



National Aeronautics and
Space Administration

16748
JSC-16478

JUL 30 1980

Lyndon B. Johnson Space Center
Houston, Texas 77058

CR-160772

STS-2
SAIL NON-AVIONICS SUBSYSTEMS
MATH MODEL REQUIREMENTS

Job Order 22-109
Contract NAS 9-15800

(JSC-16748) STS-2 SAIL NON-AVIONICS
SUBSYSTEMS MATH MODEL REQUIREMENTS (Lockheed
Engineering and Management) 484 p
HC A21/MF A01

#80-30369

CSCL 22B

Unclas
63/16 30951

Prepared By
Lockheed Engineering and Management Services Company, Inc.
Houston, Texas

For
SHUTTLE AVIONICS INTEGRATION DIVISION

July 1980



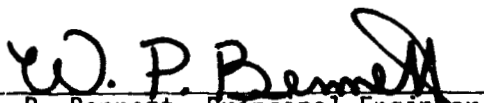
LEMSCO-14524

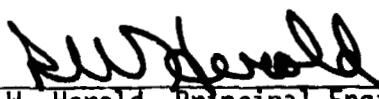
16748
JSC-16478

STS-2
SAIL NON-AVIONICS SUBSYSTEMS
MATH MODEL REQUIREMENTS


Job Order 22-109

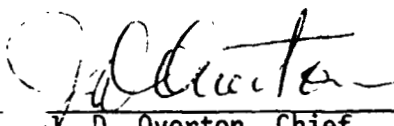
PREPARED BY


W. P. Bennett, Principal Engineer
Systems Integration Section
Systems Engineering Department, 625-21


R. W. Herold, Principal Engineer
Systems Integration Section
Systems Engineering Department, 625-21

APPROVED BY


B. E. Carlton, Supervisor
Systems Integration Section
Systems Engineering Department, 625-21


J. D. Overton, Chief
SAIL Operations Branch, EF2
SHUTTLE AVIONICS INTEGRATION DIVISION

Prepared By

Lockheed Engineering and Management Services Company, Inc.
Houston Texas

For

SHUTTLE AVIONICS INTEGRATION DIVISION
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LYNDON B. JOHNSON SPACE CENTER
HOUSTON, TEXAS

July 1980

LEMSCO-14524

SAIL NON-AVIONICS MATH MODEL CHANGE STATUS

SCR/ESCR NUMBER	DATE	MODEL/ PAGE(S)	CHANGE SUMMARY

ACKNOWLEDGEMENT

The SAIL non-avionics math model requirements contained in the appendices of this report resulted from the combined efforts of Lockheed Engineering and Management Services Company, Inc. (R. W. Herold and W. P. Bennett) and Rockwell/Downey (C. D. McPhail et. al.). These requirements are those based by the SAIL Change Control Panel.

CONTENTS

Section	Page
I. INTRODUCTION.	1
II. PURPOSE	1
III. DISCUSSION.	4
 APPENDIX	
A. APU/Hydraulics Math Model Requirements.	A-1
B. Vent Doors Math Model Requirements.	B-1
C. Umbilical Doors Math Model Requirements	C-1
D. ET Sep Pyros Math Model Requirements.	D-1
E. MPS Plumbing Math Model Requirements.	E-1
F. Fuel Cell/Cryo Math Model Requirements.	F-1
G. Atmosphere Revitalization/H2O Loops Math Model Requirements.	G-1
H. Atmosphere Revitalization/PCS-Airlock Math Model Requirements.	H-1
I. Active Thermal Control Math Model Requirements.	I-1
J. Smoke Detection Math Model Requirements	J-1
K. Water/Waste Management Math Model Requirements.	K-1
L. RCS/OMS (DFI) Math Model Requirements	L-1

TABLES

Table	Page
I. NON-AVIONICS MATH MODEL APPLICATIONS.	2

FIGURES

Figure	Page
1. SAIL Non-Avionics simulators functional interfaces.	3

I. INTRODUCTION

The SAIL non-avionics math models are required to support verification of the Ascent Ops 1 Avionics Configuration, On-Orbit Ops 2 Avionics Configuration, Entry Ops 3 Configuration, and the Backup Flight System. The non-avionics subsystems math models resident in the GTS and/or the STS and their application to testing each of the Ops configurations are summarized in Table I. The STS math models, with the exception of the RCS/OMS model, are implemented in the Ground Standard Interface Unit (GSIU) and interface with the flight critical MDMs, Development Flight Instrumentation (DFI) MDM and Operational Instrumentation (OI) MDMs via Signal Termination Modules (STMs). The RCS/OMS model output static parameter is implemented via Test Language in the Display and Control Module (DCM). The STS math models output only those measurements that are acquired by the flight software or are required for dedicated displays. Operational Instrumentation and Development Flight Instrumentation measurements that are downlinked only are not provided by the math models.

The GTS math models simulate only those subsystems, or portions of subsystems, that interface with the flight critical data bus and that are required to support GN&C testing. All instrumentation measurements nominally channelized in the OI MDMs and DFI MDMs are static parameters loaded in the GTS Non-avionics Simulator (NAS) and are outputted directly to the PCM Master Unit. The NAS will provide all OI and DFI parameters to be downlinked during OFT 1 flight. Functional interfaces of the STS and GTS non-avionics simulator are shown in figure 1.

II. PURPOSE

The purpose of this report is to provide a single source document for consistently controlling approved changes to the non-avionics math models. When changes are approved, change pages will be released and a change status page will accompany each change release. The change status page should be incorporated behind the signature page and will provide a history of all changes to this JSC report. The form of this change sheet is provided in the specified location of this document.

TABLE I.- NOR-AVIONICS MATH MODEL APPLICATIONS

MATH MODEL	IMPLEMENTATION REQUIREMENT	PRIMARY			
		ASCENT OPS 1	ON-ORBIT OPS 2 GNC SM	ENTRY OPS 3	BFS GNC SM
APU/	STS /GTS	✓	✓	✓	✓
HYDRAULICS	GTS	✓	✓	✓	✓
VENT DOORS	GTS	✓			
UMBILICAL DOORS	GTS	✓			
ET SEP PYROS	GTS	✓			
MPS PLUMBING	STS/GTS	✓			✓
FUEL CELL/CRYO	STS		✓		✓
ATMOS REVITALIZATION/H2O	STS		✓		✓
ATMOS REVITALIZATION/PCS- AIRLOCK	STS		✓		✓
ACTIVE THERMAL CONTROL	STS		✓		✓
SMOKE DETECTION SYSTEM	STS		✓		✓
WATER/WASTE MGMT	STS		✓		✓
RCS/QMS (DFI)	STS		✓		✓

SHUTTLE TEST STATION

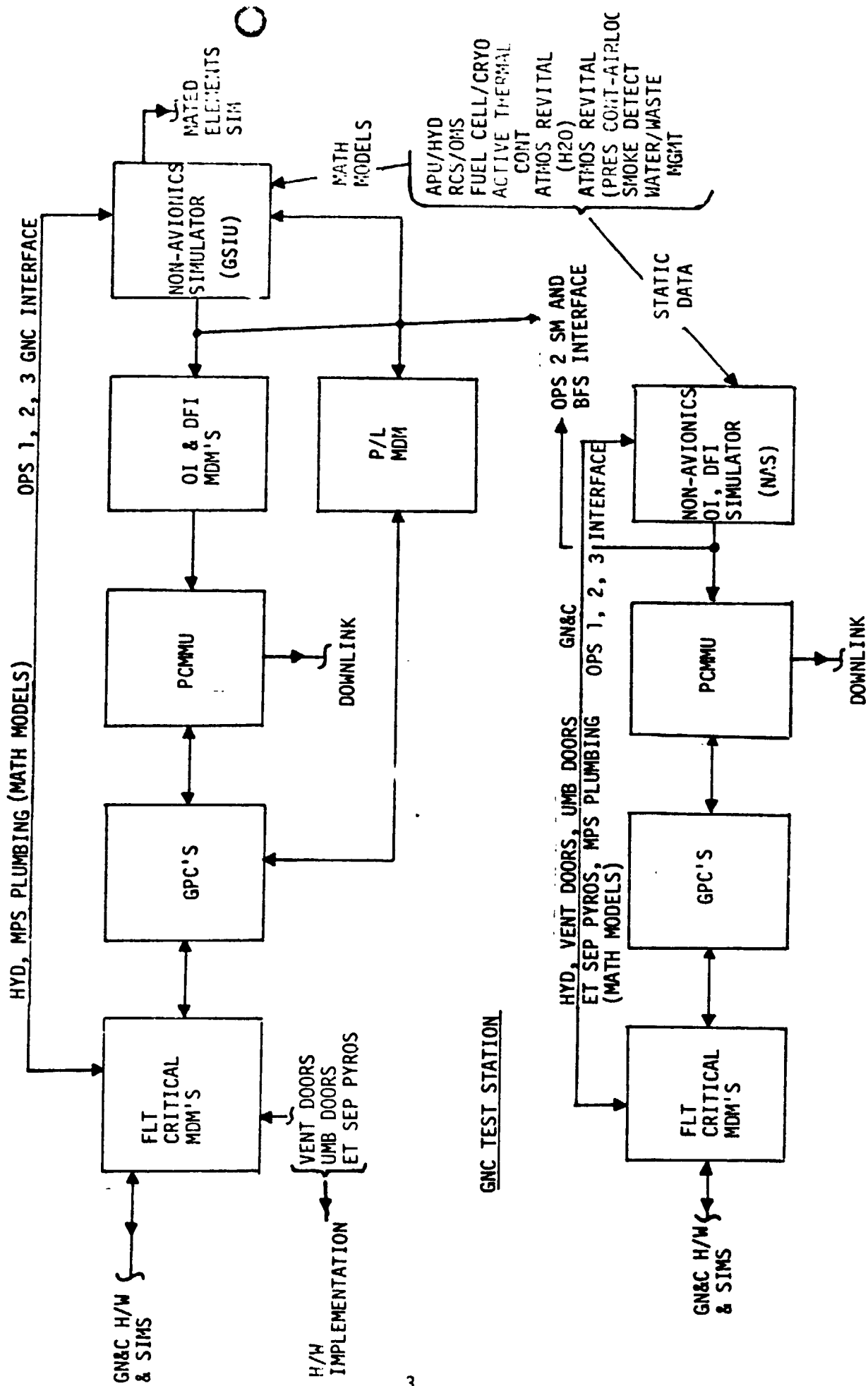


Figure 1.- SAIL Non-Avionics Simulators Interfaces.

III. DISCUSSION

The baselined SAIL non-avionics math model requirements are provided in Appendix A through L. Future approved SCR's will be identified on the Change Status Sheet which will be released with the revised math model pages and the title page (revision number change) for incorporation in this report.

APPENDIX A
APU/HYDRAULICS MATH MODEL REQUIREMENTS

TABLE OF CONTENTS

Section	Page
1.0 INTRODUCTION.	A-4
1.1 SHUTTLE TEST STATION (STS)	A-4
1.2 GN&C TEST STATION (GTS).	A-5
-----STS-----	
2.0 DETAILED REQUIREMENTS	A-7
2.1 FUNCTIONAL CHARACTERISTICS	A-7
2.1.1 APU.	A-7
2.1.2 HYD.	A-7
2.1.3 INPUT/OUTPUT	A-11
2.2 DCM UPLINK	A-11
2.3 INITIALIZATION REQUIREMENTS.	A-12
2.4 TERMINATION REQUIREMENTS	A-12
2.5 UNIQUE REQUIREMENTS.	A-13
2.5.1 $i = 1, 2, 3$	A-13
2.5.2 $\alpha = i + 3, \gamma = i - 1$	A-13
2.5.3 $K = 1, 2, 3$	A-13
2.5.4 TURBINE SPEED ($V46Roi35A>0$)=(APU i RUN MODE)	A-13
2.5.5 APU TURBINE OVERSPEED OR UNDERSPEED CONDITIONS	A-14
2.5.6 BFS MEASUREMENTS	A-15
2.5.7 APU HEATER THERMAL SWITCHES.	A-16
2.6 ANALOG MEASUREMENTS.	A-17
2.6.1 POLYNOMIAL CONVERSION METHOD	A-17
2.6.2 RANGE LIMIT CONVERSION METHOD.	A-20

Section	Page
3.0 LOGIC FLOW DIAGRAMS.	A-22
4.0 TABLES	A-40
4.1 INPUT STIMULI LIST.	A-40
4.2 OUTPUT MEASUREMENT LIST	A-46
5.0 STS REFERENCES	A-51
-----GTS-----	
12.0 GTS DETAILED REQUIREMENTS.	A-63
12.1 GTS FUNCTIONAL CHARACTERISTICS.	A-63
12.2 NAS UPLINK REQUIREMENTS	A-63
12.3 GTS INITIALIZATION REQUIREMENTS	A-63
12.4 GTS TERMINATION REQUIREMENTS.	A-65
12.5 GTS UNIQUE REQUIREMENTS	A-65
13.0 GTS LOGIC FLOW DIAGRAMS.	A-66
14.0 GTS INPUT/OUTPUT TABLES.	A-68
14.1 TABLE 14.1 - INPUT STIMULI.	A-69
14.2 TABLE 14.2 - OUTPUT MEASUREMENTS.	A-70
14.3 NAS CRT DISPLAY	A-71
15.0 REFERENCES	A-73

FIGURES

Section	Page
FIGURE 1 STS SYSTEM DATA FLOW	A-8
FIGURE 2 APU SUBSYSTEM SCHEMATIC.	A-9
FIGURE 3 HYD SUBSYSTEM SCHEMATIC.	A-10
FIGURE 4 GTS SYSTEM DATA FLOW	A-64
FIGURE 5 NAS CRT DISPLAY	A-72

1.0 INTRODUCTION

The Shuttle Avionics Integration Laboratory (SAIL) consists of a Shuttle Test Station (STS) and a GN&C Test Station (GTS). Both of these test stations use math models to simulate many of the shuttle systems for which hardware has not been provided. A group of these models are termed "non-avionic" models since they do not simulate the shuttle's avionic systems. The non-avionic models are needed to supply data for on-board software processing, to drive cockpit displays, and to respond to shuttle commands, whether they be from the cockpit switches or from the General Purpose Computers (GPC's). Because the STS and the GTS are configured differently, the non-avionic math models needed to support each test station are shown below:

<u>Non-Avionic Math Model</u>	<u>STS</u>	<u>GTS</u>
APU/Hydraulics	*	•
Main Propulsion System	•	•
RCS/OMS	*	
Fuel Cell/Cryogenics	*	
ATMOS Revital/Water Loops	*	
ATMOS Revital/Press Control - Airlock	•	
Active Thermal Control	•	
Smoke Detection	*	
Water/Waste Mgt.	*	
ET/ORB FWD SEP PYROS		*
ET UMB COUT Door/Latch		*
Vent Doors		*

Where the same math model is needed in both test stations, the math model requirements document is divided into a STS section and a GTS section, so that unique test station requirements may be identified.

1.1 SHUTTLE TEST STATION (STS)

When the TOC Display and Control Module (DCM) operator depresses the "SYS LOAD" key, the model programs, which are stored on the Fixed Head Disk in the DCM, are automatically loaded into the GSIU. The models are then activated and terminated by DCM test language statements. While the models

are operating in the GSIU, the DCM operator is able to inhibit one, all, or any combination of model outputs with test language statements. This provides the DCM operator with control of output parameter values when off-nominal conditions are desired. To simplify the models and ease the processing load on supporting test equipment, the model requirements define nominal conditions only. Further, analog values for output parameters change in step fashion when responding to inputs, except when specific change rates for particular parameters are required. The DCM operator is also able to alter the value that the model uses to generate parameter outputs. This allows the DCM operator to adjust output parameter values as needed to satisfy various mission phases.

When the model is activated, it shall check the input stimuli and shall provide appropriate output measurement values. It is preferred that the model provide output data when the input stimuli changes. Bus activity is then minimal during those mission phases when the stimuli remains constant. However, the GSIU operating system may require a cyclic model program in which case the model output rate shall be once per second.

1.2 GN&C TEST STATION (GTS)

To simplify the models and ease the processing load on supporting test equipment, the model requirements specify nominal conditions only. Analog values for output parameters change when input values dictate a change, or when the test operator manually sets parameter values. Because GTS has an incomplete set of cockpit switches, some switch inputs used in STS must be entered in GTS by the simulator operator. This method allows the use of the same logic for STS and GTS.

**STS
SECTION**

2.0 DETAILED REQUIREMENTS

This model simulates those functions of the Auxiliary Power Unit (APU) and the Hydraulics (HYD) subsystems that are in the Orbiter. To simplify the model, only those subsystem functions needed to support testing of the Shuttle avionics system are provided.

The model receives stimuli from one source, the flight system via the Signal Termination Module (STM); the model provides output parameter values to the flight system via the STM. Figure 1 illustrates the data flow in and out of the model. Tables 1 and 2 list the input stimuli and output measurements.

Internal to the model is considerable "cross-talk" between the APU and the HYD areas. An attempt was made to keep these two areas separate for modular simplicity. The "cross-talk" involved here is transparent to the user and requires no special conditioning.

2.1 FUNCTIONAL CHARACTERISTICS

2.1.1 APU

The APU subsystem consists of three APU packages providing the mechanical power necessary to drive the main hydraulic pumps. Inputs from the flight system (FS) drive the model to simulate a dedicated control unit for each APU, which will maintain the selected speed and, in the event of the limiting conditions being exceeded, will automatically shut the unit down. Override control is provided by a crew switch. The APU turbine drives the gearbox which in turn drives the main hydraulic pump. Figure 2 is a functional diagram of the APU system.

2.1.2 HYD

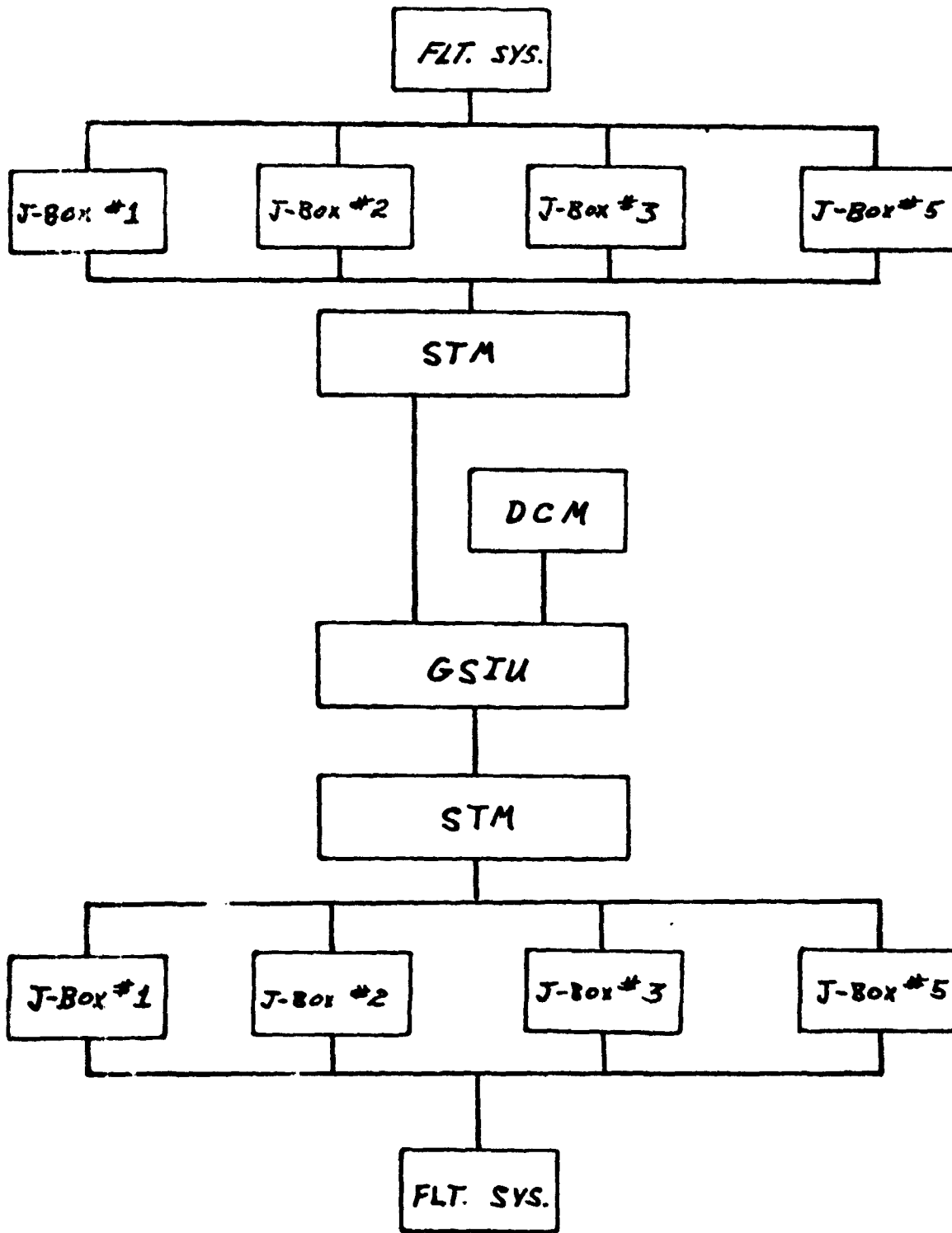
The hydraulic pump is driven by the APU, and the speed is dependent upon whether input stimuli is selected to Normal or High speed mode. Hydraulic power is supplied to aerosurface controls (elevons, rudder, body flap, and speedbrake), landing gear, wheel brakes, and nosewheel steering. Figure 3 is a functional diagram of the HYD system.

Hydraulic fluid must be cooled during main pump operation; and, therefore, the model simulates a water boiler which removes heat from the system fluid.

When the APU's are shut down (idle), a circulation pump maintains fluid circulation to prevent freezing.

A reservoir and nitrogen pressurized accumulator are also a part of the system, and the model simulates these I/O parameters also.

The hydraulic subsystem incorporates functional redundancy. This redundancy is obtained by switching valves which provide the capability for any one of the subsystems connected to the switching valves to supply the function in the event of failure of the other connected subsystems.



INPUT/OUTPUT DATA FLOW

FIGURE 1

ORIGINAL PAGE IS
OF POOR QUALITY

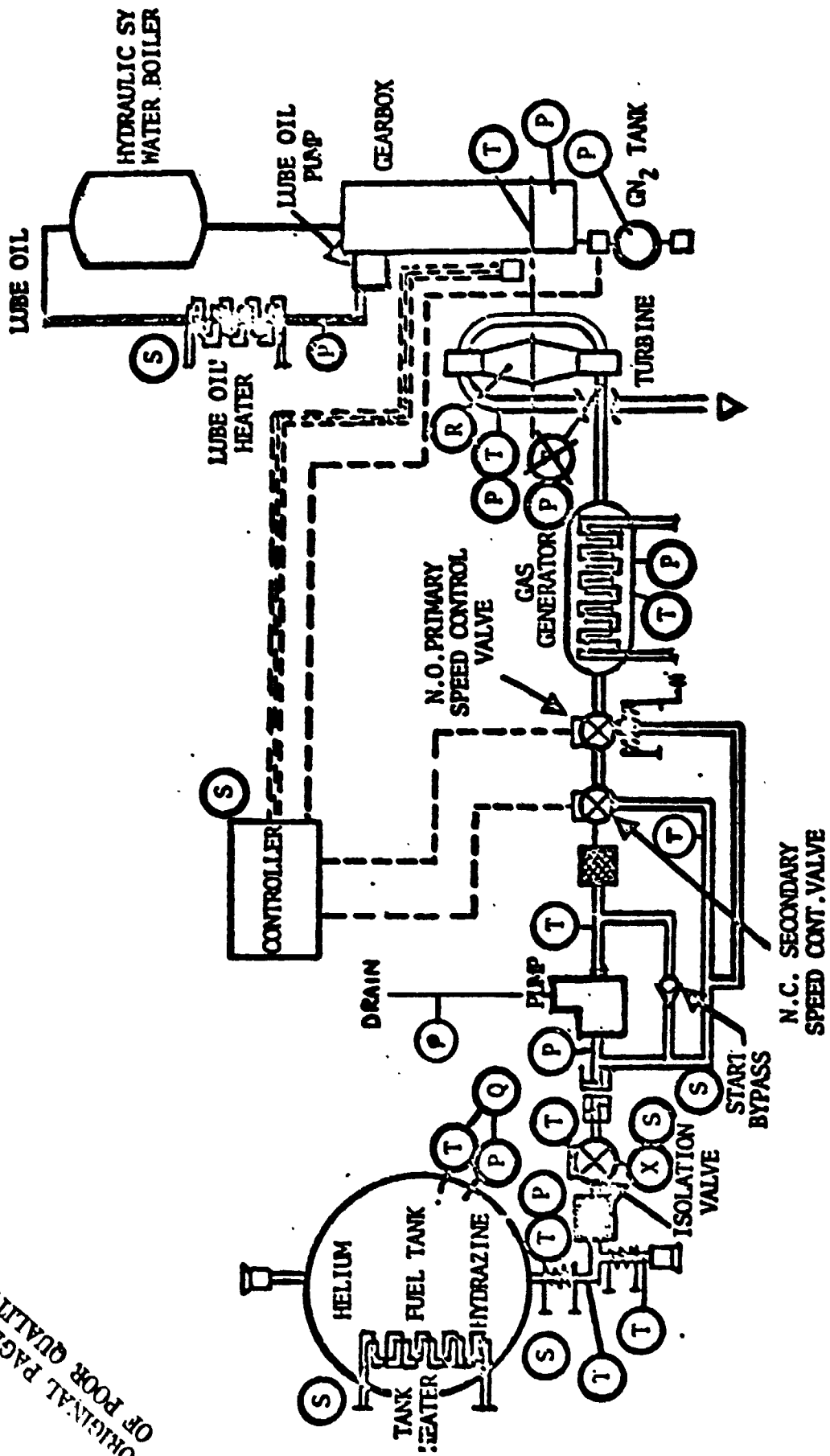


Figure 2.- Auxiliary power unit block diagram.

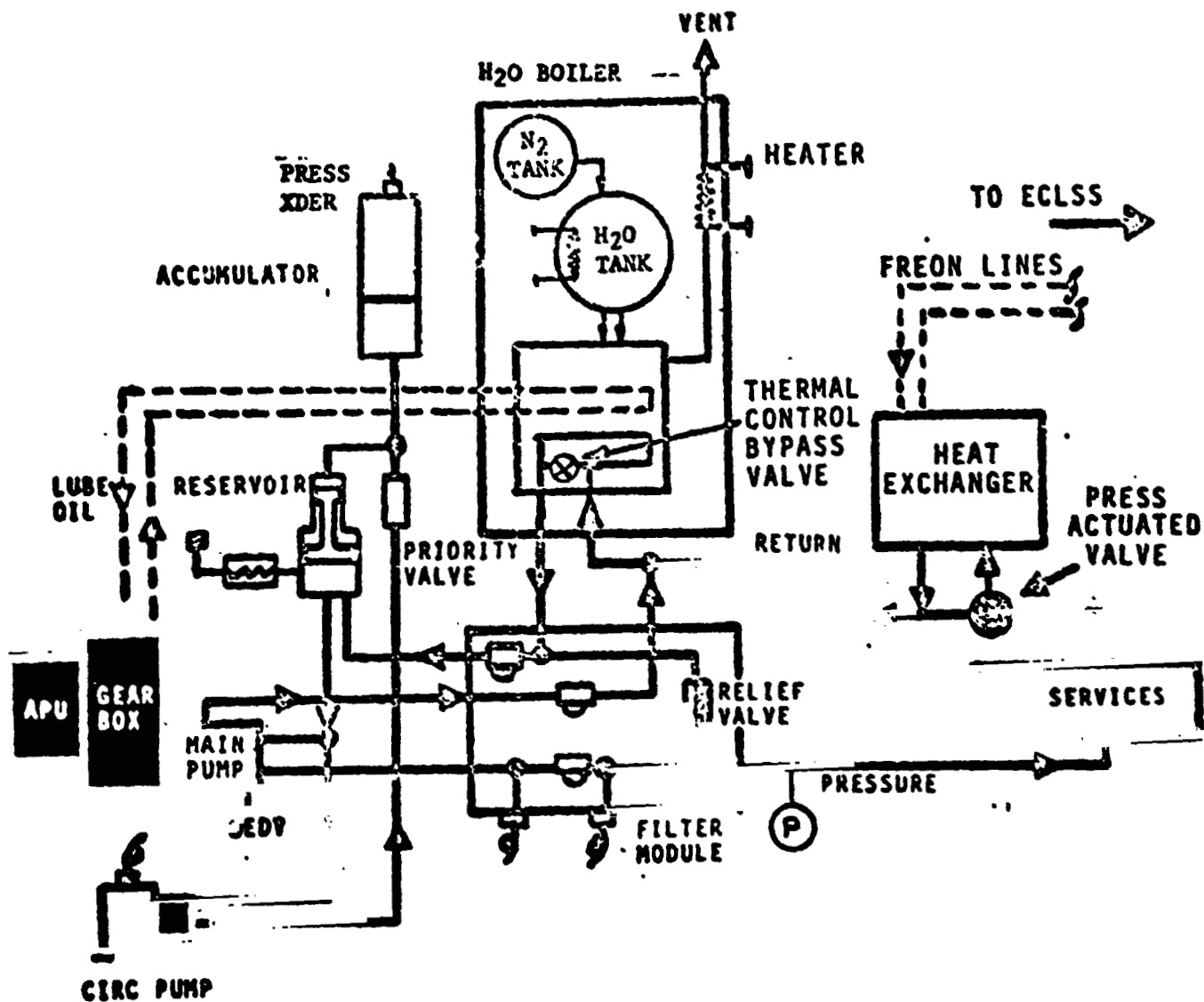


Figure 3.- Hydraulic system (typical for systems 1, 2, and 3).

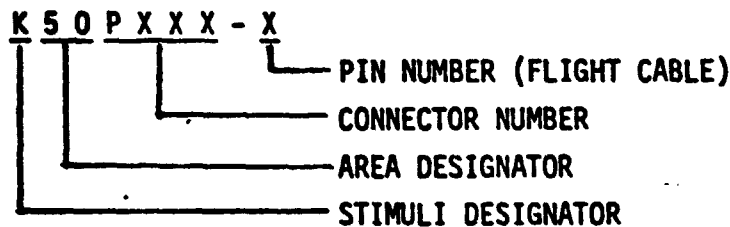
2.1.3 Input/Output

All inputs to the model are from the FS addressable at the STM. These stimuli are acted upon immediately at model execution without regard to time, and conditions are simulated in a step function manner. For example: APU fuel will always be shown as maximum quantity (pressure) and will not be depleted with time. Any time dependent inputs must be up-linked from the TOC-DCM as an abnormality (or parameter value change) in accordance with the GSIU Operating System.

For the sake of simplicity, the model will do no fault detection of stimuli, but will act upon it as received from the FS. Therefore, any fault insertion must include changes to all affected parameters in order to obtain a realistic response from the model.

All subsystem output is simulated by the model in accordance with stimuli from the FS. All measurements are made available to Systems Management (SM) and Fault Detection and Annunciation (FDA) as required.

The stimuli identification numbers used are coded to provide the following information at the SAIL flight cable/GSE/C70-1140 cable set interface.



Exceptions to this code are those stimuli with a letter for the connector number where the connector number is unknown. Also the stimuli which comes from the DCM instead of the flight cable do not agree with this code. Signal Termination Module (STM) addresses for both stimuli and measurements are yet to be defined.

2.2 DCM UPLINK

The only values passed from the DCM will be those which involve output suppression and fault insertion in accordance with the GSIU Operating System and are not a part of this document.

2.3 INITIALIZATION REQUIREMENTS

Refer to Table 2 entitled "Measurement Output from APU/HYD Model" for initialization requirements.

2.4 TERMINATION REQUIREMENTS

None.

2.5 UNIQUE REQUIREMENTS

There exists a requirement for some measurements within the model to reflect a nominal, Hi/Low, and off condition. The condition is determined by (a) the system running normally, (b) the system being idle, but the circulation pumps running, and (c) all functions in an off mode. There is also the requirement for the model to be capable of functioning in a triple-redundant mode.

In order to best show these requirements, the following criteria were set up and are used throughout this document.

2.5.1 $i = 1, 2, 3$

Where (i) represents the system; APU1, APU2, or APU3, respectively.

2.5.2 $\alpha = i + 3, \gamma = i - 1$

These relationships were established for simplicity and ease of representing logic flow diagrams within this requirements package.

2.5.3 $K = 1, 2, 3$

Where (K) represents the condition existing for the system, ie:

- 1 = Nominal Mode
- 2 = Circulation Pumps On
- 3 = Idle Mode

The value K is then used to find the correct measurement value needed to reflect the proper conditions. These measurement values will be found in Table 2 entitled, "Measurement Output from APU/HYD Model".

NOTE: The flow diagrams refer to the value tables in the following manner:

MEAS. = Value (K)

Where MEAS. is the output measurement.

VALUE is one of three possible values for that particular MEAS.

(K) is a pointer that shows which of the three values is applied.

EXAMPLE: V58T0101A = VALUE (2) = 40°F

- 2.5.4 TURBINE SPEED (V46R0135A)>0 = APU i RUN MODE
- TURBINE SPEED (V46R0135A)<=0 = APU i IDLE MODE

2.5.5 APU Turbine Overspeed or Underspeed Conditions

As described in paragraph 2.1.3, the model simulates nominal conditions only, and when off-nominal conditions are required they must be entered by the operator at the DCM console. Such is the case when simulating APU turbine overspeed or underspeed, except the model output inhibit function at the DCM is not necessary. The six DCM input commands listed in table 1 will cause the appropriate output measurements to change, thereby simulating an overspeed or underspeed condition. When the DCM commands are zero, nominal conditions are produced by the model.

2.5.6 BFS MEASUREMENTS

The hydraulic measurements listed in the following table are used by the Back-up Flight System (BFS). These measurements are processed differently than the ones listed in paragraph 2.5.6. The MDM input voltage for the BFS measurements must be converted to Flight System (FS) counts before the polynomial equation defined in paragraph 2.5.6 may be used. The conversion to FS counts must take into account two factors:

- One factor is that 5 volts into the MDM is equal to 500 FS counts, or 100 counts per volt.
- The second factor is that the BFS software shifts the FS count value by 64.

Consequently, the voltage provided by the STM to the input of the MDM must be multiplied by (100) and by (64), before the polynomial equation in paragraph 2.5.6 may be used for BFS calculations.

EXAMPLE:

MDM INPUT VOLTAGE FOR V58T0830A = 2.6 VDC

$$2.6 \times 100 \times 64 = 16640 = X$$

$$EU = A_1 X + A_0 = 0.01171875 (16640) + (-75)$$

$$EU = 120$$

MEAS MML#	T	O	C	BFS MEAS COEFFICIENTS				FLIGHT SYSTEM EU
	GSIU EU	GSIU COUNTS	MDM IN- PUT VDC	A ₃	A ₂	A ₁	A ₀	
V58T0830A	120	532	2.60	--	--	0.01171875	-75	120
↓ 880A	126	548	2.68	--	--	↓	↓	126
↓ 930A	132	565	2.76	--	--	↓	↓	132
↓ 980A	138	581	2.84	--	--	↓	↓	138
V57T0014A	144	597	2.92	--	--	↓	↓	144
↓ 18A	150	614	3.00	--	--	↓	↓	150

2.5.7 APU HEATER THERMAL SWITCHES

Certain APU heaters are controlled by thermal switches in the APU controller. For simplification of the APU math model, the operation of the thermal switches and the cycling of heater temperatures are not simulated, but instead the thermal switches are simulated closed and heater temperatures are a function of heater power only. The control logic for the thermal switches resides in the flight system Load Controller Assembly (LCA) hardware; therefore, the APU math model must send "thermal switch on" signals to the LCA. The LCA then transmits a heater power signal to the APU math model whenever the heater power switch is "ON". Since the thermal switch signals to the LCA and the math model do not have MML ID numbers, pseudo numbers have been assigned, reference Table 2 - pages A-45 and A-46.

2.6 ANALOG MEASUREMENTS

Values shown in the math model flowcharts are in GSIU counts for all analog measurements. The math model values are seen by the flight system as 0 to 5 VDC inputs. The flight system then converts these input voltages to engineering units using one of the two types of scaling equations discussed in Sections 2.6.1 and 2.6.2. The GSIU math model count values (or the count values entered at the DCM by the test operator) must consider the scaling computation done later by the flight software, so that correct flight system engineering unit values are obtained for fault detection and annunciation (FDA), and for cockpit displays. The following two sections, 2.6.1 and 2.6.2, describe the scaling equations which apply to this model. Section 2.6.1 describes the scaling equation for measurements which require the polynomial conversion method. Section 2.6.2 describes the scaling equation for measurements which require the range limit conversion method which was used on STS-1.

2.6.1 POLYNOMIAL CONVERSION METHOD

The scaling polynomial equation used by the flight system is defined in the SM FSSR. The general form of the equation is given as follows:

$$FS_{EU} = A_0 + A_1X + A_2X^2 + A_3X^3$$

where: FS_{EU} = flight system engineering units

X = flight system input voltage

A_0, A_1, A_2, A_3 = scaling polynomial coefficients

The following example shows the step by step procedure for converting analog measurements from flight system engineering units (FS_{EU}) to GSIU counts. This procedure may be used to calculate GSIU count values for fault insertion at the DCM.

Example:

For measurement no. V63R1100A, convert FS_{EU} value = 2288 to GSIU counts.

Step 1:

In the SM FSSR, look up the measurement no. (V63R1100A) within the "SMM Data Requirements - Subsystems Displays" table. The measurement no. will appear on two consecutive pages as follows: page A will show engineering units, range low value and range high value, while page B will show the scaling polynomial coefficients (labelled A_0 , A_1 , A_2 , A_3) followed by curve order, independent variable, and STS flight no. The values on page B will be of prime interest to do this example conversion, and will be referred to in the following discussion.

Step 2:

The coefficients will be used in the scaling polynomial:

$$FS_{EU} = A_0 + A_1X + A_2X^2 + A_3X^3$$

Solve the following scaling polynomial for X:

$$2288 = 443.167 + 851.956X - 143.904X^2 + 12.246X^3$$

$$\text{so } X = 3.846469$$

Step 3:

Notice the independent variable column labelled IND VR equals 2 for measurement no. V63R1100A. The 2 specifies that the independent variable X of the scaling polynomial is defined on a range of 0 to 5 VDC. So $X = 3.846$ VDC.

It is of interest to note that if IND VR had been equal to 0, X would have been defined on a range of 0 to 1023 PCM integer counts in which case X would be equal to 4 PCM counts, i.e. 3.846 rounded to the nearest integer.

However, in the example being worked, X is defined on a range of 0 to 5 VDC and $X = 3.846$ VDC.

Step 4:

Now, to convert X VDC to GSIU counts, evaluate the following equation which shows the relationship between X and GSIU counts:

$$\text{GSIU counts} = \left[X \left(\frac{1023}{K} \right) \right], \text{ rounded to the nearest integer}$$

where $K = 5$, for X defined as VDC (IND VR = 2) and

$K = 500$, for X defined as PCM counts (IND VR = 0).

For the example, evaluate:

$$\text{GSIU counts} = \left[3.846 \left(\frac{1023}{5} \right) \right], \text{ rounded to the nearest integer}$$

Therefore, GSIU counts = 787 counts.

Note that since GSIU counts are always rounded to the nearest integer, small changes will possibly occur in the values of X and consequently FS_{EU} , when the reverse calculations are made during test operations, as the following shows:

$$X = \text{GSIU counts} \left(\frac{K}{1023} \right)$$

$$X = 787 \times \left(\frac{5}{1023} \right)$$

$$\text{SO } X = 3.846529$$

And

$$FS_{EU} = 443.167 + 851.956X - 143.904X^2 + 12.246X^3$$

$$FS_{EU} = 443.167 + 851.956(3.848) - 143.904(3.848)^2 + 12.246(3.848)^3$$

$$FS_{EU} = 2288.017$$

Hence when 787 GSIU counts is inserted for measurement no. V63R1100A, a value of 2288.017 FS_{EU} will result.

2.6.2 RANGE LIMIT CONVERSION METHOD

Several analog measurements in this model are calculated according to the range limit conversion method, instead of the polynomial conversion method as described in Section 2.6.1 of this document. The form of the scaling equation for these cases is given as follows:

$$FS_{EU} = Low + \frac{GSIU_{CTS}}{1023} (High - Low)$$

where: FS_{EU} = flight system engineering units

$GSIU_{CTS}$ = GSIU math model count values

Low = Range low limit

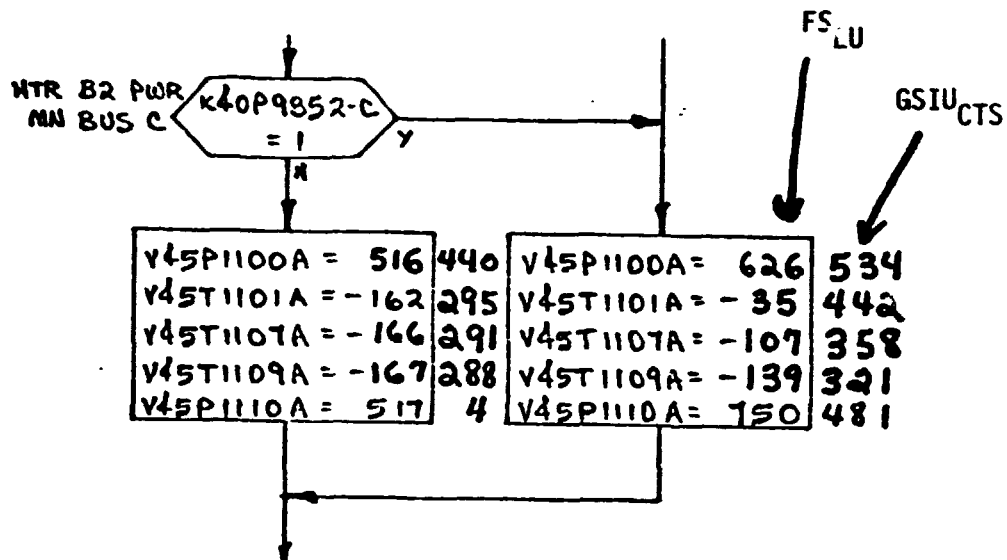
High = Range high limit

The following table shows a sample data value for each measurement which requires this type of calculation. The measurement I.D. is shown along with high and low values for the parameter range. The FS column shows the data value in flight system engineering units calculated from the GSIU counts marked CTS in the table. These measurements are marked with an asterisk (*) in the Output Measurement List marked as Table 2 in Section 4.2 of this document.

MEASUREMENT ID	RANGE LOW	RANGE HIGH	FS	CTS
V46T9180A	0	+1500	419	286
V46T9280A	0	+1500	479	327
V46T9380A	0	+1500	540	368
V46T9132A	-100	+500	56	266
V46T9270A	0	+250	86	352
V46T9513A	-75	+300	69	393
V58P0114C	0	+4000	3022	773
V58P0214C	0	+4000	3124	799
V58P0314C	0	+4000	3226	825
V58P0116C	0	+4000	3300	844
V58P0216C	0	+4000	3402	870
V58P0316C	0	+4000	3152	806

3.0 LOGIC FLOW DIAGRAMS

The logic flow diagram is made up of interconnected lines, boxes, decisions, and offpage connectors. Notice that where analog measurements are listed in boxes and decisions, the value inside the box is in flight system engineering units (FS_{EU}) while the corresponding GSIU count value is listed outside the box. For example, the box on the right hand below,



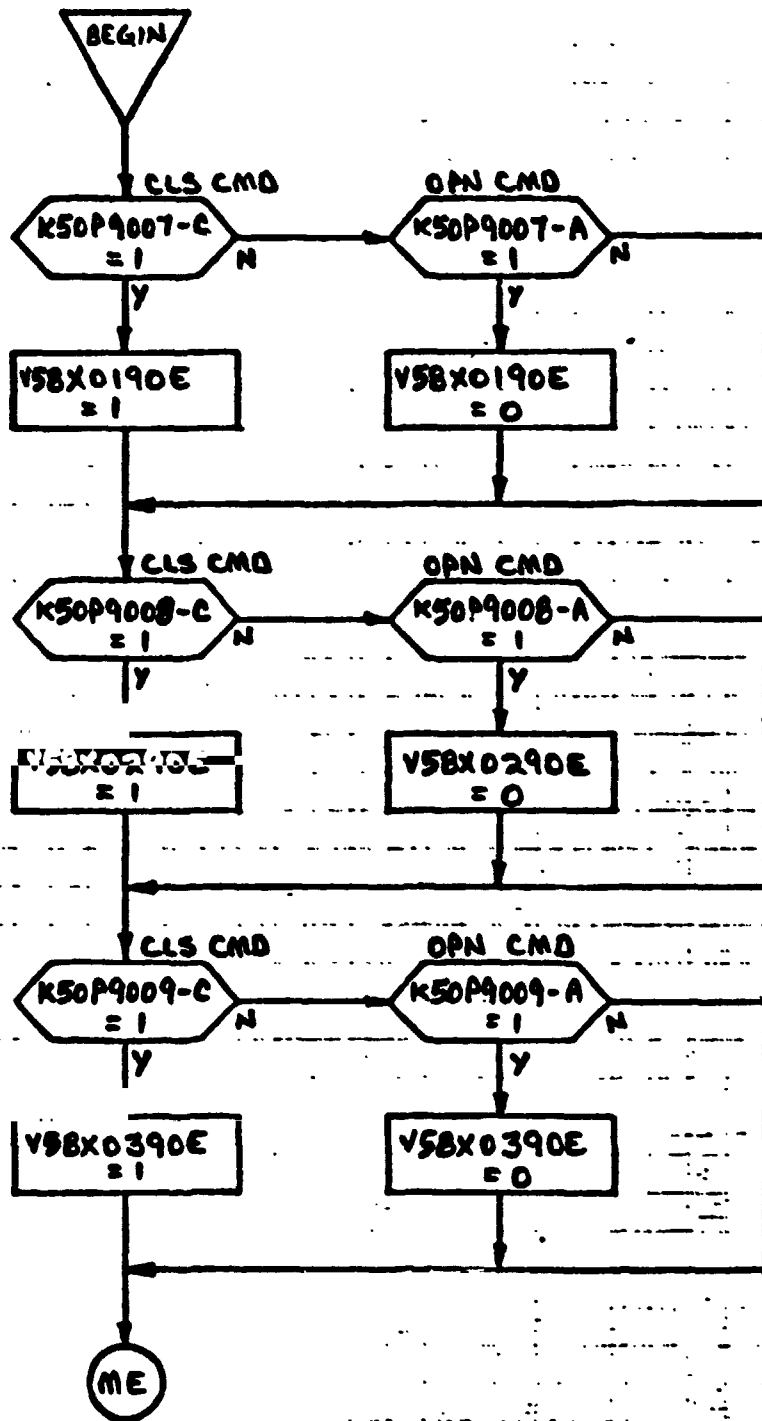
shows that V45P1100A is set equal to 626 FS_{EU} which is equivalent to 534 $GSIU_{CTS}$ shown outside the box.

ORIGINAL PAGE IS
OF POOR QUALITY

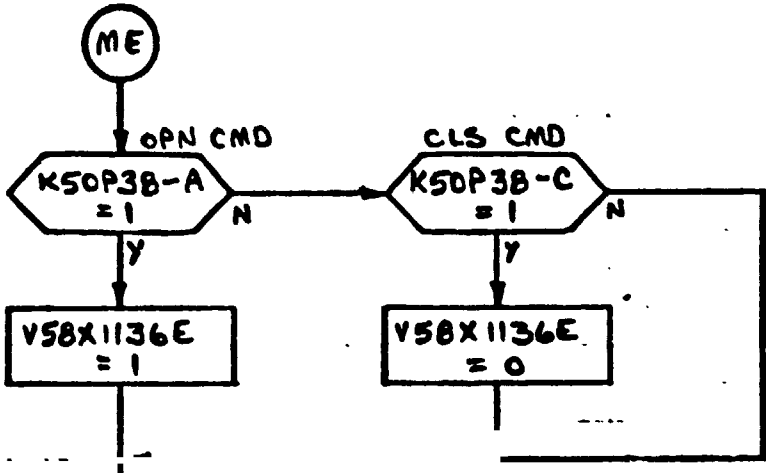
SYS 1 LDG
ISOL VLV

SYS 2 LDG
ISOL VLV

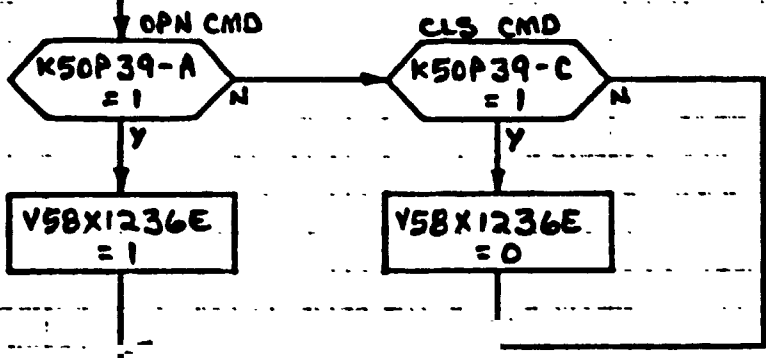
SYS 3 LDG
ISOL VLV



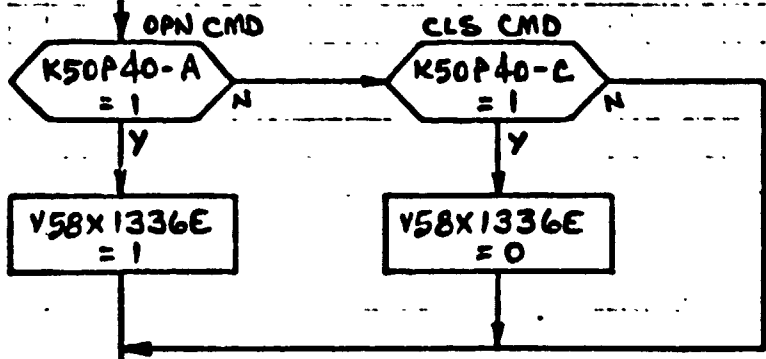
SYS 1 ME/TVC
SPLY VLV

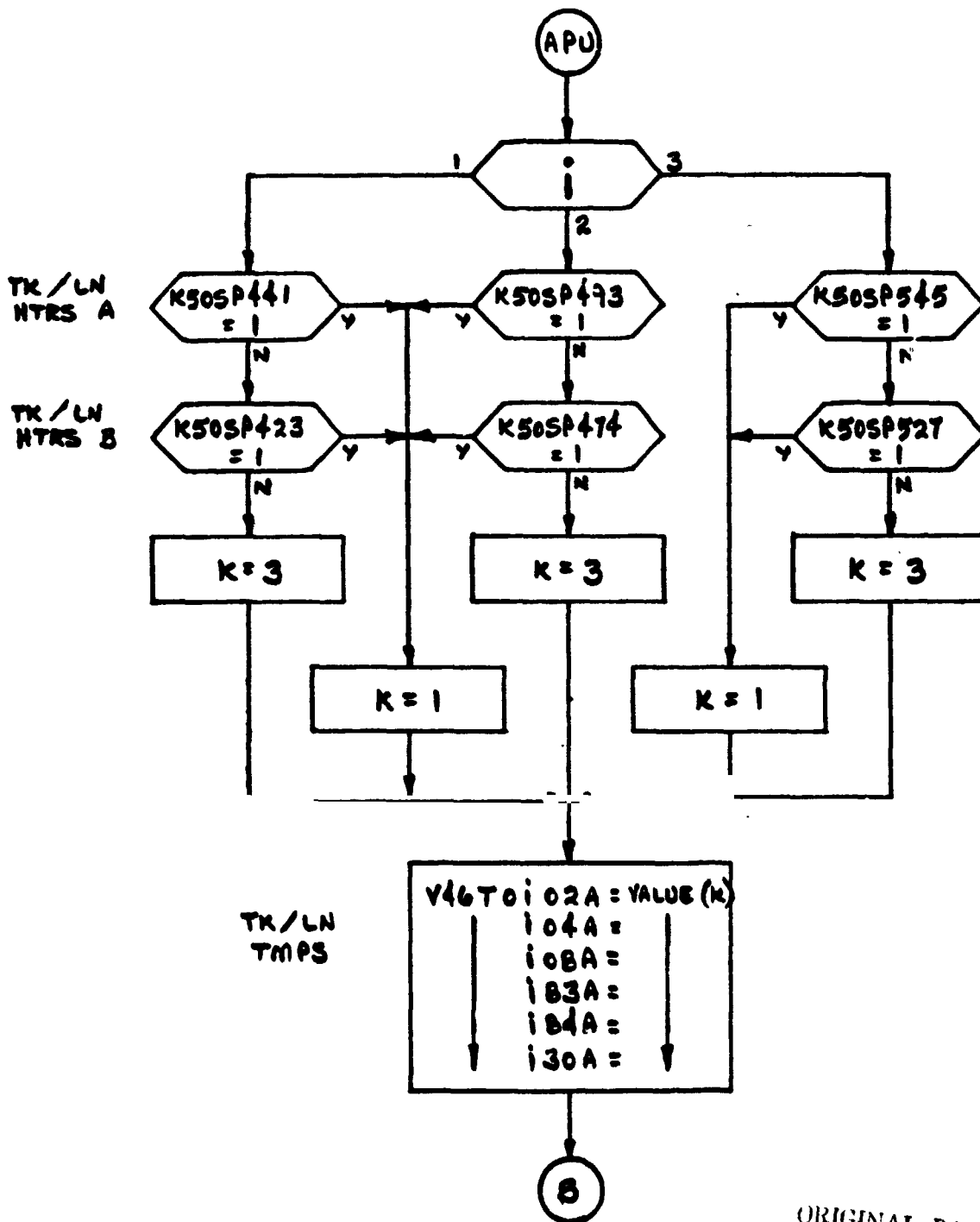


SYS 2 ME/TVC
SPLY VLV

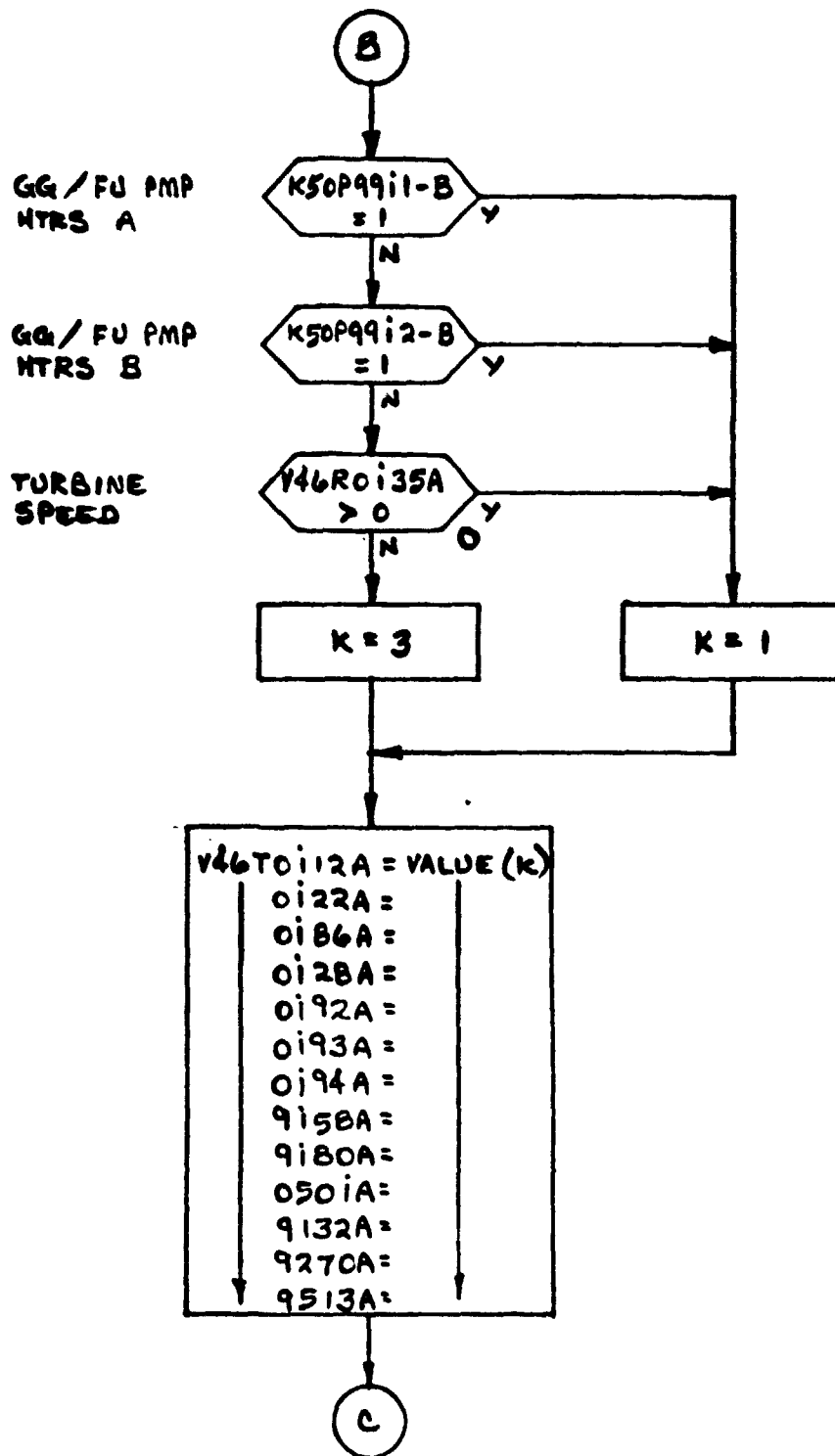


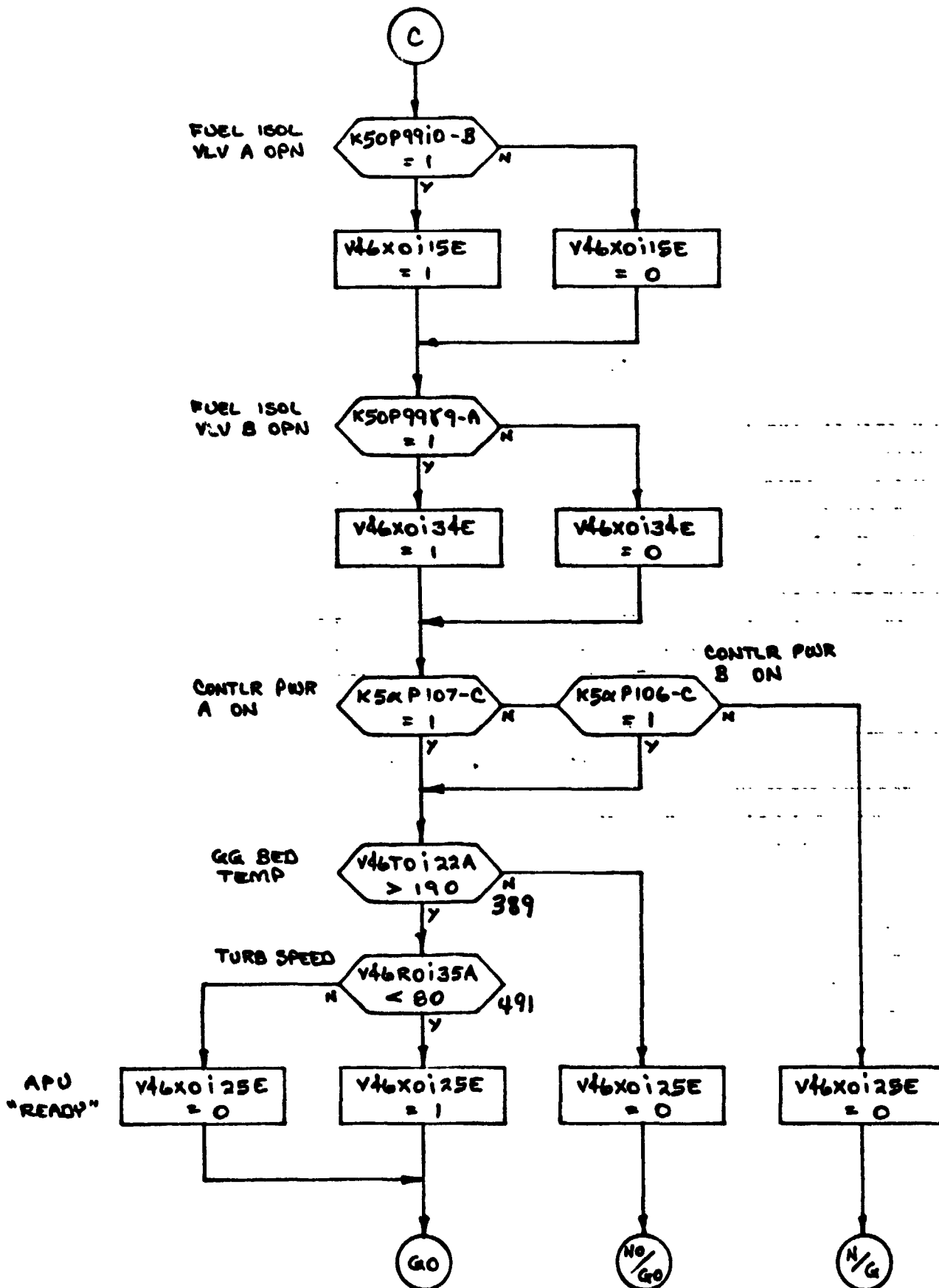
SYS 3 ME/TVC
SPLY VLV

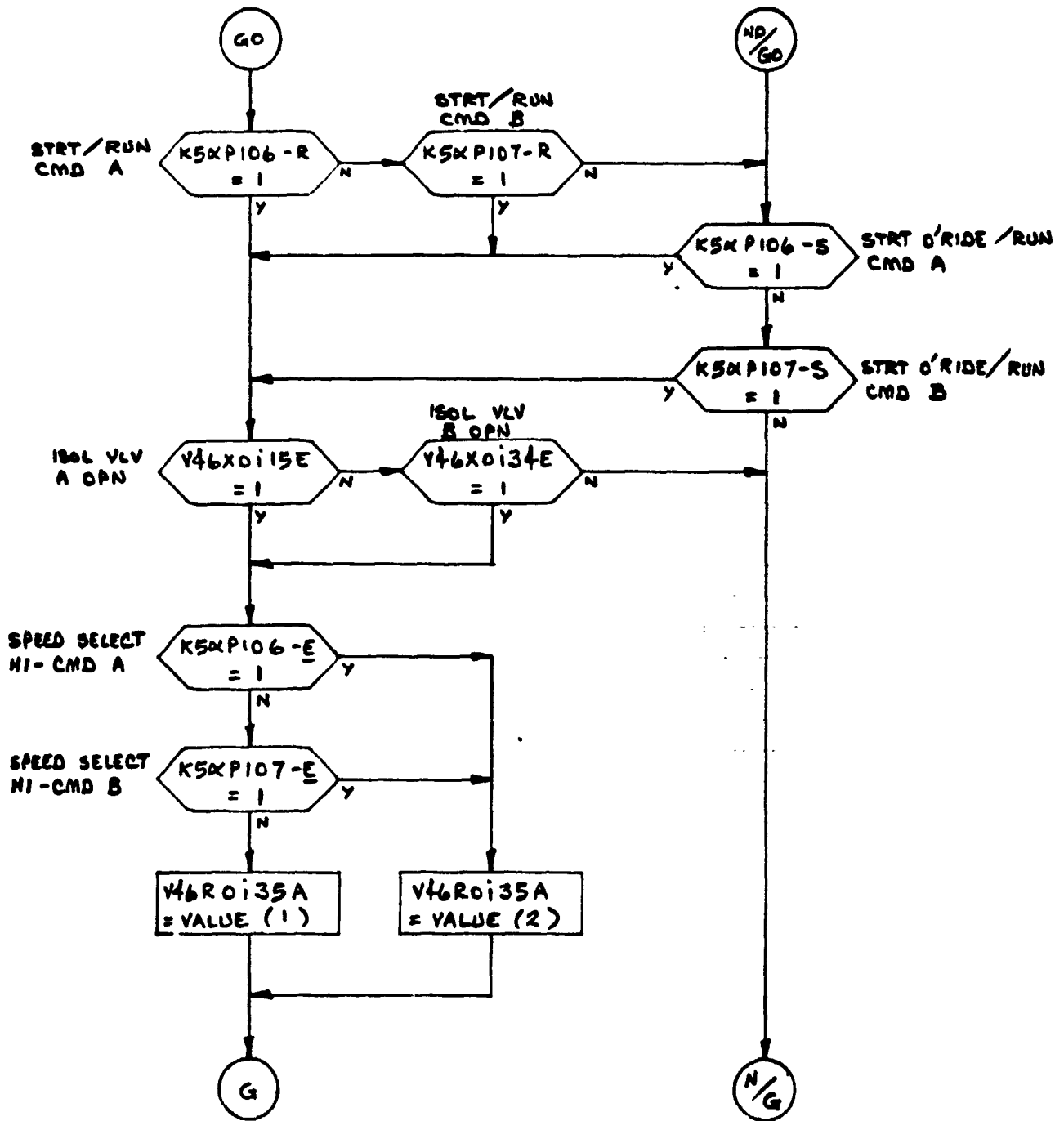


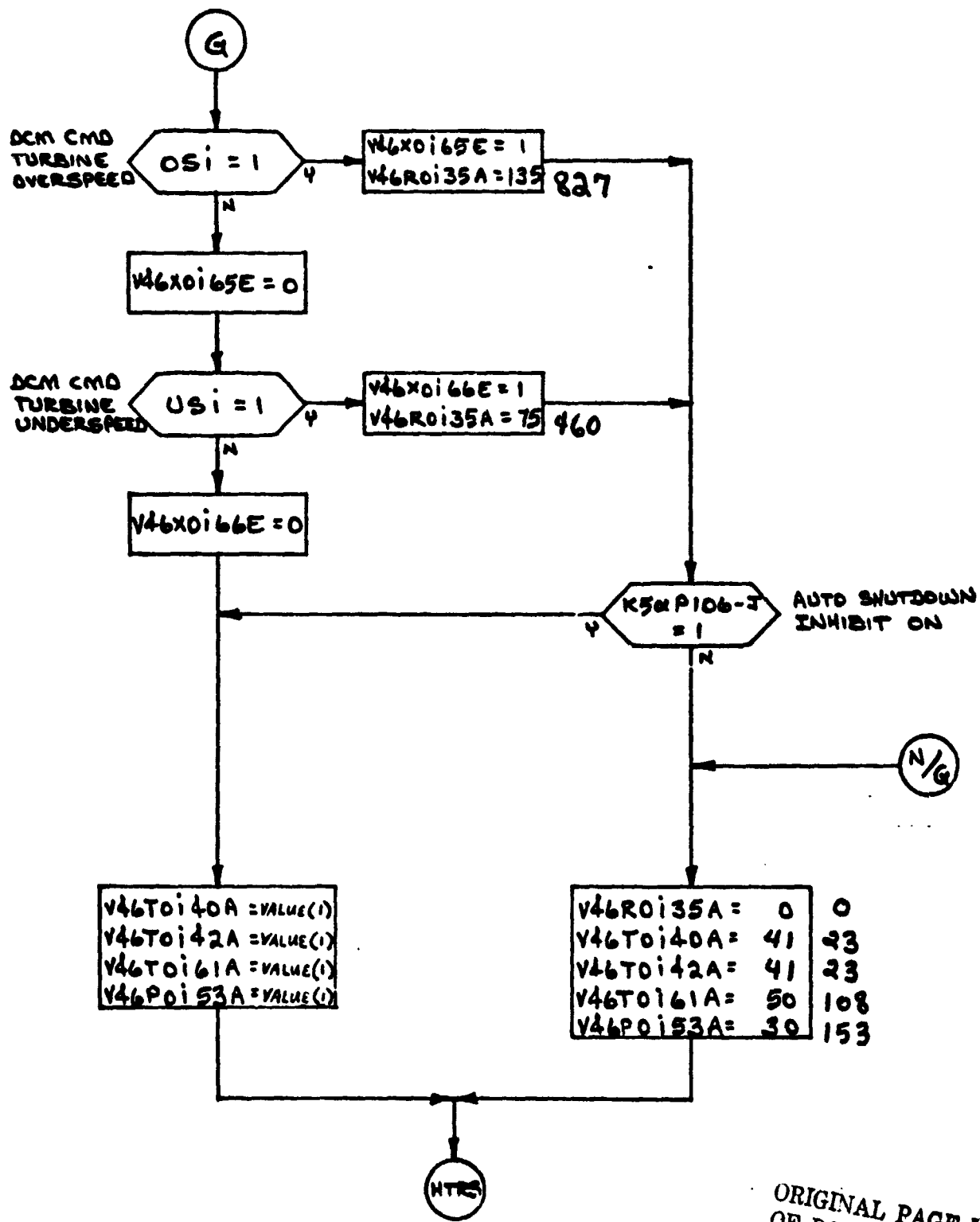


ORIGINAL PAGE IS
OF POOR QUALITY

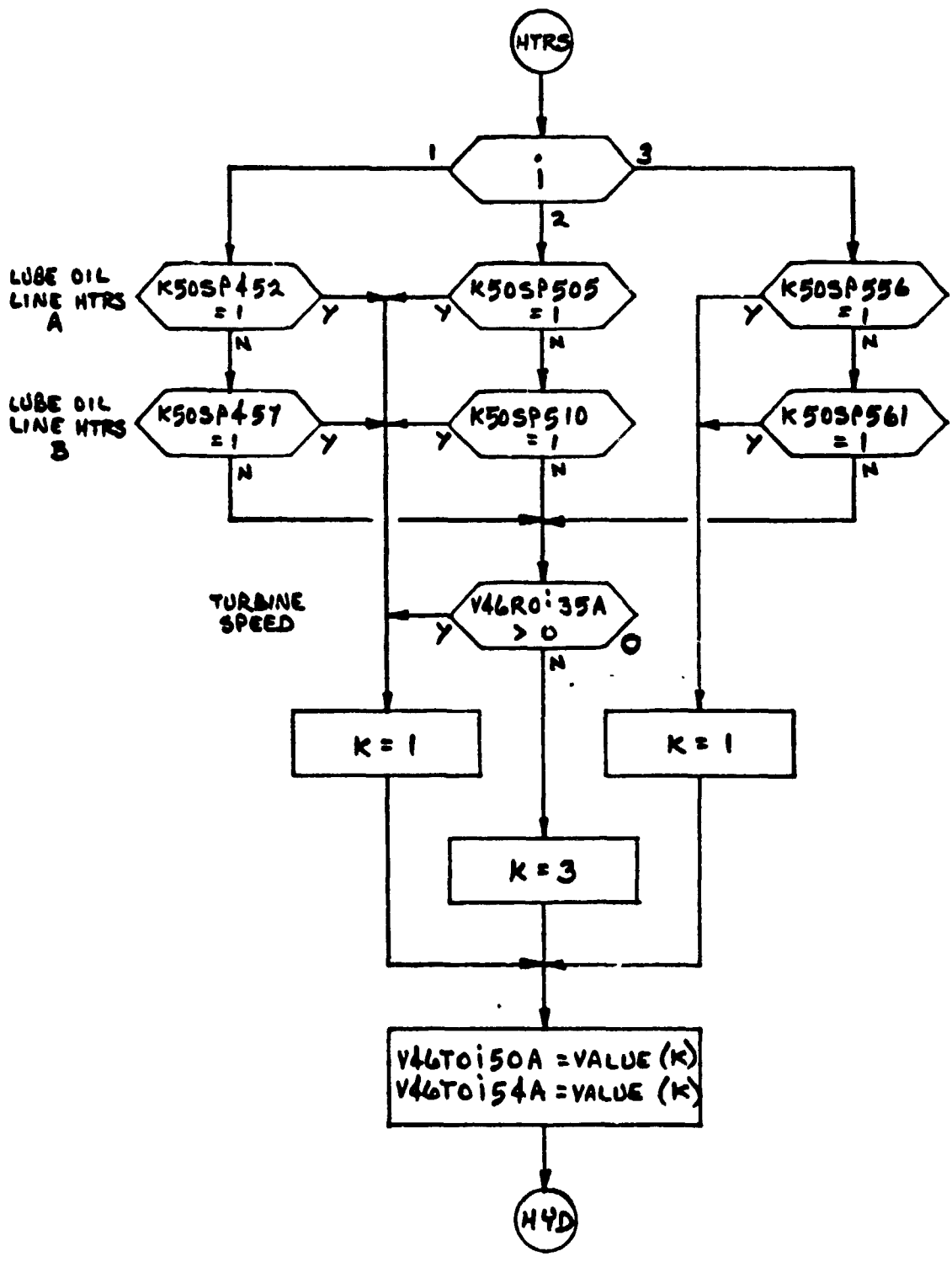


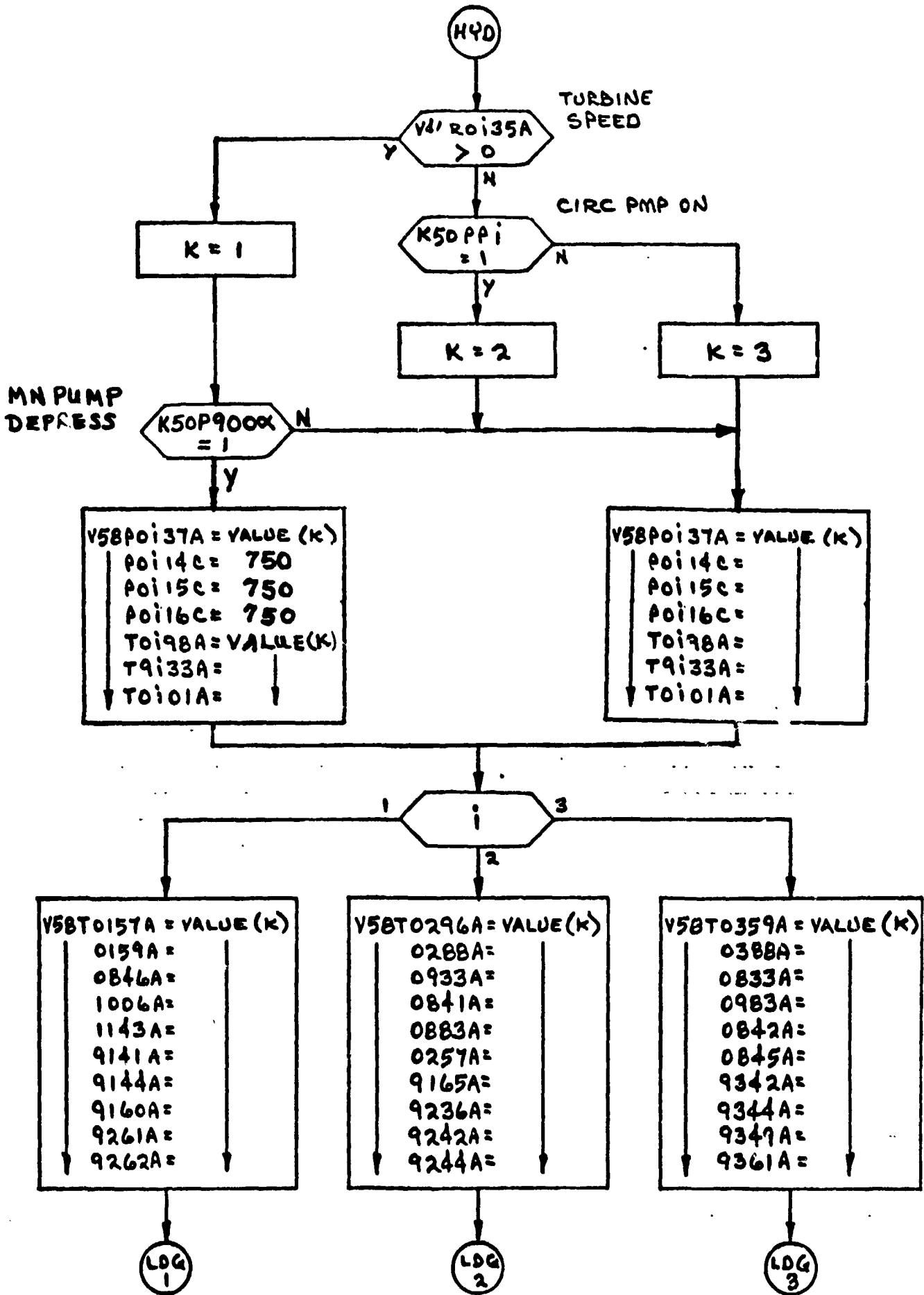


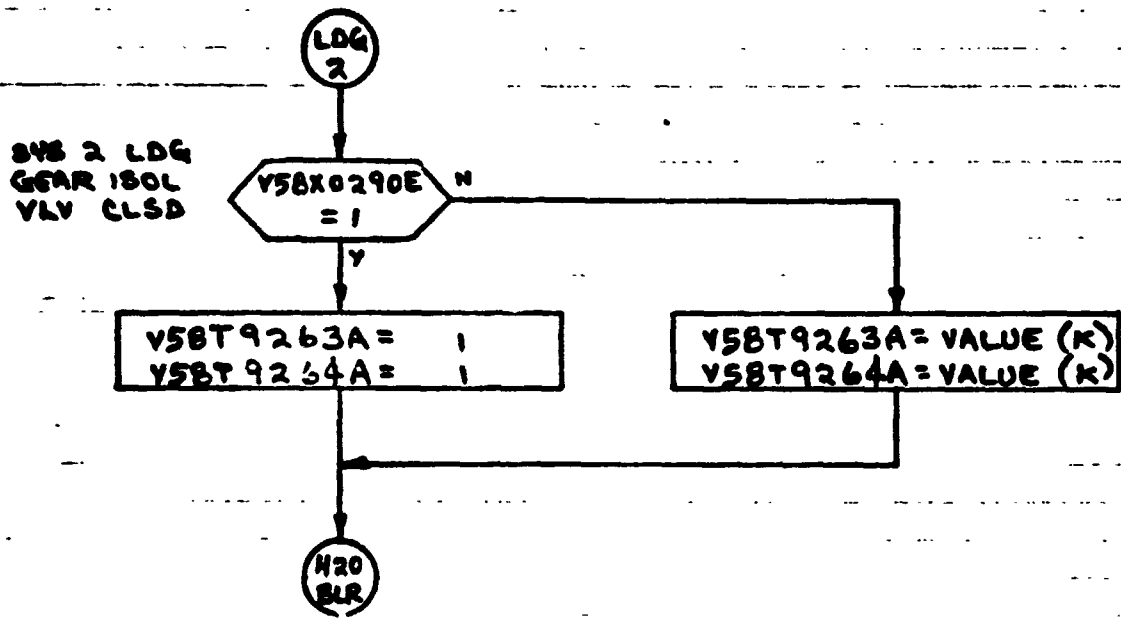
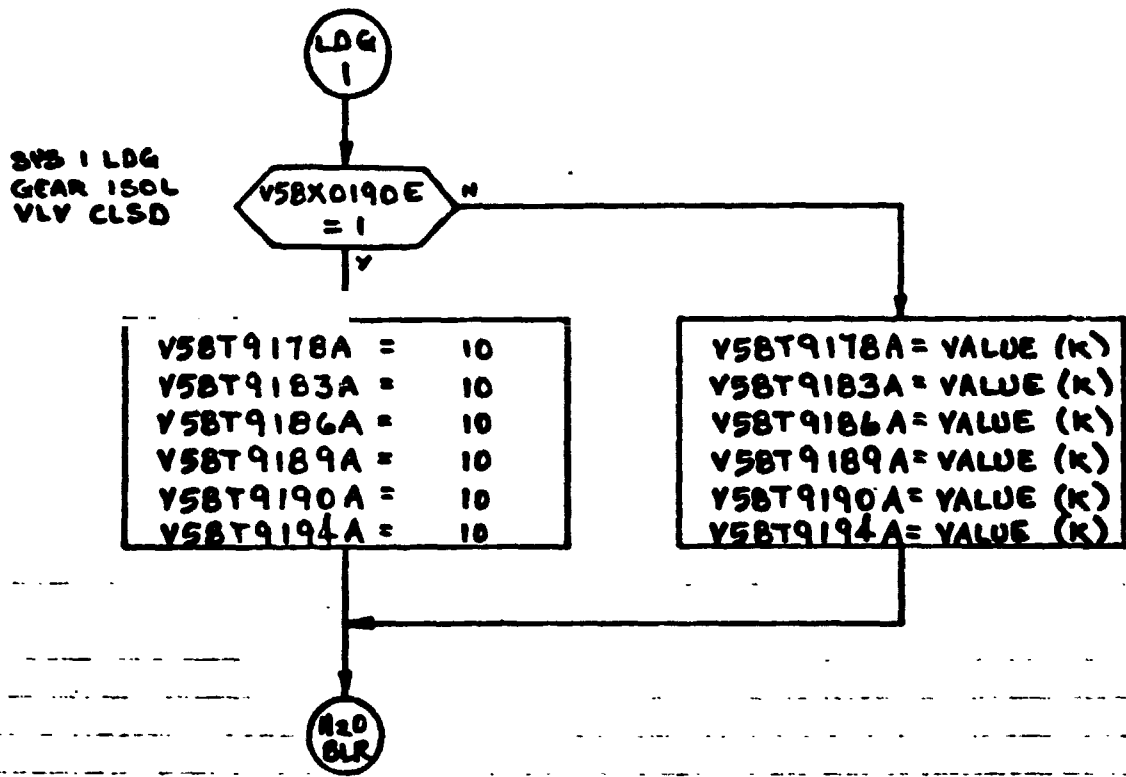


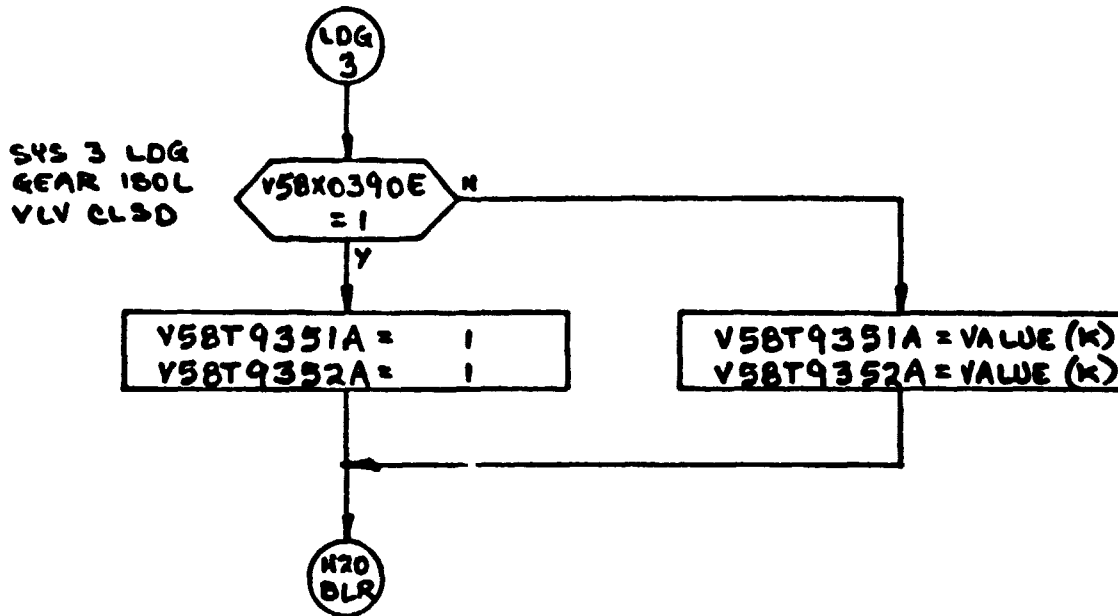


ORIGINAL PAGE IS
OF POOR QUALITY

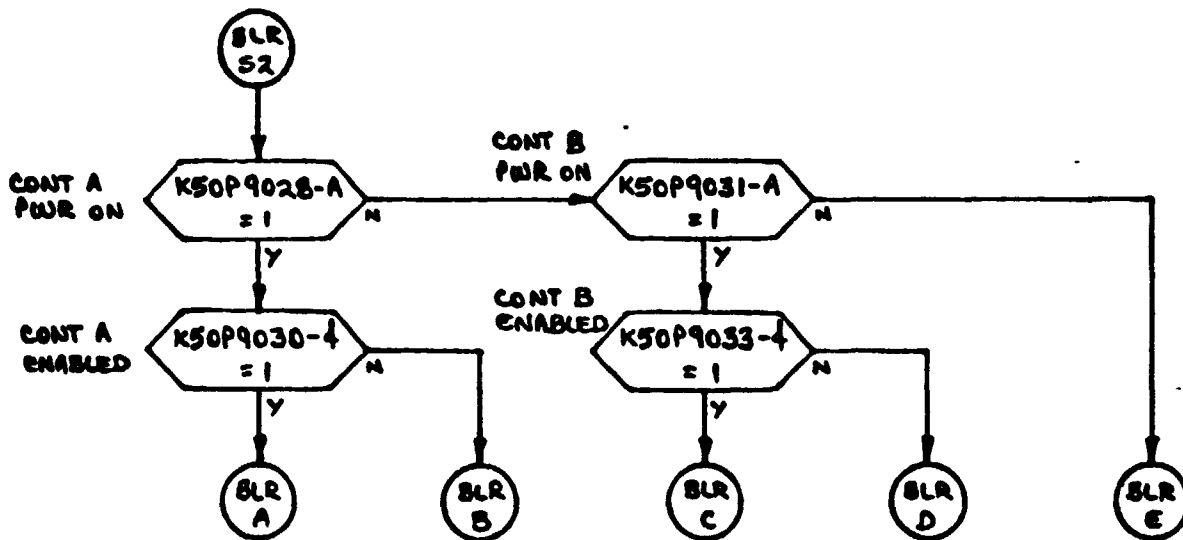
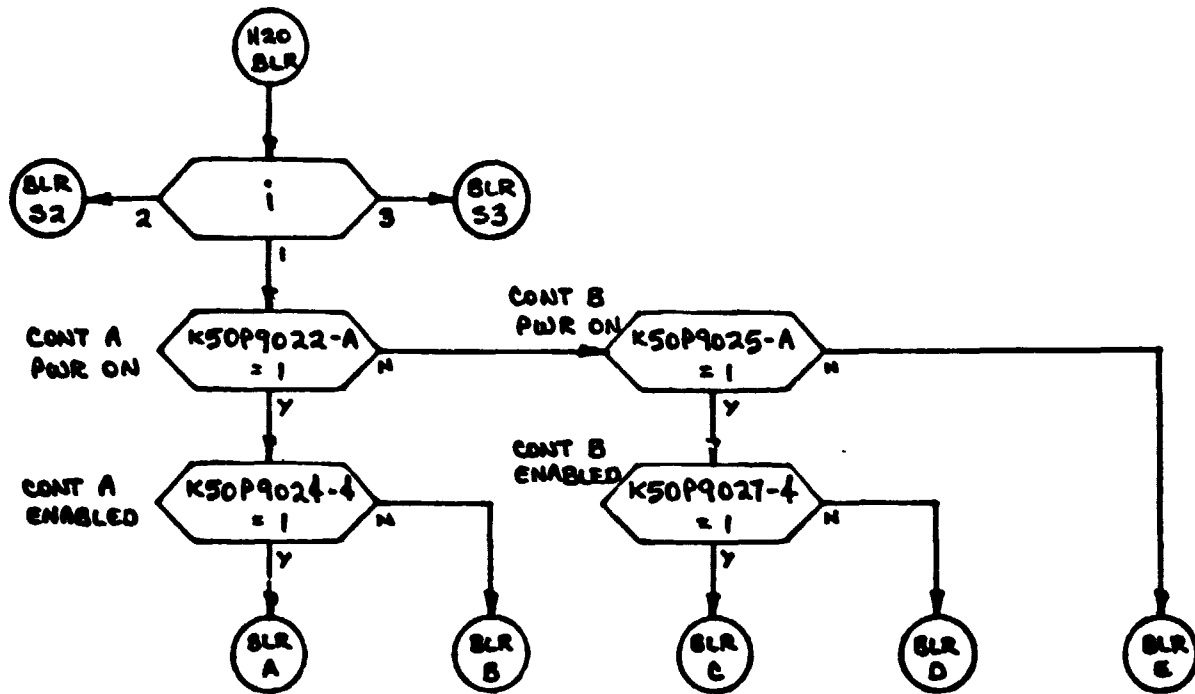


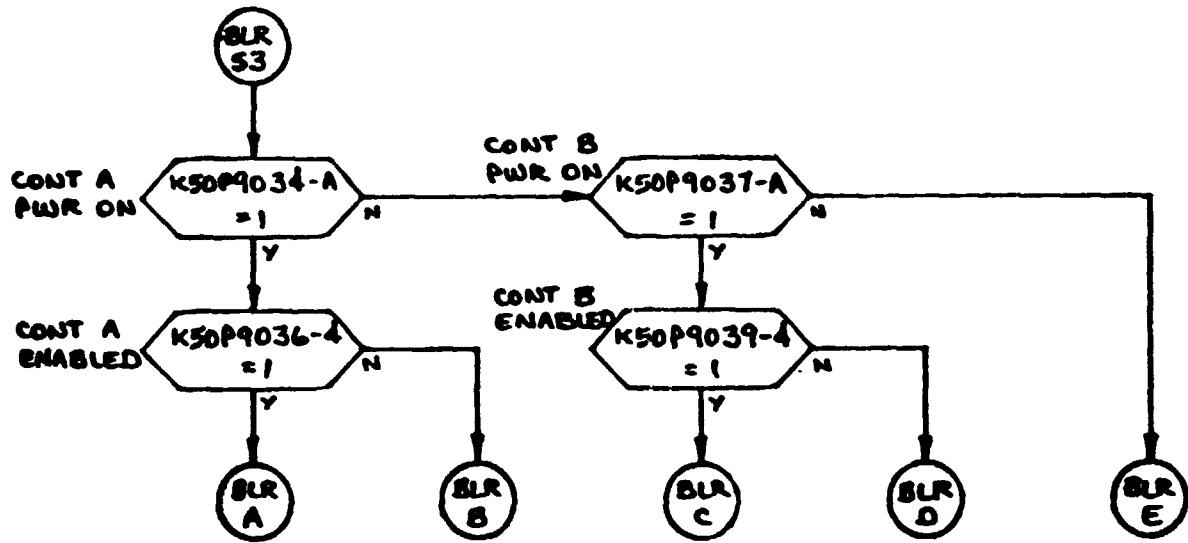






ORIGINAL PAGE IS
OF POOR QUALITY

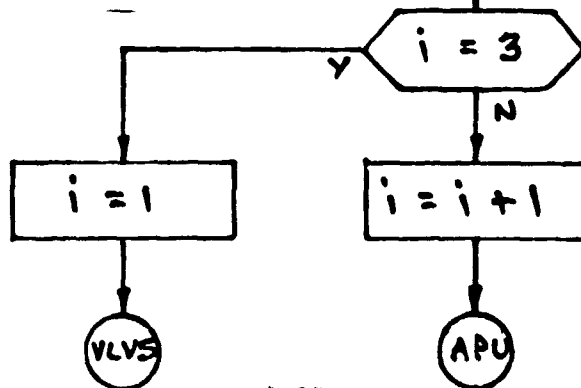




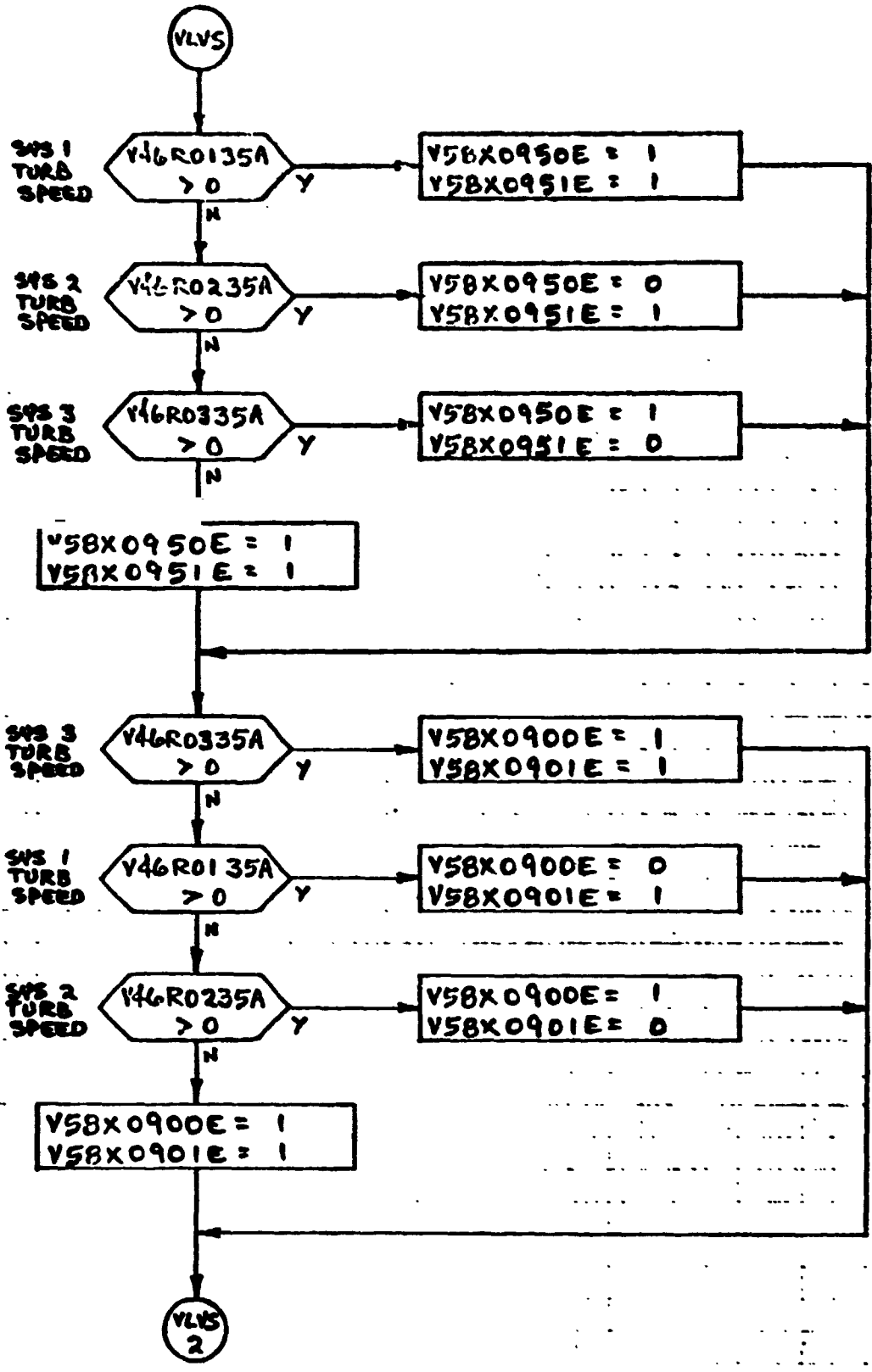
H20 BLR GN2 PRS
 H20 BLR GN2 TK TMP
 H20 BLR H20 TK TMP
 H20 BLR TMP3
 H20 BLR VENT TMP3
 H20 BLR BYP VLV IND
 H20 BLR RDY IND

V5B P0104A =
 T0i05A =
 T0i61A =
 T0i62A =
 T0i63A =
 T0i65A =
 T0i66A =
 X0i81E =
 X0i82E =

	BLR A	BLR B	BLR C	BLR D	BLR E
	25	25	0	0	0
	(K)	(K)	32	32	32
	(K)	(K)	32	32	32
	(K)	(K)	32	32	32
	32	32	(K)	(K)	32
	(K)	(K)	122	122	122
	122	122	(K)	(K)	122
	(K)	(K)	0	0	0
	1	0	1	0	0

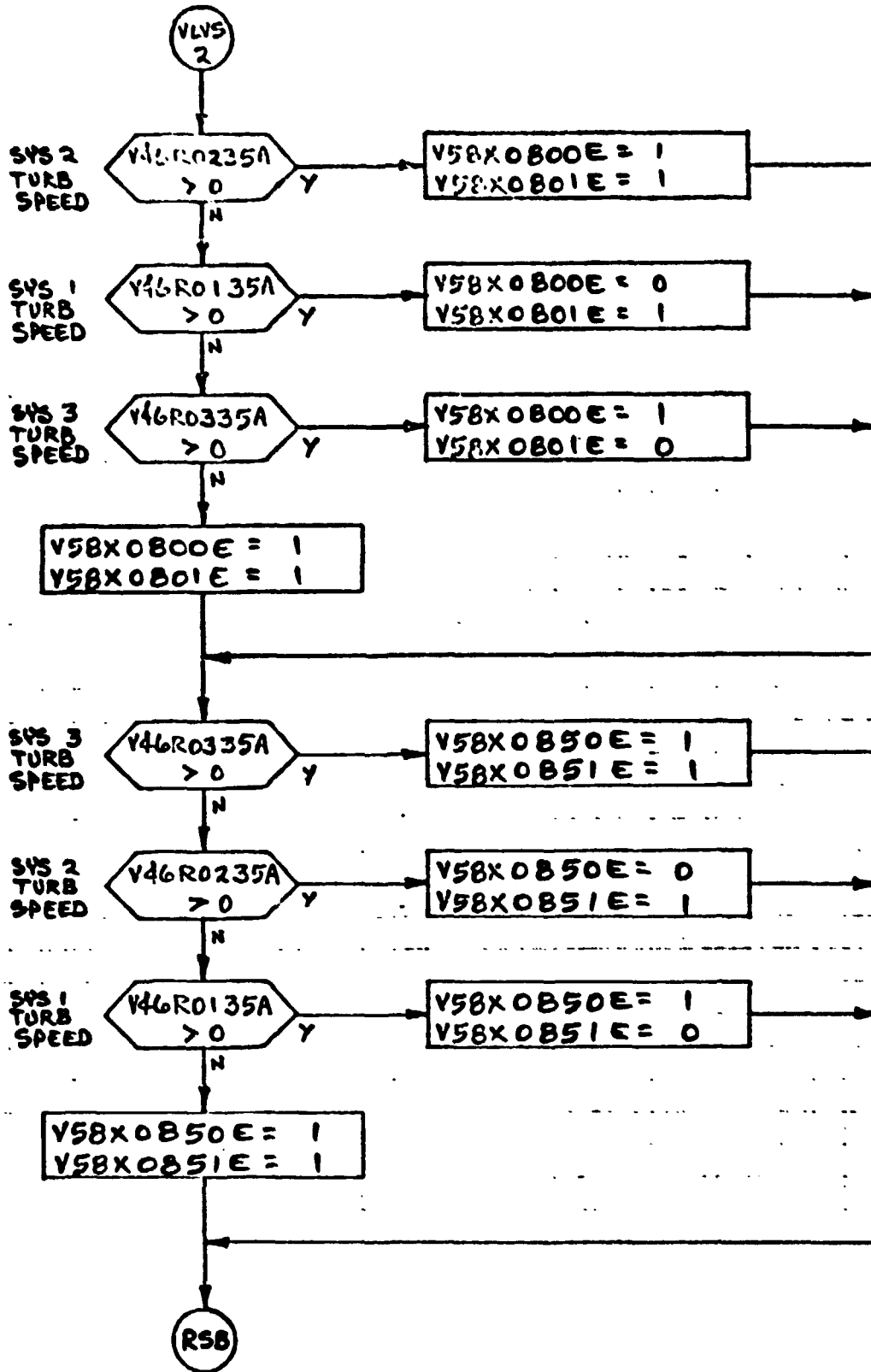


R#
OTBD
ELVN

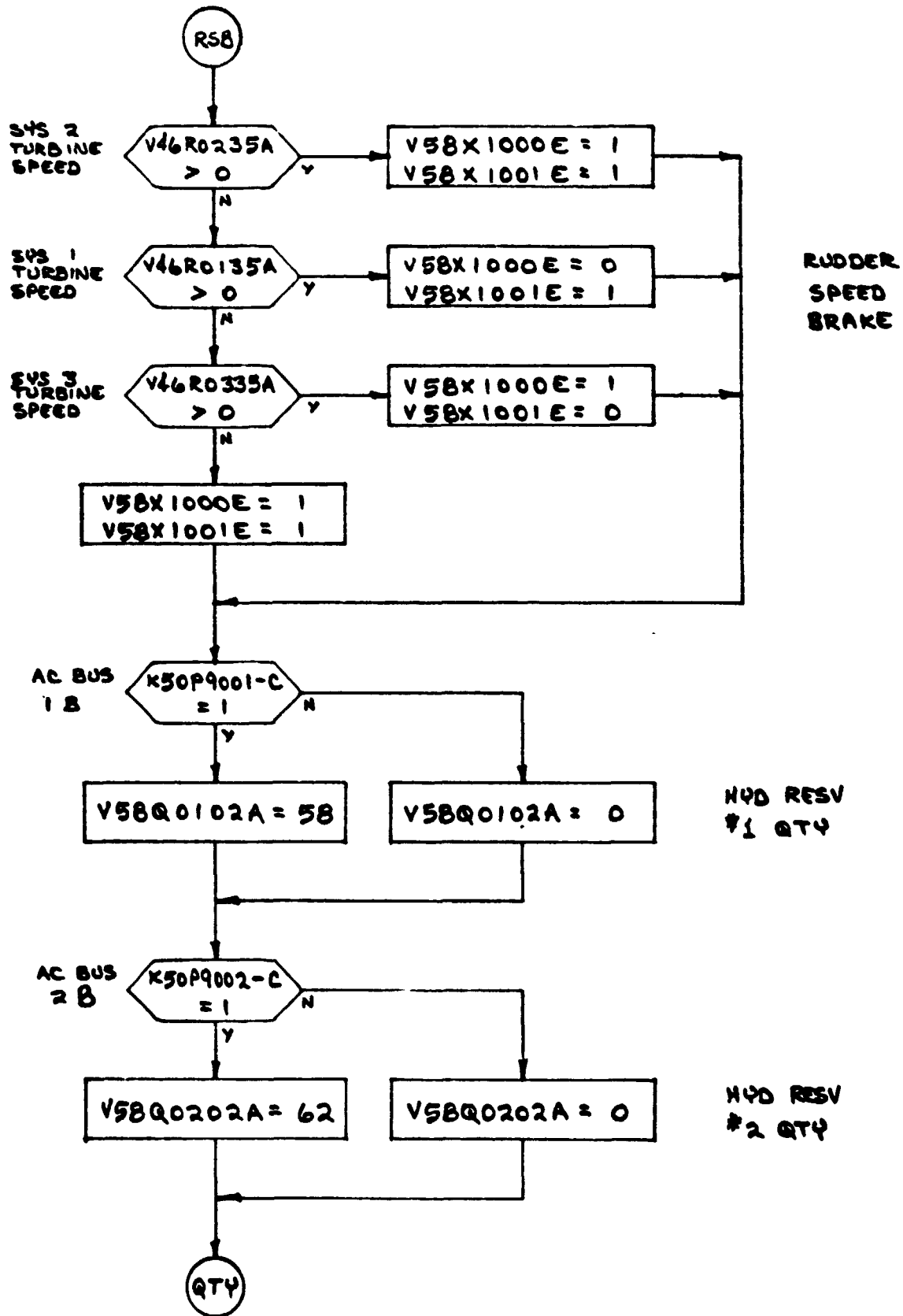


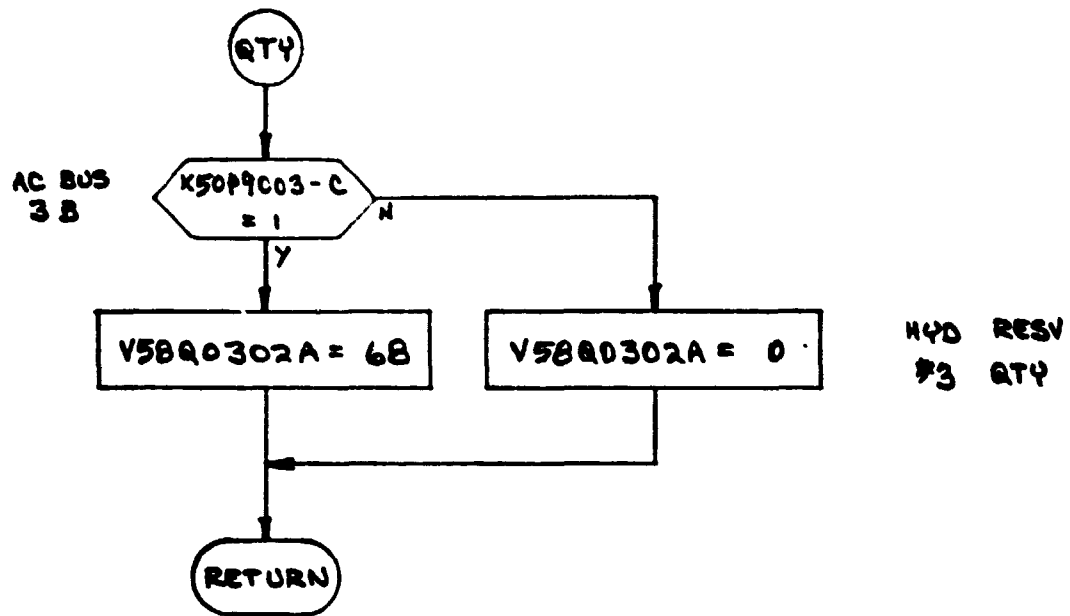
R#
INBD
ELVN

LH
INBD
ELVN



ORIGINAL PAGE IS
OF POOR QUALITY





4.0 TABLES

4.1 INPUT STIMULI LIST

Table 1 lists input stimuli to the APU/HYD model in terms of ID numbers, nomenclature, stimuli source, address and range of measurement.

STIMULI INPUT TO /HYD MODEL - TABLE 1

IDENTIFICATION NUMBER	NOMENCLATURE	SOURCE	STATES/RANGE		
			LO	HI	UNITS
K50SP423	-APU- TK/LN HTRS B SYSTEM 1 V46K0109E	FLT System	0	1	STATE
K50SP474	TK/LN HTRS B SYSTEM 2 V46K0209E		0	1	
K50SP527	TK/LN HTRS B SYSTEM 3 V46K0309E		0	1	
K50SP441	TK/LN HTRS A SYSTEM 1 V46K0103E		0	1	
K50SP493	TK/LN HTRS A SYSTEM 2 V46K0203E		0	1	
K50SP545	TK/LN HTRS A SYSTEM 3 V46K0303E		0	1	
K50SP452	LUBE OIL LN HTRS - A AUTO SYSTEM 1 V46K0116E		0	1	
K50SP505	LUBE OIL LN HTRS - A AUTO SYSTEM 2 V46K0216E		0	1	
K50SP556	LUBE OIL LN HTRS - A AUTO SYSTEM 3 V46K0316E		0	1	
K50SP457	LUBE OIL LN HTRS - B AUTO SYSTEM 1 V46K0117E		0	1	
K50SP510	LUBE OIL LN HTRS - B AUTO SYSTEM 2 V46K0217E		0	1	
K50SP561	LUBE OIL LN HTRS - B AUTO SYSTEM 3 V46K0317E		0	1	
K50P9910-B	FUEL ISOL. VLVA SYSTEM 1 V46K0121E		0	1	
K50P9920-B	FUEL ISOL. VLVA SYSTEM 2 V46K0221E		0	1	
K50p9930-B	FUEL ISOL. VLVA SYSTEM 3 V46K0321E		0	1	
K50P9911-B	GG/FU. PUMP HTRS - A AUTO SYSTEM 1 V46K0118E		0	1	
K50P9921-B	GG/FU. PUMP HTRS - A AUTO SYSTEM 2 V46K0218E		0	1	
K50P9931-B	GG/FU. PUMP HTRS - A AUTO SYSTEM 3 V46K0318E		0	1	
K50P9912-B	GG/FU. PUMP HTRS - B AUTO SYSTEM 1 V46K0119E	0	1		
K50P9922-B	GG/FU. PUMP HTRS - B AUTO SYSTEM 2 V46K0219E	0	1		
K50P9932-B	GG/FU. PUMP HTRS - B AUTO SYSTEM 3 V46K0319E	0	1	STATE	

STIMULI INPUT TO /HYD MODEL - TABLE 1

IDENTIFICATION NUMBER	NOMENCLATURE	SOURCE	STATES/RANGE		UNIT
			LO	HI	
	-APU CONTINUED-				
K54P107-C	APU CNTRL POWER A - SYSTEM 1 V46K0124E	FLT SYSTEM	0	1	STAT
K55P107-C	APU CNTRL POWER A - SYSTEM 2 V46K0224E		0	1	
K56P107-C	APU CNTRL POWER A - SYSTEM 3 V46K0324E		0	1	
K54P106-C	APU CNTRL POWER B - SYSTEM 1 V46K0144E		0	1	
K55P106-C	APU CNTRL POWER B - SYSTEM 2 V46K0244E		0	1	
K56P106-C	APU CNTRL POWER B - SYSTEM 3 V46K0344E		0	1	
K54P106-R	APU CNTRL - START/RUN CMD A SYSTEM 1 V46K0126E		0	1	
K55P106-R	APU CNTRL - START/RUN CMD A SYSTEM 2 V46K0226E		0	1	
K56P106-R	APU CNTRL - START/RUN CMD A SYSTEM 3 V46K0326E		0	1	
K54P107-R	APU CNTRL - START/RUN CMD B SYSTEM 1 V46K0146E		0	1	
K55P107-R	APU CNTRL - START/RUN CMD B SYSTEM 2 V46K0246E		0	1	
K56P107-R	APU CNTRL - START/RUN CMD B SYSTEM 3 V46K0346E		0	1	
K54P106-S	APU CNTRL - START ORIDE/RUN CMD A SYSTEM 1 V46K0127E		0	1	
K55P106-S	APU CNTRL - START ORIDE/RUN CMD A SYSTEM 2 V46K0227E		0	1	
K56P106-S	APU CNTRL - START ORIDE/RUN CMD A SYSTEM 3 V46K0327E		0	1	
K54P107-S	APU CNTRL - START ORIDE/RUN CMD B SYSTEM 1 V46K0147E		0	1	
K55P107-S	APU CNTRL - START ORIDE/RUN CMD B SYSTEM 2 V46K0247E		0	1	
K56P107-S	APU CNTRL - START ORIDE/RUN CMD B SYSTEM 3 V46K0327E		0	1	
K54P106-J	AUTO SHUTDOWN INHIBIT A SYSTEM 1 AND 3 V46K0097E		0	1	
K55P106-J	AUTO SHUTDOWN INHIBIT B SYSTEM 1 AND 2 V46K0098E		0	1	
K56P106-J	AUTO SHUTDOWN INHIBIT C SYSTEM 2 AND 3 V46K0099E		0	1	STA

FRAG 1 = least significant (right most) bit.

STIMULI INPUT TO /U/HYO MODEL - TABLE 1

IDENTIFICATION NUMBER	NOMENCLATURE	SOURCE	STATES/RANGE		
			LO	HI	UNITS
K54P106-E	SPEED SELECT HI - CMD A SYSTEM 1 V46K0129E	FLT. SYS.	0	1	STATE
K55P106-E	SPEED SELECT HI - CMD A SYSTEM 2 V46K0229E		0	1	
K56P106-E	SPEED SELECT HI - CMD A SYSTEM 3 V46K0329E		0	1	
K54P107-E	SPEED SELECT HI - CMD B SYSTEM 1 V46K0149E		0	1	
K55P107-E	SPEED SELECT HI - CMD B SYSTEM 2 V46K0249E		0	1	
K56P107-E	SPEED SELECT HI - CMD B SYSTEM 3 V46K0349E		0	1	
K50P9909-A	APU 1 FUEL ISO VLV B OPN V46K0114E		0	1	
K50P9919-A	APU 2 FUEL ISO VLV B OPN V46K0214E		0	1	
K50P9929-A	APU 3 FUEL ISO VLV B OPN V46K0314E		0	1	
OS1	TURBINE OVERSPEED CMD - SYS 1	DCM	0	1	
OS2	TURBINE OVERSPEED CMD - SYS 2		0	1	
OS3	TURBINE OVERSPEED CMD - SYS 3		0	1	
US1	TURBINE UNDERSPEED CMD - SYS 1		0	1	
US2	TURBINE UNDERSPEED CMD - SYS 2		0	1	
US3	TURBINE UNDERSPEED CMD - SYS 3		0	1	STATE

STIMULI INPUT TO 'U/HYD MODEL - TABLE 1

IDENTIFICATION NUMBER	NOMENCLATURE	SOURCE	STATES/RANGE		UNITS
			LO	HI	
K50PP1-E1	CIRC. PUMP SYSTEM 1 V58K0138E	FLT SYSTEM	0	1	STATE
K50PP2-E1	CIRC. PUMP SYSTEM 2 V58K0238E		0	1	
K50PP3-E1	CIRC. PUMP SYSTEM 3 V58K0338E		0	1	
K50P9004-I	MN. PUMP DEPR. ON SYSTEM 1 V58K0170E		0	1	
K50P9005-I	MN. PUMP DEPR. ON SYSTEM 2 V58K0270E		0	1	
K50P9006-I	MN. PUMP DEPR. ON SYSTEM 3 V58K0370E		0	1	
K50P9007-C	LG ISLN VLV CLOSED SYSTEM 1 V58K0191E		0	1	
K50P9008-C	LG ISLN VLV CLOSED SYSTEM 2 V58K0291E		0	1	
K50P9009-C	LG ISLN VLV CLOSED SYSTEM 3 V58K0391E		0	1	
K50P9007-A	LG ISLN VLV OPEN SYSTEM 1 V58K0195E		0	1	
K50P9008-A	LG ISLN VLV OPEN SYSTEM 2 V58K0295E		0	1	
K50P9009-A	LG ISLN VLV OPEN SYSTEM 3 V58K0395E		0	1	
K50P38-A	ME/TVC SPLY VLV OPEN SYSTEM 1 V58K1134E		0	1	
K50P39-A	ME/TVC SPLY VLV OPEN SYSTEM 2 V58K1234E		0	1	
K50P40-A	ME/TVC SPLY VLV OPEN SYSTEM 3 V58K1334E		0	1	
K50P38-C	ME/TVC SPLY VLV CLOSED SYSTEM 1 V58K1135E		0	1	
K50P39-C	ME/TVC SPLY VLV CLOSED SYSTEM 2 V58K1235E		0	1	
K50P40-C	ME/TVC SPLY VLV CLOSED SYSTEM 3 V58K1335E		0	1	
K50P9022-A	H ₂ O BLR CNTLR PMR/HTR A SYSTEM 1 V58K0149E		0	1	
K50P9028-A	H ₂ O BLR CNTLR PMR/HTR A SYSTEM 2 V58K0249E		0	1	
K50P9034-A	H ₂ O BLR CNTLR PMR/HTR A SYSTEM 3 V58K0349E		0	1	

STIMULI INPUT TO /HYD MODEL - TABLE

IDENTIFICATION NUMBER	NOMENCLATURE	SOURCE	STATES/RANGE			
			LO	HI	UNITS	
	-HYD- Continued					
K50P9025-A	H ₂ O BLR CNTLR PWR/HTR B SYSTEM 1 V58K0150E	FLT SYSTEM ↓	0	1	STATE	
K50P9031-A	H ₂ O BLR CNTLR PWR/HTR B SYSTEM 2 V58K0250E		0	1		
K50P9037-A	H ₂ O BLR CNTLR PWR/HTR B SYSTEM 3 V58K0350E		0	1		
K50P9024-4	H ₂ O BLR CNTLR A ENABLE SYSTEM 1 V58K0151E		0	1		
K50P9030-4	H ₂ O BLR CNTLR A ENABLE SYSTEM 2 V58K0251E		0	1		
K50P9036-4	H ₂ O BLR CNTLR A ENABLE SYSTEM 3 V58K0351E		0	1		
K50P9027-4	H ₂ O BLR CNTLR B ENABLE SYSTEM 1 V58K0152E		0	1		
K50P9033-4	H ₂ O BLR CNTLR B ENABLE SYSTEM 2 V58K0252E		0	1		
K50P9039-4	H ₂ O BLR CNTLR B ENABLE SYSTEM 3 V58K0352E		0	1		
K50P9001-C	AC BUS 1B PWR HYD. RESV QTY #1		FLT SYSTEM	0	1	STATE
K50P9002-C	AC BUS 2B PWR HYD RESV QTY #2		FLT SYSTEM	0	1	STATE
K50P9003-C	AC BUS 3B PWR HYD RESV QTY #3		FLT SYSTEM	0	1	STATE

ORIGINAL PAGE IS
OF POOR QUALITY

4.2 OUTPUT MEASUREMENT LIST

Table 2 lists all model outputs along with the initial condition value for the output. Measurement I.D. and Measurement Name precede pairs of numeric columns. The first of each pair is labeled FS indicating flight system engineering units. The second of each pair is labeled CTS indicating the GSIU count value corresponding to the FS value. I.C. indicates initial condition values. VALUE 1 typically indicates nominal values. VALUE 2 and VALUE 3 columns indicate off nominal conditions.

MEASUREMENT OUTPUT FROM APU/HYD MODEL - TABLE 2

EASUREMENT I. D.	MEASUREMENT NAME	I.C.		VALUE 1 K=1 (NOMINAL)		VALUE 2 K=2 (HI/LOH)		VALUE 3 K=3 (OFF)		UNITS	
		FS	CTS	FS	CTS	FS	CTS	FS	CTS		
	- APU -										
V46P0100A	FUEL TK. PRESS SYSTEM 1	340	695	340	696	NA		340	696	PSIA	
V46P0200A	FUEL TK. PRESS SYSTEM 2	335	685	335	685	NA		335	685	PSIA	
V46P0300A	FUEL TK. PRESS SYSTEM 3	346	708	346	708	NA		346	708	PSIA	
V46T0102A	TK. SURFACE TEMP SYSTEM 1	56	360	56	360	NA		47	303	°F	
V46T0202A	TK. SURFACE TEMP SYSTEM 2	64	411	64	411	NA		47	303	°F	
V46T0302A	TK. SURFACE TEMP SYSTEM 3	48	309	48	309	NA		47	303	°F	
V46T0104A	FUEL LN TEMP NO. 2 SYSTEM 1	80	331	80	331	NA		47	196	°F	
V46T0204A	FUEL LN TEMP NO. 2 SYSTEM 2	90	372	90	372	NA		47	196	°F	
V46T0304A	FUEL LN TMEP NO. 2 SYSTEM 3	105	434	105	434	NA		47	196	°F	
V46P0105A	FUEL TK OUT PRESS SYSTEM 1	330	675	330	675	NA		330	675	PSIA	
V46P0205A	FUEL TK OUT PRESS SYSTEM 2	335	685	335	685	NA		335	685	PSIA	
V46P0305A	FUEL TK OUT PRESS SYSTEM 3	338	692	338	692	NA		338	692	PSIA	
V46T0108A	FUEL LN TEMP NO. 1 SYSTEM 1	85	352	85	352	NA		48	201	°F	
V46T0208A	FUEL LN TEMP NO. 1 SYSTEM 2	92	381	92	381	NA		50	209	°F	
V46T0308A	FUEL LN TEMP NO. 1 SYSTEM 3	98	405	98	405	NA		52	217	°F	
V46T0112A	FUEL PUMP DISCHARGE TEMP SYSTEM 1	157.6	409	157.6	409	NA		60	158	°F	
V46T0212A	FUEL PUMP DISCHARGE TEMP SYSTEM 2	153	397	153	397	NA		60	158	°F	
V46T0312A	FUEL PUMP DISCHARGE TEMP SYSTEM 3	142	368	142	368	NA		60	158	°F	
V46X0115E	FUEL ISOL. VALVE POS. SYSTEM 1	0	0							STATE	
V46X0215E	FUEL ISOL. VALVE POS. SYSTEM 2	0	0							STATE	
V46X0315E	FUEL ISOL. VALVE POS. SYSTEM 3	0	0							STATE	

MEASUREMENT OUTPUT FROM APU/HYD MODEL - TABLE 2

MEASUREMENT I. D.	MEASUREMENT NAME	I. C.		VALUE 1 (NOMINAL)		VALUE 2 (HI/LOW)		VALUE 3 (OFF)		UNITS
		FS	CTS	FS	CTS	FS	CTS	FS	CTS	
	APU Continued									
V46T0122A	G.G. BED TEMP. SYSTEM 1	325	665	325	665	NA		160	327	°F
V46T0222A	G.G. BED TEMP. SYSTEM 2	210	430	210	430	↘		160	327	°F
V46T0322A	G.G. BED TEMP. SYSTEM 3	300	614	300	614	↘		160	327	°F
V46X0125E	APU "READY" SYSTEM 1	0	0							STATE
V46X0225E	APU "READY" SYSTEM 2	0	0							STATE
V46X0325E	APU "READY" SYSTEM 3	0	0							STATE
V46T0128A	APU 1 FUEL LINE TEMP NO. 3	156	405	156	405	NA		70	184	DEGF
V46T0228A	APU 2 FUEL LINE TEMP NO. 3	160	415	160	415	↘		70	184	DEGF
V46T0328A	APU 3 FUEL LINE TEMP NO. 3	164	426	164	426	↘		70	184	DEGF
V46T0130A	APU 1 FUEL TANK SURF TEMP AT HTR	87	663	87	663			50	509	DEGF
V46T0230A	APU 2 FUEL TANK SURF TEMP AT HTR	95	696	95	696			50	509	DEGF
V46T0330A	APU 3 FUEL TANK SURF TEMP AT HTR	102	724	102	724			50	509	DEGF
V46X0134E	APU 1 FUEL ISOL VALVE B POSITION	0	0							STATE
V46X0234E	APU 2 FUEL ISOL VALVE B POSITION	0	0							STATE
V46X0334E	APU 3 FUEL ISOL VALVE B POSITION	0	0							STATE
V46R0135A	TURBINE SPEED SYSTEM 1	0	0	83.5	512	113	692	0	0	PCT
V46R0235A	TURBINE SPEED SYSTEM 2	0	0	100.2	614	113	692	0	0	PCT
V46R0335A	TURBINE SPEED SYSTEM 3	0	0	96.86	593	113	692	0	0	PCT
V46T0140A	TURBINE E.G. TEMP. NO. 2 SYSTEM 1	631	421	631	421	NA		41	23	°F
V46T0240A	TURBINE E.G. TEMP. NO. 2 SYSTEM 2	749	501	749	501	NA		41	23	°F
V46T0340A	TURBINE E.G. TEMP. NO. 2 SYSTEM 3	1199	806	1199	806	NA		41	23	°F

MEASUREMENT OUTPUT FROM APU/HYD MODEL - TABLE 2

MEASUREMENT I. D.	MEASUREMENT NAME	I. C.		VALUE 1 K=1 (NOMINAL)		VALUE 2 K=2 (HI/LOW)		VALUE 3 K=3 (OFF)		UNITS
		FS	CTS	FS	CTS	FS	CTS	FS	CTS	
V46T0142A	TURBINE E.G. TEMP. NO. 1 SYSTEM 1	601	401	601	401	NA		41	23	°F
V46T0242A	TURBINE E.G. TEMP. NO. 1 SYSTEM 2	900	604	900	604			41	23	°F
V46T0342A	TURBINE E.G. TEMP. NO. 1 SYSTEM 3	1051	706	1051	706			41	23	°F
V46T0150A	G.B. LUBE OIL RTN. TEMP. SYSTEM 1	145	303	145	303			50	108	°F
V46T0250A	G.B. LUBE OIL RTN. TEMP. SYSTEM 2	140	293	140	293			50	108	°F
V46T0350A	G.B. LUBE OIL RTN. TEMP. SYSTEM 3	225	466	225	466			50	108	°F
V45P0151A	G.B. GN ₂ PRESS SYSTEM 1	25	851	25	851			25	851	PSIA
V46P0251A	G.B. GN ₂ PRESS SYSTEM 2	20	685	20	685			20	685	PSIA
V46P0351A	G.B. GN ₂ PRESS SYSTEM 3	15	509	15	509			15	509	PSIA
V46P0152A	APU 1 GN ₂ BOTTLE PRESS	50	170	50	170			50	170	PSIA
V46P0252A	APU 2 GN ₂ BOTTLE PRESS	40	137	40	137			40	137	PSIA
V46P0352A	APU 3 GN ₂ BOTTLE PRESS	45	153	45	153			45	153	PSIA
V46P0153A	G.B. LUBE OIL OUT. PRESS. SYSTEM 1	76	389	76	389			30	153	PSIA
V46P0253A	G.B. LUBE OIL OUT. PRESS. SYSTEM 2	78	399	78	399			30	153	PSIA
V46P0353A	G.B. LUBE OIL OUT. PRESS. SYSTEM 3	81	415	81	415			30	153	PSIA
V46T0154A	G.B. LUBE OIL OUT. TEMP. SYSTEM 1	180	466	180	466			60	158	°F
V46T0254A	G.B. LUBE OIL OUT. TEMP. SYSTEM 2	172	446	172	446			60	158	°F
V46T0354A	G.B. LUBE OIL OUT. TEMP. SYSTEM 3	168	436	168	436			60	158	°F
V46T0161A	G.B. BRING. TEMP. NO. 1 SYSTEM 1	200	415	200	415			50	108	°F
V46T0261A	G.B. BRING. TEMP. NO. 1 SYSTEM 2	190	395	190	395			50	108	°F
V46T0361A	G.B. BRING. TEMP. NO. 1 SYSTEM 3	260	538	260	538			50	108	°F
V46X0165E	TURBINE OVERSPEED (1 = overspeed) SYSTEM 1	0	0							STATE

ORIGINAL PAGE IS
OF POOR QUALITY

MEASUREMENT OUTPUT FROM APU/HYD MODEL - TABLE 2

MEASUREMENT I. D.	MEASUREMENT NAME	I. C.		VALUE 1 K=1 (NOMINAL)		VALUE 2 K=2 (HI/LOW)		VALUE 3 K=3 (OFF)		UNITS
		FS	CTS	FS	CTS	FS	CTS	FS	CTS	
V46X0265E	TURBINE OVERSPEED (1 = overspeed) SYSTEM 2	0	0							STATE
V46X0365E	TURBINE OVERSPEED (1 = overspeed) SYSTEM 3	0	0							STATE
V46X0166E	TURBINE UNDERSPEED (1 = underspeed) SYSTEM 1	0	0							STATE
V46X0266E	TURBINE UNDERSPEED (1 = underspeed) SYSTEM 2	0	0							STATE
V46X0366E	TURBINE UNDERSPEED (1 = underspeed) SYSTEM 3	0	0							STATE
V46T0183A	FUEL TEST LN. TEMP. 1 SYSTEM 1	66	274	66	274	NA		50	209	°F
V46T0283A	FUEL TEST LN. TEMP. 1 SYSTEM 2	63	262	63	262			50	209	°F
V46T0383A	FUEL TEST LN. TEMP. 1 SYSTEM 3	74	307	74	307			50	209	°F
V46T0184A	FUEL TEST LN. TEMP. 2 SYSTEM 1	150	618	150	618			5	229	°F
V46T0284A	FUEL TEST LN. TEMP. 2 SYSTEM 2	135	557	135	557			55	229	°F
V46T0384A	FUEL TEST LN. TEMP. 2 SYSTEM 3	130	536	130	536			55	229	°F
V46T0186A	FUEL PUMP DRAIN LN. TEMP. 1 SYSTEM 1	60	250	60	250			50	209	°F
V46T0286A	FUEL PUMP DRAIN LN. TEMP. 1 SYSTEM 2	55	229	55	229			50	209	°F
V46T0386A	FUEL PUMP DRAIN LN. TEMP. 1 SYSTEM 3	52	217	52	217			50	209	°F
V46P0190A	APU 1 FUEL PUMP DRAIN LINE PRESS 1	13	264	13	264			13	264	PSIA
V46P0290A	APU 2 FUEL PUMP DRAIN LINE PRESS 1	23	469	23	469			23	469	PSIA
V46P0390A	APU 3 FUEL PUMP DRAIN LINE PRESS 1	10	205	10	205			10	205	PSIA

MEASUREMENT OUTPUT FROM APU/HYD MODEL - TABLE 2

MEASUREMENT I. D.	MEASUREMENT NAME	I.C.		VALUE 1 K=1 (NOMINAL)		VALUE 2 K=2 (HI/LOW)		VALUE 3 K=3 (OFF)		UNITS
		FS	CTS	FS	CTS	FS	CTS	FS	CTS	
V46T0192A	APU 1 FU PUMP TEMP	185	385	185	385			65	139	°F
V46T0292A	APU 2 FU PUMP TEMP	176	366	176	366			67	143	°F
V46T0392A	APU 3 FU PUMP TEMP	125	262	125	262			69	147	°F
V46T0193A	APU 1 PUMP H2O LINE TEMP - PRI	61	393	61	393	NA		43	276	°F
V46T0293A	APU 2 PUMP H2O LINE TEMP - PRI	67	430	67	430			45	291	°F
V46T0393A	APU 3 PUMP H2O LINE TEMP - PRI	88	667	88	667			47	497	°F
V46T0194A	APU 1 PUMP H2O LINE TEMP - SEC	91	679	91	679			51	514	°F
V46T0294A	APU 2 PUMP H2O LINE TEMP - SEC	94	692	94	692			53	522	°F
V46T0394A	APU 3 PUMP H2O LINE TEMP - SEC	99	712	99	712			55	532	°F
V46T0501A	H2O LINE TEMP 1	48	340	48	340			41	321	°F
V46T0502A	H2O LINE TEMP 2	53	354	53	354			43	327	°F
V46T0503A	H2O LINE TEMP 3	58	368	58	368			45	331	°F
V46T9158A	APU 1 FU VLV TEMP	120	276	120	276			71	162	°F
V46T9258A	APU 2 FU VLV TEMP	115	264	115	264			73	166	°F
V46T9358A	APU 3 FU VLV TEMP	110	252	110	252			75	172	°F
* V46T9180A	APU 1 INJECTOR TUBE TEMP	419	286	419	286			130	89	°F
* V46T9280A	APU 2 INJECTOR TUBE TEMP	479	327	479	327			135	92	°F
* V46T9380A	APU 3 INJECTOR BUTE TEMP	540	368	540	368			141	96	°F
* V46T9132A	APU 1 CAVITY DRAIN LINE TEMP	56	266	56	266			49	254	°F
* V46T9270A	APU 2 FU PUMP DRAIN LINE TEMP	86	352	86	352			57	233	°F
* V46T9513A	APU 3 CAVITY DRAIN LINE TEMP	69	393	69	393			59	366	°F

* NOTE: This measurement uses the range limit conversion method of calculating FS_{EU} from GSIU_{CTS} as discussed in Section 2.6.2.

MEASUREMENT OUTPUT FROM APU/HYD MODEL - TABLE 2

MEASUREMENT I. D.	MEASUREMENT NAME	I.C.		VALUE 1 K=1 (NOMINAL)		VALUE 2 K=2 (HI/LOW)		VALUE 3 K=3 (OFF)		UNITS
		FS	CTS	FS	CTS	FS	CTS	FS	CTS	
FP1A	FUEL PUMP 1A THERMO	1	1							STATE
FP1B	FUEL PUMP 1B THERMO	1	1							STATE
FP2A	FUEL PUMP 2A THERMO	1	1							STATE
FP2B	FUEL PUMP 2B THERMO	1	1							STATE
FP3A	FUEL PUMP 3A THERMO	1	1							STATE
FP3B	FUEL PUMP 3B THERMO	1	1							STATE
AT1A	APU 1 TANK A THERMO	1	1							STATE
AF1A	APU F/LINE A THERMO	1	1							STATE
A01A	APU O/LINE A THERMO	1	1							STATE
AS1A	APU SER LINE A THERMO	1	1							STATE
AT1B	APU TANK B THERMO	1	1							STATE
AF1B	APU F/LINE 3 THERMO	1	1							STATE
A01B	APU O/LINE B THERMO	1	1							STATE
AS1B	APU SER LINE B THERMO	1	1							STATE
AT2A	APU 2 TANK A THERMO	1	1							STATE
AF2A	APU F/LINE A THERMO	1	1							STATE
A02A	APU O/LINE A THERMO	1	1							STATE
AS2A	APU SER LINE A THERMO	1	1							STATE
AT2B	APU TANK B THERMO	1	1							STATE
AF2B	APU F/LINE B THERMO	1	1							STATE
A02B	APU O/LINE B THERMO	1	1							STATE
AS2B	APU SER LINE B THERMO	1	1							STATE
AT3A	APU 3 TANK A THERMO	1	1							STATE

MEASUREMENT OUTPUT FROM APU/HYD MODEL - TABLE 2

MEASUREMENT I. D.	MEASUREMENT NAME	I. C.		VALUE 1 K=1 (NOMINAL)		VALUE 2 K=2 (HI/LOW)		VALUE 3 K=3 (OFF)		UNITS
		FS	CTS	FS	CTS	FS	CTS	FS	CTS	
AF3A	APU F/LINE A THERMO	1	1							STATE
A03A	APU O/LINE A THERMO	1	1							STATE
AS3A	APU SER LINE A THERMO	1	1							STATE
AT3B	APU TANK B THERMO	1	1							STATE
AF3B	APU F/LINE B THERMO	1	1							STATE
A03B	APU O/LINE B THERMO	1	1							STATE
AS3B	APU SER LINE B THERMO	1	1							STATE
GG1A	PUMP/GG HTR	1	1							STATE
GG1B	PUMP/GG HTR	1	1							STATE
GG2A	PUMP/GG HTR	1	1							STATE
GG2B	PUMP/GG HTR	1	1							STATE
GG3A	PUMP/GG HTR	1	1							STATE
GG3B	PUMP/GG HTR	1	1							STATE

MEASUREMENT OUTPUT FROM APU/HYD MODEL - TABLE 2

MEASUREMENT I. D.	MEASUREMENT NAME	I.C.		VALUE 1 (NOMINAL)		VALUE 2 (HI/LOW)		VALUE 3 (OFF)		UNITS
		FS	CTS	FS	CTS	FS	CTS	FS	CTS	
V58T0101A	RESVR FLUID TEMP. SYSTEM 1	120	536	120	536	40	319	35	305	°F
V58T0201A	RESVR FLUID TEMP. SYSTEM 2	124.2	548	124.2	548	40	319	35	305	°F
V58T0301A	RESVR FLUID TEMP. SYSTEM 3	117	528	117	528	40	319	35	305	°F
V58Q0102A	RESVR FLUID VOLUME SYSTEM 1	58	593	58	593	58	593	58	593	PCT
V58Q0202A	RESVR FLUID VOLUME SYSTEM 2	62	634	62	634	62	634	62	634	PCT
V58Q0302A	RESVR FLUID VOLUME SYSTEM 3	68	696	68	696	68	696	68	696	PCT
V58P0104A	H ₂ O BLR GN ₂ REG. OUT. PRESS. SYSTEM 1	0	0	25	342	25	342	25	342	PSIA
V58P0204A	H ₂ O BLR GN ₂ REG. OUT. PRESS. SYSTEM 2	0	0	28	383	28	363	28	383	PSIA
V58P0304A	H ₂ O BLR GN ₂ REG. OUT. PRESS. SYSTEM 3	0	0	27	368	27	368	27	368	PSIA
V58T0105A	H ₂ O BLR GN ₂ TK. TEMP. SYSTEM 1	31.44	0	70.04	278	70.04	278	70.04	278	°F
V58T0205A	H ₂ O BLR GN ₂ TK. TEMP. SYSTEM 2	31.44	0	103.05	589	103.05	589	103.05	539	°F
V58T0305A	H ₂ O BLR GN ₂ TK. TEMP. SYSTEM 3	31.44	0	106.94	616	106.94	616	106.94	616	°F
*V58P0114A	SUPPLY PRESS. A SYSTEM 1	3022	773	3022	773	375	96	78	20	PSIA
*V58P0214C	SUPPLY PRESS. A SYSTEM 2	3124	799	3124	799	375	96	78	20	PSIA
*V58P0314C	SUPPLY PRESS. A SYSTEM 3	3226	825	3226	825	375	96	78	20	PSIA
V58P0115C	SUPPLY PRESS. B SYSTEM 1	3200	818	3200	818	376	96	80	20	PSIA
V58P0215C	SUPPLY PRESS. B SYSTEM 2	3000	767	3000	767	376	96	80	20	PSIA

* NOTE: This measurement uses the range limit conversion method of calculating FS_{EU} from GSIU_{CTS} as discussed in Section 2.6.2.

MEASUREMENT OUTPUT FROM APU/HYD MODEL - TABLE 2

MEASUREMENT I. D.	MEASUREMENT NAME	I. C.		VALUE 1 K=1 (NOMINAL)		VALUE 2 K=2 (HI/LOW)		VALUE 3 K=3 (OFF)		UNITS
		FS	CTS	FS	CTS	FS	CTS	FS	CTS	
V58P0315C	SUPPLY PRESS B SYSTEM 3	2896	741	2896 752	741 192	376	96	80	20	PSIA
*V58P0116C	HYD SYS 1 SUPPLY PRESS C	3300	844	3300 751	844 192	375	96	78	20	PSIA
*V58P0216C	HYD SYS 2 SUPPLY PRESS C	3402	870	3402 751	870 192	375	96	78	20	PSIA
*V58P0316C	HYD SYS 3 SUPPLY PRESS C	3152	806	3152 751	806 192	375	96	78	20	PSIA
V58T0120A	HYD SYS 1 FLUID HTR OUT TMP	102	487	102	487	102	487	35	305	DEGF
V58T0220A	HYD SYS 2 FLUID HTR OUT TMP	90	454	90	454	90	454	35	305	DEGF
V58T0320A	HYD SYS 3 FLUID HTR OUT TMP	81	430	81	430	81	430	35	305	DEGF
V58P0137A	CIRC. PUMP PRESS. SYSTEM 1	50	63	50	63	374	479	80	102	PSIA
V58P0237A	CIRC. PUMP PRESS. SYSTEM 2	54	70	54	70	374	479	80	102	PSIA
V58P0337A	CIRC. PUMP PRESS. SYSTEM 3	61	78	61	78	374	479	80	102	PSIA
V58P0147A	H ₂ O BLR. GN ₂ TK. PRESS SYSTEM 1	2471	722	2471	722	2471	722	2471	722	PSIA
V58P0247A	H ₂ O BLR. GN ₂ TK. PRESS SYSTEM 2	2429	710	2429	710	2429	710	2429	710	PSIA
V58P0347A	H ₂ O BLR. GN ₂ TK. PRESS SYSTEM 3	2513	735	2513	735	2513	735	2513	735	PSIA
V58T0157A	HYD SYS 1 LH INBD ELEV ACT RTN LN TMP	141	593	141	593	30	291	30	291	DEGF
V58T0257A	HYD SYS 2 LH INBD ELEV ACT RTN LN TMP	132	569	132	569	30	291	30	291	DEGF
V58T0159A	HYD SYS 1 RH INBD ELEV ACT RTN LN TMP	147	610	147	610	30	291	30	291	DEGF
V58T0359A	HYD SYS 3 RH INBD ELEV ACT RTN LN TMP	78	421	78	421	30	291	30	291	DEGF
V58T0161A	H ₂ O BLR. TK. TEMP. SYSTEM 1	31.44	0	100.08	567	55.89	152	55.89	152	°F
V58T0261A	H ₂ O BLR. TK. TEMP. SYSTEM 2	31.44	0	105.03	603	55.89	152	55.89	152	°F

ORIGINAL PAGE IS
OF POOR QUALITY

*NOTE: This measurement uses the range limit conversion method of calculating FS_{EU} from GSIU_{CTS} as discussed in Section 2.6.2.

MEASUREMENT OUTPUT FROM APU/HYD MODEL - TABLE 2

MEASUREMENT I. D.	MEASUREMENT NAME	I. C.		VALUE 1 (NOMINAL)		VALUE 2 (HI/LOW)		VALUE 3 (OFF)		URITS
		FS	CTS	FS	CTS	FS	CTS	FS	CTS	
V58T0361A	H ₂ O BLR. TK. TEMP. SYSTEM 3	31.44	0	110.01	636	55.89	152	55.89	152	°F
V58T0162A	H ₂ O BLR. TEMP. NO. 1 SYSTEM 1	29.96	0	82.00	405	55.86	159	55.86	159	°F
V58T0262A	H ₂ O BLR. TEMP. NO. 1 SYSTEM 2	29.96	0	76.90	352	55.86	159	55.86	159	°F
V58T0362A	H ₂ O BLR. TEMP. NO. 1 SYSTEM 3	29.96	0	71.00	292	55.86	159	55.86	159	°F
V58T0163A	H ₂ O BLR. TEMP. NO. 2 SYSTEM 1	29.96	0	104.95	610	55.86	159	55.86	159	°F
V58T0263A	H ₂ O BLR. TEMP. NO. 2 SYSTEM 2	29.96	0	95.98	539	55.86	159	55.86	159	°F
V58T0363A	H ₂ O BLR. TEMP. NO. 2 SYSTEM 3	29.96	0	86.03	446	55.86	159	55.86	159	°F
V58T0165A	H ₂ O BLR. VENT TEMP. NO. 1 SYSTEM 1	150	454	150	454	122	0	122	0	°F
V58T0265A	H ₂ O BLR. VENT TEMP. NO. 1 SYSTEM 2	153	503	153	503	122	0	122	0	°F
V58T0365A	H ₂ O BLR. VENT TEMP. NO. 1 SYSTEM 3	160	618	160	618	122	0	122	0	°F
V58T0166A	H ₂ O BLR. VENT TEMP. NO. 2 SYSTEM 1	155	536	155	536	122	0	122	0	°F
V58T0266A	H ₂ O BLR. VENT TEMP. NO. 2 SYSTEM 2	157	569	157	569	122	0	122	0	°F
V58T0366A	H ₂ O BLR. VENT TEMP. NO. 2 SYSTEM 3	165	698	165	698	122	0	122	0	°F
V58X0181E	H ₂ O BLR. BYPASS CL. IND. SYSTEM 1	0	0	1	1	0	0	0	0	STATE
V58X0281E	H ₂ O BLR. BYPASS CL. IND. SYSTEM 2	0	0	1	1	0	0	0	0	STATE
V58X0381E	H ₂ O BLR. BYPASS CL. IND. SYSTEM 3	0	0	1	1	0	0	0	0	STATE
V58X0182E	H ₂ O BLR. OK SYSTEM 1	0	0	0	0	0	0	0	0	STATE
V58X0282E	H ₂ O BLR. OK SYSTEM 2	0	0	0	0	0	0	0	0	STATE
V58X0382E	H ₂ O BLR. OK SYSTEM 3	0	0	0	0	0	0	0	0	STATE

MEASUREMENT OUTPUT FROM APU/HYD MODEL - TABLE 2

MEASUREMENT I. D.	MEASUREMENT NAME	I. C.		VALUE 1 (NOMINAL)		VALUE 2 (HI/LOW)		VALUE 3 (OFF)		K=3	UNITS
		FS	CTS	FS	CTS	FS	CTS	FS	CTS		
V58X0190E	LDG. GR. ISLN. VLV. CL. IND. SYSTEM 1	0	0								STATE
V58X0290E	LDG. GR. ISLN. VLV. CL. IND. SYSTEM 2	0	0								STATE
V58X0390E	LDG. GR. ISLN. VLV. CL. IND. SYSTEM 3	0	0								STATE
V58T0198A	HYD SYS 1 RSB RETURN LINE TEMP	136.2	581	136.2	561	30	291	30	291	291	DEGF
V58T0298A	HYD SYS 2 RSB RETURN LINE TEMP	69	397	69	397	30	291	30	291	291	DEGF
V58T0398A	HYD SYS 3 RSB RETURN LINE TEMP	63	381	63	381	30	291	30	291	291	DEGF
V58T0288A	HYD SYS 2 BODY FLAP RTN LINE TEMP	75	413	75	413	30	291	30	291	291	DEGF
V58T0388A	HYD SYS 3 BODY FLAP RTN LINE TEMP	66	389	66	389	30	291	30	291	291	DEGF
V58T0296A	HYD SYS 2 RH BRAKE VLV RTN LN TMP	72	405	72	405	30	291	30	291	291	DEGF
V58X0800E	LH INBD ELVN ACTR. SW. VLV. ACTV. POSN.	0	0								STATE
V58X0801E	LH INBD ELVN ACTR. SW. VLV. PS2 POSN.	0	0								STATE
V58T0833A	LH INBD ELVN SW. VALVE LN TEMP.	40	319	40	319	30	291	30	291	291	°F
V58T0841A	LH OTBD BRAKE SW. VALVE LN TEMP.	57	364	57	364	30	291	30	291	291	°F
V58T0842A	LH INBD BRAKE SW. VALVE LN TEMP.	54	356	54	356	30	291	30	291	291	°F
V58T0845A	RH OTBD BRAKE SW. VALVE LN TEMP.	51	348	51	348	30	291	30	291	291	°F
V58T0846A	RH INBD BRAKE SW. VALVE LN TEMP.	48	340	48	340	30	291	30	291	291	°F
V58X0850E	LH OTBD ELVN ACTR. SW. VLV. ACTV. POSN.	0	0								STATE
V58X0851E	LH OTBD ELVN ACTR. SW. VLV. PS2 POSN.	0	0								STATE
V58T0883A	LH OTBD ELVN SW. VALVE LN TEMP.	45	331	45	331	30	291	30	291	291	°F

MEASUREMENT OUTPUT FROM APU/HYD MODEL - TABLE 2

MEASUREMENT I. D.	MEASUREMENT NAME	I. C.		VALUE 1 K=1 (NOMINAL)		VALUE 2 K=2 (HI/LOW)		VALUE 3 K=3 (OFF)		UNITS
		FS	CTS	FS	CTS	FS	CTS	FS	CTS	
V58X0900E	RH INBD ELVN ACTR. SW. VLV. ACTV. POSN.	0	0							STATE
V58X0901E	RH INBD ELVN ACTR. SW. VLV. PS2 POSN.	0	0							STATE
V58T0933E	RH INBD ELVN SW. VALVE LN TEMP.	42	323	42	323	30	291	30	291	°F
V58X0950E	RH OTBD ELVN ACTR. SW. VLV. ACTV. POSN	0	0							STATE
V58X0951E	RH OTBD ELVN ACTR. SW. VLV. PS2 POSN	0	0							STATE
V58T0983A	RH OTBD ELVN SW. VALVE LN TEMP.	39	315	39	315	30	291	30	291	°F
V58X1000E	RDR/SPDBK SW. VLV ACTV. POSN.	0	0							STATE
V58X1001E	RDR/SPDBK SW VLV. PS2 POSN.	0	0							STATE
V58T1006A	RUDDER SW. VALVE LN TEMP. A	36	307	33	307	30	291	30	291	°F
V58X1136E	HYD SYS 1 ME/TVC SPLY VLV OPN IND	0	0							STATE
V58T1143A	MID FUSLG. RTN. LN TEMP A	33	299	33	299	30	291	30	291	°F
V58X1236E	HYD SYS 2 ME/TVC SPLY VLV OPN IND	0	0							STATE
V58X1336E	HYD SYS 3 ME/TVC SPLY VLV OPN IND	0	0							STATE
V58P9116A	HYD SYS 1 GN2 ACCUMULATOR PRESS	2560	655	2560	655	2560	655	2560	655	PSIA
V58P9216A	HYD SYS 2 GN2 ACCUMULATOR PRESS	2400	614	2400	614	2400	614	2400	614	PSIA
V58P9316A	HYD SYS 3 GN2 ACCUMULATOR PRESS	2600	665	2600	665	2500	665	2600	665	PSIA

MEASUREMENT OUTPUT FROM APU/HYD MODEL - TABLE 2

MEASUREMENT I. D.	MEASUREMENT NAME	I. C.		VALUE 1 (NOMINAL)		VALUE 2 (HI/LOW)		VALUE 3 (OFF)		UNITS
		FS	CTS	FS	CTS	FS	CTS	FS	CTS	
V58T9133A	HYD SYS 1 FLUID HTR INLET TMP	108	503	108	503	70	401	70	401	DEGF
V58T9233A	HYD SYS 2 FLUID HTR INLET TMP	125	550	125	550	70	401	70	401	DEGF
V58T9333A	HYD SYS 3 FLUID HTR INLET TMP	170	673	170	673	70	401	70	401	DEGF
V58T9141A	HYD SYS 1 CIRC PUMP OUTLET TEMP	112.2	516	112.2	516	70	401	70	401	DEGF
V58T9242A	HYD SYS 2 CIRC PUMP OUTLET TEMP	127.2	557	127.2	557	70	401	70	401	DEGF
V58T9342A	HYD SYS 3 CIRC PUMP OUTLET TEMP	165	659	165	659	70	401	70	401	DEGF
V58T9144A	HYD SYS 1 RETURN LINE RSB TMP	93	462	93	462	30	291	30	291	DEGF
V58T9244A	HYD SYS 2 RETURN LINE RSB TMP	117	528	117	528	30	291	30	291	DEGF
V58T9344A	HYD SYS 3 RETURN LINE RSB TMP	175	687	175	687	30	291	30	291	DEGF
V58T9160A	HYD SYS 1 RTN LN BODY FLAP TMP	99	479	99	479	30	291	30	291	DEGF
V58T9165A	HYD SYS 2 RTN LN R OTBD ELEV ACT TEMP	85	442	85	442	30	291	30	291	DEGF
V58T9178A	HYD SYS 1 RTN LN LMG UPLK ACT TMP	27	282	27	282	30	291	30	291	DEGF
V58T9183A	HYD SYS 1 NLG UPLK ACT LINE TMP	24	274	24	274	30	291	30	291	DEGF
V58T9186A	HYD SYS 1 RTN LN NLG TEMP 3	87	446	87	446	30	291	30	291	DEGF
V58T9189A	HYD SYS 1 RTN LN RMG UPLK ACT TMP	21	266	21	266	30	291	30	291	DEGF
V58T9190A	HYD SYS 1 RTN LN RMG ORIFICE TMP	18	258	18	258	30	291	30	291	DEGF
V58T9194A	HYD SYS 1 RTN LN R BRK SW VLV TMP	96	471	96	471	30	291	30	291	DEGF
V58T9236A	HYD SYS 2 RTN LN BODY FLAP TMP	115	524	115	524	30	291	30	291	DEGF
V58T9261A	HYD SYS 1 RTN LN L OTBD ELEV ACT	84	438	84	438	30	291	30	291	DEGF
V58T9262A	HYD SYS 1 RTN LN R OTBD ELEV ACT	144	602	144	602	30	291	30	291	DEGF
V58T9263A	HYD SYS 2 LH BRAKE VLV RTN LN TMP	30	291	30	291	30	291	30	291	DEGF
V58T9264A	HYD SYS 2 RH BRAKE SW VLV RTN LN TMP	30	291	30	291	30	291	30	291	DEGF
V58T9349A	HYD SYS 3 RTN LN BODY FLAP TMP	160.2	647	160.2	647	30	291	30	291	DEGF

MEASUREMENT OUTPUT FROM APU/HYD MODEL - TABLE 2

MEASUREMENT I. D.	MEASUREMENT NAME	I. C.		VALUE 1 (NOMINAL)		VALUE 2 (HI/LOW)		VALUE 3 (OFF)		UNITS
		FS	CTS	FS	CTS	FS	CTS	FS	CTS	
V58T9351A	HYD SYS 3 RH BRAKE VLV RTN LN TMP	30	291	30	291	30	291	30	291	DEGF
V58T9352A	HYD SYS 3 LH BRAKE VLV RTN LN TMP	30	291	30	291	30	291	30	291	DEGF
V58T9361A	HYD SYS 3 RTN LN L OTBD ELEV ACT TMP	156	634	156	634	30	291	10	237	DEGF
V58T0830A	HYD SYS LH INBD ELEV ACT	120	532							DEGF
V58T0880A	HYD SYS LH OTBD ELEV ACT	126	548							DEGF
V58T0930A	HYD SYS NBD ELEV ACT	132	565							DEGF
V58T080A	HYD SYS OTBD ELEV ACT	138	581							DEGF
V57T0014A	RUDDER/SPEEDBRAKE PDU	144	597							DEGF
V57T0018A	BODY FLAP PDU	150	614							DEGF

5.0 STS REFERENCES:

- a) LA-B-10100-1/JSC-11174, Space Shuttle Systems Handbook OV-102
- b) LEC-9510, Orbiter 102 Simulation Requirements for SMFS/APU-HYD
- c) LEC-6992 Rev. A, Space Shuttle APU Controller Study
- d) LEC-Memo # 77-2109-055, GSIU Math Model Requirements for APU/HYD
- e) VS70-580102, Hydraulic Control Subsystem Schematic
- f) VS70-460102, Auxiliary Power Unit Schematic
- g) VL70-000137G, Hydraulic Subsystem, Orbiter MCR1750 Baseline Schematic
- h) ICD-3-1603-5, Section 2 and Section 3.8

**GTS
SECTION**

12.0 GTS DETAILED REQUIREMENTS

This model simulates the functions of the Auxiliary Power Unit (APU) and the Hydraulics (HYD) subsystems in the Orbiter. Only those flight critical functions of the APU/HYD subsystems that are addressed to the Orbiter's General Purpose Computers (GPC's) are contained in these math model requirements, namely, the hydraulic pump output pressures. This permits the use of a much simplified model which contains only those functions necessary to support GN&C testing.

APU/HYD measurements, together with measurements from other subsystems, that are addressed to the O/I PCM master unit are provided from a table of static values which is not a part of this requirements document. The tabulated values are changeable within their specified ranges by the operator at the Non-Avionics Simulator console, when performing System Management tests with O/I parameters.

Figure 4 illustrates the data flow in and out of the APU/HYD model for the GN&C Test Station.

Tables 14.1 and 14.2 list the input stimuli and the output measurements for the GTS APU/HYD model.

12.1 GTS FUNCTIONAL CHARACTERISTICS

The APU/HYD subsystem consists of three APU's which independently drive three main hydraulic pumps. Inputs from the NAS console simulate cockpit commands to turn each of the three systems ON or OFF.

12.2 NAS UPLINK REQUIREMENTS

In addition to the three ON/OFF commands simulating cockpit commands to the three APU's, the operator at the NAS console has the ability to change the value of any output parameter in the model.

12.3 GTS INITIALIZATION REQUIREMENTS

The initial conditions shall be as listed in Table 14.2.

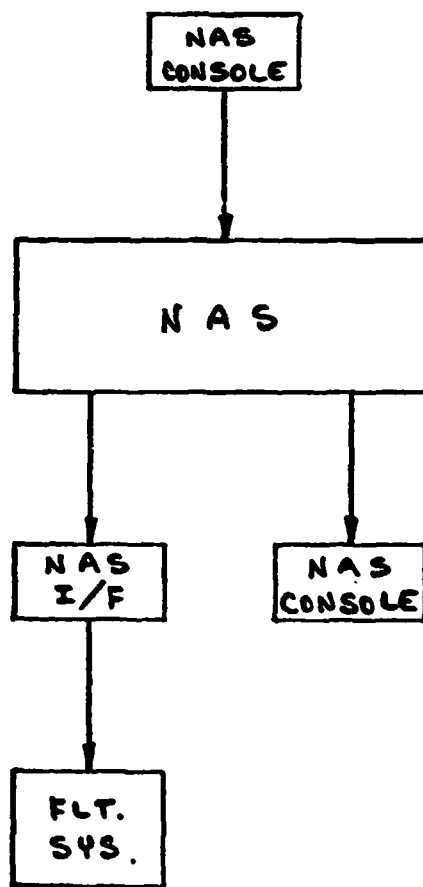


FIGURE 4 - APU/HYD DATA FLOW

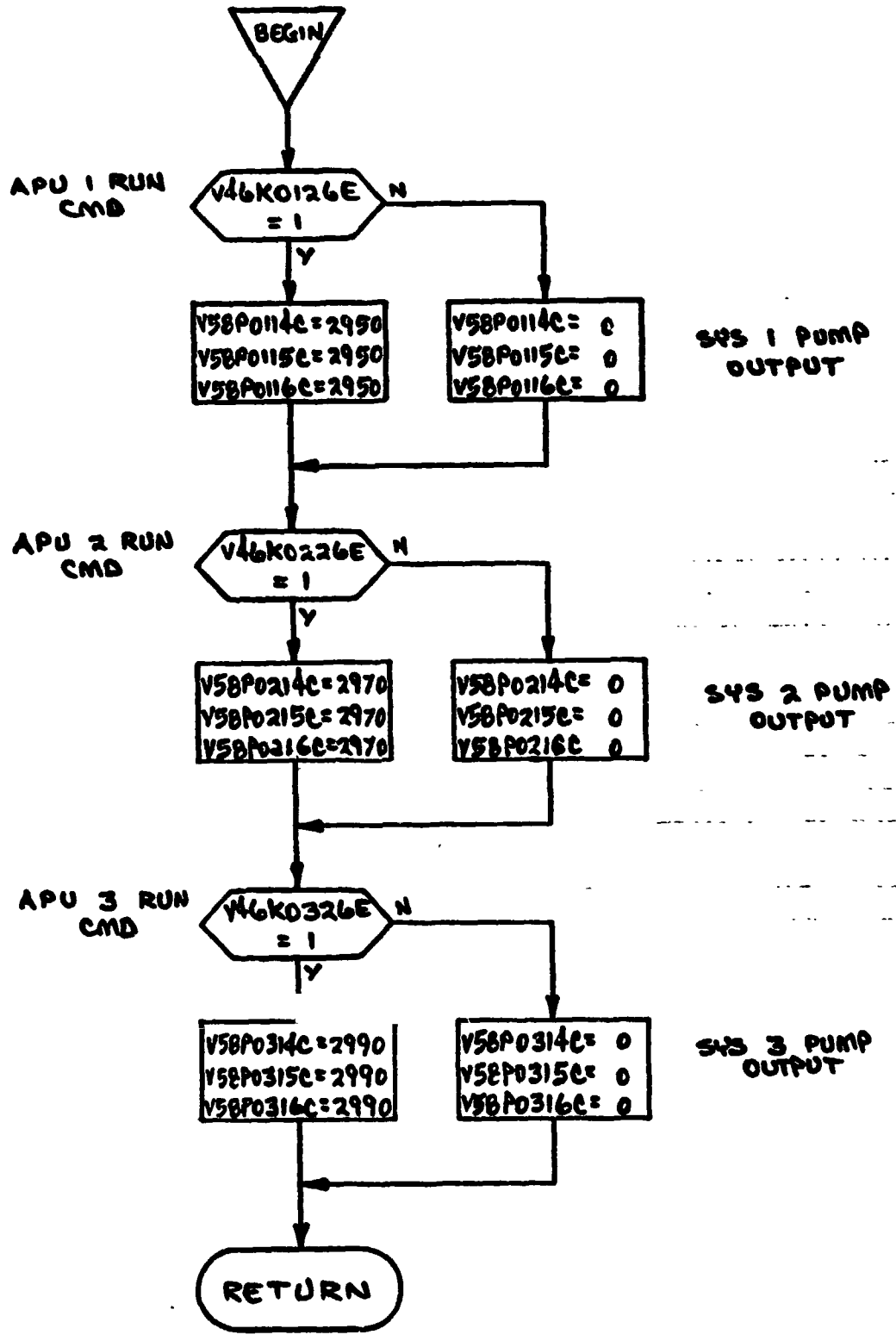
12.4 GTS TERMINATION REQUIREMENTS

None.

12.5 GTS UNIQUE REQUIREMENTS

None.

13.0 GTS LOGIC FLOW DIAGRAMS



ORIGINAL PAGE IS
OF POOR QUALITY

14.0 GTS INPUT/OUTPUT TABLES

STIMULI INPUT TO /HYD MODEL-TABLE 14.1

IDENTIFICATION NUMBER	NOMENCLATURE	SOURCE	STATES/SPACE	
			LO	HI UNITS
V46K0126E	APU 1 START/RUN CMD	From NAS Console	0	1 STATE
V46K0226E	APU 2 START/RUN CMD	From NAS Console	0	1 STATE
V46K0326E	APU 3 START/RUN CMD	From NAS Console	0	1 STATE

MEASUREMENT OUTPUT FROM APU/HYD MODEL - TABLE 14.2

MEASUREMENT I. D.	MEASUREMENT NAME	I.C.		VALUE 1 K=1 (NOMINAL)		VALUE 2 K=2 (HI/LOW)		VALUE 3 K=3 (OFF)		UNITS
		FS	CTS	FS	CTS	FS	CTS	FS	CTS	
*V58P0114C	SUPPLY PRESS. A SYSTEM 1	0		2950						PSIA ↓ PSIA
*V58P0214C	SUPPLY PRESS. A SYSTEM 2	0		2970						
*V58P0314C	SUPPLY PRESS. A SYSTEM 3	0		2990						
V58P0115C	SUPPLY PRESS. B SYSTEM 1	0		2950						
V58P0215C	SUPPLY PRESS. B SYSTEM 2	0		2970						
V58P0315C	SUPPLY PRESS. B SYSTEM 3	0		2990						
*V58P0116C	HYD SYS 1 SUPPLY PRESS C	0		2950						
*V58P0216C	HYD SYS 2 SUPPLY PRESS C	0		2970						
*V58P0316C	HYD SYS 3 SUPPLY PRESS C	0		2990						

*NOTE: This measurement uses the range limit conversion method of calculating FS_{EU} from GSIU_{CTS} as discussed in Section 2.6.2.

14.3 NAS CRT DISPLAY

Figure 5 shows the format of the NAS CRT of which APU/HYD is a part.

ORIGINAL PAGE IS
OF POOR QUALITY

FORTRAN JING

EXECUTE _____

TABULATE _____

VERIFY _____

PUNCH _____

CONTINUATION		FORTRAN STATEMENT		COMMENTS
LINE	CHARACTER	1-5	6-10	11-15
587641		VARIABLE FIELD	36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70	XXXXXXXXXX
		APU/HVD S/S		MPS X-E-M
58P0114C	HVD SUP	PRESS A SYS 1	2950	K1700X LM2 1 REPL
58P0115C	HVD SUP	PRESS B SYS 1	2950	K1701X LM2 2 REPL
58P0116C	HVD SUP	PRESS C SYS 1	2950	K1702X LM2 3 REPL
58P0214C	HVD SUP	PRESS A SYS 2	2970	K1750X LM2 1 REPL
58P0215C	HVD SUP	PRESS B SYS 2	2970	K1751X LM2 2 REPL
58P0216C	HVD SUP	PRESS C SYS 2	2970	K1752X LM2 3 REPL
58P0314C	HVD SUP	PRESS A SYS 3	2990	VE1XX E-1 READY
58P0315C	HVD SUP	PRESS B SYS 3	2990	VE2XX E-2 READY
58P0316C	HVD SUP	PRESS C SYS 3	2990	VE3XX E-3 READY
		PYRBS ET SEP		K1125X MPS 1 MNSTG
		ET/ORB SEPN ARM		K1225X MPS 2 MNSTG
		ET/ORB SEPN FIRE		K1325X MPS 3 MNSTG
		P/C A VBLT	5.0	

NOTE: DATA BLOCKS ALL SHOWN FOR (M) CMD SIGNALS. ACTUAL DATA SHOULD BE PER MODEL LOGIC.

FIGURE 5

ORIGINAL PAGE IS
 OF POOR QUALITY

15.0 REFERENCES

VS70460102 - Auxiliary Power Unit Schematic
VS70580102 - Hydraulic Control Subsystem Schematic
GNCTS-02 - GNCTS Crew Station to GTS ICD
GNCTS-06 - GTS Non-Avionics Simulator ICD
LEC Memo No. 78-GNC-260-NAS CRT Formats by N. Bauer

APPENDIX B

VENT DOORS MATH MODEL REQUIREMENTS

TABLE OF CONTENTS

<u>SECTION</u>	<u>PAGE</u>
1.0 INTRODUCTION	B-2
2.0 DETAILED REQUIREMENTS.	B-4
2.1 FUNCTIONAL CHARACTERISTICS	B-4
2.2 NAS UPLINK REQUIREMENTS.	B-4
2.3 INITIALIZATION REQUIREMENTS.	B-4
2.4 TERMINATION REQUIREMENTS	B-4
2.5 UNIQUE REQUIREMENTS.	B-4
3.0 LOGIC FLOW DIAGRAMS.	B-5
4.0 INPUT/OUTPUT TABLES.	B-22
4.1 INPUT TABLE.	B-23
4.2 OUTPUT TABLE	B-27
4.3 NAS CRT DISPLAYS	B-31
5.0 REFERENCES	B-38

FIGURES

FIGURE 1 - FLIGHT SYSTEM/NAS DATA FLOW.	B-3
---	-----

1.0 INTRODUCTION

The GN & C Test Station (GTS) uses math models to simulate many of the Shuttle systems for which hardware has not been provided. A group of these models are termed "non-avionic" models since they do not simulate the Shuttle's "avionic" systems. The "non-avionic" models are needed to supply data for on-board software processing and to respond to Shuttle commands, whether they be from cockpit switches, the General Purpose Computers (GPC's) or the Non-Avionic Simulator (NAS) console. Figure 1 provides the Flight System/NAS data flow.

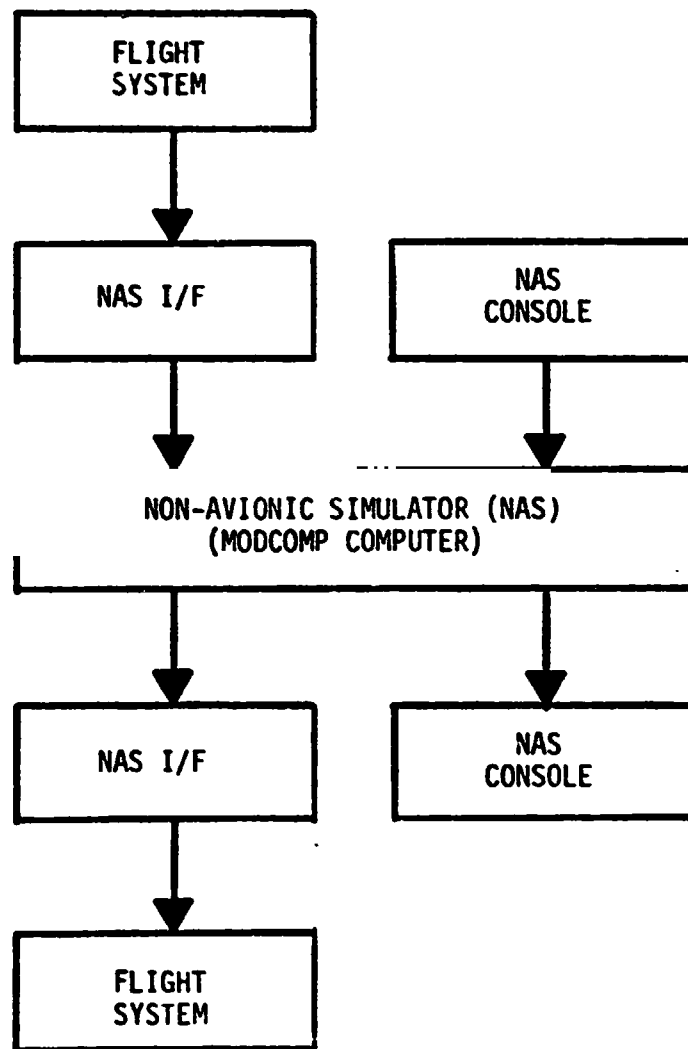


FIGURE 1 - FLIGHT SYSTEM/NAS DATA FLOW

2.0 DETAILED REQUIREMENTS

2.1 FUNCTIONAL CHARACTERISTICS

This model simulates those functions of the vent doors in the Orbiter, namely: OPEN, CLOSE, and PURGE. The vent doors permit equalization of pressures between the ambient and the unpressurized areas within the Orbiter during ascent and descent. The PURGE function expels toxic or explosive gas mixtures that may accumulate within the unpressurized areas.

2.2 NAS UPLINK REQUIREMENTS

The NAS console operator has the capability to override any math model output value with a value entered at the console. This permits the use of off-nominal data entries to test limit checking software.

2.3 INITIALIZATION REQUIREMENTS

When the math model begins running in the MODCOMP computer, the output data values shall be as defined in Table 4.2 - Initial Conditions, until altered by commands from the Flight System or the NAS console.

2.4 TERMINATION REQUIREMENTS

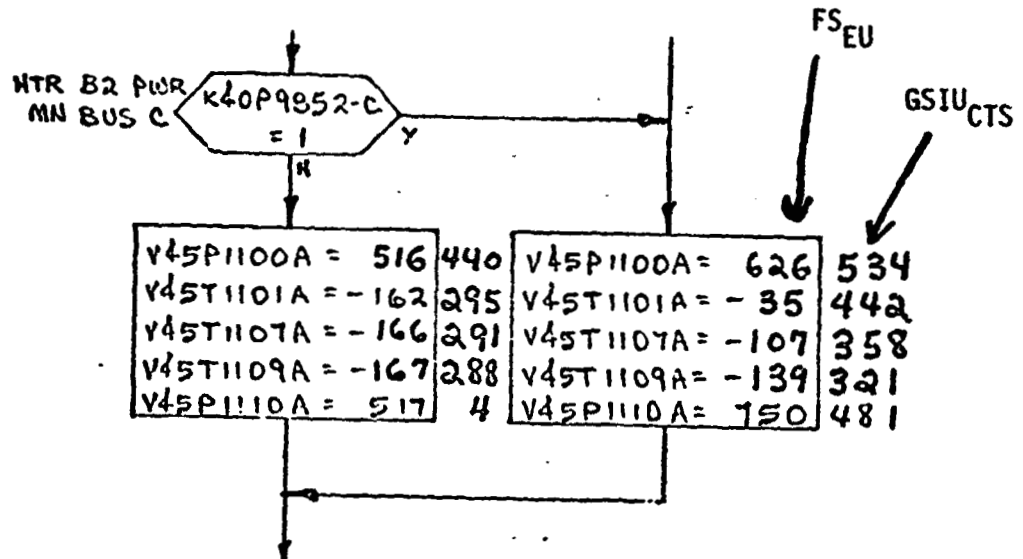
None.

2.5 UNIQUE REQUIREMENTS

None.

3.0 LOGIC FLOW DIAGRAMS

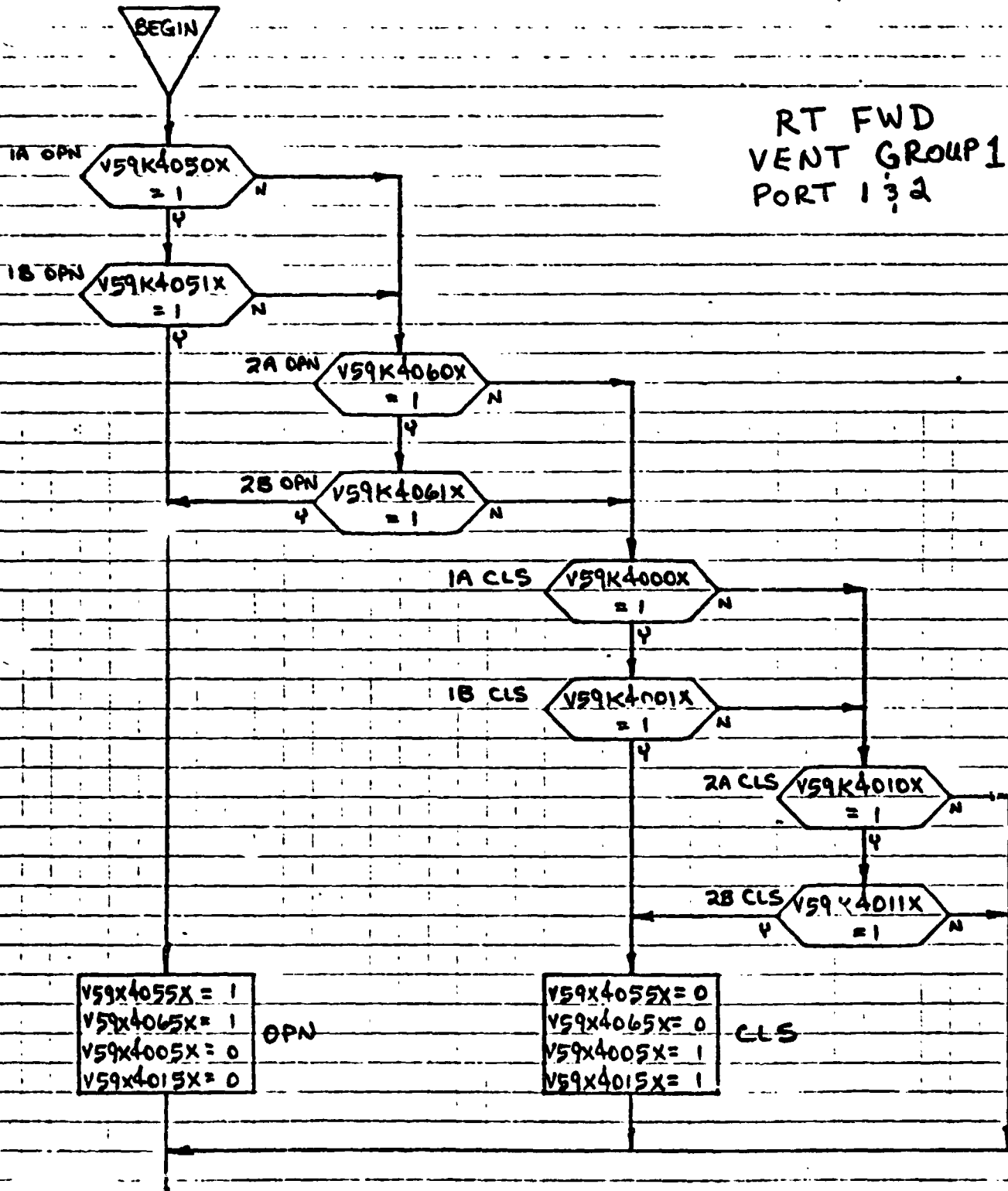
The logic flow diagram is made up of interconnected lines, boxes, decisions, and offpage connectors. Notice that where analog measurements are listed in boxes and decisions, the value inside the box is in flight system engineering units (FS_{EU}) while the corresponding GSIU count value is listed outside the box. For example, the box on the right hand below,



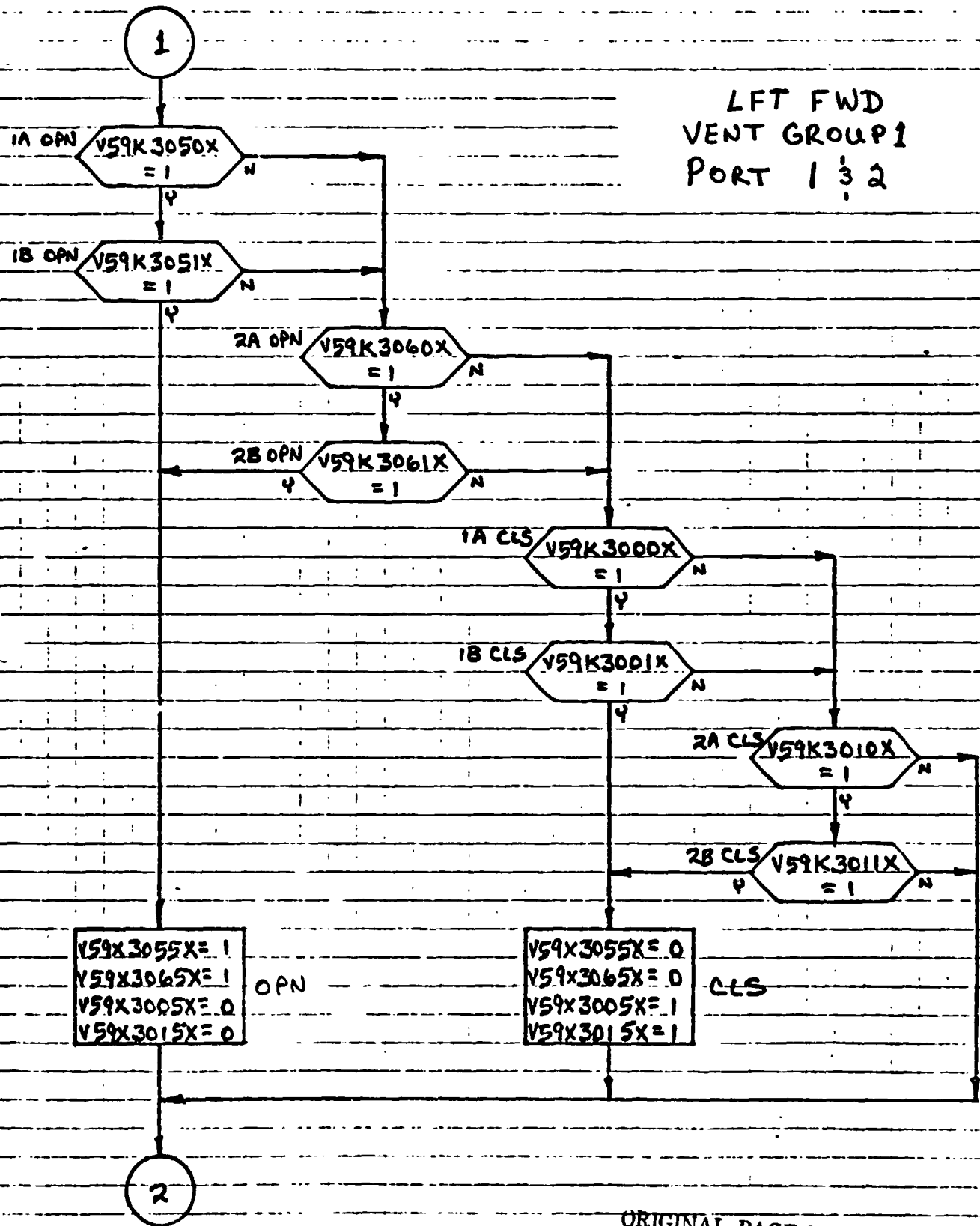
shows that V45P1100A is set equal to 626 FS_{EU} which is equivalent to 534 $GSIU_{CTS}$ shown outside the box.

ORIGINAL PAGE 1
OF FOUR QUALITY

RT FWD
VENT GROUP 1
PORT 1 3 2



LFT FWD
VENT GROUP 1
PORT 1 3 2



ORIGINAL PAGE IS
OF POOR QUALITY

2

RT FWD
VENT GROUP 1
PORT 1 & 2

PURGE

1A

V59K4100X
= 1

N

1B

V59K4101X
= 1

N

2A

V59K4110X
= 1

N

2B

V59K4111X
= 1

N

V59X4105X = 1
V59X4115X = 1

PURGE

V59X4105X = 0
V59X4115X = 0

NO
PURGE

1A

V59K3100X
= 1

N

1B

V59K3101X
= 1

N

2A

V59K3110X
= 1

N

2B

V59K3111X
= 1

N

V59X3105X = 1
V59X3115X = 1

PURGE

V59X3105X = 0
V59X3115X = 0

NO
PURGE

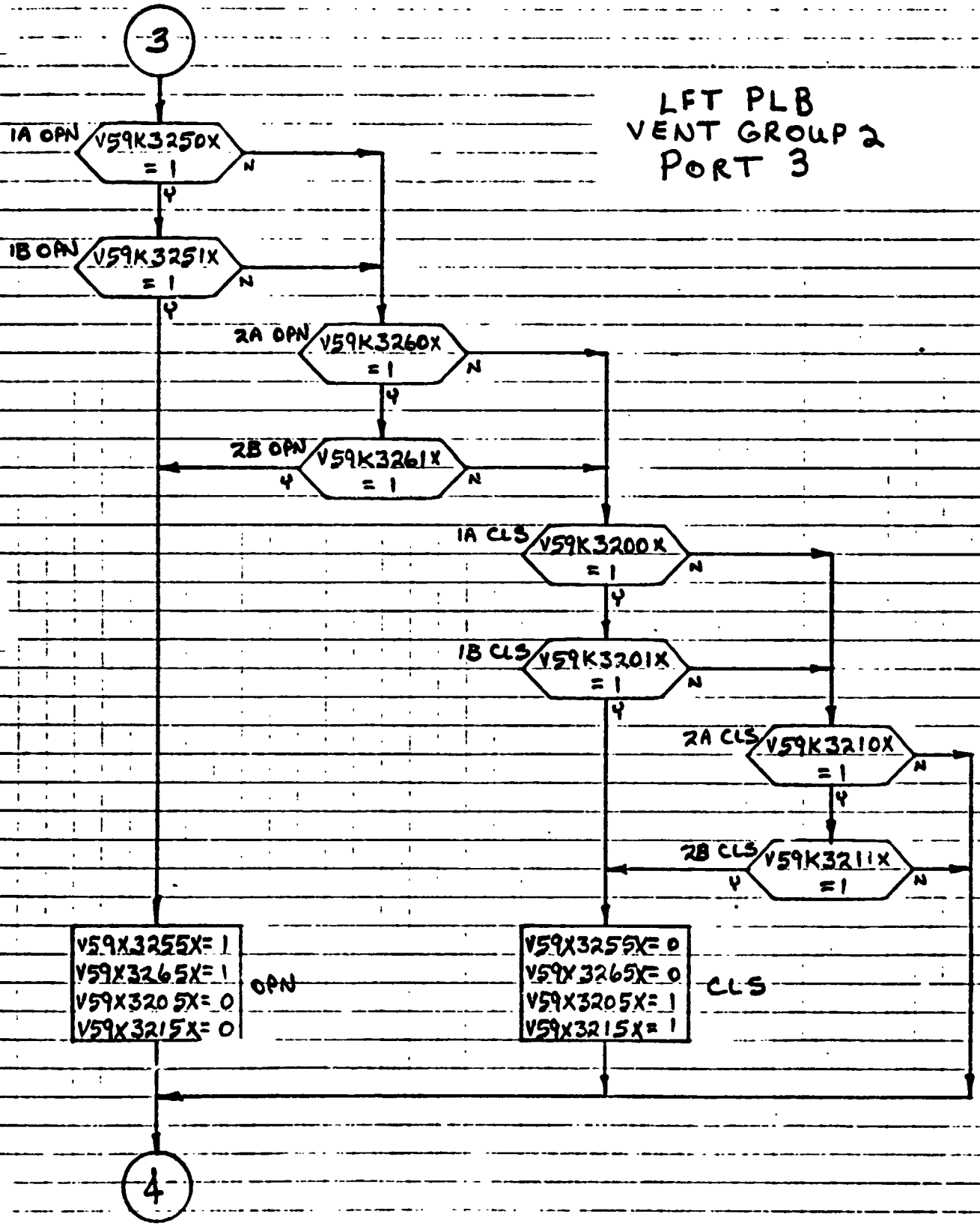
LET FWD 1 & 2

VENT DOORS

PURGE

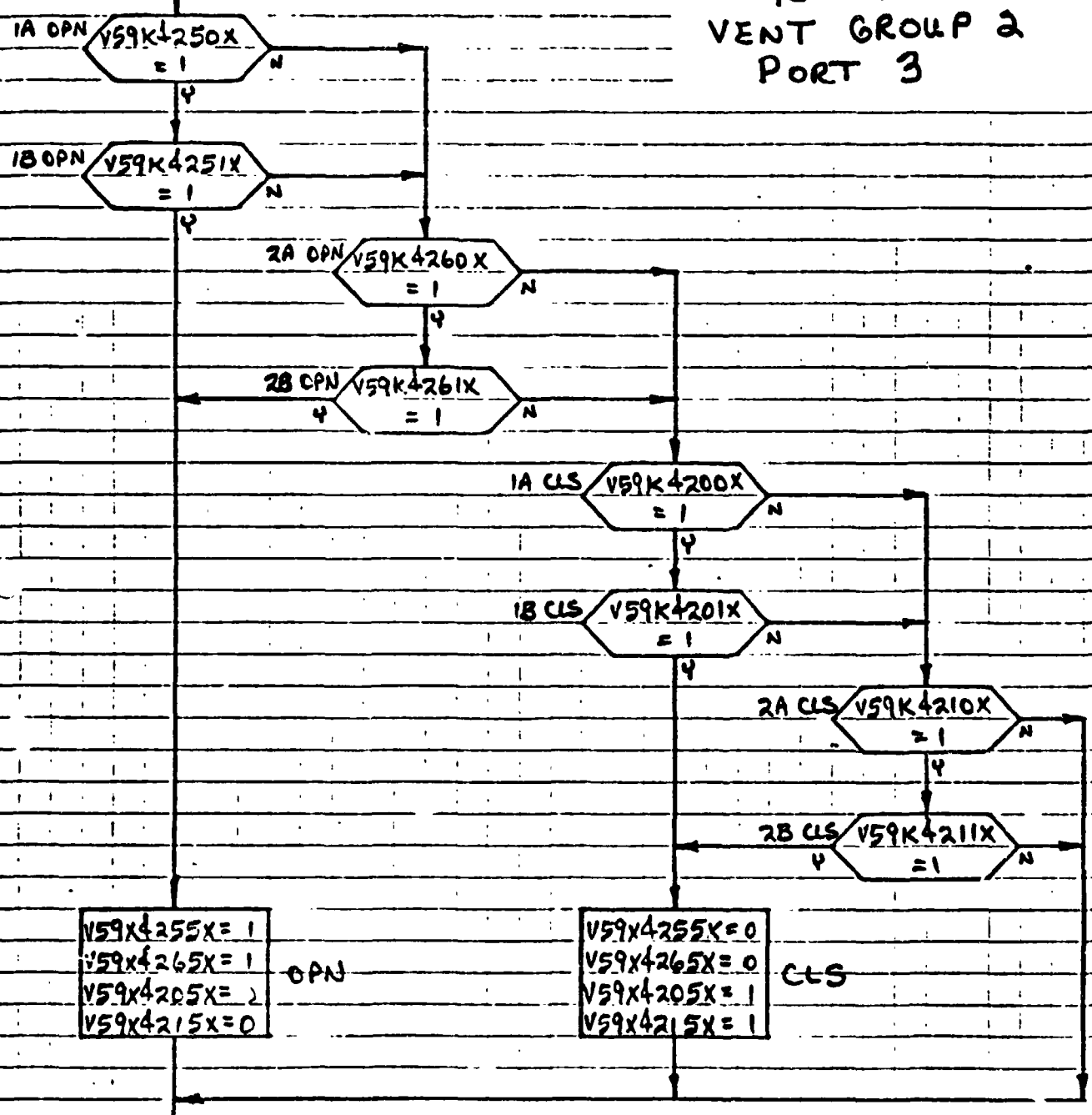
3

LFT PLB
VENT GROUP 2
PORT 3



RT PLB
VENT GROUP 2
PORT 3

4



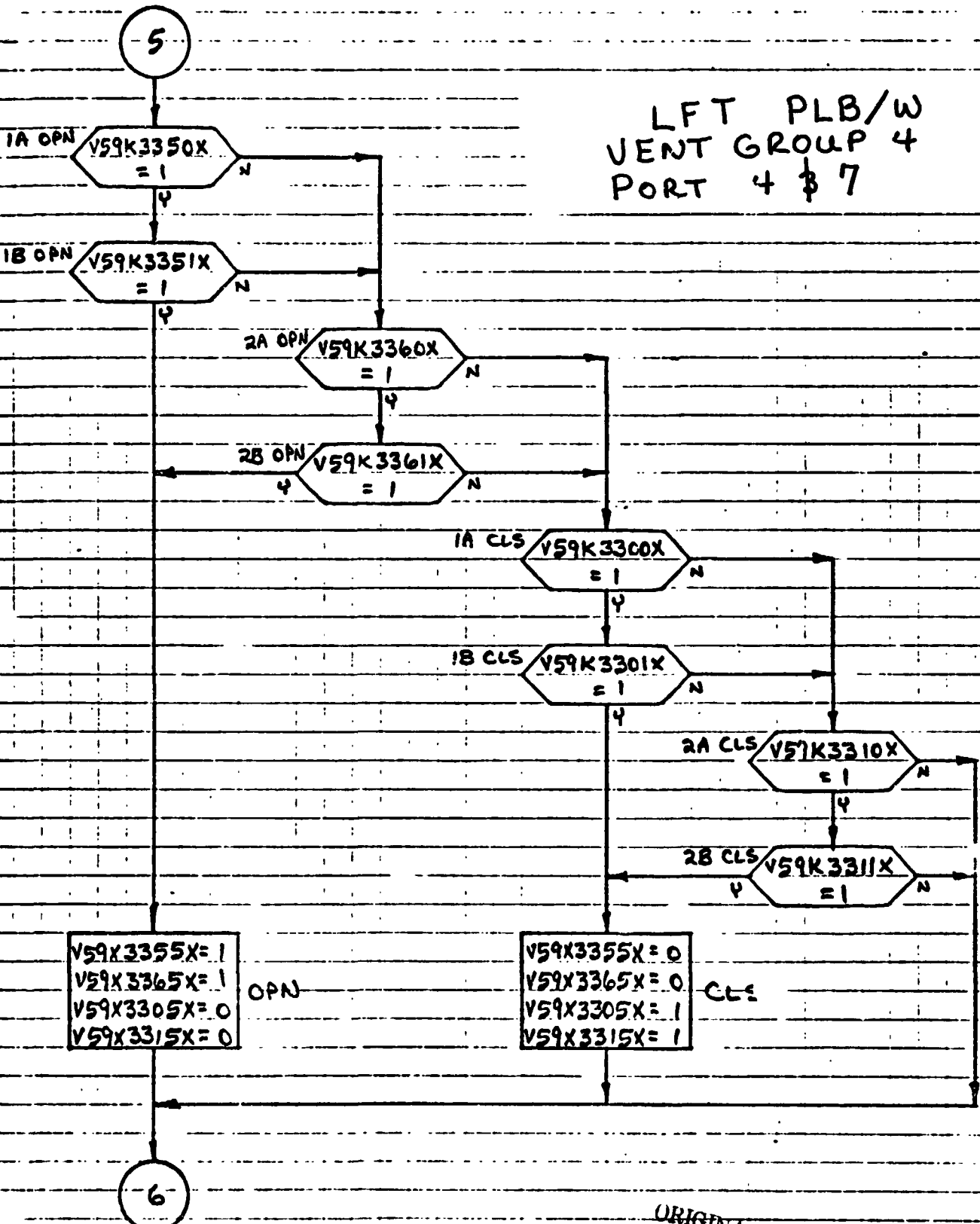
V59X4255X=1
V59X4265X=1
V59X4205X=2
V59X4215X=0

OPN

V59X4255X=0
V59X4265X=0
V59X4205X=1
V59X4215X=1

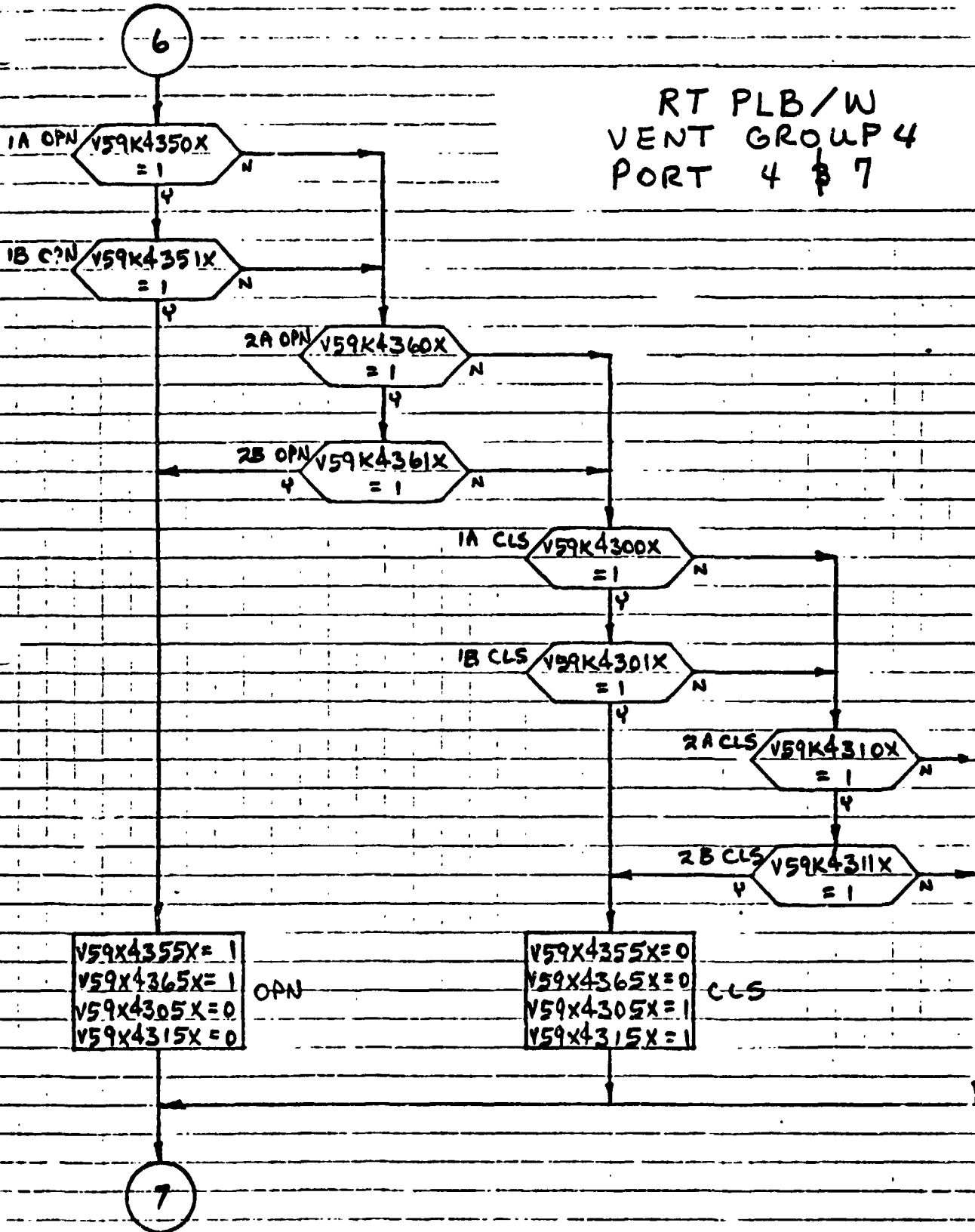
CLS

LFT PLB/W
 VENT GROUP 4
 PORT 4 & 7

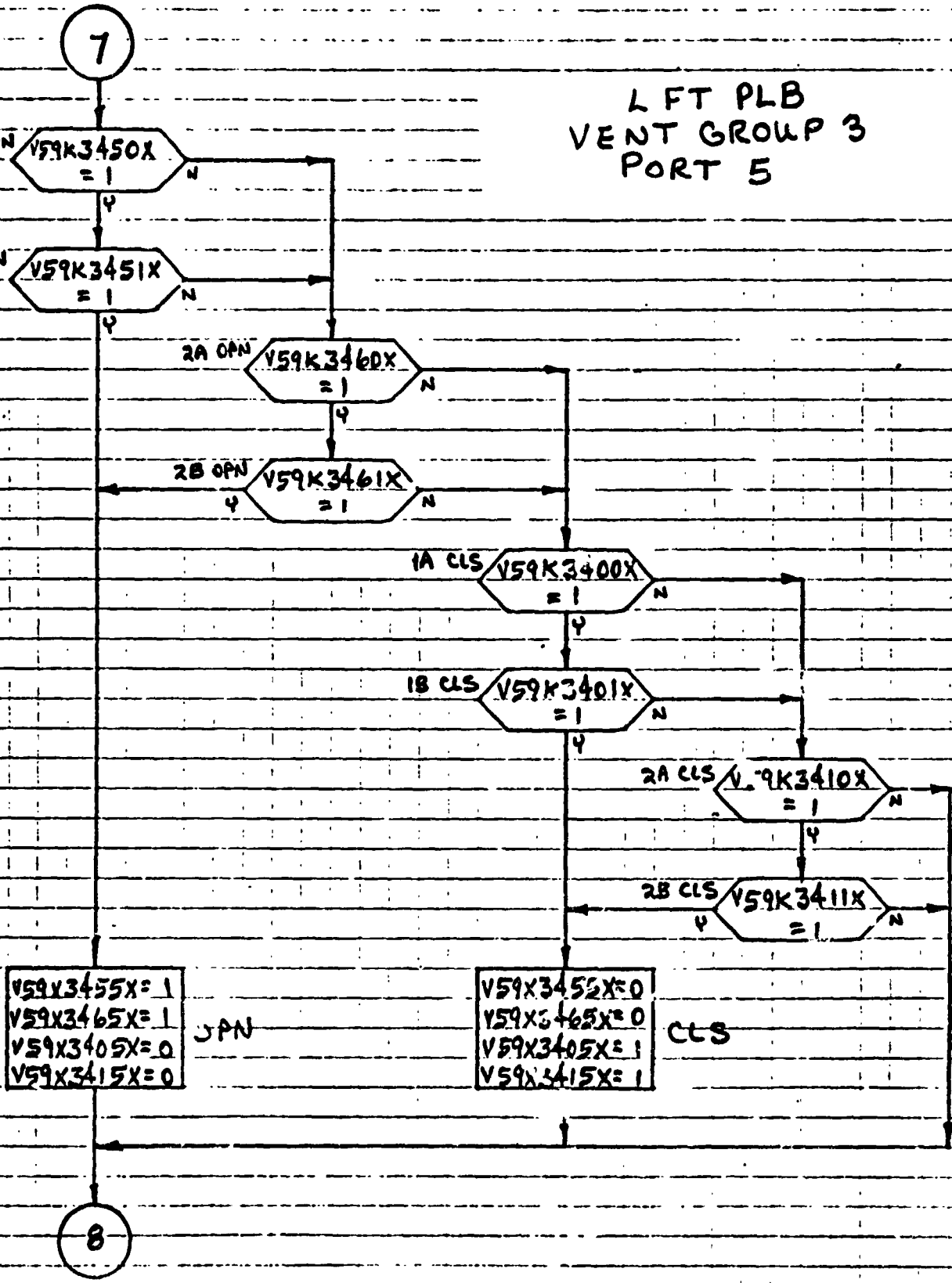


ORIGINAL PAGE IS
 OF POOR QUALITY

RT PLB/W
 VENT GROUP 4
 PORT 4 & 7

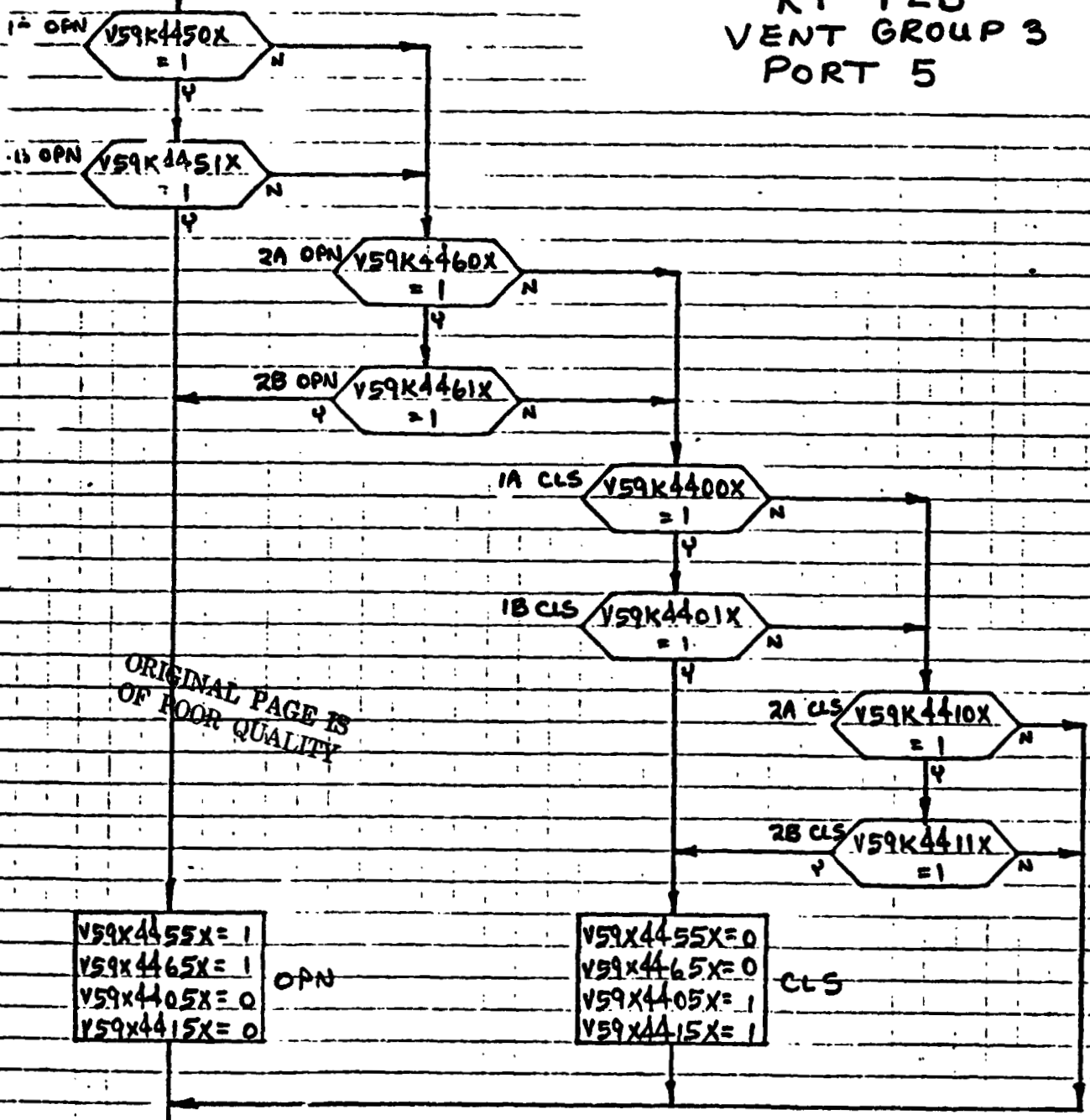


L FT PLB
VENT GROUP 3
PORT 5



RT PLB
VENT GROUP 3
PORT 5

8



ORIGINAL PAGE IS
OF POOR QUALITY

V59X4455X = 1
V59X4465X = 1
V59X4405X = 0
V59X4415X = 0

OPN

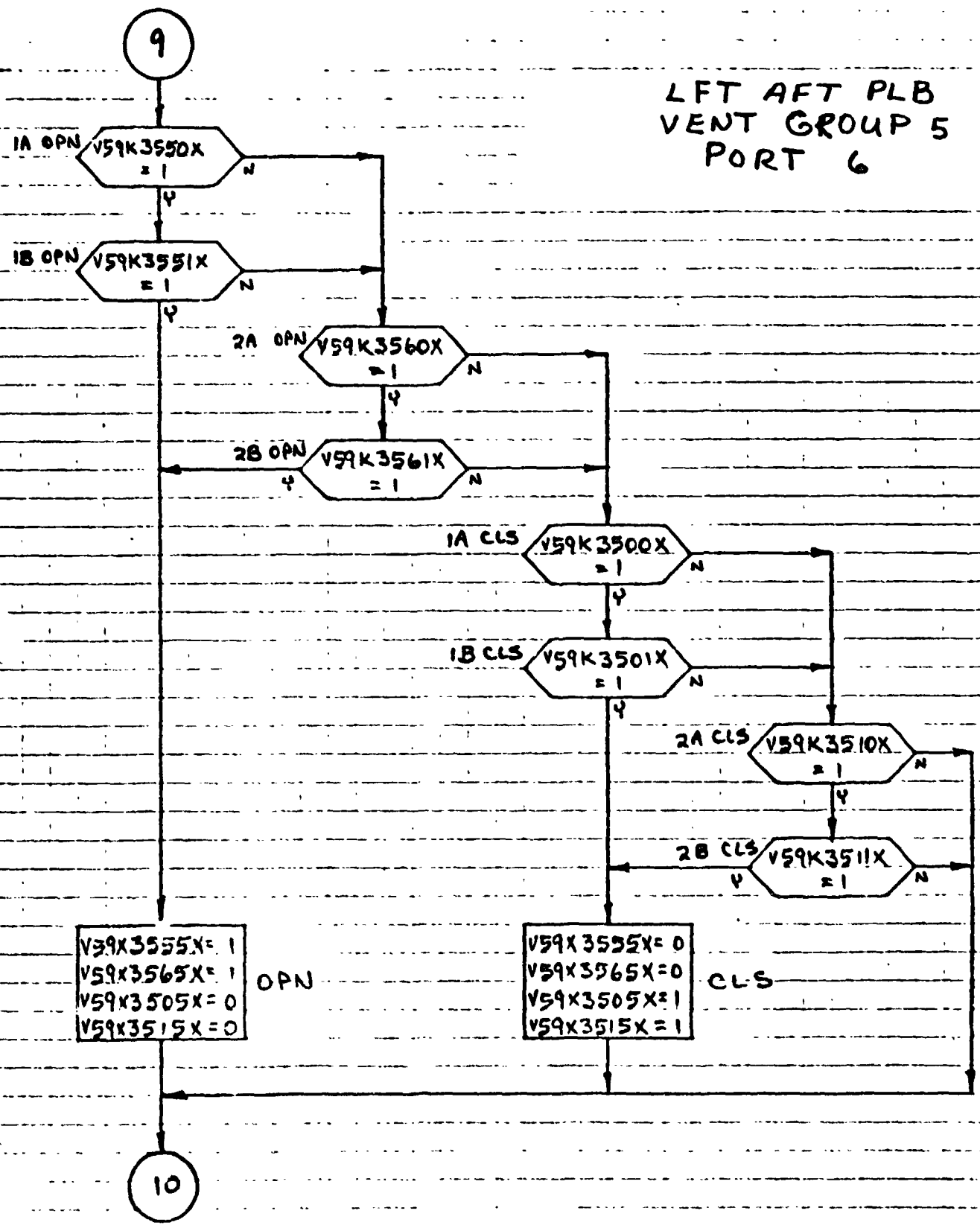
V59X4455X = 0
V59X4465X = 0
V59X4405X = 1
V59X4415X = 1

CLS

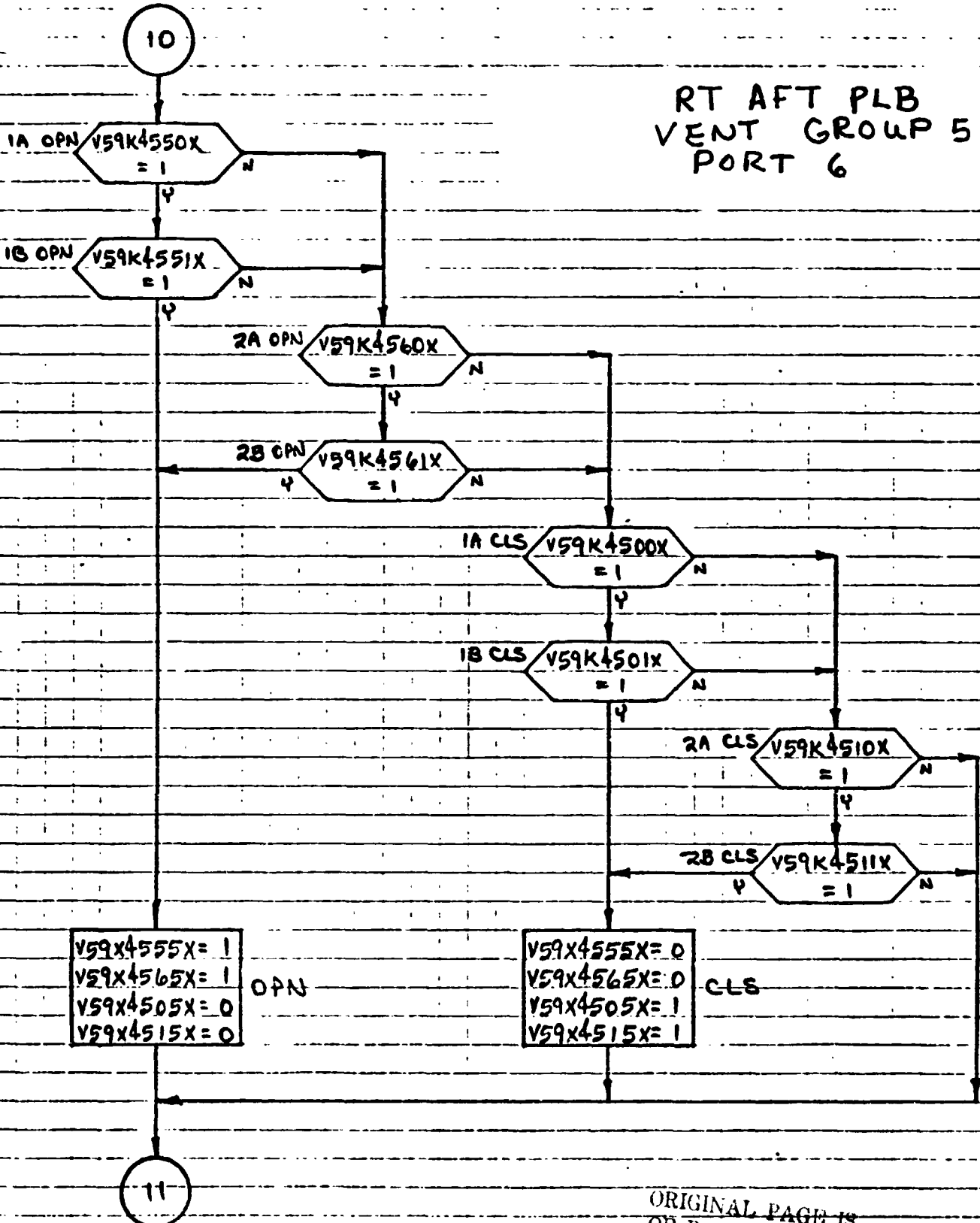
9

(-)

LFT AFT PLB
 VENT GROUP 5
 PORT 6



RT AFT PLB
VENT GROUP 5
PORT 6



V59X455X = 1
V59X456X = 1
V59X450X = 0
V59X451X = 0

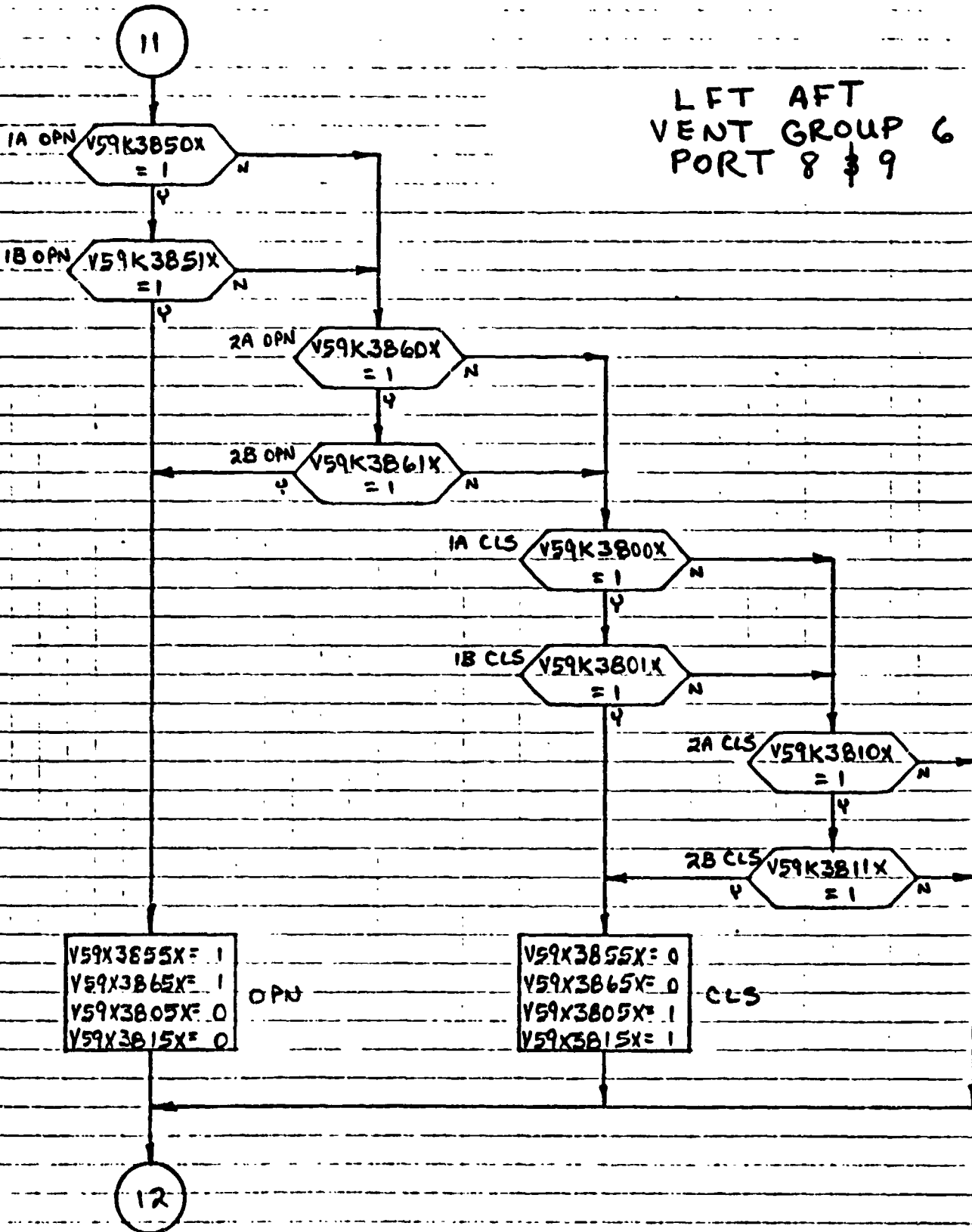
OPN

V59X455X = 0
V59X456X = 0
V59X450X = 1
V59X451X = 1

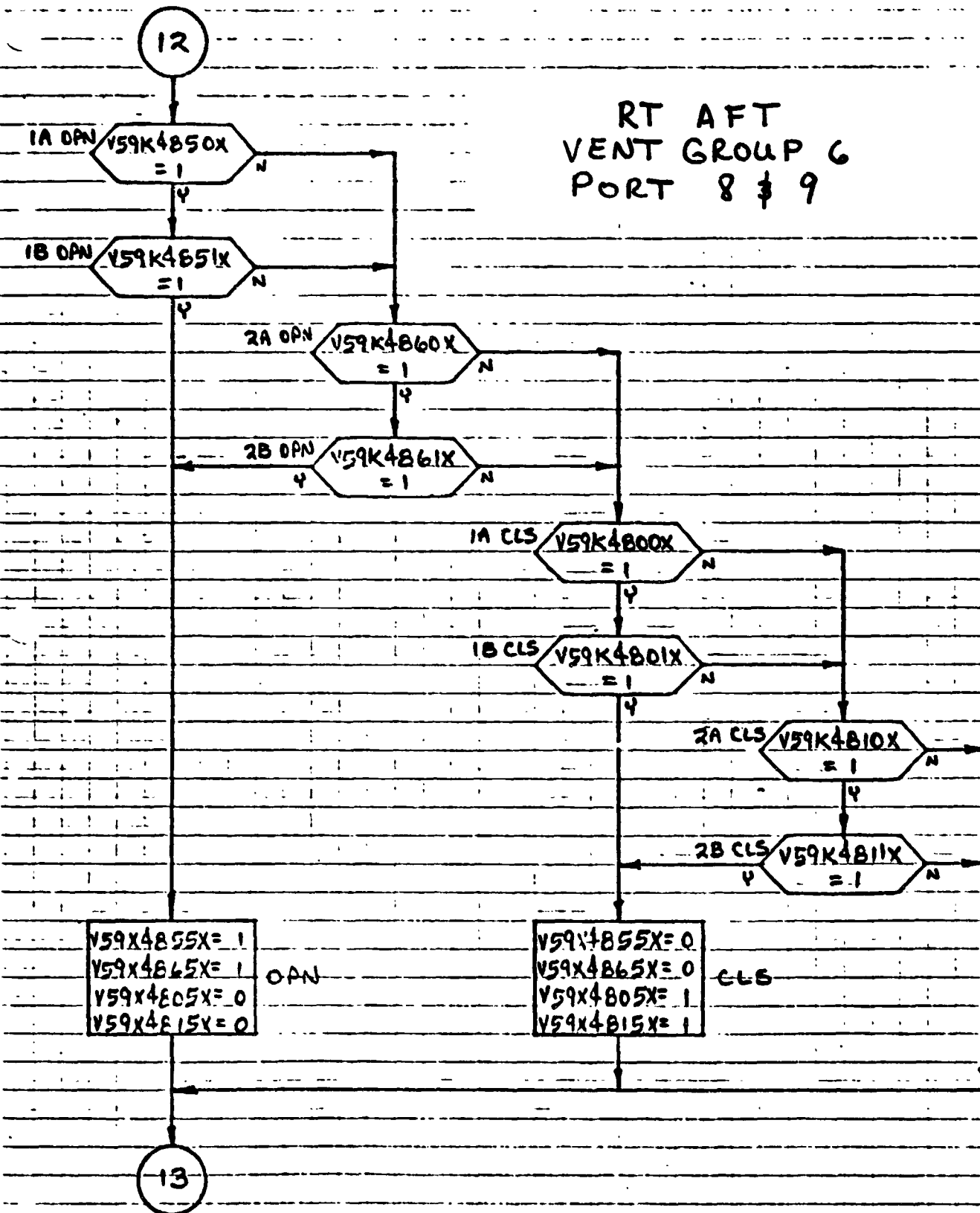
CLS

ORIGINAL PAGE IS
OF POOR QUALITY

LFT AFT
 VENT GROUP 6
 PORT 8 & 9



RT AFT
VENT GROUP 6
PORT 8 & 9



13

LFT AFT
VENT GROUP 6
PORT 8 & 9

PURGE

1A V59K3900X = 1

1B V59K3901X = 1

N

N

2A V59K3910X = 1

2B V59K3911X = 1

N

N

V59X3905X = 1
V59X3915X = 1

PURGE

V59X3905X = 0
V59X3915X = 0

NO
PURGE

1A V59K4900X = 1

1B V59K4901X = 1

N

N

2A V59K4910X = 1

2B V59K4911X = 1

N

N

RT AFT VENT 8 & 9

VENT DOORS

PURGE

V59X4905X = 1
V59X4915X = 1

PURGE

V59X4905X = 0
V59X4915X = 0

NO
PURGE

14

14

LFT AFT PLB
VENT GROUP 5
PORT 6

PURGE

1-1A

V59K3600X
= 1

N

Y

1-1B

V59K3601X
= 1

N

Y

1-2A

V59K3610X
= 1

N

Y

1-2B

V59K3611X
= 1

N

Y

V59X3605X = 1
V59X3615X = 1

PURGE

V59X3605X = 0
V59X3615X = 0

NO
PURGE

2-1A

V59K3700X
= 1

N

Y

2-1B

V59K3701X
= 1

N

Y

2-2A

V59K3710X
= 1

N

Y

2-2B

V59K3711X
= 1

N

Y

V59X3705X = 1
V59X3715X = 1

PURGE

V59X3705X = 0
V59X3715X = 0

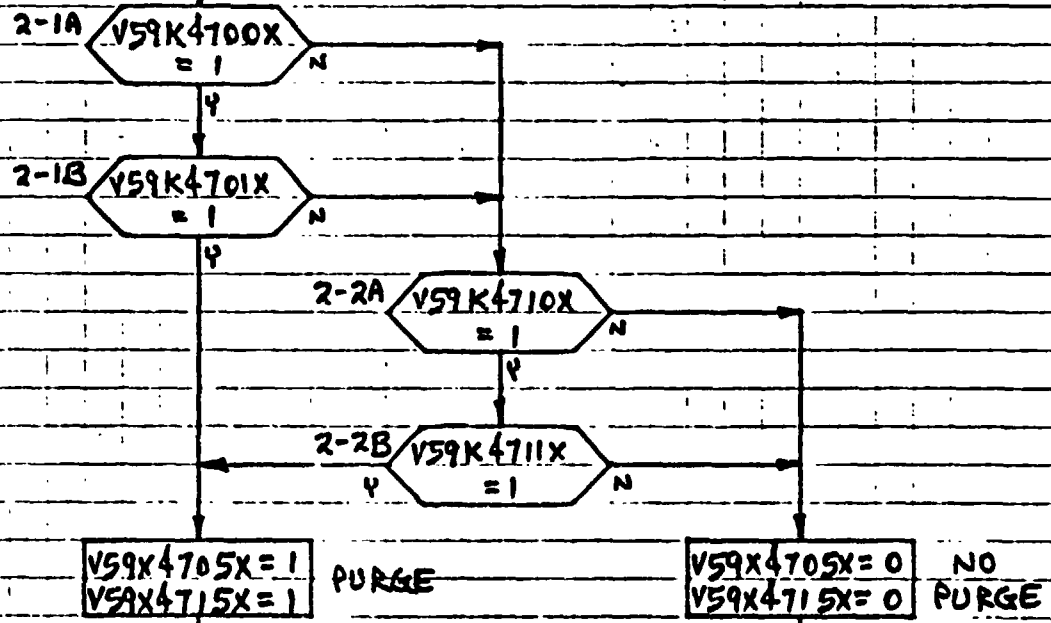
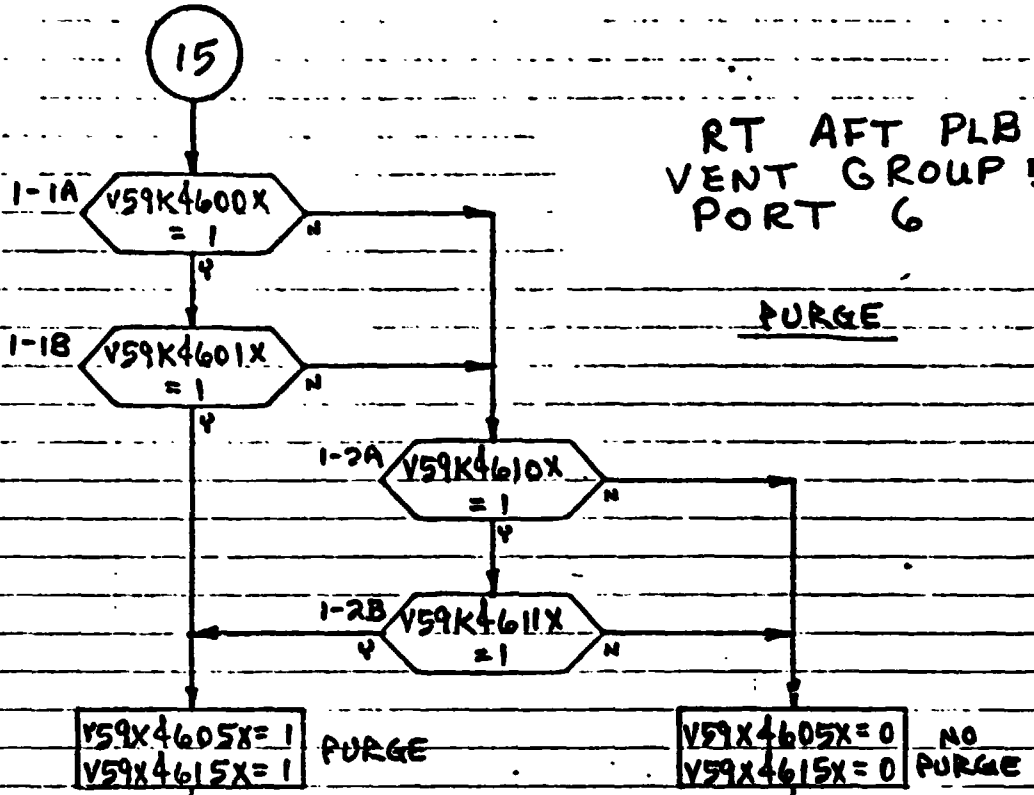
NO
PURGE

ORIGINAL PAGE IS
OF POOR QUALITY

15

RT AFT PLB
VENT GROUP 5
PORT 6

PURGE



4.0 INPUT/OUTPUT TABLES

TABLE 4.1 - .PUT STIMULI

IDENTIFICATION NUMBER	NOMENCLATURE	ADDRESS	STATES/RANGE			UNITS
			LO	HI	STATE	
V59K3050X	LFT FWD 1&2 ACT/B1 OPEN 1A CMD	FROM F.S.	0	1	STATE	
V59K3051X	LFT FWD 1&2 ACT/B1 OPEN 1B CMD					
V59K3000X	LFT FWD 1&2 ACT/B1 CLOSE 1A CMD					
V59K2001X	LFT FWD 1&2 ACT/B1 CLOSE 1B CMD					
V59K3100X	LFT FWD 1&2 ACT/B1 PURGE 1A CMD					
V59K3101X	LFT FWD 1&2 ACT/B1 PURGE 1B CMD					
V59K3060X	LFT FWD 1&2 ACT/B2 OPEN 2A CMD					
V59K3061X	LFT FWD 1&2 ACT/B2 OPEN 2B CMD					
V59K3010X	LFT FWD 1&2 ACT/B2 CLOSE 2A CMD					
V59K3011X	LFT FWD 1&2 ACT/B2 CLOSE 2B CMD					
V59K3110X	LFT FWD 1&2 ACT/B2 PURGE 2A CMD					
V59K3111X	LFT FWD 1&2 ACT/B2 PURGE 2B CMD					
V59K4050X	RT FWD 1&2 ACT/B1 OPEN 1A CMD					
V59K4051X	RT FWD 1&2 ACT/B1 OPEN 1B CMD					
V59K4000X	RT FWD 1&2 ACT/B1 CLOSE 1A CMD					
V59K4001X	RT FWD 1&2 ACT/B1 CLOSE 1B CMD					
V59K4100X	RT FWD 1&2 ACT/B1 PURGE 1A CMD					
V59K4101X	RT FWD 1&2 ACT/B1 PURGE 1B CMD					
V59K4060X	RT FWD 1&2 ACT/B2 OPEN 2A CMD					
V59K4061X	RT FWD 1&2 ACT/B2 OPEN 2B CMD					
V59K4010X	RT FWD 1&2 ACT/B2 CLOSE 2A CMD					
V59K4011X	RT FWD 1&2 ACT/B2 CLOSE 2B CMD					
V59K4110X	RT FWD 1&2 ACT/B2 PURGE 2A CMD					
V59K4111X	RT FWD 1&2 ACT/B2 PURGE 2B CMD					
V59K3260X	LFT PLB/WING 3ACT/B2 OPEN 2A CMD					
V59K3261X	LFT PLB/WING 3ACT/B2 OPEN 2B CMD					
V59K3210X	LFT PLB/WING 3ACT/B2 CLOSE 2A CMD					
V59K3211X	LFT PLB/WING 3ACT/B2 CLOSE 2B CMD					
V59K3250X	LFT PLB/WING 3ACT/B1 OPEN 1A CMD					
V59K3251X	LFT PLB/WING 3ACT/B1 OPEN 1B CMD					
V59K3200X	LFT PLB/WING 3ACT/B1 CLOSE 1A CMD					
V59K3201X	LFT PLB/WING 3ACT/B1 CLOSE 1B CMD	FROM F.S.	0	1	STATE	

TABLE 4.1 - INPUT STIMULI (CONTINUED)

IDENTIFICATION NUMBER	NOMENCLATURE	ADDRESS	STATES/RANGE		UNITS
			LO	HI	
V59K4250X	RT PLB/WING 3ACT/B1 OPEN 1A CMD	FROM F.S.	0	1	STATE
V59K4251X	RT PLB/WING 3ACT/B1 OPEN 1B CMD				
V59K42J0X	RT PLB/WING 3ACT/B1 CLOSE 1A CMD				
V59K4201X	RT PLB/WING 3ACT/B1 CLOSE 1B CMD				
V59K4260X	RT PLB/WING 3ACT/B2 OPEN 2A CMD				
V59K4261X	RT PLB/WING 3ACT/B2 OPEN 2B CMD				
V59K4210X	RT PLB/WING 3ACT/B2 CLOSE 2A CMD				
V59K4211X	RT PLB/WING 3ACT/B2 CLOSE 2B CMD				
V59K3350X	LFT PLB/WING 4&7 ACT/B1 OPEN 1A CMD				
V59K3351X	LFT PLB/WING 4&7 ACT/B1 OPEN 1B CMD				
V59K33J0X	LFT PLB/WING 4&7 ACT/B1 CLOSE 1A CMD				
V59K3301X	LFT PLB/WING 4&7 ACT/B1 CLOSE 1B CMD				
V59K3360X	LFT PLB/WING 4&7 ACT/B2 OPEN 2A CMD				
V59K3361X	LFT PLB/WING 4&7 ACT/B2 OPEN 2B CMD				
V59K3310X	LFT PLB/WING 4&7 ACT/B2 CLOSE 2A CMD				
V59K3311X	LFT PLB/WING 4&7 ACT/B2 CLOSE 2B CMD				
V59K4350X	RT PLB/WING 4&7 ACT/B1 OPEN 1A CMD				
V59K4351X	RT PLB/WING 4&7 ACT/B1 OPEN 1B CMD				
V59K4300X	RT PLB/WING 4&7 ACT/B1 CLOSE 1A CMD				
V59K4301X	RT PLB/WING 4&7 ACT/B1 CLOSE 1B CMD				
V59K4360X	RT PLB/WING 4&7 ACT/B2 OPEN 2A CMD				
V59K4361X	RT PLB/WING 4&7 ACT/B2 OPEN 2B CMD				
V59K4310X	RT PLB/WING 4&7 ACT/B2 CLOSE 2A CMD				
V59K4311X	RT PLB/WING 4&7 ACT/B2 CLOSE 2B CMD				
V59K3450X	LFT PLB/WING 5ACT/B1 OPEN 1A CMD				
V59K3451X	LFT PLB/WING 5ACT/B1 OPEN 1B CMD				
V59K3400X	LFT PLB/WING 5ACT/B1 CLOSE 1A CMD				
V59K3401X	LFT PLB/WING 5ACT/B1 CLOSE 1B CMD				
V59K3460X	LFT PLB/WING 5ACT/B2 OPEN 2A CMD				
V59K3461X	LFT PLB/WING 5ACT/B2 OPEN 2B CMD				
V59K3410X	LFT PLB/WING 5ACT/B2 CLOSE 2A CMD	FROM F.S.	0	1	STATE
V59K3411X	LFT PLB/WING 5ACT/B2 CLOSE 2B CMD				

TABLE 4.1 - INPUT STIMULI (CONTINUED)

IDENTIFICATION NUMBER	NOMENCLATURE	ADDRESS	STATES/RANGE		
			LO	HI	URITS
V59K4460X	RT PLB/WING SACT/B2 OPEN 2A CMD	FROM F.S.	0	1	STATE
V59K4461X	RT PL3/WING SACT/B2 OPEN 2B CMD				
V59K4410X	RT PLB/WING SACT/B2 CLOSE 2A CMD				
V59K4411X	RT PLB/WING SACT/B2 CLOSE 2B CMD				
V59K4450X	RT PLB/WING SACT/B1 OPEN 1A CMD				
V59K4451X	RT PLB/WING SACT/B1 OPEN 1B CMD				
V59K4400X	RT PLB/WING SACT/B1 CLOSE 1A CMD				
V59K4401X	RT PLB/WING SACT/B1 CLOSE 1B CMD				
V59K3550X	LFT AFT PLB 6ACT/B1 OPEN 1A CMD				
V59K3551X	LFT AFT PLB 6ACT/B1 OPEN 1B CMD				
V59K3500X	LFT AFT PLB 6ACT/B1 CLOSE 1A CMD				
V59K3501X	LFT AFT PLB 6ACT/B1 CLOSE 1B CMD				
V59K3600X	LFT AFT PLB 6ACT/B1 PURGE 1-1A CMD				
V59K3601X	LFT AFT PLB 6ACT/B1 PURGE 1-1B CMD				
V59K3700X	LFT AFT PLB 6ACT/B1 PURGE 2-1A CMD				
V59K3701X	LFT AFT PLB 6ACT/B1 PURGE 2-1B CMD				
V59K3560X	LFT AFT PLB 6ACT/B2 OPEN 2A CMD				
V59K3561X	LFT AFT PLB 6ACT/B2 OPEN 2B CMD				
V59K3510X	LFT AFT PLB 6ACT/B2 CLOSE 2A CMD				
V59K3511X	LFT AFT PLB 6ACT/B2 CLOSE 2B CMD				
V59K3610X	LFT AFT PLB 6ACT/B2 PURGE 1-2A CMD				
V59K3611X	LFT AFT PLB 6ACT/B2 PURGE 1-2B CMD				
V59K3710X	LFT AFT PLB 6ACT/B2 PURGE 2-2A CMD				
V59K3711X	LFT AFT PLB 6ACT/B2 PURGE 2-2B CMD				
V59K4550X	RT AFT PLB 6ACT/B1 OPEN 1A CMD				
V59K4551X	RT AFT PLB 6ACT/B1 OPEN 1B CMD				
V59K4500X	RT AFT PLB 6ACT/B1 CLOSE 1A CMD				
V59K4501X	RT AFT PLB 6ACT/B1 CLOSE 1B CMD				
V59K4600X	RT AFT PLB 6ACT/B1 PURGE 1-1A CMD				
V59K4601X	RT AFT PLB 6ACT/B1 PURGE 1-1B CMD				
V59K4700X	RT AFT PLB 6ACT/B1 PURGE 2-2A CMD	FROM F.S.	0	1	STATE
V59K4701X	RT AFT PLB 6ACT/B1 PURGE 2-2B CMD				

TABLE 4.1 - INPUT STIMULI (CONTINUED)

IDENTIFICATION NUMBER	NOMENCLATURE	ADDRESS	STATES/RANGE		UNITS
			LO	HI	
V59K4560X	RT AFT PLB 6ACT/P OPEN 2A CMD	FROM F.S.	0	1	STATE
V59K4561X	RT AFT PLB 6ACT/B2 OPEN 2B CMD				
V59K4510X	RT AFT PLB 6ACT/B2 CLOSE 2A CMD				
V59K4511X	RT AFT PLB 6ACT/B2 CLOSE 2B CMD				
V59K4610X	RT AFT PLB 6ACT/B2 PURGE 1-2A CMD				
V59K4611X	RT AFT PLB 6ACT/B2 PURGE 1-2B CMD				
V59K4710X	RT AFT PLB 6ACT/B2 PURGE 2-2A CMD				
V59K4711X	RT AFT PLB 6ACT/B2 PURGE 2-2B CMD				
V59K3850X	LFT AFT VENT 889 ACT/B1 OPEN 1A CMD				
V59K3851X	LFT AFT VENT 889 ACT/B1 OPEN 1B CMD				
V59K3800X	LFT AFT VENT 889 ACT/B1 CLOSE 1A CMD				
V59K3801X	LFT AFT VENT 889 ACT/B1 CLOSE 1B CMD				
V59K3900X	LFT AFT VENT 889 ACT/B1 PURGE 1A CMD				
V59K3901X	LFT AFT VENT 889 ACT/B1 PURGE 1B CMD				
V59K3860X	LFT AFT VENT 889 ACT/B2 OPEN 2A CMD				
V59K3861X	LFT AFT VENT 889 ACT/B2 OPEN 2B CMD				
V59K3810X	LFT AFT VENT 889 ACT/B2 CLOSE 2A CMD				
V59K3811X	LFT AFT VENT 889 ACT/B2 CLOSE 2B CMD				
V59K3910X	LFT AFT VENT 889 ACT/B2 PURGE 2A CMD				
V59K3911X	LFT AFT VENT 889 ACT/B2 PURGE 2B CMD				
V59K4850X	RT AFT VENT 889 ACT/B1 OPEN 1A CMD				
V59K4851X	RT AFT VENT 889 ACT/B1 OPEN 1B CMD				
V59K4800X	RT AFT VENT 889 ACT/B1 CLOSE 1A CMD				
V59K4801X	RT AFT VENT 889 ACT/B1 CLOSE 1B CMD				
V59K4900X	RT AFT VENT 889 ACT/B1 PURGE 1A CMD				
V59K4901X	RT AFT VENT 889 ACT/B1 PURGE 1B CMD				
V59K4860X	RT AFT VENT 889 ACT/B2 OPEN 2A CMD				
V59K4861X	RT AFT VENT 889 ACT/B2 OPEN 2B CMD				
V59K4810X	RT AFT VENT 889 ACT/B2 CLOSE 2A CMD				
V59K4811X	RT AFT VENT 889 ACT/B2 CLOSE 2B CMD				
V59K4910X	RT AFT VENT 889 ACT/B2 PURGE 2A CMD				
V59K4911X	RT AFT VENT 889 ACT/B2 PURGE 2B CMD	FROM F.S.	0	1	STATE

4.2 OUTPUT MEASUREMENT LIST

Table 2 lists all model outputs along with the initial condition value for the output. Measurement I.D. and Measurement Name precede pairs of numeric columns. The first of each pair is labeled FS indicating flight system engineering units. The second of each pair is labeled CTS indicating the GSIU count value corresponding to the FS value. I.C. indicates initial condition values. VALUE 1 typically indicates nominal values. VALUE 2 and VALUE 3 columns indicate off nominal conditions.

MEASUREMENT OUTPUT FROM VENT DOORS MODEL - TABLE 2

MEASUREMENT I. D.	MEASUREMENT NAME	I. C.		VALUE 1		VALUE 2		VALUE 3		UNITS
		FS	CTS	FS	CTS	FS	CTS	FS	CTS	
V59X3555X	LFT AFT PLB 6ACT/B1 OPEN	0	0	1	1					STATE
V59X3505X	LFT AFT PLB 6ACT/B1 CLOSE	1	1	0	0					
V59X3605X	LFT AFT PLB 6ACT/B1 PURGE 1	0	0	1	1					
V59X3705X	LFT AFT PLB 6ACT/B1 PURGE 2	0	0	1	1					
V59X3565X	LFT AFT PLB 6ACT/B2 OPEN	0	0	1	1					
V59X3515X	LFT AFT PLB 6ACT/B2 CLOSE	1	1	0	0					
V59X3615X	LFT AFT PLB 6ACT/B2 PURGE 1	0	0	1	1					
V59X3715X	LFT AFT PLB 6ACT/B2 PURGE 2	0	0	1	1					
V59X4555X	RT AFT PLB 6ACT/B1 OPEN	0	0	1	1					
V59X4505X	RT AFT PLB 6ACT/B1 CLOSE	1	1	0	0					
V59X4605X	RT AFT PLB 6ACT/B1 PURGE 1	0	0	1	1					
V59X4705X	RT AFT PLB 6ACT/B1 PURGE 2	0	0	1	1					
V59X4565X	RT AFT PLB 6ACT/B2 OPEN	0	0	1	1					
V59X4515X	RT AFT PLB 6ACT/B2 CLOSE	1	1	0	0					
V59X4615X	RT AFT PLB 6ACT/B2 PURGE 1	0	0	1	1					
V59X4715X	RT AFT PLB 6ACT/B2 PURGE 2	0	0	1	1					
V59X3855X	LFT AFT VENT 8&9 ACT/B1 OPEN	0	0	1	1					
V59X3805X	LFT AFT VENT 8&9 ACT/B1 CLOSE	1	1	0	0					
V59X3905X	LFT AFT VENT 8&9 ACT/B1 PURGE	0	0	1	1					
V59X3865X	LFT AFT VENT 8&9 ACT/B2 OPEN	0	0	1	1					
V59X3815X	LFT AFT VENT 8&9 ACT/B2 CLOSE	1	1	0	0					
V59X3915X	LFT AFT VENT 8&9 ACT/B2 PURGE	0	0	1	1					

MEASUREMENT OUTPUT FROM VENT DOORS MODEL - TABLE 2

MEASUREMENT I. D.	MEASUREMENT NAME	I.C.		VALUE 1		VALUE 2		VALUE 3		UNITS
		FS	CTS	FS	CTS	FS	CTS	FS	CTS	
V59X4855X	RT AFT VENT 8&9 ACT/B1 OPEN	0	0	1	1					STATE
V59X4805X	RT AFT VENT 8&9 ACT/B1 CLOSE	1	1	0	0					
V59X4905X	RT AFT VENT 8&9 ACT/B1 PURGE	0	0	1	1					
V59X4865X	RT AFT VENT 8&9 ACT/B2 OPEN	0	0	1	1					
V59X4815X	RT AFT VENT 8&9 ACT/B2 CLOSE	1	1	0	0					
V59X4915X	RT AFT VENT 8&9 ACT/B2 PURGE	0	0	1	1					
V59X4055X	RT FWD 1&2 ACT/B1 OPEN	0	0	1	1					
V59X4005X	RT FWD 1&2 ACT/B1 CLOSE	1	1	0	0					
V59X4105X	RT FWD 1&2 ACT/B1 PURGE	0	0	1	1					
V59X4065X	RT FWD 1&2 ACT/B2 OPEN	0	0	1	1					
V59X4015X	RT FWD 1&2 ACT/B2 CLOSE	1	1	0	0					
V59X4115X	RT FWD 1&2 ACT/B2 PURGE	0	0	1	1					
V59X3055X	LFT FWD 1&2 ACT/B1 OPEN	0	0	1	1					
V59X3005X	LFT FWD 1&2 ACT/B1 CLOSE	1	1	0	0					
V59X3105X	LFT FWD 1&2 ACT/B1 PURGE	0	0	1	1					
V59X3065X	LFT FWD 1&2 ACT/B2 OPEN	0	0	1	1					
V59X3015X	LFT FWD 1&2 ACT/B2 CLOSE	1	1	0	0					
V59X3115X	LFT FWD 1&2 ACT/B2 PURGE	0	0	1	1					
V59X3255X	LFT PLB/WING 3ACT/B1 OPEN	0	0	1	1					
V59X3205X	LFT PLB/WING 3ACT/B1 CLOSE	1	1	0	0					
V59X3265X	LFT PLB/WING 3ACT/B2 OPEN	0	0	1	1					
V59X3215X	LFT PLB/WING 3ACT/B2 CLOSE	1	1	0	0					
V59X4255X	RT PLB/WING 3ACT/B1 OPEN	0	0	1	1					

MEASUREMENT OUTPUT FROM VENT DOORS MODEL - TABLE 2

MEASUREMENT I. D.	MEASUREMENT NAME	I. C.		VALUE 1		VALUE 2		VALUE 3		UNITS
		FS	CTS	FS	CTS	FS	CTS	FS	CTS	
V59X4205X	RT PLB/WING 3ACT/B1 CLOSE	1	1	0	0					STATE
V59X4265X	RT PLB/WING 3ACT/B2 OPEN	0	0	1	1					
V59X4215X	RT PLB/WING 3ACT/B2 CLOSE	1	1	0	0					
V59X3355X	LFT PLB/WING 4&7 ACT/B1 OPEN	0	0	1	1					
V59X3305X	LFT PLB/WING 4&7 ACT/B1 CLOSE	1	1	0	0					
V59X3365X	LFT PLB/WING 4&7 ACT/B2 OPEN	0	0	1	1					
V59X3315X	LFT PLB/WING 4&7 ACT/B2 CLOSE	1	1	0	0					
V59X4355X	RT PLB/WING 4&7 ACT/B1 OPEN	0	0	1	1					
V59X4305X	RT PLB/WING 4&7 ACT/B1 CLOSE	1	1	0	0					
V59X4365X	RT PLB/WING 4&7 ACT/B2 OPEN	0	0	1	1					
V59X4315X	RT PLB/WING 4&7 ACT/B2 CLOSE	1	1	0	0					
V59X3455X	LFT PLB/WING 5ACT/B1 OPEN	0	0	1	1					
V59X3405X	LFT PLB/WING 5ACT/B1 CLOSE	1	1	0	0					
V59X3465X	LFT PLB/WING 5ACT/B2 OPEN	0	0	1	1					
V59X3415X	LFT PLB/WING 5ACT/B2 CLOSE	1	1	0	0					
V59X4455X	RT PLB/WING 5ACT/B1 OPEN	0	0	1	1					
V59X4405X	RT PLB/WING 5ACT/B1 CLOSE	1	1	0	0					
V59X4465X	RT PLB/WING 5ACT/B2 OPEN	0	0	1	1					
V59X4415X	RT PLB/WING 5ACT/B2 CLOSE	1	1	0	0					

4.3 NAS CRT DISPLAYS

PROGRAM _____
 CODED BY _____
 DATE _____

PAGE _____ OF _____
 IDENTIFICATION _____

PUNCH _____
 VERIFY _____
 EXECUTE _____

TABULATE _____
 FORTRAN CODING

FORTRAN STATEMENT

CONTINUATION

STATEMENT NO.	OPERATION	VARIABLE FIELD	COMMENTS
159473	RT PLB/WG 4/7	LF PLB/WG 5	RT PLB/WG 5
K4300X	CL 1A	K4400X CL 1A	CL 1A
*K4301X	CL 1B	*K4401X CL 1B	CL 1B
K4310X	CL 2A	K4410X CL 2A	CL 2A
*K4311X	CL 2B	*K4411X CL 2B	CL 2B
X4305X	CLIND	X4405X CLIND	CLIND
*X4315X	CLIND	*X4415X CLIND	CLIND
K4350X	OP 1A	K4350X OP 1A	OP 1A
*K4351X	OP 1B	*K4351X OP 1B	OP 1B
K4360X	OP 2A	K4360X OP 2A	OP 2A
*K4361X	OP 2B	*K4361X OP 2B	OP 2B
X4355X	OPIND	X4355X OPIND	OPIND
*X4365X	OPIND	*X4365X OPIND	OPIND

M-1

NOTE: WRITE NUMBERS 10, LETTERS I P U G / O, SYMBOLS / .

ISC Form 746 (Dec 61)

PROGRAM _____ DATE _____
 CODED BY _____ PAGE _____ OF _____
 IDENTIFICATION _____

PUNCH _____ EXECUTE _____
 VERIFY _____ TABULATE _____

FORTRAN-PAP CODING

FORTRAN STATEMENT

CONTINUATION

STATEMENT NUMBER	OPERATION	VARIABLE FIELD	COMMENTS
1	RT AFT PLB 6	LF AFT B/4	LF AFT B/4
2	PG11A	K3800X CL 1A	CLPSE
3	PG11B	*K3801X CL 1B	CLPSE
4	PG12A	K3810X CL 2A	CLPSE
5	PG12B	*K3811X CL 2B	CLPSE
6	PGIND 1	X3805X CLIND	CLPSED
7	PGIND 1	*X3815X CLIND	CLPSED
8	PG21A	K3850X OP 1A	OPEN
9	PG21B	*K3851X OP 1B	OPEN
10	PG22A	K3860X OP 2A	OPEN
11	PG22B	*K3861X OP 2B	OPEN
12	PGIND 2	X3855X OPIND	OPENED
13	PGIND 2	*X3865X OPIND	OPENED
14	PG11A	K3900X PG 1A	PURGE
15	PG11B	*K3901X PG 1B	PURGE
16	PG21A	K3910X PG 2A	PURGE
17	PG21B	*K3911X PG 2B	PURGE
18	PGIND 1	X3905X PGIND	PURGE
19	PGIND 1	*X3915X PGIND	PURGE

NOTE: WRITE NUMBERS 10, LETTERS I, O, U, G, Z, C, SYMBOLS /, * * *

5.0 REFERENCES

5.1 LEC Memo No. 78-GNC-254, NAS Functional Logic by N. Bauer, 8/18/78

5.2 LEC Memo No. 78-GNC-260, NAS CRT Formats by N. Bauer, 8/30/78

5.3 ICD-GNCTS-06, dated 8/2/78

APPENDIX C
ET UMBILICAL DOORS
NAS MATH MODEL REQUIREMENTS

TABLE OF CONTENTS

SECTION	PAGE
1.0 INTRODUCTION	C-2
2.0 DETAILED REQUIREMENTS	C-4
2.1 FUNCTIONAL CHARACTERISTICS	C-4
2.2 NAS UPLINK REQUIREMENTS.	C-4
2.3 INITIALIZATION REQUIREMENTS.	C-4
2.4 TERMINATION REQUIREMENTS	C-4
2.5 UNIQUE REQUIREMENTS.	C-4
3.0 LOGIC FLOW DIAGRAMS.	C-5
4.0 INPUT/OUTPUT TABLES.	C-12
4.1 INPUT TABLE.	C-13
4.2 OUTPUT TABLE	C-15
4.3 NAS CRT DISPLAYS	C-17
5.0 REFERENCES	C-20
FIGURES	
FIGURE 1 - FLIGHT SYSTEM/NAS DATA FLOW.	C-3

1.0 INTRODUCTION

The GN&C Test Station (GTS) uses math models to simulate many of the Shuttle systems for which hardware has not been provided. A group of these models are termed "non-avionic" models since they do not simulate the Shuttle's "avionic" systems. The "non-avionic" models are needed to supply data for on-board software processing and to respond to Shuttle commands, whether they be from cockpit switches, the General Purpose Computers (GPC's) or the Non-Avionic Simulator (NAS) console. Figure 1 provides the Flight System/NAS data flow.

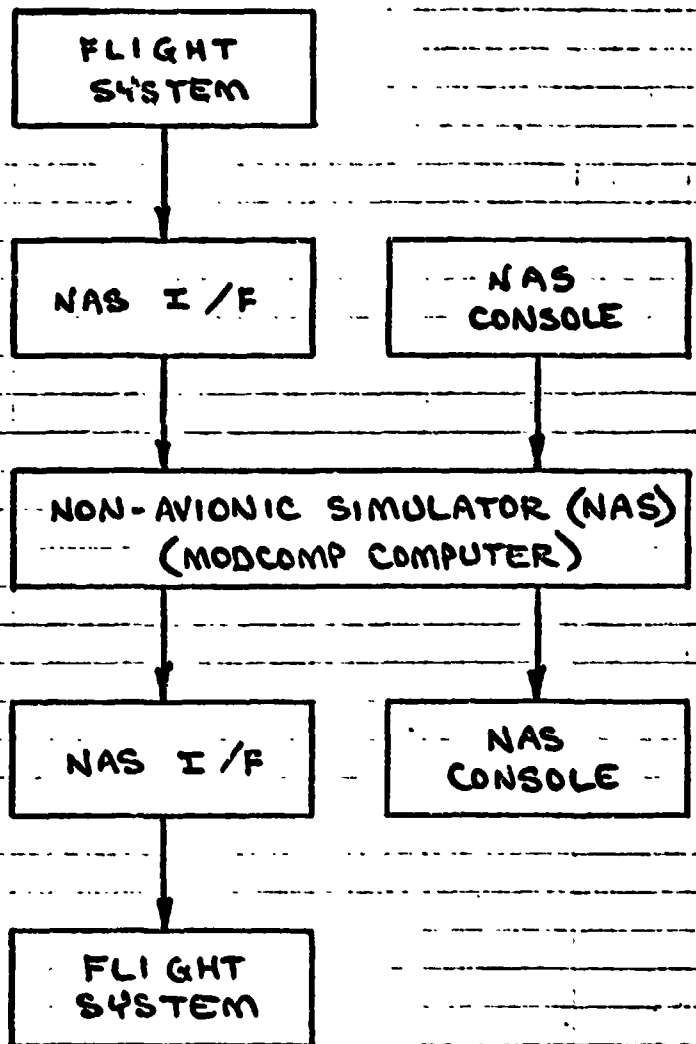


FIGURE 1 - FLIGHT SYSTEM / NAS DATA FLOW

2.0 DETAILED REQUIREMENTS

2.1 FUNCTIONAL CHARACTERISTICS

This model simulates the functions of the ET Umbilical Doors, namely: OPEN, CLOSED, LATCHED, RELEASED, LOCKED, and STOWED. The doors seal Orbiter umbilical penetrations following ET separation to ensure a unified heat shield for entry.

2.2 NAS UPLINK REQUIREMENTS

The NAS console operator has the capability to override any math model output value with a value entered at the console. This permits the use of off-nominal data entries to test limit checking software.

2.3 INITIALIZATION REQUIREMENTS

When the math model begins running in the MODCOMP computer, the output data values shall be as defined in Table 4.2-Initial Conditions, until altered by commands from the Flight System or the NAS console.

2.4 TERMINATION REQUIREMENTS

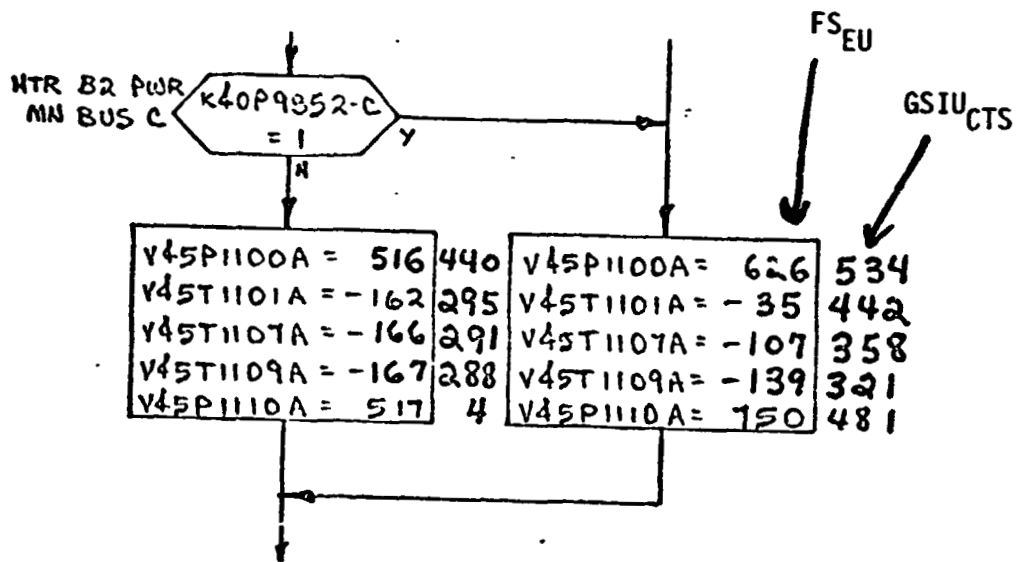
None

2.5 UNIQUE REQUIREMENTS

None

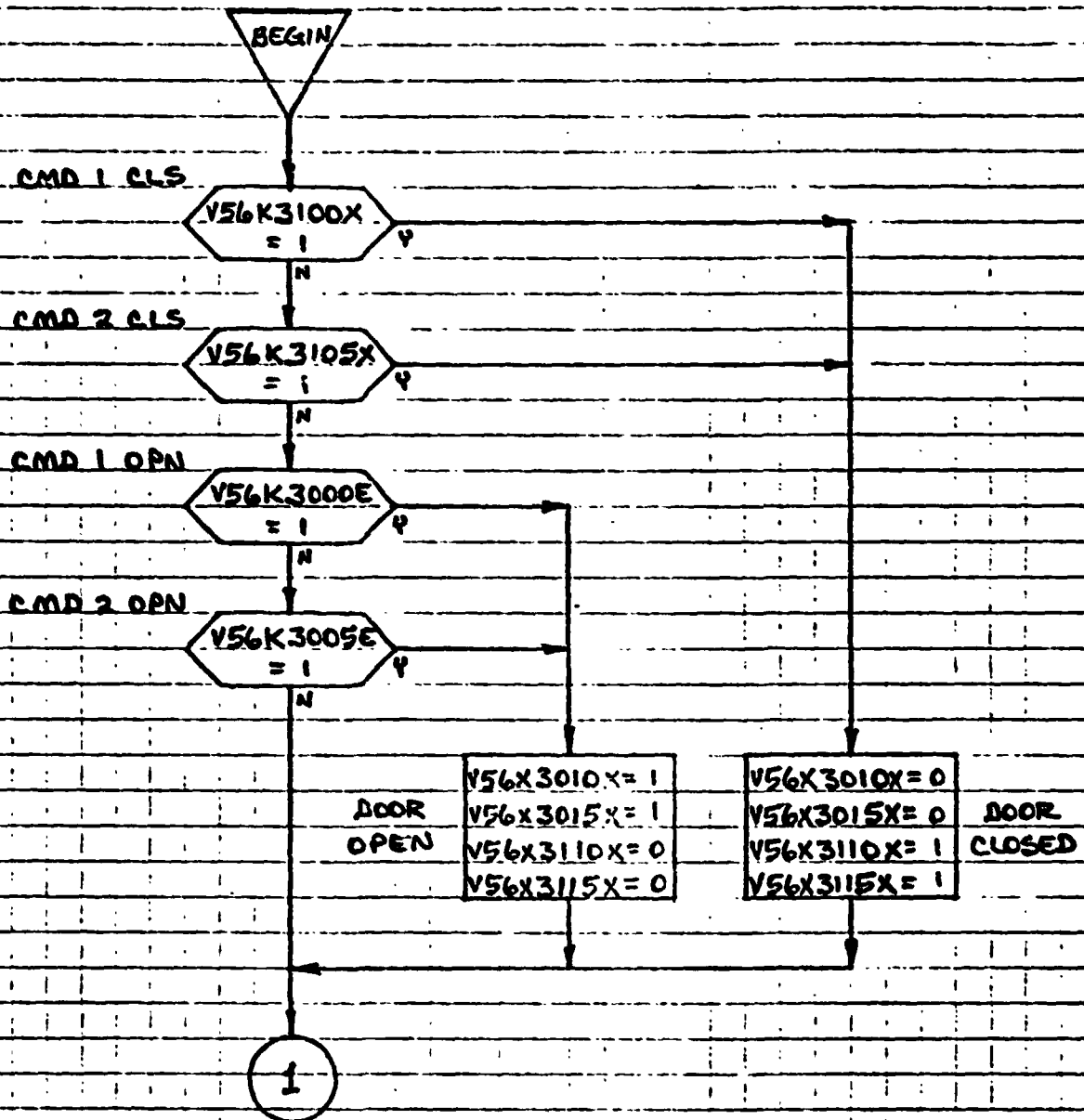
3.0 LOGIC FLOW DIAGRAMS

The logic flow diagram is made up of interconnected lines, boxes, decisions, and offpage connectors. Notice that where analog measurements are listed in boxes and decisions, the value inside the box is in flight system engineering units (FS_{EU}) while the corresponding GSIU count value is listed outside the box. For example, the box on the right hand below,



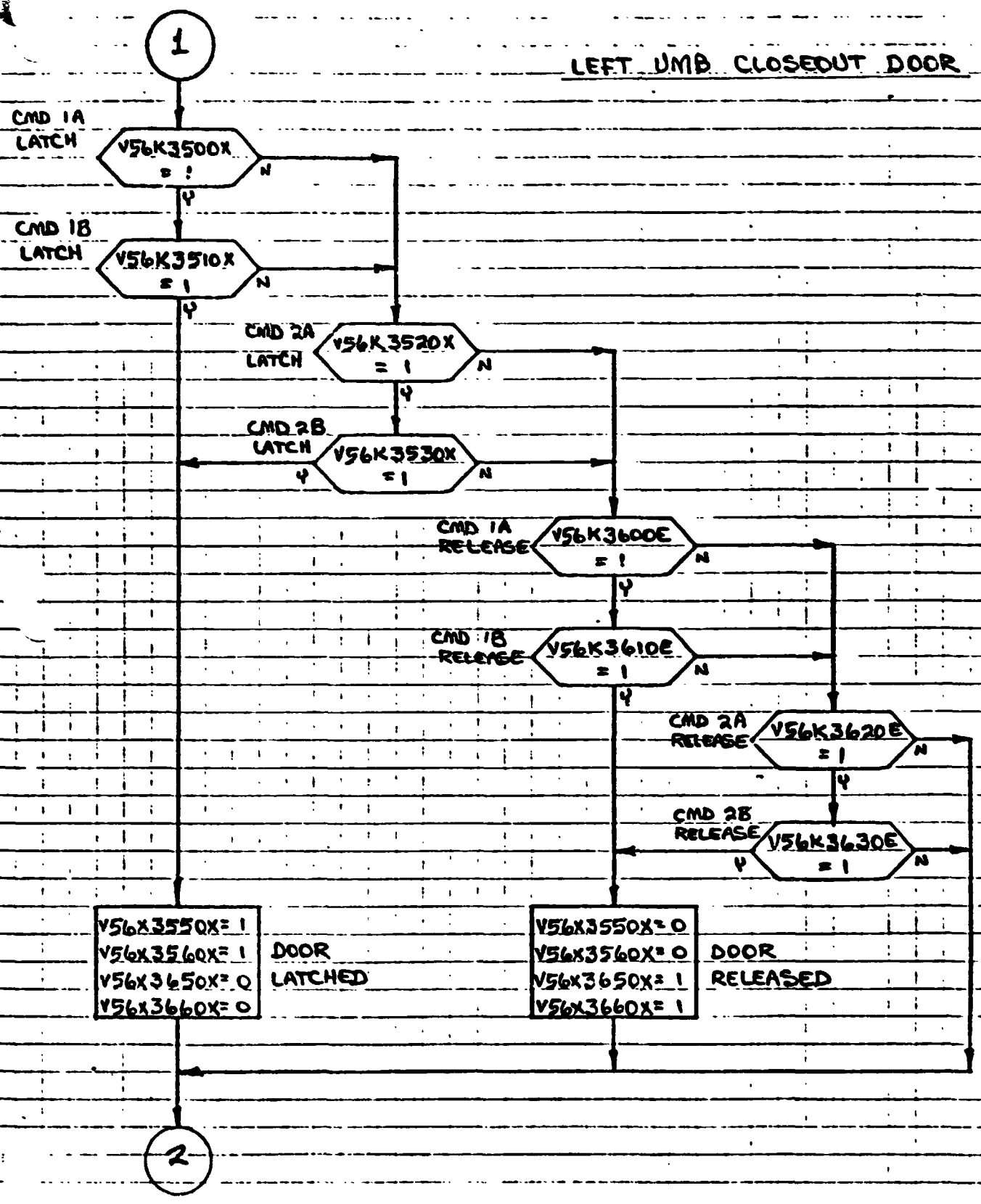
shows that $V45P1100A$ is set equal to $626\ FS_{EU}$ which is equivalent to $534\ GSIU_{CTS}$ shown outside the box.

LEFT OMB CLOSEOUT DOOR

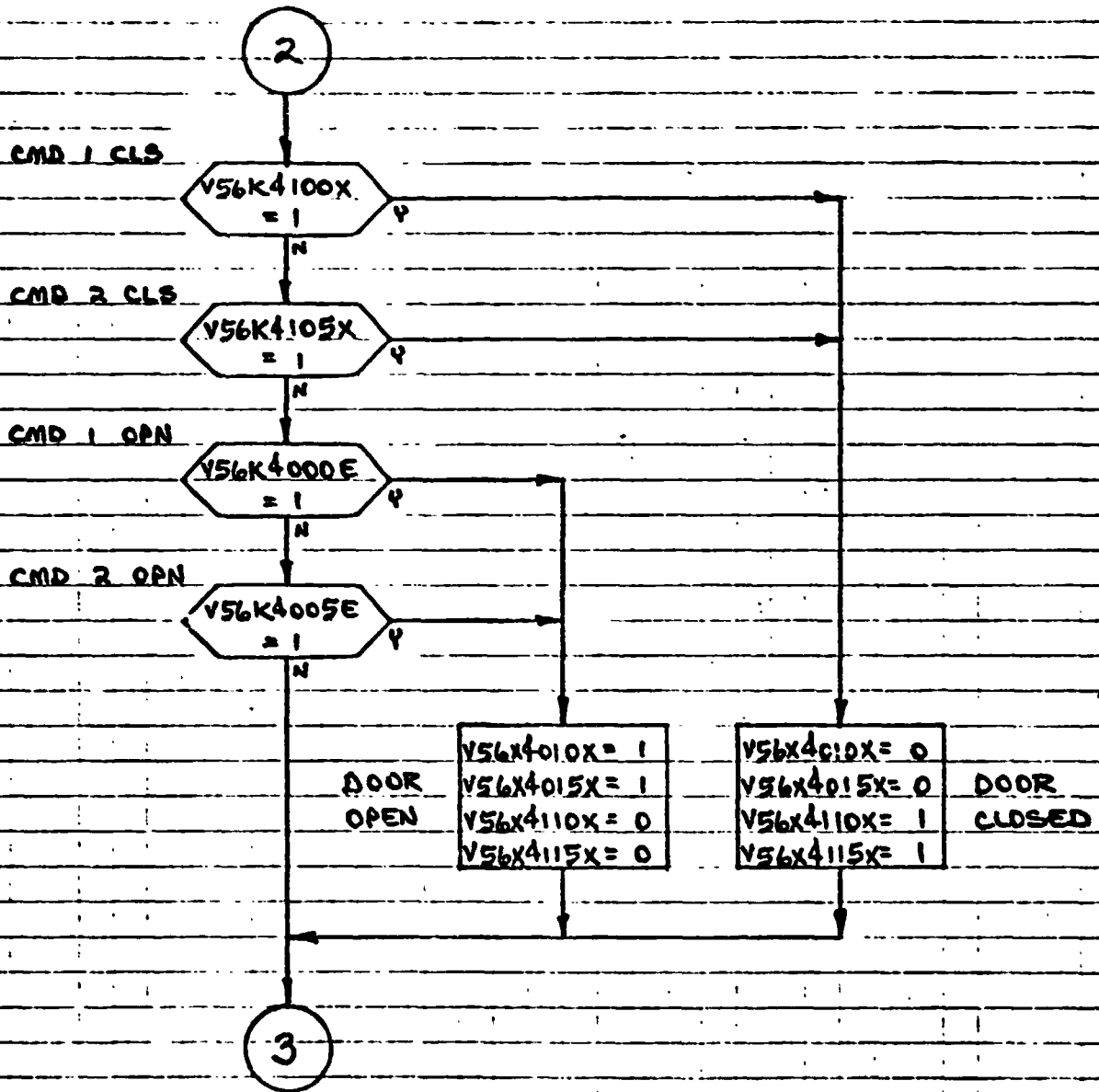


ORIGINAL PAGE IS
OF POOR QUALITY

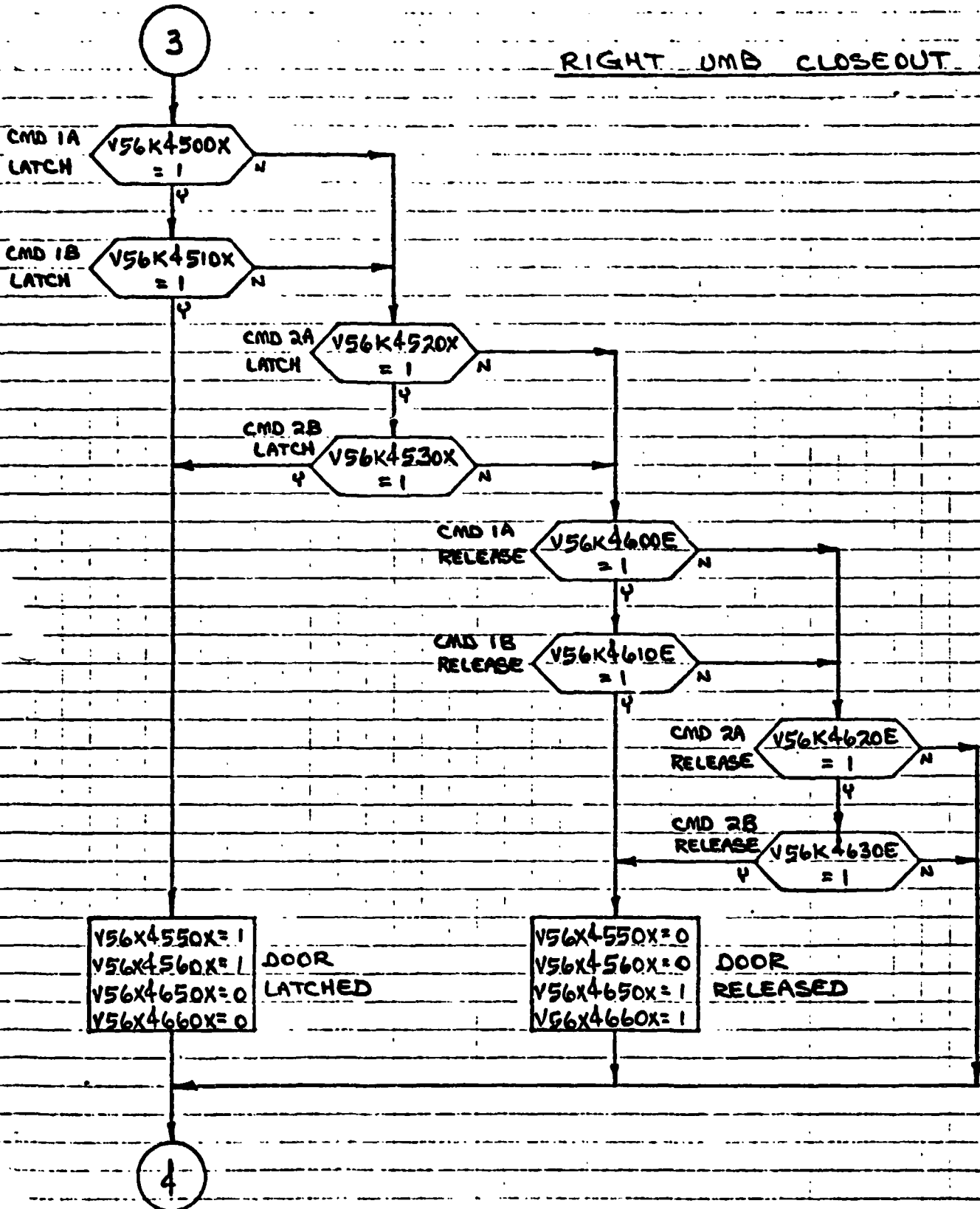
LEFT UMB CLOSEDOUT DOOR



RIGHT UMB CLOSEOUT DOOR



RIGHT UMB CLOSEOUT DOOR



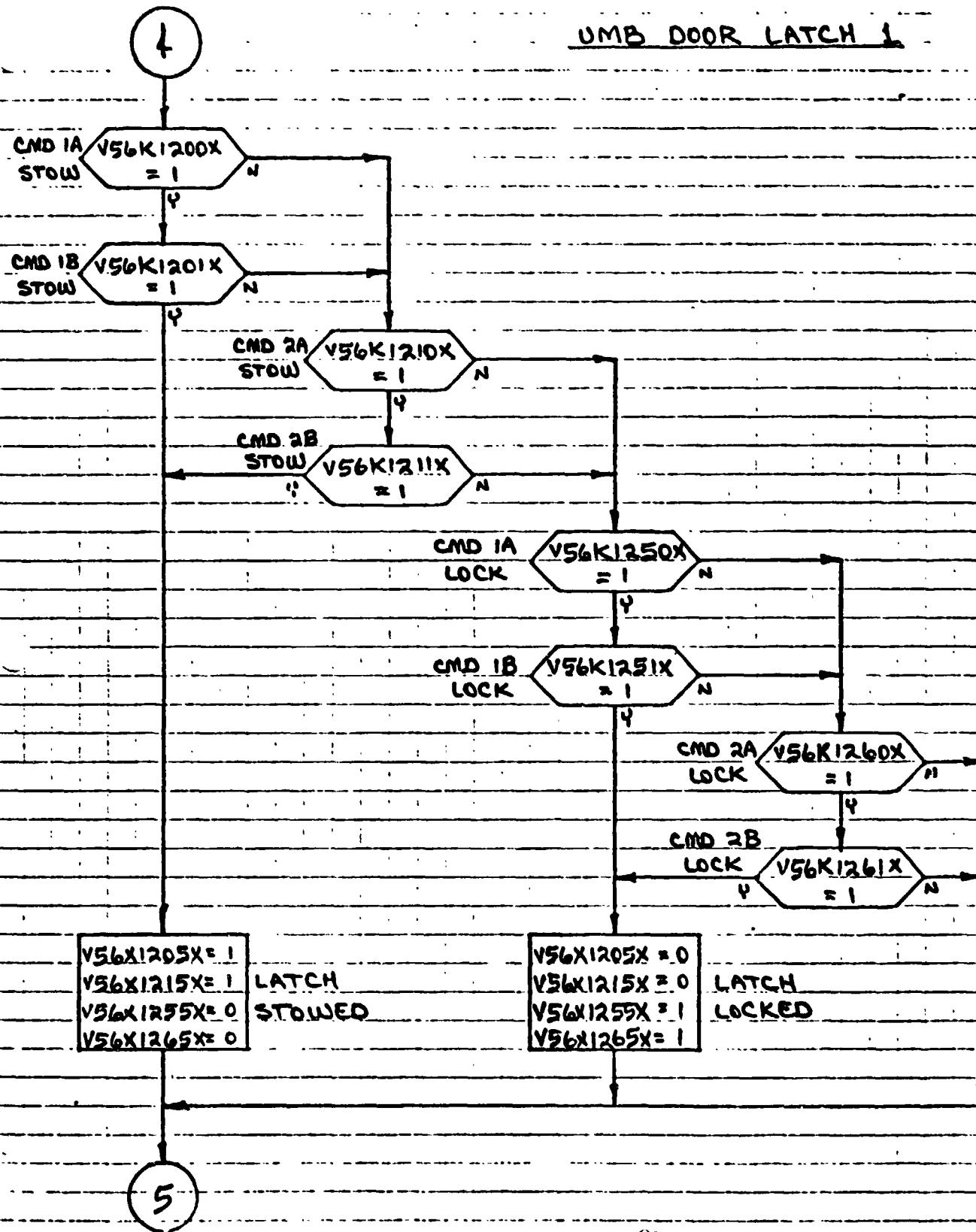
V56X4550X = 1
V56X4560X = 1
V56X4650X = 0
V56X4660X = 0

DOOR
LATCHED

V56X4550X = 0
V56X4560X = 0
V56X4650X = 1
V56X4660X = 1

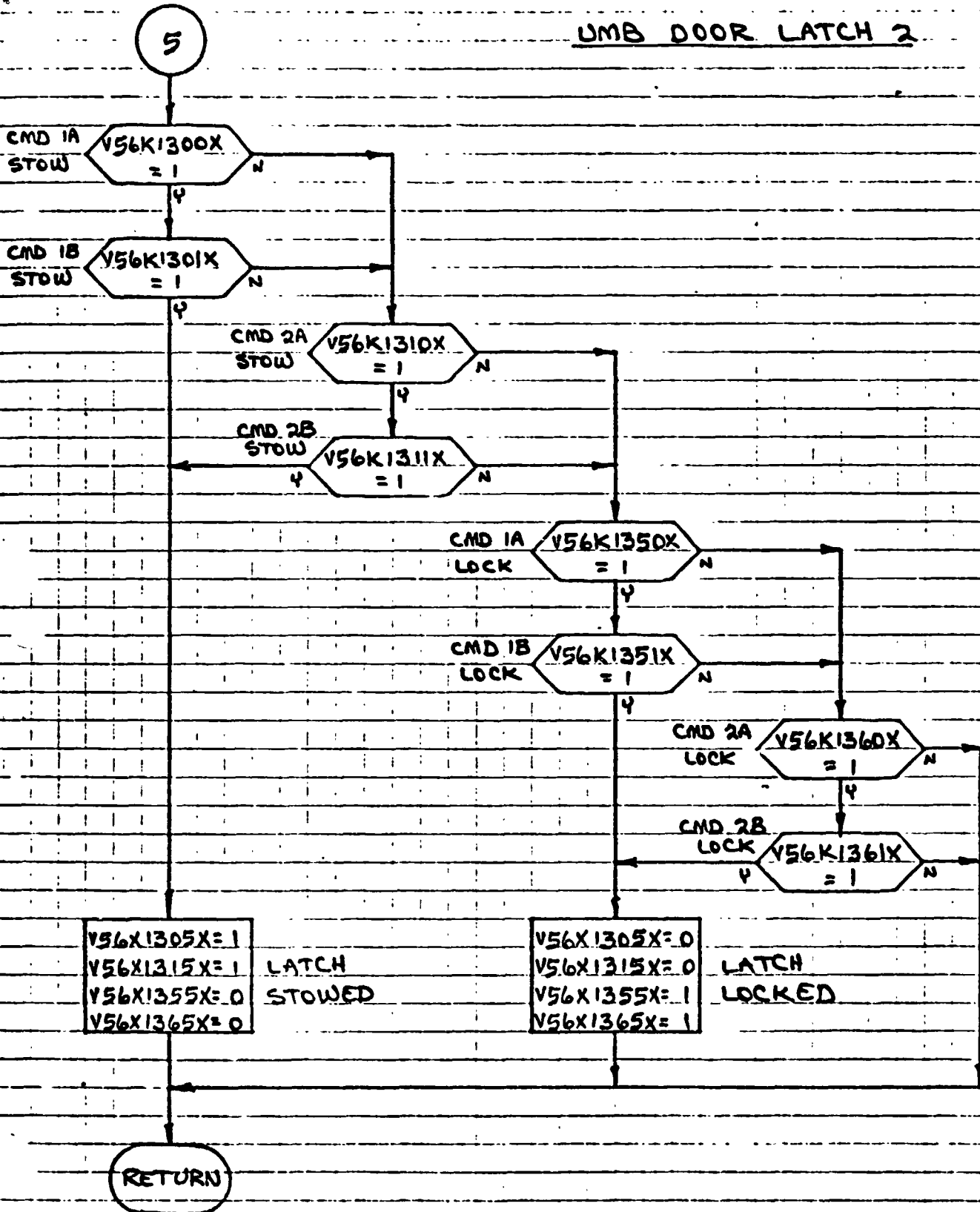
DOOR
RELEASED

UMB DOOR LATCH 1



ORIGINAL PAGE IS
OF POOR QUALITY

UMB DOOR LATCH 2



4.0 INPUT/OUTPUT TABLES

TABLE 4.1 - INPUT STIMULI

IDENTIFICATION NUMBER	NOMENCLATURE	ADDRESS	STATES/RANGE			UNITS
			LO	HI		
V56K1200X	ET UMB DOOR LATCH 1 STOW CMD 1A	FROM F.S.	0	1	STATE	
V56K1201X	ET UMB DOOR LATCH 1 STOW CMD 1B					
V56K1210X	ET UMB DOOR LATCH 1 STOW CMD 2A					
V56K1211X	ET UMB DOOR LATCH 1 STOW CMD 2B					
V56K1250X	ET UMB DOOR LATCH 1 LOCK CMD 1A					
V56K1251X	ET UMB DOOR LATCH 1 LOCK CMD 1B					
V56K1260X	ET UMB DOOR LATCH 1 LOCK CMD 2A					
V55K1261X	ET UMB DOOR LATCH 1 LOCK CMD 2B					
V56K1300X	ET UMB DOOR LATCH 2 STOW CMD 1A					
V56K1301X	ET UMB DOOR LATCH 2 STOW CMD 1B					
V56K1310X	ET UMB DOOR LATCH 2 STOW CMD 2A					
V56K1311X	ET UMB DOOR LATCH 2 STOW CMD 2B					
V56K1350X	ET UMB DOOR LATCH 2 LOCK CMD 1A					
V56K1351X	ET UMB DOOR LATCH 2 LOCK CMD 1B					
V56K1360X	ET UMB DOOR LATCH 2 LOCK CMD 2A					
V56K1361X	ET UMB DOOR LATCH 2 LOCK CMD 2B					
V56K3000E	ET LEFT UMB CLOSEOUT DOOR OPEN CMD 1	FROM NAS				
V56K3005E	ET LEFT UMB CLOSEOUT DOOR OPEN CMD 2	FROM NAS				
V56K3100X	ET LEFT UMB CLOSEOUT DOOR CLOSE CMD 1	FROM F.S.				
V56K3105X	ET LEFT UMB CLOSEOUT DOOR CLOSE CMD 2					
V56K3500X	ET LEFT UMB CLOSEOUT DOOR LATCH CMD 1A					
V56K3510X	ET LEFT UMB CLOSEOUT DOOR LATCH CMD 1B					
V56K3520X	ET LEFT UMB CLOSEOUT DOOR LATCH CMD 2A					
V56K3530X	ET LEFT UMB CLOSEOUT DOOR LATCH CMD 2B					
V56K3600E	ET LEFT UMB CLOSEOUT DOOR RELEASE CMD 1A	FROM F.S.				
V56K3610E	ET LEFT UMB CLOSEOUT DOOR RELEASE CMD 1B	FROM NAS				
V56K3620E	ET LEFT UMB CLOSEOUT DOOR RELEASE CMD 2A					
V56K3630E	ET LEFT UMB CLOSEOUT DOOR RELEASE CMD 2B					
V56K4000E	ET RIGHT UMB CLOSEOUT DOOR OPEN CMD 1	FROM F.S.				
V56K4005E	ET RIGHT UMB CLOSEOUT DOOR OPEN CMD 2	FROM NAS				
V56K4100X	ET RIGHT UMB CLOSEOUT DOOR CLOSE CMD 1					
V56K4105X	ET RIGHT UMB CLOSEOUT DOOR CLOSE CMD 2					
V56K4500X	ET RIGHT UMB CLOSEOUT DOOR LATCH CMD 1A					
V56K4510X	ET RIGHT UMB CLOSEOUT DOOR LATCH CMD 1B					
V56K4520X	ET RIGHT UMB CLOSEOUT DOOR LATCH CMD 2A					
V56K4530X	ET RIGHT UMB CLOSEOUT DOOR LATCH CMD 2B	FROM F.S.			STATE	

TABLE 4.1 - INPUT STIMULI (CONTINUED)

IDENTIFICATION NUMBER	NOMENCLATURE	ADDRESS	STATES/RANGE		UNITS
			LO	HI	
V56K4600E	ET RIGHT UMB CLOSEOUT DOOR RELEASE CMD 1A	FROM NAS	0	1	STATE
V56K4610E	ET RIGHT UMB CLOSEOUT DOOR RELEASE CMD 1B	↓	↓	↓	↓
V56K4620E	ET RIGHT UMB CLOSEOUT DOOR RELEASE CMD 2A	FROM NAS	0	1	STATE
V56K4630E	ET RIGHT UMB CLOSEOUT DOOR RELEASE CMD 2B	↓	↓	↓	↓

4.2 OUTPUT MEASUREMENT LIST

Table 2 lists all model outputs along with the initial condition value for the output. Measurement I.D. and Measurement Name precede pairs of numeric columns. The first of each pair is labeled FS indicating flight system engineering units. The second of each pair is labeled CTS indicating the GSIU count value corresponding to the FS value. I.C. indicates initial condition values. VALUE 1 typically indicates nominal values. VALUE 2 and VALUE 3 columns indicate off nominal conditions.

MEASUREMENT OUTPUT FROM ET UMB MODEL - TABLE 2

MEASUREMENT I. D.	MEASUREMENT NAME	I.C.		VALUE 1		VALUE 2		VALUE 3		UNITS
		FS	CTS	FS	CTS	FS	CTS	FS	CTS	
V56X1205X	ET UMB DOOR LATCH 1 STOWED 1	0	0	1	1					STATE
V56X1215X	ET UMB DOOR LATCH 1 STOWED 2	0	0	1	1					
V56X1255X	ET UMB DOOR LATCH 1 LOCKED 1	0	0	1	1					
V56X1265X	ET UMB DOOR LATCH 1 LOCKED 2	0	0	1	1					
V56X1305X	ET UMB DOOR LATCH 2 STOWED 1	0	0	1	1					
V56X1315X	ET UMB DOOR LATCH 2 STOWED 2	0	0	1	1					
V56X1355X	ET UMB DOOR LATCH 2 LOCKED 1	0	0	1	1					
V56X1365X	ET UMB DOOR LATCH 2 LOCKED 2	0	0	1	1					
V56X3010X	ET LF UMB CLOSEOUT DOOR OPEN 1	1	1	0	0					
V56X3015X	ET LF UMB CLOSEOUT DOOR OPEN 2	1	1	0	0					
V56X3110X	ET LF UMB CLOSEOUT DOOR CLOSED 1	0	0	1	1					
V56X3115X	ET LF UMB CLOSEOUT DOOR CLOSED 2	0	0	1	1					
V56X3550X	ET LF UMB CLOSEOUT DOOR LATCHED 1	0	0	1	1					
V56X3560X	ET LF UMB CLOSEOUT DOOR LATCHED 2	0	0	1	1					
V56X3650X	ET LF UMB CLOSEOUT DOOR RELEASED 1	1	1	0	0					
V56X3660X	ET LF UMB CLOSEOUT DOOR RELEASED 2	1	1	0	0					
V56X4010X	ET RT UMB CLOSEOUT DOOR OPEN 1	1	1	0	0					
V56X4015X	ET RT UMB CLOSEOUT DOOR OPEN 2	1	1	0	0					
V56X4110X	ET RT UMB CLOSEOUT DOOR CLOSED 1	0	0	1	1					
V56X4115X	ET RT UMB CLOSEOUT DOOR CLOSED 2	0	0	1	1					
V56X4550X	ET RT UMB CLOSEOUT DOOR LATCHED 1	0	0	1	1					
V56X4560X	ET RT UMB CLOSEOUT DOOR LATCHED 2	0	0	1	1					
V56X4650X	ET RT UMB CLOSEOUT DOOR RELEASED 1	1	1	0	0					
V56X4660X	ET RT UMB CLOSEOUT DOOR RELEASED 2	1	1	0	0					STATE

4.3 NAS CRT DISPLAYS

LINE NO.	OPERATION	VARIABLE FIELD	COMMENTS
056212	DR CL LCH 1	DR CL LCH 2	XXXXXXXXXX
K1250X	LK 1A	K1350X LK 1A	LOCK
*K1251X	LK 1B	*K1351X LK 1B	LOCK
X1260X	LK 2A	X1360X LK 2A	LOCK
*K1261X	LK 2B	*K1361X LK 2B	LOCK
X1255X	LKIND	X1355X LKIND	LOCKED
*X1265X	LKIND	*X1365X LKIND	LOCKED
K1200X	STW1A	K1300X STW1A	STOP
*K1201X	STW1B	*K1301X STW1B	STOP
K1210X	STW2A	K1310X STW2A	STOP
*K1211X	STW2B	*K1311X STW2B	STOP
X1205X	STIND	X1305X STIND	STOPPED
*X1215X	STIND	*X1315X STIND	STOPPED

NOTE: DATA BLOCKS ALL SHOWN FOR (M) CMD SIGNALS. ACTUAL DATA SHOULD BE PER MODEL LOGIC. (P-LOGICAL AND T-LOGICAL OR)

5.0 REFERENCES

5.1 LEC MEMO NO. 78-GNC-254, NAS Functional Logic by N. Bauer, 8/18/78

5.2 LEC MEMO NO. 78-GNC-260, NAS CRT Formats by N. Bauer, 8/30/78

5.3 ICD-GNCTS-06, TABLES 3-5,3-6,3-7,3-8, dated 8/2/78

APPENDIX D
ET SEP PYROS MATH MODEL REQUIREMENTS

CONTENTS

Section	Page
1. INTRODUCTION.	D-2
2. DETAILED REQUIREMENTS	D-4
2.1 <u>FUNCTIONAL CHARACTERISTICS</u>	D-4
2.2 <u>NAS UPLINK REQUIREMENTS.</u>	D-4
2.3 <u>INITIALIZATION REQUIREMENTS.</u>	D-4
2.4 <u>TERMINATION REQUIREMENTS</u>	D-4
2.5 <u>UNIQUE REQUIREMENTS.</u>	D-4
2.6 <u>ANALOG MEASUREMENTS.</u>	D-5
3. LOGIC FLOW DIAGRAMS	D-8
4. INPUT/OUTPUT TABLES	D-10
4.1 <u>INPUT STIMULI.</u>	D-11
4.2 <u>OUTPUT MEASUREMENTS.</u>	D-12
4.3 <u>NAS CRT DISPLAYS</u>	D-14
5. REFERENCES.	D-16

FIGURES

Figure	Page
1 FLIGHT SYSTEM/NAS DATA FLOW	D-3

1.0 INTRODUCTION

The GN&C Test Station (GTS) uses math models to simulate many of the Shuttle systems for which hardware has not been provided. A group of these models are termed "non-avionic" models since they do not simulate the Shuttle's "avionic" systems. The "non-avionic" models are needed to supply data for on-board software processing and to respond to Shuttle commands, whether they be from cockpit switches, the General Purpose Computers (GPC's) or the Non-Avionic Simulator (NAS) console. Figure 1 provides the Flight System/NAS data flow.

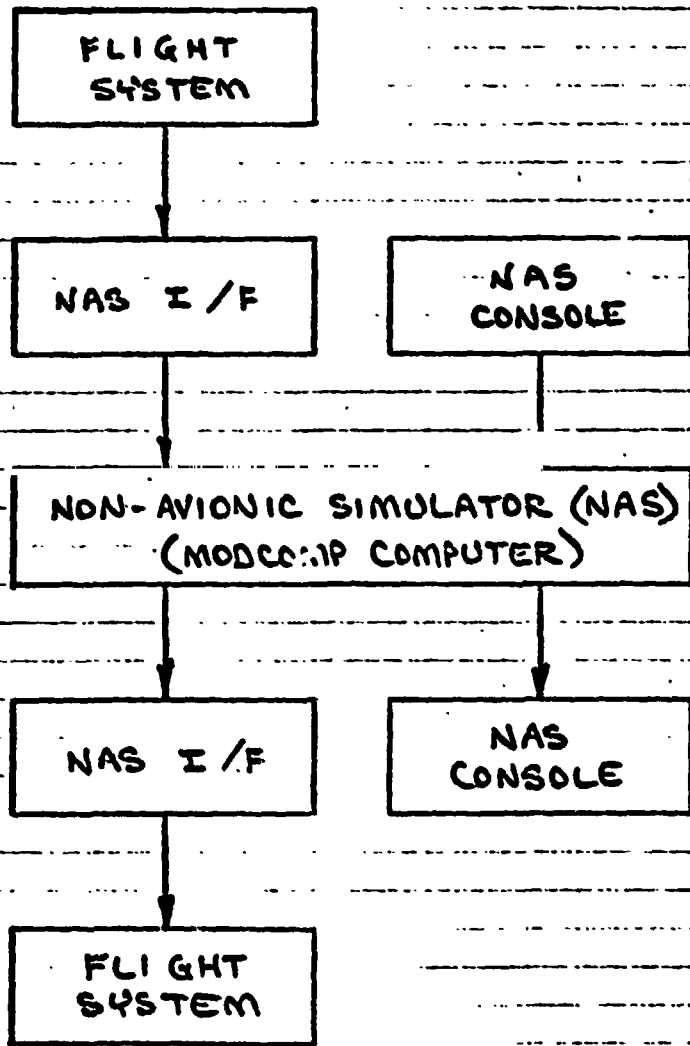


FIGURE 1 - FLIGHT SYSTEM / NAS DATA FLOW

2.0 DETAILED REQUIREMENTS

2.1 FUNCTIONAL CHARACTERISTICS

This model simulates the functions of the ET/Orbiter Forward Separation Pyro, namely: ARM and FIRE. The rear separation pyros are not part of this model because they exist in the Mission Events Controller (MEC) in the Flight System.

2.2 NAS UPLINK REQUIREMENTS

The NAS console operator has the capability to override any math model output value with a value entered at the console. This permits the use of off-nominal data entries to test limit checking software.

2.3 INITIALIZATION REQUIREMENTS

When the math model begins running in the MODCOMP computer, the output data values shall be as defined in Table 4.2 - Initial Conditions, until altered by commands from the Flight System or the NAS console.

2.4 TERMINATION REQUIREMENTS

None.

2.5 UNIQUE REQUIREMENTS

None.

2.6 ANALOG MEASUREMENTS

Values shown in the math model flowcharts are in GSIU counts for all analog measurements. The math model values are seen by the flight system as 0 to 5 VDC inputs. The flight system then converts these input voltages to engineering units using one of the two types of scaling equations discussed in Sections 2.6.1 and 2.6.2. The GSIU math model count values (or the count values entered at the DCM by the test operator) must consider the scaling computation done later by the flight software, so that correct flight system engineering unit values are obtained for fault detection and annunciation (FDA), and for cockpit displays. The following two sections, 2.6.1 and 2.6.2, describe the scaling equations which apply to this model. Section 2.6.1 describes the scaling equation for measurements which require the polynomial conversion method. Section 2.6.2 describes the scaling equation for measurements which require the range limit conversion method which was used on STS-1.

2.6.1 POLYNOMIAL CONVERSION METHOD

NONE

2.6.2 RANGE LIMIT CONVERSION METHOD

Several analog measurements in this model are calculated according to the range limit conversion method, instead of the polynomial conversion method as described in Section 2.6.1 of this document. The form of the scaling equation for these cases is given as follows:

$$FS_{EU} = Low + \frac{GSIU_{CTS}}{1023} (High - Low)$$

where: FS_{EU} = flight system engineering units

$GSIU_{CTS}$ = GSIU math model count values

Low = Range low limit

High = Range high limit

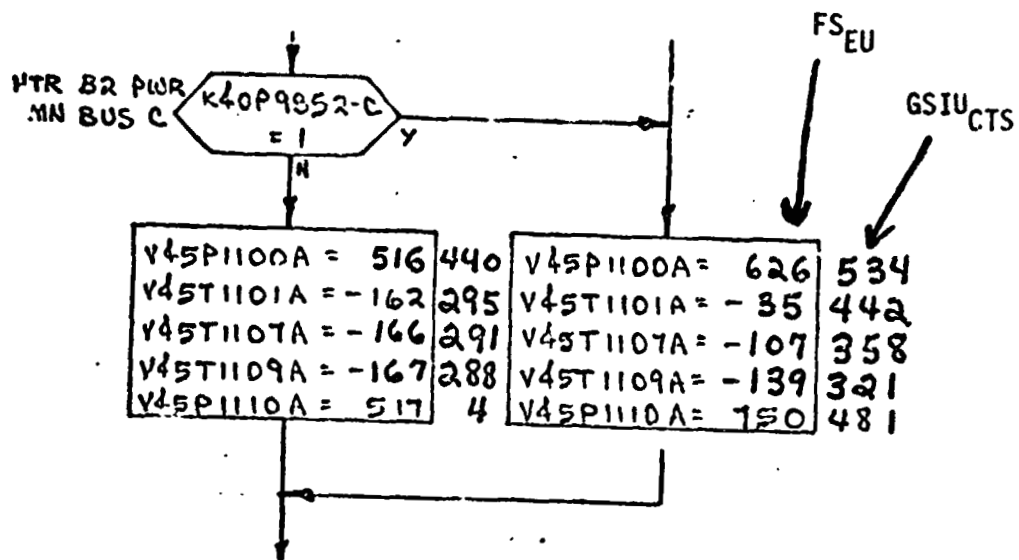
The following table shows a sample data value for each measurement which requires this type of calculation. The measurement I.D. is shown along with high and low values for the parameter range. The FS column shows the data value in flight system engineering units calculated from the GSIU counts marked CTS in the table. These measurements are marked with an asterisk (*) in the Output Measurement List marked as Table 2 in Section 4.2 of this document.

MEASUREMENT ID	RANGE LOW	RANGE HIGH	FS	CTS
V76V7079B	0	5	0	0

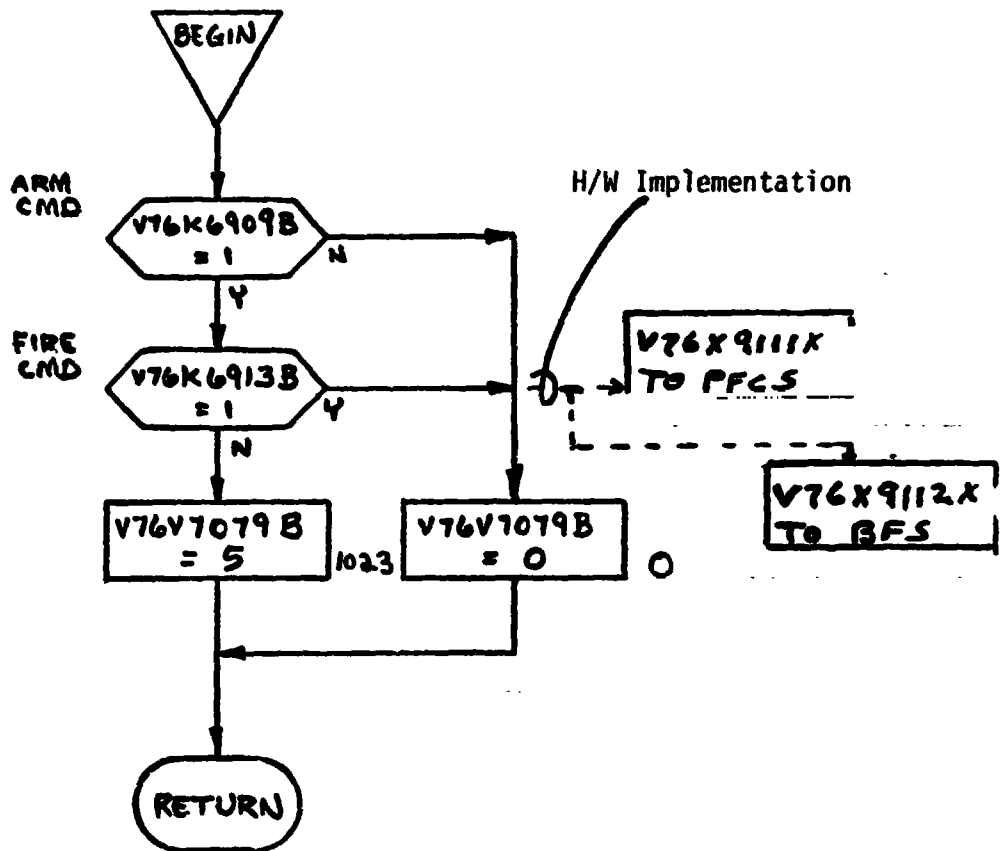
ORIGINAL PAGE IN
SERIALS SECTION

3.0 LOGIC FLOW DIAGRAMS

The logic flow diagram is made up of interconnected lines, boxes, decisions, and offpage connectors. Notice that where analog measurements are listed in boxes and decisions, the value inside the box is in flight system engineering units (FS_{EU}) while the corresponding GSIU count value is listed outside the box. For example, the box on the right hand below,



shows that V45P1100A is set equal to 626 FS_{EU} which is equivalent to 534 $GSIU_{CTS}$ shown outside the box.



NOTE: Pyro math model output of Pyro System A is also routed to the BFS to satisfy Pyro System B interface with the BFS.

4.0 INPUT/OUTPUT TABLES

TABLE 4.1 - INPUT STIMULI

IDENTIFICATION NUMBER	NOMENCLATURE	ADDRESS	STATES/RANGE		
			LO	HI	UNITS
V76K6909B	ET/ORB FWD SEP ARM CMD	FROM FLT SYS (MEC)	0	1	STATE
V76K6913B	ET/ORB FWD SEP FIRE 1 CMD	FROM FLT SYS (MEC)	0	1	STATE

4.2 OUTPUT MEASUREMENT LIST

Table 2 lists all model outputs along with the initial condition value for the output. Measurement I.D. and Measurement Name precede pairs of numeric columns. The first of each pair is labeled FS indicating flight system engineering units. The second of each pair is labeled CTS indicating the GSIU count value corresponding to the FS value. I.C. indicates initial condition values. VALUE 1 typically indicates nominal values. VALUE 2 and VALUE 3 columns indicate off nominal conditions.

MEASUREMENT OUTPUT FROM ET SEP MODEL - TABLE 2

MEASUREMENT I. D.	MEASUREMENT NAME	I.C.		VALUE 1 K=1 (NOMINAL)		VALUE 2 K=2 (HI/LOW)		VALUE 3 K=3 (OFF)		UNITS
		FS	CTS	FS	CTS	FS	CTS	FS	CTS	
*V76V7079B	ET/OPB FWD PIC SEP A CAP VOLT	0	0	5	1023					VDC

ORIGINAL PAGE IS
OF POOR QUALITY

*NOTE: This measurement uses the range limit conversion method of calculating FS_{EU} from $GSIU_{CTS}$ as discussed in section 2.6.2.

4.3 NAS CRT DISPLAYS

5.0 REFERENCES

5.1 LEC MEMO No. 78-GNC-254, NAS Functional Logic, by N. Bauer, 8/18/78

5.2 LEC MEMO No. 78-GNC-260, NAS CRT Formats, by N. Bauer, 8/30/78

5.3 ICD-GNCTS-06, Table 3-9, MEC/NAS Interface Data Sheet, 8/2/78

APPENDIX E
MPS PLUMBING MATH MODEL REQUIREMENTS

TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
1.0 INTRODUCTION.	E-3
1.1 SHUTTLE TEST STATION (STS).	E-3
1.2 GN & C TEST STATION (GTS)	E-4
- - - - - STS- - - - -	
2.0 STS DETAILED REQUIREMENTS	E-5
2.1 STS FUNCTIONAL CHARACTERISTICS.	E-5
2.2 DCM UPLINK REQUIREMENTS	E-6
2.3 STS INITIALIZATION REQUIREMENTS	E-10
2.4 STS TERMINATION REQUIREMENTS.	E-10
2.5 STS UNIQUE REQUIREMENTS	E-10
2.6 ANALOG MEASUREMENTS	E-12
3.0 LOGIC FLOW DIAGRAMS	E-15
4.0 STS INPUT/OUTPUT TABLES	E-36
4.1 STS INPUT TABLE	E-37
4.2 STS OUTPUT TABLE.	E-41
5.0 STS REFERENCES.	E-47
- - - - - GTS- - - - -	
12.0 GTS DETAILED REQUIREMENTS	E-48
12.1 GTS FUNCTIONAL CHARACTERISTICS.	E-48
12.2 NAS UPLINK REQUIREMENTS	E-50
12.3 GTS INITIALIZATION REQUIREMENTS	E-50
12.4 GTS TERMINATION REQUIREMENTS.	E-50
12.5 GTS UNIQUE REQUIREMENTS	E-50
13.0 GTS LOGIC FLOW DIAGRAMS	E-53
14.0 GTS INPUT/OUTPUT TABLES	E-89
14.1 GTS INPUT TABLE	E-90
14.2 GTS OUTPUT TABLE.	E-98
14.3 NAS CRT DISPLAY	E-102
15.0 GTS REFERENCES.	E-104

	<u>Page</u>
FIGURE 1 STS SYSTEM DATA FLOW	E-7
FIGURE 2 SUBSYSTEM SCHEMATIC.	E-8
FIGURE 2A MPS HELIUM SYSTEM SCHEMATIC.	E-9
FIGURE 3 GTS SYSTEM DATA FLOW	E-49
FIGURE 4 NAS CRT DISPLAY FORMAT	E-103

1.0 INTRODUCTION

The Shuttle Avionics Integration Laboratory (SAIL) consists of a Shuttle Test Station (STS) and a GN & C Test Station (GTS). Both of these test stations use math models to simulate many of the Shuttle systems, for which hardware has not been provided. A group of these models are termed "non-avionic" models since they do not simulate the Shuttle's avionic systems. The non-avionic models are needed to supply data for on-board software processing, to drive cockpit displays, and to respond to Shuttle commands, whether they be from the cockpit switches or from the General Purpose Computers (GPC's).

Because the STS and the GTS are configured differently, the non-avionic math models needed to support each test station are shown below.

<u>Non-Avionic Math Model</u>	<u>STS</u>	<u>GTS</u>
APU/Hydraulics	*	*
Main Propulsion System	*	*
RCS/OMS	*	
Fuel Cell/Cryogenics	*	
ATMOS Revital/Water Loops	*	
ATMOS Revital/Press Control-Airlock	*	
Active Thermal Control	*	
Smoke Detection	*	
Water/Waste Mgt.	*	
ET/ORB FWD Sep Pyros		*
ET UMB Cout Door/Latch		*
Vent Doors		*

Where the same math model is needed in both test stations, the math model requirements document is divided into a STS section and a GTS section, so that unique test station requirements may be identified.

1.1 SHUTTLE TEST STATION (STS)

When the TOC Display and Control Module (DCM) operator depresses the "SYS LOAD" key, the model programs, which are stored on the Fixed Head Disk in the DCM, are automatically loaded into the GSIU. The models are then activated and terminated by DCM test language statements. While the models are operating in the GSIU, the DCM operator is able to inhibit one, all, or any combination of model outputs with test language statements. This provides the DCM operator with control of output parameter values when off-nominal conditions are desired. To simplify the model and ease the processing load on supporting

test equipment, the model requirements define nominal conditions only. Further, analog values for output parameters change in step fashion when responding to inputs, except when specific change rates for particular parameters are required. The DCM operator is also able to alter the value that the model uses to generate parameter outputs. This allows the DCM operator to adjust output parameter values as needed to satisfy various mission phases.

When the model is activated, it shall check the input stimuli and shall provide appropriate output measurement values. It is preferred that the model provide output data when the input stimuli changes. Bus activity is then minimal during those mission phases when the stimuli remains constant. However, the GSIU operating system may require a cyclic model program in which case the model output rate shall be once per second.

1.2 GN & C TEST STATION (GTS)

To simplify the models and ease the processing load on supporting test equipment, the model requirements specify nominal conditions only. Analog values for output parameters change when input values dictate a change, or when the test operator manually sets parameter values. Because GTS has an incomplete set of cockpit switches, some switch inputs used in STS must be entered in GTS by the simulator operator. This method allows the use of the same logic for STS and GTS.

2.0 STS DETAILED REQUIREMENTS

2.1 STS FUNCTIONAL CHARACTERISTICS

This model simulates those functions of the Main Propulsion System (MPS) components that are in the Orbiter, namely valve positions, system pressures, and system temperatures. To simplify the model, only those component functions needed to support testing of the Shuttle Avionics System are provided.

The model receives stimuli from three sources: (1) the Flight System via the Signal Termination Module (STM); (2) the Marshall Mated Elements Simulator (MMES); and (3) the Test Operations Center (TOC) Display and Control Module (DCM). The GSIU model transmits parameter values to the Flight System and the MMES via the STM. Figure 1 illustrates the data flow in and out of the model. Tables 1 and 2 list the input stimuli and the output measurements, respectively.

One of the stimuli comes from the MMES and is the low level L02 signal which is used to determine the states of the L02 Engine Cut-Off (ECO) sensors in the L02 Feed Manifold, (reference logic flow chart routine 11). The ECO sensor data is transmitted to the Flight System. The MMES also transmits L02 and LH2 tank ullage pressures to the STM but these measurements are not used in the model. They are available to the TOC DCM for monitoring during testing.

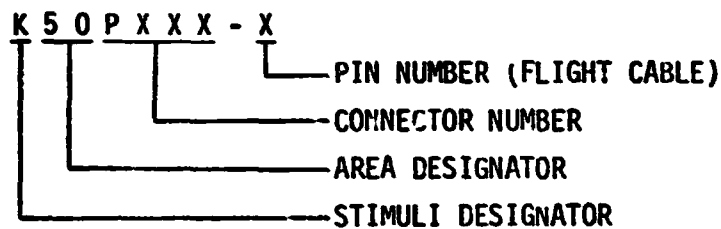
Four of the stimuli come from the TOC DCM. The helium supply pressures (HE1, HE2, HE3, and HE4) from the DCM are provided by test language and are used to establish the pressure levels in the helium system, (reference logic flow chart routine 1). These pressures are transmitted to the Flight System as well as used in the model to determine if pneumatic valves can or cannot be activated.

The remaining stimuli come from the Flight System and are used to control the valves in the model. The valves in the model are of three types: normally open, normally closed, and latching. The normally open valve remains open unless there is pneumatic pressure and a close command present in which case the valve closes. The normally closed valve remains closed unless there is pneumatic pressure and an open command present in which case the valve opens. The latching valve remains in either the open or close state depending on its

last command, unless there is pneumatic pressure and a command for it to go to its opposite state. These three types of valve actions are shown in the logic flow chart routines titles, Normally Open Valve Routine (NOVR), Normally Closed Valve Routine (NCVR), and Latching Valve Routine (LVR).

The model generates three engines ready for firing discrettes (one per engine) which are transmitted to the MMES as a valve status signal prior to engine firing, (reference logic flow chart routine 15).

The stimuli identification numbers used are coded to provide the following information at the SAIL flight cable/GSE/C7U-1140 cable set interface.



Exceptions to this code are those stimuli with a letter for the connector number where the connector number is unknown. Also the stimuli which comes from the DCM instead of the flight cable do not agree with this code.

Figure 2 and 2A are simplified schematics of the Orbiter portion of the M/S and are included in this requirements document for reference.

2.2 DCM UPLINK

A mission phase dependent variable in the Orbiter portion of the MPS is helium supply pressure. To avoid complexity in the GSIU model, the change of helium pressure to account for the operation of pneumatic valves and engine purging was not incorporated into the flowchart logic. Instead, it is intended that the DCM test language transmit new pressure values to the GSIU model at appropriate times to be specified in the TCP. A suggested set of pressure values for a nominal mission are as follows:

<u>PHASF</u>	<u>PRESSURE VALUE (PSIA)</u>
Prelaunch	2,000
Launch	4,000
Orbit	1,500
Reentry	1,000
Landing	500

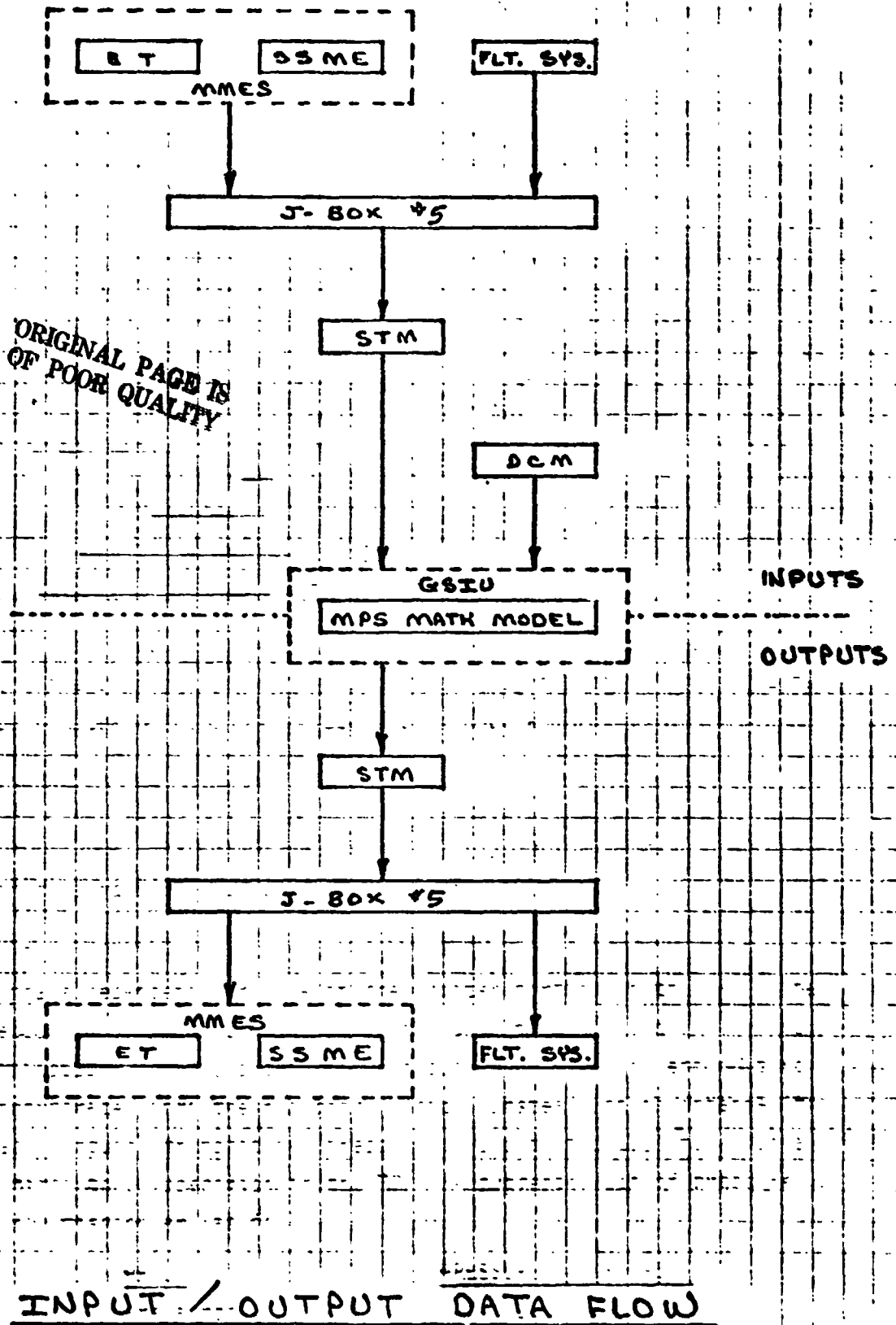


FIGURE 1

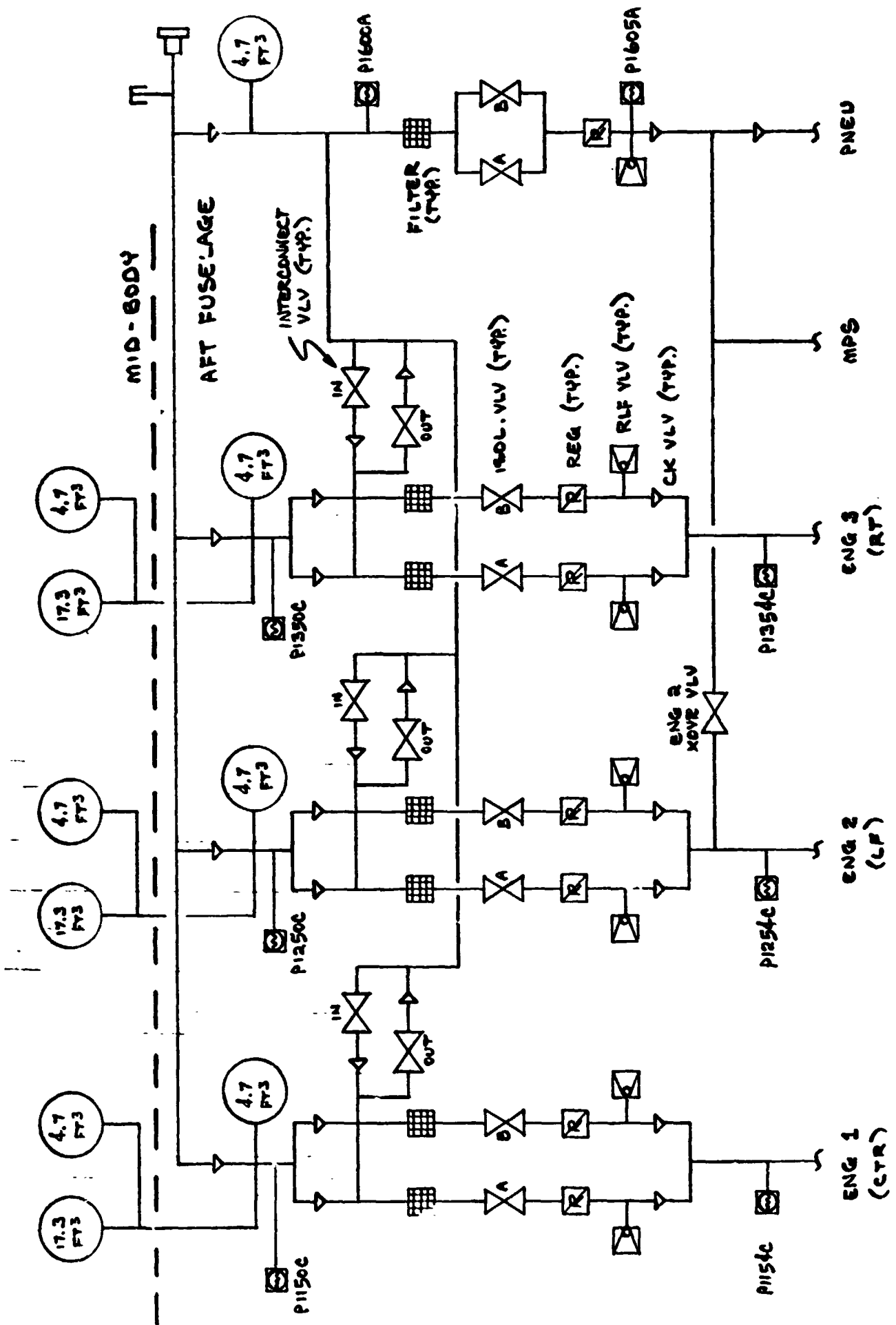


FIGURE 2A E-9

MPS HELIUM SYSTEM SCHEMATIC

Accounting for pressure usage during the mission is more for data realism than to satisfy avionics test requirements. The helium supply pressure might just as well remain fixed at 4,000 psia.

2.3 STS INITIALIZATION REQUIREMENTS

The initial conditions column in the measurements table indicates the state of the model prior to configuring for LH2 and LO2 fill operations and is for reference only. The output measurement values of the model shall reflect the state of the input stimuli when the model is made active.

2.4 STS TERMINATION REQUIREMENTS

None.

2.5 STS UNIQUE REQUIREMENTS

2.5.1 Timers

Two timers called "COUNTER" and "KOUNTER" are used in the LO2 and LH2 manifold pressure subroutines (nos. 12 and 13), respectively. The timers provide a delay before manifold pressures are set to zero. This simulates the time interval during which 20 psig helium pressure is forcing residual liquid propellants out of the manifolds following external tank separation.

2.5.2 Flags

Flags or pseudos that are used for purposes internal to the model are defined as follows:

D - Indicates valve position for the designated valve in the LVR, NCVR, and NOVR subroutines.

A,B- Indicate valve stimuli for the designated valve in the LVR, NCVR, and NOVR subroutines.

D1 thru D13 - Indicates the latching valve position for:

- D1 - L02 Feed Disconnect Valve
- D2 - LH2 Feed Disconnect Valve
- D3 - LH2 Recirculation Disconnect Valve
- D4 - L02 Outboard Fill and Drain Valve
- D5 - L02 Inboard Fill and Drain Valve
- D6 - LH2 Outboard Fill and Drain Valve
- D7 - LH2 Inboard Fill and Drain Valve
- D8 - Engine 1 L02 Prevalve
- D9 - Engine 2 L02 Prevalve
- D10 - Engine 3 L02 Prevalve
- D11 - Engine 1 LH2 Prevalve
- D12 - Engine 2 LH2 Prevalve
- D13 - Engine 3 LH2 Prevalve

2.5.3 MPS Propellant Dump Signals

Following Main Engine Cut-Off or External Tank separation, an L02 signal, an LH2 signal, and an RTLS signal are needed by the Vehicle Dynamics Math Models to compute the changes in vehicle forces and mass properties while MPS residual propellants are discharged overboard. The three signals are generated in the MPS math model and are identified as follows:

L02DP	L02 DUMP SIGNAL
LH2DP	LH2 DUMP SIGNAL
RTLSDP	RTLS DUMP SIGNAL

A state of (1) indicates a dump is in progress. These signals will be sensed by application software in the TOC DCM and will be transmitted to the VDS math models via TICM.

2.6 ANALOG MEASUREMENTS

Values shown in the math model flowcharts are in GSIU counts for all analog measurements. The math model values are seen by the flight system as 0 to 5 VDC inputs. The flight system then converts these input voltages to engineering units using one of the two types of scaling equations discussed in Sections 2.6.1 and 2.6.2. The GSIU math model count values (or the count values entered at the DCM by the test operator) must consider the scaling computation done later by the flight software, so that correct flight system engineering unit values are obtained for fault detection and annunciation (FDA), and for cockpit displays. The following two sections, 2.6.1 and 2.6.2, describe the scaling equations which apply to this model. Section 2.6.1 describes the scaling equation for measurements which require the polynomial conversion method. Section 2.6.2 describes the scaling equation for measurements which require the range limit conversion method which was used on STS-1.

2.6.1 POLYNOMIAL CONVERSION METHOD

NONE

2.6.2 RANGE LIMIT CONVERSION METHOD

Several analog measurements in this model are calculated according to the range limit conversion method, instead of the polynomial conversion method as described in Sectio. 2.6.1 of this document. The form of the scaling equation for these cases is given as follows:

$$FS_{EU} = Low + \frac{GSIU_{CTS}}{1023} (High - Low)$$

where: FS_{EU} = flight system engineering units

$GSIU_{CTS}$ = GSIU math model count values

Low = Range low limit

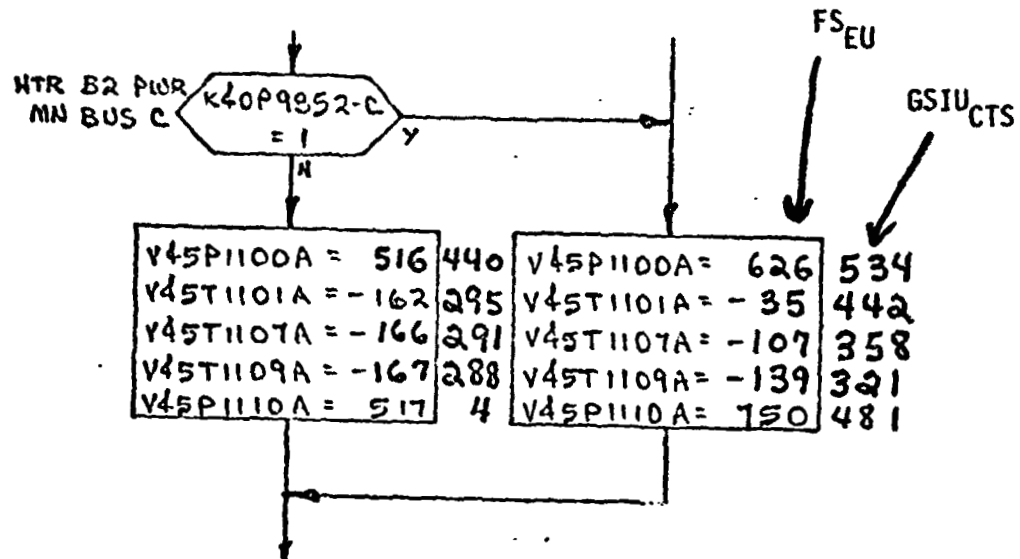
High = Range high limit

The following table shows a sample data value for each measurement which requires this type of calculation. The measurement I.D. is shown along with high and low values for the parameter range. The FS column shows the data value in flight system engineering units calculated from the GSIU counts marked CTS in the table. These measurements are marked with an asterisk (*) in the Output Measurement List marked as Table 2 in Section 4.2 of this document.

MEASUREMENT ID	RANGE LOW	RANGE HIGH	FS	CTS
V41P1100C	0	200	0	0
V41T1101C	-430	-405	-423	286
V41R1115A	0	20000	11183	572
V41P1130C	0	300	0	0
V41T1131C	-305	-255	-290	307
V41P1150C	0	5000	4198	859
V41P1154C	0	1000	752	769
V41P1200C	0	200	0	0
V41T1201C	-430	-405	-419	450
V41R1215A	0	20000	11202	573
V41P1230C	0	300	0	0
V41T1231C	-305	-255	-286	389
V41P1250C	0	5000	3998	818
V41P1254C	0	1000	754	771
V41P1300C	0	200	0	0
V41T1301C	-430	-405	-413	696
V41R1315A	0	20000	11222	574
V41P1330C	0	300	0	0
V41T1331C	-305	-255	-279	532
V41P1350C	0	5000	4101	839
V41P1354C	0	1000	756	773
V41T1428A	-430	-405	-428	82
V41P1433C	0	100	55	563
V41T1528A	-305	-255	-298	143
V41P1533C	0	300	155	529
V41P1600A	0	5000	4052	829
V41P1605A	0	1000	758	775

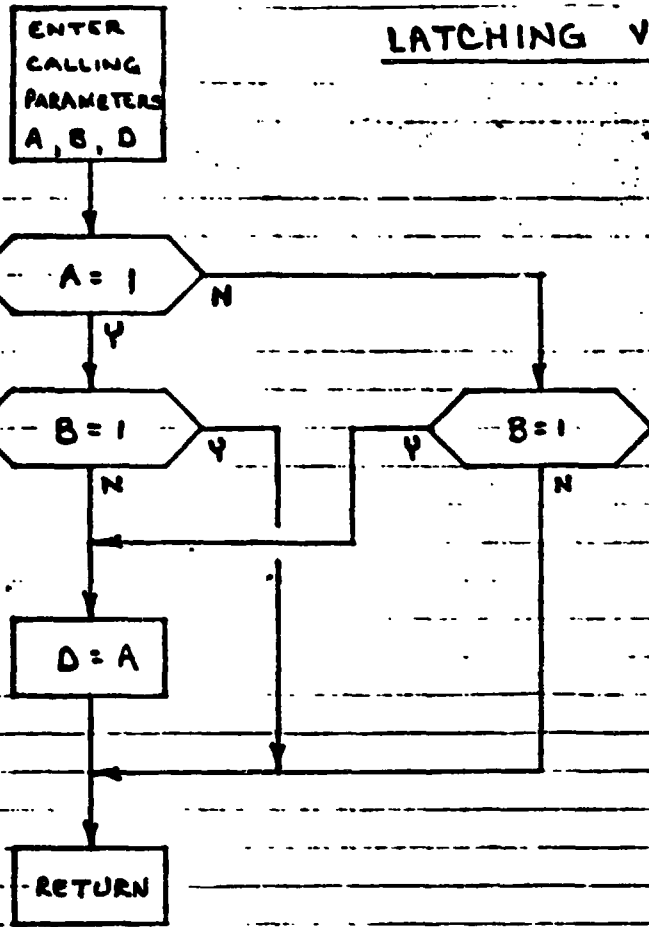
3.0 LOGIC FLOW DIAGRAMS

The logic flow diagram is made up of interconnected lines, boxes, decisions, and offpage connectors. Notice that where analog measurements are listed in boxes and decisions, the value inside the box is in flight system engineering units (FS_{EU}) while the corresponding GSIU count value is listed outside the box. For example, the box on the right hand below,

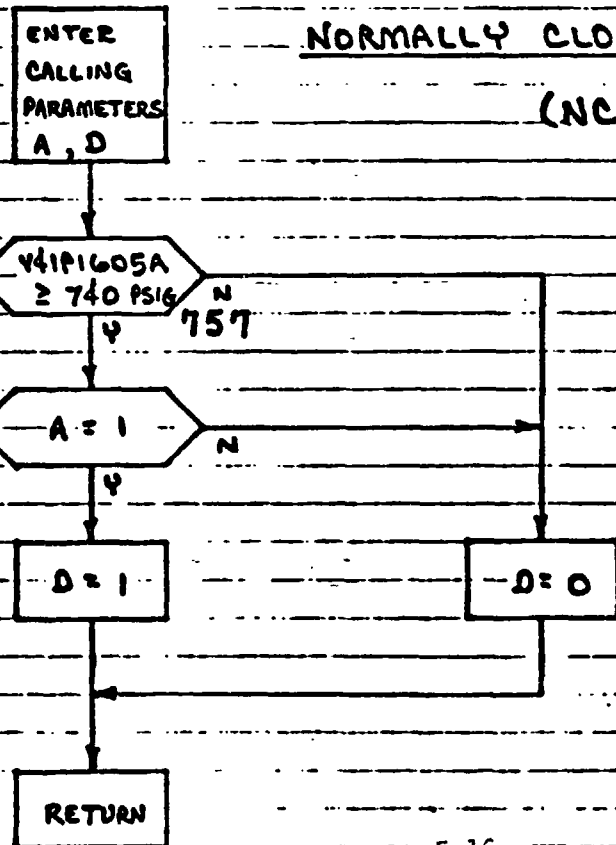


shows that V45P1100A is set equal to 626 FS_{EU} which is equivalent to 534 $GSIU_{CTS}$ shown outside the box.

LATCHING VALVE ROUTINE (LVR)



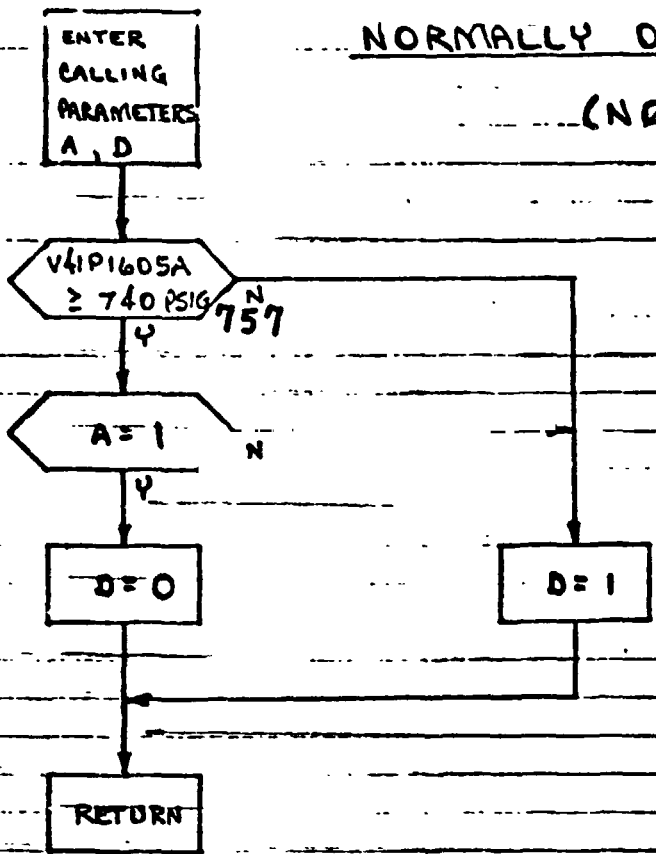
NORMALLY CLOSED VALVE ROUTINE (NCVR)



ORIGINAL PAGE IS
OF POOR QUALITY

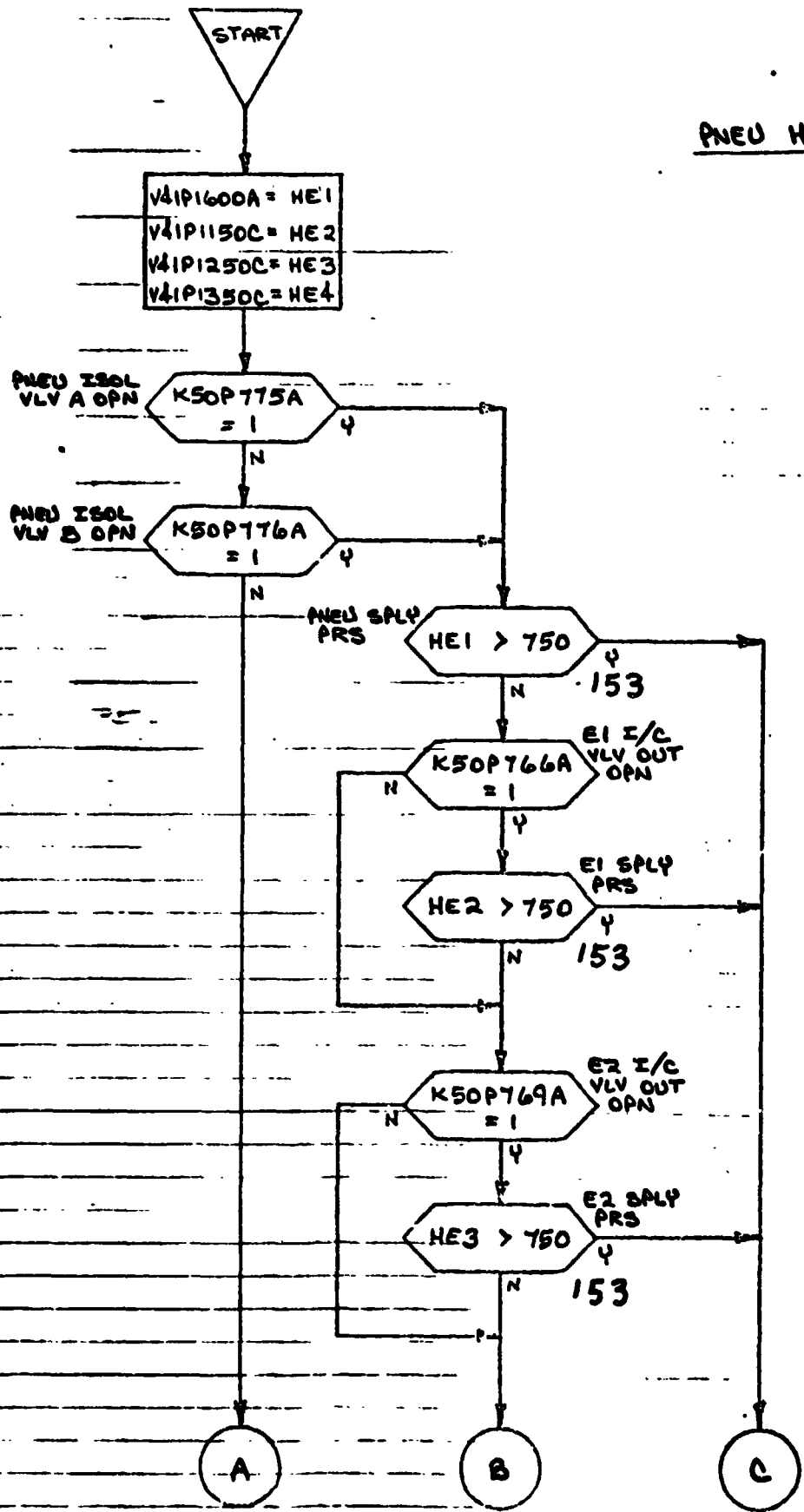
NORMALLY OPEN VALVE ROUTINE

(NOVR)

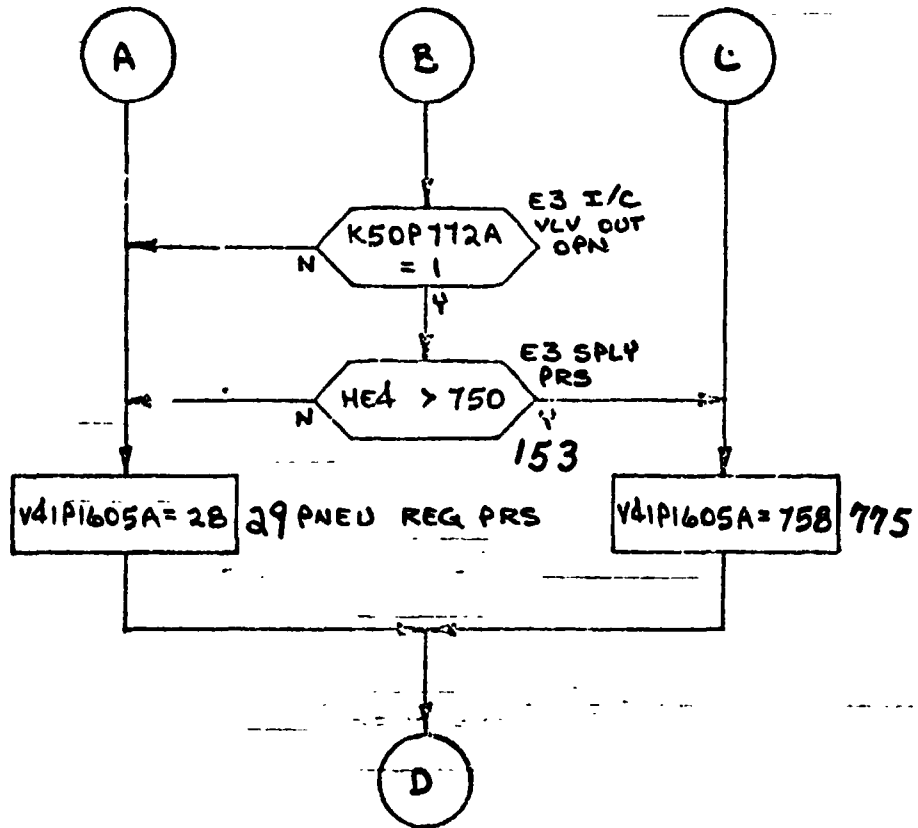


RETURN

PNEU HE PRESS

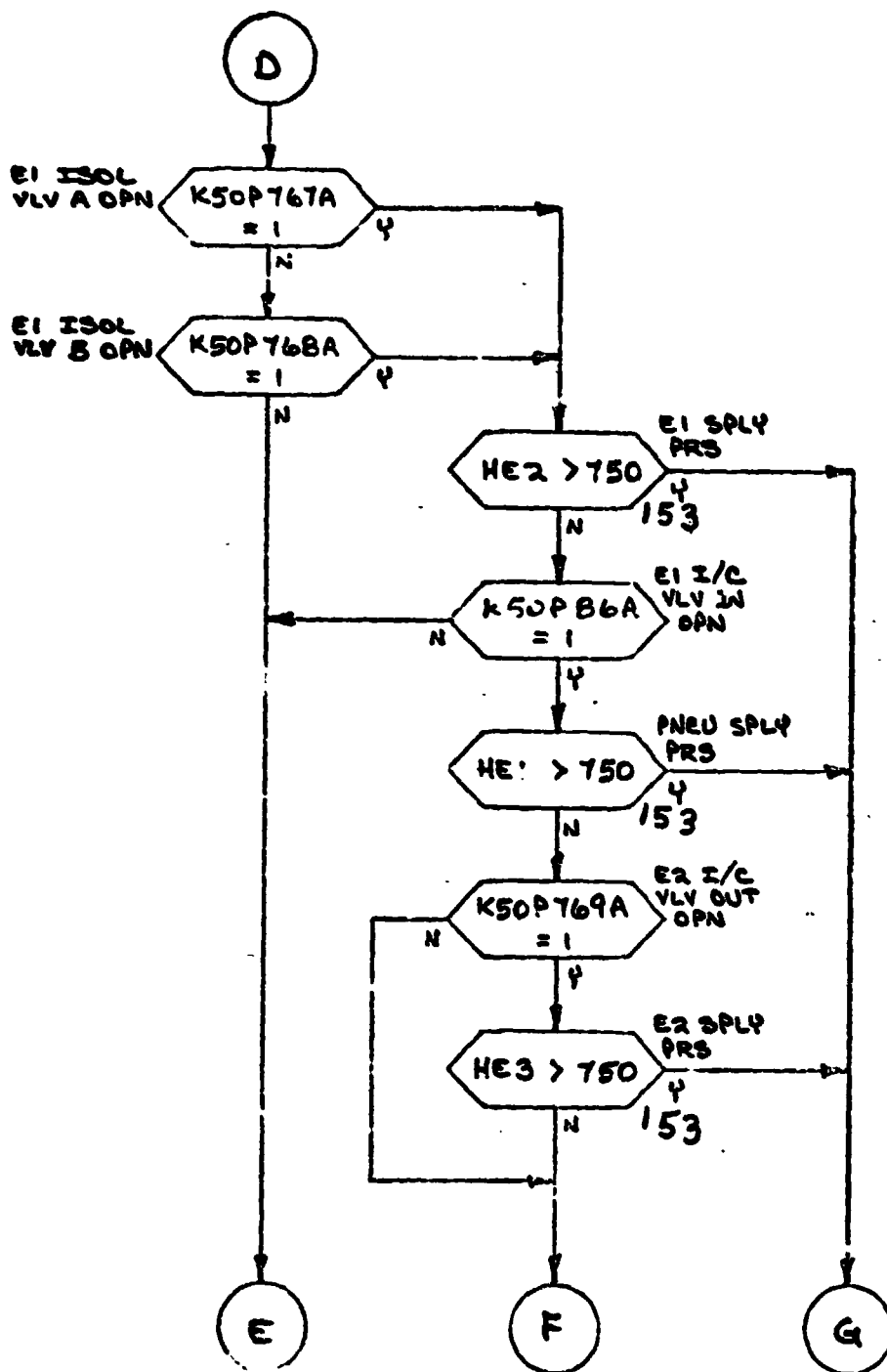


PNEU HE PRESS

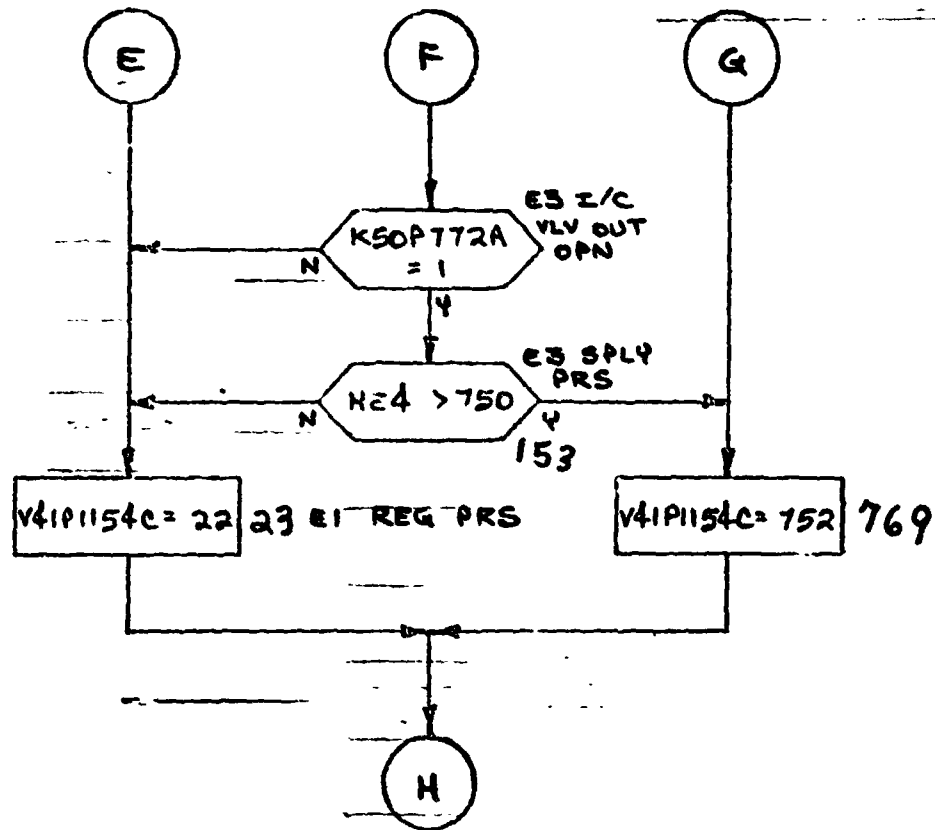


ORIGINAL PAGE IS
OF POOR QUALITY

E1 HE PRESS

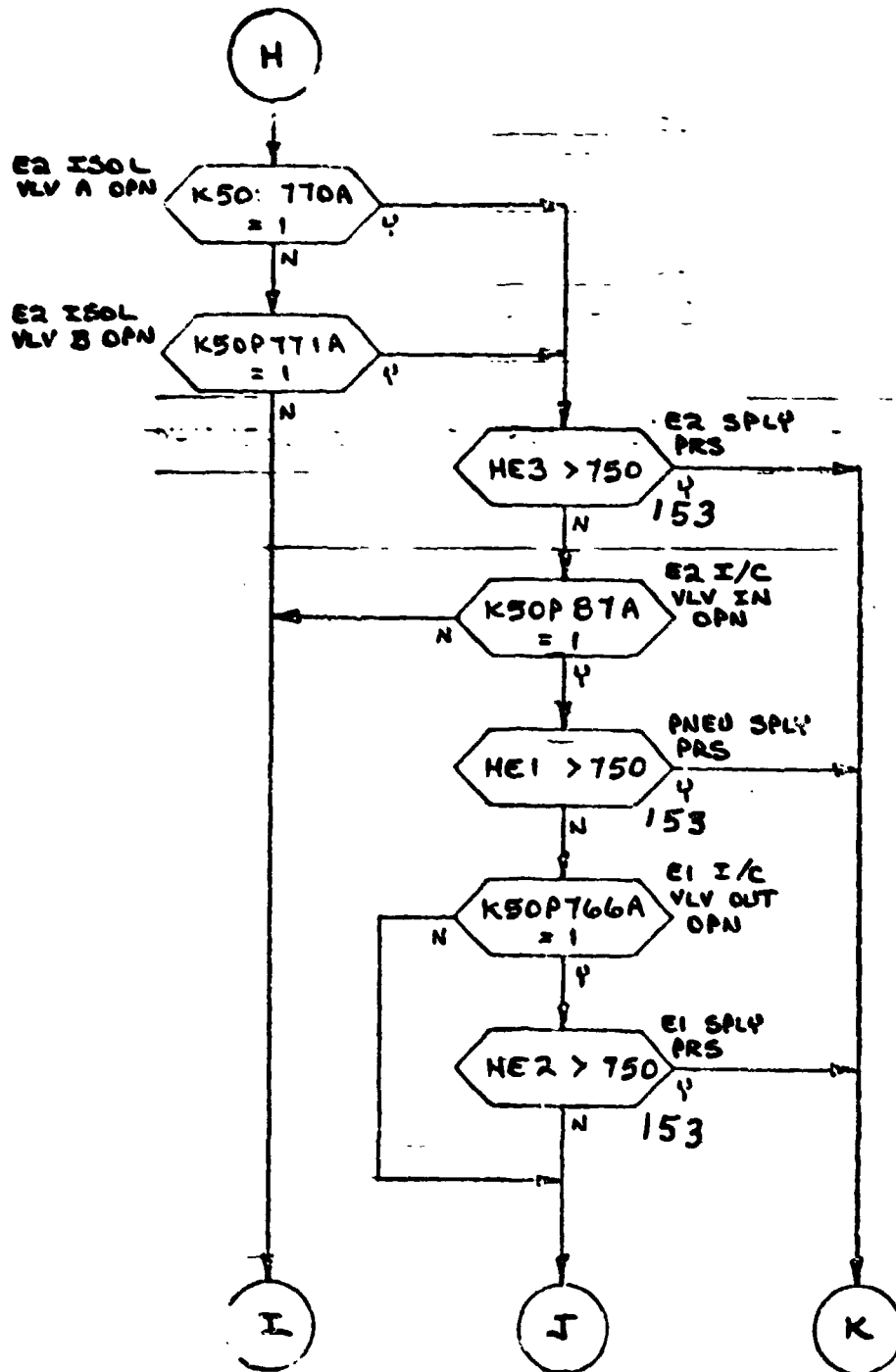


EI HE PRESS

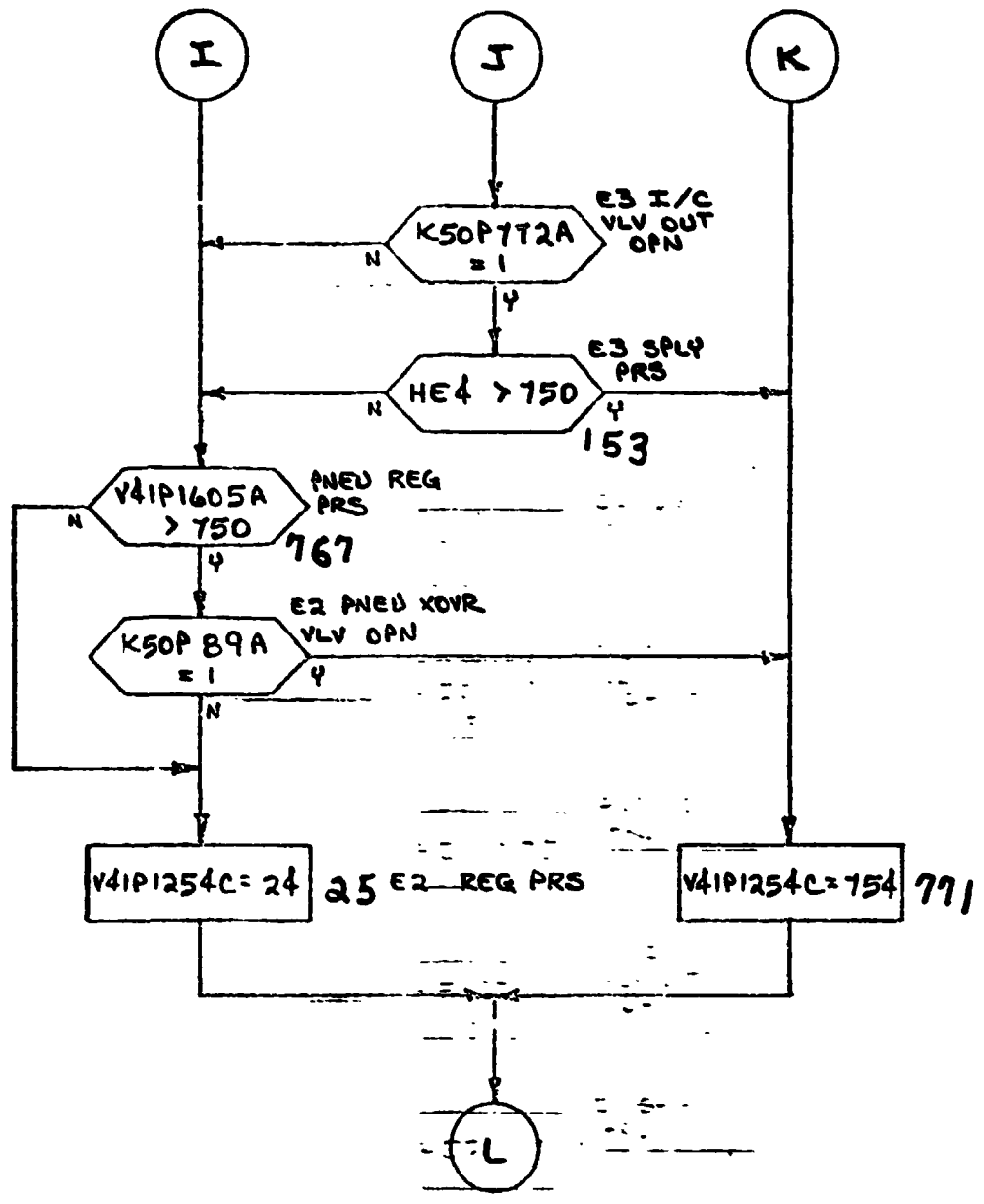


(M) 16

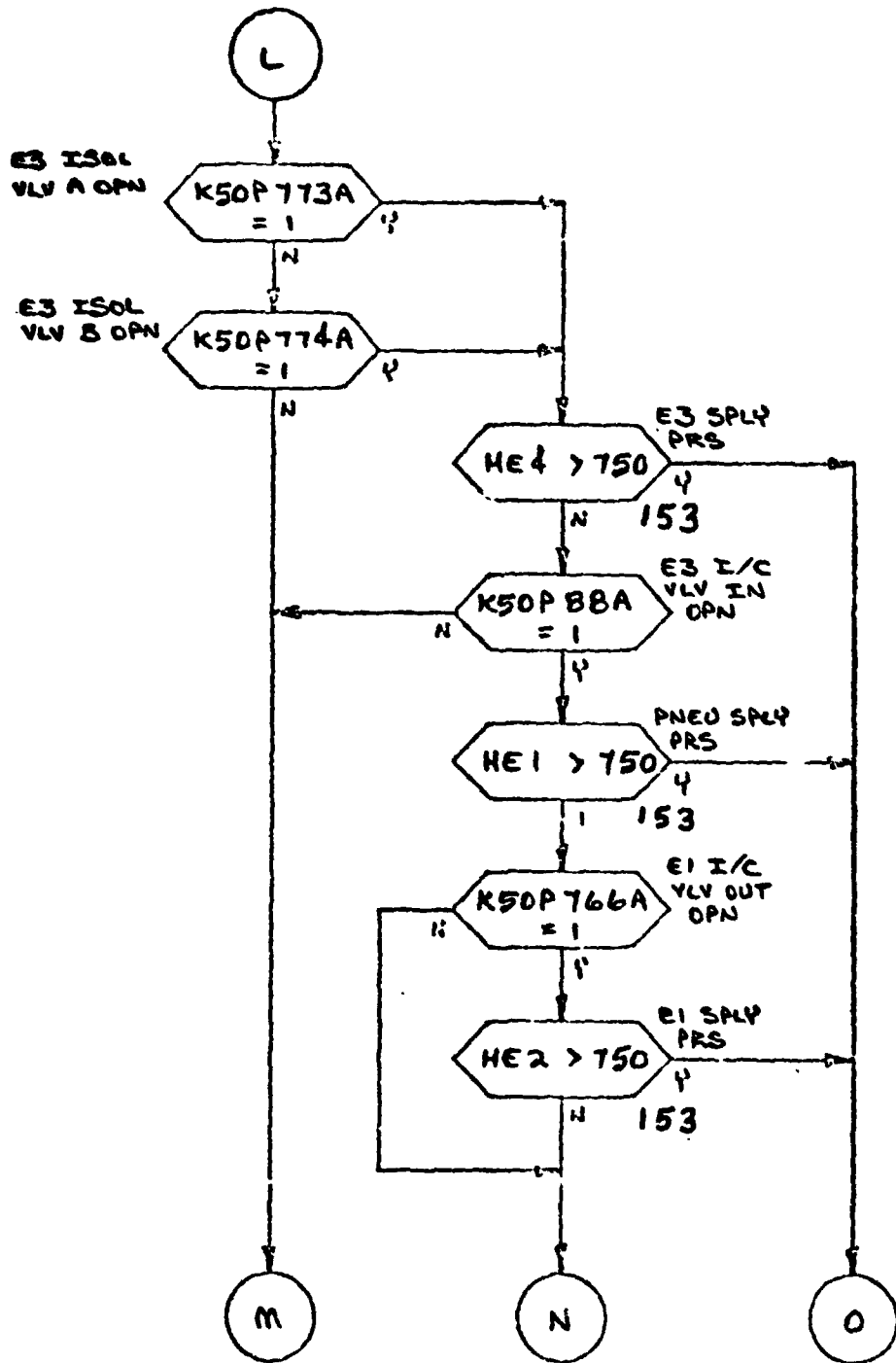
E2 HE PRESS



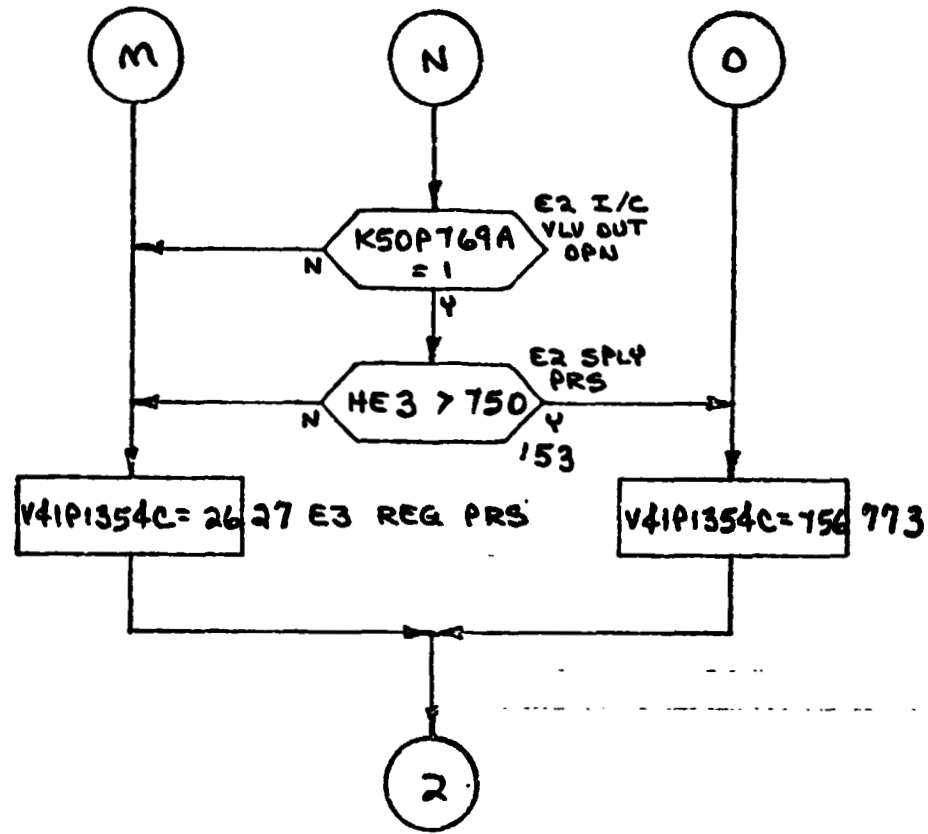
E2 HE PRESS

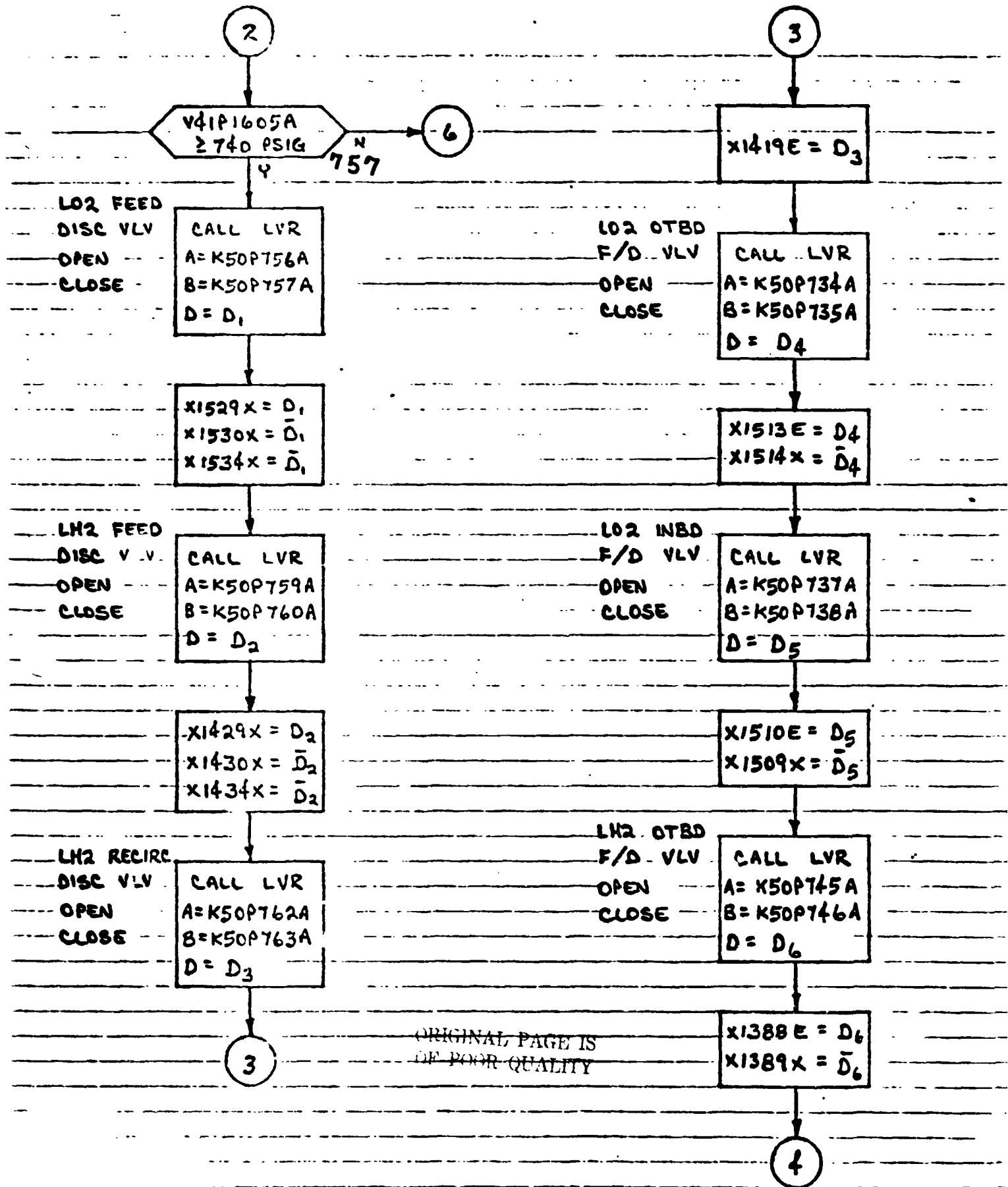


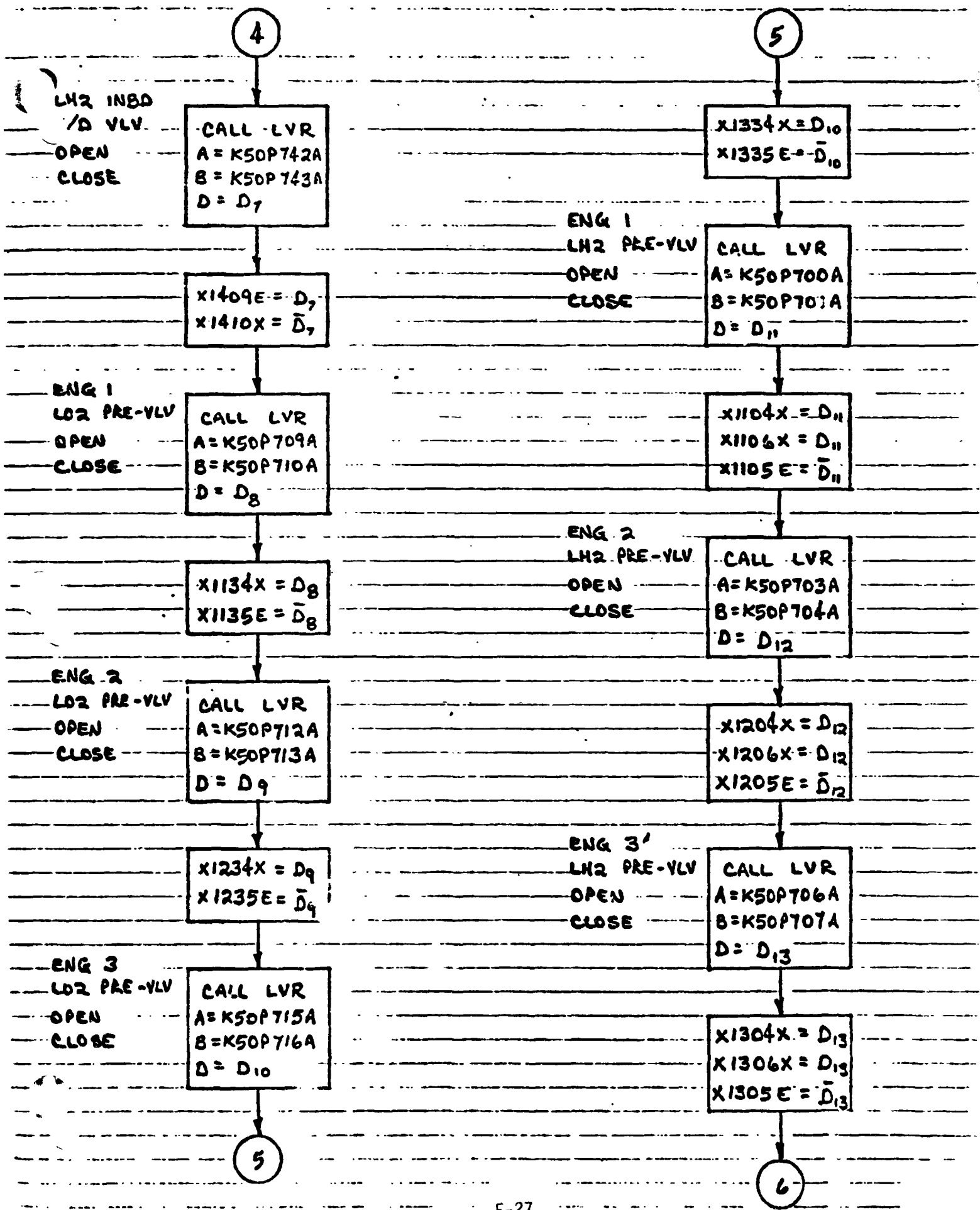
E3 HE PRESS

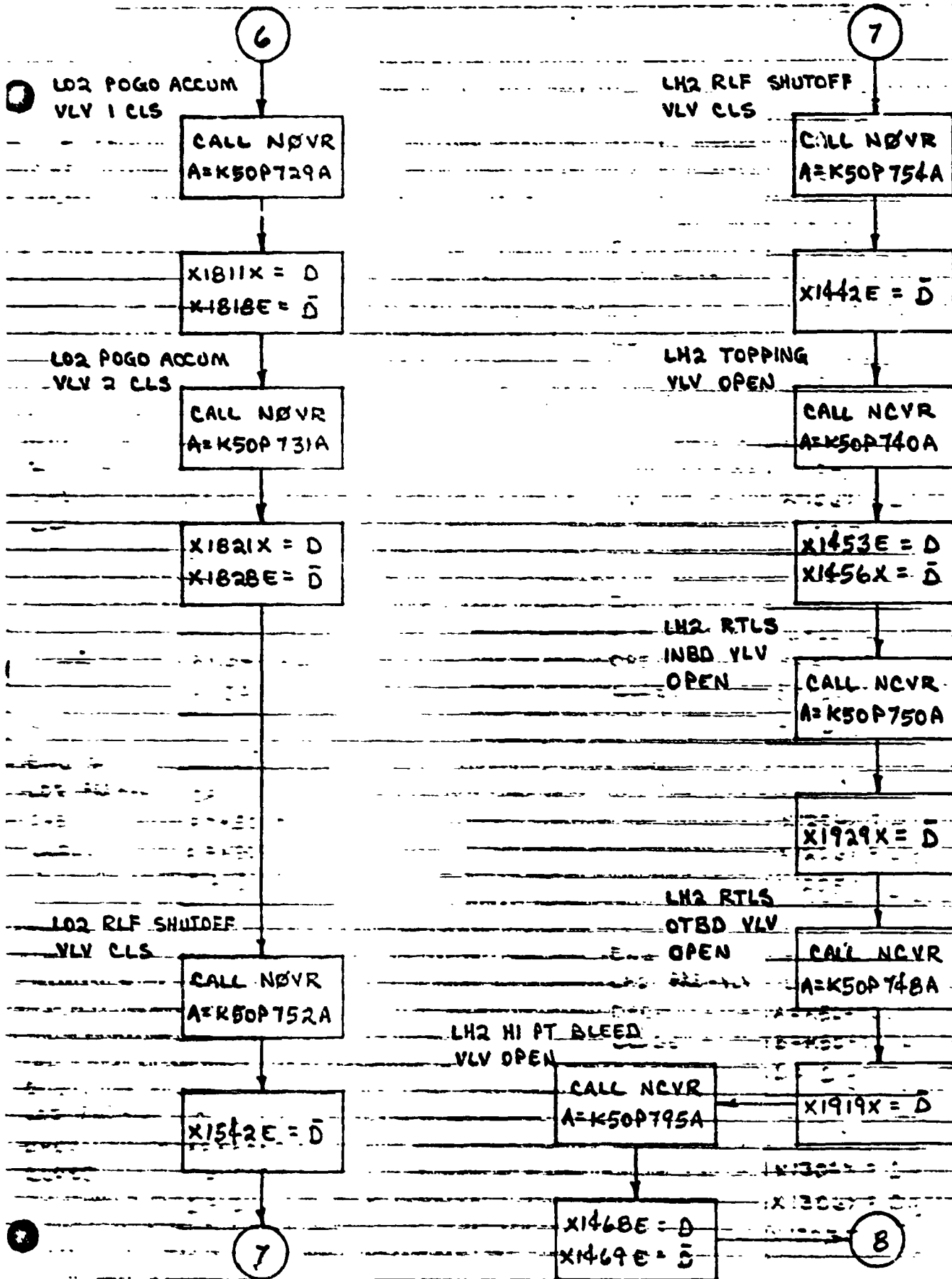


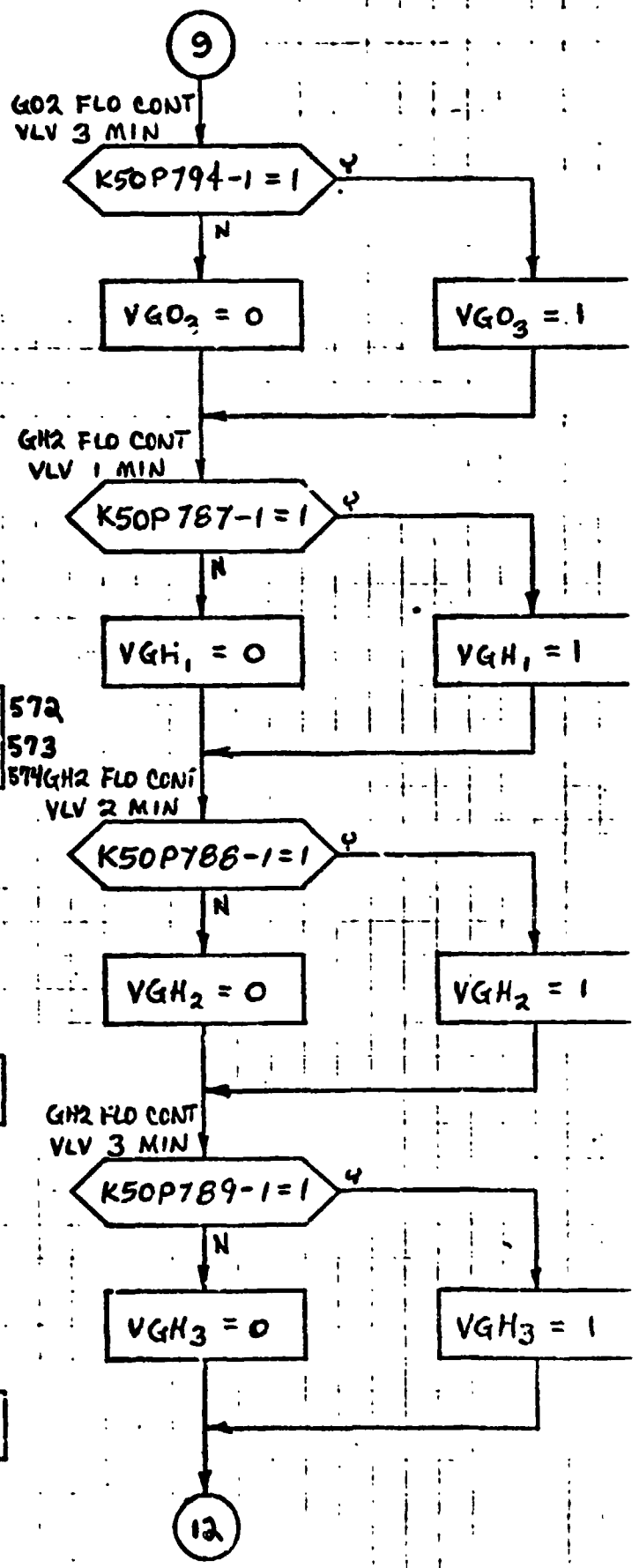
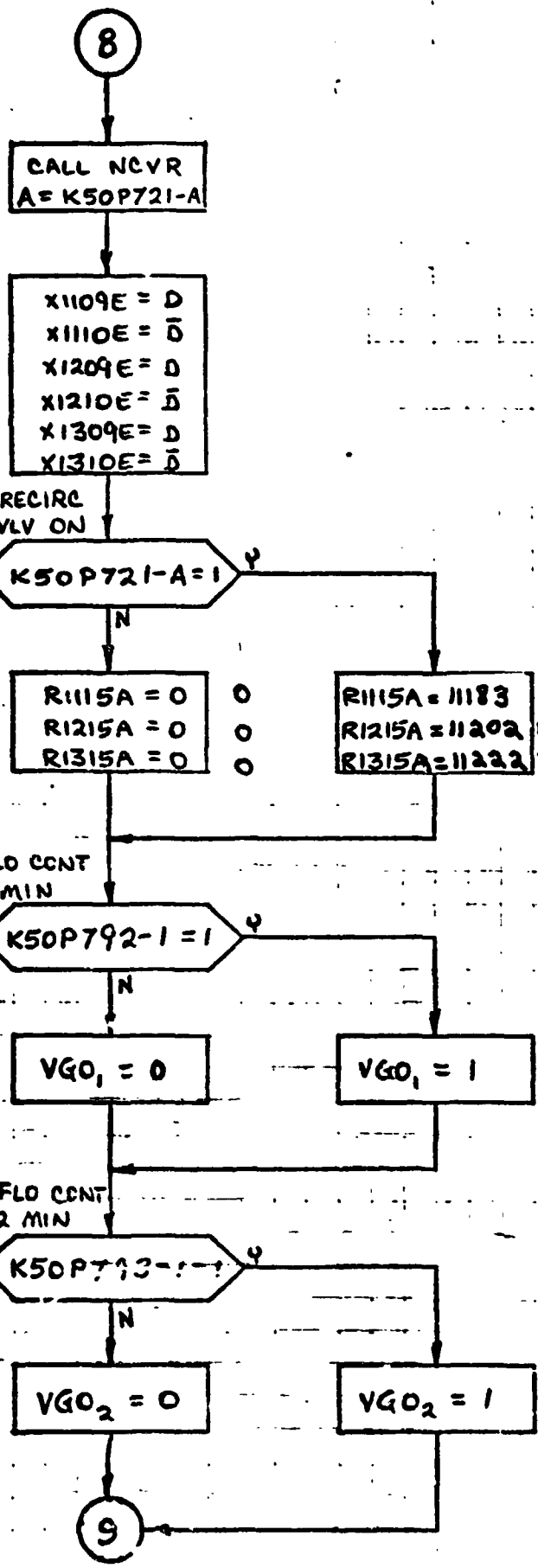
E3 HE PRESS



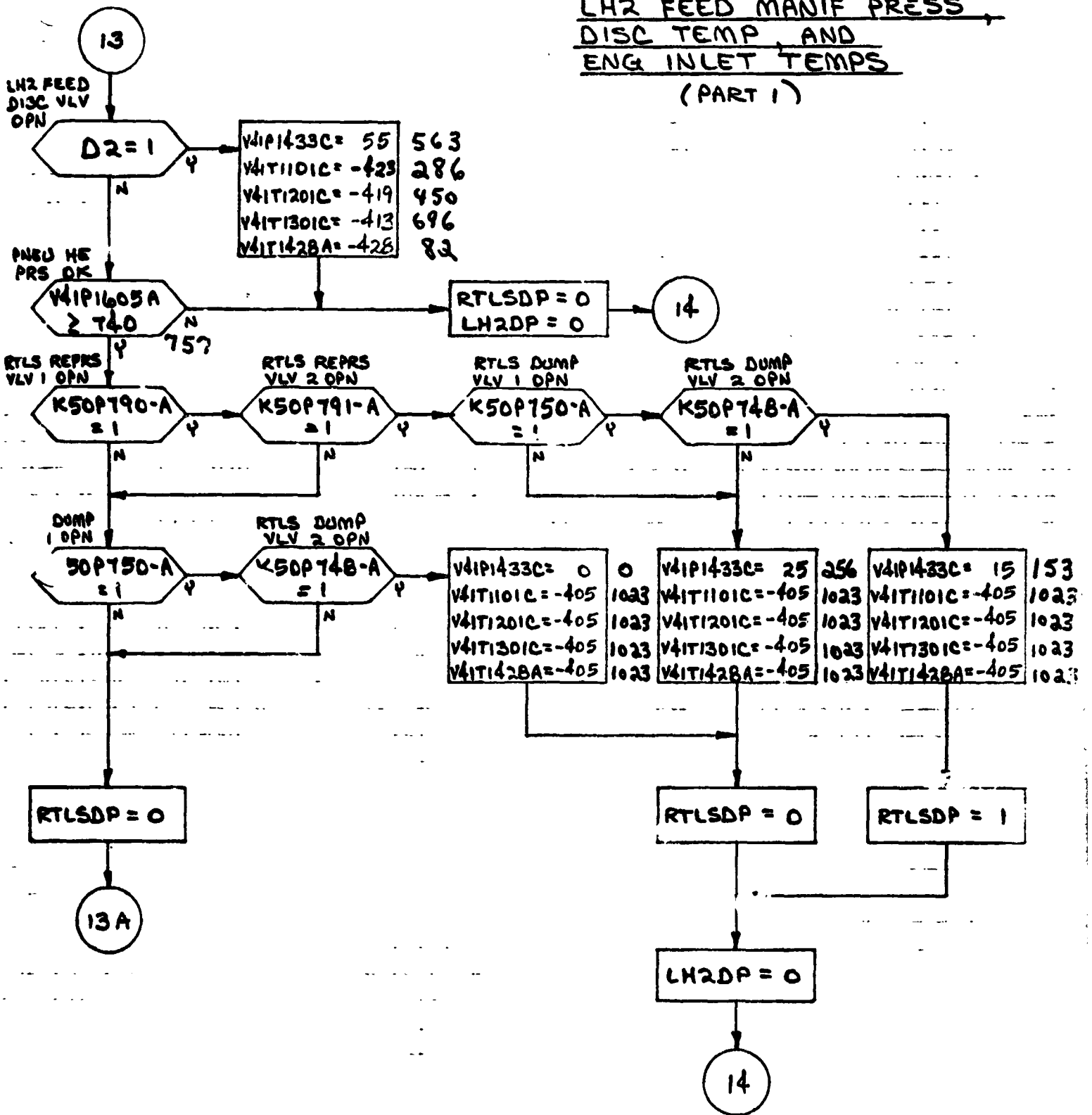




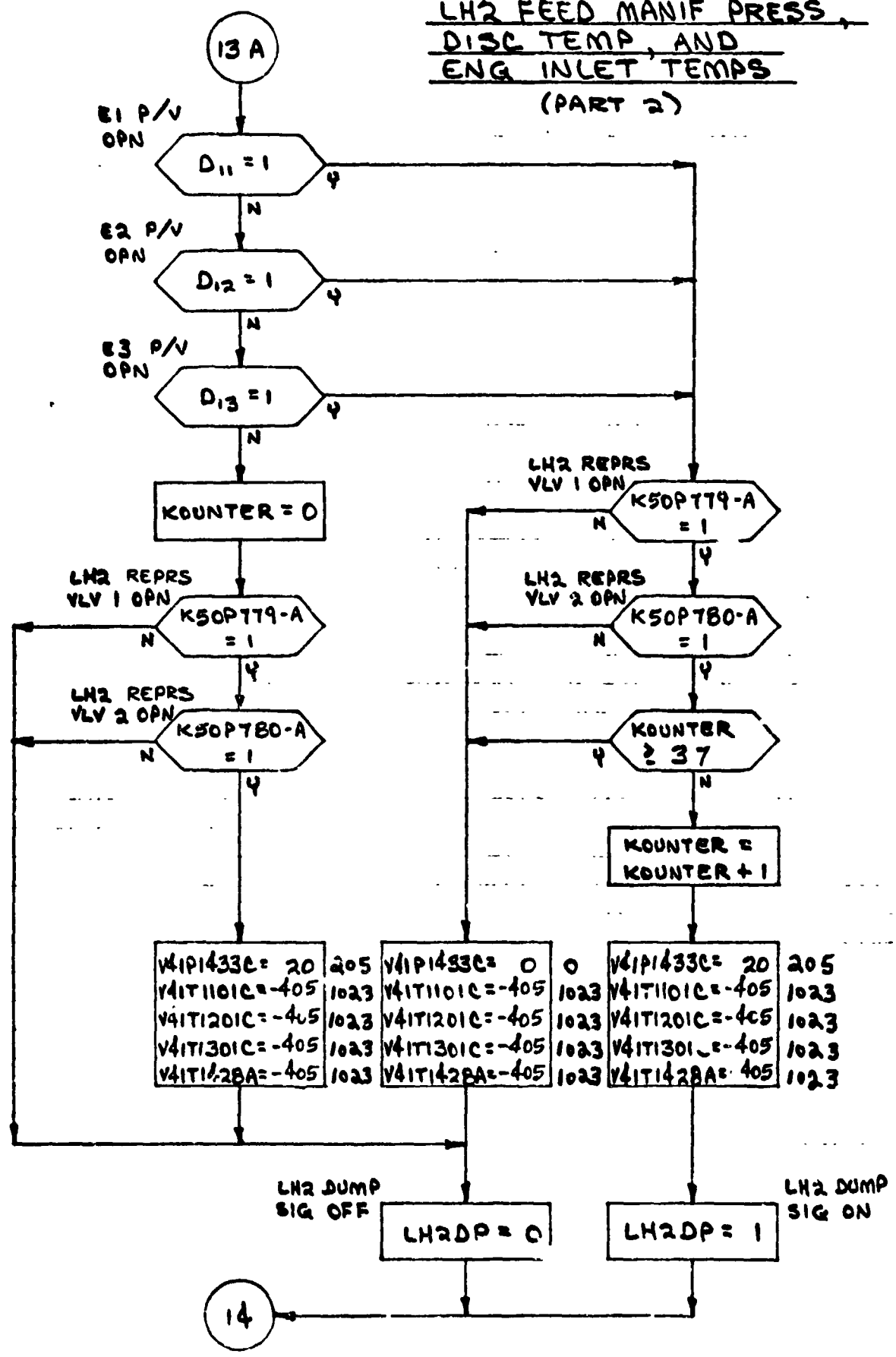




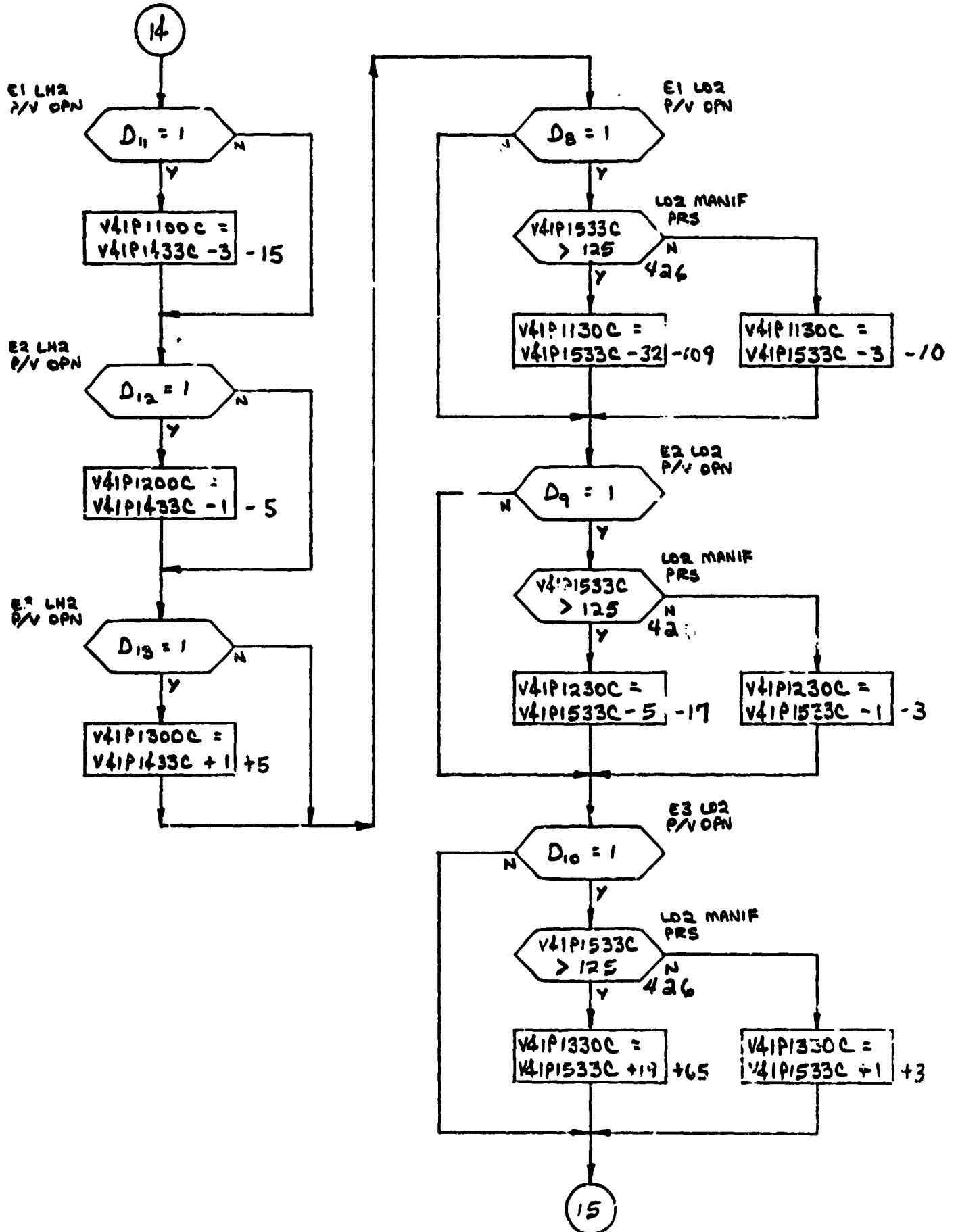
LH2 FEED MANIF PRESS
DISC TEMP AND
ENG INLET TEMPS
(PART 1)



LH2 FEED MANIF PRESS,
DISC TEMP, AND
ENG INLET TEMPS
(PART 2)

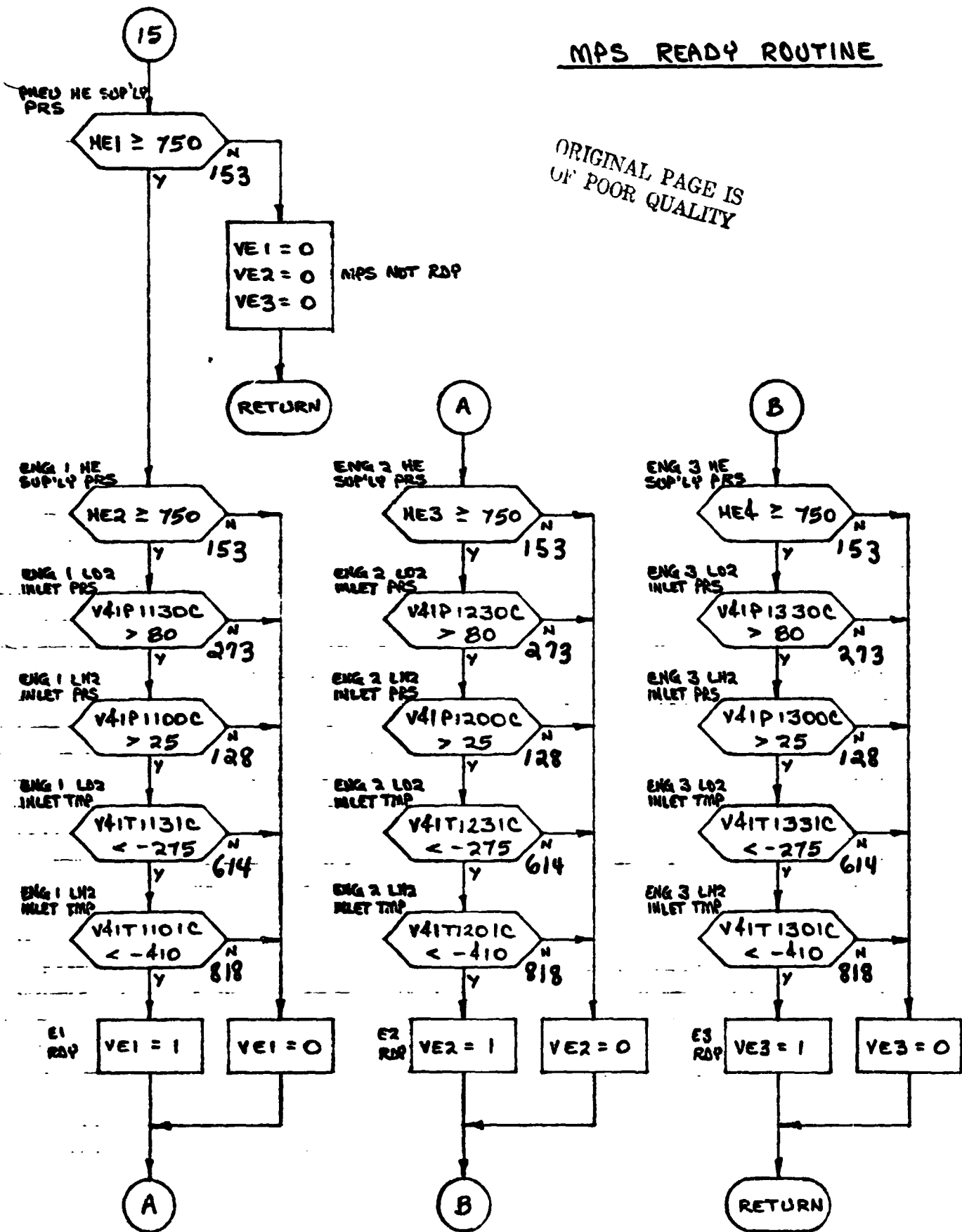


ENGINE INLET PRESSURES



MPS READY ROUTINE

ORIGINAL PAGE IS
OF POOR QUALITY



4.0 INPUT STIMULI/OUTPUT MEASUREMENT TABLES

PRECEDING PAGE BLANK NOT FILMED

4.1 STS INPUT TABLE

STIMULI INPUT TO '1' ODEL - TABLE 4.1

IDENTIFICATION NUMBER	NOMENCLATURE (V41K)	SOURCE	STATES/RANGE		UNITS
			LO	HI	
K50P700-A	ENG 1 LH2 PRE-VLV OPEN	FS	0	1	STATE
K50P701-A	ENG 1 LH2 PRE-VLV CLOSE		0	1	STATE
K50P703-A	ENG 2 LH2 PRE-VLV OPEN		0	1	STATE
K50P704-A	ENG 2 LH2 PRE-VLV CLOSE		0	1	STATE
K50P706-A	ENG 3 LH2 PRE-VLV OPEN		0	1	STATE
K50P707-A	ENG 3 LH2 PRE-VLV CLOSE		0	1	STATE
K50P709-A	ENG 1 LO2 PRE-VLV OPEN		0	1	STATE
K50P710-A	ENG 1 LO2 PRE-VLV CLOSE		0	1	STATE
K50P712-A	ENG 2 LO2 PRE-VLV OPEN		0	1	STATE
K50P713-A	ENG 2 LO2 PRE-VLV CLOSE		0	1	STATE
K50P715-A	ENG 3 LO2 PRE-VLV OPEN		0	1	STATE
K50P716-A	ENG 3 LO2 PRE-VLV CLOSE		0	1	STATE
K50P721-A	LH2 RECIRC PUMP VLV OPEN		0	1	STATE
K50P729-A	LO2 POGO ACCUM VLV 1 CLOSE		0	1	STATE
K50P731-A	LO2 POGO ACCUM VLV 2 CLOSE		0	1	STATE
K50P733-A	LO2 OVBD BLEED VLV CLOSE		0	1	STATE
K50P734-A	LO2 OTBD FILL VLV OPEN		0	1	STATE
K50P735-A	LO2 OTBD FILL VLV CLOSE		0	1	STATE
K50P737-A	LO2 INBD FILL VLV OPEN		0	1	STATE
K50P738-A	LO2 INBD FILL VLV CLOSE		0	1	STATE
K50P740-A	LH2 TOPPING VLV OPEN		0	1	STATE
K50P742-A	LH2 INBD FILL VLV OPEN		0	1	STATE
K50P743-A	LH2 INBD FILL VLV CLOSE		0	1	STATE
K50P745-A	LH2 OTBD FILL VLV OPEN		0	1	STATE
K50P746-A	LH2 OTBD FILL VLV CLOSE		0	1	STATE
K50P748-A	LH2 FEED RTLS OTBD VLV OPEN		0	1	STATE
K50P750-A	LH2 FEED RTLS INBD VLV OPEN	0	1	STATE	
K50P752-A	LO2 RELIEF SHUT-OFF VLV CLOSE	0	1	STATE	
K50P754-A	LH2 RELIEF SHUT-OFF VLV CLOSE	0	1	STATE	
K50P756-A	LO2 FEED DISC VLV OPEN	0	1	STATE	
K50P757-A	LO2 FEED DISC VLV CLOSE	0	1	STATE	
K50P759-A	LH2 FEED DISC VLV OPEN	0	1	STATE	
K50P760-A	LH2 FEED DISC VLV CLOSE	0	1	STATE	

ORIGINAL PAGE IS OF POOR QUALITY

STIMULI INPUT TO S MODEL - TABLE 4.1

IDENTIFICATION NUMBER	NOMENCLATURE (V41K)	SOURCE	STATES/RANGE			UNITS
			LO	HI		
K50P762-A	LH2 RECIRC DISC VLV OPEN (1421X)	FS	0	1	STATE	
K50P763-A	LH2 RECIRC DISC VLV CLOSE (1422X)					
K50P766-A	ENG 1 HE INTERCONNECT "OUT" VLV OPEN (1168X)					
K50P767-A	ENG 1 HE SUPPLY ISOL VLV 1 OPEN (1155X)					
K50P768-A	ENG 1 HE SUPPLY ISOL VLV 2 OPEN (1156X)					
K50P769-A	ENG 2 HE INTERCONNECT "OUT" VLV OPEN (1268X)					
K50P770-A	ENG 2 HE SUPPLY ISOL VLV 1 OPEN (1255X)					
K50P771-A	ENG 2 HE SUPPLY ISOL VLV 2 OPEN (1256X)					
K50P772-A	ENG 3 HE INTERCONNECT "OUT" VLV OPEN (1368X)					
K50P773-A	ENG 3 HE SUPPLY ISOL VLV 1 OPEN (1355X)					
K50P774-A	ENG 3 HE SUPPLY ISOL VLV 2 OPEN (1356X)					
K50P775-A	PNEU HE SUPPLY ISOL VLV 1 OPEN (1607X)					
K50P776-A	PNEU HE SUPPLY ISOL VLV 2 OPEN (1608X)					
K50P779-A	LH2 MANIFOLD REPRESS VLV 1 OPEN (1435X)					
K50P780-A	LH2 MANIFOLD REPRESS VLV 2 OPEN (1437X)					
K50P781-A	LO2 MANIFOLD REPRESS VLV 1 OPEN (1535X)					
K50P782-A	LO2 MANIFOLD REPRESS VLV 2 OPEN (1537X)					
K50P787-1	GN2 FLOW CONTROL VLV - ENG 1					
K50P788-1	GH2 FLOW CONTROL VLV - ENG 2					
K50P789-1	GH2 FLOW CONTROL VLV - ENG 3					
K50P790-A	RTLS REPRESS VLV 1 OPEN (1907X)					
K50P791-A	RTLS REPRESS VLV 2 OPEN (1908X)					
K50P792-1	GO2 FLOW CONTROL VLV - ENG 1					
K50P793-1	GO2 FLOW CONTROL VLV - ENG 2					
K50P794-1	GO2 FLOW CONTROL VLV - ENG 3					
K50P795-A	LH2 HI POINT BLEED VLV OPEN (1465E)					
HE1	PNEU HE SUPPLY PRESS	FS				
HE2	ENG 1 HE SUPPLY PRESS	OPR	5000	5000	PSIA	
HE3	ENG 2 HE SUPPLY PRESS					
HE4	ENG 3 HE SUPPLY PRESS	OPR	5000	5000	PSIA	

STIMULI INPUT TO S...ODEL - TABLE 4.1

IDENTIFICATION NUMBER	NOMENCLATURE (V41K)	SOURCE	STATES/RANGE		
			LO	HI	UNITS
K50P86-A K50P87-A K50P88-A K50P89-A	E1 HE INTERCONNECT "IN" VLV OPN E2 HE INTERCONNECT "IN" VLV OPN E3 HE INTERCONNECT "IN" VLV OPN E2 HE PNEU XOVR VLV OPN	FLT SYS ↓	0 ↓	1 ↓	STATE ↓

4.2 OUTPUT MEASUREMENT LIST

Table 2 lists all model outputs along with the initial condition value for the output. Measurement I.D. and Measurement Name precede pairs of numeric columns. The first of each pair is labeled FS indicating flight system engineering units. The second of each pair is labeled CTS indicating the GSIU count value corresponding to the FS value. I.C. indicates initial condition values. VALUE 1 typically indicates nominal values. VALUE 2 and VALUE 3 columns indicate off nominal conditions.

MEASUREMENT OUTPUT FROM MPS MODEL - TABLE 2

MEASUREMENT I. D.	MEASUREMENT NAME	I. C.		VALUE 1		VALUE 2		VALUE 3		UNITS
		FS	CTS	FS	CTS	FS	CTS	FS	CTS	
*V41P1100C	ENG 1 LH2 INLET PRESS	0	0	12 52	61 266	17	87	22	113	PSIA
*V41T1101C	ENG 1 LH2 INLET TEMP	-423	286	-405	1023					DEGF
V41X1104X	ENG 1 LH2 PRE-VLV OPEN - A	1	1	0	0					STATE
V41X1105E	ENG 1 LH2 PRE-VLV CLOSED	0	0	1	1					STATE
V41X1106X	ENG 1 LH2 PRE-VLV OPEN - B	1	1	0	0					STATE
V41X1109E	ENG 1 LH2 RECIRC VLV OPEN	1	1	0	0					STATE
V41X1110E	ENG 1 LH2 RECIRC VLV CLOSED	0	0	1	1					STATE
*V41R1115A	ENG 1 L RECIRC PUMP SPEED	11183	572	0	0					RPM
*V41P1130C	ENG 1 L02 INLET PRESS	0	0	17	58	123	419	152	518	PSIA
*V41T1131C	ENG 1 L02 INLET TEMP	-290	307	-255	1023					DEGF
V41X1134X	ENG 1 L02 PRE-VLV OPEN	1	1	0	0					STATE
V41X1135E	ENG 1 L02 PRE-VLV CLOSED	0	0	1	1					STATE
*V41P1150C	ENG 1 HE SUPPLY PRESS	4198	859							PSIA
*V41P1154C	ENG 1 HE REG OUT PRESS	752	769	22	23					PSIG
*V41P1200C	ENG 2 LH2 INLET PRESS	0	0	14 54	72 276	19	97	24	123	PSIA
*V41T1201C	ENG 2 LH2 INLET TEMP	-419	450	-405	1023					DEGF
V41X1204X	ENG 2 LH2 PRE-VLV OPEN - A	1	1	0	0					STATE
V41X1205E	ENG 2 LH2 PRE-VLV CLOSED	0	0	1	1					STATE
V41X1206X	ENG 2 LH2 PRE-VLV OPEN - B	1	1	0	0					STATE
V41X1209E	ENG 2 LH2 RECIRC VLV OPEN	1	1	0	0					STATE
V41X1210E	ENG 2 LH2 RECIRC VLV CLOSED	0	0	1	1					STATE

*NOTE: This measurement uses the range limit conversion method of calculating FS_{EU} from GSIU_{CTS} as discussed in Section 2.6.2.

MEASUREMENT OUTPUT FROM MPS MODEL - TABLE 2

MEASUREMENT I. D	MEASUREMENT NAME	I. C.		VALUE 1		VALUE 2		VALUE 3		UNITS
		FS	CTS	FS	CTS	FS	CTS	FS	CTS	
*V41R1215A	ENG 2 LH2 RECIRC VLV PUMP SPEED	11202	573	0	0					RPM
*V41P1230C	ENG 2 L02 INLET PRESS	0	0	15 154	51 525	19	65	150	512	PSIA
*V41T1231C	ENG 2 L02 INLET TEMP	-286	389	-255	1023					DEGF
V41X1234X	ENG 2 L02 PRE-VLV OPEN	1	1	0	0					STATE
V41X1235E	ENG 2 L02 PRE-VLV CLOSED	0	0	1	1					STATE
*V41P1250C	ENG 2 HE SUPPLY PRESS	3998	818							PSIA
*V41P1254C	ENG 2 HE REG OUT PRESS	754	771	24	25					PSIG
*V41P1300C	ENG 3 LH2 INLET PRESS	0	0	1 26	5 133	16 56	82 286	21	107	PSIA
*V41T1301C	ENG 3 LH2 INLET TEMP	-413	696	-405	1023					DEGF
V41X1304X	ENG 3 LH2 PRE-VLV OPEN - A	1	1	0	0					STATE
V41X1305E	ENG 3 LH2 PRE-VLV CLOSED	0	0	1	1					STATE
V41X1306X	ENG 3 LH2 PRE-VLV OPEN - B	1	1	0	0					STATE
V41X1309E	ENG 3 LH2 RECIRC VLV OPEN	1	1	0	0					STATE
V41X1310E	ENG 3 LH2 RECIRC VLV CLOSED	0	0	1	1					STATE
*V41R1315A	ENG 3 LH2 RECIRC PUMP SPEED	11222	574	0	0					RPM
*V41P1330C	ENG 3 L02 INLET PRESS	0	0	1 39	3 133	19 156	65 532	21 174	72 593	PSIA
*V41T1331C	ENG 3 L02 INLET TEMP	-279	532	-255	1023					DEGF
V41X1334X	ENG 3 L02 PRE-VLV OPEN	1	1	0	0					STATE
V41X1335E	ENG 3 L02 PRE-VLV CLOSED	0	0	1	1					STATE

ORIGINAL PAGE IS
OF POOR QUALITY

*NOTE: This measurement uses the range limit conversion method of calculating FS_{EU} from GSIU_{CTS} as discussed in section 2.6.2.

MEASUREMENT OUTPUT FROM MPS MODEL - TABLE 2

MEASUREMENT I. D.	MEASUREMENT NAME	I. C.		VALUE 1		VALUE 2		VALUE 3		UNITS
		FS	CTS	FS	CTS	FS	CTS	FS	CTS	
*V41P1350C	ENG 3 HE SUPPLY PRESS	4101	839							PSIA
*V41P1354C	ENG 3 HE REG OUT PRESS	756	773	26	27					PSIG
V41X1388E	LH2 OTBD FILL VLV OPEN	0	0	1	1					STATE
V41X1389X	LH2 OTBD FILL VLV CLOSED	1	1	0	0					STATE
V41X1409E	LH2 INBD FILL VLV OPEN	0	0	1	1					STATE
V41X1410X	LH2 INBD FILL VLV CLOSED	1	1	0	0					STATE
V41X1419E	LH2 RECIRC DISC VLV OPEN	1	1	0	0					STATE
*V41T1428A	LH2 FEED MANIFOLD DISC TEMP	-428	82	-405	1023					DEGF
V41X1429X	LH2 FEED DISC VLV OPEN	1	1	0	0					STATE
V41X1430X	LH2 FEED DISC VLV CLOSED - A	0	0	1	1					STATE
*V41P1433C	LH2 ENG MANIFOLD PRESS	55	563	15	153	20	205	25	256	PSIA
V41X1434X	LH2 FEED DISC VLV CLOSED - B	0	0	1	1					STATE
V41X1442E	LH2 FEED LINE RLF SHUT-OFF VLV CLOSED	0	0	1	1					STATE
V41X1453E	LH2 TOPPING VLV OPEN	1	1	0	0					STATE
V41X1456X	LH2 TOPPING VLV CLOSED	0	0	1	1					STATE
V41X1468E	LH2 HI POINT BLEED VLV OPEN	1	1	0	0					STATE
V41X1469E	LH2 HI POINT BLEED VLV CLOSED	0	0	1	1					STATE
V41X1509X	L02 INBD FILL VLV CLOSED	1	1	0	0					STATE
V41X1510E	L02 INBD FILL VLV OPEN	0	0	1	1					STATE
V41X1513E	L02 OTBD FILL VLV OPEN	0	0	1	1					STATE
V41X1514X	L02 OTBD FILL VLV CLOSED	1	1	0	0					STATE
*V41T1528A	L02 FEED MANIFOLD DISC TEMP	-298	143	-255	1023					DEGF

*NOTE: This measurement uses the range limit conversion method of calculating FS_{EU} from GSIU_{CTS} as discussed in section 2.6.2.

MEASUREMENT OUTPUT FROM MPS MODEL - TABLE 2

MEASUREMENT I. D.	MEASUREMENT NAME	I. C.		VALUE 1		VALUE 2		VALUE 3		UNITS
		FS	CTS	FS	CTS	FS	CTS	FS	CTS	
V41X1529X	L02 FEED DISC VLV OPEN	1	1	0	0					STATE
V41X1530X	L02 FEED DISC VLV CLOSED - A	0	0	1	1					STATE
*V41P1533C	L02 ENG MANIFOLD PRESS	155	529	20	68	0	0			PSIA
V41X1534X	L02 FEED DISC VLV CLOSED - B	0	0	1	1					STATE
V41X1542E	L02 FEED LINE RLF SHUT-OFF VLV CLOSED	0	0	1	1					STATE
V41X1580X	L02 OVBD BLEED VLV CLOSED - A	1	1	0	0					STATE
V41X1581X	L02 OVBD BLEED VLV CLOSED - B	1	1	0	0					STATE
V41X1587E	L02 OVBD BLEED VLV OPEN	0	0	1	1					STATE
*V41P1600A	PNEU VLV HE SUPPLY PRESS	4052	829							PSIA
*V41P1605A	PNEU HE REG OUT PRESS	758	775	28	29					PSIG
V41X1811X	L02 ACCUM RECIRC VLV 1 OPEN	1	1	0	0					STATE
V41X1818E	L02 ACCUM RECIRC VLV 1 CLOSED	0	0	1	1					STATE
V41X1821X	L02 ACCUM RECIRC VLV 2 OPEN	1	1	0	0					STATE
V41X1828E	L02 ACCUM RECIRC VLV 2 CLOSED	0	0	1	1					STATE
V41X1919X	LH2 RTLS OTBD DRAIN VLV LOSEL	1	1	0	0					STATE
V41X1929X	LH2 RTLS INBD DRAIN VLV CLOSED	1	1	0	0					STATE
VGH1	ENG 1 GH2 FLOW CONTROL VLV POSN - LO	0	0	1	1					STATE
VGH2	ENG 2 GH2 FLOW CONTROL VLV POSN - LO	0	0	1	1					STATE
VGH3	ENG 3 GH2 FLOW CONTROL VLV POSN - LO	0	0	1	1					STATE

*NOTE: This measurement uses the range limit conversion method of calculating FS_{EU} from GS_{EU} CTS as discussed in section 2.6.2.

MEASUREMENT OUTPUT FROM ^{11P5} MODEL - TABLE 2

MEASUREMENT I. D.	MEASUREMENT NAME	I. C.		VALUE 1		VALUE 2		VALUE 3		UNITS
		FS	CTS	FS	CTS	FS	CTS	FS	CTS	
VG01	ENG 1 G02 FLOW CONTROL VLV POSN - LO	0	0	1	1					STATE
VG02	ENG 2 G02 FLOW CONTROL VLV POSN - LO	0	0	1	1					STATE
VG03	ENG 3 G02 FLOW CONTROL VLV POSN - LO	0	0	1	1					STATE
VE1	ENG 1 PLUMBING READY DISCRETE	0	0	1	1					STATE
VE2	ENG 2 PLUMBING READY DISCRETE	0	0	1	1					STATE
.E3	ENG 3 PLUMBING READY DISCRETE	0	0	1	1					STATE
L02DP	L02 DUMP SIGNAL	0	0	1	1					STATE
LH2DP	LH2 DUMP SIGNAL	0	0	1	1					STATE
RTLSDP	RTLS DUMP SIGNAL	0	0	1	1					STATE

5.0 STS REFERENCES

5.1 VS70-415001, MAIN PROPULSION SYSTEM SCHEMATIC

5.2 382-240-CDM/76-062, ROCKWELL PRELIMINARY REQUIREMENTS

5.3 382-240-CDM/76-064, PRELIMINARY REQUIREMENTS UPDATE

5.4 LEC-7827, MPS SIMULATION REQUIREMENTS

5.5 SD76-SH-0026, MPS DUMP SEQUENCE (LEVEL C FSSR)

12.0 GTS DETAILED REQUIREMENTS

12.1 GTS FUNCTIONAL CHARACTERISTICS

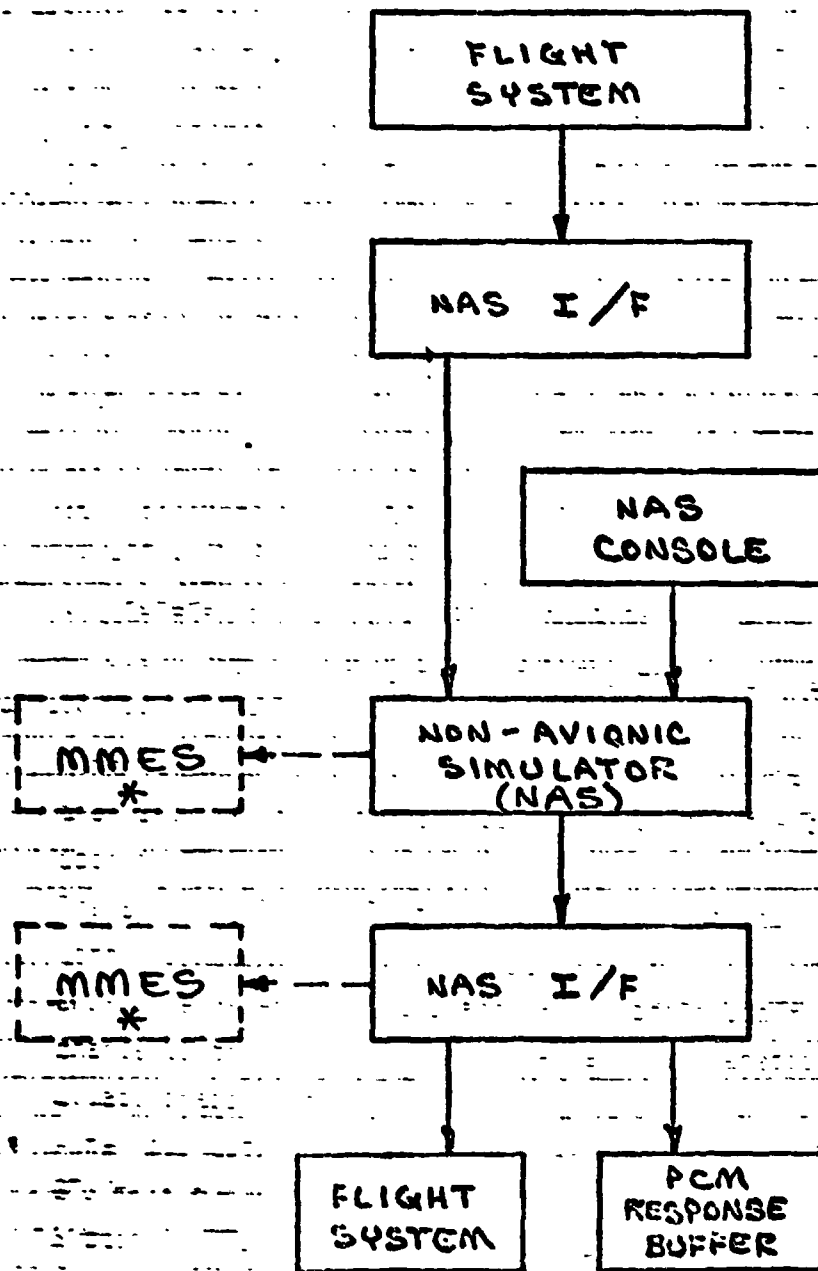
This model simulates those functions of the Main Propulsion System (MPS) components that are in the Orbiter, namely valve positions, system pressures, and system temperatures. To simplify the model, only those component functions needed to support testing of the Shuttle Avionics System are provided.

The model receives stimuli from three sources: (1) the Flight System; (2) the Marshall Mated Elements Simulator (MMES); and (3) the Non-Avionics Simulator (NAS) Console. The model transmits parameter values to the Flight System and the MMES. Figure 3 illustrates the data flow in and out of the model. Tables 14.1 and 14.2 list the input stimuli and the output measurements, respectively.

The model generates three engines ready for firing discrettes (one per engine) which are transmitted to the MMES as a valve status signal prior to engine firing, (reference logic flow chart routine 15).

The GTS math model is the same as the STS math model except for differences brought about by test station differences.

- **A front end program has been added to the GTS math model which converts the multiple input stimuli used in GTS into the singular input stimuli used in STS.**
- **The External Tank (ET) flow control valve stimuli, which the Flight Control System sends to the math model in STS, is not available in GTS and is replaced by ET LU2 and LH2 ullage pressures from the MMES. A change to the GTS logic flow diagrams was necessary to process the ullage pressure signals.**
- **A new subroutine called Engine Prevalve Routine (EPR) was added to the GTS math model to accomodate the Mainstage stimuli provided by the Flight System in GTS. The Mainstage stimuli prevent closing of the engine pre-valves while the engine is ignited.**



ORIGINAL PAGE IS
OF POOR QUALITY

* - APPLIES ONLY WHEN MMES IS USED IN GTS

FIGURE 3 - GTS SYSTEM DATA FLOW

12.2 NAS UPLINK

A mission phase dependent variable in the Orbiter portion of the MPS is helium supply pressure. To avoid complexity in the GSIU model, the change of helium pressure to account for the operation of pneumatic valves and engine purging was not incorporated into the flowchart logic. Instead, it is intended that the NAS operator transmit new pressure values to the model at appropriate times to be specified in the TCP. A suggested set of pressure values for a nominal mission are as follows:

<u>PHASE</u>	<u>PRESSURE VALUE (PSIA)</u>
Prelaunch	2,000
Launch	4,000
Orbit	1,500
Reentry	1,000
Landing	500

Accounting for pressure usage during the mission is more for data realism than to satisfy avionics test requirements. The helium supply pressure might just as well remain fixed at 4,000 psia.

Discrete stimulus K50P721-A shall be generated by the Non-Avionic Simulator (NAS) console operator to simulate a ground command to the LH2 RECIRC PUMPS during prelaunch checkout. In STS this signal comes from the flight system.

12.3 GTS INITIALIZATION REQUIREMENTS

The initial conditions column in the stimuli/measurements table indicates the state of the model prior to configuring for LH2 and LO2 fill operations and is for reference only. The output measurement values of the model shall reflect the state of the input stimuli when the model is made active.

12.4 GTS TERMINATION REQUIREMENTS

None.

12.5 GTS UNIQUE REQUIREMENTS

12.5.1 Timers

Two timers called "COUNTER" and "KOUNTER" are used in the LO2 and LH2 manifold pressure subroutine (nos. 12 and 13), respectively. The timers provide a delay before manifold pressures are set to zero. This

simulates the time interval during which 20 psig helium pressure is forcing residual liquid propellants out of the manifolds following external tank separation.

12.5.2 Flags

Flags or pseudos that are used for purposes internal to the model are defined as follows:

- D - Indicates valve position for the designated valve in the LVR, NCVR, and NOVR subroutines.
- A,B- Indicate valve stimuli for the designated valve in the LVR, NCVR, and NOVR subroutines.
- D1 thru D13 - Indicates the latching valve position for:
 - D1 - L02 Feed Disconnect Valve
 - D2 - LH2 Feed Disconnect Valve
 - D3 - LH2 Recirculation Disconnect Valve
 - D4 - L02 Outboard Fill and Drain Valve
 - D5 - L02 Inboard Fill and Drain Valve
 - D6 - LH2 Outboard Fill and Drain Valve
 - D7 - LH2 Inboard Fill and Drain Valve
 - D8 - Engine 1 L02 Prevalve
 - D9 - Engine 2 L02 Prevalve
 - D10 - Engine 3 L02 Prevalve
 - D11 - Engine 1 LH2 Prevalve
 - D12 - Engine 2 LH2 Prevalve
 - D13 - Engine 3 LH2 Prevalve

12.5.3 DISCRETE STIMULI

The following discrete stimuli from the Flight System are not used in the GTS logic flow diagrams but are to be displayed to the NAS console operator for monitoring:

<u>NOMINAL NUMBER</u>	<u>NOMENCLATURE</u>
V41K1700X	REPLACE LH2 ULLAGE PRESS XDCR # 1
V41K1701X	REPLACE LH2 ULLAGE PRESS XDCR # 2
V41K1702X	REPLACE LH2 ULLAGE PRESS XDCR # 3
V41K1750X	REPLACE LO2 ULLAGE PRESS XDCR # 1
V41K1751X	REPLACE LO2 ULLAGE PRESS XDCR # 2
V41K1752X	REPLACE LO2 ULLAGE PRESS XDCR # 3

12.5.4 MPS PROPELLANT DUMP SIGNALS

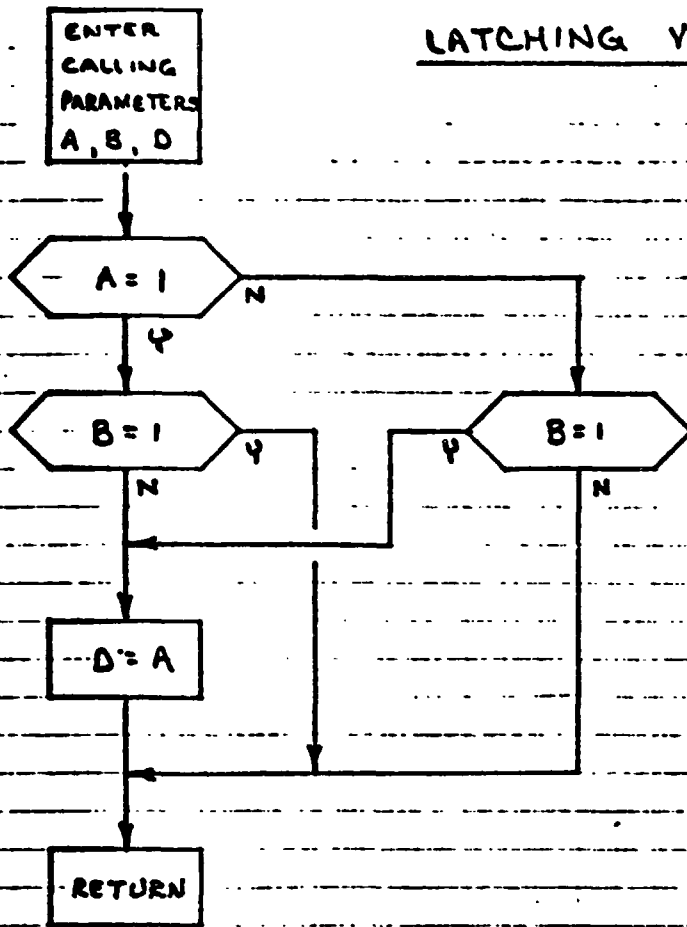
Following Main Engine Cut-Off or External Tank separation, an LO2 signal, an LH2 signal, and an RTLS signal are needed by the Vehicle Dynamics Math Models to compute the changes in vehicle forces and mass properties while MPS residual propellants are discharged overboard. The three signals are generated in the MPS math model and are identified as follows:

LO2DP	LO2 DUMP SIGNAL
LH2DP	LH2 DUMP SIGNAL
RTSDP	RTLS DUMP SIGNAL

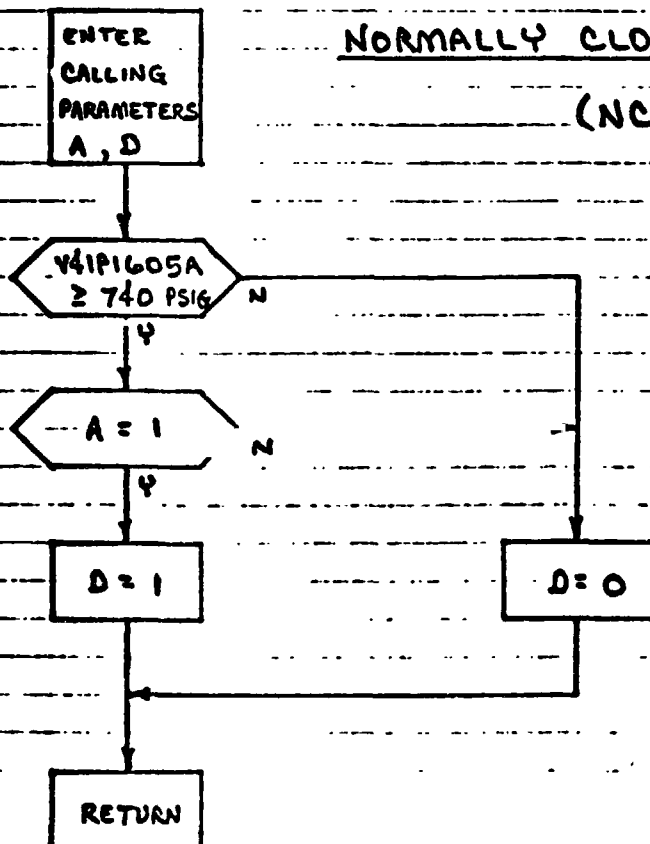
A state of (1) indicates a dump is in progress.

13.0 GTS LOGIC FLOW DIAGRAMS

LATCHING VALVE ROUTINE (LVR)



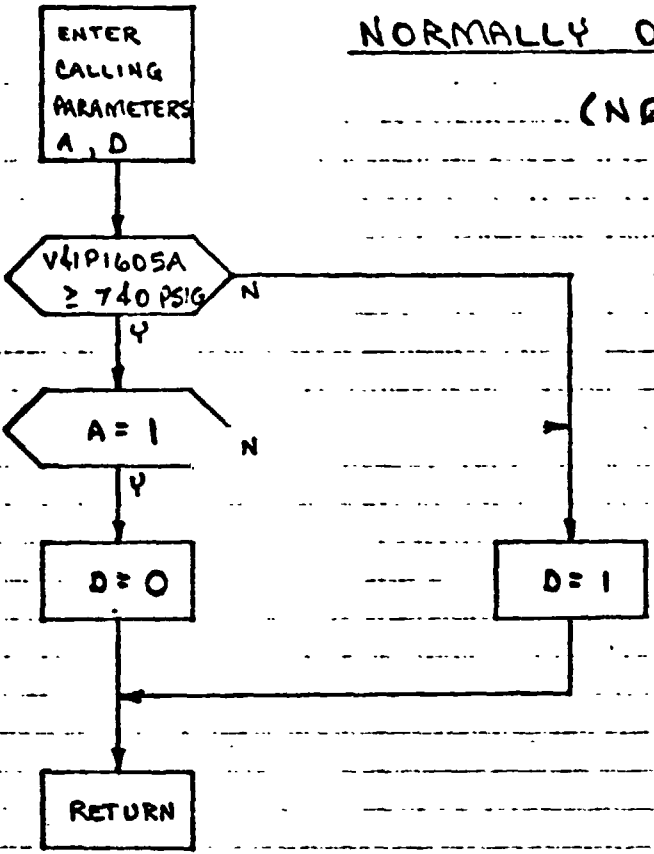
NORMALLY CLOSED VALVE ROUTINE (NCVR)



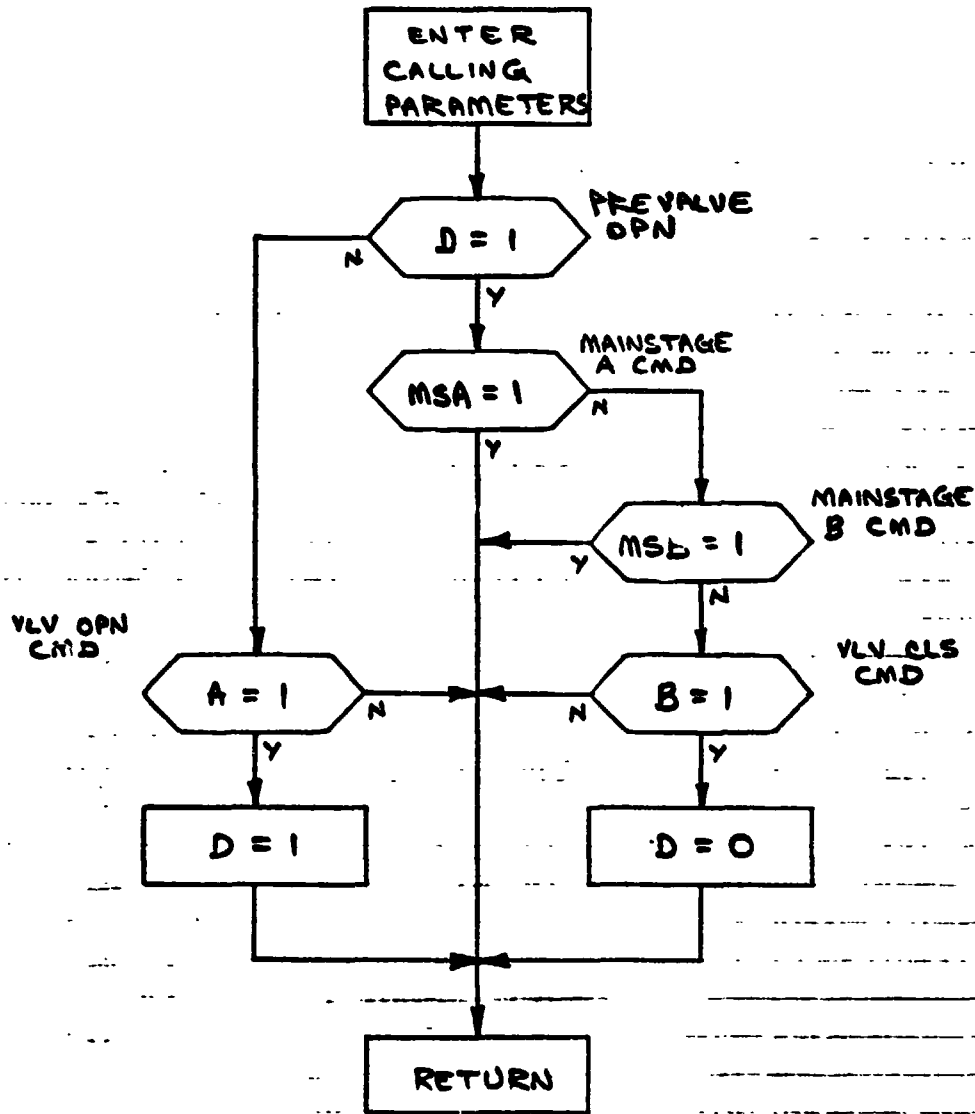
ORIGINAL PAGE IS
OF
BETTER QUALITY

U

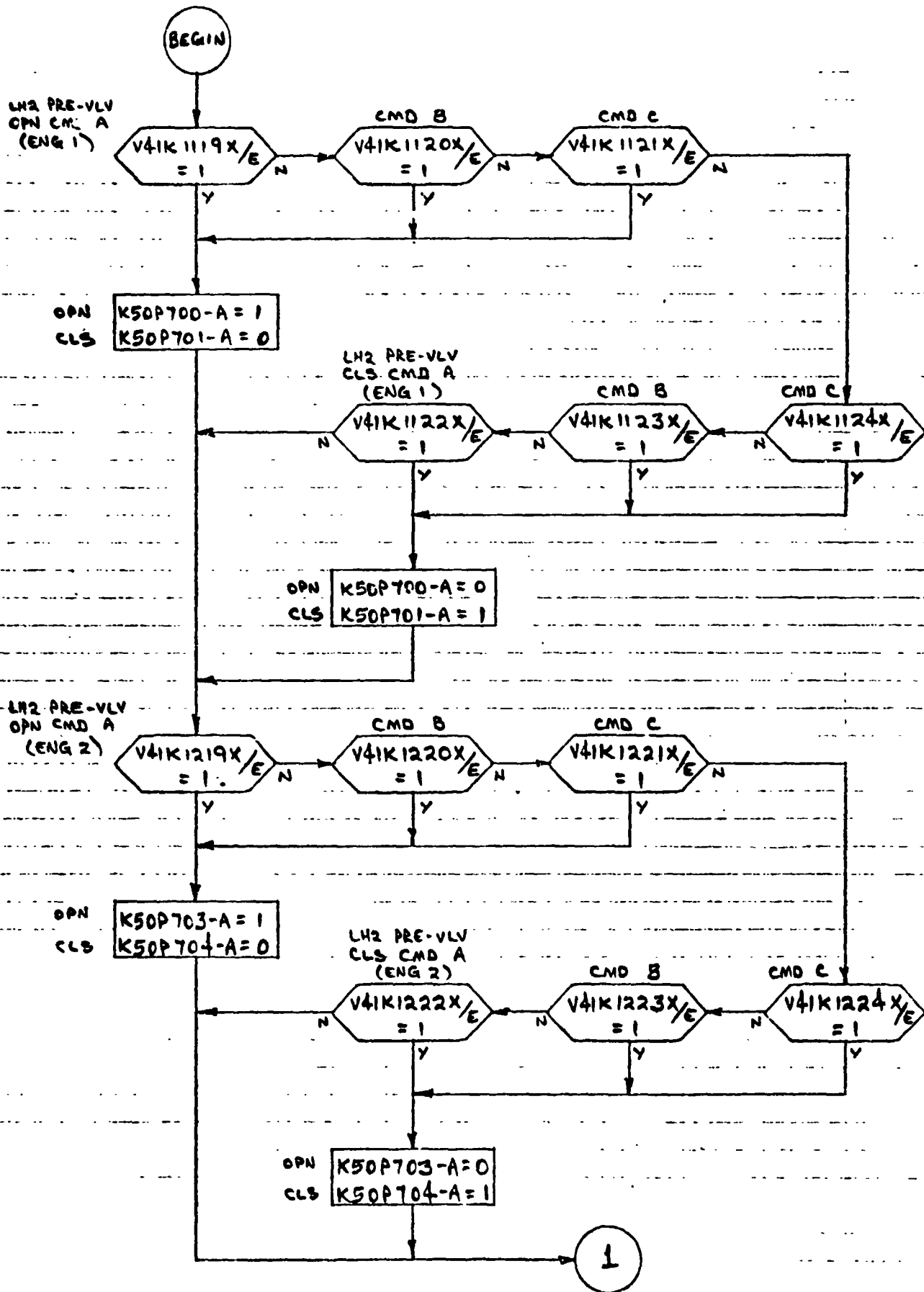
NORMALLY OPEN VALVE ROUTINE
(NOVR)

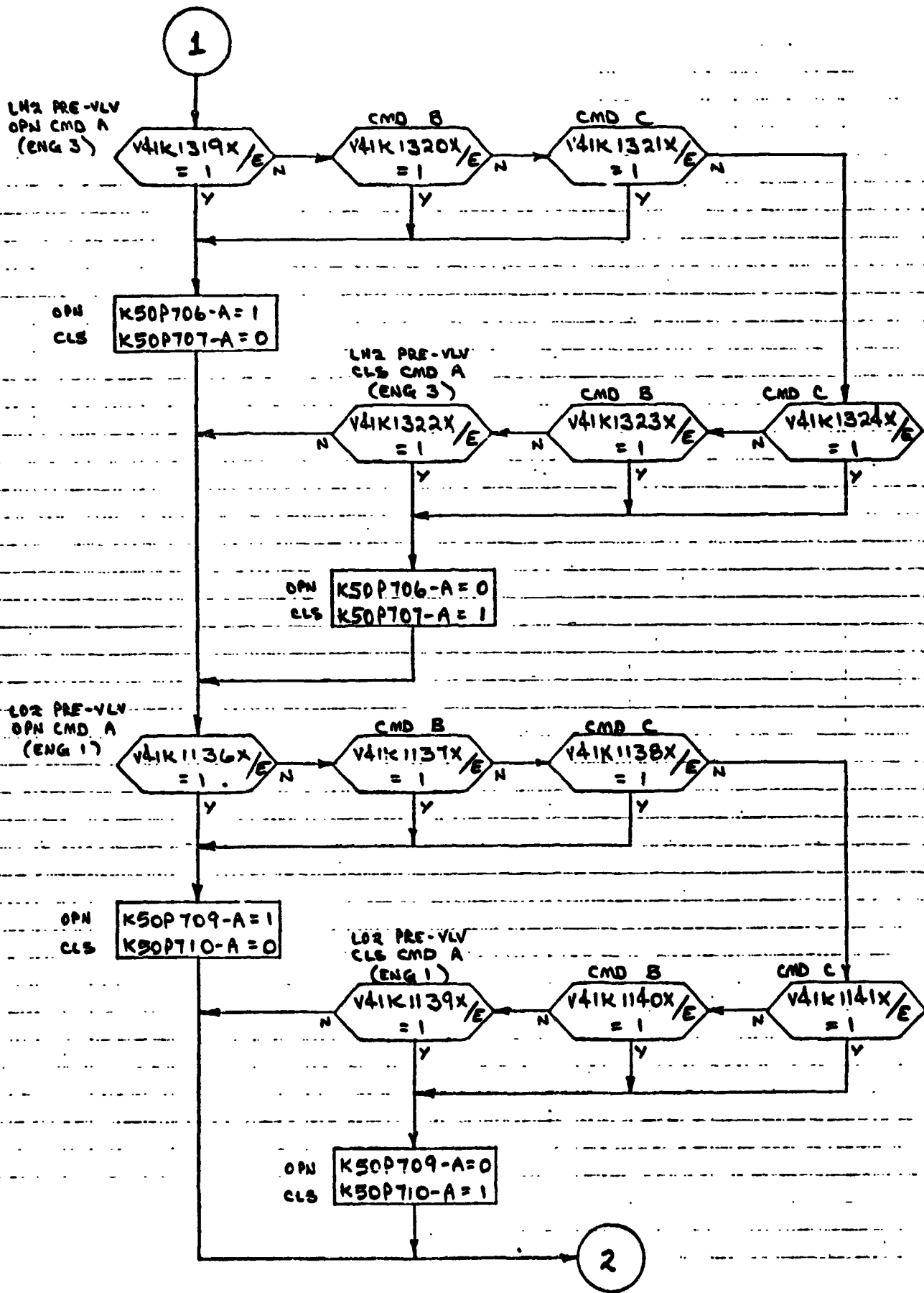


ENGINE PREVALUE ROUTINE (EPR)

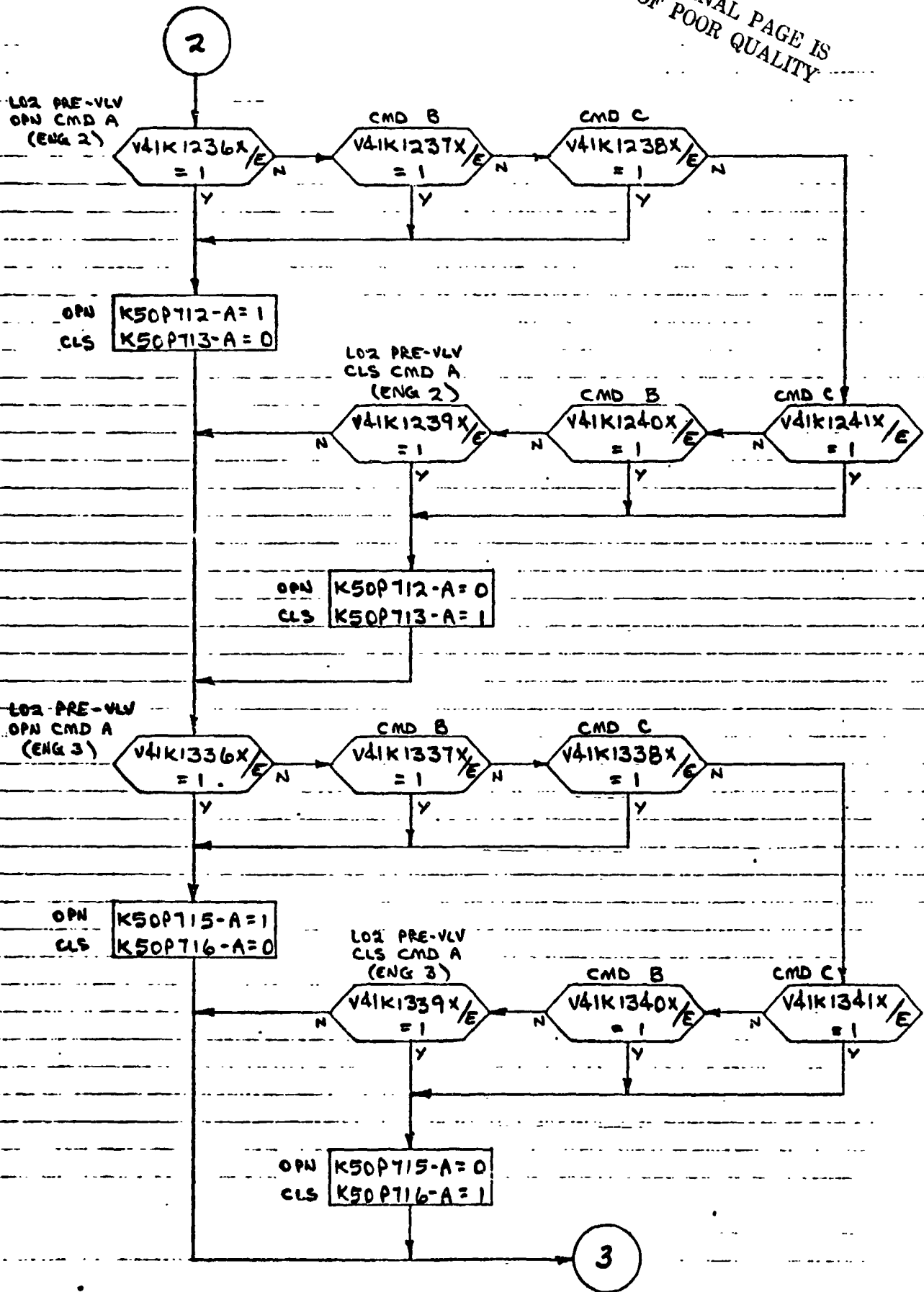


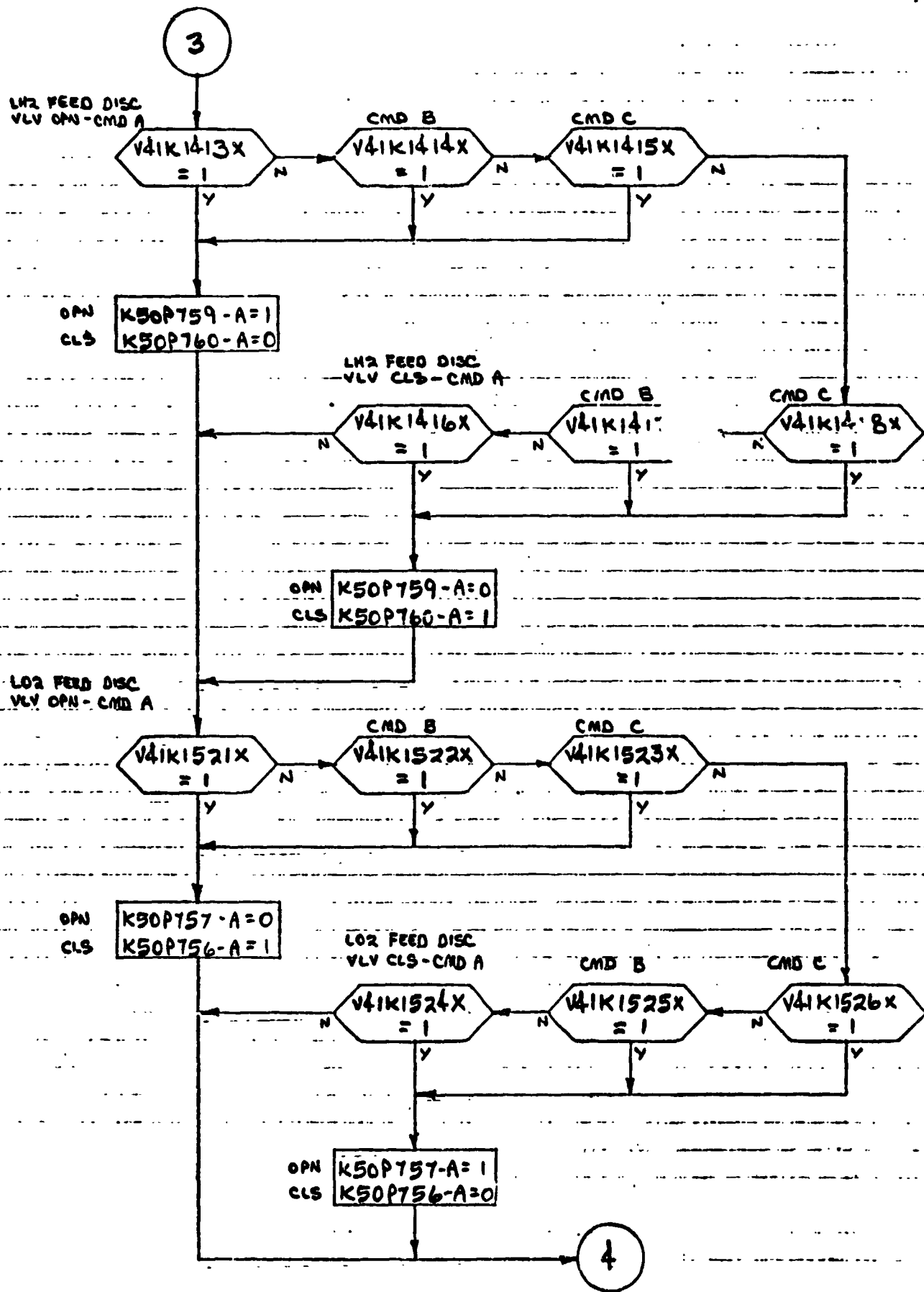
ORIGINAL PAGE IS
OF POOR QUALITY

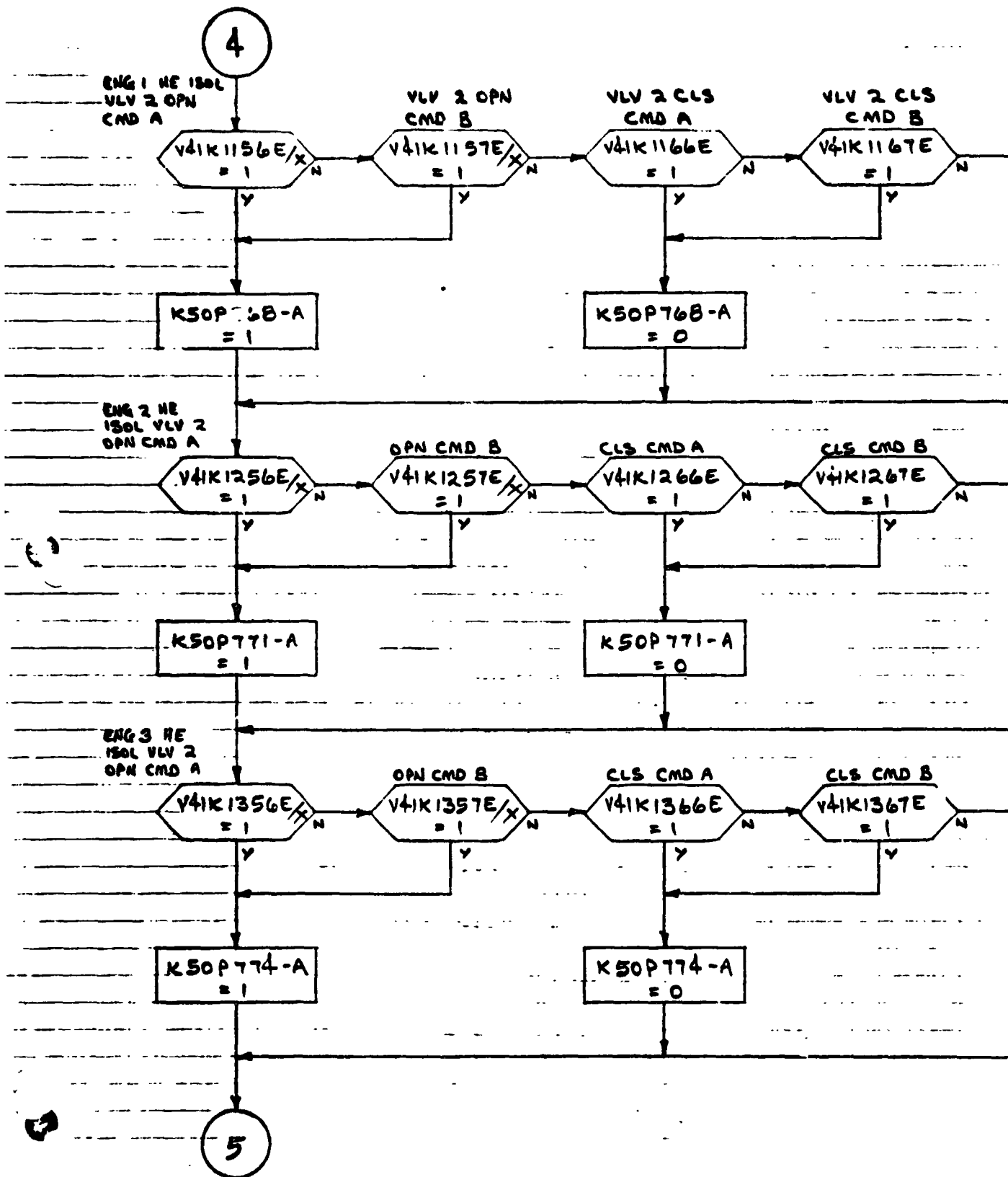


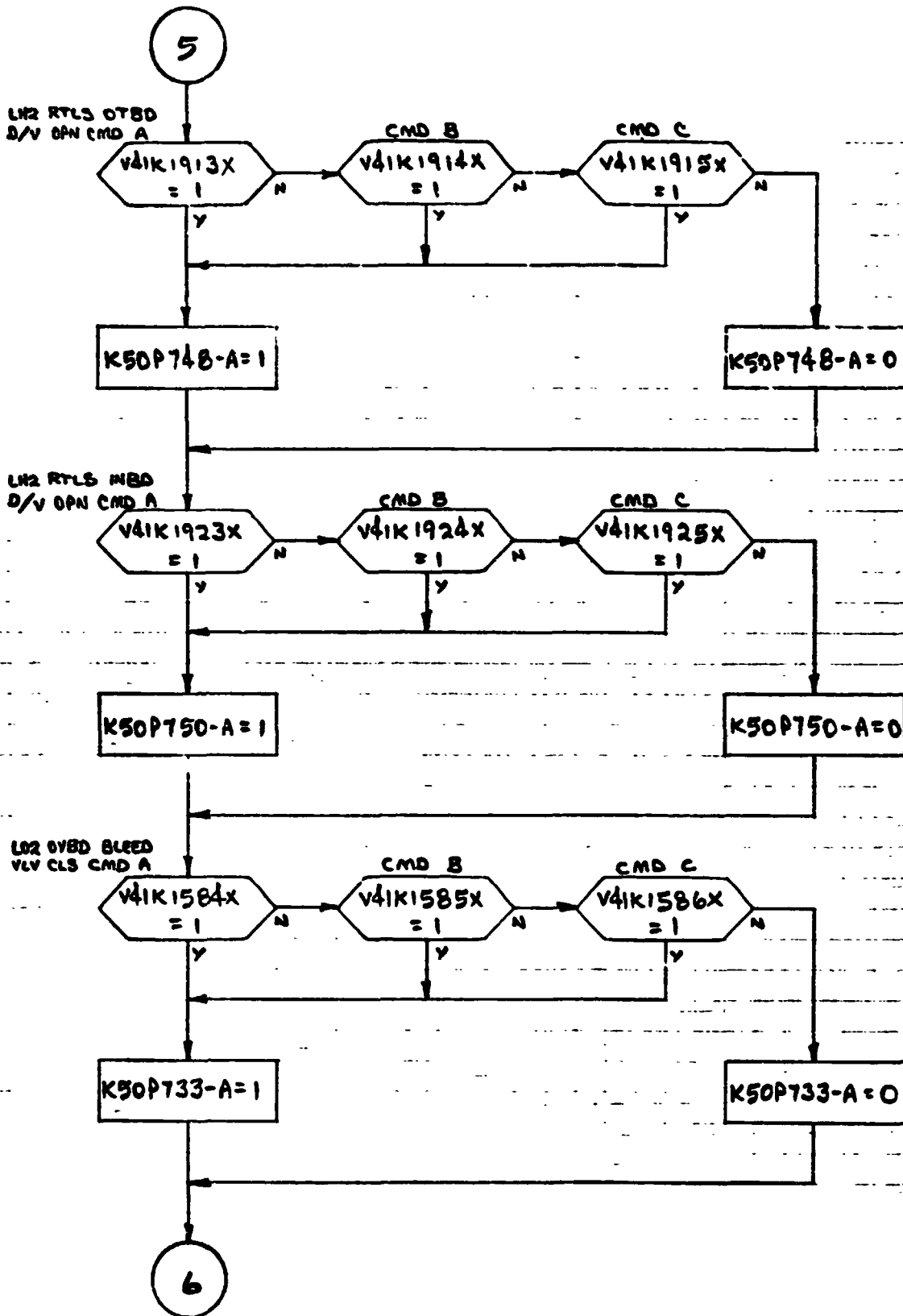


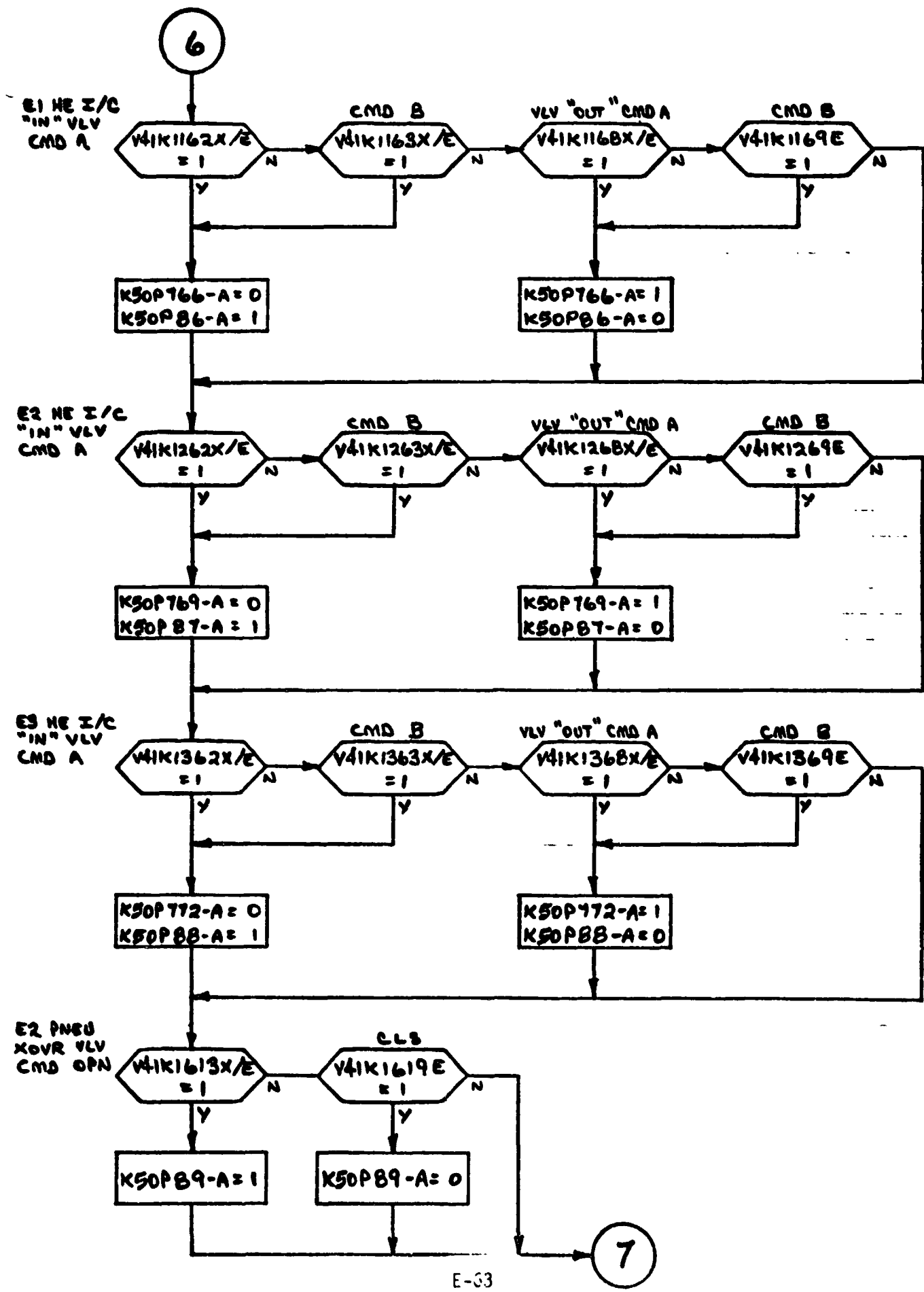
ORIGINAL PAGE IS
OF POOR QUALITY

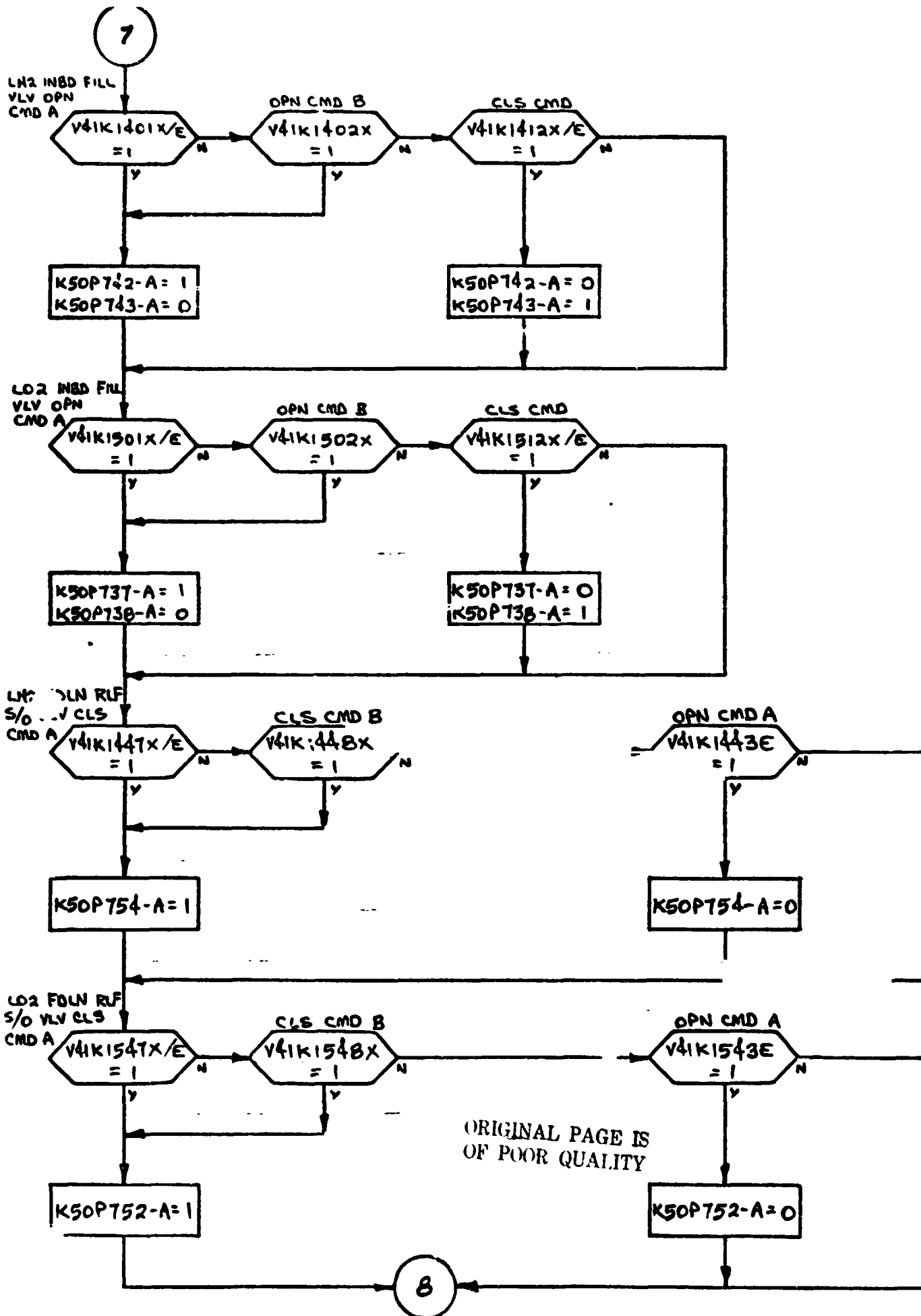


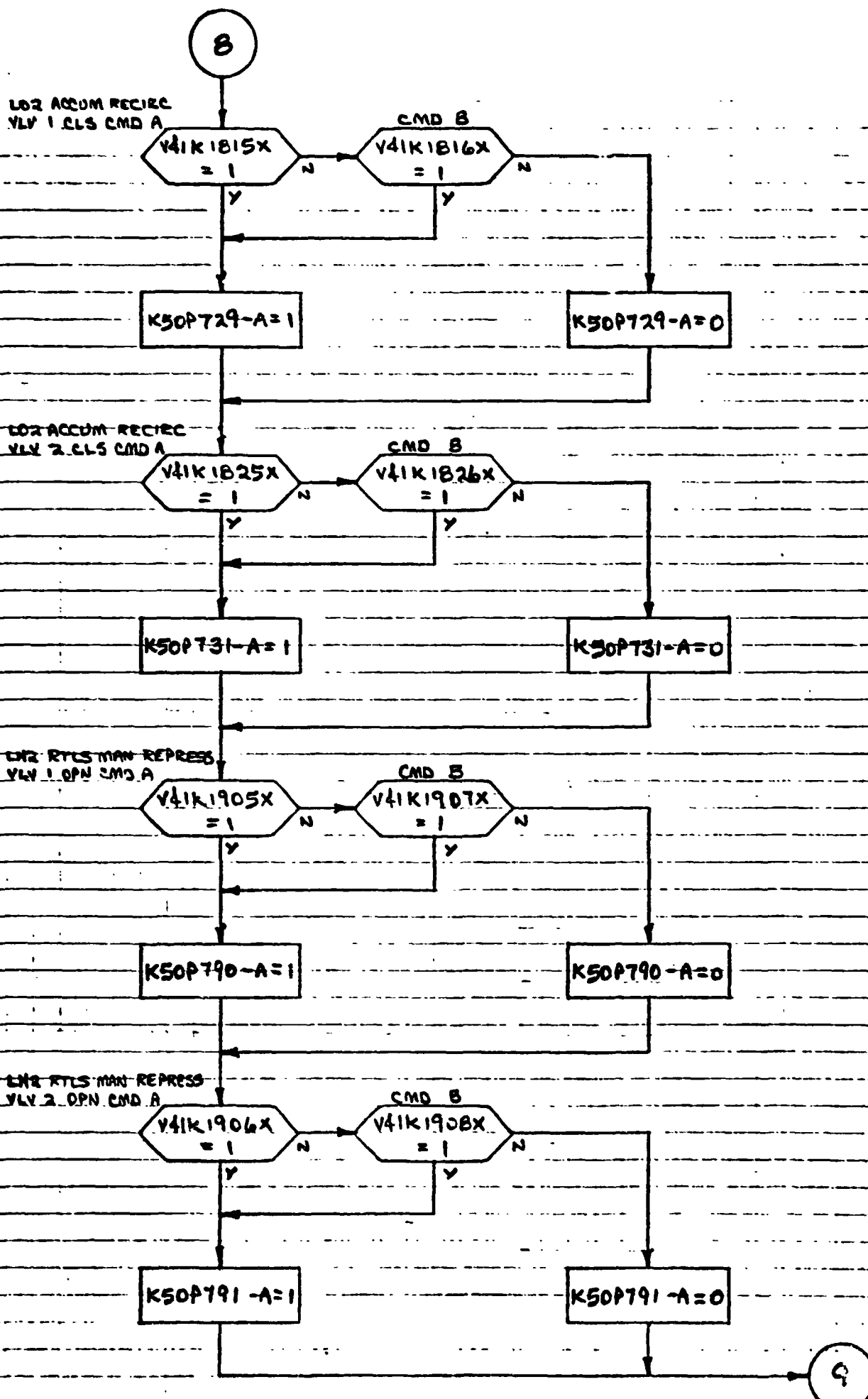


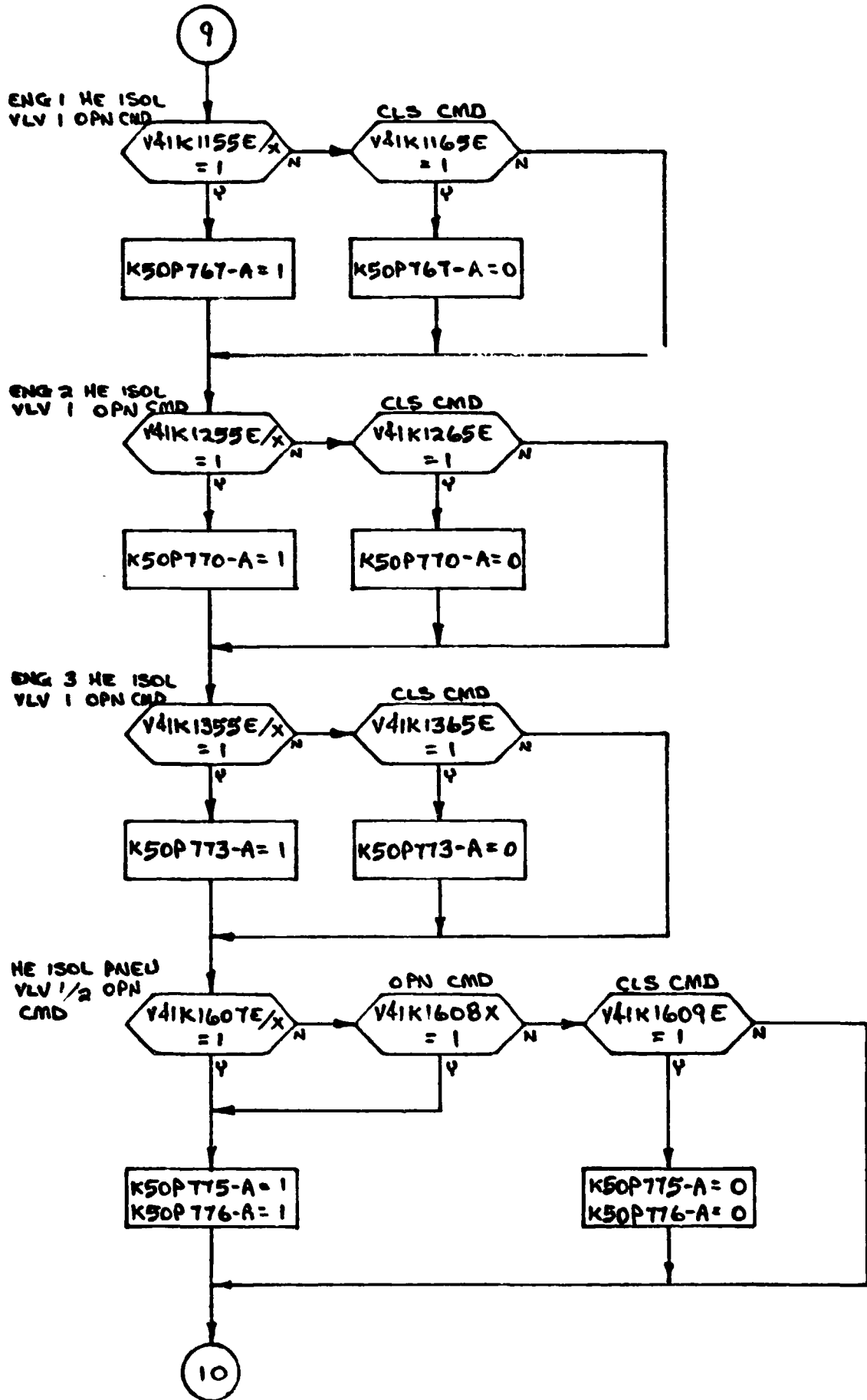


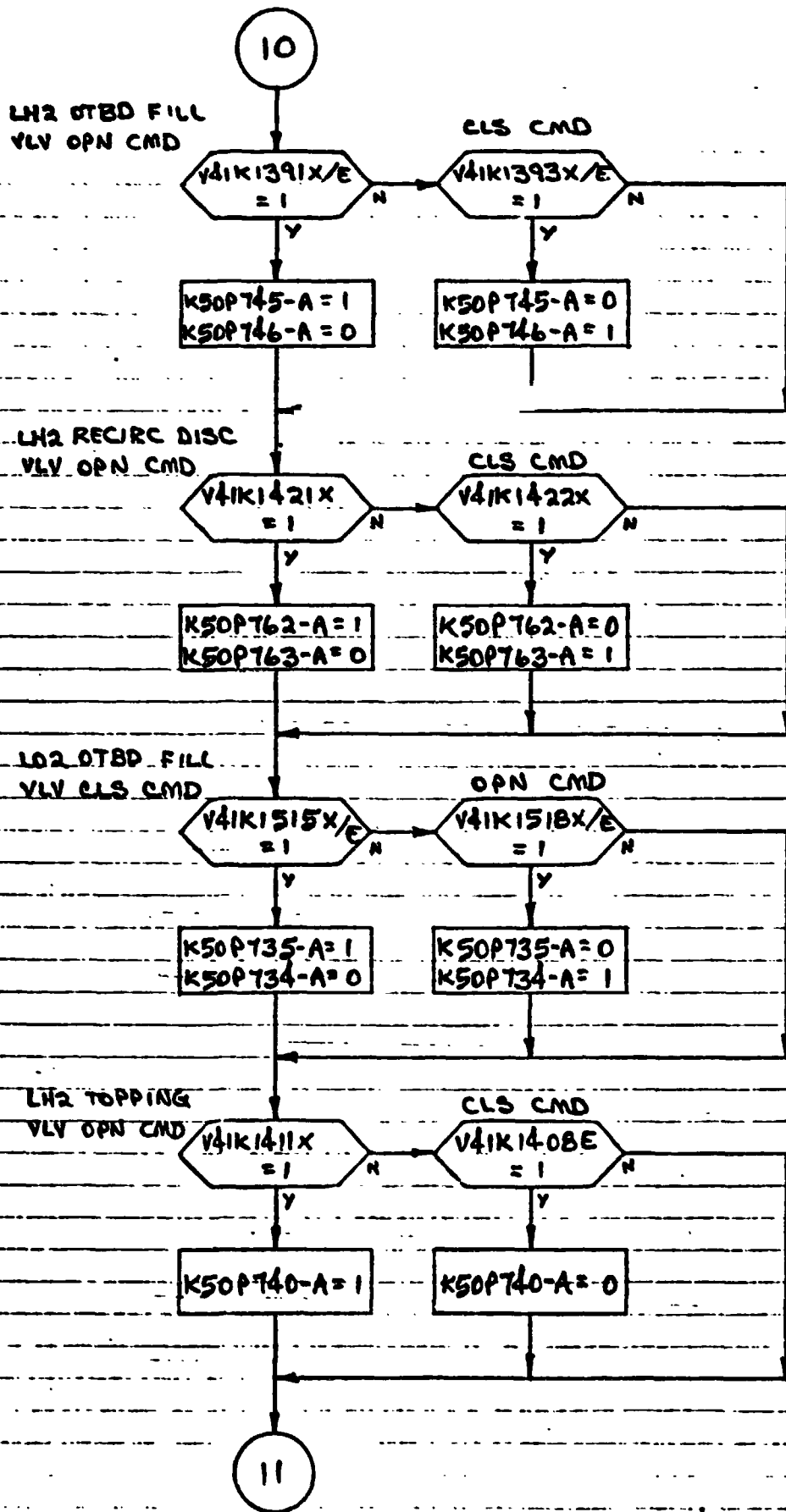


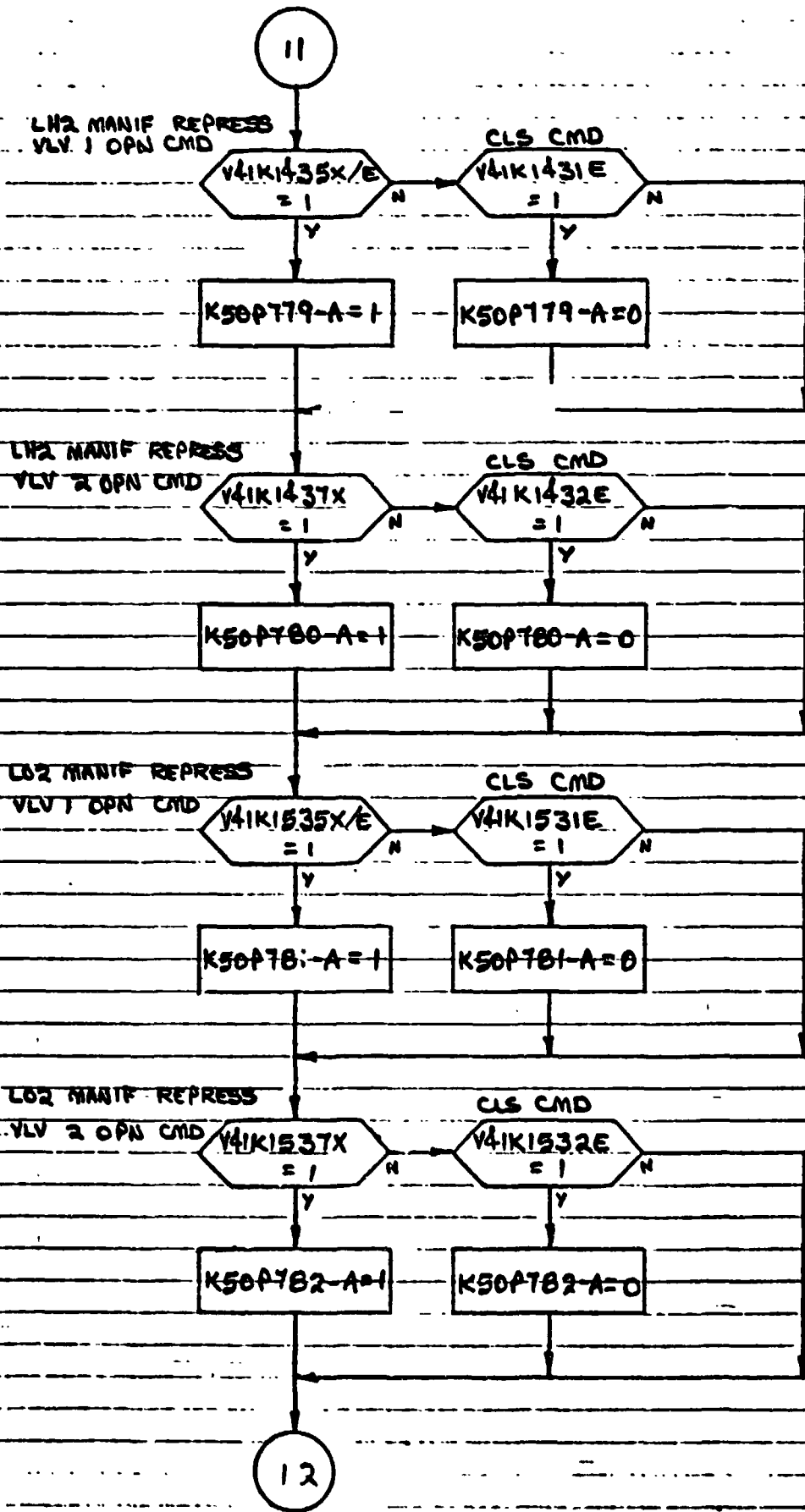


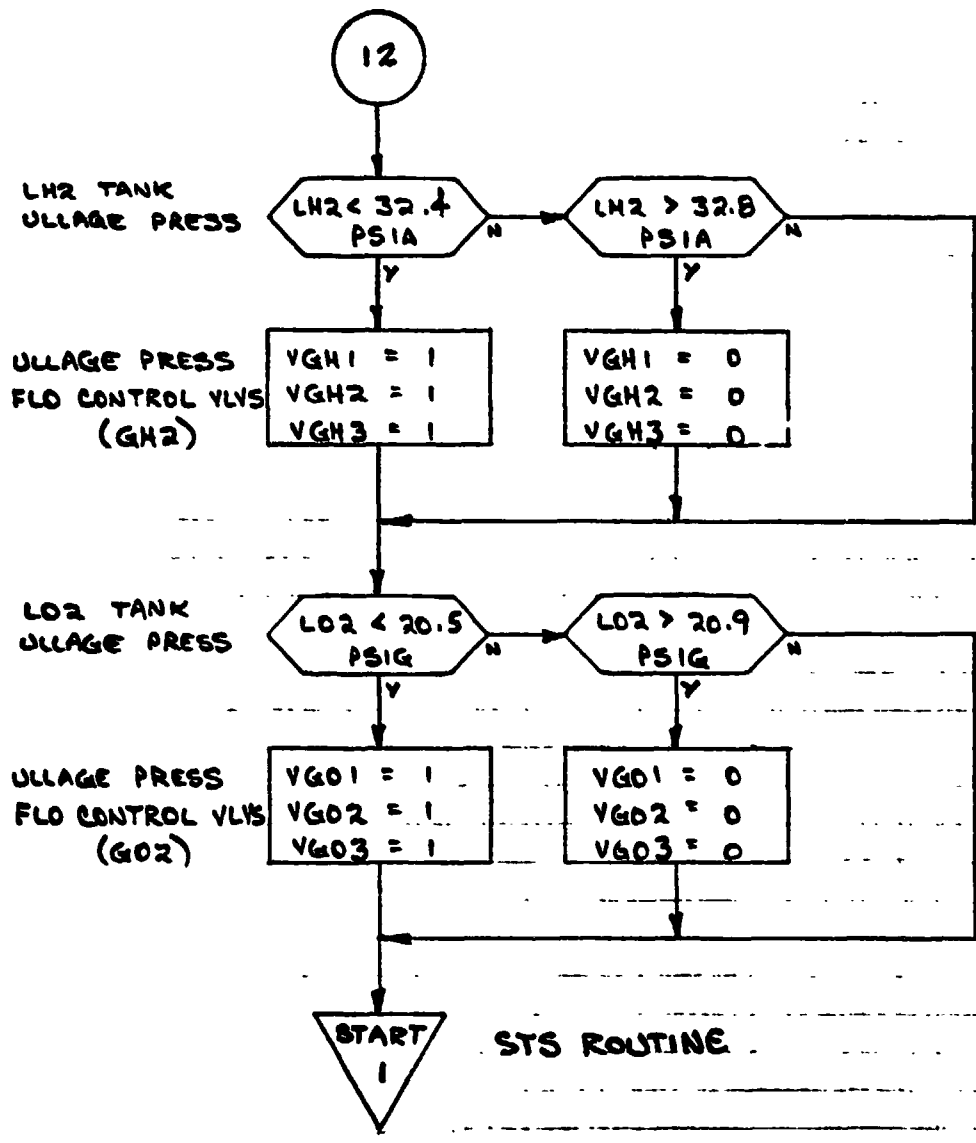




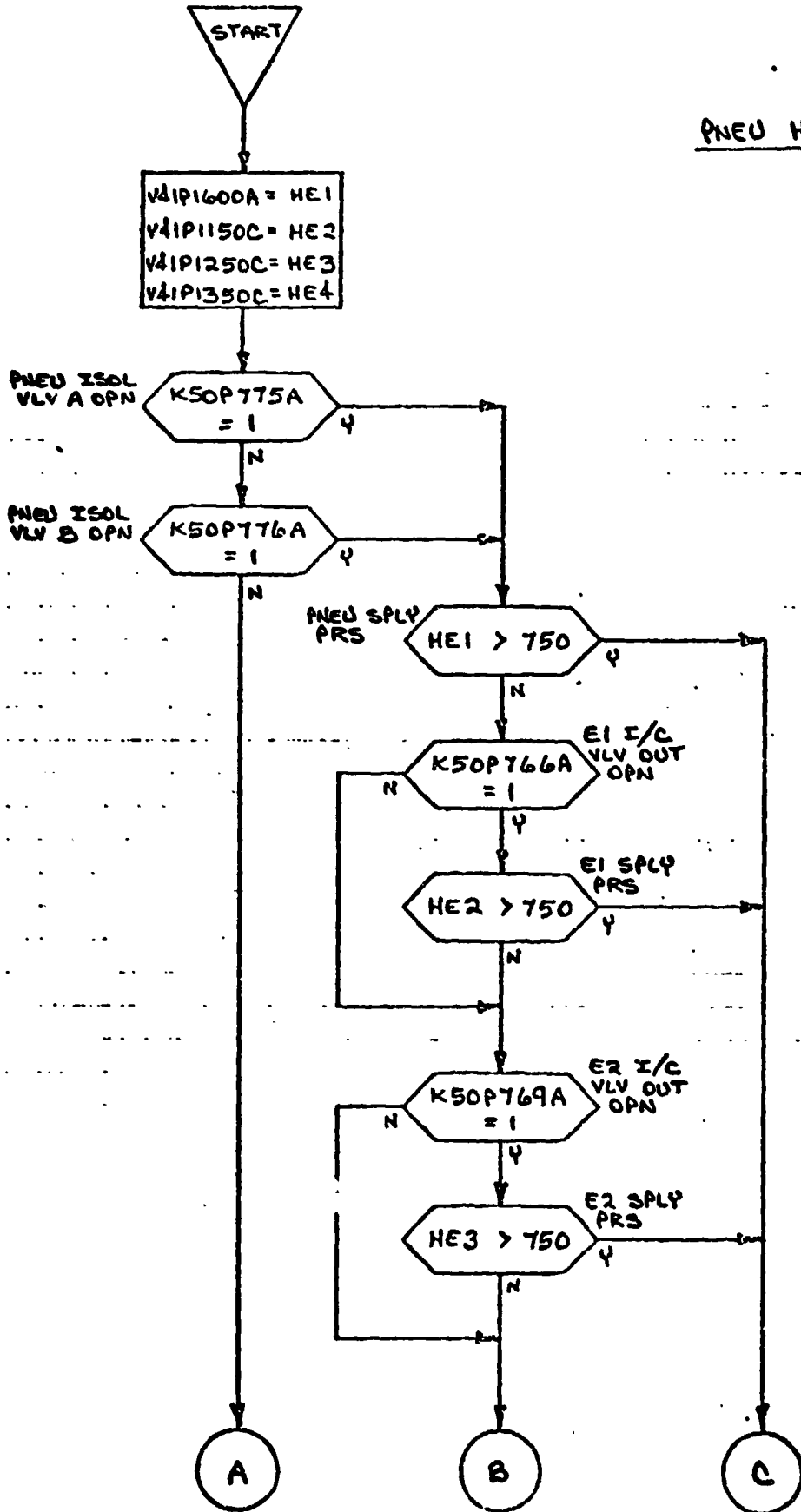




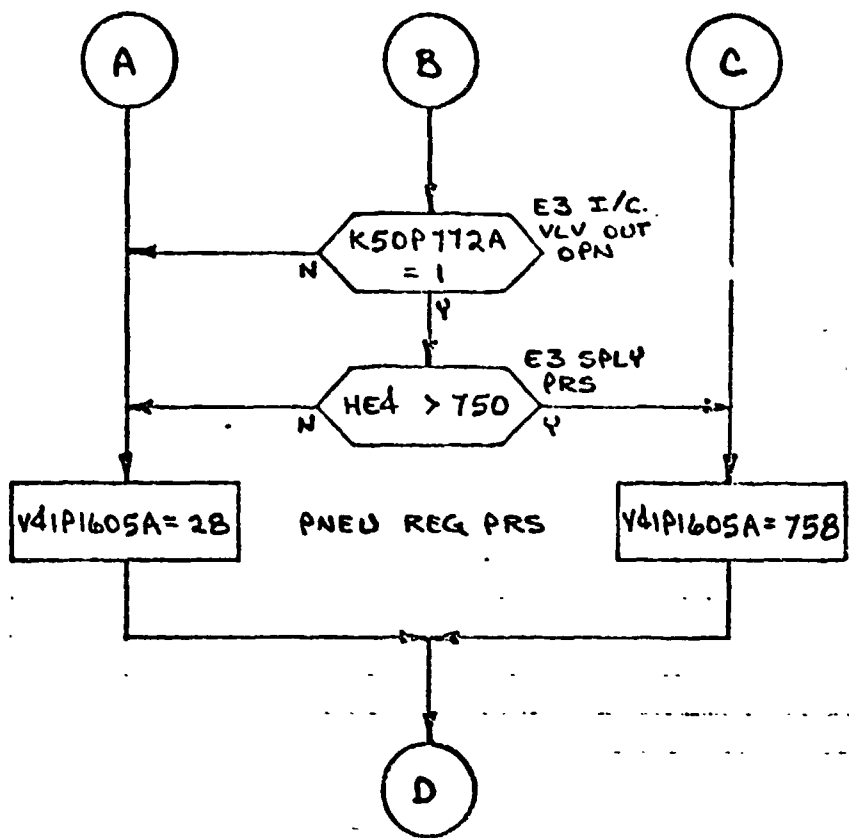




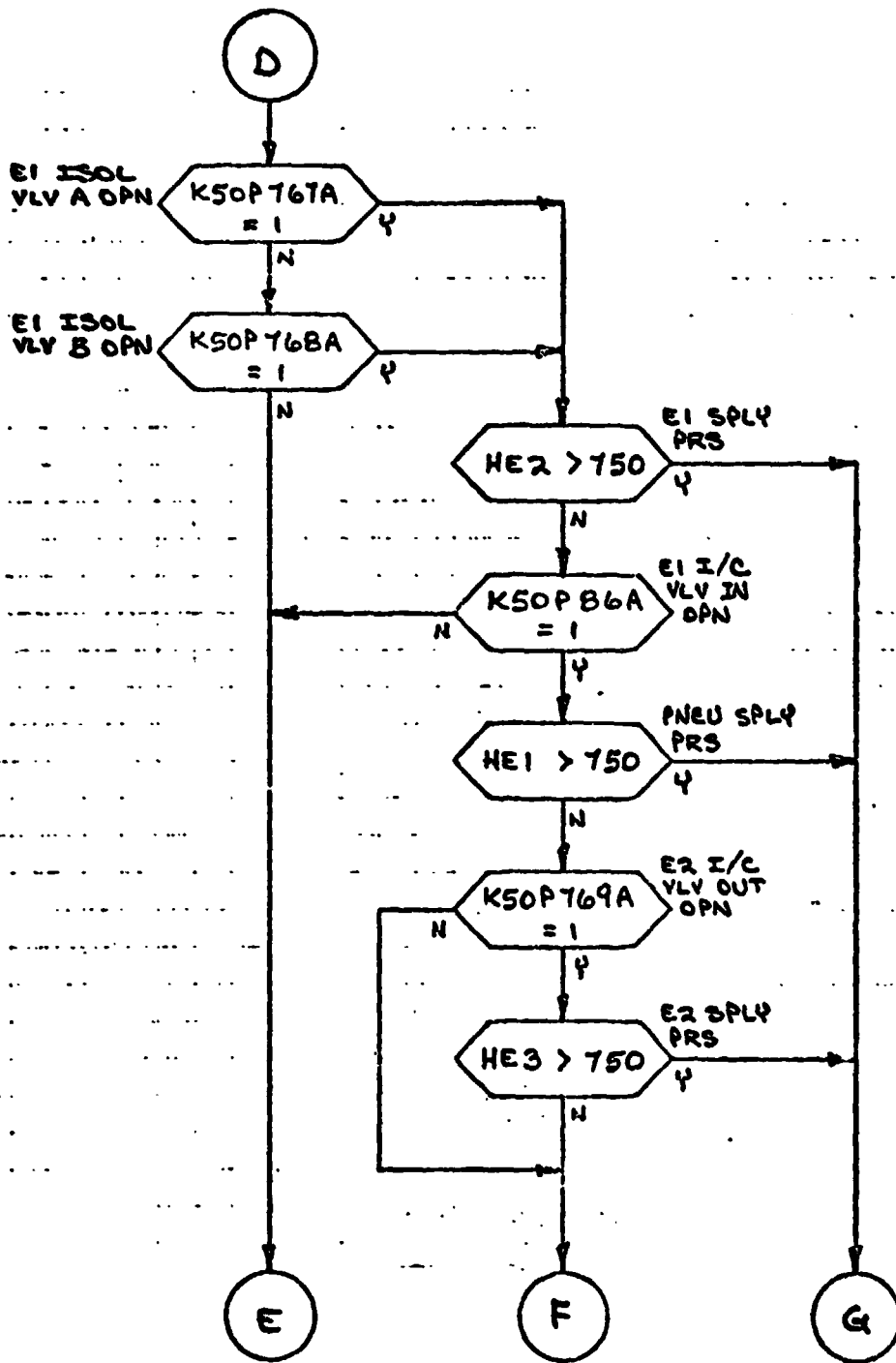
PNEU HE PRESS



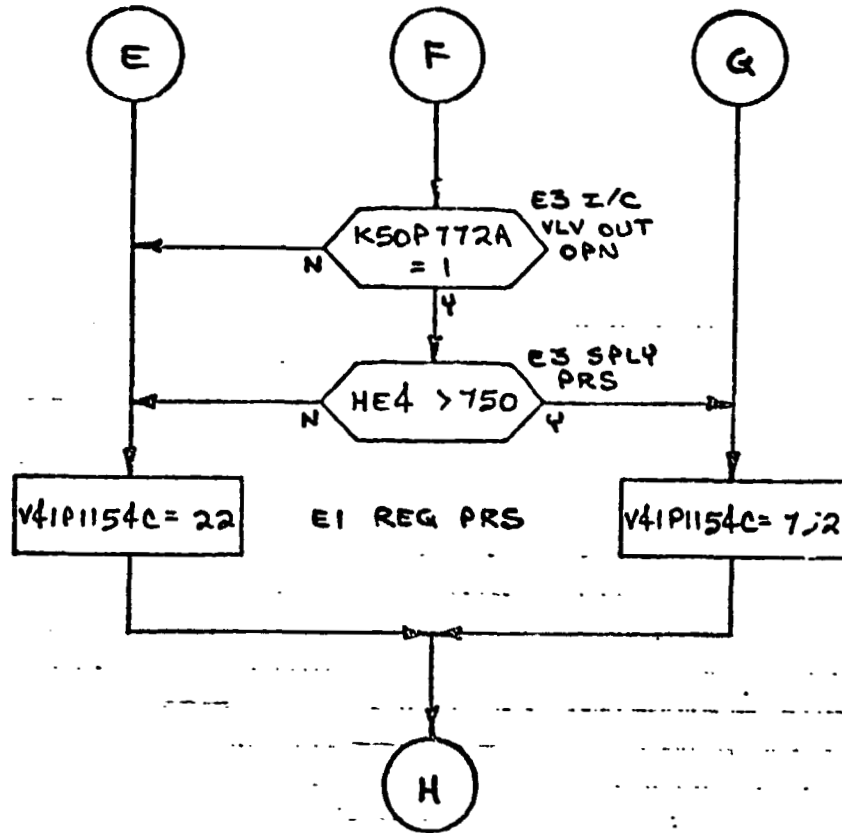
PNEU HE PRESS



E1 HE PRESS

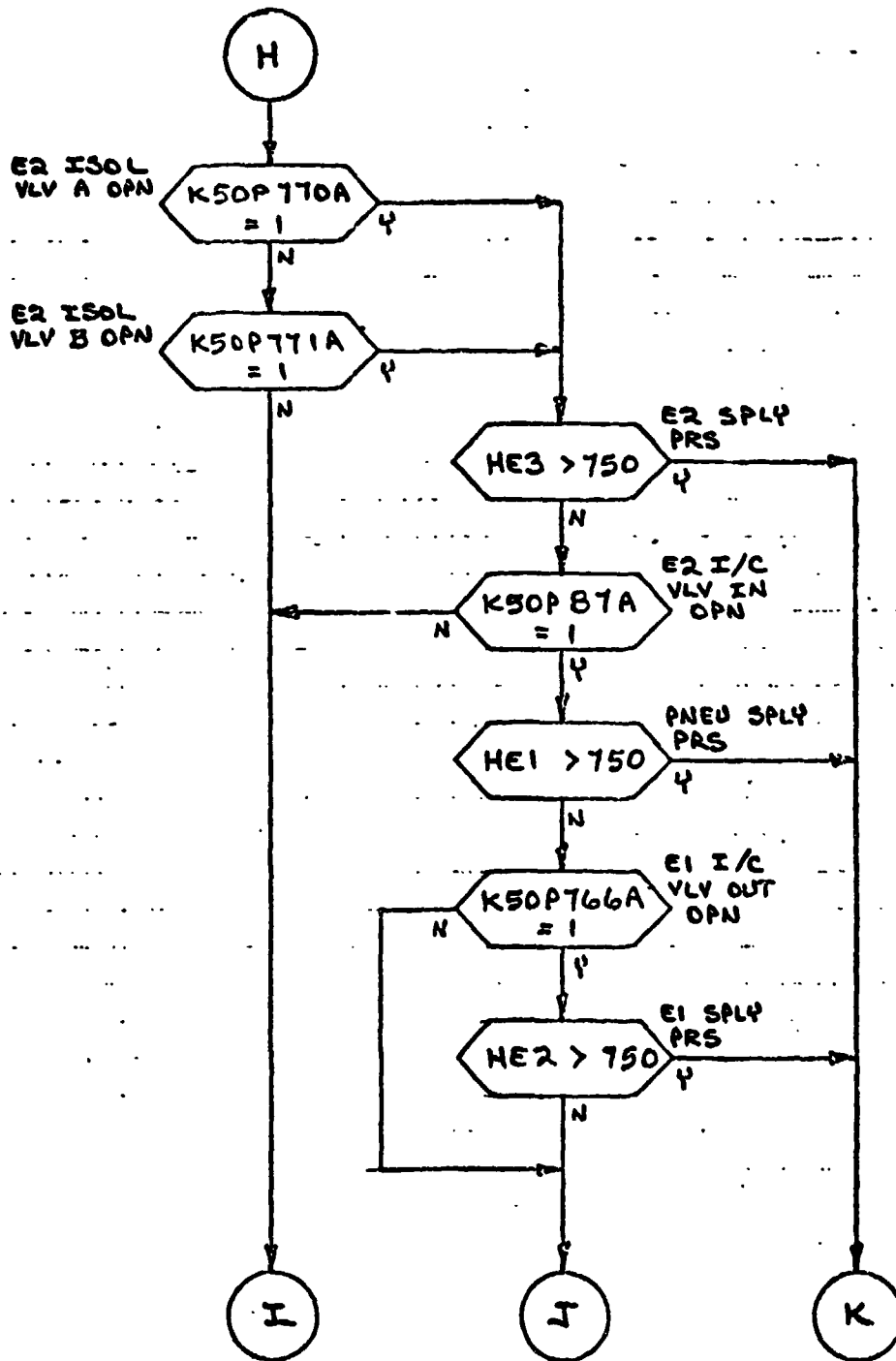


EI HE PRESS

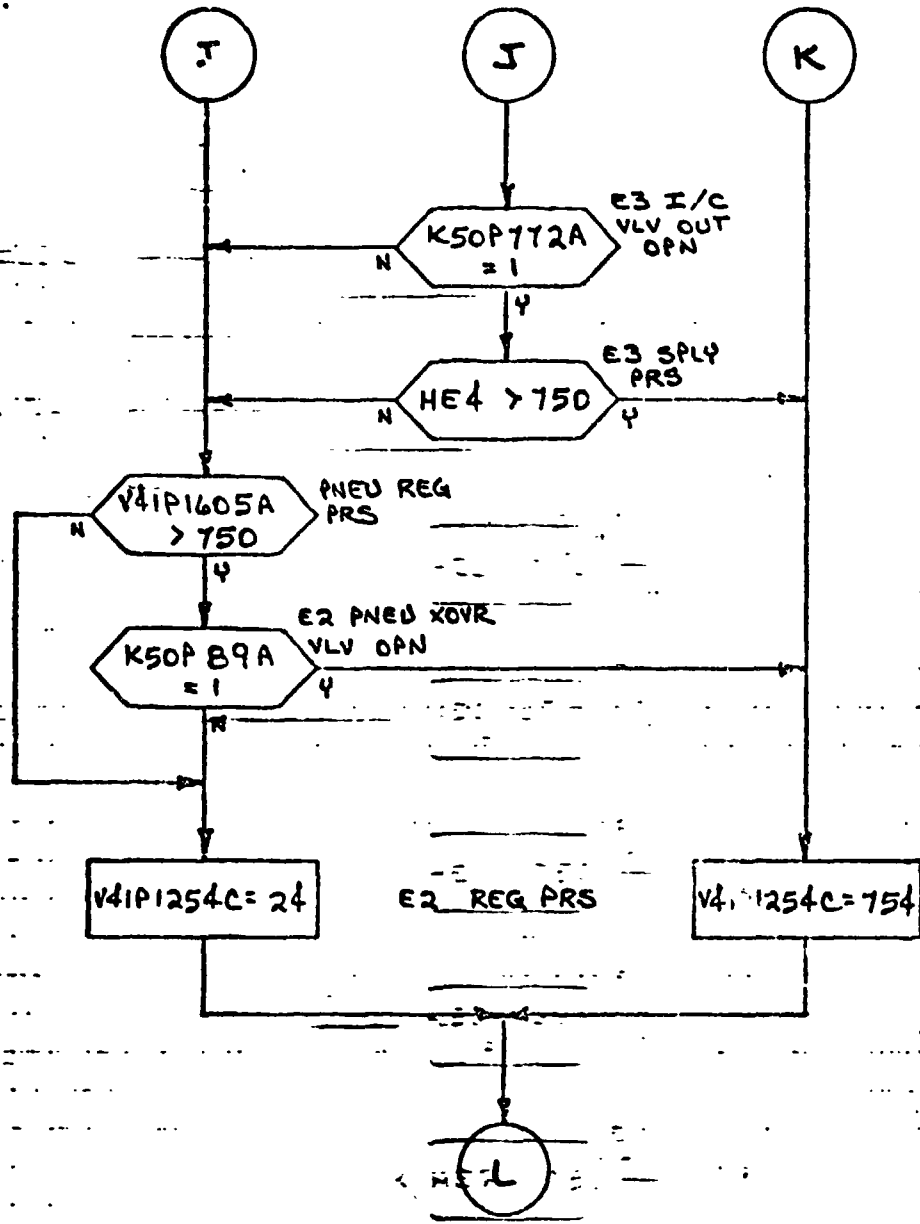


ORIGINAL PAGE IS
OF POOR QUALITY

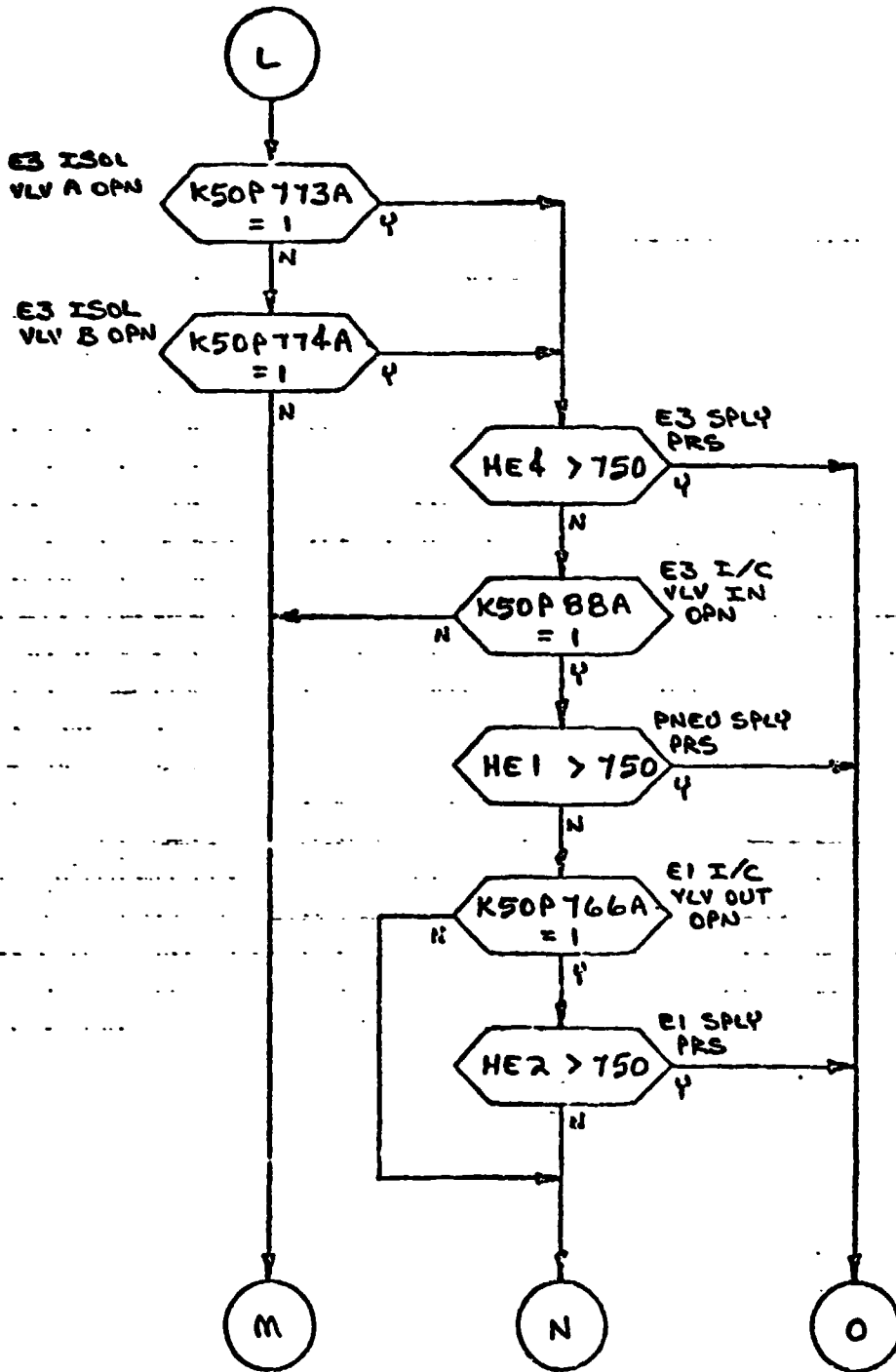
E2 HE PRESS



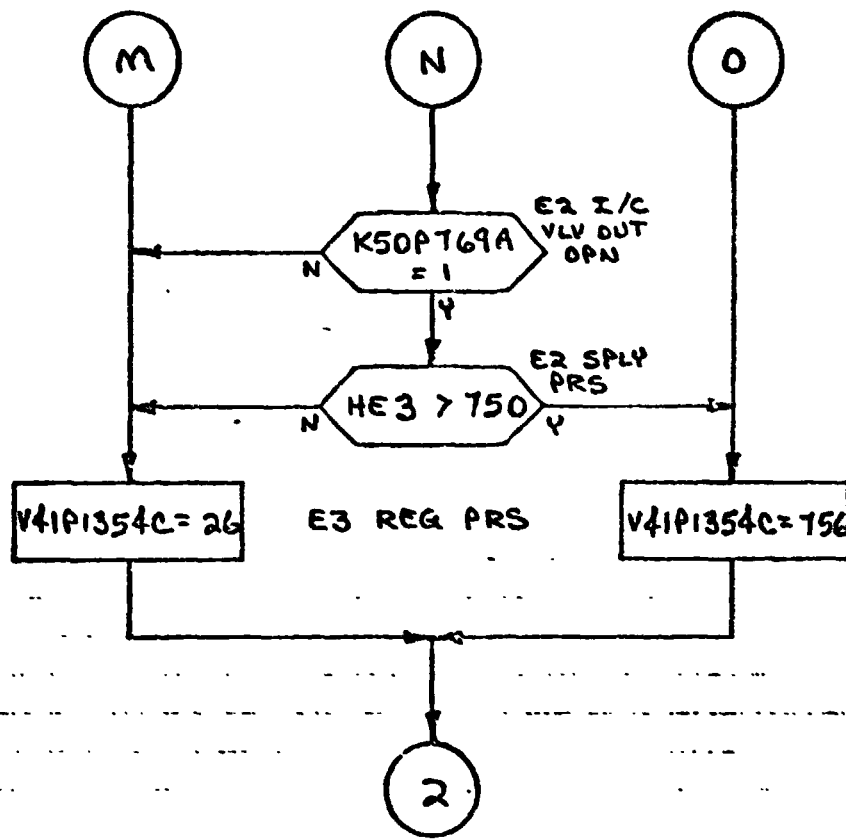
E2 HE PRESS



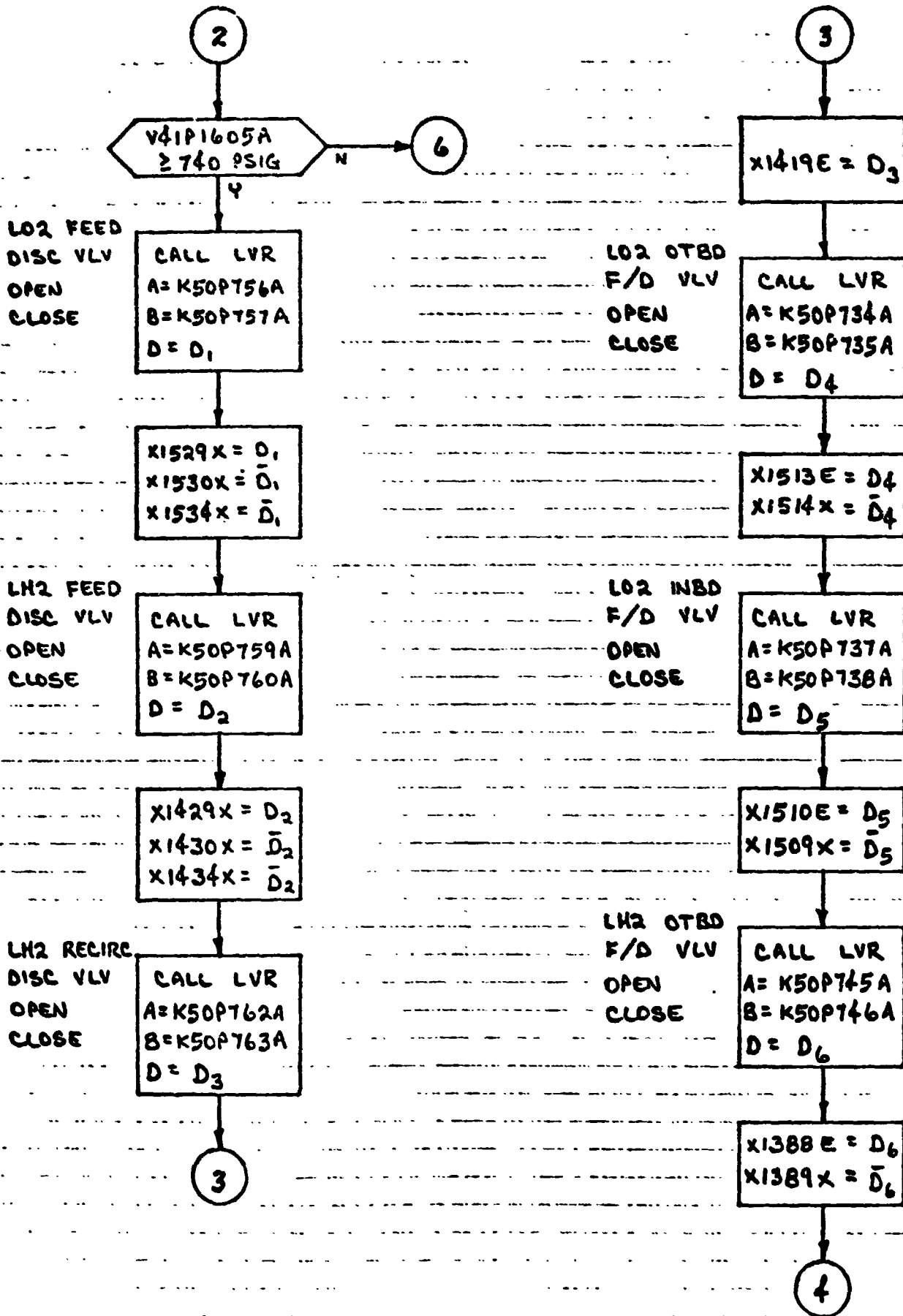
E3 HE PRESS



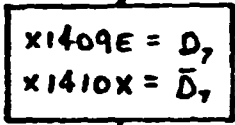
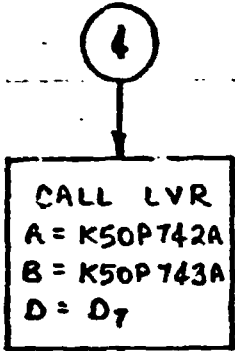
E3 HE PRESS

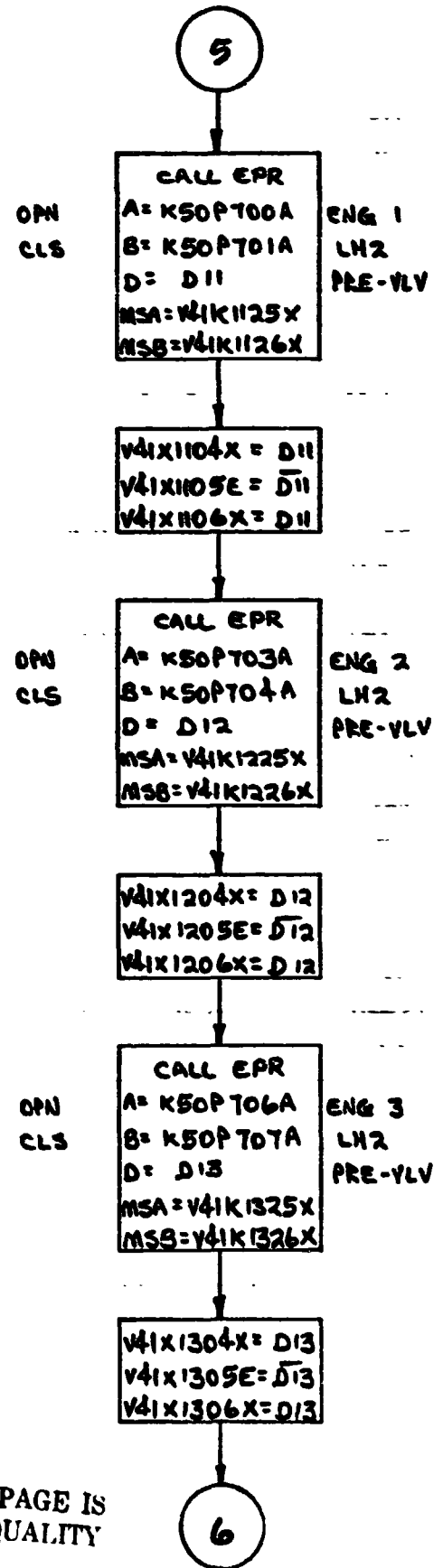
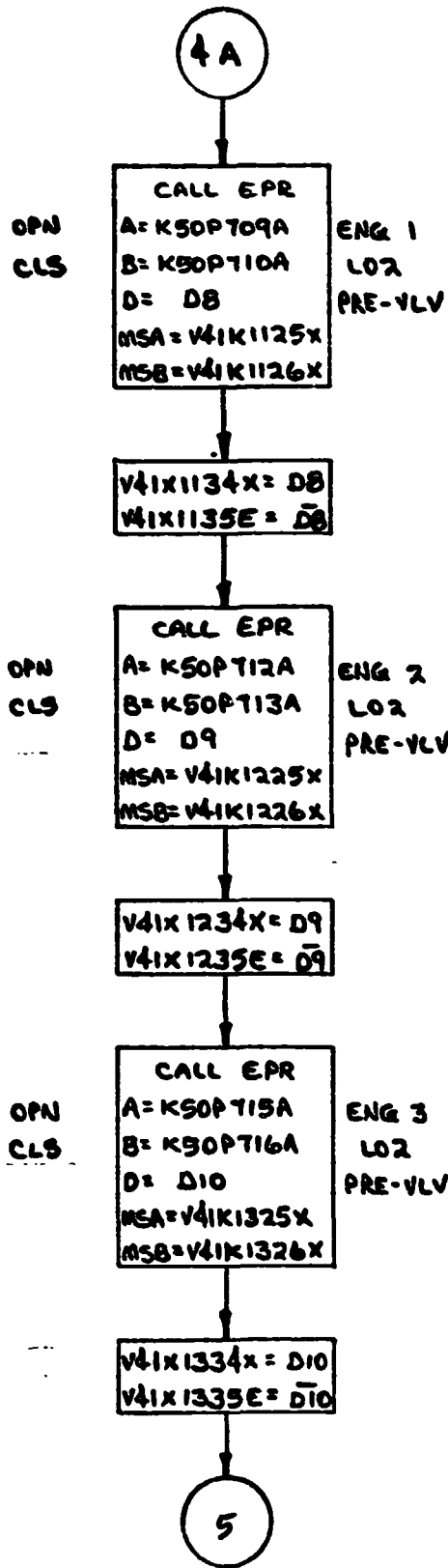


ORIGINAL PAGE IS
OF POOR QUALITY

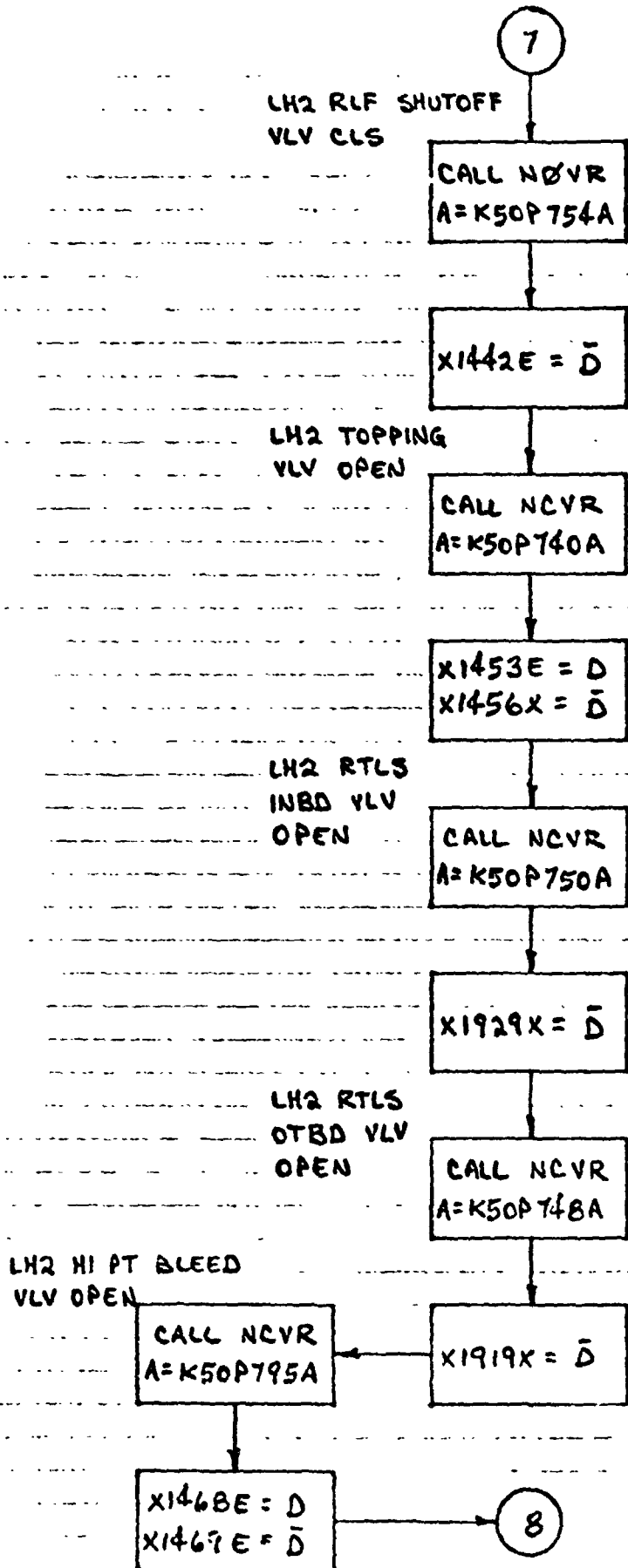
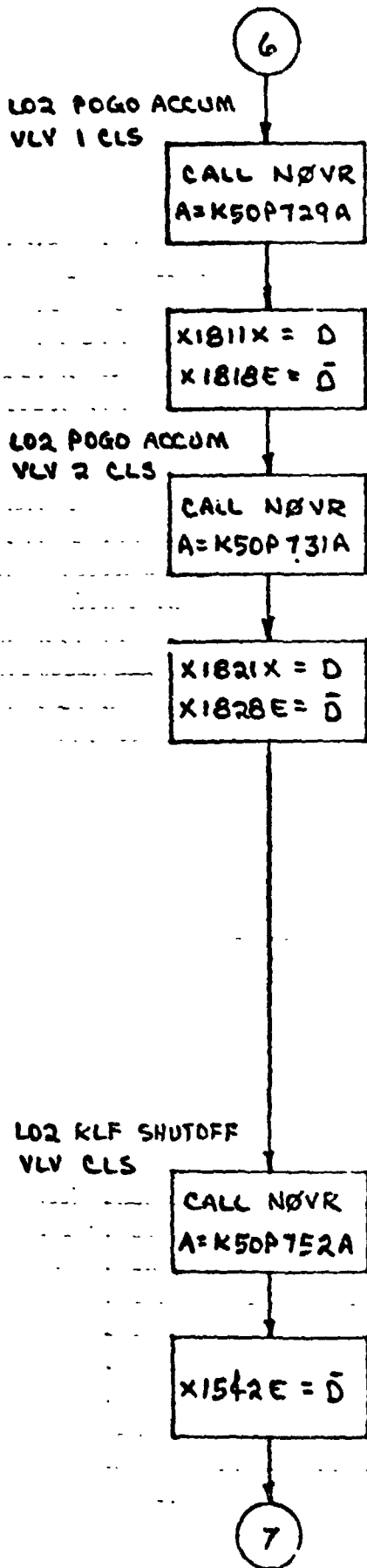


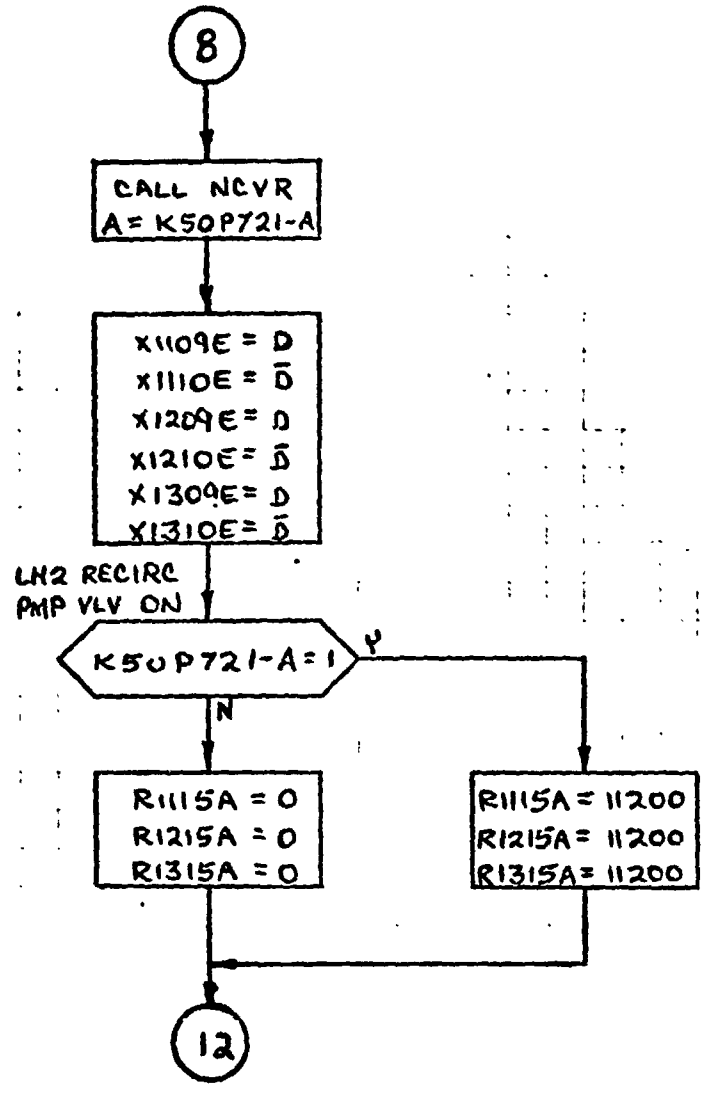
LN2 INBD
F/D VLV
OPEN
CLOSE



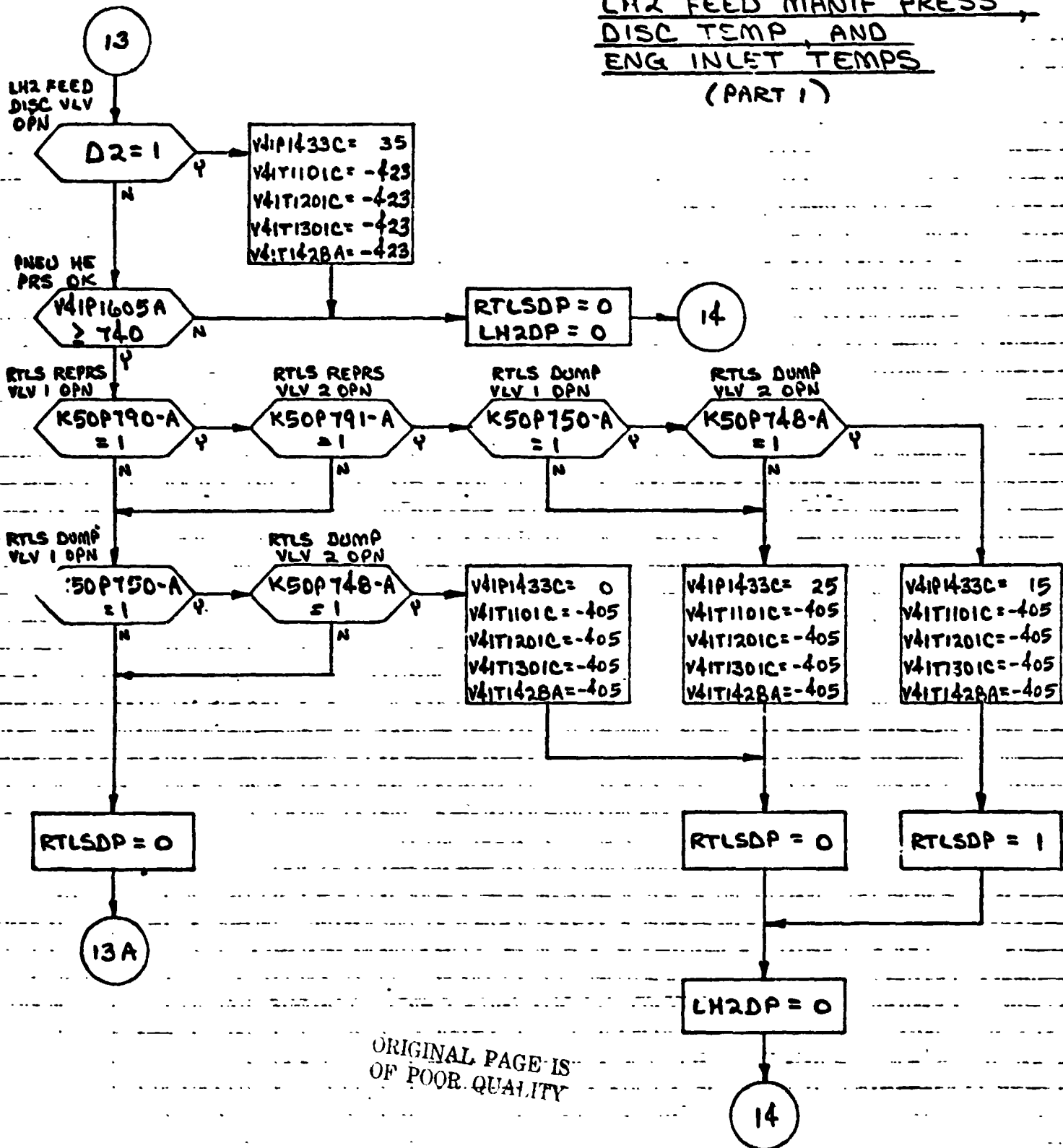


ORIGINAL PAGE IS
OF POOR QUALITY



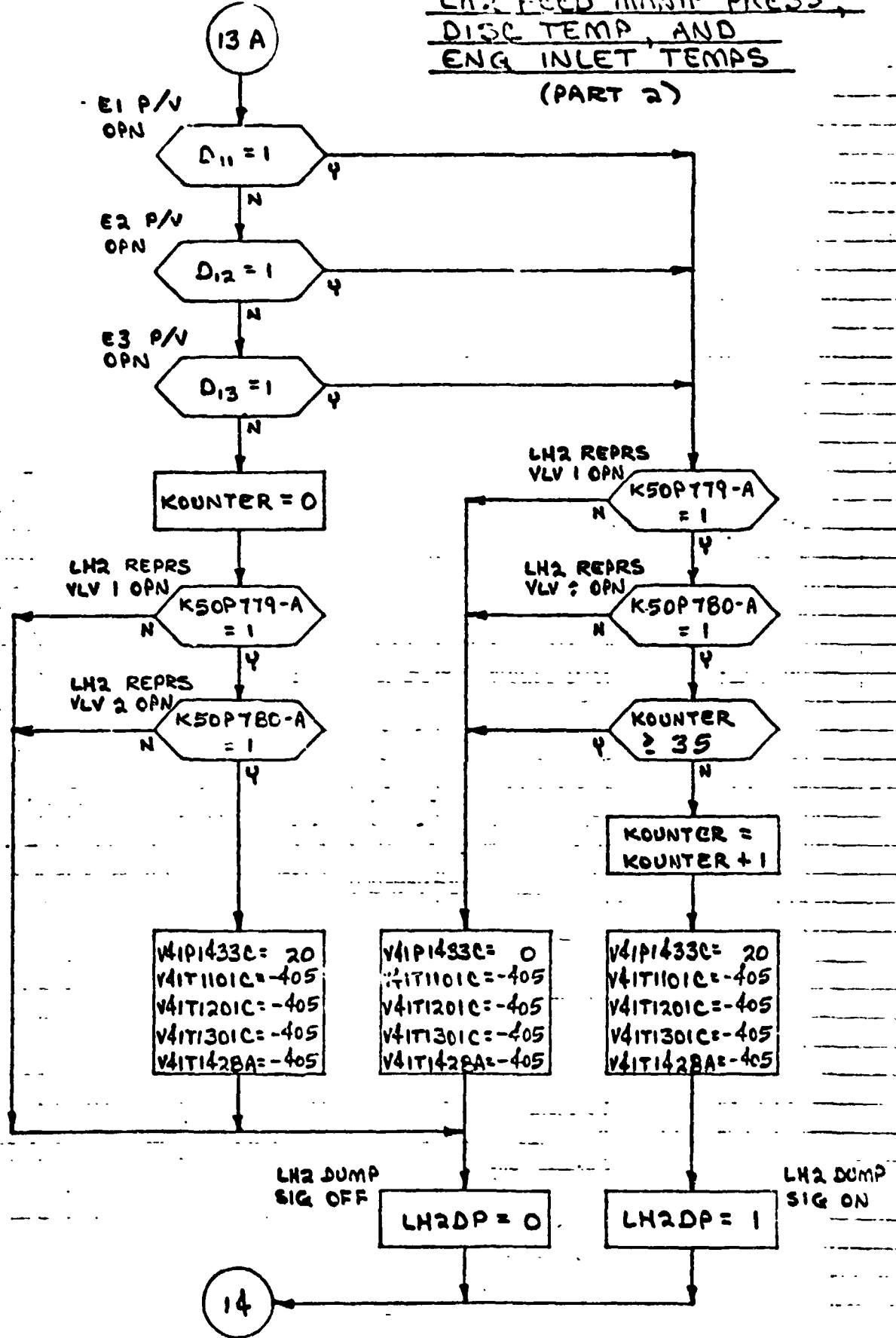


LH2 FEED MANIF PRESS
DISC TEMP, AND
ENG INLET TEMPS
(PART 1)



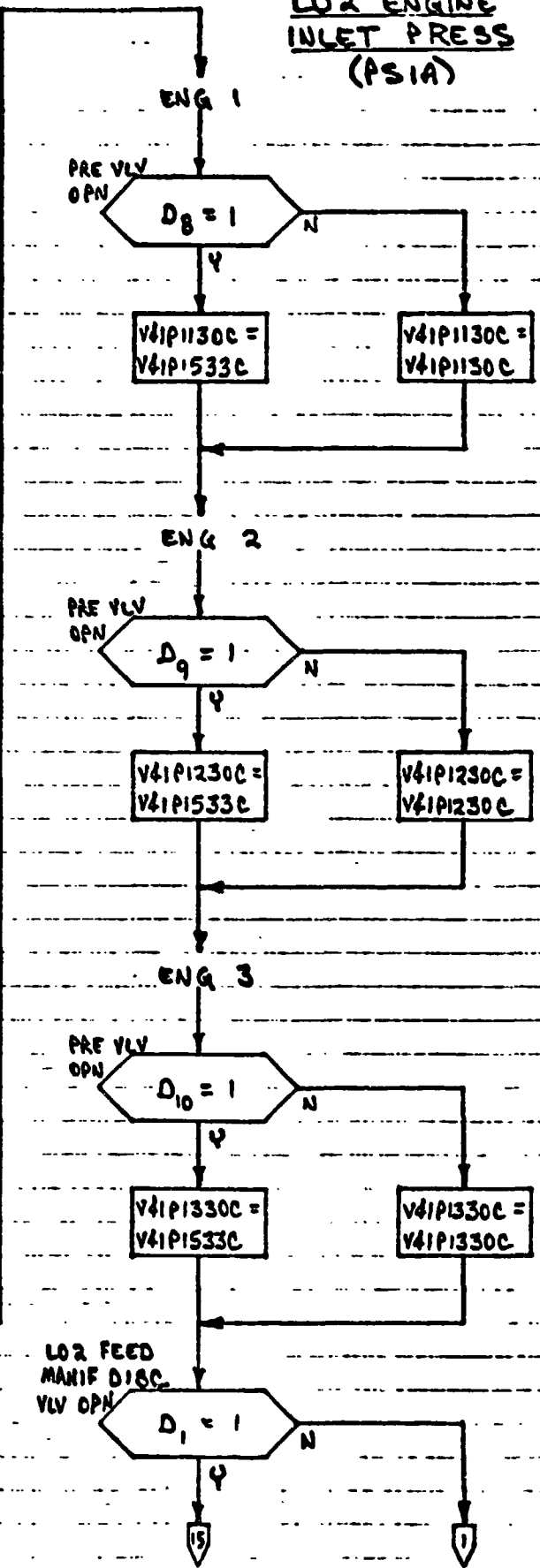
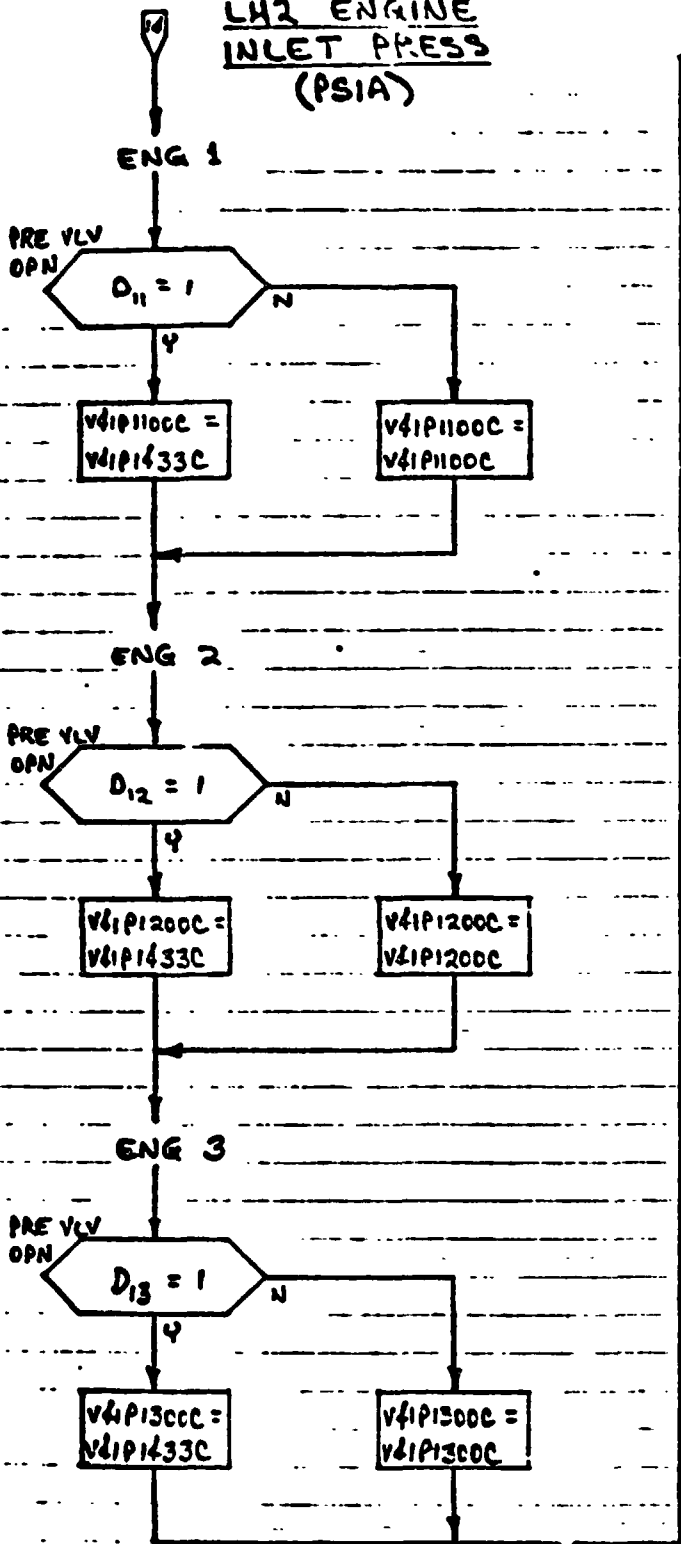
ORIGINAL PAGE IS
OF POOR QUALITY

LH2 FEED MANIF PRESS,
DISC TEMP, AND
ENG INLET TEMPS
(PART 2)

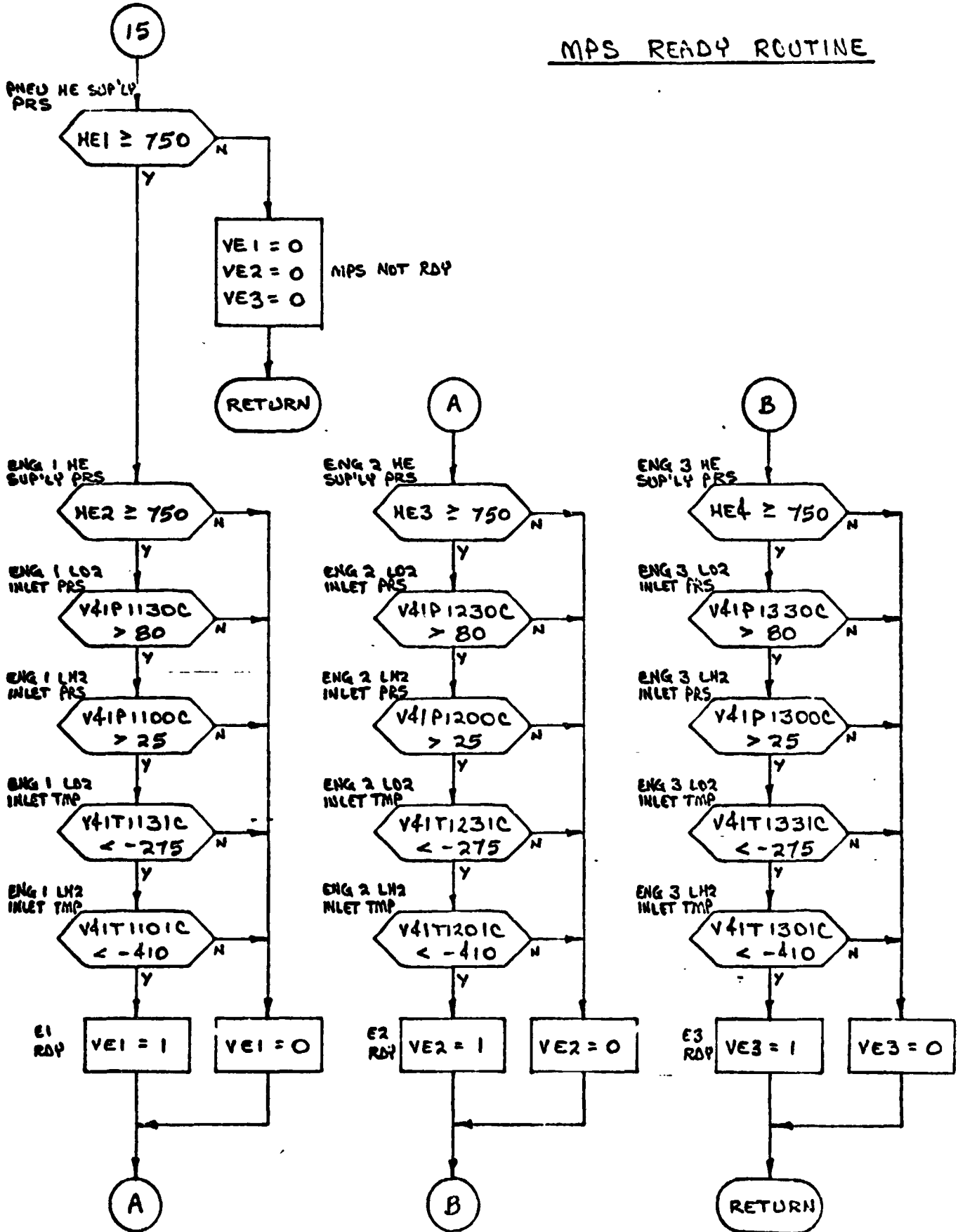


LH2 ENGINE
INLET PRESS
(PSIA)

LO2 ENGINE
INLET PRESS
(PSIA)



MPS READY ROUTINE



14.0 INPUT STIMULI/OUTPUT MEASUREMENT TABLES

PRECEDING PAGE BLANK NOT FILLED

14.1 GTS INPUT TABLE

STIMULI INPUT TO MODEL - TABLE 14.1

IDENTIFICATION NUMBER	NOMENCLATURE	SOURCE	STATES/RANGE		
			LO	HI	UNITS
V41K1119X	ENG 1 LH2 PRE-VLV OPN CMD A	FLT SYS	0	1	STATE
V41K1119E	ENG 1 LH2 PRE-VLV OPN CMD A				
V41K1120X	ENG 1 LH2 PRE-VLV OPN CMD B				
V41K1120E	ENG 1 LH2 PRE-VLV OPN CMD B				
V41K1121X	ENG 1 LH2 PRE-VLV OPN CMD C				
V41K1121E	ENG 1 LH2 PRE-VLV OPN CMD C				
V41K1122X	ENG 1 LH2 PRE-VLV CLS CMD A				
V41K1122E	ENG 1 LH2 PRE-VLV CLS CMD A				
V41K1123X	ENG 1 LH2 PRE-VLV CLS CMD B				
V41K1123E	ENG 1 LH2 PRE-VLV CLS CMD B				
V41K1124X	ENG 1 LH2 PRE-VLV CLS CMD C				
V41K1124E	ENG 1 LH2 PRE-VLV CLS CMD C				
V41K1125X	ENG 1 MAINSTAGE CMD A				
V41K1126X	ENG 1 MAINSTAGE CMD B				
V41K1136X	ENG 1 LO2 PRE-VLV OPN CMD A				
V41K1136E	ENG 1 LO2 PRE-VLV OPN CMD A				
V41K1137X	ENG 1 LO2 PRE-VLV OPN CMD B				
V41K1137E	ENG 1 LO2 PRE-VLV OPN CMD B				
V41K1138X	ENG 1 LO2 PRE-VLV OPN CMD C				
V41K1138E	ENG 1 LO2 PRE-VLV OPN CMD C				
V41K1139X	ENG 1 LO2 PRE-VLV CLS CMD A				
V41K1139E	ENG 1 LO2 PRE-VLV CLS CMD A				
V41K1140X	ENG 1 LO2 PRE-VLV CLS CMD B				
V41K1140E	ENG 1 LO2 PRE-VLV CLS CMD B				
V41K1141X	ENG 1 LO2 PRE-VLV CLS CMD C				
V41K1141E	ENG 1 LO2 PRE-VLV CLS CMD C				
V41K1155E	ENG 1 HE ISOL VLV 1 OPN CMD				
V41K1156E	ENG 1 HE ISOL VLV 2 OPN CMD A				
V41K1157E	ENG 1 HE ISOL VLV 2 OPN CMD B				
V41K1165E	ENG 1 HE ISOL VLV 1 CLS CMD				
V41K1166E	ENG 1 HE ISOL VLV 2 CLS CMD A				
V41K1167E	ENG 1 HE ISOL VLV 2 CLS CMD B				

STIMULI INPUT IO, "PS MODEL - TABLE 14.1

IDENTIFICATION NUMBER	NOMENCLATURE	SOURCE	STATES/RANGE		
			LO	HI	UNITS
V41K1219X	ENG 2 LH2 PRE-VLV OPN CMD A	FLT SYS	0	1	STATE
V41K1219E	ENG 2 LH2 PRE-VLV OPN CMD A				
V41K1220X	ENG 2 LH2 PRE-VLV OPN CMD B				
V41K1220E	ENG 2 LH2 PRE-VLV OPN CMD B				
V41K1221X	ENG 2 LH2 PRE-VLV OPN CMD C				
V41K1221E	ENG 2 LH2 PRE-VLV OPN CMD C				
V41K1222X	ENG 2 LH2 PRE-VLV CLS CMD A				
V41K1222E	ENG 2 LH2 PRE-VLV CLS CMD A				
V41K1223X	ENG 2 LH2 PRE-VLV CLS CMD B				
V41K1223E	ENG 2 LH2 PRE-VLV CLS CMD B				
V41K1224X	ENG 2 LH2 PRE-VLV CLS CMD C				
V41K1224E	ENG 2 LH2 PRE-VLV CLS CMD C				
V41K1225X	ENG 2 MAINSTAGE CMD A				
V41K1226X	ENG 2 MAINSTAGE CMD B				
V41K1236X	ENG 2 L02 PRE-VLV OPN CMD A				
V41K1236E	ENG 2 L02 PRE-VLV OPN CMD A				
V41K1237X	ENG 2 L02 PRE-VLV OPN CMD B				
V41K1237E	ENG 2 L02 PRE-VLV OPN CMD B				
V41K1238X	ENG 2 L02 PRE-VLV OPN CMD C				
V41K1238E	ENG 2 L02 PRE-VLV OPN CMD C				
V41K1239X	ENG 2 L02 PRE-VLV CLS CMD A				
V41K1239E	ENG 2 L02 PRE-VLV CLS CMD A				
V41K1240X	ENG 2 L02 PRE-VLV CLS CMD B				
V41K1240E	ENG 2 L02 PRE-VLV CLS CMD B				
V41K1241X	ENG 2 L02 PRE-VLV CLS CMD C				
V41K1241E	ENG 2 L02 PRE-VLV CLS CMD C				
V41K1255E	ENG 2 HE ISOL VLV 1 OPN CMD				
V41K1256E	ENG 2 HE ISOL VLV 2 OPN CMD A				
V41K1257E	ENG 2 HE ISOL VLV 2 OPN CMD B				
V41K1265E	ENG 2 HE ISOL VLV 1 CLS CMD				
V41K1266E	ENG 2 HE ISOL VLV 2 CLS CMD A				
V41K1267E	ENG 2 HE ISOL VLV 2 CLS CMD B				

ORIGINAL PAGE IS OF POOR QUALITY

STIMULI INPUT TO MD DEL - TABLE 14.1

IDENTIFICATION NUMBER	NOMENCLATURE	SOURCE	STATES/RANGE		UNITS
			LO	H:I	
V41K1319X	ENG 3 LH2 PRE-VLV OPN CMD A	FLT SYS	0	1	STATE
V41K1319E	ENG 3 LH2 PRE-VLV OPN CMD A		0	1	STATE
V41K1320X	ENG 3 LH2 PRE-VLV OPN CMD B	FLT SYS	0	1	STATE
V41K1320E	ENG 3 LH2 PRE-VLV OPN CMD B		0	1	STATE
V41K1321X	ENG 3 LH2 PRE-VLV OPN CMD C	FLT SYS	0	1	STATE
V41K1321E	ENG 3 LH2 PRE-VLV OPN CMD C		0	1	STATE
V41K1322X	ENG 3 LH2 PRE-VLV OPN CMD A	FLT SYS	0	1	STATE
V41K1322E	ENG 3 LH2 PRE-VLV OPN CMD A		0	1	STATE
V41K1323X	ENG 3 LH2 PRE-VLV OPN CMD B	FLT SYS	0	1	STATE
V41K1323E	ENG 3 LH2 PRE-VLV OPN CMD B		0	1	STATE
V41K1324X	ENG 3 LH2 PRE-VLV OPN CMD C	FLT SYS	0	1	STATE
V41K1324E	ENG 3 LH2 PRE-VLV OPN CMD C		0	1	STATE
V41K1325X	ENG 3 MAINSTAGE CMD A	FLT SYS	0	1	STATE
V41K1326X	ENG 3 MAINSTAGE CMD B		0	1	STATE
V41K1336X	ENG 3 L02 PRE-VLV OPN CMD A	FLT SYS	0	1	STATE
V41K1336E	ENG 3 L02 PRE-VLV OPN CMD A		0	1	STATE
V41K1337X	ENG 3 L02 PRE-VLV OPN CMD B	FLT SYS	0	1	STATE
V41K1337E	ENG 3 L02 PRE-VLV OPN CMD B		0	1	STATE
V41K1338X	ENG 3 L02 PRE-VLV OPN CMD C	FLT SYS	0	1	STATE
V41K1338E	ENG 3 L02 PRE-VLV OPN CMD C		0	1	STATE
V41K1339X	ENG 3 L02 PRE-VLV CLS CMD A	FLT SYS	0	1	STATE
V41K1339E	ENG 3 L02 PRE-VLV CLS CMD A		0	1	STATE
V41K1340X	ENG 3 L02 PRE-VLV CLS CMD B	FLT SYS	0	1	STATE
V41K1340E	ENG 3 L02 PRE-VLV CLS CMD B		0	1	STATE
V41K1341X	ENG 3 L02 PRE-VLV CLS CMD C	FLT SYS	0	1	STATE
V41K1341E	ENG 3 L02 PRE-VLV CLS CMD C		0	1	STATE
V41K1355E	ENG 3 HE ISOL VLV 1 OPN CMD	FLT SYS	0	1	STATE
V41K1356E	ENG 3 HE ISOL VLV 2 OPN CMD A		0	1	STATE
V41K1357E	ENG 3 HE ISOL VLV 2 OPN CMD B	FLT SYS	0	1	STATE
V41K1355E	ENG 3 HE ISOL VLV 1 CLS CMD		0	1	STATE
V41K1356E	ENG 3 HE ISOL VLV 2 CLS CMD A	FLT SYS	0	1	STATE
V41K1367E	ENG 3 HE ISOL VLV 2 CLS CMD B		0	1	STATE
V41K1391Y	LH2 OTBD FILL VLV OPN CMD	FLT SYS	0	1	STATE
V41K1391E	LH2 OTBD FILL VLV OPN CMD		0	1	STATE

STIMULI INPUT TO PPS MODEL - TABLE 14.1

IDENTIFICATION NUMBER	NOMENCLATURE	SOURCE	STATES/RANGE		
			LO	HI	UNITS
V41K1393X	LH2 OTBD FILL VLV CLS CMD	FLT SYS	0	1	STATE
V41K1393E	LH2 OTBD FILL VLV CLS CMD		0	1	STATE
V41K1401X	LH2 INBD FILL VLV OPN CMD A	FLT SYS	0	1	STATE
V41K1401E	LH2 INBD FILL VLV OPN CMD A		0	1	STATE
V41K1402X	LH2 INBD FILL VLV OPN CMD B	FLT SYS	0	1	STATE
V41K1411X	LH2 TOPPING VLV OPN CMD		0	1	STATE
V41K1412X	LH2 INBD FILL VLV CLS CMD	FLT SYS	0	1	STATE
V41K1412E	LH2 INBD FILL VLV CLS CMD		0	1	STATE
V41K1413X	LH2 FEED DISC VLV OPN CMD A	FLT SYS	0	1	STATE
V41K1414X	LH2 FEED DISC VLV OPN CMD B		0	1	STATE
V41K1415X	LH2 FEED DISC VLV OPN CMD C	FLT SYS	0	1	STATE
V41K1416X	LH2 FEED DISC VLV CLS CMD A		0	1	STATE
V41K1417X	LH2 FEED DISC VLV CLS CMD B	FLT SYS	0	1	STATE
V41K1418X	LH2 FEED DISC VLV CLS CMD C		0	1	STATE
V41K1421X	LH2 RECIRC DISC VLV OPN CMD	FLT SYS	0	1	STATE
V41K1422X	LH2 RECIRC DISC VLV CLS CMD		0	1	STATE
V41K1431E	LH2 MANIF REPRESS VLV 1 CLS CMD A	FLT SYS	0	1	STATE
V41K1435X	LH2 MANIF REPRESS VLV 1 OPN CMD		0	1	STATE
V41K1435E	LH2 MANIF REPRESS VLV 1 OPN CMD	FLT SYS	0	1	STATE
V41K1437X	LH2 MANIF REPRESS VLV 2 OPN CMD		0	1	STATE
V41K1443E	LH2 FEEDLINE RLF S/O VLV OPN CMD A	FLT SYS	0	1	STATE
V41K1447X	LH2 FEEDLINE RLF S/O VLV CLS CMD A		0	1	STATE
V41K1447E	LH2 FEEDLINE RLF S/O VLV CLS CMD A	FLT SYS	0	1	STATE
V41K1448X	LH2 FEEDLINE RLF S/O VLV CLS CMD B		0	1	STATE
V41K1501X	L02 INBD FILL VLV OPN CMD A	FLT SYS	0	1	STATE
V41K1501E	L02 INBD FILL VLV OPN CMD A		0	1	STATE
V41K1502X	L02 INBD FILL VLV OPN CMD B	FLT SYS	0	1	STATE
V41K1512X	L02 INBD FILL VLV CLS CMD		0	1	STATE
V41K1512E	L02 INBD FILL VLV CLS CMD	FLT SYS	0	1	STATE
V41K1515X	L02 OTBD FILL VLV CLS CMD		0	1	STATE
V41K1515E	L02 OTBD FILL VLV CLS CMD	FLT SYS	0	1	STATE
V41K1518X	L02 OTBD FILL VLV OPN CMD		0	1	STATE
V41K151	L02 OTBD FILL VLV OPN CMD	FLT SYS	0	1	STATE

STIMULI INPUT TO MODEL - TABLE 14.1

IDENTIFICATION NUMBER	NOMENCLATURE	SOURCE	STATES/RANGE		
			LO	HI	U'BITS
V41K1521X V41K1522X V41K1523X V41K1524X V41K1525X V41K1526X V41K1531E V41K1535X V41K1535E V41K1537X V41K1543E V41K1547X V41K1547E V41K1548X V41K1584X V41K1585X V41K1586X V41K1607E	L02 FEED DISC VLV OPN CMD A L02 FEED DISC VLV OPN CMD B L02 FEED DISC VLV OPN CMD C L02 FEED DISC VLV CLS CMD A L02 FEED DISC VLV CLS CMD B L02 FEED DISC VLV CLS CMD C L02 MANIF REPRESS VLV 1 CLS CMD L02 MANIF REPRESS VLV 1 OPN CMD L02 MANIF REPRESS VLV 1 OPN CMD L02 MANIF REPRESS VLV 2 OPN CMD L02 FEEDLINE RLF S/O VLV OPN CMD A L02 FEEDLINE RLF S/O VLV CLS CMD A L02 FEEDLINE RLF S/O VLV CLS CMD A L02 FEEDLINE RLF S/O VLV CLS CMD B L02 OVBD BLEED VLV CLS CMD A L02 OVBD BLEED VLV CLS CMD B L02 OVBD BLEED VLV CLS CMD C HE ISOL PNEU VLV 1/2 OPN CMD	FLT SYS	0	1	STATE
V41K1609E	HE ISOL PNEU VLV 1/2 CLS CMD	FLT SYS	0	1	STATE
V41K1613X V41K1613E	PNEU XOVR NO. 2 OPN CMD PNEU XOVR NO. 2 OPN CMD				
V41K1619E	PNEU XOVR NO. 2 CLS CMD				
V41K1700X V41K1701X	REPLACE LH2 ULLAGE PRESS #1 XDCR REPLACE LH2 ULLAGE PRESS #2 XDCR				

STIMULI INPUT TO S MODEL - TABLE 14.1

IDENTIFICATION NUMBER	NOMENCLATURE	SOURCE	STATES/RANGE		UNITS
			LO	HI	
V41K1702X	REPLACE LH2 ULLAGE PRESS #3 XDCR	FLT SYS	0	1	STATE
V41K1750X	REPLACE LO2 ULLAGE PRESS #1 XDCR				
V41K1751X	REPLACE LO2 ULLAGE PRESS #2 XDCR				
V41K1752X	REPLACE LO2 ULLAGE PRESS #3 XDCR				
V41K1815X	LO2 ACCUM RECIRC VLV 1 CLS CMD A				
V41K1816X	LO2 ACCUM RECIRC VLV 1 CLS CMD B				
V41K1825X	LO2 ACCUM RECIRC VLV 2 CLS CMD A				
V41K1826X	LO2 ACCUM RECIRC VLV 2 CLS CMD B				
V41K1905X	LH2 RTLS MAN REPRESS VLV 1 OPN CMD A				
V41K1906X	LH2 RTLS MAN REPRESS VLV 2 OPN CMD A				
V41K1907X	LH2 RTLS MAN REPRESS VLV 1 OPN CMD B				
V41K1908X	LH2 RTLS MAN REPRESS VLV 2 OPN CMD B				
V41K1913X	LH2 RTLS OTBD D/V OPN CMD A				
V41K1914X	LH2 RTLS OTBD D/V OPN CMD B				
V41K1915X	LH2 RTLS OTBD D/V OPN CMD C				
V41K1923X	LH2 RTLS INBD D/V OPN CMD A				
V41K1924X	LH2 RTLS INBD D/V OPN CMD B				
V41K1925X	LH2 RTLS INBD D/V OPN CMD C				
LH2	LH2 TANK ULLAGE PRESS	FLT SYS	0	1	STATE
LO2	LO2 TANK ULLAGE PRESS	MMES	12	42	PSIG
		MMES	12	42	PSIG
HE1	PNEU HE SUPPLY PRESS	NAS CONSOLE	0	5000	PSIA
HE2	ENG 1 HE SUPPLY PRESS	NAS CONSOLE	0	5000	PSIA
HE3	ENG 2 HE SUPPLY PRESS	NAS CONSOLE	0	5000	PSIA
HE4	ENG 3 HE SUPPLY PRESS	NAS CONSOLE	0	5000	PSIA
K50P721-A	LH2 RECIRC PUMP VLV OPN CMD	NAS CONSOLE	0	1	STATE
K50P795-A	LH2 HI PT BLEED VLV OPN CMD	NAS CONSOLE	0	1	STATE

STIMULI INPUT TO MODEL - TABLE 14.1

IDENTIFICATION NUMBER	NOMENCLATURE	SOURCE	STATES		
			LO	HI	STATE
V41K1155X	E1 HE ISOL VLV 1 OPN CMD	FLT SYS	0	1	
V41K1156X	E1 HE ISOL VLV 2 OPN CMD A				
V41K1157X	E1 HE ISOL VLV 2 OPN CMD B	KYBD	0	1	
V41K1162X	E1 HE INTERCONNECT "IN" VLV OPN CMD A				
V41K1162E	E1 HE INTERCONNECT "IN" VLV OPN CMD A	FLT SYS	0	1	
V41K1163X	E1 HE INTERCONNECT "IN" VLV OPN CMD B				
V41K1163E	E1 HE INTERCONNECT "IN" VLV OPN CMD B	--FLT SYS	0	1	
V41K1168X	E1 HE INTERCONNECT "OUT" VLV OPN CMD A				
V41K1168E	E1 HE INTERCONNECT "OUT" VLV OPN CMD A	KYBD	0	1	
V41K1169E	E1 HE INTERCONNECT "OUT" VLV OPN CMD B				
V41K1255X	E2 HE ISOL VLV 1 OPN CMD	FLT SYS	0	1	
V41K1256X	E2 HE ISOL VLV 2 OPN CMD A				
V41K1257X	E2 HE ISOL VLV 2 OPN CMD B	KYBD	0	1	
V41K1262X	E2 HE INTERCONNECT "IN" VLV OPN CMD A				
V41K1262E	E2 HE INTERCONNECT "IN" VLV OPN CMD A	FLT SYS	0	1	
V41K1263X	E2 HE INTERCONNECT "IN" VLV OPN CMD B				
V41K1263E	E2 HE INTERCONNECT "IN" VLV OPN CMD B	--FLT SYS	0	1	
V41K1268X	E2 HE INTERCONNECT "OUT" VLV OPN CMD A				
V41K1268E	E2 HE INTERCONNECT "OUT" VLV OPN CMD A	KYBD	0	1	
V41K1269E	E2 HE INTERCONNECT "OUT" VLV OPN CMD B				
V41K1355X	E3 HE ISOL VLV 1 OPN CMD	FLT SYS	0	1	
V41K1356X	E3 HE ISOL VLV 2 OPN CMD A				
V41K1357X	E3 HE ISOL VLV 2 OPN CMD B	KYBD	0	1	
V41K1362X	E3 HE INTERCONNECT "IN" VLV OPN CMD A				
V41K1362E	E3 HE INTERCONNECT "IN" VLV OPN CMD A	FLT SYS	0	1	
V41K1363X	E3 HE INTERCONNECT "IN" VLV OPN CMD B				
V41K1363E	E3 HE INTERCONNECT "IN" VLV OPN CMD B	--FLT SYS	0	1	
V41K1368X	E3 HE INTERCONNECT "OUT" VLV OPN CMD A				
V41K1368E	E3 HE INTERCONNECT "OUT" VLV OPN CMD A	KYBD	0	1	
V41K1369E	E3 HE INTERCONNECT "OUT" VLV OPN CMD B				
V41K1408E	LH2 TOPPING VLV CLS CMD	FLT SYS	0	1	
V41K1432E	LH2 MANIF REPRESS NO. 2 CL CMD				
V41K1532E	LH2 MANIF REPRESS NO. 2 CL CMD	--FLT SYS	0	1	
V41K1607X	ONEU VLV HE ISOL VLV 1 OP CMD				
V41K1608X	TWO VLV HE ISOL VLV 2 OP CMD				

14.2 GTS OUTPUT TABLE

MEASUREMENT OUTPUT FROM MPS MODEL - TABLE 14.2

IDENTIFICATION NUMBER	NOMENCLATURE	DESTINATION	STATES/RANGE			UNITS
			LO	HI	I.C.	
V41P1100C	ENG 1 LH2 INLET PRESS	FS	0	200	0	PSIA
V41T1101C	ENG 1 LH2 INLET TEMP		-430	-60	-423	DEGF
V41X1104X	ENG 1 LH2 PRE-VLV OPEN - A		0	1	1	STATE
V41X1105E	ENG 1 LH2 PRE-VLV CLOSED		0	1	0	STATE
V41X1106X	ENG 1 LH2 PRE-VLV OPEN - B		0	1	1	STATE
V41X1109E	ENG 1 LH2 RECIRC VLV OPEN		0	1	1	STATE
V41X1110E	ENG 1 LH2 RECIRC VLV CLOSED		0	1	0	STATE
V41R1115A	ENG 1 LH2 RECIRC PUMP SPEED		0	12000	11200	RPM
V41P1130C	ENG 1 LO2 RECIRC PUMP SPEED		0	300	0	PSIA
V41T1131C	ENG 1 LO2 INLET PRESS		0	255	-290	DEGF
V41X1134X	ENG 1 LO2 INLET TEMP		-305	0	1	STATE
V41X1135E	ENG 1 LO2 PRE-VLV OPEN		0	1	0	STATE
V41P1150C	ENG 1 HE SUPPLY PRESS		0	5000	4000	PSIA
V41P1154C	ENG 1 HE REG OUT PRESS		0	1000	750	PSIG
V41P1200C	ENG 2 LH2 INLET PRESS		0	200	0	PSIA
V41T1201C	ENG 2 LH2 INLET TEMP		-430	-405	-423	DEGF
V41X1204X	ENG 2 LH2 PRE-VLV OPEN - A		0	1	1	STATE
V41X1205E	ENG 2 LH2 PRE-VLV CLOSED		0	1	0	STATE
V41X1206X	ENG 2 LH2 PRE-VLV OPEN - B		0	1	1	STATE
V41X1209E	ENG 2 LH2 RECIRC VLV OPEN		0	1	1	STATE
V41X1210E	ENG 2 LH2 RECIRC VLV CLOSED		0	1	0	STATE
V41R1215A	ENG 2 LH2 RECIRC VLV PUMP SPEED		0	12000	11200	RPM
V41P1230C	ENG 2 LO2 INLET PRESS		0	300	0	PSIA
V41T1231C	ENG 2 LO2 INLET TEMP		-305	-255	-290	DEGF
V41X1234X	ENG 2 LO2 PRE-VLV OPEN		0	1	1	STATE
V41X1235E	ENG 2 LO2 PRE-VLV CLOSED		0	1	0	STATE
V41P1250C	ENG 2 HE SUPPLY PRESS		0	5000	4000	PSIA
V41P1254C	ENG 2 HE REG OUT PRESS		0	1000	750	PSIG
V41P1300C	ENG 3 LH2 INLET PRESS		0	200	0	PSIA
V41T1301C	ENG 3 LH2 INLET TEMP		-430	-405	-423	DEGF
V41X1304X	ENG 3 LH2 PRE-VLV OPEN - A		0	1	1	STATE
V41X1305E	ENG 3 LH2 PRE-VLV CLOSED		0	1	0	STATE
V41X1306X	ENG 3 LH2 PRE-VLV OPEN - B		0	1	1	STATE

IDENTIFICATION NUMBER	NOMENCLATURE	DESTINATION	STATES/RANGE			UNITS
			LO	HI	I.C.	
V41X1309E	ENG 3 LH2 RECIRC VLV OPEN	FS ↑-----↓	0	1	1	STATE
V41X1310E	ENG 3 LH2 RECIRC VLV CLOSED		0	1	0	STATE
V41R1315A	ENG 3 LH2 RECIRC PUMP SPEED		0	12000	11200	REP.
V41P1330C	ENG 3 LO2 INLET PRESS		0	300	0	PSIA
V41T1331C	ENG 3 LO2 INLET TEMP		-305	355	-290	DEGF
V41X1334X	ENG 3 LO2 PRE-VLV OPEN		0	1	1	STATE
V41X1335	ENG 3 LO2 PRE-VLV CLOSED		0	1	0	STATE
V41P1350C	ENG 3 HE SUPPLY PRESS		0	5000	4000	PSIA
V41P1354C	ENG 3 HE REG OUT PRESS		0	1000	750	PSIG
V41X1388E	LH2 OTBD FILL VLV OPEN		0	1	0	STATE
V41X1389X	LH2 OTBD FILL VLV CLOSED		0	1	1	STATE
V41X1409E	LH2 INBD FILL VLV OPEN		0	1	0	STATE
V41X1410X	LH2 INBD FILL VLV CLOSED		0	1	1	STATE
V41X1419E	LH2 RECIRC DISC VLV OPEN		0	1	1	STATE
V41X1429X	LH2 FEED DISC VLV OPEN		0	1	1	STATE
V41X1430X	LH2 FEED DISC VLV CLOSED - A		0	1	0	STATE
V41P1433C	LH2 ENG MANIFOLD PRESS		0	100	55	PSIA
V41X1434X	LH2 FEED DISC VLV CLOSED - B		0	1	0	STATE
V41X1442E	LH2 FEED LINE RLF SHUT-OFF VLV CLOSED		0	1	0	STATE
V41X1453E	LH2 TOPPING VLV OPEN		0	1	1	STATE
V41X1456X	LH2 TOPPING VLV CLOSED	0	1	0	STATE	
V41X1509X	LO2 INBD FILL VLV CLOSED	0	1	1	STATE	
V41X1510E	LO2 INBD FILL VLV OPEN	0	1	0	STATE	
V41X1513E	LO2 OTBD FILL VLV OPEN	0	1	0	STATE	
V41X1514X	LO2 OTBD FILL VLV CLOSED	0	1	1	STATE	
V41X1529X	LO2 FEED DISC VLV OPEN	0	1	1	STATE	
V41X1530X	LO2 FEED DISC VLV CLOSED - A	0	1	0	STATE	
V41P1533C	LO2 ENG MANIFOLD PRESS	0	300	155	PSIA	
V41X1534X	LO2 FEED DISC VLV CLOSED - B	0	1	0	STATE	
V41X1542E	LO2 FEED LINE RLF SHUT-OFF VLV CLOSED	0	1	0	STATE	

ORIGINAL PAGE IS OF POOR QUALITY

MEASUREMENT OUTPUT OF PS MODEL - TABLE 14.2

IDENTIFICATION NUMBER	NOMENCLATURE	DESTINATION	STATES/VALUES		
			LO	HI	I.C. UNITS
V41X1580X	LO2 OVBD BLEED VLV CLOSED - A	FS	0	1	STATE
V41X1581X	LO2 OVBD BLEED VLV CLOSED - B		0	1	STATE
V41X1587E	LO2 OVBD BLEED VLV OPEN		0	1	STATE
V41P1600A	LO2 PNEU VLV HE SUPPLY PRESS		0	5000	PSIA
V41X1811X	LO2 ACCUM RECIRC VLV 1 OPEN		0	1	STATE
V41X1818E	LO2 ACCUM RECIRC VLV 1 CLOSED		0	1	STATE
V41X1821X	LO2 ACCUM RECIRC VLV 2 OPEN		0	1	STATE
V41X1828E	LO2 ACCUM RECIRC VLV 2 CLOSED		0	1	STATE
V41X1919X	LH2 RTLS OTBD DRAIN VLV CLOSED		0	1	STATE
V41X1929X	LH2 RTLS INBD DRAIN VLV CLOSED		0	1	STATE
VGH1	ENG 1 GH2 FLOW CONTROL VLV POSN - LO	FS	0	1	STATE
VGH2	ENG 2 GH2 FLOW CONTROL VLV POSN - LO	MMES	0	1	STATE
VGH3	ENG 3 GH2 FLOW CONTROL VLV POSN - LO		0	1	STATE
VG01	ENG 1 GO2 FLOW CONTROL VLV POSN - LO		0	1	STATE
VG02	ENG 2 GO2 FLOW CONTROL VLV POSN - LO		0	1	STATE
VG03	ENG 3 GO2 FLOW CONTROL VLV POSN - LO		0	1	STATE
VE1	ENG 1 PLUMBING READY DISCRETE		0	1	STATE
VE2	ENG 2 PLUMBING READY DISCRETE		0	1	STATE
VE3	ENG 3 PLUMBING READY DISCRETE		0	1	STATE
V41P1605A	PNEU HE REG OUT PRESS	FS	0	1000	PSIG
V41X1468E	LH2 HI POINT BLEED VLV OPEN	FS	0	1	STATE
V41X1469E	LH2 HI POINT BLEED VLV CLOSED	FS	0	1	STATE
V41T1428A	LH2 FEED MANIFOLD DISC TEMP	FS	-430	-405	DEGF
V41T1528A	LO2 FEED MANIFOLD DISC TEMP	FS	-305	-255	DEGF
LO2DP	LO2 DUMP SIGNAL	FDS	0	1	STATE
LH2DP	LH2 DUMP SIGNAL	FDS	0	1	STATE
RTLSDP	RTLS DUMP SIGNAL	FDS	0	1	STATE

14.3 NAS CRT DISPLAY

Figure 4 depicts the NAS CRT display format of which MPS math model parameters are a part. The format is specified in this document to aid in implementing the MPS NAS program.

ORIGINAL PAGE IS
OF POOR QUALITY

15.0 GTS REFERENCES

- 15.1 VS70-415001, MAIN PROPULSION SYSTEM SCHEMATIC
- 15.2 382-240-CDM/76-062, ROCKWELL PRELIMINARY REQUIREMENTS
- 15.3 382-240-CDM/76-064, PRELIMINARY REQUIREMENTS UPDATE
- 15.4 LEC-7827, MPS SIMULATION REQUIREMENTS
- 15.5 SD76-SH-0026, MPS DUMP SEQUENCE (LEVEL C FSSR)
- 15.6 GNCTS-02 GNCTS CREW STATION TO GTS (ALL ELEMENTS) ICD
- 15.7 GNCTS-06 GTS/NON-AVIONICS SIMULATOR ICD

APPENDIX F
FUEL CELL/CRYO MATH MODEL REQUIREMENTS

CONTENTS

Section	Page
1. INTRODUCTION.	F-3
2. DETAILED REQUIREMENTS	F-4
2.1 <u>FUNCTIONAL CHARACTERISTICS</u>	F-4
2.1.1 FUEL CELL/CRYOGENICS SYSTEM	F-4
2.1.2 MODEL FUNCTION	F-4
2.1.3 INPUT/OUTPUT	F-8
2.2 <u>DCM UPLINK</u>	F-8
2.3 <u>INITIALIZATION REQUIREMENTS.</u>	F-8
2.4 <u>TERMINATION REQUIREMENTS</u>	F-8
2.5 <u>UNIQUE REQUIREMENTS.</u>	F-9
2.5.1 INTERNAL VARIABLES	F-9
2.6 <u>ANALOG MEASUREMENTS.</u>	F-10
2.6.1 POLYNOMIAL CONVERSION METHOD	F-10
2.6.2 RANGE LIMIT CONVERSION METHOD.	F-13
3. LOGIC FLOW DIAGRAMS	F-14
4. TABLES.	F-44
4.1 <u>INPUT STIMULI LIST</u>	F-45
4.2 <u>OUTPUT MEASUREMENTS LIST</u>	F-50
5. REFERENCES.	F-55

CONTENTS

FIGURES

Figure		Page
1.	INPUT/OUTPUT DATA FLOW.	F-5
2.	FUEL CELL/CRYO SUBSYSTEM SCHEMATIC.	F-6

ORIGINAL PAGE
NOT REPRODUCIBLE

1.0 INTRODUCTION

Math models are used to simulate many of the Shuttle systems for which hardware does not exist in SAIL. A group of these models are termed non-avionics models since they do not simulate avionics equipment. The non-avionics models are needed to provide responses to cockpit switches, to drive cockpit displays, and to supply data for on-board software processing. The following list of non-avionics models will operate within the Test Operations Center (TOC) Ground Standard Interface Unit (GSIU).

- Main Propulsion System (Orbiter Portion)
- APU/Hydraulic
- Active Thermal Control
- Atmosphere Revitalization System (H₂O Loops and PCS/Airlock)
- Fuel Cell/Cryogenics
- Smoke Detection
- Water/Waste Management

When the TOC Display and Control Module (DCM) operator depresses the "SYS LOAD" key, the model programs, which are stored on the Fixed Head Disk in the DCM, are automatically loaded into the GSIU. The models are then activated and terminated by DCM test language statements. While the models are operating in the GSIU, the DCM operator is able to inhibit one, all, or any combination of model outputs with test language statements. This provides the DCM operator with control of output parameter values when off-nominal conditions are desired. To simplify the models and ease the processing load on supporting test equipment, the model requirements define nominal conditions only. Further, analog values for output parameters change in step fashion when responding to inputs, except when specific change rates for particular parameters are required. The DCM operator is also able to alter the value that the model uses to generate parameter outputs. This allows the DCM operator to adjust output parameter values as needed to satisfy various mission phases.

When the model is activated, it shall check the input stimuli and shall provide appropriate output measurement values. It is preferred that the model provide output data when the input stimuli changes. Bus activity is then minimal during those mission phases when the stimuli remains constant. However, the GSIU operating system may require a cyclic model program in which case the model output rate shall be once per second.

2.0 DETAILED REQUIREMENTS

This model simulates the Orbiter Fuel Cell/Cryogenics System (FC/CRYO) by representing the stimulus/response relationships which exist at the power and signal interfaces between the Orbiter Avionics System and the FC/CRYO. The model has been simplified by including only those output signals which are needed to support the type of testing which will be accomplished in the Shuttle Avionics Integration Laboratory (SAIL).

The model receives stimuli from two sources (see Figure 1).

- 1) The Flight System (FS) via the Signal Termination Module (STM).
- 2) The Test Operations Center (TOC) Display and Control Module (DCM) via test language.

The model output parameters go to the FS via the STM. Tables 1 and 2 list the input and output parameters respectively. The three stimuli which come from the DCM are used to inform the model when the fuel cells are on line and providing electrical power to the FS.

2.1 FUNCTIONAL CHARACTERISTICS

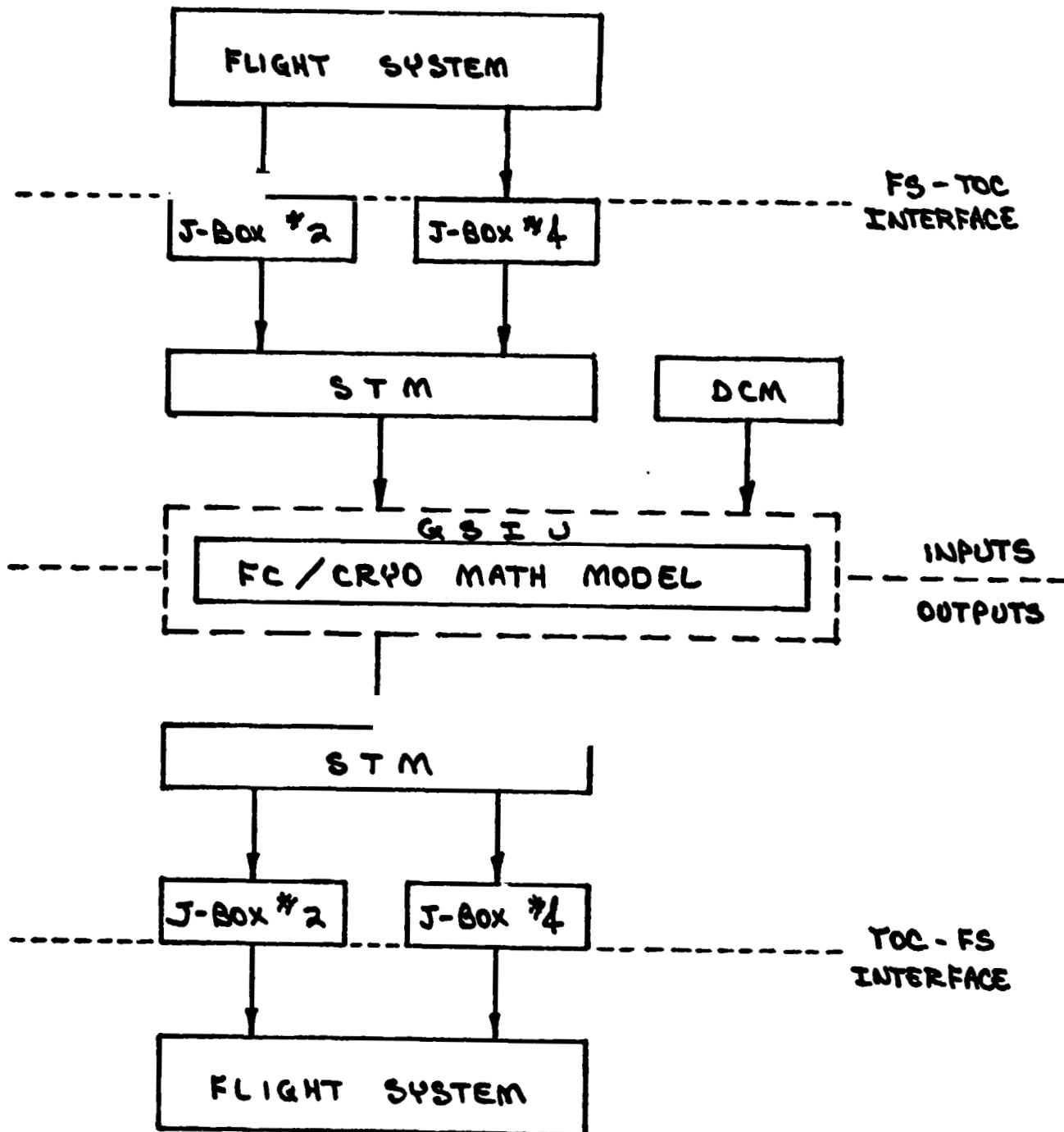
2.1.1 Fuel Cell/Cryogenics System

The FC/CRYO system provides the Orbiter with electrical power and can be divided into two major systems, 1) the fuel cell power plants where reactants are converted into electrical energy, and 2) the reactant storage and distribution system where reactants are stored in a cryogenic state, then heated to a gas and supplied to the fuel cell power plants. Gaseous oxygen is also provided for the Environmental Control and Life Support System (ECLSS) as well as potable water, a by-product of the fuel cell energy reaction. Figure 2 is a simplified schematic of the FC/CRYO system. The wiring details of hydrogen and oxygen tank 4 was not available when the FC/CRYO math model requirements were written. Consequently only tanks 1, 2 and 3 are simulated in the math model, and tank 4 is shown in dashed lines in figure 2 for reference purposes. There are three fuel cells although Figure 2 shows only one for clarity. Each fuel cell has a water coolant loop to transport heat from heat exchangers. To improve the performance of the fuel cells, purge valves are provided to flush impurities overboard. The purge operation may be performed manually or automatically by the GPC but must be initiated by the crew. Each fuel cell has a power rating of 2 to 7 KW continuous duty, or 12 KW peak duty for not more than 15 minutes. Output voltage is 28 to 32 volts DC.

2.1.2 Model Function

In preparing the requirements for the non-avionics system math models, the following ground rules were observed:

- Output all measurements addressed to flight critical MDM's.
- Output those measurement used in dedicated displays, systems management, or caution and warning.



INPUT / OUTPUT DATA FLOW

FIGURE 1

- Output those measurements needed for operation by other systems.
- Output those measurements needed during pre-launch operations, starting at T-20 minutes.
- Respond to stimuli inputs in a discrete manner (no timed transients simulating pressure or temperature build-up and decay, for example).
- Do not account for depletion of expendables during a mission.

These ground rules are intended to simplify the math models without compromising the avionics testing in SAIL. Where required, specific ground rules may be waived.

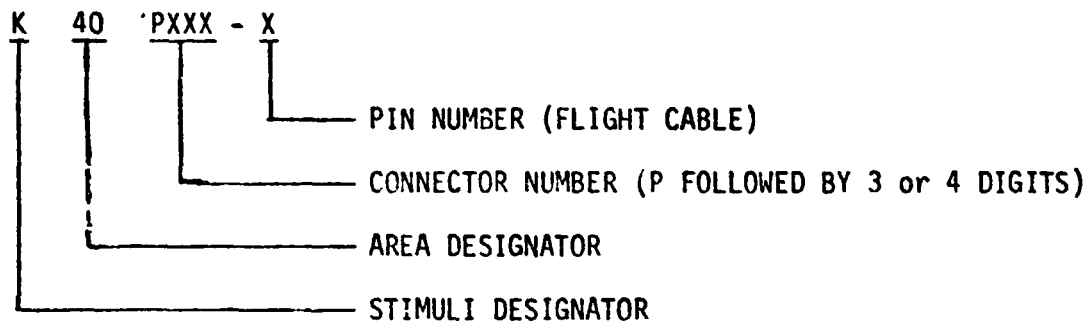
In the FC/CRYO model, the delay on start-up, while heaters reach operating temperatures, is not simulated. Temperatures will jump immediately to their nominal values. Data values remain fixed until altered by a change in input stimuli.

Since fuel cell substitutes are actually providing the vehicle power during SAIL tests, it is necessary that the DCM operator signal the FC/CRYO model when a particular fuel cell is supposed to be supplying power. This allows the proper O₂ and H₂ flow rates to be determined. The actual current flowing in the vehicle busses is not visible to the math model, so when a fuel cell is simulating supplying power, the O₂ and H₂ flow rates provided by the model will be either at their maximum or minimum value, depending on whether or not a purge is in progress. This prevents vehicle software from calculating an erroneous position for the O₂ and H₂ purge valves. There is no position indication measurement on the purge valves so flight software monitors the total reactant flow (provided by the model) and subtracts a calculated amount based on the current in the bus (provided by the fuel cell substitutes). This difference will then indicate the purge valve is open or closed.

The heaters in the O₂ and H₂ cryogenic tanks are controlled by a three position switch: 1-Off, 2-AUTO, 3-ON, and by a heater controller. The math model does not know the position of the switch. The math model will see only power or no power to the heaters as provided by the heater controller. Using a tank pressure value that is less than the low limit will cause the heater controller to provide power whenever the switch is in AUTO or ON. When no power is supplied the switch will be assumed OFF and the tank pressure value will then reflect a heaters OFF condition.

2.1.3 Input/Output

The stimuli identification for those stimuli which have their sources at the flight system via the STM are coded in terms reference Avionics Test Article (ATA) interface connector and pin number according to the following format.



Those stimuli which are uplinked to the model from the DCM are given unique alphanumeric variable names. The model output parameters whose destinations are the flight system via the STM are identified by their Master Measurement List measurements.

2.2 DCM UPLINK

Three stimuli are uplinked to the FC/CRYO math model from the DCM, one for each fuel cell. These stimuli let the math model know when a fuel cell is or is not providing power to the vehicle, so that proper O2 and H2 flow rates may be determined. Refer to Table 1. Faults are simulated by inhibiting the model output for the affected measurement(s) and uplinking the off-nominal value(s) from the DCM to the STM. The exact manner in which this is accomplished is covered in documentation for the GSIU Operating System.

2.3 INITIALIZATION REQUIREMENTS

All model outputs are functions of the inputs alone and need not be initialized since values will be calculated by the model in its first cycle. The initial condition column in Table 2 is for reference only.

2.4 TERMINATION REQUIREMENTS

None.

2.5 UNIQUE REQUIREMENTS

2.5.1 INTERNAL VARIABLES

<u>NAME</u>	<u>FUNCTION</u>	<u>STATE</u>	
		<u>0</u>	<u>1</u>
FLAG	Indicates the state of O2 pressure on the fuel cell coolant accumulator.	PRESS LO	PRESS OK
OP	Indicates the state of O2 pressure at fuel cell 3 supply valve inlet.	PRESS LO	PRESS OK
HP	Indicates the state of H2 pressure at fuel cell 3 supply valve inlet.	PRESS LO	PRESS OK
A	Represents an OPEN command in the Latching Valve Routine (LVR).	OFF	ON
B	Represents a CLOSE command in the Latching Valve Routine (LVR).	OFF	ON
V	Indicates the valve position in the Latching Valve Routine (LVR).	CLSD	OPN
V1	O2 GSE supply valve position.	OPN	CLSD
V2	H2 GSE supply valve position.	OPN	CLSD
V3	O2 isolation valve 1.	CLSD	OPN
V4	O2 isolation valve 2.	CLSD	OPN
V5	H2 isolation valve 1.	CLSD	OPN
V6	H2 isolation valve 2.	CLSD	OPN
V7	O2 ECLSS supply valve 1.	CLSD	OPN
V8	O2 ECLSS supply valve 2.	CLSD	OPN
V9	FC 1 O2 reactant supply valve.	CLSD	OPN
V10	FC 1 H2 reactant supply valve.	CLSD	OPN
V11	FC 2 O2 reactant supply valve.	CLSD	OPN
V12	FC 2 H2 reactant supply valve.	CLSD	OPN
V13	FC 3 O2 reactant supply valve.	CLSD	OPN
V14	FC 3 H2 reactant supply valve.	CLSD	OPN

2.6 ANALOG MEASUREMENTS

Values shown in the math model flowcharts are in GSIU counts for all analog measurements. The math model values are seen by the flight system as 0 to 5 VDC inputs. The flight system then converts these input voltages to engineering units using one of the two types of scaling equations discussed in Sections 2.6.1 and 2.6.2. The GSIU math model count values (or the count values entered at the DCM by the test operator) must consider the scaling computation done later by the flight software, so that correct flight system engineering unit values are obtained for fault detection and annunciation (FDA), and for cockpit displays. The following two sections, 2.6.1 and 2.6.2, describe the scaling equations which apply to this model. Section 2.6.1 describes the scaling equation for measurements which require the polynomial conversion method. Section 2.6.2 describes the scaling equation for measurements which require the range limit conversion method which was used on STS-1.

2.6.1 POLYNOMIAL CONVERSION METHOD

The scaling polynomial equation used by the flight system is defined in the SM FSSR. The general form of the equation is given as follows:

$$FS_{EU} = A_0 + A_1X + A_2X^2 + A_3X^3$$

where: FS_{EU} = flight system engineering units

X = flight system input voltage

A_0, A_1, A_2, A_3 = scaling polynomial coefficients

The following example shows the step by step procedure for converting analog measurements from flight system engineering units (FS_{EU}) to GSIU counts. This procedure may be used to calculate GSIU count values for fault insertion at the DCM.

Example:

For measurement no. V63R1100A, convert FS_{EU} value = 2288 to GSIU counts.

Step 1:

In the SM FSSR, look up the measurement no. (V63R1100A) within the "SMM Data Requirements - Subsystems Displays" table. The measurement no. will appear on two consecutive pages as follows: page A will show engineering units, range low value and range high value, while page B will show the scaling polynomial coefficients (labelled A_0, A_1, A_2, A_3) followed by curve order, independent variable, and STS flight no. The values on page B will be of prime interest to do this example conversion, and will be referred to in the following discussion.

Step 2:

The coefficients will be used in the scaling polynomial:

$$FS_{EU} = A_0 + A_1X + A_2X^2 + A_3X^3$$

Solve the following scaling polynomial for X:

$$2288 = 443.167 + 851.956X - 143.904X^2 + 12.246X^3$$

$$\text{so } X = 3.846469$$

Step 3:

Notice the independent variable column labelled IND VR equals 2 for measurement no. V63R1100A. The 2 specifies that the independent variable X of the scaling polynomial is defined on a range of 0 to 5 VDC. So $X = 3.846$ VDC.

It is of interest to note that if IND VR had been equal to 0, X would have been defined on a range of 0 to 1023 PCM integer counts in which case X would be equal to 4 PCM counts, i.e. 3.846 rounded to the nearest integer.

However, in the example being worked, X is defined as VDC and $X = 3.846$ VDC.

Step 4:

Now to convert X VDC to GSIU counts, evaluate the following equation which shows the relationship between X and GSIU counts:

$$\text{GSIU counts} = \left[X \left(\frac{1023}{K} \right) \right], \text{ rounded to the nearest integer}$$

where $K = 5$, for X defined as VDC (IND VR = 2) and

$K = 500$, for X defined as PCM counts (IND VR = 0).

For the example, evaluate:

$$\text{GSIU counts} = \left[3.846 \left(\frac{1023}{5} \right) \right], \text{ rounded to the nearest integer}$$

Therefore, GSIU counts = 787 counts.

Note that since GSIU counts are always rounded to the nearest integer, small changes will possibly occur in the values of X and consequently FS_{EU} , when the reverse calculations are made during test operations, as the following shows:

$$X = \text{GSIU counts} \left(\frac{K}{1023} \right)$$

$$X = 787 \times \left(\frac{5}{1023} \right)$$

$$\text{SO } X = 3.846529$$

And

$$FS_{EU} = 443.167 + 851.956X - 143.904X^2 + 12.246X^3$$

$$FS_{EU} = 443.167 + 851.956(3.848) - 143.904(3.848)^2 + 12.246(3.848)$$

$$FS_{EU} = 2288.017$$

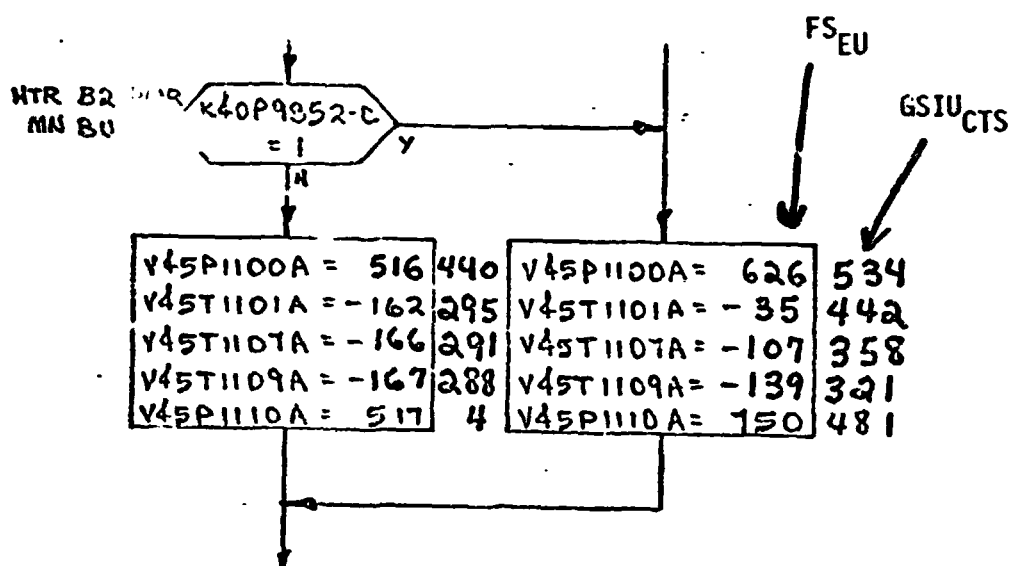
Hence when 787 GSIU counts is inserted for measurement no. V63R100A, a value of 2288.017 FS_{EU} will result.

2.6.2 RANGE LIMIT CONVERSION METHOD

NONE.

3.0 LOGIC FLOW DIAGRAMS

The logic flow diagram is made up of interconnected lines, boxes, decisions, and offpage connectors. Notice that where analog measurements are listed in boxes and decisions, the value inside the box is in flight system engineering units (FS_{EU}) while the corresponding GSIU count value is listed outside the box. For example, the box on the right hand below,

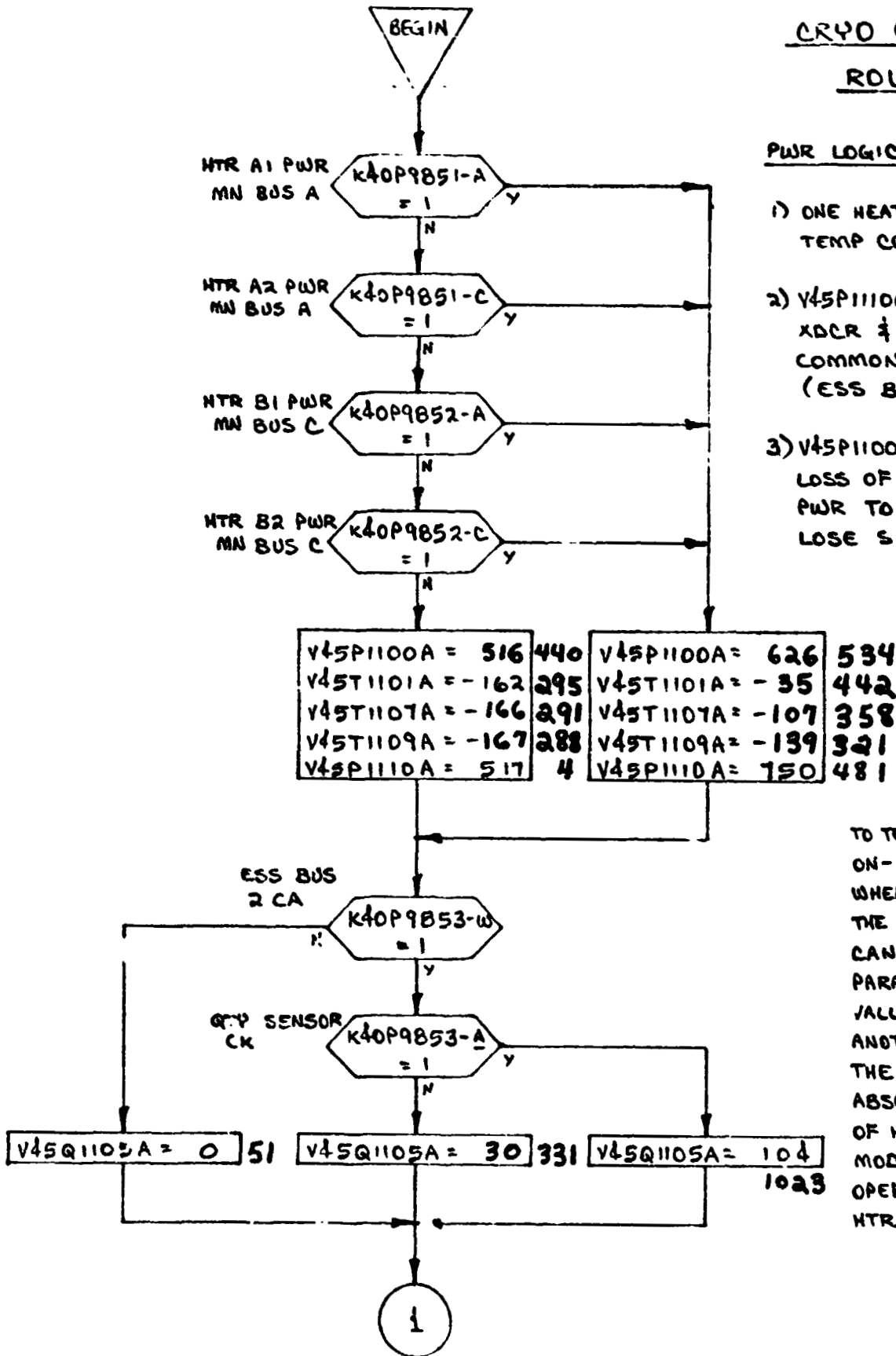


shows that V45P1100A is set equal to 626 FS_{EU} which is equivalent to 534 $GSIU_{CTS}$ shown outside the box.

CRYO O2 TANK 1
ROUTINE

PWR LOGIC:

- 1) ONE HEATER GIVES POSITIVE TEMP CONTROL .
- 2) V45P1100A PRESS PWR TO XDCR & SIGNAL AMP IS COMMON IN SC A2 . (ESS BUS 2 CA)
- 3) V45P1100A PRESS REQUIRES LOSS OF MNA AND MNB PWR TO SC OF1 TO LOSE SIGNAL .

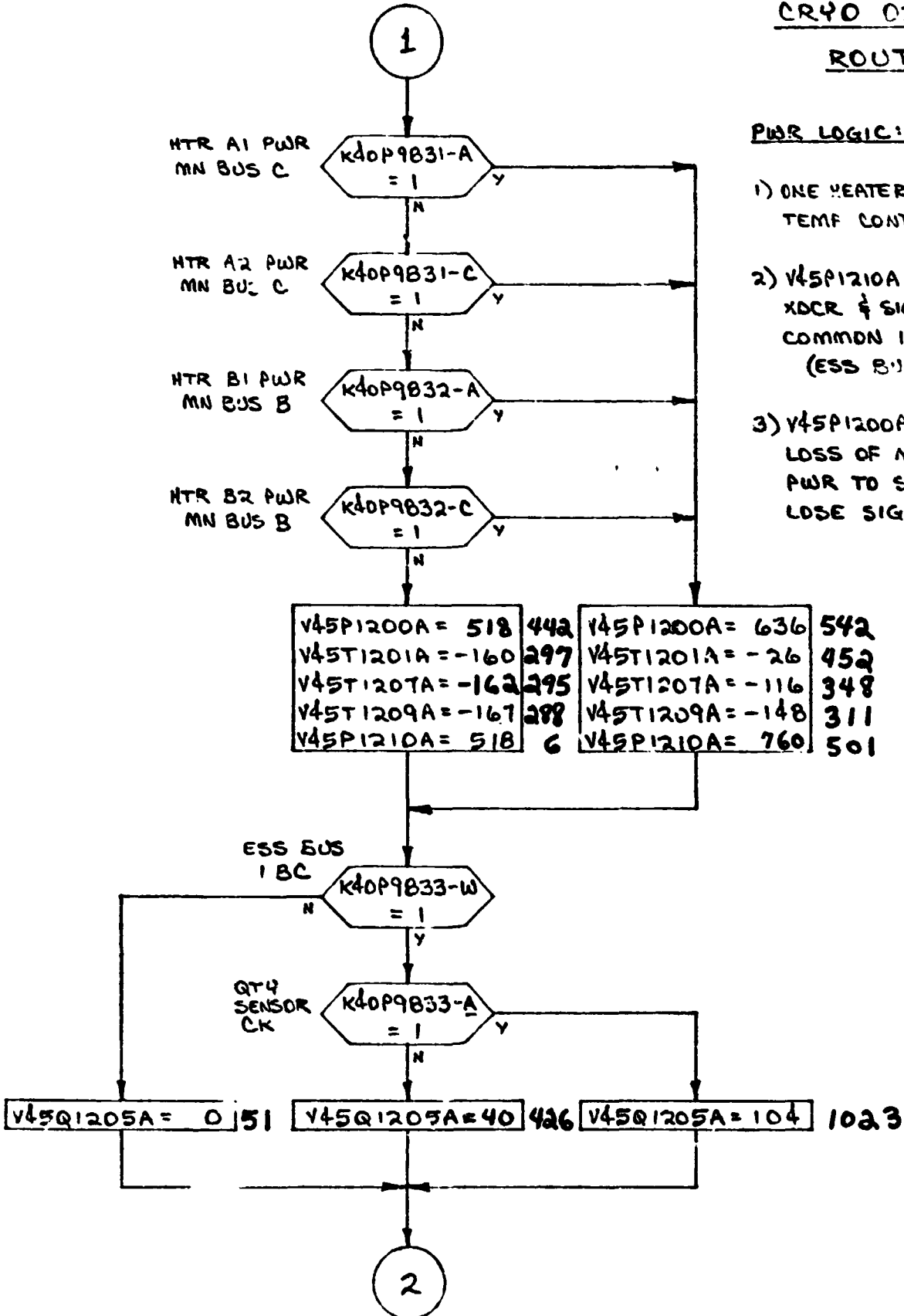


TO TEST THE HTR CONT ON-OFF CAPABILITY WHEN HTR SW ARE IN THE AUTO POSN, TDC CAN INHIBIT THIS PARAMETER'S OUTPUT VALUE AND CAN ENTER ANOTHER VALUE FROM THE DCM . THEN THE ABSENCE OR PRESENCE OF HTR PWR TO THE MODEL WILL INDICATE OPERATION OF THE HTR CONT .

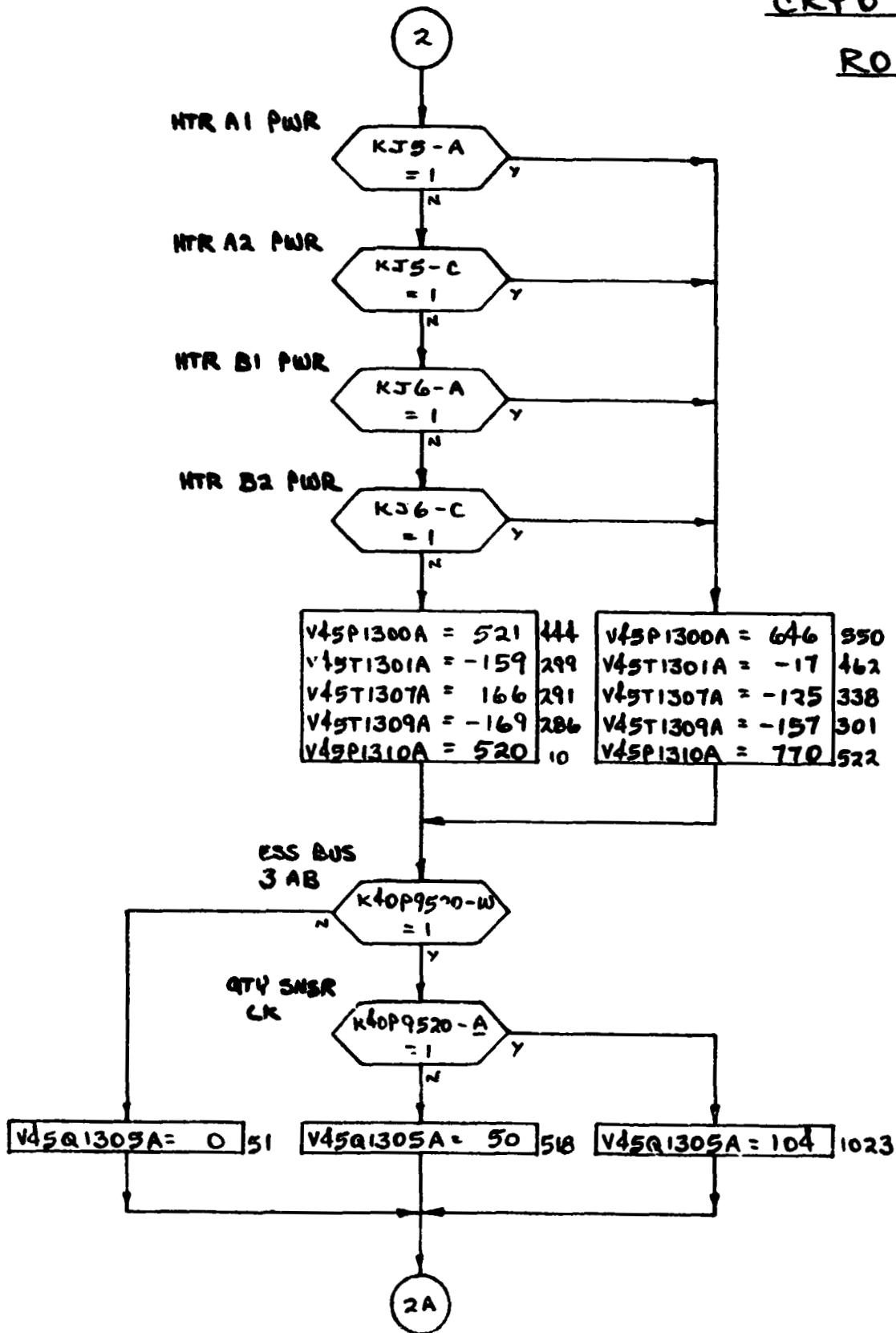
CRYO O2 TANK 2
ROUTINE

PWR LOGIC:

- 1) ONE HEATER GIVES POSITIVE TEMP CONTROL .
- 2) V45P1210A PRESS PWR TO XDCR & SIGNAL AMP IS COMMON IN SC A2 .
(ESS BUS :BC)
- 3) V45P1200A PRESS RELIEVES LOSS OF MNC AND MNC PWR TO SC OF3 TO LOSE SIGNAL .



CRYO O2 TANK 3
ROUTINE

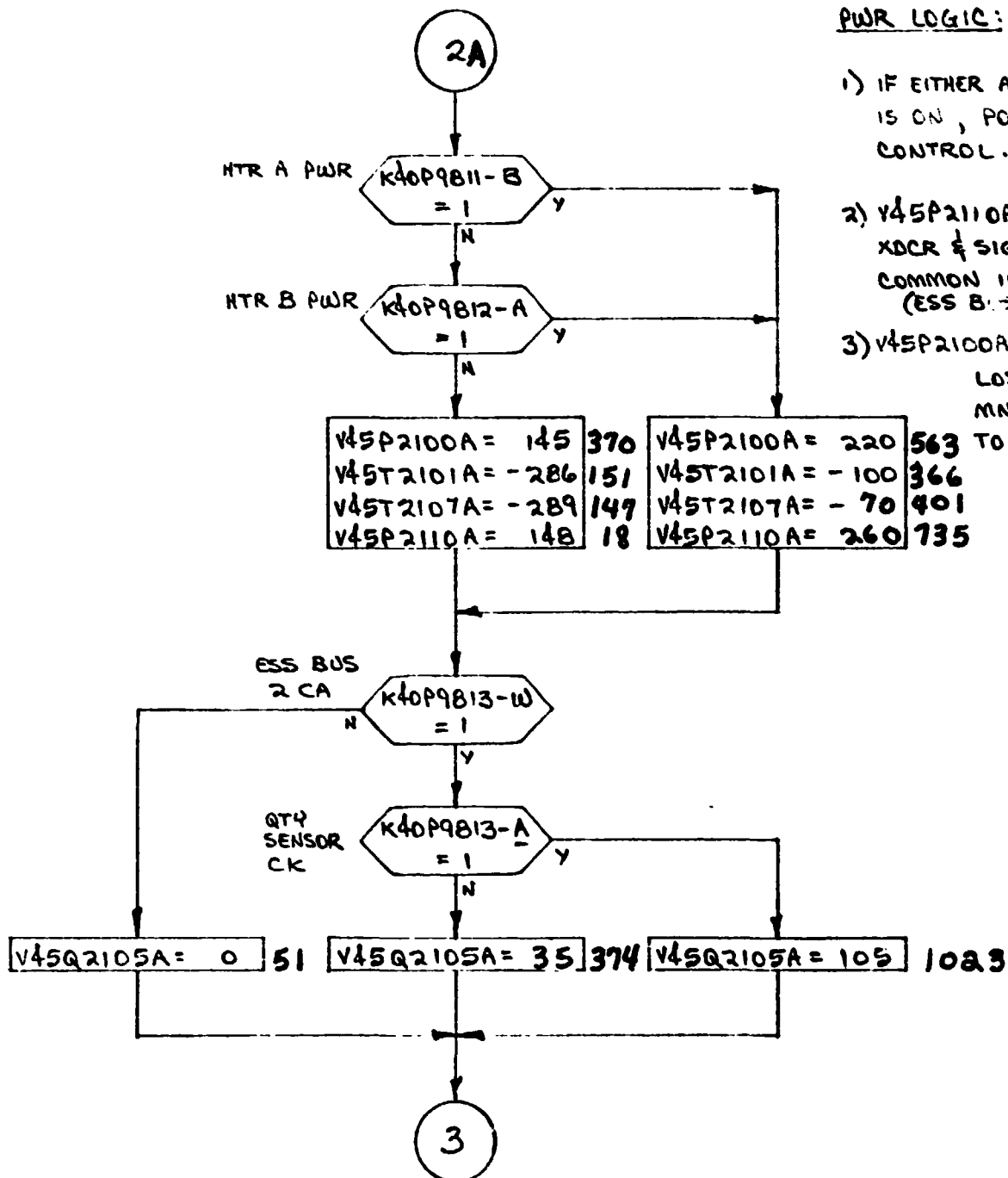


ORIGINAL PAGE 1
OF FOUR PAGES

CRYO H2 TANK 1
ROUTINE

PWR LOGIC:

- 1) IF EITHER A-PWR OR B-PWR IS ON, POSITIVE TEMP CONTROL.
- 2) V45P2110A PRESS PWR TO XDCR & SIGNAL AMP IS COMMON IN SC A1. (ESS BUS 2CA)
- 3) V45P2100A PRESS REL. TO LOSS OF MNA AND MNB PWR TO SC OF1 TO LOSE SIGNAL.

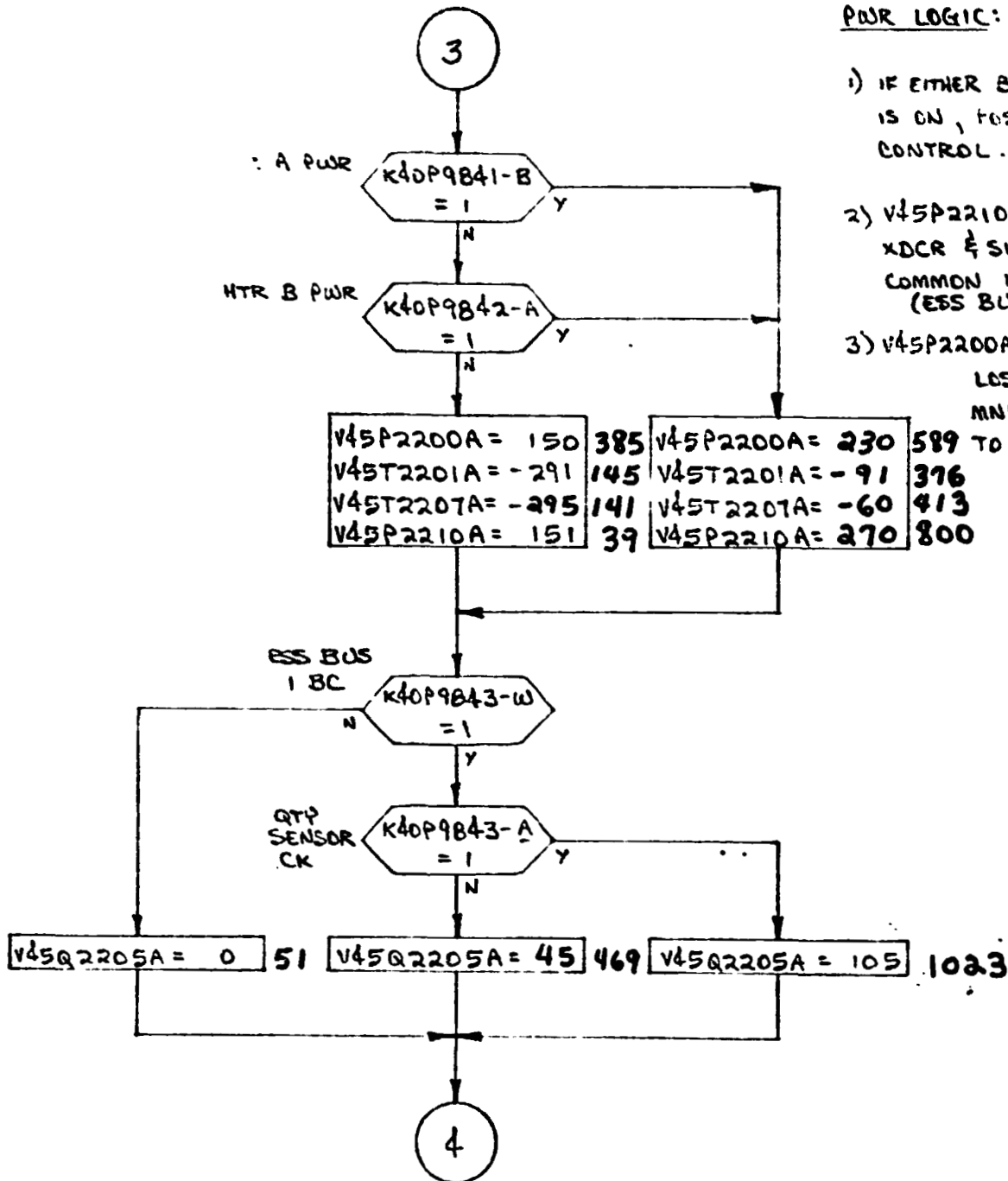


CRYO H2 TANK 2

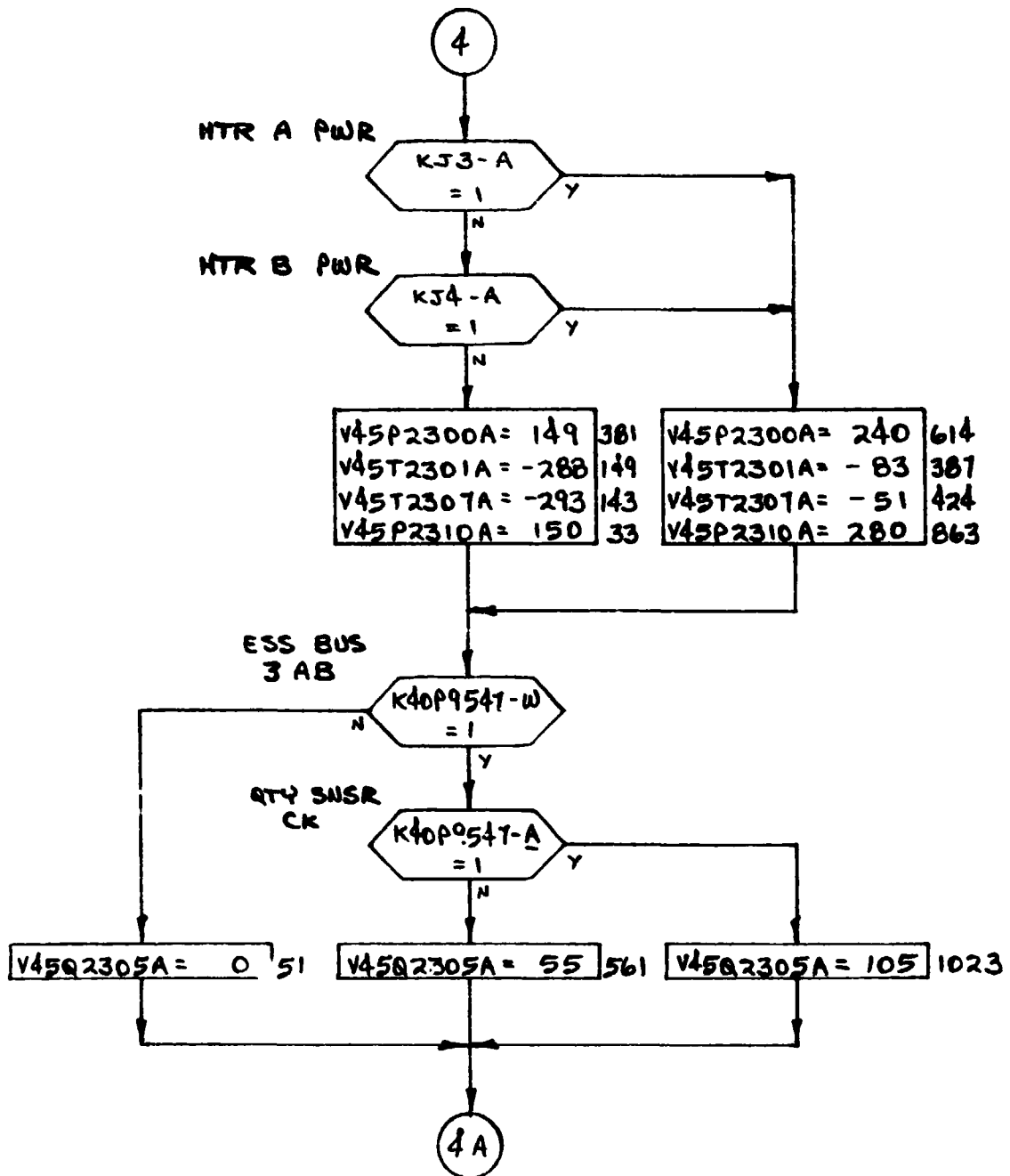
ROUTINE

PWR LOGIC:

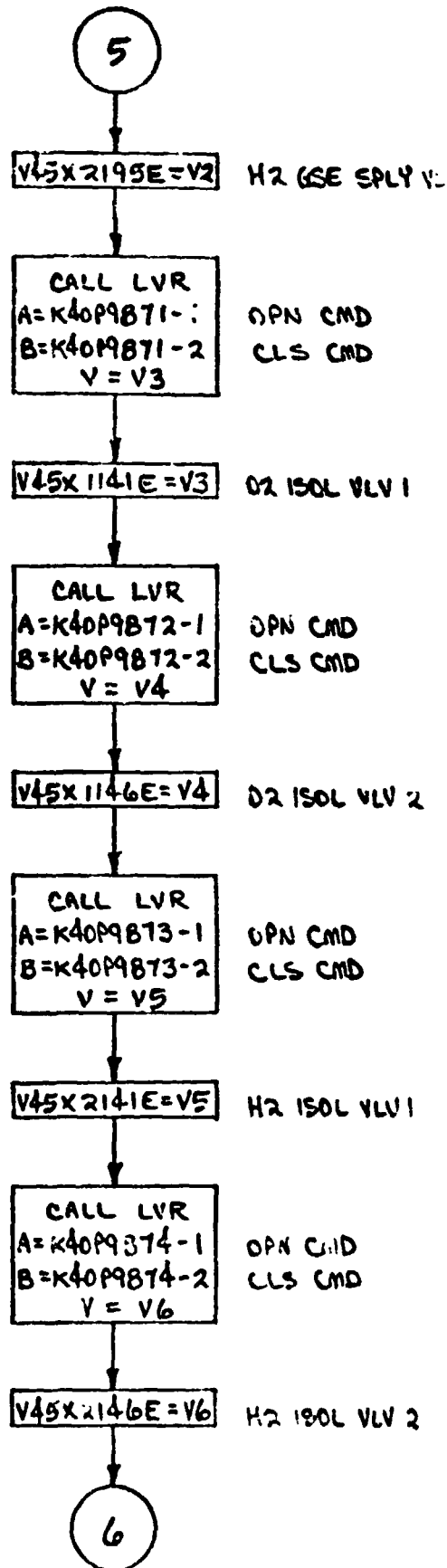
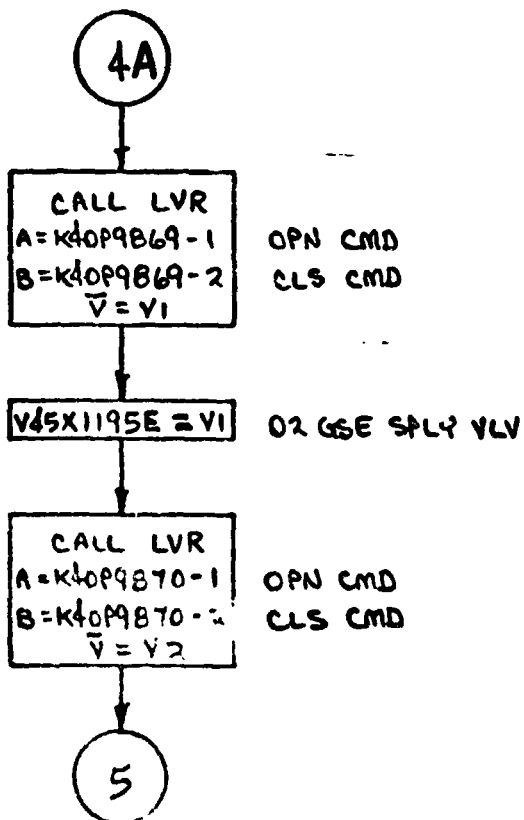
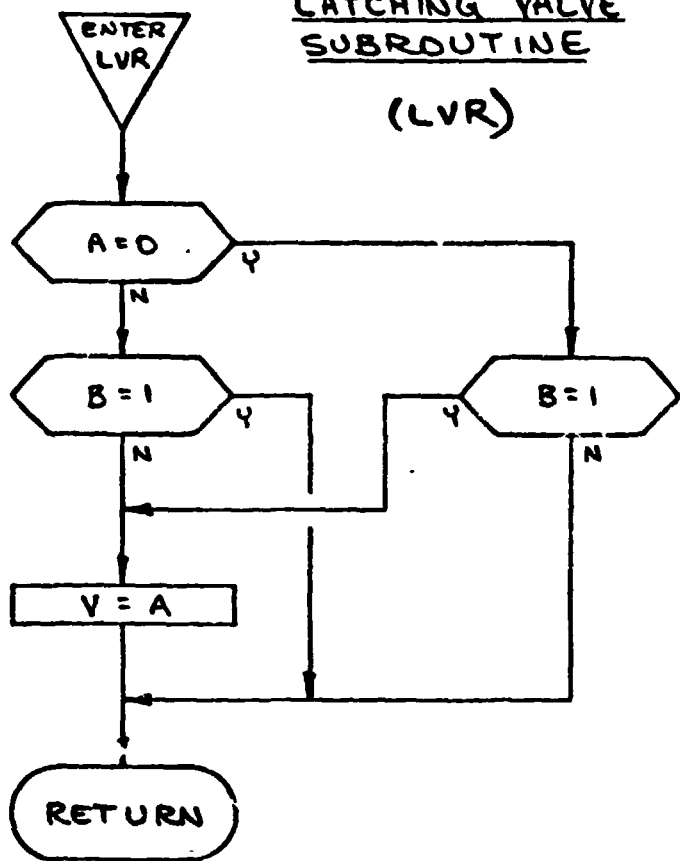
- 1) IF EITHER B-PWR OR C-PWR IS ON, POSITIVE TEMP CONTROL.
- 2) V45P2210A PRESS PWR TO XDCR & SIGNAL AMP IS COMMON IN SC A1. (ESS BUS IBC)
- 3) V45P2200A PRESS REQUIRES LOSS OF MNB AND MNC PWR TO SC OF 3 TO LOSE SIGNAL.

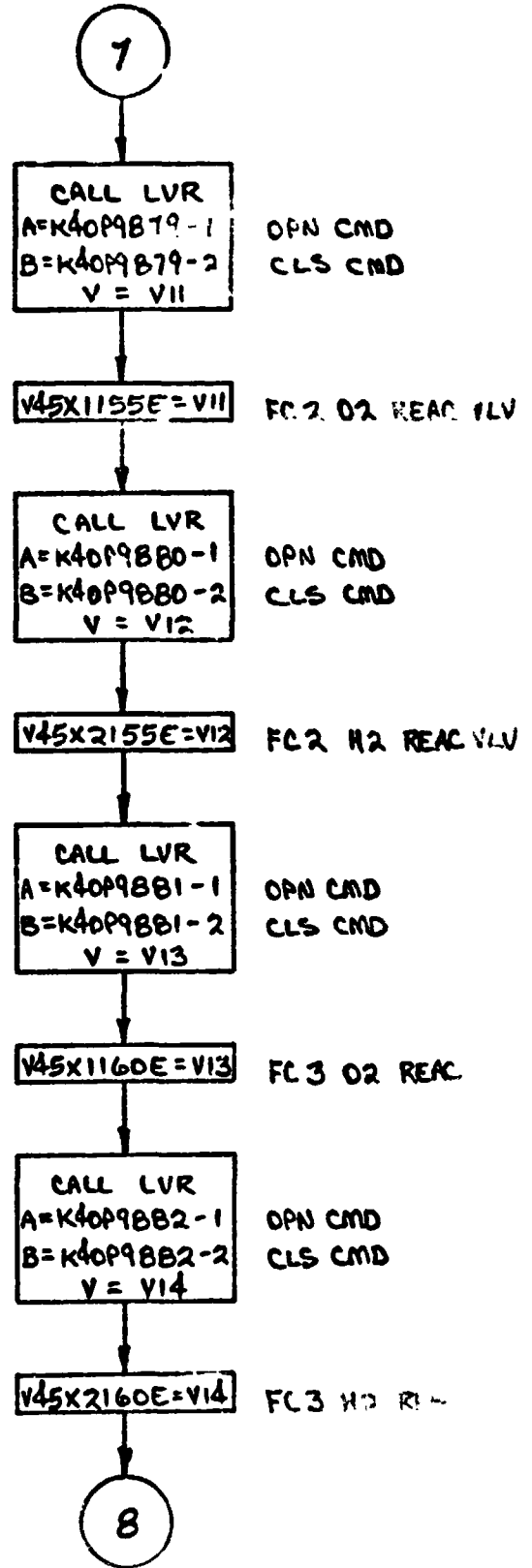
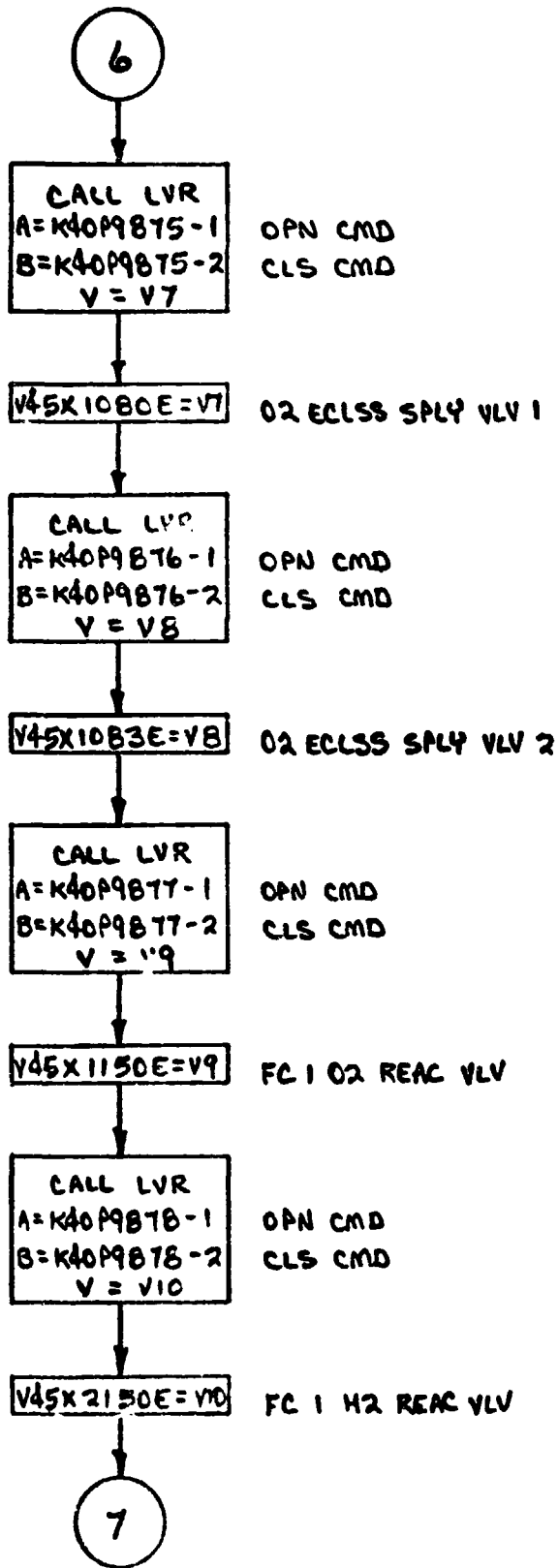


CRYO H2 TANK 3
ROUTINE

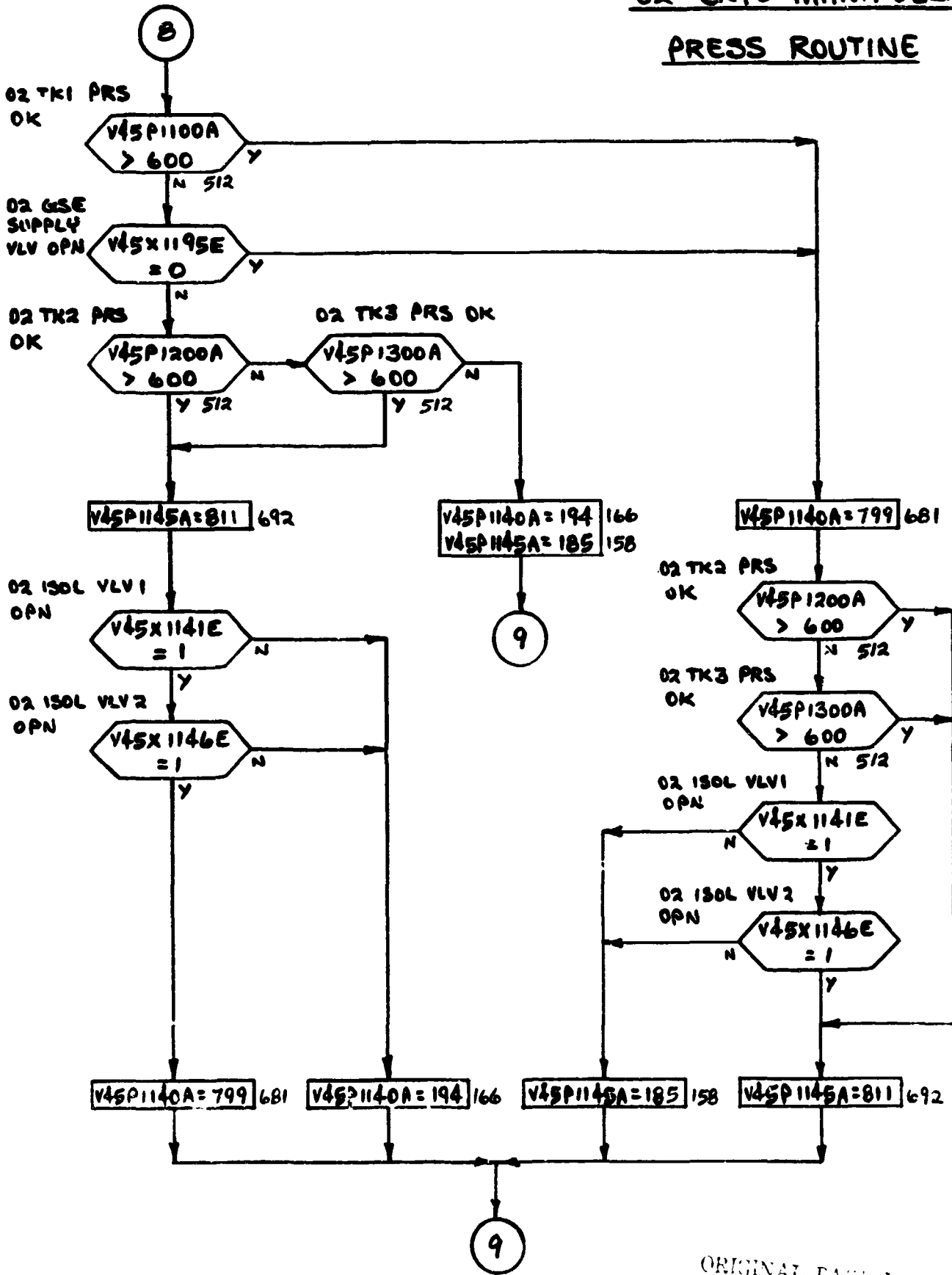


LATCHING VALVE
SUBROUTINE
(LVR)

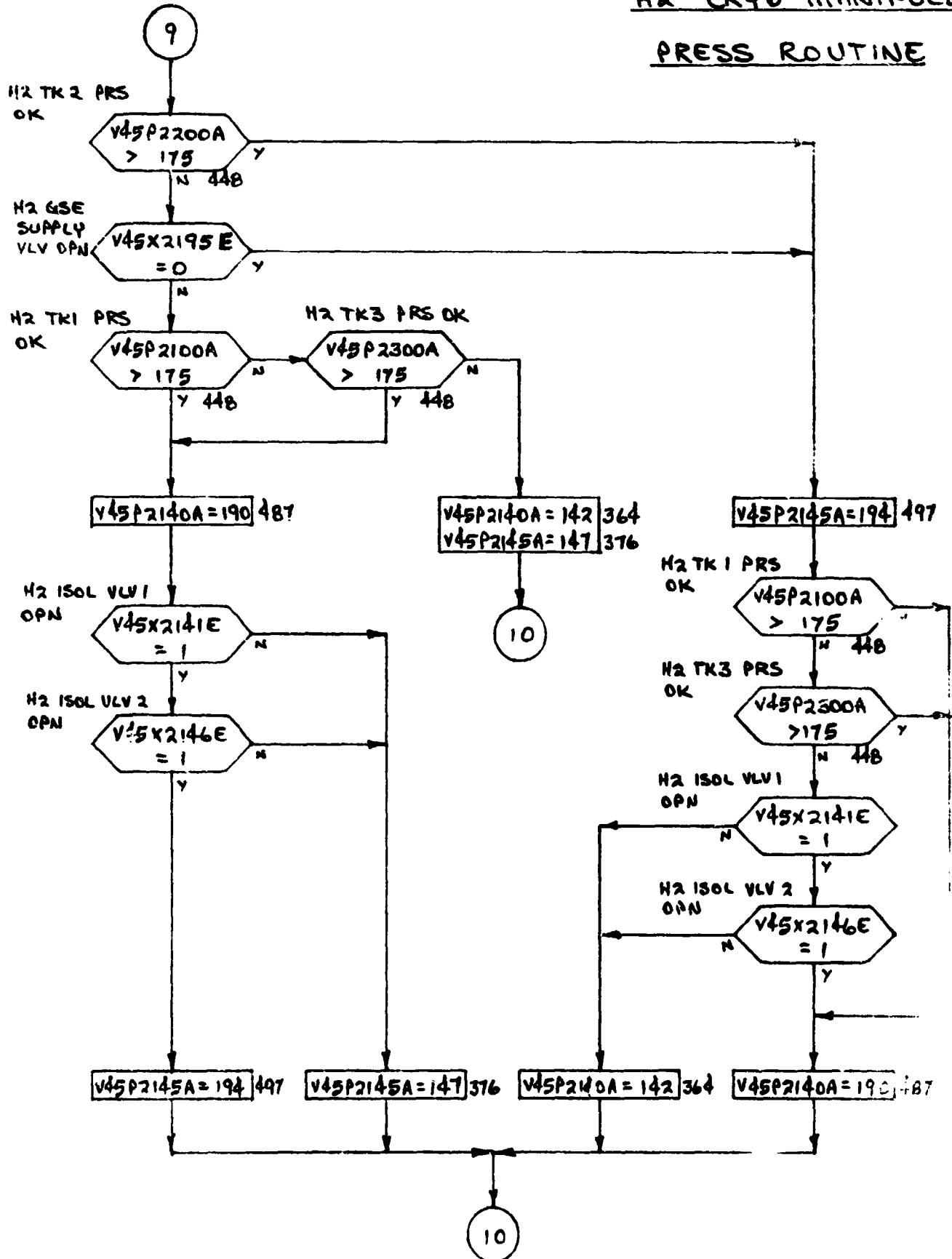


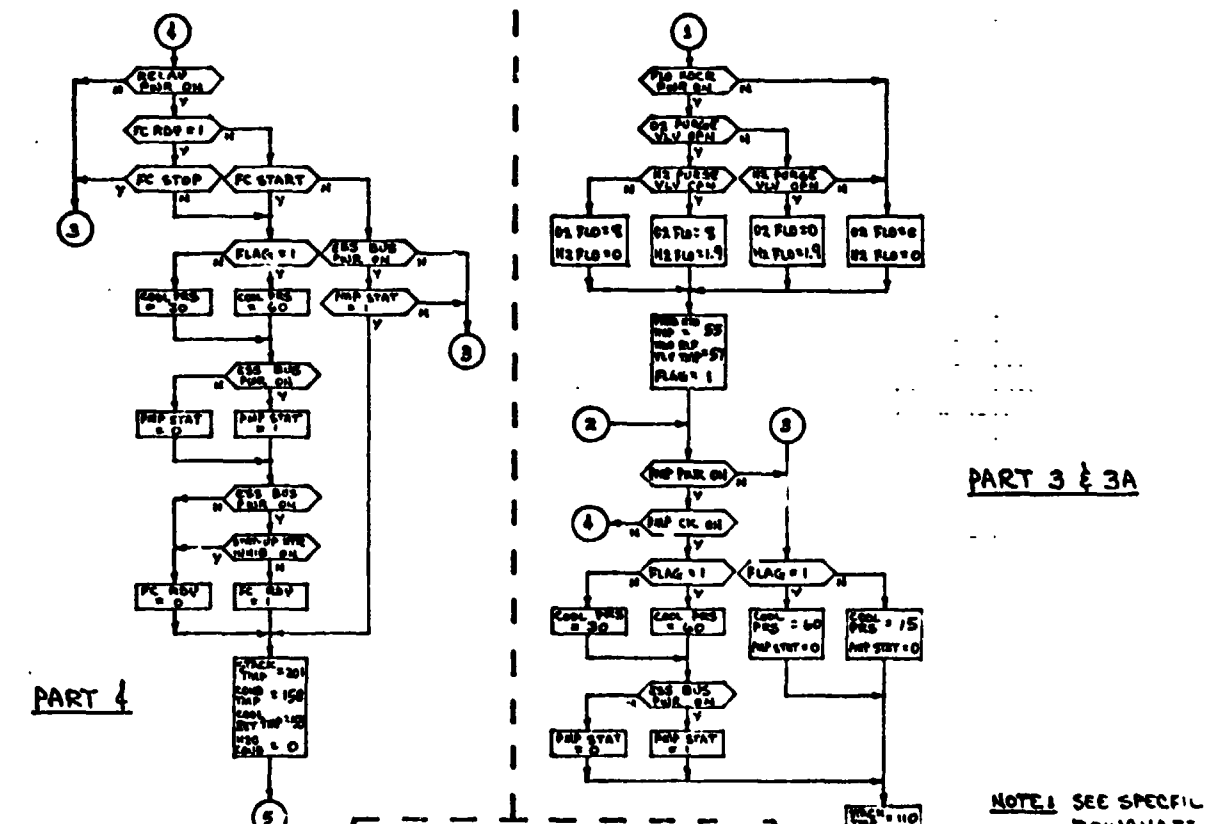
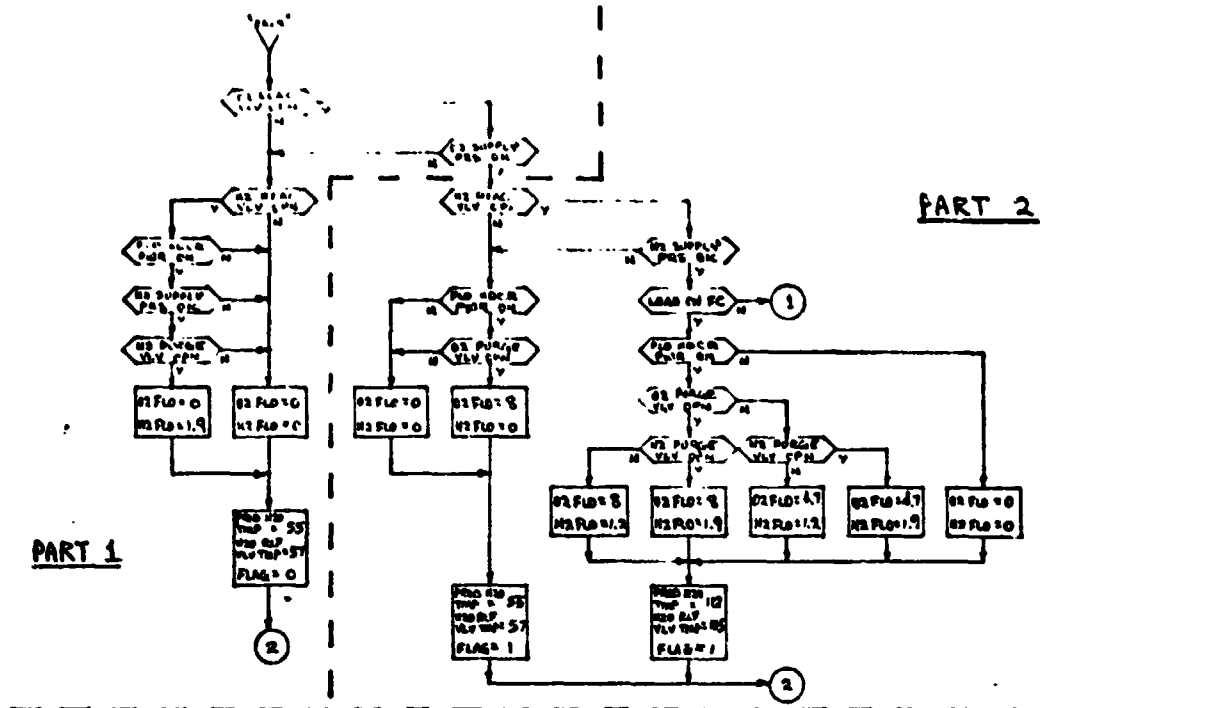


02 CRYO MANIFOLD
PRESS ROUTINE



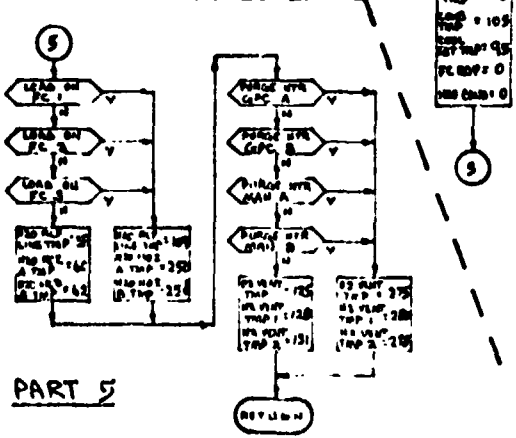
H2 CRYO MANIFOLD
PRESS ROUTINE





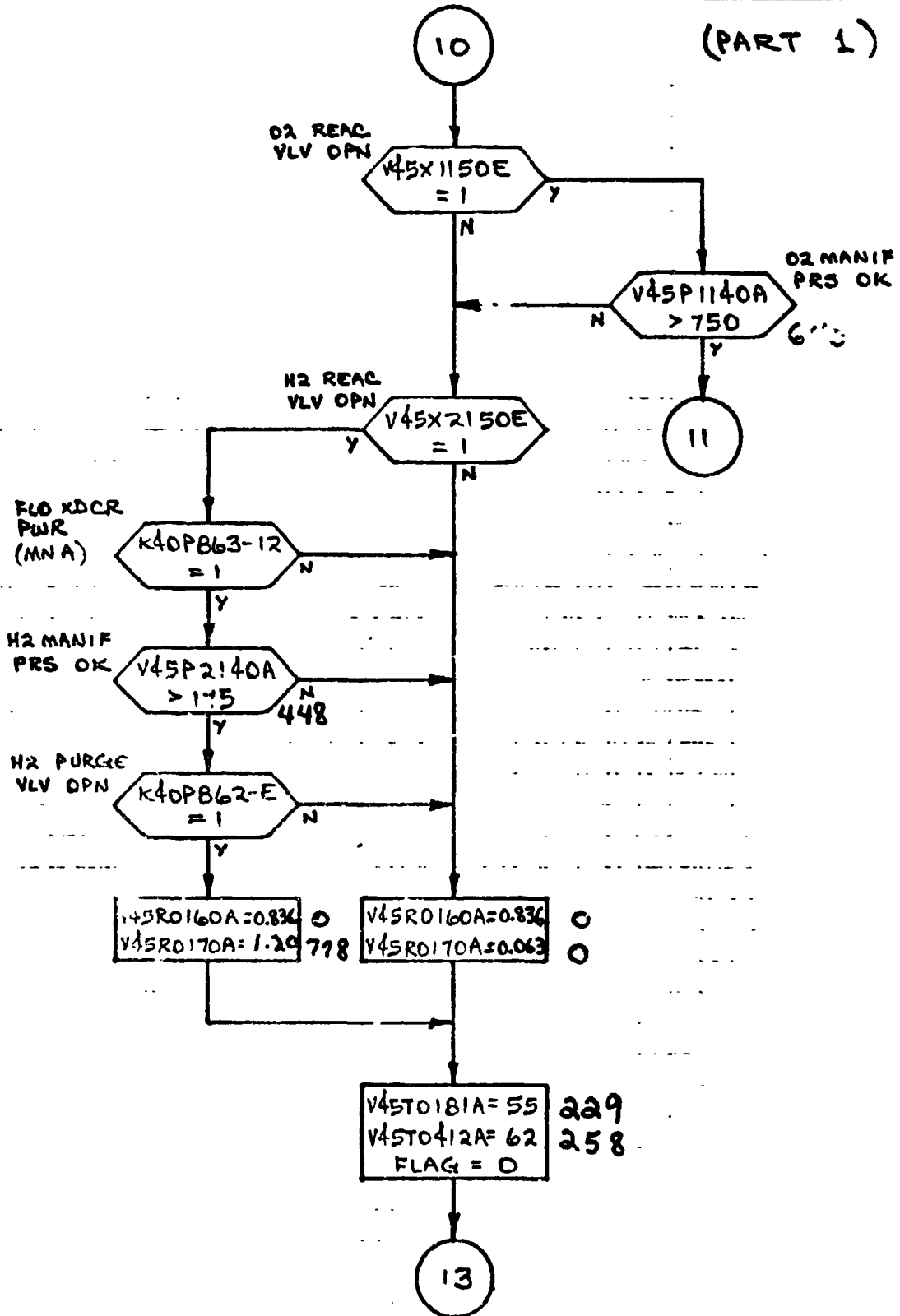
NOTE: SEE SPECIFIC FLOWCHART FOR CORRECT PARAMETER VALUES

NOTE: PARTS 1 THRU 4 ARE REPLACED FOR EACH FUEL CELL BEFORE CONTINUING TO PART 5.



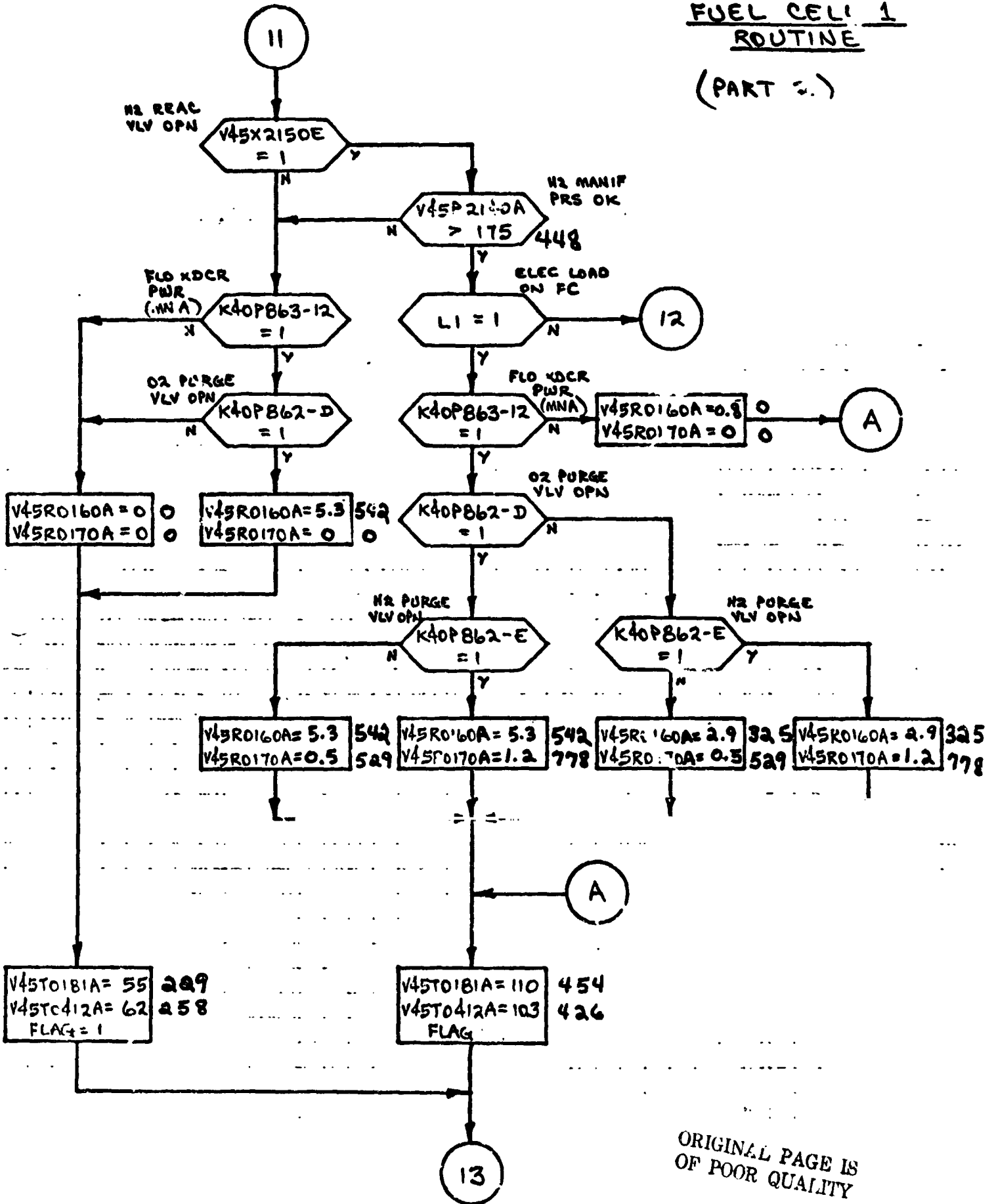
FUEL CELL ROUTINE OVERVIEW

FUEL CELL 1
ROUTINE
(PART 1)



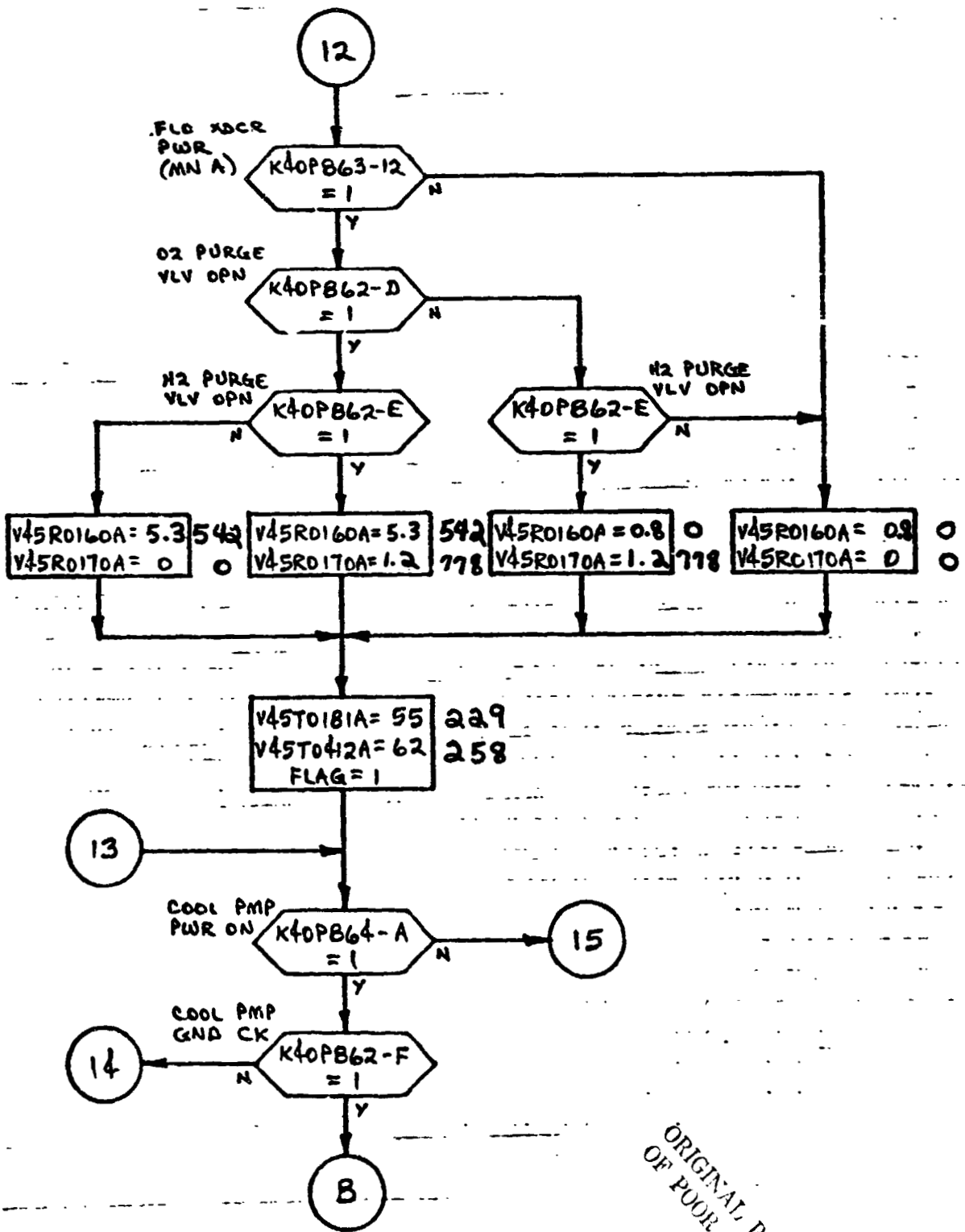
FUEL CELL 1 ROUTINE

(PART 2.)



ORIGINAL PAGE IS OF POOR QUALITY

FUEL CELL 1
ROUTINE
(PART 3)

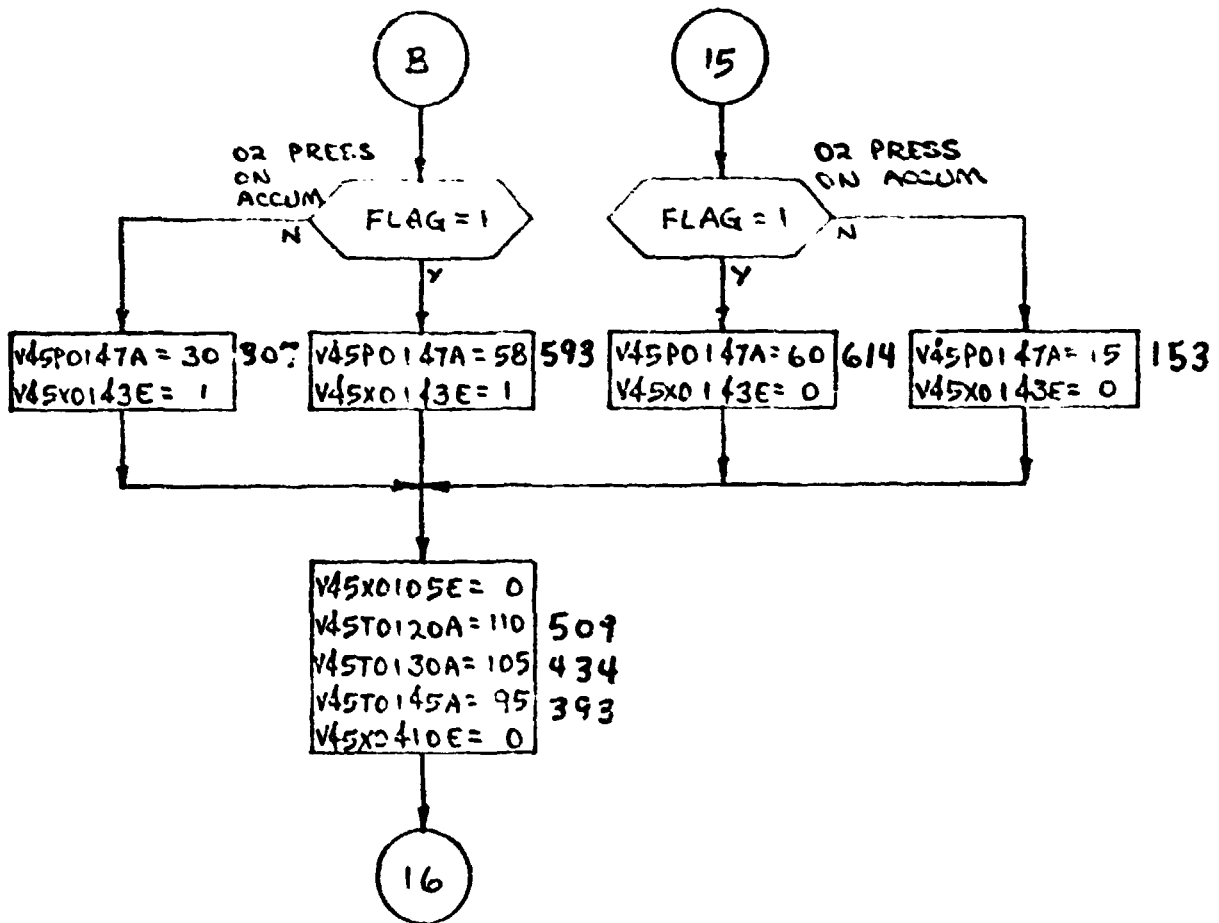


ORIGINAL PAGE IS
OF POOR QUALITY

C-4

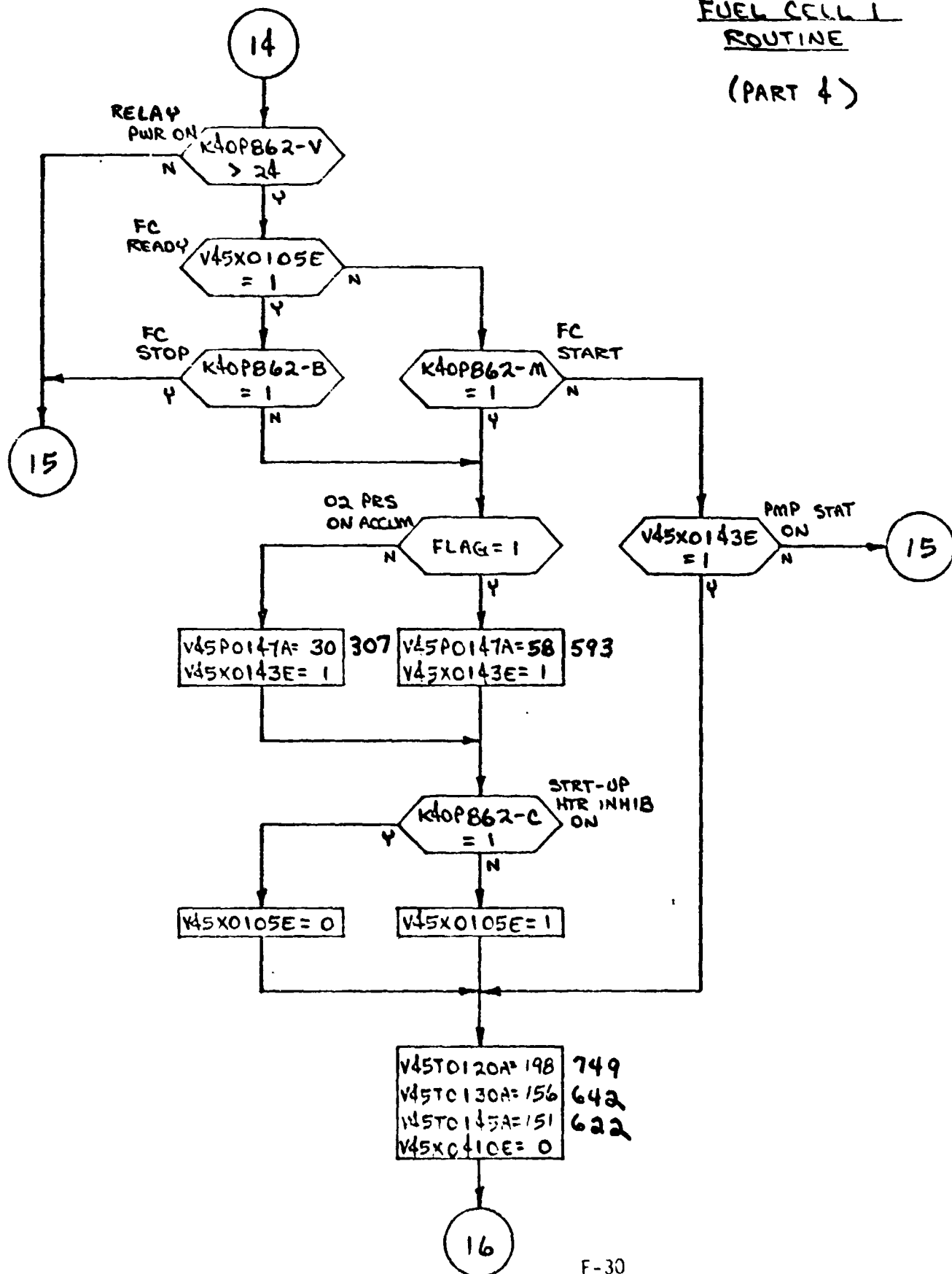
FUEL CELL 1
ROUTINE

(PART 3A)

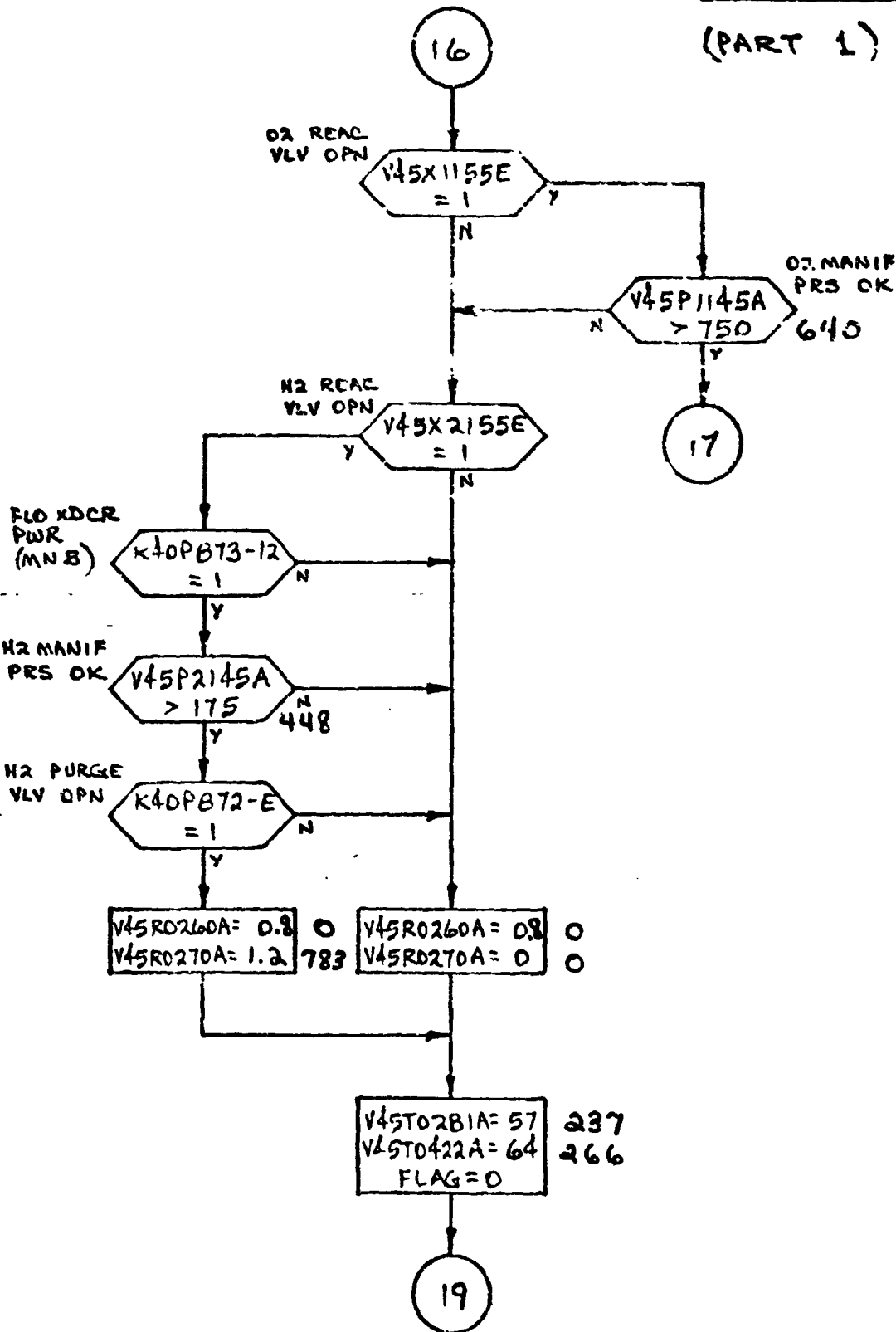


FUEL CELL 1
ROUTINE

(PART 4)

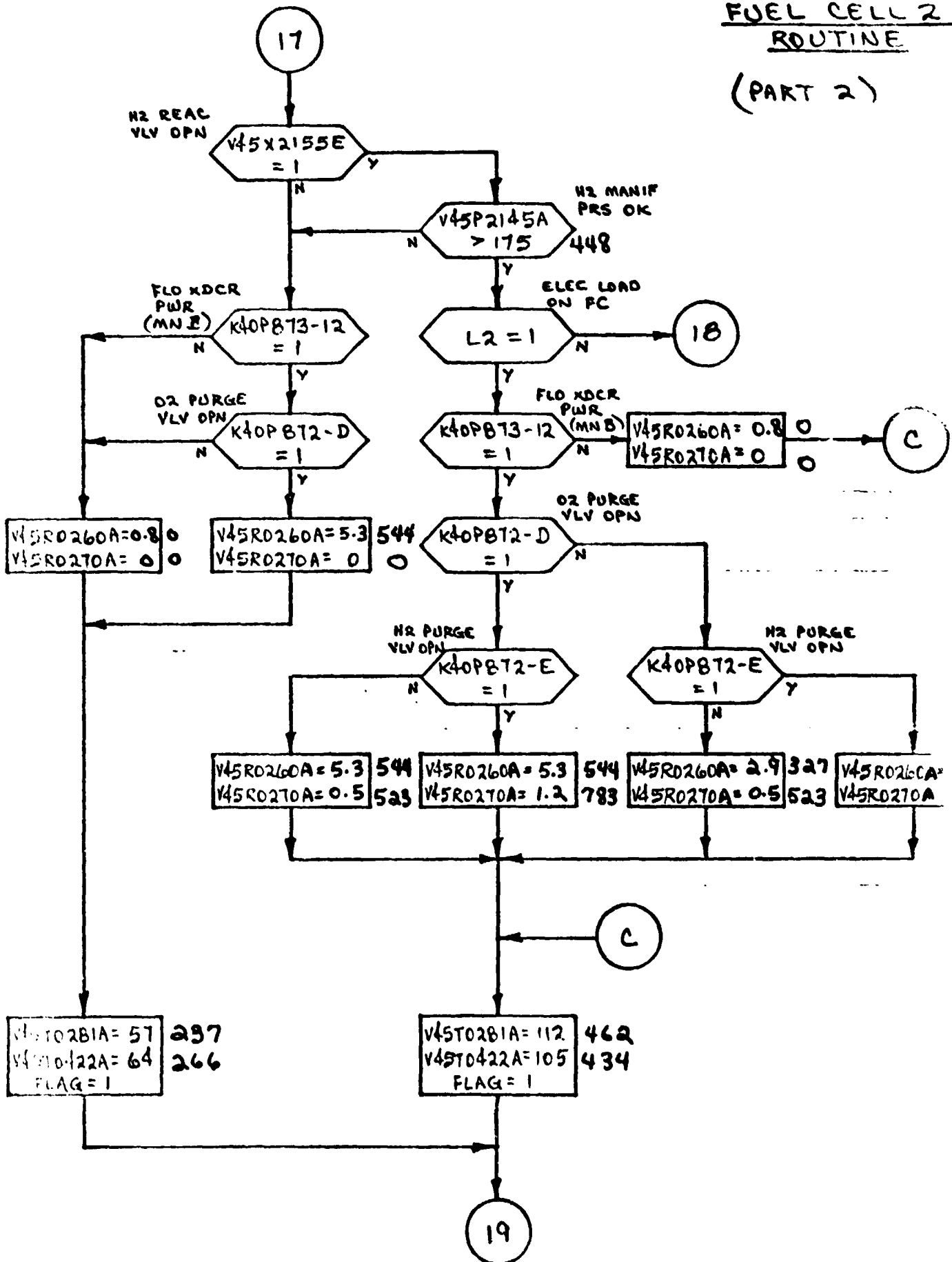


FUEL CELL 2
ROUTINE
(PART 1)

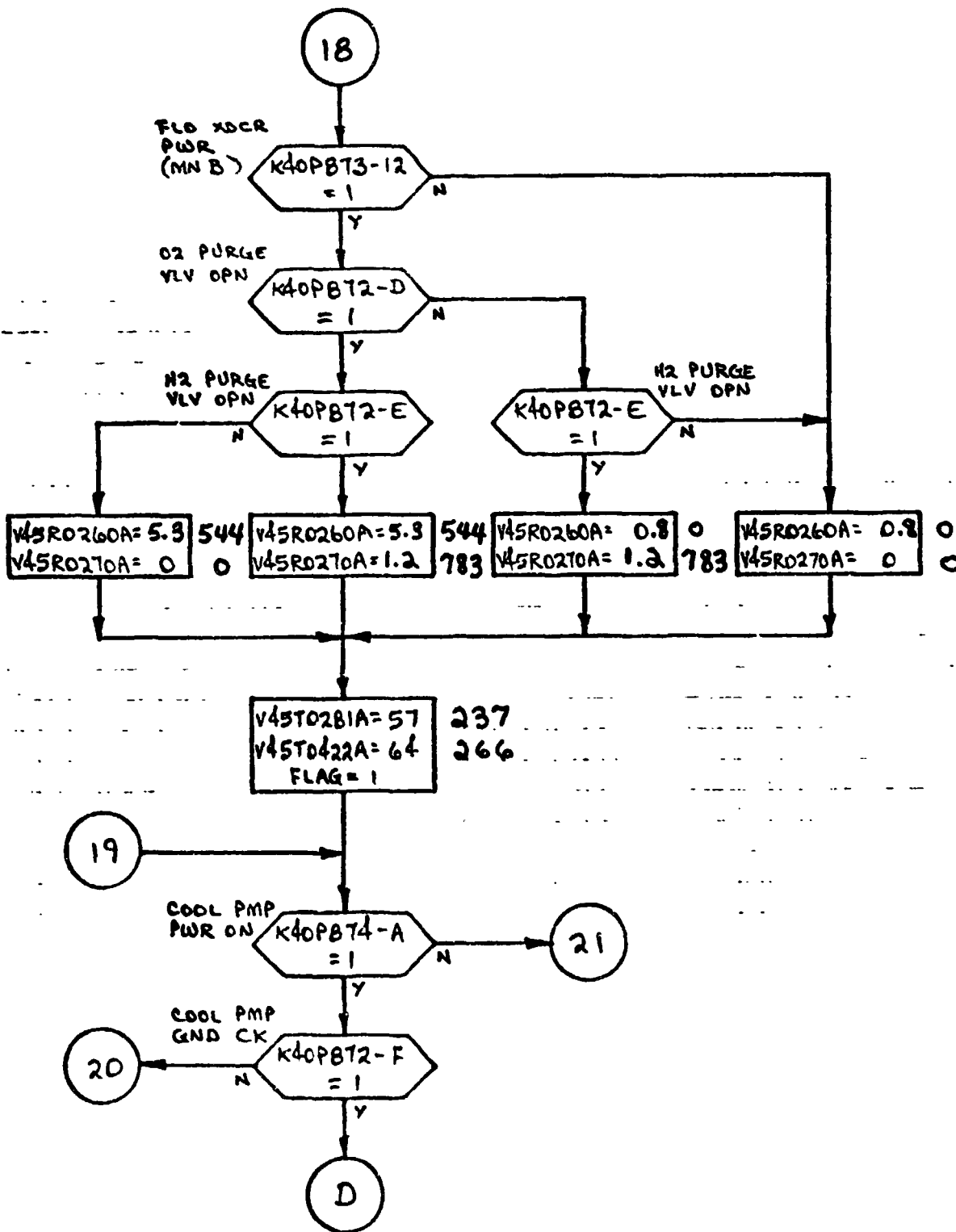


FUEL CELL 2
ROUTINE

(PART 2)

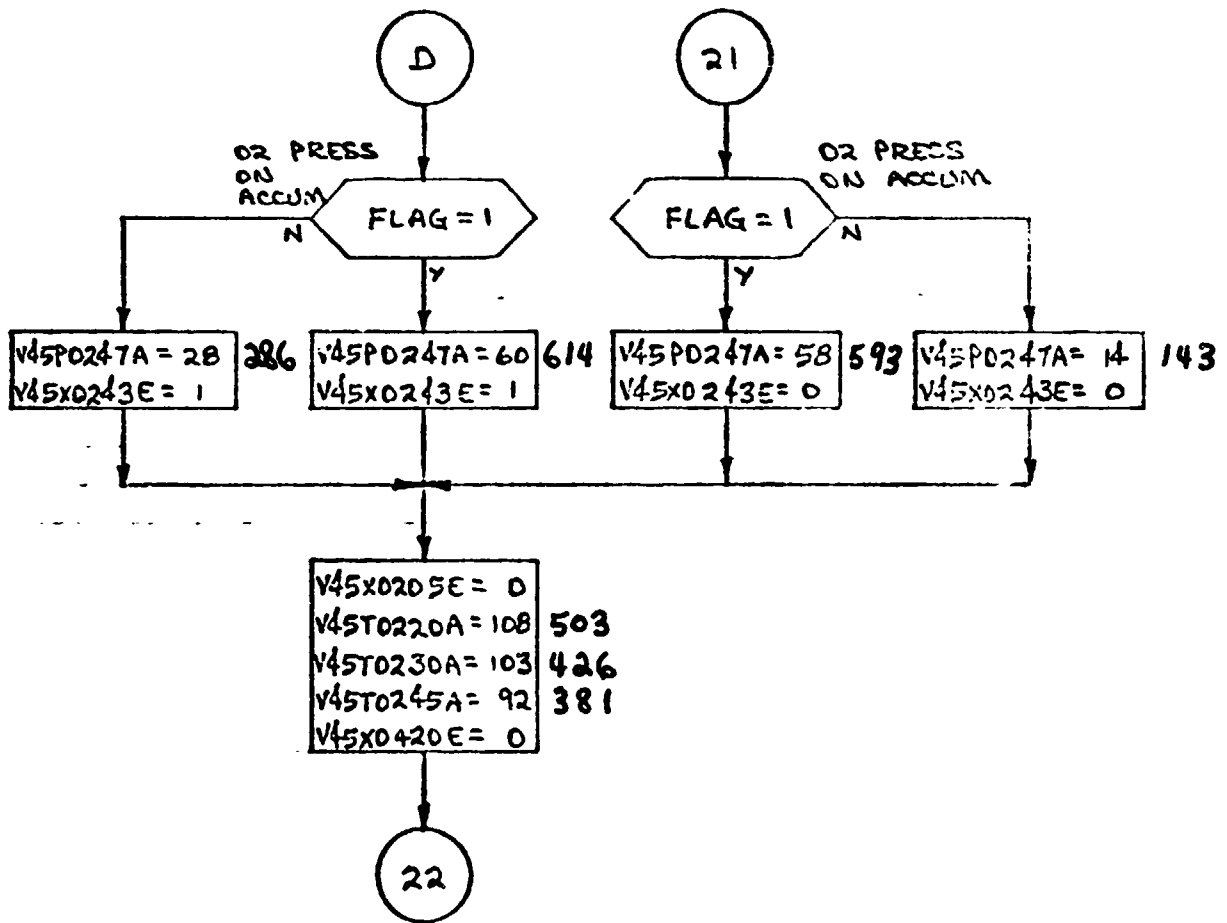


FUEL CELL 2
ROUTINE
(PART 3)

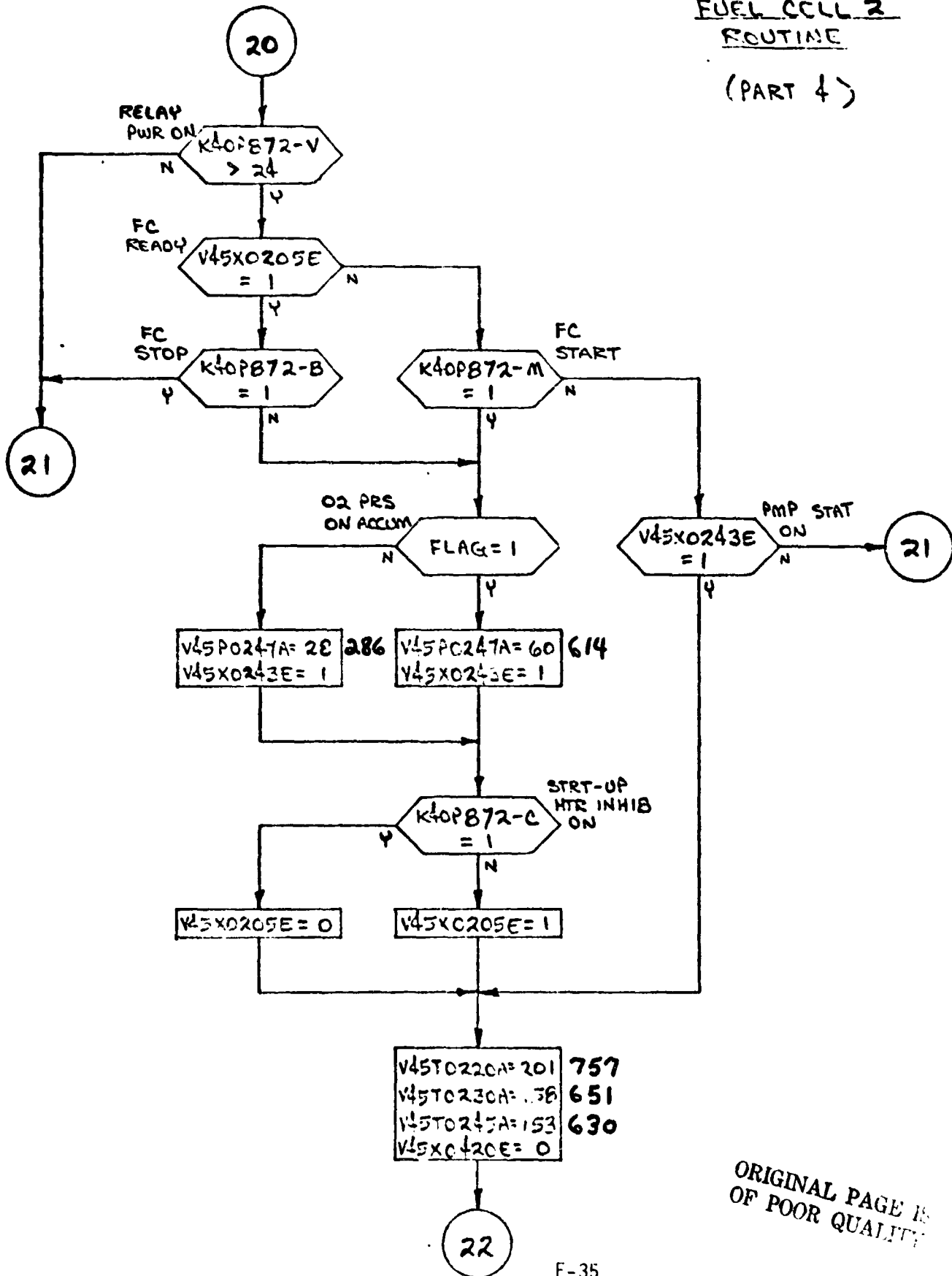


FUEL CELL 2
ROUTINE

(PART 3A)

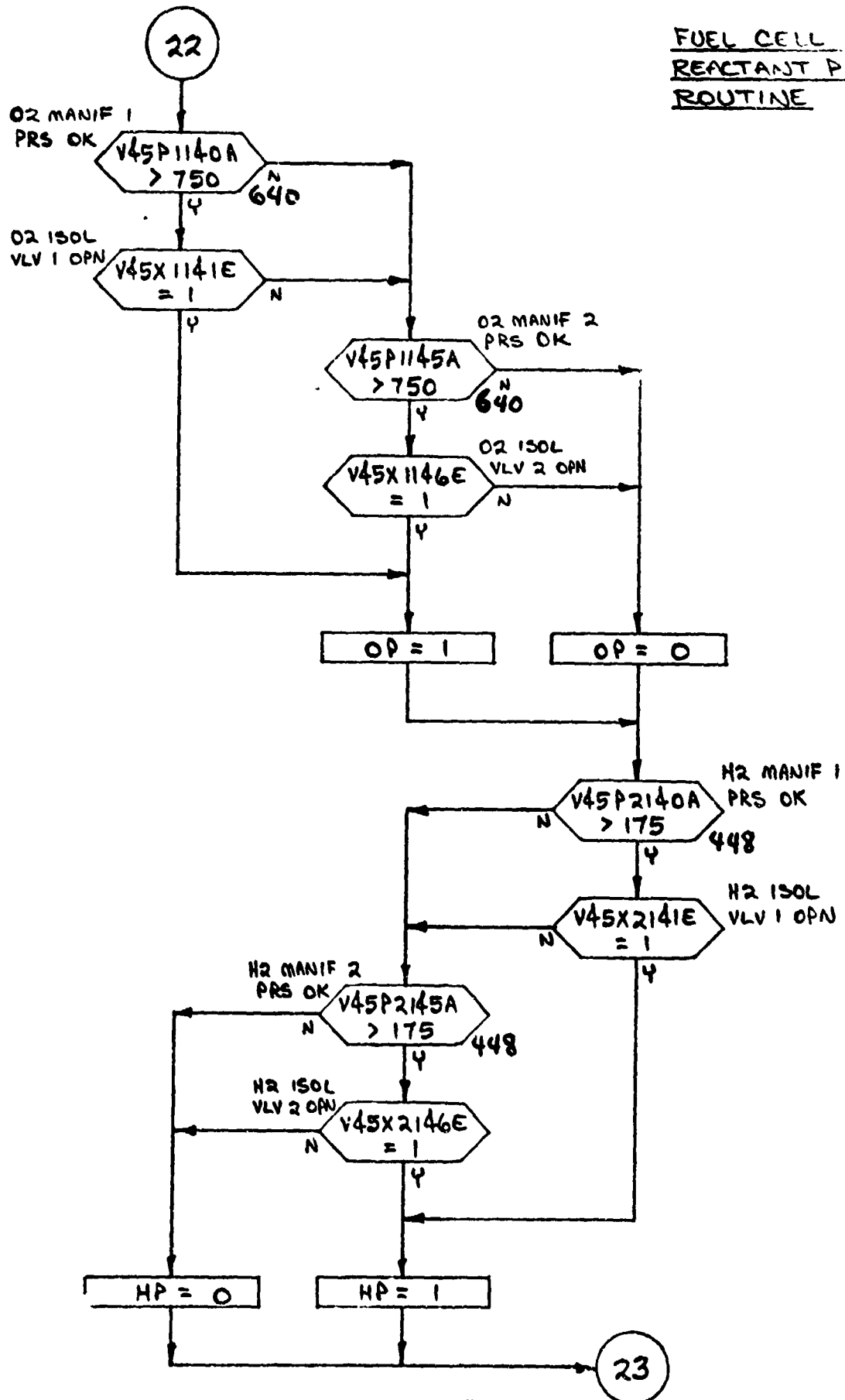


FUEL CELL 2
ROUTINE
(PART 4)



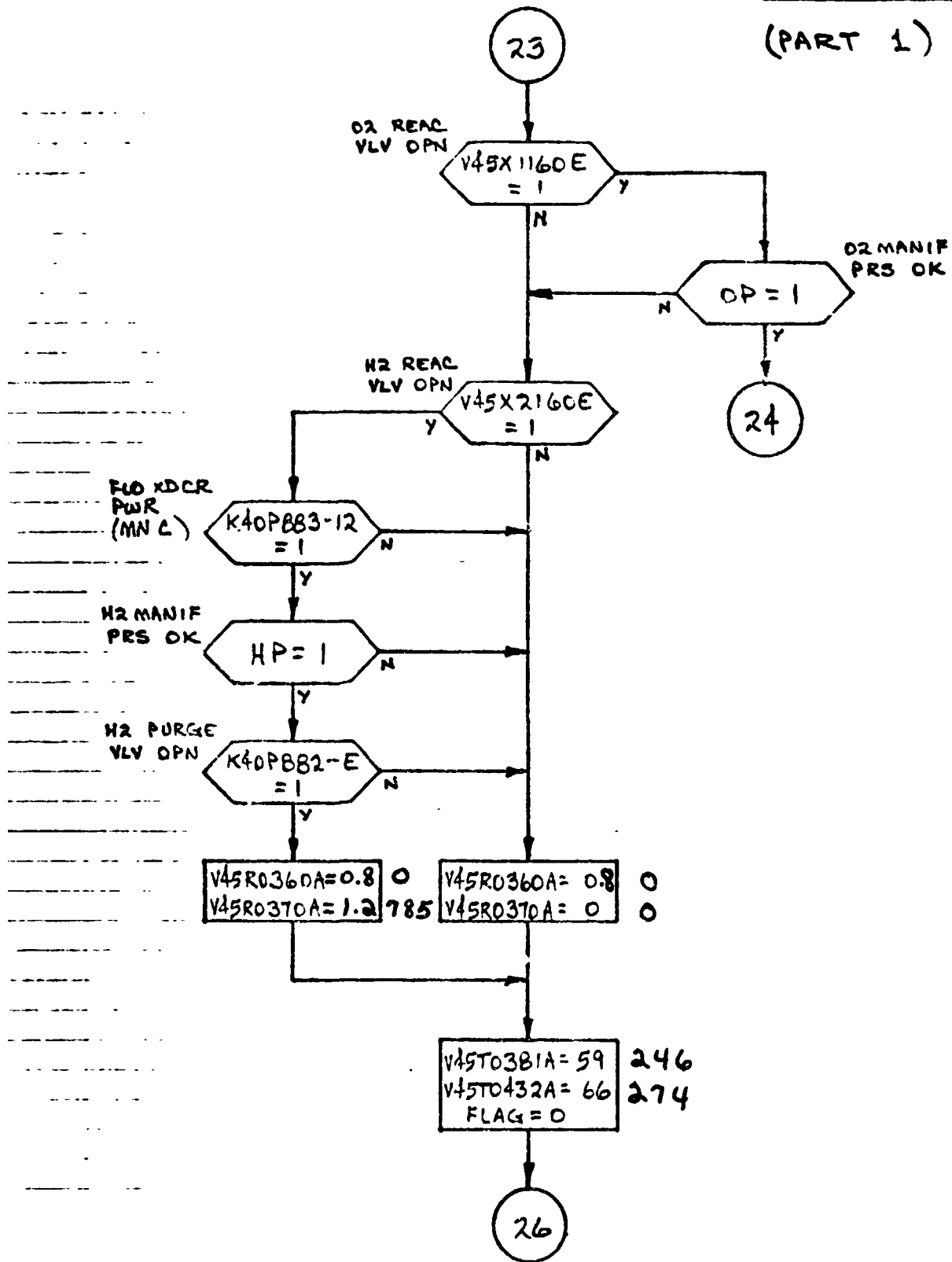
ORIGINAL PAGE IS
OF POOR QUALITY

FUEL CELL 3
REACTANT PRESS
ROUTINE



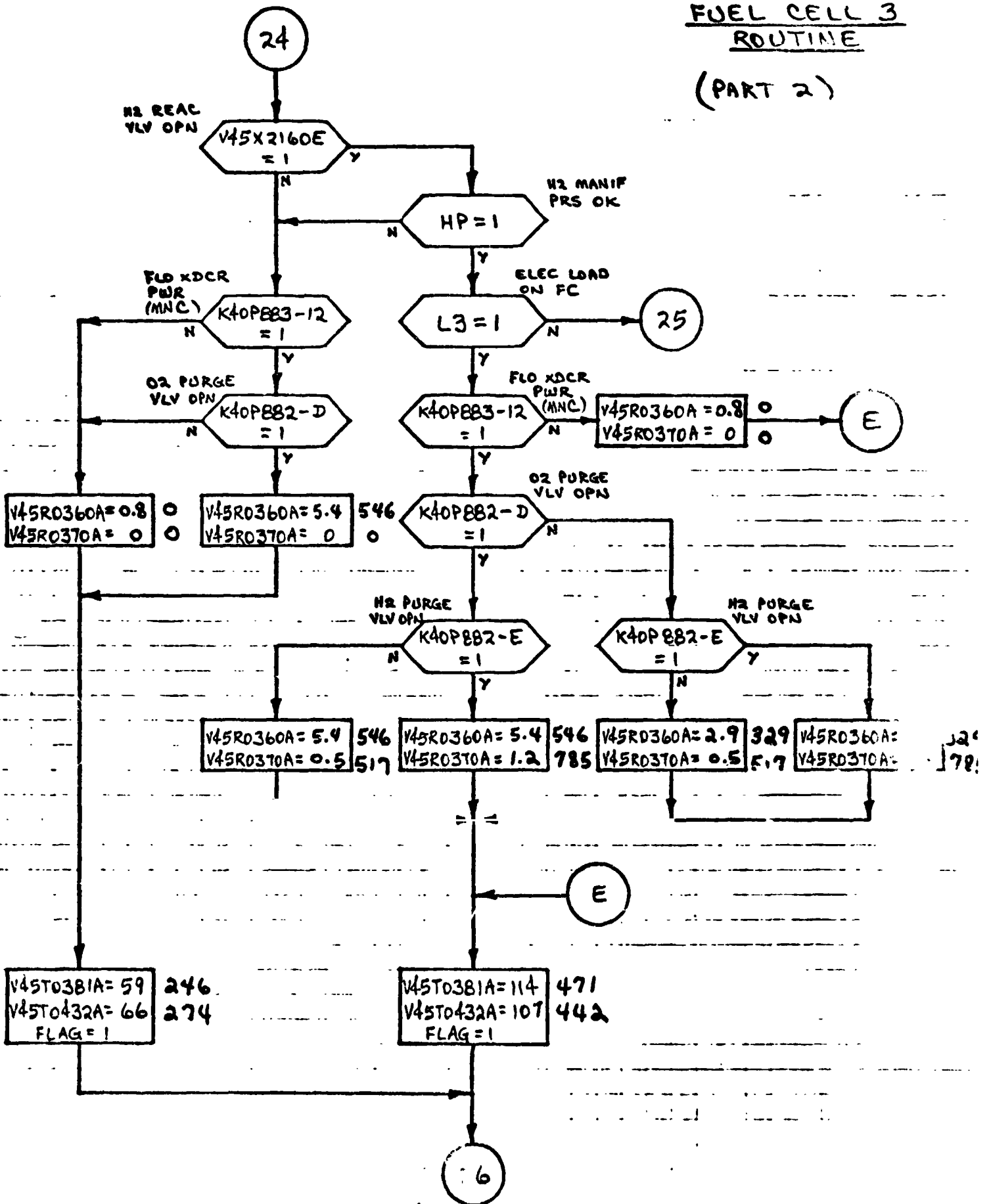
FUEL CELL 3
ROUTINE

(PART 1)

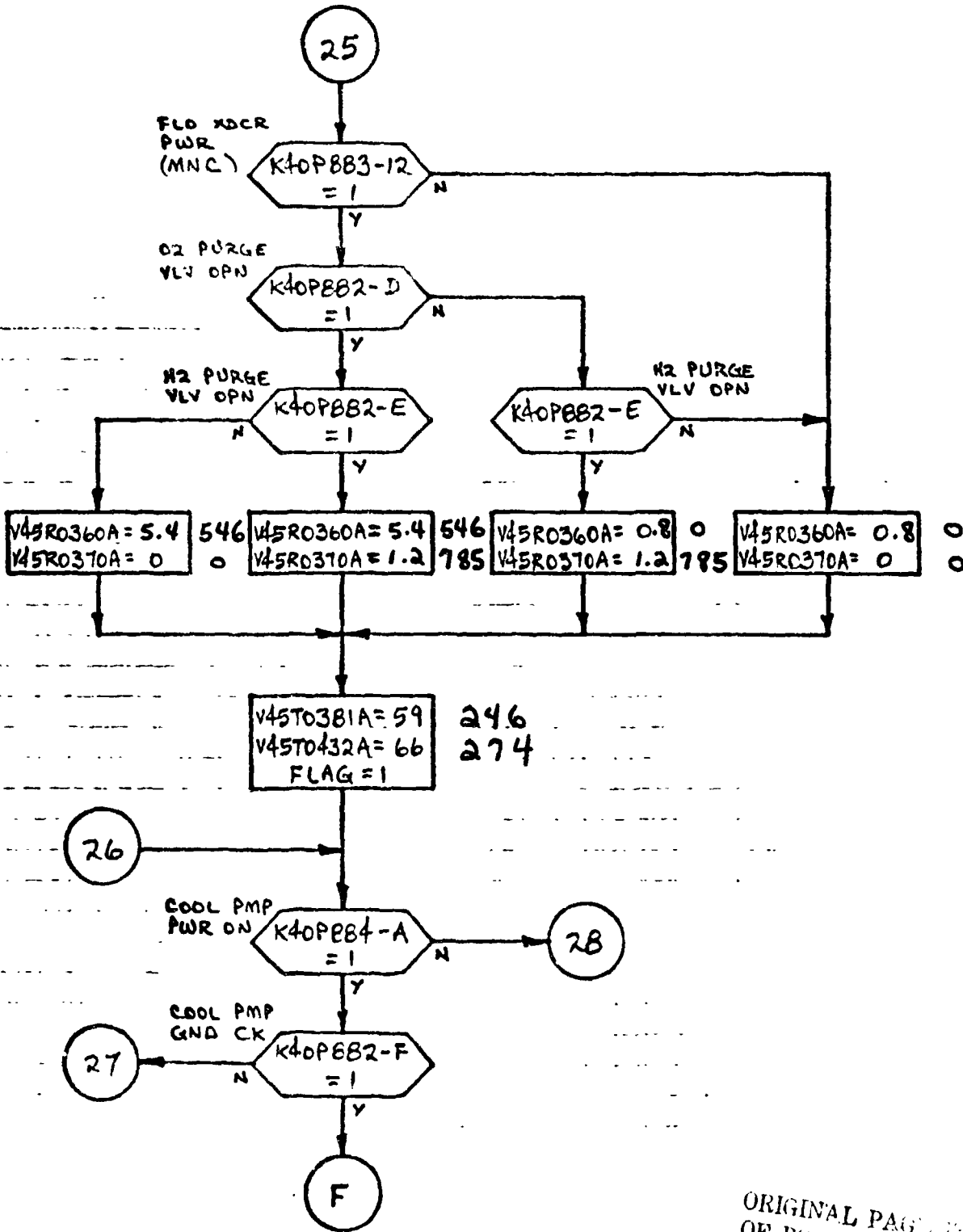


FUEL CELL 3 ROUTINE

(PART 2)



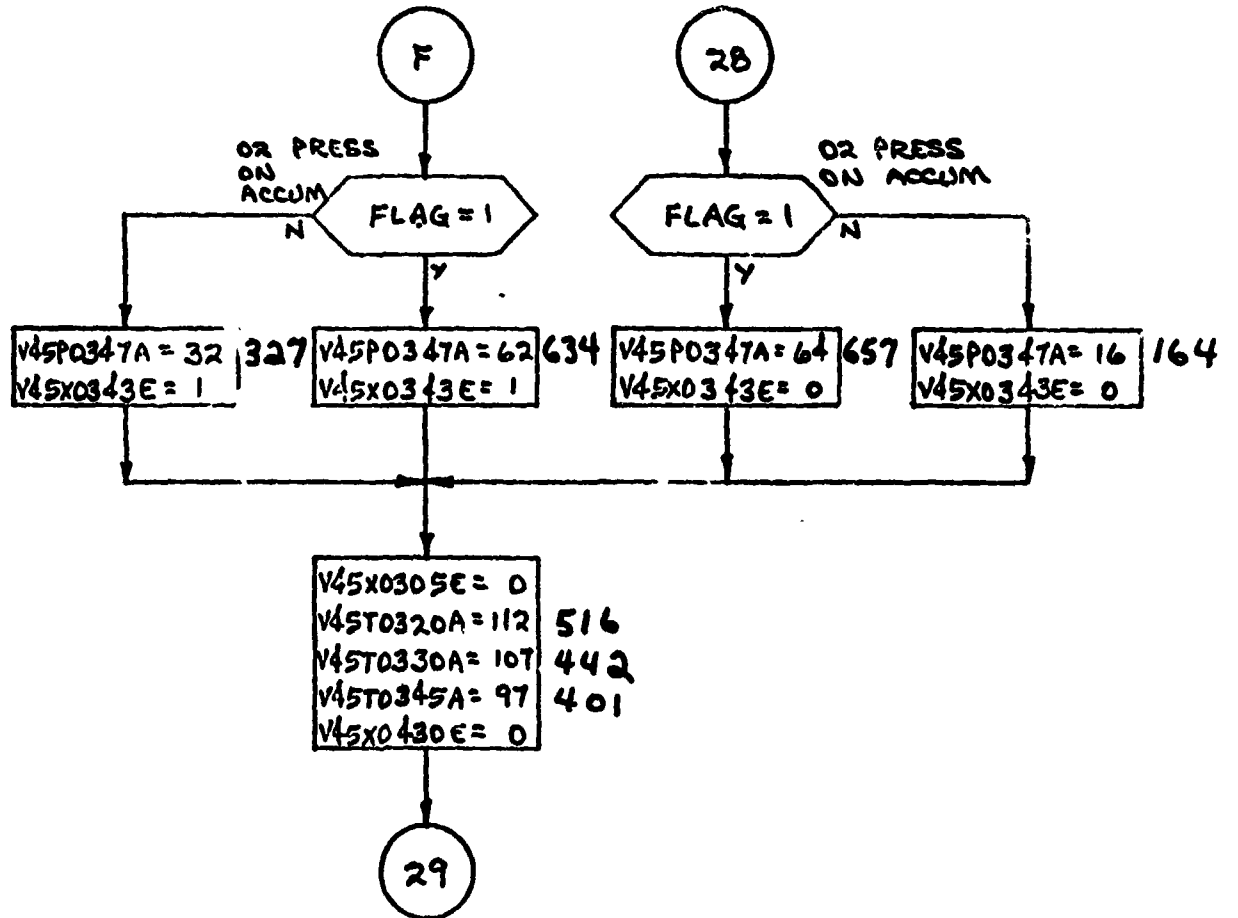
FUEL CELL 3
ROUTINE
(PART 3)



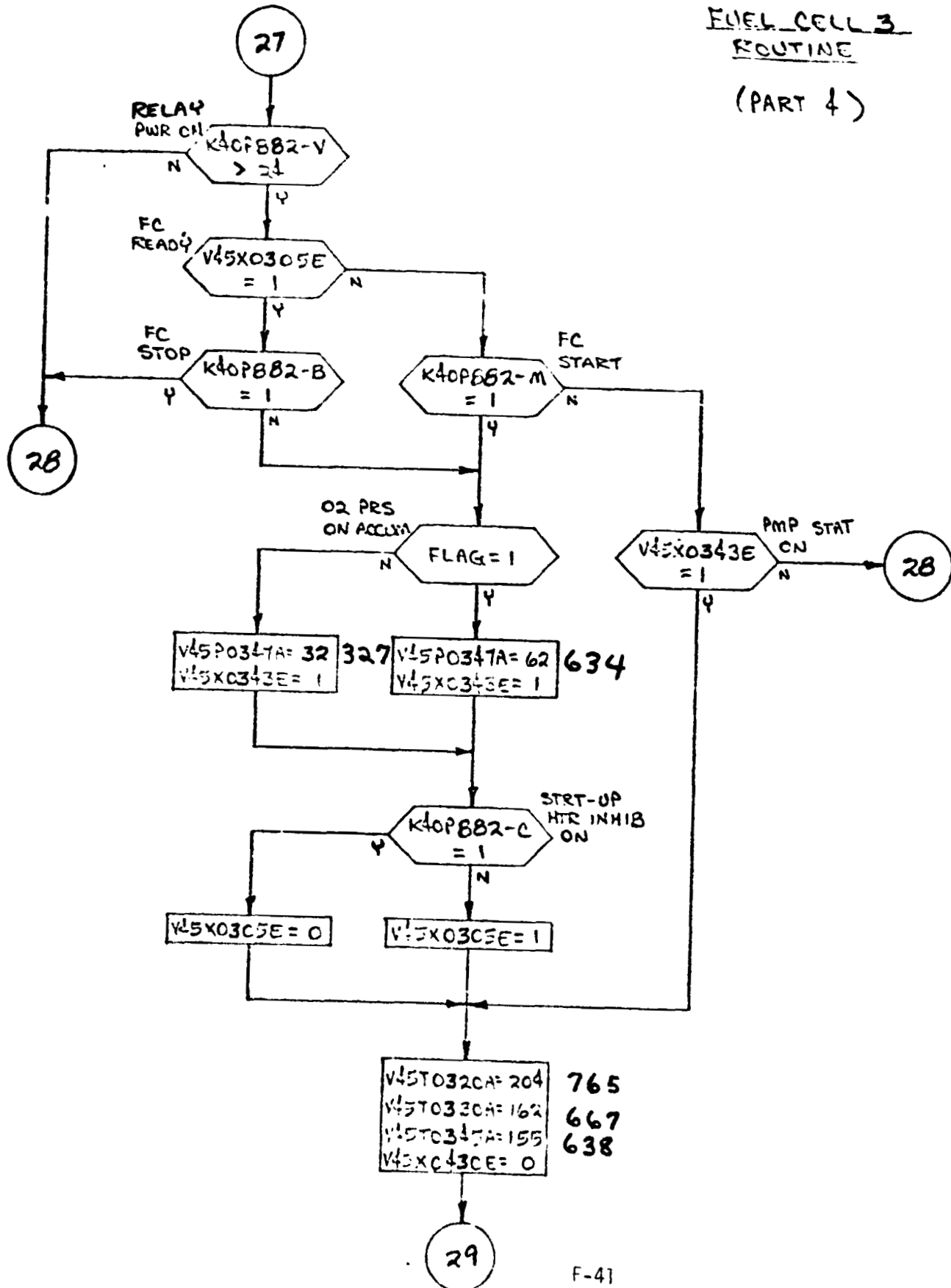
ORIGINAL PAGE IS
OF POOR QUALITY

FUEL CELL 3
ROUTINE

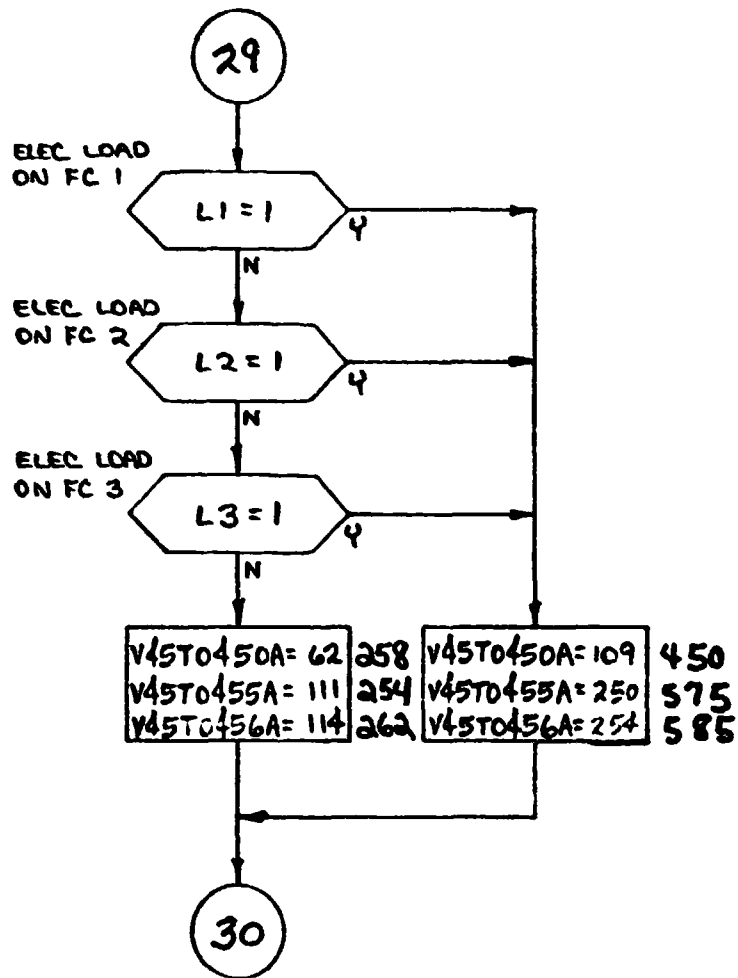
(PART 3A)



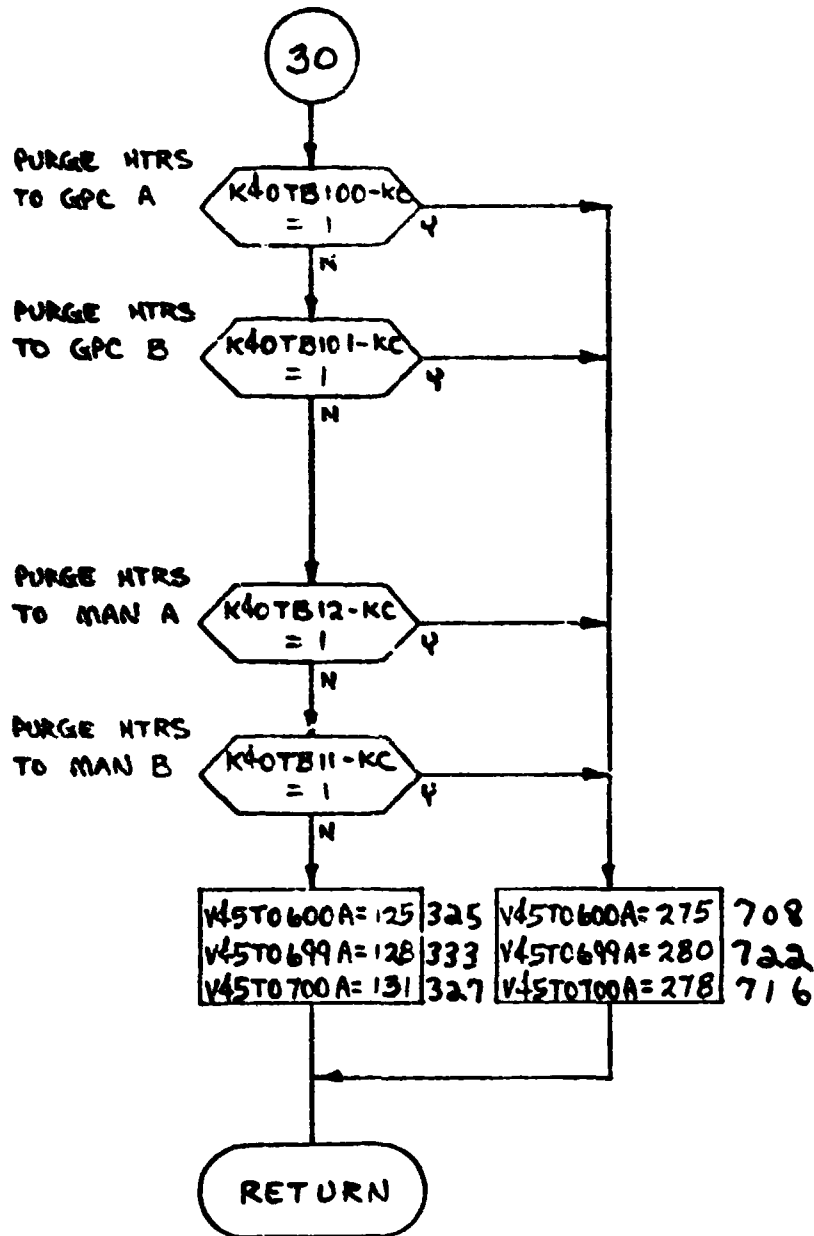
FUEL_CELL_3
ROUTINE
(PART 4)



FUEL CELL
ROUTINE
(PART 5)



PURGE HEATERS
ROUTINE



MEASUREMENT OUTPUT FROM FC/CRYO MODEL - TABLE 2

MEASUREMENT I. D.	MEASUREMENT NAME	I. C.		VALUE 1		VALUE 2		VALUE 3		UNITS
		FS	CTS	FS	CTS	FS	CTS	FS	CTS	
V45T0345A	FC 3 COOLANT RETURN TEMP	97	401	155	638					DEGF
V45P0347A	FC 3 COOLANT PRESS	62	634	16	164			64	657	PSIA
V45R0360A	FC 3 O2 FLOW	0.836	0	2.90	329	32	327			LB/HR
V45R0370A	FC 3 H2 FLOW	0.063	0	0.48	517	5.37	546			LB/HR
V45T0381A	FC 3 PRODUCT H2O LINE TEMP	59	246	114	471	1.23	785			DEGF
V45X0410E	FC 1 H2O CONDITION	0	0	1	1					STATE
V45T0412A	FC 1 H2O RELIEF VLV TEMP	62	258	103	426					DEGF
V45X0420E	FC 2 CONDITION	0	0	1	1					STATE
V45T0422A	FC 2 H2O RELIEF VLV TEMP	64	266	105	434					DEGF
V45X0430E	FC 3 H2O CONDITION	0	0	1	1					STATE
V45T0432A	FC 3 H2O RELIEF VLV TEMP	66	274	107	442					DEGF
V45T0450A	H2O RELIEF LINE TEMP	62	258	109	450					DEGF
V45T0455A	H2O RELIEF NOZZLE TEMP A	111	254	250	575					DEGF
V45T0456A	H2O RELIEF NOZZLE TEMP B	114	262	254	585					DEGF
V45T0600A	FC 02 VENT LINE TEMP	125	325	275	708					DEGF
V45T0699A	FC H2 VENT LINE TEMP 1	128	333	280	722					DEGF
V45T0700A	FC H2 VENT LINE TEMP 2	131	327	278	716					DEGF
V45X1080E	PRSD 02 ECS PRI SUPPLY VLV - OPEN	1	1	0	0					STATE
V45X1083E	PRSD 02 ECS SEC SUPPLY VLV - OPEN	1	1	0	0					STATE
V45P1100A	PRSD 02 TANK 1 PRESS	626	534	516	440					PSIA
V45T1101A	PRSD 02 TANK 1 FLUID TEMP	-35	442	-162	295					DEGF

TABLE 1 - STIMULI INPUT TO FUEL CELL/CRYO MODEL

IDENTIFICATION NUMBER	NOMENCLATURE	SOURCE	STATES/RANGE		
			LO	HI	UNITS
K40P862-B	FC 1 STOP A/STOP B	FS	0	1	STATE
K40P862-C	FC 1 START-UP HTR INHIBIT		0	1	STATE
K40P862-D	FC 1 O2 PURGE VLV OPEN		0	1	STATE
K40P862-E	FC 1 H2 PURGE VLV OPEN		0	1	STATE
K40P862-F	FC 1 K7 PUMP CHECK		0	1	STATE
K40P862-M	FC 1 START		0	1	STATE
K40P862-V	FC 1 RELAY POWER		0	1	STATE
K40P864-A	FC 1 COOLANT PUMP PHASE A		0	1	STATE
K40P872-B	FC 2 STOP A/STOP B		0	1	STATE
K40P872-C	FC 2 START-UP HTR INHIBIT		0	1	STATE
K40P872-D	FC 2 O2 PURGE VLV OPEN		0	1	STATE
K40P872-E	FC 2 H2 PURGE VLV OPEN		0	1	STATE
K40P872-F	FC 2 K7 PUMP CHECK		0	1	STATE
K40P872-M	FC 2 START		0	1	STATE
K40P872-V	FC 2 RELAY POWER		0	1	STATE
K40P874-A	FC 2 COOLANT PUMP PHASE A		0	1	STATE
K40P882-B	FC 3 STOP A/STOP B		0	1	STATE
K40P882-C	FC 3 START-UP HTR INHIBIT		0	1	STATE
K40P882-D	FC 3 O2 PURGE VLV OPEN		0	1	STATE
K40P882-E	FC 3 H2 PURGE VLV OPEN		0	1	STATE
K40P882-F	FC 3 K7 PUMP CHECK	0	1	STATE	
K40P882-M	FC 3 START	0	1	STATE	
K40P882-V	FC 3 RELAY POWER	0	1	STATE	

TABLE 1 - Continued.

IDENTIFICATION NUMBER	NOMENCLATURE	SOURCE	STATES/RANGE		UNITS
			LO	HI	
K40P884-A	FC3 COOLANT PUMP PHASE A	FS	0	1	STATE
K40P9811-B	H2 TANK 1 HTR A POWER		0	1	STATE
K40P9812-A	H2 TANK 1 HTR B POWER		0	1	STATE
K40P9813-A	H2 TANK 1 QTY CHECK SIGNAL		0	1	STATE
K40P9831-A	O2 TANK 2 HTR A1 POWER		0	1	STATE
K40P9831-C	O2 TANK 2 HTR A2 POWER		0	1	STATE
K40P9832-A	O2 TANK 2 HTR B1 POWER		0	1	STATE
K40P9832-C	O2 TANK 2 HTR B2 POWER		0	1	STATE
K40P9833-A	O2 TANK 2 QTY CHECK SIGNAL		0	1	STATE
K40P9841-B	H2 TANK 2 HTR A POWER		0	1	STATE
K40P9842-A	H2 TANK 2 HTR B POWER		0	1	STATE
K40P9843-A	H2 TANK 2 QTY CHECK SIGNAL		0	1	STATE
K40P9851-A	O2 TANK 1 HTR A1 POWER		0	1	STATE
K40P9851-C	O2 TANK 1 HTR A2 POWER		0	1	STATE
K40P9852-A	O2 TANK 1 HTR B1 POWER		0	1	STATE
K40P9852-C	O2 TANK 1 HTR B2 POWER		0	1	STATE
K40P9853-A	O2 TANK 1 QTY CHECK SIGNAL		0	1	STATE
K40P9869-1	O2 GSE SUPPLY VLV OPEN		0	1	STATE
K40P9869-2	O2 GSE SUPPLY VLV CLOSE		0	1	STATE
K40P9870-1	H2 GSE SUPPLY VLV OPEN		0	1	STATE
K40P9870-2	H2 GSE SUPPLY VLV CLOSE	0	1	STATE	

TABLE 1 - Cg inued.

IDENTIFICATION NUMBER	NOMENCLATURE	SOURCE	STATES/RANGE			UNITS
			LO	HI		
K40P9871-1	02 MANIFOLD 1 VLV OPEN	FS	0	1		STATE
K40P9871-2	02 MANIFOLD 1 VLV CLOSE		0	1		
K40P9872-1	02 MANIFOLD 2 VLV OPEN		0	1		
K40P9872-2	02 MANIFOLD 2 VLV CLOSE		0	1		
K40P9873-1	H2 MANIFOLD 1 VLV OPEN		0	1		
K40P9873-2	H2 MANIFOLD 1 VLV CLOSE		0	1		
K40P9874-1	H2 MANIFOLD 2 VLV OPEN		0	1		
K40P9874-2	H2 MANIFOLD 2 VLV CLOSE		0	1		
K40P9875-1	ECLSS 02 SUPPLY VLV 1 OPEN		0	1		
K40P9875-2	ECLSS 02 SUPPLY VLV 1 CLOSE		0	1		
K40P9876-1	ECLSS 02 SUPPLY VLV 2 OPEN		0	1		
K40P9876-2	ECLSS 02 SUPPLY VLV 2 CLOSE		0	1		
K40P9877-1	02 SUPPLY VLV OPEN - FC 1		0	1		
K40P9877-2	02 SUPPLY VLV CLOSE - FC 1		0	1		
K40P9878-1	H2 SUPPLY VLV OPEN - FC 1		0	1		
K40P9878-2	H2 SUPPLY VLV CLOSE - FC 1		0	1		
K40P9879-1	02 SUPPLY VLV OPEN - FC 2		0	1		
K40P9879-2	02 SUPPLY VLV CLOSE - FC 2		0	1		
K40P9880-1	H2 SUPPLY VLV OPEN - FC 2		0	1		
K40P9880-2	H2 SUPPLY VLV CLOSE - FC 2		0	1		
K40P9881-1	02 SUPPLY VLV OPEN - FC 3		0	1		
K40P9881-2	02 SUPPLY VLV CLOSE - FC 3	FS	0	1		STATE

TABLE 1 - Continued.

IDENTIFICATION NUMBER	NOMENCLATURE	SOURCE	STATES/RANGE			UNITS
			LO	HI		
K40P9882-1	H2 SUPPLY VLV OPEN - FC 3	FS via STM	0	1		STATE
K40P9882-2	H2 SUPPLY VLV CLOSE - FC 3	FS via STM	0	1		STATE
K40TB11-KC	H2/02 PURGE HTRS - MAN B	FS via STM	0	1		STATE
K40TB12-KC	H2/02 PURGE HTRS - MAN A	FS via STM	0	1		STATE
K40TB100-KC	H2/02 PURGE HTRS - GPC A	FS via STM	0	1		STATE
K40TB101-KC	H2/02 PURGE HTRS - GPC B	FS via STM	0	1		STATE
L1	FC 1 LOAD ON/OFF	DCM	0	1		STATE
L2	FC 2 LOAD ON/OFF	DCM	0	1		STATE
L3	FC 3 LOAD ON/OFF	DCM	0	1		STATE
K40P9853-W	O2 TANK 1 QTY XDCR PWR (ESS BUS 2CA)	FS via STM	0	1		STATE
K40P9833-W	O2 TANK 2 QTY XDCR PWR (ESS BUS 1BC)	FS via STM	0	1		STATE
K40P9813-W	H2 TANK 1 QTY XDCR PWR (ESS BUS 2CA)	FS via STM	0	1		STATE
K40P9843-W	H2 TANK 2 QTY XDCR PWR (ESS BUS 1BC)	FS via STM	0	1		STATE
K40P863-12	FLO XDCR PWR - FC 1 (MN A)	FS via STM	0	1		STATE
K40P873-12	FLO XDCR PWR - FC 2 (MN B)	FS via STM	0	1		STATE
K40P883-12	FLO XDCR PWR - FC 3 (MN C)	FS via STM	0	1		STATE

STIMULI INPUT TO () /CRYO MODEL - TABLE 1

IDENTIFICATION NUMBER	NOMENCLATURE	SOURCE	STATES/RANGE		
			LO	HI	UNITS
KJ5-A	02 TANK 3 HTR A1 PWR	FS ↓	0	1	STATE ↓
KJ5-C	02 TANK 3 HTR A2 PWR		0	1	
KJ6-A	02 TANK 3 HTR B1 PWR		0	1	
KJ6-C	02 TANK 3 HTR B2 PWR		0	1	
K40P9520-A	02 TANK 3 QTY CHECK SIGNAL		0	1	
K40P9520-W	02 TANK 3 QTY XDCR PWR (ESS BUS 3AB)		0	1	
KJ3-A	H2 TANK 3 HTR A PWR		0	1	
KJ4-A	H2 TANK 3 HTR B PWR		0	1	
K40P9547-A	H2 TANK 3 QTY CHECK SIGNAL		0	1	
K40P9547-W	H2 TANK 3 QTY XDCR PWR (ESS BUS 3AB)		0	1	

4.2 OUTPUT MEASUREMENT LIST

Table 2 lists all model outputs along with the initial condition value for the output. Measurement I.D. and Measurement Name precede pairs of numeric columns. The first of each pair is labeled FS indicating flight system engineering units. The second of each pair is labeled CTS indicating the GSIU count value corresponding to the FS value. I.C. indicates initial condition values. VALUE 1 typically indicates nominal values. VALUE 2 and VALUE 3 columns indicate off nominal conditions.

MEASUREMENT OUTPUT FROM FC/CRYO MODEL - TABLE 2

MEASUREMENT I.D.	MEASUREMENT NAME	I.C.		VALUE 1		VALUE 2		VALUE 3		UNITS
		FS	CTS	FS	CTS	FS	CTS	FS	CTS	
V45X0105E	FC 1 READY	0	0	1	1					STATE
V45T0120A	FC 1 STACK COOLANT OUT TEMP	110	509	198	749					DEGF
V45T0130A	FC 1 CONDENSER EXIT TEMP	105	434	156	542					DEGF
V45X0143E	FC 1 COOLANT PUMP STATUS	0	0	1	1					STATE
V45T0145A	FC 1 COOLANT RETURN TEMP	95	393	151	622					DEGF
V45P0147A	FC 1 COOLANT PRESS	60	614	15	153	30	307	58	593	PSIA
V45R0160A	FC 1 O2 FLOW	0.836	0	2.86	325	5.31	542			LB/HR
V45R0170A	FC 1 H2 FLOW	0.063	0	0.50	529	1.20	.776			LB/HR
V45T0181A	FC 1 PRODUCT H2O LINE TEMP	55	229	110	454					DEGF
V45X0205E	FC 2 READY	0	0	1	1					STATE
V45T0220A	FC 2 STACK COOLANT OUT TEMP	108	503	201	757					DEGF
V45T0230A	FC 2 CONDENSER EXIT TEMP	103	426	158	651					DEGF
V45X0243E	FC 2 COOLANT PUMP STATUS	0	0	1	1					STATE
V45T0245A	FC 2 COOLANT RETURN TEMP	92	381	153	630					DEGF
V45P0247A	FC 2 COOLANT PRESS	58	593	14	143	28	286	60	614	PSIA
V45R0260A	FC 2 O2 FLOW	0.836	0	2.86	327	5.34	544			LB/HR
V45R0270A	FC 2 H2 FLOW	0.063	0	0.49	523	1.22	783			LB/HR
V45T0281A	FC 2 PRODUCT H2O LINE TEMP	57	237	112	462					DEGF
V45X0305E	FC 3 READY	0	0	1	1					STATE
V45T0320A	FC 3 STACK COOLANT OUT TEMP	112	516	204	765					DEGF
V45T0330A	FC 3 CONDENSER EXIT TEMP	107	442	162	667					DEGF
V45X0343E	FC 3 COOLANT PUMP STATUS	0	0	1	1					STATE

MEASUREMENT OUTPUT FROM FC/CRYO MODEL - TABLE 2

MEASUREMENT I. D.	MEASUREMENT NAME	I. C.		VALUE 1		VALUE 2		VALUE 3		UNITS
		FS	CTS	FS	CTS	FS	CTS	FS	CTS	
V45T0345A	FC 3 COOLANT RETURN TEMP	97	401	155	638					DEGF
V45P0347A	FC 3 COOLANT PRESS	62	634	16	164	32	327	64	657	PSIA
V45R0360A	FC 3 O2 FLOW	0.836	0	2.90	329	5.37	546			LB/HR
V45R0370A	FC 3 H2 FLOW	0.063	0	0.48	517	1.23	785			LB/HR
V45T0381A	FC 3 PRODUCT H2O LINE TEMP	59	246	114	471					DEGF
V45X0410E	FC 1 H2O CONDITION	0	0	1	1					STATE
V45T0412A	FC 1 H2O RELIEF VLV TEMP	62	258	103	426					DEGF
V45X0420E	FC 2 CONDITION	0	0	1	1					STATE
V45T0422A	FC 2 H2O RELIEF VLV TEMP	64	266	105	434					DEGF
V45X0430E	FC 3 H2O CONDITION	0	0	1	1					STATE
V45T0432A	FC 3 H2O RELIEF VLV TEMP	66	274	107	442					DEGF
V45T0450A	H2O RELIEF LINE TEMP	62	258	109	450					DEGF
V45T0455A	H2O RELIEF NOZZLE TEMP A	111	254	250	575					DEGF
V45T0456A	H2O RELIEF NOZZLE TEMP B	114	262	254	585					DEGF
V45T0600A	FC 02 VENT LINE TEMP	125	325	275	708					DEGF
V45T0699A	FC H2 VENT LINE TEMP 1	128	333	280	722					DEGF
V45T0700A	FC H2 VENT LINE TEMP 2	131	327	278	716					DEGF
V45X1080E	PRSD 02 ECS PRI SUPPLY VLV - OPEN	1	1	0	0					STATE
V45X1083E	PRSD 02 ECS SEC SUPPLY VLV - OPEN	1	1	0	0					STATE
V45P1100A	PRSD 02 TANK 1 PRESS	626	534	516	440					PSIA
V45T1101A	PRSD 02 TANK 1 FLUID TEMP	-35	442	-162	295					DEGF

MEASUREMENT OUTPUT FROM FC/CRYO MODEL - TABLE 2

MEASUREMENT I. D.	MEASUREMENT NAME	I. C.		VALUE 1 (NOMINAL)		VALUE 2 (HI/LOW)		VALUE 3 (OFF)		UNITS
		FS	CTS	FS	CTS	FS	CTS	FS	CTS	
V45Q1105A	PRSD 02 TANK 1 QUANTITY	30	331	104	1023	0	51			PCNT
V45T1107A	PRSD 02 TANK 1 HTR ASSY 1 TEMP	-107	358	-166	291					DEGF
V45T1109A	PRSD 02 TANK 1 HTR ASSY 2 TEMP	-139	321	-167	288					DEGF
V45P1110A	PRSD 02 TANK 1 HTR CONTROL PRESS	750	481	517	4					PSIA
V45P1140A	PRSD 02 MANIF 1 PRESS	799	681	194	166					PSIA
V45X1141E	PRSD 02 MANIF 1 ISOL VLV - OPEN	1	1	0	0					STATE
V45P1145A	PRSD 02 MANIF 2 PRESS	811	692	185	158					PSIA
V45X1146E	PRSD 02 MANIF 2 ISOL VLV - OPEN	1	1	0	0					STATE
V45X1150E	PRSD FC 1 02 REAC VLV - OPEN	1	1	0	0					STATE
V45X1155E	PRSD FC 2 02 REAC VLV - OPEN	1	1	0	0					STATE
V45X1160E	PRSD FC 3 02 REAC VLV - OPEN	1	1	0	0					STATE
V45X1195E	PRSD 02 GSE SUPPLY VLV - CLSD	0	0	1	1					STATE
V45P1200A	PRSD 02 TANK 2 PRESS	636	542	518	442					PSIA
V45T1201A	PRSD 02 TANK 2 FLUID TEMP	-26	452	-160	297					DEGF
V45Q1205A	PRSD 02 TANK 2 QUANTITY	40	426	104	1023	0	51			PCNT
V45T1207A	PRSD 02 TANK 2 HTR ASSY 1 TEMP	-116	348	-162	295					DEGF
V45T1209A	PRSD 02 TANK 2 HTR ASSY 2 TEMP	-148	311	-167	288					DEGF
V45P1210A	PRSD 02 TANK 2 HTR CONTROL PRESS	760	501	518	6					PSIA
V45P1300A	PRSD 02 TANK 3 PRESS	646	550	521	444					PSIA
V45T1301A	PRSD 02 TANK 3 FLUID TEMP	-17	462	-159	299					DEGF
V45Q1305A	PRSD 02 TANK 3 QUANTITY	50	518	104	1023	0	51			PCNT
V45T1307A	PRSD 02 TANK 3 HTR ASSY 1 TEMP	125	338	-166	286					DEGF
V45T1309A	PRSD 02 TANK 3 HTR ASSY 2 TEMP	-157	301	-169	286					DEGF

ORIGINAL PAGE IS
OF POOR QUALITY

MEASUREMENT OUTPUT FROM FC/CRYO MODEL - TABLE 2

MEASUREMENT I. D.	MEASUREMENT NAME	I.C.		VALUE 1 K=1 (NOMINAL)		VALUE 2 K=2 (HI/LOW)		VALUE 3 K=3 (OFF)		UNITS
		FS	CTS	FS	CTS	FS	CTS	FS	CTS	
V45P1310A	PRSD O2 TANK 3 HTR CONTROL PRESS	770	522	520	10					PSIA
V45P2100A	PRSD H2 TANK 1 PRESS	220	563	145	370					PSIA
V45T2101A	PRSD H2 TANK 1 FLUID TEMP	-100	366	-286	151					DEGF
V45Q2105A	PRSD H2 TANK 1 QUANTITY	35	374	105	1023	0	51			PCNT
V45T2107A	PRSD H2 TANK 1 HTR ASSY TEMP	-70	401	-289	147					DEGF
V45P2110A	PRSD H2 TANK 1 HTR CONTROL PRESS	260	735	148	18					PSIA
V45P2140A	PRSD H2 MANIF 1 PRESS	190	487	142	364					PSIA
V45X2141E	PRSD H2 MANIF 1 ISOL VLV - OPEN	1	1	0	0					STATE
V45P2145A	PRSD H2 MANIF 2 PRESS	194	497	147	376					PSIA
V45X2146E	PRSD H2 MANIF 2 ISOL VLV - OPEN	1	1	0	0					STATE
V45X2150E	PRSD FC 1 H2 REAC VLV - OPEN	1	1	0	0					STATE
V45X2155E	PRSD FC 2 H2 REAC VLV - OPEN	1	1	0	0					STATE
V45X2160E	PRSD FC 3 H2 REAC VLV - OPEN	1	1	0	0					STATE
V45X2195E	PRSD H2 GSE SUPPLY VLV - CLSD	0	0	1	1					STATE
V45P2200A	PRSD H2 TANK 2 PRESS	230	589	150	385					PSIA
V45T2201A	PRSD H2 TANK 2 FLUID TEMP	-91	376	-291	145					DEGF
V45Q2205A	PRSD H2 TANK 2 QUANTITY	45	469	105	1023	0	51			PCNT
V45T2207A	PRSD H2 TANK 2 HTR ASSY TEMP	-60	413	-295	141					DEGF
V45P2210A	PRSD H2 TANK 2 HTR CONTROL PRESS	270	800	151	39					PSIA
V45P2300A	PRSD H2 TANK 3 PRESS	240	614	149	381					PSIA
V45T2301A	PRSD H2 TANK 3 FLUID TEMP	-83	387	-288	141					DEGF
V45Q2305A	PRSD H2 TANK 3 QUANTITY	55	561	105	1023	0	51			PCNT
V45T2307A	PRSD H2 TANK 3 HTR ASSY TEMP	-51	424	-293	145					DEGF
V45P2310A	PRSD H2 TANK 3 HTR CONTROL PRESS	280	863	150	39					PSIA

5.0 REFERENCES

- 1. LA-B-10100-1/JSC-11174, Space Shuttle Systems Handbook OV-102**
- 2. VS70-450102, Schematic Diagram - Fuel Cells**
- 3. VS70-450202, Schematic Diagram - Cryo Subsystem**
- 4. ICD-3-1603-05, Section 3.5, Interface Control Document for Fuel Cell & Cryo Controls**
- 5. SD76-SH-0027, Functional Subsystem Software Requirements (FSSR-6)**
- 6. SD72-SH-0104-1, System Definition Manual, paragraph 5.0, Fuel Cell/Cryogenic System**
- 7. LEC-9485, Orbiter 102 Subsystem Simulation Requirements**

APPENDIX G

ATMOSPHERE REVITALIZATION/H₂O MATH MODEL REQUIREMENTS

ACKNOWLEDGEMENTS:

The mathematical model flow chart appearing in Section 3 was based on one . . . prepared by Rockwell/Downey, California and provided the basic information from which this requirements document was prepared.

TABLE OF CONTENTS

Section	Page
1. INTRODUCTION.	G-3
2. DETAILED REQUIREMENTS	G-5
2.1 <u>FUNCTIONAL CHARACTERISTICS</u>	G-5
2.1.1 ARS/H ₂ O LOOPS SUBSYSTEM.	G-5
2.1.2 INPUT/OUTPUT	G-9
2.2 <u>DCM UPLINK</u>	G-10
2.3 <u>INITIALIZATION</u>	G-10
2.4 <u>TERMINATION REQUIREMENTS</u>	G-11
2.5 <u>UNIQUE REQUIREMENTS.</u>	G-11
2.6 <u>ANALOG MEASUREMENTS.</u>	G-12
2.6.1 POLYNOMIAL CONVERSION METHOD	G-12
2.6.2 RANGE LIMIT CONVERSION METHOD.	G-15
3. LOGIC FLOW DIAGRAMS.....	G-17
4. TABLES.	G-31
4.1 <u>INPUT STIMULI LIST</u>	G-31
4.2 <u>OUTPUT MEASUREMENT LIST.</u>	G-34
5. REFERENCES.	G-37

FIGURES

Figure	Page
2-1 Input/output data flow	G-6
2-2 ARS - Water coolant loops - Orbiter 102.	G-7

1. INTRODUCTION

Math models are used to simulate many of the Shuttle systems for which hardware does not exist in SAIL. A group of these models are termed non-avionic models since they do not simulate avionic equipment. The non-avionic models are needed to provide responses to cockpit switches, to drive cockpit displays, and to supply data for on-board software processing. The following list of non-avionic models will operate within the Test Operations Center (TOC) Ground Standard Interface Unit (GSIU).

- Main Propulsion System (Orbiter Portion)
- APU/Hydraulic
- Active Thermal Control
- Atmosphere Revitalization System (H₂O Loops and PCS/Airlock)
- Fuel Cell/Cryogenics
- Smoke Detection/Fire Suppression
- Water/Waste Management

When the TOC Display and Control Module (DCM) operator depresses the "SYS LOAD" key, the model programs, which are stored on the Fixed Head Disk in the DCM, are automatically loaded into the GSIU. The models are then activated and terminated by DCM test language statements. While the models are operating in the GSIU, the DCM operator is able to inhibit one, all, or any combination of model outputs with test language statements. This provides the DCM operator with control of output parameter values when off-nominal conditions are desired. To simplify the models and ease the processing load on supporting test equipment, the model requirements define nominal conditions only. Further, analog values for output parameters change in step fashion when responding to inputs, except when specific change rates for particular parameters are required. The DCM operator is also able to alter the value that the model uses to generate parameter outputs. This allows the DCM operator to adjust output parameter values needed to satisfy various mission phases.

When the model is activated, it shall check the input stimuli and shall provide appropriate output measurement values. It is preferred that the model provide output data when the input stimuli change. Bus activity is then minimal during those mission phases when the stimuli remain constant. However, the GSIU operating system may require a cyclic model program in which case the model output rate shall be once per second.

ORIGINAL PAGE IS
OF POOR QUALITY

2. DETAILED REQUIREMENTS

This model simulates those functions of the ARS/H₂O Loops Subsystem that are in the Orbiter. To simplify the model, only those subsystem functions needed to support testing of the Shuttle avionics system are provided.

The model receives stimuli from one source, the flight system via the Signal Termination Module (STM); the model provides output parameter values to the flight system via the STM. Figure 2-1 illustrates the data flow in and out of the model. Tables 2-1 and 2-2 list the input stimuli and output measurements. Figure 2-2 illustrates the general functioning of the ARS/H₂O Loops Subsystem.

2.1 FUNCTIONAL CHARACTERISTICS

2.1.1 ARS WATER COOLANT LOOPS

Thermal control within the cabin area and the avionics bays (1, 2, and 3) is accomplished by two parallel water coolant loops. For OV-102, both water coolant loops will be operated simultaneously during launch and entry. During orbital operations, only one water coolant loop will be operated. The water coolant loops (fig. 2-2) remove crew and equipment generated heat, and transport it to the active thermal control subsystem (ATCS) interchanger for heat rejection. Each coolant loop is identical with the exception that the primary loop contains two parallel mounted pumps and a shuttle check valve, while the secondary has only one pump and no shuttle check valve.

As depicted in figure 2-2 water flow leaving the pump first passes through a shuttle check valve (primary coolant loop only) to prevent flow around the inactive pump. On leaving the valve, the water coolant encounters a relief device. After this, the water coolant enters the silver ion generation (SIG) water chiller which cools fuel cell water to allow the water management subsystem SIG to provide proper water purification. From the SIG water chiller, the water coolant divides into two different paths.

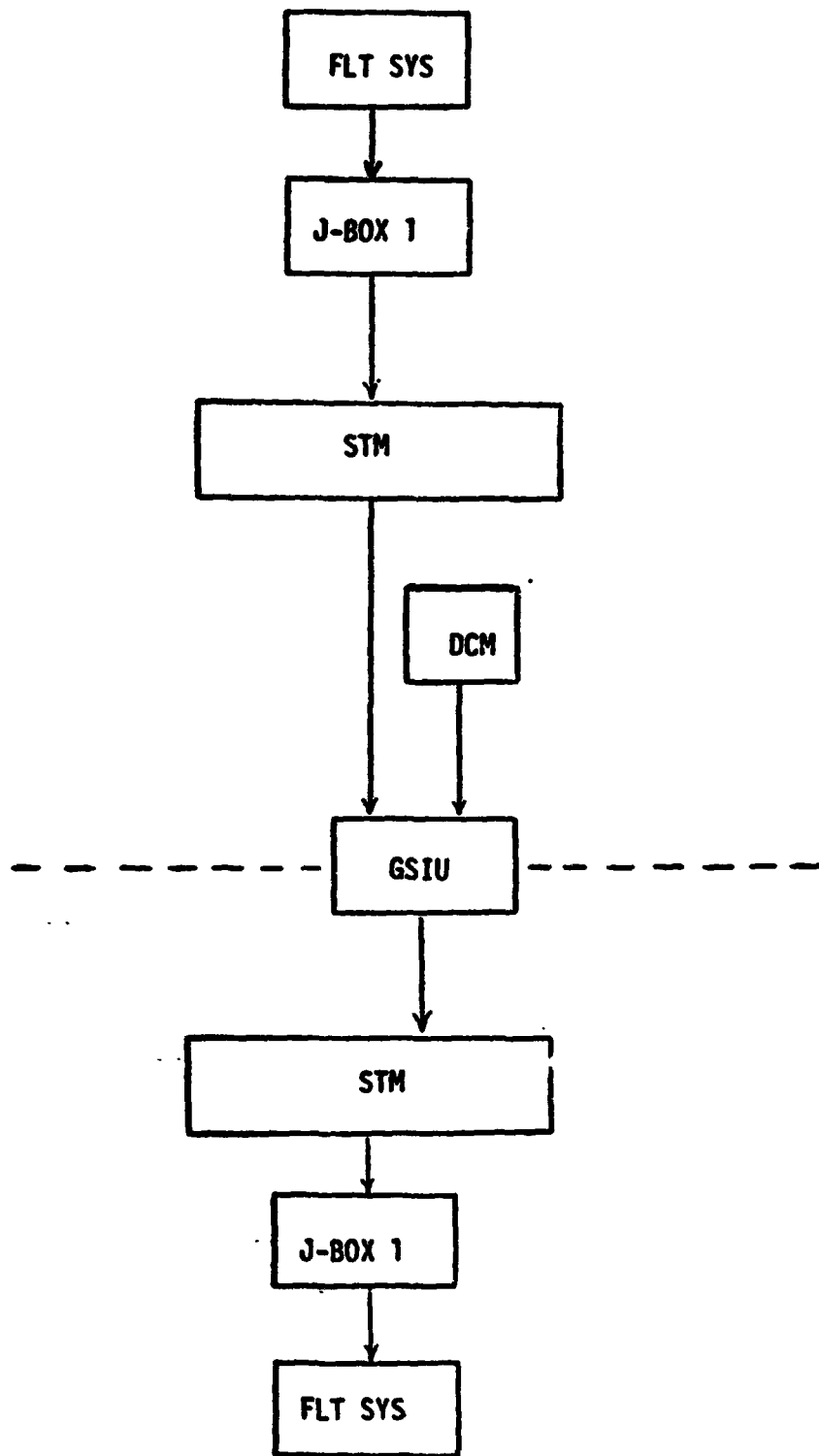


Figure 2-1.- Input/output data flow

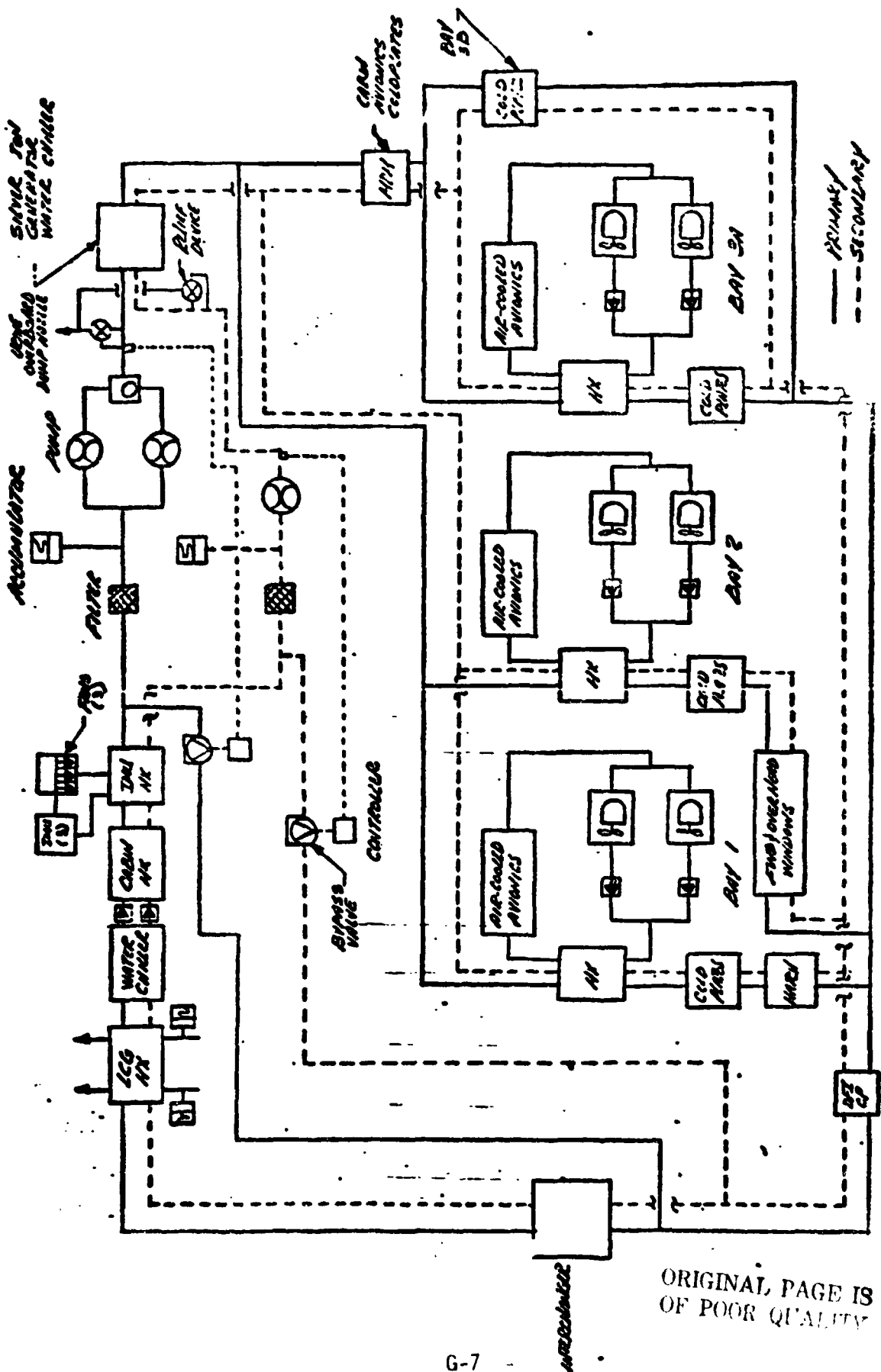


Figure 2-2.-- ARS ~ water coolant loops - Orbite 102.

- o One path provides water coolant to the cabin (MDM) avionics coldplates to pick up heat generated by the MDM's. From the coldplates, the flow divides into two parallel paths. One path directs water coolant through avionics bay 3A heat exchanger to absorb heat generated by various avionics equipment and then through the avionics bay coldplates. The second path provides water coolant to avionics bay 3B coldplates. From this point, the water coolant merges with coolant exiting bay 3A into a single path.
- o The second path divides into two parallel paths, thus entering in-cabin avionics bays 1 and 2. In these avionics bays, the water coolant flows through the avionics bay heat exchanger, and then the avionics bay coldplates. The water coolant leaving avionics bay 1 coldplates enters the hatch coolant loop, and the water coolant exiting avionics bay 2 enters the forward and overhead windows coolant loops. After leaving the hatch and windows, the water coolant merges with coolant exiting bays 3A and 3B into a single path.

Downstream of this point, the water coolant encounters the DFI coldplates and then the water bypass valve line. The bypass valve can be either automatically or manually controlled. In the auto mode, the bypass valve controls the water temperature in the water coolant pump package to $63 \pm 2.5^{\circ}\text{F}$ by bypassing coolant around the water/freon interchanger. For different phases of the mission, the bypass valve will be controlled as follows:

- o Launch and Entry - The bypass valve will be driven manually to the full flow through interchanger position, then the valve will be left in the manual mode.
- o Orbital - The bypass valve will be manually set to a predetermined position to match the required freon flow through the interchanger.

The water coolant that is bypassed around the interchanger then passes through the main loop filter. Downstream of the filter is the loop accumulator which maintains a constant pump inlet pressure and compensates for

thermal expansion and contraction of the coolant loop. From here, the water coolant returns to the pump for recirculation. The water coolant not bypassed continues through the interchanger for heat rejection. After this, the water coolant travels through the liquid cooling garment (LCG) heat exchanger, whose function is to supply chilled water to the airlock support subsystem for crewmen LCG cooling prior to EVA. From the LCG heat exchanger, the water coolant passes through a water chiller to cool water for crewman consumption. Then the water coolant goes through a check valve and the cabin condensing heat exchanger whose function is to remove sensible and latent heat from the cabin atmosphere. After leaving the cabin condensing heat exchanger, the water coolant is directed to the IMU heat exchanger where heat is absorbed by a convective conductive process. From the IMU heat exchanger, the water coolant returns to the coolant pump and accumulator assembly.

2.1.2 INPUT/OUTPUT

All inputs to the model are from the FS addressable at the STM. These stimuli are acted upon immediately at model execution without regard to time, and conditions are simulated in a step function manner. Any time-dependent inputs must be up-linked from the TOC-DCM as an abnormality (or parameter value change) in accordance with the GSIU Operating System.

For the sake of simplicity, the model will do no fault detection of stimuli, but will act upon it as received from the FS. Therefore, any fault insertion must include changes to all affected parameters in order to obtain a realistic response from the model.

All subsystem output is simulated by the model in accordance with stimuli from the FS. All measurements are made available to Systems Management (SM) and Fault Detection and Annunciation (FDA) as required.

STIMULI

INITIAL VALUE

T1	38
T2	38
R1	300
R2	300
L1 = 1	1
L2 = 1	1

All other stimuli will be initialized to 0.

2.4 TERMINATION REQUIREMENTS

None.

2.5 UNIQUE REQUIREMENTS

The following internal variables were introduced into the logic to facilitate computations.

- T₁ - Cabin H_x in TEMP - LOOP 1
- T₂ - Cabin H_x in TEMP - LOOP 2
- R₁ - H₂O INTCHGR flow rate - LOOP 1
- R₂ - H₂O INTCHGR flow rate - LOOP 2
- F1 - Internal logic flag
- T_c - Cabin TEMP
- L1 - Internal counter
- L2 - Internal counter

2.6 ANALOG MEASUREMENTS

Values shown in the math model flowcharts are in GSIU counts for all analog measurements. The math model values are seen by the flight system as 0 to 5 VDC inputs. The flight system then converts these input voltages to engineering units using one of the two types of scaling equations discussed in Sections 2.6.1 and 2.6.2. The GSIU math model count values (or the count values entered at the DCM by the test operator) must consider the scaling computation done later by the flight software, so that correct flight system engineering unit values are obtained for fault detection and annunciation (FDA), and for cockpit displays. The following two sections, 2.6.1 and 2.6.2, describe the scaling equations which apply to this model. Section 2.6.1 describes the scaling equation for measurements which require the polynomial conversion method. Section 2.6.2 describes the scaling equation for measurements which require the range limit conversion method which was used on STS-1.

2.6.1 POLYNOMIAL CONVERSION METHOD

The scaling polynomial equation used by the flight system is defined in the SM FSSR. The general form of the equation is given as follows:

$$FS_{EU} = A_0 + A_1X + A_2X^2 + A_3X^3$$

where: FS_{EU} = flight system engineering units

X = flight system input voltage

A_0, A_1, A_2, A_3 = scaling polynomial coefficients

The following example shows the step by step procedure for converting analog measurements from flight system engineering units (FS_{EU}) to GSIU counts. This procedure may be used to calculate GSIU count values for fault insertion at the DCM.

Example:

For measurement no. V63R1100A, convert FS_{EU} value = 2288 to GSIU counts.

Step 1:

In the SM FSSR, look up the measurement no. (V63R1100A) within the "SMM Data Requirements - Subsystems Displays" table. The measurement no. will appear on two consecutive pages as follows: page A will show engineering units, range low value and range high value, while page B will show the scaling polynomial coefficients (labelled A_0, A_1, A_2, A_3) followed by curve order, independent variable, and STS flight no. The values on page B will be of prime interest to do this example conversion, and will be referred to in the following discussion.

Step 2:

The coefficients will be used in the scaling polynomial:

$$FS_{EU} = A_0 + A_1X + A_2X^2 + A_3X^3$$

Solve the following scaling polynomial for X:

$$2288 = 443.167 + 851.956X - 143.904X^2 + 12.246X^3$$

$$\text{so } X = 3.846469$$

Step 3:

Notice the independent variable column labelled IND VR equals 2 for measurement no. V63R1100A. The 2 specifies that the independent variable X of the scaling polynomial is defined on a range of 0 to 5 VDC. So $X = 3.846$ VDC.

It is of interest to note that if IND VR had been equal to 0, X would have been defined on a range of 0 to 1023 PCM integer counts in which case X would be equal to 4 PCM counts, i.e. 3.846 rounded to the nearest integer.

However, in the example being worked, X is defined as VDC and $X = 3.846$ VDC.

Step 4:

Now to convert X VDC to GSIU counts, evaluate the following equation which shows the relationship between X and GSIU counts:

$$\text{GSIU counts} = \left[X \left(\frac{1023}{K} \right) \right], \text{ rounded to the nearest integer}$$

where $K = 5$, for X defined as VDC (IND VR = 2) and

$K = 500$, for X defined as PCM counts (IND VR = 0).

For the example, evaluate:

$$\text{GSIU counts} = \left[3.846 \left(\frac{1023}{5} \right) \right], \text{ rounded to the nearest integer}$$

Therefore, GSIU counts = 787 counts.

Note that since GSIU counts are always rounded to the nearest integer, small changes will possibly occur in the values of X and consequently FS_{EU} , when the reverse calculations are made during test operations, as the following shows:

$$X = \text{GSIU counts} \left(\frac{K}{1023} \right)$$

$$X = 787 \times \left(\frac{5}{1023} \right)$$

$$\text{SO } X = 3.846529$$

And

$$FS_{EU} = 443.167 + 851.956X - 143.904X^2 + 12.246X^3$$

$$FS_{EU} = 443.157 + 851.956(3.848) - 143.904(3.848)^2 + 12.246(3.848)^3$$

$$FS_{EU} = 2288.017$$

Hence when 787 GSIU counts is inserted for measurement no. V63R1100A, a value of 2288.017 FS_{EU} will result.

2.6.2 RANGE LIMIT CONVERSION METHOD

Several analog measurements in this model are calculated according to the range limit conversion method, instead of the polynomial conversion method as described in Section 2.6.1 of this document. The form of the scaling equation for these cases is given as follows:

$$FS_{EU} = Low + \frac{GSIU_{CTS}}{1023} (High - Low)$$

where: FS_{EU} = flight system engineering units

$GSIU_{CTS}$ = GSIU math model count values

Low = Range low limit

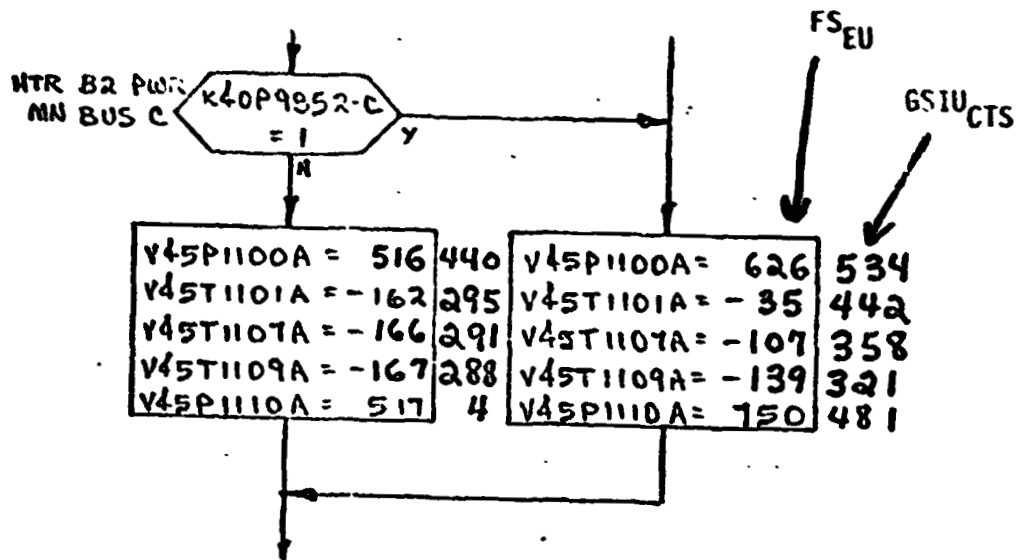
High = Range high limit

The following table shows a sample data value for each measurement which requires this type of calculation. The measurement I.D. is shown along with high and low values for the parameter range. The FS column shows the data value in flight system engineering units calculated from the GSIU counts marked CTS in the table. These measurements are marked with an asterisk (*) in the Output Measurement List marked as Table 2 in Section 4.2 of this document.

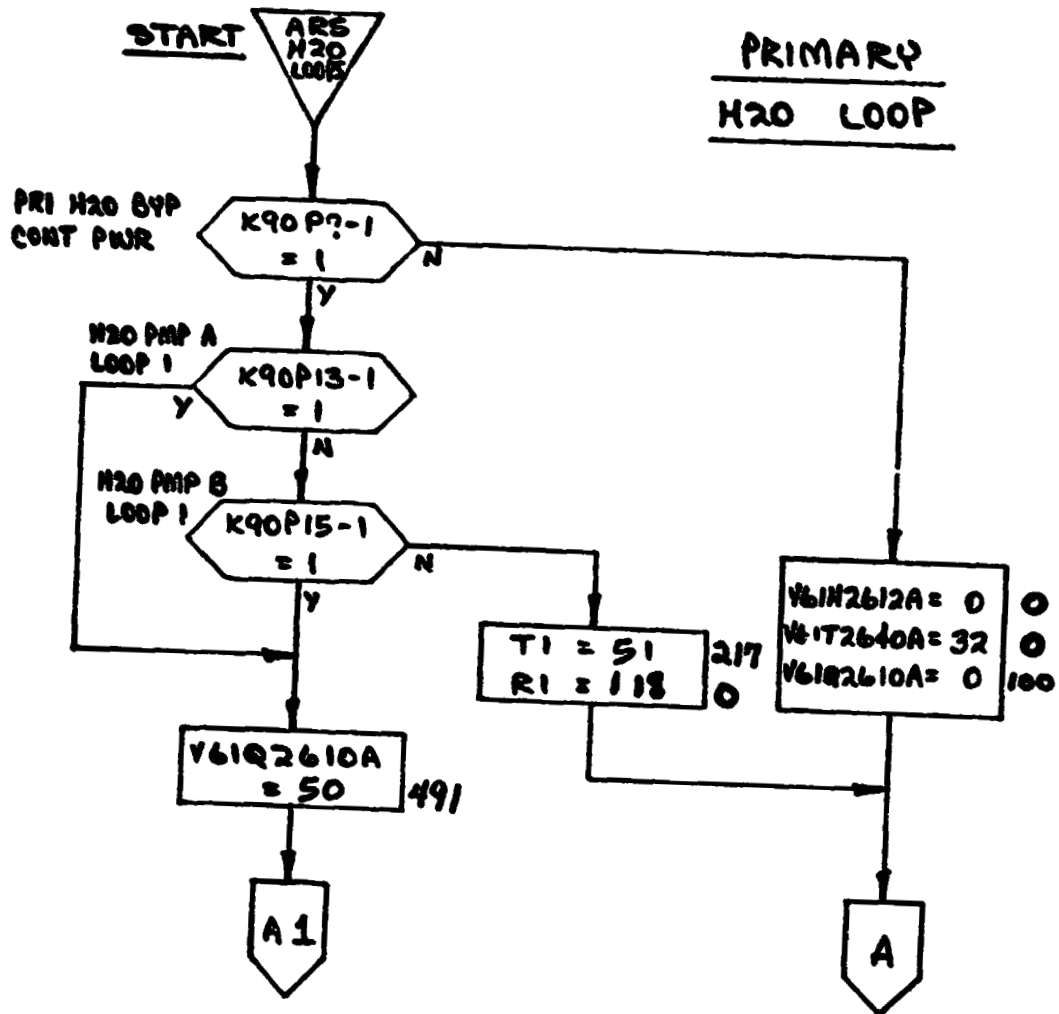
MEASUREMENT ID	RANGE LOW	RANGE HIGH	FS	CTS
V61P2540A	0	30	5.2	177
V61Q2551A	0	100	51	522
V61H2612A	0	100	2	20
V61H2712A	0	100	95	972

3.0 LOGIC FLOW DIAGRAMS

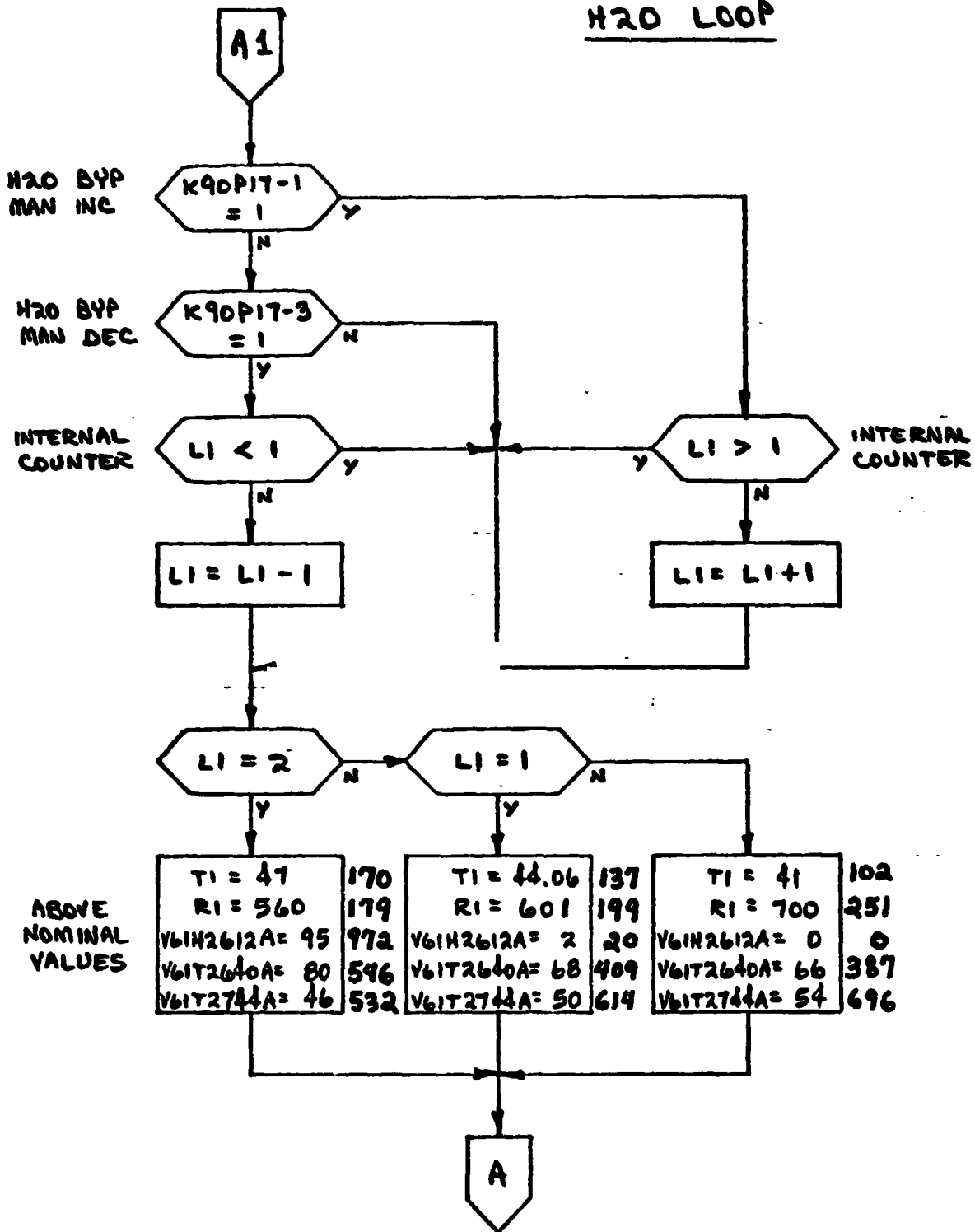
The logic flow diagram is made up of interconnected lines, boxes, decisions, and offpage connectors. Notice that where analog measurements are listed in boxes and decisions, the value inside the box is in flight system engineering units (FS_{EU}) while the corresponding GSIU count value is listed outside the box. For example, the box on the right hand below,



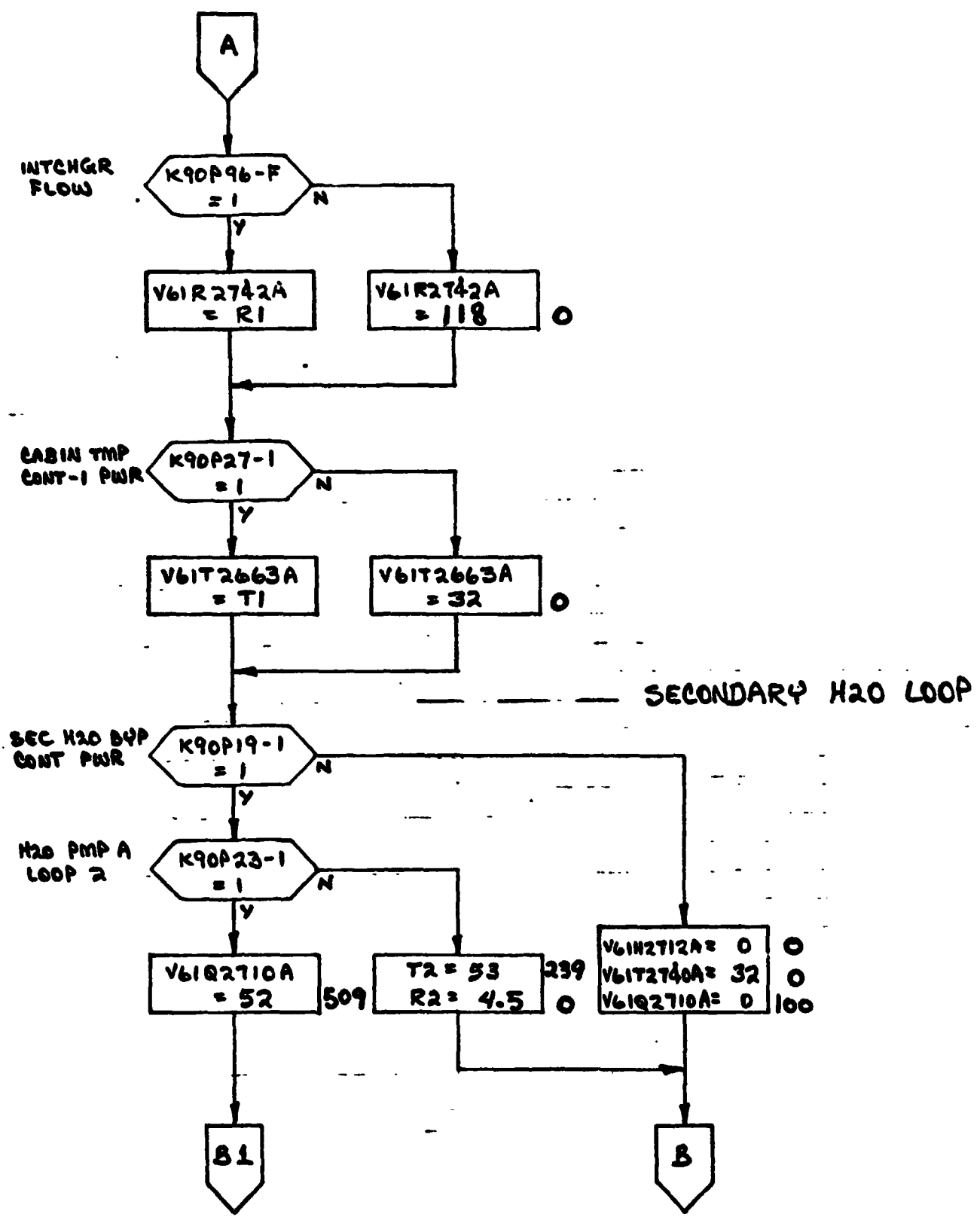
shows that V45P1100A is set equal to 626 FS_{EU} which is equivalent to 534 $GSIU_{CTS}$ shown outside the box.



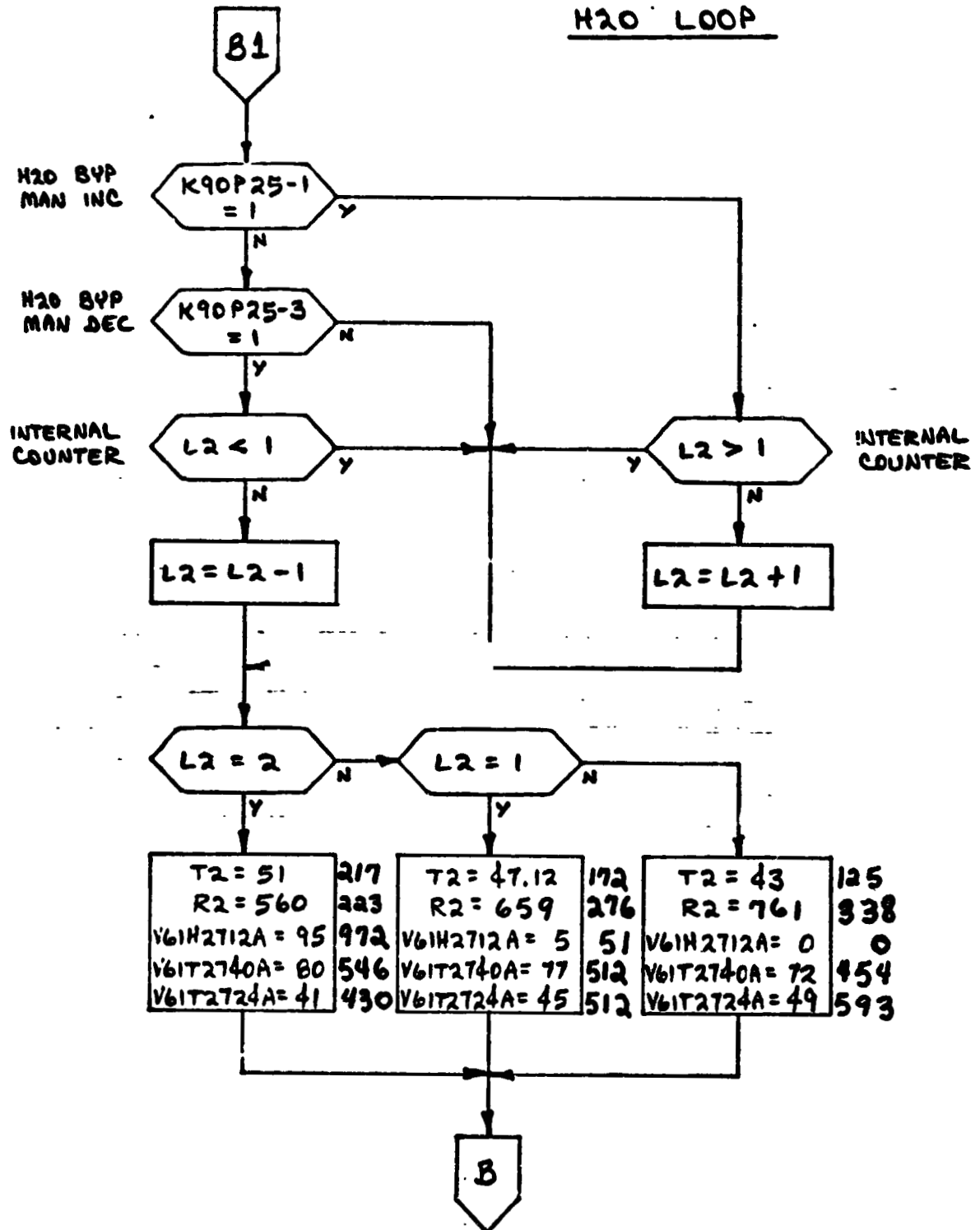
PRIMARY
H2O LOOP



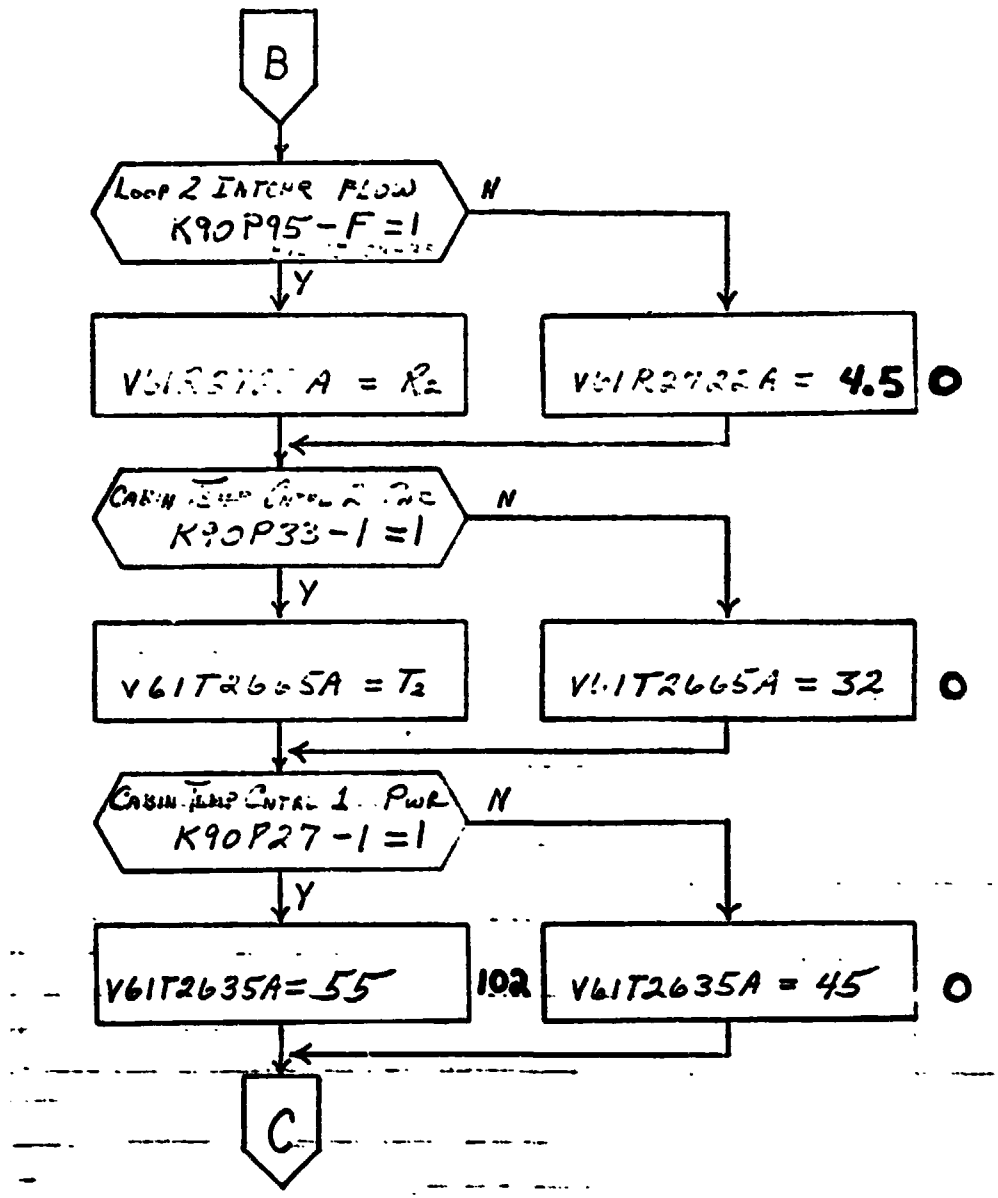
ORIGINAL PAGE IS
OF GOOD QUALITY

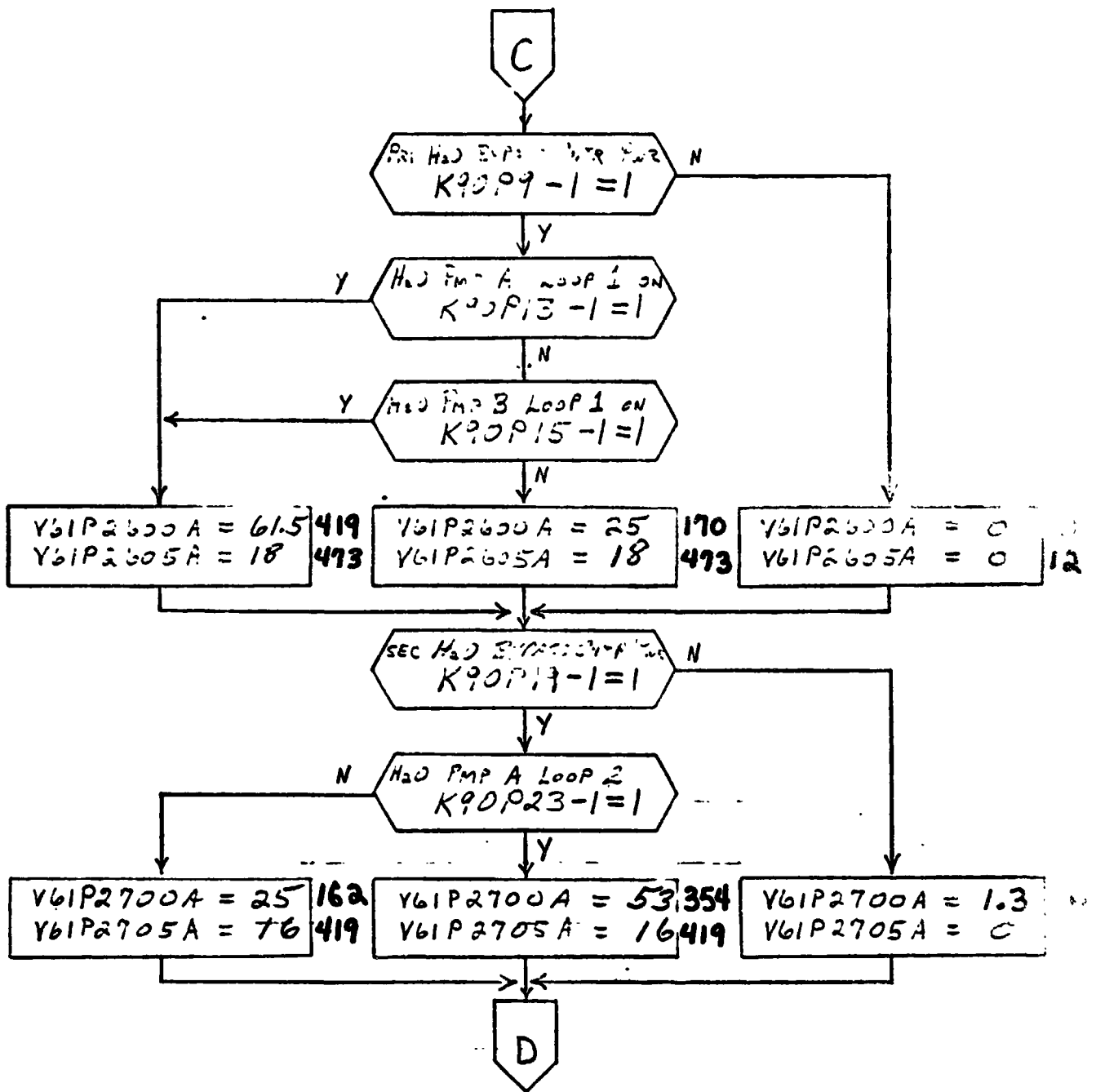


SECONDARY
H2O LOOP

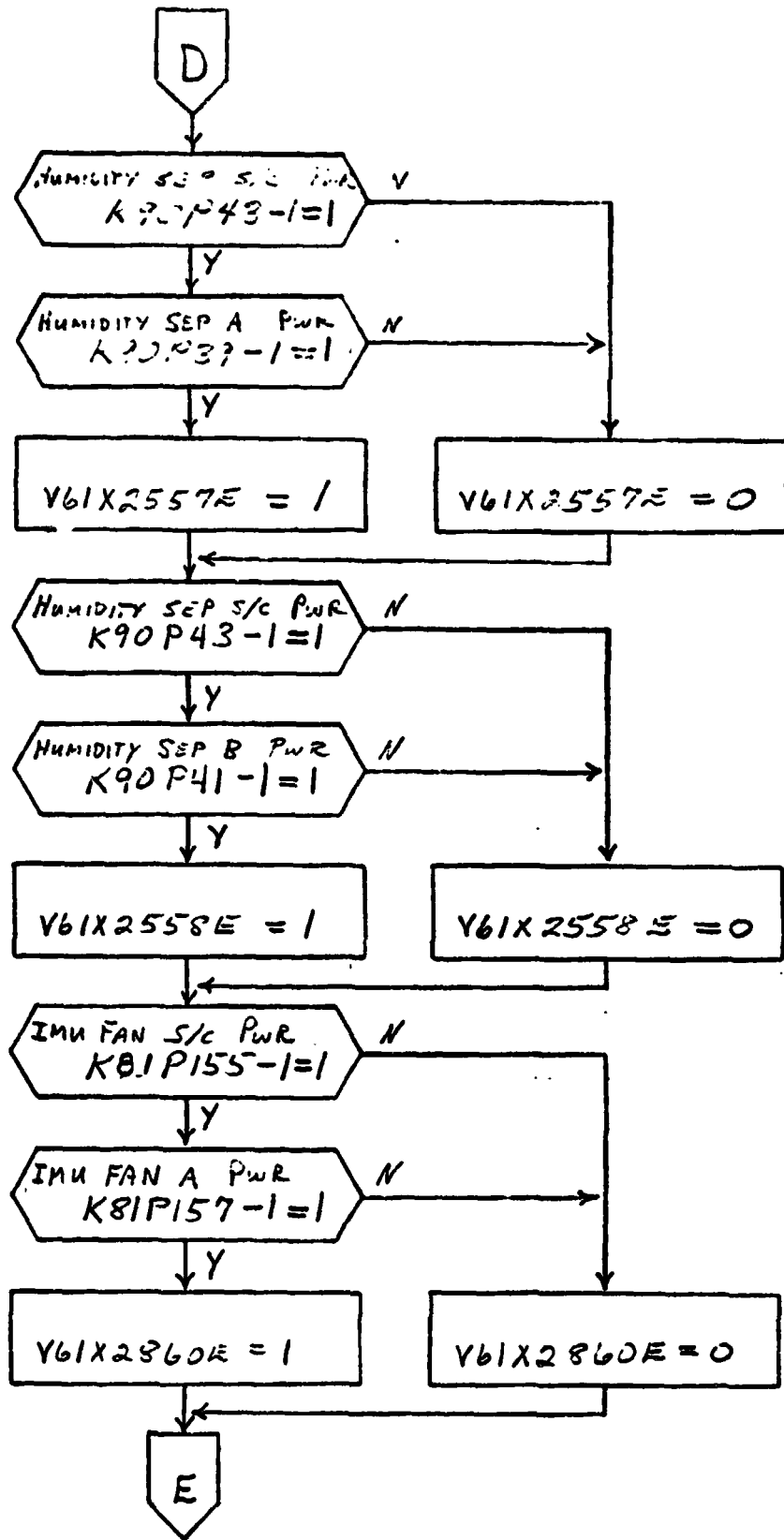


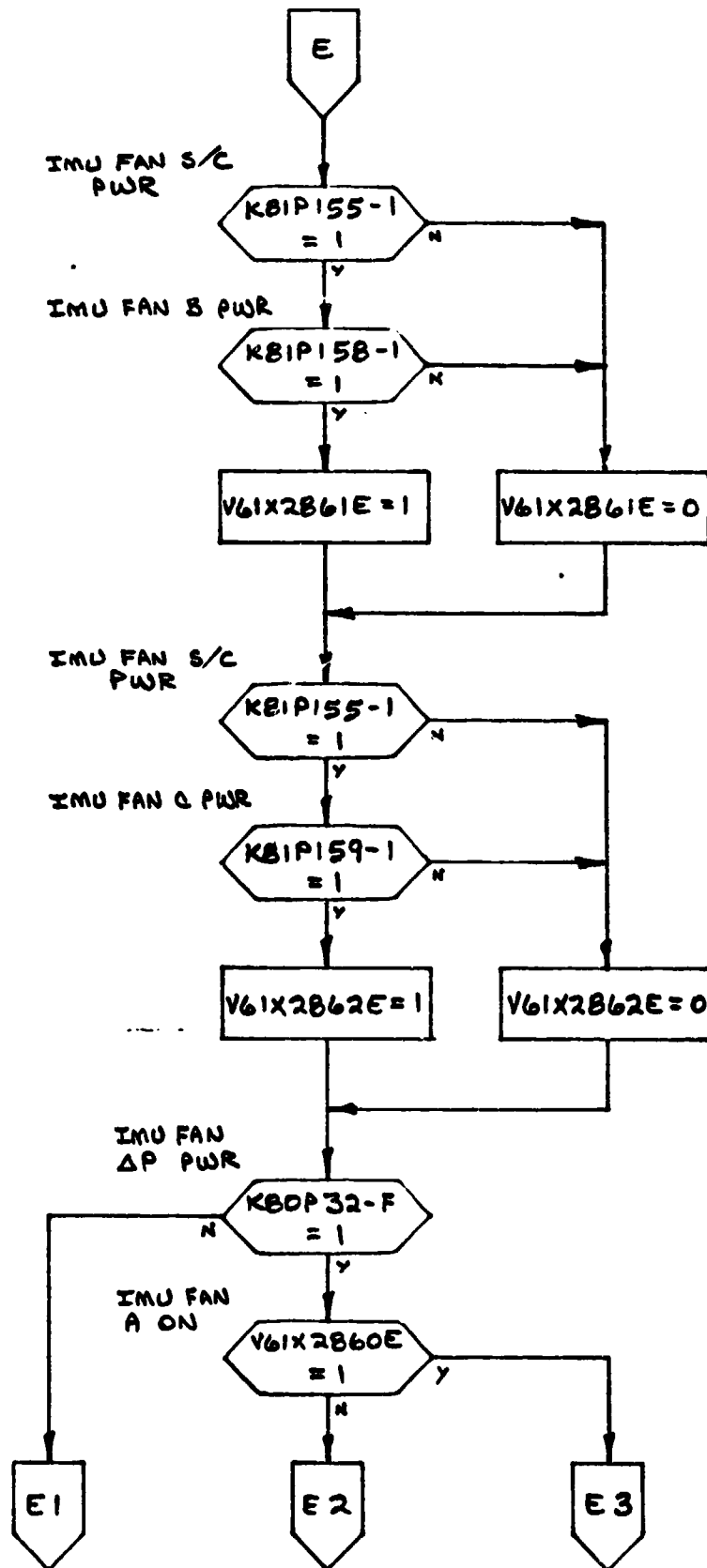
T2 = 51	217	T2 = 47.12	172	T2 = 43	125
R2 = 560	223	R2 = 659	276	R2 = 761	338
V61H2712A = 95	972	V61H2712A = 5	51	V61H2712A = 0	0
V61T2740A = 80	546	V61T2740A = 77	512	V61T2740A = 72	454
V61T2724A = 41	430	V61T2724A = 45	512	V61T2724A = 49	593

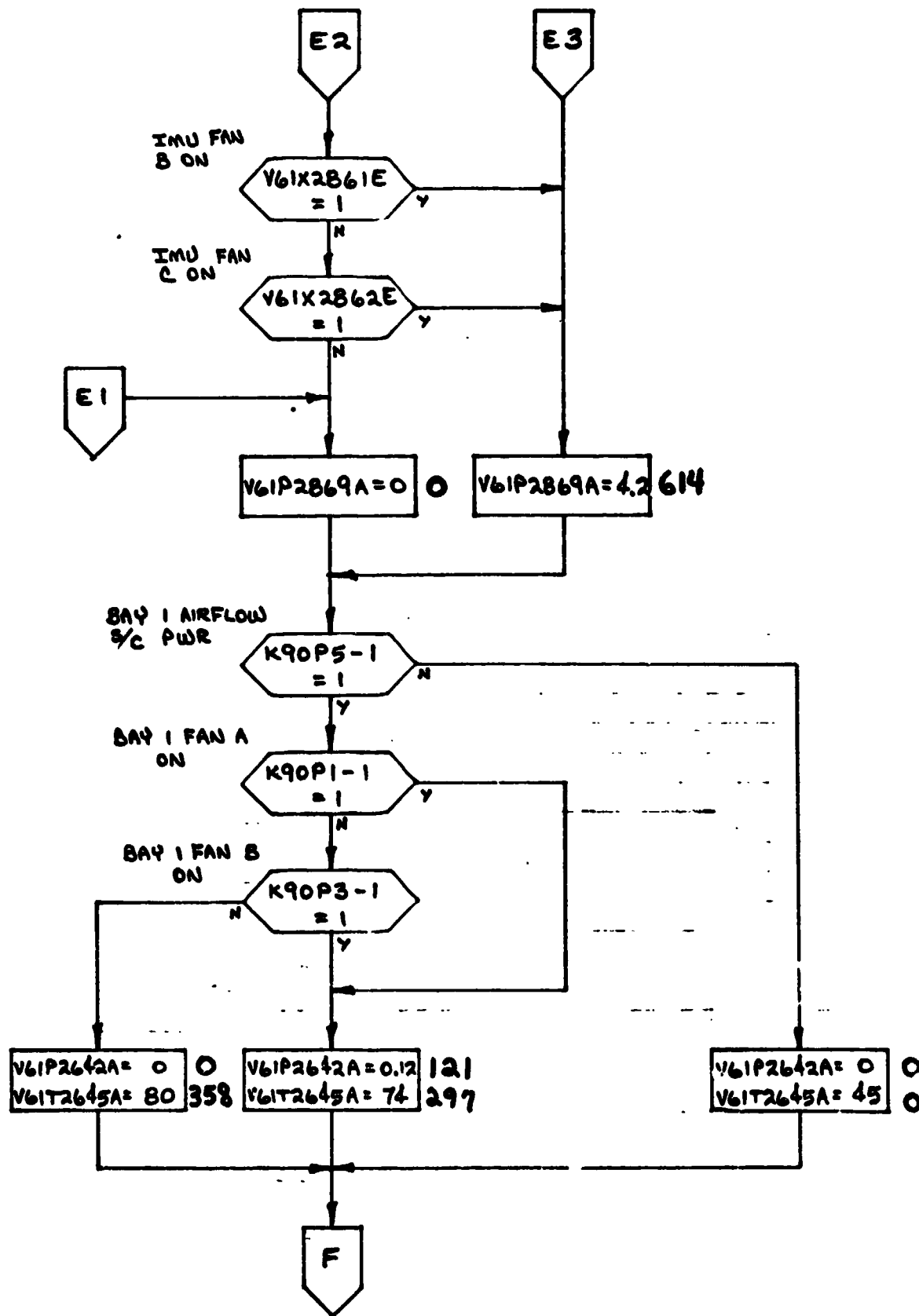




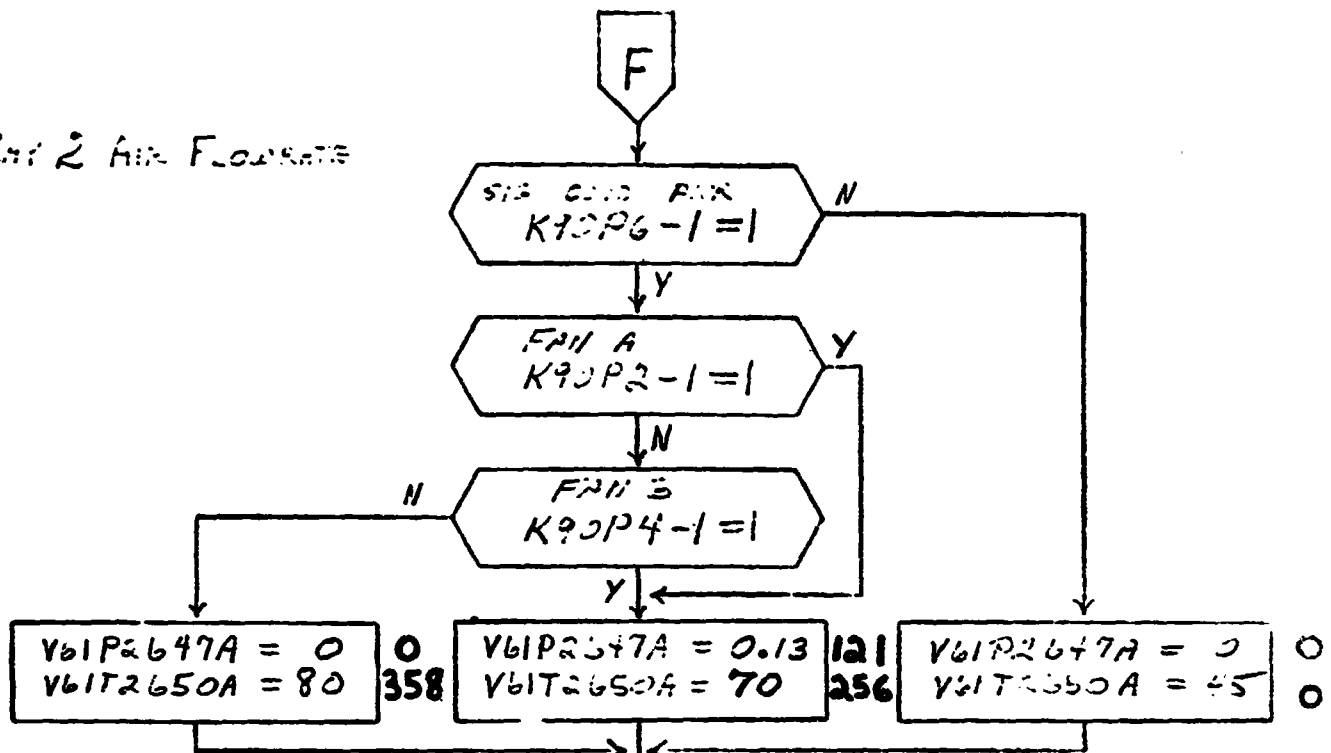
ORIGINAL PAGE IS
OF POOR QUALITY



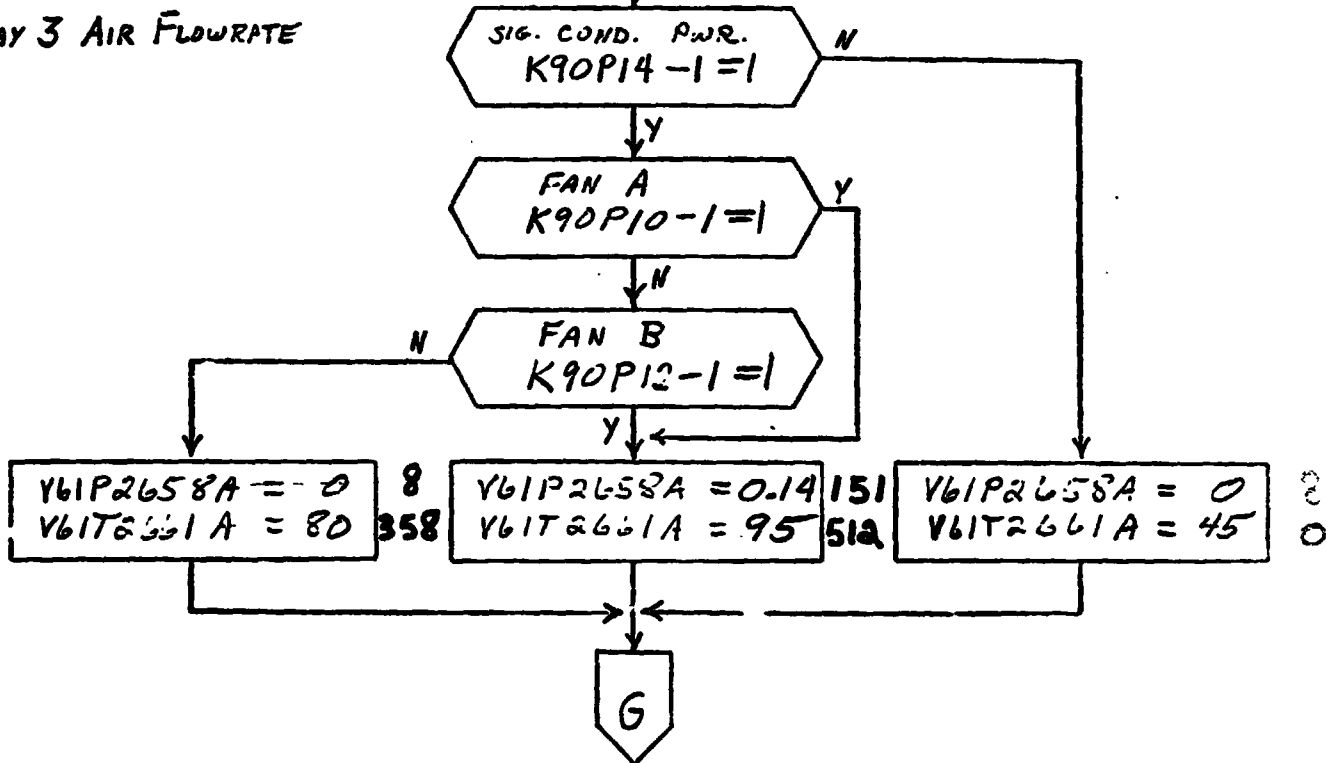




Bay 2 Air Flowrate

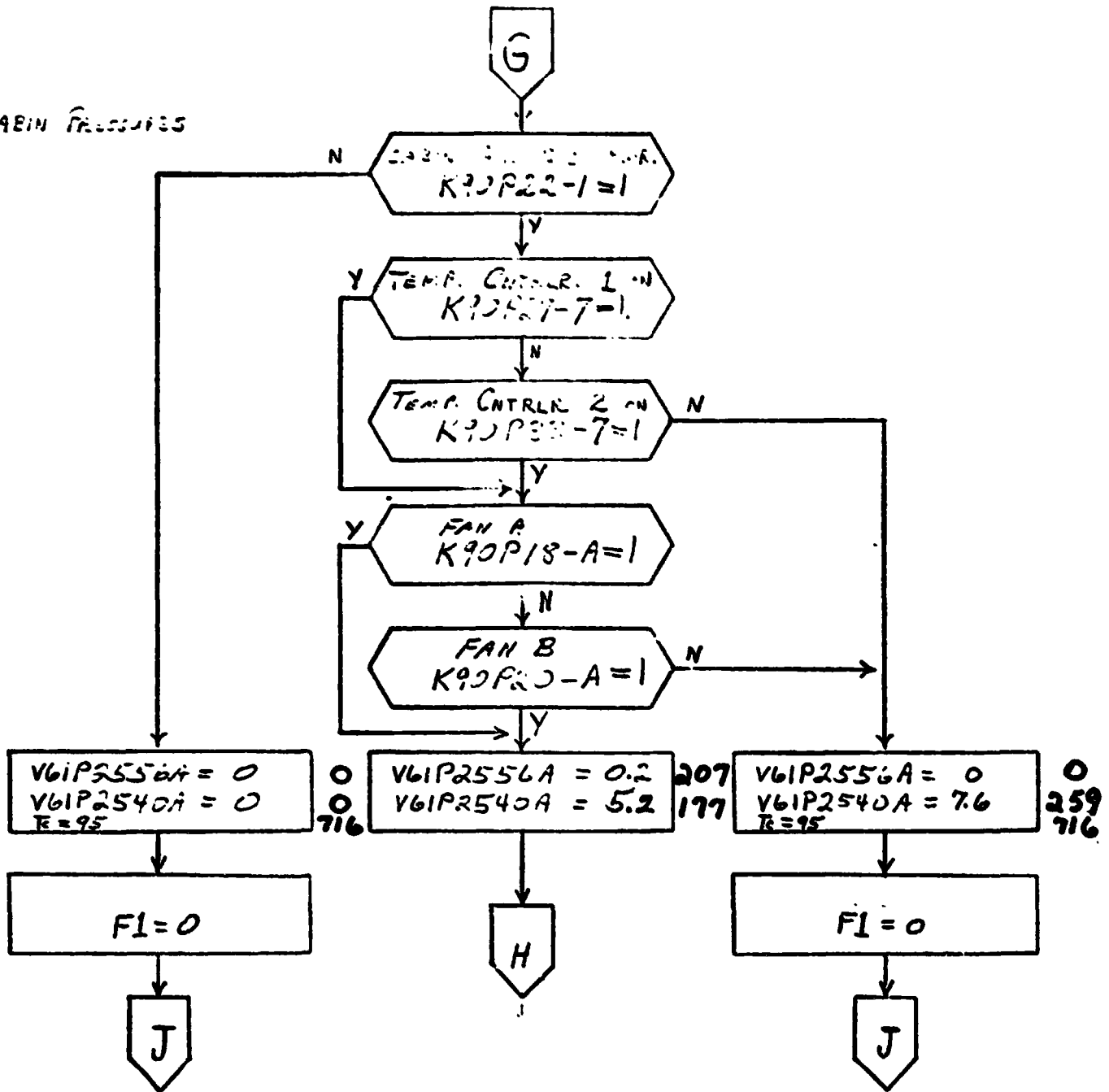


Bay 3 Air Flowrate

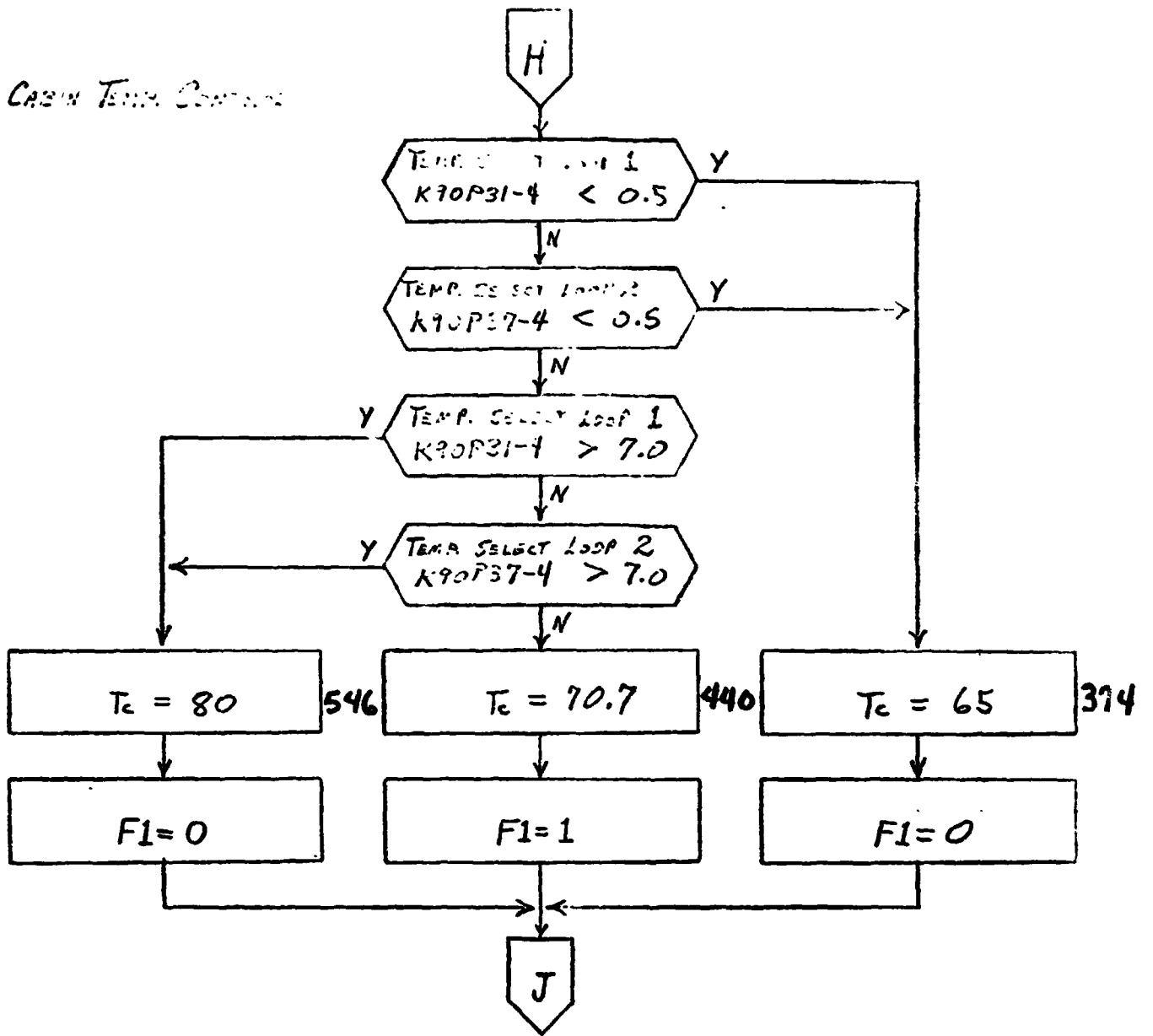


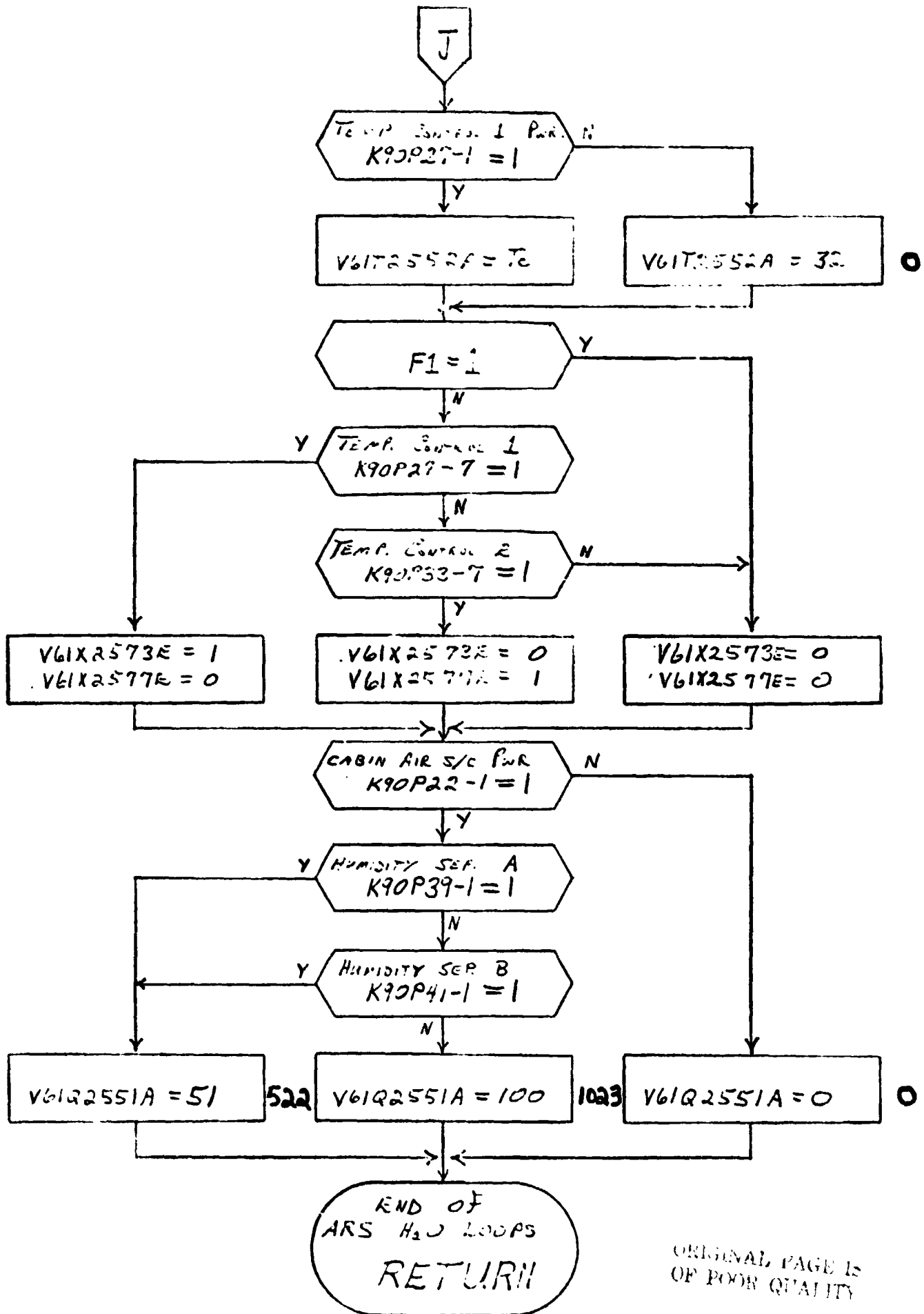
ORIGINAL PAGE IS
OF POOR QUALITY

CABIN PRESSURE



CASIN TEMP CONTROL





ORIGINAL PAGE IS OF POOR QUALITY

4. TABLES

4.1 INPUT STIMULI LIST

Table 1 lists input stimuli to the ARS/H₂O Loops model in terms of ID numbers, nomenclature, stimuli source, address, and range of parameter.

TABLE 2-1.-- STIMULI (PUT TO ARS-H2O LOOPS)

IDENTIFICATION NUMBER	NOMENCLATURE	SOURCE	STATES/RANGE			UNITS
			LO	HI		
V61K2120E	CABIN TEMP. CNTRL - LOOP 1 ON	FS via STM	0	1	STATE	
V61K2121E	CABIN TEMP. CNTRL - LOOP 2 ON		0	1	STATE	
V61K2450E	HUMIDITY SEPARATOR A ON		0	1	STATE	
V61K2455E	HUMIDITY SEPARATOR B ON		0	1	STATE	
V61K2566A	CABIN TEMP SELECTOR - LOOP 1		0	7.5	VDC	
V61K2567A	CABIN TEMP SELECTOR - LOOP 2		0	7.5	VDC	
V61K2585E	CABIN FAN A ON		0	1	STATE	
V61K2590E	CABIN FAN B ON		0	1	STATE	
V61K2601E	H ₂ O PUMP A - LOOP 1 ON		0	1	STATE	
V61K2606E	H ₂ O PUMP B - LOOP 1 ON		0	1	STATE	
V61K2701E	H ₂ O PUMP - LOOP 2 ON		0	1	STATE	
V61K2747E	H ₂ O BYPASS MNL-INCR - LOOP 1		0	1	STATE	
V61K2748E	H ₂ O BYPASS MNL-DECR - LOOP 1		0	1	STATE	
V61K2770E	AV. BAY 1 FAN A ON		0	1	STATE	
V61K2775E	AV. BAY 1 FAN B ON		0	1	STATE	
V61K2780E	AV. BAY 2 FAN A ON		0	1	STATE	
V61K2785E	AV. BAY 2 FAN B ON		0	1	STATE	
V61K2790E	AV. BAY 3 FAN A ON		0	1	STATE	
V61K2795E	AV. BAY 3 FAN B ON		0	1	STATE	
V61K2847E	H ₂ O BYPASS MNL-INCR - LOOP 2		0	1	STATE	
V61K2848E	H ₂ O BYPASS MNL-DECR - LOOP 2	0	1	STATE		

TABLE 2-1. continued.

IDENTIFICATION NUMBER	NOMENCLATURE	SOURCE	STATES/RANGE		UNITS
			LO	HI	
V61K2849E	IMU FAN A	FS via STM	0	1	STATE
V61K2852E	IMU FAN B		0	1	
V61K2855E	IMU FAN C		0	1	
N/A	CABIN TEMP. CNTRLR 1 PWR	PNL L4-Cb 117	0	1	
N/A	CABIN TEMP. CNTRLR 2 PWR	PNL L4-CB 119	0	1	
N/A	INTCHGR FLOW - H ₂ O LOOP 1 PWR	PNL 014-CB 35	0	1	
N/A	INTCHGR FLOW - H ₂ O LOOP 2 PWR	PNL 015-CB-35	0	1	
N/A	AV. BAY 1 S/C POWER	PNL L4-CB-127	0	1	
N/A	AV. BAY 2 S/C POWER	PNL L4-CB-118	0	1	
N/A	AV. BAY 3 S/C POWER	PNL L4-CB 120	0	1	
N/A	H ₂ O BYPASS CNTRLR - PRI	PNL L4-CB 121	0	1	
N/A	H ₂ O BYPASS CNTRLR - SEC.	PNL L4-CB 93	0	1	
N/A	IMU FAN S/C POWER	PNL L4-CB 81	0	1	
N/A	CABIN AIR S/C POWER	PNL L4-CB 94	0	1	
N/A	HUMIDITY SEP S/C POWER	PNL L4-CB 80	0	1	
N/A	IMU FAN ΔP POWER	FS VIA STM	0	1	

4.2 OUTPUT MEASUREMENT LIST

Table 2 lists all model outputs along with the initial condition value for the output. Measurement I.D. and Measurement Name precede pairs of numeric columns. The first of each pair is labeled FS indicating flight system engineering units. The second of each pair is labeled CTS indicating the GSIU count value corresponding to the FS value. I.C. indicates initial condition values. VALUE 1 typically indicates nominal values. VALUE 2 and VALUE 3 columns indicate off nominal conditions.

MEASUREMENT OUTPUT FROM AR/H₂O MODEL - TABLE 2

MEASUREMENT I. D.	MEASUREMENT NAME	I. C.		VALUE 1		VALUE 2		VALUE 3		UNITS
		FS	CTS	FS	CTS	FS	CTS	FS	CTS	
V61P2540A	CO ₂ PARTIAL PRESSURE	5.2	177	0	0	7.6	259			MMHG
V61Q2551A	CABIN HUMIDITY	51	522	0	0	100	1023			PERCENT
V61T2552A	CABIN TEMP.	70.7	440	32 95	0 716	65	374	80	546	DEG. F.
V61P2556A	CABIN FAN DELTA PRESSURE	0	0	0.2	207					PSID
V61X2557E	HUMIDITY SEP A SPEED	0	0	1	1					STATE
V61X2558E	HUMIDITY SEP B SPEED	0	0	1	1					STATE
V61X2573E	CABIN TEMP CTL FULL HX-LOOP 1	0	0	1	1					STATE
V61X2577E	CABIN TEMP CTL FULL HX-LOOP 2	0	0	1	1					STATE
V61P2600A	H ₂ O PUMP OUT PRESS - PRI	61.5	419	0	0	25	170			PSIA
V61P2605A	H ₂ O PUMP IN PRESS-PRI	18	473	0	12					PSIA
V61Q2610A	H ₂ O ACCUM QTY-PRI	50	491	0	100					PERCENT
V61H2612A	H ₂ O BYPASS VLV. POS.-PRI	2	20	0	0	95	972			PERCENT
V61T2635A	CABIN HX OUT TEMP.	55	102	45	0					DEG. F.
V61T2640A	H ₂ O PUMP OUT TEM.-LOOP 1	68	409	32	0	66	387	80	546	DEG. F.
V61P2642A	AV. BAY 1 DELTA PRESS.	0	0	0.12	121					PSID
V61T2645A	AV. BAY 1 OUT AIR TEMP.	74	297	45	0	80	358			DEG. F.
V61P2647A	AV. BAY 2 DELTA PRESS.	0.13	121	0	0					PSID
V61T2650A	AV. BAY 2 OUT AIR TEMP.	70	256	45	0	80	358			DEG. F.
V61P2658A	AV. BAY 3 DELTA PRESS.	0.14	151	0	8					PSID
V61T2661A	AV. BAY 3 OUT AIR TEMP.	95	512	45	0	80	358			DEG. F.
V61T2663A	CABIN HX IN. TEMP.-LOOP 1	44.06	137	32 51	0 217	41	102	47	170	DEG. F.

*NOTE: This measurement uses the range limit conversion method of calculating FSEU from GSIUCTS as discussed in section 2.2.2.

MEASUREMENT OUTPUT FROM AR/H₂O MODEL - TABLE 2

MEASUREMENT I. D.	MEASUREMENT NAME	I. C.		VALUE 1		VALUE 2		VALUE 3		UNITS
		FS	CTS	FS	CTS	FS	CTS	FS	CTS	
V61T2665A	CABIN HX IN. TEMP. - LOOP 2	47.12	172	32	0	43	125	51	217	DEG.F.
V61P2700A	H ₂ O PUMP OUT PRESS-SEC.	53	354	1.3	0	25	162			PSIA
V61P2705A	H ₂ O PUMP IN. PRESS-SEC.	16	419	0	10					PSIA
V61Q2710A	H ₂ O ACCUM. QTY-SEC.	52	509	0	100					PERCENT
V61H2712A	H ₂ O BYPASS VLV. POS.-SEC	95	972	0	0	5	51			PERCENT
V61R2722A	H ₂ O INTCHGR. FLOW - LOOP 2	659	276	4.5	0	560	223	761	338	PPH
V61T2724A	H ₂ O INTCHGR. OUT TEMP. - LOOP 2	45	512	41	430	49	593			DEG.F.
V61T2740A	H ₂ O PUMP OUT TEMP - LOOP 2	77	512	32	0	72	454	80	546	DEG.F.
V61R2742A	H ₂ O INTCHGR. FLOW - LOOP 1	118	0	560	179	601	199	700	251	PPH
V61T2744A	H ₂ O INTCHGR. OUT TEMP. - LOOP 1	50	614	46	532	54	696			DEG.F.
V61X2860E	IMU FAN A SPEED	0	0	1	1					STATE
V61X2861E	IMU FAN B SPEED	0	0	1	1					
V61X2862E	IMU FAN C SPEED	0	0	1	1					
V61P2869A	IMU FAN ΔP	4.2	614	0	0					INCHES H ₂ O

*NOTE: This measurement uses the range limit conversion method of calculating FS_{EU} from GSIU_{CTS} as discussed in section 2.6.2.

5. REFERENCES

LA-B-10100-1/JSC-11174-Space Shuttle Systems Handbook OV-102

Schematic Diagram Atmospheric Revitalization Subsystem VS70-610102 (5/20/77)

Interface Control Document 3-1603-05

Orbiter 102 Subsystem Simulation Requirements for ECLSS - LEC-9485

APPENDIX H
ATMOSPHERE REVITALIZATION/PCS MATH MODEL REQUIREMENTS

CONTENTS

Section	Page
1. INTRODUCTION.	H-3
2. DETAILED REQUIREMENTS	H-5
2.1 <u>FUNCTIONAL CHARACTERISTICS</u>	H-5
2.1.1 MODEL FUNCTION	H-9
2.1.2 INPUT/OUTPUT	H-10
2.2 <u>DCM UPLINK</u>	H-10
2.3 <u>INITIALIZATION REQUIREMENTS.</u>	H-11
2.4 <u>TERMINATION REQUIREMENTS</u>	H-11
2.5 <u>UNIQUE REQUIREMENTS.</u>	H-11
2.6 <u>ANALOG MEASUREMENTS.</u>	H-12
2.6.1 POLYNOMIAL CONVERSION METHOD	H-12
2.6.2 RANGE LIMIT CONVERSION METHOD.	H-15
3. LOGIC FLOW DIAGRAMS	H-17
4. TABLES.	H-35
5. REFERENCES.	H-43

CONTENTS

TABLES

Table		Page
1	STIMULI INPUTS TO ARS/PCS MODEL	H-36
1A	STIMULI TO MML CORRELATION.	H-38
2	MEASUREMENT OUTPUTS FROM ARS/PCS MODEL.	H-40

FIGURES

Figure		
1	Input/Output Data Flow	H-6
2	ATMOS Pressure and Control System Simplified Schematic.	H-7
3	AIRLOCK SIMPLIFIED SCHEMATIC.	H-8

1.0 INTRODUCTION:

Math models are used to simulate many of the Shuttle systems for which hardware does not exist in SAIL. A group of these models are termed non-avionics models since they do not simulate avionic equipment. The non-avionics models are needed to provide responses to cockpit switches, to drive cockpit displays, and to supply data for on-board software processing. The following list of non-avionic models will operate within the Test Operations Center (TOC) Ground Standard Interface Unit (GSIU).

- Main Propulsion System (Orbiter Portion)
- APU/Hydraulic System
- Active Thermal Control System
- Atmosphere Revitalization - H₂O Loops and Atmos Circ System
- Atmosphere Revitalization - Pressurization and Control System/Airlock
- Fuel Cell/Cryogenics System
- Smoke Detection System
- Water/Waste Management System

When the TOC Display and Control Module (DCM) operator depresses the "SYS LOAD" key, the model programs, which are stored on the Fixed Head Disk in the DCM, are automatically loaded into the GSIU. The models are then activated and terminated by DCM test language statements. While the models are operating in the GSIU, the DCM operator is able to inhibit one, all, or any combination of model outputs with test language statements. This provides the DCM operator with control of output parameter values when off-nominal conditions are desired. To simplify the models and ease the processing load on supporting test equipment, the model requirements define nominal conditions only. Further, a. . . values for output parameters change in step fashion when responding to inputs, except when specific change rates for particular parameters are required. The DCM operator is also able to alter the value that the model uses to generate parameter outputs.

This allows the DCM operator to adjust output parameter values as needed to satisfy various mission phases.

When the model is activated, it shall check the input stimuli and shall provide appropriate output measurement values. It is preferred that the model provide output data when the input stimuli changes. Bus activity is then minimal during those mission phases when the stimuli remains constant. However, the GSIU operating system may require a cyclic model program in which case the model output rate shall be once per second.

2.0 DETAILED REQUIREMENTS

This model simulates the Orbiter Atmosphere Revitalization/Pressurization and Control-Airlock System (AR/PCS-Airlock) by representing the stimulus/response relationships which exist at the power and signal interfaces between the Orbiter Avionics System and the AR/PCS-Airlock. The Model has been simplified by including only those output signals which are needed to support the type of testing which will be accomplished in the Shuttle Avionics Integration Laboratory (SAIL).

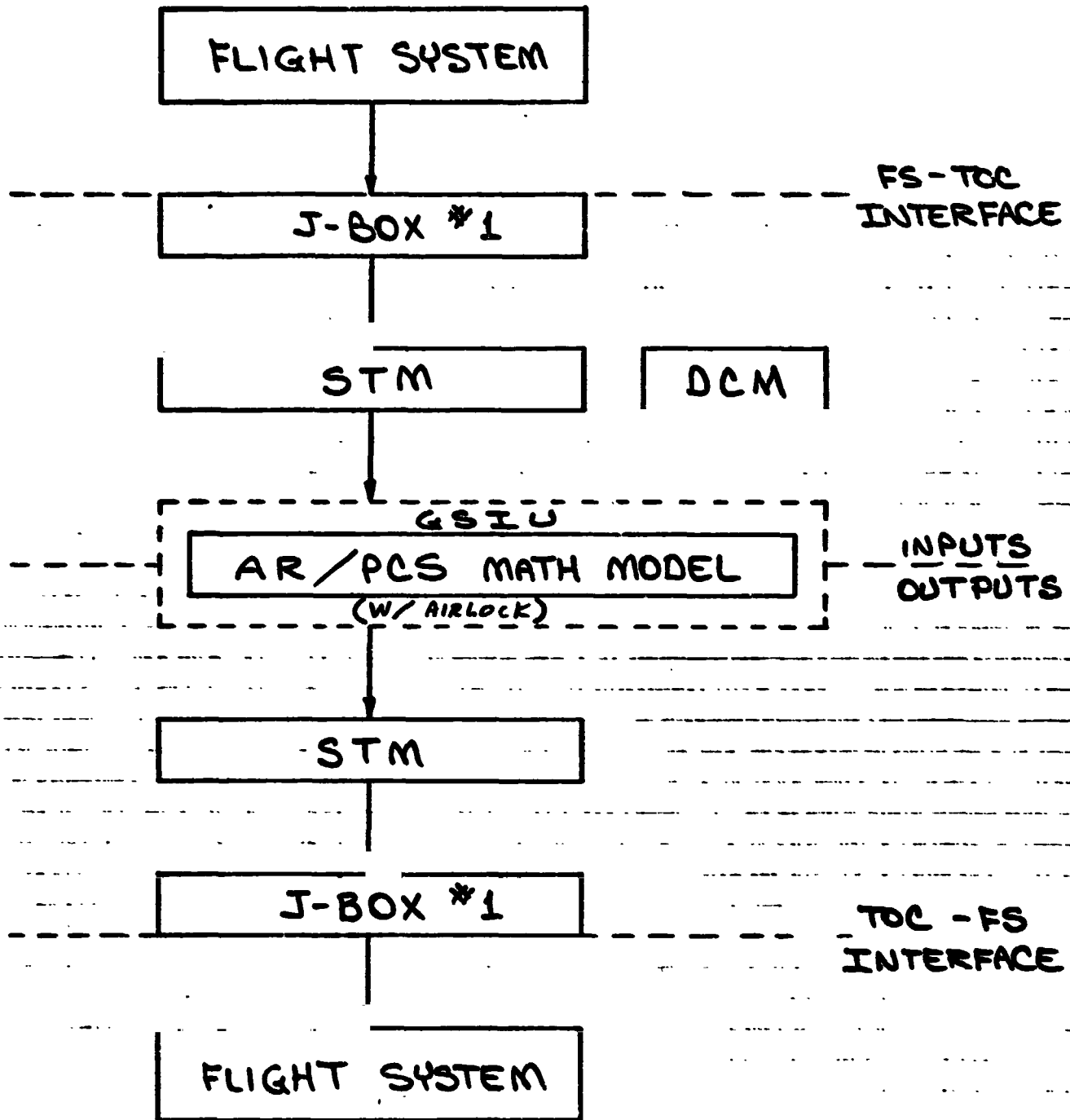
The model receives stimuli from two sources (see Figure 1).

- 1) The Flight System (FS) via the Signal Termination Module (STM).
- 2) The Test Operations Center (TOC) Display and Control Module (DCM) via test language.

The model output parameters go to the FS via the STM. Tables 1 and 2 list the input and output parameters respectively. The eight stimuli which come from the DCM are used to inform the model when the position of manually operated cockpit valves are changed.

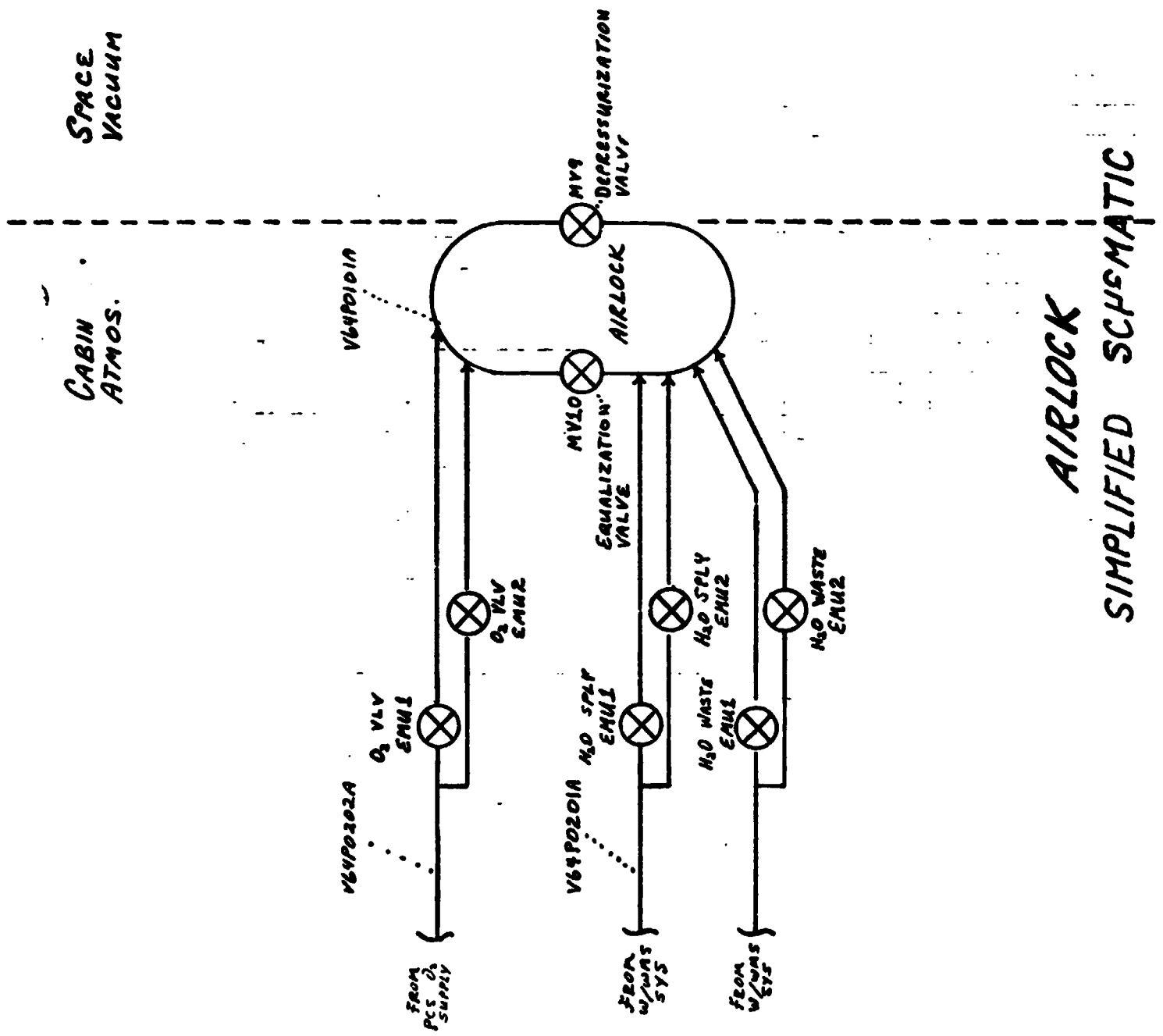
2.1 FUNCTIONAL CHARACTERISTICS

The AR/PCS provides the Orbiter with a pressurized atmosphere of oxygen and nitrogen, and supplies nitrogen for pressurization of the Orbiters' potable and waste water system. Two lines from the Fuel Cell/Cryogenic System (FC/CRYO) supply oxygen to the AR/PCS, which are backed up by an emergency oxygen tank in the AR/PCS. Four nitrogen tanks in the AR/PCS supply the necessary nitrogen. For reliability, two independent systems control the atmosphere and water pressurization, with crossover valves providing additional reliability. Figure 2 and figure 3 are simplified schematics of the AR/PCS and airlock, respectively, showing the various tanks, regulators, and valves.



INPUT / OUTPUT DATA FLOW

FIGURE 1



AIRLOCK
SIMPLIFIED SCHEMATIC

FIGURE 3

2.1.1 MODEL FUNCTION

In preparing the requirements for the non-avionic system math models, the following ground rules were observed:

- Output all measurements addressed to flight critical MDM's.
- Output those measurements used in dedicated displays, systems management, or caution and warning.
- Output those measurements needed for operation by other systems.
- Output those measurements needed during pre-launch operations, starting at T-20 minutes.
- Respond to stimuli inputs in a discrete manner (no timed transients simulating pressure or temperature build-up and decay, for example).
- Do not account for depletion of expendables during a mission.

These ground rules are intended to simplify the math models without compromising the avionics testing in SAIL. Where required, specific ground rules may be waived.

In the AR/PCS-Airlock math model, the OPEN or CLOSED position of the manual valves must be entered from the DCM by the test operator when cockpit valves are changed, so that the AP/PCS-Airlock math model will generate realistic data.

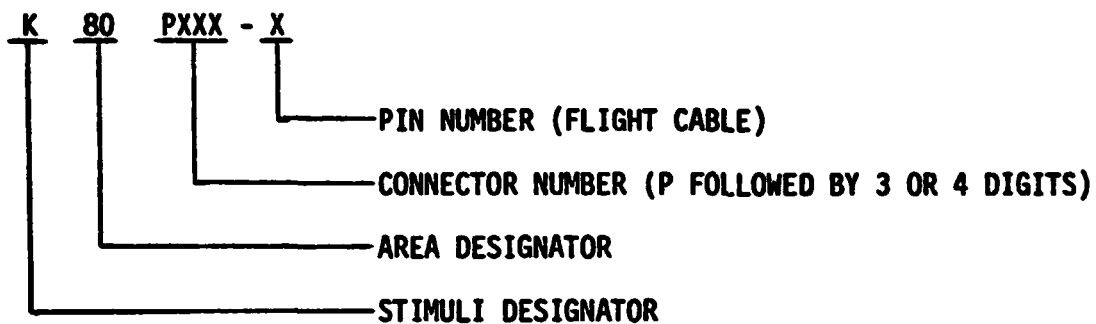
Fixed values are provided for the pressure and temperature of the oxygen and nitrogen tanks. Tank quantities, as calculated by the flight system GPC based on tank pressures and temperatures, will remain unchanged unless different pressure and temperature values are sent from the DCM in TOC while the math model's output for these parameters is inhibited.

The AR/PCS math model is dependent upon the FC/CRYO math model for oxygen supply data. The FC/CRYO math model therefore must be operating when using the AR/PCS math model. The W/WMS math model likewise is dependent

upon the AR/PCS math model for nitrogen supply data. Therefore the AR/PCS model must be operating when using the W/WMS model. The AR/PCS math model incorporates the functions of the Airlock (A/L) subsystem. All required A/L parameters are included in this document.

2.1.2 INPUT/OUTPUT

The stimuli identification for those stimuli which have their sources at the flight system via the STM are coded in terms reference Avionics Test Article (ATA) interface connector and pin number according to the following format.



The stimuli which are uplinked to the model from the DCM are given unique alphanumeric variable names. The model output parameters whose destinations are the flight system via the STM are identified by their Master Measurement List measurements.

2.2 DCM UPLINK

Ten stimuli are uplinked to the AR/PCS-Airlock math model in the GSIU from the TOC DCM. These stimuli let the math model know when a manual valve in the AR/PCS-Airlock has been opened or closed by the crew, so that proper data values may be generated by the math model. These stimuli are listed in Table 1.

Faults are simulated by inhibiting the model output for the affected measurement(s) and uplinking the off-nominal value(s) from the DCM to the STM. The exact manner in which this is accomplished is covered in documentation for the GSIU Operating System.

2.3 INITIALIZATION REQUIREMENTS

V64P0101A = 14.4

2.4 TERMINATION REQUIREMENTS

NONE

2.5 UNIQUE REQUIREMENTS

The math model uses three internal variables (A, B, and V) in a subroutine called Latching Valve Routine (LVR). A and B represent the state of CLOSE and OPEN stimuli, respectively, to a valve. V represents the OPENED or CLOSED state of the valve based on A and B values.

2.6 ANALOG MEASUREMENTS

Values shown in the math model flowcharts are in GSIU counts for all analog measurements. The math model values are seen by the flight system as 0 to 5 VDC inputs. The flight system then converts these input voltages to engineering units using one of the two types of scaling equations discussed in Sections 2.6.1 and 2.6.2. The GSIU math model count values (or the count values entered at the DCM by the test operator) must consider the scaling computation done later by the flight software, so that correct flight system engineering unit values are obtained for fault detection and annunciation (FDA), and for cockpit displays. The following two sections, 2.6.1 and 2.6.2, describe the scaling equations which apply to this model. Section 2.6.1 describes the scaling equation for measurements which require the polynomial conversion method. Section 2.6.2 describes the scaling equation for measurements which require the range limit conversion method which was used on STS-1.

2.6.1 POLYNOMIAL CONVERSION METHOD

The scaling polynomial equation used by the flight system is defined in the SM FSSR. The general form of the equation is given as follows:

$$FS_{EU} = A_0 + A_1X + A_2X^2 + A_3X^3$$

where: FS_{EU} = flight system engineering units

X = flight system input voltage

A_0, A_1, A_2, A_3 = scaling polynomial coefficients

The following example shows the step by step procedure for converting analog measurements from flight system engineering units (FS_{EU}) to GSIU counts. This procedure may be used to calculate GSIU count values for fault insertion at the DCM.

Example:

For measurement no. V63R1100A, convert FS_{EU} value = 2288 to GSIU counts.

Step 1:

In the SM FSSR, look up the measurement no. (V63R1100A) within the "SMM Data Requirements - Subsystems Displays" table. The measurement no. will appear on two consecutive pages as follows: page A will show engineering units, range low value and range high value, while page B will show the scaling polynomial coefficients (labelled A_0, A_1, A_2, A_3) followed by curve order, independent variable, and STS flight no. The values on page B will be of prime interest to do this example conversion, and will be referred to in the following discussion.

Step 2:

The coefficients will be used in the scaling polynomial:

$$FS_{EU} = A_0 + A_1X + A_2X^2 + A_3X^3$$

Solve the following scaling polynomial for X:

$$2288 = 443.167 + 851.956X - 143.904X^2 + 12.246X^3$$

so $X = 3.846469$

Step 3:

Notice the independent variable column labelled IND VR equals 2 for measurement no. V63R1100A. The 2 specifies that the independent variable X of the scaling polynomial is defined on a range of 0 to 5 VDC. So $X = 3.846$ VDC.

It is of interest to note that if IND VR had been equal to 0, X would have been defined on a range of 0 to 1023 PCM integer counts in which case X would be equal to 4 PCM counts, i.e. 3.846 rounded to the nearest integer.

However, in the example being worked, X is defined as VDC and $X = 3.846$ VDC.

Step 4:

Now to convert X VDC to GSIU counts, evaluate the following equation which shows the relationship between X and GSIU counts:

$$\text{GSIU counts} = \left[X \left(\frac{1023}{K} \right) \right], \text{ rounded to the nearest integer}$$

where K = 5, for X defined as VDC (IND VR = 2) and

K = 500, for X defined as PCM counts (IND VR = 0).

For the example, evaluate:

$$\text{GSIU counts} = \left[3.846 \left(\frac{1023}{5} \right) \right], \text{ rounded to the nearest integer}$$

Therefore, GSIU counts = 787 counts.

Note that since GSIU counts are always rounded to the nearest integer, small changes will possibly occur in the values of X and consequently FS_{EU} , when the reverse calculations are made during test operations, as the following shows:

$$X = \text{GSIU counts} \left(\frac{K}{1023} \right)$$

$$X = 787 \times \left(\frac{5}{1023} \right)$$

$$\text{SO } X = 3.846529$$

And

$$FS_{EU} = 443.167 + 851.956X - 143.904X^2 + 12.246X^3$$

$$FS_{EU} = 443.167 + 851.956(3.848) - 143.904(3.848)^2 + 12.246(3.848)^3$$

$$FS_{EU} = 2288.017$$

Hence when 787 GSIU counts is inserted for measurement no. V63R1100A, a value of 2288.017 FS_{EU} will result.

2.6.2 RANGE LIMIT CONVERSION METHOD

Several analog measurements in this model are calculated according to the range limit conversion method, instead of the polynomial conversion method as described in Section 2.6.1 of this document. The form of the scaling equation for these cases is given as follows:

$$FS_{EU} = Low + \frac{GSIU_{CTS}}{1023} (High - Low)$$

where: FS_{EU} = flight system engineering units

$GSIU_{CTS}$ = GSIU math model count values

Low = Range low limit

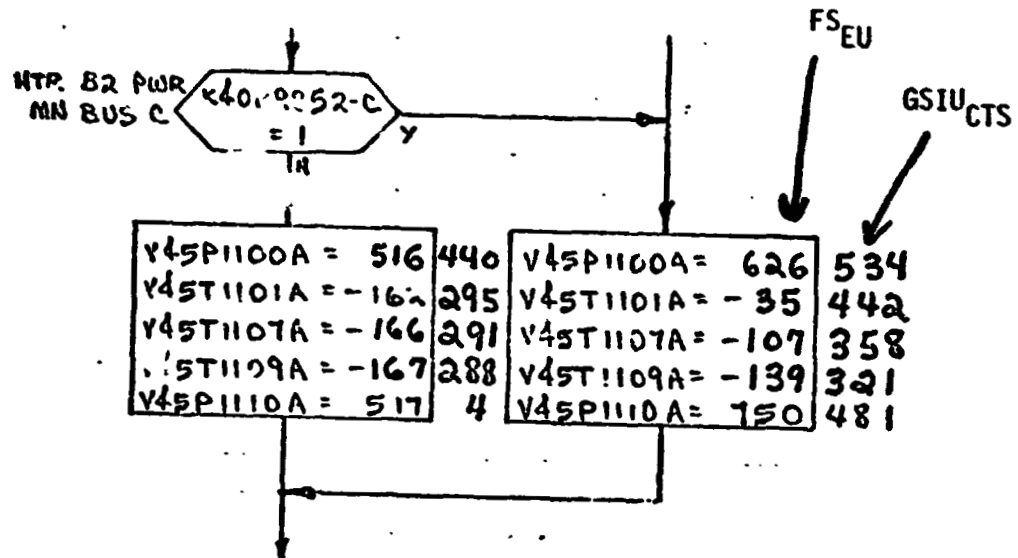
High = Range high limit

The following table shows a sample data value for each measurement which requires this type of calculation. The measurement I.D. is shown along with high and low values for the parameter range. The FS column shows the data value in flight system engineering units calculated from the GSIU counts marked CTS in the table. These measurements are marked with an asterisk (*) in the Output Measurement List marked as Table 2 in Section 4.2 of this document.

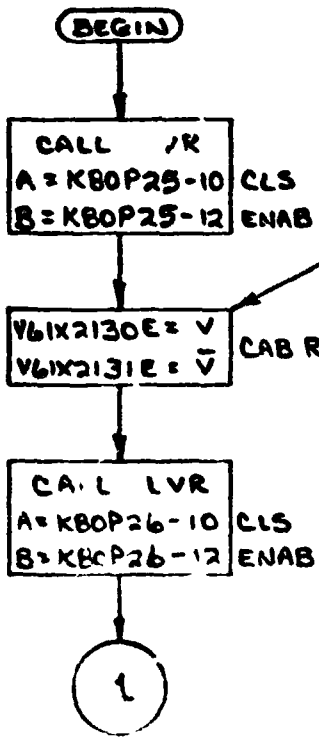
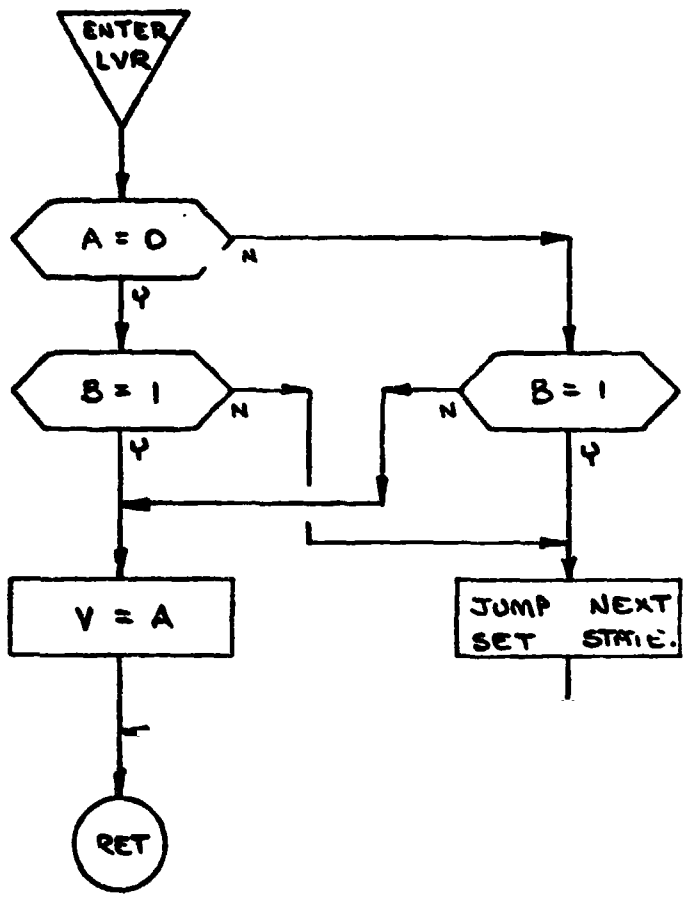
MEASUREMENT ID	RANGE LOW	RANGE HIGH	FS	CTS
V64P0201A	0	40	16	409
V64P0202A	0	1500	760	518

3.0 LOGIC FLOW DIAGRAMS

The logic flow diagram is made up of interconnected lines, boxes, decisions, and offpage connectors. Notice that where analog measurements are listed in boxes and decisions, the value inside the box is in flight system engineering units (FS_{EU}) while the corresponding GSIU count value is listed outside the box. For example, the box on the right hand below,



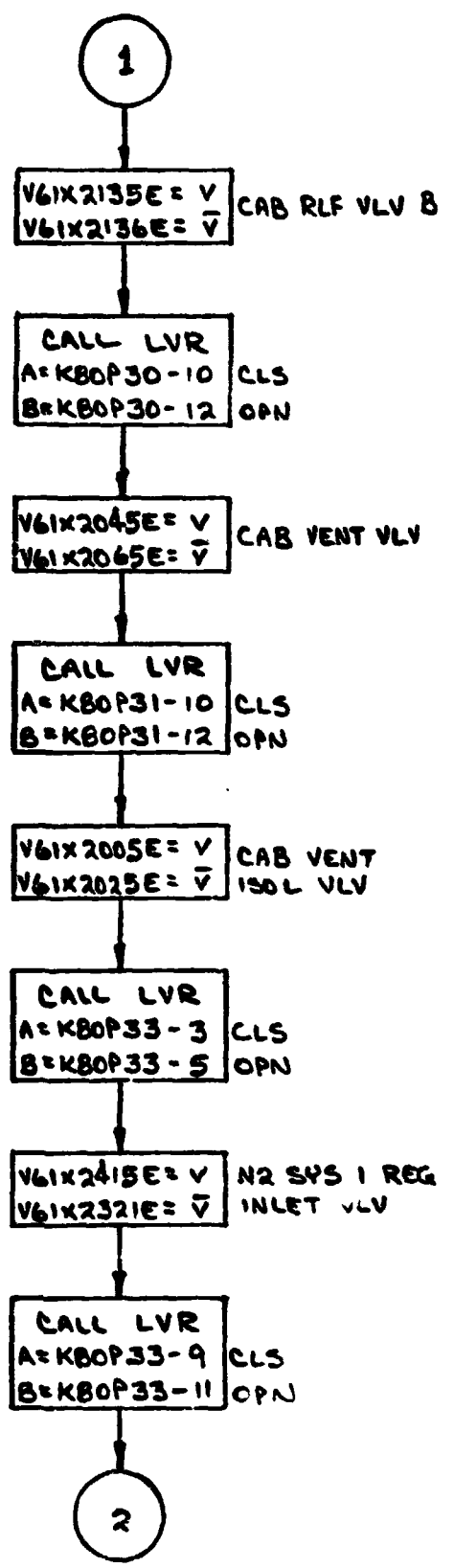
shows that V45P1100A is set equal to 626 FS_{EU} which is equivalent to 534 $GSIU_{CTS}$ shown outside the box.



TYPICAL SET STATEMENT

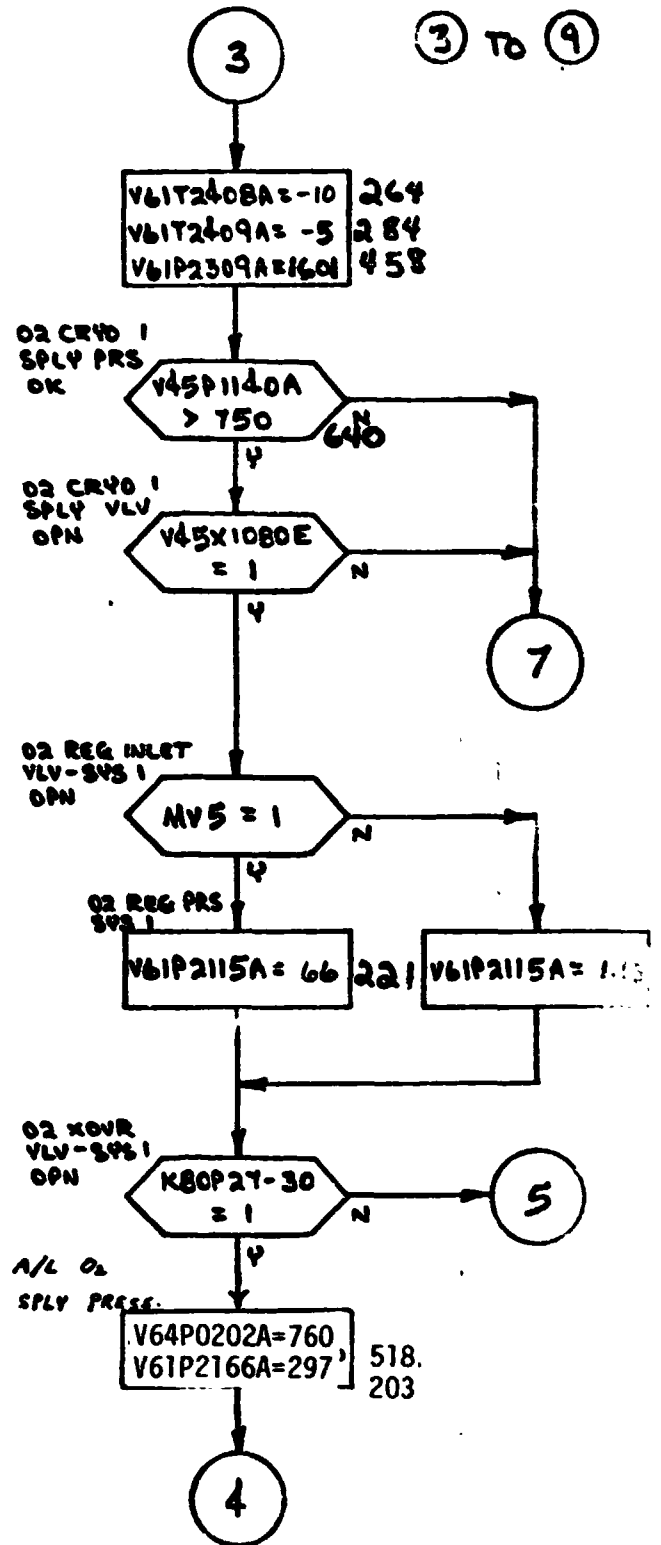
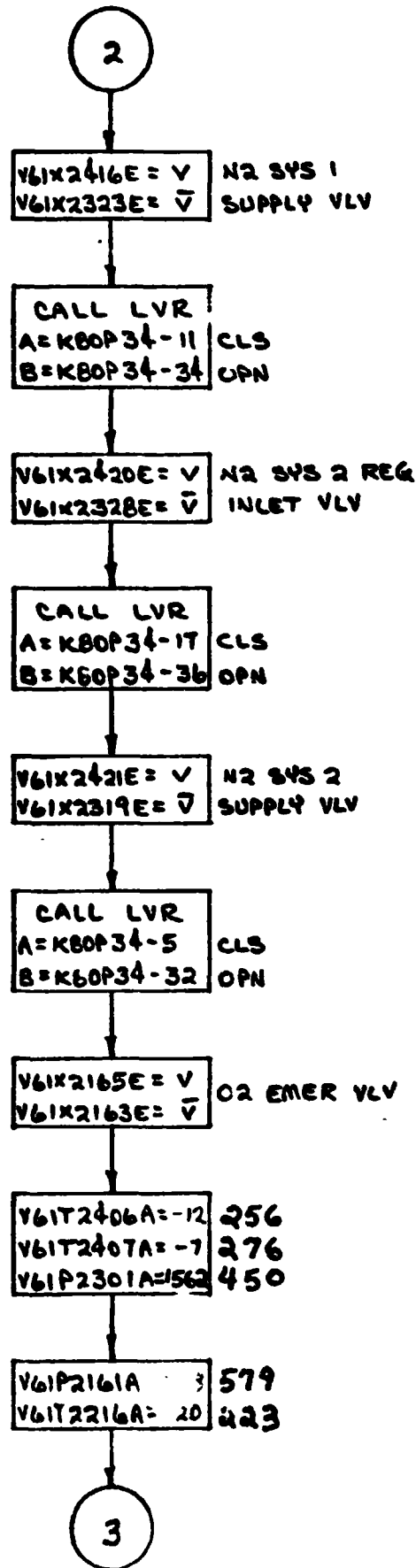
LVR

(BEGIN) TO (3)



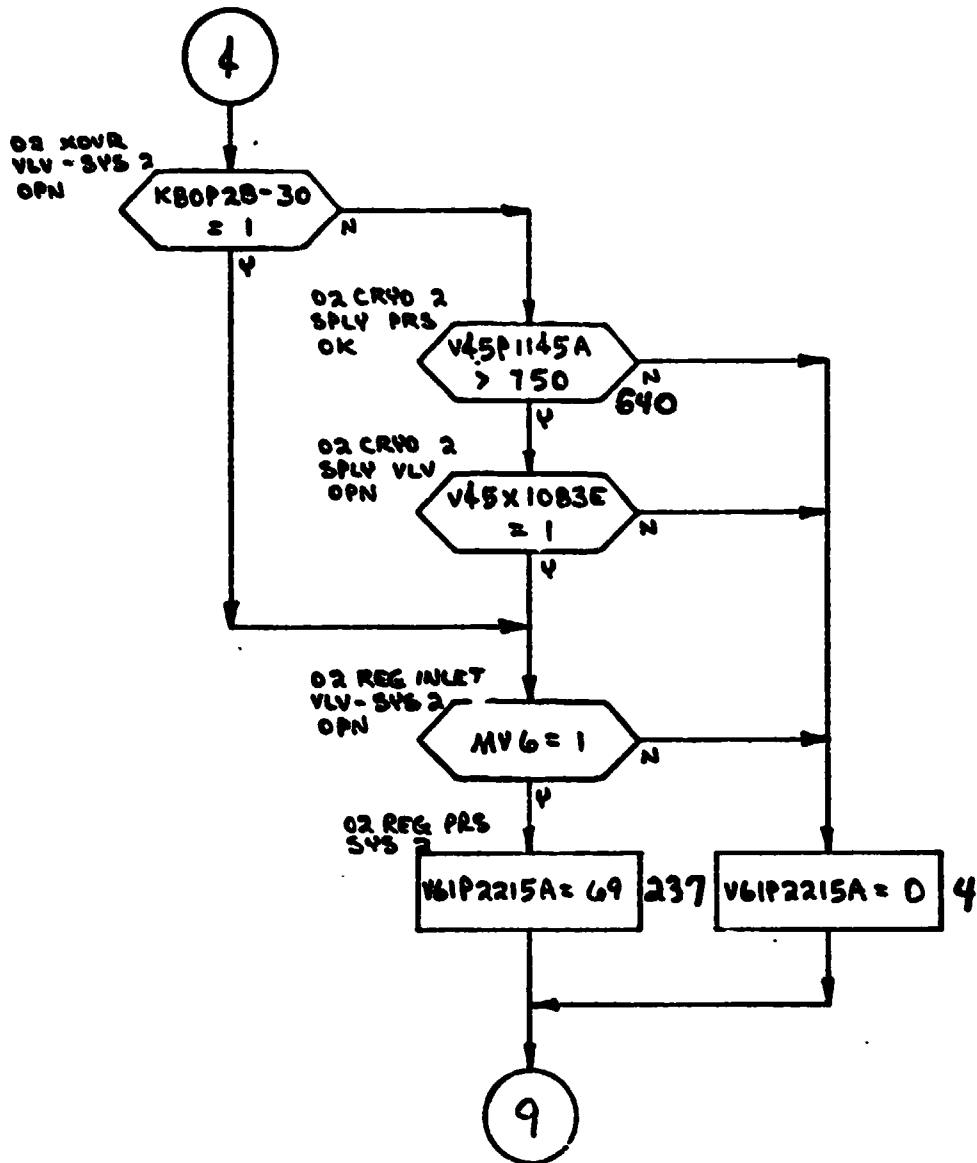
O2 PRESSURES

③ TO ⑨



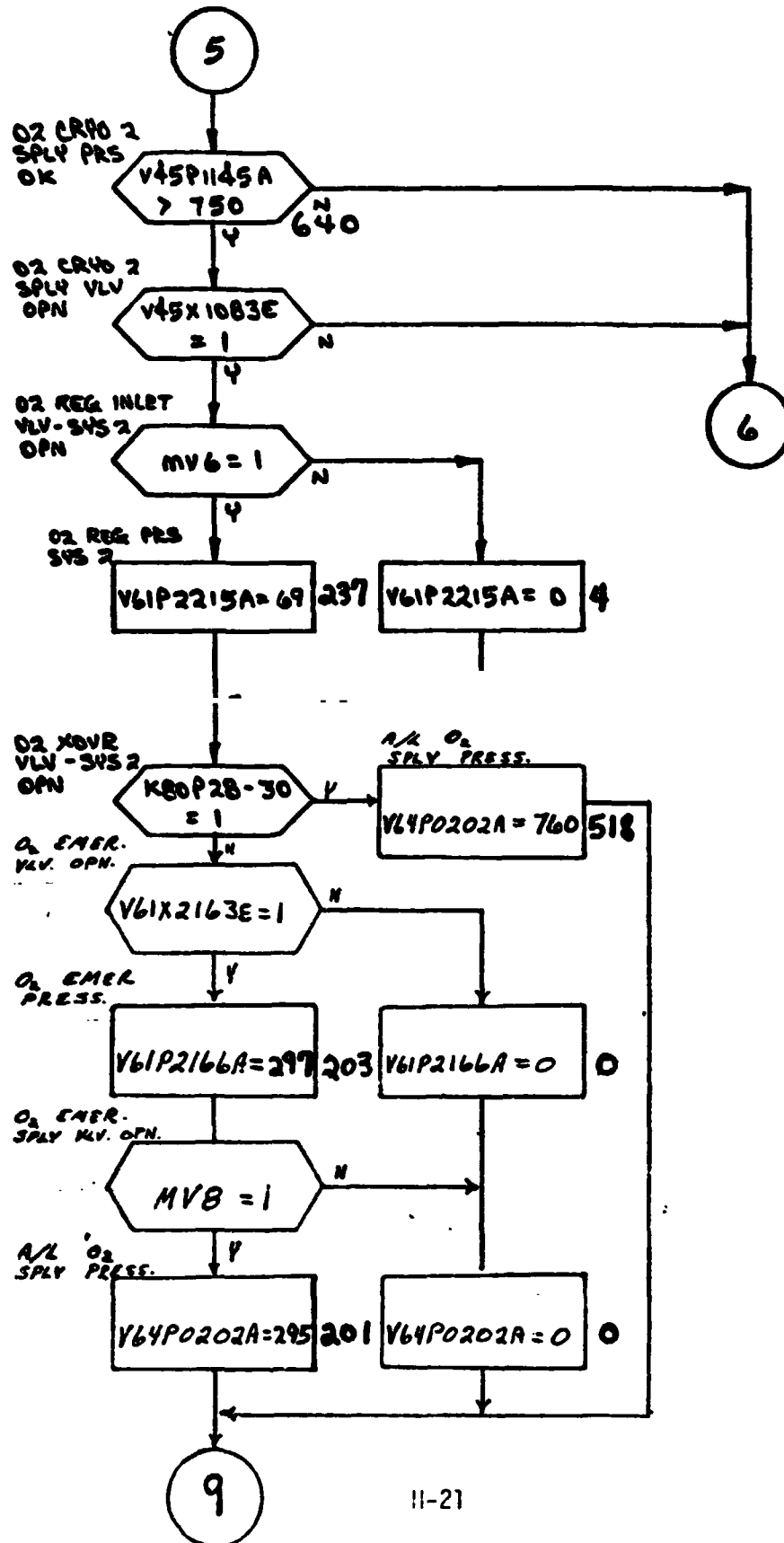
02 PRESSURES

③ To ④

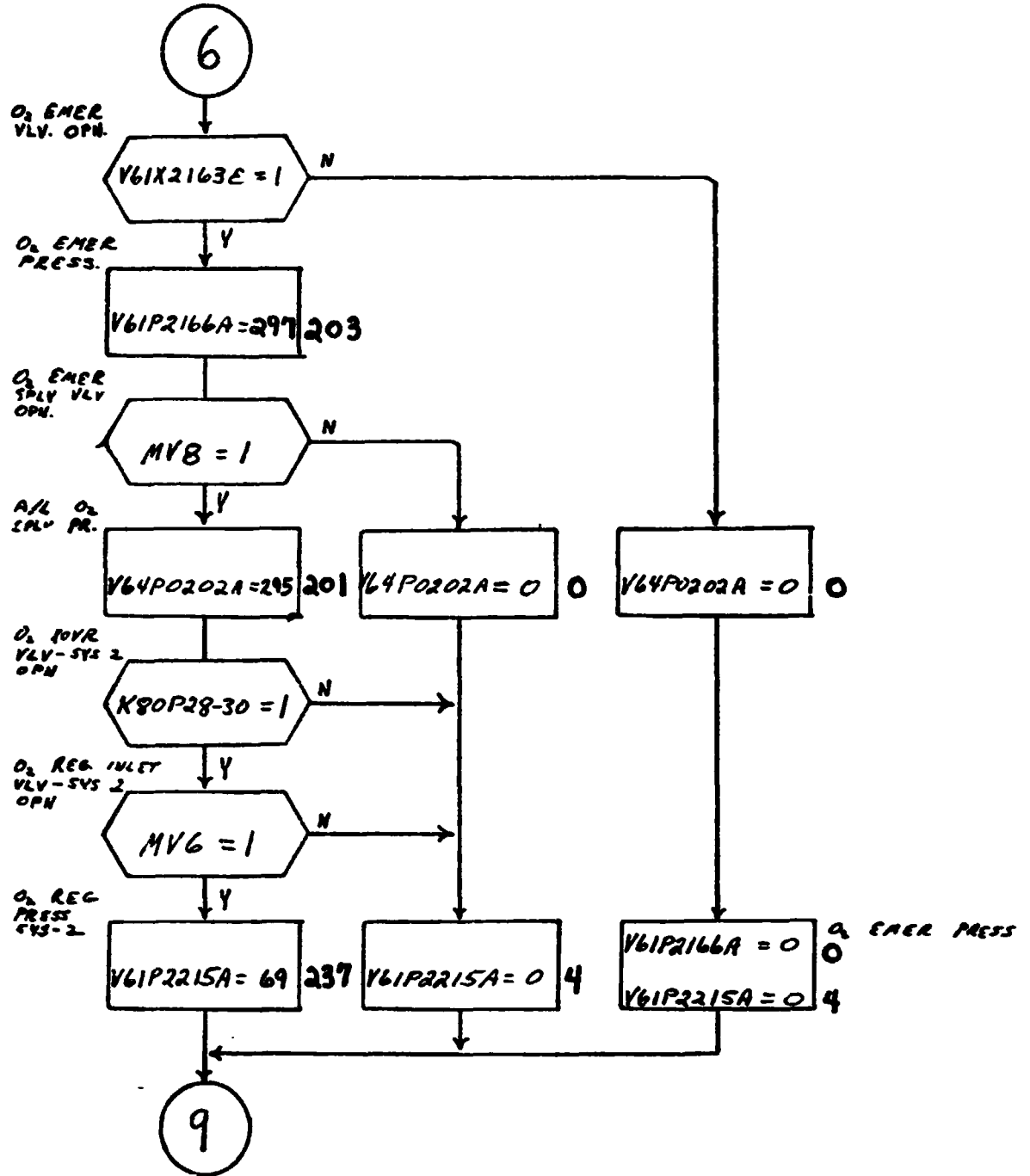


O₂ PRESSURES

③ To ⑨

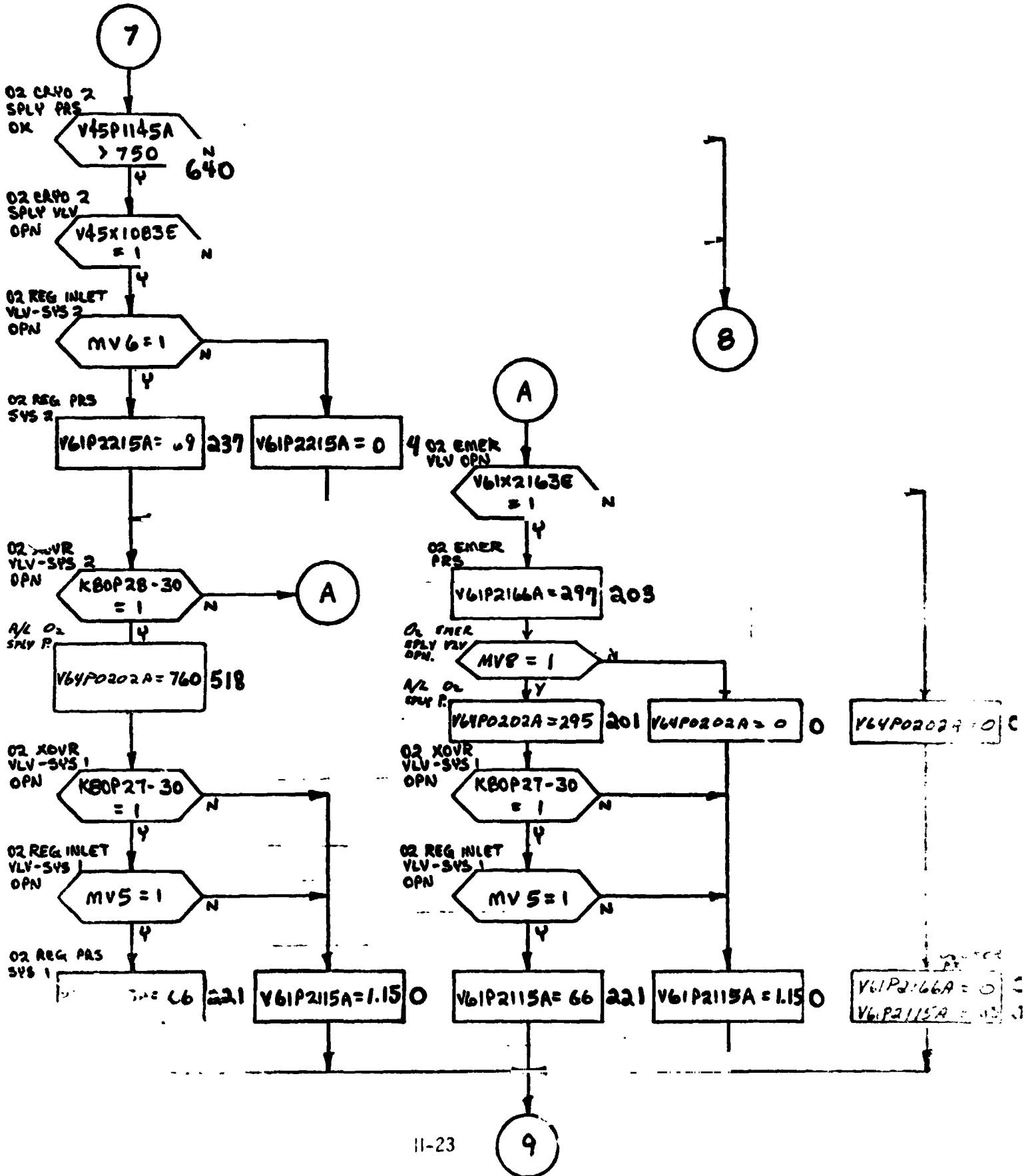


O₂ PRESSURES



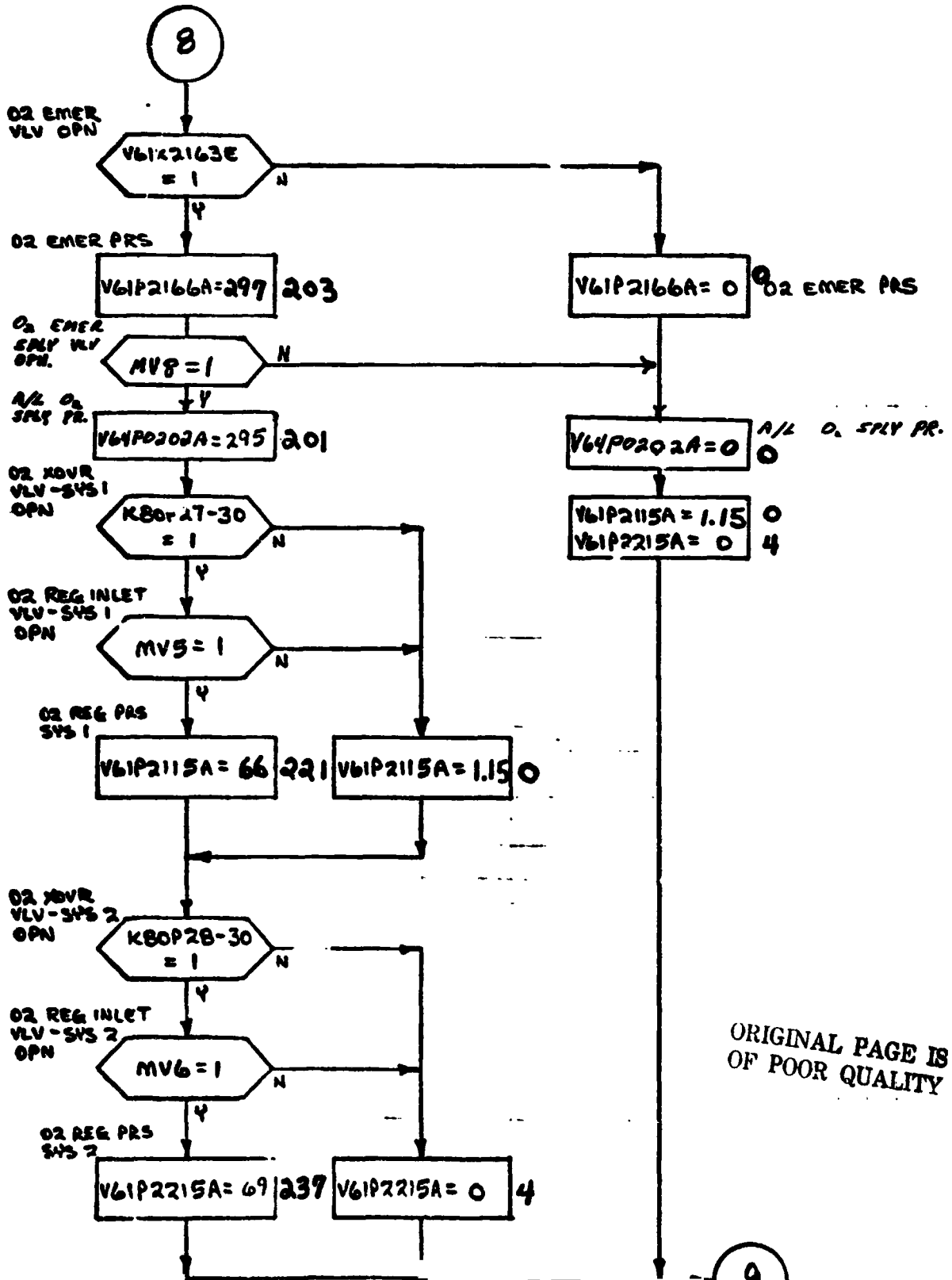
O2 PRESSURES

③ TO ⑨



O2 PRESSURES

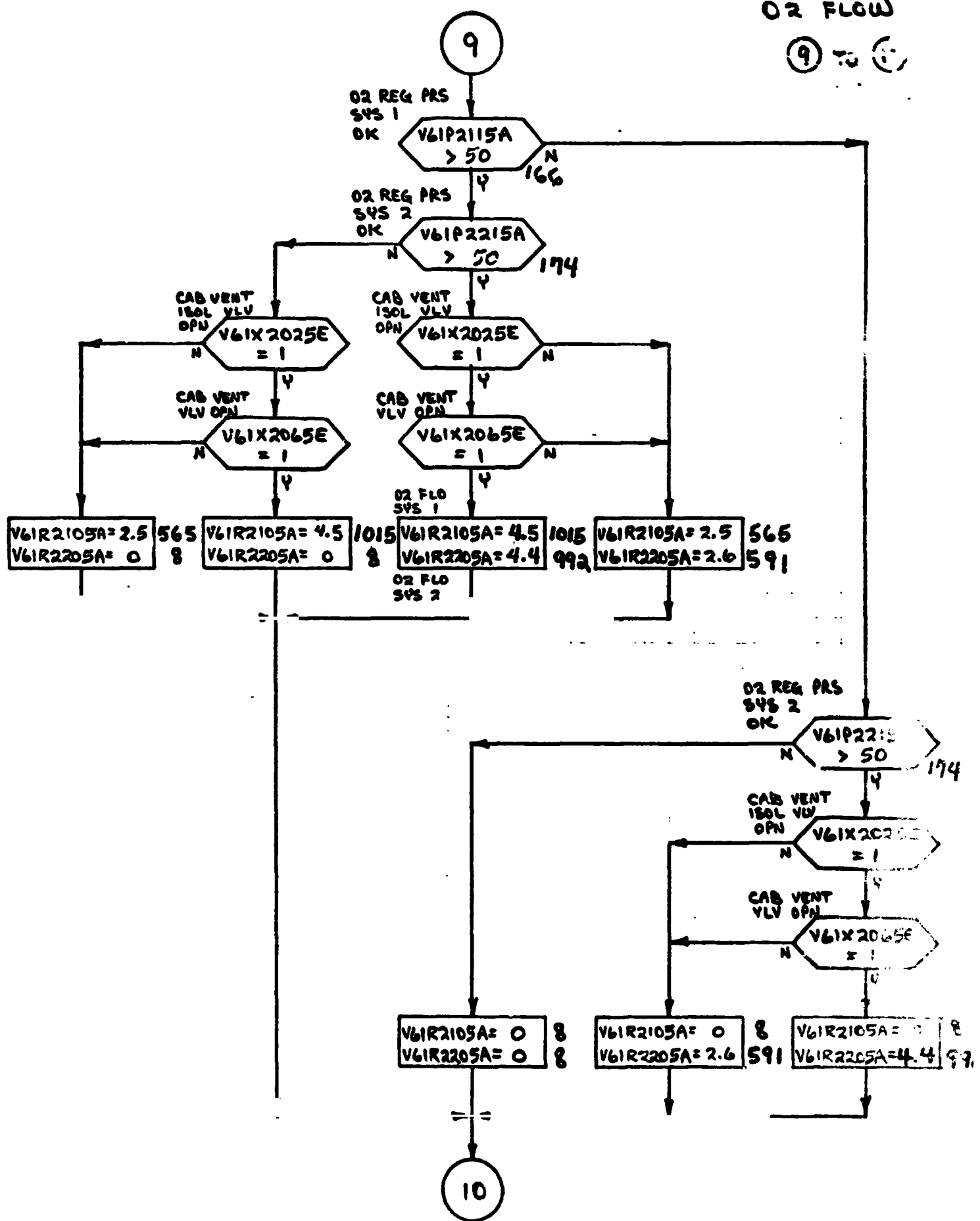
③ TO ⑨



ORIGINAL PAGE IS OF POOR QUALITY

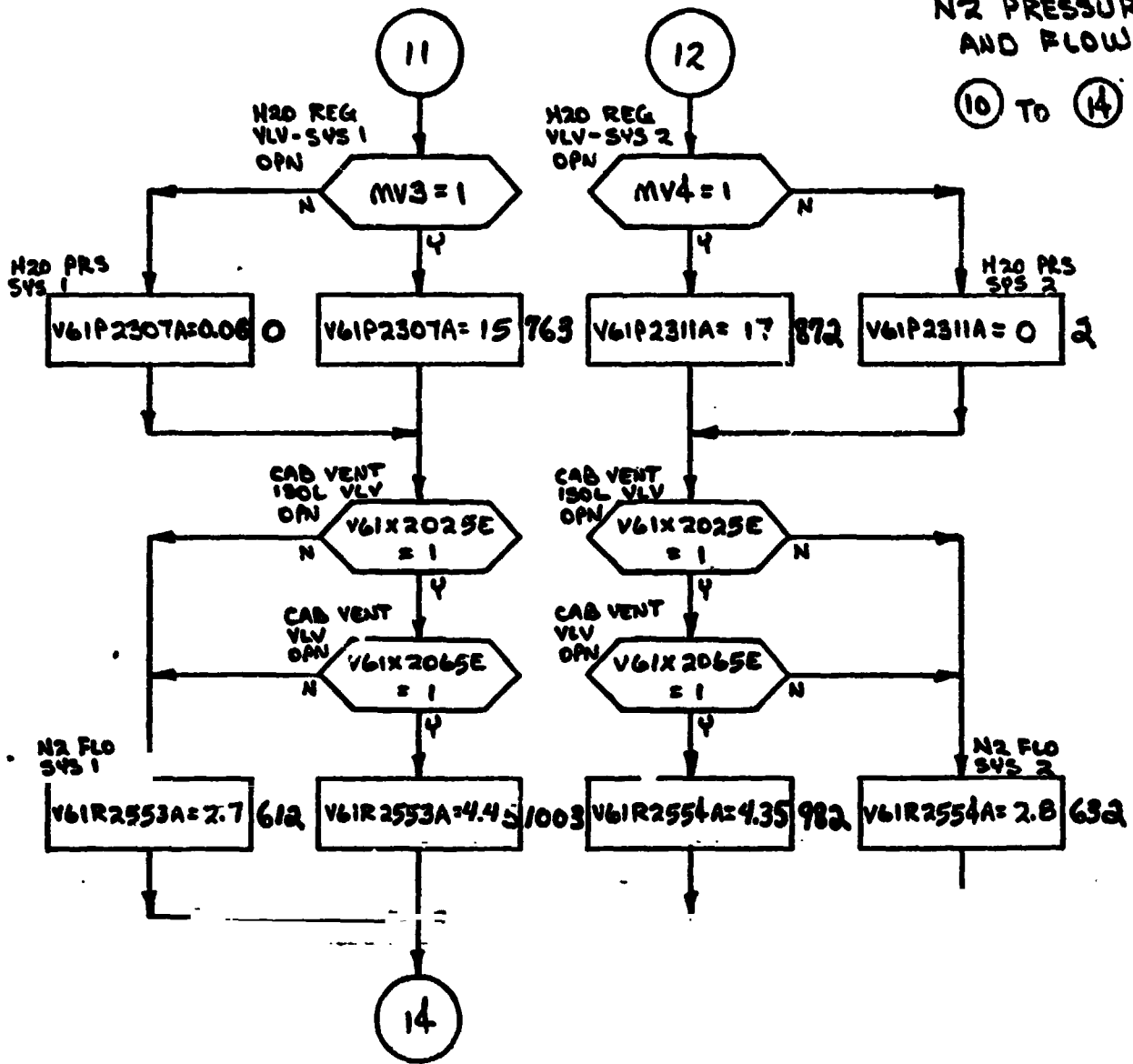
O2 FLOW

⑨ to ⑩



N2 PRESSURES AND FLOWS

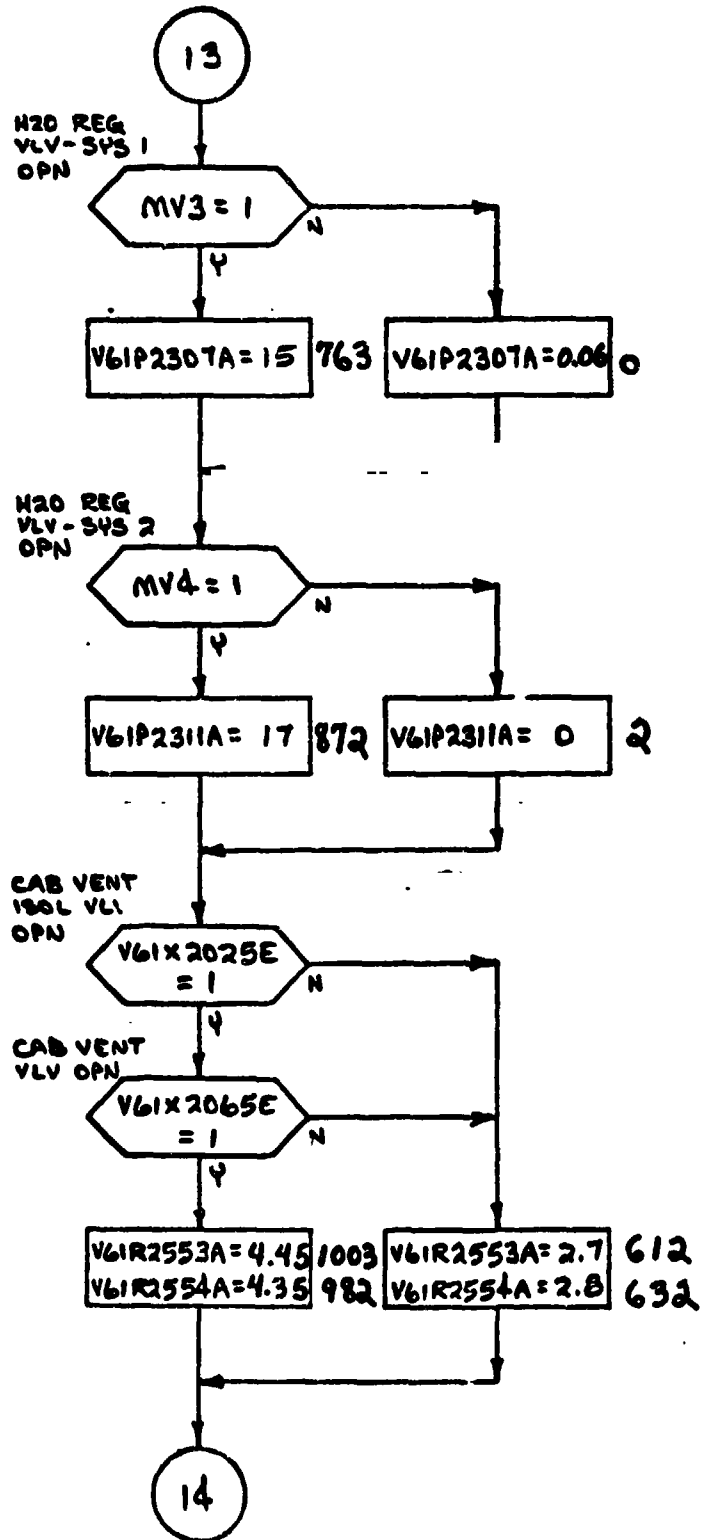
⑩ To ⑭

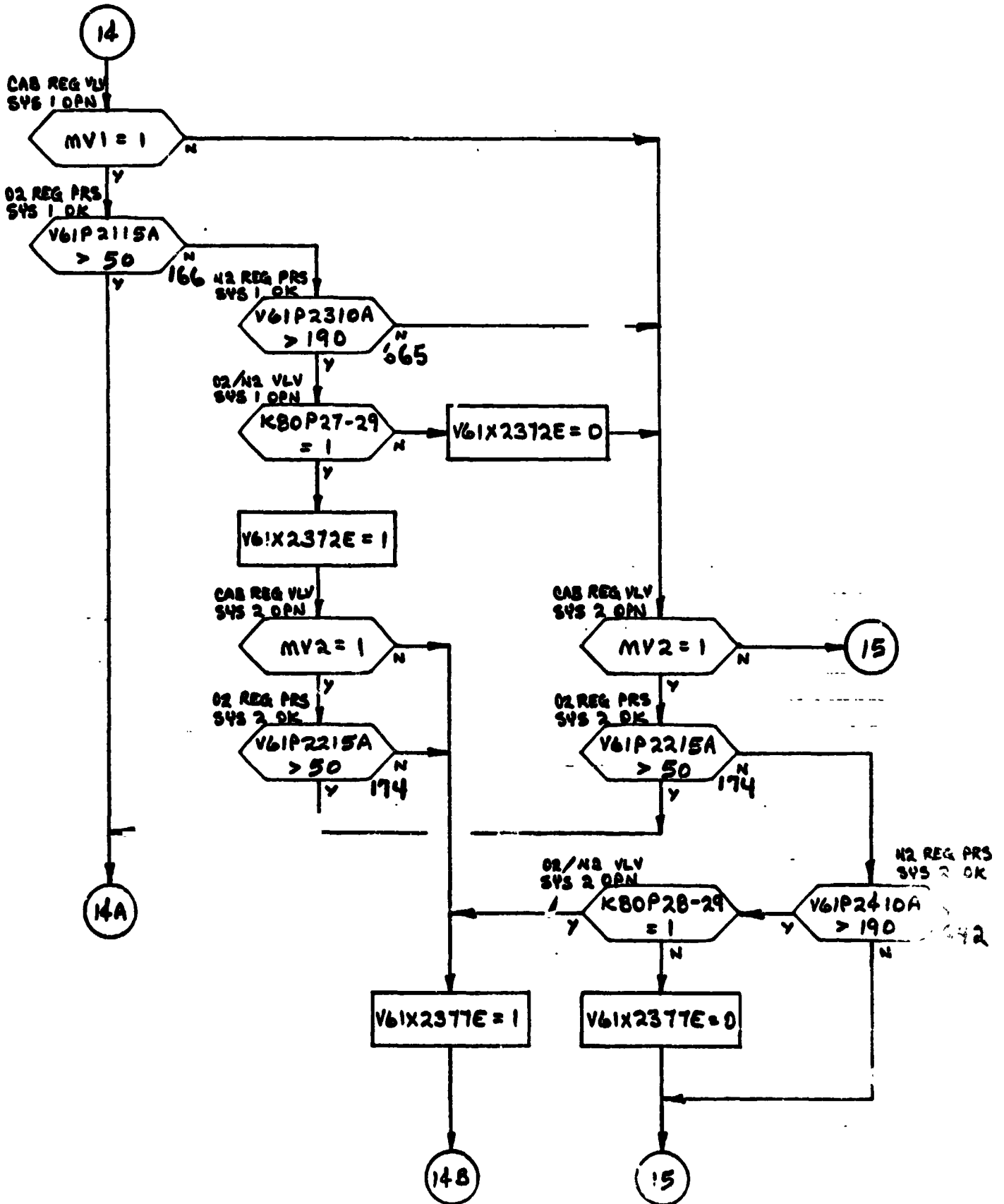


ORIGINAL PAGE IS
OF POOR QUALITY

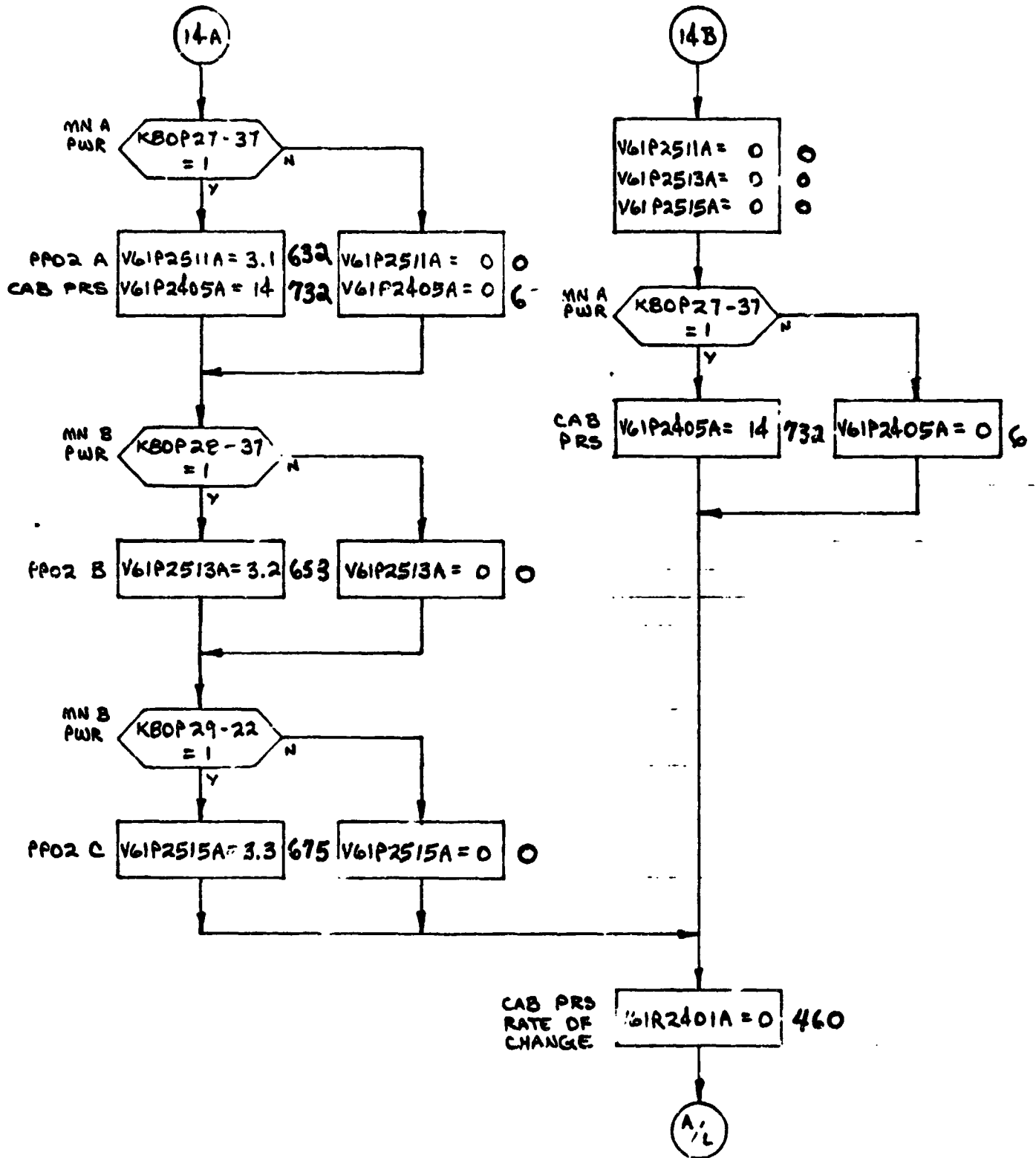
N2 PRESSURES
AND FLOWS

⑩ To ⑭

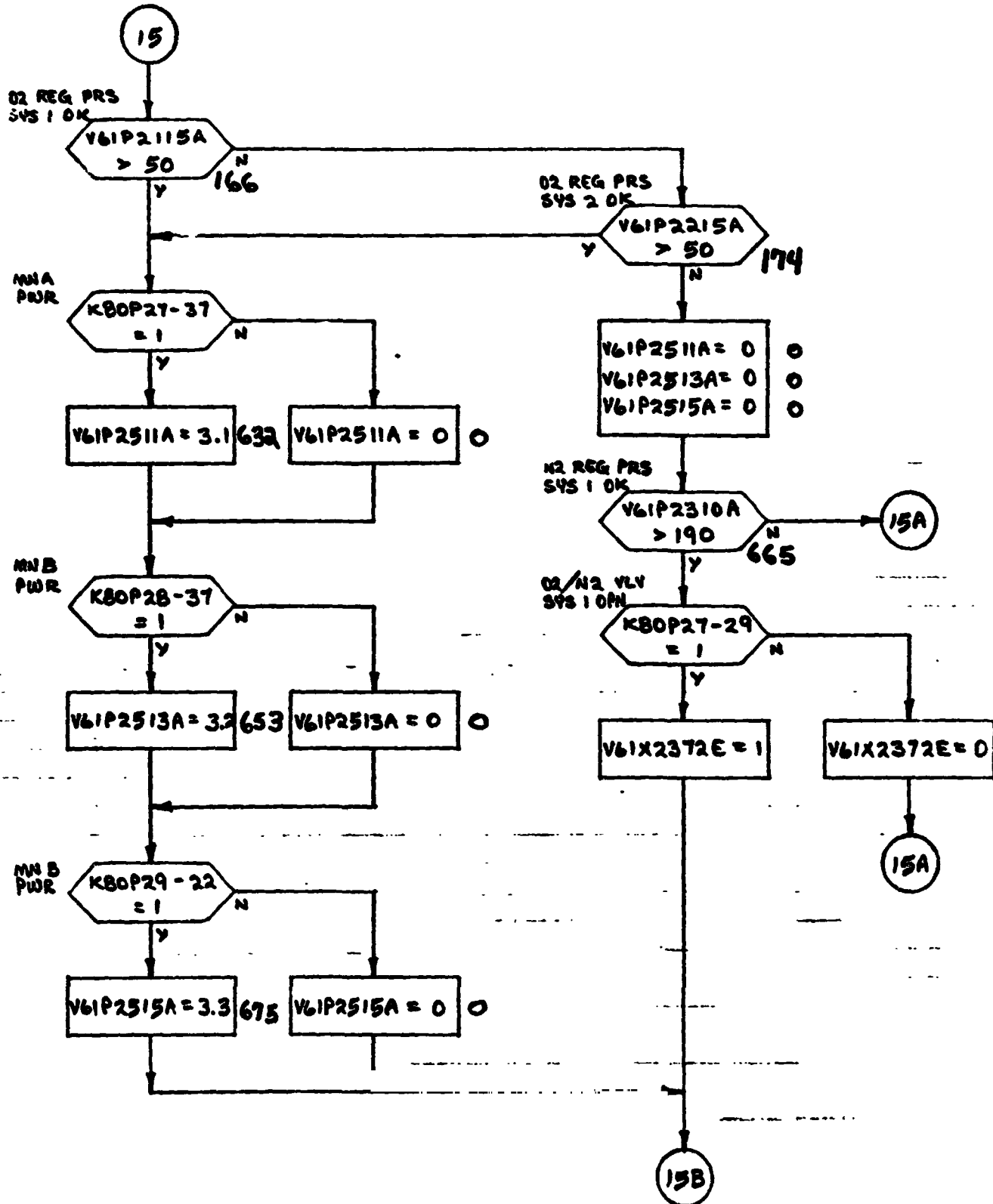




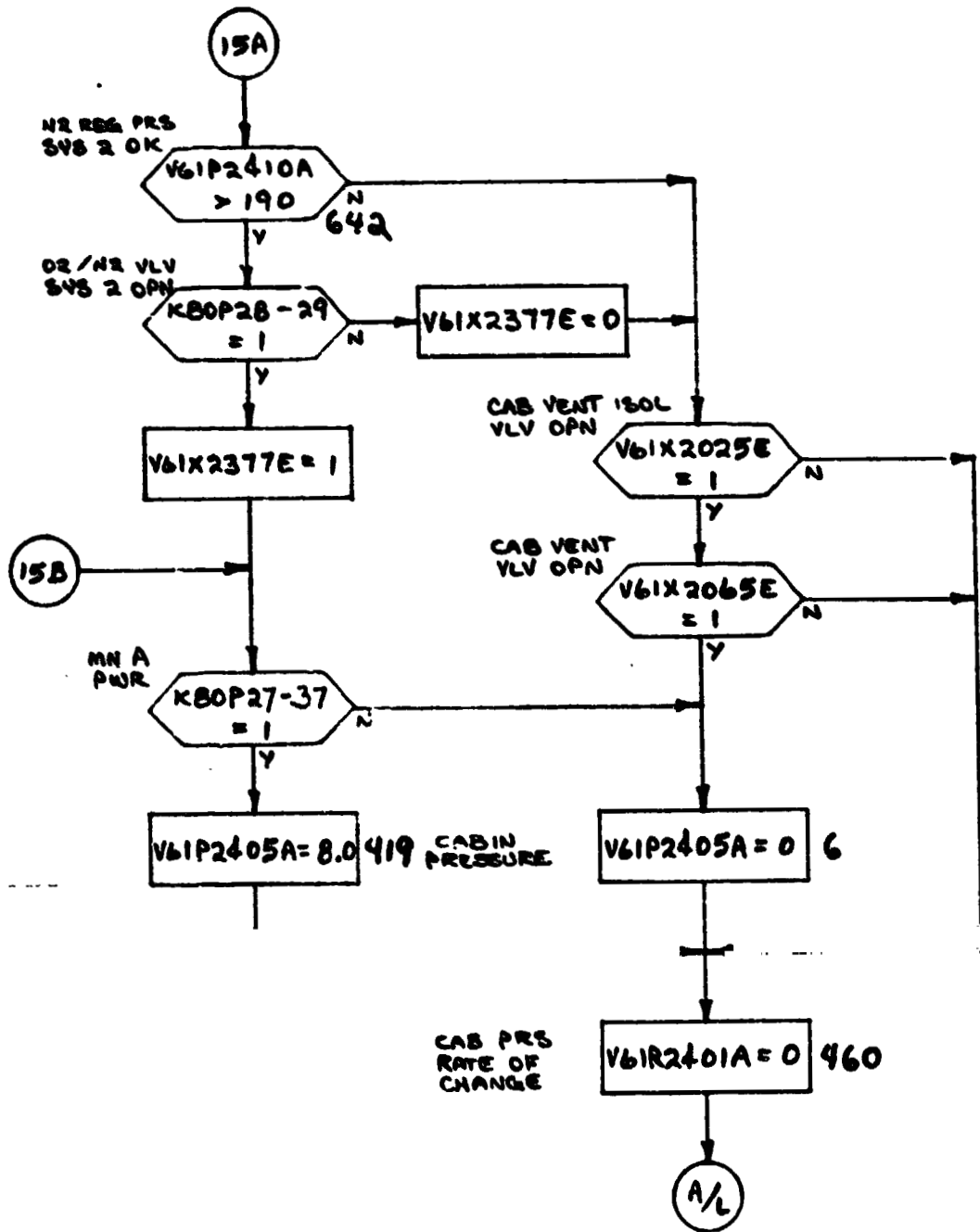
CABIN PRESS,
 PARTIAL O2 PRESS,
 & CABIN PRESS RATE
 OF CHANGE



PARTIAL O2 PRESS

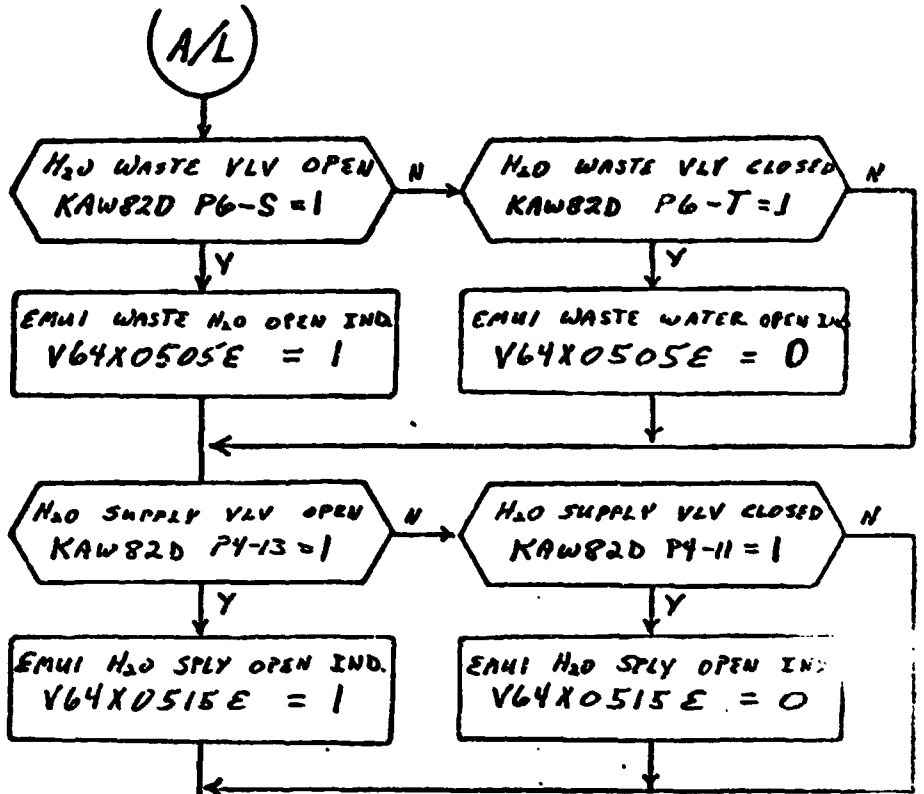


EMERGENCY
CABIN PRESS,
& PRESS RATE OF
CHANGE

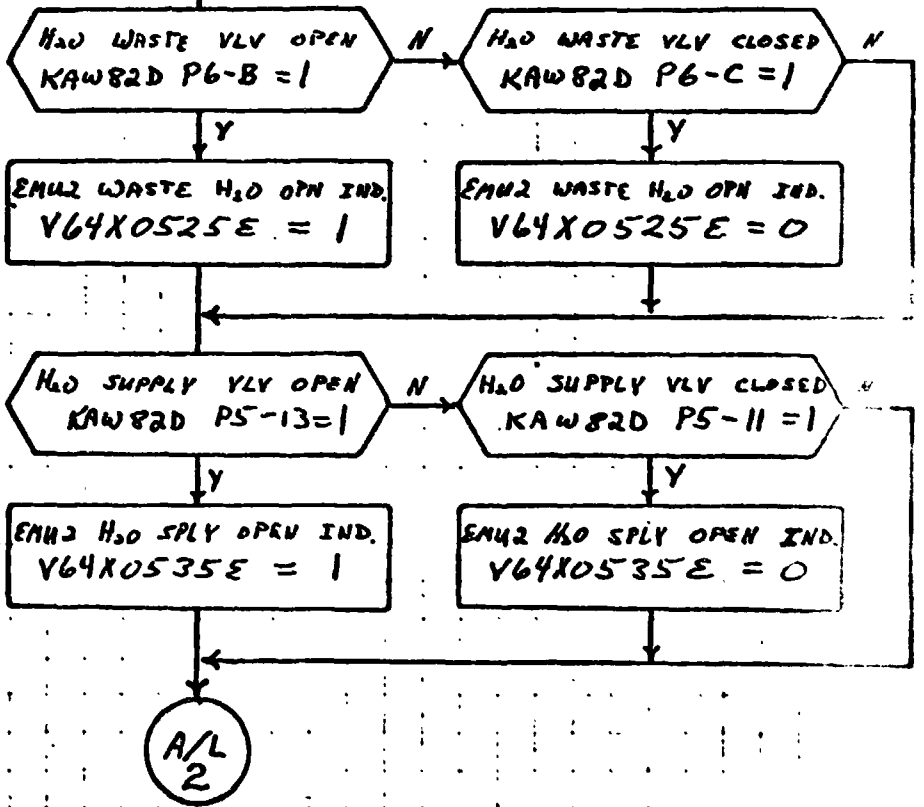


ORIGINAL PAGE IS
OF POOR QUALITY

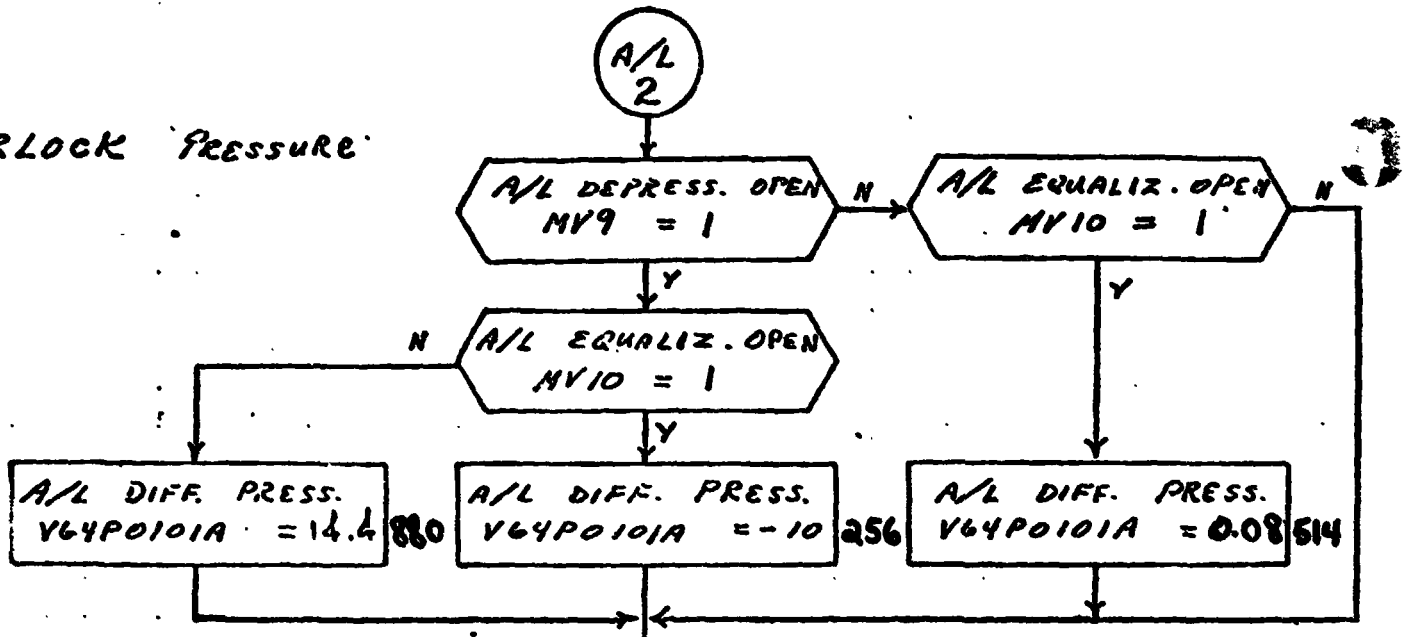
AIRLOCK EMU1



AIRLOCK EMU2



AIRLOCK PRESSURE



H₂O SUPPLY

4.0 TABLES

TABLE 1 - STIMULI INPUTS TO ARS/PCS MODEL

IDENTIFICATION NUMBER	NOMENCLATURE	SOURCE	STATES/RANGE		
			LO	HI	UNITS
K80P25-10	Cabin RLF VLV A CMD-Close	FLT SYS	0	1	State
K80P25-12	Cabin RLF VLV A CMD-Enable	FLT SYS	0	1	State
K80P26-10	Cabin RLF VLV B CMD-Close	FLT SYS	0	1	State
K80P26-12	Cabin RLF VLV B CMD-Enable	FLT SYS	0	1	State
K80P27-29	02/N2 Cont VLV SYS 1-Open, Auto	FLT SYS	0	1	State
K80P27-30	02/SYS 1 XOVV VLV CMD-Open	FLT SYS	0	1	State
K80P28-29	02/N2 Cont VLV SYS 2-Open, Auto	FLT SYS	0	1	State
K80P28-30	02 SYS 2 XOVV VLV CMD-Open	FLT SYS	0	1	State
K80P30-10	Cabin Vent VLV CMD-Close	FLT SYS	0	1	State
K80P30-12	Cabin Vent VLV CMD-Open	FLT SYS	0	1	State
K80P31-10	Cabin Vent ISOL VLV CMD-Close	FLT SYS	0	1	State
K80P31-12	Cabin Vent ISOL VLV CMD-Open	FLT SYS	0	1	State
K80P33-3	N2 SYS 1 REG Inlet CMD-Close	FLT SYS	0	1	State
K80P33-5	N2 SYS 1 REG Inlet CMD-Open	FLT SYS	0	1	State
K80P33-9	N2 SYS 1 SPLY CMD-Close	FLT SYS	0	1	State
K 33-11	N2 SYS 1 SPLY CMD-Open	FLT SYS	0	1	State
K80P34-5	02 EMER CMD-Close	FLT SYS	0	1	State
K80P34-11	N2 SYS 2 Reg Inlet CMD-Close	FLT SYS	0	1	State
K80P34-17	N2 SYS 2 SPLY CMD-Close	FLT SYS	0	1	State
K80P34-32	02 EMER CMD-Open	FLT SYS	0	1	State
K80P34-34	N2 SYS 2 Reg Inlet CMD-Open	FLT SYS	0	1	State
K80P34-36	N2 SYS 2 SPLY CMD-Open	FLT SYS	0	1	State
MV1	SYS 1 Cabin Reg. Inlet VLV CMD-Open	DCM OPER	0	1	State
MV2	SYS 2 Cabin Reg. Inlet VLV CMD-Open	DCM OPER	0	1	State
MV3	SYS 1 H2O TNK Reg Inlet VLV CMD-Open	DCM OPER	0	1	State
MV4	SYS 2 H2O TNK Reg. Inlet VLV CMD-Open	DCM OPER	0	1	State
MV5	SYS 1 02 REG Inlet VLV CMD-Open	DCM OPER	0	1	State
MV6	SYS 2 02 REG Inlet VLV CMD-Open	DCM OPER	0	1	State
MV7	N2 XOVV VLV CMD-Open	DCM OPER	0	1	State
MV8	02 EMER Supply VLV CMD-Open	DCM OPER	0	1	State
MV9	A/L DEPRESSURIZATION VALVE OPEN	DCM OPER	0	1	State
MV10	A/L EQUALIZATION VALVE OPEN	DCM OPER	0	1	State
K80P27-37	CABIN PRESS SENSOR PWR MN BUS A	FLT SYS	0	1	State
K80P28-37	PWR MN BUS B	FLT SYS	0	1	State
K80P29-22	PWR MN BUS B	FLT SYS	0	1	State

STIMULI INPUT TO A., PCS MODEL - TABLE 9

IDENTIFICATION NUMBER	NOMENCLATURE	DESTINATION	STATES/RANGE		
			LO	HI	UNIT
KAW82D P6-S	EMU 1 WASTE H ₂ O VLV - OPEN	FLT SYS	0	1	STATI
KAW82D P6-T	EMU 1 WASTE H ₂ O VLV - CLOSED	FLT SYS	0	1	STATI
KAW82D P4-13	EMU 1 H ₂ O SUPPLY VLV - OPEN	FLT SYS	0	1	STATI
KAW82D P4-11	EMU 1 H ₂ O SUPPLY VLV - CLOSED	FLT SYS	0	1	STATI
KAW82D P6-B	EMU 2 WASTE H ₂ O VLV - OPEN	FLT SYS	0	1	STATI
KAW82D P6-C	EMU 2 WASTE H ₂ O VLV - CLOSED	FLT SYS	0	1	STATI
KAW82D P5-13	EMU 2 H ₂ O SUPPLY VLV - OPEN	FLT SYS	0	1	STATI
KAW82D P5-11	EMU 2 H ₂ O SUPPLY VLV - CLOSED	FLT SYS	0	1	STATI

TABLE 1-A - STIMULI TO MML CORRELATION

	IDENTIFICATION NUMBER	MML NUMBER	
AR/PCS	K80P25-10	V61K2133E	
	K80P25-12	V61K2134E	
	K80P26-10	V61K2137E	
	K80P26-12	V61K2138E	
	K80P27-29	V61K2370/71E	
	K80P27-30	K61K2100E	
	K80P28-29	K61K2375/76E	
	K80P28-30	V61K2200E	
	K80P30-10	V61K2040E	
	K80P30-12	V61K2060E	
	K80P31-10	V61K2000E	
	K80P31-12	V61K2020E	
	K80P33-3	V61K2305E	
	K80P33-5	V61K2304E	
	K80P33-9	V61K2325E	
	K80P33-11	V61K2322E	
	K80P34-5	V61K2164E	
	K80P34-11	V61K2318E	
	K80P34-17	V61K2315E	
	K80P34-32	V61K2162E	
	K80P34-34	V61K2317E	
	K80P34-36	V61K2314E	
	A/L	KAW82D P6-S	V64K0500E
		KAW82D P6-T	V64K0501E
		KAW82D P4-13	V64K0510E
		KAW82D P4-11	V64K0511E
KAW82D P6-B		V64K0520E	
KAW82D P6-C		V64K0521E	
KAW82D P5-13		V64K0530E	
KAW82D P5-11		V64K0531E	

4.2 OUTPUT MEASUREMENT LIST

Table 2 lists all model outputs along with the initial condition value for the output. Measurement I.D. and Measurement Name precede pairs of numeric columns. The first of each pair is labeled FS indicating flight system engineering units. The second of each pair is labeled CTS indicating the GSIU count value corresponding to the FS value. I.C. indicates initial condition values. VALUE 1 typically indicates nominal values. VALUE 2 and VALUE 3 columns indicate off nominal conditions.

MEASUREMENT OUTPUT FROM AP/PCS MODEL - TABLE 2

MEASUREMENT I. D.	MEASUREMENT NAME	I.C.		VALUE 1		VALUE 2		VALUE 3		UNITS
		FS	CTS	FS	CTS	FS	CTS	FS	CTS	
V61X237	N2 SYS 1 Reg Inlet VLV-Open	1	1	0	0					STATE
V61X237E	N2 SYS 1 Supply VLV-Open	1	1	0	0					STATE
V61X2328E	N2 SYS 2 Reg Inlet VLV-Open	0	0	1	1					STATE
V61X2372E	O2/N2 CNTLR VLV-SYS 1 Open	1	1	0	0					STATE
V61X2377E	O2/N2 CNTLR VLV-SYS 2 Open	0	0	1	1					STATE
V61R2401A	Cabin Press Rate of Change	0	460							PSI/MIN
V61P2405A	Cabin Press	14	732	0	6	8	419			PSIA
V61T2406A	SYS 1 N2 Tank 1 Temp	-12	256							DEGF
V61T2407A	SYS 1 N2 Tank 2 Temp	-7	276							DEGF
V61T2408A	SYS 2 N2 Tank 1 Temp	-10	264							DEGF
V61T2409A	SYS 2 N2 Tank 2 Temp	-5	284							DEGF
V61P2410A	SYS 2 N2 200 PSI Press	0	0	228	771					PSIA
V61X2415E	N2 SYS 1 Reg Inlet VLV-Closed	0	0	1	1					STATE
V61X2416E	N2 SYS 1 Supply VLV-Closed	0	0	1	1					STATE
V61X2420E	N2 SYS 2 Reg Inlet VLV-Closed	1	1	0	0					STATE
V61X2421E	N2 SYS 2 Supply VLV-Closed	1	1	0	0					STATE
V61P2511A	O2 Partial Press-A	3.1	632	0	0					PSIA
V61P2513A	O2 Partial Press-B	3.2	653	0	0					PSIA
V61P2515A	O2 Partial Press-C	3.3	675	0	0					PSIA
V61R2553A	SYS 1 N2 Flowrate	2.7	612	0	4	4.45	1003			LB/HR
V61R2554A	SYS 2 N2 Flowrate	0	8	2.8	632	4.35	982			LB/HR

MEASUREMENT OUTPUT FROM AR/PCS MODEL - TABLE 2

MEASUREMENT D.	MEASUREMENT NAME	I.C.		VALUE 1		VALUE 2		VALUE 3		UNITS
		FS	CTS	FS	CTS	FS	CTS	FS	CTS	
V61X2005E	Cabin Vent ISOL VLV-CLOSED	1	1	0	0					STATE
V61X2025E	Cabin Vent ISOL VLV-OPEN	0	0	1	1					STATE
V61X2045E	Cabin Vent VLV-CLOSED	1	1	0	0					STATE
V61X2065E	Cabin Vent VLV-OPEN	0	0	1	1					STATE
V61R2105A	SYS 1 O2 Flowrate	2.5	565	0	8	4.5	1015			LB/HR
V61P2115A	O2 Reg Press Sys 1	66	221	1.15	0					PSIA
V61X2130E	Cabin Press RLF VLV A- CLOSED	0	0	1	1					STATE
V61X2135E	Cabin Press RLF VLV A-Enabled	1	1	0	0					STATE
V61X2136E	Cabin Press RLF VLV B-CLOSED	0	0	1	1					STATE
V61P2161A	Cabin Press RLF VLV B-ENABLED	1	1	0	0					STATE
V61X2163E	EMER O2 Tank Press	2058	579							PSIA
V61X2165E	O2 EMER VLV-Open	0	0	1	1					STATE
V61P2166A	O2 EMER VLV-Close	1	1	0	0					STATE
V61R2205A	EMER O2 Supply Press	297	203	0	0					PSIA
V61P2215A	SYS 2 O2 Flowrate	0	8	2.6	591	4.4	992			LB/HR
V61T2216A	O2 REG Press SYS 2	0	4	69	237					PSIA
V61P2301A	EMER O2 Tank Temp	-20	223							DEGF
V61P2307A	SYS 1 N2 Supply Press	1562	450							PSIA
V61P2309A	SYS 1 N2 17 PSI Press	15	763	0.06	0					PSIG
V61P2310A	SYS 2 N2 Supply Press	1601	458							PSIA
V61P2311A	SYS 1 N2 200 PSI Press	224	782	0	16					PSIA
V61X2319E	SYS 2 N2 17 PSI Press	0	2	17	872					PSIG
V61X2319E	N2 SYS 2 Supply VLV-Open	0	0	1	1					STATE

MEASUREMENT OUTPUT FROM AR/PCS MODEL - TABLE 2

MEASUREMENT I. D.	MEASUREMENT NAME	I. C.		VALUE 1		VALUE 2		VALUE 3		UNITS
		FS	CTS	FS	CTS	FS	CTS	FS	CTS	
V64P011A	-AIRLOCK- AIRLOCK DIFFERENTIAL PRESS	14.4	880	-10	256	0.08	514			PSID
V64P0201A	EVLSS H2O SUPPLY PRESS	16	409							PSIG
V64P0202A	EVLSS O2 SUPPLY PRESS	760	518	295	201	0	0			PSIA
V64X0505E	EMU 1 H2O WASTE-OPEN	0	0	1	1					STATE
V64X0515E	EMU 1 H2O SUPPLY-OPEN	0	0	1	1					STATE
V64X0525E	EMU 2 H2O WASTE-OPEN	0	0	1	1					STATE
V64X0535E	EMU 2 H2O SUPPLY-OPEN	0	0	1	1					STATE

*NOTE: This measurement uses the range limit conversion method of calculating FS_{EU} from GSIU_{CTS} as discussed in Section 2.6.2.

5.0 REFERENCES

LA-8-10100-1/JSC-11174, Space Shuttle Systems Handbook OV-102.

V570-610202, Schematic Diagram-Atmosphere Revitalization/Pressure Control System.

ICD-3-1603-05, Section 3.3, Interface Control Documents for Atmosphere Revitalization Subsystem.

S076-SH-0027, Functional Subsystem Software Requirements (FSSR-6).

LEC Memo #77-2109-060, GSIU Math Model Requirements.

Shuttle Operational Data Book, Section 4.6, ECLSS.

- PIRN #106 To ICD-3-1603-05.

APPENDIX I
ACTIVE THERMAL CONTROL MATH MODEL REQUIREMENTS

TABLE OF CONTENTS

Section	Page
1. INTRODUCTION.	I-2
2. DETAILED REQUIREMENTS	I-3
2.1 FUNCTIONAL CHARACTERISTICS	I-3
2.1.1 Active Thermal Control System.	I-3
2.1.2 Model Function	I-5
2.1.3 Input/Output	I-5
2.2 DCM UPLINK REQUIREMENTS.	I-5
2.3 INITIALIZATION REQUIREMENTS.	I-8
2.4 TERMINATION REQUIREMENTS	I-3
2.5 UNIQUE REQUIREMENTS.	I-8
2.6 ANALOG MEASUREMENTS.	I-9
2.6.1 Polynomial Conversion Method	I-9
2.6.2 Range Limit Conversion Method.	I-12
3. LOGIC FLOW DIAGRAMS	I-14
4. TABLES.	I-24
4.1 TABLE 1 - INPUT STIMULI LIST	I-25
4.2 TABLE 2 - OUTPUT MEASUREMENTS LIST	I-27
5. REFERENCES.	I-30
FIGURES	
FIGURE 1 - SYSTEM DATA FLOW	I-4
FIGURE 2 - ATCS SCHEMATIC	I-6

1.0 INTRODUCTION

Math models are used to simulate many of the Shuttle systems for which hardware does not exist in SAIL. A group of these models are termed non-avionics models since they do not simulate avionic equipment. The non-avionics models are needed to provide responses to cockpit switches, to drive cockpit displays, and to supply data for on-board software processing. The following list of non-avionic models will operate within the Test Operations Center (TOC) Ground Standard Interface Unit (GSIU).

- Main Propulsion System (Orbiter Portion)
- APU/Hydraulic
- Active Thermal Control
- Atmosphere Revitalization System - H₂O Loops
- Fuel Cell/Cryogenics
- Atmosphere Revitalization/Pressure Control System (With Airlock)
- Smoke Detection/Fire Suppression
- Water/Waste Management

When the TOC Display and Control Module (DCM) operator depresses the "SYS LOAD" key, the model programs, which are stored on the Fixed Head Disk in the DCM, are automatically loaded into the GSIU. The models are then activated and terminated by DCM test language statements. While the models are operating in the GSIU, the DCM operator is able to inhibit one, all, or any combination of model outputs with test language statements. This provides the DCM operator with control of output parameter values when off-nominal conditions are desired. To simplify the models and ease the processing load on supporting test equipment, the model requirements define nominal conditions only. Further, analog values for output parameters change in step fashion when responding to inputs, except when specific change rates for particular parameters are required. The DCM operator is also able to alter the value that the model uses to generate parameter outputs. This allows the DCM operator to adjust output parameter values as needed to satisfy various mission phases.

When the model is activated, it shall check the input stimuli and shall provide appropriate output measurement values. It is preferred that the model provide output data when the input stimuli changes. Bus activity is then minimal during those mission phases when the stimuli remains constant. However, the GSIU operating system may require a cyclic model program in which case the model output rate shall be once per second.

2.0 DETAILED REQUIREMENTS

This model simulates the Orbiter Active Thermal Control System (ATCS) by representing the stimulus/response relationships which exist at the power and signal interfaces between the Orbiter Avionics System and the ATCS. The model has been simplified by including only those output signals which are needed to support the type of testing which will be accomplished in the Shuttle Avionics Integration Laboratory (SAIL).

The model receives stimuli from two sources (see figure 1):

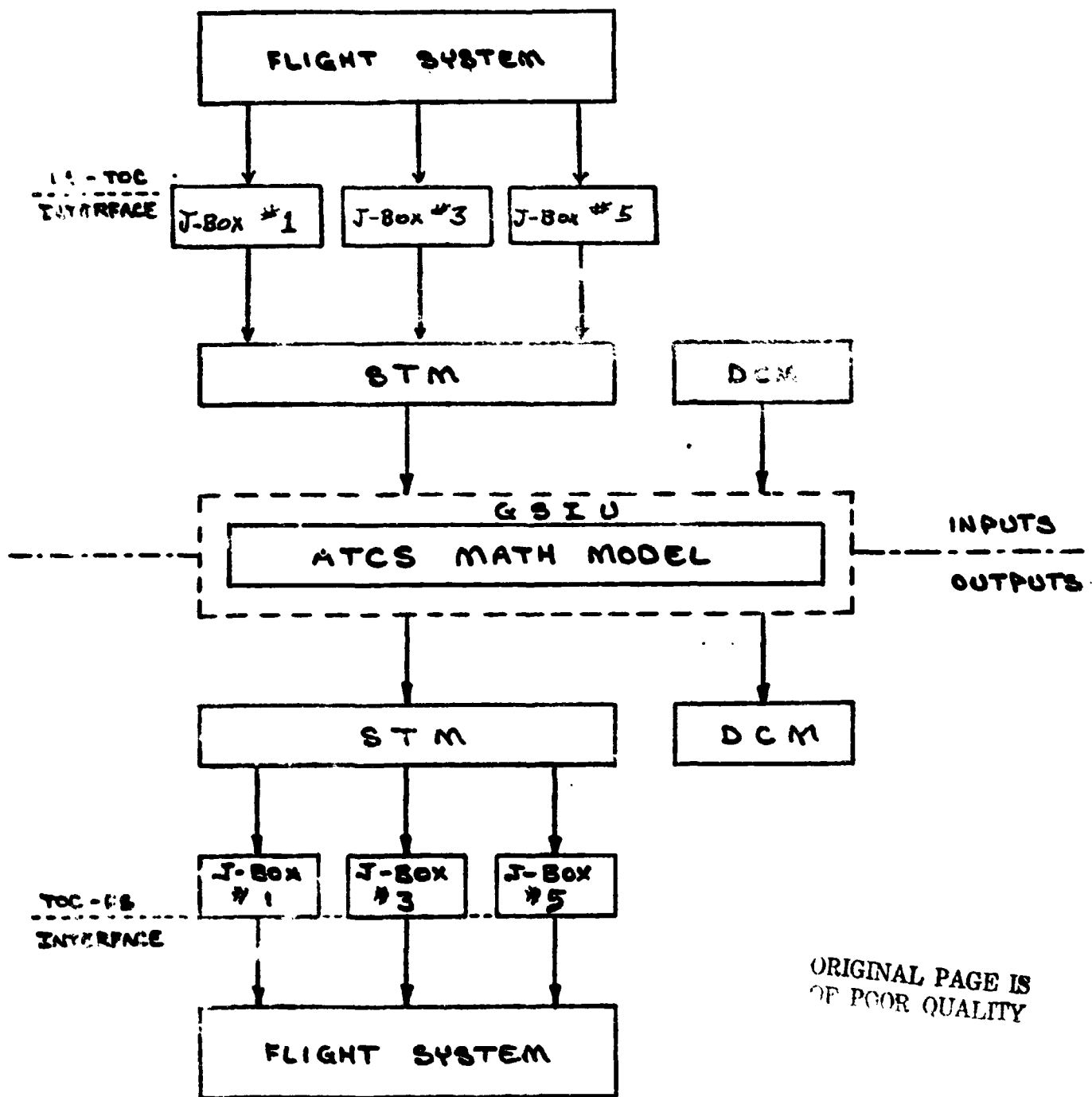
- 1) The Flight System (FS) via the Signal Termination Module (STM).
- 2) The TOC DCM.

The model output parameters to the flight system via the STM and in addition transmits error flags back to the DCM. Tables 1 and 2 list the input and output parameters respectively. The four stimuli which come from the DCM are used to inform the model of the mission phase which is being simulated. This mode of implementation permits realistic model responses while avoiding an overly complex model. The ten error flags which are transmitted to the DCM are used to indicate that the model has received conflicting stimuli.

2.1 FUNCTIONAL CHARACTERISTICS

2.1.1 Active Thermal Control System

The ATCS transports thermal energy in the unpressurized area of the Orbiter, provides temperature control of selected onboard equipment and rejects excess heat overboard. The ATCS consists of two freon 21 coolant loops which flow in parallel through similar components, and have redundant centrifugal pumps. The ATCS cools the water coolant loops through an interchanger, heats the Orbiter's hydraulic fluid and crew compartment cryogenic makeup oxygen, and transports the heat generated by the payload, fuel cell power plants, and various cold plate electronics. The ATCS rejects the excess heat overboard during different phases of the mission by means of its radiator subsystem, flash evaporators, ammonia boiler, and GSE heat exchanger. During on-orbit operations, whenever the payload bay doors are opened, heat is rejected to space by the radiator subsystem with the flash evaporator subsystem on standby to provide supplemental cooling when needed. Whenever the payload bay doors are closed, heat is rejected by the flash evaporator subsystem. The flash evaporator also provides cooling above 140,000 feet during ascent and above 100,000 feet during entry. The ammonia boiler system provides cooling during entry starting at 100,000 feet and continuing for 15 minutes after landing. The GSE heat exchanger provides thermal control during ground operations; no overboard heat rejection is provided during the period from lift-off until the vehicle reaches 140,000 feet.



INPUT / OUTPUT DATA FLOW

FIGURE 1

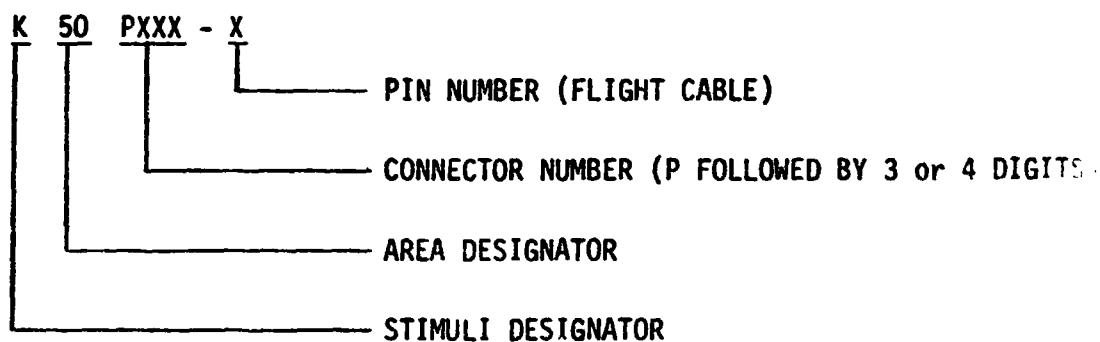
2.1.2 Model Function

The model generates values for quantity, flow, temperature, pressure, and valve positions for each of the two freon coolant loops. The values are dependent upon input stimuli from the flight system via the STM and upon mission phase indicators uplinked from the DCM. A static set of nominal values are generated for the flash evaporator heater temperatures and for the parameters from the ammonia boiler supply tanks. These static values are sufficient to meet test objectives and they greatly simplify the model.

Referring to the schematic of the ATCS, figure 2, the flowchart starts at the flow proportioning valves and progresses around the coolant loops in a clockwise manner, ending at the flash exporator. Once a complete cycle has been made and values have been assigned to the output parameters, the values are transmitted to the flight system via the STM.

2.1.3 Input/Output

The stimuli identification for those stimuli which have their sources at the flight system via the STM are coded in terms reference Avionics Test Article (ATA) interface connector and pin number according to the following format.



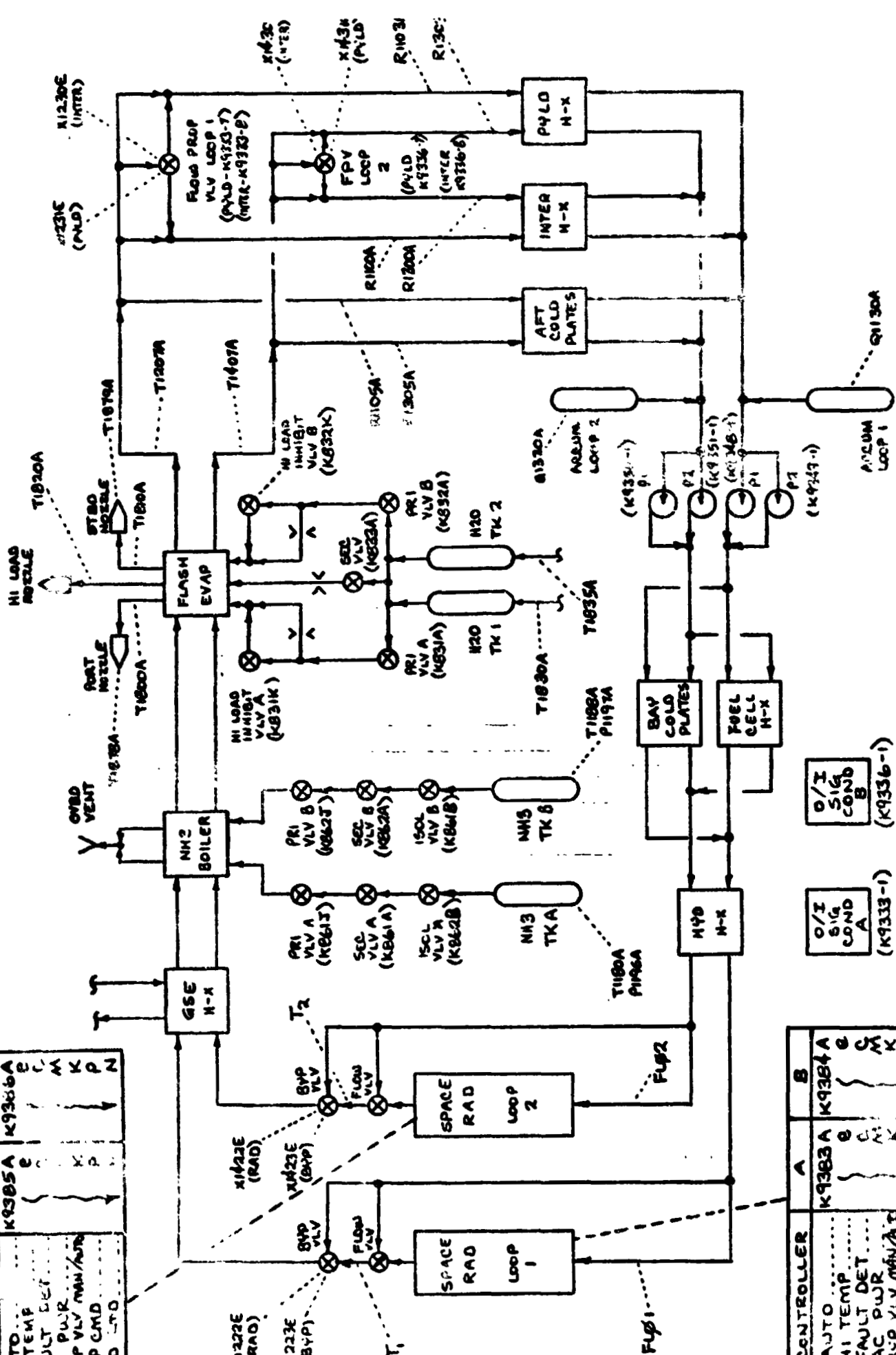
Those stimuli which are uplinked to the model from the DCM are given unique alphanumeric variable names. The model output parameters whose destinations are the flight system via the STM are identified by their Master Measurement List measurements. Any error flags which are downlinked to the DCM are given unique alphanumeric variable names.

2.2 DCM UPLINK

Mission phase flags for the ATCS model are uplinked from the DCM by the test operator to assure that the model response is appropriate for the mission phase/segment or Orbiter configuration being simulated. The following definitions explain the mission phase flags:

CONTROLLER	A	B
AUTO	K9385A	K9386A
HI TEMP		
FAULT DET		
AC PWR		
BYP VLV MAN/AUT		
BYP CMD		
RAD LTD		

CONTROLLER	A	B
AUTO	K9383A	K9384A
HI TEMP		
FAULT DET		
AC PWR		
BYP VLV MAN/AUT		
BYP CMD		
RAD CMD		



NOTE:
K DESIGNATES SPINDLES

FREON CO ANT LOOPS

FIGURE 2

- **GSE** - When equal to one, ground support equipment provides cooling for the ATCS. Zero indicates no ground cooling.
- **P1** - When equal to one, the payload doors are open and the radiator panel for ATCS loop one is deployed. Zero indicates the loop one radiator panel is not deployed and cannot provide cooling.
- **P2** - When equal to one, the payload doors are open and the radiator panel for ATCS loop two is deployed. Zero indicates the loop two radiator panel is not deployed and cannot provide cooling.

Appropriate values for the mission flags in each mission phase are tabulated below:

PHASE	FLAGS		
	GSE (b)	P1	P2
Prelaunch	1	0	0
Ascent to 140K	0	0	0
Ascent above 140K	0	0	0
On-Orbit	0	(a)	(a)
Entry above 100K	0	0	0
Entry below 100K	0	0	0
Landing +15 minutes	1	0	0

- (a) Value of flag depends on Orbit configuration.
- (b) Briefly setting GSE to one during phase transitions will prevent transient alarms for V63T1207A and V63T1407A.

Faults are simulated by inhibiting the model output for the affected measurement(s) and uplinking the off-nominal value(s) from the DCM. The exact manner in which this is accomplished is covered in documentation for the GSIU Operating System.

2.3 INITIALIZATION REQUIREMENTS

All model outputs are functions of the inputs alone and need not be initialized since values will be calculated by the model in its first cycle. The initial condition column in table 2 represents the ATCS in a ready for launch configuration and is for reference only.

2.4 TERMINATION REQUIREMENTS

None

2.5 UNIQUE REQUIREMENTS

2.5.1 Internal Variables -

The model uses four internal variables to determine the values of output parameters.

ID#	DESCRIPTIONS
FLO 1	A discrete which represents loop 1 flow through the radiator (1), or flow bypassing the radiator (0).
FLO 2	A discrete which represents loop 2 flow through the radiator (1), or flow bypassing, the radiator (0).
T1	An analog which represents loop 1 radiator outlet temperature.
T2	An analog which represents loop 2 radiator outlet temperature.

2.6 ANALOG MEASUREMENTS

Values shown in the math model flowcharts are in GSIU counts for all analog measurements. The math model values are seen by the flight system as 0 to 5 VDC inputs. The flight system then converts these input voltages to engineering units using one of the two types of scaling equations discussed in Sections 2.6.1 and 2.6.2. The GSIU math model count values (or the count values entered at the DCM by the test operator) must consider the scaling computation done later by the flight software, so that correct flight system engineering unit values are obtained for fault detection and annunciation (FDA), and for cockpit displays. The following two sections, 2.6.1 and 2.6.2, describe the scaling equations which apply to this model. Section 2.6.1 describes the scaling equation for measurements which require the polynomial conversion method. Section 2.6.2 describes the scaling equation for measurements which require the range limit conversion method which was used on STS-1.

2.6.1 POLYNOMIAL CONVERSION METHOD

The scaling polynomial equation used by the flight system is defined in the SM FSSR. The general form of the equation is given as follows:

$$FS_{EU} = A_0 + A_1X + A_2X^2 + A_3X^3$$

where: FS_{EU} = flight system engineering units

X = flight system input voltage

A_0, A_1, A_2, A_3 = scaling polynomial coefficients

The following example shows the step by step procedure for converting analog measurements from flight system engineering units (FS_{EU}) to GSIU counts. This procedure may be used to calculate GSIU count values for fault insertion at the DCM.

Example:

For measurement no. V63R1100A, convert FS_{EU} value = 2288 to GSIU counts.

Step 1:

In the SM FSSR, look up the measurement no. (V63R1100A) within the "SMM Data Requirements - Subsystems Displays" table. The measurement no. will appear on two consecutive pages as follows: page A will show engineering units, range low value and range high value, while page B will show the scaling polynomial coefficients (labelled A_0, A_1, A_2, A_3) followed by curve order, independent variable, and STS flight no. The values on page B will be of prime interest to do this example conversion, and will be referred to in the following discussion.

Step 2:

The coefficients will be used in the scaling polynomial:

$$FS_{EU} = A_0 + A_1X + A_2X^2 + A_3X^3$$

Solve the following scaling polynomial for X:

$$2288 = 443.167 + 851.956X - 143.904X^2 + 12.246X^3$$

$$\text{so } X = 3.846469$$

Step 3:

Notice the independent variable column labelled IND VR equals 2 for measurement no. V63R1100A. The 2 specifies that the independent variable X of the scaling polynomial is defined on a range of 0 to 5 VDC. So $X = 3.846$ VDC.

It is of interest to note that if IND VR had been equal to 0, X would have been defined on a range of 0 to 1023 PCM integer counts in which case X would be equal to 4 PCM counts, i.e. 3.846 rounded to the nearest integer.

However, in the example being worked, X is defined as VDC and $X = 3.846$ VDC.

Step 4:

Now to convert X VDC to GSIU counts, evaluate the following equation which shows the relationship between X and GSIU counts:

$$\text{GSIU counts} = \left[X \left(\frac{1023}{K} \right) \right], \text{ rounded to the nearest integer}$$

where $K = 5$, for X defined as VDC (IND VR = 2) and

$K = 500$, for X defined as PCM counts (IND VR = 0).

For the example, evaluate:

$$\text{GSIU counts} = \left[3.846 \left(\frac{1023}{5} \right) \right], \text{ rounded to the nearest integer}$$

Therefore, GSIU counts = 787 counts.

Note that since GSIU counts are always rounded to the nearest integer, small changes will possibly occur in the values of X and consequently FS_{EU} , when the reverse calculations are made during test operations, as the following shows:

$$X = \text{GSIU counts} \left(\frac{K}{1023} \right)$$

$$X = 787 \times \left(\frac{5}{1023} \right)$$

$$\text{SO } X = 3.846529$$

And

$$FS_{EU} = 443.167 + 851.956X - 143.904X^2 + 12.246X^3$$

$$FS_{EU} = 443.167 + 851.956(3.848) - 143.904(3.848)^2 + 12.246(3.848)^3$$

$$FS_{EU} = 2288.017$$

Hence when 787 GSIU counts is inserted for measurement no. V63R1100A, a value of 2288.017 FS_{EU} will result.

2.6.2 RANGE LIMIT CONVERSION METHOD

Several analog measurements in this model are calculated according to the range limit conversion method, instead of the polynomial conversion method as described in Section 2.6.1 of this document. The form of the scaling equation for these cases is given as follows:

$$FS_{EU} = Low + \frac{GSIU_{CTS}}{1023} (High - Low)$$

where: FS_{EU} = flight system engineering units

$GSIU_{CTS}$ = GSIU math model count values

Low = Range low limit

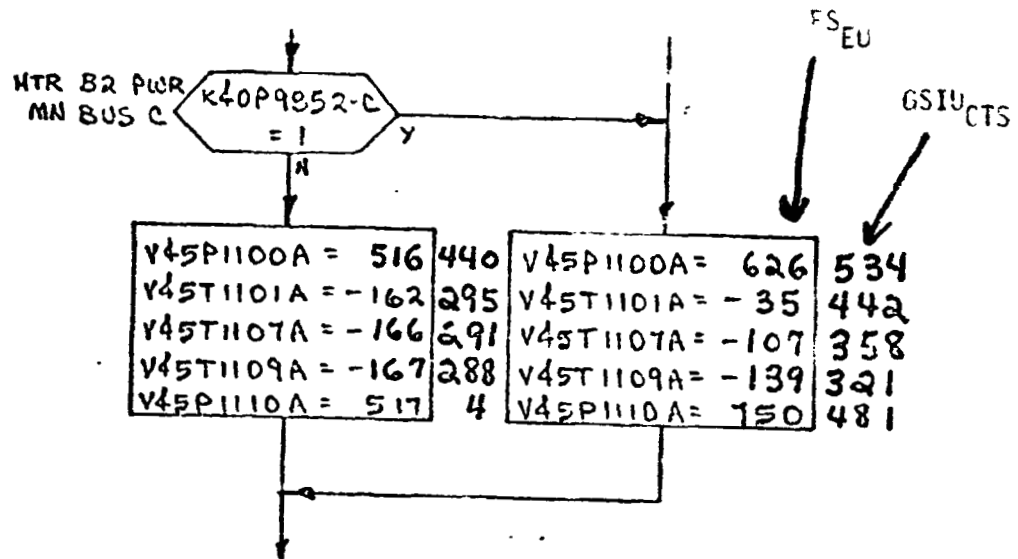
High = Range high limit

The following table shows a sample data value for each measurement which requires this type of calculation. The measurement I.D. is shown along with high and low values for the parameter range. The FS column shows the data value in flight system engineering units calculated from the GSIU counts marked CTS in the table. These measurements are marked with an asterisk (*) in the Output Measurement List marked as Table 2 in Section 4.2 of this document.

MEASUREMENT ID	RANGE LOW	RANGE HIGH	FS	CTS
V63T1180A	-75	175	65	573
V63T1188A	-75	175	70	593
V63P1196A	0	600	450	767
V63P1197A	0	600	475	810

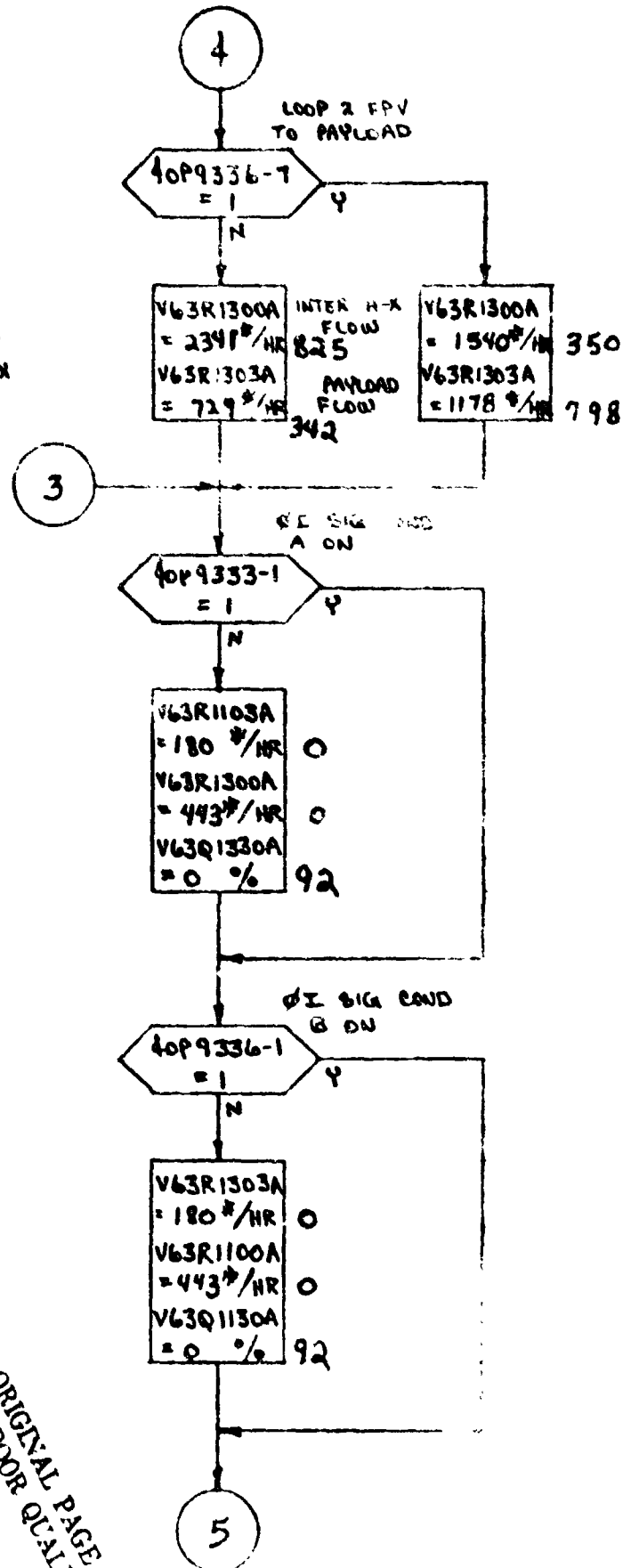
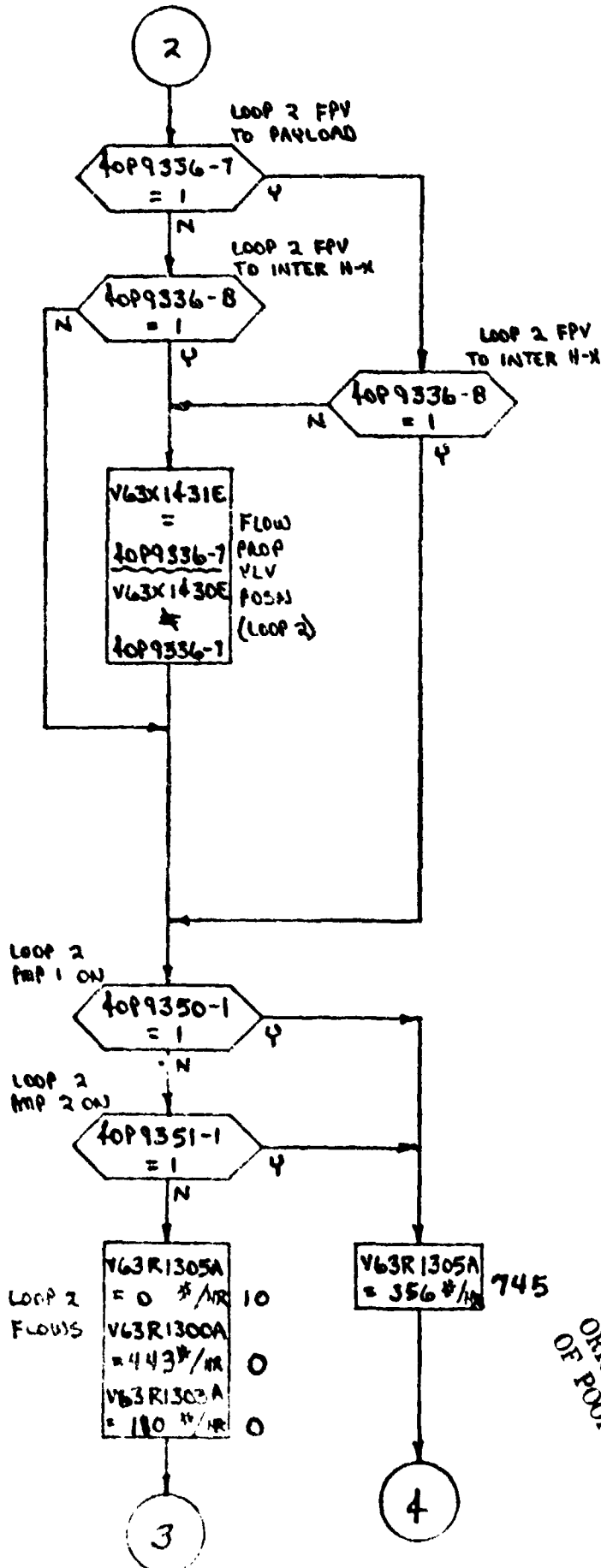
3.0 LOGIC FLOW DIAGRAMS

The logic flow diagram is made up of interconnected lines, boxes, decisions, and offpage connectors. Notice that where analog measurements are listed in boxes and decisions, the value inside the box is in flight system engineering units (FS_{EU}) while the corresponding GSIU count value is listed outside the box. For example, the box on the right hand below,



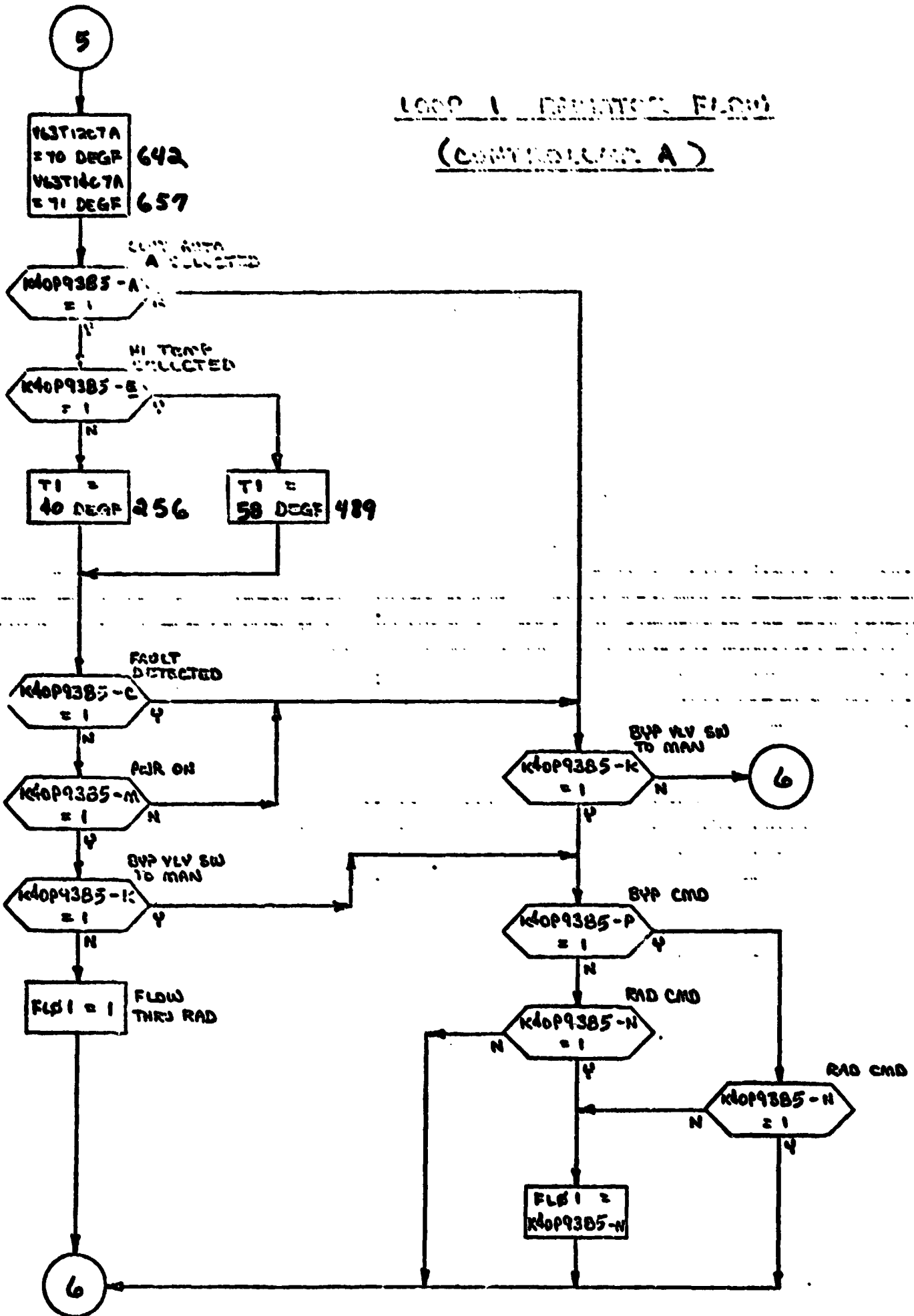
shows that $V45P1100A$ is set equal to $626\ FS_{EU}$ which is equivalent to $534\ GSIU_{CTS}$ shown outside the box.

4.0 TABLES



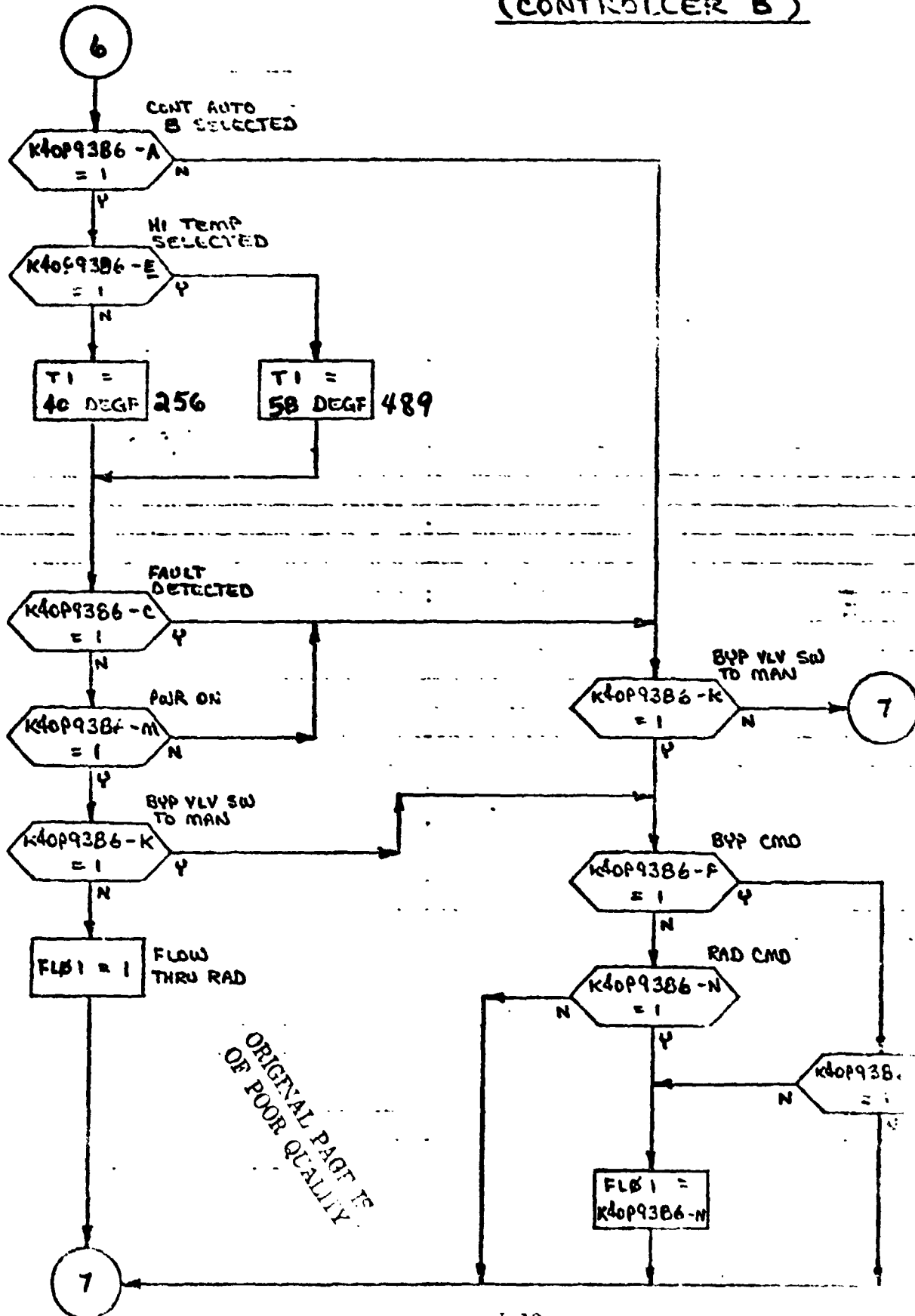
ORIGINAL PAGE IS
OF POOR QUALITY

LOOP 1 DIAGNOSTIC FLOW
(CONTROLLER A)

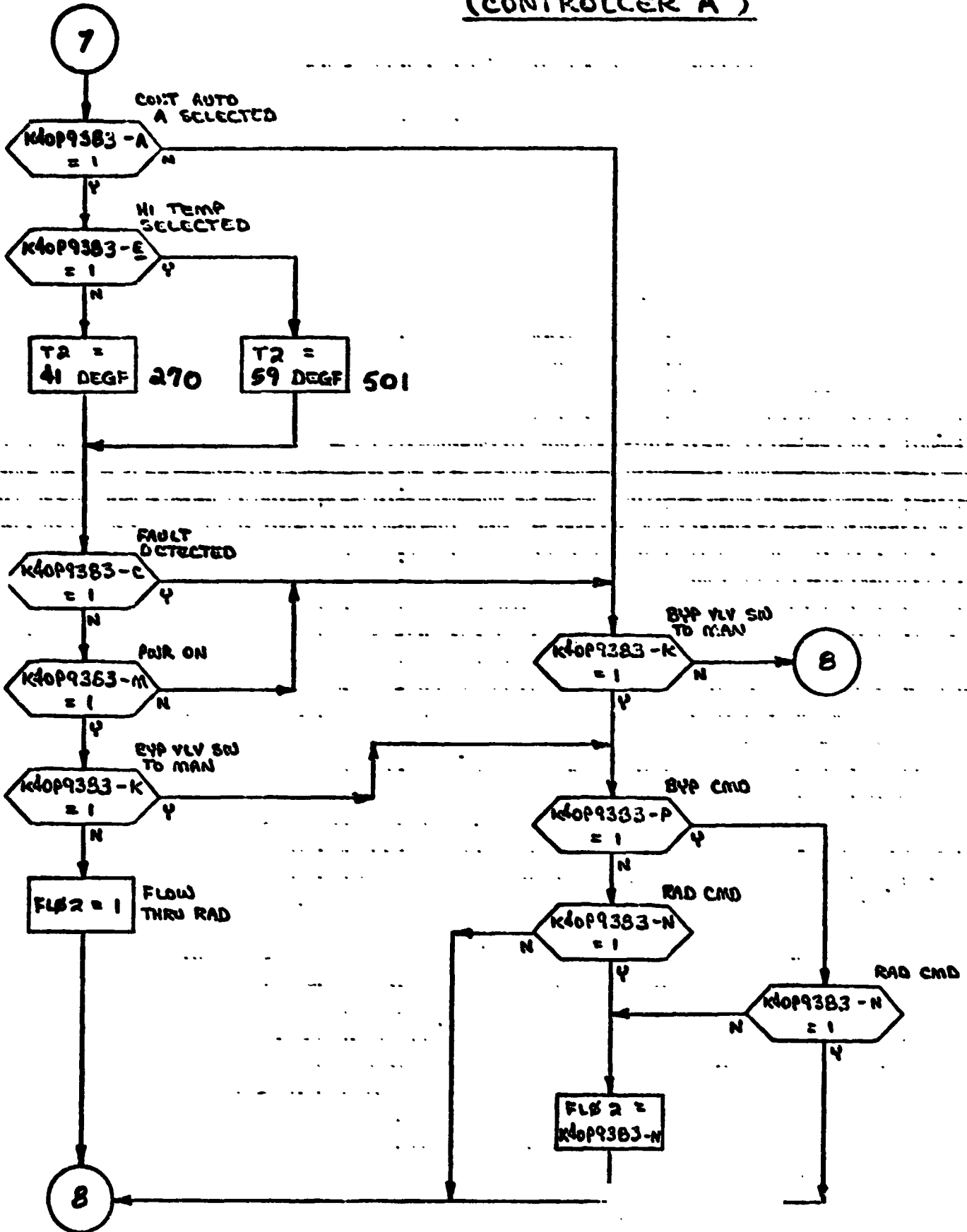


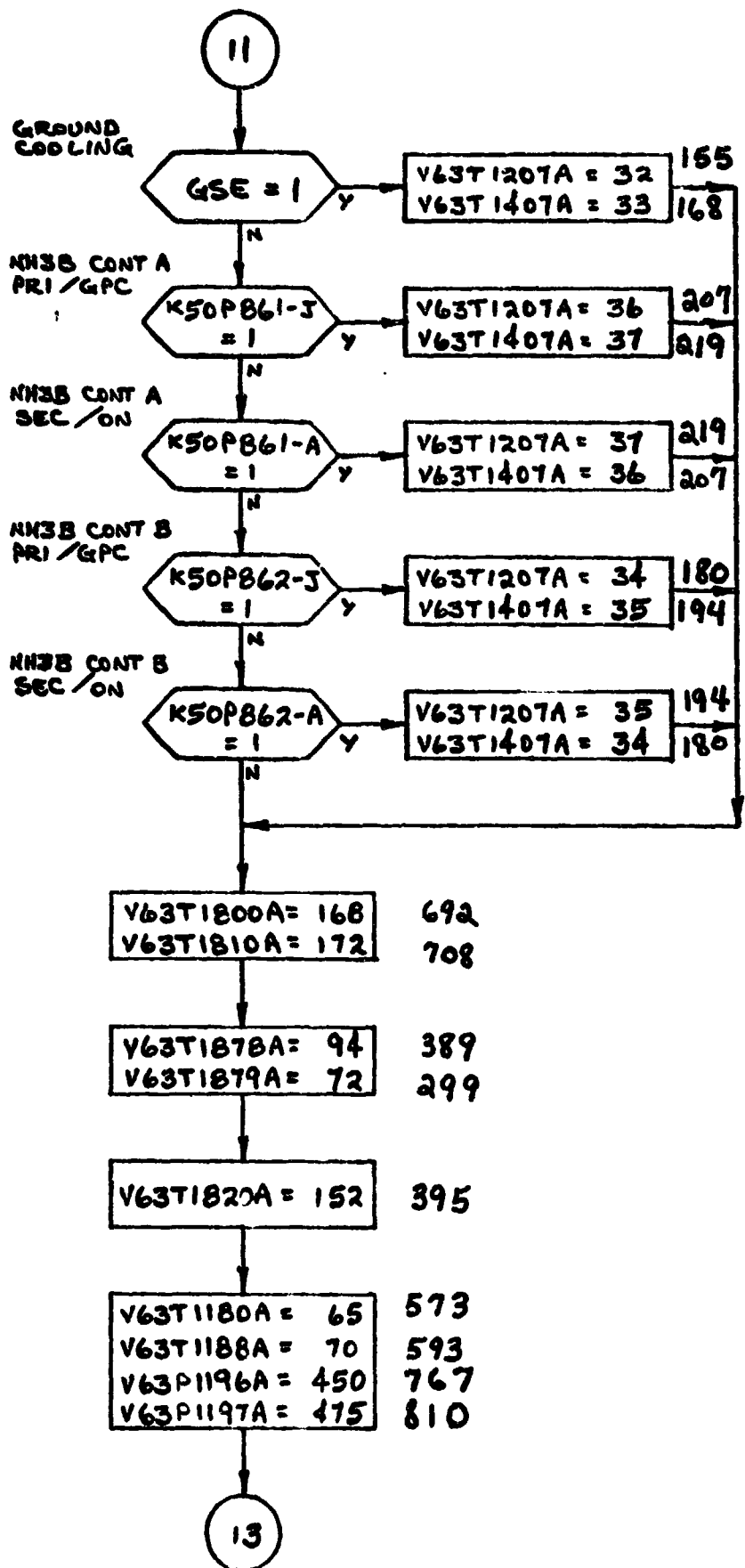
LOOP 1 RADIATOR FLOW

(CONTROLLER B)



LOOP 2 RADIATOR FLOW (CONTROLLER A)





13

V63T1208A	=	100.7
V63T1209A	=	80
V63T1408A	=	109
V63T1409A	=	96
V63T1801A	=	160
V63T1802A	=	164
V63T1821A	=	156
V63T1870A	=	85
V63T1871A	=	89
V63T1872A	=	86
V63T1873A	=	90
V63T1874A	=	87
V63T1875A	=	91
V63T1876A	=	88
V63T1877A	=	92
V63T1890A	=	256
V63R9159A	=	420

739
514
820 DFI MEAS.
616 Added BY
415 REV. A.
426
405
546
571
552
577
559
583
565
591
661
878

RETURN

4.0 TABLES

TABLE 1 - STIMULUS PUT TO ATCS MODEL

IDENTIFICATION NUMBER	NOMENCLATURE	SOURCE	STM ADDRESS		STATES/RANGE		UNITS
			CELL	CHANNEL	LO	HI	
K50P831-A	FLASH EVAP PRI A CONT CMD	FS			0	1	STATE
K50P831-K	FLASH EVAP PRI A HI LOAD ENABLE CMD	FS			0	1	STATE
K50P832-A	FLASH EVAP PRI B CONT CMD	FS			0	1	STATE
K50P832-K	FLASH EVAP PRI B HI LOAD ENABLE CMD	FS			0	1	STATE
K50P833-A	FLASH EVAP SEC CONT CMD	FS			0	1	STATE
K50P861-A	NH3 BOILER CONT A (SEC/ON) CMD	FS			0	1	STATE
K50P861-J	NH3 BOILER CONT A (PRI/GPC) CMD	FS			0	1	STATE
K50P861-B	NH3 BOILER ISOL VLV (SYS A) CMD	FS			0	1	STATE
K50P862-A	NH3 BOILER CONT B (SEC/ON) CMD	FS			0	1	STATE
K50P862-J	NH3 BOILER CONT B (PRI/GPC) CMD	FS			0	1	STATE
K50P862-B	NH3 BOILER ISOL VLV (SYS B) CMD	FS			0	1	STATE
K40P9333-1	OI SIG COND A PWR ON CMD	FS			0	1	STATE
K40P9333-7	FCL 1 FLO PROP VLV (PYLD H-X) CMD	FS			0	1	STATE
K40P9333-8	FCL 1 FLO PROP VLV (INTER H-X) CMD	FS			0	1	STATE
K40P9336-1	OI SIG COND B PWR ON CMD	FS			0	1	STATE
K40P9336-7	FCL 2 FLO PROP VLV (PYLD H-X) CMD	FS			0	1	STATE
K40P9336-8	FCL 2 FLO PROP VLV (INTER H-X) CMD	FS			0	1	STATE
K40P9348-1	FCL 1 PUMP 1 PWR ON CMD	FS			0	1	STATE
K40P9349-1	FCL 1 PUMP 2 PWR ON CMD	FS			0	1	STATE
K40P9350-1	FCL 2 PUMP 1 PWR ON CMD	FS			0	1	STATE
K40P9351-1	FCL 2 PUMP 2 PWR ON CMD	FS			0	1	STATE
K40P9383-A	FCL 2 RAD TEMP CONT VLV AUTO A CMD	FS			0	1	STATE
K40P9383-C	FCL 2 RAD TEMP CONT AUTO B-FAULT DET A	FS			0	1	STATE
K40P9383-E	FCL 2 RAD TEMP CONT A-HI TEMP CMD	FS			0	1	STATE
K40P9383-K	FCL 2 BYP VLV (MAN/CONT A AUTO) CMD	FS			0	1	STATE
K40P9383-M	FCL 2 RAD TEMP CONT A PWR ON CMD	FS			0	1	STATE
K40P9383-N	FCL 2 RAD MAN FLOW A CMD	FS			0	1	STATE
K40P9383-P	FCL 2 RAD MAN BYPASS A CMD	FS			0	1	STATE
K40P9384-A	FCL 2 RAD TEMP CONT VLV AUTO B CMD	FS			0	1	STATE
K40P9384-C	FCL 2 RAD TEMP CONT AUTO A-FAULT DET B	FS			0	1	STATE
K40P9384-E	FCL 2 RAD TEMP CONT B-HI TEMP CMD	FS			0	1	STATE

ORIGINAL PAGE IS OF POOR QUALITY

TABLE 1 - STIMULUS INPUT ATCS MODEL

IDENTIFICATION NUMBER	NOMENCLATURE	SOURCE	STM ADDRESS		STATES/RANGE		UNIT
			CELL	CHANNEL	LO	HI	
K40P9384-K	FCL 2 BYP VLV (MAN/CONT B AUTO) CMD	FS			0	1	STATE
K40P9384-M	FCL 2 RAD TEMP CONT B PWR ON CMD	FS			0	1	STATE
K40P9384-N	FCL 2 RAD MAN FLOW B CMD	FS			0	1	STATE
K40P9384-P	FCL 2 RAD MAN BYPASS B CMD	FS			0	1	STATE
K40P9385-A	FCL 1 RAD TEMP CONT VLV AUTO A CMD	FS			0	1	STATE
K40P9385-C	FCL 1 RAD TEMP CONT AUTO B-FAULT DET A	FS			0	1	STATE
K40P9385-E	FCL 1 RAD TEMP CONT A - HI TEMP CMD	FS			0	1	STATE
K40P9385-K	FCL 1 BYP VLV (MAN/CONT A AUTO) CMD	FS			0	1	STATE
K40P9385-M	FCL 1 RAD TEMP CONT A PWR ON CMD	FS			0	1	STATE
K40P9385-N	FCL 1 RAD MAN FLOW A CMD	FS			0	1	STATE
K40P9385-P	FCL 1 RAD MAN BYPASS A CMD	FS			0	1	STATE
K40P9386-A	FCL 1 RAD TEMP CONT VLV AUTO B CMD	FS			0	1	STATE
K40P9386-C	FCL 1 RAD TEMP CONT AUTO A-FAULT DET B	FS			0	1	STATE
K40P9386-E	FCL 1 RAD TEMP CONT B-HI TEMP CMD	FS			0	1	STATE
K40P9386-K	FCL 1 BYP VLV (MAN/CONT B AUTO) CMD	FS			0	1	STATE
K40P9386-M	FCL 1 RAD TEMP CONT B PWR ON CMD	FS			0	1	STATE
K40P9386-N	FCL 1 RAD MAN FLOW B CMD	FS			0	1	STATE
K40P9386-P	FCL 1 RAD MAN BYPASS B CMD	FS			0	1	STATE
GSE	GSE COOLING FLAG	DCM			0	1	STATE
P1	FCL 1-SPACE RAD DEPLOYED FLAG	DCM			0	1	STATE
P2	FCL 2-SPACE RAD DEPLOYED FLAG	DCM			0	1	STATE

4.2 OUTPUT MEASUREMENT LIST

Table 2 lists all model outputs along with the initial condition value for the output. Measurement I.D. and Measurement Name precede pairs of numeric columns. The first of each pair is labeled FS indicating flight system engineering units. The second of each pair is labeled CTS indicating the GSIU count value corresponding to the FS value. I.C. indicates initial condition values. VALUE 1 typically indicates nominal values. VALUE 2 and VALUE 3 columns indicate off nominal conditions.

MEASUREMENT OUTPUT FROM ATCS MODEL - TABLE 2

MEASUREMENT I. D.	MEASUREMENT NAME	I. C.		VALUE 1		VALUE 2		VALUE 3		UNITS
		FS	CTS	FS	CTS	FS	CTS	FS	CTS	
V63R1100A	FCL 1 INTER H-X FLOWRATE	2288	787	443	0	1488	328			1b/hr
V63R1103A	FCL 1 PYLD H-X FLOWRATE	701	321	180	0	1152	759			1b/hr
V63R1105A	FCL 1 COLDPLATE NETWORK FLOWRATE	348	728	0	10					1b/hr
V63Q1130A	FCL 1 ACCUMULATOR QUANTITY	60	581	0	92					PCNT
*V63T1180A	NH3 SYS A TANK TEMP	65	573							DEGF
*V63T1188A	NH3 SYS B TANK TEMP	70	593							DEGF
*V63P1196A	NH3 SYS A TANK PRESS	450	767							PSIA
*V63P1197A	NH3 SYS B TANK PRESS	475	810							PSIA
V63T1207A	FCL 1 EVAP OUT TEMP.	32	155	38	231	42	286	70	642	DEGF
V63T1208A	FCL 1 RAD OUTLET TEMP	100.7	739	40	256	34	180	58	489	DEGF
V63T1209A	FCL 1 RAD INLET TEMP	80	514	35	194	36	207	37	219	DEGF
V63X1222E	FCL 1 RAD BYP VLV POSN-RAD	0	0	1	1					STATE
V63X1223E	FCL 1 RAD BYP VLV POSN-BYP	1	1	0	0					STATE
V63X1230E	FCL 1 FLO PROP VLV POSN-INTER H-X	1	1	0	0					STATE
V63X1231E	FCL 1 FLO PROP VLV POSN-PYLD H-X	0	0	1	1					STATE
V63R1300A	FCL 2 INTER H-X FLOWRATE	2341	825	443	0	1540	350			1b/hr
V63R1303A	FCL 2 PYLD H-X FLOWRATE	729	342	180	0	1178	798			1b/hr
V63R1305A	FCL 2 COLDPLATE NETWORK FLOWRATE	356	745	0	10					1b/hr
V63Q1330A	FCL 2 ACCUMULATOR QUANTITY	65	622	0	92					PCNT
V63T1407A	FCL 2 EVAP OUT TEMP	33	168	39	246	43	297	71	657	DEGF
V63T1408A	FCL 2 RAD OUTLET TEMP	109	820	41	270	35	194	59	501	DEGF
				34	180	36	207	37	219	DEGF

*NOTE: This measurement uses the range limit conversion method of calculating FS_{EI} from GSIU_{CTS} as discussed in version 2.0.2

MEASUREMENT OUTPUT FROM ATCS MODEL - TABLE 2

MEASUREMENT I. D.	MEASUREMENT NAME	I. C.		VALUE 1		VALUE 2		VALUE 3		UNITS
		FS	CTS	FS	CTS	FS	CTS	FS	CTS	
V63T1409A	FCL 2 RAD INLET TEMP	96	616							DEGF
V63X1422E	FCL 2 RAD BYP VLV POSN-RAD	0	0	1	1					STATE
V63X1423E	FCL 2 RAD BYP VLV POSN-BYP	1	1	0	0					STATE
V63X1430E	FCL 2 FLO PROP VLV POSN-INTER H-X	1	1	0	0					STATE
V63X1431E	FCL 2 FLO PROP VLV POSN-PYLD H-X	0	0	1	1					STATE
V63T1800A	FLASH EVAP TOPPING DUCT-PORT TEMP	168	692							DEGF
V63T1801A	FL EVAP TOPPING DUCT TEMP D	160	415							DEGF
V63T1802A	FL EVAP TOPPING DUCT TEMP E	164	426							DEGF
V63T1810A	FLASH EVAP TOPPING DUCT-STBD TEMP	172	708							DEGF
V63T1820A	FLASH EVAP HI LOAD DUCT TEMP	152	395							DEGF
V63T1821A	FL EVAP HI LOAD DUCT TEMP B	156	405							DEGF
V63T1870A	FLASH EVAP H ₂ O FDLN TEMP 1-L	85	546							DEGF
V63T1871A	FLASH EVAP H ₂ O FDLN TEMP 1-R	89	571							DEGF
V63T1872A	FLASH EVAP H ₂ O FDLN TEMP 2-L	86	552							DEGF
V63T1873A	FLASH EVAP H ₂ O FDLN TEMP 2-R	90	577							DEGF
V63T1874A	FLASH EVAP H ₂ O FDLN TEMP 3-L	87	559							DEGF
V63T1875A	FLASH EVAP H ₂ O FDLN TEMP 3-R	91	583							DEGF
V63T1876A	FLASH EVAP H ₂ O FDLN TEMP 4-L	88	565							DEGF
V63T1877A	FLASH EVAP H ₂ O FDLN TEMP 4-R	92	591							DEGF
V63T1878A	FLASH EVAP NOZZLE TEMP - LEFT	94	389							DEGF
V63T1879A	FLASH EVAP NOZZLE TEMP - RIGHT	72	299							DEGF
V63T1890A	FL EVAP HI LOAD NOZ TEMP C	256	661							DEGF
V63R9159A	MID-BODY DFI LOOP FLOWRATE	420	878							lb/hr

ORIGINAL PAGE IS
OF POOR QUALITY

5.0 REFERENCES:

- a) LA-B-10100-1/JSC-11174, Space Shuttle Systems Handbook OV-102.**
- b) VS70-630102, Schematic Diagram - Active Thermal Control System.**
- c) ICD-3-1603-05, Section 3.4, Interface Control Document for ATCS.**
- d) SD76-SH-0027, Functional Subsystem Software Requirements (FSSR-6).**
- e) LEC-9485, Orbiter 102 Subsystem Simulation Requirements.**
- f) PIRN - 0084 / PIRN - 0091**
- g) MCR - 5445**

APPENDIX J
SMOKE DETECTION MATH MODEL REQUIREMENTS

TABLE OF CONTENTS

Section	Page
1. INTRODUCTION.	J-2
2. DETAILED REQUIREMENTS	J-3
2.1 <u>FUNCTIONAL CHARACTERISTICS</u>	J-3
2.1.1 Smoke Detection Subsystem (SDS).	J-3
2.1.2 Input/Output	J-6
2.2 <u>DCM UPLINK</u>	J-6
2.3 <u>INITIALIZATION REQUIREMENTS.</u>	J-6
2.4 <u>TERMINATION REQUIREMENTS</u>	J-7
2.5 <u>UNIQUE REQUIREMENTS.</u>	J-7
2.5.1 Concentration Values	J-7
2.6 <u>ANALOG MEASUREMENTS.</u>	J-8
2.6.1 Polynomial Conversion Method	J-8
2.6.2 Range Limit Conversion Method.	J-11
3. LOGIC FLOW DIAGRAMS	J-12
4. TABLES.	J-23
4.1 <u>TABLE 1 - INPUT STIMULI LIST</u>	J-23
4.2 <u>TABLE 2 - OUTPUT MEASUREMENT LIST.</u>	J-25

FIGURES

Figure	Page
1 I/O FLOW.	J-4
2 FUNCTIONAL DIAGRAM.	J-5

1.0 INTRODUCTION

Math models are used to simulate many of the Shuttle systems for which hardware does not exist in SAIL. A group of these models are termed non-avionic models since they do not simulate avionics equipment. The non-avionic models are needed to provide responses to cockpit switches, to drive cockpit displays, and to supply data for on-board software processing. The following list of non-avionic models will operate within the Test Operations Center (TOC) Ground Standard Interface Unit (GSIU).

- o Main Propulsion System (Orbiter Portion)
- o APU/Hydraulic
- o Active Thermal Control
- o Atmosphere Revitalization (H2O Loops and PCS-Airlock)
- o Fuel Cell/Cryogenics
- o Smoke Detection
- o Water/Waste Management

When the TOC Display and Control Module (DCM) operator depresses the "SYS LOAD" key, the model programs, which are stored on the Fixed Head Disk in the DCM, are automatically loaded into the GSIU. The models are then activated and terminated by DCM test language statements. While the models are operating in the GSIU, the DCM operator is able to inhibit one, all, or any combination of model outputs with test language statements. This provides the DCM operator with control of output parameter values when off-nominal conditions are desired. To simplify the model and ease the processing load on supporting test equipment, the model requirements define nominal conditions only. Further, analog values for output parameters change in step fashion when responding to inputs, except when specific change rates for particular parameters are required. The DCM operator is also able to alter the value that the model uses to generate parameter outputs. This allows the DCM operator to adjust output parameter values as needed to satisfy various mission phases.

When the model is activated, it shall check the input stimuli and shall provide appropriate output measurement values. It is preferred that the model provide output data when the input stimuli change. Bus activity is then minimal during those mission phases when the stimuli remain constant. However, the GSIU operating system may require a cyclic model program in which case the model output rate shall be once per second.

2.0 DETAILED REQUIREMENTS

The model simulates those functions of the Smoke Detection (SD) subsystem in the Orbiter. To simplify the model, only those subsystem functions needed to support testing of the Shuttle avionics system are provided.

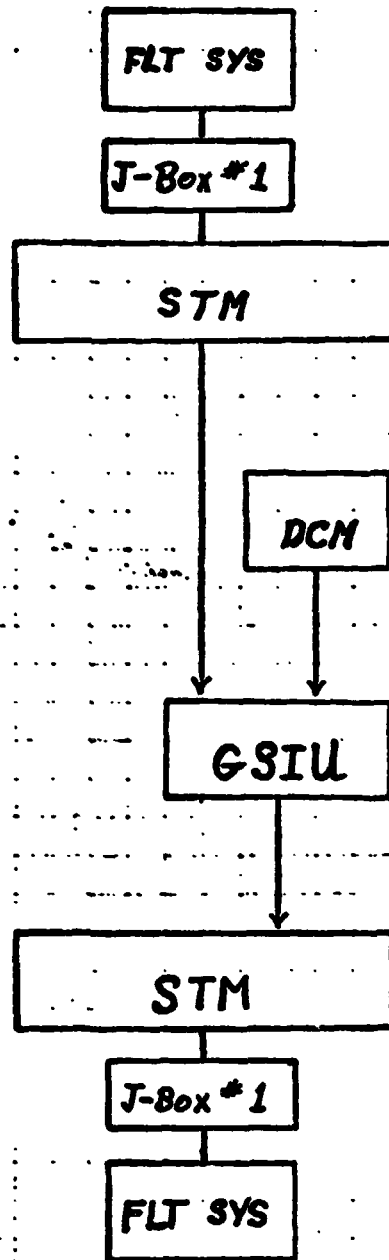
The model receives stimuli from two different sources, the flight system (FS) and the Display Control Module (DCM) via the Signal Termination Module (STM). The model provides output parameter values to the FS via the STM. Figure 1 illustrates the data flow in and out of the model. Tables 1 and 2 list the impact stimuli and output measurements.

2.1 FUNCTIONAL CHARACTERISTICS

2.1.1 Smoke Detection System (SDS)

The SDS consists of several detector head (detector) assemblies. Each detector head shall sense any significant increase in the gaseous or particulate products of combustion or decomposition within the cabin or avionics bays. The logic device shall use the input and send a signal to appropriate warning lights on the detection and fire suppression control panel. The detector shall be designed to provide a warning during the incipient stage (the starting phase or pre-smoke stage) of a potential fire condition to permit certain cabin or avionics system evaluation and troubleshooting prior to an overheat condition or outbreak of an open flame. A functional diagram is provided in Figure 2.

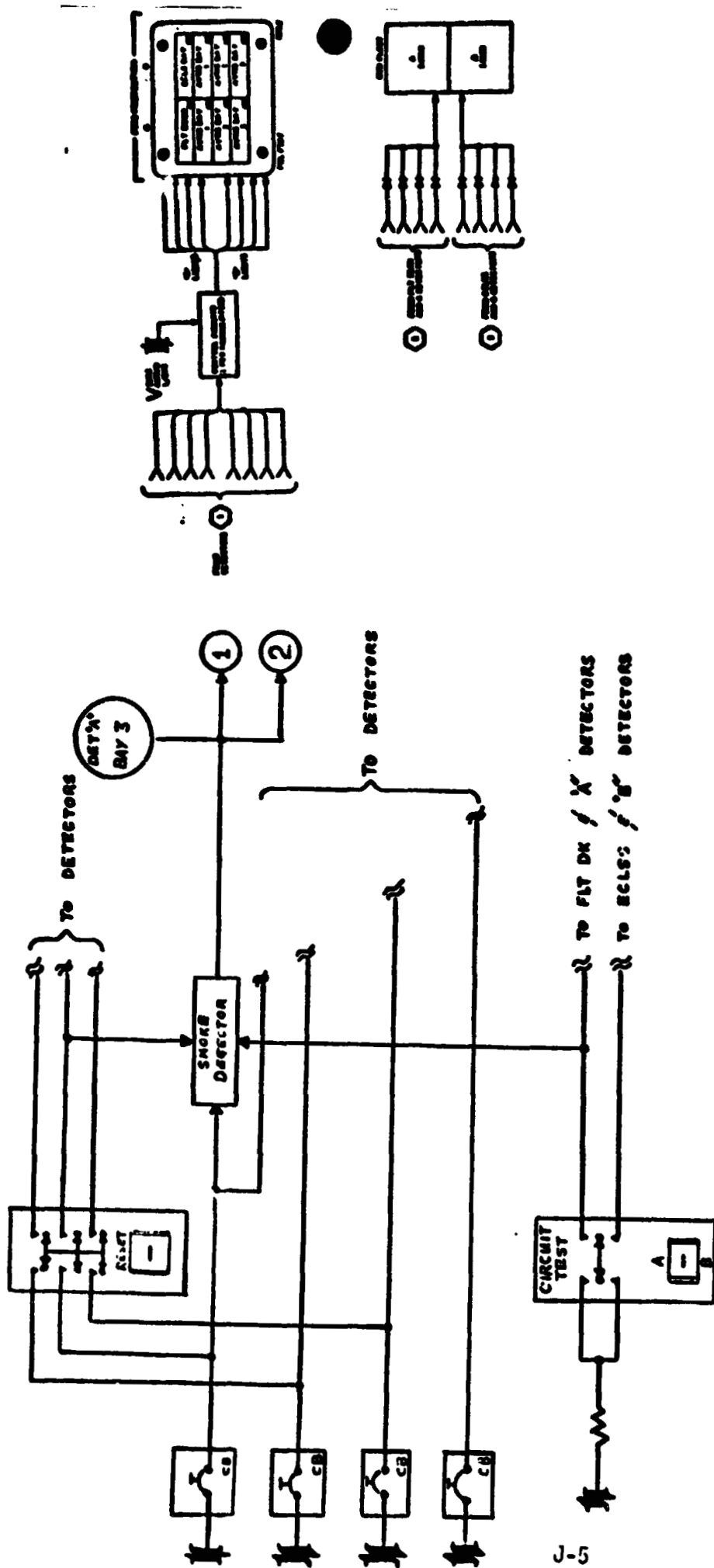
- A.** The detector function is to sense a predetermined concentration or rate of increase of concentration of gaseous or particulate products of combustion or decomposition and then, through a built-in logic unit, send a signal to the smoke detection and fire suppression control panel. The signal turns on the "smoke warning" light for the affected area.
- B.** The crew, alerted by this warning may monitor the concentration level and start a systematic investigation of the equipment in the affected area and take appropriate action.
- C.** When the smoke (incipient fire) condition exists, the "reset" button on the panel may be pressed to verify the smoke condition. If the incipient fire condition has been corrected, the "smoke warning" Light will remain off. The detector is now ready to sense a new incipient fire. In the event that the smoke or incipient fire condition still exists, the warning light will come on again. The concentration level may be monitored to verify if the level is increasing or decreasing during the trouble-shooting period.
- D.** The detector can be interrogated in flight or on ground for an electrical operability check, by depressing a "circuit-test" button on the panel.



INPUT / OUTPUT DATA FLOW

FIGURE 1

ORIGINAL PAGE IS
OF POOR QUALITY



SMOKE DETECTOR

Figure 2

2.1.2 Input/Output

All inputs to the model are from the FS (addressable at the STM), and from the DCM uplink. These stimuli are acted upon immediately at model execution without regard to time, and conditions are simulated in a step function manner.

For the sake of simplicity, the model will do no fault detection of stimuli, but will act upon it as received from the FS. Therefore, any fault insertion must include changes to all affected parameters in order to obtain a realistic response from the model.

All subsystem output is simulated by the model in accordance with stimuli from the FS. All measurements are made available to Systems Management (SM) and Fault Detection and Annunciation (FDS) as required.

The stimuli identification numbers used are coded to provide the following information at the SAIL flight cable/GSE/C70-1140 cable set interface.

K 5 0 P X X X - X
..... — PIN NUMBER (FLIGHT CABLE)
 —— CONNECTOR NUMBER
 —— AREA DESIGNATOR
 —— STIMULI DESIGNATOR

Exceptions to this code are those stimuli with a letter for the connector number where the connector number is unknown. Also the stimuli which comes from the DCM instead of the flight cable do not agree with this code. Signal Termination Module (STM) addresses for both stimuli and measurements are yet to be defined.

2.2 DCM UPLINK

The value which represents the concentration of smoke sensed by a detector will be input to the model by using PARAMS, via DCM uplink. The capability will exist to provide one value per detector.

The only other values to be passed from the DCM will be those which involve output suppression and fault insertion in accordance with the GSIU Operating System and are not a part of this document.

2.3 INITIALIZATION REQUIREMENTS

The following parameters will be initialized as shown below:

- o CLOSE CIRCUIT BREAKERS 6 & 7 on PANEL 016
- o CLOSE CIRCUIT BREAKERS 7 & 8 on PANEL 014
- o CLOSE CIRCUIT BREAKER 7 on PANEL 015

- o Parameters should be initialized as indicated in Table 2.

2.4 TERMINATION REQUIREMENTS

NONE

2.5 UNIQUE REQUIREMENTS

2.5.1 SMOKE CONCENTRATION VALUES

Particle concentration values are input to the model via the DCM uplink. Once set from the DCM, they remain constant until another value is uplinked. The DCM utility program 'PARAMS' will be used for the uplink.

2.6 ANALOG MEASUREMENTS

Values shown in the math model flowcharts are in GSIU counts for all analog measurements. The math model values are seen by the flight system as 0 to 5 VDC inputs. The flight system then converts these input voltages to engineering units using one of the two types of scaling equations discussed in Sections 2.6.1 and 2.6.2. The GSIU math model count values (or the count values entered at the DCM by the test operator) must consider the scaling computation done later by the flight software, so that correct flight system engineering unit values are obtained for fault detection and annunciation (FDA), and for cockpit displays. The following two sections, 2.6.1 and 2.6.2, describe the scaling equations which apply to this model. Section 2.6.1 describes the scaling equation for measurements which require the polynomial conversion method. Section 2.6.2 describes the scaling equation for measurements which require the range limit conversion method which was used on STS-1.

2.6.1 POLYNOMIAL CONVERSION METHOD

The scaling polynomial equation used by the flight system is defined in the SM FSSR. The general form of the equation is given as follows:

$$FS_{EU} = A_0 + A_1X + A_2X^2 + A_3X^3$$

where: FS_{EU} = flight system engineering units

X = flight system input voltage

A_0, A_1, A_2, A_3 = scaling polynomial coefficients

The following example shows the step by step procedure for converting analog measurements from flight system engineering units (FS_{EU}) to GSIU counts. This procedure may be used to calculate GSIU count values for fault insertion at the DCM.

Example:

For measurement no. V63R1100A, convert FS_{EU} value = 2288 to GSIU counts.

Step 1:

In the SM FSSR, look up the measurement no. (V63R1100A) within the "SMM Data Requirements - Subsystems Displays" table. The measurement no. will appear on two consecutive pages as follows: page A will show engineering units, range low value and range high value, while page B will show the scaling polynomial coefficients (labelled A_0, A_1, A_2, A_3) followed by curve order, independent variable, and STS flight no. The values on page B will be of prime interest to do this example conversion, and will be referred to in the following discussion.

Step 2:

The coefficients will be used in the scaling polynomial:

$$FS_{EU} = A_0 + A_1X + A_2X^2 + A_3X^3$$

Solve the following scaling polynomial for X:

$$2288 = 443.167 + 851.956X - 143.904X^2 + 12.246X^3$$

$$\text{so } X = 3.846469$$

Step 3:

Notice the independent variable column labelled IND VR equals 2 for measurement no. V63R1100A. The 2 specifies that the independent variable X of the scaling polynomial is defined on a range of 0 to 5 VDC. So $X = 3.846$ VDC.

It is of interest to note that if IND VR had been equal to 0, X would have been defined on a range of 0 to 1023 PCM integer counts in which case X would be equal to 4 PCM counts, i.e. 3.846 rounded to the nearest integer.

However, in the example being worked, X is defined as VDC and $X = 3.846$ VDC.

Step 4:

Now to convert X VDC to GSIU counts, evaluate the following equation which shows the relationship between X and GSIU counts:

$$\text{GSIU counts} = \left[X \left(\frac{1023}{K} \right) \right], \text{ rounded to the nearest integer}$$

where $K = 5$, for X defined as VDC (IND VR = 2) and

$K = 500$, for X defined as PCM counts (IND VR = 0).

For the example, evaluate:

$$\text{GSIU counts} = \left[3.846 \left(\frac{1023}{5} \right) \right], \text{ rounded to the nearest integer}$$

Therefore, GSIU counts = 787 counts.

Note that since GSIU counts are always rounded to the nearest integer, small changes will possibly occur in the values of X and consequently FS_{EU} , when the reverse calculations are made during test operations, as the following shows:

$$X = \text{GSIU counts} \left(\frac{K}{1023} \right)$$

$$X = 787 \times \left(\frac{5}{1023} \right)$$

$$\text{SO } X = 3.846529$$

And

$$FS_{EU} = 443.167 + 851.956X - 143.904X^2 + 12.246X^3$$

$$FS_{EU} = 443.167 + 851.956(3.848) - 143.904(3.848)^2 + 12.246(3.848)^3$$

$$FS_{EU} = 2288.017$$

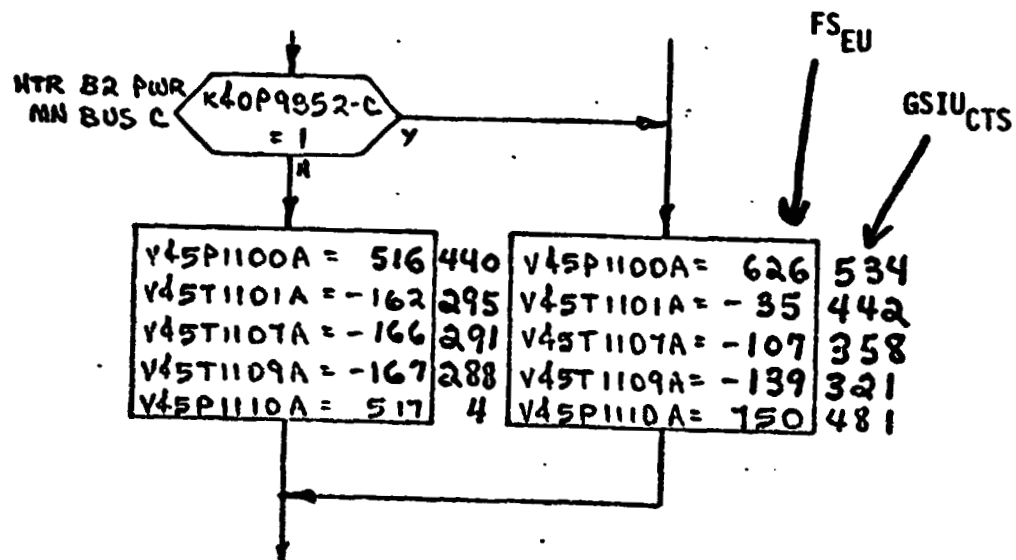
Hence when 787 GSIU counts is inserted for measurement no. V63R1100A, a value of 2288.017 FS_{EU} will result.

2.6.2 RANGE LIMIT CONVERSION METHOD

NONE.

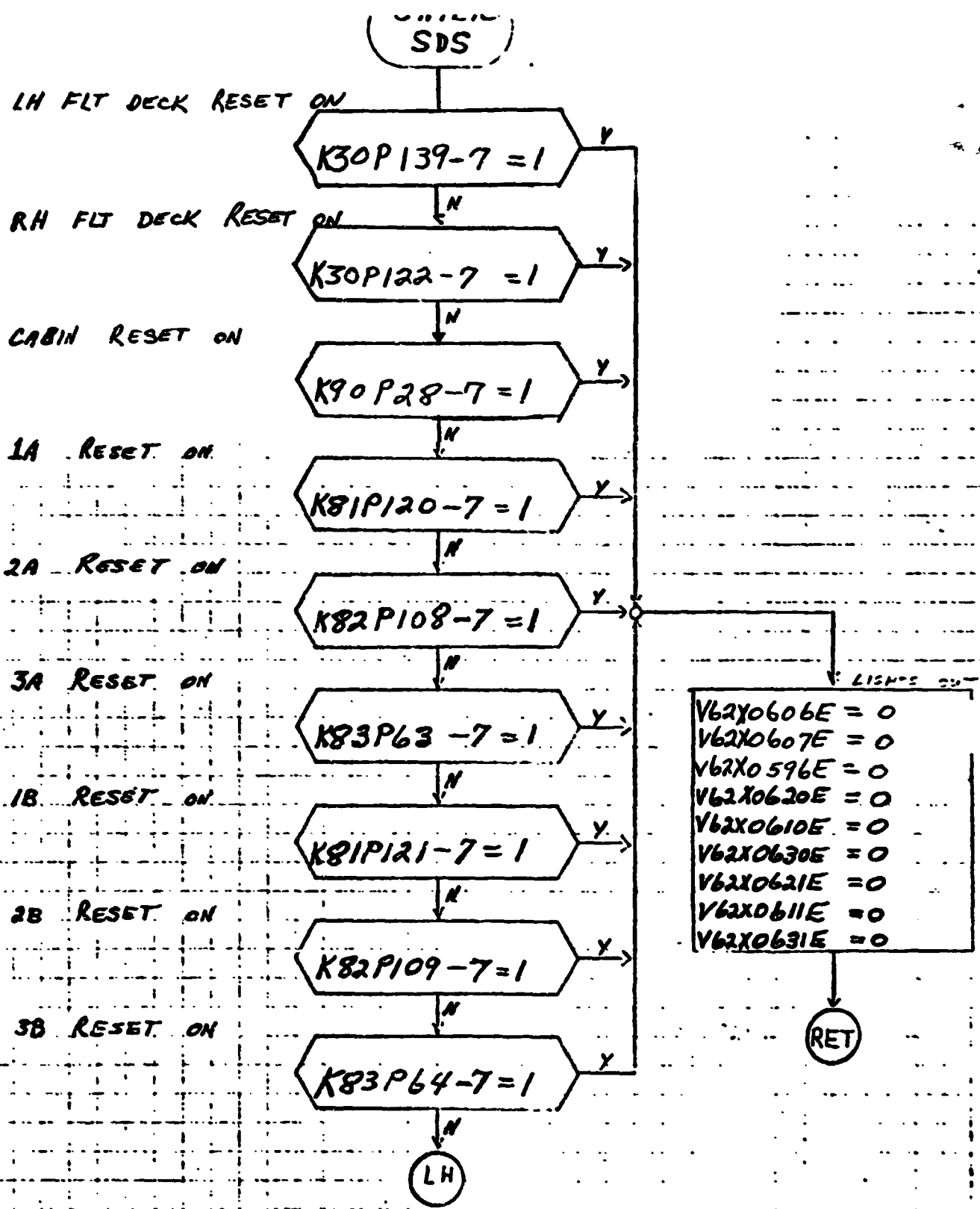
3.0 LOGIC FLOW DIAGRAMS

The logic flow diagram is made up of interconnected lines, boxes, decisions, and offpage connectors. Notice that where analog measurements are listed in boxes and decisions, the value inside the box is in flight system engineering units (FS_{EU}) while the corresponding GSIU count value is listed outside the box. For example, the box on the right hand below,

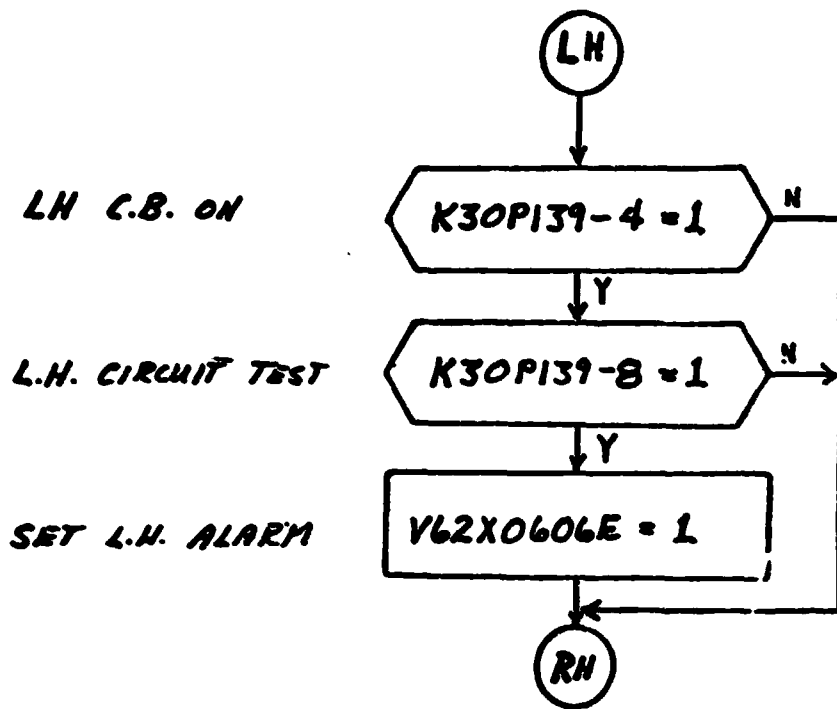


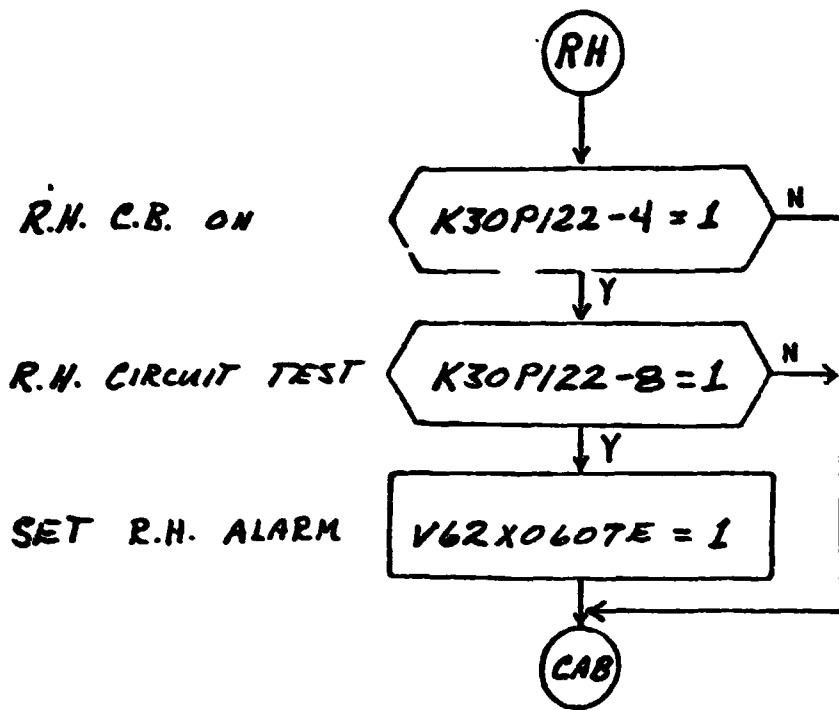
shows that V45P1100A is set equal to 626 FS_{EU} which is equivalent to 534 $GSIU_{CTS}$ shown outside the box.

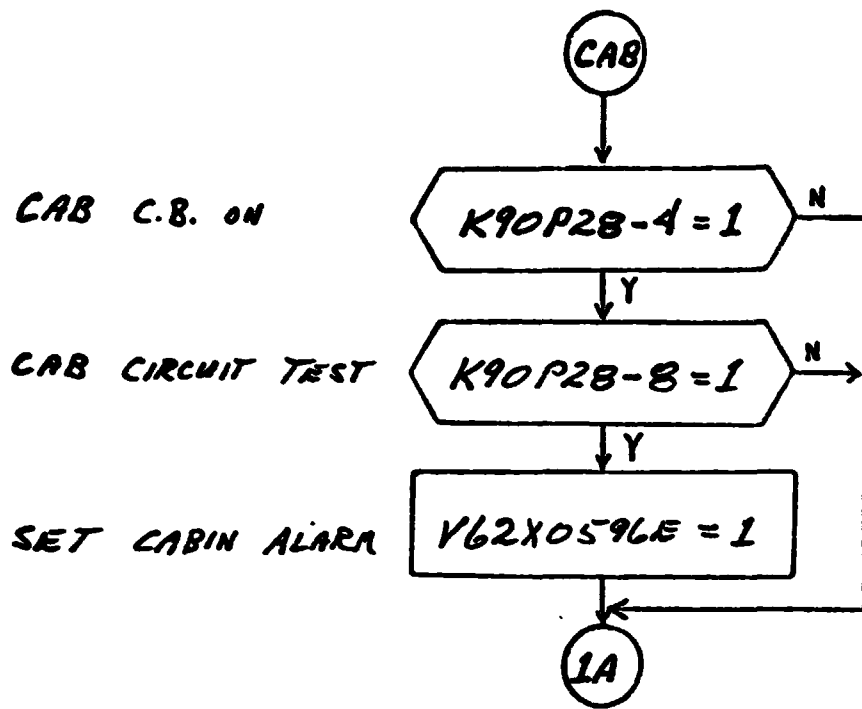
CONFIDENTIAL



ORIGINAL PAGE IS
OF POOR QUALITY





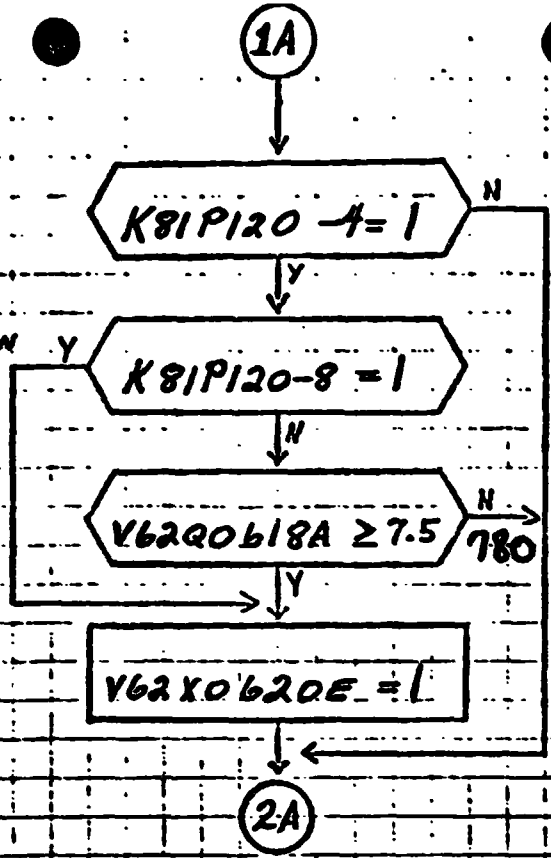


1A CB ON

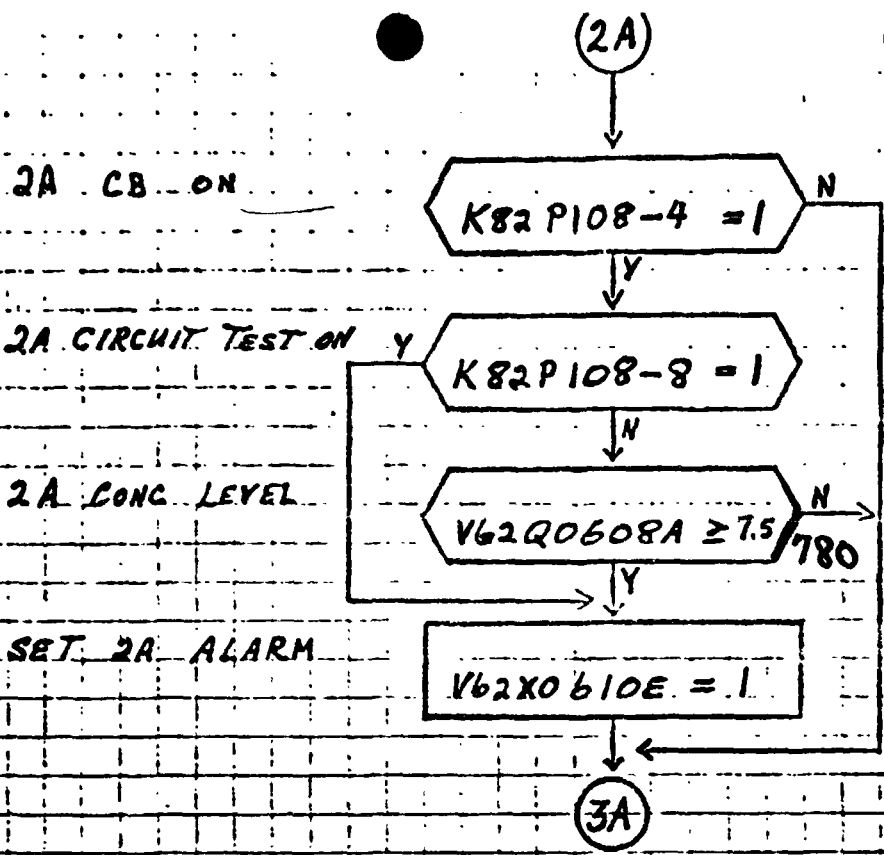
1A CIRCUIT TEST ON

1A CONC LEVEL

SET 1A ALARM



ORIGINAL PAGE IS
OF POOR QUALITY

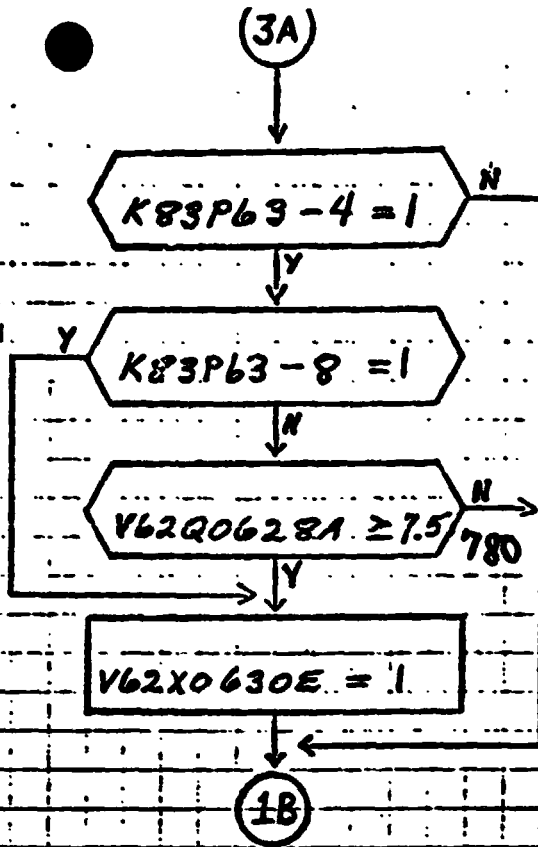


3A CB ON

3A CIRCUIT TEST ON

3A CONC LEVEL

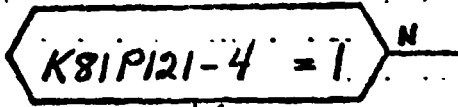
SET 3A ALARM



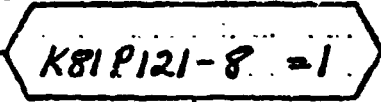
ORIGINAL PAGE IS
OF POOR QUALITY

(1B)

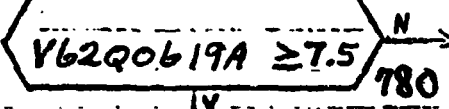
1B CB ON



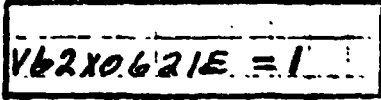
1B CIRCUIT TEST ON



1B CONC LEVEL



SET 1B ALARM



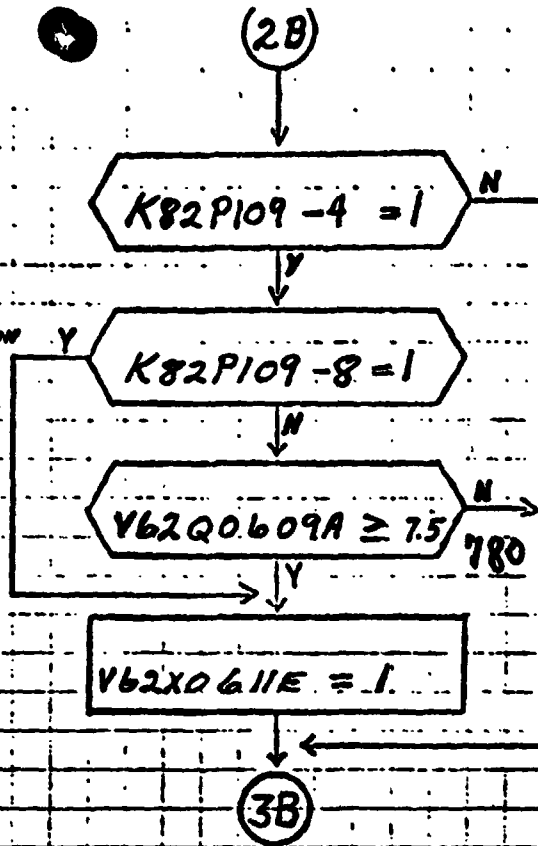
(2B)

2B CB ON

2B CIRCUIT TEST ON

2B CONC LEVEL

SET 2B ALARM



(38)

3B CB ON

K83P64-4 = 1

3B CIRCUIT TEST ON

K83P64-8 = 1

3B CONC LEVEL

V62Q0629A ≥ 7.5

SET 3rd ALARM

V62X0631E = 1

RET

SMOKE CONC. MEAS.

UNLINKED

V62Q0608A =	VALUE
V62Q0609A =	"
V62Q0618A =	"
V62Q0619A =	"
V62Q0628A =	"
V62Q0629A =	"

END OF SDS

RETURN

4.0 TABLES

4.1 INPUT STIMULI LIST

Table 1 lists input stimuli to the SDS model in terms of ID numbers, nomenclature, stimuli source, address and range of measurement.

TABLE 1 - STIMULI INPUT TO SDS MODEL

IDENTIFICATION NUMBER	NOMENCLATURE	SOURCE	STATES/RANGE		
			LO	HI	UNITS
81P120-8	BAY 1/DETECTOR A	FS VIA STM	0	1	STATE
82P108-8	BAY 2/DETECTOR A		0	1	
83P63-8	BAY 3/DETECTOR A		0	1	
30P139-8	LEFT FLT DECK		0	1	
90P28-8	CABIN		0	1	
81P121-8	BAY 1/DETECTOR B		0	1	
82P109-8	BAY 2/DETECTOR B		0	1	
83P64-8	BAY 3/DETECTOR B		0	1	
30P122-8	RIGHT FLT DECK		0	1	
81P121-7	BAY 1/DETECTOR B		0	1	
83P63-7	BAY 3/DETECTOR A		0	1	
83P64-7	BAY 3/DETECTOR B		0	1	
82P108-7	BAY 2/DETECTOR A		0	1	
30P139-7	LEFT FLT DECK		0	1	
30P122-7	RIGHT FLT DECK		0	1	
81P120-7	BAY 1/DETECTOR A	FS VIA STM	0	1	STATE
82P109-7	BAY 2/DETECTOR B		0	1	
90P28-7	CABIN		0	1	

TABLE 1 - STIMULI INPUT TO SDS MODEL

IDENTIFICATION NUMBER	NOMENCLATURE	SOURCE	STATES/RANGE		
			LO	HI	UNITS
30P139-4	LEFT FLT. DECK MN A PWR PANEL 014/CB7	FS VIA STM →	0	1	STATE
30P122-4	RT FLT. DECK MN A PWR PANEL 014/CB7		0	1	
90P28-4	CABIN MN C PWR PANEL 016/CB6		0	1	
81P120-4	BAY 1/DETECTOR A MN C PWR PANEL 016/CB7		0	1	
82P113-4	BAY 2/DETECTOR B MN C PWR PANEL 016/CB7		0	1	
82P108-4	BAY 2/DETECTOR A MN A FWR PANEL 014/CB8		0	1	
83P64-4	BAY 3/DETECTOR B MN A PWR PANEL 014/CB8		0	1	
83P63-4	PAY 1/DETECTOR A MN B PWR PANEL 015/CB7		0	1	
81P121-4	BAY 1/DETECTOR B MN B PWR PANEL 015/CB7		FS VIA STM →	0	1

4.2 OUTPUT MEASUREMENT LIST

Table 2 lists all model outputs along with the initial condition value for the output. Measurement I.D. and Measurement Name precede pairs of numeric columns. The first of each pair is labeled FS indicating flight system engineering units. The second of each pair is labeled CTS indicating the GSIU count value corresponding to the FS value. I.C. indicates initial condition values. VALUE 1 typically indicates nominal values. VALUE 2 and VALUE 3 columns indicate off nominal conditions.

MEASUREMENT OUTPUT FROM SDS MODEL - TABLE 2

MEASUREMENT I. D.	MEASUREMENT NAME	I. C.		VALUE 1		VALUE 2		VALUE 3		UNITS
		FS	CTS	FS	CTS	FS	CTS	FS	CTS	
V6200608A	SMOKE DET. CONC. A AV. BAY 2	0.71	620							MG/M ³
V6200609A	SMOKE DET. CONC. B. AV. BAY 2	1.00	667							MG/M ³
V6200618A	SMOKE DET. CONC. A AV. BAY 1	1.29	698							MG/M ³
V6200619A	SMOKE DET. CONC. B AV. BAY 1	1.60	723							MG/M ³
V6200628A	SMOKE DET. CONC. A AV. BAY 3	1.91	743							MG/M ³
V6200629A	SMOKE DET. CONC. B AV. BAY 3	2.20	760							MG/M ³
V62X0606E	LH FLT DECK SM DET SIG	0	0	1	1					STATE
V62X0607E	RH FLT DECK SM DET SIG	0	0	1	1					STATE
V62X0596E	SM DET SIG CABIN	0	0	1	1					STATE
V62X0620E	SM DET SIG 1A	0	0	1	1					STATE
V62X0610E	SM DET SIG 2A	0	0	1	1					STATE
V62X0630E	SM DET SIG 3A	0	0	1	1					STATE
V62X0621E	SM DET SIG 1B	0	0	1	1					STATE
V62X0611E	SM DET SIG 2B	0	0	1	1					STATE
V62X0631E	SM DET SIG 3B	0	0	1	1					STATE

APPLICABLE DOCUMENTS

- 1) VS70-620102, Smoke Detection Schematic**
- 2) LEC-9361, Smoke Detection Subsystem Simulation Software Specification**
- 3) ICD-3-1603-05, Section 3.10**
- 4) Functional Subsystem Software Requirements Manual Part A, Revision D (SD76-SH-0027D)**

APPENDIX K
WATER/WASTE MANAGEMENT MATH MODEL REQUIREMENTS

TABLE OF CONTENTS

Section	Page
1. INTRODUCTION.	K-2
2. DETAILED REQUIREMENTS	K-4
2.1 <u>FUNCTIONAL CHARACTERISTICS</u>	K-4
2.1.1 WATER MANAGEMENT SUBSYSTEM	K-4
2.1.2 WASTE MANAGEMENT SUBSYSTEM	K-3
2.1.3 INPUT/OUTPUT	K-8
2.2 <u>DCM UPLINK</u>	K-9
2.3 <u>INITIALIZATION</u>	K-9
2.4 <u>TERMINATION REQUIREMENTS</u>	K-9
2.5 <u>UNIQUE REQUIREMENTS.</u>	K-9
2.6 <u>ANALOG MEASUREMENTS.</u>	K-10
2.6.1 POLYNOMIAL CONVERSION METHOD	K-10
2.6.2 RANGE LIMIT CONVERSION METHOD.	K-13
3. LOGIC FLOW DIAGRAMS.....	K-14
4. TABLES.	K-25
4.1 <u>INPUT STIMULI LIST</u>	K-25
4.2 <u>OUTPUT MEASUREMENT LIST.</u>	K-31
5. REFERENCES.	K-35

FIGURES

Figure	Page
2-1 INPUT/OUTPUT DATA FLOW.	K-5
2-2 WATER/WASTE MANAGEMENT SUBSYSTEM.	K-6
2-3 WASTE MANAGEMENT SUBSYSTEM - WASTE COLLECTOR.	K-7

1. INTRODUCTION

Math models are used to simulate many of the Shuttle systems for which hardware does not exist in SAIL. A group of these models are termed non-avionic models since they do not simulate avionic equipment. The non-avionic models are needed to provide responses to cockpit switches, to drive cockpit displays, and to supply data for on-board software processing. The following list of non-avionic models will operate within the Test Operations Center (TOC) Ground Standard Interface Unit (GSIU).

- Main Propulsion System (Orbiter Portion)
- APU/Hydraulic
- Active Thermal Control
- Atmosphere Revitalization System/H₂O Loops
- Fuel Cell/Cryogenics
- Smoke Detection
- Water/Waste Management
- Atmosphere Revitalization/Pressure Control System (with AIRLOCK)

When the TOC Display and Control Module (DCM) operator depresses the "SYS LOAD" key, the model programs, which are stored on the Fixed Head Disk in the DCM, are automatically loaded into the GSIU. The models are then activated and terminated by DCM test language statements. While the models are operating in the GSIU, the DCM operator is able to inhibit one, all, or any combination of model outputs with test language statements. This provides the DCM operator with control of output parameter values when off-nominal conditions are desired. To simplify the models and ease the processing load on supporting test equipment, the model requirements define nominal conditions only. Further, analog values for output parameters change in step fashion when responding to inputs, except when specific change rates for particular parameters are required. The DCM operator is also able to alter the value that the model uses to generate parameter outputs. This allows the DCM operator to adjust output parameter values as needed to satisfy various mission phases.

When the model is activated, it shall check the input stimuli and shall provide appropriate output measurement values. It is preferred that the model provide output data when the input stimuli change. Bus activity is then minimal during those mission phases when the stimuli remain constant. However, the GSIU operating system may require a cyclic model program in which case the model output rate shall be once per second.

2. DETAILED REQUIREMENTS

This model simulates those functions of the Water/Waste Management (W/WMS) subsystem that are in the Orbiter. To simplify the model, only those subsystem functions needed to support testing of the Shuttle avionics system are provided.

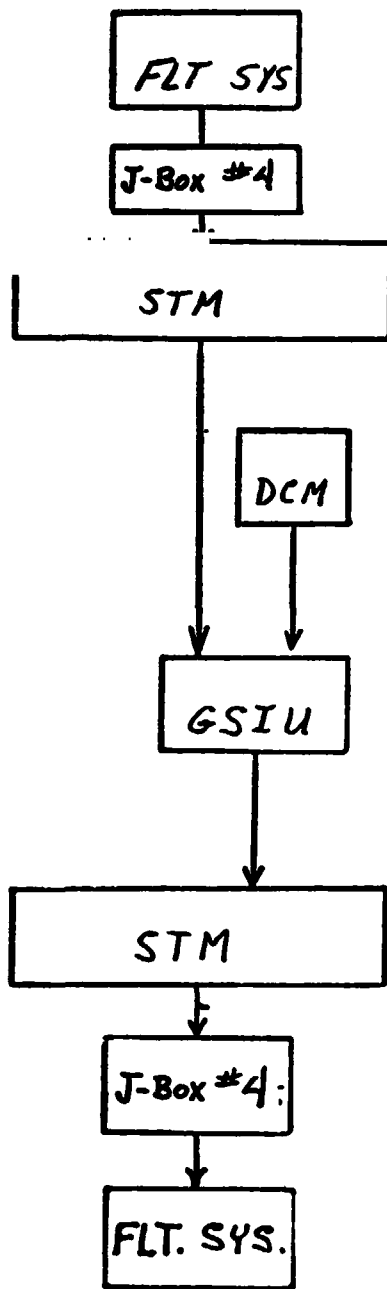
The model receives stimuli from one source, the flight system via the Signal Termination Module (STM); the model provides output parameter values to the flight system via the STM. Figure 2-1 illustrates the data flow in and out of the model. Tables 2-1 and 2-2 list the input stimuli and output measurements. Figures 2-2 and 2-3 illustrate the general functioning of the W/WMS Subsystem.

2.1 FUNCTIONAL CHARACTERISTICS

2.1.1 WATER MANAGEMENT SUBSYSTEM

The water management subsystem performs the primary functions of supplying potable water to the crew for metabolic consumption, to the ATCS flash evaporators for vehicle thermal control purposes, and to the airlock support subsystem for recharging the extravehicular life support system. The water management subsystem achieves these objectives by collecting and processing water produced at a rate of approximately 0.8 pound per kwhr by the Orbiter fuel cells before distributing the water to the various sources.

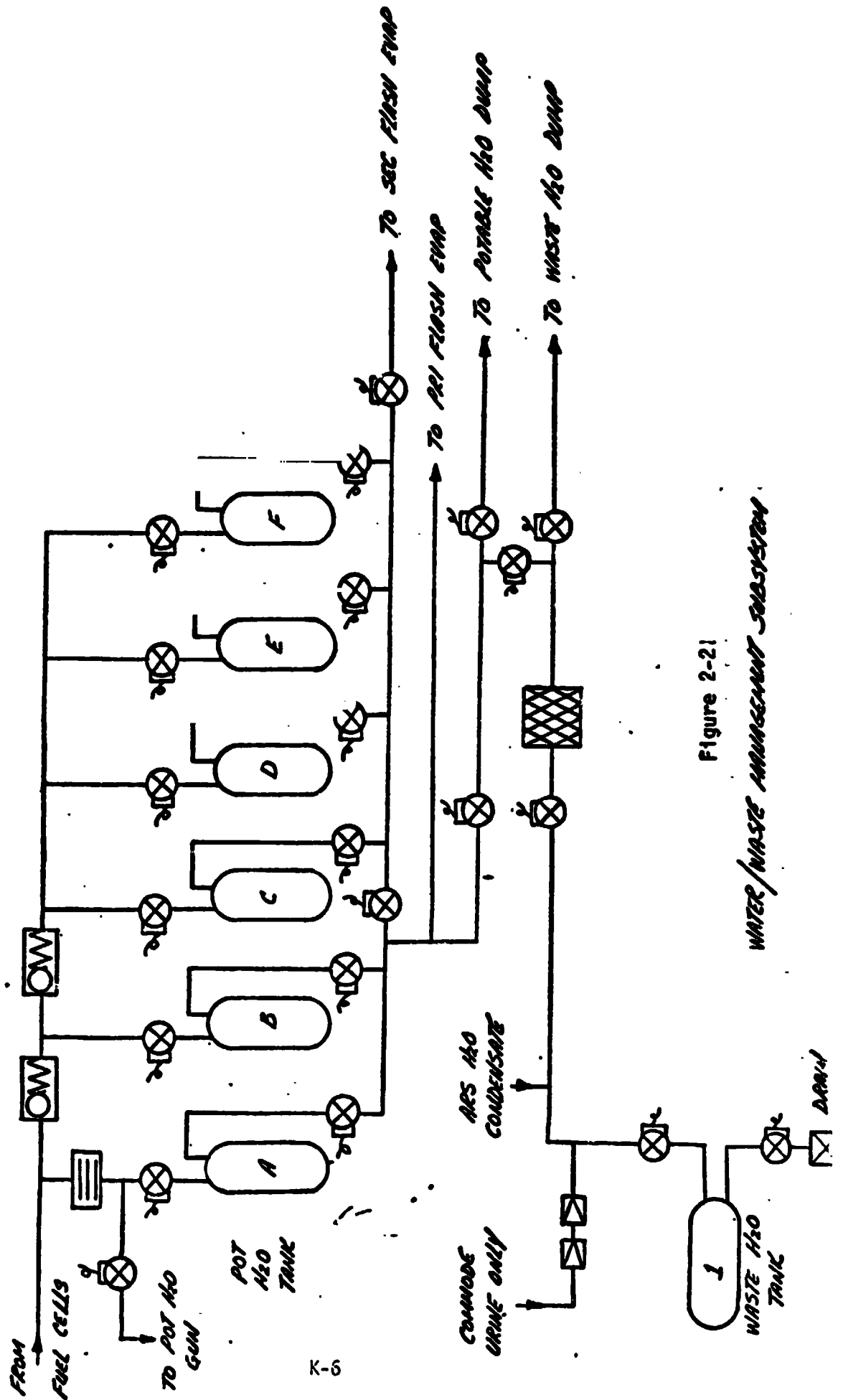
After the water is properly treated, the potable water is stored in four tanks containing metallic bellows. The water is expelled from the tank by nitrogen gas supplied at approximately 10 psig by the atmospheric revitalization pressure control subsystem (ARPCS) or in contingency conditions by cabin atmospheric pressure. Should the fuel cell production rates exceed the water usage requirements and storage capability, the water management subsystem provides the capability to dump the excess potable water overboard.



INPUT OUTPUT DATA FLOW

FIGURE 2-1

ORIGINAL PAGE IS
POOR QUALITY



K-6

Figure 2-21

WATER/WASTE MANAGEMENT SUBSYSTEM

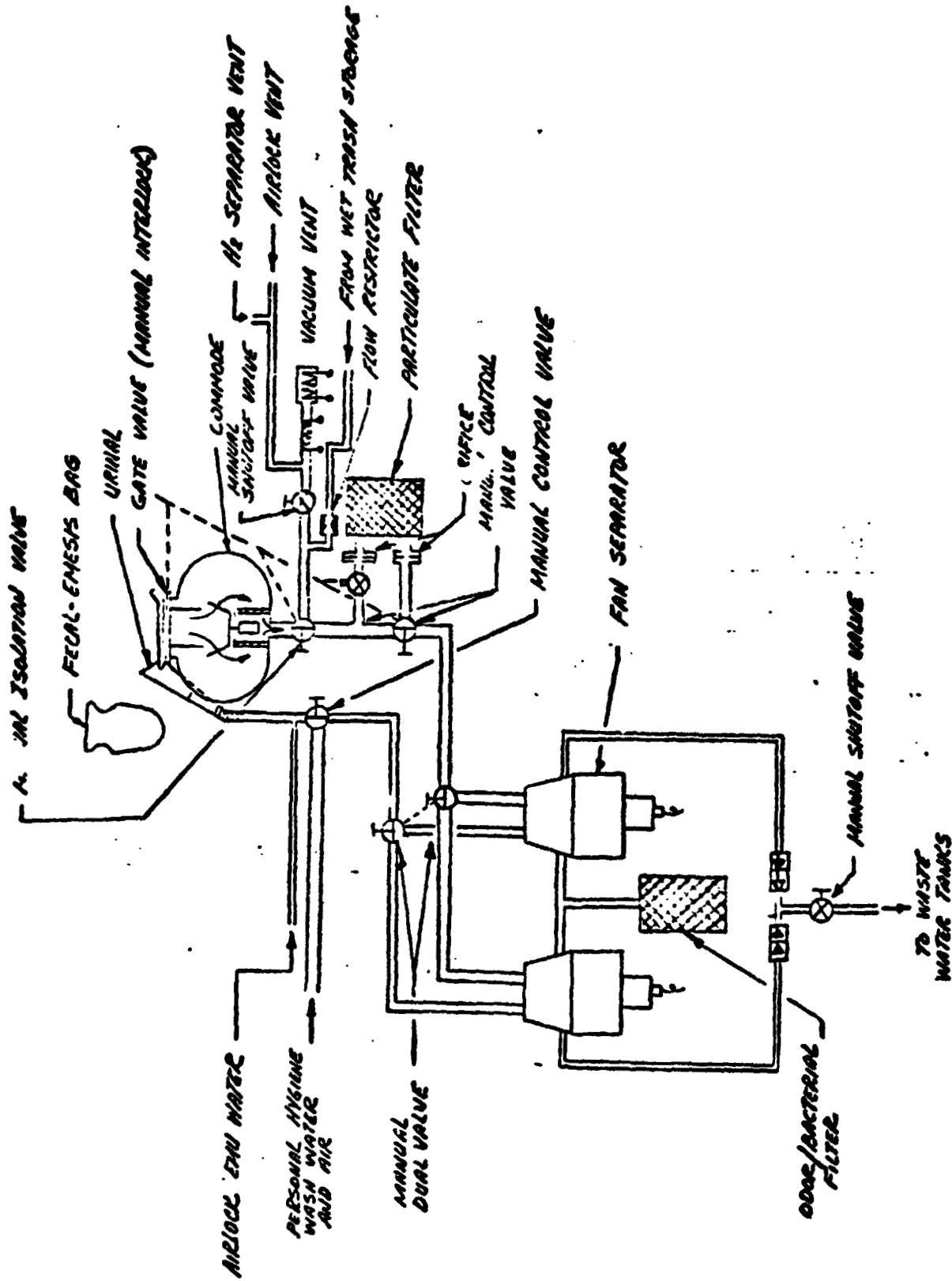


Figure 2-3

WASTE MANAGEMENT SUBSYSTEM - WASTE COLLECTOR

ORIGINAL PAGE IS OF POOR QUALITY

2.1.2 WASTE MANAGEMENT SUBSYSTEM

The waste management subsystem provides for collecting, treating, and storing fecal, urine, cabin humidity condensate, personal hygiene, and airlock waste water. To accomplish these tasks, the waste management subsystem employs a waste collection system which handles solid and liquid wastes separately.

Solid wastes, such as fecal material and toilet paper, are collected in a commode or fecal collection system. Fecal material is directed into the collector by air flow and the air is passed through a bacteria filter before returning to the cabin. The fecal material entering the collector is impinged on the inside surface of the collector by a slinger device. The waste material is vacuum dried for reduction of mass and bacteria control. In the event the commode malfunctions, a backup fecal collection system is provided. The backup system consists of using fecal collection bags.

Liquid wastes are collected by a urine/waste water collection system which is comprised primarily of a urinal collector, water separators and waste storage tanks. The urinal collector, used in conjunction with a fan/water separator, collects and transfers the urine into the waste storage tanks.

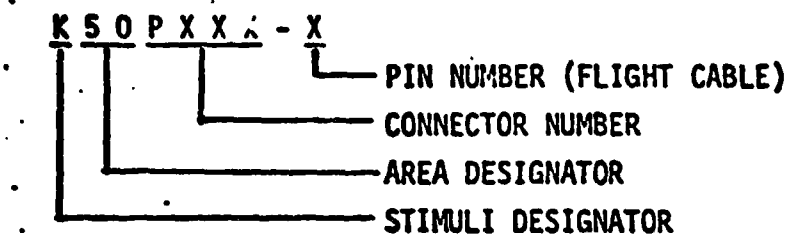
2.1.3 INPUT/OUTPUT

All inputs to the model are from the FS addressable at the STM. These stimuli are acted upon immediately at model execution without regard to time, and conditions are simulated in a step function manner. Any time dependent inputs must be up-linked from the TOC-DCM as an abnormality (or parameter value change) in accordance with the GSIU Operating System.

For the sake of simplicity, the model will do no fault detection of stimuli, but will act upon it as received from the FS. Therefore, any fault insertion must include changes to all affected parameters in order to obtain a realistic response from the model.

All subsystem output is simulated by the model in accordance with stimuli from the FS. All measurements are made available to Systems Management (SM) and Fault Detection and Annunciation (FDA) as required.

The stimuli identification numbers used are coded to provide the following information at the SAIL flight cable/GSE/C70-1140 cable set interface.



Exceptions to this code are those stimuli with a letter for the connector number where the connector number is unknown. Also, the stimuli which comes from the DCM instead of the flight cable do not agree with this code. Signal Termination Module (STM) addresses for both stimuli and measurements are yet to be defined.

2.2 DCM UPLINK

The only values passed from the DCM will be those which involve output suppression and fault insertion in accordance with the GSIU Operating System and are not a part of this document.

2.3 INITIALIZATION

Parameters will be initialized with the values found in the IC (Initial Condition) column of Table 2.

2.4 TERMINATION REQUIREMENTS

NONE

2.5 UNIQUE REQUIREMENTS

NONE

2.6 ANALOG MEASUREMENTS

Values shown in the math model flowcharts are in GSIU counts for all analog measurements. The math model values are seen by the flight system as 0 to 5 VDC inputs. The flight system then converts these input voltages to engineering units using one of the two types of scaling equations discussed in Sections 2.6.1 and 2.6.2. The GSIU math model count values (or the count values entered at the DCM by the test operator) must consider the scaling computation done later by the flight software, so that correct flight system engineering unit values are obtained for fault detection and annunciation (FDA), and for cockpit displays. The following two sections, 2.6.1 and 2.6.2, describe the scaling equations which apply to this model. Section 2.6.1 describes the scaling equation for measurements which require the polynomial conversion method. Section 2.6.2 describes the scaling equation for measurements which require the range limit conversion method which was used on STS-1.

2.6.1 POLYNOMIAL CONVERSION METHOD

The scaling polynomial equation used by the flight system is defined in the SM FSSR. The general form of the equation is given as follows:

$$FS_{EU} = A_0 + A_1X + A_2X^2 + A_3X^3$$

where: FS_{EU} = flight system engineering units

X = flight system input voltage

A_0, A_1, A_2, A_3 = scaling polynomial coefficients

The following example shows the step by step procedure for converting analog measurements from flight system engineering units (FS_{EU}) to GSIU counts. This procedure may be used to calculate GSIU count values for fault insertion at the DCM.

Example:

For measurement no. V63R1100A, convert FS_{EU} value = 2288 to GSIU counts.

Step 1:

In the SM FSSR, look up the measurement no. (V63R1100A) within the "SMM Data Requirements - Subsystems Displays" table. The measurement no. will appear on two consecutive pages as follows: page A will show engineering units, range low value and range high value, while page B will show the scaling polynomial coefficients (labelled A_0, A_1, A_2, A_3) followed by curve order, independent variable, and STS flight no. The values on page B will be of prime interest to do this example conversion, and will be referred to in the following discussion.

Step 2:

The coefficients will be used in the scaling polynomial:

$$FS_{EU} = A_0 + A_1X + A_2X^2 + A_3X^3$$

Solve the following scaling polynomial for X:

$$2288 = 443.167 + 851.956X - 143.904X^2 + 12.246X^3$$

$$\text{so } X = 3.846469$$

Step 3:

Notice the independent variable column labelled IND VR equals 2 for measurement no. V63R1100A. The 2 specifies that the independent variable X of the scaling polynomial is defined on a range of 0 to 5 VDC. So $X = 3.846$ VDC.

It is of interest to note that if IND VR had been equal to 0, X would have been defined on a range of 0 to 1023 PCM integer counts in which case X would be equal to 4 PCM counts, i.e. 3.846 rounded to the nearest integer.

However, in the example being worked, X is defined as VDC and $X = 3.846$ VDC.

Step 4:

Now to convert X VDC to GSIU counts, evaluate the following equation which shows the relationship between X and GSIU counts:

$$\text{GSIU counts} = \left[X \left(\frac{1023}{K} \right) \right], \text{ rounded to the nearest integer}$$

where $K = 5$, for X defined as VDC (IND VR = 2) and

$K = 500$, for X defined as PCM counts (IND VR = 0).

For the example, evaluate:

$$\text{GSIU counts} = \left[3.846 \left(\frac{1023}{5} \right) \right], \text{ rounded to the nearest integer}$$

Therefore, GSIU counts = 787 counts.

Note that since GSIU counts are always rounded to the nearest integer, small changes will possibly occur in the values of X and consequently FS_{EU} , when the reverse calculations are made during test operations, as the following shows:

$$X = \text{GSIU counts} \left(\frac{K}{1023} \right)$$

$$X = 787 \times \left(\frac{5}{1023} \right)$$

$$\text{SO } X = 3.846529$$

And

$$FS_{EU} = 443.167 + 851.956X - 143.904X^2 + 12.246X^3$$

$$FS_{EU} = 443.167 + 851.956(3.848) - 143.904(3.848)^2 + 12.246(3.848)^3$$

$$FS_{EU} = 2288.017$$

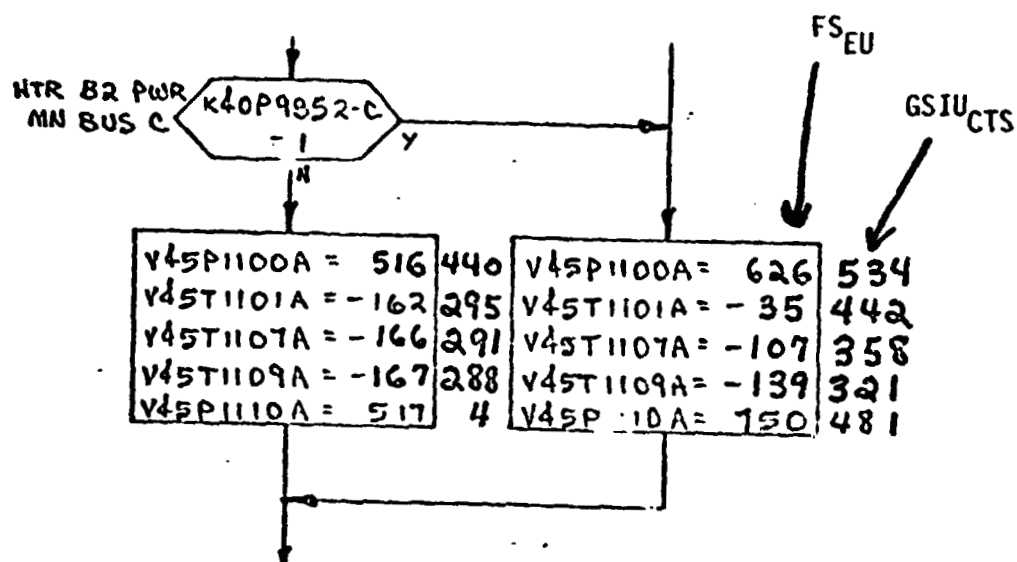
Hence when 787 GSIU counts is inserted for measurement no. V53R1100A, a value of 2288.017 FS_{EU} will result.

2.6.2 RANGE LIMIT CONVERSION METHOD

NONE.

3.0 LOGIC FLOW DIAGRAMS

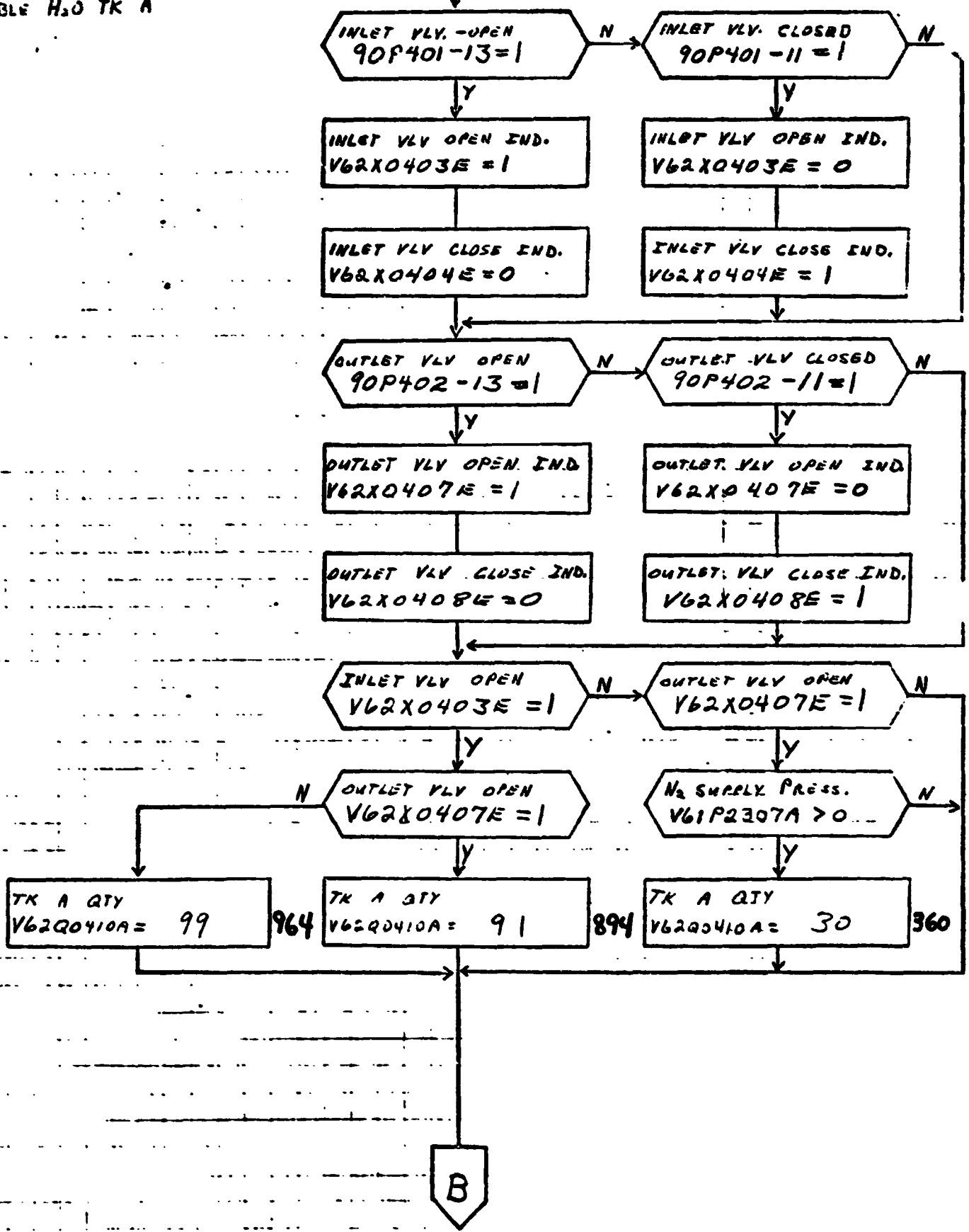
The logic flow diagram is made up of interconnected lines, boxes, decisions, and offpage connectors. Notice that where analog measurements are listed in boxes and decisions, the value inside the box is in flight system engineering units (FS_{EU}) while the corresponding GSIU count value is listed outside the box. For example, the box on the right hand below,



shows that V45P1100A is set equal to 626 FS_{EU} which is equivalent to 534 GSIU_{CTS} shown outside the box.

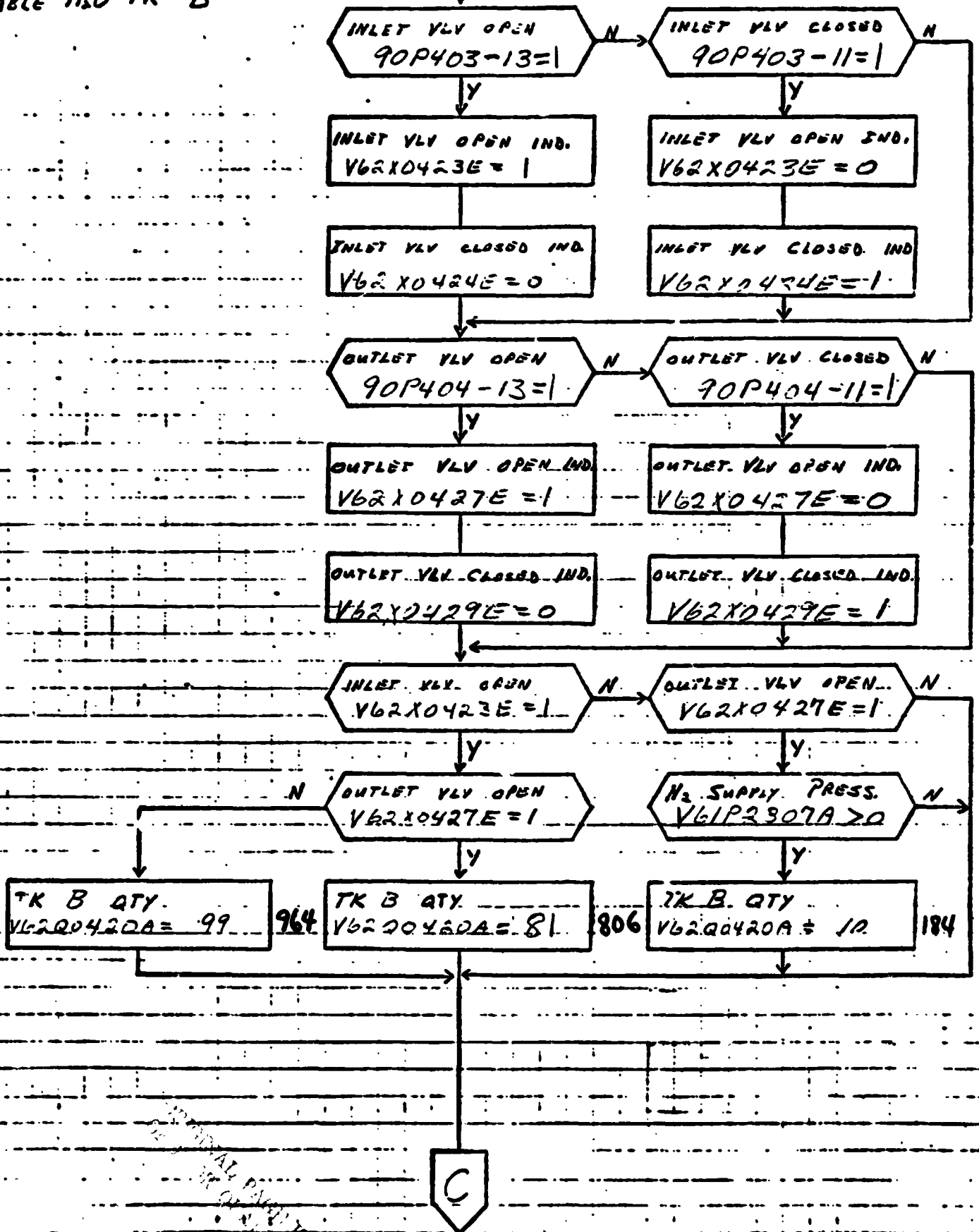
WATER MANAGEMENT

POTABLE H₂O TK A

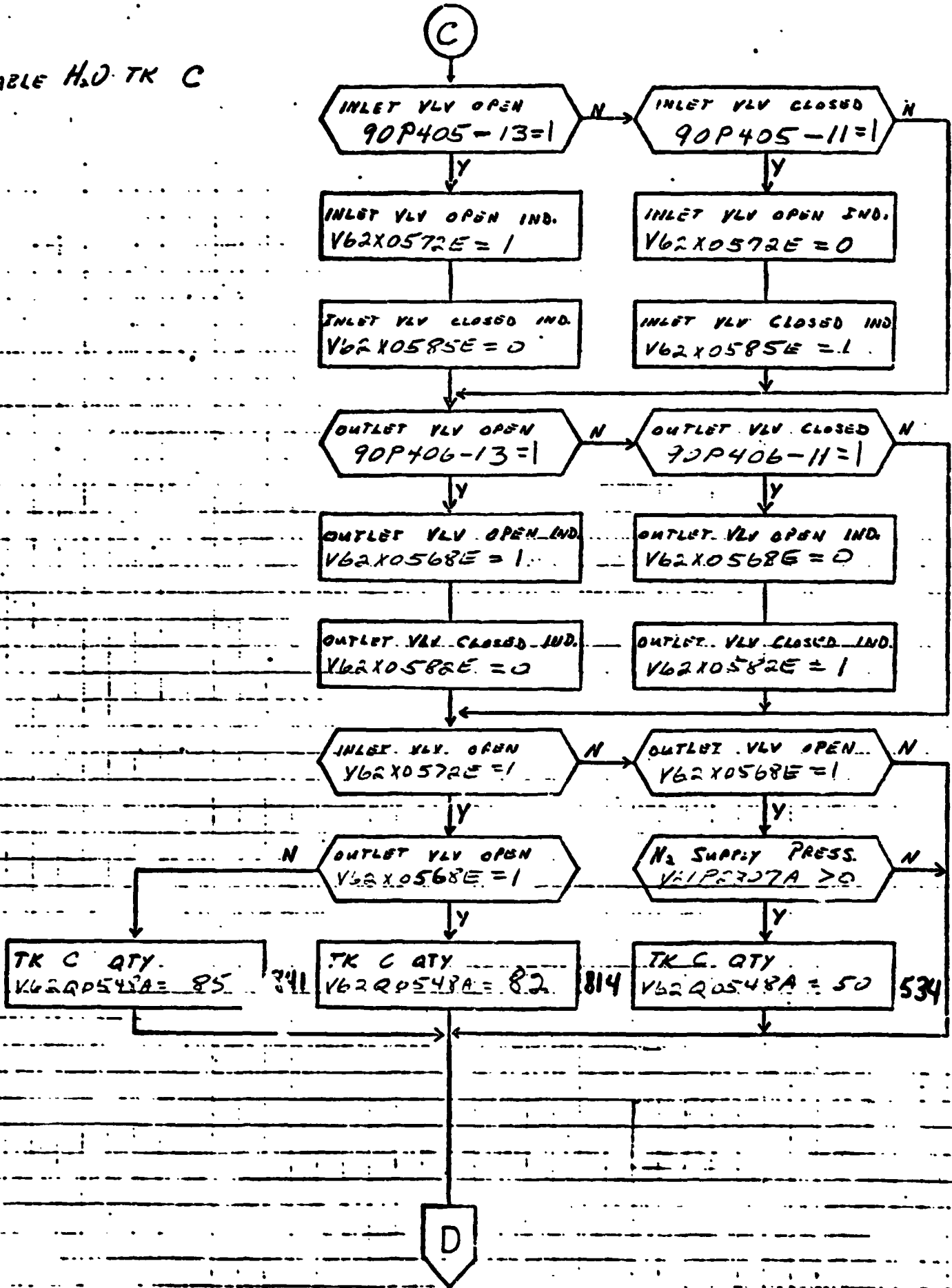


POTABLE H₂O TK B

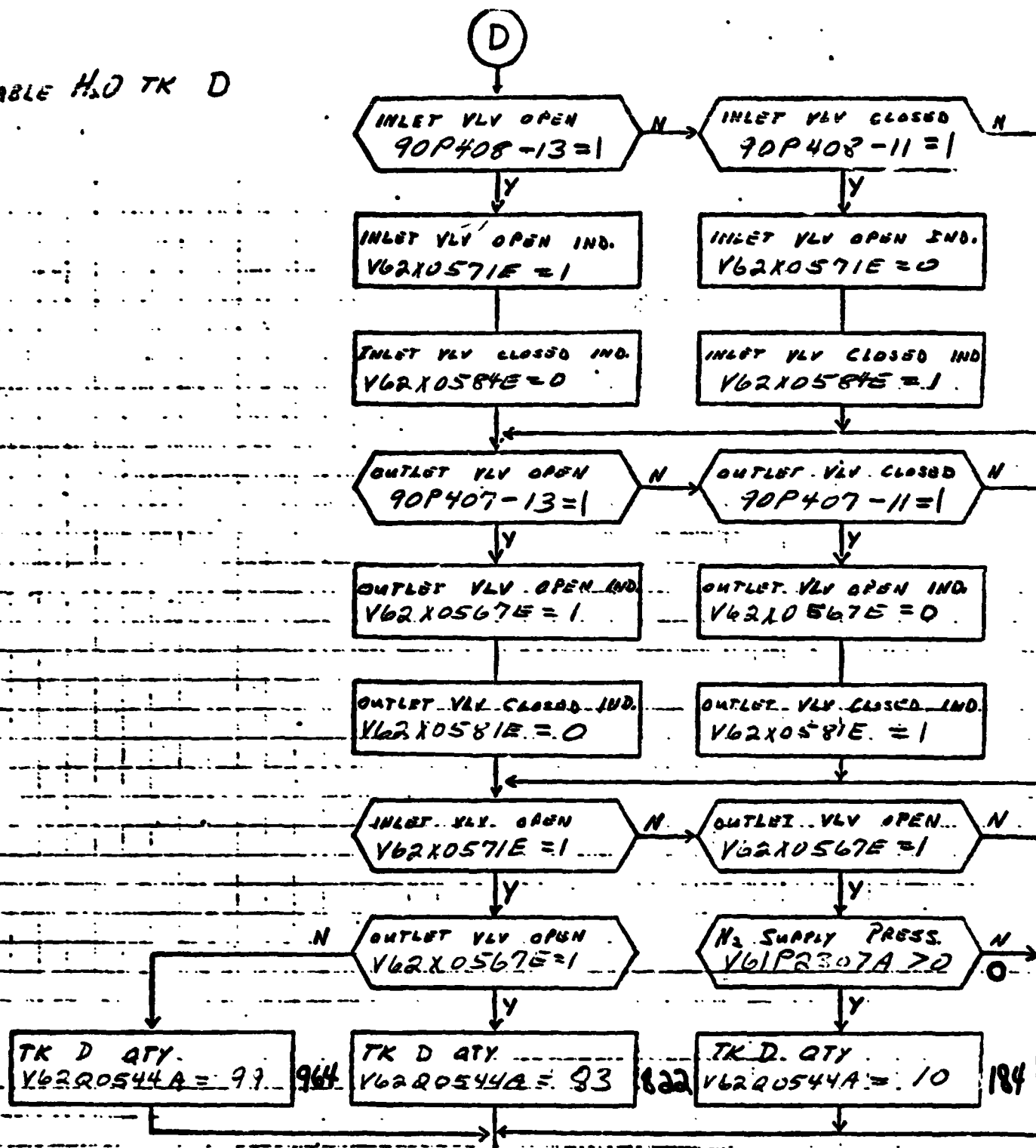
(B)



POTABLE H₂O TK C



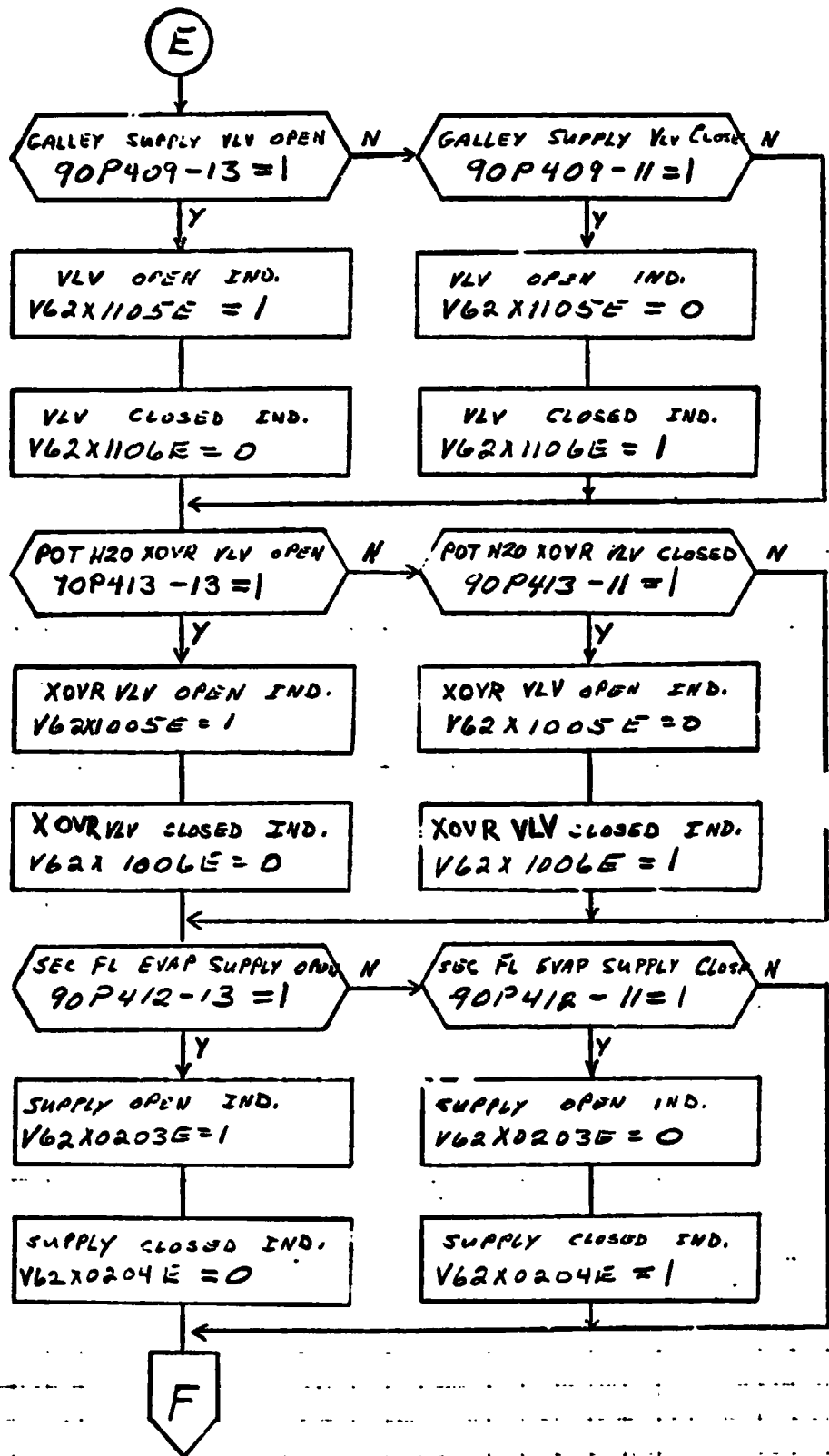
POTABLE H₂O TK D



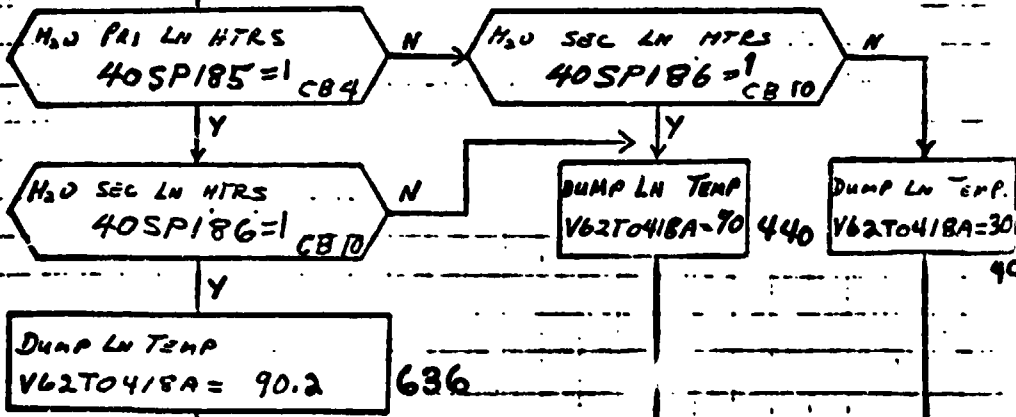
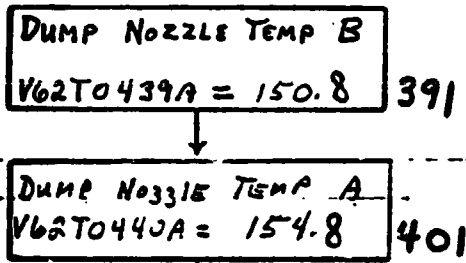
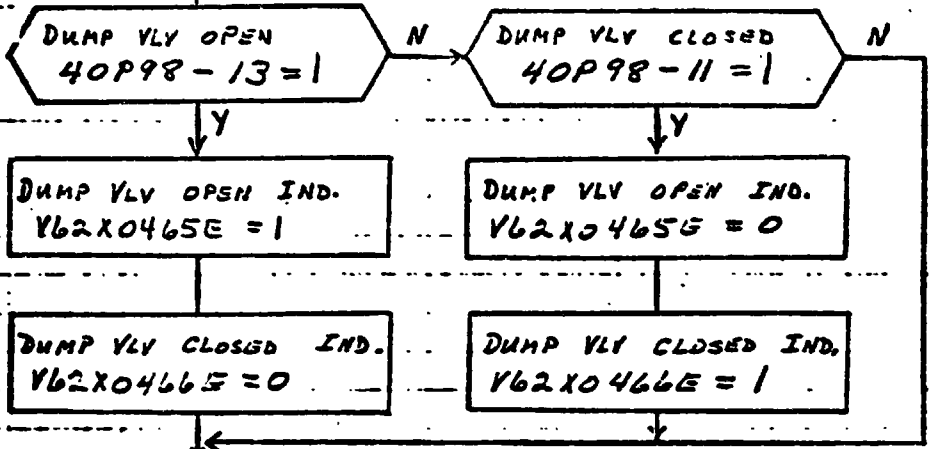
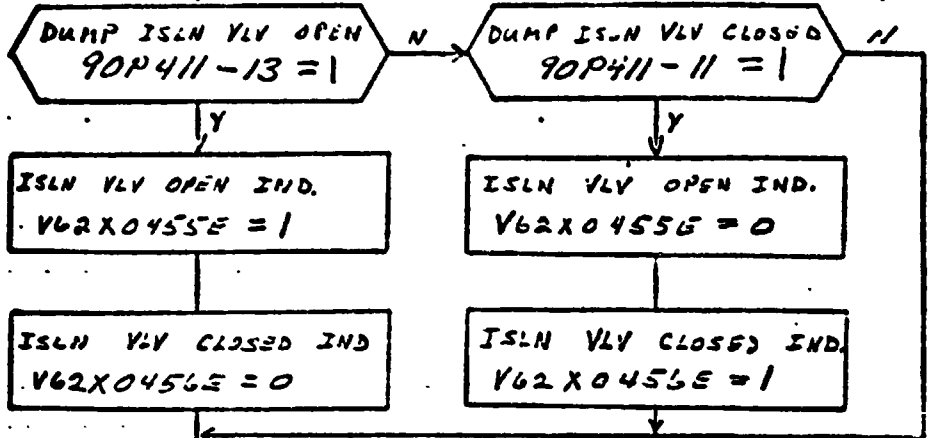
TANK E	V62R9150A =	85	841
TANK F	V62R9160A =	86	849

ORIGINAL PAGE IS
OF POOR QUALITY





F

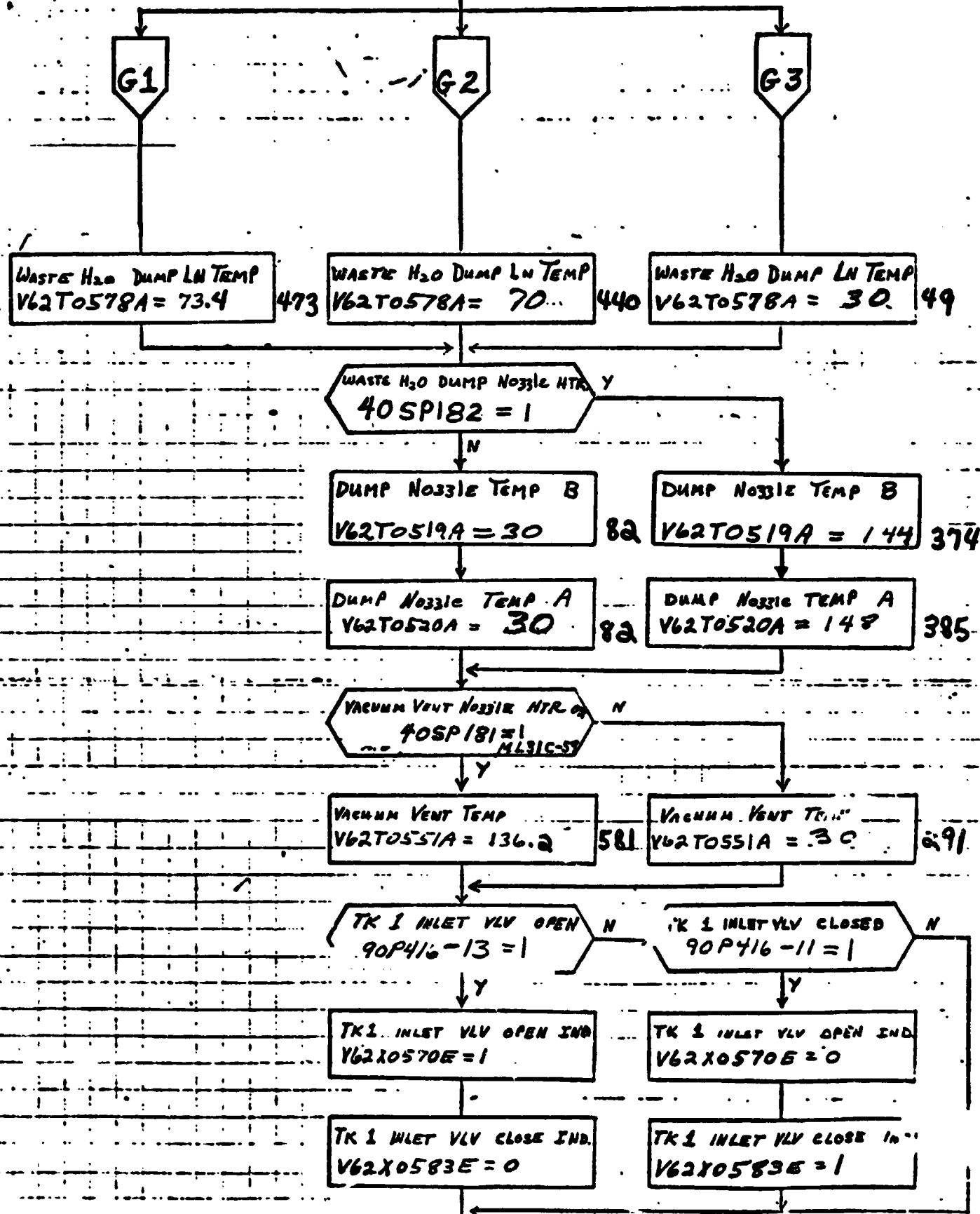


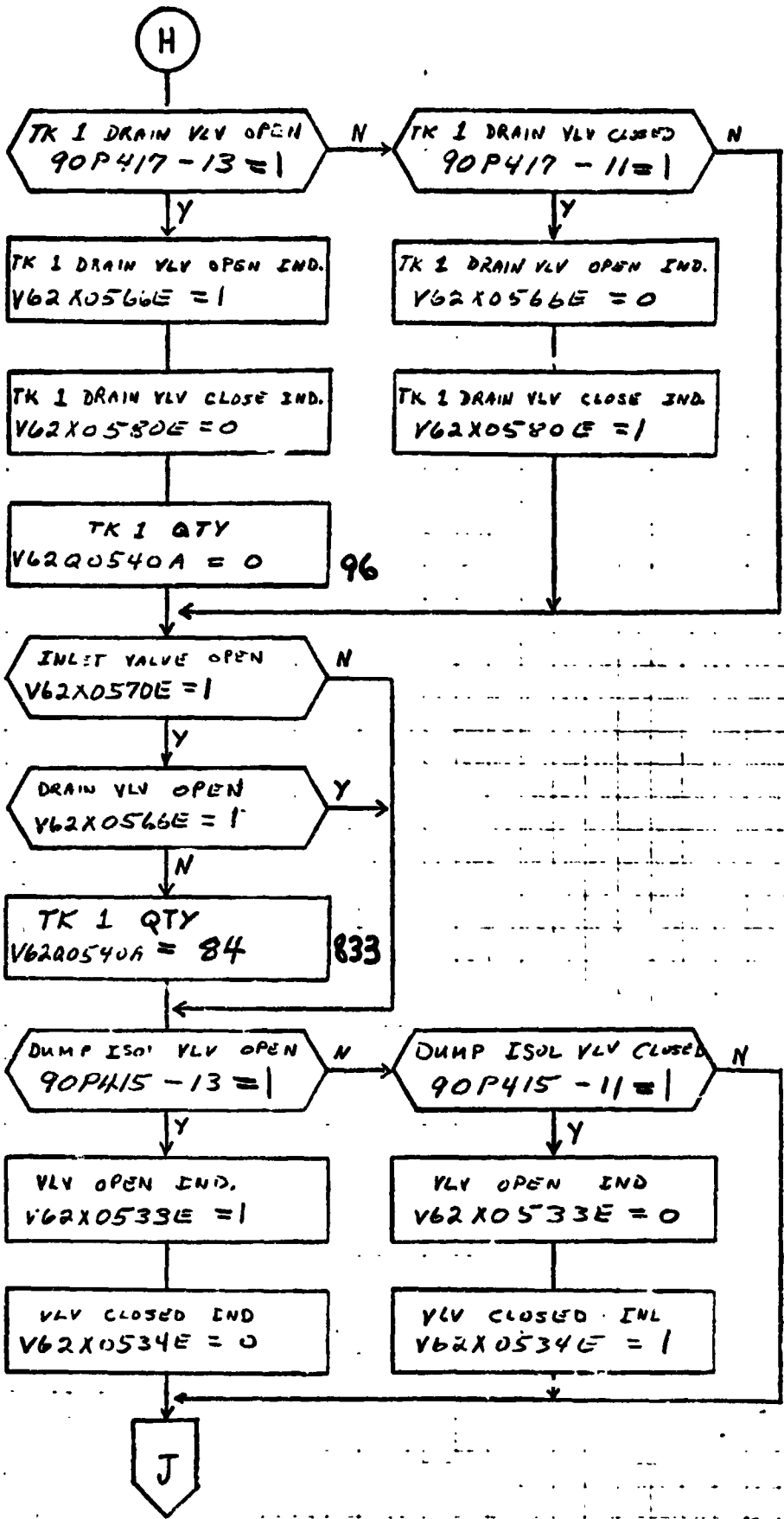
G1

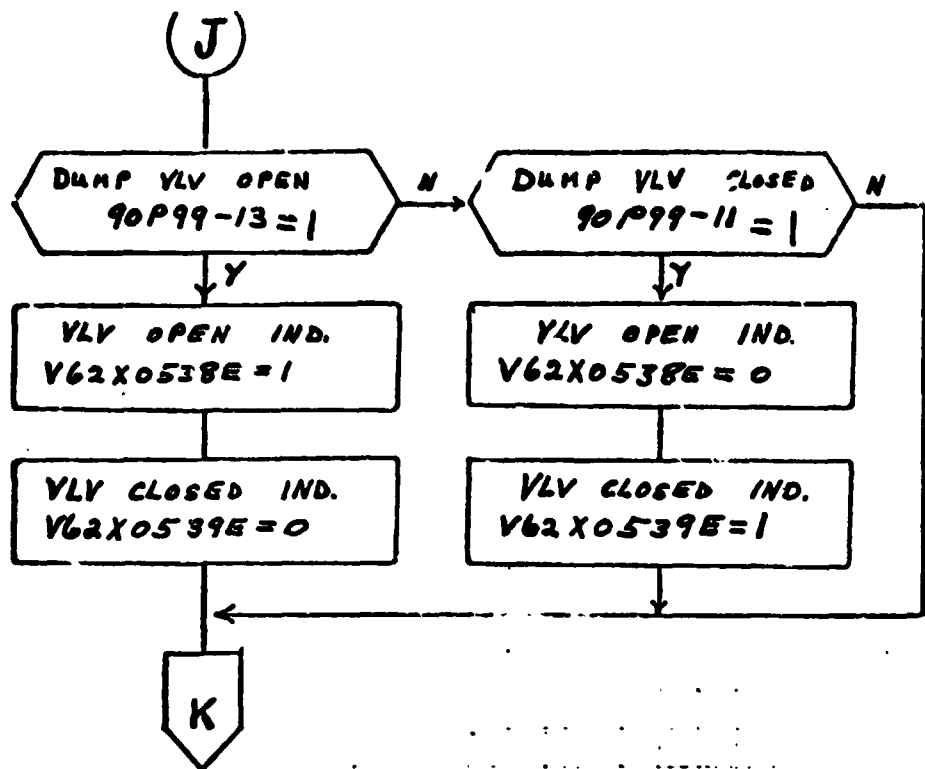
G2

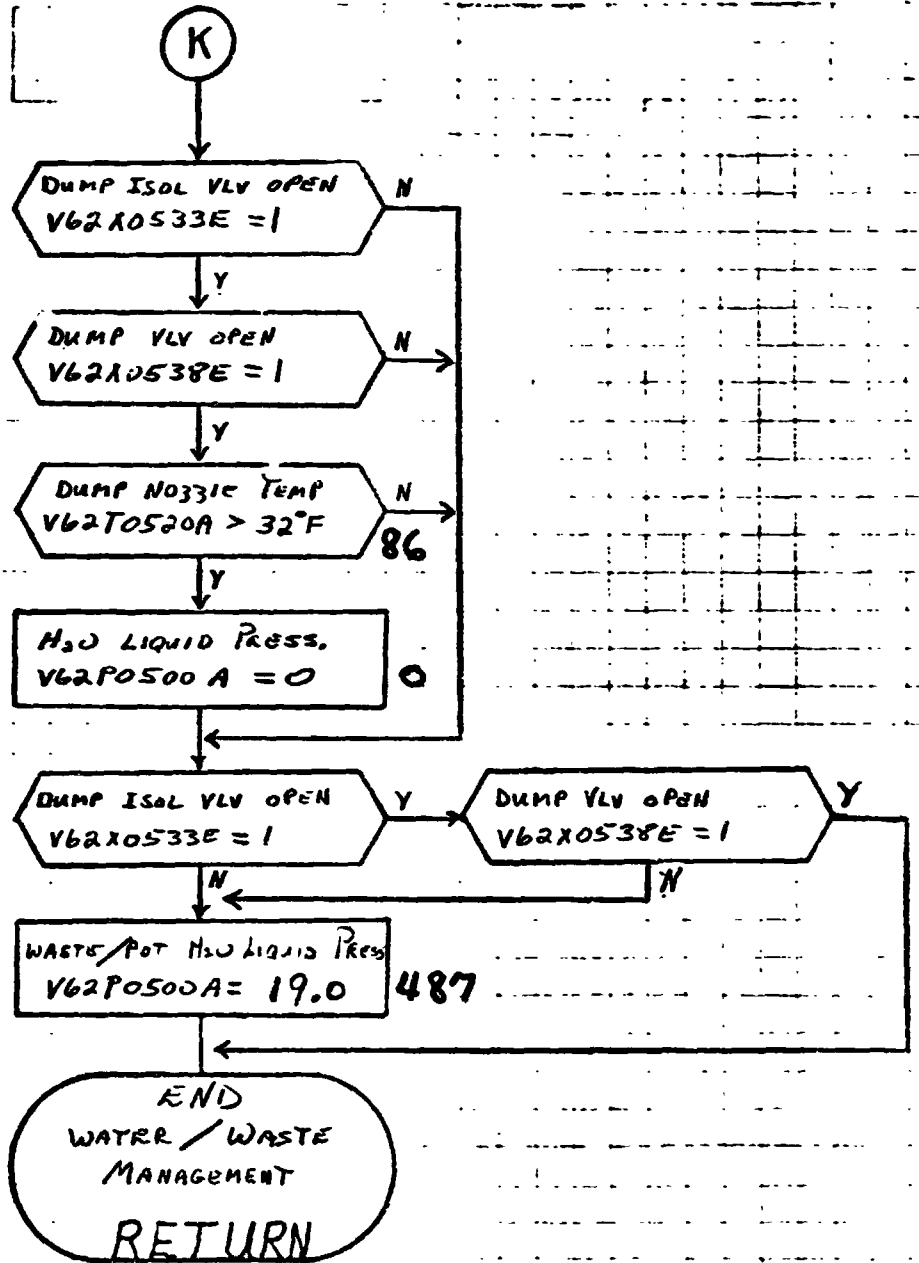
G3

WASTE MANAGEMENT









ORIGINAL PAGE IS
OF POOR QUALITY

4. TABLES

4.1 INPUT STIMULI LIST

Table 1 lists input stimuli to the W/WMS model in terms of ID numbers, nomenclature, stimuli source, and range of parameter.

STIMULI INPUT T(/WMS) MODEL-TABLE 2-1

IDENTIFICATION NUMBER	NOMENCLATURE	SOURCE	STATES/RANGE		
			LO	HI	UNITS
V62K0200E	SEC FLASH EVAP. SUPPLY OPEN 90P412-13	FS VIA STM	0	1	STATE
V62K0201E	SEC FLASH EVAP. SUPPLY CLOSE 90P412-11	FS VIA STM	0	1	STATE
V61P2307A	N ₂ REG PRESS 80P27-18	AR/PCS MODEL	0	20	PIG

ORIGINAL PAGE IS
OF POOR QUALITY

STIMULI INPUT TO WMS, MODEL-TABLE 2-1 (continued)

IDENTIFICATION NUMBER	NOMENCLATURE	SOURCE	ST./S/RANGE			UNITS
			LO	HI		
V62K0401E	POT. H ₂ O TK A INLET VLV OPEN 90P401-13	FS VIA STM	0	1		STATE
V62K0402E	POT. H ₂ O TK A INLET VLV CLOSE 90P401-11	FS VIA STM	0	1		STATE
V62K0405E	POT. H ₂ O TK A OUTLET VLV OPEN 90P402-13	FS VIA STM	0	1		STATE
V62K0406E	POT. H ₂ O TK A OUTLET VLV CLOSE 90P402-11	FS VIA STM	0	1		STATE
V62K0421E	POT. H ₂ O TK B INLET VLV OPEN 90P403-13	FS VIA STM	0	1		STATE
V62K0422E	POT. H ₂ O TK B INLET VLV CLOSE 90P403-11	FS VIA STM	0	1		STATE
V62K0425E	POT. H ₂ O TK B OUTLET VLV OPEN 90P404-13	FS VIA STM	0	1		STATE
V62K0426E	POT. H ₂ O TK B OUTLET VLV CLOSE 90P404-11	FS VIA STM	0	1		STATE

STIMULI INPUT TO (MMS) MODEL-TABLE 2-1

IDENTIFICATION NUMBER	NOMENCLATURE	SOURCE	STATES/RANGE			UNITS
			LO	HI		
V62K0450E	POT. H ₂ O DUMP ISLN VLV OPEN 90P411-13	FS VIA STM	0	1		STATE
V62K0452E	POT. H ₂ O DUMP ISLN VLV CLOSE 90P411-11	FS VIA STM	0	1		STATE
V62K0460E	POT. H ₂ O DUMP VLV OPEN 40P98-13	FS VIA STM	0	1		STATE
V62K0462E	POT. H ₂ O DUMP VLV CLOSE 40P98-11	FS VIA STM	0	1		STATE
V62K0530E	WASTE H ₂ O DUMP ISLN VLV OPEN 90P415-13	FS VIA STM	0	1		STATE
V62K0531E	WASTE H ₂ O DUMP ISLN VLV CLOSE 90P415-11	FS VIA STM	0	1		STATE
V62K0535E	WASTE H ₂ O DUMP VLV OPEN 90P99-13	FS VIA STM	0	1		STATE
V62K0536E	WASTE H ₂ O DUMP VLV CLOSE 90P99-11	FS VIA STM	0	1		STATE
V62K0541E	WASTE H ₂ O DUMP NOZZLE 40SP182	FS VIA STM	0	1		STATE

STIMULI INPUT TO (MMS) MODEL-TABLE 2-1

IDENTIFICATION NUMBER	NOMENCLATURE	SOURCE	STATES/RANGE		UNITS
			LO	HI	
V62K0549E	VACUUM VENT HTR ON ~40SP181	FS VIA STM	0	1	STATE
V62K0710E	WASTE TK 1 INLET VLV OPEN 90P416-13	FS VIA STM	0	1	STATE
V62K0711E	WASTE TK 1 INLET VLV CLOSE 90P416-11	FS VIA STM	0	1	STATE
V62K0714E	WASTE TK 1 DRAIN VLV CLOSE 90P417-11	FS VIA STM	0	1	STATE
V62K0715E	WASTE TK 1 DRAIN VLV OPEN 90P417-13	FS VIA STM	0	1	STATE
V62K0750E	WASTE TK 2 INLET VLV OPEN 90P408-13	FS VIA STM	0	1	STATE
V62K0751E	WASTE TK 2 INLET VLV CLOSE 90P408-11	FS VIA STM	0	1	STATE
V62K0754E	WASTE TK 2 DRAIN VLV CLOSE 90P407-11	FS VIA STM	0	1	STATE
V62K0755E	WASTE TK 2 DRAIN VLV OPEN 90P407-13	FS VIA STM	0	1	STATE

STIMULI INPUT T (M/WMS) MODEL-TABLE 2-1

IDENTIFICATION NUMBER	NOMENCLATURE	SOURCE	STATES/RANGE		
			LO	HI	UNITS
V62K0770E	POT. H ₂ O TK C INLET VLV OPEN 90P405-13	FS VIA STM	0	1	STATE
V62K0771E	POT. H ₂ O TK C INLET VLV CLOSE 90P405-11	FS VIA STM	0	1	STATE
V62K0774E	POT. H ₂ O TK C OUTLET VLV OPEN 90P406-13	FS VIA STM	0	1	STATE
V62K0775E	POT. H ₂ O TK C OUTLET VLV CLOSE 90P406-11	FS VIA STM	0	1	STATE
V62K1000E	POT. H ₂ O XOVR VLV OPEN 90P413-13	FS VIA STM	0	1	STATE
V62K1002E	POT. H ₂ O XOVR VLV CLOSE 90P413-11	FS VIA STM	0	1	STATE
V62K1100E	GALLEY SUPPLY VLV OPEN 90P409-13	FS VIA STM	0	1	STATE
V62K1102E	GALLEY SUPPLY VLV CLOSE 90P409-11	FS VIA STM	0	1	STATE
N/A	H ₂ O LN HTRS -- PRI 40SP185	FS VIA STM	0	1	STATE
N/A	H ₂ O LN HTRS-sec. 40SP186	FS VIA STM	0	1	STATE

4.2 OUTPUT MEASUREMENT LIST

Table 2 lists all model outputs along with the initial condition value for the output. Measurement I.D. and Measurement Name precede pairs of numeric columns. The first of each pair is labeled FS indicating flight system engineering units. The second of each pair is labeled CTS indicating the GSIU count value corresponding to the FS value. I.C. indicates initial condition values. VALUE 1 typically indicates nominal values. VALUE 2 and VALUE 3 columns indicate off nominal conditions.

MEASUREMENT OUTPUT FROM W/WMS MODEL - TABLE 2

MEASUREMENT I. D.	MEASUREMENT NAME	I. C.		VALUE 1		VALUE 2		VALUE 3		UNITS
		FS	CTS	FS	CTS	FS	CTS	FS	CTS	
V62X0203E	SEC FLASH EVAP SUPPLY OPEN IND	0	0	1	1					STATE
V62X0204E	SEC FLASH EVAP SUPPLY CLOSE IND	1	1	0	0					STATE
V62X0405E	POT. H ₂ O TK A INLET VLV OPEN IND	0	0	1	1					STATE
V62X0404E	POT. H ₂ O TK A INLET VLV CLOSE IND	1	1	0	0					STATE
V62X0407E	POT. H ₂ O TK A OUTLET VLV OPEN IND	0	0	1	1					STATE
V62X0408E	POT. H ₂ O TK A OUTLET VLV CLOSE IND	1	1	0	0					STATE
V62Q0410A	POT. H ₂ O TK A QTY	91	894	30	360	99	964			PCT
V62T0418A	POT. H ₂ O DUMP LINE TEMP	90.2	636	30	49	70	440			DEGF
V62Q0420A	POT. H ₂ O TK B QTY	81	806	10	184	99	964			PCT
V62X0423E	POT. H ₂ O TK B INLET VLV OPEN IND	0	0	1	1					STATE
V62X0424E	POT. H ₂ O TK B INLET VLV CLOSE IND	1	1	0	0					STATE
V62X0427E	POT. H ₂ O TK B OUTLET VLV OPEN IND	0	0	1	1					STATE
V62X0429E	POT. H ₂ O TK B OUTLET VLV CLOSE IND	1	1	0	0					STATE
V62P0430A	POT. H ₂ O STORAGE INLET PRESS.	35	716							PSIA
V62T0439A	POT. H ₂ O DUMP NOZZLE TEMP. B.	150.8	391							DEGF
V62T0440A	POT. H ₂ O DUMP NOZZLE TEMP	154.8	401							DEGF
V62X0455E	POT. H ₂ O DUMP ISOL VLV OPEN IND	0	0	1	1					STATE
V62X0456E	POT. H ₂ O DUMP ISOL VLV CLOSE IND	1	1	0	0					STATE
V62X0465E	POT. H ₂ O DUMP VLV OPEN IND.	0	0	1	1					STATE
V62X0466E	POT. H ₂ O DUMP VLV CLOSE IND.	1	1	0	0					STATE
V62P0500A	WASTE/POT. H ₂ O LIQUID PRESS	19.0	487	0	0					PSIG
V62T0519A	WASTE H ₂ O DUMP NOZZLE TEMP. B.	144	374	30	82					DEGF
V62T0520A	WASTE H ₂ O DUMP NOZZLE TEMP.	148	385	30	82					DEGF

MEASUREMENT OUTPUT FROM W/MMS MODEL - TABLE 2

MEASUREMENT I. D.	MEASUREMENT NAME	I. C.		VALUE 1		VALUE 2		VALUE 3		UNITS
		FS	CTS	FS	CTS	FS	CTS	FS	CTS	
V62X0533E	WASTE H ₂ O DUMP ISOL VLV OPEN IND	0	0	1	1					STATE
V62X0534E	WASTE H ₂ O DUMP ISOL VLV CLOSED IND	1	1	0	0					STATE
V62X0538E	WASTE H ₂ O DUMP VLV OPEN IND	0	0	1	1					STATE
V62X0539E	WASTE H ₂ O DUMP VLV CLOSED IND	1	1	0	0					STATE
V62Q0540A	WASTE H ₂ O TK 1 QTY	84	833	0	96					PCT
V62Q0544A	POT. TK D OR WASTE TK 2 QTY.	83	822	10	184	99	964			PCT
V62Q0548A	POT. H ₂ O TK C QTY	82	814	50	534	85	841			PCT
V62T0551A	VACUUM VENT TEMP	136.2	581	30	291					DEGF
V62X0566E	WASTE H ₂ O TK 1 DRAIN OPEN IND	0	0	1	1					STATE
V62X0567E	POT. TK D OR WASTE TK 2 OUT. VLV OPEN IND	0	0	1	1					STATE
V62X0568E	POT. H ₂ O TK C OUTLET VLV OPEN IND	0	0	1	1					STATE
V62X0570E	WASTE TK 1 INLET VLV OPEN IND	0	0	1	1					STATE
V62X0571E	POT. TK D OR WASTE TK 2 INLET VLV OPEN IND	0	0	1	1					STATE
V62X0572E	POT H ₂ O TK C INLET VLV OPEN IND	0	0	1	1					STATE
V62T0578A	WASTE H ₂ O DUMP LINE TEMP	73.4	473	30	49	70	440			DEGF
V62X0580E	WASTE TK 1 DRAIN VLV CLOSE IND	1	1	0	0					STATE
V62X0581E	WASTE H ₂ O TK 2 OUTLET VLV CLOSE IND	1	1	0	0					STATE
V62X0582E	POT. H ₂ O TK C OUTLET VLV CLOSE IND	1	1	0	0					STATE
V62X0583E	WASTE TK 1 INLET VLV CLOSE IND	1	1	0	0					STATE
V62X0584E	POT. TK D OR WASTE TK 2 INLET VLV CLOSE IND	1	1	0	0					STATE

MEASUREMENT OUTPUT FROM W/WMS MODEL - TABLE 2

MEASUREMENT I. D.	MEASUREMENT NAME	I. C.		VALUE 1		VALUE 2		VALUE 3		UNITS
		FS	CTS	FS	CTS	FS	CTS	FS	CTS	
V62X0585E	POT. H ₂ O TK C INLET VLV CLOSE IND	1	1	0	0					STATE
V62X1005E	POT. H ₂ O XOVR VLV OPEN IND	0	0	1	1					STATE
V62X1006E	POT. H ₂ O XOVR VLV CLOSE IND	1	1	0	0					STATE
V62X1105E	POT. H ₂ O GALLEY SUPPLY VLV OPEN IND	0	0	1	1					STATE
V62X1106E	POT. H ₂ O GALLEY SUPPLY VLV CLOSE IND	1	1	0	0					STATE
V62Q9150A	POT. H ₂ O TANK E QTY	85	841							PERCENT
V62Q9160A	POT. H ₂ O TANK F QTY	86	849							PERCENT

5. REFERENCES

- a) LA-B-10100-1/JSC-11174 - Space Shuttle Systems Handbook OV-102
- b) Potable Water Storage OV-102 Space Shuttle Dwg. 6.4 (6-15-77)
- c) Waste Management OV-102 Space Shuttle Dwg. 6.5 (6-1-77)
- d) Schematic Diagram Waste Mgm't Subsystem Dwg. VS70-620202 (8-24-77)
- e) Schematic Diagram Water Mgm't Subsystem Dwg. VS70-620302 (7-26-77)
- f) ICD-3-1603-5, Section 3.7

APPENDIX L
RCS/OMS MATH MODEL REQUIREMENTS

TABLE OF CONTENTS

Section	Page
1. INTRODUCTION	L-2
2. DETAILED REQUIREMENTS	L-3
2.1 Functional Characteristics	L-3
2.1.2 INPUT/OUTPUT	L-3
2.2 DCM Uplink	L-3
2.3 Initialization	L-3
2.4 Termination Requirements	L-3
2.5 Unique Requirements.	L-3
2.6 Analog Measurements.	L-5
2.6.1 Polynomial Conversion Method	L-5
2.6.2 Range Limit Conversion Method.	L-8
3. LOGIC FLOW DIAGRAMS	L-9
4. TABLES.	L-11
4.1 Input Stimuli.	L-11
4.2 Output Measurement List.	L-12
5. REFERENCES.	L-15

FIGURES

Figure	Page
2-1 INPUT/OUTPUT DATA FLOW	L-4

1. INTRODUCTION:

Math models are used to simulate many of the Shuttle systems for which hardware does not exist in SAIL. A group of these models are termed non-avionic models since they do not simulate avionic equipment. The non-avionic models are needed to provide responses to cockpit switches, to drive cockpit displays, and to supply data for on-board software processing. The following list of non-avionic models will operate within the Test Operations Center (TOC) Ground Standard Interface Unit (GSIU).

- Main Propulsion System (Orbiter Portion)
- APU/Hydraulic
- Active Thermal Control
- Atmosphere Revitalization System
- Fuel Cell/Cryogenics
- Smoke Detection
- Water/Waste Management
- Reaction Control System/Orbiter Maneuvering System (RCS/OMS)

When the TOC Display and Control Module (DCM) operator depresses the "SYS LOAD" key, the model programs, which are stored on the Fixed Head Disk in the DCM, are automatically loaded into the GSIU. The models are then activated and terminated by DCM test language statements. While the models are operating in the GSIU, the DCM operator is able to inhibit one, all, or any combination of model outputs with test language statements. This provides the DCM operator with control of output parameter values when off-nominal conditions are desired. To simplify the models and ease the processing load on supporting test equipment, the model requirements define nominal conditions only. Further, analog values for output parameters change in step fashion when responding to inputs, except when specific change rates for particular parameters are required. The DCM operator is also able to alter the value that the model uses to generate parameter outputs. This allows the DCM operator to adjust output parameter values as needed to satisfy various mission phases.

2. DETAILED REQUIREMENTS

The RCS/OMS model is a Rockwell application requirement implemented via Test Language in the DCM. This model outputs those DFI parameters not found in the avionics model. The model receives input from one source, the DCM. The model provides output parameter values to the flight system via the STM. Figure 2-1 illustrates the data flow in and out of the model. Table 2-1 lists the output measurements.

2.1 Functional Characteristics

This RCS/OMS model is a special case function to provide the Developmental Flight Instrumentation (DFI) measurements found in Table 1 to the flight system. These instrumentation measurements could not be output by the RCS/OMS Vehicle Dynamics model because of the absence of a hardware interface.

This model, therefore, does none of the RCS/OMS logic functions. It merely outputs the aforementioned measurements as static values.

2.1.2 INPUT/OUTPUT

Any time-dependent inputs must be up-linked from the TOC-DCM as an abnormality (or parameter value change) in accordance with the GSIU Operating System.

For the sake of simplicity, the model will do no fault detection of stimuli. Therefore, any fault insertion must include changes to all affected parameters in order to obtain a realistic response from the model.

2.2 DCM Uplink

The only values passed from the DCM will be those which involve output suppression and fault insertion in accordance with the GSIU Operating System and are not a part of this document.

2.3 Initialization

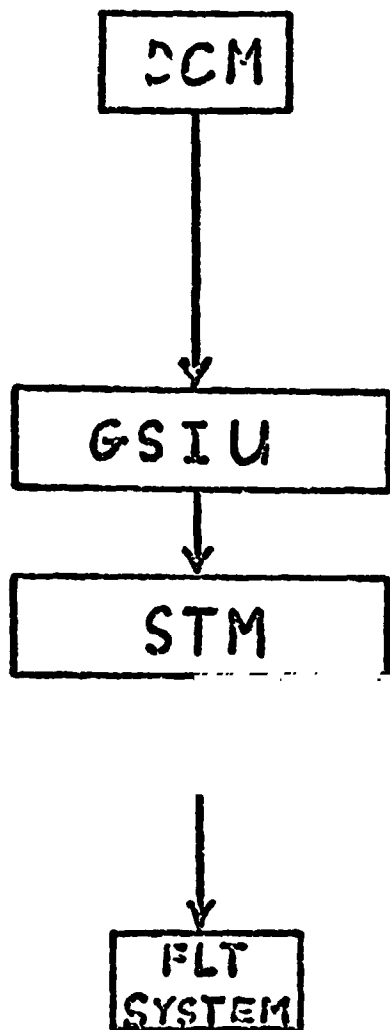
Parameters will be initialized with the values found in the IC (Initial Condition) column of Table 1.

2.4 Termination Requirements

None.

2.5 Unique Requirements

This model has no input requirements except those from the DCM (see section 2.2 above).



INPUT / OUTPUT DATA FLOW

FIGURE 2-1

2.6 ANALOG MEASUREMENTS

Values shown in the math model flowcharts are in GSIU counts for all analog measurements. The math model values are seen by the flight system as 0 to 5 VDC inputs. The flight system then converts these input voltages to engineering units using one of the two types of scaling equations discussed in Sections 2.6.1 and 2.6.2. The GSIU math model count values (or the count values entered at the DCM by the test operator) must consider the scaling computation done later by the flight software, so that correct flight system engineering unit values are obtained for fault detection and annunciation (FDA) and for cockpit displays. The following two sections, 2.6.1 and 2.6.2, describe the scaling equations which apply to this model. Section 2.6.1 describes the scaling equation for measurements which require the polynomial conversion method. Section 2.6.2 describes the scaling equation for measurements which require the range limit conversion method which was used on STS-1.

2.6.1 POLYNOMIAL CONVERSION METHOD

The scaling polynomial equation used by the flight system is defined in the SM .SSR. The general form of the equation is given as follows:

$$FS_{EU} = A_0 + A_1X + A_2X^2 + A_3X^3$$

where: FS_{EU} = flight system engineering units

X = flight system input voltage

A_0, A_1, A_2, A_3 = scaling polynomial coefficients

The following example shows the step by step procedure for converting analog measurements from flight system engineering units (FS_{EU}) to GSIU counts. This procedure may be used to calculate GSIU count values for fault insertion at the DCM.

Example:

For measurement no. V63R1100A, convert FS_{EU} value = 2288 to GSIU counts.

Step 1:

In the SM FSSR, look up the measurement no. (V63R1100A) within the "SMM Data Requirements - Subsystems Displays" table. The measurement no. will appear on two consecutive pages as follows: page A will show engineering units, range low value and range high value, while page B will show the scaling polynomial coefficients (labelled A_0, A_1, A_2, A_3) followed by curve order, independent variable, and STS flight no. The values on page B will be of prime interest to do this example conversion, and will be referred to in the following discussion.

Step 2:

The coefficients will be used in the scaling polynomial:

$$FS_{EU} = A_0 + A_1X + A_2X^2 + A_3X^3$$

Solve the following scaling polynomial for X:

$$2288 = 443.167 + 851.956X - 143.904X^2 + 12.246X^3$$

$$\text{so } X = 3.846469$$

Step 3:

Notice the independent variable column labelled IND VR equals 2 for measurement no. V63R1100A. The 2 specifies that the independent variable X of the scaling polynomial is defined on a range of 0 to 5 VDC. So $X = 3.846$ VDC.

It is of interest to note that if IND VR had been equal to 0, X would have been defined on a range of 0 to 1023 PCM integer counts in which case X would be equal to 4 PCM counts, i.e. 3.846 rounded to the nearest integer.

However, in the example being worked, X is defined as VDC and $X = 3.846$ VDC.

Step 4:

Now to convert X VDC to GSIU counts, evaluate the following equation which shows the relationship between X and GSIU counts:

$$\text{GSIU counts} = \left[X \left(\frac{1023}{K} \right) \right], \text{ rounded to the nearest integer}$$

where K = 5, for X defined as VDC (IND VR = 2) and
K = 500, for X defined as PCM counts (IND VR = 0).

For the example, evaluate:

$$\text{GSIU counts} = \left[3.846 \left(\frac{1023}{5} \right) \right], \text{ rounded to the nearest integer}$$

Therefore, GSIU counts = 787 counts.

Note that since GSIU counts are always rounded to the nearest integer, small changes will possibly occur in the values of X and consequently FS_{EU} , when the reverse calculations are made during test operations, as the following shows:

$$X = \text{GSIU counts} \left(\frac{K}{1023} \right)$$

$$X = 787 \times \left(\frac{5}{1023} \right)$$

$$\text{SO } X = 3.846529$$

And

$$FS_{EU} = 443.167 + 851.956X - 143.904X^2 + 12.246X^3$$

$$FS_{EU} = 443.167 + 851.956(3.848) - 143.904(3.848)^2 + 12.246(3.848)^3$$

$$FS_{EU} = 2288.017$$

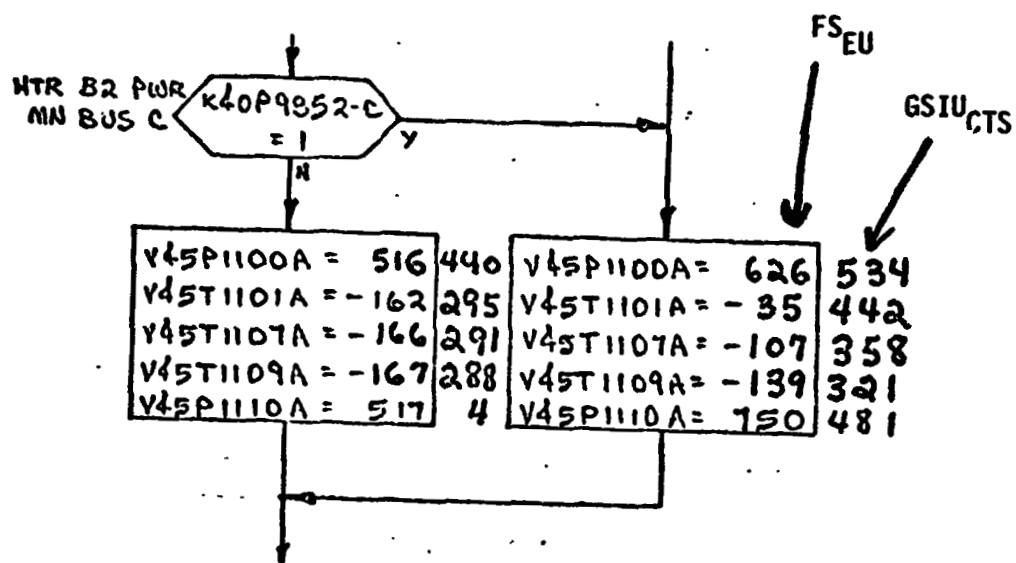
Hence when 787 GSIU counts is inserted for measurement no. V63R1100A, a value of 2288.017 FS_{EU} will result.

2.6.2 RANGE LIMIT CONVERSION METHOD

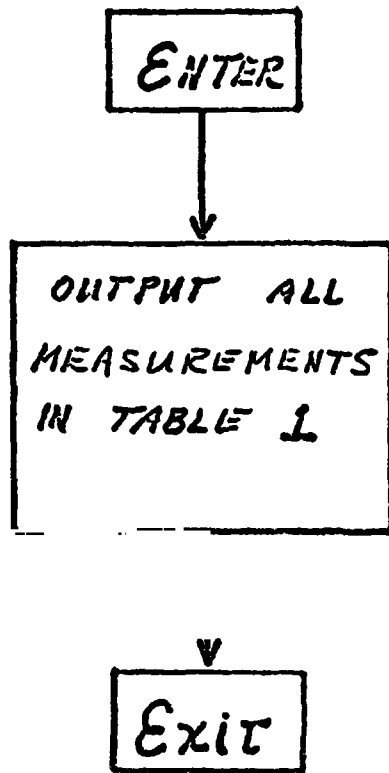
NONE.

3.0 LOGIC FLOW DIAGRAMS

The logic flow diagram is made up of interconnected lines, boxes, decisions, and offpage connectors. Notice that where analog measurements are listed in boxes and decisions, the value inside the box is in flight system engineering units (FS_{EU}) while the corresponding GSIII count value is listed outside the box. For example, the box on the right hand below,



shows that V45P1100A is set equal to 626 FS_{EU} which is equivalent to 534 $GSIIU_{CTS}$ shown outside the box.



RCS/OMS
FLOW DIAGRAM

4. TABLES

4.1 INPUT STIMULI

NONE

4.2 OUTPUT MEASUREMENT LIST

Table 2 lists all model outputs along with the initial condition value for the output. Measurement I.D. and Measurement Name precede pairs of numeric columns. The first of each pair is labeled FS indicating flight system engineering units. The second of each pair is labeled CTS indicating the GSIU count value corresponding to the FS value. I.C. indicates initial condition values. VALUE 1 typically indicates nominal values. VALUE 2 and VALUE 3 columns indicate off nominal conditions.

MEASUREMENT OUTPUT FROM RCS/OMS MODEL - TABLE 2

MEASUREMENT I. D.	MEASUREMENT NAME	I. C.		VALUE 1		VALUE 2		VALUE 3		UNITS
		FS	CTS	FS	CTS	FS	CTS	FS	CTS	
	- RCS -									
V42T2305A	RCS-L AFT HSG THERM SW TEMP 2	104.0	732							DEGF
V42T3305A	RCS-R AFT HSG THERM SW TEMP 2	105.0	737							DEGF
V42T9044A	FRCS FU TK FILL MANIF LOC 2 THERMO	98.22	630							DEGF
V42T9045A	FRCS OX TK FILL MANIF LOC 2 THERMO	99.2	636							DEGF
V42T9432A	RCS-L OX/HE TEST PORT LN. TEMP	106.23	681							DEGF
V42T9442A	RCS-L OX TK OTBD UPR SKIN TEMP	45.41	293							DEGF
V42T9449A	RCS-L OX VLV TEMP Y WEB OTBD	108.15	694							DEGF
V42T9561A	RCS-R OX/HE TEST PORT LN. TEMP	107.2	687							DEGF
	- OMS -									
V43T4700A	OMS-L POD RCS PRESS PNL SUPT TEMP 1	58.21	374							DEGF
V43T4706A	OMS-L POD GSE SERVICE PNL TEMP	78.2	323							DEGF
V43T4707A	OMS-L POD ENG SERVICE PNL TEMP	74.22	477							DEGF
V43T4710A	OMS-L POD RCS PRESS PNL SUPT TEMP 2	60.2	552							DEGF
V43T4711A	OMS-L POD RCS HSG VERNIER CMPT TEMP 2	111.2	458							DEGF
V43T4718A	OMS-L POD OX/HE TEST PORT FIG TEMP 2	82.1	642							DEGF
V43T5710A	OMS-R POD RCS PRESS PNL SUPT TEMP 2	61.2	557							DEGF
V43T5711A	OMS-R POD RCS HSG VERNIER CMPT TEMP 2	112.2	462							DEGF
V43T5718A	OMS-R POD OX/HE TEST PORT FIG TEMP 2	83.1	647							DEGF
V43T6234A	OMS BHD FU HI PT BLEED LN TEMP	94.0	692							DEGF
V43T6235A	OMS BHD OX HI PT BLEED LN TEMP	95.0	696							DEGF
V43T6236A	OMS-AFT FUSLG LO PT OX DRN LN TEMP-L	90.22	579							DEGF
V43T6237A	OMS-AFT FUSLG LO PT OX DRN LN TEMP-R	91.18	585							DEGF

MEASUREMENT OUTPUT FROM RCS/OMS MODEL - TABLE 2

MEASUREMENT I. D.	MEASUREMENT NAME	I. C.		VALUE 1		VALUE 2		VALUE 3		UNITS
		FS	CTS	FS	CTS	FS	CTS	FS	CTS	
V43T6238A	OMS-AFT FU HI PT BLEED LN TEMP	92.0	683							DEGF
V43T6239A	OMS-AFT OX HI PT BLEED LN TEMP	93.0	687							DEGF
V43T6240A	OMS-AFT FULSG XFD FU FLX LN-L TEMP	88.30	567							DEGF
V43T6241A	OMS-AFT FULSG XFD FU FLX LN-R TEMP	89.26	573							DEGF
V43T6242A	OMS-AFT FUSLG OX LN CTR TEMP	87.34	561							DEGF
V43T6243A	OMS-AFT FUSLG OX XFD LINE L TEMP	85.42	548							DF°F
V43T6244A	OMS-AFT FUSLG OX XFD LINE R TEMP	86.38	554							DEGF
V43T9002A	OMS-L POD OX ISLN VLV TEMP	50.21	323							DEGF
V43T9290A	OMS-R XFD/POD OX COUPLING TEMP	56.29	362							DEGF
V43T9459A	OMS-L Eng COVER THERMOSTAT TEMP	72.29	464							DEGF
V43T9464A	OMS-L FU/HE TEST PORT LN. TEMP	84	651							DEGF
V43T9467A	OMS-L OXIDIZER DRAIN LN. TEMP	66	577							DEGF
V43T9470A	OMS-L OX FLG TEMP POD/ORBR INTFC	55.33	356							DEGF
V43T9471A	OMS-L FU FLG TEMP POD/ORBR INTFC	57.25	368							DEGF
V43T9551A	OMS-R OXIDIZER DRAIN LN. TEMP.	67	581							DEGF
V43T9553A	OMS-R ENG COVER THERMOSTAT TEMP.	73.26	471							DEGF

5. REFERENCES

- a) Rockwell Internai Letter No. 382-460-JTK-78-012 subject; Justification for Adding a DFI MDM (DC02) to SAIL in Support of Mission Profile Tests.
- b) Interface Revision Notice (IRN) P0084.
- c) Interface Revision Notice (IRN) P0094.