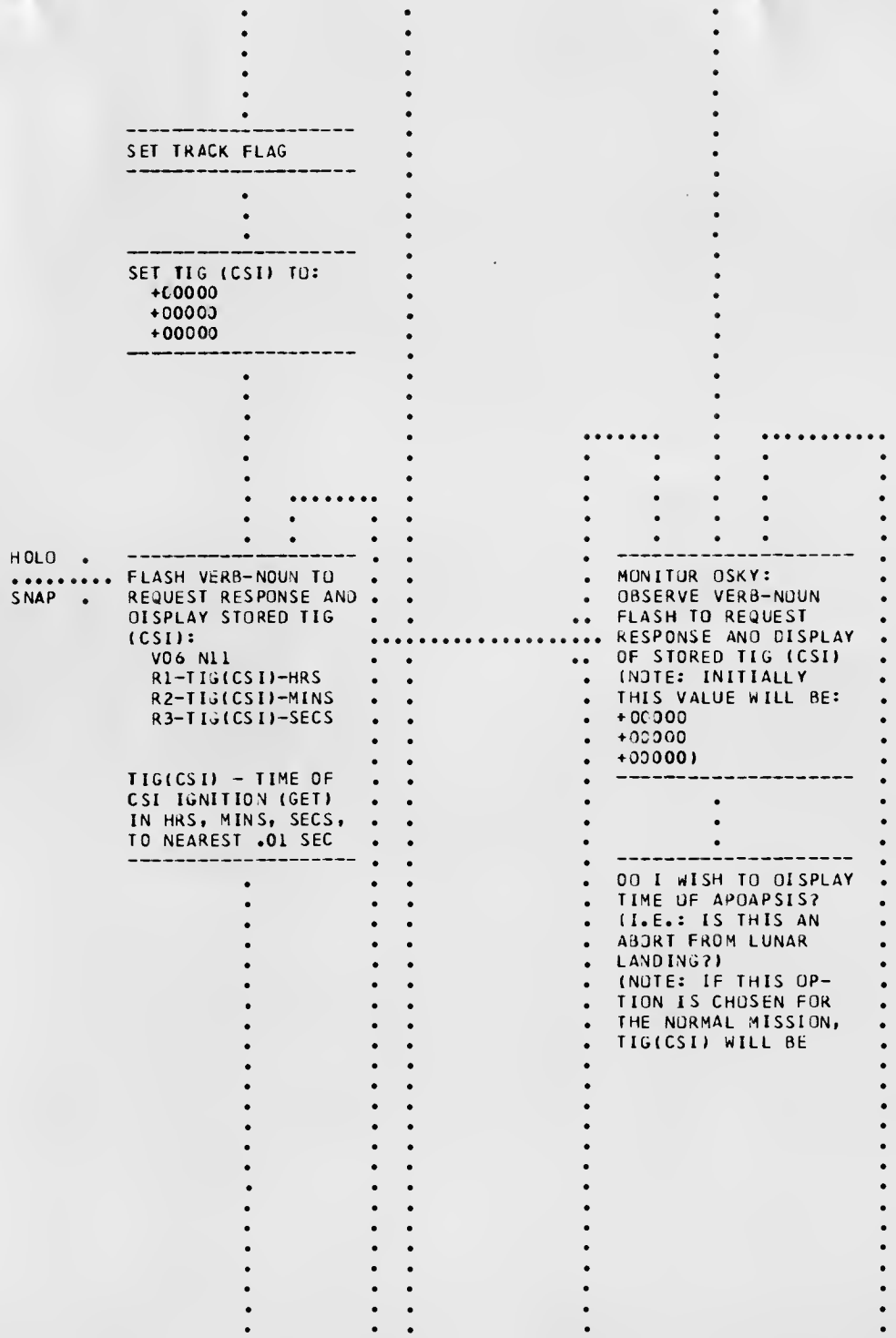


#10

#20

#30

#40


SET TRACK FLAG
SET TIG (CSI) TO:
+00000
+00000
+00000
HOLO
SNAP
FLASH VERB-NOUN TO
REQUEST RESPONSE AND
DISPLAY STORED TIG
(CSI):
V06 N11
R1-TIG(CSI)-HRS
R2-TIG(CSI)-MINS
R3-TIG(CSI)-SECS
TIG(CSI) - TIME OF
CSI IGNITION (GET)
IN HRS, MINS, SECS,
TO NEAREST .01 SEC
MONITOR OSKY:
OBSERVE VERB-NOUN
FLASH TO REQUEST
RESPONSE AND DISPLAY
OF STORED TIG (CSI)
(NOTE: INITIALLY
THIS VALUE WILL BE:
+00000
+00000
+00000)
DO I WISH TO DISPLAY
TIME OF APOAPSIS?
(I.E.: IS THIS AN
ABORT FROM LUNAR
LANDING?)
(NOTE: IF THIS OP-
TION IS CHOSEN FOR
THE NORMAL MISSION,
TIG(CSI) WILL BE

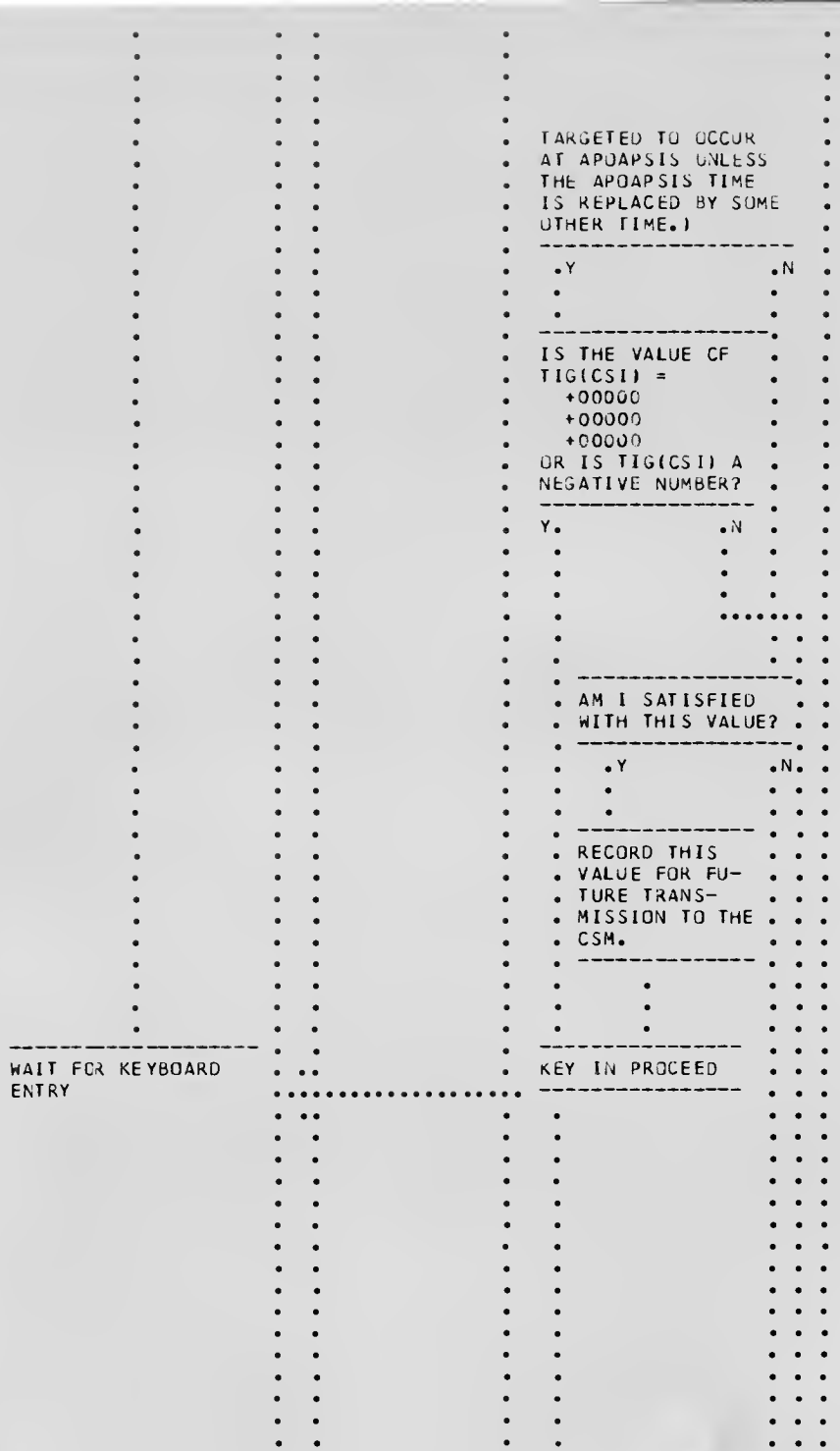
#50

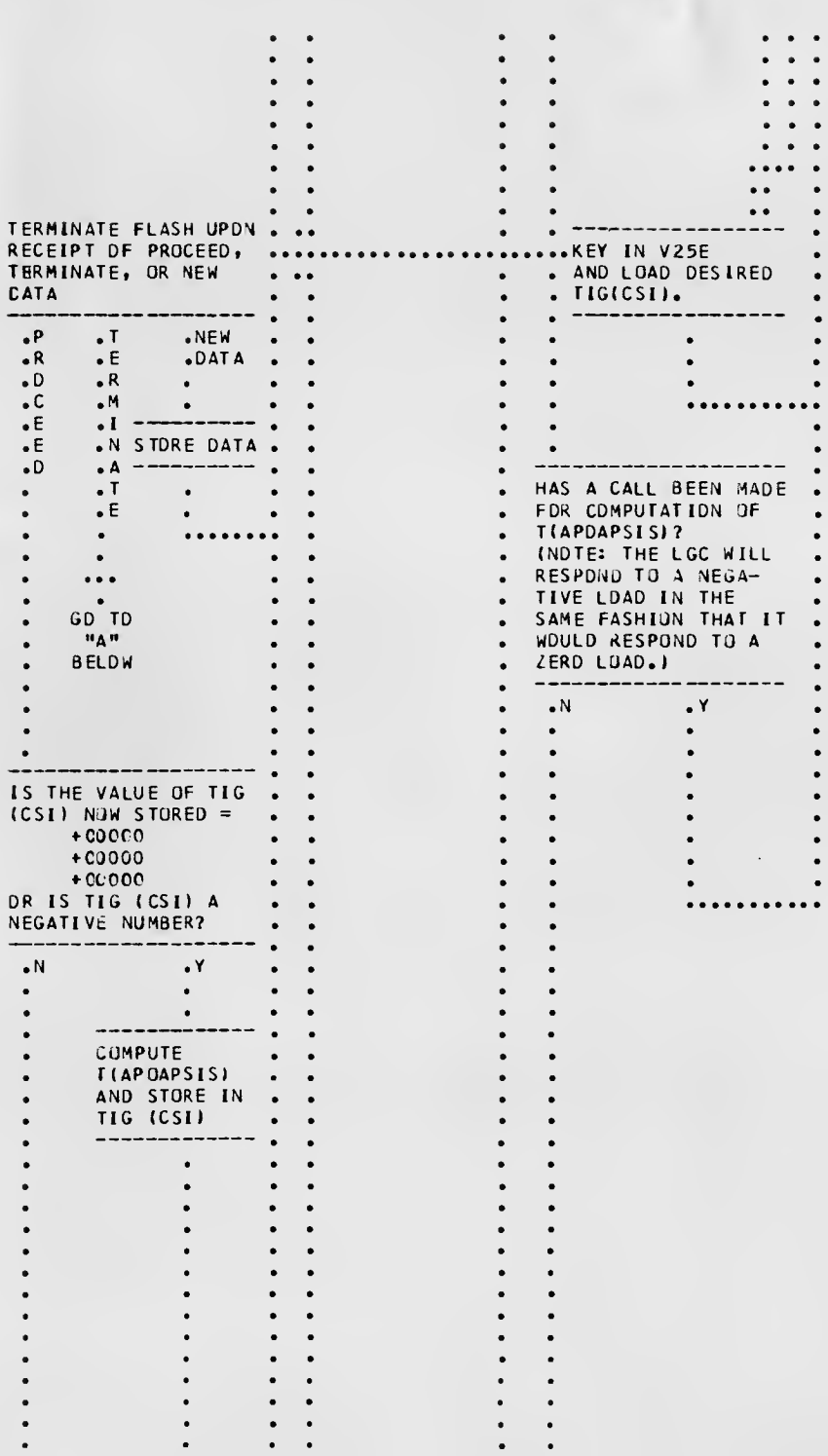
#60

#70

#80

#90


TARGETED TO OCCUR AT APOAPSIS UNLESS THE APOAPSIS TIME IS REPLACED BY SOME OTHER TIME.)
#100
Y
N
IS THE VALUE OF TIG(CSI) = +00000 +00000 +00000 OR IS TIG(CSI) A NEGATIVE NUMBER?
#110
Y
N
#120
AM I SATISFIED WITH THIS VALUE?
Y
N
RECORD THIS VALUE FOR FUTURE TRANSMISSION TO THE CSM.
#130
WAIT FOR KEYBOARD ENTRY
KEY IN PROCEED
#140



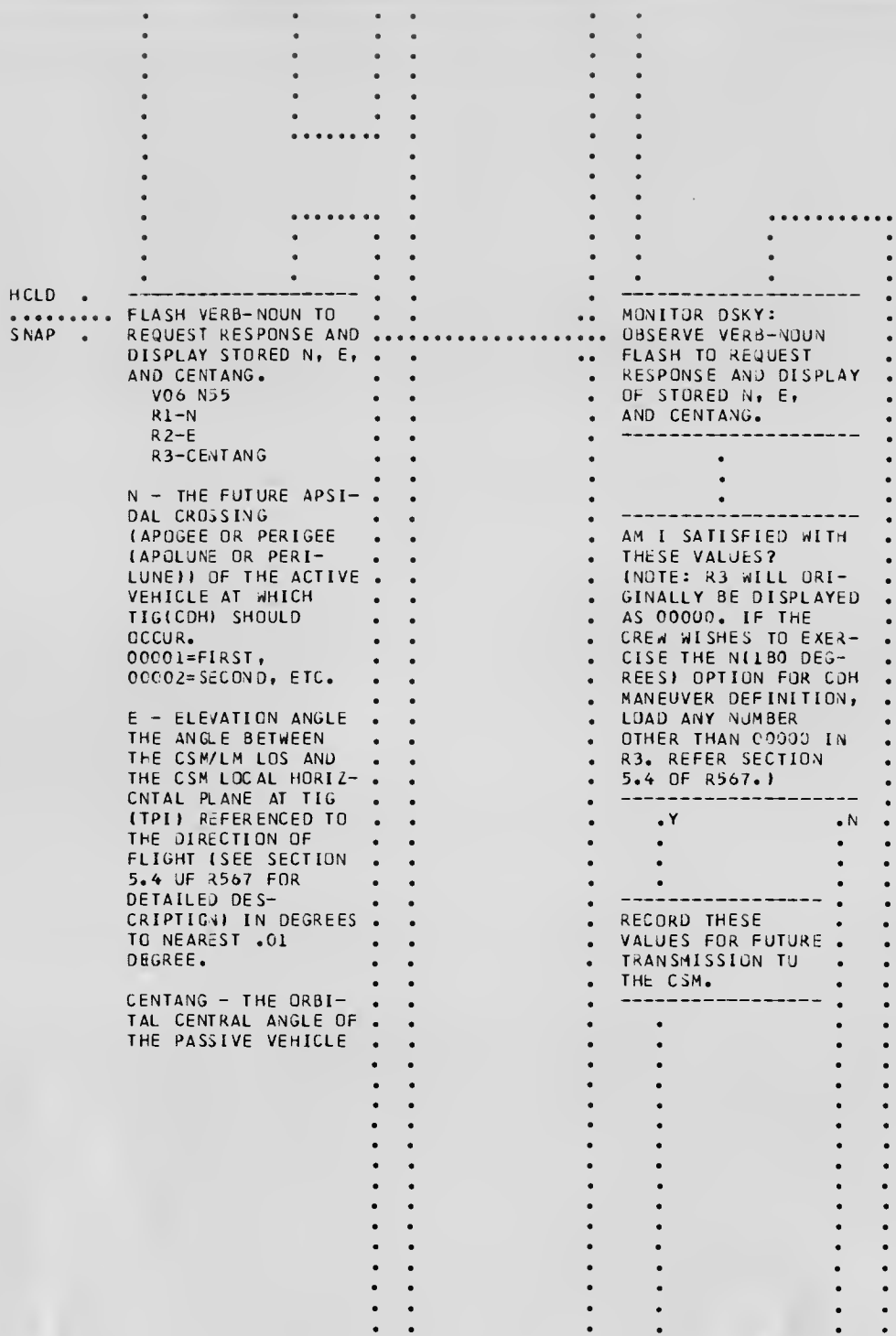
#150

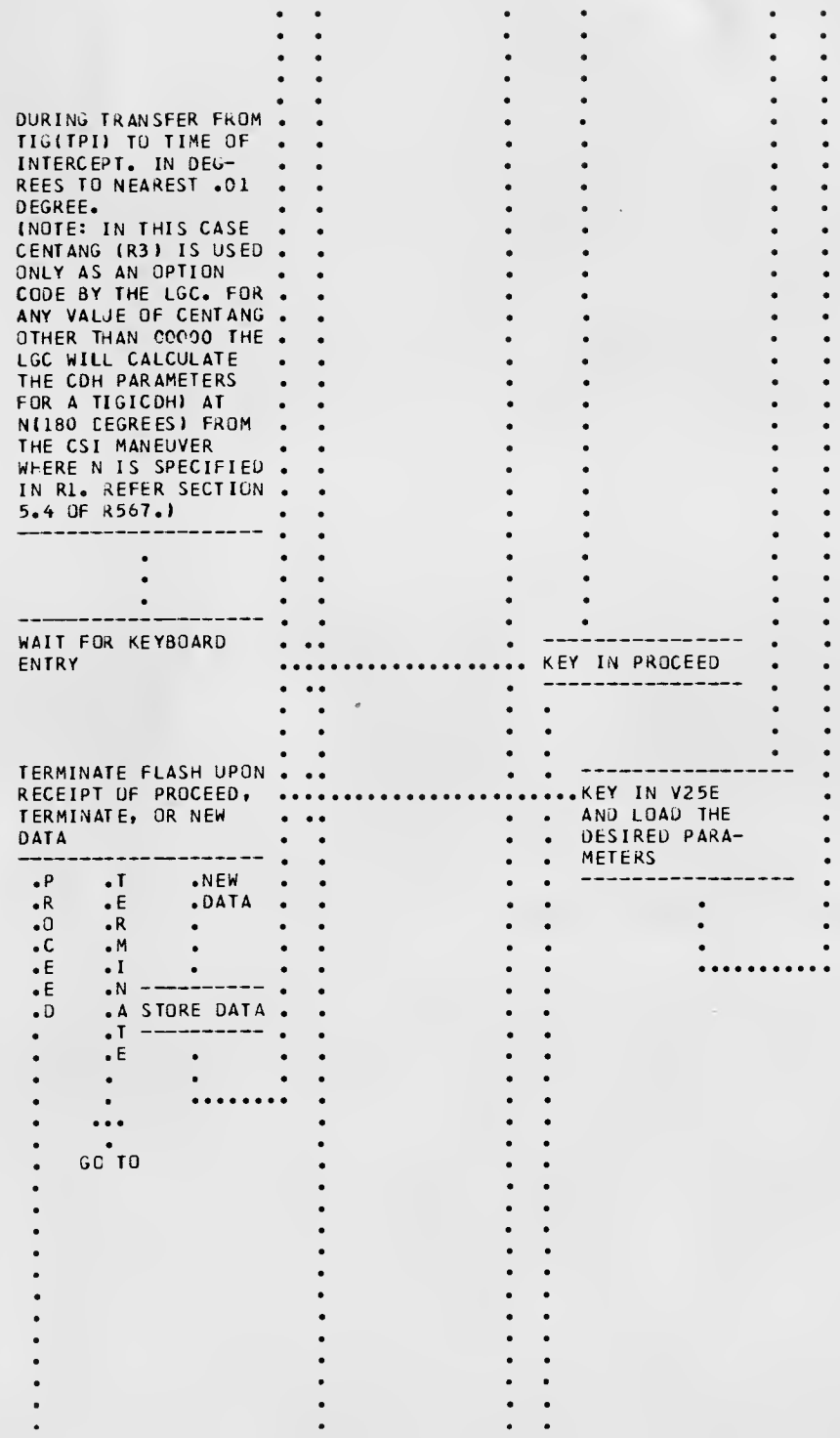
#160

#170

#180

#190


HOLD
SNAP
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY STORED N, E, AND CENTANG.
V06 N55
R1-N
R2-E
R3-CENTANG
N - THE FUTURE APSIDAL CROSSING (APOGEE OR PERIGEE (APOLUNE OR PERILUNE)) OF THE ACTIVE VEHICLE AT WHICH TIG(CDH) SHOULD OCCUR.
00001=FIRST,
00002=SECOND, ETC.
E - ELEVATION ANGLE THE ANGLE BETWEEN THE CSM/LM LOS AND THE CSM LOCAL HORIZONTAL PLANE AT TIG (TPI) REFERENCED TO THE DIRECTION OF FLIGHT (SEE SECTION 5.4 OF R567 FOR DETAILED DESCRIPTION) IN DEGREES TO NEAREST .01 DEGREE.
CENTANG - THE ORBITAL CENTRAL ANGLE OF THE PASSIVE VEHICLE
MONITOR DSKY: OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY OF STORED N, E, AND CENTANG.
#200
#210
AM I SATISFIED WITH THESE VALUES? (NOTE: R3 WILL ORIGINALLY BE DISPLAYED AS 00000. IF THE CREW WISHES TO EXERCISE THE N(180 DEGREES) OPTION FOR CDH MANEUVER DEFINITION, LOAD ANY NUMBER OTHER THAN 00000 IN R3. REFER SECTION 5.4 OF R567.)
#220
Y
N
#230
RECORD THESE VALUES FOR FUTURE TRANSMISSION TO THE CSM.



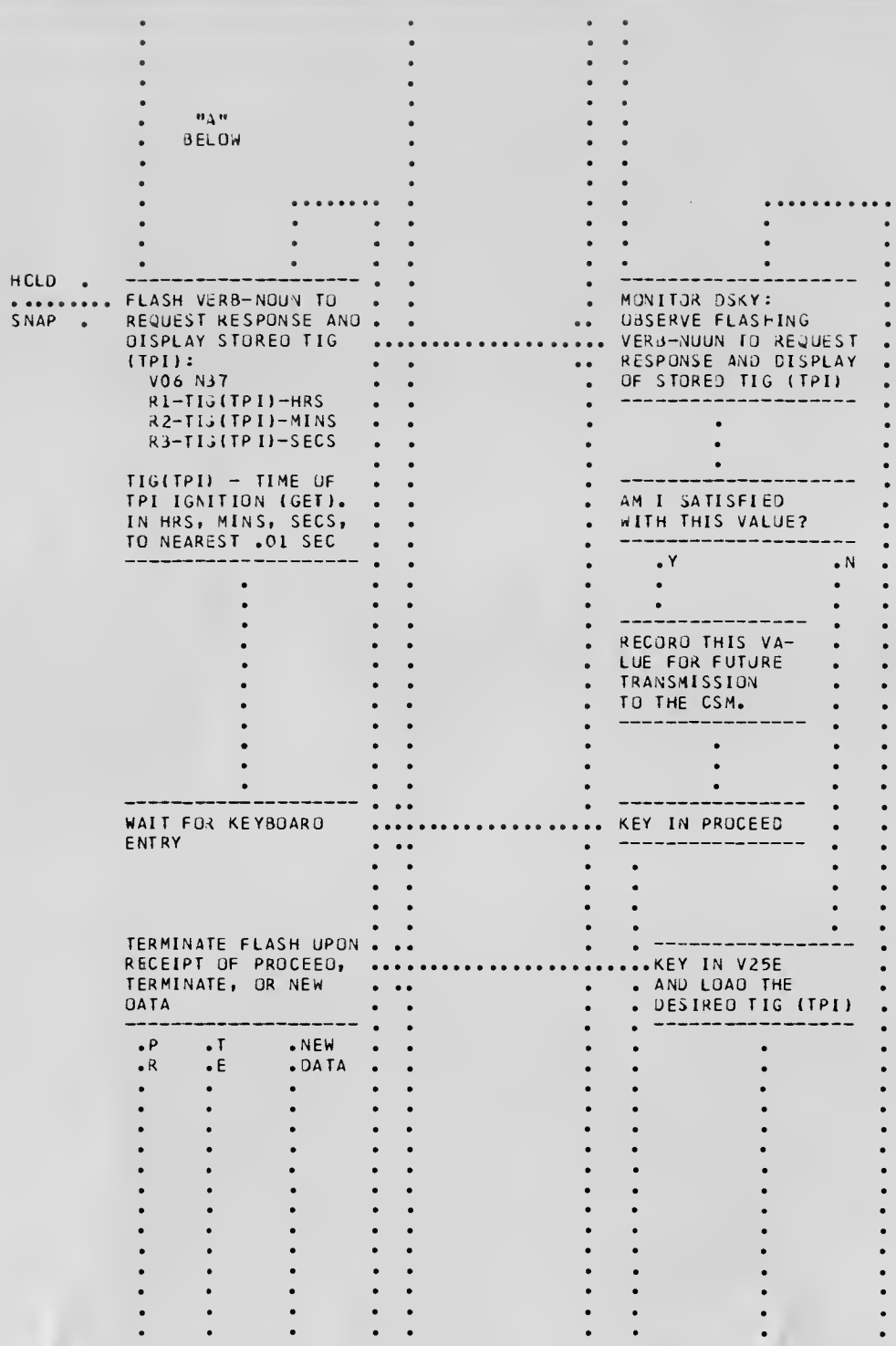
#240

#250

#260

#270

#280



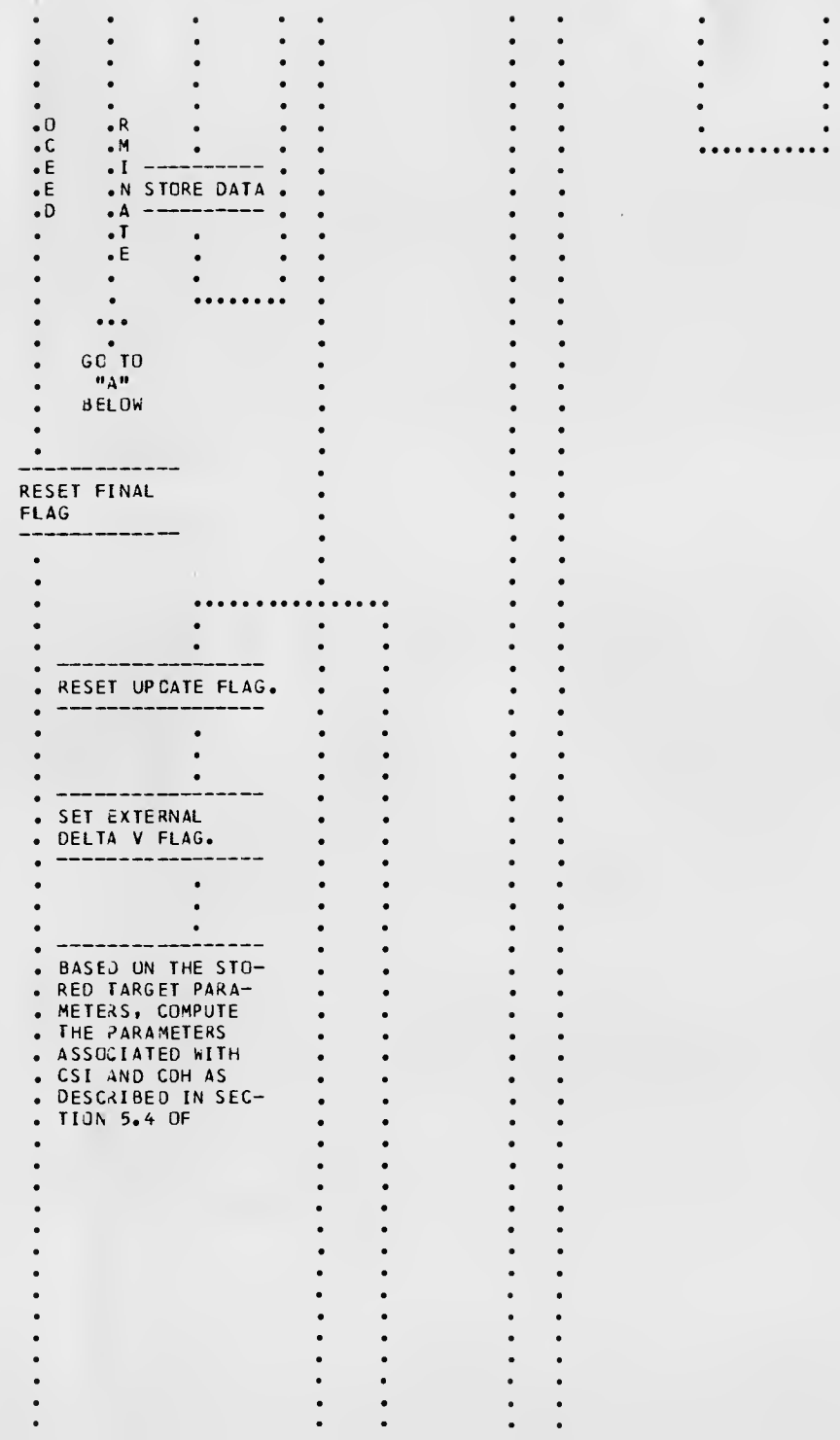
#290

#300

#310

#320

#330



#340

#350

#360

#370

#380

```
R567.
  ESTABLISH ALARM
IF;

  (A) ON FIRST
  ITERATION THERE
  IS NO INTER-
  SECTION OF
  THE DESIRED LOS
  AT TPI WITH THE
  CIRCLE DESCRIB-
  ED IN SECTION
  5.4 OF R567.
  (ALARM CODE
  00600)

  (B) ON ANY TWO
  CONSECUTIVE
  ITERATIONS THE
  MAGNITUDE OF
  DELTA V(CSI) IS
  GREATER THAN
  1000 FPS.
  (ALARM CODE
  00606)

  (C) THE ITERA-
  TION COUNTER
  EXCEEDS 15
  WITHOUT ARRI-
  VING AT A PRO-
  BLEM SOLUTION.
  (ALARM CODE
  00605)

  (D) PERICENTER
  ALT (POST CSI)
  IS LESS THAN
  35,000 FT.
  (LUNAR ORBIT)
  OR 85 NM (EARTH
  ORBIT).
  (ALARM CODE
  00601)

  (E) PERICENTER
  ALT (POST CDH)
```

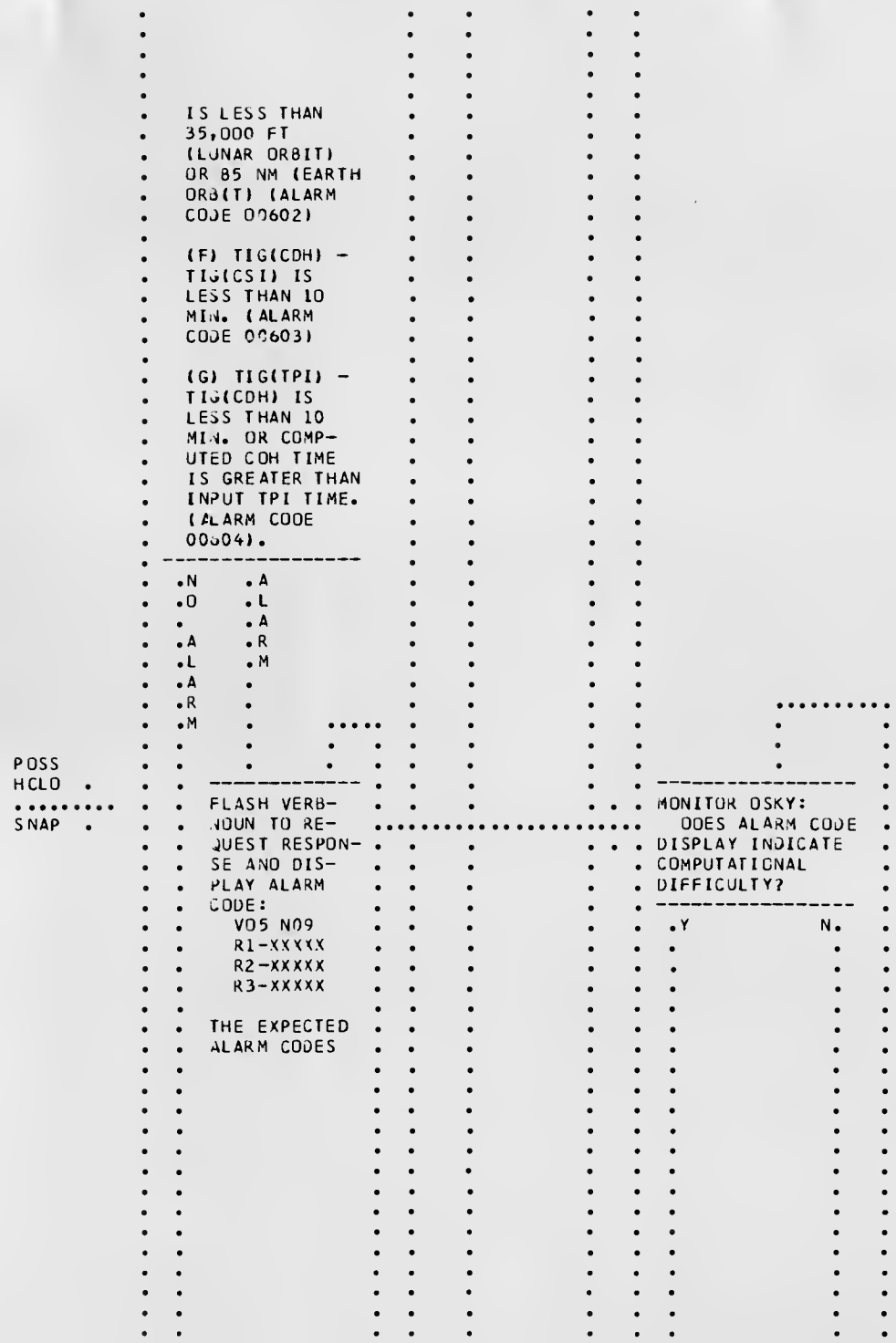
#390

#400

#410

#420

#430

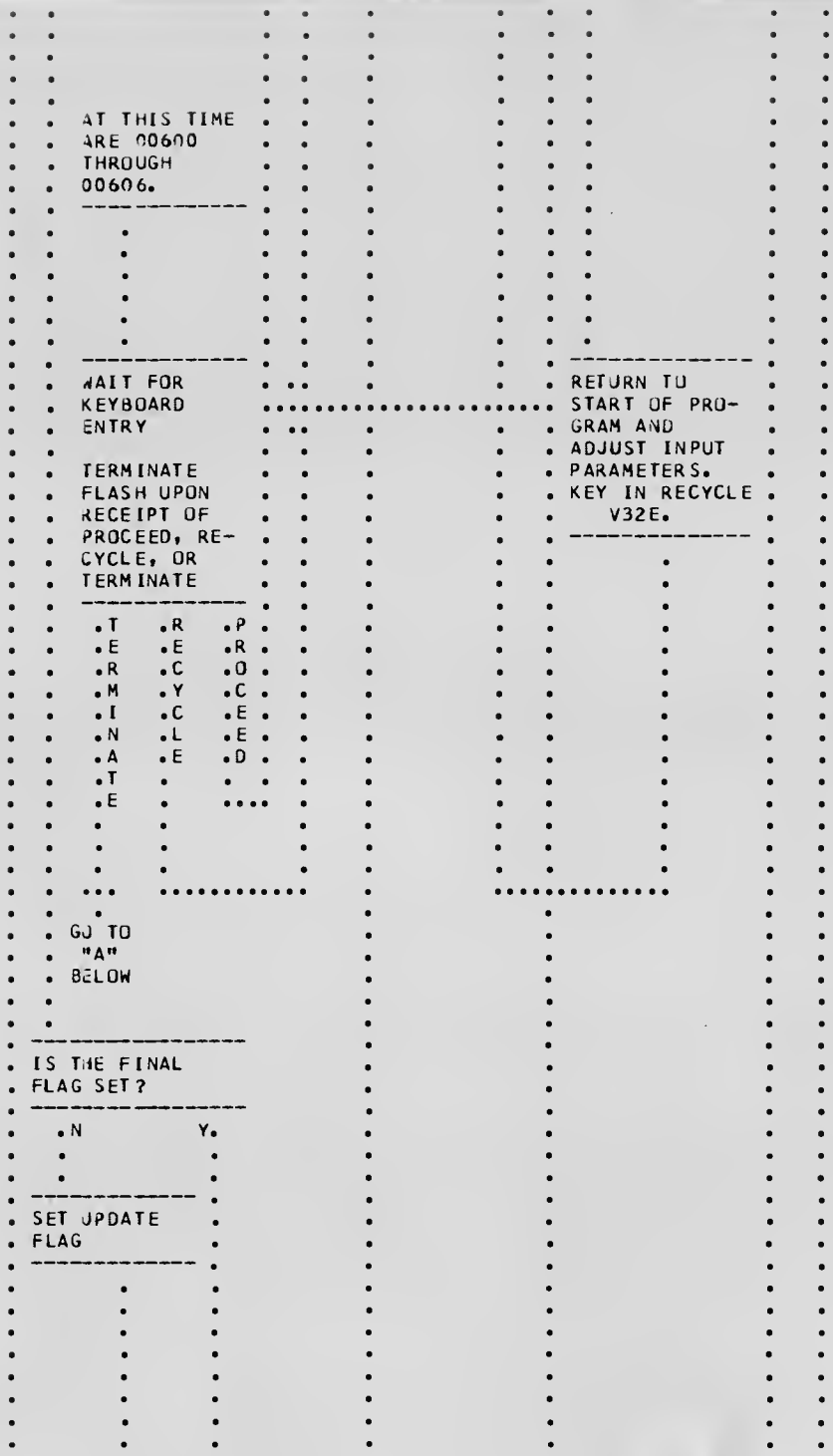


#440

#450

#460

#470



#480

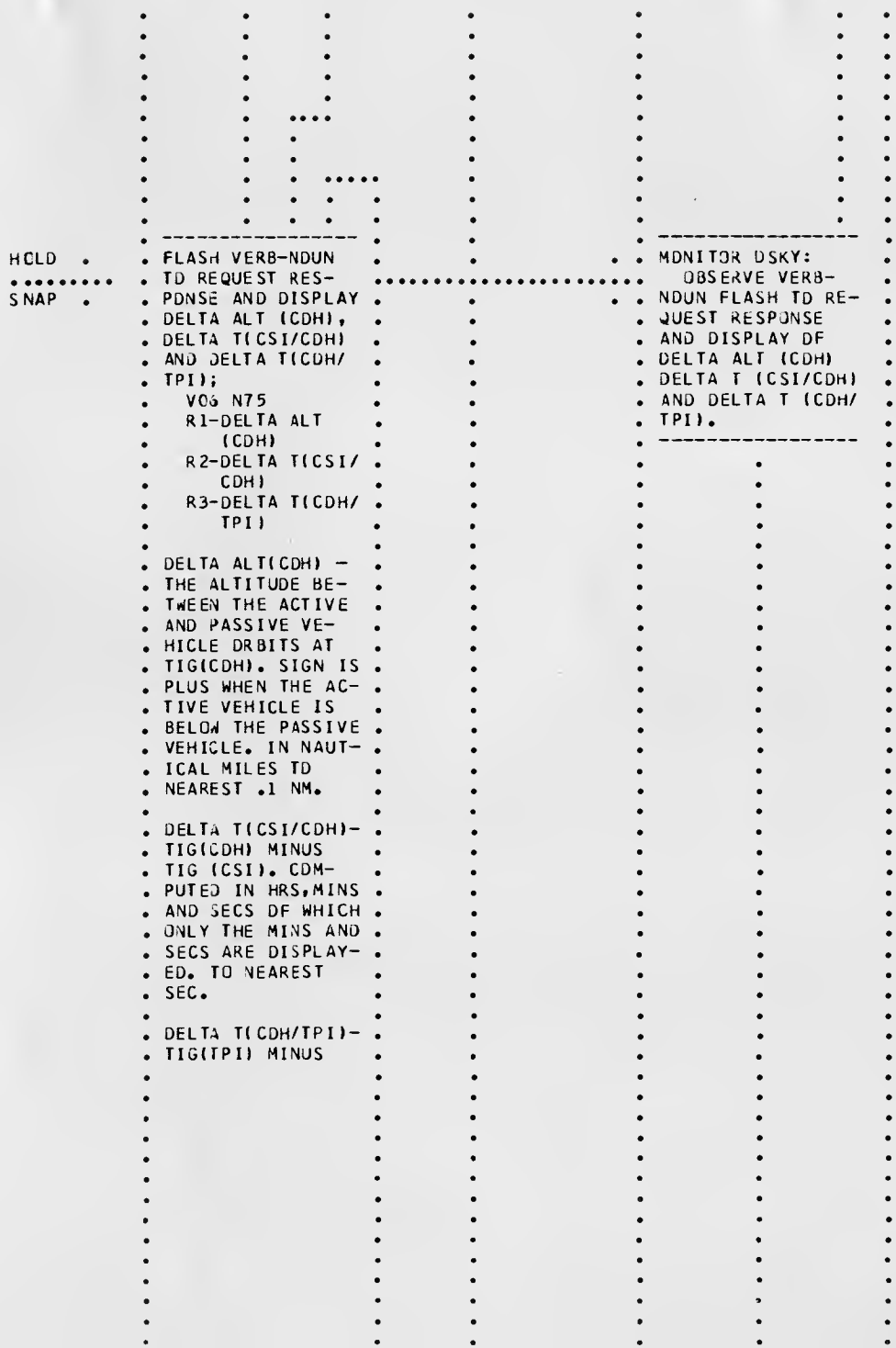
#490

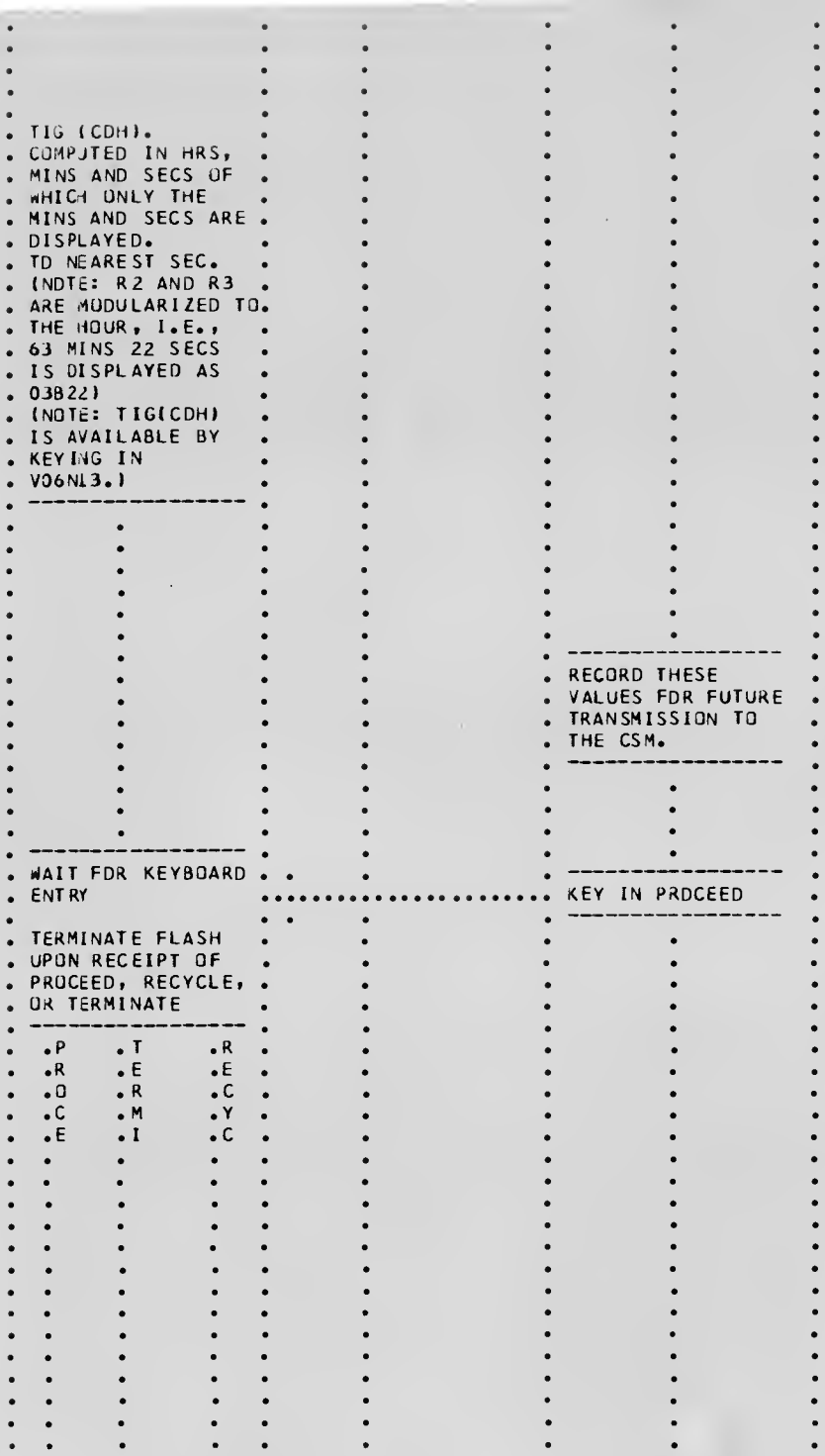
#500

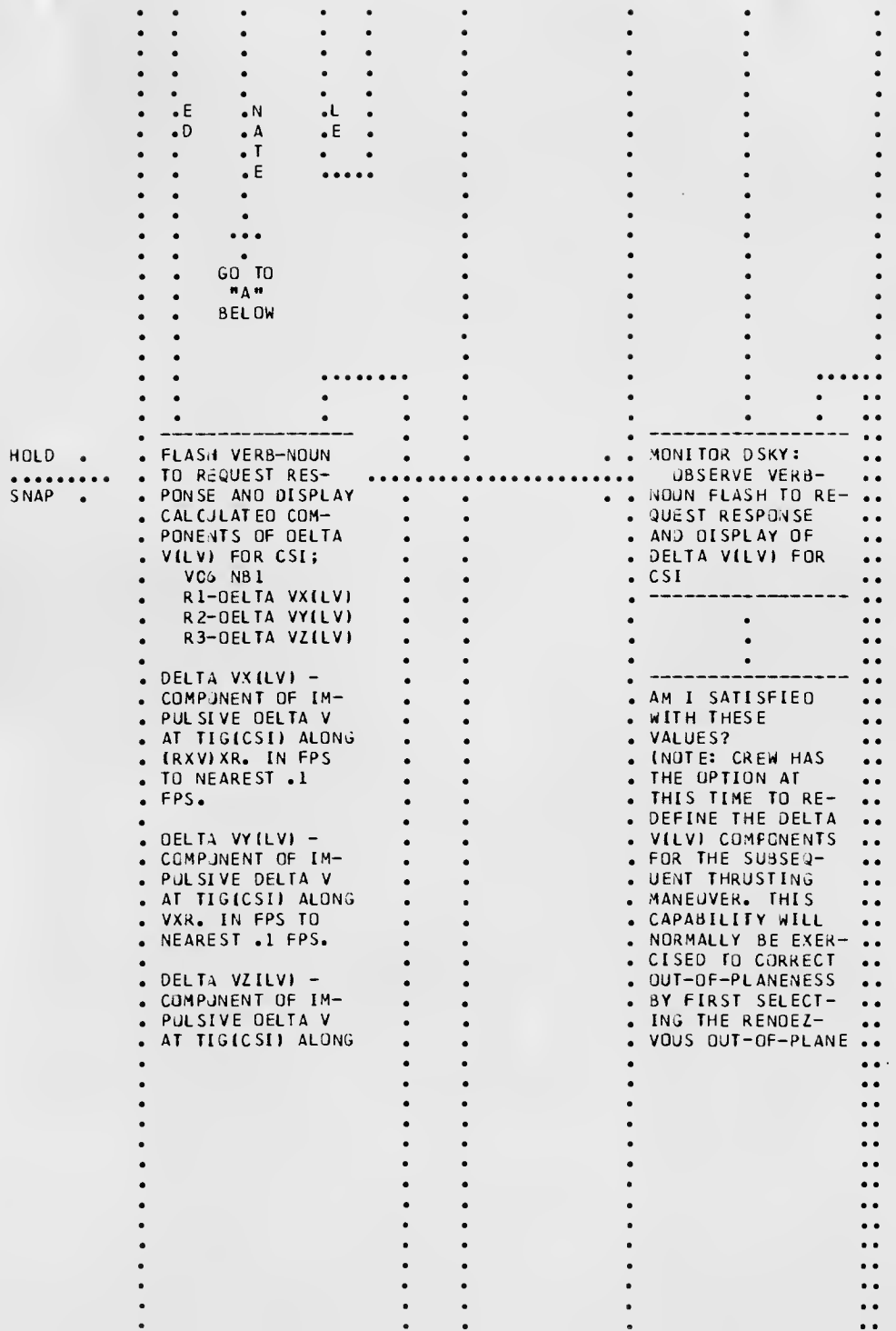
#510

#520

#530


HOLD
SNAP
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY DELTA ALT (CDH), DELTA T(CSI/CDH) AND DELTA T(CDH/TPI);
V06 N75
R1-DELTA ALT (CDH)
R2-DELTA T(CSI/CDH)
R3-DELTA T(CDH/TPI)
DELTA ALT(CDH) - THE ALTITUDE BETWEEN THE ACTIVE AND PASSIVE VEHICLE ORBITS AT TIG(CDH). SIGN IS PLUS WHEN THE ACTIVE VEHICLE IS BELOW THE PASSIVE VEHICLE. IN NAUTICAL MILES TO NEAREST .1 NM.
DELTA T(CSI/CDH)-TIG(CDH) MINUS TIG (CSI). COMPUTED IN HRS,MINS AND SECS OF WHICH ONLY THE MINS AND SECS ARE DISPLAYED. TO NEAREST SEC.
DELTA T(CDH/TPI)-TIG(TPI) MINUS
MONITOR DSKY: OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY OF DELTA ALT (CDH) DELTA T (CSI/CDH) AND DELTA T (CDH/TPI).
#540
#550
#560
#570
#580


TIG (CDH).
COMPUTED IN HRS,
MINS AND SECS OF
WHICH ONLY THE
MINS AND SECS ARE
DISPLAYED.
TO NEAREST SEC.
(NOTE: R2 AND R3
ARE MODULARIZED TO
THE HOUR, I.E.,
63 MINS 22 SECS
IS DISPLAYED AS
03B22)
(NOTE: TIG(CDH)
IS AVAILABLE BY
KEYING IN
V06N13.)
#590
#600
RECORD THESE
VALUES FOR FUTURE
TRANSMISSION TO
THE CSM.
#610
WAIT FOR KEYBOARD
ENTRY
KEY IN PROCEED
TERMINATE FLASH
UPON RECEIPT OF
PROCEED, RECYCLE,
OR TERMINATE
#620
PROCEED
TERMINATE
RECYCLE



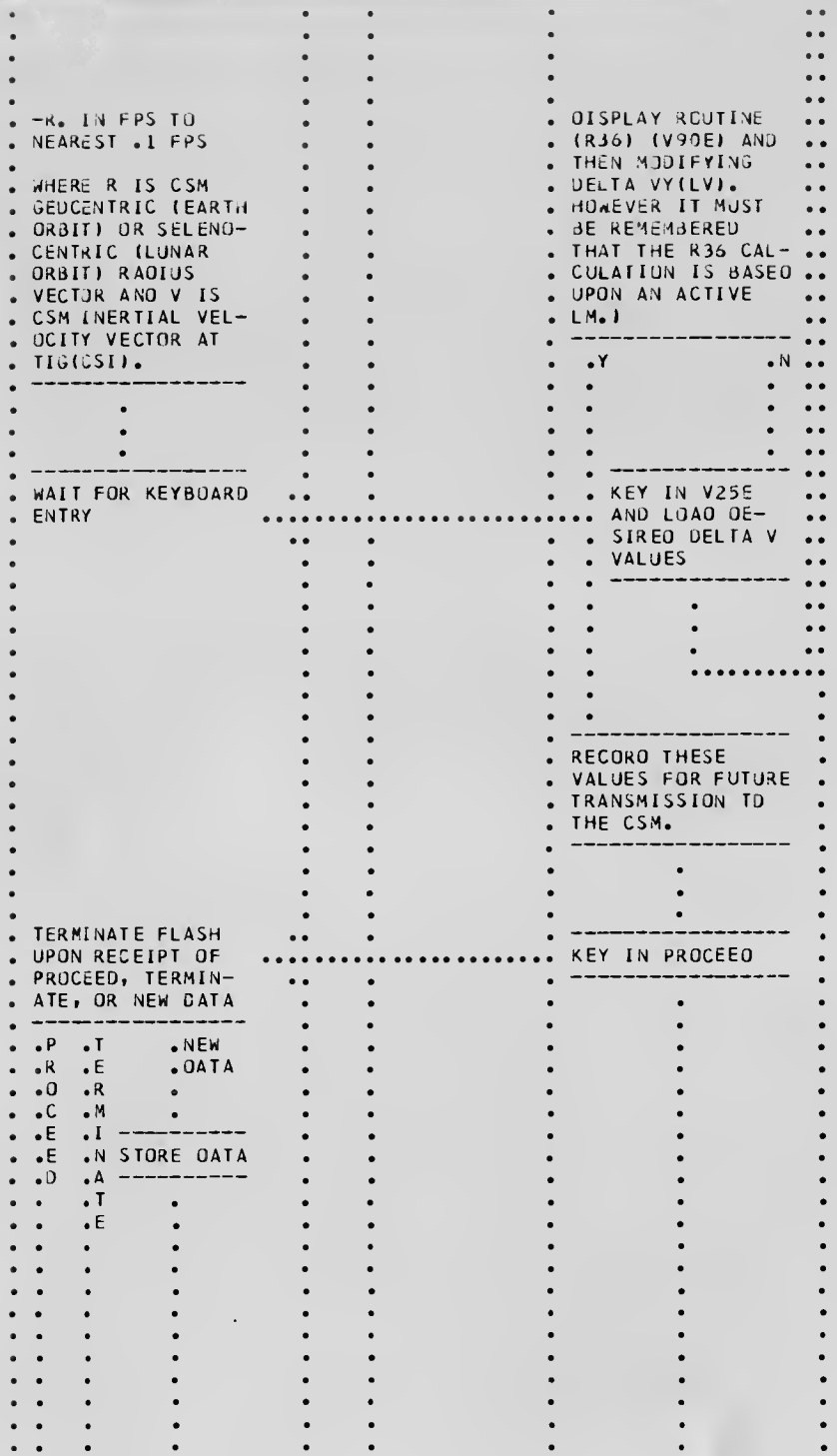
#630

#640

#650

#660

#670



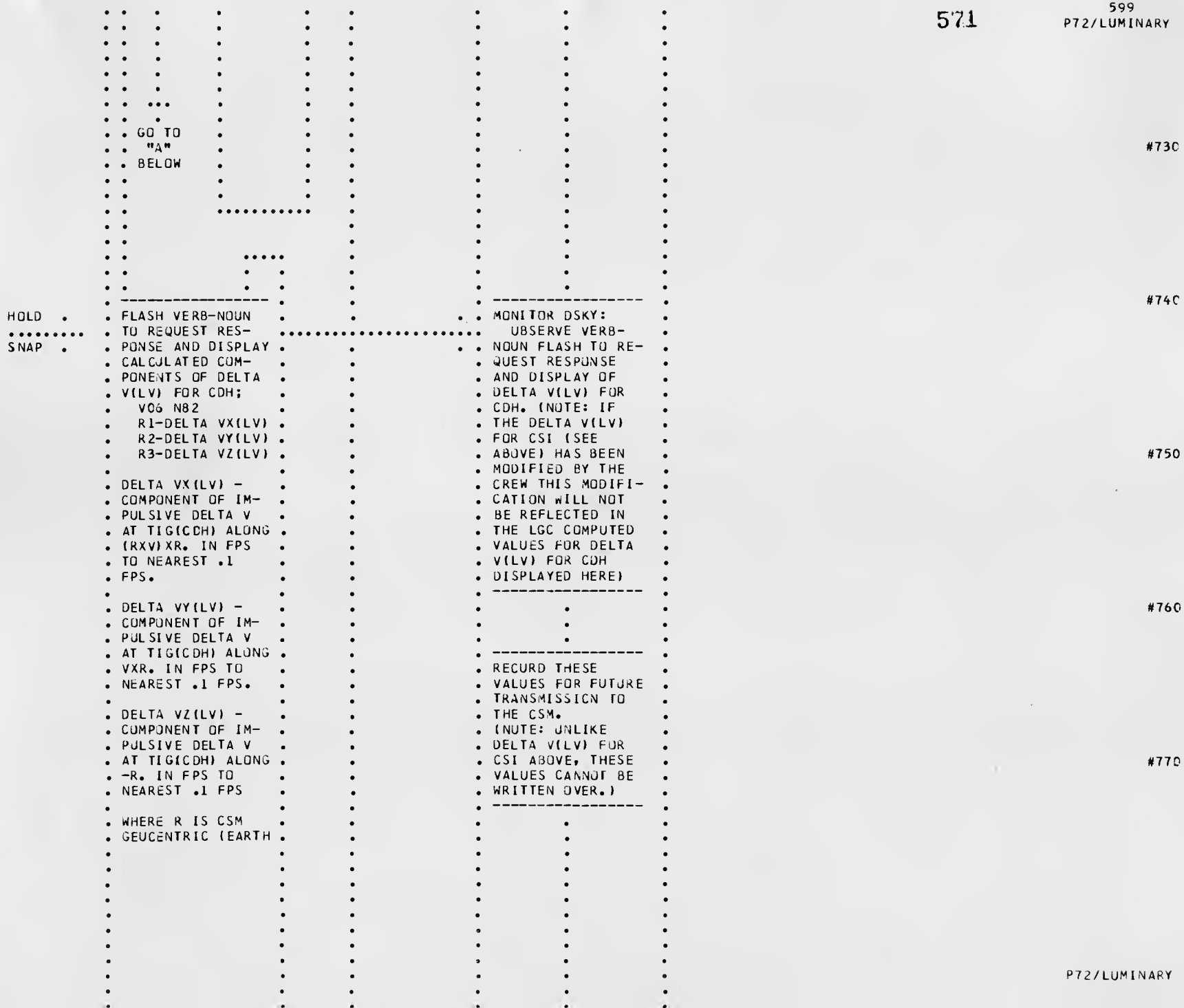
#680

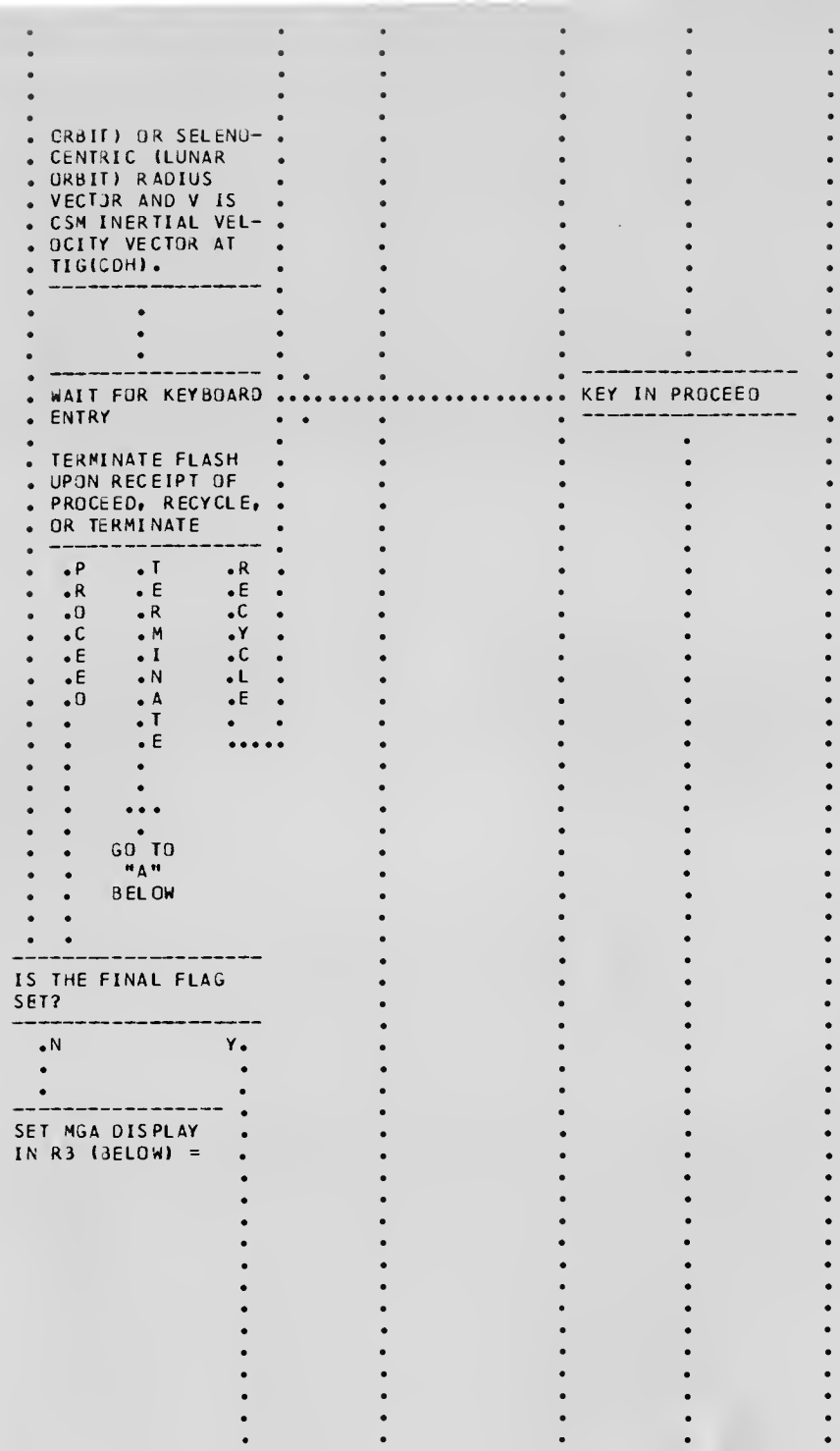
#690

#700

#710

#720


GO TO "A" BELOW
HOLD
SNAP
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY CALCULATED COMPONENTS OF DELTA V(LV) FOR CDH;
V06 N82
R1-DELTA VX(LV)
R2-DELTA VY(LV)
R3-DELTA VZ(LV)
DELTA VX(LV) - COMPONENT OF IMPULSIVE DELTA V AT TIG(CDH) ALONG (RXV)XR. IN FPS TO NEAREST .1 FPS.
DELTA VY(LV) - COMPONENT OF IMPULSIVE DELTA V AT TIG(CDH) ALONG VXR. IN FPS TO NEAREST .1 FPS.
DELTA VZ(LV) - COMPONENT OF IMPULSIVE DELTA V AT TIG(CDH) ALONG -R. IN FPS TO NEAREST .1 FPS
WHERE R IS CSM GEOCENTRIC (EARTH
MONITOR DSKY: OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY OF DELTA V(LV) FOR CDH. (NOTE: IF THE DELTA V(LV) FOR CSI (SEE ABOVE) HAS BEEN MODIFIED BY THE CREW THIS MODIFICATION WILL NOT BE REFLECTED IN THE LGC COMPUTED VALUES FOR DELTA V(LV) FOR CDH DISPLAYED HERE)
RECORD THESE VALUES FOR FUTURE TRANSMISSION TO THE CSM.
(NOTE: UNLIKE DELTA V(LV) FOR CSI ABOVE, THESE VALUES CANNOT BE WRITTEN OVER.)
#730
#740
#750
#760
#770



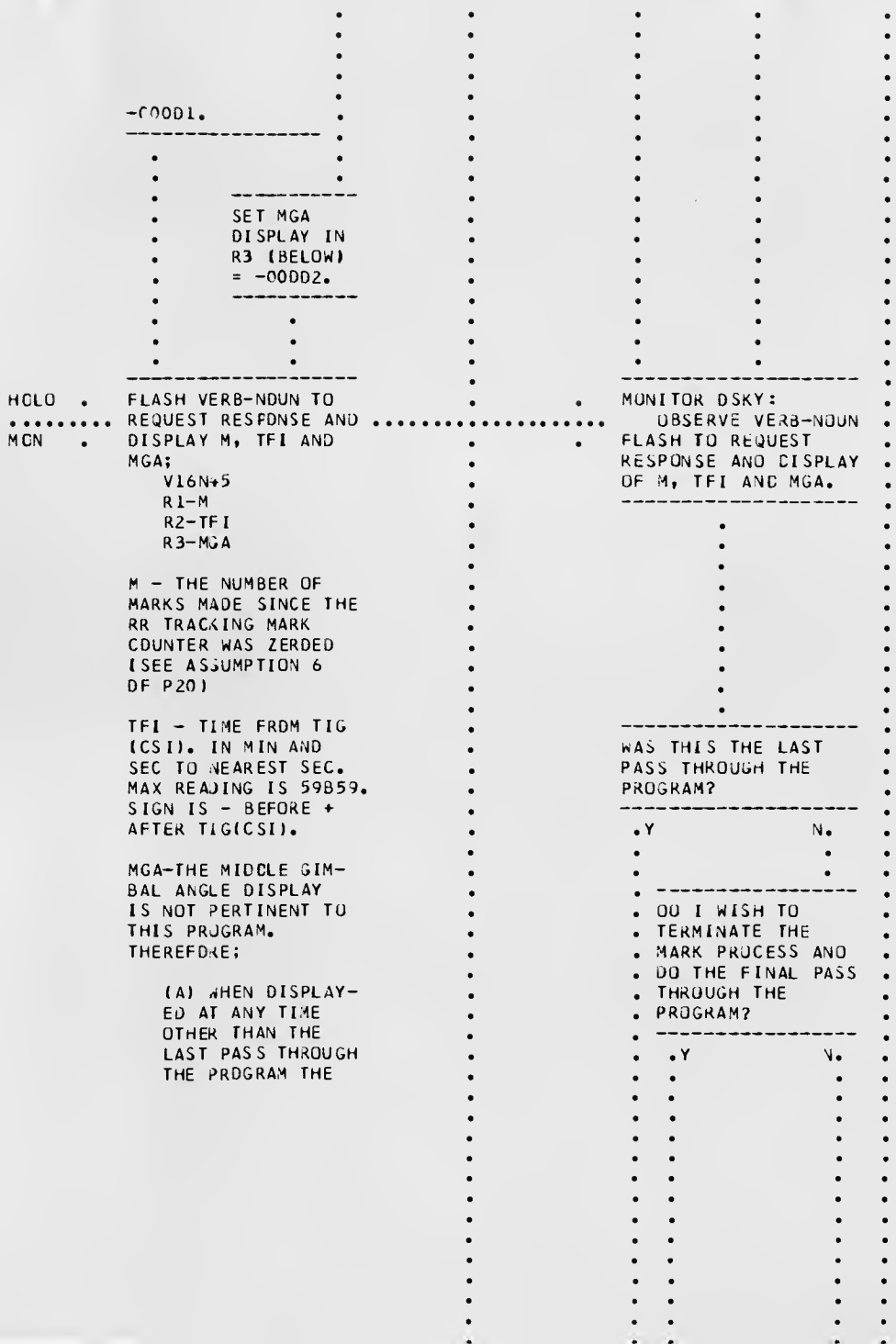
#780

#790

#800

#810

#820



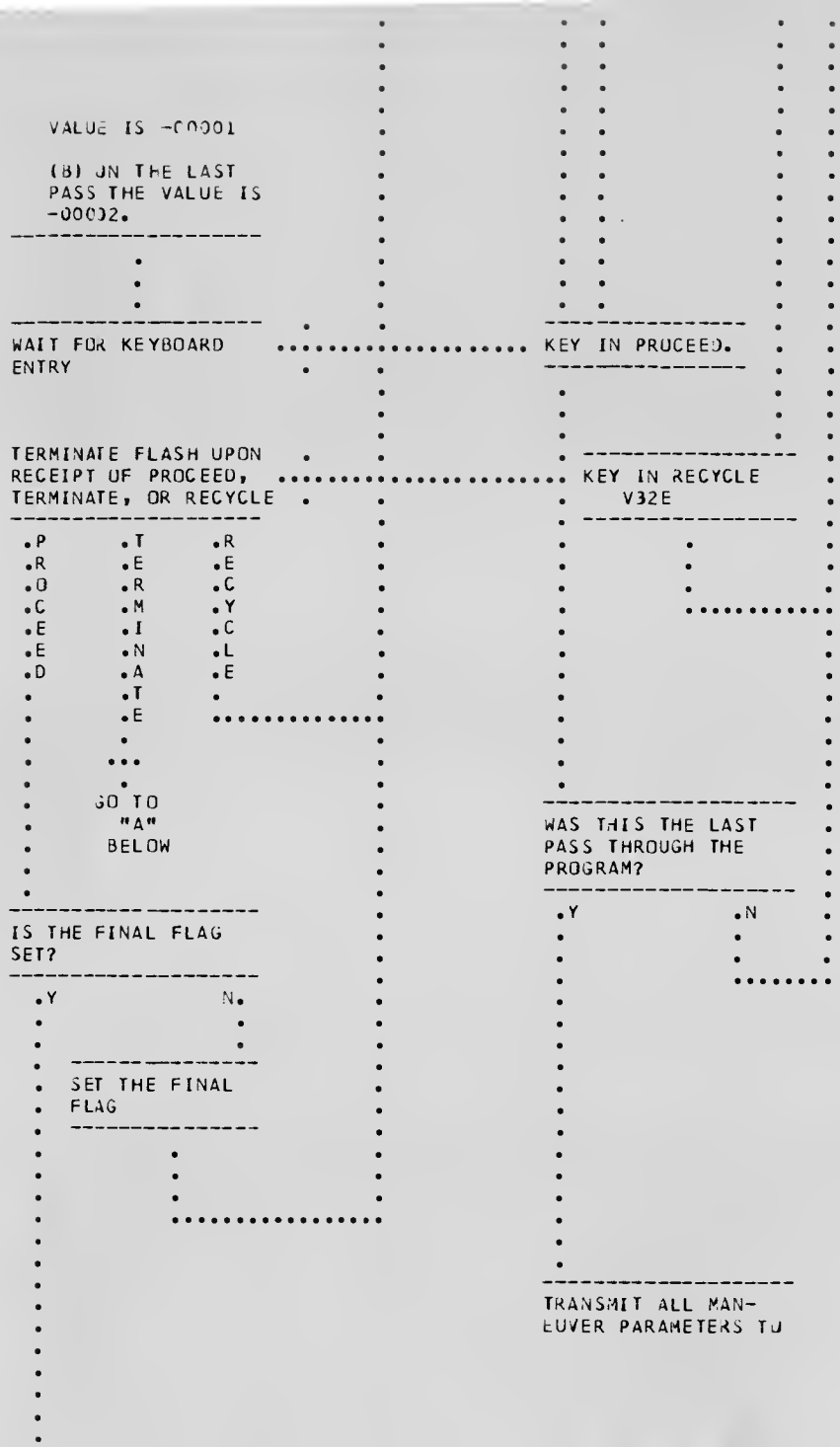
#830

#840

#850

#860

#870



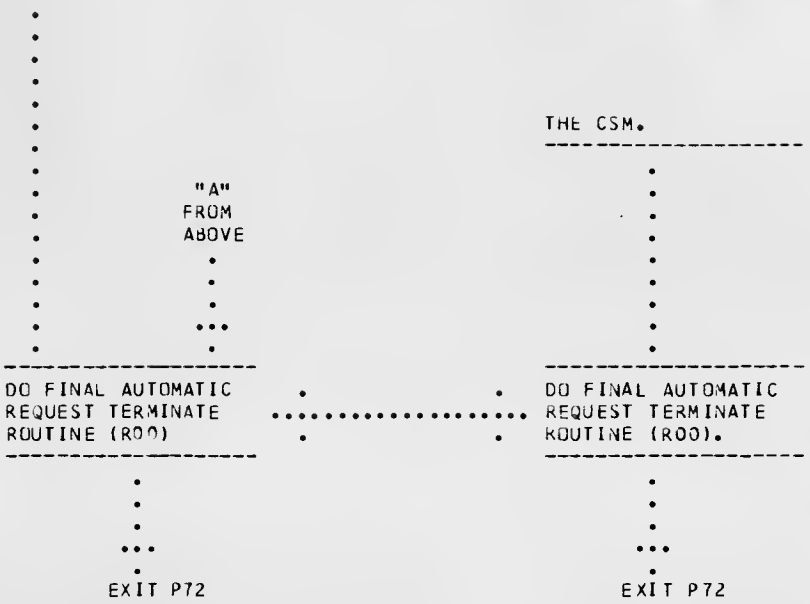
#880

#890

#900

#910

#920



#930

#940

#950

CHANGE CONTROL NOTES

REV 01 PCR 254,540,623
REV 00(LUM 1A) PCR 695,752
REV 01 EDITORIAL
REV 02 EDITORIAL
REV 03(LUM 1E) PCN 1145

CSM CONSTANT DELTA ALTITUDE (CDH) REV 05 12/01/71
TARGETING PROGRAM (P73)

PURPOSE: (1) TO CALCULATE PARAMETERS ASSOCIATED WITH THE CONCENTRIC FLIGHT PLAN MANEUVERS WITH THE EXCEPTION OF CO-ELLIPTIC SEQUENCE INITIATION (CSI) FOR CSM EXECUTION OF THE MANEUVERS UNDER CONTROL OF THE CMC. THE CONCENTRIC FLIGHT PLAN MANEUVERS ARE THE CO-ELLIPTIC SEQUENCE INITIATION (CSI), THE CONSTANT DELTA ALTITUDE MANEUVER (CDH), THE TRANSFER PHASE INITIATION (TPI), AND THE TRANSFER PHASE FINAL (TPF) OR BRAKING MANEUVER.

(2) TO CALCULATE THESE PARAMETERS BASED UPON MANEUVER DATA APPROVED AND KEYED INTO THE LGC BY THE ASTRONAUT.

(3) TO DISPLAY TO THE ASTRONAUT AND THE GROUND DEPENDENT VARIABLES ASSOCIATED WITH THE CONCENTRIC FLIGHT PLAN MANEUVERS FOR APPROVAL BY THE ASTRONAUT/GROUND.

ASSUMPTIONS: (1) THIS PROGRAM IS BASED UPON PREVIOUS COMPLETION OF THE CO-ELLIPTIC SEQUENCE INITIATION (CSI) TARGETING PROGRAM (P72). THEREFORE:

(A) AT A SELECTED TPI TIME THE LINE OF SIGHT BETWEEN THE CSM AND THE LM WAS SELECTED TO BE A PRESCRIBED ANGLE (E) FROM THE HORIZONTAL PLANE DEFINED AT THE CSM POSITION.

(B) THE TIME BETWEEN CSI IGNITION AND CDH IGNITION WAS COMPUTED TO BE GREATER THAN 10 MINUTES.

(C) THE TIME BETWEEN CDH IGNITION AND TPI IGNITION WAS COMPUTED TO BE GREATER THAN 10 MINUTES.

(D) THE VARIATION OF THE ALTITUDE DIFFERENCE BETWEEN THE ORBITS WAS MINIMIZED.

(E) CSI BURN WAS DEFINED SUCH THAT THE IMPULSIVE DELTA V WAS IN THE CSM HORIZONTAL PLANE AT CSI IGNITION.

(F) THE PERICENTER ALTITUDES OF THE ORBITS FOLLOWING CSI AND CDH WERE COMPUTED TO BE GREATER THAN 35,000 FT. (LUNAR ORBIT) OR 85 NM (EARTH ORBIT).

(G) THE CSI AND CDH MANEUVERS WERE ASSUMED TO BE PARALLEL TO THE PLANE OF THE LM ORBIT, HOWEVER CREW MODIFICATION OF DELTA V(LV) COMPONENTS MAY HAVE RESULTED IN AN OUT-OF-PLANE CSI MANEUVER.

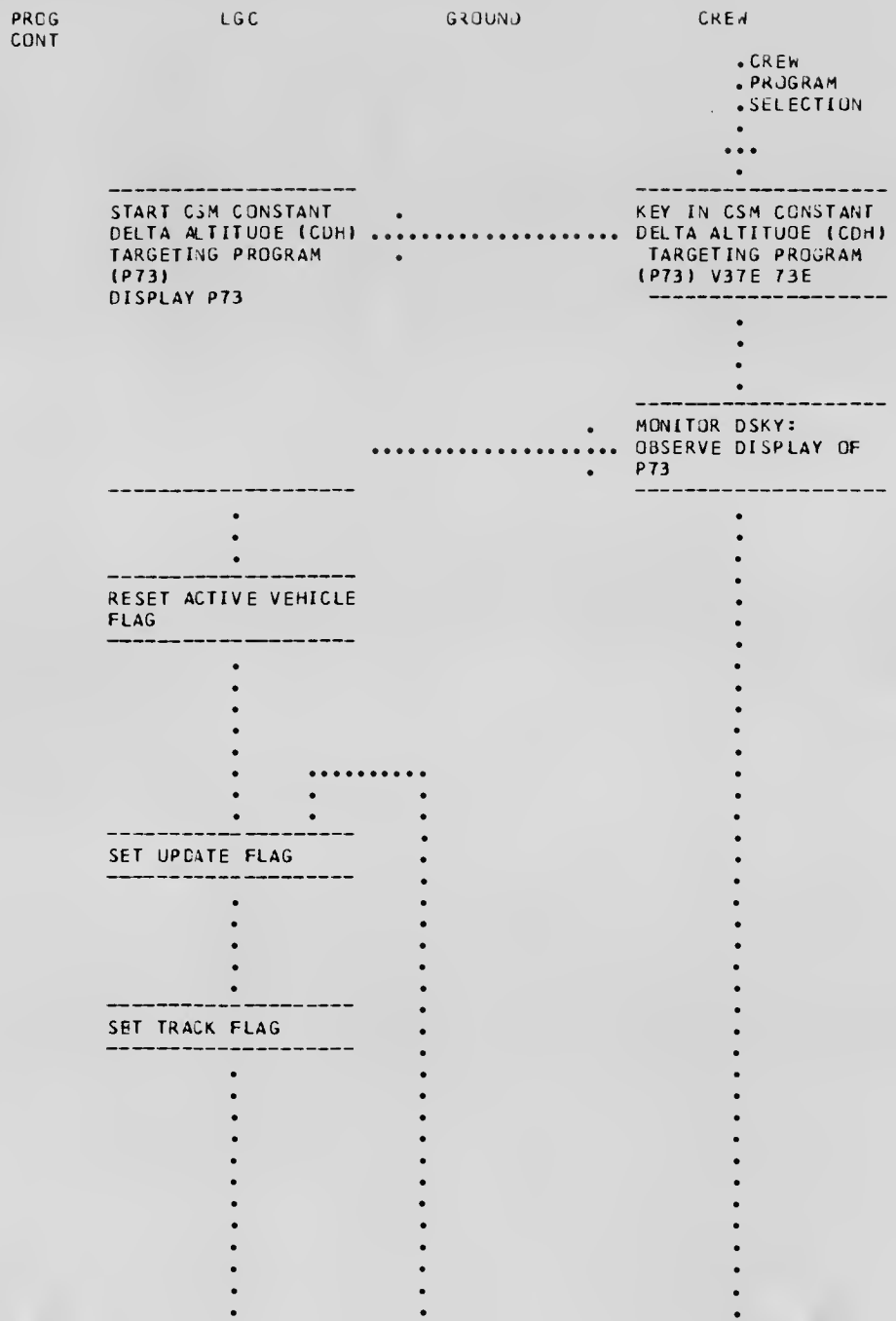
UNLESS THE INPUTS TO THIS PROGRAM ARE CHANGED FROM THOSE VALUES INSERTED IN P72, THE CALCULATED PARAMETERS FOR THE REMAINING MANEUVERS OF THE CONCENTRIC FLIGHT PLAN WILL VARY FROM THOSE ORIGINALLY CALCULATED AND DISPLAYED ONLY DUE TO THE CONTINUOUS RADAR UPDATING OF THE LM OR CSM ORBIT.

(2) LGC COMPUTED VARIABLES MAY BE STORED FOR LATER VERIFICATION BY THE GROUND. THESE STORAGE CAPABILITIES ARE NORMALLY LIMITED ONLY TO THE PARAMETERS FOR ONE THRUSTING MANEUVER AT A TIME EXCEPT FOR CONCENTRIC FLIGHT PLAN MANEUVER SEQUENCES.

(3) THE RENDEZVOUS RADAR MAY OR MAY NOT BE USED TO UPDATE THE LM OR CSM STATE VECTORS FOR THIS PROGRAM. IF RADAR USE IS DESIRED THE RADAR SHOULD HAVE BEEN TURNED ON AND LOCKED ON THE CSM BY PREVIOUS SELECTION OF P20. RADAR SIGHTING MARKS WILL BE MADE AUTOMATICALLY APPROXIMATELY ONCE A MINUTE WHEN ENABLED BY THE TRACK AND UPDATE FLAGS. THE RENDEZVOUS TRACKING MARK COUNTER IS ZEROED BY THE SELECTION OF P20 AND AFTER EACH THRUSTING MANEUVER.

(4) THERE IS NO REQUIREMENT FOR ISS OPERATION DURING THIS PROGRAM UNLESS AUTOMATIC STATE VECTOR UPDATING IS DESIRED BY THE RENDEZVOUS NAVIGATION PROGRAM (P20). IF SELECTED, P20 WILL DEFINE THE STATUS OF THE ISS.

(5) THIS PROGRAM IS SELECTED BY THE ASTRONAUT BY DSKY ENTRY.

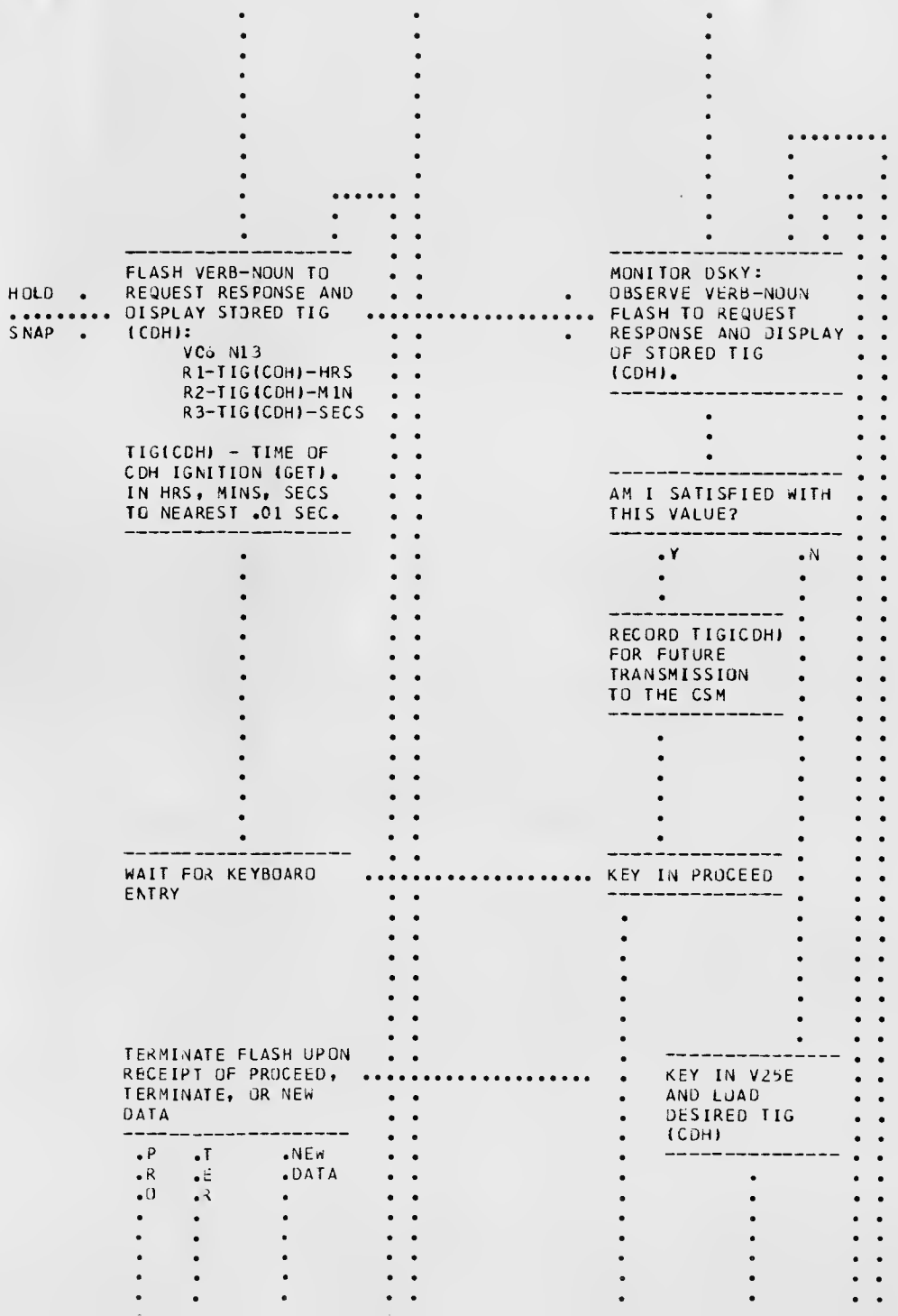

PROG CONT
LGC
GROUND
CREW
.CREW
.PROGRAM
.SELECTION
START CSM CONSTANT DELTA ALTITUDE (CDH) TARGETING PROGRAM (P73) DISPLAY P73
KEY IN CSM CONSTANT DELTA ALTITUDE (CDH) TARGETING PROGRAM (P73) V37E 73E
MONITOR DSKY: OBSERVE DISPLAY OF P73
RESET ACTIVE VEHICLE FLAG
SET UPDATE FLAG
SET TRACK FLAG

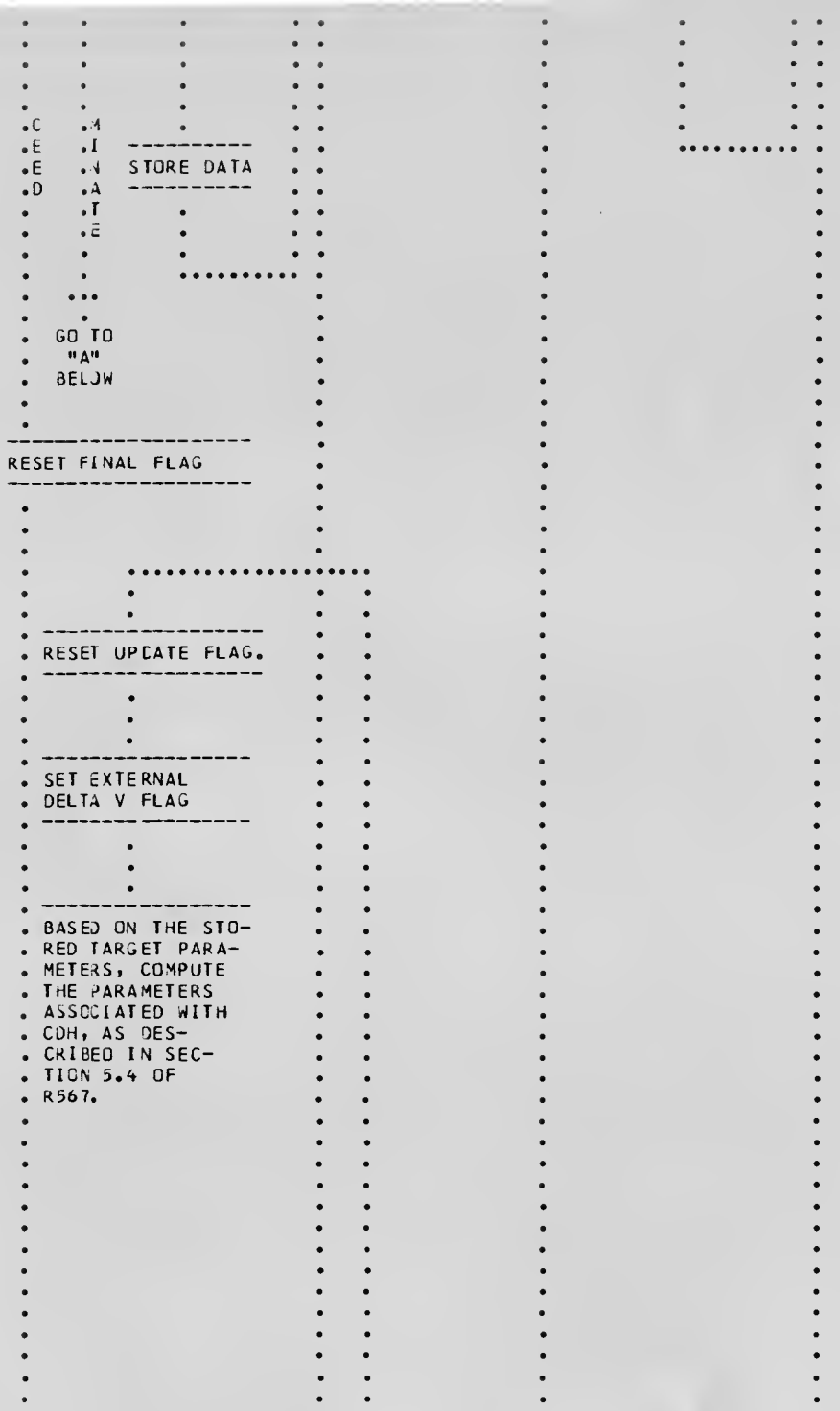
#10

#20

#30

#40


HOLD
SNAP
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY STORED TIG (CDH):
V06 N13
R1-TIG(CDH)-HRS
R2-TIG(CDH)-MIN
R3-TIG(CDH)-SECS
TIG(CDH) - TIME OF CDH IGNITION (GET). IN HRS, MINS, SECS TO NEAREST .01 SEC.
WAIT FOR KEYBOARD ENTRY
TERMINATE FLASH UPON RECEIPT OF PROCEED, TERMINATE, OR NEW DATA
.PRO
.TER
.NEW DATA
MONITOR DSKY: OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY OF STORED TIG (CDH).
AM I SATISFIED WITH THIS VALUE?
.Y
.N
RECORD TIG(CDH) FOR FUTURE TRANSMISSION TO THE CSM
KEY IN PROCEED
KEY IN V25E AND LOAD DESIRED TIG (CDH)



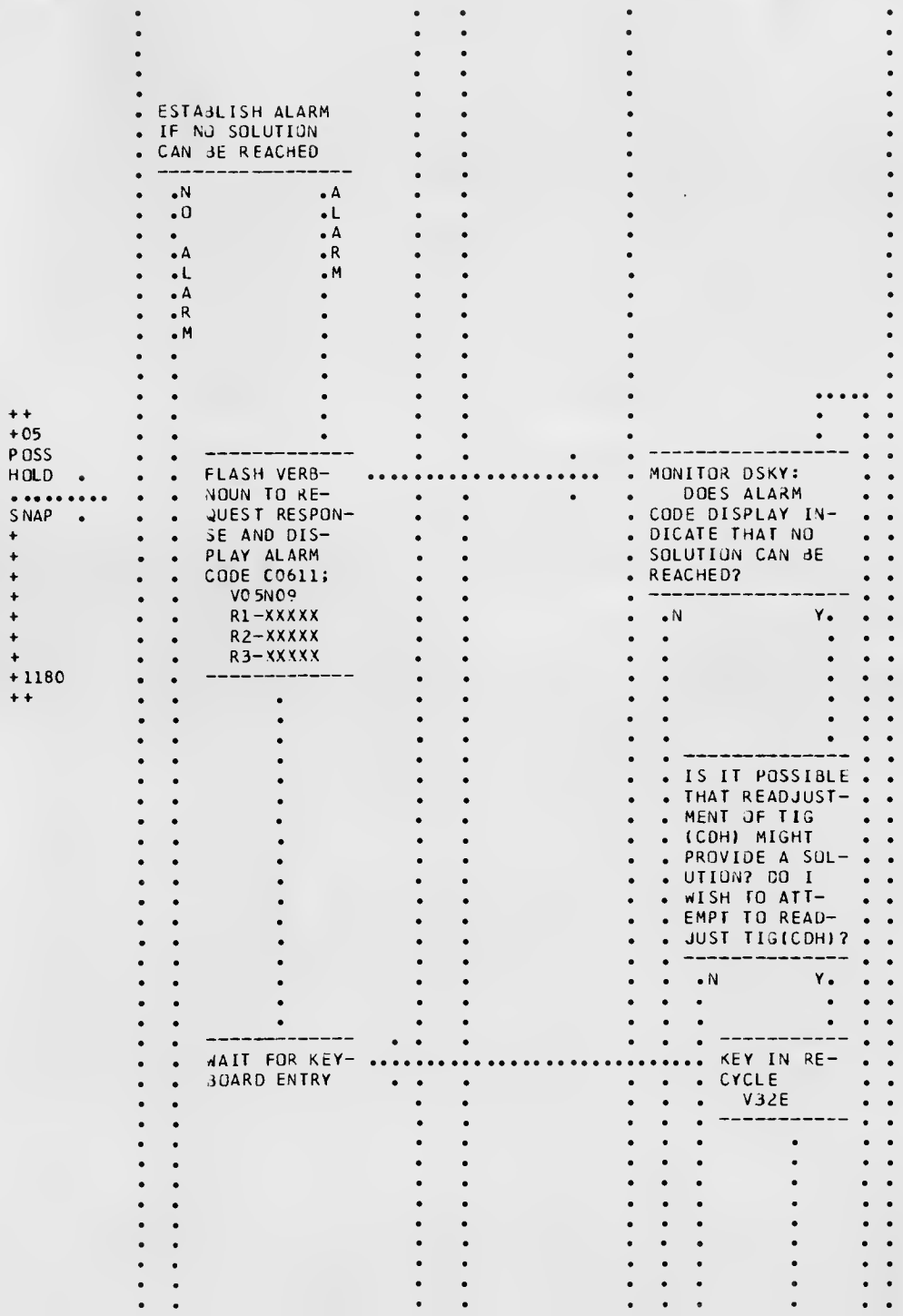
#110

#120

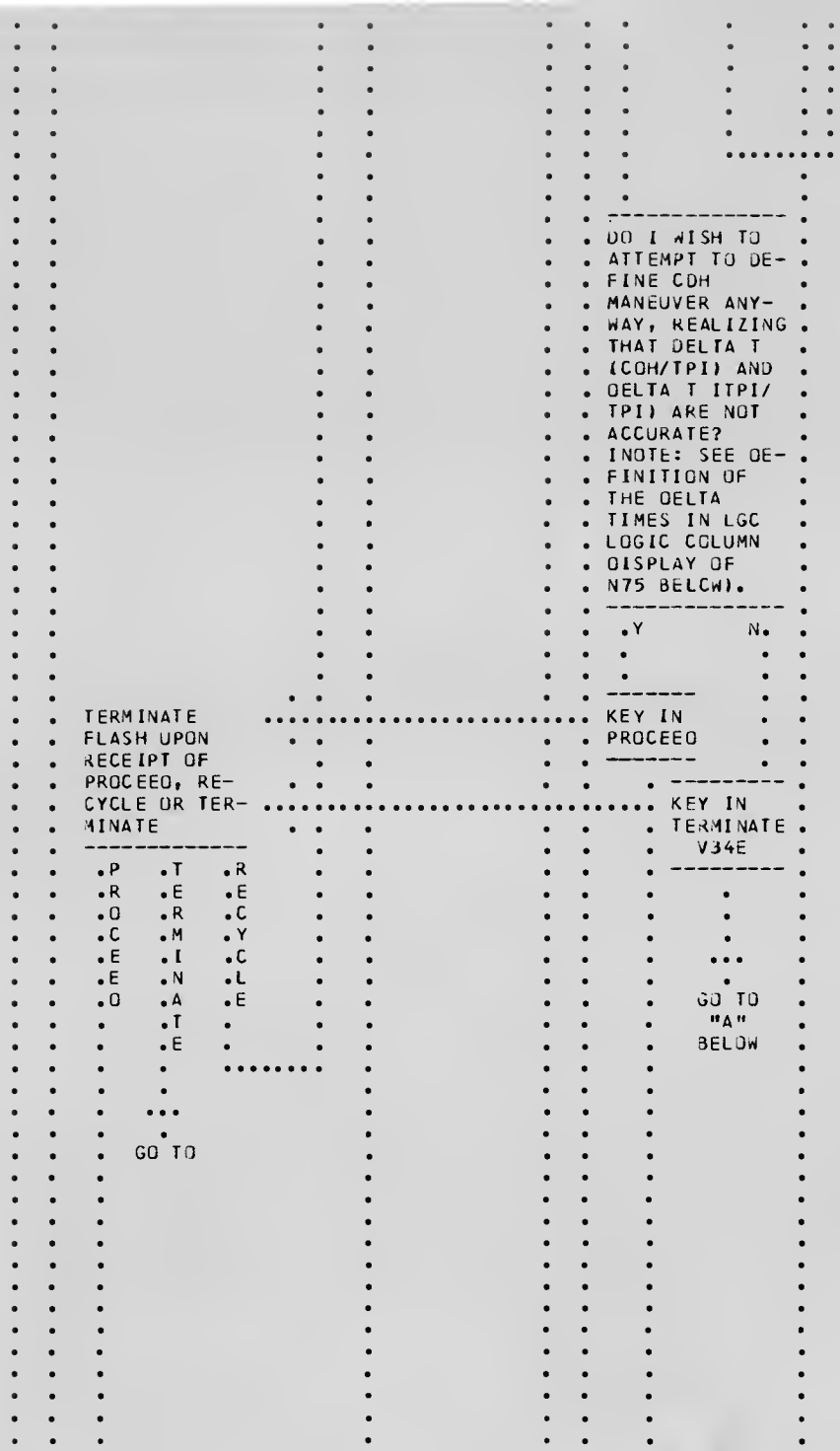
#130

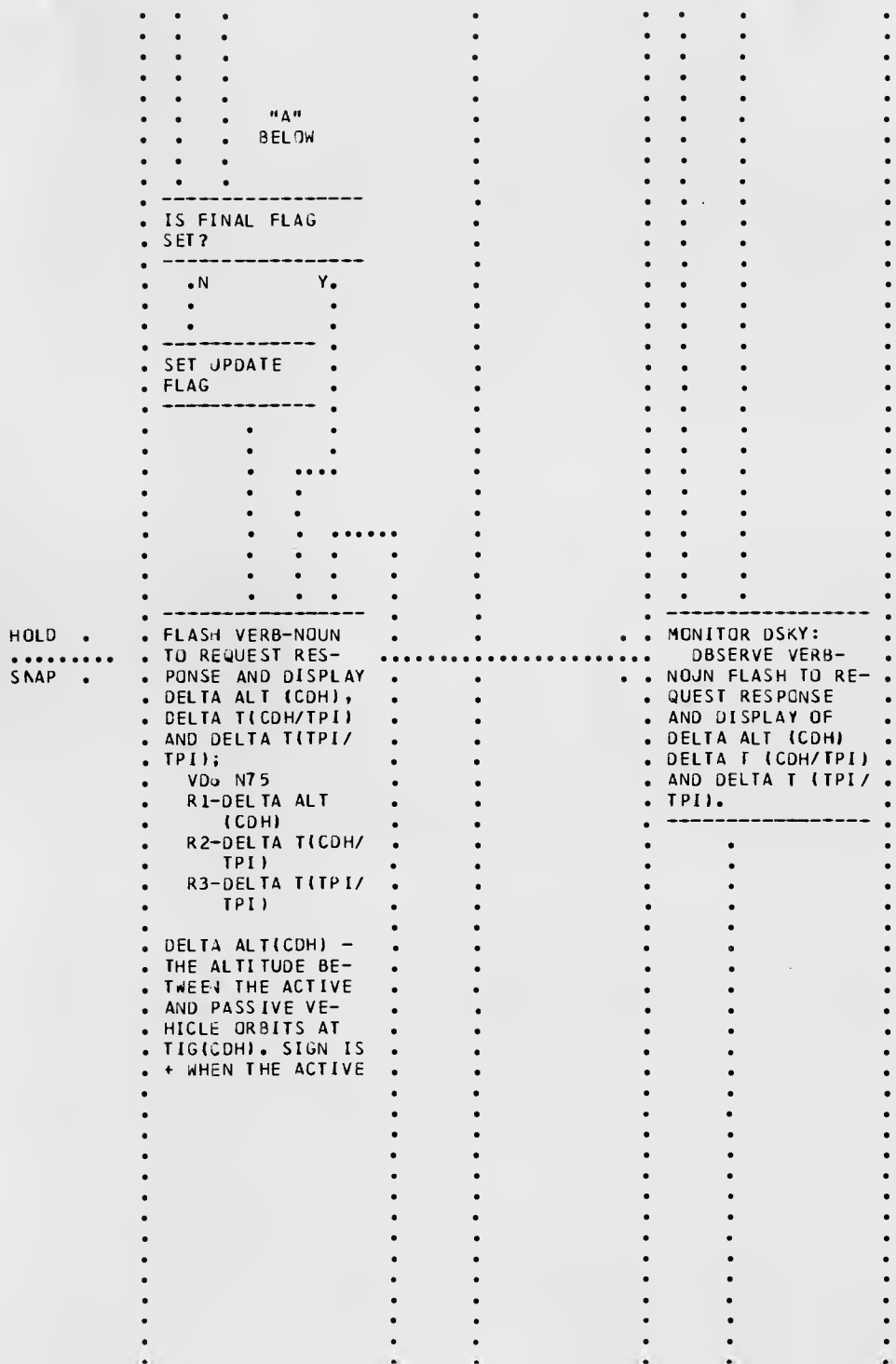
#140

#150



#160
#170
#180
#190
#200


DO I WISH TO ATTEMPT TO DEFINE CDH MANEUVER ANYWAY, REALIZING THAT DELTA T (CDH/TPI) AND DELTA T ITPI/TPI) ARE NOT ACCURATE? INOTE: SEE DEFINITION OF THE DELTA TIMES IN LGC LOGIC COLUMN DISPLAY OF N75 BELOW).
.Y
N.
KEY IN PROCEED
TERMINATE FLASH UPON RECEIPT OF PROCEED, RECYCLE OR TERMINATE
.P .R .O .C .E .E .O
.T .E .R .M .I .N .A .T .E
.R .E .C .Y .C .L .E
GO TO
KEY IN TERMINATE V34E
GO TO "A" BELOW
#210
#220
#230
#240
#250



#260

#270

#280

#290

```
                . VEHICLE IS BELOW
                . THE PASSIVE
                . VEHICLE. IN NAU-
                . TICAL MILES TO
                . NEAREST .1 NM.
                .
                . DELTA T(CDH/TPI)-
                . TIG(TPI) AS DE-
                . FINED BY THIS
                . PROGRAM MINUS
                . TIG(CDH). COM-
                . PUTED IN HRS,
                . MINS, AND SECS OF
                . WHICH ONLY THE
                . MINS AND SECS
                . ARE DISPLAYED. TO
                . NEAREST SEC.
                .
                . DELTA T(TPI/TPI)-
                . TIG(TPI) AS DE-
                . FINED BY THIS
                . PROGRAM MINUS TIG
                . (TPI) AS DEFINED
                . EARLIER BY P72.
                . COMPUTED IN HRS,
                . MINS, AND SECS OF
                . WHICH ONLY THE
                . MINS AND SECS ARE
++              . DISPLAYED. TO
+05             . NEAREST SEC.
+               . NOTE: R2 IS
+               . COMPUTED MODULO
+               . ONE HOUR IF IT IS
+               . POSITIVE, I.E.,
+               . 63 MINUTES 22
+               . SECONDS IS DIS-
+               . PLAYED AS 03822.
+               . IF IT IS NEG-
+               . ATIVE, IT IS LIM-
+               . ITED INSTEAD,
+               . I.E., -63 MINUTES
+               . 22 SECONDS IS
+               . DISPLAYED AS
+               . -59B59.
+               . R3 IS ALWAYS
+               . COMPUTED MODULO
+               . ONE HOUR.
+1180           . ----------------
++              .       .
                .       .
                .       .
                .       .
                .       .
                .       .
                .       .
                .       .
                .       .
                .       .
                .       .
                .       .
                .       .
                .       .
                .       .
                .       .
```

#300

#310

#320

#330

#340

#350

RECORD THESE VALUES FOR FUTURE TRANSMISSION TO THE CSM.

#360

WAIT FOR KEYBOARD ENTRY

TERMINATE FLASH UPON RECEIPT OF PROCEED, RECYCLE, OR TERMINATE

KEY IN PROCEED

PROCEED

TERMINATE

RECYCLE

#370

#380

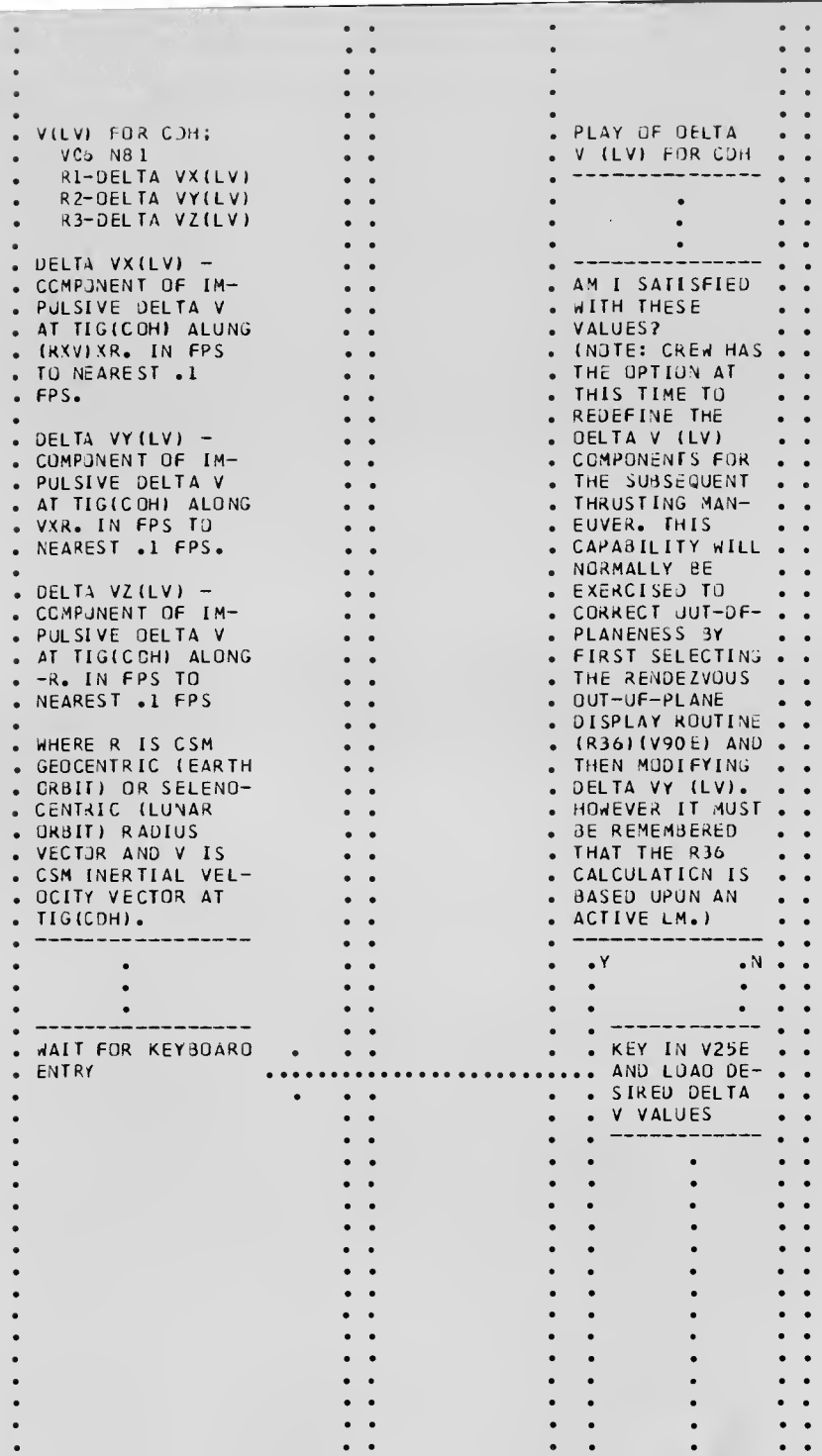
GO TO "A" BELOW

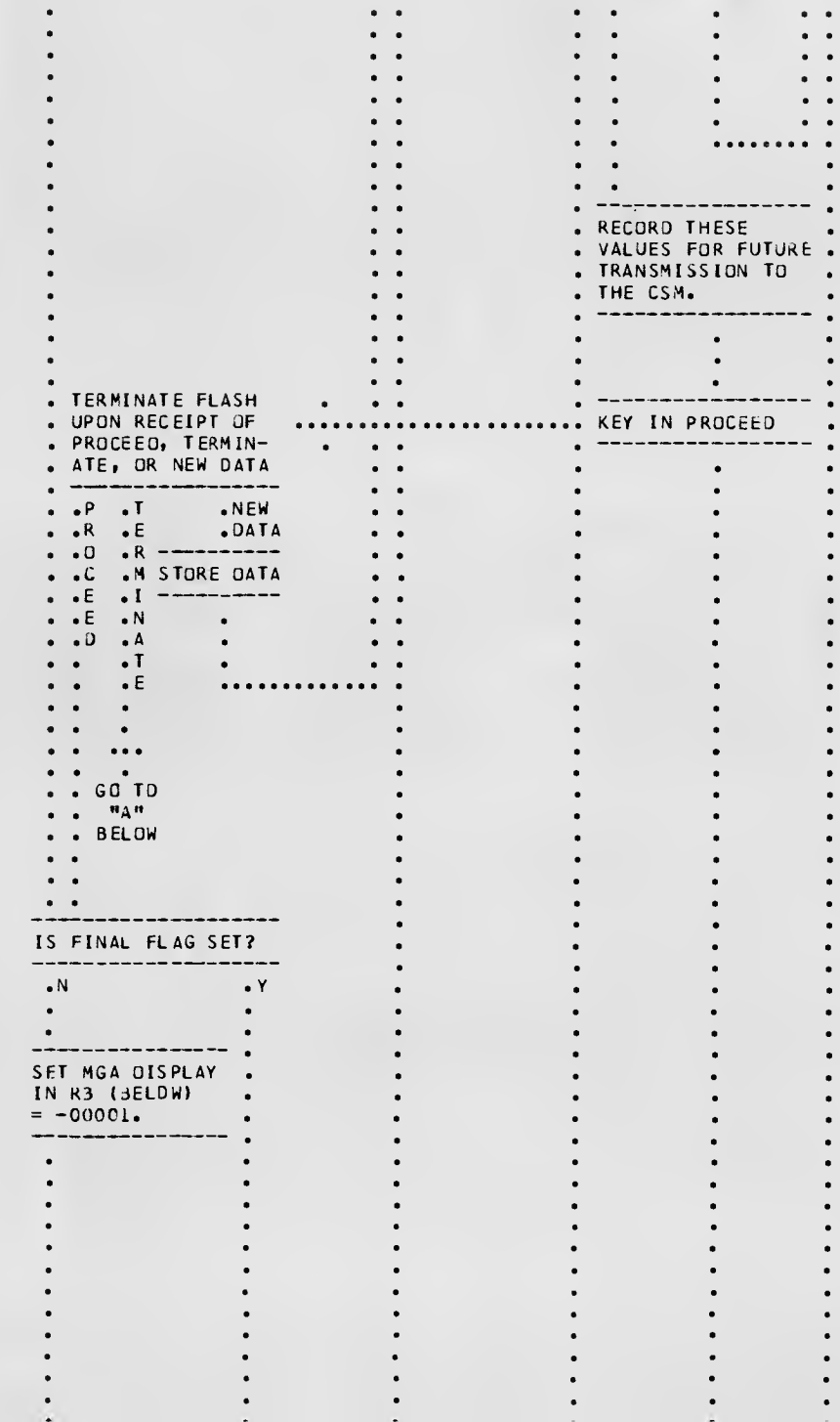
#390

HOLD SNAP

FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY CALCULATED COMPONENTS OF DELTA

MONITOR DSKY: OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DIS-


V(LV) FOR CDH;
VC5 N81
R1-DELTA VX(LV)
R2-DELTA VY(LV)
R3-DELTA VZ(LV)
DELTA VX(LV) - COMPONENT OF IMPULSIVE DELTA V AT TIG(COH) ALONG (RXV)XR. IN FPS TO NEAREST .1 FPS.
DELTA VY(LV) - COMPONENT OF IMPULSIVE DELTA V AT TIG(COH) ALONG VXR. IN FPS TO NEAREST .1 FPS.
DELTA VZ(LV) - COMPONENT OF IMPULSIVE DELTA V AT TIG(COH) ALONG -R. IN FPS TO NEAREST .1 FPS
WHERE R IS CSM GEOCENTRIC (EARTH ORBIT) OR SELENOCENTRIC (LUNAR ORBIT) RADIUS VECTOR AND V IS CSM INERTIAL VELOCITY VECTOR AT TIG(COH).
WAIT FOR KEYBOARD ENTRY
PLAY OF DELTA V (LV) FOR CDH
AM I SATISFIED WITH THESE VALUES? (NOTE: CREW HAS THE OPTION AT THIS TIME TO REDEFINE THE DELTA V (LV) COMPONENTS FOR THE SUBSEQUENT THRUSTING MANEUVER. THIS CAPABILITY WILL NORMALLY BE EXERCISED TO CORRECT OUT-OF-PLANENESS BY FIRST SELECTING THE RENDEZVOUS OUT-OF-PLANE DISPLAY ROUTINE (R36)(V90E) AND THEN MODIFYING DELTA VY (LV). HOWEVER IT MUST BE REMEMBERED THAT THE R36 CALCULATION IS BASED UPON AN ACTIVE LM.)
Y
N
KEY IN V25E AND LOAD DESIRED DELTA V VALUES
#400
#410
#420
#430
#440



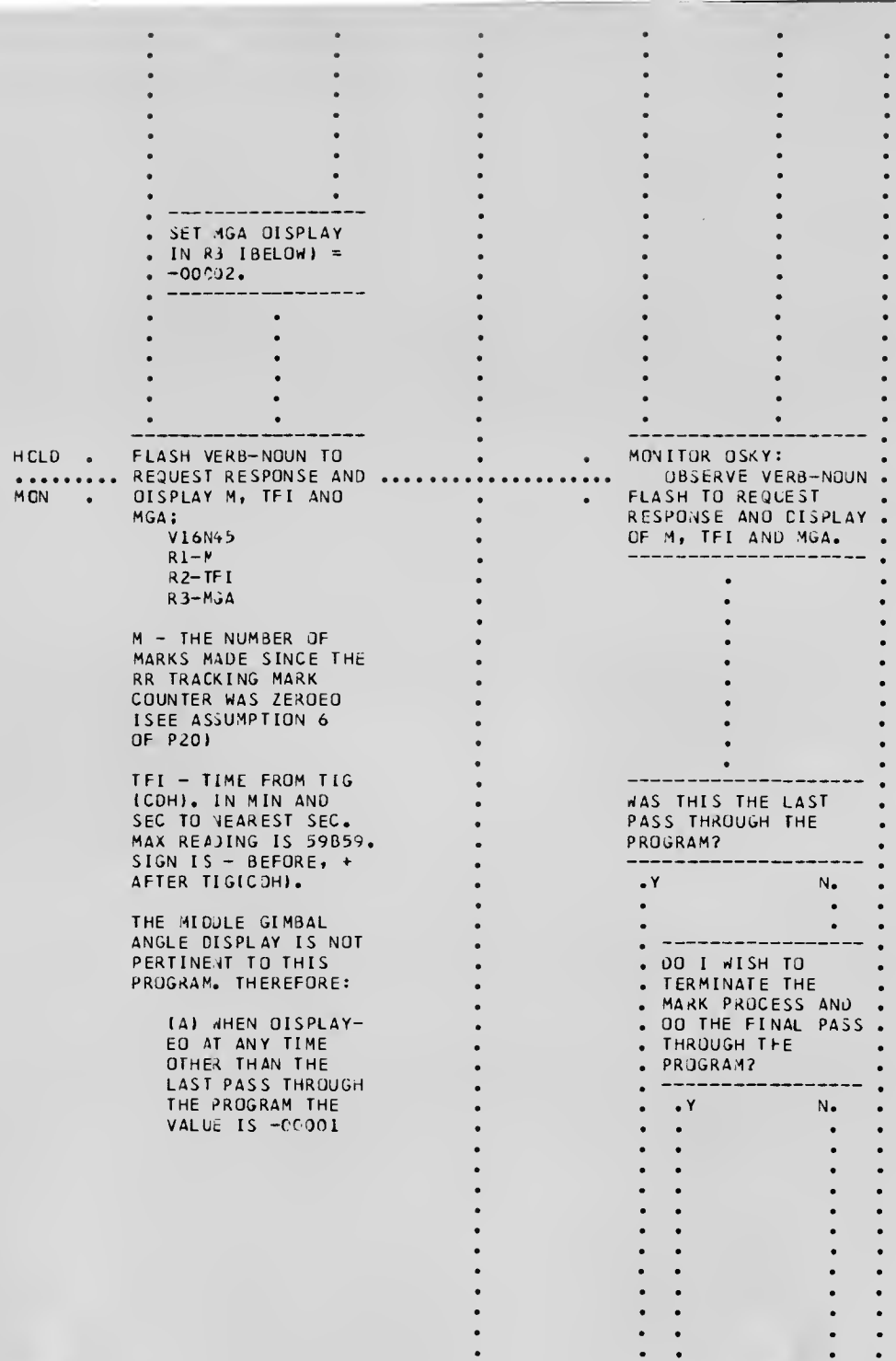
#450

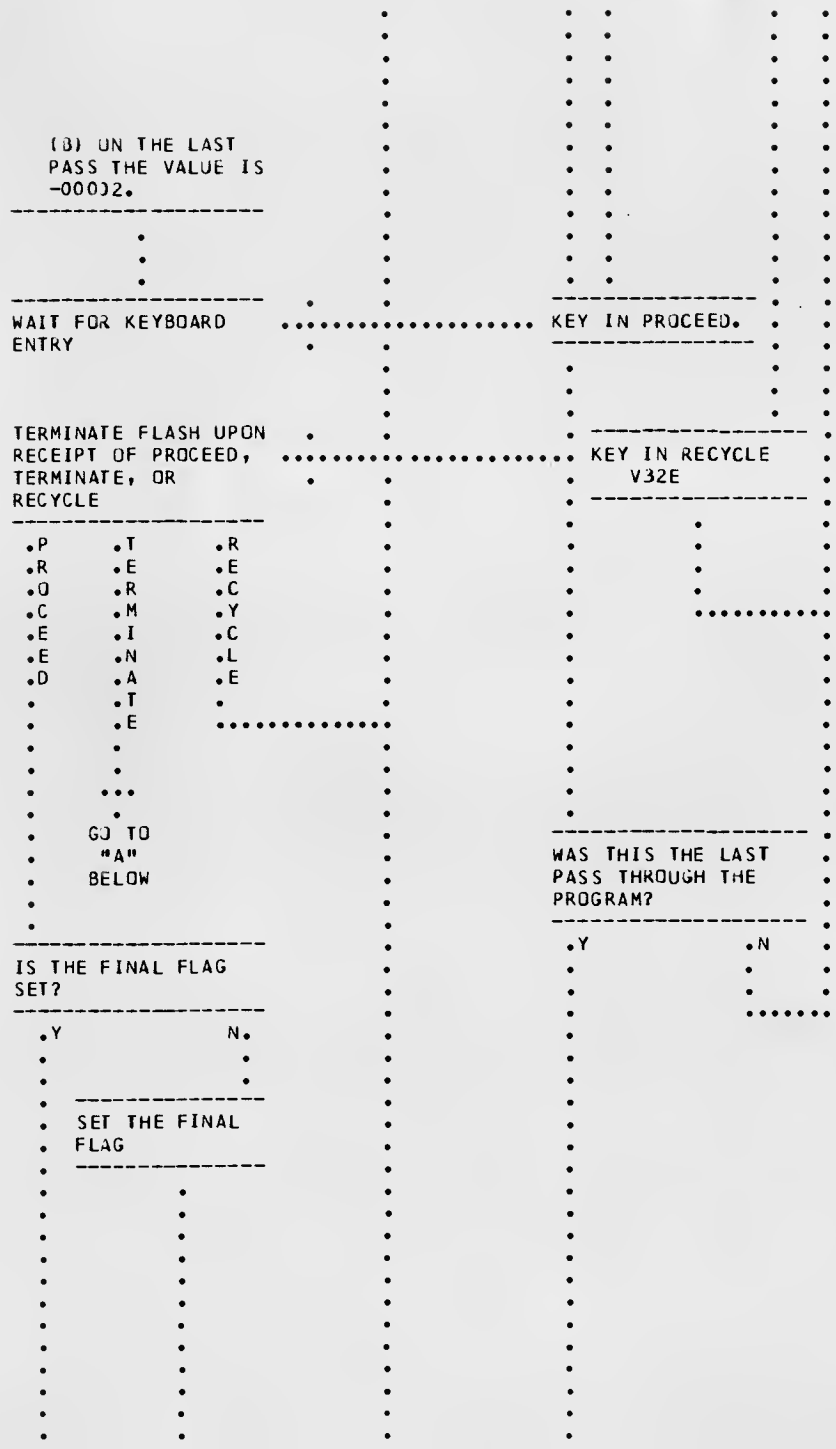
#460

#470

#480

#490


SET MGA DISPLAY IN R3 (BELOW) = -00002.
#500
#510
HOLD MON
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY M, TFI AND MGA;
V16N45
R1-M
R2-TFI
R3-MGA
M - THE NUMBER OF MARKS MADE SINCE THE RR TRACKING MARK COUNTER WAS ZEROED (SEE ASSUMPTION 6 OF P20)
TFI - TIME FROM TIG (COH). IN MIN AND SEC TO NEAREST SEC. MAX READING IS 59B59. SIGN IS - BEFORE, + AFTER TIG(COH).
THE MIDDLE GIMBAL ANGLE DISPLAY IS NOT PERTINENT TO THIS PROGRAM. THEREFORE:
(A) WHEN DISPLAYED AT ANY TIME OTHER THAN THE LAST PASS THROUGH THE PROGRAM THE VALUE IS -00001
MONITOR OSKY:
OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY OF M, TFI AND MGA.
#520
WAS THIS THE LAST PASS THROUGH THE PROGRAM?
#530
Y
N
DO I WISH TO TERMINATE THE MARK PROCESS AND DO THE FINAL PASS THROUGH THE PROGRAM?
#540
Y
N



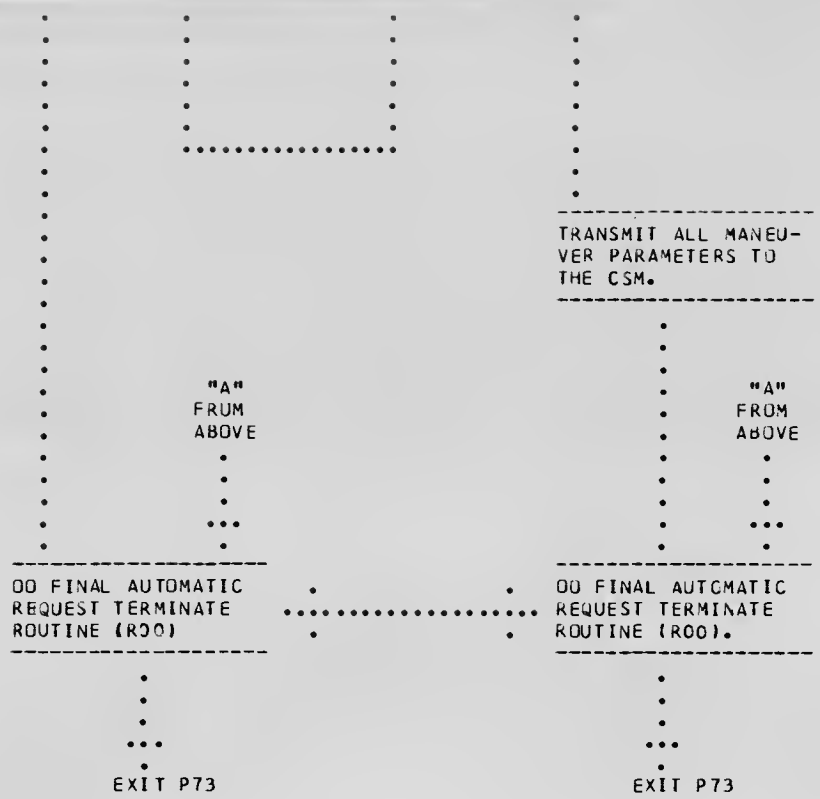
#550

#560

#570

#580

#590



#600

#610

#620

CHANGE CONTROL NOTES

LOGIC REV 01 PCR 540,623
REV 02 PCR 752, EDITORIAL
REV 03 EDITORIAL
REV 04(LUM 1D) PCN 1009
REV 05(LUM1E) PCN 1180

CSM TRANSFER PHASE INITIATION (TPI) TARGETING PROGRAM (P74) REV C5 12/01/71

PURPOSE: (1) TO CALCULATE THE REQUIRED DELTA V AND OTHER INITIAL CONDITIONS REQUIRED BY THE CMC FOR CSM EXECUTION OF THE TRANSFER PHASE INITIATION (TPI) MANEUVER, GIVEN:

(A) TIME OF IGNITION TIG (TPI) OR THE ELEVATION ANGLE (E) OF THE CSM/LM LOS AT TIG(TPI).

(B) CENTRAL ANGLE OF TRANSFER (CENTANG) FROM TIG(TPI) TO INTERCEPT TIME.

(2) TO CALCULATE TIG (TPI) GIVEN E OR E GIVEN TIG (TPI).

(3) TO CALCULATE THESE PARAMETERS BASED UPON MANEUVER DATA APPROVED AND KEYED INTO THE LGC BY THE ASTRONAUT.

(4) TO DISPLAY TO THE ASTRONAUT AND THE GROUND CERTAIN DEPENDENT VARIABLES ASSOCIATED WITH THE MANEUVER FOR APPROVAL BY THE ASTRONAUT/GROUND.

ASSUMPTIONS: (1) LGC COMPUTED VARIABLES MAY BE STORED FOR LATER VERIFICATION BY THE GROUND. THESE STORAGE CAPABILITIES ARE LIMITED ONLY TO THE PARAMETERS FOR ONE THRUSTING MANEUVER AT A TIME EXCEPT FOR CONCENTRIC FLIGHT PLAN MANEUVER SEQUENCES.

(2) THE RENDEZVOUS RADAR MAY OR MAY NOT BE USED TO UPDATE THE LM OR CSM STATE VECTORS FOR THIS PROGRAM. IF RADAR USE IS DESIRED THE RADAR SHOULD BE TURNED ON AND LOCKED ON THE CSM BY PREVIOUS SELECTION OF P20. RADAR SIGHTING MARKS WILL BE MADE AUTOMATICALLY APPROXIMATELY ONCE A MINUTE WHEN ENABLED BY THE TRACK AND UPDATE FLAGS (SEE P20). THE RENDEZVOUS TRACKING MARK COUNTER IS ZEROED BY THE SELECTION OF P20 AND AFTER EACH THRUSTING MANEUVER.

(3) THERE IS NO REQUIREMENT FOR ISS OPERATION DURING THIS PROGRAM UNLESS AUTOMATIC STATE VECTOR UPDATING IS DESIRED BY THE RENDEZVOUS NAVIGATION PROGRAM (P20). IF SELECTED, P20 WILL DEFINE THE STATUS OF THE ISS.

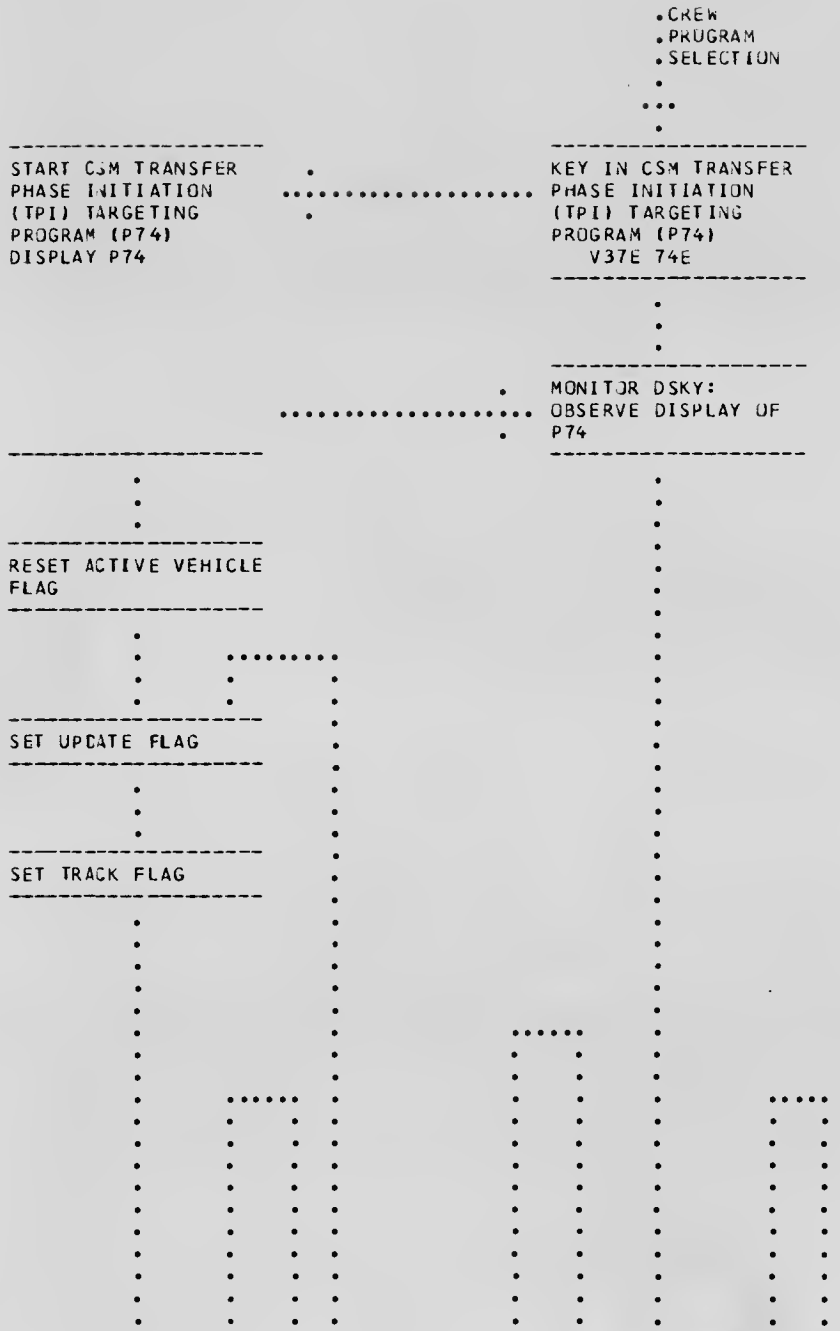
(4) ONCE THE PARAMETERS REQUIRED FOR COMPUTATION OF THE MANEUVER HAVE BEEN COMPLETELY SPECIFIED, THE VALUE OF THE ACTIVE VEHICLE CENTRAL ANGLE OF TRANSFER IS COMPUTED AND STORED. THIS NUMBER WILL BE AVAILABLE FOR DISPLAY TO THE ASTRONAUT THROUGH THE USE OF V06N52.

THE ASTRONAUT WOULD CALL THIS DISPLAY TO VERIFY THAT THE CENTRAL ANGLE OF TRANSFER OF THE ACTIVE VEHICLE IS NOT WITHIN 170 TO 190 DEGREES. IF THE ANGLE IS WITHIN THIS ZONE THE ASTRONAUT SHOULD REASSESS THE INPUT TARGETING PARAMETERS BASED UPON DELTA V AND EXPECTED MANEUVER TIME.

++ (5) THIS PROGRAM IS SELECTED BY THE ASTRONAUT BY DSKY ENTRY.
+05
+1180 (6) THE DELTA V IN LOS COORDINATES (N59) IS AVAILABLE AT FL V16 N45 AFTER EACH COMPUTATION CYCLE.
++

PROG	LGC	GROUND	CREW

CONT



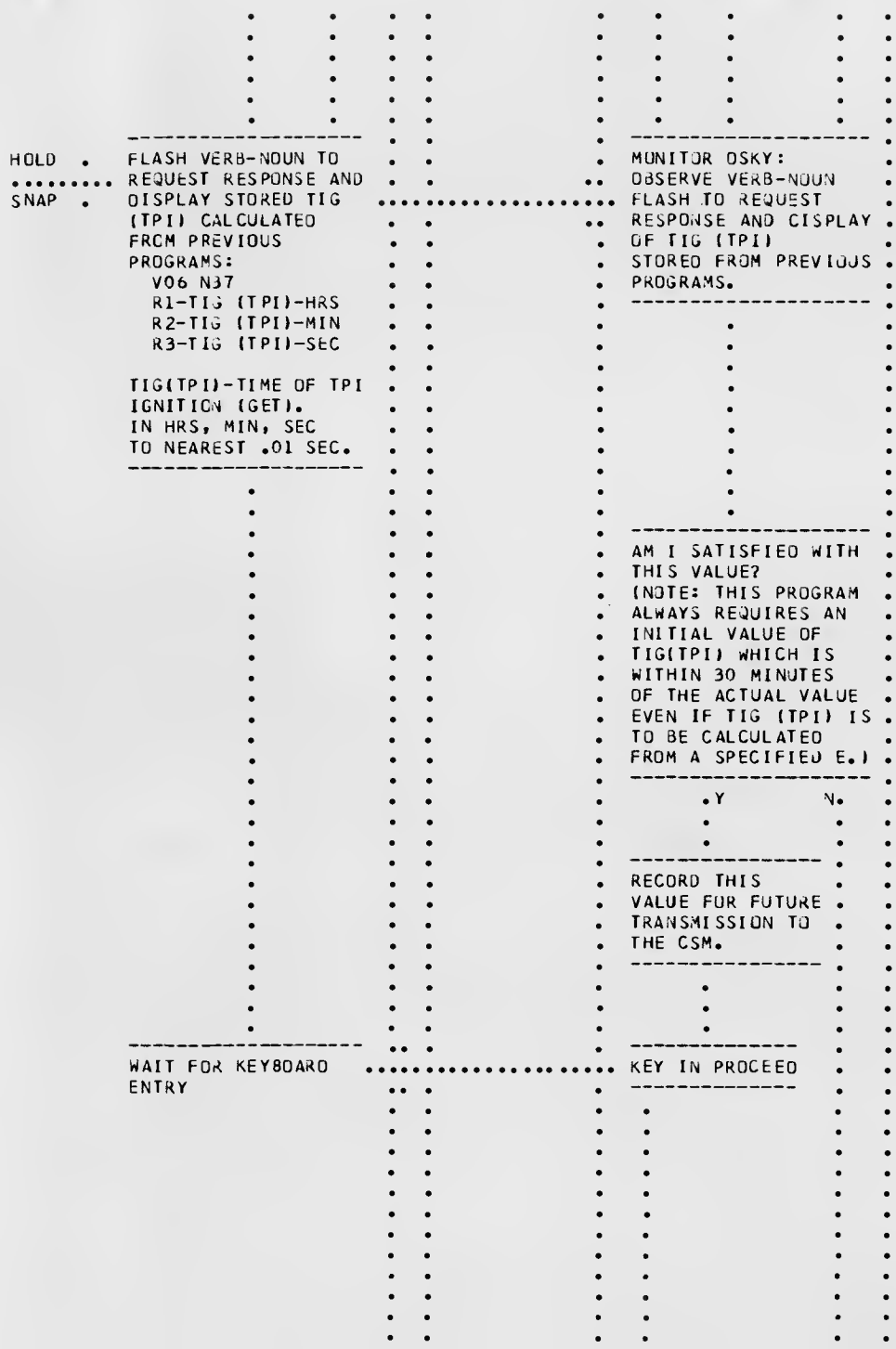
#10

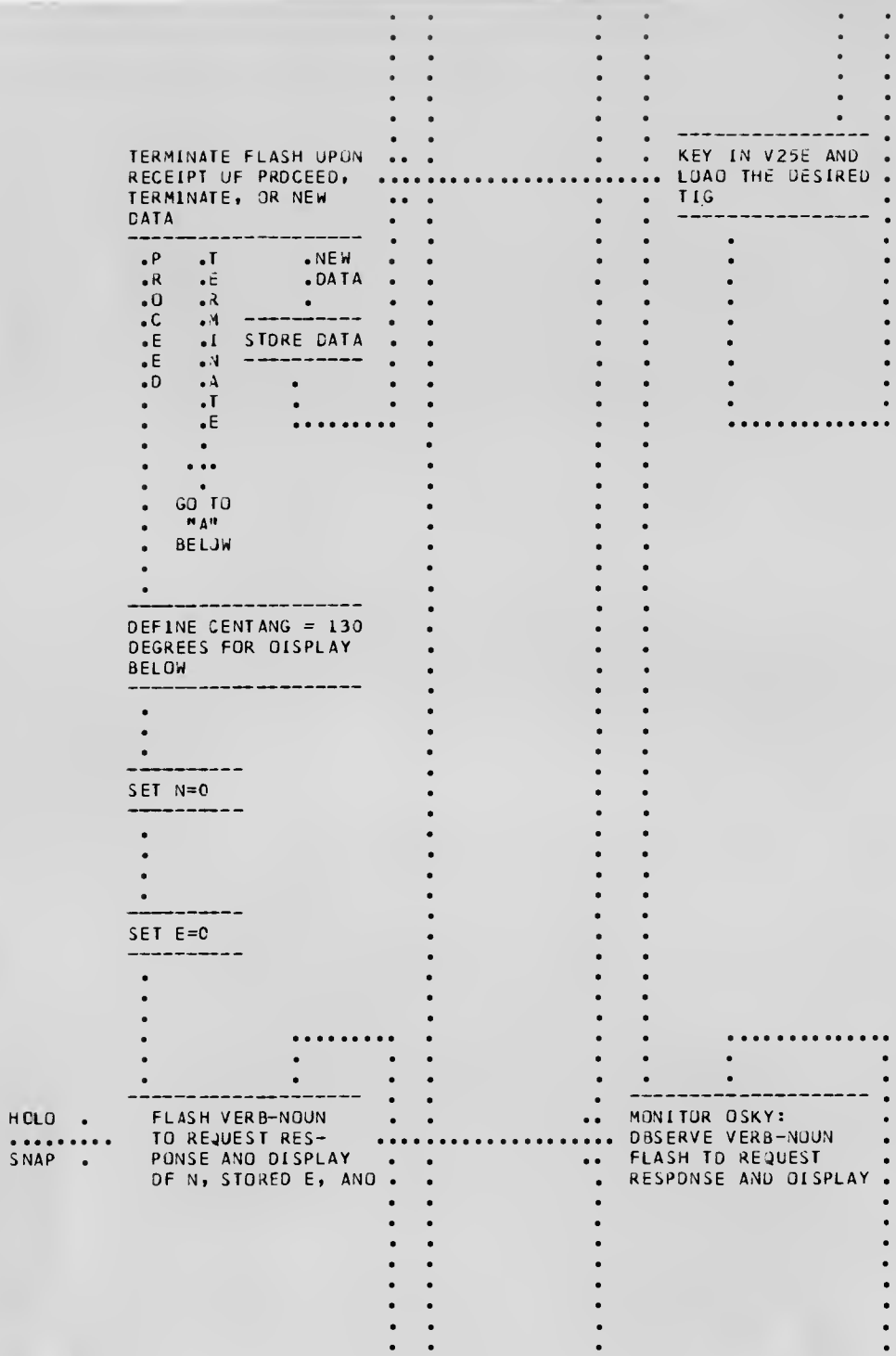
#20

#30

#40

#50


HOLD
SNAP
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY STORED TIG (TPI) CALCULATED FROM PREVIOUS PROGRAMS:
V06 N37
R1-TIG (TPI)-HRS
R2-TIG (TPI)-MIN
R3-TIG (TPI)-SEC
TIG(TPI)-TIME OF TPI IGNITION (GET). IN HRS, MIN, SEC TO NEAREST .01 SEC.
WAIT FOR KEYBOARD ENTRY
MONITOR OSKY: OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY OF TIG (TPI) STORED FROM PREVIOUS PROGRAMS.
AM I SATISFIED WITH THIS VALUE? (NOTE: THIS PROGRAM ALWAYS REQUIRES AN INITIAL VALUE OF TIG(TPI) WHICH IS WITHIN 30 MINUTES OF THE ACTUAL VALUE EVEN IF TIG (TPI) IS TO BE CALCULATED FROM A SPECIFIED E.)
Y
N
RECORD THIS VALUE FOR FUTURE TRANSMISSION TO THE CSM.
KEY IN PROCEED
#60
#70
#80
#90
#100



#110

#120

#130

#140

#150

CENTANG:
  V06 N55
  R1-N
  R2-E
  R3-CENTANG

N-THE FUTURE APSIDAL CROSSING (APOCENTER OR PERICENTER) OF THE ACTIVE VEHICLE AT WHICH TIG(COH) SHOULD OCCUR.
  00001=FIRST
  00002=SECOND
  ETC.
(NOTE: IN THIS CASE, N IS THE NUMBER OF TARGET OFFSETS. WHEN N IS ZERO, USE CONIC INTEGRATION TO DETERMINE THE INITIAL POSITION AND VELOCITY OF THE TARGET AT INTERCEPT TIME. WHEN N IS NON-ZERO, USE PRECISION INTEGRATION AND THE INDICATED NUMBER OF OFFSETS.
  00000-KEPLER CONIC INTEGRATION WITH NO TARGET OFFSET

  00001-PRECISION INTEGRATION WITH ONE TARGET OFFSET

  00002-PRECISION INTEGRATION

OF N, STORED E AND CENTANG:

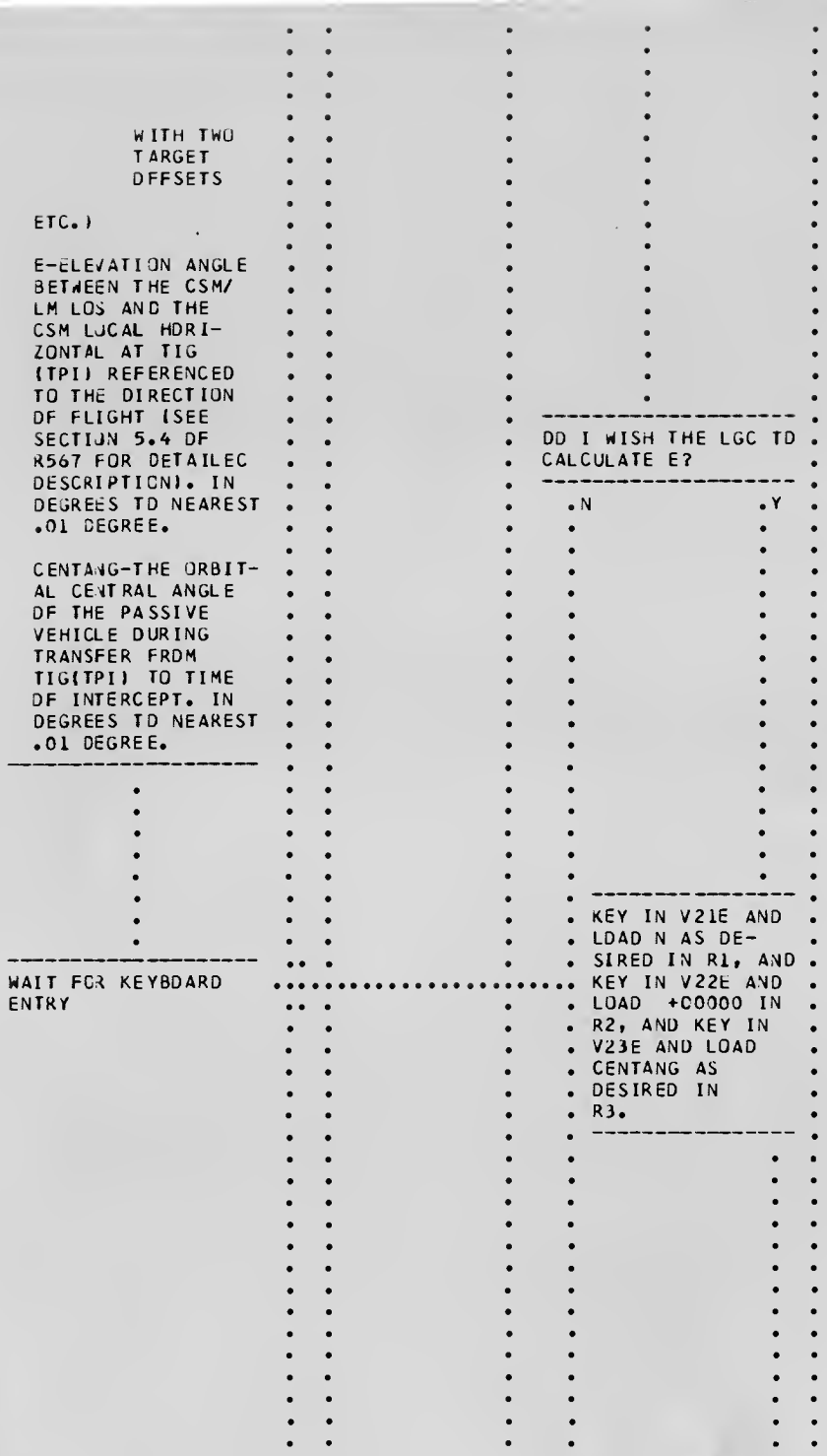
#160

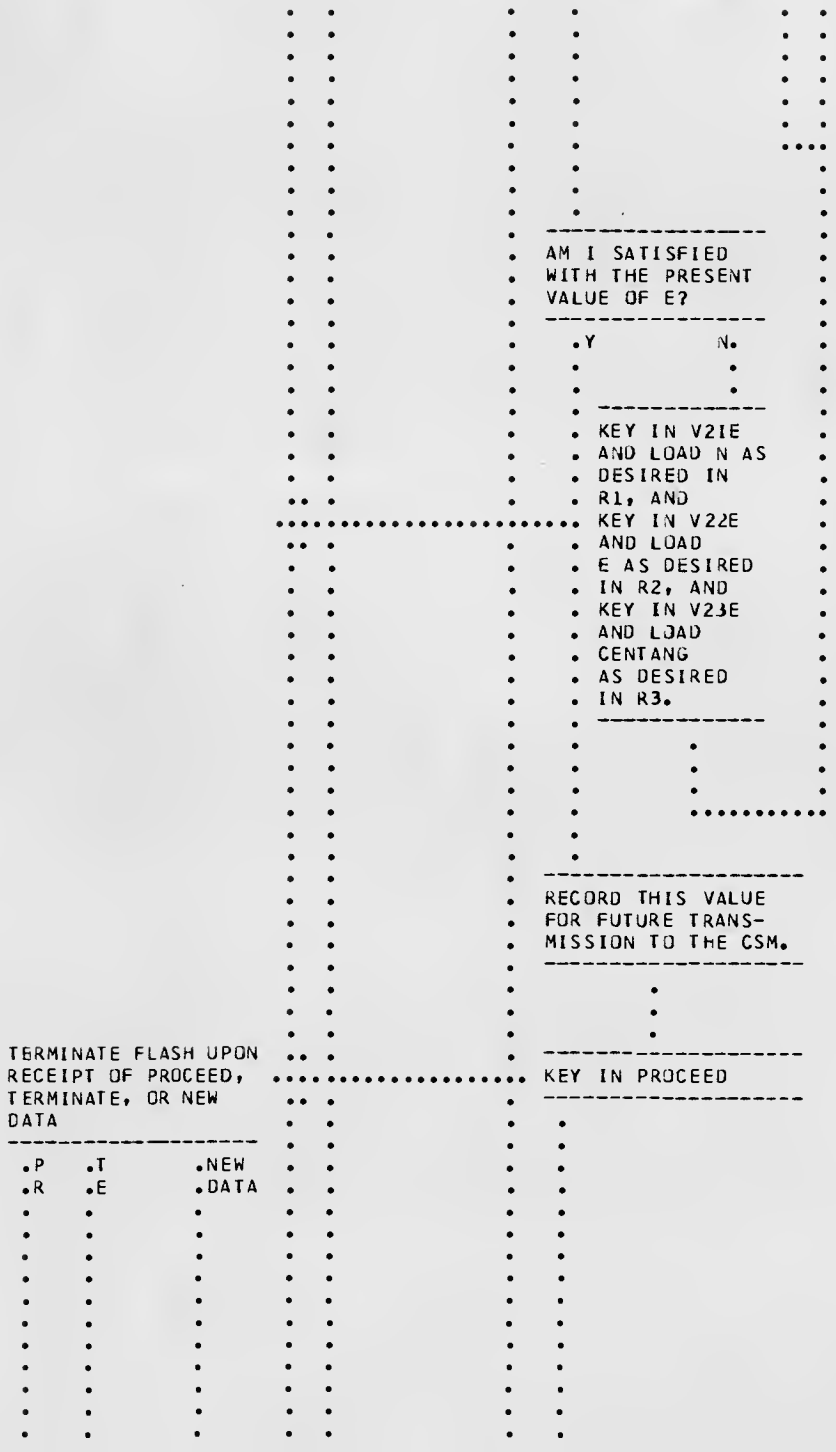
#170

#180

#190

#200


WITH TWO TARGET OFFSETS
ETC.)
E-ELEVATION ANGLE BETWEEN THE CSM/LM LOS AND THE CSM LOCAL HORIZONTAL AT TIG (TPI) REFERENCED TO THE DIRECTION OF FLIGHT (SEE SECTION 5.4 OF R567 FOR DETAILED DESCRIPTION). IN DEGREES TO NEAREST .01 DEGREE.
CENTANG-THE ORBITAL CENTRAL ANGLE OF THE PASSIVE VEHICLE DURING TRANSFER FROM TIG(TPI) TO TIME OF INTERCEPT. IN DEGREES TO NEAREST .01 DEGREE.
WAIT FOR KEYBOARD ENTRY
DO I WISH THE LGC TO CALCULATE E?
N
Y
KEY IN V21E AND LOAD N AS DESIRED IN R1, AND KEY IN V22E AND LOAD +C0000 IN R2, AND KEY IN V23E AND LOAD CENTANG AS DESIRED IN R3.
#210
#220
#230
#240
#250



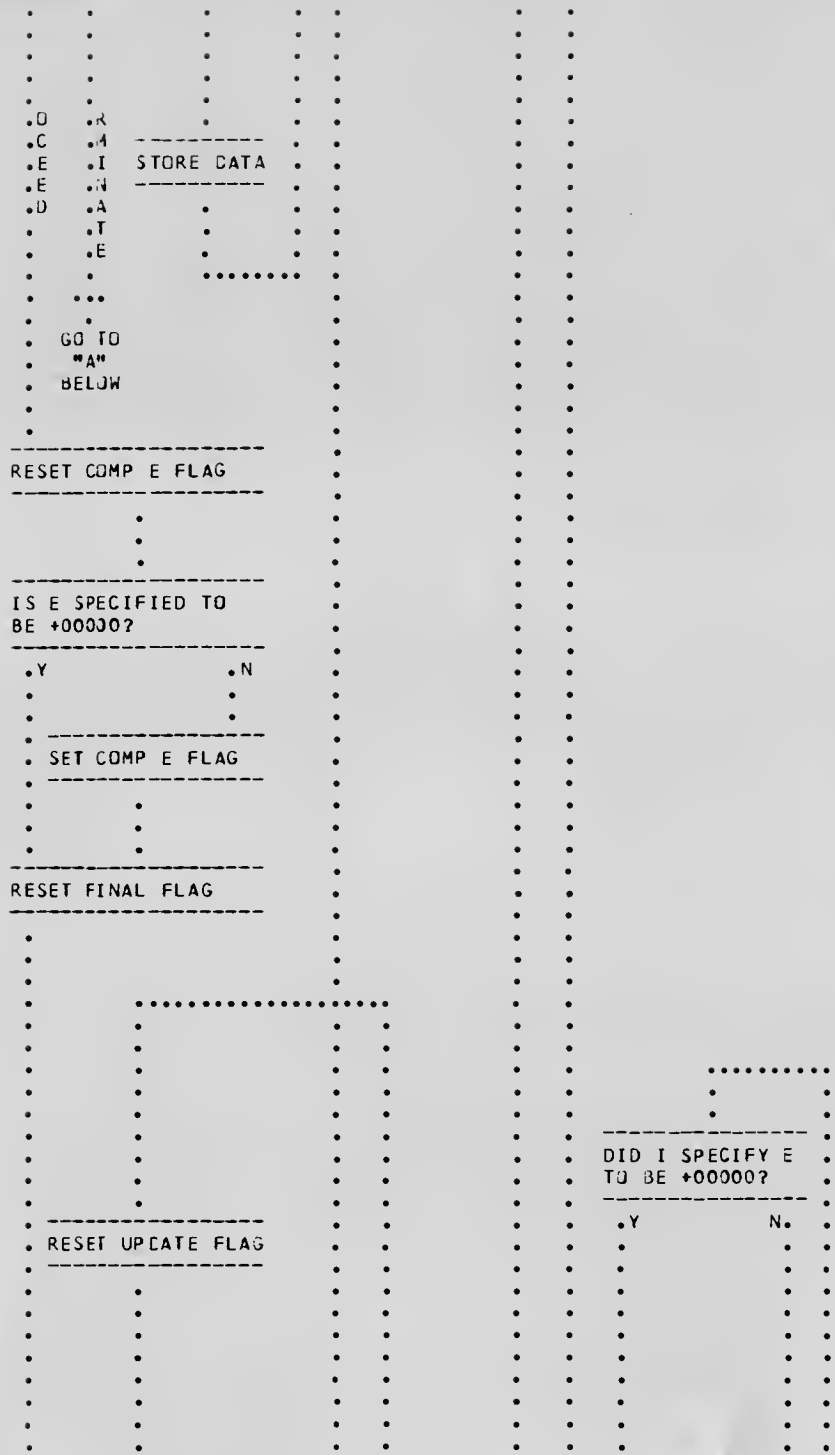
#260

#270

#280

#290

#300



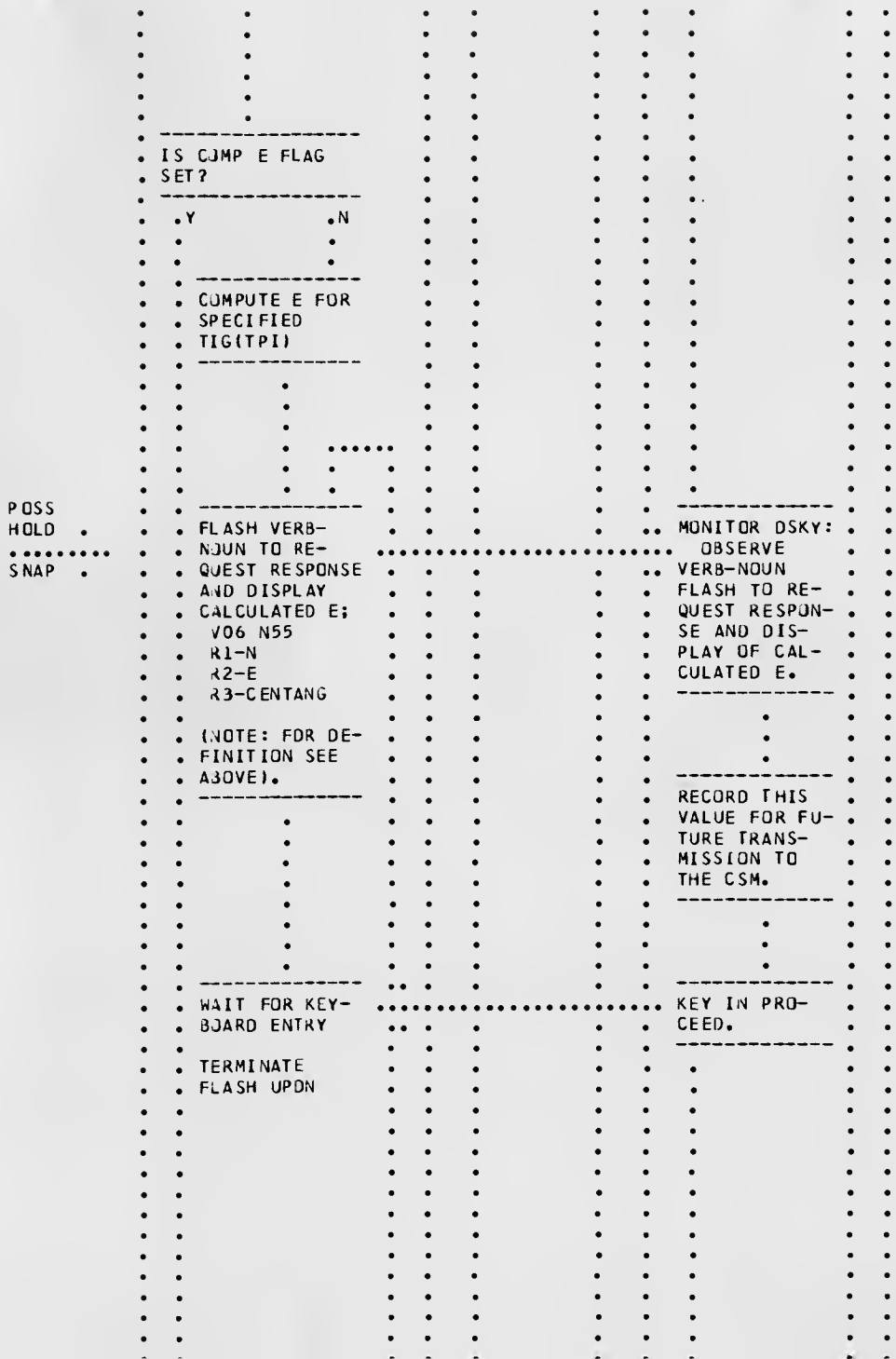
#310

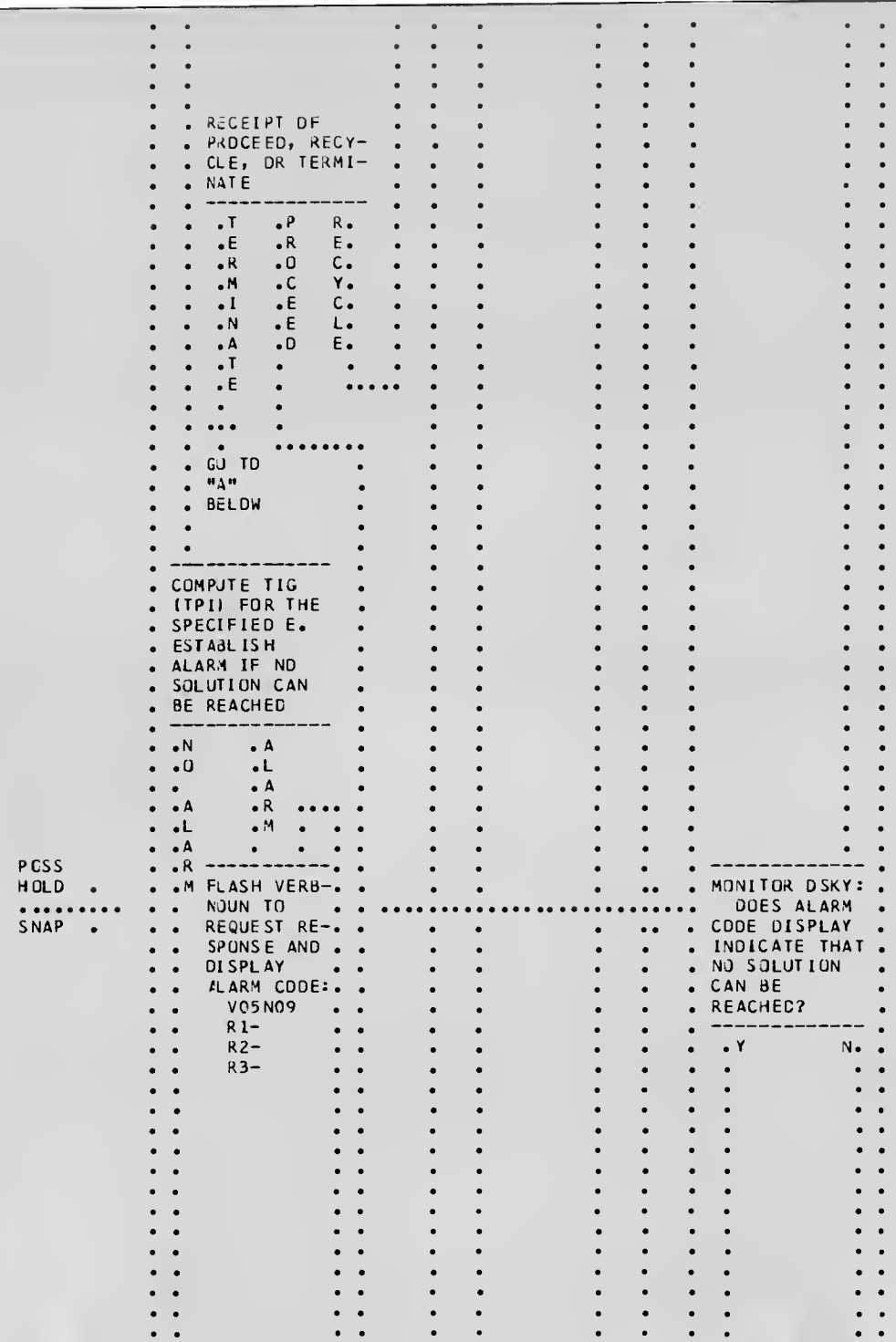
#320

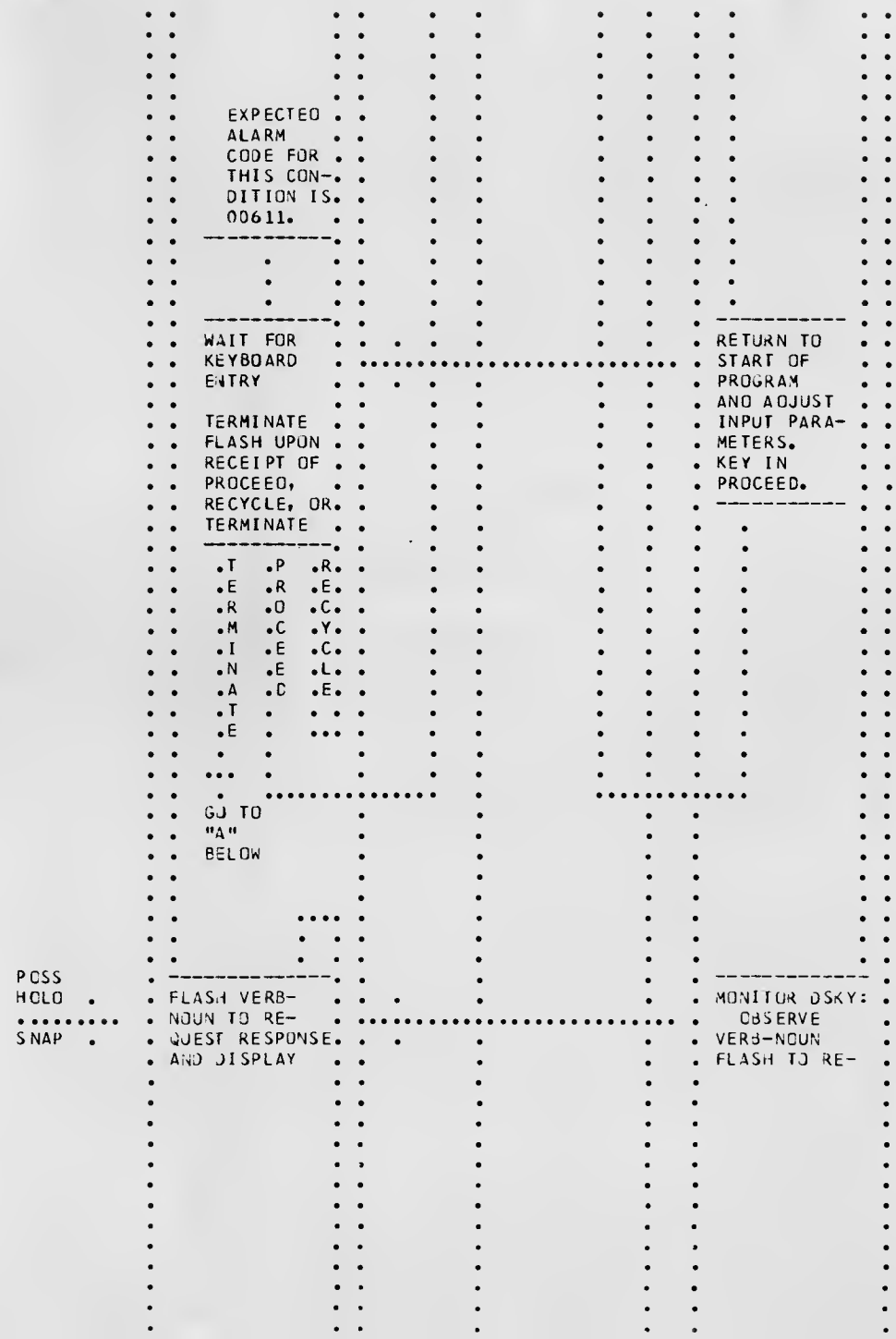
#330

#340

#350


IS COMP E FLAG SET?
Y
N
COMPUTE E FOR SPECIFIED TIG(TPI)
POSS HOLD
SNAP
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY CALCULATED E;
V06 N55
R1-N
R2-E
R3-CENTANG
(NOTE: FOR DEFINITION SEE ABOVE).
WAIT FOR KEYBOARD ENTRY
TERMINATE FLASH UPON
MONITOR DSKY: OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY OF CALCULATED E.
RECORD THIS VALUE FOR FUTURE TRANSMISSION TO THE CSM.
KEY IN PROCEED.
#360
#370
#380
#390
#400


RECEIPT OF PROCEED, RECYCLE, OR TERMINATE
TERMINATE
PROCEED
RECYCLE
GO TO "A" BELOW
COMPUTE TIG (TPI) FOR THE SPECIFIED E. ESTABLISH ALARM IF NO SOLUTION CAN BE REACHED
NO
ALARM
PROCEED
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY ALARM CODE:
V05N09
R1-
R2-
R3-
MONITOR DSKY: DOES ALARM CODE DISPLAY INDICATE THAT NO SOLUTION CAN BE REACHED?
Y
N
#410
#420
#430
#440
#450
PROCEED
HOLD
SNAP

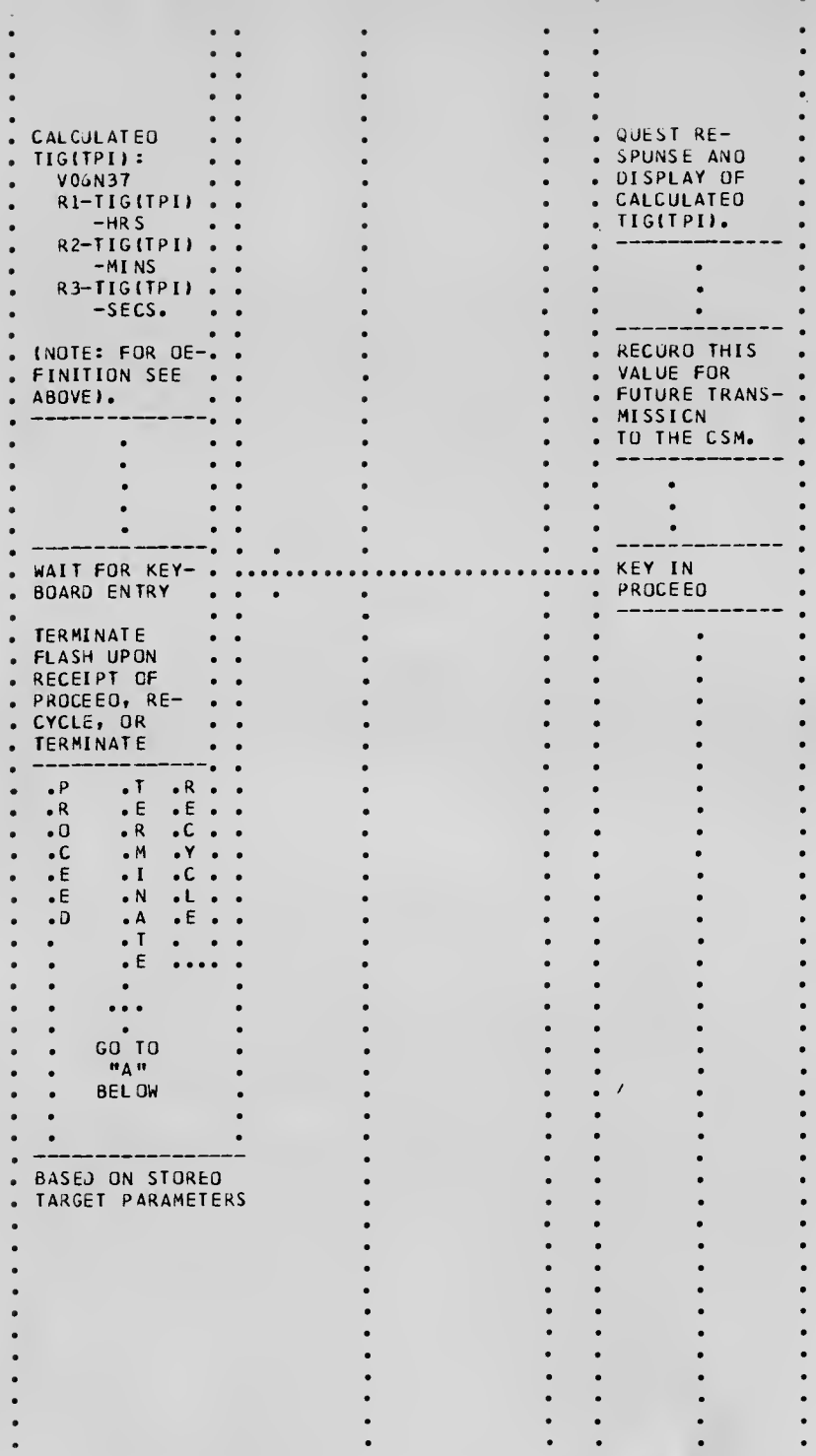


#460

#470

#480

#490



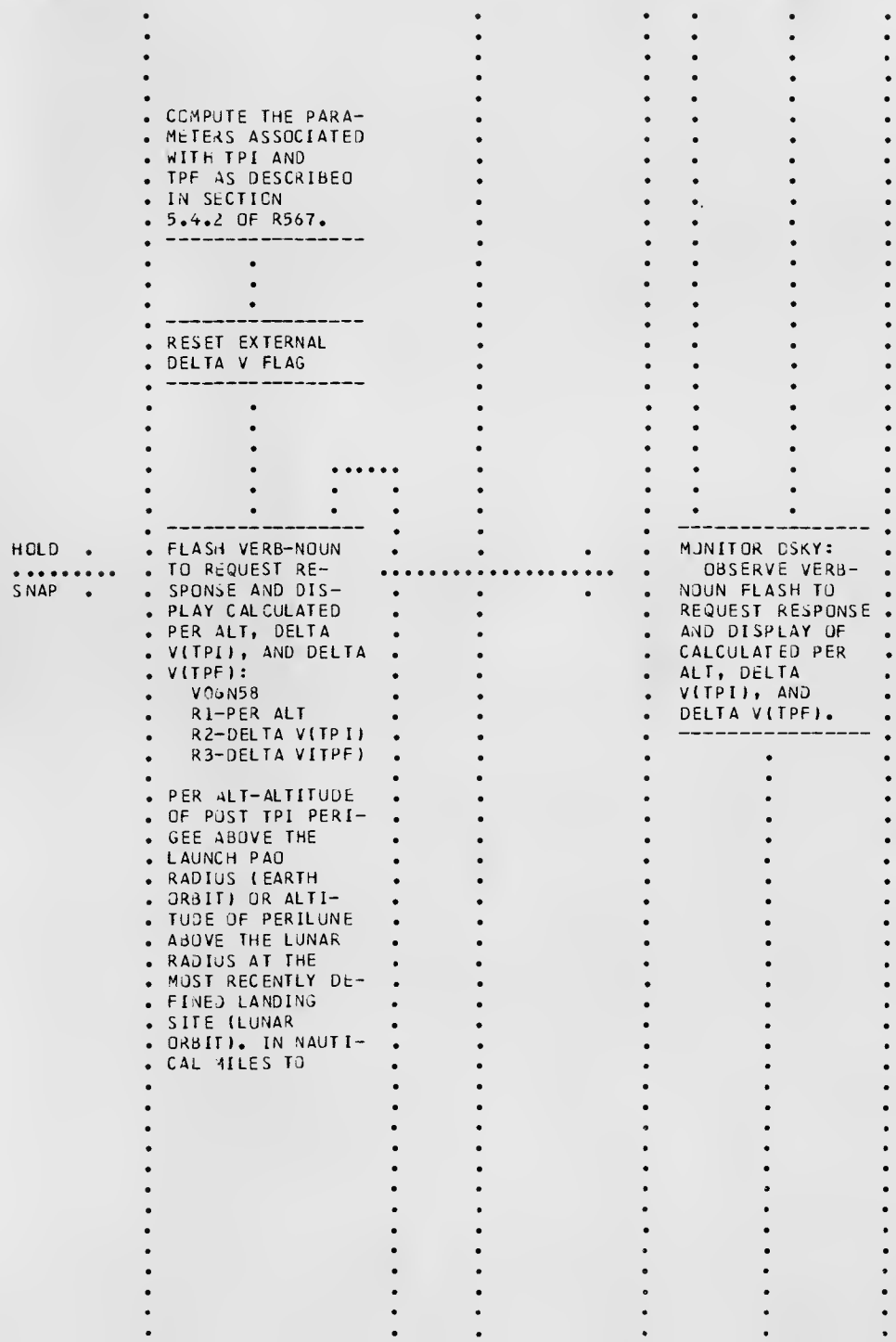
#500

#510

#520

#530

#540



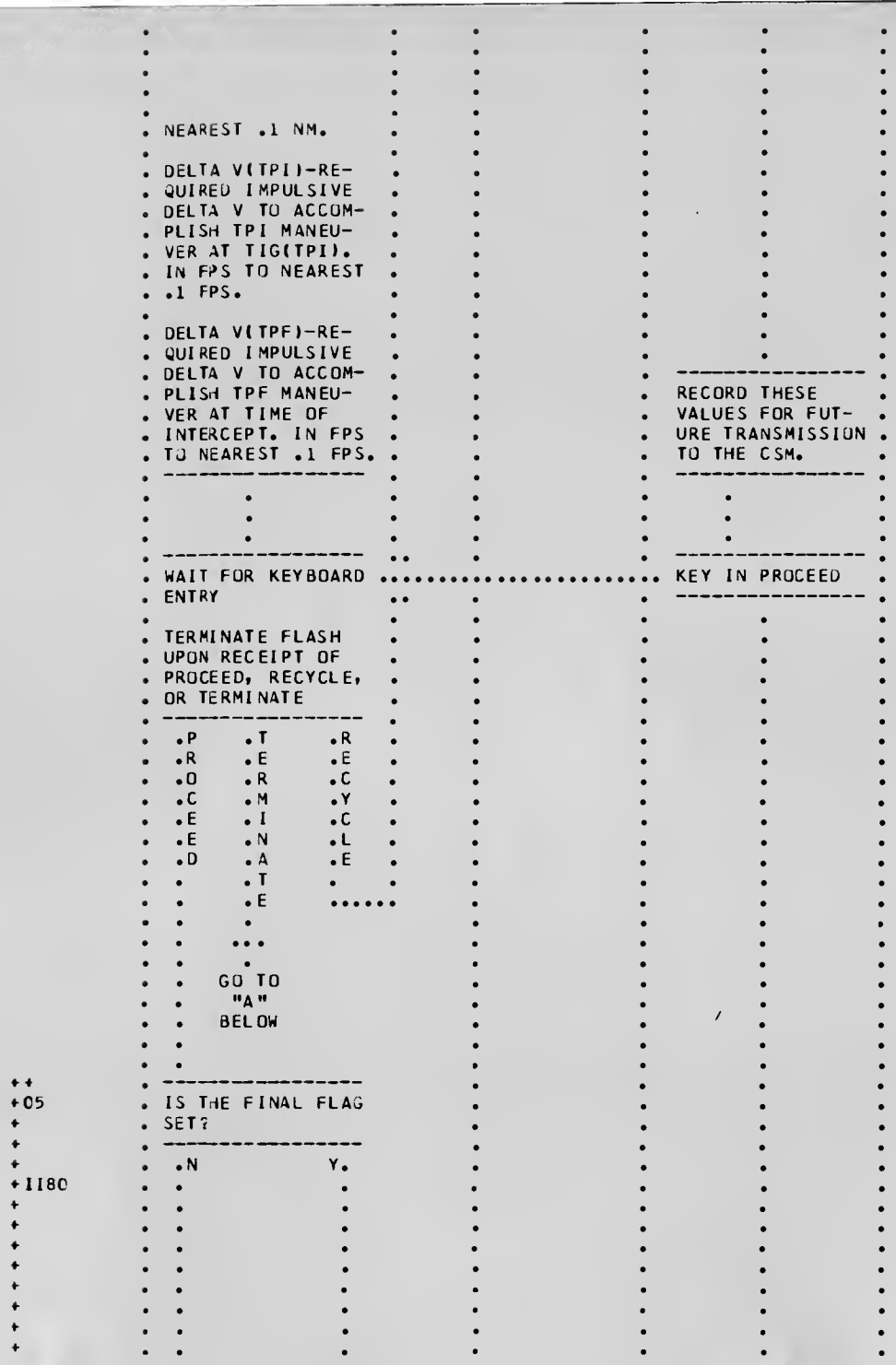
#550

#560

#570

#580

#590


NEAREST .1 NM.
DELTA V(TPI)-REQUIRED IMPULSIVE DELTA V TO ACCOMPLISH TPI MANEUVER AT TIG(TPI). IN FPS TO NEAREST .1 FPS.
DELTA V(TPF)-REQUIRED IMPULSIVE DELTA V TO ACCOMPLISH TPF MANEUVER AT TIME OF INTERCEPT. IN FPS TO NEAREST .1 FPS.
RECORD THESE VALUES FOR FUTURE TRANSMISSION TO THE CSM.
WAIT FOR KEYBOARD ENTRY
KEY IN PROCEED
TERMINATE FLASH UPON RECEIPT OF PROCEED, RECYCLE, OR TERMINATE
.PROCEED
.RECYCLE
.TERMINATE
GO TO "A" BELOW
IS THE FINAL FLAG SET?
.N
Y.
#600
#610
#620
#630
#640
+05
+1180

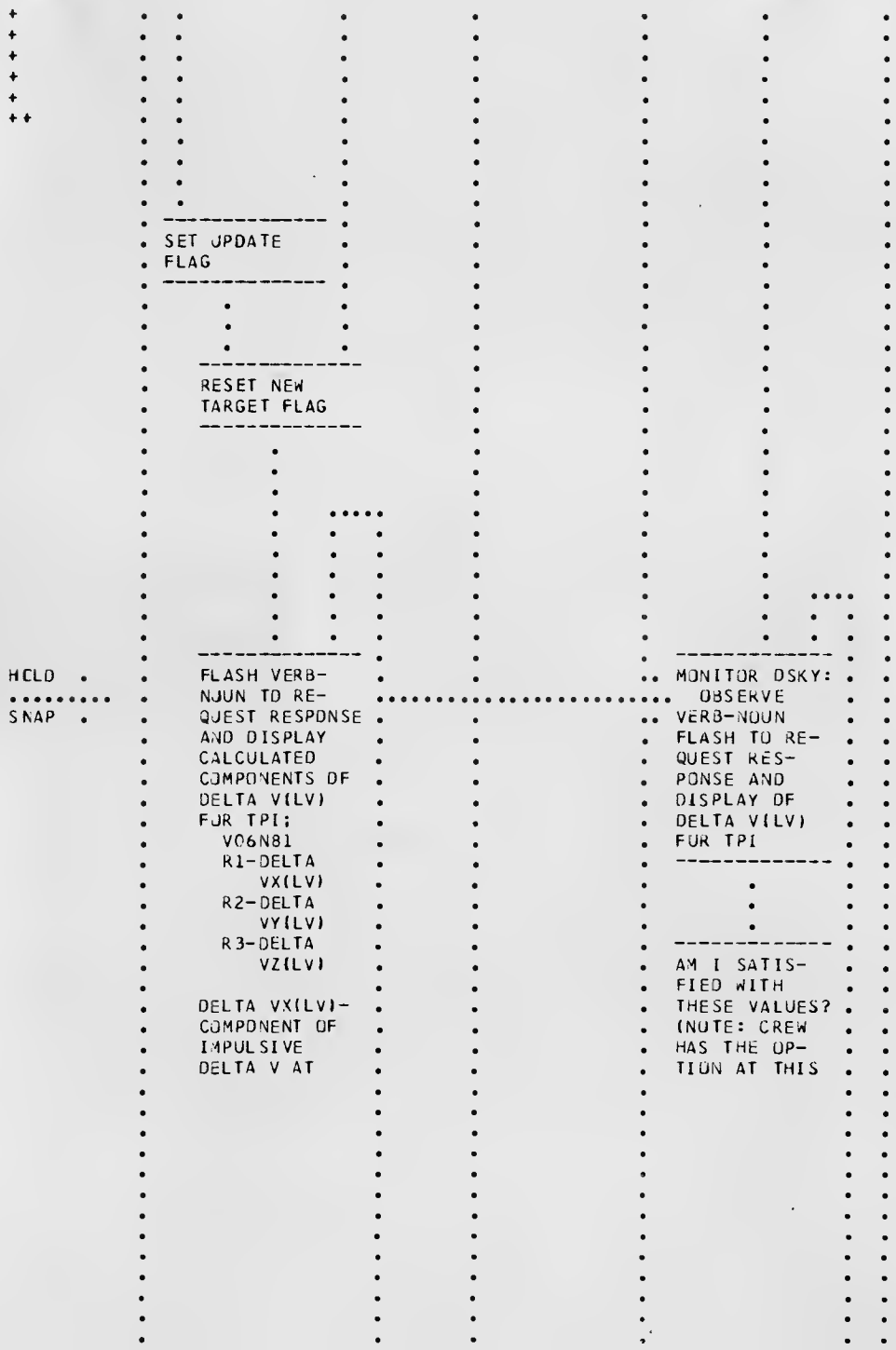
#650

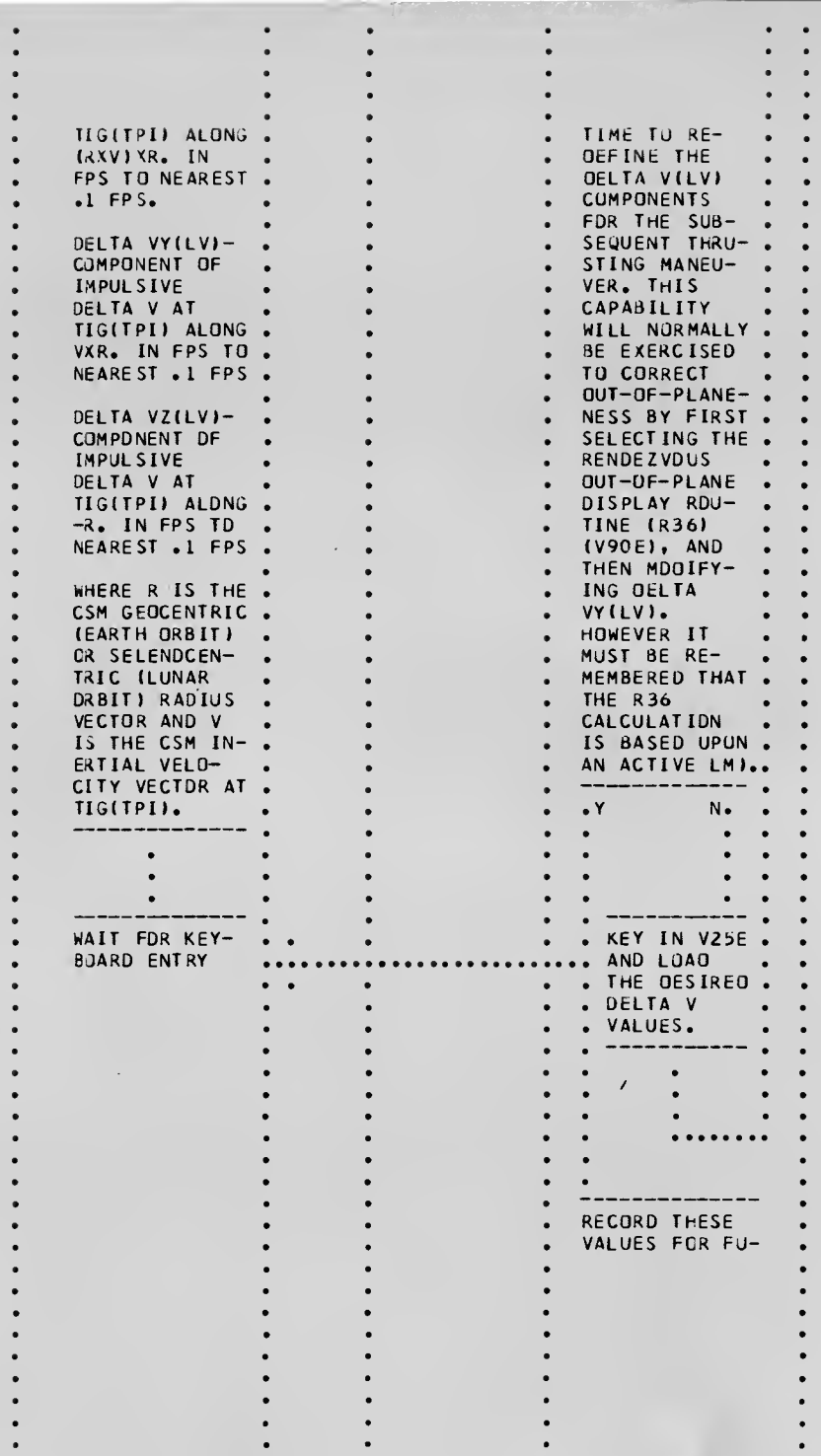
#660

#670

#680

#690





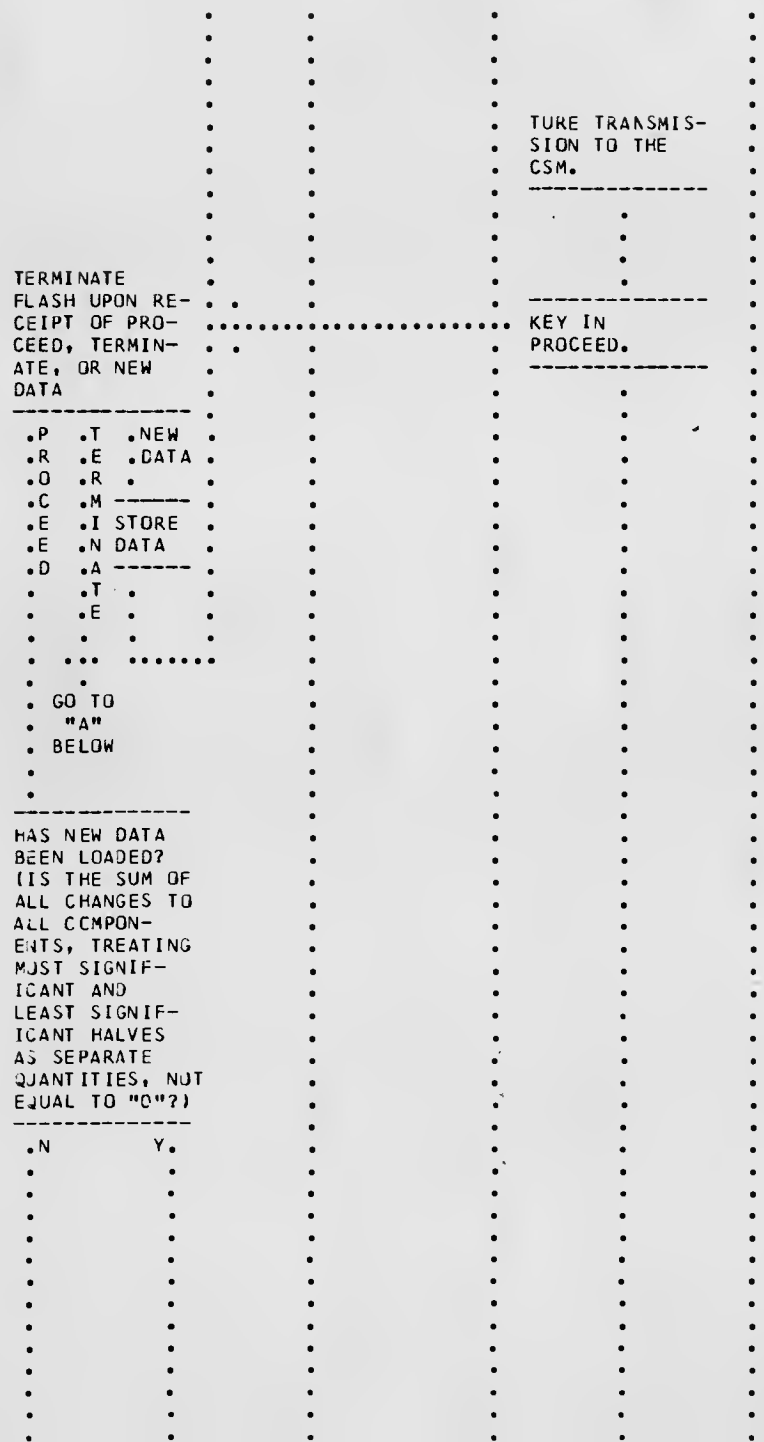
#700

#710

#720

#730

#740



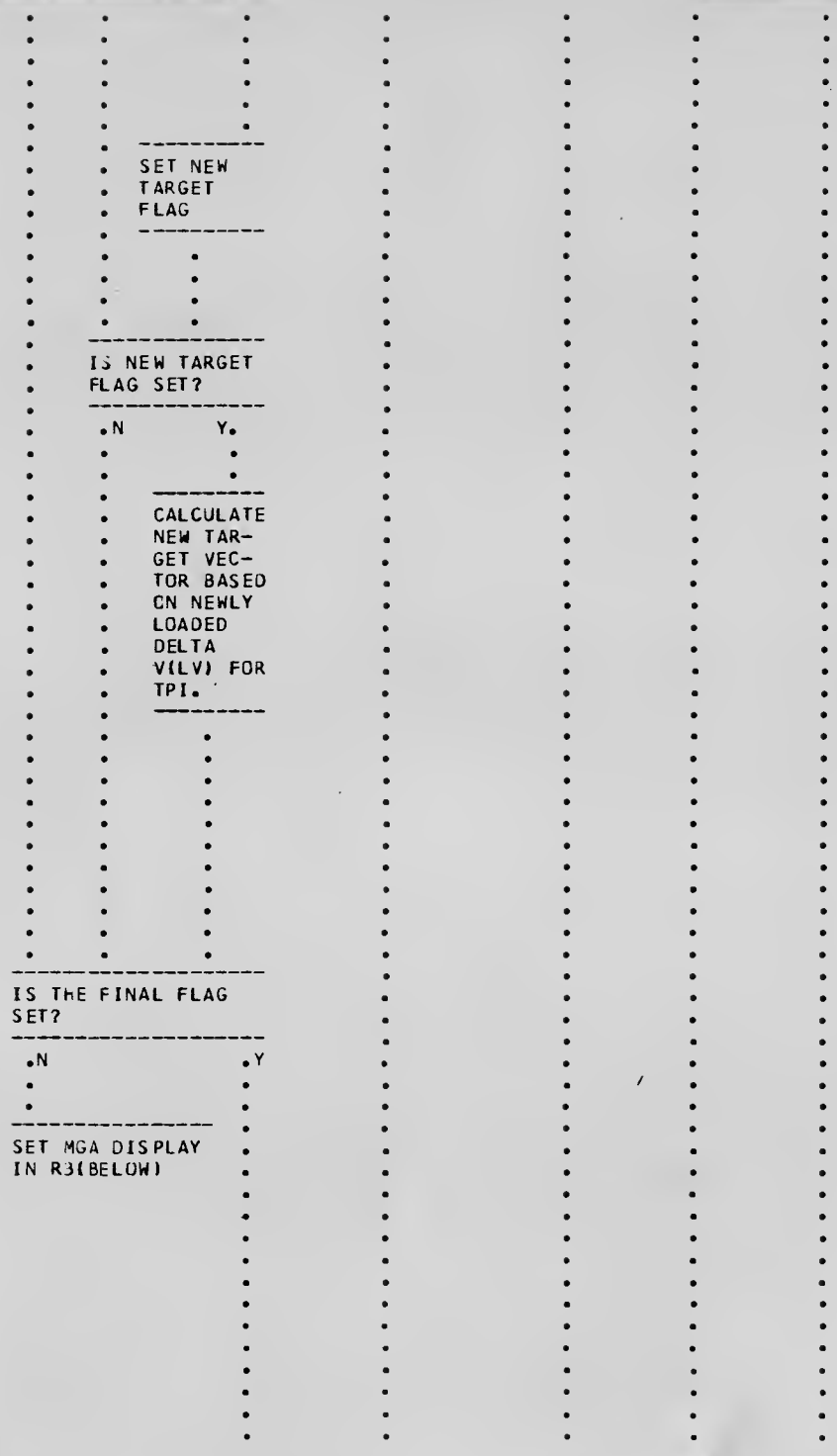
#750

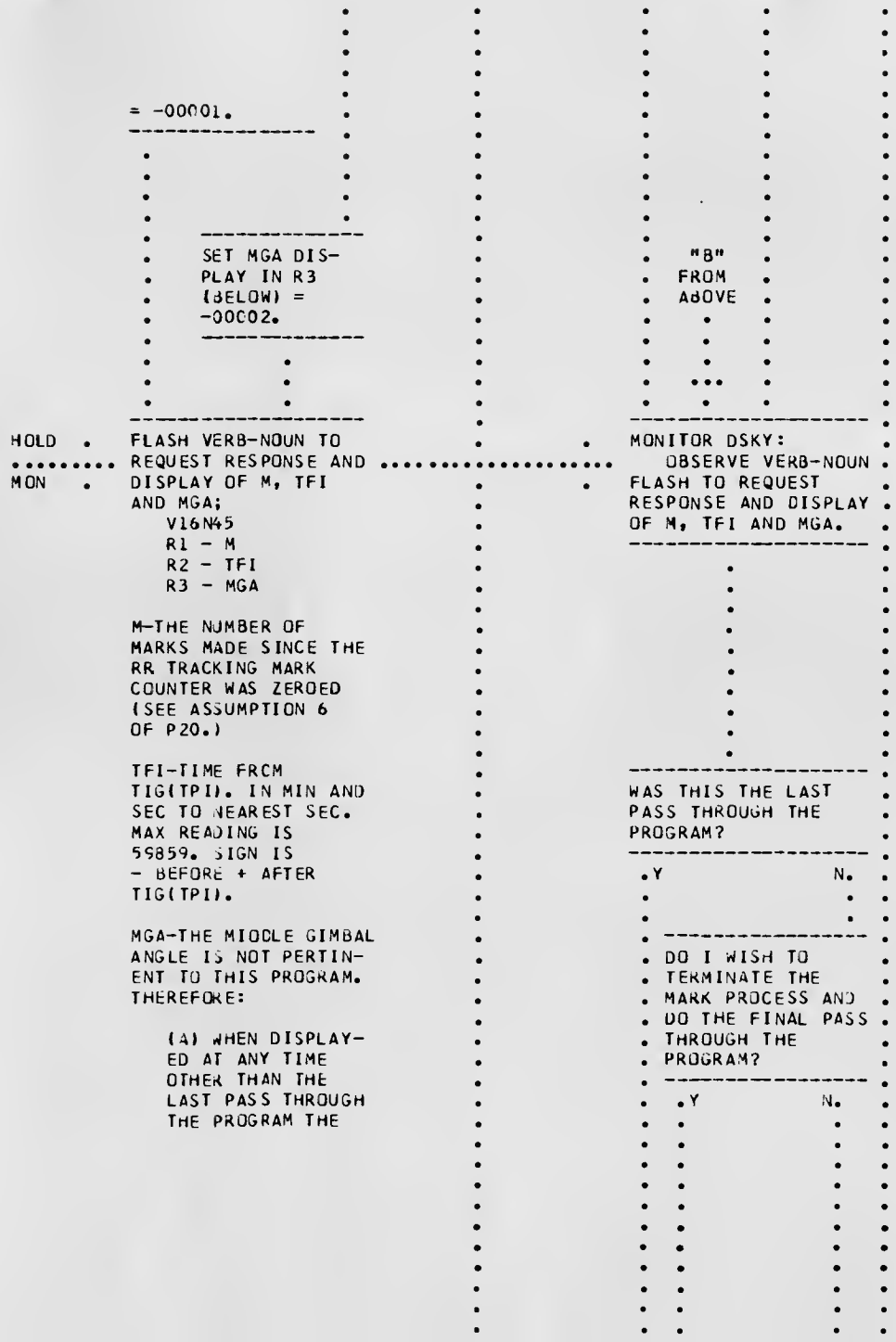
#760

#770

#780

#790


SET NEW TARGET FLAG
#800
IS NEW TARGET FLAG SET?
N
Y
#810
CALCULATE NEW TARGET VECTOR BASED ON NEWLY LOADED DELTA V(LV) FOR TPI.
#820
#830
IS THE FINAL FLAG SET?
N
Y
#840
SET MGA DISPLAY IN R3(BELOW)



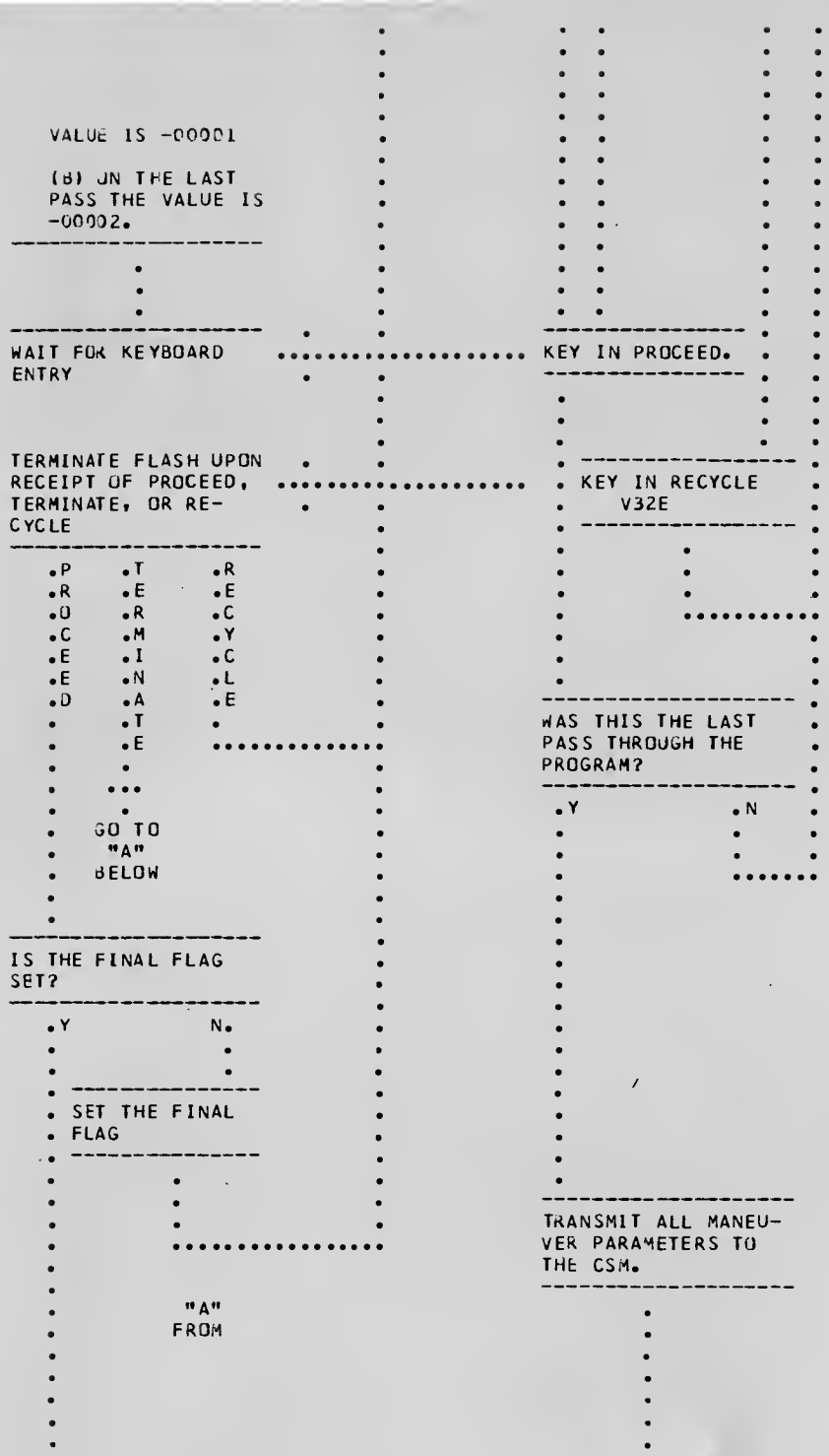
#850

#860

#870

#880

#890



#900

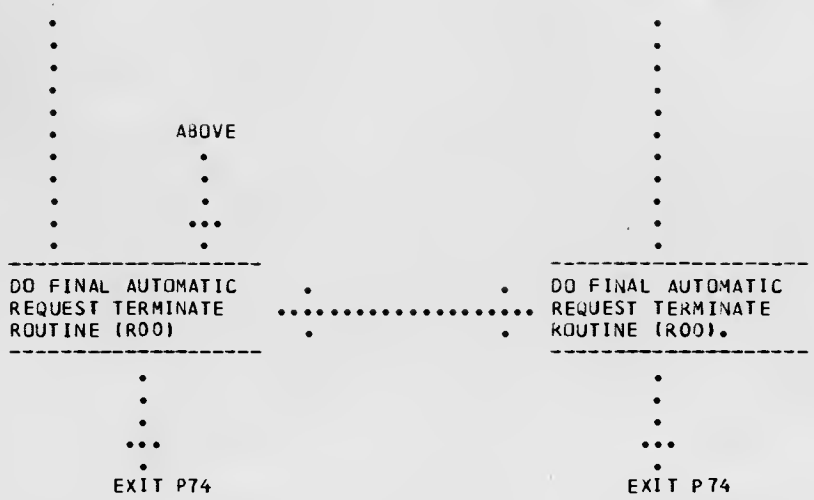
#910

#920

#930

#940

#950



#960

CHANGE CONTROL NOTES

REV 01 PCR 627
REV 00(LUM 1A) PCR 268
REV 01(LUM 1B) PCR 812.2
REV 02 EDITORIAL
REV 03(LUM 1D) PCR 1048, PCN 1009
REV 04(LUM 1E) PCR 1066
REV 05 PCN 1180

CSM TRANSFER PHASE MIDCOURSE ITPM) TARGETING PROGRAM IP75) REV (6 12/01/71

PURPOSE: (1) TO CALCULATE THE REQUIRED DELTA V AND OTHER INITIAL CONDITIONS REQUIRED BY THE CMC FOR CSM EXECUTION OF THE NEXT MIDCOURSE CORRECTION OF THE TRANSFER PHASE OF AN ACTIVE CSM RENDEZVOUS.

ASSUMPTIONS: (1) THERE IS NO REQUIREMENT FOR ISS OPERATION DURING THIS PROGRAM UNLESS AUTOMATIC STATE VECTOR UPDATING IS DESIRED BY THE RENDEZVOUS NAVIGATION PROGRAM (P20). IF SELECTED, P20 WILL DEFINE THE STATUS OF THE ISS.

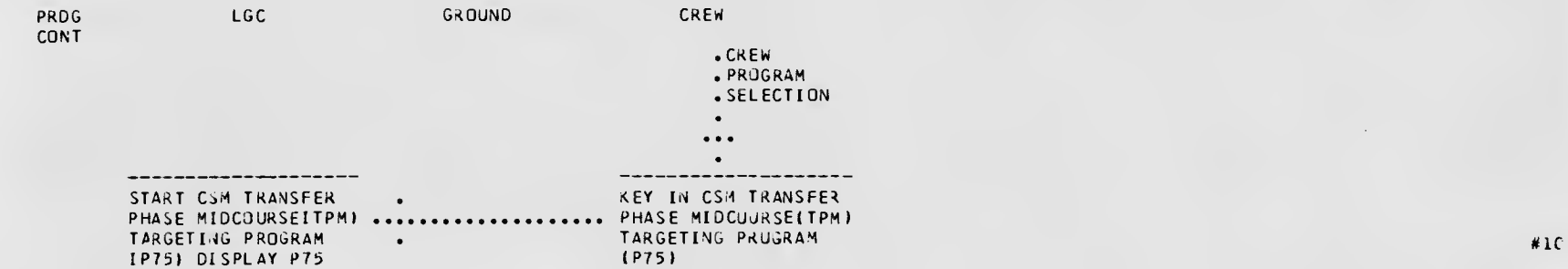
(2) THE RENDEZVOUS RADAR IS ON AND IS LOCKED ON THE CSM. THIS WAS DONE DURING PREVIOUS SELECTION OF P20. RADAR SIGHTING MARKS WILL BE MADE AUTOMATICALLY APPROXIMATELY ONCE A MINUTE WHEN ENABLED BY THE TRACK AND UPDATE FLAGS. THE RENDEZVOUS TRACKING MARK COUNTER IS ZEROED BY THE SELECTION OF P20 AND AFTER EACH THRUSTING MANEUVER.

(3) THE TIME OF INTERCEPT (T(INT)) WAS DEFINED BY PREVIOUS COMPLETION OF THE TRANSFER PHASE INITIATION (TPI) TARGETING PROGRAM (P74) AND IS PRESENTLY AVAILABLE IN LGC STORAGE.

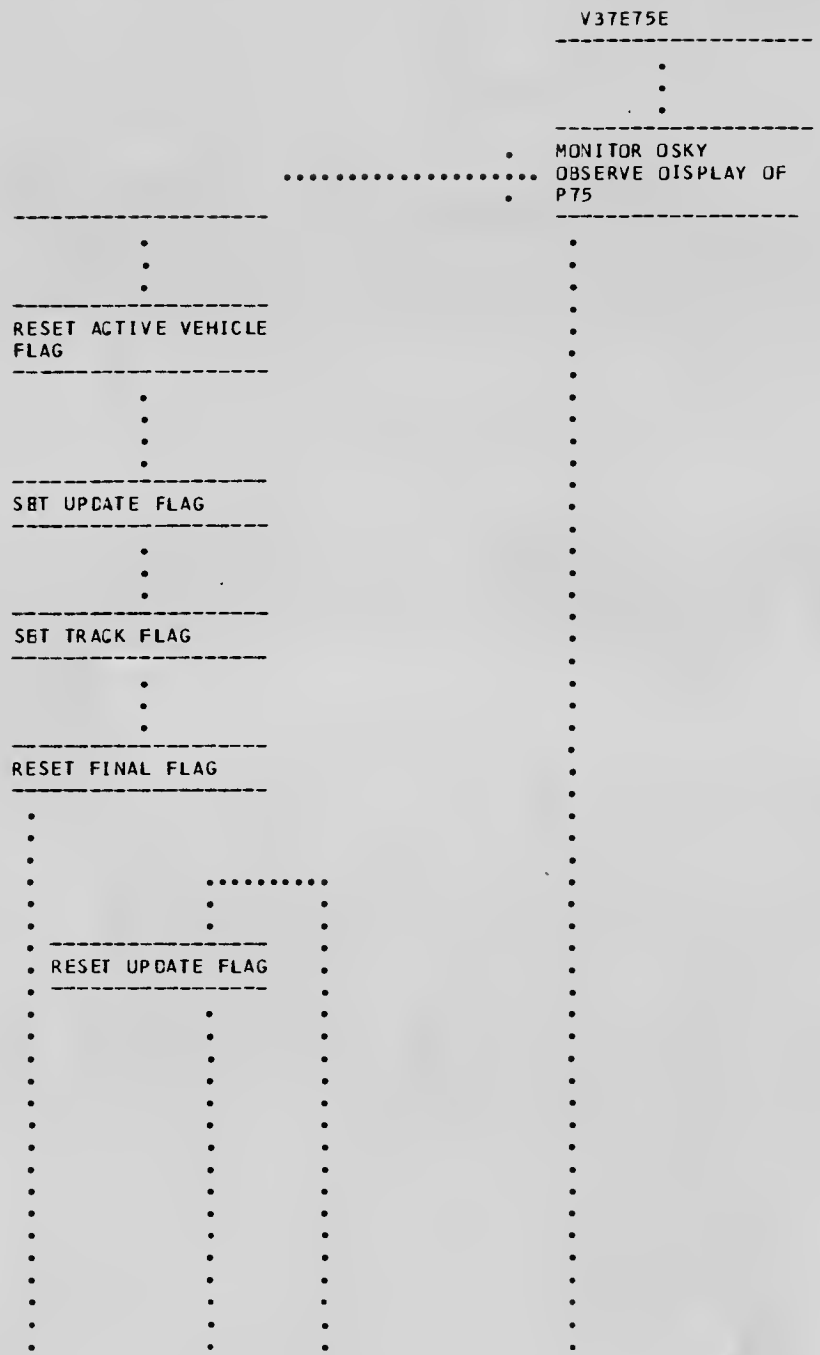
(4) ONCE THE PARAMETERS REQUIRED FOR COMPUTATION OF THE MANEUVER HAVE BEEN COMPLETELY SPECIFIED, THE VALUE OF THE ACTIVE VEHICLE CENTRAL ANGLE OF TRANSFER IS COMPUTED AND STORED. THIS NUMBER WILL BE AVAILABLE FOR DISPLAY TO THE ASTRONAUT THROUGH THE USE OF V06N52.

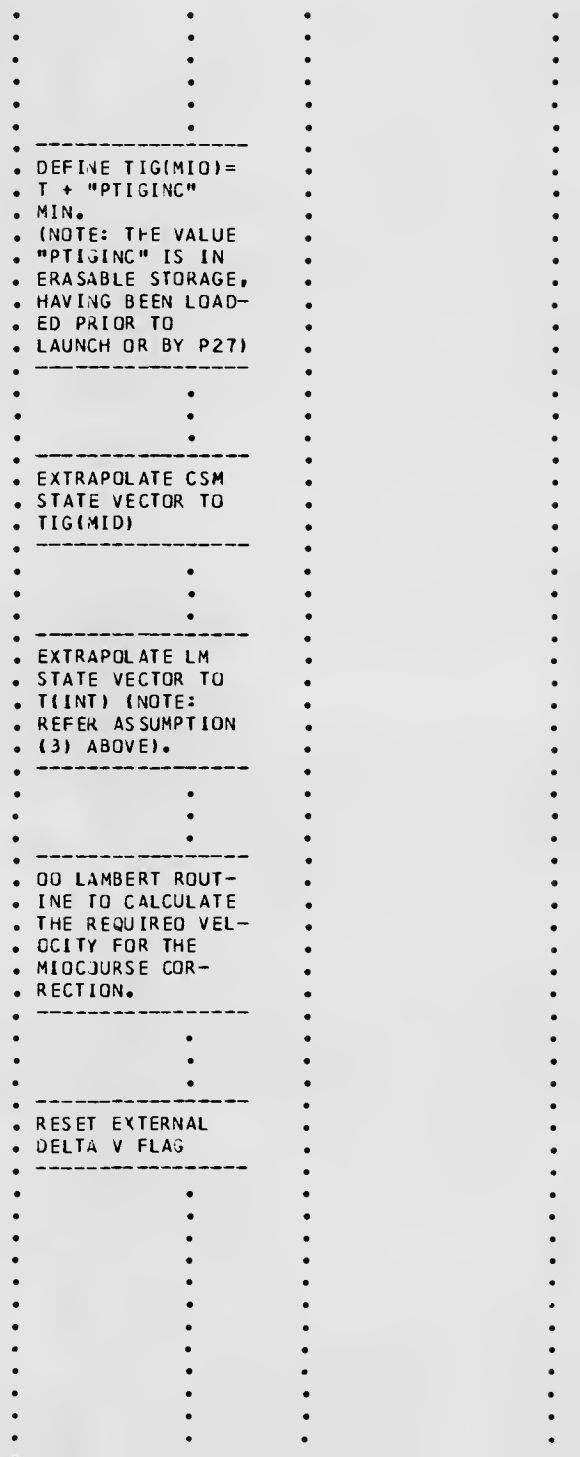
THE ASTRONAUT WOULD CALL THIS DISPLAY TO VERIFY THAT THE CENTRAL ANGLE OF TRANSFER OF THE ACTIVE VEHICLE IS NOT WITHIN 170 TO 190 DEGREES. IF THE ANGLE IS WITHIN THIS ZONE THE ASTRONAUT SHOULD REASSESS THE INPUT TARGETING PARAMETERS BASED UPON DELTA V AND EXPECTED MANEUVER TIME.

(5) THE PROGRAM IS SELECTED BY THE ASTRONAUT BY DSKY ENTRY PRIOR TO ANY ANTICIPATED CMC RENDEZVOUS MIDCOURSE
++ CORRECTION REQUIRING LM PARAMETER COMPUTATION.
+06
+1180 (6) THE DELTA V IN LOS COORDINATES (N59) IS AVAILABLE AT FL V16 N45 AFTER EACH COMPUTATION CYCLE.
++



#10


V37E75E
MONITOR OSKY
OBSERVE OISPLAY OF
P75
#20
RESET ACTIVE VEHICLE
FLAG
#30
SBT UPDATE FLAG
SBT TRACK FLAG
#40
RESET FINAL FLAG
#50
RESET UPDATE FLAG



#60

#70

#80

#90

#100

#110

#120

#130

#140

#150

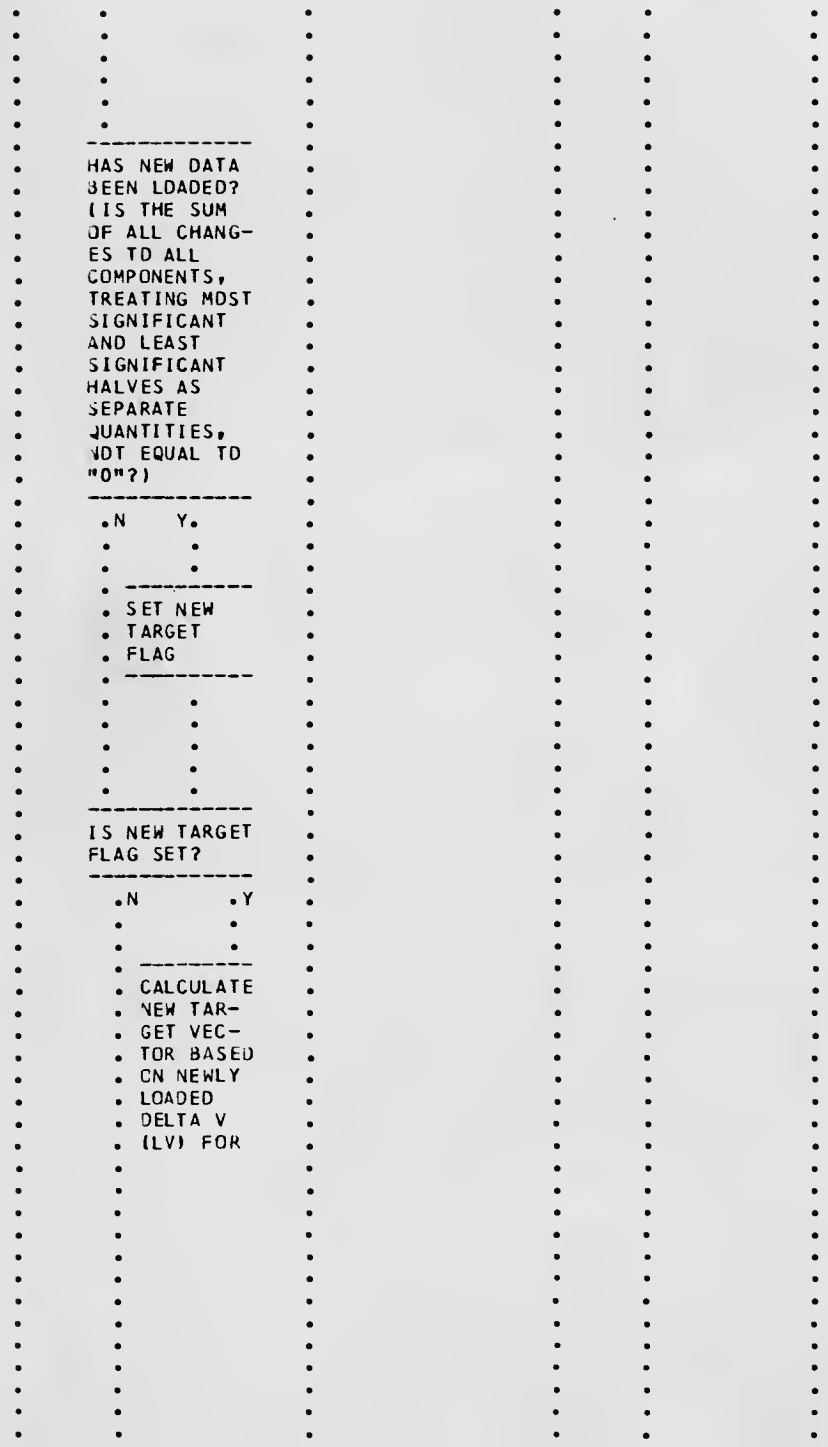
#160 #170 #180 #190 #200

#210

#220

#230

#240



#250

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#270

#280

#290

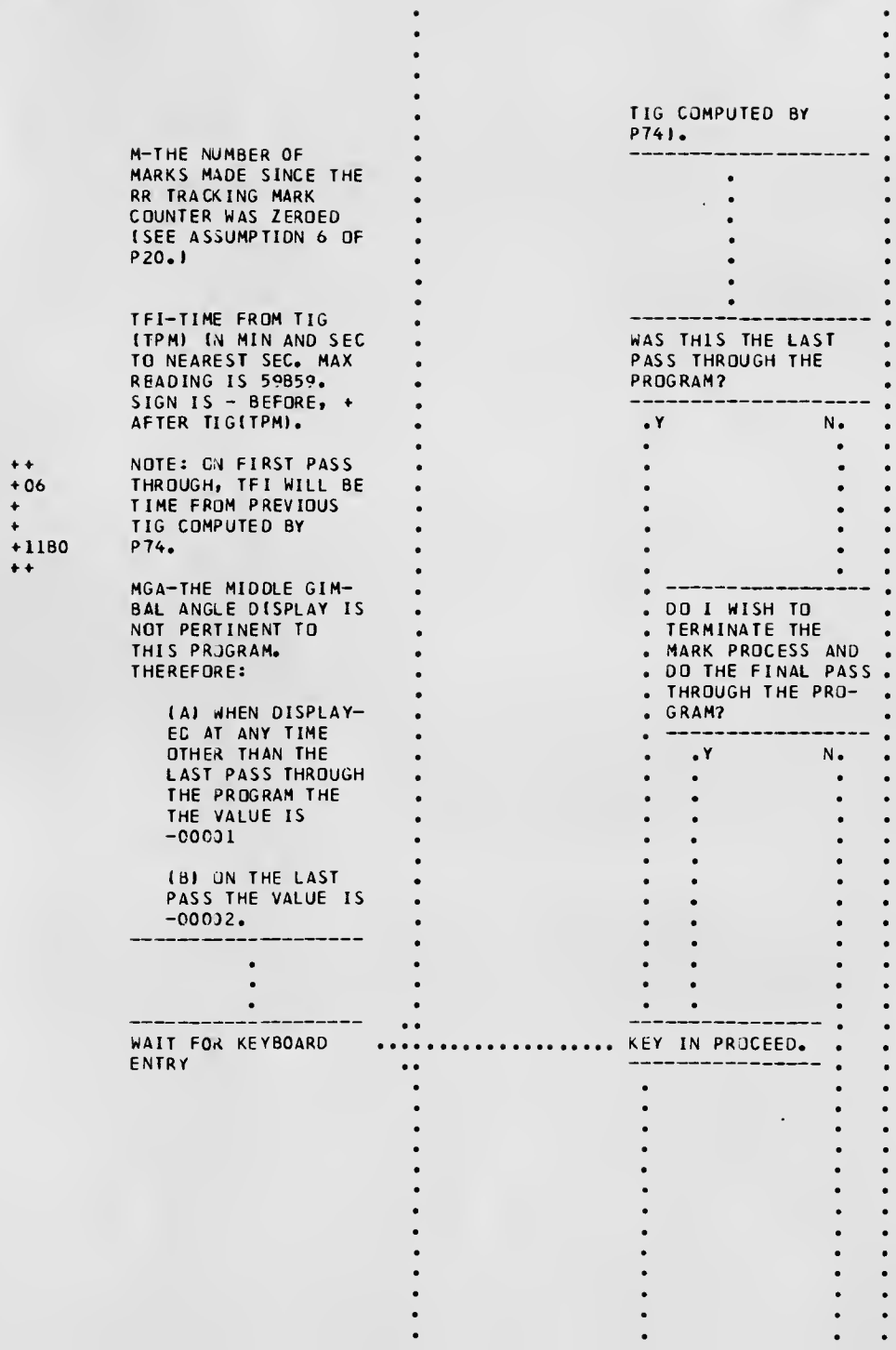
#300

#310

#320

#330

#340



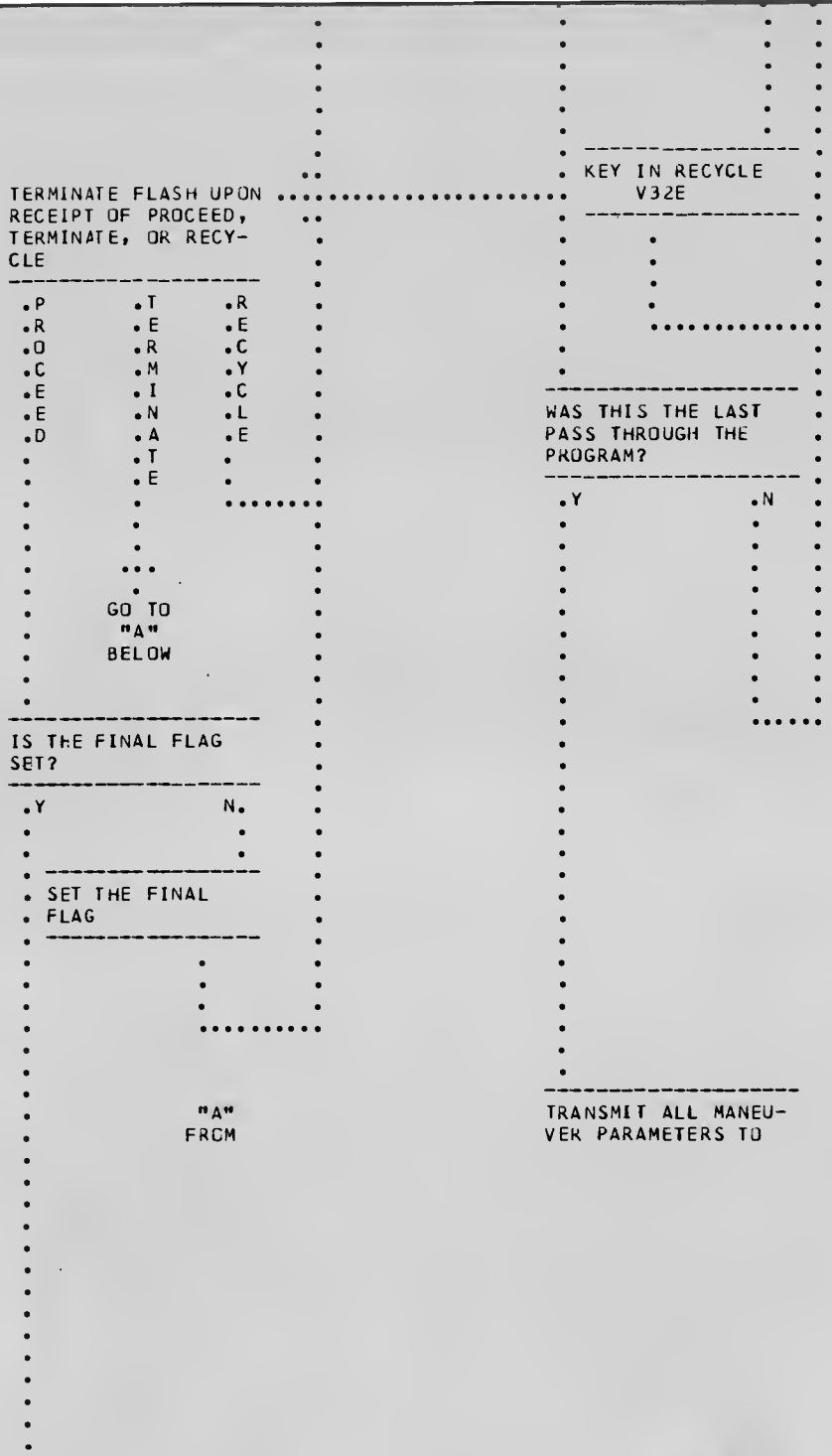
#350

#360

#370

#380

#390

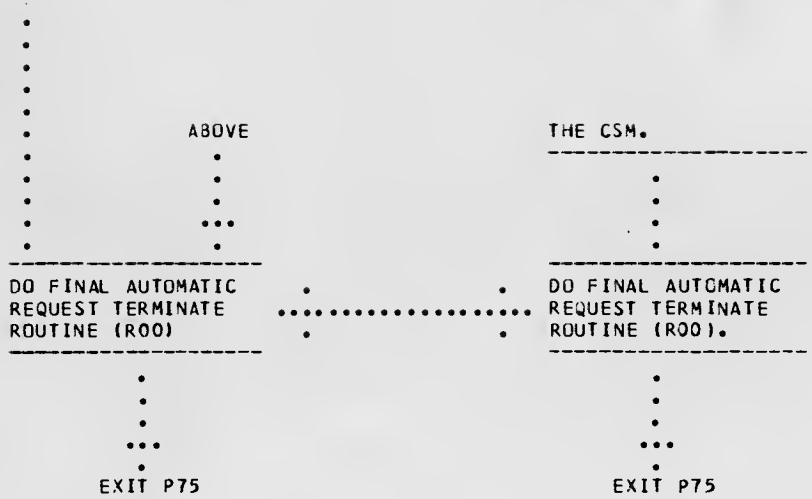


#400

#410

#420

#430



#440

#450

CHANGE CONTROL NOTES

REV 01 PCN 502,627
REV 02(LUM 18) PCR 812.2, EDITORIAL
REV 03 EDITORIAL
REV 04 PCN 1009
REV 05(LUM 1E) PCR 1066
REV 06 PCN 1180

TARGET DELTA V PROGRAM (P76) REV 04 11/02/70

PURPOSE: (1) TO PROVIDE A MEANS OF NOTIFYING THE LGC THAT THE CSM HAS CHANGED ITS ORBITAL PARAMETERS BY THE EXECUTION OF A THRUSTING MANEUVER.

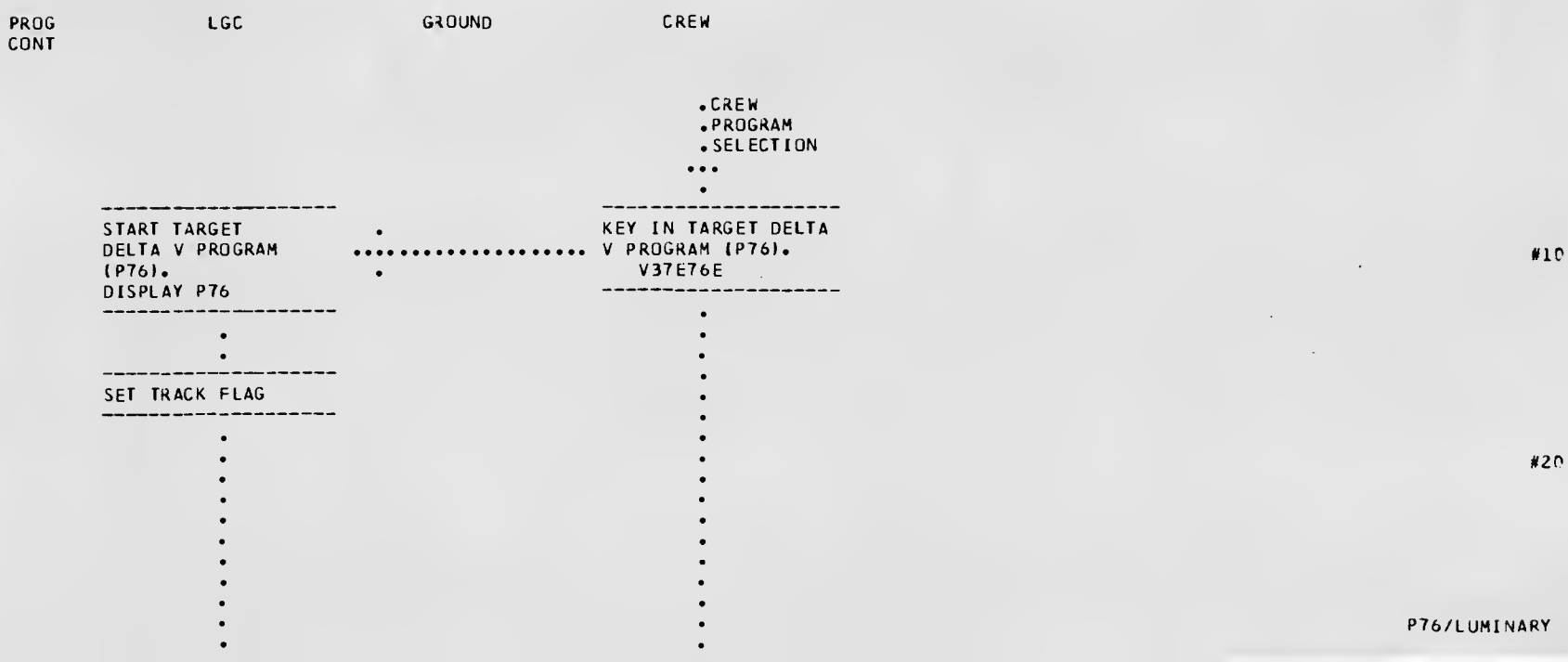
(2) TO PROVIDE TO THE LGC THE DELTA V APPLIED TO THE CSM TO ENABLE AN UPDATING OF THE CSM STATE VECTOR.

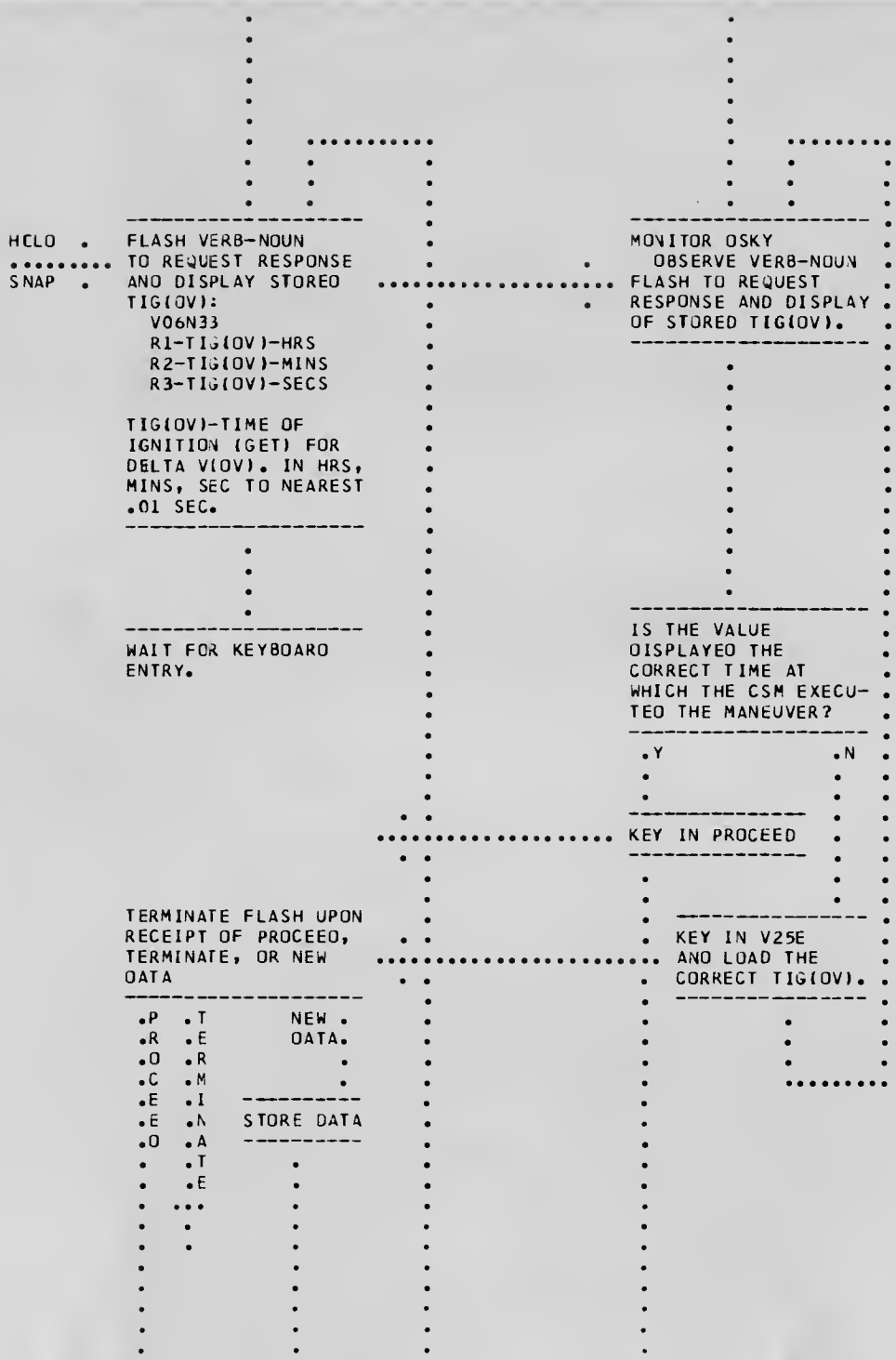
ASSUMPTIONS: (1) THE LM CREW HAS THE DELTA V TO BE APPLIED TO THE CSM IN LOCAL VERTICAL AXES AT A SPECIFIED TIG. THESE VALUES ARE DISPLAYED PRIOR TO TIG BY THE THRUSTING PROGRAMS (P40 AND P41 IN THE CMC). NO PROVISION IS MADE IN THESE THRUSTING PROGRAMS TO DISPLAY THE RESULTS OF THE MANEUVER IN A FORM USABLE BY THIS PROGRAM. IF THE BURN IS NOT NOMINAL AND THIS DELTA V IS NOT AS SPECIFIED OR IF TIG IS NOT AS ORIGINALLY SPECIFIED, CONSULT BACKUP PROCEDURES.

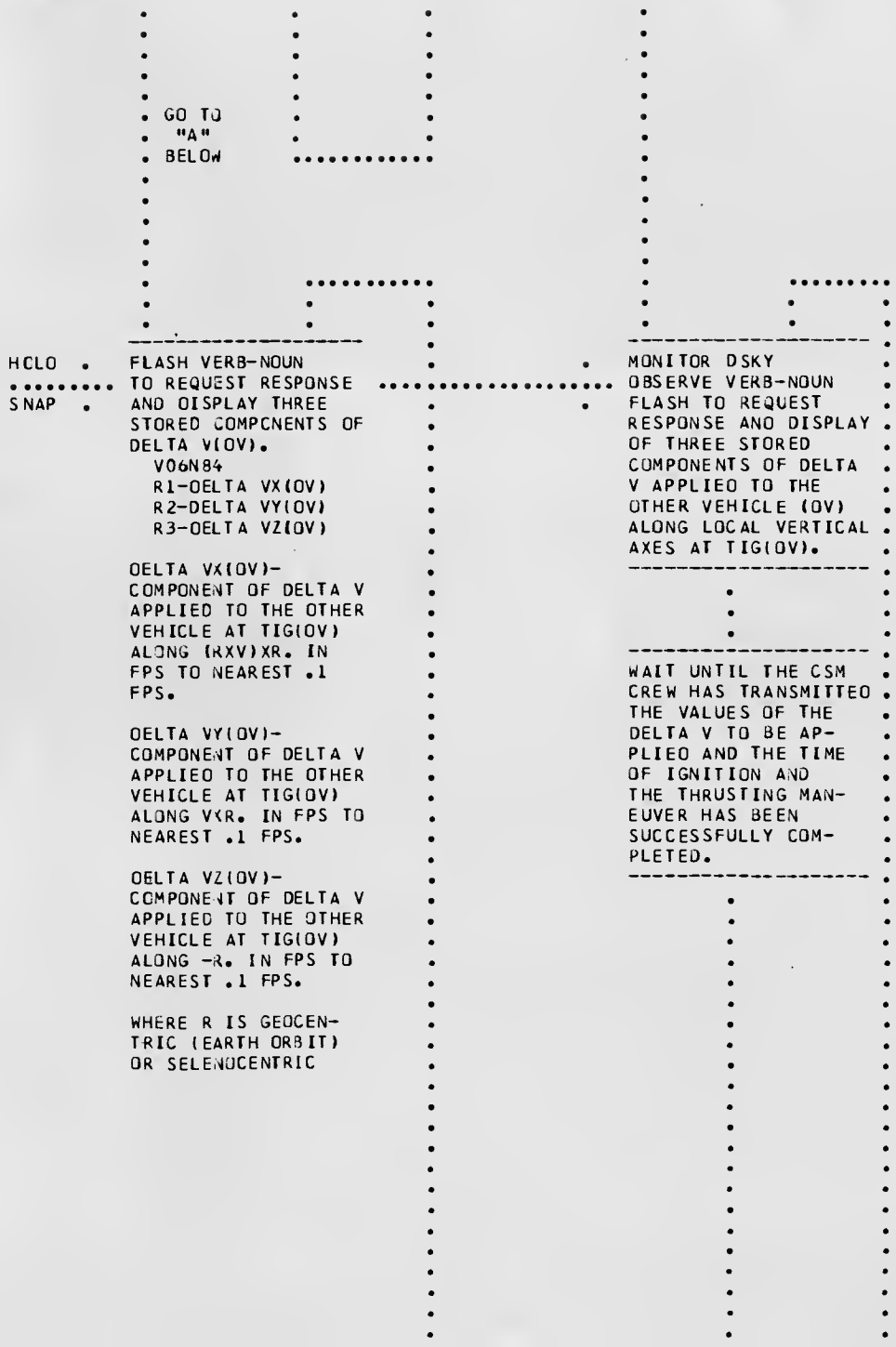
(2) IF THE RENDEZVOUS NAVIGATION PROGRAM (P20) OR THE LUNAR SURFACE NAVIGATION PROGRAM (P22) IS IN PROCESS THIS PROGRAM MUST BE SELECTED PRIOR TO THE CSM THRUSTING MANEUVER. THIS CAN BE ASSURED BY VOICE COMMUNICATION BETWEEN THE LM AND CSM.

(3) THIS PROGRAM IS SELECTED BY THE ASTRONAUT BY OSKY ENTRY.

(4) THE CONTENTS OF NOUN 84 ARE INITIALIZED WITH THE VALUE OF NOUN 81 AT ENTRANCE TO P76.




HCLO
SNAP
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY STOREO TIG(OV):
V06N33
R1-TIG(OV)-HRS
R2-TIG(OV)-MINS
R3-TIG(OV)-SECS
TIG(OV)-TIME OF IGNITION (GET) FOR DELTA V(OV). IN HRS, MINS, SEC TO NEAREST .01 SEC.
WAIT FOR KEYBOARD ENTRY.
TERMINATE FLASH UPON RECEIPT OF PROCEED, TERMINATE, OR NEW DATA
PROCEED
TERMINATE
NEW DATA
STORE DATA
MONITOR OSKY
OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY OF STORED TIG(OV).
IS THE VALUE DISPLAYED THE CORRECT TIME AT WHICH THE CSM EXECUTED THE MANEUVER?
Y
N
KEY IN PROCEED
KEY IN V25E AND LOAD THE CORRECT TIG(OV).
#30
#40
#50
#60
#70



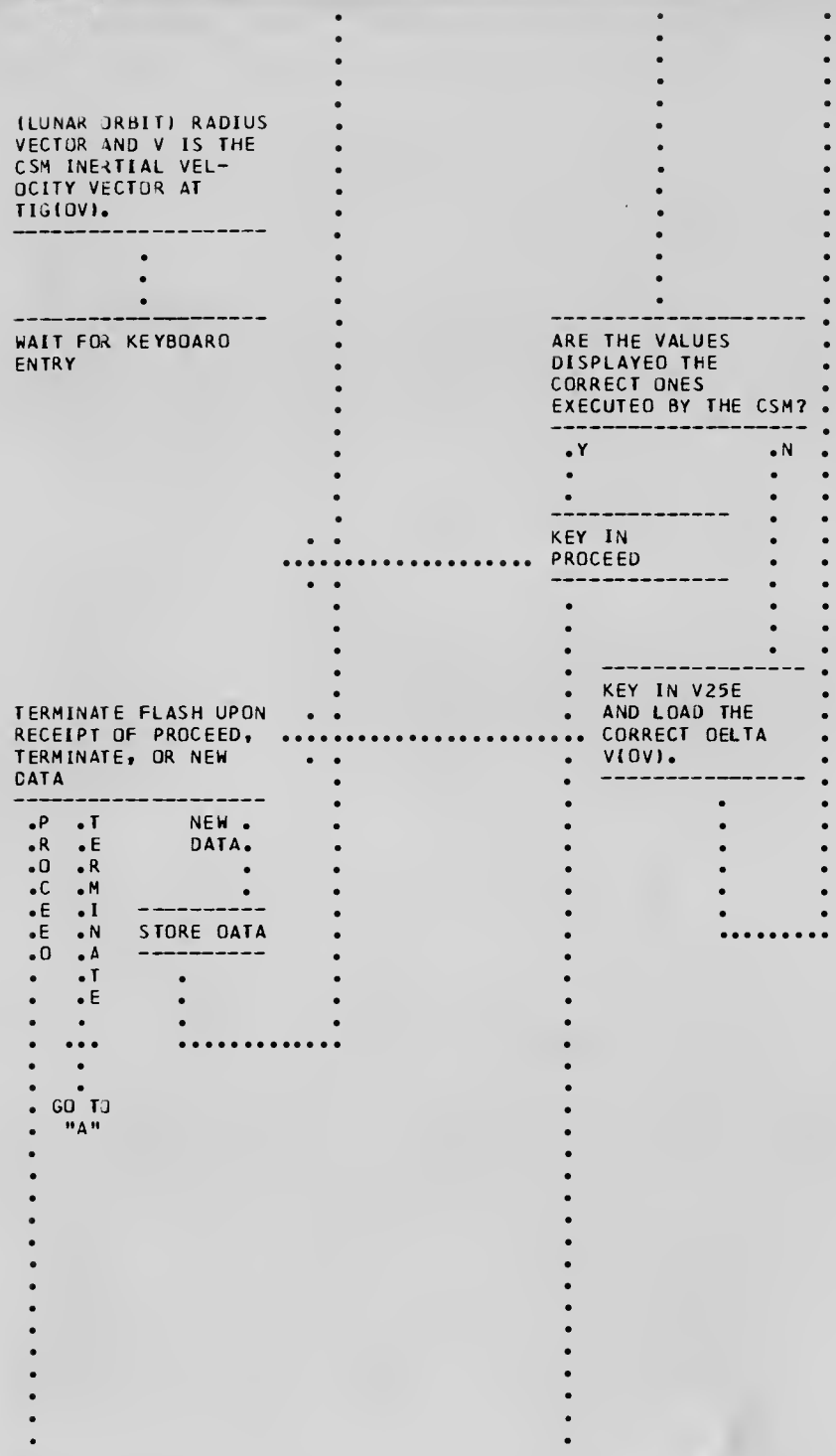
#80

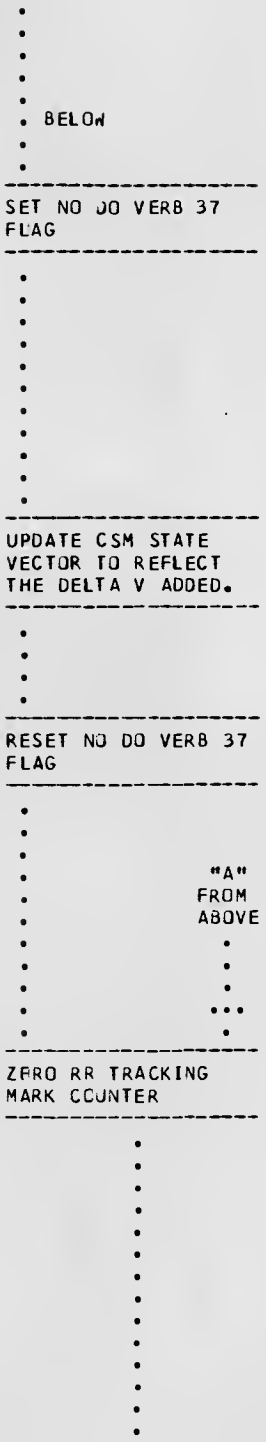
#90

#100

#110

#120


(LUNAR ORBIT) RADIUS VECTOR AND V IS THE CSM INERTIAL VELOCITY VECTOR AT TIG(OV).
#130
WAIT FOR KEYBOARD ENTRY
ARE THE VALUES DISPLAYED THE CORRECT ONES EXECUTED BY THE CSM?
.Y
.N
#140
KEY IN PROCEED
KEY IN V25E AND LOAD THE CORRECT DELTA V(OV).
#150
TERMINATE FLASH UPON RECEIPT OF PROCEED, TERMINATE, OR NEW DATA
.PROCEED
.TERMINATE
NEW DATA
STORE DATA
#160
GO TO "A"
#170

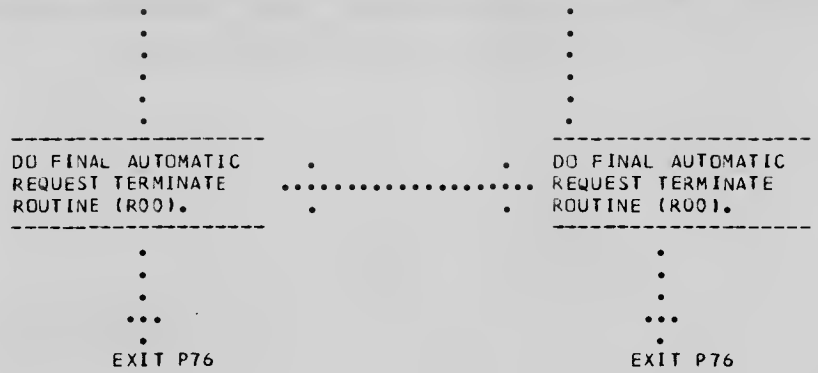


#180

#190

#200

#210



#220

#230

CHANGE CONTROL NOTES

LOGIC REV 01 PCR 468
REV 02(LUM 1B) PCR 826.2
REV 03(LUM 1C) PCR 863.2
REV 04 PCN 1009

++ IMPULSIVE DELTA V PROGRAM (P77) REV 02 12/01/71
+02
+1180

PURPOSE: (1) TO PROVIDE A MEANS OF NOTIFYING THE LGC THAT THE LM HAS CHANGED (OR WILL CHANGE) ITS ORBITAL PARAMETERS BY THE
++ EXECUTION OF A THRUSTING MANEUVER WHEN AVERAGE G IS NOT RUNNING.

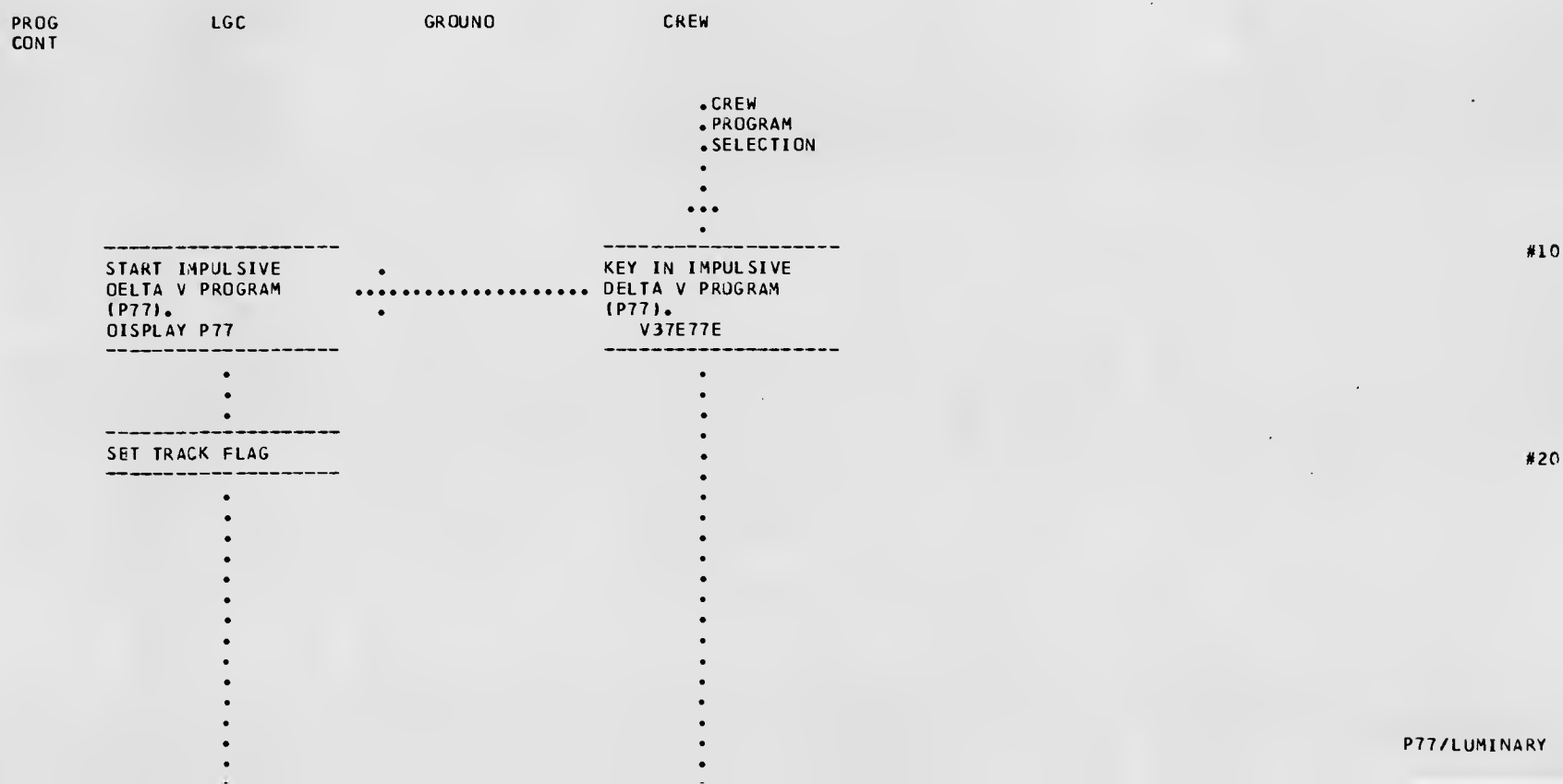
(2) TO PROVIDE TO THE LGC THE DELTA V APPLIED TO THE LM TO ENABLE AN UPDATING OF THE LM STATE VECTOR.

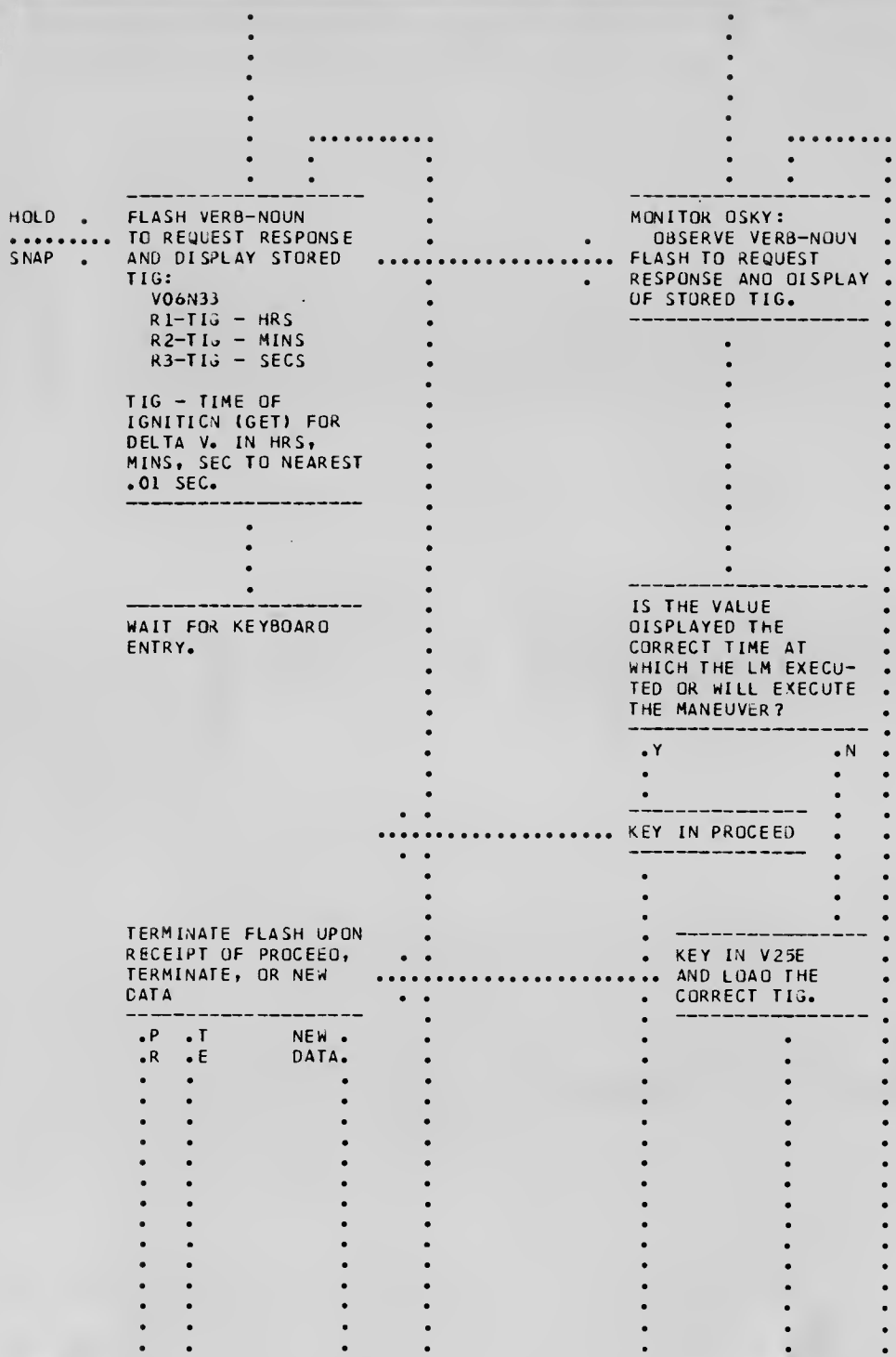
ASSUMPTIONS: (1) THE LM CREW HAS THE DELTA V APPLIED TO THE LM IN LOCAL VERTICAL AXES AT A SPECIFIED TIG.

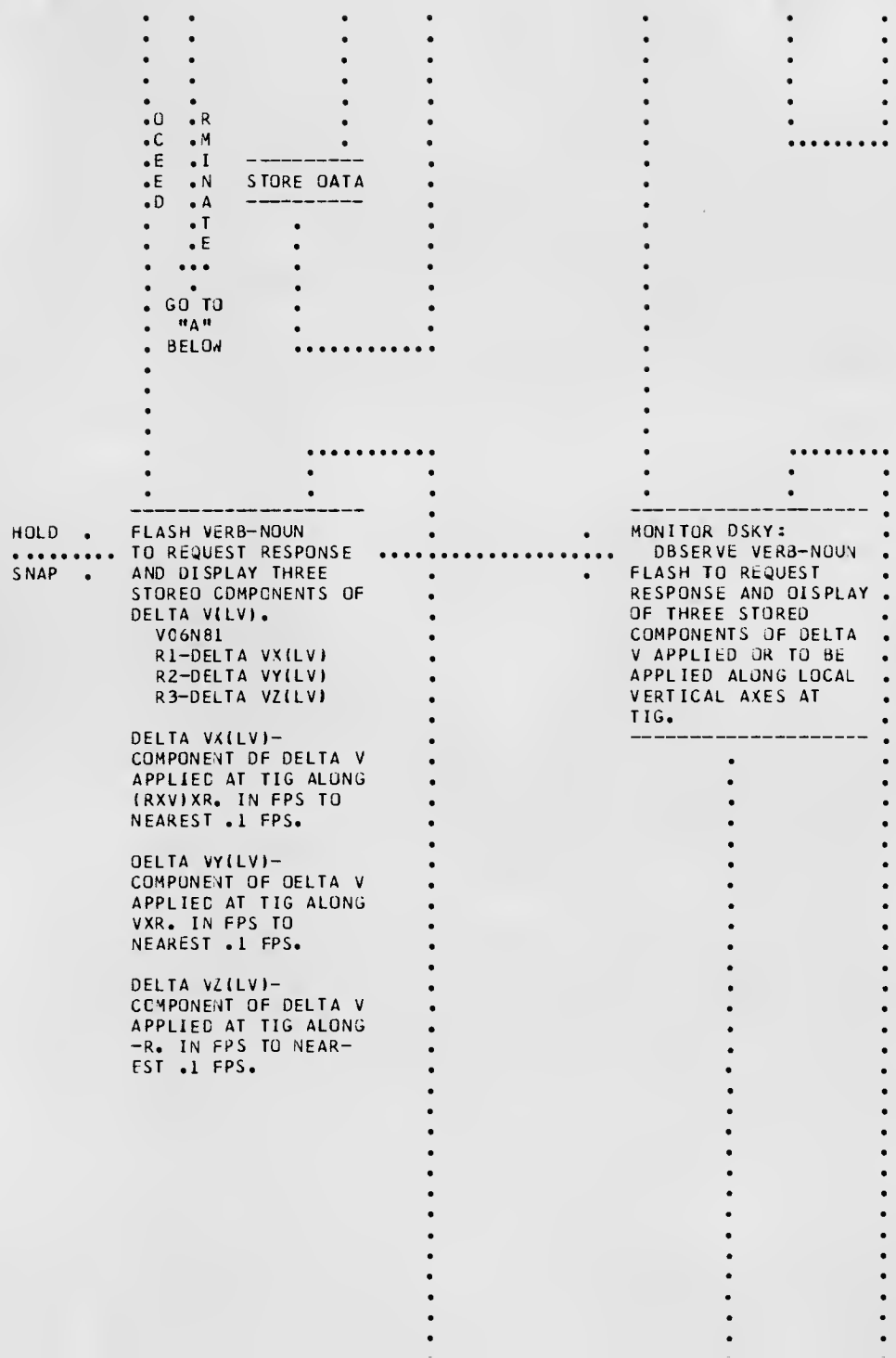
(2) R03 SHOULD BE PERFORMED AFTER P77 TO UPDATE LEMMASS.

(3) THIS PROGRAM IS SELECTED BY THE ASTRONAUT BY DSKY ENTRY.

(4) THE CONTENTS OF NOUN 81 IS THE SAME AS THE PREVIOUS VALUE OF NOUN 81 AT ENTRANCE TO P77.




HOLD
SNAP
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY STORED TIG:
V06N33
R1-TIG - HRS
R2-TIG - MINS
R3-TIG - SECS
TIG - TIME OF IGNITION (GET) FOR DELTA V. IN HRS, MINS, SEC TO NEAREST .01 SEC.
WAIT FOR KEYBOARD ENTRY.
TERMINATE FLASH UPON RECEIPT OF PROCEED, TERMINATE, OR NEW DATA
.P
.R
.T
.E
NEW DATA.
MONITOR OSKY:
OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY OF STORED TIG.
#30
#40
IS THE VALUE DISPLAYED THE CORRECT TIME AT WHICH THE LM EXECUTED OR WILL EXECUTE THE MANEUVER?
#50
.Y
.N
KEY IN PROCEED
#60
KEY IN V25E AND LOAD THE CORRECT TIG.
#70

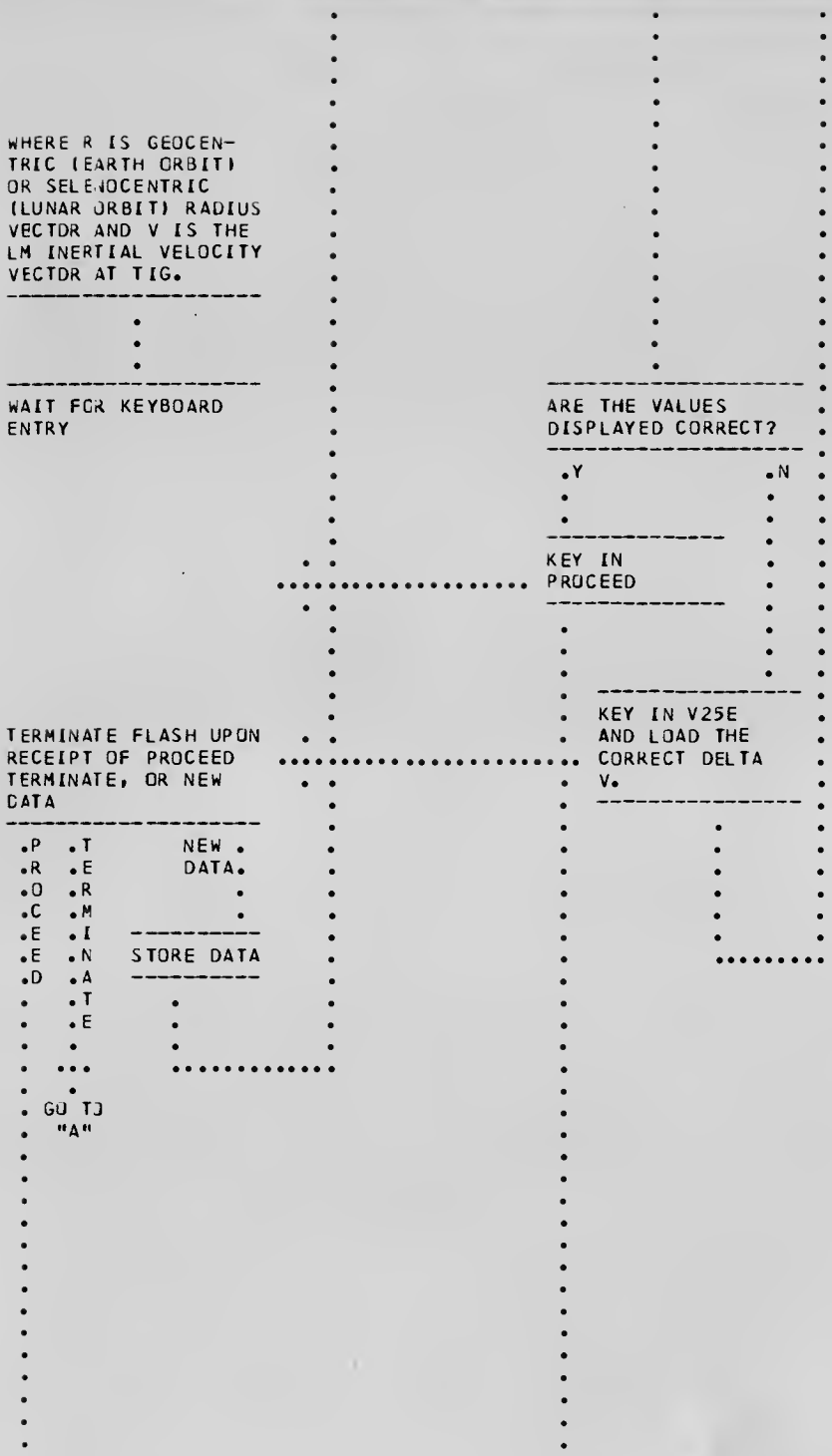

.O .R
.C .M
.E .I
.E .N
.D .A
.T
.E
STORE DATA
GO TO "A" BELOW
HOLD SNAP
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY THREE STOREO COMPONENTS OF DELTA V(LV).
V06N81
R1-DELTA VX(LV)
R2-DELTA VY(LV)
R3-DELTA VZ(LV)
DELTA VX(LV)- COMPONENT OF DELTA V APPLIED AT TIG ALONG (RXV)XR. IN FPS TO NEAREST .1 FPS.
DELTA VY(LV)- COMPONENT OF DELTA V APPLIED AT TIG ALONG VXR. IN FPS TO NEAREST .1 FPS.
DELTA VZ(LV)- COMPONENT OF DELTA V APPLIED AT TIG ALONG -R. IN FPS TO NEAR- EST .1 FPS.
MONITOR DSKY: OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND OISPLAY OF THREE STORED COMPONENTS OF DELTA V APPLIED OR TO BE APPLIED ALONG LOCAL VERTICAL AXES AT TIG.

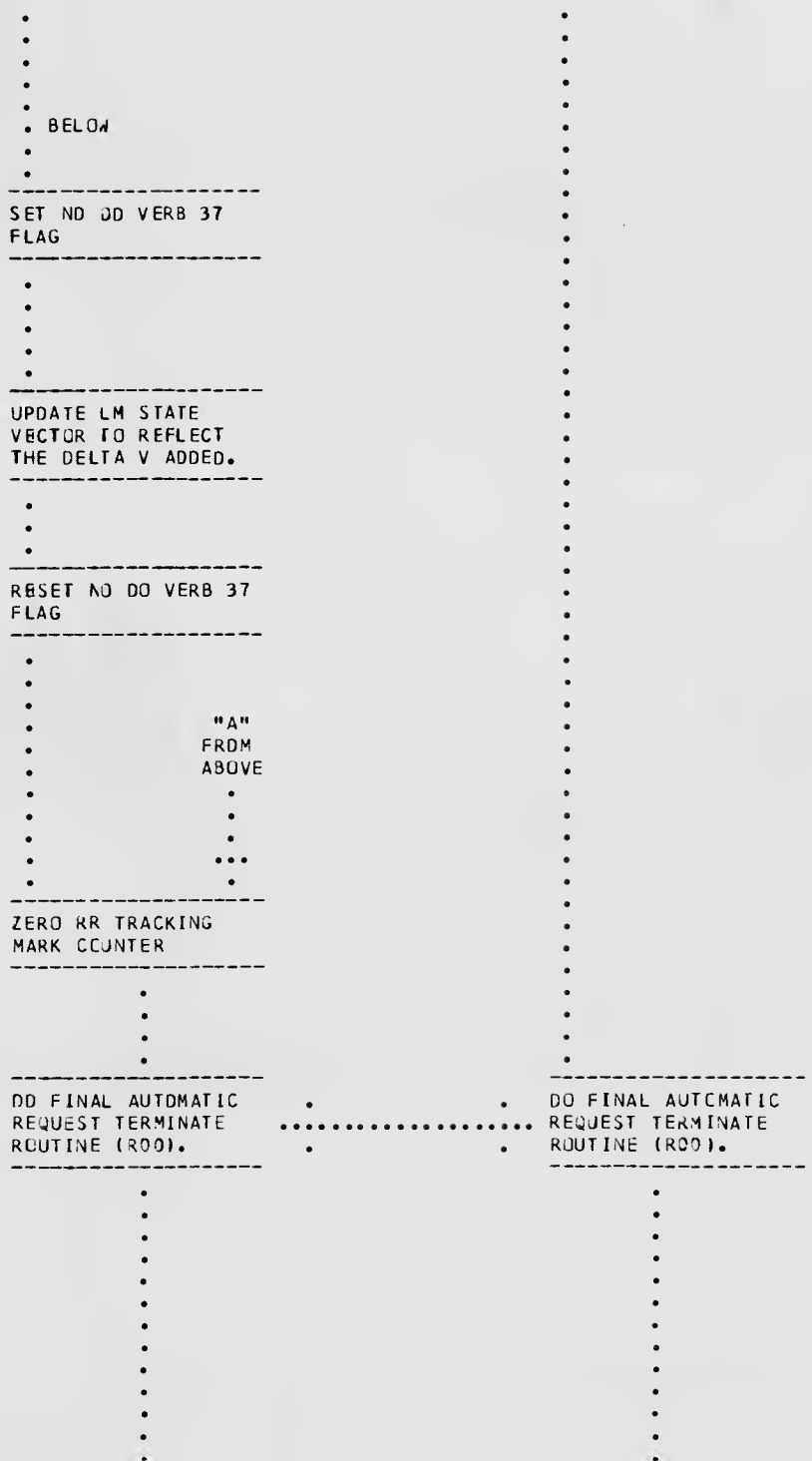
#80

#90

#100

#110


WHERE R IS GEOCENTRIC (EARTH ORBIT) OR SELENOCENTRIC (LUNAR ORBIT) RADIUS VECTOR AND V IS THE LM INERTIAL VELOCITY VECTOR AT TIG.
#120
WAIT FOR KEYBOARD ENTRY
#130
ARE THE VALUES DISPLAYED CORRECT?
Y
N
KEY IN PROCEED
#140
KEY IN V25E AND LOAD THE CORRECT DELTA V.
TERMINATE FLASH UPON RECEIPT OF PROCEED TERMINATE, OR NEW DATA
#150
PROCEED
TERMINATE
NEW DATA
STORE DATA
#160
GO TO "A"


BELOW
SET NO DO VERB 37 FLAG
#170
UPDATE LM STATE VECTOR TO REFLECT THE DELTA V ADDED.
#180
RESET NO DO VERB 37 FLAG
#190
"A" FROM ABOVE
ZERO RR TRACKING MARK COUNTER
#200
DO FINAL AUTOMATIC REQUEST TERMINATE ROUTINE (R00).
DO FINAL AUTOMATIC REQUEST TERMINATE ROUTINE (R00).
#210

#22C

CHANGE CONTROL NOTES

REV 01(LUM 1E) PCR 348
REV 02 PCN 1180

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****
****

4.4.10 LUMINARY ROUTINES

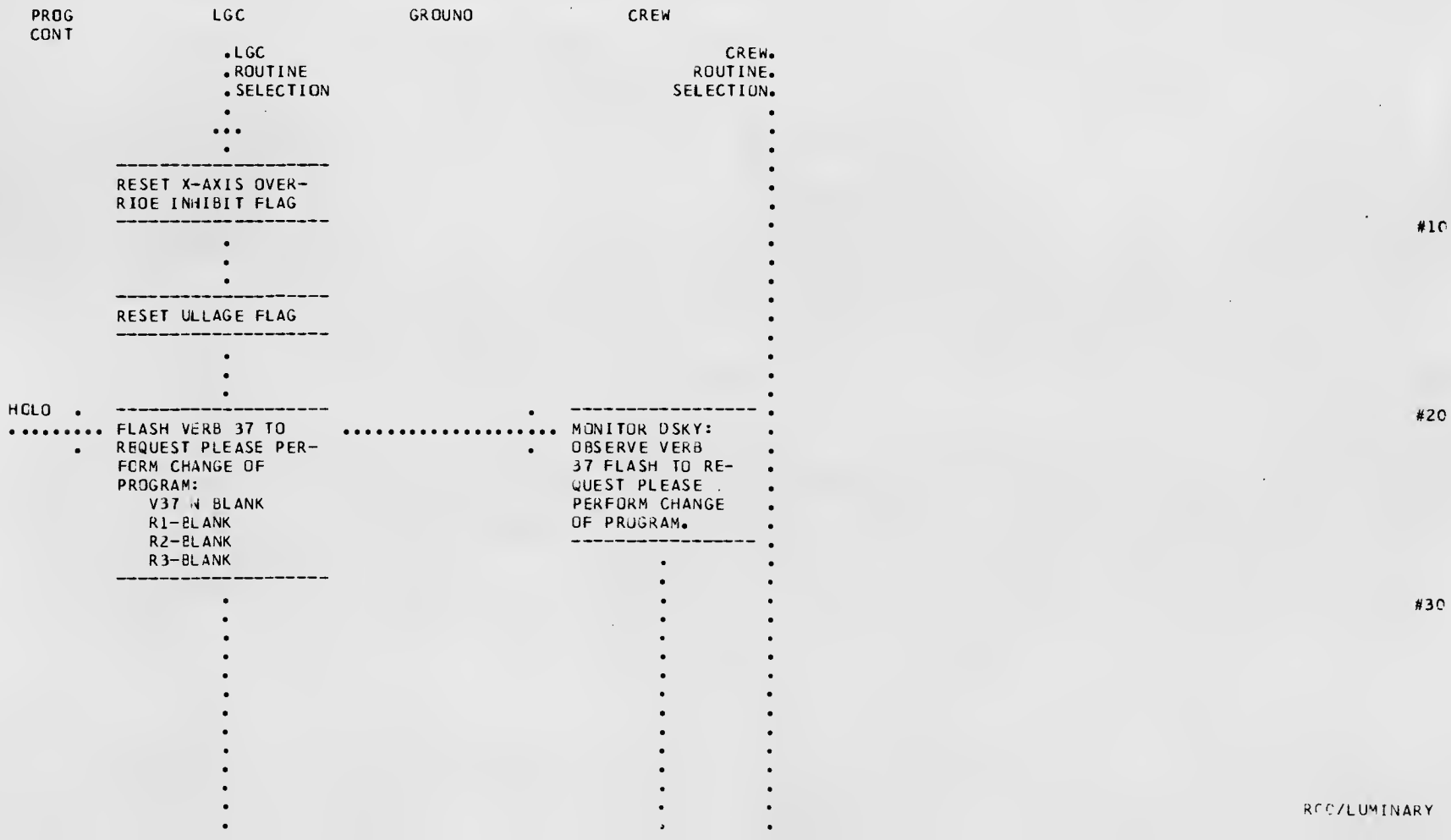
****
****
****

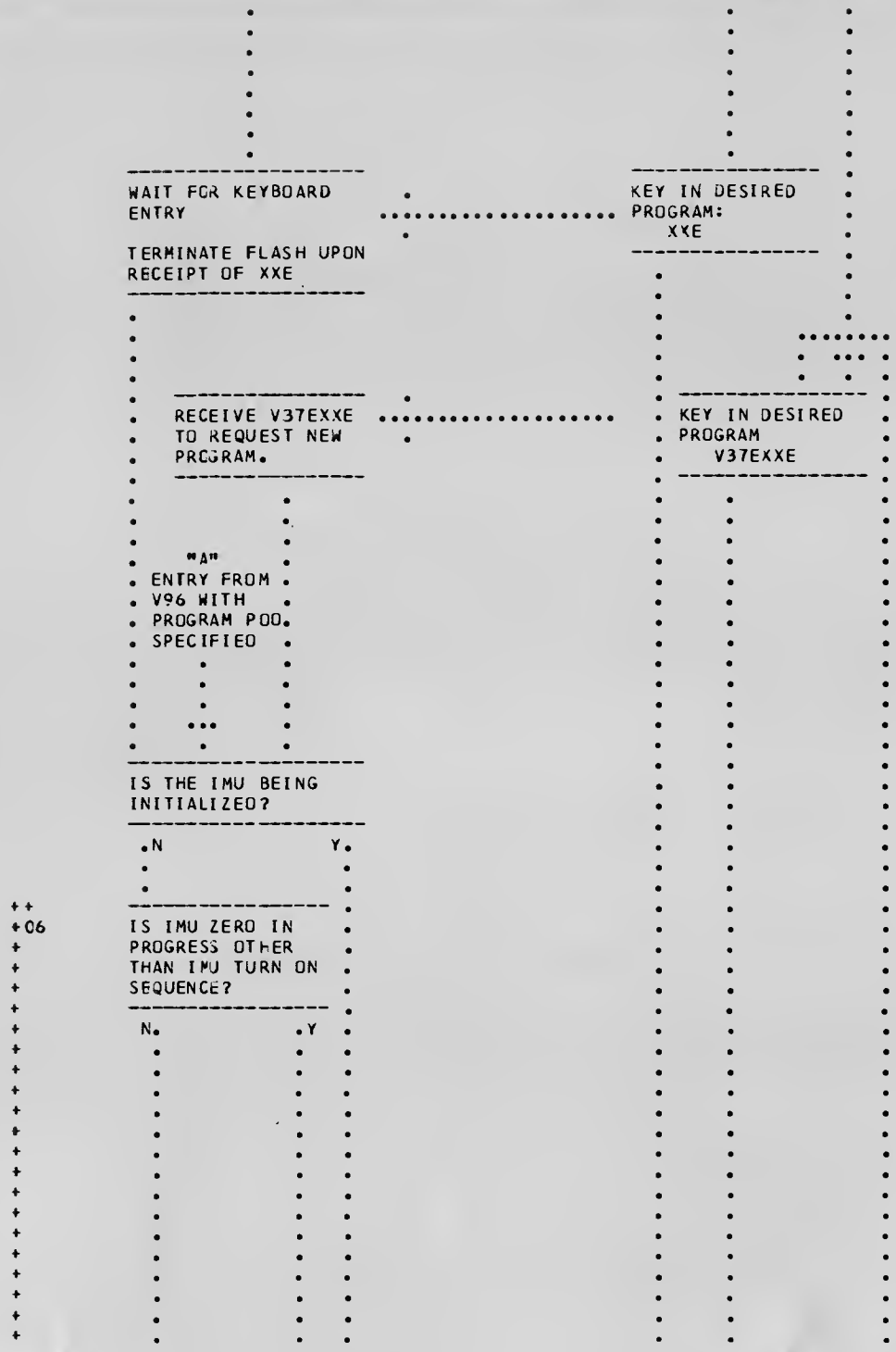
FINAL AUTOMATIC REQUEST TERMINATE ROUTINE (R00) REV C6 12/01/71

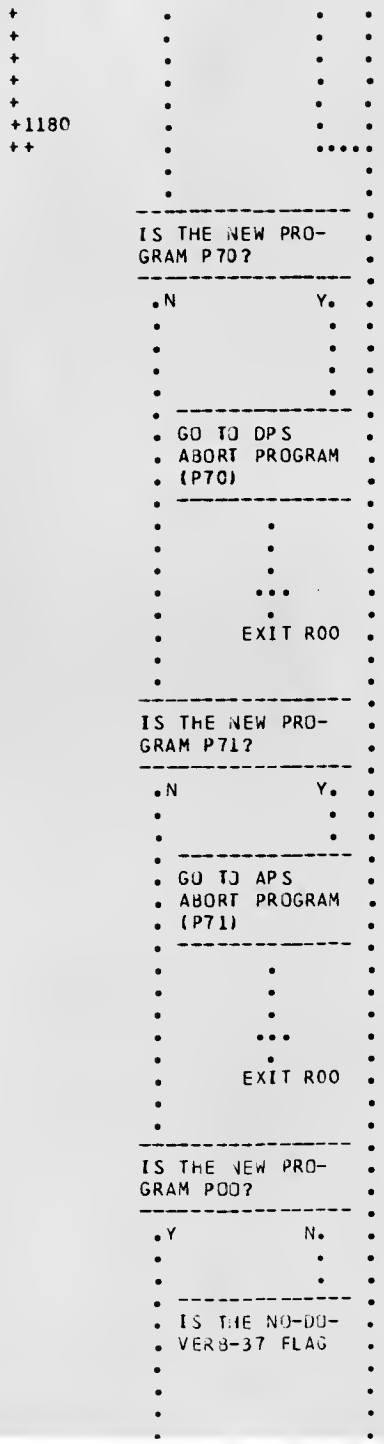
PURPOSE: (1) TO PROVIDE A STANDARD EXIT FOR PROGRAMS, AND AN OPTION TO SELECT ANY PROGRAM DESIRED.

(2) TO PROVIDE A GENERAL DESCRIPTION OF THE COMPUTER ACTIVITY FOLLOWING ANY V37EXXE.

ASSUMPTIONS: (1) THE CALLING PROGRAM HAS SUCCESSFULLY COMPLETED ALL ITS FUNCTIONS OR THE OPERATOR HAS PREMATURELY TERMINATED THE PROGRAM.




WAIT FOR KEYBOARD ENTRY
TERMINATE FLASH UPON RECEIPT OF XXE
KEY IN DESIRED PROGRAM: XXE
RECEIVE V37EXXE TO REQUEST NEW PROGRAM.
KEY IN DESIRED PROGRAM V37EXXE
"A" ENTRY FROM V96 WITH PROGRAM P00 SPECIFIED
IS THE IMU BEING INITIALIZED?
N
Y
IS IMU ZERO IN PROGRESS OTHER THAN IMU TURN ON SEQUENCE?
N
Y
#06
#40
#50
#60
#70



#80

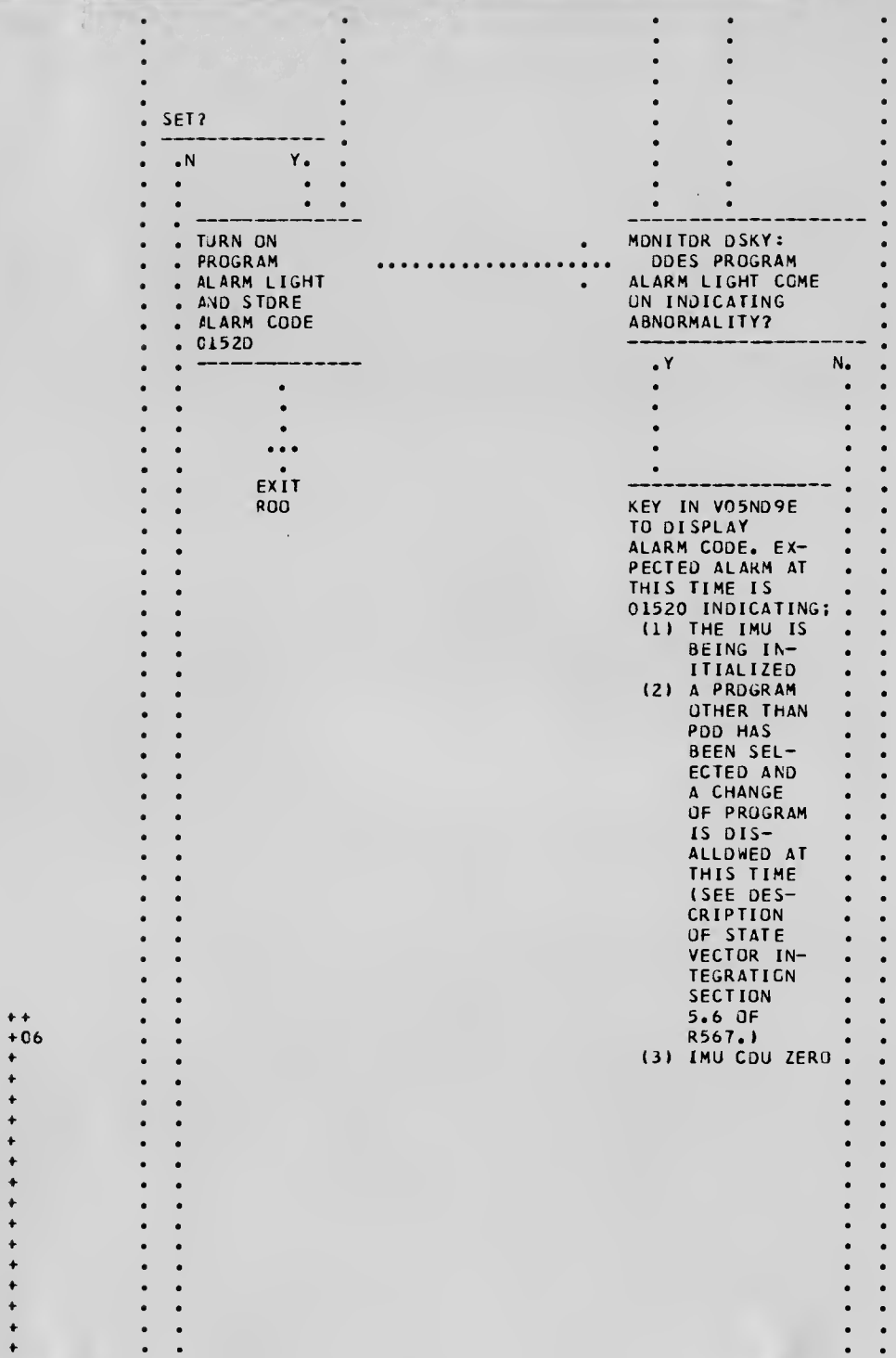
#90

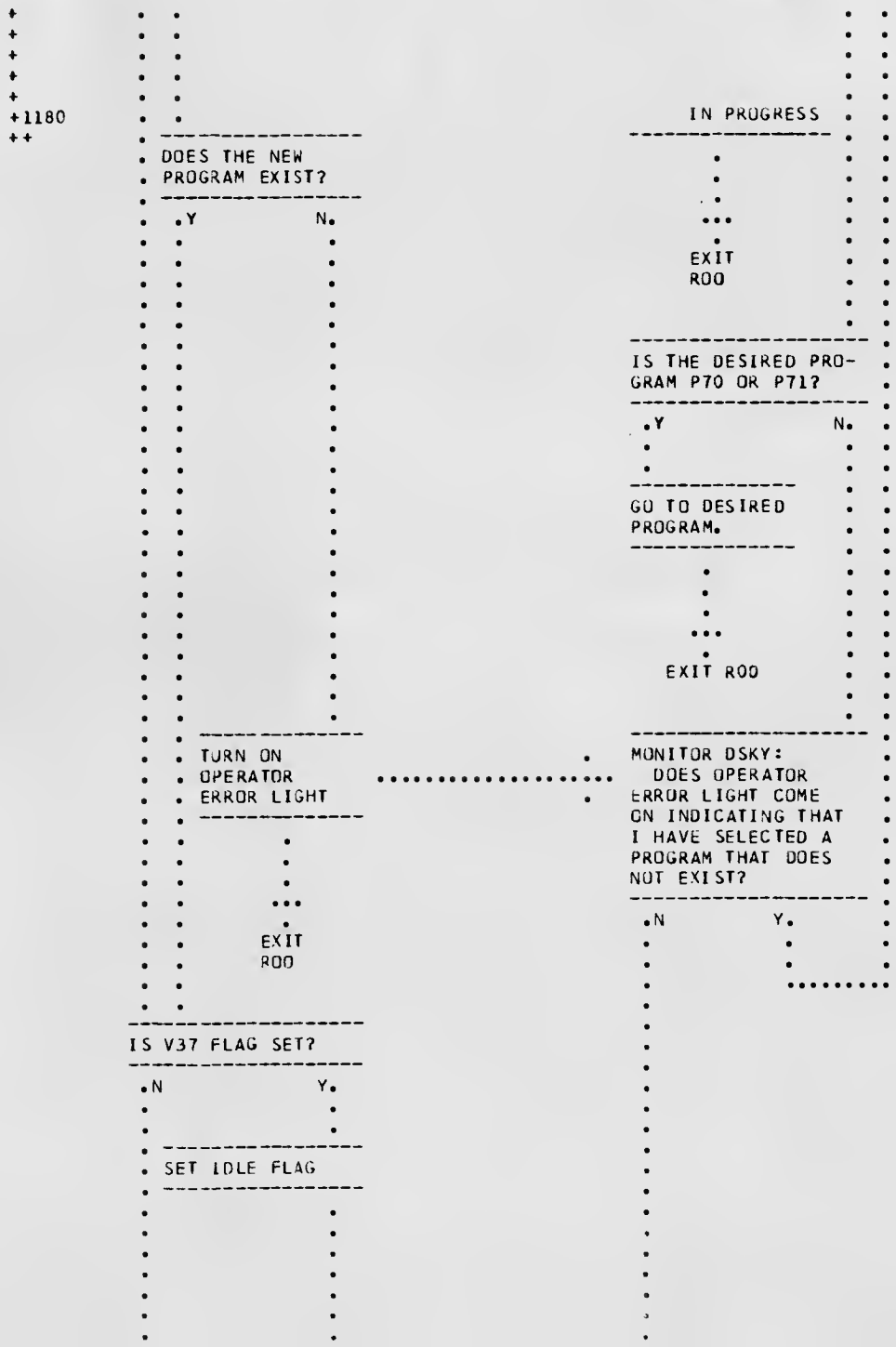
#100

#110

#120

#130


SET?
.N
Y.
TURN ON PROGRAM ALARM LIGHT AND STORE ALARM CODE 01520
EXIT R00
MONITOR DSKY: DOES PROGRAM ALARM LIGHT COME ON INDICATING ABNORMALITY?
.Y
N.
KEY IN V05ND9E TO DISPLAY ALARM CODE. EXPECTED ALARM AT THIS TIME IS 01520 INDICATING;
(1) THE IMU IS BEING INITIALIZED
(2) A PROGRAM OTHER THAN P00 HAS BEEN SELECTED AND A CHANGE OF PROGRAM IS DISALLOWED AT THIS TIME (SEE DESCRIPTION OF STATE VECTOR INTEGRATION SECTION 5.6 OF R567.)
(3) IMU CDU ZERO
#140
#150
#160
#170
#180



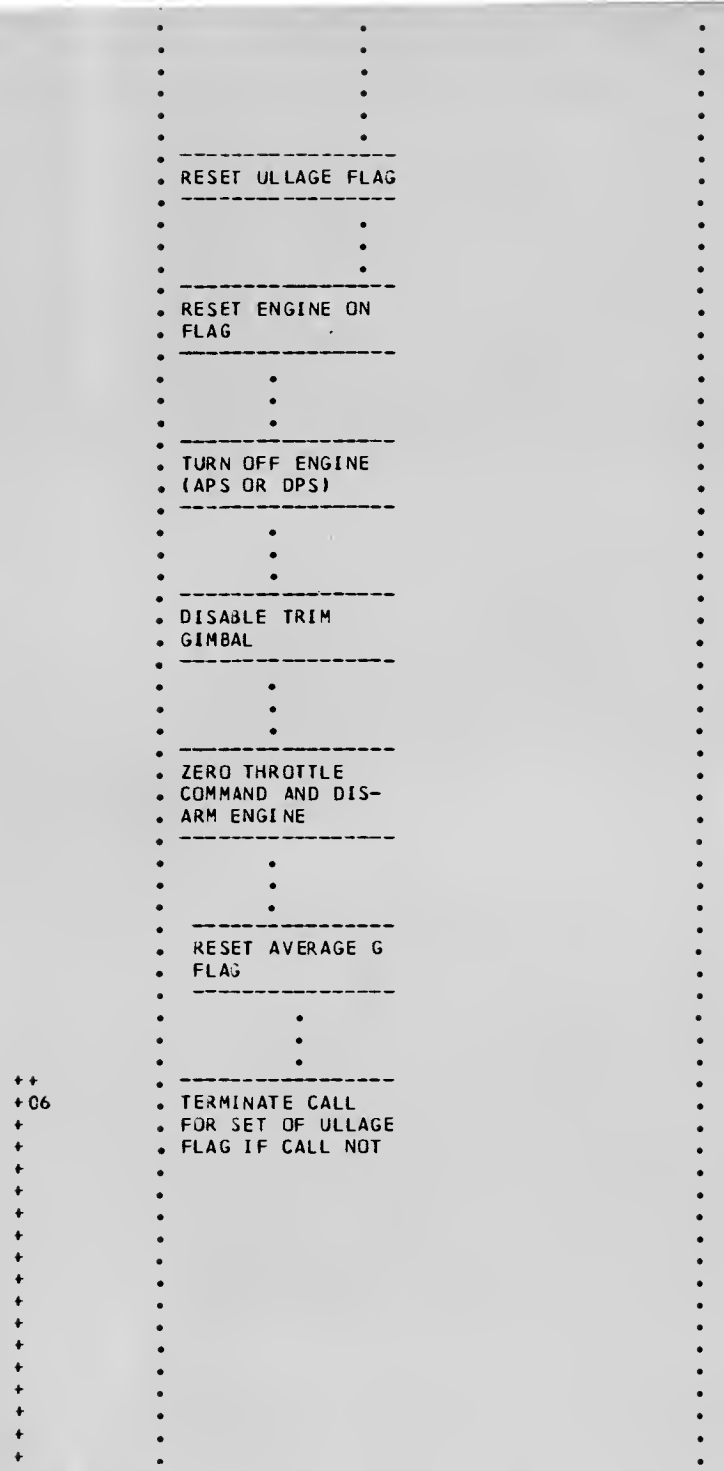
#190

#200

#210

#220

#230



#240

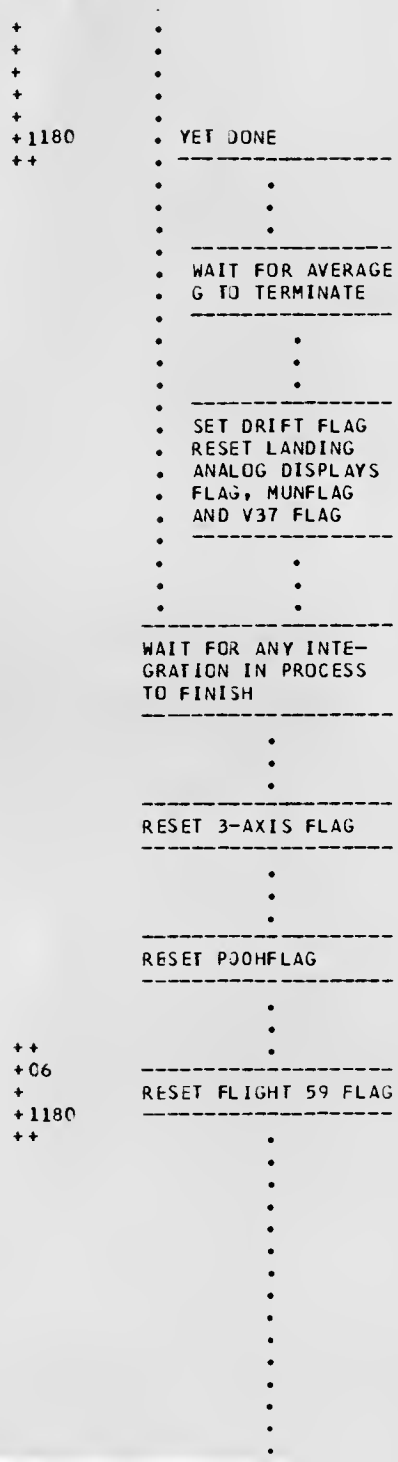
#250

#260

#270

#280

06



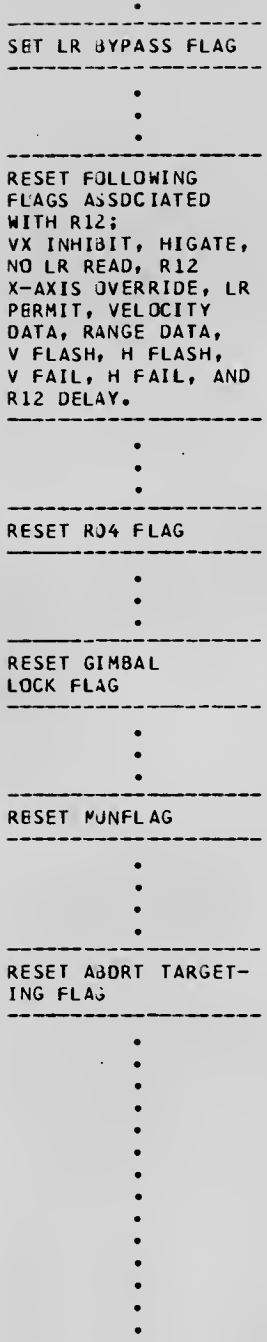
#290

#300

#310

#320

#330

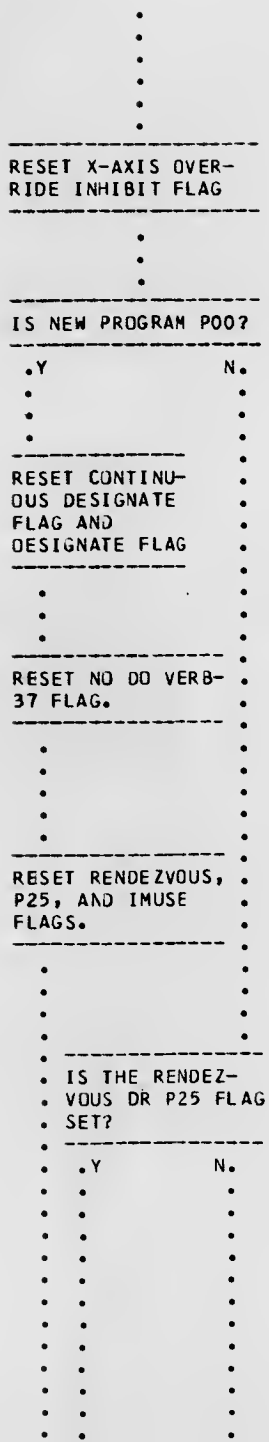


#340

#350

#360

#370



#380

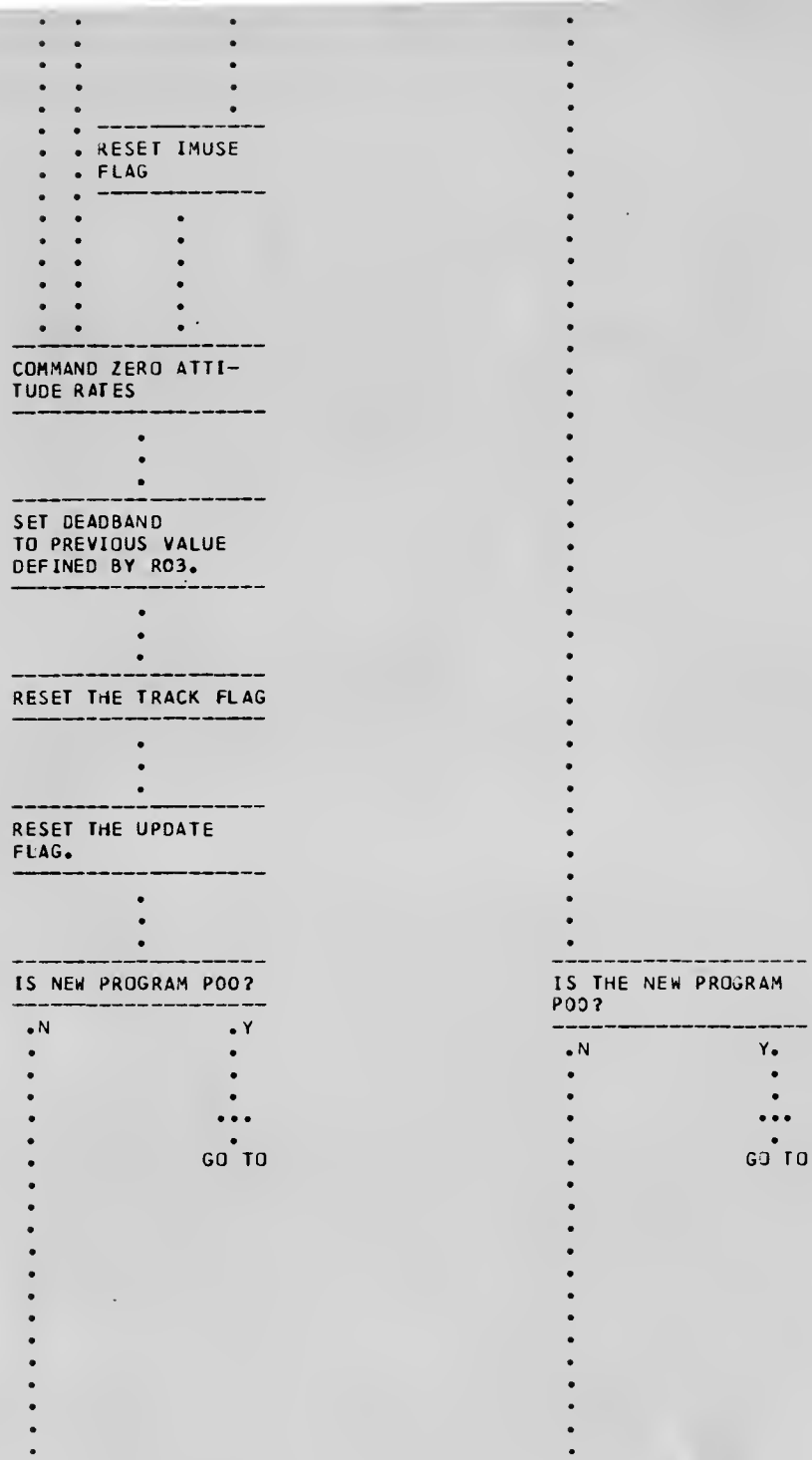
#390

#400

#410

#420

#430

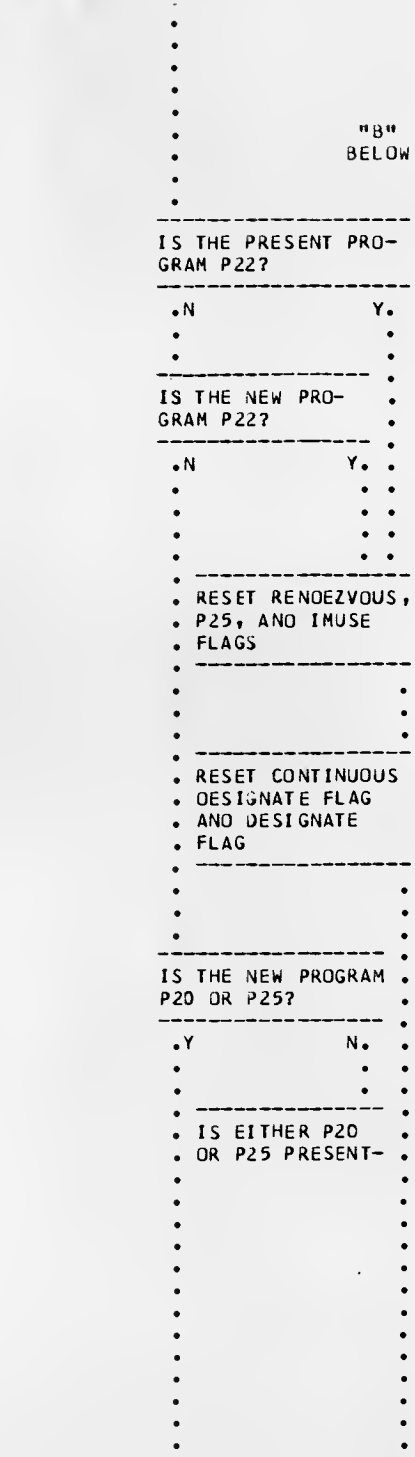


#440

#450

#460

#470



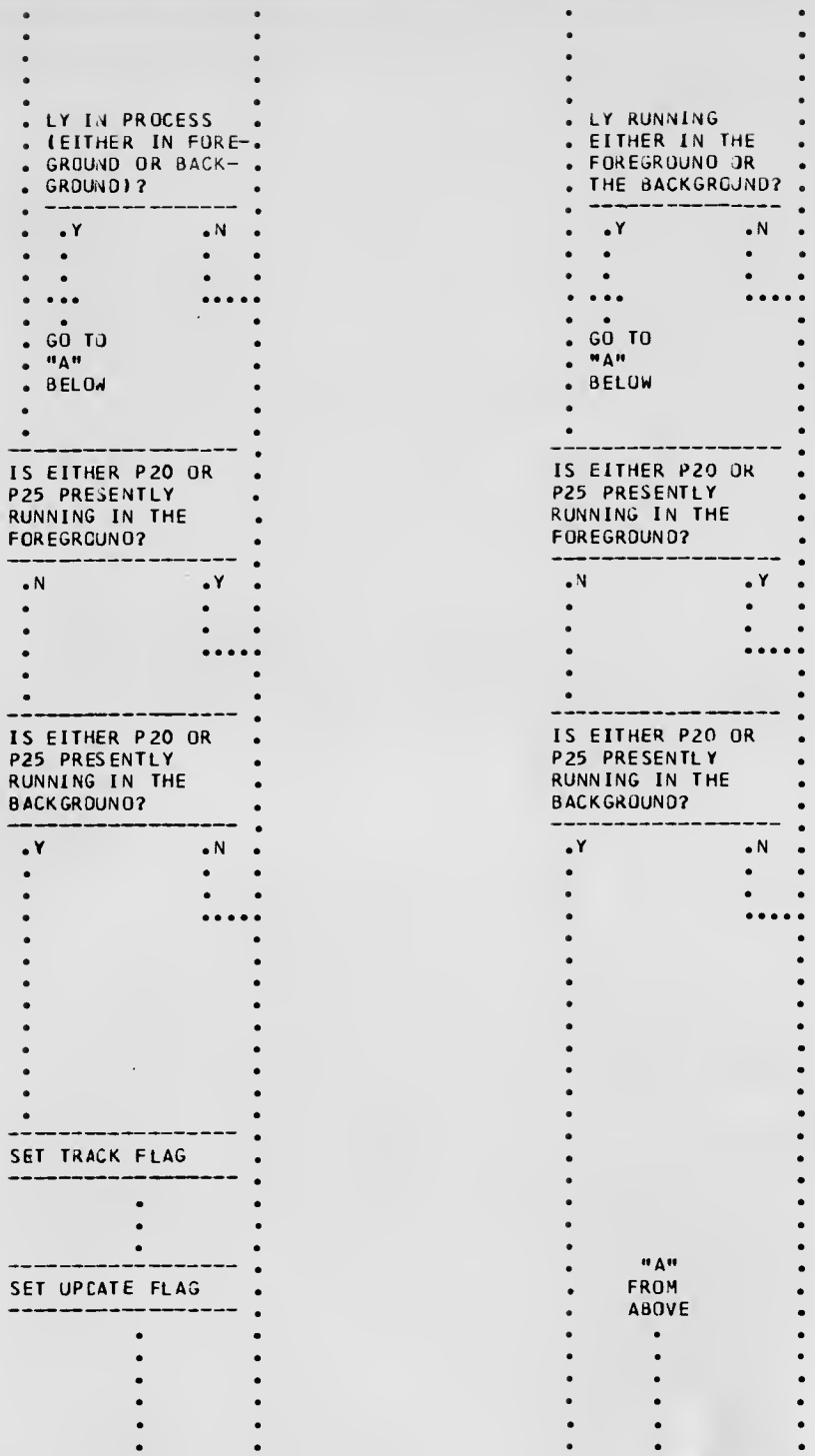
#480

#490

#500

#510

#520



#530

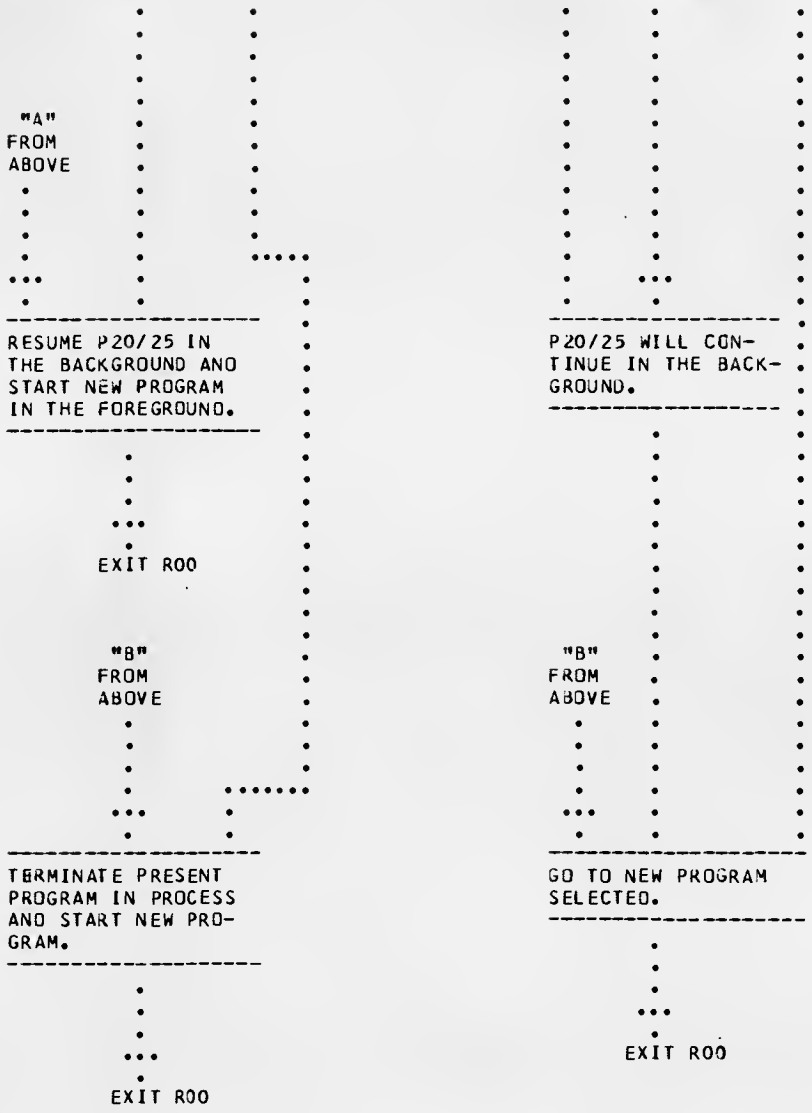
#540

#550

#560

#570

#580



#590

#600

#610

#620

#630

CHANGE CONTROL NOTES

REV 01 - PCR 80,86,118,137,214,453
REV 02(LUM 1B) PCR 798.2, EDITORIAL
REV 03(LUM 1C) PCR 893, EDITORIAL
REV 04(LUM 1D) PCR 892,898, PCN 1009
REV 05(LUM 1E) PCN 1145
REV 06 PCN 1180

ERASABLE AND CHANNEL MODIFICATION ROUTINE (R01) REV 04 02/17/71

PURPOSE: (1) TO PROVIDE MANUAL CAPABILITY OF CHANGING FLAGWORD BITS OR CHANNEL BITS.

ASSUMPTIONS: (1) THIS PROCEDURE CAN BE PERFORMED AT ANY TIME.

(2) THIS PROCEDURE IS NOT RESTRICTED TO FLAGWORDS OR CHANNELS BUT CAN MODIFY ANY LEGITIMATE ERASABLE LOCATION > 30.

DESCRIPTION: (1) NOUN 07 MUST BE LOADED BY V25N07E.

(2) NOUN 07 IS A THREE COMPONENT OCTAL NOUN WITH THE FOLLOWING DEFINITION:

R1 = AN ADDRESS SPECIFYING EITHER THE ECADR OF AN ERASABLE LOCATION OR THE NUMBER OF A CHANNEL:
IF R1>30, THE ADDRESS IS ASSUMED TO BE AN ECADR;
IF R1<30, THE ADDRESS IS ASSUMED TO BE A CHANNEL NUMBER.

AS IN ALL ATTEMPTS TO MODIFY CHANNEL 7, THE REQUEST IS IGNORED IF R1=7.

R2 = UP TO FIVE OCTAL DIGITS SPECIFYING BITS IN THE WORD TO BE SET (E.G.: 200 IS BIT 8).

R3 = POSITIVE NON-ZERO INDICATES A "1" IS TO BE SET INTO BIT POSITIONS SPECIFIED IN R2. ZERO, NEGATIVE, OR BLANK INDICATES A "0".

(3) AS AN EXAMPLE, SETTING OF BITS 1, 3 AND 13 TO "1" IN FLAGWORD 8 REQUIRES THE FOLLOWING SEQUENCE:

```
V25N07E
  104E
10005E
    1E
```

RESETTING THE SAME BITS TO "0" REQUIRES THE SEQUENCE:

```
V25N07E
  104E
10005E
    0E
```

(4) SETTING OF BIT 10 OF CHANNEL 12 TO "1" REQUIRES THE FOLLOWING SEQUENCE:

```
V25N07E
   12E
 1000E
    1E
```

RESETTING THE SAME BIT TO "0" REQUIRES THE SEQUENCE:

```
V25N07E
   12E
 1000E
    0E
```

CHANGE CONTROL NOTES

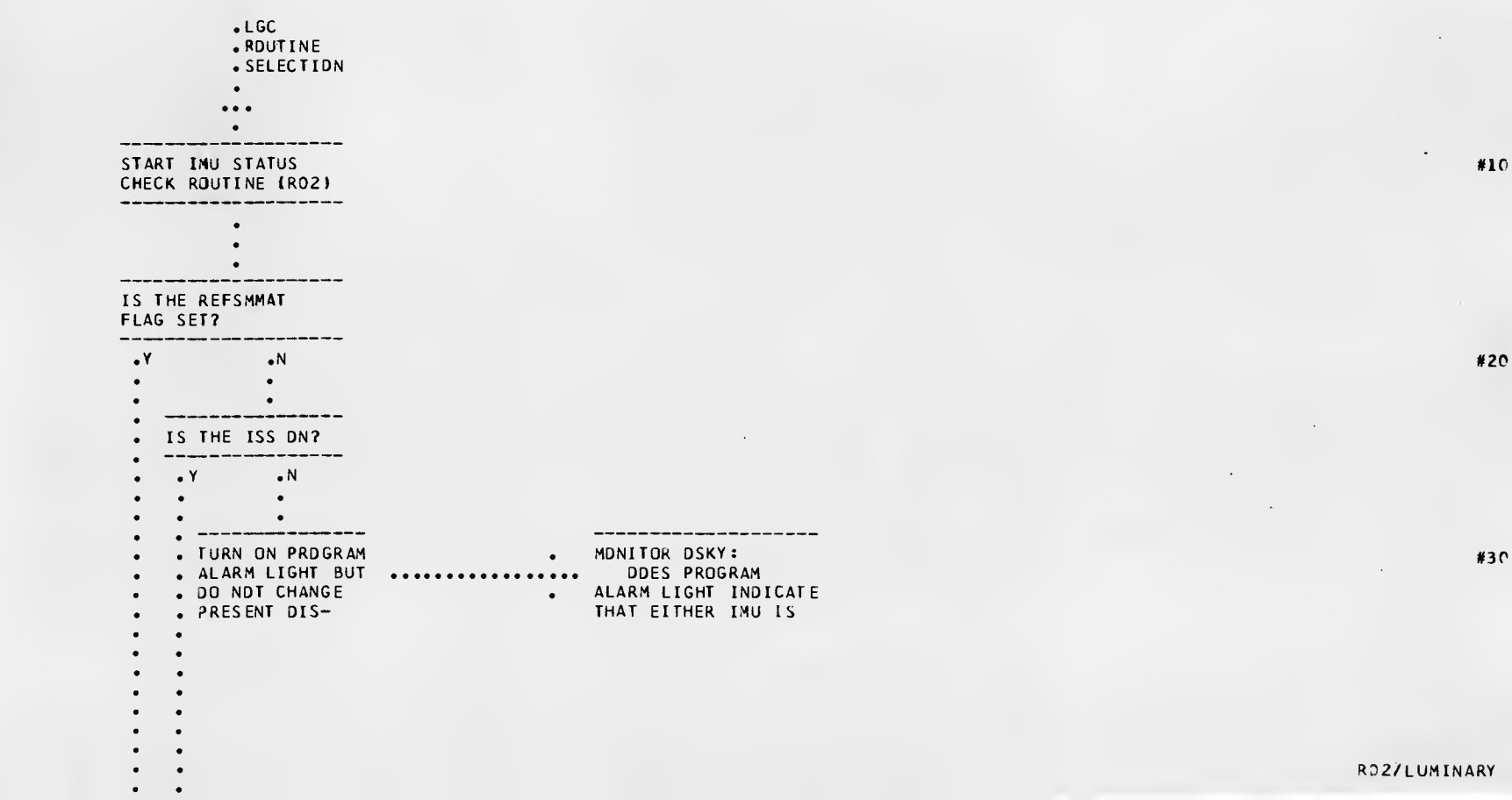
LOGIC REV 00 PCR 79
      REV 01 EDITORIAL
      REV 02(LUM 1C) PCR 806.2, EDITORIAL
      REV 03(LUM 1D) PCR 302.2, PCN 1009
      REV 04(LUM 1E) PCN 1145

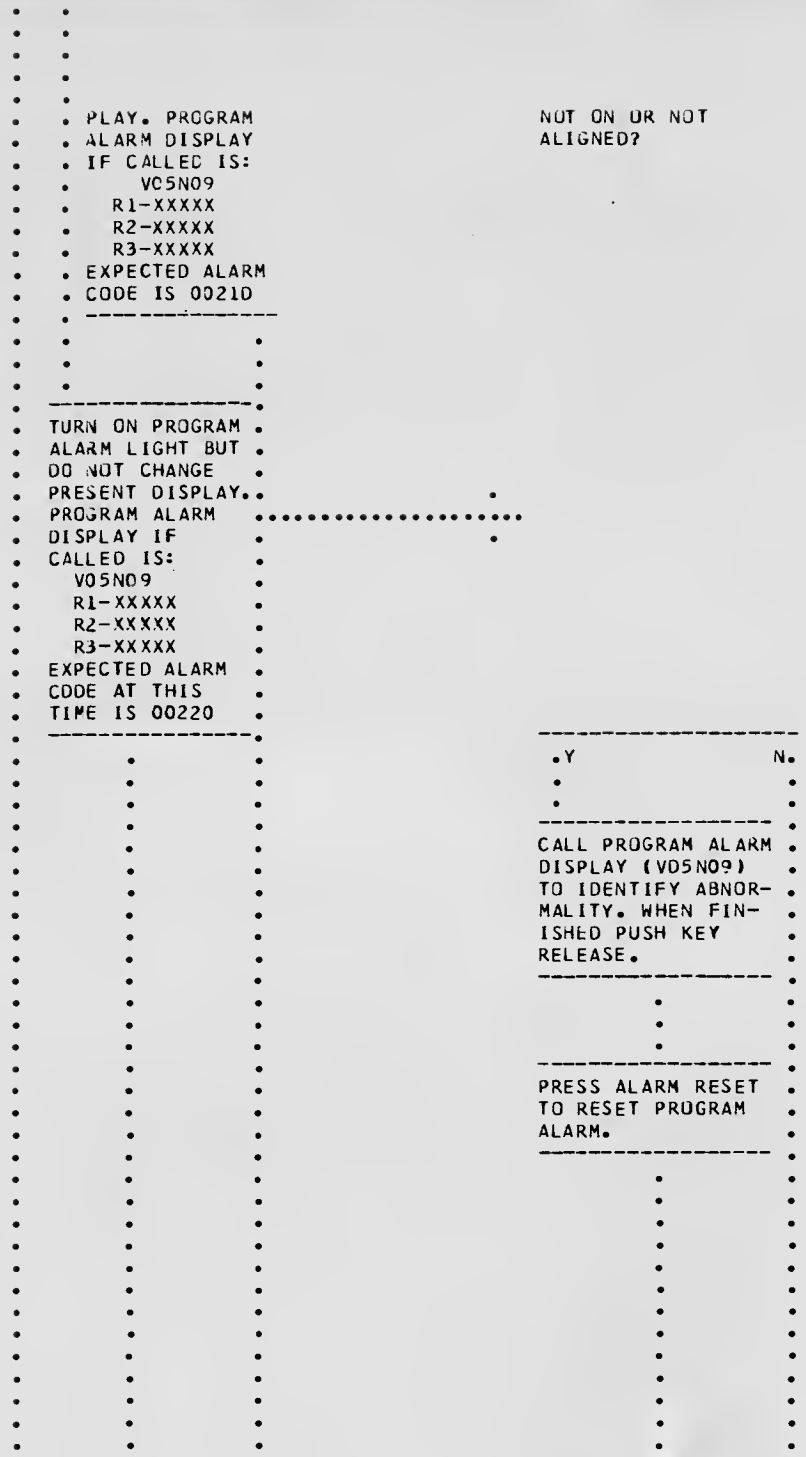
IMU STATUS CHECK ROUTINE (R02) REV 03 12/03/69

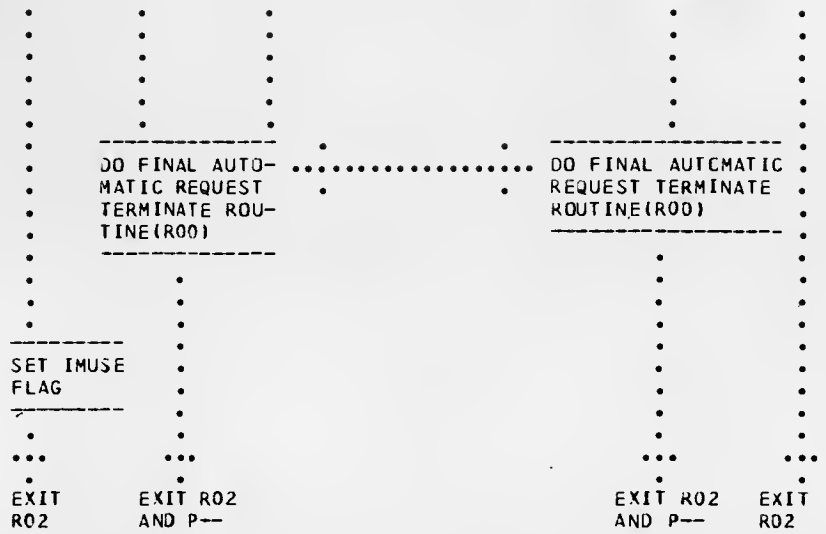
PURPOSE: (1) TO CHECK WHETHER IMU IS ON AND, IF ON, WHETHER IT IS ALIGNED TO AN ORIENTATION KNOWN BY THE LGC.

(2) TO ESTABLISH A PROGRAM ALARM AND STORE AN ALARM CODE IF THE IMU IS OFF OR NOT ALIGNED TO AN ORIENTATION KNOWN BY THE LGC.

ASSUMPTIONS: (1) THE ROUTINE IS AUTOMATICALLY SELECTED BY THE PROGRAM IN PROCESS.




PLAY. PROGRAM ALARM DISPLAY IF CALLED IS:
V05N09
R1-XXXXX
R2-XXXXX
R3-XXXXX
EXPECTED ALARM CODE IS 00210
NOT ON OR NOT ALIGNED?
#40
TURN ON PROGRAM ALARM LIGHT BUT DO NOT CHANGE PRESENT DISPLAY.
PROGRAM ALARM DISPLAY IF CALLED IS:
V05N09
R1-XXXXX
R2-XXXXX
R3-XXXXX
EXPECTED ALARM CODE AT THIS TIME IS 00220
#50
#60
Y
N
CALL PROGRAM ALARM DISPLAY (V05N09) TO IDENTIFY ABNORMALITY. WHEN FINISHED PUSH KEY RELEASE.
#70
PRESS ALARM RESET TO RESET PROGRAM ALARM.
#80



#90

#100

CHANGE CONTROL NOTES

REV 01 PCR 413
REV 02 EDITORIAL
REV 03 EDITORIAL

DAP DATA LOAD RDUTINE (R03) REV 06 12/01/71

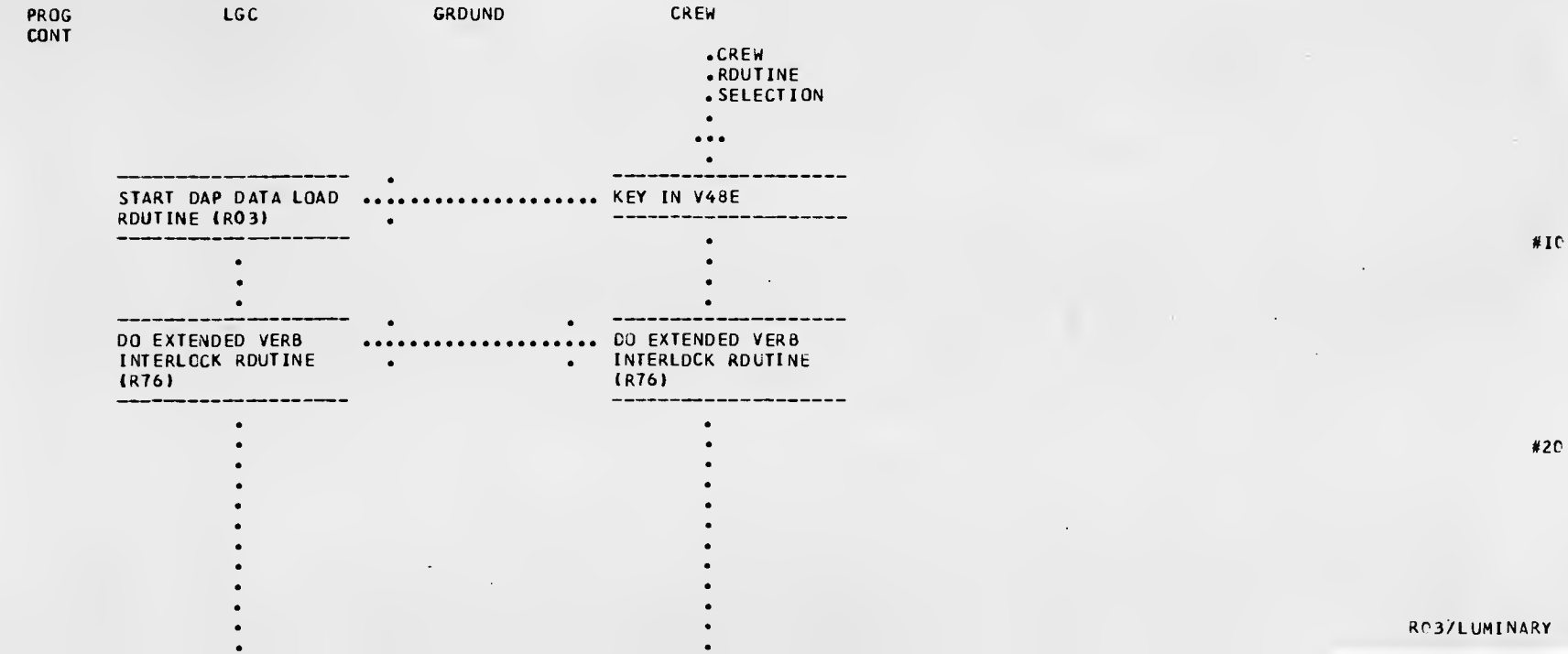
PURPDSE: (1) TO PRDVIDE THE CREW WITH A MEANS OF DISPLAYING AND SPECIFYING:
(A) THE SPACECRAFT CONFIGURATIDN AND CERTAIN AUTOPILOT RESPONSE PARAMETERS (R1 DF N46)
(B) THE DESIRED CONFIGURATIDN FDR AUTD THRDTTLE AND ABORT/ABDRT STAGE CHANNEL BIT PRDTECTION
(C) THE MASSES DF THE LM AND CSM (N47)
(D) THE DESIRED DPS ENGINE GIMBAL TRIM ANGLES (N48)

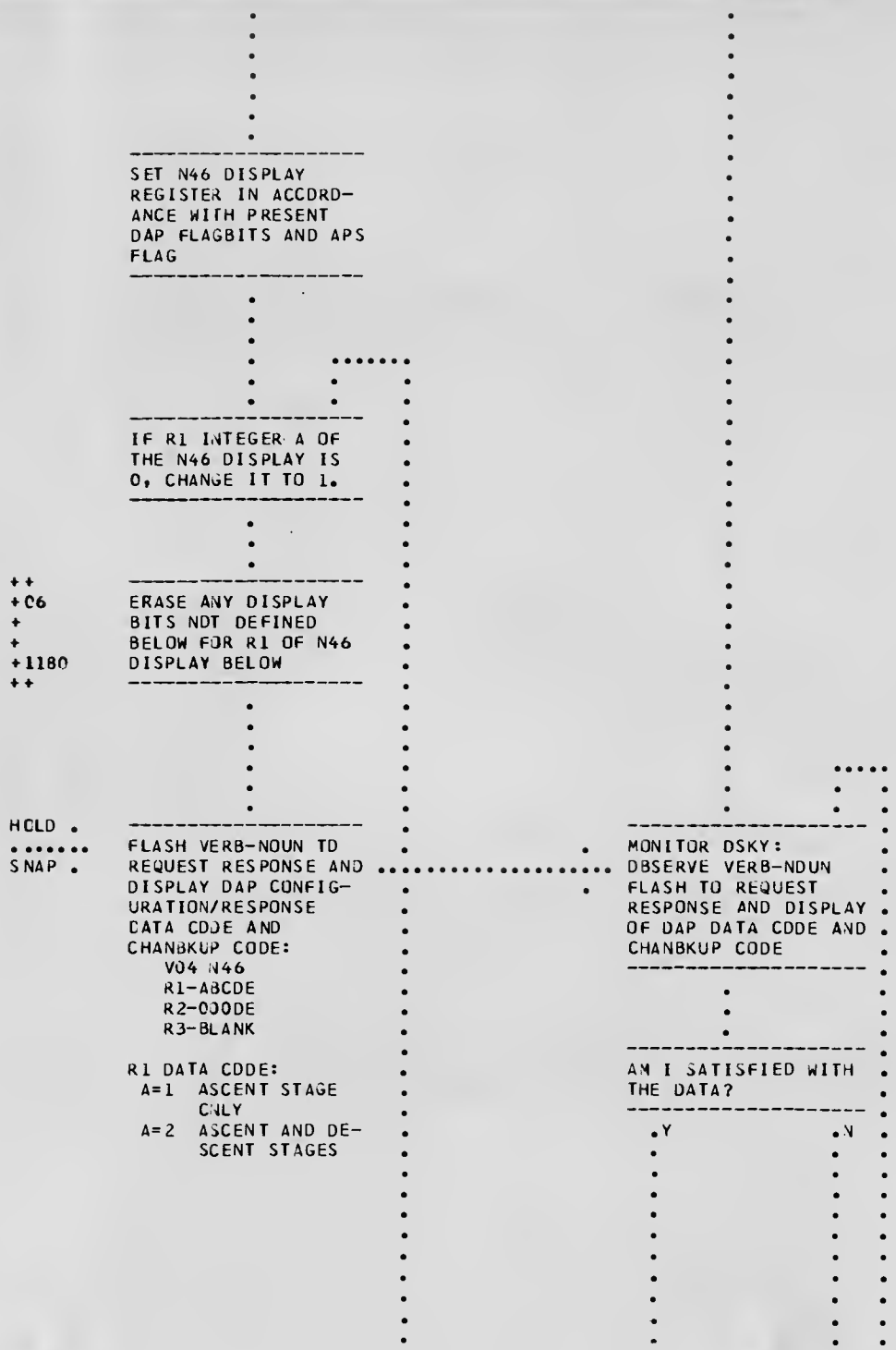
(2) TD PERFDRM DPS ENGINE GIMBAL TRIM.

ASSUMPTIDNS: (1) THIS RDUTINE IS MANUALLY SELECTED BY THE CREW. IT SHDULD NOT BE SELECTED AT TIMES WHEN IT WDULD DVERWRITE AN ATTITUDE DEADBAND THAT WAS SELECTED AUTDMATICALLY BY THE LGC. THIS RDUTINE SHDULD NDT BE SELECTED DURING PDWERED FLIGHT IN DRDER TD AVDID DIFFICULTIES ASSDCIATED WITH THE SETTING DF THE ATTITUDE DEADBAND AND THE MASSES.

(2) IN GENERAL, A 1.0 DEGREE DEADBAND IS DESIRABLE FDR PDWERED FLIGHT. THEREFDRE, IF THE ASTRONAUT SELECTS R03 AFTER THE LGC SETS A 1.0 DEGREE DEADBAND (THIS HAPPENS WHEN R60 IS CALLED) HE SHDULD EXERCISE CARE THAT THE CDRRECT PDWERED FLIGHT DEADBAND IS SET BY R03.

(3) R2 DF N46 CAN BE LDADED BY DSKY ENTRY V22N46E, WITHDUT ACTUALLY SELECTING R03. REVIEW DF THIS REGISTER IS ACCDMPLISHED BY DSKY ENTRY V04N46E.




SET N46 DISPLAY REGISTER IN ACCORD-ANCE WITH PRESENT DAP FLAGBITS AND APS FLAG
#30
IF R1 INTEGER A OF THE N46 DISPLAY IS 0, CHANGE IT TO 1.
#40
++
+C6
+
+
+1180
++
ERASE ANY DISPLAY BITS NOT DEFINED BELOW FOR R1 OF N46 DISPLAY BELOW
#50
HOLD .
.....
SNAP .
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY DAP CONFIG-URATION/RESPONSE DATA CODE AND CHANBKUP CODE:
V04 N46
R1-ABCDE
R2-OOODE
R3-BLANK
R1 DATA CODE:
A=1 ASCENT STAGE ONLY
A=2 ASCENT AND DE-SCENT STAGES
MONITOR DSKY: OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY OF DAP DATA CODE AND CHANBKUP CODE
#60
AM I SATISFIED WITH THE DATA?
#70
Y
N

A=3 ASCENT AND DE-
SCENT STAGES
DOCKED WITH CSM
B=0 2 JET TRANSLA-
TION, RCS SYS-
TEM A
B=1 2 JET TRANSLA-
TION, RCS SYS-
TEM B
B=2 4 JET TRANS-
LATION
B=3 4 JET TRANS-
LATION
C=0 FINE SCALING
ACA (4 DEG/SEC)
C=1 NORMAL SCALING
ACA (20 DEG/SEC)
D=0 ATT DEADBAND,
0.3 DEGREES
D=1 ATT DEADBAND,
1.0 DEGREE
D=2 ATT DEADBAND,
5.0 DEGREES.
E= KALCMANU RATE
0= .2 DEG/SEC
1= .5 DEG/SEC
2= 2 DEG/SEC
3= 10 DEG/SEC
NOTE: ACA SCALING
AS SHOWN IS FOR LM
ALONE.
IF THE LM IS DOCKED
WITH THE CSM THESE
++ VALUES ARE 10 TIMES
+06 LESS.
+ B=2 OR 3 DO NOT
+ DIFFER EXCEPT FOR
+1180 MINIMUM IMPULSE JET
++ SELECTION.
R2 DATA CODE:
D=0 ACCEPT AUTO/
MAN THROTTLE
DISCRETE
(CHANNEL 30
BIT 5)
D=1 ASSUME AUTO
THRDTTLE

#80

#90

#100

#110

#120

E=0 ACCEPT ABORT/
ABORT STAGE
DISCRETE
(CHANNEL 30
BITS 1 AND 4)
E=1 IGNORE ABORT/
ABORT STAGE
DISCRETE

#130

WAIT FOR KEYBOARD
ENTRY

KEY IN PRO-
CEED

#140

KEY IN V21E OR
V24E AND LOAD
DESIREO DATA

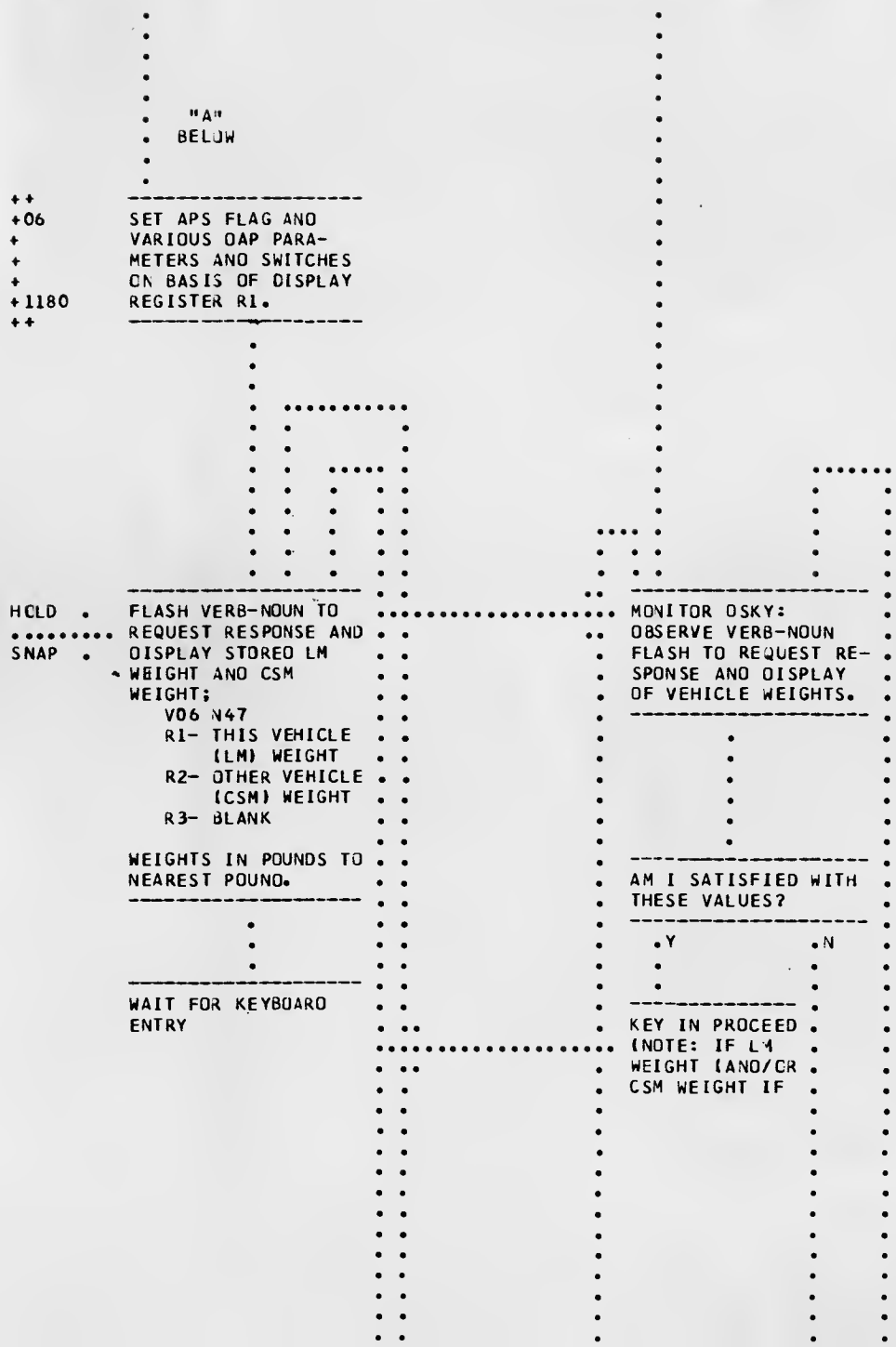
#150

TERMINATE FLASH UPON
RECEIPT OF PROCEED,
TERMINATE, OR NEW
DATA

.P .T .NEW OATA
.R .E .
.O .R .
.C .M
.E .I STORE OATA
.E .N
.D .A .
. .T .
. .E .
. .
. .
. ...
. .
. GO TO

#160

#170

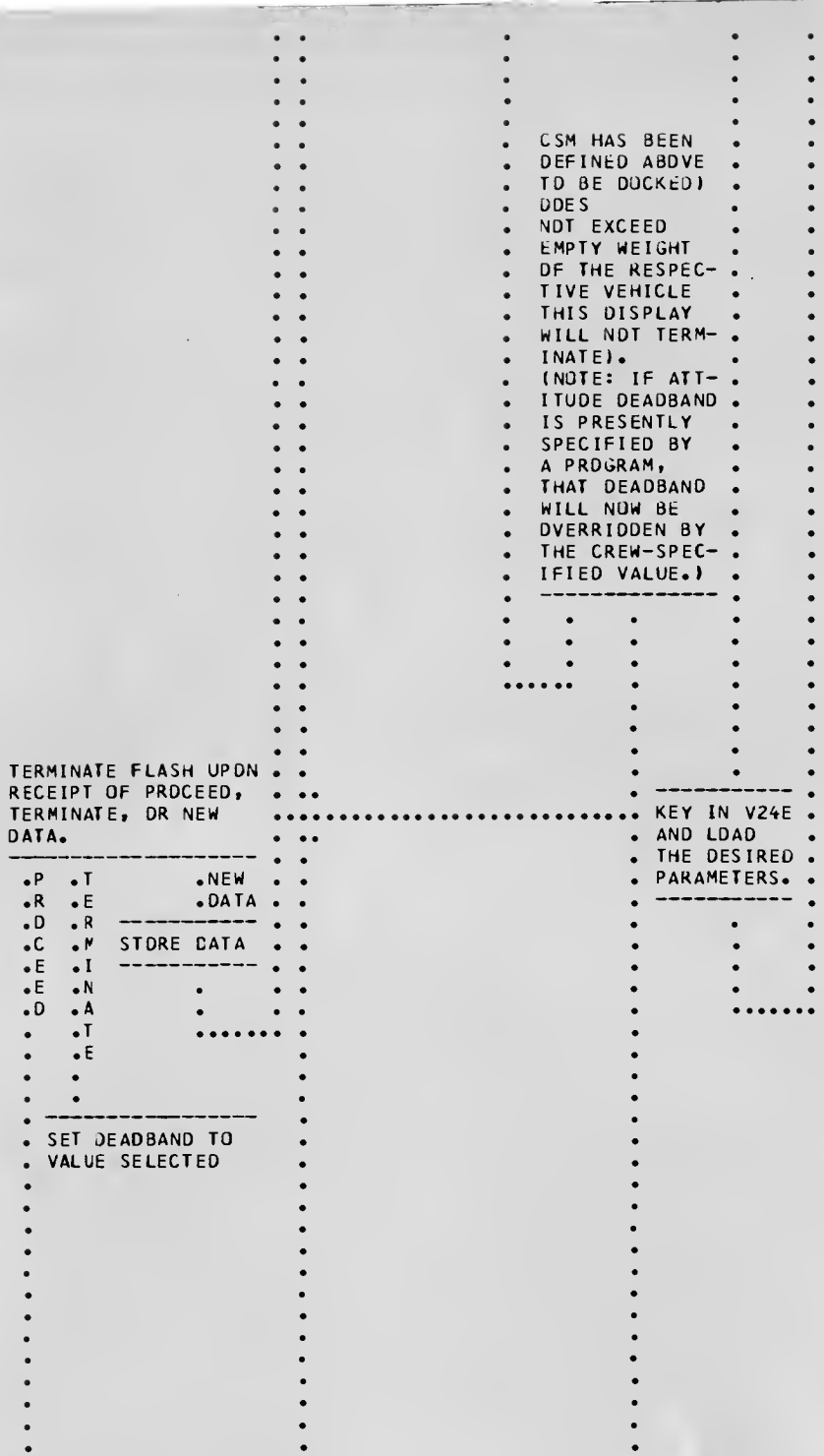


#180

#190

#200

#210



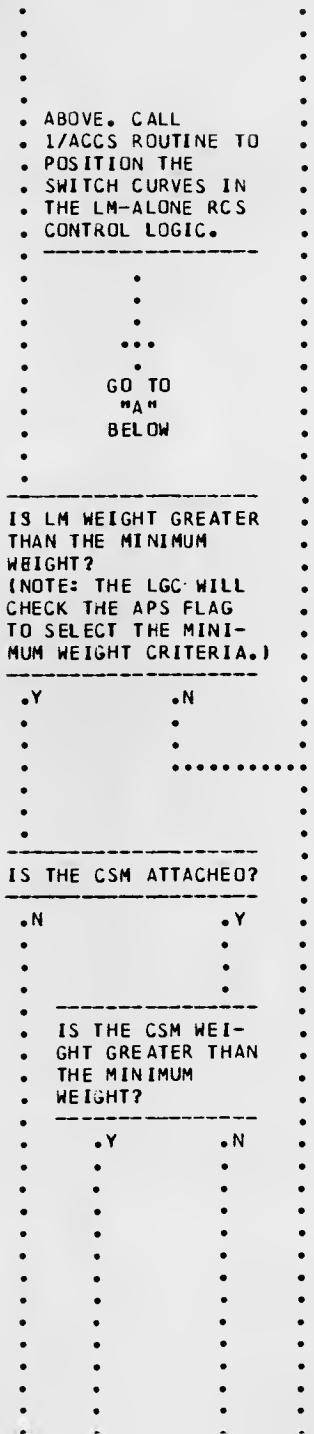
#220

#230

#240

#250

#260



#270

#280

#290

#300

#310

#320

TRANSFER DATA TO OAP

#330

SET DEADBAND TO VALUE SELECTED ABOVE. CALL 1/ACCS ROUTINE TO RECOMPUTE THE FUNCTIONS OF MASS ON THE BASIS OF THE NEW VALUES AND TO REPOSITION THE SWITCH CURVES FOR THE LM-ALONE RCS CONTROL LOGIC ON THE BASIS OF THE NEW DEADBAND.

#340

IS APS FLAG SET?

Y

N

GO TO "A" BELOW

#350

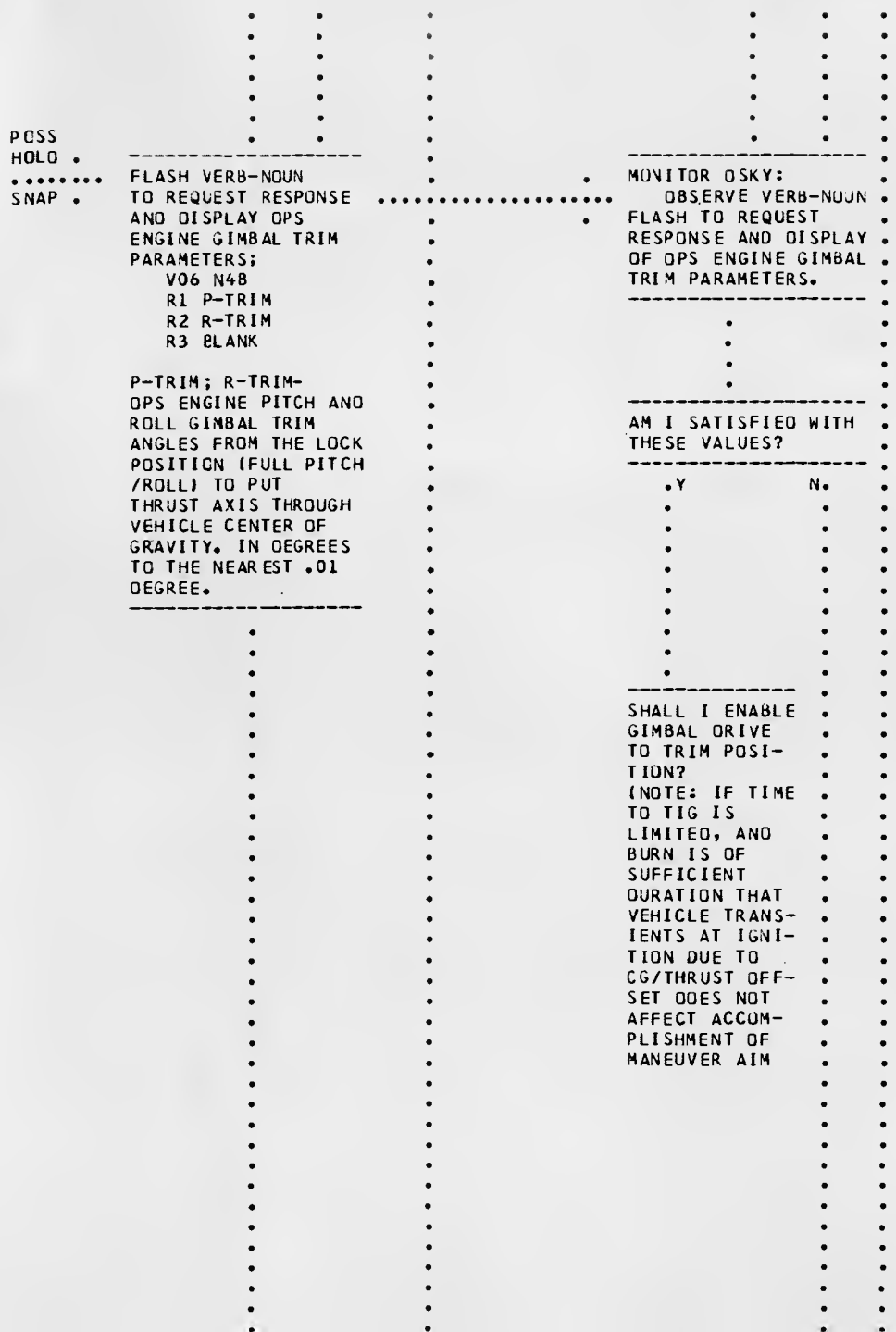
IS THE DESCENT STAGE ATTACHED?

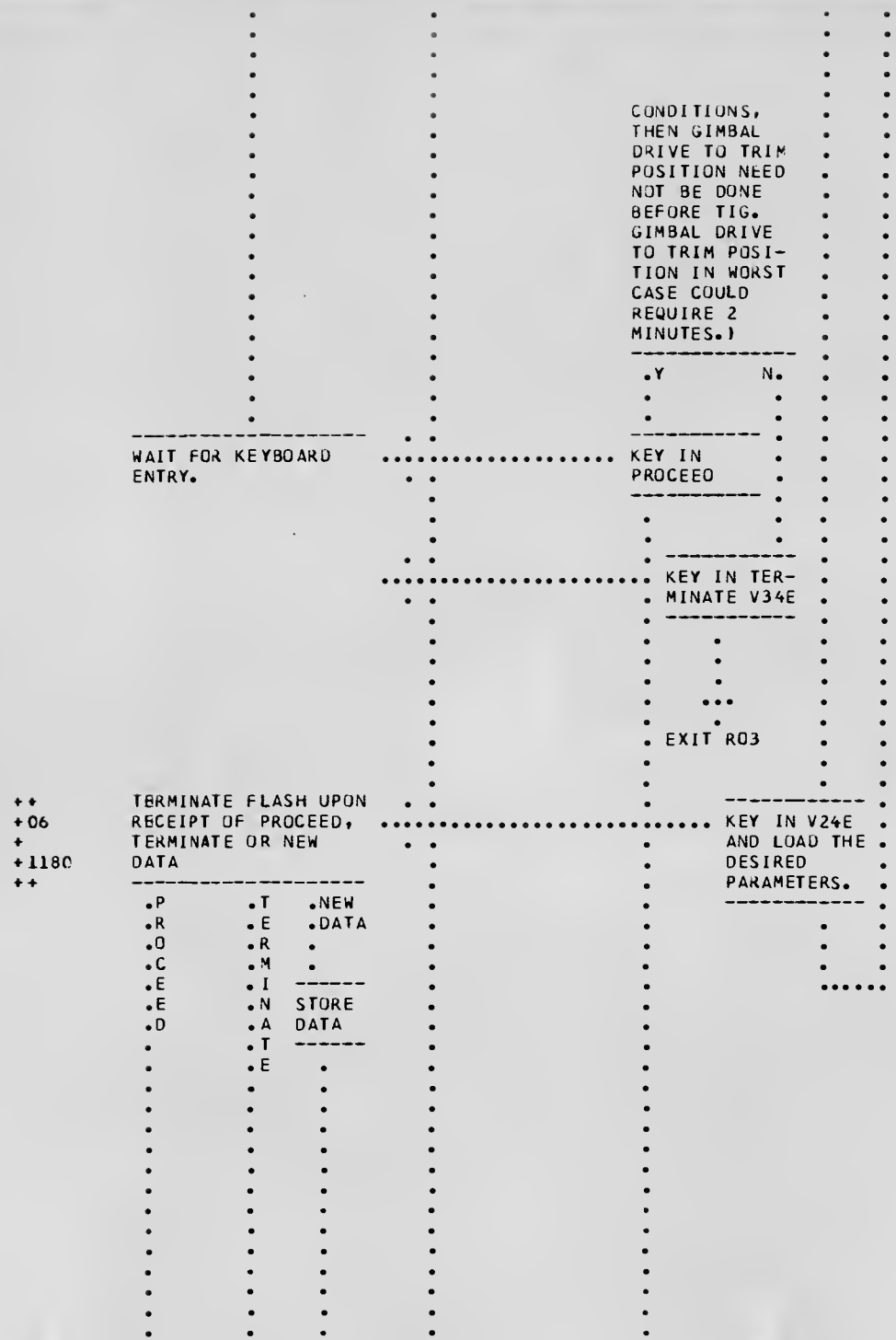
N

Y

EXIT R03

#360


POSS HOLO SNAP
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY OPS ENGINE GIMBAL TRIM PARAMETERS;
V06 N48
R1 P-TRIM
R2 R-TRIM
R3 BLANK
P-TRIM; R-TRIM- OPS ENGINE PITCH AND ROLL GIMBAL TRIM ANGLES FROM THE LOCK POSITION (FULL PITCH /ROLL) TO PUT THRUST AXIS THROUGH VEHICLE CENTER OF GRAVITY. IN DEGREES TO THE NEAREST .01 DEGREE.
MONITOR OSKY: OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY OF OPS ENGINE GIMBAL TRIM PARAMETERS.
#370
AM I SATISFIED WITH THESE VALUES?
#380
Y
N
SHALL I ENABLE GIMBAL DRIVE TO TRIM POSITION?
(NOTE: IF TIME TO TIG IS LIMITED, AND BURN IS OF SUFFICIENT DURATION THAT VEHICLE TRANSIENTS AT IGNITION DUE TO CG/THRUST OFFSET DOES NOT AFFECT ACCOMPLISHMENT OF MANEUVER AIM
#390
#400



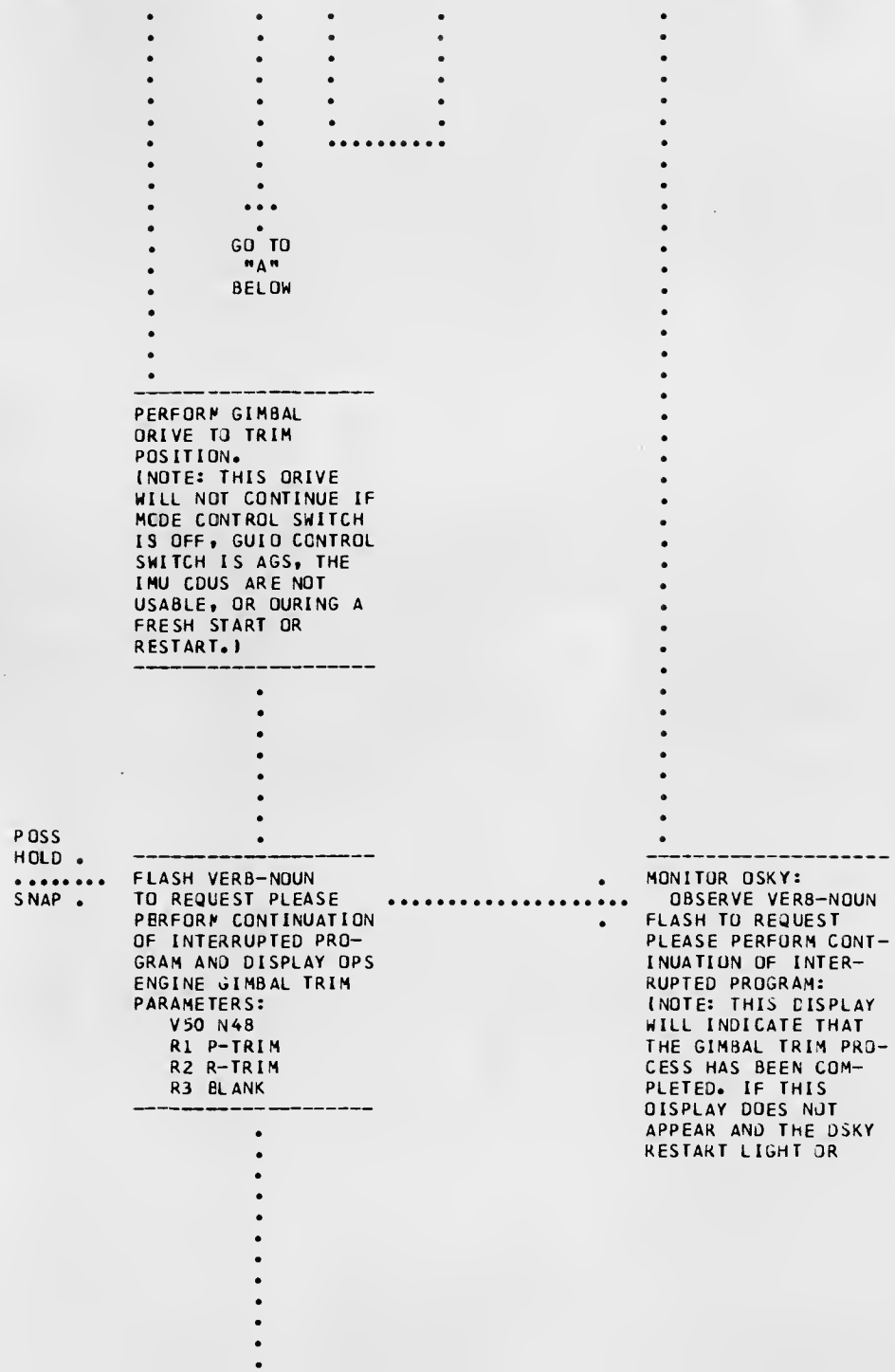
#410

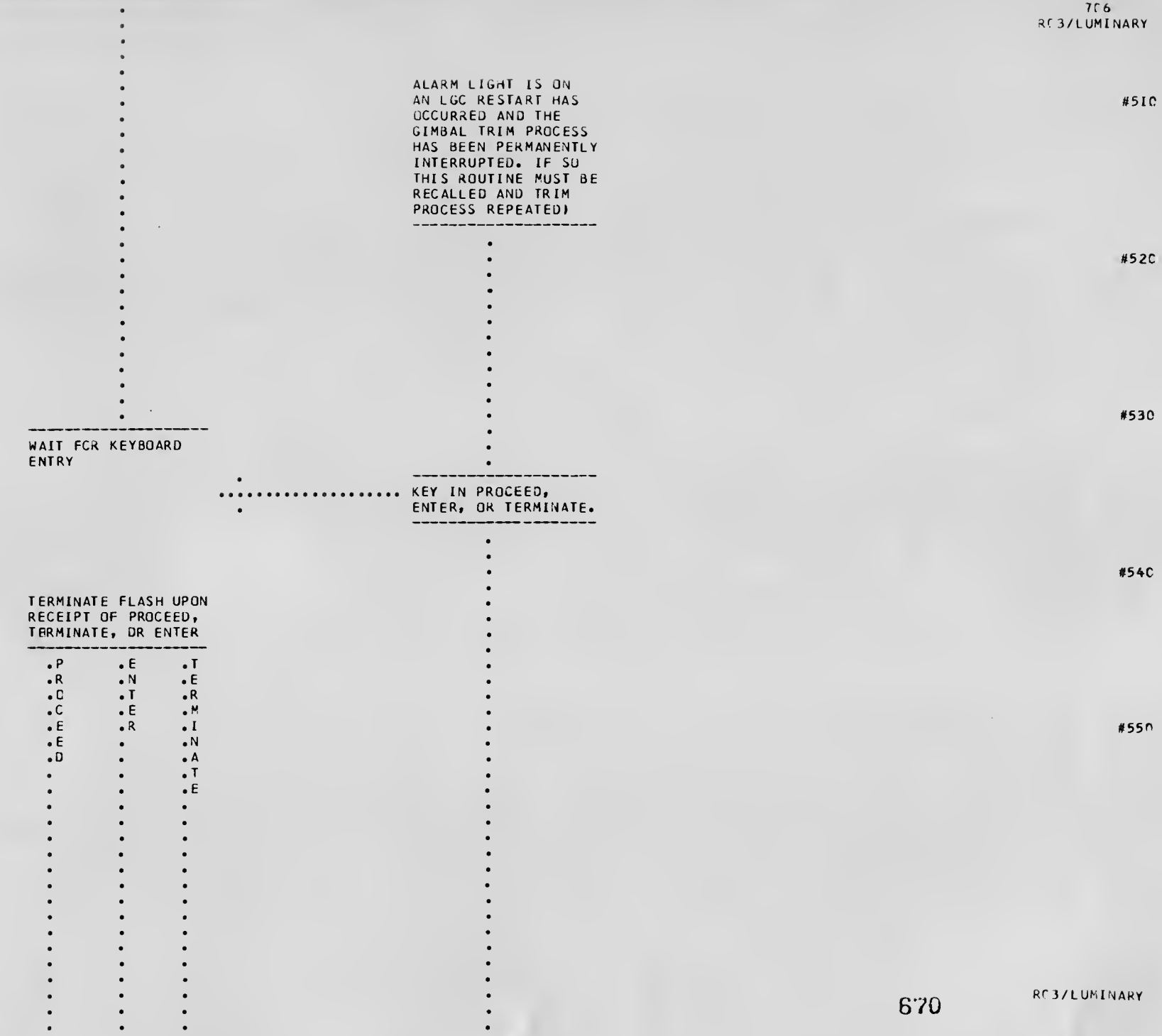
#420

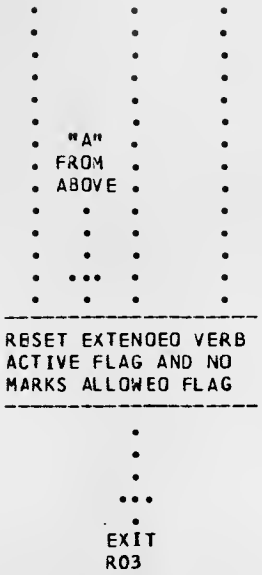
#430

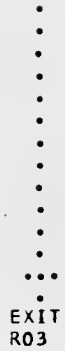
#440

#450


GO TO "A" BELOW
PERFORM GIMBAL DRIVE TO TRIM POSITION. (NOTE: THIS DRIVE WILL NOT CONTINUE IF MODE CONTROL SWITCH IS OFF, GUID CONTROL SWITCH IS AGS, THE IMU CDUS ARE NOT USABLE, OR DURING A FRESH START OR RESTART.)
POSS HOLD . SNAP .
FLASH VERB-NOUN TO REQUEST PLEASE PERFORM CONTINUATION OF INTERRUPTED PROGRAM AND DISPLAY OPS ENGINE GIMBAL TRIM PARAMETERS:
V50 N48
R1 P-TRIM
R2 R-TRIM
R3 BLANK
MONITOR DSKY: OBSERVE VER8-NOUN FLASH TO REQUEST PLEASE PERFORM CONTINUATION OF INTERRUPTED PROGRAM: (NOTE: THIS DISPLAY WILL INDICATE THAT THE GIMBAL TRIM PROCESS HAS BEEN COMPLETED. IF THIS DISPLAY DOES NOT APPEAR AND THE DSKY RESTART LIGHT OR
#460
#470
#480
#490
#500


ALARM LIGHT IS ON
AN LGC RESTART HAS
OCCURRED AND THE
GIMBAL TRIM PROCESS
HAS BEEN PERMANENTLY
INTERRUPTED. IF SO
THIS ROUTINE MUST BE
RECALLED AND TRIM
PROCESS REPEATED)
#510
#520
#530
WAIT FOR KEYBOARD
ENTRY
KEY IN PROCEED,
ENTER, OR TERMINATE.
#540
TERMINATE FLASH UPON
RECEIPT OF PROCEED,
TERMINATE, OR ENTER
PROCEED
ENTER
TERMINATE
#550





#560

#570

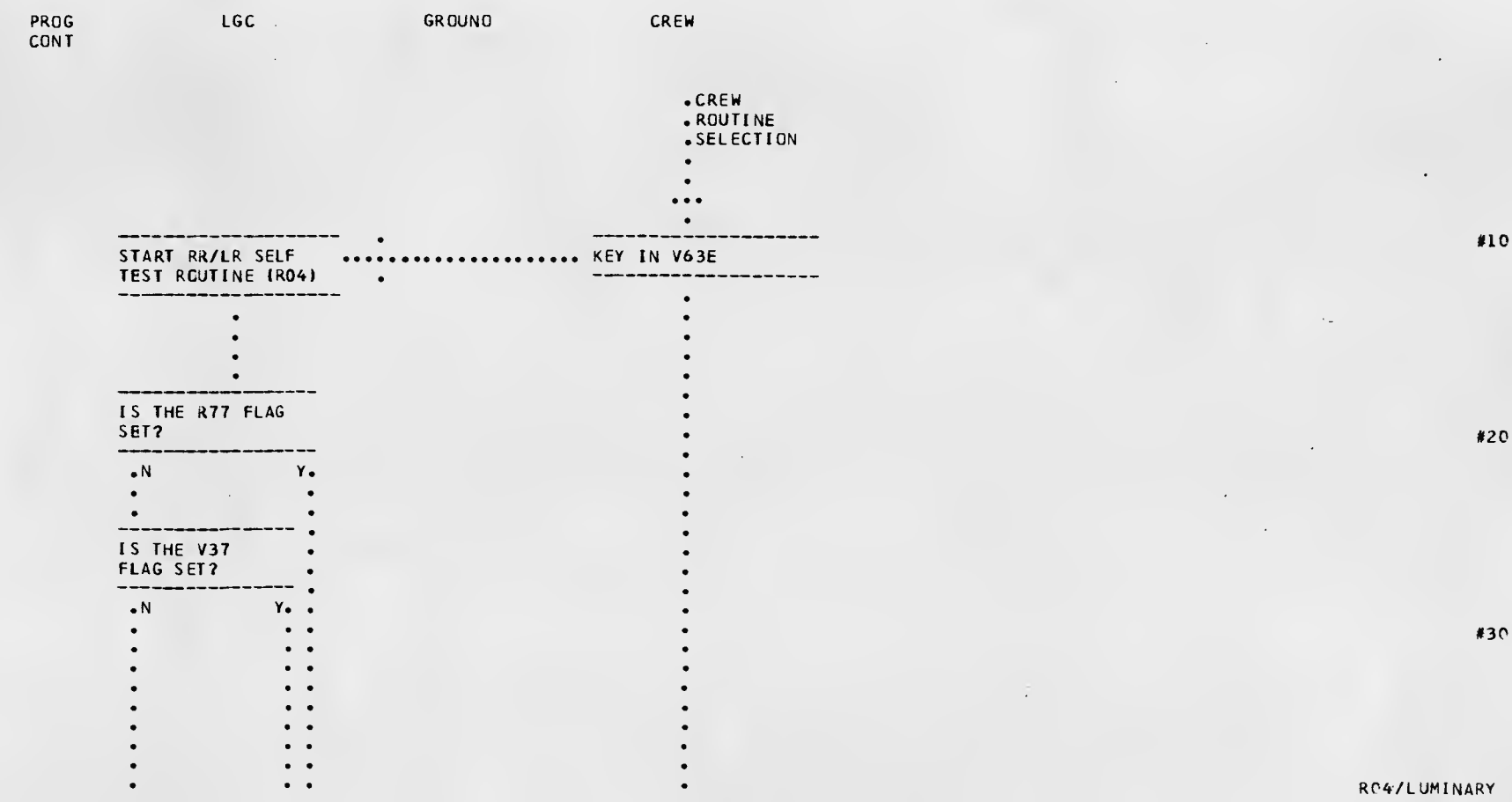
CHANGE CONTROL NOTES

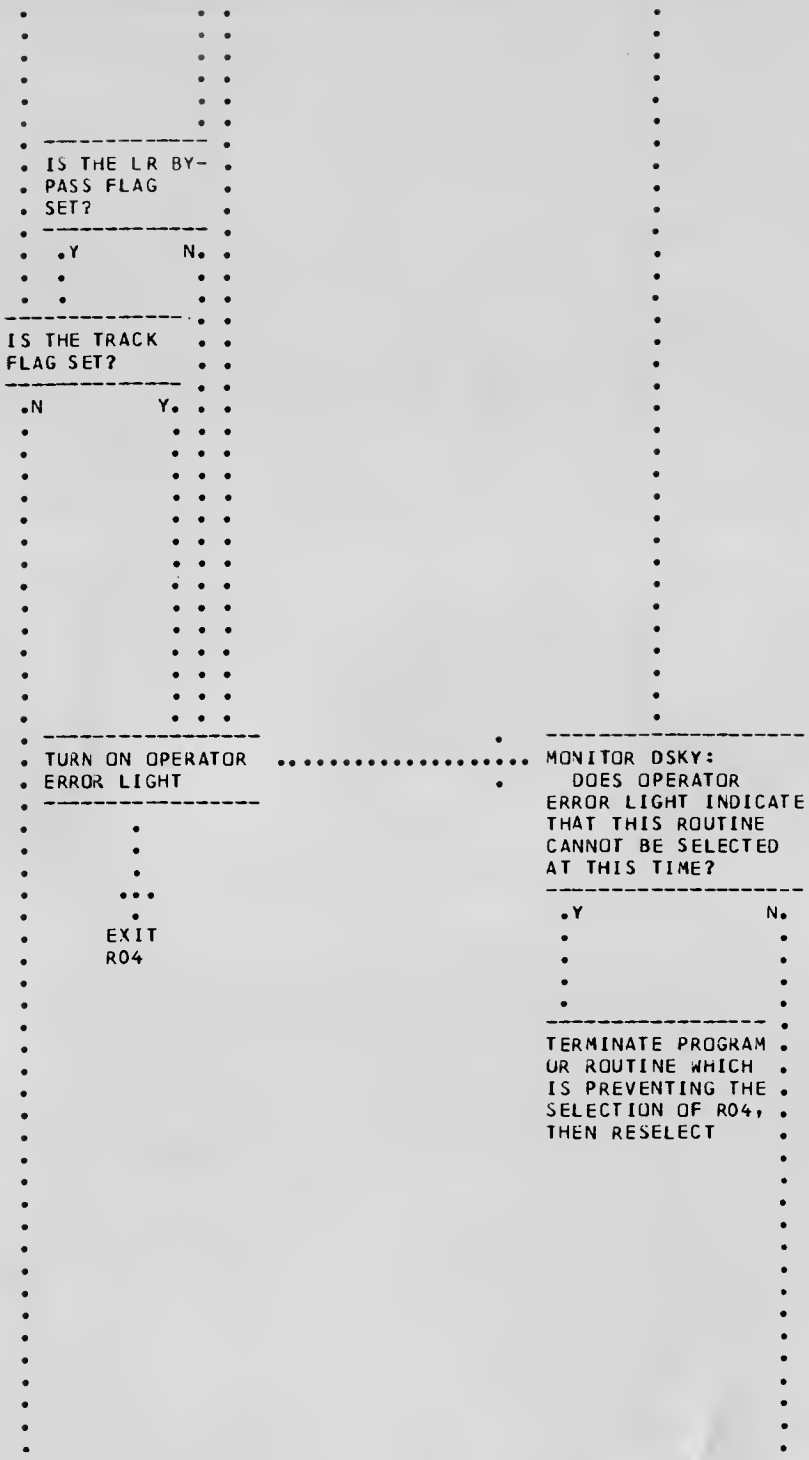
REV 01 PCR 184,419,452,618
REV 02(LUM 1B) PCR 816, EDITORIAL
REV 03 EDITORIAL
REV 04 PCN 1009
REV 05(LUM 1E) PCR 1107,1109, PCN 1145
REV 06 PCN 1180

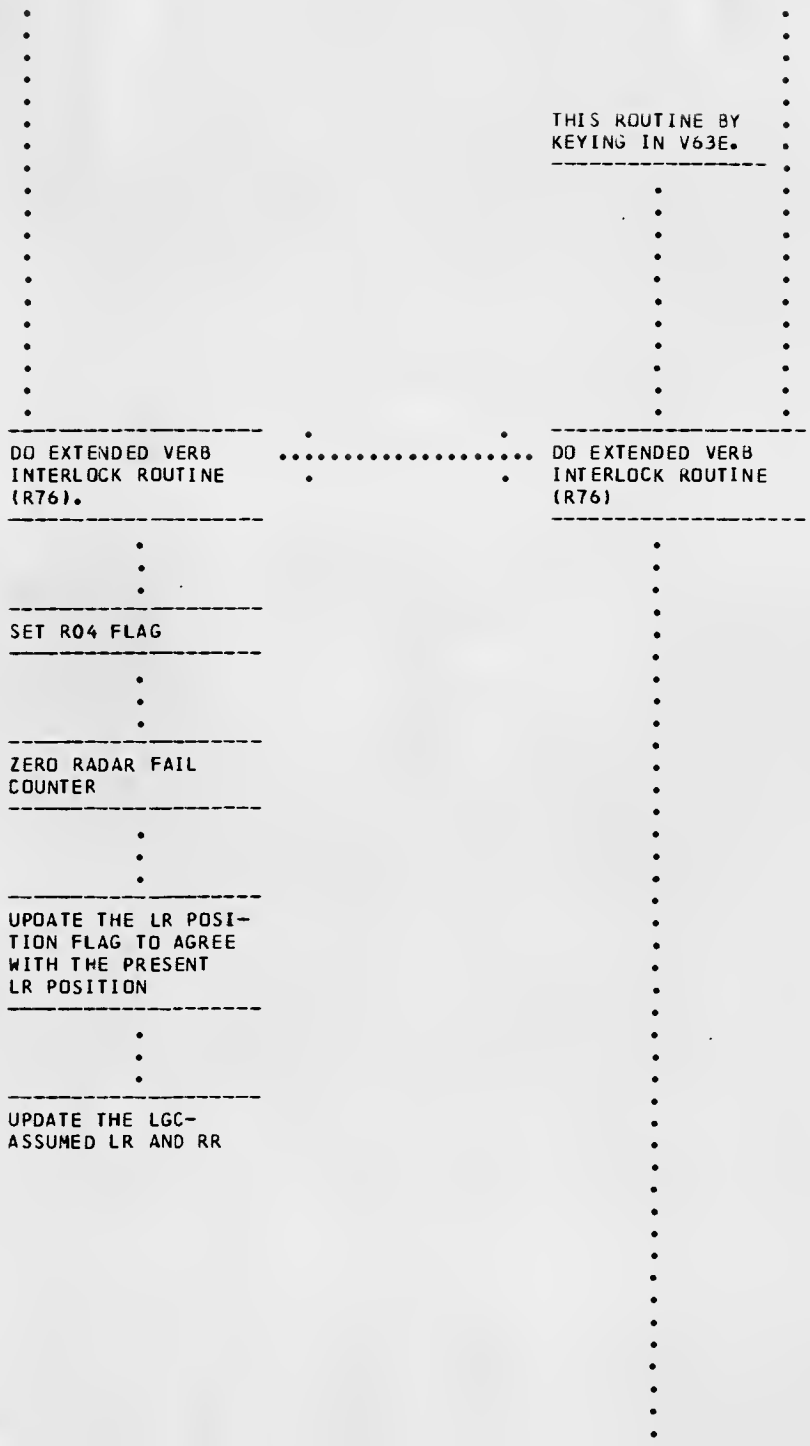
RR/LR SELF TEST ROUTINE (R04) REV 06 12/01/71

PURPOSE: (1) TO PROVIDE SUITABLE DSKY DISPLAYS AND LGC DOWNLINK INFORMATION TO SUPPORT THE SELF TESTS OF THE RENDEZVOUS RADAR (RR) OR THE LANDING RADAR (LR).

ASSUMPTIONS: (1) THIS ROUTINE IS MANUALLY SELECTED BY THE ASTRONAUT BY DSKY ENTRY (V63E) IN CONJUNCTION WITH MANUAL SELECTION OF THE APPROPRIATE RADAR SELF TEST AT THE LM CONSOLE (RADAR TEST SWITCH-RNDZ/OFF/LDG).
++
+06 (2) THE ROUTINE CANNOT BE CALLED IF SOME OTHER PROGRAM OR ROUTINE IS USING THE RR OR LR, OR IF THE TRACK FLAG IS
+1180 SET (WHICH IS DONE BY P20,P22,P25,P30, P32-35, P72-75, P76 AND P77).
++




IS THE LR BY-PASS FLAG SET?
Y
N
IS THE TRACK FLAG SET?
N
Y
TURN ON OPERATOR ERROR LIGHT
EXIT R04
MONITOR DSKY: DOES OPERATOR ERROR LIGHT INDICATE THAT THIS ROUTINE CANNOT BE SELECTED AT THIS TIME?
Y
N
TERMINATE PROGRAM OR ROUTINE WHICH IS PREVENTING THE SELECTION OF R04, THEN RESELECT
#40
#50
#60
#70


THIS ROUTINE BY KEYING IN V63E.
#80
#90
DO EXTENDED VERB INTERLOCK ROUTINE (R76).
DO EXTENDED VERB INTERLOCK ROUTINE (R76)
SET RO4 FLAG
#100
ZERO RADAR FAIL COUNTER
#110
UPDATE THE LR POSITION FLAG TO AGREE WITH THE PRESENT LR POSITION
#120
UPDATE THE LGC-ASSUMED LR AND RR

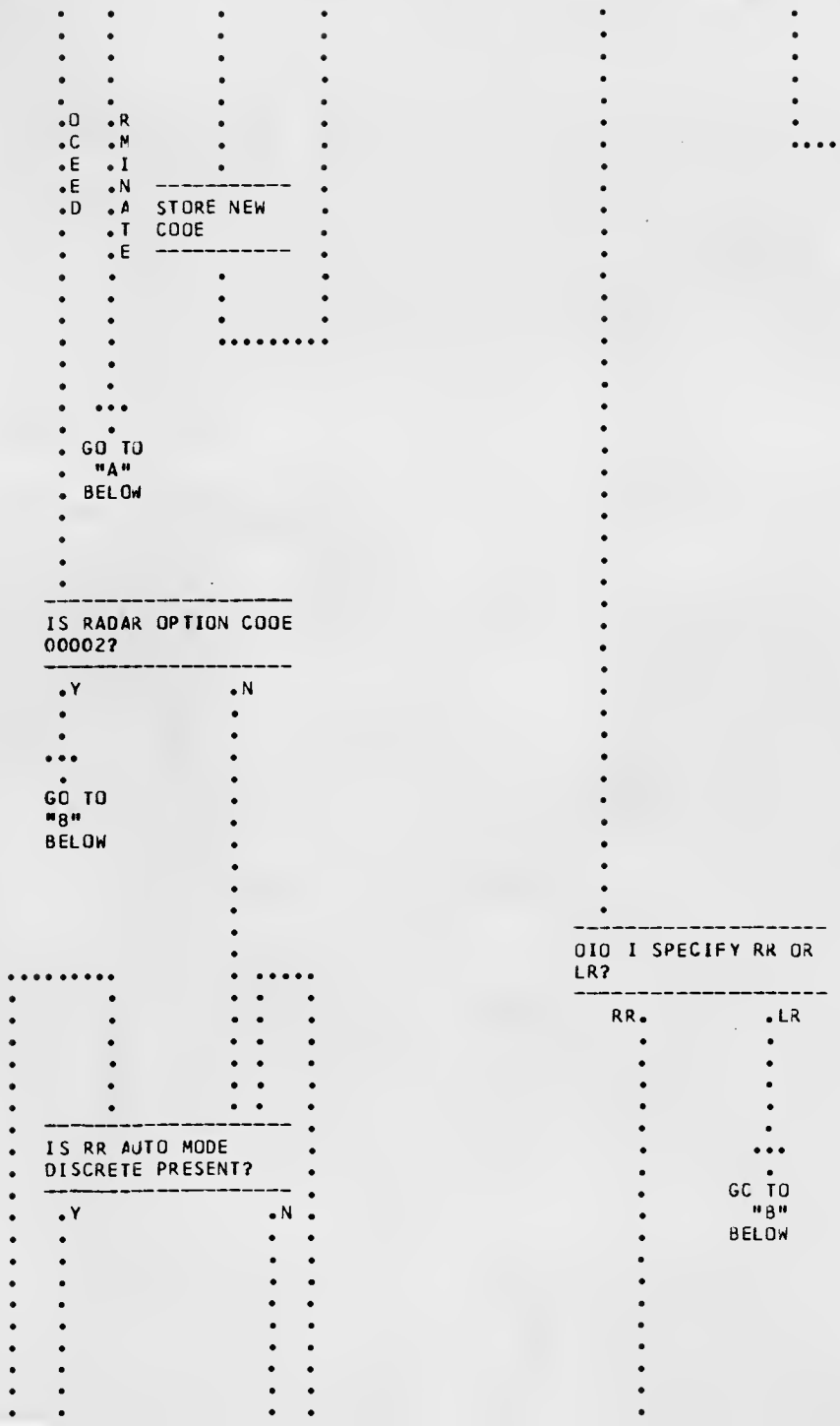
#130

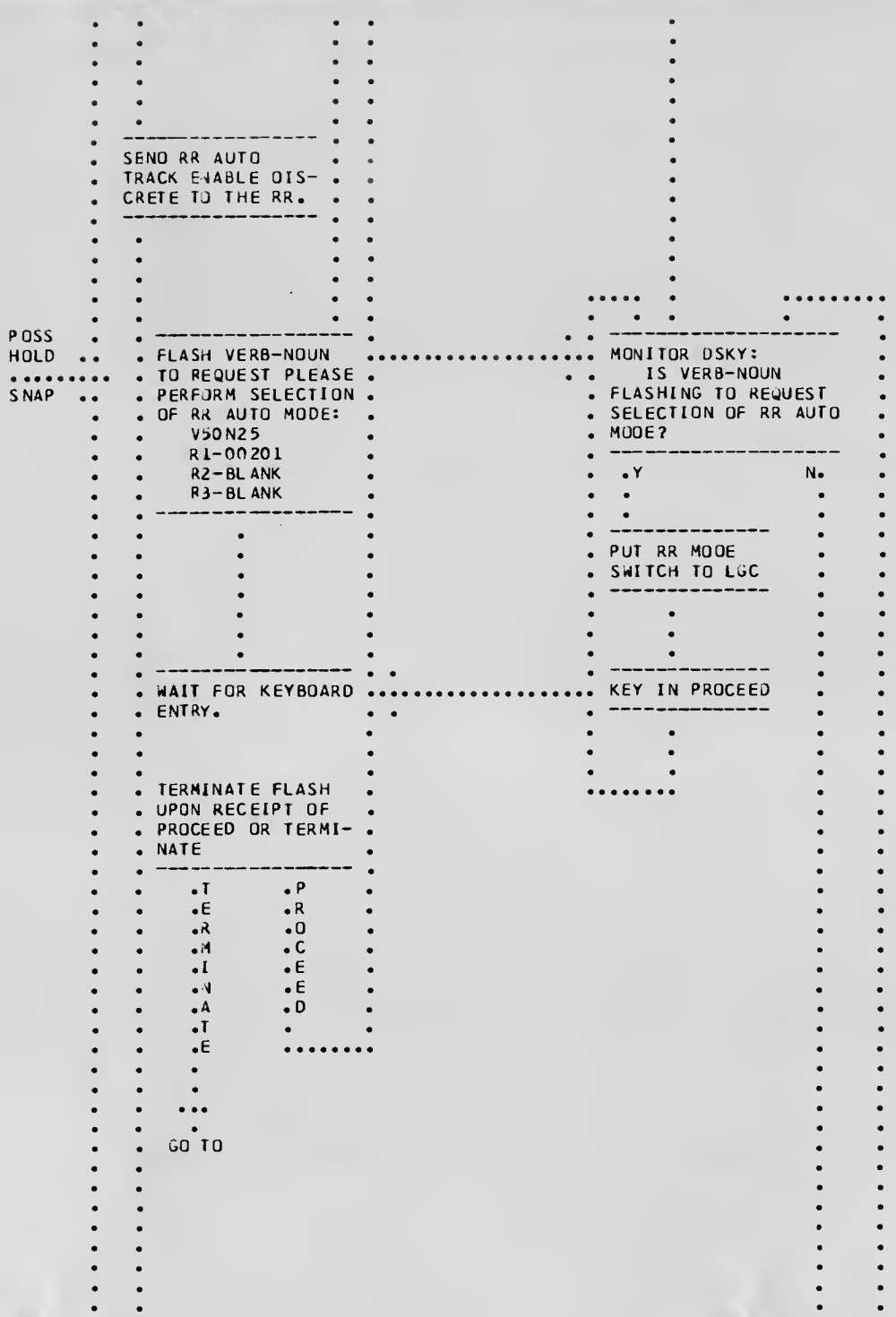
#140

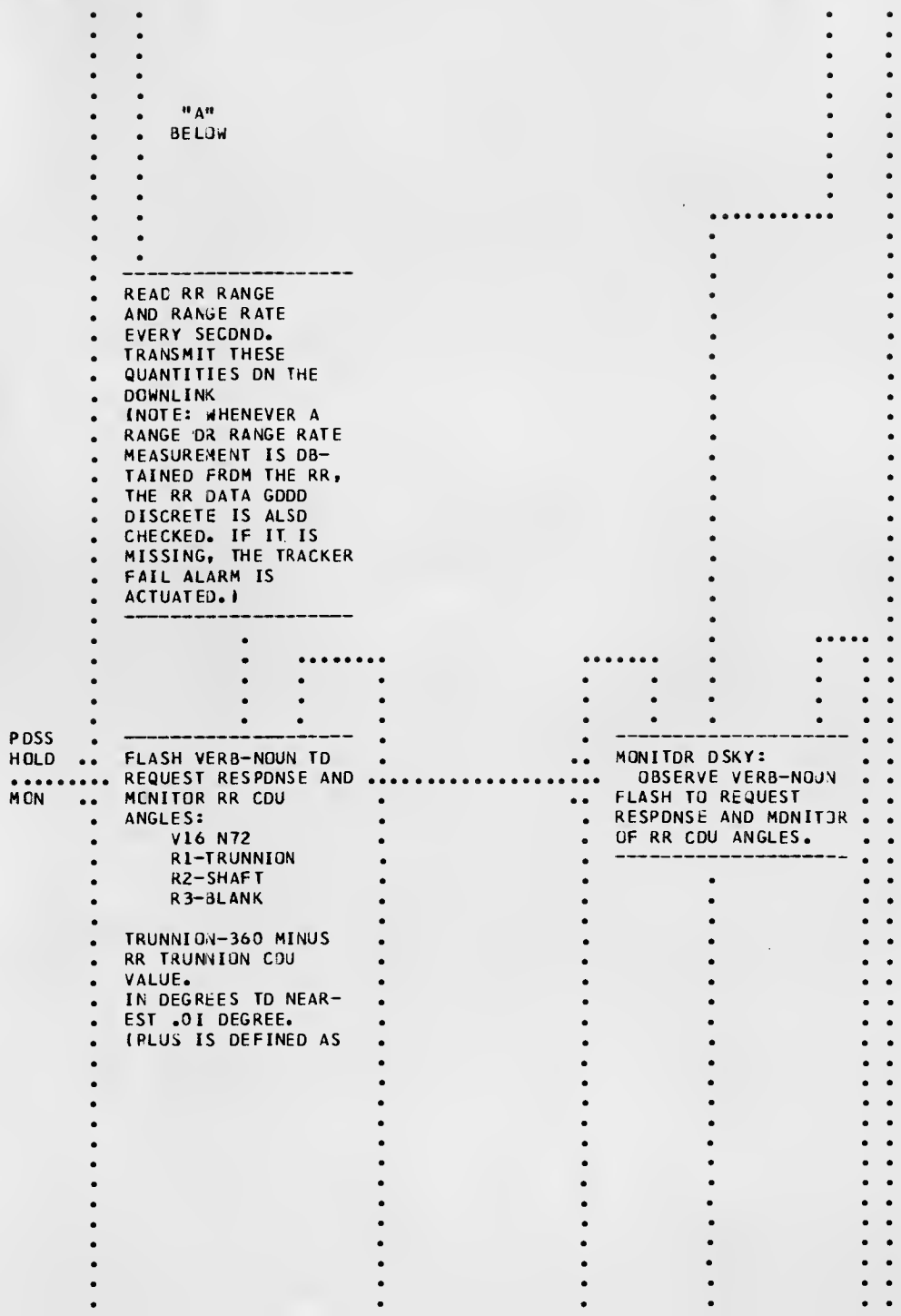
#150

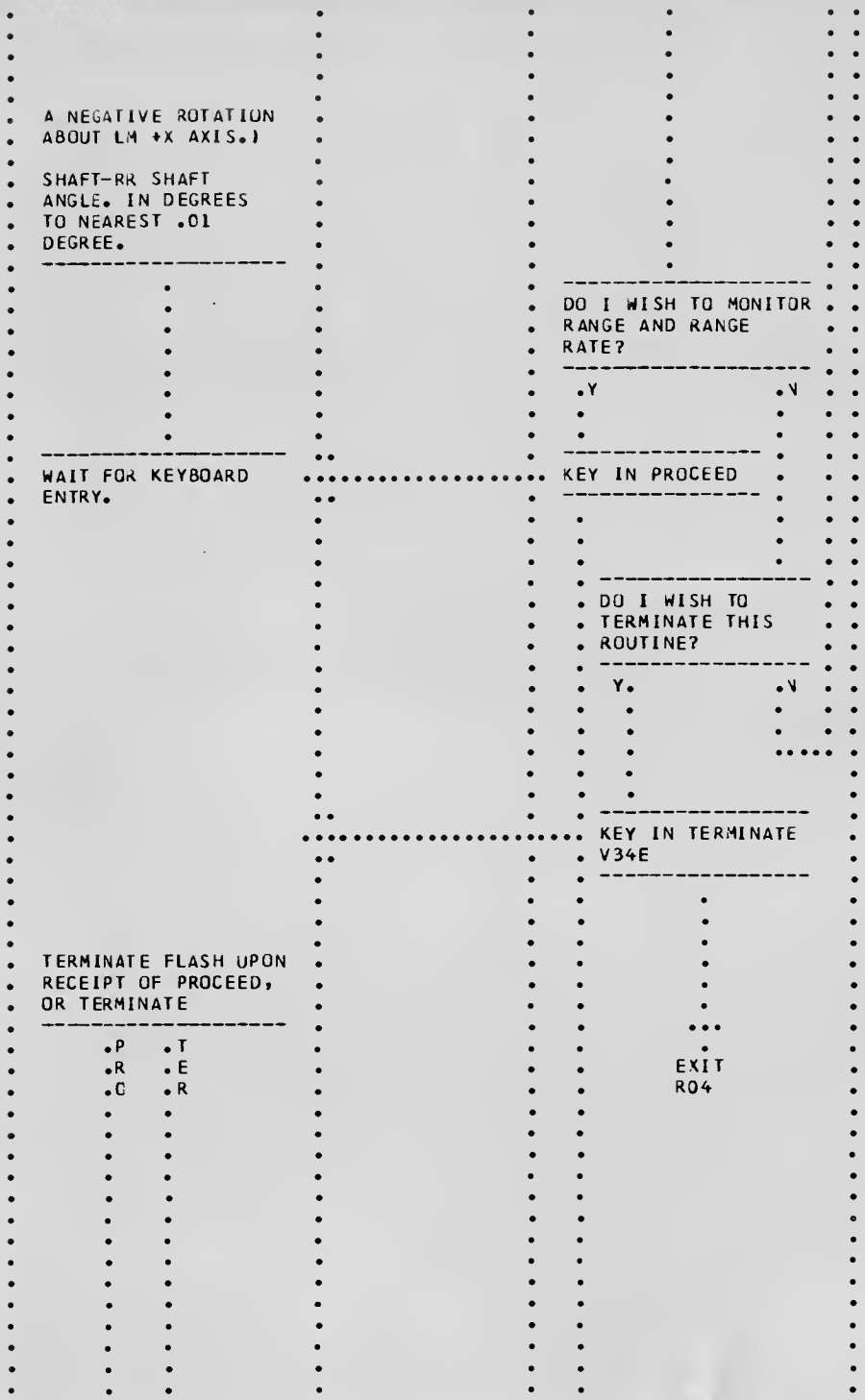
#160

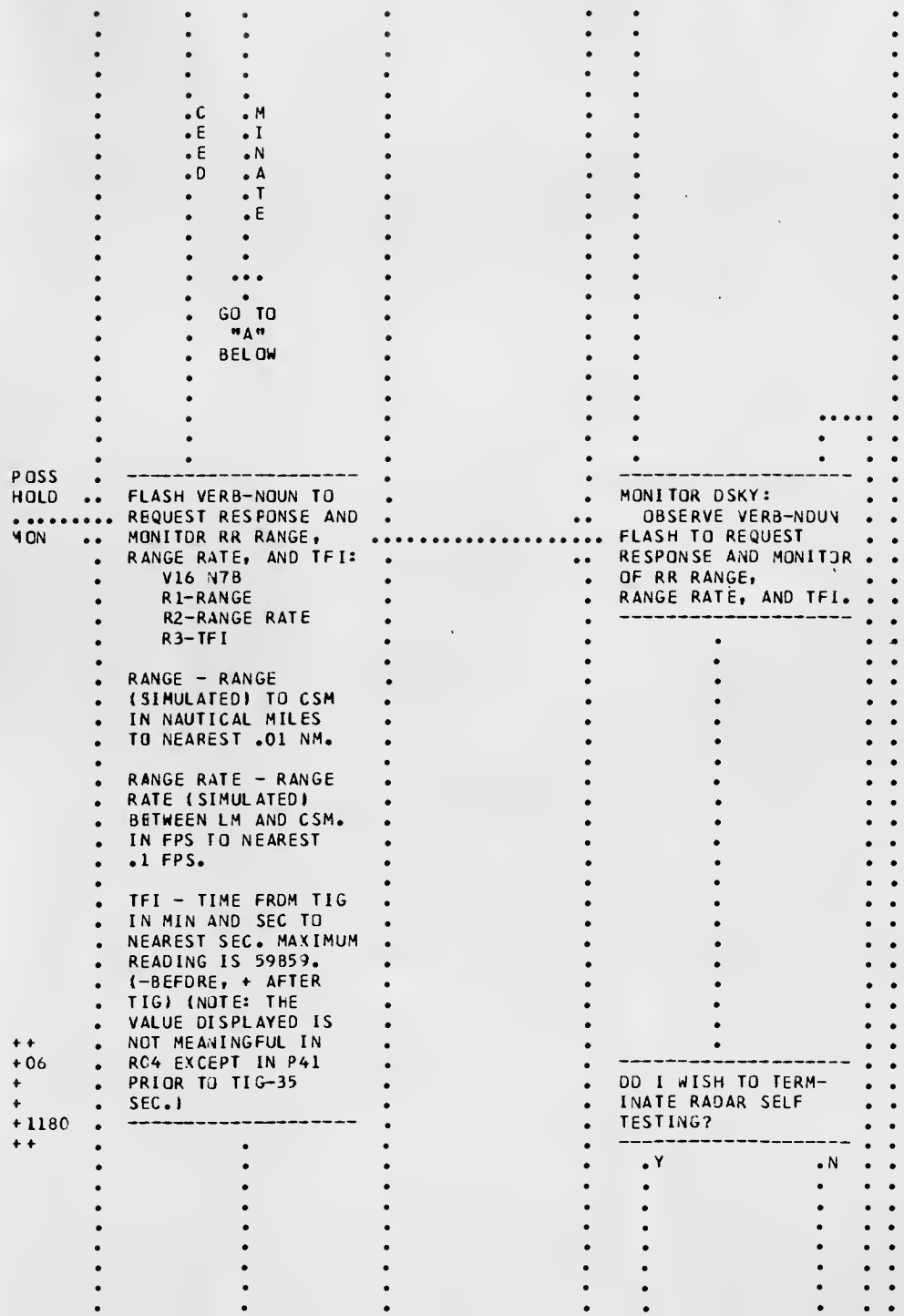
#170

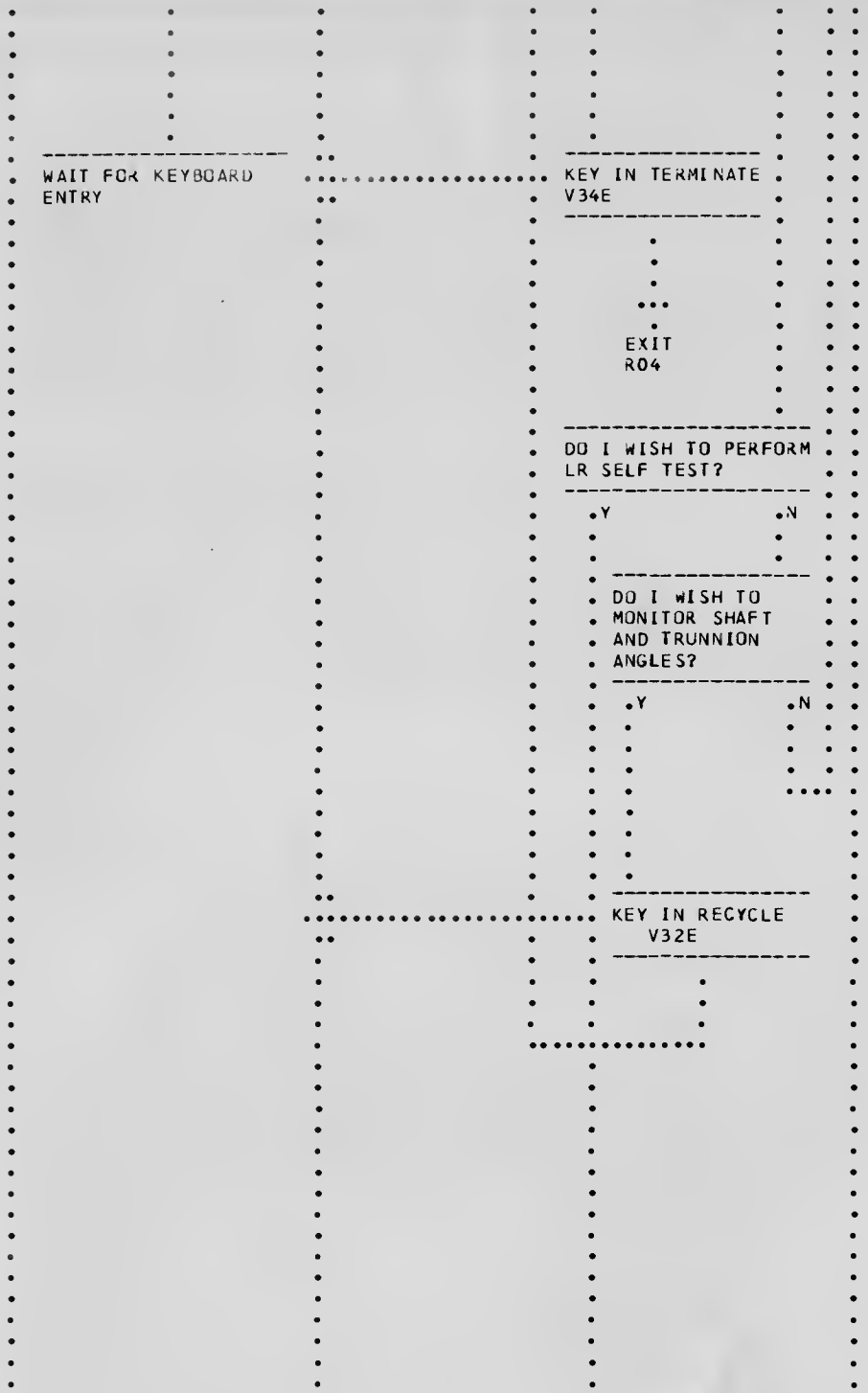

#180
#190
#200
#210
#220
#230
ORMINATE
STORE NEW CODE
GO TO "A" BELOW
IS RADAR OPTION CODE 00002?
Y
N
GO TO "8" BELOW
IS RR AUTO MODE DISCRETE PRESENT?
Y
N
DIO I SPECIFY RR OR LR?
RR
LR
GO TO "8" BELOW

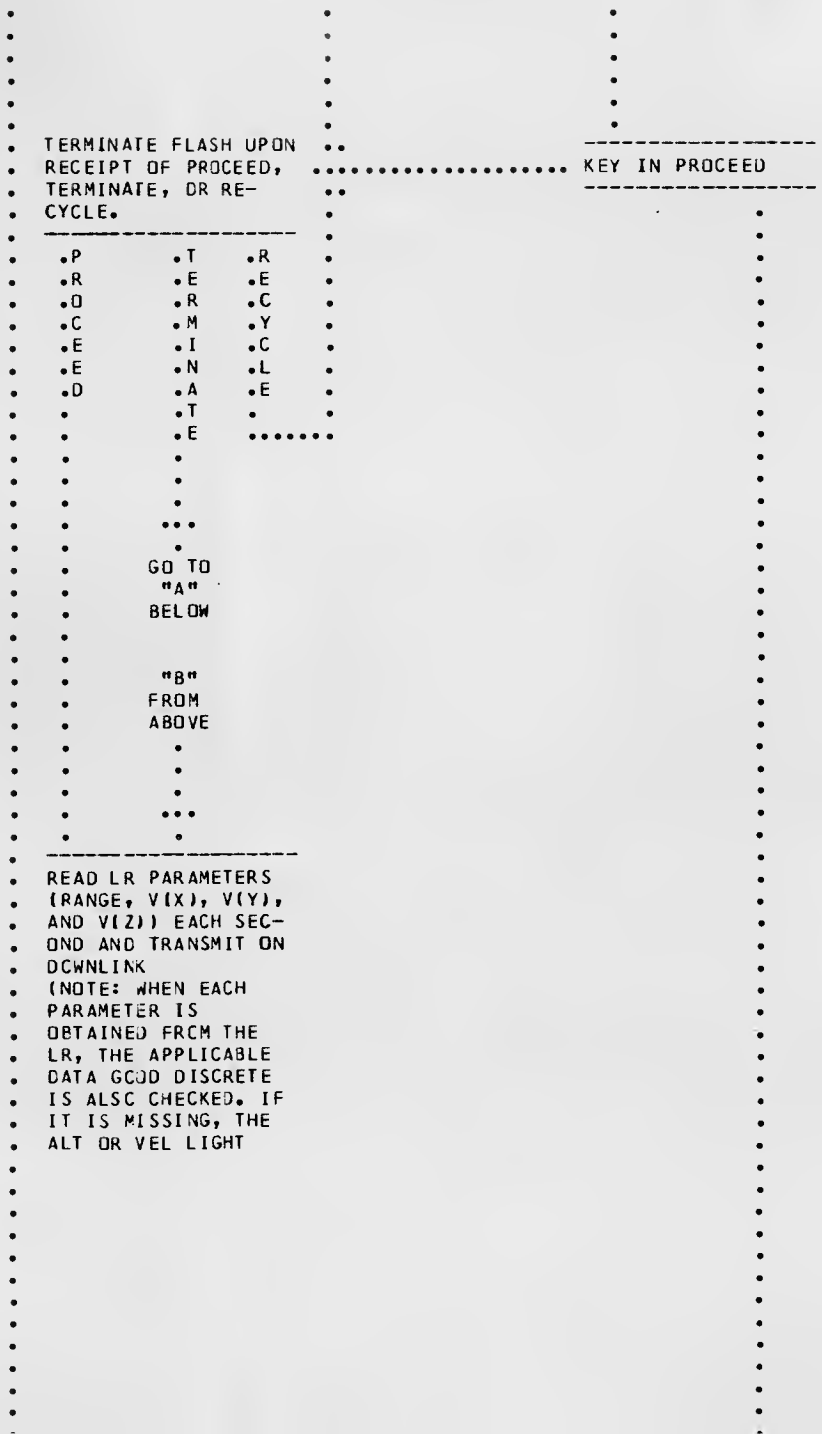

SEND RR AUTO TRACK ENABLE DISCRETE TO THE RR.
POSS HOLD
SNAP
FLASH VERB-NOUN TO REQUEST PLEASE PERFORM SELECTION OF RR AUTO MODE:
V50N25
R1-00201
R2-BLANK
R3-BLANK
WAIT FOR KEYBOARD ENTRY.
TERMINATE FLASH UPON RECEIPT OF PROCEED OR TERMINATE
TERMINATE
PROCEED
GO TO
MONITOR DSKY: IS VERB-NOUN FLASHING TO REQUEST SELECTION OF RR AUTO MODE?
Y
N
PUT RR MODE SWITCH TO LGC
KEY IN PROCEED
#240
#250
#260
#270
#280


"A"
BELOW
READ RR RANGE
AND RANGE RATE
EVERY SECDND.
TRANSMIT THESE
QUANTITIES DN THE
DOWNLINK
(NOTE: WHENEVER A
RANGE DR RANGE RATE
MEASUREMENT IS DB-
TAINED FRDM THE RR,
THE RR DATA GDDD
DISCRETE IS ALSD
CHECKED. IF IT IS
MISSING, THE TRACKER
FAIL ALARM IS
ACTUATED.)
#290
#300
#310
PDSS
HOLD
MON
FLASH VERB-NOUN TD
REQUEST RESPDNSE AND
MCNITOR RR CDU
ANGLES:
V16 N72
R1-TRUNNION
R2-SHAFT
R3-BLANK
TRUNNION-360 MINUS
RR TRUNNION CDU
VALUE.
IN DEGREES TD NEAR-
EST .01 DEGREE.
(PLUS IS DEFINED AS
MONITDR DSKY:
OBSERVE VERB-NOUN
FLASH TO REQUEST
RESPDNSE AND MDNITDR
DF RR CDU ANGLES.
#320
#330


A NEGATIVE ROTATION ABOUT LM +X AXIS.)
SHAFT-RR SHAFT ANGLE. IN DEGREES TO NEAREST .01 DEGREE.
DO I WISH TO MONITOR RANGE AND RANGE RATE?
#340
.Y
.N
WAIT FOR KEYBOARD ENTRY.
KEY IN PROCEED
#350
DO I WISH TO TERMINATE THIS ROUTINE?
Y.
.N
#360
KEY IN TERMINATE V34E
#370
TERMINATE FLASH UPON RECEIPT OF PROCEED, OR TERMINATE
.P
.R
.C
.T
.E
.R
EXIT R04


#380
#390
#400
#410
#420
#430
POSS HOLD ON
FLASH VERB-NOUN TO REQUEST RESPONSE AND MONITOR RR RANGE, RANGE RATE, AND TFI:
V16 N78
R1-RANGE
R2-RANGE RATE
R3-TFI
RANGE - RANGE (SIMULATED) TO CSM IN NAUTICAL MILES TO NEAREST .01 NM.
RANGE RATE - RANGE RATE (SIMULATED) BETWEEN LM AND CSM. IN FPS TO NEAREST .1 FPS.
TFI - TIME FROM TIG IN MIN AND SEC TO NEAREST SEC. MAXIMUM READING IS 59859. (-BEFORE, + AFTER TIG) (NOTE: THE VALUE DISPLAYED IS NOT MEANINGFUL IN R04 EXCEPT IN P41 PRIOR TO TIG-35 SEC.)
++
+06
+
+
+1180
++
CEE DMINATE
GO TO "A" BELOW
MONITOR DSKY: OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND MONITOR OF RR RANGE, RANGE RATE, AND TFI.
DO I WISH TO TERMINATE RADAR SELF TESTING?
Y
N


WAIT FOR KEYBOARD ENTRY
KEY IN TERMINATE V34E
EXIT R04
#440
DO I WISH TO PERFORM LR SELF TEST?
#450
Y
N
DO I WISH TO MONITOR SHAFT AND TRUNNION ANGLES?
#460
Y
N
KEY IN RECYCLE V32E
#470



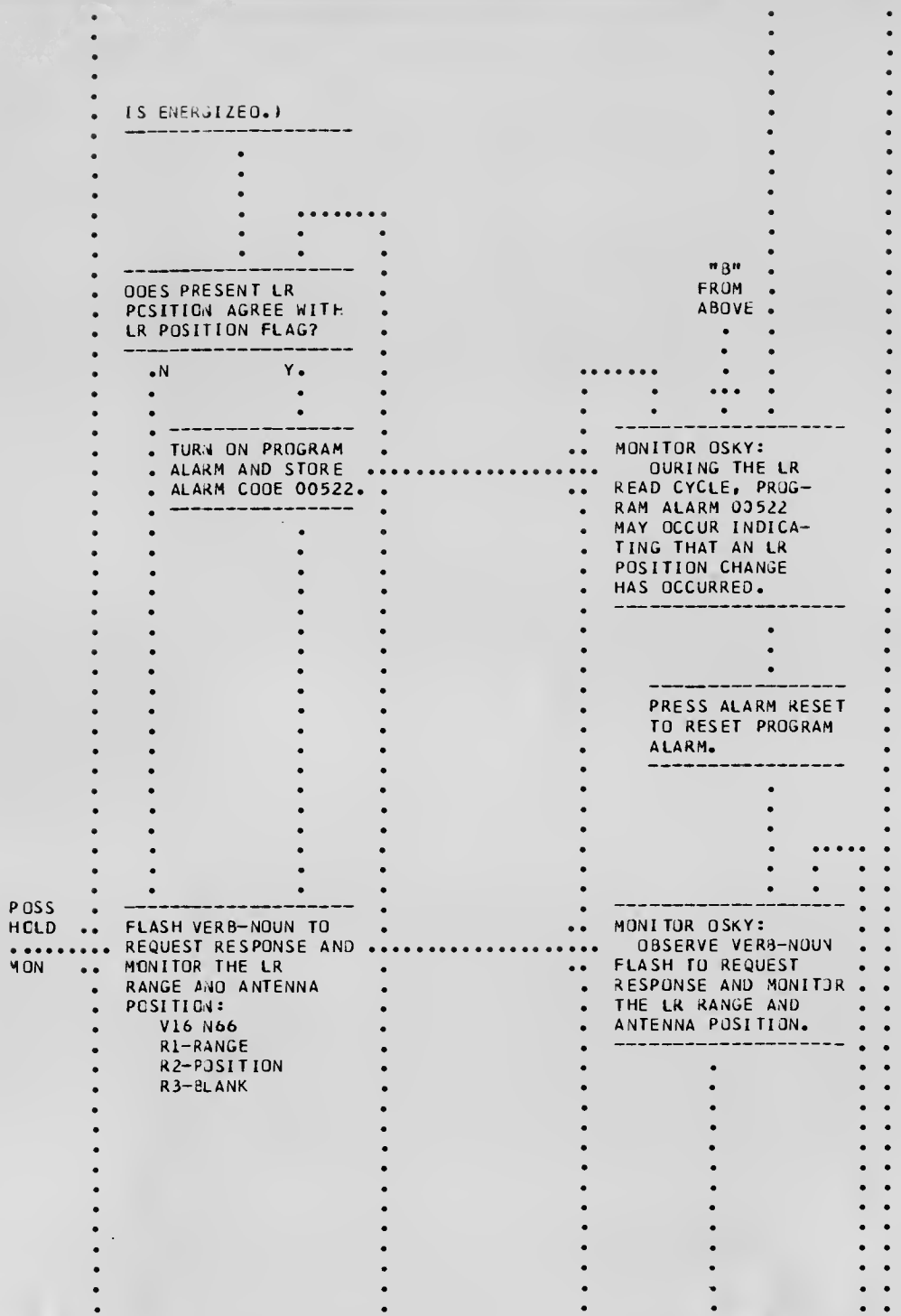
#480

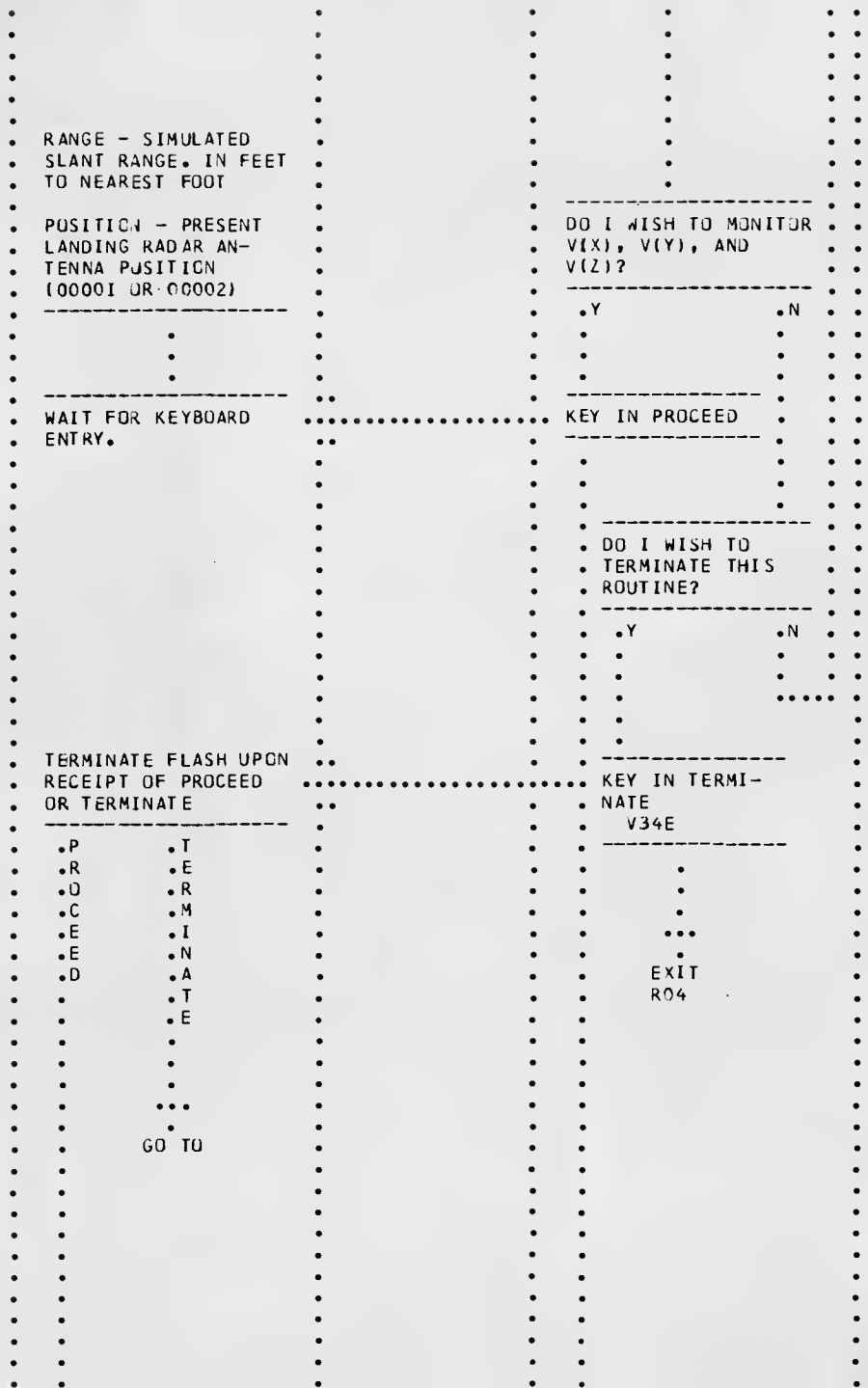
#490

#500

#510

#520


IS ENERGIZED.)
DOES PRESENT LR POSITION AGREE WITH LR POSITION FLAG?
N
Y
TURN ON PROGRAM ALARM AND STORE ALARM CODE 00522.
"B" FROM ABOVE
MONITOR OSKY: DURING THE LR READ CYCLE, PROGRAM ALARM 00522 MAY OCCUR INDICATING THAT AN LR POSITION CHANGE HAS OCCURRED.
PRESS ALARM RESET TO RESET PROGRAM ALARM.
POSS HOLD MON
FLASH VERB-NOUN TO REQUEST RESPONSE AND MONITOR THE LR RANGE AND ANTENNA POSITION:
V16 N66
R1-RANGE
R2-POSITION
R3-BLANK
MONITOR OSKY: OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND MONITOR THE LR RANGE AND ANTENNA POSITION.
#530
#540
#550
#560
#570



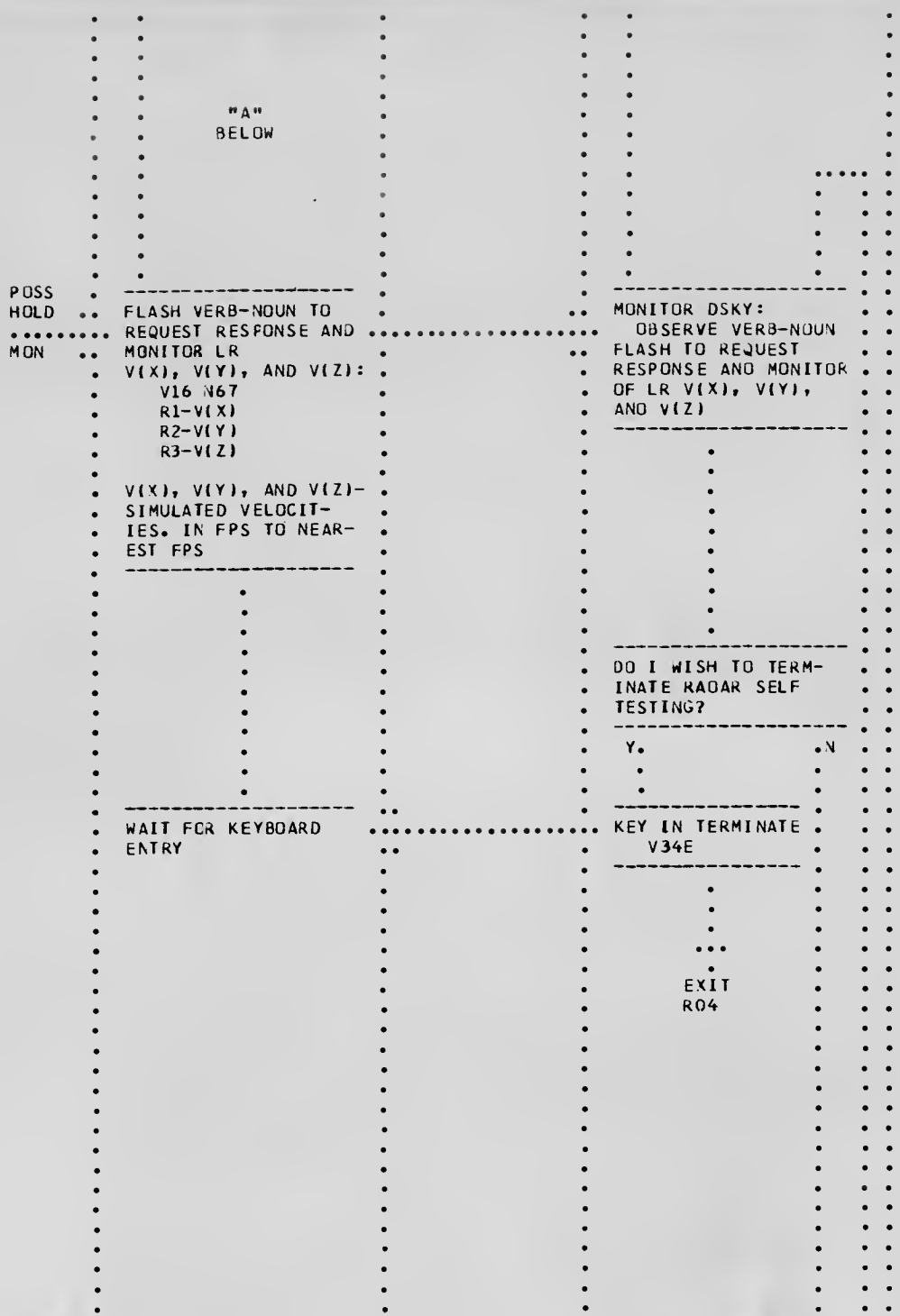
#580

#590

#600

#610

#620



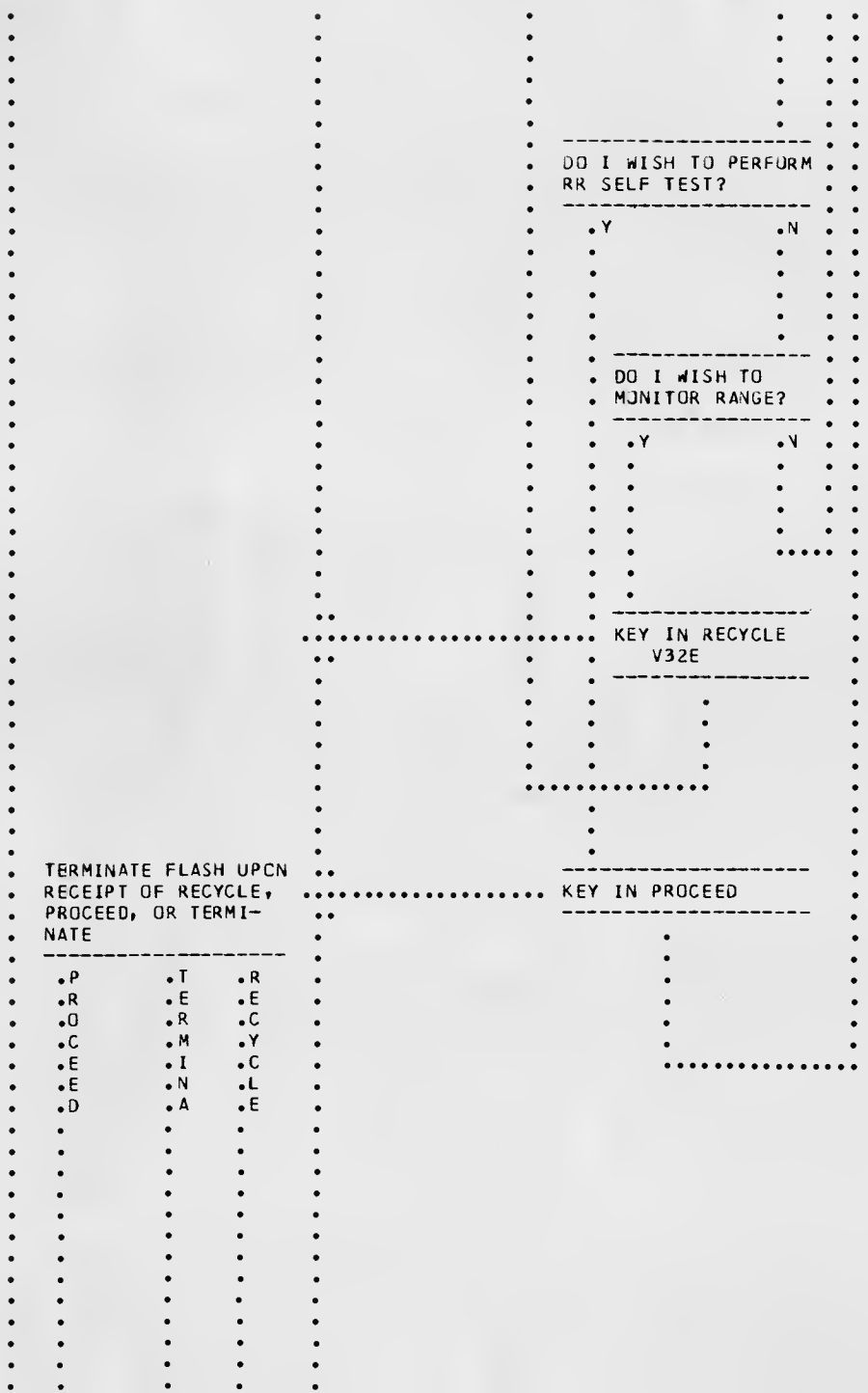
#630

#640

#650

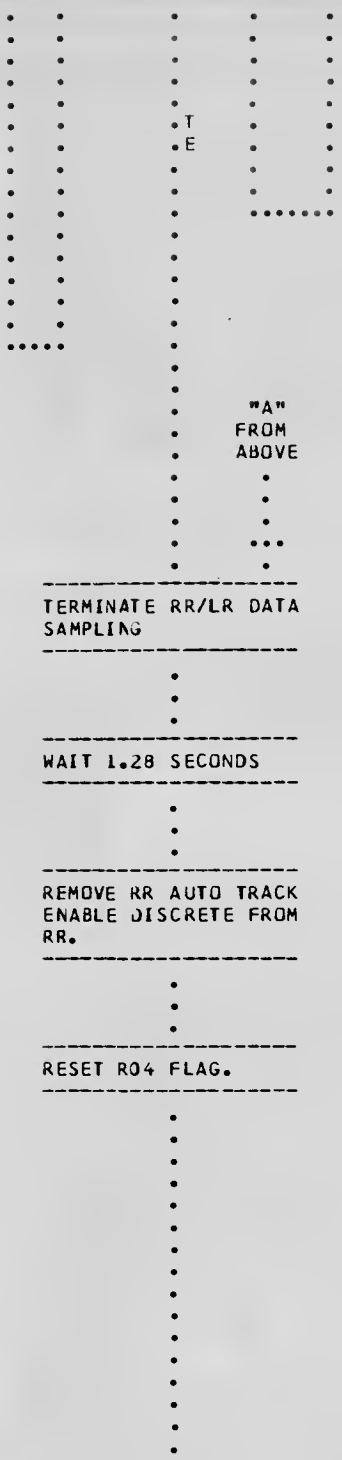
#660

#670


DO I WISH TO PERFORM RR SELF TEST?
.Y
.N
#680
DO I WISH TO MONITOR RANGE?
.Y
.N
#690
KEY IN RECYCLE V32E
#700
KEY IN PROCEED
#710
TERMINATE FLASH UPON RECEIPT OF RECYCLE, PROCEED, OR TERMINATE
.PROCEED
.TERMINATE
.RECYCLE

#720

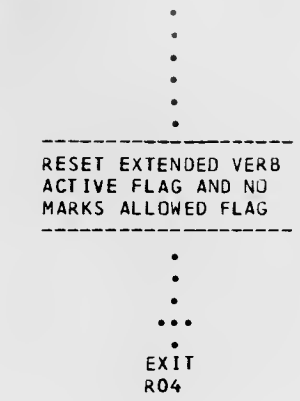
#730



#740

#750

#760



#770

#780

CHANGE CONTROL NOTES

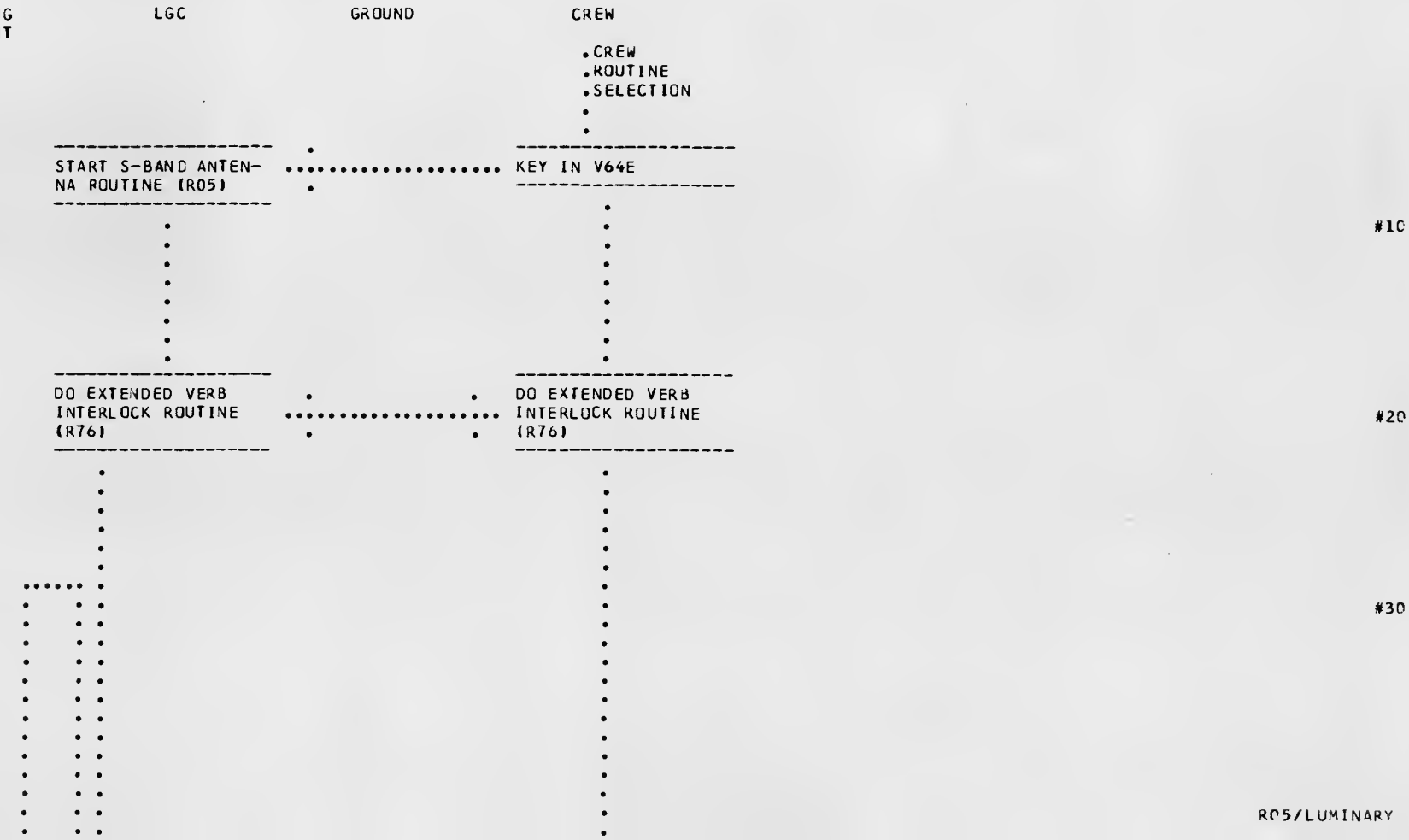
REV 01 PCR 95,406,420,490,615
REV 02(LUM 18) PCR 780,817,EDITORIAL
REV 03 EDITORIAL
REV 04(LUM 1D) PCR 892, PCN 1039
REV 05(LUM 1E) PCR 317.2, PCN 1145
REV 06 PCN 1180

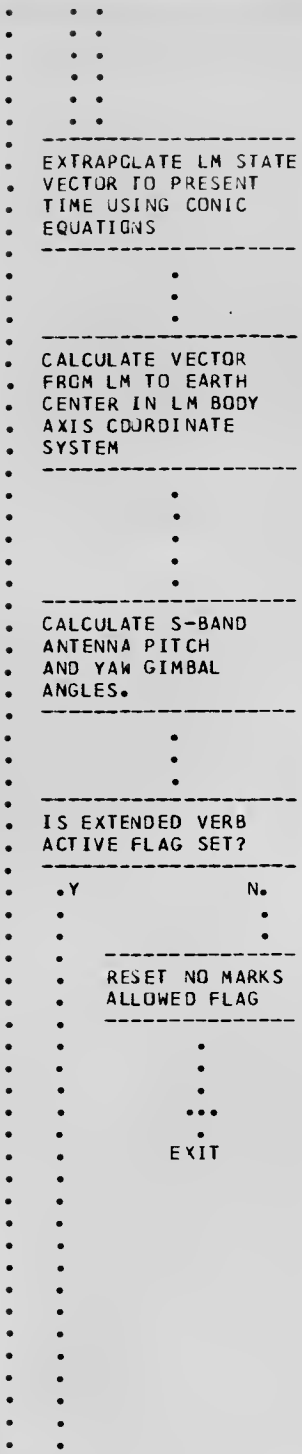
S-BAND ANTENNA ROUTINE (R05) REV 03 12/03/69

PURPOSE: (1) TO COMPUTE AND DISPLAY THE TWO STEERABLE S-BAND ANTENNA GIMBAL ANGLES WHICH WILL POINT THE ANTENNA TOWARD THE CENTER OF THE EARTH.

ASSUMPTIONS: (1) THE IMU IS ON AND ALIGNED.

(3) THIS ROUTINE IS SELECTED BY THE ASTRONAUT BY DSKY ENTRY.




EXTRAPOLATE LM STATE VECTOR TO PRESENT TIME USING CONIC EQUATIONS
#40
CALCULATE VECTOR FROM LM TO EARTH CENTER IN LM BODY AXIS COORDINATE SYSTEM
#50
CALCULATE S-BAND ANTENNA PITCH AND YAW GIMBAL ANGLES.
#60
IS EXTENDED VERB ACTIVE FLAG SET?
Y
N.
#70
RESET NO MARKS ALLOWED FLAG
EXIT

R05

HCLO
MCN

FLASH VERB-NOUN TO REQUEST RESPONSE AND MONITOR OF THE S-BAND ANTENNA GIMBAL ANGLES
V06 N51
R1-ALPHA
R2-BETA
R3-BLANK

ALPHA-PITCH ANGLE. S-BAND ANTENNA PITCH GIMBAL ROTATION ABOUT THE BISECTOR OF THE ANGLE BETWEEN THE +Y AND -X AXIS. (-90 < ALPHA < 270).
IN DEGREES TO NEAREST .01 DEGREE.

BETA-YAW ANGLE. S-BAND ANTENNA YAW GIMBAL ROTATION ABOUT THE YAW GIMBAL AXIS (FIXED TO THE ANTENNA). (-90 < BETA < 90).
IN DEGREES TO NEAREST .01 DEGREE.

(NOTE: DISPLAY LIMITS ARE ANGLE CONVENTIONS RATHER THAN HARDWARE LIMITS (SEE SECTION 5.6 OF R567)).

.A
.U

MONITOR DSKY:
OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND MONITOR OF THE S-BAND ANTENNA PITCH AND YAW GIMBAL ANGLES REQUIRED TO POINT THE ANTENNA AT EARTH CENTER WITH THE LM AT ITS PRESENT POSITION AND ATTITUDE.

#80
#90
#100
#110
#120

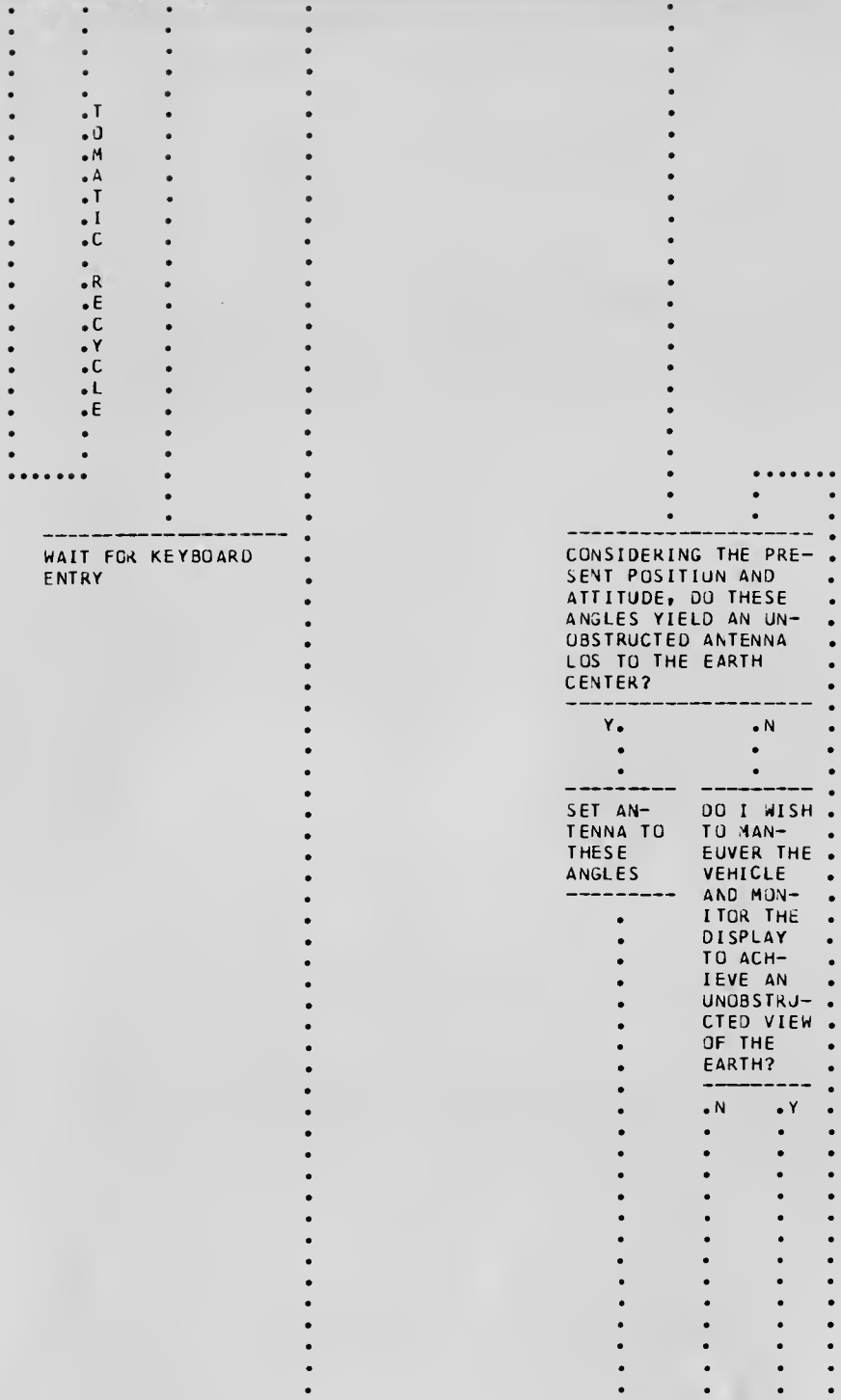
#130

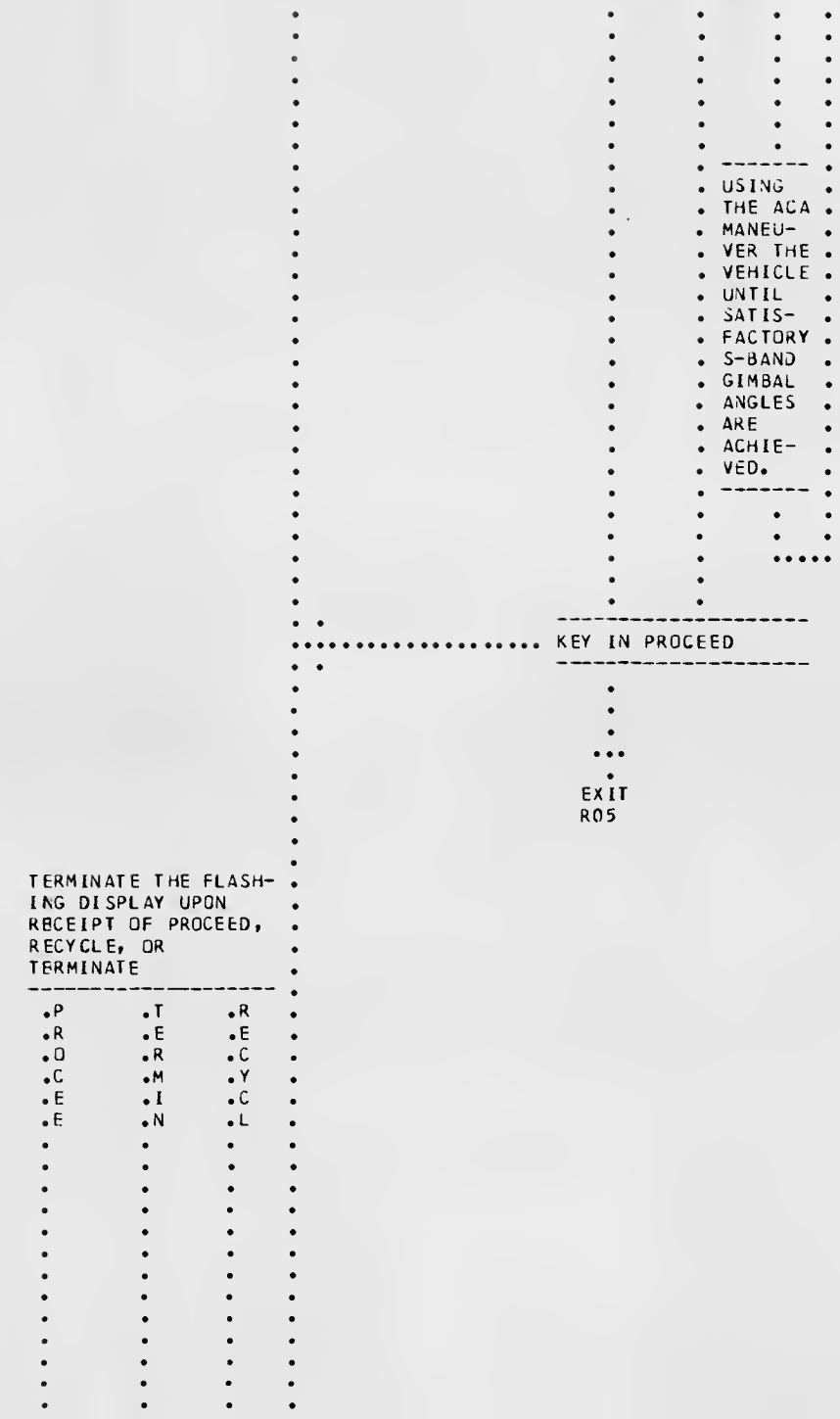
#140

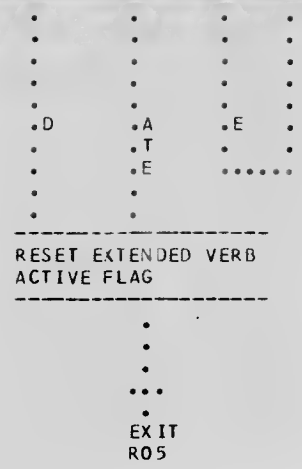
#150

#160

#170




USING THE ACA MANEU- VER THE VEHICLE UNTIL SATIS- FACTORY S-BAND GIMBAL ANGLES ARE ACHIE- VED.
#180
#190
KEY IN PROCEED
#200
EXIT R05
#210
TERMINATE THE FLASH- ING DISPLAY UPON RECEIPT OF PROCEED, RECYCLE, OR TERMINATE
.P .R .O .C .E .E
.T .E .R .M .I .N
.R .E .C .Y .C .L
#220



#23C

#24C

CHANGE CONTROL NOTES

LOGIC REV 01 PCR 15
LOGIC REV 02(LUM 18) PCR 832.2
REV 03 EDITORIAL

R10/R11/R12 SERVICE ROUTINE (R09) REV 06 12/01/71

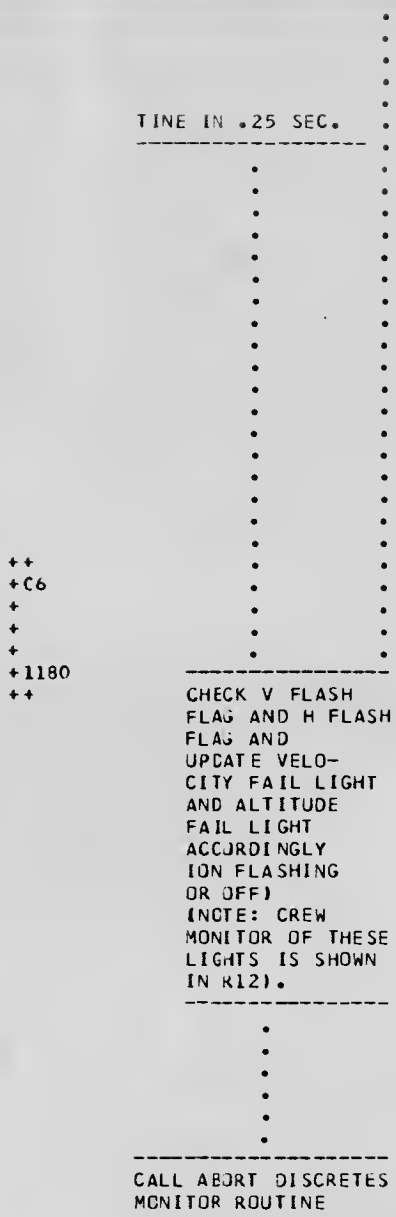
PURPOSE: (1) TO UPDATE THE LR VELOCITY FAIL AND ALTITUDE FAIL LIGHTS.

(2) TO CALL THE ABORT DISCRETES MONITOR ROUTINE (R11) APPROXIMATELY EVERY .25 SECONDS.

ASSUMPTIONS: (1) THIS ROUTINE IS CALLED EVERY 2 SECONDS BY SERVICER (AVERAGE G), BUT ONLY DURING P12,63,64,66,70, OR 71.

(2) AFTER BEING CALLED BY SERVICER THIS ROUTINE RECALLS ITSELF 7 TIMES, ONCE EVERY .25 SECONDS.

(3) PIP COUNTER IS SET TO 7 EACH TIME SERVICER CALLS THIS ROUTINE.



#40

#50

++
+C6
+
+
+
+1180
++

#60

#70

#80

(R11)

EXIT R09

#9C

CHANGE CONTROL NOTES

REV 01 PCR 214
REV 02 EDITORIAL
REV 03 PCR 285, EDITORIAL
REV 04(LUM 1D) PCR 988
REV 05(LUM 1E) PCN 1145
REV 06 PCN 1180

LANDING ANALOG DISPLAYS ROUTINE (R10) REV 66 12/01/71

PURPOSE: (1) TO CALCULATE THE FOLLOWING PARAMETERS AND TRANSMIT THEM TO THE LM METERS FOR DISPLAY BY CREW SELECTION:

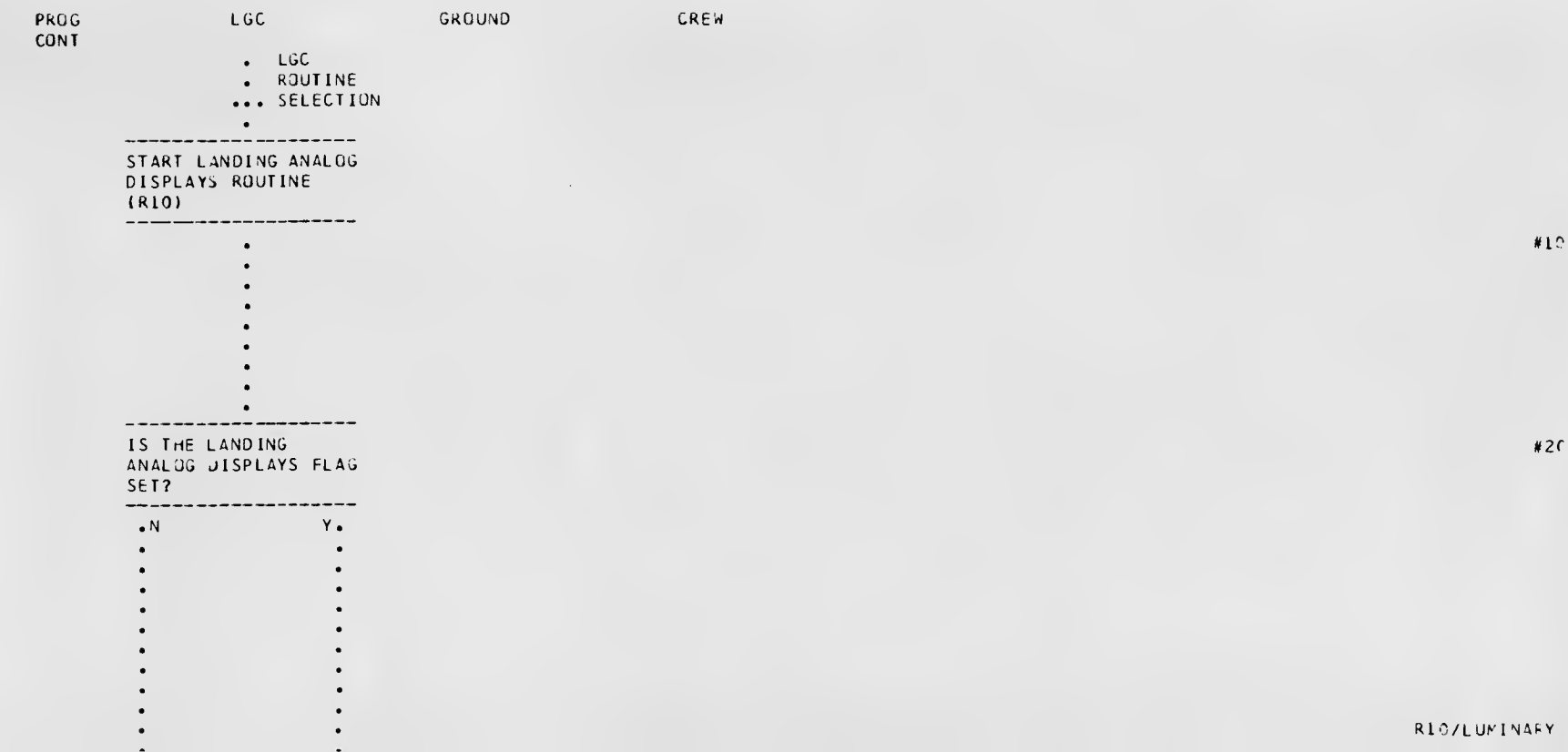
(A) FORWARD VELOCITY - SEE SECTION 5 OF R567 FOR DEFINITION.

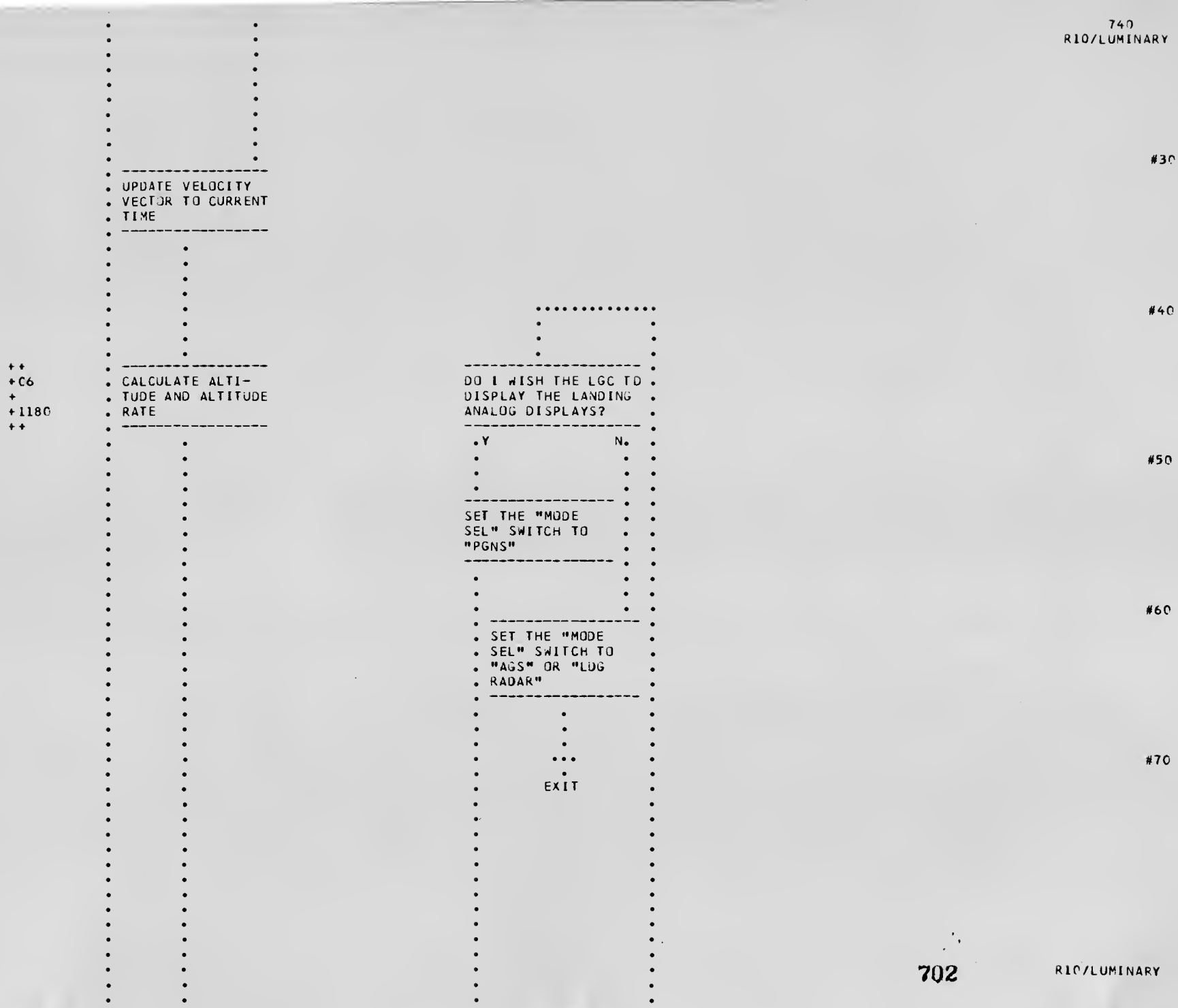
(B) LATERAL VELOCITY - SEE SECTION 5 OF R567 FOR DEFINITION.

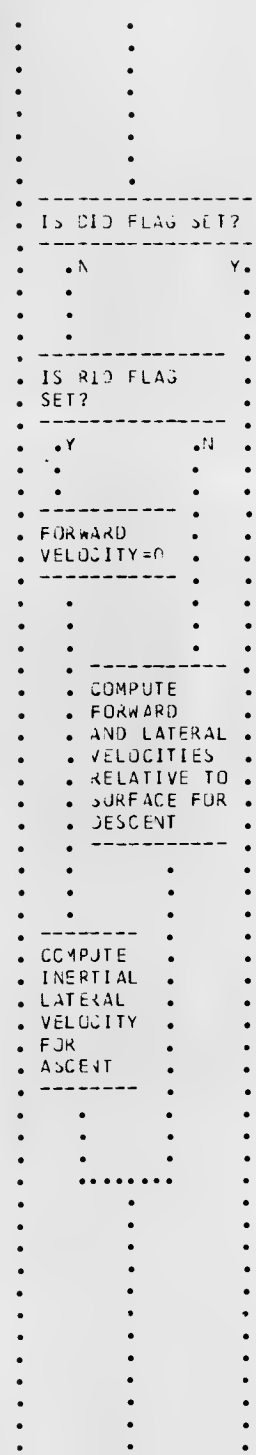
(C) ALTITUDE - THE PRESENT ALTITUDE OF THE LM ABOVE THE LUNAR RADIUS AT THE DESIGNATED LANDING SITE.

(D) ALTITUDE RATE - THE PRESENT RATE OF CHANGE OF ALTITUDE ((C) ABOVE).

ASSUMPTIONS: (1) THIS ROUTINE IS AUTOMATICALLY CALLED EVERY .25 SECONDS BY THE ABORT DISCRETES MONITOR ROUTINE (R11), BUT ONLY WHEN AVERAGE G IS ON DURING P12,63,64,66,70, OR 71. DURING P12,P70, AND P71 FORWARD VELOCITY IS SET TO ZERO AND LATERAL VELOCITY IS INERTIAL VELOCITY IN THE CROSSRANGE AXIS.




#30
UPDATE VELOCITY VECTOR TO CURRENT TIME
#40
++
+C6
+
+1180
++
CALCULATE ALTI-TUDE AND ALTITUDE RATE
DO I WISH THE LGC TO DISPLAY THE LANDING ANALOG DISPLAYS?
Y
N
#50
SET THE "MODE SEL" SWITCH TO "PGNS"
#60
SET THE "MODE SEL" SWITCH TO "AGS" OR "LDG RADAR"
#70
EXIT



R1

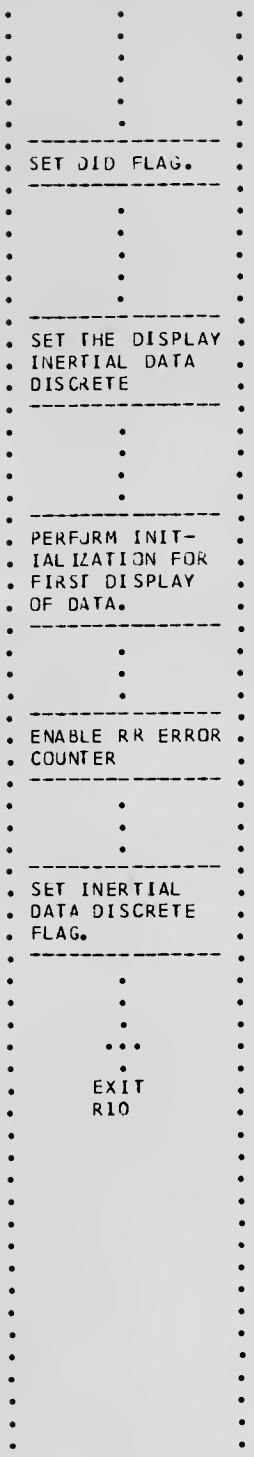
#80

#90

#100

#110

#120



#130

#140

#150

#160

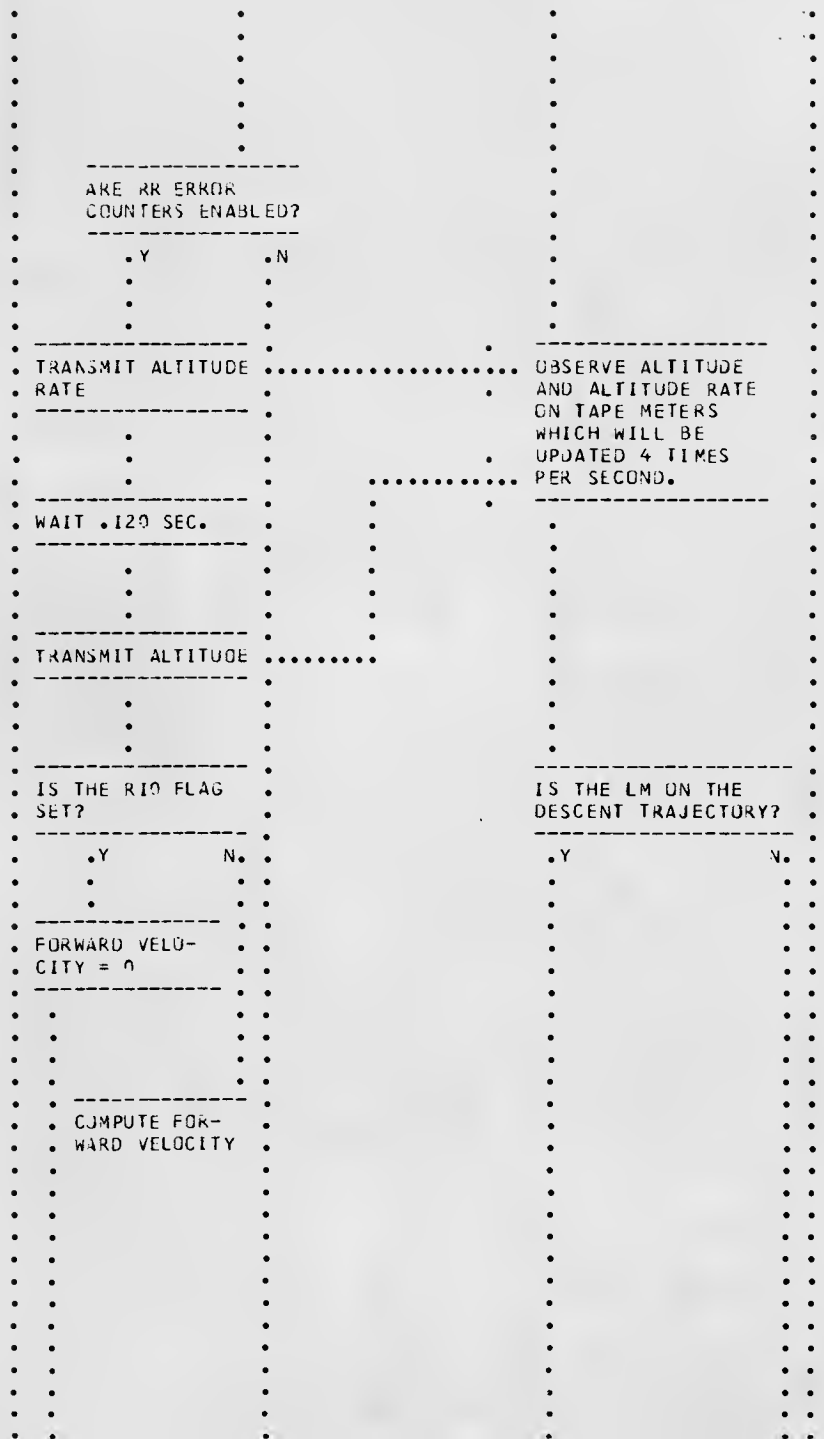
#170

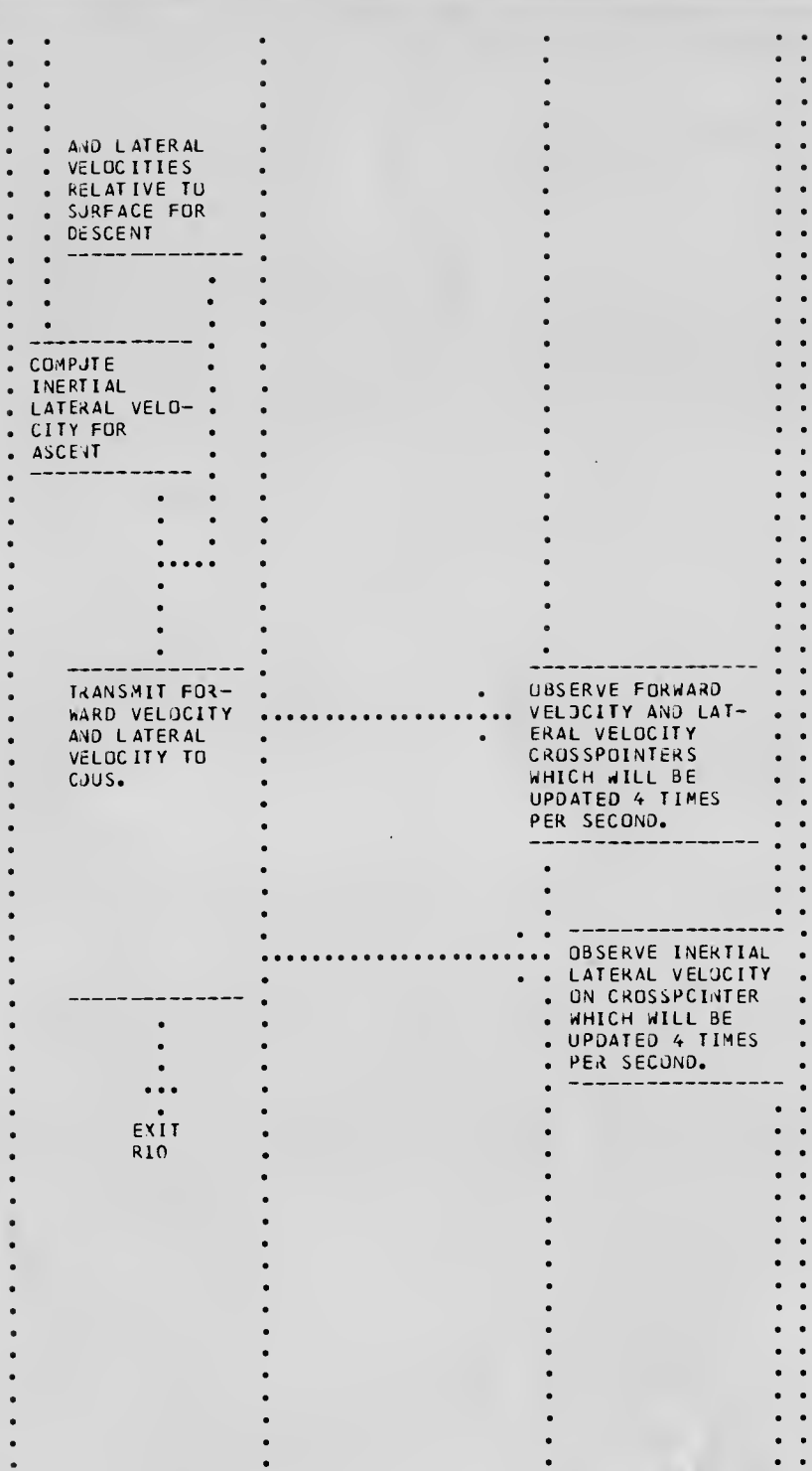
#180

#190

#200

#210





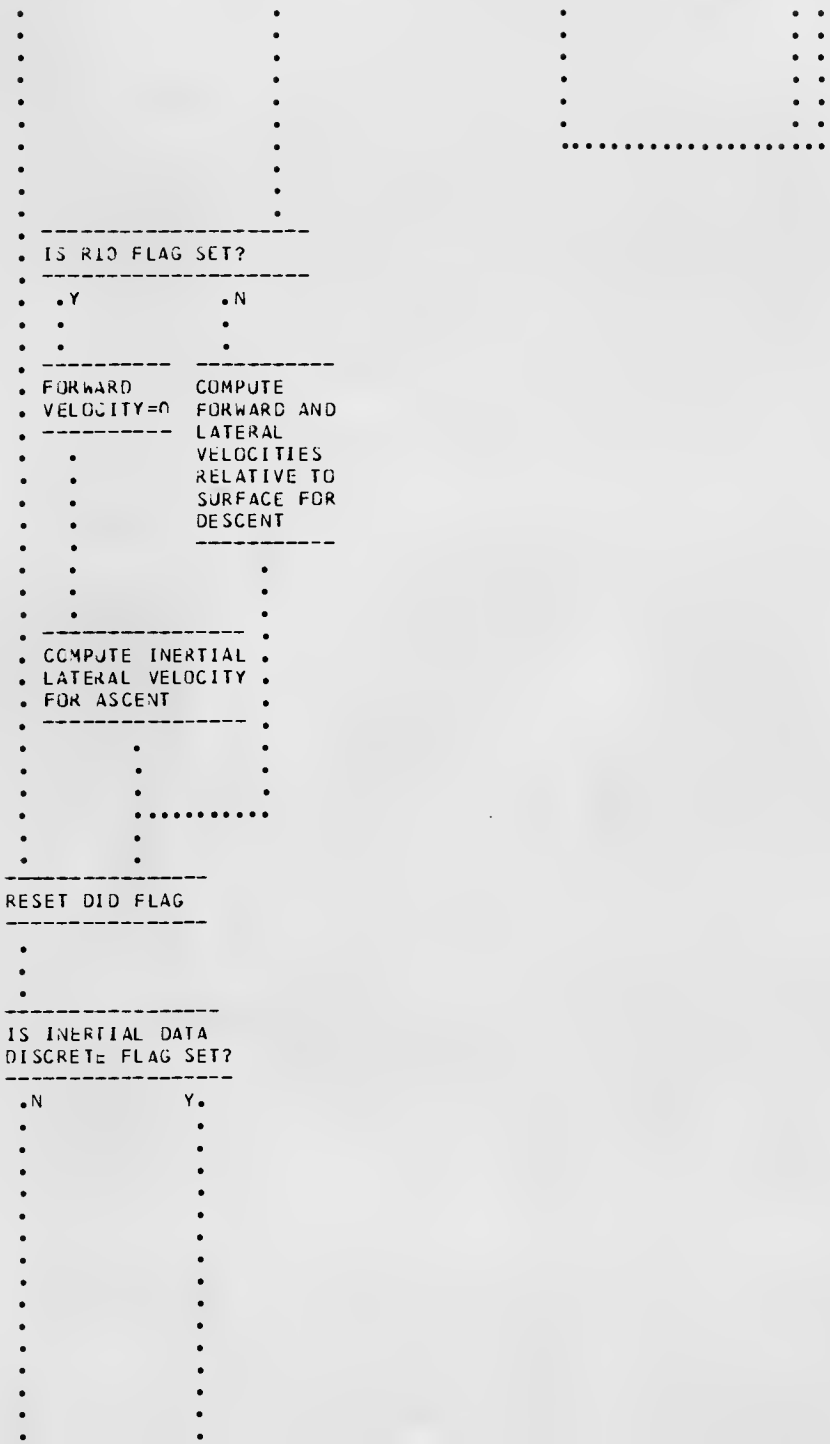
#220

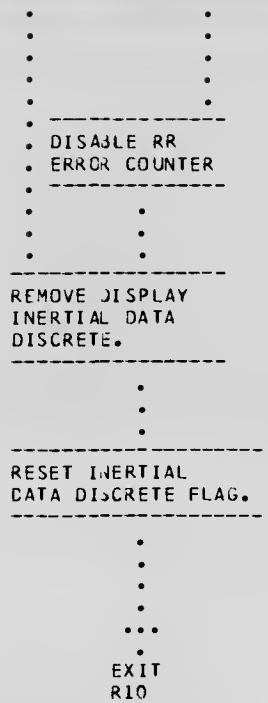
#230

#240

#250

#260


IS R10 FLAG SET?
#270
Y
N
FORWARD VELOCITY=0
COMPUTE FORWARD AND LATERAL VELOCITIES RELATIVE TO SURFACE FOR DESCENT
#280
COMPUTE INERTIAL LATERAL VELOCITY FOR ASCENT
#290
RESET DID FLAG
#300
IS INERTIAL DATA DISCRETE FLAG SET?
N
Y
#310



#320

#330

CHANGE CONTROL NOTES

REV 01 PCR 475,499,617
REV 02 EDITORIAL
REV 03(LUM 1C) PCR 285
REV 05(LUM 1E) PCR 1110, PCN 1145
REV 06 PCN 1180

ABORT DISCRETES MONITOR ROUTINE (R11) REV C4 12/01/71

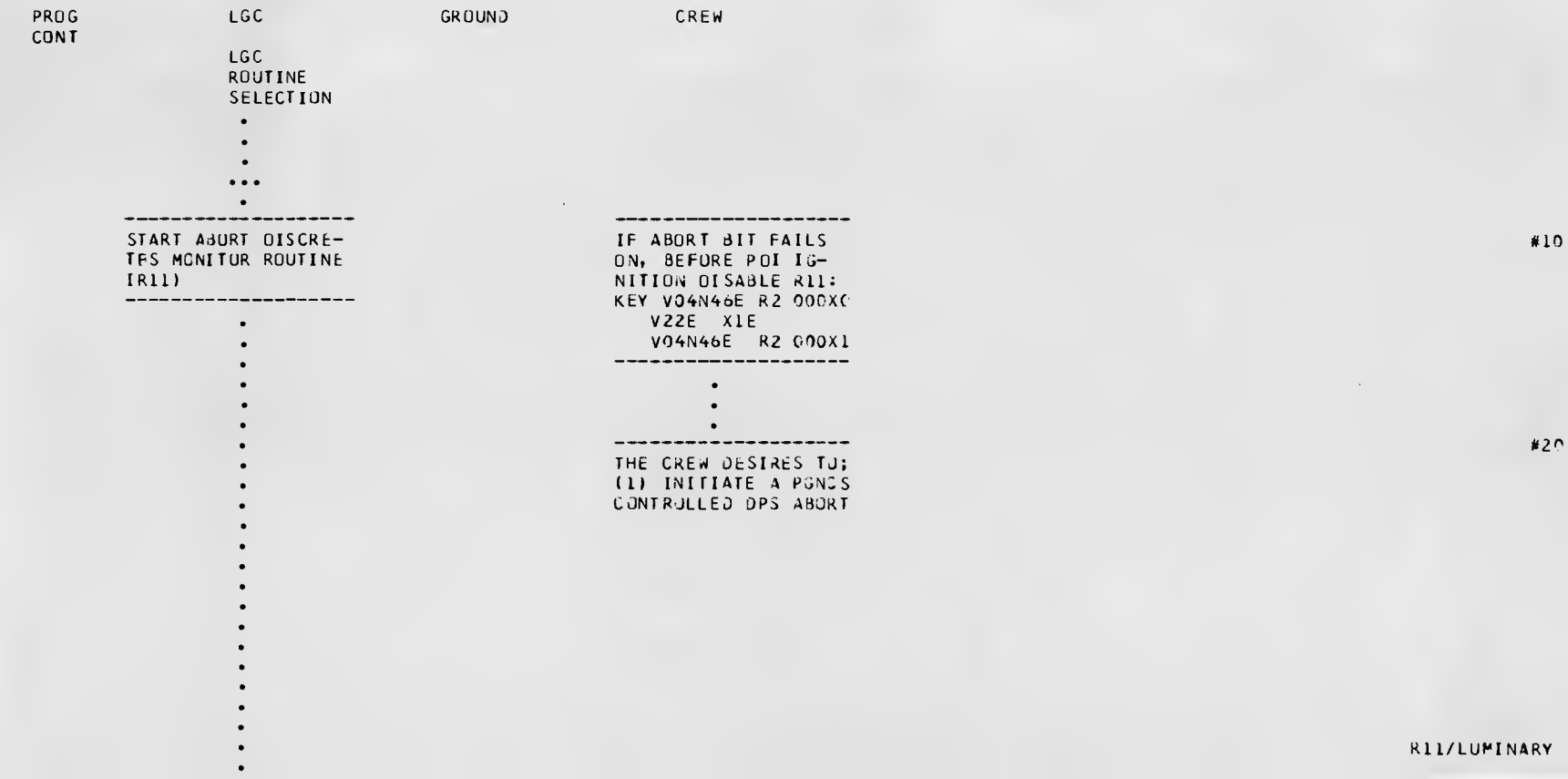
PURPOSE: (1) TO MONITOR THE ABORT AND ABORT STAGE DISCRETES TO THE LGC WHICH INDICATE WHETHER THE CREW DESIRES TO ABORT FROM THE POWERED LANDING MANEUVER AND IF SO THE TYPE OF ABORT (DPS OR APS) DESIRED.

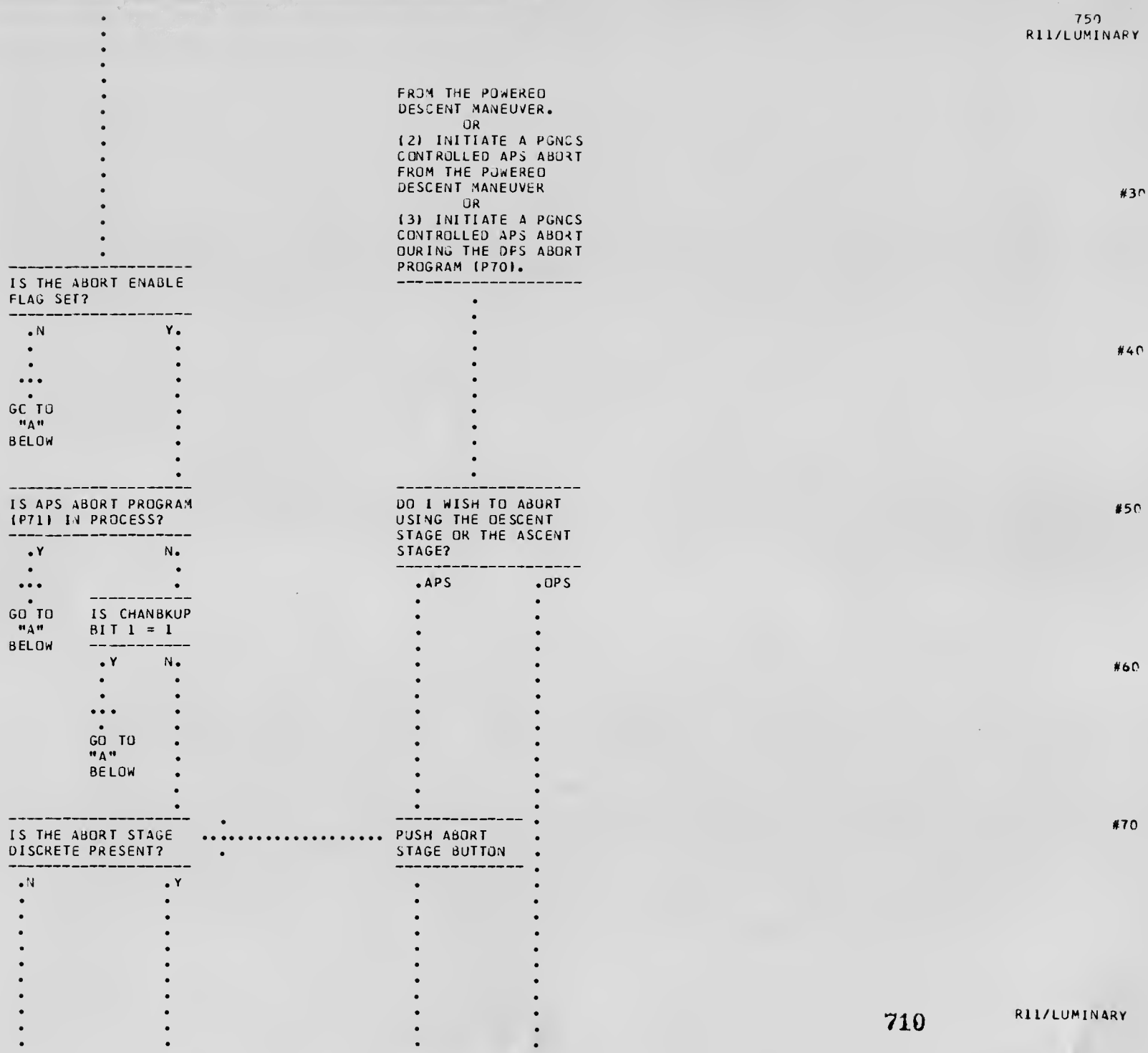
(2) TO SELECT THE CORRECT LGC PROGRAM FOR THE TYPE OF ABORT COMMANDED BY THE CREW.

(3) TO CALL THE LANDING ANALOG DISPLAYS ROUTINE (R10). (SEE ASSUMPTION (1)).

ASSUMPTIONS: (1) THIS ROUTINE IS CALLED EVERY 0.25 SECONDS BY THE R10/R11/R12 SERVICE ROUTINE (R09), BUT ONLY DURING P12,63, 64,66,70, OR 71 WHEN SERVICER (AVERAGE G) IS IN PROCESS. IN TURN IT CALLS THE LANDING ANALOG DISPLAYS ROUTINE (R10).

++
+C4 (2) IF CHANBKUP BIT 1 IS PRESET TO PROTECT AGAINST A FAILURE OF EITHER THE ABORT OR ABORT STAGE CHANNEL BITS
+1180 (1 AND 4 OF CHANNEL 30), THE ABORT AND ABORT STAGE PUSH BUTTONS HAVE NO EFFECT ON THE LGC SOFTWARE.
++




FROM THE POWERED DESCENT MANEUVER.
OR
(2) INITIATE A PGNCS CONTROLLED APS ABORT FROM THE POWERED DESCENT MANEUVER
OR
(3) INITIATE A PGNCS CONTROLLED APS ABORT DURING THE DPS ABORT PROGRAM (P70).
#30
#40
IS THE ABORT ENABLE FLAG SET?
.N
Y.
GO TO "A" BELOW
IS APS ABORT PROGRAM (P71) IN PROCESS?
DO I WISH TO ABORT USING THE DESCENT STAGE OR THE ASCENT STAGE?
#50
.Y
N.
.APS
.OPS
GO TO "A" BELOW
IS CHANBKUP BIT 1 = 1
#60
.Y
N.
GO TO "A" BELOW
IS THE ABORT STAGE DISCRETE PRESENT?
PUSH ABORT STAGE BUTTON
#70
.N
.Y

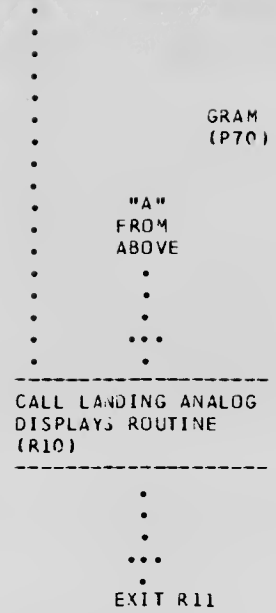
#80

#90

#100

#110

#120



#130

#140

CHANGE CONTROL NOTES

REV 01 NO PCR'S
REV 02(LUM 1C) PCR 285
REV 03(LUM 1E) PCR 1107
REV 04 PCN 1180

DESCENT STATE VECTOR UPDATE ROUTINE (R12) REV C7 12/01/71

PURPOSE: (1) TO OBTAIN VEHICLE RANGE AND VELOCITY DATA RELATIVE TO THE LUNAR SURFACE FROM THE LR.

(2) TO INCORPORATE THE LR RANGE AND VELOCITY DATA INTO THE LM STATE VECTOR.

(3) TO NOTIFY THE CREW OF ABNORMALITIES IN THE PROCESS OF LGC INTERROGATION OF THE LR.

(4) TO COMMAND THE LR TO POSITION #2.

ASSUMPTIONS: (1) THE NECESSARY PARAMETERS (AS DESCRIBED IN SECTION 5.3 OF R567) FOR CONVERSION OF THE LR DATA TO STATE VECTOR UPDATES ARE STORED IN THE LGC.

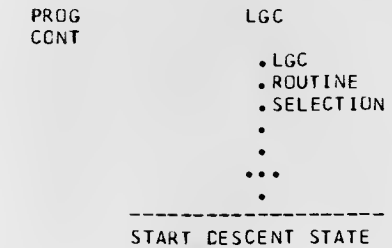
(2) THE FORMAT OF THE LR DATA AND THE TECHNIQUE OF ITS TRANSFER TO THE LGC ARE AS DESCRIBED IN SECTION 5.3 OF R567.

(3) THE LR PERMIT FLAG HAS BEEN RESET PRIOR TO THE START OF THIS ROUTINE BY R00. UNTIL THIS FLAG IS SET BY A MANUAL DSKY ENTRY (SEE (4) BELOW), NO LR DATA WILL BE INCORPORATED INTO THE LM STATE VECTOR.

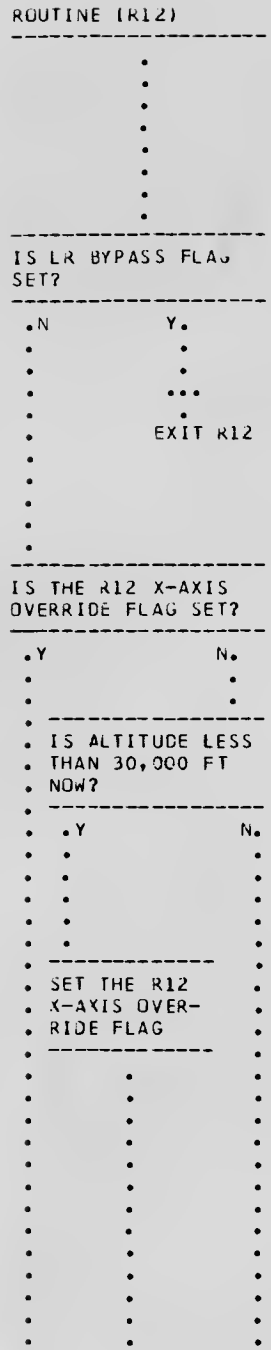
(4) THERE ARE 2 EXTENDED VERBS AVAILABLE TO THE CREW TO ALLOW MANUAL CONTROL OF THE USE OF LR DATA FOR STATE VECTOR UPDATING: V57E ENABLES THE USE OF GOOD LR DATA; V58E PREVENTS THE USE OF ALL LR DATA.

(5) THE L, R, M, AND S COUNTERS WERE ZEROED BY P63. THE LR BYPASS FLAG WAS SET BY R00 AND RESET BY P63. THE FOLLOWING FLAGS WERE RESET BY R00: VX INHIBIT, HIGATE, NO LR READ, R12 X-AXIS OVERRIDE, LR PERMIT, VELOCITY DATA, RANGE DATA, V FLASH, H FLASH, VFAIL, HFAIL, AND R12 DELAY. THE COUNTERS STILBAOH AND STILBADV WERE SET TO TWO BY P63, AND 511CTR WAS SET TO FOUR. HLROFF IS INITIALIZED TO 50 FEET IN P63.

++
+C7 (6) THIS ROUTINE IS CALLED EVERY 2 SECONDS BY SERVICER (AVERAGE G), BUT ONLY DURING P63, 64, 66, 70 OR 71.
+1180 HOWEVER THE ROUTINE IS IMMEDIATELY BYPASSED IF THE LR BYPASS FLAG IS SET. THIS FLAG IS ALWAYS SET BY R00, P70 AND
++ P71. IT IS RESET BY P63.



#10


ROUTINE (R12)
IS LR BYPASS FLAG SET?
N.
Y.
EXIT R12
IS THE R12 X-AXIS OVERRIDE FLAG SET?
Y.
N.
IS ALTITUDE LESS THAN 30,000 FT NOW?
Y.
N.
SET THE R12 X-AXIS OVER-RIDE FLAG

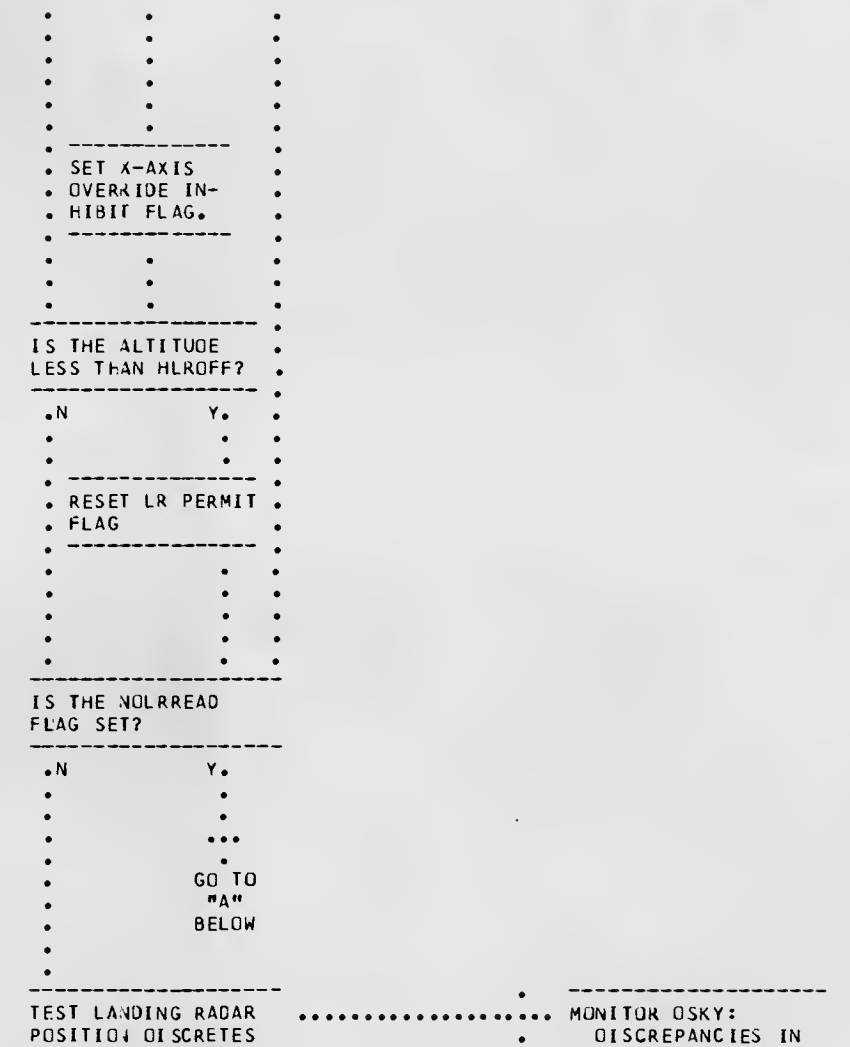
#2C

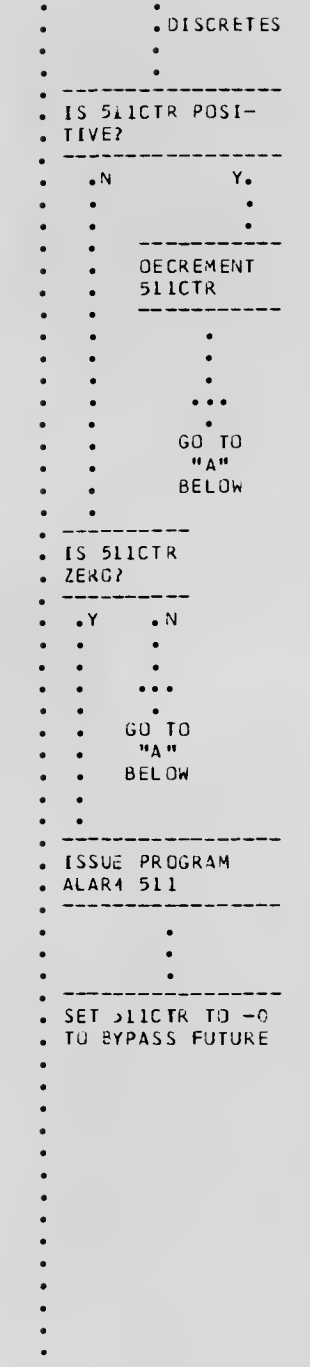
#3C

#4C

#5C

#6C

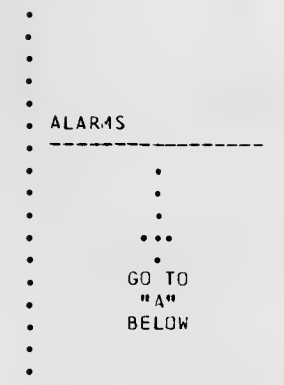

SET X-AXIS OVERRIDE INHIBIT FLAG.
#70
IS THE ALTITUDE LESS THAN HLROFF?
N
Y
RESET LR PERMIT FLAG
#80
IS THE NOLRREAD FLAG SET?
#90
N
Y
GO TO "A" BELOW
TEST LANDING RADAR POSITION DISCRETES
#100
POS 1 OR POS 2
NEITHER DISCRETE OR BOTH
MONITOR OSKY: DISCREPANCIES IN LR/LGC OPERATION THAT ARE NOT PRIORITY ALARMS WILL BE ALARMED AS FOLLOWS:

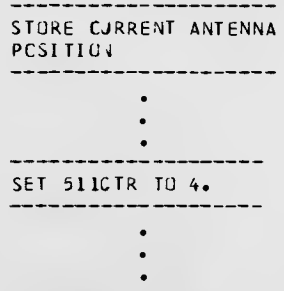


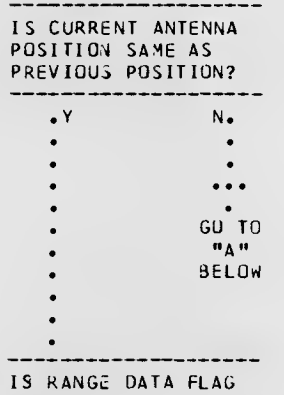
(A) PROGRAM ALARM LIGHT AND STEREO ALARM CODE:
(1) 00520-(SEE R20) NO RADAR SAMPLING REQUESTED FROM RADAR AT THIS TIME. #110
(2) 00511-EITHER OR BOTH DISCRETES; LR POSITION INDETERMINABLE. #120

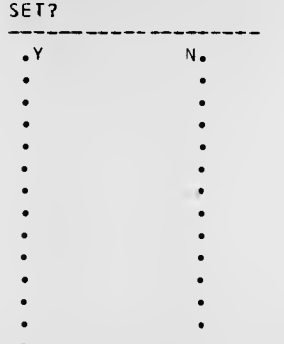
(B) ALTITUDE FAIL LIGHT ON STEADY:
(1) LR RANGE DATA GOOD DISCRETE WAS NOT PRESENT BEFORE AND AFTER LR ALTITUDE SAMPLING. #130 #140

(C) VELOCITY FAIL LIGHT ON STEADY:
(1) LR VELOCITY DATA GOOD DISCRETE WAS NOT PRESENT BEFORE AND AFTER LR VELOCITY #150









SAMPLING.
(SEE R20)

(D) ALTITUDE FAIL LIGHT FLASHING:
(1) LR ALTITUDE REASONABILITY TEST WAS FAILED.

(E) VELOCITY FAIL LIGHT FLASHING:
(1) LR VELOCITY REASONABILITY TEST WAS FAILED.

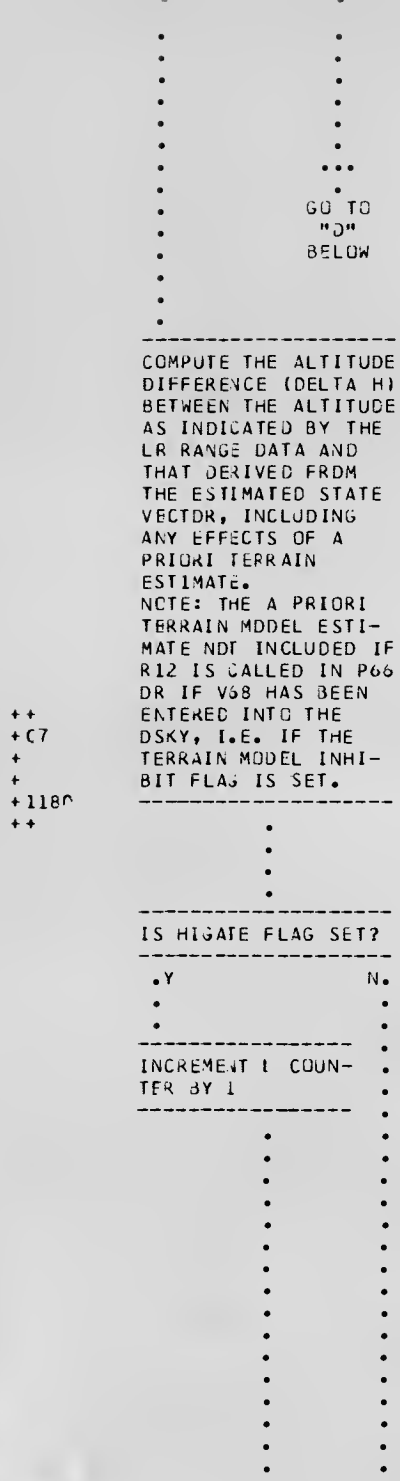
#160

#170

#180

#190

#200



#210

#220

#230

#240

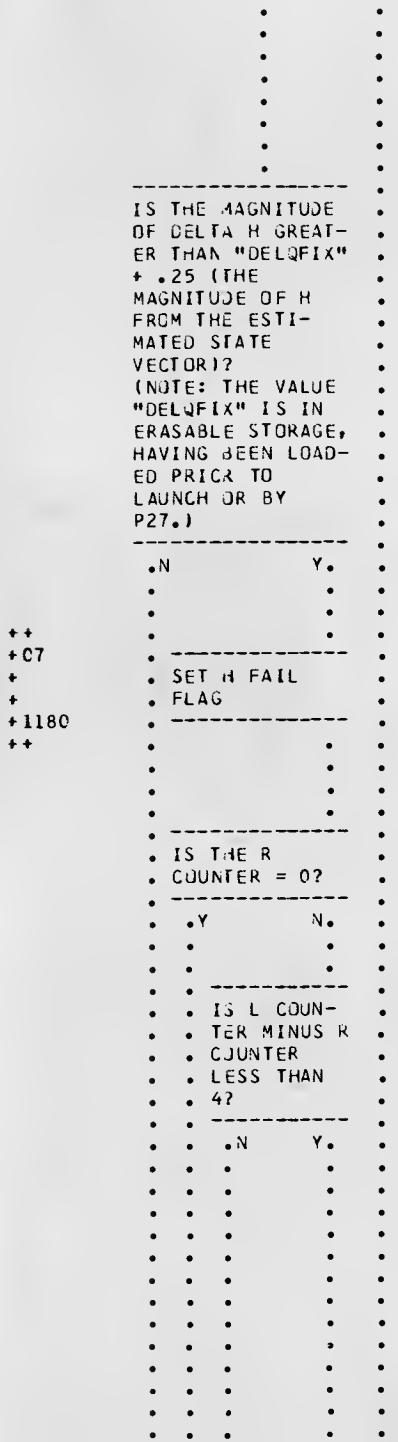
#250

#260

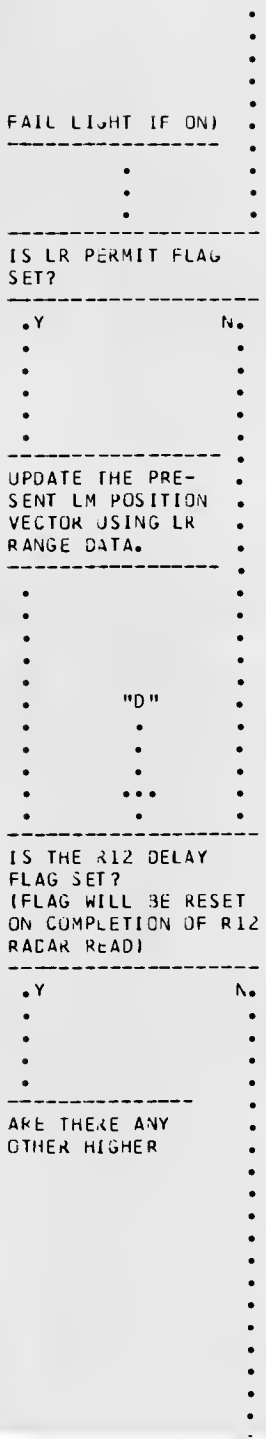
#270

#280

#290




SET H FLASH FLAG (NOTE: R09 WILL MONITOR THIS FLAG AND FLASH ALTITUDE FAIL LIGHT).
#300
#310
SET R COUNTER= L COUNTER.
#320
GO TO "D" BELOW
++
+07
+
+1180
++
RESET H FAIL FLAG
#330
RESET H FLASH FLAG (NOTE: R09 WILL MONITOR THIS FLAG AND TURN OFF FLASH OF ALTITUDE
#340



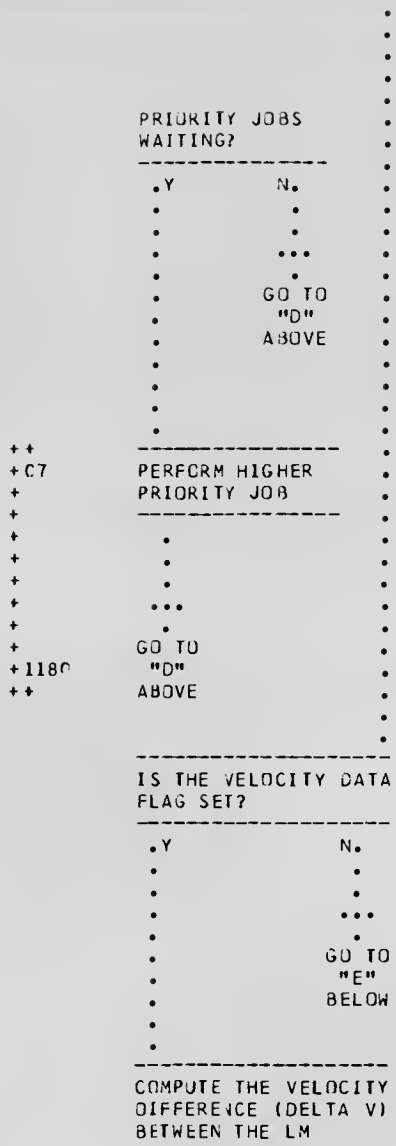
#350

#360

#370

#380

#390

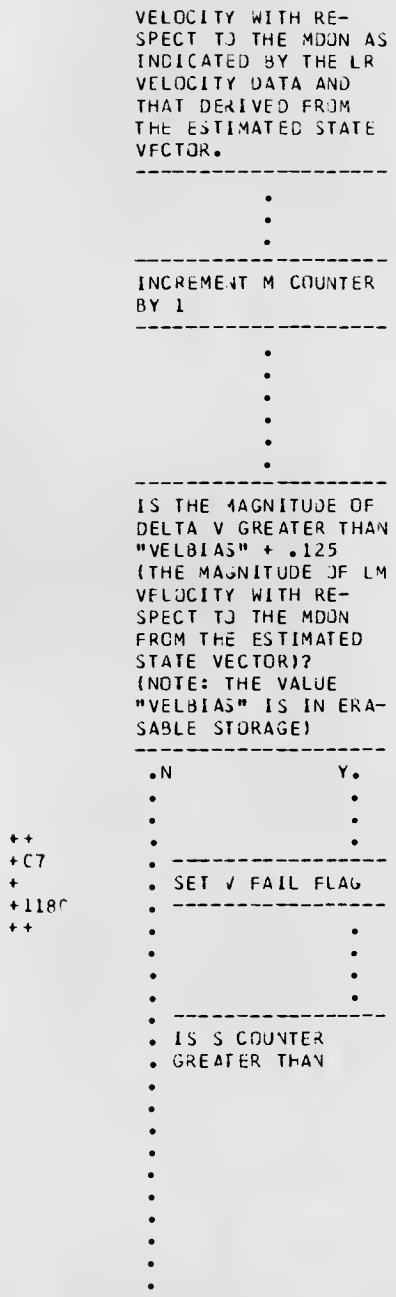


#400

#410

#420

#430



#44C

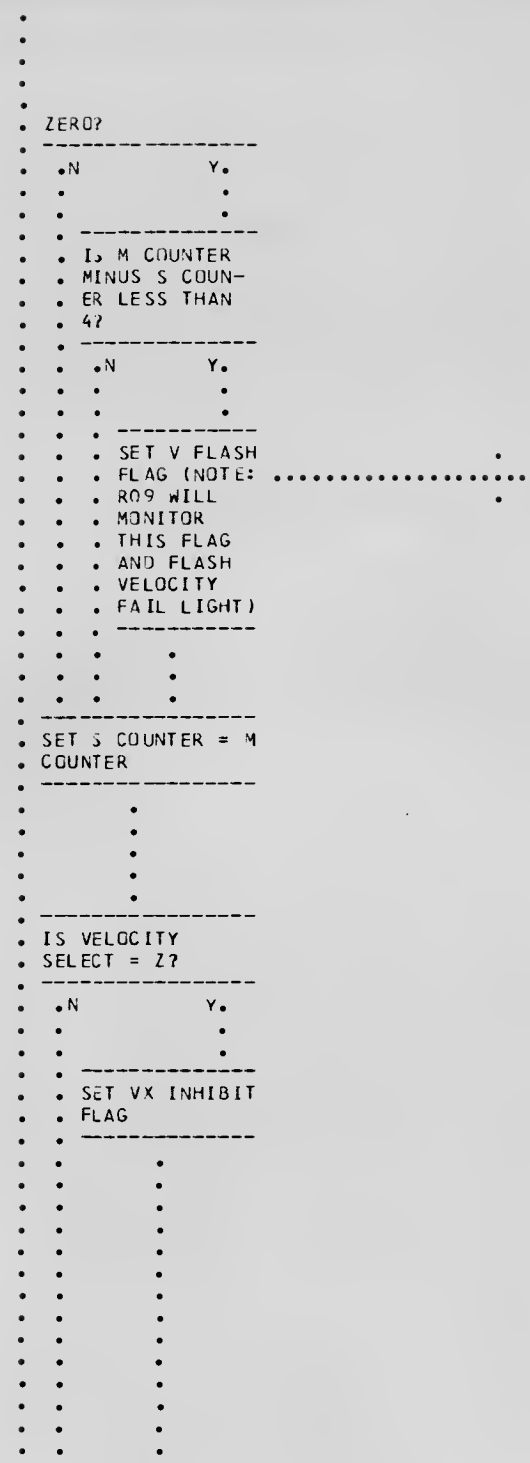
#45C

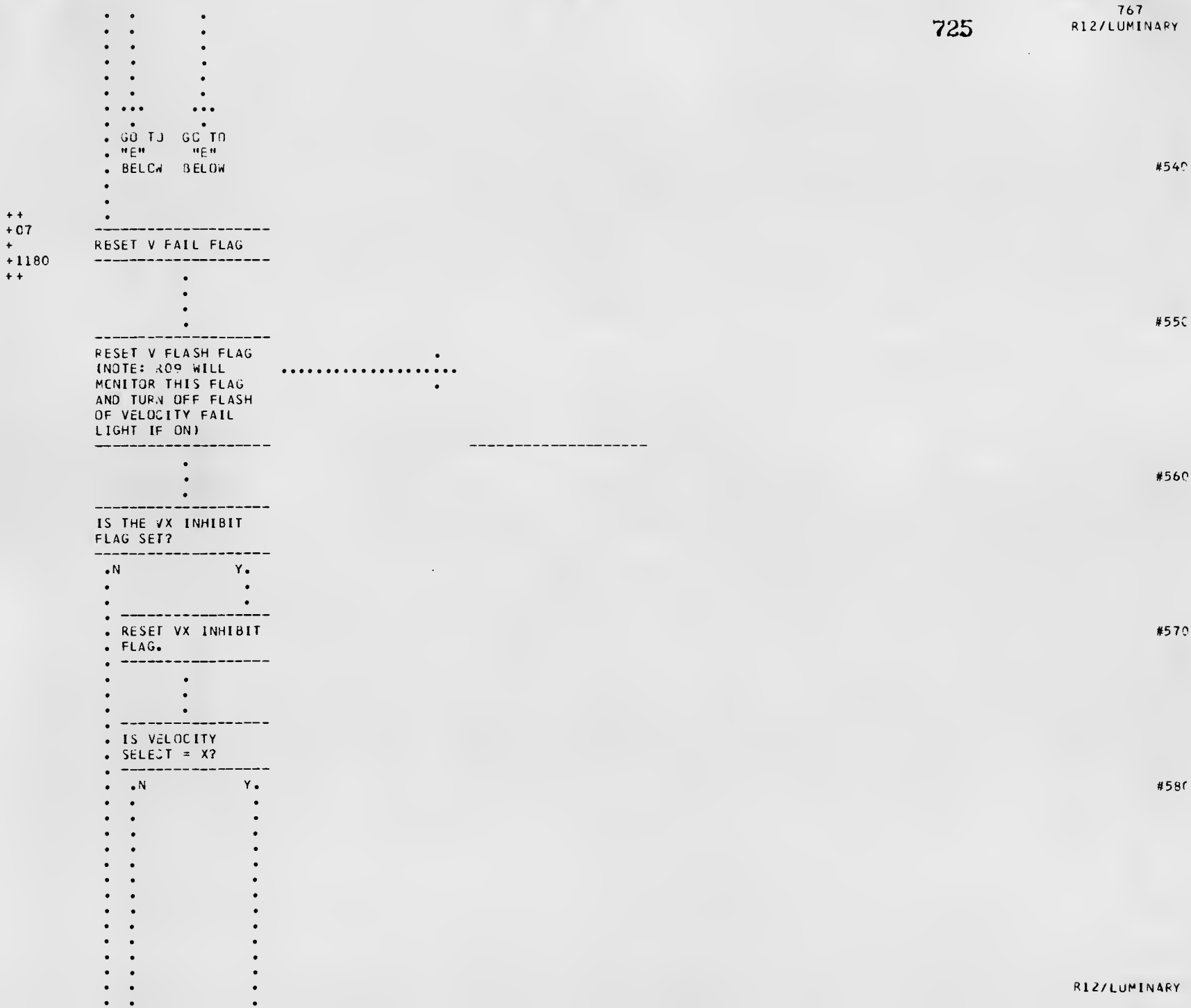
#46C

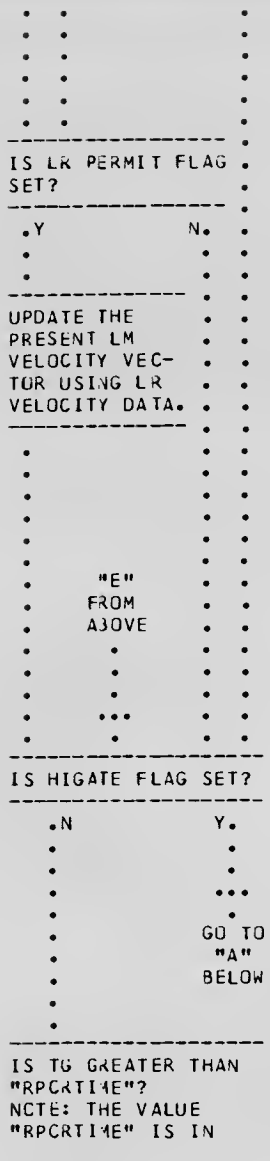
#47C

#48C

++
+C7
+
+118C
++


ZERO?
N
Y
#490
IS M COUNTER MINUS S COUNTER LESS THAN 4?
N
Y
#500
SET V FLASH FLAG (NOTE: R09 WILL MONITOR THIS FLAG AND FLASH VELOCITY FAIL LIGHT)
#510
SET S COUNTER = M COUNTER
#520
IS VELOCITY SELECT = Z?
N
Y
#530
SET VX INHIBIT FLAG


GO TO "E" BELOW
GO TO "E" BELOW
#540
++
+07
+
+1180
++
RESET V FAIL FLAG
#550
RESET V FLASH FLAG (NOTE: R09 WILL MONITOR THIS FLAG AND TURN OFF FLASH OF VELOCITY FAIL LIGHT IF ON)
#560
IS THE VX INHIBIT FLAG SET?
N
Y
RESET VX INHIBIT FLAG.
#570
IS VELOCITY SELECT = X?
N
Y
#580



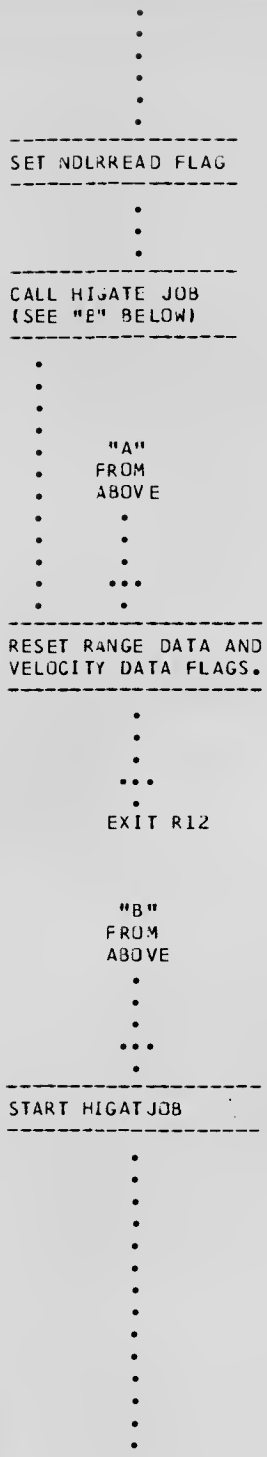
#590

#600

#610

#620

```
ERASABLE STORAGE
HAVING BEEN LOADED
PRIOR TO LAUNCH OR
BY P27.
A V59E MAY ALSO
AFFECT RPCRTIME BY
SETTING IT TO POSMAX.
--------------------
    .N            Y.
    .              .
    .              .
    .             ...
    .              .
    .            GO TO
    .             "A"
    .            BELOW
    .
    .
--------------------
IS XBXP GREATER THAN
"QSW"?
NOTE: XBXP IS THE
X-COMPONENT OF THE
X-VECTOR IN PLATFORM
COORDINATES. THE
VALUE "QSW" IS IN
ERASABLE STORAGE
HAVING BEEN LOADED
PRIOR TO LAUNCH OR
BY P27.
ALSO A V59E MAY SET
"QSW" TO -1
--------------------
    .Y          .N
    .            .
    .            .
    .           ...
    .            .
    .          GO TO
    .           "A"
    .          BELOW
    .
    .
------------------
SET HIGATE FLAG
------------------
           .
           .
           .
           .
           .
           .
           .
           .
           .
           .
           .
           .
           .
           .
```



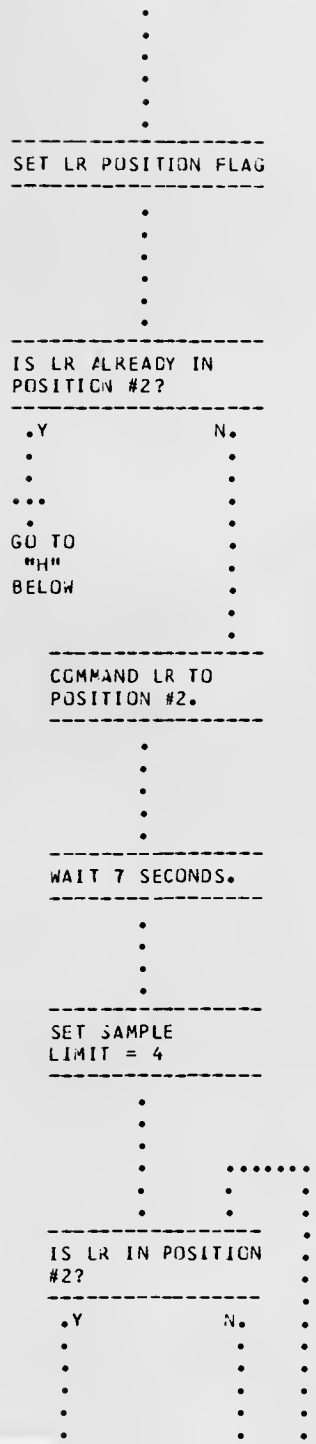
#680

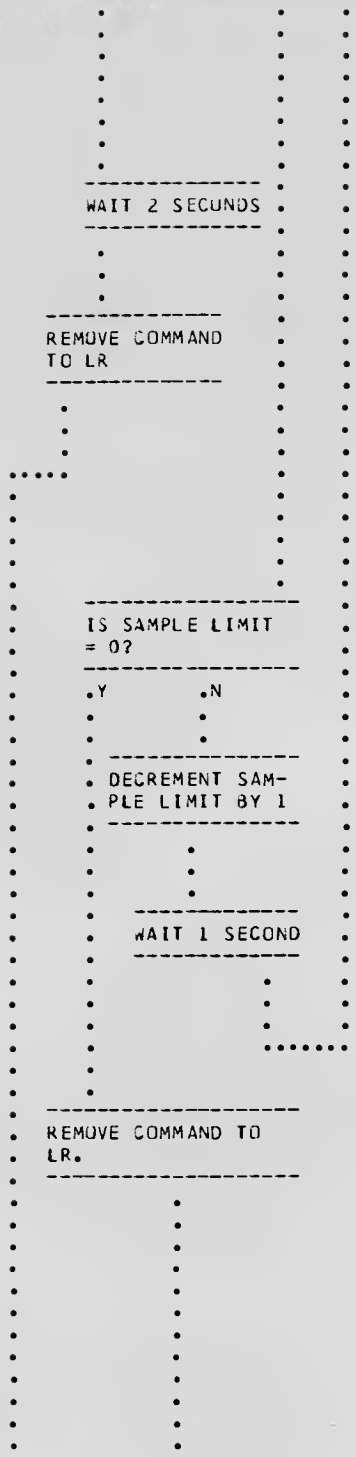
#690

#700

#710

#720


SET LR POSITION FLAG
#730
IS LR ALREADY IN POSITION #2?
Y
N
#740
GO TO "H" BELOW
#750
COMMAND LR TO POSITION #2.
#760
WAIT 7 SECONDS.
#770
SET SAMPLE LIMIT = 4
IS LR IN POSITION #2?
#780
Y
N



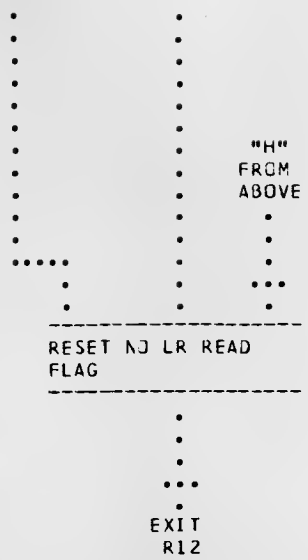
#790

#800

#810

#820

#830



#840

#850

CHANGE CONTROL NOTES

REV 00 PCR 13
REV 01 PCR 118,137,214,216,226,234,244,246,248,253,568,632,639
REVS 02,03(LUM 1B) PCR 817,820,839,855, EDITORIAL
REV 04(LUM 1C) PCR 285,943, EDITORIAL
REV 05(LUM 1D) PCR 298,310,892,896,898,942,988,1021,1022,1025
1027, PCN 1009
REV 06(LUM 1E) PCR 319,341, PCN 1145
REV 07 PCN 1180

LANDING AUTO MODES MONITOR ROUTINE (R13) REV C6 12/01/71

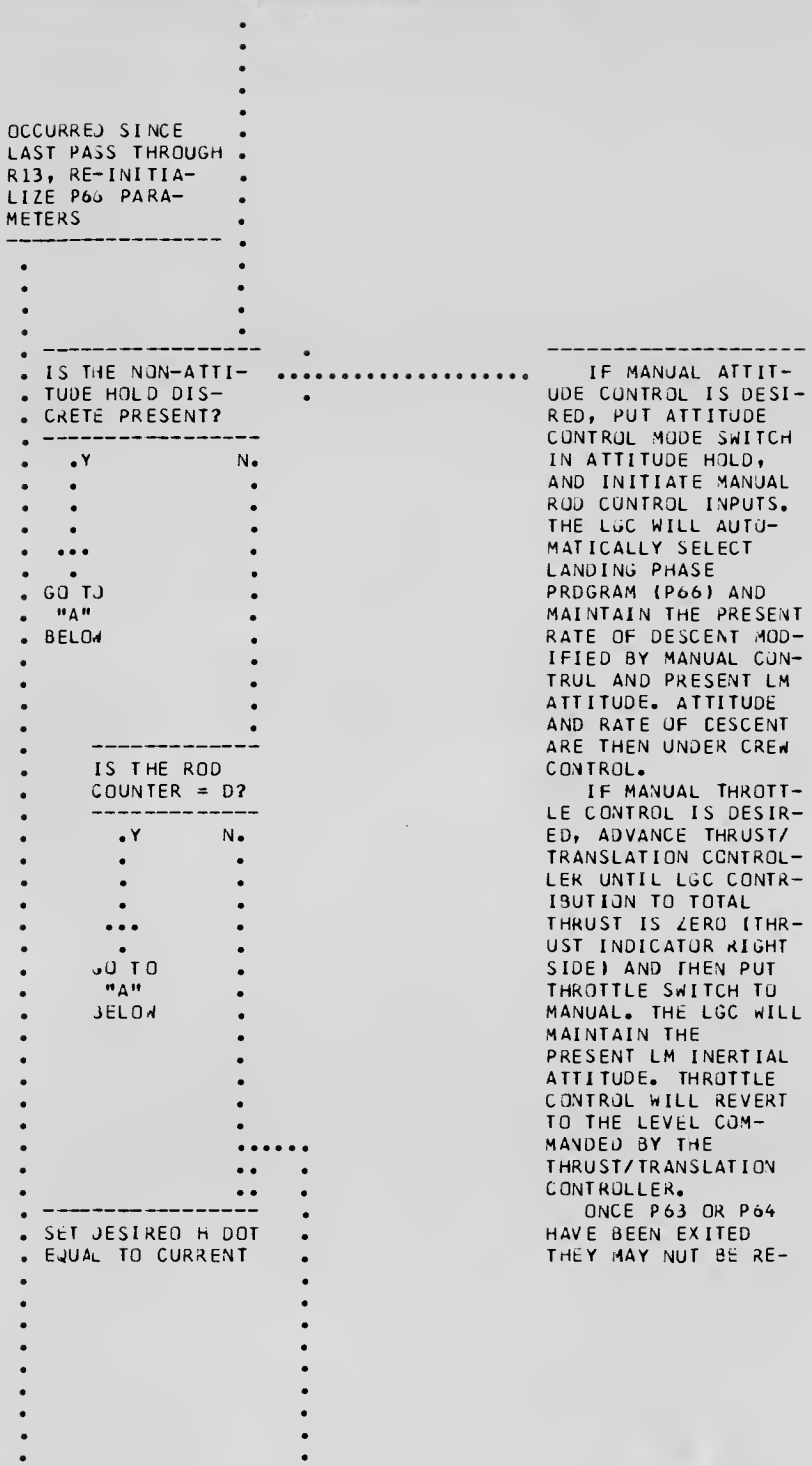
PURPOSE: (1) TO MONITOR THE AUTO STABILIZATION DISCRETE DURING THE POWERED LANDING MANEUVER IN ORDER TO DETECT IF AND WHEN THE ATTITUDE MODE CONTROL SWITCH IS MOVED FROM AUTO TO ATTITUDE HOLD.

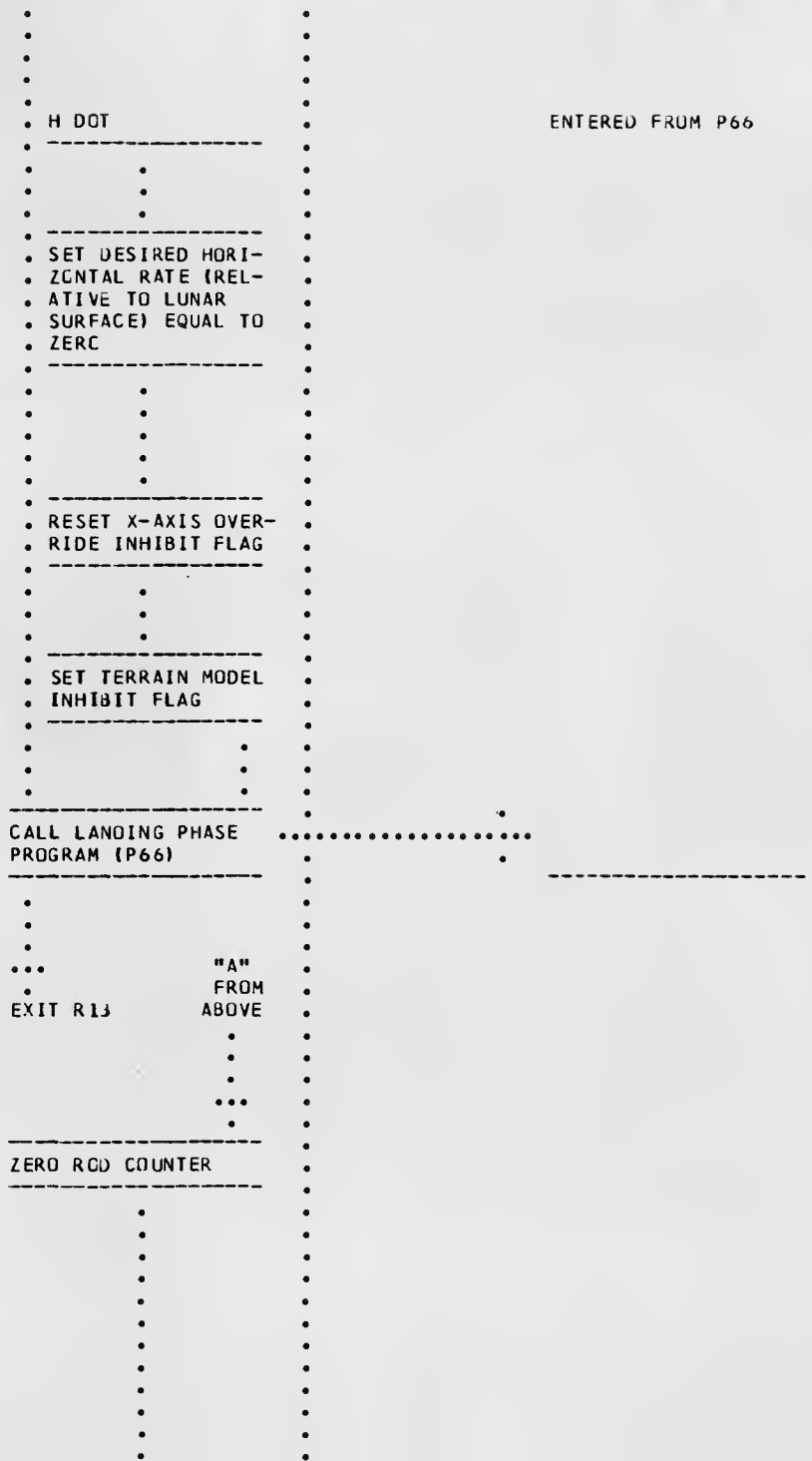
(2) TO INITIALIZE HORIZONTAL AND VERTICAL VELOCITIES FOR P66.

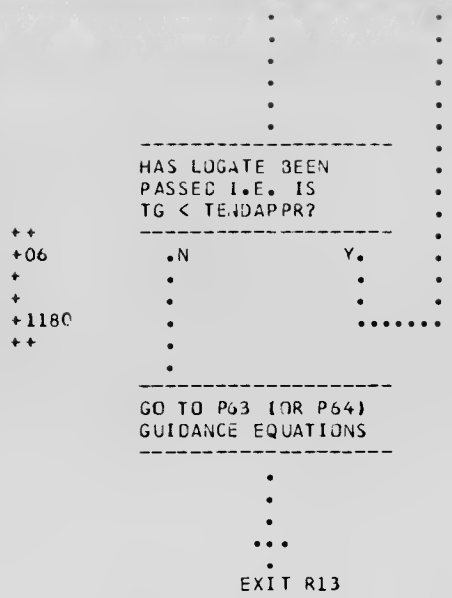
ASSUMPTIONS: 1) THIS ROUTINE WILL OPERATE IDENTICALLY FOR EITHER PGNCS OR AGS GUIDANCE CONTROL SELECTION.

(2) THIS ROUTINE IS AUTOMATICALLY CALLED EVERY 2 SECONDS (DEPENDING ON LOSS) BY THE LANDING GUIDANCE CALCULATION CYCLE BETWEEN THROTTLE-UP IN P63 AND V37E68E SELECTION OF P68.

(3) PLACING THE THROTTLE CONTROL SWITCH INTO MANUAL IN P63, P64 OR P65 WILL CUT OFF THE LGC (I.E. AUTO) THROTTLE SIGNAL; THUS ENGINE THRUST LEVEL WILL IMMEDIATELY DROP TO THAT COMMANDED BY WHICHEVER HAND THROTTLE IS "LIVE". THEREFORE A TRANSITION FROM AUTO-THROTTLE TO MANUAL THROTTLE CONTROL CANNOT BE SMOOTH: IF THE SWITCH IS PUT IN MANUAL BEFORE THE MANUAL THROTTLE IS BROUGHT UP, THRUST WILL DROP; IF THE MANUAL THROTTLE IS BROUGHT UP BEFORE THE SWITCH IS "SWITCHED", SINCE THE MANUAL AND AUTO-THROTTLE SIGNALS ARE ADDED, THERE WILL BE IRREGULAR THROTTLING AS THE LGC CORRECTS FOR THE EXCESSIVE THRUST.


OCCURRED SINCE LAST PASS THROUGH R13, RE-INITIALIZE P66 PARAMETERS
IS THE NON-ATTITUDE HOLD DISCRETE PRESENT?
Y
N
GO TO "A" BELOW
IS THE ROD COUNTER = 0?
Y
N
GO TO "A" BELOW
SET DESIRED H DOT EQUAL TO CURRENT
IF MANUAL ATTITUDE CONTROL IS DESIRED, PUT ATTITUDE CONTROL MODE SWITCH IN ATTITUDE HOLD, AND INITIATE MANUAL ROD CONTROL INPUTS.
THE LGC WILL AUTOMATICALLY SELECT LANDING PHASE PROGRAM (P66) AND MAINTAIN THE PRESENT RATE OF DESCENT MODIFIED BY MANUAL CONTRUL AND PRESENT LM ATTITUDE. ATTITUDE AND RATE OF DESCENT ARE THEN UNDER CREW CONTROL.
IF MANUAL THROTTLE CONTROL IS DESIRED, ADVANCE THRUST/TRANSLATION CONTROLLER UNTIL LGC CONTRIBUTION TO TOTAL THRUST IS ZERO (THRUST INDICATOR RIGHT SIDE) AND THEN PUT THROTTLE SWITCH TO MANUAL. THE LGC WILL MAINTAIN THE PRESENT LM INERTIAL ATTITUDE. THROTTLE CONTROL WILL REVERT TO THE LEVEL COMMANDED BY THE THRUST/TRANSLATION CONTROLLER.
ONCE P63 OR P64 HAVE BEEN EXITED THEY MAY NOT BE RE-
#30
#40
#50
#60
#70


H DOT
ENTERED FROM P66
#80
SET DESIRED HORI-
ZONTAL RATE (REL-
ATIVE TO LUNAR
SURFACE) EQUAL TO
ZERO
#90
RESET X-AXIS OVER-
RIDE INHIBIT FLAG
#100
SET TERRAIN MODEL
INHIBIT FLAG
CALL LANDING PHASE
PROGRAM (P66)
#110
"A"
FROM
ABOVE
EXIT R13
#120
ZERO RCD COUNTER



#130

#140

CHANGE CONTROL NOTES

REV 01 EDITORIAL
REV 00(LUM 1A) PCR 700,737
REV 02 EDITORIAL
REV 03(LUM 1C) PCR 285,EDITORIAL
REV 04(LUM 1D) PCR 988, PCN 1009,1035,1037
REV 05(LUM 1E) PCN 1145
REV 06 PCN 1180

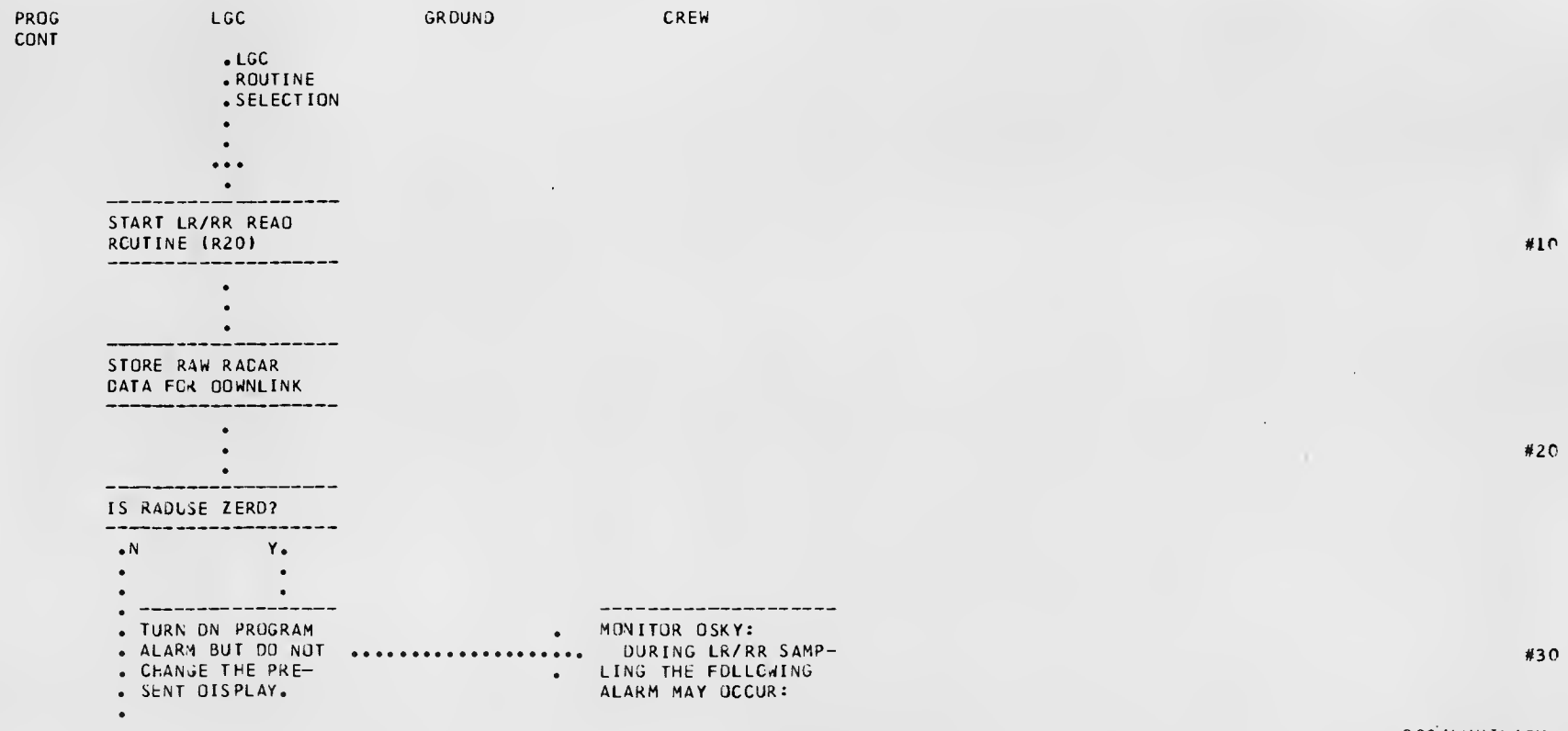
LR/RR READ ROUTINE (R20) REV 05 12/01/71

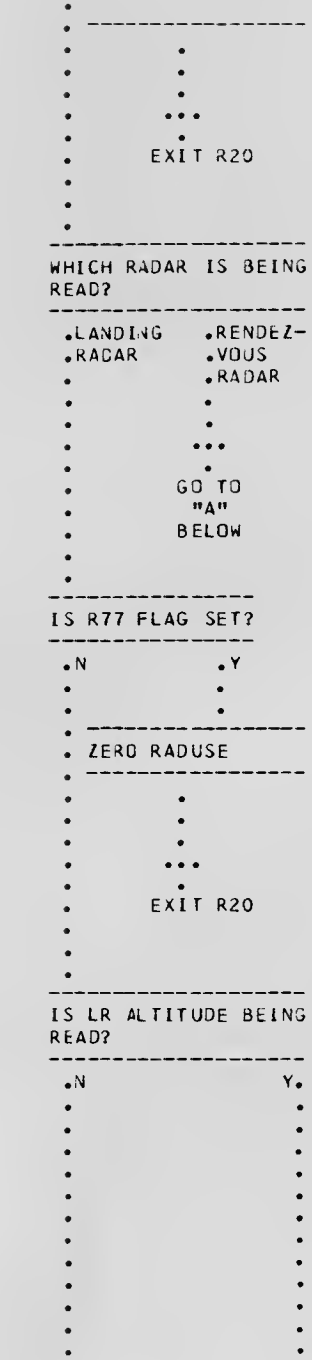
PURPOSE: (1) READ THE LR/RR PARAMETER REQUESTED BY THE CALLING ROUTINE TO PERFORM VARIOUS CHECKS TO ENSURE THAT THE SYSTEM IS OPERATING CORRECTLY, AND TO ISSUE AN ALARM IF NO RADAR SAMPLING REQUESTED.

ASSUMPTIONS: (1) THE NUMBER OF SAMPLES (NSAMP) IS SET TO ZERO BY ALL USERS EXCEPT R12.

(2) THE CALLING ROUTINE HAS THE APPROPRIATE CHANNEL 13 BIT SPECIFICATION IN RADUSE, AND HAS WRITTEN IT INTO CHANNEL 13.

++
+05 (3) THIS ROUTINE IS AUTOMATICALLY CALLED BY A RADARUPT (LGC INTERRUPT) CAUSED BY EXPIRATION OF A TIME DELAY
+ (90-100 MS) AFTER BIT 4 OF CHANNEL 13 IS SET. THE ROUTINES THAT SET BIT 4 OF CHANNEL 13 ARE THE LR/RR SELF TEST
+ ROUTINE (R04), THE DESCENT STATE VECTOR UPDATE ROUTINE (R12) (FOR THE INITIAL READ OF A SEQUENCE), THE RR DATA READ
+1180 ROUTINE (R22), THE LR SPURIOUS TEST ROUTINE (R77), AND THE FINE PREFERRED TRACKING ATTITUDE ROUTINE (R65). THE BIT
++ IS ALSO SET BY R20 ITSELF TO CONTINUE THE R12 LR READ SEQUENCE.





PROGRAM ALARM
00520 -NO RADAR SAMPLING REQUESTED FROM RADAR AT THIS TIME.

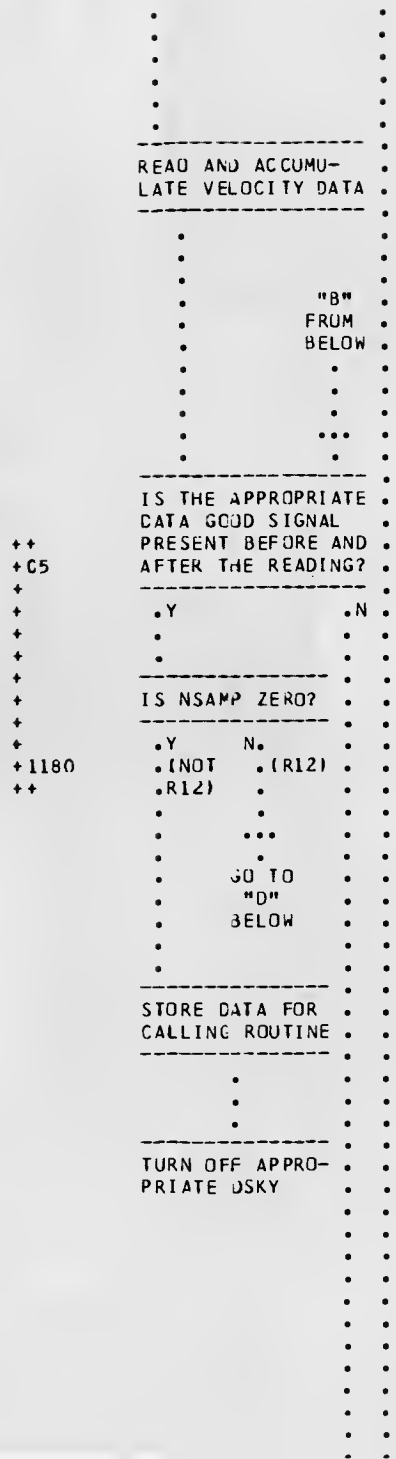
#40

#50

#60

#70

#80



++
+C5
+
+
+
+
+
+
+
+
+1180
++

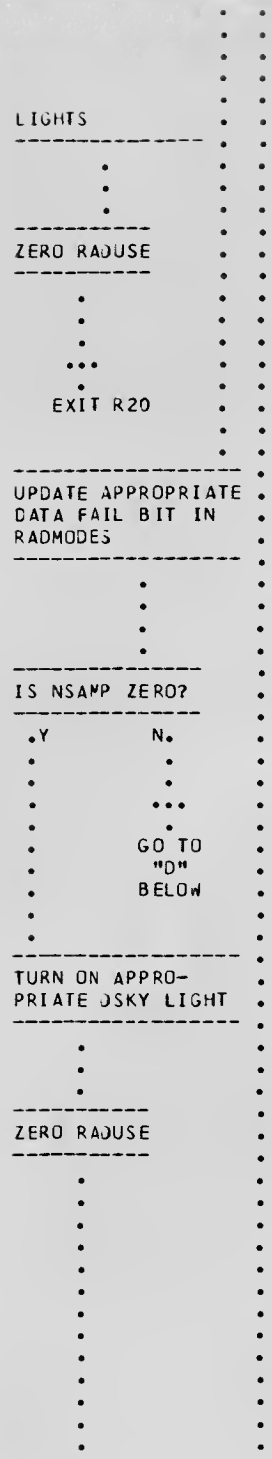
#90

#10D

#110

#120

#130



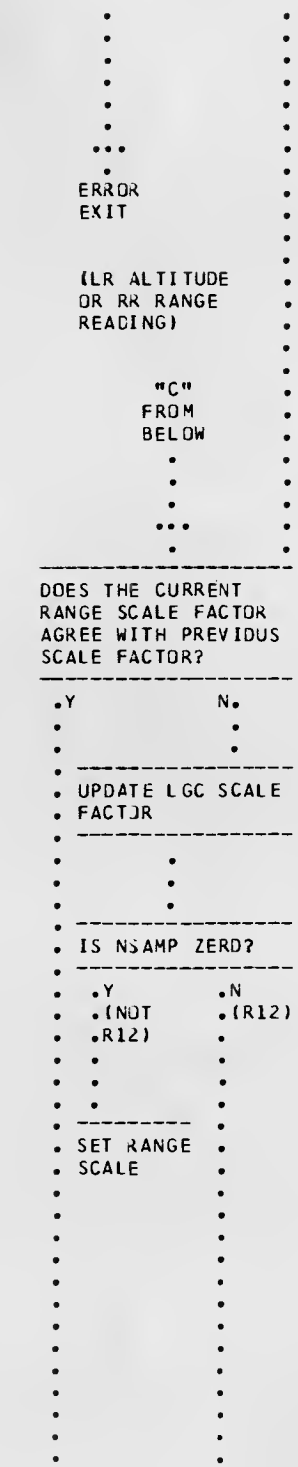
#140

#150

#160

#170

#180

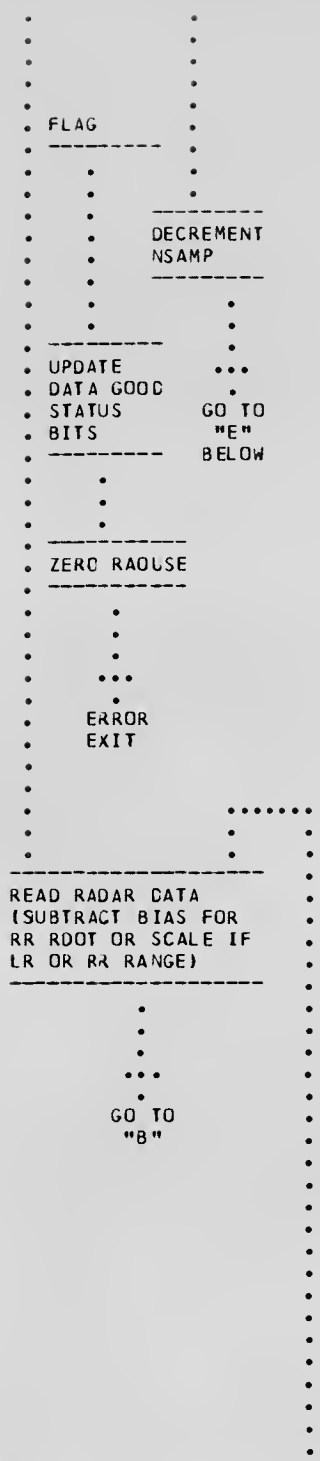


#190

#200

#210

#220



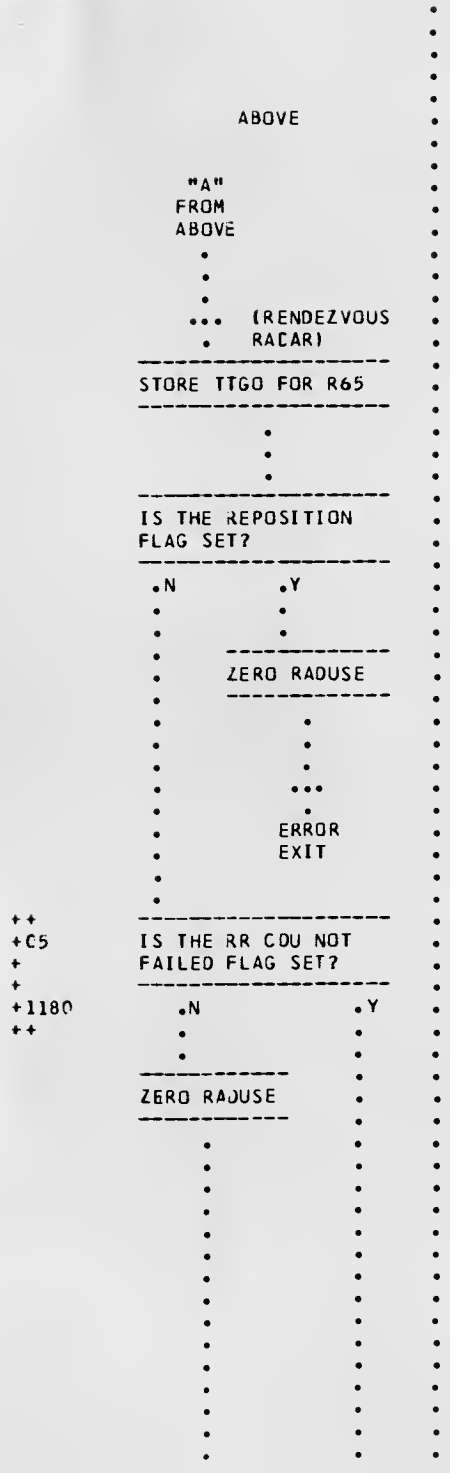
#230

#240

#250

#260

#270



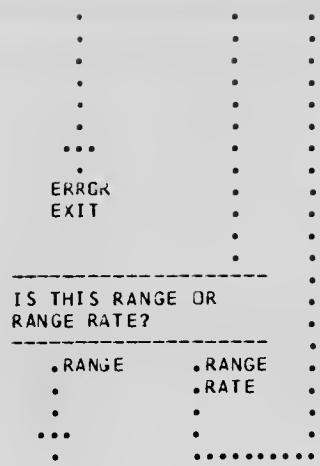
#280

#290

#300

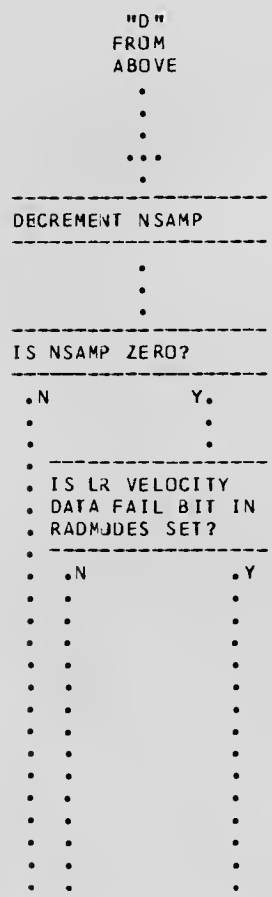
#310

#320



#330

#340



#350

#360

#370

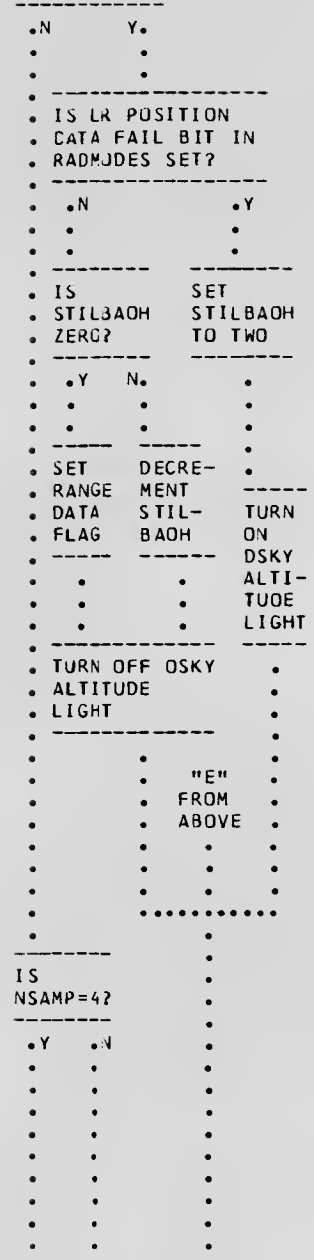
#380

#390

#400

#410

#420



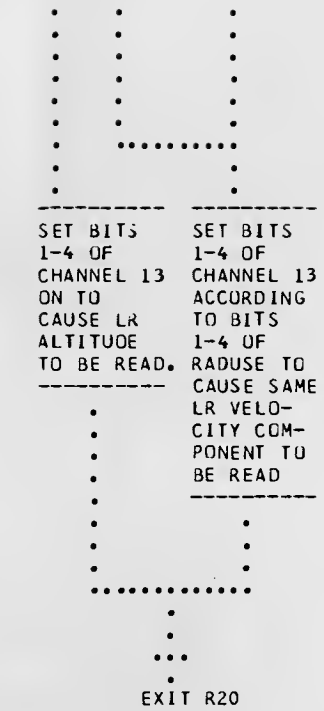
#430

#440

#450

#460

#470



#480

#490

#500

CHANGE CONTROL NOTES

REV 01 PCR 214,457
REV 02(LUM 1B) PCR B17,820, EDITORIAL
REV 03(LUM 1D) PCR B92,979
REV 04(LUM 1E) PCN 1145
REV 05 PCN 1180

RR DESIGNATE ROUTINE (R21) REV 03 12/01/71

PURPOSE: (1) TO POINT THE RENDEZVOUS RADAR (RR) AT THE CSM UNTIL AUTOMATIC ACQUISITION OF THE CSM IS ACCOMPLISHED BY THE RADAR WHILE THE LM IS IN ORBIT OR ON THE LUNAR SURFACE.

ASSUMPTIONS: (1) THE RR SERVOS MAY BE COMMANDED BY THE LGC AFTER THE LGC ISSUES THE TRACK ENABLE DISCRETE UNTIL RANGE RATE LOCKON IS ACHIEVED BY THE RR.

(2) THE SELECTION AND TERMINATION OF P20,P22, AND P25 ARE SUBJECT TO SPECIAL OPERATING PROCEDURES DIFFERENT FROM THOSE FOR ALL OTHER PROGRAMS:

(A) SELECTION

(1) ALWAYS BY V37EXXE.

++ (2) IF ANY OTHER PROGRAM IS RUNNING AT THE TIME OF P20/22/25 SELECTION THE NEW PROGRAM WILL
+03 REPLACE THE OLD. THIS INCLUDES P20/22/25 SELECTION WHENEVER EITHER P20,22, OR 25 IS RUNNING.

\+ (3) IF P20 OR P25 IS RUNNING, SELECTION OF ANY PROGRAM OTHER THAN P00, P22, OR P25 WILL RESULT
\+ IN P20 OR P25 CONTINUING AND THE NEW PROGRAM ALSO OPERATING WITH ITS NUMBER DISPLAYED IN THE
\+ DSKY PROG LIGHTS.

+1180 (4) IF P20 OR P25 IS RUNNING, SELECTION OF P00, P22, OR P25 WILL RESULT IN THE TERMINATION OF THE OLD
++ PROGRAM AND OPERATION OF THE NEW.

(B) TERMINATION

(1) BY SELECTION OF P00, V56E OR BY V34E.

(2) P00 SELECTION WILL TERMINATE P20,22, AND 25 AND ANY OTHER PROGRAM IN PROCESS, AND ESTABLISH P00.

(3) V56E SELECTION WILL SELECT THE TERMINATE TRACKING ROUTINE (R56) WHICH WILL TERMINATE ONLY P20 OR P25 IF EITHER OF THESE PROGRAMS IS RUNNING IN CONJUNCTION WITH ANOTHER PROGRAM. IN ALL OTHER CASES R56 WILL SELECT R00. V56E MAY BE PERFORMED ANY TIME DURING P20,22, OR 25 OPERATION.

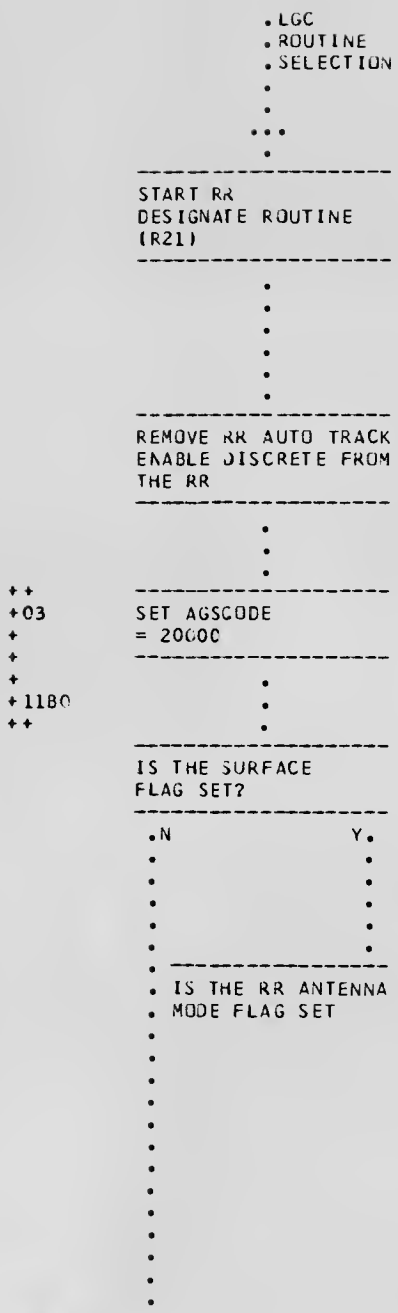
++ (4) THE LGC WILL ACT UPON V34E ONLY IN RESPONSE TO A FLASHING VERB-NOUN. IF THIS DISPLAY WAS
+03 ORIGINATED BY P20,22, OR 25, V34E WILL RESULT IN AN IDENTICAL LGC RESPONSE TO THAT OF V56E,
\+ THAT IS, SELECTION OF R56 EXCEPT IN THE CASE OF A VC6 N49 DISPLAY. IF THIS DISPLAY WAS NOT
\+ ORIGINATED BY P20,22, OR 25, (SUCH AS P32 WHILE RUNNING WITH P20) THE LGC WILL GO TO R00,
+1180 HOWEVER THE PROGRAM IN THE BACKGROUND WILL CONTINUE. THE NEW PROGRAM SELECTED FOLLOWS THE
++ SELECTION RULES ABOVE, (A).

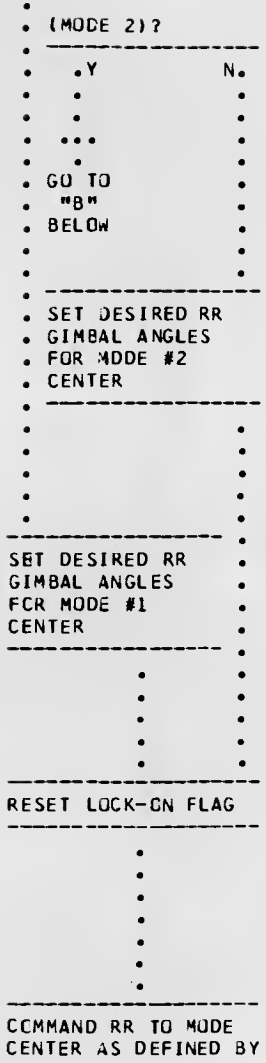
(5) ALTHOUGH IT IS NOT CLEARLY SHOWN IN THE LOGIC BELOW A V34E RESPONSE TO A PRIORITY DISPLAY MUST BE DELAYED 2 SECONDS FROM DISPLAY INITIATION WHEREAS THE DELAY IS NOT NECESSARY FOR A V56E RESPONSE.

(3) THIS ROUTINE IS AUTOMATICALLY CALLED BY THE RENDEZVOUS NAVIGATION PROGRAM (P20) AND THE LUNAR SURFACE NAVIGATION PROGRAM (P22).

PROG	LGC	GROUND	CREW

CONT


.LGC
.ROUTINE
.SELECTION
START RR
DESIGNATE ROUTINE
(R21)
#10
REMOVE RR AUTO TRACK
ENABLE DISCRETE FROM
THE RR
#20
++
+03
+
+
+
+1180
++
SET AGSCODE
= 20000
#30
IS THE SURFACE
FLAG SET?
.N
Y.
#40
IS THE RR ANTENNA
MODE FLAG SET


(MODE 2)?
Y
N
GO TO "B" BELOW
SET DESIRED RR GIMBAL ANGLES FOR MODE #2 CENTER
SET DESIRED RR GIMBAL ANGLES FOR MODE #1 CENTER
RESET LOCK-ON FLAG
COMMAND RR TO MODE CENTER AS DEFINED BY

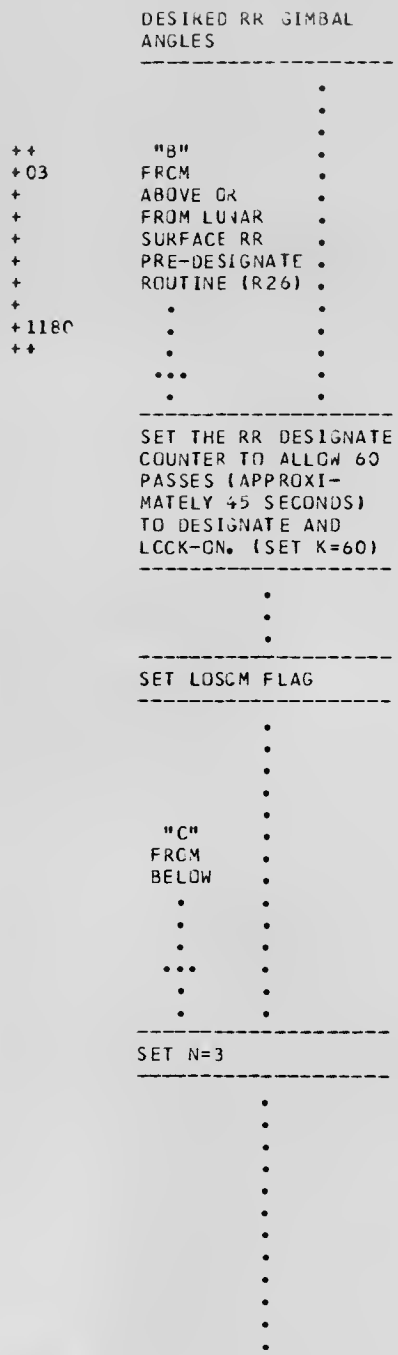
#50

#60

#70

#80

#90



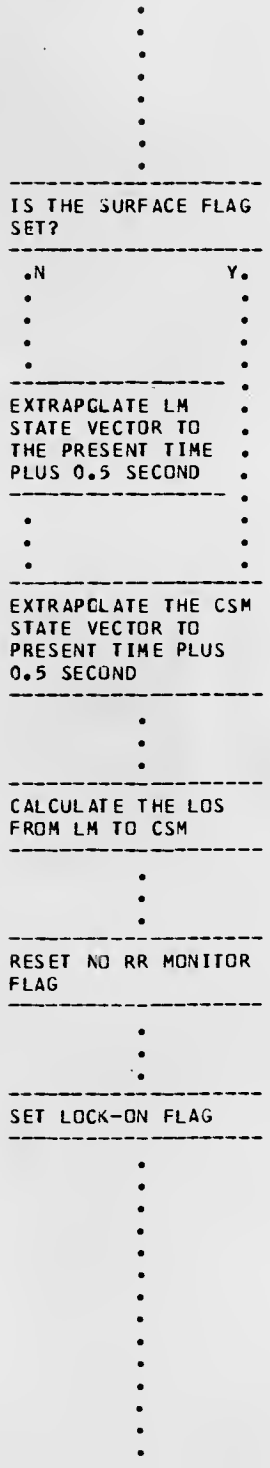
#100

#110

#120

#130

#140



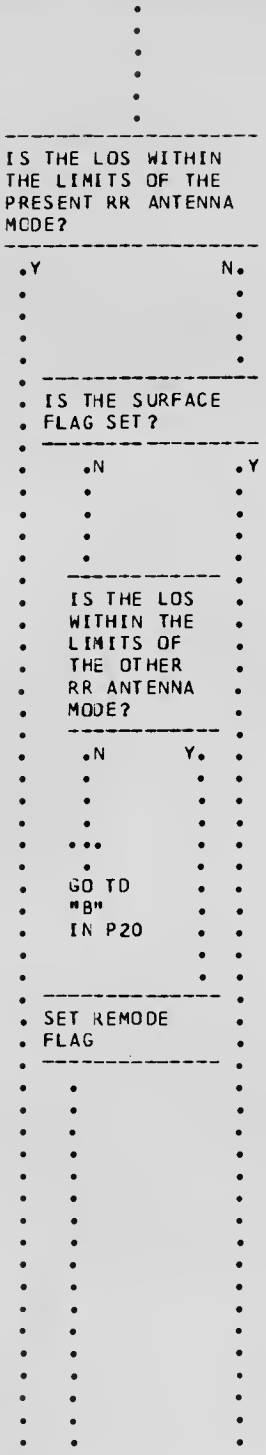
#150

#160

#170

#180

#190

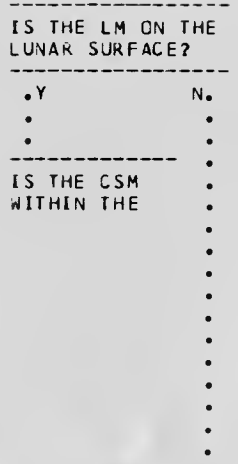


#200

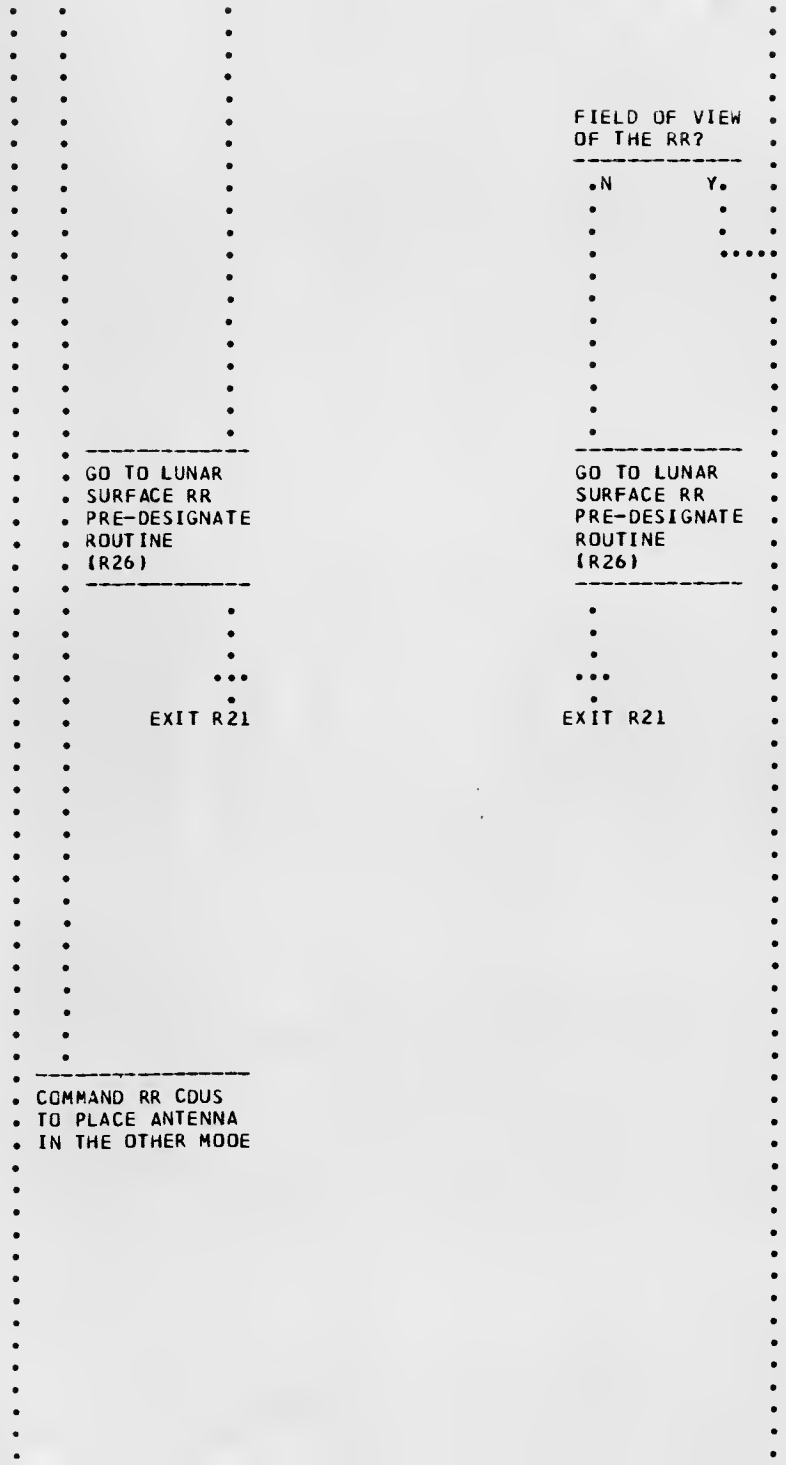
#210

#220

#230



#240



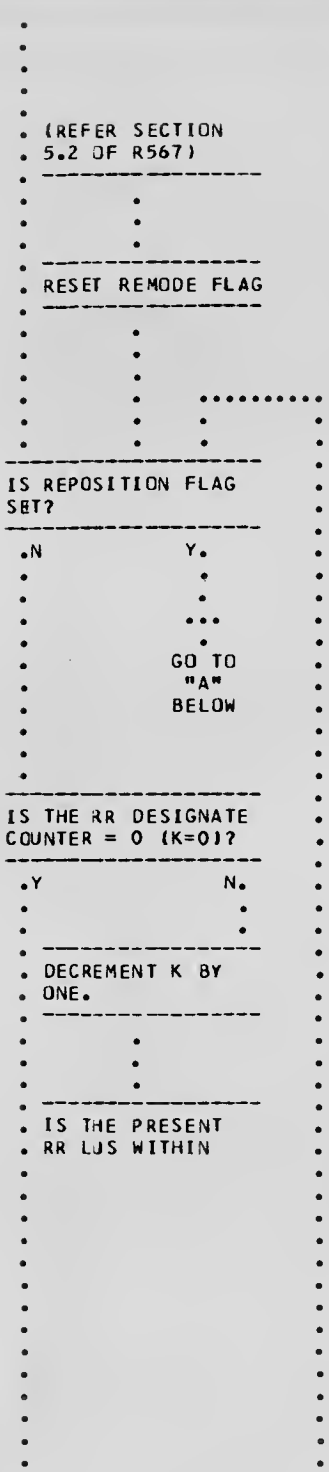
#250

#260

#270

#280

#290

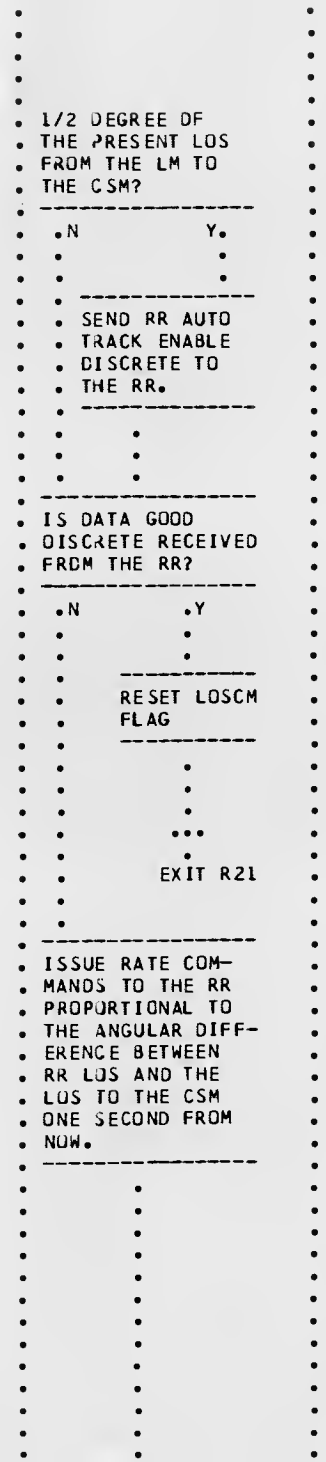


#300

#310

#320

#330



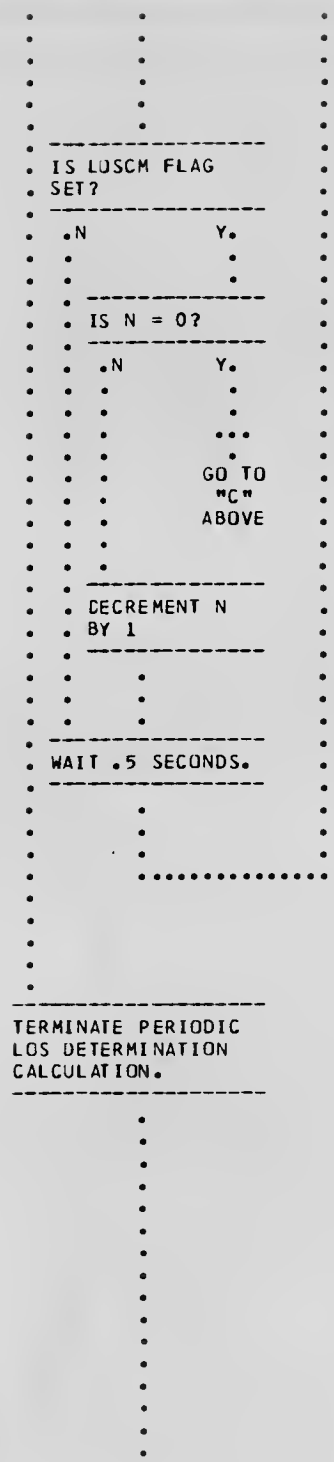
#340

#350

#360

#370

#380



#390

#400

#410

#420

#430

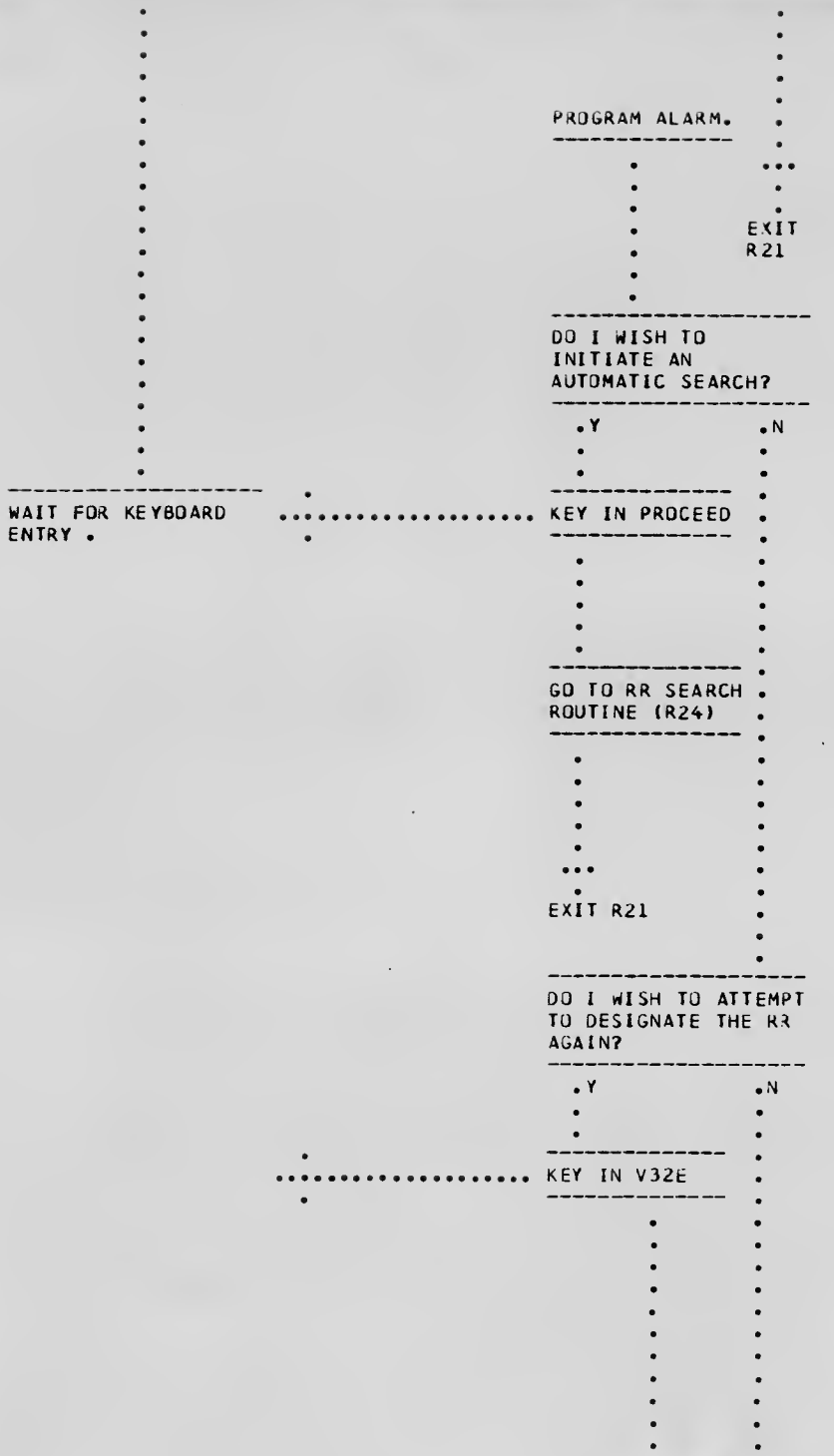
#440

#450

#460

#470

#480



#490

#500

#510

#520

#530

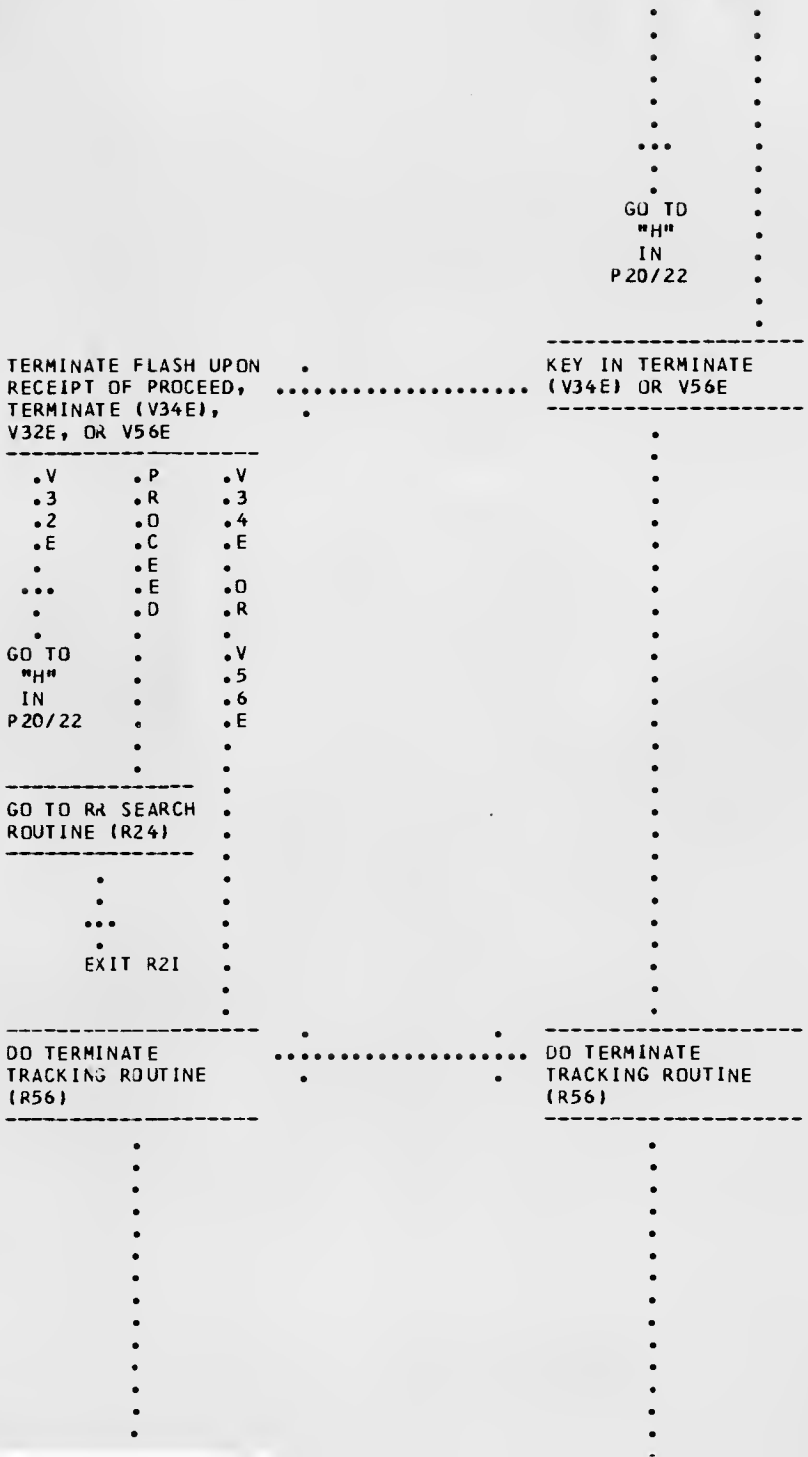
#540

#550

#560

#570

#580



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...
.
EXIT R21 AND P20/22
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.
...
.
EXIT R21 AND P20/22
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#590

CHANGE CONTROL NOTES

REV 01 PCR 226,432,451,562,640
REV 00(LUM 1A) PCR 722
REV 01(LUM 1B) EDITORIAL
REV 02 EDITORIAL
REV 03 PCN 1180

RR DATA READ ROUTINE (R22) REV 05 12/01/71

PURPOSE: (1) TO PROCESS AUTOMATIC RR MARK DATA TO UPDATE THE STATE VECTOR OF EITHER LM OR CSM AS DEFINED BY THE RENDEZVOUS NAVIGATION PROGRAM (P20), OR THE LUNAR SURFACE NAVIGATION PROGRAM (P22).

(2) TO MAINTAIN THE LM +Z AXIS ALIGNED ALONG THE LOS FROM THE LM TO THE CSM WITHIN THE IMPULSE LIMIT CYCLE OF THE DAP WHEN P20 IS IN PROCESS.

ASSUMPTIONS: (1) THE ROUTINE IS AUTOMATICALLY CALLED BY THE RENDEZVOUS NAVIGATION PROGRAM (P20), OR THE LUNAR SURFACE NAVIGATION PROGRAM (P22).

(2) THE SELECTION AND TERMINATION OF P20,P22, AND P25 ARE SUBJECT TO SPECIAL OPERATING PROCEDURES DIFFERENT FROM ALL OTHER PROGRAMS:

(A) SELECTION

(1) ALWAYS BY V37EXXE.

++ +05 + + + +1180 ++ (2) IF ANY OTHER PROGRAM IS RUNNING AT THE TIME OF P20/22/25 SELECTION THE NEW PROGRAM WILL REPLACE THE OLD. THIS INCLUDES P20/22/25 SELECTION WHENEVER EITHER P20,22, OR 25 IS RUNNING.

(3) IF P20 OR P25 IS RUNNING, SELECTION OF ANY PROGRAM OTHER THAN P00, P22, OR P25 WILL RESULT IN P20 OR P25 CONTINUING AND THE NEW PROGRAM ALSO OPERATING WITH ITS NUMBER IN THE OSKY PROG LIGHTS.

(4) IF P20 OR P25 IS RUNNING, SELECTION OF P00, P22, OR P25 WILL RESULT IN THE TERMINATION OF THE OLD PROGRAM AND OPERATION OF THE NEW.

(B) TERMINATION

(1) BY SELECTION OF P00, V56E OR BY V34E.

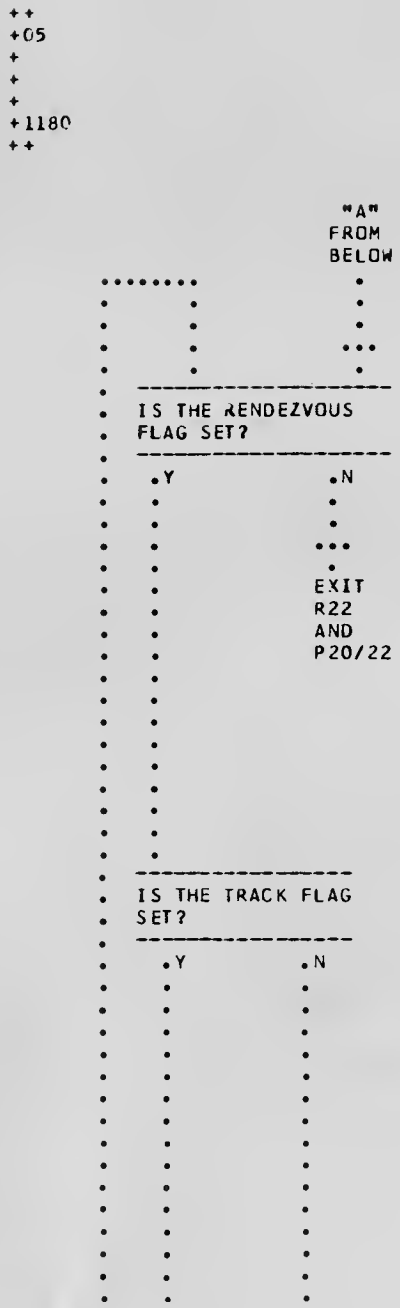
(2) P00 SELECTION WILL TERMINATE P20,22,AND 25 AND ANY OTHER PROGRAM IN PROCESS; AND ESTABLISH P00.

(3) V56E SELECTION WILL SELECT THE TERMINATE TRACKING ROUTINE (R56) WHICH WILL TERMINATE ONLY P20 OR P25 IF EITHER OF THESE PROGRAMS IS RUNNING IN CONJUNCTION WITH ANOTHER PROGRAM. IN ALL OTHER CASES R56 WILL SELECT R00. V56E MAY BE PERFORMED ANY TIME DURING P20,22, OR 25 OPERATION.

++ +05 + + +1180 ++ (4) THE LGC WILL ACT UPON V34E ONLY IN RESPONSE TO A FLASHING VERB-NOUN. IF THIS DISPLAY WAS ORIGINATED BY P20,22, OR 25, V34E WILL RESULT IN AN IDENTICAL LGC RESPONSE TO THAT OF V56E, THAT IS, SELECTION OF R56 EXCEPT IN THE CASE OF A V06 N49 DISPLAY. IF THIS DISPLAY WAS NOT ORIGINATED BY P20,22, OR 25 (SUCH AS P32, WHILE RUNNING WITH P20) THE LGC WILL GO TO R00, HOWEVER THE PROGRAM IN THE BACKGROUND WILL CONTINUE. THE NEW PROGRAM SELECTED FOLLOWS THE SELECTION RULES ABOVE, (A).

(5) ALTHOUGH IT IS NOT CLEARLY SHOWN IN THE LOGIC BELOW A V34E RESPONSE TO A PRIORITY DISPLAY MUST BE DELAYED 2 SECONDS FROM DISPLAY INITIATION WHEREAS THE DELAY IS NOT NECESSARY FOR A V56E RESPONSE.

PRDG CONT	LGC	GROUND	CREW


"A"
FROM
BELOW
IS THE RENDEZVOUS
FLAG SET?
Y
N
EXIT
R22
AND
P20/22
IS THE TRACK FLAG
SET?
Y
N

#10

#20

#30

#40


GO TO "E" IN P2D/22
IS THE RR AUTO TRACK ENABLE DISCRETE ISSUED?
.Y
.N
GO TO "B" IN P2D/P22
IS RR AUTO MODE DISCRETE PRESENT?
.Y
N.
GO TO "C"
HAS RR TRACK ENABLE DISCRETE BEEN REMOVED? (NOTE: THIS DISCRETE IS REMOVED BY A HARDWARE RESTART AND ALSO BY THE RR MONITOR (R25) IF THE RR GIMBAL ANGLES ARE OUTSIDE THE ALLOW-ABLE LIMITS)
.Y
N.
GO TO "B" IN P2D/P22
IS RR MODE SWITCH IN LGC?
.Y
.N
GO TO "C"

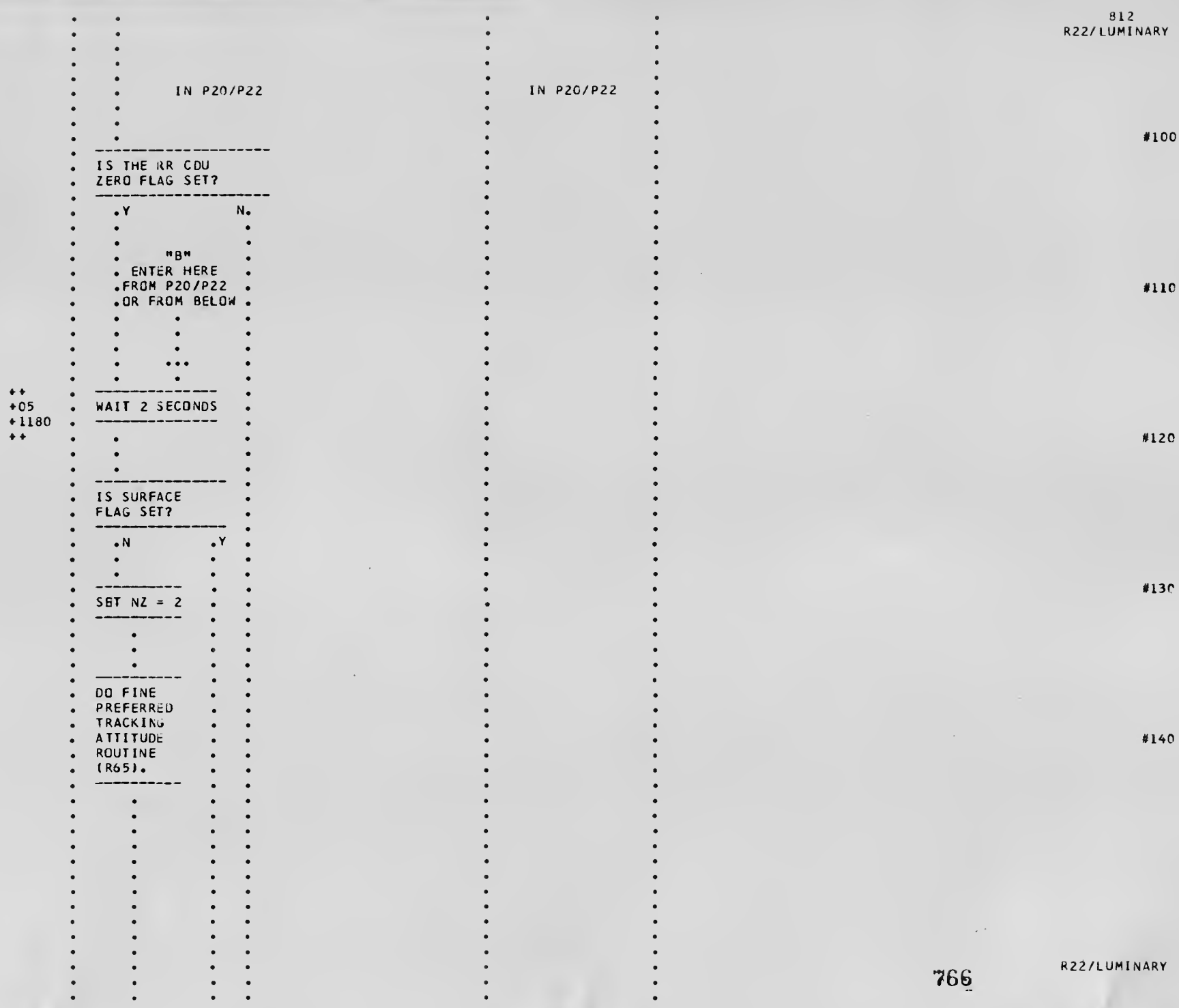
#50

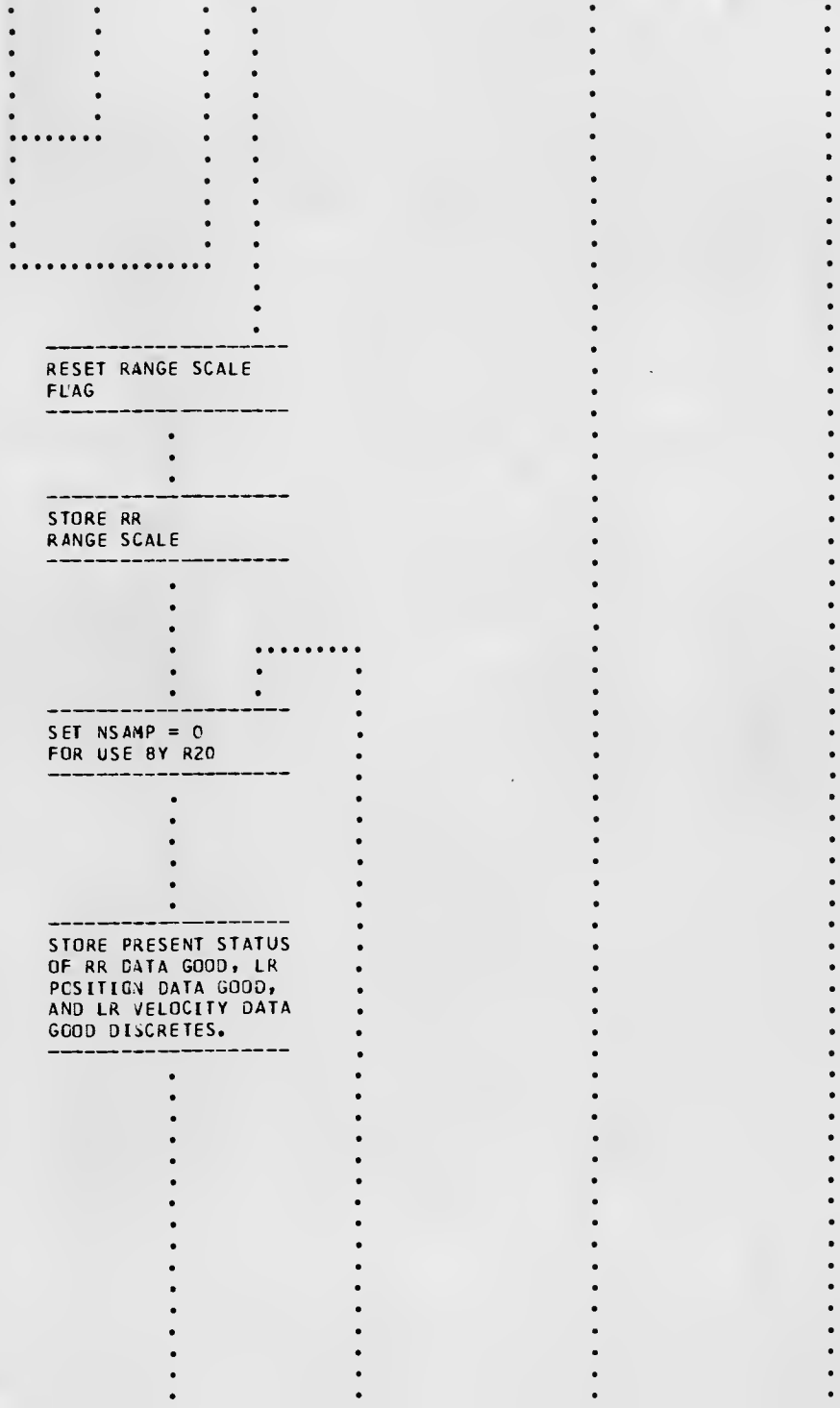
#60

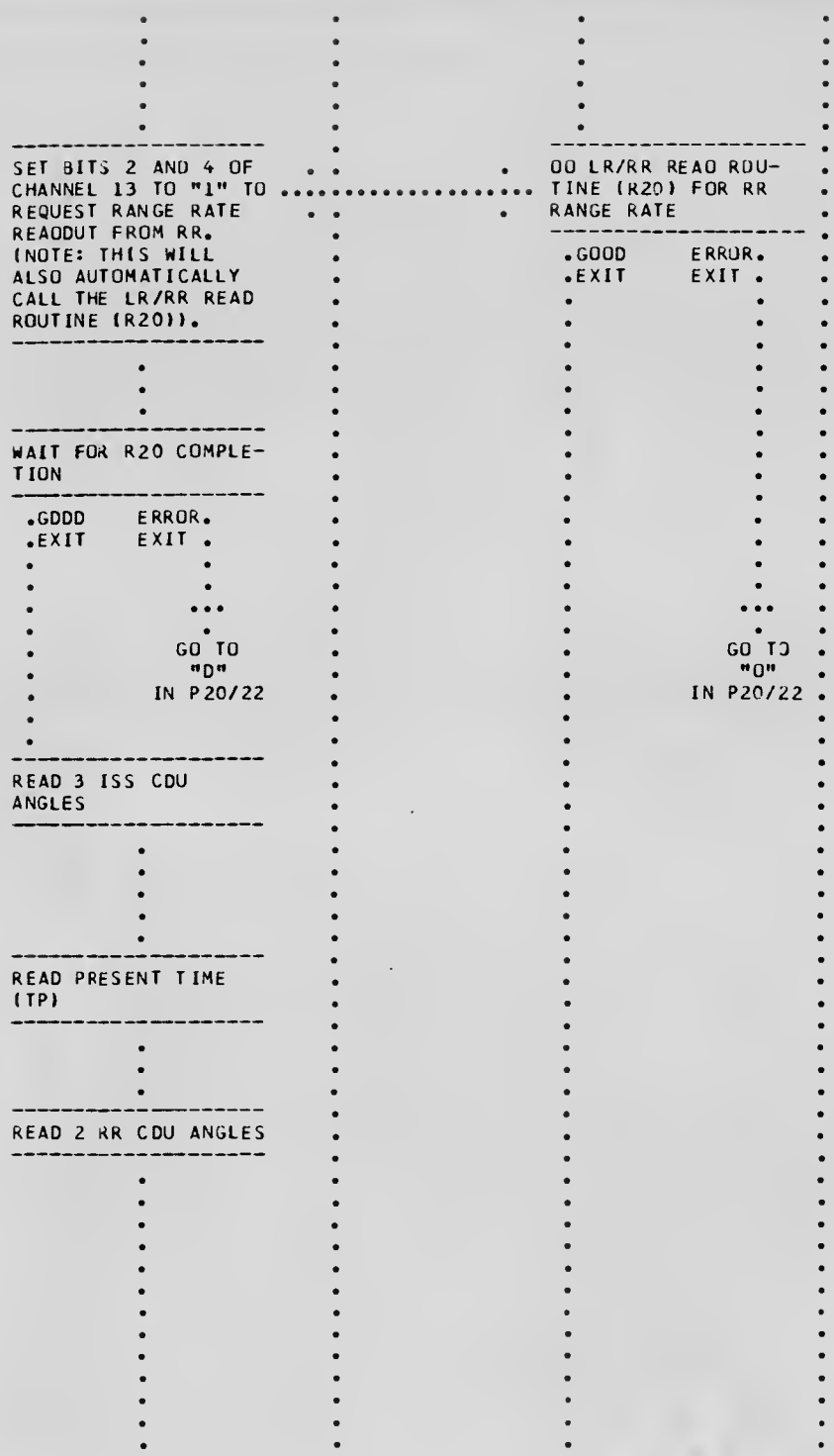
#70

#80

#90


IN P20/P22
IS THE RR CDU ZERO FLAG SET?
Y
N
"B" ENTER HERE FROM P20/P22 OR FROM BELOW
WAIT 2 SECONDS
IS SURFACE FLAG SET?
N
Y
SBT NZ = 2
DO FINE PREFERRED TRACKING ATTITUDE ROUTINE (R65).
IN P20/P22
#100
#110
#120
#130
#140


RESET RANGE SCALE FLAG
#150
STORE RR RANGE SCALE
#160
SET NSAMP = 0 FOR USE BY R20
#170
STORE PRESENT STATUS OF RR DATA GOOD, LR POSITION DATA GOOD, AND LR VELOCITY DATA GOOD DISCRETES.
#180
#190



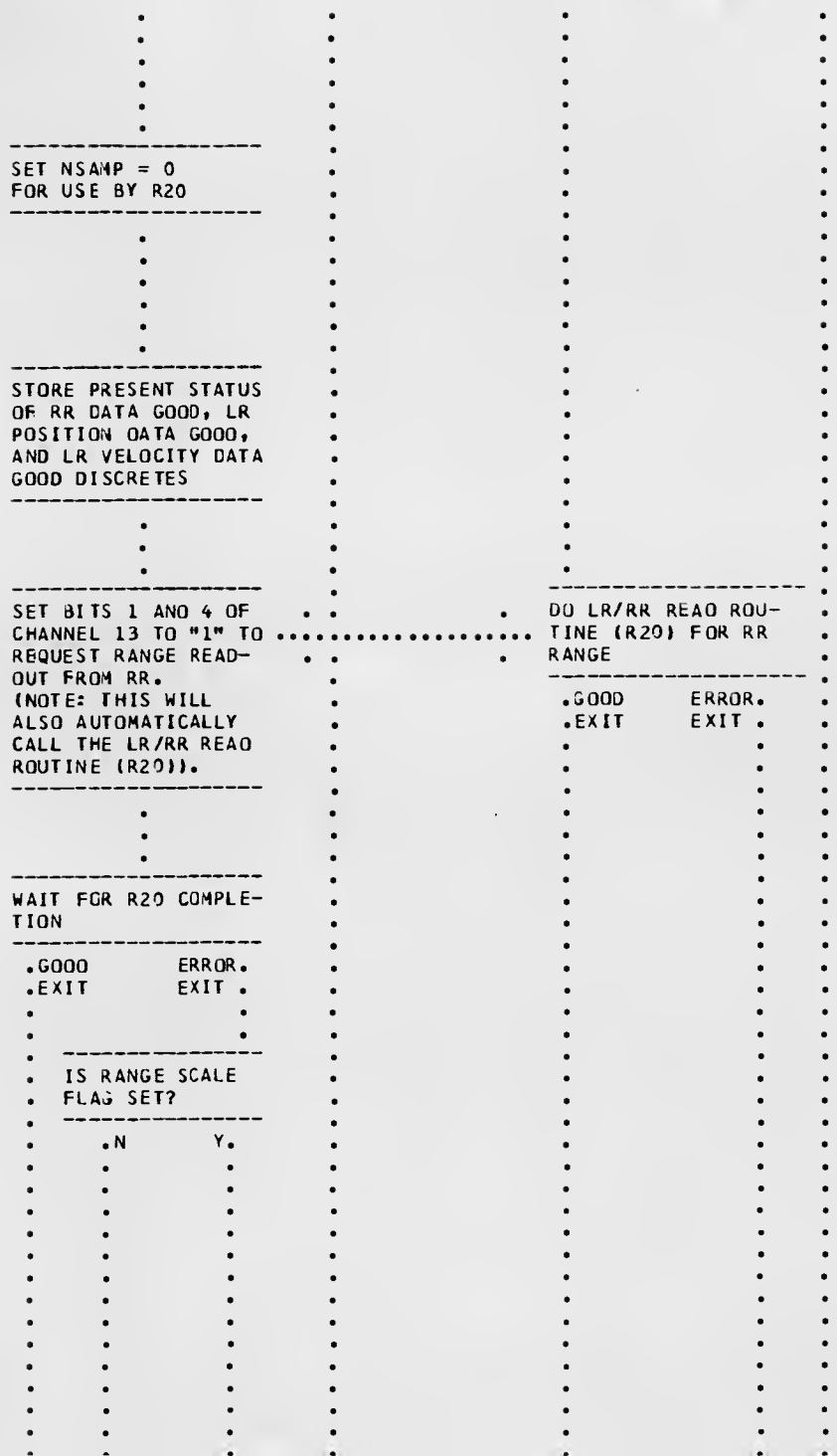
#200

#210

#220

#230

#240



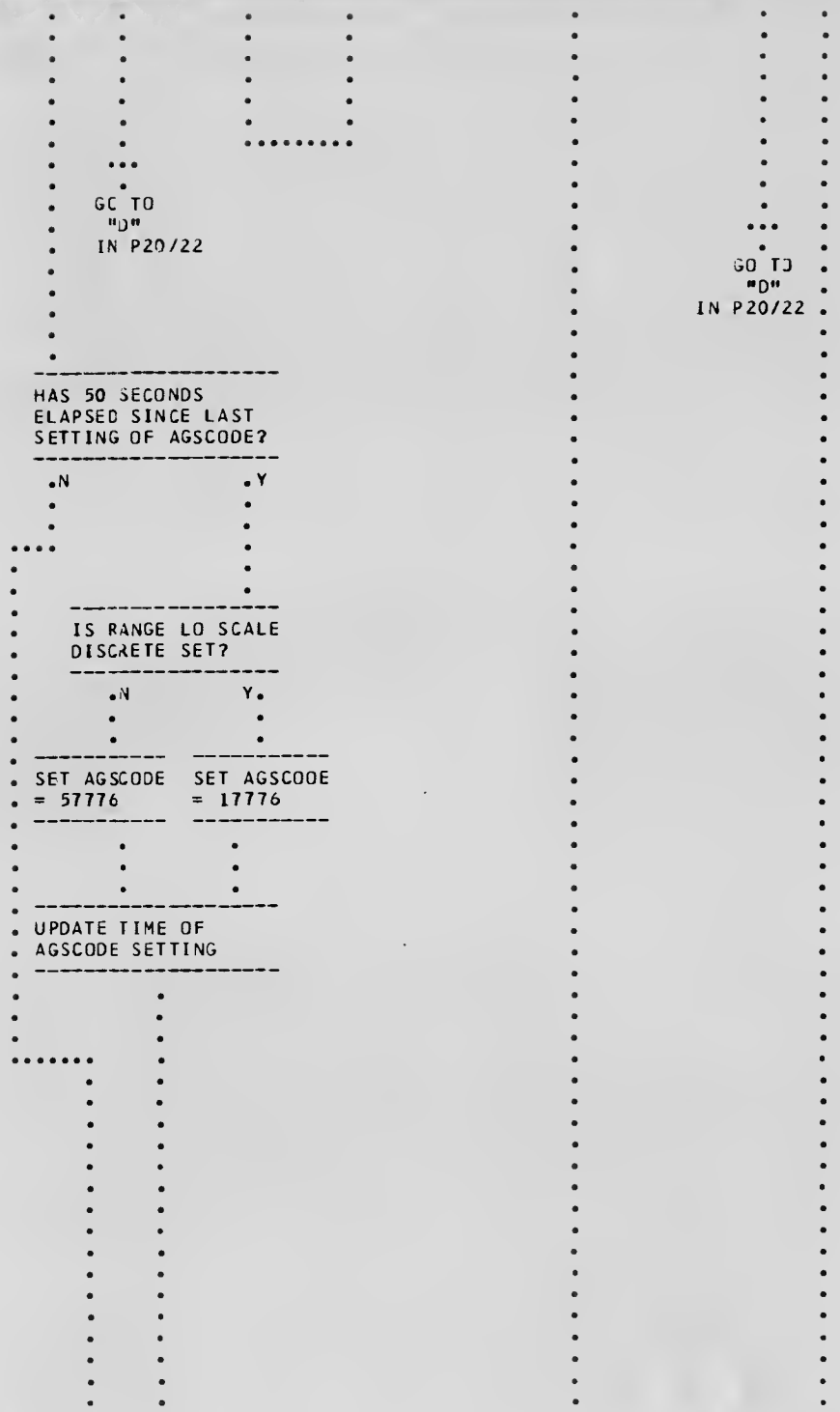
#250

#260

#270

#280

#290

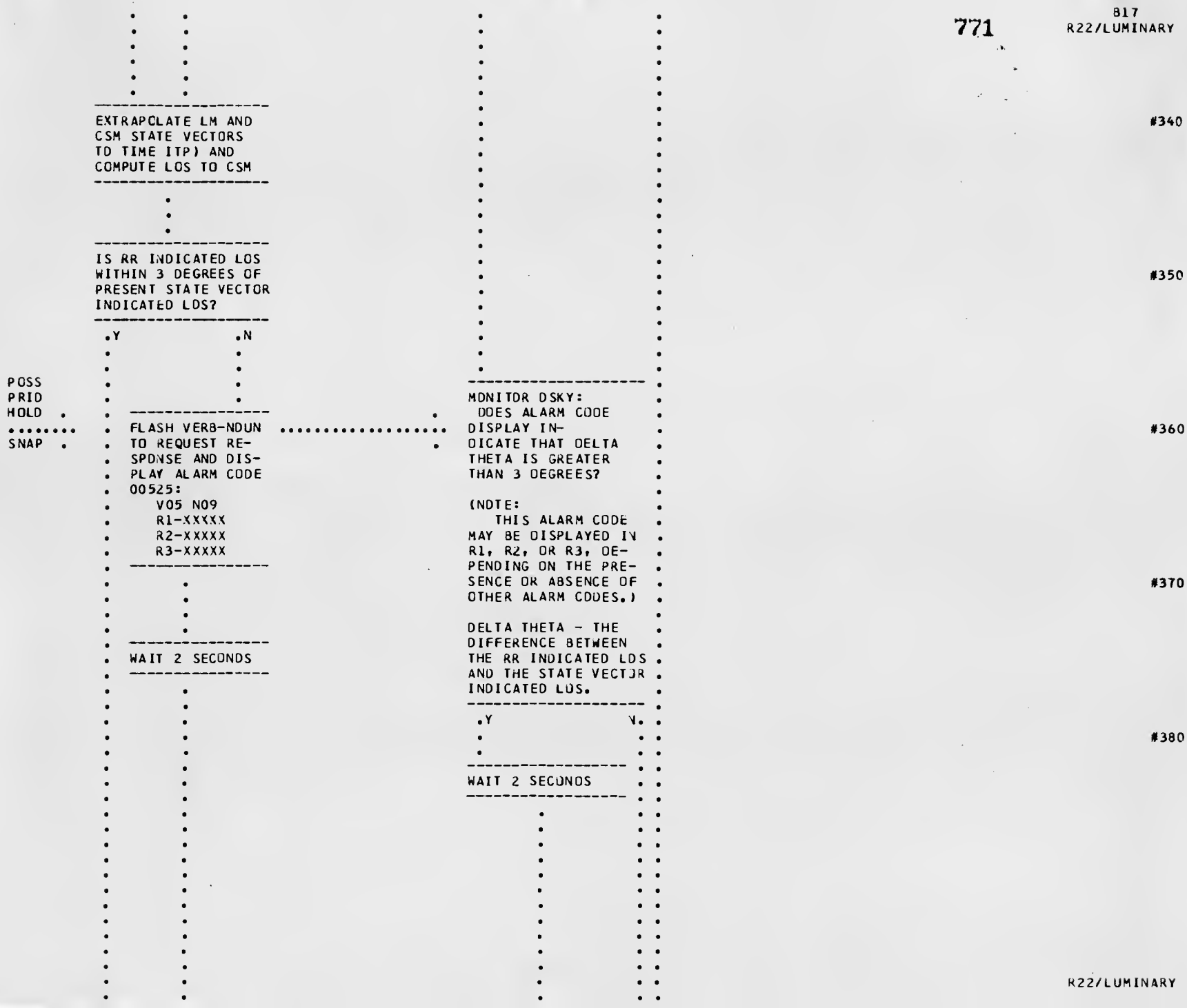


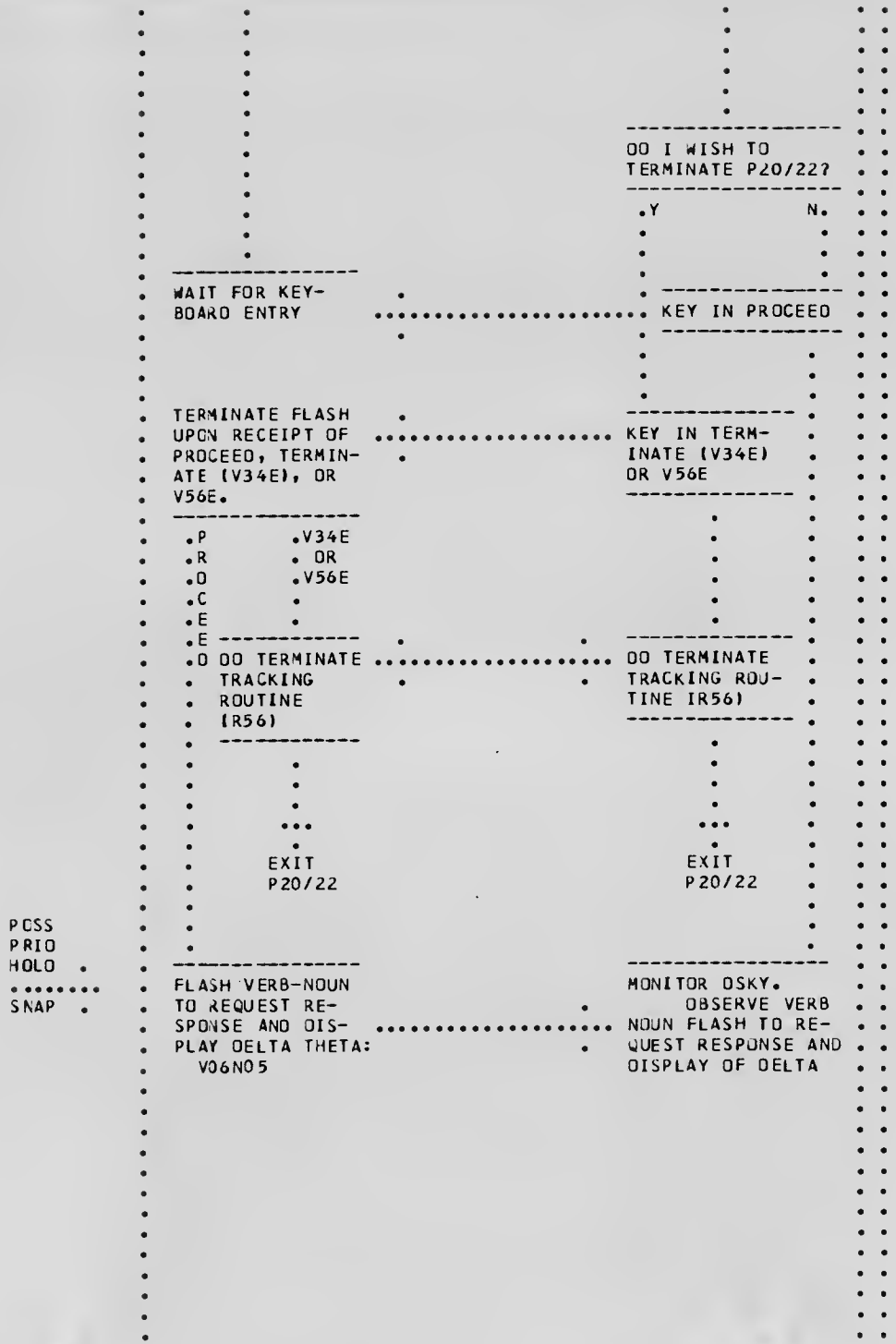
#300

#310

#320

#330


EXTRAPOLATE LM AND CSM STATE VECTORS TO TIME ITP) AND COMPUTE LOS TO CSM
#340
IS RR INDICATED LOS WITHIN 3 DEGREES OF PRESENT STATE VECTOR INDICATED LOS?
#350
Y
N
POSS PRID HOLD
SNAP
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY ALARM CODE
00525:
V05 N09
R1-XXXXX
R2-XXXXX
R3-XXXXX
#360
WAIT 2 SECONDS
MONITOR DSKY: DOES ALARM CODE DISPLAY INDICATE THAT DELTA THETA IS GREATER THAN 3 DEGREES?
(NOTE: THIS ALARM CODE MAY BE DISPLAYED IN R1, R2, OR R3, DEPENDING ON THE PRESENCE OR ABSENCE OF OTHER ALARM CODES.)
#370
DELTA THETA - THE DIFFERENCE BETWEEN THE RR INDICATED LOS AND THE STATE VECTOR INDICATED LOS.
Y
N
#380
WAIT 2 SECONDS



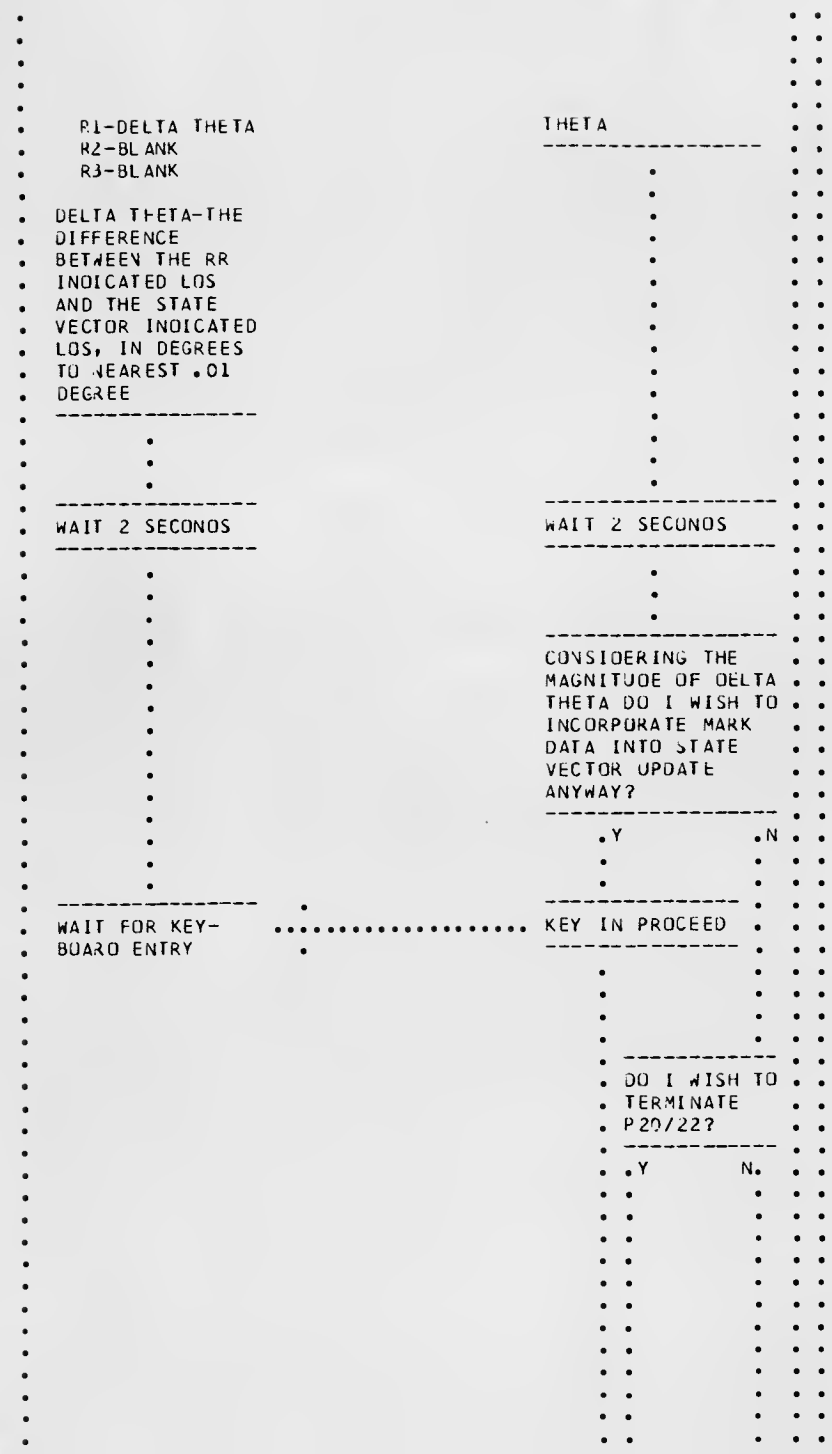
#390

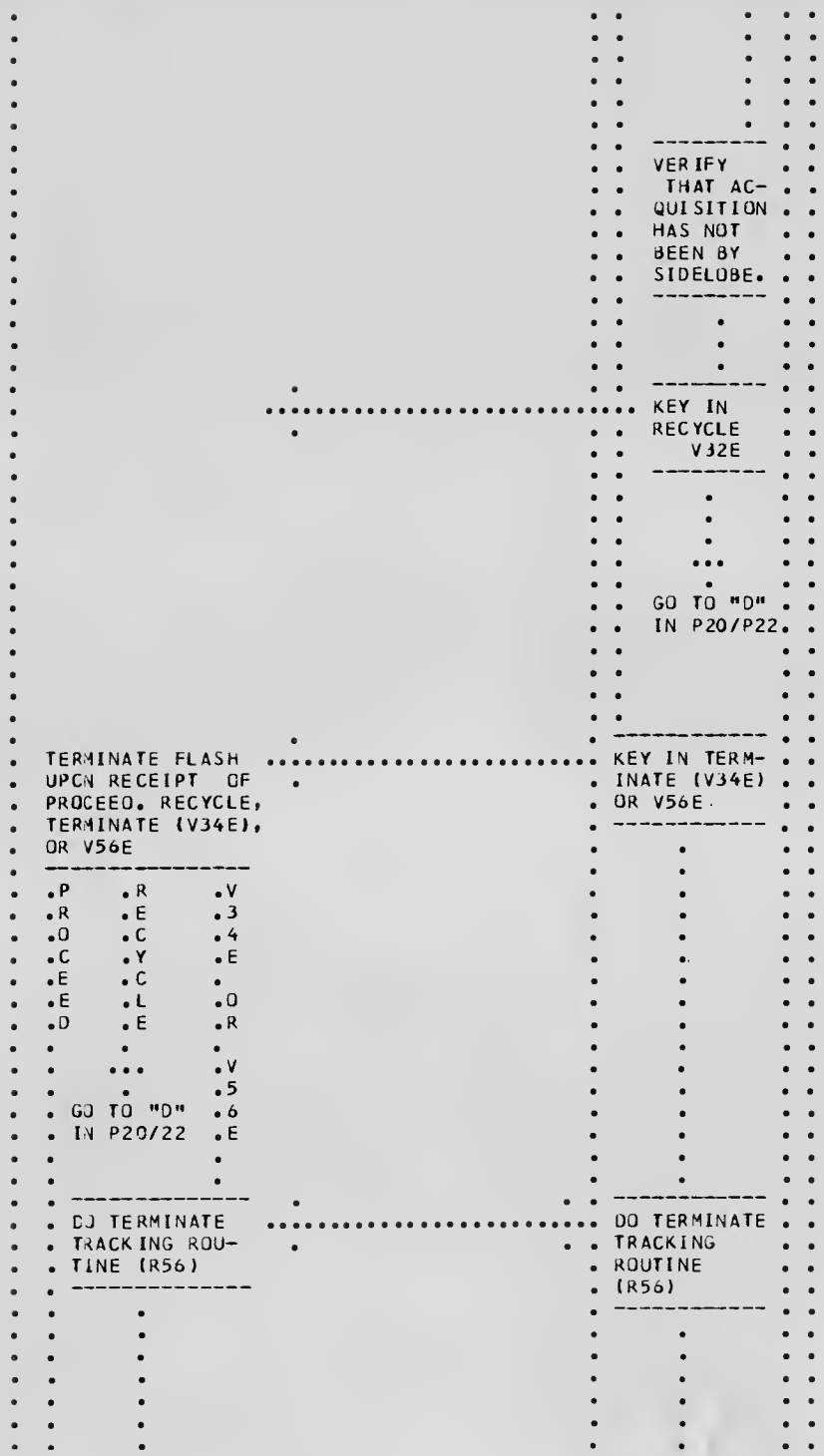
#400

#410

#420

#430


R1-DELTA THETA
R2-BLANK
R3-BLANK
DELTA THETA-THE DIFFERENCE BETWEEN THE RR INDICATED LOS AND THE STATE VECTOR INDICATED LOS, IN DEGREES TO NEAREST .01 DEGREE
WAIT 2 SECONDS
WAIT FOR KEY-BOARD ENTRY
THETA
WAIT 2 SECONDS
CONSIDERING THE MAGNITUDE OF DELTA THETA DO I WISH TO INCORPORATE MARK DATA INTO STATE VECTOR UPDATE ANYWAY?
Y
N
KEY IN PROCEED
DO I WISH TO TERMINATE P20/22?
Y
N
#440
#450
#460
#470
#480



#490

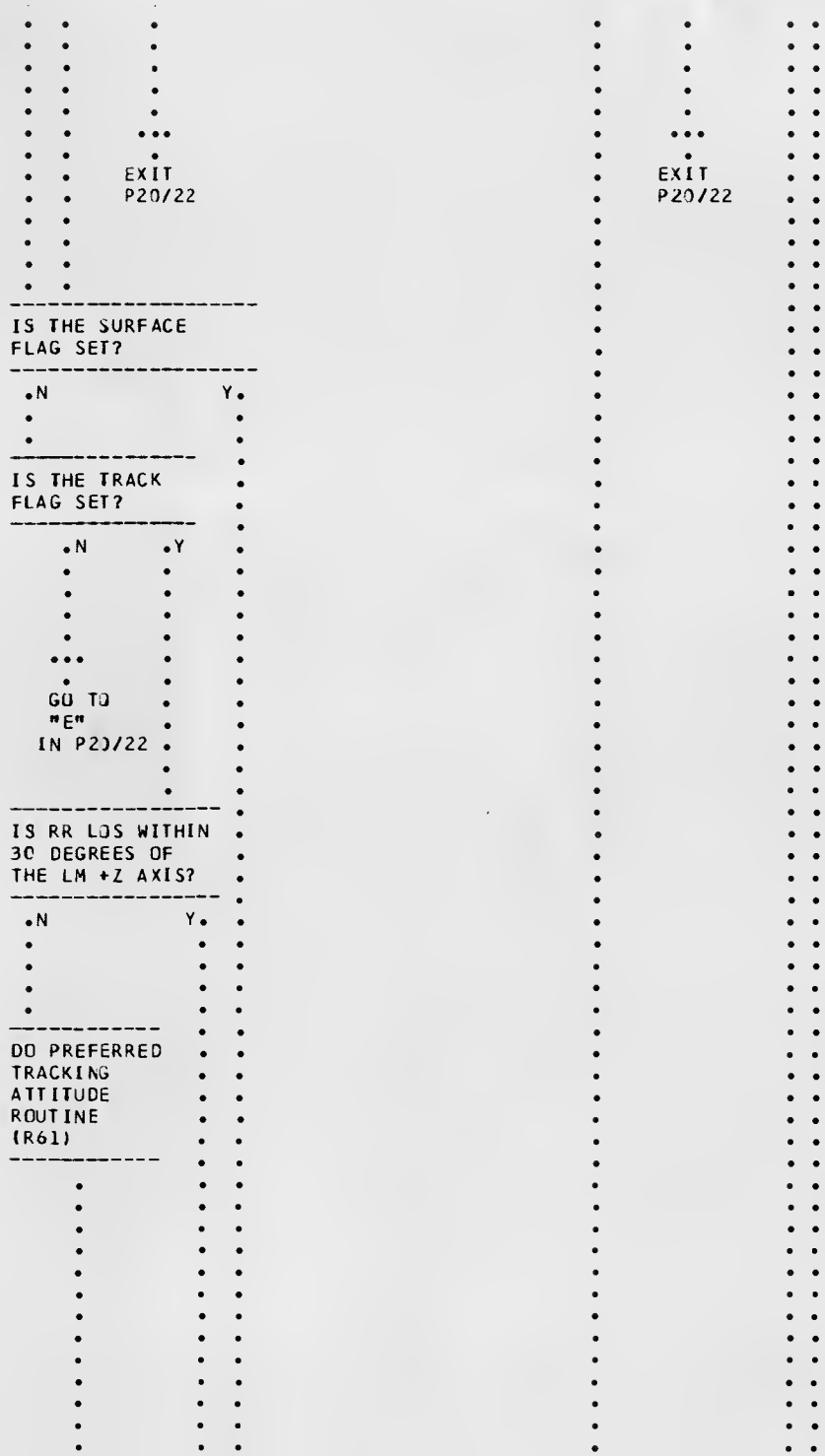
#500

#510

#520

#530

#540



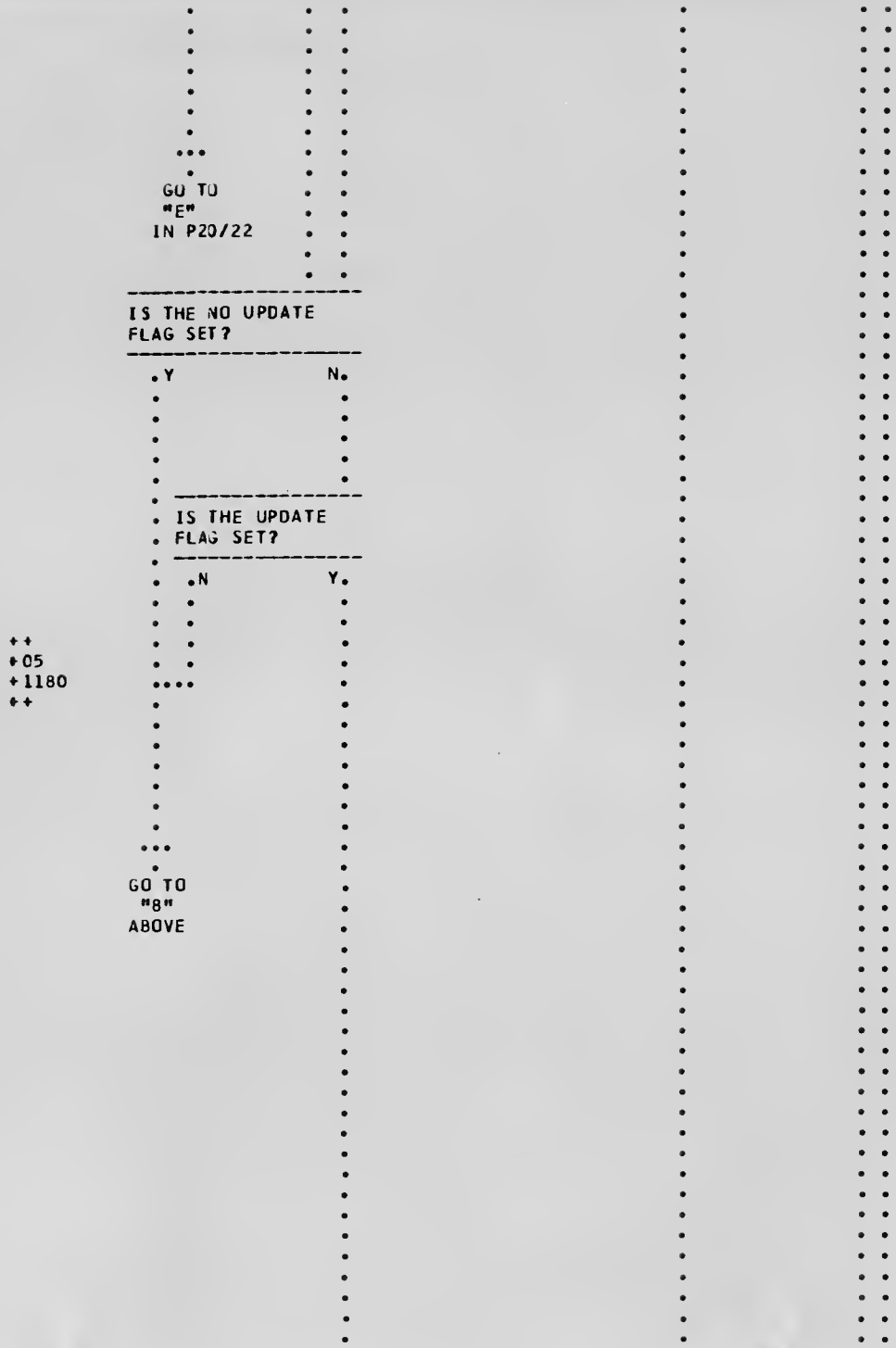
#550

#560

#570

#580

#590



#600

#610

#620

#630

#64D

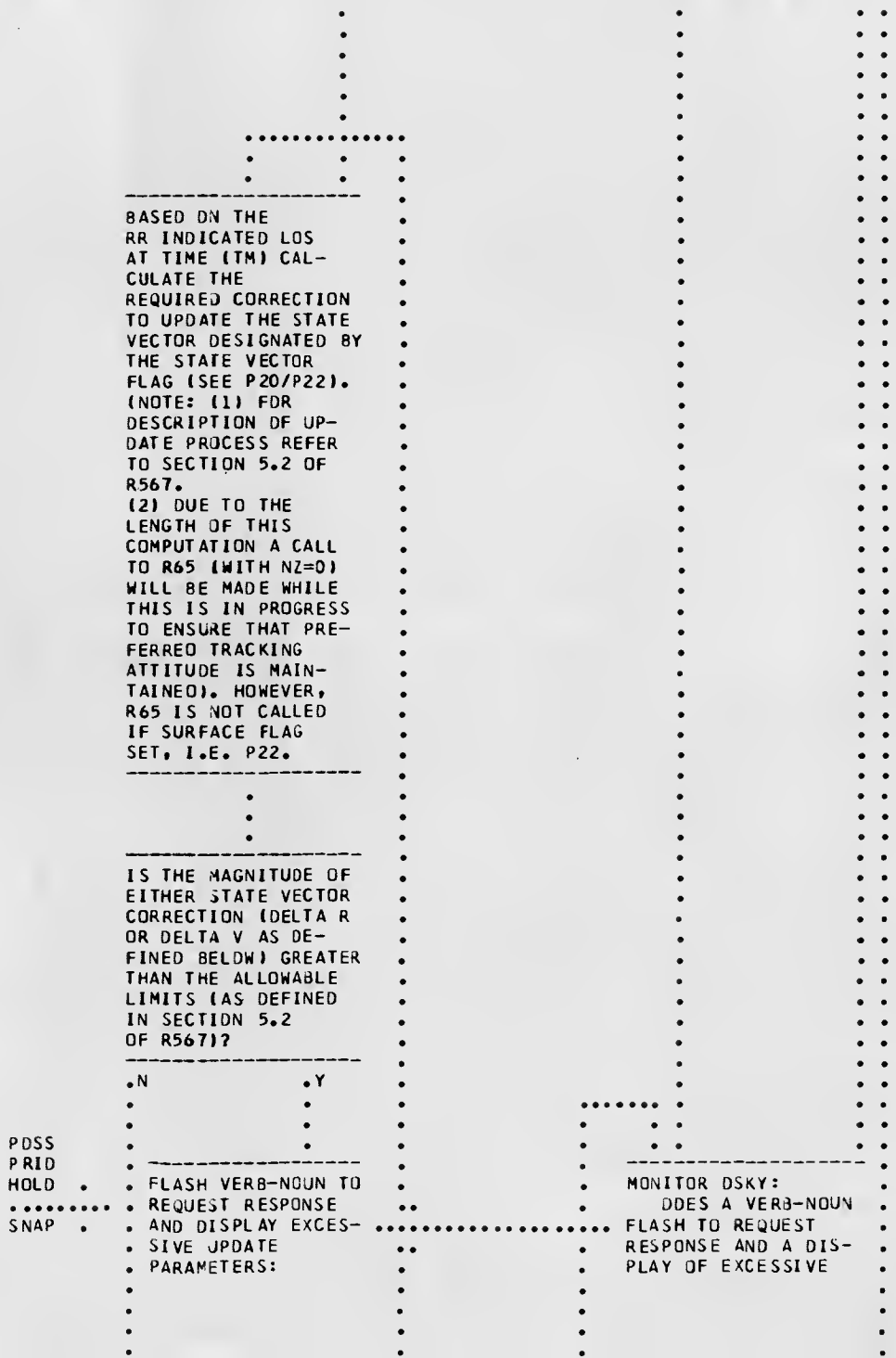
#650

#660

#670

#680

#690



V06N49
R1-DELTA R
R2-DELTA V
R3-SOURCE CODE

DELTA R-MAGNITUDE OF THE DIFFERENCE BETWEEN THE POSITION STATE VECTOR BEFORE AND AFTER INCORPORATION OF THIS MARK DATA. IN N.M. TO NEAREST .01 N.M.

DELTA V-MAGNITUDE OF THE DIFFERENCE BETWEEN THE VELOCITY STATE VECTOR BEFORE AND AFTER INCORPORATION OF THIS MARK DATA. IN FT/SEC TO NEAREST .1FT/SEC.

(NOTE: BOTH PARAMETERS ARE NOT NECESSARILY EXCESSIVE.)

SOURCE CODE - ERROR SOURCE THAT CAUSED THIS DISPLAY WHERE R3 = 0000X

- X=1 - RR RANGE
- X=2 - RR RANGE RATE
- X=3 - RR SHAFT ANGLE
- X=4 - RR TRUNNION ANGLE

UPDATE PARAMETERS INDICATE THAT THE MOST RECENTLY PROCESSED RR MARK DATA WILL RESULT IN AN EXCESSIVE UPDATE?

Y	N

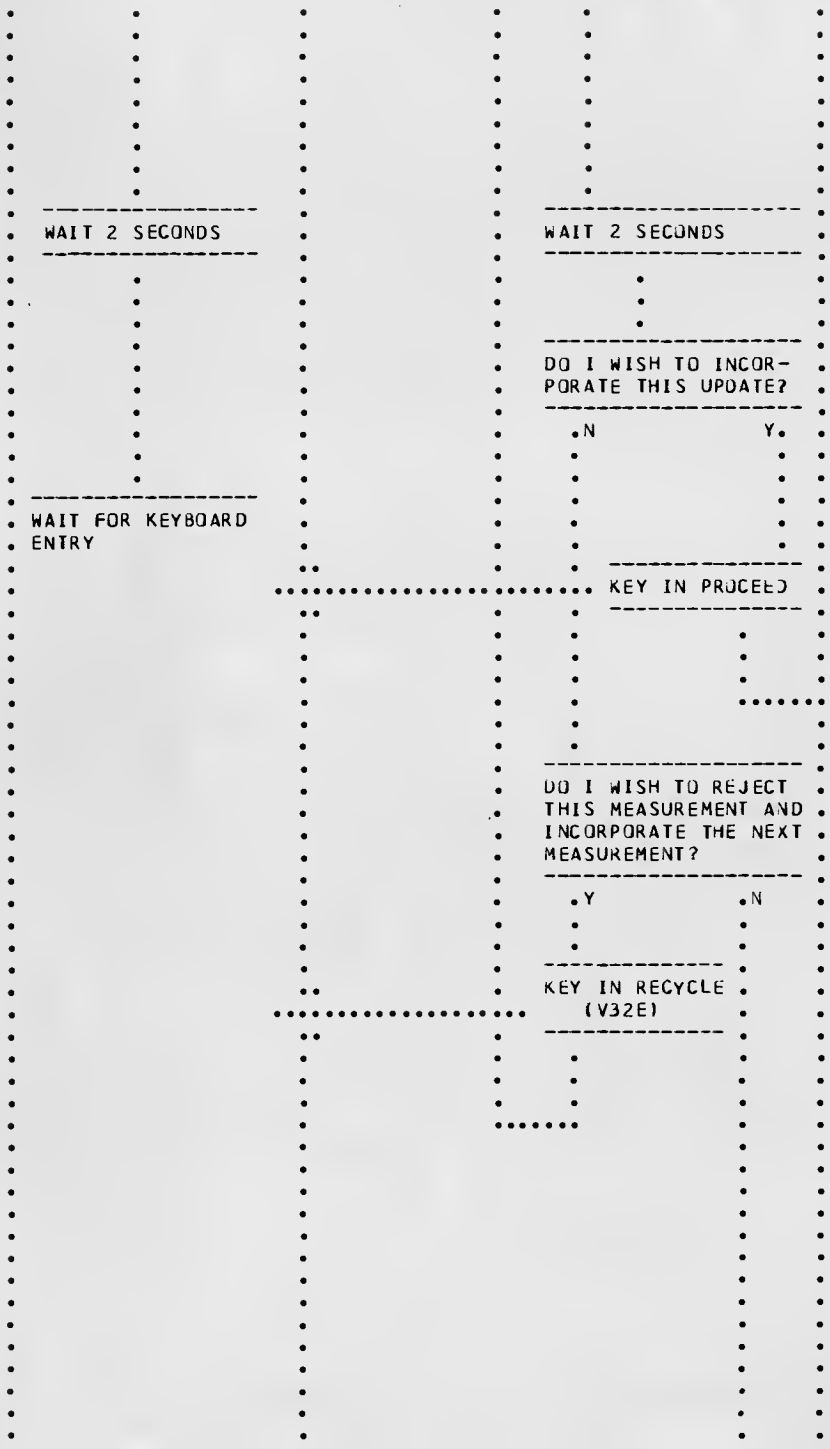
#700

#710

#720

#730

#740



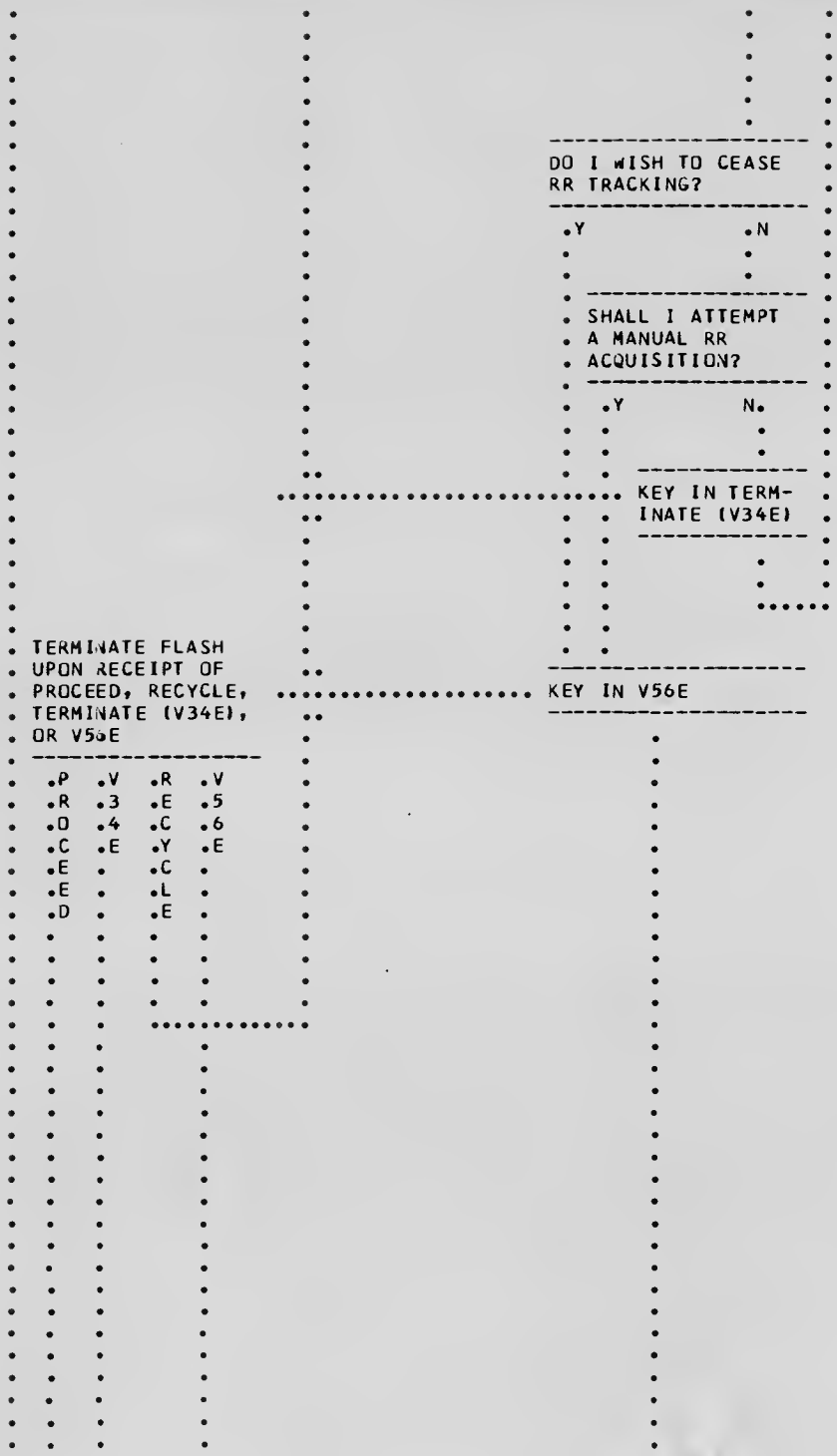
#750

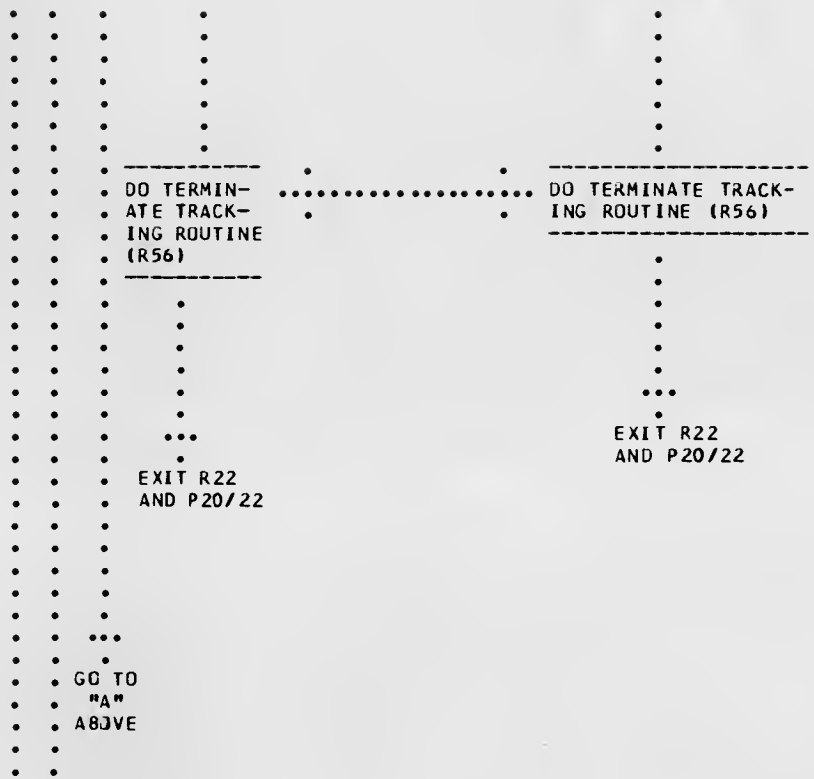
#760

#770

#780

#790


DO I WISH TO CEASE RR TRACKING?
.Y
.N
#800
SHALL I ATTEMPT A MANUAL RR ACQUISITION?
.Y
N.
KEY IN TERMINATE (V34E)
#810
KEY IN V56E
#820
TERMINATE FLASH UPON RECEIPT OF PROCEED, RECYCLE, TERMINATE (V34E), OR V56E
.P .V .R .V
.R .3 .E .5
.D .4 .C .6
.C .E .Y .E
.E . .C .
.E . .L .
.D . .E .
#830



#840

#850

#860

#870

#880

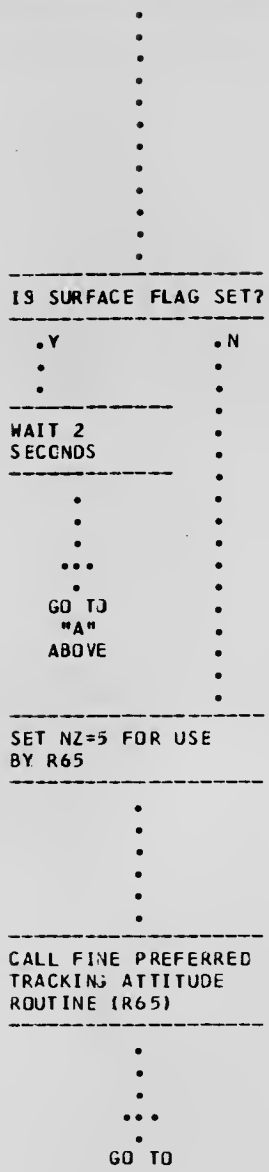
#890

#900

#910

#920

#930



"A"
ABOVE

#940

CHANGE CONTROL NOTES

REV C1	PCR 39,226,400,451,562
REV C0(LUM 1A)	PCR 736
REV C1(LUM 1B)	PCR 818,EDITORIAL
REV 02 EDITORIAL	
REV 03	PCN 1009
REV 04(LUM 1E)	PCR 317.2,324,347, PCN 1145
REV 05	PCN 1180

RR MANUAL ACQUISITION ROUTINE (R23) REV 03 12/01/71

PURPOSE: (1) TO ACQUIRE THE CSM BY MANUAL OPERATION OF THE RENDEZVOUS RADAR(RR) WHILE THE LM IS IN FLIGHT.

ASSUMPTIONS: (1) THE ROUTINE IS AUTOMATICALLY CALLED BY THE RENDEZVOUS NAVIGATION PROGRAM (P20) IN RESPONSE TO AN ASTRONAUT REQUEST FOR A MANUAL ACQUISITION.

(2) THE RR MANUAL ACQUISITION ROUTINE (R23) MAY ONLY BE SELECTED IF P20 IS NOT RUNNING IN CONJUNCTION WITH ANOTHER PROGRAM.

(3) THE SELECTION AND TERMINATION OF P20,P22, AND P25 ARE SUBJECT TO SPECIAL OPERATING PROCEDURES DIFFERENT FROM ALL OTHER PROGRAMS;

(A) SELECTION

(1) ALWAYS BY V37EXXE.

(2) IF ANY OTHER PROGRAM IS RUNNING AT THE TIME OF P20/22/25 SELECTION THE NEW PROGRAM WILL REPLACE THE OLD. THIS INCLUDES P20/22/25 SELECTION WHENEVER EITHER P20,22, OR 25 IS RUNNING.

(3) IF P20 OR P25 IS RUNNING, SELECTION OF ANY PROGRAM OTHER THAN P00, P22, OR P25 WILL RESULT IN P20 OR P25 CONTINUING AND THE NEW PROGRAM ALSO OPERATING WITH ITS NUMBER IN THE OSKY PROG LIGHTS.

(4) IF P20 OR P25 IS RUNNING, SELECTION OF P00, P22, OR P25 WILL RESULT IN THE TERMINATION OF THE OLD PROGRAM AND OPERATION OF THE NEW.

(B) TERMINATION

(1) BY SELECTION OF P00, V56E OR BY V34E.

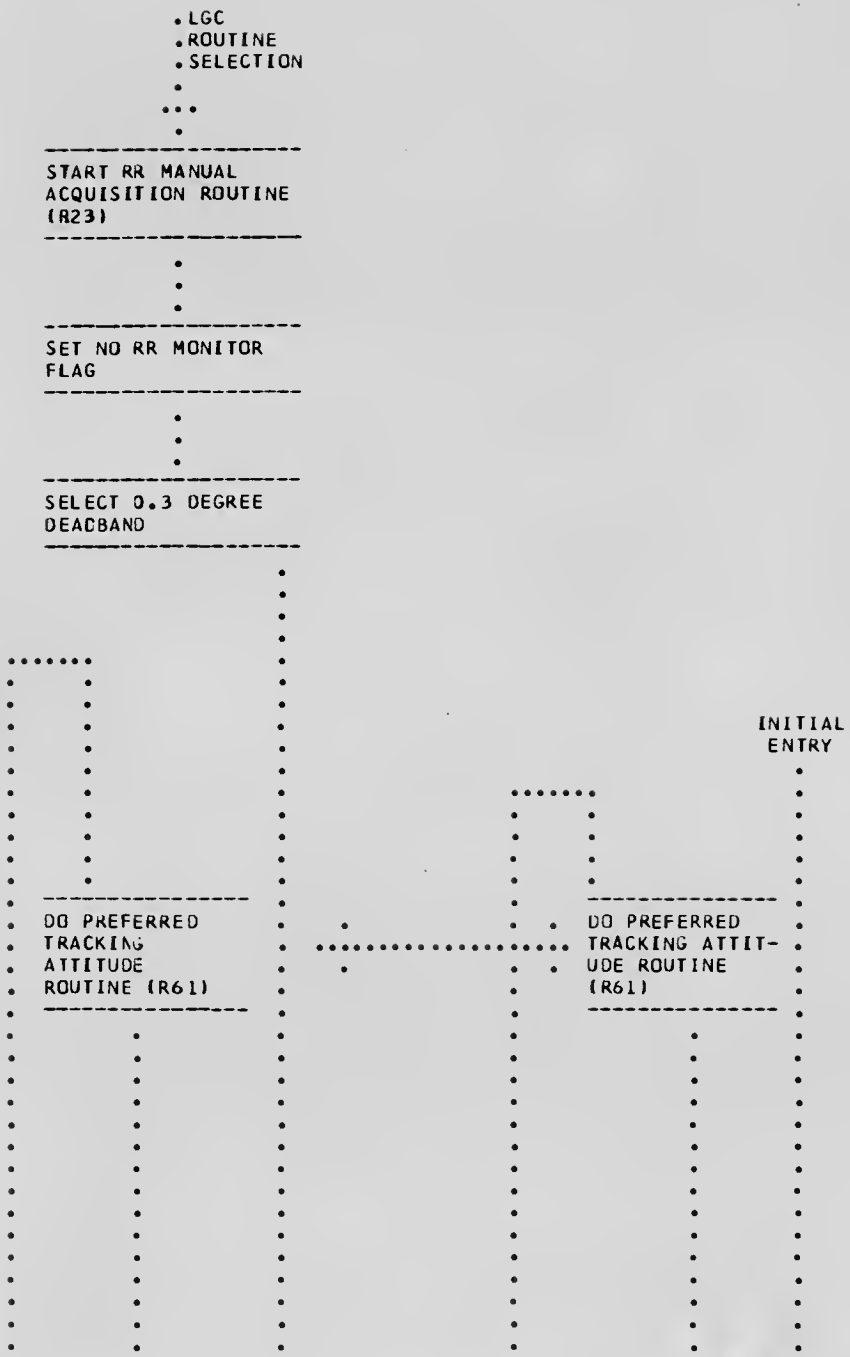
(2) P00 SELECTION WILL TERMINATE P20,22, AND 25 AND ANY OTHER PROGRAM IN PROCESS; AND ESTABLISH P00.

(3) V56E SELECTION WILL SELECT THE TERMINATE TRACKING ROUTINE (R56) WHICH WILL TERMINATE ONLY P20 OR P25 IF EITHER OF THESE PROGRAMS IS RUNNING IN CONJUNCTION WITH ANOTHER PROGRAM. IN ALL OTHER CASES R56 WILL SELECT R00. V56E MAY BE PERFORMED ANY TIME DURING P20,22 OR 25 OPERATION.

(4) THE LGC WILL ACT UPON V34E ONLY IN RESPONSE TO A FLASHING VERB-NOUN. IF THIS DISPLAY WAS ORIGINATED BY P20,22, OR 25, V34E WILL RESULT IN AN IDENTICAL LGC RESPONSE TO THAT OF V56E, THAT IS, SELECTION OF R56 EXCEPT IN THE CASE OF A V06 N49 DISPLAY. IF THIS DISPLAY WAS NOT ORIGINATED BY P20,22, OR 25 (SUCH AS P32, WHILE RUNNING WITH P20) THE LGC WILL GO TO R00, HOWEVER THE PROGRAM IN THE BACKGROUND WILL CONTINUE. THE NEW PROGRAM SELECTED FOLLOWS THE SELECTION RULES ABOVE, (A).

(5) ALTHOUGH IT IS NOT CLEARLY SHOWN IN THE LOGIC BELOW A V34E RESPONSE TO A PRIORITY DISPLAY MUST BE DELAYED 2 SECONDS FROM DISPLAY INITIATION WHEREAS THE DELAY IS NOT NECESSARY FOR A V56E RESPONSE.

PROG CONT	LGC	GROUND	CREW


LGC
ROUTINE
SELECTION
START RR MANUAL ACQUISITION ROUTINE (R23)
SET NO RR MONITOR FLAG
SELECT 0.3 DEGREE DEADBAND
INITIAL ENTRY
DO PREFERRED TRACKING ATTITUDE ROUTINE (R61)
DO PREFERRED TRACKING ATTIT-UDE ROUTINE (R61)

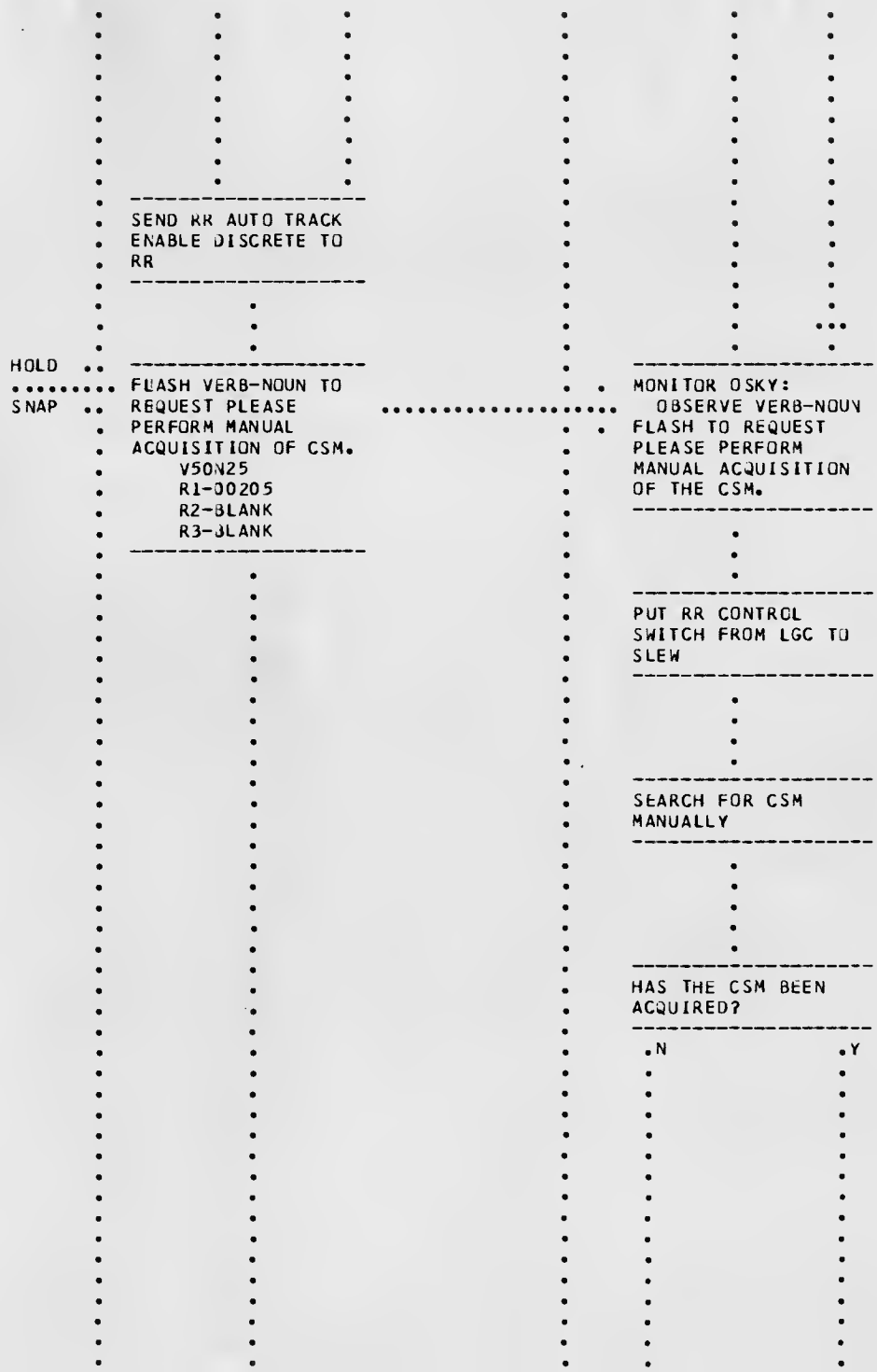
#10

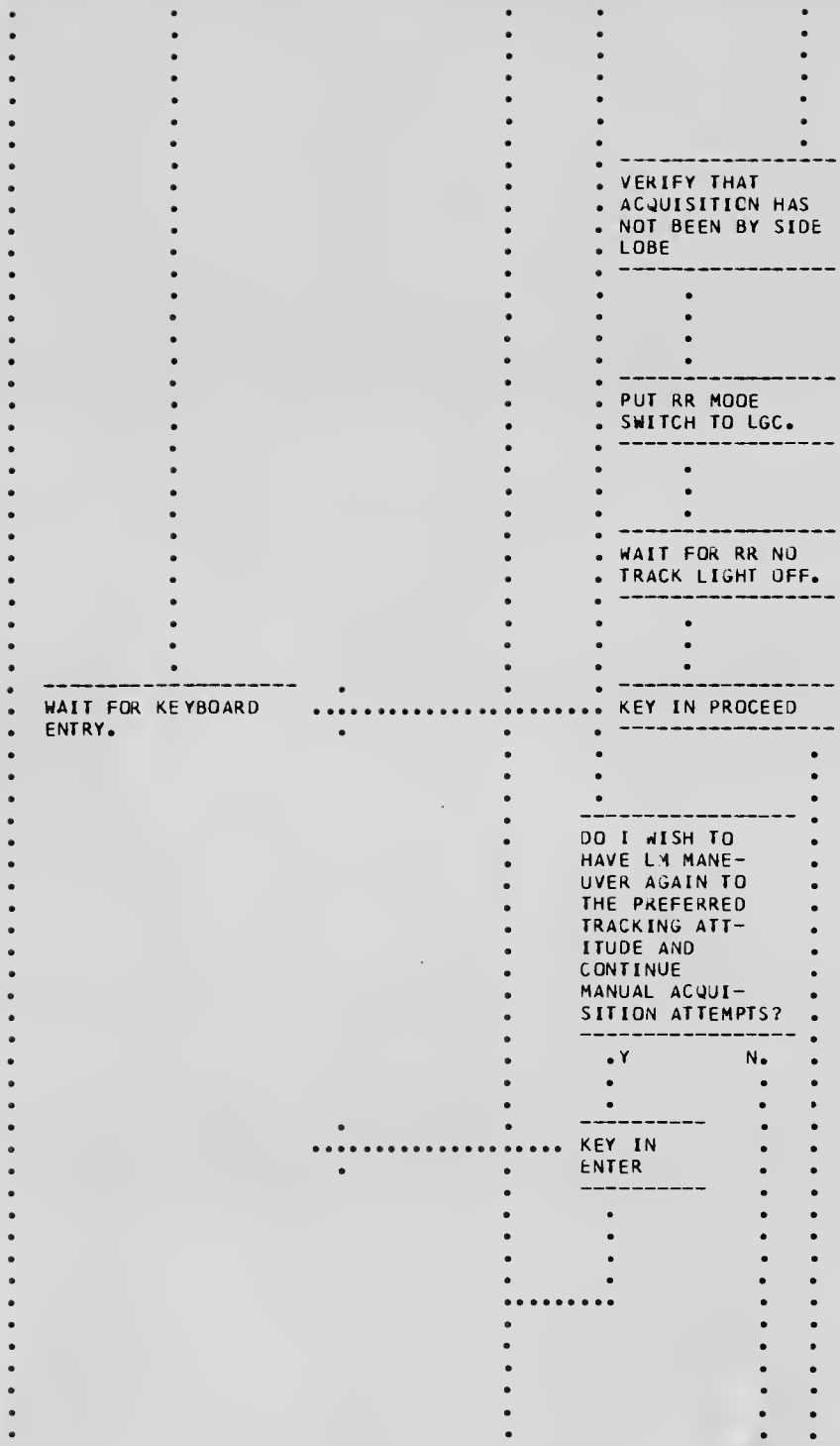
#20

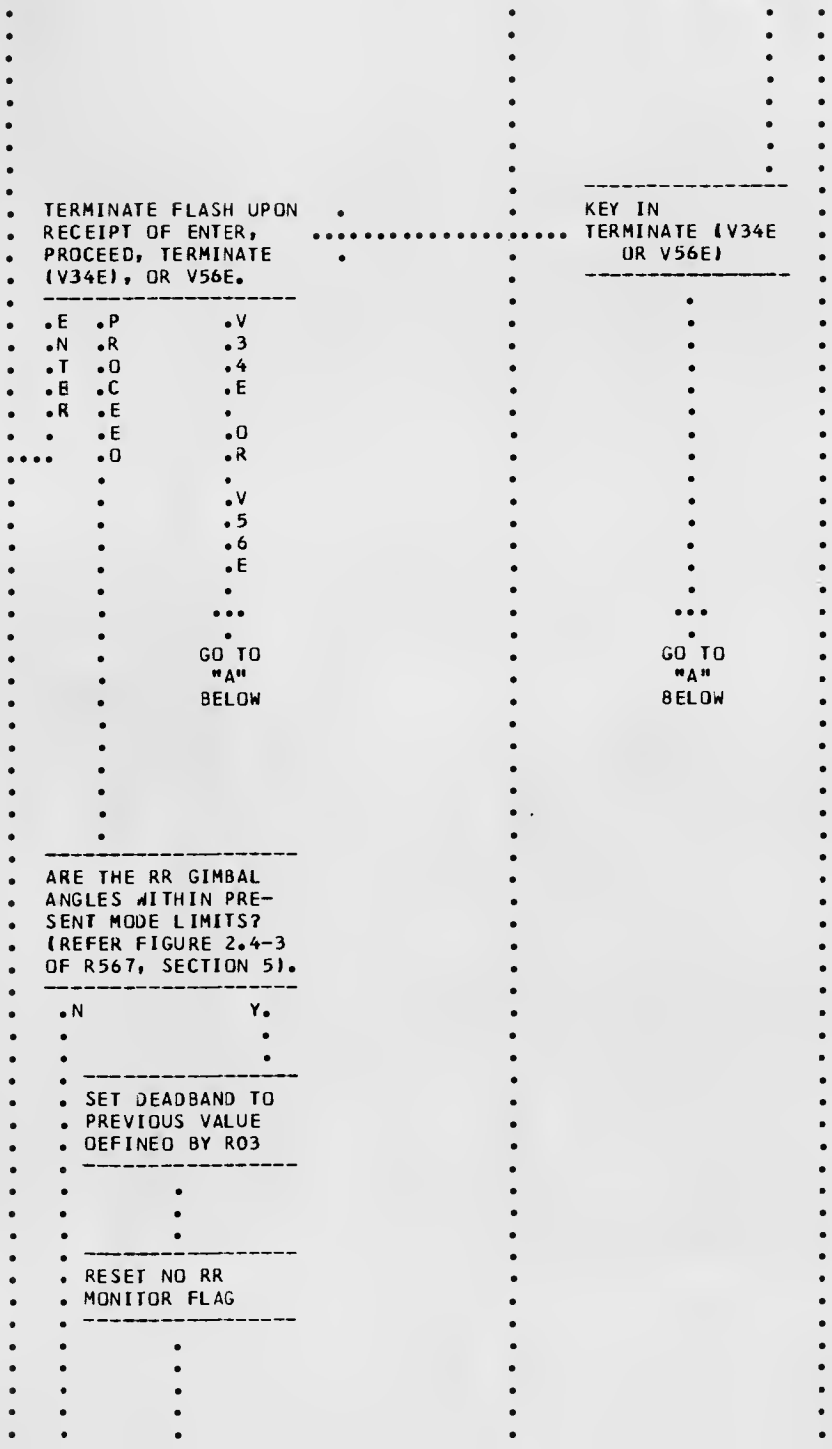
#30

#40

#50


SEND RR AUTO TRACK ENABLE DISCRETE TO RR
HOLD
SNAP
FLASH VERB-NOUN TO REQUEST PLEASE PERFORM MANUAL ACQUISITION OF CSM.
V50N25
R1-00205
R2-BLANK
R3-BLANK
MONITOR OSKY:
OBSERVE VERB-NOUN FLASH TO REQUEST PLEASE PERFORM MANUAL ACQUISITION OF THE CSM.
PUT RR CONTROL SWITCH FROM LGC TO SLEW
SEARCH FOR CSM MANUALLY
HAS THE CSM BEEN ACQUIRED?
N
Y
#60
#70
#80
#90


#100
VERIFY THAT ACQUISITION HAS NOT BEEN BY SIDE LOBE
#110
PUT RR MODE SWITCH TO LGC.
#120
WAIT FOR RR NO TRACK LIGHT OFF.
WAIT FOR KEYBOARD ENTRY.
KEY IN PROCEED
#130
DO I WISH TO HAVE LM MANEUVER AGAIN TO THE PREFERRED TRACKING ATTITUDE AND CONTINUE MANUAL ACQUISITION ATTEMPTS?
#140
Y
N.
KEY IN ENTER
#150



#160

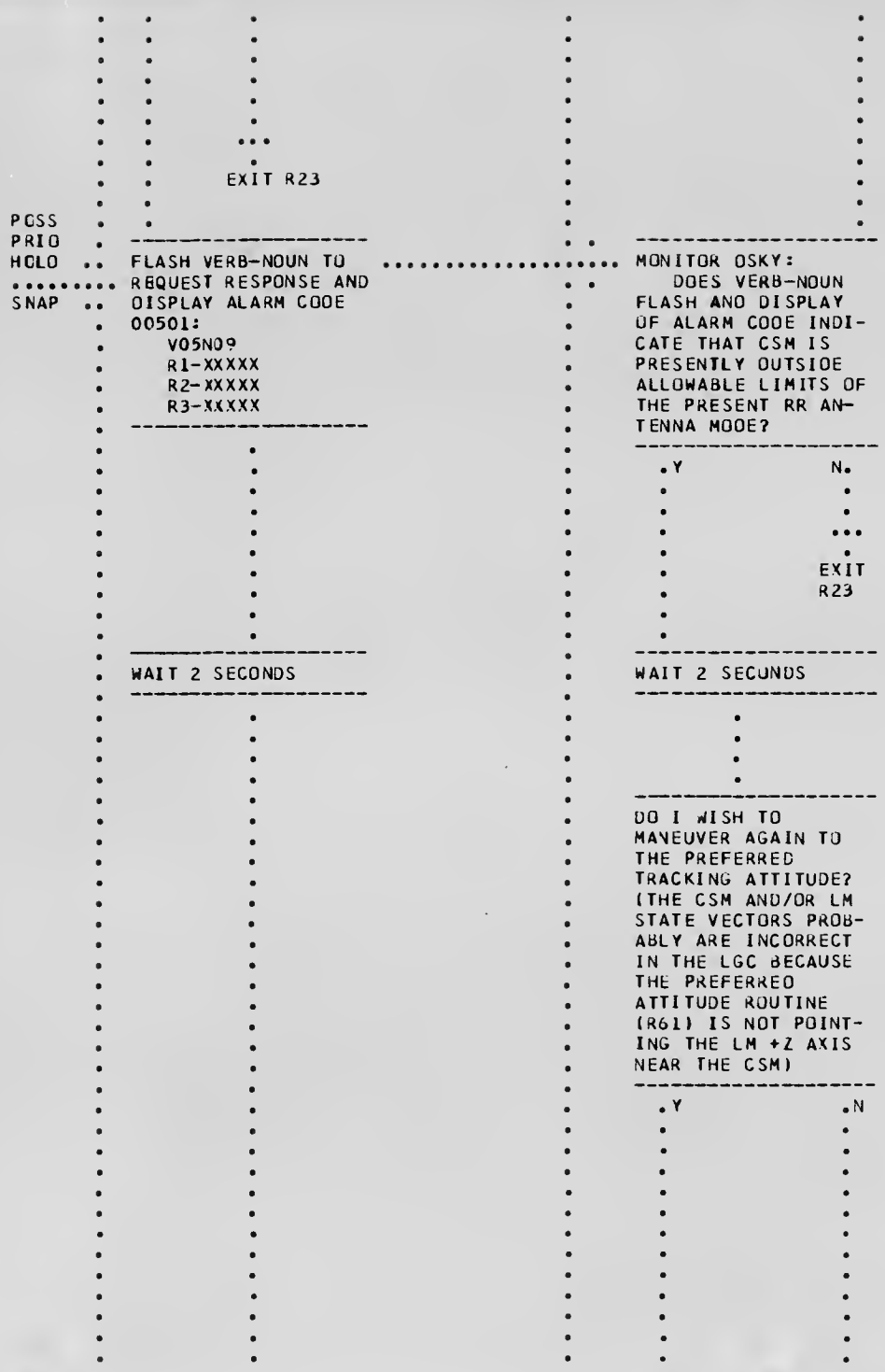
#170

#180

#190

#200

#210


EXIT R23
POSS PRIO HOLD SNAP
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY ALARM CODE 00501:
V05N09
R1-XXXXX
R2-XXXXX
R3-XXXXX
WAIT 2 SECONDS
MONITOR OSKY:
DOES VERB-NOUN FLASH AND DISPLAY OF ALARM CODE INDICATE THAT CSM IS PRESENTLY OUTSIDE ALLOWABLE LIMITS OF THE PRESENT RR ANTENNA MODE?
Y
N
EXIT R23
WAIT 2 SECONDS
DO I WISH TO MANEUVER AGAIN TO THE PREFERRED TRACKING ATTITUDE? (THE CSM AND/OR LM STATE VECTORS PROBABLY ARE INCORRECT IN THE LGC BECAUSE THE PREFERRED ATTITUDE ROUTINE (R61) IS NOT POINTING THE LM +Z AXIS NEAR THE CSM)
Y
N
#220
#230
#240
#250
#260

#270

#280

#290

#300

#310

CHANGE CONTROL NOTES

LOGIC REV 01 PCR 86,226,409,451,562
REV 02 EDITORIAL
REV 03 PCN 1180

RR SEARCH ROUTINE (R24) REV 03 12/01/71

PURPOSE: (1) TO ACQUIRE THE CSM BY A SEARCH PATTERN WHEN THE RENDEZVOUS RADAR HAS FAILED TO ACQUIRE THE CSM IN THE AUTOMATIC TRACKING MODE.

(2) TO ALLOW THE ASTRONAUT TO CONFIRM THAT REACQUISITION HAS NOT BEEN BY SIDELOBE.

ASSUMPTIONS: (1) THE ROUTINE IS AUTOMATICALLY CALLED BY THE RR DESIGNATE ROUTINE (R21) IN RESPONSE TO AN ASTRONAUT REQUEST FOR A SEARCH ACQUISITION.

(2) THE SELECTION AND TERMINATION OF P20, P22, AND P25, ARE SUBJECT TO SPECIAL OPERATING PROCEDURES DIFFERENT FROM ALL OTHER PROGRAMS;

(A) SELECTION

(1) ALWAYS BY V37EXXE.

++ (2) IF ANY OTHER PROGRAM IS RUNNING AT THE TIME OF P20/22/25 SELECTION THE NEW PROGRAM WILL REPLACE THE
+03 OLD. THIS INCLUDES P20/22/25 SELECTION WHENEVER EITHER P20, 22, OR 25 IS RUNNING.
+ (3) IF P20 OR P25 IS RUNNING, SELECTION OF ANY PROGRAM OTHER THAN P00, P22, OR P25 WILL RESULT IN P20 OR
+ P25 CONTINUING AND THE NEW PROGRAM ALSO OPERATING WITH ITS NUMBER IN THE OPR PROG LIGHTS.
+1180 (4) IF P20 OR P25 IS RUNNING, SELECTION OF P00, P22, OR P25 WILL RESULT IN THE TERMINATION OF THE OLD
++ PROGRAM AND OPERATION OF THE NEW.

(B) TERMINATION

(1) BY SELECTION OF P00, P22, V56E OR BY V34E.

(2) P00 SELECTION WILL TERMINATE P20, 22, AND 25 AND ANY OTHER PROGRAM IN PROCESS, AND ESTABLISH P00.

(3) V56E SELECTION WILL SELECT THE TERMINATE TRACKING ROUTINE (R56) WHICH WILL TERMINATE ONLY P20 OR P25 IF EITHER OF THESE PROGRAMS ARE RUNNING IN CONJUNCTION WITH ANOTHER PROGRAM. IN ALL OTHER CASES R56 WILL SELECT R00. V56E MAY BE PERFORMED ANY TIME DURING P20, 22, OR 25 OPERATION.

++ (4) THE LGC WILL ACT UPON V34E ONLY IN RESPONSE TO A FLASHING VERB-NOUN. IF THIS DISPLAY WAS ORIGINATED BY
+03 P20, 22, OR 25, V34E WILL RESULT IN AN IDENTICAL LGC RESPONSE TO THAT OF V56E, THAT IS SELECTION OF R56
+ EXCEPT IN THE CASE OF A V06 N49 DISPLAY. IF THIS DISPLAY WAS NOT ORIGINATED BY P20, 22, OR 25 (SUCH
+ AS P32, WHILE RUNNING WITH P20) THE LGC WILL GO TO R00, HOWEVER THE PROGRAM IN THE BACKGROUND WILL
+1180 CONTINUE. THE NEW PROGRAM SELECTED FOLLOWS THE SELECTION RULES ABOVE, (A).
++

(5) THE INITIALIZATION OF THE W MATRIX (SEE SECTION 5.2.4.2 OF R567) IS ENABLED BY:

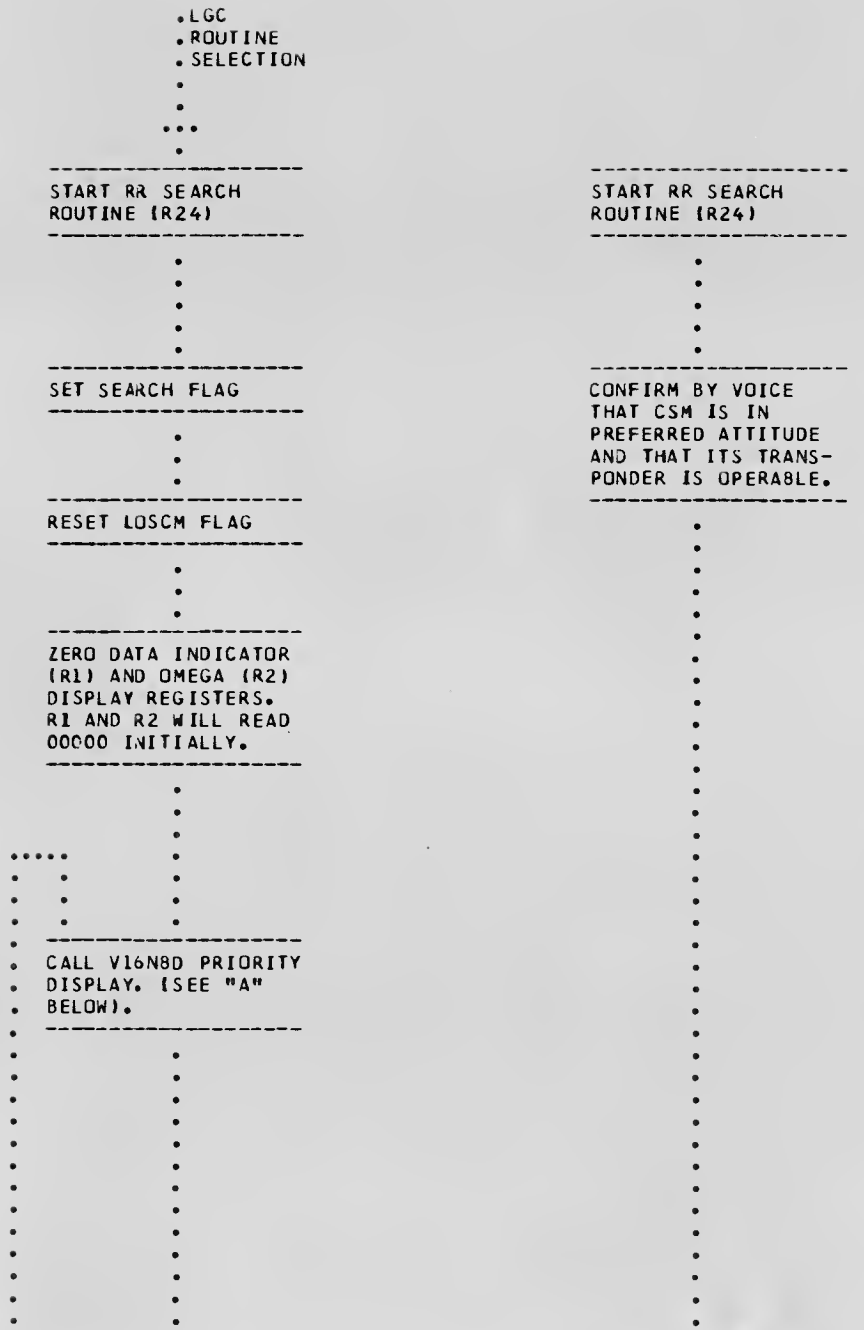
(A) A MANUAL OPR ENTRY.

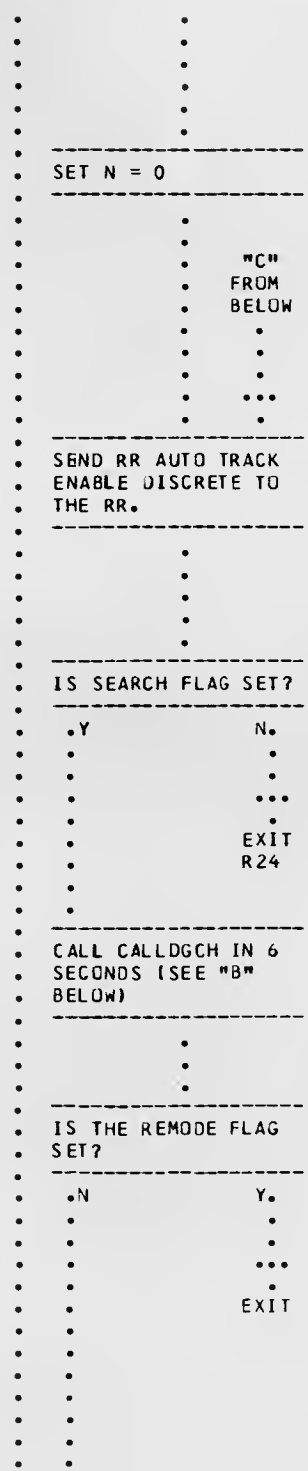
(B) COMPUTER FRESH START.

(C) STATE VECTOR UPDATE FROM THE GROUND (P27) (EXCEPT FOR UPDATE OF LANDING SITE VECTOR WHEN THE LM IS ON THE LUNAR SURFACE).

(D) THE POWERED ASCENT PROGRAM (P12) INVALIDATES THE W-MATRIX USED BY P22 AND CAUSES P20 TO RE-INITIALIZE THE W-MATRIX WHEN SELECTED.

PROG CONT	LGC	GROUND	CREW


.LGC
.ROUTINE
.SELECTION
START RR SEARCH ROUTINE (R24)
SET SEARCH FLAG
RESET LOSCM FLAG
ZERO DATA INDICATOR (R1) AND OMEGA (R2) DISPLAY REGISTERS. R1 AND R2 WILL READ 00000 INITIALLY.
CALL V16N8D PRIORITY DISPLAY. (SEE "A" BELOW).
START RR SEARCH ROUTINE (R24)
CONFIRM BY VOICE THAT CSM IS IN PREFERRED ATTITUDE AND THAT ITS TRANS-PONDER IS OPERABLE.
#10
#20
#30
#40
#50



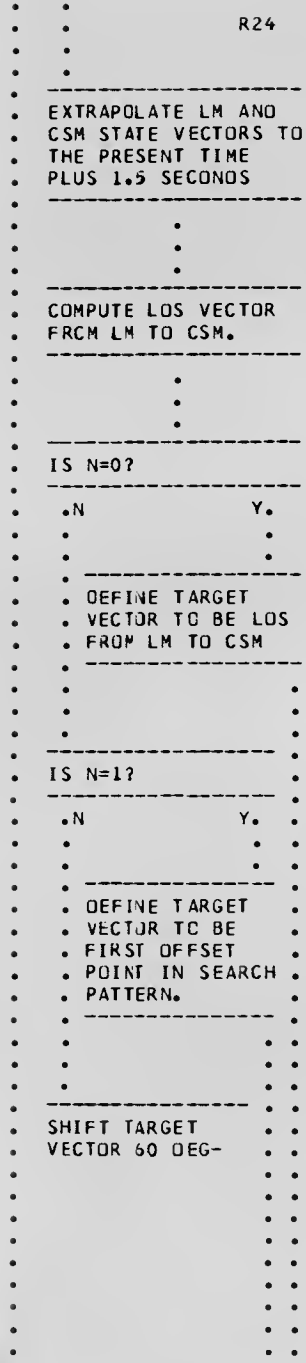
#60

#70

#80

#90

#10C



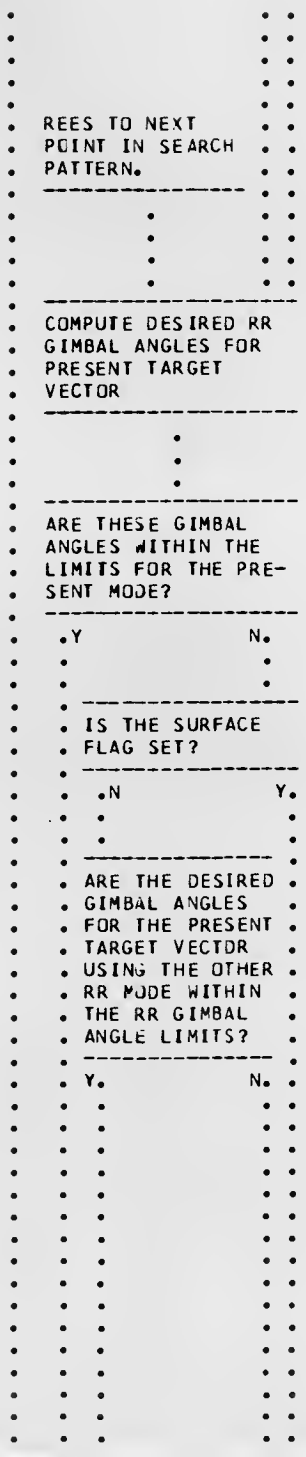
#110

#120

#130

#140

#150



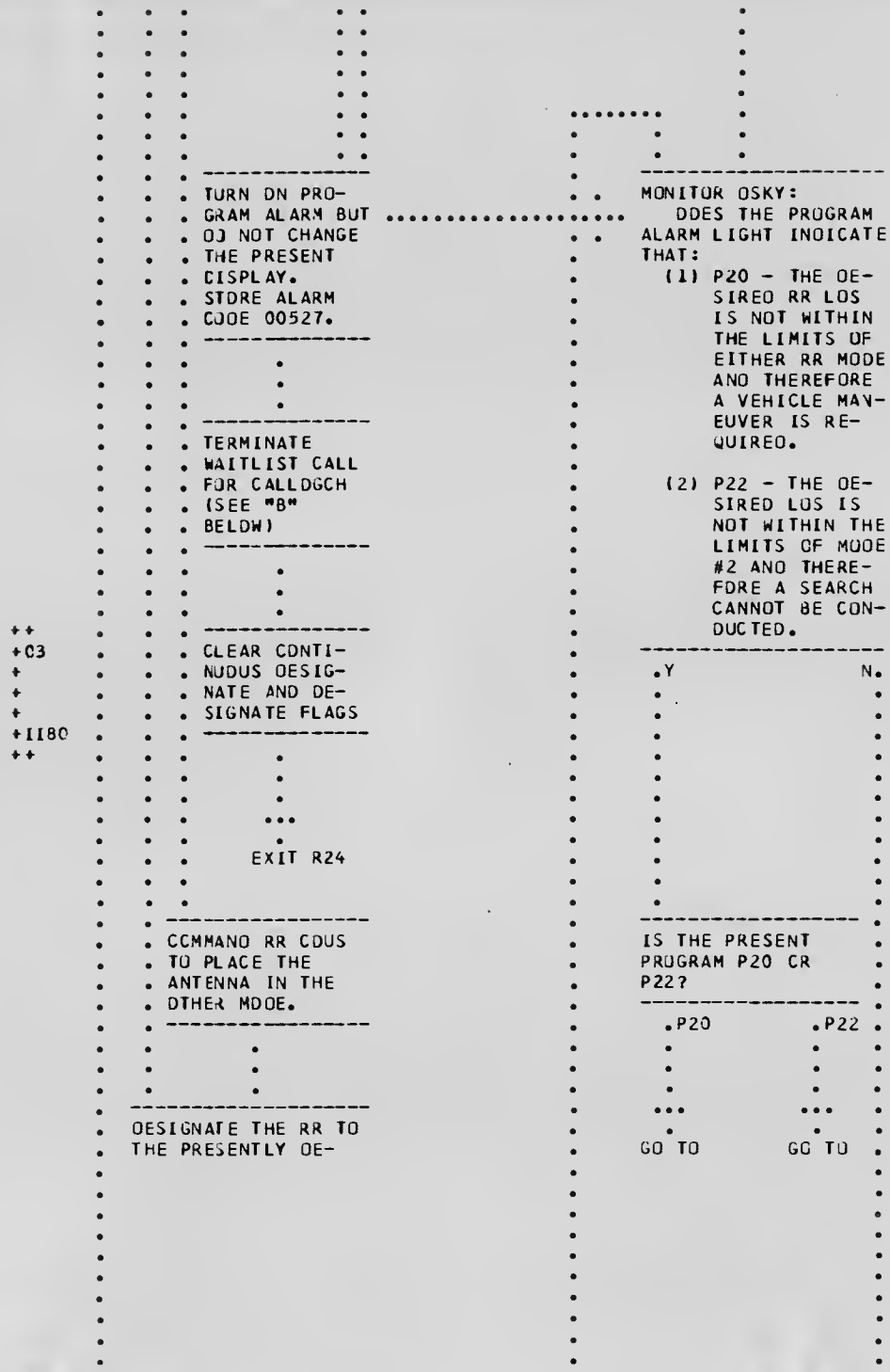
#160

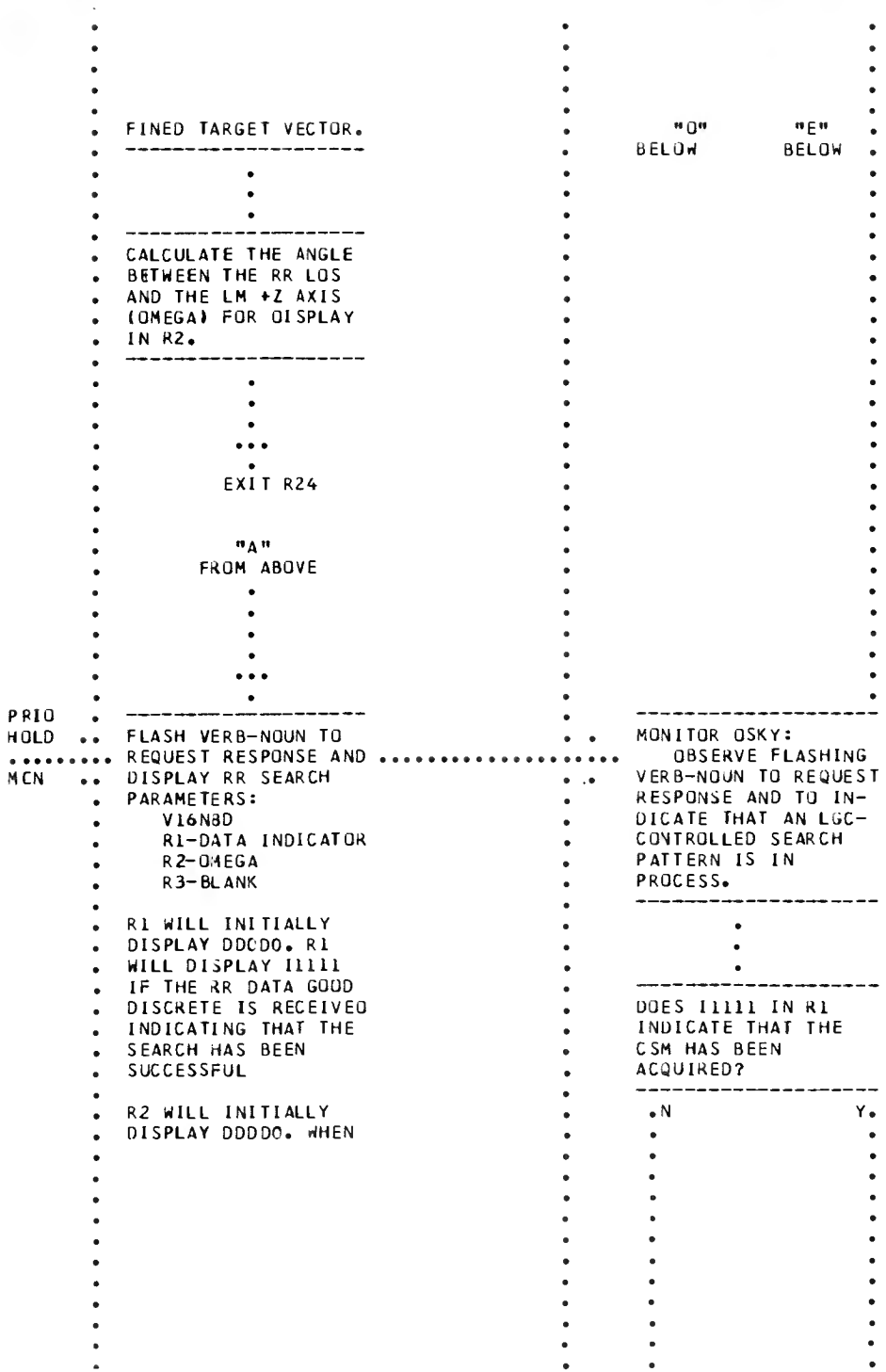
#170

#180

#190

#200


TURN ON PRO-
GRAM ALARM BUT
OO NOT CHANGE
THE PRESENT
DISPLAY.
STORE ALARM
CODE 00527.
TERMINATE
WAITLIST CALL
FOR CALLDSCH
(SEE "B"
BELOW)
CLEAR CONTI-
NUOUS DESIG-
NATE AND DE-
SIGNATE FLAGS
EXIT R24
COMMAND RR COUS
TO PLACE THE
ANTENNA IN THE
OTHER MODE.
DESIGNATE THE RR TO
THE PRESENTLY DE-
MONITOR OSKY:
DOES THE PROGRAM
ALARM LIGHT INDICATE
THAT:
(1) P20 - THE DE-
SIRED RR LOS
IS NOT WITHIN
THE LIMITS OF
EITHER RR MODE
AND THEREFORE
A VEHICLE MAN-
EUVER IS RE-
QUIRED.
(2) P22 - THE DE-
SIRED LOS IS
NOT WITHIN THE
LIMITS OF MODE
#2 AND THERE-
FORE A SEARCH
CANNOT BE CON-
DUCTED.
Y
N
IS THE PRESENT
PROGRAM P20 OR
P22?
P20
P22
GO TO
GO TO
#210
#220
#230
#240
#250



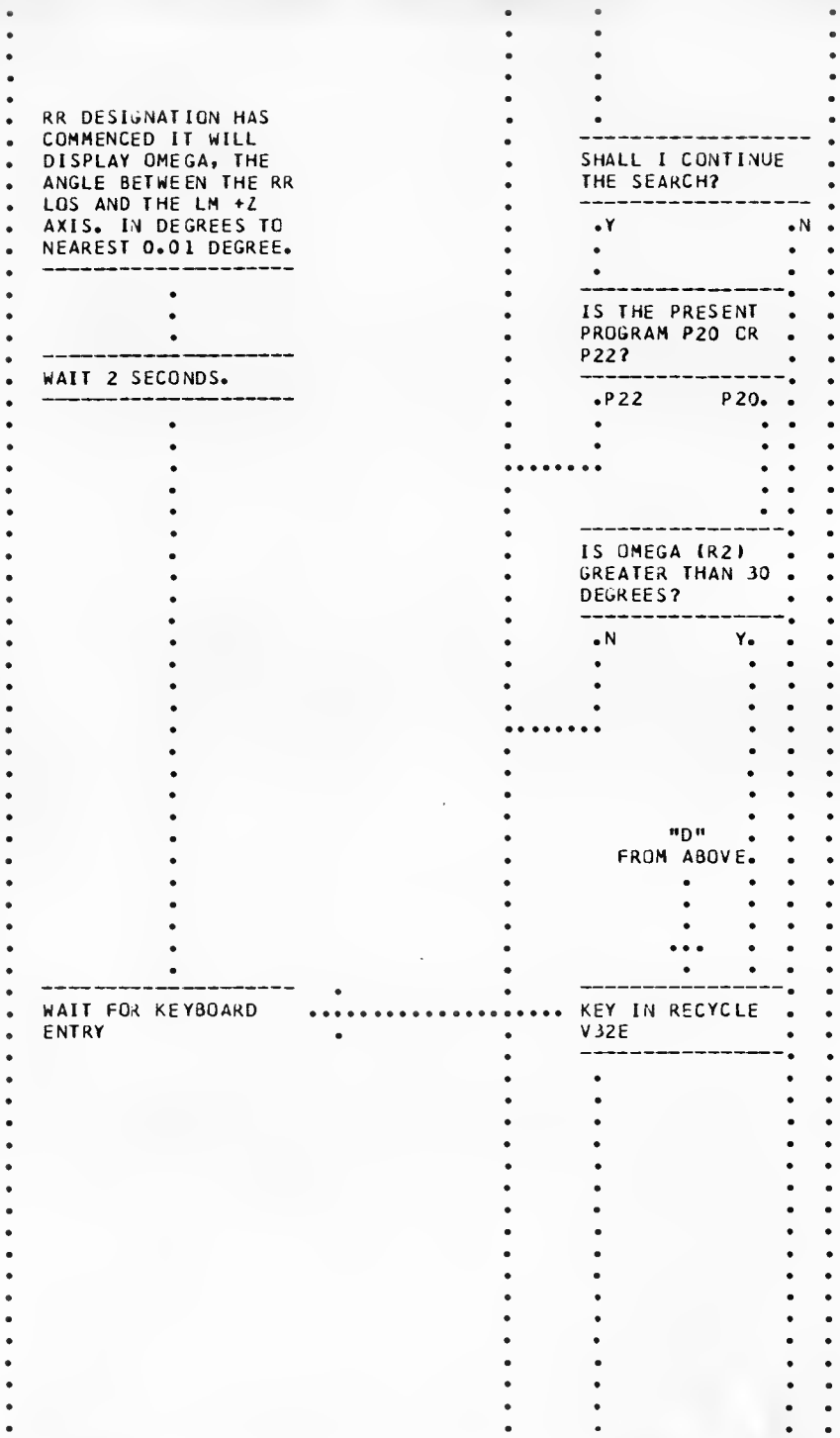
#260

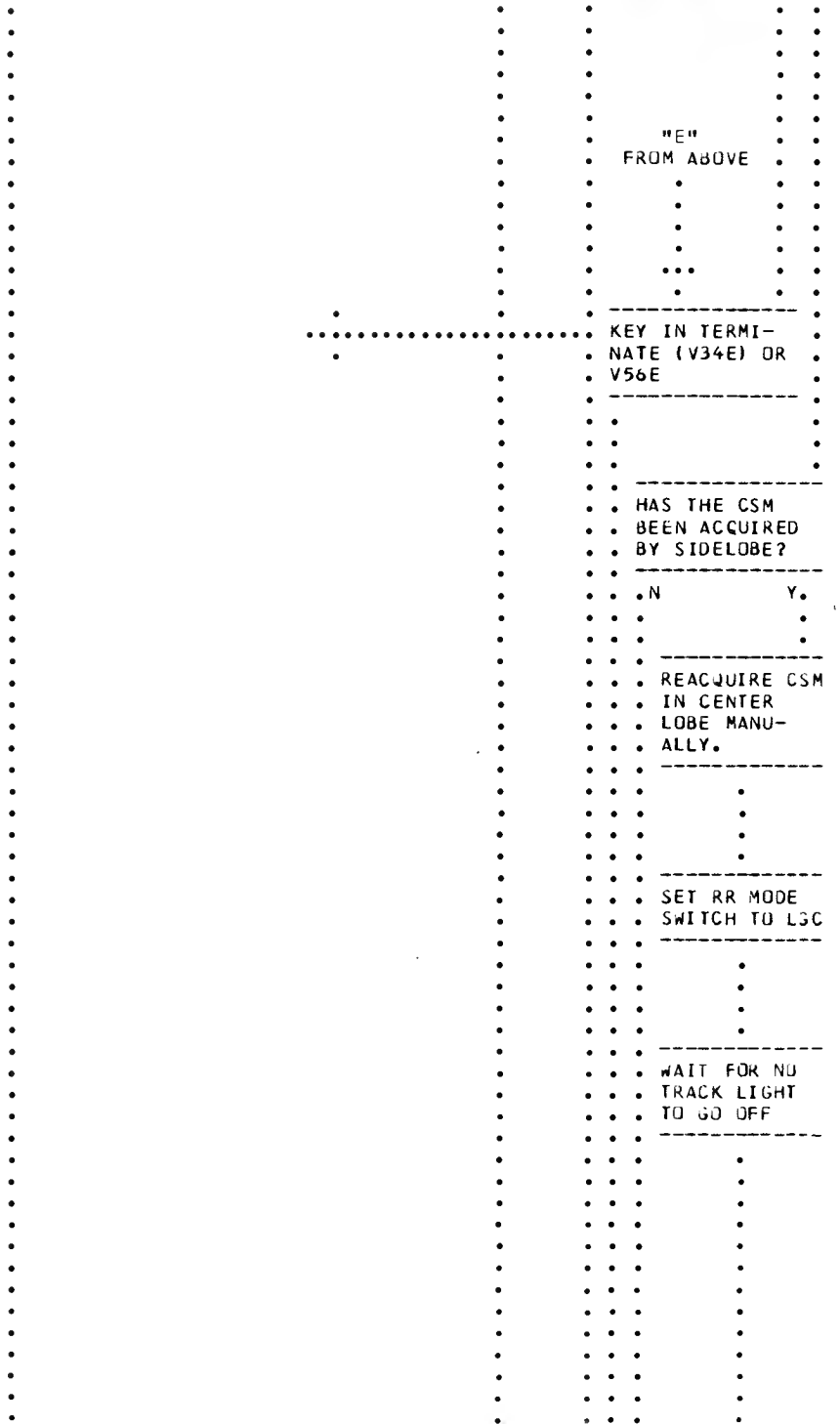
#270

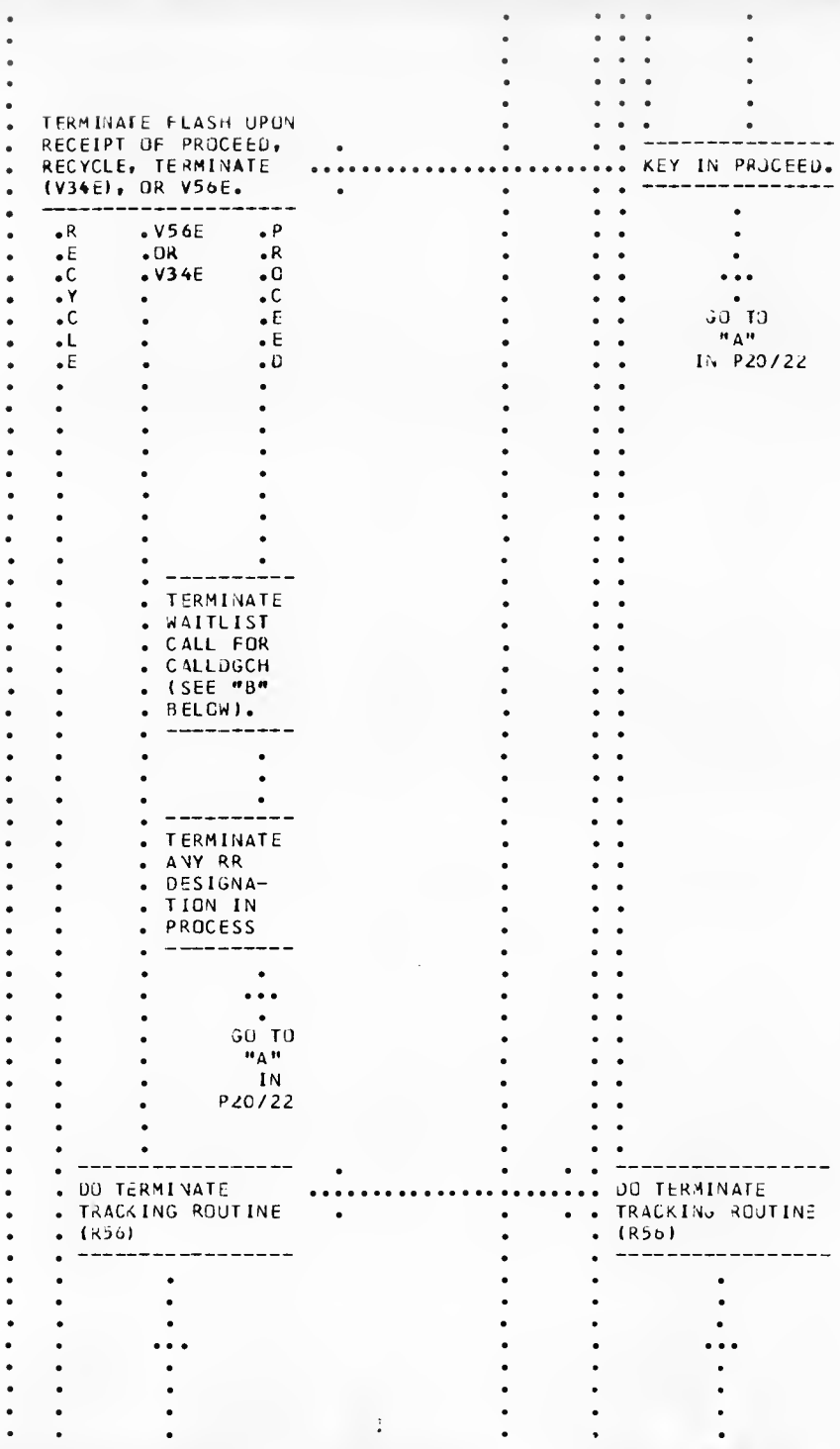
#280

#290

#300


RR DESIGNATION HAS COMMENCED IT WILL DISPLAY OMEGA, THE ANGLE BETWEEN THE RR LOS AND THE LM +Z AXIS. IN DEGREES TO NEAREST 0.01 DEGREE.
WAIT 2 SECONDS.
WAIT FOR KEYBOARD ENTRY
SHALL I CONTINUE THE SEARCH?
.Y
.N
IS THE PRESENT PROGRAM P20 OR P22?
.P22
P20.
IS OMEGA (R2) GREATER THAN 30 DEGREES?
.N
Y.
"D" FROM ABOVE.
KEY IN RECYCLE V32E
#310
#320
#330
#340
#350


"E"
FROM ABOVE
KEY IN TERMI-
NATE (V34E) OR
V56E
#360
HAS THE CSM
BEEN ACQUIRED
BY SIDELOBE?
#370
N
Y
REACQUIRE CSM
IN CENTER
LOBE MANU-
ALLY.
#380
SET RR MODE
SWITCH TO LGC
#390
WAIT FOR NO
TRACK LIGHT
TO GO OFF
#400



#410

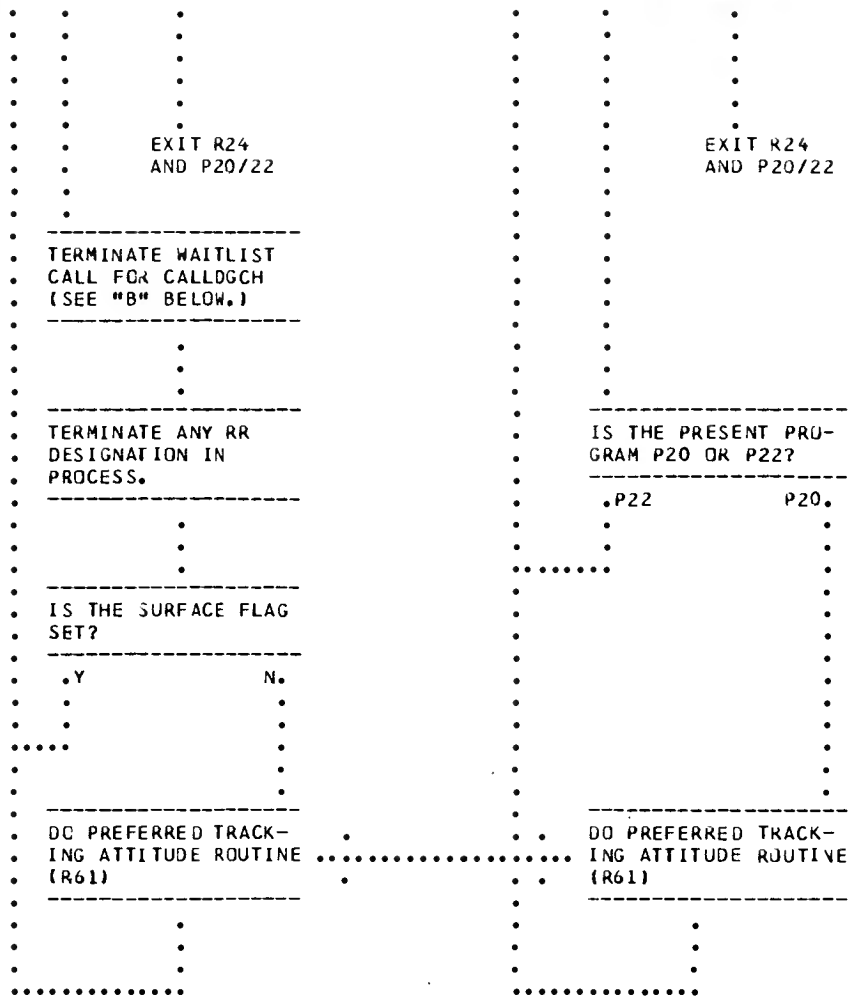
#420

#430

#440

#450

#460



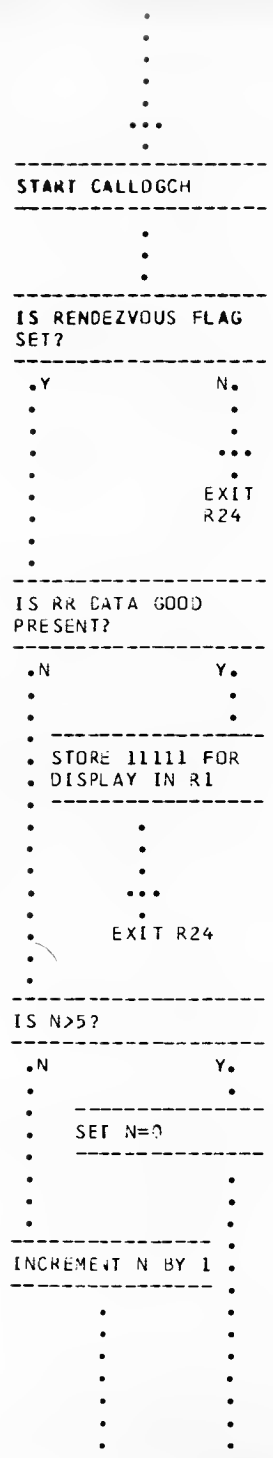
#470

#480

#490

#500

"B"
FROM ABOVE



#51C

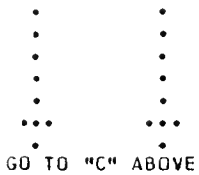
#52C

#53C

#54C

#55C

#56C



#570

CHANGE CONTROL NOTES

REV 00 PCR 124
REV 01 PCR 409, 451, 562
REV 00(LUM 1A) PCR 744
REV 02 EDITORIAL
REV 03 PCN 1180

RR MONITOR ROUTINE (R25) REV 04 02/17/71

PURPOSE: (1) TO MONITOR THE RR STATUS WITH RESPECT TO MODE CHANGES, RR CDU FAILURE, AND RR GIMBAL POSITIONS.

(2) TO COMMAND THE RR GIMBALS TO ONE OF TWO REFERENCE POSITIONS (DEPENDENT UPON RR ANTENNA MODE) IF THE RR GIMBAL ANGLES EXCEED PREDEFINED LIMITS (AS DESCRIBED IN FIG 2.4-3 OF SECTION 5 OF R-567).

(3) TO ZERO THE RR CDUS WHEN THE RR IS FIRST PUT IN AUTO MODE.

ASSUMPTIONS: (1) THE PREDEFINED LIMITS OF PURPOSE (2) ABOVE ALLOW THE ANGLE BETWEEN THE LM +Z AXIS AND THE RR LOS TO BE GREATER THAN 30 DEGREES DURING NORMAL RR TRACKING UNDER CONTROL OF THE RENDEZVOUS NAVIGATION PROGRAM (P20) OR THE LUNAR SURFACE NAVIGATION PROGRAM (P22).

WHILE IN FLIGHT, THE 30 DEGREE LIMIT DEFINED IN THE RR DATA READ ROUTINE (R22) WILL ACT TO KEEP THE RR LOS WITHIN THIS LIMIT W.R.T. THE LM +Z AXIS. THIS WILL BE ACCOMPLISHED BY LM ATTITUDE MANEUVERS UNDER THE CONTROL OF THE PREFERRED TRACKING ATTITUDE ROUTINE (R61). THEREFORE, IN FLIGHT, WHEN THE TRACK FLAG (SEE P20) IS SET, THE LIMITS DEFINED BY THIS ROUTINE SHOULD NEVER BE EXCEEDED AND IT SHOULD ONLY BE NECESSARY FOR THIS ROUTINE TO CONTROL THE RR GIMBALS WHEN THE TRACK FLAG IS RESET (AS DURING MANEUVERS FOR THRUSTING, ETC).

WHILE ON THE LUNAR SURFACE RR DESIGNATION IS INHIBITED IF THE LOS TO THE CSM IS NOT WITHIN THE ALLOWABLE RR GIMBAL LIMITS OF MODE # 2.

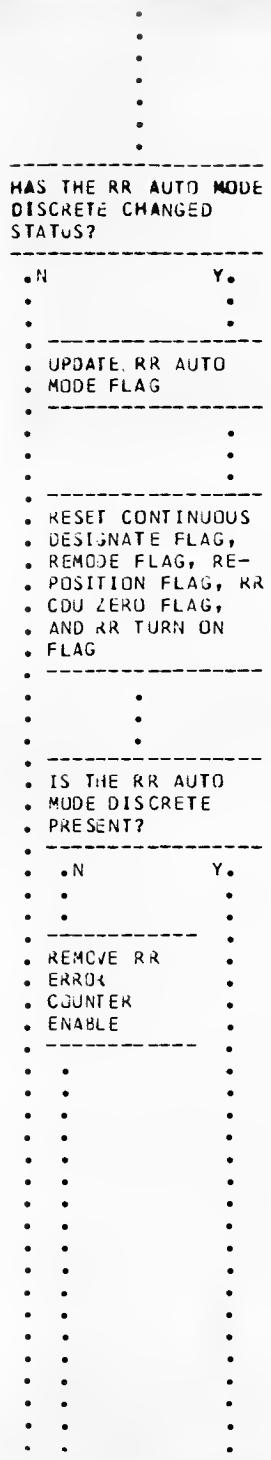
(2) THIS ROUTINE IS AUTOMATICALLY CALLED EVERY 0.48 SECONDS WHENEVER THE LGC IS ON.

(3) THIS ROUTINE WILL SET THE RR CDU ZERO DISCRETE IF THE RR MODE SWITCH IS NOT IN THE LGC POSITION.

PROG CONT	LGC	GROUND	CREW
	.LGC .ROUTINE .SELECTION		
	START RR MONITOR ROUTINE (R25)		
	.		

#10

R25/LUMINARY


HAS THE RR AUTO MODE DISCRETE CHANGED STATUS?
N
Y
UPDATE RR AUTO MODE FLAG
RESET CONTINUOUS DESIGNATE FLAG, REMODE FLAG, RE-POSITION FLAG, RR CDU ZERO FLAG, AND RR TURN ON FLAG
IS THE RR AUTO MODE DISCRETE PRESENT?
N
Y
REMOVE RR ERROR COUNTER ENABLE

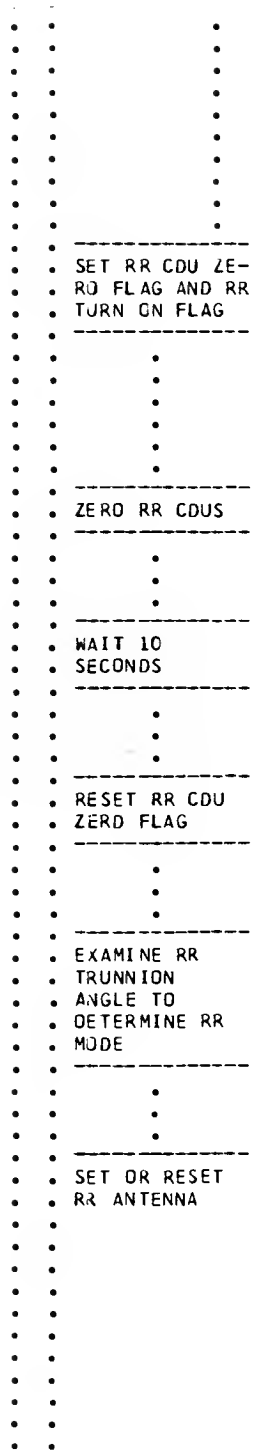
#2C

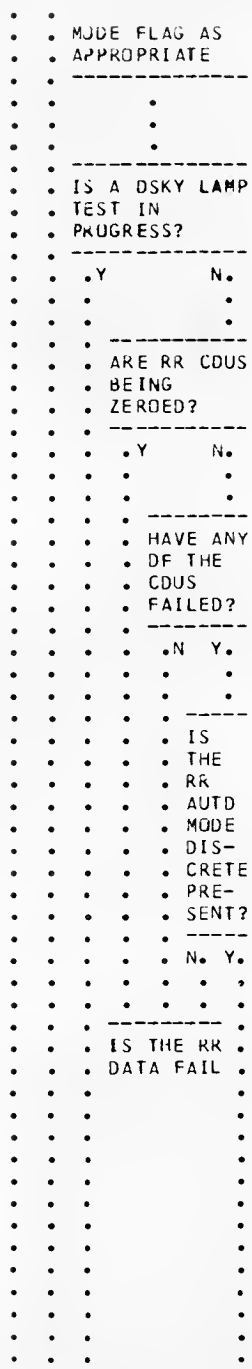
#3C

#4C

#5C

#6C


SET RR CDU ZE-
RO FLAG AND RR
TURN ON FLAG
#70
ZERO RR CDUS
#80
WAIT 10
SECONDS
#90
RESET RR CDU
ZERD FLAG
EXAMINE RR
TRUNNION
ANGLE TO
OETERMINE RR
MODE
#100
SET OR RESET
RR ANTENNA
#110

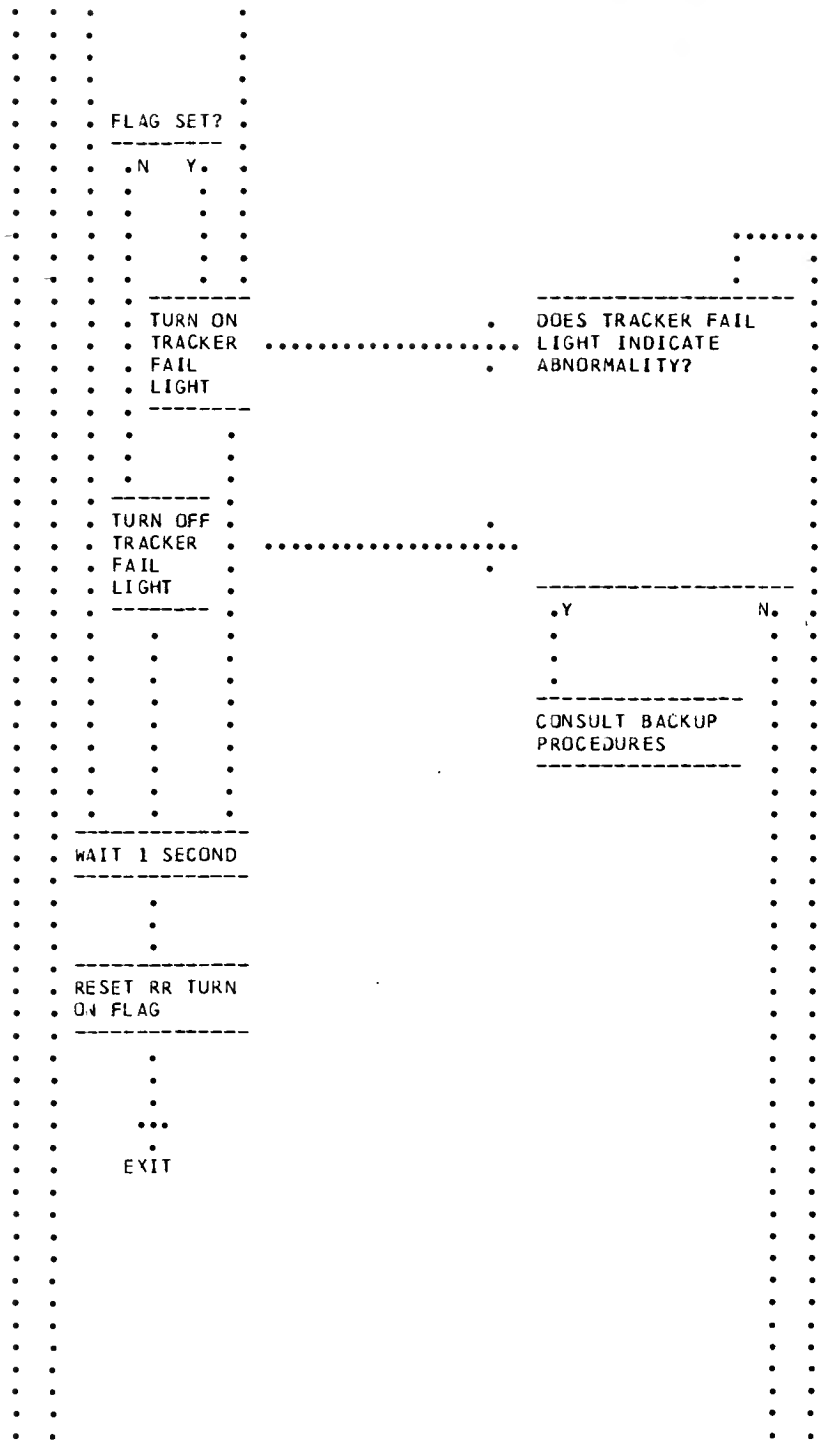


#12C

#13C

#14C

#15C


FLAG SET?
N
Y
TURN ON TRACKER FAIL LIGHT
TURN OFF TRACKER FAIL LIGHT
WAIT 1 SECOND
RESET RR TURN ON FLAG
EXIT
DOES TRACKER FAIL LIGHT INDICATE ABNORMALITY?
Y
N
CONSULT BACKUP PROCEDURES
#160
#170
#180
#190
#200

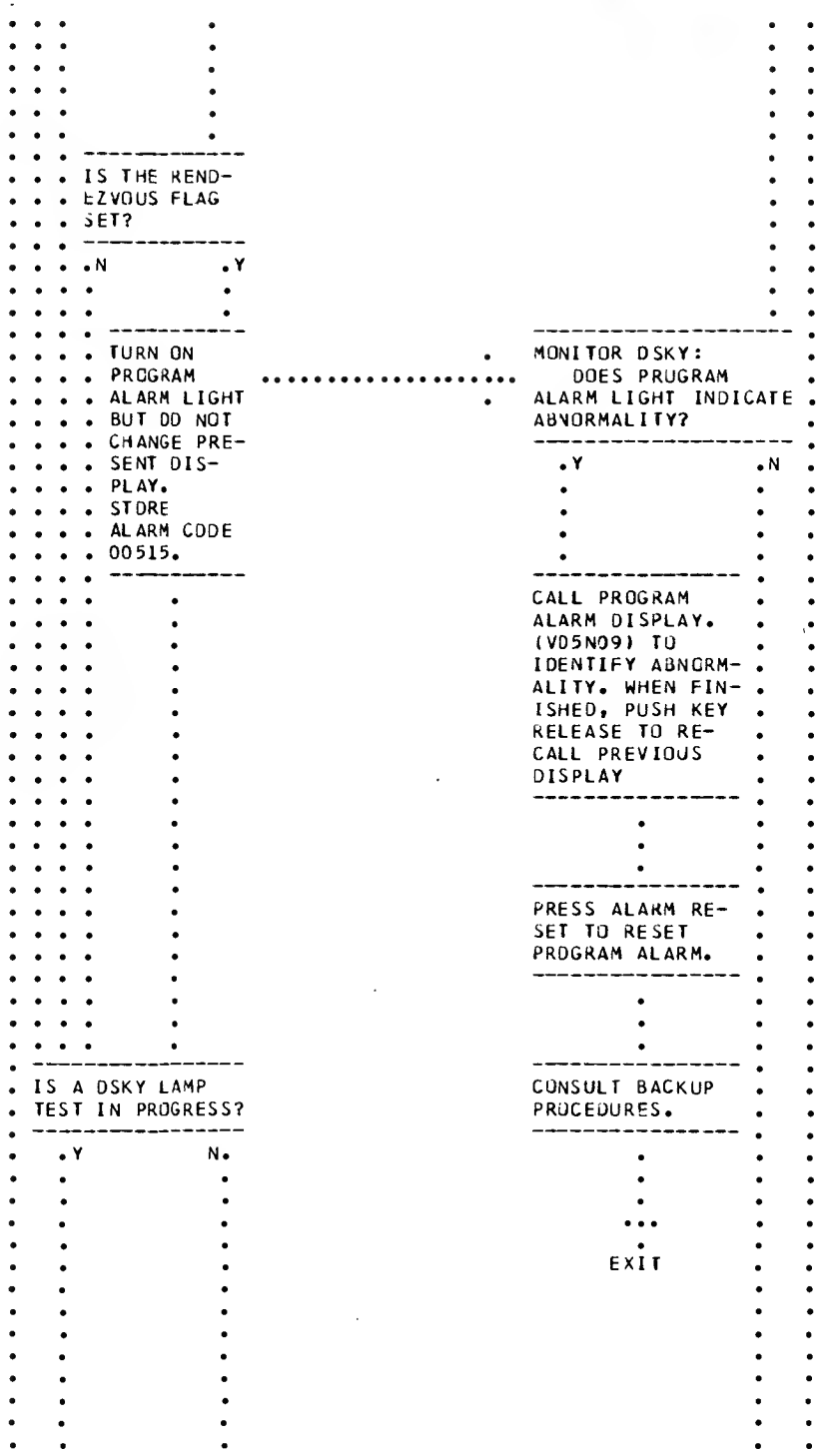
#210

#220

#230

#240

#250



#260

#270

#280

#290

#300

R25

#310

IS THE RR CDU ZERO FLAG SET?

Y / N

#320

HAVE ANY OF THE CDUS FAILED?

N / Y

#330

IS THE RR AUTO MODE DISCRETE PRESENT?

#340

N / Y

IS THE RR DATA FAIL FLAG SET?

#350

N / Y

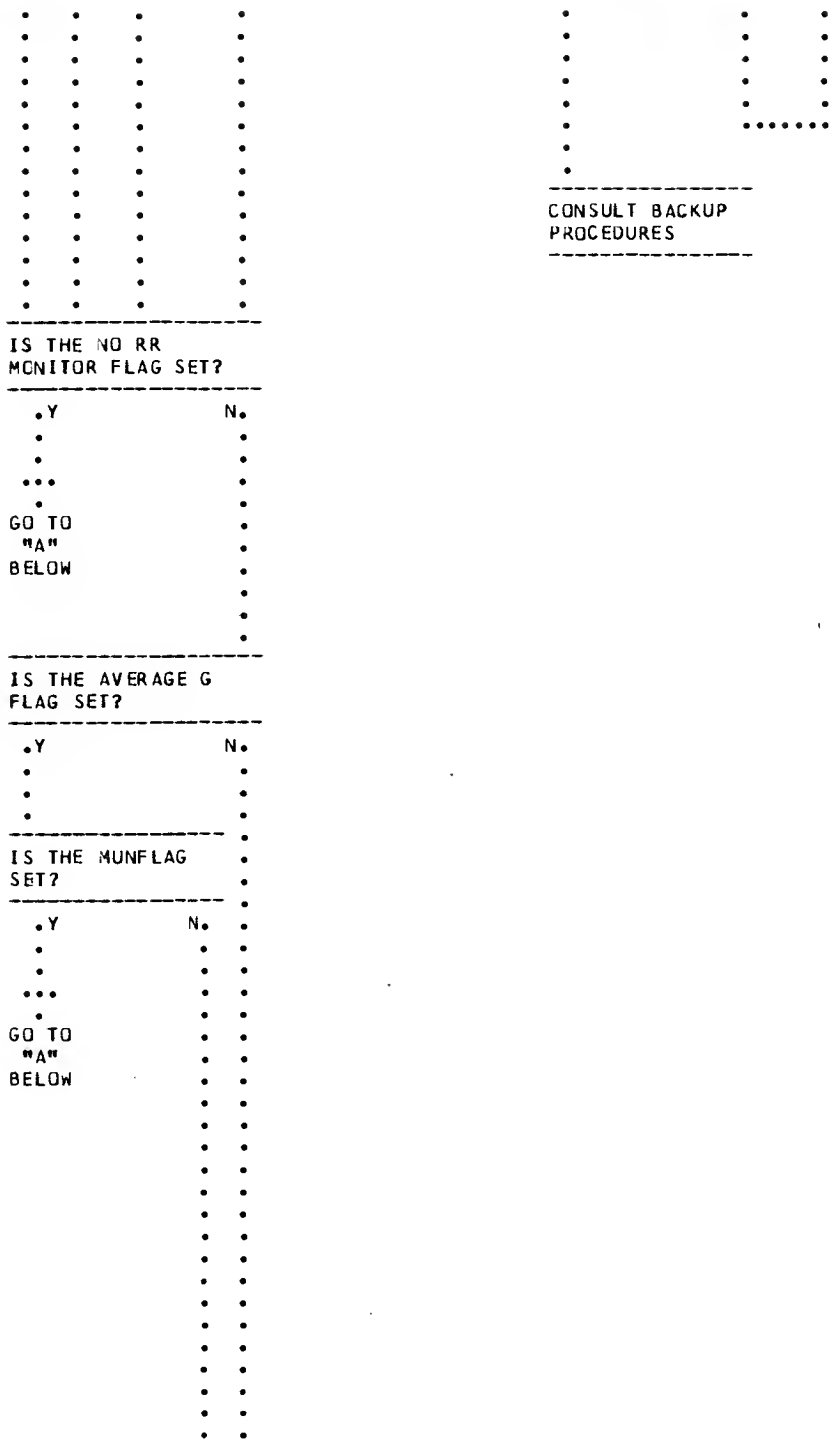
TURN ON TRACKER FAIL LIGHT

DOES TRACKER FAIL LIGHT INDICATE ABNORMALITY?

#360

TURN OFF TRACKER FAIL LIGHT

Y / N



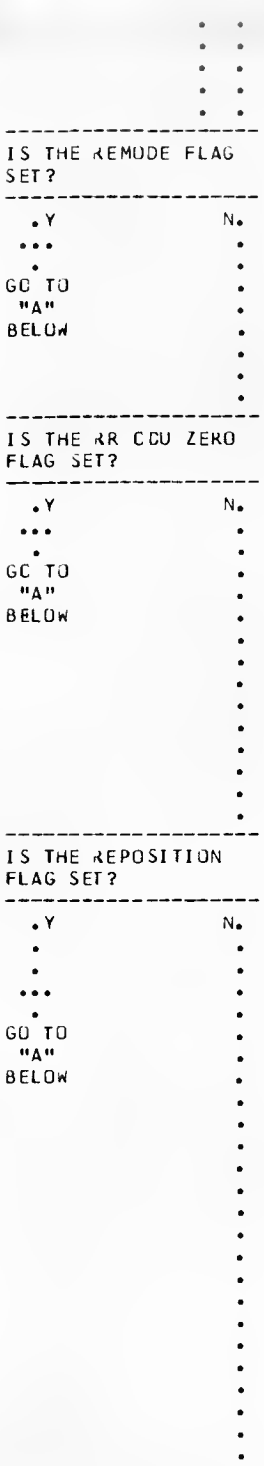
#370

#380

#390

#400

#410



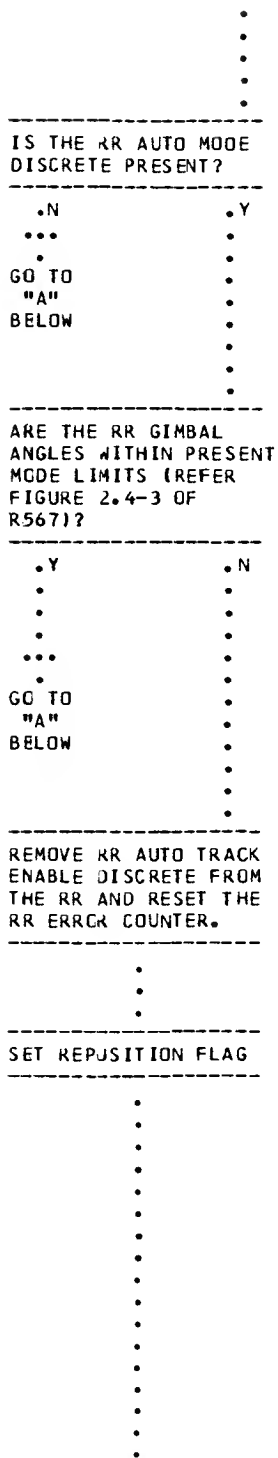
#420

#430

#440

#450

#460

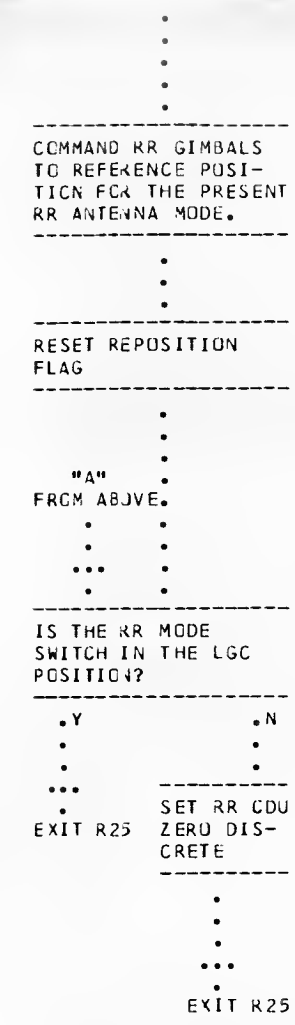


#470

#480

#490

#500



#510

#520

#530

#540

#550

CHANGE CONTROL NOTES

LOGIC REV 01 PCR 97, 410
REV 02(LUM 1B) PCR 848
REV 03 EDITORIAL
REV 04(LUM 1E) PCN 1145

LUNAR SURFACE RR PRE-DESIGNATE ROUTINE (R26) REV 04 12/01/71

PURPOSE: (1) TO DETERMINE THE RR LOS TO THE CSM AT THE TIME WHEN THE CSM ENTERS THE RR FIELD OF VIEW.

(2) TO DESIGNATE THE RR, BEFORE ARRIVAL OF THE CSM IN THE FIELD OF VIEW, TO AN ORIENTATION THAT WILL PERMIT THE ACQUISITION OF THE CSM IMMEDIATELY UPON ITS ENTRY INTO THE FIELD OF VIEW.

ASSUMPTIONS: (1) P22 WILL NOT BE INITIATED BY THE CREW UNTIL LESS THAN 10 MINUTES BEFORE THE CSM IS EXPECTED TO ARRIVE WITHIN THE RR FIELD OF VIEW.

(2) THE SELECTION AND TERMINATION OF P20, P22, AND P25 ARE SUBJECT TO SPECIAL OPERATING PROCEDURES WHICH DIFFER FROM THOSE FOR ALL OTHER PROGRAMS:

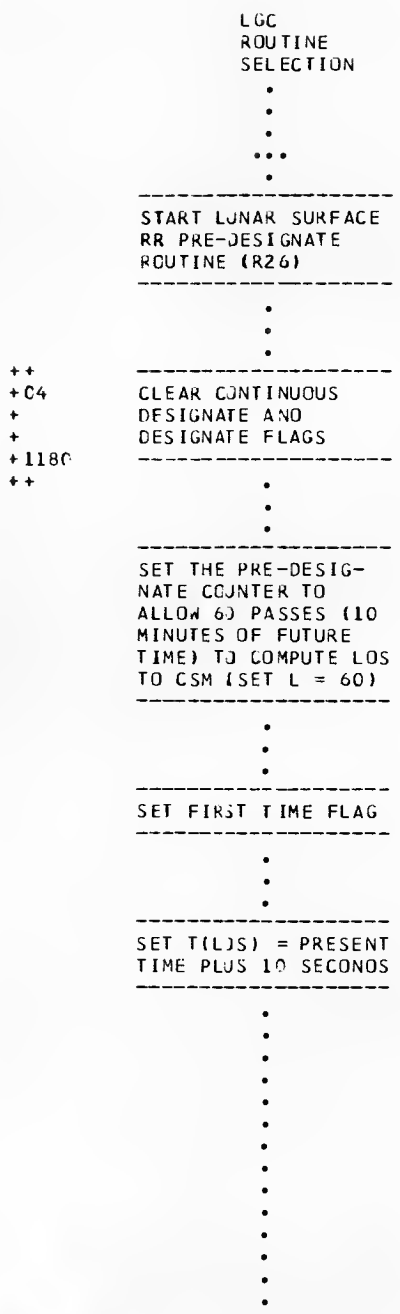
(A) SELECTION
(1) ALWAYS BY V37EXXE.
(2) IF ANY OTHER PROGRAM IS RUNNING AT THE TIME OF P20/22/25 SELECTION, THE NEW PROGRAM WILL REPLACE
++ THE OLD. THIS INCLUDES P20/22/25 SELECTION WHEN EITHER P20 OR P22 OR P25 IS RUNNING.
+04 (3) IF P20 OR P25 IS RUNNING, SELECTION OF ANY PROGRAM OTHER THAN P00, P22, OR P25 WILL RESULT IN
+ P20 OR P25 CONTINUING AND THE NEW PROGRAM ALSO OPERATING WITH ITS NUMBER DISPLAYED IN THE DSKY
+ PROG LIGHTS.
+1180 (4) IF P20 OR P25 IS RUNNING, SELECTION OF P00, P22, OR P25 WILL RESULT IN THE TERMINATION OF THE OLD
++ PROGRAM AND OPERATION OF THE NEW.

(B) TERMINATION
(1) BY SELECTION OF P00, V56E, OR V34E.
(2) SELECTION OF P00 WILL TERMINATE P20, P22, P25, AND ANY OTHER PROGRAM IN PROCESS, AND ESTABLISH P00.
(3) SELECTION OF V56E CALLS THE TERMINATE TRACKING ROUTINE (R56) TO TERMINATE ONLY P20 OR P25, IF EITHER OF THESE PROGRAMS IS RUNNING IN CONJUNCTION WITH ANOTHER PROGRAM. IN ALL OTHER CASES, R56 WILL SELECT R00. V56E MAY BE PERFORMED AT ANY TIME DURING P20, P22, OR P25 OPERATION.
++ (4) THE LGC WILL RECOGNIZE V34E ONLY IN RESPONSE TO A FLASHING VERB-NOUN. IF THE FLASHING VERB-NOUN
+04 DISPLAY WAS ORIGINATED BY P20, P22, OR P25, V34E WILL PRODUCE AN LGC RESPONSE IDENTICAL TO THAT
+ OF V56E, THAT IS, SELECTION OF R56 EXCEPT IN THE CASE OF A V06 N49 DISPLAY. IF THIS DISPLAY WAS
+ NOT ORIGINATED BY P20, P22, OR P25 (FOR EXAMPLE, BY P32 WHILE RUNNING IN CONJUNCTION WITH P20)
+1180 THE LGC WILL GO TO R00, BUT THE PROGRAM IN THE BACKGROUND WILL CONTINUE. THE NEW PROGRAM SELECTED
++ FOLLOWS THE SELECTION RULES ABOVE, (A).

(3) THIS ROUTINE IS CALLED AUTOMATICALLY BY THE RR DESIGNATE ROUTINE (R21) DURING THE LUNAR SURFACE NAVIGATION PROGRAM (P22) IF THE CSM HAS NOT YET ARRIVED IN THE RR MODE 2 FIELD OF VIEW.

PROG	LGC	GROUND	CREW

CONT



#10

#20

#30

#40

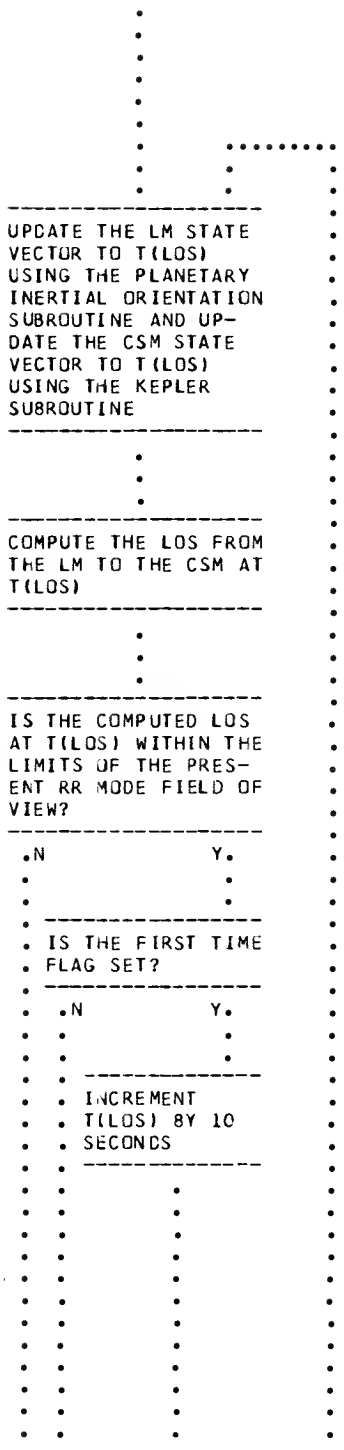
#50

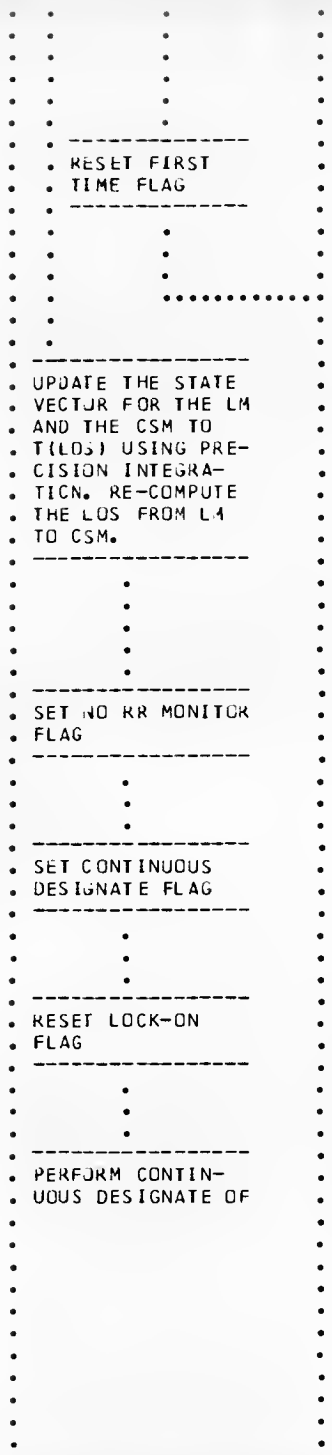
#60

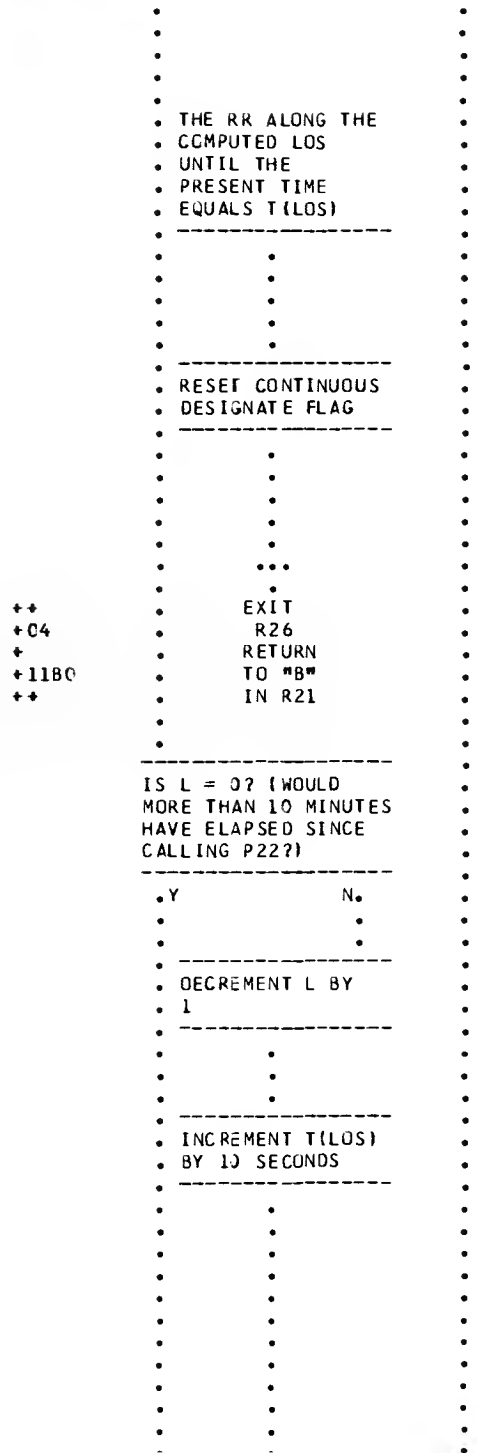
#70

#80

#90


UPDATE THE LM STATE VECTOR TO T(LOS) USING THE PLANETARY INERTIAL ORIENTATION SUBROUTINE AND UP-DATE THE CSM STATE VECTOR TO T(LOS) USING THE KEPLER SUBROUTINE
COMPUTE THE LOS FROM THE LM TO THE CSM AT T(LOS)
IS THE COMPUTED LOS AT T(LOS) WITHIN THE LIMITS OF THE PRES-ENT RR MODE FIELD OF VIEW?
N
Y
IS THE FIRST TIME FLAG SET?
N
Y
INCREMENT T(LOS) BY 10 SECONDS


RESET FIRST TIME FLAG
#100
UPDATE THE STATE VECTOR FOR THE LM AND THE CSM TO T(LOS) USING PRECISION INTEGRATION. RE-COMPUTE THE LOS FROM LM TO CSM.
#110
#120
SET NO RR MONITOR FLAG
#130
SET CONTINUOUS DESIGNATE FLAG
RESET LOCK-ON FLAG
#140
PERFORM CONTINUOUS DESIGNATE OF



#150

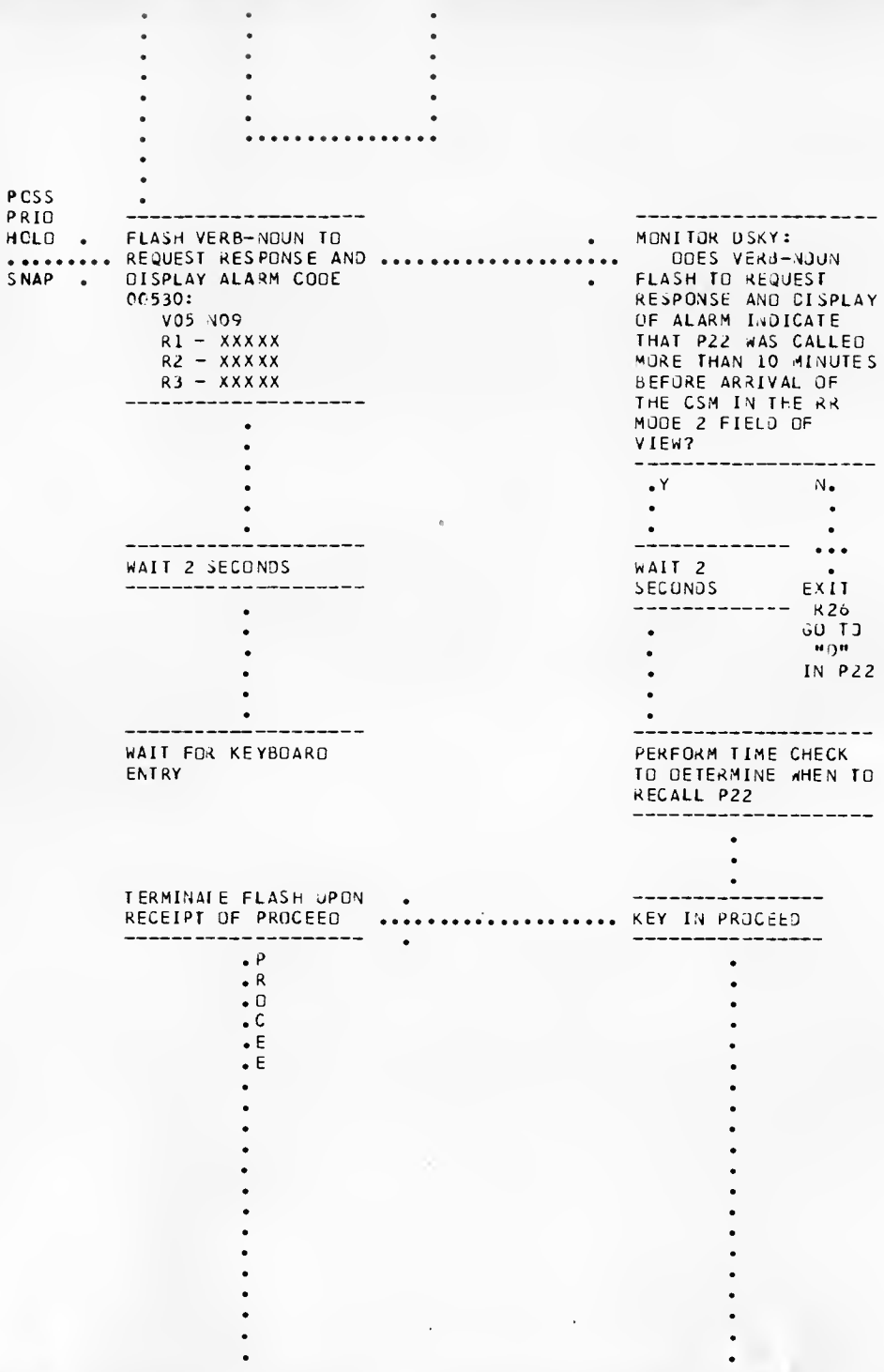
#160

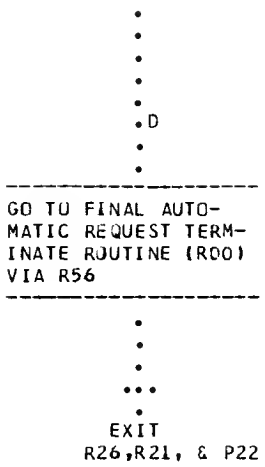
#170

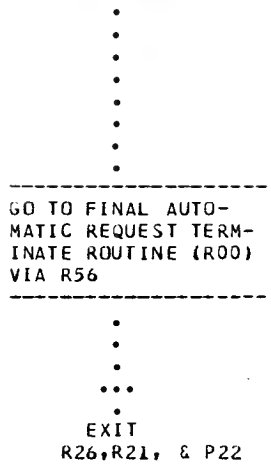
++
+04
+
+1180
++

#180

#190


#200
POSS PRIO HOLD SNAP
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY ALARM CODE 00530:
V05 N09
R1 - XXXXX
R2 - XXXXX
R3 - XXXXX
MONITOR DSKY: DOES VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY OF ALARM INDICATE THAT P22 WAS CALLED MORE THAN 10 MINUTES BEFORE ARRIVAL OF THE CSM IN THE RR MODE 2 FIELD OF VIEW?
#210
Y
N
#220
WAIT 2 SECONDS
WAIT 2 SECONDS
EXIT R26 GO TO "0" IN P22
#230
WAIT FOR KEYBOARD ENTRY
PERFORM TIME CHECK TO DETERMINE WHEN TO RECALL P22
TERMINATE FLASH UPON RECEIPT OF PROCEED
KEY IN PROCEED
#240
P R O C E E





#25C

#26C

CHANGE CONTROL NOTES

REV 00(LUM 1A)	PCR 722 (ORIGINATED)
REV 01	EDITORIAL
REV 02	EDITORIAL
REV 03(LUM 1E)	PCN 1145
REV 04	PCN 1180

ORBITAL PARAMETERS DISPLAY ROUTINE (R30) REV 05 02/17/71

PURPOSE: (1) TO PROVIDE THE ASTRONAUT PERTINENT ORBITAL PARAMETERS COMPUTED BY THE LGC TO SUPPLEMENT ORBITAL INFORMATION PROVIDED HIM BY THE GROUND.

ASSUMPTIONS: (1) THE COMPUTATIONS MADE DURING THIS ROUTINE ARE UPDATED ABOUT EVERY TWO SECONDS ONLY IF THE AVERAGE G ROUTINE IS ON WHEN THIS ROUTINE IS CALLED.

(2) THE VALUE OF TFF OR TF PER WILL BE MADE TO COUNT DOWN IF THE AVERAGE G ROUTINE IS NOT ON WHEN THIS ROUTINE IS CALLED.

(3) IF TFF IS NOT COMPUTABLE (PER ALT IS GREATER THAN 300,000 FT IN EARTH ORBIT OR GREATER THAN 35,000 FT IN LUNAR ORBIT) THE LGC WILL SET TFF EQUAL TO -59859 AND COMPUTE TF PER AND STORE IT IN N32. THE ASTRONAUT MAY CALL IT BY KEYING IN V16N32E.

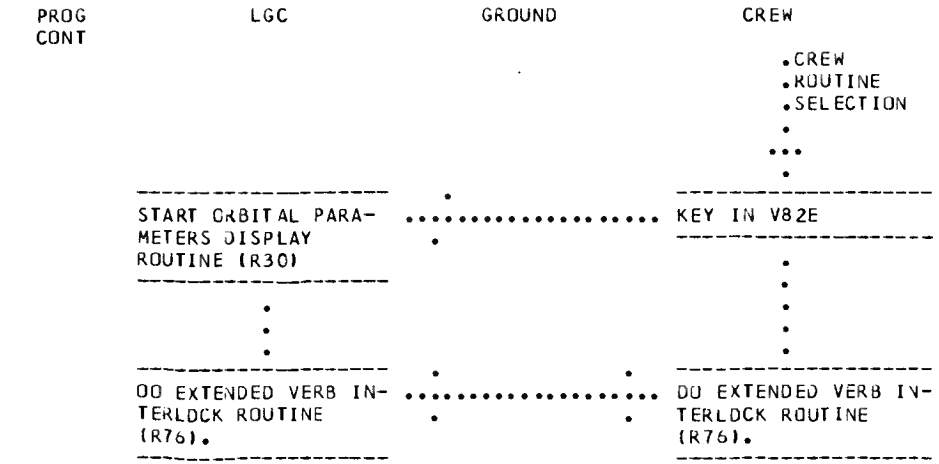
(4) TO MONITOR THE PROGRESS OF STATE VECTOR INTEGRATION, THE TIME ASSOCIATED WITH THE ADVANCING (REGRESSING) STATE IS AVAILABLE BY KEYING IN V06N38E:

V06N38
R1-TET-HRS
R2-TET-MINS
R3-TET-SECS.

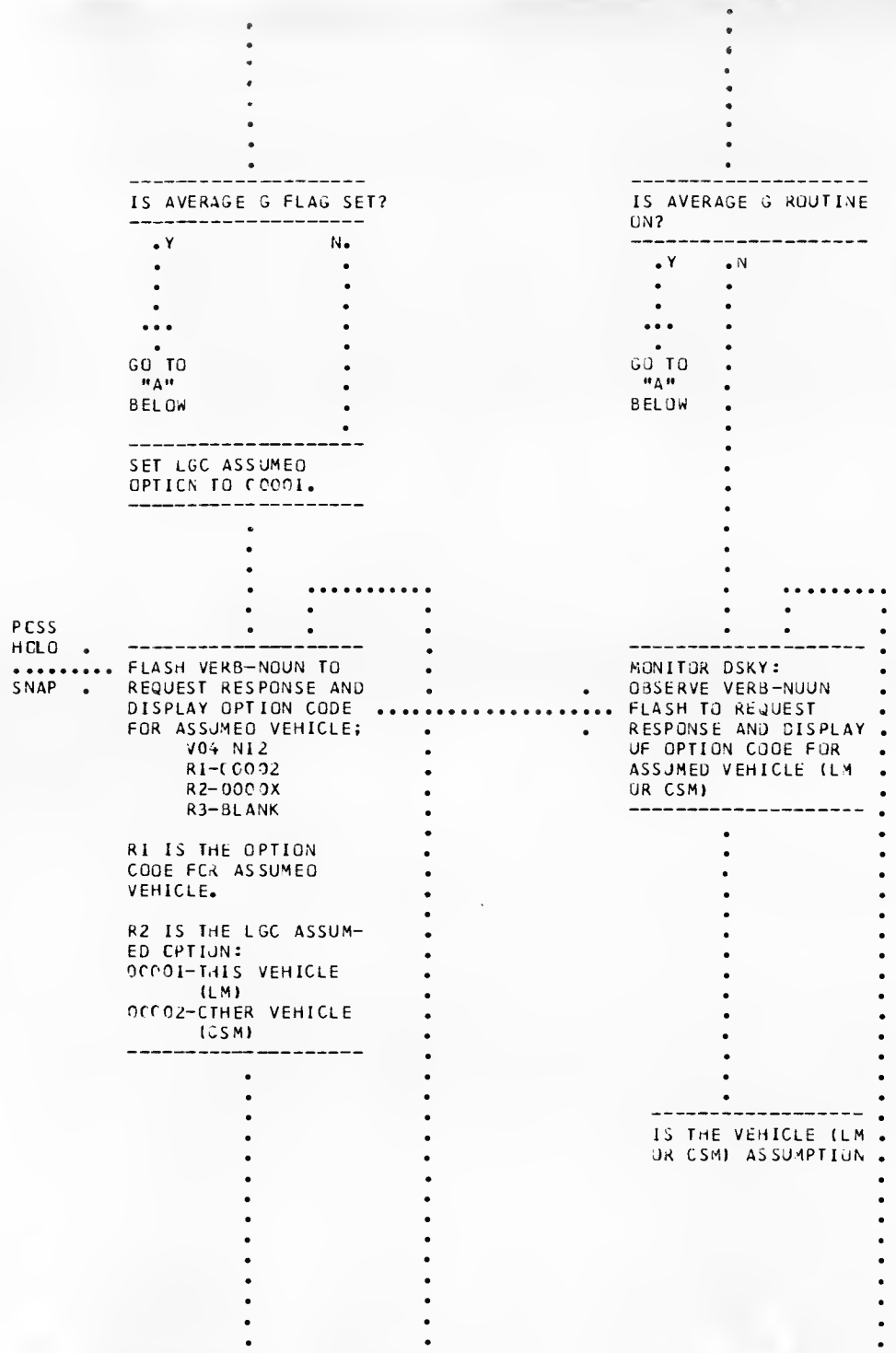
TET-THE TIME (GET) TO WHICH THE STATE VECTOR INTEGRATION PROCESS HAS PRESENTLY CALCULATED THE STATE VECTOR. IN HRS,MINS, AND SECS TO NEAREST .01 SEC.

(5) THIS ROUTINE MAY BE SELECTED WHILE THE LM IS EITHER IN EARTH OR LUNAR ORBIT.

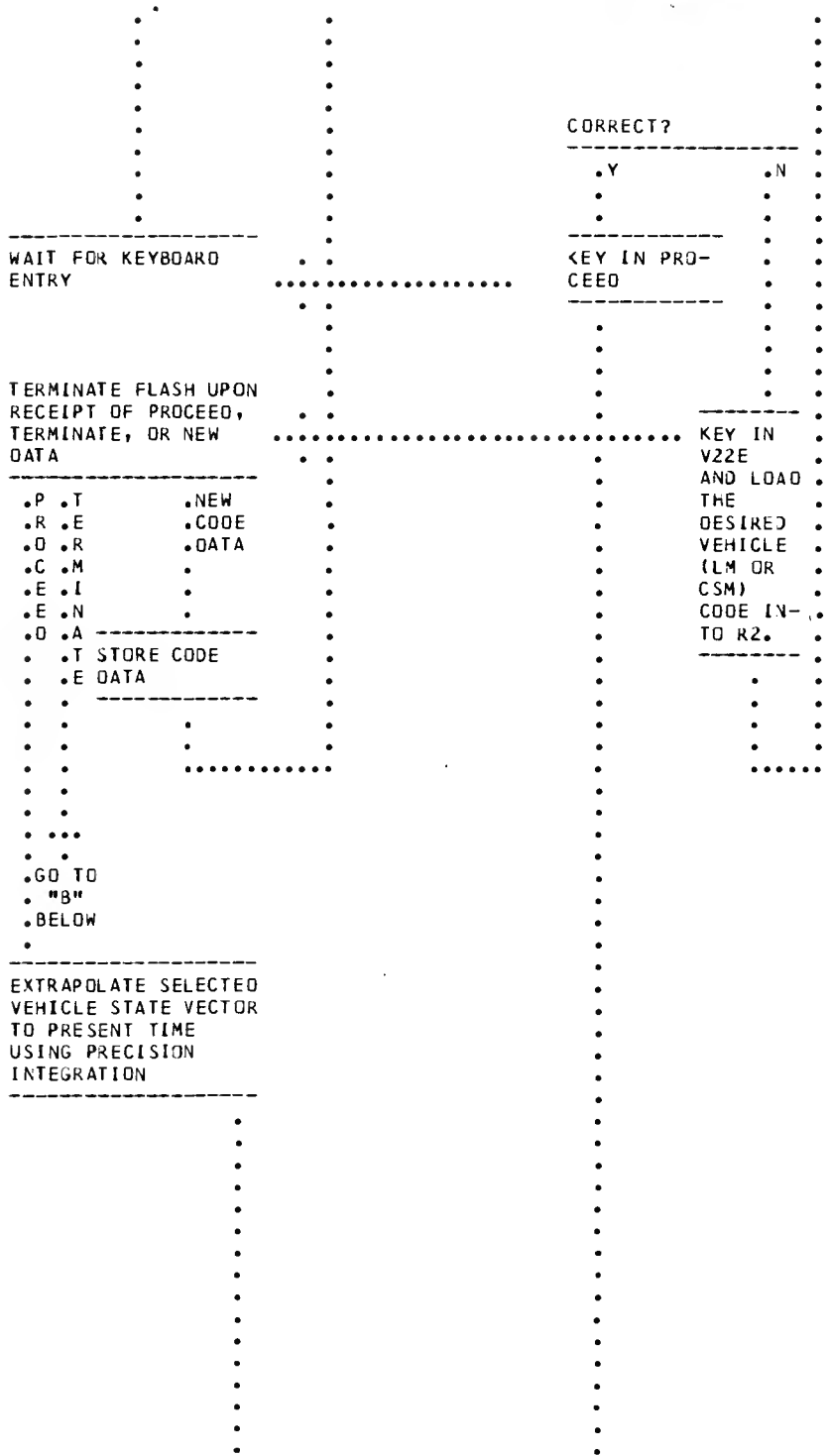
(6) THIS ROUTINE IS MANUALLY SELECTED BY THE ASTRONAUT BY DSKY ENTRY.

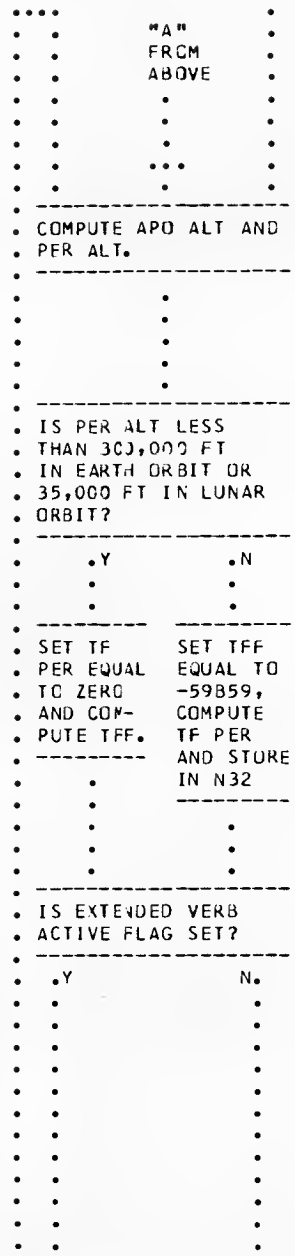


#10



#2C
#3C
#4C
#5C
#6C
#7C


CORRECT?
.Y
.N
WAIT FOR KEYBOARD ENTRY
KEY IN PRO-CEED
#80
TERMINATE FLASH UPON RECEIPT OF PROCEED, TERMINATE, OR NEW DATA
KEY IN V22E AND LOAD THE DESIRED VEHICLE (LM OR CSM) CODE IN-TO R2.
.P .T .NEW
.R .E .CODE
.O .R .DATA
.C .M
.E .I
.E .N
.O .A
.T STORE CODE
.E DATA
#90
#100
.GO TO "B" BELOW
EXTRAPOLATE SELECTED VEHICLE STATE VECTOR TO PRESENT TIME USING PRECISION INTEGRATION
#110



#12C

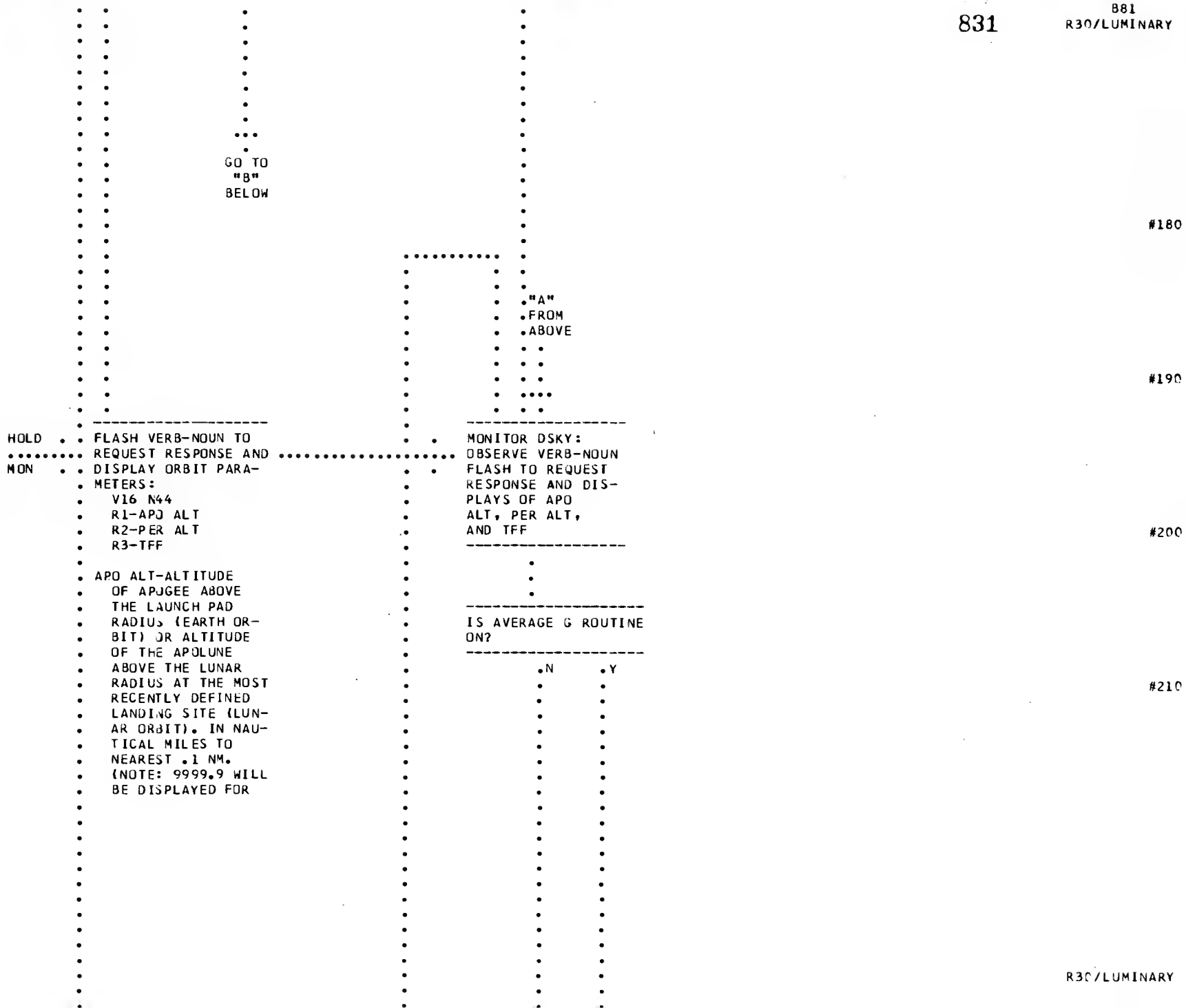
#13C

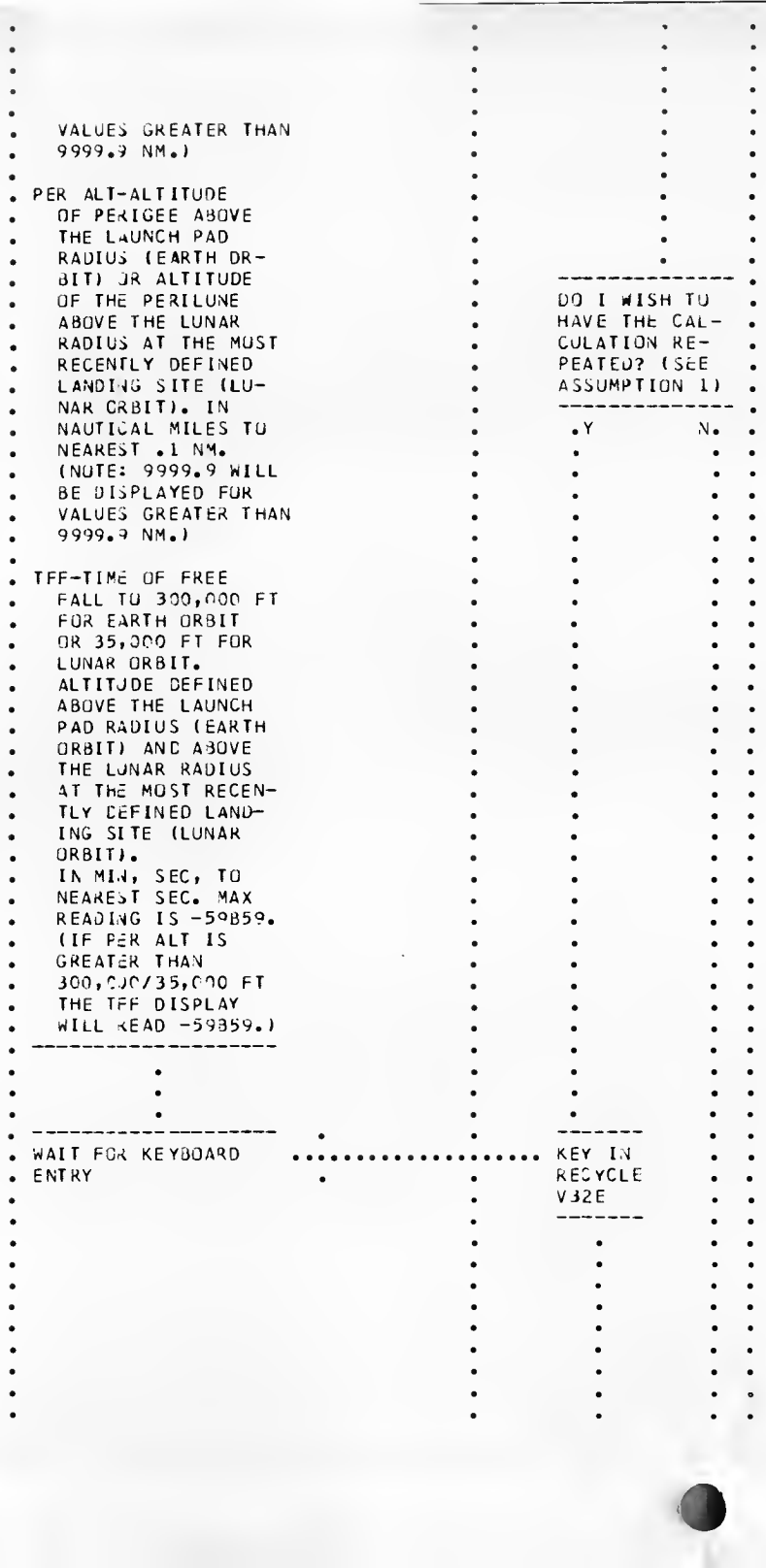
#14C

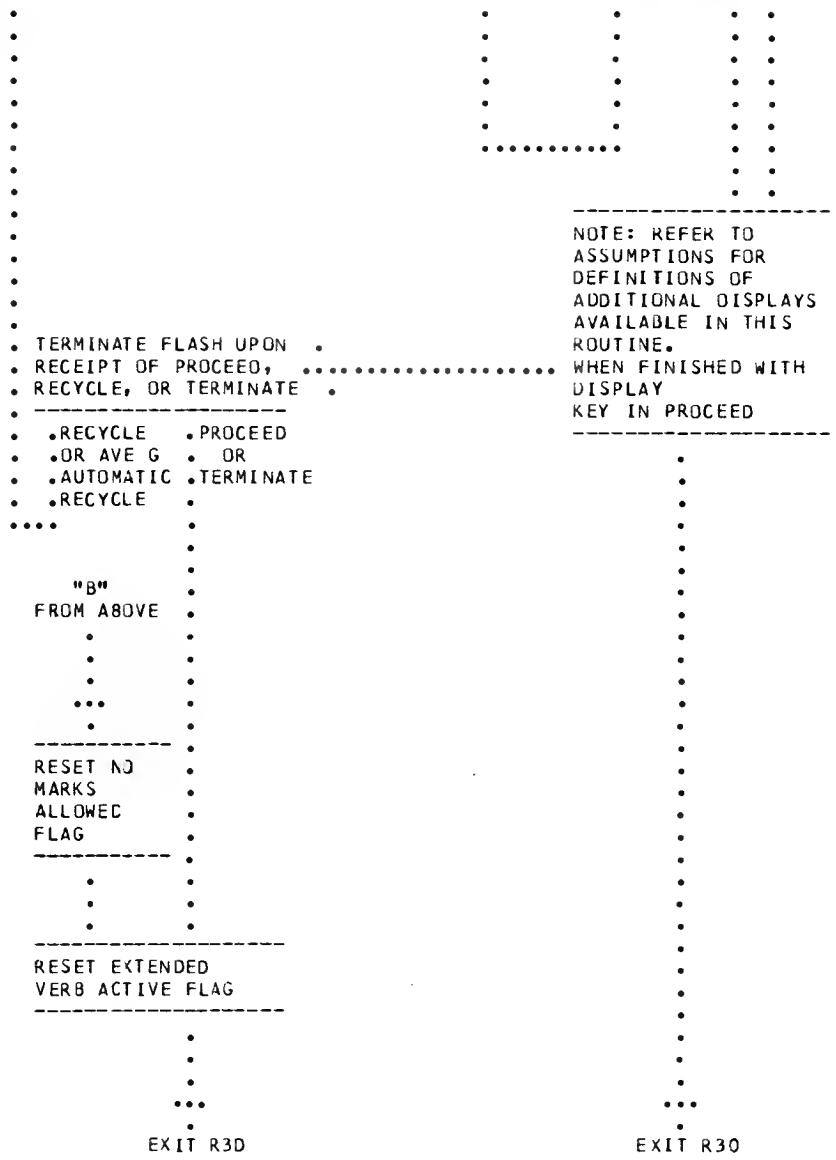
#15C

#16C

#17C


GO TO
"B"
BELOW
"A"
FROM
ABOVE
HOLD
MON
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY ORBIT PARAMETERS:
V16 N44
R1-APO ALT
R2-PER ALT
R3-TFF
APO ALT-ALTITUDE OF APOGEE ABOVE THE LAUNCH PAD RADIUS (EARTH ORBIT) OR ALTITUDE OF THE APOLUNE ABOVE THE LUNAR RADIUS AT THE MOST RECENTLY DEFINED LANDING SITE (LUNAR ORBIT). IN NAUTICAL MILES TO NEAREST .1 NM. (NOTE: 9999.9 WILL BE DISPLAYED FOR
MONITOR DSKY: OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAYS OF APO ALT, PER ALT, AND TFF
IS AVERAGE G ROUTINE ON?
N
Y
#180
#190
#200
#210


VALUES GREATER THAN 9999.9 NM.)
PER ALT-ALTITUDE OF PERIGEE ABOVE THE LAUNCH PAD RADIUS (EARTH ORBIT) OR ALTITUDE OF THE PERILUNE ABOVE THE LUNAR RADIUS AT THE MOST RECENTLY DEFINED LANDING SITE (LUNAR ORBIT). IN NAUTICAL MILES TO NEAREST .1 NM. (NOTE: 9999.9 WILL BE DISPLAYED FOR VALUES GREATER THAN 9999.9 NM.)
TFF-TIME OF FREE FALL TO 300,000 FT FOR EARTH ORBIT OR 35,000 FT FOR LUNAR ORBIT. ALTITUDE DEFINED ABOVE THE LAUNCH PAD RADIUS (EARTH ORBIT) AND ABOVE THE LUNAR RADIUS AT THE MOST RECENTLY DEFINED LANDING SITE (LUNAR ORBIT). IN MIN, SEC, TO NEAREST SEC. MAX READING IS -59B59. (IF PER ALT IS GREATER THAN 300,000/35,000 FT THE TFF DISPLAY WILL READ -59B59.)
WAIT FOR KEYBOARD ENTRY
DO I WISH TO HAVE THE CALCULATION REPEATED? (SEE ASSUMPTION 1)
.Y
N.
KEY IN RECYCLE V32E
#220
#230
#240
#250
#260
#270



#280

#290

#300

#310

#320

CHANGE CONTROL NOTES

LOGIC REV 01 PCR 405,490,518,604,614
      REV 02 EDITORIAL
      REV 03 EDITORIAL
      REV 04 PCN 1009
      REV 05(LUM LE) PCN 1145

RENDEZVOUS PARAMETER DISPLAY ROUTINE (R31) REV 05 02/17/71

PURPOSE: (1) TO DISPLAY AT ASTRONAUT REQUEST LGC CALCULATED RENDEZVOUS PARAMETERS (RANGE, RANGE RATE, THETA).

ASSUMPTIONS: (1) RANGE AND RANGE RATE ARE CALCULATED BY THE LGC ON THE BASIS OF THE STORED LM AND CSM STATE VECTORS AND DO NOT REQUIRE THAT THE ISS BE ON. THE ISS MUST BE ON AND ALIGNED TO A "KNOWN" ORIENTATION IF A CORRECT DISPLAY OF THETA IS DESIRED. THE RANGE/RANGE RATE/THETA DISPLAY IS NOT INHIBITED IF THE ISS IS NOT ON AND ALIGNED. THE RENDEZVOUS RADAR IS NOT REQUIRED TO BE OPERATING.

(2) TO MONITOR THE PROGRESS OF STATE VECTOR INTEGRATION; THE TIME ASSOCIATED WITH THE ADVANCING (REGRESSING) STATE IS AVAILABLE BY KEYING IN V06N38E:

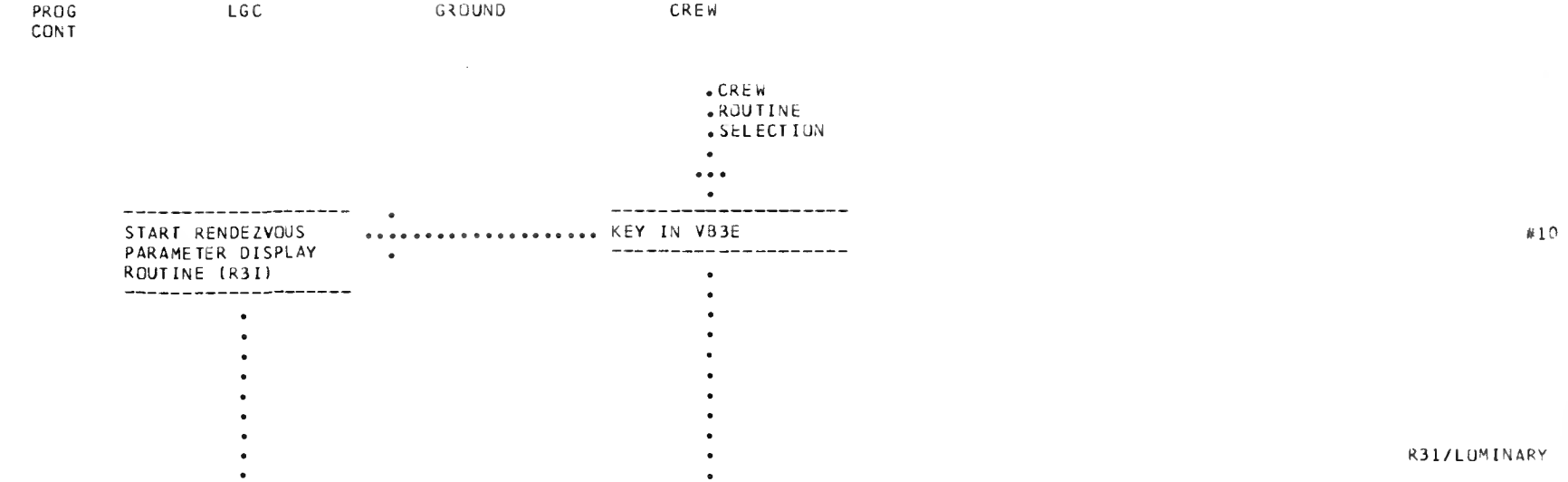
V06N38
R1-TET-HRS
R2-TET-MINS
R3-TET-SECS

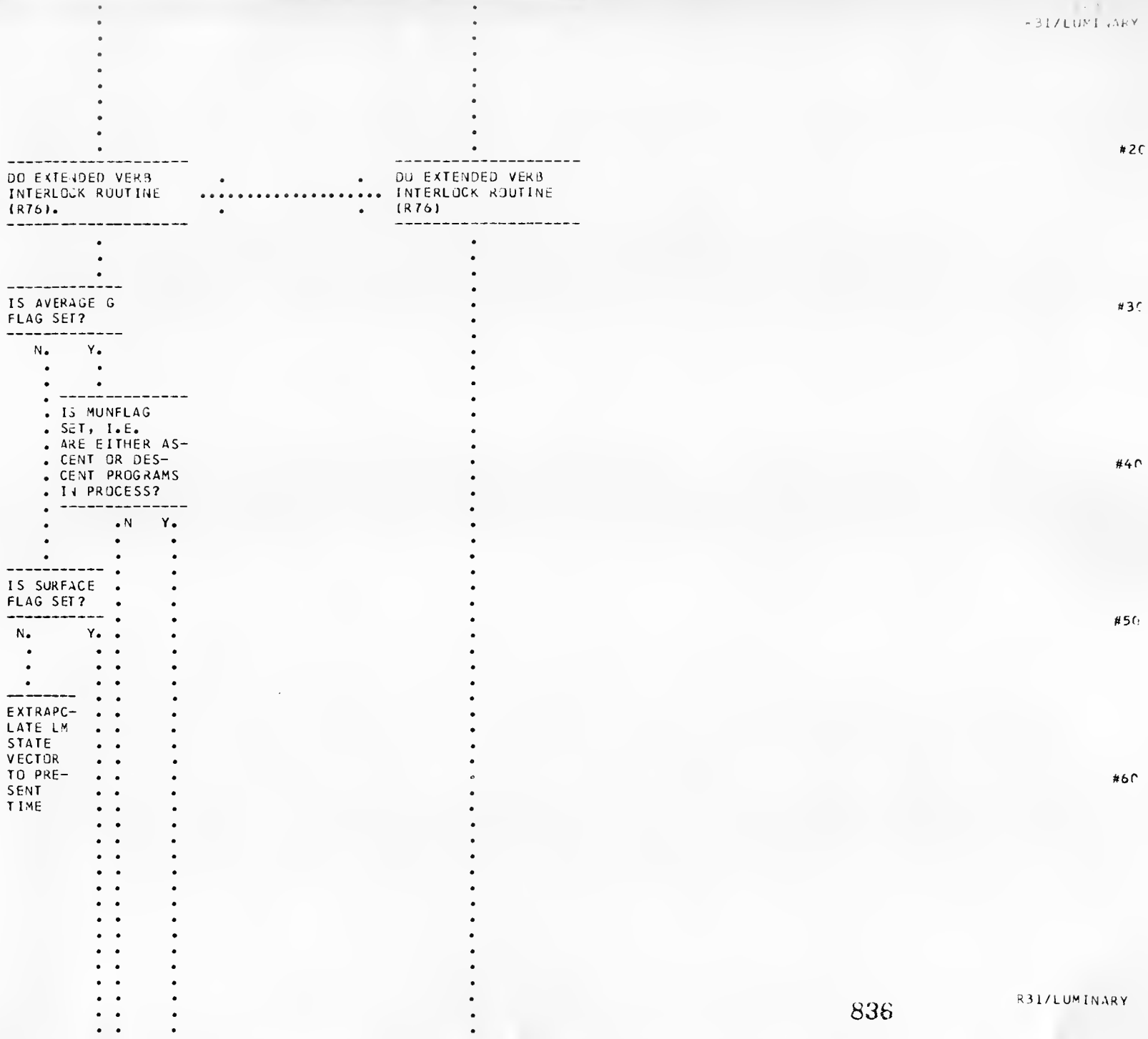
TET-THE TIME (GET) TO WHICH THE STATE VECTOR INTEGRATION PROCESS HAS PRESENTLY CALCULATED THE STATE VECTOR. IN HRS, MINS, AND SECS TO NEAREST .01 SEC.

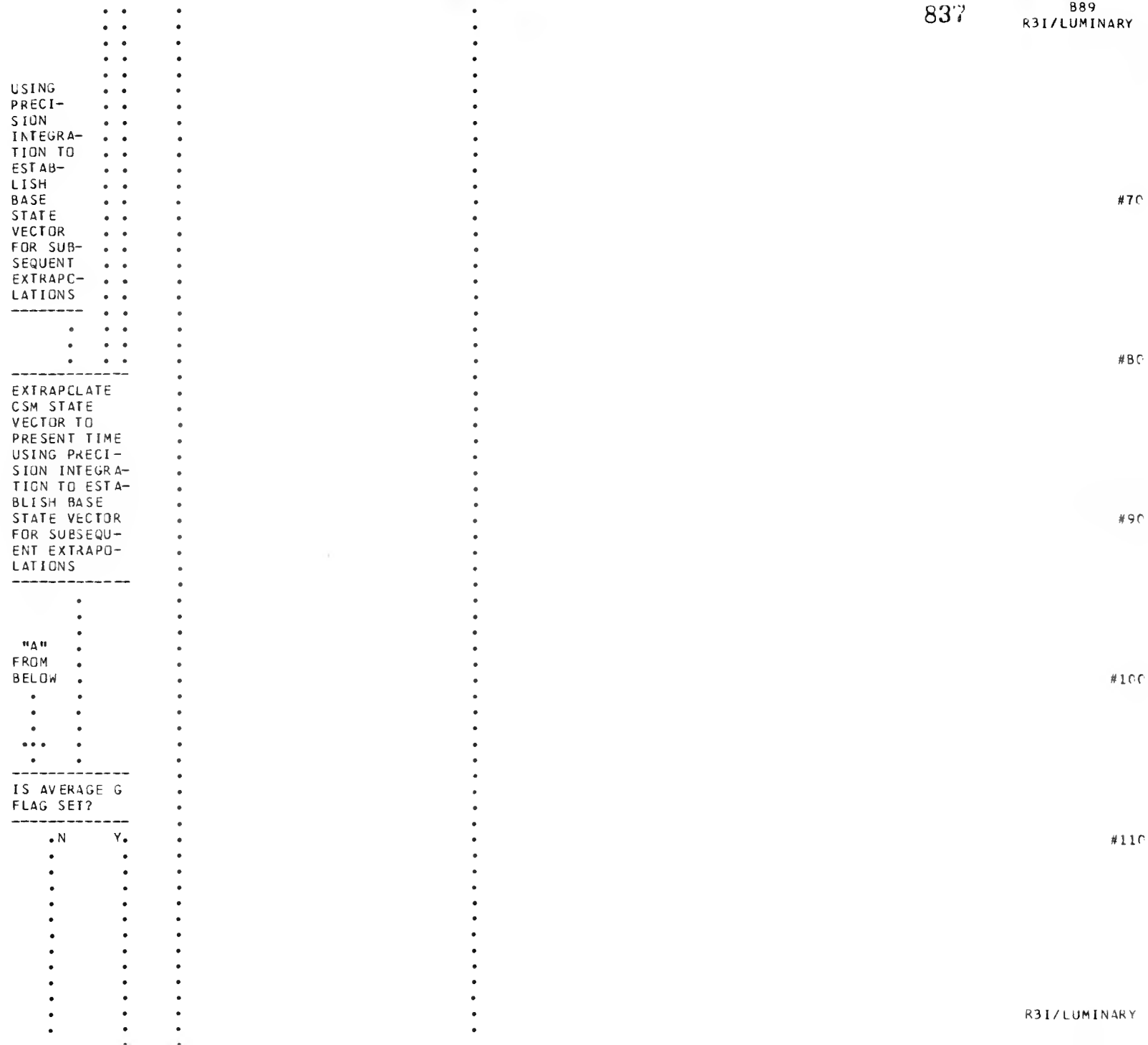
(3) IF NAVIGATION MARKS ARE MADE AFTER THIS ROUTINE IS SELECTED AND RUNNING, THE EFFECT OF THE MARKS ON THE STATE VECTOR WILL NOT BE EXHIBITED IN THE DISPLAY OF RANGE AND RANGE RATE. TO SEE THE EFFECT OF THE NAVIGATION MARKS ON THE RANGE AND RANGE RATE IN N54, THE ASTRONAUT MUST TERMINATE THIS ROUTINE (PROCEED) AND RE-SELECT IT (V83E).

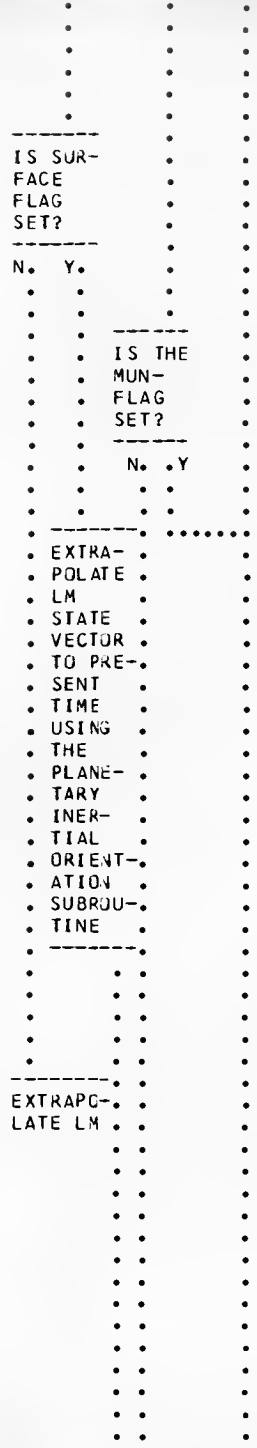
(4) IF R31 IS RUN FOR A LONG TIME IN COASTING FLIGHT THE RANGE AND RANGE RATE INFORMATION IN N54 WILL BEGIN TO DEGENERATE BECAUSE OF THE CONIC EXTRAPOLATIONS OF THE STATE VECTORS.

(5) THE ROUTINE IS SELECTED BY THE ASTRONAUT BY DSKY ENTRY.




DO EXTENDED VERB INTERLOCK ROUTINE (R76).
DO EXTENDED VERB INTERLOCK ROUTINE (R76)
#20
IS AVERAGE G FLAG SET?
#30
N.
Y.
IS MUNFLAG SET, I.E. ARE EITHER ASCENT OR DESCENT PROGRAMS IN PROCESS?
#40
N
Y.
IS SURFACE FLAG SET?
#50
N.
Y.
EXTRAPOLATE LM STATE VECTOR TO PRESENT TIME
#60


USING PRECI-SION INTEGRA-TION TO ESTAB-LISH BASE STATE VECTOR FOR SUB-SEQUENT EXTRAPC-LATIONS
#70
#80
EXTRAPOLATE CSM STATE VECTOR TO PRESENT TIME USING PRECI-SION INTEGRA-TION TO ESTA-BLISH BASE STATE VECTOR FOR SUBSEQU-ENT EXTRAPO-LATIONS
#90
"A" FROM BELOW
#100
IS AVERAGE G FLAG SET?
N
Y
#110

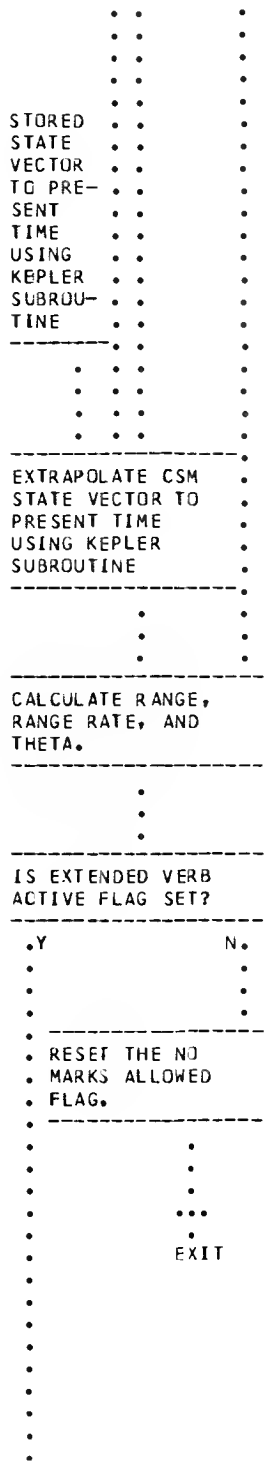


#120

#130

#140

#150



#160

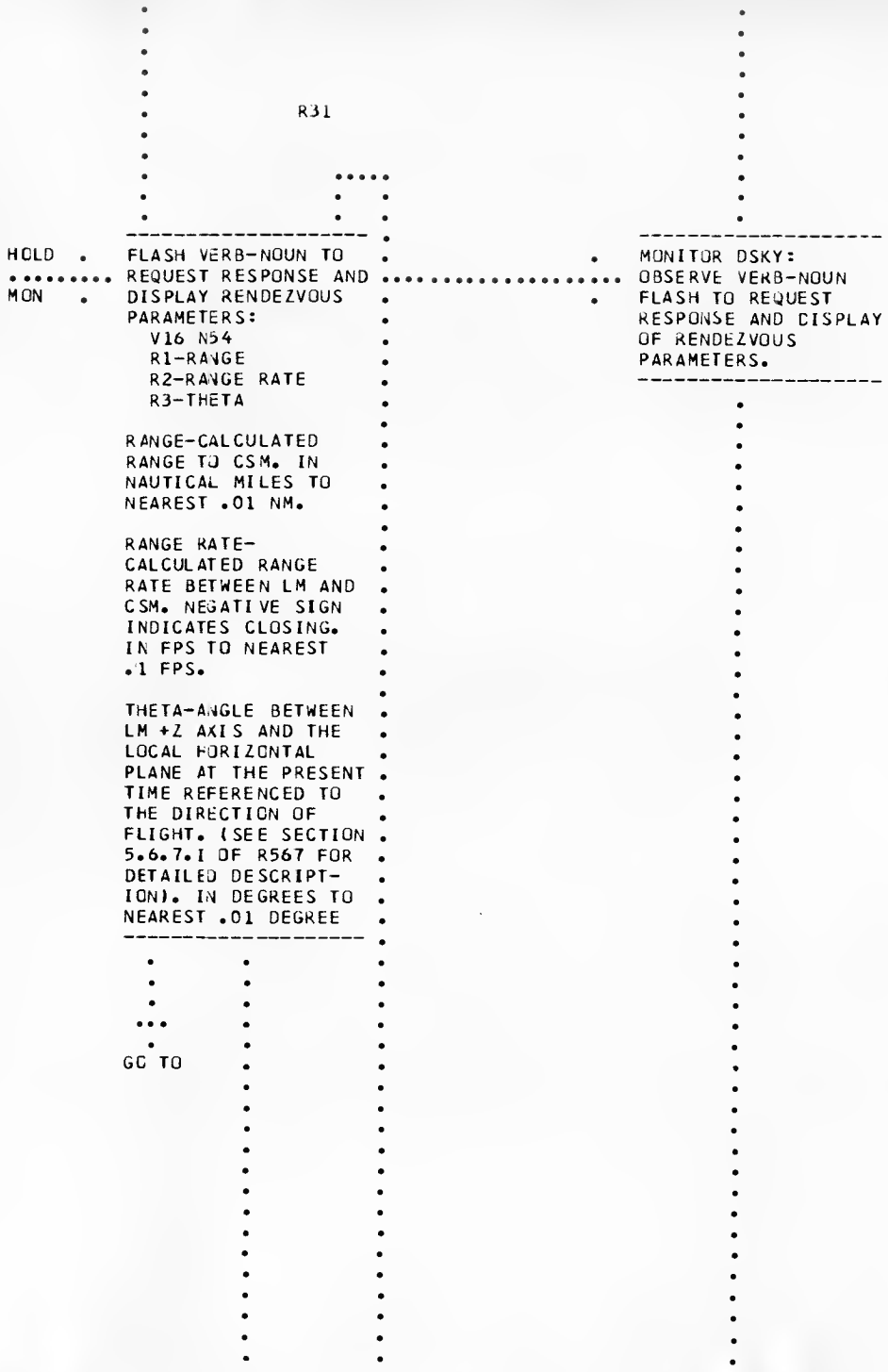
#170

#180

#190

#200

#210

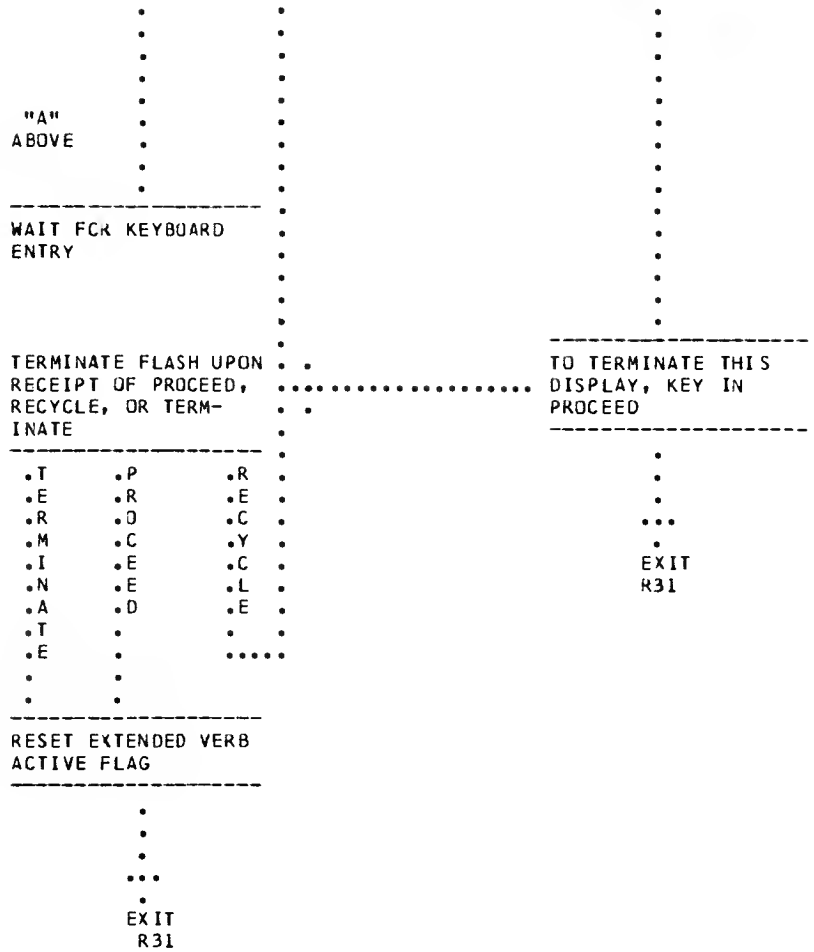


#220

#230

#240

#250



#260

#270

#280

#290

CHANGE CONTROL NOTES

REV 01 PCR 190,614,622
REV 02(LUM 1A) PCR 654,EDITORIAL
REV 03 EDITORIAL
REV 04 PCN 1009
REV 05(LUM 1E) PCN 1145

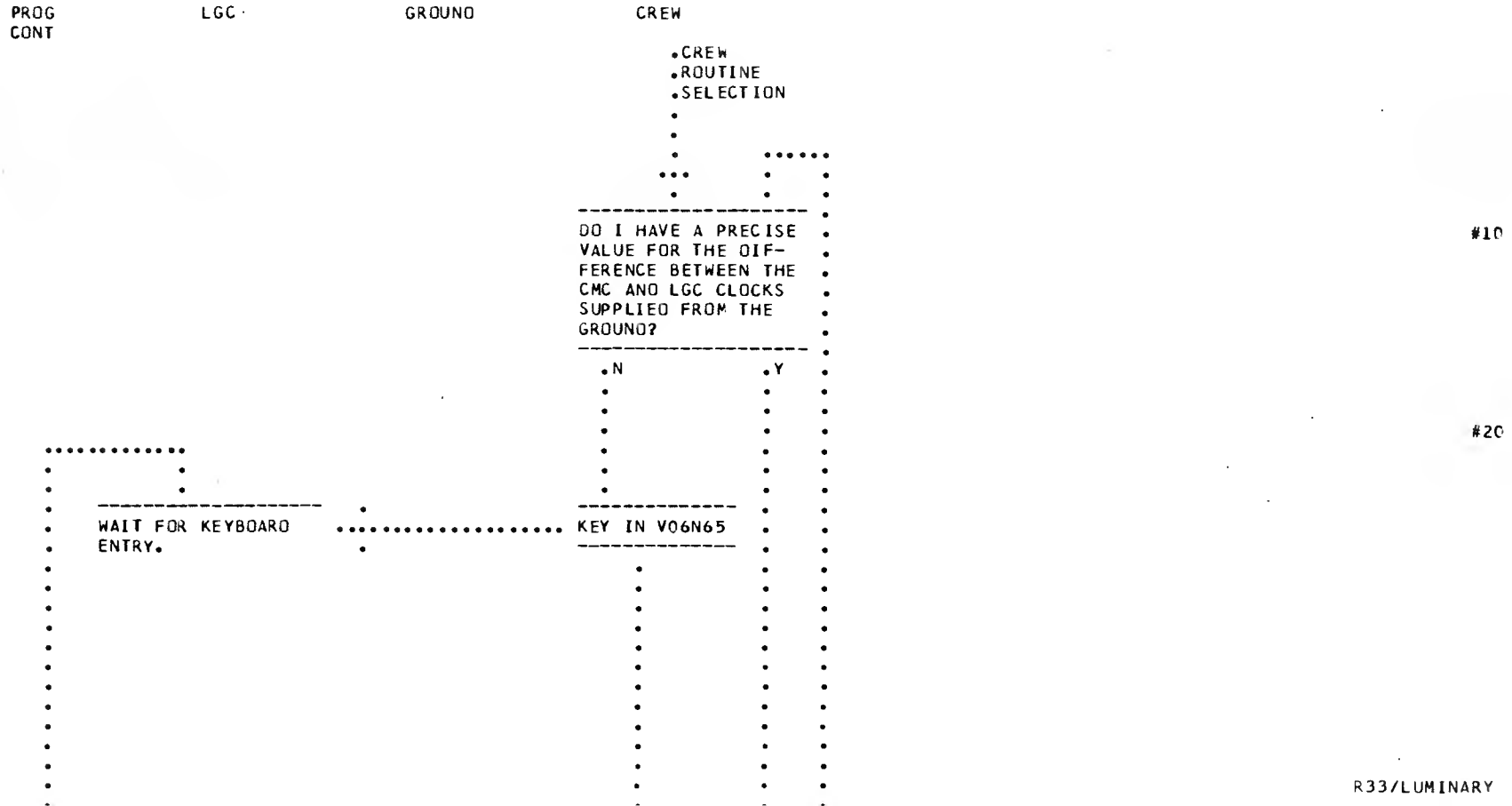
LGC/CMC CLOCK SYNCHRONIZATION ROUTINE (R33) REV 01 01/09/69

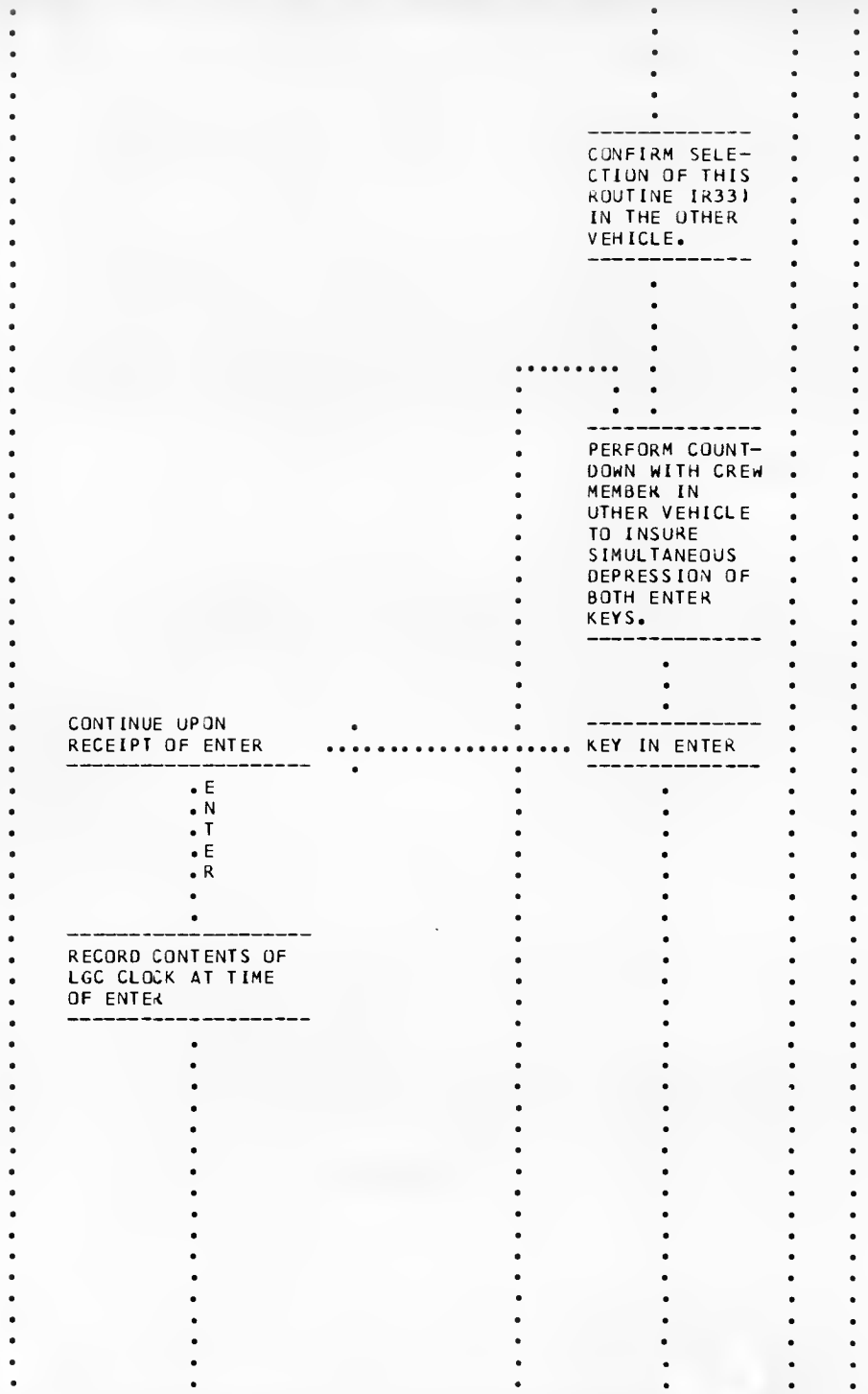
PURPOSE: (1) TO SYNCHRONIZE THE LGC CLOCK WITH THE CMC CLOCK.

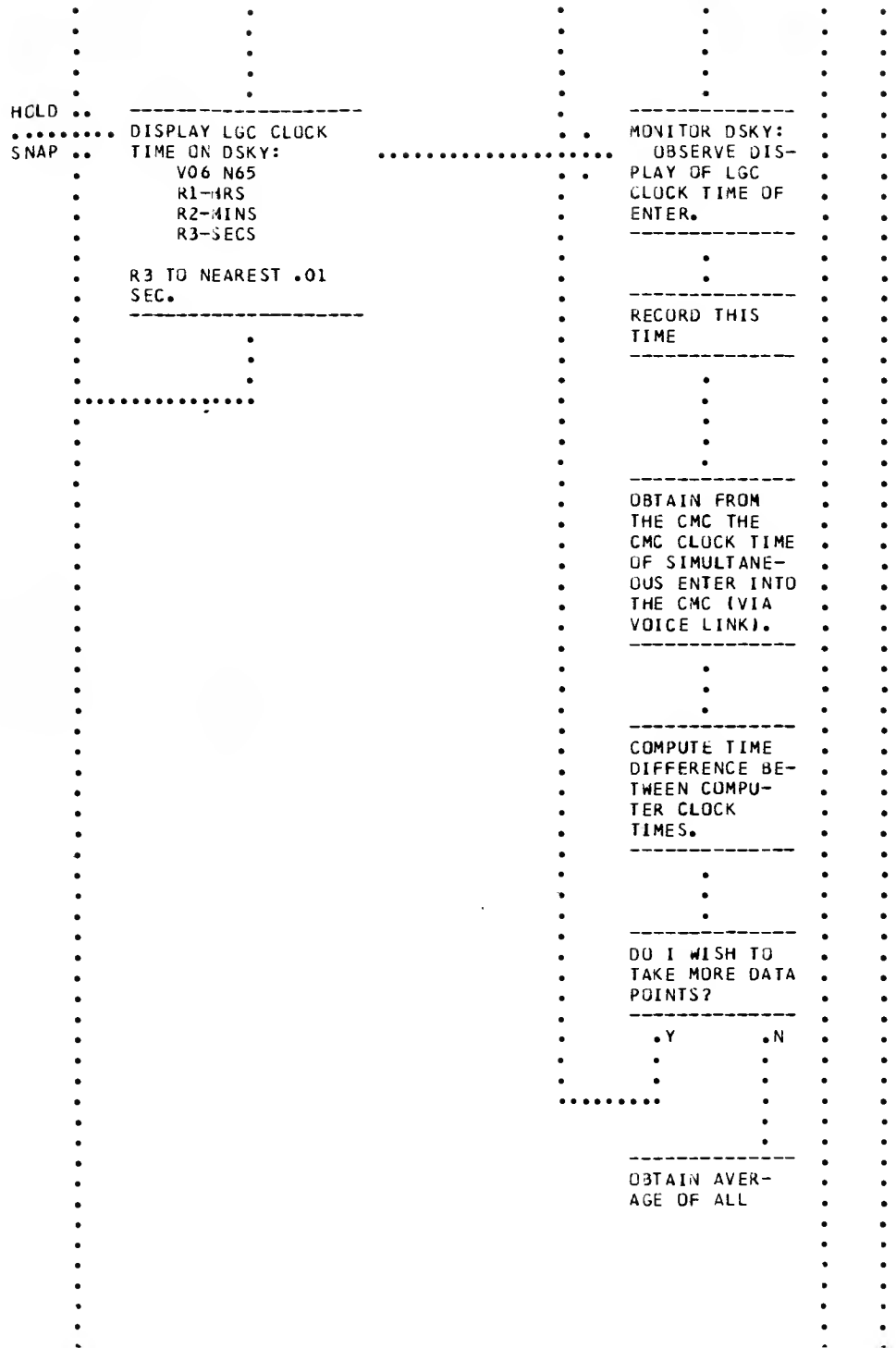
ASSUMPTIONS: (1) SYNCHRONIZATION REQJIRES A OETERMINATION OF THE VALUE OF THE OIFFERENCE BETWEEN THE TWO CLOCKS. THIS VALUE MAY BE OBTAINEO OIRECTLY FROM COOROINATEO READING OF THE TWO CLOCKS OR MAY BE PROVIOED BY THE GROUNO FROM OOWNLINK MONITORING OF THE CLOCKS.

(2) THE LGC IS ON. THE CMC NEEO ONLY BE ON UNTIL SATISFACTORY COMPARATIVE READINGS HAVE BEEN MAOE BY THE CREW OR GROUND.

(3) THIS ROUTINE IS SELECTEO BY THE ASTRONAUT BY OSKY ENTRY.




CONFIRM SELECTION OF THIS ROUTINE (R33) IN THE OTHER VEHICLE.
#30
PERFORM COUNTDOWN WITH CREW MEMBER IN OTHER VEHICLE TO INSURE SIMULTANEOUS DEPRESSION OF BOTH ENTER KEYS.
#40
KEY IN ENTER
#50
CONTINUE UPON RECEIPT OF ENTER
ENTER
#60
RECORD CONTENTS OF LGC CLOCK AT TIME OF ENTER
#70



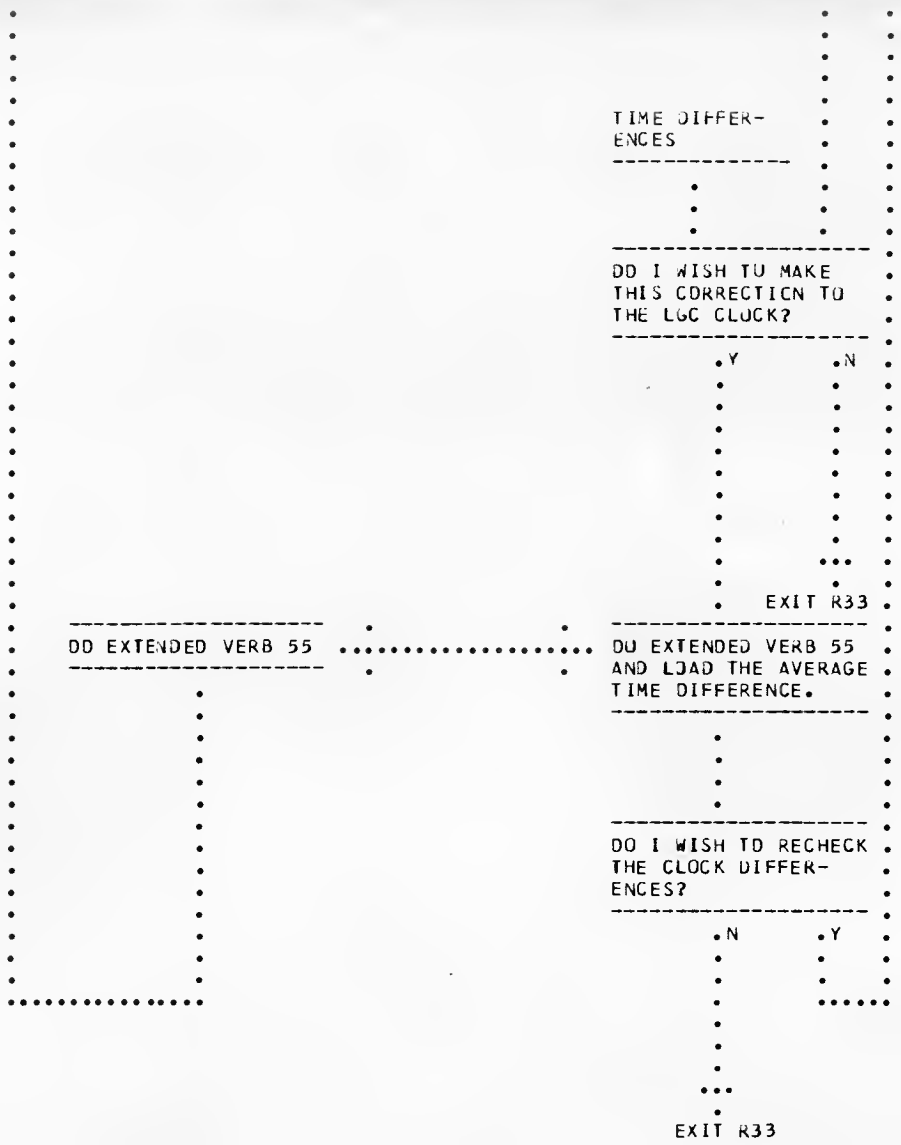
#80

#90

#100

#110

#120



#130

#140

#150

#160

#170

CHANGE CONTROL NOTES

LOGIC REV 01 PCR 513

RENDEZVOUS OUT-OF-PLANE DISPLAY ROUTINE (R36) REV 03 09/03/70

PURPOSE: (1) TO DISPLAY AT ASTRONAUT REQUEST LGC CALCULATED RENDEZVOUS OUT-OF-PLANE PARAMETERS (Y, Y DOT, PSI)

ASSUMPTIONS: (1) THESE PARAMETERS ARE CALCULATED BY THE LGC ON THE BASIS OF THE STORED LM AND CSM STATE VECTORS AND DO NOT REQUIRE THAT THE ISS BE ON.

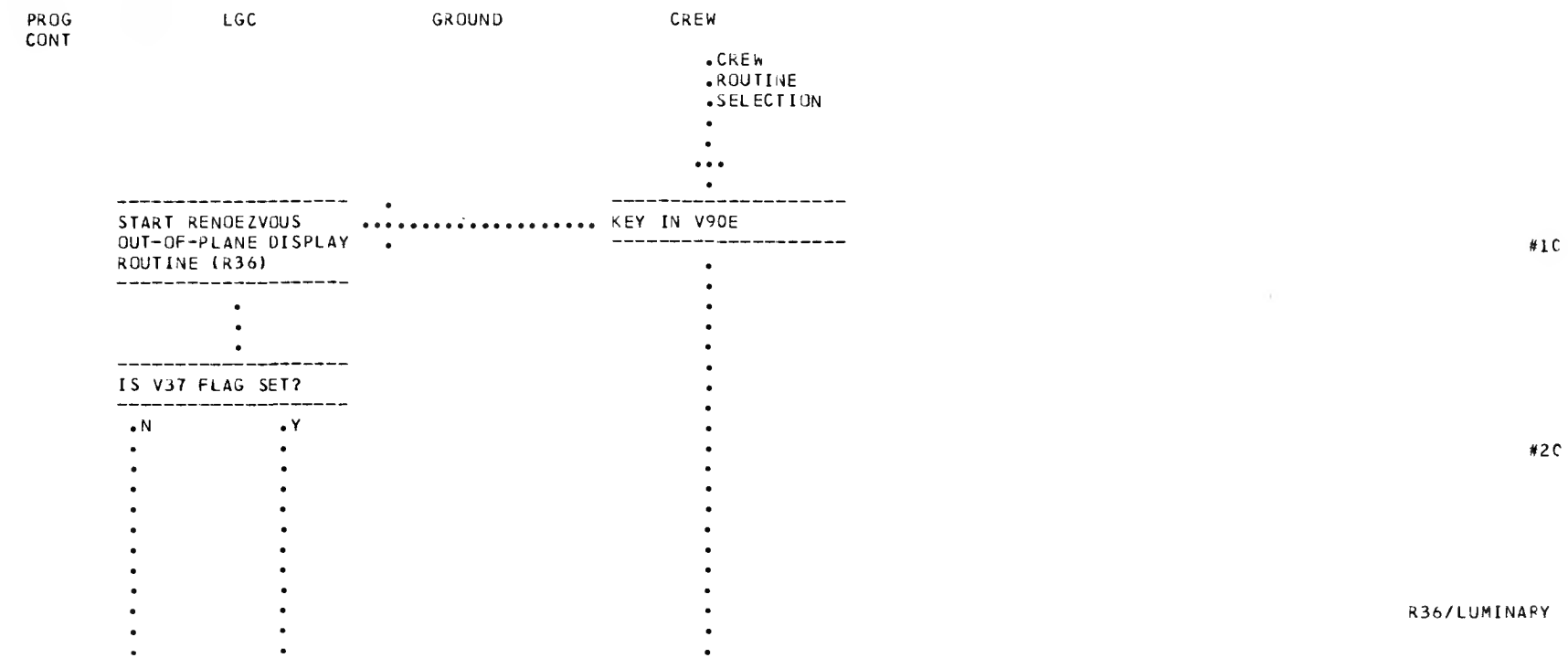
(2) TO MONITOR THE PROGRESS OF STATE VECTOR INTEGRATION, THE TIME ASSOCIATED WITH THE ADVANCING (REGRESSING) STATE IS AVAILABLE BY KEYING IN V06N38E:

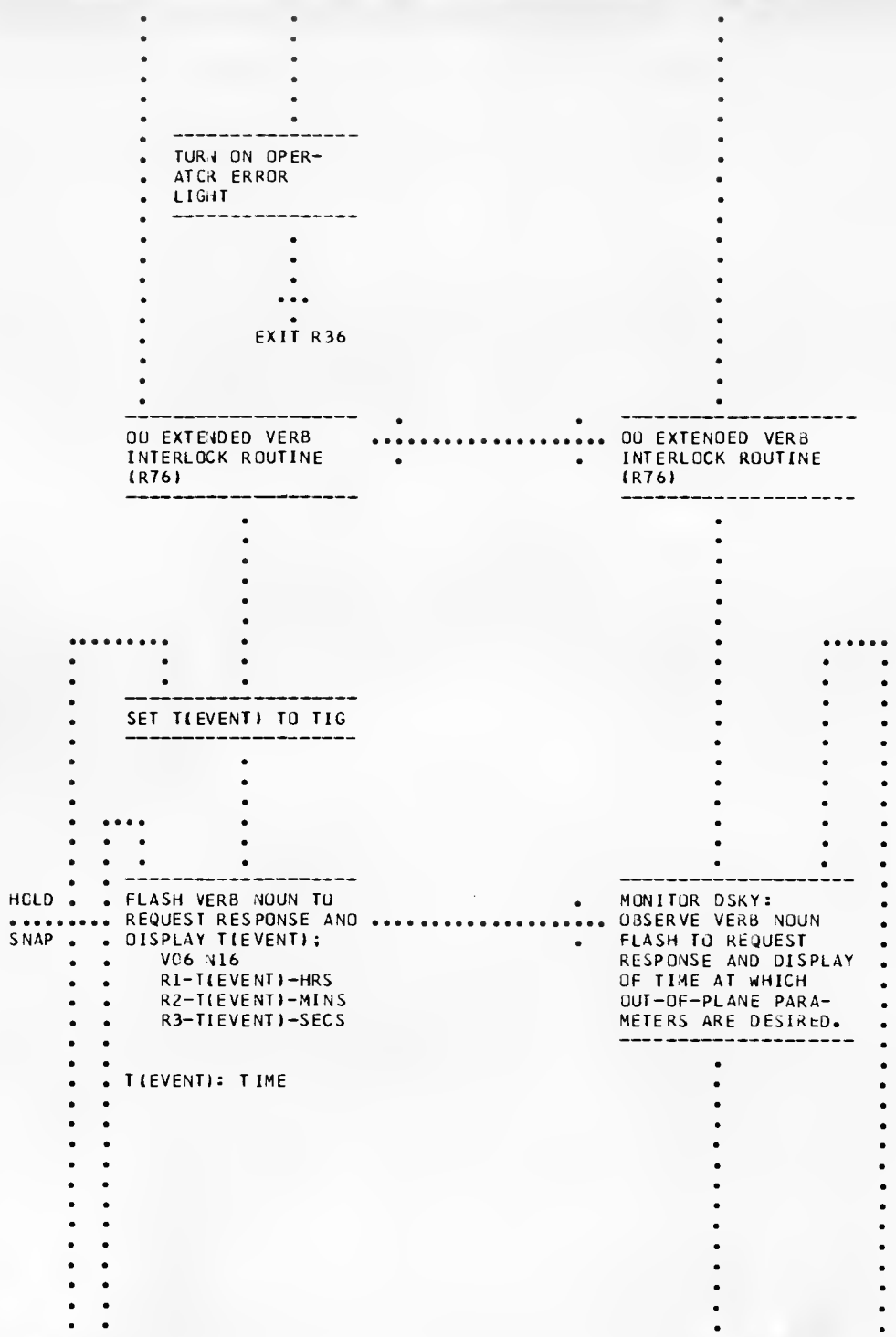
V06N38
R1-TET-HRS
R2-TET-MINS
R3-TET-SECS

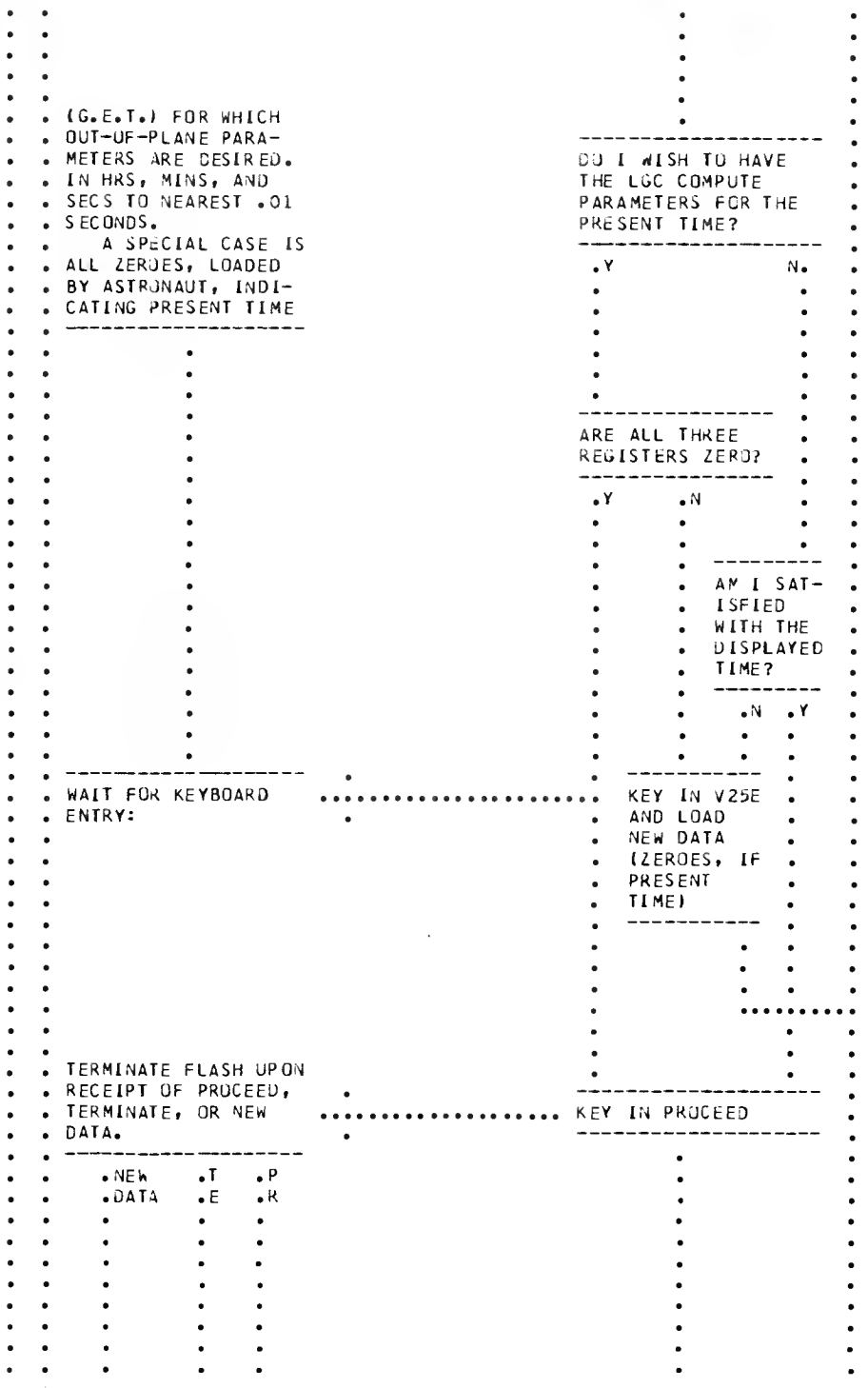
TET-THE TIME (GET) TO WHICH THE STATE VECTOR INTEGRATION PROCESS HAS PRESENTLY CALCULATED THE STATE VECTOR. IN HRS,MINS, AND SECS TO NEAREST .01 SEC.

(3) THIS ROUTINE MAY NOT BE CALLED WHILE AVERAGE G IS RUNNING.

(4) THE ROUTINE IS SELECTED BY THE ASTRONAUT BY DSKY ENTRY.




TURN ON OPER-
ATOR ERROR
LIGHT
EXIT R36
00 EXTENDED VERB
INTERLOCK ROUTINE
(R76)
00 EXTENDED VERB
INTERLOCK ROUTINE
(R76)
#30
#40
SET T(EVENT) TO TIG
#50
HOLD
SNAP
FLASH VERB NOUN TO
REQUEST RESPONSE AND
DISPLAY T(EVENT);
V06 N16
R1-T(EVENT)-HRS
R2-T(EVENT)-MINS
R3-T(EVENT)-SECS
T(EVENT): TIME
MONITOR DSKY:
OBSERVE VERB NOUN
FLASH TO REQUEST
RESPONSE AND DISPLAY
OF TIME AT WHICH
OUT-OF-PLANE PARA-
METERS ARE DESIRED.
#60



#70

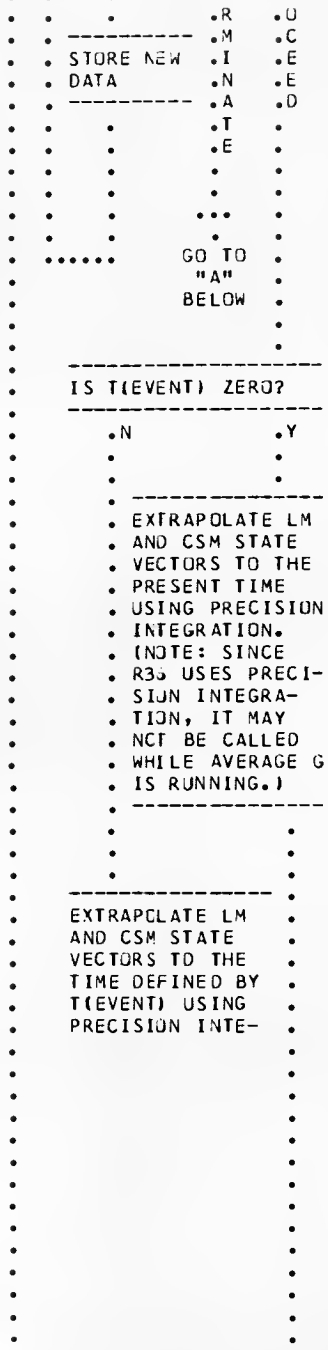
#80

#90

#100

#110

#120

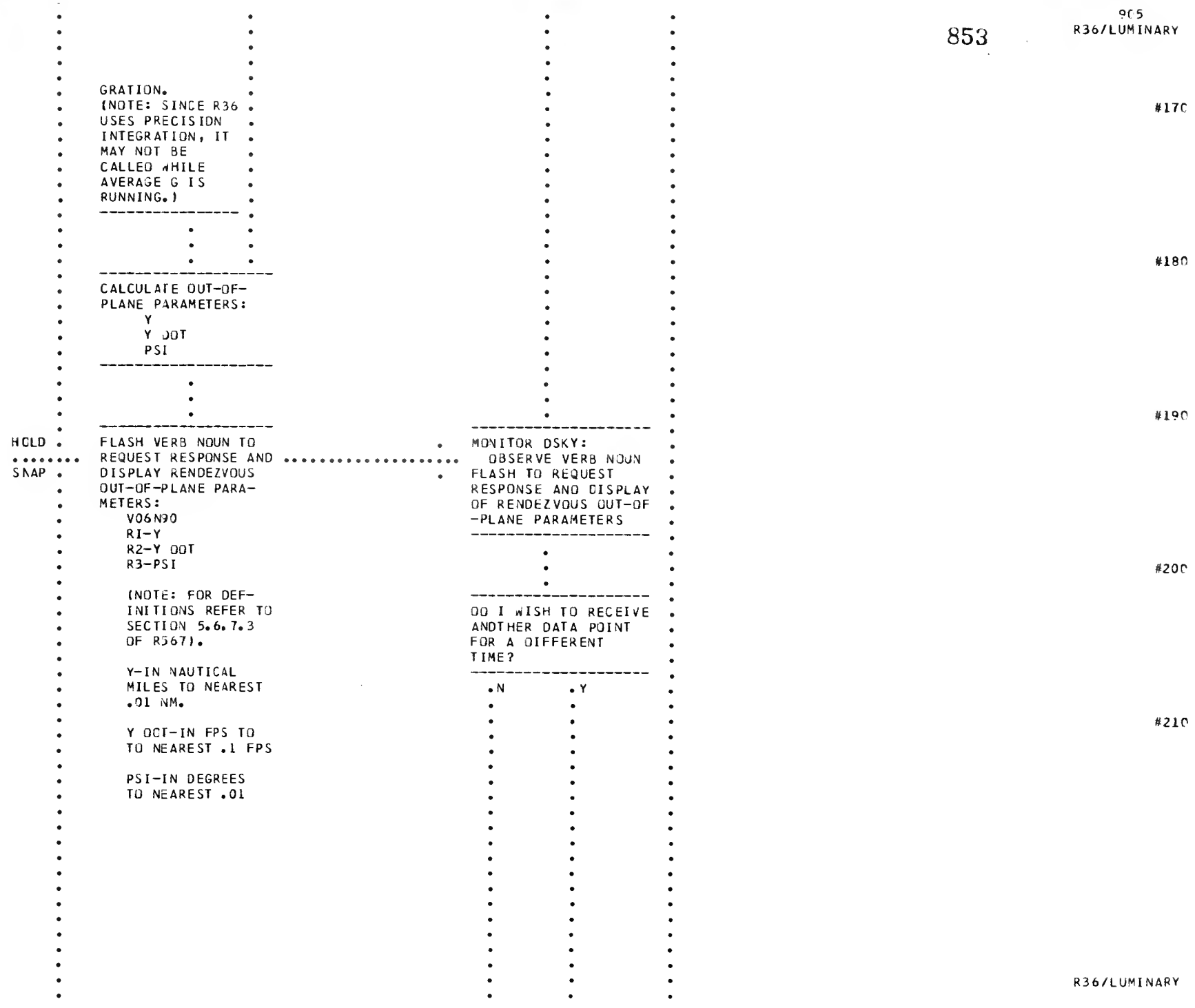


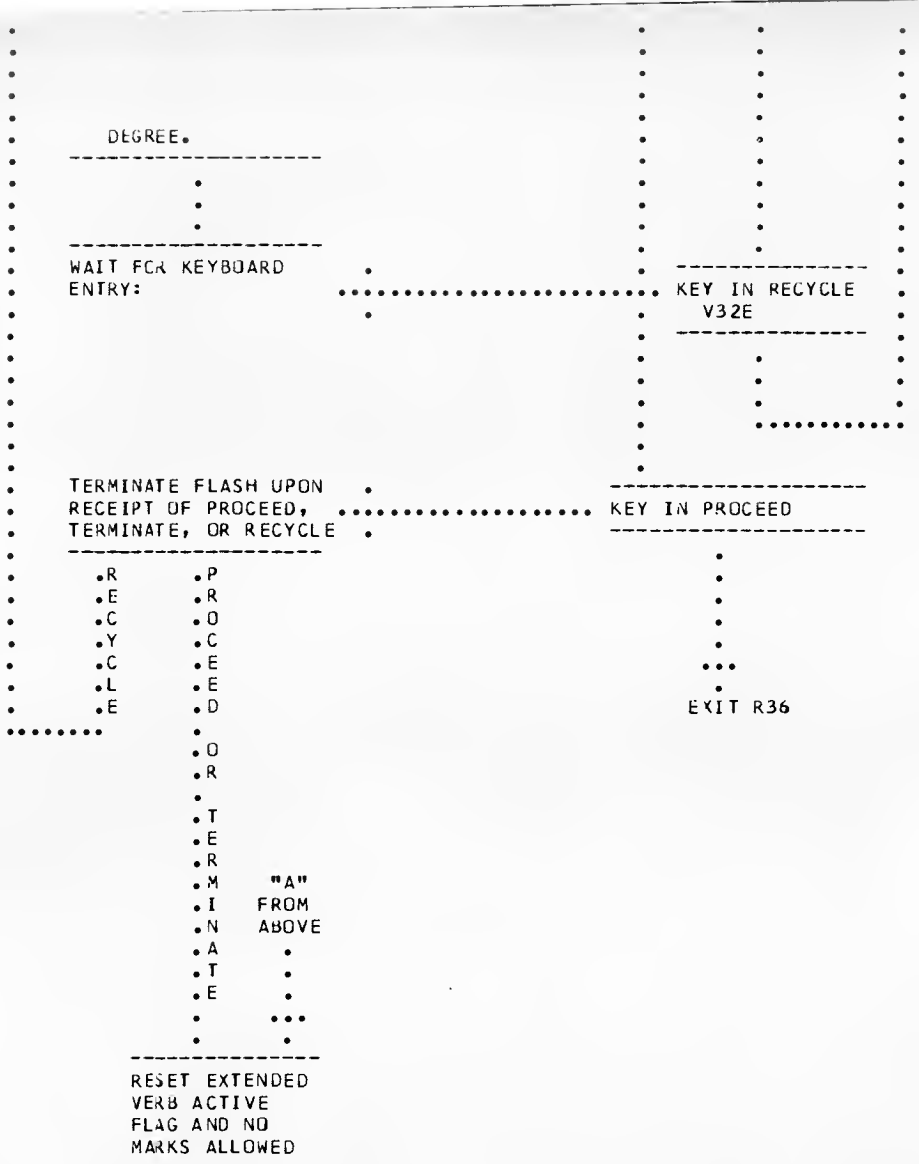
#130

#140

#150

#160


GRATION.
(NOTE: SINCE R36
USES PRECISION
INTEGRATION, IT
MAY NOT BE
CALLED WHILE
AVERAGE G IS
RUNNING.)
CALCULATE OUT-OF-
PLANE PARAMETERS:
Y
Y DOT
PSI
#170
#180
#190
HOLD
SNAP
FLASH VERB NOUN TO
REQUEST RESPONSE AND
DISPLAY RENDEZVOUS
OUT-OF-PLANE PARA-
METERS:
V06N90
R1-Y
R2-Y DOT
R3-PSI
(NOTE: FOR DEF-
INITIONS REFER TO
SECTION 5.6.7.3
OF R567).
Y-IN NAUTICAL
MILES TO NEAREST
.01 NM.
Y DOT-IN FPS TO
TO NEAREST .1 FPS
PSI-IN DEGREES
TO NEAREST .01
MONITOR DSKY:
OBSERVE VERB NOUN
FLASH TO REQUEST
RESPONSE AND DISPLAY
OF RENDEZVOUS OUT-OF
-PLANE PARAMETERS
#200
DO I WISH TO RECEIVE
ANOTHER DATA POINT
FOR A DIFFERENT
TIME?
N
Y
#210



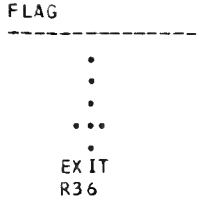
#220

#230

#240

#250

#260



#270

CHANGE CONTROL NOTES

LOGIC REV 01 PCR 407,614
REV 02(LUM 1C) PCR 936.2,EDITORIAL
REV 03(LUM 1D) PCR 1015

DPS/APS THRUST FAIL ROUTINE (R40) REV 05 12/01/71

PURPOSE: (1) TO MONITOR THE IMU PIPA OUTPUTS FOR EVIDENCE OF DPS OR APS THRUST.

(2) TO INITIATE ENGINE FAIL PROCEDURES IF THE THRUST MONITOR INDICATES A LACK OF ENGINE THRUST.

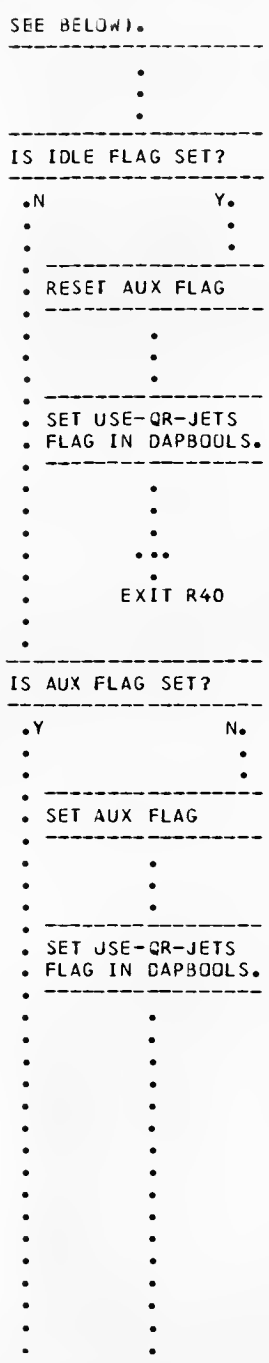
ASSUMPTIONS: (1) THIS ROUTINE IS CALLED EVERY 2 SECONDS BY SERVICER.

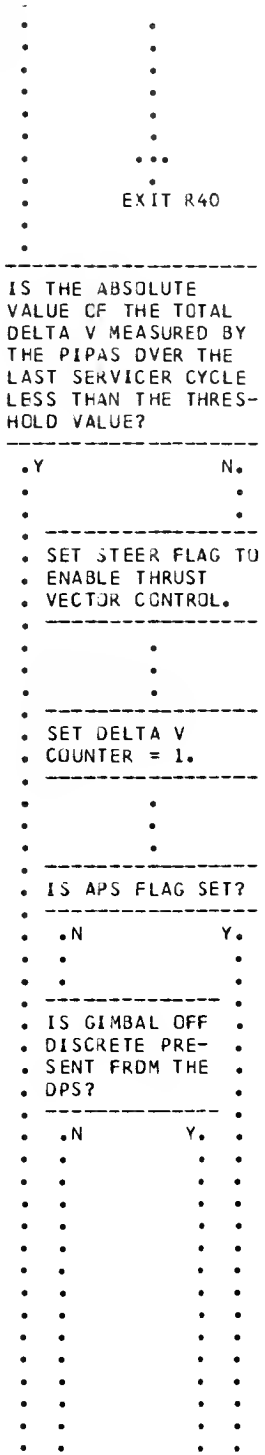
(2) THE THRUSTING PROGRAM WILL DEFINE THE THRESHOLD VALUE FOR THE DELTA V COMPARISON TO BE ONE OF THREE VALUES;
(A) DPS WITH DOCKED CSM = 12 CM/SEC
(B) DPS WITH LM ALONE = 36 CM/SEC
(C) APS WITH LM ALONE = 308 CM/SEC

THE DPS VALUES ((A) AND (B)) ARE SUCH THAT NORMAL 10% THROTTLING WILL NOT INDICATE A THRUST FAILURE.

(3) THE THRUSTING PROGRAM WILL INITIALLY SET THE DELTA V COUNTER TO 4.

PROG CONT	LGC	GROUND	CREW	
	.LGC .ROUTINE .SELECTION			
	START DPS/APS THRUST FAIL ROUTINE (R40)			#10
	. . .			
	RESET STEER FLAG TO DISABLE THRUST VECTOR CONTROL. (NOTE: IF THRUST IS SATISFACTORY THIS FLAG WILL BE IMMEDIATELY SET AGAIN.			#20


SEE BELOW).
IS IDLE FLAG SET?
N.
Y.
#30
RESET AUX FLAG
SET USE-QR-JETS FLAG IN DAPBOOLS.
#40
EXIT R40
#50
IS AUX FLAG SET?
Y.
N.
SET AUX FLAG
#60
SET USE-QR-JETS FLAG IN DAPBOOLS.



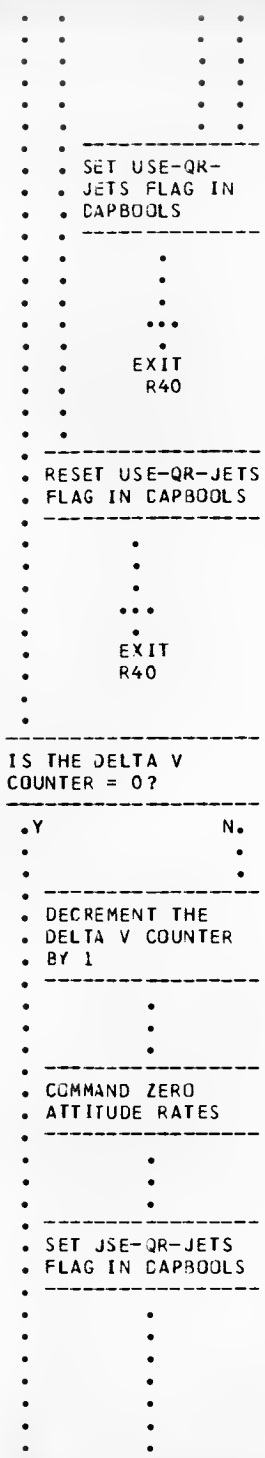
#70

#80

#90

#100

#110



#120

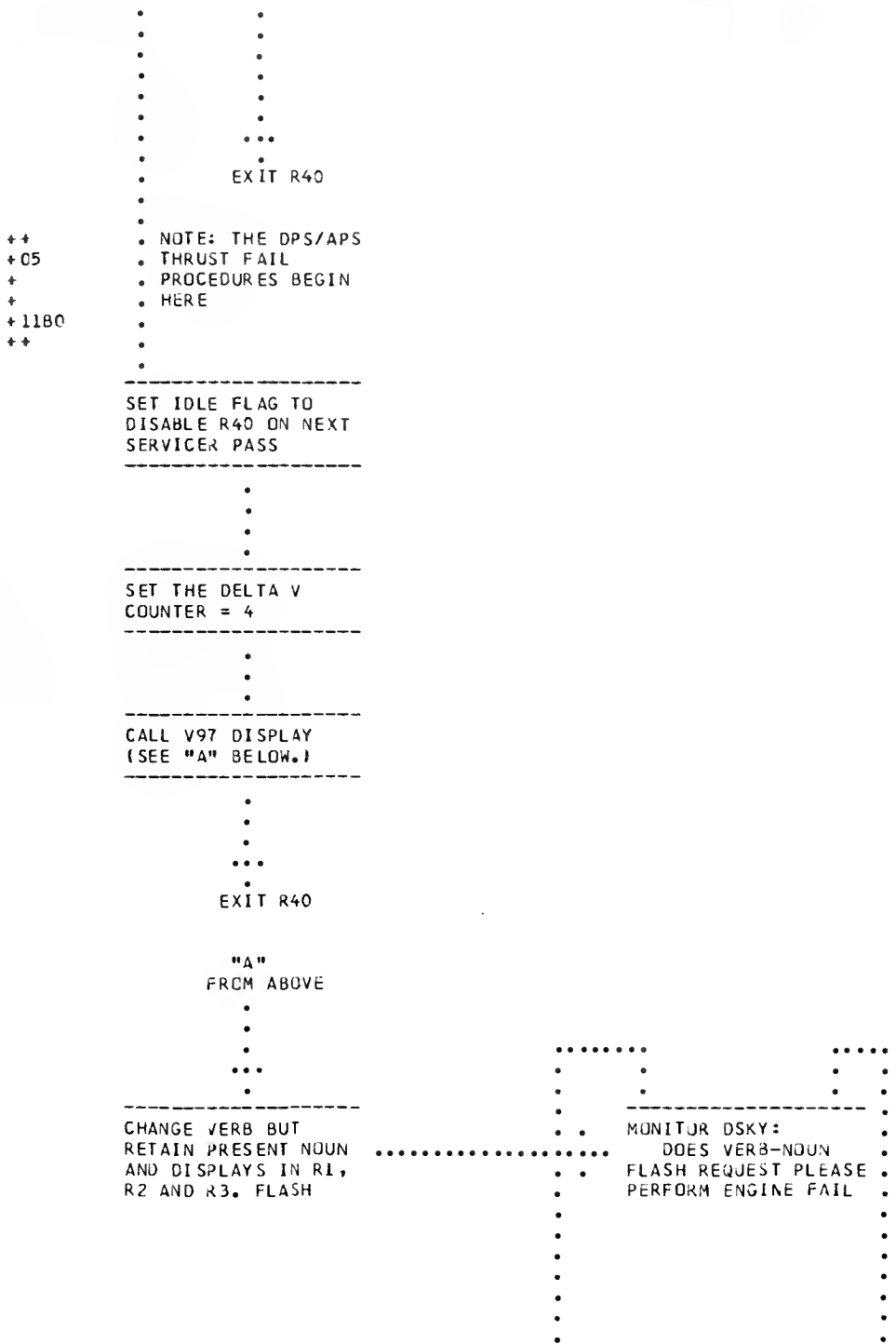
#130

#140

#150

#160

#170



++
+05
+
+
+1180
++

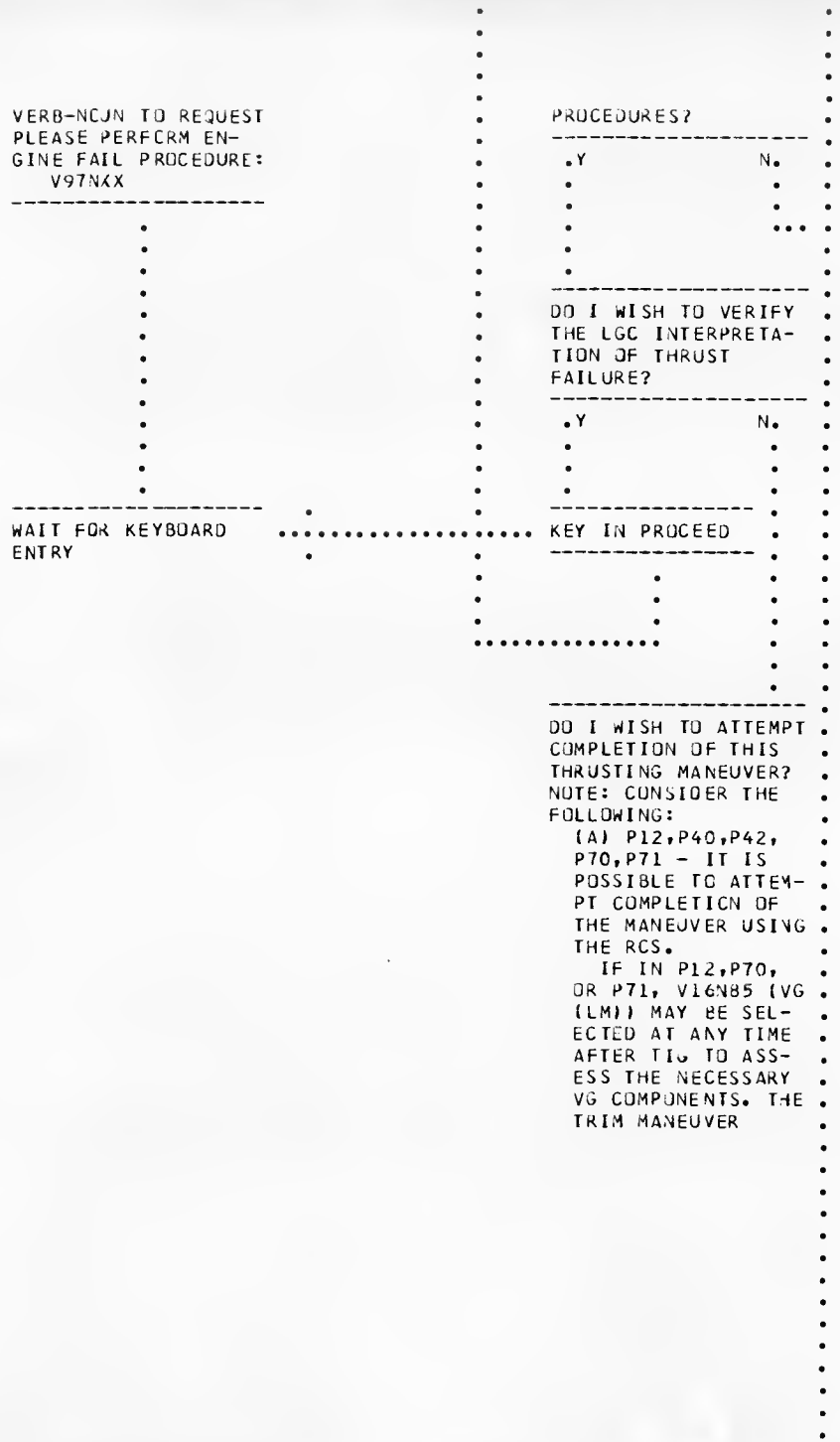
#180

#190

#200

#210

#220



#230

#240

#250

#260

#270

SHOULD NOT BE ATTEMPTED WITH THIS DISPLAY HOWEVER. TO PERFORM THE RCS TRIM MANEUVER PROCEED AS FOR P40 AND P42 AS FOLLOWS.

IF IN P40 OR P42, THE V16N85 DISPLAY CAN ONLY BE OBTAINED BY OPTING FOR THE RCS TRIM MANEUVER, I.E.: KEY IN "ENTER" IN RESPONSE TO V97 (NDW), THEN "ENTER" IN RESPONSE TO V99, THEN "PROCEED" IN RESPONSE TO V16N40 (V16N94 FOR P12, P70 AND P71).

(B) P40,P42 - THE NORMAL DISPLAY (V06N40-TFC,VG, DELTA VM) IS AVAILABLE TO ASSESS ANTICIPATED DURATION OF BURN.

(C) P12,70,71 - FOR AN ATTEMPTED RESTART OF THE MAIN ENGINE THE LGC WILL MAKE NO CALCULATION TO ANTICIPATE A POSSIBLE MINIMUM IMPULSE BURN. V16N77 (TG, VGY(LM), VI) MAY BE SELECTED AT THIS TIME TO ASSESS TG.

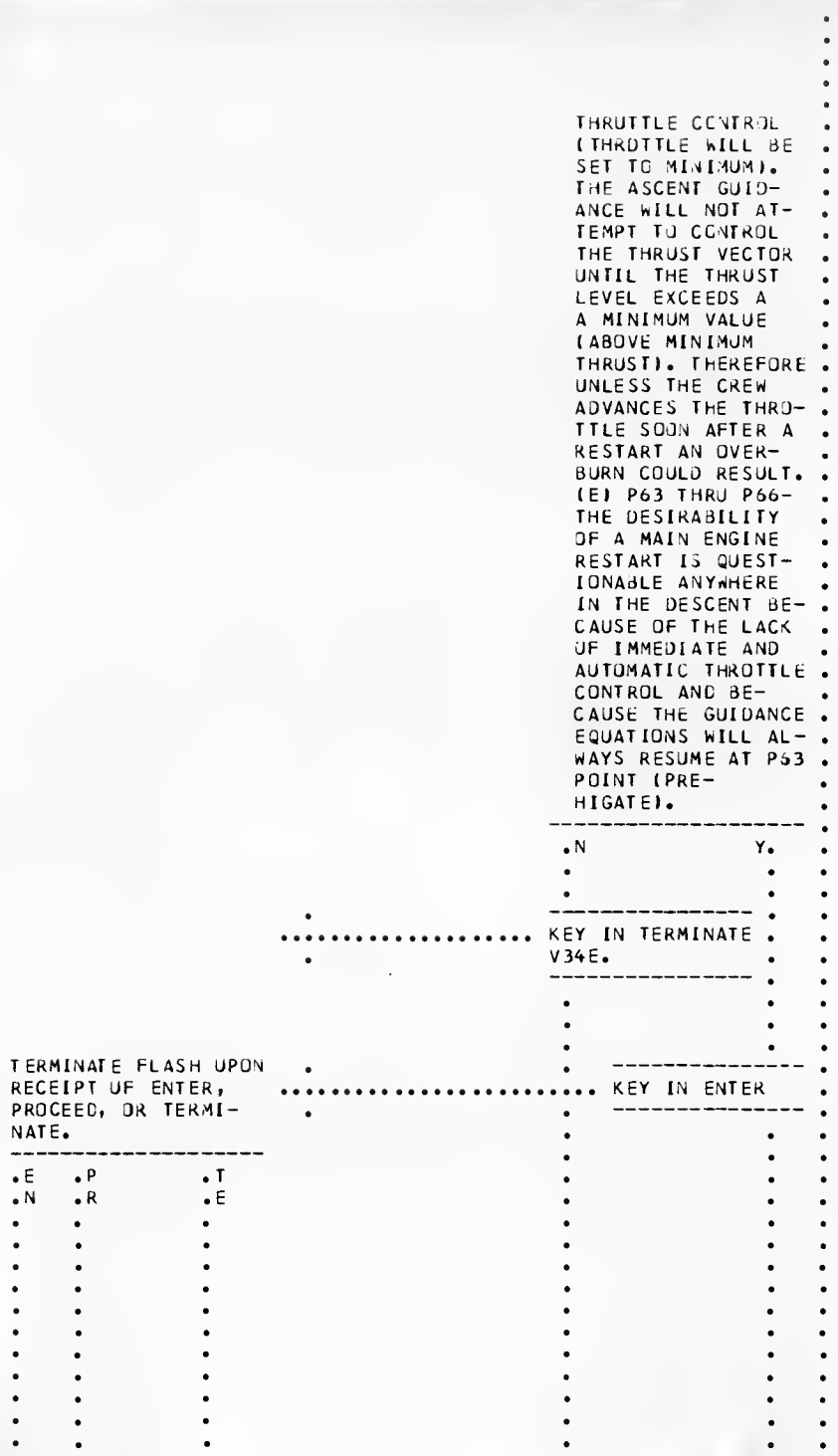
(D) P70 - FOR AN ATTEMPTED RESTART OF THE OPS THE LGC WILL EXERCISE NO

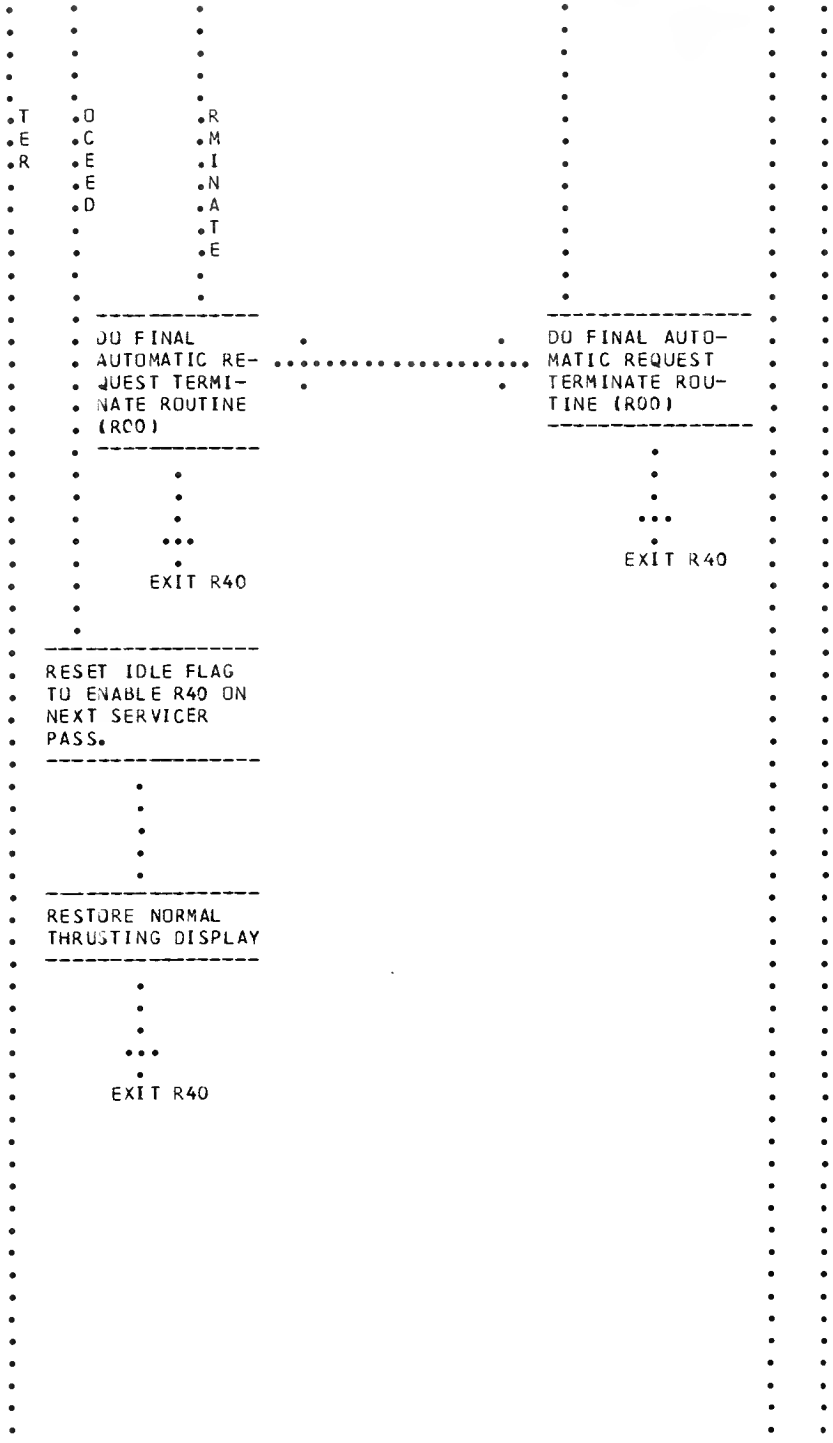
#280

#290

#300

#310


THROTTLE CONTROL (THRDTTLE WILL BE SET TO MINIMUM). THE ASCENT GUIDANCE WILL NOT ATTEMPT TO CONTROL THE THRUST VECTOR UNTIL THE THRUST LEVEL EXCEEDS A A MINIMUM VALUE (ABOVE MINIMUM THRUST). THEREFORE UNLESS THE CREW ADVANCES THE THROTTLE SOON AFTER A RESTART AN OVERBURN COULD RESULT. (E) P63 THRU P66- THE DESIRABILITY OF A MAIN ENGINE RESTART IS QUESTIONABLE ANYWHERE IN THE DESCENT BECAUSE OF THE LACK OF IMMEDIATE AND AUTOMATIC THROTTLE CONTROL AND BECAUSE THE GUIDANCE EQUATIONS WILL ALWAYS RESUME AT P63 POINT (PREHIGATE).
#320
#330
#340
#350
#360
N
Y
KEY IN TERMINATE V34E.
KEY IN ENTER
TERMINATE FLASH UPON RECEIPT OF ENTER, PROCEED, OR TERMINATE.
E
N
P
R
T
E



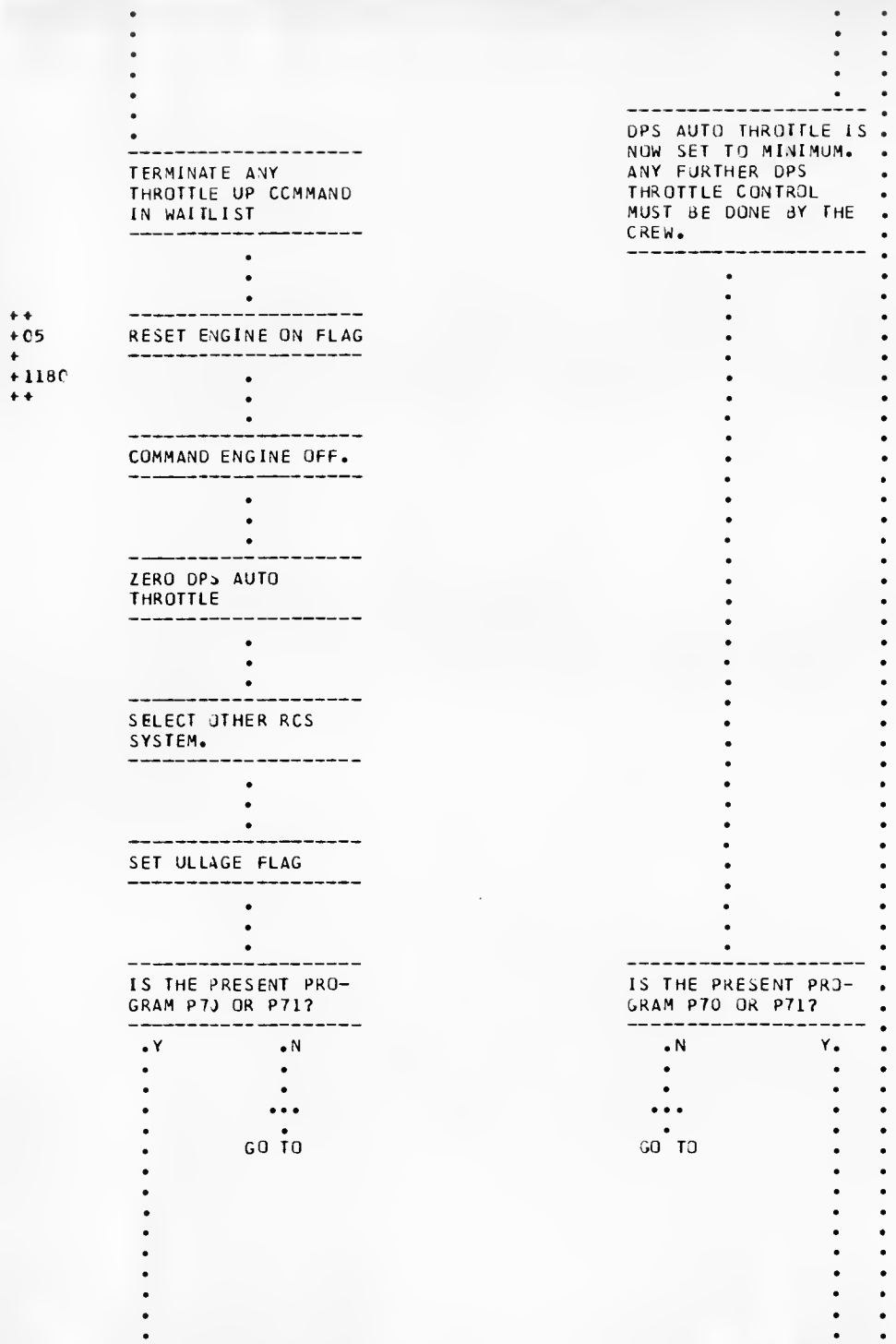
#370

#380

#390

#400

#410



++
+05
+
+1180
++

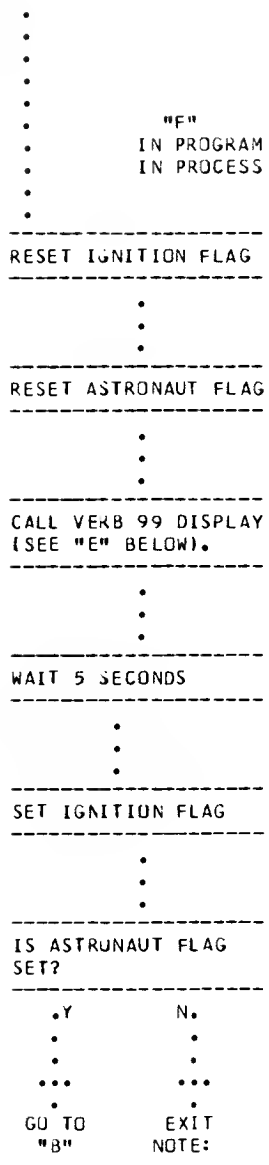
#420

#430

#440

#450

#460



"F"
IN PROGRAM
IN PROCESS

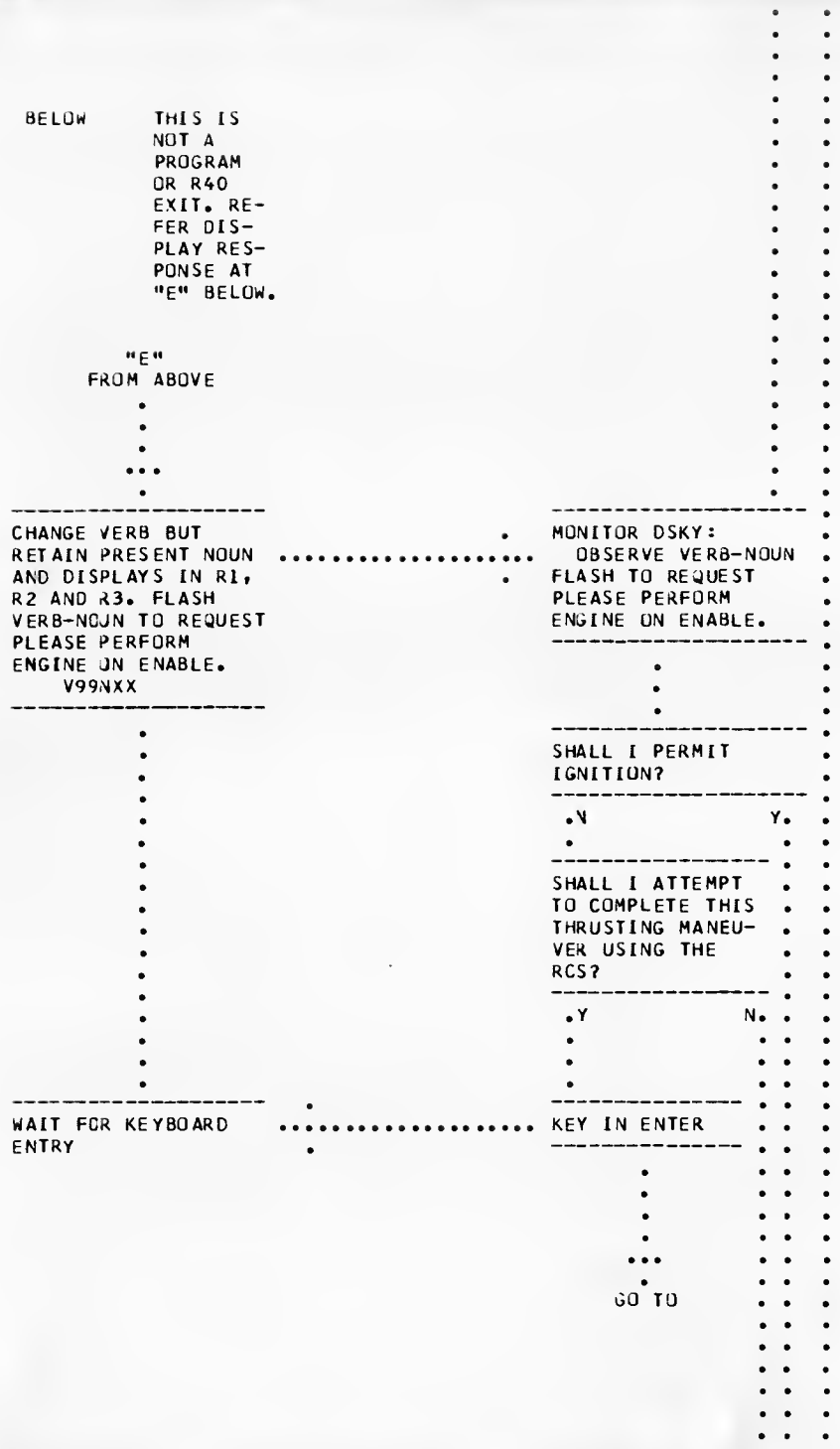
#470

#480

#490

#500

#510



#520

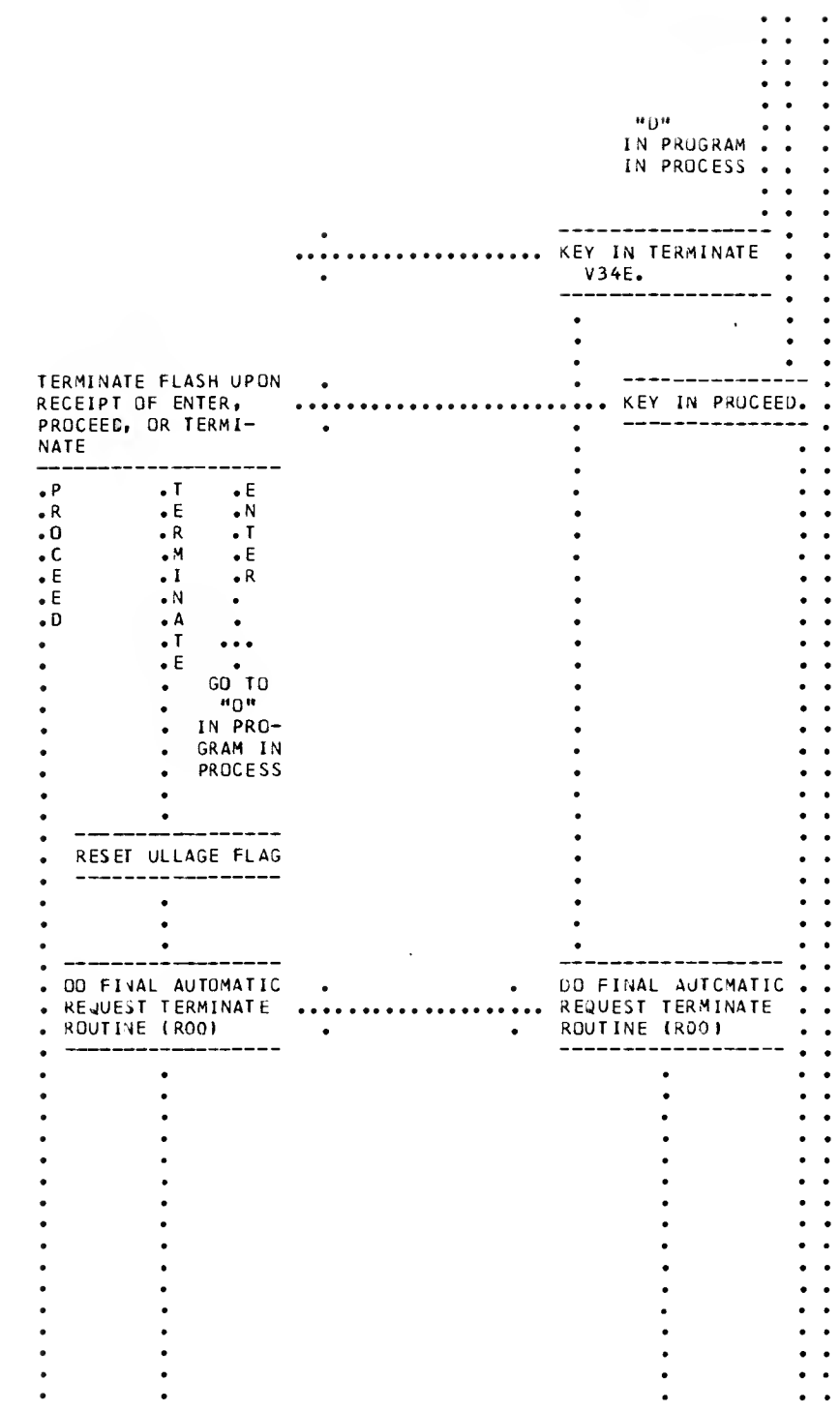
#530

#540

#550

#560

#570

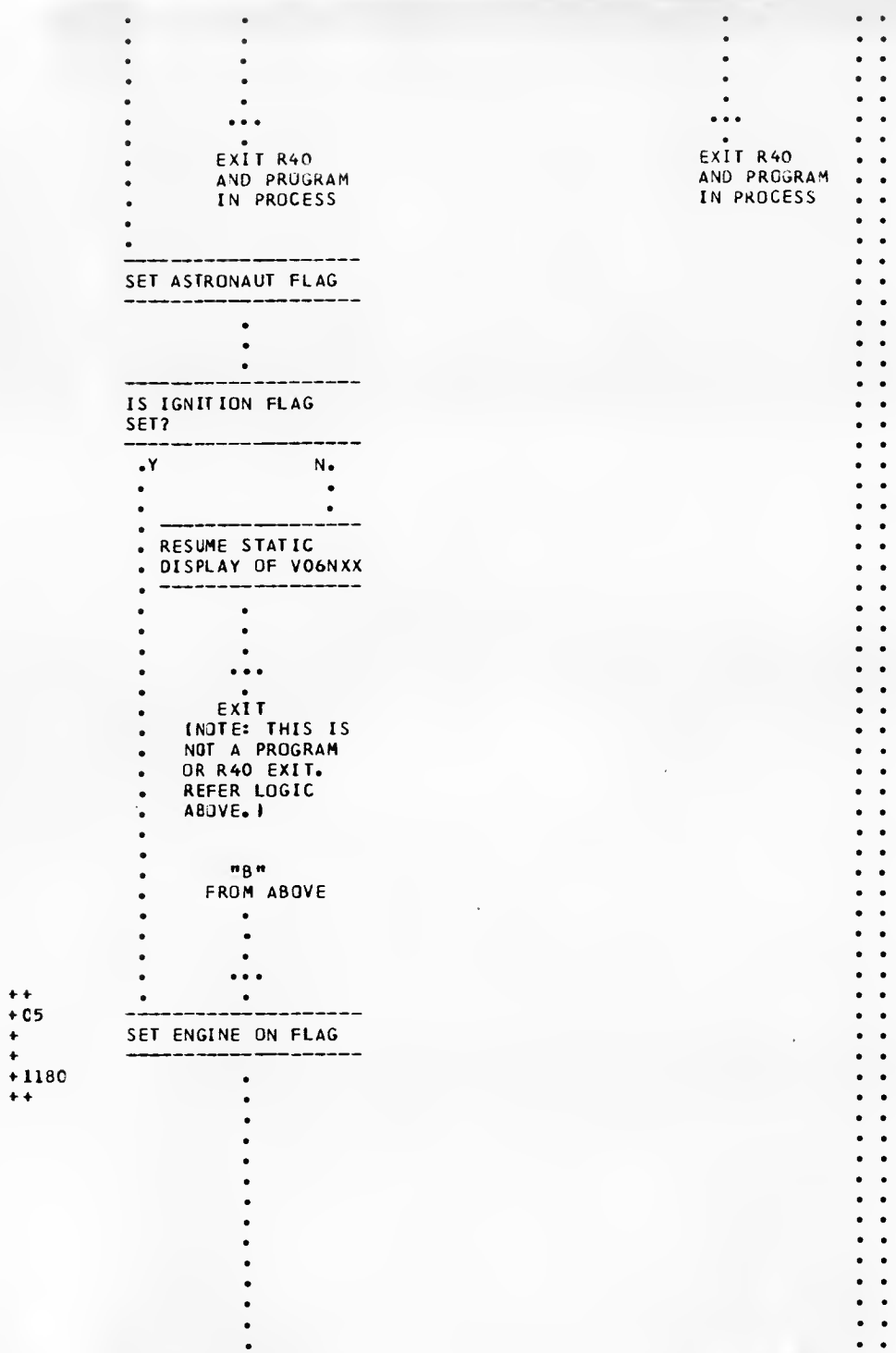


#580

#590

#600

#610



#620

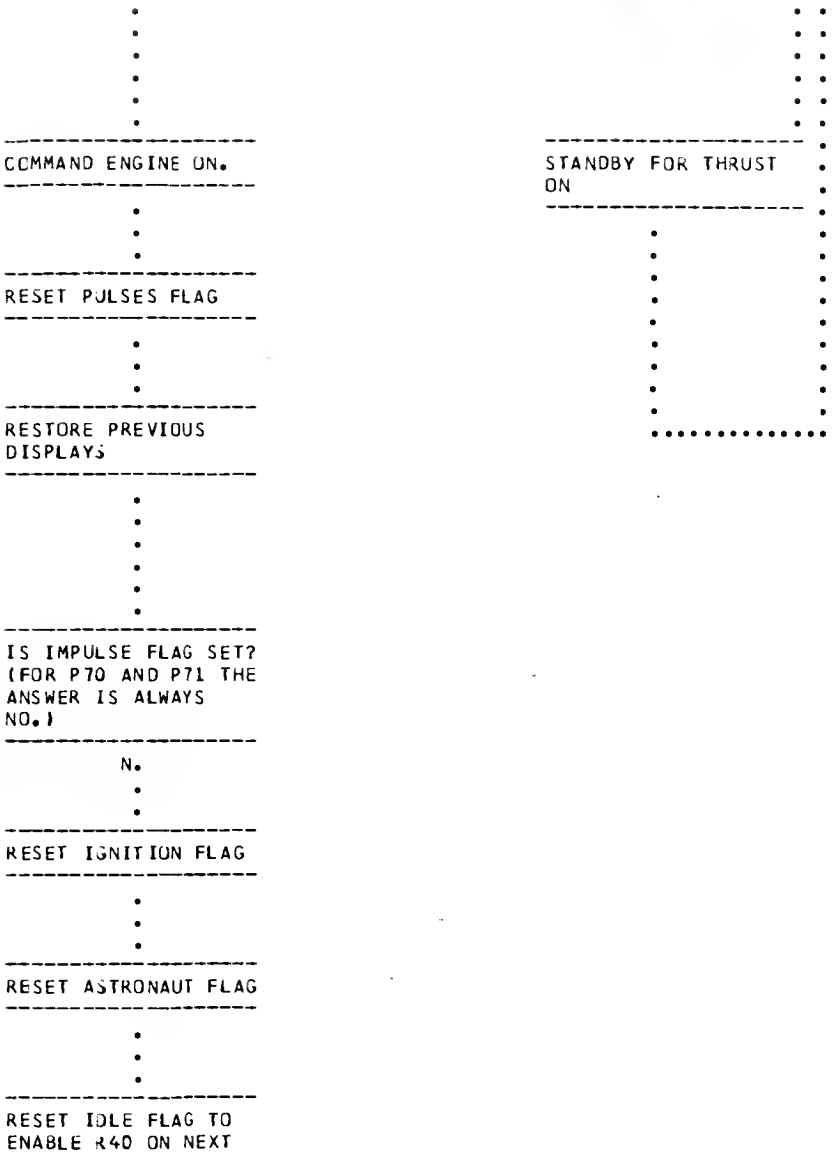
#630

#640

#650

#660

++
+05
+
+1180
++


COMMAND ENGINE ON.
RESET PULSES FLAG
RESTORE PREVIOUS DISPLAYS
IS IMPULSE FLAG SET? (FOR P70 AND P71 THE ANSWER IS ALWAYS NO.)
N.
RESET IGNITION FLAG
RESET ASTRONAUT FLAG
RESET IDLE FLAG TO ENABLE R40 ON NEXT
STANDBY FOR THRUST ON
#670
#680
#690
#700
#710

```
SERVICER PASS.
--------------------
          .
          .
          .
--------------------
CALL FOR RESET OF                                    #720
ULLAGE FLAG IN .5
SEC.
--------------------
          .
          .
          .
         ...
          .
        EXIT R40                                     #730
```

CHANGE CONTROL NOTES

REV 01 PCR 8,121,144,472,612
REV 02(LUM 18) PCR 838, EDITORIAL
REV 03(LUM 1C) PCR 285, EDITORIAL
REV 04(LUM 1E) PCR 334
REV 05 PCN 1180

STATE VECTOR INTEGRATION (MID TO AVE) ROUTINE (R41) REV 05 12/01/71

PURPOSE: (1) TO INTEGRATE THE STATE VECTOR OF THIS VEHICLE TO THE TIME AT WHICH THE AVERAGE G ROUTINE WILL BE TURNED ON BY THE CALLING PROGRAM.

(2) TO DEFINE A NEW TIG IN THE EVENT THE STATE VECTOR CANNOT BE INTEGRATED TO THE TIME ORIGINALLY DEFINED AND TO ESTABLISH A PROGRAM ALARM TO INFORM THE CREW THAT TIG HAS BEEN SLIPPED.

ASSUMPTIONS: (1) THERE IS A SIGNIFICANT AMOUNT OF TIME REQUIRED BY THE LGC TO UPDATE THE LM STATE VECTOR. THE FOLLOWING APPROXIMATE TIMES APPLY:

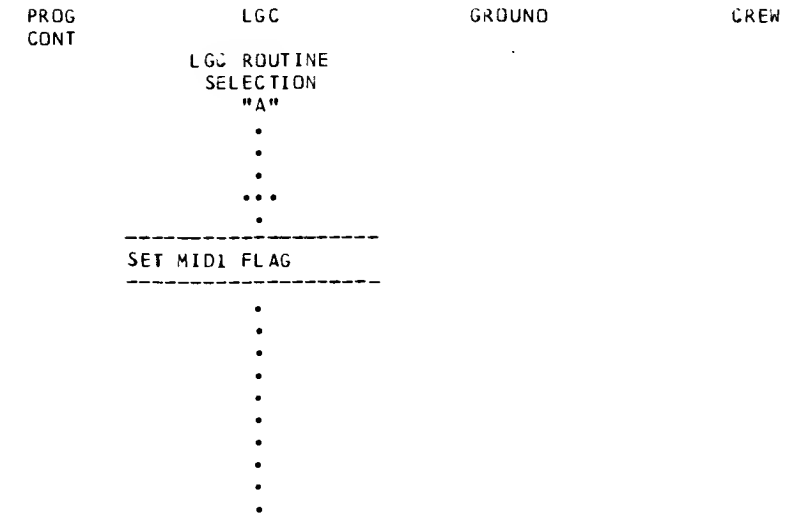
1.7 SECONDS PER TIME STEP IN EARTH ORBIT
++ 3.6 SECONDS PER TIME STEP IN LUNAR ORBIT
+05 .70 SECONDS ON LUNAR SURFACE (NO TIME STEPS INVOLVED IN THIS CASE)
+1180 WHERE TIME STEP IS APPROXIMATELY EQUAL TO:
++ 250 SECONDS IN EARTH ORBIT
350 SECONDS IN LUNAR ORBIT

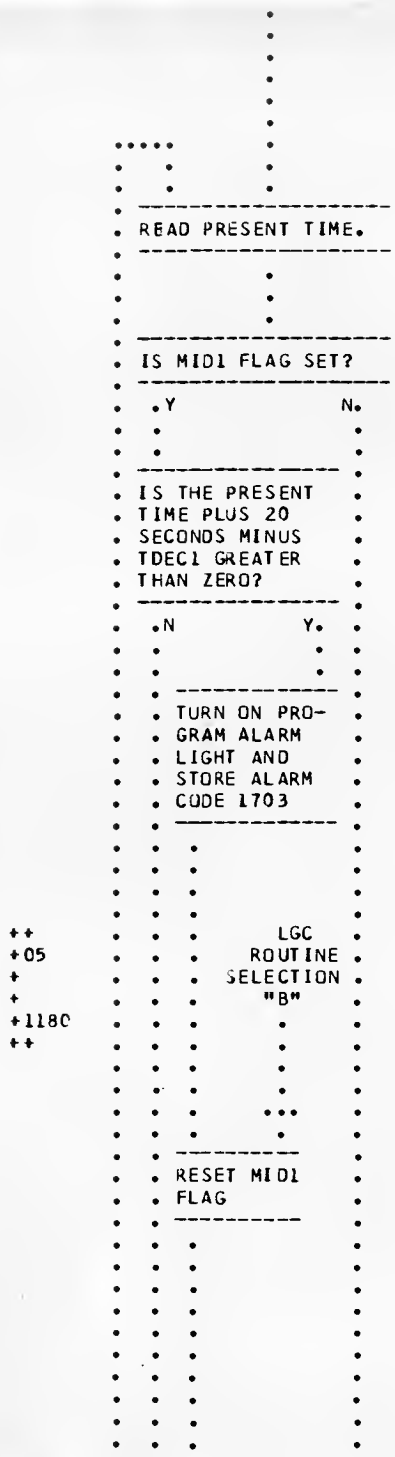
(2) TO MONITOR THE PROGRESS OF STATE VECTOR INTEGRATION, THE TIME ASSOCIATED WITH THE ADVANCING (REGRESSING) STATE IS AVAILABLE BY KEYING IN V06N38E:

V06N38
R1-TET-HRS
R2-TET-MINS
R3-TET-SECS

TET-THE TIME (GET) TO WHICH THE STATE VECTOR INTEGRATION HAS PRESENTLY CALCULATED THE STATE VECTOR. IN HRS., MINS., AND SECS. TO NEAREST .01 SEC.

(3) THE ROUTINE IS AUTOMATICALLY SELECTED BY P12, P40, P41, P42, P47, AND P63.





++
+05
+
+
+1180
++

#20

#30

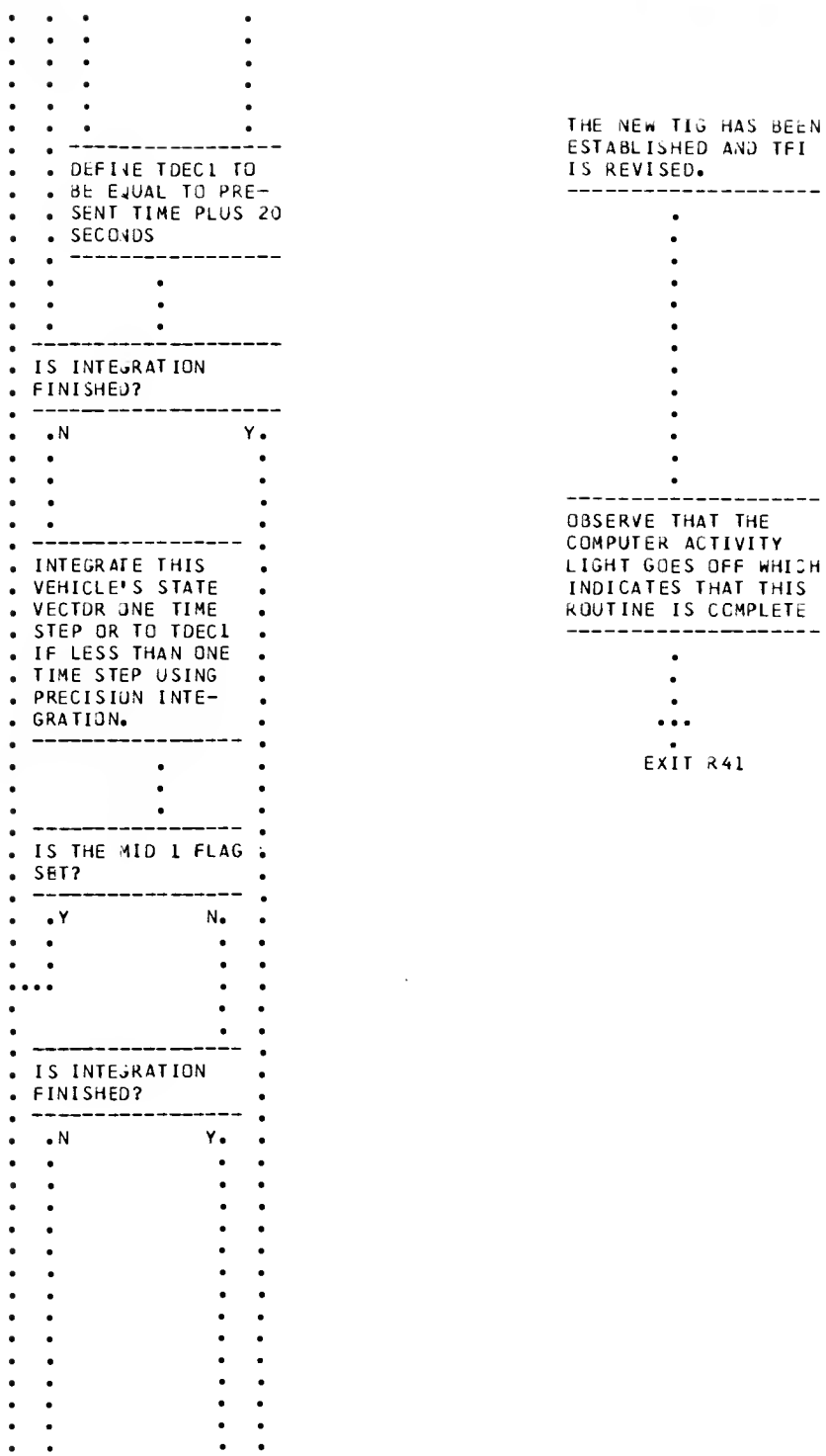
#40

MONITOR DSKY PROGRAM ALARM LIGHT DURING THE PERIOD FROM TIG -50 SECONDS TO BLANKING AT TIG-35. IF LIGHT COMES ON DURING THIS TIME (AND ALARM CODE IS 1703) IT INDICATES THAT TIG WILL BE SLIPPED AS REQUIRED TO GET THE STATE VECTOR INTEGRATED TO A NEW TIG -29.9 SECONDS.

IF THIS ALARM CONDITION OCCURS THE TFI DISPLAY WILL CONTINUE TO COUNT BASED ON THE ORIGINAL TIME UNTIL INTEGRATION IS COMPLETE AND A NEW TIG IS ESTABLISHED. THE DISPLAY WILL NOT BLANK HOWEVER UNTIL

#50

#60



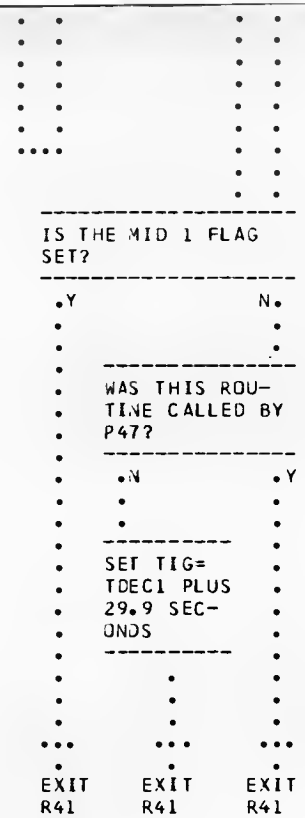
#70

#80

#90

#100

#110



#120

#130

#140

CHANGE CONTROL NOTES .

REV 01 PCR 437,559,614
REV 00(LUM 1A) PCR 758,761.1
REV 03 EDITORIAL
REV 04(LUM 1D) PCR 892, PCN 1009
REV 05 PCN 1180

AGS INITIALIZATION ROUTINE (R47) REV 5 12/01/71

PURPOSE: (1) TO PROVIDE THE AGS ABURT ELECTRONICS ASSEMBLY (AEA) WITH THE LM AND CSM STATE VECTORS (POSITION, VELOCITY, TIME) IN LM IMU COORDINATES BY MEANS OF THE LGC DIGITAL DOWNLINK.

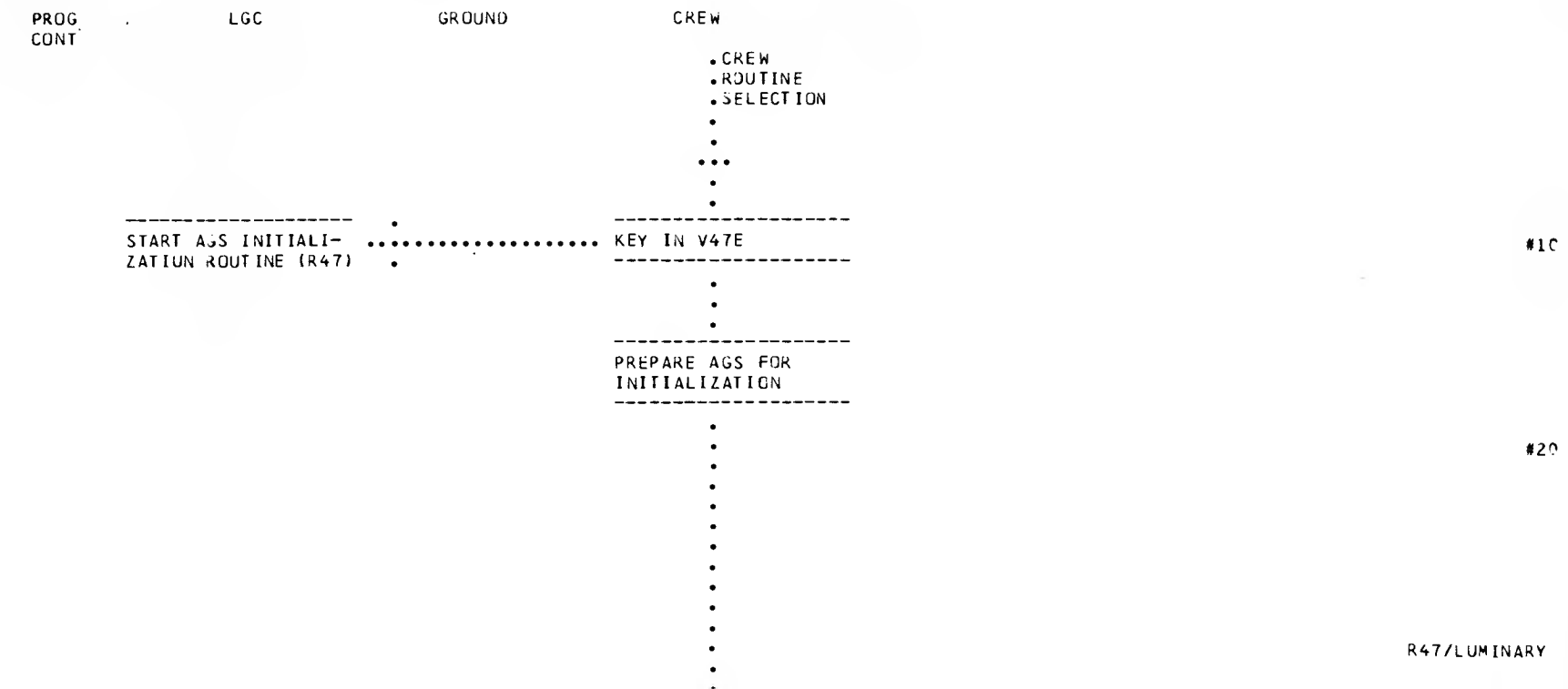
(2) TO ZERO THE ICDU, LGC, AND AEA GIMBAL ANGLE COUNTERS SIMULTANEOUSLY IN ORDER TO ESTABLISH A COMMON ZERO REFERENCE FOR THE MEASUREMENT OF GIMBAL (EULER) ANGLES WHICH DEFINE LM ATTITUDE WITH RESPECT TO THE IMU STABLE MEMBER.

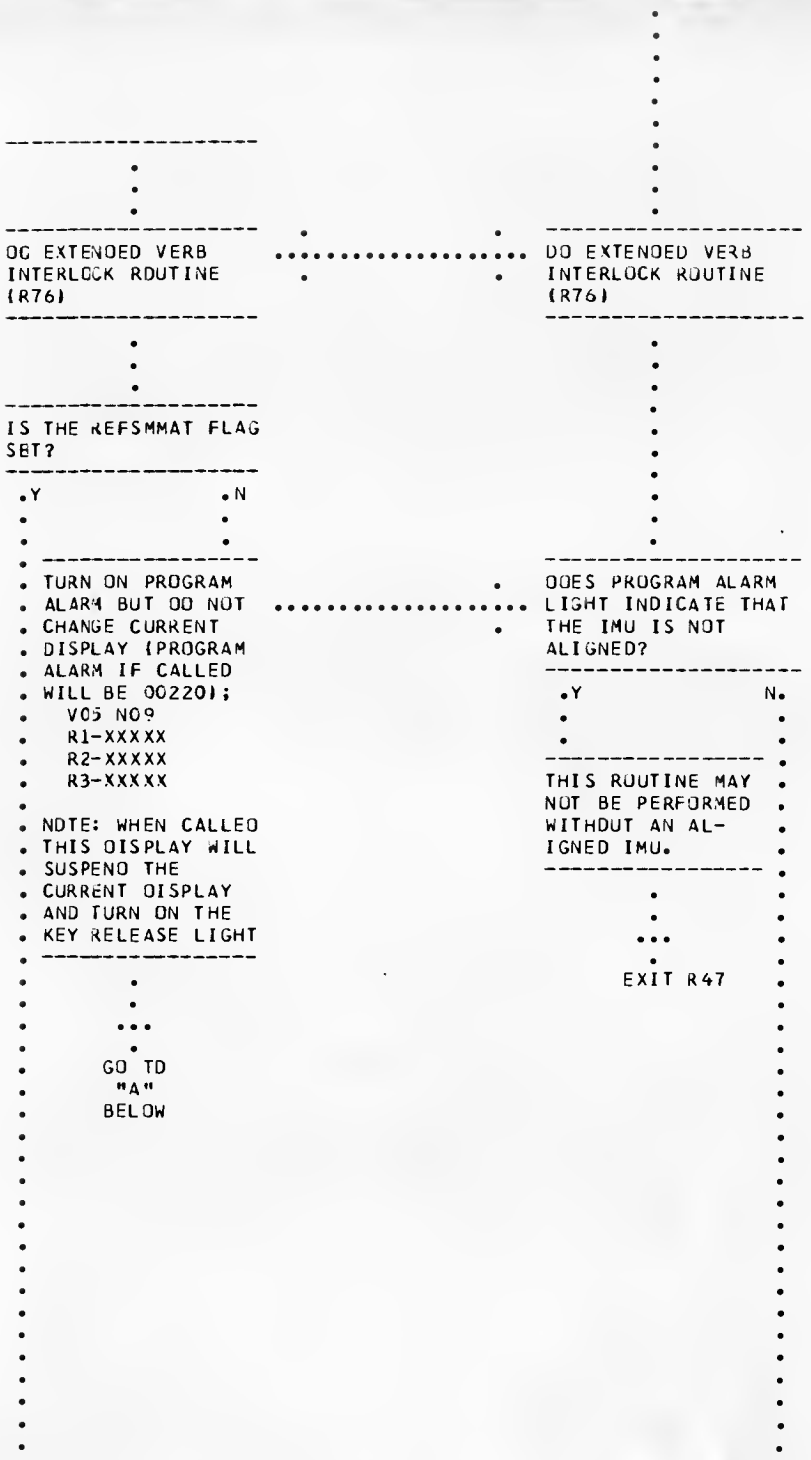
(3) TO ESTABLISH THE GROUND ELAPSED TIME OF AEA CLOCK ZERO IF THE AEA CLOCK IS ZEROED DURING THIS ROUTINE.

++
+05
ASSUMPTIONS: (1) THE LGC DOWNLINK DATA FORMAT AND SCALING ARE DEFINED IN SECTION 2 OF R567.
+1180
++ (2) THIS ROUTINE IS SELECTED BY THE ASTRONAUT BY OSKY ENTRY AND IS COORDINATED WITH THE PARALLEL AEA PROGRAM BY ASTRONAUT PROCEDURE. THIS ROUTINE MAY BE CALLED AT ANY TIME THAT ANOTHER EXTENDED VERB IS NOT IN PROCESS.

(3) ZEROING OF THE ICDU, LGC, AND AEA GIMBAL ANGLE COUNTERS OCCURS WHEN THE IMUSE FLAG IS NOT SET AND THE IMU IS NOT BEING USED.

(4) THE DAP IS TURNED OFF DURING CDU ZERO.



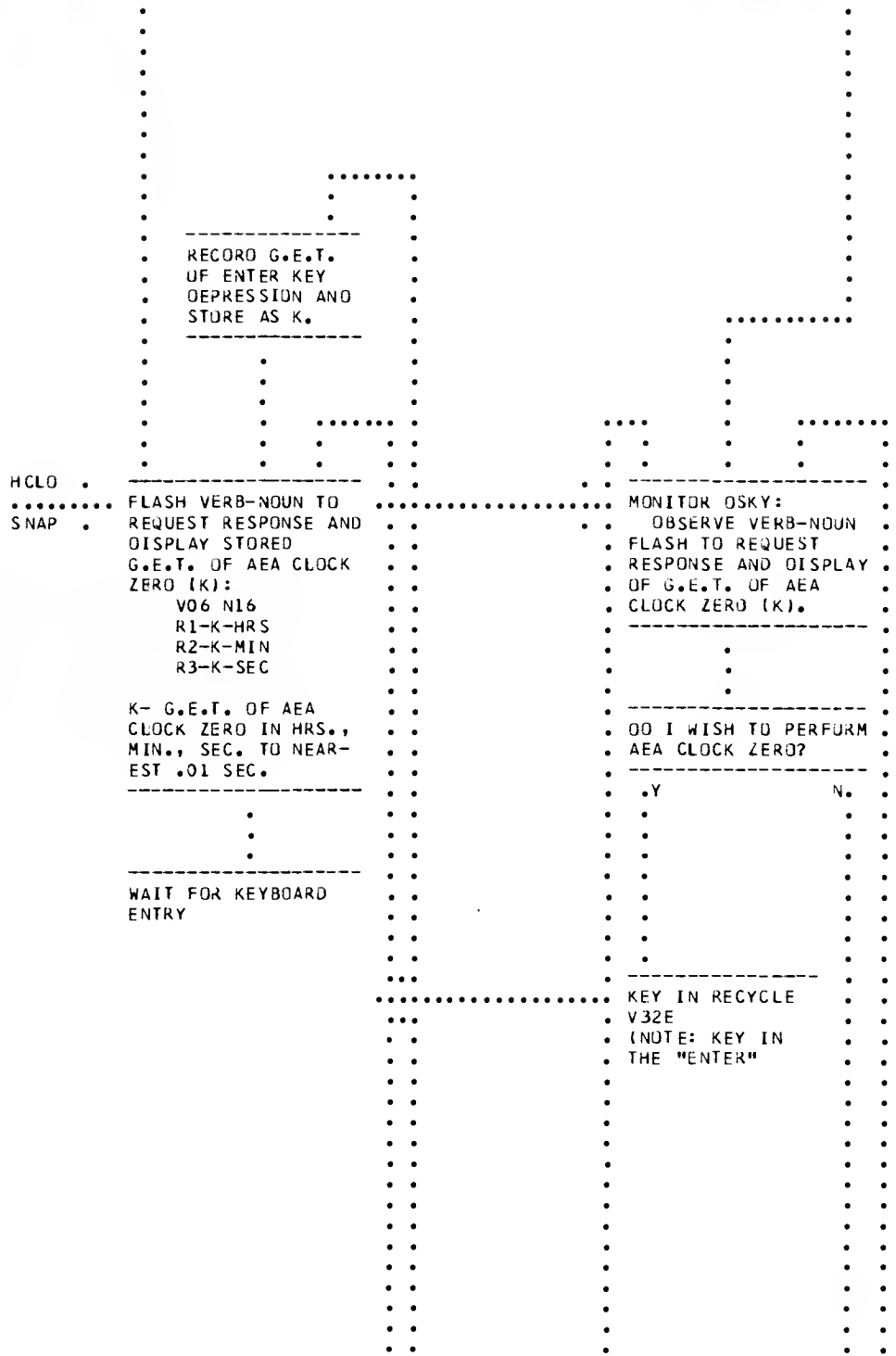

DO EXTENDED VERB INTERLOCK ROUTINE (R76)
IS THE REFSMMAT FLAG SET?
Y
N
TURN ON PROGRAM ALARM BUT DO NOT CHANGE CURRENT DISPLAY (PROGRAM ALARM IF CALLED WILL BE 00220);
V05 N09
R1-XXXXX
R2-XXXXX
R3-XXXXX
NOTE: WHEN CALLED THIS DISPLAY WILL SUSPEND THE CURRENT DISPLAY AND TURN ON THE KEY RELEASE LIGHT
GO TO "A" BELOW
DO EXTENDED VERB INTERLOCK ROUTINE (R76)
DOES PROGRAM ALARM LIGHT INDICATE THAT THE IMU IS NOT ALIGNED?
Y
N
THIS ROUTINE MAY NOT BE PERFORMED WITHOUT AN ALIGNED IMU.
EXIT R47

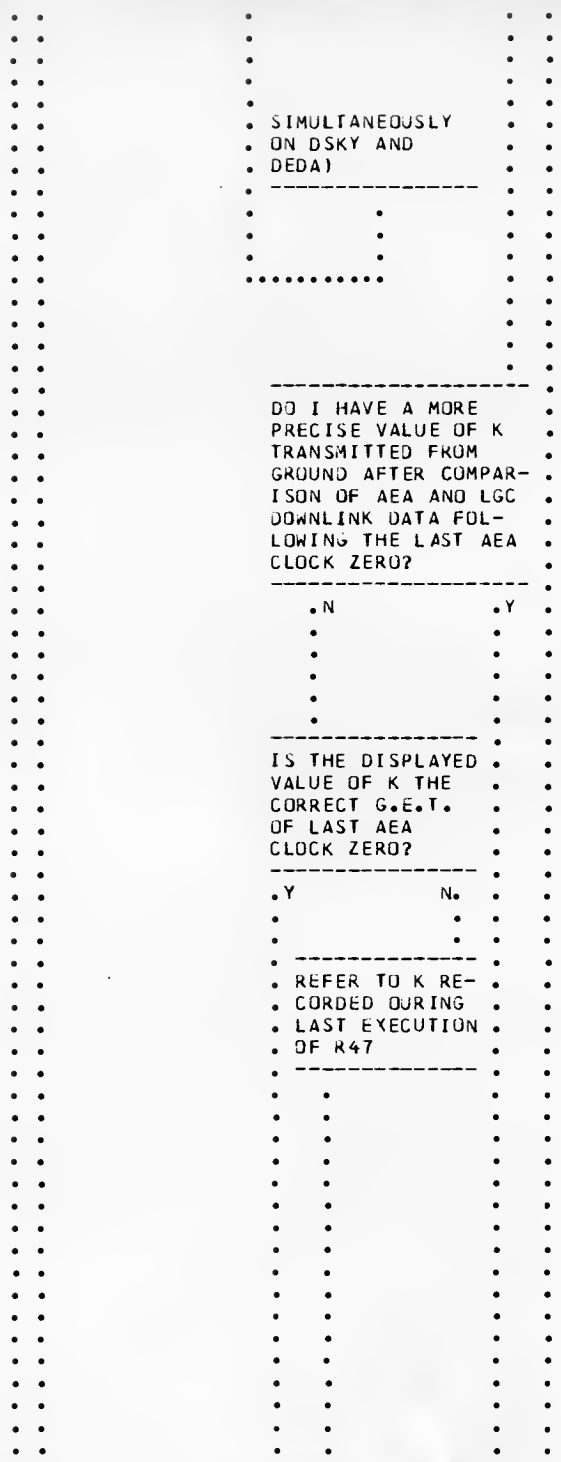
#30

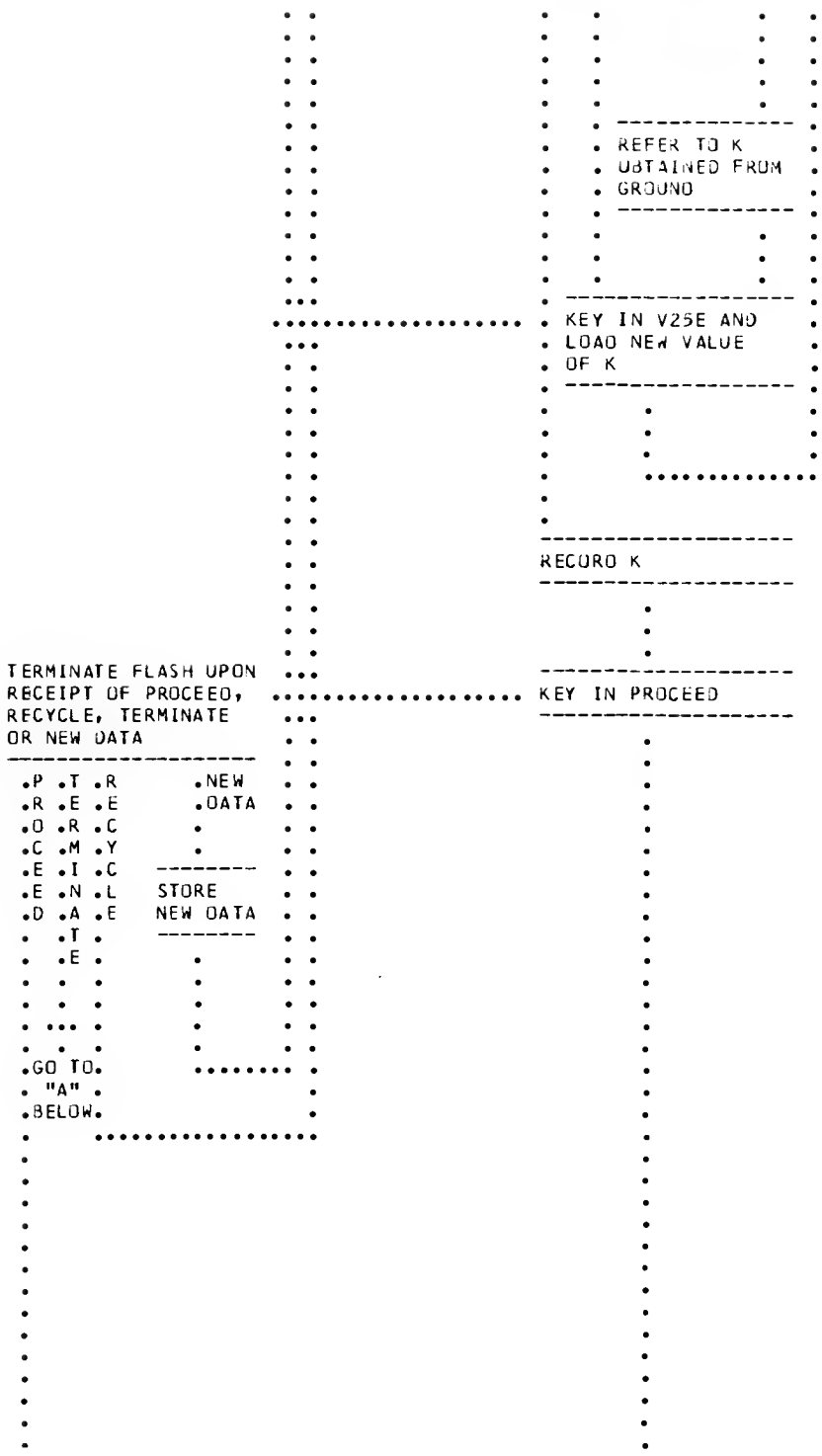
#40

#50

#60


#70
#80
#90
#100
#110
HCLO
SNAP
RECORD G.E.T. OF ENTER KEY DEPRESSION AND STORE AS K.
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY STORED G.E.T. OF AEA CLOCK ZERO (K):
V06 N16
R1-K-HRS
R2-K-MIN
R3-K-SEC
K- G.E.T. OF AEA CLOCK ZERO IN HRS., MIN., SEC. TO NEAREST .01 SEC.
WAIT FOR KEYBOARD ENTRY
MONITOR OSKY: OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY OF G.E.T. OF AEA CLOCK ZERO (K).
DO I WISH TO PERFORM AEA CLOCK ZERO?
.Y
N.
KEY IN RECYCLE V32E (NOTE: KEY IN THE "ENTER"


SIMULTANEOUSLY ON DSKY AND DEDA)
#120
DO I HAVE A MORE PRECISE VALUE OF K TRANSMITTED FROM GROUND AFTER COMPARISON OF AEA AND LGC DOWNLINK DATA FOLLOWING THE LAST AEA CLOCK ZERO?
#130
N
Y
#140
IS THE DISPLAYED VALUE OF K THE CORRECT G.E.T. OF LAST AEA CLOCK ZERO?
#150
Y
N
REFER TO K RECORDED DURING LAST EXECUTION OF R47
#160



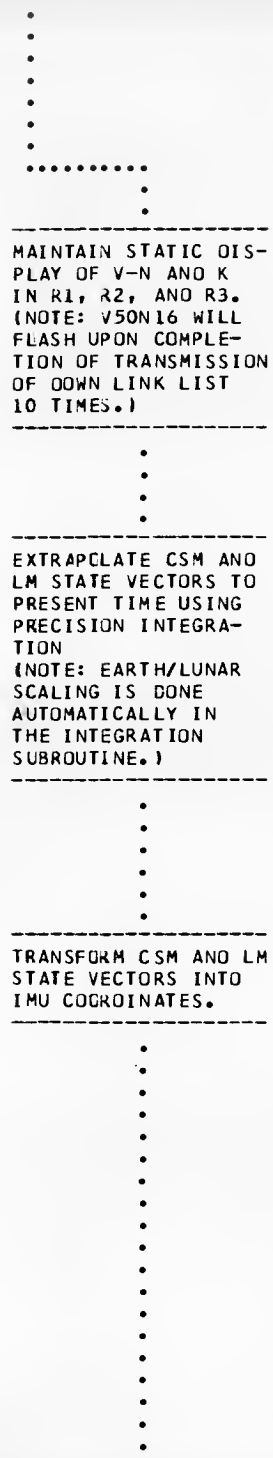
#170

#180

#190

#200

#210

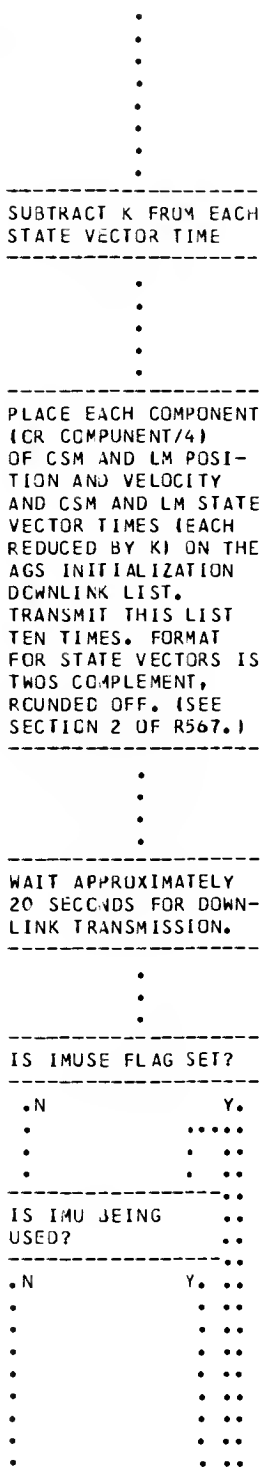


#220

#230

#240

#250



#260

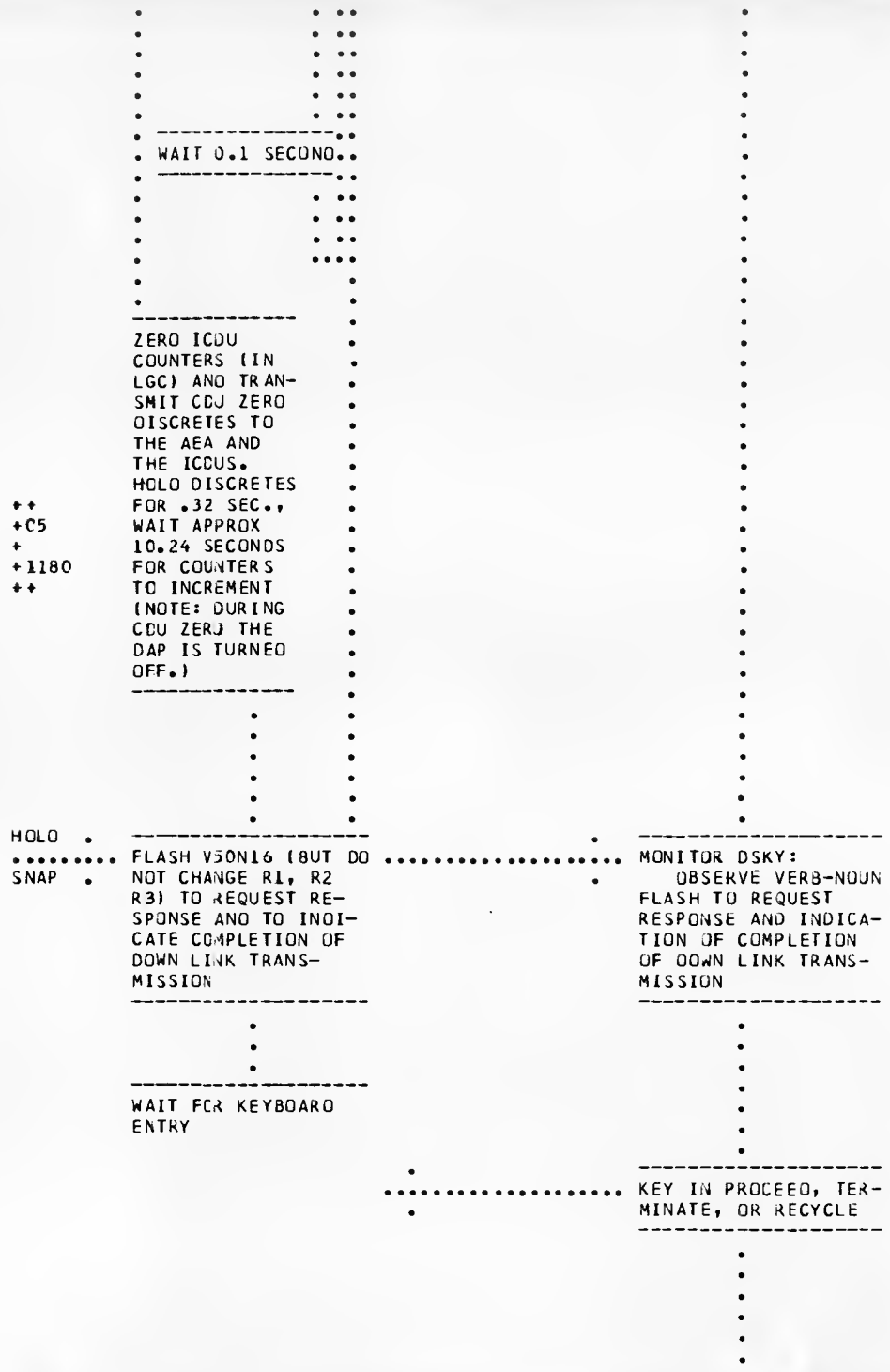
#270

#280

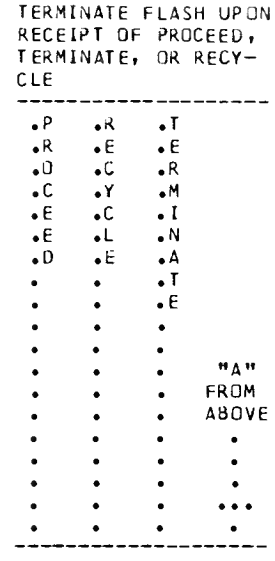
#290

#300

#310


WAIT 0.1 SECOND
ZERO ICDU COUNTERS (IN LGC) AND TRANSMIT CDU ZERO DISCRETES TO THE AEA AND THE ICDUS. HOLD DISCRETES FOR .32 SEC., WAIT APPROX 10.24 SECONDS FOR COUNTERS TO INCREMENT (NOTE: DURING CDU ZERO THE DAP IS TURNED OFF.)
HOLD SNAP
FLASH V50N16 (BUT DO NOT CHANGE R1, R2 R3) TO REQUEST RESPONSE AND TO INDICATE COMPLETION OF DOWN LINK TRANSMISSION
MONITOR DSKY: OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND INDICATION OF COMPLETION OF DOWN LINK TRANSMISSION
WAIT FOR KEYBOARD ENTRY
KEY IN PROCEED, TERMINATE, OR RECYCLE

#380



#390

#400

#410

CHANGE CONTROL NOTES

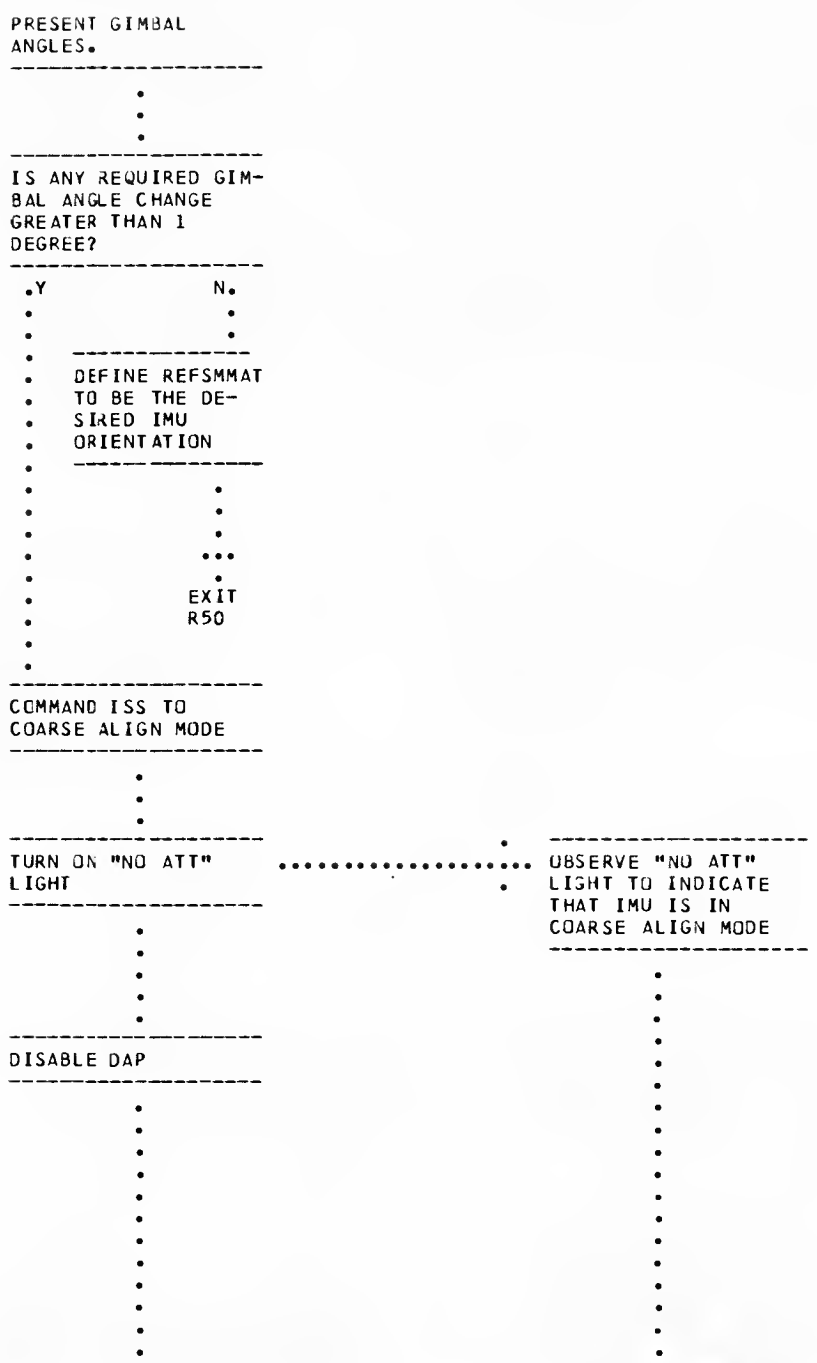
REV 01 PCR 184,408
REV 02 EDITORIAL
REV 03 EDITORIAL
REV 04(LUM 1E) PCR 1130, PCN 1145
REV 05 PCN 1180

COARSE ALIGN ROUTINE (R50) REV C1 08/09/69

PURPOSE: (1) TO COARSE ALIGN THE IMU TO A DESIRED INERTIAL ORIENTATION.

ASSUMPTIONS: (1) THE DESIRED IMU INERTIAL ORIENTATION HAS BEEN SPECIFIED BY THE CALLING PROGRAM.

(2) THE ROUTINE IS AUTOMATICALLY SELECTED BY THE IMU REALIGN PROGRAM (P52).


PRESENT GIMBAL ANGLES.
IS ANY REQUIRED GIMBAL ANGLE CHANGE GREATER THAN 1 DEGREE?
Y
N.
DEFINE REFSMMAT TO BE THE DESIRED IMU ORIENTATION
EXIT R50
COMMAND ISS TO COARSE ALIGN MODE
TURN ON "NO ATT" LIGHT
OBSERVE "NO ATT" LIGHT TO INDICATE THAT IMU IS IN COARSE ALIGN MODE
DISABLE DAP

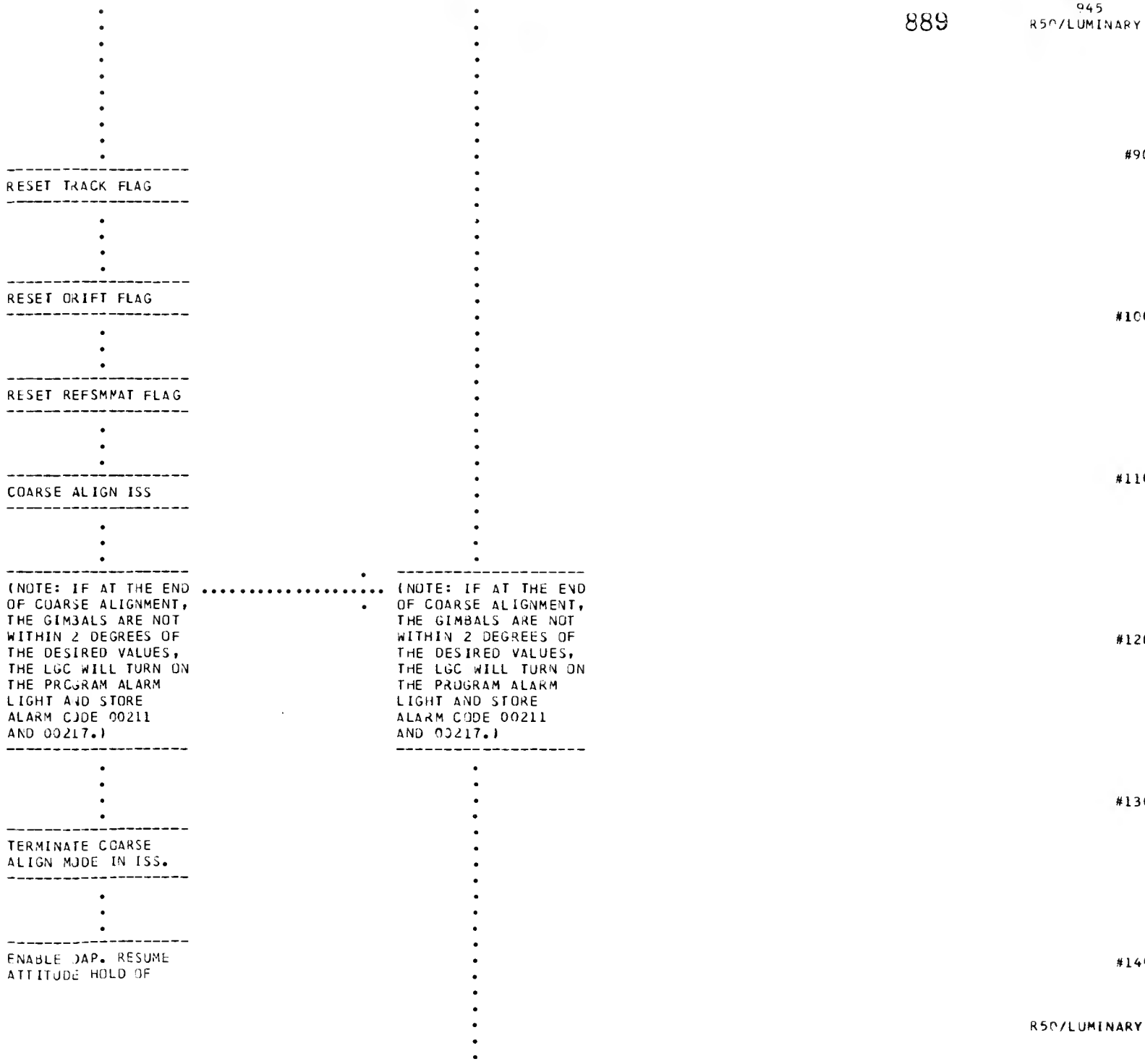
#40

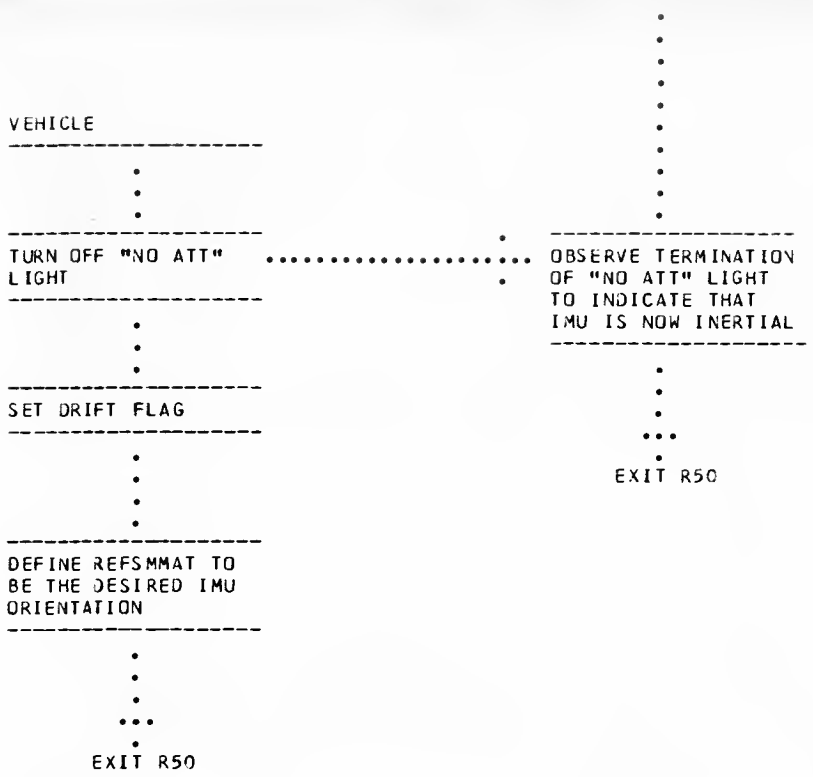
#50

#60

#70

#80


RESET TRACK FLAG
RESET DRIFT FLAG
RESET REFSMMAT FLAG
COARSE ALIGN ISS
(NOTE: IF AT THE END OF COARSE ALIGNMENT, THE GIMBALS ARE NOT WITHIN 2 DEGREES OF THE DESIRED VALUES, THE LGC WILL TURN ON THE PROGRAM ALARM LIGHT AND STORE ALARM CODE 00211 AND 00217.)
TERMINATE COARSE ALIGN MODE IN ISS.
ENABLE DAP. RESUME ATTITUDE HOLD OF
(NOTE: IF AT THE END OF COARSE ALIGNMENT, THE GIMBALS ARE NOT WITHIN 2 DEGREES OF THE DESIRED VALUES, THE LGC WILL TURN ON THE PROGRAM ALARM LIGHT AND STORE ALARM CODE 00211 AND 00217.)
#90
#100
#110
#120
#130
#140



#150

#160

#170

CHANGE CONTROL NOTES

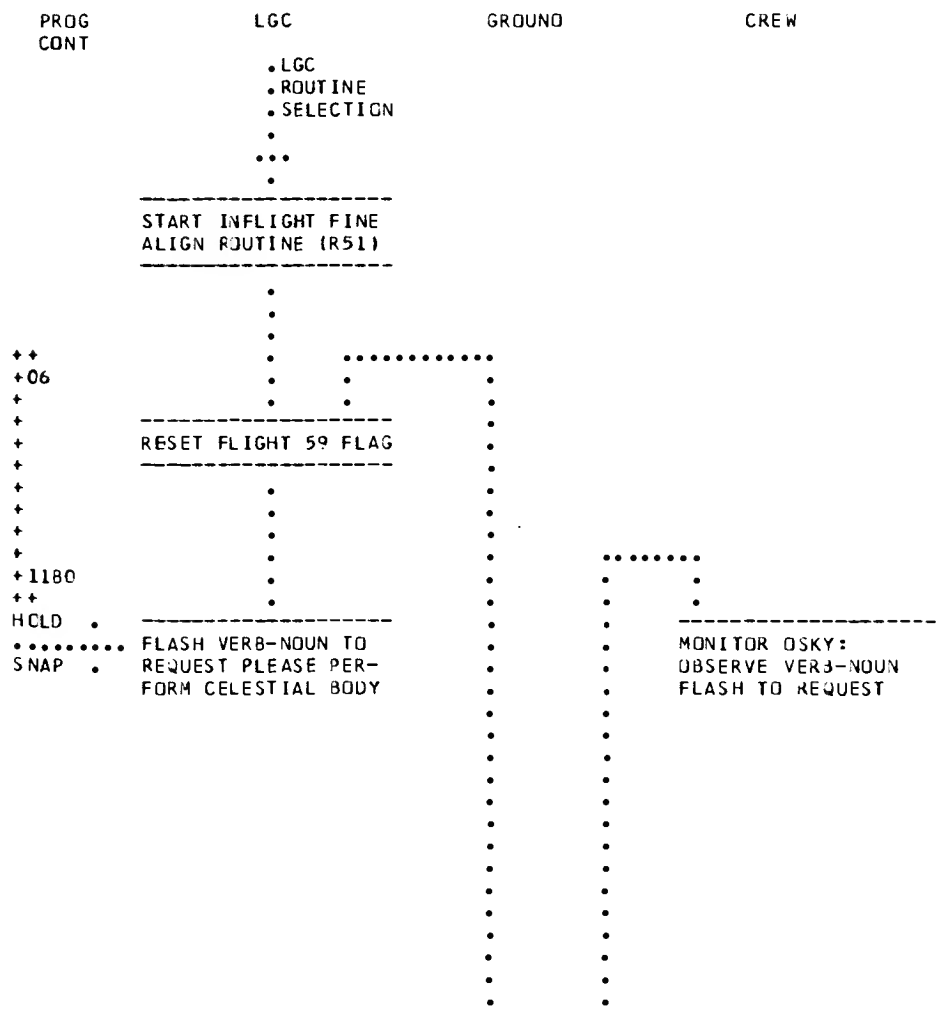
LOGIC REV C1 NO PCR'S

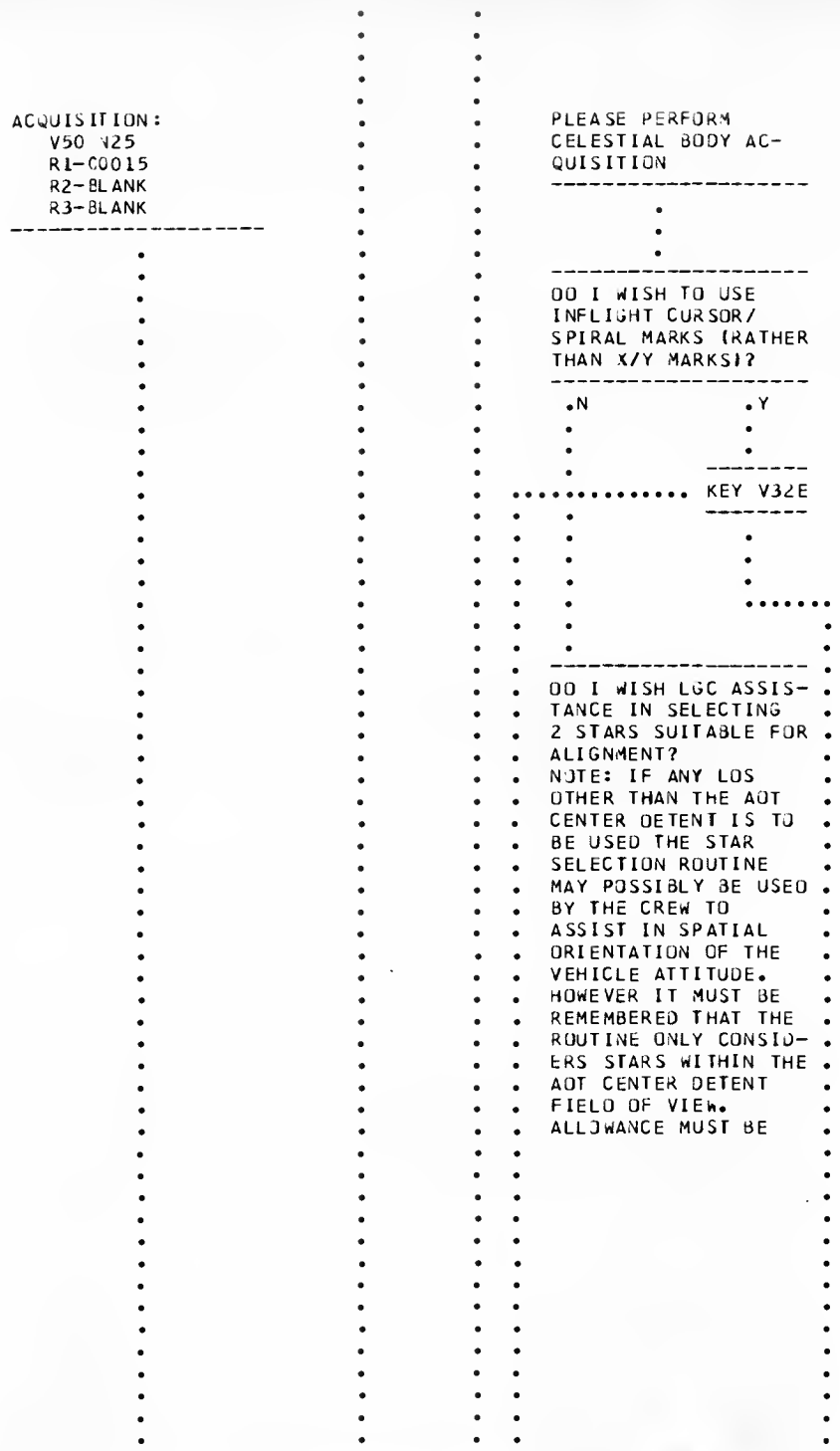
INFLIGHT FINE ALIGN ROUTINE (R51) REV 16 12/01/71

PURPOSE: (1) TO OBTAIN THE NECESSARY STAR, PLANET OR SUN SIGHTINGS AND THEN TO FINE ALIGN THE IMU TO A DESIRED INERTIAL ORIENTATION WHILE THE LM IS IN FLIGHT.

ASSUMPTIONS: (1) THE DESIRED IMU INERTIAL ORIENTATION HAS BEEN SPECIFIED BY THE CALLING PROGRAM.

(2) THE ROUTINE IS AUTOMATICALLY SELECTED BY THE IMU REALIGN PROGRAM (P52).




ACQUISITION:
V50 N25
R1-C0015
R2-BLANK
R3-BLANK
PLEASE PERFORM CELESTIAL BODY ACQUISITION
DO I WISH TO USE INFLIGHT CURSOR/ SPIRAL MARKS (RATHER THAN X/Y MARKS)?
.N
.Y
KEY V32E
DO I WISH LGC ASSISTANCE IN SELECTING 2 STARS SUITABLE FOR ALIGNMENT?
NOTE: IF ANY LOS OTHER THAN THE AOT CENTER DETENT IS TO BE USED THE STAR SELECTION ROUTINE MAY POSSIBLY BE USED BY THE CREW TO ASSIST IN SPATIAL ORIENTATION OF THE VEHICLE ATTITUDE. HOWEVER IT MUST BE REMEMBERED THAT THE ROUTINE ONLY CONSIDERS STARS WITHIN THE AOT CENTER DETENT FIELD OF VIEW. ALLOWANCE MUST BE

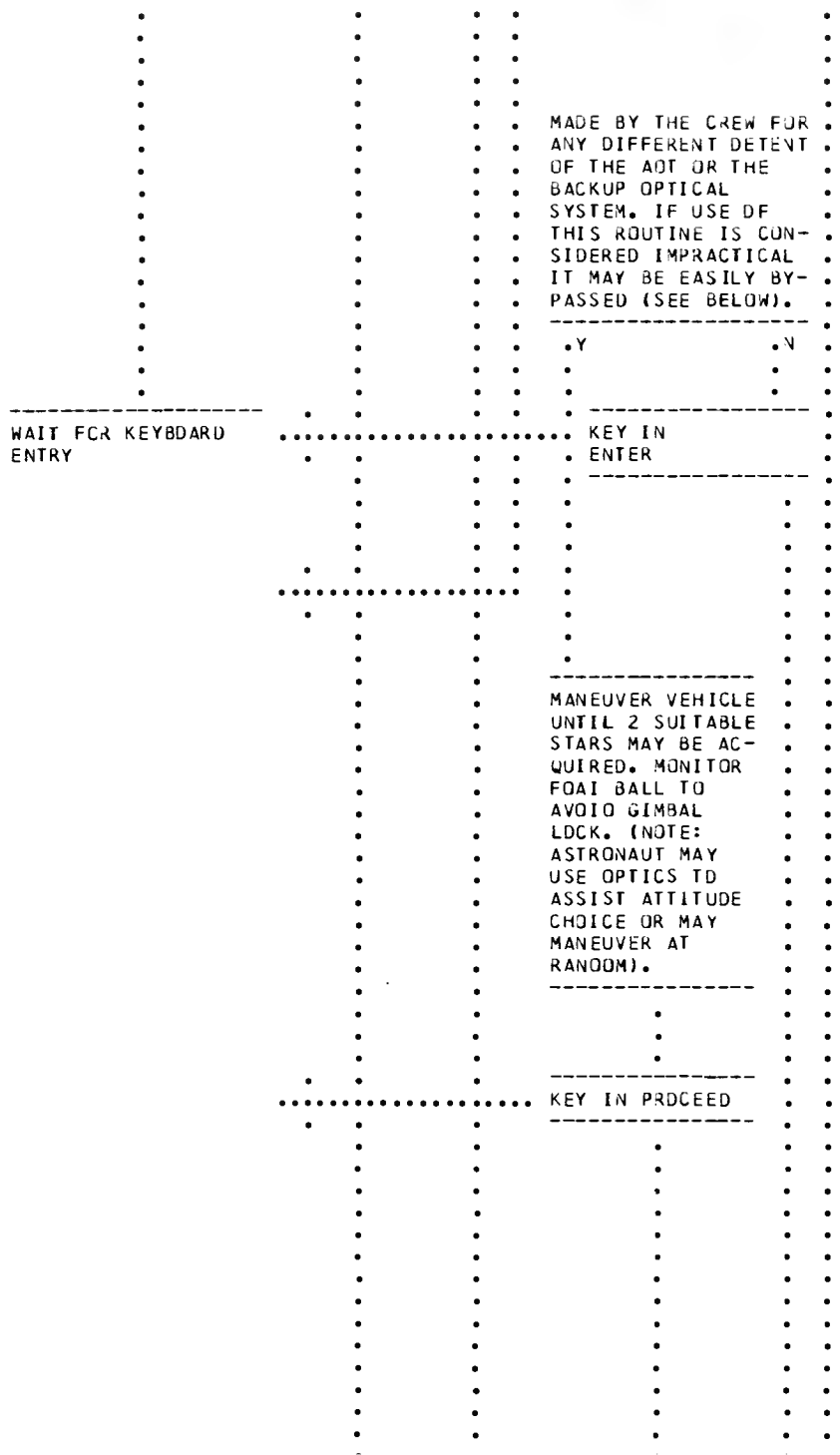
#30

#40

#50

#60

#70



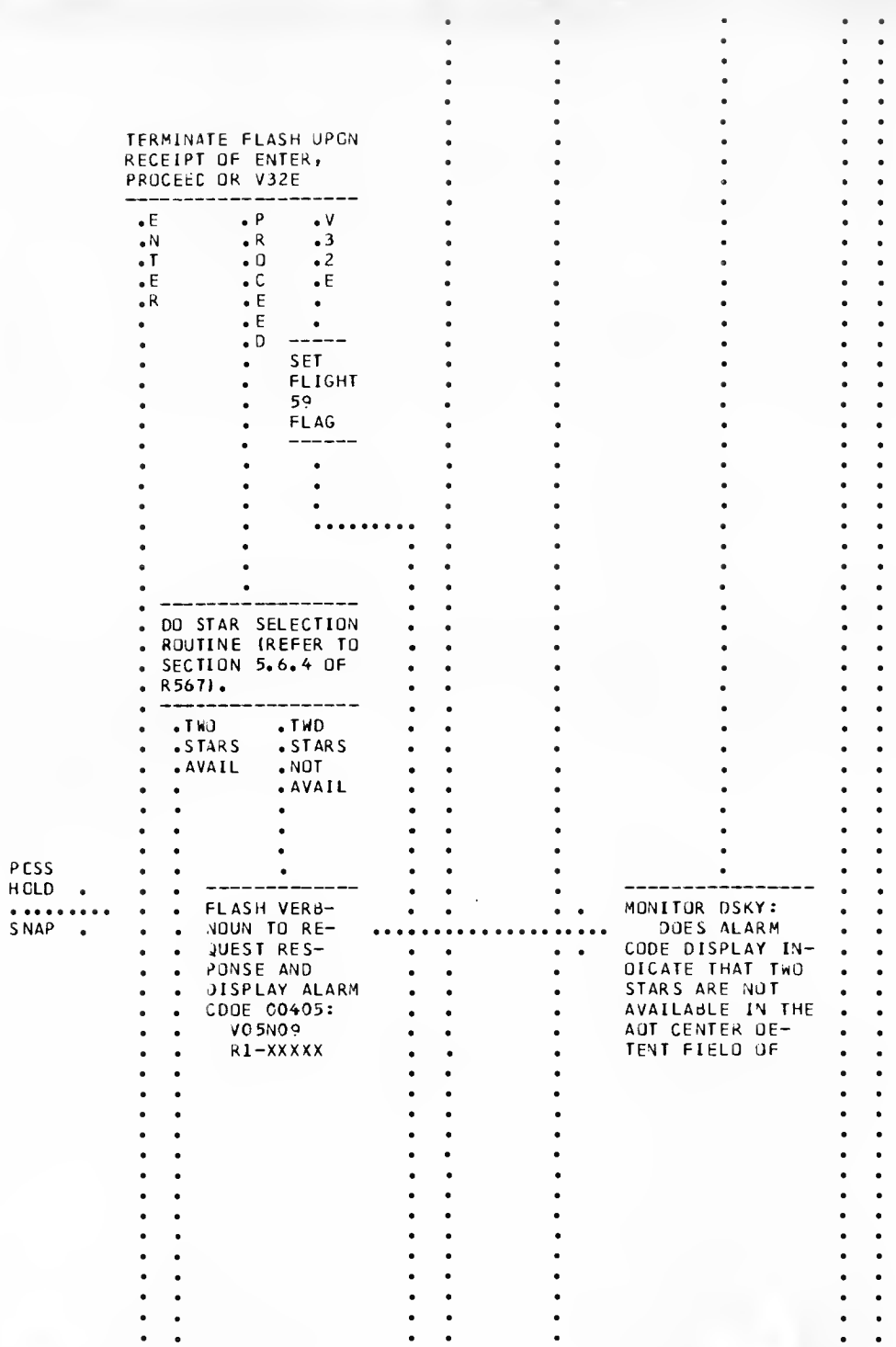
#80

#90

#100

#110

#120



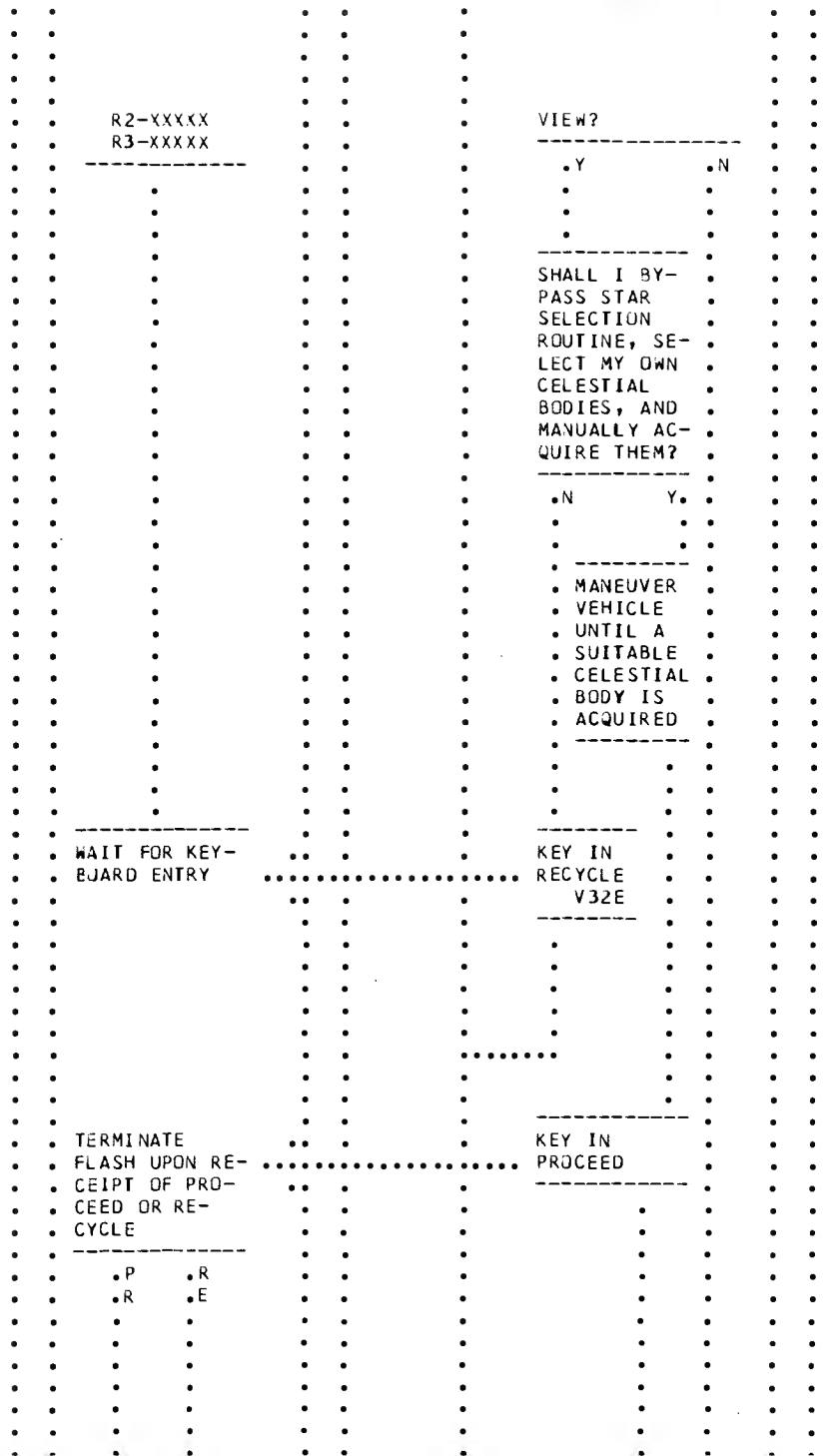
#130

#140

#150

#160

#170



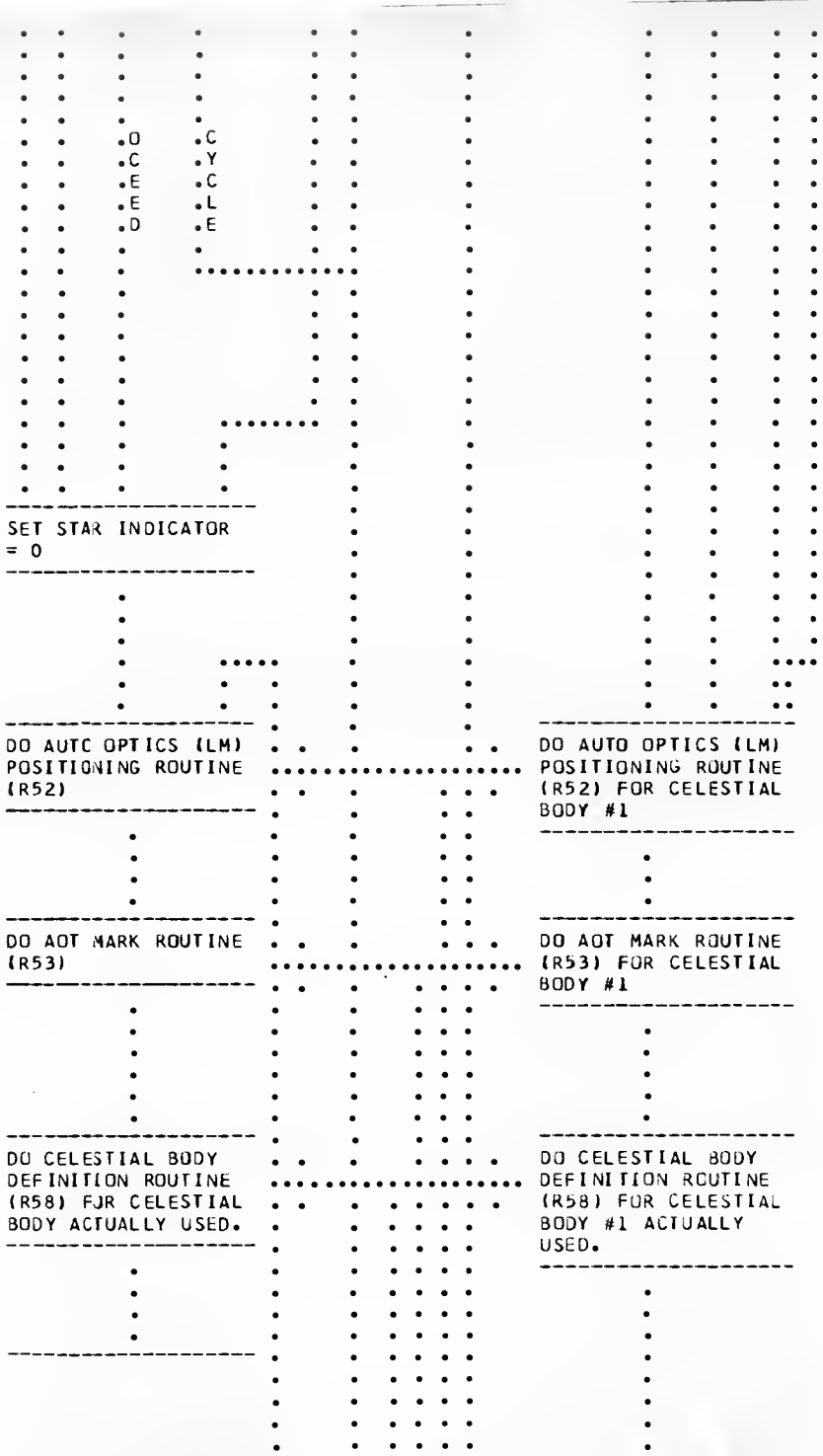
#180

#190

#200

#210

#220



#230

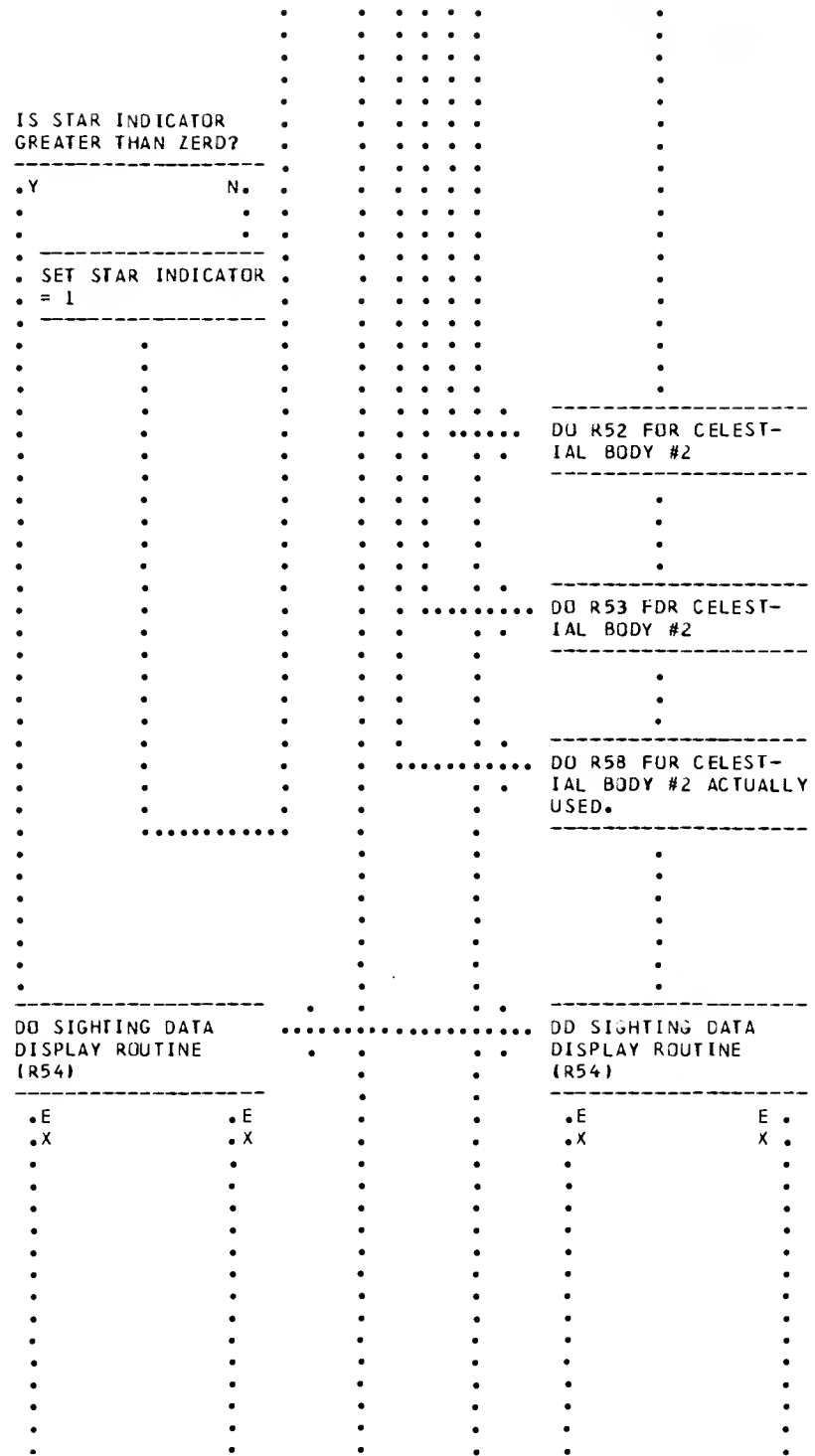
#240

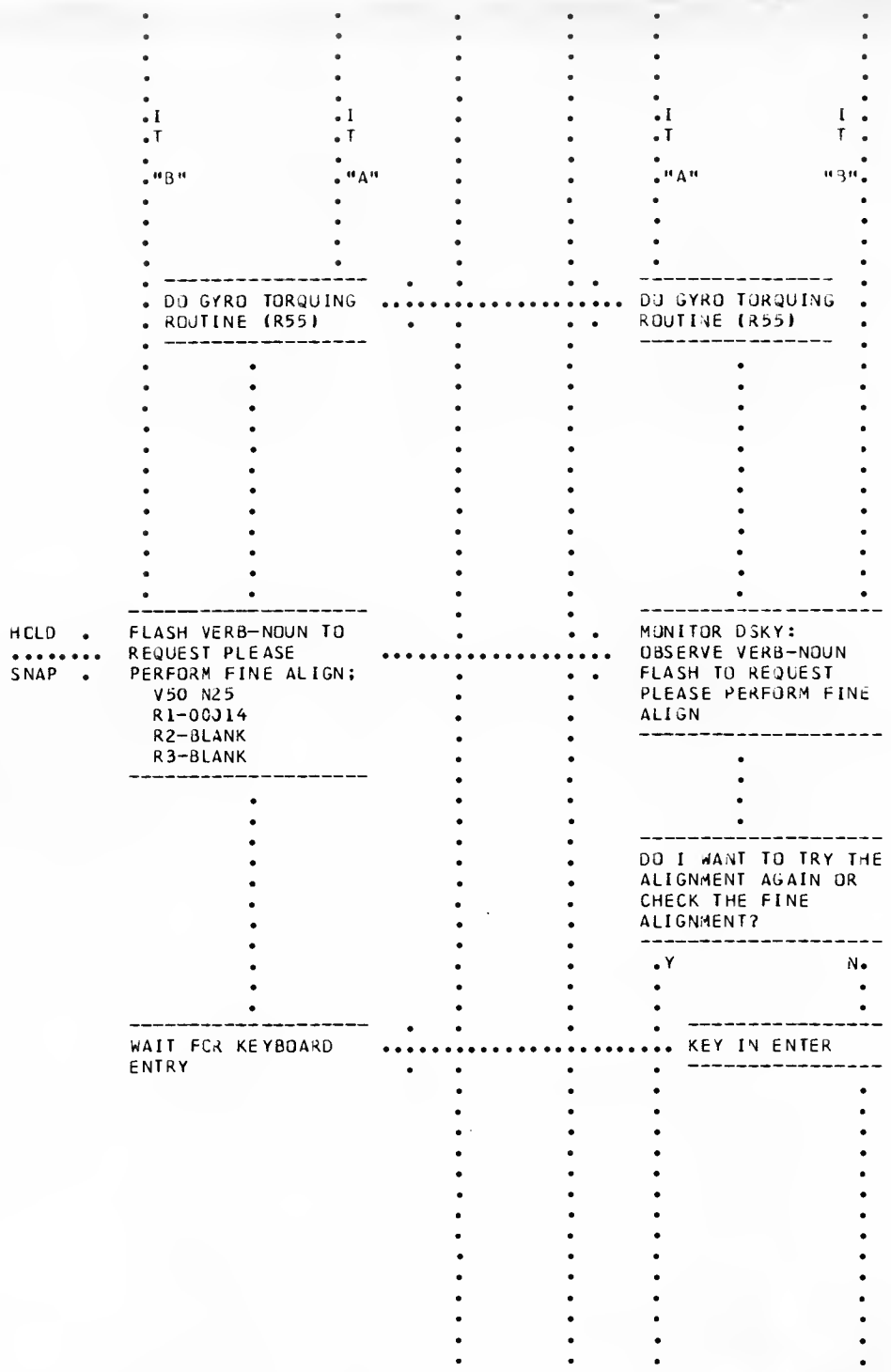
#250

#260

#270

#280


IS STAR INDICATOR GREATER THAN ZERO?
Y
N
SET STAR INDICATOR = 1
DO R52 FOR CELESTIAL BODY #2
#290
#300
DO R53 FOR CELESTIAL BODY #2
#310
DO R58 FOR CELESTIAL BODY #2 ACTUALLY USED.
#320
DO SIGHTING DATA DISPLAY ROUTINE (R54)
DO SIGHTING DATA DISPLAY ROUTINE (R54)
EXIT
EXIT
EXIT



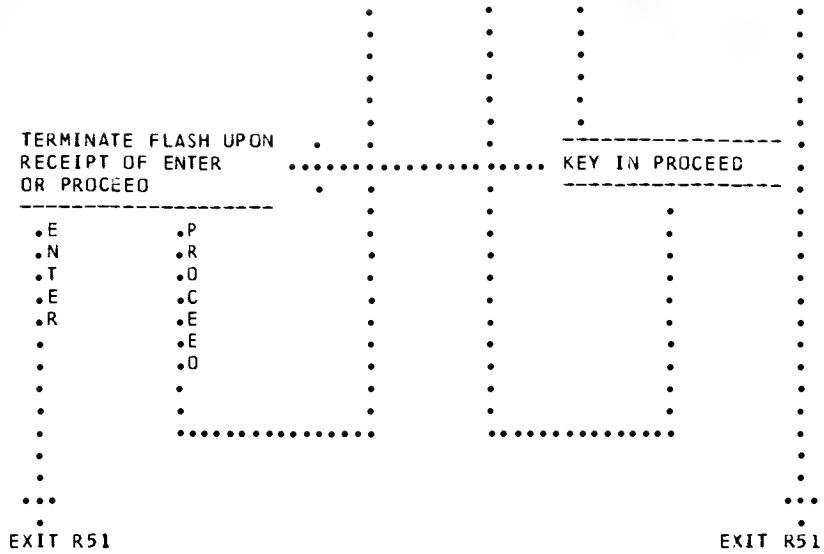
#330

#340

#350

#360

#370



#380

#390

#400

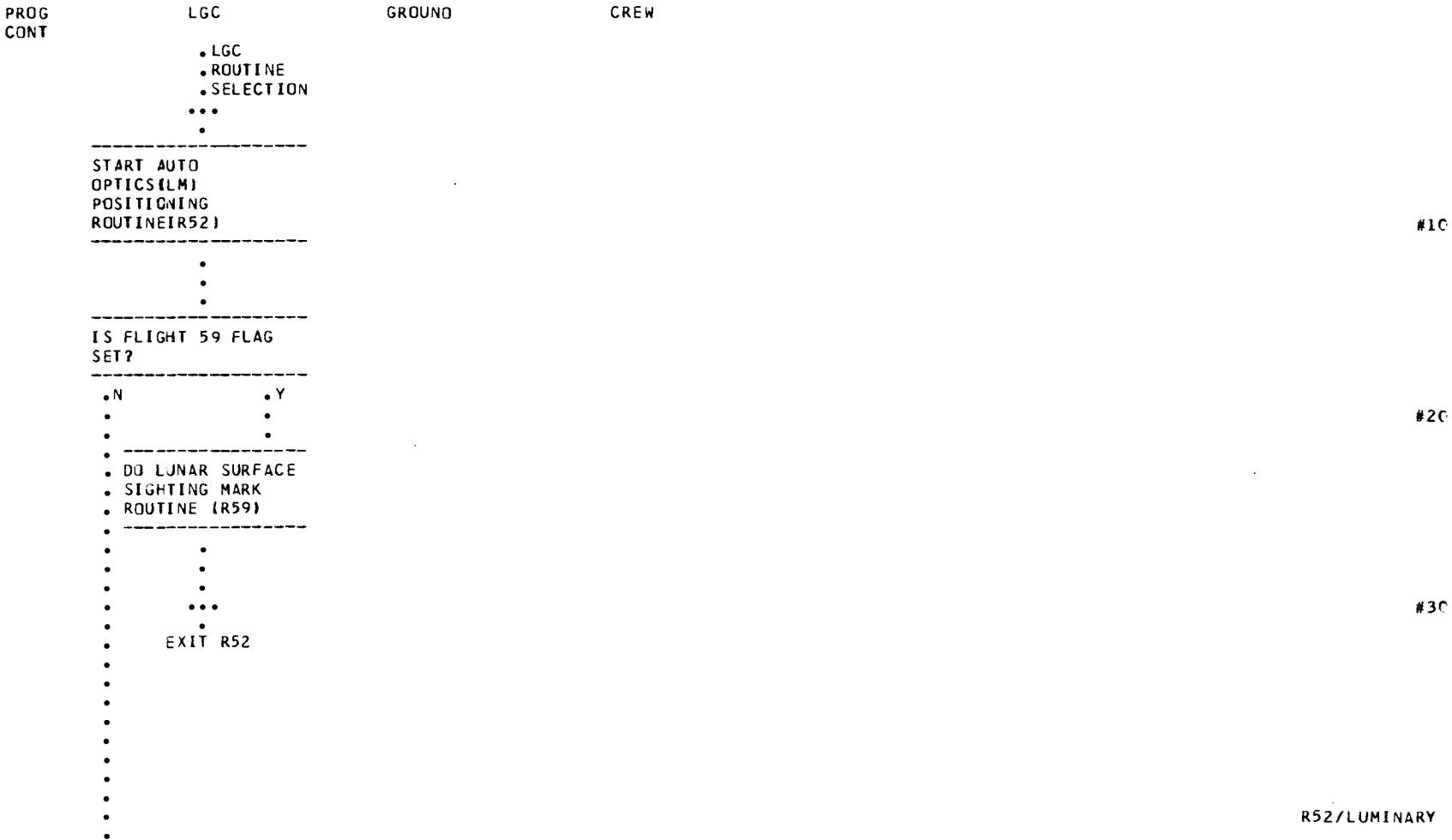
CHANGE CONTROL NOTES

REV 01 PCR 134
REV 02 EDITORIAL
REV 03 EDITORIAL
REV 04 PCN 1009
REV 05 PCR 335,1044, PCN 1145
REV 06 PCN 1180

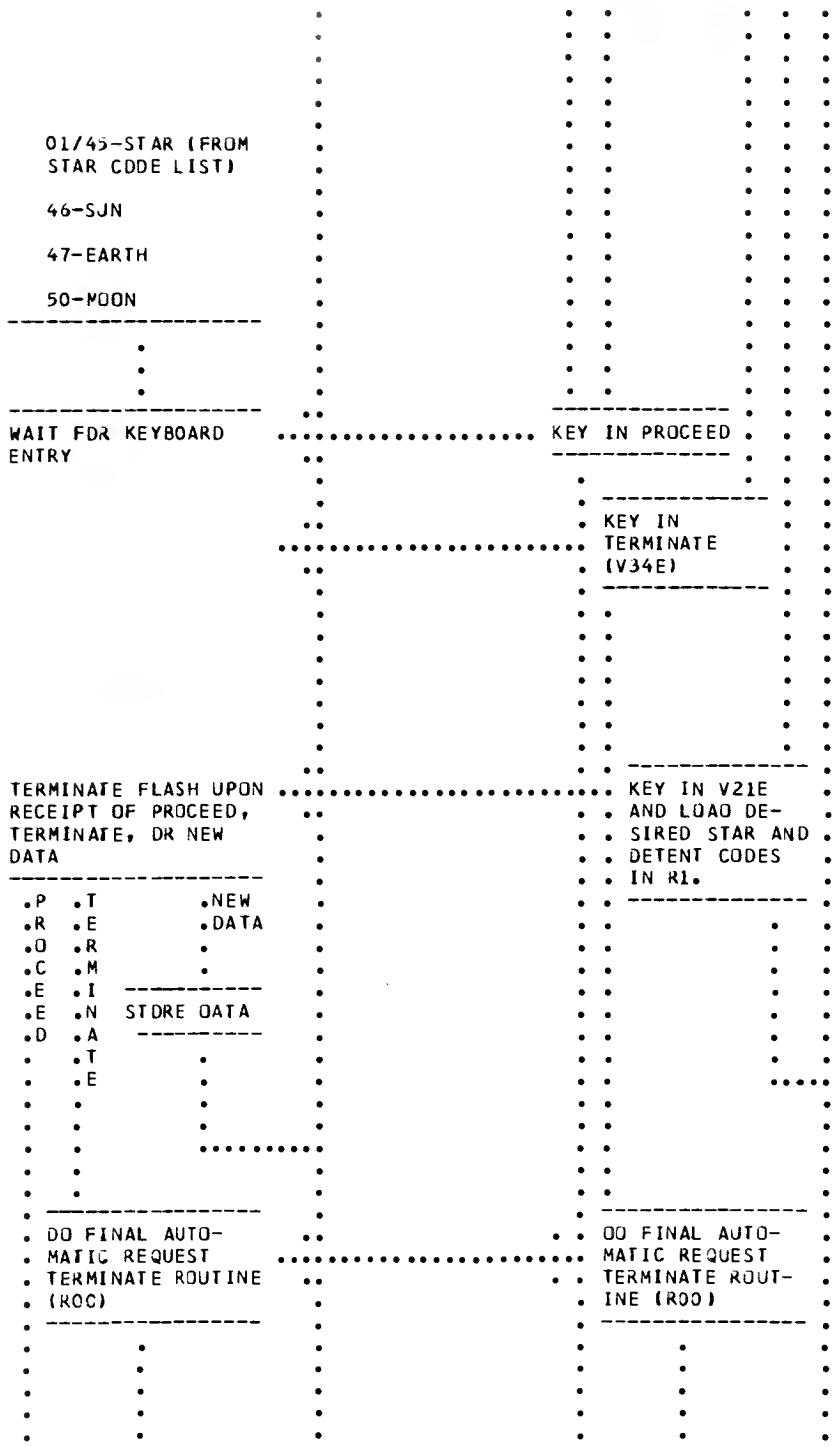
AUTOMATIC OPTICS(LM) POSITIONING ROUTINE(R52) REV 05 02/17/71

PURPOSE: (1) TO POINT THE LOS OF ANY AOT DETENT OR THE LOS OF A BACKUP OPTICAL SYSTEM AT A SPECIFIED CELESTIAL BODY BY MANEUVERING THE LM.

ASSUMPTION: (1) THE ROUTINE IS AUTOMATICALLY SELECTED BY THE INFLIGHT FINE ALIGN ROUTINE (R51).




HOLD
SNAP
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY AOT DETENT AND STAR CODE:
V01N70
R1-ABCDE
R2-BLANK
R3-BLANK
R1 IS AOT DETENT CODE AND STAR CODE:
A,B-O
C-AOT DETENT
D,E-STAR CODE
WHERE:
AOT DETENT (C) - THE AOT DETENT CODE USED FOR SIGHTING:
0 = COAS CALIBRATION
1 = FRONT LEFT DETENT
2 = FRONT CENTER DETENT
3 = FRONT RIGHT DETENT
4 = REAR RIGHT DETENT
5 = REAR CENTER DETENT
6 = REAR LEFT DETENT
7 = BACK-UP OPTICAL SYSTEM
STAR CODE - THE DESIGNATION OF THE CELESTIAL BODY TO BE USED. ALL DESIGNATIONS IN OCTAL.
00-PLANET
MONITOR DSKY: OBSERVE FLASHING VERB-NOUN TO REQUEST RESPONSE AND DISPLAY OF ADT DETENT AND STAR CODE.
#4C
#5C
ARE THE AOT DETENT AND STAR CODE DISPLAYS CORRECT FOR THE DESIRED SIGHTINGS?
#6C
Y
N
IS THIS A COAS CALIBRATION?
#7C
N
Y
IS THIS COAS CALIBRATION SATISFACTORY?
#8C
N
Y



#90

#100

#110

#120

#130

#14C

EXIT
R52

RESET 3-AXIS FLAG

#15C

IS AUT DETENT CODE
= 00XXX OR XX7XX?

.N .Y

#16C

DEFINE LOS AZI-
MUTH ACCORDING
TO SPECIFIED DE-
TENT AND LOS
ELEVATION TO BE
45 DEGREES.

#17C

IS THE BACKUP OP-
TICAL SYSTEM BEING
USED?

.Y N.

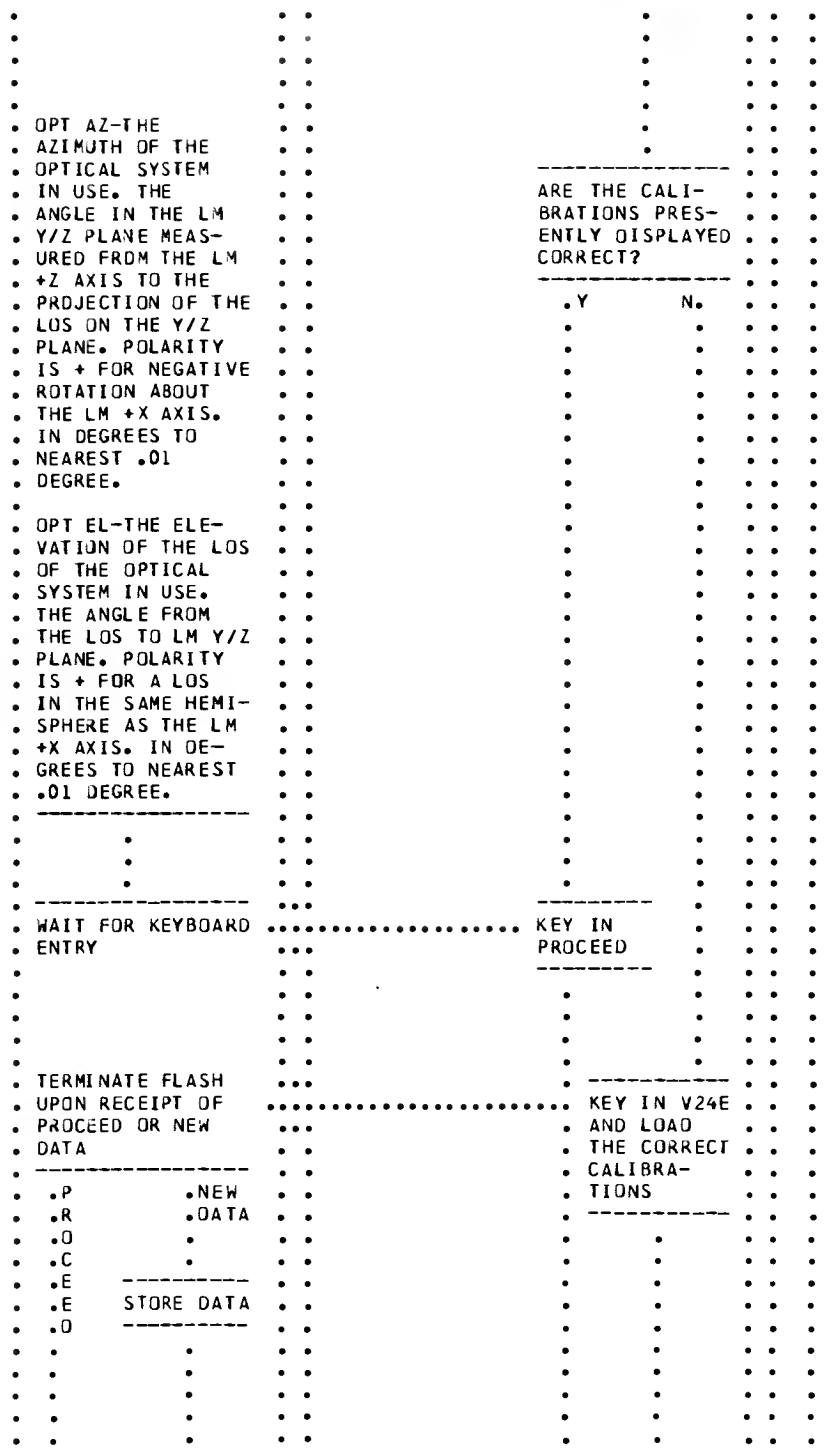
EXIT
R52

POSS
HOLD
SNAP

FLASH VERB-NOUN
TO REQUEST RESPO-
NSE AND DISPLAY
BACKUP OPTICAL
SYSTEM LOS
DEFINITION:
V06 N87
R1-OPT AZ
R2-OPT EL
R3-BLANK

MONITOR OSKY:
OBSERVE VERB-
NOUN FLASH TO
REQUEST RESPON-
SE AND DISPLAY
OF BACKUP
OPTICAL SYSTEM
LOS DEFINITION.

#18C



#190

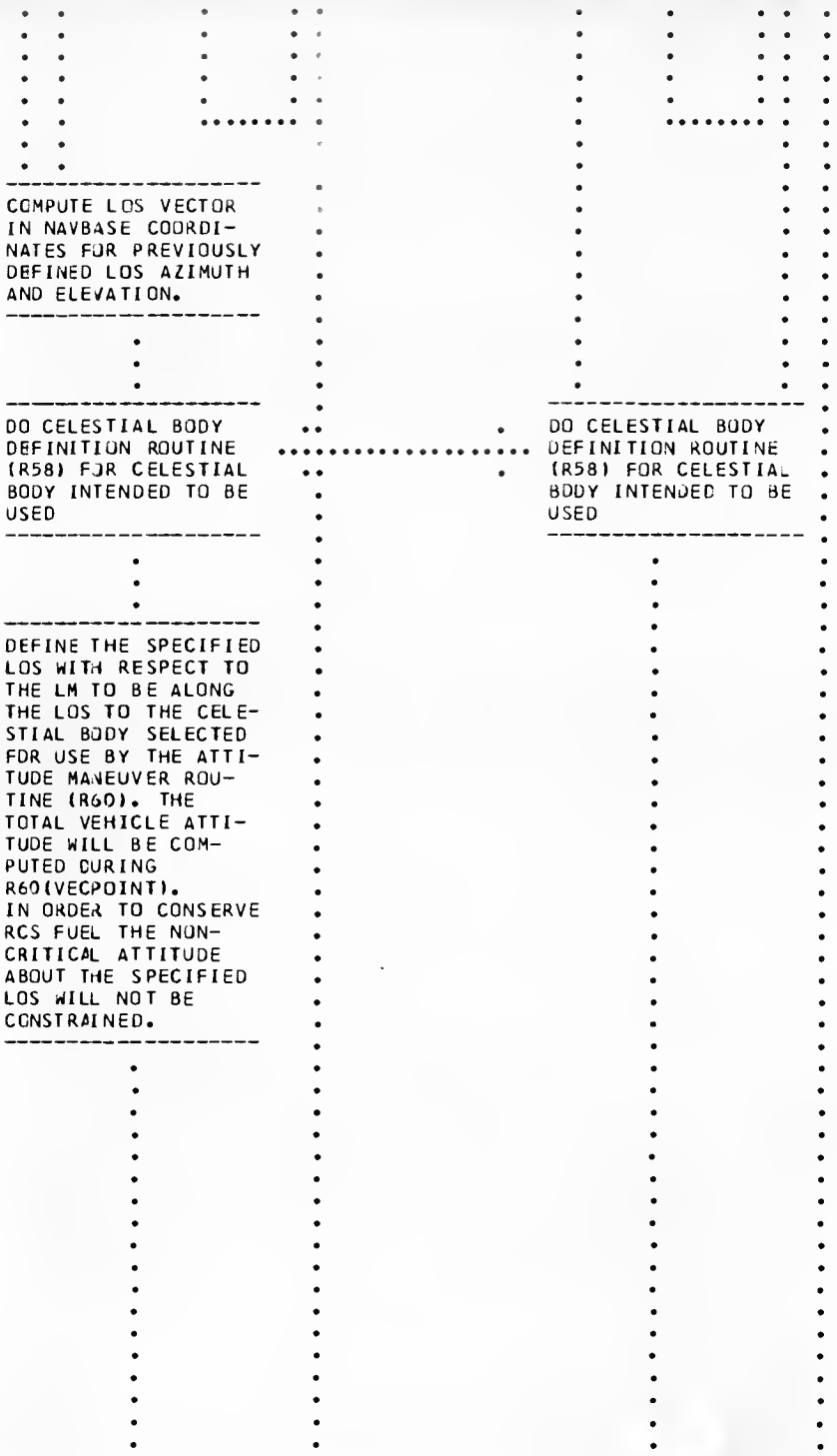
#200

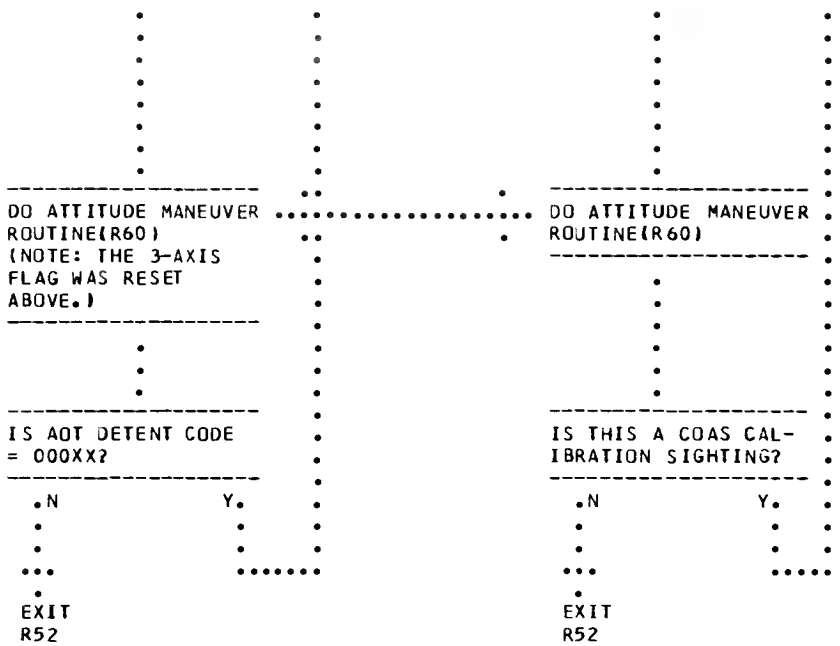
#210

#220

#230

#240


COMPUTE LOS VECTOR IN NAVBASE COORDINATES FOR PREVIOUSLY DEFINED LOS AZIMUTH AND ELEVATION.
#250
DO CELESTIAL BODY DEFINITION ROUTINE (R58) FOR CELESTIAL BODY INTENDED TO BE USED
#260
DO CELESTIAL BODY DEFINITION ROUTINE (R58) FOR CELESTIAL BODY INTENDED TO BE USED
DEFINE THE SPECIFIED LOS WITH RESPECT TO THE LM TO BE ALONG THE LOS TO THE CELESTIAL BODY SELECTED FOR USE BY THE ATTITUDE MANEUVER ROUTINE (R60). THE TOTAL VEHICLE ATTITUDE WILL BE COMPUTED DURING R60(VECPOINT). IN ORDER TO CONSERVE RCS FUEL THE NONCRITICAL ATTITUDE ABOUT THE SPECIFIED LOS WILL NOT BE CONSTRAINED.
#270
#280
#290



#300

#310

CHANGE CONTROL NOTES

REV 01 EDITORIAL
REV 00(LUM 1A) PCR 699,702
REV 02 EDITORIAL
REV 03 EDITORIAL
REV 04 PCN 1009
REV 05 PCR 1044

PURPOSE: (1) TO REQUEST AND PROCESS SIGHTING MARKS (USING THE AOT OR THE COAS) ON CELESTIAL BODIES FOR USE BY THE ALIGNMENT PROGRAMS (LUNAR SURFACE AND INFLIGHT).
++
+05
ASSUMPTIONS: (1) MULTIPLE SIGHTINGS UP TO A MAXIMUM OF FIVE IN EACH AXIS (X AND Y) MAY BE USED TO DETERMINE THE AVERAGE LOS VECTOR TO THE CELESTIAL BODY.
+11B0
++

(2) A BACKUP OPTICAL SYSTEM (COAS) MAY BE USED FOR SIGHTINGS, HOWEVER IN THIS CASE THE CREW MUST LOAD CALIBRATED LOS AZIMUTH AND ELEVATION DATA ASSOCIATED WITH THIS LOS.

(3) THIS ROUTINE IS AUTOMATICALLY CALLED BY P51,R51, AND R59.

(4) THIS ROUTINE ENABLES THE MARKRUPT ROUTINE (R57) WHICH IS AUTOMATICALLY CALLED BY CREW ACTIVITY WITH ANY OF THE FOLLOWING BUTTONS/SWITCHES: MARK X BUTTON, MARK Y BUTTON, MARK REJECT BUTTON, DESCENT RATE SWITCH (+ OR - ROD).

PERFORM SIGHTING MARK PROCEDURE ADHERING TO THE FOLLOWING PRINCIPLES:

(A) X/Y MARKS
1. ADJUST AOT RETICLE TO ZERO BEFORE PERFORMING MARKS.
2. A MARK IS MADE WHEN THE TARGET BODY CROSSES THE X OR Y RETICLE LINE BY PRESSING THE APPROPRIATE MARK PUSHBUTTON.
3. MARKS NEED NOT BE MADE IN PAIRS. THE X AND Y MARK COUNTERS CAN STORE UP TO 5 MARKS IN EACH COUNTER. ANY SUBSEQUENT MARKING WILL OVERWRITE THE 5TH MARK.
4. A 1 IN THE FIRST DIGIT (1000 X) OF R2 OR R3 IS A MARK REJECT INDICATOR. (I.E. A MARK REJECT WILL DECREMENT THAT REGISTER). THIS INDICATOR IS POSITIONED BY THE LAST MARK TAKEN.
5. ANY NUMBER OF MARKS TAKEN CAN BE REJECTED BY PRESSING THE "MARK REJECT" PUSHBUTTON. THE LAST MARK (IN THE SELECTED REGISTER) WILL BE THE FIRST TO BE REJECTED. KEY "ENTER" TO CHANGE THE REJECT OPTION (SEE 4 ABOVE). A 00115 ALARM WILL OCCUR IF MARK REJECT IS ATTEMPTED WITH NO MARK IN THAT REGISTER.
6. THE LGC WILL MATCH AND AVERAGE THE LOS OF EACH X AND Y PAIR TO DEFINE A FINAL LOS. ANY UNMATCHED MARKS WILL BE DISREGARDED BY THE LGC.
7. AFTER EACH MARK, THE CREW MAY:
   A. TERMINATE MARKING. KEY IN PRO (IF BOTH X AND Y MARK REGISTERS ARE GREATER THAN ZERO).
   B. CONTINUE MARKING ON THE SAME CELESTIAL BODY (USE THE APPROPRIATE MARK BUTTON).
   C. THROW AWAY ALL DATA ON THE PRESENT CELESTIAL BODY, SELECT A NEW BODY, AND CONTINUE MARKING. KEY V32E.
   D. CHANGE REJECT OPTION. KEY ENTER.

(B) CURSOR/SPIRAL MARKS
1. MARKS ARE MADE SINGLY BY PUSHING THE MARK X OR MARK Y PUSHBUTTON OR ACTIVATING THE ROD SWITCH. V52 CALLS FOR CURSOR MARKS, V53 FOR SPIRAL MARKS. ANY MARK WILL CALL MARKRUPT ROUTINE R57 AND FLASH VERB 21/22 NOUN 79 REQUEST TO LOAD THE APPROPRIATE CURSOR/SPIRAL ANGLE (SEE R57). THE LGC WILL NOT CONSIDER A MARK COMPLETED UNTIL THE CURSOR OR SPIRAL DATA IS ENTERED. IT IS THEREFORE NOT POSSIBLE TO REMARK OR REJECT A MARK IF DATA HAS NOT BEEN LOADED. ANOTHER MARK ACTION ON FV 21/22 N79 WILL NOT OVERWRITE THE PREVIOUS MARK.
2. A MARK REJECT WILL REJECT A MARK AND ITS ASSOCIATED CURSOR OR SPIRAL DATA TO ANY DEPTH AS LONG AS ANY MARKS REMAIN. A 00115 ALARM WILL OCCUR IF A MARK REJECT IS ATTEMPTED WITHOUT ANY MARKS IN THAT REGISTER. KEY ENTER ON VERB V52 OR V53 (ALSO SEE 3 BELOW) TO CHANGE THE MARK REJECT (OR CURSOR/SPIRAL) OPTION.
3. MARKS NEED NOT BE MADE IN PAIRS. IT IS USUALLY MORE CONVENIENT TO MAKE ALL CURSOR (OR SPIRAL) MARKS IN SEQUENCE. KEY ENTER ON V52 OR V53 (SEE 2 ABOVE ALSO) TO CHANGE THE CURSOR/SPIRAL MARK (OR MARK REJECT) OPTION. THE CURSOR AND SPIRAL MARK COUNTERS CAN STORE UP TO 5 MARKS IN EACH COUNTER. ANY

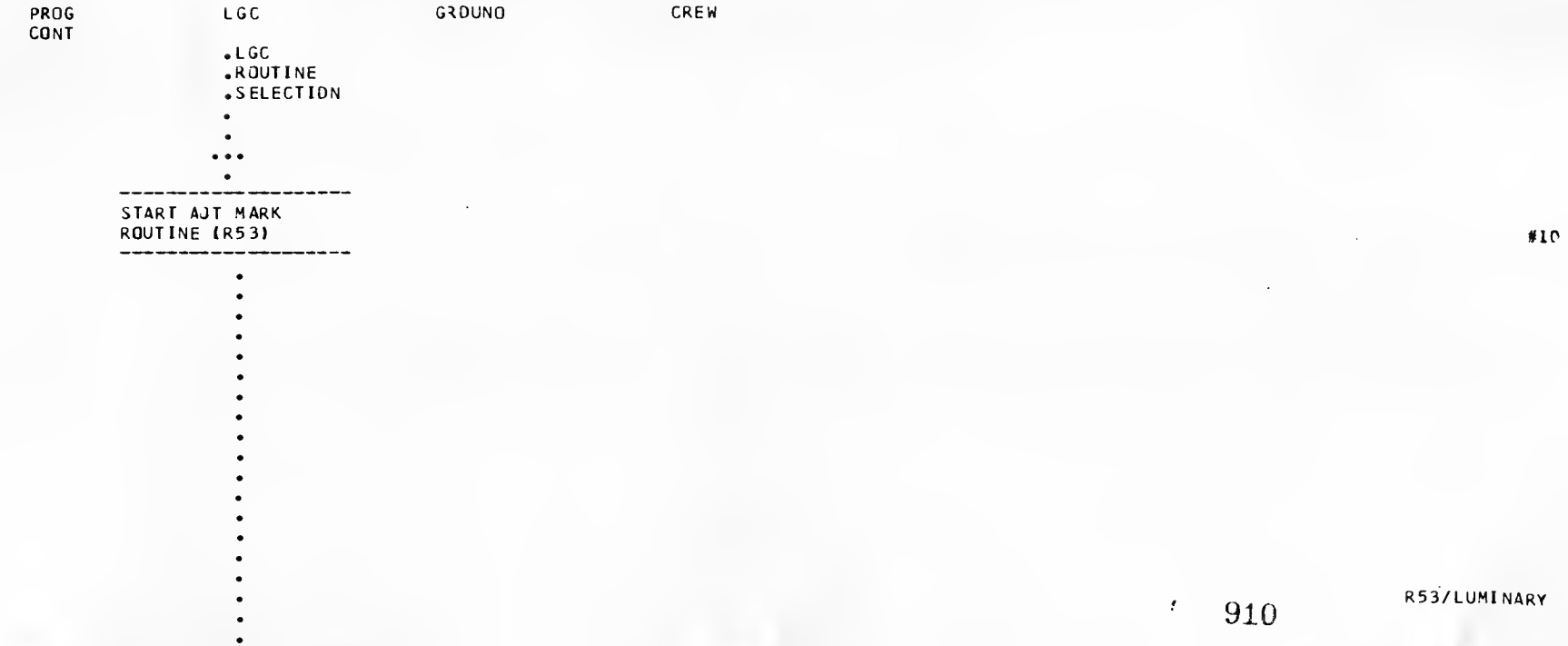
SUBSEQUENT MARKING WILL OVERWRITE THE 5TH MARK.

4. IT IS NOT NECESSARY TO WRITE DOWN THE CURSOR OR SPIRAL ANGLES. THE DSKY WILL REQUEST THE CURSOR OR SPIRAL ANGLES WHEN A MARKING ACTION IS MADE. DATA MAY BE READ DIRECTLY FROM THE AOT COUNTER AND LOADED INTO THE DSKY.
5. THE LGC WILL PROCESS UP TO 5 CURSOR AND 5 SPIRAL MARKS FOR EACH CELESTIAL BODY. THE LGC WILL MATCH AND AVERAGE THE LOS OF EACH CURSOR AND SPIRAL PAIR TO DEFINE A FINAL LOS. ANY UNMATCHED MARKS WILL BE DISREGARED BY THE LGC.
6. AFTER EACH MARK THE CREW MAY:
   A. TERMINATE THE MARKING SEQUENCE BY KEYING "PRO" ON FLASHING V52 OR V53 (IF CURSOR AND SPIRAL MARK COUNTERS GREATER THAN ZERO).
   B. CONTINUE MARKING ON THE SAME CELESTIAL BODY.
   C. THROW AWAY ALL DATA ON PRESENT CELESTIAL BODY BY KEYING IN "V32E". A NEW CELESTIAL BODY MAY THEN BE SELECTED.
   D. CHANGE REJECT OPTION AND REQUEST CHANGE TO SPIRAL (OR CURSOR) MARKS. KEY ENTER.

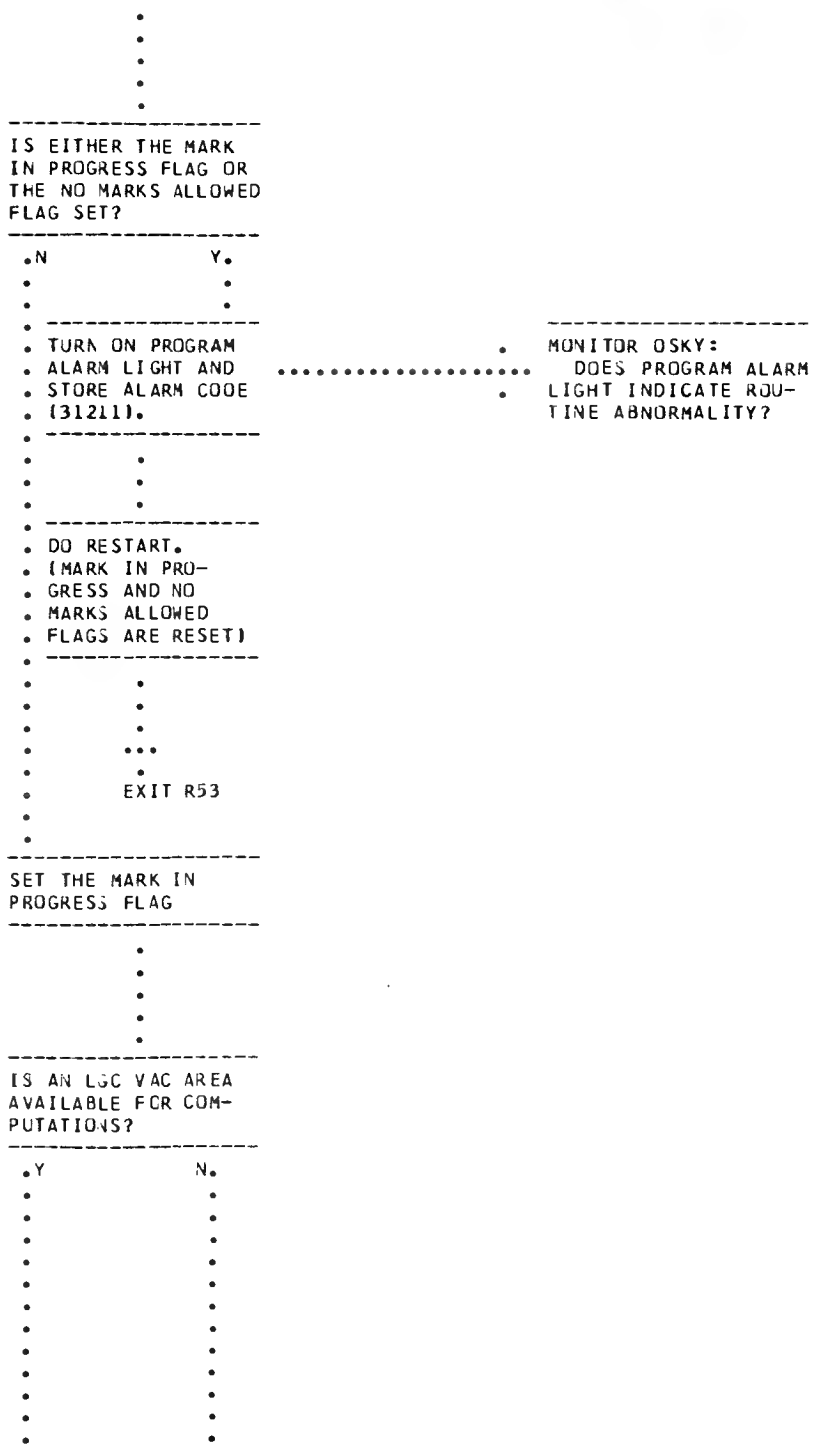
(C) X/Y MARKING OR CURSOR/SPIRAL MARKING

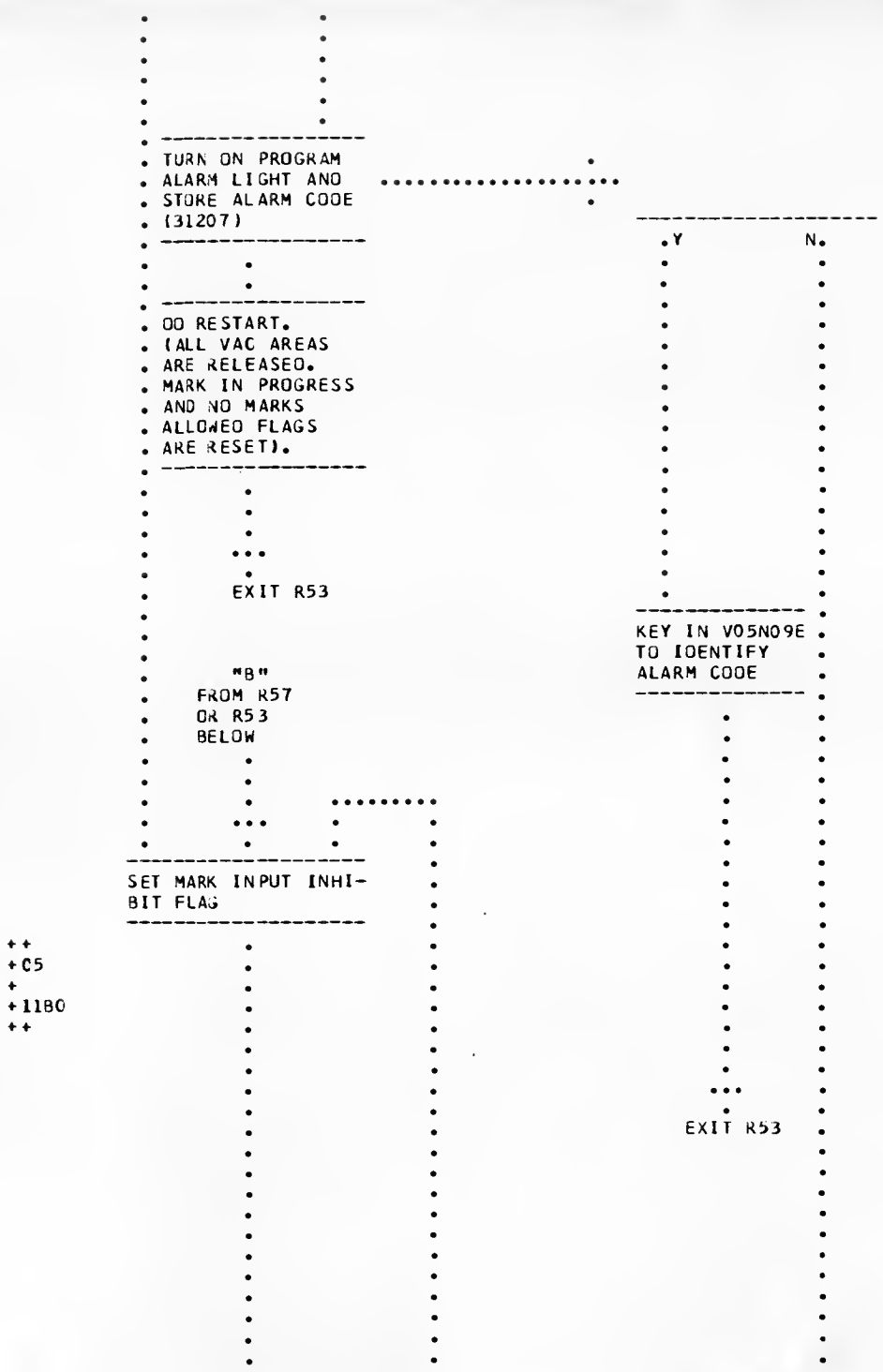
1. THIS ROUTINE AND THE CALLING ALIGNMENT PROGRAM MAY BE TERMINATED AT ANY TIME BY KEYING "V34E".
2. A 00111 ALARM WILL OCCUR WHEN A "PROCEED" FROM MARK REQUEST IS ATTEMPTED WITH ZERO MARKS IN EITHER MARK COUNTER (NO MARK PAIR). OTHER ALARMS ARE ALSO POSSIBLE (SEE R57).
3. A 00112 ALARM WILL OCCUR IF ANY OF THE FOLLOWING BUTTONS ARE ACTIVATED ON A DISPLAY OTHER THAN A MARK REQUEST DISPLAY:
   MARK X BUTTON, MARK Y BUTTON, MARK REJECT BUTTON, AND DESCENT RATE SWITCH (+ OR - ROD) WHEN AVERAGE G FLAG IS NOT SET.
4. A 00113 ALARM WILL OCCUR IF THE ROD SWITCH IS ACTIVATED DURING X/Y MARK REQUEST DISPLAY V54N71.

++
+05
+
+1180
++



#10


IS EITHER THE MARK IN PROGRESS FLAG OR THE NO MARKS ALLOWED FLAG SET?
#20
N
Y
TURN ON PROGRAM ALARM LIGHT AND STORE ALARM CODE (31211).
MONITOR OSKY: DOES PROGRAM ALARM LIGHT INDICATE ROUTINE ABNORMALITY?
#30
DO RESTART. (MARK IN PROGRESS AND NO MARKS ALLOWED FLAGS ARE RESET)
#40
EXIT R53
SET THE MARK IN PROGRESS FLAG
#50
IS AN LGC VAC AREA AVAILABLE FOR COMPUTATIONS?
#60
Y
N



++
+C5
+
+1180
++

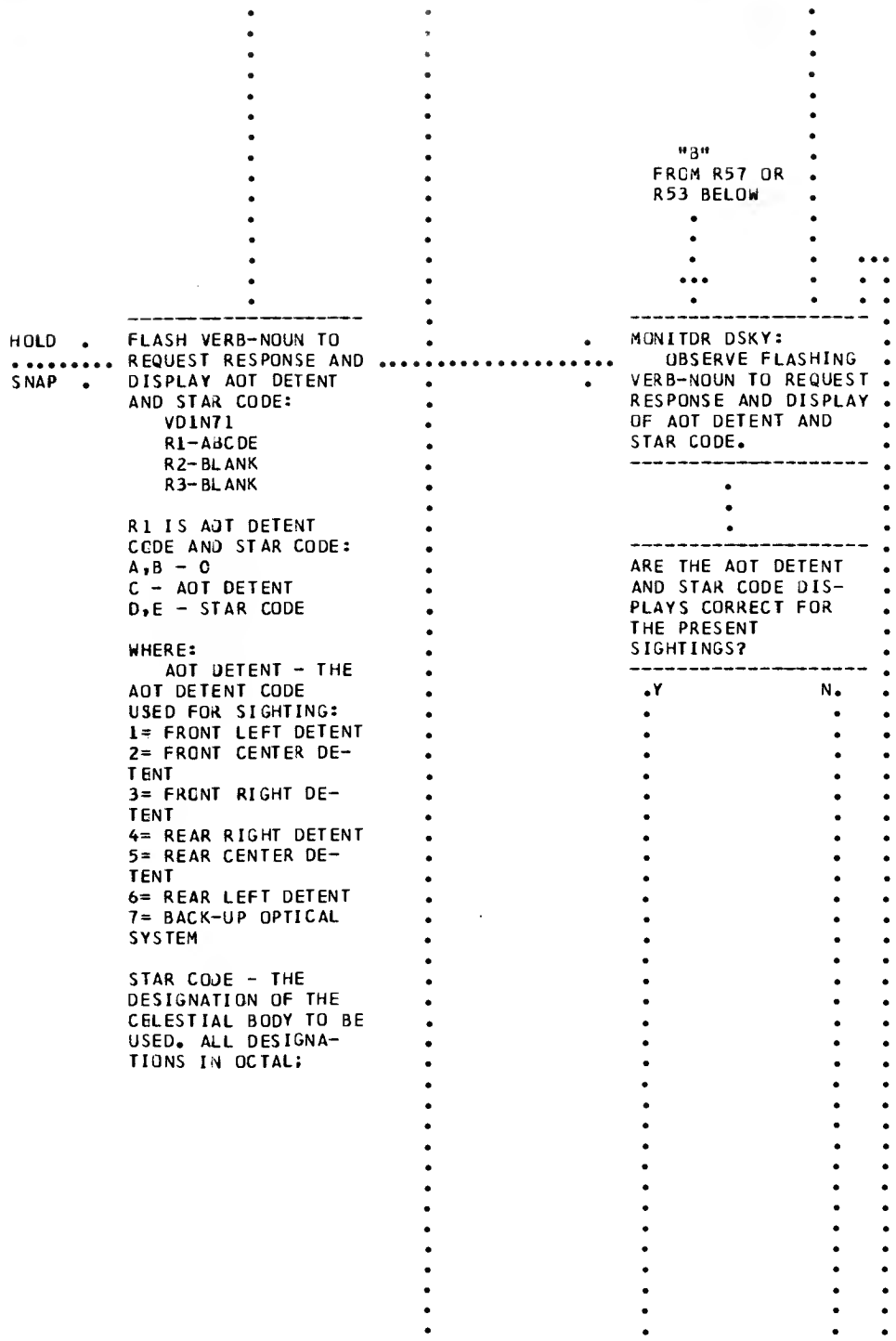
#70

#80

#90

#100

#110



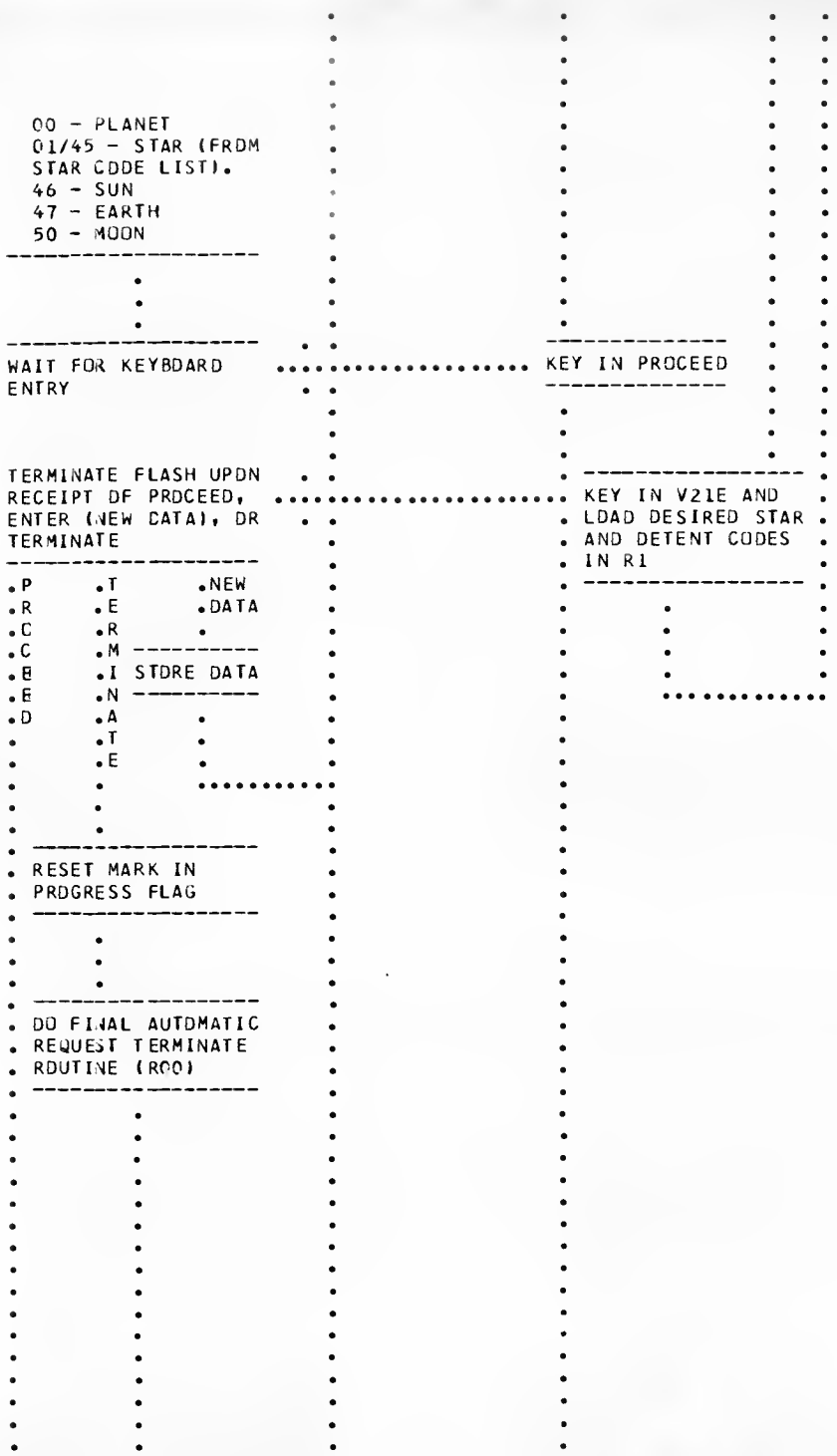
#120

#130

#140

#150

#160



#170

#180

#190

#200

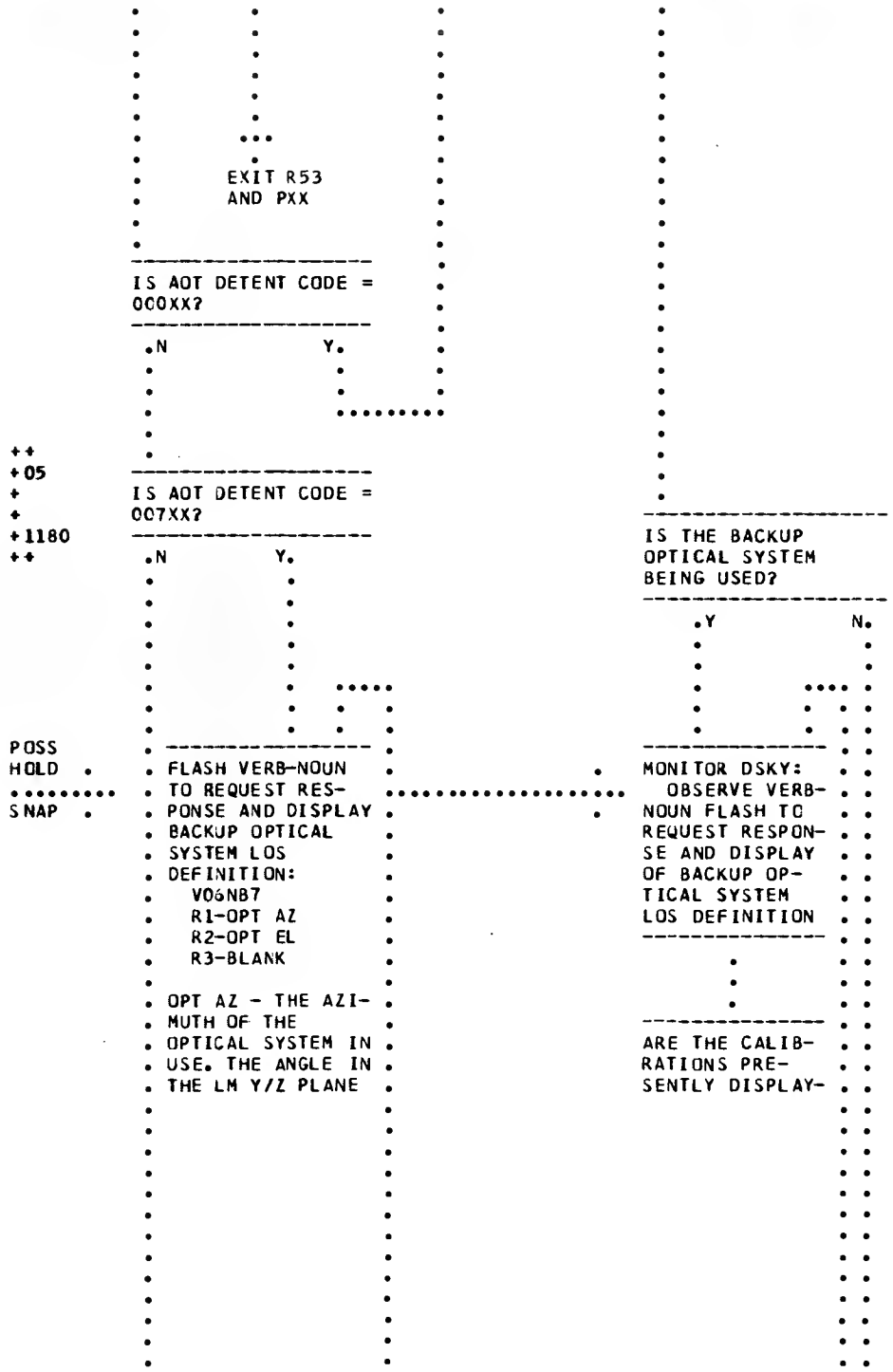
#210

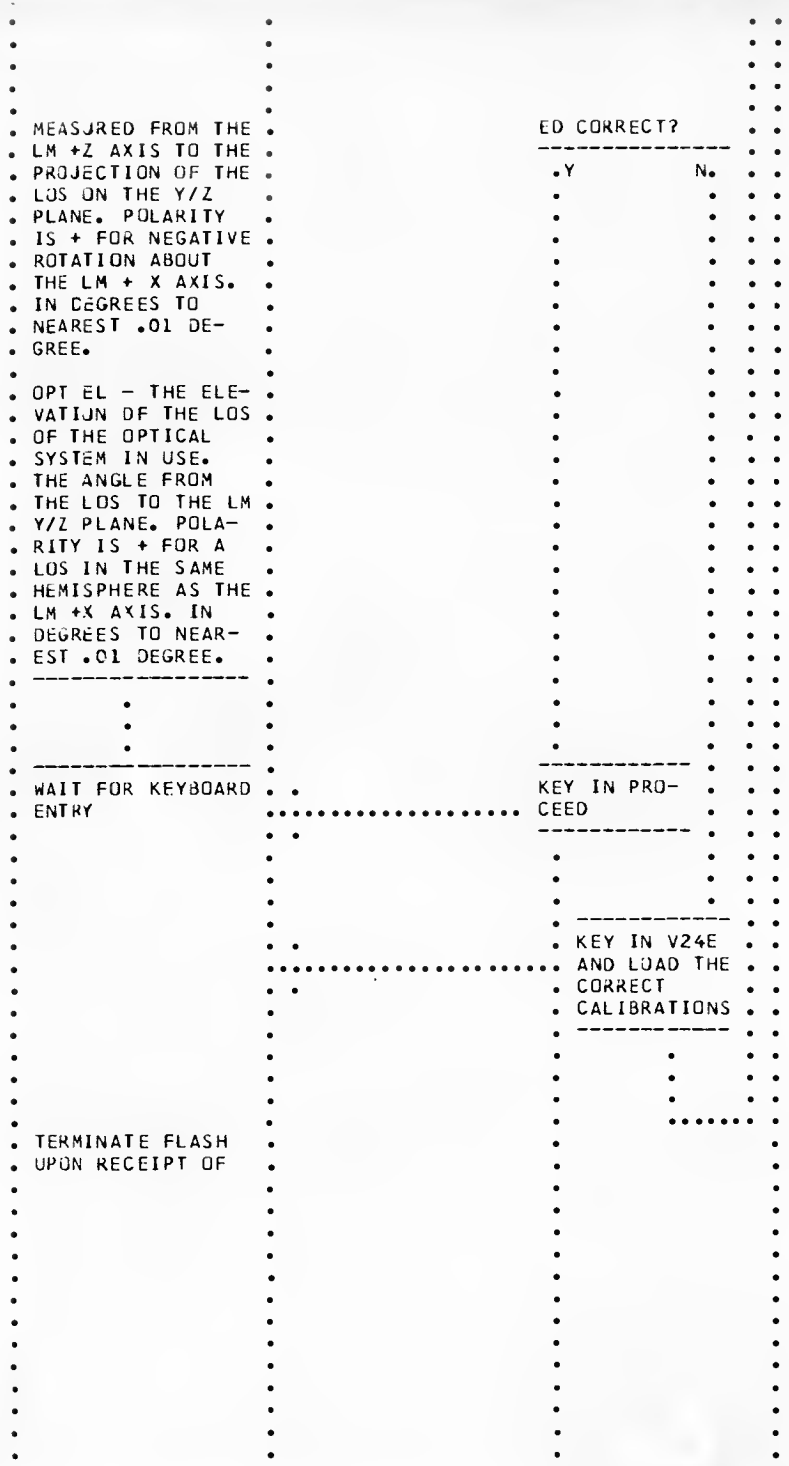
#220

#230

#240

#250





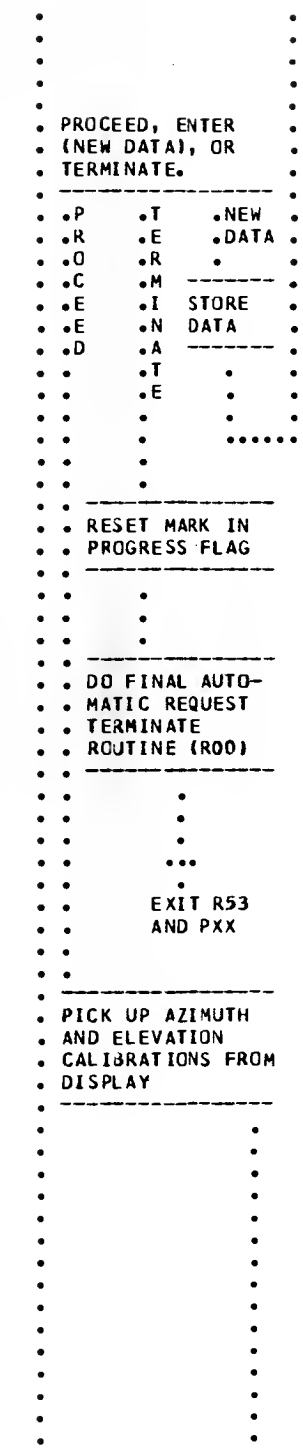
#260

#270

#280

#290

#300



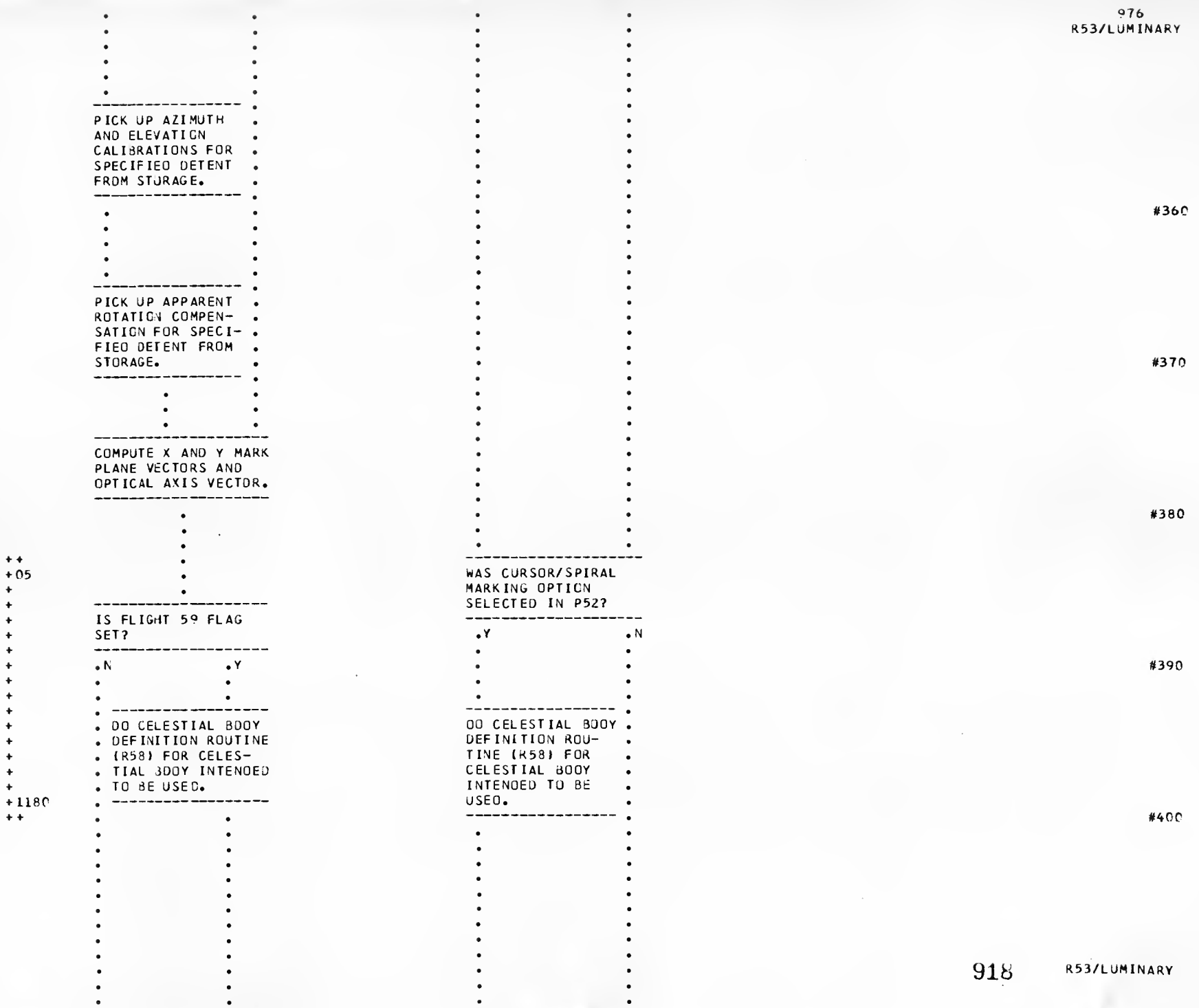
#310

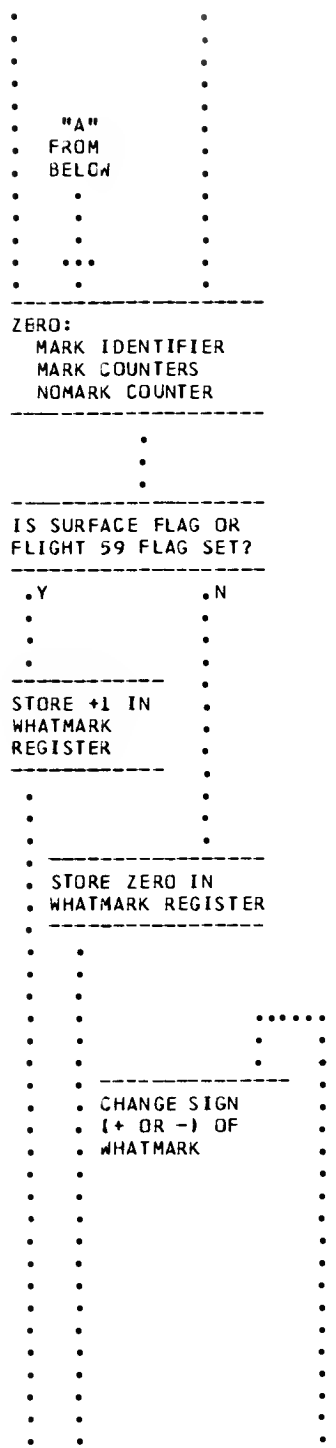
#320

#330

#340

#350


PICK UP AZIMUTH AND ELEVATION CALIBRATIONS FOR SPECIFIED DETENT FROM STORAGE.
PICK UP APPARENT ROTATION COMPENSATION FOR SPECIFIED DETENT FROM STORAGE.
COMPUTE X AND Y MARK PLANE VECTORS AND OPTICAL AXIS VECTOR.
IS FLIGHT 59 FLAG SET?
.N
.Y
DO CELESTIAL BODY DEFINITION ROUTINE (R58) FOR CELESTIAL BODY INTENDED TO BE USED.
WAS CURSOR/SPIRAL MARKING OPTION SELECTED IN P52?
.Y
.N
DO CELESTIAL BODY DEFINITION ROUTINE (R58) FOR CELESTIAL BODY INTENDED TO BE USED.
#360
#370
#380
#390
#400
++
+05
+1180
++



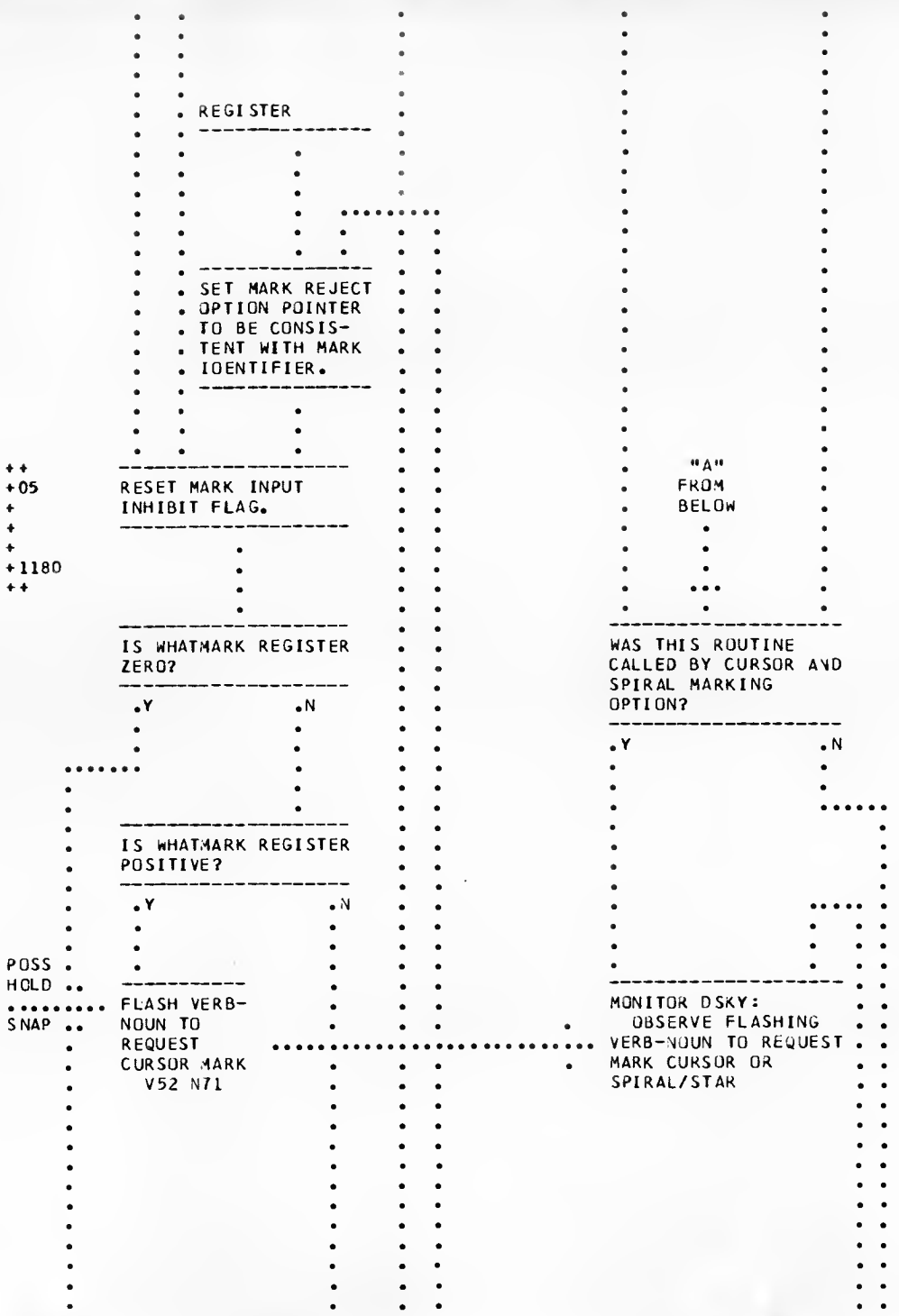
#410

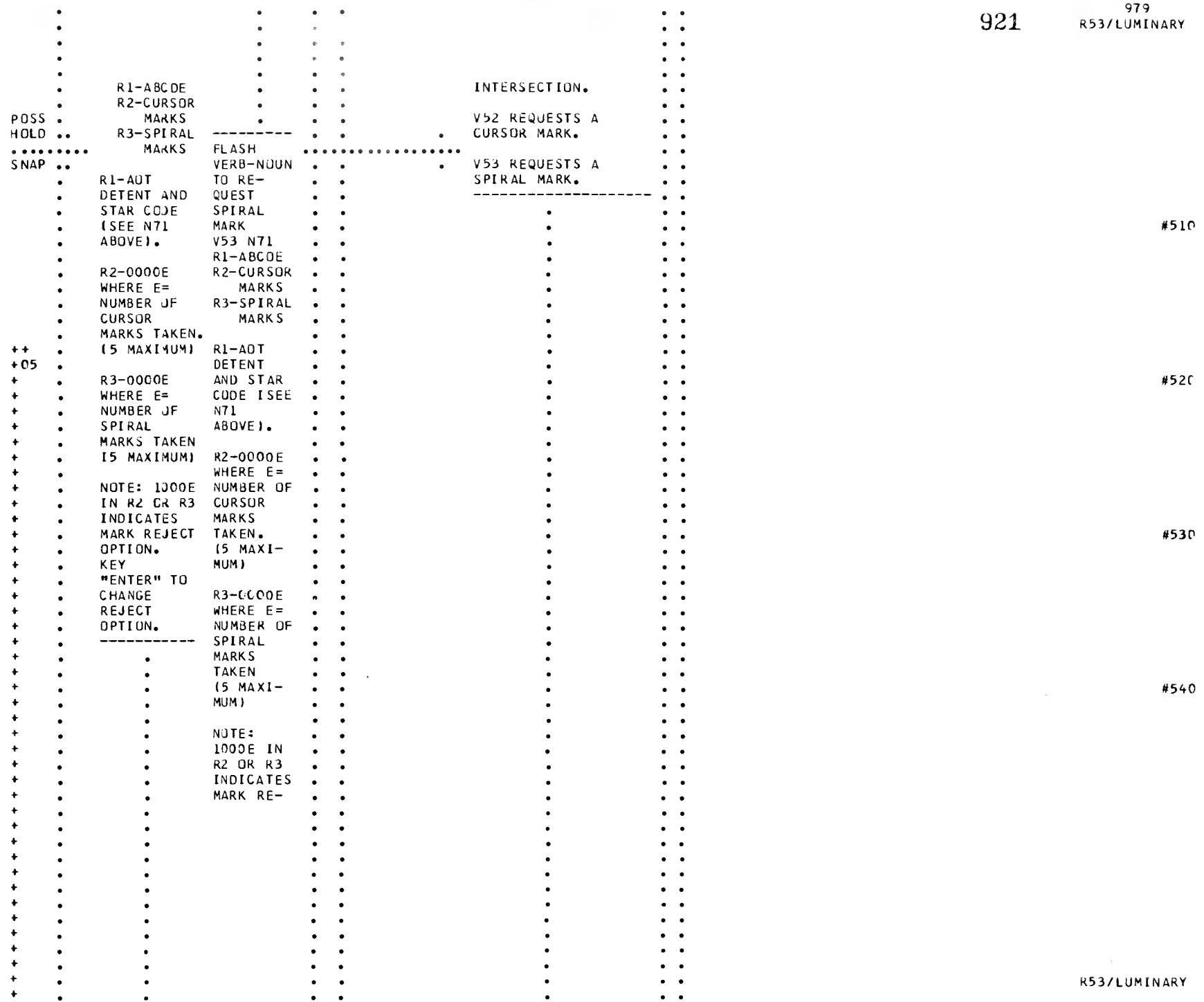
#420

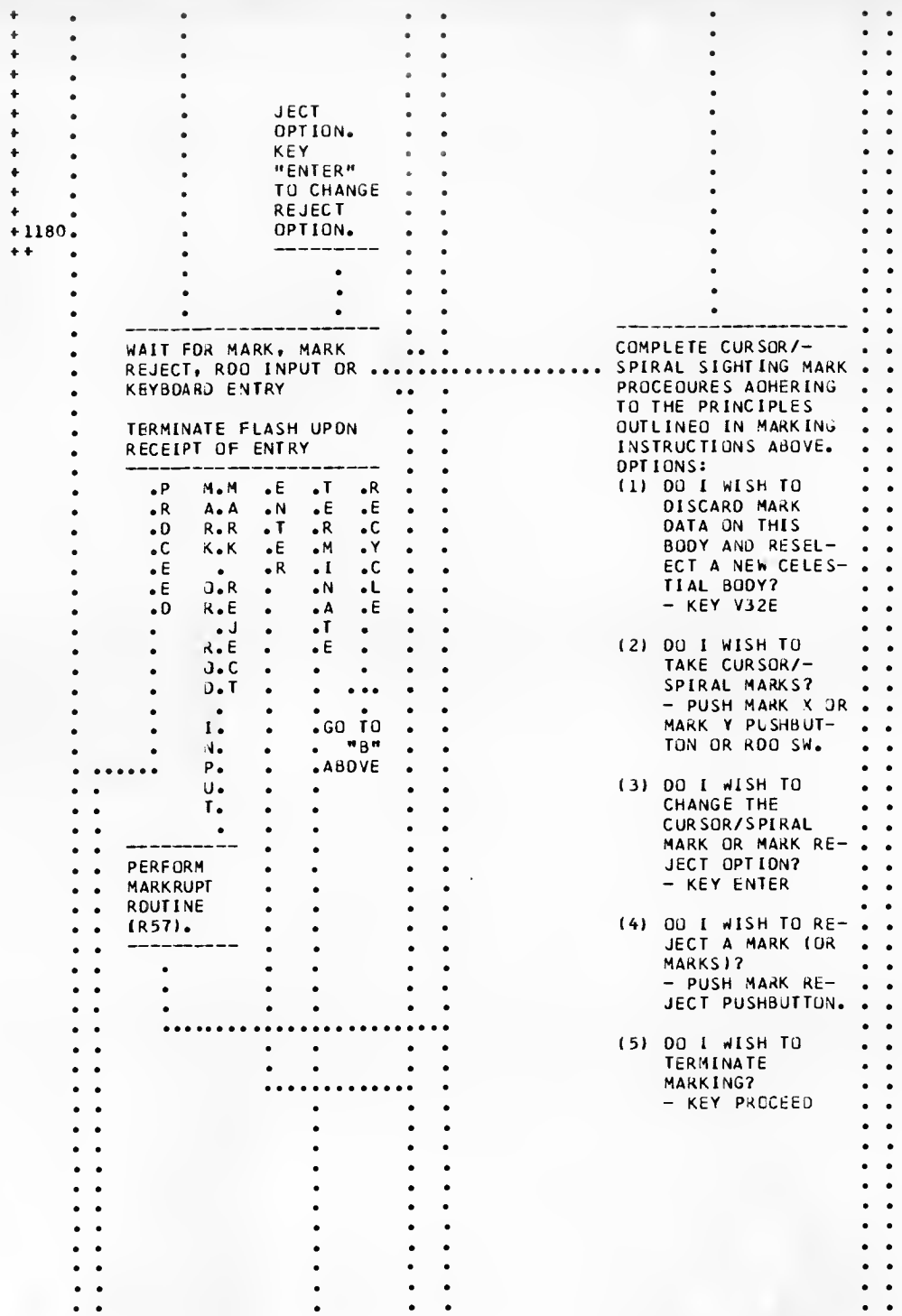
#430

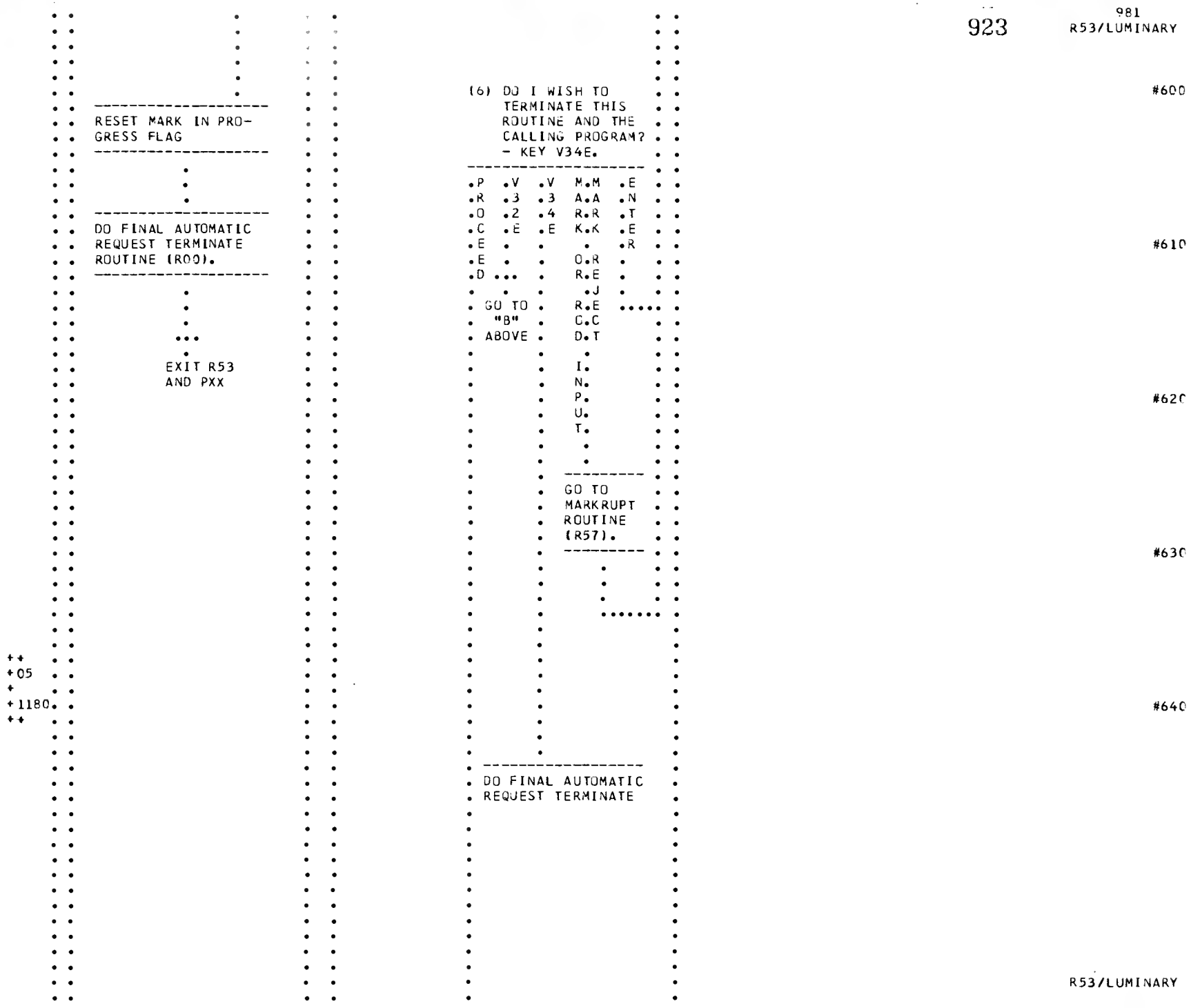
#440

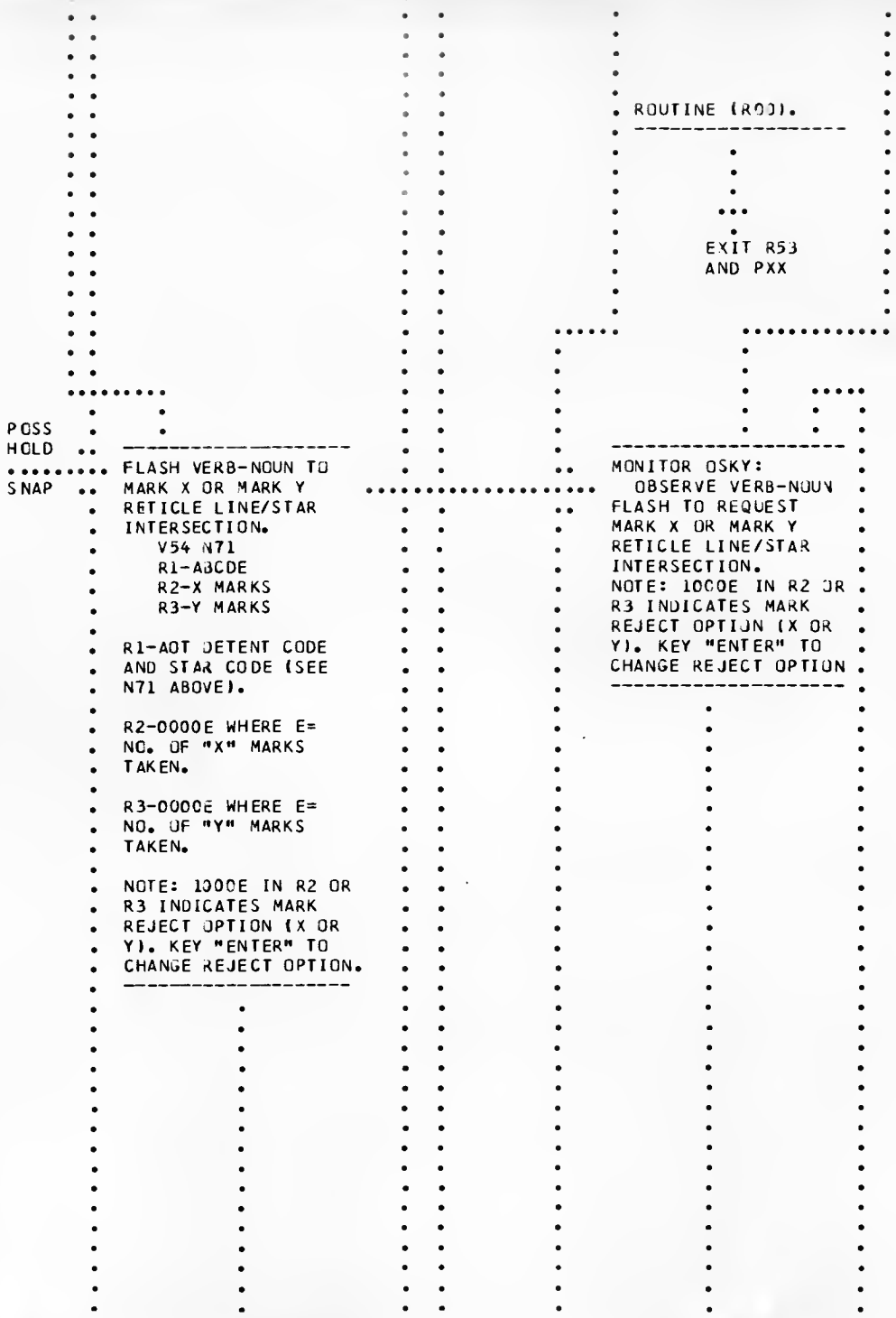
#450

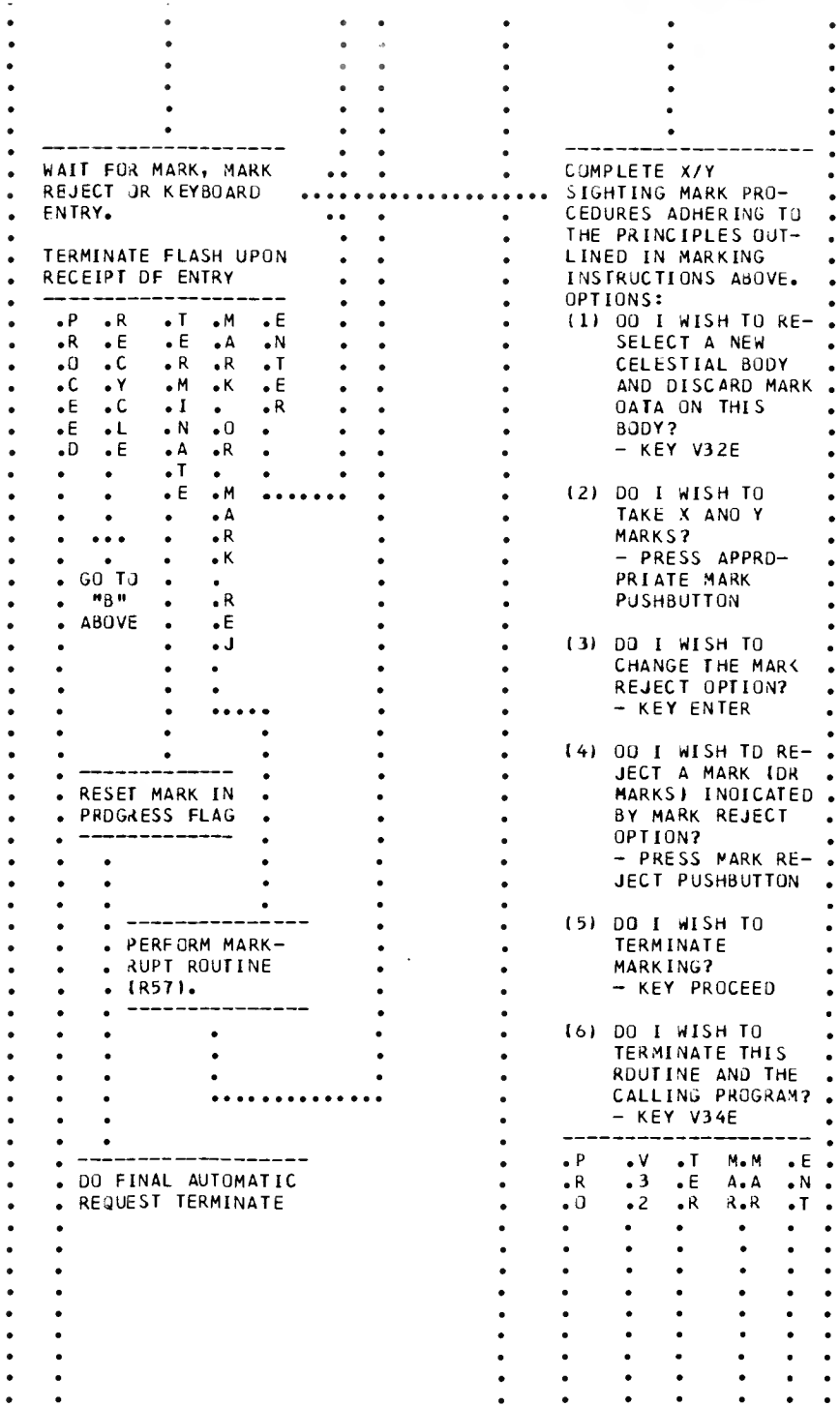

REGISTER
SET MARK REJECT OPTION POINTER TO BE CONSIS-TENT WITH MARK IDENTIFIER.
#460
++
+05
+
+
+1180
++
RESET MARK INPUT INHIBIT FLAG.
#470
"A" FROM BELOW
IS WHATMARK REGISTER ZERO?
WAS THIS ROUTINE CALLED BY CURSOR AND SPIRAL MARKING OPTION?
#480
.Y
.N
.Y
.N
IS WHATMARK REGISTER POSITIVE?
#490
POSS HOLD
SNAP
FLASH VERB-NOUN TO REQUEST CURSOR MARK V52 N71
MONITOR DSKY: OBSERVE FLASHING VERB-NOUN TO REQUEST MARK CURSOR OR SPIRAL/STAR
#500


R1-ABCDE
R2-CURSOR
MARKS
R3-SPIRAL
MARKS
POSS
HOLD
SNAP
FLASH
VERB-NOUN
TO RE-
QUEST
SPIRAL
MARK
V53 N71
R1-ABCDE
R2-CURSOR
MARKS
R3-SPIRAL
MARKS
R1-AOT
DETENT AND
STAR CODE
(SEE N71
ABOVE).
R2-0000E
WHERE E=
NUMBER OF
CURSOR
MARKS TAKEN.
(5 MAXIMUM)
R3-0000E
WHERE E=
NUMBER OF
SPIRAL
MARKS TAKEN
(5 MAXIMUM)
NOTE: 10000E
IN R2 OR R3
INDICATES
MARK REJECT
OPTION.
KEY
"ENTER" TO
CHANGE
REJECT
OPTION.
INTERSECTION.
V52 REQUESTS A
CURSOR MARK.
V53 REQUESTS A
SPIRAL MARK.
#510
#520
#530
#540


JECT
OPTION.
KEY
"ENTER"
TO CHANGE
REJECT
OPTION.
1180
WAIT FOR MARK, MARK REJECT, ROO INPUT OR KEYBOARD ENTRY
TERMINATE FLASH UPON RECEIPT OF ENTRY
.P M.M .E .T .R
.R A.A .N .E .E
.O R.R .T .R .C
.C K.K .E .M .Y
.E . .R .I .C
.E O.R . .N .L
.O R.E . .A .E
. .J . .T .
. R.E . .E .
. O.C . . .
. O.T . . ...
. . . .
. I. . .GO TO
. N. . . "B"
. P. . .ABOVE
. U. . .
. T. . .
.
PERFORM MARKRUPT ROUTINE (R57).
COMPLETE CURSOR/-SPIRAL SIGHTING MARK PROCEOURES AOHERING TO THE PRINCIPLES OUTLINEO IN MARKING INSTRUCTIONS ABOVE.
OPTIONS:
(1) OO I WISH TO DISCARD MARK DATA ON THIS BODY AND RESEL-ECT A NEW CELES-TIAL BODY?
- KEY V32E
(2) OO I WISH TO TAKE CURSOR/-SPIRAL MARKS?
- PUSH MARK X OR MARK Y PUSHBUT-TON OR ROO SW.
(3) OO I WISH TO CHANGE THE CURSOR/SPIRAL MARK OR MARK RE-JECT OPTION?
- KEY ENTER
(4) OO I WISH TO RE-JECT A MARK (OR MARKS)?
- PUSH MARK RE-JECT PUSHBUTTON.
(5) OO I WISH TO TERMINATE MARKING?
- KEY PROCEED
#550
#560
#570
#580
#590


RESET MARK IN PRO-
GRESS FLAG
DO FINAL AUTOMATIC
REQUEST TERMINATE
ROUTINE (R00).
EXIT R53
AND PXX
(6) DO I WISH TO
TERMINATE THIS
ROUTINE AND THE
CALLING PROGRAM?
- KEY V34E.
.P .R .O .C .E .E .D
.V .3 .2 .E
.V .3 .4 .E
M.M A.A R.R K.K O.R R.E .J R.E C.C D.T
.E .N .T .E .R
GO TO
"B"
ABOVE
I. N. P. U. T.
GO TO
MARKRUPT
ROUTINE
(R57).
DO FINAL AUTOMATIC
REQUEST TERMINATE
++
+05
+
+1180.
++
#600
#610
#620
#630
#640


ROUTINE (R00).
EXIT R53
AND PXX
#650
#660
POSS
HOLD
SNAP
FLASH VERB-NOUN TO
MARK X OR MARK Y
RETICLE LINE/STAR
INTERSECTION.
V54 N71
R1-ABCDE
R2-X MARKS
R3-Y MARKS
R1-AOT DETENT CODE
AND STAR CODE (SEE
N71 ABOVE).
R2-0000E WHERE E=
NO. OF "X" MARKS
TAKEN.
R3-0000E WHERE E=
NO. OF "Y" MARKS
TAKEN.
NOTE: 10000 IN R2 OR
R3 INDICATES MARK
REJECT OPTION (X OR
Y). KEY "ENTER" TO
CHANGE REJECT OPTION.
MONITOR OSKY:
OBSERVE VERB-NOUN
FLASH TO REQUEST
MARK X OR MARK Y
RETICLE LINE/STAR
INTERSECTION.
NOTE: 10000 IN R2 OR
R3 INDICATES MARK
REJECT OPTION (X OR
Y). KEY "ENTER" TO
CHANGE REJECT OPTION
#670
#680
#690



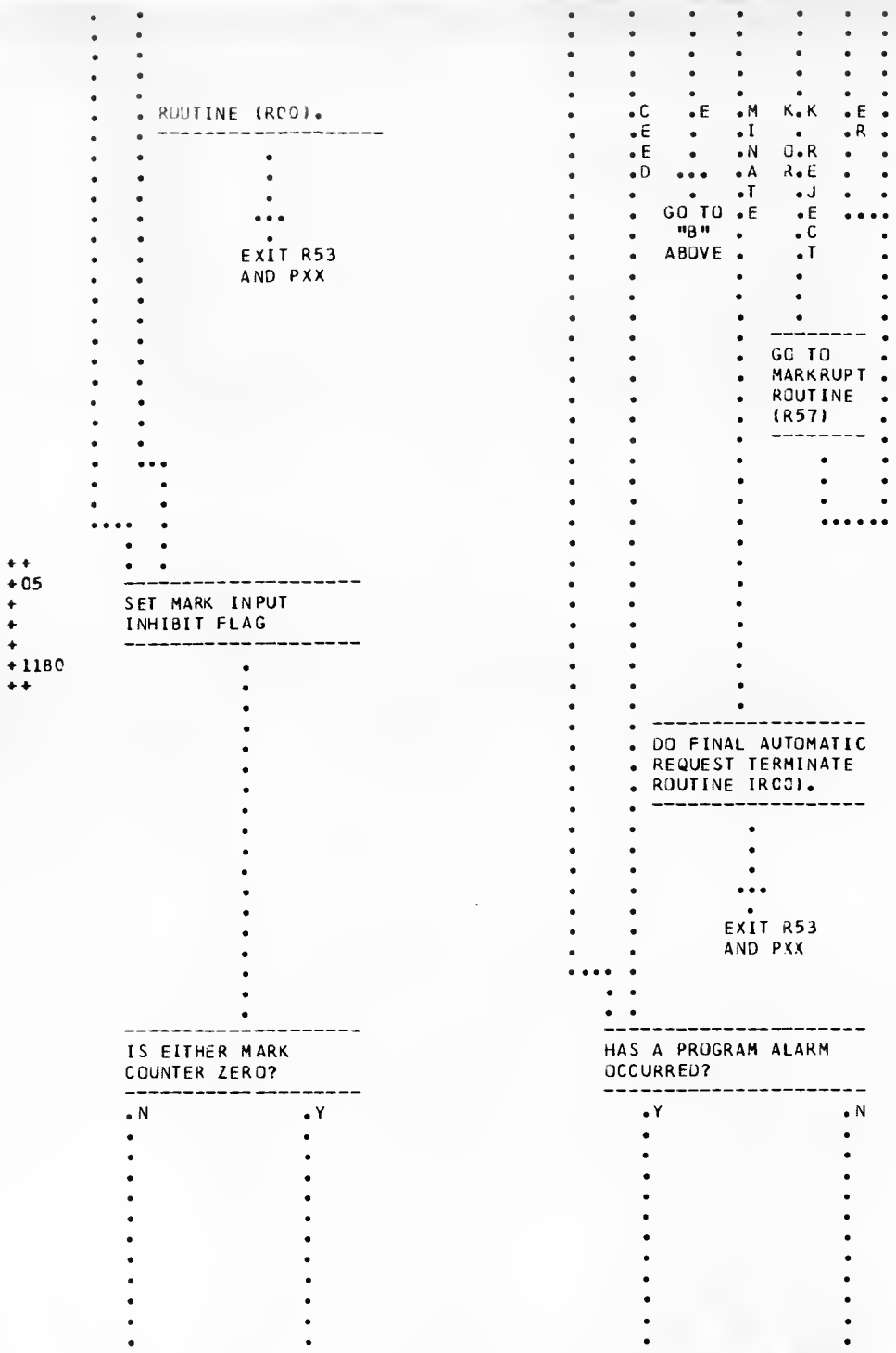
#700

#710

#720

#730

#740



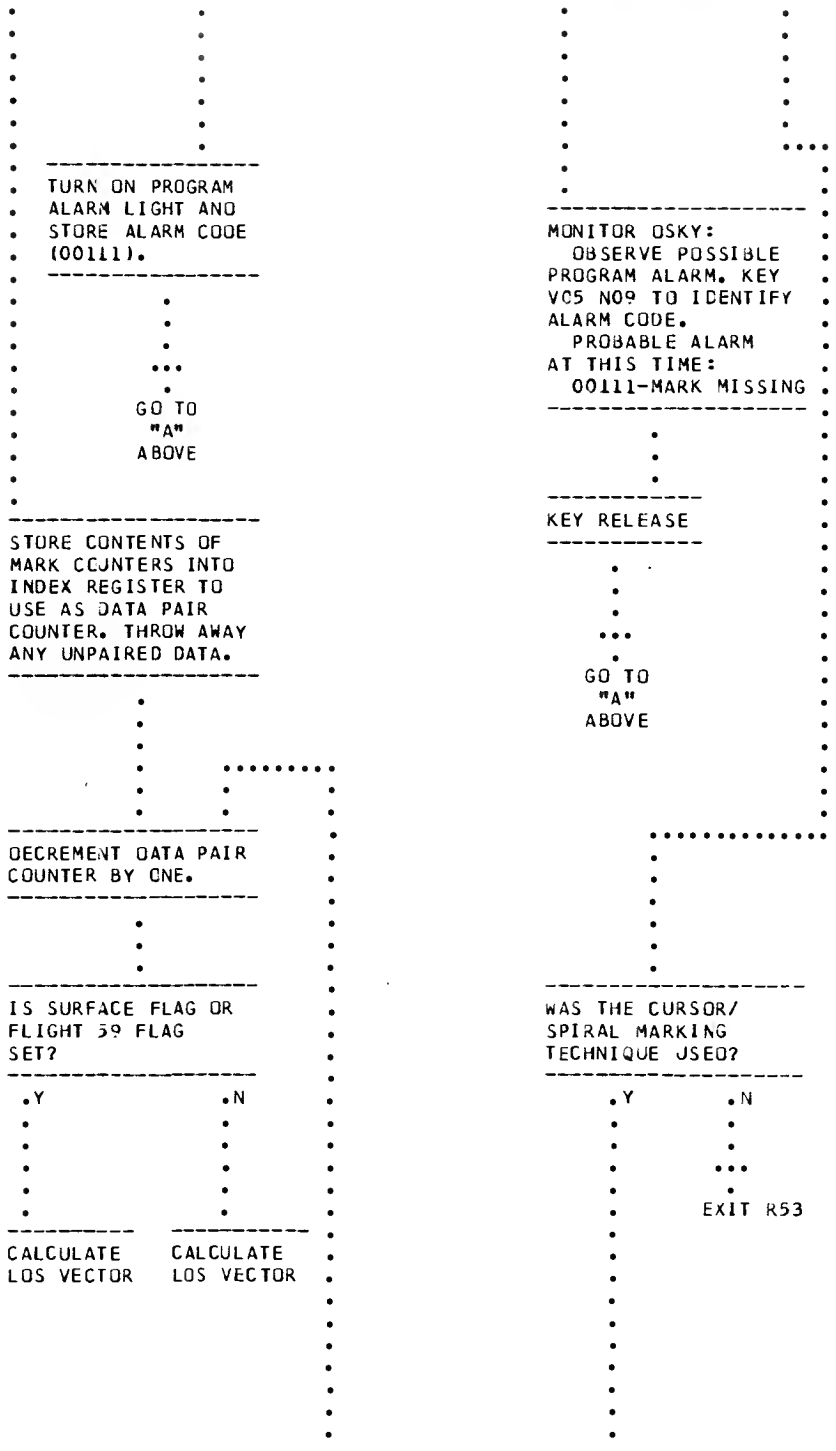
#750

#760

#770

#780

#790


TURN ON PROGRAM ALARM LIGHT AND STORE ALARM CODE (00111).
GO TO "A" ABOVE
STORE CONTENTS OF MARK COUNTERS INTO INDEX REGISTER TO USE AS DATA PAIR COUNTER. THROW AWAY ANY UNPAIRED DATA.
DECREMENT DATA PAIR COUNTER BY ONE.
IS SURFACE FLAG OR FLIGHT 59 FLAG SET?
Y
N
CALCULATE LOS VECTOR
CALCULATE LOS VECTOR
MONITOR OSKY: OBSERVE POSSIBLE PROGRAM ALARM. KEY VCS NO9 TO IDENTIFY ALARM CODE. PROBABLE ALARM AT THIS TIME: 00111-MARK MISSING
KEY RELEASE
GO TO "A" ABOVE
WAS THE CURSOR/ SPIRAL MARKING TECHNIQUE USED?
Y
N
EXIT R53
#800
#810
#820
#830
#840

```
TO CELES-     TO CELES-
TIAL BODY     TIAL BODY
STARTING      STARTING
WITH THE      WITH THE
MOST RE-      MOST RECENT
CENT PAIR     PAIR OF X/Y
OF CURSOR/    MARK DATA
SPIRAL        AND AVERAGE
MARK DATA     WITH PRE-
AND AVER-     VIOUSLY
AGE WITH      COMPUTED
PREVIOUSLY    LOS VECTOR
COMPUTED      TO THE BODY
LOS VECTOR    ----------
TO THE
BODY.

REJECT
DATA PAIR
IF:
(1) CELES-
    TIAL
    BODY
    IS
    LESS
    THAN 2
    DEGREES
    FROM
    AOT
    OPTIC
    AXIS.

(2) CELES-
    TIAL
    BODY IS
    GREATER
    THAN
    28.5
    DEGREES
    FROM
    AOT
    OPTIC
    AXIS
    (EDGE
    OF FOV).

(3) MORE
```

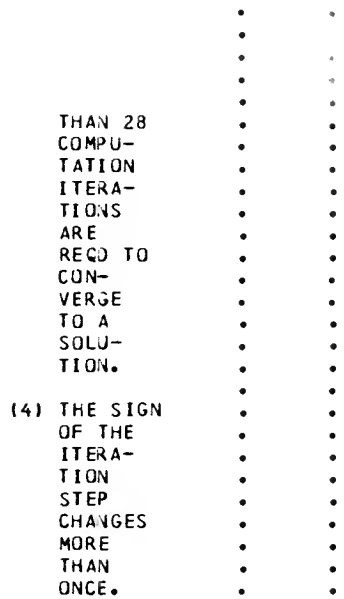
#850

#860

#870

#880

#890



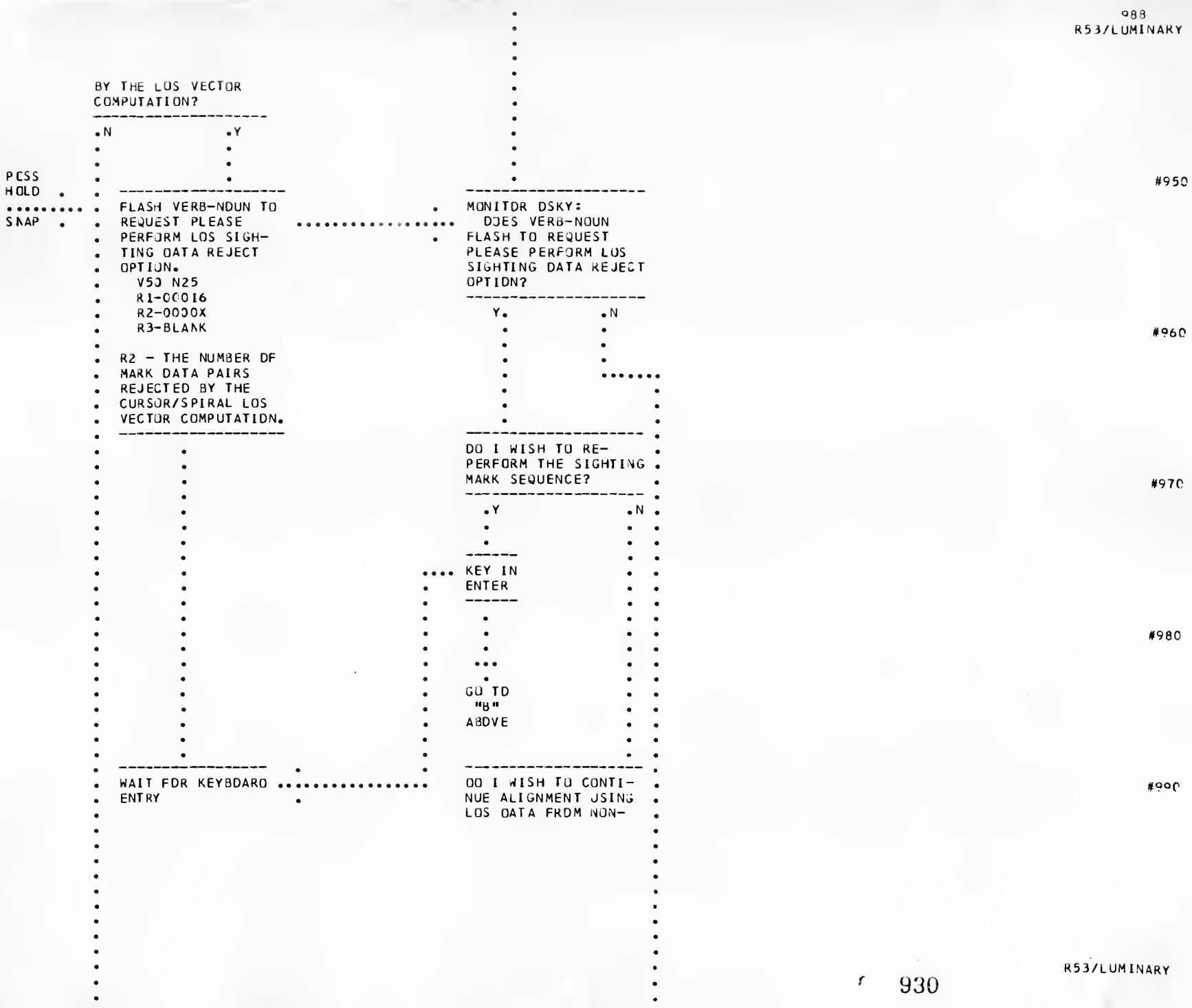
#900

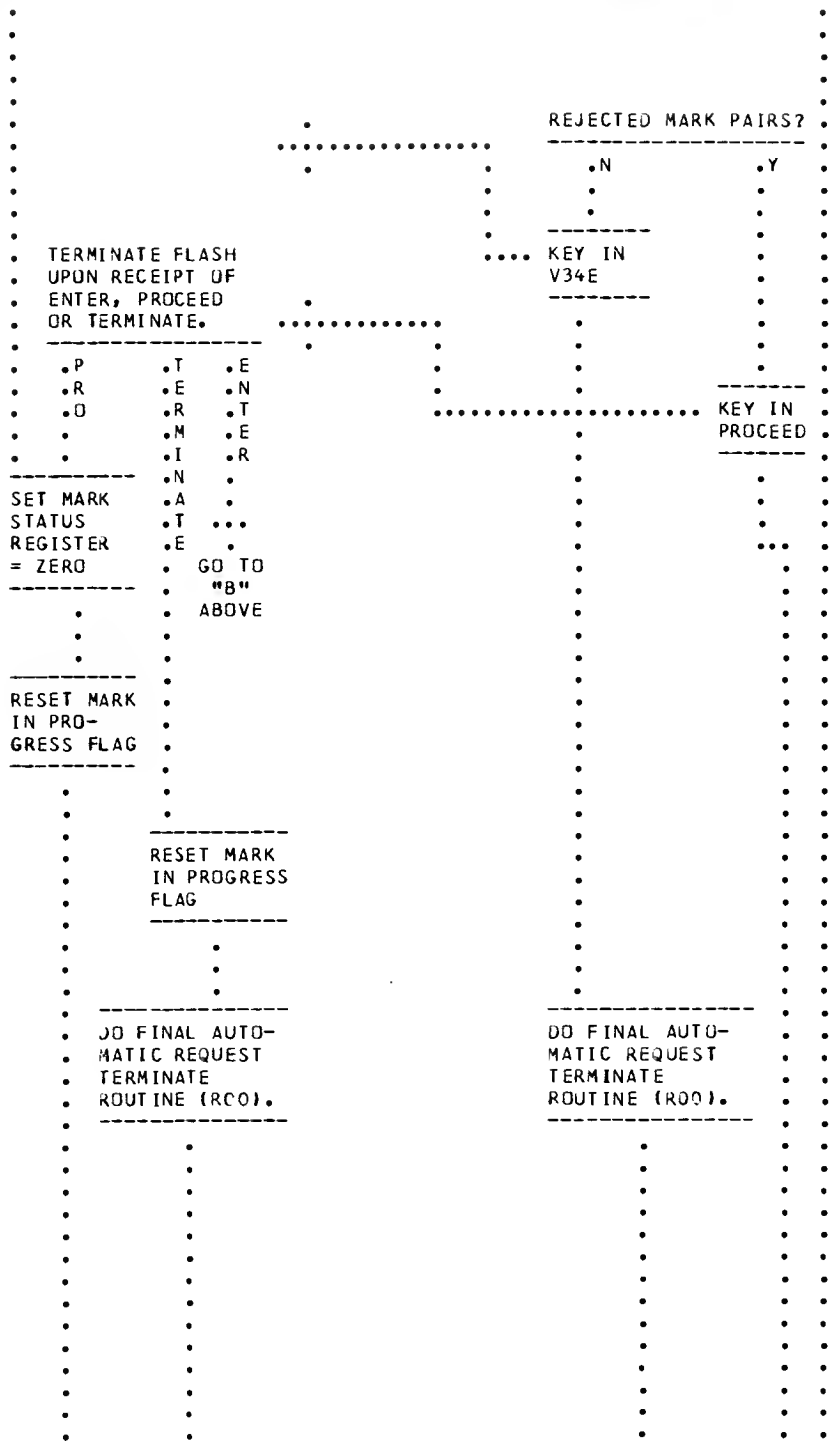
#910

#920

#930

#940


BY THE LOS VECTOR COMPUTATION?
N
Y
PCSS HOLD
SNAP
FLASH VERB-NOUN TO REQUEST PLEASE PERFORM LOS SIGHTING DATA REJECT OPTION.
V50 N25
R1-00016
R2-0000X
R3-BLANK
R2 - THE NUMBER OF MARK DATA PAIRS REJECTED BY THE CURSOR/SPIRAL LOS VECTOR COMPUTATION.
WAIT FOR KEYBOARD ENTRY
MONITOR DSKY: DOES VERB-NOUN FLASH TO REQUEST PLEASE PERFORM LOS SIGHTING DATA REJECT OPTION?
Y.
.N
DO I WISH TO RE-PERFORM THE SIGHTING MARK SEQUENCE?
.Y
.N
KEY IN ENTER
GO TO "B" ABOVE
DO I WISH TO CONTINUE ALIGNMENT USING LOS DATA FROM NON-
#950
#960
#970
#980
#990



#1000

#1010

#1020

#1030

#1040

#1050

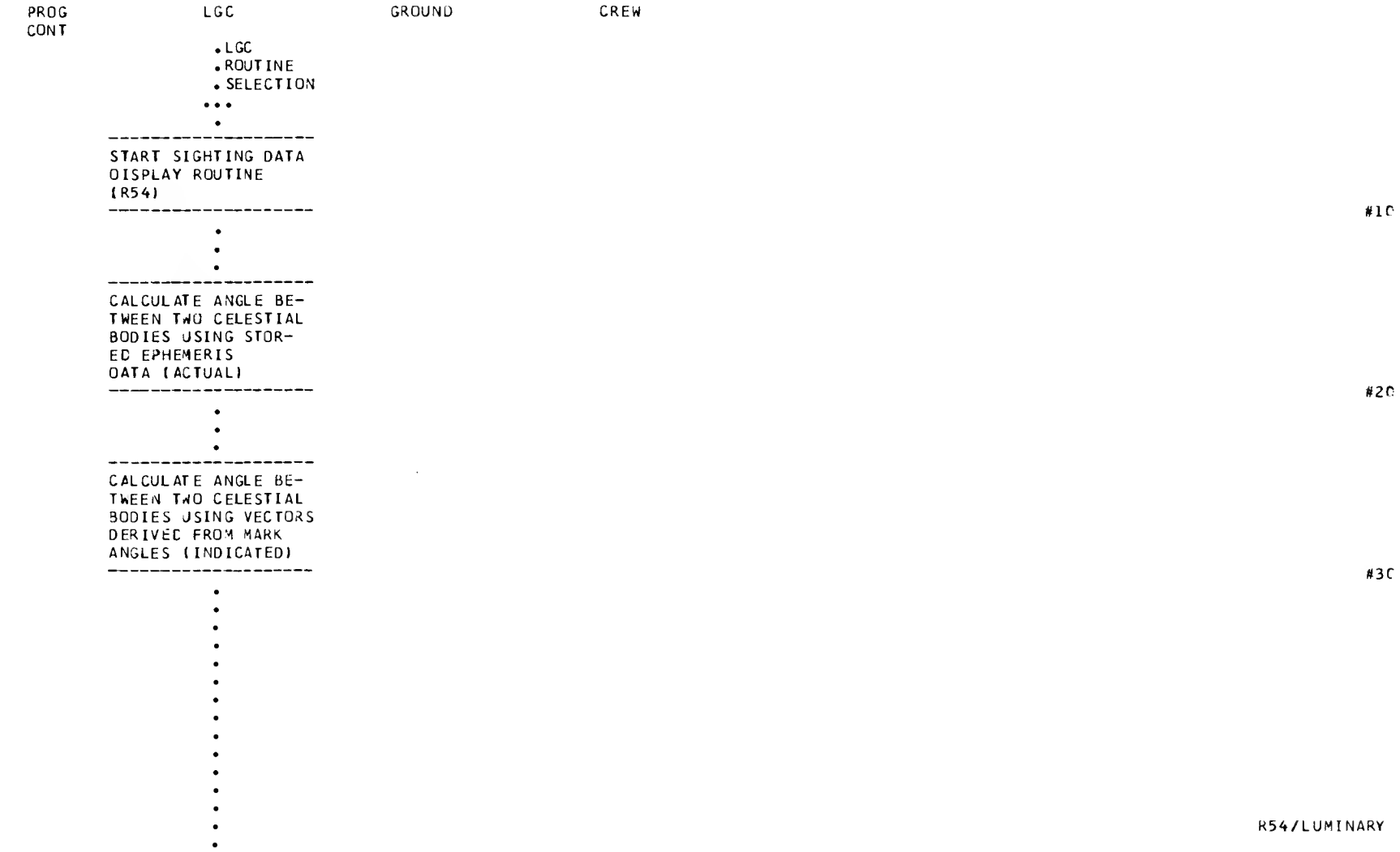
CHANGE CONTROL NOTES

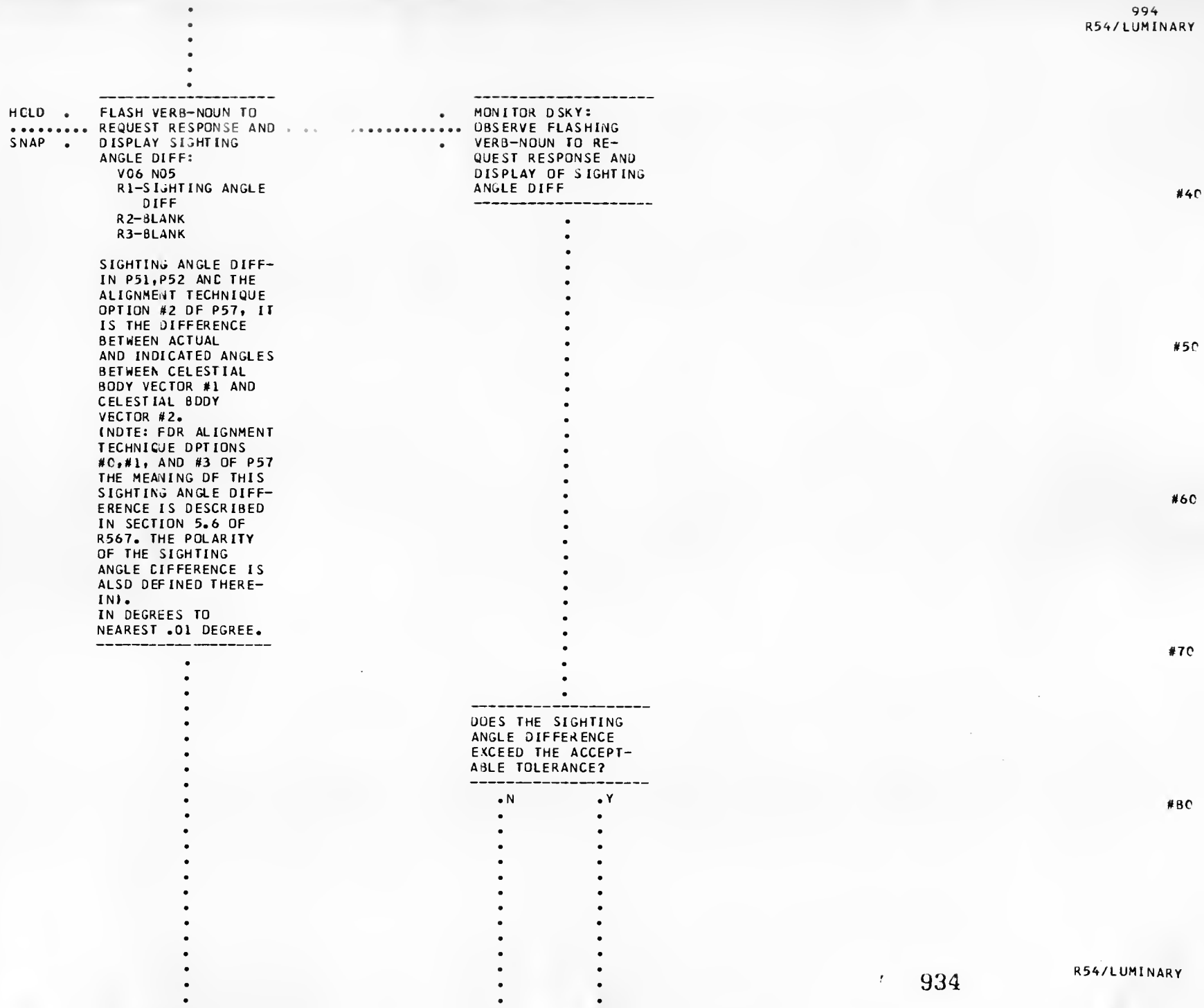
REV 01 PCR 527
REV 00 (LUM 1A) PCR 699
REV 01 (LUM 1B) PCR 801.2
REV 02 EDITORIAL
REV 03 PCN 1009
REV 04 (LUM 1E) PCR 1044
REV 05 PCN 1180

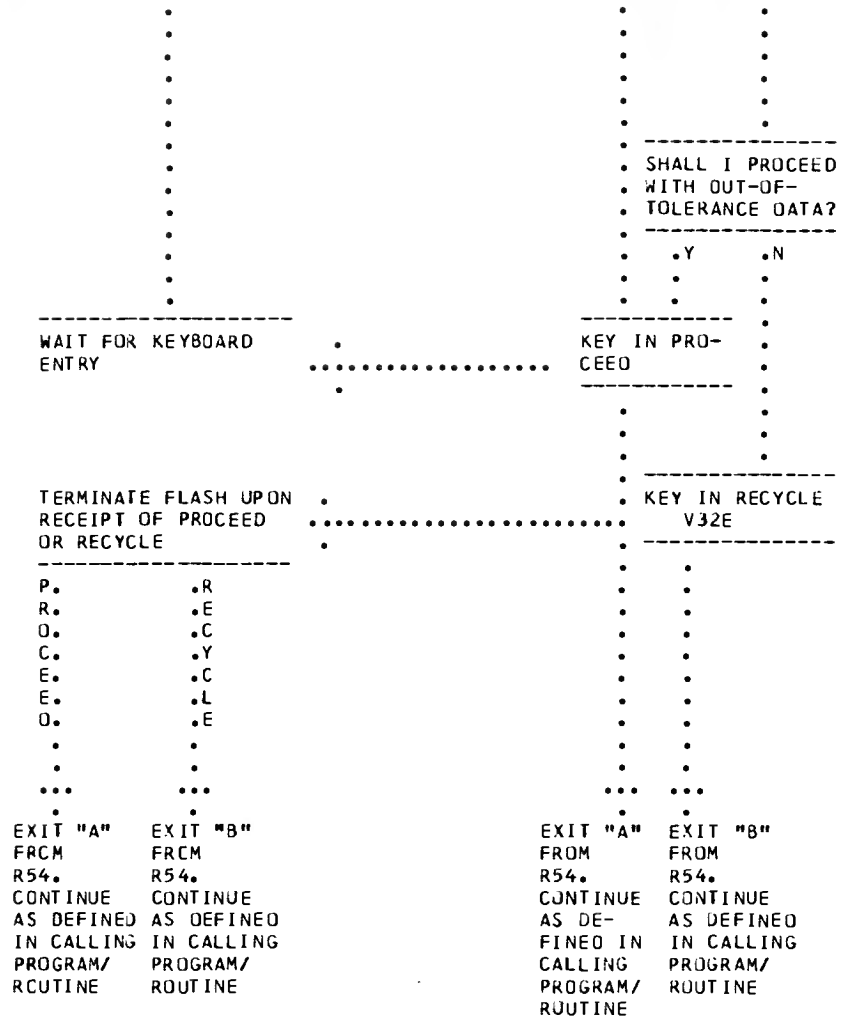
SIGHTING DATA DISPLAY ROUTINE (R54) REV C2 12/03/69

PURPOSE: (1) TO DISPLAY THE ACCURACY OF A PAIR OF CELESTIAL BODY SIGHTINGS, OR ALIGNMENT VECTORS.

ASSUMPTIONS: (1) THE ROUTINE IS NORMALLY AUTOMATICALLY SELECTED BY THE IMU ORIENTATION DETERMINATION PROGRAM (P51), THE INFLIGHT FINE ALIGN ROUTINE (R51), OR THE LUNAR SURFACE ALIGN PROGRAM (P57).




HOLD
SNAP
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY SIGHTING ANGLE DIFF:
V06 N05
R1-SIGHTING ANGLE DIFF
R2-BLANK
R3-BLANK
SIGHTING ANGLE DIFF- IN P51,P52 AND THE ALIGNMENT TECHNIQUE OPTION #2 OF P57, IT IS THE DIFFERENCE BETWEEN ACTUAL AND INDICATED ANGLES BETWEEN CELESTIAL BODY VECTOR #1 AND CELESTIAL BODY VECTOR #2. (NOTE: FOR ALIGNMENT TECHNIQUE OPTIONS #0,#1, AND #3 OF P57 THE MEANING OF THIS SIGHTING ANGLE DIFF- ERENCE IS DESCRIBED IN SECTION 5.6 OF R567. THE POLARITY OF THE SIGHTING ANGLE DIFFERENCE IS ALSO DEFINED THERE- IN). IN DEGREES TO NEAREST .01 DEGREE.
MONITOR DSKY: OBSERVE FLASHING VERB-NOUN TO RE- QUEST RESPONSE AND DISPLAY OF SIGHTING ANGLE DIFF
#40
#50
#60
#70
DOES THE SIGHTING ANGLE DIFFERENCE EXCEED THE ACCEPT- ABLE TOLERANCE?
N
Y
#80



#90

#100

#110

#120

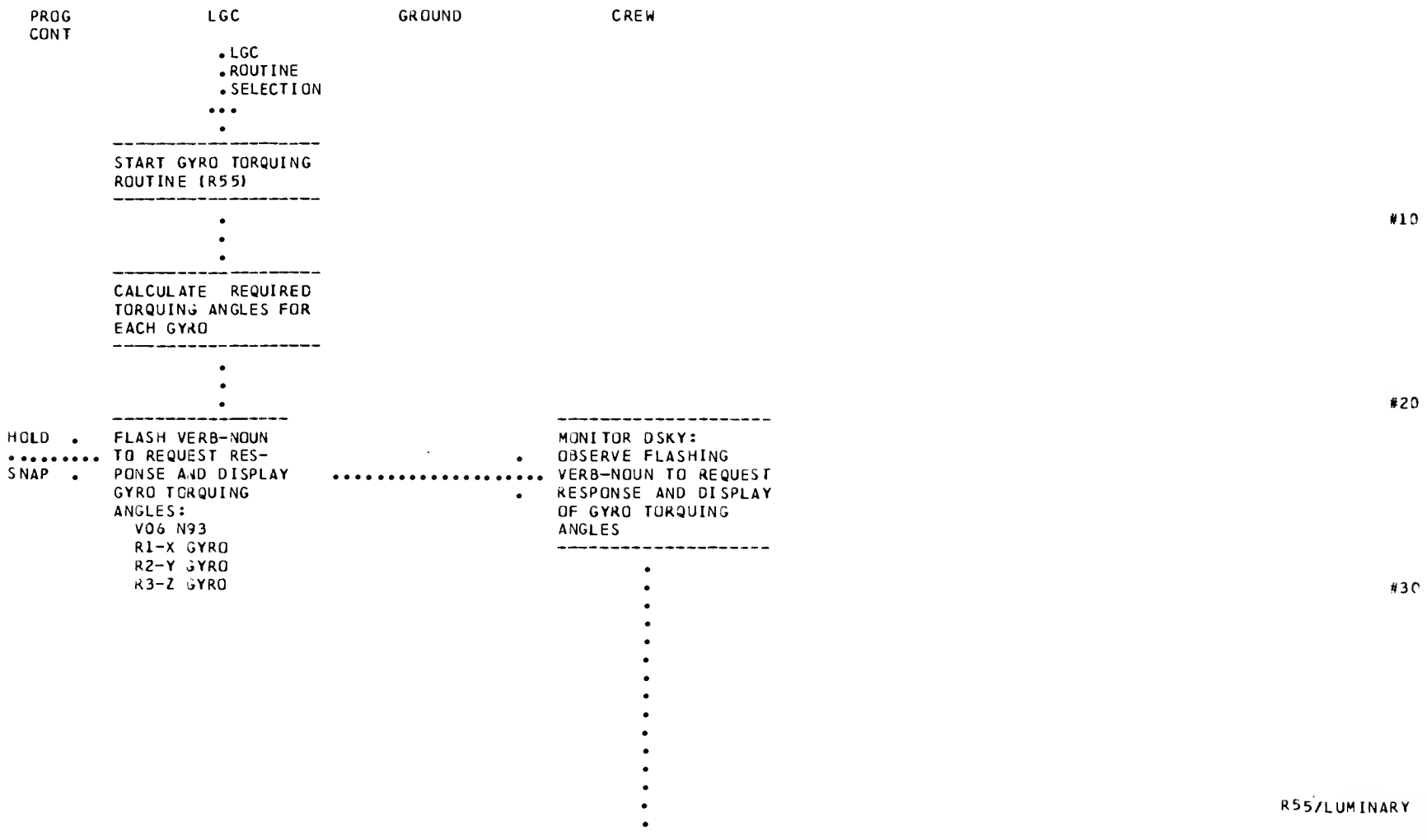
CHANGE CONTROL NOTES

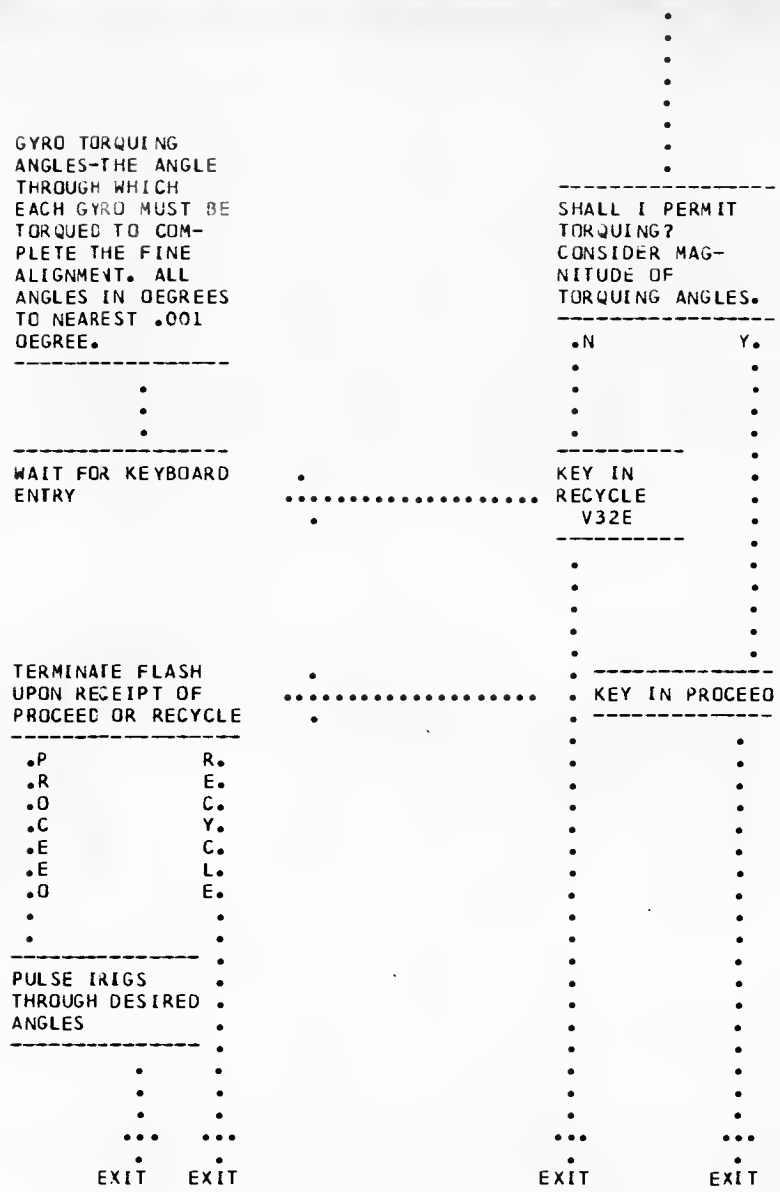
REV 01 NO PCRS
REV 02(LUM 1C) PCR 972

GYRO TORQUING ROUTINE (R55) REV 01 01/07/69

PURPOSE: (1) TO CALCULATE GYRO TORQUING ANGLES FOR FINAL (FINE) ALIGNMENT OF THE INERTIAL PLATFORM DURING AN INFLIGHT ALIGNMENT; TO DISPLAY THESE ANGLES AND TO TORQUE THE GYROS.

ASSUMPTIONS: (1) THE ROUTINE IS AUTOMATICALLY SELECTED BY THE INFLIGHT FINE ALIGN ROUTINE (R51).




GYRO TORQUING ANGLES-THE ANGLE THROUGH WHICH EACH GYRO MUST BE TORQUED TO COMPLETE THE FINE ALIGNMENT. ALL ANGLES IN DEGREES TO NEAREST .001 DEGREE.
WAIT FOR KEYBOARD ENTRY
TERMINATE FLASH UPON RECEIPT OF PROCEED OR RECYCLE
.P R.
.R E.
.O C.
.C Y.
.E C.
.E L.
.O E.
PULSE IRIGS THROUGH DESIRED ANGLES
EXIT
EXIT
SHALL I PERMIT TORQUING? CONSIDER MAGNITUDE OF TORQUING ANGLES.
.N
Y.
KEY IN RECYCLE V32E
KEY IN PROCEED
EXIT
EXIT

#40

#50

#60

#70

R55 R55 R55 R55 #80

CHANGE CONTROL NOTES

NO PCRS

TERMINATE TRACKING ROUTINE (R56) REV C5 12/01/71

PURPOSE: (1) TO TERMINATE PROGRAMS P20,P22, OR P25

ASSUMPTIONS: (1) THE SELECTION AND TERMINATION OF P20, P22, AND P25 ARE SUBJECT TO SPECIAL OPERATING PROCEDURES DIFFERENT FROM THOSE FOR ALL OTHER PROGRAMS:

(A) SELECTION

(1) ALWAYS BY V37EXXE

(2) IF ANY OTHER PROGRAM IS RUNNING AT THE TIME OF P20/22/25 SELECTION, THE NEW PROGRAM WILL REPLACE THE OLD. THIS INCLUDES P20/22/25 SELECTION WHEN ANY OF P20,22, OR 25 IS RUNNING.

++
+05
+
+
+
+1180
++

(3) IF P20 OR P25 IS RUNNING, SELECTION OF ANY PROGRAM OTHER THAN P00, P22, OR P25 WILL RESULT IN P20 OR P25 CONTINUING, AND THE NEW PROGRAM ALSO OPERATING WITH ITS NUMBER DISPLAYED IN THE OSKY PROG LIGHTS.

(4) IF P20 OR P25 IS RUNNING, SELECTION OF P00, P22, OR P25 WILL RESULT IN THE TERMINATION OF THE OLD PROGRAM, AND OPERATION OF THE NEW.

(B) TERMINATION

(1) BY SELECTION OF P00, V56E, OR BY V34E.

(2) P00 SELECTION WILL TERMINATE P20,22, AND 25 AND ANY OTHER PROGRAM IN PROCESS, AND ESTABLISH P00.

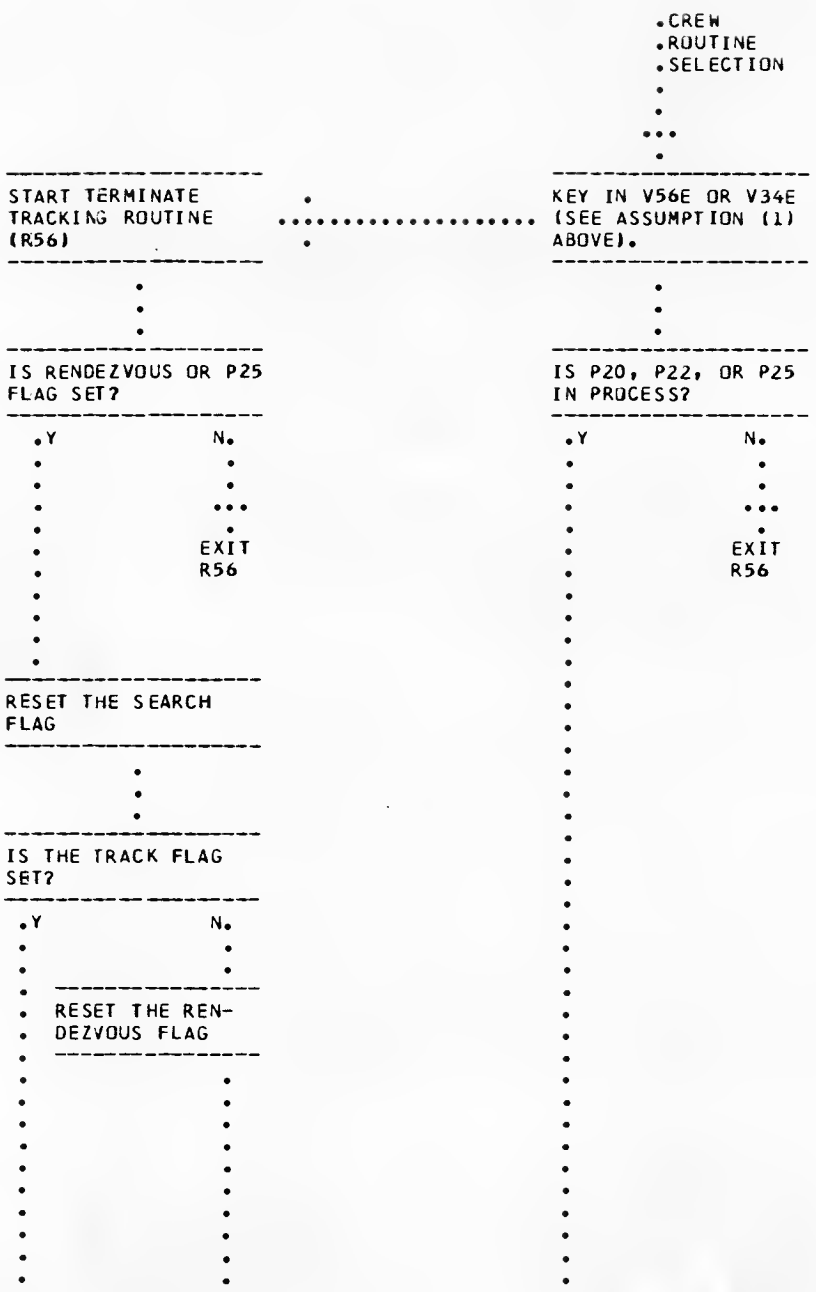
(3) V56E SELECTION WILL SELECT THE TERMINATE TRACKING ROUTINE (R56) WHICH WILL TERMINATE ONLY P20 OR P25 IF EITHER OF THESE PROGRAMS IS RUNNING IN CONJUNCTION WITH ANOTHER PROGRAM. IN ALL OTHER CASES R56 WILL SELECT R00. V56E MAY BE PERFORMED ANY TIME DURING P20,22, OR 25 OPERATION.

++
+05
+
+1180
++

(4) THE LGC WILL ACT UPON V34E ONLY IN RESPONSE TO A FLASHING VERB-NOUN. IF THIS DISPLAY WAS ORIGINATED BY P20,22, OR 25, V34E WILL RESULT IN AN IDENTICAL LGC RESPONSE TO THAT OF V56E, THAT IS, SELECTION OF R56 EXCEPT IN THE CASE OF A V06 N49 DISPLAY. IF THIS DISPLAY WAS NOT ORIGINATED BY P20, 22, OR 25 (SUCH AS P32, WHILE RUNNING WITH P20) THE LGC WILL GO TO R00, HOWEVER THE PROGRAM IN THE BACKGROUND WILL CONTINUE. THE NEW PROGRAM SELECTED FOLLOWS THE SELECTION RULES ABOVE, (A).

PROG	LGC	GROUND	CREW

CONT



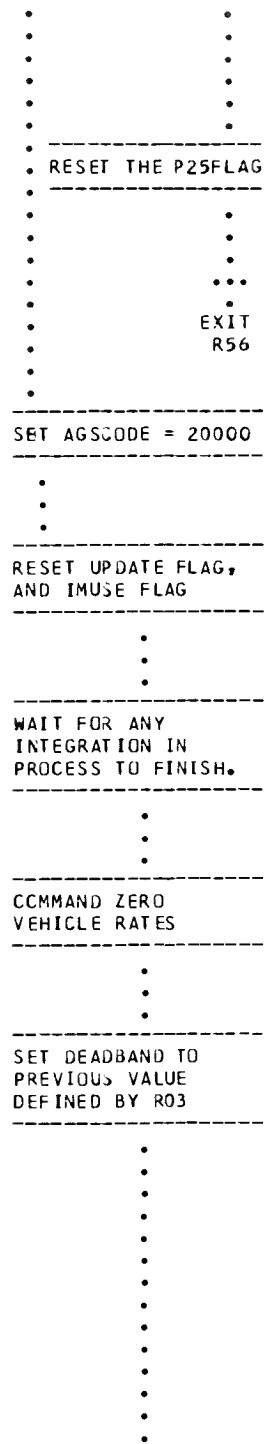
#10

#20

#30

#40

#50



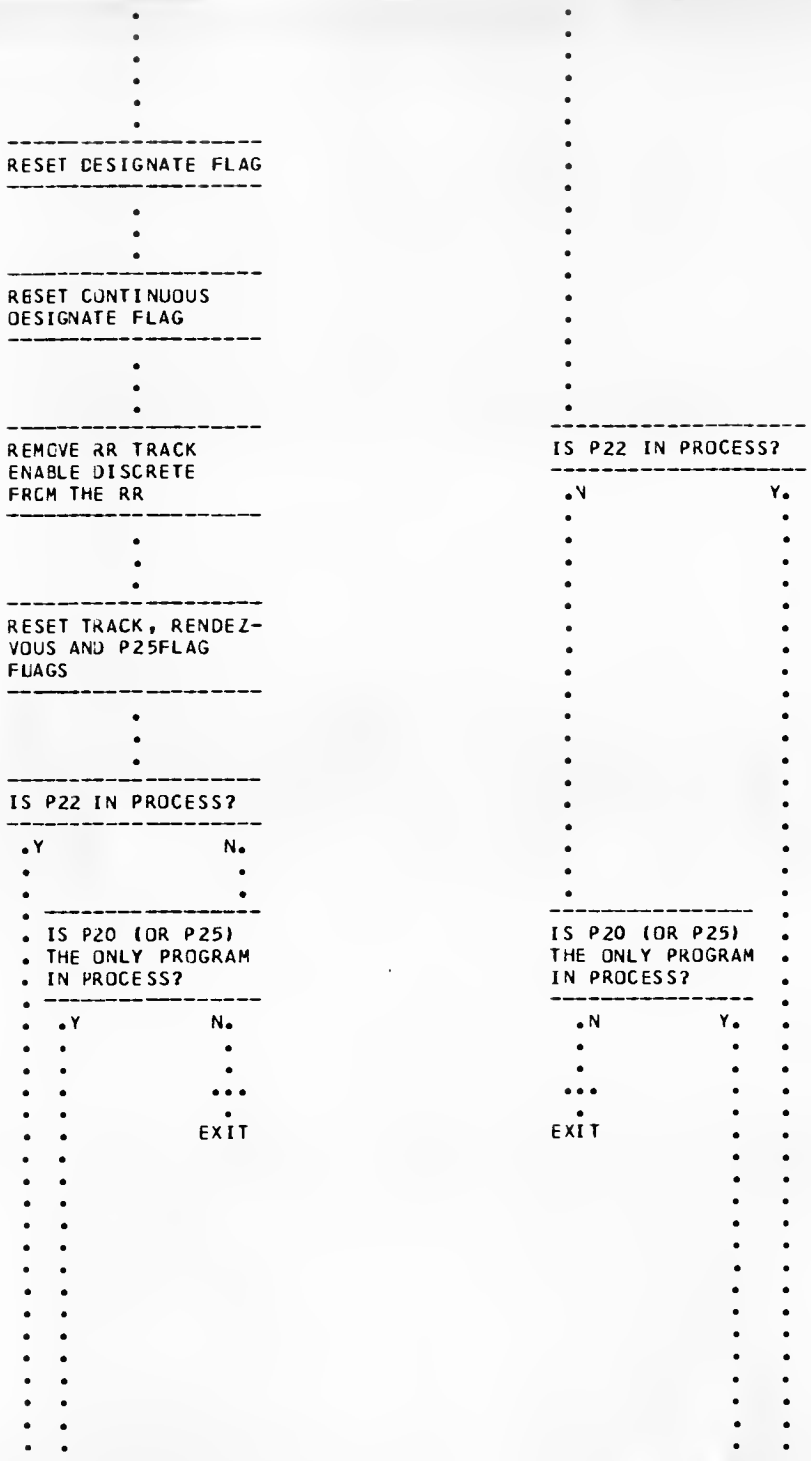
#60

#70

#80

#90

#100

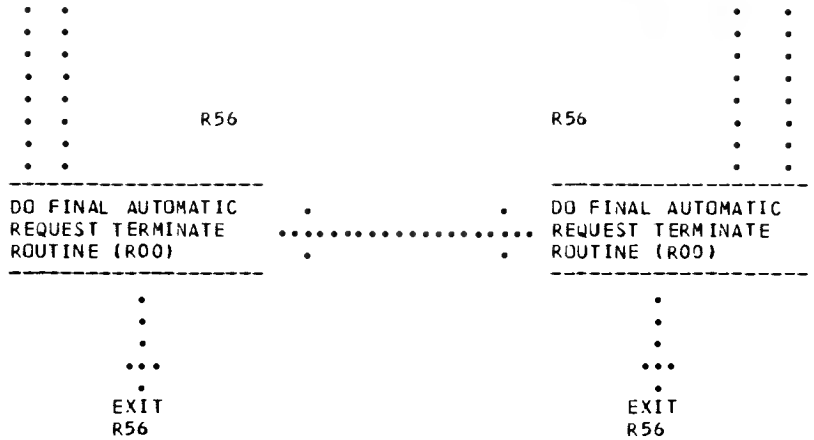


#110

#120

#130

#140



#150

#160

CHANGE CONTROL NOTES

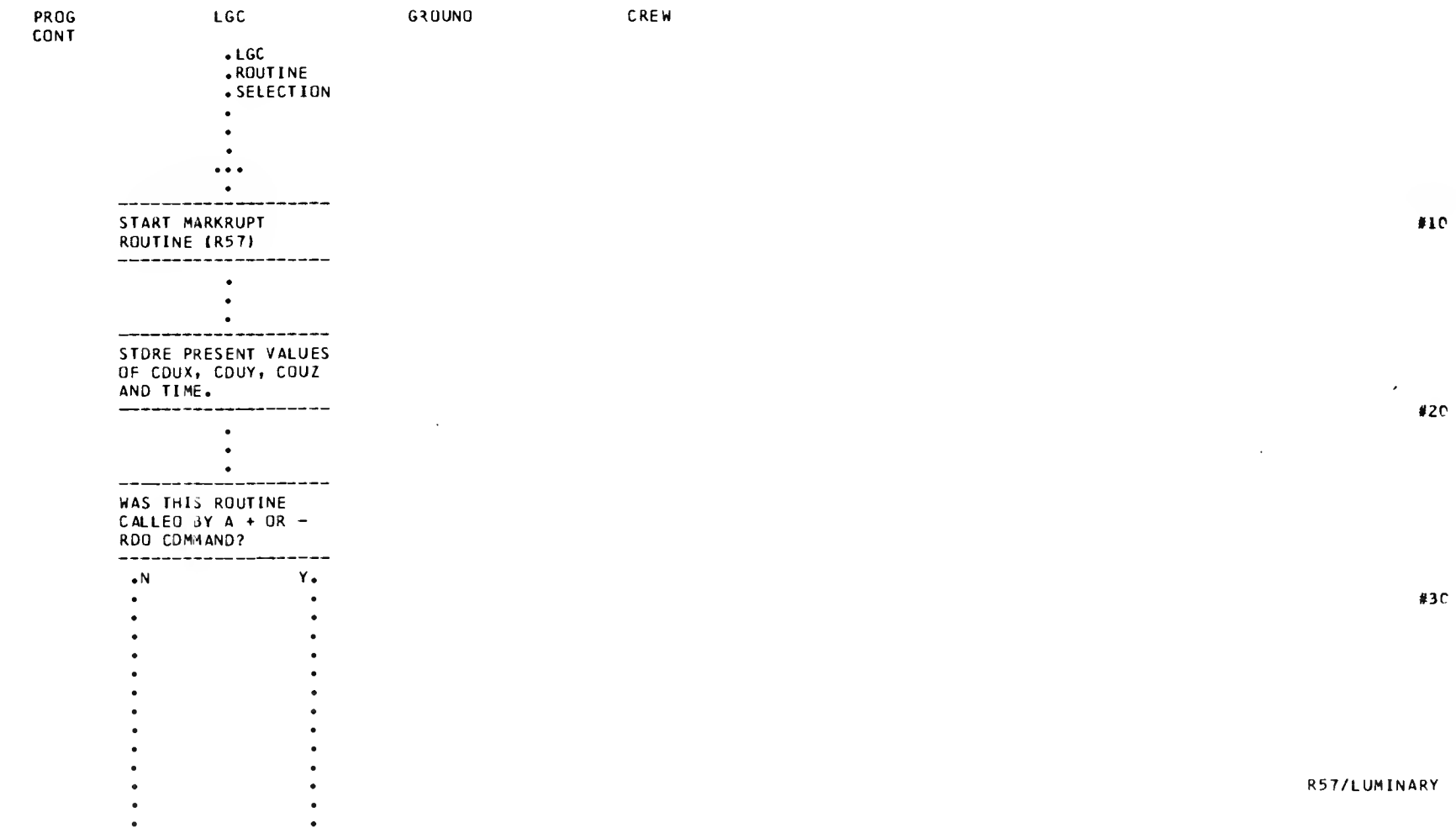
REV 01 PCR 451
REV 02 EDITORIAL
REV 03 EDITORIAL
REV 04(LUM 1E) PCR 324, PCN 1145
REV 05 PCN 1180

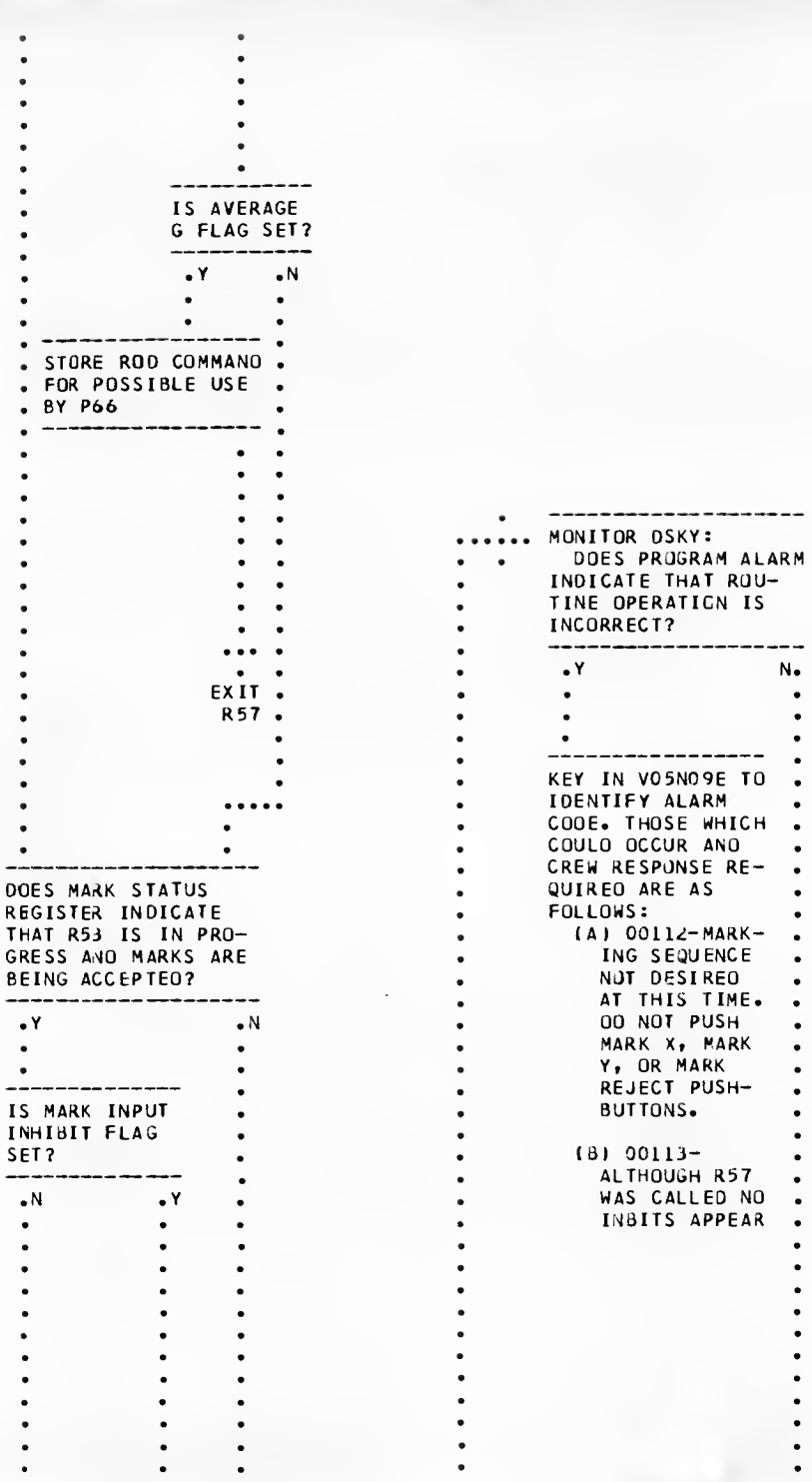
MARKRUPT ROUTINE (R57) REV 06 12/01/71

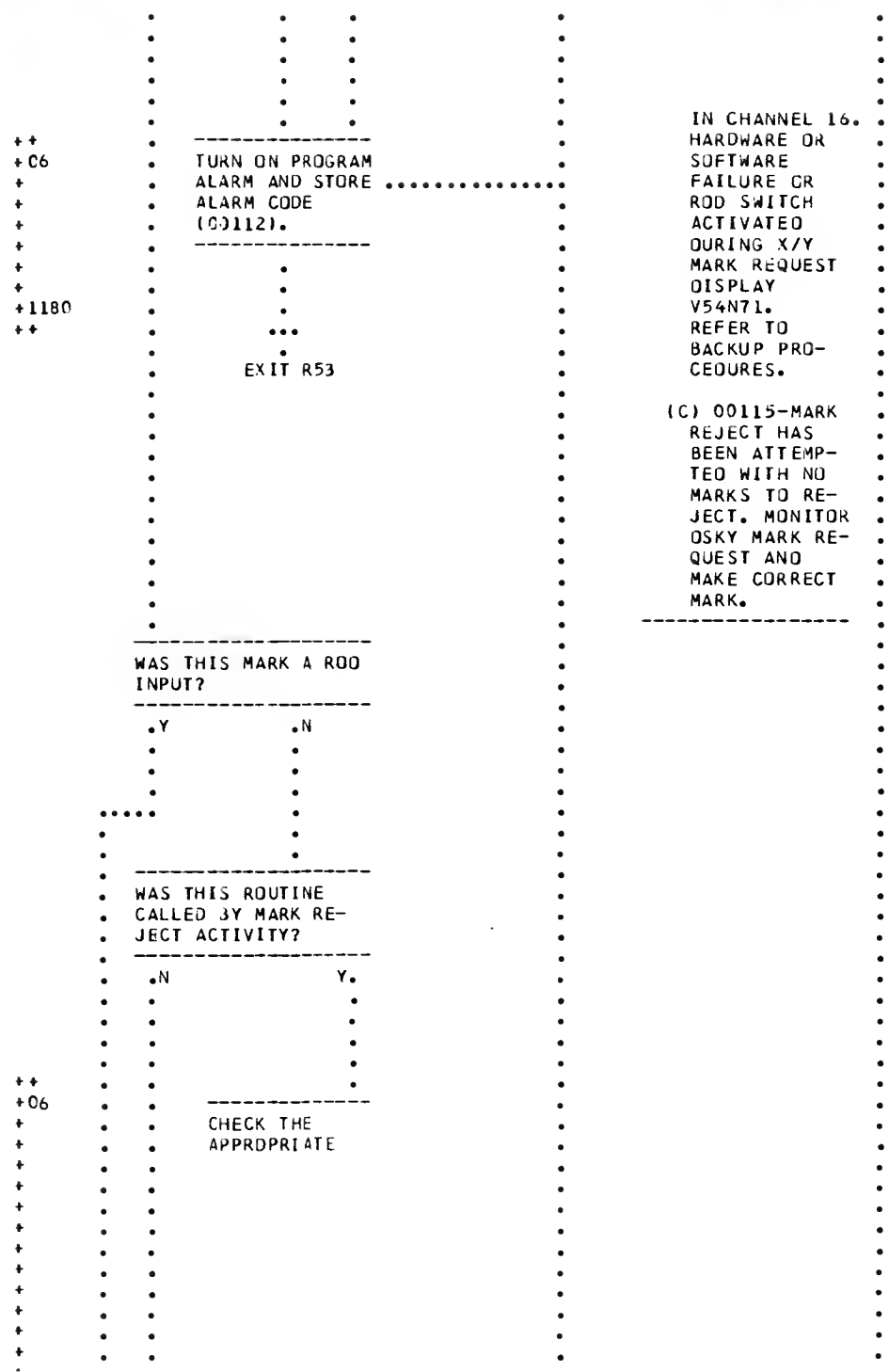
PURPOSE: (1) TO ACCEPT AND PROCESS CREW INPUTS (MARK X, MARK Y, AND MARK REJECT) ASSOCIATED WITH THE ALIGNMENT MARKING PROCESS.

(2) TO ACCEPT AND STORE CREW INPUTS (PLUS AND MINUS ROD COMMANDS) ASSOCIATED WITH THE RATE OF DESCENT PHASE (P66) OF THE LUNAR LANDING.

ASSUMPTIONS: (1) THIS ROUTINE IS AUTOMATICALLY CALLED WHENEVER THE MARK X PUSHBUTTON, MARK Y PUSHBUTTON, MARK REJECT PUSHBUTTON, OR THE DES RATE (+ OR -) SWITCH ARE USED BY THE CREW, EITHER IN FLIGHT OR ON THE LUNAR SURFACE.




IS AVERAGE G FLAG SET?
.Y
.N
STORE ROD COMMANO FOR POSSIBLE USE BY P66
EXIT R57
DOES MARK STATUS REGISTER INDICATE THAT R53 IS IN PRO-GRESS AND MARKS ARE BEING ACCEPTED?
.Y
.N
IS MARK INPUT INHIBIT FLAG SET?
.N
.Y
MONITOR DSKY:
DOES PROGRAM ALARM INDICATE THAT ROU-TINE OPERATION IS INCORRECT?
.Y
N.
KEY IN V05N09E TO IDENTIFY ALARM COOE. THOSE WHICH COULD OCCUR AND CREW RESPONSE RE-QUIRED ARE AS FOLLOWS:
(A) 00112-MARK-ING SEQUENCE NOT DESIRED AT THIS TIME. DO NOT PUSH MARK X, MARK Y, OR MARK REJECT PUSH-BUTTONS.
(B) 00113-ALTHOUGH R57 WAS CALLED NO INBITS APPEAR
#40
#50
#60
#70
#80



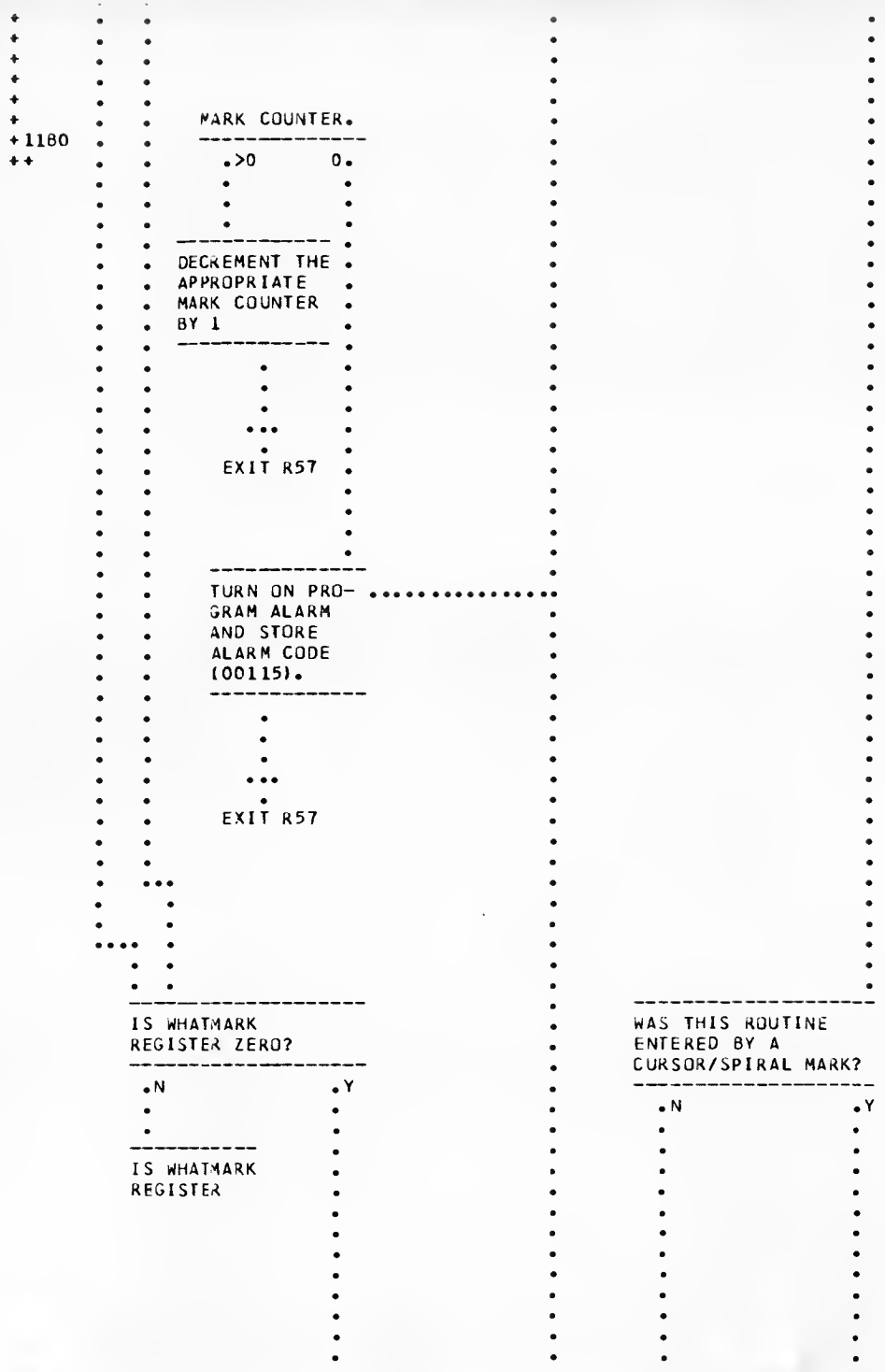
#90

#100

#110

#120

#130



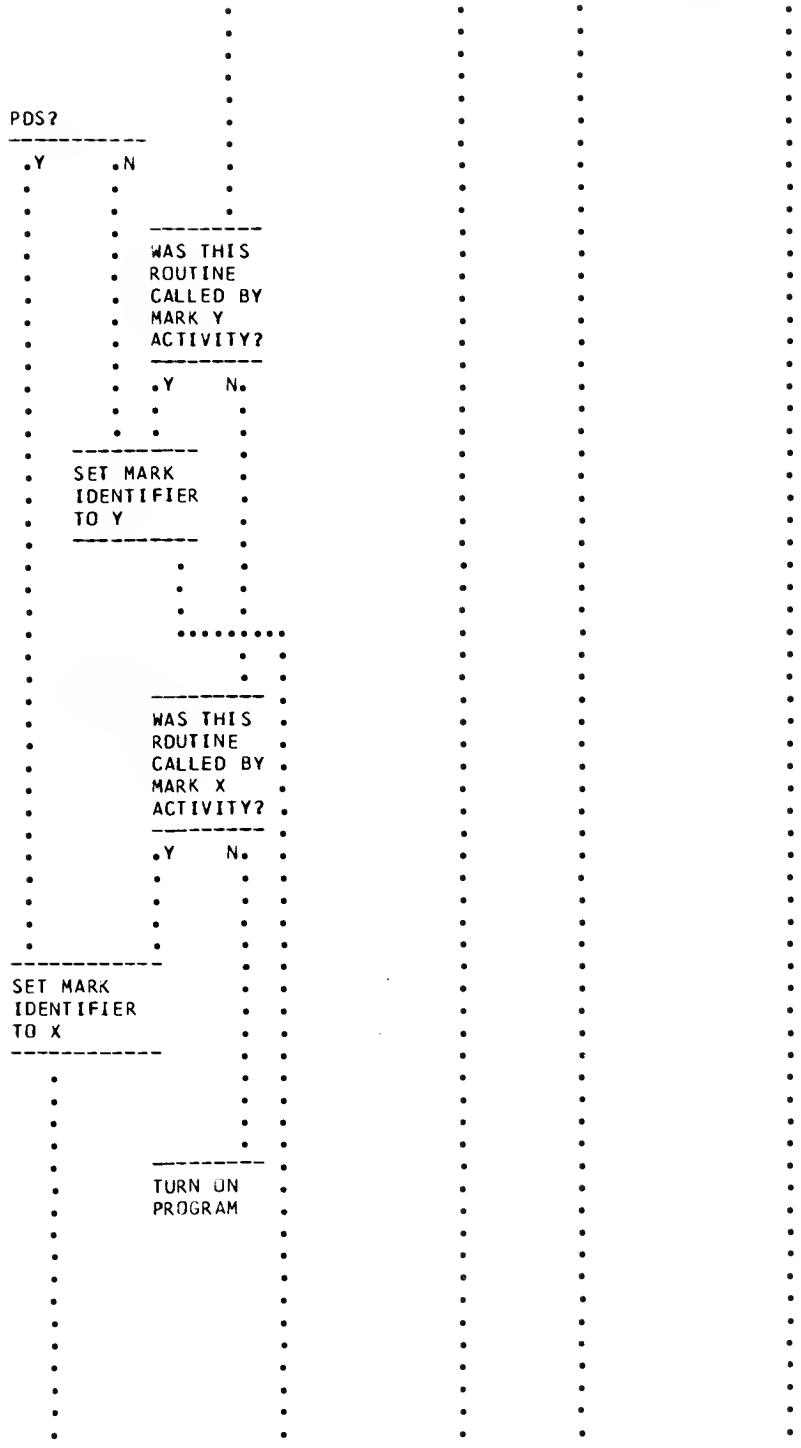
#140

#150

#160

#170

#180



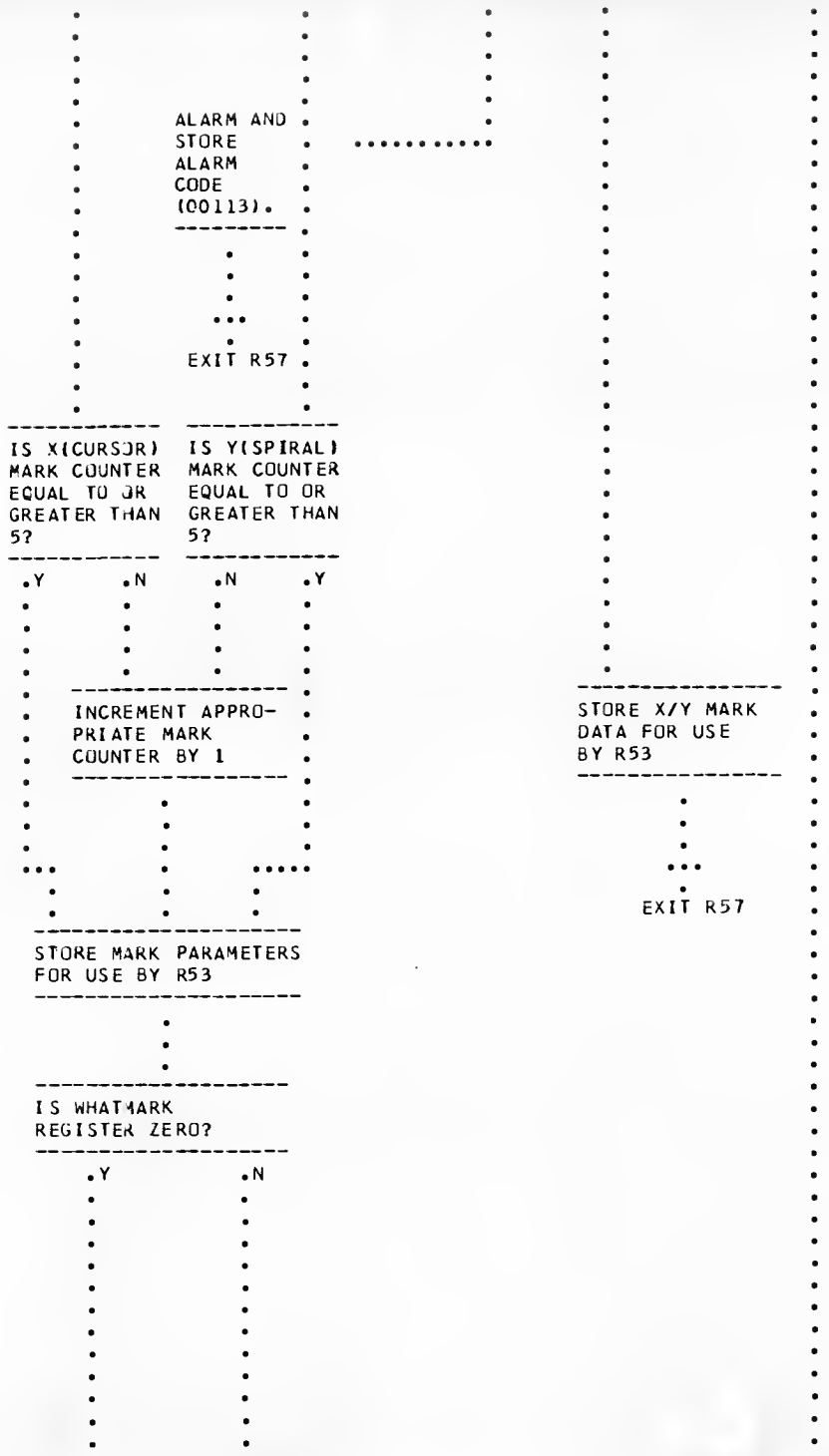
#190

#200

#210

#220

#230



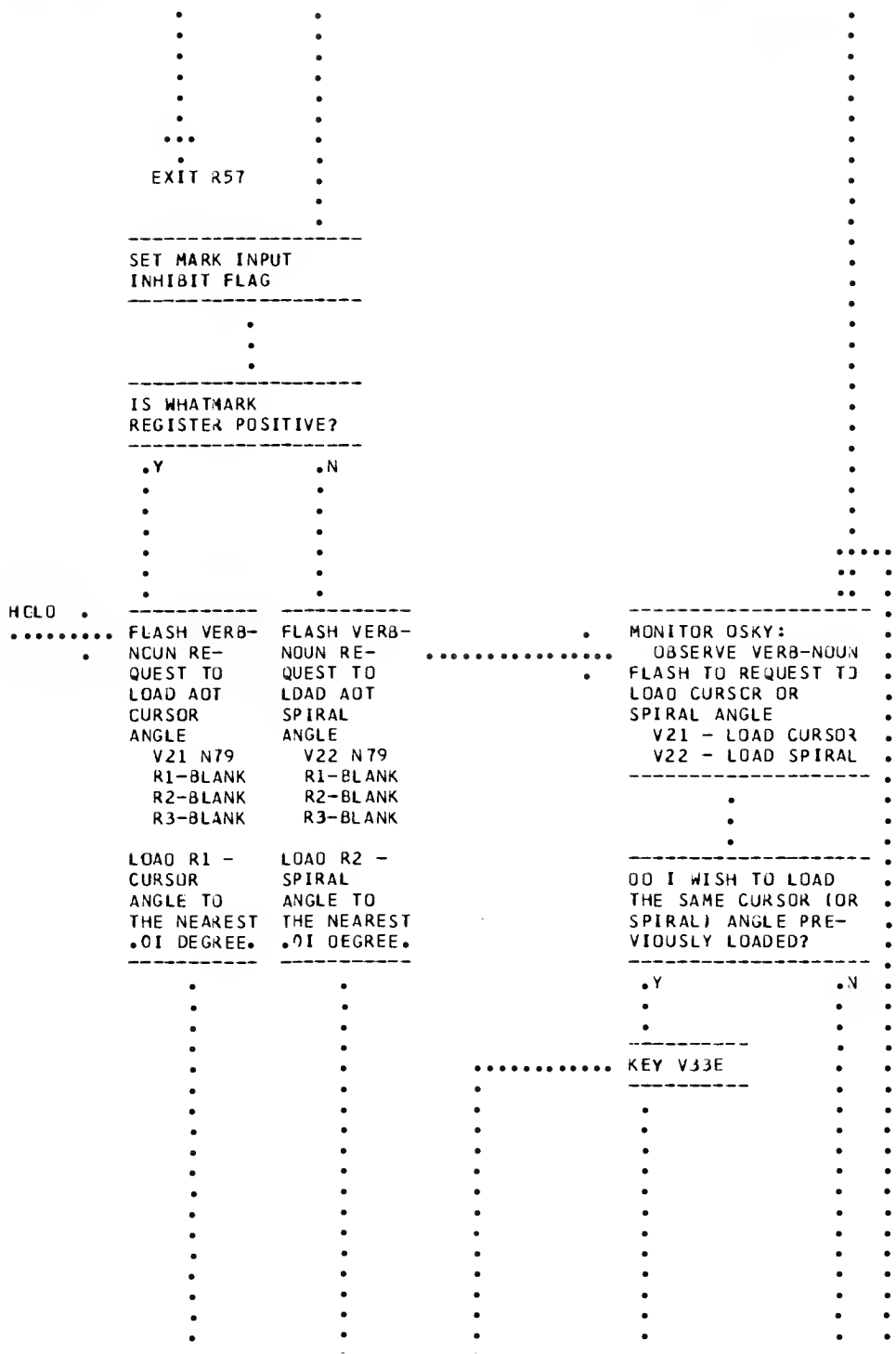
#240

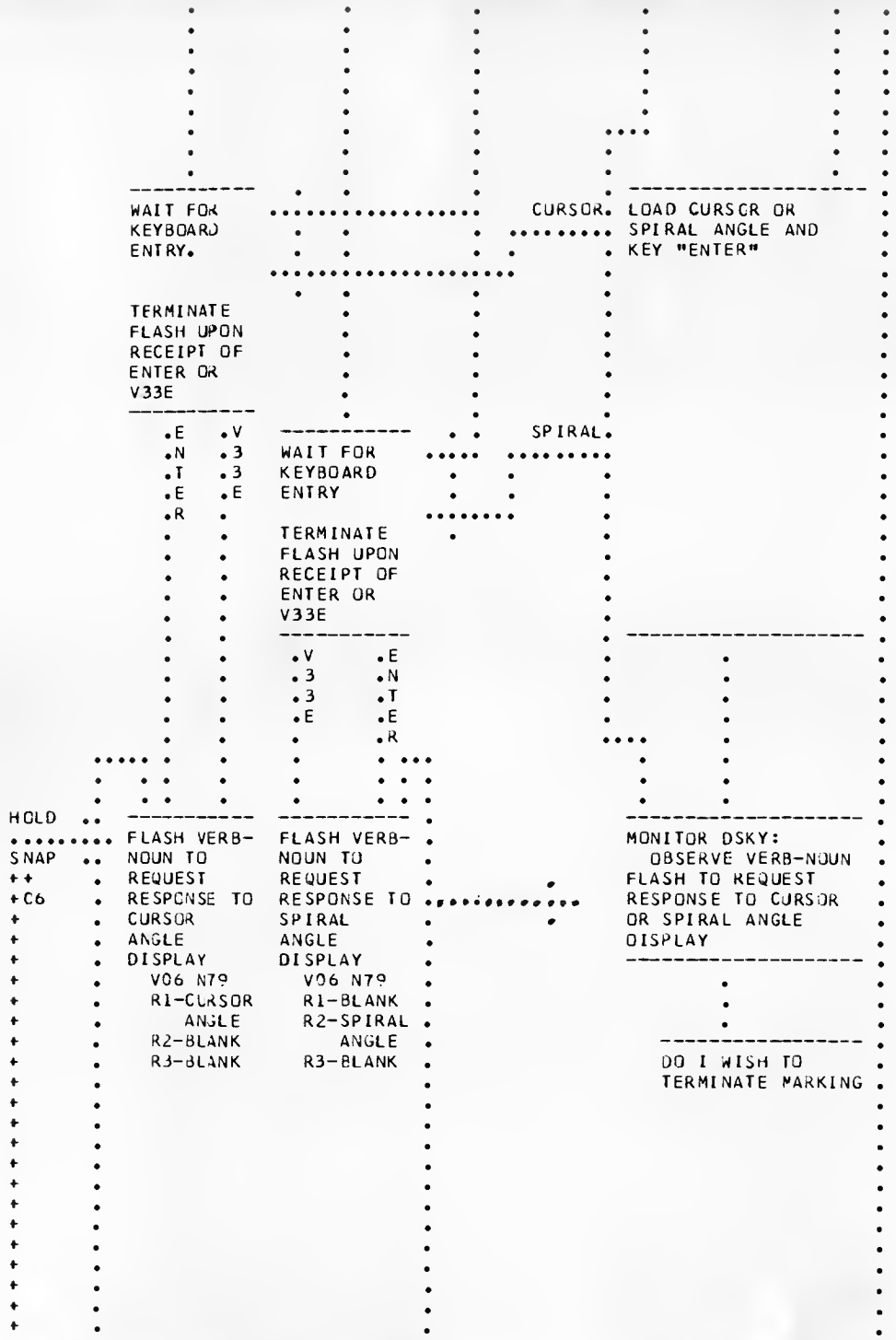
#250

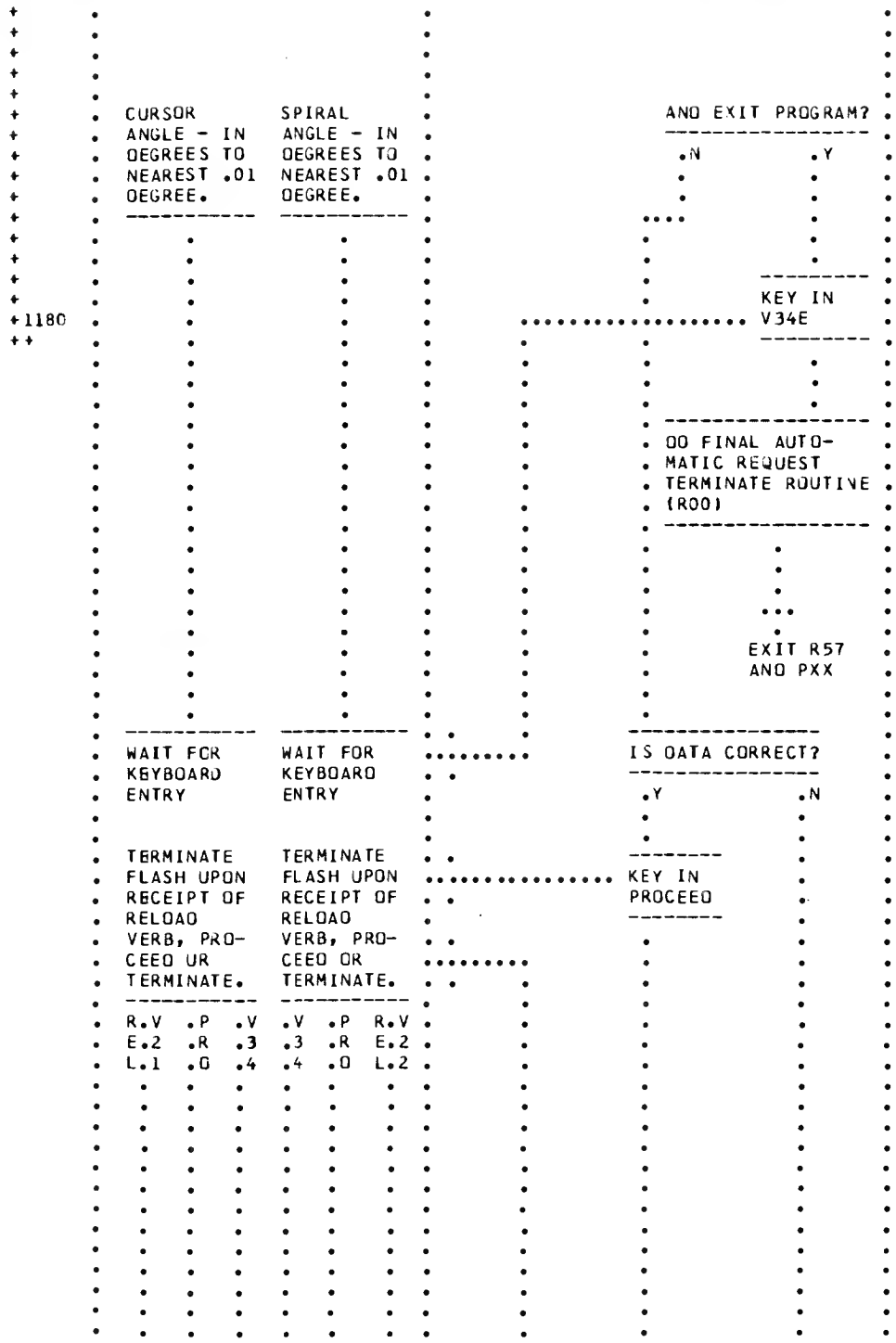
#260

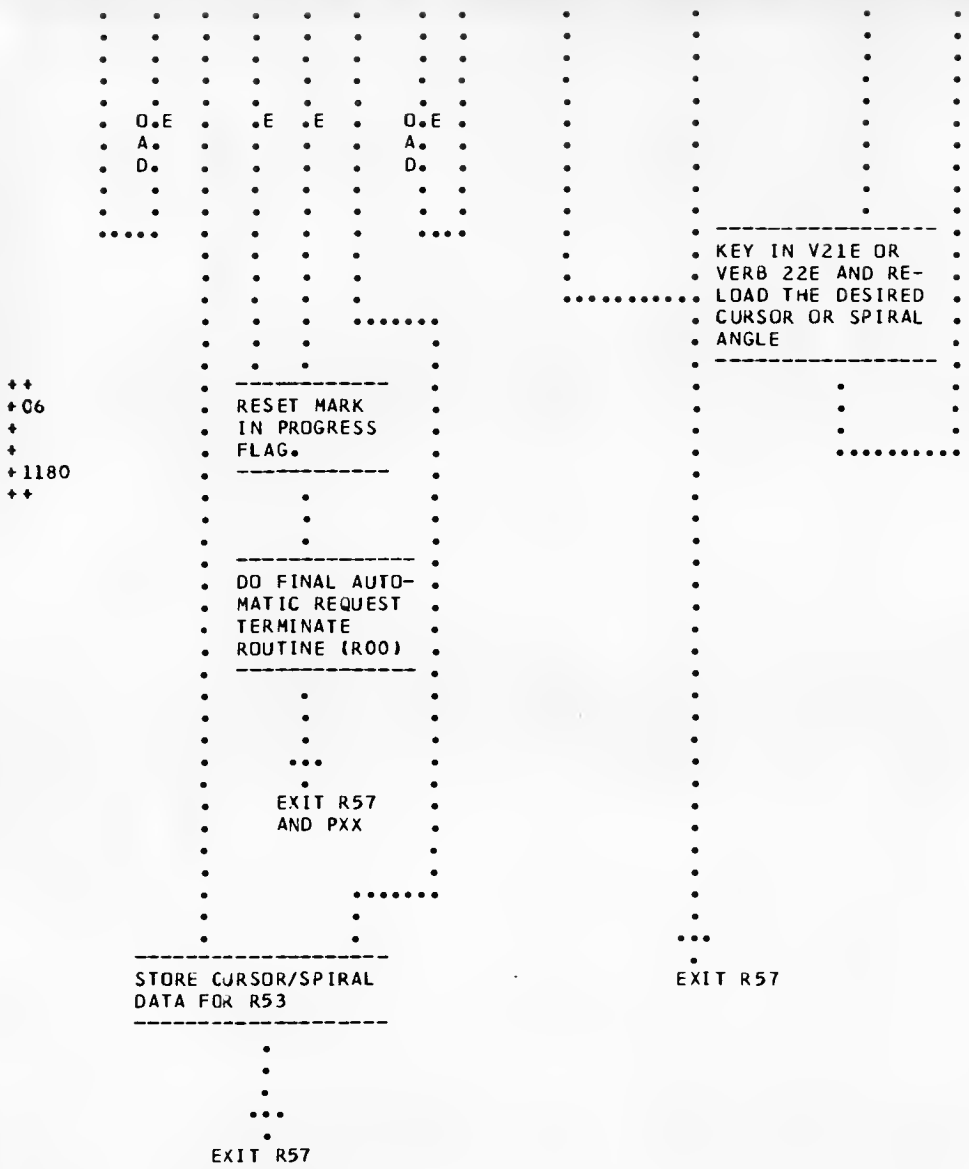
#270

#280


EXIT R57
SET MARK INPUT INHIBIT FLAG
IS WHATMARK REGISTER POSITIVE?
.Y
.N
HCLO
FLASH VERB-NOUN REQUEST TO LOAD AOT CURSOR ANGLE V21 N79 R1-BLANK R2-BLANK R3-BLANK
FLASH VERB-NOUN REQUEST TO LOAD AOT SPIRAL ANGLE V22 N79 R1-BLANK R2-BLANK R3-BLANK
LOAD R1 - CURSOR ANGLE TO THE NEAREST .01 DEGREE.
LOAD R2 - SPIRAL ANGLE TO THE NEAREST .01 DEGREE.
MONITOR OSKY: OBSERVE VERB-NOUN FLASH TO REQUEST TO LOAD CURSOR OR SPIRAL ANGLE V21 - LOAD CURSOR V22 - LOAD SPIRAL
DO I WISH TO LOAD THE SAME CURSOR (OR SPIRAL) ANGLE PREVIOUSLY LOADED?
.Y
.N
KEY V33E
#290
#300
#310
#320
#330


WAIT FOR KEYBOARD ENTRY.
TERMINATE FLASH UPON RECEIPT OF ENTER OR V33E
.E .V .N .3 .T .3 .E .E .R .
WAIT FOR KEYBOARD ENTRY
TERMINATE FLASH UPON RECEIPT OF ENTER OR V33E
.V .3 .3 .E .E .N .T .E .R .
CURSOR.
SPIRAL.
LOAD CURSOR OR SPIRAL ANGLE AND KEY "ENTER"
#340
#350
#360
HOLD
SNAP
++
+C6
+
FLASH VERB-NOUN TO REQUEST RESPONSE TO CURSOR ANGLE DISPLAY
V06 N79
R1-CURSOR ANGLE
R2-BLANK
R3-BLANK
FLASH VERB-NOUN TO REQUEST RESPONSE TO SPIRAL ANGLE DISPLAY
V06 N79
R1-BLANK
R2-SPIRAL ANGLE
R3-BLANK
MONITOR DSKY: OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE TO CURSOR OR SPIRAL ANGLE DISPLAY
#370
DO I WISH TO TERMINATE MARKING
#380


CURSOR ANGLE - IN OEGREES TO NEAREST .01 OEGREE.
SPIRAL ANGLE - IN OEGREES TO NEAREST .01 OEGREE.
AND EXIT PROGRAM?
.N
.Y
KEY IN V34E
00 FINAL AUTO-MATIC REQUEST TERMINATE ROUTINE (R00)
EXIT R57 AND PXX
WAIT FOR KEYBOARD ENTRY
WAIT FOR KEYBOARD ENTRY
IS OATA CORRECT?
.Y
.N
TERMINATE FLASH UPON RECEIPT OF RELOAO VERB, PRO-CEEO UR TERMINATE.
TERMINATE FLASH UPON RECEIPT OF RELOAO VERB, PRO-CEEO OR TERMINATE.
KEY IN PROCEEO
R.V E.2 L.1
.P .R .O
.V .3 .4
.V .3 .4
.P .R .O
R.V E.2 L.2
1180
#390
#400
#410
#420



#430

#440

#450

#460

#470

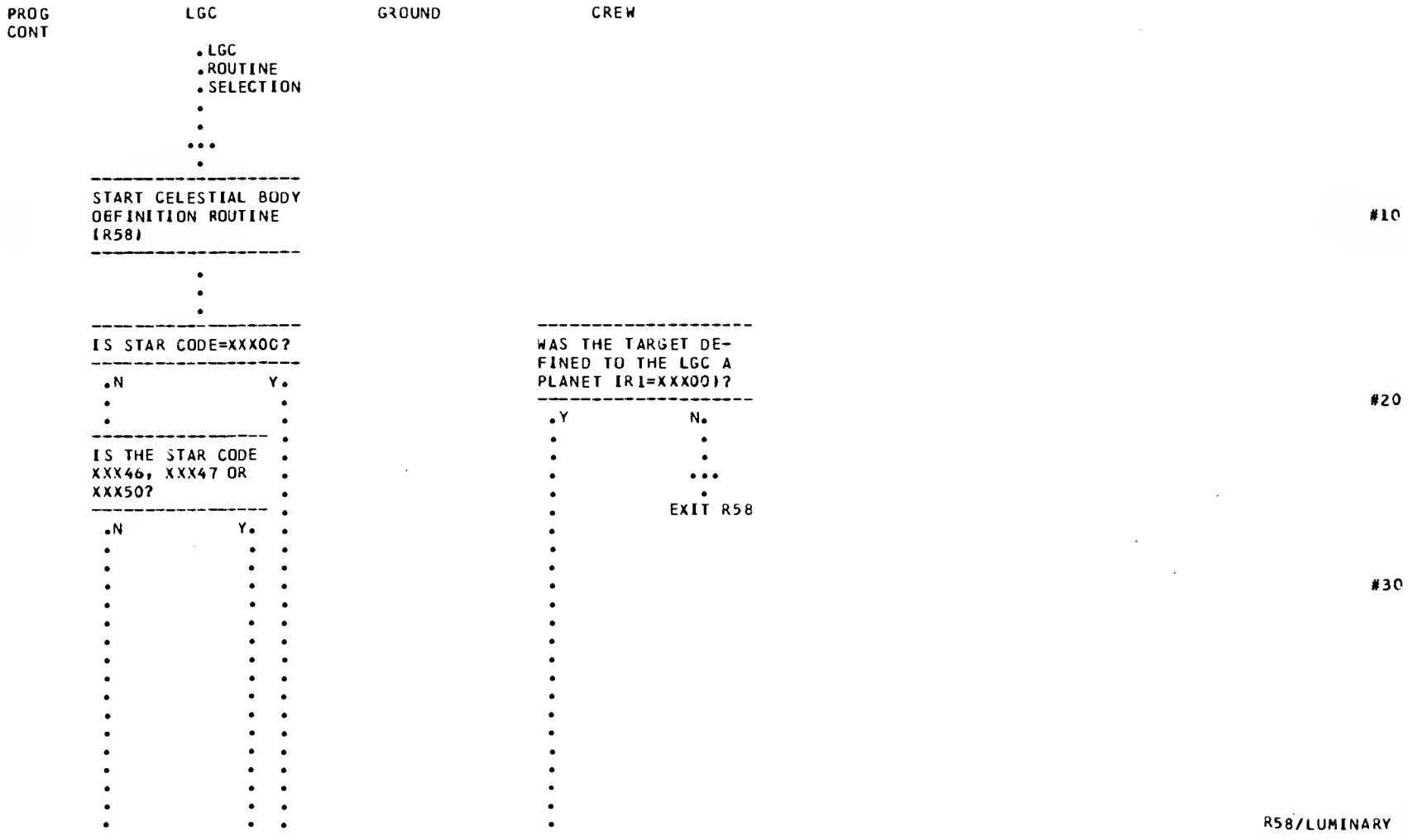
CHANGE CONTROL NOTES

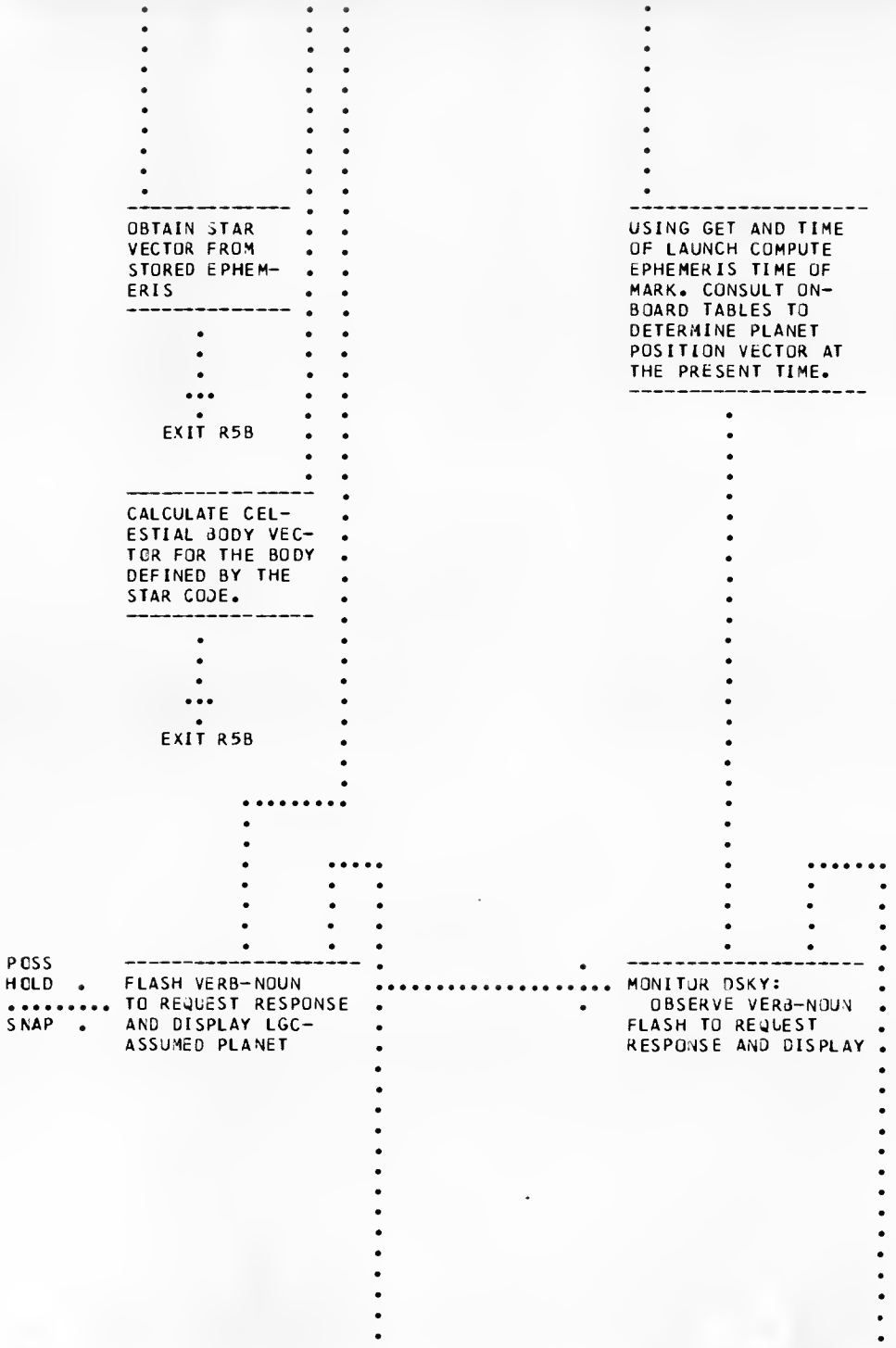
REV C5(LUM 1E) PCR 333,1044
REV C6 PCN 1180

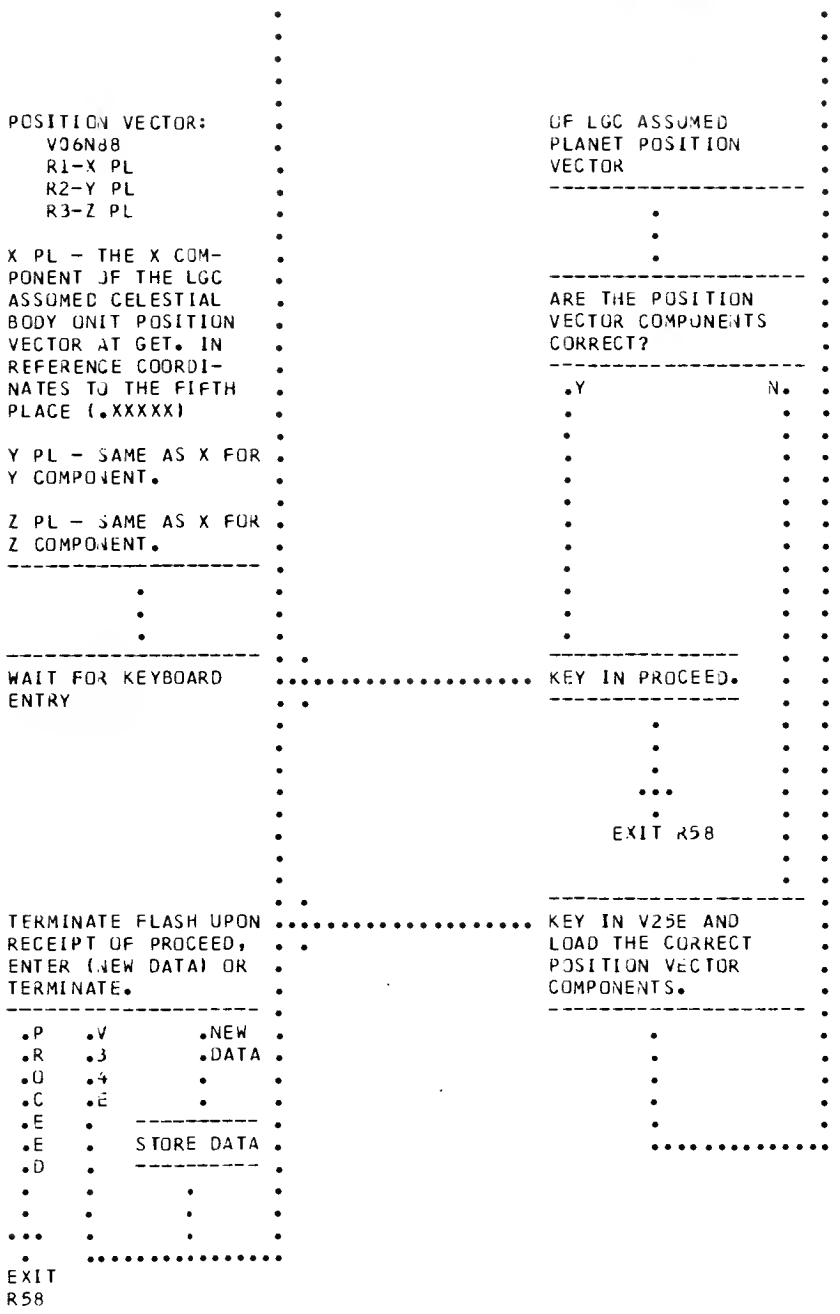
CELESTIAL BODY DEFINITION ROUTINE (R58) REV 05 02/17/71

PURPOSE: (1) TO OBTAIN THE CORRECT CELESTIAL BODY VECTOR FROM INFORMATION SPECIFIED BY THE CREW DURING IMU ALIGNMENTS.

ASSUMPTION: (1) THIS ROUTINE IS AUTOMATICALLY CALLED BY P51, P57, R51, R52, R53 AND R59.




OBTAIN STAR VECTOR FROM STORED EPHEM-ERIS
EXIT R5B
USING GET AND TIME OF LAUNCH COMPUTE EPHEMERIS TIME OF MARK. CONSULT ON-BOARD TABLES TO DETERMINE PLANET POSITION VECTOR AT THE PRESENT TIME.
#40
CALCULATE CEL-ESTIAL BODY VEC-TOR FOR THE BODY DEFINED BY THE STAR CODE.
EXIT R5B
#50
#60
#70
POSS HOLD
SNAP
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY LGC-ASSUMED PLANET
MONITOR DSKY: OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY



#80

#90

#100

#110

#120

#130

CHANGE CONTROL NOTES

REV 01 EDITORIAL
REV 02 EDITORIAL
REV 03 EDITORIAL
REV 04(LUM 1D) PCR 983, PCN 1039
REV 05(LUM 1E) PCR 1044

LUNAR SURFACE SIGHTING MARK ROUTINE (R59) REV 05 12/01/71

PURPOSE: (1) WHILE ON THE LUNAR SURFACE, TO PERFORM CURSOR/SPIRAL AOT SIGHTINGS ON A CELESTIAL BODY (NAVIGATION STAR, PLANET, OR THE SUN) FOR USE BY THE LUNAR SURFACE ALIGN PROGRAM (P57).

(2) WHILE INFLIGHT, TO PERFORM CURSOR/SPIRAL AOT SIGHTINGS ON A CELESTIAL BODY AS A BACKUP ALIGNMENT OPTION FOR USE BY THE IMU ALIGNMENT PROGRAM (P52).

ASSUMPTIONS: (1) WHILE ON THE LUNAR SURFACE NAVIGATION STARS MAY NOT BE VISIBLE. THE SUN OR A PLANET MAY NOT BE VISIBLE. ALTHOUGH VISIBLE, THE CELESTIAL BODY MAY BE AT TOO HIGH AN ELEVATION TO BE EFFECTIVE FOR AZIMUTH DETERMINATION DURING THE ALIGNMENT OPTION WHICH REQUIRES A SIGHTING ON ONLY ONE CELESTIAL BODY (OPTION 00003). THE MAXIMUM USABLE ELEVATION IN THIS CASE IS 70 DEGREES ABOVE THE LUNAR HORIZON. FOR ALIGNMENT OPTIONS REQUIRING SIGHTINGS ON TWO CELESTIAL BODIES, AS IN P52 AND OPTION 2 OF P57, THE LOS BETWEEN THESE BODIES SHOULD FORM A MINIMUM ANGLE OF 50 DEGREES.

```
++
+05
+1180
++
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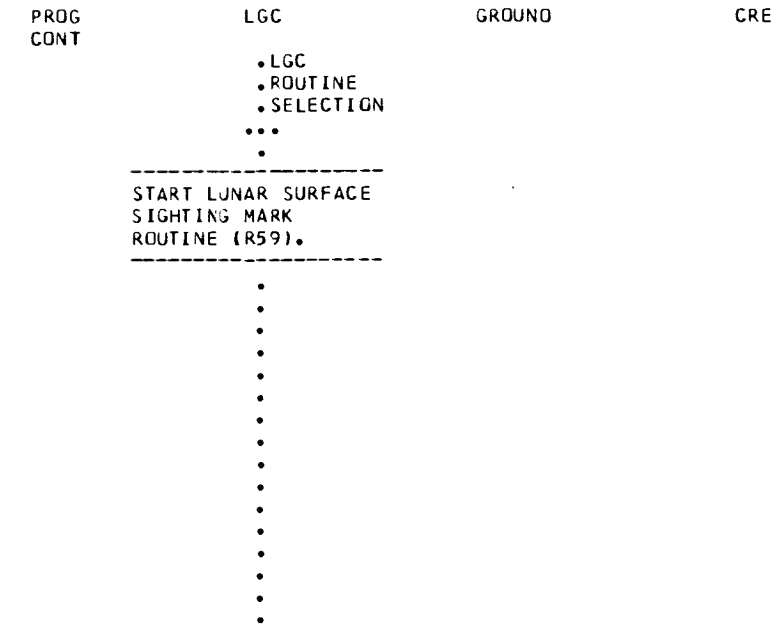
(2) A NEUTRAL DENSITY FILTER FOR THE AOT IS AVAILABLE FOR USE DURING SUN SIGHTINGS.

(3) MULTIPLE SIGHTINGS MAY BE USED TO DETERMINE THE "AVERAGE" LOS VECTOR TO THE BODY.

(4) THE REAR DETENTS OF THE AOT MAY BE USED IF NECESSARY.

(5) THE ROUTINE IS AUTOMATICALLY CALLED BY THE LUNAR SURFACE ALIGN PROGRAM (P57) AND AUTO OPTICS POSITIONING ROUTINE (R52).



#10

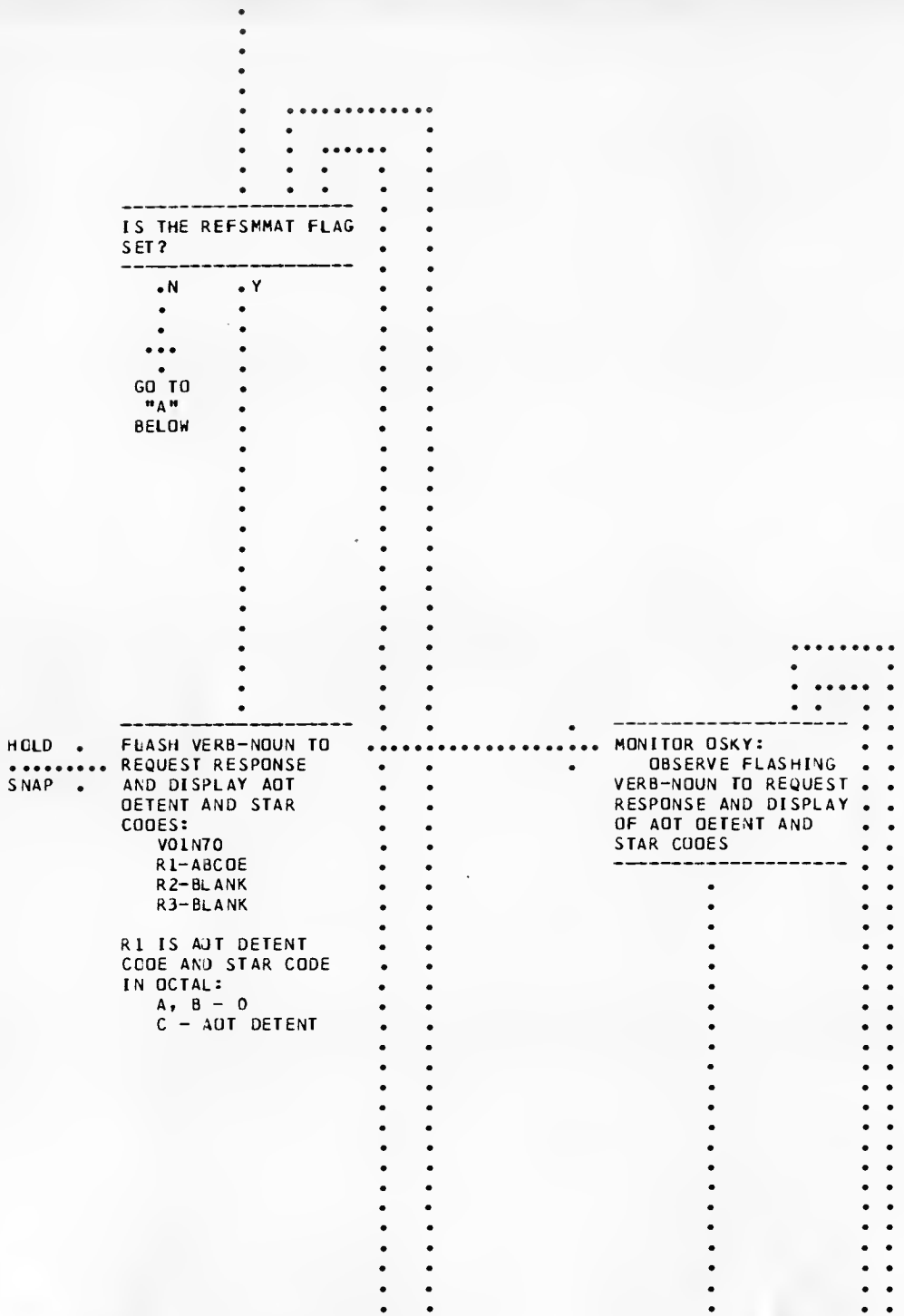
#20

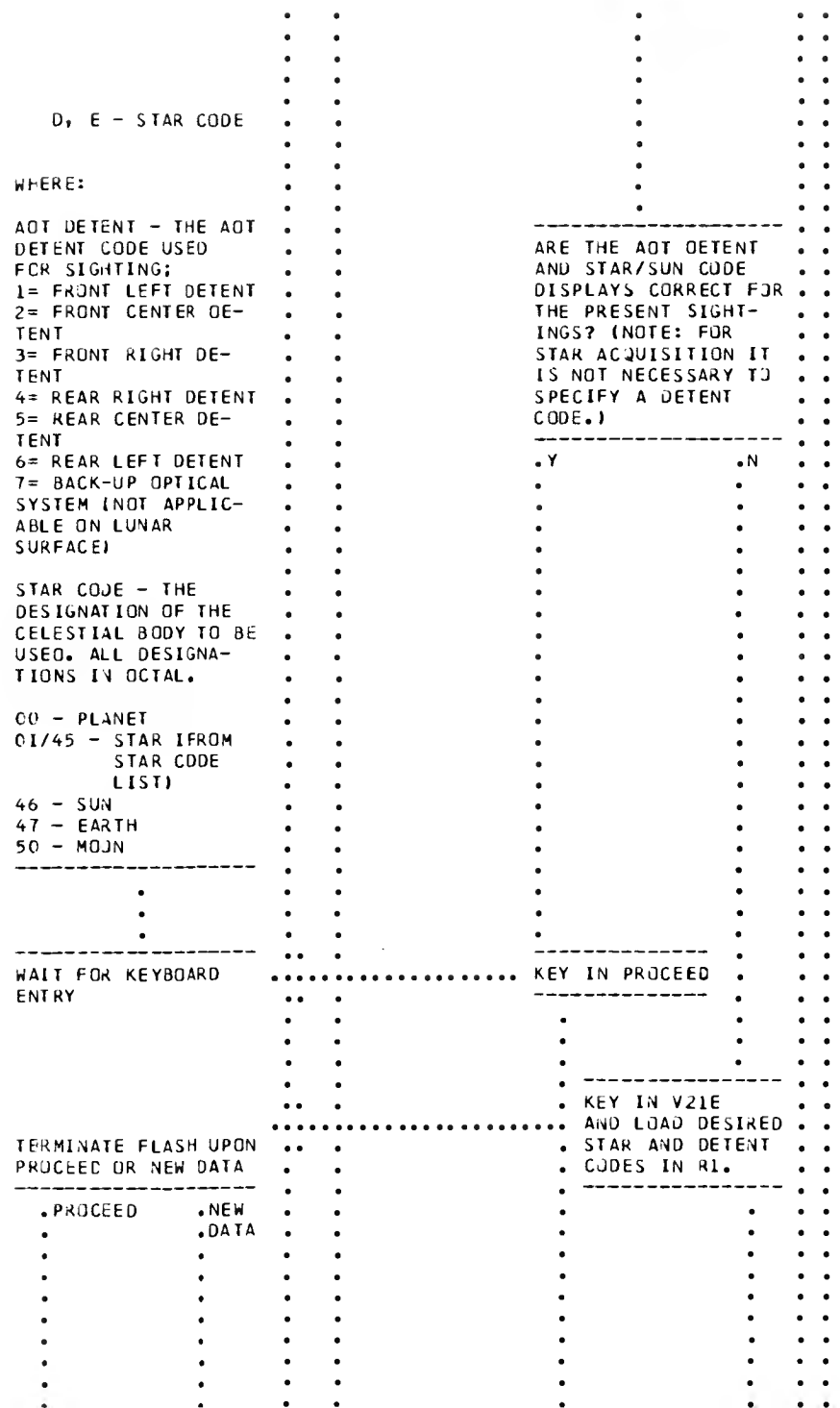
#30

#40

#50

#60


IS THE REFSMMAT FLAG SET?
N
Y
GO TO "A" BELOW
HOLD
SNAP
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY AOT OETENT AND STAR CODES:
V01N70
R1-ABCOE
R2-BLANK
R3-BLANK
R1 IS AOT DETENT CODE AND STAR CODE IN OCTAL:
A, B - 0
C - AOT DETENT
MONITOR OSKY: OBSERVE FLASHING VERB-NOUN TO REQUEST RESPONSE AND DISPLAY OF AOT OETENT AND STAR CODES



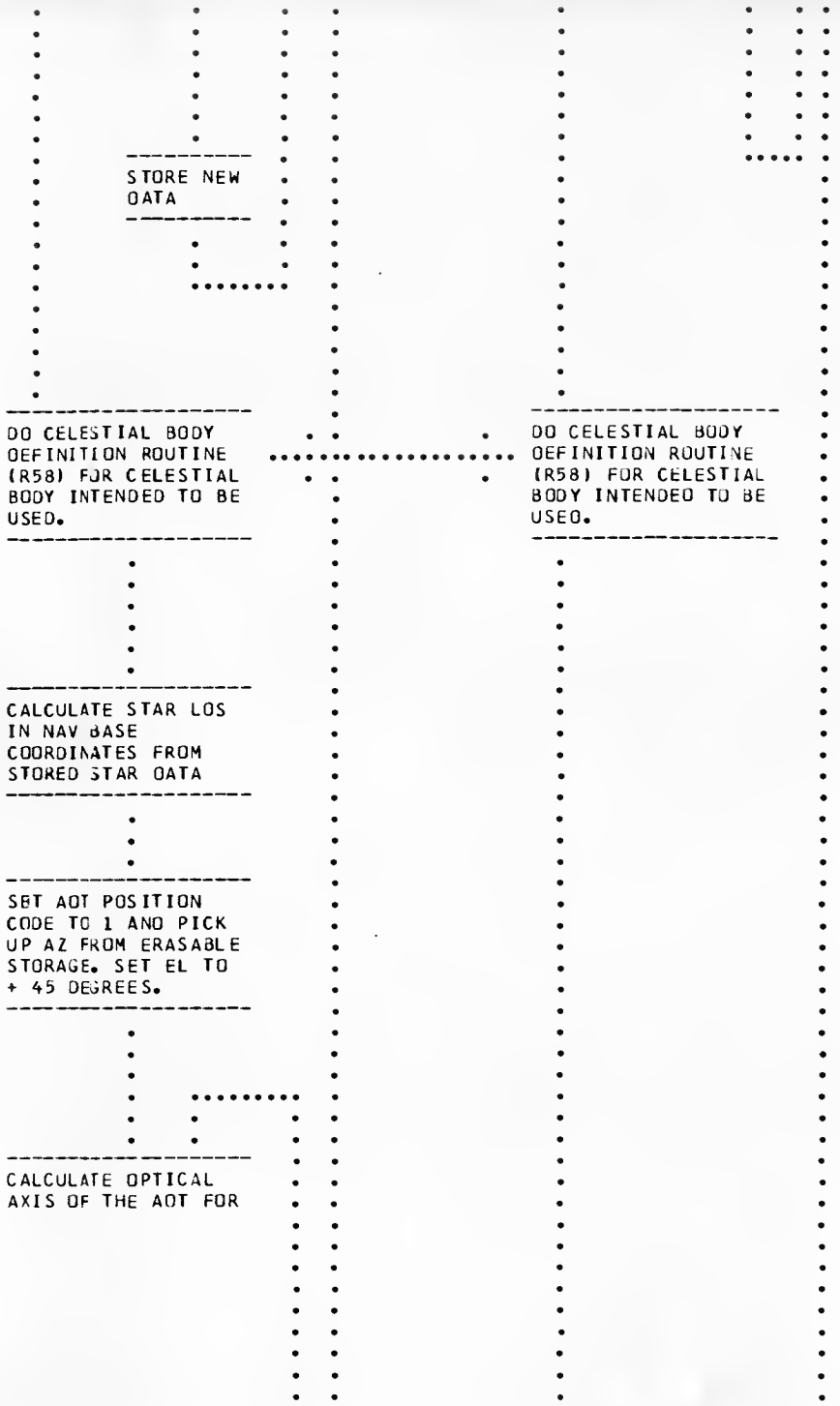
#70

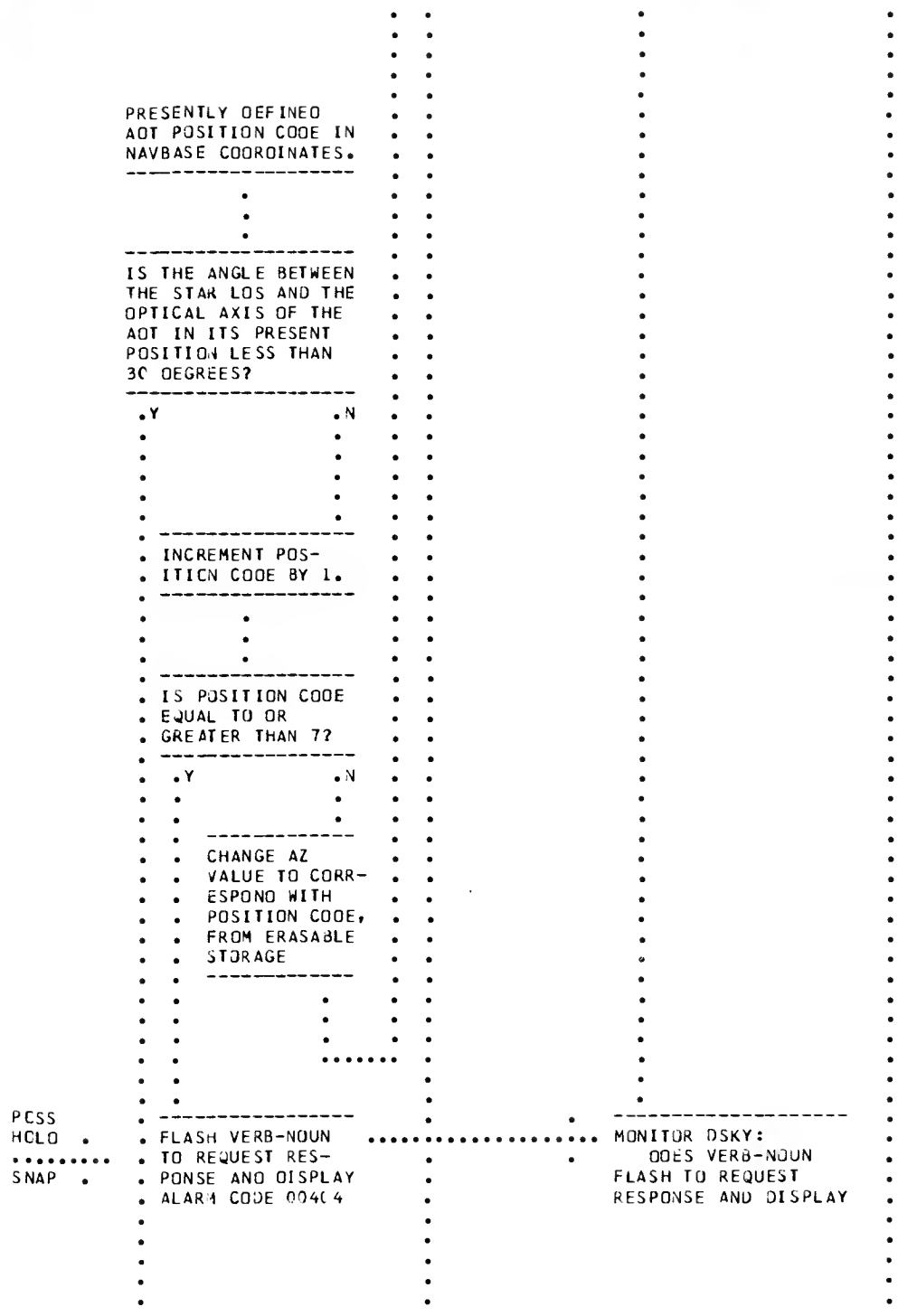
#80

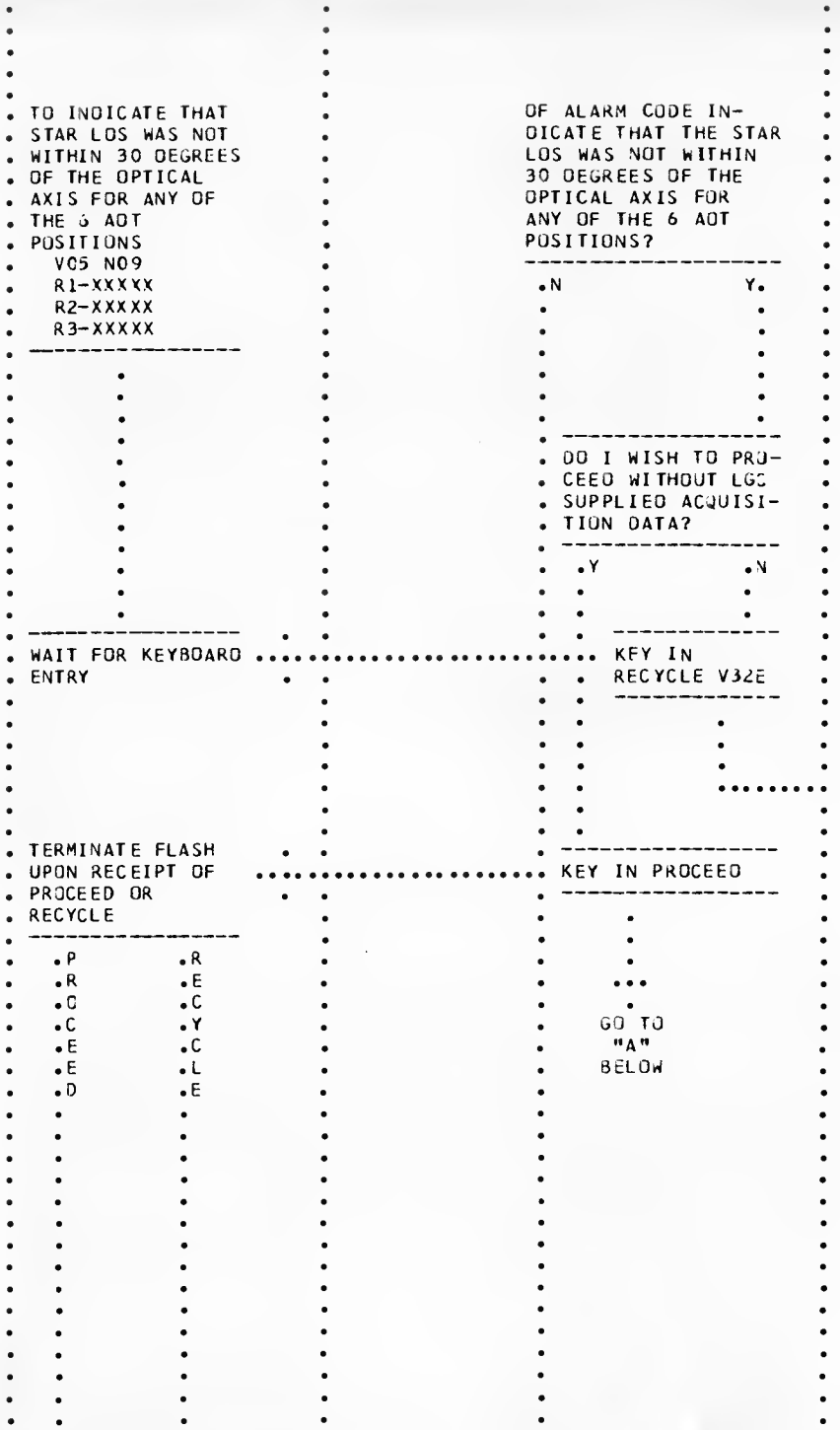
#90

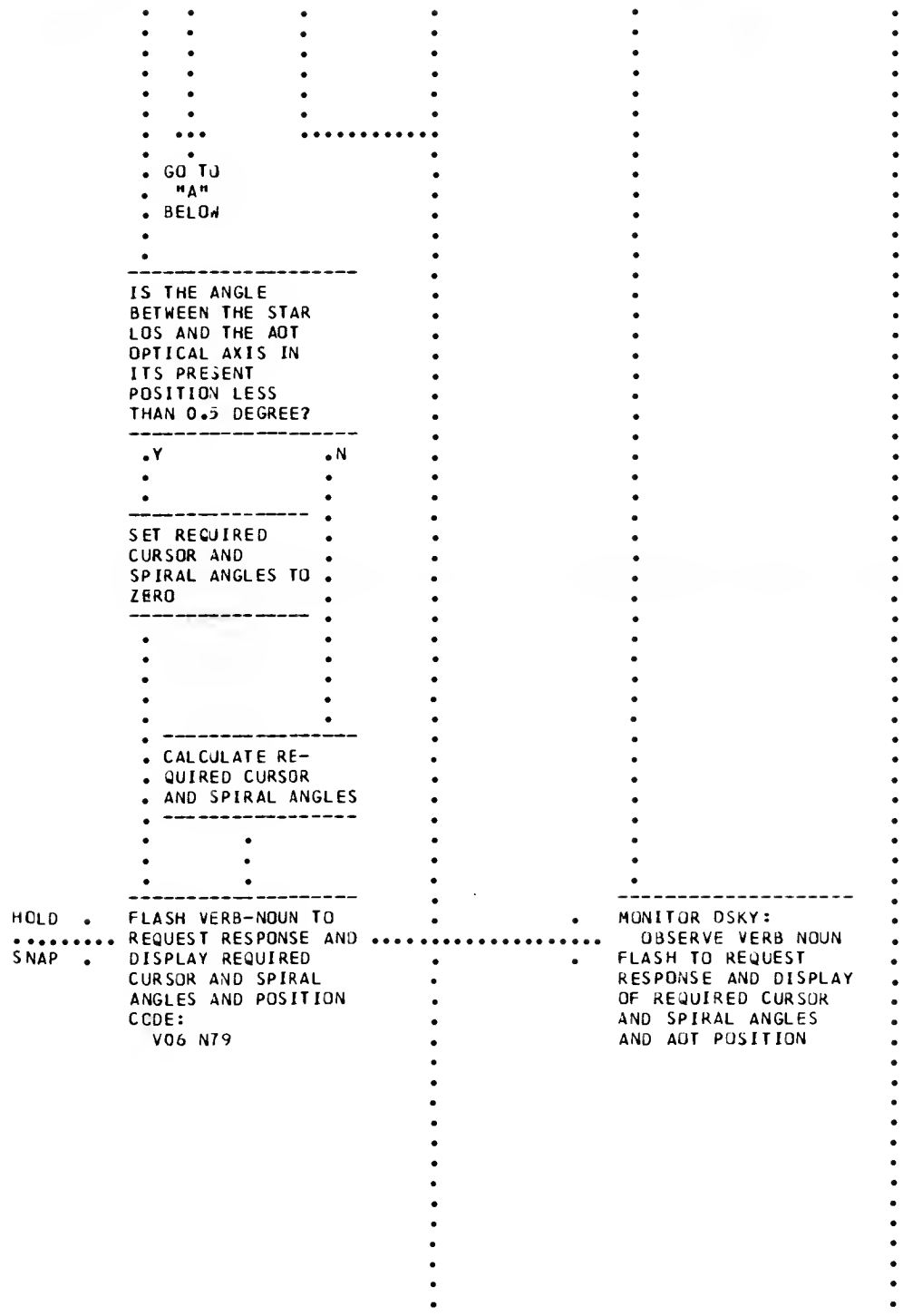
#100

#110


STORE NEW OATA
#120
DO CELESTIAL BODY OEFINITION ROUTINE (R58) FOR CELESTIAL BODY INTENDED TO BE USED.
DO CELESTIAL BODY OEFINITION ROUTINE (R58) FOR CELESTIAL BODY INTENDED TO BE USEO.
#130
#140
CALCULATE STAR LOS IN NAV BASE COORDINATES FROM STORED STAR OATA
#150
SBT AOT POSITION CODE TO 1 AND PICK UP AZ FROM ERASABLE STORAGE. SET EL TO + 45 DEGREES.
#160
CALCULATE OPTICAL AXIS OF THE AOT FOR


PRESENTLY DEFINED AOT POSITION CODE IN NAVBASE COORDINATES.
#170
IS THE ANGLE BETWEEN THE STAR LOS AND THE OPTICAL AXIS OF THE AOT IN ITS PRESENT POSITION LESS THAN 30 DEGREES?
#180
Y
N
INCREMENT POSITION CODE BY 1.
#190
IS POSITION CODE EQUAL TO OR GREATER THAN 77
#200
Y
N
CHANGE AZ VALUE TO CORRESPONO WITH POSITION CODE, FROM ERASABLE STORAGE
#210
PCSS
HCLO
SNAP
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY ALARM CODE 00404
MONITOR DSKY: OOES VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY
#220


TO INDICATE THAT STAR LOS WAS NOT WITHIN 30 DEGREES OF THE OPTICAL AXIS FOR ANY OF THE 6 AOT POSITIONS
V05 N09
R1-XXXXX
R2-XXXXX
R3-XXXXX
WAIT FOR KEYBOARD ENTRY
TERMINATE FLASH UPON RECEIPT OF PROCEED OR RECYCLE
.P .R
.R .E
.O .C
.C .Y
.E .C
.E .L
.D .E
OF ALARM CODE INDICATE THAT THE STAR LOS WAS NOT WITHIN 30 DEGREES OF THE OPTICAL AXIS FOR ANY OF THE 6 AOT POSITIONS?
.N
Y.
#230
DO I WISH TO PROCEED WITHOUT LGC SUPPLIED ACQUISITION DATA?
#240
.Y
.N
KEY IN RECYCLE V32E
#250
KEY IN PROCEED
#260
GO TO "A" BELOW



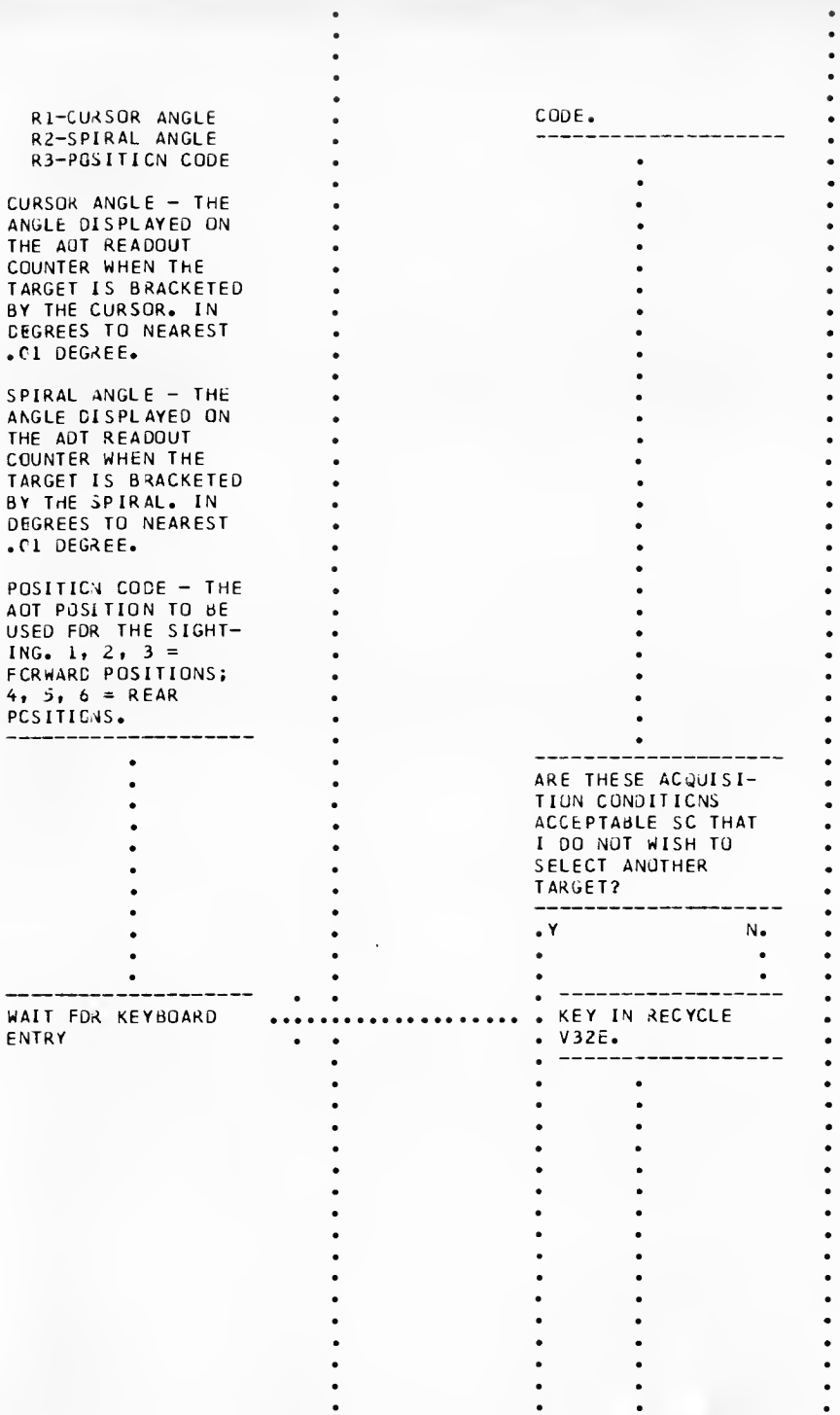
#270

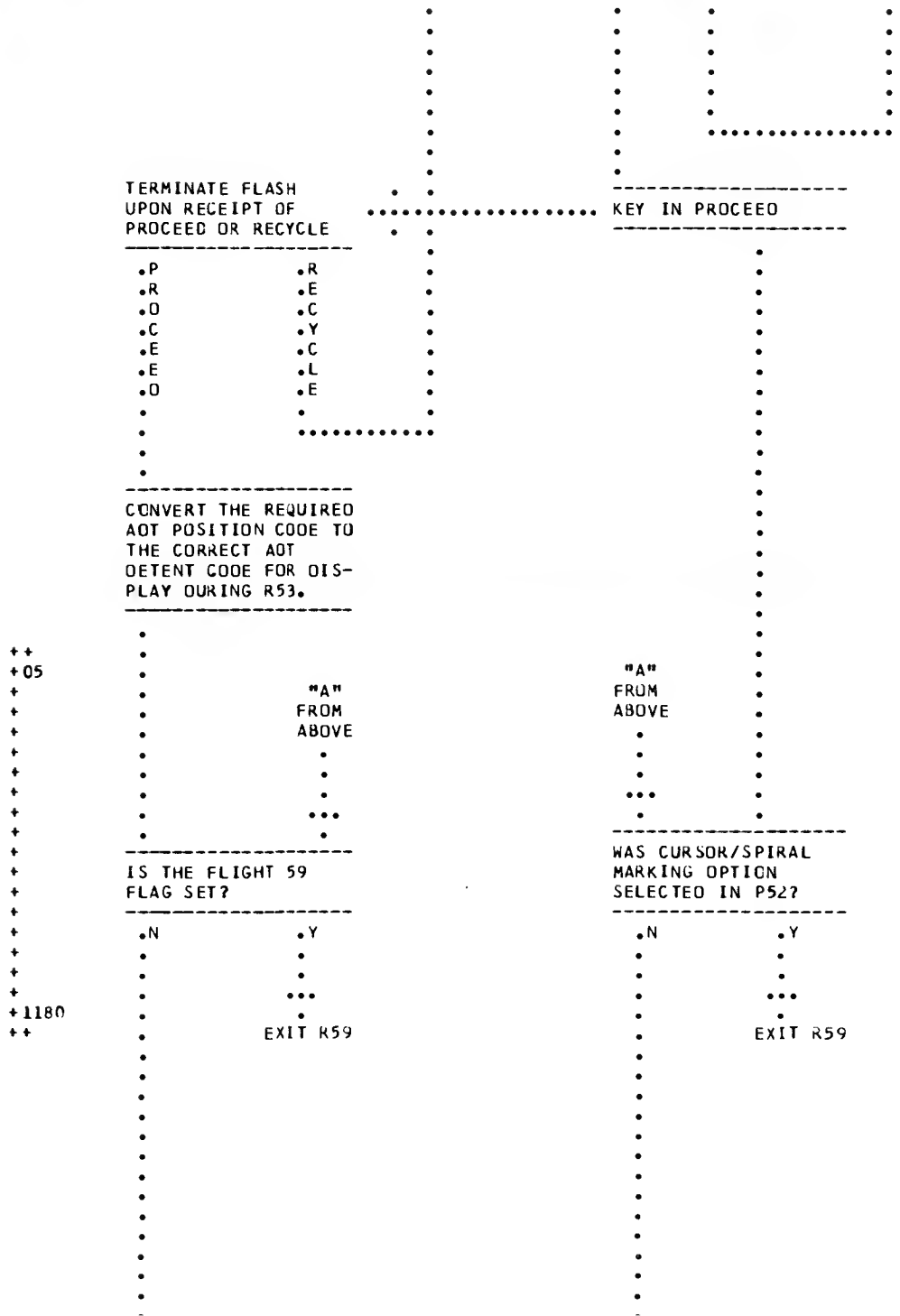
#280

#290

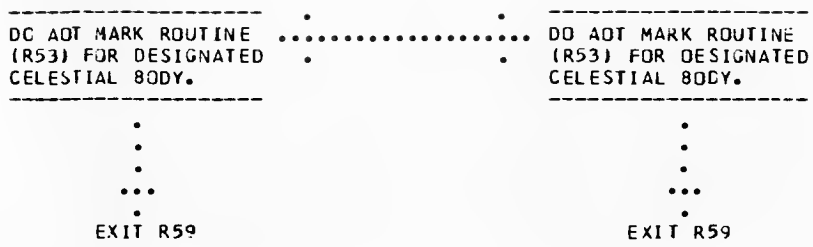
#300

#310


R1-CURSOR ANGLE
R2-SPIRAL ANGLE
R3-POSITION CODE
CURSOR ANGLE - THE ANGLE DISPLAYED ON THE AOT READOUT COUNTER WHEN THE TARGET IS BRACKETED BY THE CURSOR. IN DEGREES TO NEAREST .01 DEGREE.
SPIRAL ANGLE - THE ANGLE DISPLAYED ON THE AOT READOUT COUNTER WHEN THE TARGET IS BRACKETED BY THE SPIRAL. IN DEGREES TO NEAREST .01 DEGREE.
POSITION CODE - THE AOT POSITION TO BE USED FOR THE SIGHTING. 1, 2, 3 = FORWARD POSITIONS; 4, 5, 6 = REAR POSITIONS.
WAIT FOR KEYBOARD ENTRY
CODE.
ARE THESE ACQUISITION CONDITIONS ACCEPTABLE SO THAT I DO NOT WISH TO SELECT ANOTHER TARGET?
.Y
N.
KEY IN RECYCLE V32E.
#320
#330
#340
#350
#360


TERMINATE FLASH UPON RECEIPT OF PROCEED OR RECYCLE
KEY IN PROCEED
#370
.P .R .O .C .E .E .O
.R .E .C .Y .C .L .E
#380
CONVERT THE REQUIRED AOT POSITION CODE TO THE CORRECT AOT DETENT CODE FOR DISPLAY DURING R53.
++
+05
+1180
++
#390
"A" FROM ABOVE
"A" FROM ABOVE
IS THE FLIGHT 59 FLAG SET?
WAS CURSOR/SPIRAL MARKING OPTION SELECTED IN P52?
#400
.N .Y
.N .Y
EXIT R59
EXIT R59

#410



#420

EXIT R59

EXIT R59

CHANGE CONTROL NOTES

REV 01 EDITORIAL
REV 00(LUM 1A) PCR 699
REV 01(LUM 1B) EDITORIAL
REV 02 EDITORIAL
REV 03(LUM 1D) PCR 982, PCN 1009
REV 04(LUM 1E) PCR 1044
REV 05 PCN 1180

ATTITUDE MANEUVER ROUTINE(R60) REV 05 12/01/71

PURPOSE: (1) TO MANEUVER THE LM TO AN ATTITUDE SPECIFIED BY THE PROGRAM IN PROCESS.

ASSUMPTIONS: (1) THE FINAL ATTITUDE DESIRED, DEFINED AS FOLLOWS, HAS BEEN STORED BY THE CALLING PROGRAM:

(A) A SPECIFIC BODY FIXED VECTOR AND A DIRECTION IN SPACE TO WHICH THIS VECTOR IS TO BE ALIGNED (THE 3-AXIS FLAG IS RESET).

(B) A THREE AXIS (ORTHOGONAL) INERTIAL ORIENTATION TO WHICH THE THREE BODY AXES ARE TO BE ALIGNED (THE 3-AXIS FLAG IS SET).

(2) THE MANEUVER MAY BE PERFORMED AUTOMATICALLY BY THE PGNCS OR PERFORMED MANUALLY WITH AN OPTIONAL FINAL AUTOMATIC PGNCS-CONTROLLED TRIM MANEUVER. THIS OPTIONAL TRIM MANEUVER SHOULD BE CONSIDERED ESSENTIAL FOR MANEUVERS TO THRUSTING ATTITUDES.

(3) THE DOCKED CONFIGURATION OF THE VEHICLES HAS BEEN CORRECTLY DEFINED TO THE LGC VIA R03.

(4) THE PGNCS CAN GENERATE TWO TYPES OF ATTITUDE ERRORS FOR DISPLAY ON THE FDAI:
MODE I - SELECTED BY EXTENDED VERB 61. AUTOPILOT FOLLOWING ERRORS USED AS A MONITOR OF THE DAP'S ABILITY TO TRACK AUTOMATIC STEERING COMMANDS.
MODE II- SELECTED BY EXTENDED VERB 62. TOTAL ATTITUDE ERRORS USED TO ASSIST CREW IN MANUALLY MANEUVERING THE VEHICLE.

++
+05 PGNCS-DERIVED VEHICLE ATTITUDE RATES MAY ALSO BE DISPLAYED VIA SELECTION BY EXTENDED VERB 60.
+ DISPLAY SELECTION IS ALWAYS BASED UPON THE LAST ENTRY MADE IN THE DSKY WITH THE EXCEPTION THAT MODE II ATTITUDE
+ ERROR DISPLAYS ARE AUTOMATICALLY SELECTED AT THE BEGINNING OF R60. (SEE ASSUMPTION (12) BELOW). FOR A MORE DETAILED
+1180 DESCRIPTION OF THESE DISPLAYS, REFER TO SEC 3 OF R567, PARA. 3.2.6.
++

(5) THE DAP DATA LOAD ROUTINE (R03) HAS BEEN PERFORMED PRIOR TO THIS ROUTINE.

(6) THE ATTITUDE DEADBAND USED BY THIS ROUTINE WILL BE THAT MOST RECENTLY SELECTED BY THE ASTRONAUT VIA R03, UNLESS THAT DEADBAND HAS BEEN OVERRIDDEN BY THE PROGRAM IN PROCESS IN WHICH CASE THE PROGRAM-SPECIFIED DEADBAND WILL BE USED.

(7) THE ATTITUDE MANEUVER RATE FOR AN AUTOMATIC MANEUVER WILL BE THAT WHICH WAS LAST SPECIFIED BY THE ASTRONAUT VIA R03.

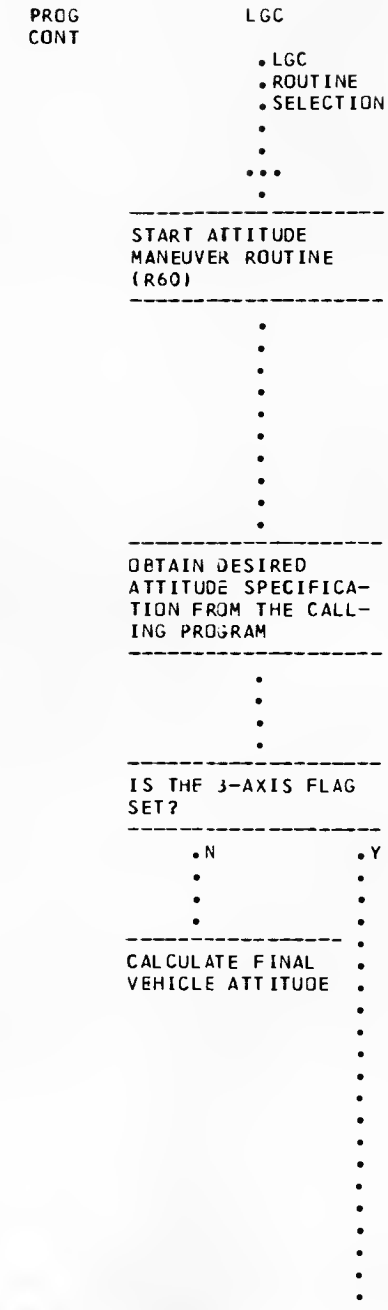
(8) THE X-AXIS OVERRIDE OPTION IS NOT INHIBITED DURING THIS ROUTINE, BUT IT SHOULD NOT BE EXERCISED WHEN THE LGC IS SPECIFYING A DESIRED YAW ATTITUDE, I.E.: DURING AN AUTOMATIC LGC-CONTROLLED MANEUVER.

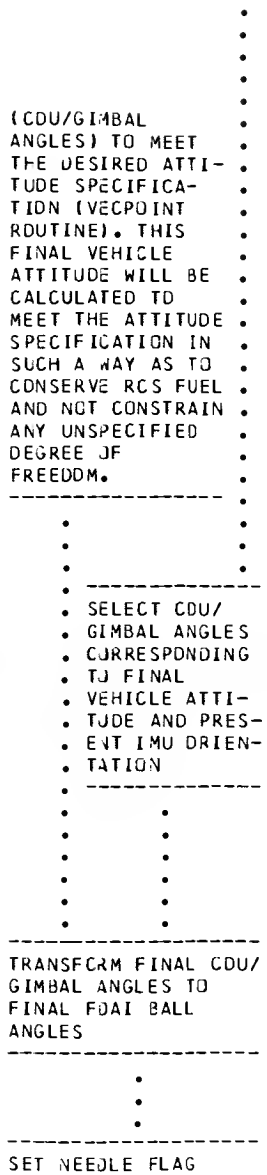
(9) THE ROUTINE IS AUTOMATICALLY SELECTED BY THE PROGRAM OR ROUTINE REQUIRING THE ATTITUDE MANEUVER.

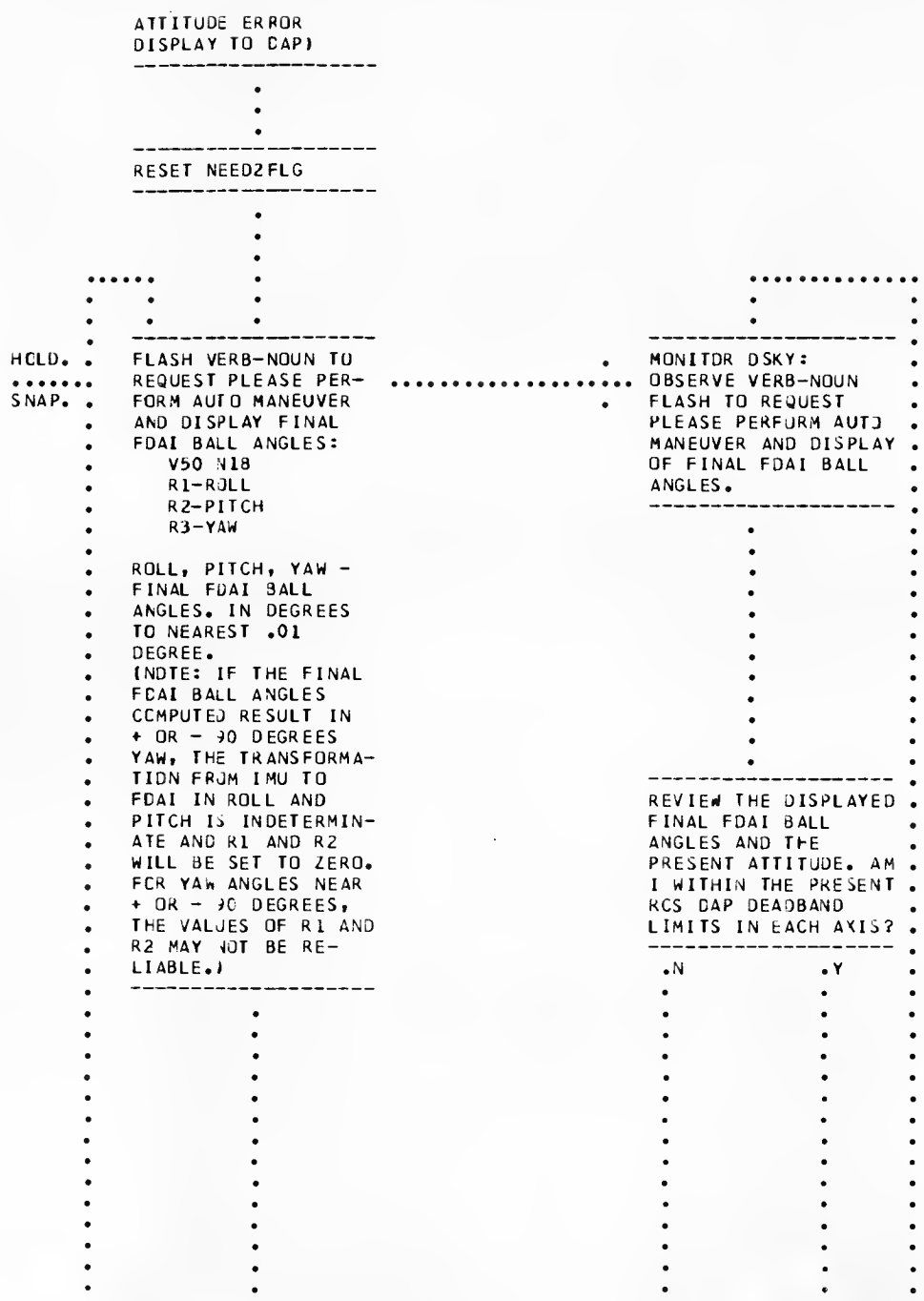
(10) IF THIS ROUTINE WAS SELECTED BY THE PREFERRED TRACKING ATTITUDE ROUTINE (R61) OR THE FINE PREFERRED TRACKING ATTITUDE ROUTINE (R65), THE V50N18 IN THIS ROUTINE IS A PRIORITY DISPLAY. THE V50N18 DISPLAY WILL REMAIN UP A MINIMUM OF 2 SECONDS. RESPONSE AFTER 2 SECONDS WILL CAUSE THE PROGRAM TO CONTINUE AS DESCRIBED. EXTENDED VERBS ARE ALLOWED DURING THE MANEUVER.

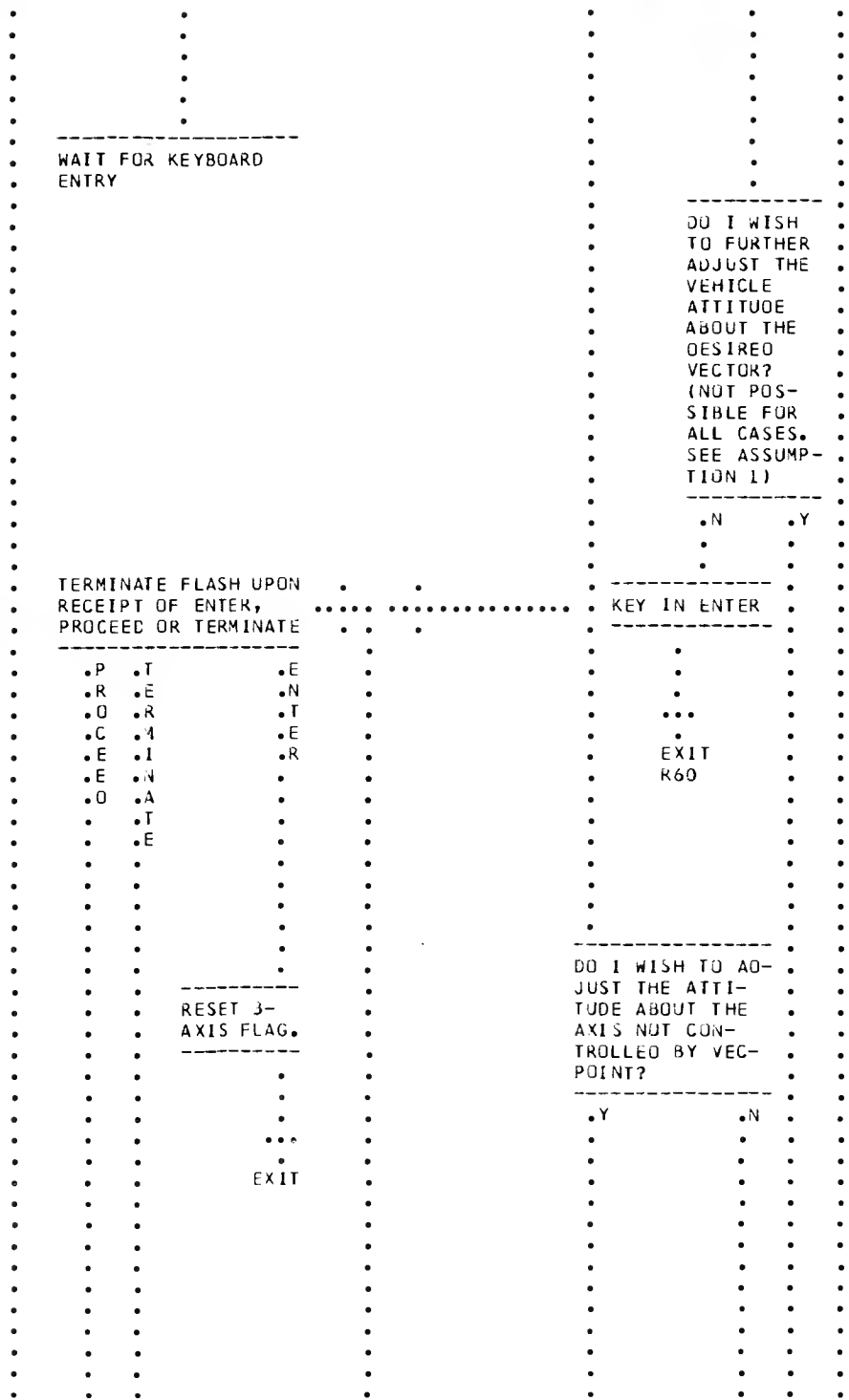
(11) WHEN THIS ROUTINE IS SELECTED BY A PROGRAM OTHER THAN P20 OR P25, ALL DISPLAYS ARE NORMAL. THE DSKY REGISTERS 1,2 AND 3 AND VERB-NOUN WILL BE BLANK DURING THE MANEUVERS.

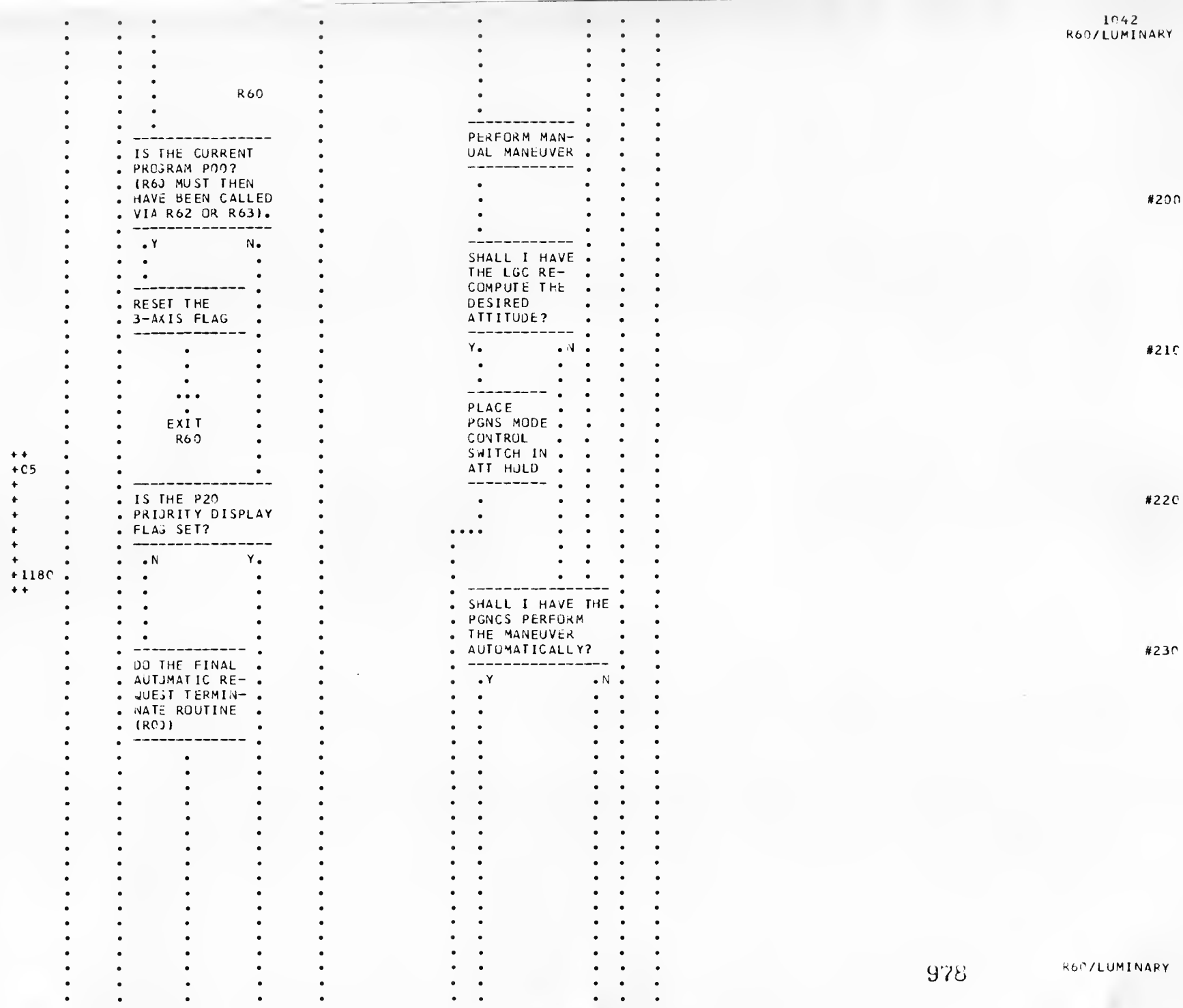
(12) WHEN THIS ROUTINE IS SELECTED, THE ATTITUDE ERROR NEEDLE DRIVE IS AUTOMATICALLY SET TO MODE 2 ATTITUDE ERRORS, AND IS NOT SUBSEQUENTLY RESET BY THIS ROUTINE.

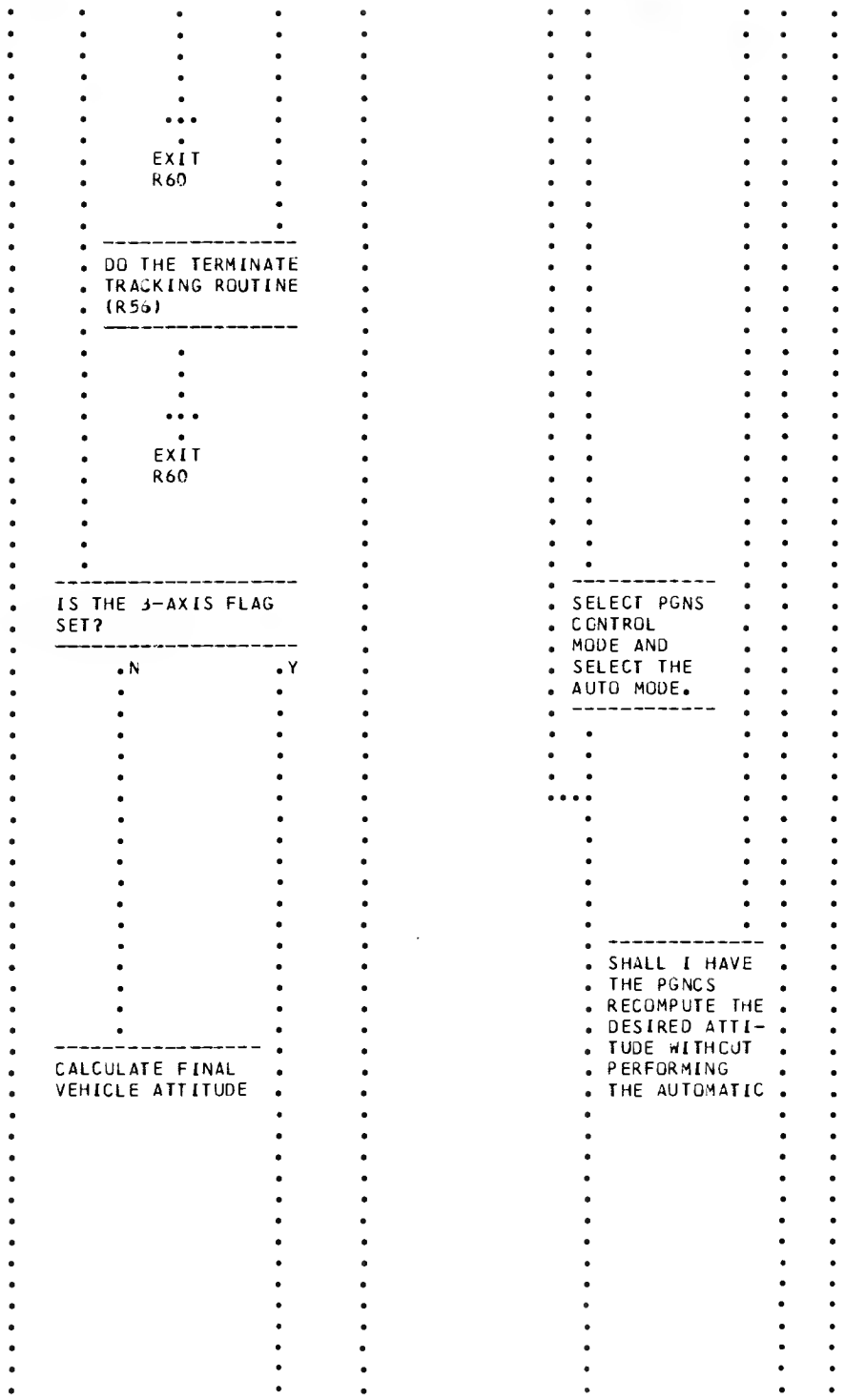

PROG CONT
LGC
GROUND
CREW
• LGC
• ROUTINE
• SELECTION
START ATTITUDE MANEUVER ROUTINE (R60)
#10
#20
OBTAIN DESIRED ATTITUDE SPECIFICATION FROM THE CALLING PROGRAM
#30
IS THE 3-AXIS FLAG SET?
N
Y
#40
CALCULATE FINAL VEHICLE ATTITUDE


(CDU/GIMBAL ANGLES) TO MEET THE DESIRED ATTITUDE SPECIFICATION (VECPOINT ROUTINE). THIS FINAL VEHICLE ATTITUDE WILL BE CALCULATED TO MEET THE ATTITUDE SPECIFICATION IN SUCH A WAY AS TO CONSERVE RCS FUEL AND NOT CONSTRAIN ANY UNSPECIFIED DEGREE OF FREEDOM.
#50
#60
SELECT CDU/ GIMBAL ANGLES CORRESPONDING TO FINAL VEHICLE ATTITUDE AND PRESENT IMU ORIENTATION
#70
#80
TRANSFORM FINAL CDU/ GIMBAL ANGLES TO FINAL FDAI BALL ANGLES
#90
SET NEEDLE FLAG (SPECIFY MODE 2


ATTITUDE ERROR
DISPLAY TO DAP)
RESET NEED2FLG
HOLD.
SNAP.
FLASH VERB-NOUN TO
REQUEST PLEASE PER-
FORM AUTO MANEUVER
AND DISPLAY FINAL
FDAI BALL ANGLES:
V50 N18
R1-ROLL
R2-PITCH
R3-YAW
ROLL, PITCH, YAW -
FINAL FDAI BALL
ANGLES. IN DEGREES
TO NEAREST .01
DEGREE.
(NOTE: IF THE FINAL
FDAI BALL ANGLES
COMPUTED RESULT IN
+ OR - 90 DEGREES
YAW, THE TRANSFORMA-
TION FROM IMU TO
FDAI IN ROLL AND
PITCH IS INDETERMIN-
ATE AND R1 AND R2
WILL BE SET TO ZERO.
FOR YAW ANGLES NEAR
+ OR - 90 DEGREES,
THE VALUES OF R1 AND
R2 MAY NOT BE RE-
LIABLE.)
MONITOR DSKY:
OBSERVE VERB-NOUN
FLASH TO REQUEST
PLEASE PERFORM AUTO
MANEUVER AND DISPLAY
OF FINAL FDAI BALL
ANGLES.
REVIEW THE DISPLAYED
FINAL FDAI BALL
ANGLES AND THE
PRESENT ATTITUDE. AM
I WITHIN THE PRESENT
RCS DAP DEADBAND
LIMITS IN EACH AXIS?
.N
.Y
#100
#110
#120
#130
#140


WAIT FOR KEYBOARD ENTRY
DO I WISH TO FURTHER ADJUST THE VEHICLE ATTITUOE ABOUT THE OESIREO VECTOR? (NOT POS-SIBLE FOR ALL CASES. SEE ASSUMP-TION 1)
#150
#160
.N
.Y
KEY IN ENTER
TERMINATE FLASH UPON RECEIPT OF ENTER, PROCEED OR TERMINATE
.PROCEED
.TERMINATE
.ENTER
EXIT R60
#170
#180
RESET 3-AXIS FLAG.
DO I WISH TO AO-JUST THE ATTI-TUDE ABOUT THE AXIS NOT CON-TROLLED BY VEC-POINT?
.Y
.N
#190
EXIT


R60
IS THE CURRENT PROGRAM P00? (R60 MUST THEN HAVE BEEN CALLED VIA R62 OR R63).
Y
N
RESET THE 3-AXIS FLAG
EXIT R60
IS THE P20 PRIORITY DISPLAY FLAG SET?
N
Y
DO THE FINAL AUTOMATIC RE-QUEST TERMIN-NATE ROUTINE (R00)
PERFORM MAN-UAL MANEUVER
SHALL I HAVE THE LGC RE-COMPUTE THE DESIRED ATTITUDE?
Y
N
PLACE PGNS MODE CONTROL SWITCH IN ATT HOLD
SHALL I HAVE THE PGNCS PERFORM THE MANEUVER AUTOMATICALLY?
Y
N
+05
+1180
#200
#210
#220
#230



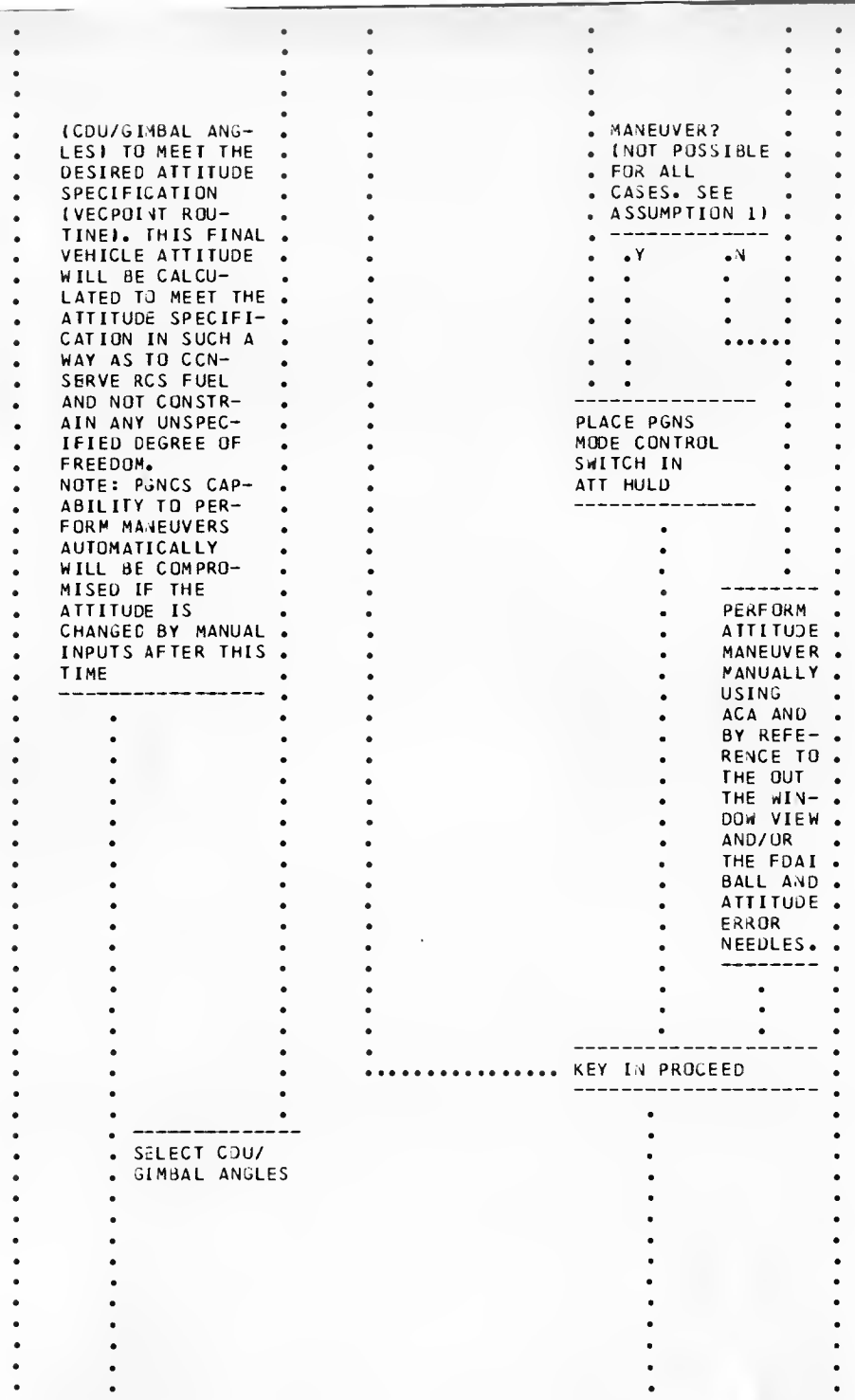
#240

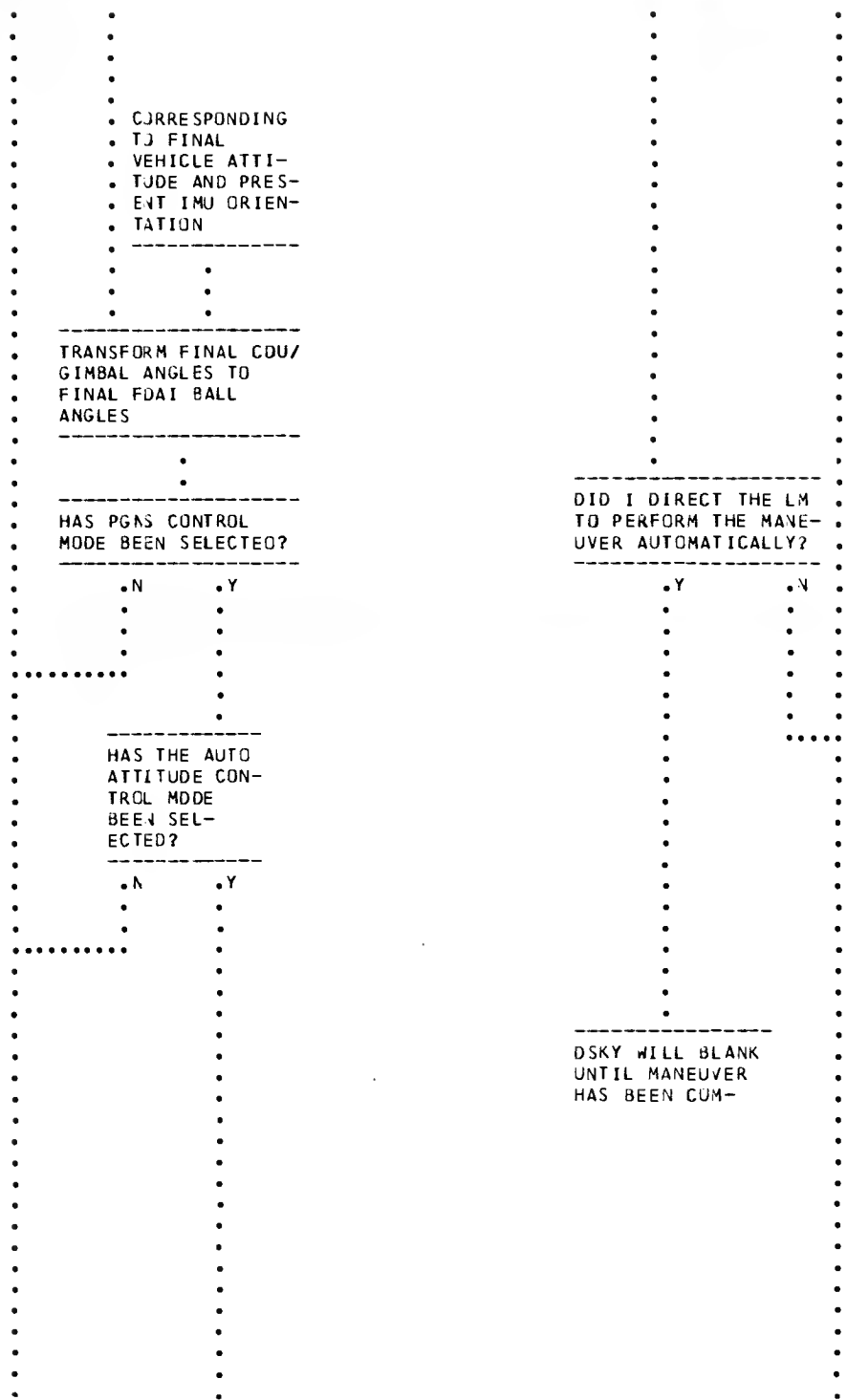
#250

#260

#270

#280


(CDU/GIMBAL ANGLES) TO MEET THE DESIRED ATTITUDE SPECIFICATION (VECPOINT ROUTINE). THIS FINAL VEHICLE ATTITUDE WILL BE CALCULATED TO MEET THE ATTITUDE SPECIFICATION IN SUCH A WAY AS TO CONSERVE RCS FUEL AND NOT CONSTRAIN ANY UNSPECIFIED DEGREE OF FREEDOM.
NOTE: PGNCS CAPABILITY TO PERFORM MANEUVERS AUTOMATICALLY WILL BE COMPROMISED IF THE ATTITUDE IS CHANGED BY MANUAL INPUTS AFTER THIS TIME
SELECT CDU/ GIMBAL ANGLES
MANEUVER? (NOT POSSIBLE FOR ALL CASES. SEE ASSUMPTION 1)
.Y
.N
PLACE PGNS MODE CONTROL SWITCH IN ATT HOLD
PERFORM ATTITUDE MANEUVER MANUALLY USING ACA AND BY REFERENCE TO THE OUT THE WINDOW VIEW AND/OR THE FDAI BALL AND ATTITUDE ERROR NEEDLES.
KEY IN PROCEED
#290
#300
#310
#320
#330



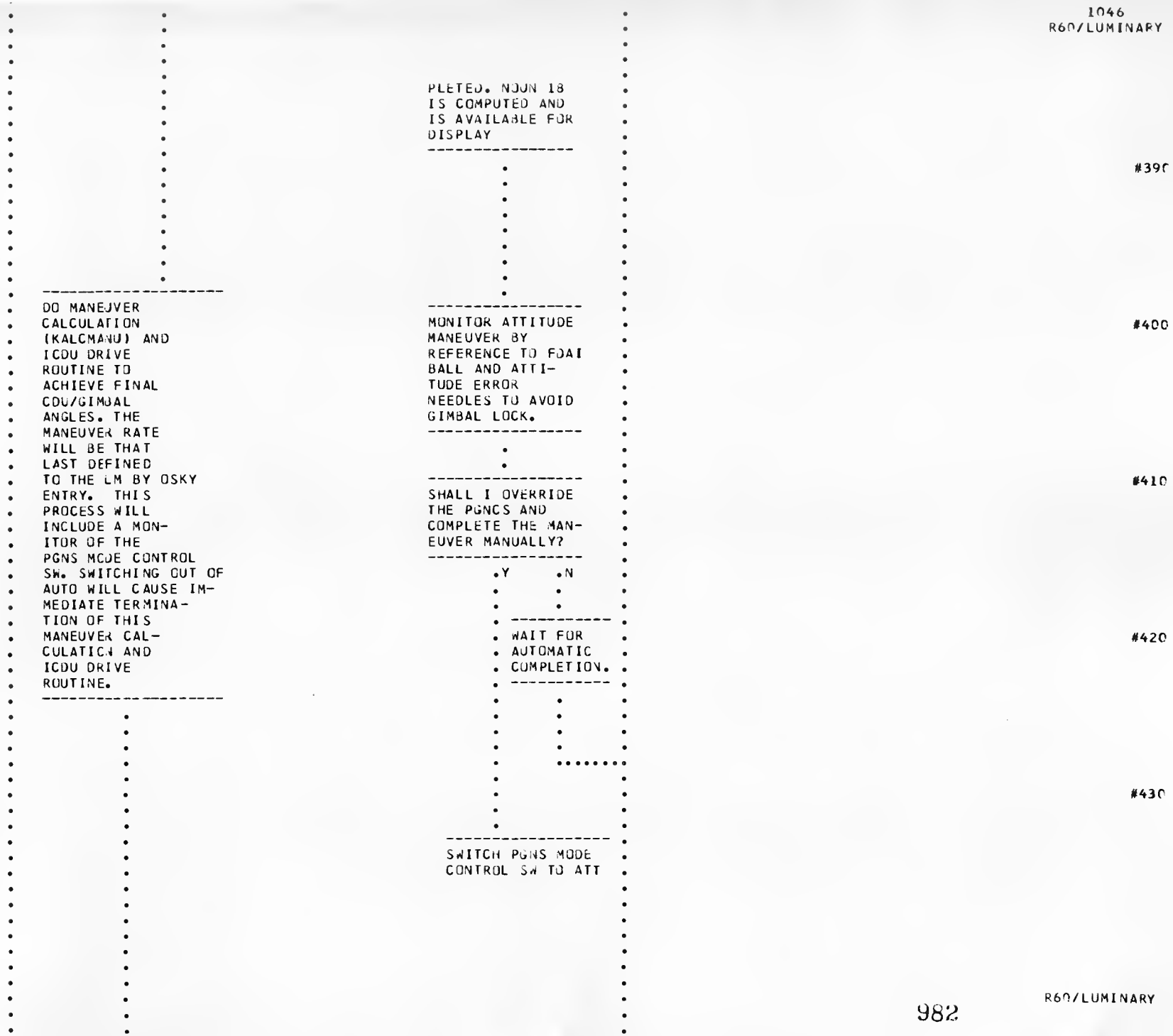
#340

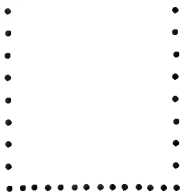
#350

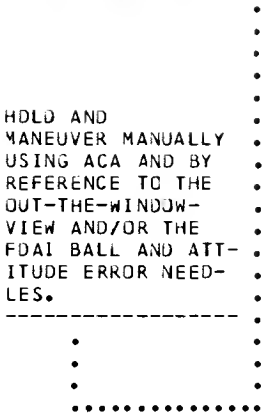
#360

#370

#380


PLETED. NOUN 18 IS COMPUTED AND IS AVAILABLE FOR DISPLAY
#390
MONITOR ATTITUDE MANEUVER BY REFERENCE TO FDAI BALL AND ATTI-TUDE ERROR NEEDLES TO AVOID GIMBAL LOCK.
#400
SHALL I OVERRIDE THE PGNCS AND COMPLETE THE MAN-EUVER MANUALLY?
#410
Y
N
WAIT FOR AUTOMATIC COMPLETION.
#420
DO MANEUVER CALCULATION (KALCMANU) AND ICDU DRIVE ROUTINE TO ACHIEVE FINAL CDU/GIMBAL ANGLES. THE MANEUVER RATE WILL BE THAT LAST DEFINED TO THE LM BY OSKY ENTRY. THIS PROCESS WILL INCLUDE A MON-ITOR OF THE PGNS MODE CONTROL SW. SWITCHING OUT OF AUTO WILL CAUSE IM-MEDIATE TERMINA-TION OF THIS MANEUVER CAL-CULATION AND ICDU DRIVE ROUTINE.
#430
SWITCH PGNS MODE CONTROL SW TO ATT





#440

#450

CHANGE CONTROL NOTES

REV 01 PCR 9,86,164,226,234,433,446,637
REV 02 (LUM 1B) PCR 841, EDITORIAL
REV 03 EDITORIAL
REV 04(LUM 1E) PCR 336, PCN 1145
REV 05 PCN 1180

PREFERRED TRACKING ATTITUDE ROUTINE (R61) REV 05 12/01/71

PURPOSE: (1) TO PERFORM A SINGLE AUTOMATIC TRIM MANEUVER TO THE PREFERRED TRACKING ATTITUDE IF MANEUVER REQUIRED IS LESS THAN A SPECIFIED FUNCTION OR, IF NOT, TO NOTIFY THE CREW THAT AN ATTITUDE MANEUVER TO THE PREFERRED TRACKING ATTITUDE IS REQUIRED VIA R60.

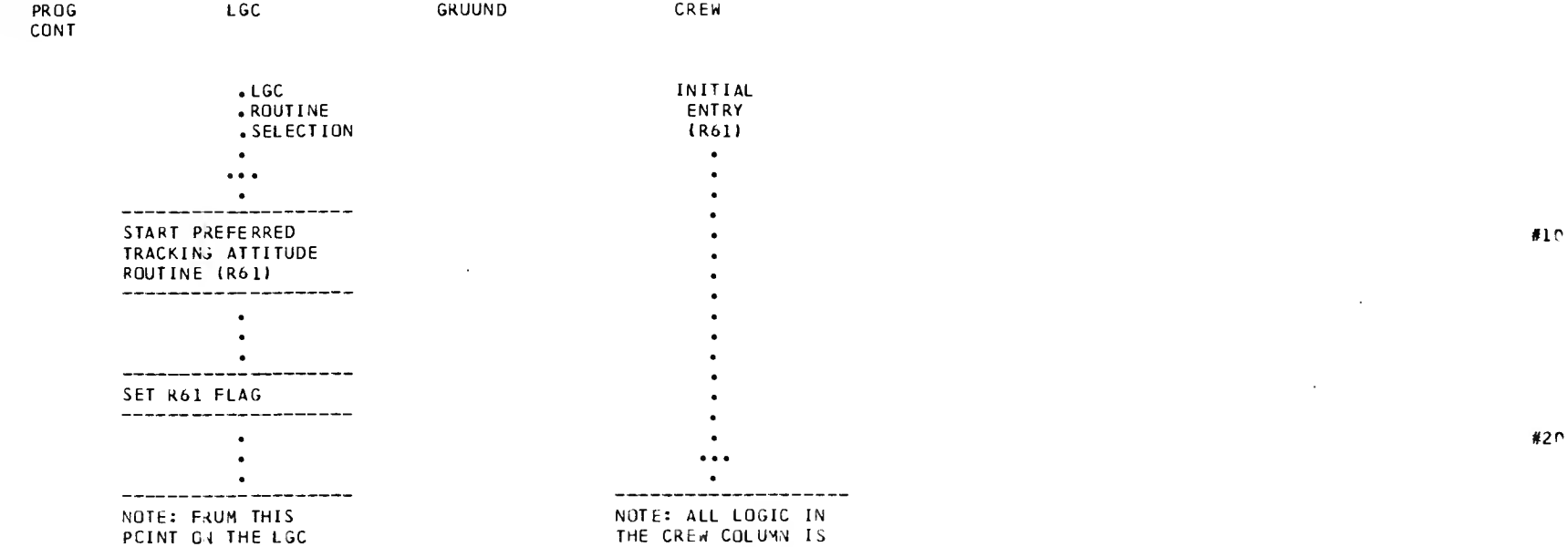
(2) TO COMPUTE THE PREFERRED TRACKING ATTITUDE OF THE LM WHICH ENABLES RR TRACKING OF THE CSM, AND CSM TRACKING OF THE LM BEACON.

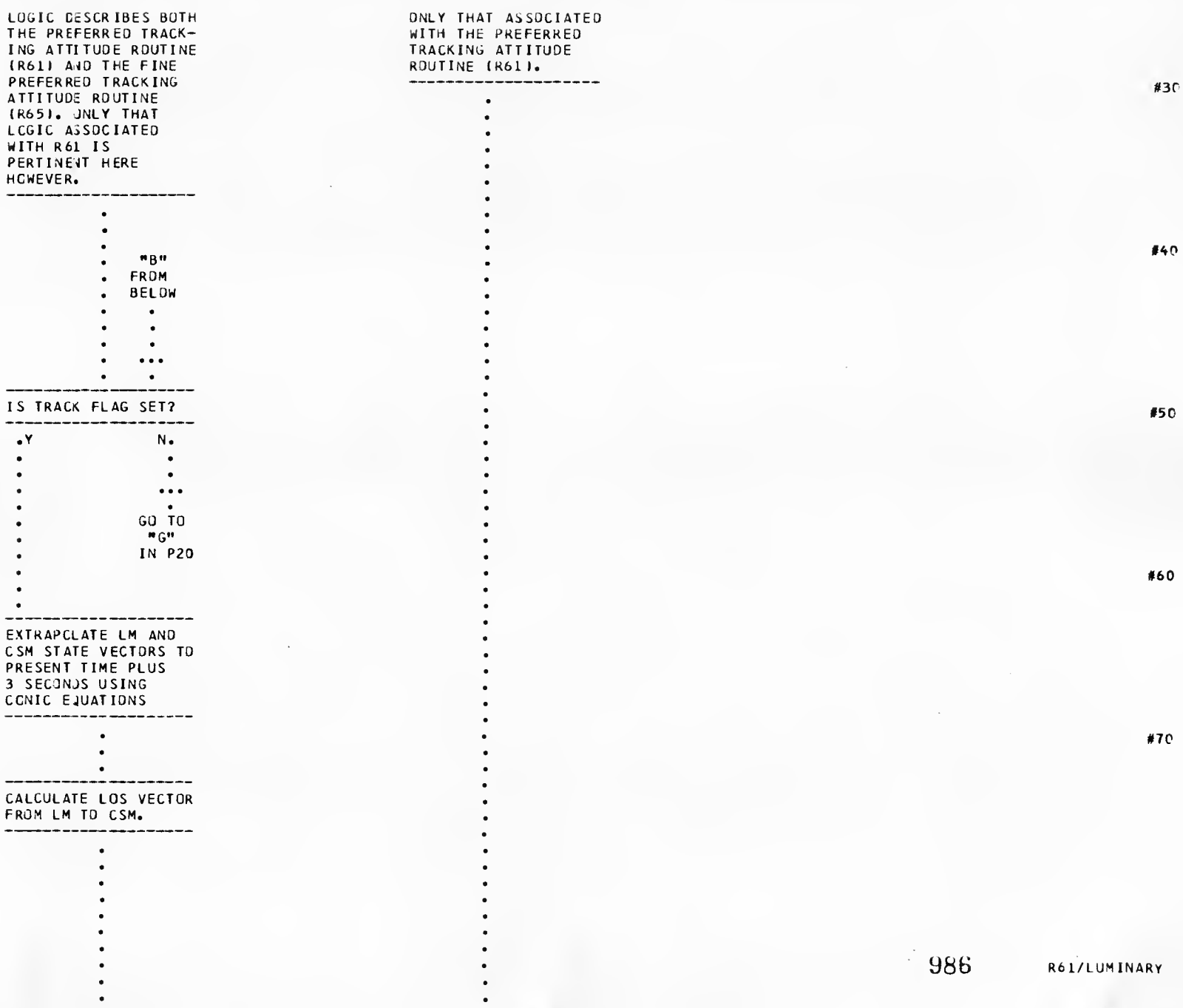
ASSUMPTIONS: (1) THE PREFERRED TRACKING ATTITUDE IS DEFINED AS FOLLOWS:

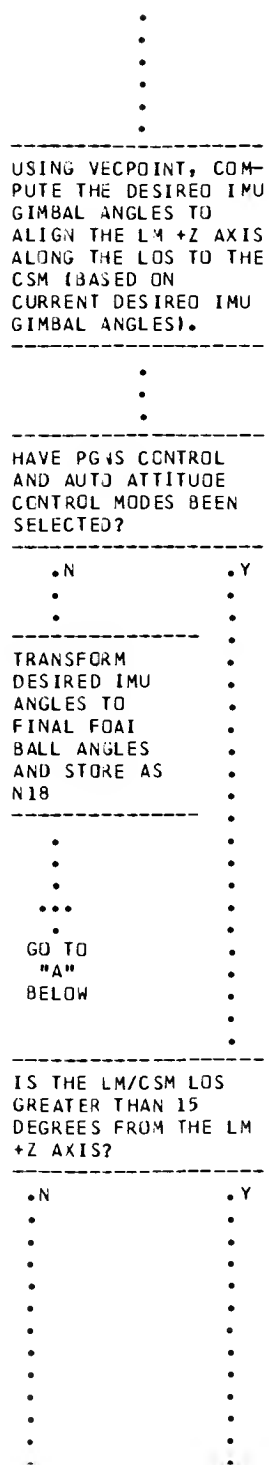
(A) THE LM +Z AXIS IS ALIGNED ALONG THE LOS TO THE CSM.

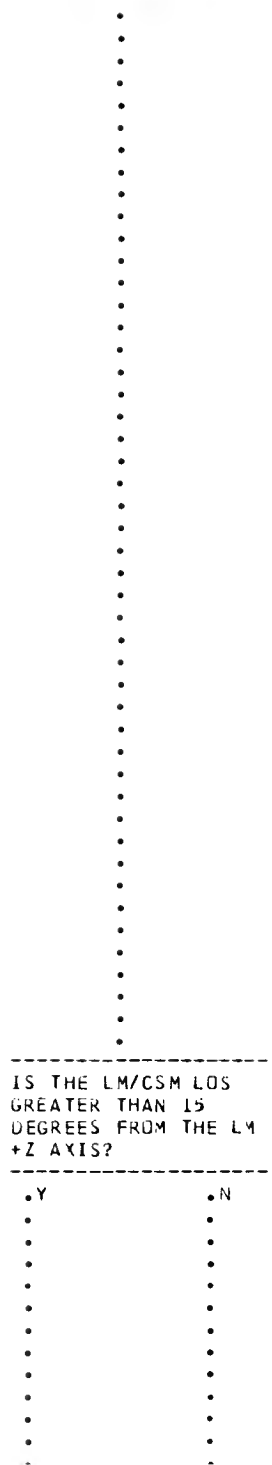
(B) THE ROLL ATTITUDE (ABOUT LM +Z AXIS) IS UNDEFINED, BUT MAINTAINED AT THE ORIENTATION RESULTING FROM THE R60 MANEUVER, OR FROM MANUAL CREW ADJUSTMENT.

(2) THE ROUTINE IS AUTOMATICALLY CALLED BY THE RENDEZVOUS NAVIGATION PROGRAM (P20), THE RR DATA READ ROUTINE (R22), THE RR MANUAL ACQUISITION ROUTINE (R23), AND THE RR SEARCH ROUTINE (R24).




LOGIC DESCRIBES BOTH THE PREFERRED TRACK-ING ATTITUDE ROUTINE (R61) AND THE FINE PREFERRED TRACKING ATTITUDE ROUTINE (R65). ONLY THAT LOGIC ASSOCIATED WITH R61 IS PERTINENT HERE HOWEVER.
"B" FROM BELOW
IS TRACK FLAG SET?
Y
N.
GO TO "G" IN P20
EXTRAPOLATE LM AND CSM STATE VECTORS TO PRESENT TIME PLUS 3 SECONDS USING CONIC EQUATIONS
CALCULATE LOS VECTOR FROM LM TO CSM.
ONLY THAT ASSOCIATED WITH THE PREFERRED TRACKING ATTITUDE ROUTINE (R61).
#30
#40
#50
#60
#70





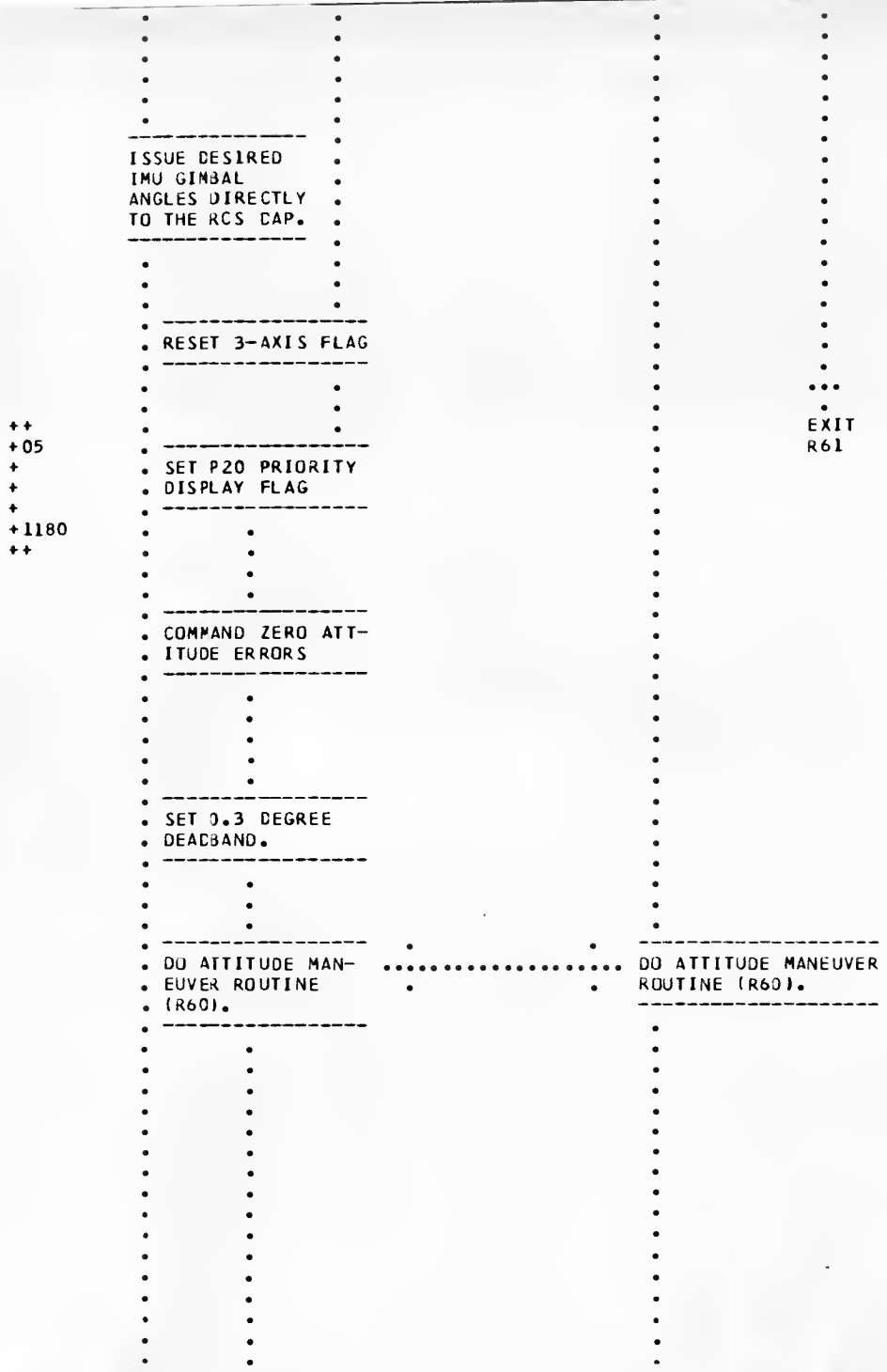
#80

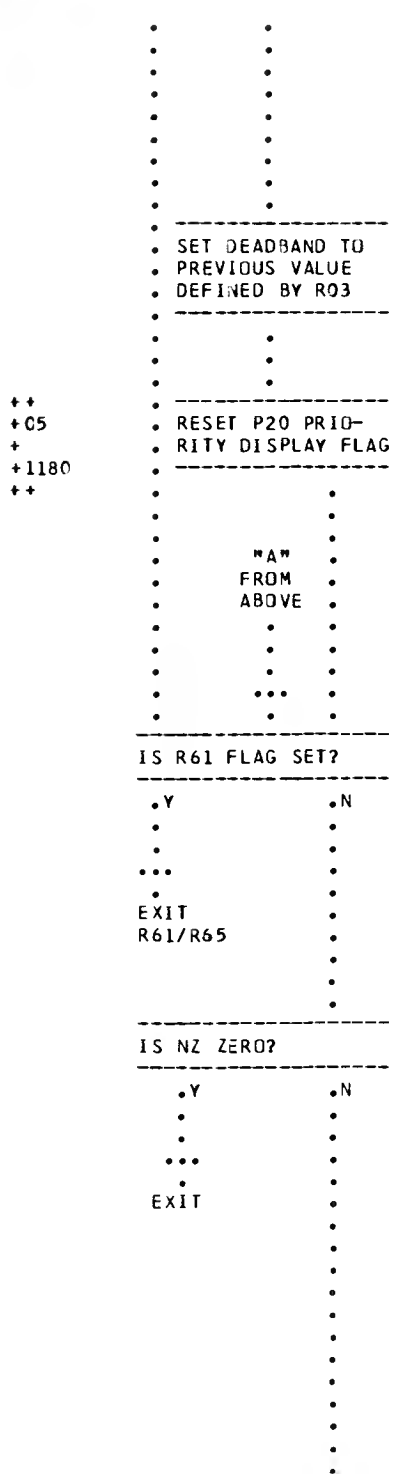
#90

#100

#110

#120


#130
ISSUE DESIRED IMU GIMBAL ANGLES DIRECTLY TO THE RCS CAP.
#140
RESET 3-AXIS FLAG
EXIT R61
++
+05
+
+
+
+1180
++
SET P20 PRIORITY DISPLAY FLAG
#150
COMMAND ZERO ATTITUDE ERRORS
#160
SET 0.3 DEGREE DEADBAND.
#170
DO ATTITUDE MANEUVER ROUTINE (R60).
DO ATTITUDE MANEUVER ROUTINE (R60).



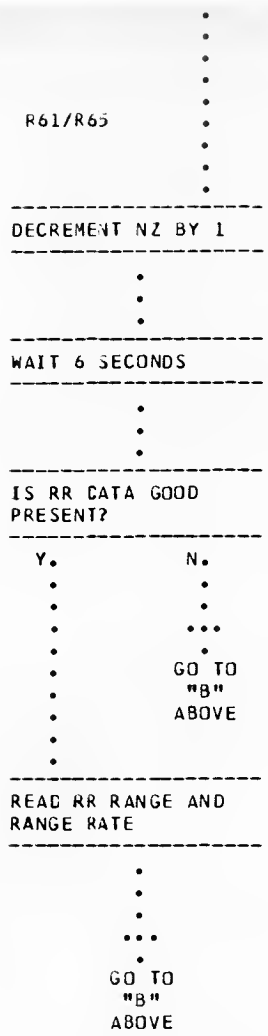
#180

#190

#200

#210

#220



#230

#240

#250

#260

CHANGE CONTROL NOTES

REV 01 PCR 39,634
REV 02 (LUM 1A) PCR 642,716, EDITORIAL
REV 03 EDITORIAL
REV 04(LUM 1E) PCN 1145
REV 05 PCN 1180

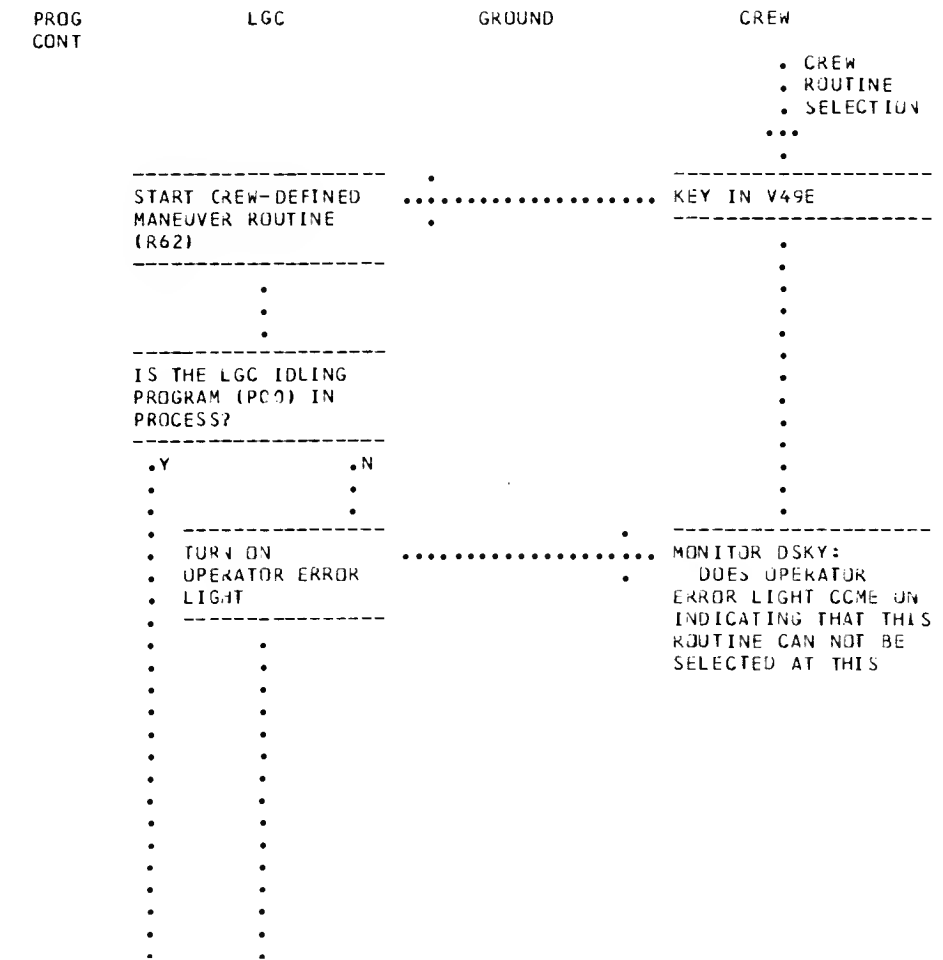
CREW-DEFINED MANEUVER ROUTINE (R62) REV 03 12/03/69

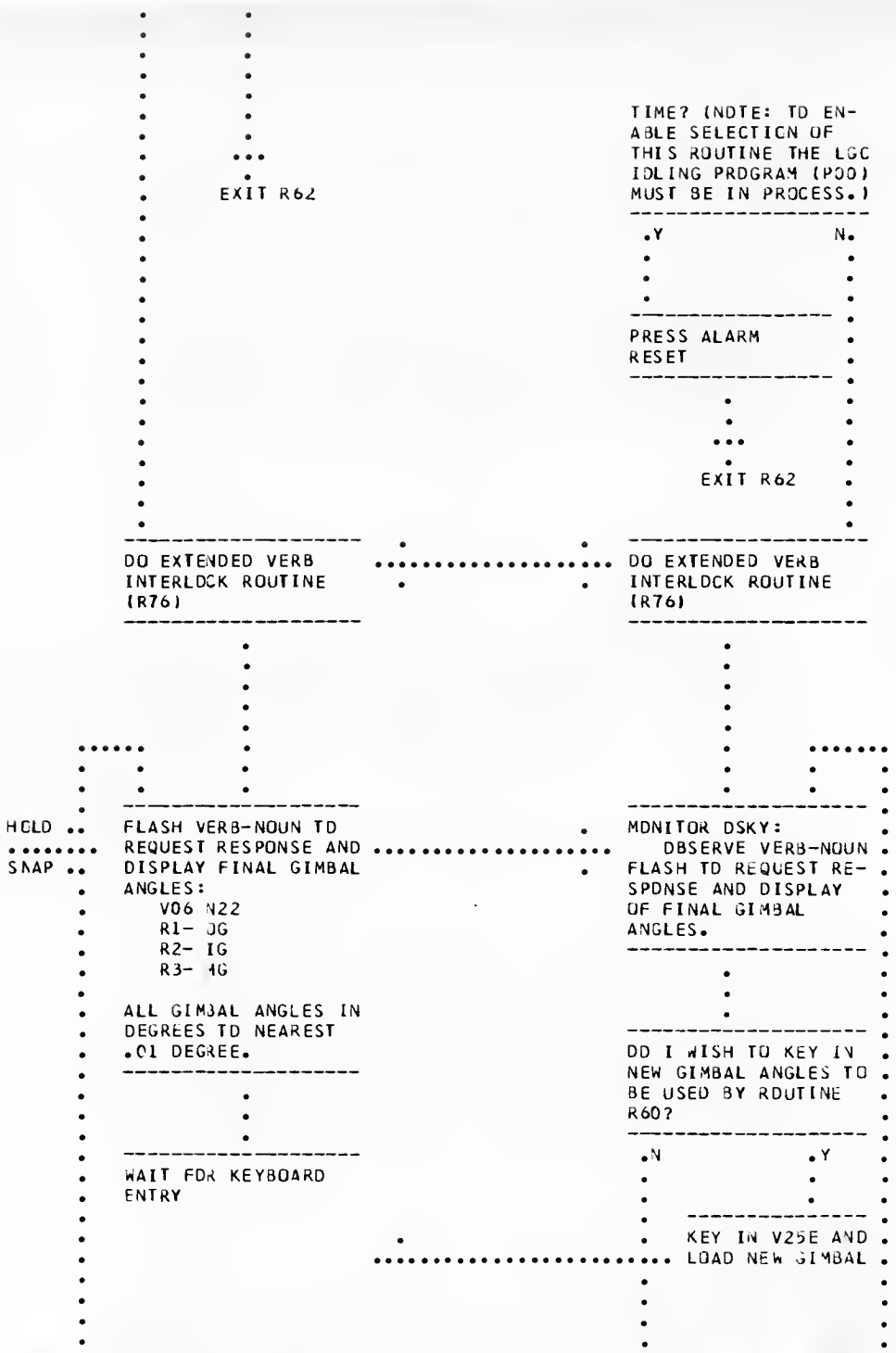
PURPOSE: (1) TO PROVIDE THE CREW WITH THE ABILITY TO SPECIFY A FINAL VEHICLE ATTITUDE FOR USE BY AN LGC-CONTROLLED ATTITUDE MANEUVER.

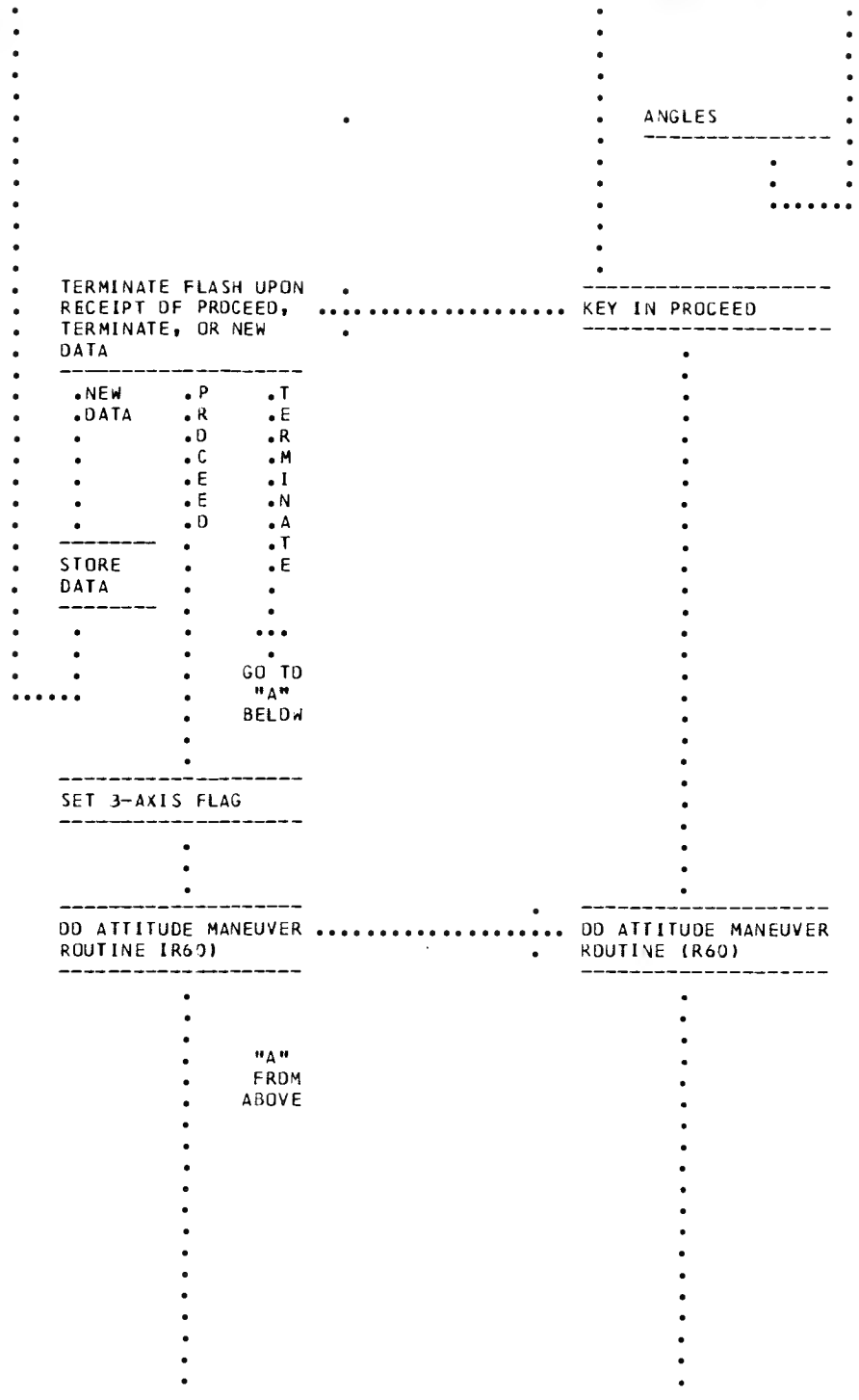
ASSUMPTIONS: (1) THE ROUTINE IS MANUALLY SELECTED BY THE ASTRONAUT BY DSKY ENTRY.

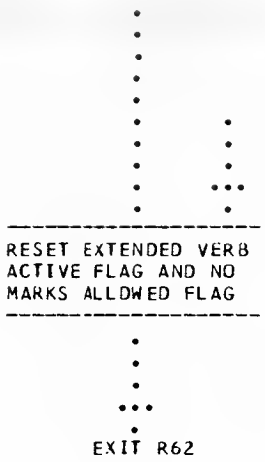
(2) THE DAP DEADBAND DURING THIS ROUTINE IS AS DEFINED BY THE DAP DATA LOAD ROUTINE (R03).

(3) THIS ROUTINE CAN ONLY BE ENTERED FROM THE LGC IDLING PROGRAM (P00).




EXIT R62
TIME? (NOTE: TO ENABLE SELECTION OF THIS ROUTINE THE LGC IDLING PROGRAM (P00) MUST BE IN PROCESS.)
.Y
N.
PRESS ALARM RESET
EXIT R62
DO EXTENDED VERB INTERLOCK ROUTINE (R76)
DO EXTENDED VERB INTERLOCK ROUTINE (R76)
#30
#40
#50
#60
#70
#80
HOLD
SNAP
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY FINAL GIMBAL ANGLES:
V06 N22
R1- OG
R2- IG
R3- MG
ALL GIMBAL ANGLES IN DEGREES TO NEAREST .01 DEGREE.
WAIT FOR KEYBOARD ENTRY
MONITOR DSKY:
OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY OF FINAL GIMBAL ANGLES.
DO I WISH TO KEY IN NEW GIMBAL ANGLES TO BE USED BY ROUTINE R60?
.N
.Y
KEY IN V25E AND LOAD NEW GIMBAL


ANGLES
#90
TERMINATE FLASH UPON RECEIPT OF PROCEED, TERMINATE, OR NEW DATA
KEY IN PROCEED
#100
NEW DATA
PROCEED
TERMINATE
STORE DATA
#110
GO TO "A" BELOW
SET 3-AXIS FLAG
#120
DO ATTITUDE MANEUVER ROUTINE (R60)
DO ATTITUDE MANEUVER ROUTINE (R60)
#130
"A" FROM ABOVE



#140

#150

CHANGE CONTROL NOTES

REV 01 EDITORIAL
REV 02 EDITORIAL
REV 03 EDITORIAL

RENDEZVOUS FINAL ATTITUDE ROUTINE (R63) REV 03 12/03/69

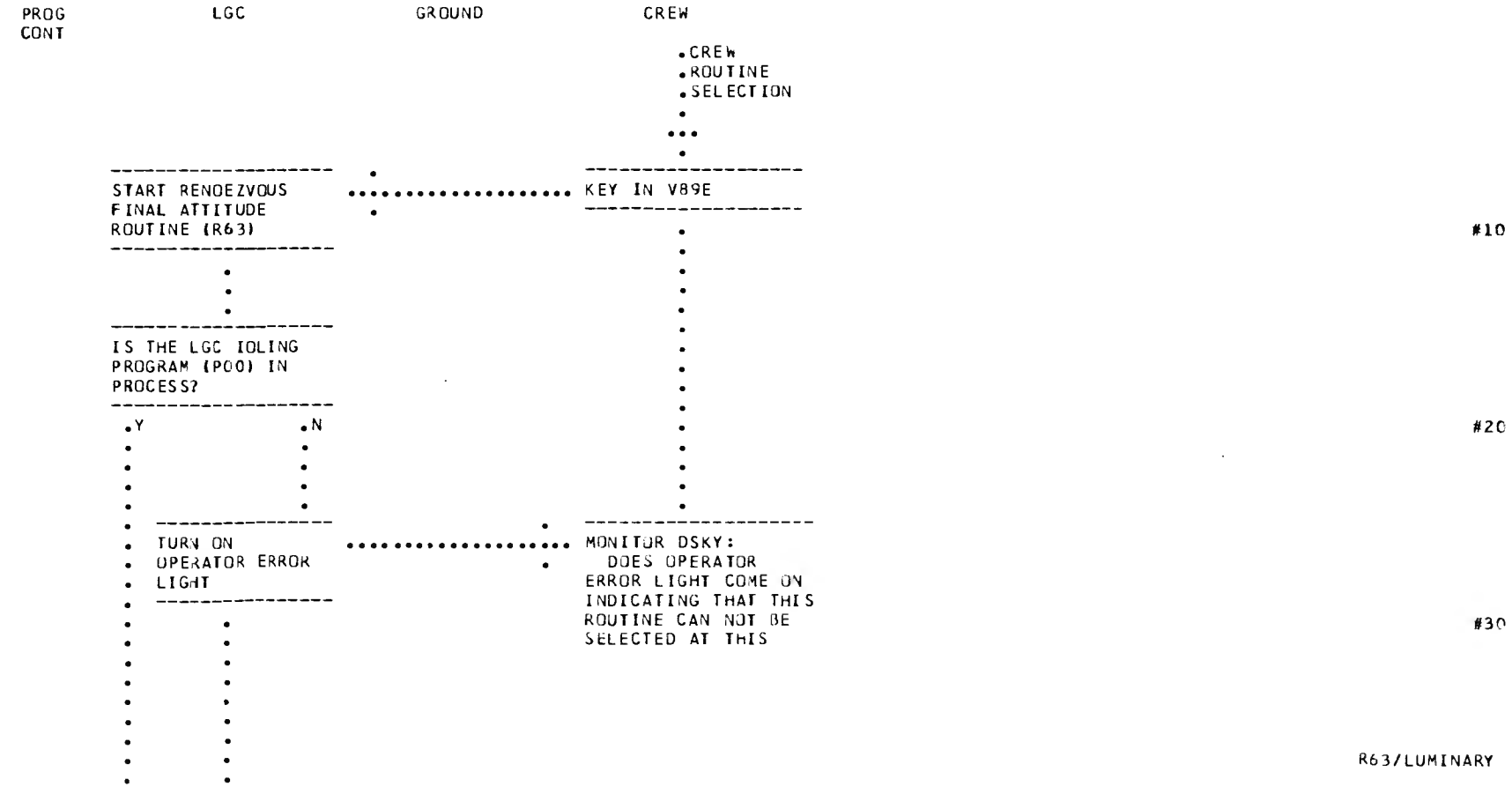
PURPOSE: (1) TO CALCULATE AND DISPLAY THE FINAL FDAI BALL ANGLES REQUIRED TO POINT THE LM +Z OR +X AXIS AT THE CSM.

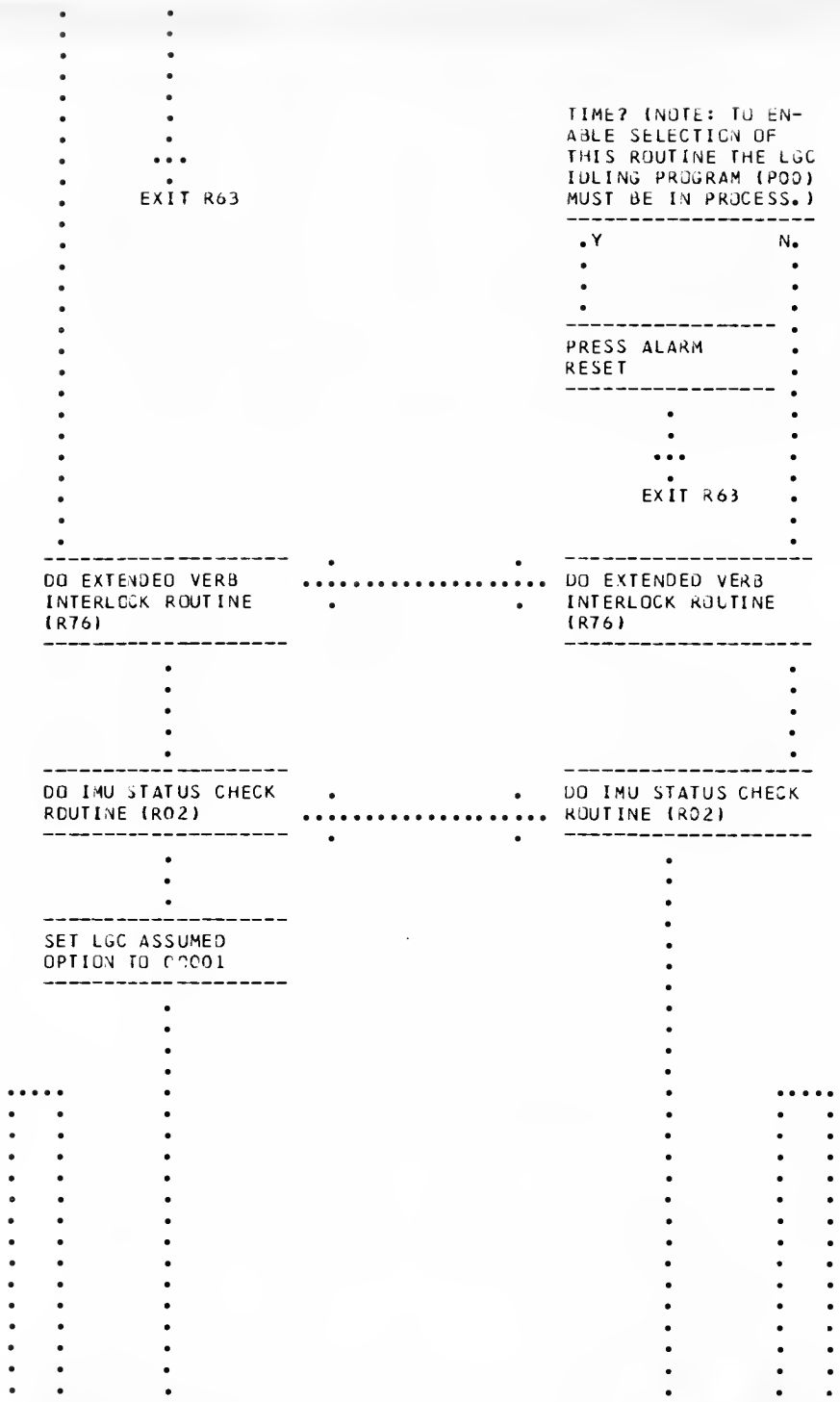
(2) TO CALL THE ATTITUDE MANEUVER ROUTINE (R60) FOR AUTOMATIC MANEUVER CAPABILITY.

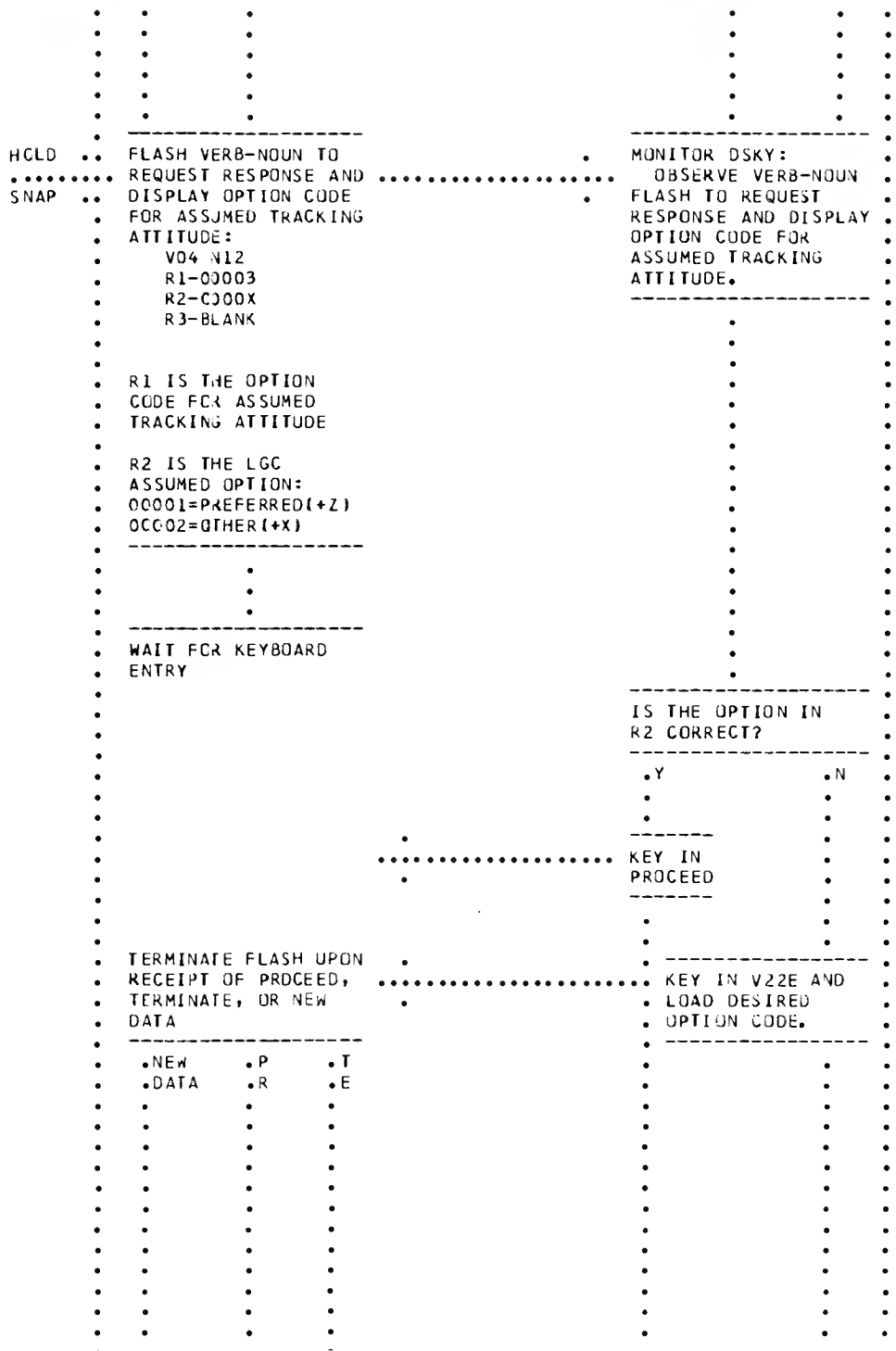
ASSUMPTIONS: (1) TO SAVE TIME THE LM ATTITUDE CONTROL MODE SHOULD BE PRESELECTED (FOR AUTOMATIC MANEUVERS, R03 SHOULD HAVE BEEN DONE AND THE AUTO MODE SELECTED).

(2) THIS ROUTINE CAN ONLY BE SELECTED DURING THE LGC IDLING PROGRAM (P00).

(3) THIS ROUTINE IS SELECTED BY THE ASTRONAUT BY DSKY ENTRY.




EXIT R63
TIME? (NOTE: TO ENABLE SELECTION OF THIS ROUTINE THE LGC IDLING PROGRAM (P00) MUST BE IN PROCESS.)
Y
N
PRESS ALARM RESET
EXIT R63
DO EXTENDED VERB INTERLOCK ROUTINE (R76)
DO EXTENDED VERB INTERLOCK ROUTINE (R76)
DO IMU STATUS CHECK ROUTINE (R02)
DO IMU STATUS CHECK ROUTINE (R02)
SET LGC ASSUMED OPTION TO 00001
#40
#50
#60
#70
#80

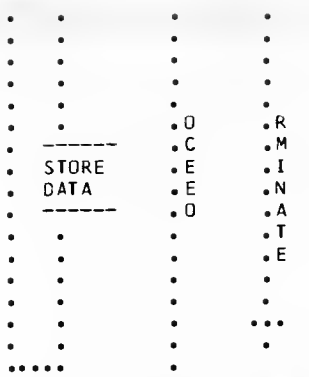


#90

#100

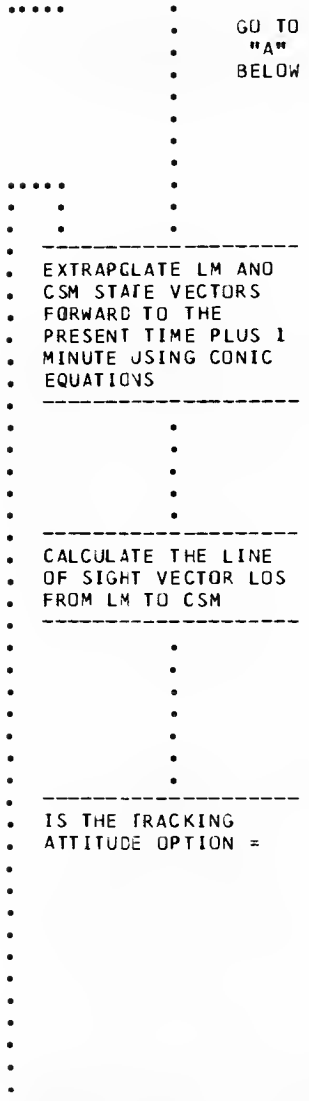
#110

#120



#130

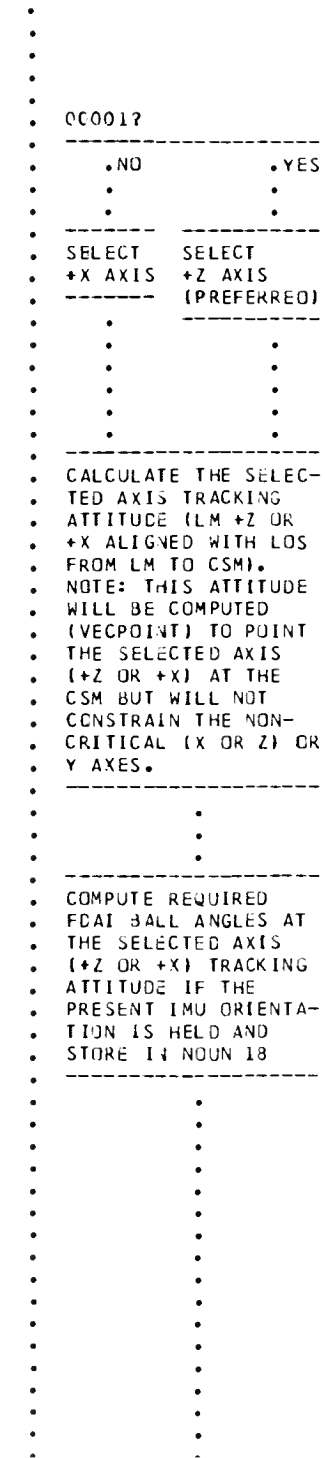
#140



#150

#160

#170



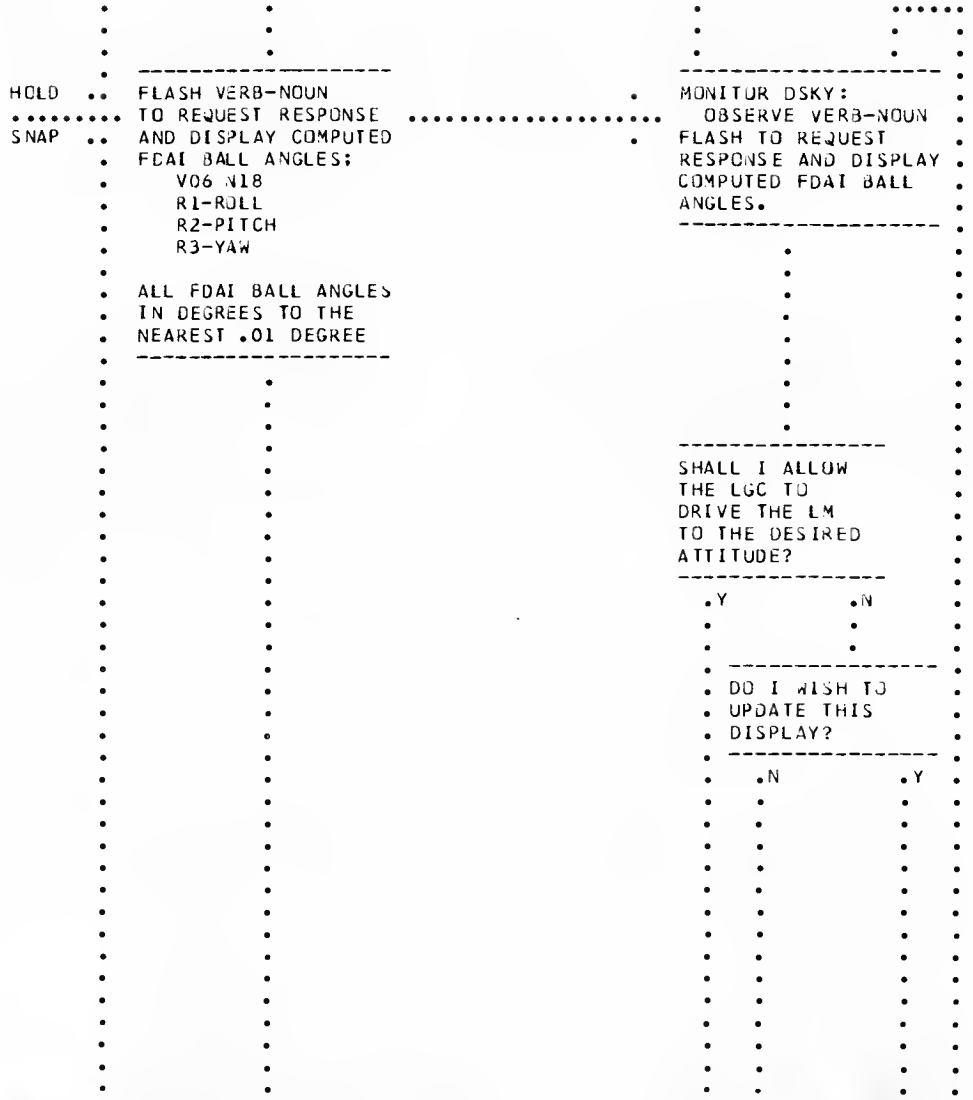
#18C

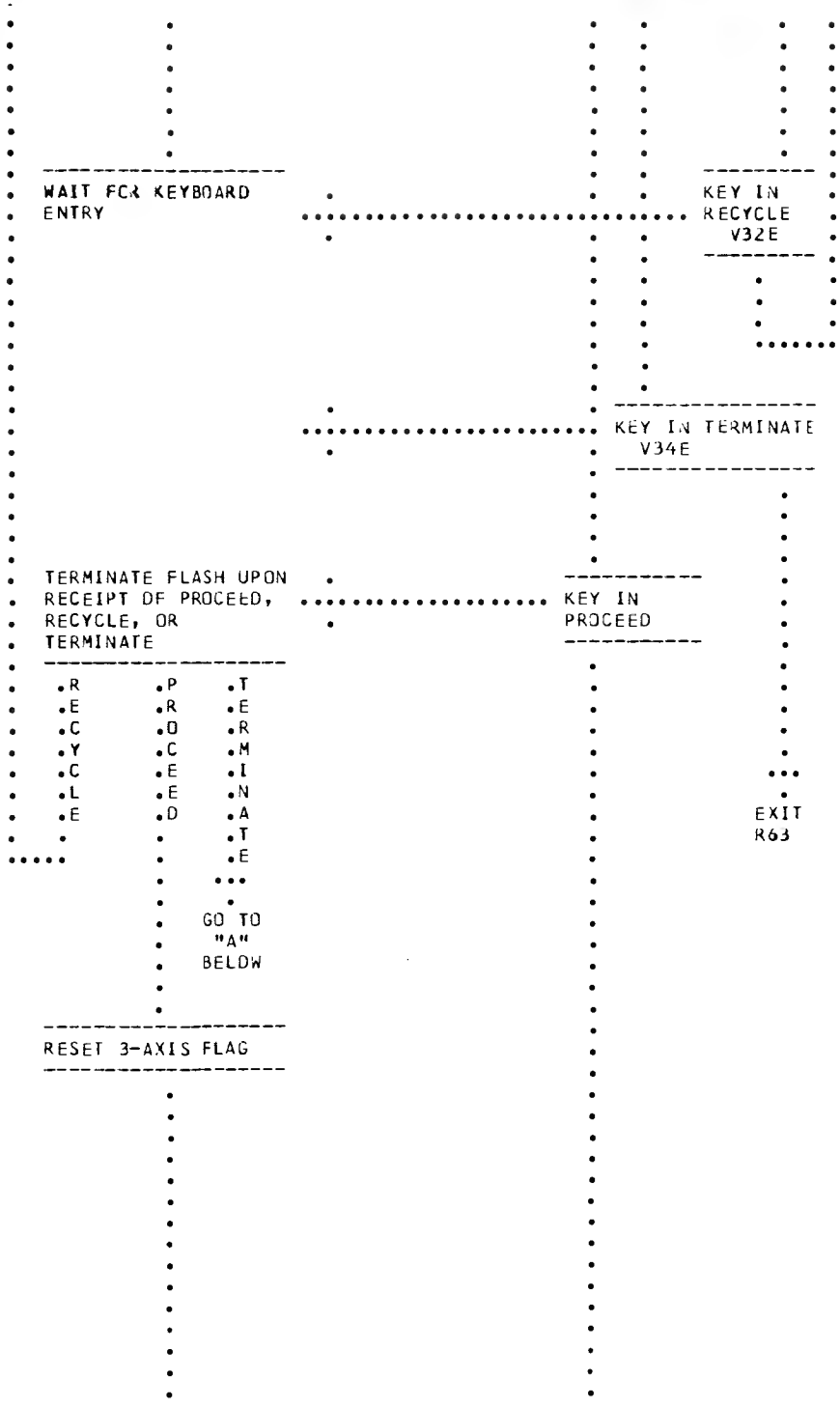
#19C

#20C

#21C

#22C


STORE ATTITUDE SPECIFICATION FOR SELECTED AXIS (+Z OR +X) TRACKING ATTITUDE FOR USE BY THE ATTITUDE MANEUVER ROUTINE (R60).
#230
HOLD
SNAP
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY COMPUTED FDAI BALL ANGLES:
V06 N18
R1-ROLL
R2-PITCH
R3-YAW
ALL FDAI BALL ANGLES IN DEGREES TO THE NEAREST .01 DEGREE
MONITOR DSKY:
OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY COMPUTED FDAI BALL ANGLES.
#240
#250
SHALL I ALLOW THE LGC TO DRIVE THE LM TO THE DESIRED ATTITUDE?
#260
.Y
.N
DO I WISH TO UPDATE THIS DISPLAY?
#270
.N
.Y



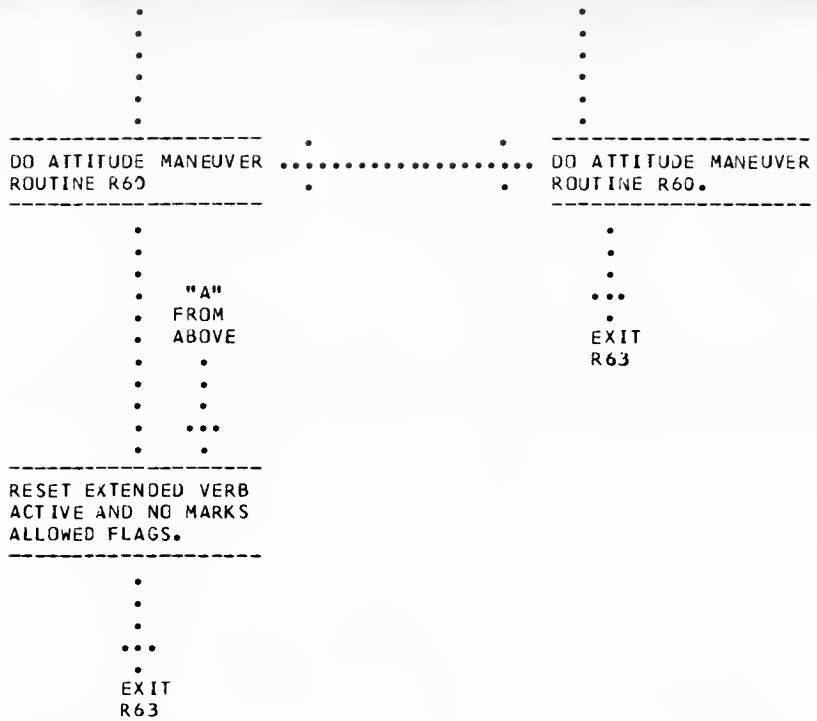
#280

#290

#300

#310

#320



#330

#340

#350

CHANGE CONTROL NOTES

REV 01 PCR 490,498,531
REV 02 EDITORIAL
REV 03 EDITORIAL

FINE PREFERRED TRACKING ATTITUDE ROUTINE (R65) REV 05 12/01/71

PURPOSE: (1) TO PERFORM A CONTINUOUS SERIES OF AUTOMATIC TRIM MANEUVERS TO THE PREFERRED TRACKING ATTITUDE IF EACH MANEUVER REQUIRED IS LESS THAN A SPECIFIED FUNCTION OR, IF NOT, TO NOTIFY THE CREW THAT AN ATTITUDE MANEUVER TO THE PREFERRED TRACKING ATTITUDE IS REQUIRED VIA R60.

(2) TO COMPUTE THE PREFERRED TRACKING ATTITUDE OF THE LM WHICH ENABLES RR TRACKING OF THE CSM AND CSM TRACKING OF THE LM BEACON.

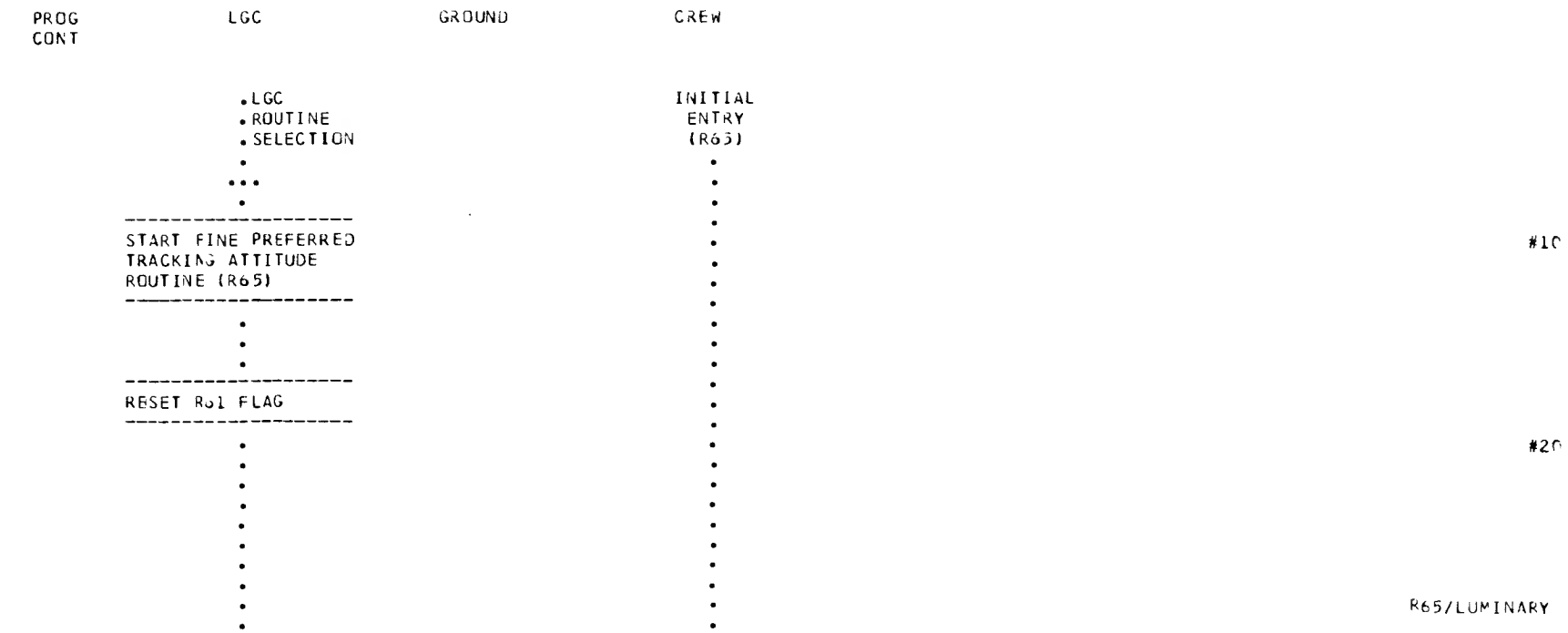
ASSUMPTIONS: (1) THE PREFERRED TRACKING ATTITUDE IS DEFINED AS FOLLOWS:

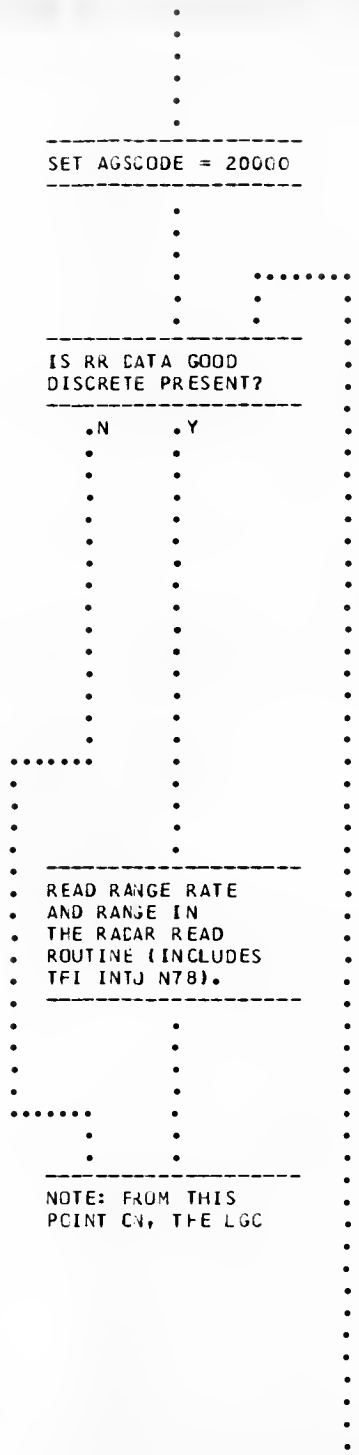
(A) THE LM +Z AXIS IS ALIGNED ALONG THE LOS TO THE CSM.

(B) THE ROLL ATTITUDE (ABOUT LM +Z AXIS) IS UNDEFINED, BUT MAINTAINED AT THE ORIENTATION RESULTING FROM THE R60 MANEUVER, OR FROM MANUAL CREW ADJUSTMENT.

(2) THIS ROUTINE WILL ITERATE NZ TIMES, WHERE NZ IS DEFINED BY THE CALLING PROGRAM/ROUTINE.

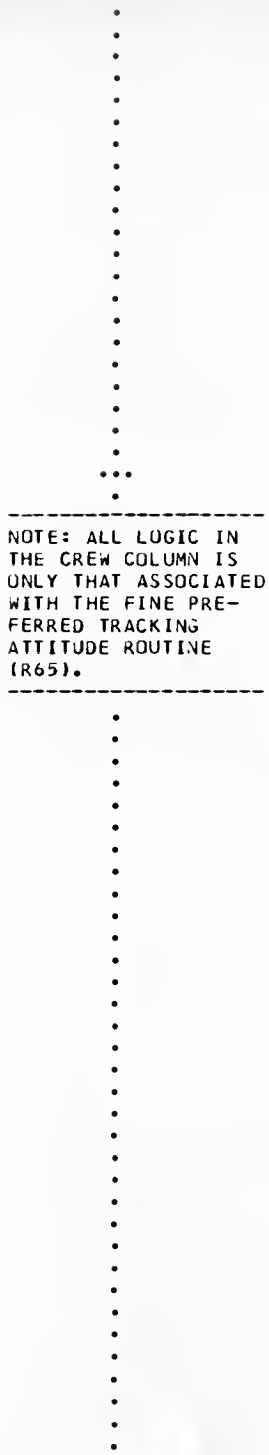
(3) THE ROUTINE IS AUTOMATICALLY CALLED BY THE PREFERRED TRACKING ATTITUDE PROGRAM (P25), AND THE RR DATA READ ROUTINE (R22).




SET AGSCODE = 20000
IS RR DATA GOOD
DISCRETE PRESENT?
N
Y
READ RANGE RATE
AND RANGE IN
THE RADAR READ
ROUTINE (INCLUDES
TFI INTO N78).
NOTE: FROM THIS
POINT ON, THE LGC

#30

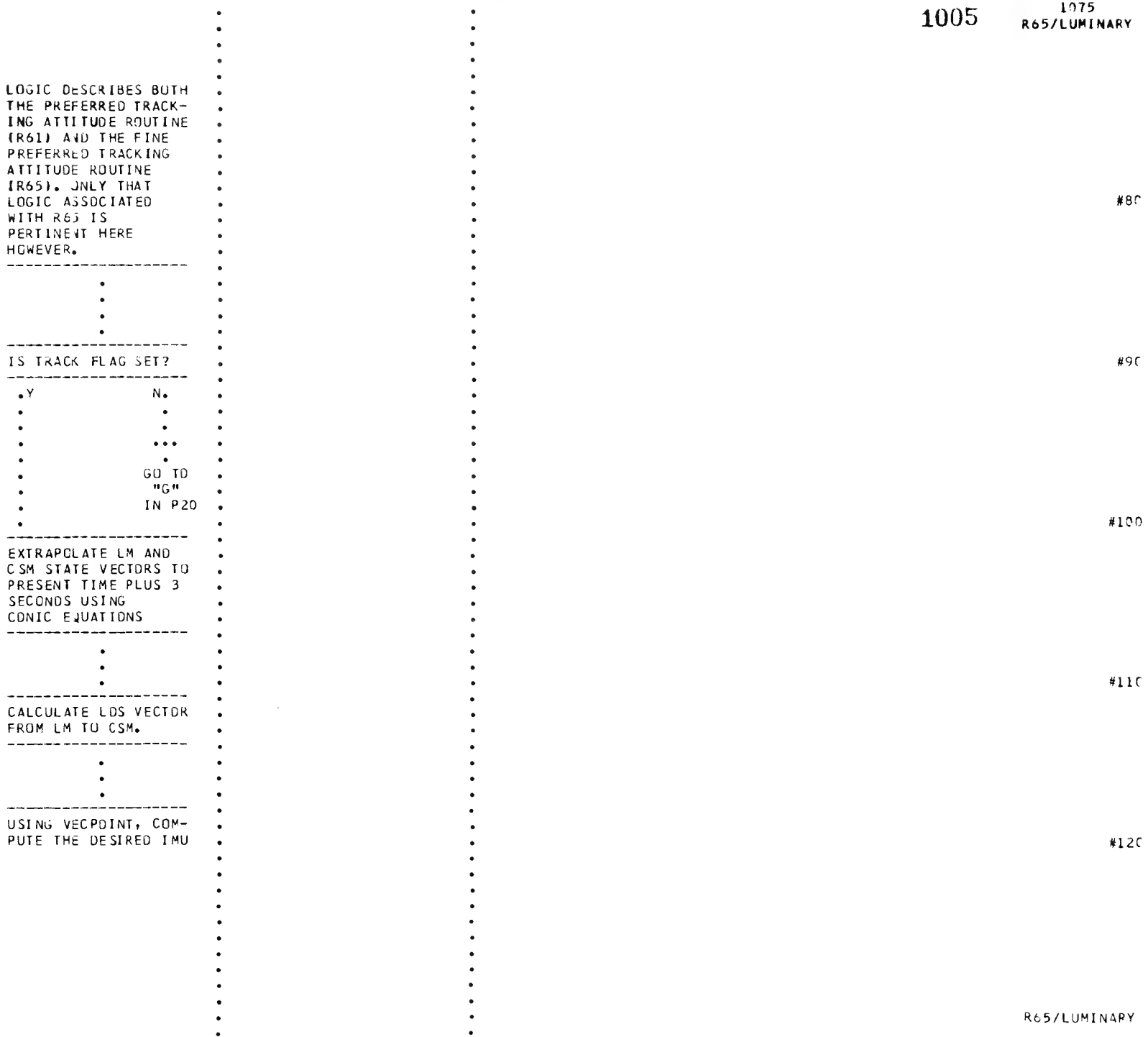
#40

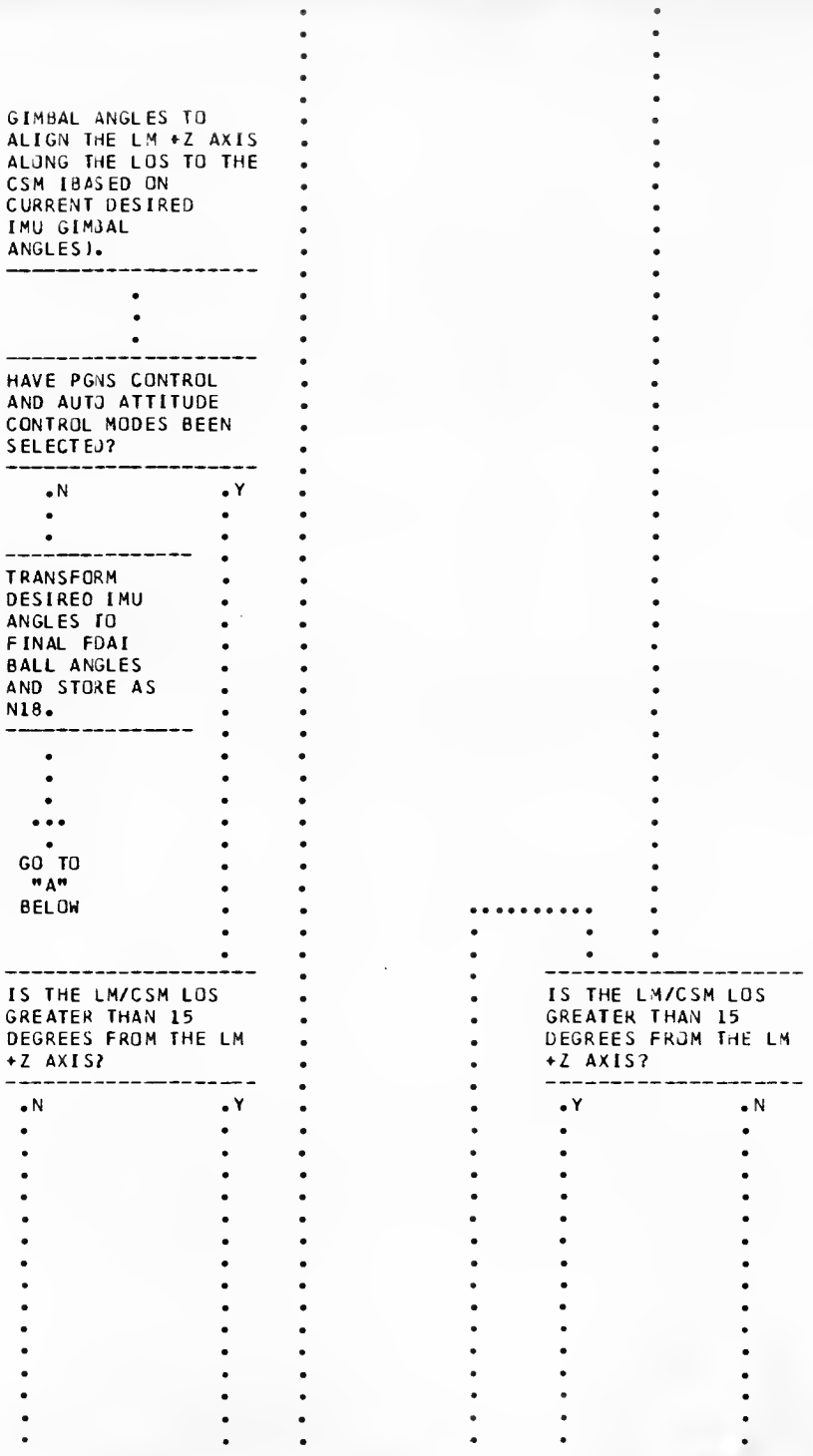

NOTE: ALL LOGIC IN
THE CREW COLUMN IS
ONLY THAT ASSOCIATED
WITH THE FINE PRE-
FERRED TRACKING
ATTITUDE ROUTINE
(R65).

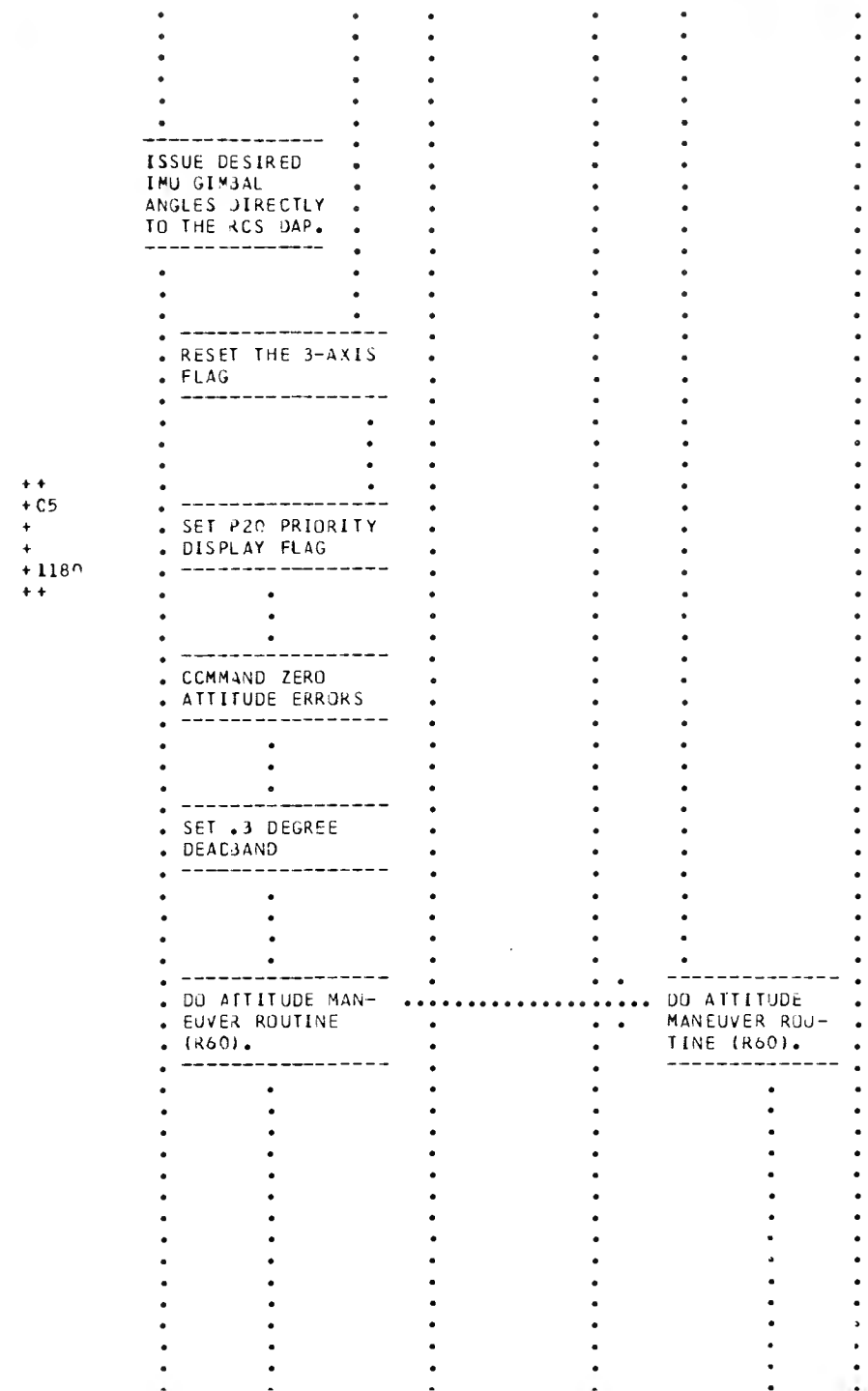
#50

#60

#70


LOGIC DESCRIBES BOTH THE PREFERRED TRACKING ATTITUDE ROUTINE (R61) AND THE FINE PREFERRED TRACKING ATTITUDE ROUTINE (R65). ONLY THAT LOGIC ASSOCIATED WITH R65 IS PERTINENT HERE HOWEVER.
#80
IS TRACK FLAG SET?
#90
Y
N
GO TO "G" IN P20
#100
EXTRAPOLATE LM AND CSM STATE VECTORS TO PRESENT TIME PLUS 3 SECONDS USING CONIC EQUATIONS
#110
CALCULATE LOS VECTOR FROM LM TO CSM.
#120
USING VECPOINT, COMPUTE THE DESIRED IMU


GIMBAL ANGLES TO ALIGN THE LM +Z AXIS ALONG THE LOS TO THE CSM (BASED ON CURRENT DESIRED IMU GIMBAL ANGLES).
#130
HAVE PGNS CONTROL AND AUTO ATTITUDE CONTROL MODES BEEN SELECTED?
N
Y
#140
TRANSFORM DESIRED IMU ANGLES TO FINAL FDAI BALL ANGLES AND STORE AS N18.
#150
GO TO "A" BELOW
IS THE LM/CSM LOS GREATER THAN 15 DEGREES FROM THE LM +Z AXIS?
#160
N
Y
IS THE LM/CSM LOS GREATER THAN 15 DEGREES FROM THE LM +Z AXIS?
Y
N



#17C

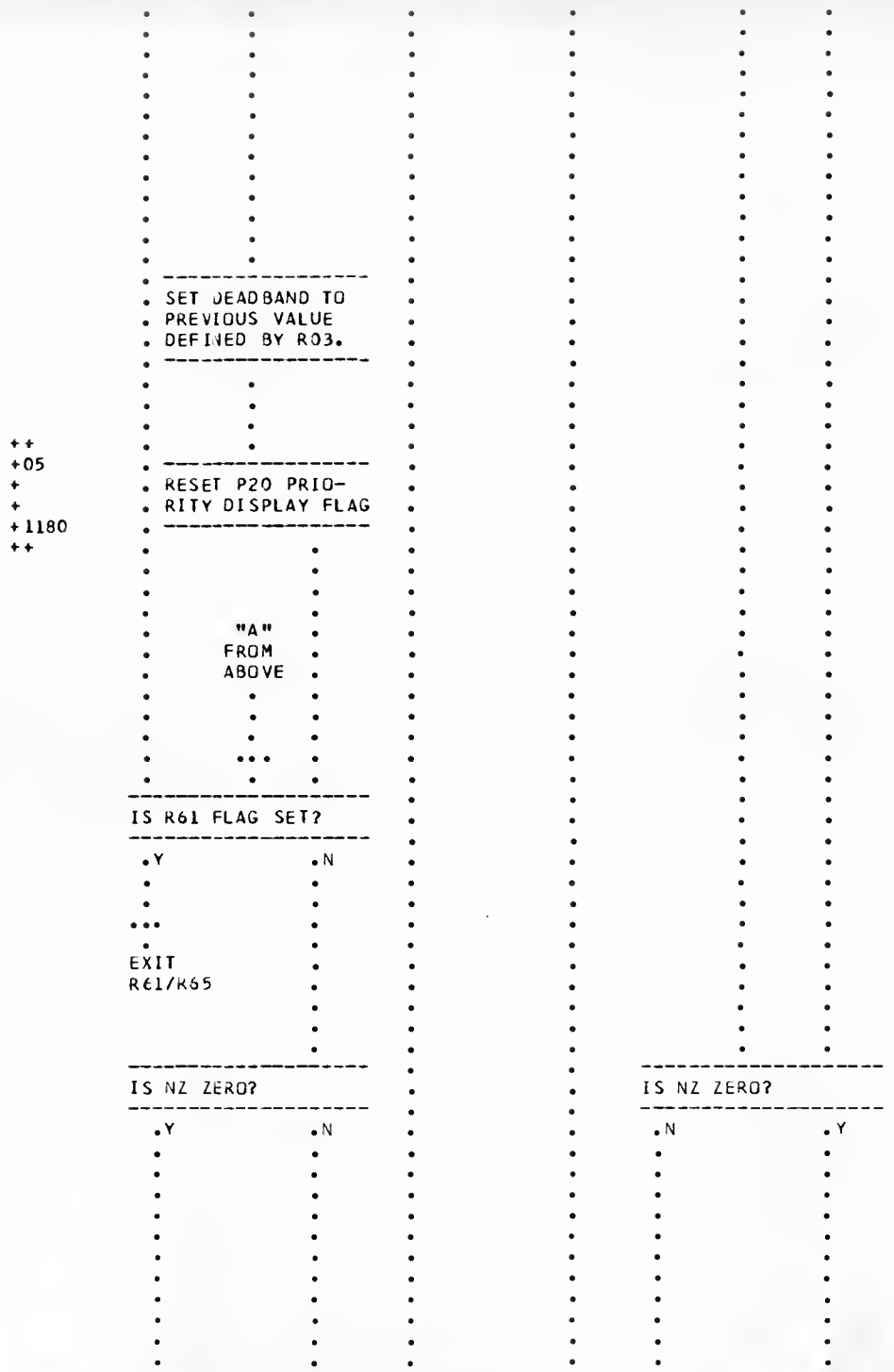
#18C

+C5

#19C

#20C

#21C



#220

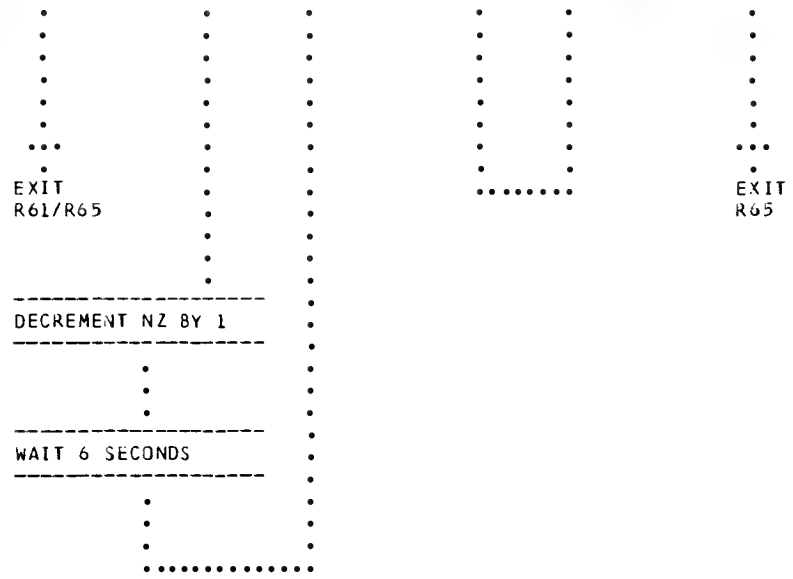
#230

#240

#250

#260

++
+05
+
+
+1180
++



#270

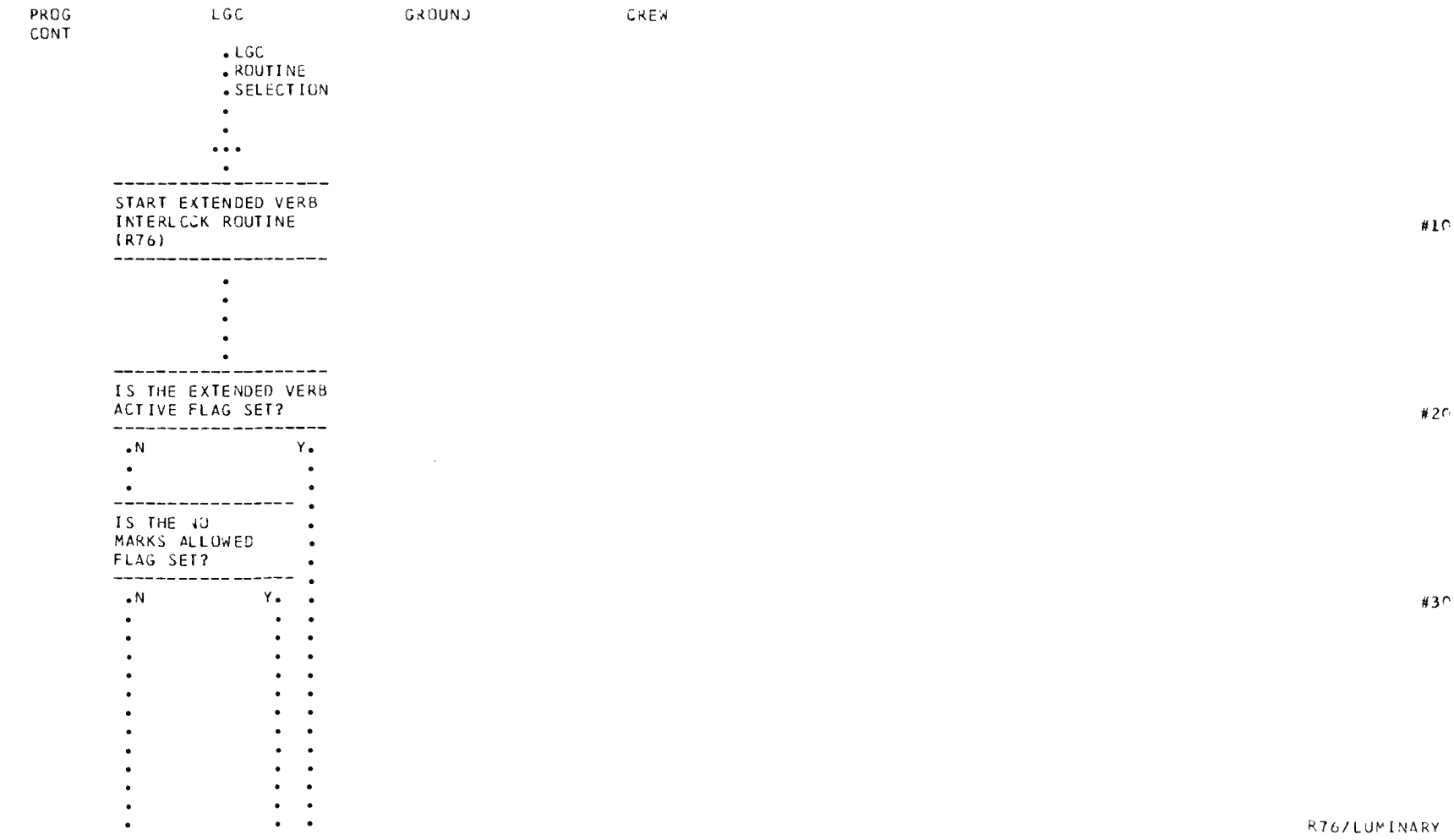
#280

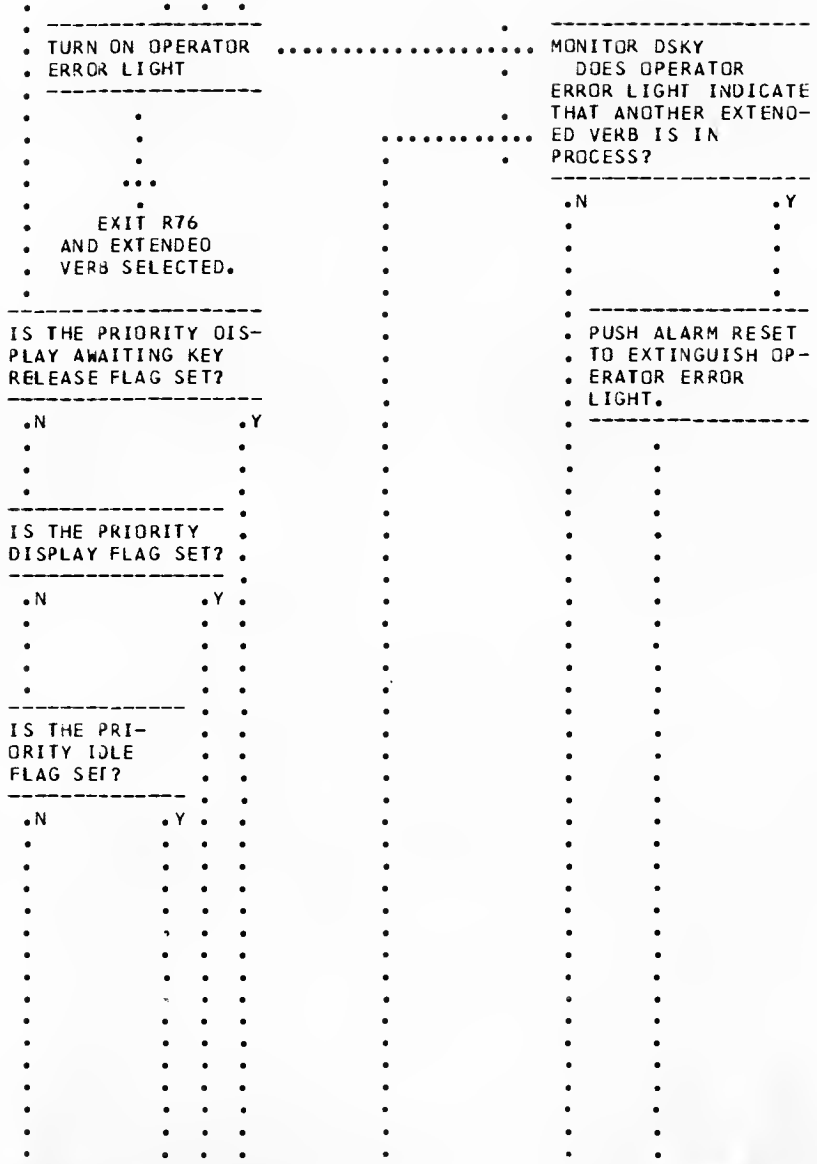
CHANGE CONTROL NOTES

REV 01 PCR 39,634
REV 00(LUM 1A) PCR 642,716
REV 01(LUM 1B) PCR 780
REV 02 EDITORIAL
REV 03 PCN 1C39
REV 04(LUM 1E) PCR 324
REV 05 PCN 1180

EXTENDED VERB INTERLOCK ROUTINE (R76) REV 03 12/01/71

++
PURPOSE: (1) TO INHIBIT SELECTION OF EXTENDED VERBS UNDER CERTAIN CIRCUMSTANCES.
+03
ASSUMPTIONS: (1) THIS ROUTINE IS CALLED BY THE FOLLOWING EXTENDED VERBS: V41N20, V41N72, V42, V43, V47(R47), V48(R03), V49(R62), V55, V63(R34), V64(R05), V67, V70(P27), V71(P27), V72(P27), V73(P27), V82(R30), V83(R31), V85, V89(R63), V90(R36), V91, V92 (P07).
+1180
++



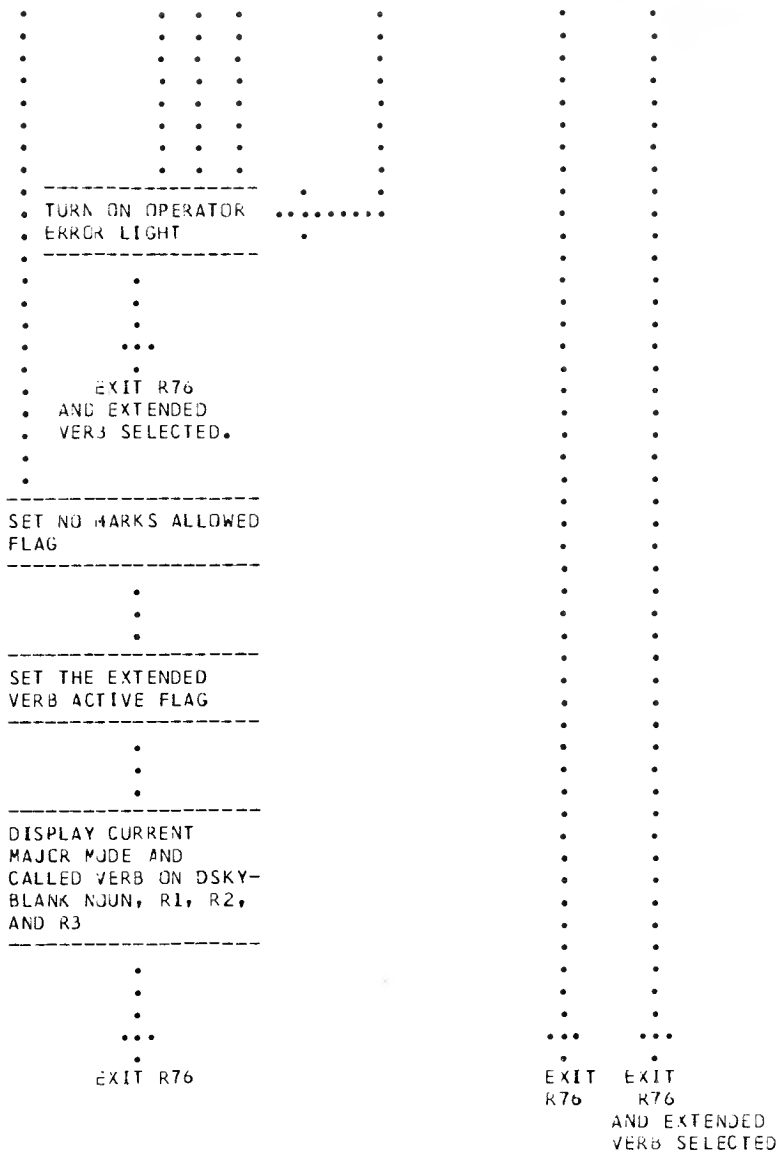

IS THE MARK IN PROGRESS FLAG SET?
N
Y
TURN ON OPERATOR ERROR LIGHT
EXIT R76 AND EXTENDED VERB SELECTED.
MONITOR DSKY DOES OPERATOR ERROR LIGHT INDICATE THAT ANOTHER EXTENDED VERB IS IN PROCESS?
N
Y
PUSH ALARM RESET TO EXTINGUISH OPERATOR ERROR LIGHT.
IS THE PRIORITY DISPLAY AWAITING KEY RELEASE FLAG SET?
N
Y
IS THE PRIORITY DISPLAY FLAG SET?
N
Y
IS THE PRIORITY IDLE FLAG SET?
N
Y

#40

#50

#60

#70



#8C

#9C

#10C

#11C

#12C

CHANGE CONTROL NOTES

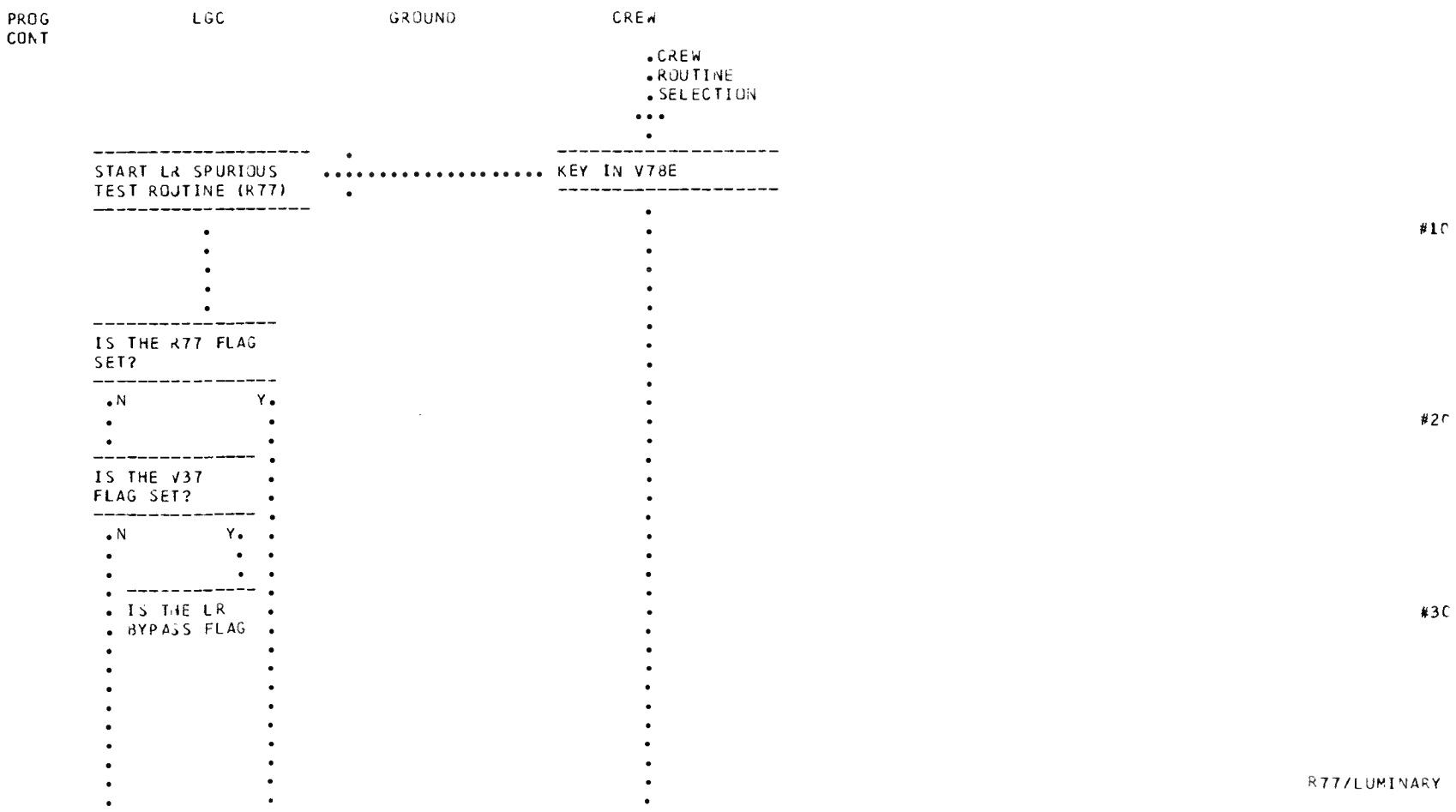
REV 01 (NO PCRS)
REV 02 EDITORIAL
REV 03 PCN 1180

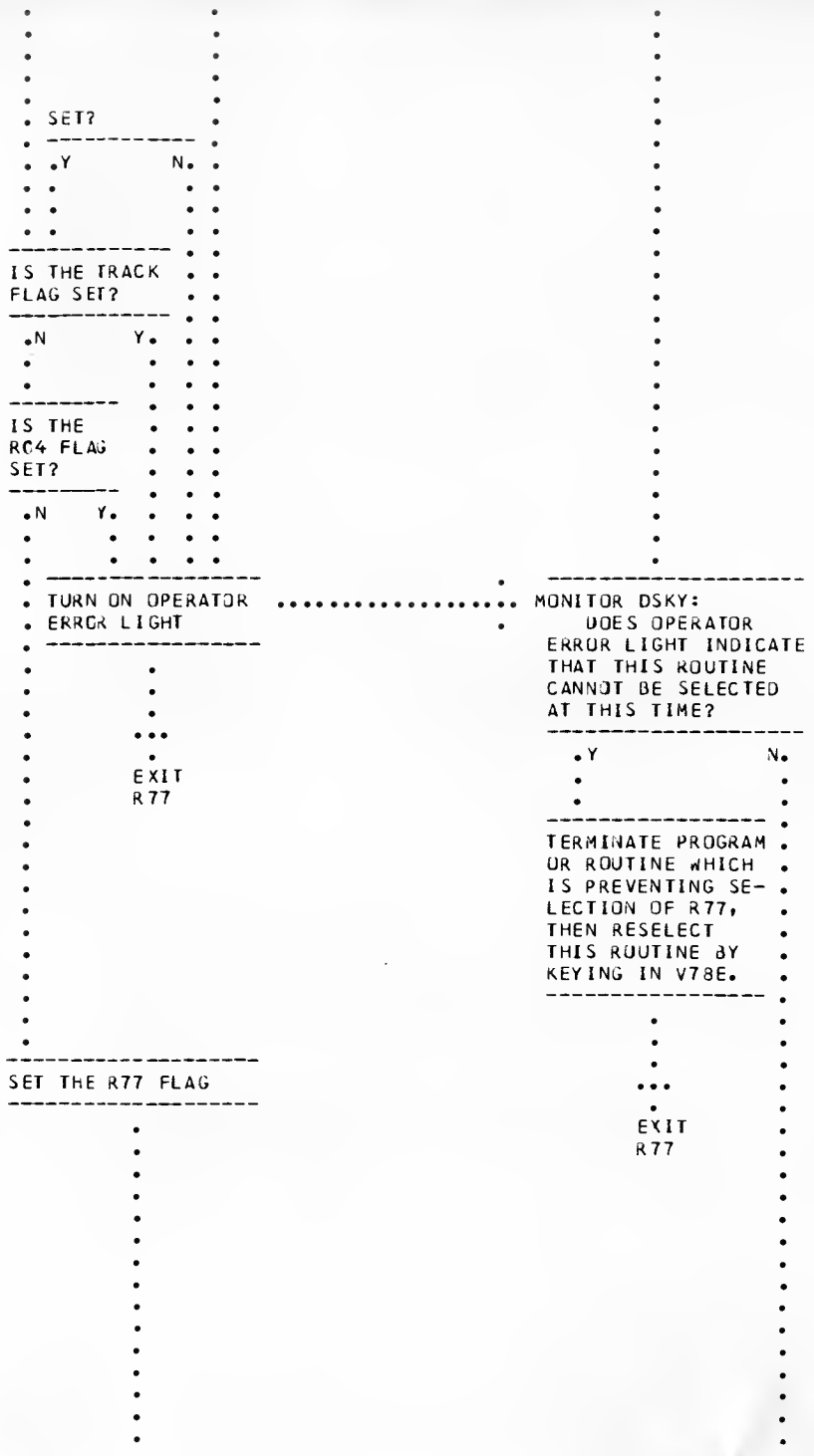
LR SPURIOUS TEST ROUTINE (R77) REV C4 09/03/70

PURPOSE: (1) TO READ OUT THE RANGE AND VELOCITY DATA FROM THE LANDING RADAR (LR) AND PUT IT ON THE LGC DOWNLINK DURING LR SPURIOUS RETURN TESTS.

ASSUMPTIONS: (1) THE LR DATA IS PLACED ON THE DOWNLINK REGARDLESS OF THE STATUS OF THE LR RANGE DATA GOOD AND VELOCITY DATA GOOD DISCRETES.

(2) THIS ROUTINE IS MANUALLY SELECTED BY DSKY ENTRY (V78E) AND MAY BE CALLED ONLY WHEN NO OTHER PROGRAM OR ROUTINE IS USING EITHER RADAR. THE ROUTINE MUST BE TERMINATED BY MANUAL DSKY ENTRY (V79E).



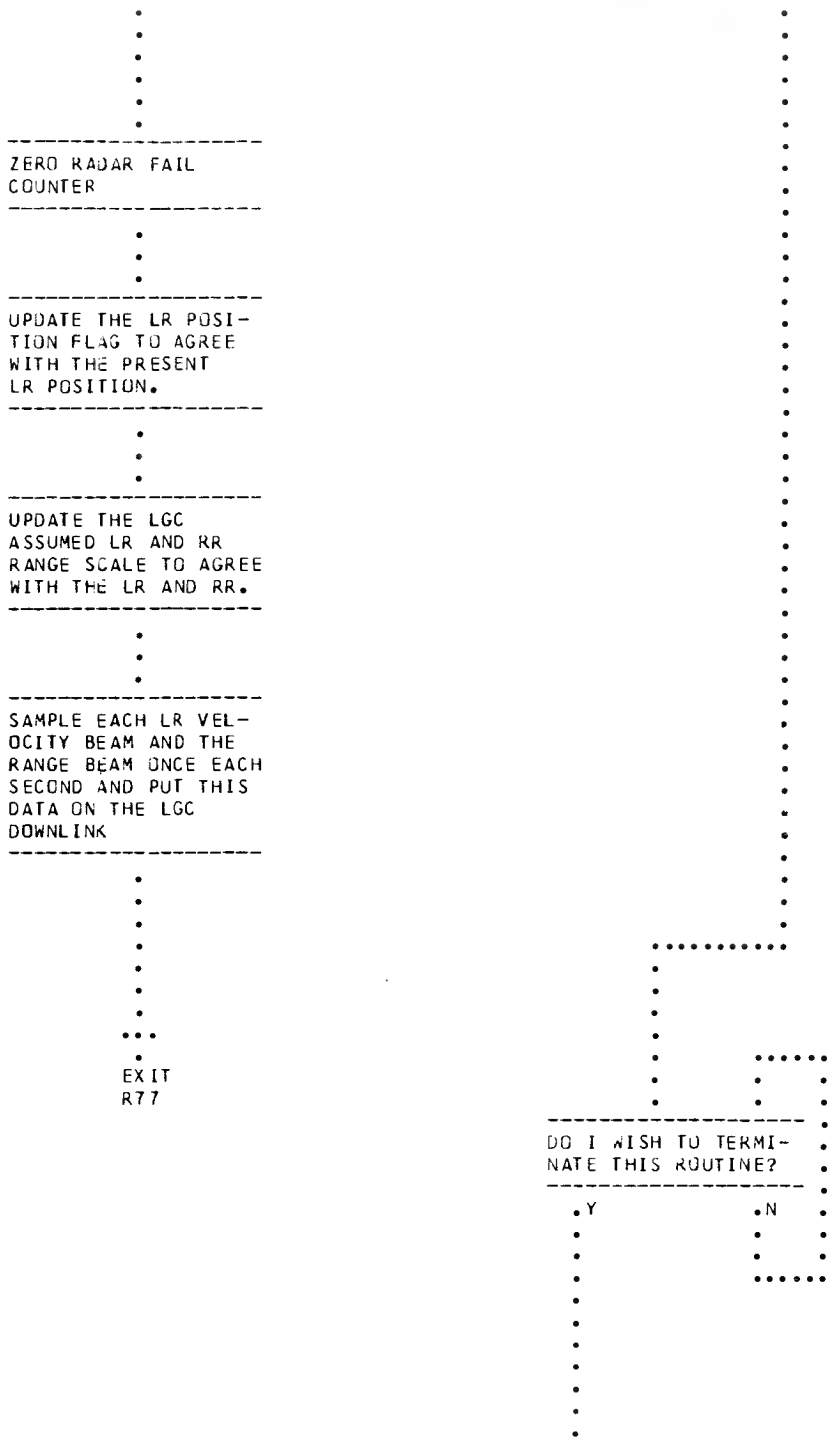

SET?
Y
N
IS THE TRACK FLAG SET?
N
Y
IS THE RC4 FLAG SET?
N
Y
TURN ON OPERATOR ERROR LIGHT
EXIT R77
SET THE R77 FLAG
MONITOR DSKY: DOES OPERATOR ERROR LIGHT INDICATE THAT THIS ROUTINE CANNOT BE SELECTED AT THIS TIME?
Y
N
TERMINATE PROGRAM OR ROUTINE WHICH IS PREVENTING SELECTION OF R77, THEN RESELECT THIS ROUTINE BY KEYING IN V78E.
EXIT R77

#40

#50

#60

#70



#80

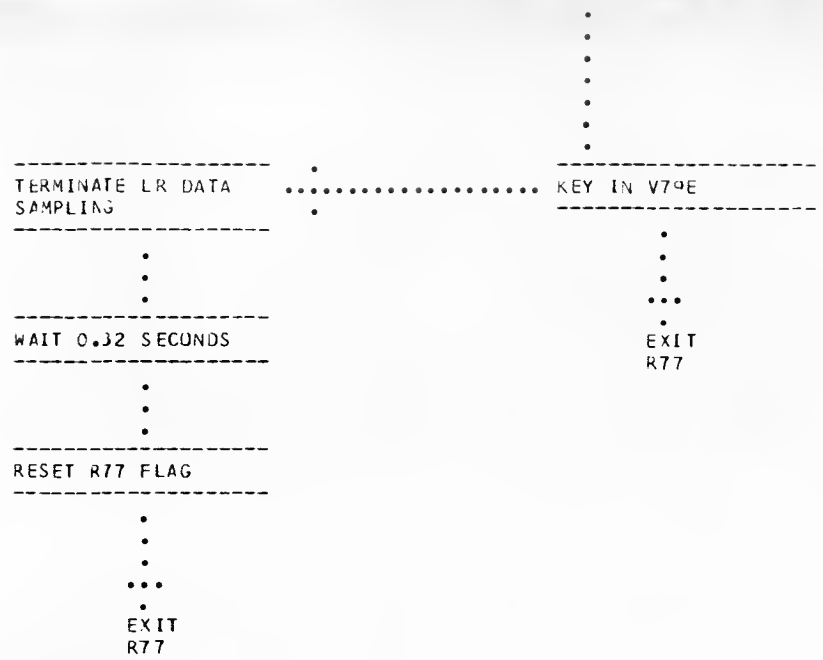
#90

#100

#110

#120

#130



#140

#150

#160

CHANGE CONTROL NOTES

LOGIC REV 01 PCR 229
REV 02 EDITORIAL
REV 03 EDITORIAL
REV 04(LUM 1D) PCR 892

4.4.11 EXTENDED VERBS (AND VERB 36)

V36, REQUEST FRESH START REV 6 12/01/71

PURPOSE: (1) TO INITIATE A COMPUTER FRESH START.

ASSUMPTIONS: (1) THIS PROCESS MAY BE SELECTED AT ANY TIME.

(2) FRESH START CAN BE INITIATED IN ANY OF THE FOLLOWING WAYS:

(A) VIA PROGRAM IF PHASE TABLE DISAGREEMENT IS DETECTED FOLLOWING A RESTART (ALARM CODE 01107).
(B) VIA PROGRAM IF SELF CHECK IS INTERRUPTED BY A RESTART DURING ITS ERASABLE MEMORY CHECK AND ERASABLE MEMORY IS SUSPECT.
(C) BY SIMULTANEOUS DEPRESSING OF THE MARK REJECT AND ERROR RESET BUTTONS DURING A RESTART.
(D) DSKY ENTRY OF V36E.

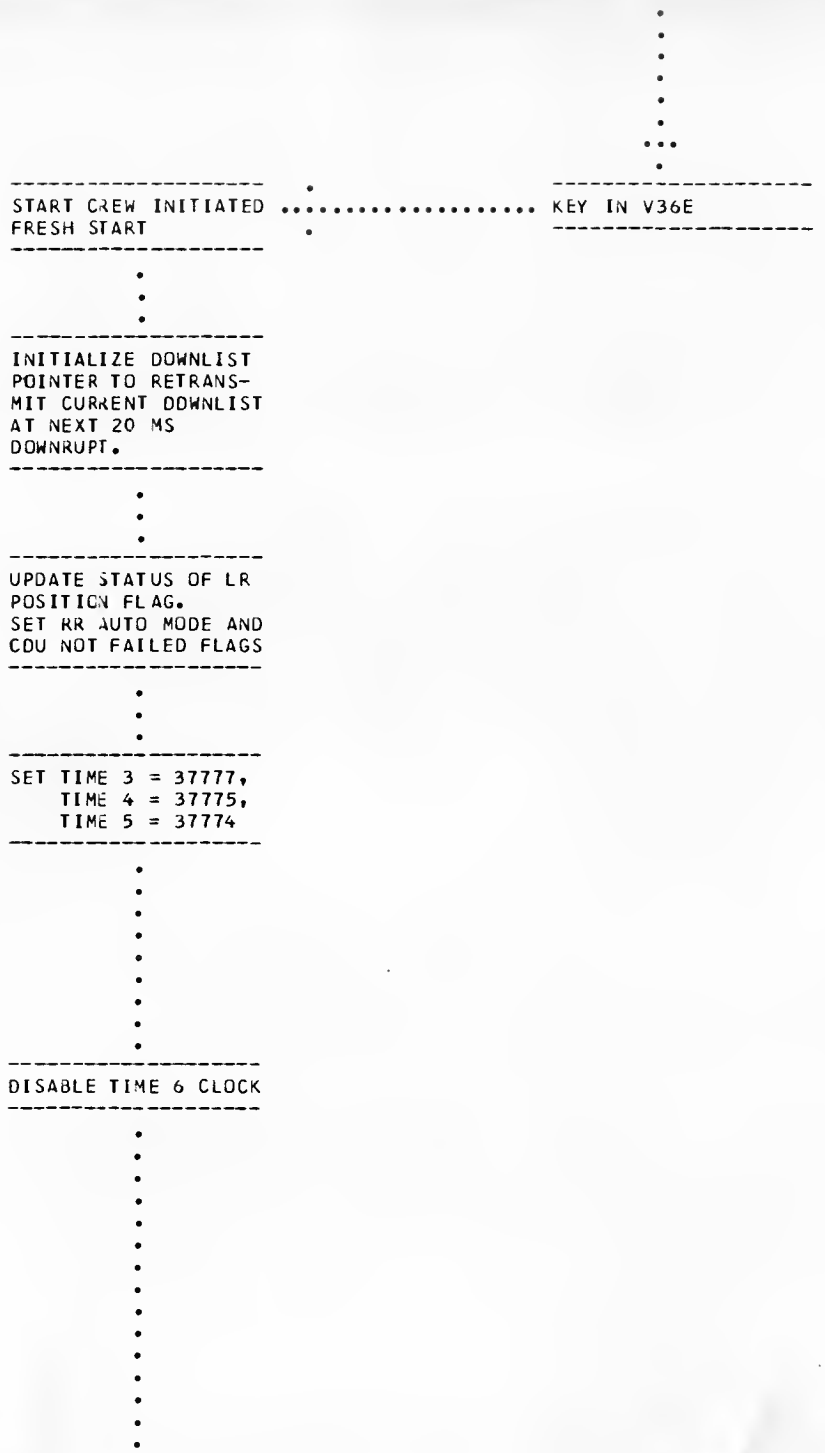
NOTE: A COMMANDED FRESH START (V36) WILL TURN OFF THE ENGINE, AS WILL PRESSING "MARK REJECT" AND "ERROR RESET" DURING A RESTART.
THUS: "A" AND "B" DO NOT SHUT OFF THE DPS OR APS, "C" AND "D" WILL SHUT OFF THE DPS OR APS.

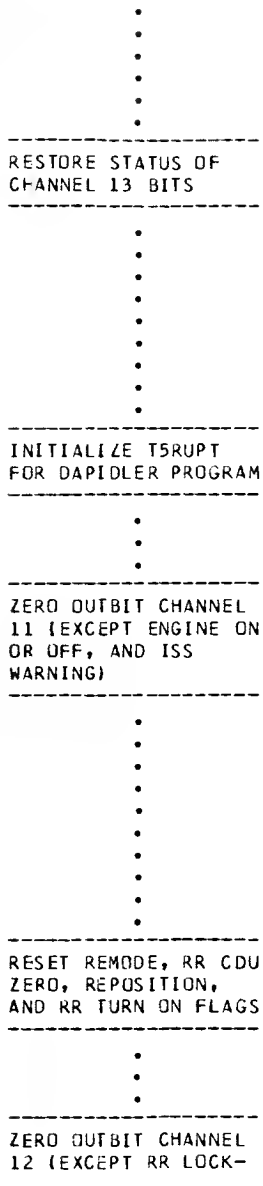
(3) IF FRESH START INTERRUPTS STATE VECTOR INTEGRATION, THE STATE VECTOR MAY BE INVALIDATED.

NOTE: LGC FRESH START INITIALIZES ALL FLAGWORDS (SEE EXCEPTIONS BELOW), CLEARS ALL JOB CORE SET AND VAC AREAS, SETS WAITLIST TASKS TO ENDTASK, INITIALIZES ALL OUTPUT CHANNELS, INITIALIZES DAP IDLING PROGRAM, INITIALIZES DOWNLINK TO COAST-AND-ALIGN DOWNLIST, BLANKS THE DSKY , AND EXITS TO AN IDLING STATE (DUMMY JOB).

LGC FRESH START DOES NOT ALTER THE STATE OF THE FOLLOWING FLAG BITS:
(1) APSFLAG, WHICH INDICATES IF THE DESCENT STAGE IS ATTACHED.
(2) SURFACE FLAG, WHICH INDICATES IF THE LM STATE IS ON THE LUNAR SURFACE.
(3) LMOONFLG, WHICH INDICATES IF THE LM STATE IS EARTH OR LUNAR CENTERED.
(4) CMOONFLG, WHICH INDICATES IF THE CSM STATE IS EARTH OR LUNAR CENTERED.
(5) REFSMMAT FLAG, WHICH INDICATES IF REFSMMAT IS VALID.
(6) NODOP07 FLAG, WHICH INDICATES LIFTOFF HAS OCCURRED.

PROG CONT	LGC	GROUND	CREW
			CREW SELECTION


START CREW INITIATED FRESH START
KEY IN V36E
#10
INITIALIZE DOWNLIST POINTER TO RETRANSMIT CURRENT DOWNLIST AT NEXT 20 MS DOWNRUPT.
#20
UPDATE STATUS OF LR POSITION FLAG.
SET RR AUTO MODE AND CDU NOT FAILED FLAGS
#30
SET TIME 3 = 37777,
TIME 4 = 37775,
TIME 5 = 37774
#40
DISABLE TIME 6 CLOCK
#50



#60

#70

#80

#90

#100

```
ON ENABLE, GIMBAL
TRIM DRIVES, ENABLE
IMU ERROR COUNTERS,
ZERO IMU CDUS, AND
COARSE ALIGN
ENABLE).
--------------------
          .
          .
          .
--------------------
RESET NO RR MONITOR
FLAG (R25)
--------------------
          .
          .
          .
          .
--------------------
RESET R77 FLAG
--------------------
          .
          .
          .
--------------------
ZERO OUTBIT CHANNEL
13 (EXCEPT TELEMETRY
BITS, RESET TRAP
BITS, AND T6RUPT
BIT).
--------------------
          .
          .
          .
--------------------
SET HAND CONTROL
RUPT BIT IN CHANNEL
13.
--------------------
          .
          .
          .
--------------------
ZERO OUTBIT CHANNEL
14 (EXCEPT GYRO
ENABLE AND THRUST
DRIVE)
--------------------
          .
          .
          .
          .
          .
          .
          .
          .
          .
          .
          .
          .
          .
          .
```

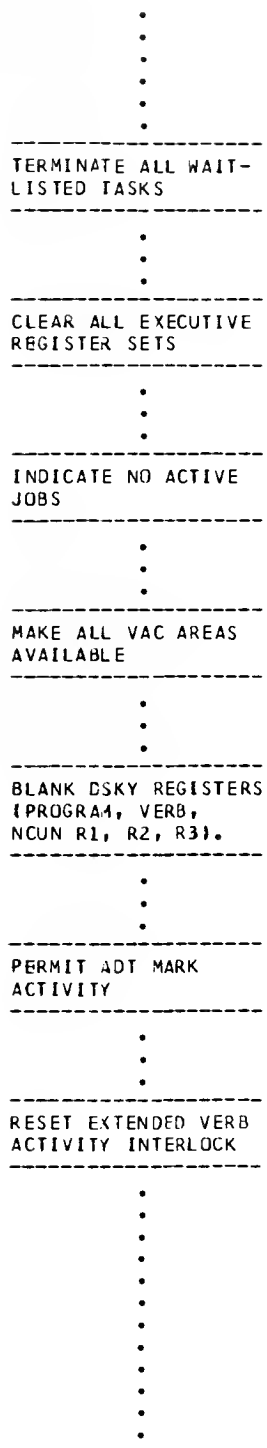
#110

#120

#130

#140

#150



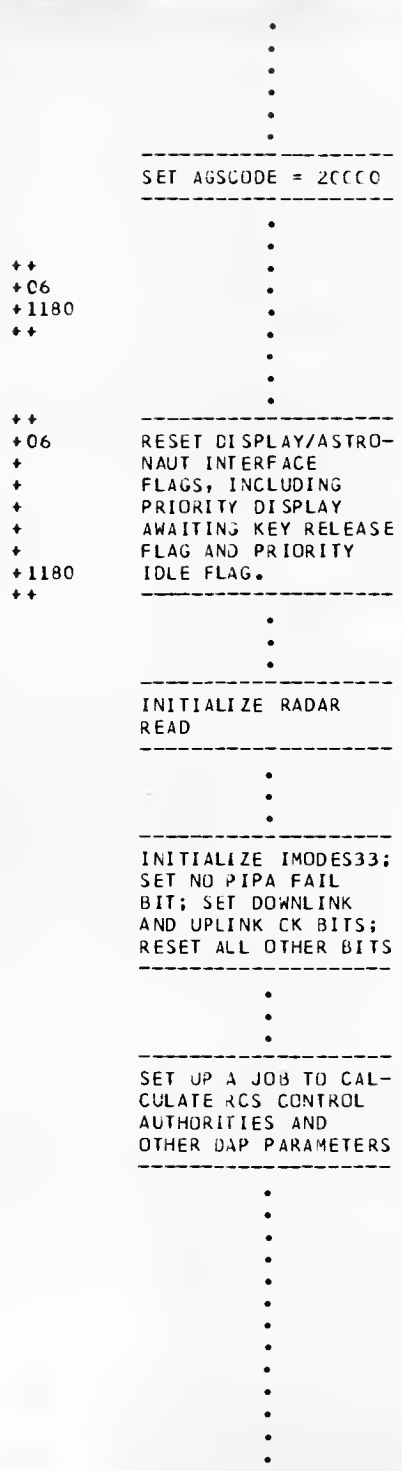
#160

#170

#180

#190

#200



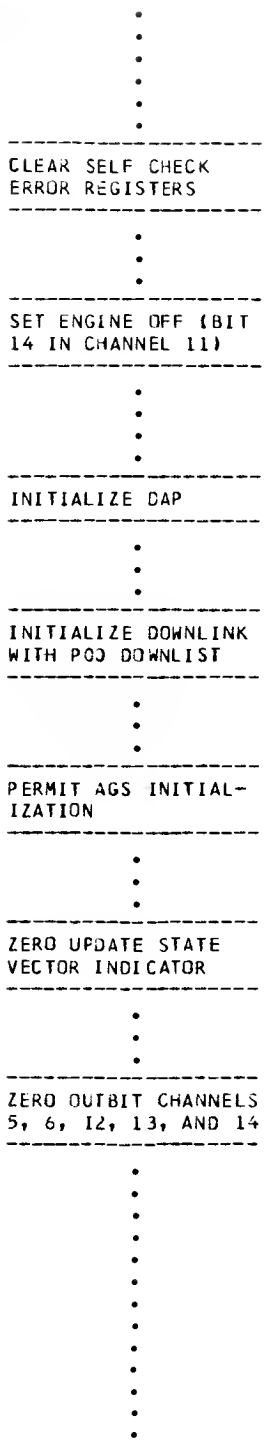
#210

#220

#230

#240

#250


CLEAR SELF CHECK ERROR REGISTERS
SET ENGINE OFF (BIT 14 IN CHANNEL 11)
#260
INITIALIZE DAP
#270
INITIALIZE DOWNLINK WITH POO DOWNLIST
PERMIT AGS INITIAL-IZATION
#280
ZERO UPDATE STATE VECTOR INDICATOR
#290
ZERO OUTBIT CHANNELS 5, 6, 12, 13, AND 14

#300

```
ZERO CHANNEL 77
```

#310

```
IS ISS IN COARSE
ALIGN MODE AND IN
GIMBAL LOCK?
```

```
.N                .Y
.                 .
.                 .
.   ENABLE COARSE
.   ALIGN MODE
.
.                 .
.                 .
.                 .
```

#320

```
CLEAR PHASE TABLE
```

#330

```
LOAD -0 INTO MODREG
```

#340

```
INITIALIZE IMU
(INHIBIT IMU FAIL)
```

```
SET MAXIMUM DEADBAND,
KALCMANU RATE AND
DAP FLAGWORD BITS
```

.
.
.
.
.
.

INHIBIT DAP TURN ON AND ERROR NEEDLE DISPLAY UNTIL ICDU'S ARE ZEROED. #350

.
.
.

RESET ALL FLAGWORDS (EXCEPT REFSMMAT, SURFACE, CMCONFLG, LMOONFLG, NODOP07, AND APS FLAGS). SET THE IDLE AND LR BYPASS FLAGS. #360

.
.
.
... #370
.
EXIT V36

CHANGE CONTROL NOTES

REV 00 PCR 496
REV 01 EDITORIAL
REV 02 EDITORIAL
REV 03 EDITORIAL
REV 04(LUM 1D) PCR 302.2,315.2,892,996,PCN 1009
REV 05(LUM 1E) PCR 324, PCN 1059,1145
REV 06 PCN 1189

V40N20, ZERO IMU CDUS REV 05 12/01/71

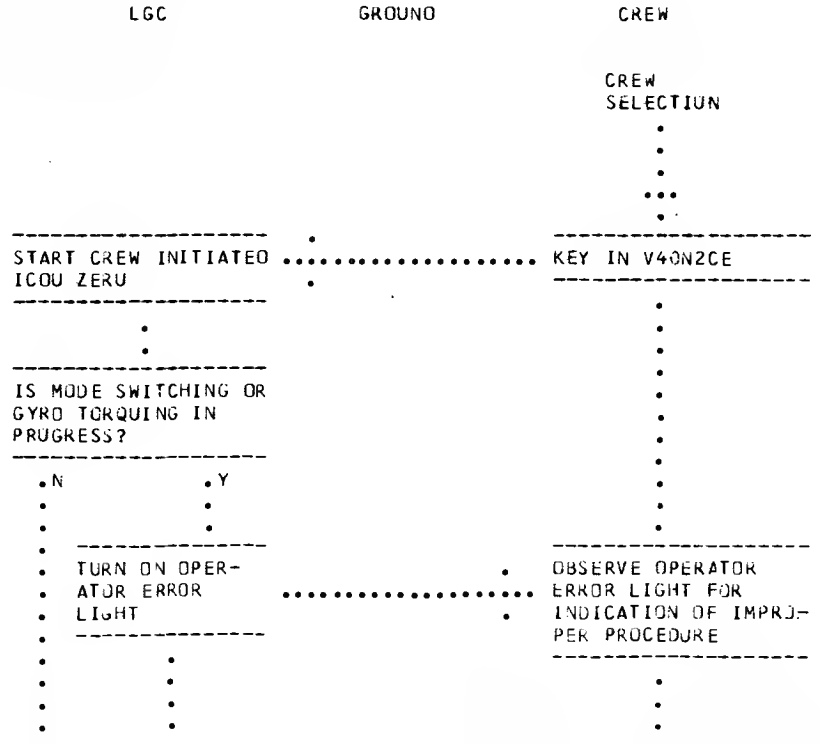
PURPOSE: (1) TO INSURE SYNCHRONIZATION OF THE IMU COU COUNTERS AND THE ICDU COUNTERS IN THE LGC.

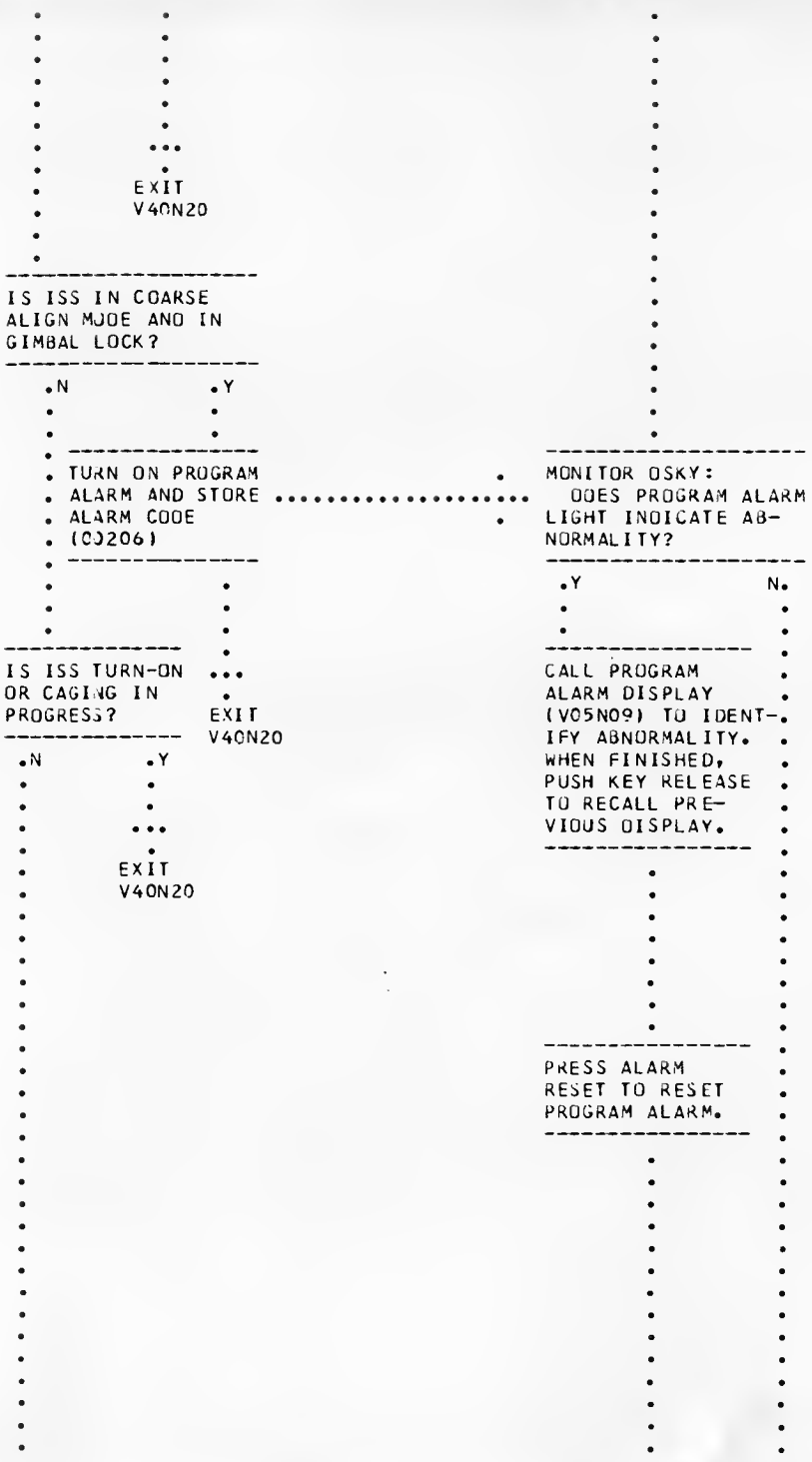
(2) TO TERMINATE THE IMJ COARSE ALIGN MODE AND ENTER THE INERTIAL MODE.

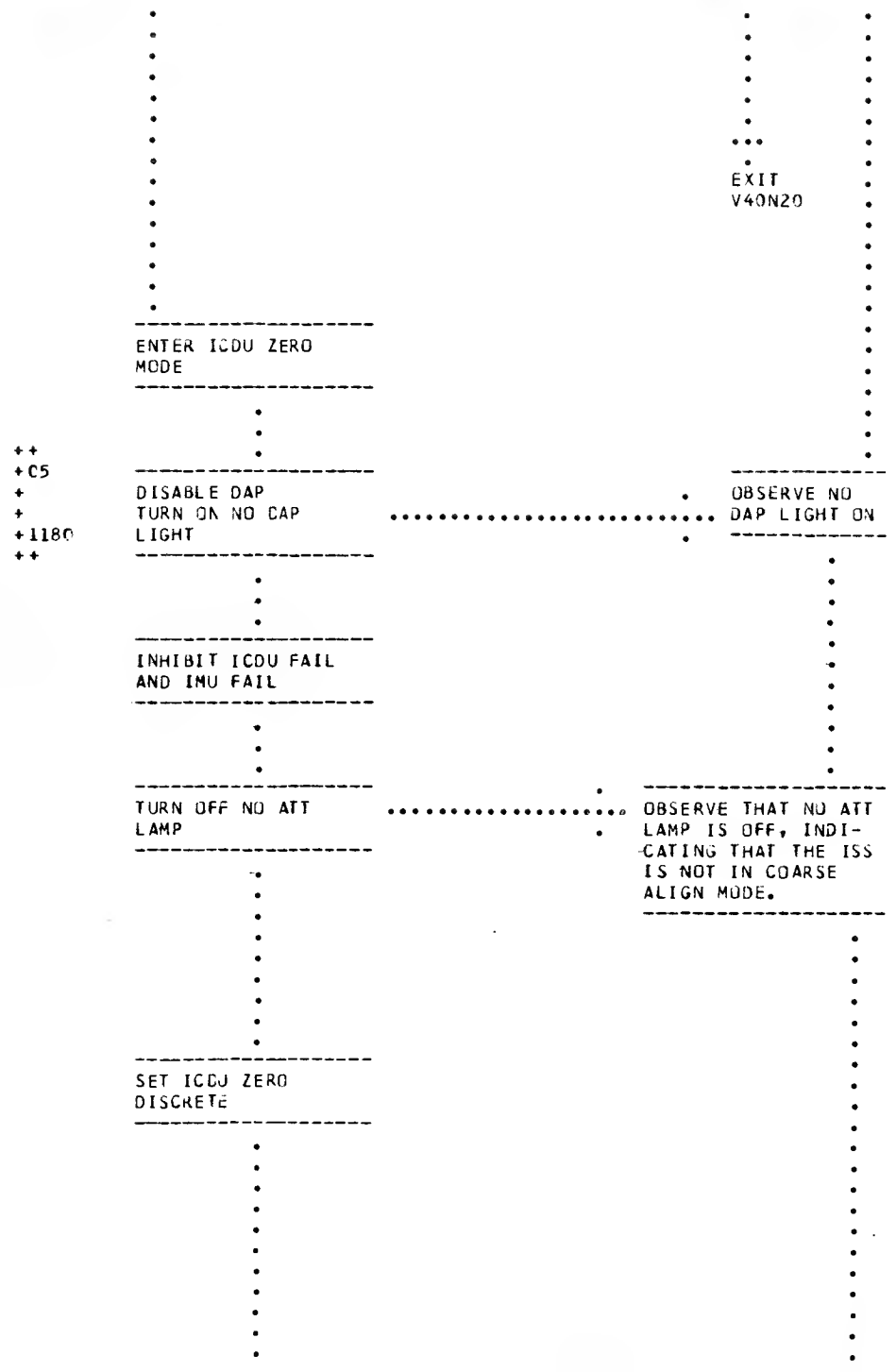
ASSUMPTIONS: (1) THIS EXTENDED VERB (V40N20) MAY BE CREW-SELECTED BY OSKY ENTRY. A VALID IMU ZERO (SYNCHRONIZATION OF COU COUNTERS) CAN BE ACHIEVED ONLY IF THE ISS IS ENERGIZED (NO ALARM 00210). THIS PROCESS MAY BE SELECTED EVEN IF ANOTHER EXTENDED VERB IS BEING PROCESSED. ASIDE FROM THE ICDU ZERO PROCEDURE WHICH FORMS A NORMAL PART OF THE ISS TURN-ON, THE ASTRONAUT CAN COMMAND ICDU ZERO PROCEDURES ONLY BY CALLING V40N20 OR BY CALLING R47 (VIA V47).

(2) V40 MAY NOT BE SELECTED IF IMU MODE SWITCHING IS IN PROGRESS, NOR IF GYRO TORQUING IS IN PROGRESS, NOR IF THE IMU IS IN THE COARSE ALIGN MODE AND IN GIMBAL LOCK.

++
+05 (3) THIS VERB DISABLES THE DAP FOR APPROXIMATELY 10 SECONDS. A V37 MAJOR MODE CHANGE IS NOT ALLOWED DURING THIS
+ INTERVAL. AN ATTEMPT TO USE V37 HERE WILL RESULT IN A PROGRAM ALARM 01520. RESTORATION OF PROGRAM SELECTION
+118C CAPABILITY REQUIRES COMPLETION OF THIS EXTENDED VERB ROUTINE.
++




EXIT
V40N20
IS ISS IN COARSE ALIGN MODE AND IN GIMBAL LOCK?
N
Y
TURN ON PROGRAM ALARM AND STORE ALARM CODE (00206)
IS ISS TURN-ON OR CAGING IN PROGRESS?
N
Y
EXIT
V40N20
MONITOR OSKY: DOES PROGRAM ALARM LIGHT INDICATE ABNORMALITY?
Y
N
CALL PROGRAM ALARM DISPLAY (V05N09) TO IDENTIFY ABNORMALITY. WHEN FINISHED, PUSH KEY RELEASE TO RECALL PREVIOUS DISPLAY.
PRESS ALARM RESET TO RESET PROGRAM ALARM.
#30
#40
#50
#60
#70



#80

#90

#100

#110

#120

#130

ZERO LGC ICOU COUNTERS

#140

IS IMU ON?

Y

N

TURN ON PROGRAM ALARM AND STORE ALARM CODE (00210)

WAIT 320 MS

IS ISS TURN-ON OR CAGING IN PROGRESS?

N

Y

EXIT V40N20

MONITOR OSKY: DOES PROGRAM ALARM LIGHT INDICATE ABNORMALITY?

#150

Y

N

CALL PROGRAM ALARM DISPLAY (V05N09) TO IDENTIFY ABNORMALITY. WHEN FINISHED, PUSH KEY RELEASE TO RECALL PREVIOUS DISPLAY.

#160

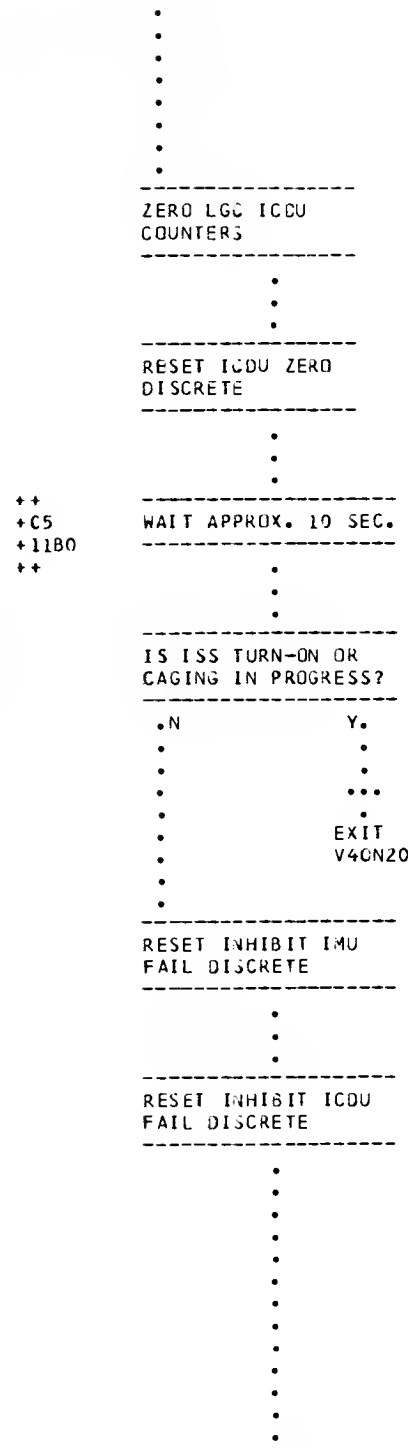
PRESS ALARM RESET TO RESET PROGRAM ALARM

#170

EXIT

#180

V40N20



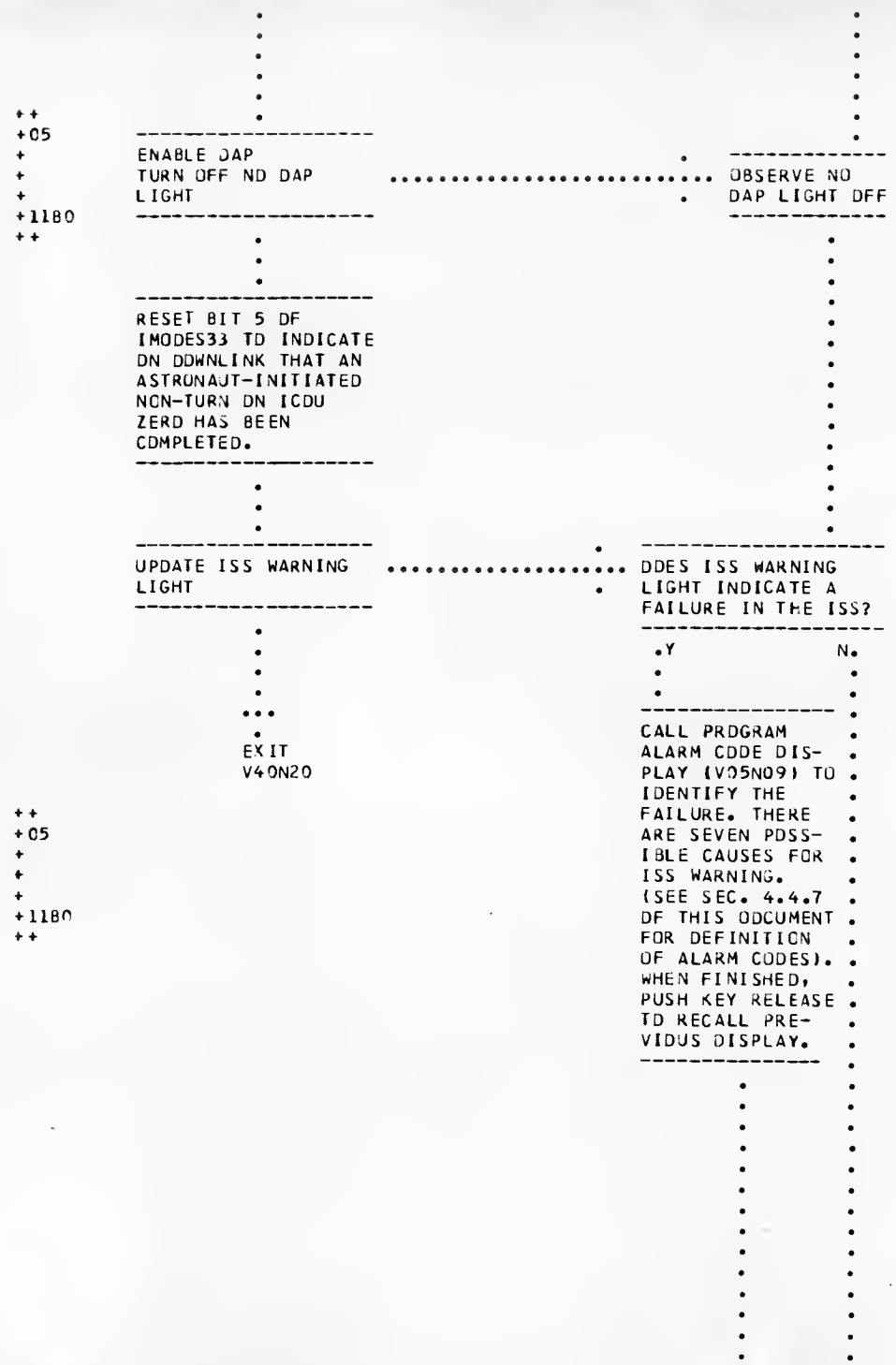
++
+C5
+1180
++

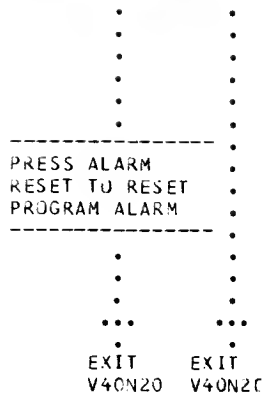
#190

#200

#210

#220


ENABLE DAP
TURN OFF ND DAP
LIGHT
OBSERVE NO
DAP LIGHT OFF
RESET BIT 5 OF
IMODES33 TO INDICATE
ON DOWNLINK THAT AN
ASTRONAUT-INITIATED
NON-TURN ON ICDU
ZERO HAS BEEN
COMPLETED.
UPDATE ISS WARNING
LIGHT
DOES ISS WARNING
LIGHT INDICATE A
FAILURE IN THE ISS?
Y
N
CALL PROGRAM
ALARM CODE DIS-
PLAY (V05N09) TO
IDENTIFY THE
FAILURE. THERE
ARE SEVEN POSS-
IBLE CAUSES FOR
ISS WARNING.
(SEE SEC. 4.4.7
OF THIS DOCUMENT
FOR DEFINITION
OF ALARM CODES).
WHEN FINISHED,
PUSH KEY RELEASE
TO RECALL PRE-
VIOUS DISPLAY.
EXIT
V40N20
++
+05
+1180
++
#230
#240
#250
#260
#270



#280

#290

CHANGE CONTROL NOTES

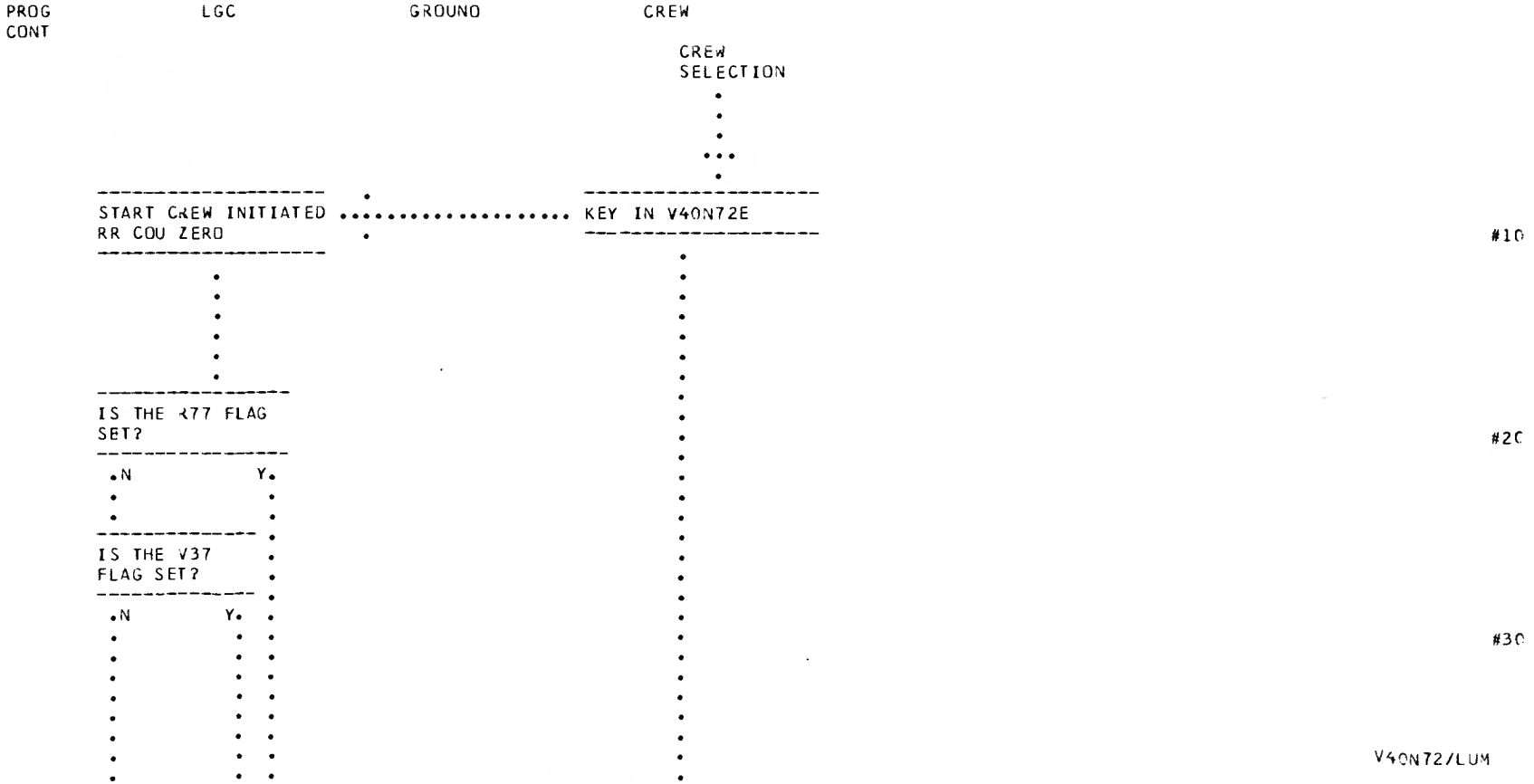
REV 00 PCR 496
REV 01 EDITORIAL
REV 02 EDITORIAL
REV 03 EDITORIAL
REV 04(LUM 1E) PCR 1088, PCN 1145
REV 05 PCN 1180

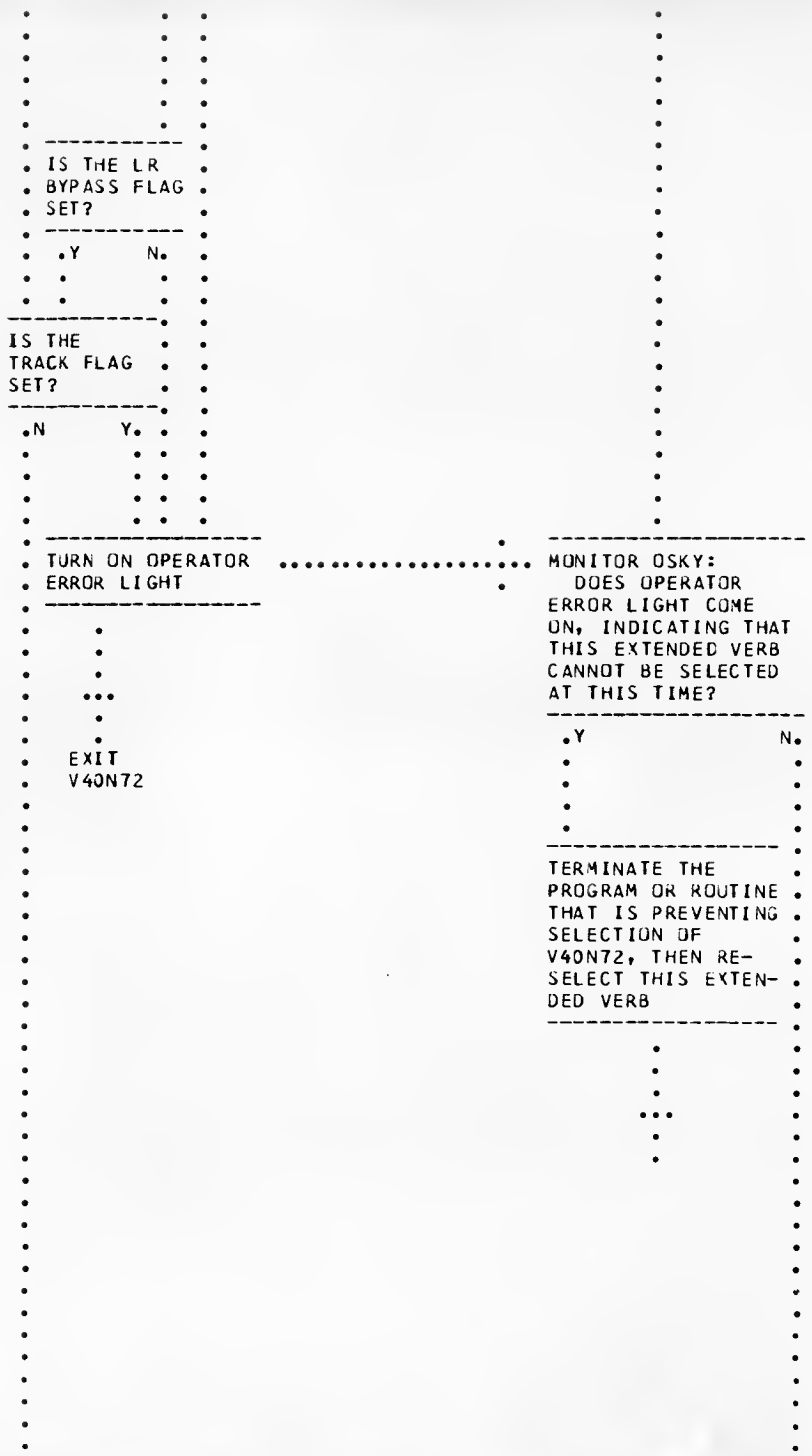
V40N72, ZERO RR CDUS REV 05 12/01/71

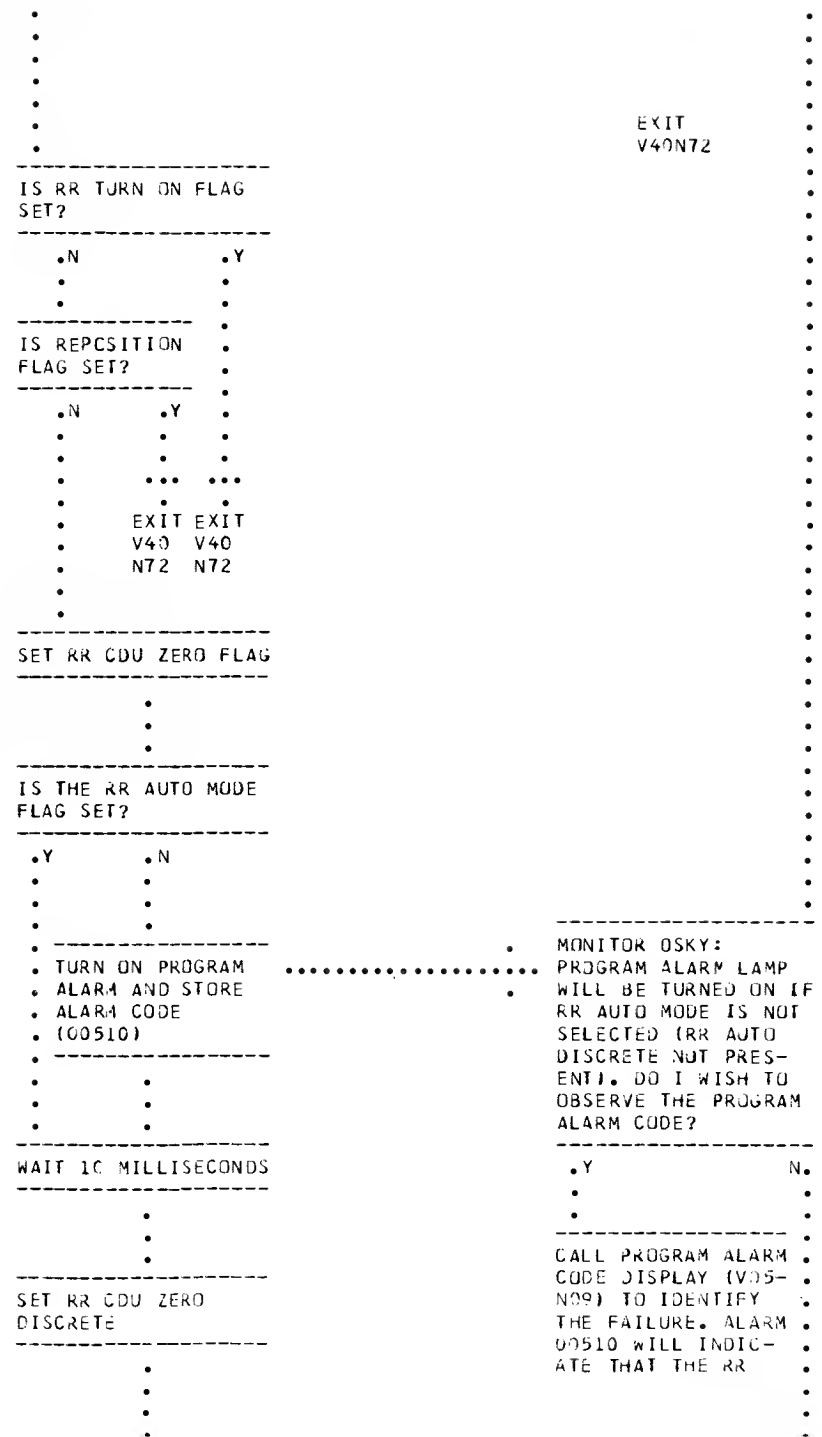
PURPOSE: (1) TO ZERO THE RR CDUS.

(2) TO DETERMINE THE RR ANTENNA MODE.

ASSUMPTIONS: (1) THE PROCESS IS CREW SELECTED BY DSKY ENTRY.
++
+05 (2) THIS PROCESS MAY BE SELECTED AT ANY TIME EXCEPT WHEN A READ SEQUENCE OF EITHER RADAR OR A RR DESIGNATE IS IN
+ PROGRESS, OR WHEN THE TRACK FLAG IS SET (IT IS SET BY P20, P22, P25, P30, P32-35, P72-77).
+1180
++ (3) EXCEPT FOR THE RESTRICTIONS NOTED IN (2) ABOVE, THIS PROCESS CAN BE SELECTED AT ANY TIME IN COMBINATION WITH
ANY OTHER EXTENDED VERB.




IS THE LR BYPASS FLAG SET?
.Y
N.
IS THE TRACK FLAG SET?
.N
Y.
TURN ON OPERATOR ERROR LIGHT
EXIT V40N72
MONITOR OSKY: DOES OPERATOR ERROR LIGHT COME ON, INDICATING THAT THIS EXTENDED VERB CANNOT BE SELECTED AT THIS TIME?
.Y
N.
TERMINATE THE PROGRAM OR ROUTINE THAT IS PREVENTING SELECTION OF V40N72, THEN RE-SELECT THIS EXTENDED VERB
#40
#50
#60
#70



#80

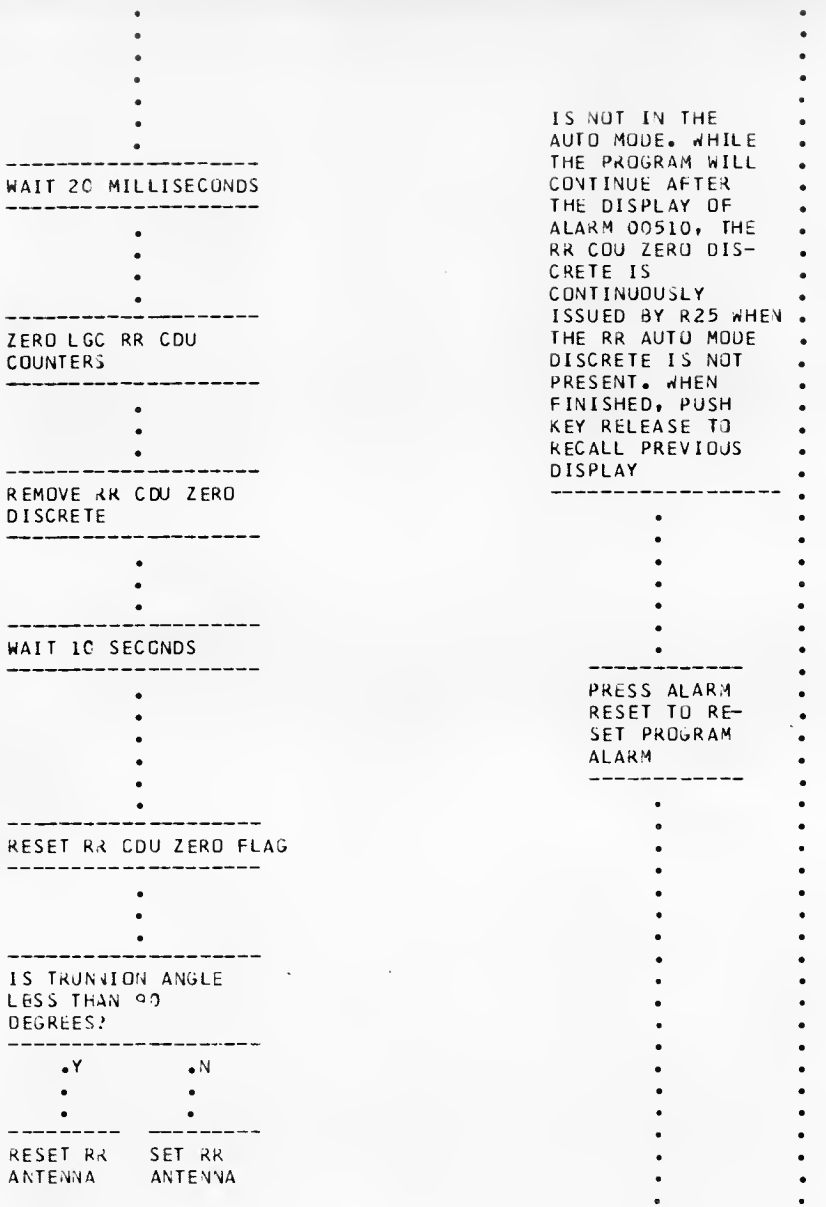
#90

#100

#110

#120

#130



IS NOT IN THE AUTO MODE. WHILE THE PROGRAM WILL CONTINUE AFTER THE DISPLAY OF ALARM 00510, THE RR CDU ZERO DISCRETE IS CONTINUOUSLY ISSUED BY R25 WHEN THE RR AUTO MODE DISCRETE IS NOT PRESENT. WHEN FINISHED, PUSH KEY RELEASE TO RECALL PREVIOUS DISPLAY

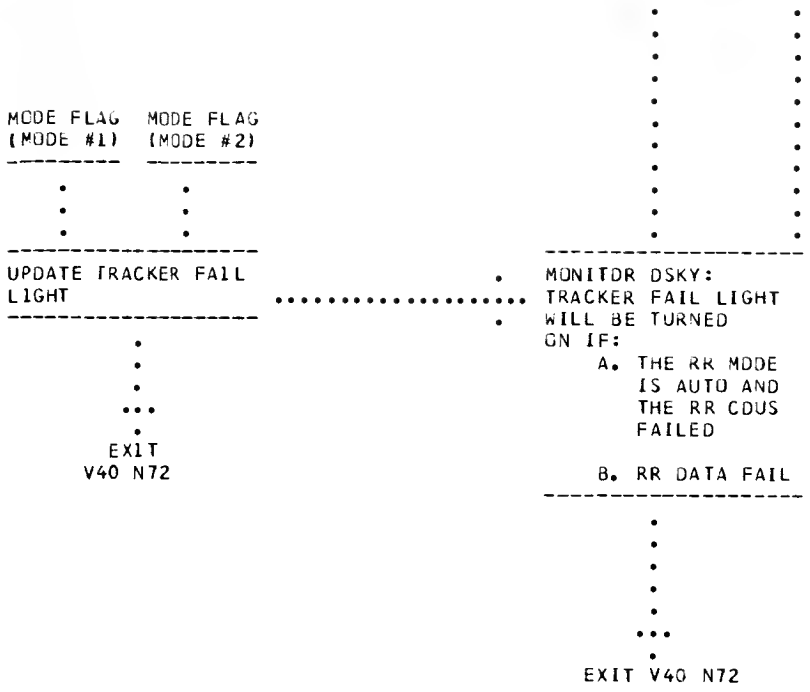
#140

#150

#160

#170

#180



#190

#200

#210

CHANGE CONTROL NOTES

LOGIC REV 00 PCR 496
LOGIC REV 01 EDITORIAL
REV 02(LUM 18) PCR 848,EDITORIAL
REV 03 EDITORIAL
REV 04(LUM 10) PCR 892
REV 05 PCN 1180

V41N20, COARSE ALIGN IMU CODS REV 05 12/01/71

PURPOSE: (1) TO COARSE ALIGN THE IMU TO GIMBAL ANGLES SPECIFIED BY THE ASTRONAUT.

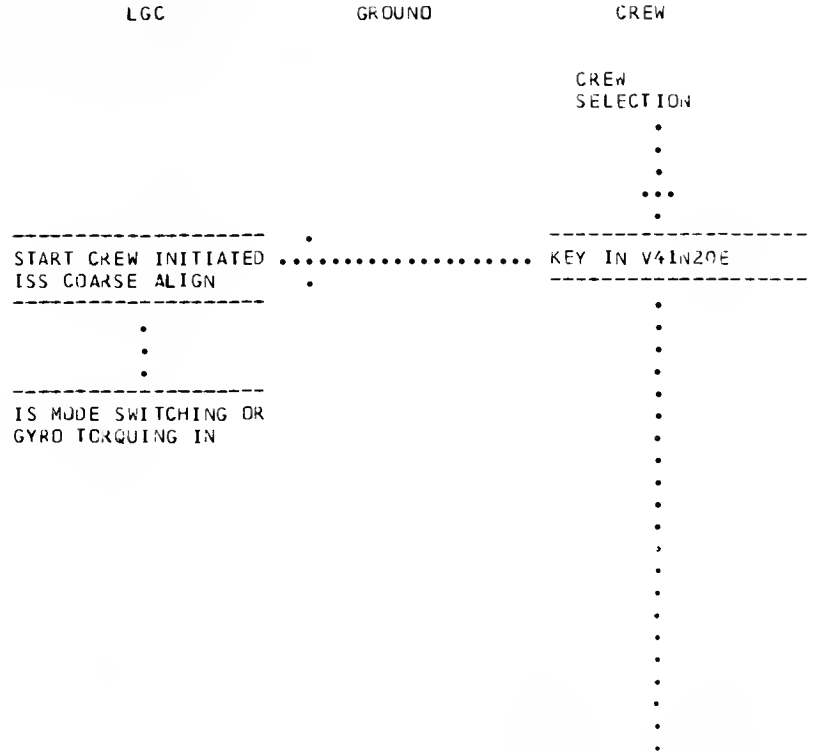
ASSUMPTIONS: (1) EXTENDED VERB V41 MAY BE CREW SELECTED ONLY WHEN NO OTHER EXTENDED VERB WHICH HAS SET THE EXTENDED VERB INTERLOCK IS ACTIVE. IT MAY NOT BE SELECTED WHEN AN ICDU ZERO IS IN PROCESS, NOR WHEN GYRO TORQUING IS IN PROCESS, NOR WHEN A PREVIOUSLY SELECTED COARSE ALIGNMENT IS IN PROGRESS. V41N20 IS INHIBITED WHILE THE GIMBALS ARE BEING TORQUED TO A DESIRED COARSE ALIGN ATTITUDE, BUT IS NOT INHIBITED WHEN IN THE COARSE ALIGN MODE IF THE GIMBALS ARE NOT BEING TORQUED.

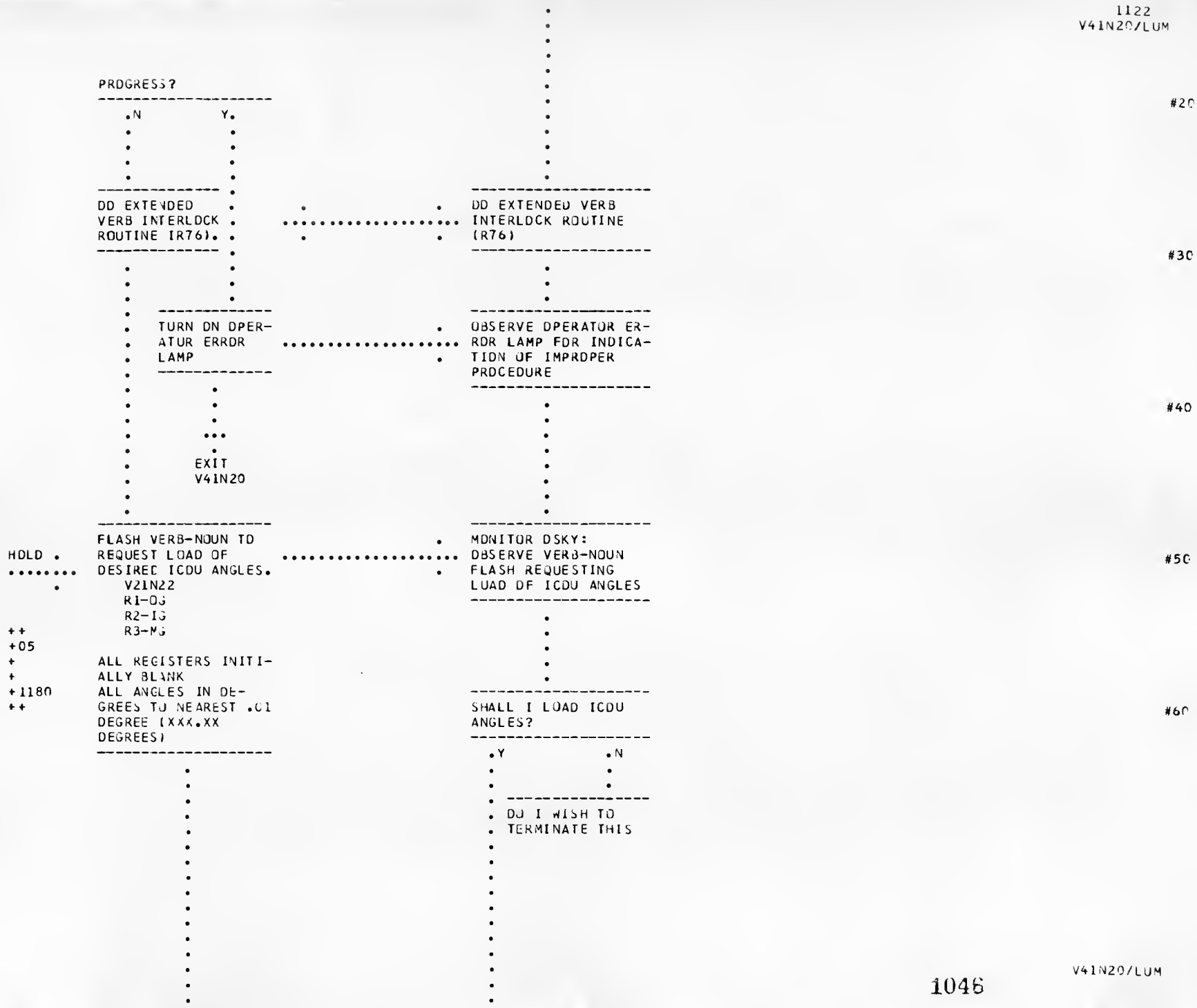
(2) V41 MAY ONLY BE USED WITH N20(ICDU ANGLES) OR WITH N72(RR CDU ANGLES).

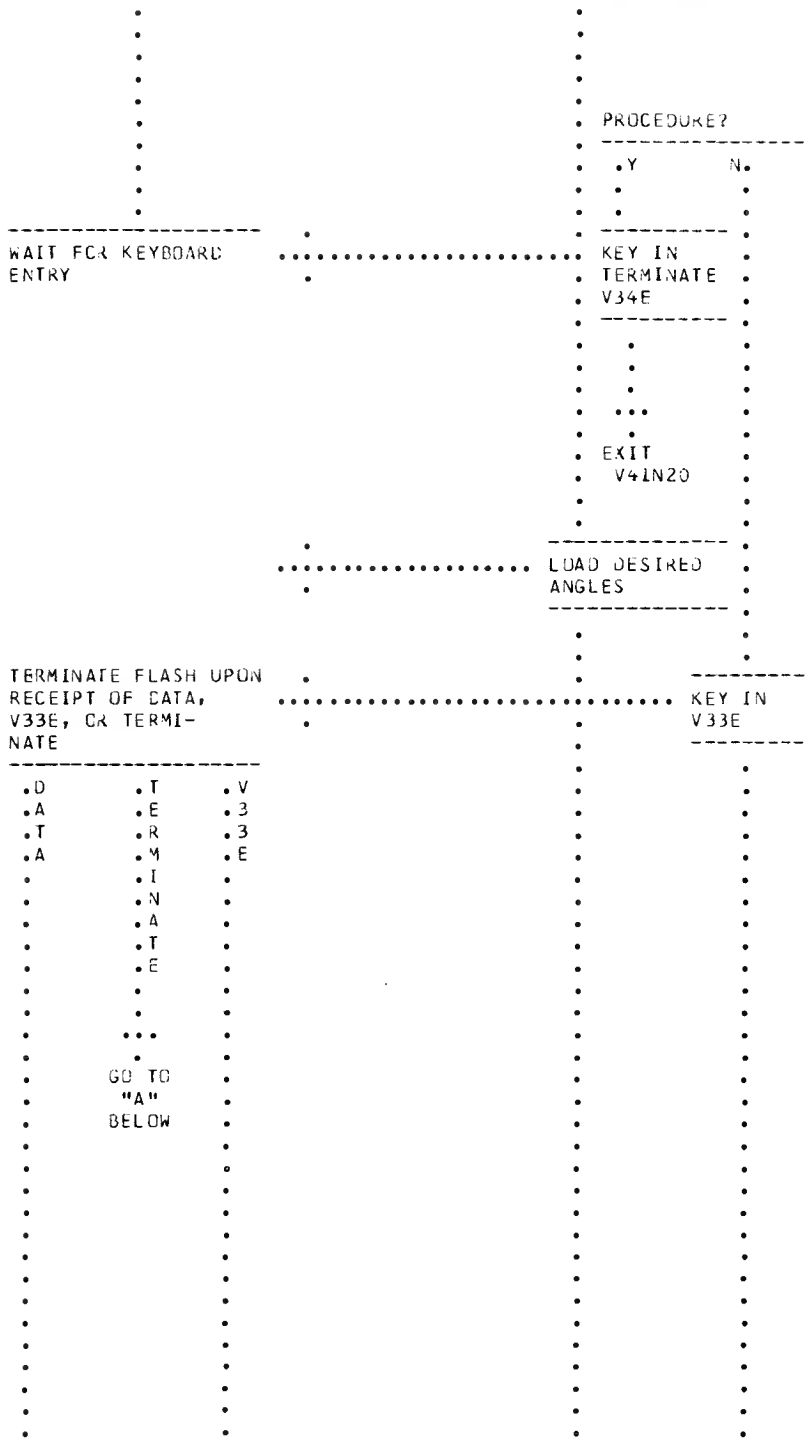
(3) THE ACCURACY OF THE ALIGNMENT IS TESTED TO A TOLERANCE OF +2 DEGREES. IF THIS TOLERANCE IS EXCEEDED, THE ASTRONAUT IS NOTIFIED VIA A PROGRAM ALARM (00211).

(4) THIS PROCESS RESETS THE TRACK FLAG AND THE REFSMMAT FLAG AND DISABLES IMU COMPENSATION AND THE DAP.

(5) AFTER ACCOMPLISHING COARSE ALIGNMENT, THE COARSE ALIGN MODE MAY BE TERMINATED BY KEYING IN V42N20E.




PROGRESS?
N
Y
DD EXTENDED VERB INTERLOCK ROUTINE (R76).
TURN ON OPERATOR ERROR LAMP
EXIT V41N20
FLASH VERB-NOUN TO REQUEST LOAD OF DESIRED ICDU ANGLES.
V21N22
R1-OG
R2-IG
R3-MG
HOLD
ALL REGISTERS INITIALLY BLANK
ALL ANGLES IN DEGREES TO NEAREST .01 DEGREE (XXX.XX DEGREES)
DD EXTENDED VERB INTERLOCK ROUTINE (R76)
OBSERVE OPERATOR ERROR LAMP FOR INDICATION OF IMPROPER PROCEDURE
MONITOR DSKY: OBSERVE VERB-NOUN FLASH REQUESTING LOAD OF ICDU ANGLES
SHALL I LOAD ICDU ANGLES?
Y
N
DO I WISH TO TERMINATE THIS
#20
#30
#40
#50
#60



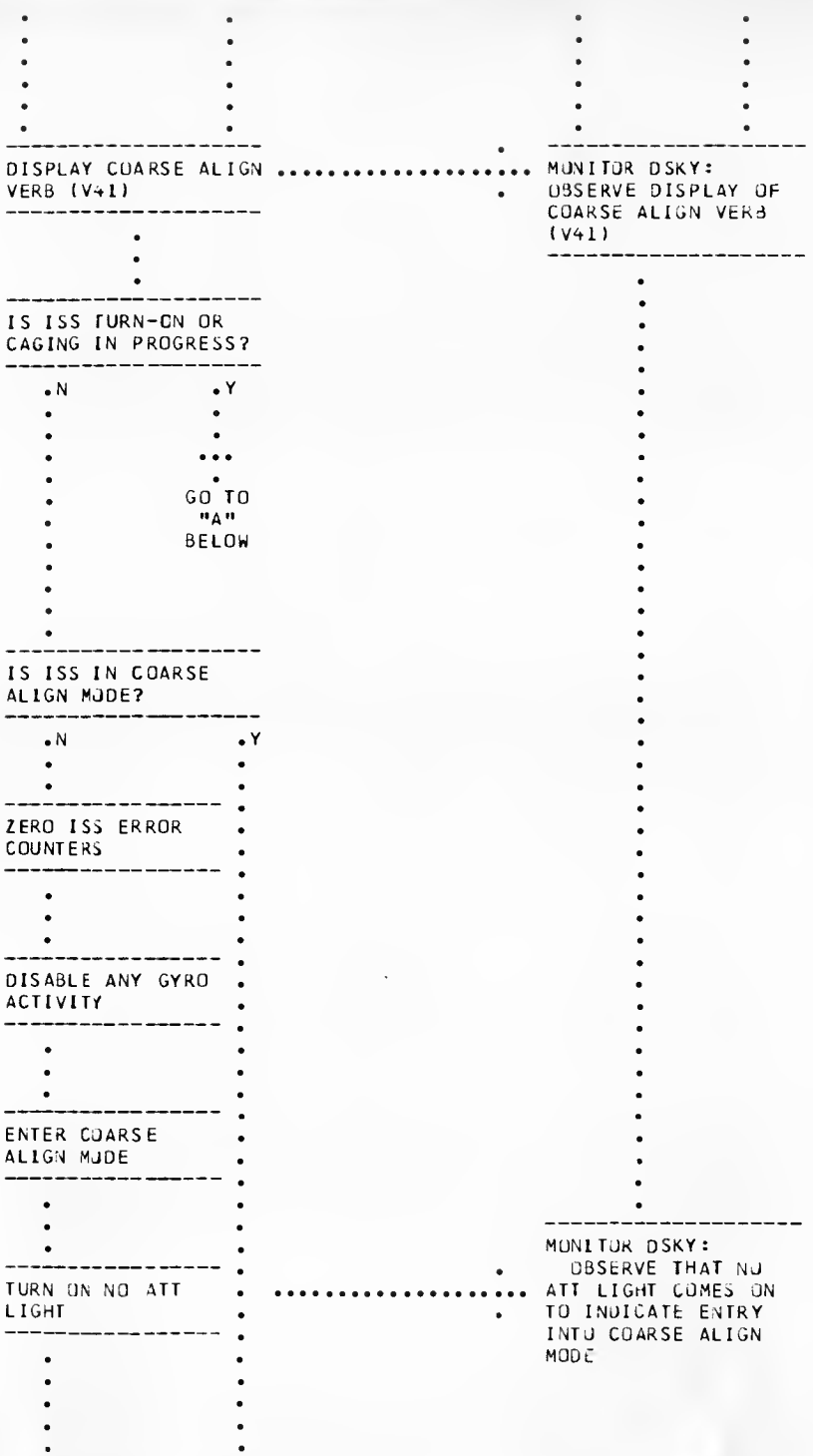
#70

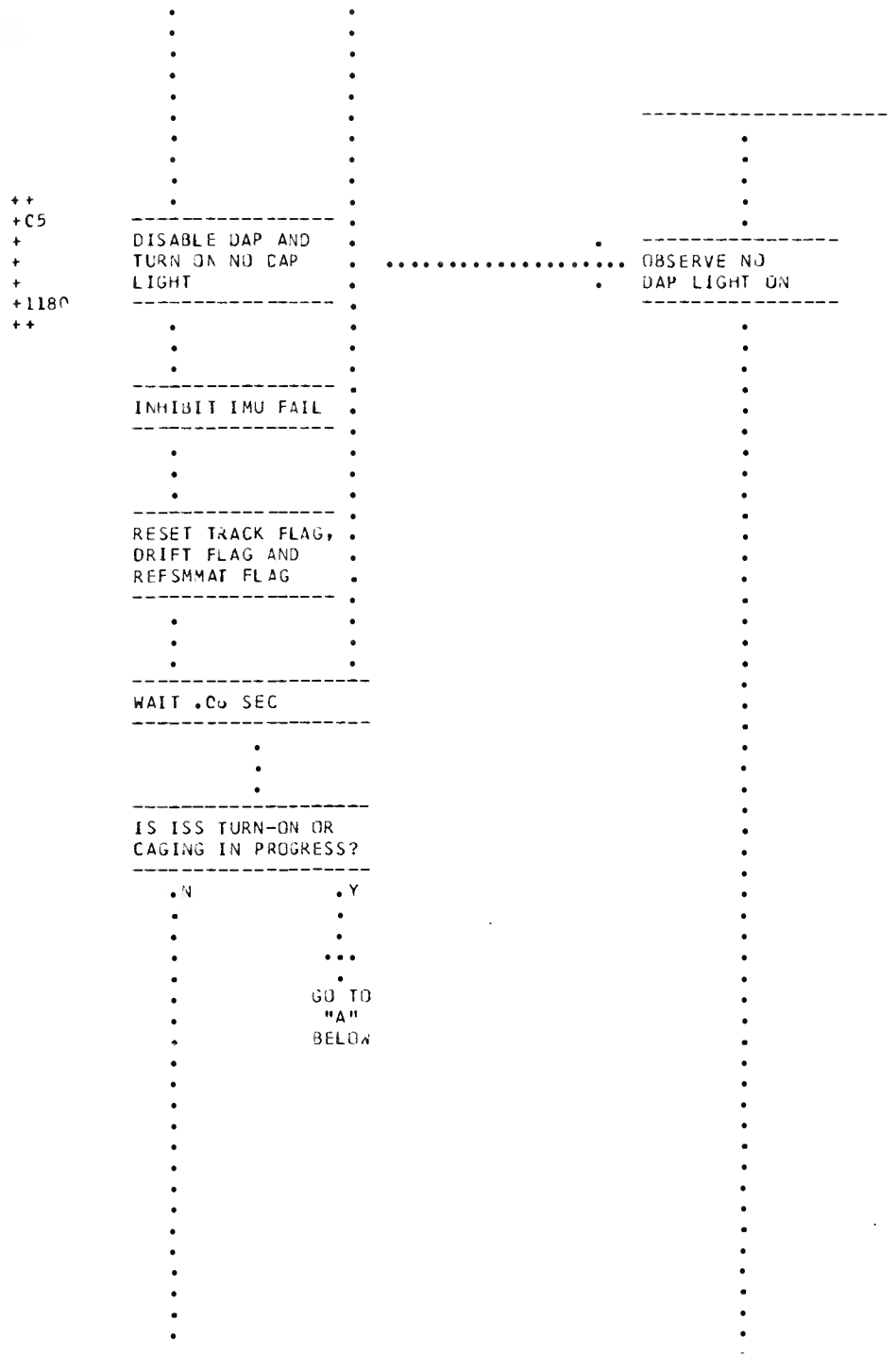
#80

#90

#100

#110


DISPLAY COARSE ALIGN VERB (V41)
MONITOR DSKY: OBSERVE DISPLAY OF COARSE ALIGN VERB (V41)
#120
IS ISS TURN-ON OR CAGING IN PROGRESS?
.N
.Y
GO TO "A" BELOW
#130
IS ISS IN COARSE ALIGN MODE?
.N
.Y
#140
ZERO ISS ERROR COUNTERS
#150
DISABLE ANY GYRO ACTIVITY
#160
ENTER COARSE ALIGN MODE
TURN ON NO ATT LIGHT
MONITOR DSKY: OBSERVE THAT NO ATT LIGHT COMES ON TO INDICATE ENTRY INTO COARSE ALIGN MODE
#170

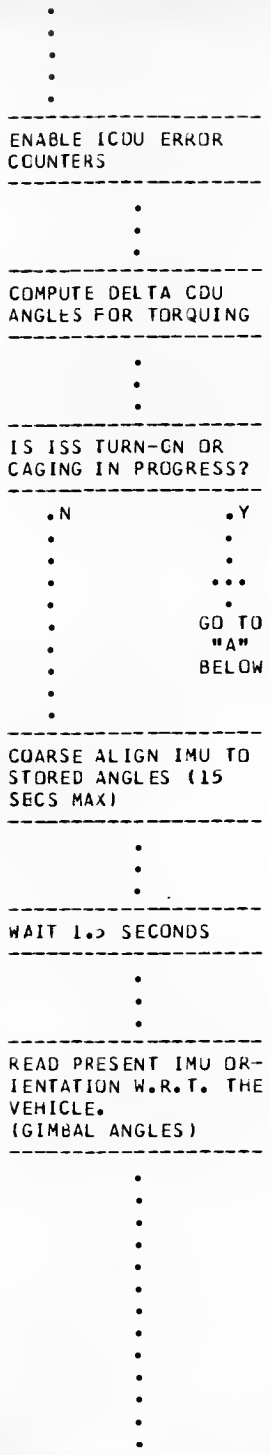


#180

#190

#200

#210



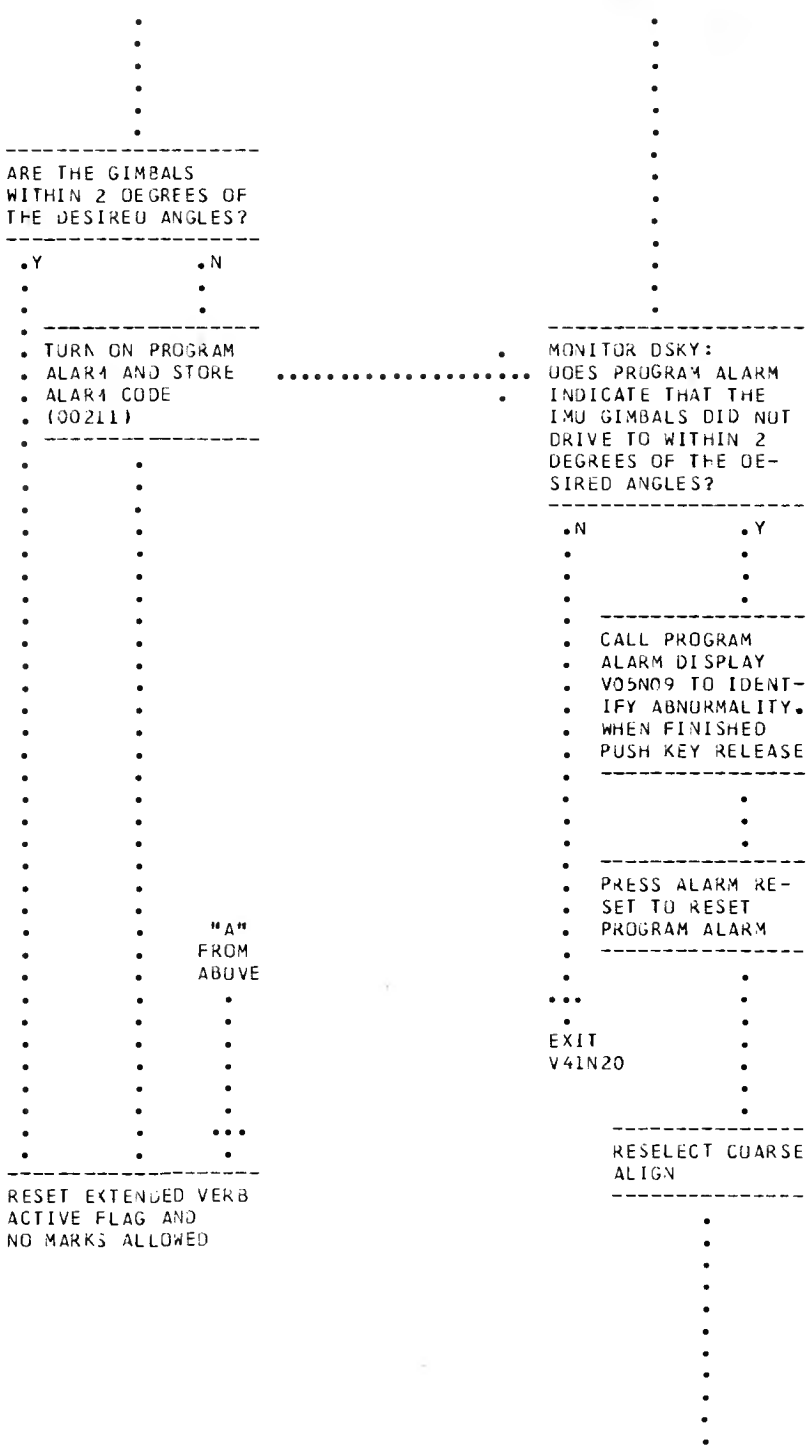
#220

#230

#240

#250

#260


ARE THE GIMBALS WITHIN 2 DEGREES OF THE DESIRED ANGLES?
Y
N
TURN ON PROGRAM ALARM AND STORE ALARM CODE (00211)
"A" FROM ABOVE
RESET EXTENDED VERB ACTIVE FLAG AND NO MARKS ALLOWED
MONITOR DSKY: DOES PROGRAM ALARM INDICATE THAT THE IMU GIMBALS DID NOT DRIVE TO WITHIN 2 DEGREES OF THE DESIRED ANGLES?
N
Y
CALL PROGRAM ALARM DISPLAY V05N09 TO IDENTIFY ABNORMALITY. WHEN FINISHED PUSH KEY RELEASE
PRESS ALARM RESET TO RESET PROGRAM ALARM
EXIT V41N20
RESELECT COARSE ALIGN
#270
#280
#290
#300
#310
#320

#330

CHANGE CONTROL NOTES

REV 00 PCR 185
REV 01 EDITORIAL
REV 02 EDITORIAL
REV 03 EDITORIAL
REV 04(LUM 1E) PCN 1145
REV 05 PCN 1180

V41N72, COARSE ALIGN RR CDUS REV 06 12/01/71

PURPOSE: (1) TO DRIVE THE RENDEZVOUS RADAR SHAFT AND TRUNNION TO ANGLES SPECIFIED BY THE ASTRONAUT.

ASSUMPTIONS: (1) THE PROCESS IS CREW SELECTED BY DSKY ENTRY.

(2) THE PROCESS MAY NOT BE SELECTED WHEN ANOTHER EXTENDED VERB WHICH ALSO SETS THE EXTENDED VERB INTERLOCK IS ACTIVE.

++
+06
+
+1180
++ (3) THIS PROCESS MAY BE SELECTED AT ANY TIME EXCEPT WHEN A READ SEQUENCE OF EITHER RADAR OR A RR DESIGNATE IS IN PROGRESS, OR WHEN THE TRACK FLAG IS SET (IT IS SET BY P20, P22, P25, P30, P32-35, P72-77).

++ (4) THE CONTINUOUS DESIGNATE MODE MUST BE TERMINATED BY DSKY ENTRY OF V44.

(5) THE CONTINUOUS DESIGNATE MODE INHIBITS RR GIMBAL MONITOR ROUTINE (R25).

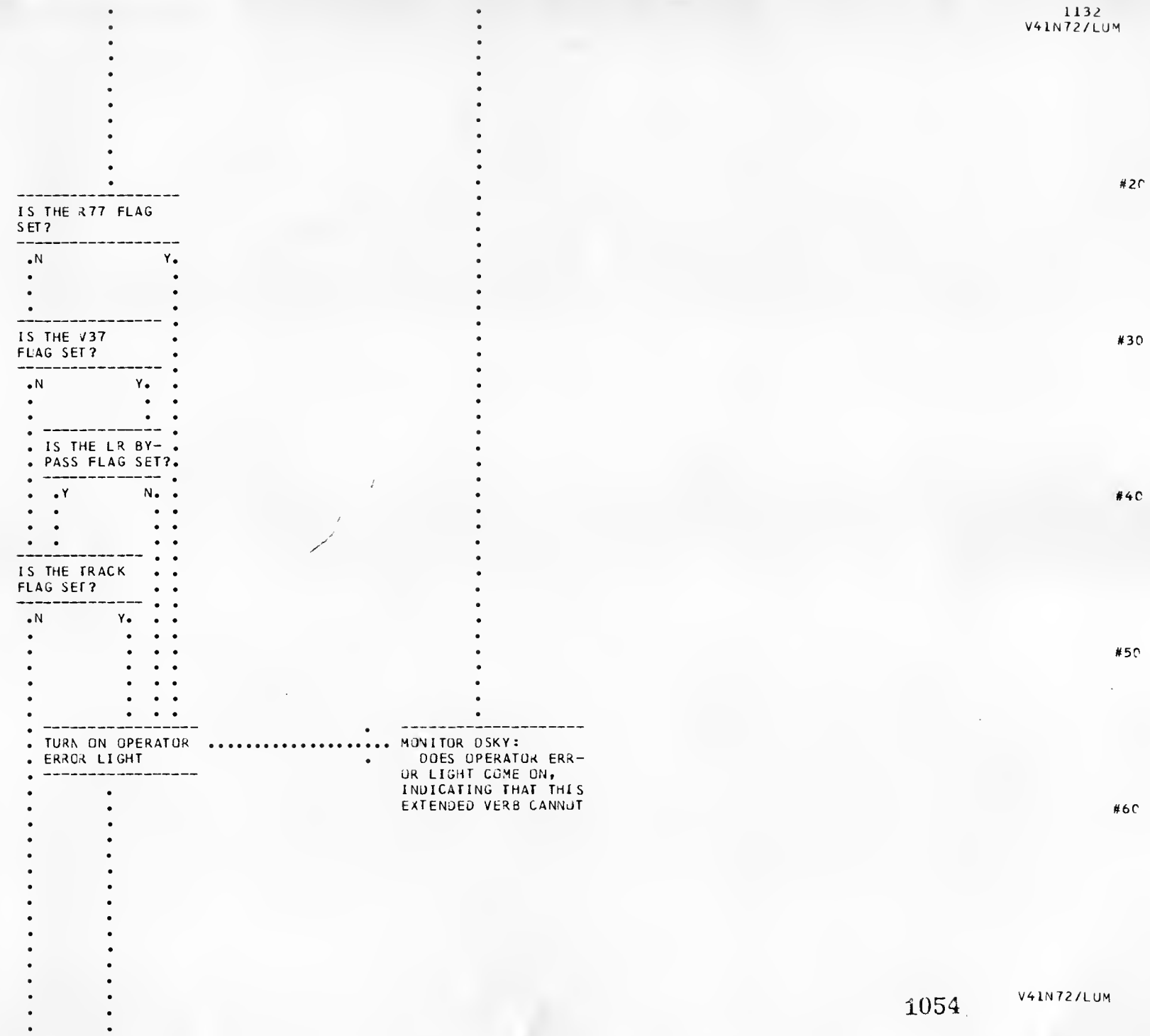
(6) THE RR SHAFT AND TRUNNION LIMITS ARE:

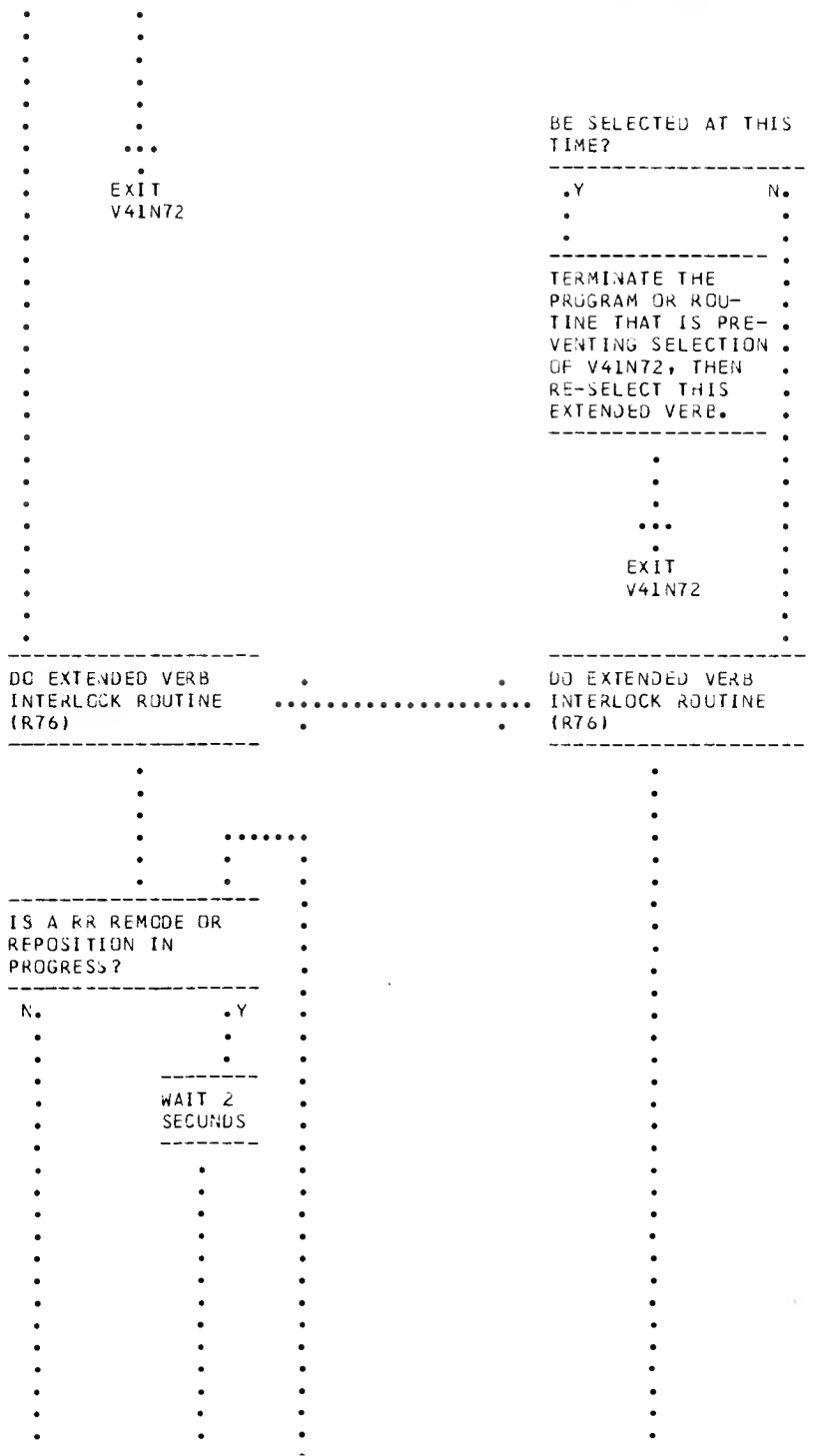
(A) MODE 1: SHAFT -70 DEG TO +59 DEG, TRUNNION -55 DEG TO +55 DEG.

(B) MODE 2: SHAFT -25 DEG TO -139 DEG, TRUNNION -125 DEG TO -235 DEG.

(C) MODE 1, CONTINUOUS DESIGNATE ONLY: SHAFT -85 DEG., TO +59 DEG., TRUNNION -55 DEG. TO +55 DEG.

#10


#20
IS THE R77 FLAG SET?
.N
Y.
#30
IS THE V37 FLAG SET?
.N
Y.
IS THE LR BY-PASS FLAG SET?
.Y
N.
#40
IS THE TRACK FLAG SET?
.N
Y.
#50
TURN ON OPERATOR ERROR LIGHT
MONITOR DSKY:
DOES OPERATOR ERROR LIGHT COME ON, INDICATING THAT THIS EXTENDED VERB CANNOT
#60

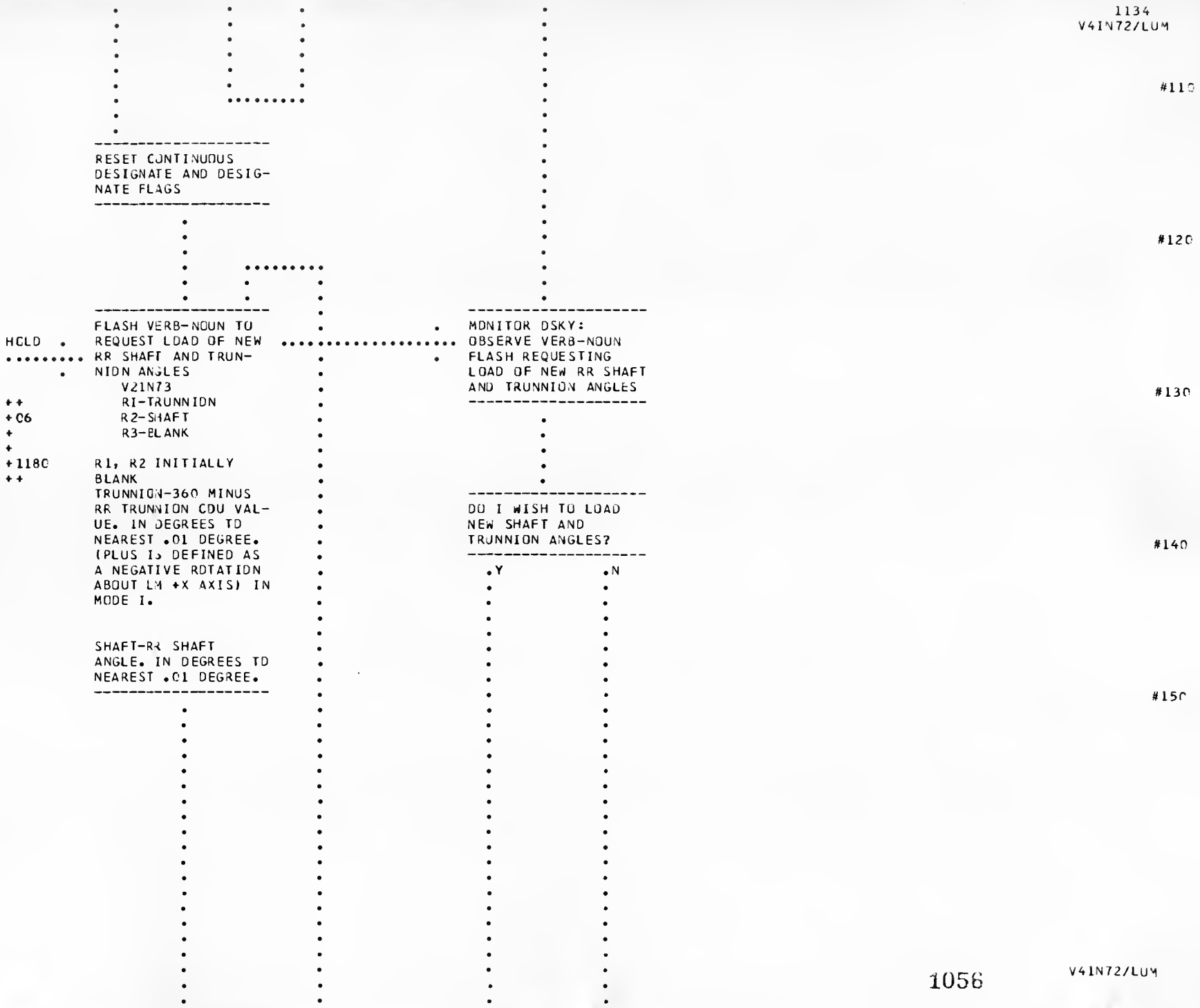

EXIT
V41N72
BE SELECTED AT THIS TIME?
Y
N
TERMINATE THE PROGRAM OR ROUTINE THAT IS PREVENTING SELECTION OF V41N72, THEN RE-SELECT THIS EXTENDED VERB.
EXIT
V41N72
DO EXTENDED VERB INTERLOCK ROUTINE (R76)
DO EXTENDED VERB INTERLOCK ROUTINE (R76)
IS A RR REMODE OR REPOSITION IN PROGRESS?
N
Y
WAIT 2 SECONDS

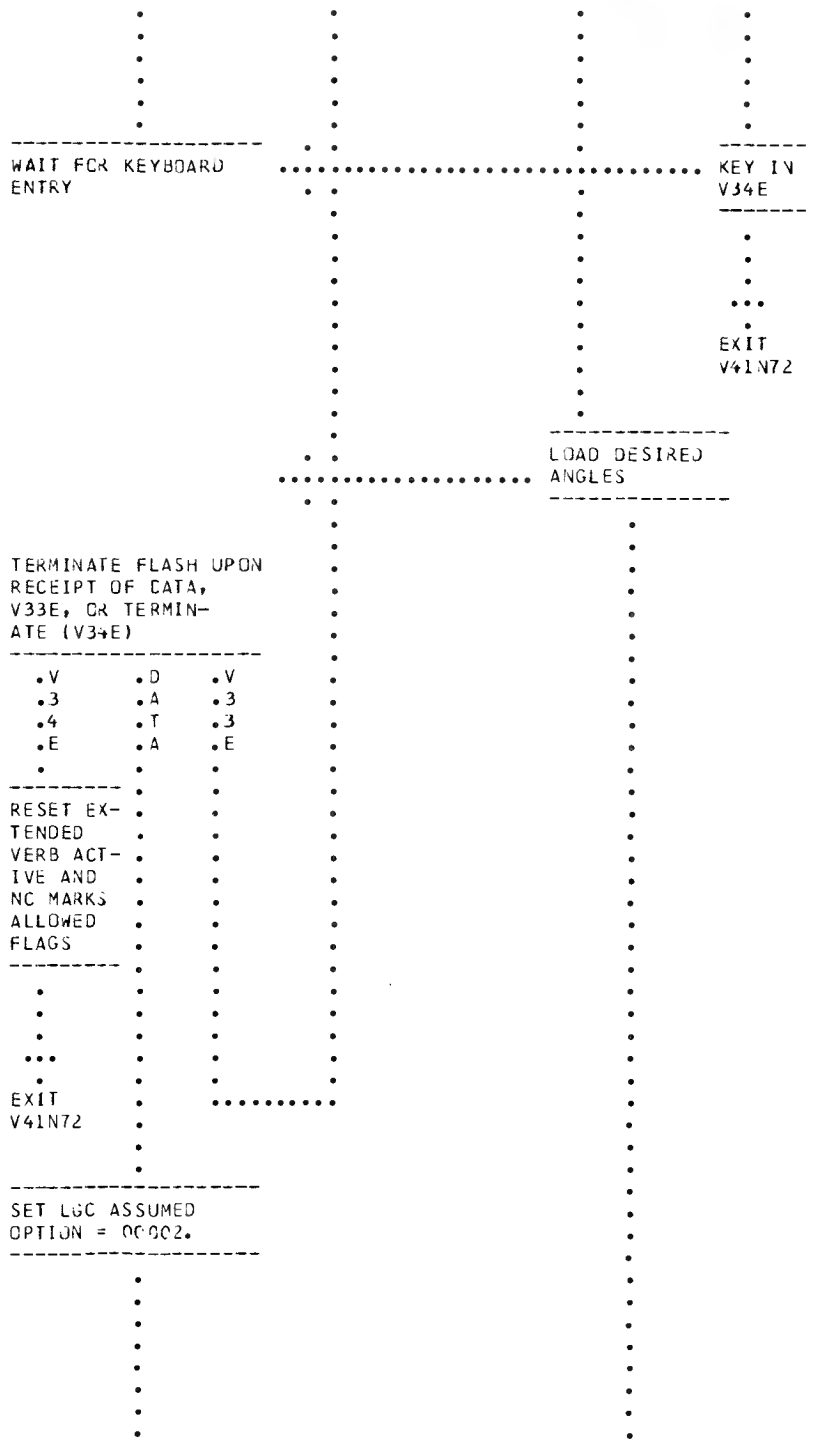
#70

#80

#90

#100


RESET CONTINUOUS DESIGNATE AND DESIGNATE FLAGS
#110
#120
FLASH VERB-NOUN TO REQUEST LOAD OF NEW RR SHAFT AND TRUNNION ANGLES
V21N73
R1-TRUNNION
R2-SHAFT
R3-BLANK
HOLD
+ +
+06
+
+
+1180
+ +
R1, R2 INITIALLY BLANK
TRUNNION-360 MINUS RR TRUNNION CDU VALUE. IN DEGREES TO NEAREST .01 DEGREE. (PLUS IS DEFINED AS A NEGATIVE ROTATION ABOUT LM +X AXIS) IN MODE 1.
SHAFT-RR SHAFT ANGLE. IN DEGREES TO NEAREST .01 DEGREE.
MONITOR DSKY: OBSERVE VERB-NOUN FLASH REQUESTING LOAD OF NEW RR SHAFT AND TRUNNION ANGLES
#130
DO I WISH TO LOAD NEW SHAFT AND TRUNNION ANGLES?
#140
.Y
.N
#150



#160

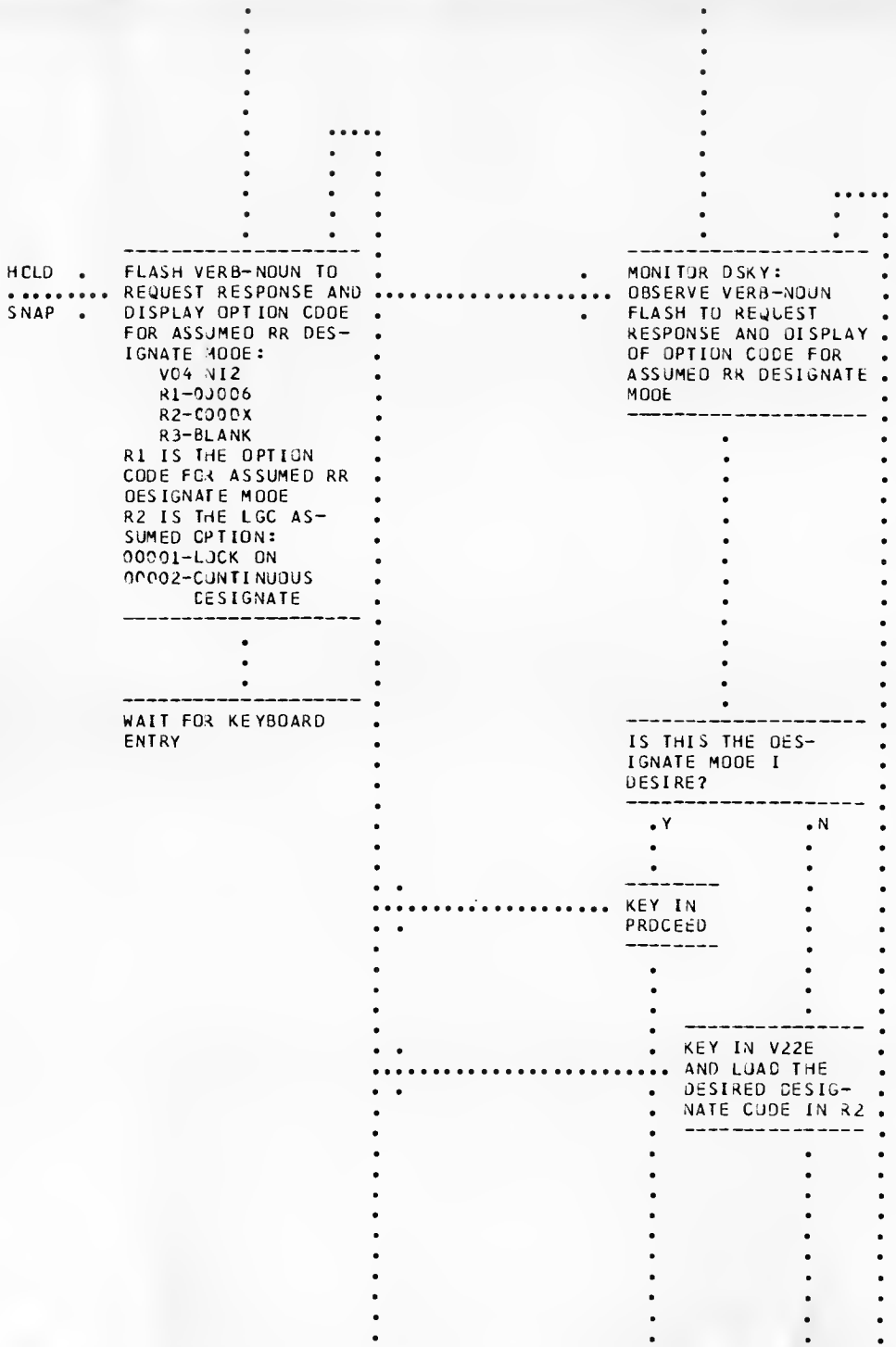
#170

#180

#190

#200

#210



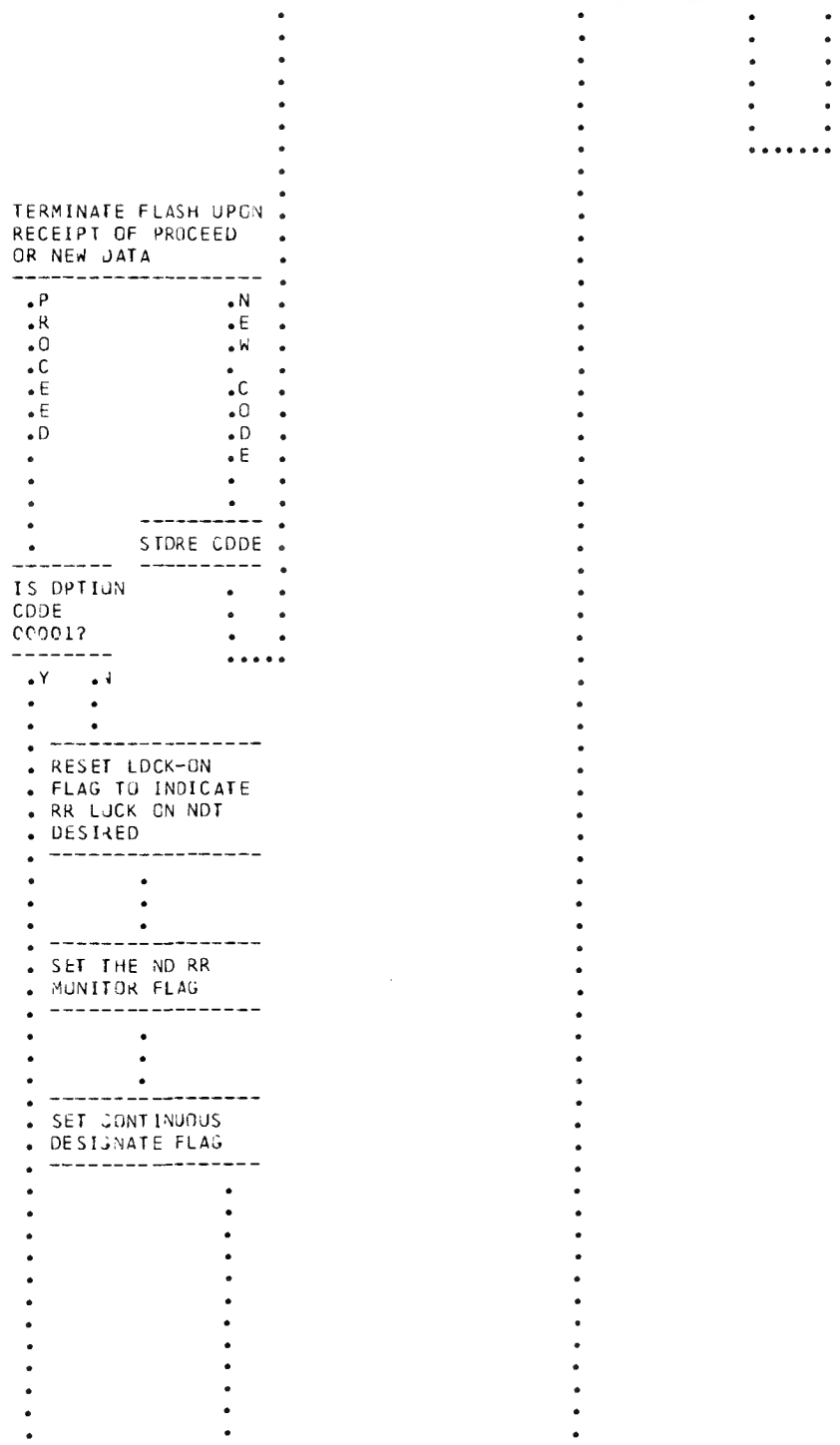
#220

#230

#240

#250

#260



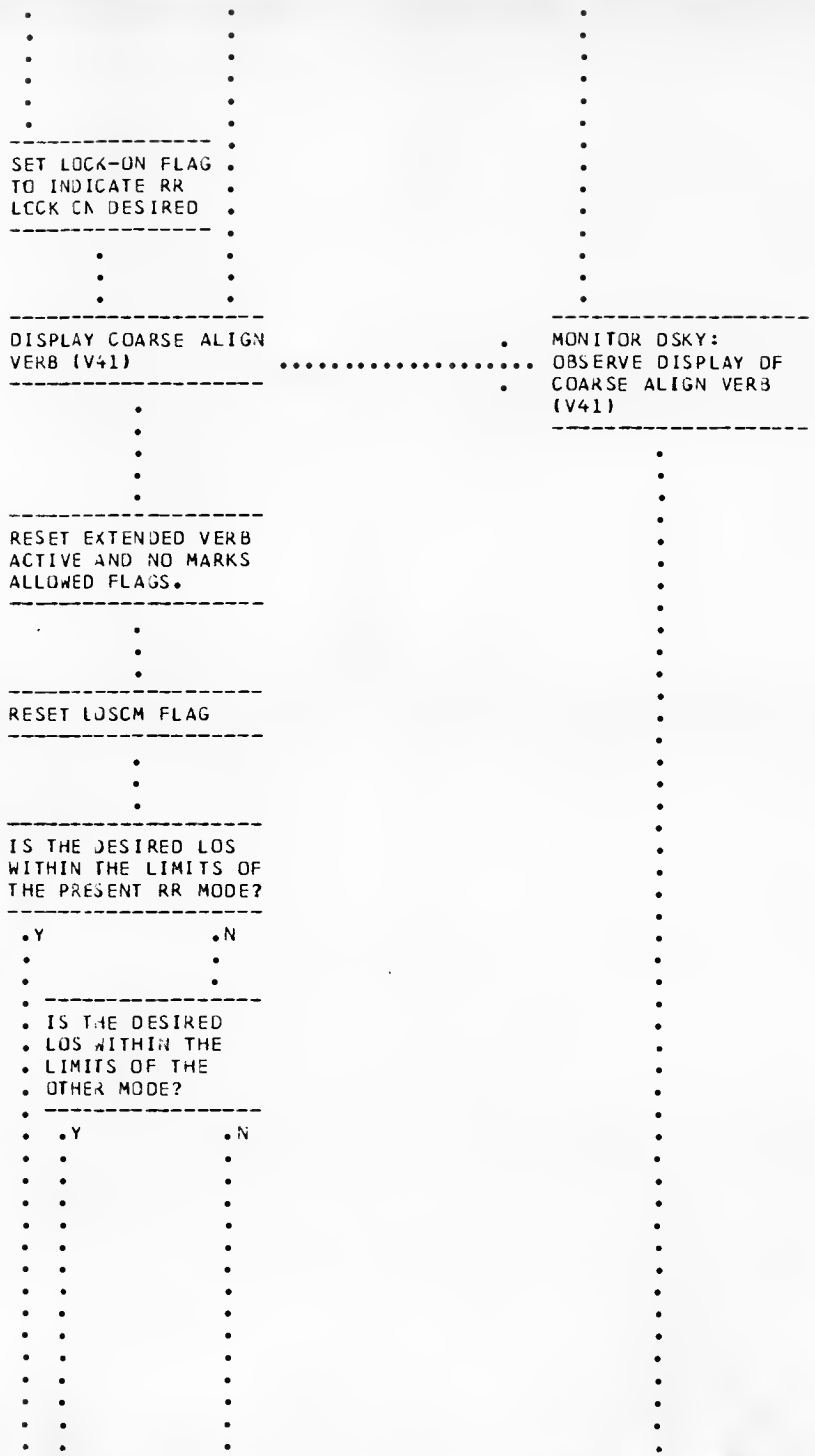
#270

#280

#290

#300

#310



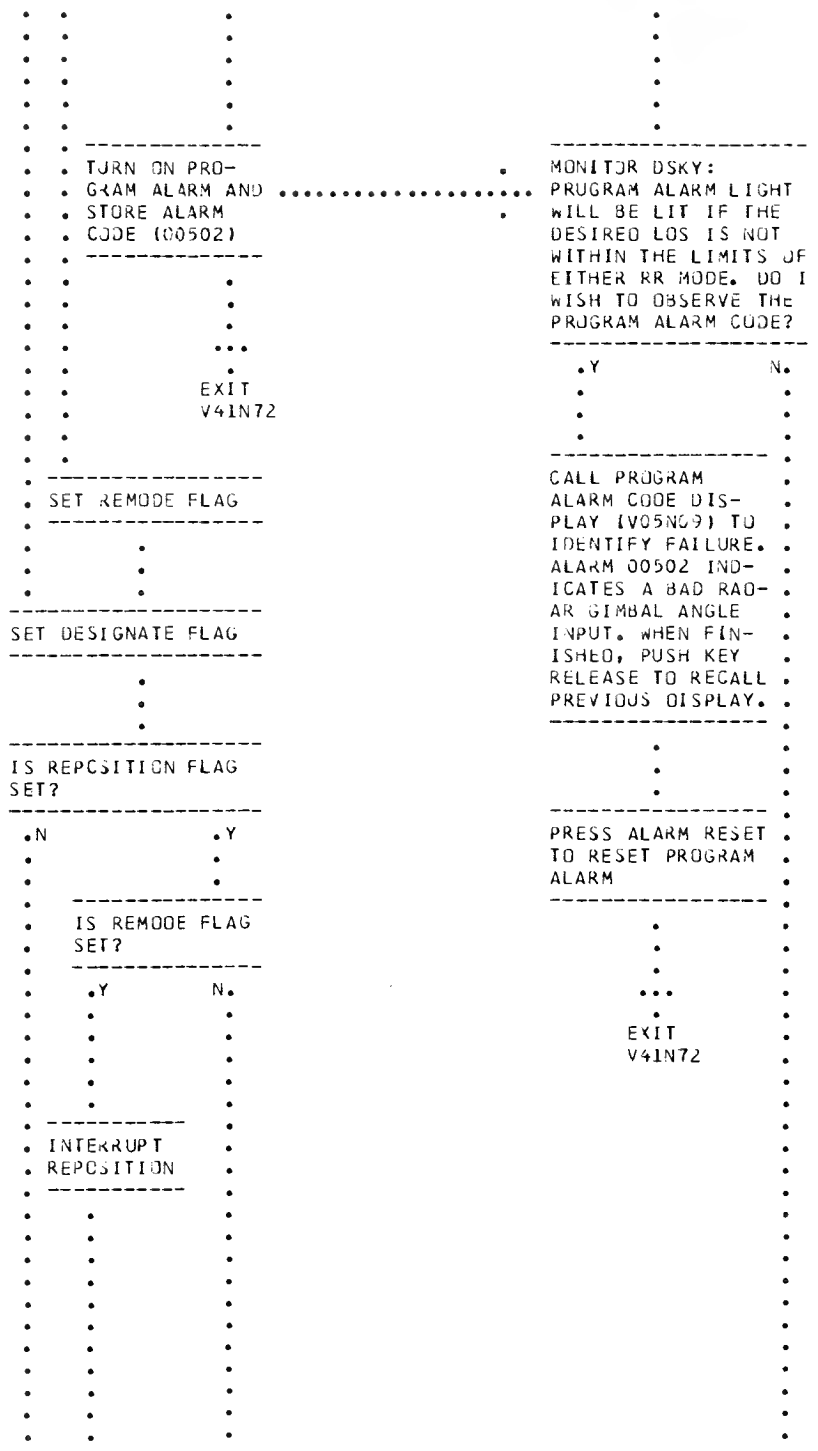
#320

#330

#340

#350

#360



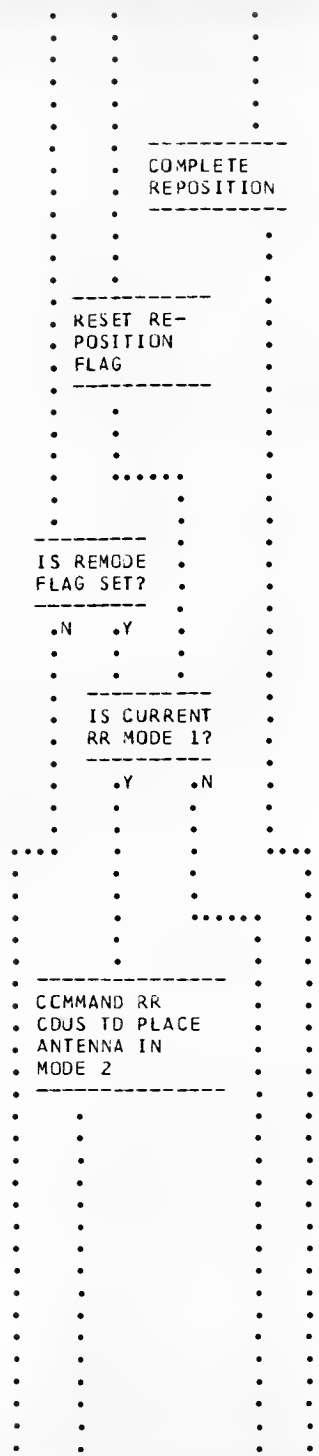
#370

#380

#390

#400

#410



#420

#430

#440

#450

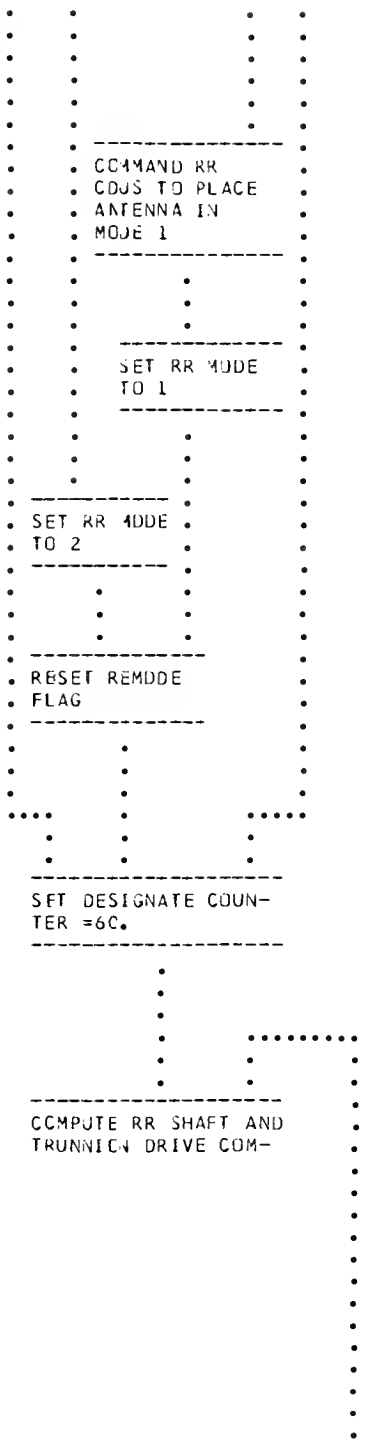
#46C

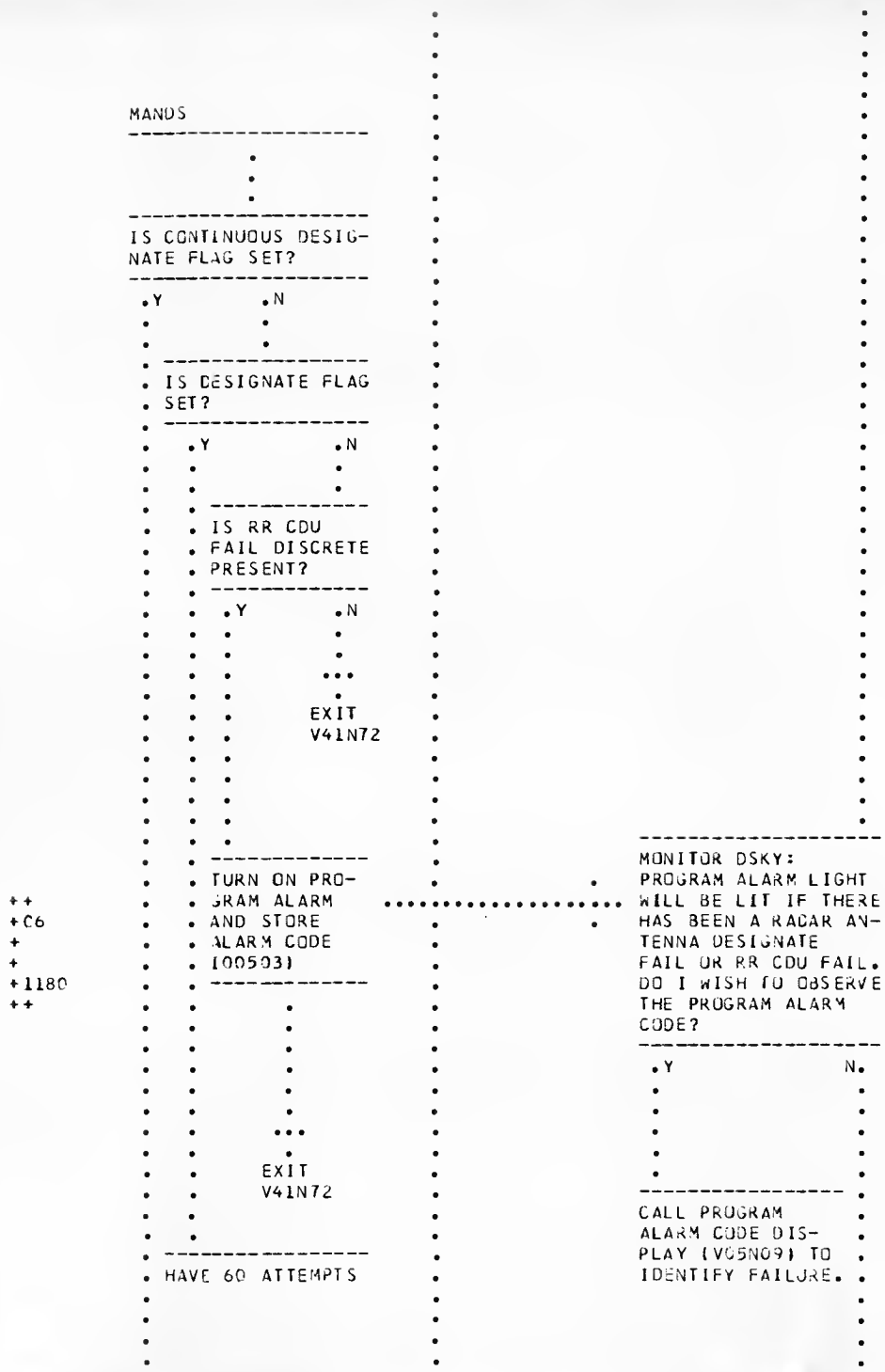
#47C

#48C

#49C

#50C





++
+C6
+
+
+1180
++

#510

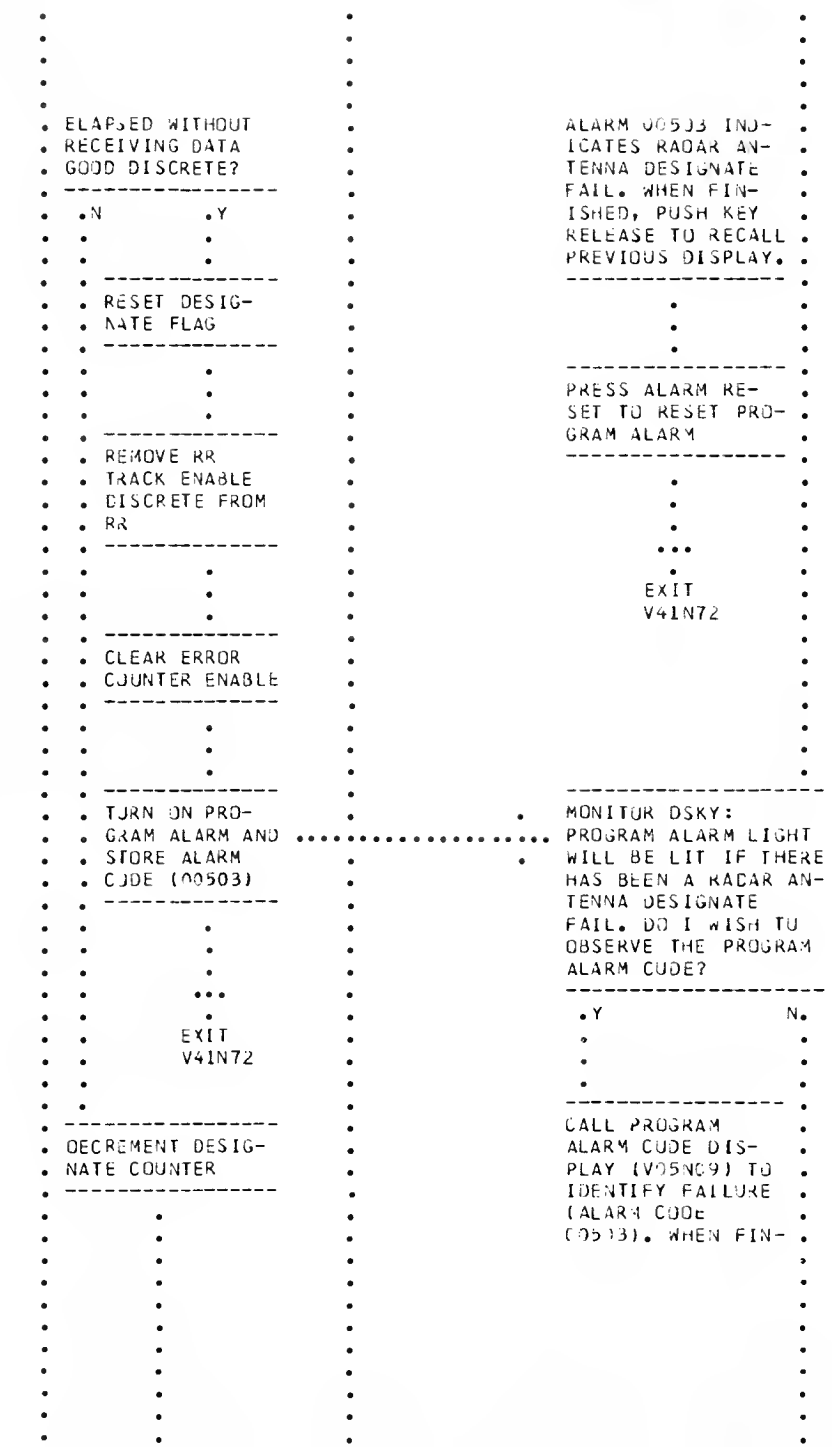
#520

#530

#540

#550

#560



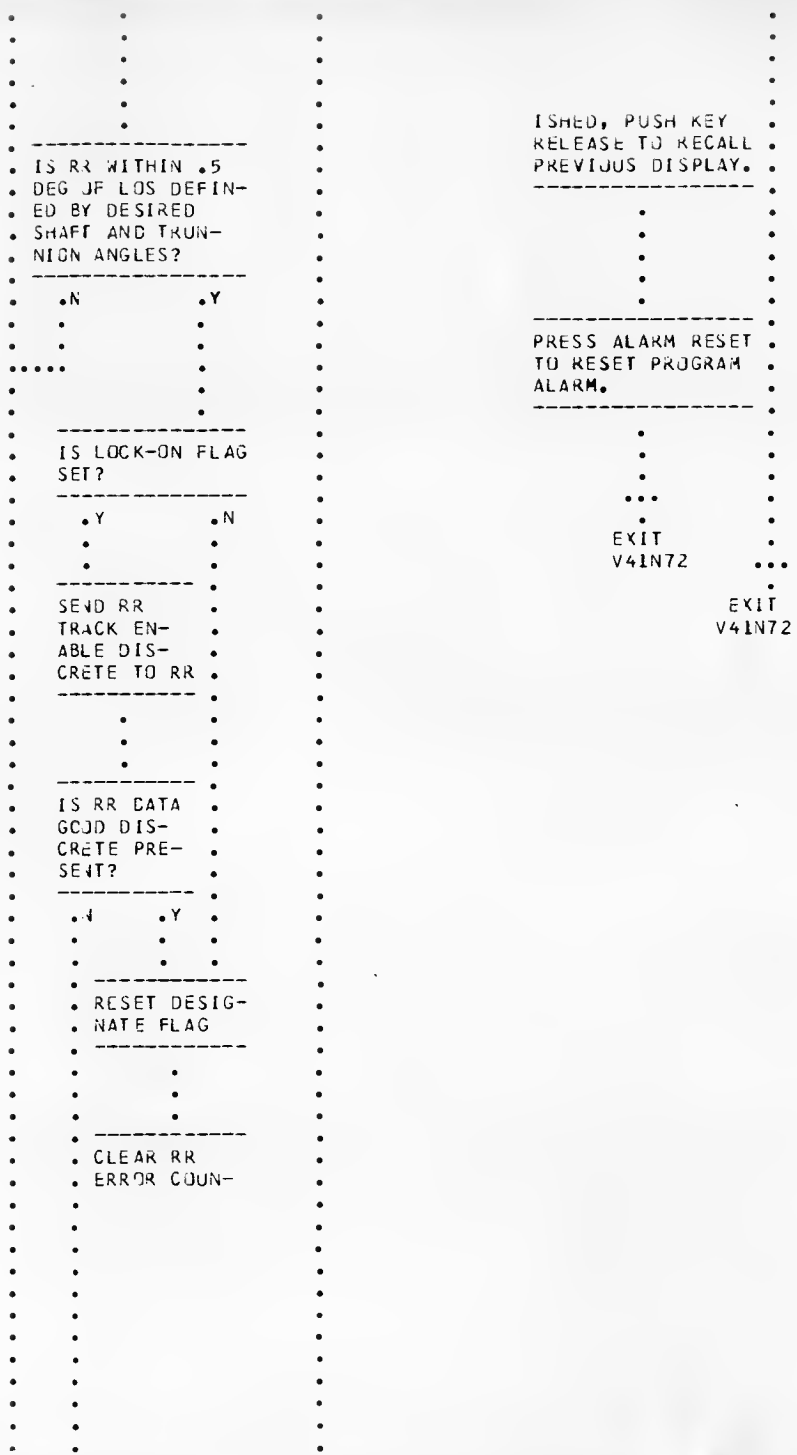
#570

#580

#590

#600

#610



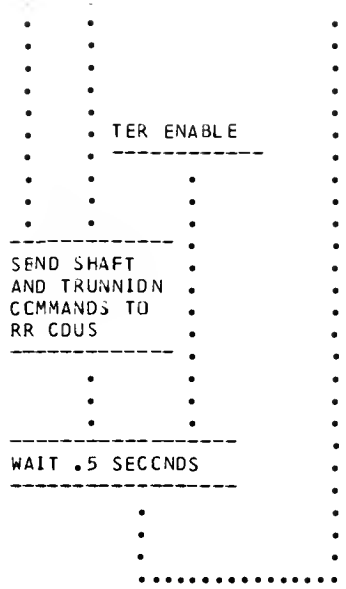
#620

#630

#640

#650

#660



#670

#680

CHANGE CONTROL NOTES

REV 00 PCR 96,185,490
REV 01 EDITORIAL
REV 02 EDITORIAL
REV 03 EDITORIAL
REV 04(LUM 1D) PCR 892
REV 05(LUM 1E) PCN 1145
REV 06 PCN 1180

V42, FINE ALIGN IMU REV C3 12/01/71

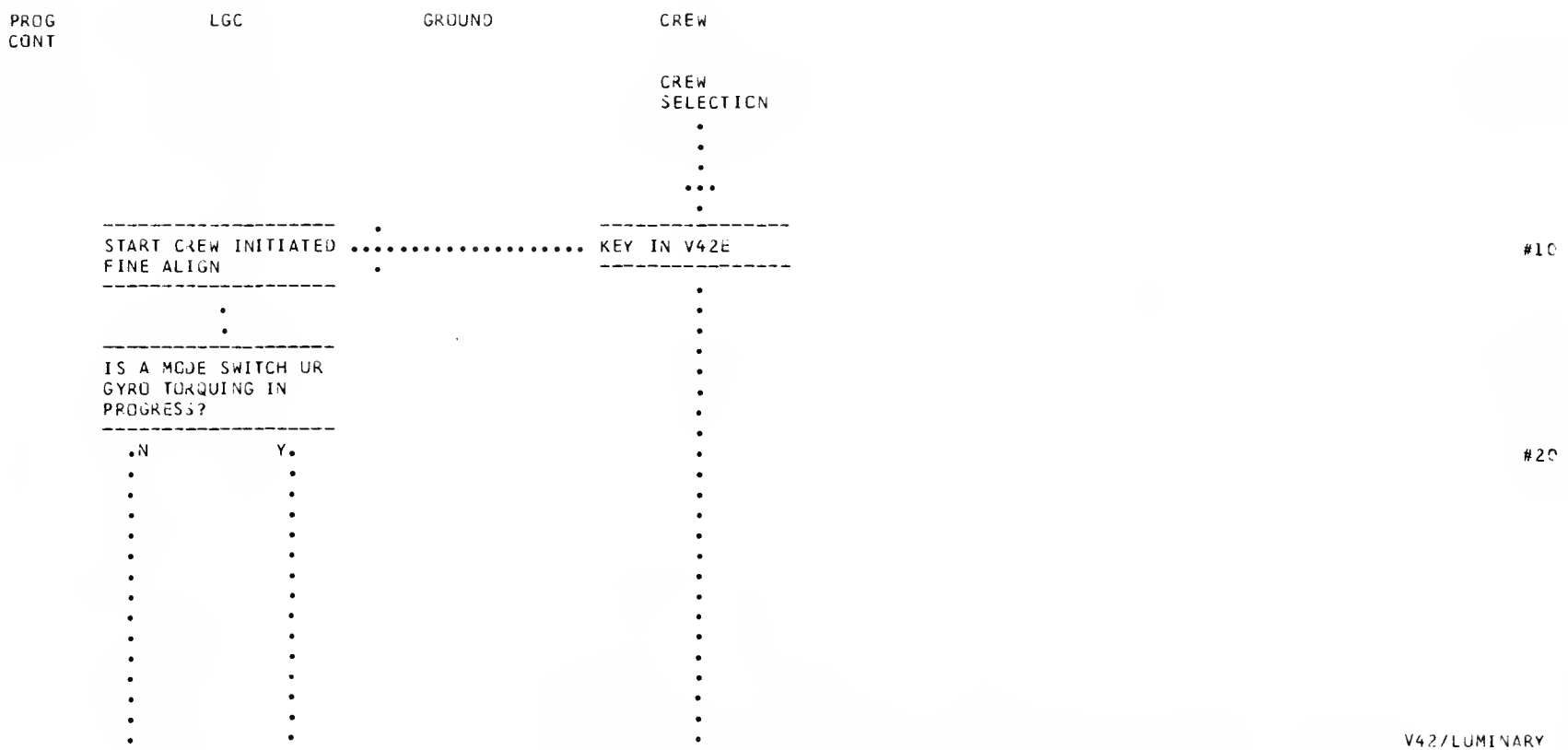
PURPOSE: (1) TO FINE ALIGN THE STABLE MEMBER BY TORQUING THE GYROS.

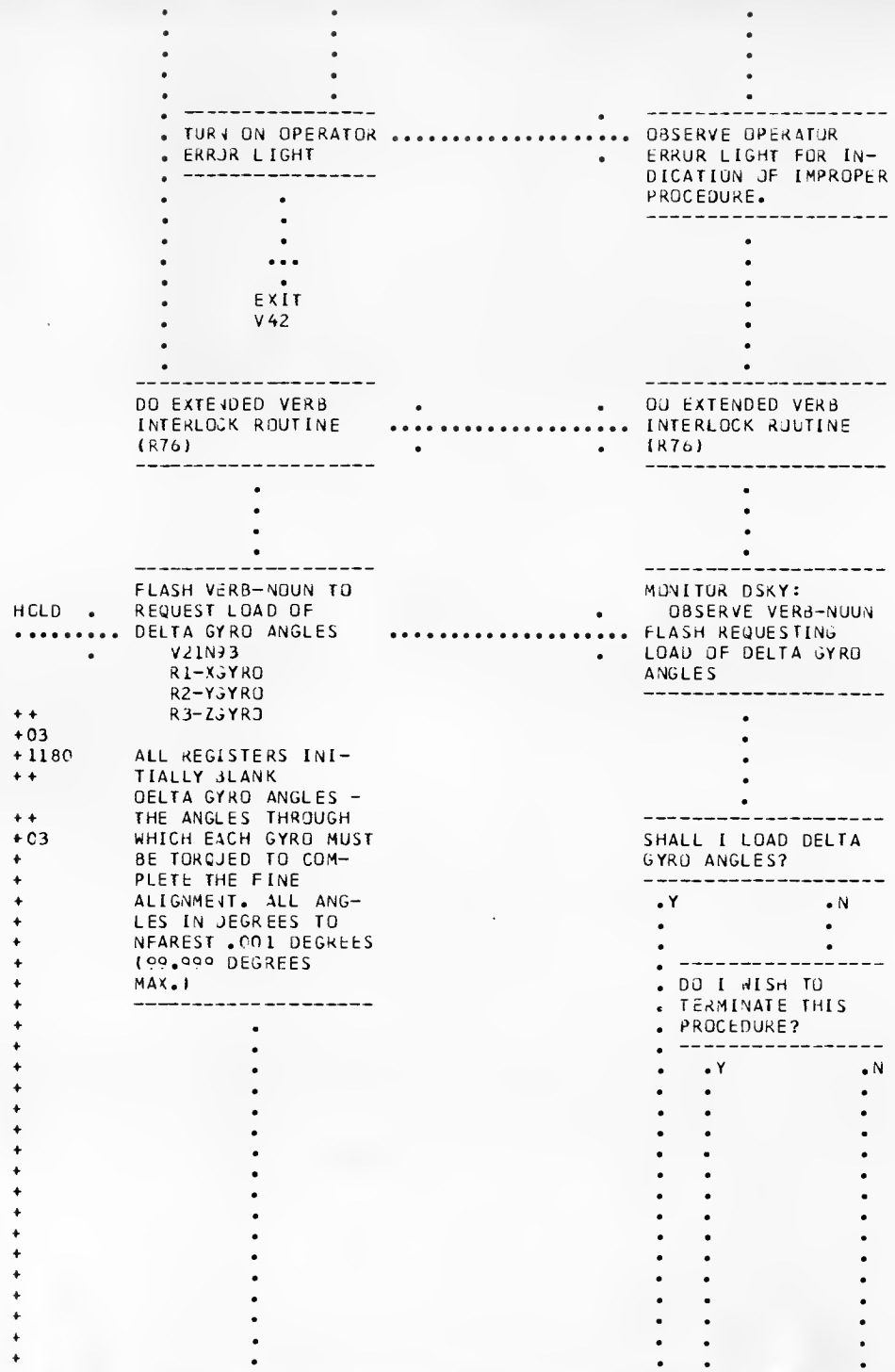
ASSUMPTIONS: (1) THE PROCESS IS CREW SELECTED BY DSKY ENTRY.

(2) VERB 42 MAY NOT BE SELECTED WHEN ANOTHER EXTENDED VERB WHICH ALSO SETS THE EXTENDED VERB INTERLOCK IS ACTIVE, OR WHEN ANOTHER PROGRAM IS TORQUING THE GYROS, ZEROING THE ISS CDUS, OR COARSE ALIGNING THE IMU.

(3) THIS VERB IS NOT PROGRAMMED TO ACCEPT DELTA GYRO ANGLES LARGER THAN 99.999 DEGREES. A SPECIAL PROCEDURE, FOR GROUND USE ONLY, MAKES USE OF A DOUBLE PRECISION LOAD COMBINED WITH V42 WHEN LARGE ANGLE GYRO TORQUING IS REQUIRED.

WARNING: THE DELTA GYRO ANGLES COMMANDED MUST BE LIMITED TO SUCH A SIZE AS NOT TO DRIVE THE MIDDLE GIMBAL INTO GIMBAL LOCK. IN PRACTICE, THIS MEANS THAT THE MIDDLE GIMBAL ANGLE SHOULD NEVER EXCEED 70 DEGREES (POINT AT WHICH GIMBAL LOCK WARNING LAMP IS LIT).




TURN ON OPERATOR ERROR LIGHT
EXIT V42
OBSERVE OPERATOR ERROR LIGHT FOR INDICATION OF IMPROPER PROCEDURE.
DO EXTENDED VERB INTERLOCK ROUTINE (R76)
DO EXTENDED VERB INTERLOCK ROUTINE (R76)
HOLD
FLASH VERB-NOUN TO REQUEST LOAD OF DELTA GYRO ANGLES
V21N93
R1-XGYRO
R2-YGYRO
R3-ZGYRO
MONITOR DSKY: OBSERVE VERB-NOUN FLASH REQUESTING LOAD OF DELTA GYRO ANGLES
+ +
+03
+1180
+ +
ALL REGISTERS INITIALLY BLANK
DELTA GYRO ANGLES - THE ANGLES THROUGH
+ +
+03
WHICH EACH GYRO MUST BE TORQUED TO COMPLETE THE FINE ALIGNMENT. ALL ANGLES IN DEGREES TO NEAREST .001 DEGREES (99.999 DEGREES MAX.)
SHALL I LOAD DELTA GYRO ANGLES?
.Y
.N
DO I WISH TO TERMINATE THIS PROCEDURE?
.Y
.N

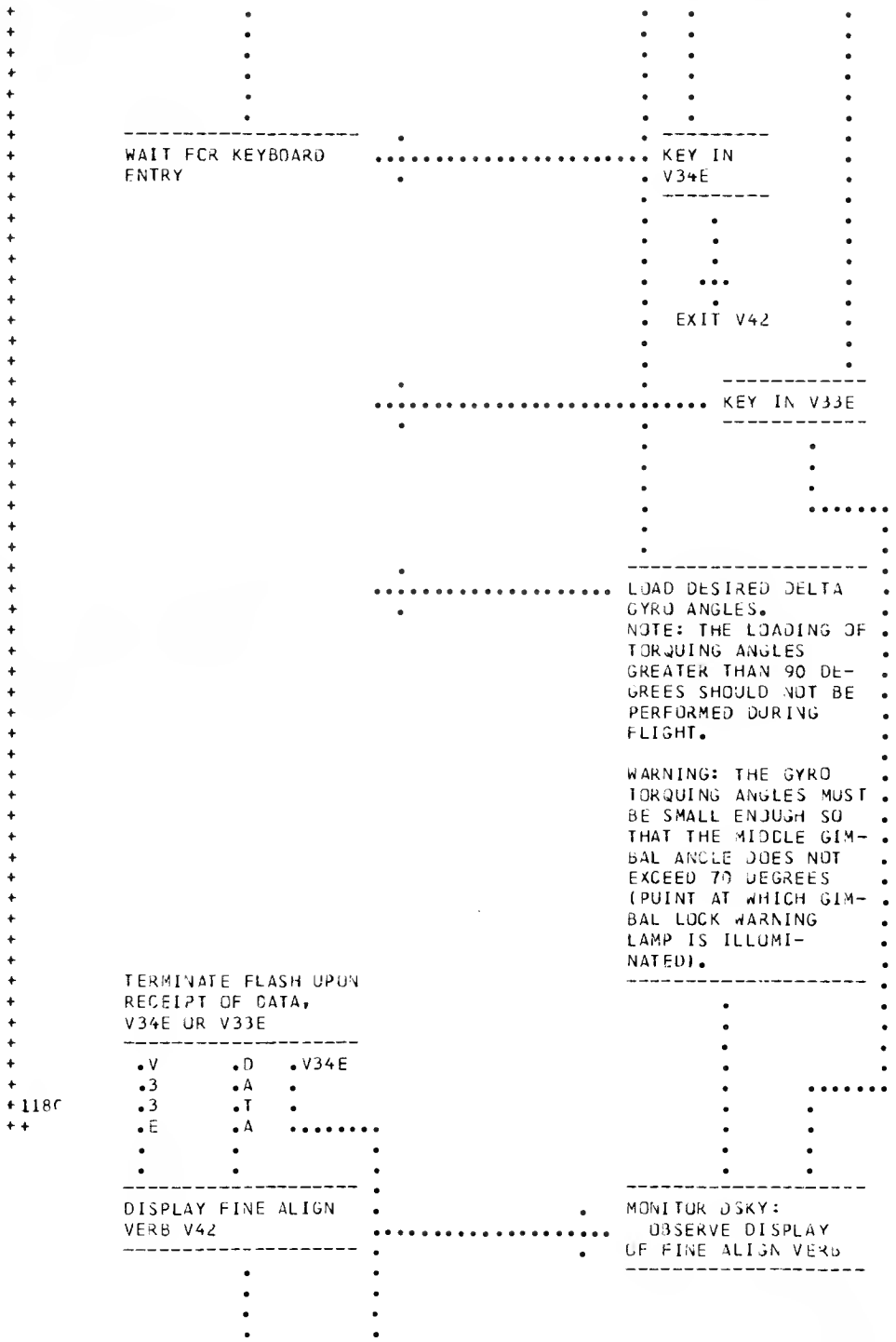
#3C

#4C

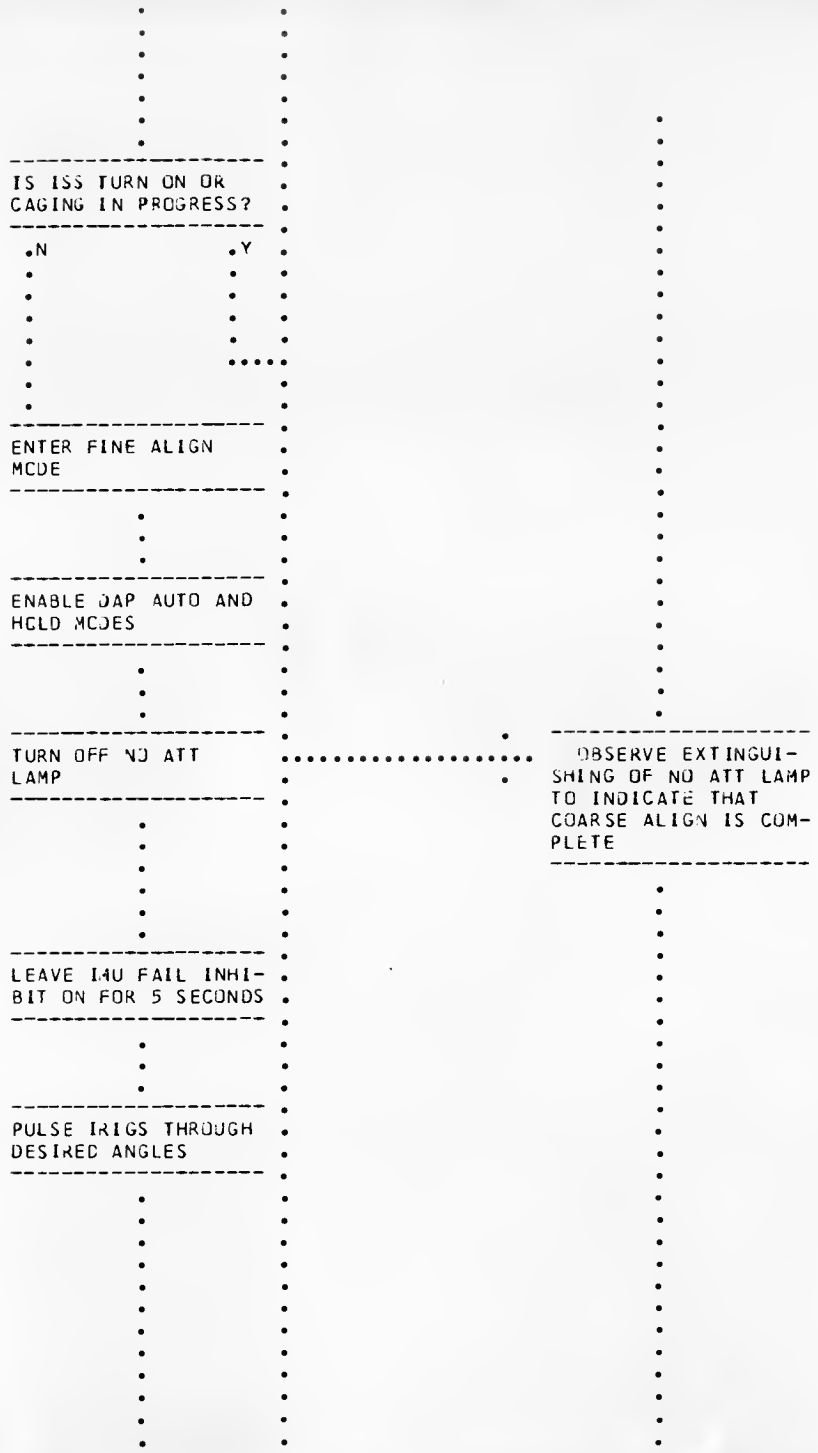
#5C

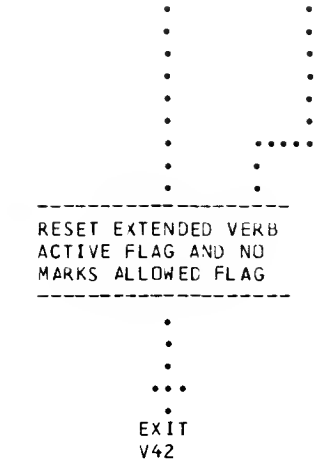
#6C

#7C



#80
#90
#100
#110
#120
1180
++


#13C
IS ISS TURN ON OR CAGING IN PROGRESS?
N
Y
#14C
ENTER FINE ALIGN MODE
#15C
ENABLE DAP AUTO AND HOLD MODES
TURN OFF NO ATT LAMP
OBSERVE EXTINGUISHING OF NO ATT LAMP TO INDICATE THAT COARSE ALIGN IS COMPLETE
#16C
LEAVE IMU FAIL INHIBIT ON FOR 5 SECONDS
#17C
PULSE IRIGS THROUGH DESIRED ANGLES



#180

#190

CHANGE CONTROL NOTES

REV 00 PCR 496
REV 01 EDITORIAL
REV 02(LUM 1E) PCN 1145
REV 03 PCN 1180

V43, LOAD FDAI ERROR NEEDLES (TEST ONLY) REV C5 12/01/71

PURPOSE: (1) TO DISPLAY ASTRONAUT-SPECIFIED ANGLES ON THE FDAI ERROR NEEDLES.

ASSUMPTIONS: (1) THE PROCESS IS CREW SELECTED BY DSKY ENTRY.

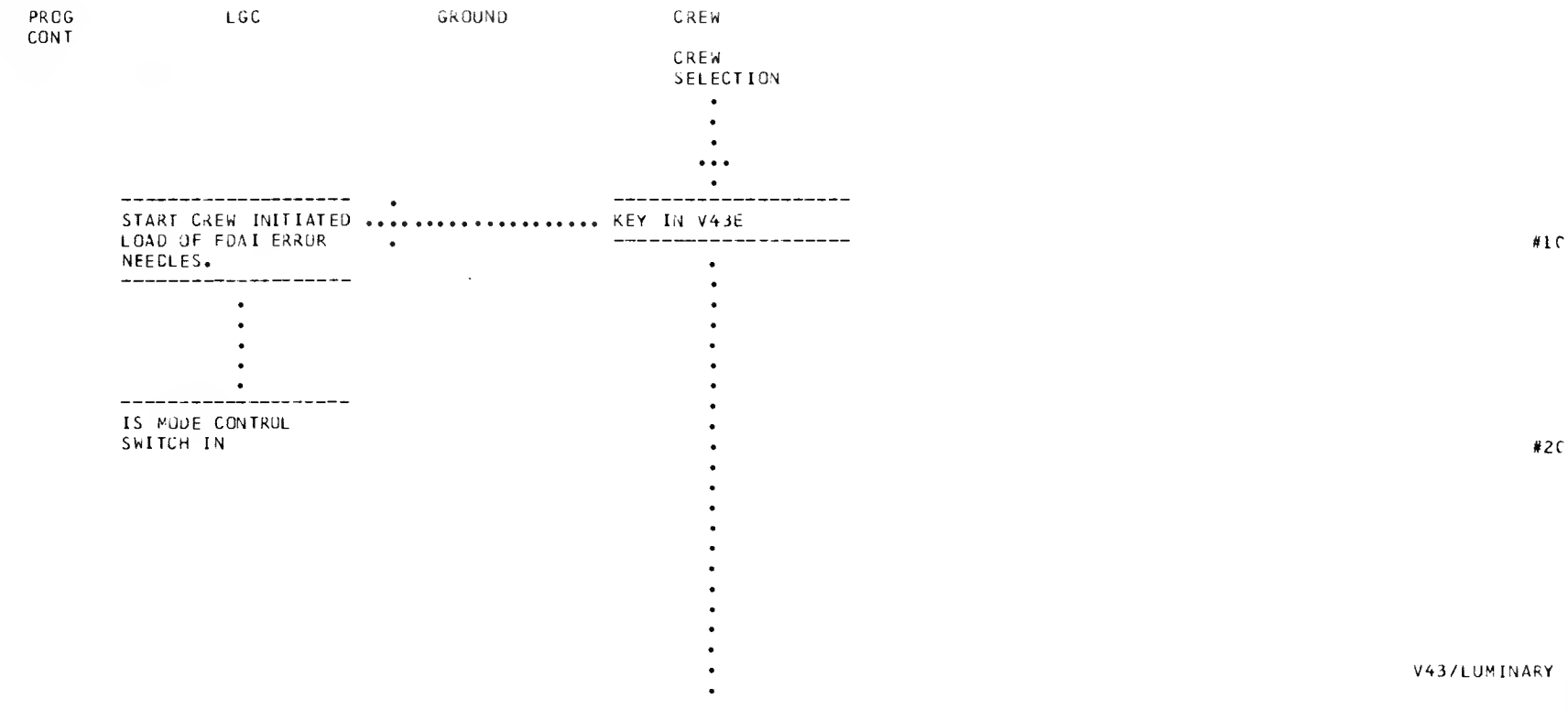
(2) VERB 43 MAY NOT BE SELECTED IF THE IMU IS IN THE COARSE ALIGN OR ZERO ICDU MODE.

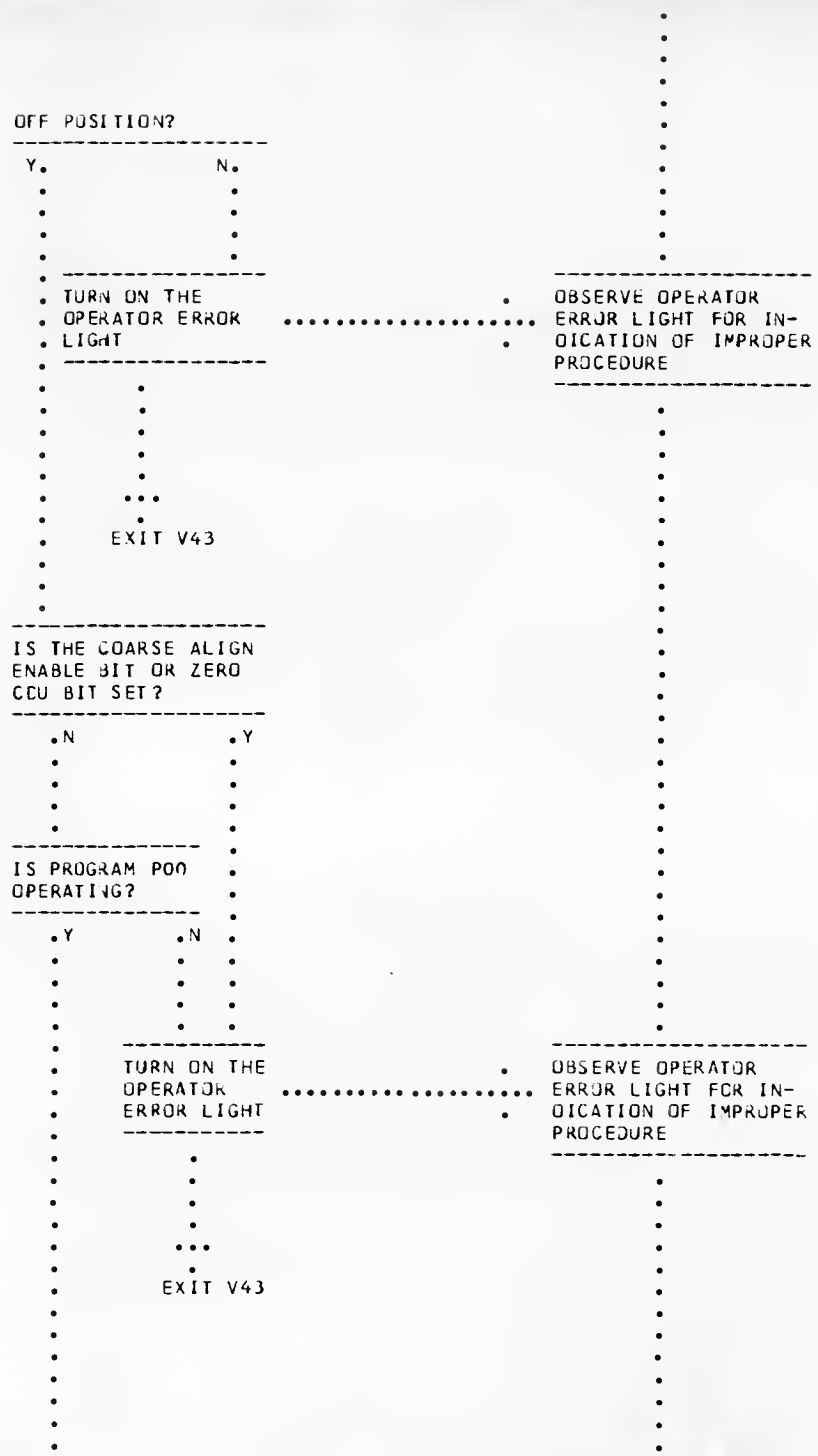
(3) THE MAXIMUM ERROR ANGLE THAT CAN BE DISPLAYED BY THE FDAI IS PLUS OR MINUS 5 DEGREES, LIMITED BY THE NEEDLE STOPS.

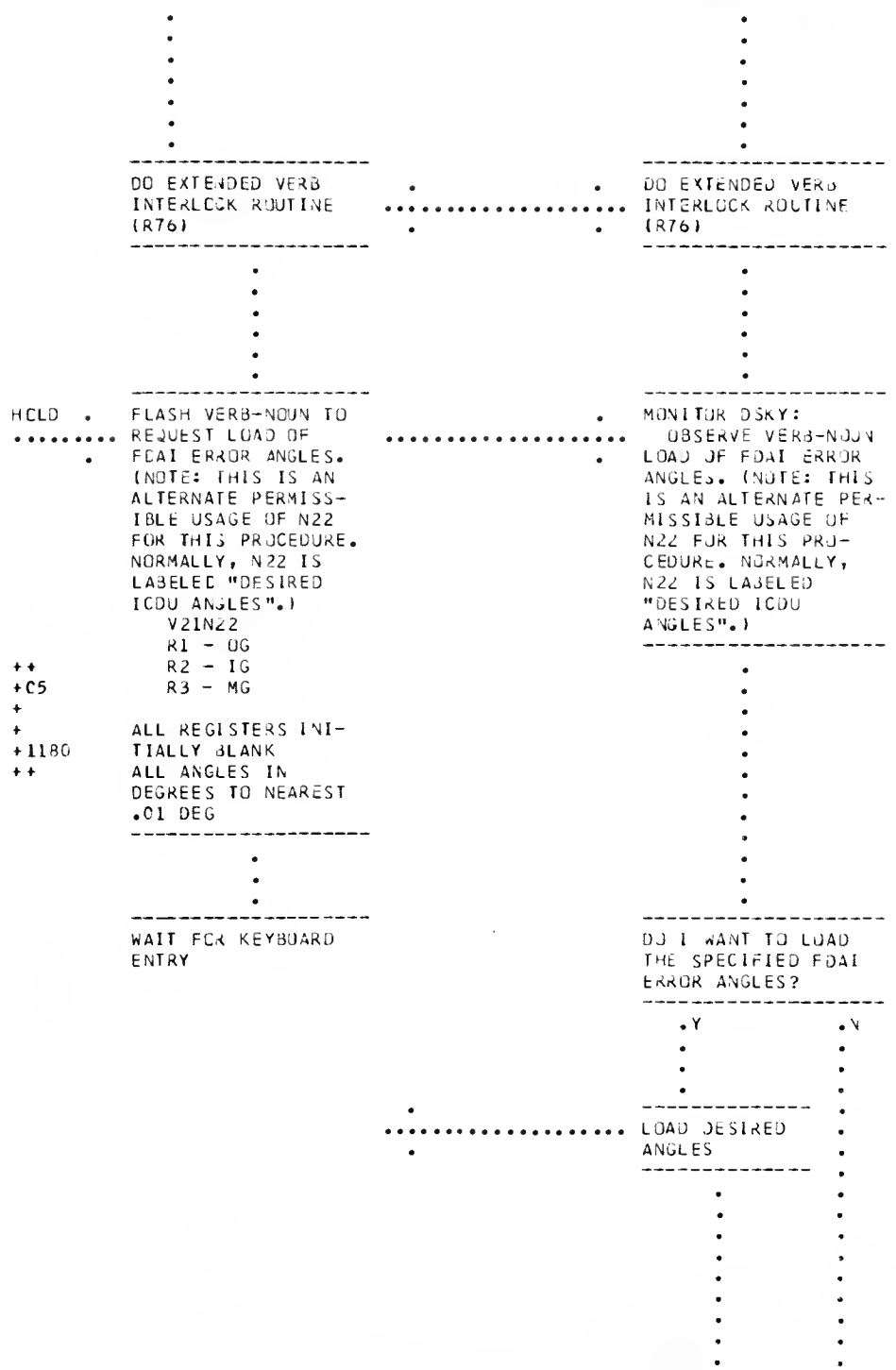
(4) THIS PROCESS MAY BE SELECTED ONLY IN P00.

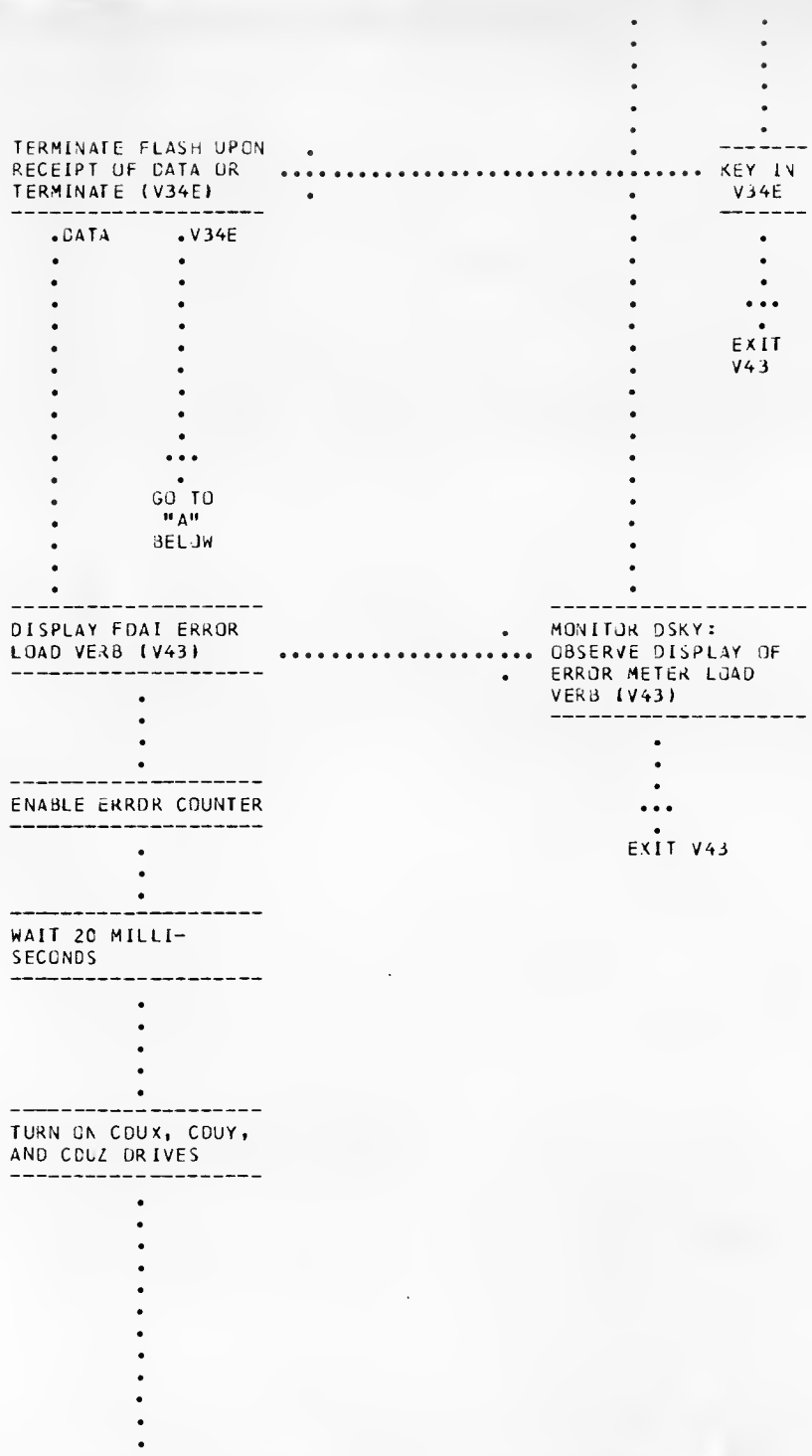
(5) THIS PROCESS MAY BE SELECTED ONLY IF THE PGNS MODE CONTROL SWITCH IS OFF.

(6) THIS EXTENDED VERB CANNOT BE SELECTED CONCURRENTLY WITH ANY OTHER EXTENDED VERB WHICH ALSO SETS THE EXTENDED VERB INTERLOCK.




OFF POSITION?
Y.
N.
TURN ON THE OPERATOR ERROR LIGHT
OBSERVE OPERATOR ERROR LIGHT FOR IN-DICATION OF IMPROPER PROCEDURE
#3C
EXIT V43
#4C
IS THE COARSE ALIGN ENABLE BIT OR ZERO CDU BIT SET?
.N
.Y
#5C
IS PROGRAM P00 OPERATING?
.Y
.N
#6C
TURN ON THE OPERATOR ERROR LIGHT
OBSERVE OPERATOR ERROR LIGHT FOR IN-DICATION OF IMPROPER PROCEDURE
#7C
EXIT V43


DO EXTENDED VERB INTERLOCK ROUTINE (R76)
DO EXTENDED VERB INTERLOCK ROUTINE (R76)
#80
HOLD
FLASH VERB-NOUN TO REQUEST LOAD OF FDAI ERROR ANGLES. (NOTE: THIS IS AN ALTERNATE PERMISSIBLE USAGE OF N22 FOR THIS PROCEDURE. NORMALLY, N22 IS LABELED "DESIRED ICDU ANGLES".)
V21N22
R1 - OG
R2 - IG
R3 - MG
ALL REGISTERS INITIALLY BLANK
ALL ANGLES IN DEGREES TO NEAREST .01 DEG
MONITOR DSKY: OBSERVE VERB-NOUN LOAD OF FDAI ERROR ANGLES. (NOTE: THIS IS AN ALTERNATE PERMISSIBLE USAGE OF N22 FOR THIS PROCEDURE. NORMALLY, N22 IS LABELED "DESIRED ICDU ANGLES".)
#90
#100
#110
WAIT FOR KEYBOARD ENTRY
DO I WANT TO LOAD THE SPECIFIED FDAI ERROR ANGLES?
.Y
.N
#120
LOAD DESIRED ANGLES



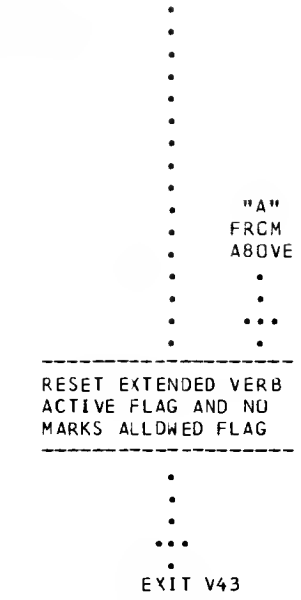
#130

#140

#150

#160

#170



#180

#190

#200

CHANGE CONTROL NOTES

REV 00 PCR 496
REV 01 EDITORIAL
REV 02 EDITORIAL
REV 03 EDITORIAL
REV 04(LUM 1E) PCN 1145
REV 05 PCN 1180

V44, TERMINATE RR CONTINUOUS DESIGNATE REV 03 12/01/71

PURPOSE: (1) TO TERMINATE THE CONTINUOUS DESIGNATE OPTION OF V41N72.

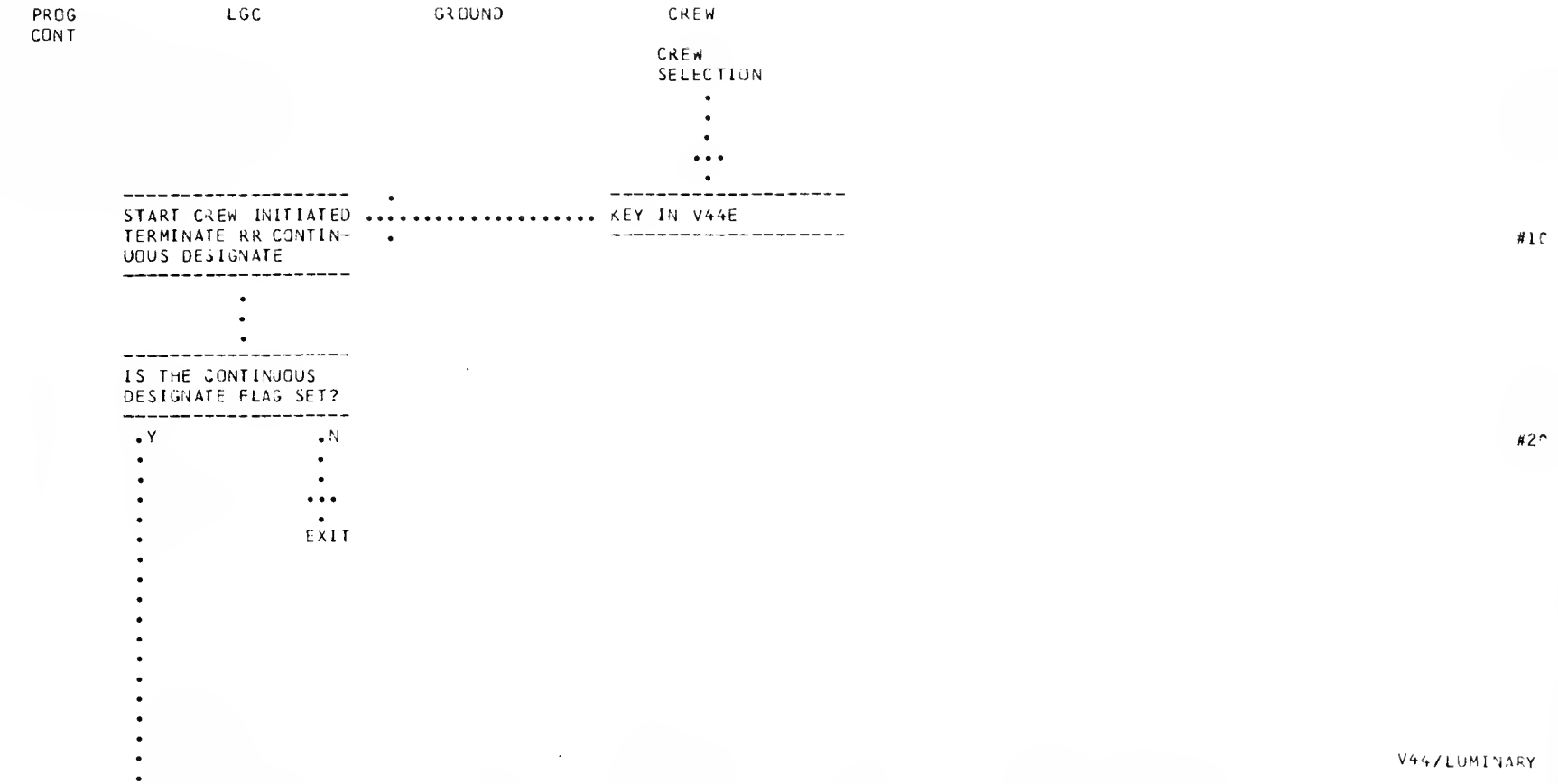
(2) TO DISABLE THE RR CDU ERROR COUNTERS.

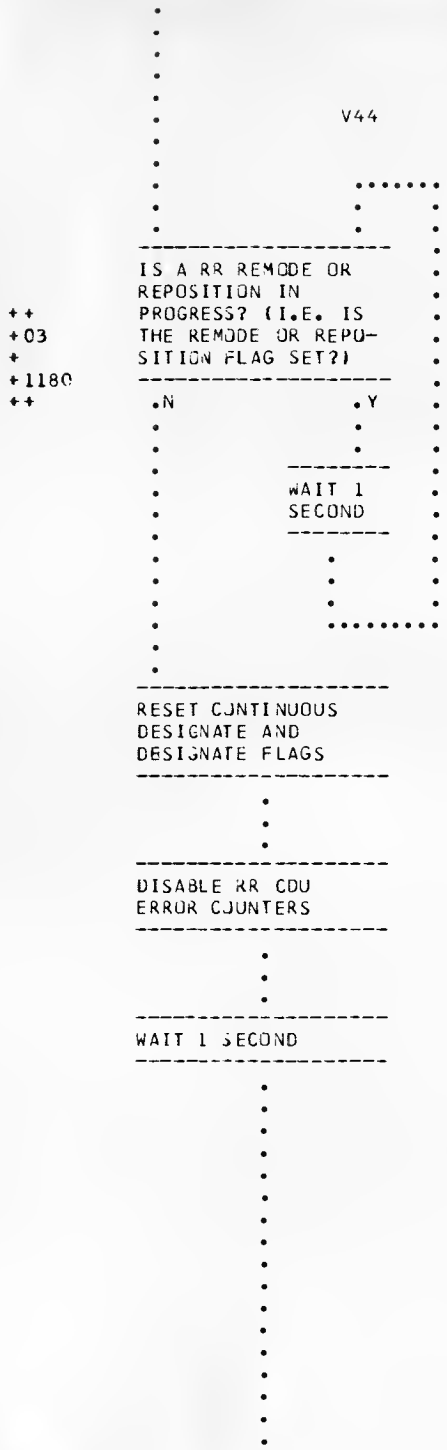
(3) TO ENABLE R25.

ASSUMPTIONS: (1) THE PROCESS IS CREW SELECTED BY DSKY ENTRY.

(2) V44E IS EFFECTIVE ONLY IF RR CONTINUOUS DESIGNATION (V41N72, COARSE ALIGN RR CDUS, OPTION 2) IS IN PROGRESS.

(3) THE PROCESS MAY BE SELECTED AT ANY TIME.





++
+03
+
+1180
++

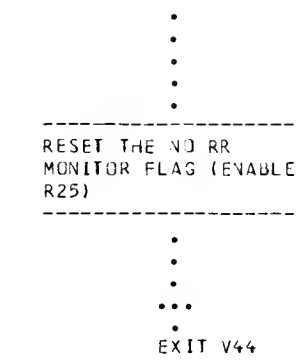
#3C

#4C

#5C

#6C

#7C



#8C

CHANGE CONTROL NOTES

REV 00A PCR 496
REV 02(LUM 1E) PCN 1145
REV 03 PCN 1180

V47, INITIALIZE AGS (R47) REV 01 08/09/69

NOTE: THIS EXTENDED VERB IS USED TO CALL ROUTINE 47. SEE R47 FOR THE LOGIC SPECIFICATION FLOW FOR AGS INITIALIZATION.

CHANGE CONTROL NOTES

REV 01 PCR 184

V48, START DAP DATA LOAD (R03) REV 01 08/09/69

NOTE: THIS EXTENDED VERB IS USED TO CALL ROUTINE 03. SEE R03 FOR THE LOGIC SPECIFICATION FLOW FOR THE DAP DATA LOAD.

CHANGE CONTROL NOTES

REV 01 PCR 184

V49, START CREW-DEFINED MANEUVER (R62) REV 01 08/09/69

NOTE: THIS EXTENDED VERB IS USED TO CALL ROUTINE 62. SEE R62 FOR THE LOGIC SPECIFICATION FLOW FOR THE CREW-DEFINED MANEUVER.

CHANGE CONTROL NOTES

REV 01 PCR 496

V50, PLEASE PERFORM REV 01 08/09/69

PURPOSE: (1) TO INTERRUPT A PROGRAM OR ROUTINE AND REQUEST ASTRONAUT RESPONSE TO THE ACTION DEFINED BY THE CHECKLIST CODE DISPLAYED ON THE DSKY.

ASSUMPTIONS: (1) THIS VERB IS ALWAYS INTERNALLY INITIATED BY THE PROGRAM IN PROCESS, AND SHOULD NOT BE SELECTED BY THE CREW.

(2) THE VERB ALWAYS APPEARS WITH N25 AS A FLASHING DISPLAY ON THE DSKY

(3) RESPONSES TO THE DSKY DISPLAY OF THIS VERB ARE DESCRIBED IN SECTION 4.2 OF THIS DOCUMENT.

CHANGE CONTROL NOTES

REV 01 PCR 496

V52, MARK CURSOR REV 02 02/17/71

NOTE: THIS EXTENDED VERB IS USED IN R53. REFER TO THAT ROUTINE FOR LOGIC DESCRIPTION OF PERFORMING SIGHTING MARKS ON CELESTIAL BODIES.

CHANGE CONTROL NOTES

REV 00 PCR 496
REV 02(LUM 1E) PCR 1044

V53, MARK SPIRAL REV 02 02/17/71

NOTE: THIS EXTENDED VERB IS USED IN R53. REFER TO THAT ROUTINE FOR LOGIC DESCRIPTION OF PERFORMING SIGHTING MARKS ON CELESTIAL BODIES.

CHANGE CONTROL NOTES

LOGIC REV 00 PCR 496
REV 02(LUM 1E) PCR 1044

V54, MARK X OR Y RETICLE REV 02 02/17/71

NOTE: THIS EXTENDED VERB IS USED IN R53. REFER TO THAT ROUTINE FOR LOGIC DESCRIPTION OF PERFORMING SIGHTING MARKS ON CELESTIAL BODIES.

CHANGE CONTROL NOTES

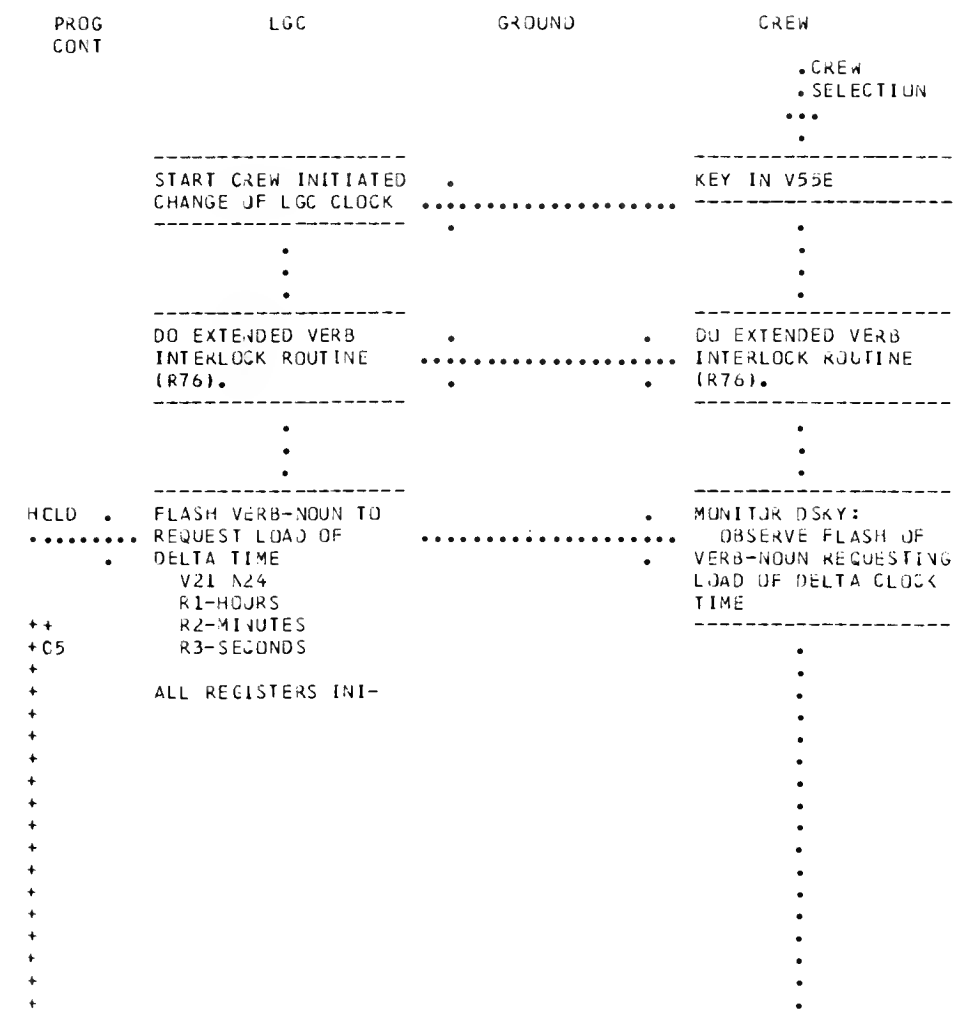
LOGIC REV 00 PCR 496
REV 02(LUM 1E) PCR 1044

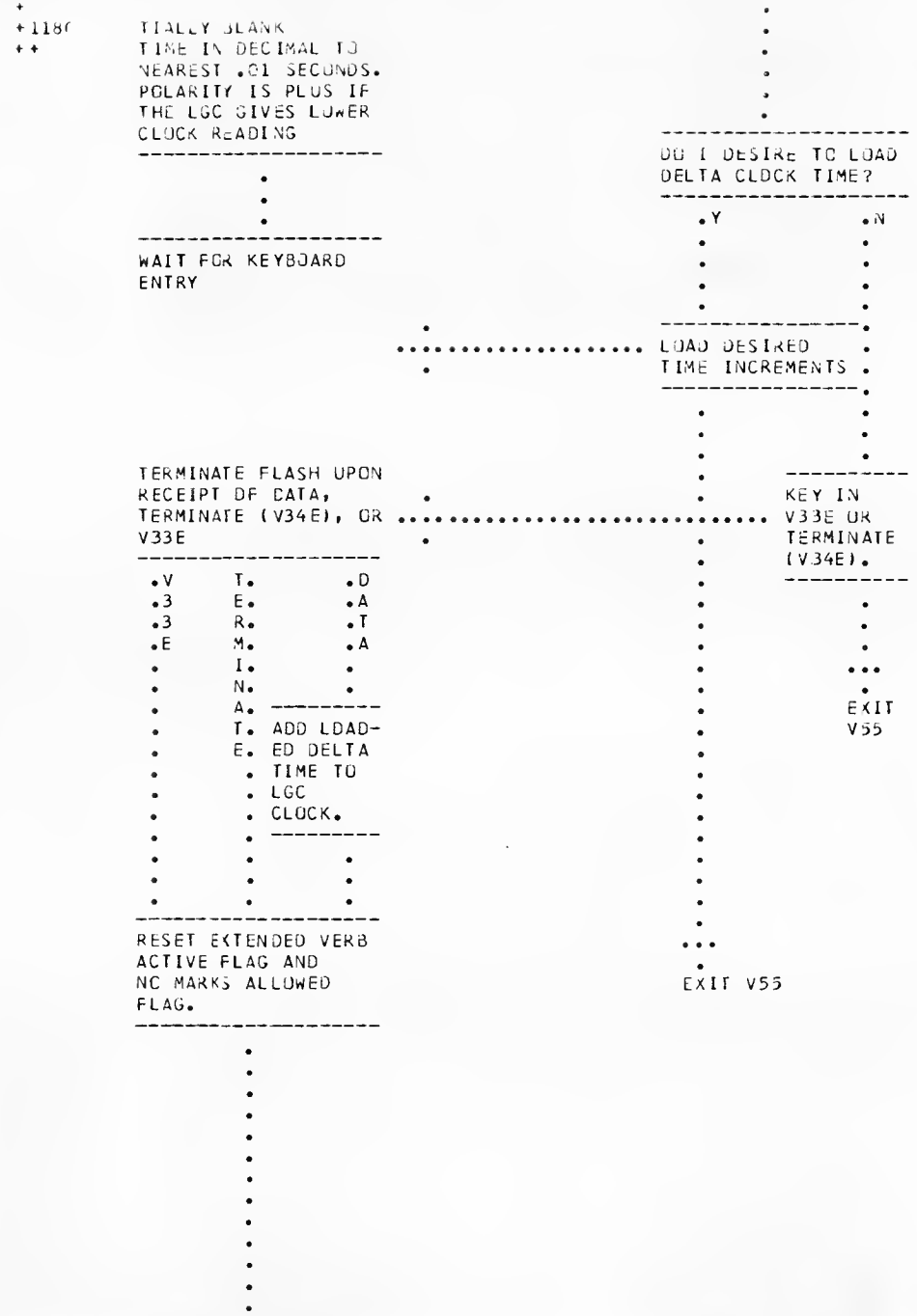
V55, INCREMENT LGC TIME (DECIMAL) REV 5 12/01/71

PURPOSE: (1) TO CHANGE THE LGC CLOCK TIME USING INCREMENTS (OR DECREMENTS) LOADED BY THE ASTRONAUT.

ASSUMPTIONS: (1) THE PROCESS IS CREW SELECTED BY DSKY ENTRY.

(2) THE PROCESS MAY NOT BE SELECTED WHEN ANOTHER EXTENDED VERB WHICH ALSO SETS THE EXTENDED VERB INTERLOCK IS ACTIVE.




TALLY BLANK
TIME IN DECIMAL TO
NEAREST .01 SECONDS.
POLARITY IS PLUS IF
THE LGC GIVES LOWER
CLOCK READING
WAIT FOR KEYBOARD
ENTRY
TERMINATE FLASH UPON
RECEIPT OF DATA,
TERMINATE (V34E), OR
V33E
V33E
TERMINATE
(V34E).
ADD LOAD-
ED DELTA
TIME TO
LGC
CLOCK.
RESET EXTENDED VERB
ACTIVE FLAG AND
NC MARKS ALLOWED
FLAG.
DO I DESIRE TO LOAD
DELTA CLOCK TIME?
Y
N
LOAD DESIRED
TIME INCREMENTS
KEY IN
V33E OR
TERMINATE
(V34E).
EXIT
V55
EXIT V55

```
    .
    .
    .
    .
    .
    .
   ...
    .
   EXIT
   V55
```

CHANGE CONTROL NOTES

```
REV 00    PCR 496
REV 01    EDITORIAL
REV 02    EDITORIAL
REV 03    EDITORIAL
REV 04(LUM 1E)    PCN 1145
REV 05    PCN 1180
```

V56, REQUEST TERMINATE TRACKING ROUTINE (R56) REV 01 08/09/69

NOTE: THIS EXTENDED VERB IS USED TO CALL ROUTINE 56. REFER TO R56 FOR THE LOGIC SPECIFICATION FLOW FOR TERMINATING TRACKING.

CHANGE CONTROL NOTES

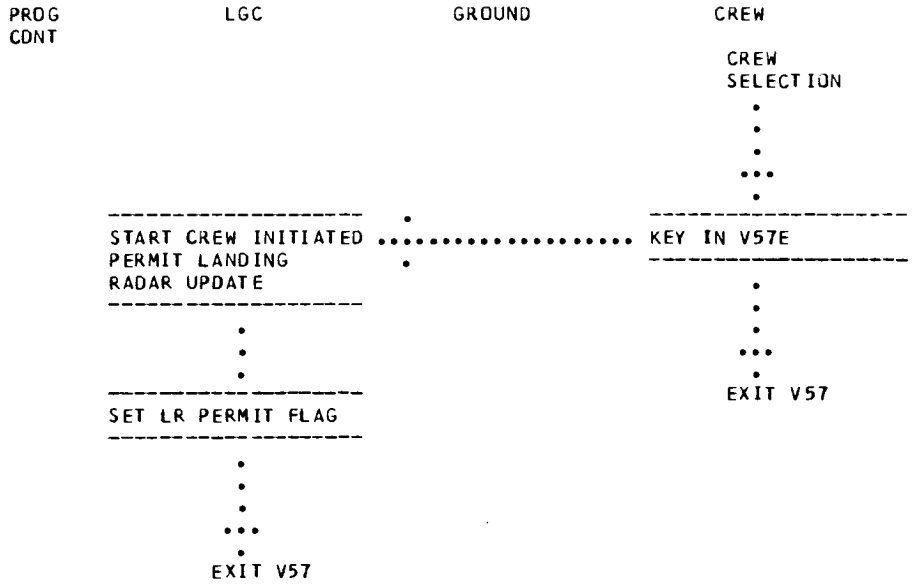
REV 01 PCR 496

V57, PERMIT LANDING RADAR UPDATE REV C4 02/17/71

PURPOSE: (1) TO ALLOW THE INCORPORATION OF LR DATA DURING STATE VECTOR UPDATING BY SETTING THE LR PERMIT FLAG.

ASSUMPTIONS: (1) THE PROCESS IS CREW SELECTED BY DSKY ENTRY.

(2) THE PROCESS IS ONLY EFFECTIVE IN R12, DESCENT STATE VECTOR UPDATE ROUTINE.



#10

#20

CHANGE CONTROL NOTES

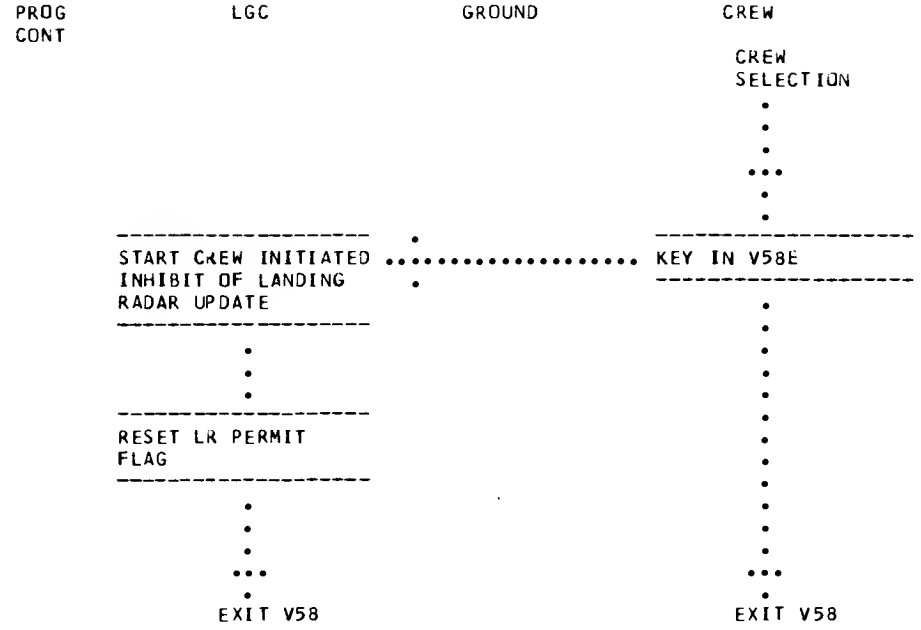
REV C0 PCR 118
REV 01 EDITORIAL
REV 02(LUM 18) PCR 814
REV 03 EDITORIAL
REV 04(LUM 1E) PCR 334

V58, INHIBIT LANDING RADAR UPDATE REV 01 08/09/69

PURPOSE: (1) TO INHIBIT THE INCORPORATION OF LANDING RADAR DATA DURING DESCENT STATE VECTOR UPDATE.

ASSUMPTIONS: (1) THE PROCESS IS CREW SELECTED BY DSKY ENTRY.

(2) THE PROCESS IS ONLY EFFECTIVE IN R12, DESCENT STATE VECTOR UPDATE ROUTINE.



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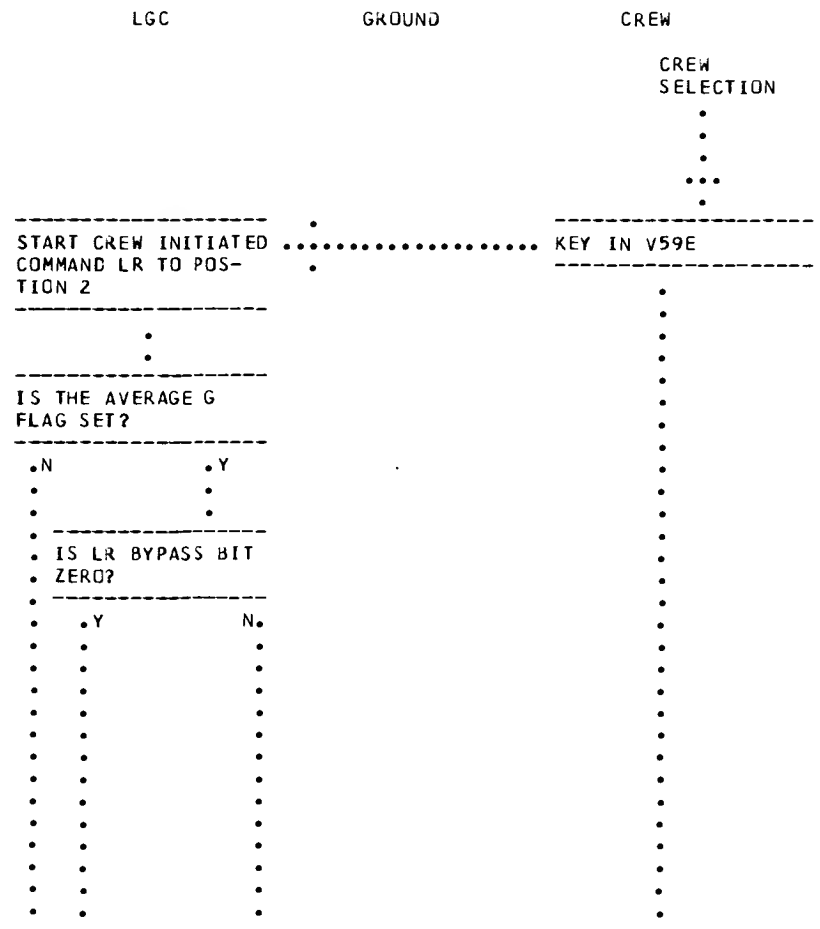
CHANGE CONTROL NOTES

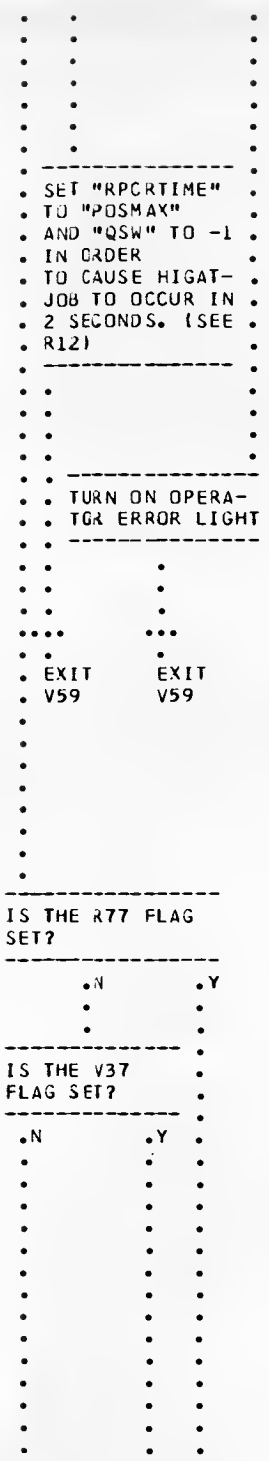
REV 01 PCR 118

V59, COMMAND LR TO POSITION 2 REV 05 12/01/71

PURPOSE: (1) TO DRIVE THE LANDING RACAR TO POSITION 2 (FINAL APPROACH).

(2) TO CAUSE HIGATJOB (HI-GATE) TO OCCUR WITHIN 2 SECONDS IF THE LR IS STUCK IN POSITION #2 DURING P63 POWERED
++ FLIGHT.
+05
ASSUMPTIONS: (1) THE PROCESS MAY ONLY BE SELECTED IF ANOTHER PROGRAM IS NOT USING EITHER LR OR RR, AND THE TRACK FLAG IS NOT
+1180 SET. WITH AVERAGE G ON, HOWEVER, IT IS SELECTABLE IN P63, P64 AND P66 ONLY.
++
(2) THE PROCESS IS CREW SELECTED BY OSKY ENTRY.




SET "RPCRTIME" TO "POSMAX" AND "QSW" TO -1 IN ORDER TO CAUSE HIGAT- JOB TO OCCUR IN 2 SECONDS. (SEE R12)
TURN ON OPERA- TOR ERROR LIGHT
EXIT V59
EXIT V59
IS THE R77 FLAG SET?
N
Y
IS THE V37 FLAG SET?
N
Y

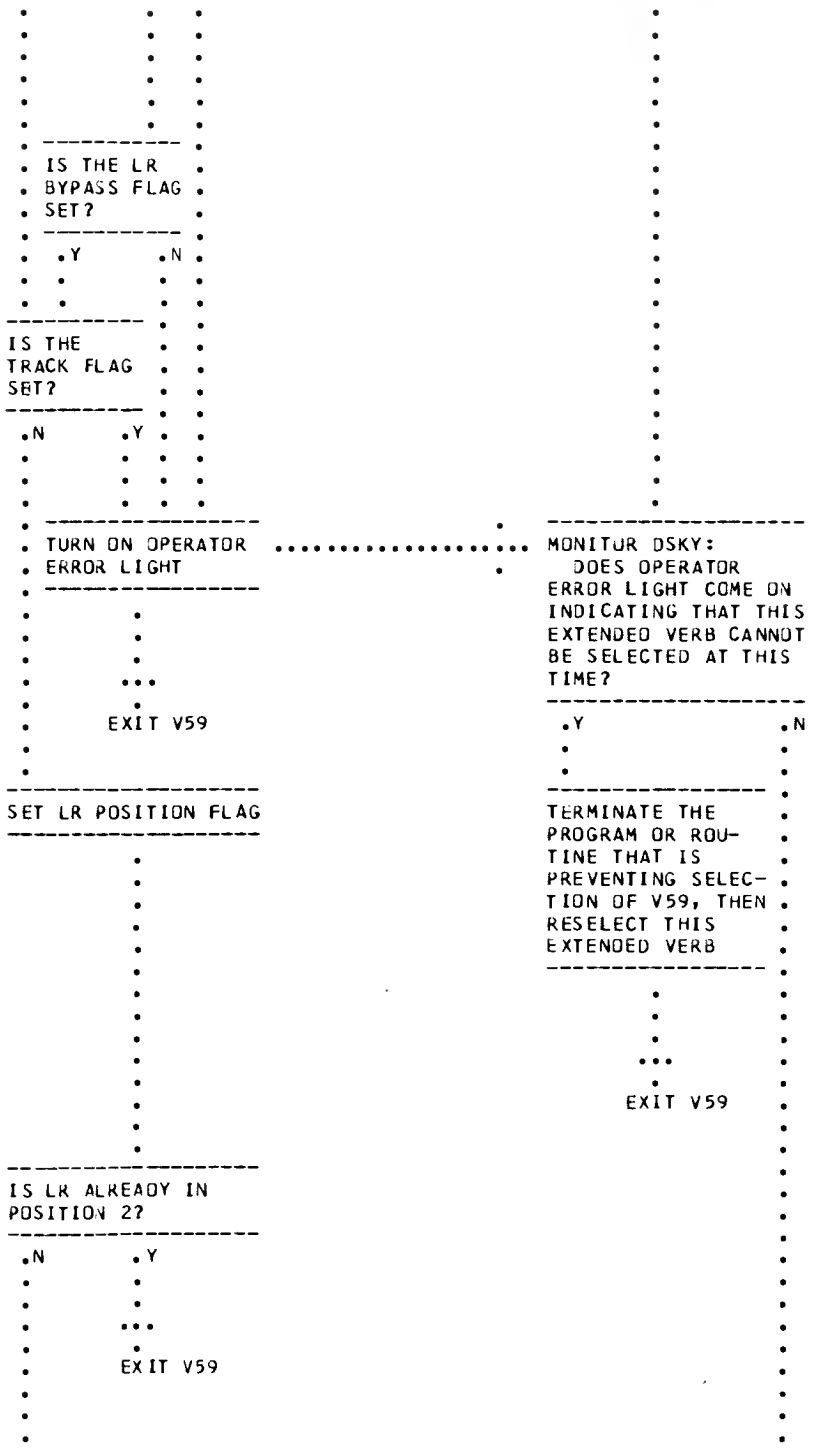
#30

#40

#50

#60

#70



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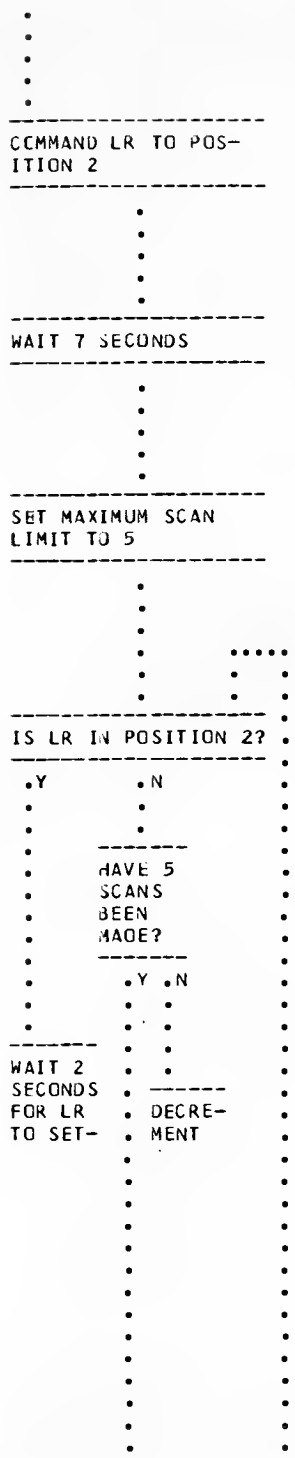
#120

#130



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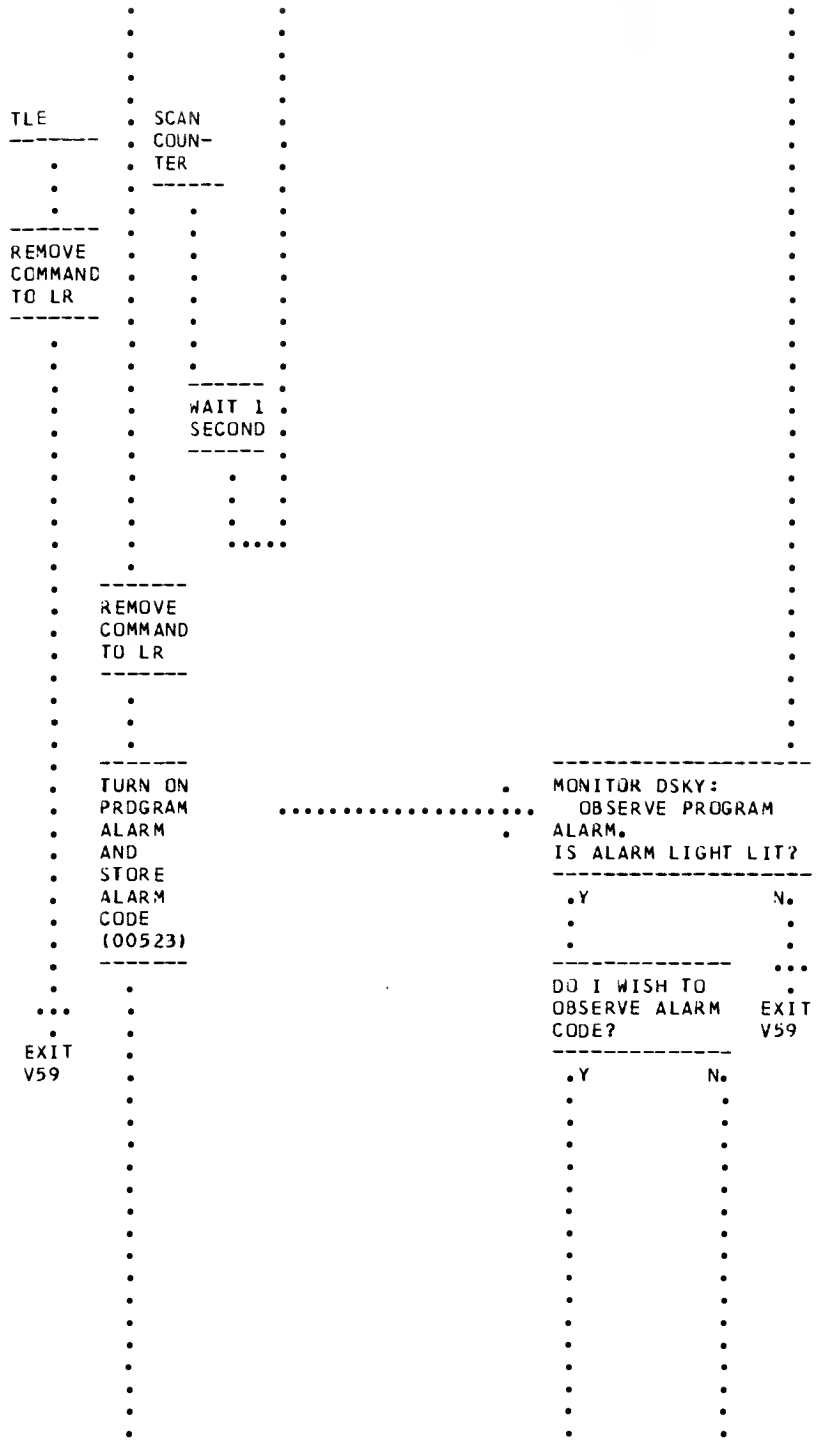

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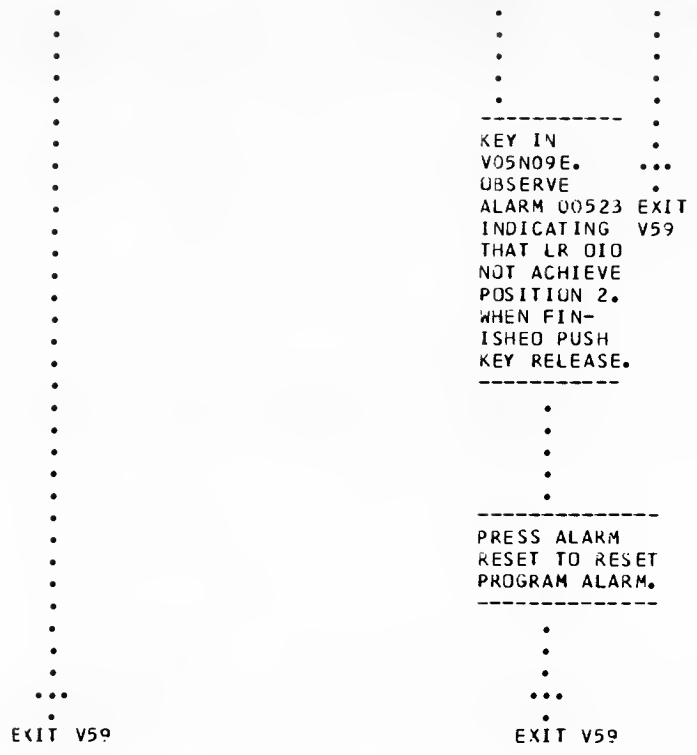


#230

#240

#250

#260

CHANGE CONTROL NOTES

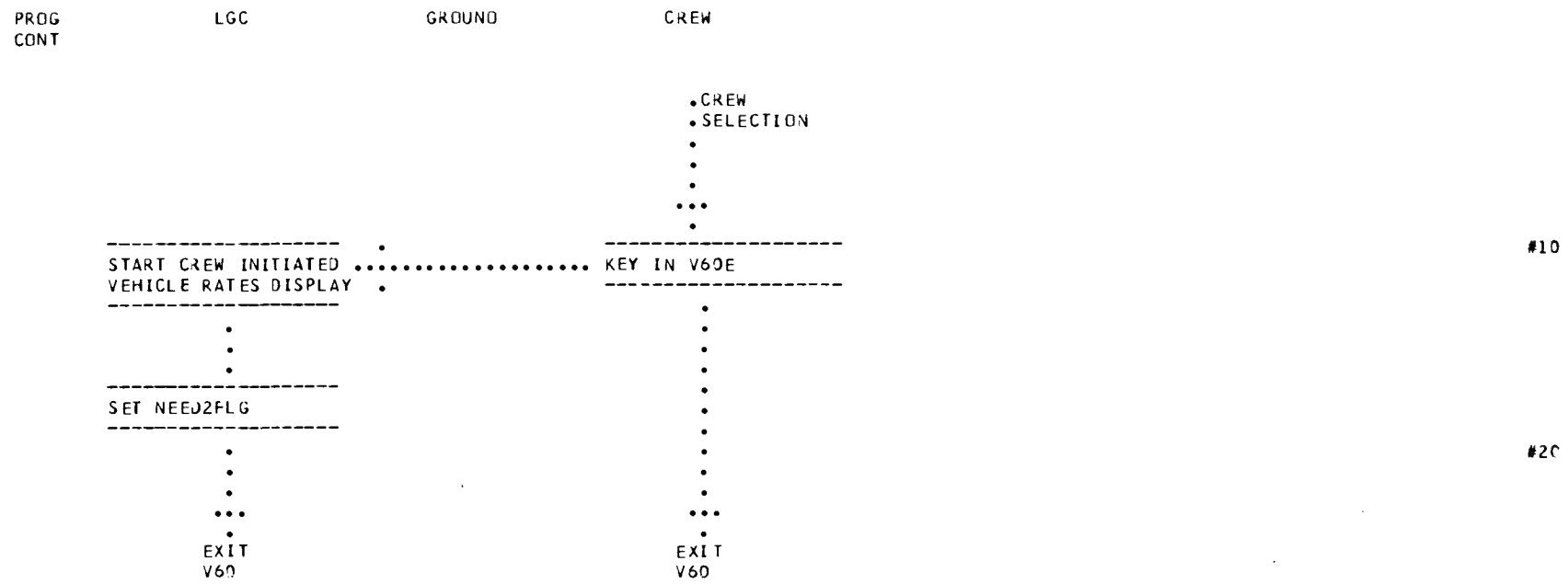
REV 00 PCR 420
REV 01 EDITORIAL
REV 00(LUM 18) PCR 841,EDITORIAL
REV 02(LUM 1C) PCR 895,EDITORIAL
REV 03(LUM 1D) PCR 298,892, PCN 1009
REV 04(LUM 1E) PCN 1145
REV 05 PCN 1180

V60, DISPLAY VEHICLE RATES REV 01 08/04/69

PURPOSE: (1) TO DISPLAY ON THE FDAI ERROR NEEDLES THE PGNCS DERIVED VEHICLE ATTITUDE RATES.

ASSUMPTIONS: (1) THE PROCESS IS CREW SELECTED BY DSKY ENTRY.

(2) THIS PROCESS MAY BE SELECTED AT ANY TIME. IT SHOULD BE NOTED, HOWEVER, THAT VEHICLE RATES ARE AVAILABLE ONLY WHEN THE DAP IS TURNED ON, I. E., GUID CONT IN PGNS AND PGNS MODE CONT NOT OFF.



CHANGE CONTROL NOTES

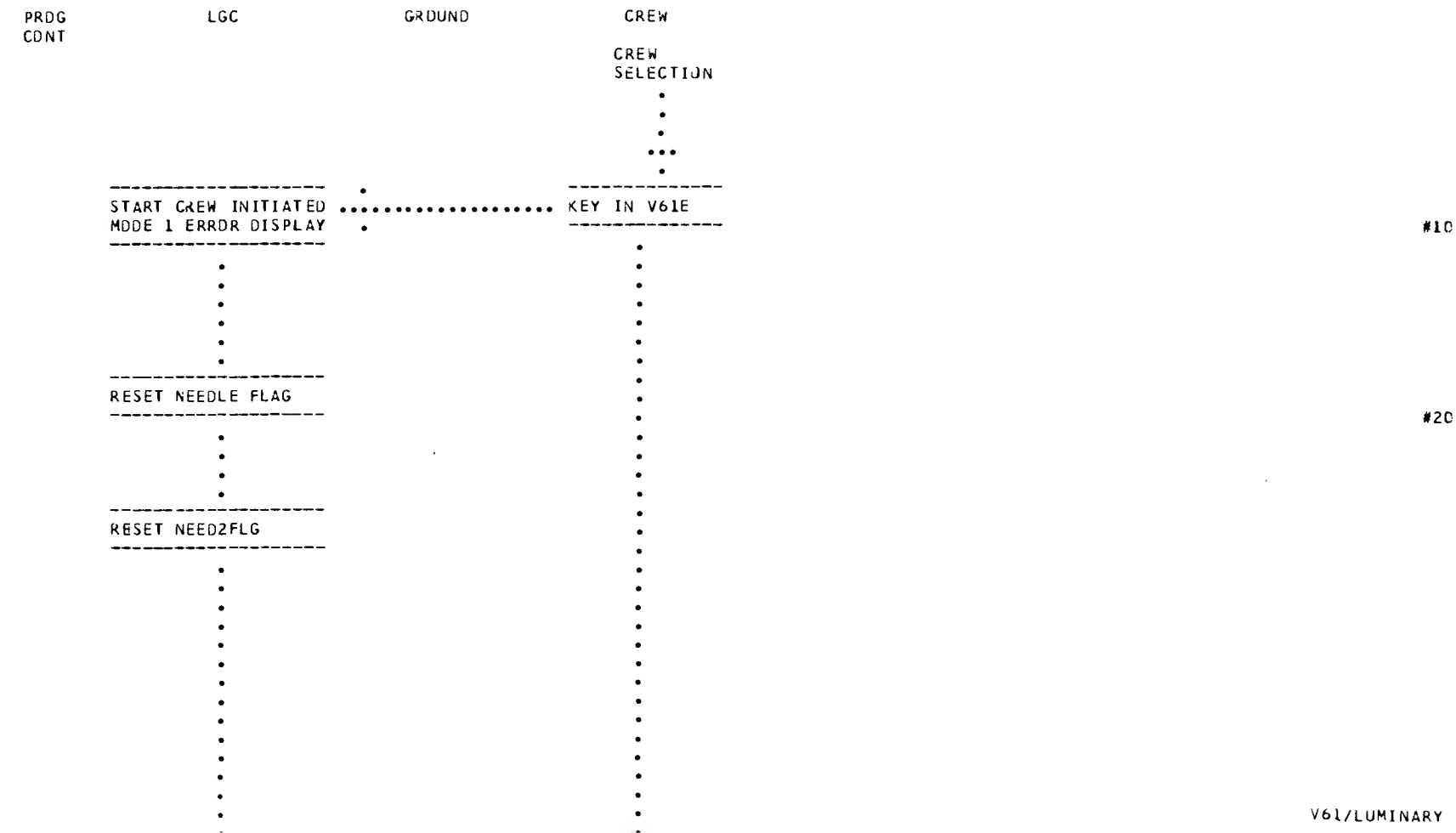
REV 01 PCR 841(ORIGINATED)

V61, DISPLAY DAP ATTITUDE ERROR REV 02 08/05/69

PURPOSE: (1) TO DISPLAY ON THE FDAI ERROR NEEDLES THE DIFFERENCE BETWEEN THE CURRENT CDU ANGLES AND THE DAP COMMANDED ANGLES.

ASSUMPTIONS: (1) THE PROCESS IS CREW SELECTED BY DSKY ENTRY.

(2) THIS PROCESS MAY BE SELECTED AT ANY TIME.



```
      .
      .
      .
      .
      .
      .
     ...
      .
    EXIT
    V61
```


```
      .
      .
      .
      .
      .
      .
     ...
      .
    EXIT
    V61
```


CHANGE CONTROL NOTES

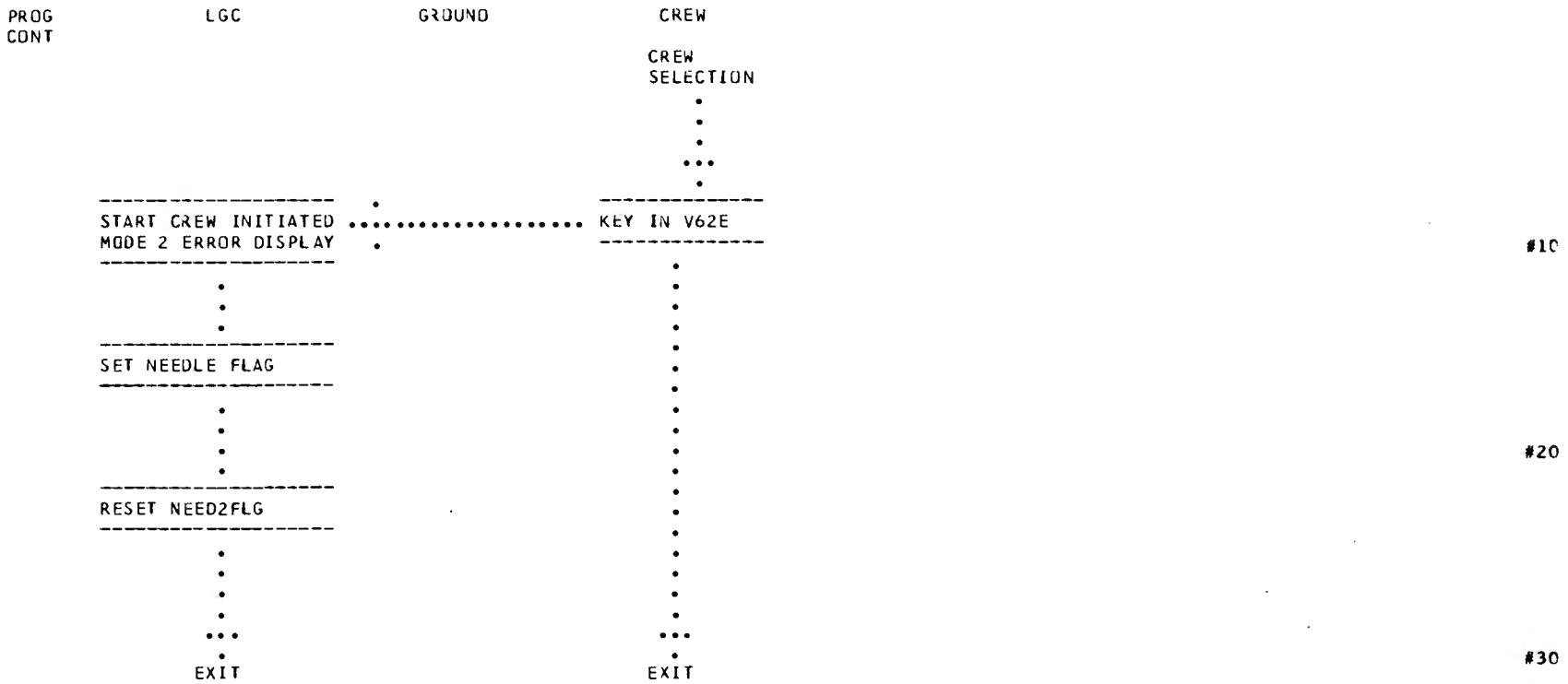
REV 00 PCR 420
REV 01 EDITORIAL
REV 02(LUM 1B) PCR 841

V62, DISPLAY TOTAL ATTITUDE ERROR REV 02 08/05/69

PURPOSE: (1) TO DISPLAY THE TOTAL ATTITUDE ERROR (N22(DESIRED ICDU ANGLES) MINUS N20(PRESENT ICDU ANGLES)) ON THE FDAI ERROR NEEDLES.

ASSUMPTIONS: (1) THE PROCESS IS CREW SELECTED BY DSKY ENTRY.

(2) THIS PROCESS MAY BE SELECTED AT ANY TIME.



V62

V62

CHANGE CONTROL NOTES

LOGIC REV 00 PCR 164, 420
      REV 01   EDITORIAL
      REV 02(LUM 1B)   PCR 841

V63, START RR/LR SELF TEST ROUTINE (R04) REV C1 08/09/69

NOTE: THIS EXTENDED VERB IS USED TO CALL ROUTINE 04. SEE R04 FOR THE LOGIC SPECIFICATION FLOW FOR THE RR/LR SELF TEST.

CHANGE CONTROL NOTES

REV 01 PCR 420

V64, START S-BAND ANTENNA ROUTINE (R05) REV C1 08/09/69

NOTE: THIS EXTENDED VERB IS USED TO CALL ROUTINE 05. SEE R05 FOR THE LOGIC SPECIFICATION FLOW FOR THE S-BAND ANTENNA CALCULATIONS.

CHANGE CONTROL NOTES

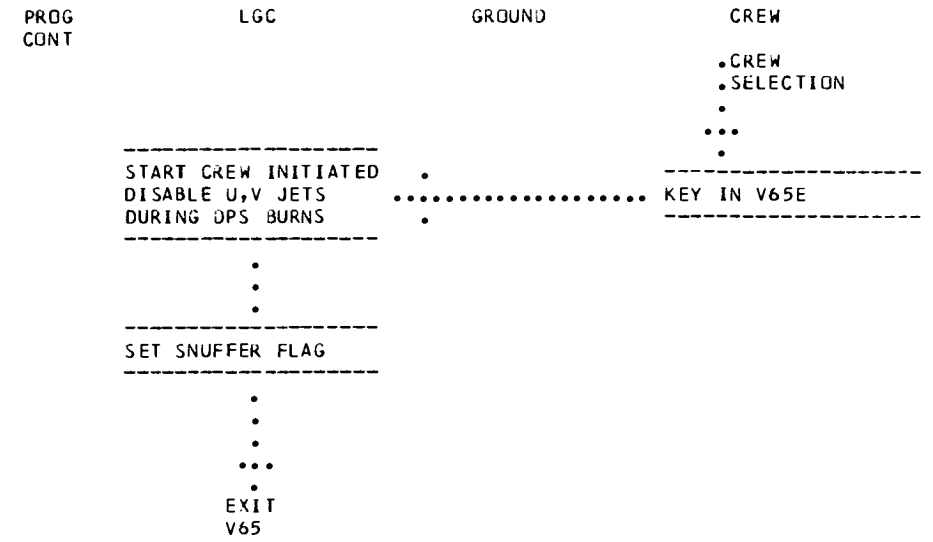
REV 01 PCR 496

V65, DISABLE U,V JETS DURING DPS BURNS REV 01 08/09/69

PURPOSE: (1) TO INHIBIT U AND V RCS JET FIRINGS DURING DPS POWERED FLIGHT.

ASSUMPTIONS: (1) THE PROCESS IS CREW SELECTED BY DSKY ENTRY.

(2) THE PROCESS MAY BE SELECTED AT ANY TIME.



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CHANGE CONTROL NOTES

LOGIC REV 01 PCR 539

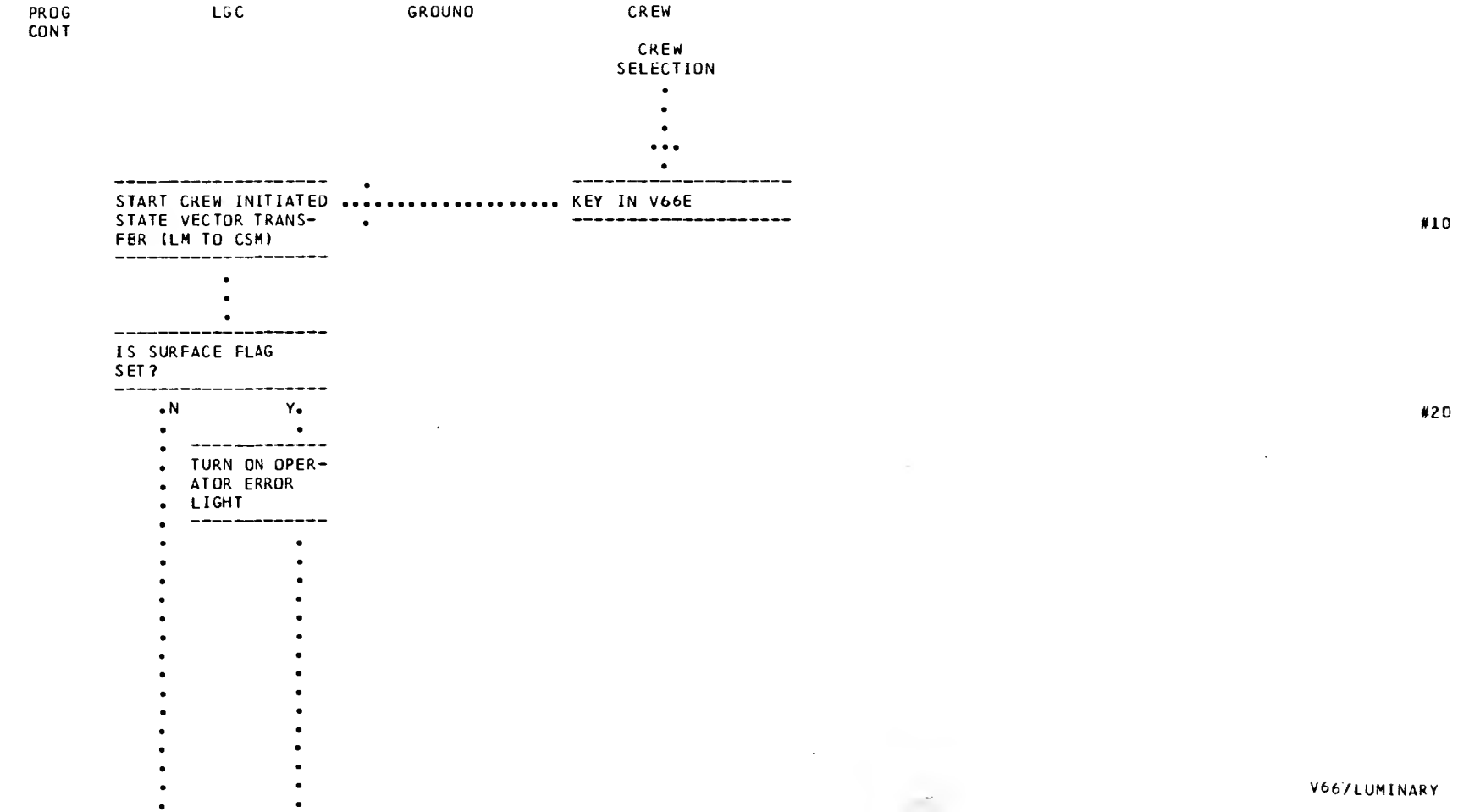
V66, VEHICLES ATTACHED, MOVE THIS VEHICLE STATE VECTOR TO OTHER VEHICLE STATE VECTOR

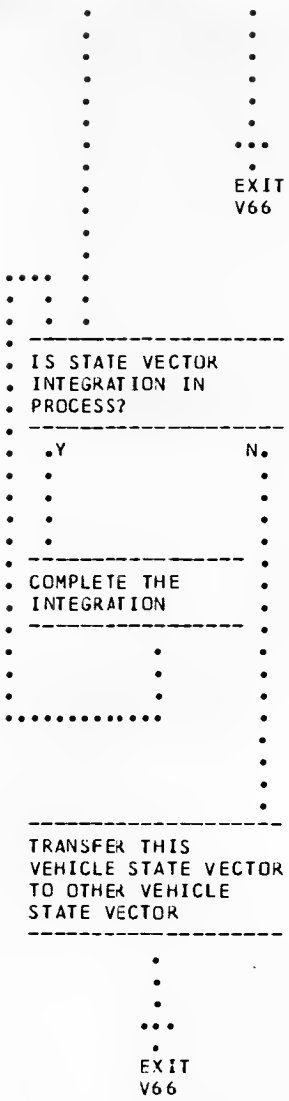
REV 02 08/07/69

PURPOSE: (1) TO TRANSFER THE LM STATE VECTOR INFORMATION TO THE CSM STATE VECTOR.

ASSUMPTIONS: (1) THE PROCESS IS CREW SELECTED BY OSKY ENTRY.

(2) THE TRANSFER OF THE STATE VECTOR INFORMATION MAY BE ACCOMPLISHED AT ANY TIME EXCEPT WHEN AVERAGE G IS IN PROCESS OR WHEN THE SURFACE FLAG IS SET.




EXIT
V66
IS STATE VECTOR INTEGRATION IN PROCESS?
Y
N
COMPLETE THE INTEGRATION
TRANSFER THIS VEHICLE STATE VECTOR TO OTHER VEHICLE STATE VECTOR
EXIT
V66

#30

#40

#50

#60

#70

CHANGE CONTROL NOTES

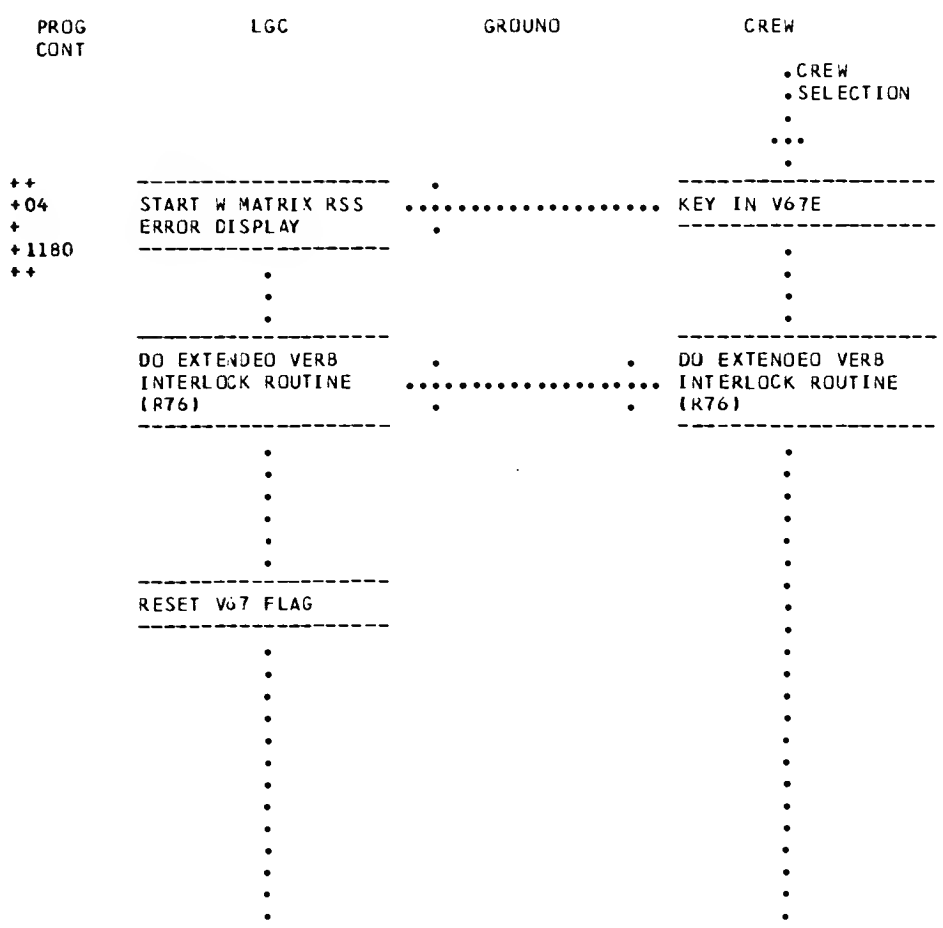
LOGIC REV 00 PCR 496
REV 01 EDITORIAL
REV 02(LUM 18) PCR 805,EDITORIAL

++ V67, W MATRIX RSS ERROR DISPLAY REV 04 12/01/71
+04
+1180
PURPOSE: (1) TO PROVIDE A MEANS OF DISPLAYING W MATRIX INFORMATION AND REINITIALIZING THE W MATRIX IF DESIRED.
++

ASSUMPTIONS: (1) NO OTHER EXTENDED VERB WHICH SETS THE EXTENDED VERB INTERLOCK IS ACTIVE.

(2) THIS PROCESS IS CREW SELECTED BY OSKY ENTRY.

(3) IF NEW VALUES OF RMS POSITION, VELOCITY, AND BIAS ERRORS ARE LOADED IN THIS ROUTINE, W MATRIX INITIALIZATION OCCURS THE NEXT TIME A NAVIGATION MEASUREMENT IS MADE.



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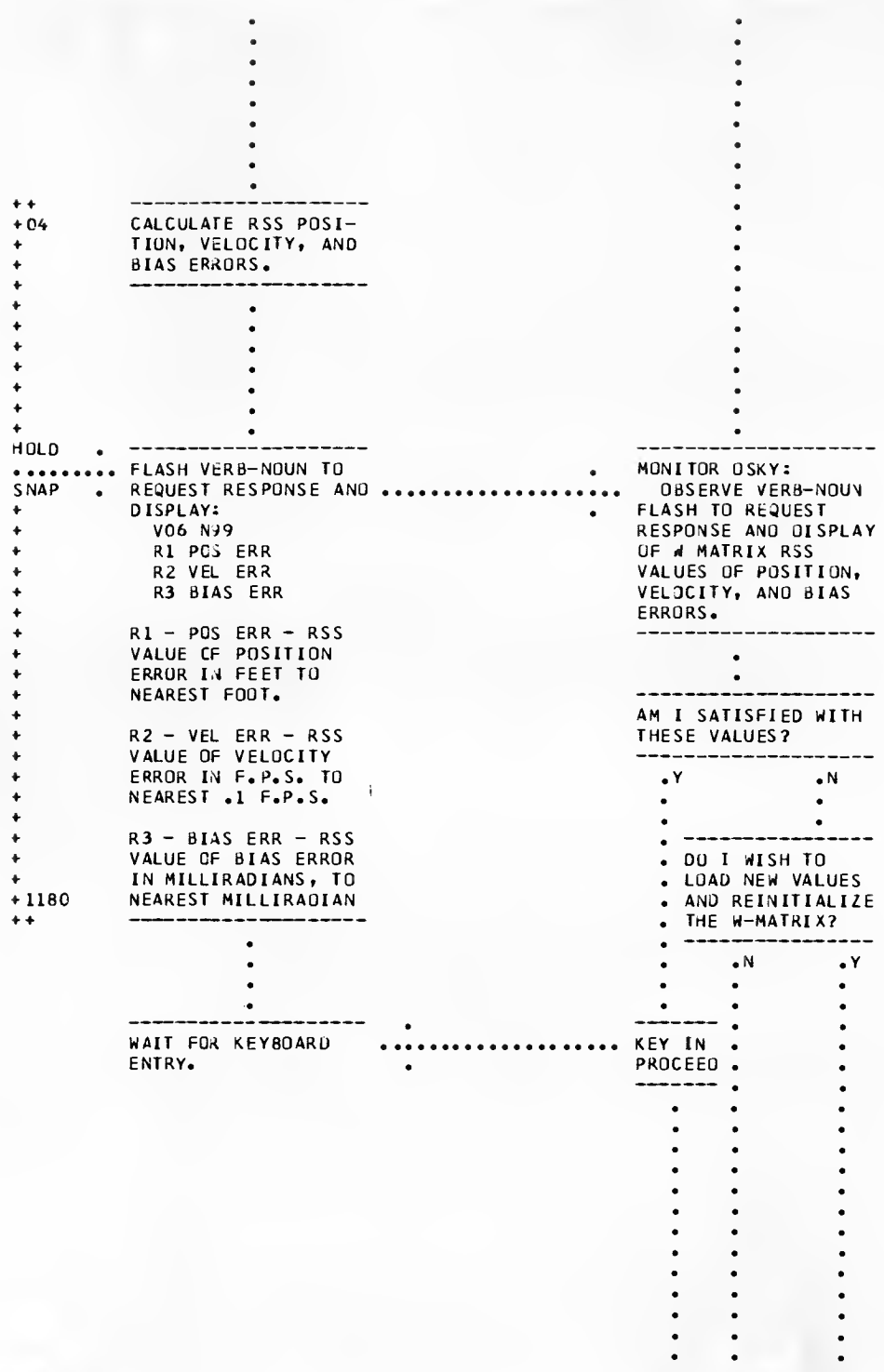
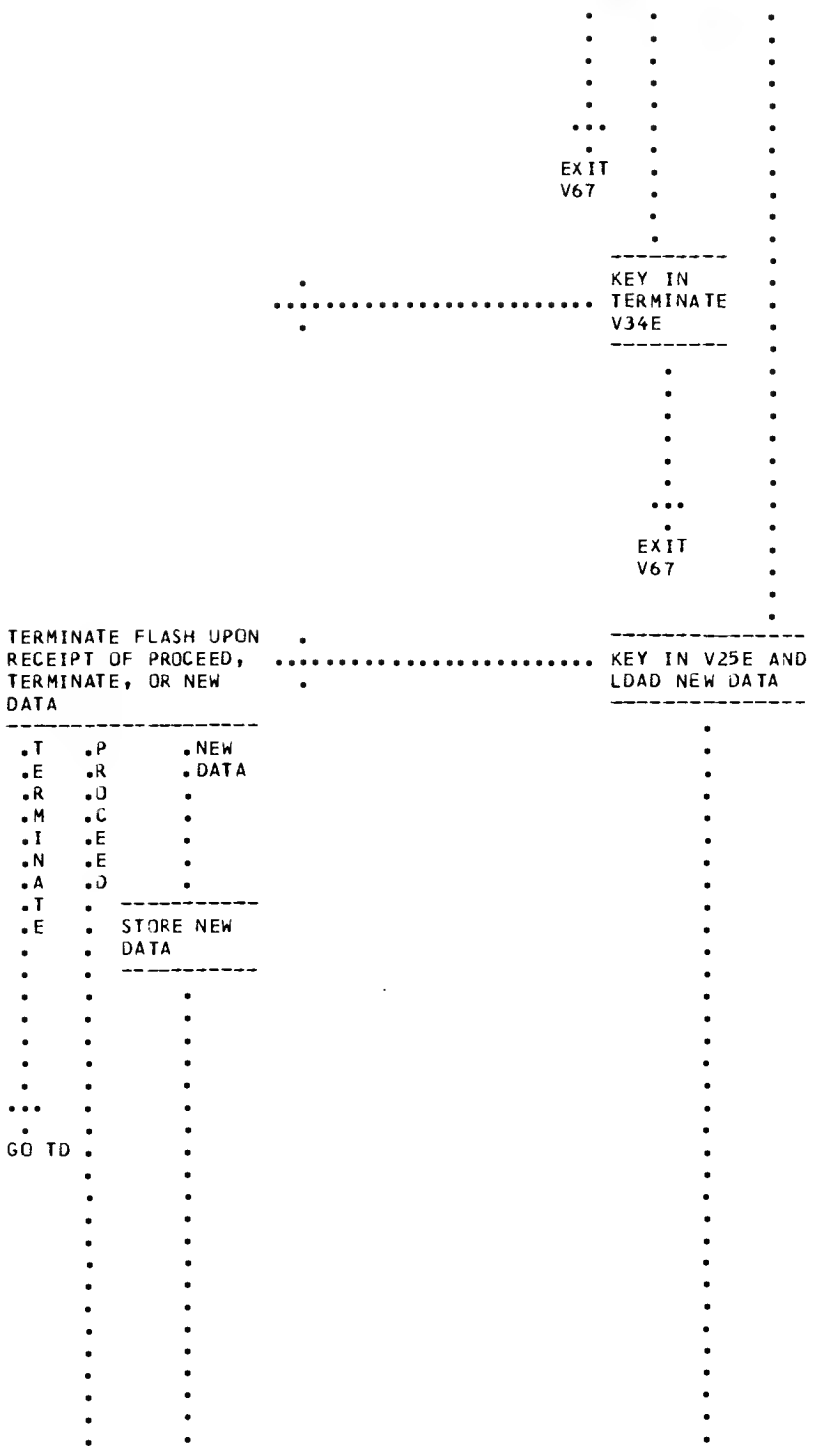

++
+04
CALCULATE RSS POSITION, VELOCITY, AND BIAS ERRORS.
HOLD
SNAP
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY:
V06 N99
R1 POS ERR
R2 VEL ERR
R3 BIAS ERR
R1 - POS ERR - RSS VALUE OF POSITION ERROR IN FEET TO NEAREST FOOT.
R2 - VEL ERR - RSS VALUE OF VELOCITY ERROR IN F.P.S. TO NEAREST .1 F.P.S.
R3 - BIAS ERR - RSS VALUE OF BIAS ERROR IN MILLIRADIANS, TO NEAREST MILLIRADIAN
+1180
++
WAIT FOR KEYBOARD ENTRY.
MONITOR OSKY:
OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY OF # MATRIX RSS VALUES OF POSITION, VELOCITY, AND BIAS ERRORS.
AM I SATISFIED WITH THESE VALUES?
Y
N
DO I WISH TO LOAD NEW VALUES AND REINITIALIZE THE W-MATRIX?
N
Y
KEY IN PROCEED
#30
#40
#50
#60
#70
#80



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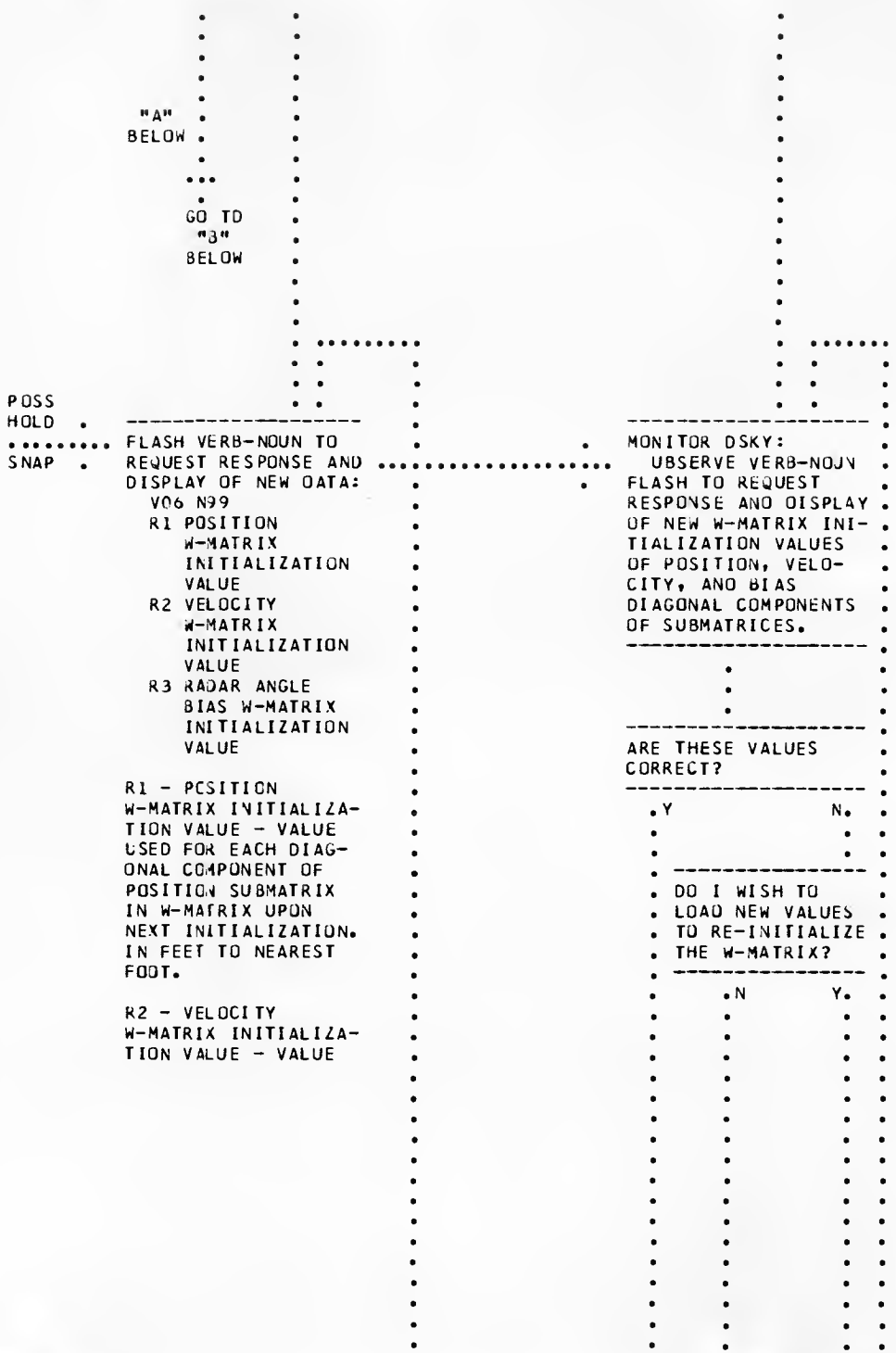

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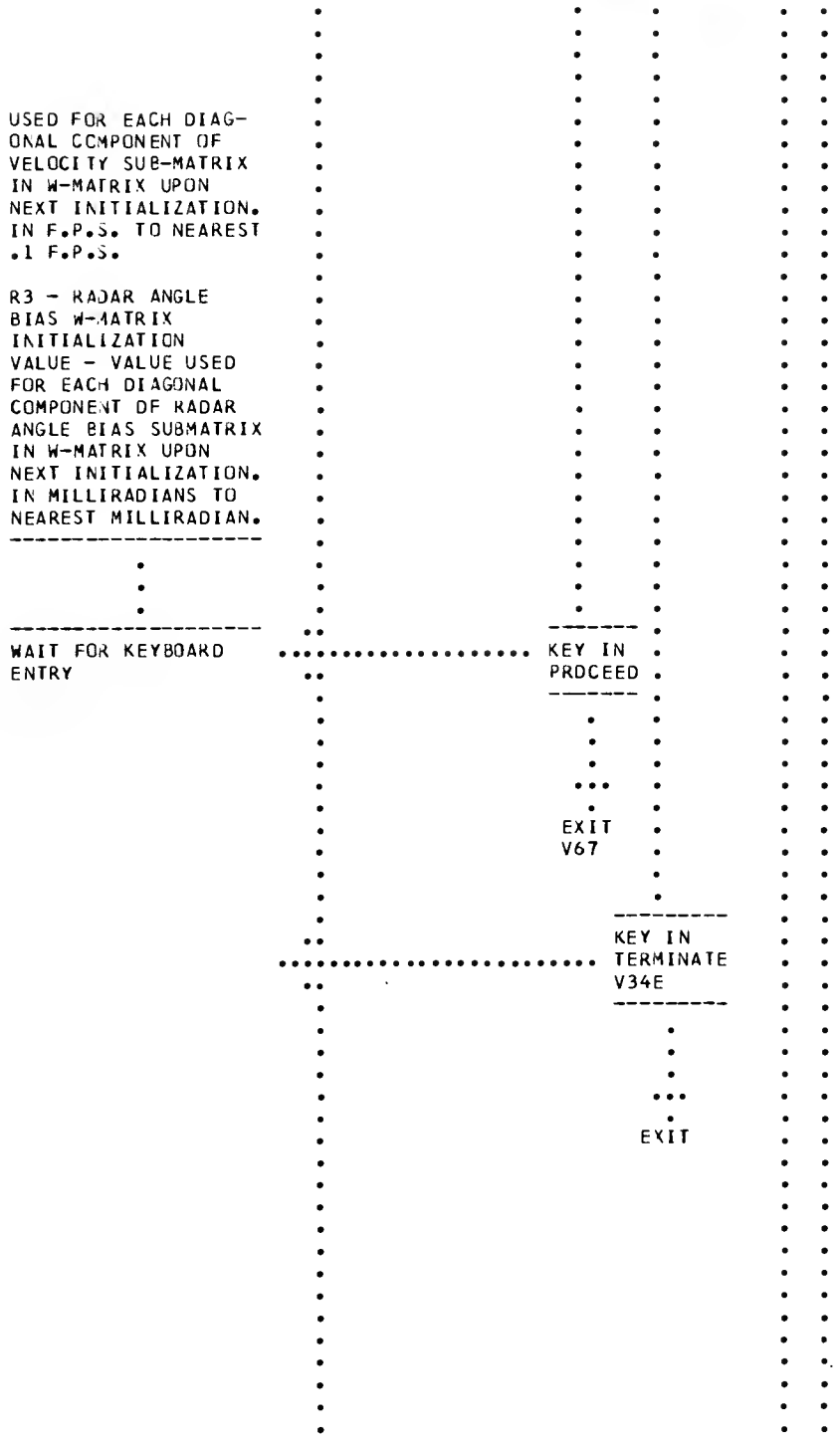

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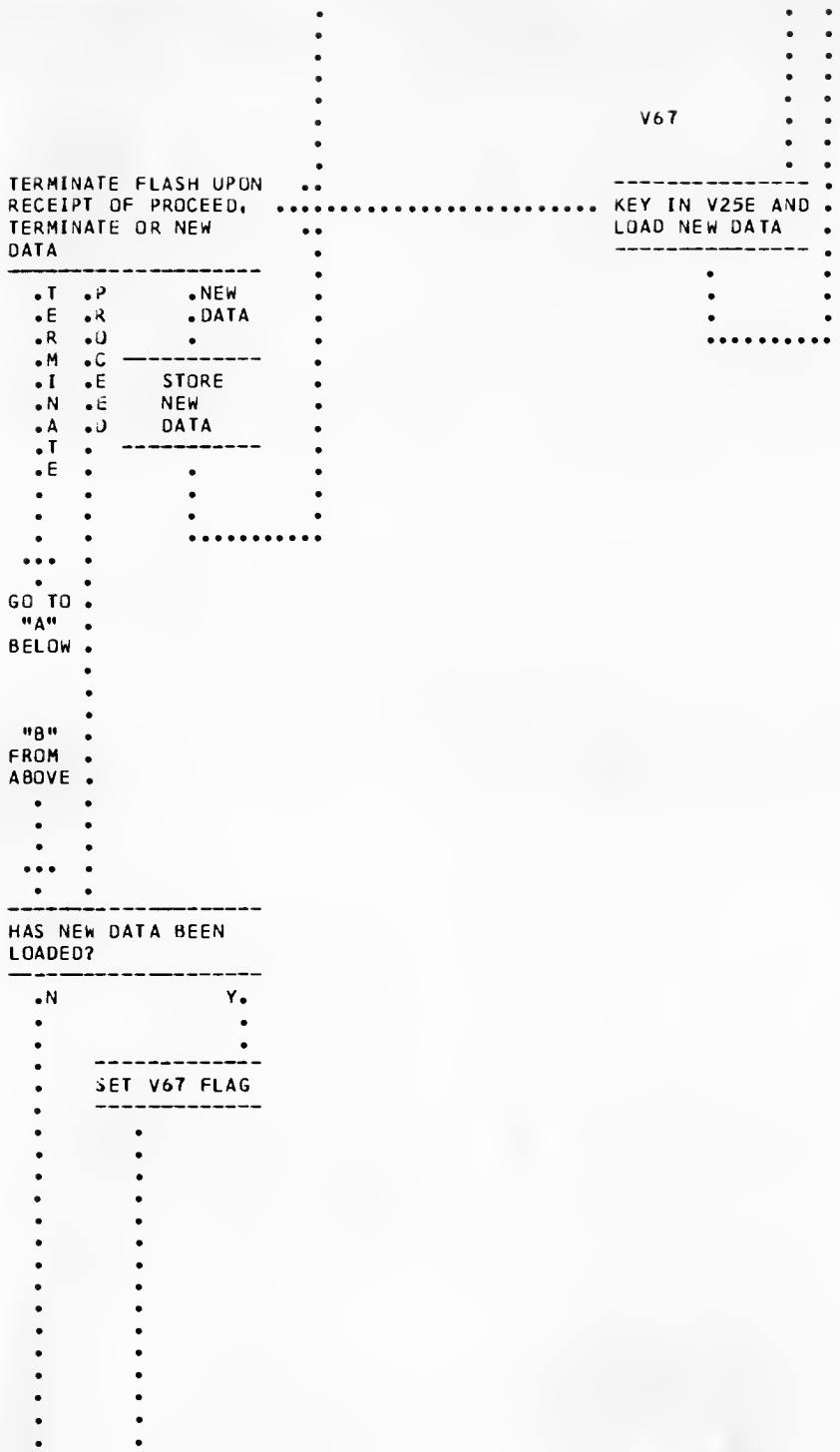
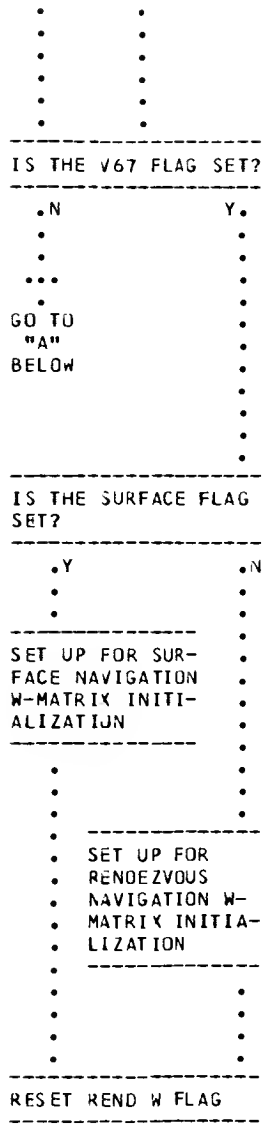

V67
TERMINATE FLASH UPON RECEIPT OF PROCEED, TERMINATE OR NEW DATA
KEY IN V25E AND LOAD NEW DATA
#230
TERMINATE
PROCEED
NEW DATA
STORE NEW DATA
#240
GO TO "A" BELOW
"B" FROM ABOVE
#250
HAS NEW DATA BEEN LOADED?
#260
N
Y
SET V67 FLAG
#270



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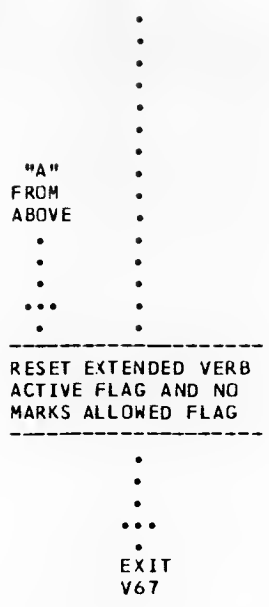
#300

#310



#320

#330

#340

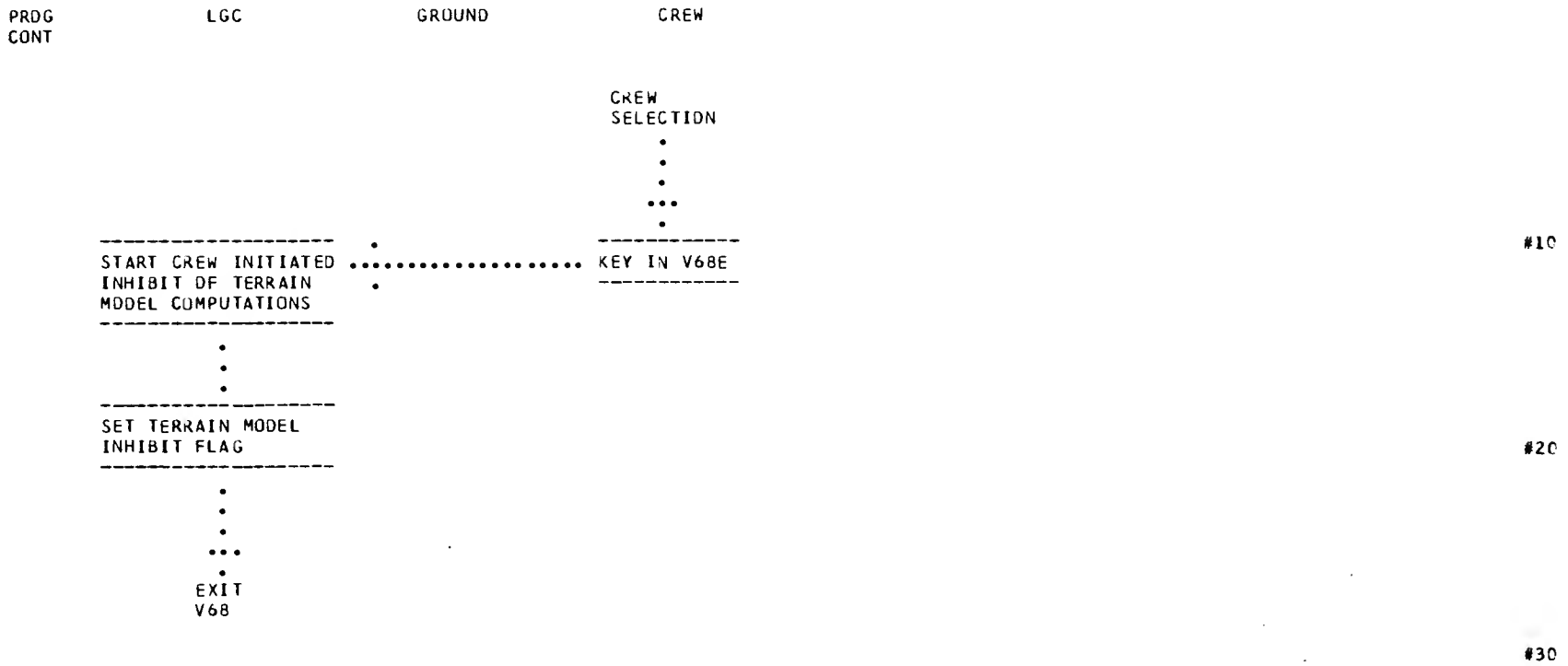
CHANGE CONTROL NOTES

REV 00 PCR 173,420
REV 01 EDITORIAL
REV 00(LUM 1A) PCR 732
REV 01(LUM 1B) EDITORIAL
REV 02 EDITORIAL
REV 03(LUM 1E) PCN 1145
REV 04 PCN 1180

V68, INHIBIT TERRAIN MODEL COMPUTATIONS REV 01 09/03/70

PURPOSE: (1) TO PERMIT THE ASTRONAUT TO BYPASS TERRAIN MODEL COMPUTATIONS WHEN THE TERRAIN MODELING CAUSES ADVERSE EFFECTS.

ASSUMPTIONS: (1) THE PROCESS IS CREW SELECTED BY DSKY ENTRY.



CHANGE CONTROL NOTES

REV 01 PCN 1035

V69, RESTART REV 03 12/03/69

PURPOSE: (1) TO CAUSE A COMPUTER RESTART.

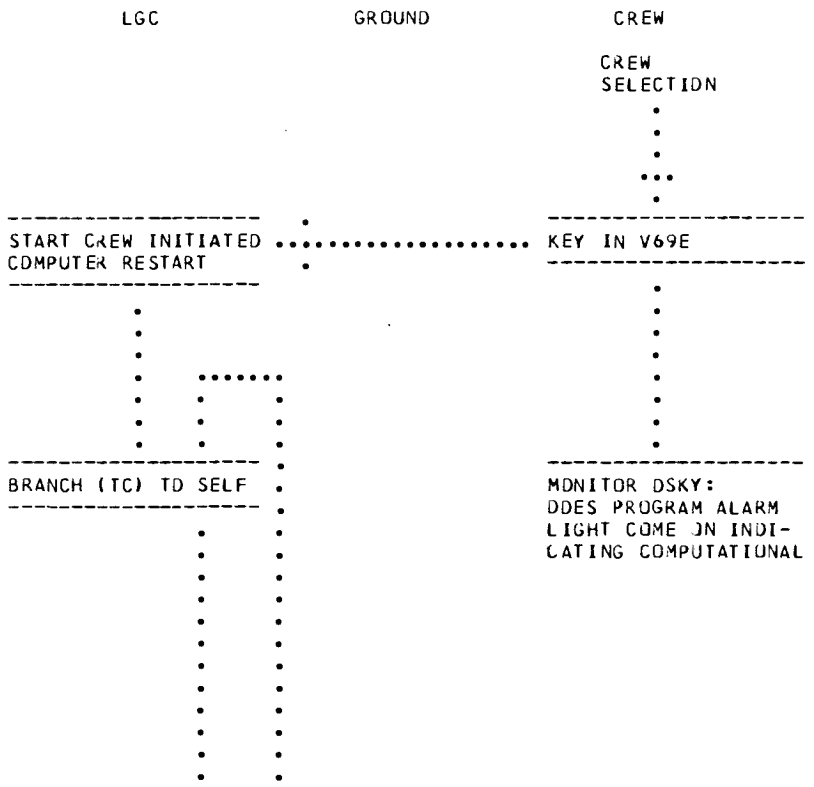
ASSUMPTIONS: (1) THE RESTART IS CREW INITIATED BY DSKY ENTRY.

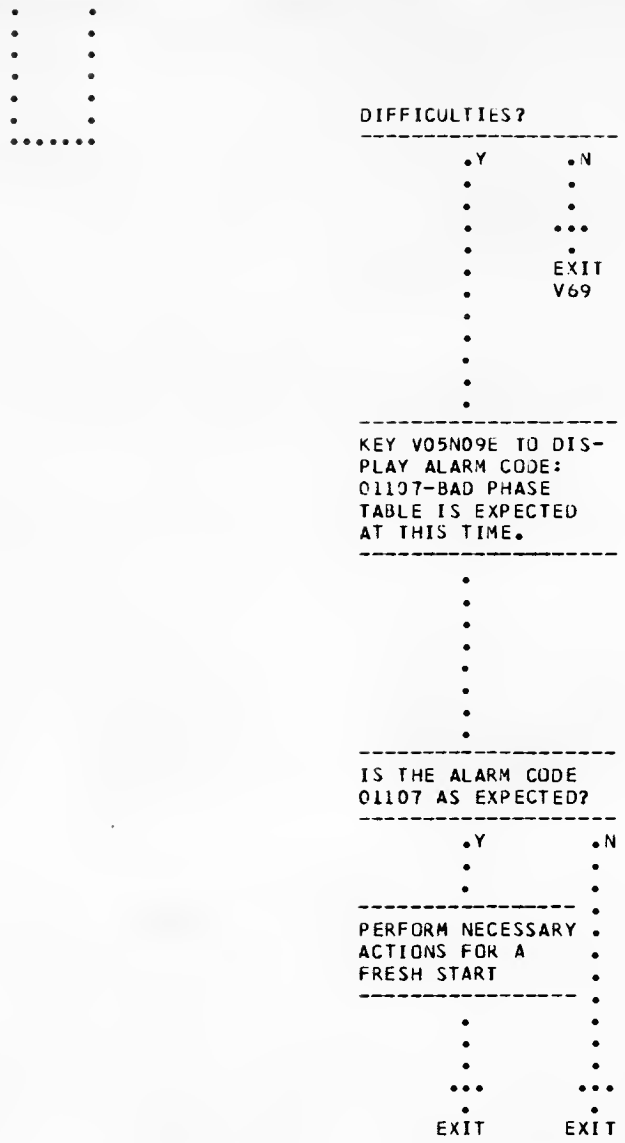
(2) V69E DOES NOT DIRECTLY SELECT RESTART PROCESSING. IT CAUSES A SITUATION WHICH SATISFIES ONE OF THE CONDITIONS FOR AN AUTOMATIC RESTART, I.E.: TOO MANY CONSECUTIVE TC INSTRUCTIONS.

(3) LGC RESTART LOGIC WILL CLEAR ALL JOB CORE SETS AND VAC AREAS, AND SET THE WAITLIST TO CALL ENDTASK.

(4) ALL EXTENDED VERB AND DISPLAY ACTIVITY WILL BE STOPPED. RESTARTABLE TASKS AND JOBS WILL THEN BE RESTARTED BY REFERENCE TO INFORMATION CONTAINED IN THE PHASE TABLE.

(5) A V69E MAY BE SELECTED AT ANY TIME.




DIFFICULTIES?
Y
N
EXIT
V69
KEY V05N09E TO DISPLAY ALARM CODE:
01107-BAD PHASE TABLE IS EXPECTED AT THIS TIME.
IS THE ALARM CODE 01107 AS EXPECTED?
Y
N
PERFORM NECESSARY ACTIONS FOR A FRESH START
EXIT
EXIT

#30

#40

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#70

V69 V69

CHANGE CONTROL NOTES

LOGIC REV 00 PCR 496
REV 01 EDITORIAL
REV 02 EDITORIAL
REV 03 EDITORIAL

V70, START LGC UPDATE: LIFTOFF TIME REV 01 08/09/69

NOTE: THIS EXTENDED VERB IS USED BY UPDATE PROGRAM P27 ONLY. SEE P27 FOR THE LOGIC SPECIFICATION FLOW FOR UPDATING THE LIFTOFF TIME.

CHANGE CONTROL NOTES

REV 01 PCR 496

V71, START LGC UPDATE: BLOCK ADDRESS REV 01 08/09/69

NOTE: THIS EXTENDED VERB IS USED BY UPDATE PROGRAM P27 ONLY. SEE P27 FOR THE LOGIC SPECIFICATION FLOW FOR A BLOCK ADDRESS UNIVERSAL UPDATE.

CHANGE CONTROL NOTES

REV 01 PCR 496

V72, START LGC UPDATE: SINGLE ADDRESS REV 01 08/09/69

NOTE: THIS EXTENDED VERB IS USED WITH UPDATE PROGRAM P27 ONLY. SEE P27 FOR THE LOGIC SPECIFICATION FLOW FOR A SINGLE ADDRESS UNIVERSAL JPDATE.

CHANGE CONTROL NOTES

REV 01 PCR 456

V73, START LGC UPDATE: LGC TIME (OCTAL) REV 01 08/09/69

NOTE: THIS EXTENDED VERB IS USED BY THE UPDATE PROGRAM P27 ONLY. SEE P27 FOR THE LOGIC SPECIFICATION FLOW FOR THE OCTAL UPDATE OF LGC TIME.

CHANGE CONTROL NOTES

REV 01 PCR 496

V74, INITIALIZE ERASABLE DUMP VIA DOWNLINK REV C4 02/17/71

PURPOSE: (1) TO DUMP ALL EIGHT BANKS OF ERASABLE MEMORY VIA DOWNLINK.

ASSUMPTIONS: (1) THE PROCESS IS CREW SELECTED BY DSKY ENTRY.

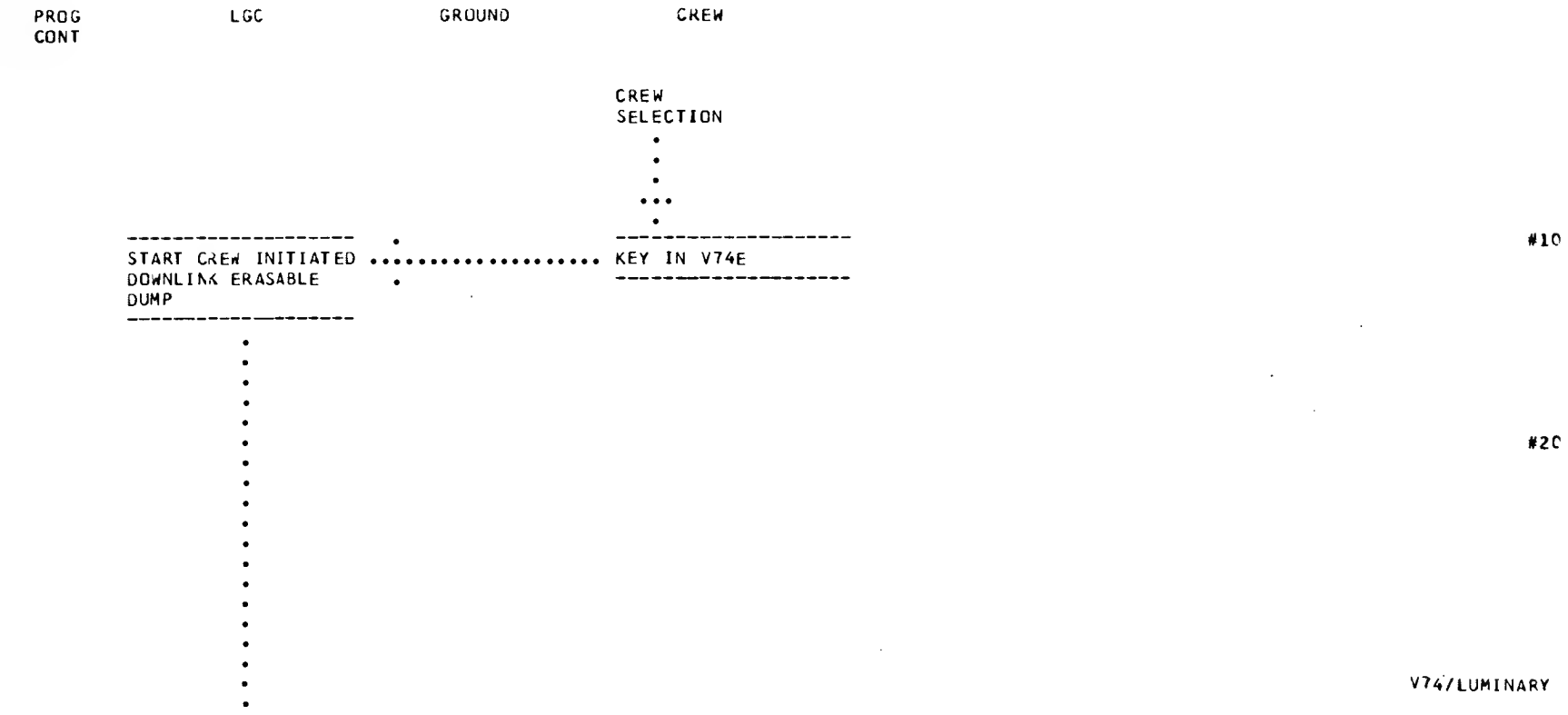
(2) THE DUMP OF EACH BANK IS PRECEDED BY AN ID WORD, SYNCH BITS, ECADR, AND TIME.

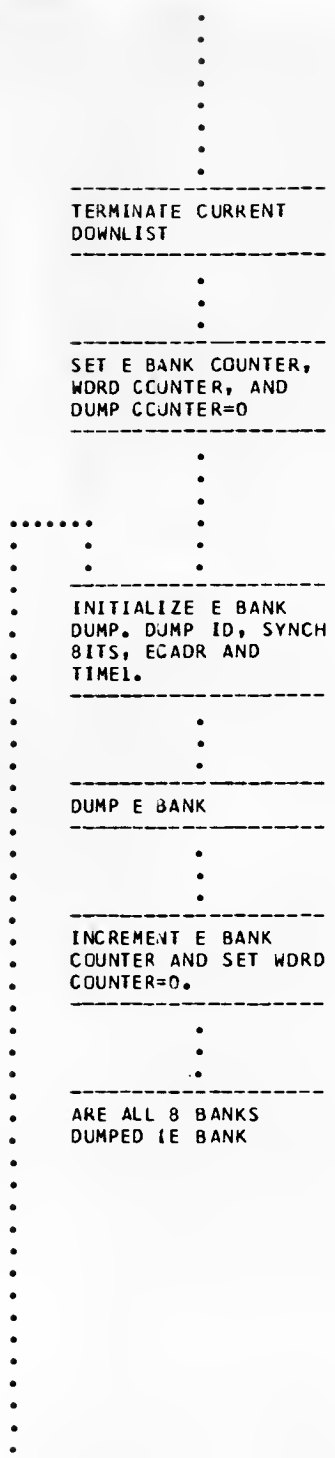
(3) THE E BANKS ARE DUMPED IN ORDER, STARTING WITH E BANK ZERO.

(4) DUMPING OF ALL EIGHT BANKS IS REPEATED ONCE (2 COMPLETE DUMPS) TO FACILITATE SUCCESSFUL GROUND RECORDING.

(5) THE TIME REQUIRED FOR 2 COMPLETE DUMPS IS 41.6 SECONDS.

(6) THIS PROCESS CAN BE SELECTED CONCURRENTLY WITH ANY OTHER EXTENDED VERB, BUT SHOULD NOT BE SELECTED WITH V47 (R47, AGS INITIALIZATION ROUTINE).




TERMINATE CURRENT DOWNLIST
SET E BANK COUNTER, WORD COUNTER, AND DUMP COUNTER=0
INITIALIZE E BANK DUMP. DUMP ID, SYNCH BITS, ECADR AND TIME1.
DUMP E BANK
INCREMENT E BANK COUNTER AND SET WORD COUNTER=0.
ARE ALL 8 BANKS DUMPED IE BANK

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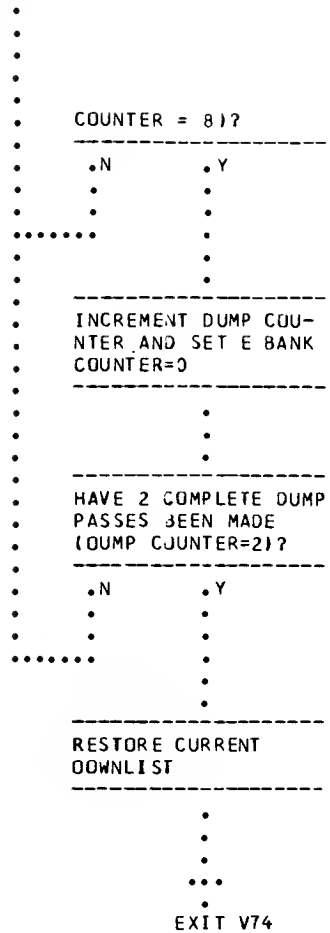

#70

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#100

CHANGE CONTROL NOTES

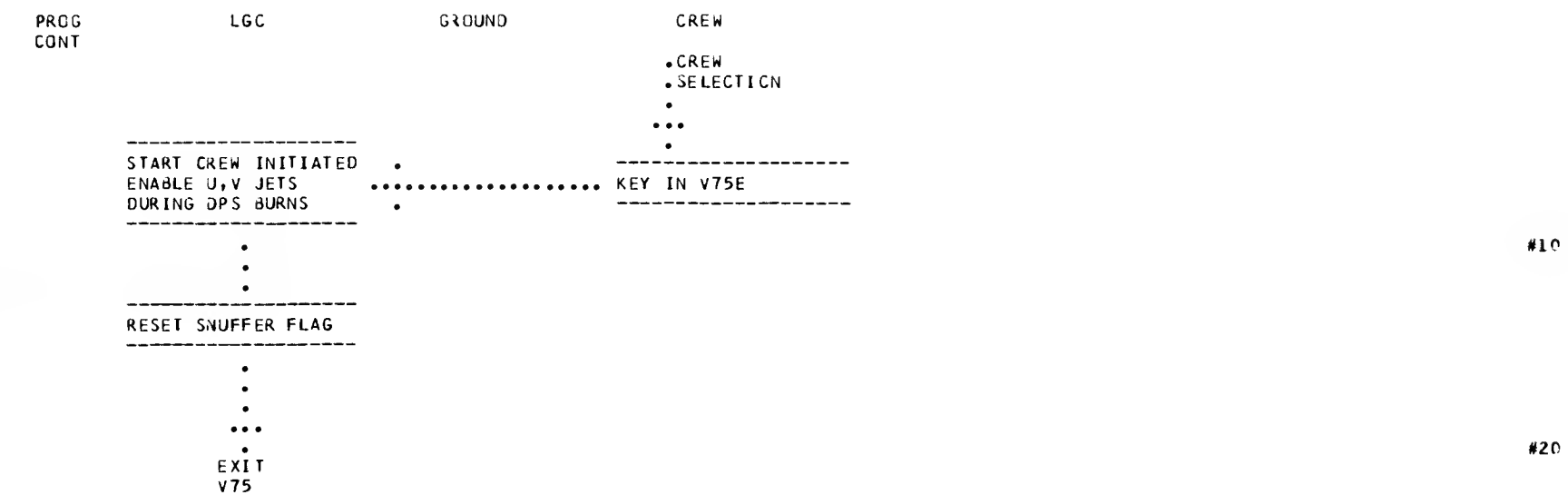
REV 00 PCR 496
REV 01 EDITORIAL
REV 02(LUM 1B) PCR 277,EDITORIAL
REV 03 EDITORIAL
REV 04(LUM 1E) PCN 1145

V75, ENABLE U,V JETS DURING DPS BURNS REV C1 08/09/69

PURPOSE: (1) TO ENABLE U AND V RCS JET FIRINGS DURING DPS POWERED FLIGHT.

ASSUMPTIONS: (1) THE PROCESS IS CREW SELECTED BY DSKY ENTRY.

(2) THE PROCESS MAY BE SELECTED AT ANY TIME.



CHANGE CONTROL NOTES

LOGIC REV C1 PCR 539

V76, MINIMUM IMPULSE COMMAND MODE REV C4 02/17/71

PURPOSE: (1) TO ENABLE THE MINIMUM IMPULSE MODE OF THE DAP.

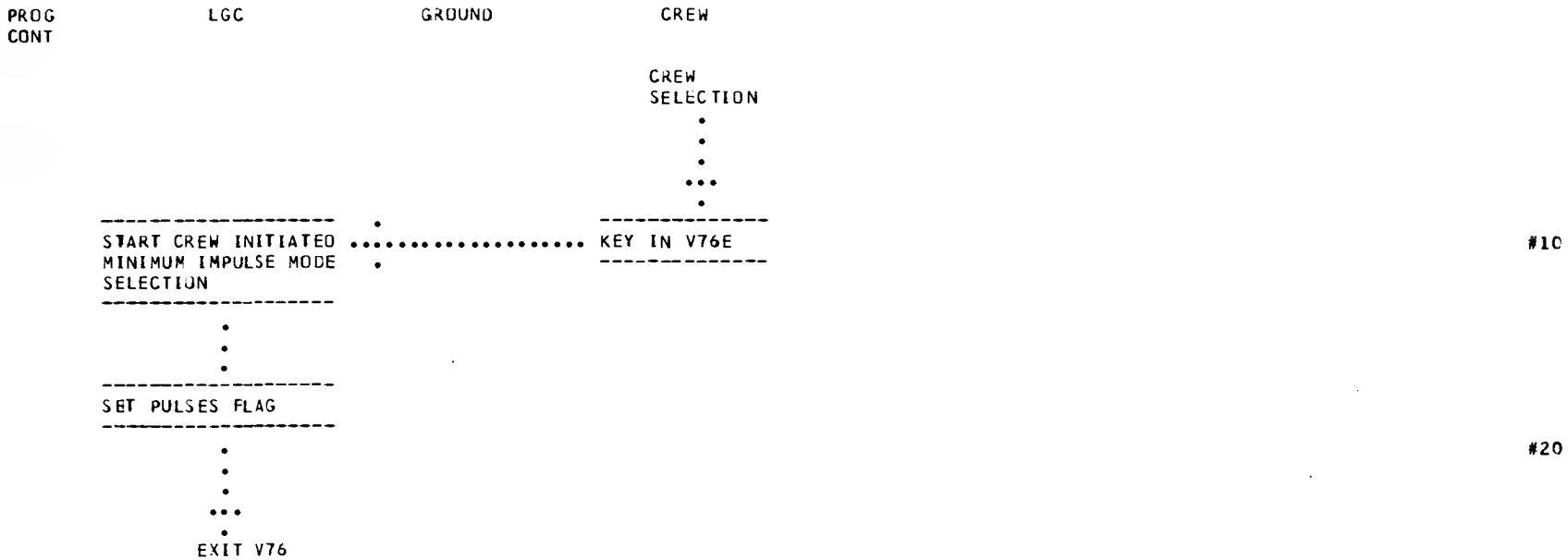
ASSUMPTIONS: (1) THE PROCESS IS CREW SELECTED BY OSKY ENTRY.

(2) TO OBTAIN THE MINIMUM IMPULSE MODE, THE GUID CONT SWITCH MUST BE AT PGNS AND THE PGNS MODE CONTROL SWITCH AT ATT HOLD.

(3) THE MINIMUM IMPULSE MODE WILL REMAIN ENABLED UNTIL CANCELLED BY RATE MODE SELECTION (SEE V77); OR BY FRESH START; OR BY P12,P40,P41,P42,P63,P70,P71 OR BY R40.

(4) WHENEVER THE MINIMUM IMPULSE MODE IS IN EFFECT THE "NO DAP" OSKY LIGHT WILL COME ON.

(5) THE PROCESS MAY BE SELECTED AT ANY TIME.



CHANGE CONTROL NOTES

REV 00 PCR 496
REV 01 EDITORIAL
REV 02 EDITORIAL
REV 03 EDITORIAL
REV 04(LUM 1E) PCR 1134, PCN 1145

V77, RATE COMMAND AND ATTITUDE HOLD MODE REV 02 12/03/69

PURPOSE: (1) TO ENABLE THE RATE COMMAND MODE OF THE DAP.

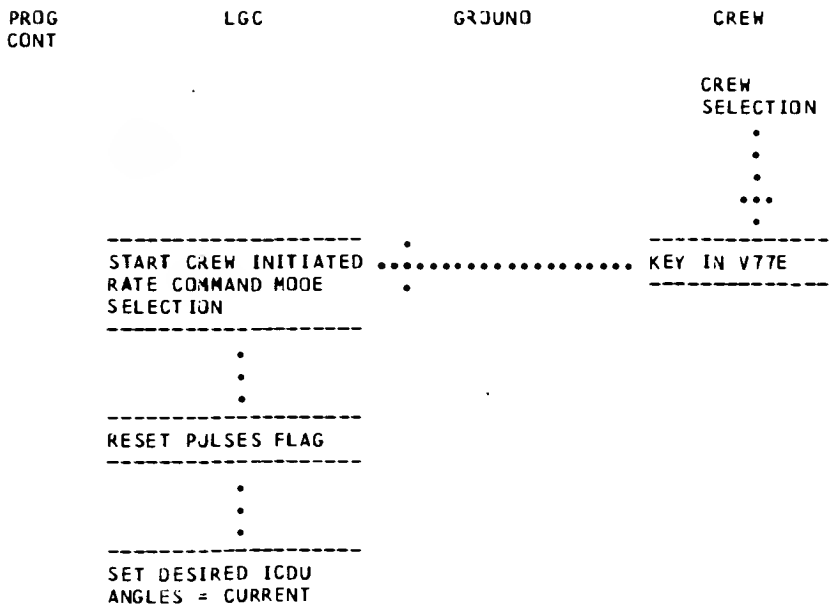
(2) TO SET DESIRED ICDU ANGLES EQUAL TO ACTUAL ICDU ANGLES.

ASSUMPTIONS: (1) THE PROCESS IS CREW SELECTED BY DSKY ENTRY.

(2) TO OBTAIN THE RATE COMMAND MODE, THE GUID CONT SWITCH MUST BE AT PGNS AND THE PGNS MODE CONTROL SWITCH AT ATT HOLD.

(3) THE RATE COMMAND MODE WILL REMAIN ENABLED UNTIL CANCELLED BY MINIMUM IMPULSE MODE SELECTION (SEE V76), OR BY P68.

(4) THE PROCESS MAY BE SELECTED AT ANY TIME.



#30

ICDU ANGLES

EXIT
V77

CHANGE CONTROL NOTES

LOGIC REV 00 PCR 496
REV 01 EDITORIAL
REV 02 EDITORIAL

V78, START LR SPURIOUS TEST (R77) REV 01 08/09/69

NOTE: THIS EXTENDED VERB IS USED TO CALL ROUTINE 77. SEE R77 FOR THE LOGIC SPECIFICATION FLOW FOR THE LR SPURIOUS TEST.

CHANGE CONTROL NOTES

REV 01 PCR 229

V79, STOP LR SPURIOUS TEST (R77) REV 01 08/09/69

NOTE: THIS EXTENDED VERB IS USED TO TERMINATE ROUTINE 77. SEE R77 FOR THE LOGIC SPECIFICATION FLOW FOR THE LR SPURIOUS TEST.

CHANGE CONTROL NOTES

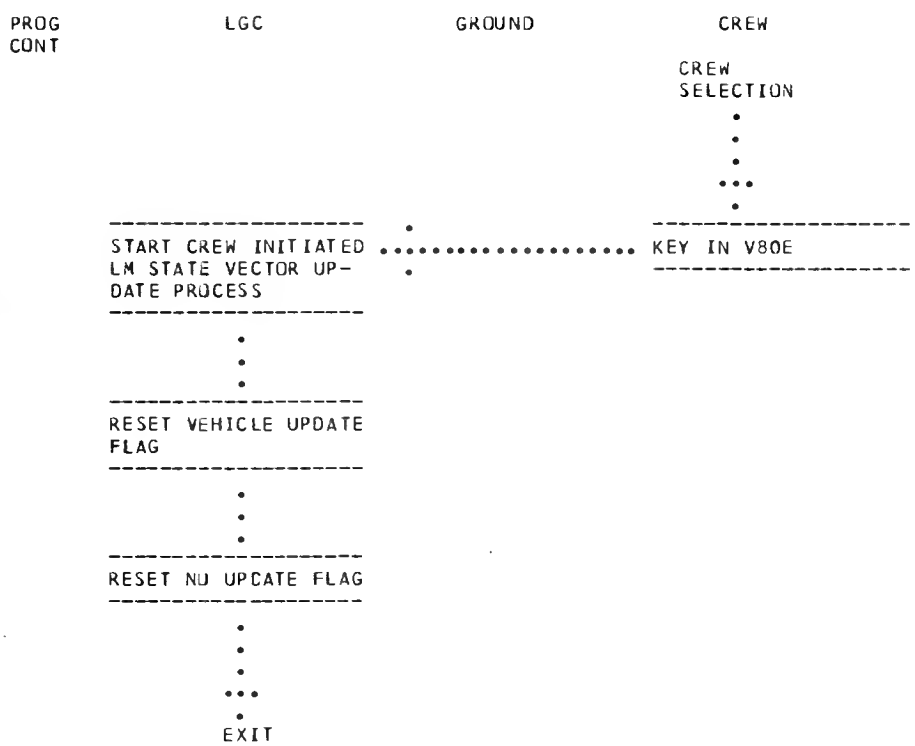
REV 01 PCR 229

V80, ENABLE LM STATE VECTOR UPDATE REV C2 08/07/69

PURPOSE: (1) TO CAUSE THE RENDEZVOUS DATA PROCESSING RESULTS TO UPDATE THE LM STATE VECTOR.

ASSUMPTIONS: (1) THE PROCESS IS CREW SELECTED BY DSKY ENTRY.

(2) THE PROCESS MAY BE SELECTED AT ANY TIME.



V80

CHANGE CONTROL NOTES

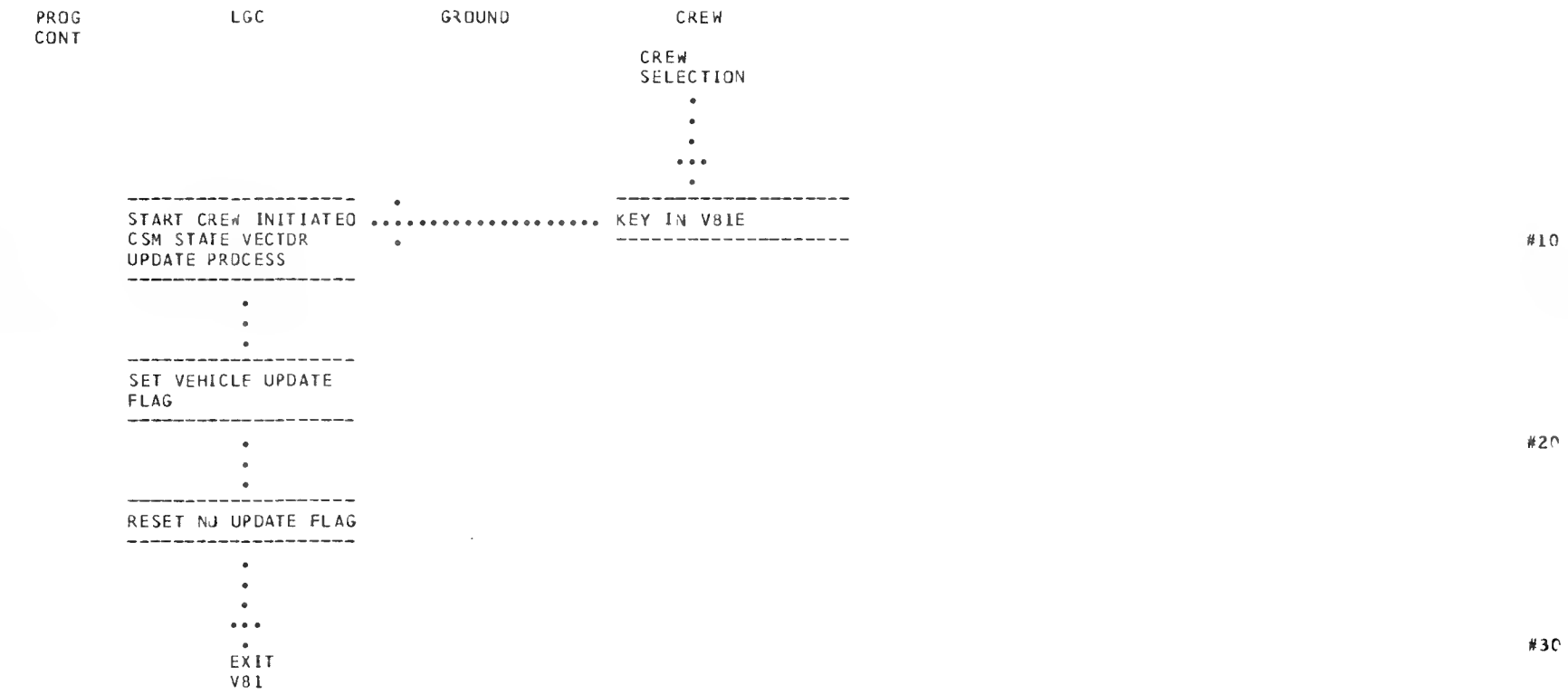
REV 00 PCR 496
REV 01 EDITORIAL
REV 02 EDITORIAL

V81, ENABLE CSM STATE VECTOR UPDATE REV C2 08/07/69

PURPOSE: (1) TO CAUSE THE RENDEZVOUS DATA PROCESSING RESULTS TO UPDATE THE CSM STATE VECTOR.

ASSUMPTIONS: (1) THE PROCESS IS CREW SELECTED BY DSKY ENTRY.

(2) THE PROCESS MAY BE SELECTED AT ANY TIME.



CHANGE CONTROL NOTES

LOGIC REV 00 PCR 496
REV 01 EDITORIAL
REV 02 EDITORIAL

V82, REQUEST ORBITAL PARAMETERS DISPLAY (R30) REV 01 08/09/69

NOTE: THIS EXTENDED VERB IS USED TO CALL ROUTINE 30. SEE R30 FOR THE LOGIC SPECIFICATION FLOW FOR REQUESTING THE ORBITAL PARAMETERS DISPLAY.

CHANGE CONTROL NOTES

REV 01 PCR 496

V83, REQUEST RENDEZVOUS PARAMETER DISPLAY (R31) REV 01 08/09/69

NOTE: THIS EXTENDED VERB IS USED TO CALL ROUTINE 31. SEE R31 FOR THE LOGIC SPECIFICATION FLOW FOR REQUESTING THE RENDEZVOUS PARAMETER DISPLAY.

CHANGE CONTROL NOTES

REV 01 PCR 496

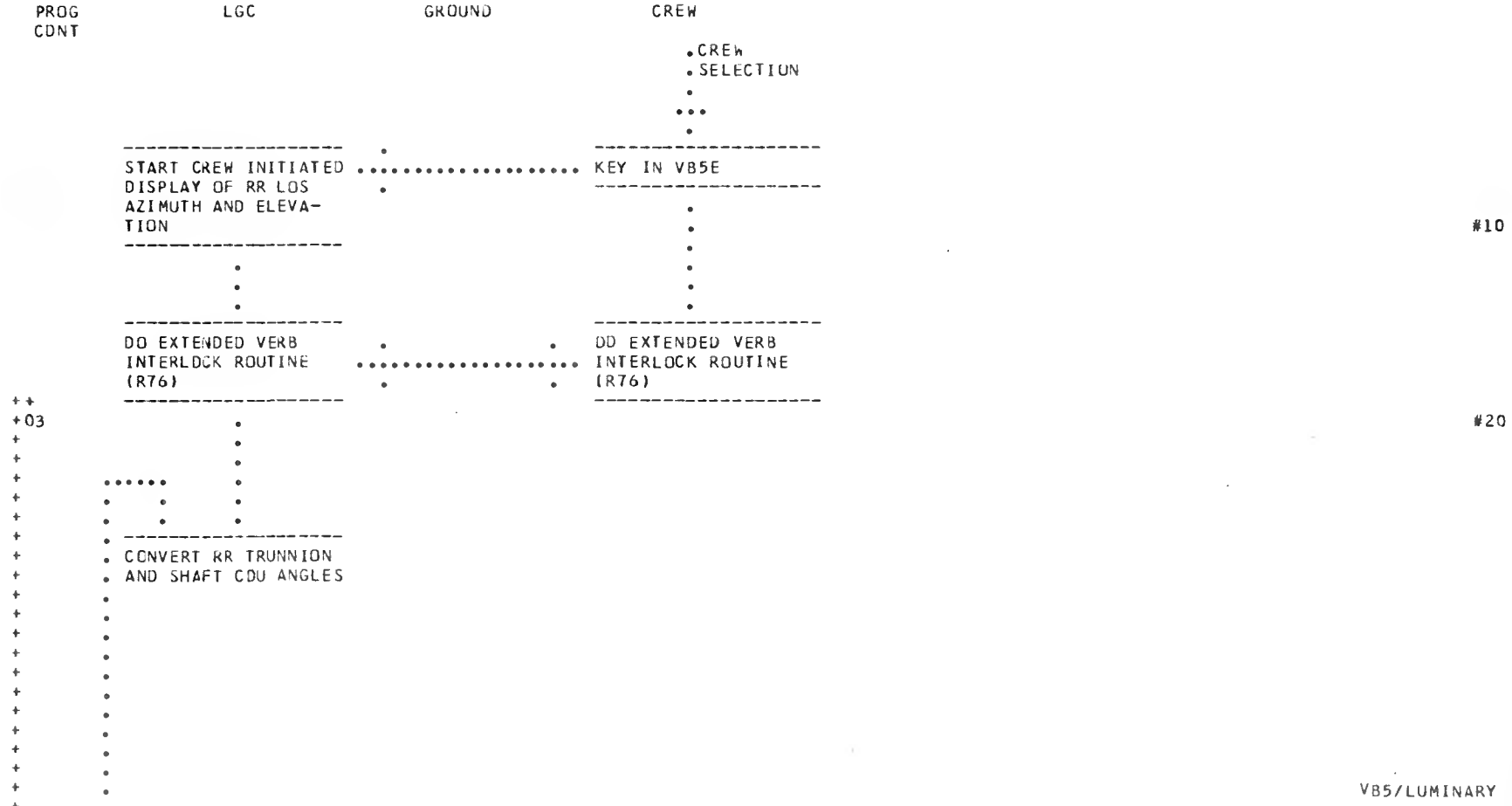
V85, DISPLAY RR LOS AZIMUTH AND ELEVATION REV 03 12/01/71

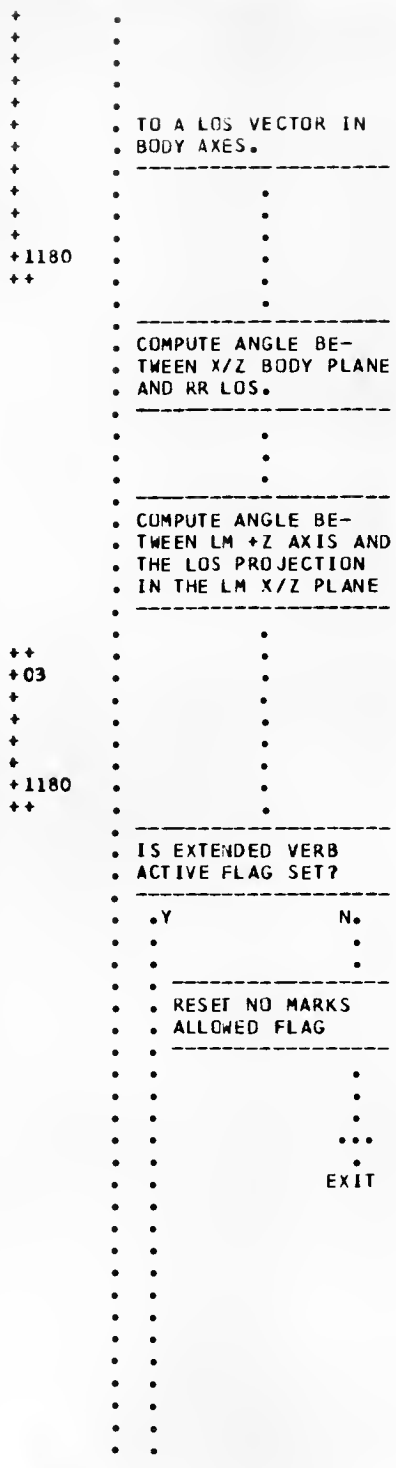
PURPOSE: (1) TO DISPLAY RR ANTENNA AZIMUTH AND ELEVATION.

ASSUMPTIONS: (1) THE PROCESS IS CREW SELECTED BY DSKY ENTRY.

(2) THIS PROCESS CAN BE SELECTED ANY TIME ANOTHER EXTENDED VERB OR ROUTINE (SEE R53) WHICH ALSO SETS THE EXTENDED VERB INTERLOCK IS NOT ACTIVE.

(3) IF THE RR IS NOT IN THE AUTO MODE THE ANGLES DISPLAYED BY THIS PROCESS MAY BE INCORRECT BECAUSE THE RR CDU ZERO DISCRETE WILL BE PRESENT AS LONG AS THE RR MODE IS NOT IN AUTO.




TO A LOS VECTOR IN
BODY AXES.
1180
COMPUTE ANGLE BE-
TWEEN X/Z BODY PLANE
AND RR LOS.
COMPUTE ANGLE BE-
TWEEN LM +Z AXIS AND
THE LOS PROJECTION
IN THE LM X/Z PLANE
03
1180
IS EXTENDED VERB
ACTIVE FLAG SET?
Y
N.
RESET NO MARKS
ALLOWED FLAG
EXIT

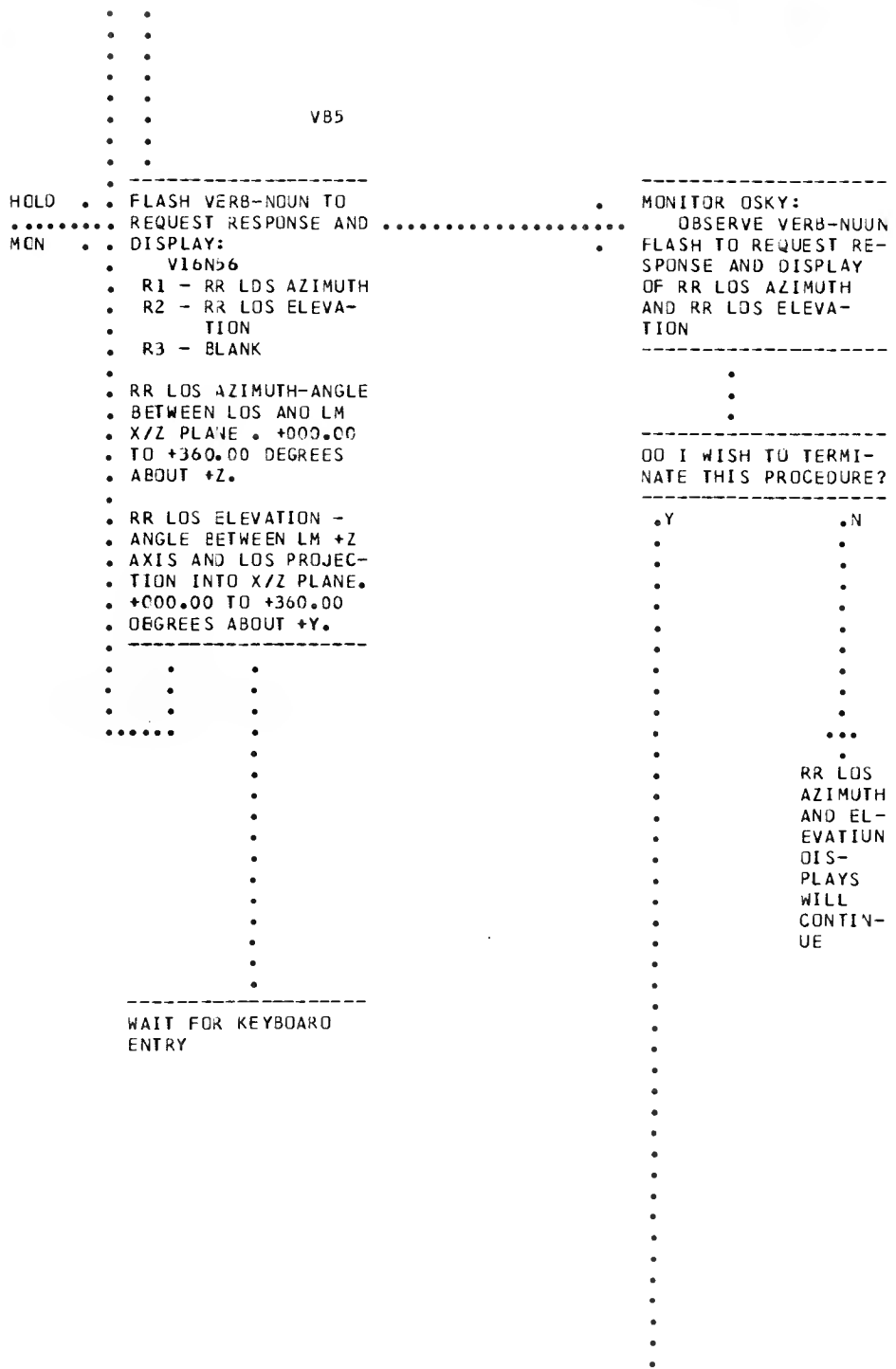
#30

#40

#50

#60

#70



#80

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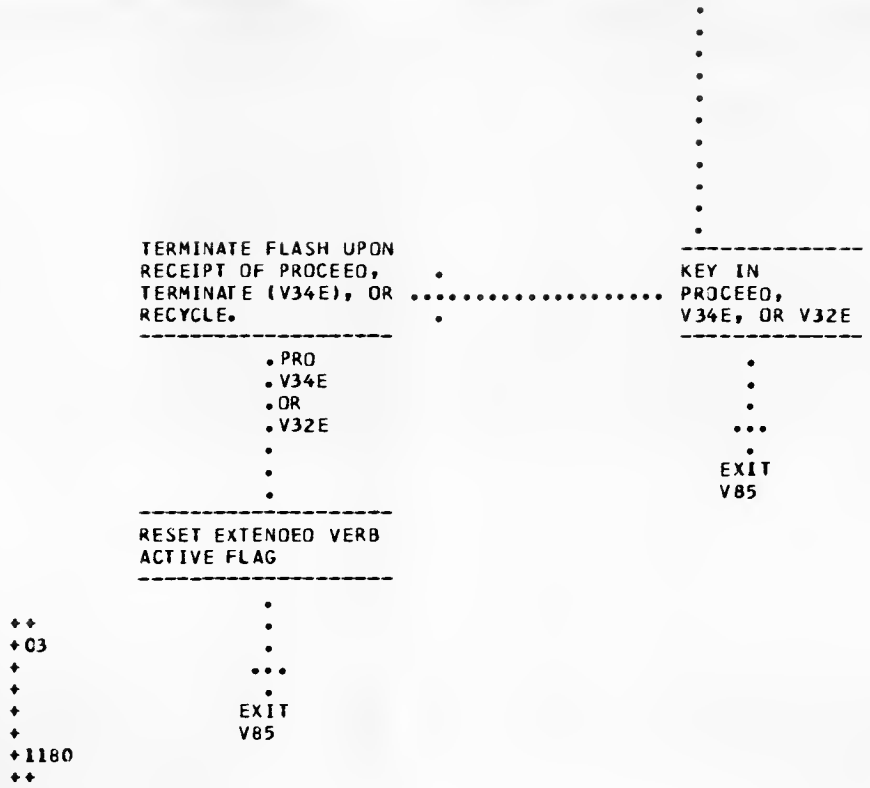
#110

#120



#130

#140

#150

++
+03
+
+
+
+
+1180
++

CHANGE CONTROL NOTES

LOGIC REV 01 PCR 623
REV 02 EDITORIAL
REV 03 PCN 1180

V89, START RENDEZVOUS FINAL ATTITUDE MANEUVER (R63) REV 01 08/09/69

NOTE: THIS EXTENDED VERB IS USED TO CALL ROUTINE 63. SEE R63 FOR THE LOGIC SPECIFICATION FLOW TO START RENDEZVOUS FINAL ATTITUDE MANEUVER ROUTINE (R63).

CHANGE CONTROL NOTES

REV 01 PCR 496

V90, REQUEST RENDEZVOUS OUT-OF-PLANE DISPLAY (R36) REV 01 08/09/69

NOTE: THIS EXTENDED VERB IS USED TO CALL ROUTINE 36. SEE R36 FOR THE LOGIC SPECIFICATION FLOW FOR REQUESTING THE RENDEZVOUS OUT-OF-PLANE DISPLAY.

CHANGE CONTROL NOTES

REV 01 PCR 496

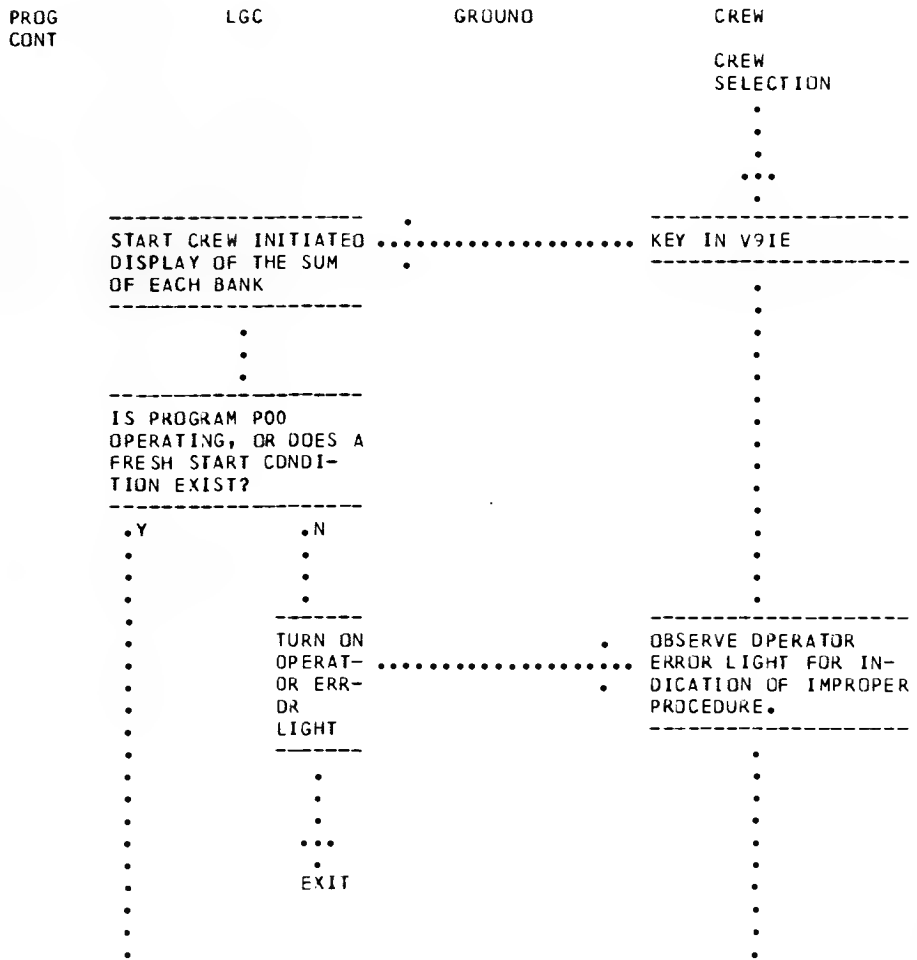
V91, DISPLAY BANKSUM REV 01 08/09/69

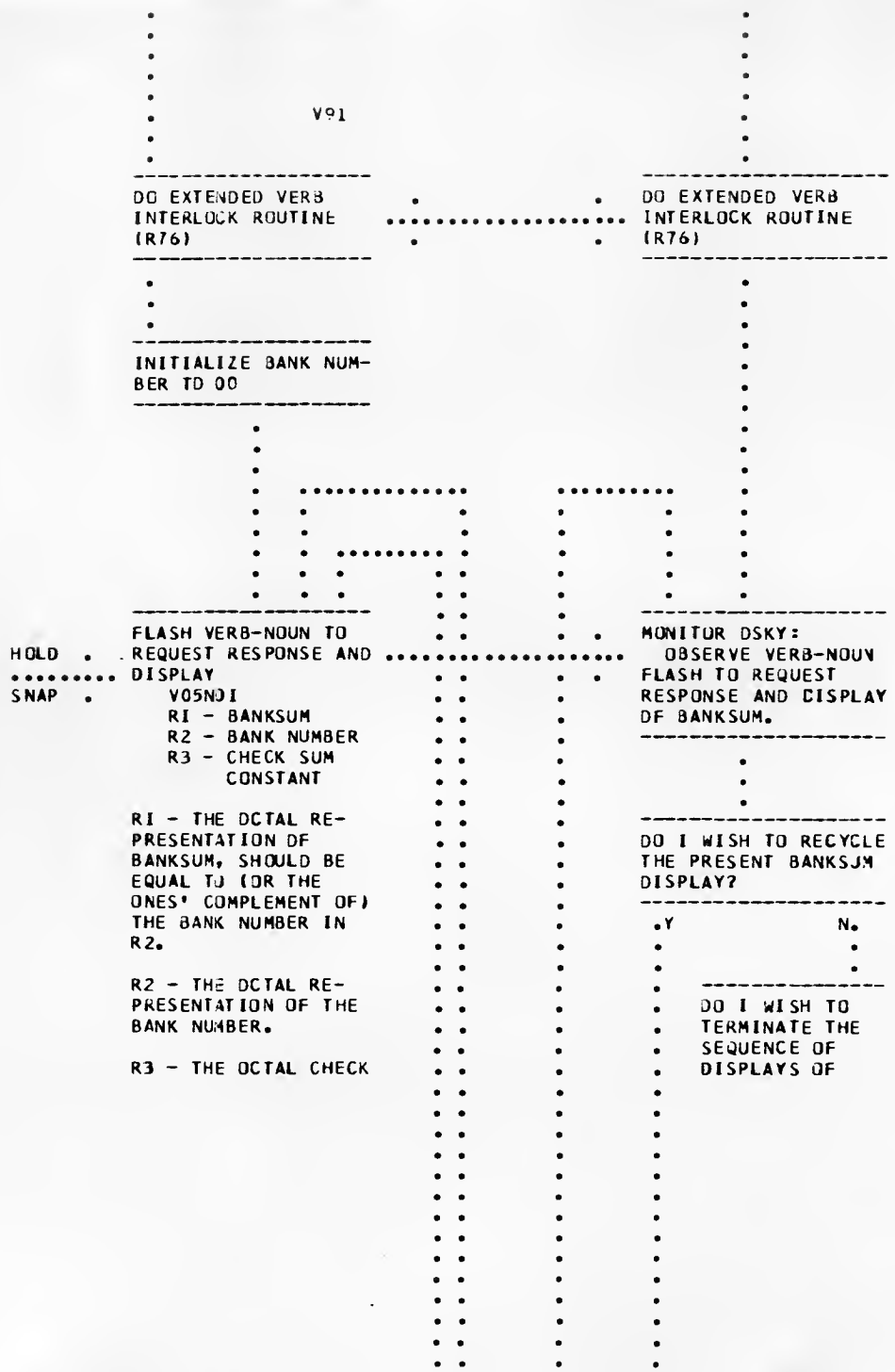
PURPOSE: (1) DISPLAY THE SUM OF EACH BANK FOR COMPARISON.

ASSUMPTIONS: (1) THE PROCESS IS CREW SELECTED BY OSKY ENTRY.

(2) P00 IS OPERATING, OR A FRESH START CONDITION EXISTS.

(3) NO OTHER EXTENDED VERB WHICH SETS THE EXTENDED VERB INTERLOCK IS ACTIVE.




V91
DO EXTENDED VERB INTERLOCK ROUTINE (R76)
DO EXTENDED VERB INTERLOCK ROUTINE (R76)
INITIALIZE BANK NUMBER TO 00
HOLD
SNAP
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY
V05N01
R1 - BANKSUM
R2 - BANK NUMBER
R3 - CHECK SUM CONSTANT
R1 - THE OCTAL REPRESENTATION OF BANKSUM, SHOULD BE EQUAL TO (OR THE ONES' COMPLEMENT OF) THE BANK NUMBER IN R2.
R2 - THE OCTAL REPRESENTATION OF THE BANK NUMBER.
R3 - THE OCTAL CHECK
MONITOR DSKY: OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY OF BANKSUM.
DO I WISH TO RECYCLE THE PRESENT BANKSUM DISPLAY?
Y
N
DO I WISH TO TERMINATE THE SEQUENCE OF DISPLAYS OF

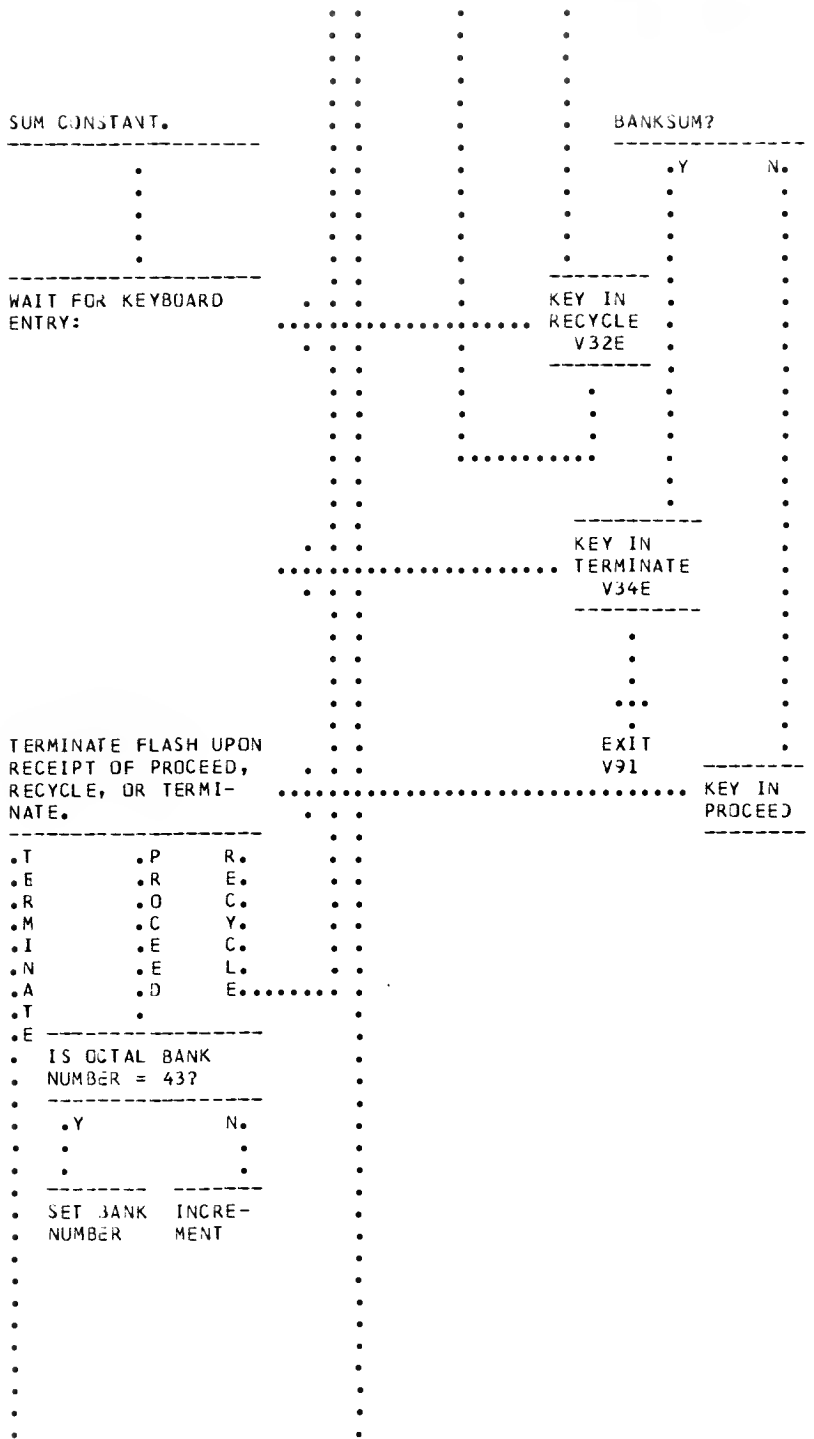
#40

#50

#60

#70

#80



#90

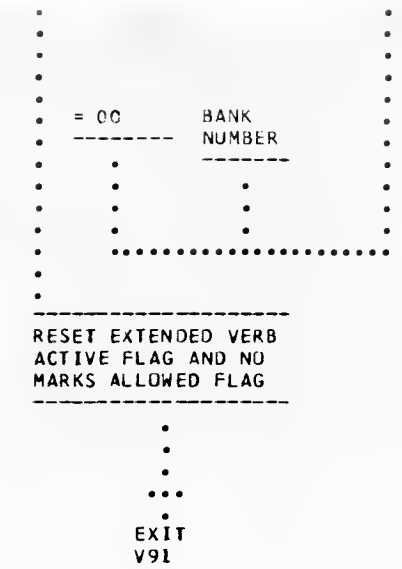
#100

#110

#120

#130

#140



#150

CHANGE CONTROL NOTES

REV 01 PCR 496

V92, START IMU PERFORMANCE TESTS (GROUND USE) REV 01 08/09/69

NOTE: THIS EXTENDED VERB IS USED TO OPERATE THE IMU PERFORMANCE TEST (P07). A DESCRIPTION OF THIS PROGRAM IS CONTAINED IN SECTION 1 OF R557(PRELAUNCH TEST PROGRAMS FOR SUNDANCE AND LUMINARY, FIGURE 1.4.1-1)

CHANGE CONTROL NOTES

REV 01 PCR 496

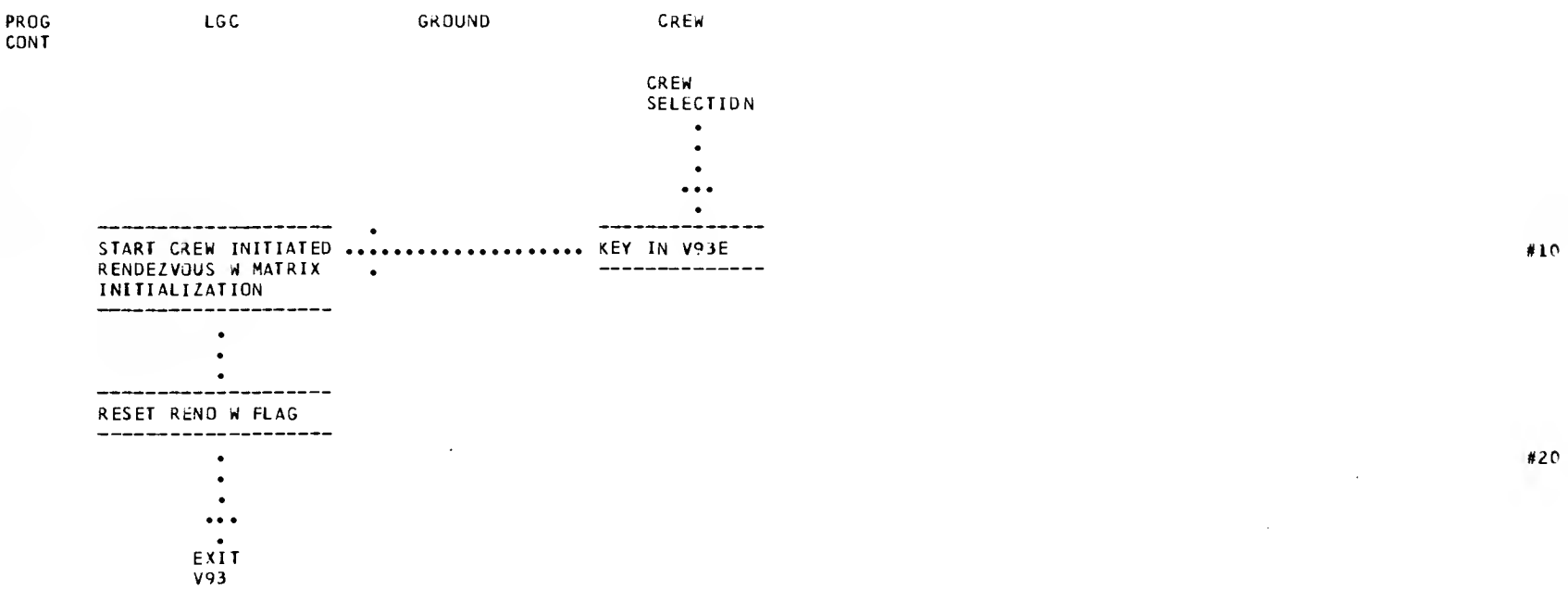
V93, ENABLE W MATRIX INITIALIZATION REV 01 08/09/69

PURPOSE: (1) TO REQUEST REINITIALIZATION OF THE RENDEZVOUS W MATRIX.

ASSUMPTIONS: (1) THIS PROCESS RESETS THE REND W FLAG INDICATING THAT THE RENDEZVOUS W MATRIX IS NOT VALID AND MUST BE REINITIALIZED BEFORE BEING USED. THE REND W FLAG IS AUTOMATICALLY SET FOLLOWING W MATRIX INITIALIZATION OR REINITIALIZATION.

(2) THE PROCESS IS CREW SELECTED BY DSKY ENTRY.

(3) THIS PROCESS MAY BE SELECTED AT ANY TIME.



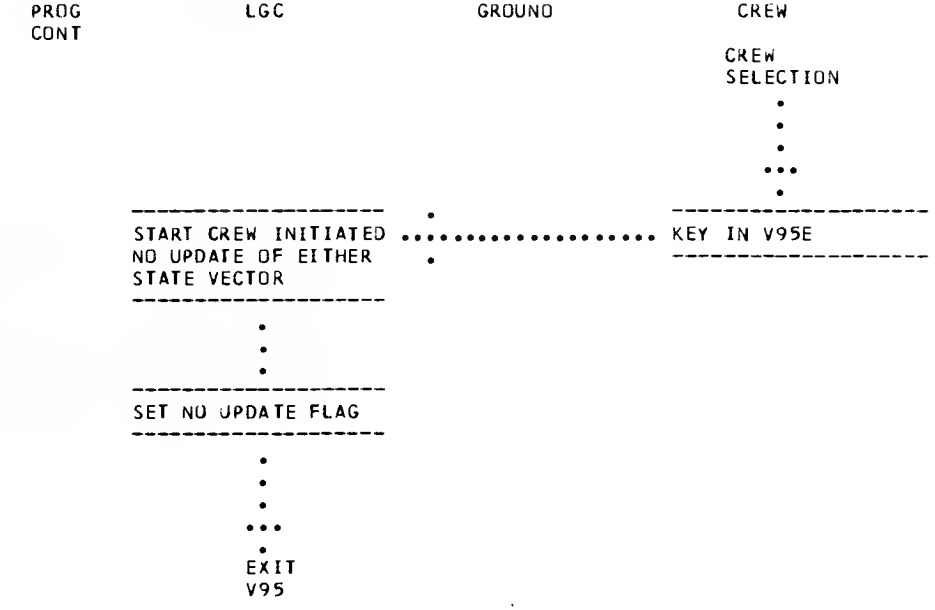
CHANGE CONTROL NOTES

REV C1 PCR 496

V95, NO UPDATE OF EITHER STATE VECTOR REV 01 08/09/69

PURPOSE: (1) TO PREVENT LM OR CSM STATE VECTOR UPDATING BY P20 OR P22.

ASSUMPTION: (1) THE PROCESS IS CREW SELECTED BY OSKY ENTRY.



#10

#20

CHANGE CONTROL NOTES

REV 01 PCR 496

V96, INTERRUPT INTEGRATION AND GO TO P00 REV 02 08/07/69

PURPOSE: (1) TO PROVIDE A MEANS OF SUSPENDING STATE VECTOR INTEGRATION.

ASSUMPTIONS: (1) IF THE COASTING INTEGRATION ROUTINE IS IN OPERATION, IT IS TERMINATED AT THE END OF THE CURRENT TIME STEP.

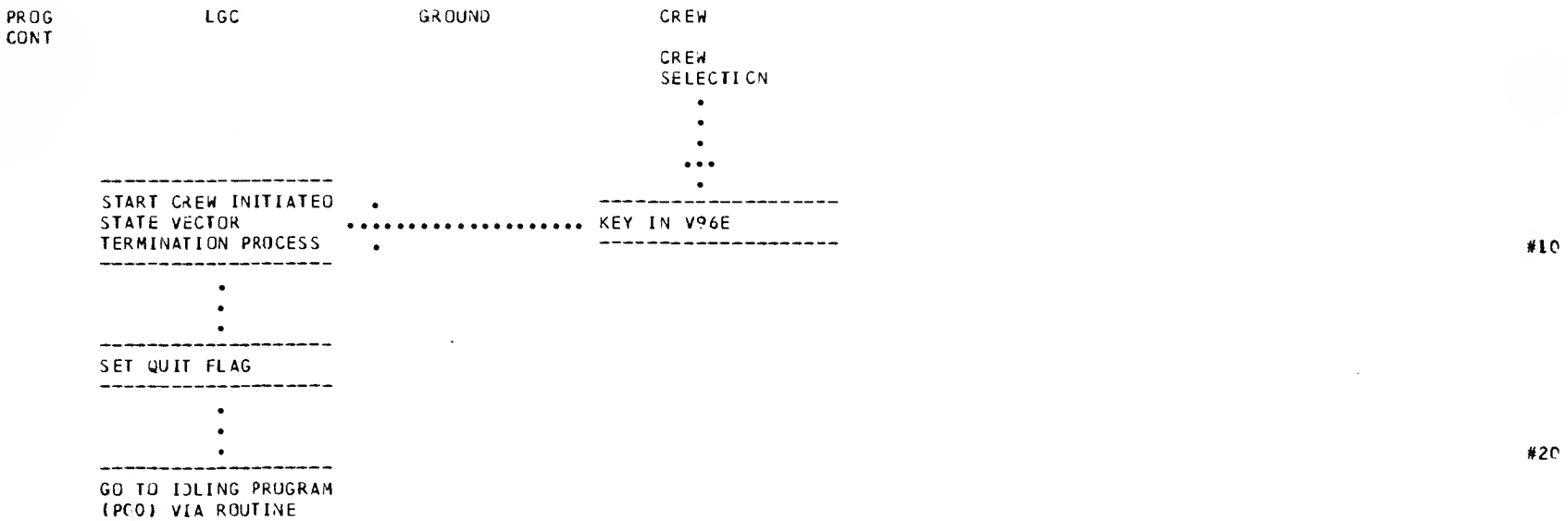
(2) THE CURRENT PROGRAM IS TERMINATED.

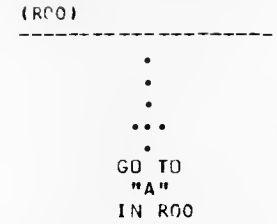
(3) THE LGC IDLING PROGRAM (P00) IS ACTIVATED.

(4) P00 STATE VECTOR INTEGRATION IS BYPASSED UNTIL A NEW PROGRAM SELECTION IS MADE.

(5) THIS PROCESS DOES NOT MAINTAIN STATE VECTOR SYNCHRONIZATION, THEREFORE INCORRECT W MATRIX EXTRAPOLATION MAY RESULT.

(6) THE PROCESS IS CREW SELECTED BY OSKY ENTRY.





#30

CHANGE CONTROL NOTES

LOGIC REV 00 PCR 146
REV 01 PCR 507
LOGIC REV 02 EDITORIAL

V97, PERFORM ENGINE FAIL PROCEDURE REV 01 08/09/69

NOTE: EXTENDED VERB 97 IS USED IN THE DPS/APS THRUST FAIL ROUTINE R40. SEE R4C FOR THE LOGIC SPECIFICATION FLOW FOR DISPLAY OF DPS/APS THRUST FAIL.

CHANGE CONTROL NOTES

REV 01 PCR 496

V99, ENABLE ENGINE IGNITION REV 02 08/07/69

NOTE: EXTENDED VERB 99 IS USED IN PROGRAMS P12, P40, P42, P63 AND ROUTINE R40. SEE P12, P40, P42, P63, AND R40 FOR THE LOGIC SPECIFICATION FLOWS RELATING TO ENGINE IGNITION.

CHANGE CONTROL NOTES

REV 00 PCR 496
REV 01 EDITORIAL
REV 02 EDITORIAL

LUMINARY 1E

Internal Distribution List

Group 23A	D. Lutkevich	DL 7-211	(11)
	Berberian	Kriegsman	
	Brand	Levine	
	Gustafson	Muller	
	Higgins	Pu	
	Kachmar	Robertson	
	Klumpp		
Group 23B	C. Flynn	DL7-221L	(3)
	Klawsnik	Reed	
	Nayar		
Group 23B	C. Taylor	DL7-221L	(7)
	Barnert	Lollar	
	Brodeur	McCoy	
	Cramer	Ostanek	
	Hamilton	Rye	
Group 23B	J. Flaherty	DL7-238A	(8)
	Adler	Millard	
	Albert	Moore	
	Berman	Volante	
	Eyles	Schulenberg	
Group 23C	M. Erickson	DL7-215J	(1)
	Weissman		
Group 23D	N. Auker	DL7-213	(11)
	Drake	Kiburz	
	Dunbar (6)	Larson	
	Johnson	Watson	
Group 23H	R. Shane	DL7-272	(4)
	Cogliano	Kossuth	
	Reber	O'Connor	
Group 23N	G. Grover	DL11-201	(4)
	Blanchard	Ogletree	
	Johnson	Tanner	

Group 23P	B. Hwoschinsky	DL7-203	(2)
	Battin	Copps	
Group 23P	E. Talbot	DL7-252	(3)
	Greene	Stubbs	
	Stameris		
Group 23S	P. Amsler	DL7-240	(17)
	Adams	McOuat	
	Edmonds	Megna	
	Felleman	O'Donnell	
	Goodwin	Sheridan	
	Grace	St. Amand	
	Heinemann	Werner	
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