SPS PROGRAM (P40) LOGIC REV 16 11/27/68

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

(2) TO CALCULATE AND DISPLAY THE GIMBAL ANGLES WHICH WOULD RESULT WITH THE PRESENT IMU ORIENTATION IF THE VEHICLE WERE MANEUVERED TO THE PREFERRED VEHICLE ATTITUDE FOR A SPS THRUSTING MANEUVER. THE CREW IS THEREBY GIVEN AN OPPORTUNITY TO PERFORM THE MANEUVER WITH:

(A) THE PRESENT IMU ORIENTATION, IF THE MIDDLE GIMBAL ANGLE IS NOT GREATER THAN 45 DEGREES, AND THE IMU HAS BEEN ALIGNED WITHIN THE LAST 3 HRS.

(B) A NEW ORIENTATION ACHIEVED BY SELECTION OF P52.

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

(4) TO CONTROL THE GNCS DURING COUNTDOWN, IGNITION, THRUSTING, AND THRUST TERMINATION OF A GNCS CONTROLLED SPS MANEUVER.

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

(2) THE REQUIRED STEERING EQUATIONS ARE IDENTIFIED BY THE PRIOR PRE-THRUST PROGRAM, WHICH EITHER SET OR RESET THE EXTERNAL DELTA V STEERING FLAG. FOR EXTERNAL DELTA V STEERING, VG IS CALCULATED ONCE FOR THE SPECIFIED TIME OF IGNITION. THEREAFTER BOTH DURING THRUSTING AND UNTIL THE CREW NOTIFIES THE CMC TRIM THRUSTING HAS BEEN COMPLETED THE CMC UPDATES VG ONLY AS A RESULT OF ACCELEROMETER INPUTS.
FOR LAMBERT STEERING VG IS CALCULATED AND UPDATED SIMILARLY, HOWEVER IT IS ALSO UPDATED PERIODICALLY BY LAMBERT SOLUTIONS TO CORRECT FOR CHANGES IN THE CSM STATE VECTOR.

(3) IT IS NORMALLY REQUIRED THAT THE ISS BE ON FOR 15 MINUTES PRIOR TO A THRUSTING MANEUVER.

(4) THE TTE CLOCK 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 INTEGRATION CAN NOT BE COMPLETED ON TIME.

(6) THE SPS THRUSTING PROGRAM DOES NOT MONITOR THE SC CONTROL DISCRETE (CHANNEL 31 BIT 15) DURING THRUSTING. THIS MEANS THAT THE CMC WILL CONTINUE TO GENERATE ENGINE ACTUATOR COMMANDS, SPS ENGINE ON DISCRETE, AND FDAI ATTITUDE ERROR NEEDLE COMMANDS UNTIL THE CMC SOLUTION INDICATES ENGINE OFF AT WHICH TIME THESE COMMANDS AND THE ENGINE ON DISCRETE ARE TERMINATED. HOWEVER, THIS PROGRAM IS NOT WRITTEN TO TAKE INTO ACCOUNT THE SITUATION WHERE CONTROL MAY BE TAKEN AWAY FROM THE GNCS AND THEN GIVEN BACK, AND IT IS NOT RECOMMENDED. IN EVENT CONTROL IS TAKEN AWAY FROM THE GNCS, THE CMC WILL ONLY BE RESPONSIBLE FOR COMPUTATION OF POSITION AND VELOCITY.

(7) ROUTINE R03 HAS BEEN PERFORMED PRIOR TO SELECTION OF THIS PROGRAM. IN ORDER FOR THE GNCS TO PERFORM THE ATTITUDE MANEUVER AND CONTROL THE THRUSTING MANEUVER THE ASTRONAUT MUST KEY IN V46E AT SOME TIME PRIOR TO THE ATTITUDE MANEUVER.

(8) THE VALUE OF DELTA V REQUIRED WILL BE STORED IN THE LOCAL VERTICAL COORDINATE SYSTEM AND IS AVAILABLE DURING THIS PROGRAM UNTIL AVERAGE G TURN ON BY KEYING IN V06N81.

(9) THE ORBIT PARAMETER DISPLAY ROUTINE (R30) MAY BE CALLED DURING THIS PROGRAM BY KEYING IN V82E.

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

PROG CONT	CMC	GROUND	CREW	CHECKLIST	TIME	TOTAL TIME
			.CREW PROG. .SELECTION			
	START SPS PROGRAM (P40) DISPLAY PROGRAM 40		KEY IN SPS PROGRAM (P40) V37E 40E			#10
			MONITOR DSKY: OBSERVE DISPLAY OF PROGRAM 40			#20
	DO IMU STATUS CHECK ROUTINE (R02)		DO IMU STATUS CHECK ROUTINE (R02)			#30
	IS EXTERNAL DELTA V FLAG SET? .N / .Y					#40
	SET CSTEER= ECSTEER IN STEER LAW					

#50

SET CSTEER=0
IN STEER LAW

#60

COMPUTE INITIAL
THRUST DIRECTION AND
INITIAL VALUE OF VG
VECTOR AND STORE IN
N81 (VG LOCAL VERT-
ICAL)

#70

FROM INITIAL THRUST
DIRECTION AND ENGINE
BELL TRIM ANGLES
COMPUTE PREFERRED
IMU ORIENTATION:

#80

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

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

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

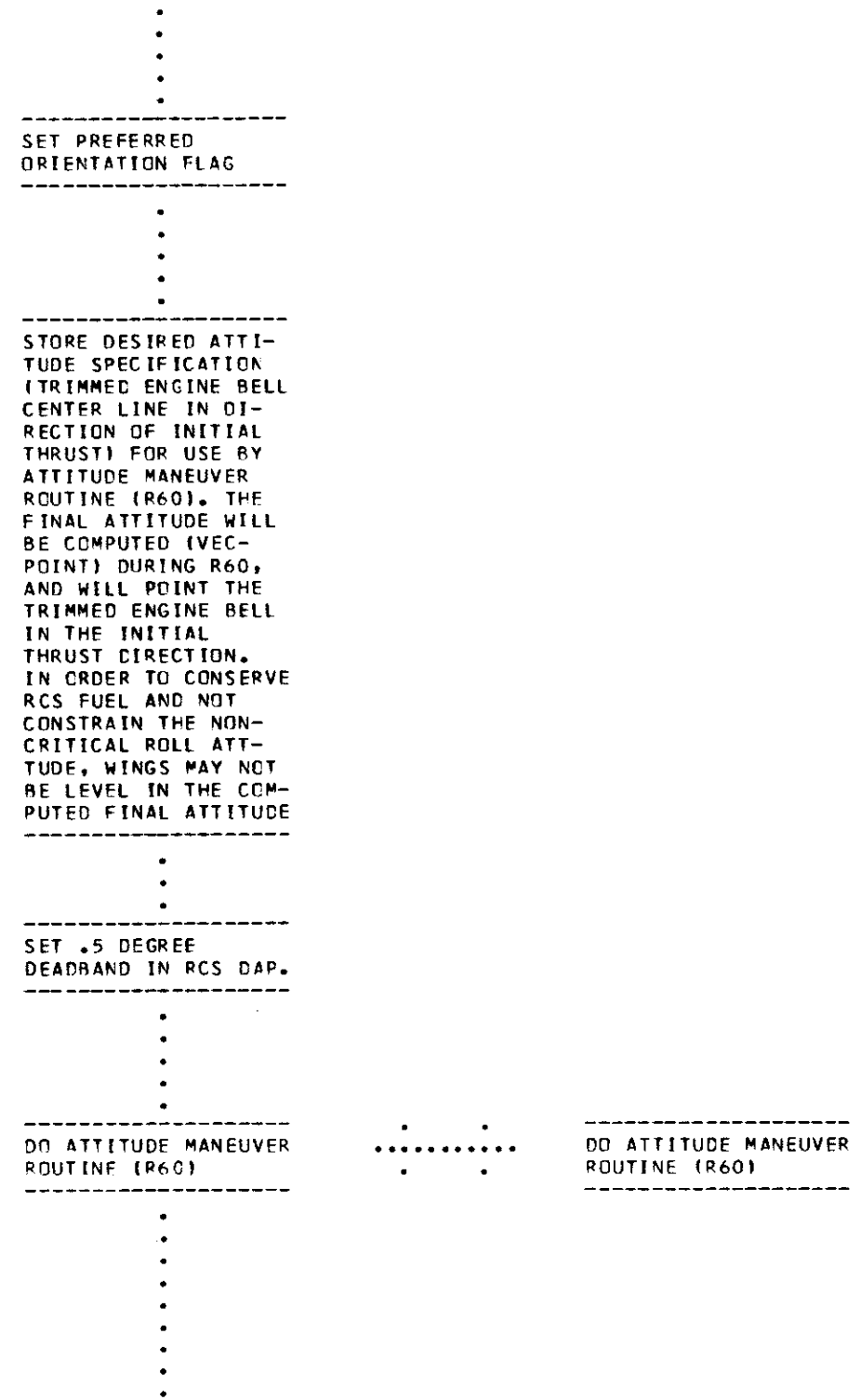
#90

WHERE:

X -CSM = THE CSM X AXIS AT IGNITION (AT THE PREFERRED VEHICLE ATTITUDE)

R = THE CSM POSITION RADIUS VECTOR AT TIG.

#100



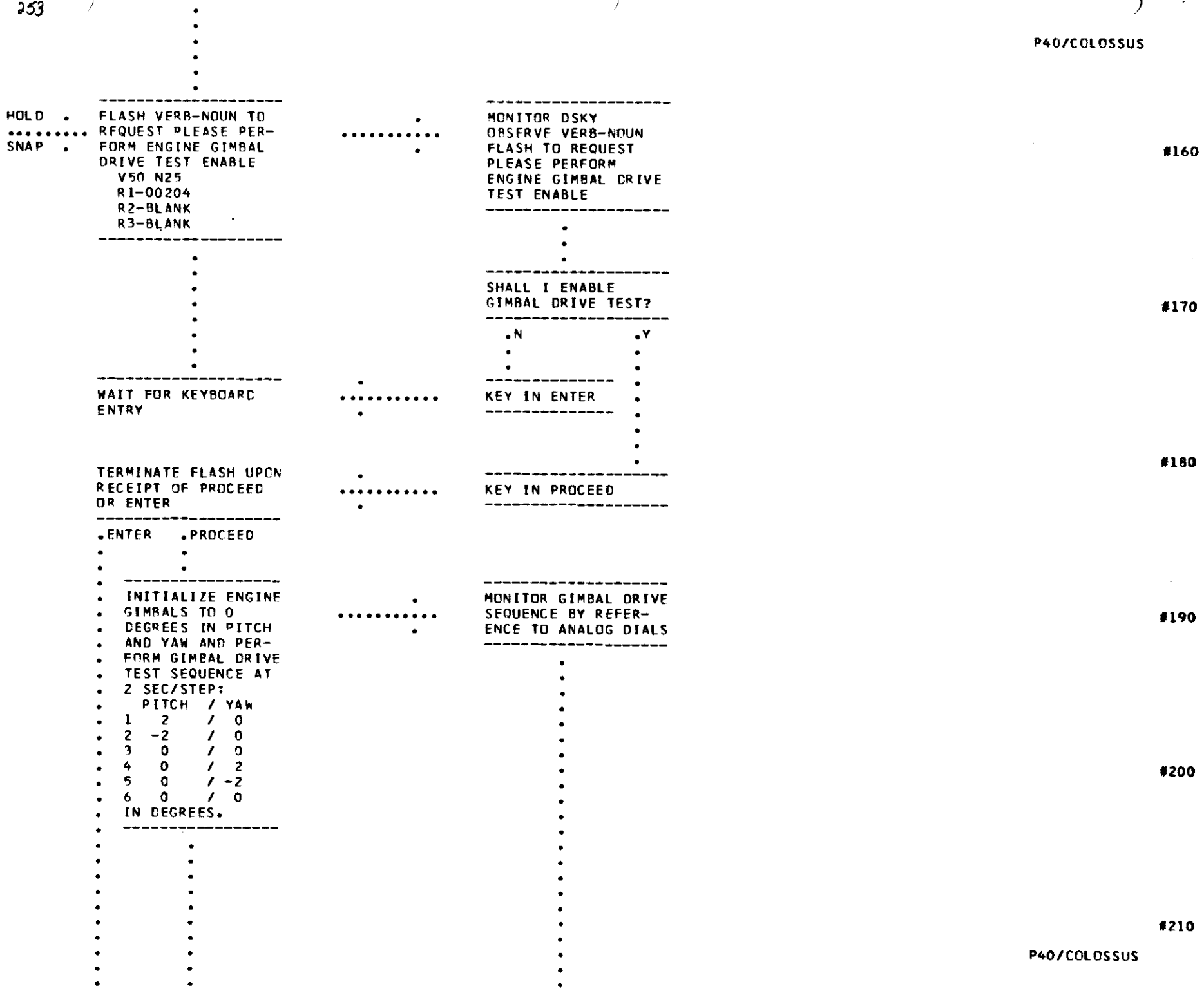
#110

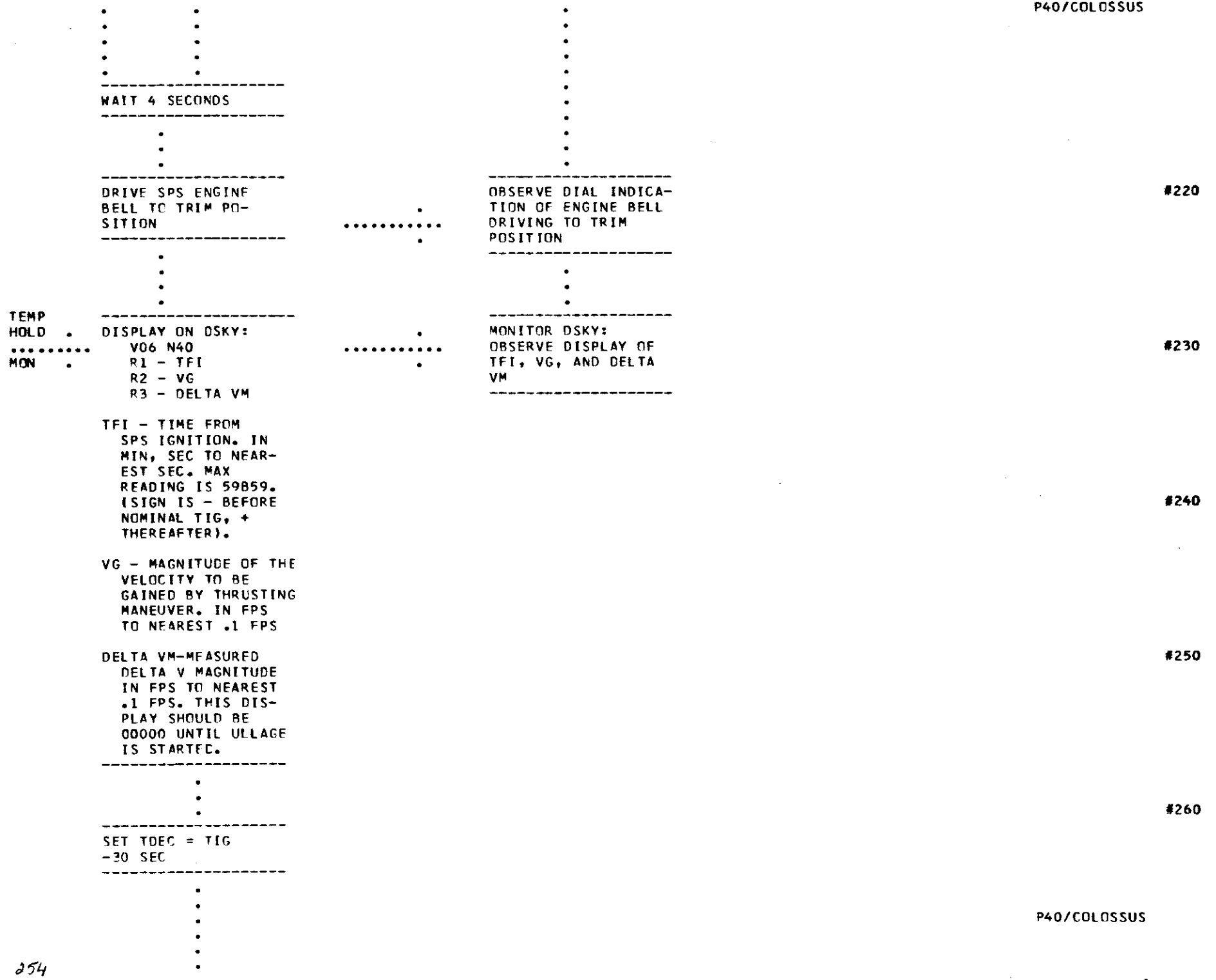
#120

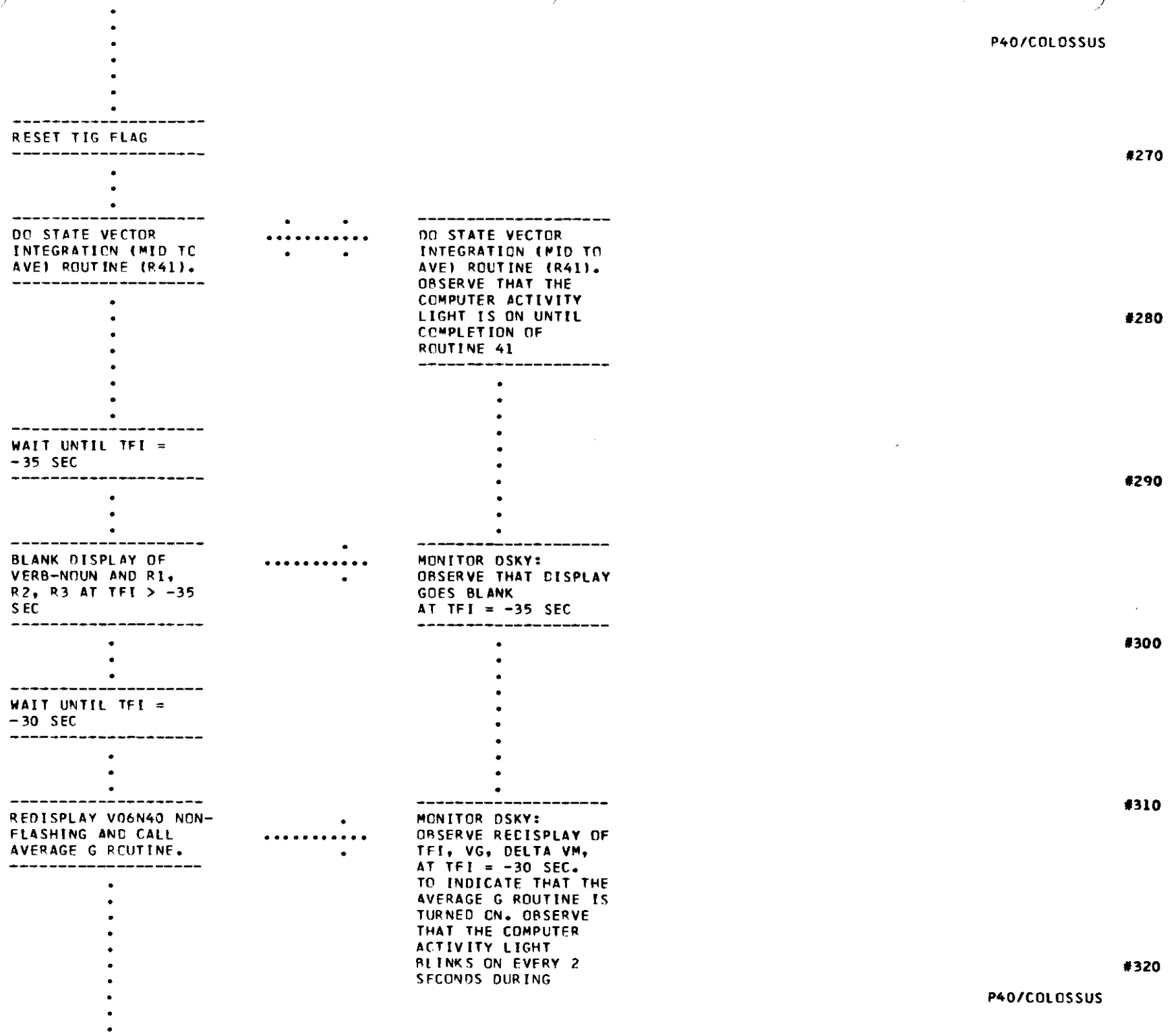
#130

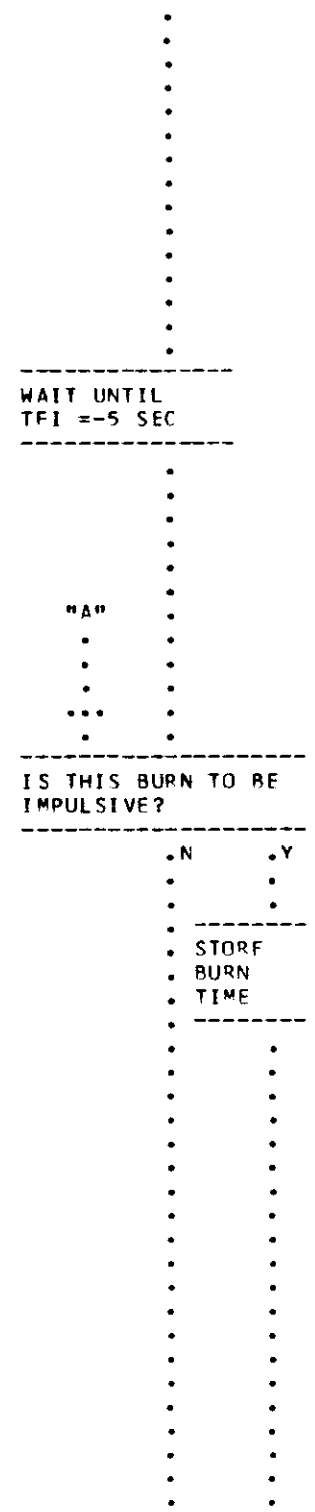
#140

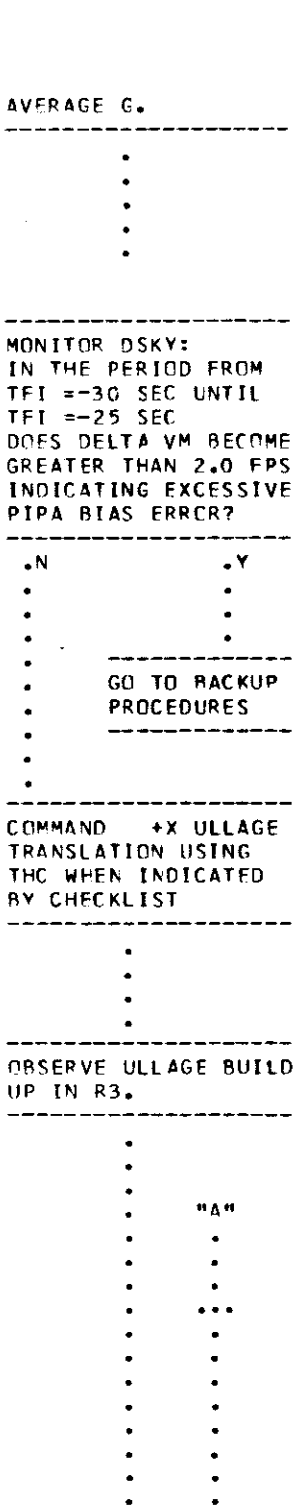
#150


HOLD
SNAP
FLASH VERB-NOUN TO REQUEST PLEASE PERFORM ENGINE GIMBAL DRIVE TEST ENABLE
V50 N25
R1-00204
R2-BLANK
R3-BLANK
MONITOR DSKY OBSERVE VERB-NOUN FLASH TO REQUEST PLEASE PERFORM ENGINE GIMBAL DRIVE TEST ENABLE
#160
SHALL I ENABLE GIMBAL DRIVE TEST?
#170
N
Y
WAIT FOR KEYBOARD ENTRY
KEY IN ENTER
TERMINATE FLASH UPON RECEIPT OF PROCEED OR ENTER
#180
KEY IN PROCEED
ENTER
PROCEED
INITIALIZE ENGINE GIMBALS TO 0 DEGREES IN PITCH AND YAW AND PERFORM GIMBAL DRIVE TEST SEQUENCE AT 2 SEC/STEP:
PITCH / YAW
1 2 / 0
2 -2 / 0
3 0 / 0
4 0 / 2
5 0 / -2
6 0 / 0
IN DEGREES.
MONITOR GIMBAL DRIVE SEQUENCE BY REFERENCE TO ANALOG DIALS
#190
#200
#210


WAIT 4 SECONDS
DRIVE SPS ENGINE BELL TO TRIM POSITION
OBSERVE DIAL INDICATION OF ENGINE BELL DRIVING TO TRIM POSITION
#220
TEMP HOLD MON
DISPLAY ON DSKY:
V06 N40
R1 - TFI
R2 - VG
R3 - DELTA VM
MONITOR DSKY:
OBSERVE DISPLAY OF TFI, VG, AND DELTA VM
#230
TFI - TIME FROM SPS IGNITION. IN MIN, SEC TO NEAREST SEC. MAX READING IS 59859. (SIGN IS - BEFORE NOMINAL TIG, + THEREAFTER).
#240
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 SHOULD BE 00000 UNTIL ULLAGE IS STARTED.
#250
#260
SET TDEC = TIG -30 SEC


RESET TIG FLAG
#270
DO STATE VECTOR INTEGRATION (MID TO AVE) ROUTINE (R41).
DO STATE VECTOR INTEGRATION (MID TO AVE) ROUTINE (R41). OBSERVE THAT THE COMPUTER ACTIVITY LIGHT IS ON UNTIL COMPLETION OF ROUTINE 41
#280
WAIT UNTIL TFI = -35 SEC
#290
BLANK DISPLAY OF VERB-NOUN AND R1, R2, R3 AT TFI > -35 SEC
MONITOR DSKY: OBSERVE THAT DISPLAY GOES BLANK AT TFI = -35 SEC
#300
WAIT UNTIL TFI = -30 SEC
REDISPLAY V06N40 NON-FLASHING AND CALL AVERAGE G ROUTINE.
MONITOR DSKY: OBSERVE REDISPLAY OF TFI, VG, DELTA VM, AT TFI = -30 SEC. TO INDICATE THAT THE AVERAGE G ROUTINE IS TURNED ON. OBSERVE THAT THE COMPUTER ACTIVITY LIGHT BLINKS ON EVERY 2 SECONDS DURING
#310
#320





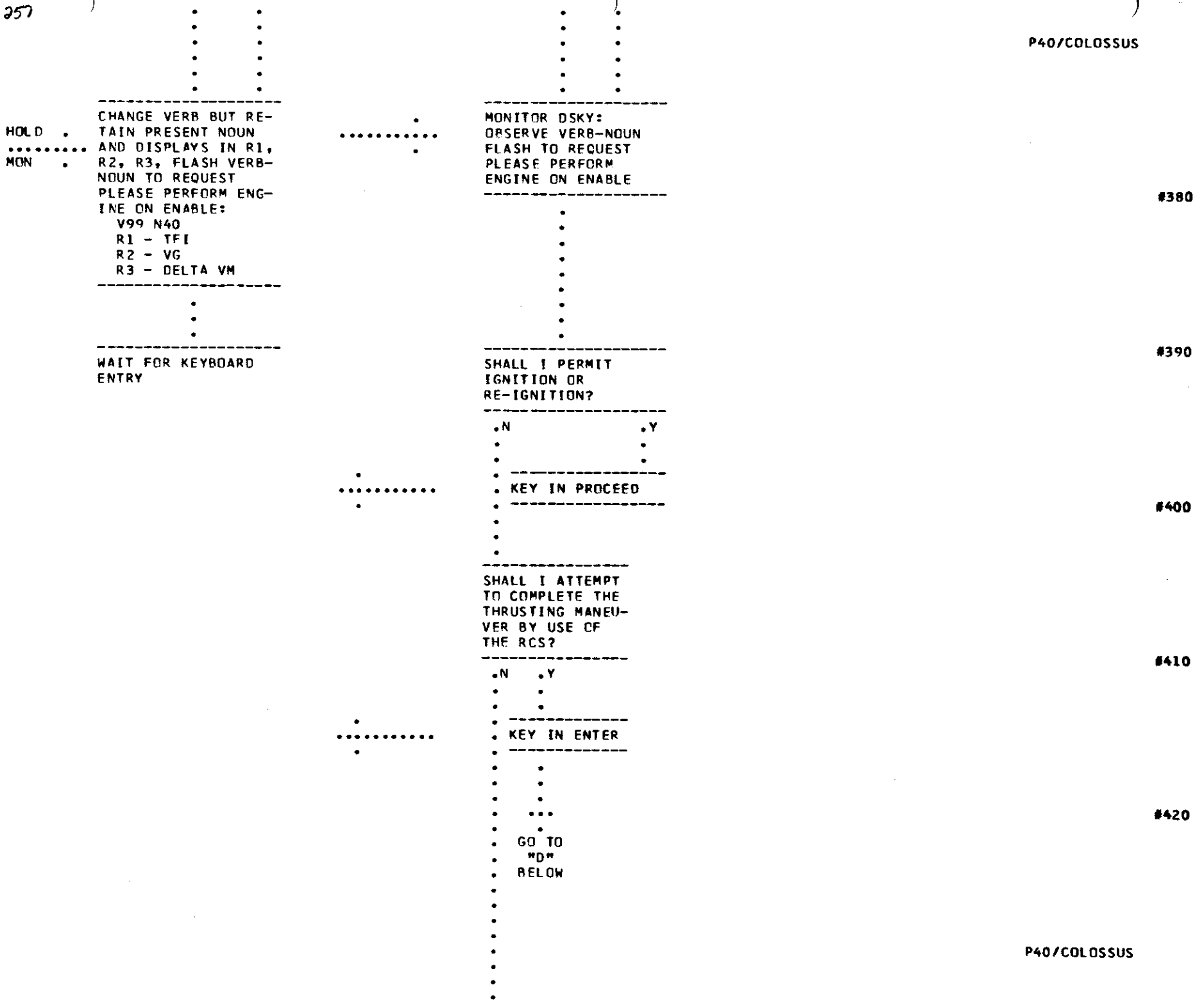
#330

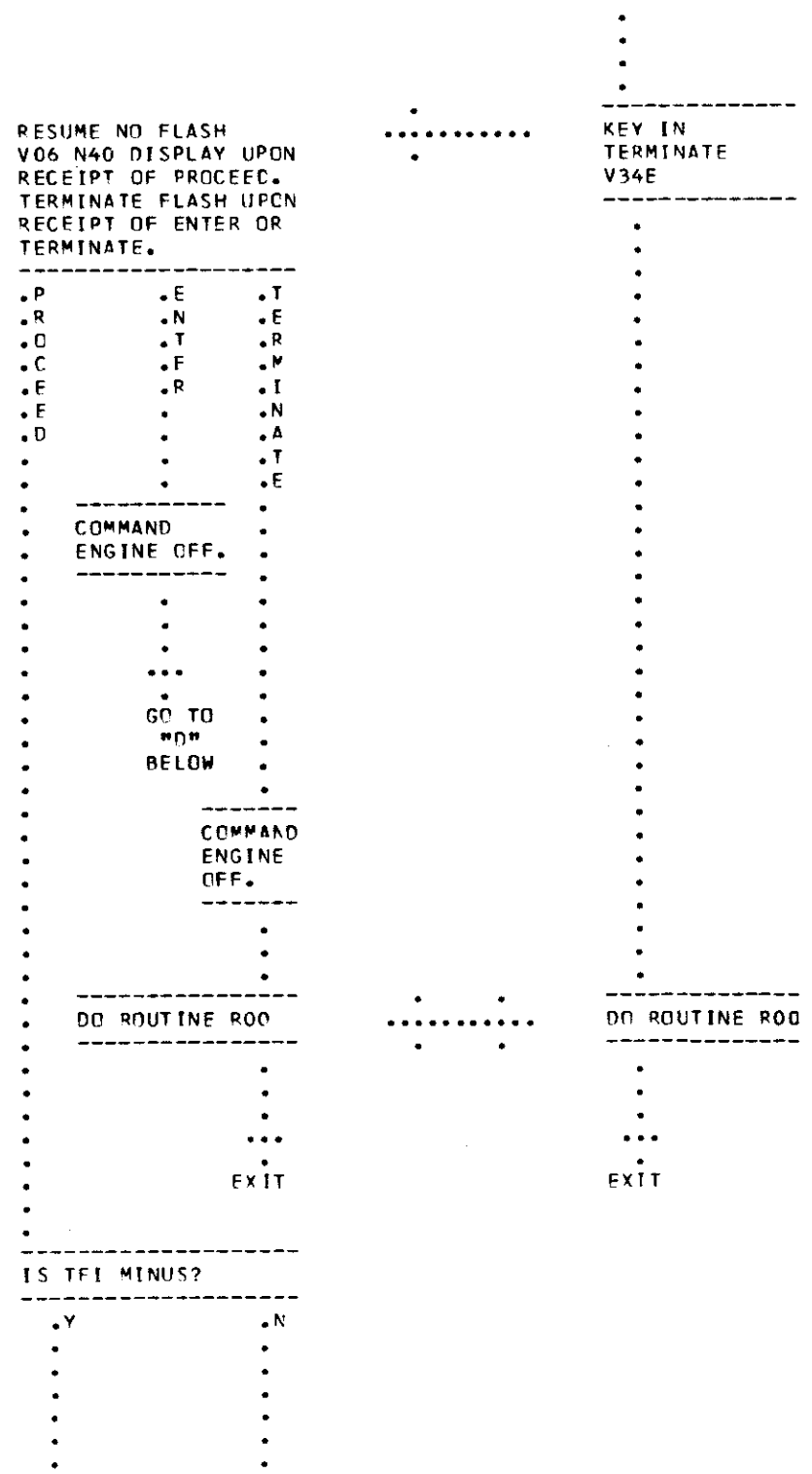
#340

#350

#360

#370


CHANGE VERB BUT RETAIN PRESENT NOUN AND DISPLAYS IN R1, R2, R3, FLASH VERB-NOUN TO REQUEST PLEASE PERFORM ENGINE ON ENABLE:
V99 N40
R1 - TFI
R2 - VG
R3 - DELTA VM
HOLD
MON
WAIT FOR KEYBOARD ENTRY
MONITOR DSKY: OBSERVE VERB-NOUN FLASH TO REQUEST PLEASE PERFORM ENGINE ON ENABLE
#380
SHALL I PERMIT IGNITION OR RE-IGNITION?
#390
N
Y
KEY IN PROCEED
#400
SHALL I ATTEMPT TO COMPLETE THE THRUSTING MANEUVER BY USE OF THE RCS?
#410
N
Y
KEY IN ENTER
#420
GO TO "D" BELOW



#430

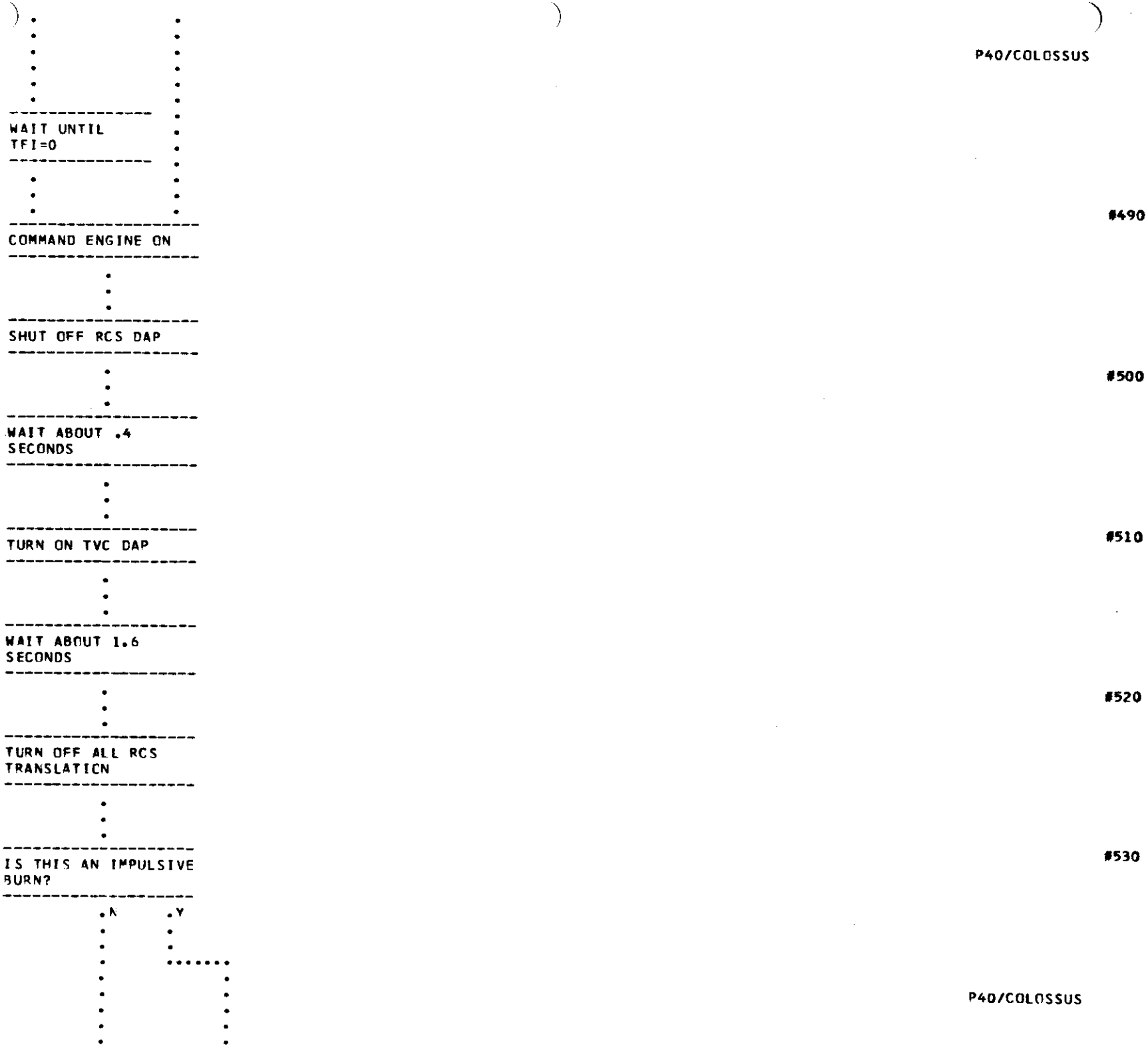
#440

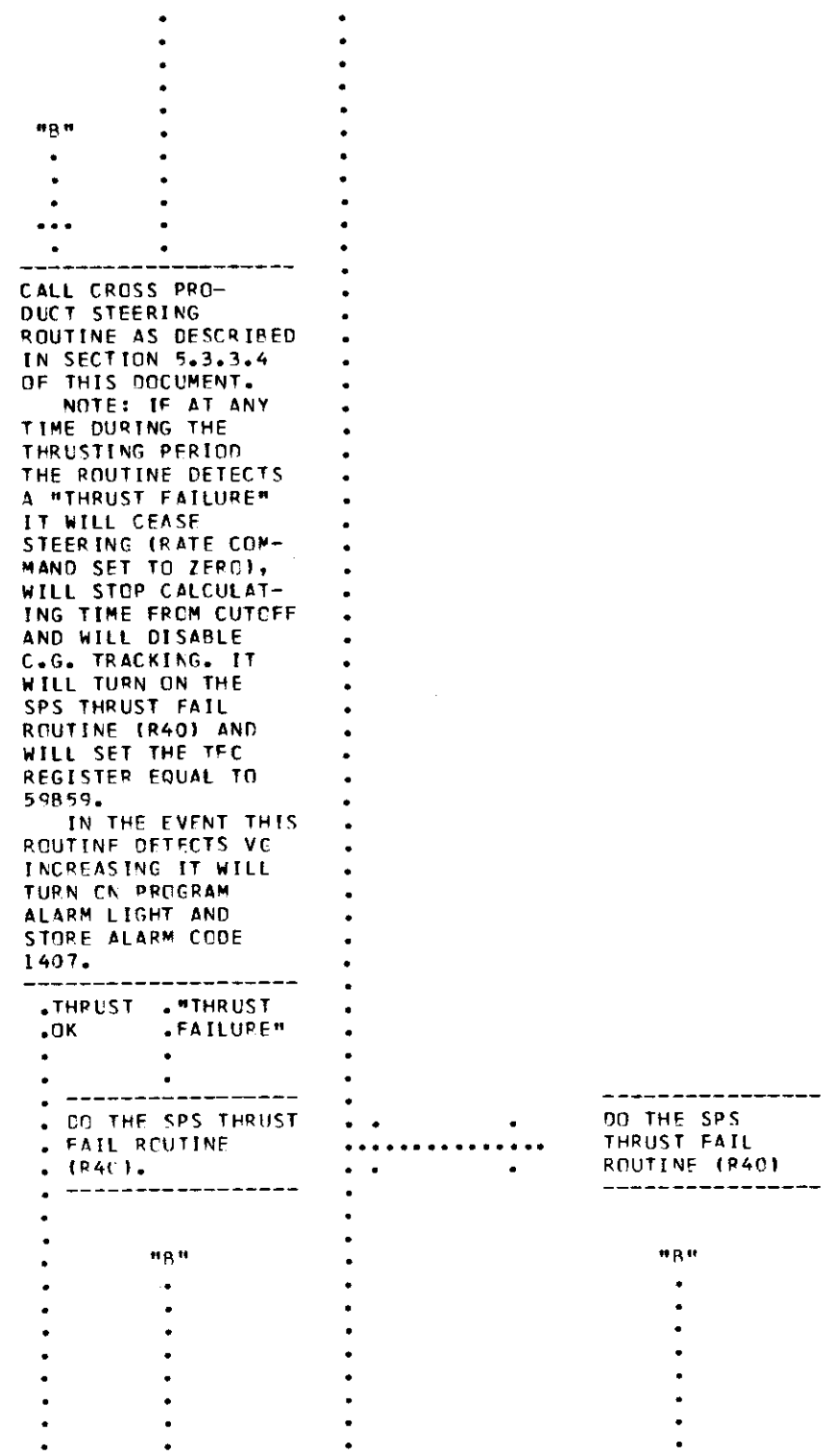
#450

#460

#470

#480


WAIT UNTIL TFI=0
#490
COMMAND ENGINE ON
SHUT OFF RCS DAP
#500
WAIT ABOUT .4 SECONDS
TURN ON TVC DAP
#510
WAIT ABOUT 1.6 SECONDS
#520
TURN OFF ALL RCS TRANSLATION
IS THIS AN IMPULSIVE BURN?
#530
N
Y



#540

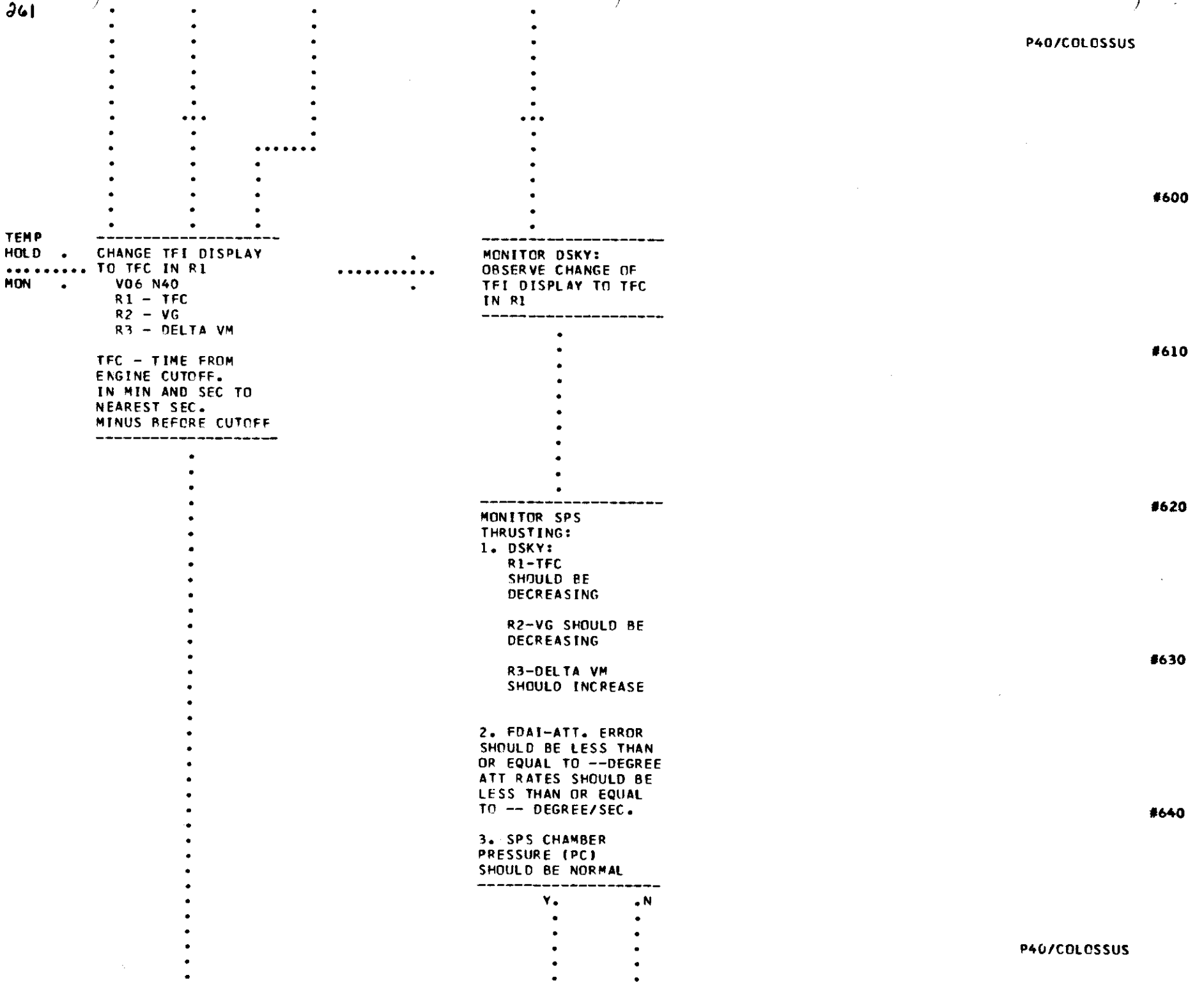
#550

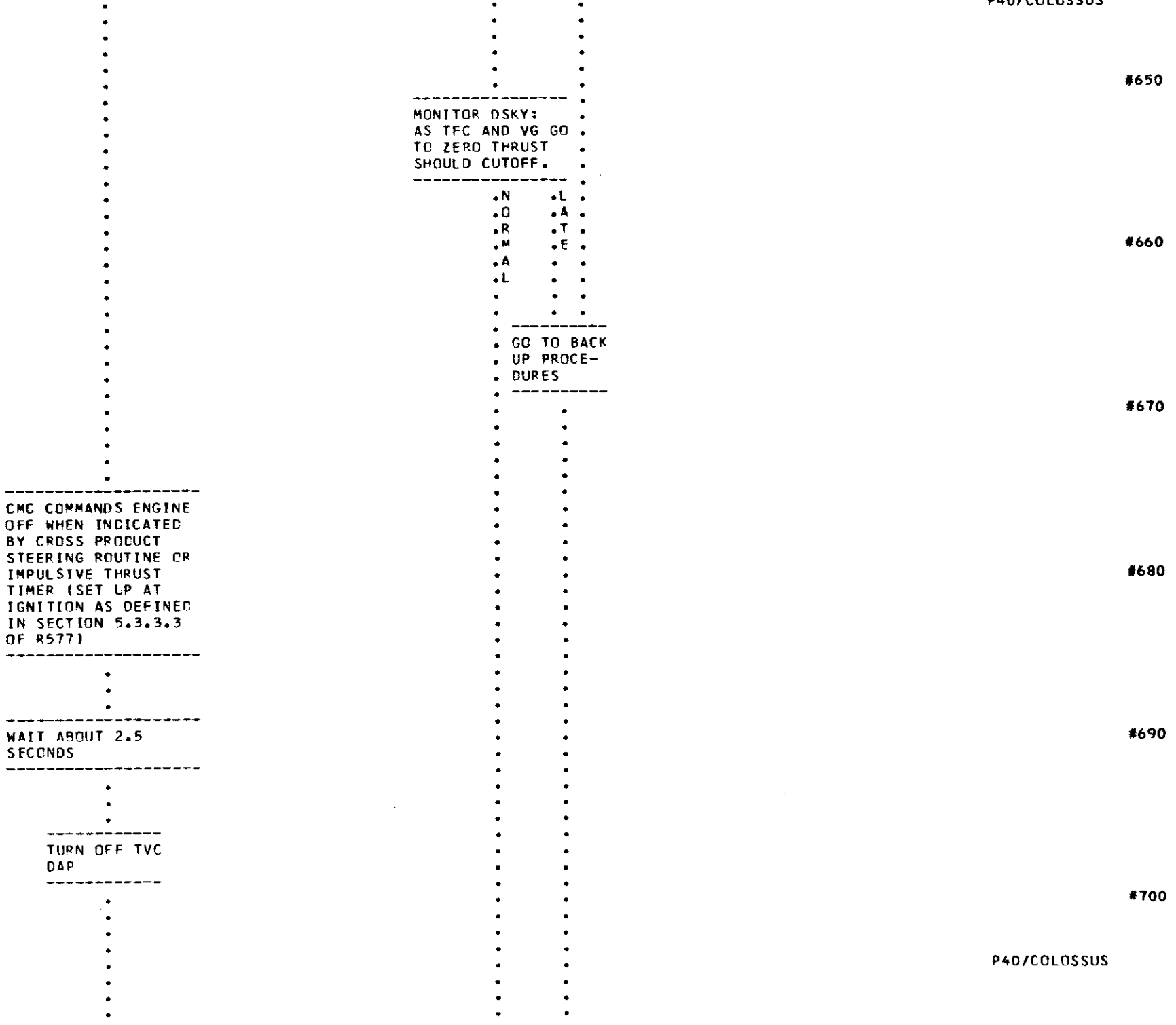
#560

#570

#580

#590


TEMP HOLD
MON
CHANGE TFI DISPLAY TO TFC IN R1
V06 N40
R1 - TFC
R2 - VG
R3 - DELTA VM
TFC - TIME FROM ENGINE CUTOFF. IN MIN AND SEC TO NEAREST SEC. MINUS BEFORE CUTOFF
MONITOR DSKY: OBSERVE CHANGE OF TFI DISPLAY TO TFC IN R1
MONITOR SPS 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 --DEGREE ATT RATES SHOULD BE LESS THAN OR EQUAL TO -- DEGREE/SEC.
3. SPS CHAMBER PRESSURE (PC) SHOULD BE NORMAL
Y.
.N
#600
#610
#620
#630
#640



P40/COLOSSUS

#650

#660

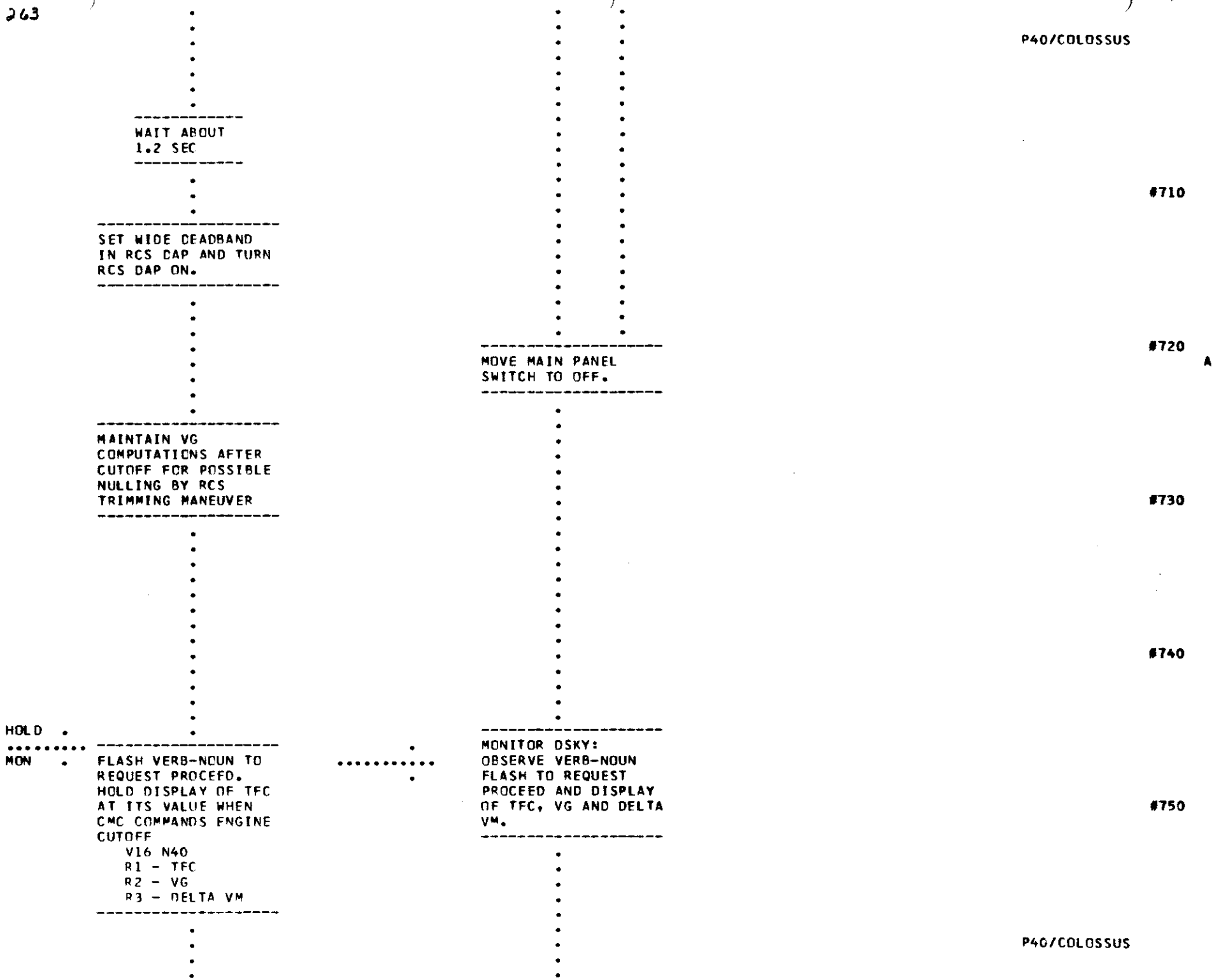
#670

#680

#690

#700

P40/COLOSSUS


WAIT ABOUT 1.2 SEC
SET WIDE DEADBAND IN RCS DAP AND TURN RCS DAP ON.
MAINTAIN VG COMPUTATIONS AFTER CUTOFF FOR POSSIBLE NULLING BY RCS TRIMMING MANEUVER
HOLD
MON
FLASH VERB-NOUN TO REQUEST PROCEED. HOLD DISPLAY OF TFC AT ITS VALUE WHEN CMC COMMANDS ENGINE CUTOFF
V16 N40
R1 - TFC
R2 - VG
R3 - DELTA VM
MOVE MAIN PANEL SWITCH TO OFF.
MONITOR DSKY: OBSERVE VERB-NOUN FLASH TO REQUEST PROCEED AND DISPLAY OF TFC, VG AND DELTA VM.
#710
#720
A
#730
#740
#750

#760

WAIT FOR KEYBOARD ENTRY

#770

KEY IN PROCEED

TERMINATE FLASH UPON RECEIPT OF PROCEED.

#780

PROCEED

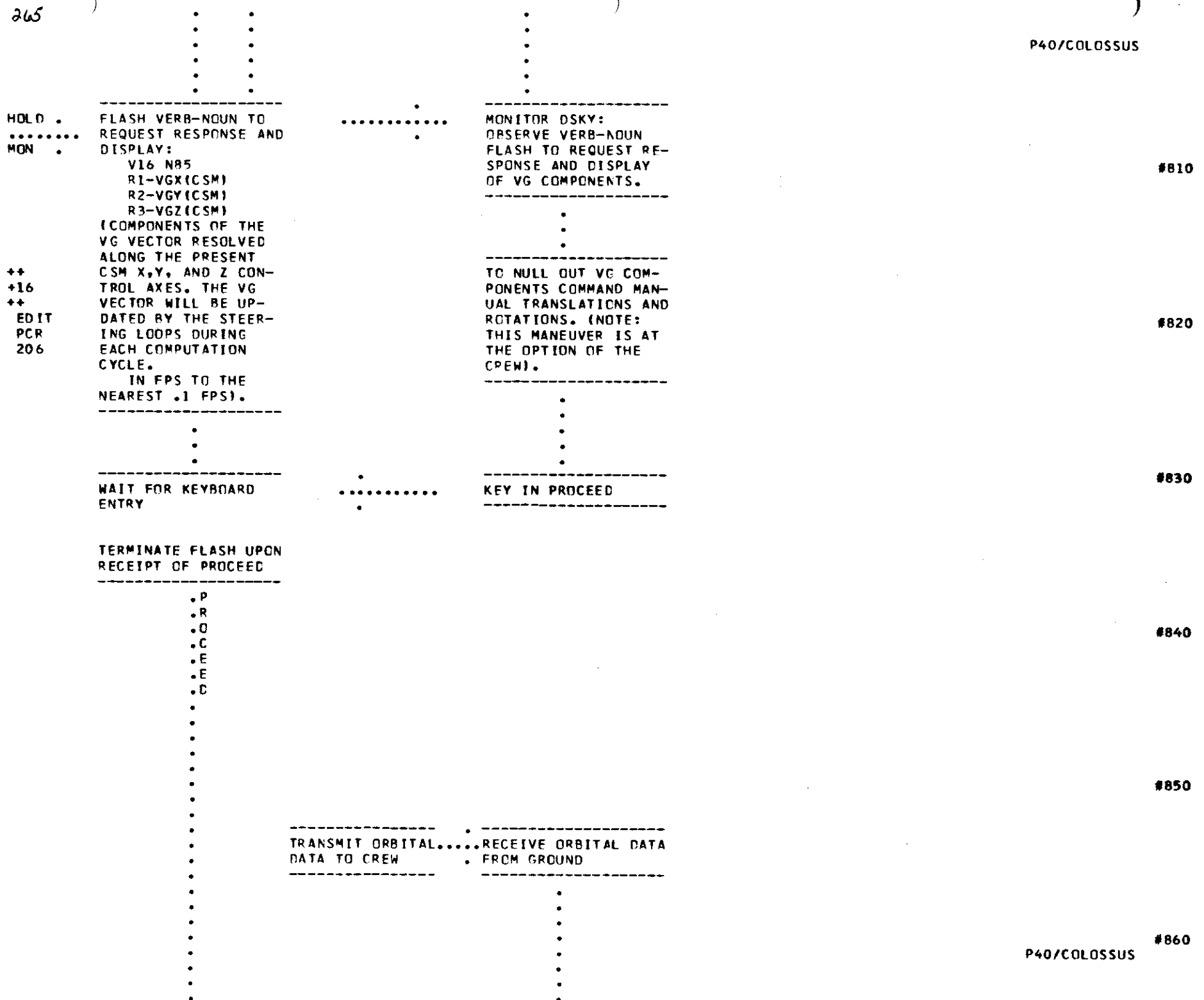
"D"

#790

SET MINIMUM DEADBAND IN RCS DAP

"D"

#800


HOLD
MON
++
+16
++
EDIT
PCR
206
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY:
V16 N85
R1-VGX(CSM)
R2-VGY(CSM)
R3-VGZ(CSM)
(COMPONENTS OF THE VG VECTOR RESOLVED ALONG THE PRESENT CSM X,Y, AND Z CONTROL AXES. THE VG VECTOR WILL BE UPDATED BY THE STEERING LOOPS DURING EACH COMPUTATION CYCLE.
IN FPS TO THE NEAREST .1 FPS).
MONITOR DSKY: OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY OF VG COMPONENTS.
#810
TO NULL OUT VG COMPONENTS COMMAND MANUAL TRANSLATIONS AND ROTATIONS. (NOTE: THIS MANEUVER IS AT THE OPTION OF THE CREW).
#820
WAIT FOR KEYBOARD ENTRY
KEY IN PROCEED
#830
TERMINATE FLASH UPON RECEIPT OF PROCEED
.PROCEED
#840
#850
TRANSMIT ORBITAL DATA TO CREW
RECEIVE ORBITAL DATA FROM GROUND
#860

#870

CHANGE CONTROL NOTES

REV 11 PCR MIT 32
REV 12 PCR MIT 32
REV 13 PCR MIT 66
        PCR MIT 80 - 98
        PCR NASA 151
REV 14 PCR 401.1
        PCR 463
REV 15 PCR 206
REV 16 PCR 206 EDITORIAL

RCS PROGRAM (P41) LCGIC REV 16 11/27/68

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

(2) TO CALCULATE THE GIMBAL ANGLES WHICH WOULD RESULT WITH THE PRESENT IMU ORIENTATION IF THE VEHICLE +X-AXIS WERE ALIGNED TO THE THRUST VECTOR. THE CREW IS THEREBY GIVEN AN OPPORTUNITY TO PERFORM THE MANEUVER WITH:

(A) THE PRESENT IMU ORIENTATION (NOT RECOMMENDED IF MIDDLE GIMBAL ANGLE IS GREATER THAN 45 DEGREES), IF THE IMU HAS NOT BEEN ALIGNED WITHIN THE LAST 3 HRS, REALIGNMENT IS DESIRABLE.

(B) A NEW ORIENTATION ACHIEVED BY SELECTION OF P52

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

(4) TO PROVIDE SUITABLE DISPLAYS FOR MANUAL EXECUTION OF THE THRUSTING MANEUVER.

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

(2) THE REQUIRED STEERING EQUATIONS ARE IDENTIFIED BY THE PRIOR PRETHRUST PROGRAM, WHICH EITHER SET OR RESET THE EXTERNAL DELTA V STEERING FLAG. FOR EXTERNAL DELTA V STEERING, VG IS CALCULATED ONCE FOR THE SPECIFIED TIME OF IGNITION. THEREAFTER BOTH DURING THRUSTING AND UNTIL THE CREW NOTIFIES THE CMC TRIM THRUSTING HAS BEEN COMPLETED, THE CMC UPDATES VG ONLY AS A RESULT OF ACCELEROMETER INPUTS.
FOR LAMBERT STEERING VG IS CALCULATED AND UPDATED SIMILARLY, HOWEVER IT IS ALSO UPDATED PERIODICALLY BY LAMBERT SOLUTIONS TO CORRECT FOR CHANGES IN THE CSM STATE VECTOR.

(3) IT IS NORMALLY REQUIRED THAT THE ISS BE ON FOR 15 MINUTES PRIOR TO A THRUSTING MANEUVER.

(4) THE TTE CLOCK 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 INTEGRATION CAN NOT BE COMPLETED ON TIME.

(6) ROUTINE R03 HAS BEEN PERFORMED PRIOR TO SELECTION OF THIS PROGRAM. IN ORDER FOR THE GNCS TO PERFORM THE ATTITUDE MANEUVER AND MAINTAIN ATTITUDE CONTROL THE ASTRONAUT MUST KEY IN V46E AT SOME TIME PRIOR TO THE ATTITUDE MANEUVER.

(7) THE VALUE OF DELTA V REQUIRED AT TIG IN LOCAL VERTICAL COORDINATES IS STORED IN NOUN 81 AND MAY BE CALLED UNTIL AVERAGE G IS TURNED ON BY KEYING IN V06N81E.

(8) THE ORBIT PARAMETER DISPLAY ROUTINE (R30) MAY BE CALLED DURING THIS PROGRAM BY KEYING IN V82E.

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

PROG CONT	CMC	GROUND	CREW	CHECKLIST	TIME	TOTAL TIME
			.CREW PROG. .SELECTION			
	START RCS PROGRAM DISPLAY PROGRAM 41	. ...	KEY IN RCS PROGRAM (P41) V37E 41E			#10
		. ...	MONITOR DSKY: OBSERVE DISPLAY OF PROGRAM 41			#20
	. . .					
	DO IMU STATUS CHECK ROUTINE (R02)	. ...	DO IMU STATUS CHECK ROUTINE (R02)			
	. . .					#30
	SET CSTEER =0.					
	. . .					
	COMPUTE INITIAL THRUST DIRECTION AND INITIAL VALUE OF VG VECTOR AND STORE IN NOUN 81 (VG LOCAL VERTICAL)					#40
	. . . . .					
	COMPUTE PREFERRED IMU ORIENTATION:					#50

```
X   = UNIT (X    ) =
-SM         -CSM

UNIT (T)
      -


Y   = UNIT (Y    ) =                                          #60
-SM         -CSM

UNIT (X    X R)
      -CSM  -

Z   = UNIT (X  X Y  )
-SM         -SM  -SM                                         #70

WHERE:
T = INITIAL THRUST
-   VECTOR

R = THE CSM POSITION
-   RADIUS VECTOR AT
    TIG

X    , Y    = THE CSM
-CSM  -CSM   CONTROL                                         #80
             AXIS.
--------------------
           .
           .
           .
--------------------
SET PREFERRED
ORIENTATION FLAG
--------------------
           .                                                 #90
           .
           .
--------------------
STORE DESIRED ATTIT-
UDE SPECIFICATION
FOR USE BY ATTITUDE
MANEUVER ROUTINE
(R60). THE FINAL
ATTITUDE WILL BE
COMPUTED DURING R60                                          #100
AND WILL POINT THE
+X TRANSLATION AXIS
IN THE INITITAL
THRUST DIRECTION.
HOWEVER, IN ORDER TO
CONSERVE RCS FUEL
AND NOT CONSTRAIN
THE NONCRITICAL ROLL
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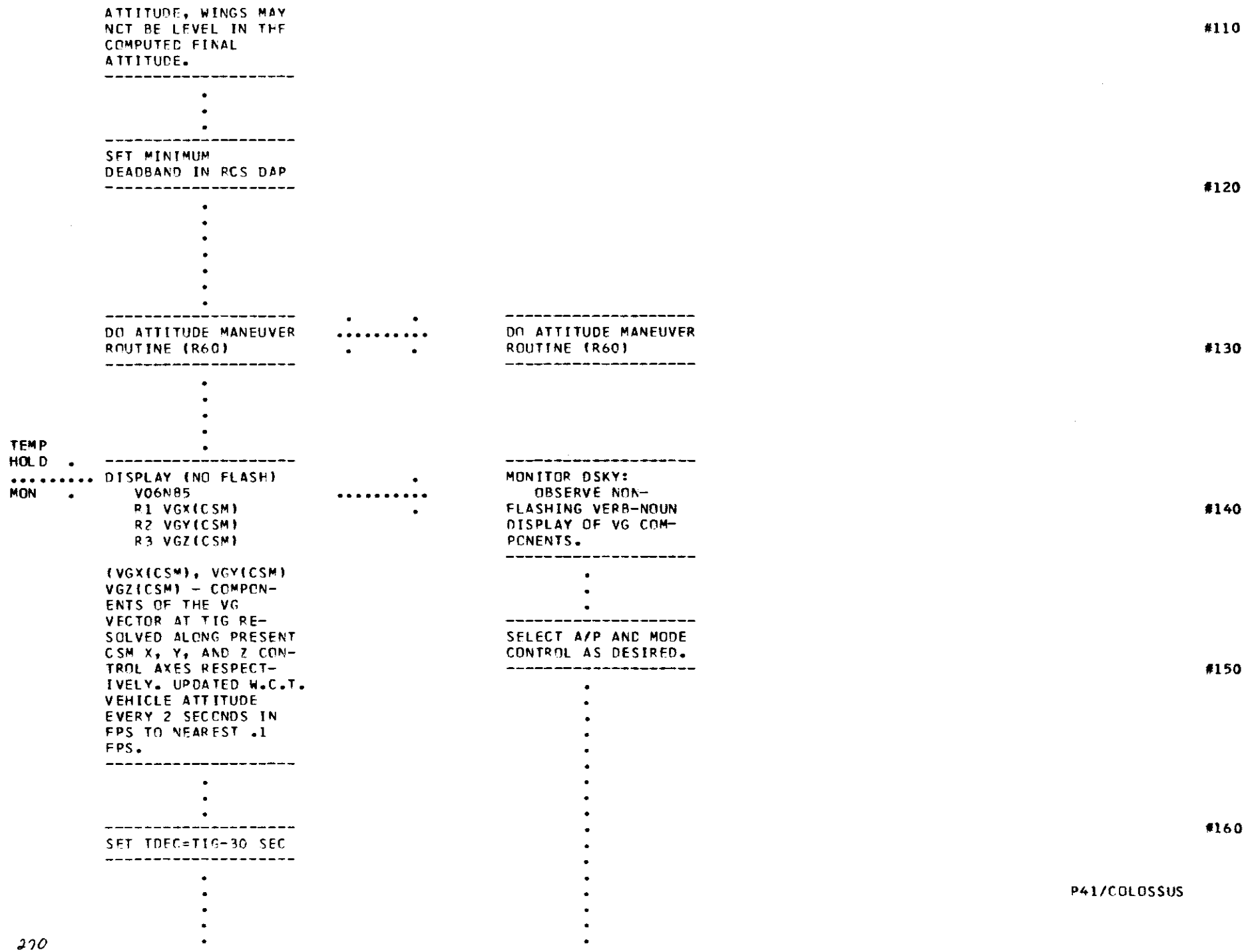
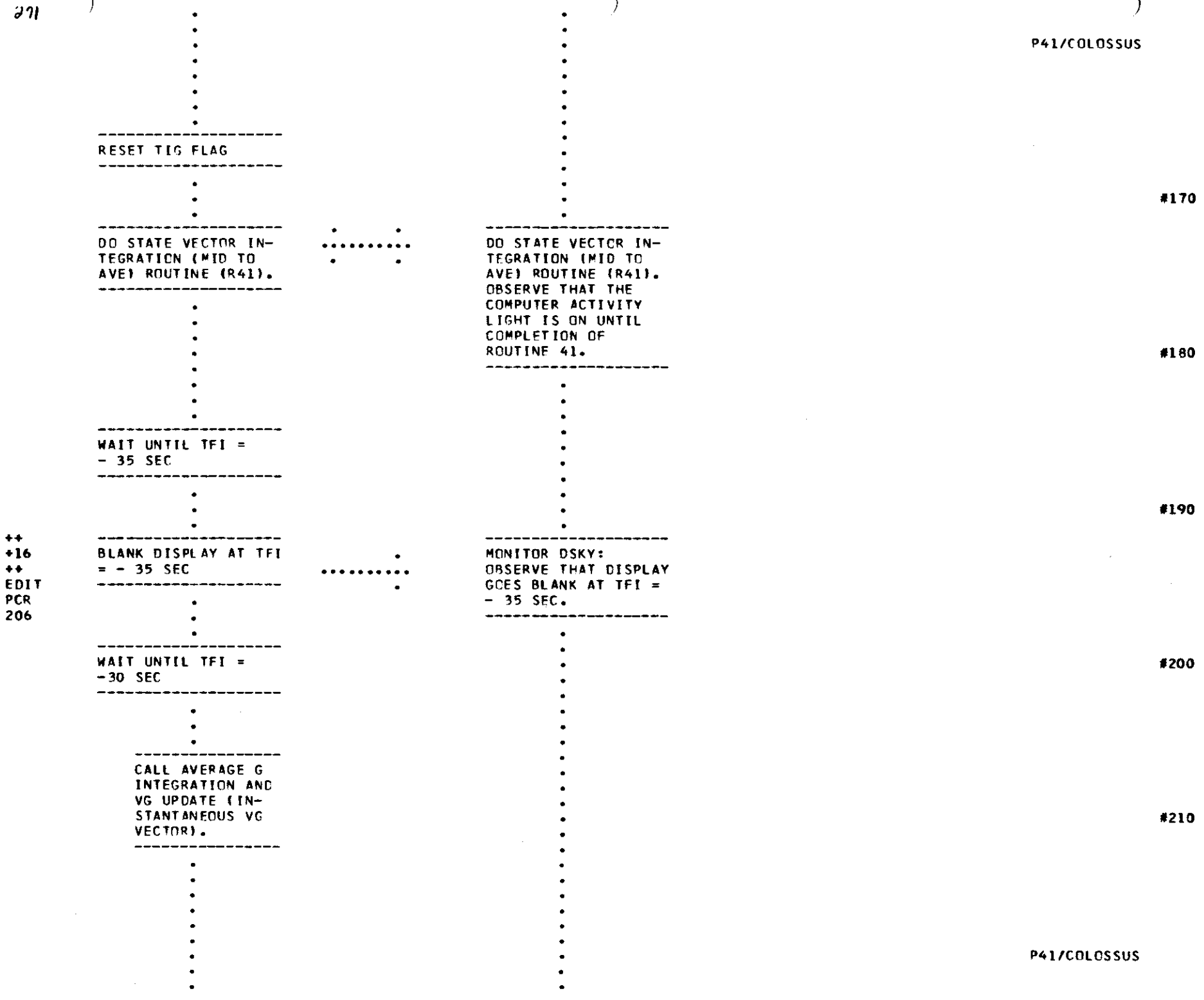
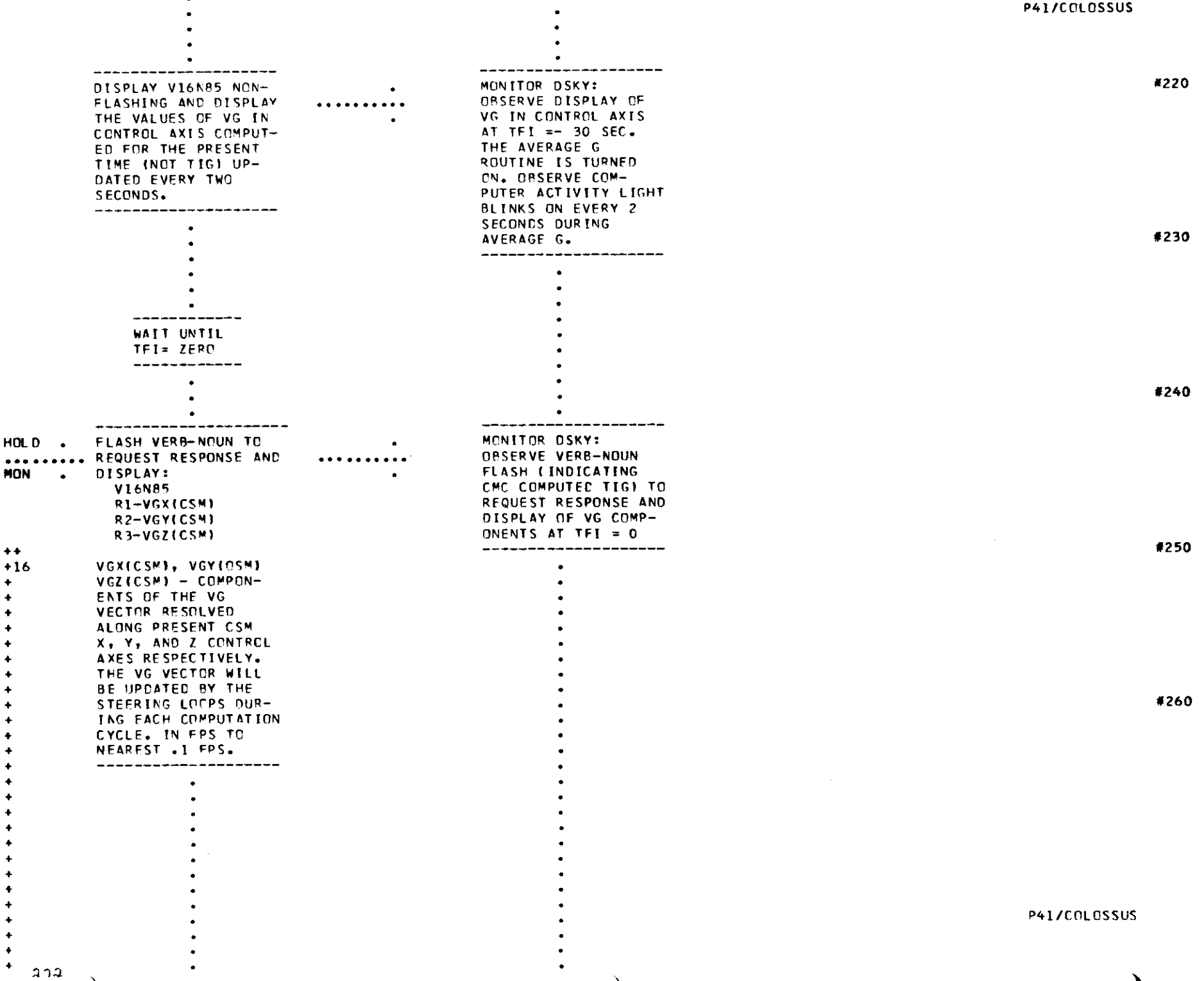
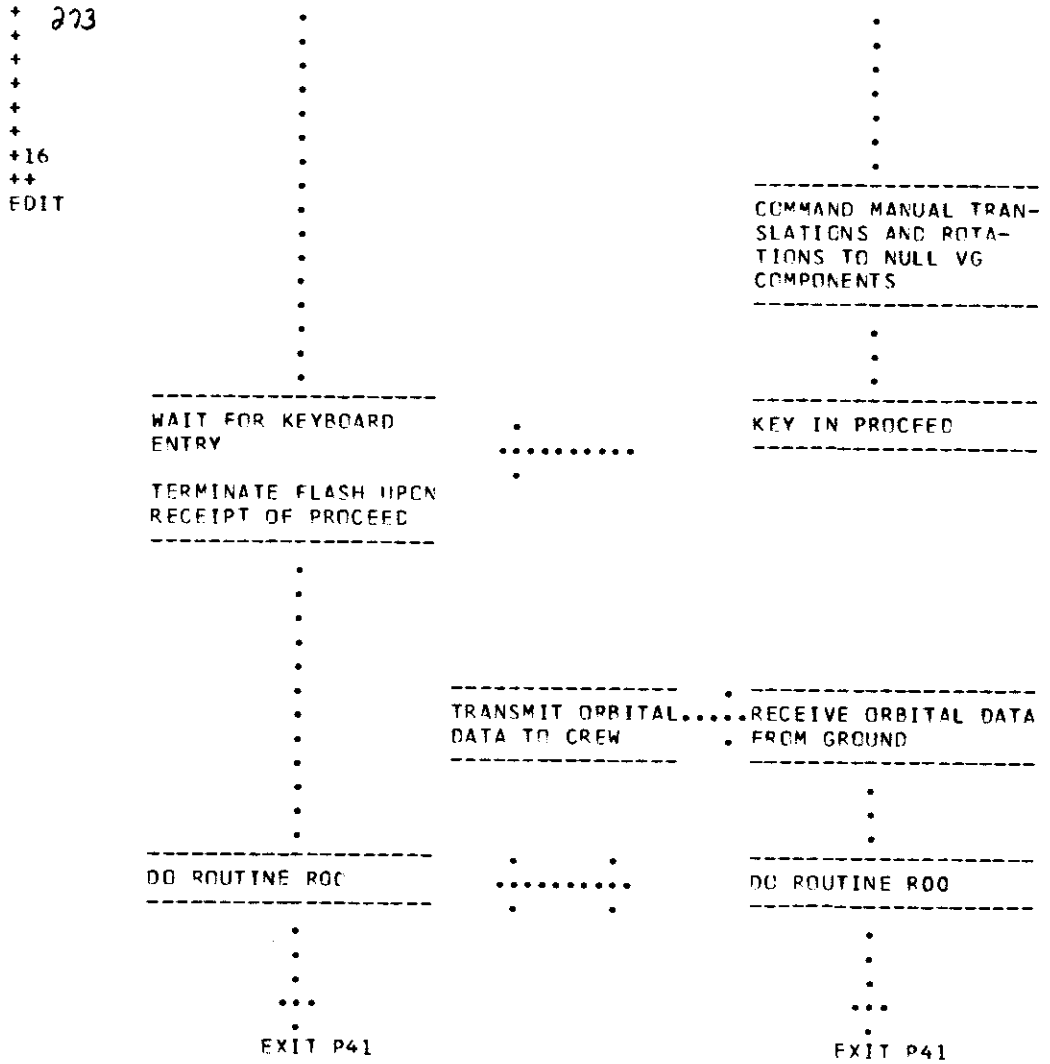

ATTITUDE, WINGS MAY NOT BE LEVEL IN THE COMPUTED FINAL ATTITUDE.
SET MINIMUM DEADBAND IN RCS DAP
DO ATTITUDE MANEUVER ROUTINE (R60)
DO ATTITUDE MANEUVER ROUTINE (R60)
TEMP HOLD
MON
DISPLAY (NO FLASH)
V06N85
R1 VGX(CSM)
R2 VGY(CSM)
R3 VGZ(CSM)
MONITOR DSKY:
OBSERVE NON-FLASHING VERB-NOUN DISPLAY OF VG COMPONENTS.
SELECT A/P AND MODE CONTROL AS DESIRED.
(VGX(CSM), VGY(CSM) VGZ(CSM) - COMPONENTS OF THE VG VECTOR AT TIG RESOLVED ALONG PRESENT CSM X, Y, AND Z CONTROL AXES RESPECTIVELY. UPDATED W.C.T. VEHICLE ATTITUDE EVERY 2 SECONDS IN FPS TO NEAREST .1 FPS.
SET TDEC=TIG-30 SEC
#110
#120
#130
#140
#150
#160



++
+16
++
EDIT
PCR
206


DISPLAY V16N85 NON-FLASHING AND DISPLAY THE VALUES OF VG IN CONTROL AXIS COMPUTED FOR THE PRESENT TIME (NOT TIG) UPDATED EVERY TWO SECONDS.
MONITOR DSKY: OBSERVE DISPLAY OF VG IN CONTROL AXIS AT TFI =- 30 SEC. THE AVERAGE G ROUTINE IS TURNED ON. OBSERVE COMPUTER ACTIVITY LIGHT BLINKS ON EVERY 2 SECONDS DURING AVERAGE G.
#220
#230
WAIT UNTIL TFI= ZERO
#240
HOLD MON
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY: V16N85 R1-VGX(CSM) R2-VGY(CSM) R3-VGZ(CSM)
MONITOR DSKY: OBSERVE VERB-NOUN FLASH (INDICATING CMC COMPUTED TIG) TO REQUEST RESPONSE AND DISPLAY OF VG COMPONENTS AT TFI = 0
#250
++
+16
VGX(CSM), VGY(CSM) VGZ(CSM) - COMPONENTS OF THE VG VECTOR RESOLVED ALONG PRESENT CSM X, Y, AND Z CONTROL AXES RESPECTIVELY. THE VG VECTOR WILL BE UPDATED BY THE STEERING LOOPS DURING EACH COMPUTATION CYCLE. IN FPS TO NEAREST .1 FPS.
#260



CHANGE CONTROL NOTES

LOGIC REV 11	PCR MIT 32
LOGIC REV 12	PCR MIT 32 PCR MIT 34
LOGIC REV 13	PCR MIT 66 PCR NASA 151
LOGIC REV 14	PCR 401.1
LOGIC REV 15	PCR 206
LOGIC REV 16	PCR 206 EDITORIAL

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THRUST MONITOR PROGRAM (P47) LCGIC REV 11 06/20/68

PURPOSE: (1) TO MONITOR VEHICLE ACCELERATION DURING A NON GNCS CONTROLLED THRUSTING MANEUVER.

(2) TO DISPLAY THE DELTA V APPLIED TO THE VEHICLE BY THIS THRUSTING MANEUVER.

ASSUMPTIONS: (1) IT IS NORMALLY REQUIRED THAT THE ISS BE ON FOR 15 MINUTES PRIOR TO A THRUSTING MANEUVER.
++
+11 (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 DESIRED TO DO ANY FINAL PHASE THRUSTING MANEUVERS AUTOMATICALLY UNDER GNCS CONTROL THEY MUST BE ACCOMPLISHED VIA SELECTION OF TRANSFER PHASE INITIATION (TPI) PROGRAM (P34) AND THEN THE SPS THRUSTING PROGRAM (P40) OR THE RCS THRUSTING PROGRAM (P41).

(4) RANGE, RANGE RATE, AND THETA MAY BE DISPLAYED DURING THIS PROGRAM BY CALLING THE RENDEZVOUS PARAMETER DISPLAY ROUTINE NO 1 (R31) WITH V83E.

(5) RANGE, RANGE RATE, AND PHI MAY BE DISPLAYED DURING THIS PROGRAM BY CALLING THE RENDEZVOUS PARAMETER DISPLAY ROUTINE NO 2 (R34) WITH V85E.

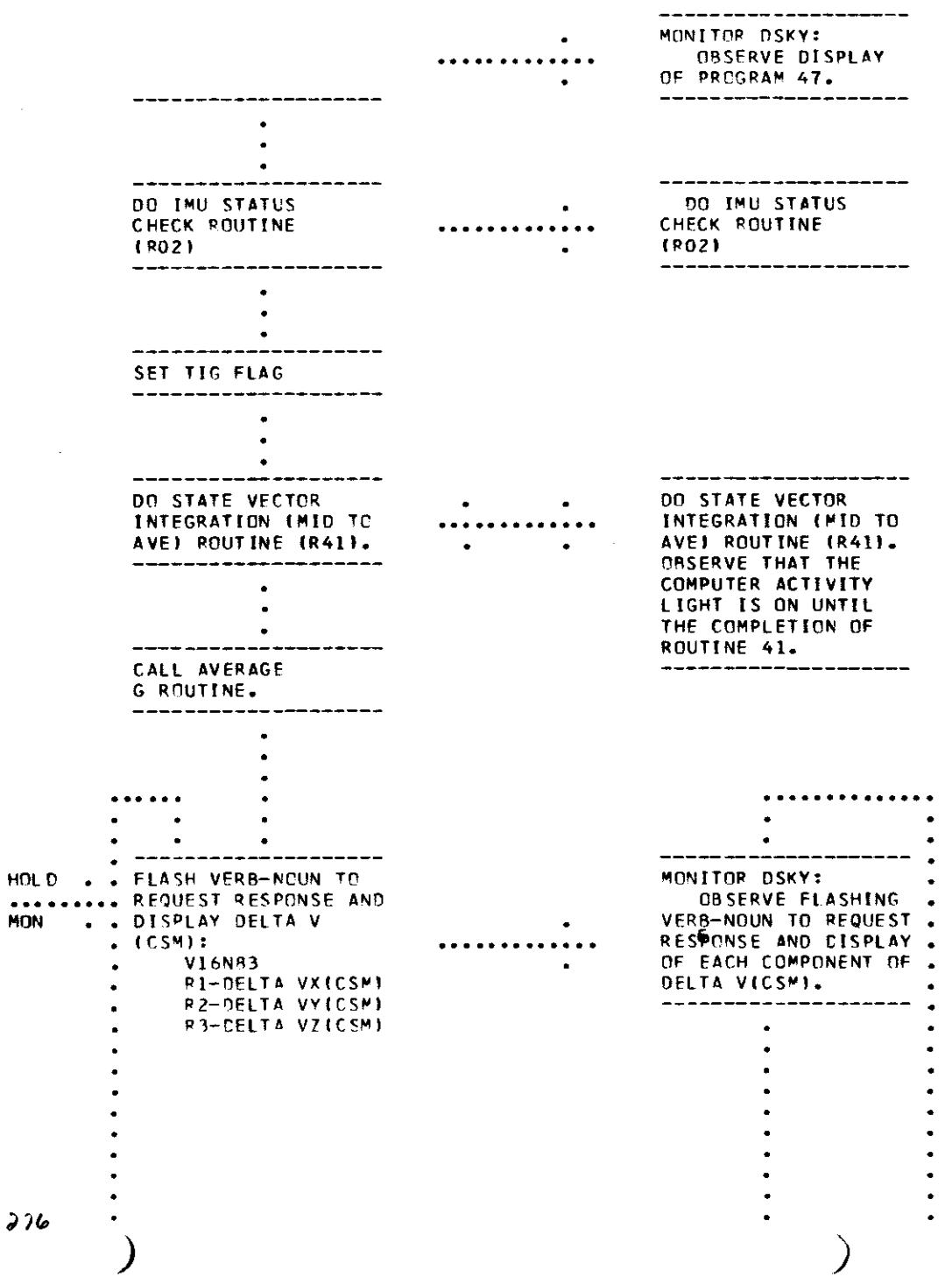
(6) VI, H AND H-DOT MAY BE CALLED BY KEYING IN V16N62E. THE DISPLAY OF H IN LUNAR ORBIT WILL BE INVALID.

(7) THE ORBIT PARAMETER DISPLAY ROUTINE MAY BE CALLED DURING THIS PROGRAM BY KEYING IN V82E.

(8) THIS PROGRAM SHOULD BE TURNED ON JUST PRIOR TO THE PLANNED THRUSTING MANEUVER AND TERMINATED AS SOON AS POSSIBLE FOLLOWING THE MANEUVER IN ORDER TO KEEP ERRORS OF BIAS AND AVERAGE G AT A MINIMUM.

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

PROG CONT	CMC	GROUND	CREW	CHECKLIST	TIME	TOTAL TIME
			.CREW . . .PROGRAM .SELECTION			
	START THRUST MONITOR PROGRAM (P47). DISPLAY P47.	. ...	KEY IN THRUST MONITOR PROGRAM (P47) V37E47E			#10


MONITOR DSKY:
OBSERVE DISPLAY
OF PROGRAM 47.
#20
DO IMU STATUS
CHECK ROUTINE
(R02)
DO IMU STATUS
CHECK ROUTINE
(R02)
#30
SET TIG FLAG
DO STATE VECTOR
INTEGRATION (MID TO
AVE) ROUTINE (R41).
DO STATE VECTOR
INTEGRATION (MID TO
AVE) ROUTINE (R41).
OBSERVE THAT THE
COMPUTER ACTIVITY
LIGHT IS ON UNTIL
THE COMPLETION OF
ROUTINE 41.
#40
CALL AVERAGE
G ROUTINE.
#50
HOLD
MON
FLASH VERB-NOUN TO
REQUEST RESPONSE AND
DISPLAY DELTA V
(CSM):
V16N83
R1-DELTA VX(CSM)
R2-DELTA VY(CSM)
R3-DELTA VZ(CSM)
MONITOR DSKY:
OBSERVE FLASHING
VERB-NOUN TO REQUEST
RESPONSE AND DISPLAY
OF EACH COMPONENT OF
DELTA V(CSM).
#60

DELTA VX(CSM) - COMPONENT OF INTEGRATED ACCELERATION ALONG CSM CONTROL +X AXIS. IN FPS TO NEAREST .1 FPS.

DELTA VY(CSM) - COMPONENT OF INTEGRATED ACCELERATION ALONG CSM CONTROL +Y AXIS. IN FPS TO NEAREST .1 FPS.

DELTA VZ(CSM) - COMPONENT OF INTEGRATED ACCELERATION ALONG CSM CONTROL +Z AXIS. IN FPS TO NEAREST .1 FPS.

NOTE1: R1,R2, AND R3 WILL READ 00000 INITIALLY AND WILL REMAIN SO (EXCEPT FOR ACCELEROMETER BIASES) UNTIL A THRUSTING MANEUVER IS STARTED. THEY WILL BE UPDATED EVERY 2 SEC.

NOTE2: IN THE EVENT THIS PROGRAM IS USED TO MONITOR MANEUVERS WITH A DELTA V GREATER THAN 9999.9 FPS THIS DISPLAY WILL ONLY LOSE THE HIGH ORDER DIGIT. IT WILL OTHERWISE READ CORRECTLY.

PERFORM THRUSTING MANEUVER AS DESIRED MONITOR FDAI BALL TO AVOID GIMBAL LOCK

#70

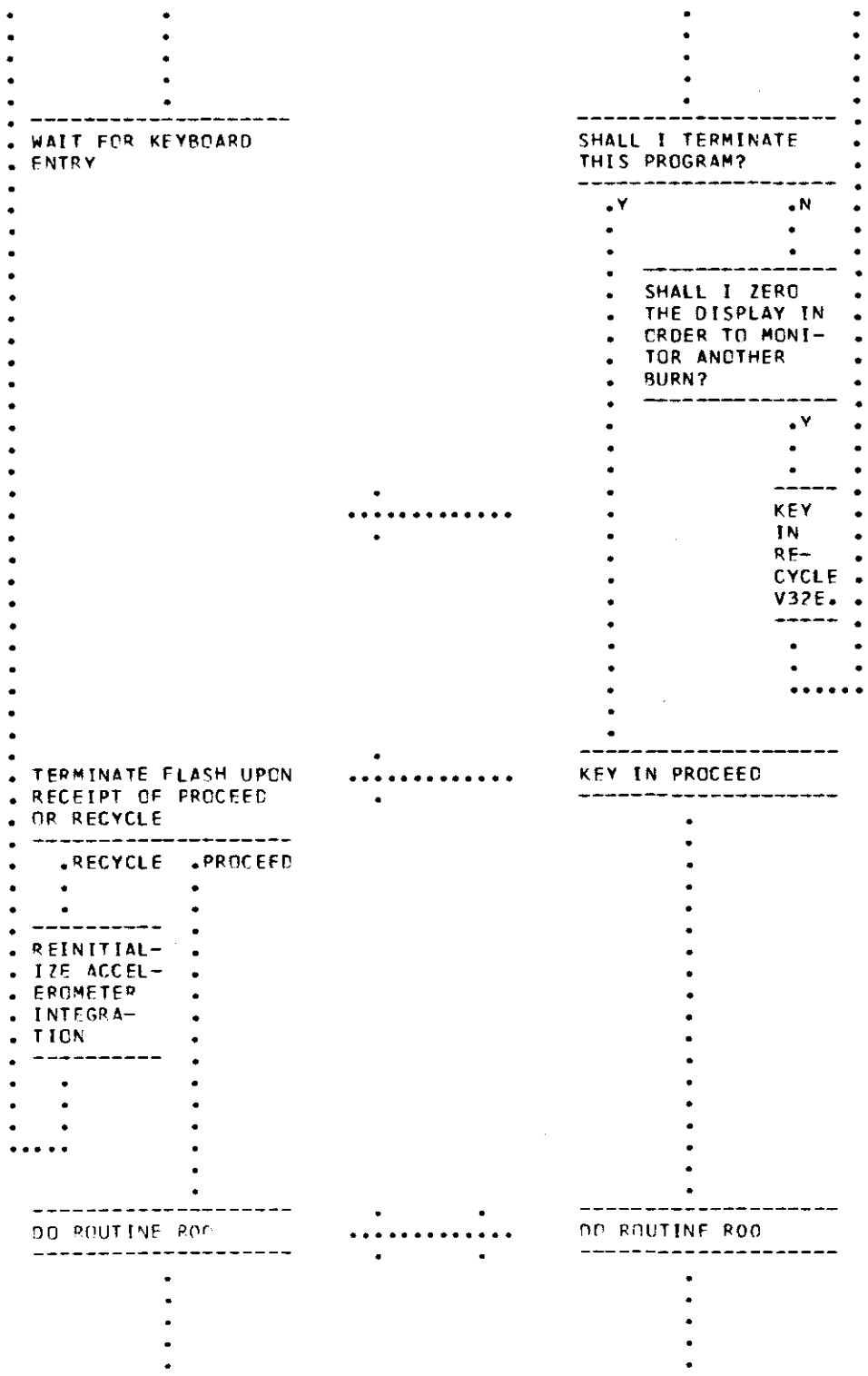
#80

#90

#100

#110

#120



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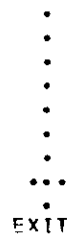

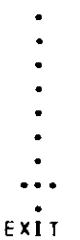

CHANGE CONTROL NOTES

REV 07 PCR MIT 32
REV 08 PCR MIT 32
REV 09 PCR NASA 64
REV 10 PCR MIT 66
REV 11 PCR 401.1

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IMU ORIENTATION DETERMINATION PROGRAM (P51) LOGIC REV 06 04/02/68

PURPOSE: (1) TO DETERMINE THE INERTIAL ORIENTATION OF THE IMU USING SIGHTINGS ON TWO CELESTIAL BODIES USING THE SCANNING TELESCOPE OR THE SEXTANT.

ASSUMPTIONS: (1) THE IMU MAY BE:

(A) OFF (STANDBY)

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

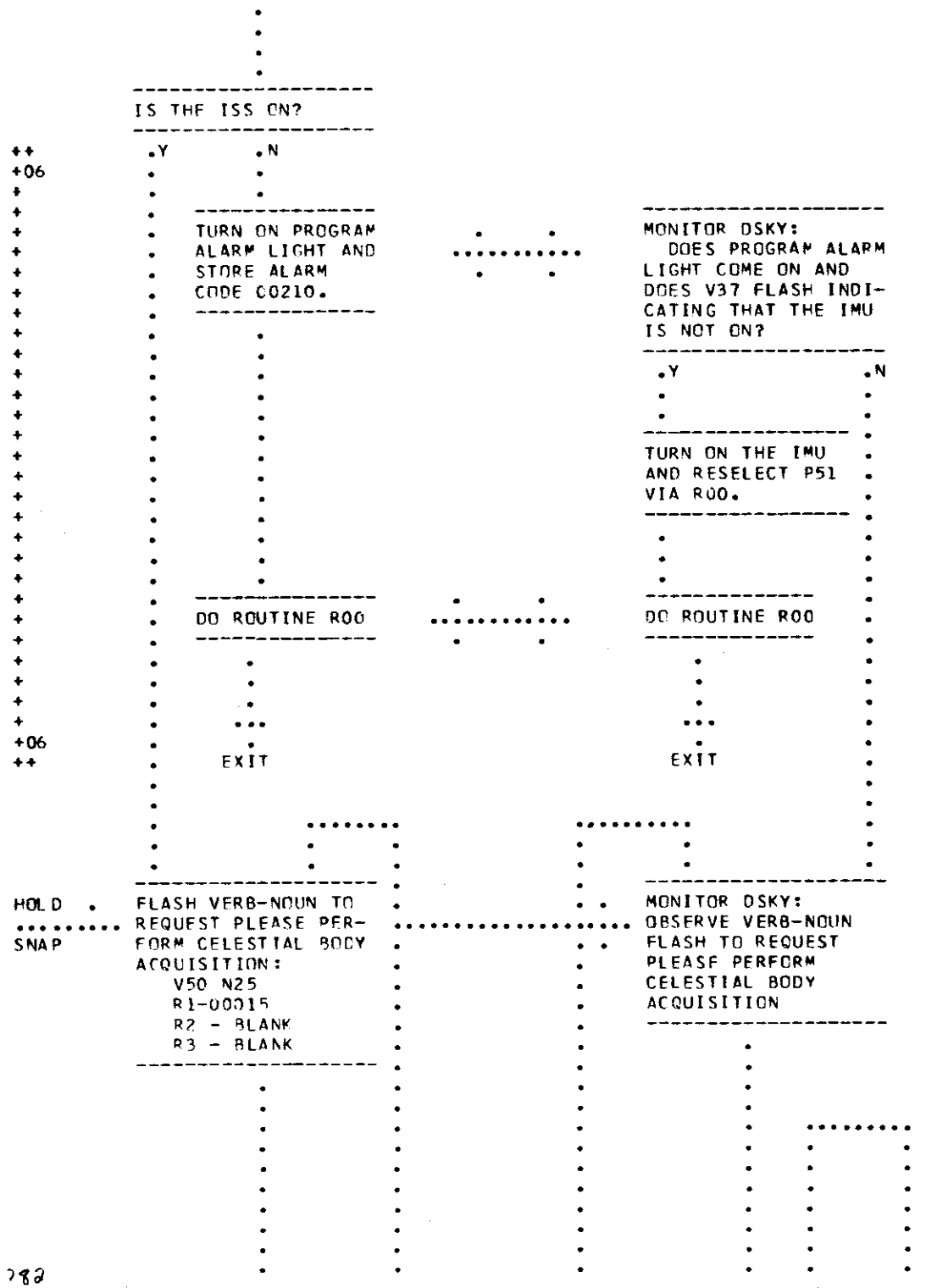
++
+06 IF (A) IS TRUE, THE IMU MUST BE TURNED ON BEFORE THIS PROGRAM CAN BE PERFORMED.
+ IF (B) IS TRUE THIS PROGRAM CAN BE COMPLETED.
+06
++

(2) THERE ARE NO RESTRAINTS UPON THE CSM ATTITUDE CONTROL MODES IN THIS PROGRAM.

(3) 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 CMC PROGRAMS.

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

PROG CONT	CMC	GROUND	CREW	CHECKLIST	TIME	TOTAL TIME
			.CREW PROG .SELECTION			
	START IMU ORIENTATION DETERMINATION PROGRAM (P51) DISPLAY PROGRAM 51	.	KEY IN IMU ORIENTATION DETERMINATION PROGRAM (P51) V37E 51E			#10
		.	MONITOR DSKY: OBSERVE DISPLAY OF PROGRAM 51			#20
	.				P51/COLOSSUS	


IS THE ISS ON?
Y
N
TURN ON PROGRAM ALARM LIGHT AND STORE ALARM CODE 00210.
DO ROUTINE R00
EXIT
MONITOR DSKY:
DOES PROGRAM ALARM LIGHT COME ON AND DOES V37 FLASH INDICATING THAT THE IMU IS NOT ON?
Y
N
TURN ON THE IMU AND RESELECT P51 VIA R00.
DO ROUTINE R00
EXIT
HOLD
SNAP
FLASH VERB-NOUN TO REQUEST PLEASE PERFORM CELESTIAL BODY ACQUISITION:
V50 N25
R1-00015
R2 - BLANK
R3 - BLANK
MONITOR DSKY:
OBSERVE VERB-NOUN FLASH TO REQUEST PLEASE PERFORM CELESTIAL BODY ACQUISITION

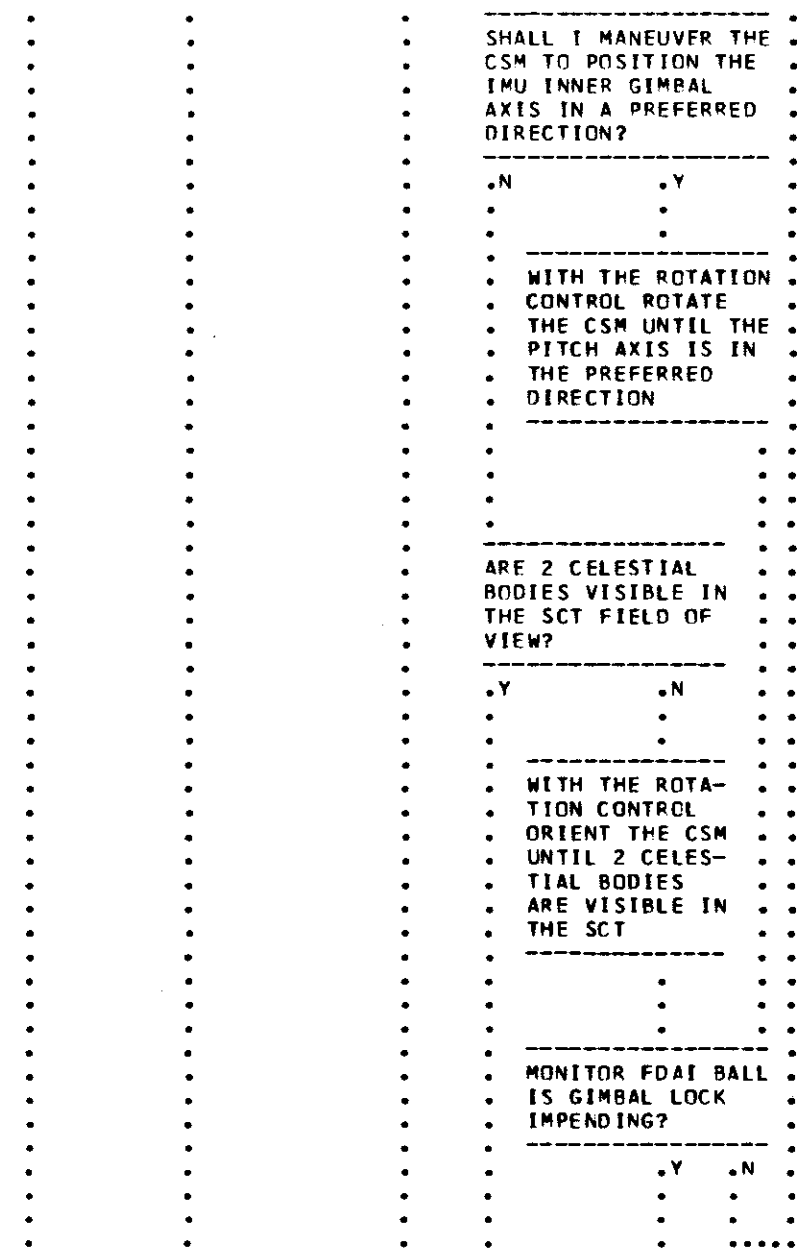
#30

#40

#50

#60

#70



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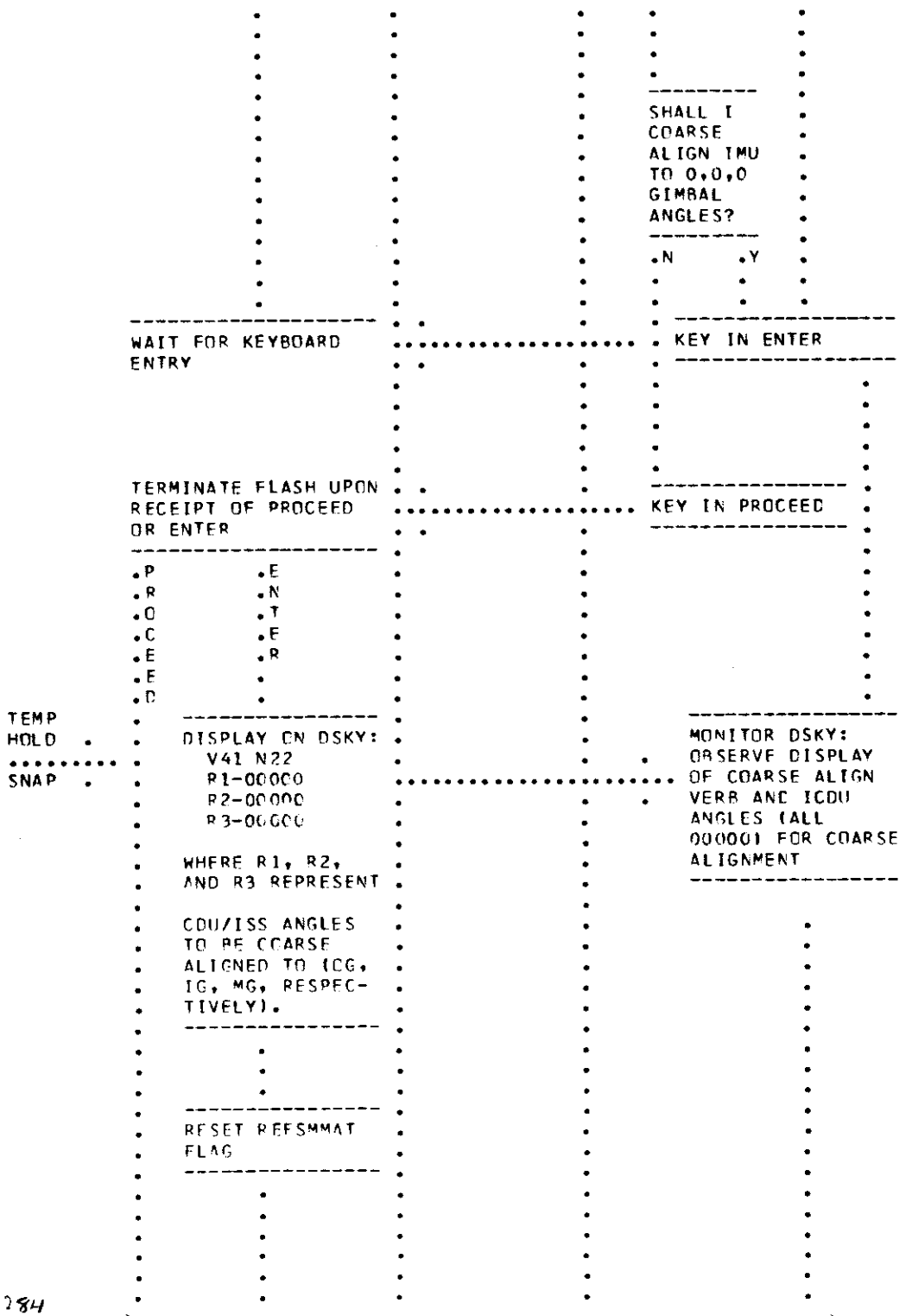
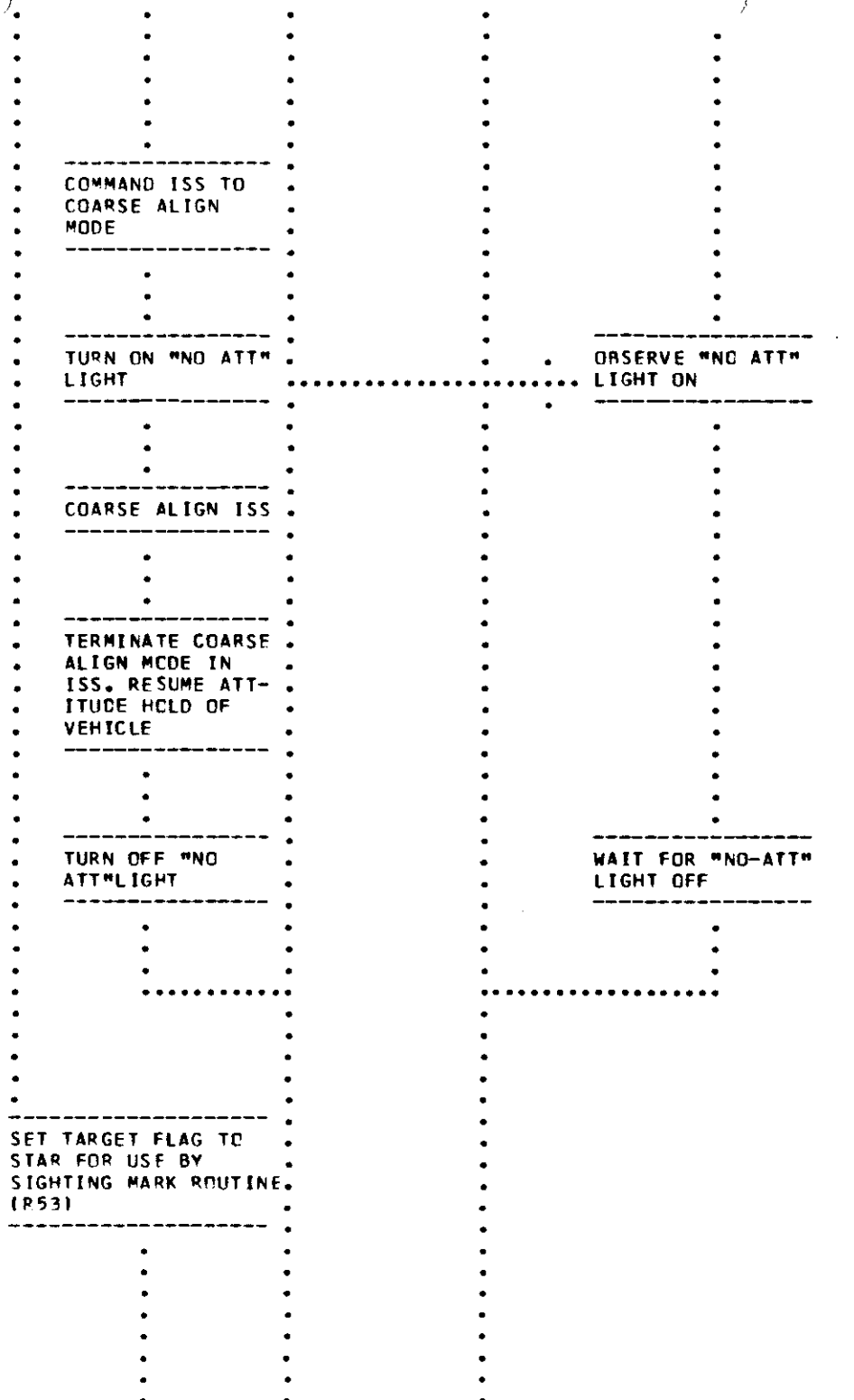

SHALL I COARSE ALIGN IMU TO 0,0,0 GIMBAL ANGLES?
.N
.Y
WAIT FOR KEYBOARD ENTRY
KEY IN ENTER
TERMINATE FLASH UPON RECEIPT OF PROCEED OR ENTER
KEY IN PROCEED
.P
.R
.O
.C
.E
.E
.D
.E
.N
.T
.E
.R
TEMP HOLD
SNAP
DISPLAY ON DSKY:
V41 N22
R1-00000
R2-00000
R3-00000
WHERE R1, R2, AND R3 REPRESENT
CDU/ISS ANGLES TO BE COARSE ALIGNED TO (CG, IG, MG, RESPECTIVELY).
RESET REFSMMAT FLAG
MONITOR DSKY:
OBSERVE DISPLAY OF COARSE ALIGN VERB AND ICDU ANGLES (ALL 00000) FOR COARSE ALIGNMENT
#140
#150
#160
#170
#180



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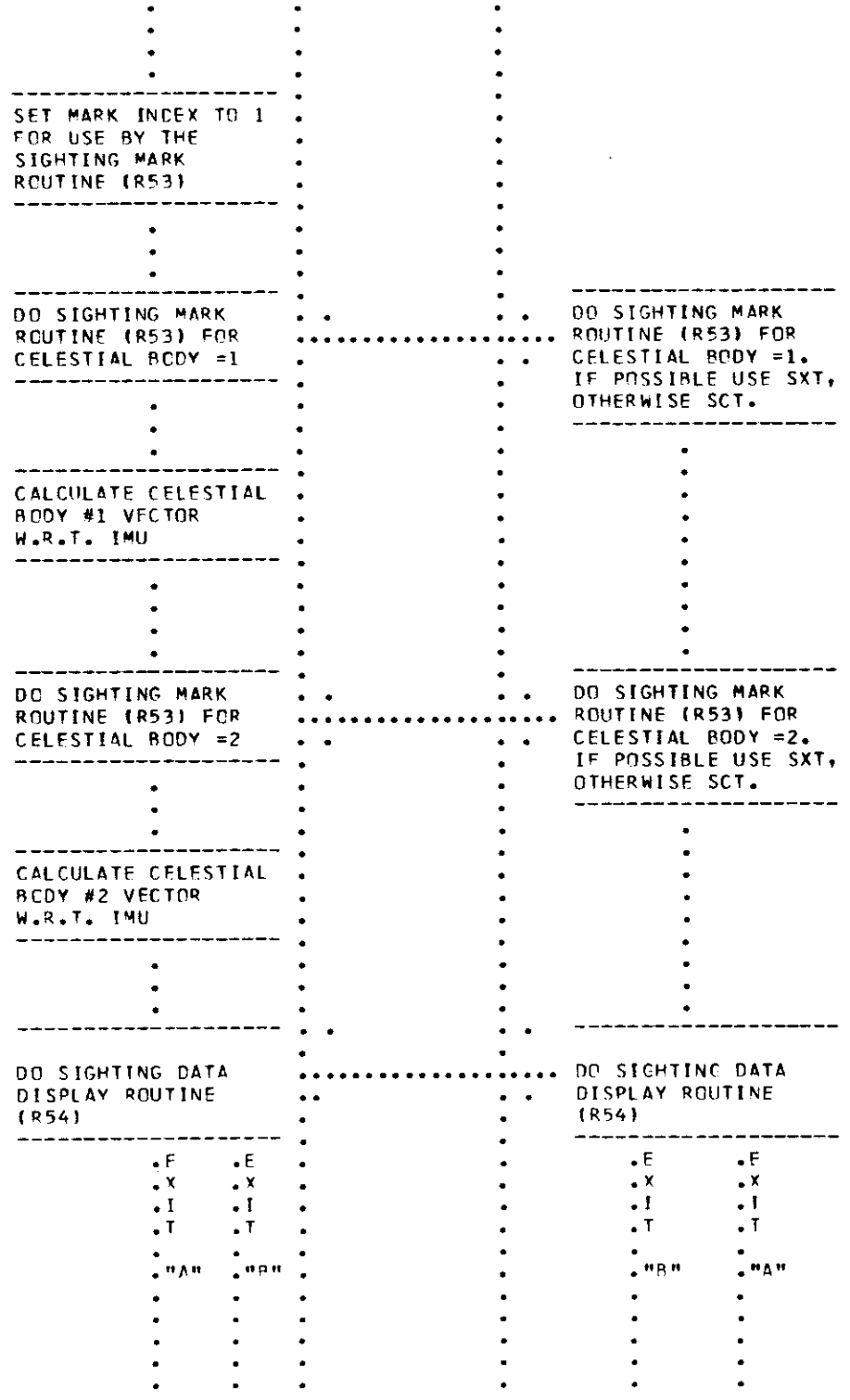
#220

#230

#240



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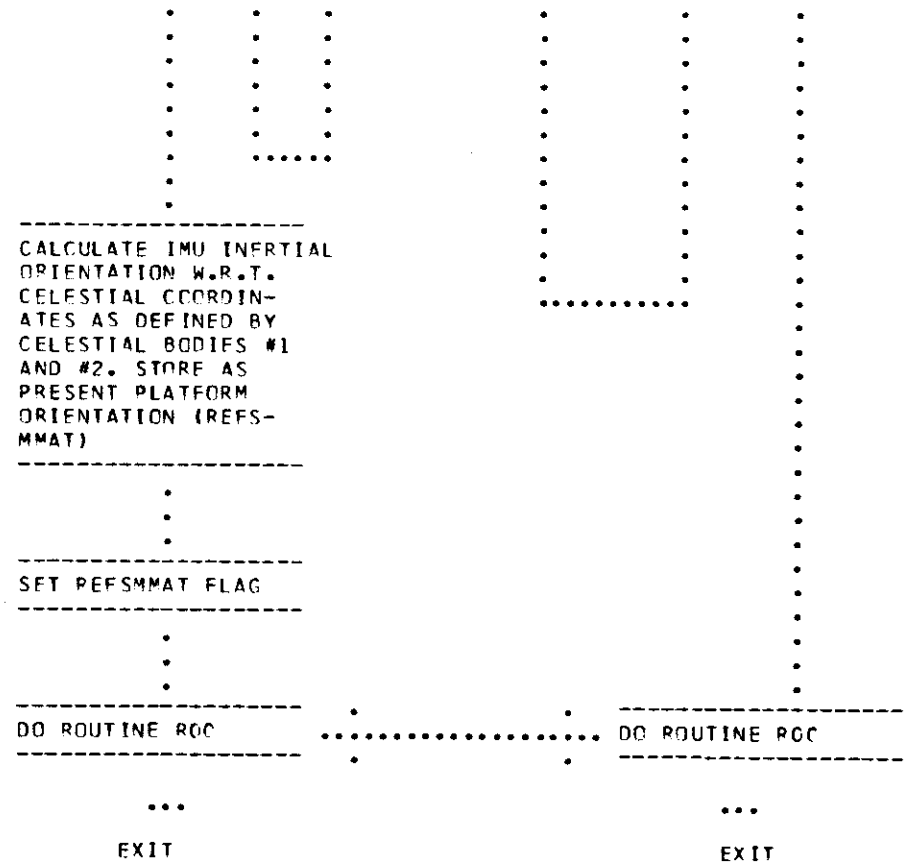

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CHANGE CONTROL NOTES

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PURPOSE: (1) TO ALIGN THE IMU FROM A "KNOWN" (SEE ASSUMPTION 4) ORIENTATION TO ONE OF FOUR ORIENTATIONS SELECTED BY THE ASTRONAUT USING SIGHTINGS ON TWO CELESTIAL BODIES WITH THE SCANNING TELESCOPE OR THE SEXTANT:

(A) PREFERRED ORIENTATION

AN OPTIMUM ORIENTATION FOR A PREVIOUSLY CALCULATED MANEUVER. THIS ORIENTATION MUST BE CALCULATED AND STORED BY A PREVIOUSLY SELECTED PROGRAM.

(B) LANDING SITE ORIENTATION

$$\underline{X}_{SM} = \mathrm{UNIT}(\underline{R}_{LS})$$

$$\underline{Y}_{SM} = \mathrm{UNIT}(\underline{?} \times \underline{X}_{SM})$$

$$\underline{Z}_{SM} = \mathrm{UNIT}(\underline{H}_{CSM} \times \underline{X}_{SM})$$

WHERE: THE ORIGIN IS THE CENTER OF THE MOON.

$\underline{R}_{LS}$ = THE POSITION OF THE MOST RECENTLY DEFINED LANDING SITE AT TIME, T (ALIGN) SELECTED BY THE ASTRONAUT.

$\underline{H}_{CSM}$ = THE ANGULAR MOMENTUM VECTOR OF THE CSM ($\underline{R}_{CSM} \times \underline{V}_{CSM}$) AT TIME T(ALIGN) SELECTED BY THE ASTRONAUT.

A SPECIAL CASE OF THE LANDING SITE ORIENTATION OCCURS WHEN T(ALIGN) IS DEFINED AS THE TIME OF LUNAR LANDING T(LAND). THIS CASE MAY OCCUR ONLY IF T(LAND) HAS BEEN DEFINED BY THE MSFN, TRANSMITTED TO THE ASTRONAUT AND THE ASTRONAUT HAS THEN DEFINED T(ALIGN) TO BE T(LAND) IN THIS PROGRAM.

(C) NOMINAL ORIENTATION

$$\underline{X}_{SM} = \mathrm{UNIT}(\underline{V} \times \underline{?})$$

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

$$\underline{Z}_{SM} = \mathrm{UNIT}(-\underline{R})$$

WHERE:

$\underline{R}$ = THE GEOCENTRIC (EARTH ORBIT) OR SELENOCENTRIC (LUNAR ORBIT) RADIUS VECTOR AT TIME T (ALIGN) SELECTED BY THE ASTRONAUT

$\underline{V}$ = THE INERTIAL VELOCITY VECTOR AT TIME T (ALIGN) SELECTED BY THE ASTRONAUT.

(D) REFSMMAT

SEE ASSUMPTION (4)

ASSUMPTIONS: (1) THE DOCKED CONFIGURATION MAY BE SIVB/CSM, LM/CSM, OR CSM. THE PRESENT CONFIGURATION SHOULD HAVE BEEN ENTERED INTO THE CMC BY COMPLETION OF THE DAP DATA LOAD ROUTINE R03.

(2) THERE ARE NO RESTRAINTS UPON THE CSM ATTITUDE CONTROL MODES IN THIS PROGRAM.

++ +15 ++ EDIT (3) 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 POINT THE SXT AT ASTRONAUT OR CMC SELECTED STARS EITHER MANUALLY BY CREW INPUT OR AUTOMATICALLY UNDER CMC CONTROL.

(4) THE ISS IS ON AND HAS BEEN ALIGNED TO A KNOWN ORIENTATION WHICH IS STORED IN THE CMC (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).

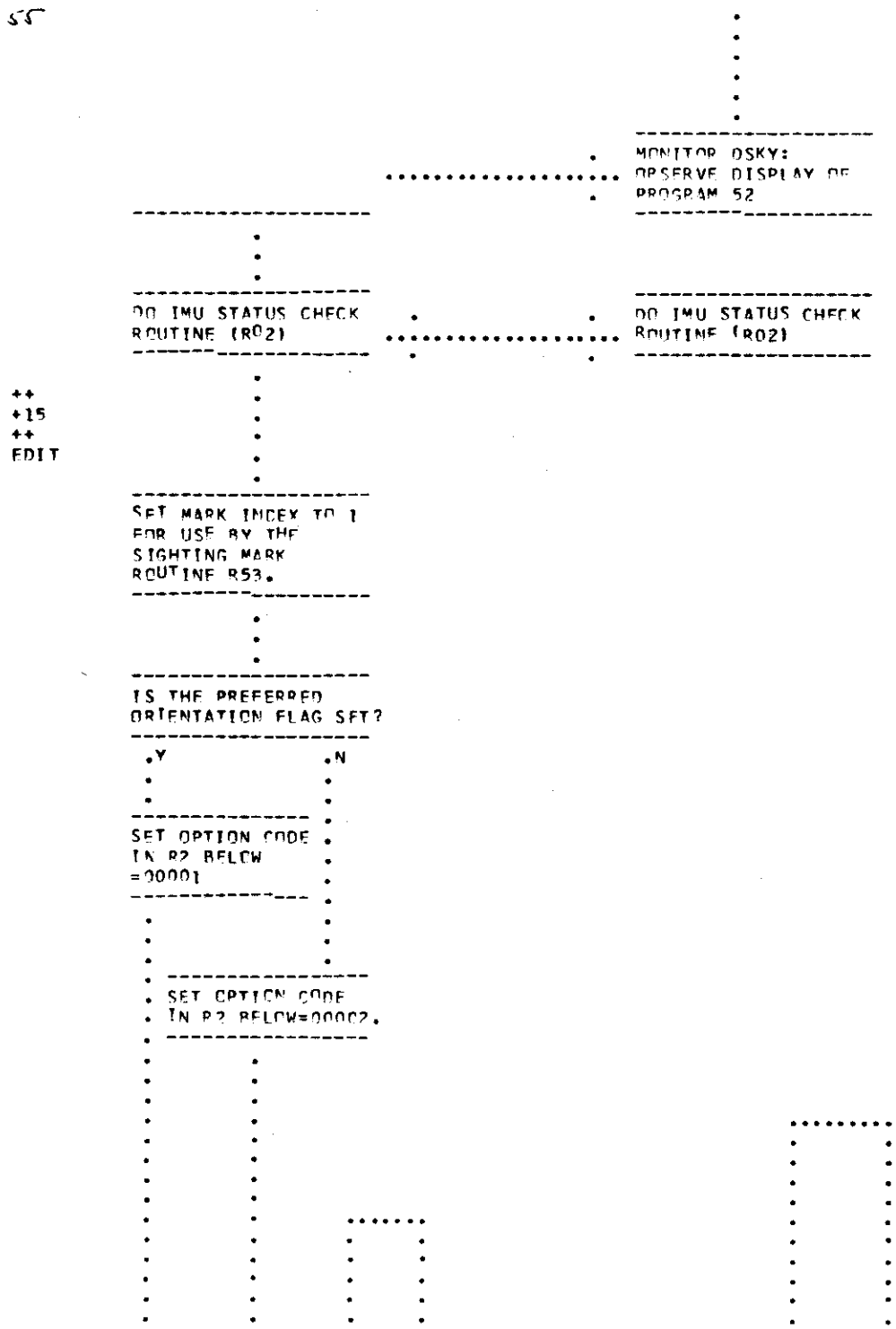
(5) THE LANDING SITE ORIENTATION IS USED FOR:

(A) ALIGNING THE CSM STABLE MEMBER TO THE SAME ORIENTATION AS THE LM STABLE MEMBER PRIOR TO LM/CSM SEPARATION

(B) ALIGNING THE CSM STABLE MEMBER TO THE SAME ORIENTATION AS THE LM STABLE MEMBER PRIOR TO LM ASCENT FROM THE LUNAR SURFACE.

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

PROG CONT	CMC	GROUND	CREW	CHECKLIST	TIME	TOTAL TIME
			•CREW PROG •SELECTION • ••• •			
	START IMU REALIGN PROGRAM (P52) DISPLAY PROGRAM 52	• ••••••••••••••••••• •	KEY IN IMU REALIGN PROGRAM (P52) V37E 52E			#10



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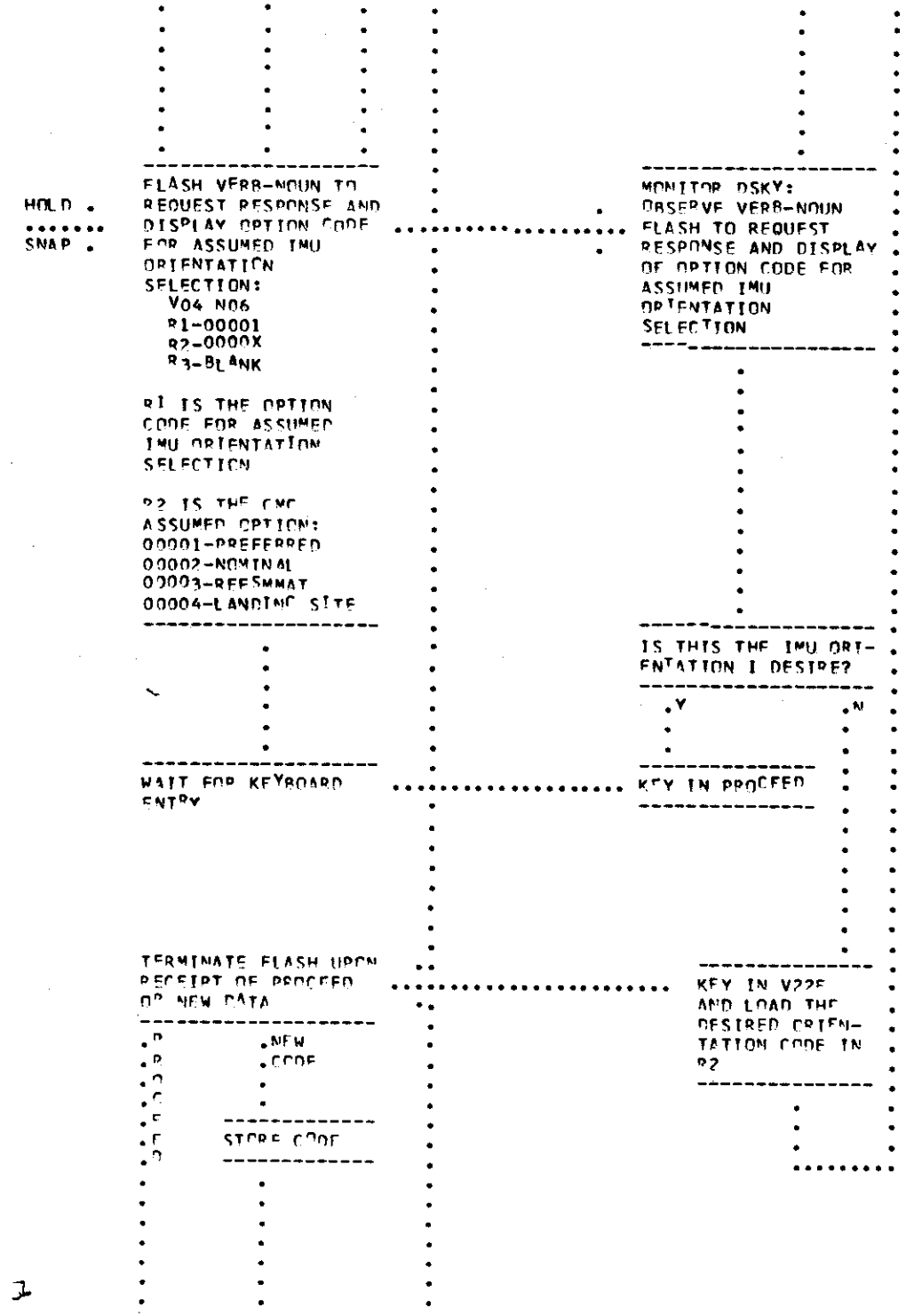
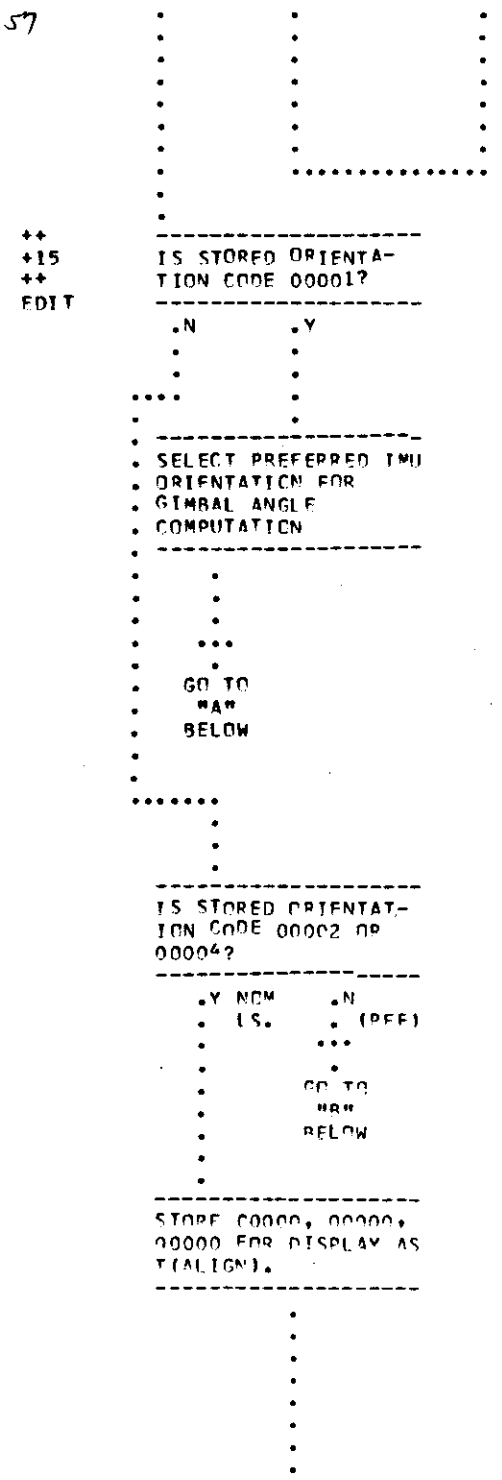
+15
++
EDIT


#70
#80
#90
#100
#110
#120
HOLD
SNAP
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY OPTION CODE FOR ASSUMED IMU ORIENTATION SELECTION:
V04 N06
R1-00001
R2-0000X
R3-BLANK
R1 IS THE OPTION CODE FOR ASSUMED IMU ORIENTATION SELECTION
R2 IS THE CMC ASSUMED OPTION:
00001-PREFERRED
00002-NOMINAL
00003-REFSMMAT
00004-LANDING SITE
WAIT FOR KEYBOARD ENTRY
TERMINATE FLASH UPON RECEIPT OF PROCEED OR NEW DATA
PROCEED
NEW CODE
STORE CODE
MONITOR DSKY: OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY OF OPTION CODE FOR ASSUMED IMU ORIENTATION SELECTION
IS THIS THE IMU ORIENTATION I DESIRE?
Y
N
KEY IN PROCEED
KEY IN V22E AND LOAD THE DESIRED ORIENTATION CODE IN R2



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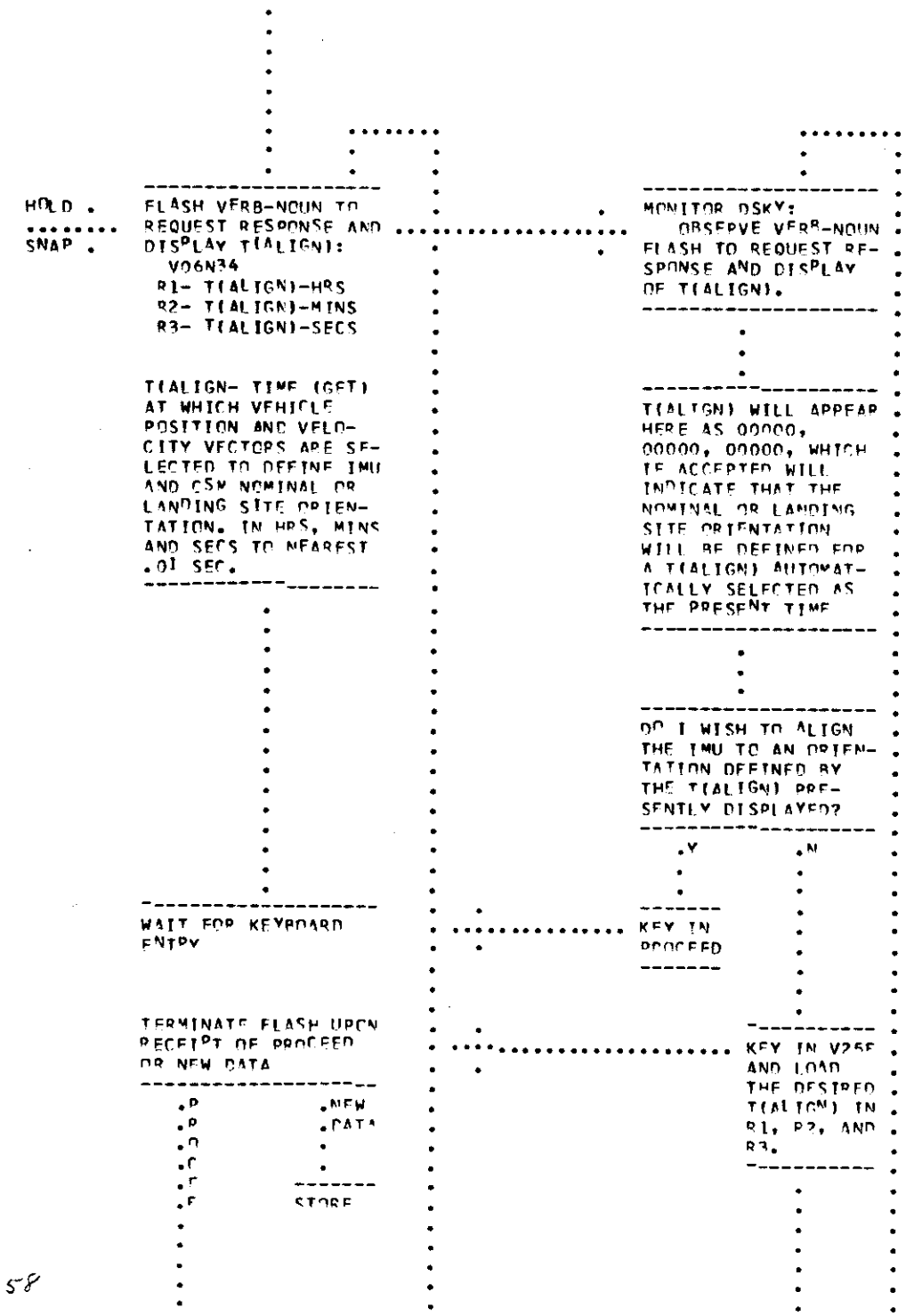
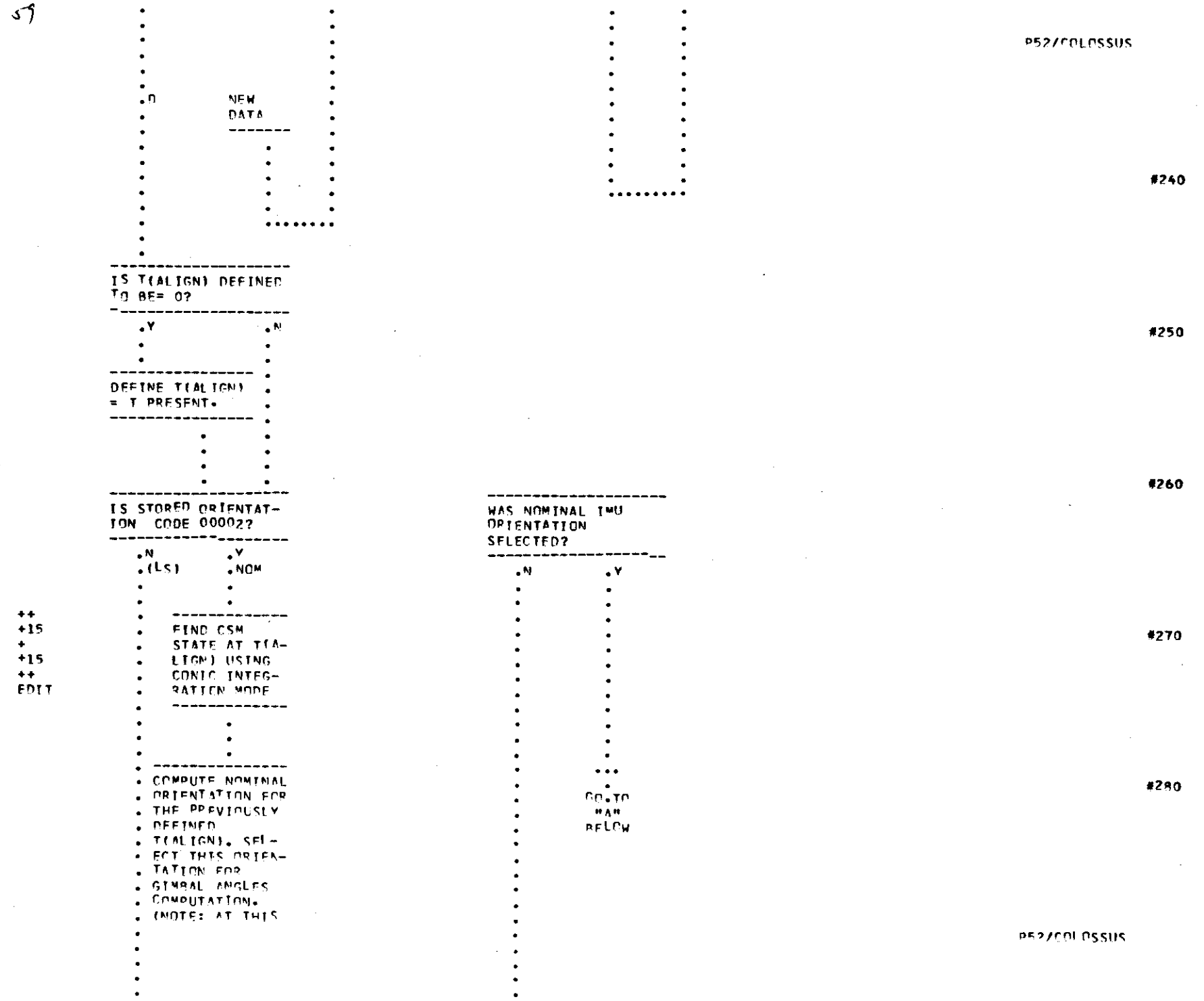


#180 #190 #200 #210 #220 #230


.D
NEW DATA
IS T(ALIGN) DEFINED TO BE= 0?
.Y
.N
DEFINE T(ALIGN) = T PRESENT.
IS STORED ORIENTATION CODE 00002?
.N (LS)
.Y NOM
FIND CSM STATE AT T(ALIGN) USING CONIC INTEGRATION MODE
COMPUTE NOMINAL ORIENTATION FOR THE PREVIOUSLY DEFINED T(ALIGN). SELECT THIS ORIENTATION FOR GIMBAL ANGLES COMPUTATION. (NOTE: AT THIS
WAS NOMINAL IMU ORIENTATION SELECTED?
.N
.Y
GO TO "A" BELOW
#240
#250
#260
#270
#280

++
+15
+
+15
++
EDIT

#290

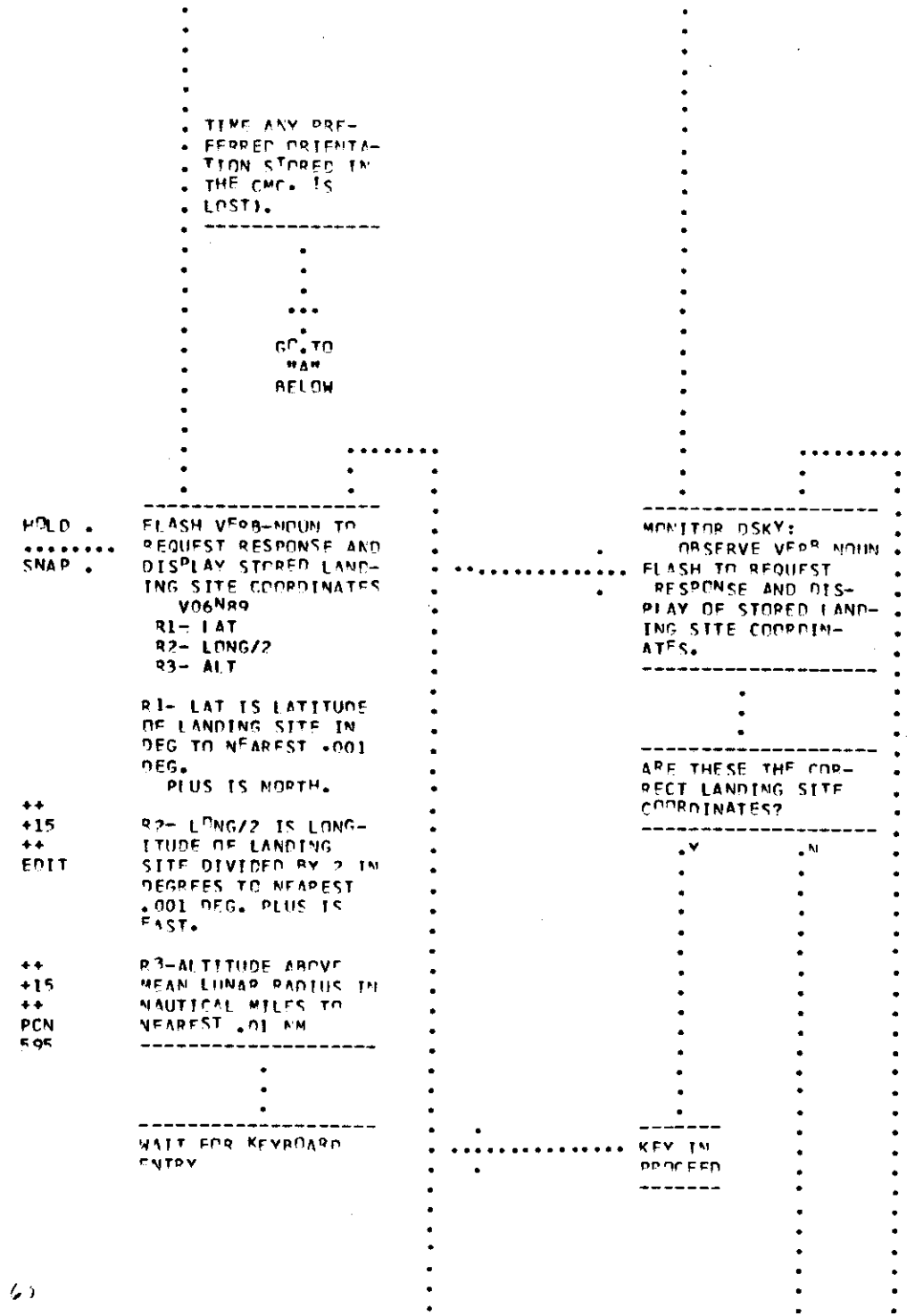
#300

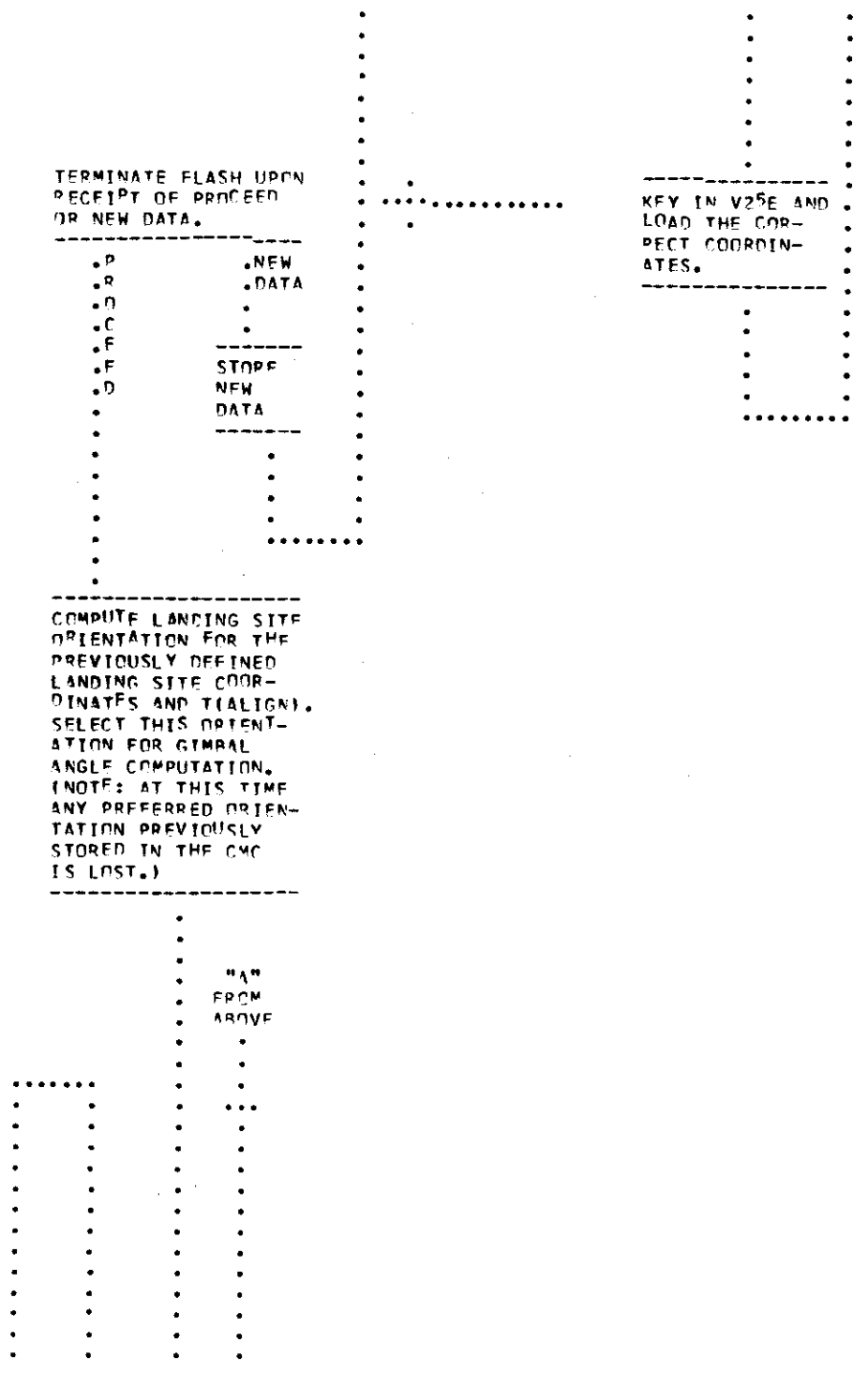
#310

#320

#330

#340





++
+15
++
EDIT

#350

#360

#370

#380

#390

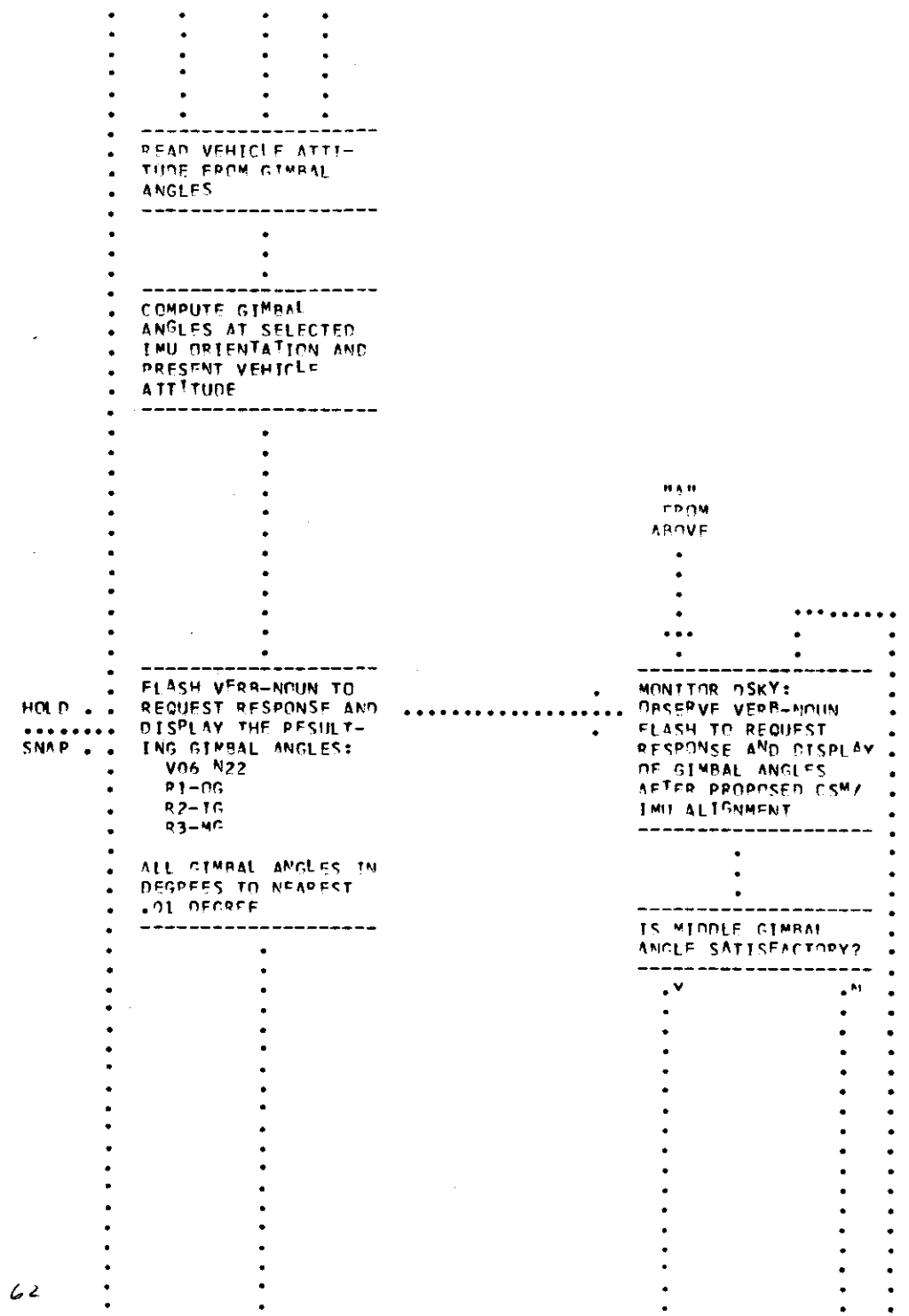
#400

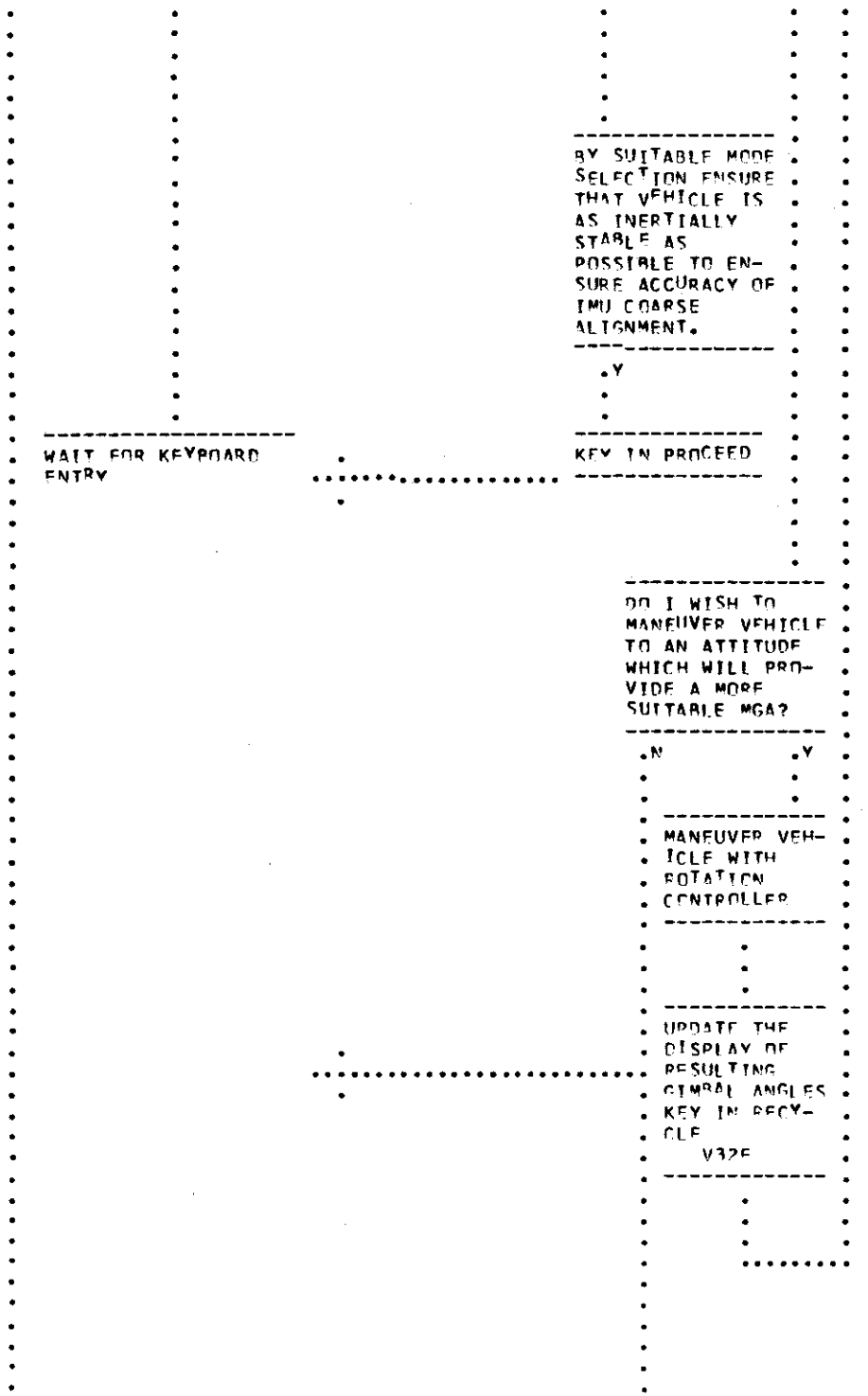
#410

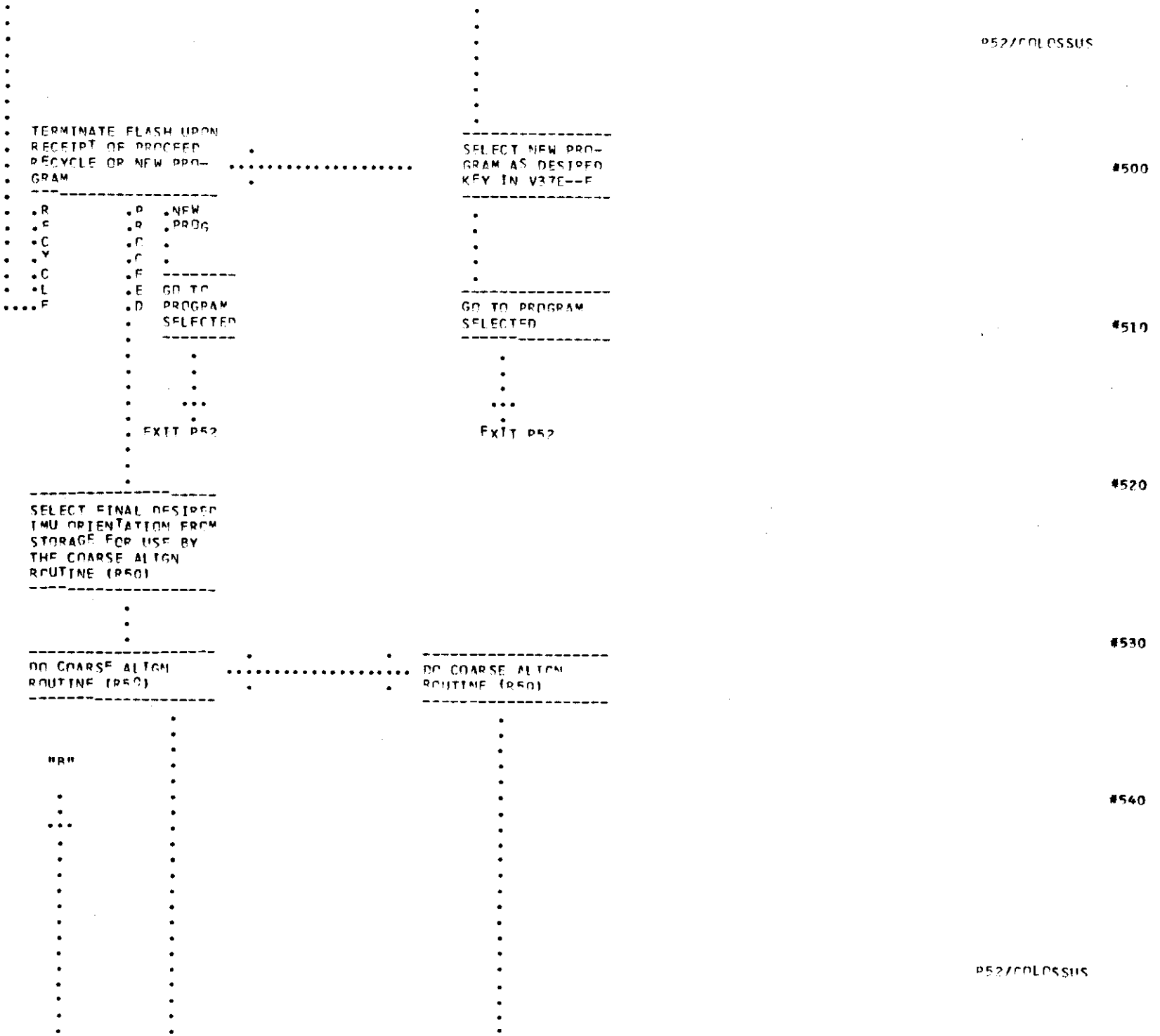
#420

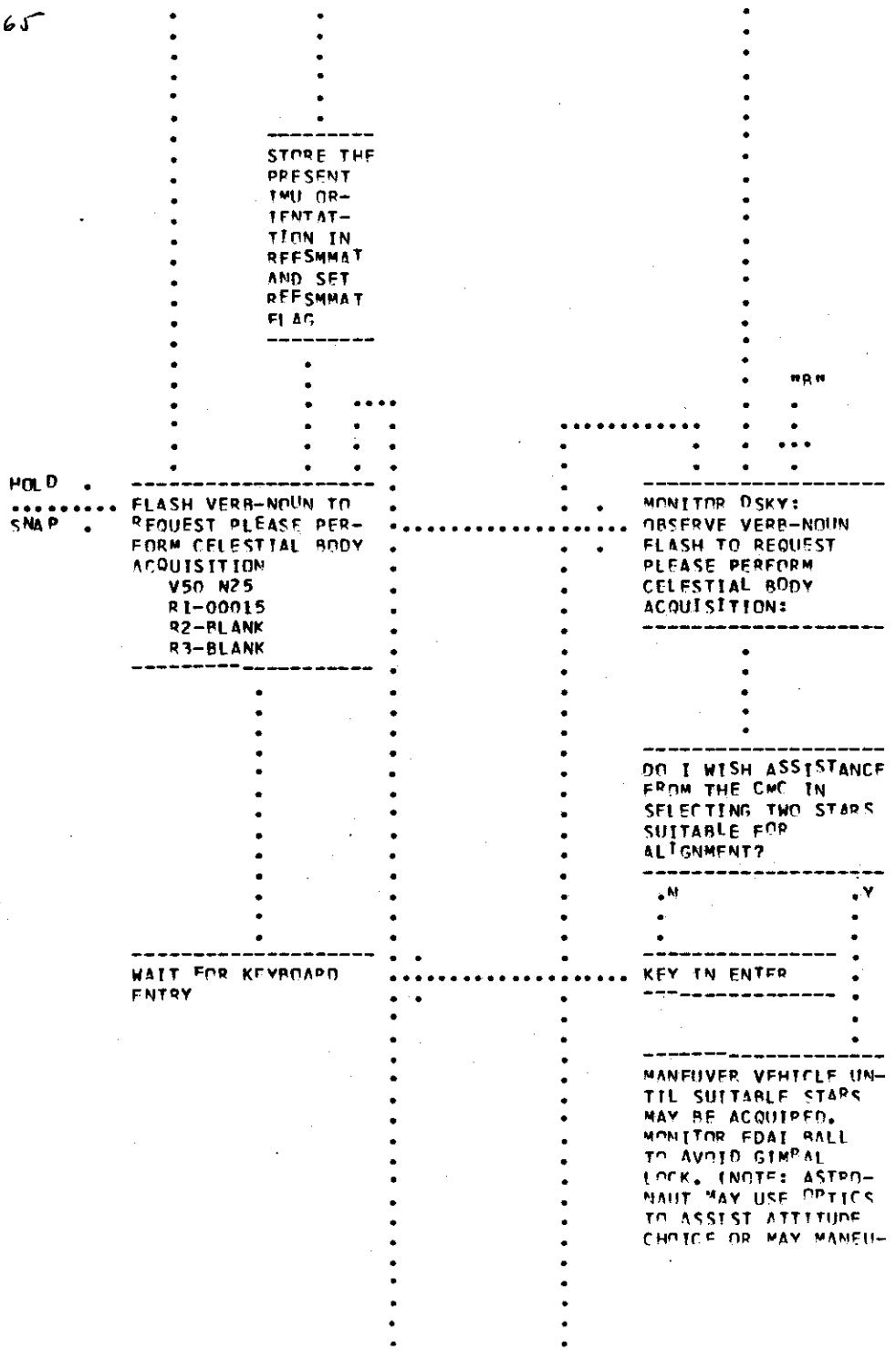
#430

#440




BY SUITABLE MODE SELECTION ENSURE THAT VEHICLE IS AS INERTIALLY STABLE AS POSSIBLE TO ENSURE ACCURACY OF IMU COARSE ALIGNMENT.
#450
WAIT FOR KEYBOARD ENTRY
KEY IN PROCEED
#460
DO I WISH TO MANEUVER VEHICLE TO AN ATTITUDE WHICH WILL PROVIDE A MORE SUITABLE MGA?
#470
N
Y
MANEUVER VEHICLE WITH ROTATION CONTROLLER
#480
UPDATE THE DISPLAY OF RESULTING GIMBAL ANGLES KEY IN RECYCLE
V32E
#490


TERMINATE FLASH UPON RECEIPT OF PROCEED RECYCLE OR NEW PRO- GRAM
R
E
C
Y
C
L
E
P
R
O
C
E
E
D
NEW PROG
GO TO PROGRAM SELECTED
EXIT P52
SELECT NEW PRO- GRAM AS DESIRED KEY IN V37E--E
GO TO PROGRAM SELECTED
EXIT P52
#500
#510
#520
SELECT FINAL DESIRED IMU ORIENTATION FROM STORAGE FOR USE BY THE COARSE ALIGN ROUTINE (R50)
DO COARSE ALIGN ROUTINE (R50)
DO COARSE ALIGN ROUTINE (R50)
#530
"RR"
#540



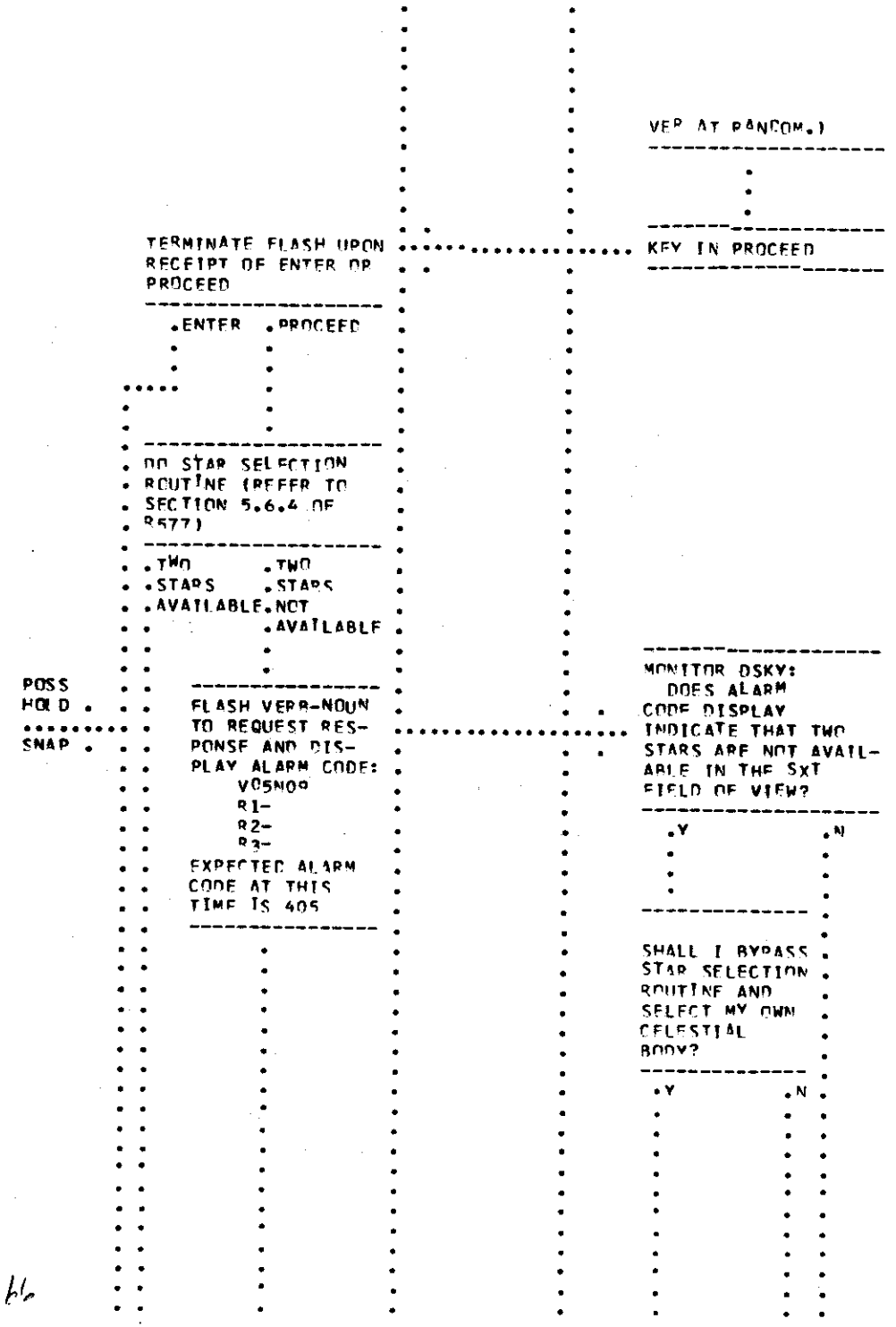
#550

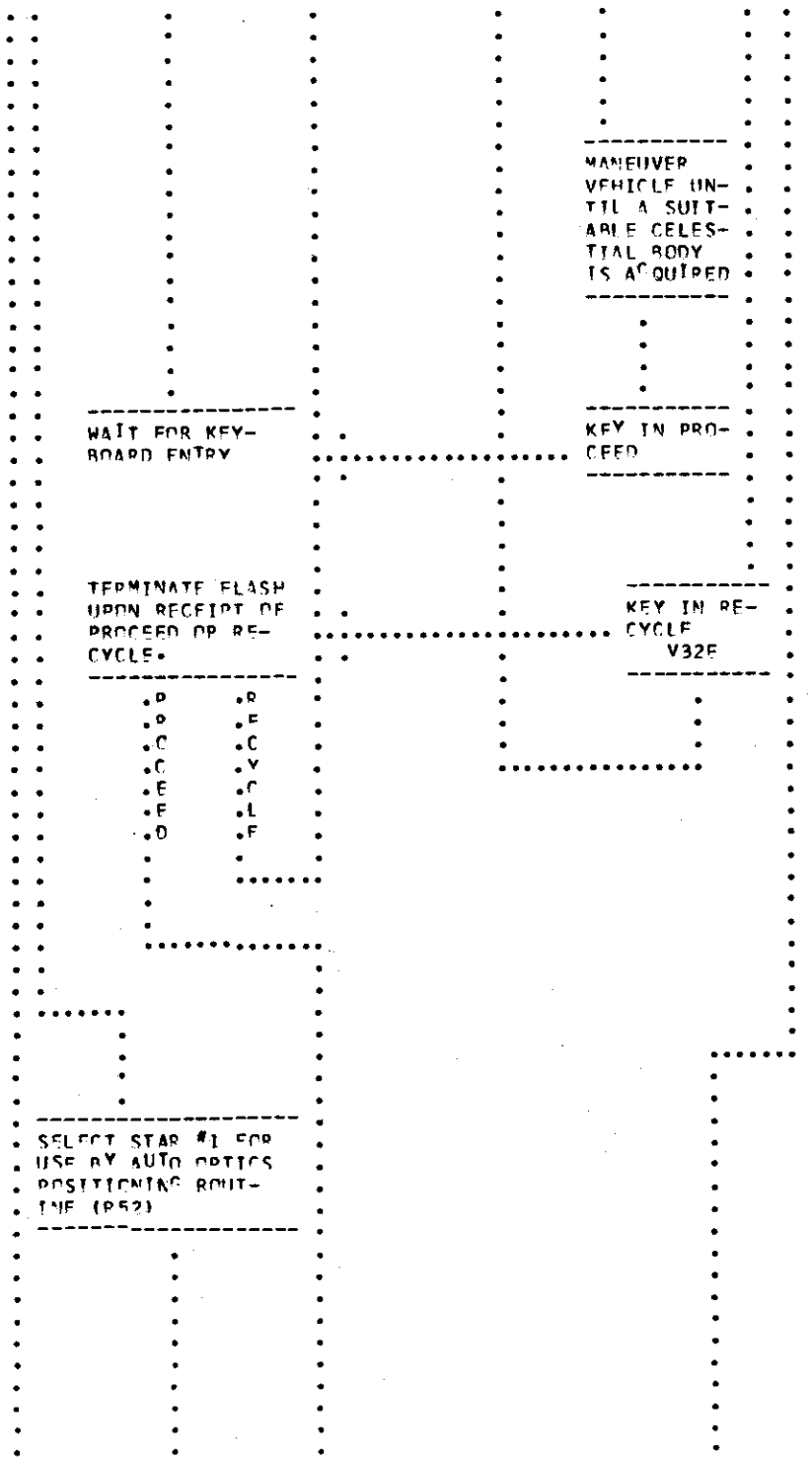
#560

#570

#580

#590


VER AT RANDOM.)
KEY IN PROCEED
TERMINATE FLASH UPON RECEIPT OF ENTER OR PROCEED
.ENTER
.PROCEED
DO STAR SELECTION ROUTINE (REFER TO SECTION 5.6.4 OF R577)
.TWO STARS AVAILABLE
.TWO STARS NOT AVAILABLE
POSS HOLD SNAP
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY ALARM CODE:
V05N09
R1-
R2-
R3-
EXPECTED ALARM CODE AT THIS TIME IS 405
MONITOR DSKY: DOES ALARM CODE DISPLAY INDICATE THAT TWO STARS ARE NOT AVAILABLE IN THE SXT FIELD OF VIEW?
.Y
.N
SHALL I BYPASS STAR SELECTION ROUTINE AND SELECT MY OWN CELESTIAL BODY?
.Y
.N
#600
#610
#620
#630
#640
#650



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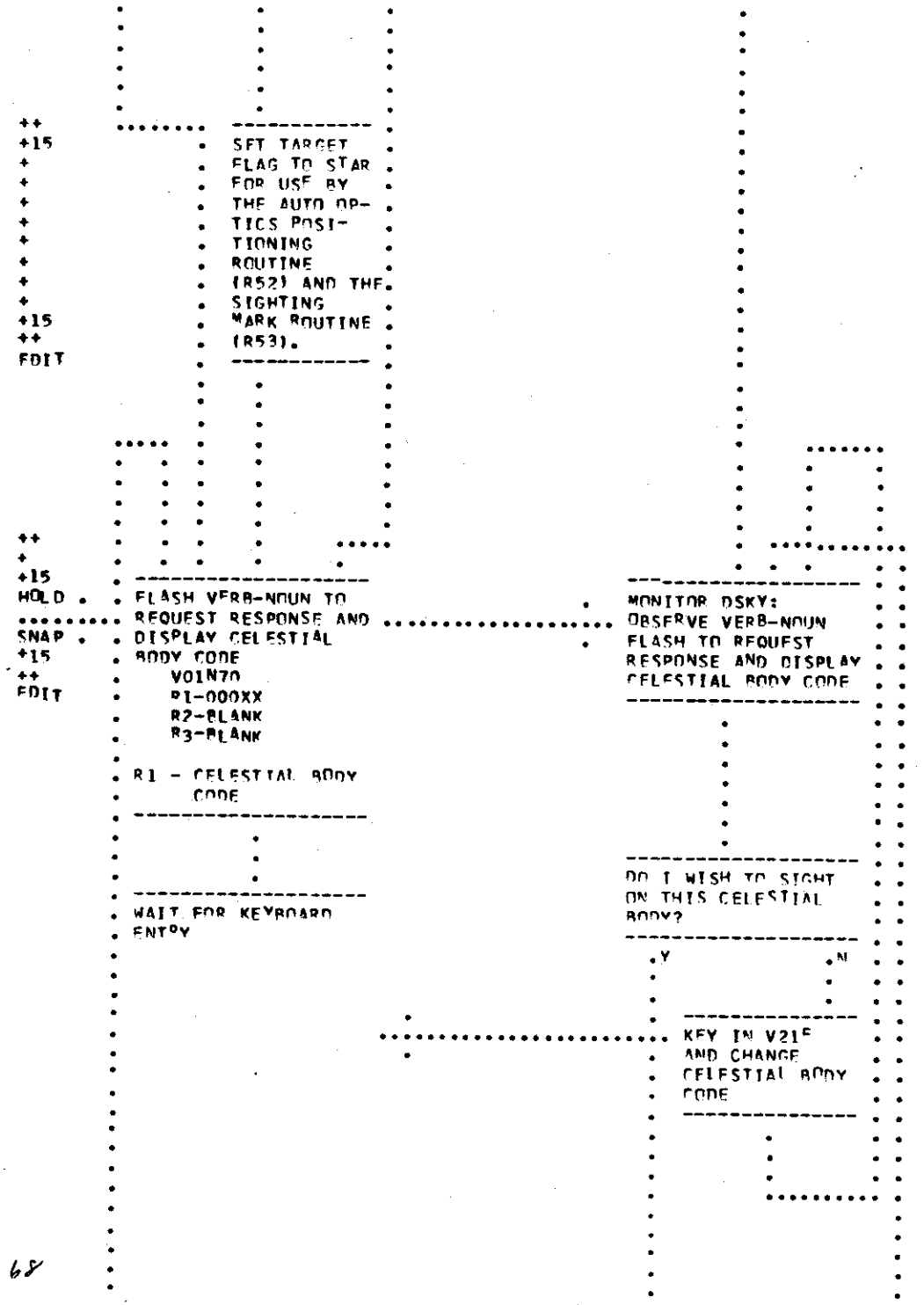
#680

#690

#700



#710

#720

#730

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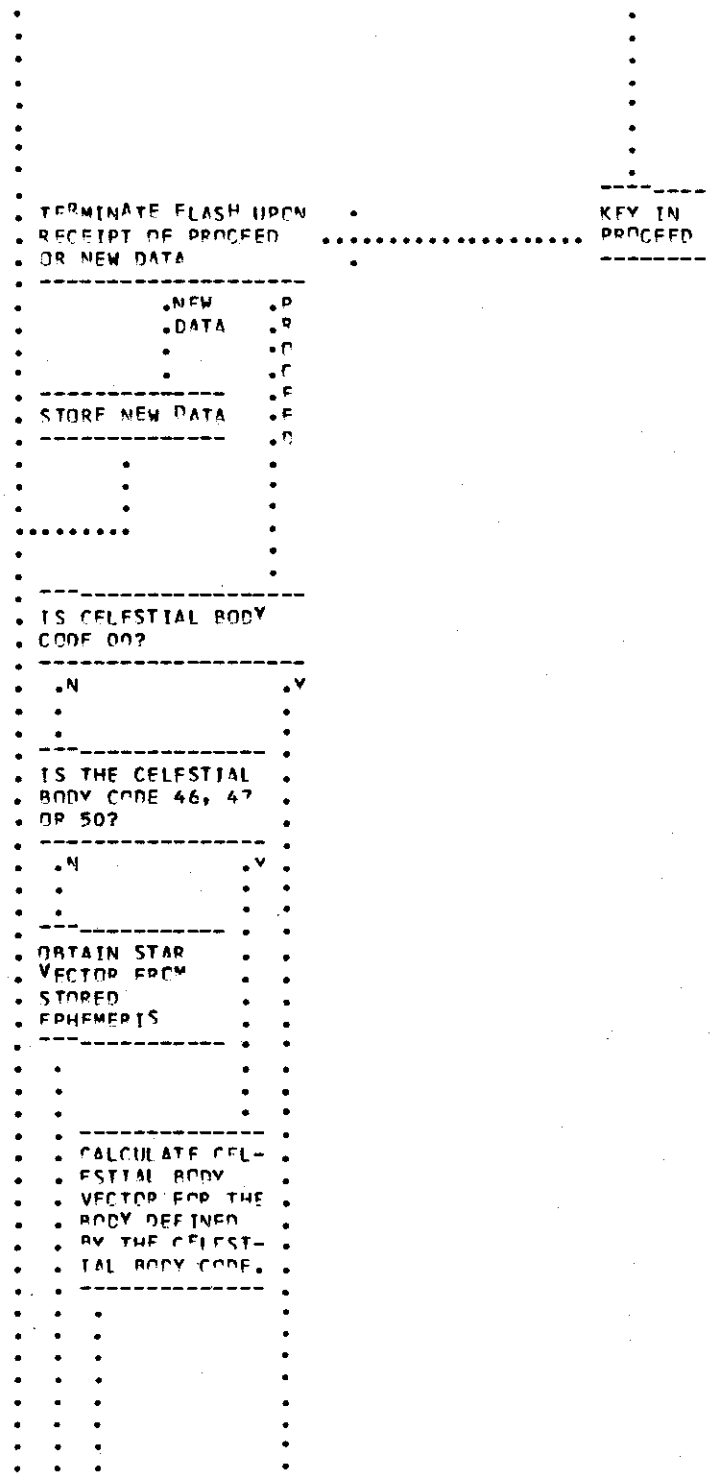
#750



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#770

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#790

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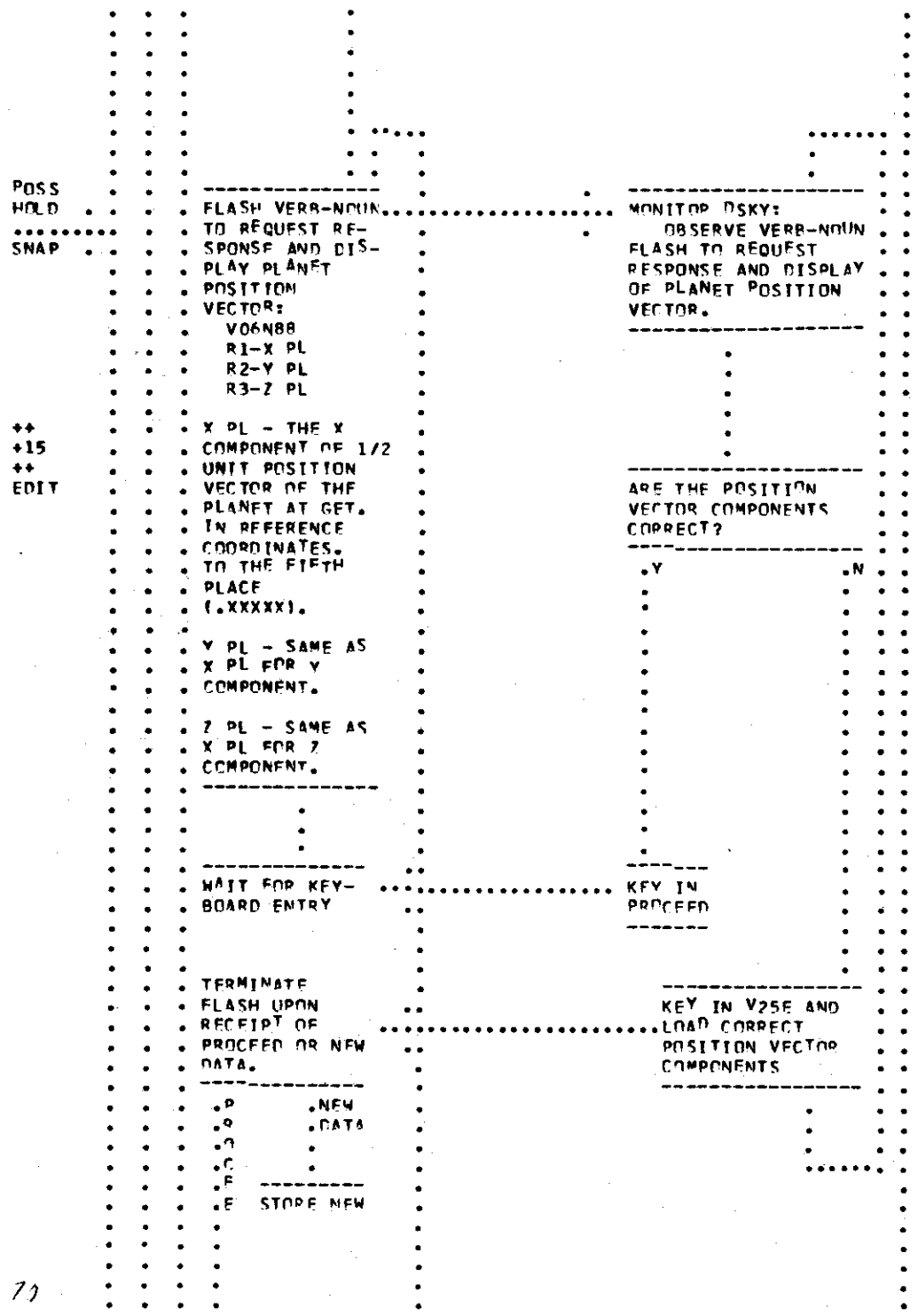
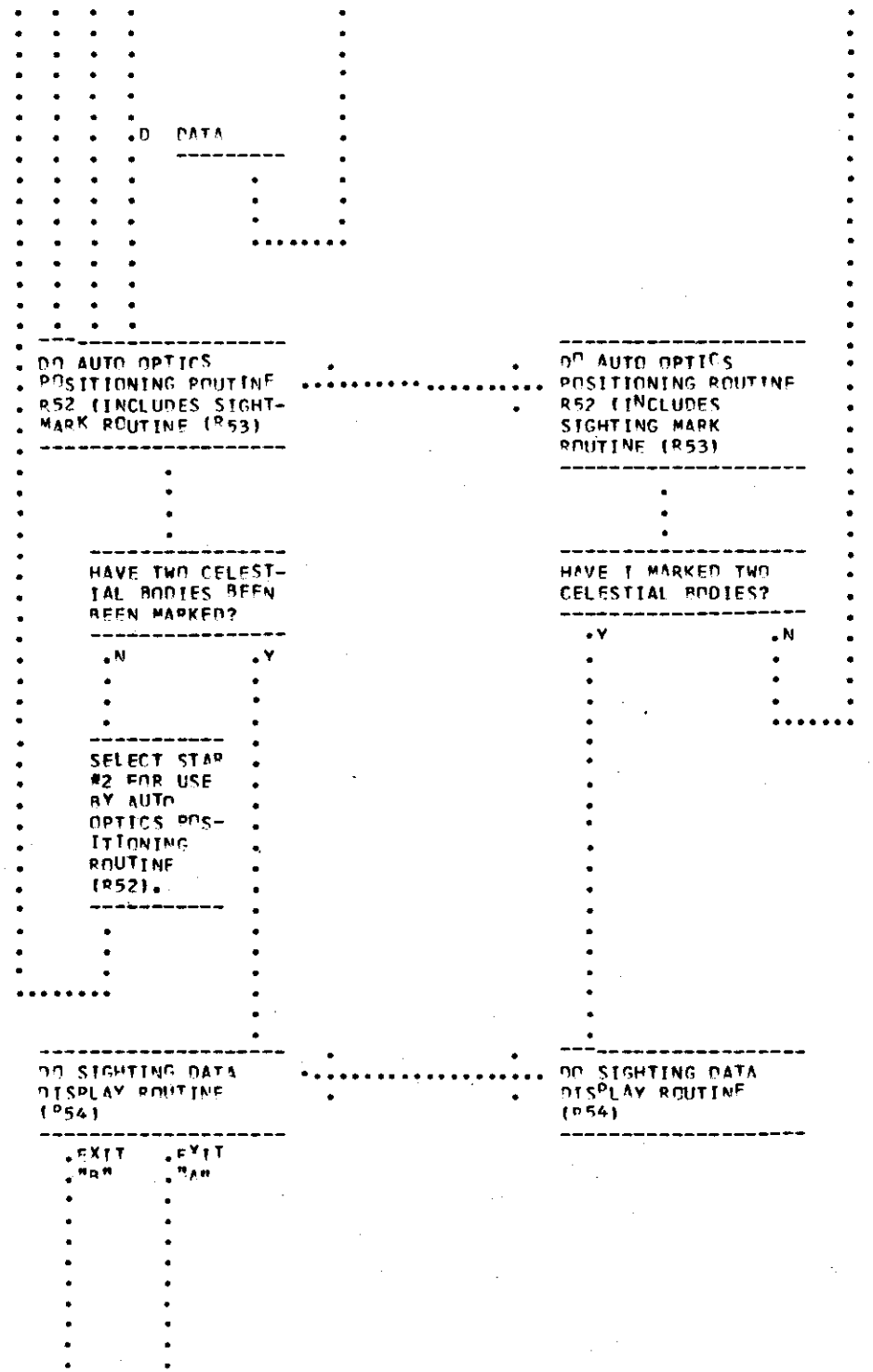
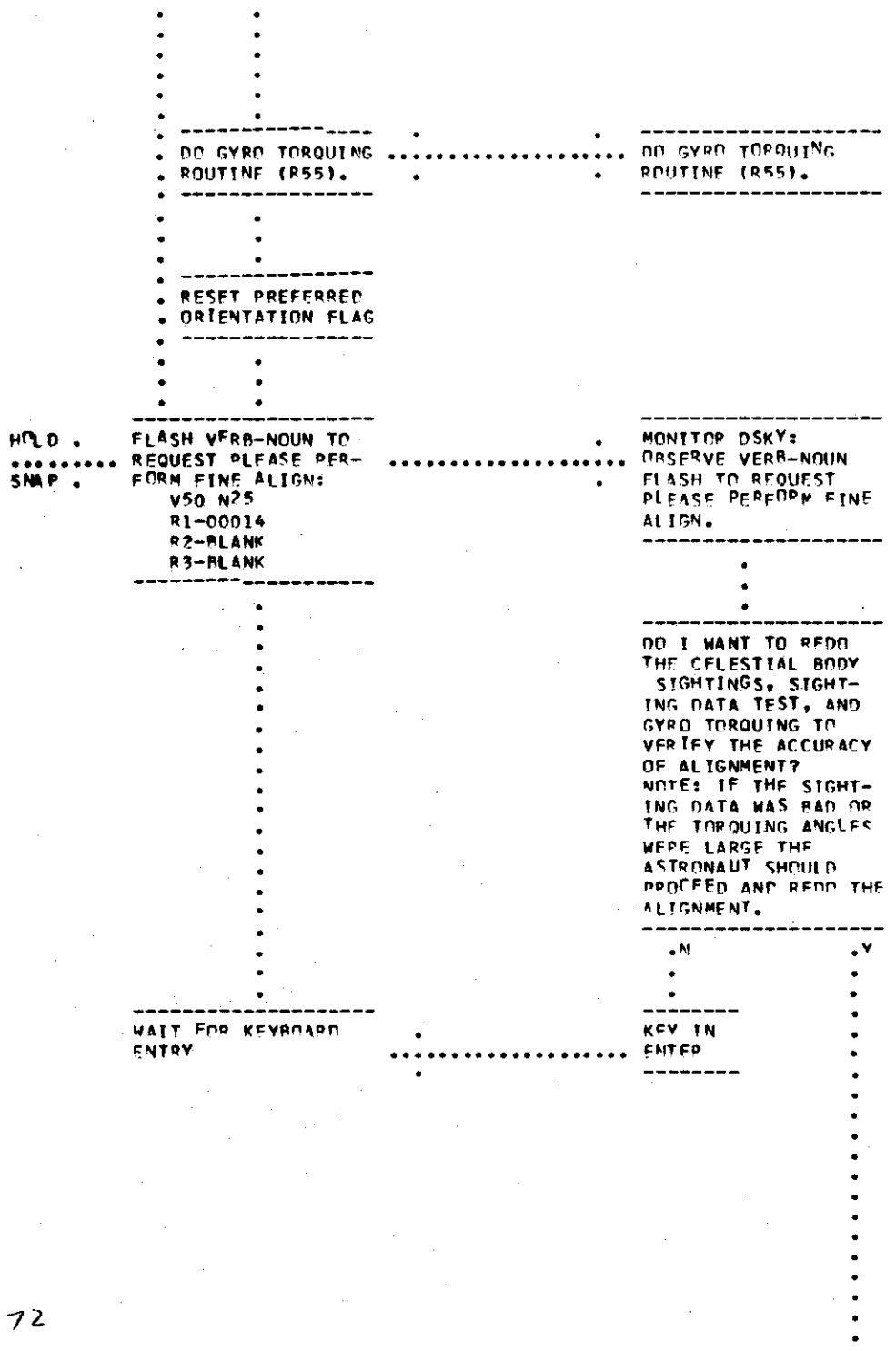
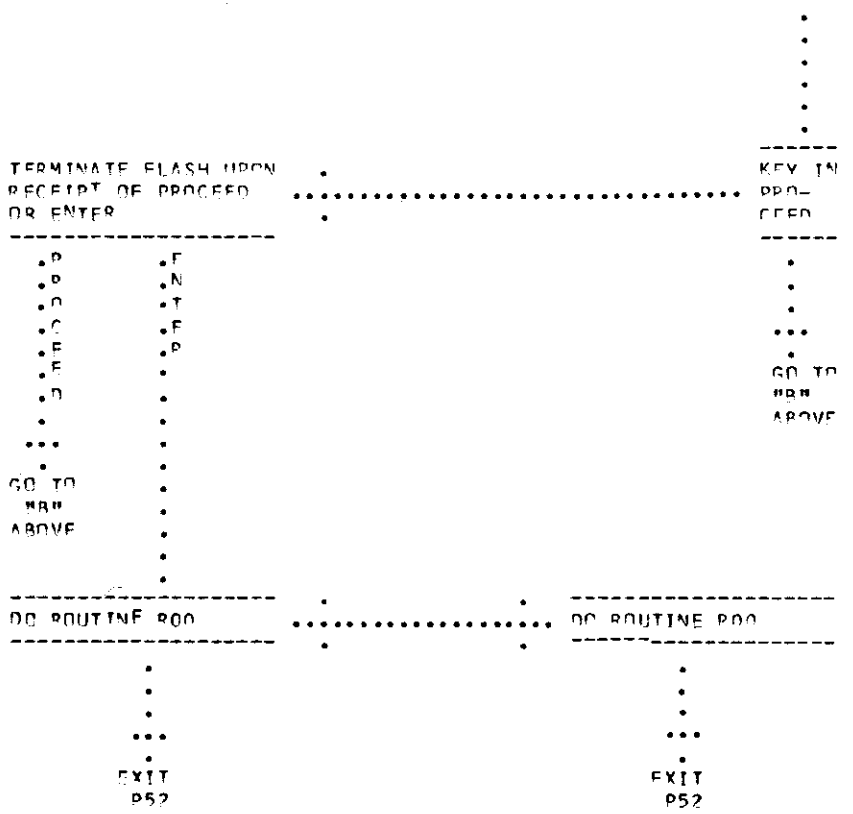
#810



P52/COLOSSUS


#870
DO AUTO OPTICS POSITIONING ROUTINE R52 (INCLUDES SIGHT-MARK ROUTINE (R53)
DO AUTO OPTICS POSITIONING ROUTINE R52 (INCLUDES SIGHTING MARK ROUTINE (R53)
#880
HAVE TWO CELEST-IAL BODIES BEEN BEEN MARKED?
HAVE I MARKED TWO CELESTIAL BODIES?
#890
.N
.Y
.Y
.N
SELECT STAR #2 FOR USE BY AUTO OPTICS POS-ITIONING ROUTINE (R52).
#900
++
+15
++
EDIT
#910
DO SIGHTING DATA DISPLAY ROUTINE (R54)
DO SIGHTING DATA DISPLAY ROUTINE (R54)
.EXIT "AA"
.EXIT "AA"
#920


DO GYRO TORQUING ROUTINE (R55).
RESET PREFERRED ORIENTATION FLAG
HOLD
SNAP
FLASH VERB-NOUN TO REQUEST PLEASE PERFORM FINE ALIGN:
V50 N25
R1-00014
R2-BLANK
R3-BLANK
WAIT FOR KEYBOARD ENTRY
DO GYRO TORQUING ROUTINE (R55).
MONITOR DSKY: OBSERVE VERB-NOUN FLASH TO REQUEST PLEASE PERFORM FINE ALIGN.
DO I WANT TO REDO THE CELESTIAL BODY SIGHTINGS, SIGHTING DATA TEST, AND GYRO TORQUING TO VERIFY THE ACCURACY OF ALIGNMENT?
NOTE: IF THE SIGHTING DATA WAS BAD OR THE TORQUING ANGLES WERE LARGE THE ASTRONAUT SHOULD PROCEED AND REDO THE ALIGNMENT.
N
Y
KEY IN ENTER
#930
#940
#950
#960
#970



#980

#990

#1000

CHANGE CONTROL NOTES

REV 12 PCR MIT 38
REV 13 PCR MIT 56
PCR MIT 99
REV 14 PCR 430.1
REV 15 PCN 525

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PURPOSE: (1) TO DETERMINE THE INERTIAL ORIENTATION OF THE IMU USING A BACK UP OPTICAL DEVICE.

ASSUMPTIONS: (1) THE IMU 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.

(2) THIS PROGRAM IS IDENTICAL TO P51 EXCEPT THAT R56 IS CALLED IN PLACE OF R53

(3) THE CSM ATTITUDE CONTROL MODE SELECTED IS AT THE OPTION OF THE CREW.

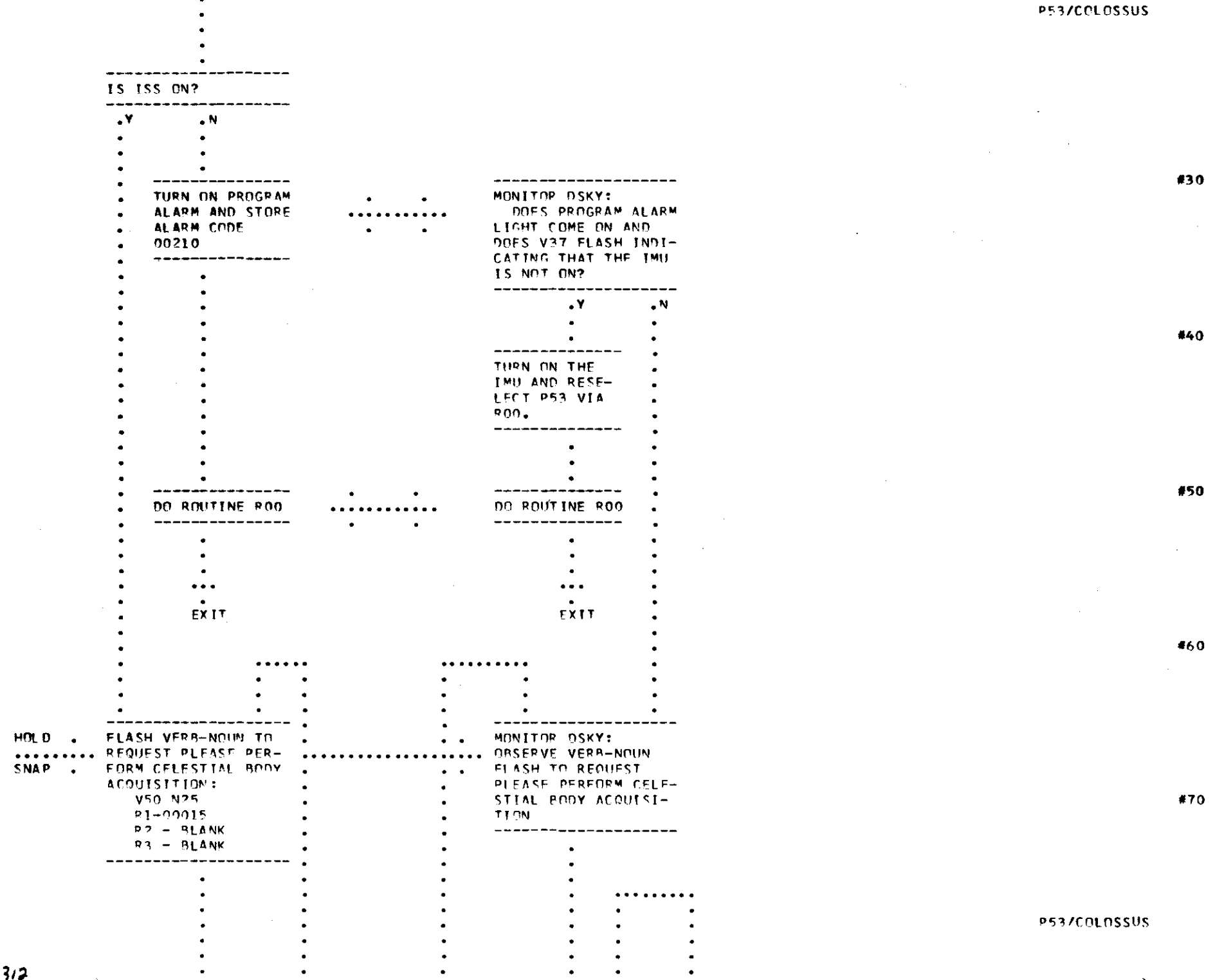
(4) TIME AND RCS FUEL MAY BE SAVED, AND SUBSEQUENT IMU ALIGNMENT DECISIONS GREATLY SIMPLIFIED IF THIS PROGRAM IS PERFORMED IN SUCH A WAY AS TO LEAVE THE IMU INERTIALLY STABILIZED AT AN ORIENTATION AS CLOSE AS POSSIBLE TO THE OPTIMUM ORIENTATION REQUIRED BY FUTURE CMC PROGRAMS.

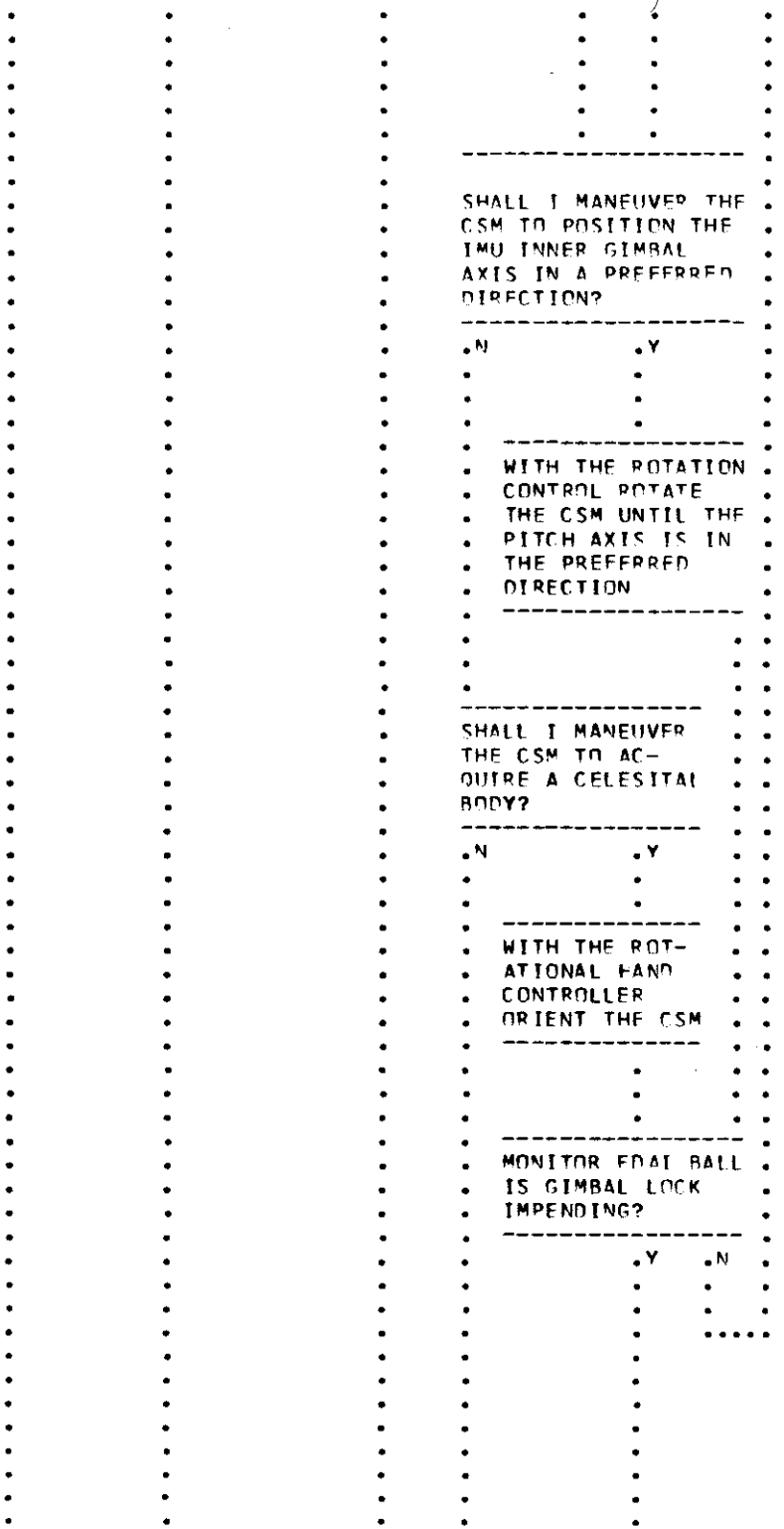
(5) THE PROGRAM IS SELECTED BY THE ASTRONAUT BY DSKY ENTRY.

```
PROG        CMC                 GROUND              CREW                                  CHECKLIST         TIME    TOTAL
CONT                                                                                                                TIME

                                                     .CREW PROG
                                                     .SELECTION
                                                     .
                                                    ...
                                                     .
     -------------------                       ------------------
     START BACK UP IMU    .                    KEY IN BACK UP IMU
     ORIENTATION DETERMI- .................... ORIENTATION DETERMI-
     NATION PROGRAM (P53) .                    NATION PROGRAM (P53)
     DISPLAY PROGRAM 53                            V37E 53E                                                  #10
                                               ------------------

                                               ------------------
                                             . MONITOR DSKY:
                          ...................  OBSERVE DISPLAY OF
                                             . PROGRAM 53
     -------------------                       ------------------
               .                                                                                             #20
               .
               .
               .
               .
               .
               .
```


IS ISS ON?
.Y
.N
TURN ON PROGRAM ALARM AND STORE ALARM CODE 00210
DO ROUTINE R00
EXIT
MONITOR DSKY:
DOES PROGRAM ALARM LIGHT COME ON AND DOES V37 FLASH INDICATING THAT THE IMU IS NOT ON?
.Y
.N
TURN ON THE IMU AND RESELECT P53 VIA R00.
DO ROUTINE R00
EXIT
#30
#40
#50
#60
#70
HOLD .
SNAP .
FLASH VERB-NOUN TO REQUEST PLEASE PERFORM CELESTIAL BODY ACQUISITION:
V50 N25
R1-00015
R2 - BLANK
R3 - BLANK
MONITOR DSKY:
OBSERVE VERB-NOUN FLASH TO REQUEST PLEASE PERFORM CELESTIAL BODY ACQUISITION



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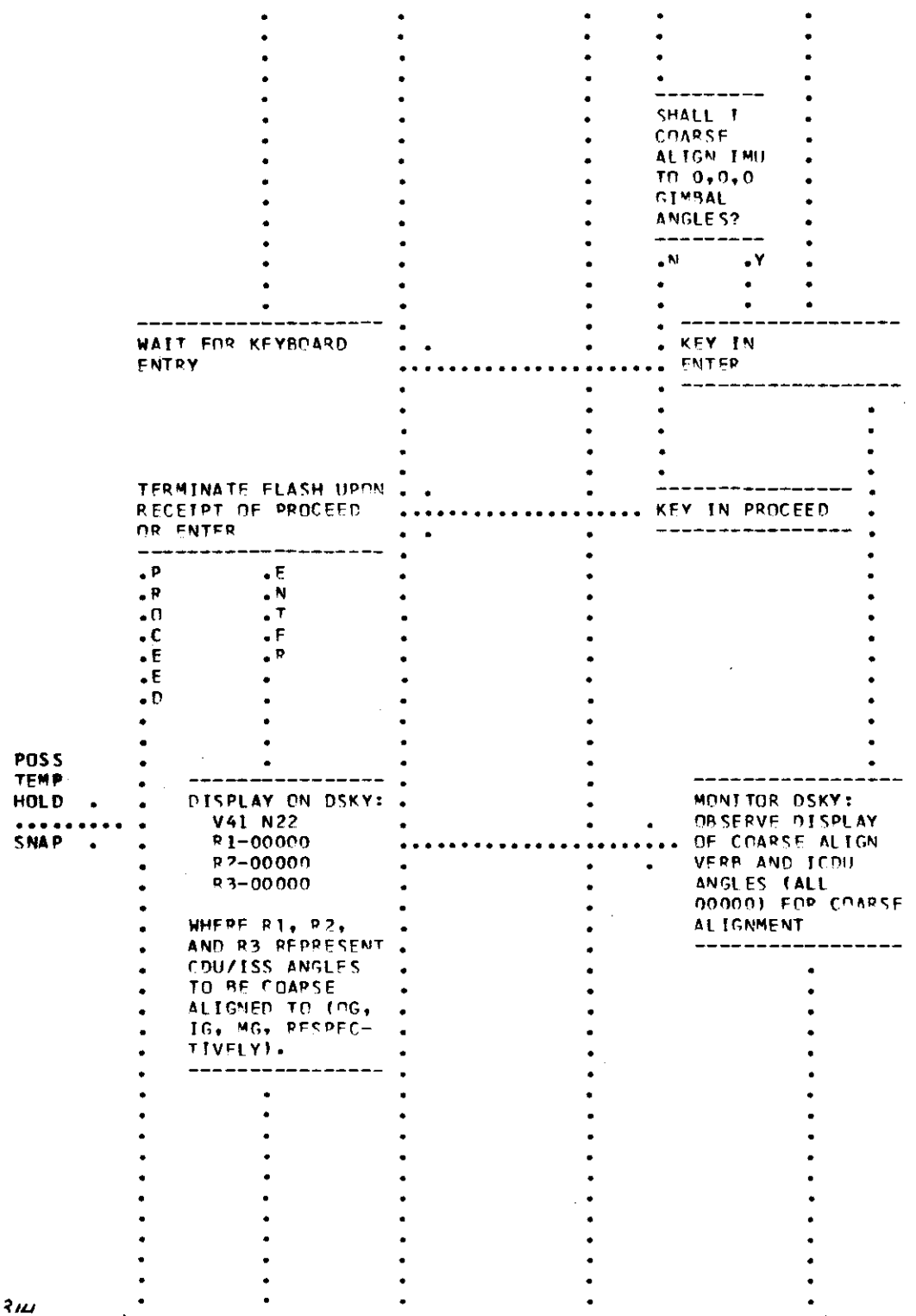
#120



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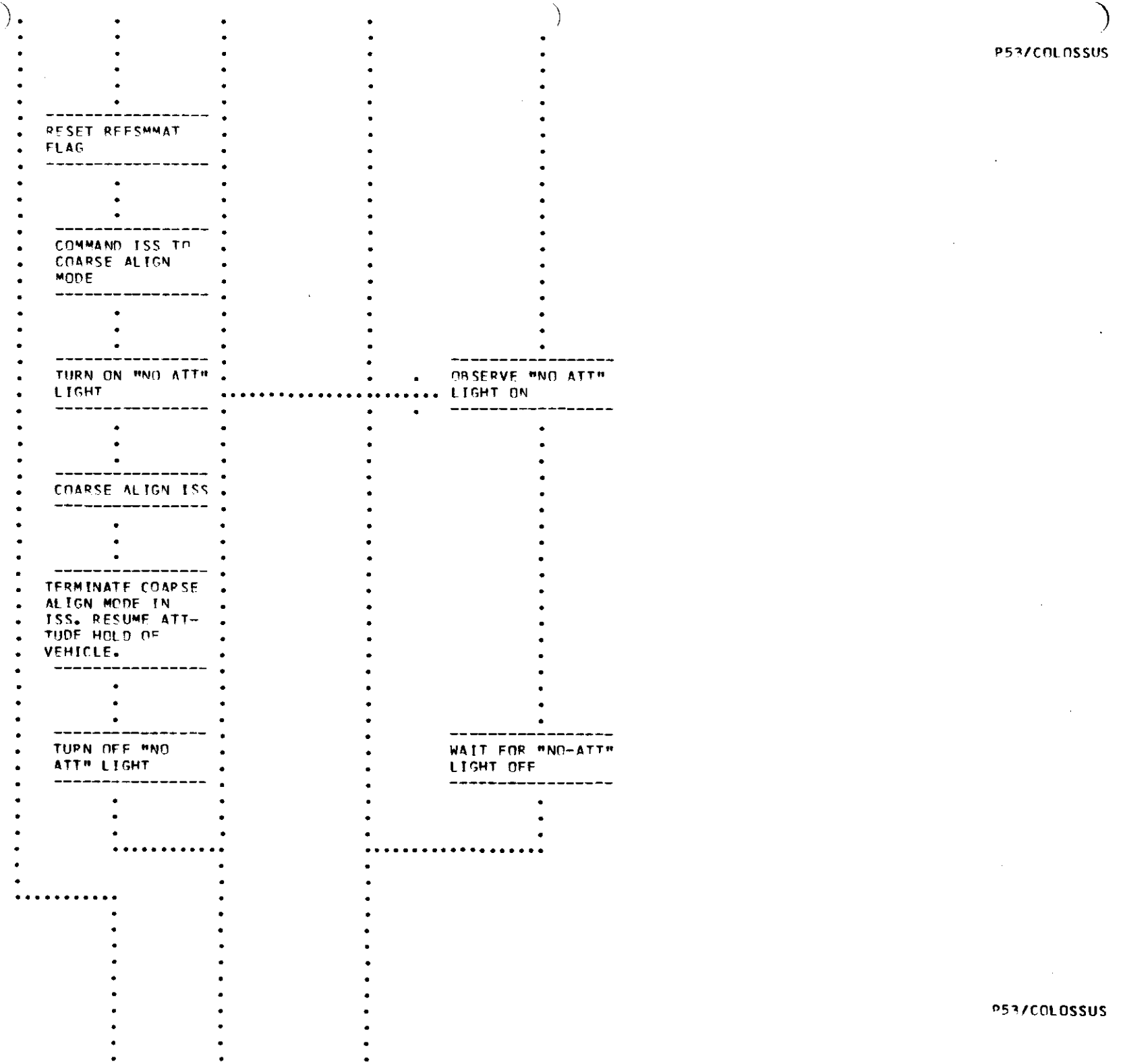
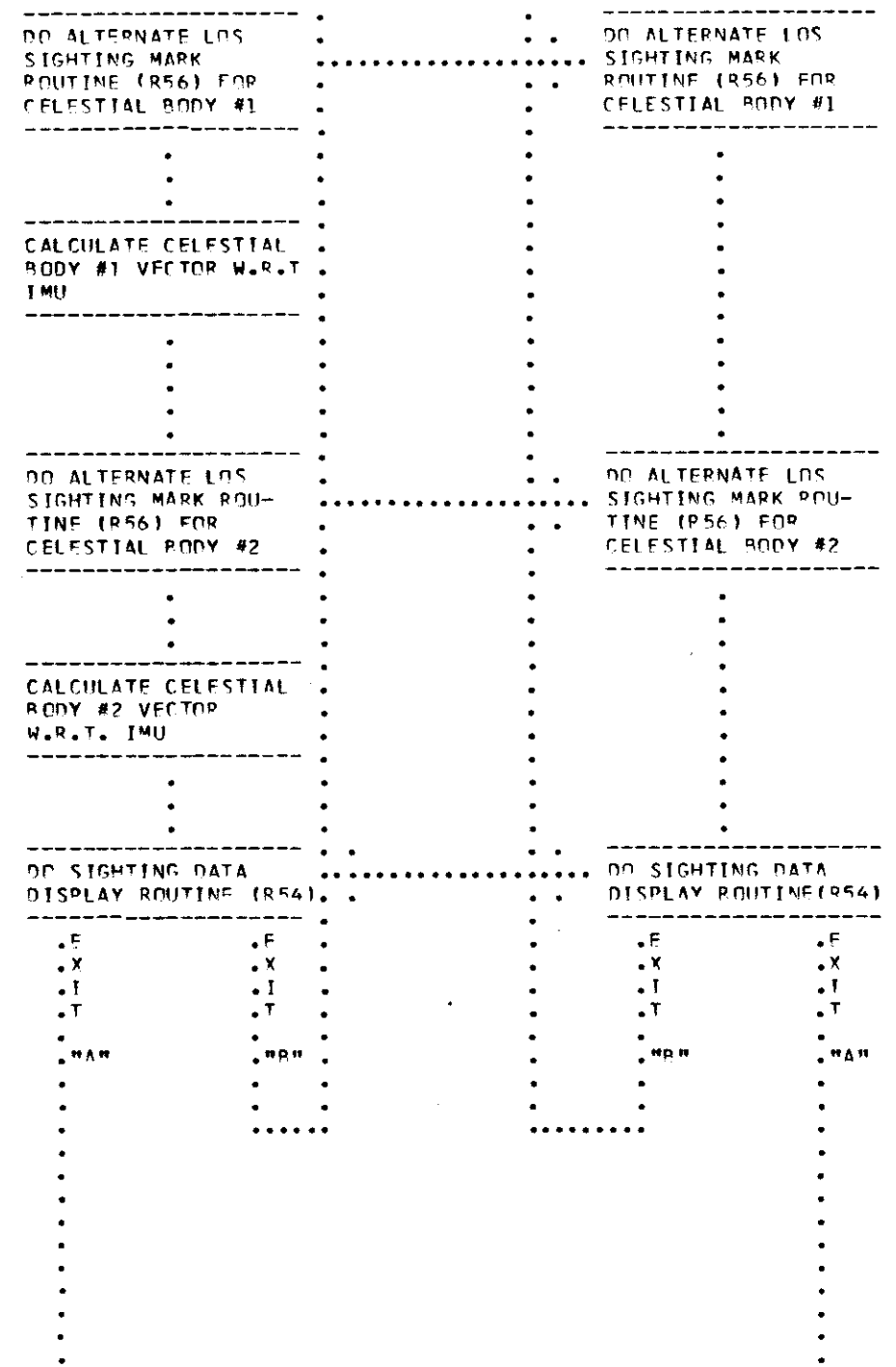
#160

#170

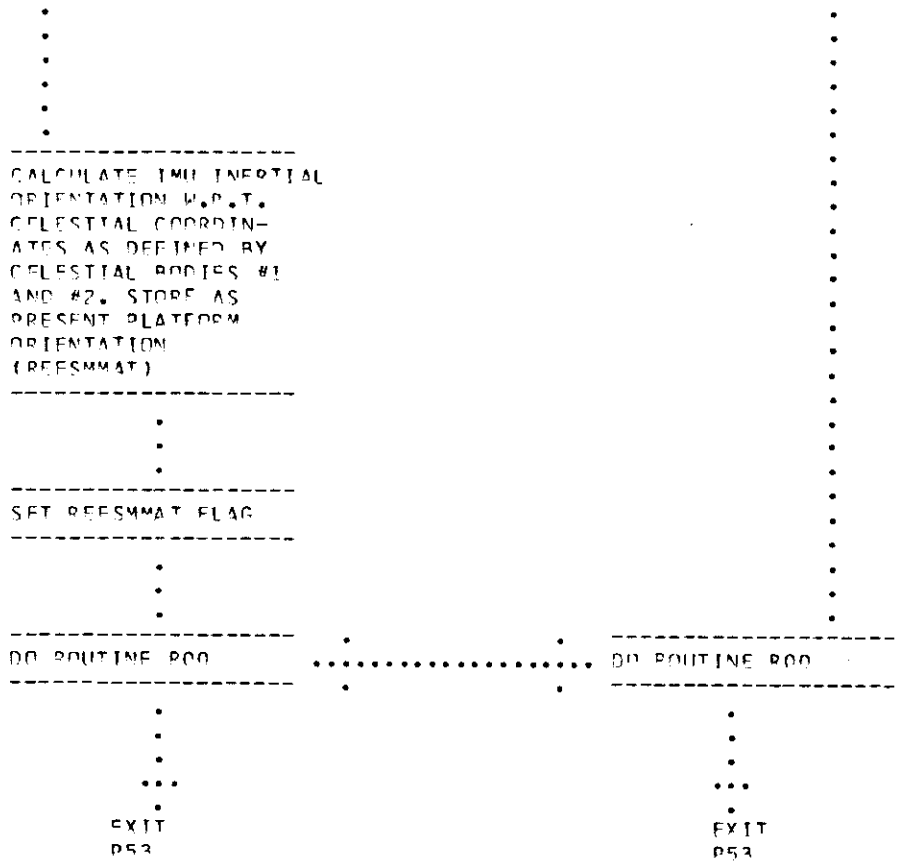
#180


RESET REFSMMAT FLAG
#190
COMMAND ISS TO COARSE ALIGN MODE
TURN ON "NO ATT" LIGHT
OBSERVE "NO ATT" LIGHT ON
#200
COARSE ALIGN ISS
#210
TERMINATE COARSE ALIGN MODE IN ISS. RESUME ATT-TUDE HOLD OF VEHICLE.
TURN OFF "NO ATT" LIGHT
WAIT FOR "NO-ATT" LIGHT OFF
#220
#230

++
+07
++
EDIT
PCR
206



#240
#250
#260
#270
#280



#290

#300

#310

CHANGE CONTROL NOTES

LOGIC REV 06 PCR MIT 52
LOGIC REV 07 PCR 206 EDITORIAL

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PURPOSE: (1) TO ALIGN THE IMU FROM A "KNOWN" (SEE ASSUMPTION 4) ORIENTATION TO ONE OF FOUR ORIENTATIONS SELECTED BY THE ASTRONAUT USING SIGHTINGS ON TWO CELESTIAL BODIES WITH A BACK-UP OPTICAL DEVICE:

(A) PREFERRED ORIENTATION

AN OPTIMUM ORIENTATION FOR A PREVIOUSLY CALCULATED MANEUVER. THIS ORIENTATION MUST BE CALCULATED AND STORED BY A PREVIOUSLY SELECTED PROGRAM.

(B) 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: THE ORIGIN IS THE CENTER OF THE MOON.

R_{-LS} = THE POSITION OF THE MOST RECENTLY DEFINED LANDING SITE AT TIME, T(ALIGN) SELECTED BY THE ASTRONAUT

H_{-CSM} = THE ANGULAR MOMENTUM VECTOR OF THE CSM ($R_{-CSM} \times V_{-CSM}$) AT TIME T (ALIGN) SELECTED BY THE ASTRONAUT.

A SPECIAL CASE OF THE LANDING SITE ORIENTATION OCCURS WHEN T (ALIGN) IS DEFINED AS THE TIME OF LUNAR LANDING T (LAND). THIS CASE MAY OCCUR ONLY IF T (LAND) HAS BEEN DEFINED BY THE MSFN, TRANSMITTED TO THE ASTRONAUT, AND THE ASTRONAUT HAS THEN DEFINED T (ALIGN) TO BE T (LAND) IN THIS PROGRAM.

(C) NOMINAL ORIENTATION

$$X_{-SM} = UNIT(V \times Z)_{-SM}$$

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

$$Z_{-SM} = UNIT(-R)$$

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 T (ALIGN) SELECTED BY THE ASTRONAUT.

(D) REFSMMAT

SEE ASSUMPTION (4)

ASSUMPTIONS: (1) THE DOCKED CONFIGURATION MAY BE SIVB/CSM, LM/CSM, OR CSM. THE PRESENT CONFIGURATION SHOULD HAVE BEEN ENTERED INTO THE CMC BY COMPLETION OF THE DAP DATA LOAD ROUTINE R03.

(2) THERE ARE NO RESTRAINTS UPON THE CSM ATTITUDE CONTROL MODES IN THIS PROGRAM.

(3) 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 POINT THE SXT AT ASTRONAUT OR CMC SELECTED STARS EITHER MANUALLY BY CREW INPUT OR AUTOMATICALLY UNDER CMC CONTROL.

(4) THE ISS IS ON AND HAS BEEN ALIGNED TO A KNOWN ORIENTATION WHICH IS STORED IN THE CMC (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).

(5) THE LANDING SITE ORIENTATION IS USED FOR:

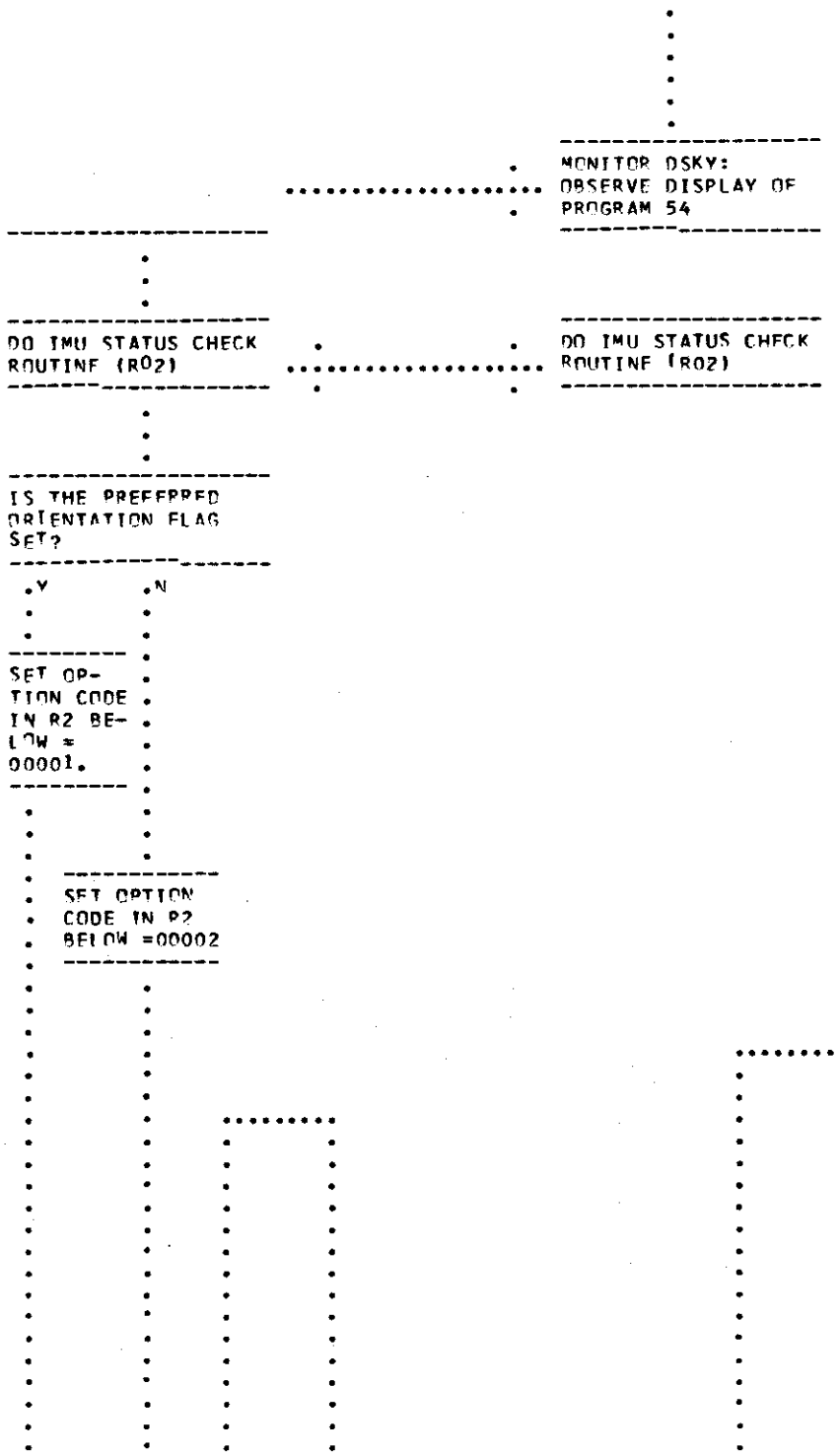
(A) ALIGNING THE CSM STABLE MEMBER TO THE SAME ORIENTATION AS THE LM STABLE MEMBER PRIOR TO LM/CSM SEPARATION

(B) ALIGNING THE CSM STABLE MEMBER TO THE SAME ORIENTATION AS THE LM STABLE MEMBER PRIOR TO LM ASCENT FROM THE LUNAR SURFACE.

(6) THIS PROGRAM IS IDENTICAL TO P52 EXCEPT THAT R56 IS CALLED IN PLACE OF R52 AND R53.

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

PROG CONT	CMC	GROUND	CREW	CHECKLIST	TIME	TOTAL TIME
			.CREW PROG .SELECTION			
	START BACKUP IMU RE- ALIGN PROGRAM (P54) DISPLAY PROGRAM 54	. . . . . .	START BACKUP IMU RE- ALIGN PROGRAM (P54) V37E 54E			#10


MONITOR DSKY:
OBSERVE DISPLAY OF
PROGRAM 54
DO IMU STATUS CHECK
ROUTINE (R02)
DO IMU STATUS CHECK
ROUTINE (R02)
IS THE PREFERRED
ORIENTATION FLAG
SET?
Y
N
SET OP-
TION CODE
IN R2 BE-
LOW =
00001.
SET OPTION
CODE IN R2
BELOW =00002

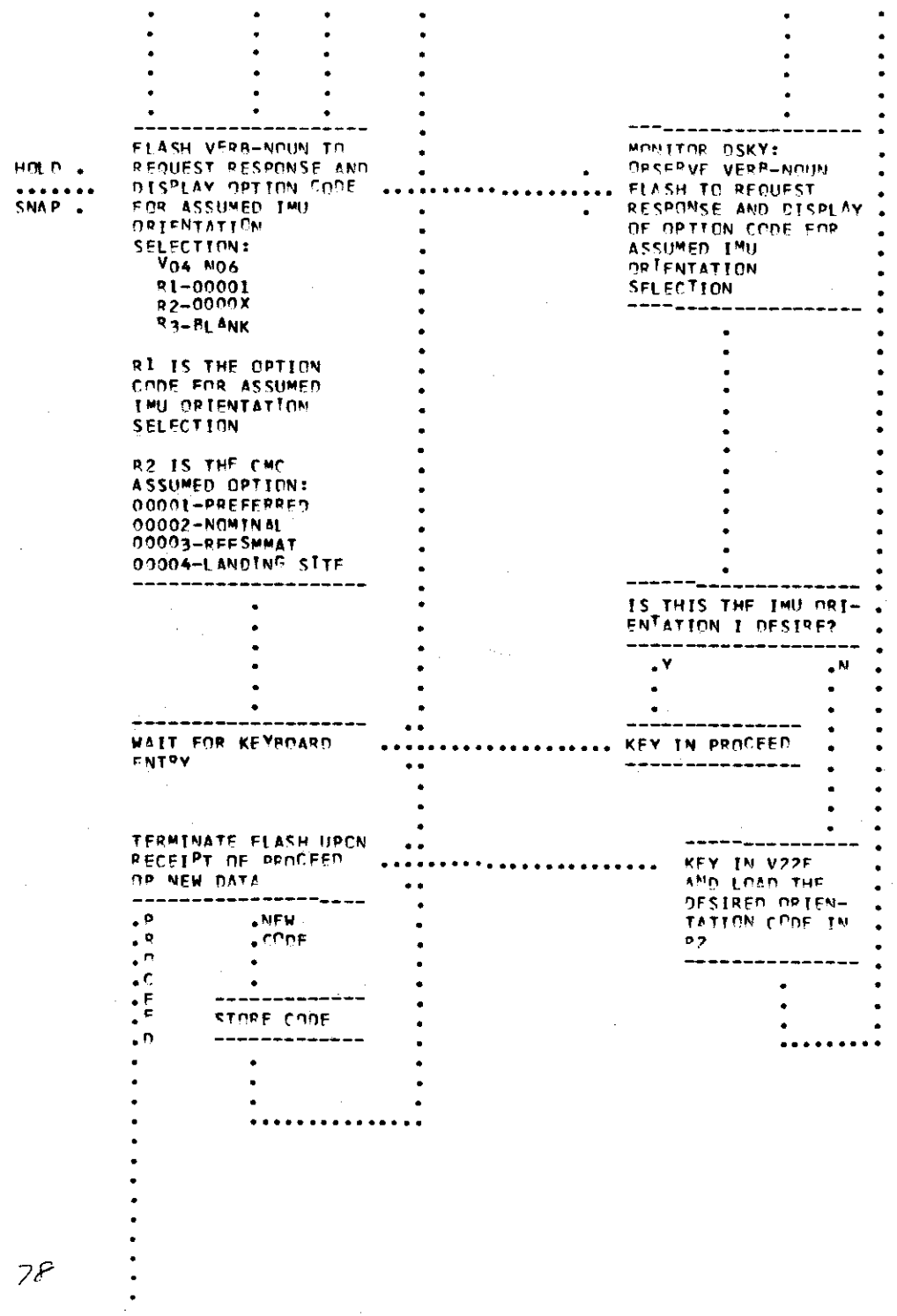
#20

#30

#40

#50

#60



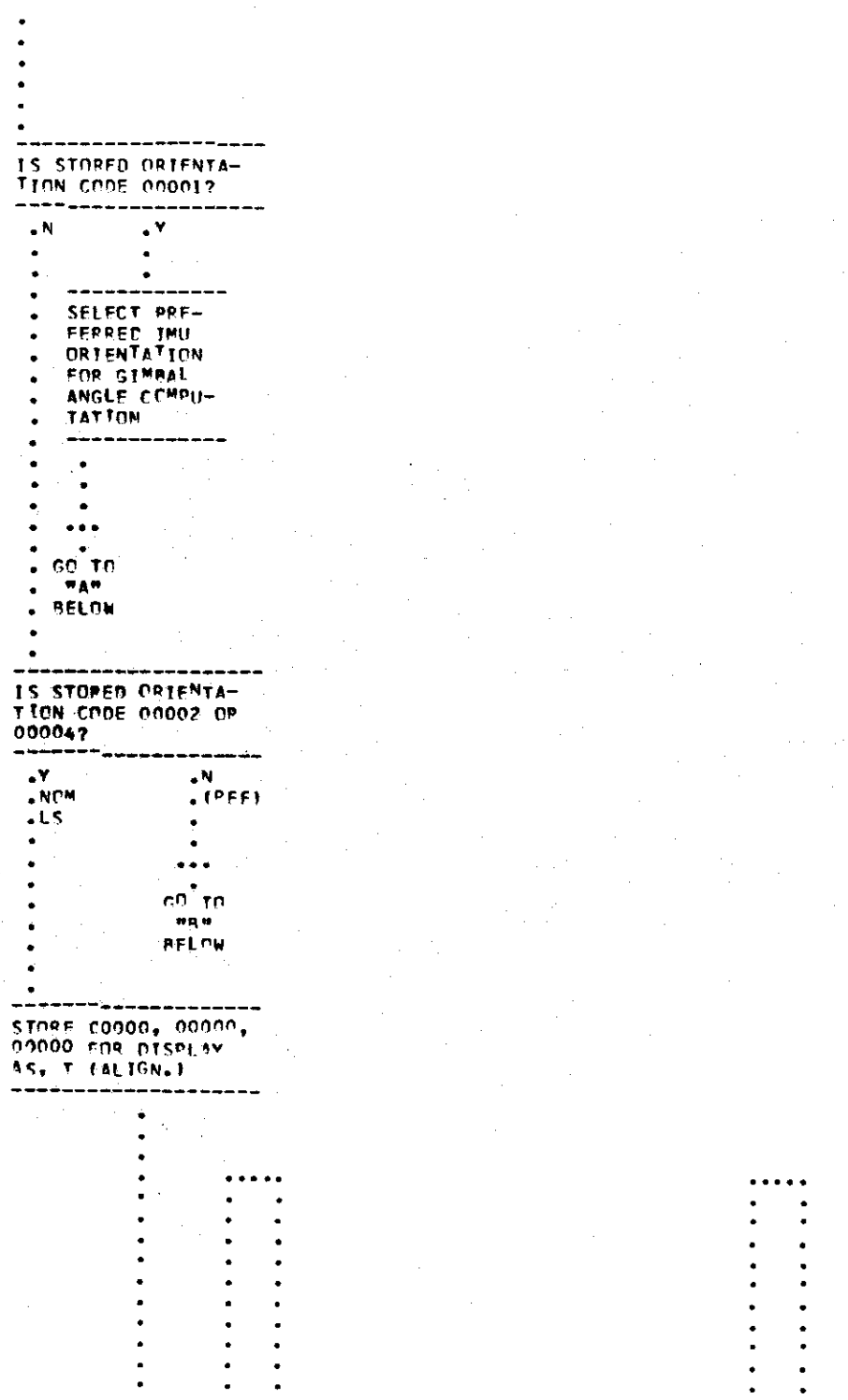
#70

#80

#90

#100

#110



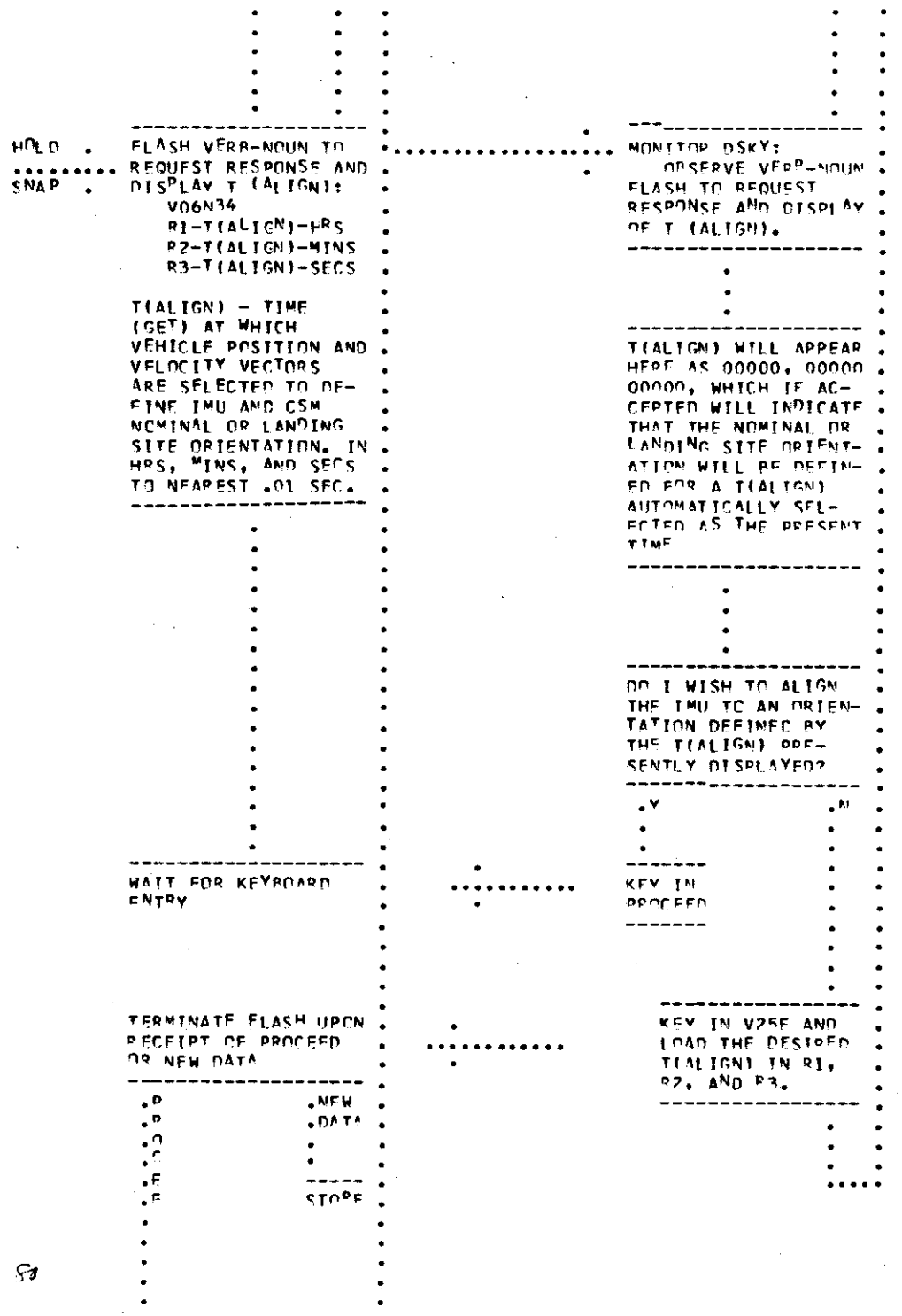
#120

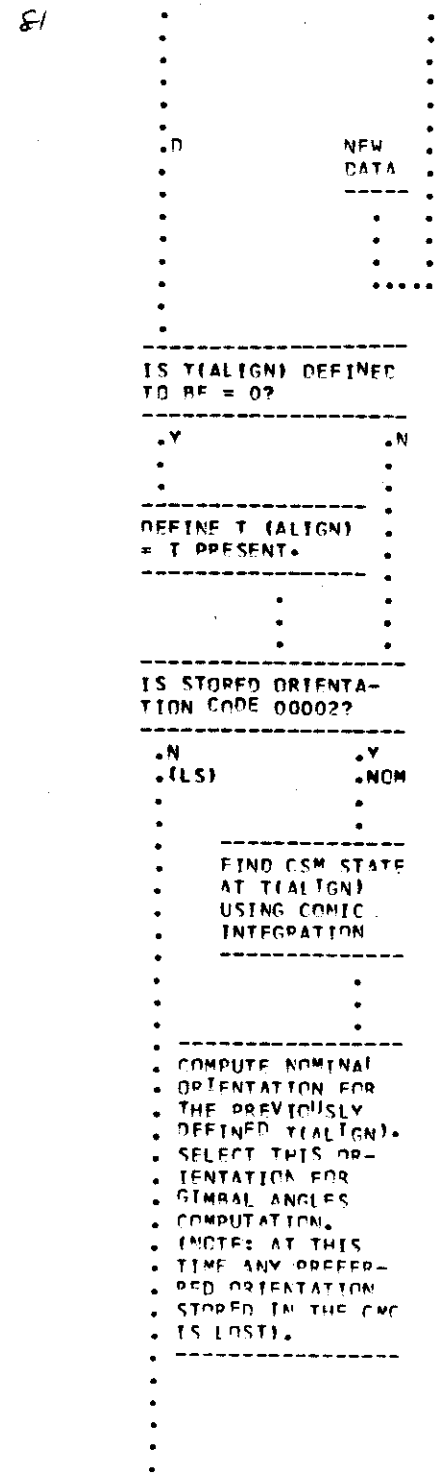
#130

#140

#150

#160


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 VEHICLE POSITION AND VELOCITY VECTORS ARE SELECTED TO DEFINE IMU AND CSM NOMINAL OR LANDING SITE ORIENTATION. IN HRS, MINS, AND SECS TO NEAREST .01 SEC.
WAIT FOR KEYBOARD ENTRY
TERMINATE FLASH UPON RECEIPT OF PROCEED OR NEW DATA
.PROCEED
.NEW DATA
STOPF
MONITOR DSKY:
OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY OF T (ALIGN).
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
DO I WISH TO ALIGN THE IMU TO AN ORIENTATION DEFINED BY THE T(ALIGN) PRESENTLY DISPLAYED?
.Y
.N
KEY IN PROCEED
KEY IN V25E AND LOAD THE DESIRED T(ALIGN) IN R1, R2, AND R3.
#170
#180
#190
#200
#210
#220



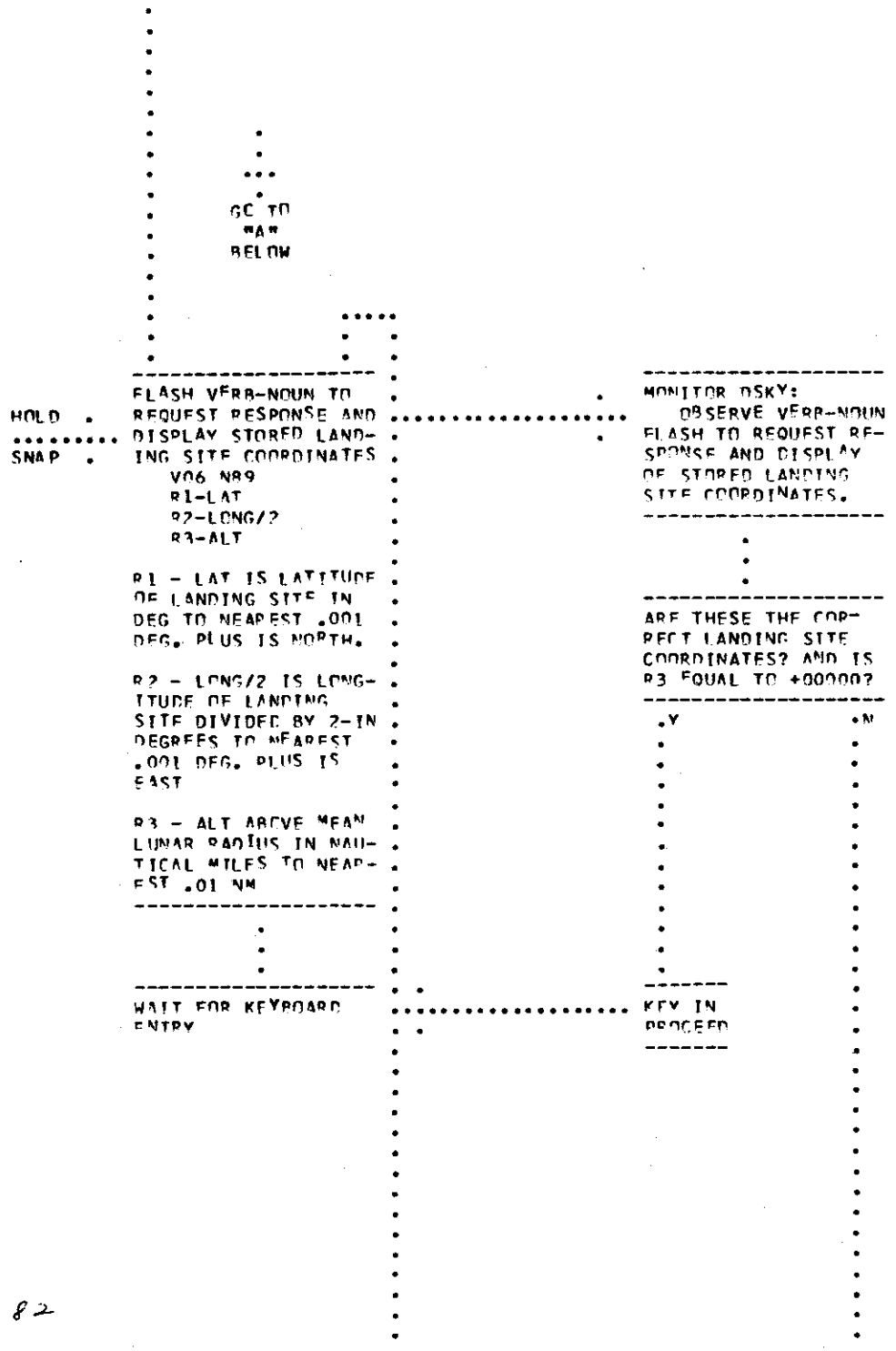
#230

#240

#250

#260

#270



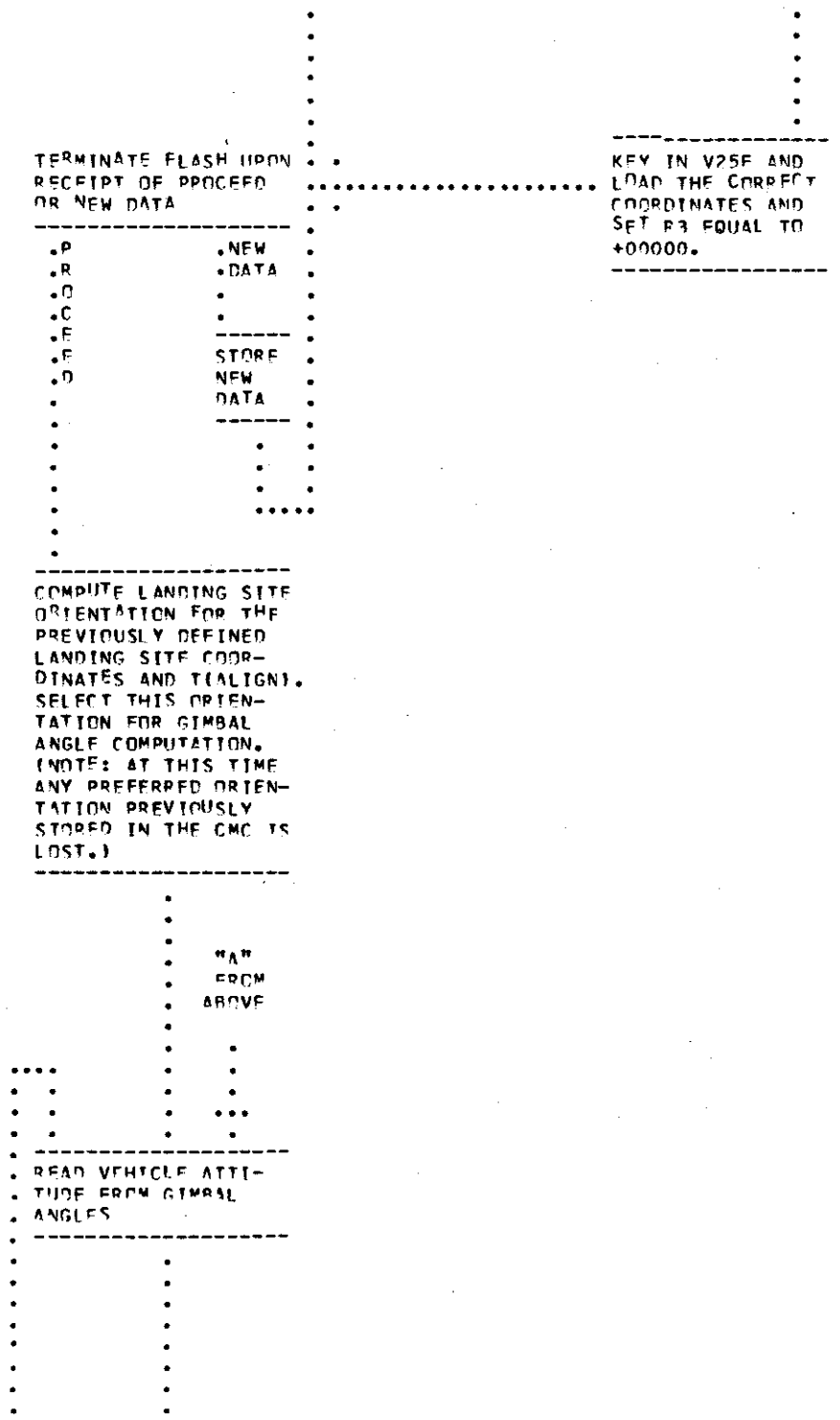
#280

#290

#300

#310

#320



#330

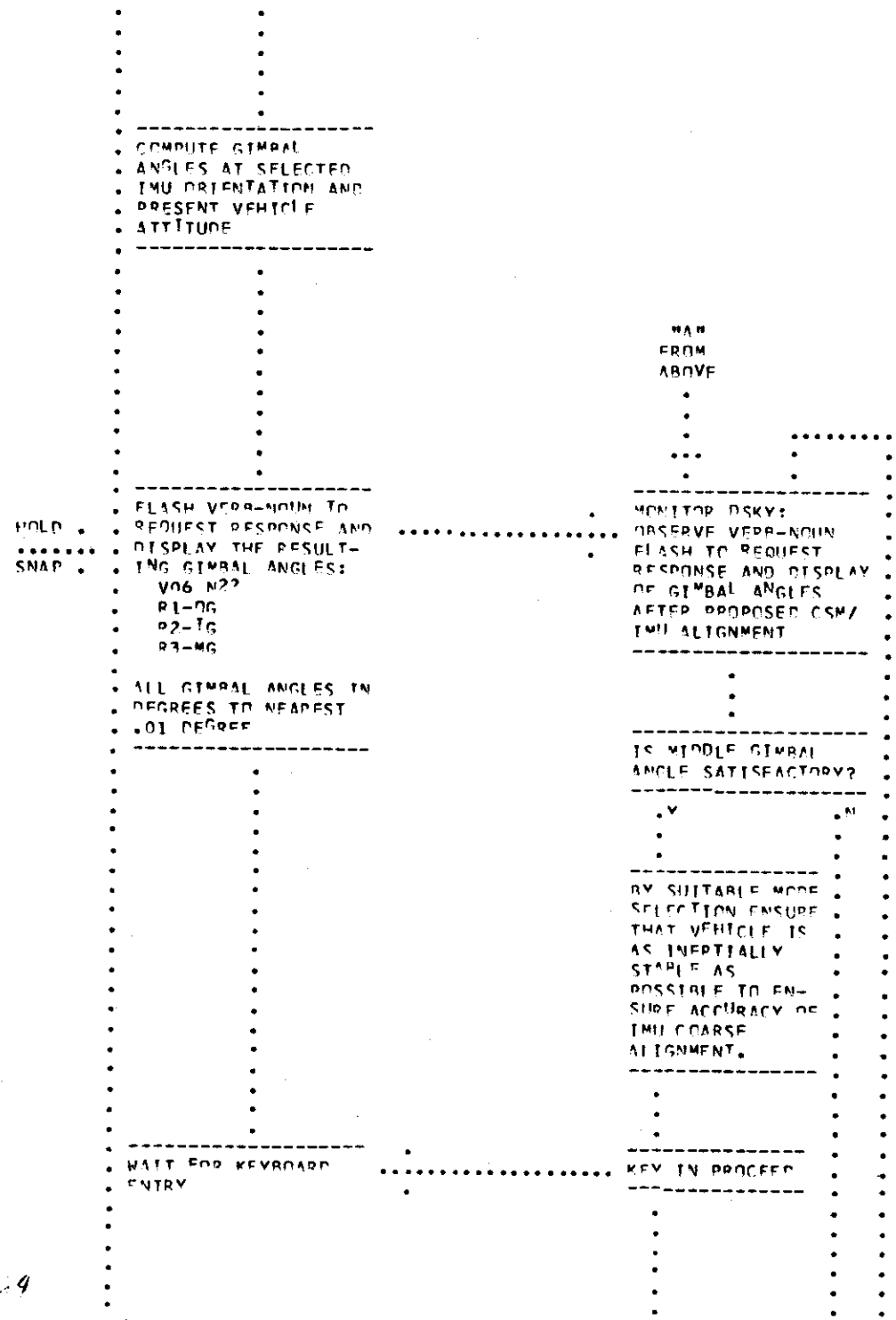
#340

#350

#360

#370

#380



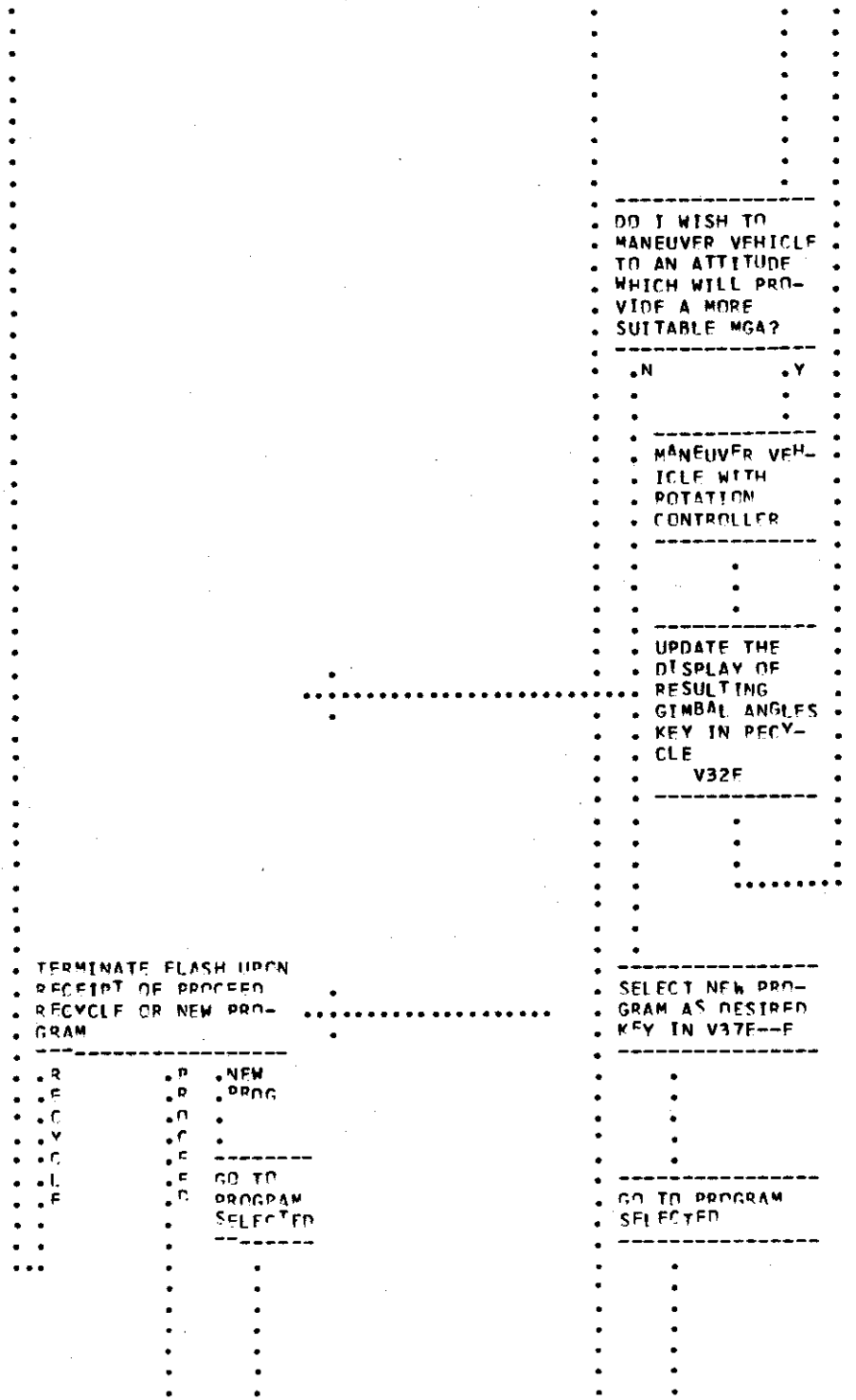
#390

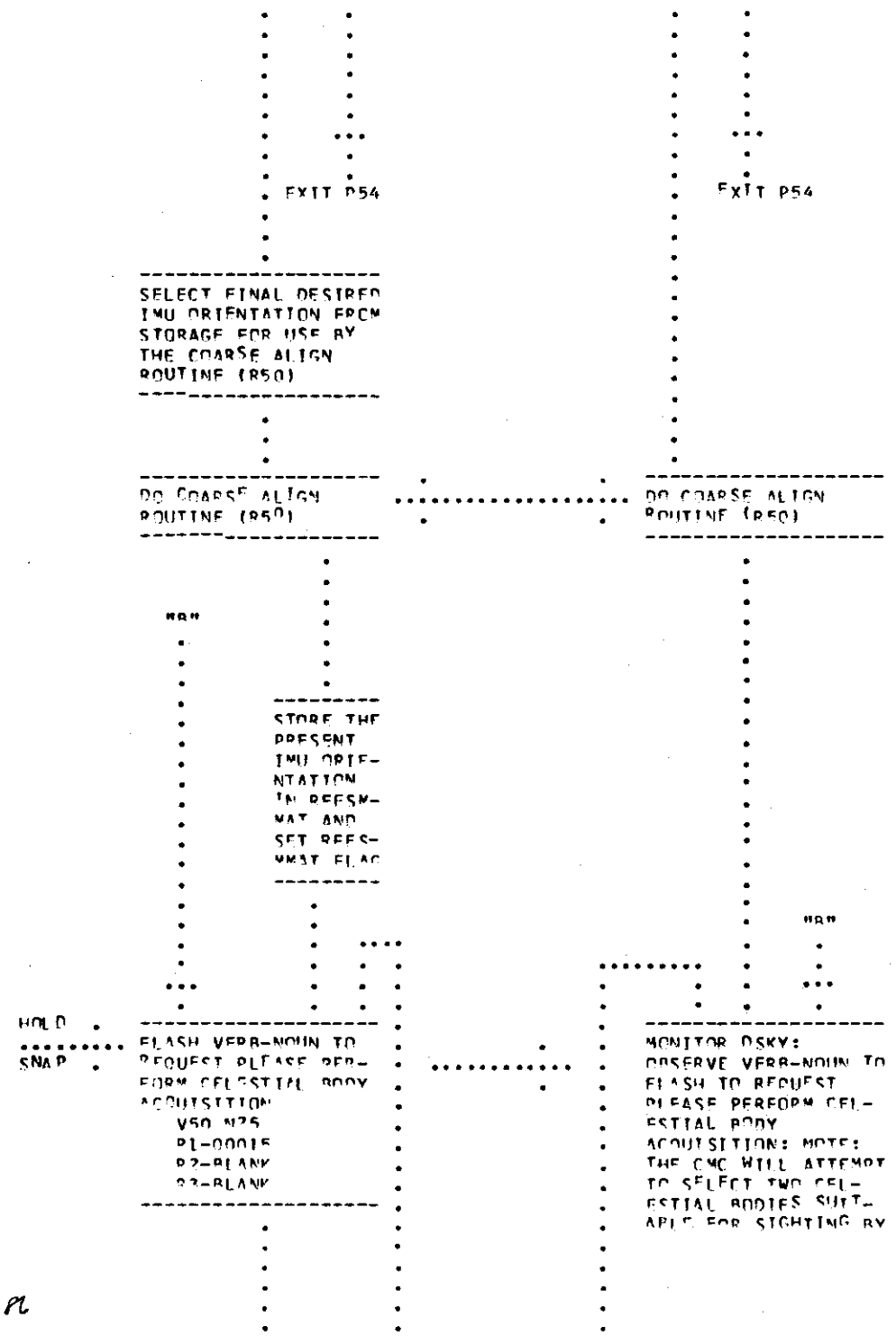
#400

#410

#420

#430


DO I WISH TO MANEUVER VEHICLE TO AN ATTITUDE WHICH WILL PROVIDE A MORE SUITABLE MGA?
#440
N
Y
MANEUVER VEHICLE WITH ROTATION CONTROLLER
#450
UPDATE THE DISPLAY OF RESULTING GIMBAL ANGLES KEY IN PROCEDURE V32E
#460
#470
TERMINATE FLASH UPON RECEIPT OF PROCEED RECYCLE OR NEW PROGRAM
R
E
C
Y
C
L
E
P
R
O
C
E
D
NEW PROG
GO TO PROGRAM SELECTED
SELECT NEW PROGRAM AS DESIRED KEY IN V37E--E
#480
GO TO PROGRAM SELECTED
#490



#500

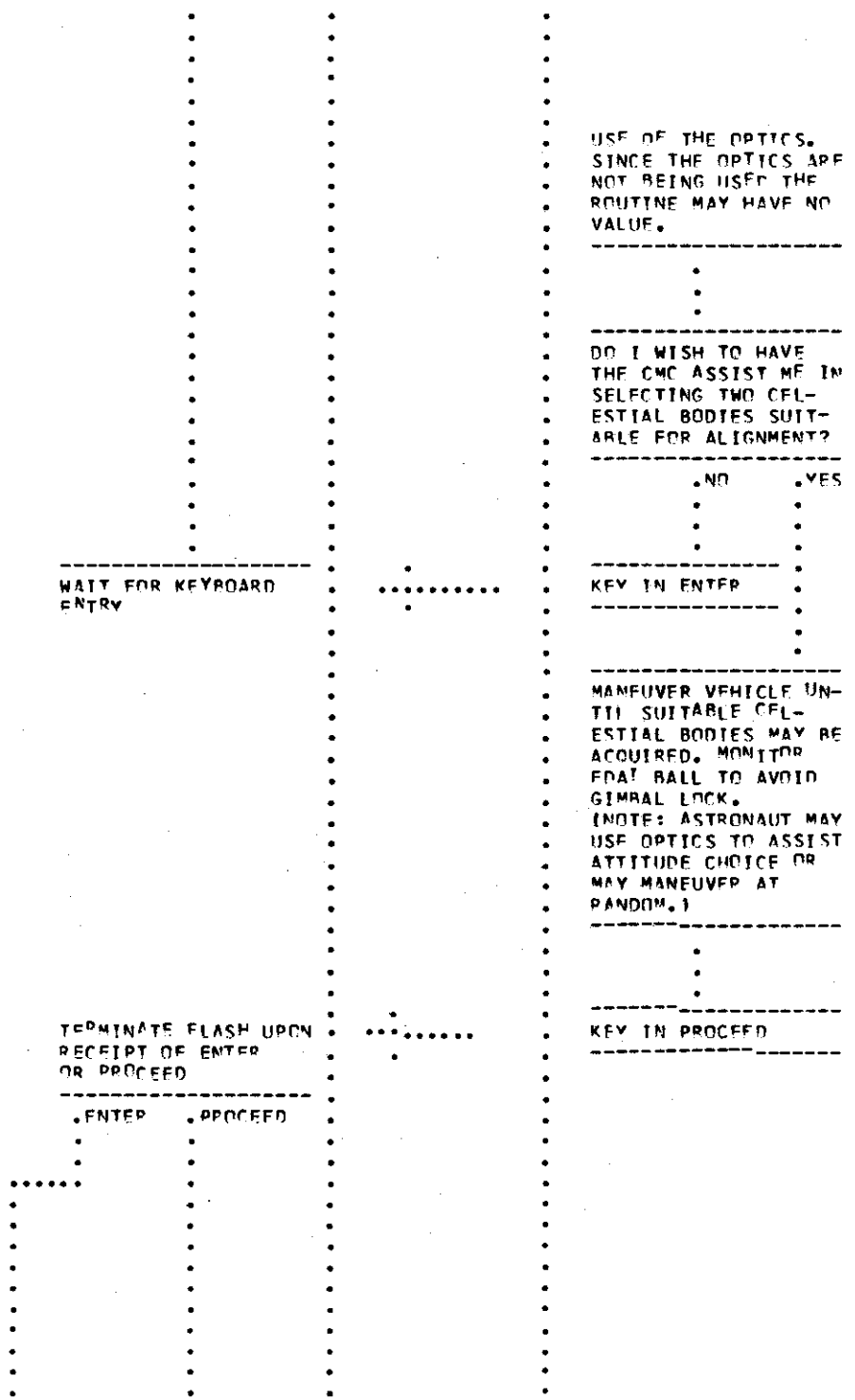
#510

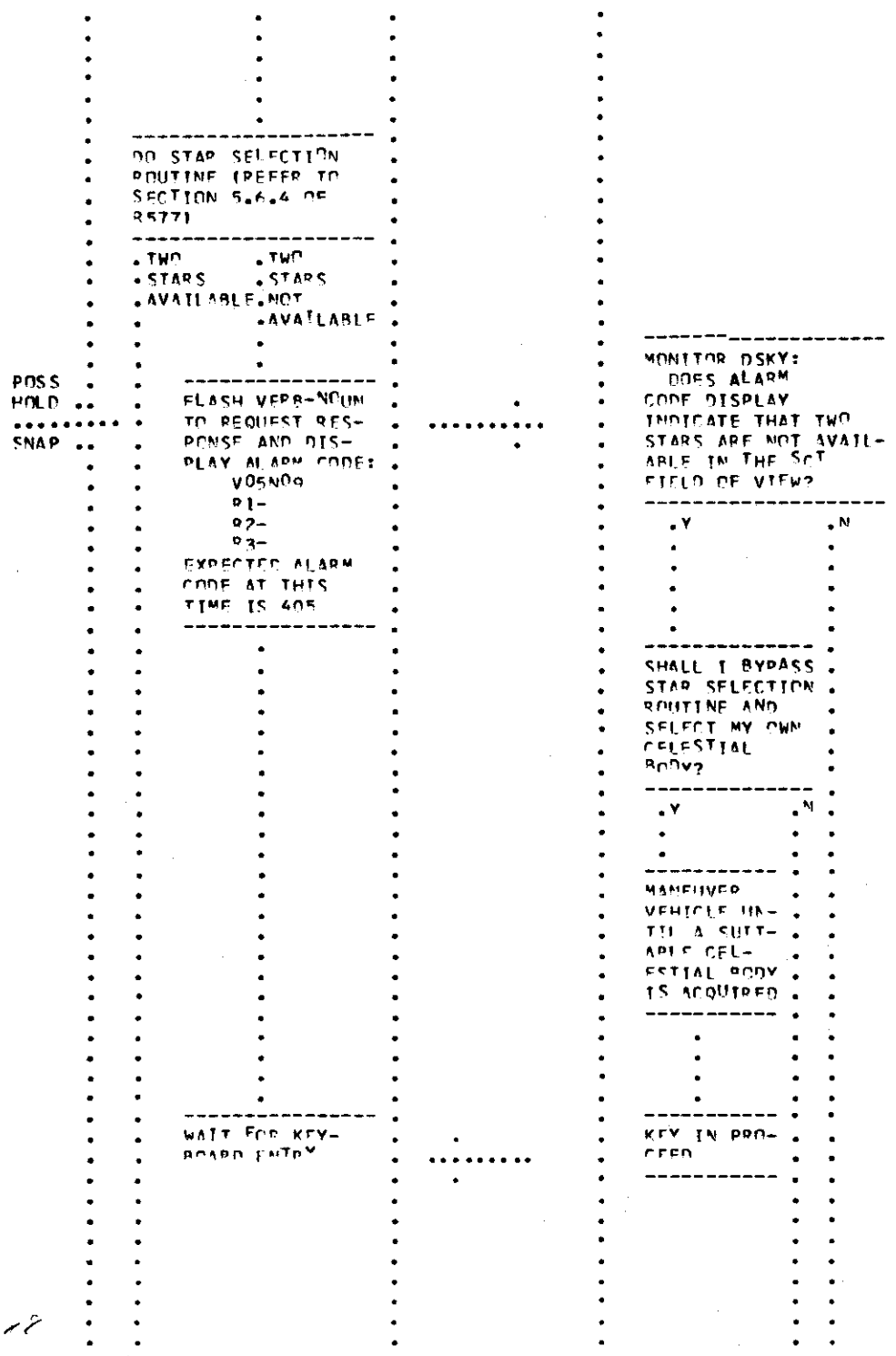
#520

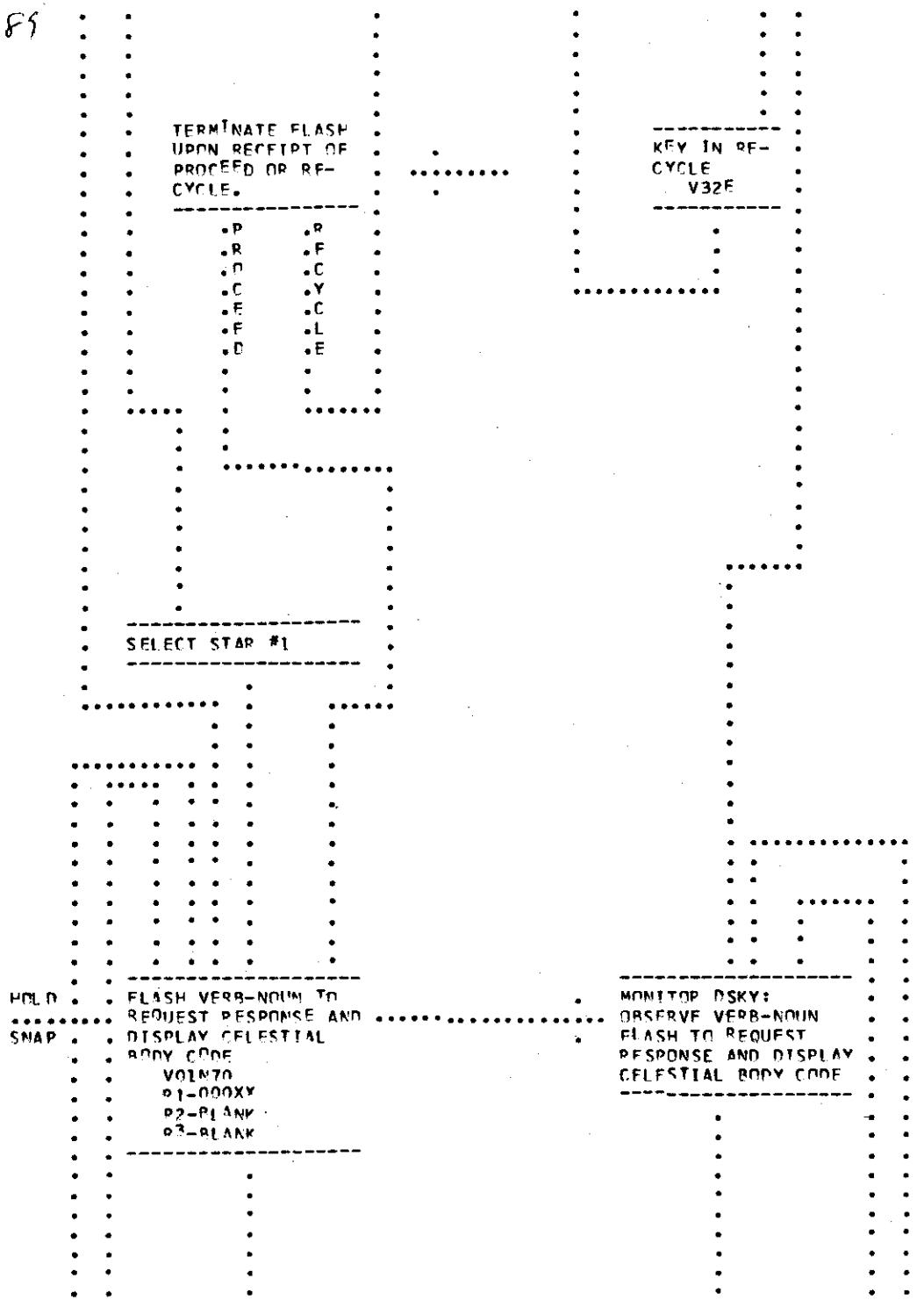
#530

#540

PL


USE OF THE OPTICS. SINCE THE OPTICS ARE NOT BEING USED THE ROUTINE MAY HAVE NO VALUE.
#550
DO I WISH TO HAVE THE CMC ASSIST ME IN SELECTING TWO CELESTIAL BODIES SUITABLE FOR ALIGNMENT?
#560
NO
YES
WAIT FOR KEYBOARD ENTRY
KEY IN ENTER
#570
MANEUVER VEHICLE UNTIL SUITABLE CELESTIAL BODIES MAY BE ACQUIRED. MONITOR FDAI BALL TO AVOID GIMBAL LOCK. (NOTE: ASTRONAUT MAY USE OPTICS TO ASSIST ATTITUDE CHOICE OR MAY MANEUVER AT RANDOM.)
#580
TERMINATE FLASH UPON RECEIPT OF ENTER OR PROCEED
KEY IN PROCEED
#590
ENTER
PROCEED


DO STAR SELECTION ROUTINE (REFER TO SECTION 5.6.4 OF R577)
TWO STARS AVAILABLE
TWO STARS NOT AVAILABLE
POSS HOLD
SNAP
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY ALARM CODE: V05N09 R1- R2- R3-
EXPECTED ALARM CODE AT THIS TIME IS 405
WAIT FOR KEYBOARD ENTRY
MONITOR DSKY: DOES ALARM CODE DISPLAY INDICATE THAT TWO STARS ARE NOT AVAILABLE IN THE SCT FIELD OF VIEW?
Y
N
SHALL I BYPASS STAR SELECTION ROUTINE AND SELECT MY OWN CELESTIAL BODY?
Y
N
MANEUVER VEHICLE UNTIL A SUITABLE CELESTIAL BODY IS ACQUIRED
KEY IN PROCEED
#600
#610
#620
#630
#640
#650



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#670

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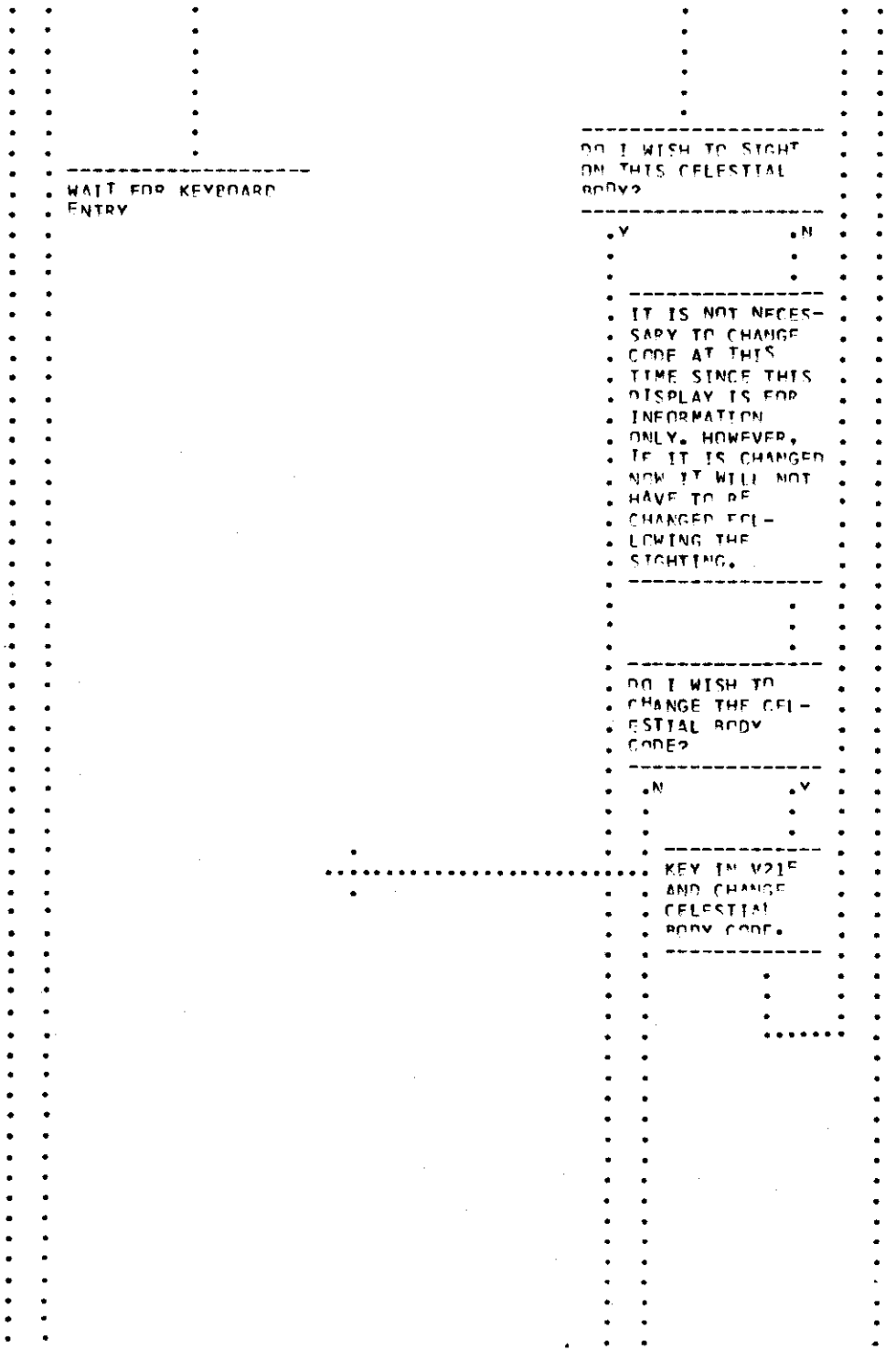

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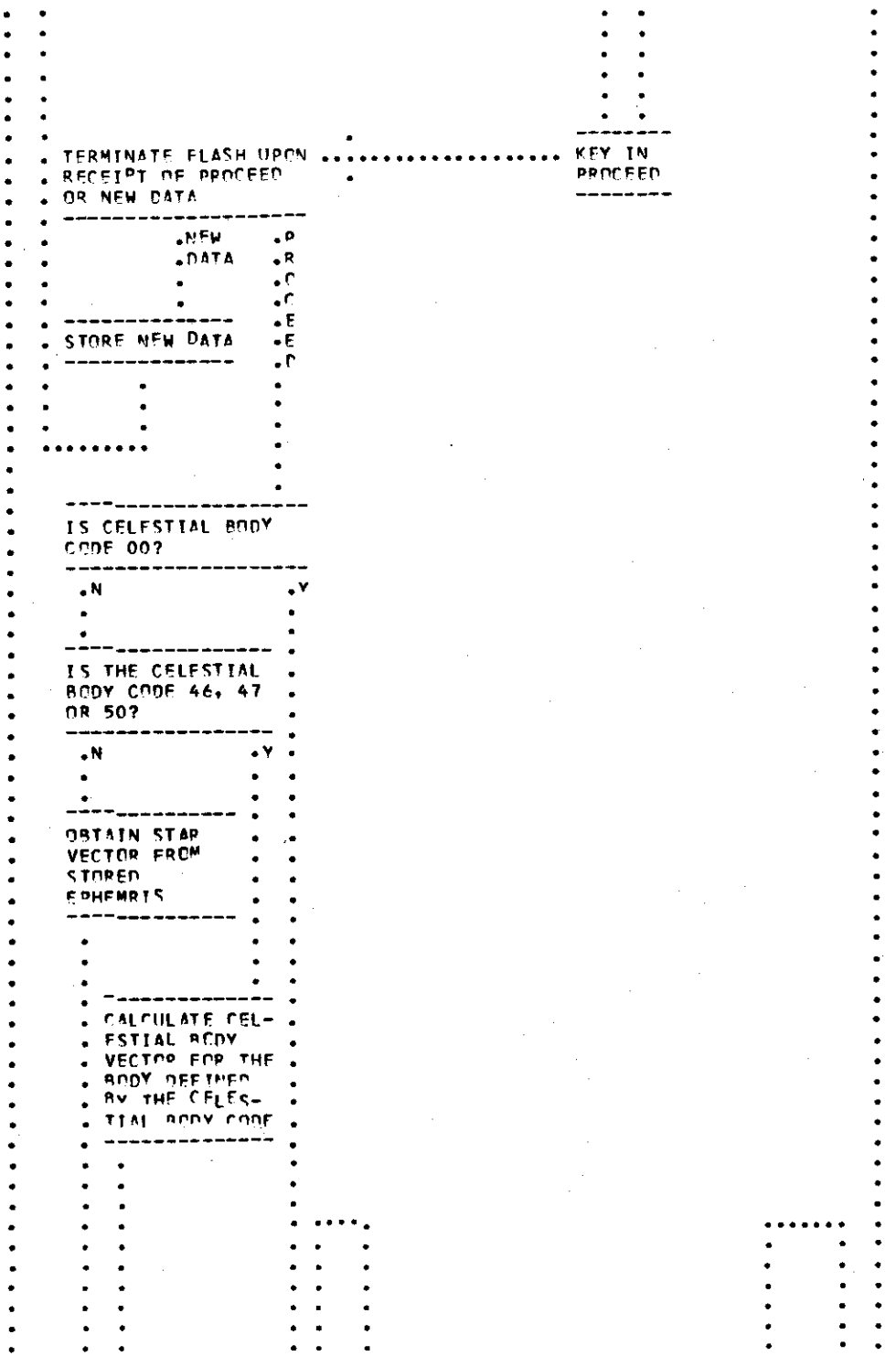

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#790

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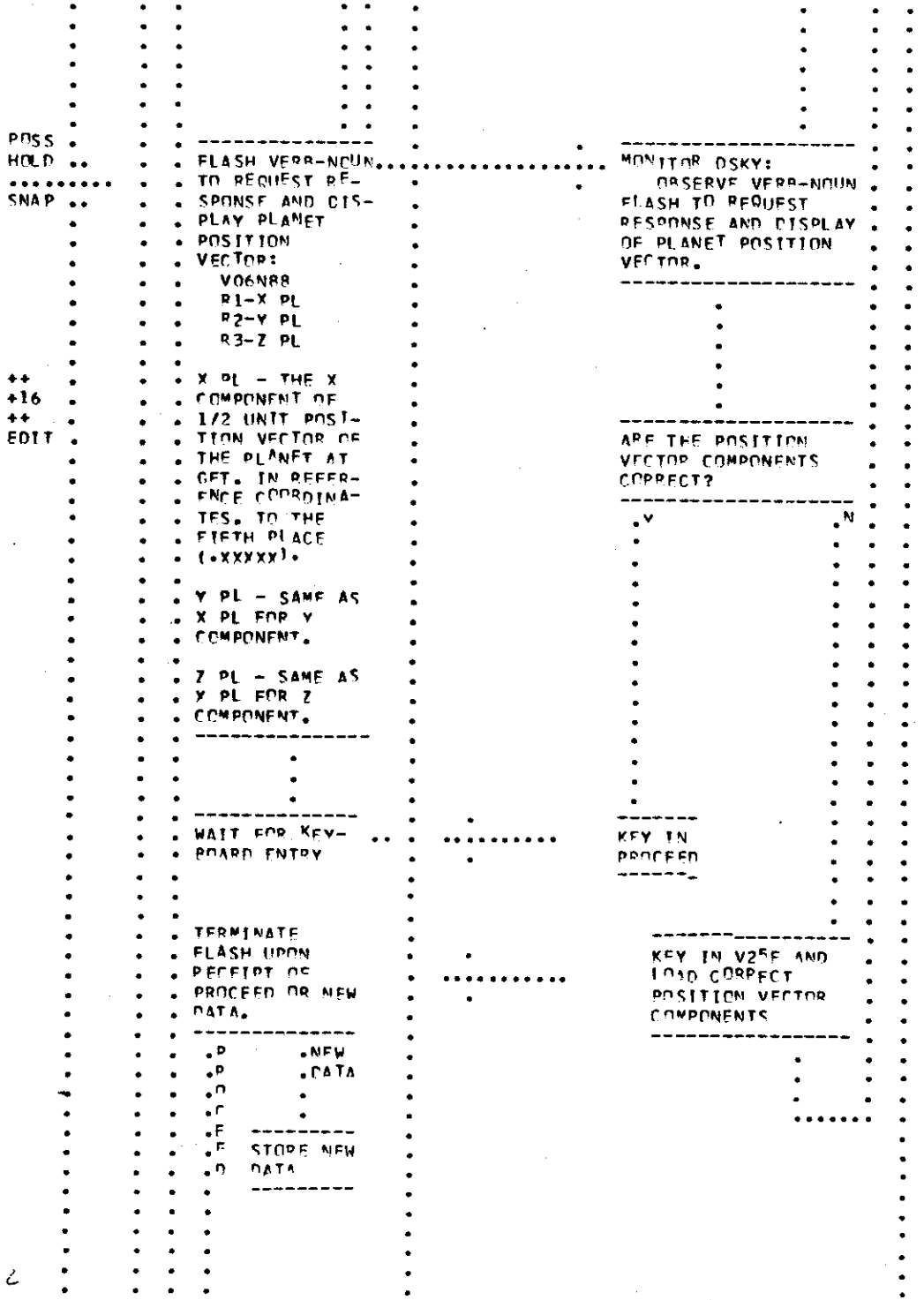
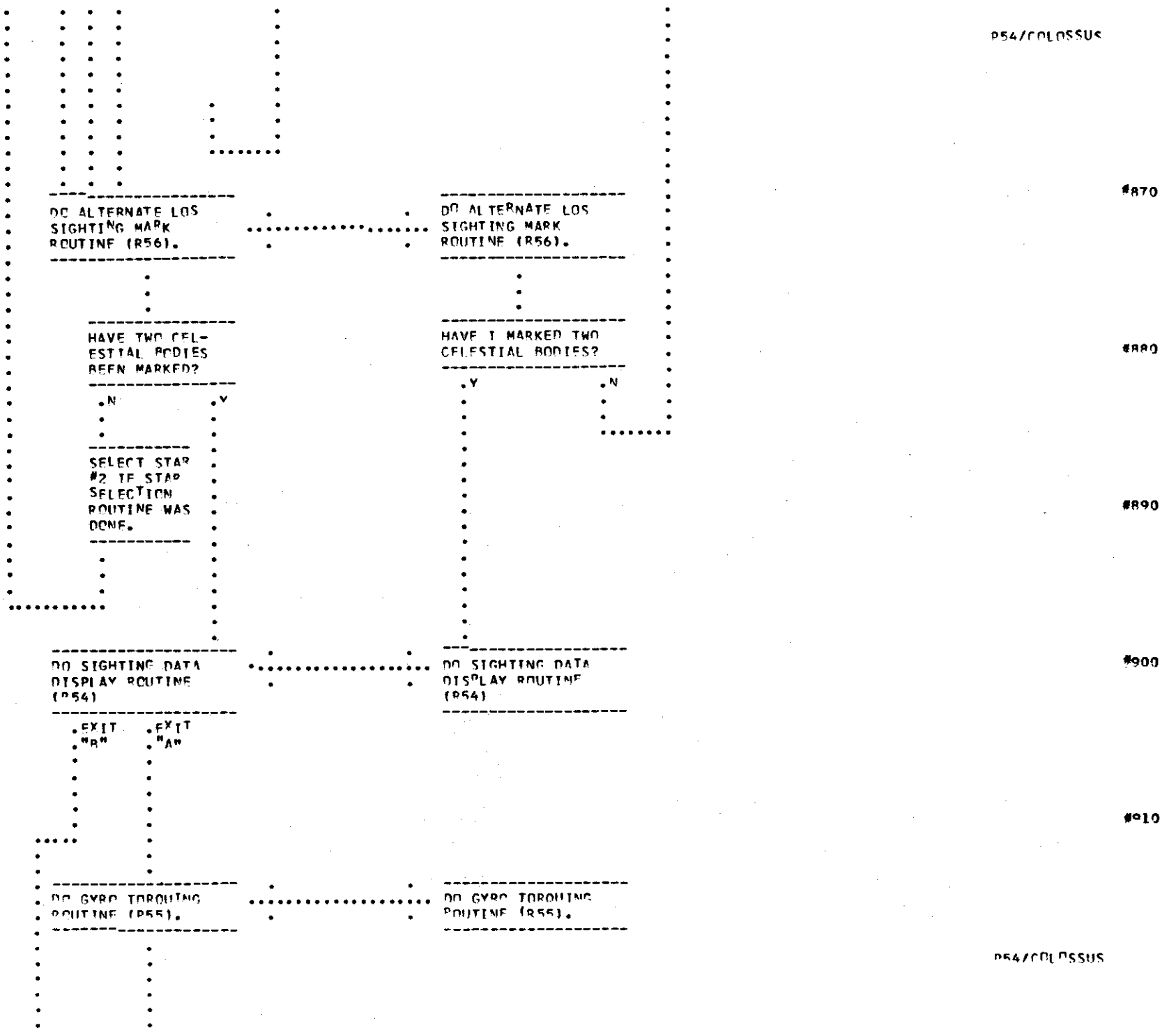

POSS HOLD
SNAP
++ +16 ++ EDIT
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY PLANET POSITION VECTOR:
V06N88
R1-X PL
R2-Y PL
R3-Z PL
X PL - THE X COMPONENT OF 1/2 UNIT POSITION VECTOR OF THE PLANET AT GET. IN REFERENCE COORDINATES. TO THE FIFTH PLACE (+XXXXX).
Y PL - SAME AS X PL FOR Y COMPONENT.
Z PL - SAME AS Y PL FOR Z COMPONENT.
WAIT FOR KEYBOARD ENTRY
TERMINATE FLASH UPON RECEIPT OF PROCEED OR NEW DATA.
PROCEED
NEW DATA
STORE NEW DATA
MONITOR DSKY: OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY OF PLANET POSITION VECTOR.
ARE THE POSITION VECTOR COMPONENTS CORRECT?
Y
N
KEY IN PROCEED
KEY IN V25E AND LOAD CORRECT POSITION VECTOR COMPONENTS
#810
#820
#830
#840
#850
#860



#870

#880

#890

#900

#910

#920

RESET PREFERRED ORIENTATION FLAG.

#930

HOLD . SNAP .

FLASH VERB-NOUN TO REQUEST PLEASE PERFORM FINE ALIGN CHECK
V50 N25
R1-00014
R2-BLANK
R3-BLANK

MONITOR DSKY: OBSERVE VERB-NOUN FLASH TO REQUEST PLEASE PERFORM FINE ALIGN CHECK.

#940

DO I WANT TO REDO THE CELESTIAL BODY SIGHTINGS, SIGHTING DATA TEST, AND GYRO TORQUING TO VERIFY THE ACCURACY OF ALIGNMENT?
NOTE: IF THE SIGHTING DATA WAS BAD OR THE TORQUING ANGLES WERE LARGE THE ASTRONAUT SHOULD PROCEED AND REDO THE ALIGNMENT.

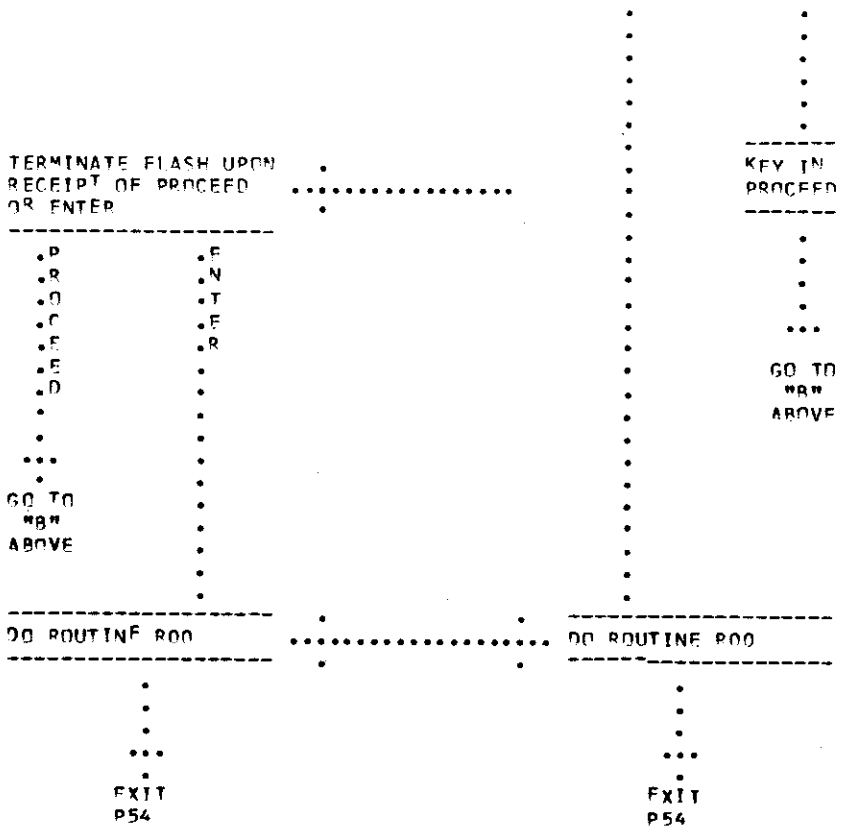
#950

N / Y

#960

WAIT FOR KEYBOARD ENTRY

KEY IN ENTER



#970

#980

#990

CHANGE CONTROL NOTES

REV 12 PCR MIT 38
REV 13 PCR MIT 66
PCR MIT 99
REV 14 PCR 439.1
REV 15 PCR 206 EDITORIAL
REV 16 EDITORIAL

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ENTRY-PREPARATION PROGRAM (P61) LOGIC REV 13 11/27/68

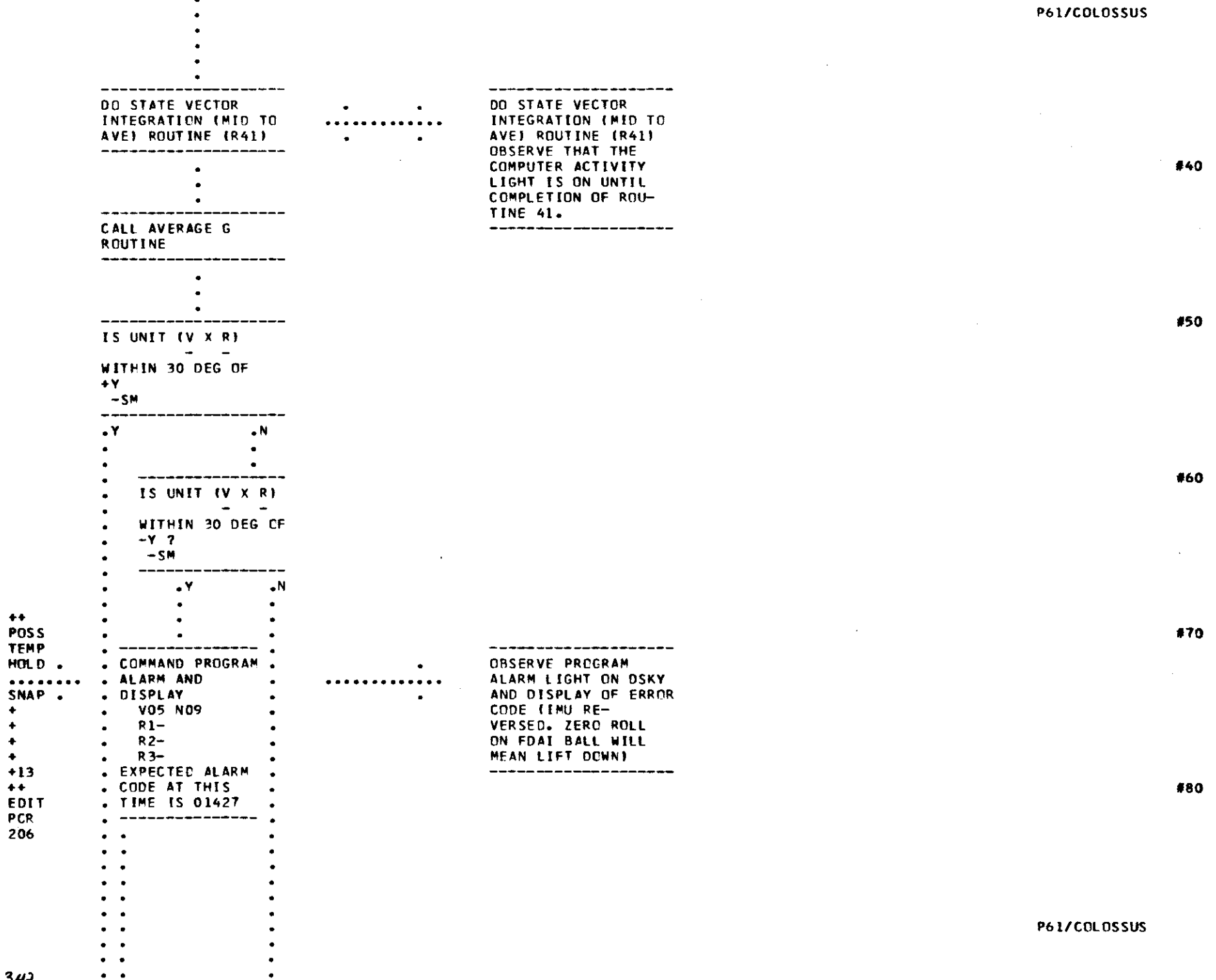
PURPOSE: (1) TO START NAVIGATION, CHECK IMU ALIGNMENT, AND PROVIDE ENTRY MONITOR SYSTEM INITIALIZATION DATA.

ASSUMPTIONS: (1) THE PROGRAM IS ENTERED WITH ADEQUATE FREE FALL TIME TO COMPLETE THE MANEUVERS FROM A WORST CASE STARTING ATTITUDE.

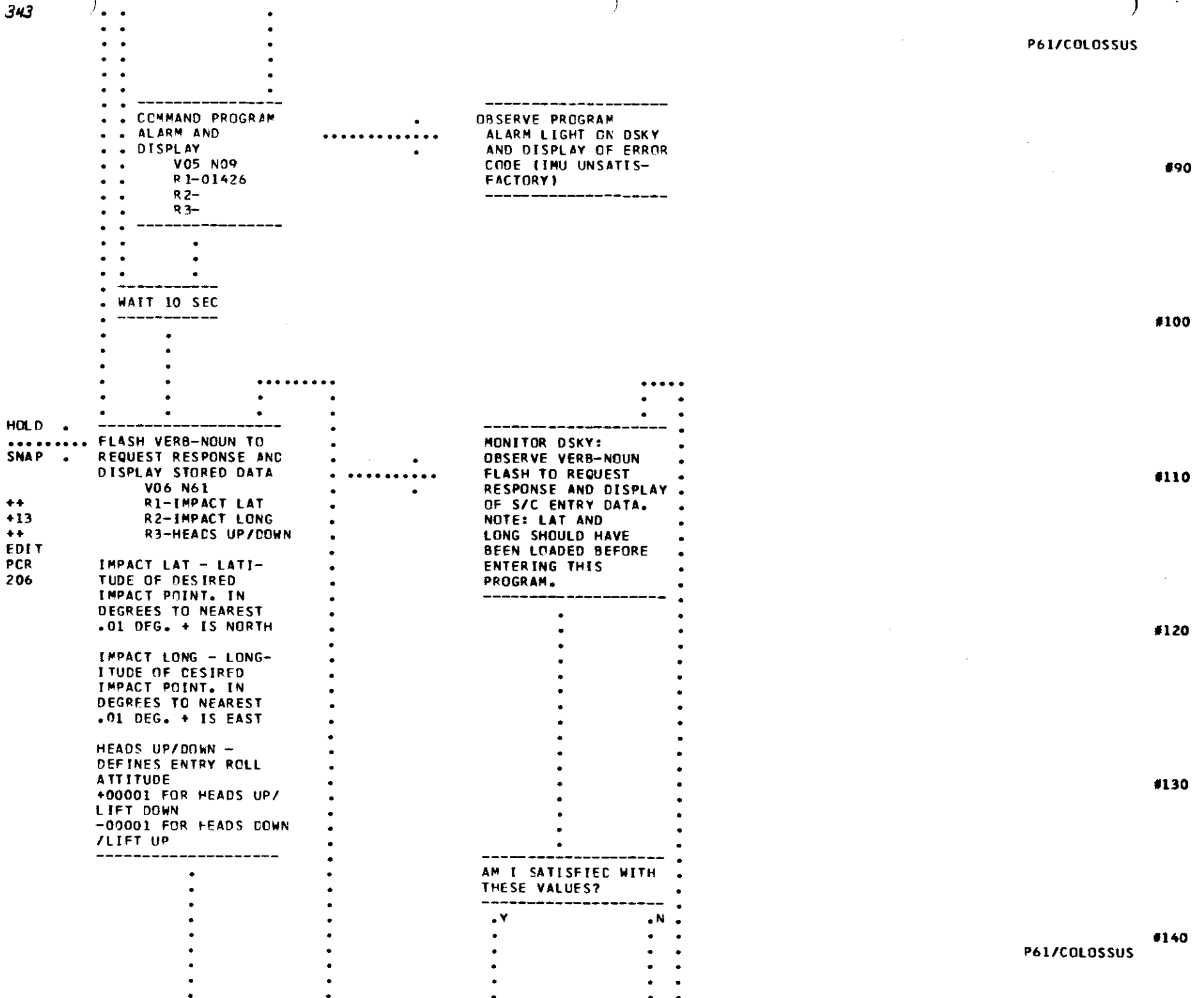
(2) THE ISS IS ON AND PRECISELY ALIGNED TO A SATISFACTORY ORIENTATION.

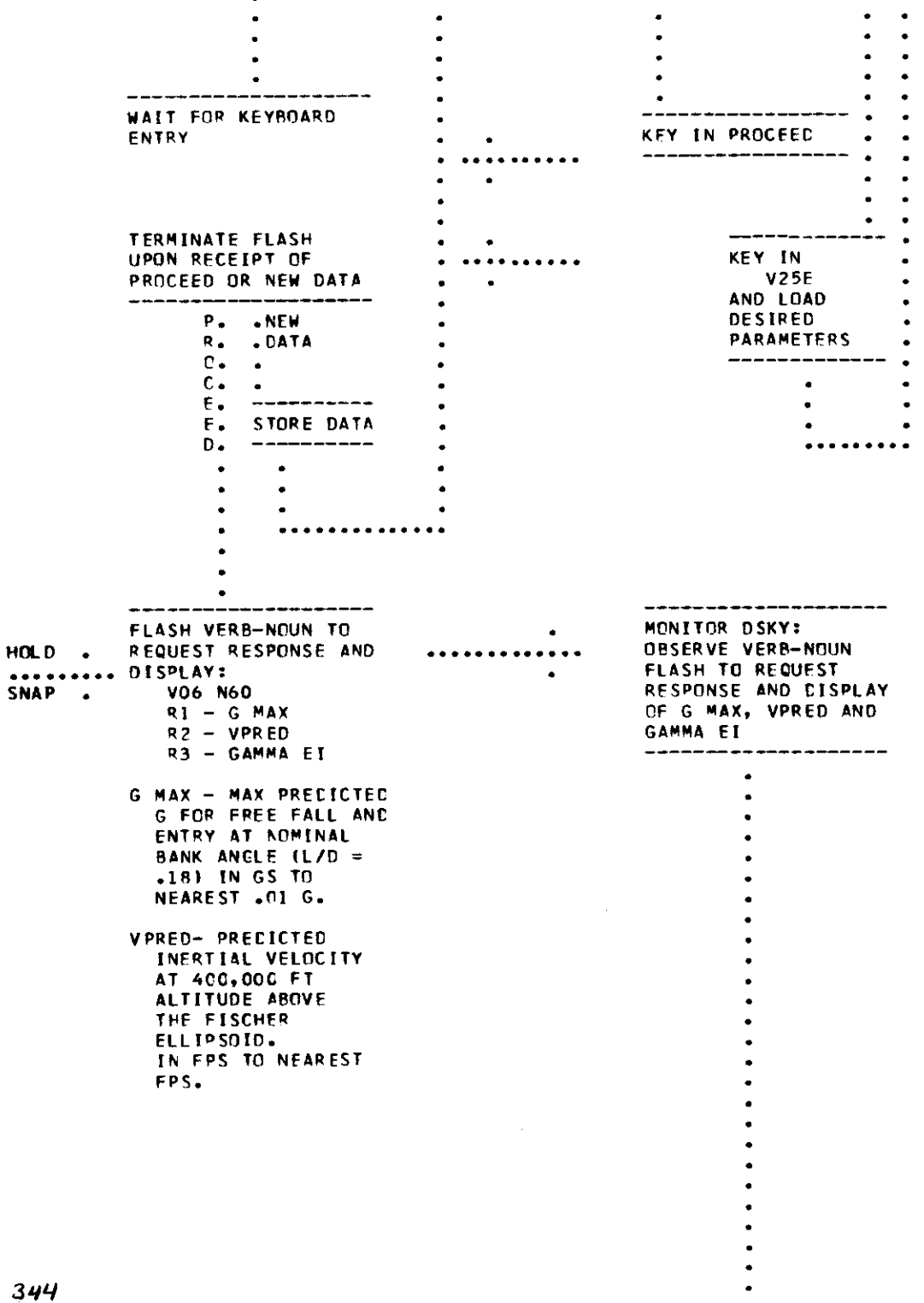
(3) THE PROGRAM IS SELECTED BY THE ASTRONAUT BY DSKY ENTRY.

PROG CONT	CMC	GROUND	CREW	CHECKLIST	TIME	TOTAL TIME
			.CREW PROG .SELECTION			
	START ENTRY-PREPARATION PROGRAM (P61) DISPLAY PROGRAM 61		KEY IN ENTRY PREPARATION PROGRAM (P61) V37E 61E			#10
			MONITOR DSKY: OBSERVE DISPLAY OF PROGRAM 61			
						#20
	DO IMU STATUS CHECK ROUTINE (R02)		DO IMU STATUS CHECK ROUTINE (R02)			
	SET TIG FLAG					#30
					P61/COLOSSUS	



P61/COLOSSUS


COMMAND PROGRAM ALARM AND DISPLAY V05 N09 R1-01426 R2- R3-
WAIT 10 SEC
OBSERVE PROGRAM ALARM LIGHT ON DSKY AND DISPLAY OF ERROR CODE (IMU UNSATISFACTORY)
#90
#100
HOLD
SNAP
++
+13
++
EDIT
PCR
206
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY STORED DATA V06 N61 R1-IMPACT LAT R2-IMPACT LONG R3-HEADS UP/DOWN
IMPACT LAT - LATITUDE OF DESIRED IMPACT POINT. IN DEGREES TO NEAREST .01 DEG. + IS NORTH
IMPACT LONG - LONGITUDE OF DESIRED IMPACT POINT. IN DEGREES TO NEAREST .01 DEG. + IS EAST
HEADS UP/DOWN - DEFINES ENTRY ROLL ATTITUDE +00001 FOR HEADS UP/LIFT DOWN -00001 FOR HEADS DOWN/LIFT UP
MONITOR DSKY: OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY OF S/C ENTRY DATA. NOTE: LAT AND LONG SHOULD HAVE BEEN LOADED BEFORE ENTERING THIS PROGRAM.
#110
#120
#130
AM I SATISFIED WITH THESE VALUES?
.Y
.N
#140


WAIT FOR KEYBOARD ENTRY
KEY IN PROCEED
TERMINATE FLASH UPON RECEIPT OF PROCEED OR NEW DATA
P. .NEW
R. .DATA
O.
C.
E. ----------
F. STORE DATA
D. ----------
KEY IN V25E AND LOAD DESIRED PARAMETERS
#150
#160
HOLD
SNAP
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY:
V06 N60
R1 - G MAX
R2 - VPRED
R3 - GAMMA EI
MONITOR DSKY: OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY OF G MAX, VPRED AND GAMMA EI
#170
G MAX - MAX PREDICTED G FOR FREE FALL AND ENTRY AT NOMINAL BANK ANGLE (L/D = .18) IN GS TO NEAREST .01 G.
#180
VPRED- PREDICTED INERTIAL VELOCITY AT 400,000 FT ALTITUDE ABOVE THE FISCHER ELLIPSOID. IN FPS TO NEAREST FPS.
#190

GAMMA EI - FLIGHT PATH ANGLE. ANGLE BETWEEN INERTIAL VELOCITY AND THE LOCAL HORIZONTAL AT THE ENTRY INTERFACE ALTITUDE AT 400,000 FT ALTITUDE ABOVE THE FISCHER ELLIPSOID. IN DEGREES TO NEAREST .01 DEG.

MINUS INDICATES FLIGHT PATH IS BELOW THE HORIZONTAL PLANE.

#200

RECORD DATA IF NECESSARY

#210

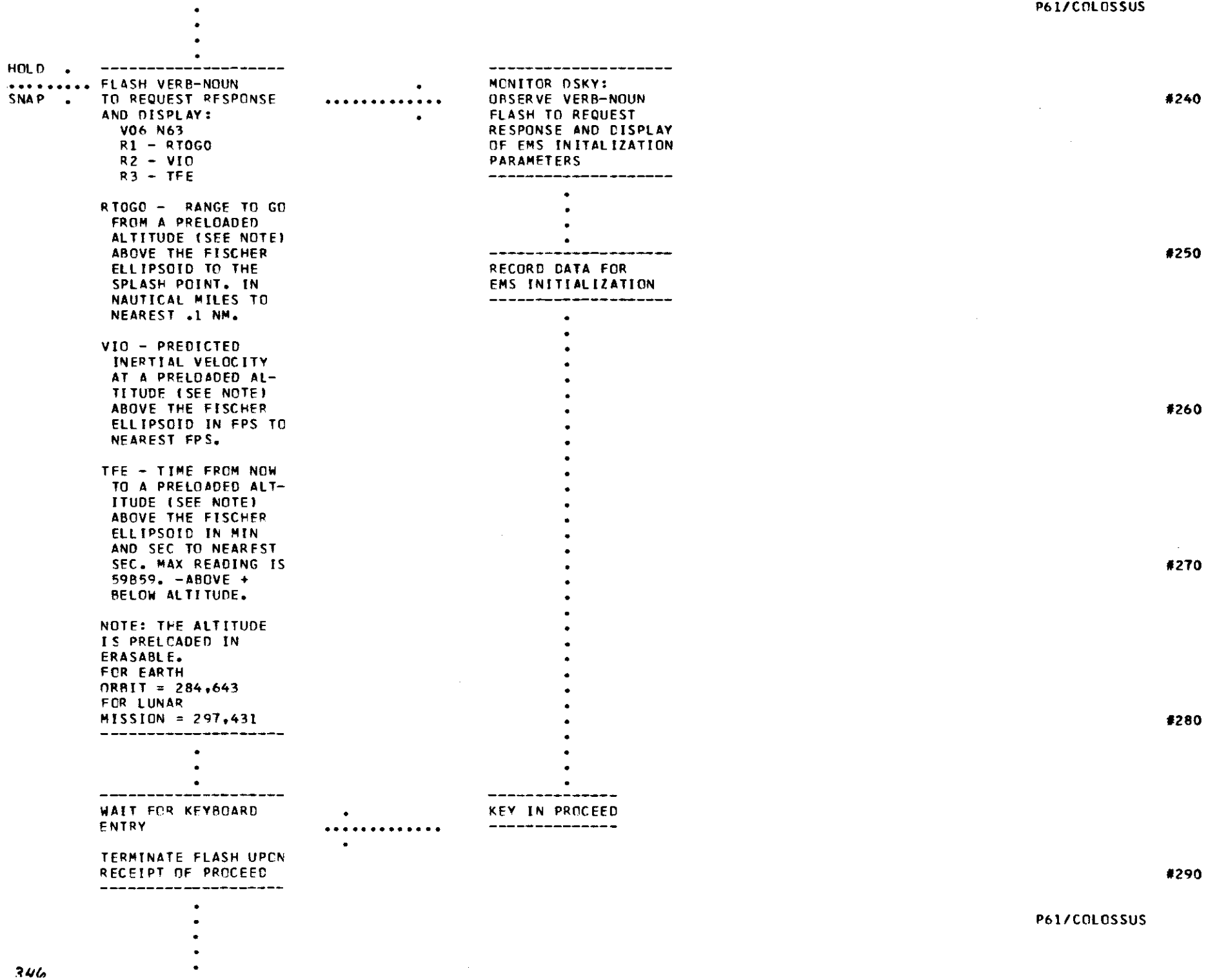
#220

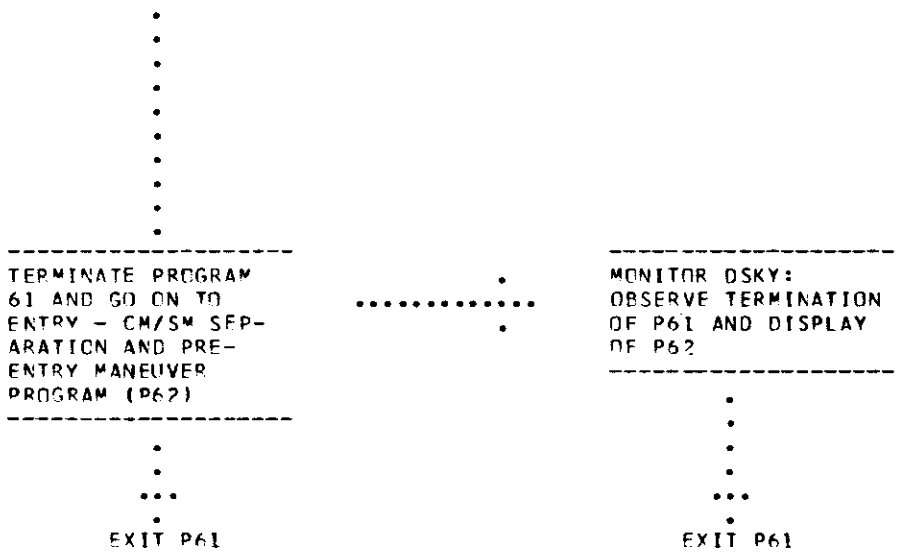
KEY IN PROCEED

WAIT FOR KEYBOARD ENTRY

TERMINATE FLASH UPON RECEIPT OF PROCEED

#230


HOLD
SNAP
FLASH VERB-NOUN
TO REQUEST RESPONSE
AND DISPLAY:
V06 N63
R1 - RTOGO
R2 - VIO
R3 - TFE
RTOGO - RANGE TO GO FROM A PRELOADED ALTITUDE (SEE NOTE) ABOVE THE FISCHER ELLIPSOID TO THE SPLASH POINT. IN NAUTICAL MILES TO NEAREST .1 NM.
VIO - PREDICTED INERTIAL VELOCITY AT A PRELOADED ALTITUDE (SEE NOTE) ABOVE THE FISCHER ELLIPSOID IN FPS TO NEAREST FPS.
TFE - TIME FROM NOW TO A PRELOADED ALTITUDE (SEE NOTE) ABOVE THE FISCHER ELLIPSOID IN MIN AND SEC TO NEAREST SEC. MAX READING IS 59B59. -ABOVE + BELOW ALTITUDE.
NOTE: THE ALTITUDE IS PRELOADED IN ERASABLE.
FOR EARTH ORBIT = 284,643
FOR LUNAR MISSION = 297,431
WAIT FOR KEYBOARD ENTRY
TERMINATE FLASH UPON RECEIPT OF PROCEED
MONITOR DSKY:
OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY OF EMS INITALIZATION PARAMETERS
RECORD DATA FOR EMS INITIALIZATION
KEY IN PROCEED
#240
#250
#260
#270
#280
#290



#300

#310

CHANGE CONTROL NOTES

REV 09 PCR MIT 32
DELETE ASSUMPTION 5
REV 10 PCR MIT 42
REV 11 PCR 50
REV 12 PCR MIT 149
REV 13 PCR 206 EDITORIAL

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ENTRY - CM/SM SEPARATION AND PRE-ENTRY MANEUVER
PROGRAM (P62) LOGIC REV 11 11/27/68

PURPOSE: (1) TO NOTIFY CREW WHEN THE GNCS IS PREPARED FOR CM/SM SEPARATION.

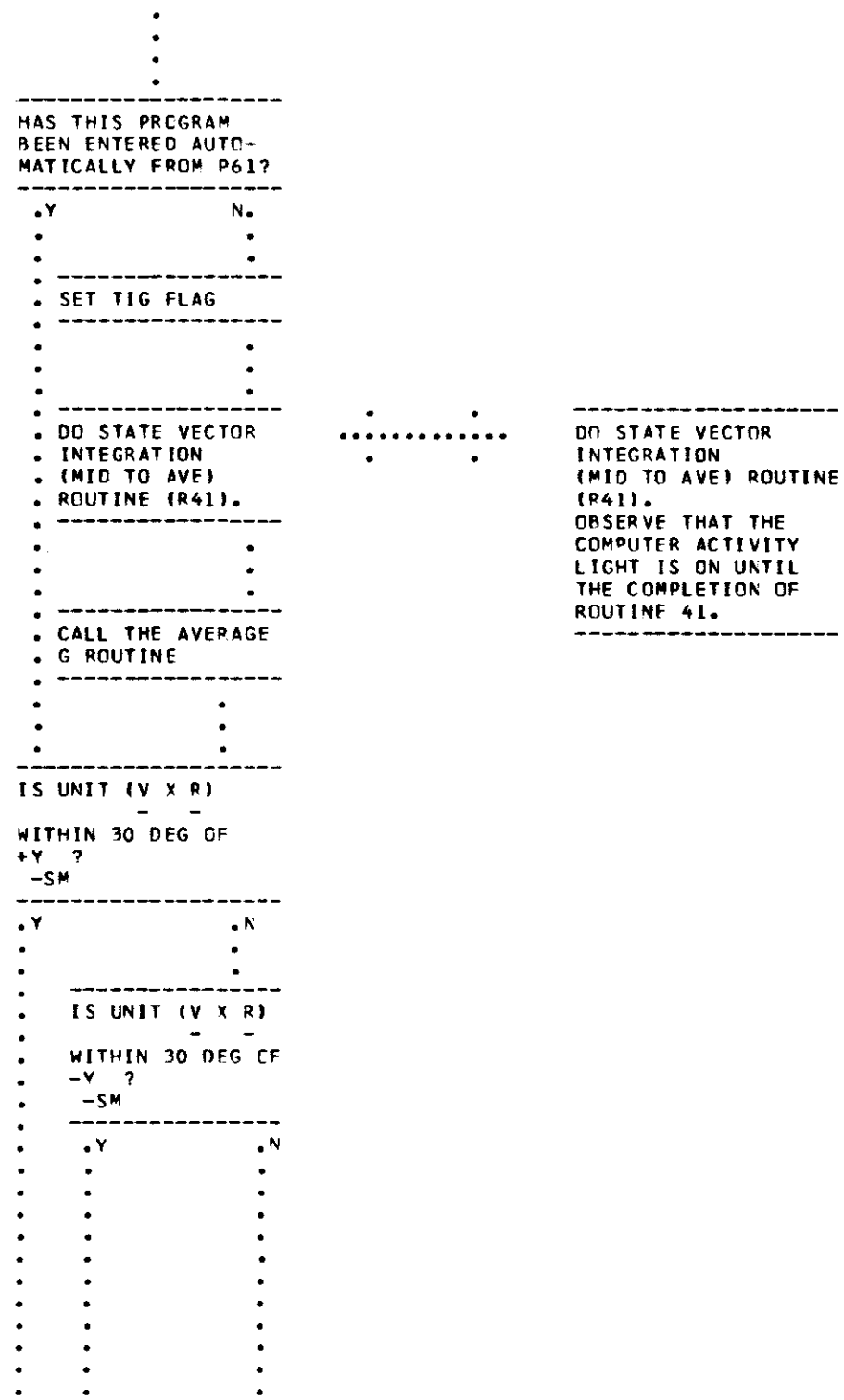
(2) TO ORIENT THE CM TO THE CORRECT ATTITUDE FOR ATMOSPHERIC ENTRY.

ASSUMPTIONS: (1) THE PROGRAM IS ENTERED WITH ADEQUATE FREE FALL TIME TO ACCOMPLISH CM/SM SEPARATION AND TO COMPLETE THE MANEUVER FROM A WORST CASE STARTING ATTITUDE.

(2) THE IMU IS SATISFACTORILY ALIGNED FOR ENTRY.

(3) THE PROGRAM IS AUTOMATICALLY SELECTED BY THE ENTRY-PREPARATION PROGRAM (P61) OR IT MAY BE SELECTED MANUALLY.

PROG CONT	CMC	GROUND	CREW	CHECKLIST	TIME	TOTAL TIME
	.CMC PROG .SELECTION		.CREW PROG .SELECTION			
	START ENTRY- CM/SM SEPARATION AND PRE-ENTRY MANEUVER PROGRAM (P62). DISPLAY PROGRAM 62		KEY IN ENTRY: CM/SM SEPARATION AND PRE-ENTRY MANEUVER PROGRAM (P62) V37E 62E			#10
			MONITOR DSKY: OBSERVE DISPLAY OF PROGRAM 62			#20
	DO IMU STATUS CHECK ROUTINE R02.		DO IMU STATUS CHECK ROUTINE R02.			#30
					P62/COLOSSUS	


HAS THIS PROGRAM BEEN ENTERED AUTO-MATICALLY FROM P61?
Y
N
SET TIG FLAG
DO STATE VECTOR INTEGRATION (MID TO AVE) ROUTINE (R41).
CALL THE AVERAGE G ROUTINE
IS UNIT (V X R) WITHIN 30 DEG OF +Y ? -SM
Y
N
IS UNIT (V X R) WITHIN 30 DEG OF -Y ? -SM
Y
N
DO STATE VECTOR INTEGRATION (MID TO AVE) ROUTINE (R41). OBSERVE THAT THE COMPUTER ACTIVITY LIGHT IS ON UNTIL THE COMPLETION OF ROUTINE 41.

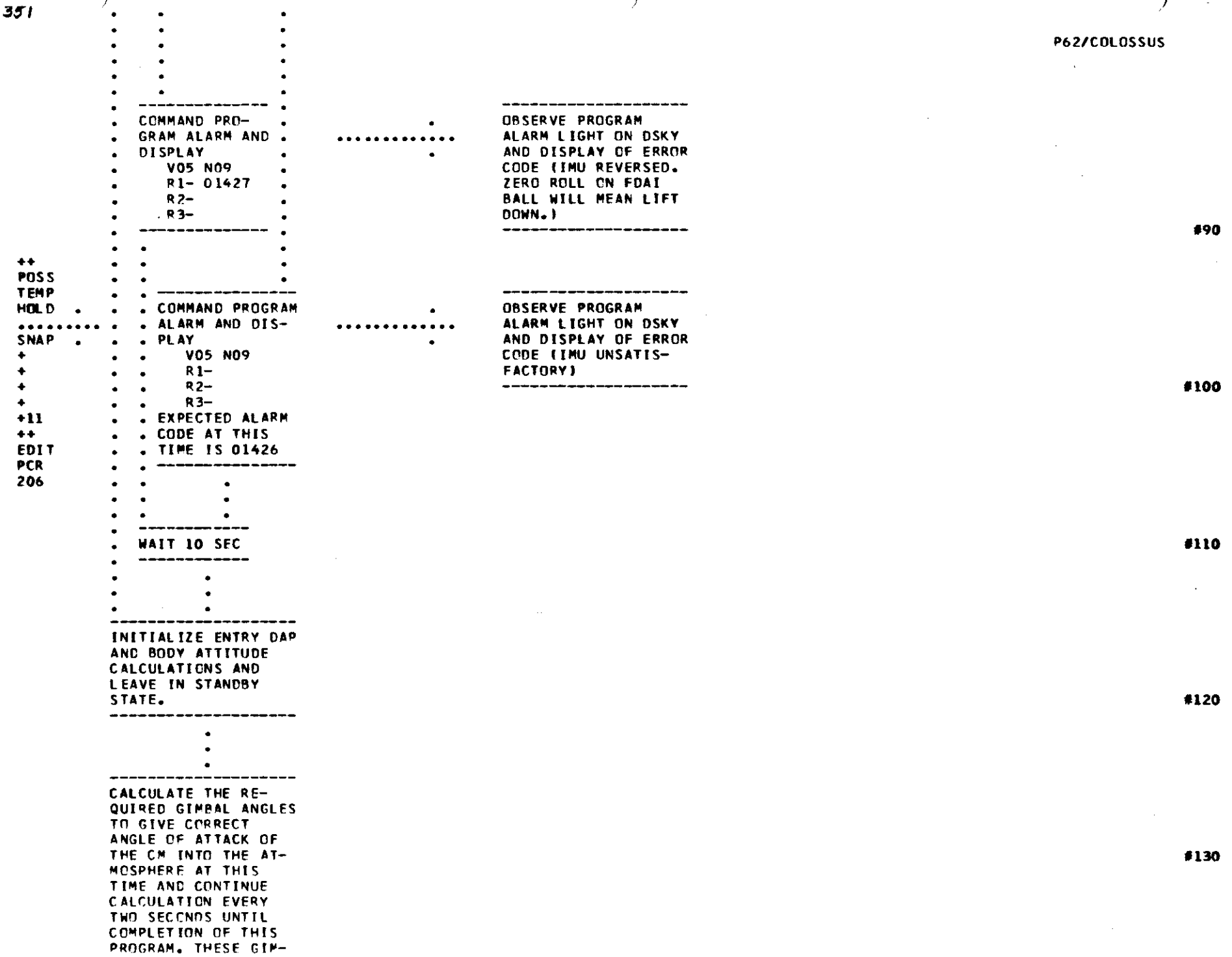
#40

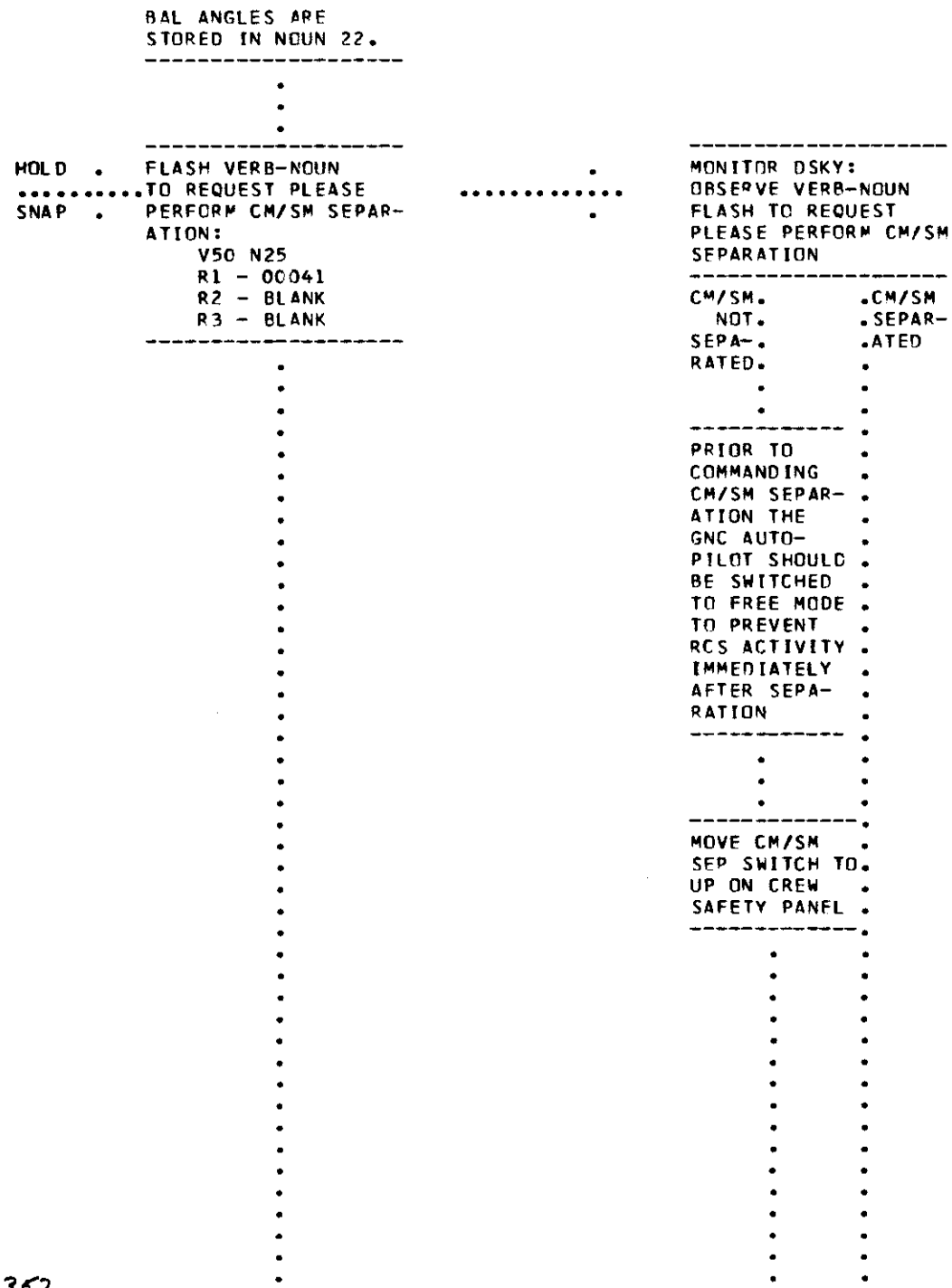
#50

#60

#70

#80


COMMAND PRO-
GRAM ALARM AND
DISPLAY
V05 N09
R1- 01427
R2-
R3-
OBSERVE PROGRAM
ALARM LIGHT ON DSKY
AND DISPLAY OF ERROR
CODE (IMU REVERSED.
ZERO ROLL ON FDAI
BALL WILL MEAN LIFT
DOWN.)
#90
++
POSS
TEMP
HOLD
SNAP
+
+
+
+11
++
EDIT
PCR
206
COMMAND PROGRAM
ALARM AND DIS-
PLAY
V05 N09
R1-
R2-
R3-
OBSERVE PROGRAM
ALARM LIGHT ON DSKY
AND DISPLAY OF ERROR
CODE (IMU UNSATIS-
FACTORY)
#100
EXPECTED ALARM
CODE AT THIS
TIME IS 01426
WAIT 10 SEC
#110
INITIALIZE ENTRY DAP
AND BODY ATTITUDE
CALCULATIONS AND
LEAVE IN STANDBY
STATE.
#120
CALCULATE THE RE-
QUIRED GIMBAL ANGLES
TO GIVE CORRECT
ANGLE OF ATTACK OF
THE CM INTO THE AT-
MOSPHERE AT THIS
TIME AND CONTINUE
CALCULATION EVERY
TWO SECONDS UNTIL
COMPLETION OF THIS
PROGRAM. THESE GIM-
#130



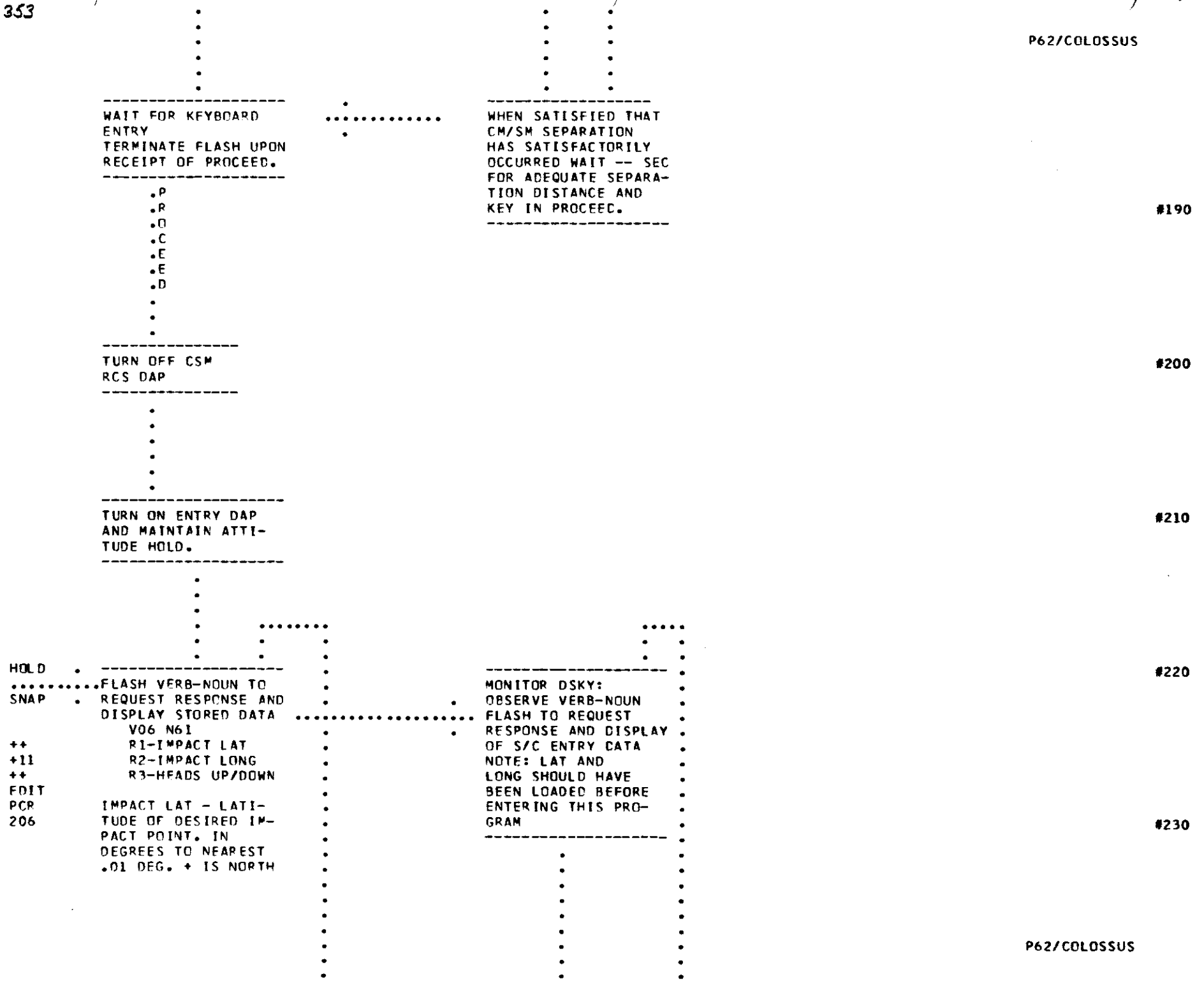
#140

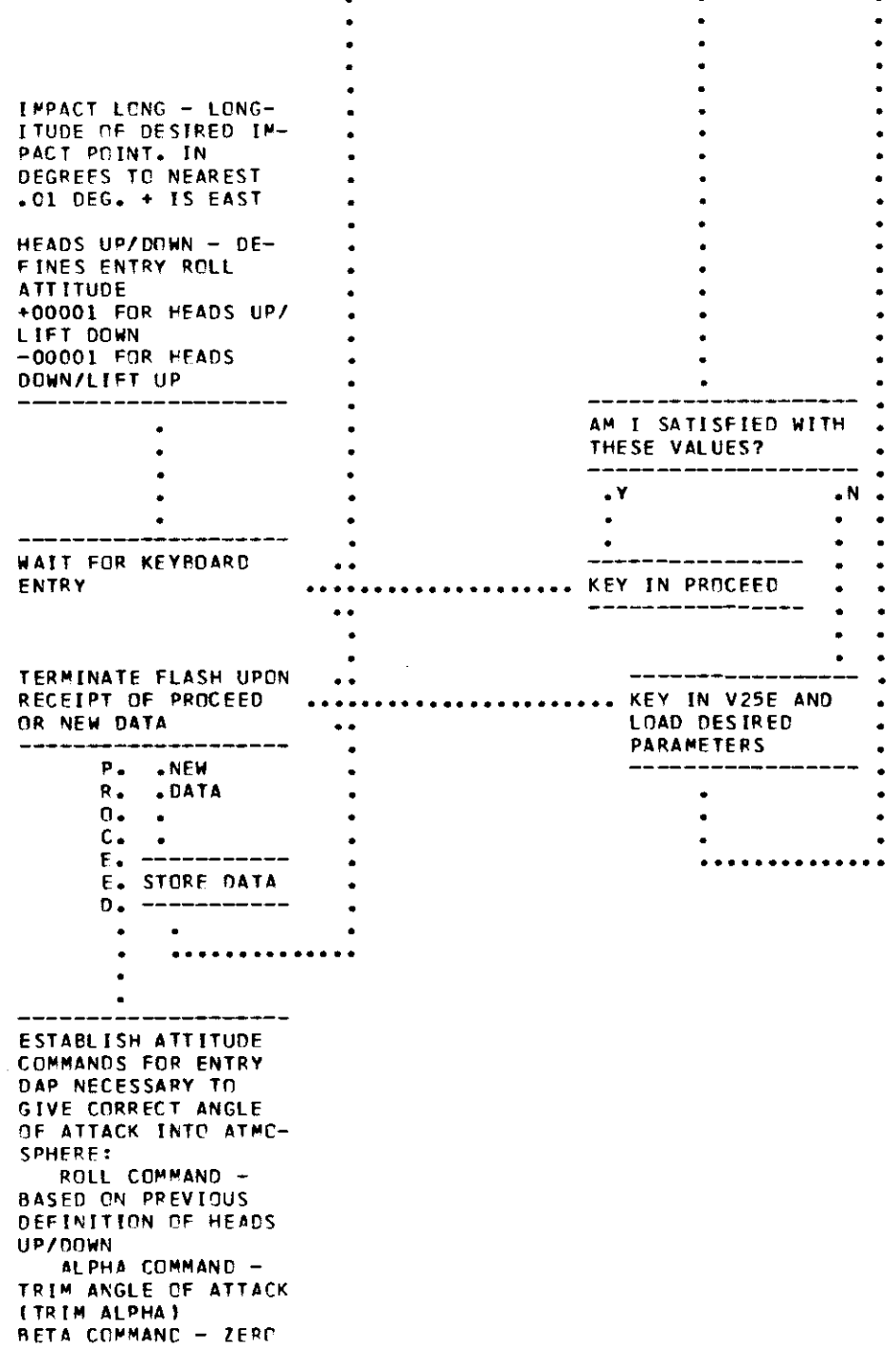
#150

#160

#170

#180


WAIT FOR KEYBOARD ENTRY TERMINATE FLASH UPON RECEIPT OF PROCEED.
.P .R .O .C .E .E .D
TURN OFF CSM RCS DAP
TURN ON ENTRY DAP AND MAINTAIN ATTI-TUDE HOLD.
WHEN SATISFIED THAT CM/SM SEPARATION HAS SATISFACTORILY OCCURRED WAIT -- SEC FOR ADEQUATE SEPARA-TION DISTANCE AND KEY IN PROCEED.
#190
#200
#210
#220
#230
HOLD
SNAP
++
+11
++
EDIT
PCR
206
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY STORED DATA
V06 N61
R1-IMPACT LAT
R2-IMPACT LONG
R3-HEADS UP/DOWN
IMPACT LAT - LATI-TUDE OF DESIRED IM-PACT POINT. IN DEGREES TO NEAREST .01 DEG. + IS NORTH
MONITOR DSKY: OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY OF S/C ENTRY DATA
NOTE: LAT AND LONG SHOULD HAVE BEEN LOADED BEFORE ENTERING THIS PRO-GRAM



#240

#250

#260

#270

#280

#290

FOR LIFT DOWN THIS ATTITUDE WILL BE OBTAINED AFTER A SIMPLE PITCH DOWN MANEUVER FROM THE SEPARATION ATTITUDE. FOR LIFT UP AN ADDITIONAL 180 DEGREES OF ROLL IS REQUIRED.

#300

TURN ON ENTRY DAP

#310

TEMP HOLD . ..... MON .

DISPLAY ON DSKY DESIRED FINAL GIMBAL ANGLES:
V06 N22
R1- OG ROLL
R2- IG PITCH
R3- MG YAW

IN DEGREES TO NEAREST .01 DEG.

MONITOR DSKY: OBSERVE DISPLAY OF FINAL GIMBAL ANGLES.

#320

#330

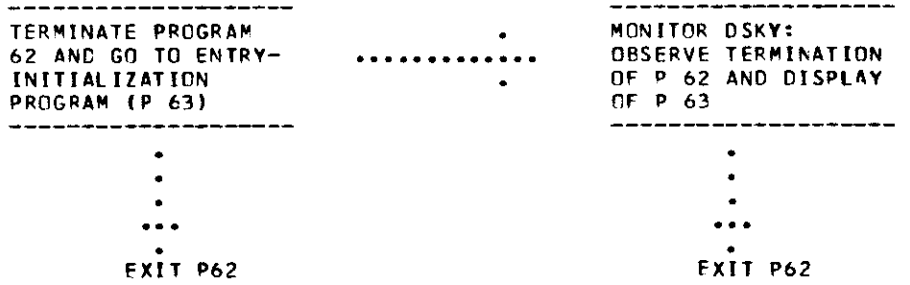
IS THE ANGLE ALPHA ALREADY WITHIN 45 DEGREES?

.Y

.N

WAIT UNTIL CM ANGLE OF ATTACK (ALPHA) IS WITHIN 45 DEGREES AND THEN WAIT AN ADDITIONAL 21 SECONDS.

#340



#350

CHANGE CONTROL NOTES

REV 07 PCR MIT 32
REV 08 PCR MIT 41
REV 09 PCR MIT 66
REV 10 PCR MIT 152
REV 11 PCR 206 EDITORIAL

ENTRY-INITIALIZATION PROGRAM (P63) LOGIC REV 06 04/09/68

PURPOSE: (1) TO INITIALIZE THE ENTRY EQUATIONS.

(2) TO CONTINUE TO HOLD THE CM TO THE CORRECT ATTITUDE WITH RESPECT TO THE ATMOSPHERE FOR THE ONSET OF ENTRY DECELERATION.

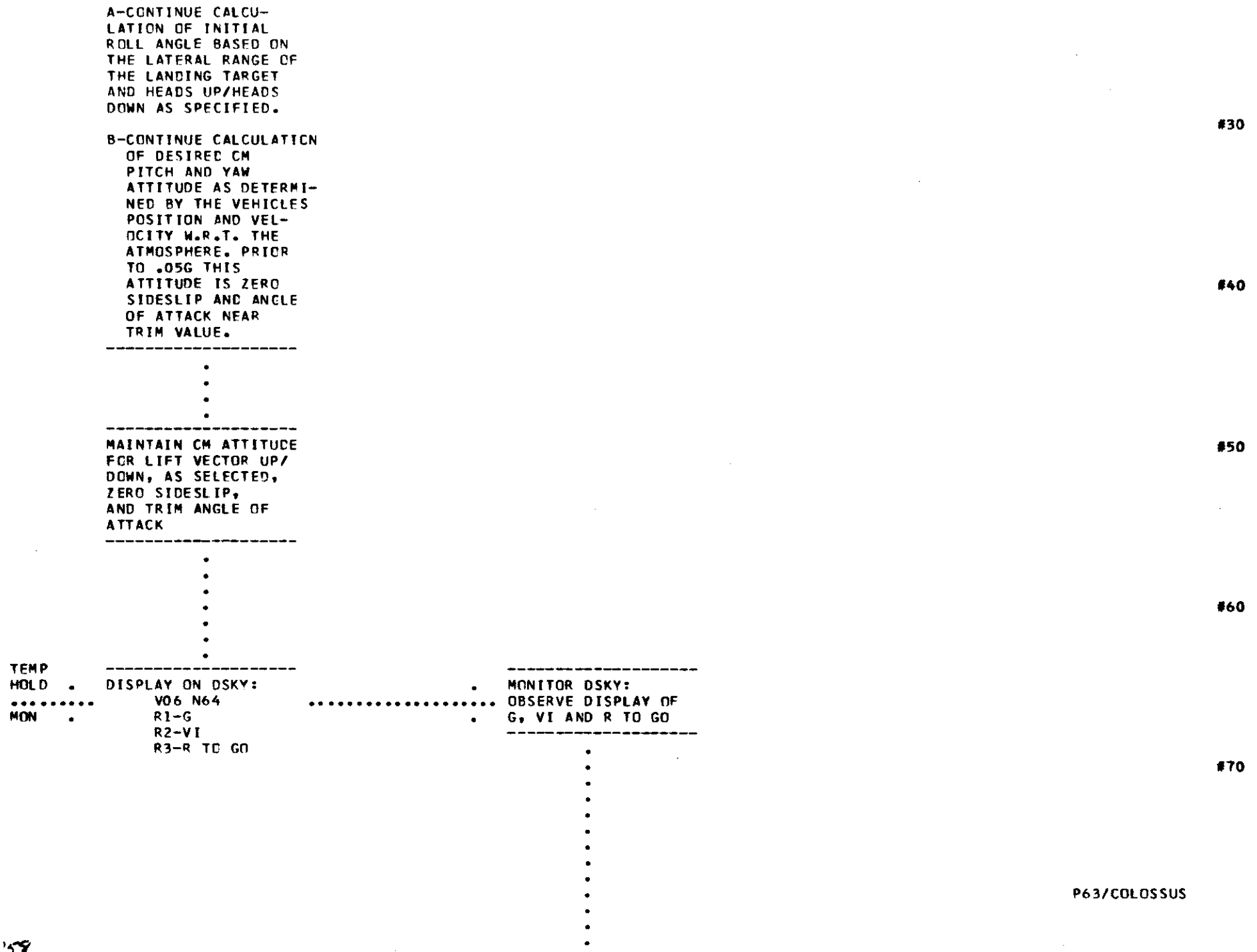
(3) TO ESTABLISH ENTRY DSKY DISPLAYS.

(4) TO SENSE .05G AND DISPLAY THIS EVENT TO THE CREW BY SELECTING THE ENTRY-POST 0.05G PROGRAM (P64).

ASSUMPTIONS: (1) THE PROGRAM IS AUTOMATICALLY SELECTED BY THE ENTRY-CM/SM SEPARATION AND PRE-ENTRY MANEUVER PROGRAM (P62).

(2) THE ASTRONAUT MAY MONITOR N64(G,VI,R TO TARG) DURING THIS PROGRAM BY KEYING IN V16 N64E. HE ALSO MAY MONITOR N68 (BETA, VI, HDOT) BY KEYING IN V16N68E.

PROG CONT	CMC	GROUND	CREW	CHECKLIST	TIME	TOTAL TIME
	.CMC PROG .SELECTION • • ••• •					
	START ENTRY - INITIALIZATION PROGRAM (63) DISPLAY PROGRAM 63	.	MONITOR DSKY: OBSERVE DISPLAY OF PROGRAM 63			#10
	• • • •					
	PERFORM ENTRY INITIALIZATION ROUTINE WHICH INCLUDES:					#20


A-CONTINUE CALCU-
LATION OF INITIAL
ROLL ANGLE BASED ON
THE LATERAL RANGE OF
THE LANDING TARGET
AND HEADS UP/HEADS
DOWN AS SPECIFIED.
#30
B-CONTINUE CALCULATION
OF DESIRED CM
PITCH AND YAW
ATTITUDE AS DETERMI-
NED BY THE VEHICLES
POSITION AND VEL-
OCITY W.R.T. THE
ATMOSPHERE. PRIOR
TO .05G THIS
ATTITUDE IS ZERO
SIDESLIP AND ANGLE
OF ATTACK NEAR
TRIM VALUE.
#40
MAINTAIN CM ATTITUDE
FOR LIFT VECTOR UP/
DOWN, AS SELECTED,
ZERO SIDESLIP,
AND TRIM ANGLE OF
ATTACK
#50
#60
TEMP
HOLD
MON
DISPLAY ON DSKY:
V06 N64
R1-G
R2-VI
R3-R TO GO
MONITOR DSKY:
OBSERVE DISPLAY OF
G, VI AND R TO GO
#70

G-ACCELERATION IN G TC NEAREST .01G

VI-INERTIAL VELOCITY IN FPS TO NEAREST FPS

R TO GO - RANGE TC GO TO THE DESIRED SPLASH POINT ASSUMING SPLASH POINT LOCATED AT CALCULATED IMPACT TIME. IN NAUTICAL MILES TO NEAREST .1 NM. NEGATIVE AND COUNTING DOWN WHEN APPROACHING TARGET, POSITIVE AND COUNTING UP WHEN LEAVING TARGET.

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WAIT FOR .05G INDICATION

.
.
.

ENTRY LOGIC DETECTS .05G

.
.
.

CHANGE ENTRY DAP FROM ATTITUDE HOLD IN ALPHA AND BETA TO RATE DAMPING IN PITCH AND YAW, ROLL UNCHANGED.

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.

MONITOR GNCS CONTROL OF PRE - .05G CM ATTITUDE:

(1) DSKY:

R1-G-INCREASING

R2-VI-NOMINAL

R3-R TO GO NEGATIVE AND COUNTING DOWN WHEN APPROACHING TARGET, POSITIVE AND COUNTING UP WHEN LEAVING TARGET.

(2) FDAI:

ATTITUDE RATES LESS THAN--DEG./SEC.

ATTITUDE ERRORS LESS THAN --DEG.

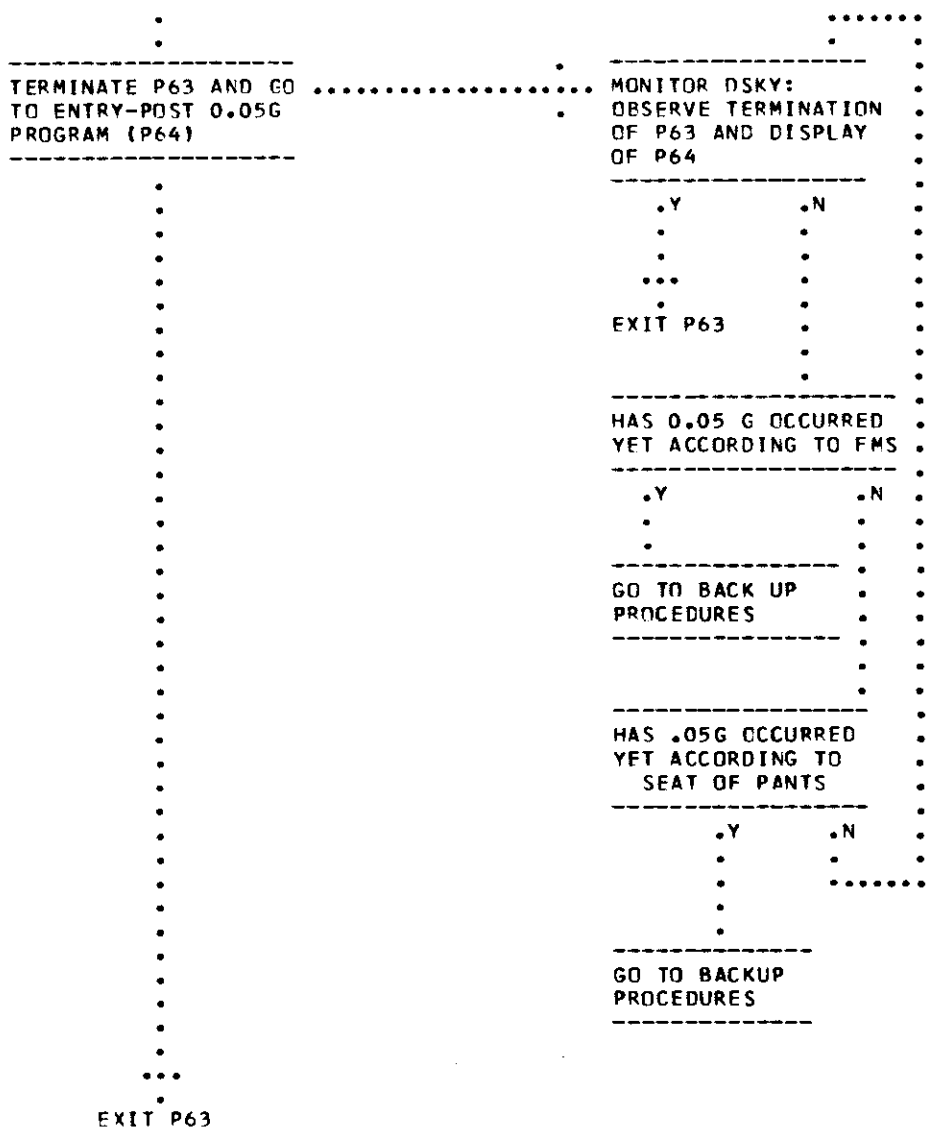
#80

#90

#100

#110

#120



#130

#140

#150

#160

#170

CHANGE CONTROL NOTES

REV 06 PCR MIT 66 0C240000

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ENTRY - POST 0.05 G PROGRAM (P64) LOGIC REV 07 11/27/68

PURPOSE: (1) TO START ENTRY GUIDANCE AT .05G SELECTING ROLL ATTITUDE, CONSTANT DRAG LEVEL, AND DRAG THRESHOLD, KA, WHICH ARE KEYED TO THE .05G POINT.

(2) SELECT FINAL PHASE (P67) IF V <27000 FPS WHEN .2G OCCURS.

(3) ITERATE FOR UPCONTROL SOLUTION (P65) IF V >27000 FPS AND IF ALTITUDE RATE AND DRAG LEVEL CONDITIONS ARE SATISFIED

(4) SELECT FINAL PHASE (P67) IF NO UPCONTROL SOLUTION EXISTS WITH VL >18000 FPS.

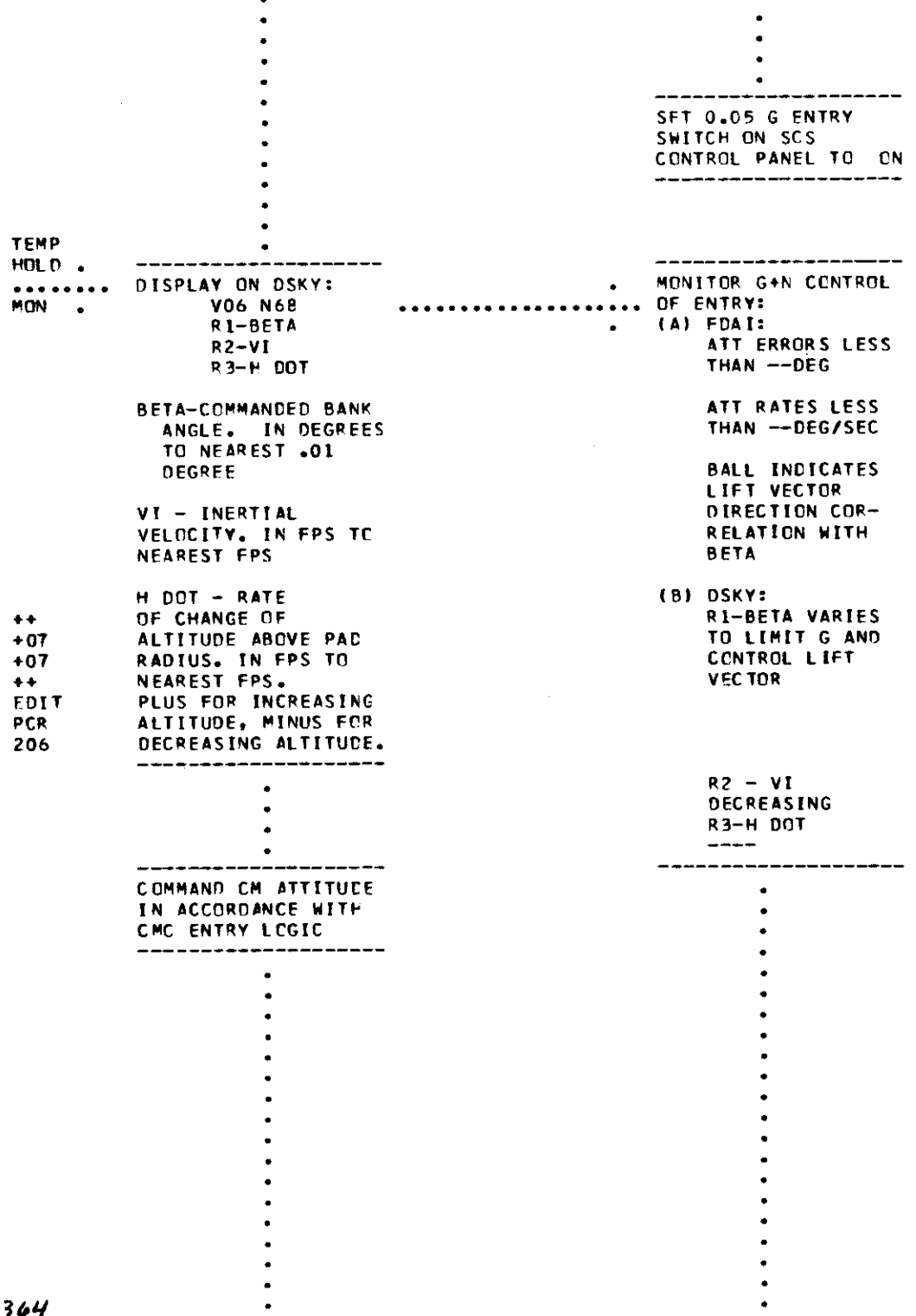
(5) TO ESTABLISH THE 0.05 G MODE IN SCS.

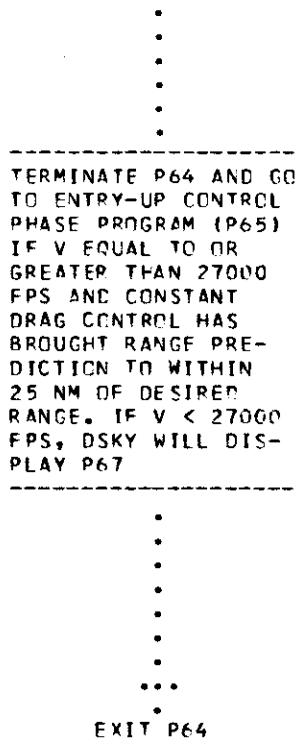
(6) TO CONTINUE ENTRY DSKY DISPLAYS.

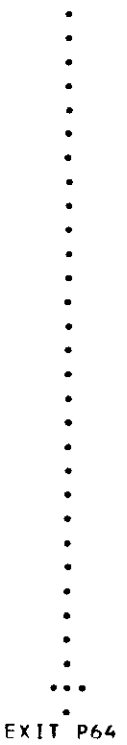
ASSUMPTIONS: (1) THE PROGRAM IS AUTOMATICALLY SELECTED BY THE ENTRY INITIALIZATION PROGRAM (P 63).

(2) THE ASTRONAUT MAY MONITOR N64(G,VI,R TO TARG) DURING THIS PROGRAM BY KEYING IN V16N64E. HE ALSO MAY MONITOR N68 (BETA, VI, HDOT) BY KEYING IN V16 N68E.

PROG CONT	CMC	GROUND	CREW	CHECKLIST	TIME	TOTAL TIME
	.CMC PROG. .SELECTION					
	START ENTRY-POST 0.05 G PROGRAM (P 64)					#10
	DISPLAY PROGRAM 64	.....	MONITOR DSKY: OBSERVE DISPLAY OF PROGRAM 64			#20
						P64/COLOSSUS


SET 0.05 G ENTRY
SWITCH ON SCS
CONTROL PANEL TO ON
TEMP
HOLD
MON
DISPLAY ON DSKY:
V06 N68
R1-BETA
R2-VI
R3-H DOT
BETA-COMMANDED BANK ANGLE. IN DEGREES TO NEAREST .01 DEGREE
VI - INERTIAL VELOCITY. IN FPS TO NEAREST FPS
H DOT - RATE OF CHANGE OF ALTITUDE ABOVE PAD RADIUS. IN FPS TO NEAREST FPS. PLUS FOR INCREASING ALTITUDE, MINUS FOR DECREASING ALTITUDE.
++
+07
+07
++
EDIT
PCR
206
COMMAND CM ATTITUDE IN ACCORDANCE WITH CMC ENTRY LOGIC
MONITOR G+N CONTROL OF ENTRY:
(A) FDAI:
ATT ERRORS LESS THAN --DEG
ATT RATES LESS THAN --DEG/SEC
BALL INDICATES LIFT VECTOR DIRECTION CORRELATION WITH BETA
(B) DSKY:
R1-BETA VARIES TO LIMIT G AND CONTROL LIFT VECTOR
R2 - VI DECREASING
R3-H DOT
#30
#40
#50
#60





#70

#80

#90

CHANGE CONTROL NOTES

REV 06 PCR MIT 66
REV 07 PCR 206 EDITORIAL

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ENTRY - UP CONTRCL PRCGRAM (P65) LOGIC REV 08 11/27/68

PURPOSE: (1) TO EXECUTE ENTRY - UP CONTRCL GUIDANCE WHICH STEERS THE CM TO A CONTROLLED EXIT (SKIP OUT) CONDITION.

(2) TO ESTABLISH ENTRY - UP CONTROL DISPLAYS WHICH ARE USED IN CONJUNCTION WITH THE EMS TO DETERMINE FOR THE ASTRONAUT IF THE BACKUP PROCEDURES SHOULD BE IMPLEMENTED.

(3) TO SENSE EXIT (DRAG ACCELERATION LESS THAN 07 FPS^2) AND THEREUPON TO SELECT THE ENTRY - BALLISTIC PHASE PROGRAM (P66).

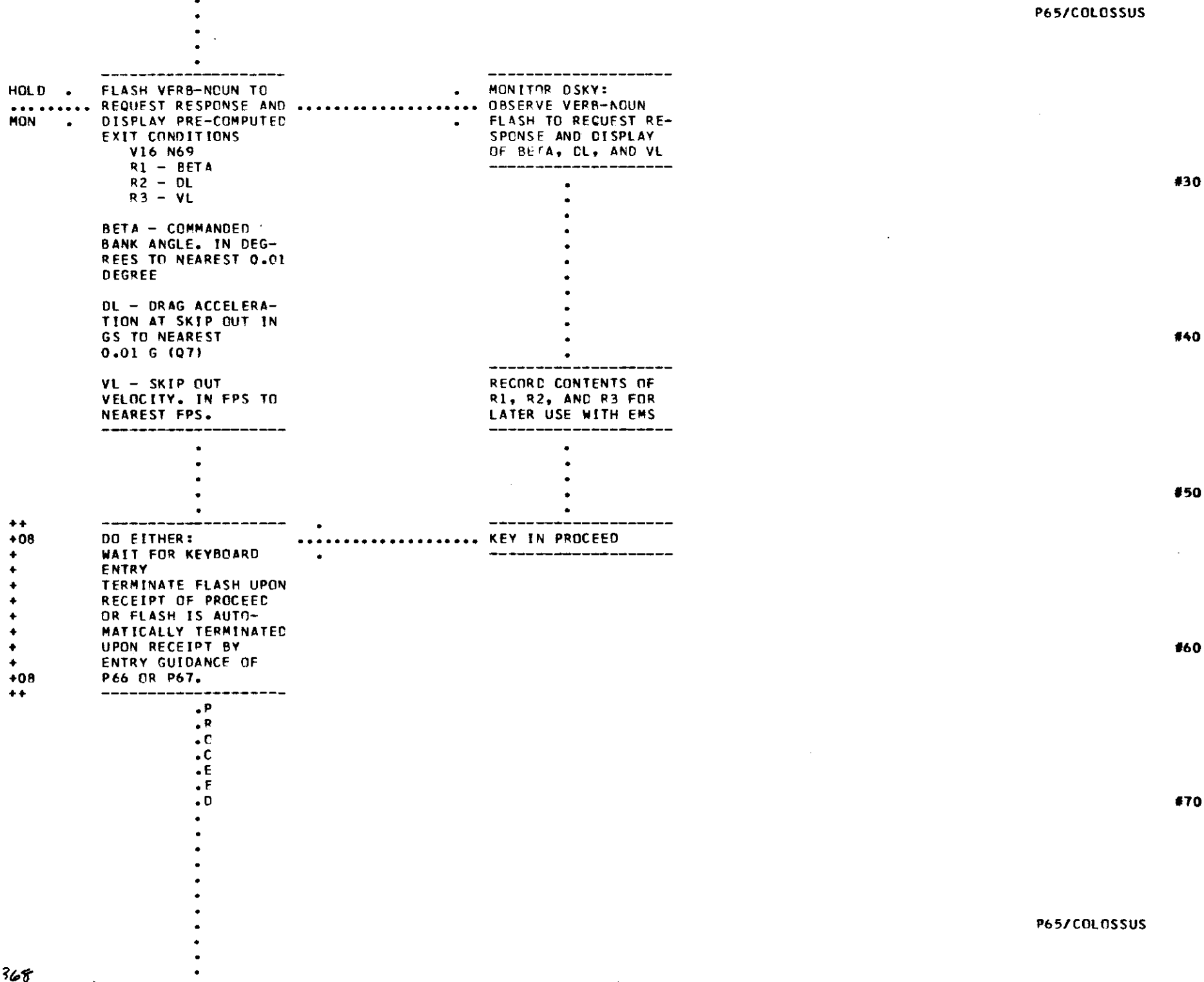
(4) WHERE RDOT IS NEGATIVE AND THE V IS SUFFICIENTLY LOW (V-VL-C18 NEG), PROGRAM WILL EXIT DIRECTLY TO P67 (FINAL PHASE).

ASSUMPTIONS: (1) THIS PROGRAM IS AUTOMATICALLY SELECTED BY THE ENTRY - POST 0.05G PROGRAM (P64) WHEN CONSTANT DRAG CONTROL HAS BROUGHT RANGE PREDICTICN TO WITHIN 25 N.M. OF THE DESIRED RANGE. IT IS SKIPPED IN EARTH ORBIT MISSIONS.

(2) THE ASTRONAUT MAY MONITOR N64(G,VI,R TO TARG) CURING THIS PROGRAM BY KEYING IN V16N64E. HE ALSO MAY MONITOR N68 (BETA, VI, HDOT) BY KEYING IN V16 N68E.

(3) MANUAL RESPCNSE TO N69 IS NOT NECESSARY TO TERMINATE P65. SELECTION OF EITHER P66 OR P67 BY ENTRY GUIDANCE PROVIDES AUTOMATIC TERMINATION.

PROG CONT	CMC	GROUND	CREW	CHECKLIST	TIME	TOTAL TIME
	.CMC PRCG .SELECTICN					
	START ENTRY - UP CONTROL PHASE PROGRAM (65)					#10
	.					
	DISPLAY PROGRAM 65	.....	MONITOR DSKY: OBSERVE DISPLAY OF PROGRAM 65			#20
	.				P65/COLOSSUS	


HOLD
MON
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY PRE-COMPUTED EXIT CONDITIONS
V16 N69
R1 - BETA
R2 - DL
R3 - VL
BETA - COMMANDED BANK ANGLE. IN DEGREES TO NEAREST 0.01 DEGREE
DL - DRAG ACCELERATION AT SKIP OUT IN GS TO NEAREST 0.01 G (Q7)
VL - SKIP OUT VELOCITY. IN FPS TO NEAREST FPS.
MONITOR DSKY: OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY OF BETA, DL, AND VL
RECORD CONTENTS OF R1, R2, AND R3 FOR LATER USE WITH EMS
KEY IN PROCEED
DO EITHER:
WAIT FOR KEYBOARD ENTRY
TERMINATE FLASH UPON RECEIPT OF PROCEED OR FLASH IS AUTOMATICALLY TERMINATED UPON RECEIPT BY ENTRY GUIDANCE OF P66 OR P67.
.P
.R
.C
.C
.E
.F
.D
#30
#40
#50
#60
#70

TEMP HOLD . ..... MON .

DISPLAY ON DSKY:
V06 N68
R1 - BETA
R2 - VI
R3 - H DOT

BETA - COMMANDED BANK ANGLE. IN DEGREES TO NEAREST 0.01 DEGREE

VI - INERTIAL VELOCITY. IN FPS TO NEAREST FPS

H DOT - RATE OF CHANGE OF ALTITUDE ABOVE PAD RADIUS IN FPS TO NEAREST FPS. PLUS FOR INCREASING ALTITUDE MINUS FOR DECREASING ALTITUDE.

COMMAND CM ATTITUDE IN ACCORDANCE WITH CMC ENTRY LOGIC

MONITOR G&N CONTROL OF ENTRY:

(A) FDAI:
ATT ERRORS LESS THAN -- DEG
ATT RATE LESS THAN -- DEG/SEC. #80

#90

#100

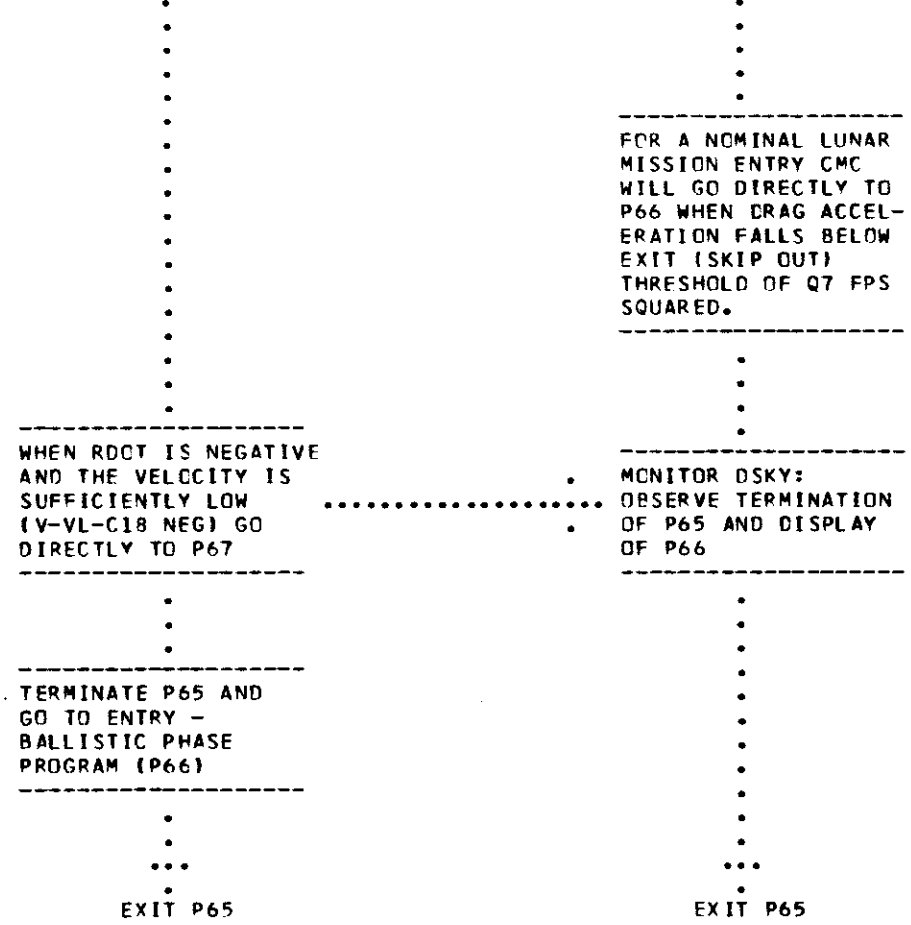
(B) DSKY:
R1 - BETA VARIES TO LIMIT G AND CONTROL LIFT VECTOR

R2-VI DECREASING

R3-H DOT ----

NOTE: BACKUP PROCEDURES SHOULD BE IMPLEMENTED IF THIS DSKY DISPLAY AND/OR EMS INDICATE DIVERGENCE FROM ACCEPTABLE OPERATIONAL ENVELOPE #110

#120



CHANGE CONTROL NOTES

REV 06 PCR MIT 66
REV 07 PCR MIT 481
REV 07 PCR MIT 206
08 EDITORIAL

ENTRY - BALLISTIC PROGRAM (P66) LOGIC REV 07 05/07/68

PURPOSE: (1) TO MAINTAIN CM ATTITUDE DURING BALLISTIC (SKIP OUT) PHASE FOR ATMOSPHERIC RE-ENTRY.

(2) TO SENSE RE-ENTRY (DRAG ACCELERATION BUILDS UP TO Q7 + 0.5 FPS^2 OR APPROX. 0.2G) AND THEREUPON TO SELECT THE ENTRY - FINAL PHASE PROGRAM (P67).

ASSUMPTIONS: (1) THIS PROGRAM IS AUTOMATICALLY SELECTED BY THE ENTRY - UP CONTROL PROGRAM (P65) WHEN DRAG ACCELERATION BECOMES LESS THAN Q7 FPS^2.

(2) THE ASTRONAUT MAY MONITOR N64 (G, VI, R TO TARG) DURING THIS PROGRAM BY KEYING IN V16 N64E. HE ALSO MAY MONITOR N68 (BETA, VI, HDOT) BY KEYING IN V16 N68E.

PROG CONT	CMC	GROUND	CREW	CHECKLIST	TIME	TOTAL TIME
	.CMC PROG .SELECTION					
	START ENTRY - BALLISTIC PROGRAM (P66)					
	.					#10
	DISPLAY PROGRAM 66	.....	MONITOR DSKY: OBSERVE DISPLAY OF PROGRAM 66			
	.		.			
	ESTABLISH ATTITUDE COMMANDS FOR ENTRY DAP NECESSARY TO GIVE CORRECT ANGLE OF ATTACK INTO THE ATMOSPHERE:					#20
++ +07 + + + +	ROLL COMMAND-MAINTAIN LAST COMPUTED VALUE			P66/COLOSSUS		#30

FROM ENTRY GUIDANCE UNLESS ACCELERATION GOES BELOW .05 G IN WHICH CASE MAINTAIN ZERO DEGREES UNTIL TERMINATION OF P66.
ALPHA COMMAND-TRIM ANGLE OF ATTACK (TRIM ALPHA)
BETA COMMAND-ZERO.

#40

CALCULATE FINAL GIMBAL ANGLES REQUIRED BASED ON PRESENT STATE VECTOR. REPEAT CALCULATION EVERY TWO SECONDS UNTIL TERMINATION OF P66.

#50

#60

TEMP HOLD . ..... MON .

DISPLAY ON DSKY:
THE DESIRED GIMBAL ANGLES TO WHICH THE ENTRY DAP WILL ORIENT THE CM
V06 N22
R1-CG ROLL
R2-IG PITCH
R3-MG YAW

ALL COMMANDED GIMBAL ANGLES IN DEGREES TO NEAREST 0.01 DEGREE.

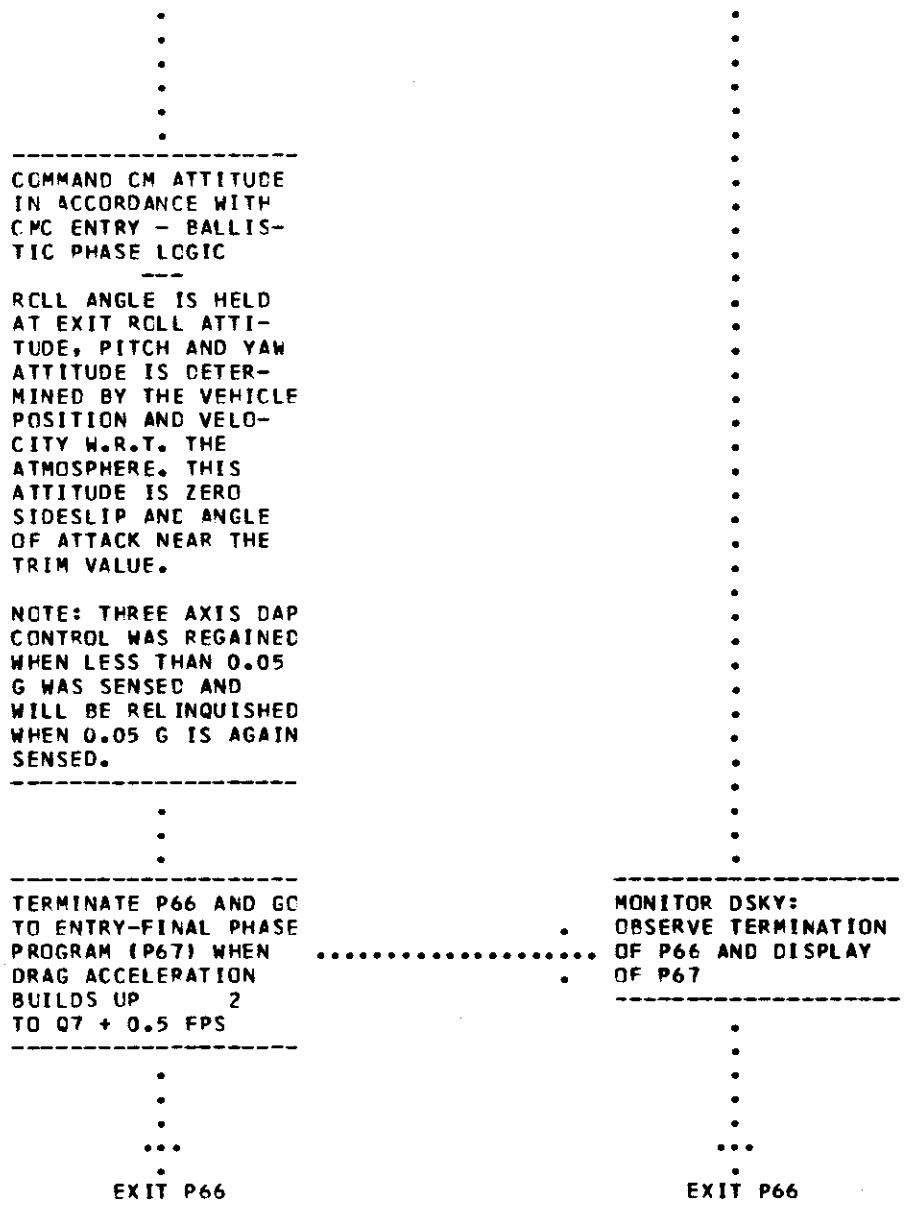
MONITOR GNCS CONTROL OF ENTRY:

FDAI: ATTITUDE ERROR NEEDLES - DIFFERENCE BETWEEN THE TOTAL DESIRED ATTITUDE AND THE ACTUAL ATTITUDE (FLY TO POLARITY).

#70

BALL: ACTUAL GIMBAL ANGLES READ ON BALL SHOULD AGREE WITH COMMANDED GIMBAL ANGLES READ ON DSKY.

#80



#90

#100

#110

#120

CHANGE CONTROL NOTES

REV 06 PCR MIT 66 00176000
REV 07 PCR NASA 155 00177000

'74

APOLLO COMPUTER LOGIC CHECKLIST INTERFACE

ENTRY - FINAL PHASE PROGRAM (P67)

LOGIC REV 09 11/29/68
CHECKLIST REV 10 04/27/68

PURPOSE: (1) TO CONTINUE ENTRY GUIDANCE AFTER Q7 + 0.5FPS^2 (OR APPROX. 0.2G) UNTIL TERMINATION OF STEERING WHEN THE CM VELOCITY WRT EARTH = 1000 FT/SEC (ALTITUDE IS APPROXIMATELY 65,000 FT.).

(2) TO CONTINUE ENTRY DSKY DISPLAYS.

ASSUMPTIONS: (1) THE PROGRAM IS AUTOMATICALLY SELECTED BY:

(A) P65 WHEN ADOT IS NEGATIVE AND THE V IS SUFFICIENTLY LOW (V-VL-C18 NEG)

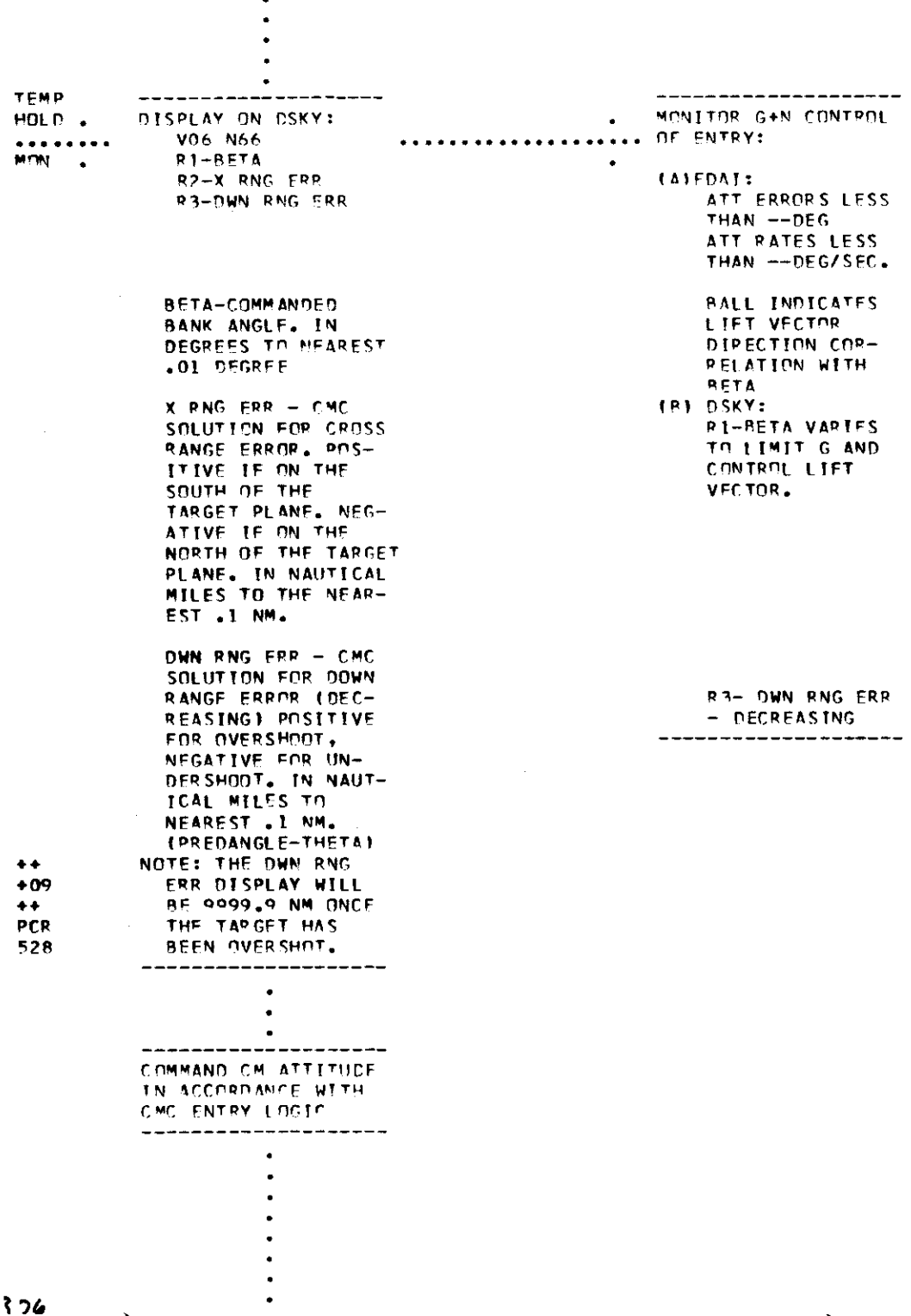
(B) P66 WHEN DRAG ACCELERATION BUILDS UP TO Q7 + 0.5 FPS.^{2} (OR APPROX. 0.2G)

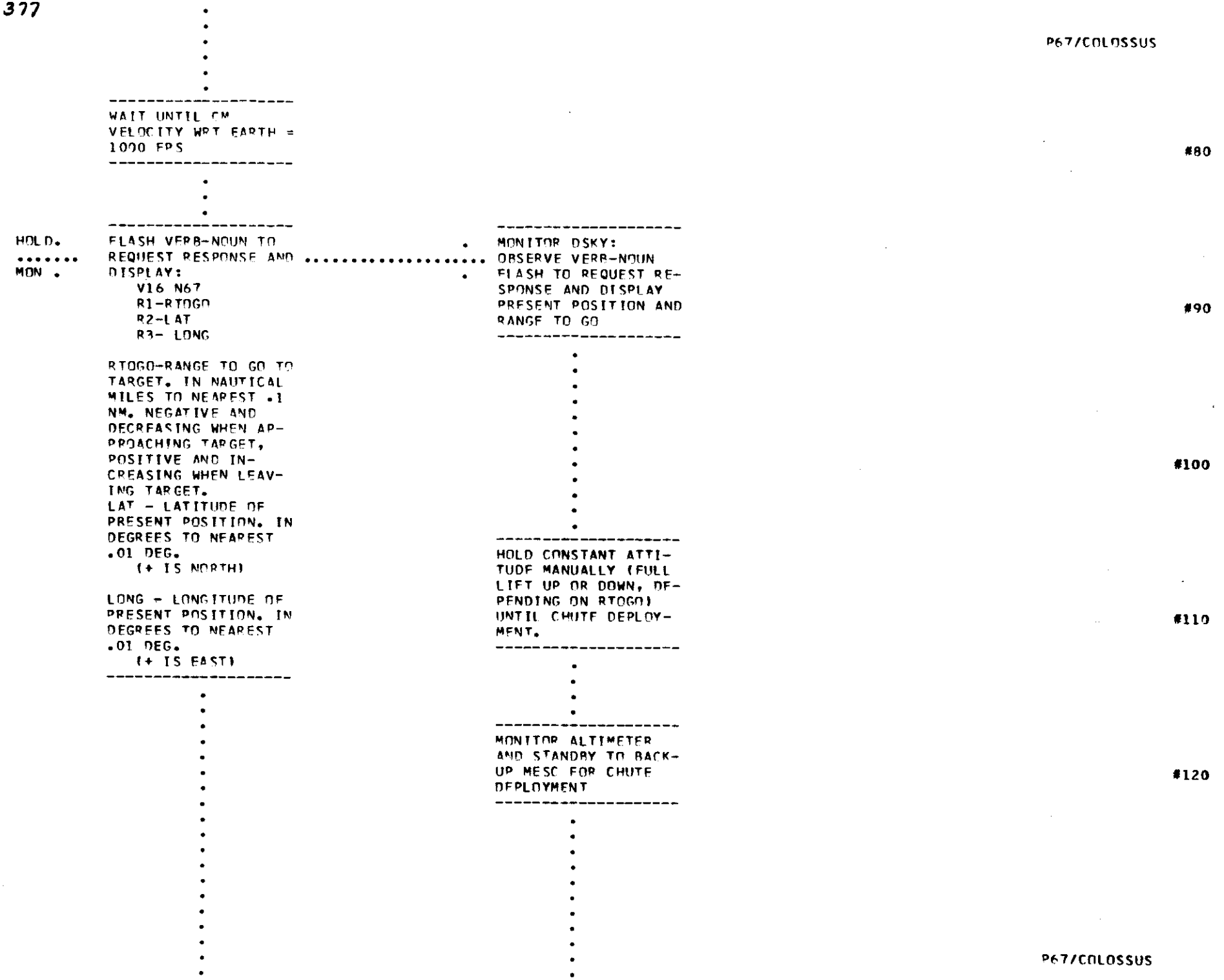
(C) P64 IF NO UPCONTROL SOLUTION EXISTS WITH VL > 18000 FPS

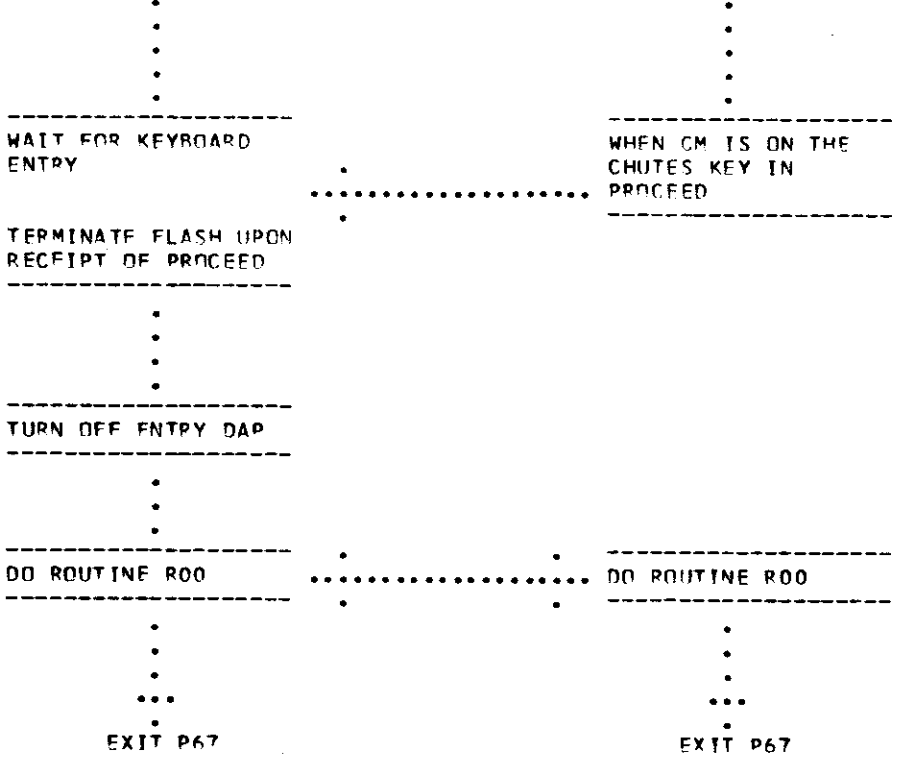
(2) THE ASTRONAUT MAY MONITOR N64 (G,VI,R TO GO) DURING THIS PROGRAM BY KEYING IN V16 N64E. HE ALSO MAY MONITOR N68 (BETA, VI, HDOT) BY KEYING IN V16N68E.

PROG CONT	CMC	GROUND	CREW	CHECKLIST	TIME	TOTAL TIME
	.CMC PROG. .SELECTION					
	START ENTRY-FINAL PHASE PROGRAM (P 67)					#10
	DISPLAY PROGRAM 67	.....	MONITOR DSKY: OBSERVE DISPLAY OF PROGRAM 67			#20

P67/COLOSSUS


TEMP
HOLD .
.....
MON .
DISPLAY ON DSKY:
V06 N66
R1-BETA
R2-X RNG ERR
R3-DWN RNG ERR
BETA-COMMANDED BANK ANGLE. IN DEGREES TO NEAREST .01 DEGREE
X RNG ERR - CMC SOLUTION FOR CROSS RANGE ERROR. POSITIVE IF ON THE SOUTH OF THE TARGET PLANE. NEGATIVE IF ON THE NORTH OF THE TARGET PLANE. IN NAUTICAL MILES TO THE NEAREST .1 NM.
DWN RNG ERR - CMC SOLUTION FOR DOWN RANGE ERROR (DECREASING) POSITIVE FOR OVERSHOOT, NEGATIVE FOR UNDERSHOOT. IN NAUTICAL MILES TO NEAREST .1 NM. (PREDANGLE-THETA)
++
+09
++
PCR
528
NOTE: THE DWN RNG ERR DISPLAY WILL BE 9999.9 NM ONCE THE TARGET HAS BEEN OVERSHOT.
COMMAND CM ATTITUDE IN ACCORDANCE WITH CMC ENTRY LOGIC
MONITOR G+N CONTROL OF ENTRY:
(A)FDAI:
ATT ERRORS LESS THAN --DEG
ATT RATES LESS THAN --DEG/SEC.
BALL INDICATES LIFT VECTOR DIRECTION CORRELATION WITH BETA
(B) DSKY:
R1-BETA VARIES TO LIMIT G AND CONTROL LIFT VECTOR.
R3- DWN RNG ERR - DECREASING
#30
#40
#50
#60
#70


WAIT UNTIL CM VELOCITY WRT EARTH = 1000 FPS
#80
HOLD. MON.
FLASH VERB-NOUN TO REQUEST RESPONSE AND DISPLAY:
V16 N67
R1-RTOGO
R2-LAT
R3- LONG
RTOGO-RANGE TO GO TO TARGET. IN NAUTICAL MILES TO NEAREST .1 NM. NEGATIVE AND DECREASING WHEN APPROACHING TARGET, POSITIVE AND INCREASING WHEN LEAVING TARGET.
LAT - LATITUDE OF PRESENT POSITION. IN DEGREES TO NEAREST .01 DEG.
(+ IS NORTH)
LONG - LONGITUDE OF PRESENT POSITION. IN DEGREES TO NEAREST .01 DEG.
(+ IS EAST)
MONITOR DSKY: OBSERVE VERB-NOUN FLASH TO REQUEST RESPONSE AND DISPLAY PRESENT POSITION AND RANGE TO GO
#90
#100
HOLD CONSTANT ATTITUDE MANUALLY (FULL LIFT UP OR DOWN, DEPENDING ON RTOGO) UNTIL CHUTE DEPLOYMENT.
#110
MONITOR ALTIMETER AND STANDBY TO BACK-UP MESC FOR CHUTE DEPLOYMENT
#120



#130

#140

#150

CHANGE CONTROL NOTES

REV 07 PCR MIT 66
REV 08 PCR 206
REV 09 PCR 528