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Lyndon B. Johnson Space Center
Houston, Texas 77058

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STS-2
SAIL NON-AVIONICS SUBSYSTEMS
MATH MODEL REQUIREMENTS

Job Order 22-109
Contract NAS 9-15800

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Prepared By

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

For

SHUTTLE AVIONICS INTEGRATION DIVISION

July 1980

LEMSCO-14524

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PREPARED BY

W. P. Bennett

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

R. W. Herold

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

APPROVED BY

B. E. Carlton

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

J. D. Overton

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

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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 base-lined by the SAIL Change Control Panel.

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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.— NON-AVIONICS MATH MODEL APPLICATIONS

MATH MODEL	IMPLEMENTATION REQUIREMENT	PRIMARY				BFS	
		ASCENT OPS 1	ON-ORBIT OPS 2 GNC	ON-ORBIT OPS 2 SM	ENTRY OPS 3	GNC	SM
APU/ HYDRAULICS	STS / 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/OMS (DFI)	STS			✓			✓

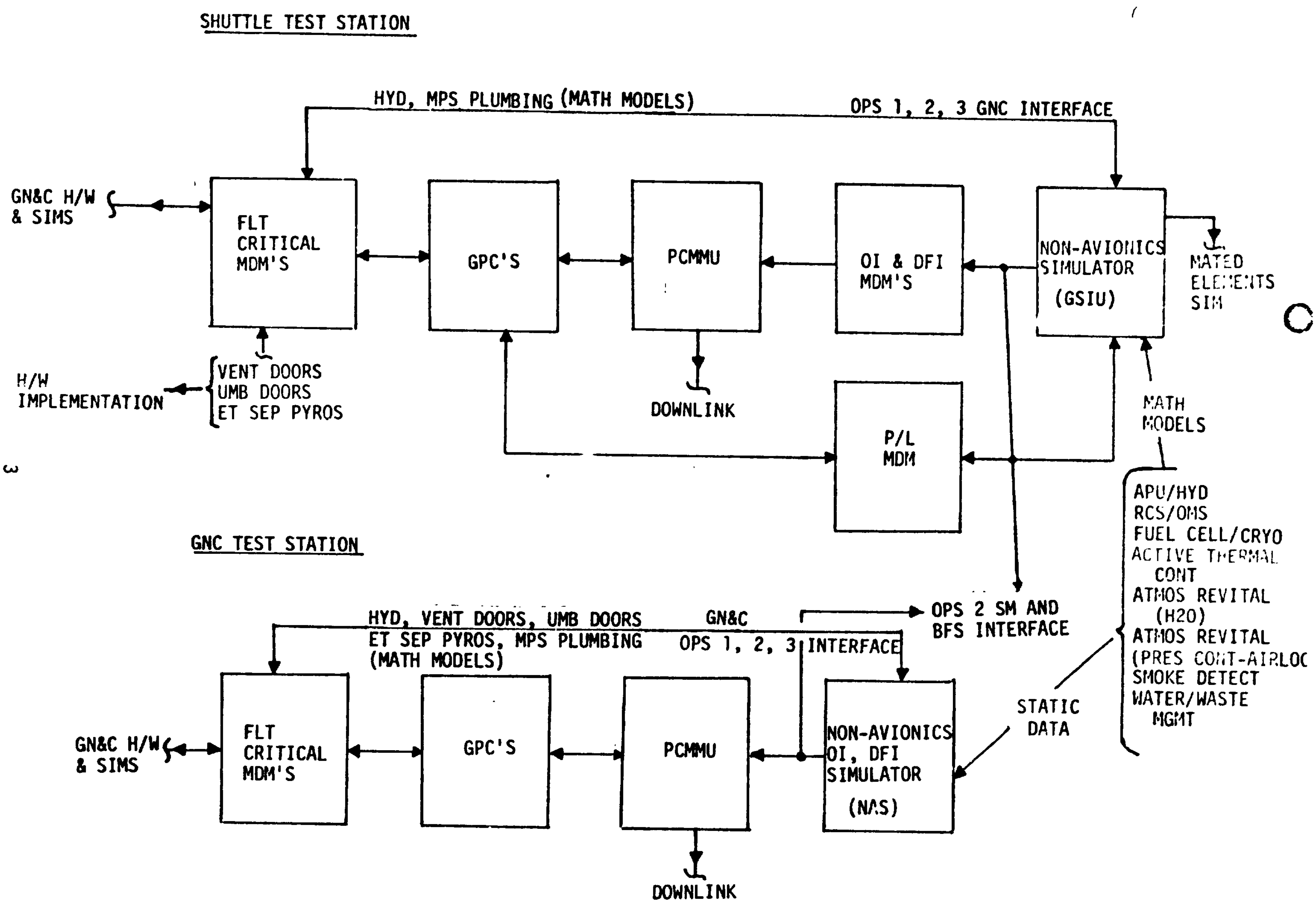


Figure 1.— SAIL Non-Avionics Simulators Interfaces.

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

FIGURES

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:

Non-Avionic Math Model	STS	GTS
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 is 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

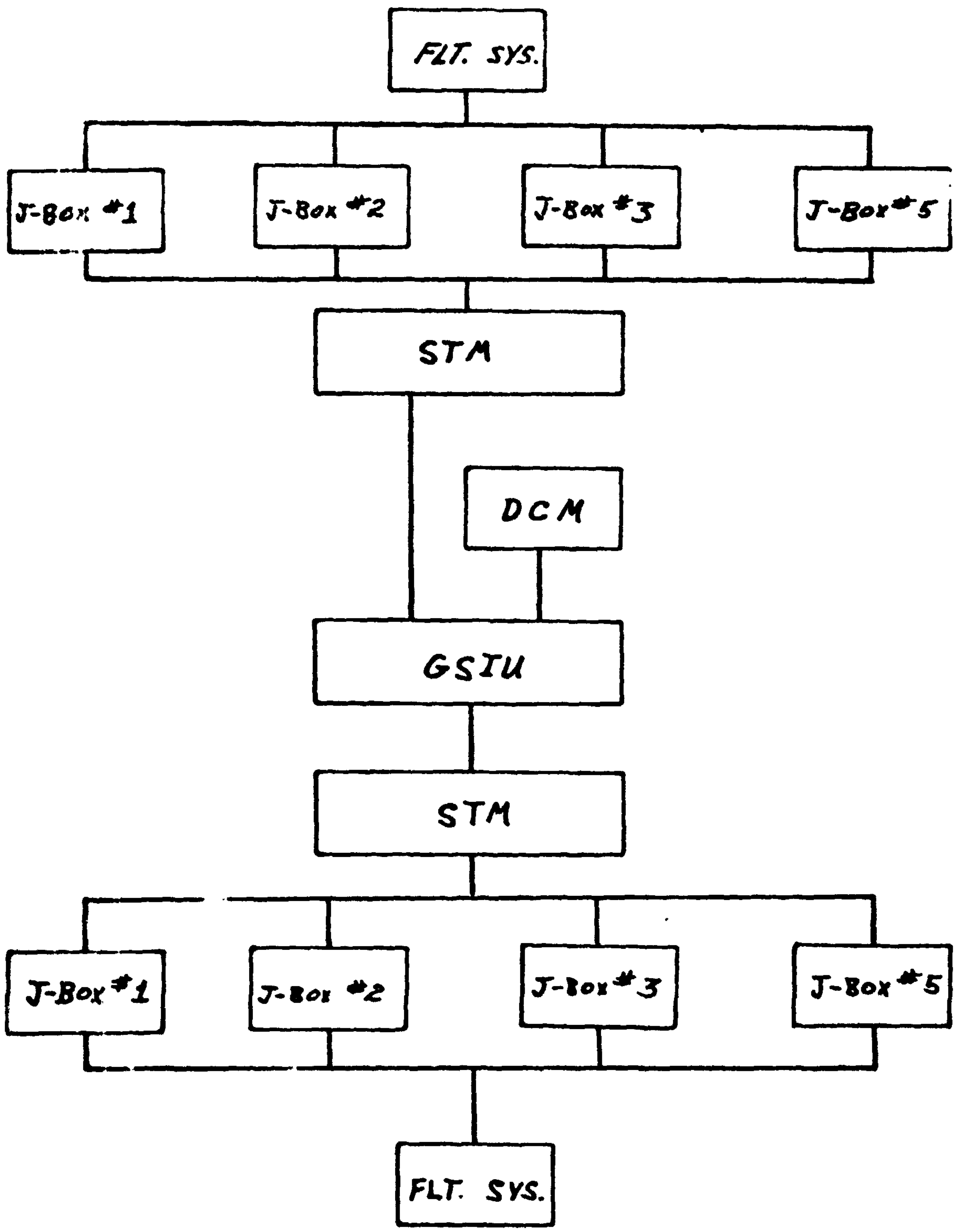
The hydraulic pump is driven by the APU, and the speed is dependent upon whether input stimuli is selected to Normal or High speed mode. Hydraulic power is supplied to aerosurface controls (elevons, rudder, body flap, and speedbrake), landing gear, wheel brakes, and nosewheel steering. Figure 3 is a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

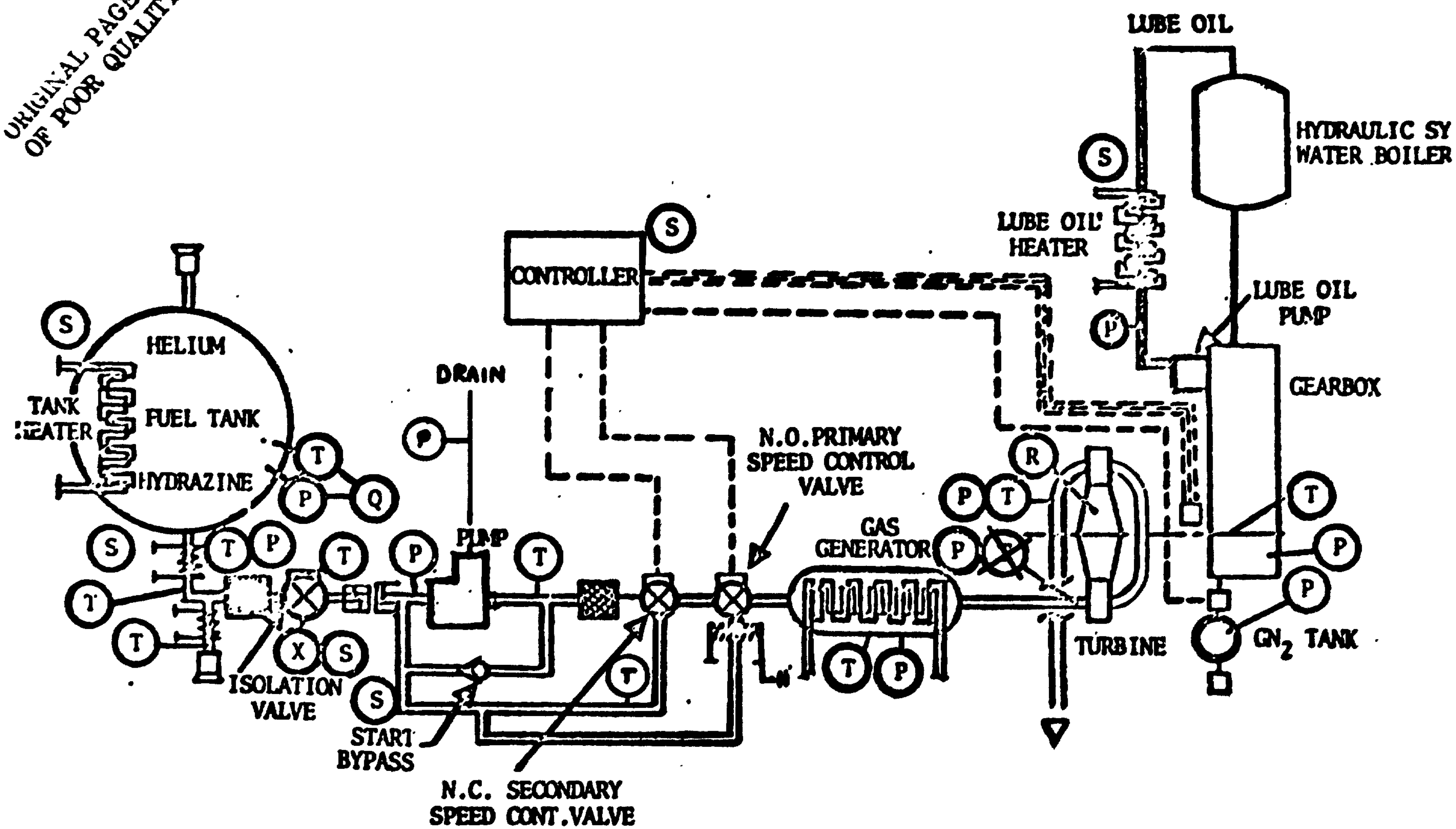


Figure 2.— Auxiliary power unit block diagram.

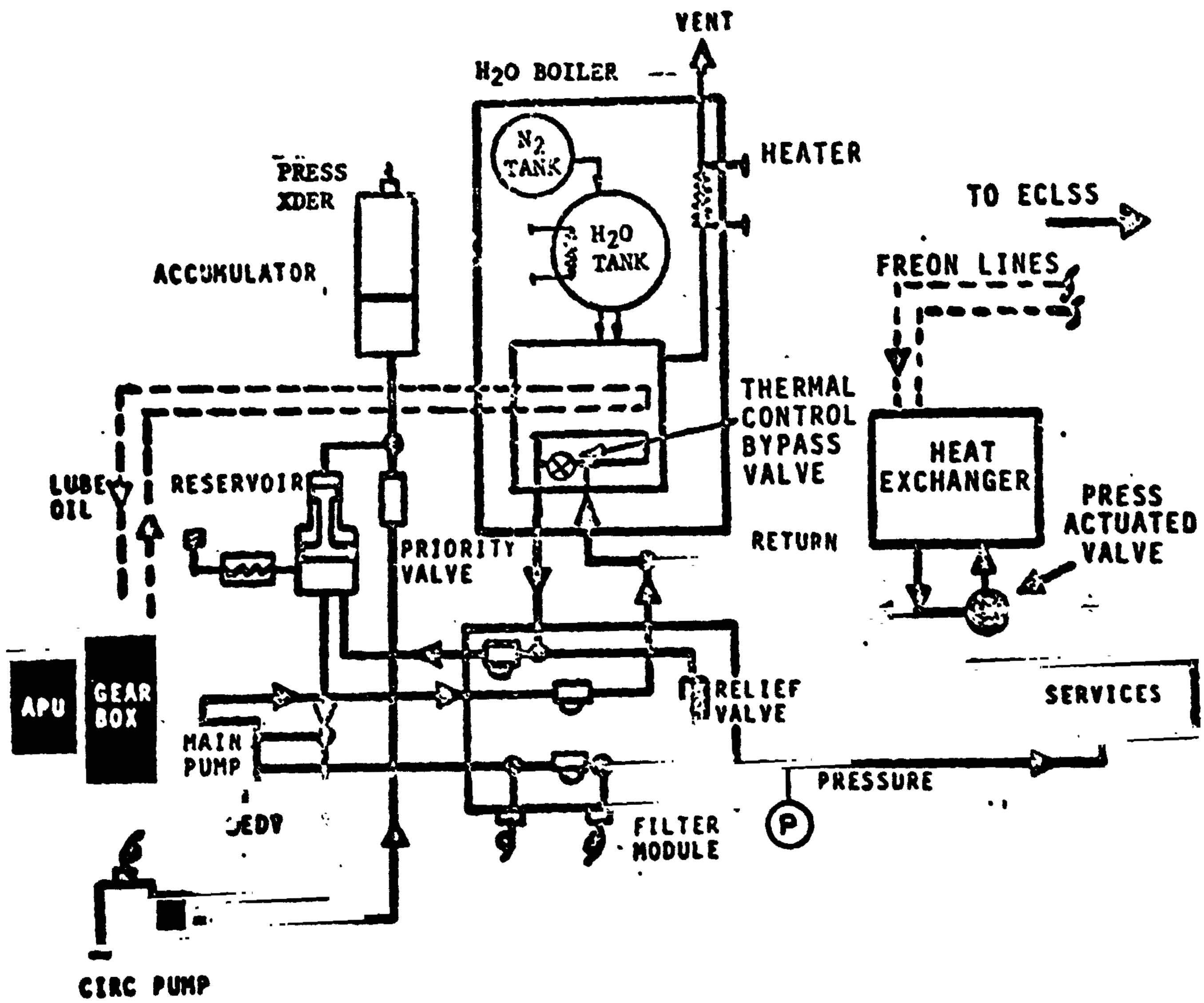


Figure 3.– Hydraulic system (typical for systems 1, 2, and 3).

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.

```
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 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 (V46R0i35A)>0 = APU i RUN MODE

TURBINE SPEED (V46R0i35A)$\leq$0 = APU i IDLE MODE

2.5.5 <u>APU Turbine Overspeed or Underspeed Conditions</u>

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.

<u>EXAMPLE:</u>

MDM INPUT VOLTAGE FOR V58T0830A = 2.6 VDC

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

$EU = A_1X + A_0 = 0.01171875\ (16640) + (-75)$

$EU = 120$

MEAS MML#	T O C			BFS MEAS COEFFICIENTS				FLIGHT SYSTEM EU
	GSIU EU	GSIU COUNTS	MDM INPUT 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 [illegible] 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:

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

so X = 3.846169

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 r[illegible]ded to the nearest integer.

However, in the example being worked, X is def[illegible] 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:

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

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

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

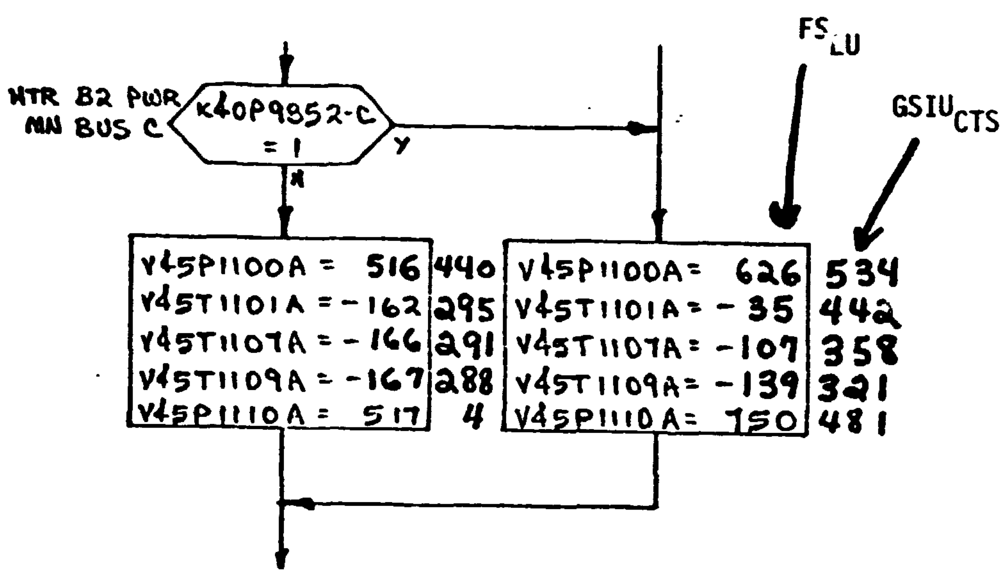
High = Range high limit

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.

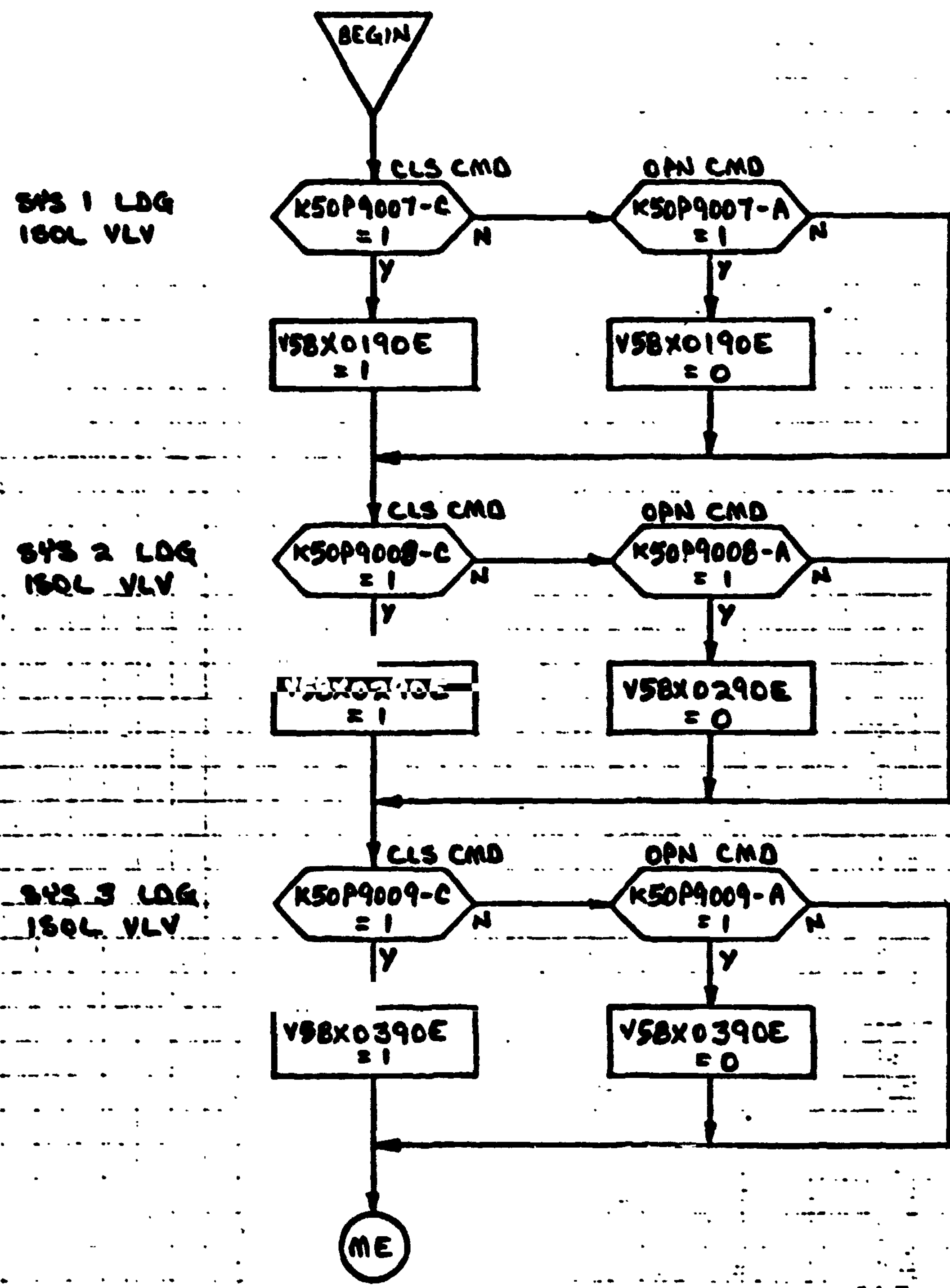
MEASUREMENT ID	RANGE LOW	RANGE HIGH	FS	CTS
V46T9180A	0	+1500	419	286
V46T9280A	0	+1500	479	327
V46T9380A	0	+1500	540	368
V46T9132A	-100	+500	56	266
V46T9270A	0	+250	86	352
V46T9513A	-75	+300	69	393
V58P0114C	0	+4000	3022	773
V58P0214C	0	+4000	3124	799
V58P0314C	0	+4000	3226	825
V58P0116C	0	+4000	3300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

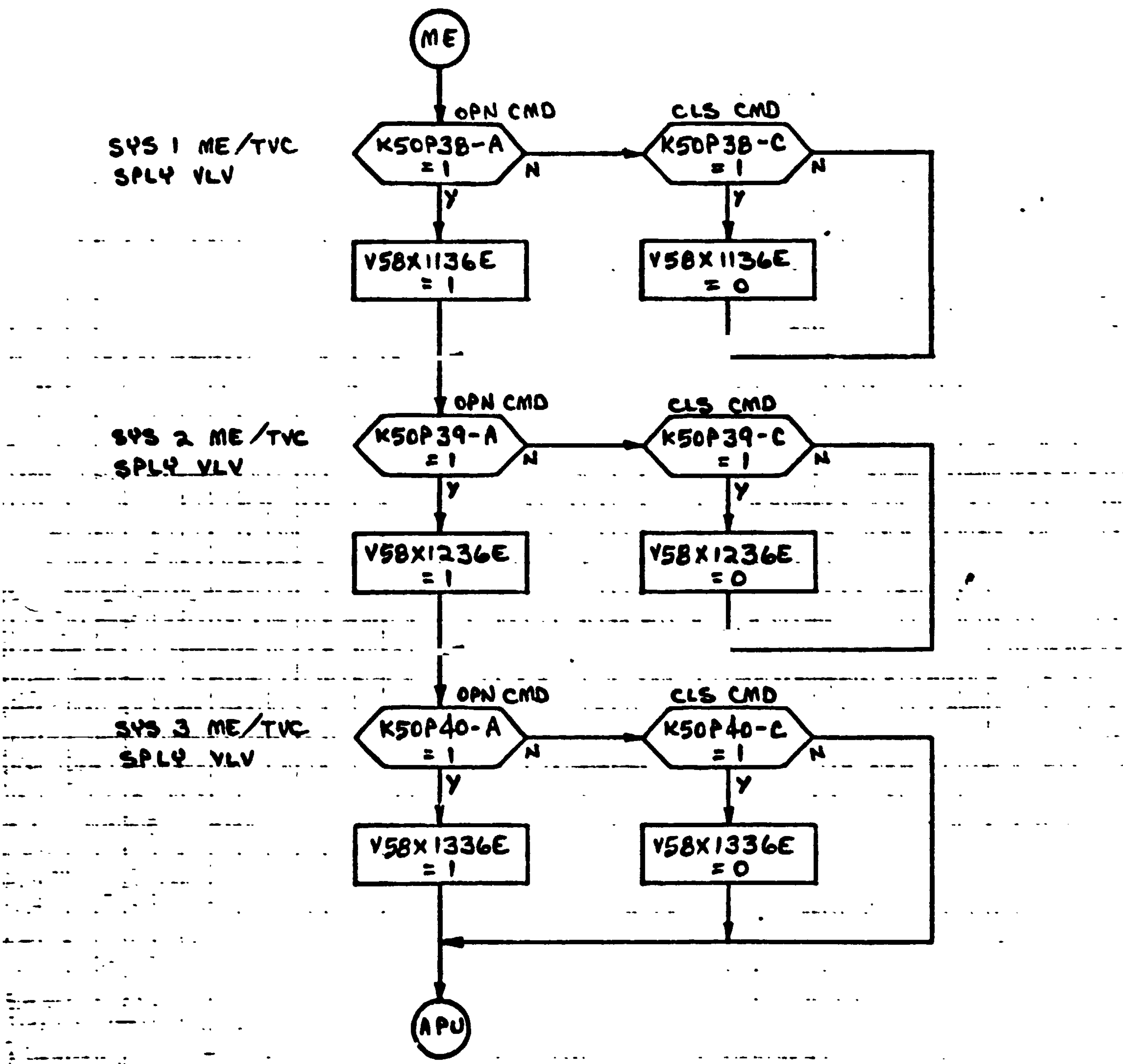
3.0 LOGIC FLOW DIAGRAMS

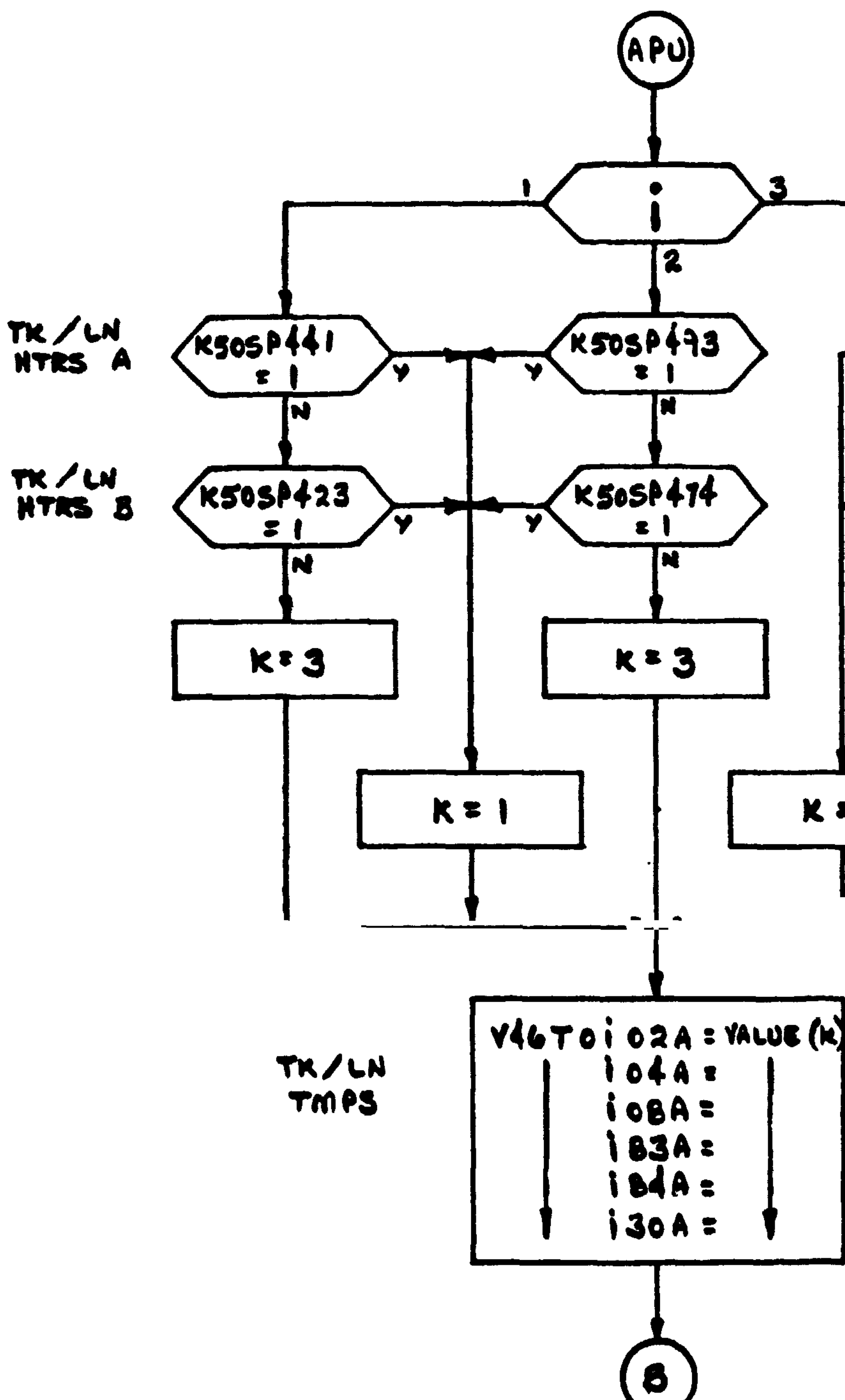
The logic flow diagram is made up of interconnected lines, boxes, decisions, and offpage connectors. Notice that where analog measurements are listed in boxes and decisions, the value inside the box is in flight system engineering units (FS_{EU}) while the corresponding GSIU count value is listed outside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


BEGIN
SYS 1 LDG ISOL VLV
CLS CMD
K50P9007-C = 1
N
Y
OPN CMD
K50P9007-A = 1
N
Y
V58X0190E = 1
V58X0190E = 0
SYS 2 LDG ISOL VLV
CLS CMD
K50P9008-C = 1
N
Y
OPN CMD
K50P9008-A = 1
N
Y
= 1
V58X0290E = 0
SYS 3 LDG ISOL VLV
CLS CMD
K50P9009-C = 1
N
Y
OPN CMD
K50P9009-A = 1
N
Y
V58X0390E = 1
V58X0390E = 0
ME


ME
SYS 1 ME/TVC
SPLY VLV
OPN CMD
K50P38-A
= 1
Y
N
CLS CMD
K50P38-C
= 1
V58X1136E
= 1
V58X1136E
= 0
SYS 2 ME/TVC
SPLY VLV
OPN CMD
K50P39-A
= 1
CLS CMD
K50P39-C
= 1
V58X1236E
= 1
V58X1236E
= 0
SYS 3 ME/TVC
SPLY VLV
OPN CMD
K50P40-A
= 1
CLS CMD
K50P40-C
= 1
V58X1336E
= 1
V58X1336E
= 0
APU



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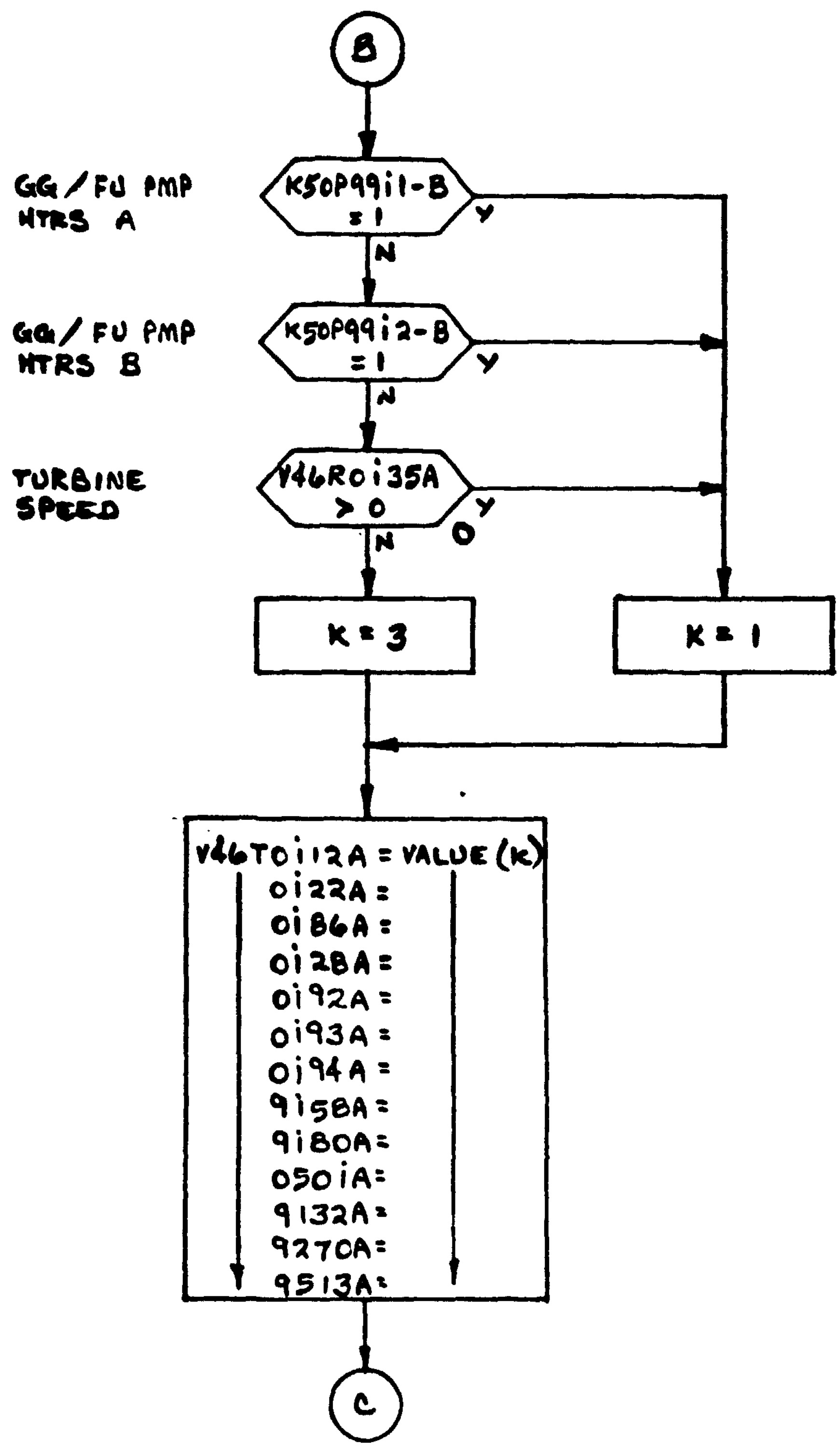
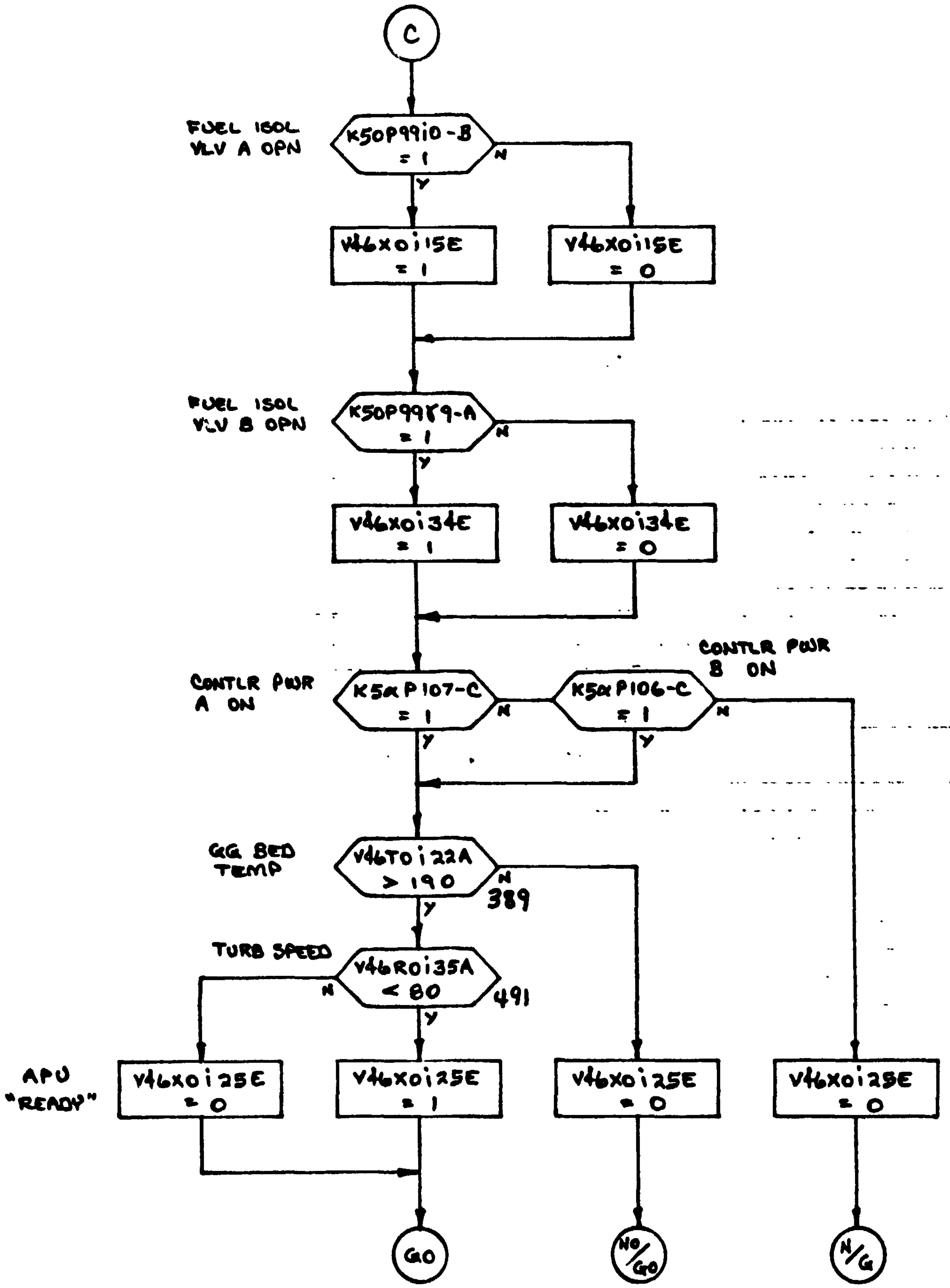
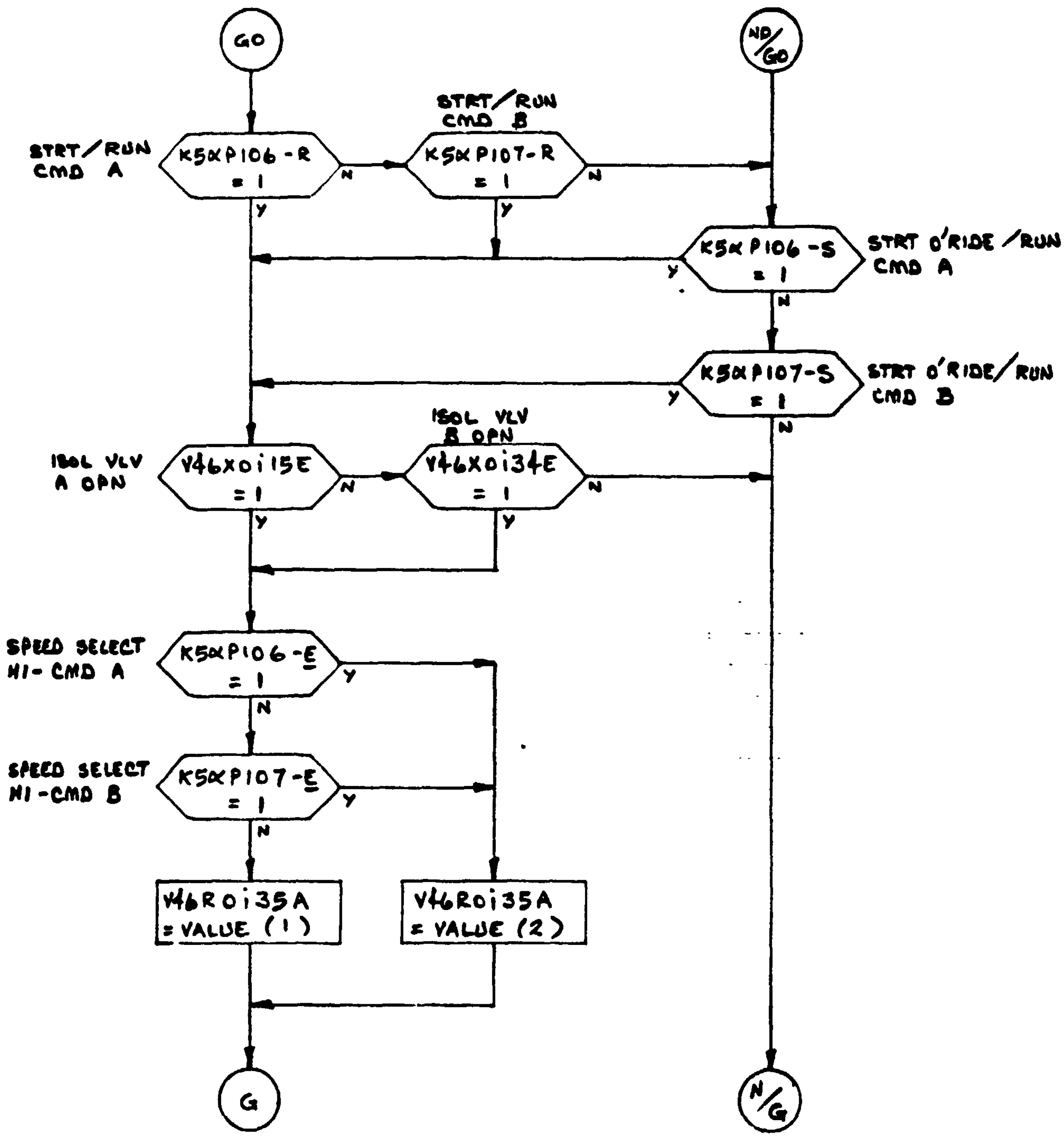
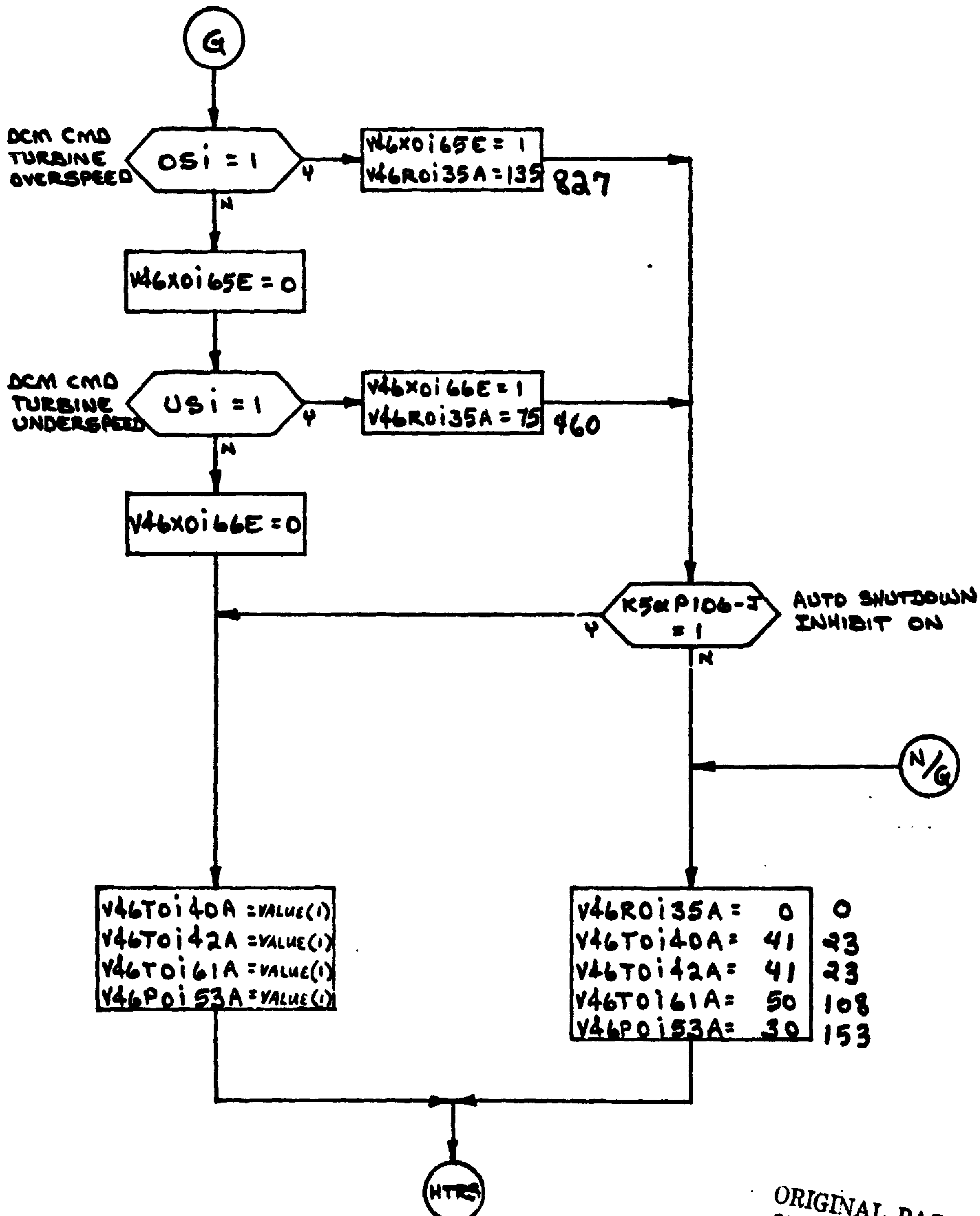

B
GG / FU PMP HTRS A
K50P99i1-B = 1
Y
N
GG / FU PMP HTRS B
K50P99i2-B = 1
TURBINE SPEED
V46R0i35A > 0
K = 3
K = 1
V46T0i12A = VALUE (K)
0i22A =
0i86A =
0i2BA =
0i92A =
0i93A =
0i94A =
9i5BA =
9i80A =
050iA =
9i32A =
9270A =
9513A =
C


C
FUEL ISOL VLV A OPN
K50P9910-B = 1
N
Y
V46X0115E = 1
V46X0115E = 0
FUEL ISOL VLV B OPN
K50P9989-A = 1
V46X0134E = 1
V46X0134E = 0
CONTLR PWR A ON
K50P107-C = 1
CONTLR PWR B ON
K50P106-C = 1
GG BED TEMP
V46T0122A > 190
389
TURB SPEED
V46R0135A < 80
491
APU "READY"
V46X0125E = 0
V46X0125E = 1
V46X0125E = 0
V46X0125E = 0
GO
NO/GO
N/G


GO
NO/GO
STRT/RUN CMD A
K5αP106-R = 1
STRT/RUN CMD B
K5αP107-R = 1
K5αP106-S = 1
STRT O'RIDE/RUN CMD A
K5αP107-S = 1
STRT O'RIDE/RUN CMD B
ISOL VLV A OPN
V46X0115E = 1
ISOL VLV B OPN
V46X0134E = 1
SPEED SELECT HI-CMD A
K5αP106-E = 1
SPEED SELECT HI-CMD B
K5αP107-E = 1
V46R0135A = VALUE (1)
V46R0135A = VALUE (2)
G
N/G
Y
N



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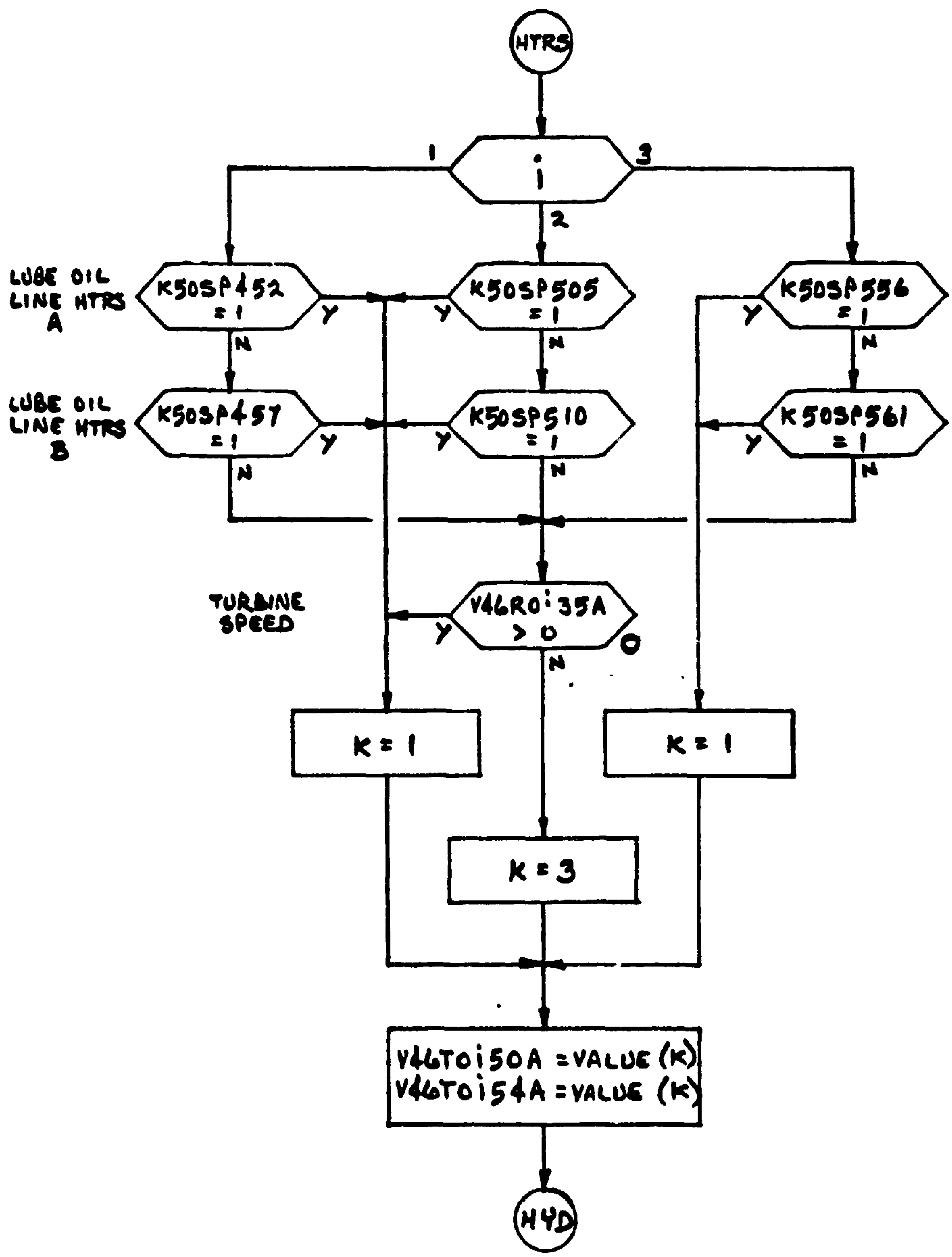
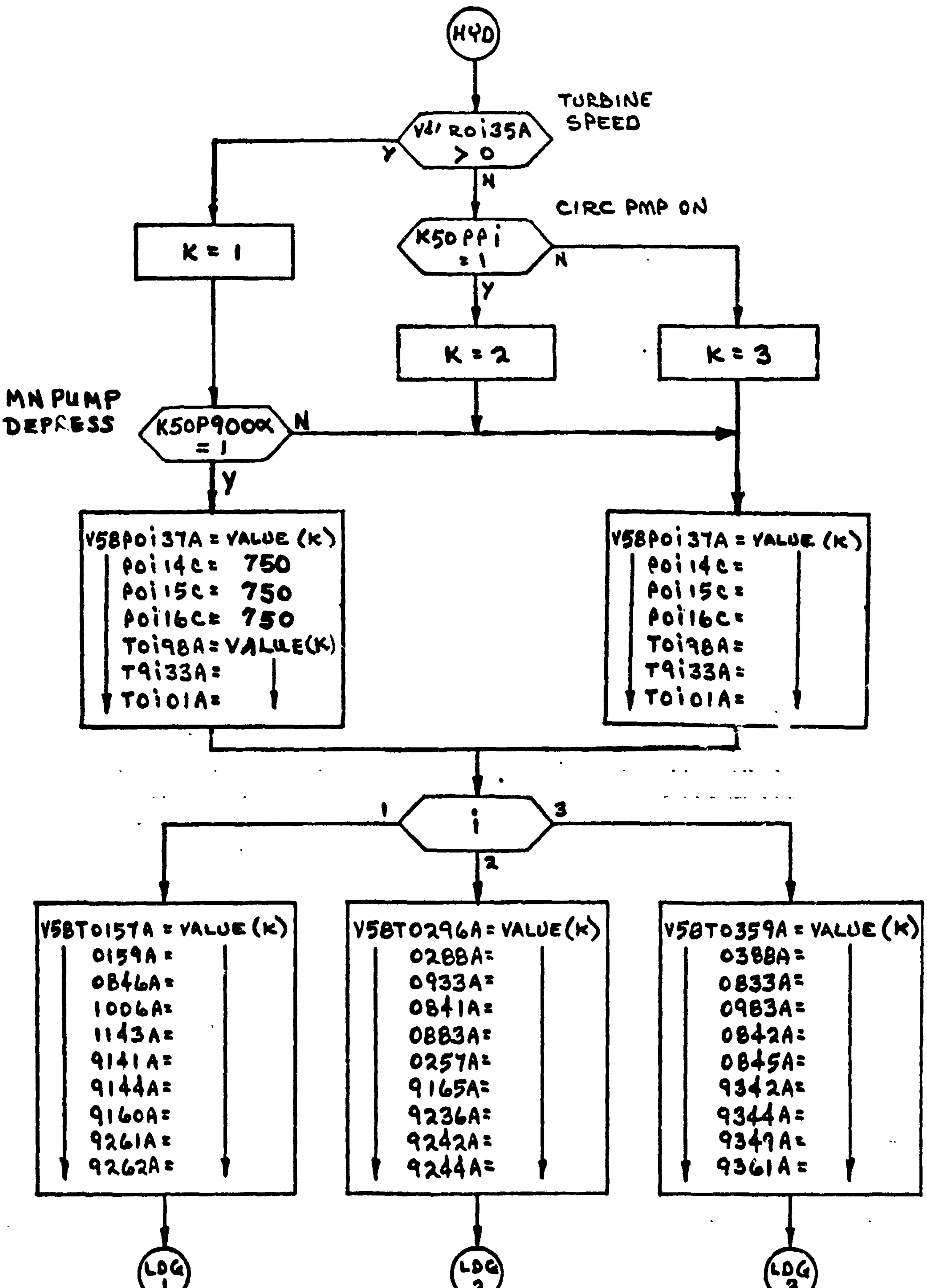
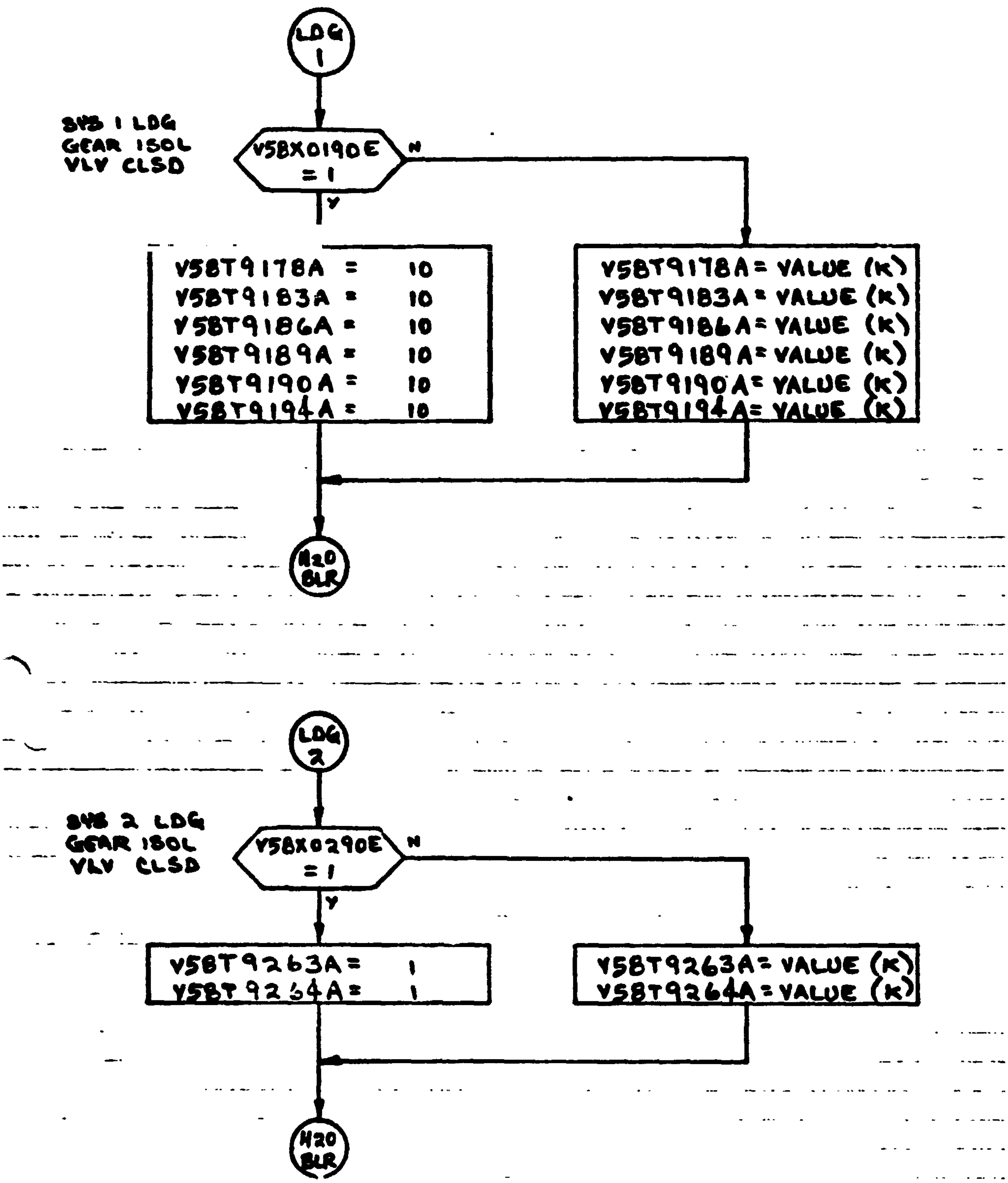
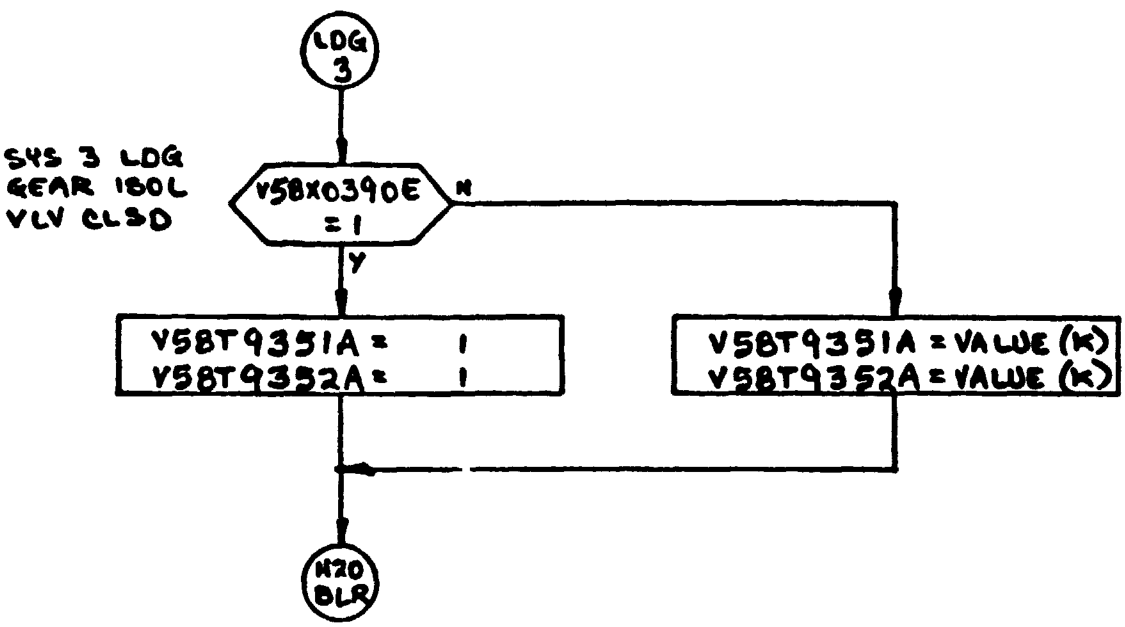
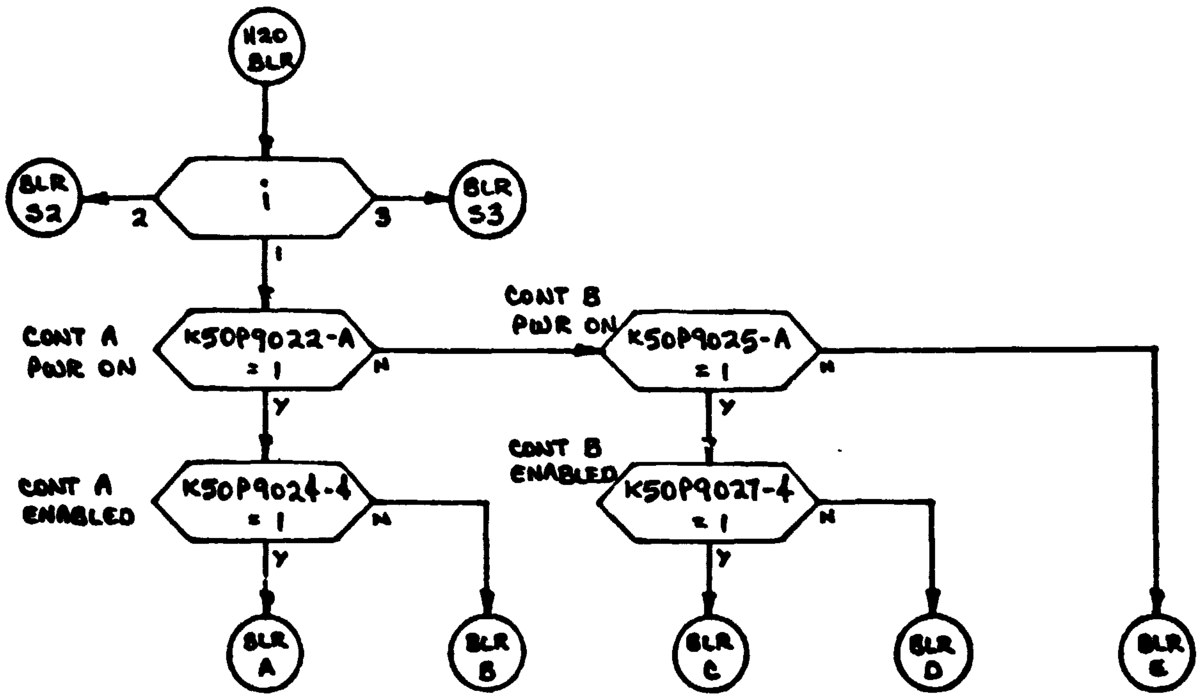

HTRS
i
1
2
3
LUBE OIL LINE HTRS A
K50SP452 = 1
K50SP505 = 1
K50SP556 = 1
LUBE OIL LINE HTRS B
K50SP457 = 1
K50SP510 = 1
K50SP561 = 1
Y
N
TURBINE SPEED
V46R0i35A > 0
O
K = 1
K = 1
K = 3
V46T0i50A = VALUE (K)
V46T0i54A = VALUE (K)
H4D

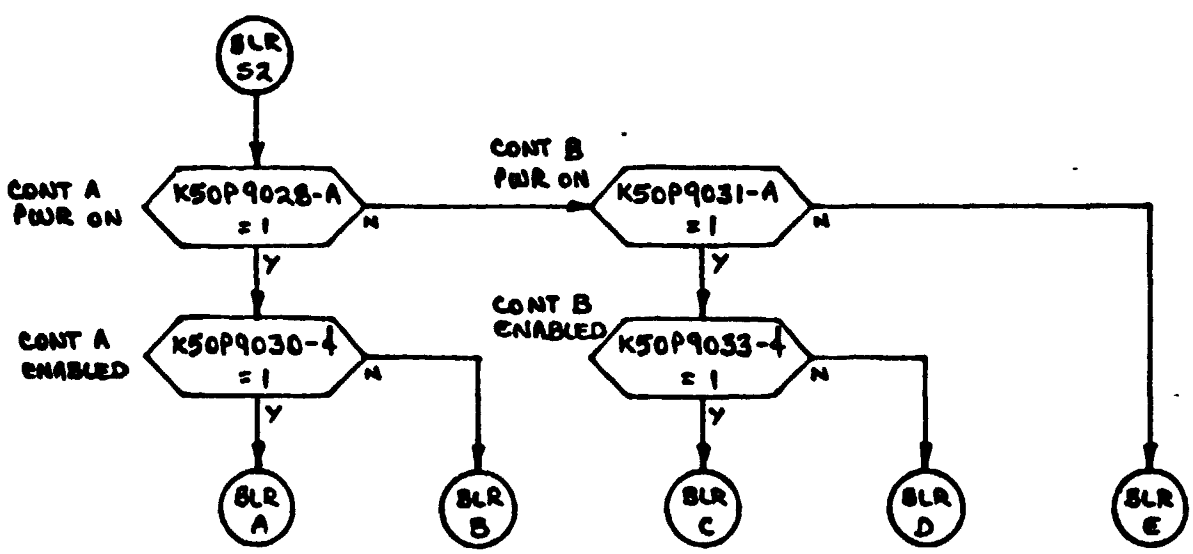

HYD
TURBINE SPEED
V41R0135A > 0
Y
N
CIRC PMP ON
K50PP1 = 1
N
Y
K = 1
K = 2
K = 3
MN PUMP DEPRESS
K50P900X = 1
N
Y
V58P0137A = VALUE (K)
P0114C = 750
P0115C = 750
P0116C = 750
T0198A = VALUE(K)
T9133A =
T0101A =
V58P0137A = VALUE (K)
P0114C =
P0115C =
P0116C =
T0198A =
T9133A =
T0101A =
i
1
2
3
V58T0157A = VALUE (K)
0159A =
0846A =
1006A =
1143A =
9141A =
9144A =
9160A =
9261A =
9262A =
V58T0296A = VALUE (K)
0288A =
0933A =
0841A =
0883A =
0257A =
9165A =
9236A =
9242A =
9244A =
V58T0359A = VALUE (K)
0388A =
0833A =
0983A =
0842A =
0845A =
9342A =
9344A =
9349A =
9361A =
LDG 1
LDG 2
LDG 3

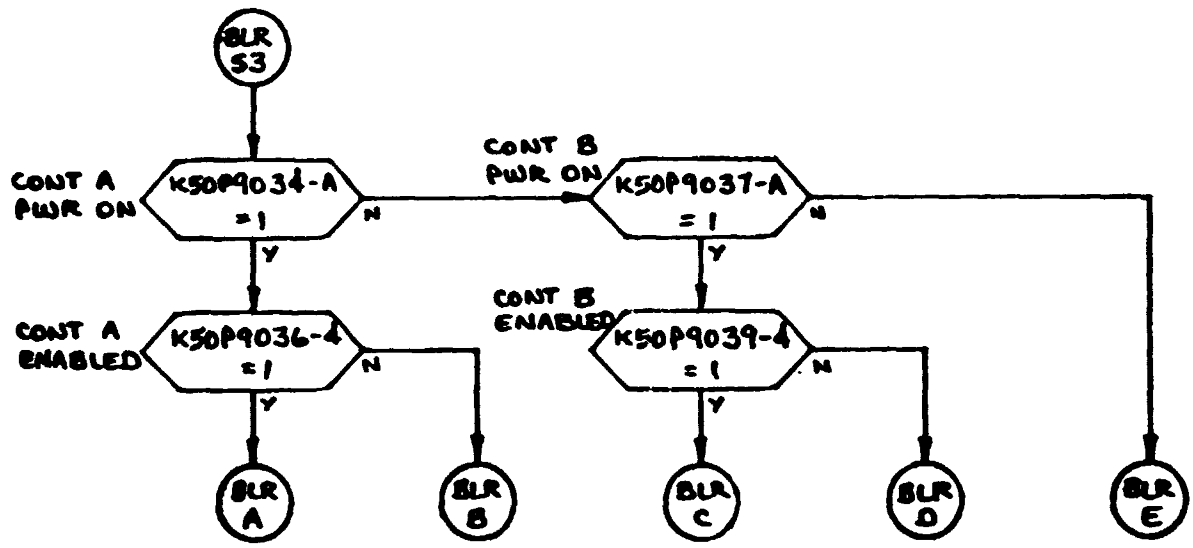


LDG 1
SYS 1 LDG GEAR ISOL VLV CLSD
V58X0190E = 1
N
Y
V58T9178A = 10
V58T9183A = 10
V58T9186A = 10
V58T9189A = 10
V58T9190A = 10
V58T9194A = 10
V58T9178A = VALUE (K)
V58T9183A = VALUE (K)
V58T9186A = VALUE (K)
V58T9189A = VALUE (K)
V58T9190A = VALUE (K)
V58T9194A = VALUE (K)
H2O BLR
LDG 2
SYS 2 LDG GEAR ISOL VLV CLSD
V58X0290E = 1
N
Y
V58T9263A = 1
V58T9264A = 1
V58T9263A = VALUE (K)
V58T9264A = VALUE (K)
H2O BLR

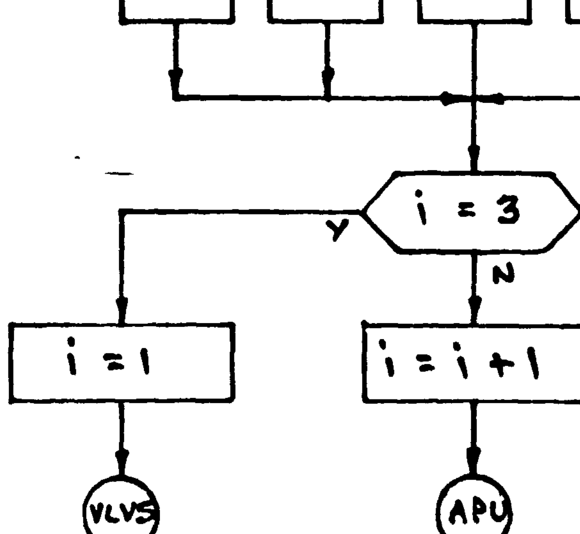

LDG 3
SYS 3 LDG GEAR ISOL VLV CLSD
V58X0390E = 1
N
Y
V58T9351A = 1
V58T9352A = 1
V58T9351A = VALUE (K)
V58T9352A = VALUE (K)
H2O BLR

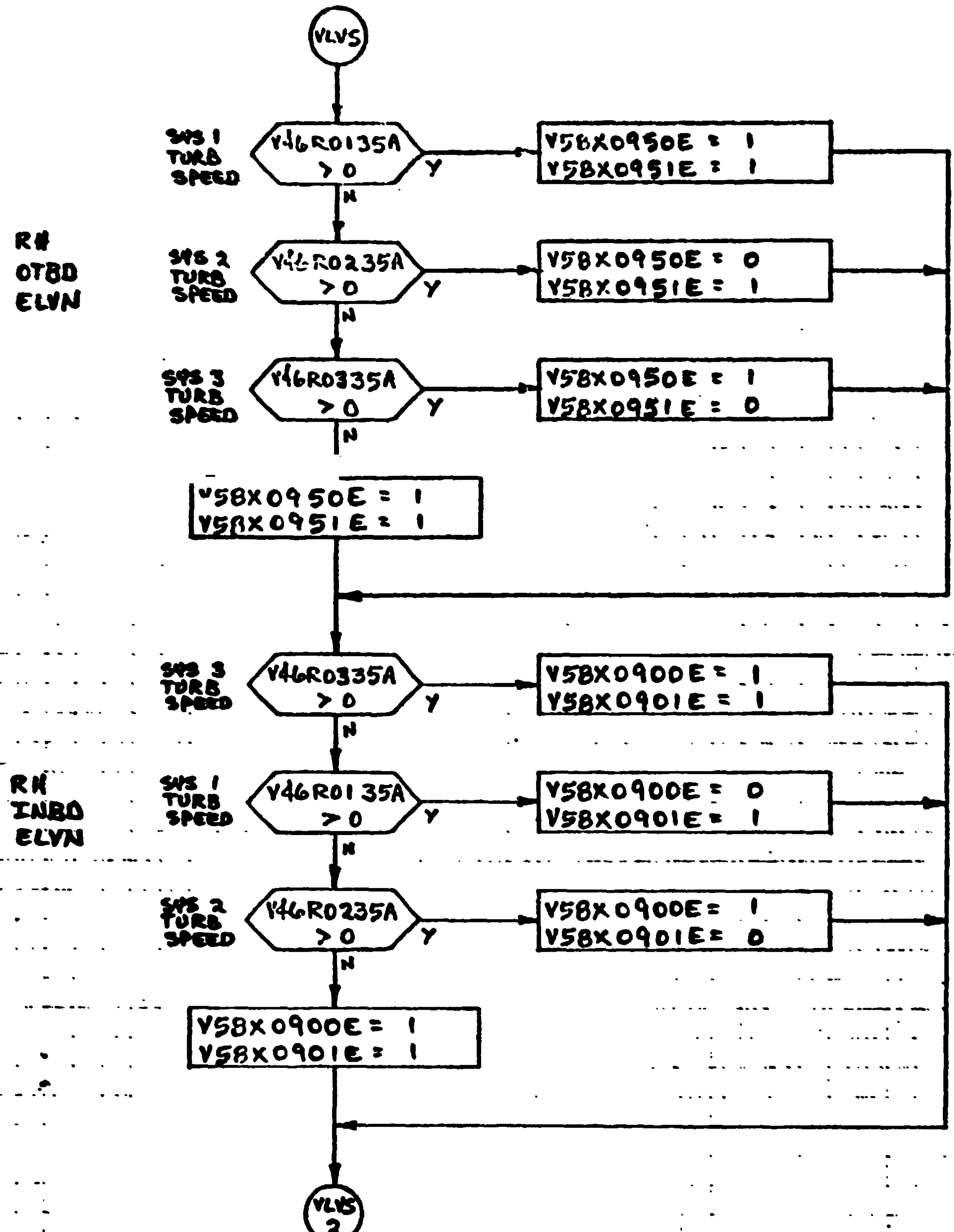

H2O BLR
i
BLR S2
BLR S3
2
3
1
CONT A PWR ON
K50P9022-A = 1
N
CONT B PWR ON
K50P9025-A = 1
N
Y
CONT A ENABLED
K50P9024-4 = 1
N
CONT B ENABLED
K50P9027-4 = 1
N
Y
BLR A
BLR B
BLR C
BLR D
BLR E

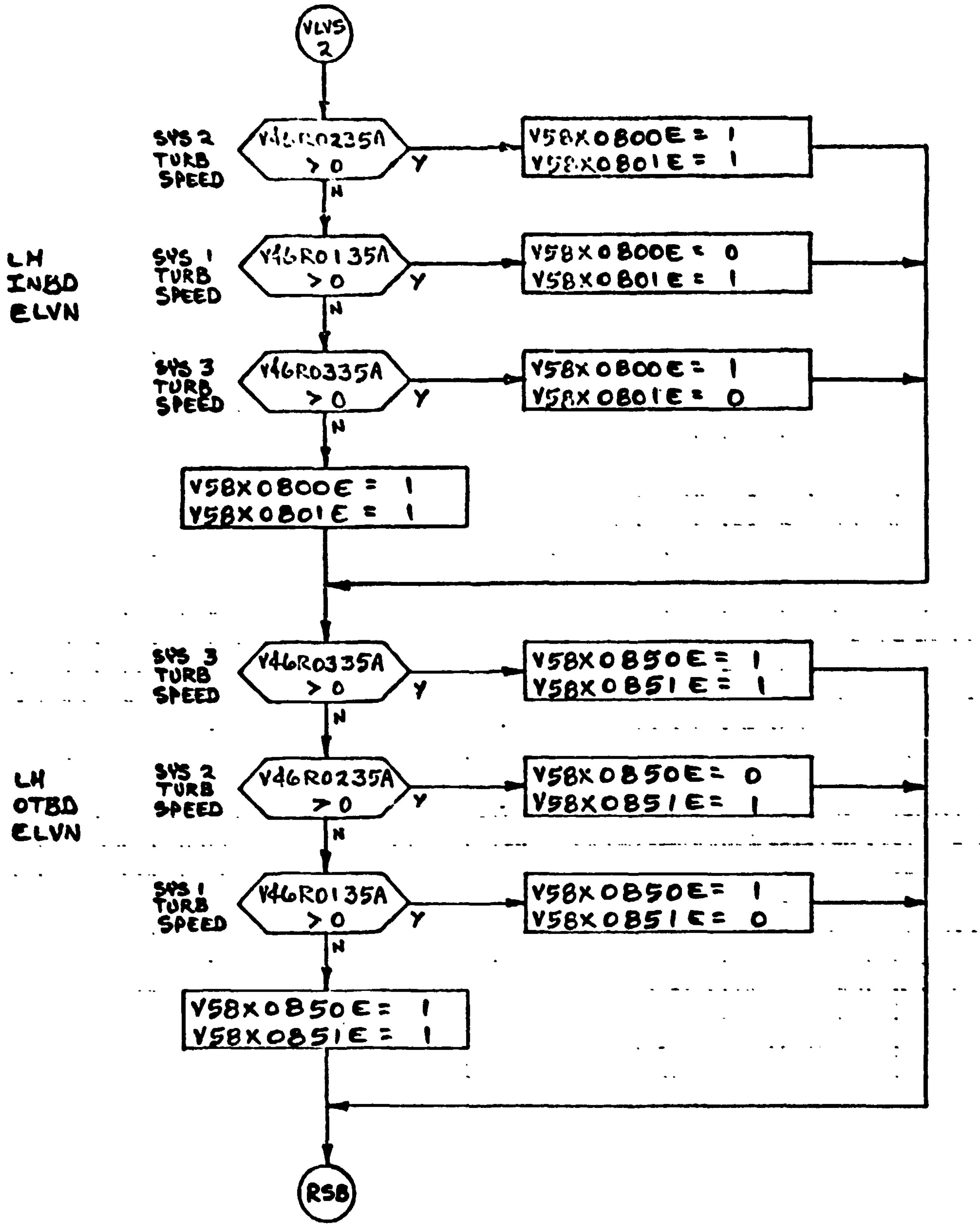

BLR S2
CONT A PWR ON
K50P9028-A = 1
N
CONT B PWR ON
K50P9031-A = 1
N
Y
CONT A ENABLED
K50P9030-4 = 1
N
CONT B ENABLED
K50P9033-4 = 1
N
Y
BLR A
BLR B
BLR C
BLR D
BLR E



		BLR A	BLR B	BLR C	BLR D	BLR E
H [illegible]LR GN2 PRS	V58P0104A =	25	25	0	0	0
H20 BLR GN2 TK TMP	T0105A =	(K)	(K)	32	32	32
H20 BLR H20 TK TMP	T0161A =	(K)	(K)	32	32	32
H20 BLR TMPS	T0162A =	(K)	(K)	32	32	32
	T0163A =	32	32	(K)	(K)	32
H20 BLR VENT TMPS	T0165A =	(K)	(K)	122	122	122
	T0166A =	122	122	(K)	(K)	122
H20 BLR BYP VLV IND	X0181E =	(K)	(K)	0	0	0
H20 BLR RDY IND	X0182E =	1	0	1	0	0




VLVS
SYS 1 TURB SPEED
V46R0135A > 0
Y
N
V58X0950E = 1
V58X0951E = 1
RH OTBD ELVN
SYS 2 TURB SPEED
V46R0235A > 0
V58X0950E = 0
V58X0951E = 1
SYS 3 TURB SPEED
V46R0335A > 0
V58X0950E = 1
V58X0951E = 0
V58X0950E = 1
V58X0951E = 1
SYS 3 TURB SPEED
V46R0335A > 0
V58X0900E = 1
V58X0901E = 1
RH INBD ELVN
SYS 1 TURB SPEED
V46R0135A > 0
V58X0900E = 0
V58X0901E = 1
SYS 2 TURB SPEED
V46R0235A > 0
V58X0900E = 1
V58X0901E = 0
V58X0900E = 1
V58X0901E = 1
VLVS 2



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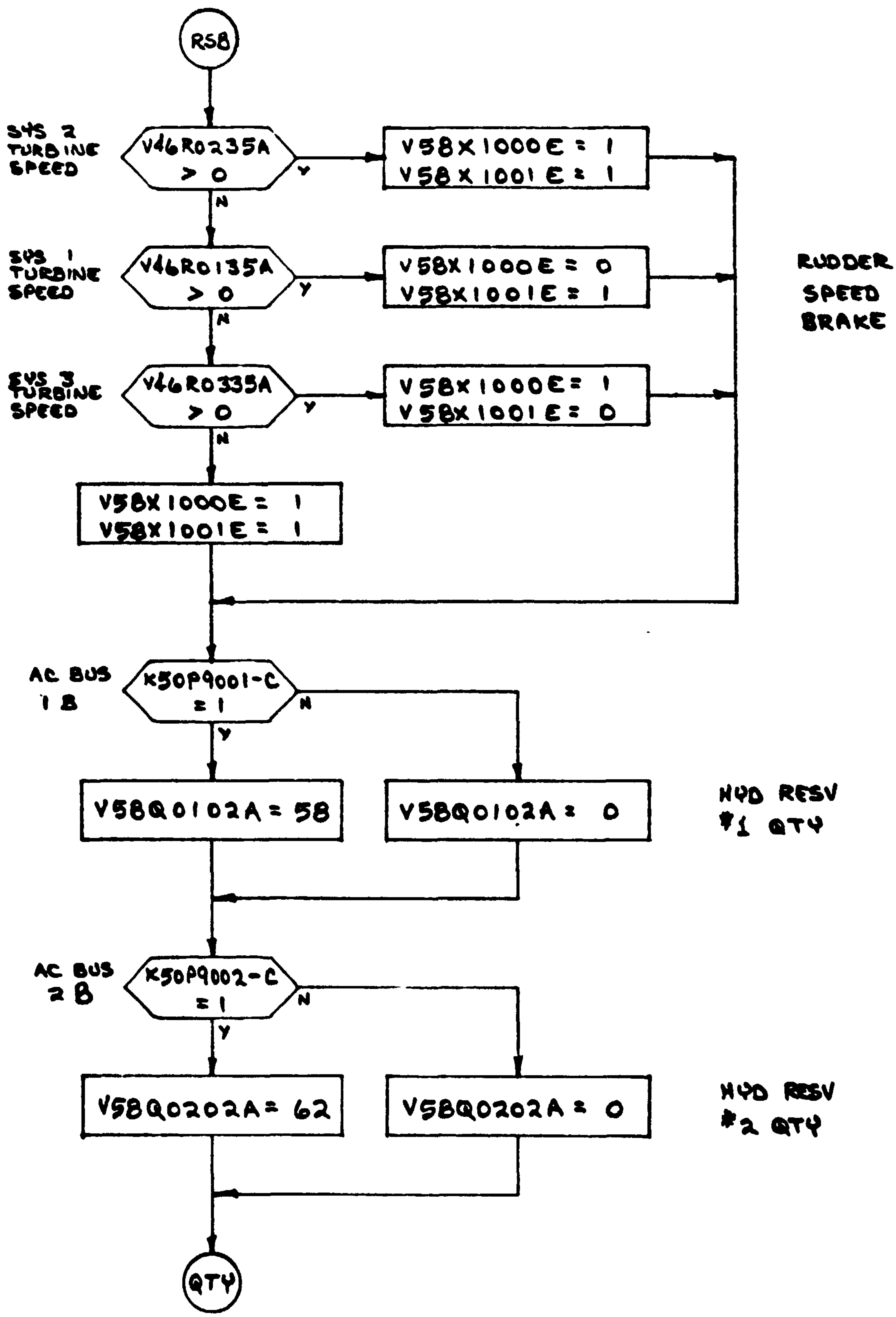
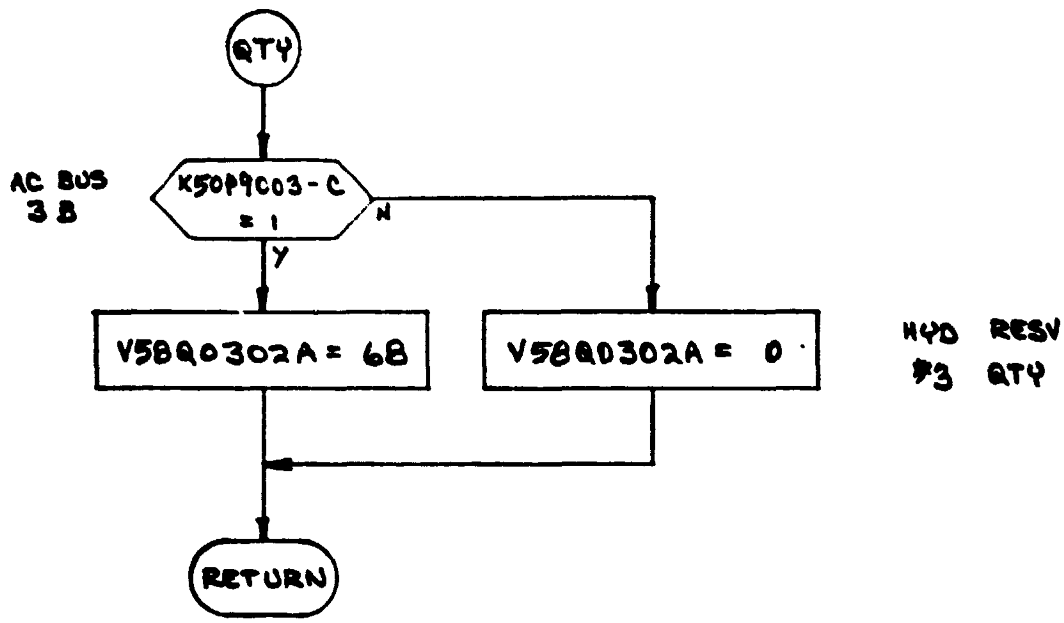

RSB
SYS 2 TURBINE SPEED
V46R0235A > 0
V58X1000E = 1
V58X1001E = 1
SYS 1 TURBINE SPEED
V46R0135A > 0
V58X1000E = 0
V58X1001E = 1
SYS 3 TURBINE SPEED
V46R0335A > 0
V58X1000E = 1
V58X1001E = 0
V58X1000E = 1
V58X1001E = 1
RUDDER SPEED BRAKE
AC BUS 1 B
K50P9001-C = 1
V58Q0102A = 58
V58Q0102A = 0
HYD RESV #1 QTY
AC BUS 2 B
K50P9002-C = 1
V58Q0202A = 62
V58Q0202A = 0
HYD RESV #2 QTY
QTY
Y
N


QTY
AC BUS
3 B
K50P9C03-C
= 1
Y
N
V58Q0302A = 68
V58Q0302A = 0
HYD RESV
#3 QTY
RETURN

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
	-APU-				
K50SP423	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		
			LO	HI	UNIT
	-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/HYD 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 V46K[illegible]14E		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 LO	HI	UNITS
	-HYD-				
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	
•K50P9004-1	MN. PUMP DEPR. ON SYSTEM 1 V58K0170E		0	1	
K50P9005-1	MN. PUMP DEPR. ON SYSTEM 2 V58K0270E		0	1	
K50P9006-1	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_2O BLR CNTLR PWR/HTR A SYSTEM 1 V58K0149E		0	1	
K50P9028-A	H_2O BLR CNTLR PWR/HTR A SYSTEM 2 V58K0249E		0	1	
K50P9034-A	H_2O BLR CNTLR PWR/HTR A SYSTEM 3 V58K0349E		0	1	STATE

STIMULI INPUT TO(J/HYD MODEL- TABLE

IDENTIFICATION NUMBER	NOMENCLATURE	SOURCE	STATES/RANGE		
			LO	HI	UNITS
	-HYD- Continued				
K50P9025-A	H_2O BLR CNTLR PWR/HTR B SYSTEM 1 V58K0150E	FLT SYSTEM	0	1	STATE
K50P9031-A	H_2O BLR CNTLR PWR/HTR B SYSTEM 2 V58K0250E		0	1	
K50P9037-A	H_2O BLR CNTLR PWR/HTR B SYSTEM 3 V58K0350E		0	1	
K50P9024-4	H_2O BLR CNTLR A ENABLE SYSTEM 1 V58K0151E		0	1	
K50P9030-4	H_2O BLR CNTLR A ENABLE SYSTEM 2 V58K0251E		0	1	
K50P9036-4	H_2O BLR CNTLR A ENABLE SYSTEM 3 V58K0351E		0	1	
K50P9027-4	H_2O BLR CNTLR B ENABLE SYSTEM 1 V58K0152E		0	1	
K50P9033-4	H_2O BLR CNTLR B ENABLE SYSTEM 2 V58K0252E		0	1	
K50P9039-4	H_2O 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

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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 (NOMINAL)	K=1	VALUE 2 (HI/LOW)	K=2	VALUE 3 (OFF)	K=3	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	331	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) K=1		VALUE 2 (HI/LOW) K=2		VALUE 3 (OFF) K=3		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 (NOMINAL) K=1		VALUE 2 (HI/LOW) K=2		VALUE 3 (OFF) K=3		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
V46P0151A	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
V46PC352A	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

MEASUREMENT OUTPUT FROM APU/HYD MODEL - TABLE 2

MEASUREMENT I. D.	MEASUREMENT NAME	I.C.		VALUE 1 (NOMINAL) K=1		VALUE 2 (HI/LOW) K=2		VALUE 3 (OFF) K=3		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			[illegible]	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 (NOMINAL) K=1		VALUE 2 (HI/LOW) K=2		VALUE 3 (OFF) K=3		UNITS
		FS	CTS	FS	CTS	FS	CTS	FS	CTS	
V46T0192A	APU 1 FU PUMP TEMP	185	385	185	385	NA		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 H20 LINE TEMP - PRI	61	393	61	393			43	276	°F
V46T0293A	APU 2 PUMP H20 LINE TEMP - PRI	67	430	67	430			45	291	°F
V46T0393A	APU 3 PUMP H20 LINE TEMP - PRI	88	667	88	667			47	497	°F
V46T0194A	APU 1 PUMP H20 LINE TEMP - SEC	91	679	91	679			51	514	°F
V46T0294A	APU 2 PUMP H20 LINE TEMP - SEC	94	692	94	692			53	522	°F
V46T0394A	APU 3 PUMP H20 LINE TEMP - SEC	99	712	99	712			55	532	°F
V46T0501A	H20 LINE TEMP 1	48	340	48	340			41	321	°F
V46T0502A	H20 LINE TEMP 2	53	354	53	354			43	327	°F
V46T0503A	H20 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 (NOMINAL) K=1		VALUE 2 (HI/LOW) K=2		VALUE 3 (OFF) K=3		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 (NOMINAL) K=1		VALUE 2 (HI/LOW) K=2		VALUE 3 (OFF) K=3		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) K=1		VALUE 2 (HI/LOW) K=2		VALUE 3 (OFF) K=3		UNITS
		FS	CTS	FS	CTS	FS	CTS	FS	CTS	
	-HYD-									
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_2O BLR GN_2 REG. OUT. PRESS. SYSTEM 1	0	0	25	342	25	342	25	342	PSIA
V58P0204A	H_2O BLR GN_2 REG. OUT. PRESS. SYSTEM 2	0	0	28	383	28	363	28	383	PSIA
V58P0304A	H_2O BLR GN_2 REG. OUT. PRESS. SYSTEM 3	0	0	27	368	27	368	27	368	PSIA
V58T0105A	H_2O BLR GN_2 TK. TEMP. SYSTEM 1	31.44	0	70.04	278	70.04	278	70.04	278	°F
V58T0205A	H_2O BLR GN_2 TK. TEMP. SYSTEM 2	31.44	0	103.05	589	103.05	589	103.05	589	°F
V58T0305A	H_2O 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 751	773 192	375	96	78	20	PSIA
*V58P0214C	SUPPLY PRESS. A SYSTEM 2	3124	799	3124 751	799 192	375	96	78	20	PSIA
*V58P0314C	SUPPLY PRESS. A SYSTEM 3	3226	825	3226 751	825 192	375	96	78	20	PSIA
V58P0115C	SUPPLY PRESS. B SYSTEM 1	3200	818	3200 752	818 192	376	96	80	20	PSIA
V58P0215C	SUPPLY PRESS. B SYSTEM 2	3000	767	3000 752	767 192	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. FS	I.C. CTS	VALUE 1 (NOMINAL) K=1 FS	VALUE 1 (NOMINAL) K=1 CTS	VALUE 2 (HI/LOW) K=2 FS	VALUE 2 (HI/LOW) K=2 CTS	VALUE 3 (OFF) K=3 FS	VALUE 3 (OFF) K=3 CTS	UNITS
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_2O BLR. GN_2 TK. PRESS SYSTEM 1	2471	722	2471	722	2471	722	2471	722	PSIA
V58P0247A	H_2O BLR. GN_2 TK. PRESS SYSTEM 2	2429	710	2429	710	2429	710	2429	710	PSIA
V58P0347A	H_2O 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_2O BLR. TK. TEMP. SYSTEM 1	31.44	0	100.08	567	55.89	152	55.89	152	°F
V58T0261A	H_2O BLR. TK. TEMP. SYSTEM 2	31.44	0	105.03	603	55.89	152	55.89	152	°F

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*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) K=1		VALUE 2 (HI/LOW) K=2		VALUE 3 (OFF) K=3		UNITS
		FS	CTS	FS	CTS	FS	CTS	FS	CTS	
V58T0361A	H_2O BLR. TK. TEMP. SYSTEM 3	31.44	0	110.01	636	55.89	152	55.89	152	°F
V58T0162A	H_2O BLR. TEMP. NO. 1 SYSTEM 1	29.96	0	82.00	405	55.86	159	55.86	159	°F
V58T0262A	H_2O BLR. TEMP. NO. 1 SYSTEM 2	29.96	0	76.90	352	55.86	159	55.86	159	°F
V58T0362A	H_2O BLR. TEMP. NO. 1 SYSTEM 3	29.96	0	71.00	292	55.86	159	55.86	159	°F
V58T0163A	H_2O BLR. TEMP. NO. 2 SYSTEM 1	29.96	0	104.95	610	55.86	159	55.86	159	°F
V58T0263A	H_2O BLR. TEMP. NO. 2 SYSTEM 2	29.96	0	95.98	539	55.86	159	55.86	159	°F
V58T0363A	H_2O BLR. TEMP. NO. 2 SYSTEM 3	29.96	0	86.03	446	55.86	159	55.86	159	°F
V58T0165A	H_2O BLR. VENT TEMP. NO. 1 SYSTEM 1	150	454	150	454	122	0	122	0	°F
V58T0265A	H_2O BLR. VENT TEMP. NO. 1 SYSTEM 2	153	503	153	503	122	0	122	0	°F
V58T0365A	H_2O BLR. VENT TEMP. NO. 1 SYSTEM 3	160	618	160	618	122	0	122	0	°F
V58T0166A	H_2O BLR. VENT TEMP. NO. 2 SYSTEM 1	155	536	155	536	122	0	122	0	°F
V58T0266A	H_2O BLR. VENT TEMP. NO. 2 SYSTEM 2	157	569	157	569	122	0	122	0	°F
V58T0366A	H_2O BLR. VENT TEMP. NO. 2 SYSTEM 3	165	698	165	698	122	0	122	0	°F
V58X0181E	H_2O BLR. BYPASS CL. IND. SYSTEM 1	0	0	1	1	0	0	0	0	STATE
V58X0281E	H_2O BLR. BYPASS CL. IND. SYSTEM 2	0	0	1	1	0	0	0	0	STATE
V58X0381E	H_2O BLR. BYPASS CL. IND. SYSTEM 3	0	0	1	1	0	0	0	0	STATE
V58X0182E	H_2O BLR. OK SYSTEM 1	0	0							STATE
V58X0282E	H_2O BLR. OK SYSTEM 2	0	0							STATE
V58X0382E	H_2O BLR. OK SYSTEM 3	0	0							STATE

MEASUREMENT OUTPUT FROM APU/HYD MODEL - TABLE 2

MEASUREMENT I. D.	MEASUREMENT NAME	I.C.		VALUE 1 (NOMINAL) K=1		VALUE 2 (HI/LOW) K=2		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	581	30	291	30	291	DEGF
V58T0298A	HYD SYS 2 RSB RETURN LINE TEMP	69	397	69	397	30	291	30	291	DEGF
V58T0398A	HYD SYS 3 RSB RETURN LINE TEMP	63	381	63	381	30	291	30	291	DEGF
V58T0288A	HYD SYS 2 BODY FLAP RTN LINE TEMP	75	413	75	413	30	291	30	291	DEGF
V58T0388A	HYD SYS 3 BODY FLAP RTN LINE TEMP	66	389	66	389	30	291	30	291	DEGF
V58T0296A	HYD SYS 2 RH BRAKE VLV RTN LN TMP	72	405	72	405	30	291	30	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	°F
V58T0841A	LH OTBD BRAKE SW. VALVE LN TEMP.	57	364	57	364	30	291	30	291	°F
V58T0842A	LH INBD BRAKE SW. VALVE LN TEMP.	54	356	54	356	30	291	30	291	°F
V58T0845A	RH OTBD BRAKE SW. VALVE LN TEMP.	51	348	51	348	30	291	30	291	°F
V58T0846A	RH INBD BRAKE SW. VALVE LN TEMP.	48	340	48	340	30	291	30	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	°F

MEASUREMENT OUTPUT FROM APU/HYD MODEL - TABLE 2

MEASUREMENT I. D.	MEASUREMENT NAME	I.C.		VALUE 1 (NOMINAL) K=1		VALUE 2 (HI/LOW) K=2		VALUE 3 (OFF) K=3		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) K=1		VALUE 2 (HI/LOW) K=2		VALUE 3 (OFF) K=3		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	[illegible]	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) K=1		VALUE 2 (HI/LOW) K=2		VALUE 3 (OFF) K=3		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 [illegible] NBD ELEV ACT	132	565							DEGF
V58T[illegible]080A	HYD SYS [illegible] 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.

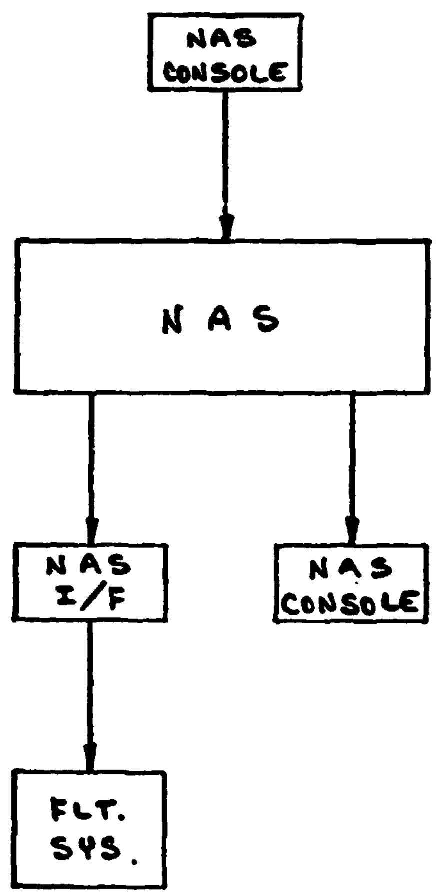


FIGURE 4 - APU/HYD DATA FLOW

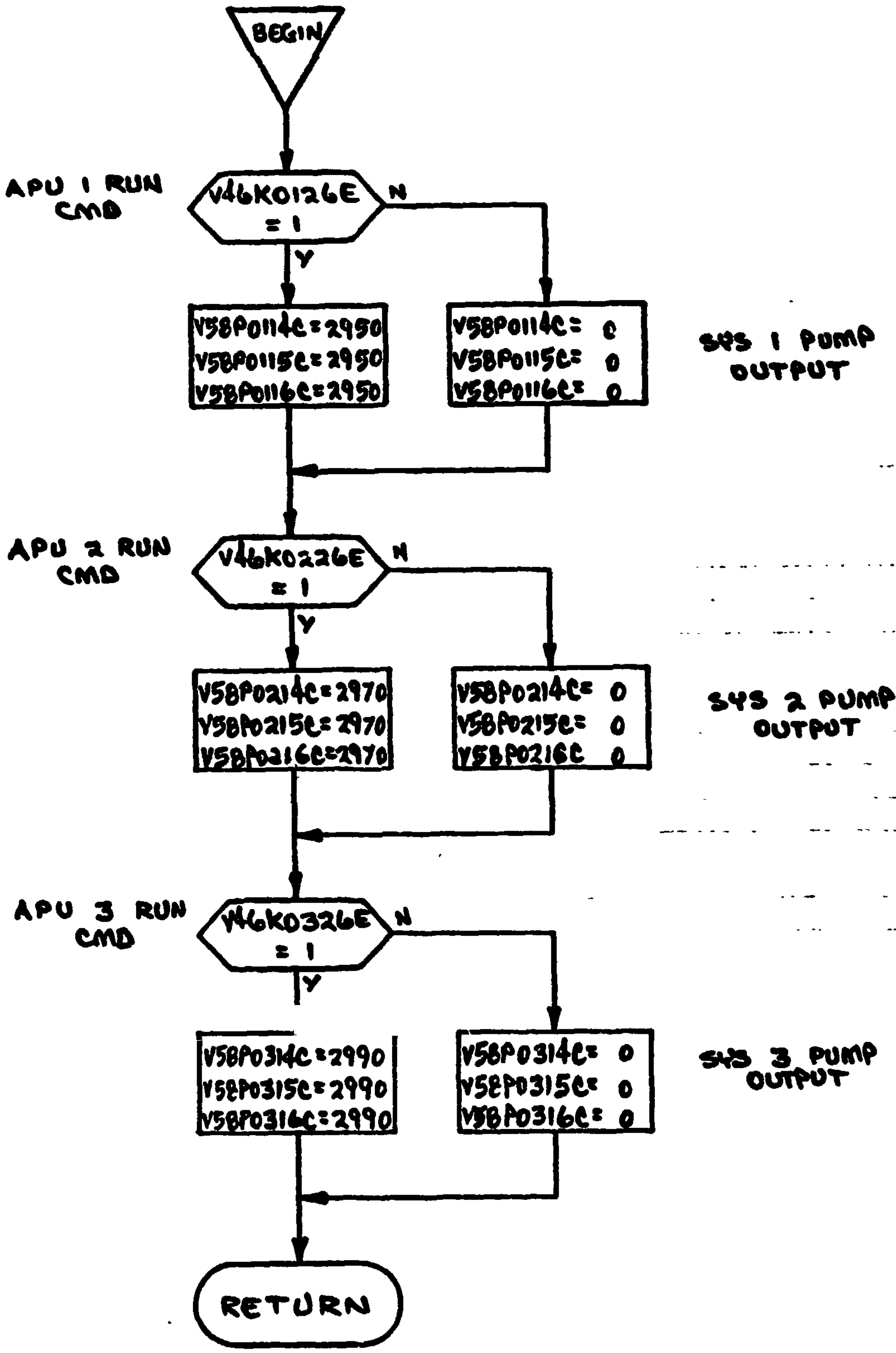
12.4 GTS TERMINATION REQUIREMENTS

None.

12.5 GTS UNIQUE REQUIREMENTS

None.

13.0 GTS LOGIC FLOW DIAGRAMS



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14.0 GTS INPUT/OUTPUT TABLES

STIMULI INPUT TO (J/HYD MODEL-TABLE 14.1

IDENTIFICATION NUMBER	NOMENCLATURE	SOURCE	STATES/RANGE		
			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 (NOMINAL) K=1		VALUE 2 (HI/LOW) K=2		VALUE 3 (OFF) K=3		UNITS
		FS	CTS	FS	CTS	FS	CTS	FS	CTS	
*V58P0114C	SUPPLY PRESS. A SYSTEM 1	0		2950						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						PSIA

*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.

FORTRAN CODING

PUNCH ____ VERIFY ____ TABULATE ____ EXECUTE ____

DATE ____ PAGE ____ IDENTIFICATION ____

FORTRAN STATEMENT

587641				XX:XX:XX
	APU/HYD S/S		MPS X-E-MS	
58P0114C	HYD SUP PRESS A SYS 1	2950	K1700X LH2 1	REPL
58P0115C	HYD SUP PRESS B SYS 1	2950	K1701X LH2 2	REPL
58P0116C	HYD SUP PRESS C SYS 1	2950	K1702X LH2 3	REPL
			K1750X LØ2 1	REPL
58P0214C	HYD SUP PRESS A SYS 2	2970	K1751X LØ2 2	REPL
58P0215C	HYD SUP PRESS B SYS 2	2970	K1752X LØ2 3	REPL
58P0216C	HYD SUP PRESS C SYS 2	2970		
			VE1XXX E-1	READY
58P0314C	HYD SUP PRESS A SYS 3	2990	VE2XXX E-2	READY
58P0315C	HYD SUP PRESS B SYS 3	2990	VE3XXX E-3	READY
58P0316C	HYD SUP PRESS C SYS 3	2990		
			K1125X MPS 1	MNSTG
	PYRØS ET SEP		K1225X MPS 2	MNSTG
			K1325X MPS 3	MNSTG
76K6909B	ET/ØRB SEPN ARM	ARM		
76K6913B	ET/ØRB SEPN FIRE	FIRE		
76V7079B	ET/ØRB P/C A VØLT	5.0		

NOTE: WRITE NUMBERS 10, LETTERS IØUGZC, SYMBOLS /.,+

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

FIGURE 5

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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

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 processin, and to responc to Shuttle commands, whether they be from cockpit switches, th. General Purpose Computers (GPC's) or the Non-Avionic Simulator (NAS) console. Figure I provides the Flight System/NAS data flow.

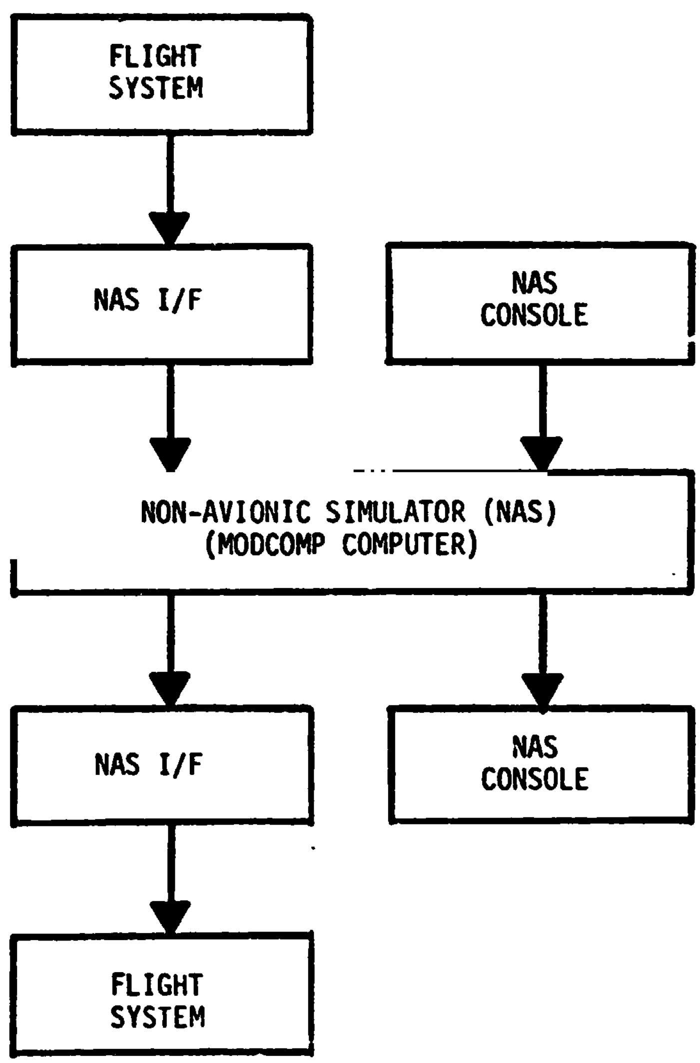


FIGURE 1 - FLIGHT SYSTEM/NAS DATA FLOW

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

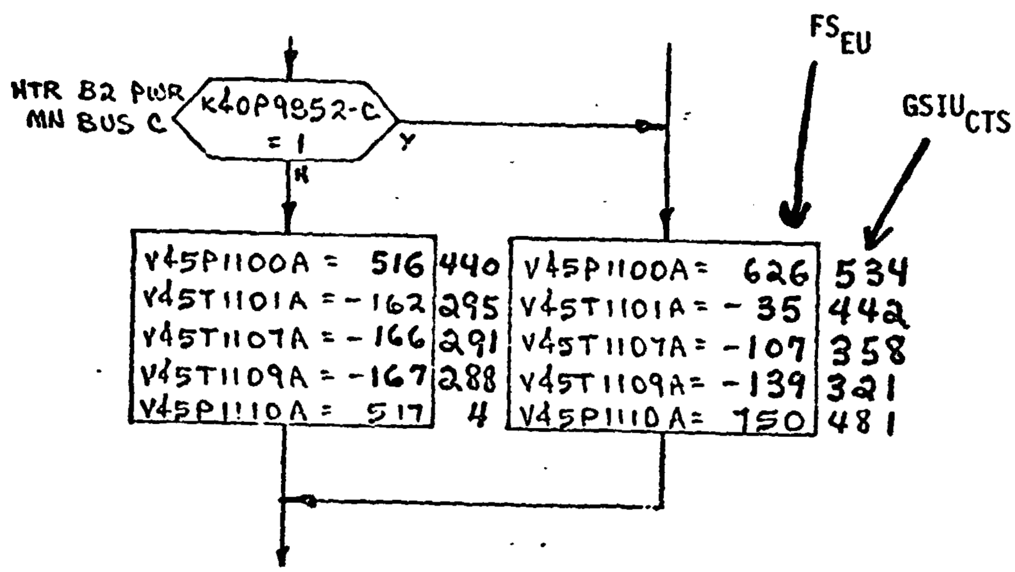
None.

2.5 UNIQUE REQUIREMENTS

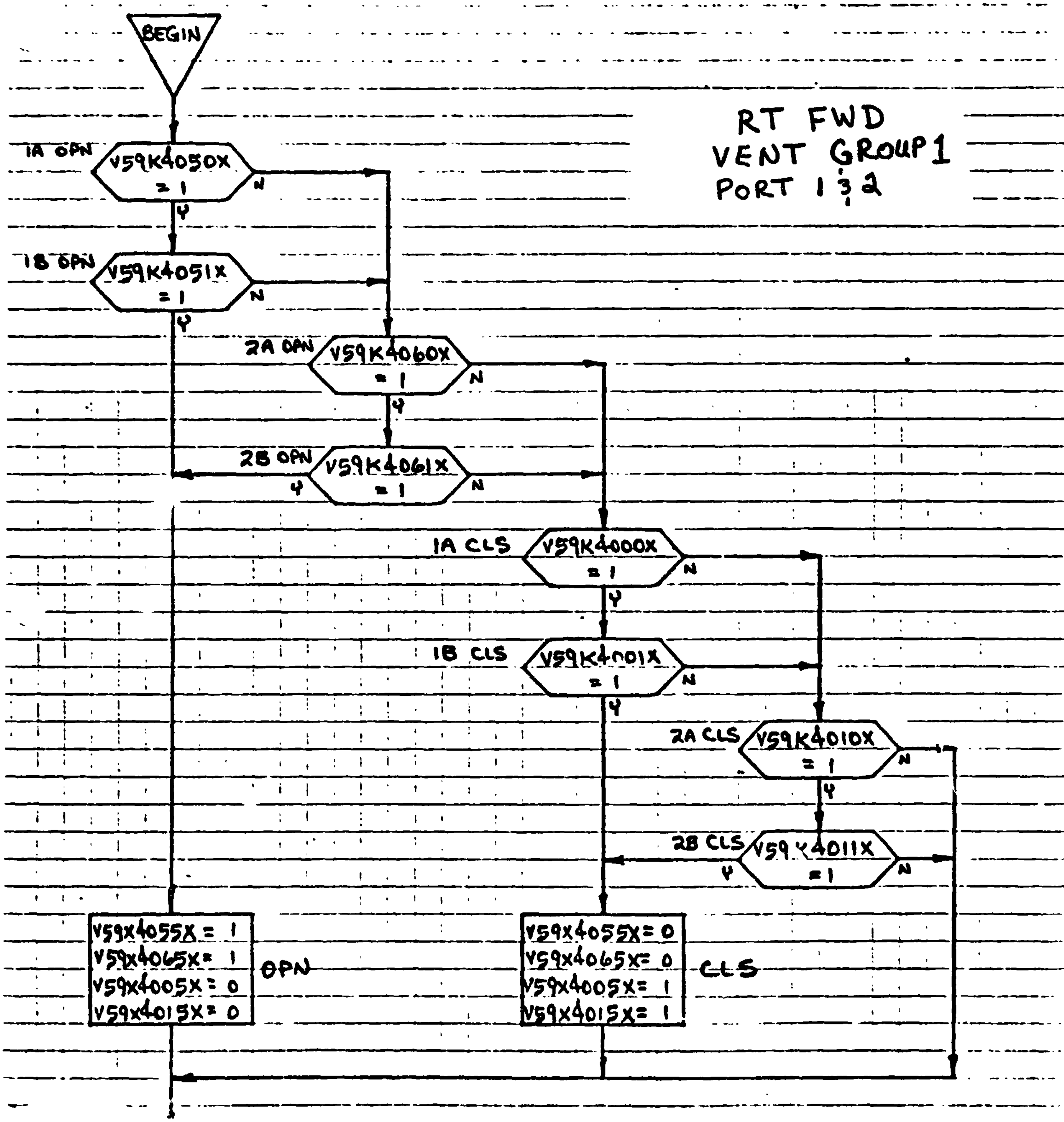
None.

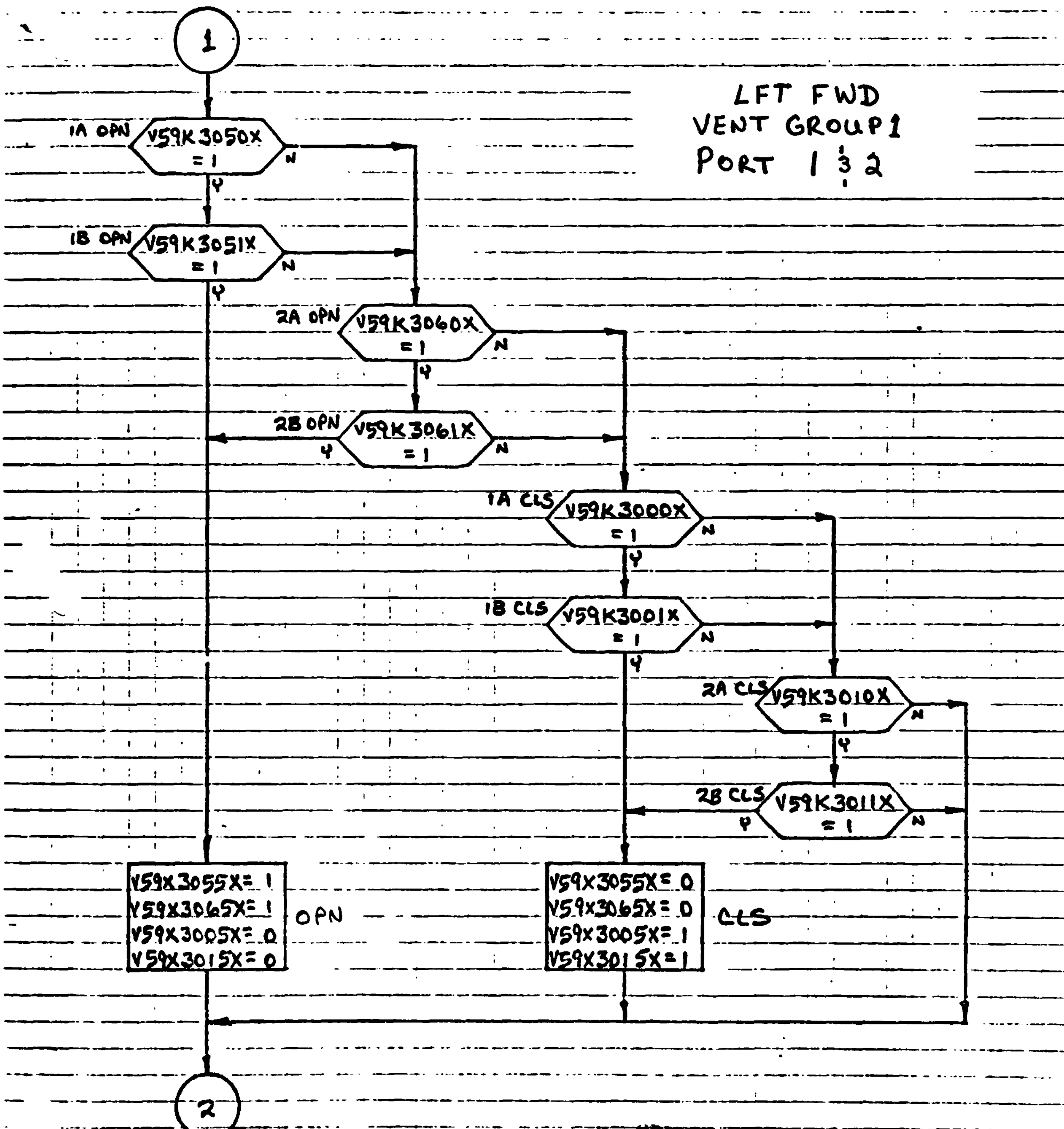
3.0 LOGIC FLOW DIAGRAMS

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 exa le, 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.


RT FWD
VENT GROUP 1
PORT 1 ; 2
BEGIN
1A OPN
V59K4050X = 1
1B OPN
V59K4051X = 1
2A OPN
V59K4060X = 1
2B OPN
V59K4061X = 1
1A CLS
V59K4000X = 1
1B CLS
V59K4001X = 1
2A CLS
V59K4010X = 1
2B CLS
V59K4011X = 1
Y
N
V59X4055X = 1
V59X4065X = 1
V59X4005X = 0
V59X4015X = 0
OPN
V59X4055X = 0
V59X4065X = 0
V59X4005X = 1
V59X4015X = 1
CLS



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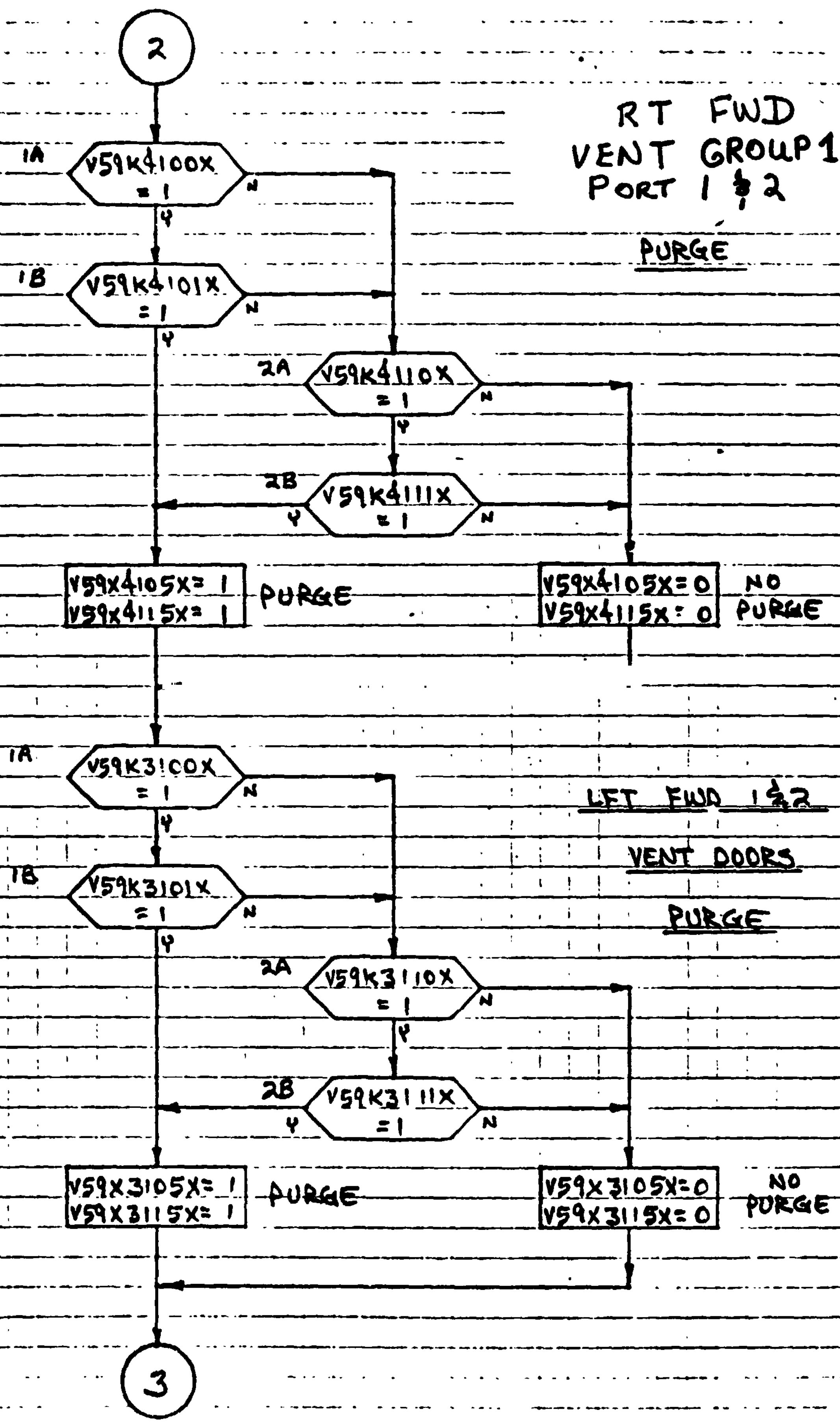
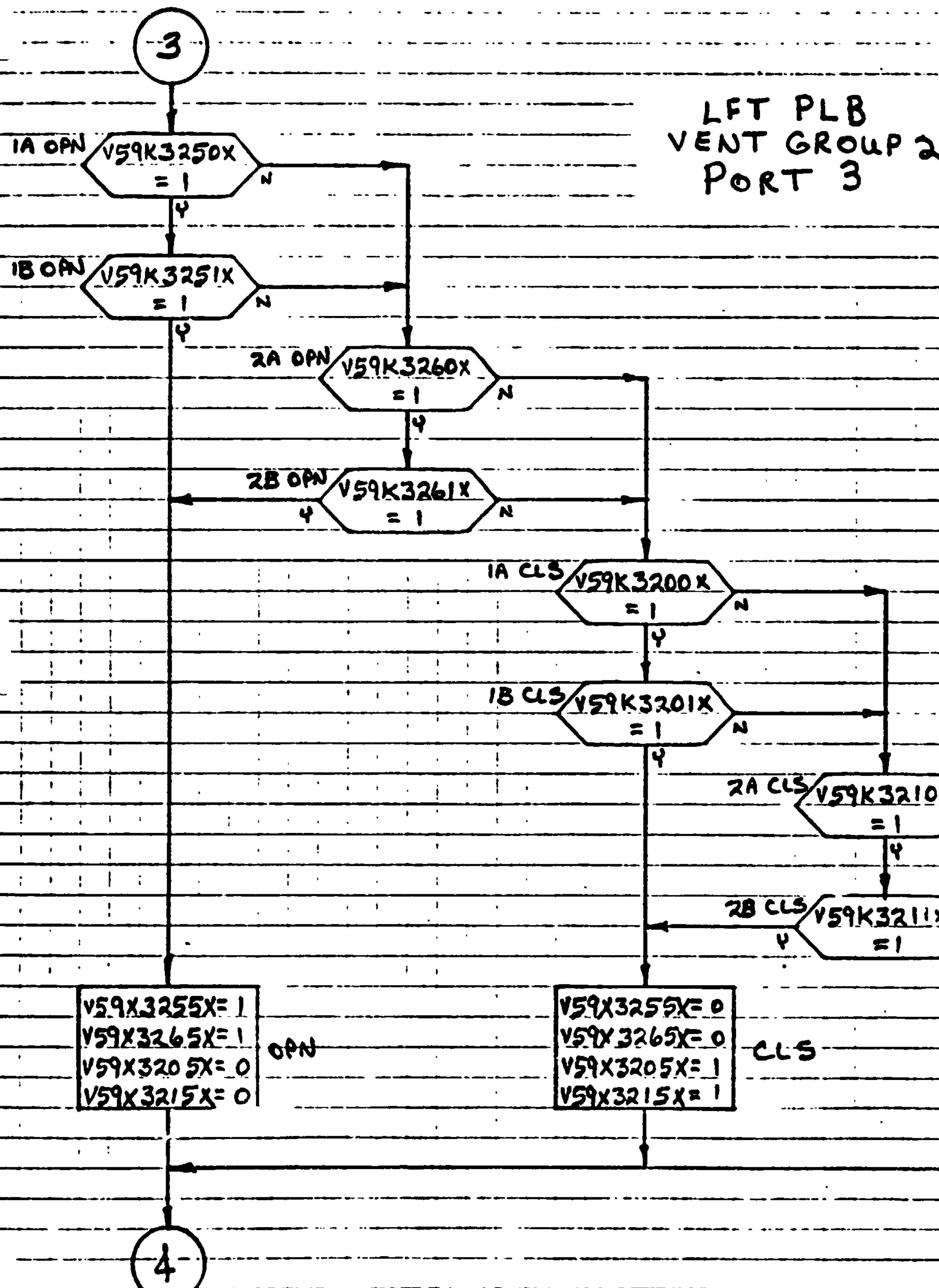
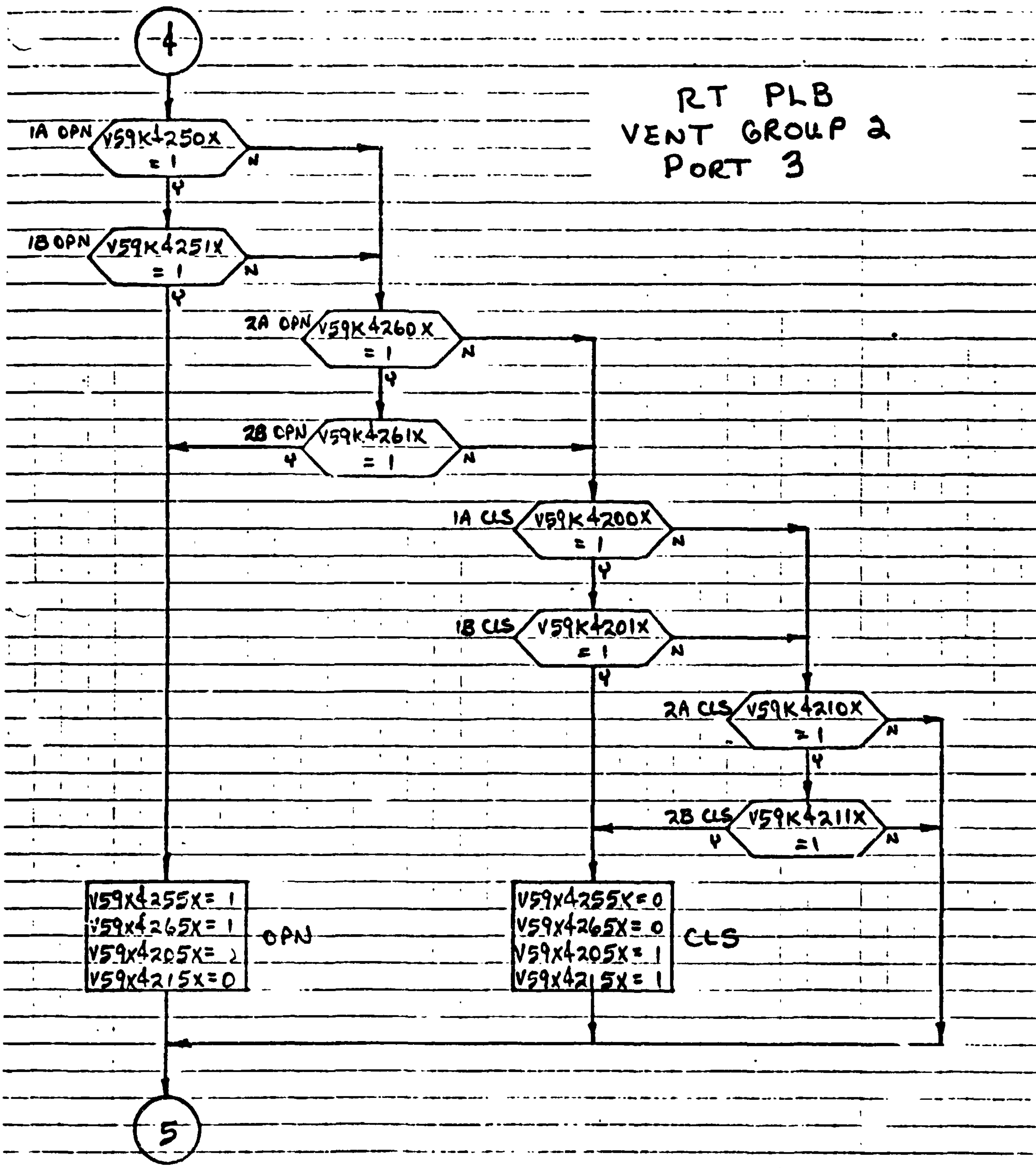
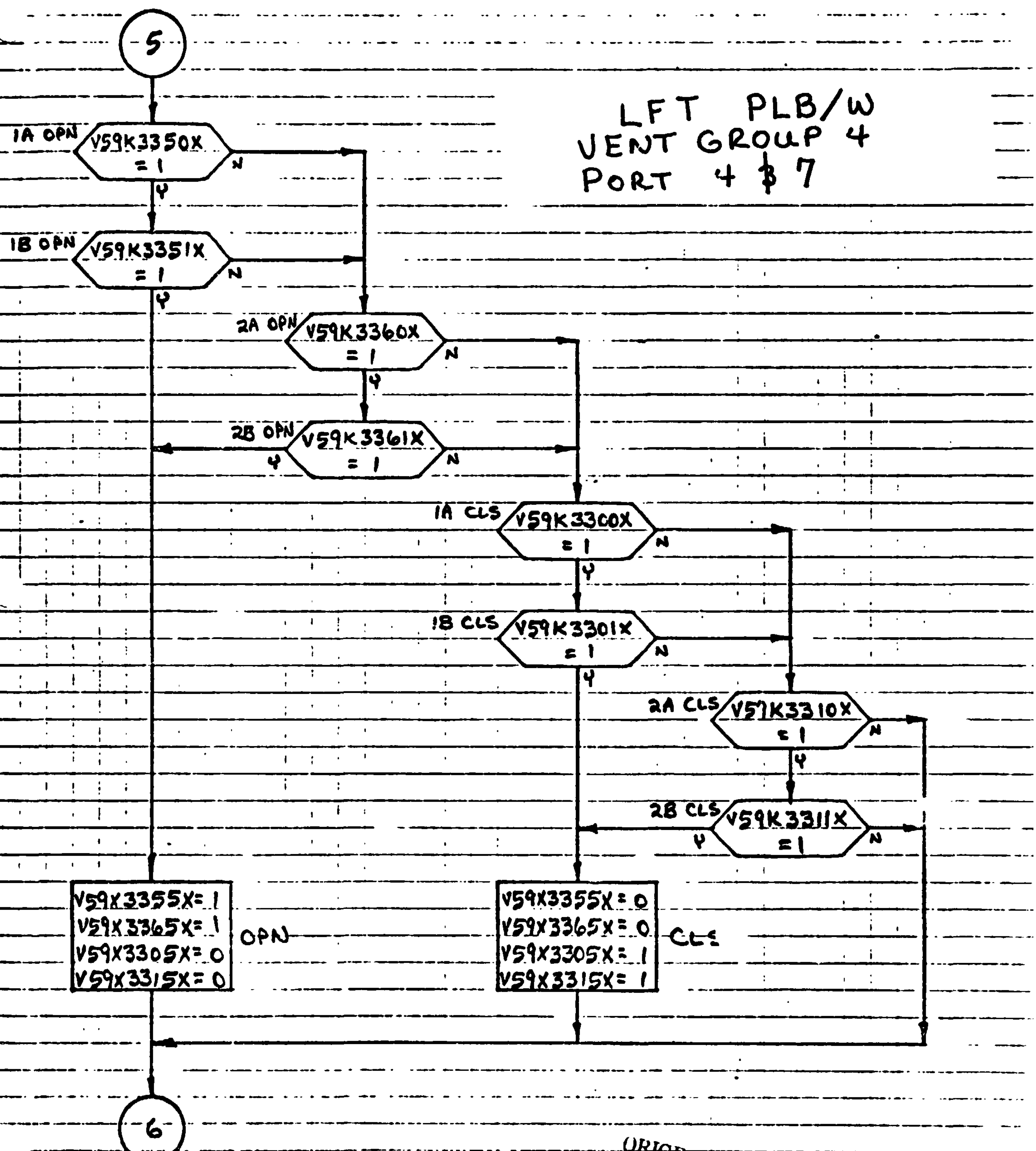

2
RT FWD
VENT GROUP 1
PORT 1 & 2
PURGE
1A
V59K4100X = 1
1B
V59K4101X = 1
2A
V59K4110X = 1
2B
V59K4111X = 1
Y
N
V59X4105X = 1
V59X4115X = 1
PURGE
V59X4105X = 0
V59X4115X = 0
NO PURGE
LFT FWD 1 & 2
VENT DOORS
PURGE
1A
V59K3100X = 1
1B
V59K3101X = 1
2A
V59K3110X = 1
2B
V59K3111X = 1
V59X3105X = 1
V59X3115X = 1
PURGE
V59X3105X = 0
V59X3115X = 0
NO PURGE
3



LFT PLB
VENT GROUP 2
PORT 3
3
1A OPN
V59K3250X = 1
1B OPN
V59K3251X = 1
2A OPN
V59K3260X = 1
2B OPN
V59K3261X = 1
1A CLS
V59K3200X = 1
1B CLS
V59K3201X = 1
2A CLS
V59K3210X = 1
2B CLS
V59K3211X = 1
Y
N
V59X3255X= 1
V59X3265X= 1
V59X3205X= 0
V59X3215X= 0
OPN
V59X3255X= 0
V59X3265X= 0
V59X3205X= 1
V59X3215X= 1
CLS
4



RT PLB
VENT GROUP 2
PORT 3
4
1A OPN
V59K4250X = 1
1B OPN
V59K4251X = 1
2A OPN
V59K4260X = 1
2B OPN
V59K4261X = 1
1A CLS
V59K4200X = 1
1B CLS
V59K4201X = 1
2A CLS
V59K4210X = 1
2B CLS
V59K4211X = 1
Y
N
V59X4255X = 1
V59X4265X = 1
V59X4205X = 2
V59X4215X = 0
OPN
V59X4255X = 0
V59X4265X = 0
V59X4205X = 1
V59X4215X = 1
CLS
5



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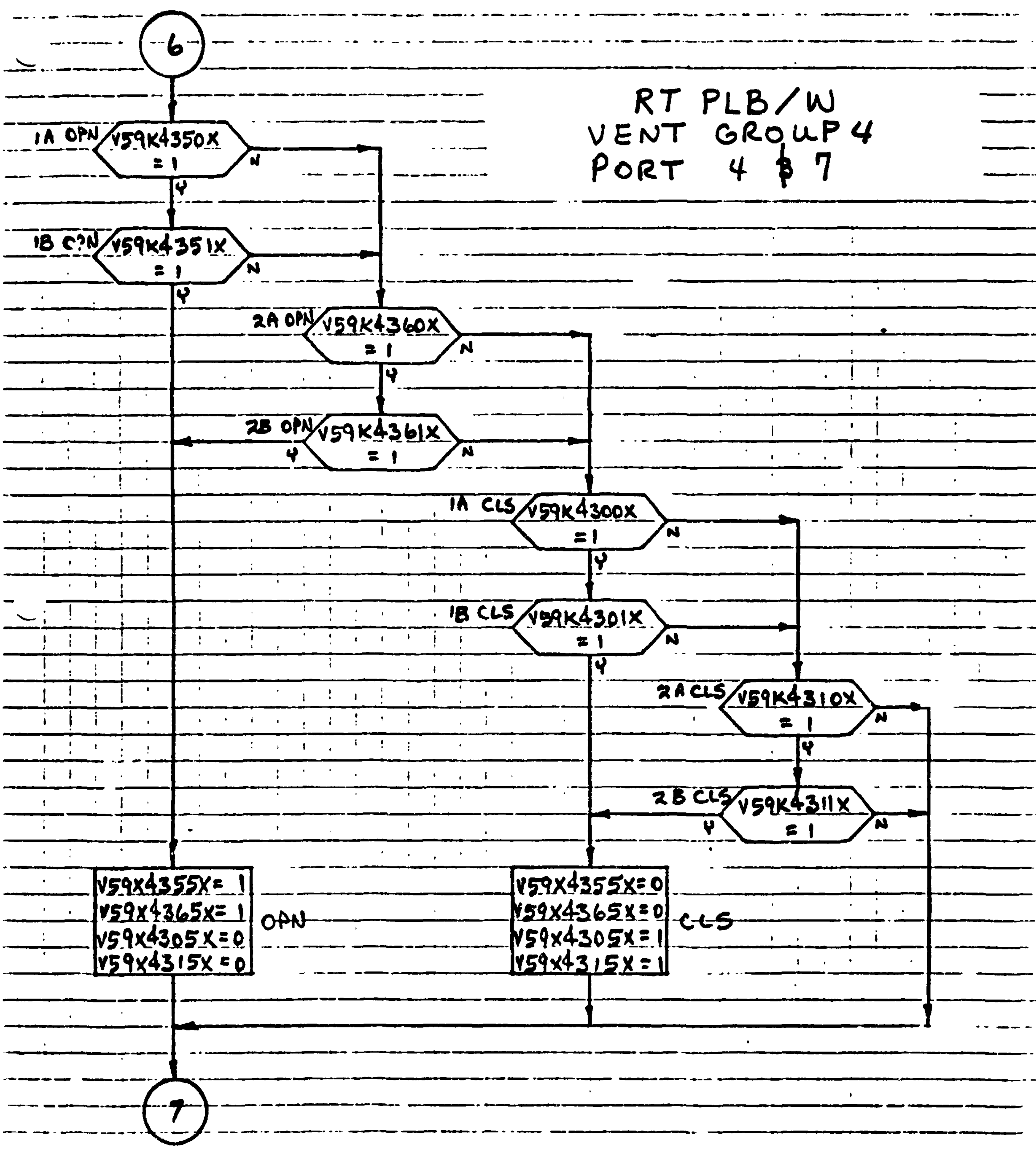
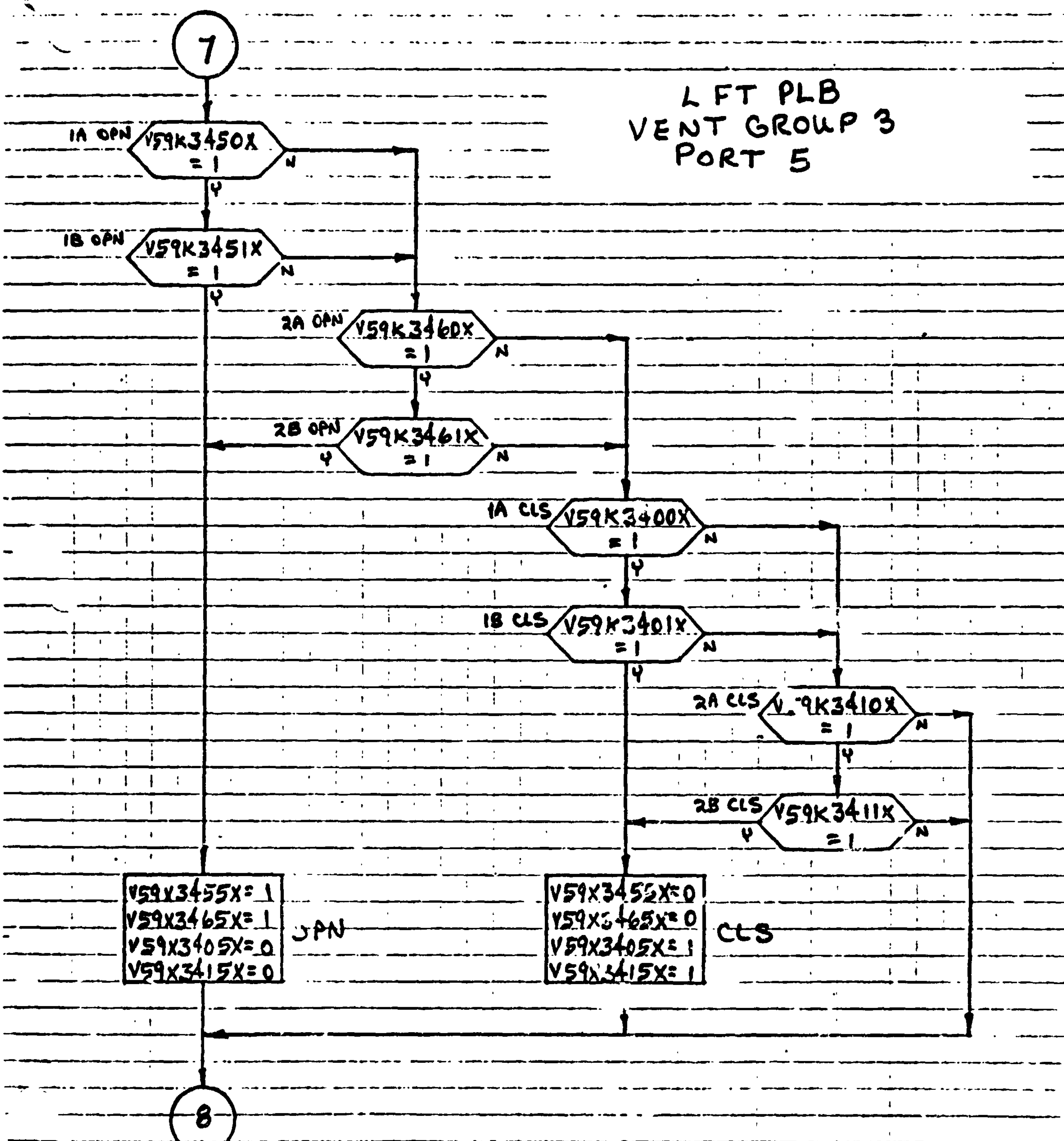
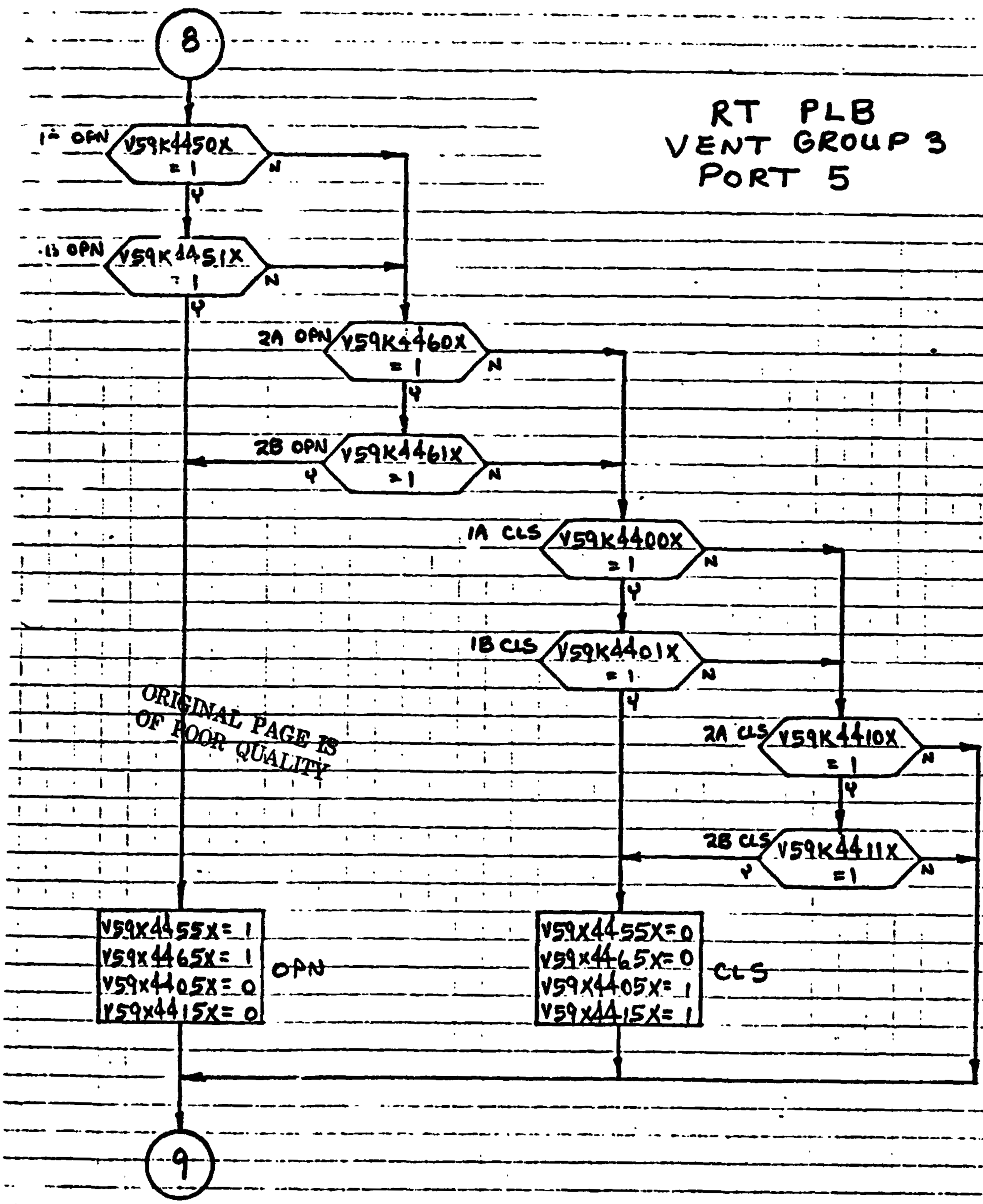


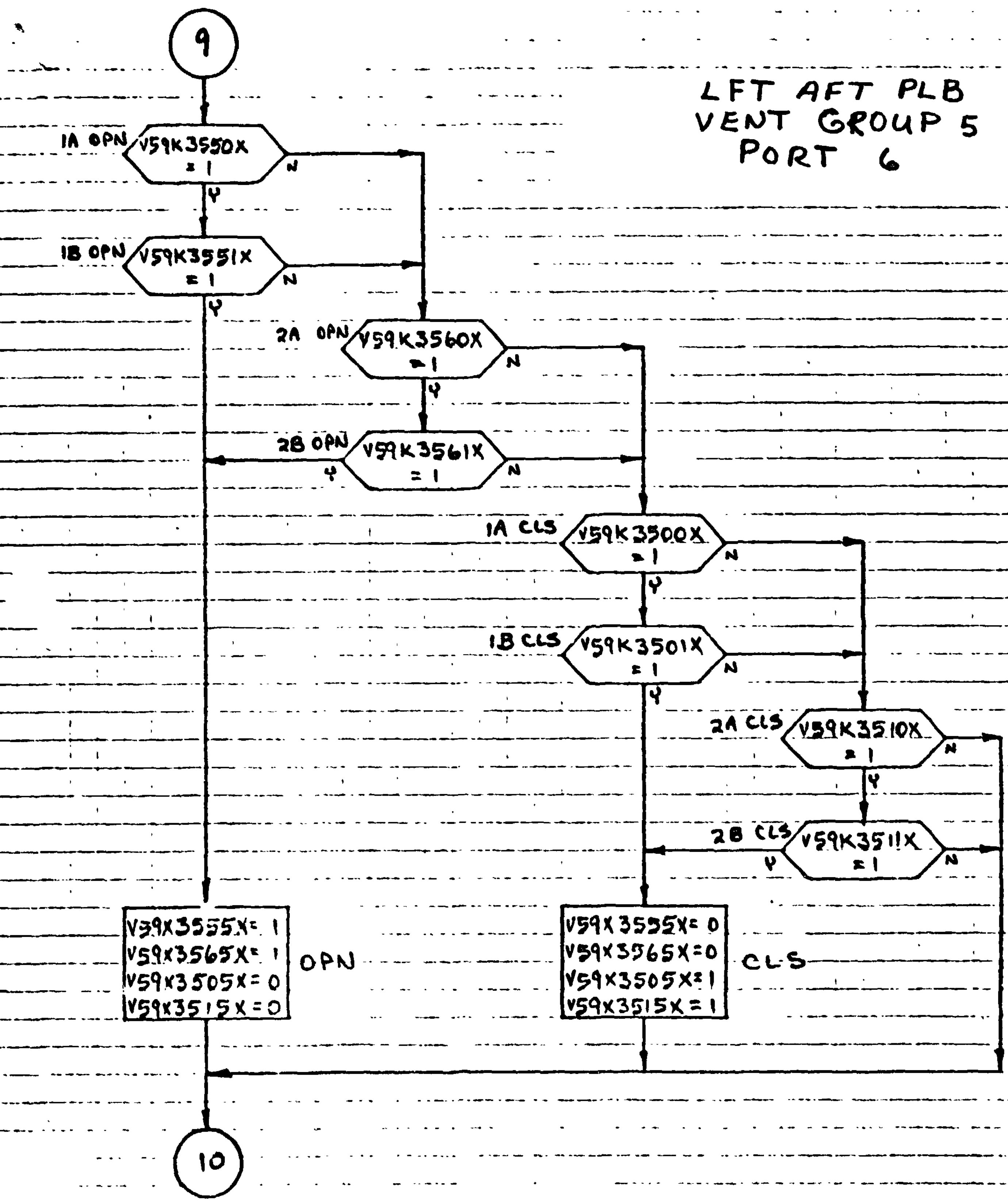
RT PLB/W
VENT GROUP 4
PORT 4 & 7
6
1A OPN V59K4350X = 1
1B OPN V59K4351X = 1
2A OPN V59K4360X = 1
2B OPN V59K4361X = 1
1A CLS V59K4300X = 1
1B CLS V59K4301X = 1
2A CLS V59K4310X = 1
2B CLS V59K4311X = 1
Y
N
V59X4355X= 1
V59X4365X= 1
V59X4305X=0
V59X4315X=0
OPN
V59X4355X=0
V59X4365X=0
V59X4305X=1
V59X4315X=1
CLS
7

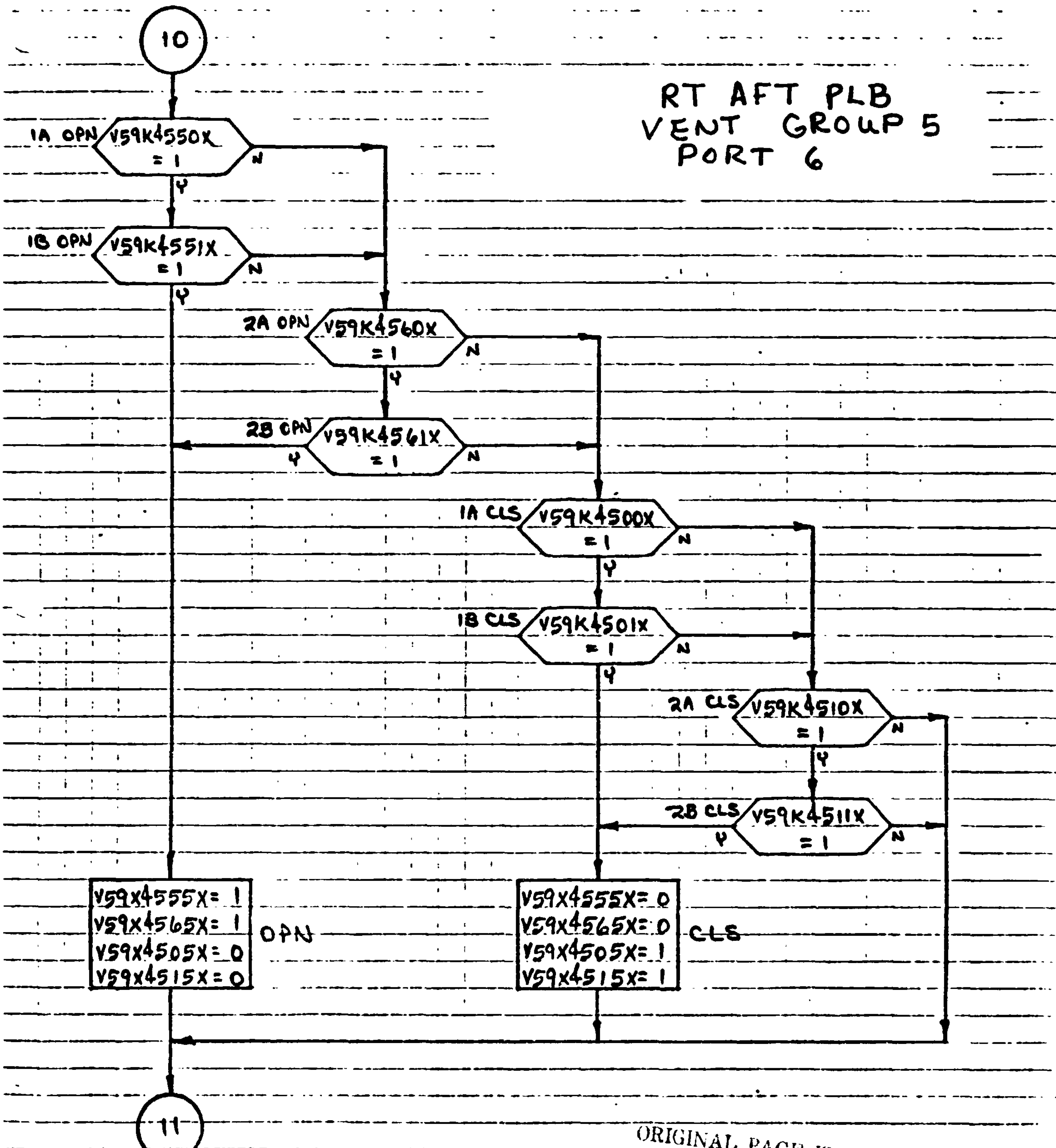


LFT PLB
VENT GROUP 3
PORT 5
7
1A OPN
V59K3450X = 1
1B OPN
V59K3451X = 1
2A OPN
V59K3460X = 1
2B OPN
V59K3461X = 1
1A CLS
V59K3400X = 1
1B CLS
V59K3401X = 1
2A CLS
V59K3410X = 1
2B CLS
V59K3411X = 1
Y
N
V59X3455X= 1
V59X3465X= 1
V59X3405X= 0
V59X3415X= 0
OPN
V59X3455X= 0
V59X3465X= 0
V59X3405X= 1
V59X3415X= 1
CLS
8



RT PLB
VENT GROUP 3
PORT 5
8
1A OPN
V59K4450X = 1
1B OPN
V59K4451X = 1
2A OPN
V59K4460X = 1
2B OPN
V59K4461X = 1
1A CLS
V59K4400X = 1
1B CLS
V59K4401X = 1
2A CLS
V59K4410X = 1
2B CLS
V59K4411X = 1
Y
N
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
9
1A OPN
V59K3550X
= 1
1B OPN
V59K3551X
= 1
2A OPN
V59K3560X
= 1
2B OPN
V59K3561X
= 1
1A CLS
V59K3500X
= 1
1B CLS
V59K3501X
= 1
2A CLS
V59K3510X
= 1
2B CLS
V59K3511X
= 1
Y
N
V59X3555X= 1
V59X3565X= 1
V59X3505X= 0
V59X3515X= 0
OPN
V59X3555X= 0
V59X3565X= 0
V59X3505X= 1
V59X3515X= 1
CLS
10



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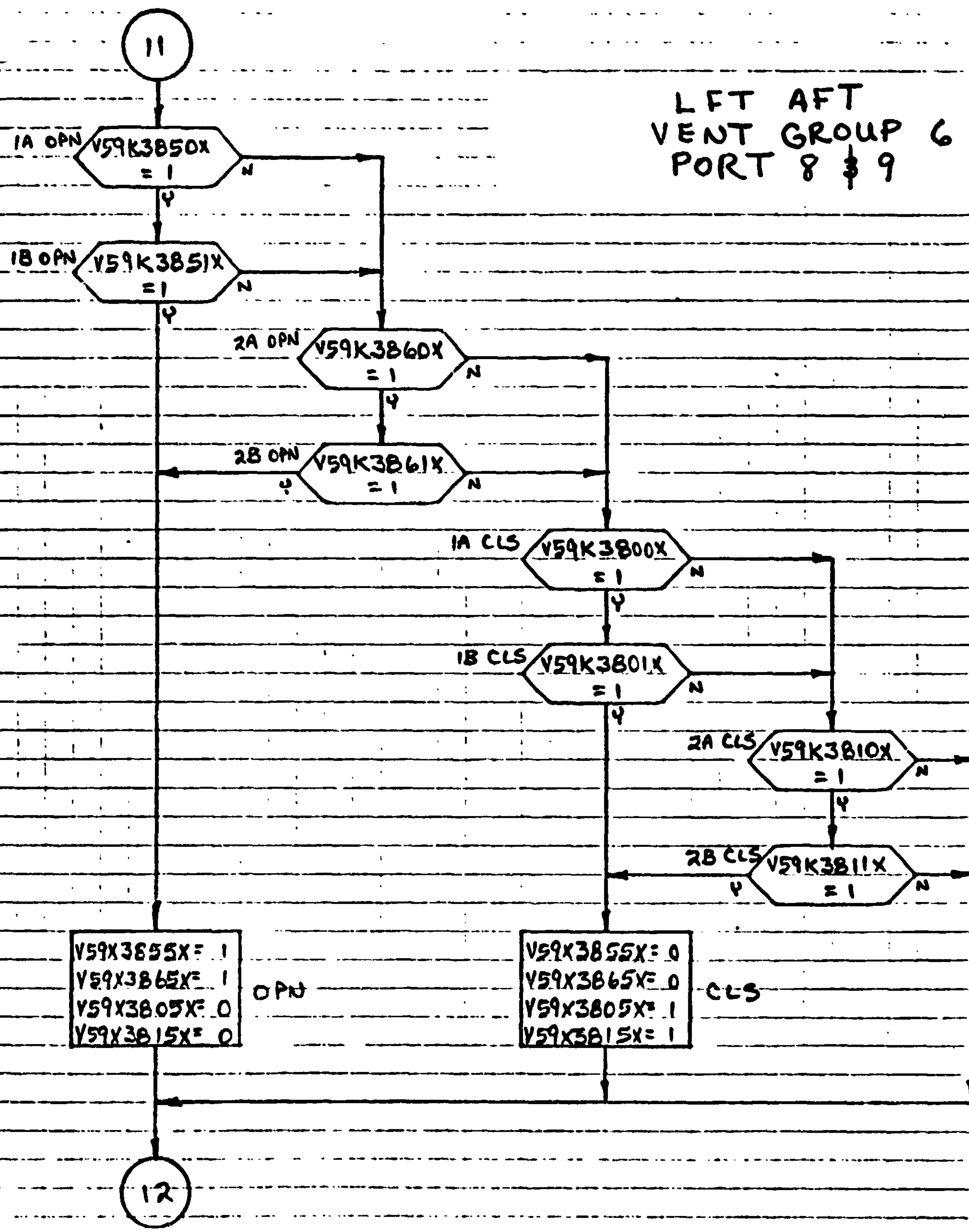
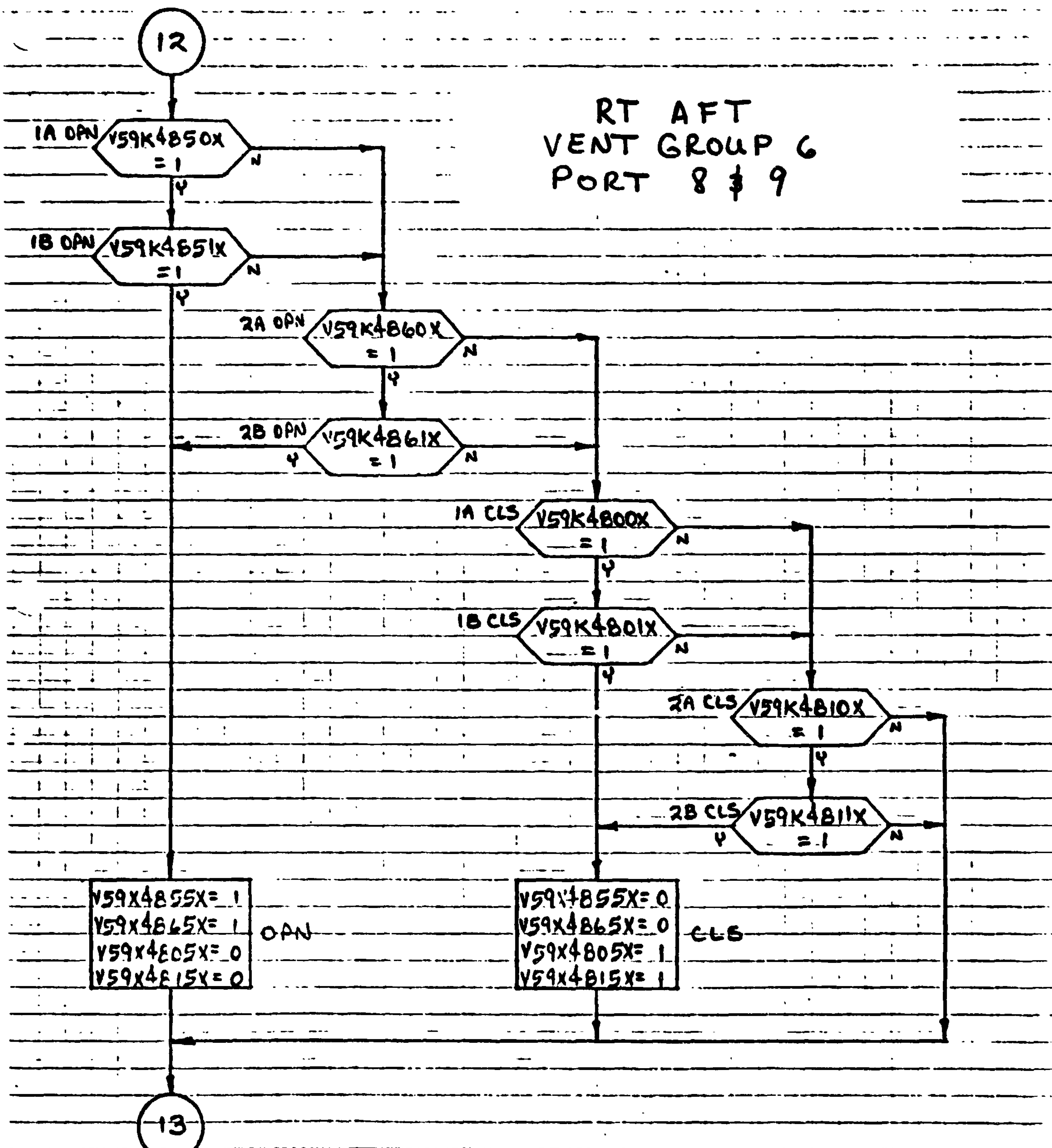
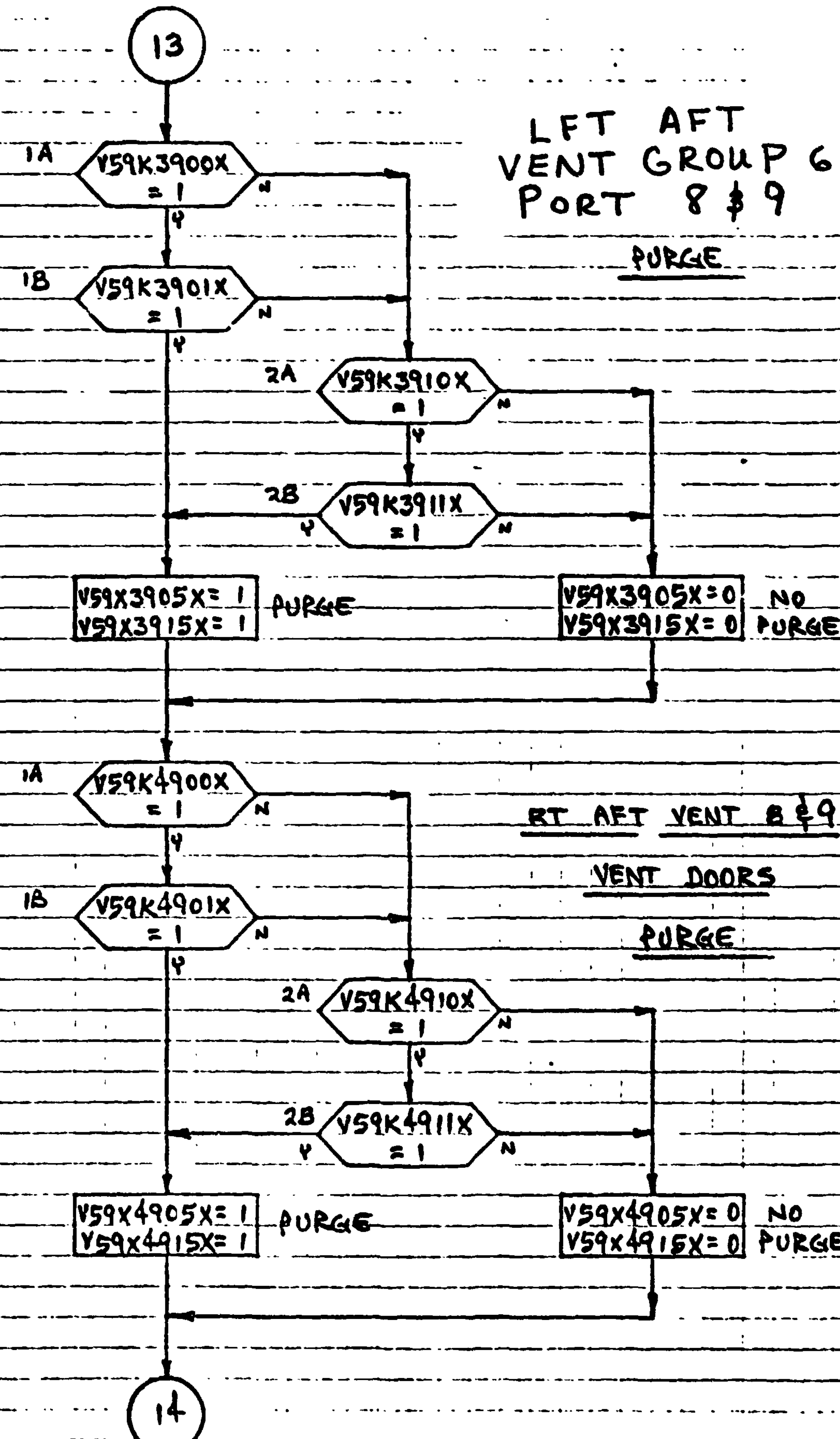
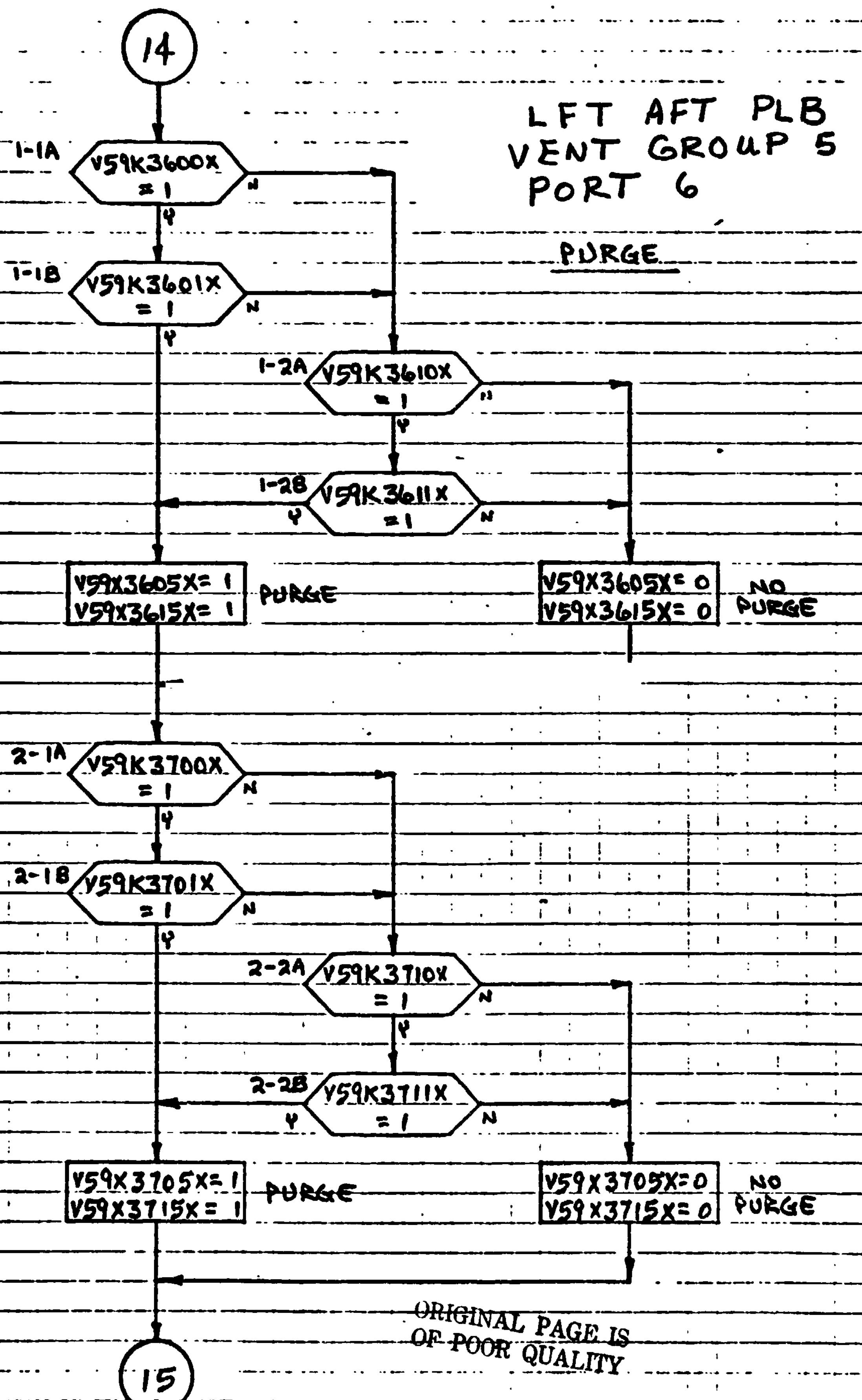
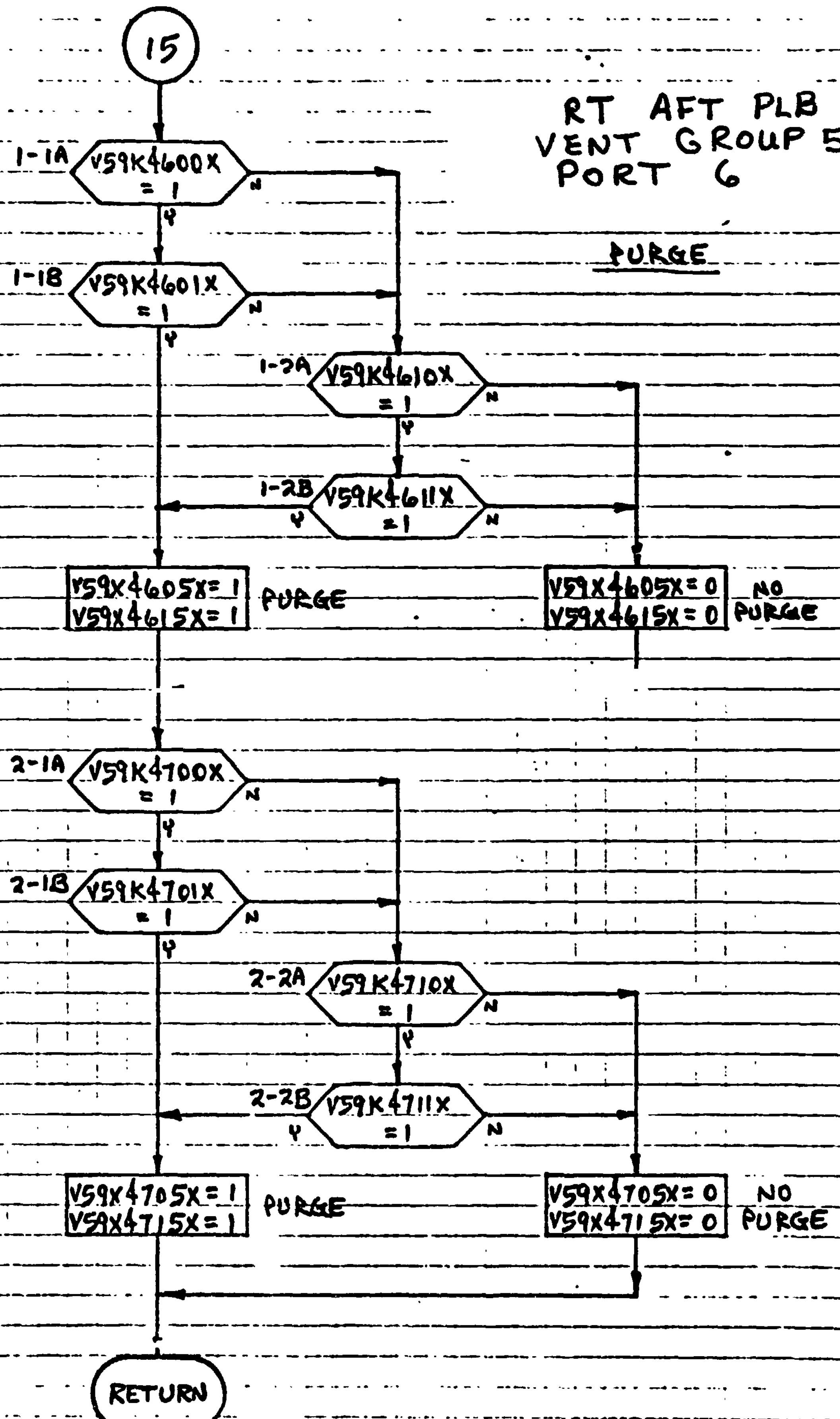

LFT AFT
VENT GROUP 6
PORT 8 & 9
11
1A OPN
V59K3850X = 1
1B OPN
V59K3851X = 1
2A OPN
V59K3860X = 1
2B OPN
V59K3861X = 1
1A CLS
V59K3800X = 1
1B CLS
V59K3801X = 1
2A CLS
V59K3810X = 1
2B CLS
V59K3811X = 1
Y
N
V59X3855X = 1
V59X3865X = 1
V59X3805X = 0
V59X3815X = 0
OPN
V59X3855X = 0
V59X3865X = 0
V59X3805X = 1
V59X3815X = 1
CLS
12


12
RT AFT
VENT GROUP 6
PORT 8 $ 9
1A OPN
V59K4850X = 1
Y
N
1B OPN
V59K4851X = 1
2A OPN
V59K4860X = 1
2B OPN
V59K4861X = 1
1A CLS
V59K4800X = 1
1B CLS
V59K4801X = 1
2A CLS
V59K4810X = 1
2B CLS
V59K4811X = 1
V59X4855X= 1
V59X4865X= 1
V59X4805X= 0
V59X4815X= 0
OPN
V59X4855X= 0
V59X4865X= 0
V59X4805X= 1
V59X4815X= 1
CLS
13


LFT AFT
VENT GROUP 6
PORT 8 & 9
PURGE
13
1A
V59K3900X = 1
1B
V59K3901X = 1
2A
V59K3910X = 1
2B
V59K3911X = 1
V59X3905X = 1
V59X3915X = 1
PURGE
V59X3905X = 0
V59X3915X = 0
NO PURGE
RT AFT VENT 8 & 9
VENT DOORS
PURGE
1A
V59K4900X = 1
1B
V59K4901X = 1
2A
V59K4910X = 1
2B
V59K4911X = 1
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
1-1B
V59K3601X = 1
1-2A
V59K3610X = 1
1-2B
V59K3611X = 1
Y
N
V59X3605X= 1
V59X3615X= 1
PURGE
V59X3605X= 0
V59X3615X= 0
NO PURGE
2-1A
V59K3700X = 1
2-1B
V59K3701X = 1
2-2A
V59K3710X = 1
2-2B
V59K3711X = 1
V59X3705X= 1
V59X3715X= 1
PURGE
V59X3705X= 0
V59X3715X= 0
NO PURGE
15


15
RT AFT PLB
VENT GROUP 5
PORT 6
PURGE
1-1A
V59K4600X = 1
1-1B
V59K4601X = 1
1-2A
V59K4610X = 1
1-2B
V59K4611X = 1
V59X4605X = 1
V59X4615X = 1
PURGE
V59X4605X = 0
V59X4615X = 0
NO PURGE
2-1A
V59K4700X = 1
2-1B
V59K4701X = 1
2-2A
V59K4710X = 1
2-2B
V59K4711X = 1
V59X4705X = 1
V59X4715X = 1
PURGE
V59X4705X = 0
V59X4715X = 0
NO PURGE
RETURN

4.0 INPUT/OUTPUT TABLES

TABLE 4.1 - .PUT STIMULI

IDENTIFICATION NUMBER	NOMENCLATURE	ADDRESS	STATES/RANGE LO	STATES/RANGE HI	STATES/RANGE UNITS
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		
			LO	HI	UNITS
V59K4250X	RT PLB/WING 3ACT/B1 OPEN 1A CMD	FROM F.S.	0	1	STATE
V59K4251X	RT PLB/WING 3ACT/B1 OPEN 1B CMD				
V59K4200X	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				
V59K3300X	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				
V59K3411X	LFT PLB/WING 5ACT/B2 CLOSE 2B CMD	FROM F.S.	0	1	STATE

TABLE 4.1 - INPUT STIMULI (CONTINUED)

IDENTIFICATION NUMBER	NOMENCLATURE	ADDRESS	STATES/RANGE		
			LO	HI	UNITS
V59K4460X	RT PLB/WING 5ACT/B2 OPEN 2A CMD	FROM F.S.	0	1	STATE
V59K4461X	RT PLB/WING 5ACT/B2 OPEN 2B CMD				
V59K4410X	RT PLB/WING 5ACT/B2 CLOSE 2A CMD				
V59K4411X	RT PLB/WING 5ACT/B2 CLOSE 2B CMD				
V59K4450X	RT PLB/WING 5ACT/B1 OPEN 1A CMD				
V59K4451X	RT PLB/WING 5ACT/B1 OPEN 1B CMD				
V59K4400X	RT PLB/WING 5ACT/B1 CLOSE 1A CMD				
V59K4401X	RT PLB/WING 5ACT/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				
V59K4701X	RT AFT PLB 6ACT/B1 PURGE 2-2B CMD	FROM F.S.	0	1	STATE

TABLE 4.1 - INPUT STIMULI (CONTINUED)

IDENTIFICATION NUMBER	NOMENCLATURE	ADDRESS	STATES/RANGE		
			LO	HI	UNITS
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 8&9 ACT/B1 OPEN 1A CMD				
V59K3851X	LFT AFT VENT 8&9 ACT/B1 OPEN 1B CMD				
V59K3800X	LFT AFT VENT 8&9 ACT/B1 CLOSE 1A CMD				
V59K3801X	LFT AFT VENT 8&9 ACT/B1 CLOSE 1B CMD				
V59K3900X	LFT AFT VENT 8&9 ACT/B1 PURGE 1A CMD				
V59K3901X	LFT AFT VENT 8&9 ACT/B1 PURGE 1B CMD				
V59K3860X	LFT AFT VENT 8&9 ACT/B2 OPEN 2A CMD				
V59K3861X	LFT AFT VENT 8&9 ACT/B2 OPEN 2B CMD				
V59K3810X	LFT AFT VENT 8&9 ACT/B2 CLOSE 2A CMD				
V59K3811X	LFT AFT VENT 8&9 ACT/B2 CLOSE 2B CMD				
V59K3910X	LFT AFT VENT 8&9 ACT/B2 PURGE 2A CMD				
V59K3911X	LFT AFT VENT 8&9 ACT/B2 PURGE 2B CMD				
V59K4850X	RT AFT VENT 8&9 ACT/B1 OPEN 1A CMD				
V59K4851X	RT AFT VENT 8&9 ACT/B1 OPEN 1B CMD				
V59K4800X	RT AFT VENT 8&9 ACT/B1 CLOSE 1A CMD				
V59K4801X	RT AFT VENT 8&9 ACT/B1 CLOSE 1B CMD				
V59K4900X	RT AFT VENT 8&9 ACT/B1 PURGE 1A CMD				
V59K4901X	RT AFT VENT 8&9 ACT/B1 PURGE 1B CMD				
V59K4860X	RT AFT VENT 8&9 ACT/B2 OPEN 2A CMD				
V59K4861X	RT AFT VENT 8&9 ACT/B2 OPEN 2B CMD				
V59K4810X	RT AFT VENT 8&9 ACT/B2 CLOSE 2A CMD				
V59K4811X	RT AFT VENT 8&9 ACT/B2 CLOSE 2B CMD				
V59K4910X	RT AFT VENT 8&9 ACT/B2 PURGE 2A CMD				
V59K4911X	RT AFT VENT 8&9 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					STATE

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					
[illegible]X4915X	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					STATE

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					STATE

4.3 NAS CRT DISPLAYS

PROGRAM ____________ FORTRAN-FAP CODING DATE ______

CODED BY ____________ PAGE ____ OF ____

PUNCH ______ VERIFY ______ TABULATE ______ EXECUTE ______ IDENTIFICATION ______

```
V59012   RT FWD 1/2                 RT FWD 1/2                     LF FWD 1/2              XX:XX:XX
         ----------                 ----------                     ----------

 K4000X  CL 1A   CLØSE     K4100X  PG 1A   PURGE        K3050X  ØP 1A   ØPEN
*K4001X  CL 1B   CLØSE    *K4101X  PG 1B   PURGE       *K3051X  ØP 1B   ØPEN
         +                         +                            +
 K4010X  CL 2A   CLØSE     K4110X  PG 2A   PURGE        K3060X  ØP 2A   ØPEN
*K4011X  CL 2B   CLØSE    *K4111X  PG 2B   PURGE       *K3061X  ØP 2B   ØPEN
 X4005X  CLIND   CLØSED    X4105X  PGIND   PURGE        X3055X  ØPIND   ØPENED
*X4015X  CLIND   CLØSED   *X4115X  PGIND   PURGE       *X3065X  ØPIND   ØPENED
                                   ----------
 K4050X  ØP 1A   ØPEN              LF FWD 1/2           K3100X  PG 1A   PURGE
*K4051X  ØP 1B   ØPEN              ----------          *K3101X  PG 1B   PURGE
         +                 K3000X  CL 1A   CLØSE                +
 K4060X  ØP 2A   ØPEN     *K3001X  CL 1B   CLØSE        K3110X  PG 2A   PURGE
*K4061X  ØP 2B   ØPEN              +                   *K3111X  PG 2B   PURGE
 X4055X  ØPIND   ØPENED    K3010X  CL 2A   CLØSE        X3105X  PGIND   PURGE
*X4065X  ØPIND   ØPENED   *K3011X  CL 2B   CLØSE       *X3115X  PGIND   PURGE
                           X3005X  CLIND   CLØSED
                          *X3015X  CLIND   CLØSED
```

JSC Form 244 (Dec 65)

NOTE: WRITE NUMBERS 10, LETTERS IØUGZC, SYMBOLS /.,*

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

(* - LOGICAL AND)
(+ - LOGICAL OR)

FORTRAN-FAP CODING

PROGRAM ____ CODED BY ____ + OR C

PUNCH ____ VERIFY ____ TABULATE ____ EXECUTE ____

DATE ____ PAGE ____ OF ____ IDENTIFICATION ____

STATEMENT NUMBER / LOCATION	OPERATION		VARIABLE FIELD		COMMENTS		IDENTIFICATION
V59347	LT PLB/WG 3		RT PLB/WG 3		LF PLB/WG 4/7		XX:XX:XX
K3200X	CL 1A	CLØSE	K4200X CL 1A	CLØSE	K3300X CL 1A	CLØSE	
*K3201X	CL 1B	CLØSE	*K4201X CL 1B	CLØSE	*K3301X CL 1B	CLØSE	
	+		+		+		
K3210X	CL 2A	CLØSE	K4210X CL 2A	CLØSE	K3310X CL 2A	CLØSE	
*K3211X	CL 2B	CLØSE	*K4211X CL 2B	CLØSE	*K3311X CL 2B	CLØSE	
X3205X	CLIND	CLØSED	X4205X CLIND	CLØSED	X3305X CLIND	CLØSED	
*X3215X	CLIND	CLØSED	*X4215X CLIND	CLØSED	*X3315X CLIND	CLØSED	
K3250X	ØP 1A	ØPEN	K4250X ØP 1A	ØPEN	K3350X ØP 1A	ØPEN	
*K3251X	ØP 1B	ØPEN	*K4251X ØP 1B	ØPEN	*K3351X ØP 1B	ØPEN	
	+		+		+		
K3260X	ØP 2A	ØPEN	K4260X ØP 2A	ØPEN	K3360X ØP 2A	ØPEN	
*K3261X	ØP 2B	ØPEN	*K4261X ØP 2B	ØPEN	*K3361X ØP 2B	ØPEN	
X3255X	ØPIND	ØPENED	X4255X ØPIND	ØPENED	X3355X ØPIND	ØPENED	
*X3265X	ØPIND	ØPENED	*X4265X ØPIND	ØPENED	*X3365X ØPIND	ØPENED	

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NOTE: WRITE NUMBERS 10, LETTERS IØUGZC, SYMBOLS /.,*

NASA

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PUNCH ____ VERIFY ____ TABULATE ____ EXECUTE ____

DATE ____ PAGE ____ OF ____ IDENTIFICATION ____

```
STATEMENT NUMBER / LOCATION | OPERATION | VARIABLE FIELD | COMMENTS          | IDENT.
V59473   RT PLB/WG 4/7            LF PLB/WG 5            RT PLB/WG 5      XX:XX :XX
         ------------------       --------------         --------------
K4300X   CL 1A  CLØSE      K3400X  CL 1A  CLØSE    K4400X  CL 1A  CLØSE
*K4301X  CL 1B  CLØSE     *K3401X  CL 1B  CLØSE   *K4401X  CL 1B  CLØSE
         +                         +                       +
K4310X   CL 2A  CLØSE      K3410X  CL 2A  CLØSE    K4410X  CL 2A  CLØSE
*K4311X  CL 2B  CLØSE     *K3411X  CL 2B  CLØSE   *K4411X  CL 2B  CLØSE
X4305X   CLIND  CLØSED     K3405X  CLIND  CLØSED   X4405X  CLIND  CLØSED
*X4315X  CLIND  CLØSED    *K3415X  CLIND  CLØSED  *X4415X  CLIND  CLØSED

K4350X   ØP 1A  ØPEN       K3450X  ØP 1A  ØPEN     K4350X  ØP 1A  ØPEN
*K4351X  ØP 1B  ØPEN      *K3451X  ØP 1B  ØPEN    *K4351X  ØP 1B  ØPEN
         +                         +                       +
K4360X   ØP 2A  ØPEN       K3460X  ØP 2A  ØPEN     K4360X  ØP 2A  ØPEN
*K4361X  ØP 2B  ØPEN      *K3461X  ØP 2B  ØPEN    *K4361X  ØP 2B  ØPEN
X4355X   ØPIND  ØPENED     K3455X  ØPIND  ØPENED   X4355X  ØPIND  ØPENED
*X4365X  ØPIND  ØPENED    *K3465X  ØPIND  ØPENED  *X4365X  ØPIND  ØPENED
```

IBC Form 244 (Dec 61)

NOTE: WRITE NUMBERS 10, LETTERS IØUG/C, SYMBOLS /·+

PROGRAM ______ FORTRAN-FAP CODING DATE ______

CODED BY ______ PAGE ____ OF ____

+ OR C PUNCH ______ VERIFY ______ TABULATE ______ EXECUTE ______ IDENTIFICATION

Location	Operation		Variable field			Comments		
V5900.6	LF AFT PLB 6			LF AFT PLB 6		RT AFT PLB 6		XX:XX:XX
K3500X	CL 1A	CLØSE	K3600X	CL 1A	CLØSE	K4500X	CL 1A	CLØSE
*K3501X	CL 1B	CLØSE	*K3601X	CL 1B	CLØSE	*K4501X	CL 1B	CLØSE
	+			+			+	
K3510X	CL 2A	CLØSE	K3610X	CL 2A	CLØSE	K4510X	CL 2A	CLØSE
*K3511X	CL 2B	CLØSE	*K3611X	CL 2B	CLØSE	*K4511X	CL 2B	CLØSE
X3505X	CLIND	CLØSED	X3605X	CLIND	CLØSED	X4505X	CLIND	CLØSED
*X3515X	CLIND	CLØSED	*X3615X	CLIND	CLØSED	*X4515X	CLIND	CLØSED
K3550X	ØP 1A	ØPEN	K3650X	ØP 1A	ØPEN	K4550X	ØP 1A	ØPEN
*K3551X	ØP 1B	ØPEN	*K3651X	ØP 1B	ØPEN	*K4551X	ØP 1B	ØPEN
	+			+			+	
K3560X	ØP 2A	ØPEN	K3660X	ØP 2A	ØPEN	K4560X	ØP 2A	ØPEN
*K3561X	ØP 2B	ØPEN	*K3661X	ØP 2B	ØPEN	*K4561X	ØP 2B	ØPEN
X3555X	ØPIND	ØPENED	X3655X	ØPIND	ØPENED	X4555X	ØPIND	ØPENED
*X3565X	ØPIND	ØPENED	*X3665X	ØPIND	ØPENED	*X4565X	ØPIND	ØPENED

JSC Form 244 (Dec 65)

NOTE: WRITE NUMBERS 10, LETTERS IØUGZO, SYMBOLS /-+

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FORTRAN-FAP CODING

DATE ______ PAGE ____ OF ____

PUNCH ______ VERIFY ______ TABULATE ______ EXECUTE ______ IDENTIFICATION ______

FORTRAN STATEMENT

LOCATION	OPERATION	VARIABLE FIELD			COMMENTS			IDENTIFICATION
V59689	RT AFT PLB 6		LF AFT 8/9		LF AFT 8/9		XX:XX	:XX
K4600X	PG11A	PURGE 1	K3800X CL 1A	CLØSE	K3900X PG 1A	PURGE		
*K4601X	PG11B	PURGE 1	*K3801X CL 1B	CLØSE	*K3901X PG 1B	PURGE		
	+		+		+			
K4610X	PG12A	PURGE 1	K3810X CL 2A	CLØSE	K3910X PG 2A	PURGE		
*K4611X	PG12B	PURGE 1	*K3811X CL 2B	CLØSE	*K3911X PG 2B	PURGE		
X4605X	PGIND	PURGE 1	X3805X CLIND	CLØSED	X3905X PGIND	PURGE		
*X4615X	PGIND	PURGE 1	*X3815X CLIND	CLØSED	*X3915X PGIND	PURGE		
K4700X	PG21A	PURGE 2	K3850X ØP 1A	ØPEN				
*K4701X	PG21B	PURGE 2	*K3851X ØP 1B	ØPEN				
	+		+					
K4710X	PG22A	PURGE 2	K3860X ØP 2A	ØPEN				
*K4711X	PG22B	PURGE 2	*K3861X ØP 2B	ØPEN				
X4705X	PGIND	PURGE 2	X3855X ØPIND	ØPENED				
*X4715X	PGIND	PURGE 2	*X3865X ØPIND	ØPENED				

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NOTE: WRITE NUMBERS 10, LETTERS IØUGZC, SYMBOLS /.,* PROGRAM

CODED BY

FORTRAN-FAP CODING

DATE

PAGE ___ OF ___

IDENTIFICATION

* OR C

PUNCH ___ VERIFY ___ TABULATE ___ EXECUTE ___

FORTRAN STATEMENT

STATEMENT NUMBER / LOCATION	OPERATION	VARIABLE FIELD			COMMENTS
V59089	RT AFT 8/9		RT AFT 8/9		
K4800X	CL 1A	CLØSE	K4900X	PG 1A	PURGE
*K4801X	CL 1B	CLØSE	*K4901X	PG 1B	PURGE
	+			+	
K4810X	CL 2A	CLØSE	K4910X	PG 2A	PURGE
*K4811X	CL 2B	CLØSE	*K4911X	PG 2B	PURGE
X4805X	CLIND	CLØSED	X4905X	PGIND	PURGE
*X4815X	CLIND	CLØSED	*X4915X	PGIND	PURGE
K4850X	ØP 1A	ØPEN			
*K4851X	ØP 1B	ØPEN			
	+				
K4860X	ØP 2A	ØPEN			
*K4861X	ØP 2B	ØPEN			
X4855X	ØPIND	ØPENED			
*X4865X	ØPIND	ØPENED			

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NOTE: WRITE NUMBERS 10, LETTERS IØUGZC, 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

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.

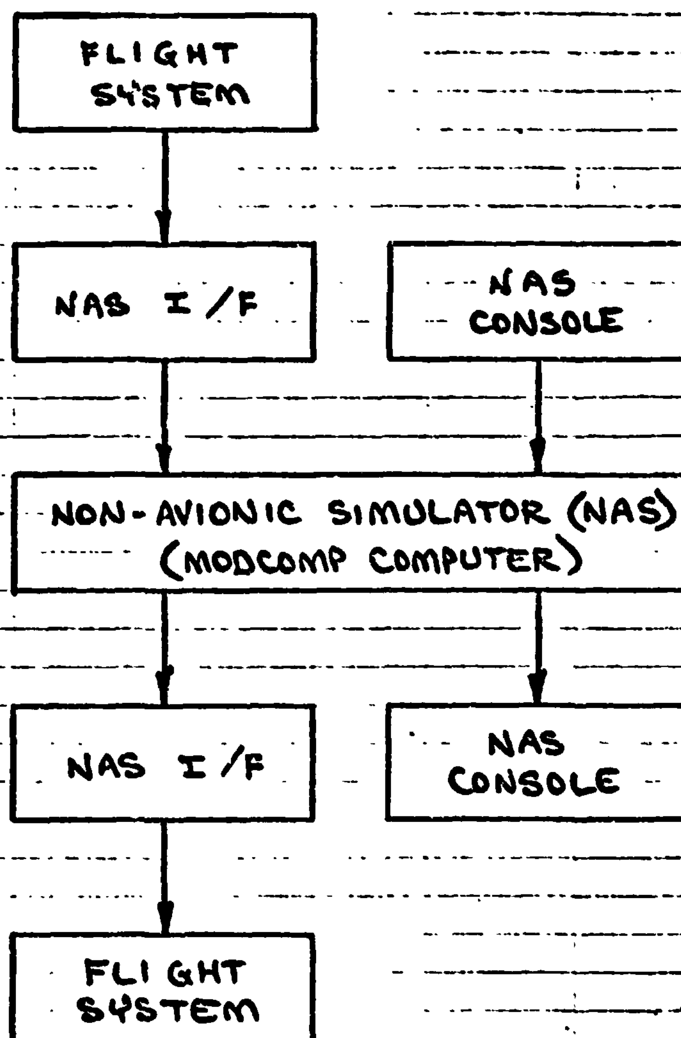


FIGURE 1 - FLIGHT SYSTEM/NAS DATA FLOW

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

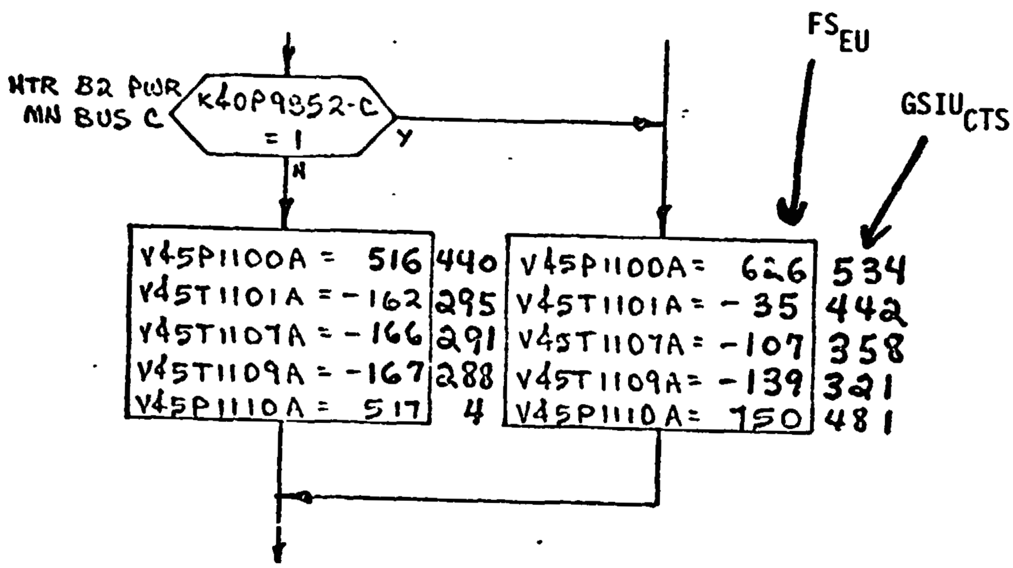
None

2.5 UNIQUE REQUIREMENTS

None

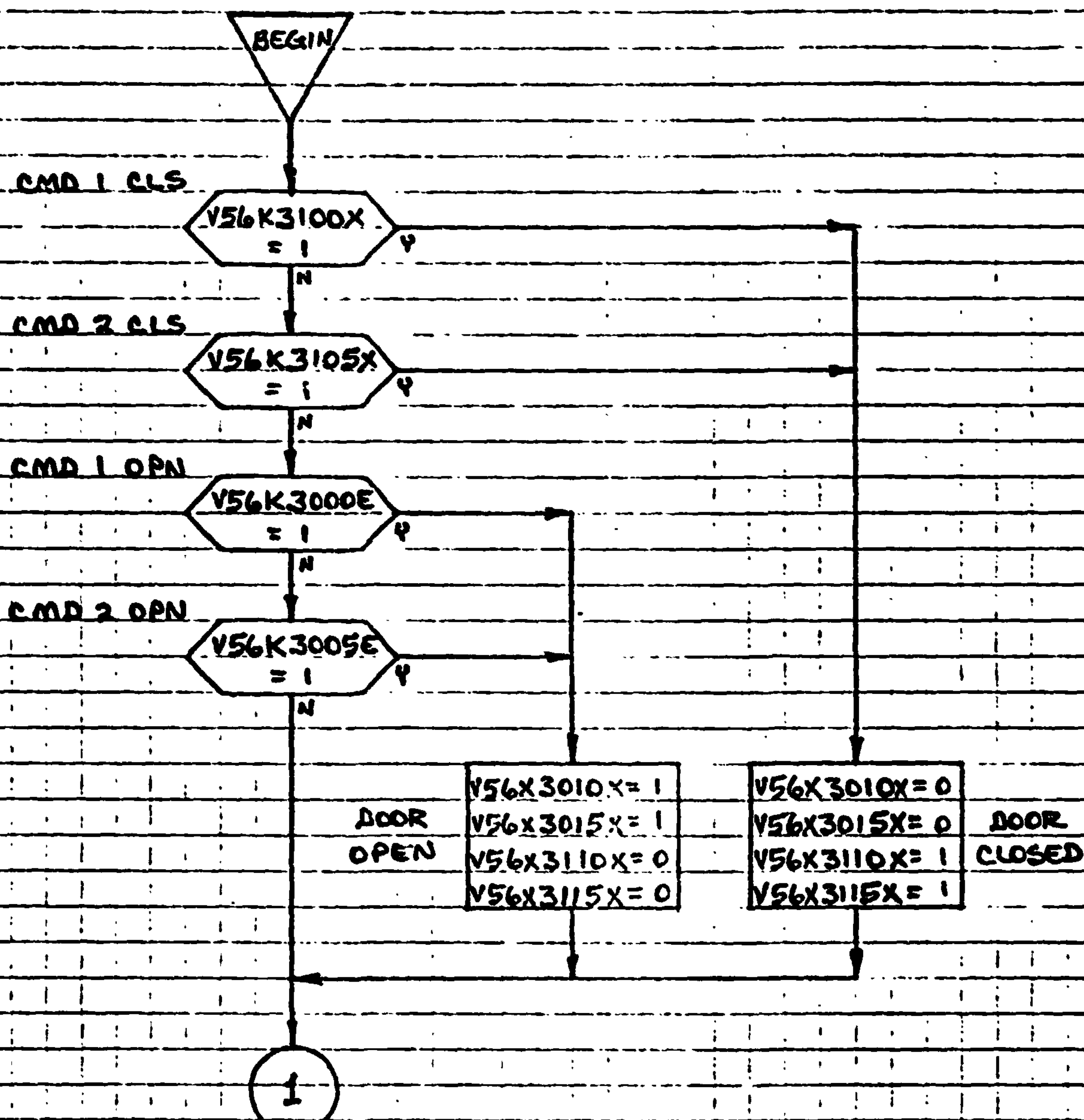
3.0 LOGIC FLOW DIAGRAMS

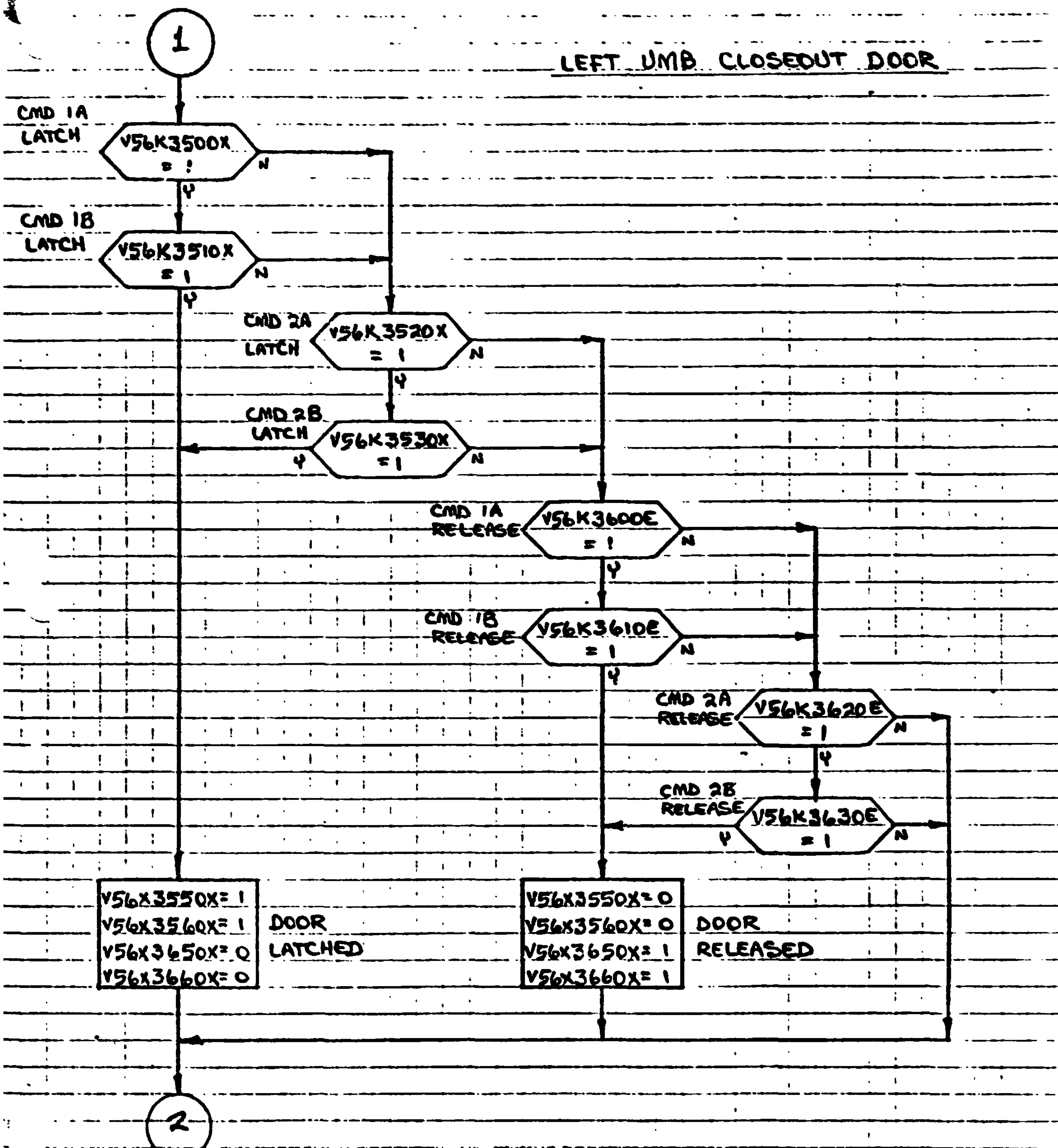
The logic flow diagram is made up of interconnected lines, boxes, decisions, and offpage connectors. Notice that where analog measurements are listed in boxes and decisions, the value inside the box is in flight system engineering units (FS_{EU}) while the corresponding GSIU count value is listed outside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



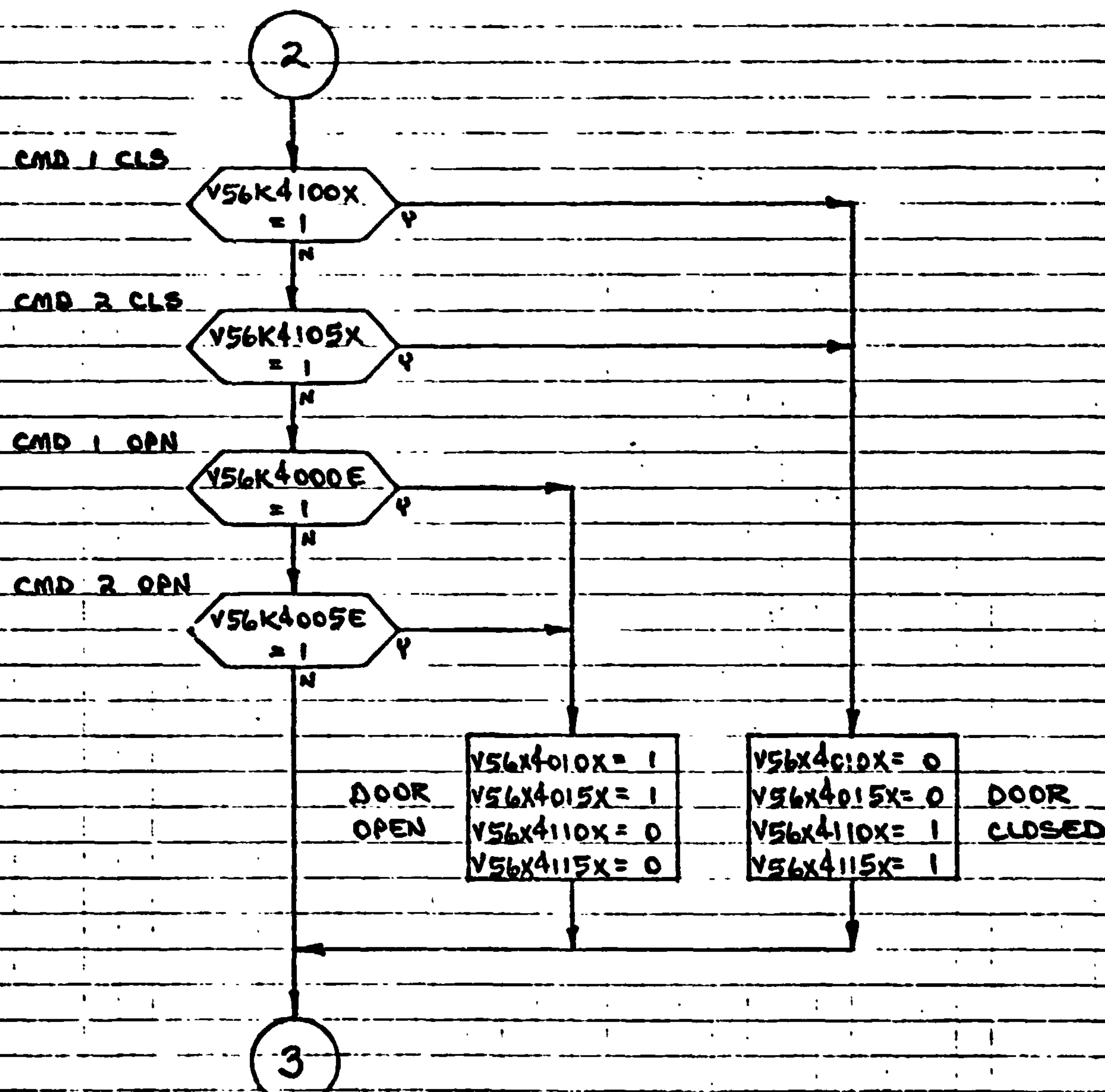
shows that V45P1100A is set equal to 626 FS_{EU} which is equivalent to 534 $GSIU_{CTS}$ shown outside the box.

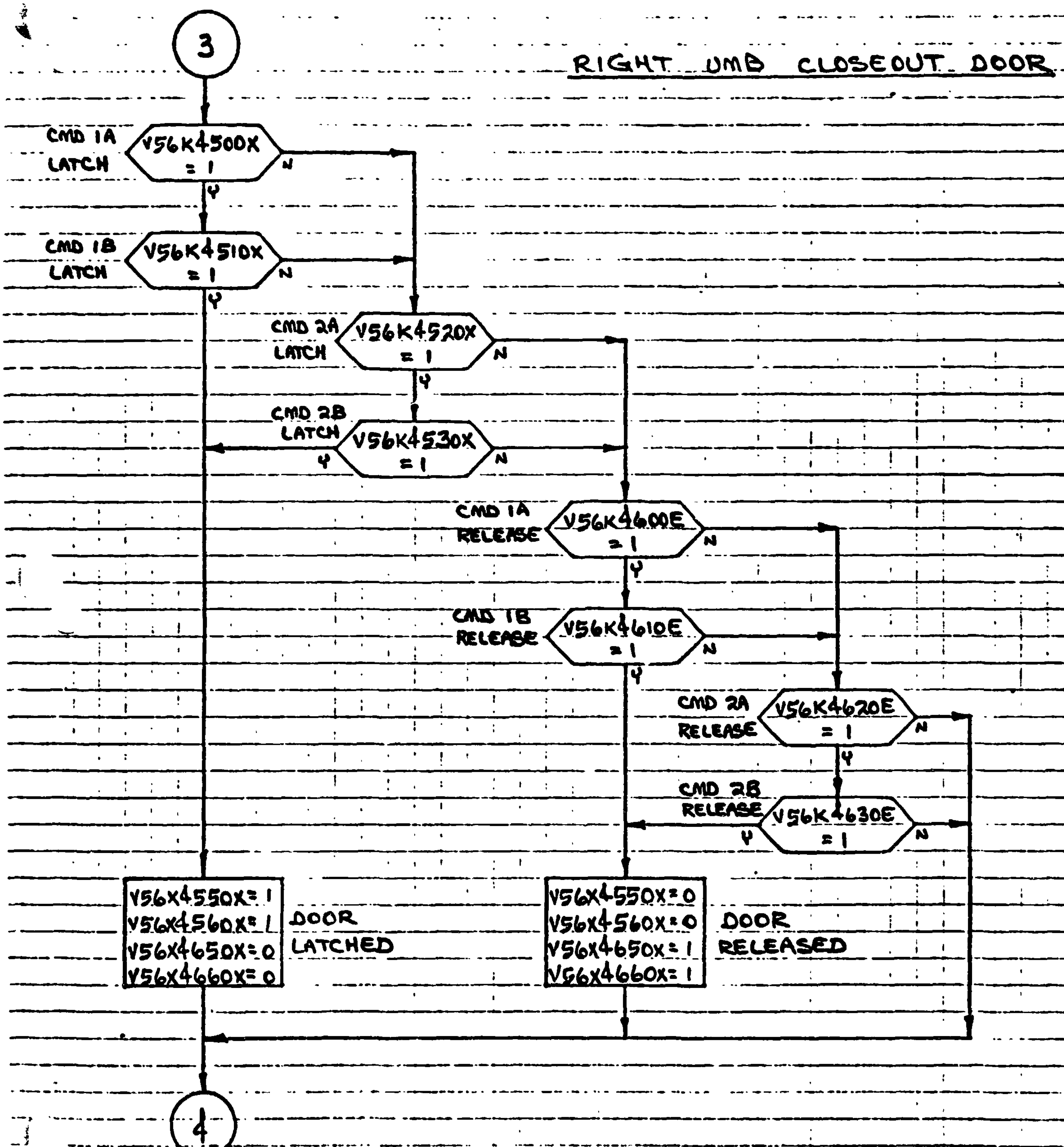
LEFT UMB CLOSEOUT DOOR



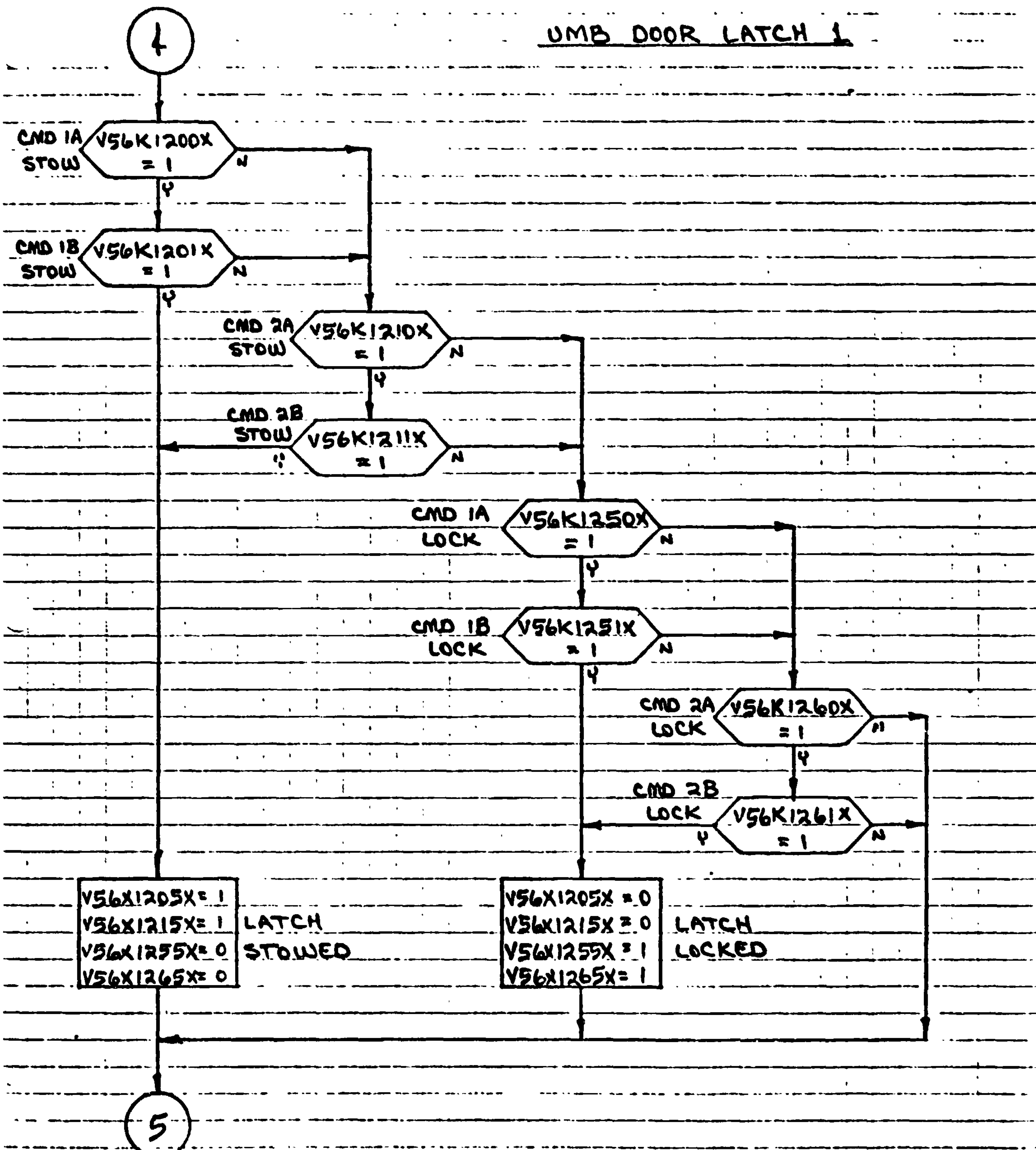

1
LEFT UMB CLOSEOUT DOOR
CMD 1A LATCH
V56K3500X = 1
CMD 1B LATCH
V56K3510X = 1
CMD 2A LATCH
V56K3520X = 1
CMD 2B LATCH
V56K3530X = 1
CMD 1A RELEASE
V56K3600E = 1
CMD 1B RELEASE
V56K3610E = 1
CMD 2A RELEASE
V56K3620E = 1
CMD 2B RELEASE
V56K3630E = 1
Y
N
V56X3550X= 1
V56X3560X= 1
V56X3650X= 0
V56X3660X= 0
DOOR LATCHED
V56X3550X= 0
V56X3560X= 0
V56X3650X= 1
V56X3660X= 1
DOOR RELEASED
2

RIGHT UMB CLOSEOUT DOOR





3
RIGHT UMB CLOSEOUT DOOR
CMD 1A LATCH
V56K4500X = 1
CMD 1B LATCH
V56K4510X = 1
CMD 2A LATCH
V56K4520X = 1
CMD 2B LATCH
V56K4530X = 1
CMD 1A RELEASE
V56K4600E = 1
CMD 1B RELEASE
V56K4610E = 1
CMD 2A RELEASE
V56K4620E = 1
CMD 2B RELEASE
V56K4630E = 1
Y
N
V56X4550X = 1
V56X4560X = 1
V56X4650X = 0
V56X4660X = 0
DOOR LATCHED
V56X4550X = 0
V56X4560X = 0
V56X4650X = 1
V56X4660X = 1
DOOR RELEASED
4



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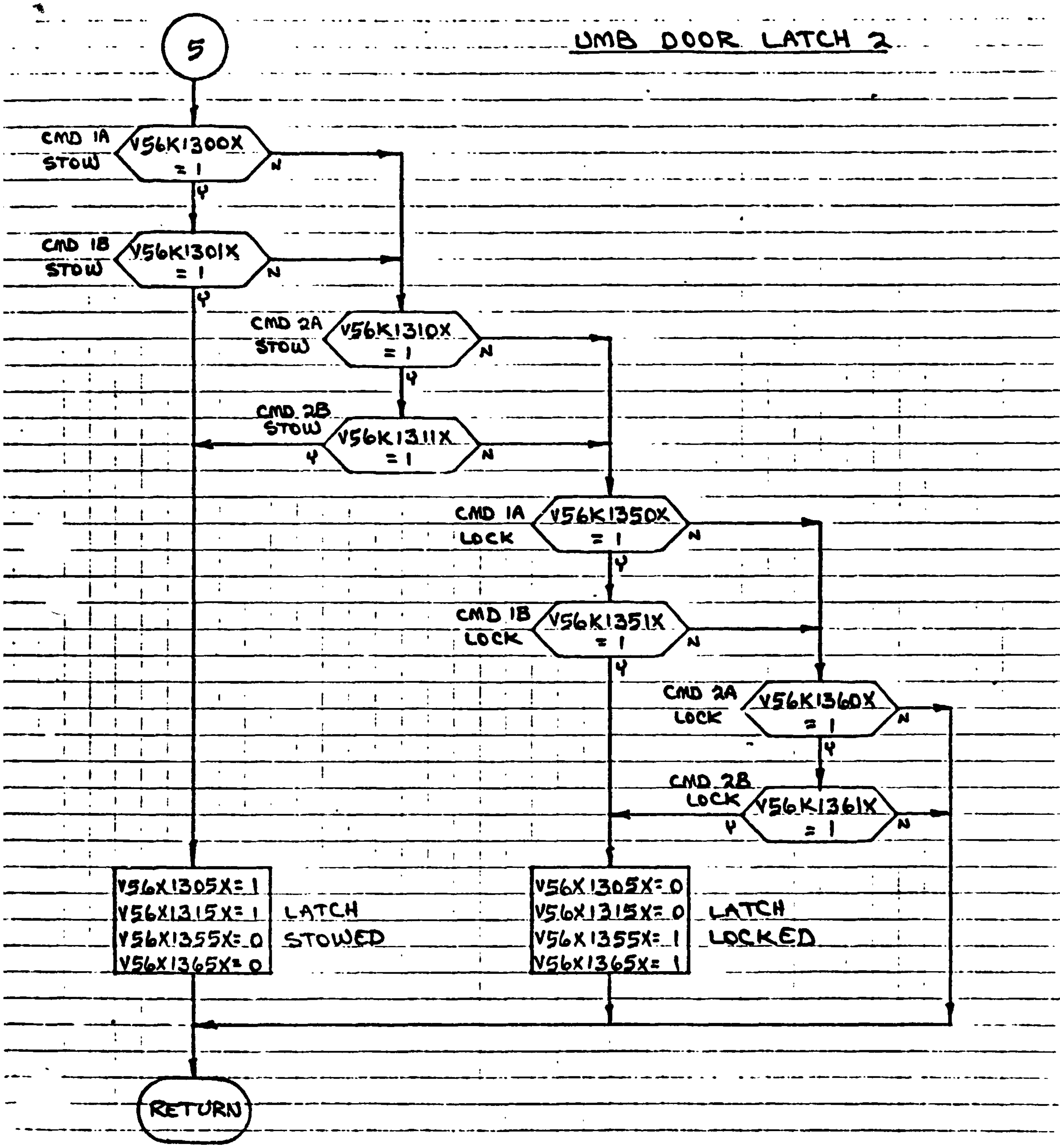
5
UMB DOOR LATCH 2
CMD 1A STOW
V56K1300X = 1
CMD 1B STOW
V56K1301X = 1
CMD 2A STOW
V56K1310X = 1
CMD 2B STOW
V56K1311X = 1
CMD 1A LOCK
V56K1350X = 1
CMD 1B LOCK
V56K1351X = 1
CMD 2A LOCK
V56K1360X = 1
CMD 2B LOCK
V56K1361X = 1
Y
N
V56X1305X = 1
V56X1315X = 1
V56X1355X = 0
V56X1365X = 0
LATCH STOWED
V56X1305X = 0
V56X1315X = 0
V56X1355X = 1
V56X1365X = 1
LATCH LOCKED
RETURN

4.0 INPUT/OUTPUT TABLES

TABLE 4.1 - INPUT STIMULI

IDENTIFICATION NUMBER	NOMENCLATURE	ADDRESS	STATES/RANGE LO	STATES/RANGE HI	UNITS
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				
V56K1261X	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	FROM F.S.			
V56K3600E	ET LEFT UMB CLOSEOUT DOOR RELEASE CMD 1A	FROM NAS			
V56K3610E	ET LEFT UMB CLOSEOUT DOOR RELEASE CMD 1B				
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				
V56K4005E	ET RIGHT UMB CLOSEOUT DOOR OPEN CMD 2	FROM NAS			
V56K4100X	ET RIGHT UMB CLOSEOUT DOOR CLOSE CMD 1	FROM F.S.			
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.	0	1	STATE

TABLE 4.1 - INPUT STIMULI (CONTINUED)

IDENTIFICATION NUMBER	NOMENCLATURE	ADDRESS	STATES/RANGE		
			LO	HI	UNITS
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	↓	↓	↓	↓
V56K4630E	ET RIGHT UMB CLOSEOUT DOOR RELEASE CMD 2B	FROM NAS	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 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

PROGRAM ____________ **FORTRAN-FAP CODING** DATE ________

CODED BY ____________ PAGE ____ OF ____

PUNCH ______ VERIFY ______ TABULATE ______ EXECUTE ______ IDENTIFICATION ______

FORTRAN STATEMENT

Location	Operation	Data	Location	Operation	Data	Identification
U56L12						XX:XX:XX
	DR CL LCH 1			DR CL LCH 2		
K1250X	LK 1A	LØCK	K1350X	LK 1A	LØCK	
#K1251X	LK 1B	LØCK	#K1351X	LK 1B	LØCK	
	+			+		
K1260X	LK 2A	LØCK	K1360X	LK 2A	LØCK	
#K1261X	LK 2B	LØCK	#K1361X	LK 2B	LØCK	
X1255X	LKIND	LØCKED	X1355X	LKIND	LØCKED	
#X1265X	LKIND	LØCKED	#X1365X	LKIND	LØCKED	
K1200X	STW1A	STØW	K1300X	STW1A	STØW	
#K1201X	STW1B	STØW	#K1301X	STW1B	STØW	
	+			+		
K1210X	STW2A	STØW	K1310X	STW2A	STØW	
#K1211X	STW2B	STØW	#K1311X	STW2B	STØW	
X1205X	STIND	STØWED	X1305X	STIND	STØWED	
#X1215X	STIND	STØWED	#X1315X	STIND	STØWED	

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NOTE: WRITE NUMBERS 10, LETTERS IØUGZC, SYMBOLS /.,*

NOTE: DATA BLOCKS ALL SHOWN FOR (HI) CMD SIGNALS. ACTUAL DATA SHOULD BE PER MODEL LOGIC. (#- LOGICAL AND, +- LOGICAL OR)

PROGRAM ______ FORTRAN-FAP CODING DATE ______

CODED BY ______ PAGE ___ OF ___

+ OR C PUNCH ____ VERIFY ____ TABULATE ____ EXECUTE ____ IDENTIFICATION

STATEMENT NUMBER / LOCATION	OPERATION		VARIABLE FIELD		COMMENTS			IDENTIFICATION
U56DLR								XX:XX:XX
	L UMB CØUT DR		L/R CØUT DRS		RT UMB CØUT DR			
K3100X	CL 1	CLØSE	KYBD ØP LRD	ØPEN	K4100X	CL 1	CLØSE	
	+		X3010X ØPIND	ØPEN L		+		
K3105X	CL 2	CLØSE	*X3015X ØPIND	ØPEN L	K4105X	CL 2	CLØSE	
X3110X	CLIND	CLØSED	*K4010X ØPIND	ØPEN R	X4110X	CLIND	CLØSED	
*X3115X	CLIND	CLØSED	*X4015X ØPIND	ØPEN R	*X4115X	CLIND	CLØSED	
K3500X	LH 1A	LATCH	KYBD ØP LRD	RELEASE	K4500X	LH 1A	LATCH	
*K3510X	LH 1B	LATCH	K3650X REL L	RELEASED	*K4510X	LH 1B	LATCH	
	+		*K3660X REL L	RELEASED		+		
K3520X	LH 2A	LATCH	*K4650X REL R	RELEASED	K4520X	LH 2A	LATCH	
*K3530X	LH 2B	LATCH	*K4660X REL R	RELEASED	*K4530X	LH 2B	LATCH	
X3550X	LHIND	LATCHED			X4550X	LHIND	LATCHED	
*X3560X	LHIND	LATCHED			*X4560X	LHIND	LATCHED	

NOTE: WRITE NUMBERS 10, LETTERS IØUG/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, TABLES 3-5,3-6,3-7,3-8, dated 8/2/78

APPENDIX D

ET SEP PYROS MATH MODEL REQUIREMENTS

CONTENTS

FIGURES

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.

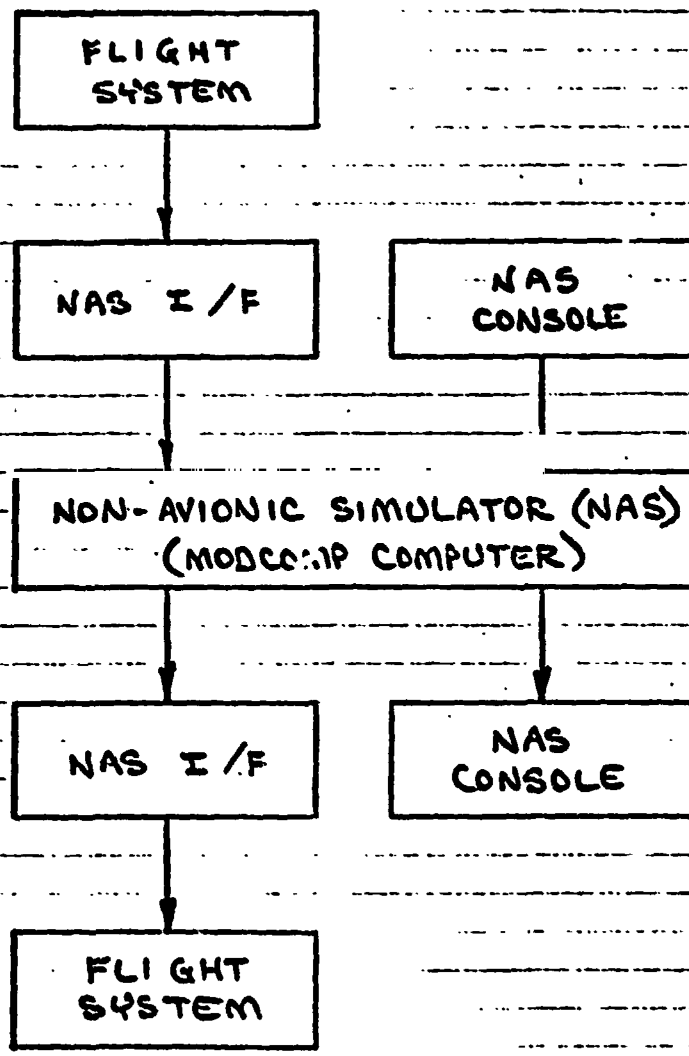


FIGURE 1 - FLIGHT SYSTEM/NAS DATA FLOW

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 - Inital 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

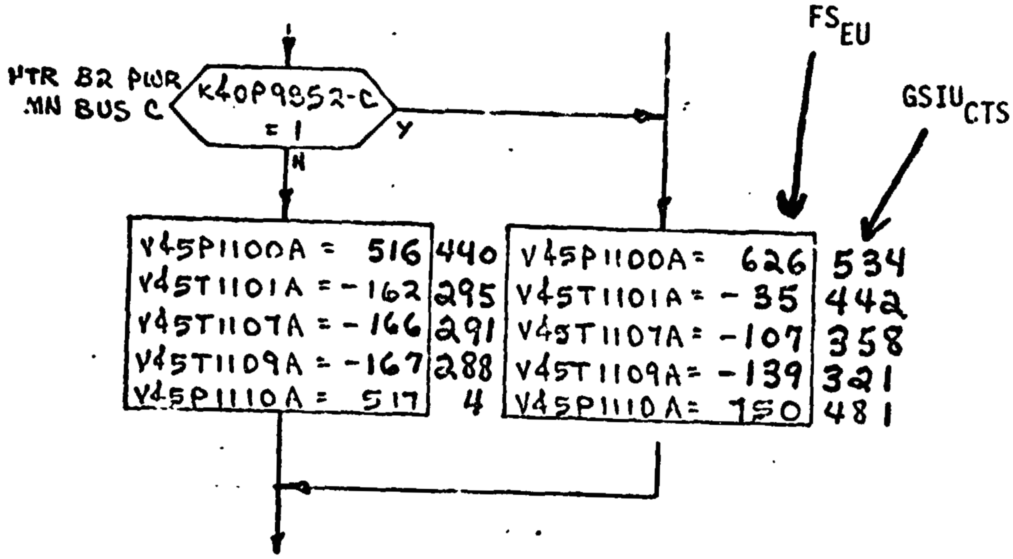
High = Range high limit

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.

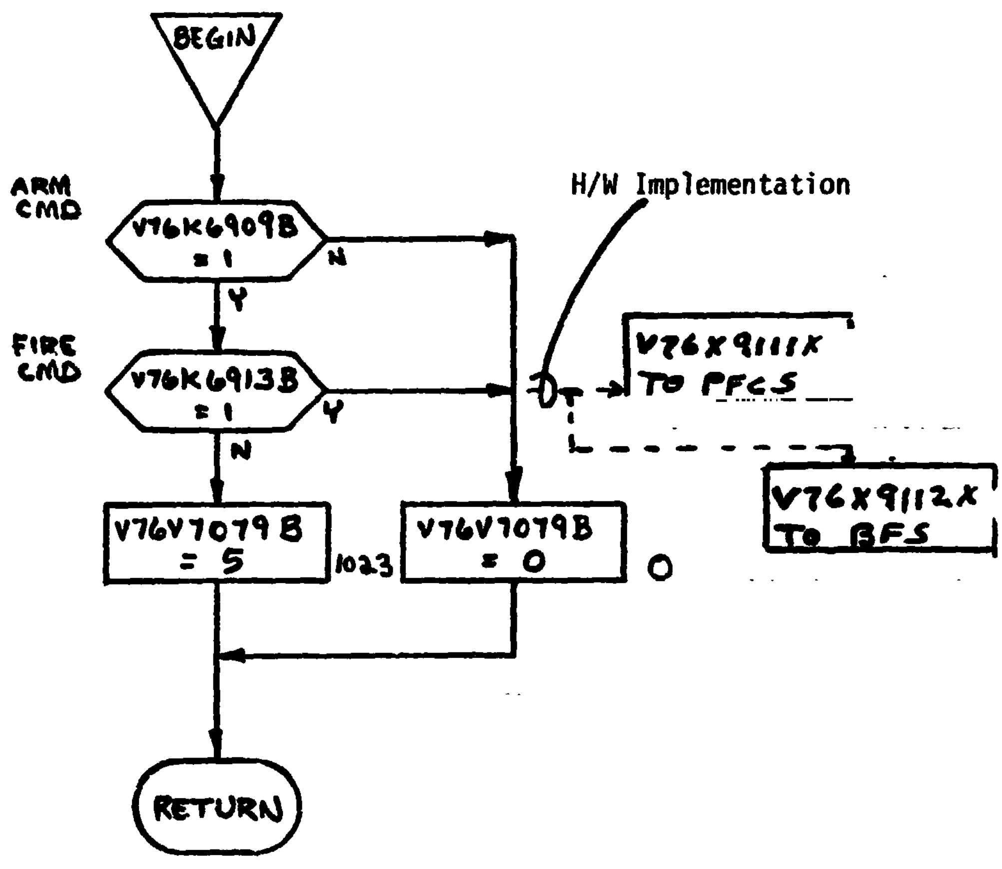
MEASUREMENT ID	RANGE LOW	RANGE HIGH	FS	CTS
V76V7079B	0	5	0	0

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 route. to the BFS to satisfy Pyro System B interface with the BFS.

4.0 INPUT/OUTPUT TAGLES

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

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*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

PROGRAM ____________ FORTRAN-FAP CODING DATE ________

CODED BY ____________ PAGE ____ OF ____

+ OR C PUNCH ______ VERIFY ______ TABULATE ______ EXECUTE ______ IDENTIFICATION

STATEMENT NUMBER	FORTRAN STATEMENT				IDENTIFICATION
587641					XX:XX:XX
	HYD/APU S/S		MPS X-E-MS		
	58P0114C HYD SUP PRESS A SYS 1	2950	K1700X LH2 1	REPL	
	58P0115C HYD SUP PRESS B SYS 1	2950	K1701X LH2 2	REPL	
			K1702X LH2 3	REPL	
	58P0214C HYD SUP PRESS A SYS 2	2950	K1750X LO2 1	REPL	
	58P0215C HYD SUP PRESS B SYS 2	2950	K1751X LO2 2	REPL	
			K1752X LO2 3	REPL	
	58P0314C HYD SUP PRESS A SYS 3	2950			
	58P0315C HYD SUP PRESS B SYS 3	2950	VE1XXX E-1	READY	
			VE2XXX E-2	READY	
	PYRØS ET SEP		VE3XXX E-3	READY	
	76K6909B ET/ØRB SEPN A A	ARM	K1125X MPS 1	MNSTG	
	76K6913B ET/ØRB SEPN FIRE	FIRE	K1225X MPS 2	MNSTG	
	76V7079B ET/ØRB P/C A VØLT	5.0	K1325X MPS 3	MNSTG	

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NOTE: WRITE NUMBERS 10, LETTERS IØUGZC, 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, Table 3-9, MEC/NAS Interface Data Sheet, 8/2/78

APPENDIX E

MPS PLUMBING MATH MODEL REQUIREMENTS

TABLE OF CONTENTS

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.

Non-Avionic Math Model	STS	GTS
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 LO2 signal which is used to determine the states of the LO2 Engine Cut-Off (ECO) sensors in the LO2 Feed Manifold, (reference logic flow chart routine 11). The ECO sensor data is transmitted to the Flight System. The MMES also transmits LO2 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 discretes (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/C70-1140 cable set interface.

```
K 5 0 P X X X - X
|  |    |      |
|  |    |      └──PIN NUMBER (FLIGHT CABLE)
|  |    └─────────CONNECTOR NUMBER
|  └──────────────AREA DESIGNATOR
└─────────────────STIMULI DESIGNATOR
```

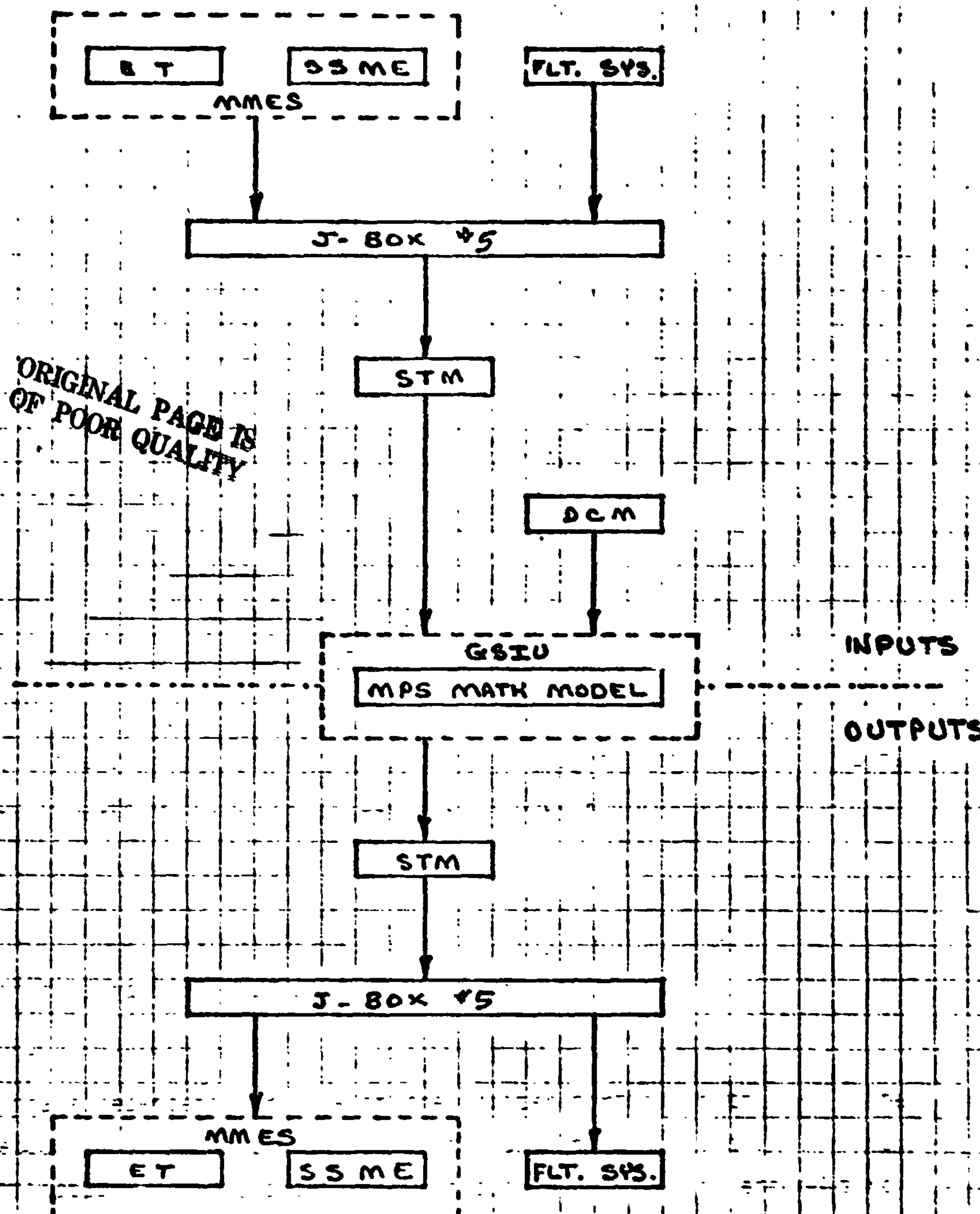
Exceptions to this code are those stimuli with a letter for the connector number where the connector number is unknown. Also the stimuli which comes from the DCM instead of the flight cable do not agree with this code.

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

2.2 DCM UPLINK

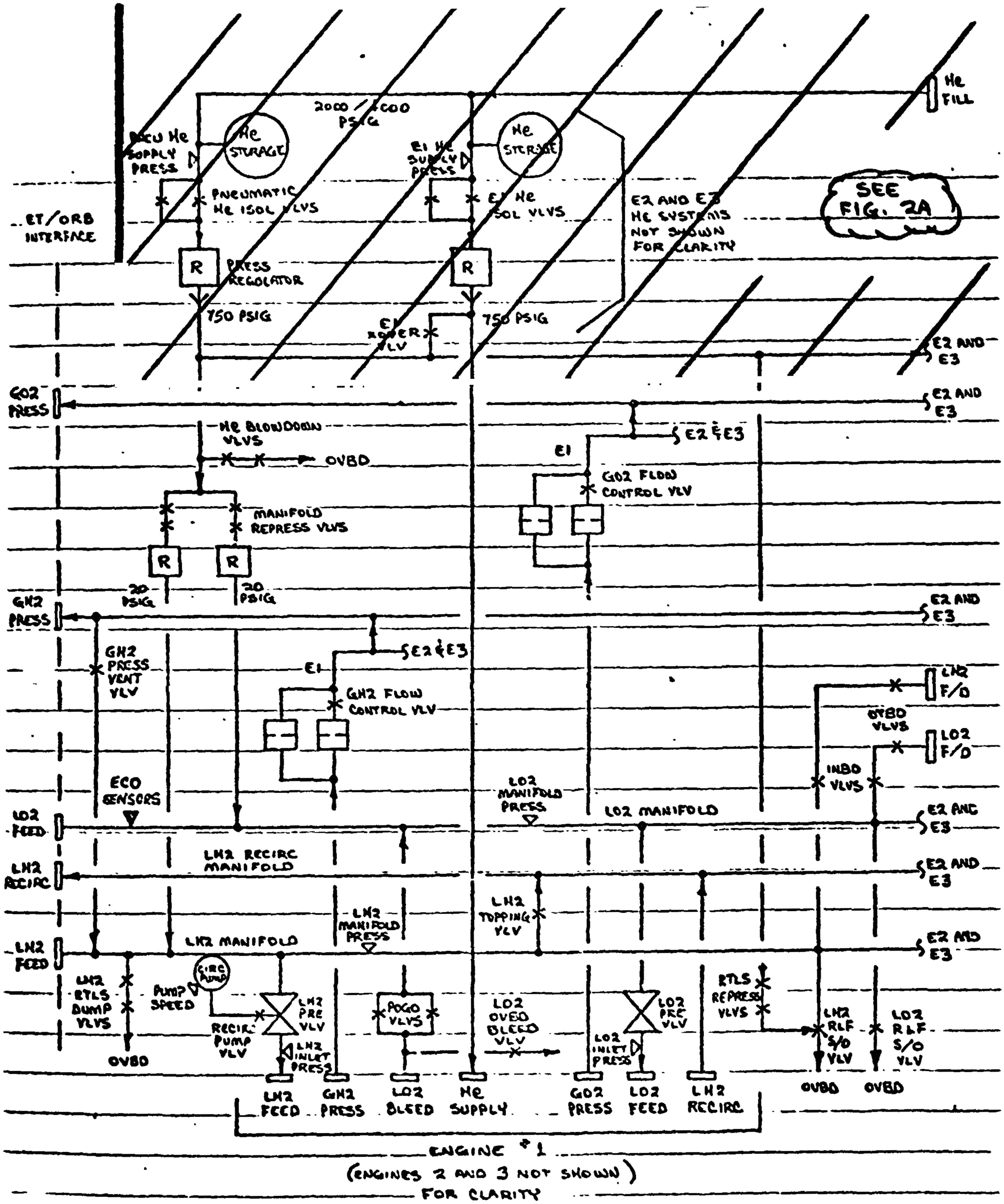
A mission phase dependent variable in the Orbiter portion of the MPS is helium supply pressure. To avoid complexity in the GSIU model, the change of helium pressure to account for the operation of pneumatic valves and engine purging was not incorporated into the flowchart logic. Instead, it is intended 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:

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



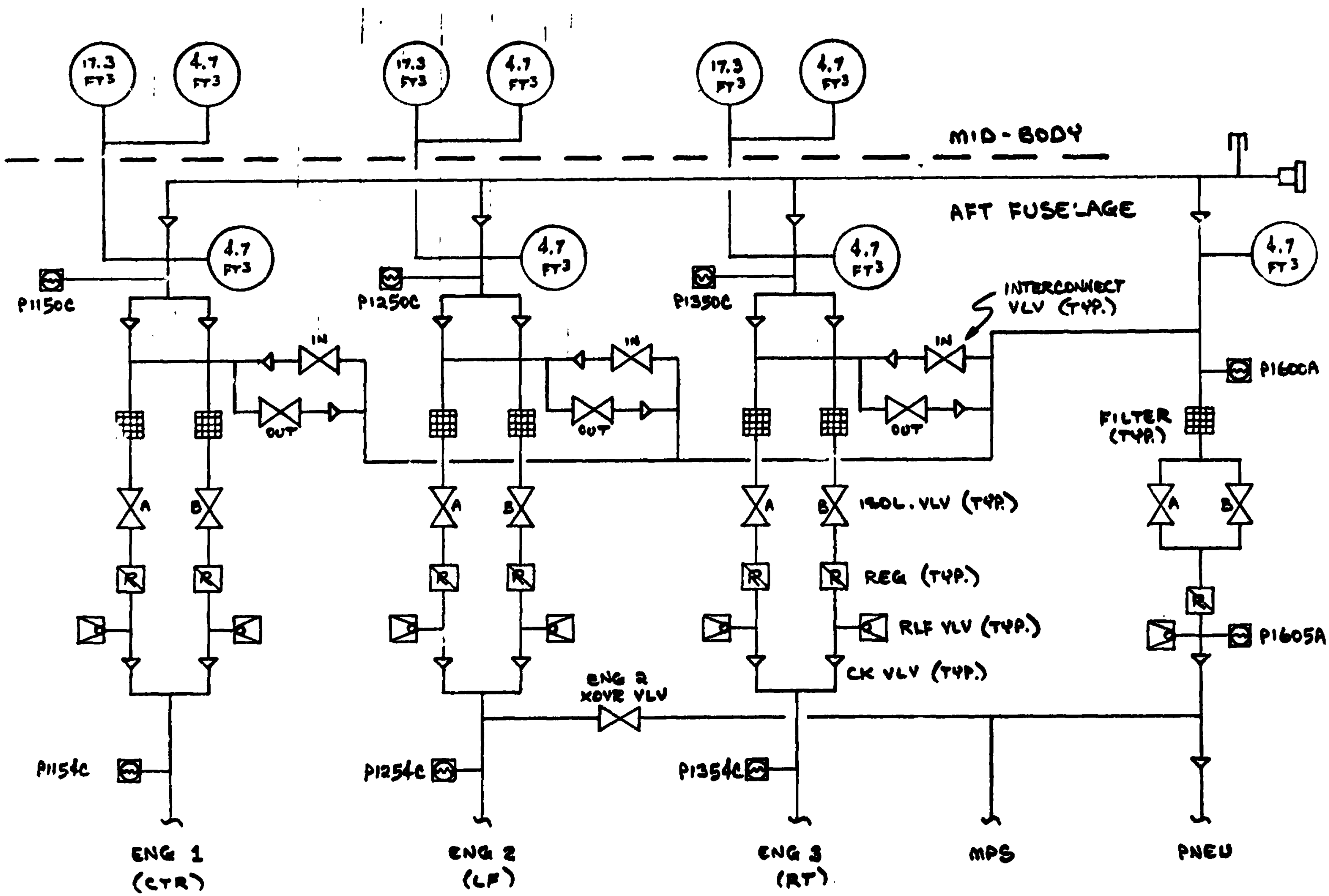
INPUT / OUTPUT DATA FLOW

FIGURE 1



ORBITER PART OF MAIN PROPULSION SYSTEM

FIGURE 2



MPS HELIUM SYSTEM SCHEMATIC

FIGURE 2A

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 - LO2 Feed Disconnect Valve
D2 - LH2 Feed Disconnect Valve
D3 - LH2 Recirculation Disconnect Valve
D4 - LO2 Outboard Fill and Drain Valve
D5 - LO2 Inboard Fill and Drain Valve
D6 - LH2 Outboard Fill and Drain Valve
D7 - LH2 Inboard Fill and Drain Valve
D8 - Engine 1 LO2 Prevalve
D9 - Engine 2 LO2 Prevalve
D10 - Engine 3 LO2 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 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
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 engireering units

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

Low = Range low limit

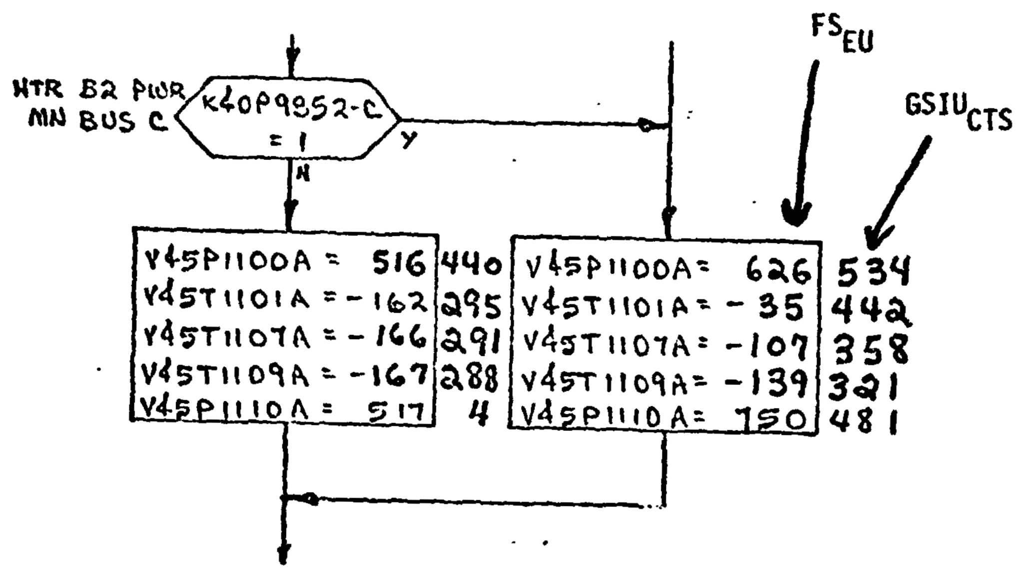
High = Range high limit

The following table shows a sample data value for each measurement which requircs 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

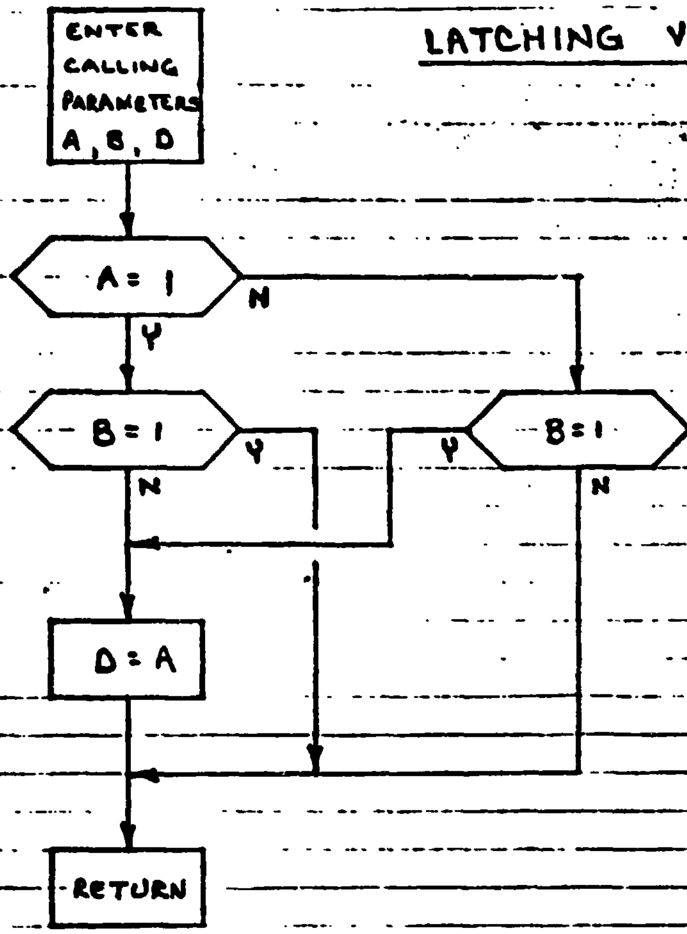
3.0 LOGIC FLOW DIAGRAMS

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,

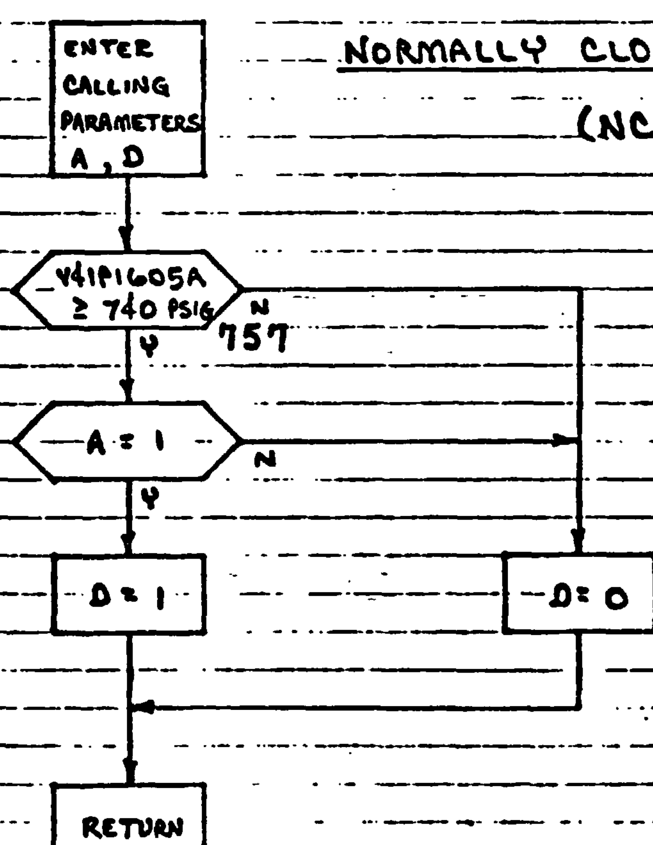


shows that V45P1100A is set equal to 626 FS_{EU} which is equivalent to 534 $GSIU_{CTS}$ shown outside the box.

LATCHING VALVE ROUTINE (LVR)

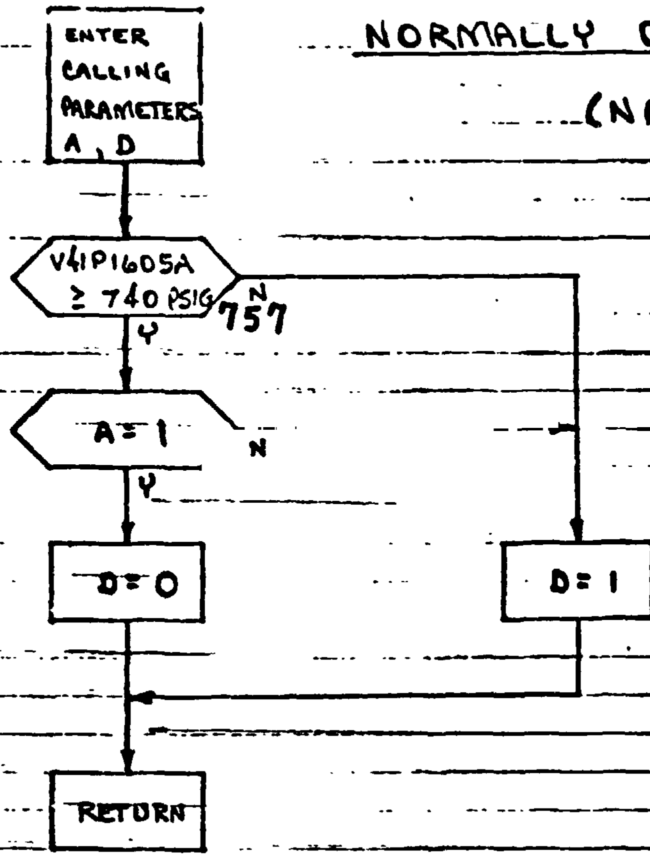


NORMALLY CLOSED VALVE ROUTINE (NCVR)

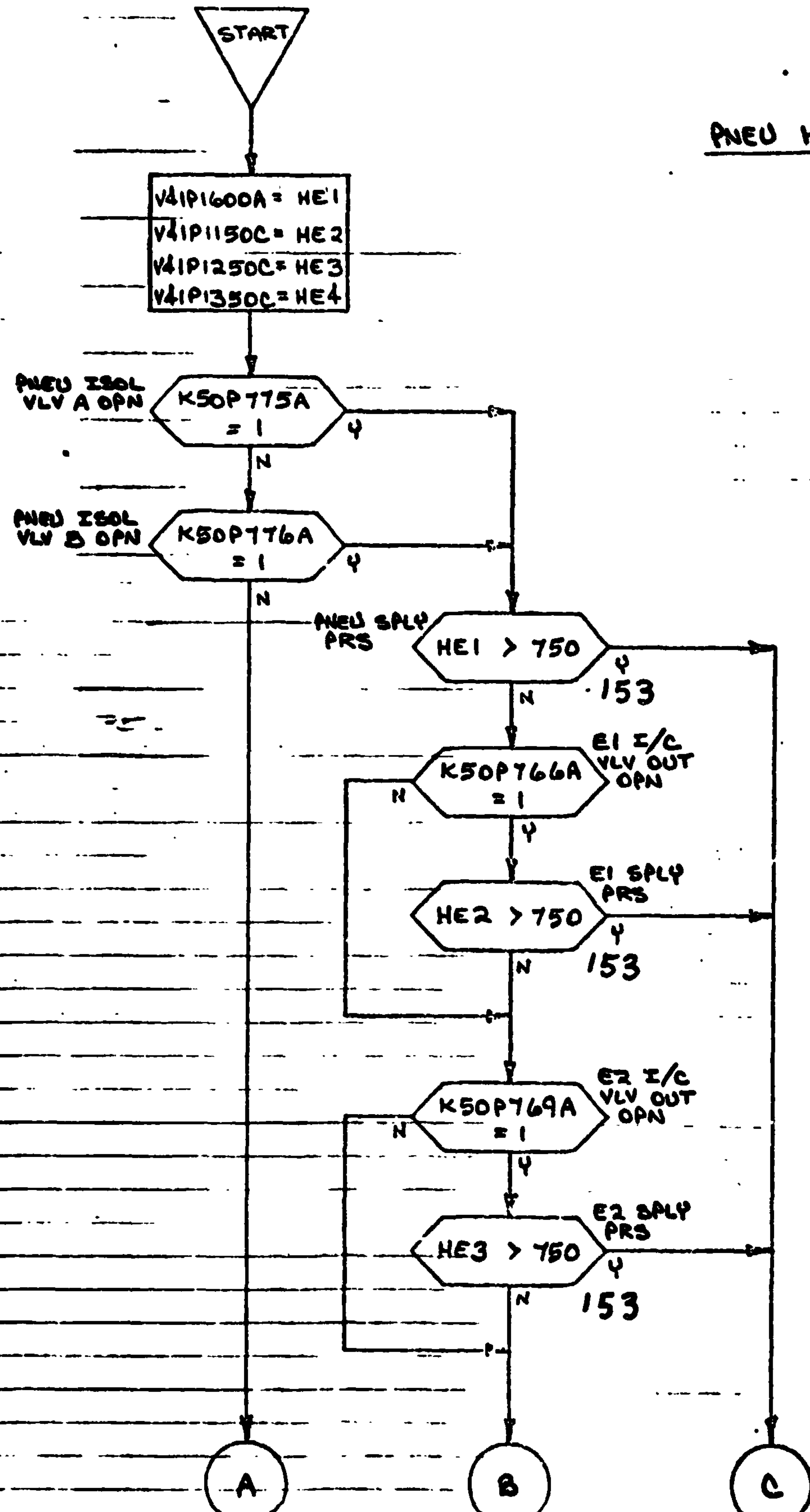


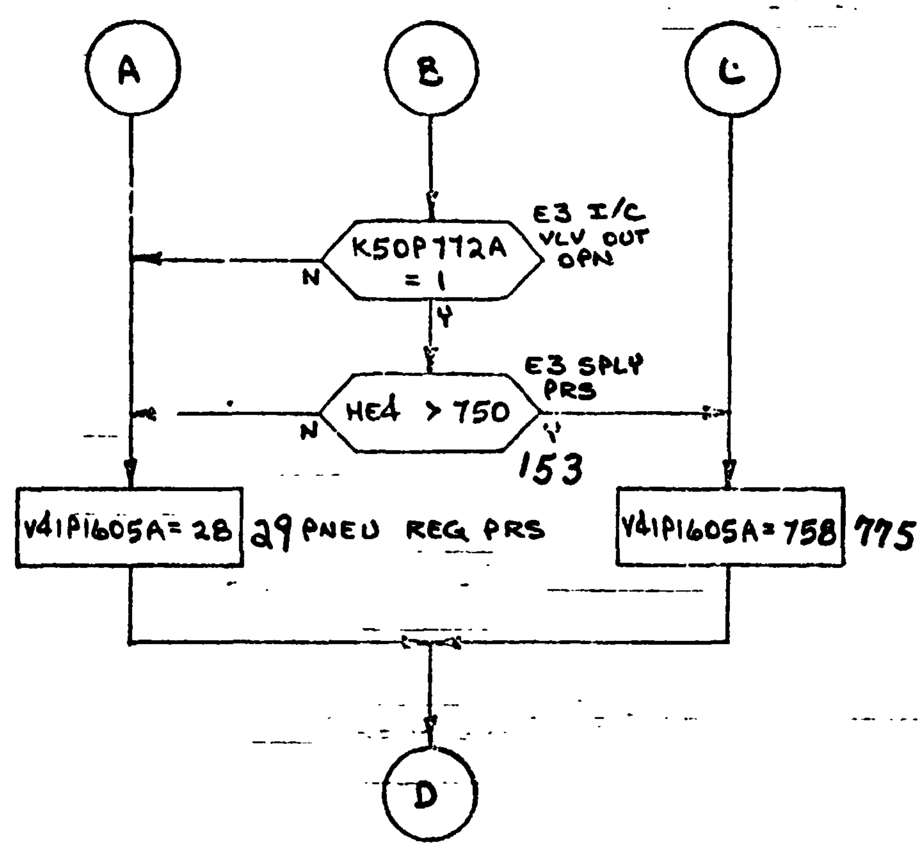
NORMALLY OPEN VALVE ROUTINE

(NØVR)

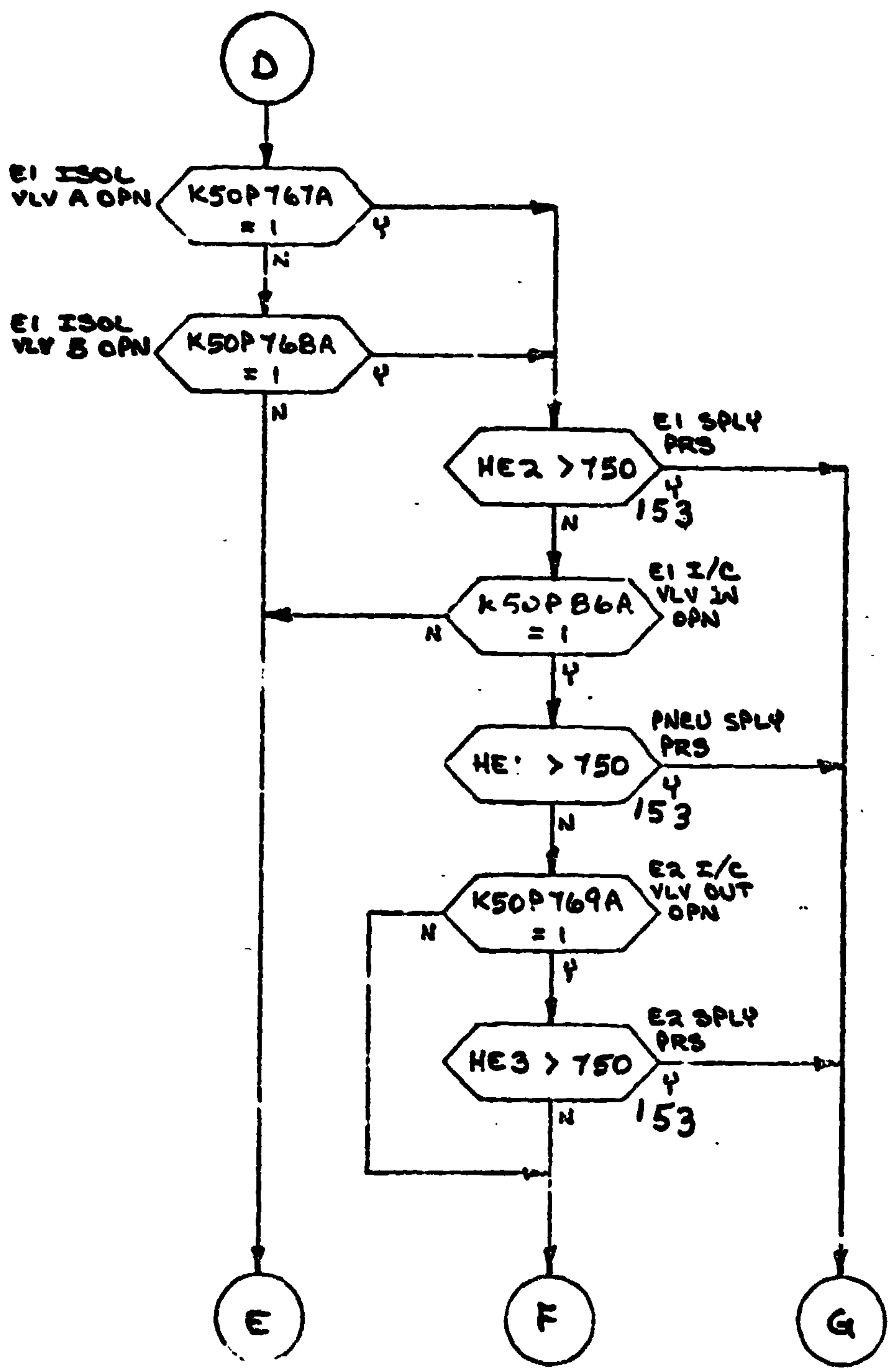


PNEU HE PRESS



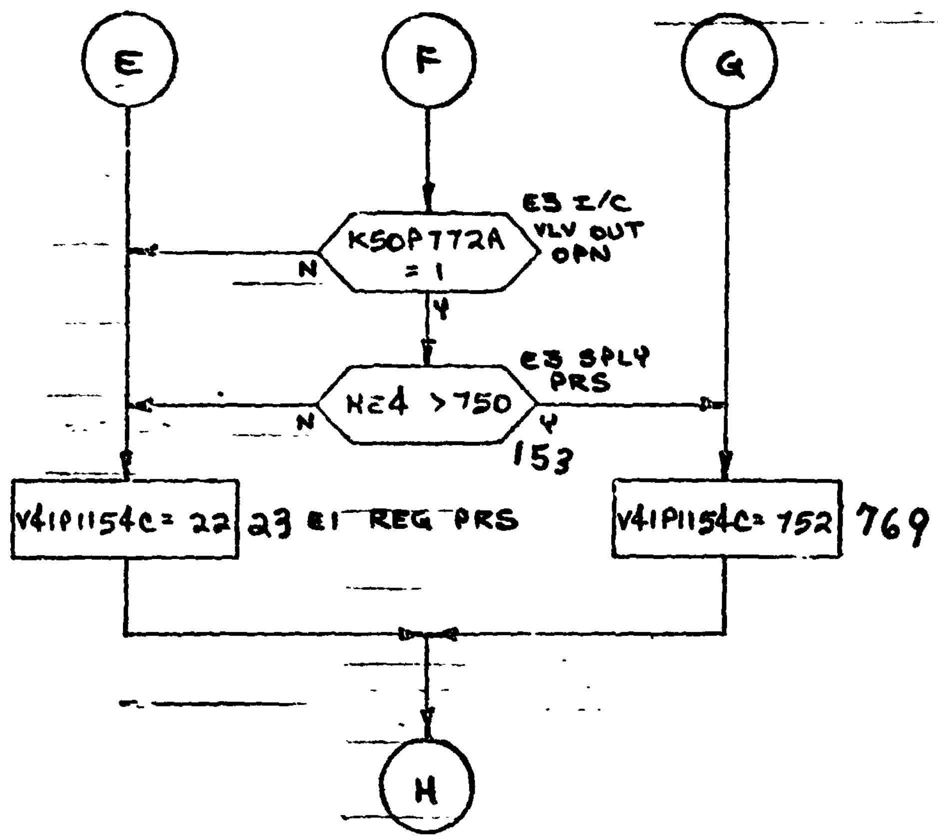

A
B
C
K50P772A = 1
E3 I/C VLV OUT OPN
N
Y
HE4 > 750
E3 SPLY PRS
153
V41P1605A = 28
29 PNEU REG PRS
V41P1605A = 758
775
D

E1 HE PRESS

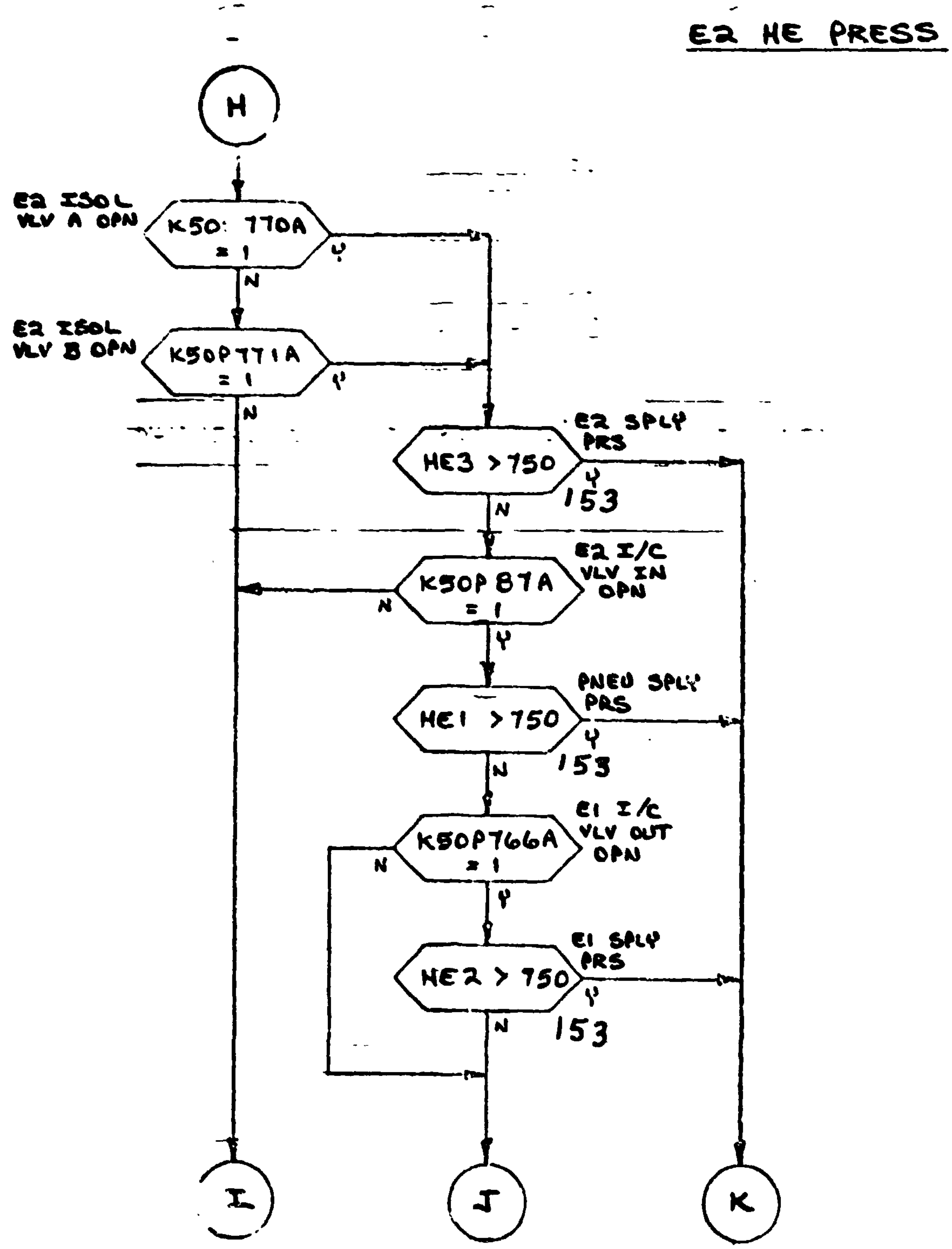


D
E1 ISOL VLV A OPN
K50P767A = 1
Y
N
E1 ISOL VLV B OPN
K50P768A = 1
Y
N
E1 SPLY PRS
HE2 > 750
Y
153
N
E1 I/C VLV IN OPN
K50P86A = 1
N
Y
PNEU SPLY PRS
HE1 > 750
Y
153
N
E2 I/C VLV OUT OPN
K50P769A = 1
N
Y
E2 SPLY PRS
HE3 > 750
Y
153
N
E
F
G

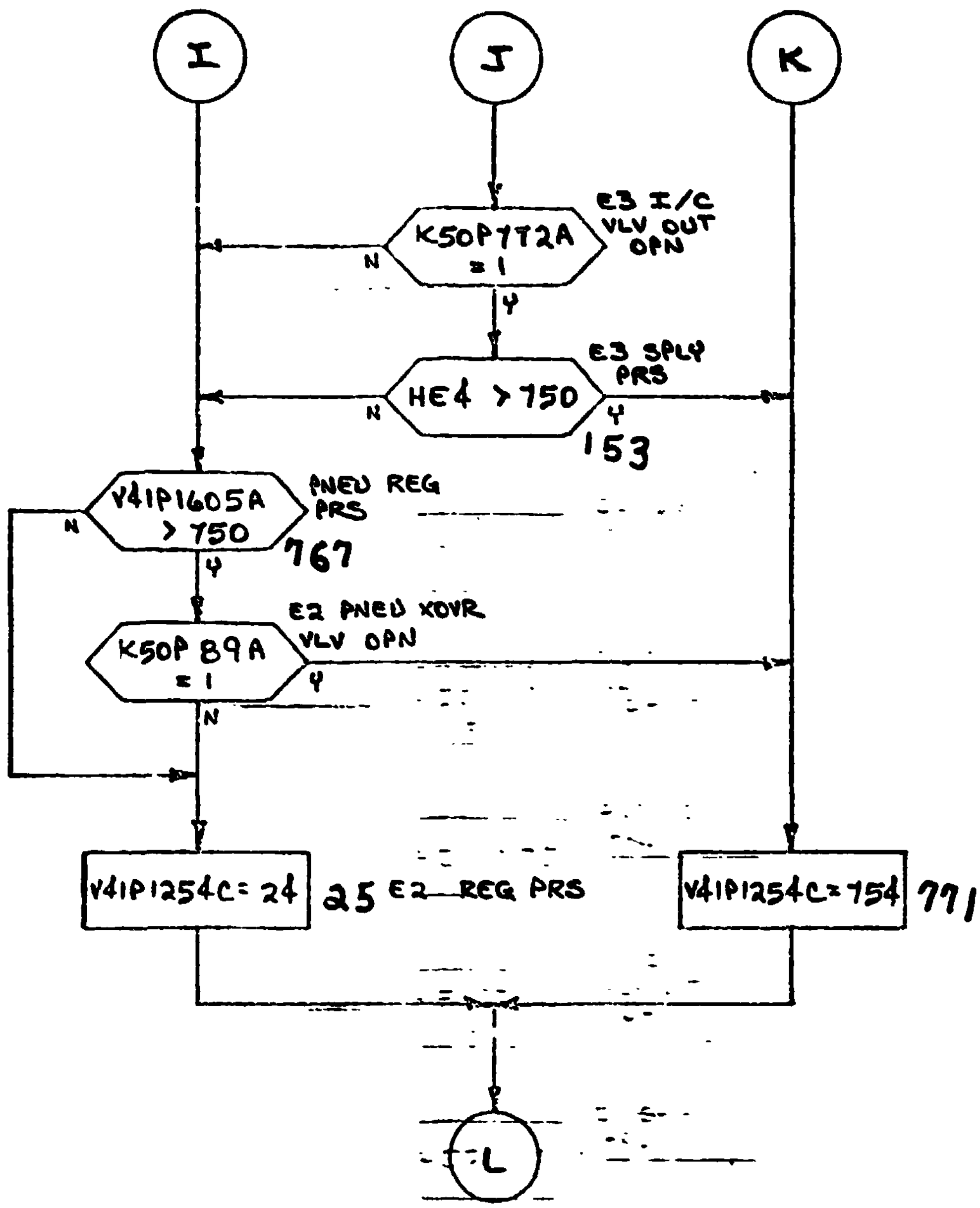
E1 HE PRESS



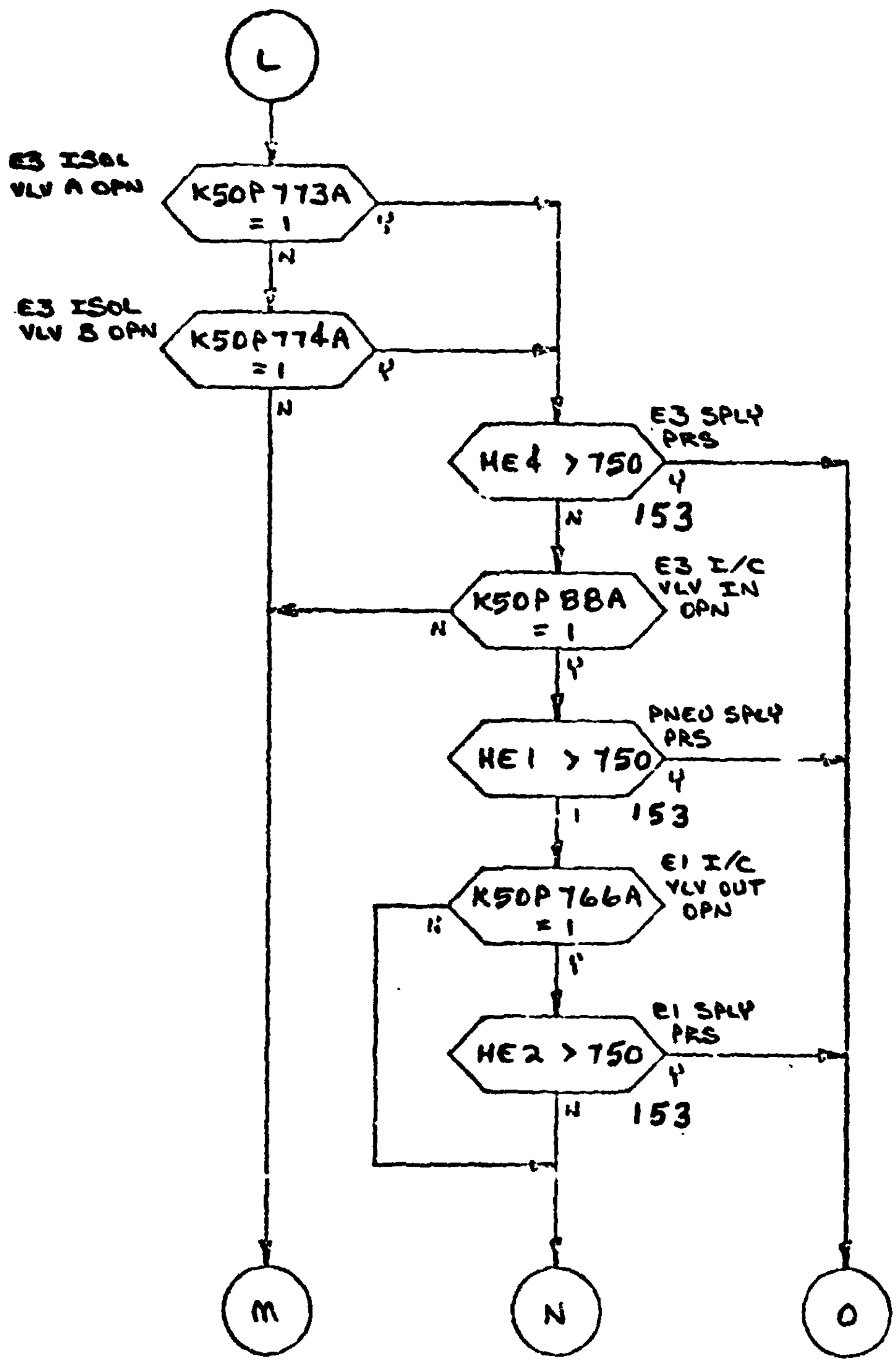
E
F
G
K50P772A = 1
E3 I/C VLV OUT OPN
N
Y
He4 >750
E3 SPLY PRS
N
Y
153
V41P1154C = 22
23 E1 REG PRS
V41P1154C = 752
769
H


E2 HE PRESS
H
E2 ISOL VLV A OPN
K50: 770A = 1
Y
N
E2 ISOL VLV B OPN
K50P771A = 1
Y
N
HE3 > 750
E2 SPLY PRS
Y
153
N
K50P 87A = 1
E2 I/C VLV IN OPN
N
Y
HE1 > 750
PNEU SPLY PRS
Y
153
N
K50P766A = 1
E1 I/C VLV OUT OPN
N
Y
HE2 > 750
E1 SPLY PRS
Y
153
N
I
J
K

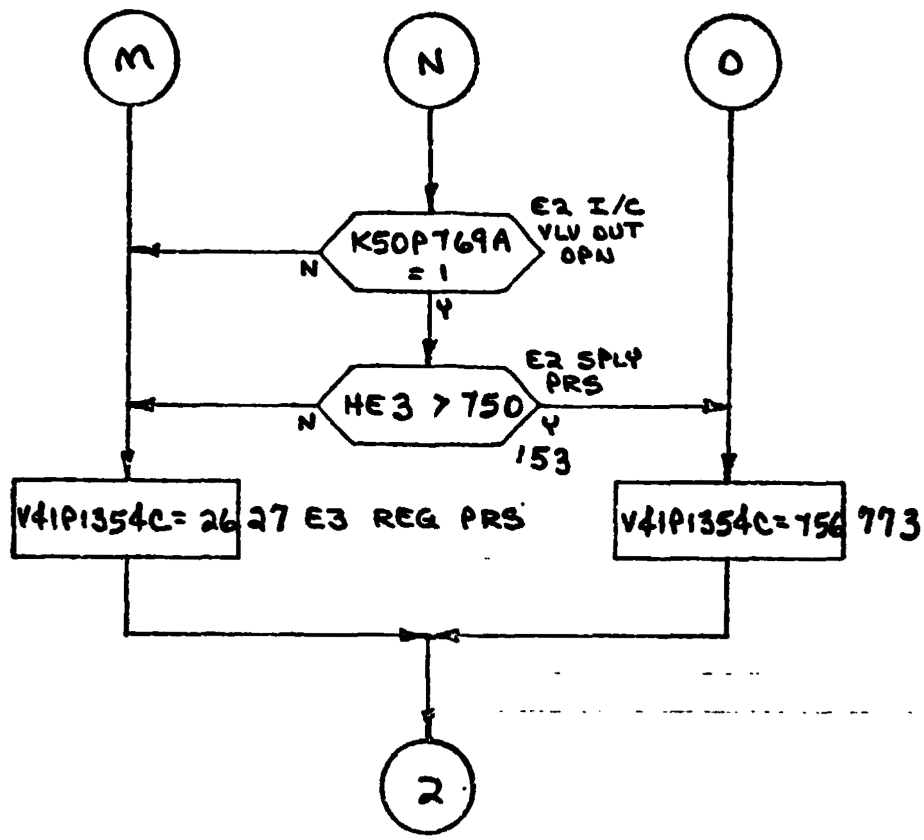
E2 HE PRESS

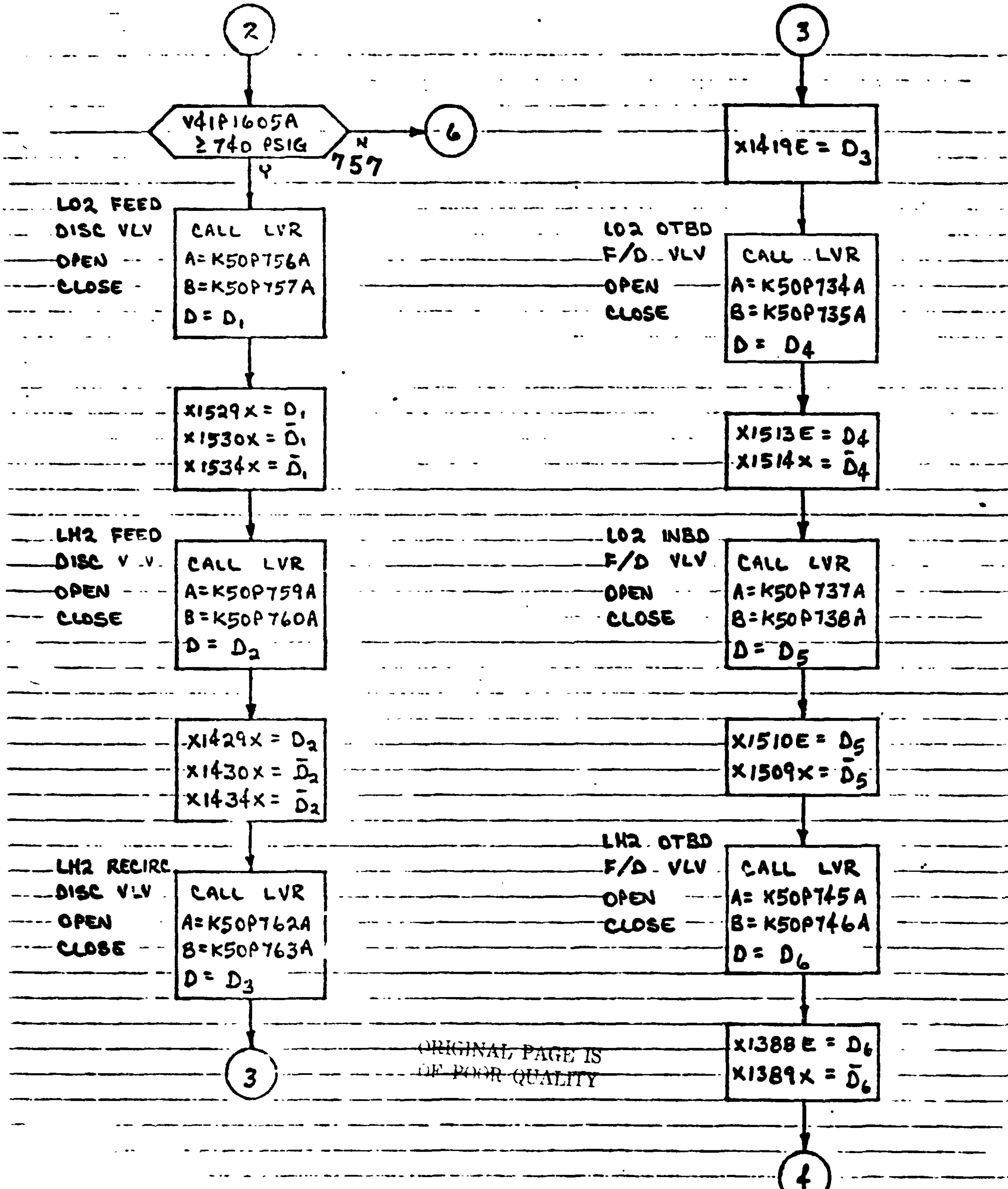

I
J
K
K50P772A = 1
E3 I/C VLV OUT OPN
N
Y
HE4 > 750
E3 SPLY PRS
153
V41P1605A > 750
PNEU REG PRS
767
K50P 89A = 1
E2 PNEU XOVR VLV OPN
V41P1254C = 24
25
E2 REG PRS
V41P1254C = 754
771
L

E3 HE PRESS

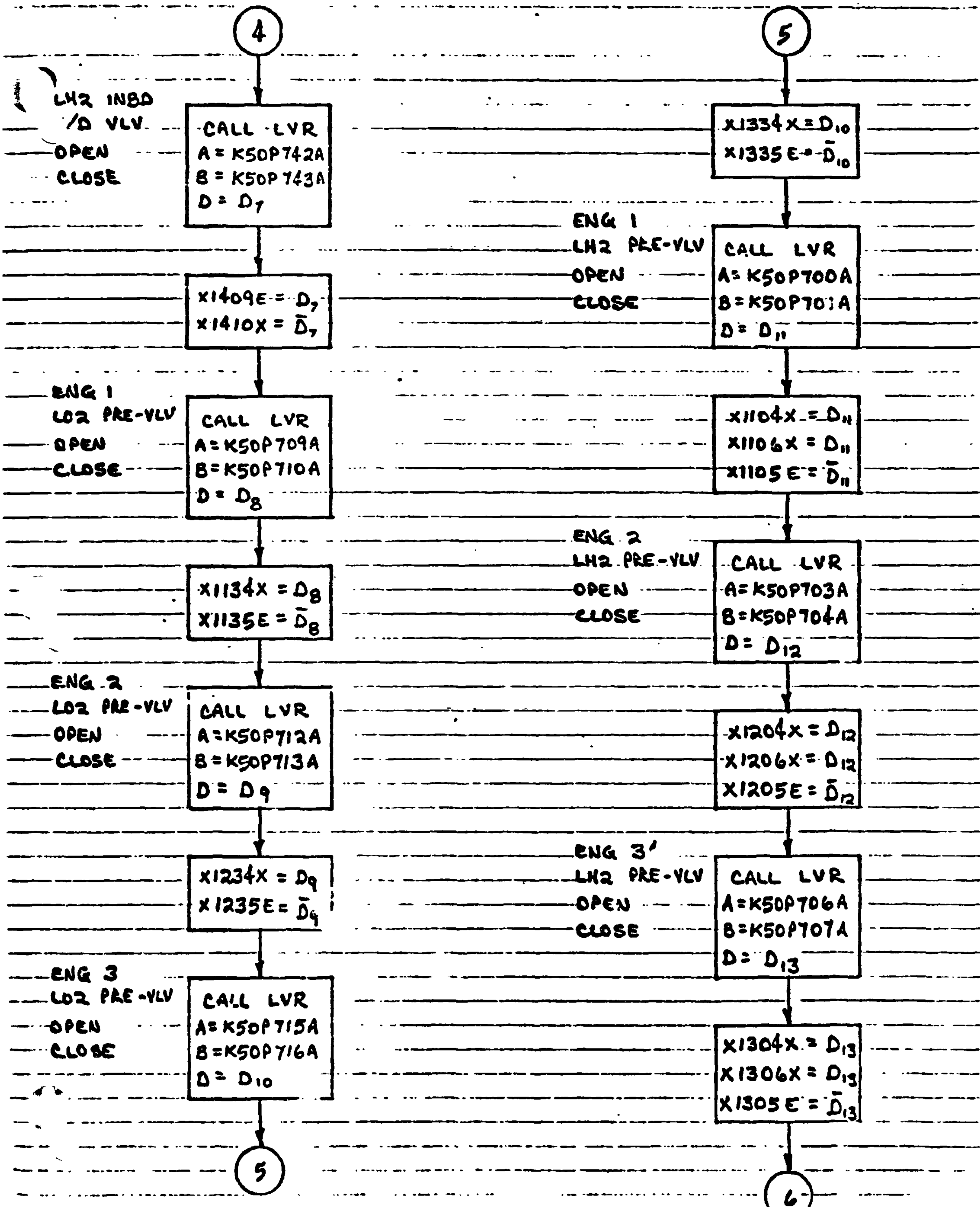

L
E3 ISOL VLV A OPN
K50P773A = 1
Y
N
E3 ISOL VLV B OPN
K50P774A = 1
Y
N
E3 SPLY PRS
HE4 > 750
Y
153
N
E3 I/C VLV IN OPN
K50P88A = 1
N
Y
PNEU SPLY PRS
HE1 > 750
Y
153
E1 I/C VLV OUT OPN
K50P766A = 1
Y
E1 SPLY PRS
HE2 > 750
Y
153
N
M
N
O

E3 HE PRESS

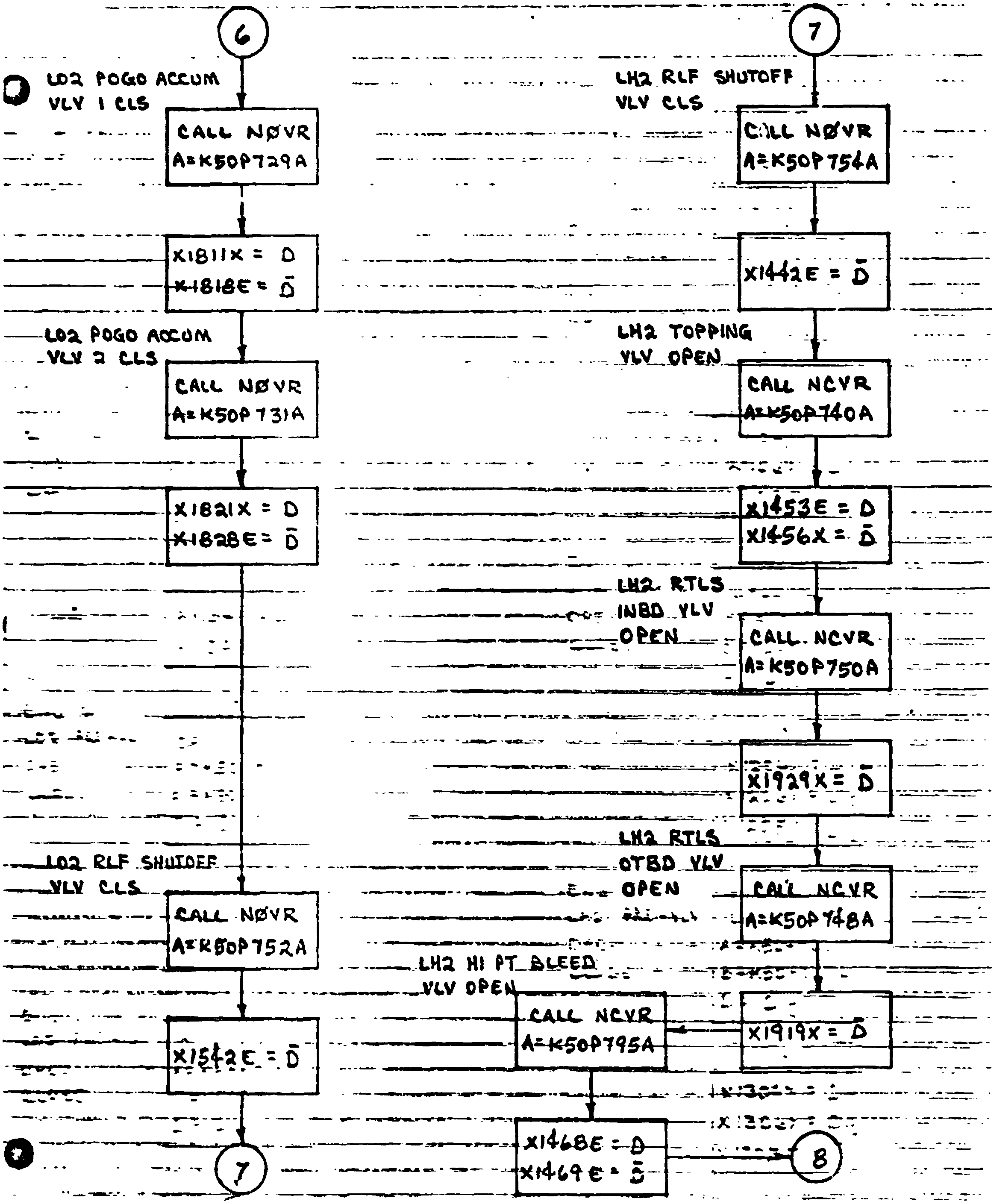

M
N
O
K50P769A = 1
E2 I/C VLV OUT OPN
N
Y
HE3 > 750
E2 SPLY PRS
N
Y
153
V41P1354C= 26 27 E3 REG PRS
V41P1354C= 756 773
2

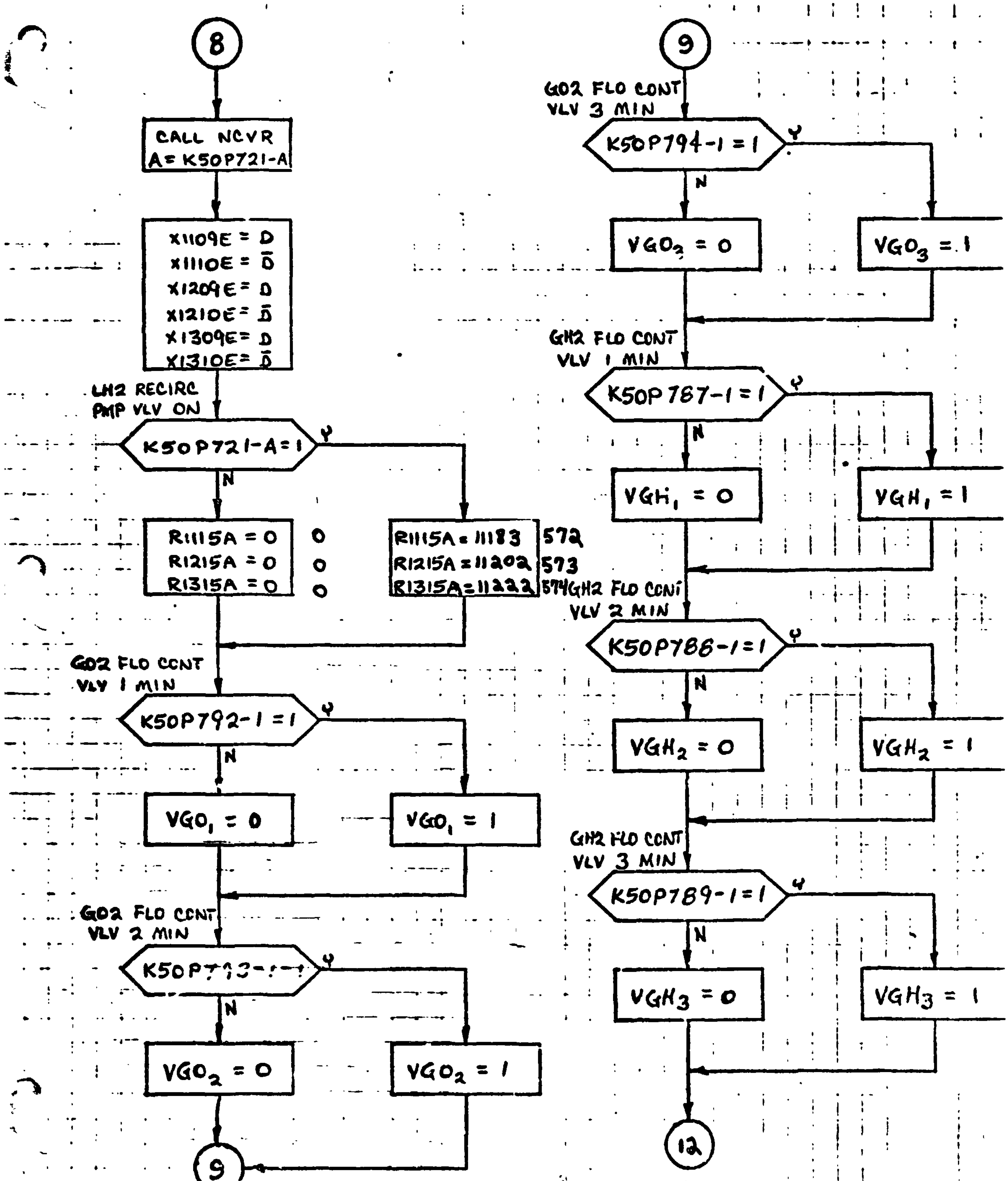


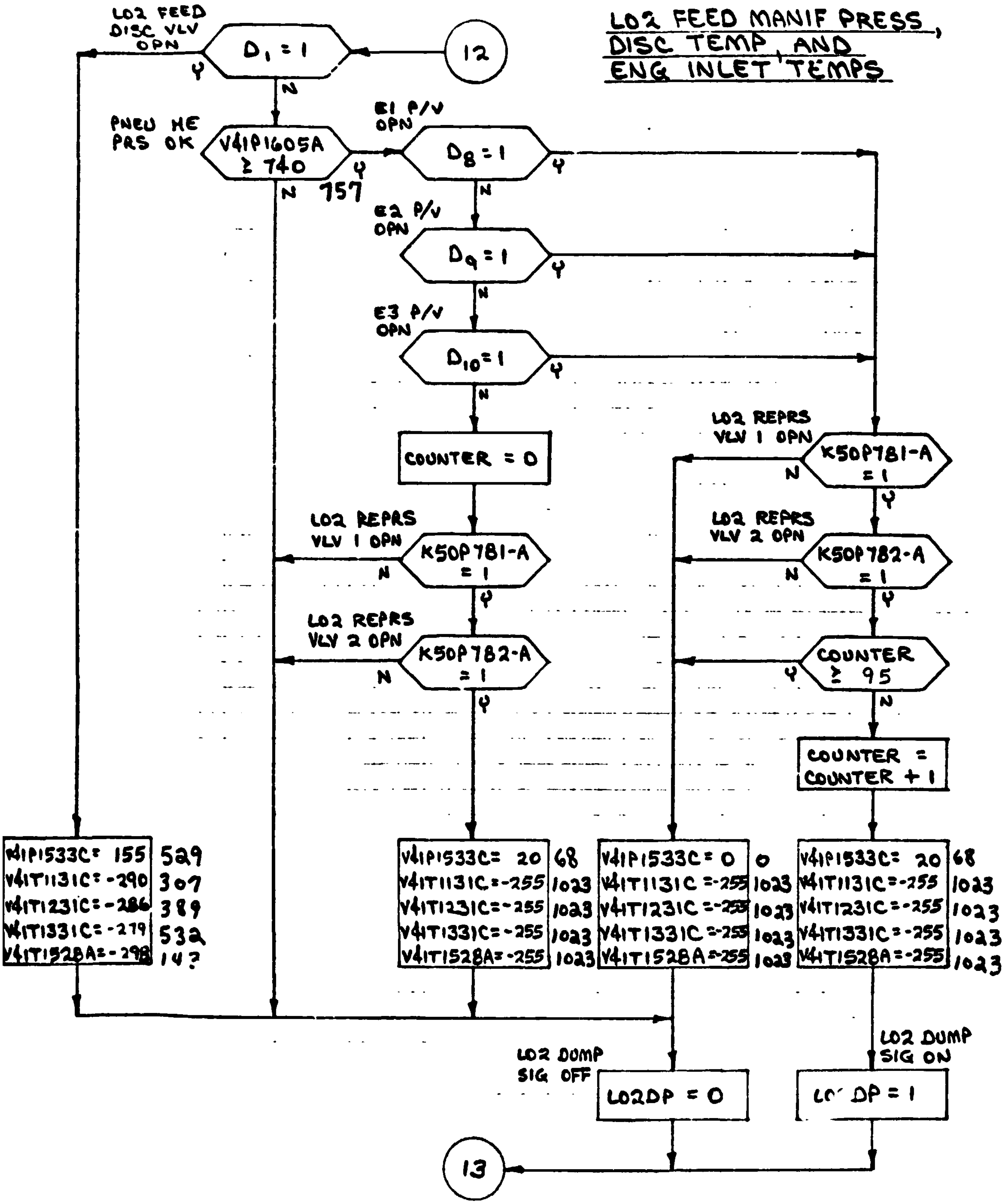
2
V41P1605A
≥ 740 PSIG
N
757
6
Y
LO2 FEED
DISC VLV
OPEN
CLOSE
CALL LVR
A=K50P756A
B=K50P757A
D = D1
X1529X = D1
X1530X = D̄1
X1534X = D̄1
LH2 FEED
DISC V.V.
OPEN
CLOSE
CALL LVR
A=K50P759A
B=K50P760A
D = D2
X1429X = D2
X1430X = D̄2
X1434X = D̄2
LH2 RECIRC
DISC VLV
OPEN
CLOSE
CALL LVR
A=K50P762A
B=K50P763A
D = D3
3
3
X1419E = D3
LO2 OTBD
F/D VLV
OPEN
CLOSE
CALL LVR
A=K50P734A
B=K50P735A
D = D4
X1513E = D4
X1514X = D̄4
LO2 INBD
F/D VLV
OPEN
CLOSE
CALL LVR
A=K50P737A
B=K50P738A
D = D5
X1510E = D5
X1509X = D̄5
LH2 OTBD
F/D VLV
OPEN
CLOSE
CALL LVR
A= K50P745A
B= K50P746A
D = D6
X1388E = D6
X1389X = D̄6
4



4
LH2 INBD
/D VLV
OPEN
CLOSE
CALL LVR
A = K50P742A
B = K50P743A
D = D7
X1409E = D7
X1410X = D̄7
ENG 1
LO2 PRE-VLV
OPEN
CLOSE
CALL LVR
A=K50P709A
B=K50P710A
D = D8
X1134X = D8
X1135E = D̄8
ENG 2
LO2 PRE-VLV
OPEN
CLOSE
CALL LVR
A=K50P712A
B=K50P713A
D = D9
X1234X = D9
X1235E = D̄9
ENG 3
LO2 PRE-VLV
OPEN
CLOSE
CALL LVR
A= K50P715A
B=K50P716A
D= D10
5
5
X1334X = D10
X1335E = D̄10
ENG 1
LH2 PRE-VLV
OPEN
CLOSE
CALL LVR
A= K50P700A
B=K50P701A
D= D11
X1104X = D11
X1106X = D11
X1105E = D̄11
ENG 2
LH2 PRE-VLV
OPEN
CLOSE
CALL LVR
A=K50P703A
B=K50P704A
D= D12
X1204X = D12
X1206X = D12
X1205E = D̄12
ENG 3'
LH2 PRE-VLV
OPEN
CLOSE
CALL LVR
A=K50P706A
B=K50P707A
D= D13
X1304X = D13
X1306X = D13
X1305E = D̄13
6


6
7
LO2 POGO ACCUM VLV 1 CLS
CALL NØVR A=K50P729A
X1811X = D
X1818E = D̄
LO2 POGO ACCUM VLV 2 CLS
CALL NØVR A=K50P731A
X1821X = D
X1828E = D̄
LO2 RLF SHUTOFF VLV CLS
CALL NØVR A=K50P752A
X1542E = D̄
7
LH2 RLF SHUTOFF VLV CLS
CALL NØVR A=K50P754A
X1442E = D̄
LH2 TOPPING VLV OPEN
CALL NCVR A=K50P740A
X1453E = D
X1456X = D̄
LH2 RTLS INBD VLV OPEN
CALL NCVR A=K50P750A
X1929X = D̄
LH2 RTLS OTBD VLV OPEN
CALL NCVR A=K50P748A
X1919X = D̄
LH2 HI PT BLEED VLV OPEN
CALL NCVR A=K50P795A
X1468E = D
X1469E = D̄
8


8
CALL NCVR
A= K50P721-A
X1109E = D
X1110E = D̄
X1209E = D
X1210E = D̄
X1309E = D
X1310E = D̄
LH2 RECIRC
PMP VLV ON
K50P721-A=1
Y
N
R1115A = 0
R1215A = 0
R1315A = 0
0
0
0
R1115A = 11183
R1215A = 11202
R1315A = 11222
572
573
574
GO2 FLO CONT
VLV 1 MIN
K50P792-1 =1
Y
N
VGO1 = 0
VGO1 = 1
GO2 FLO CONT
VLV 2 MIN
Y
N
VGO2 = 0
VGO2 = 1
9
9
GO2 FLO CONT
VLV 3 MIN
K50P794-1 = 1
Y
N
VGO3 = 0
VGO3 = 1
GH2 FLO CONT
VLV 1 MIN
K50P787-1 = 1
Y
N
VGH1 = 0
VGH1 = 1
GH2 FLO CONT
VLV 2 MIN
K50P788-1=1
Y
N
VGH2 = 0
VGH2 = 1
GH2 FLO CONT
VLV 3 MIN
K50P789-1=1
Y
N
VGH3 = 0
VGH3 = 1
12



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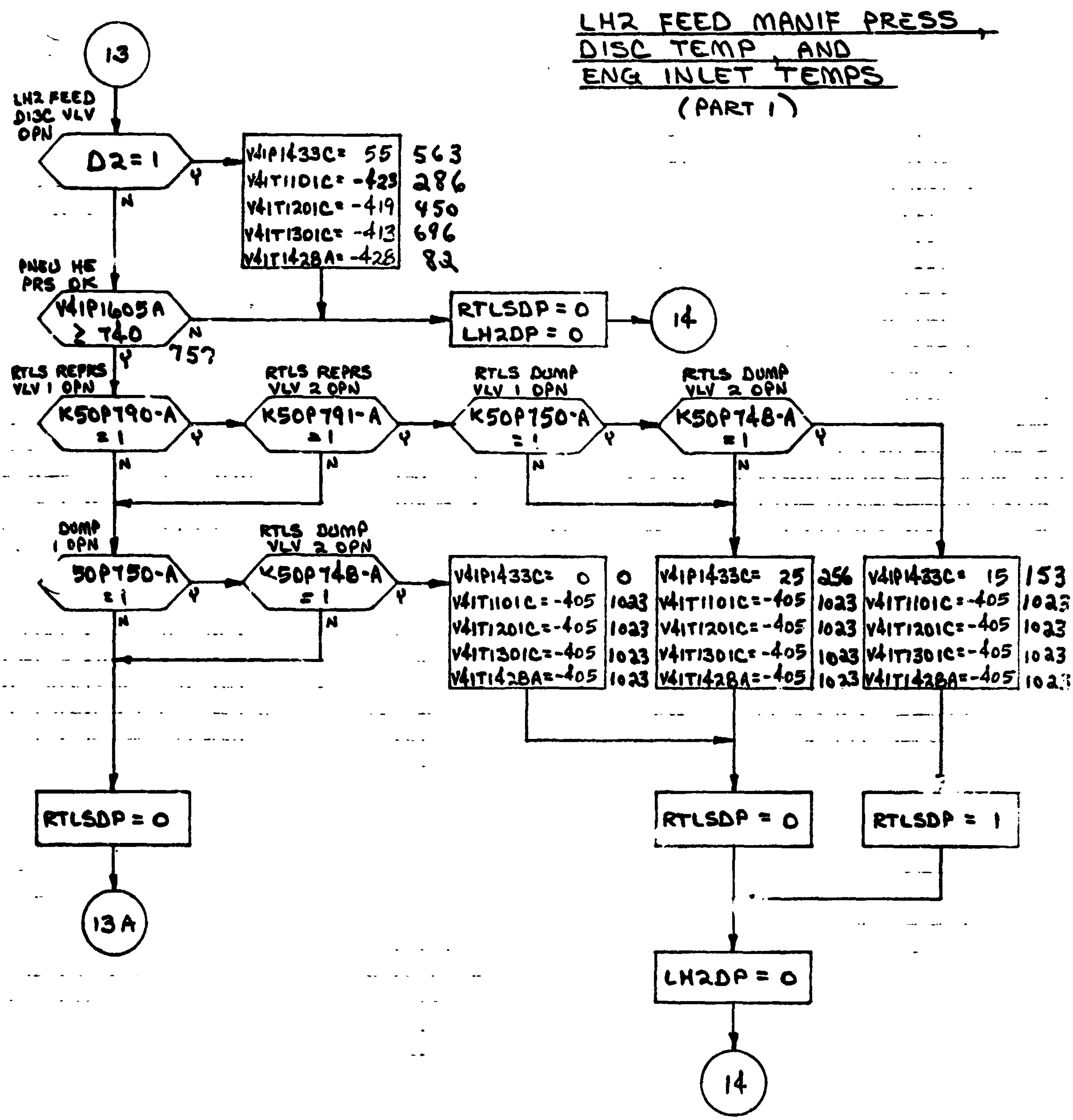
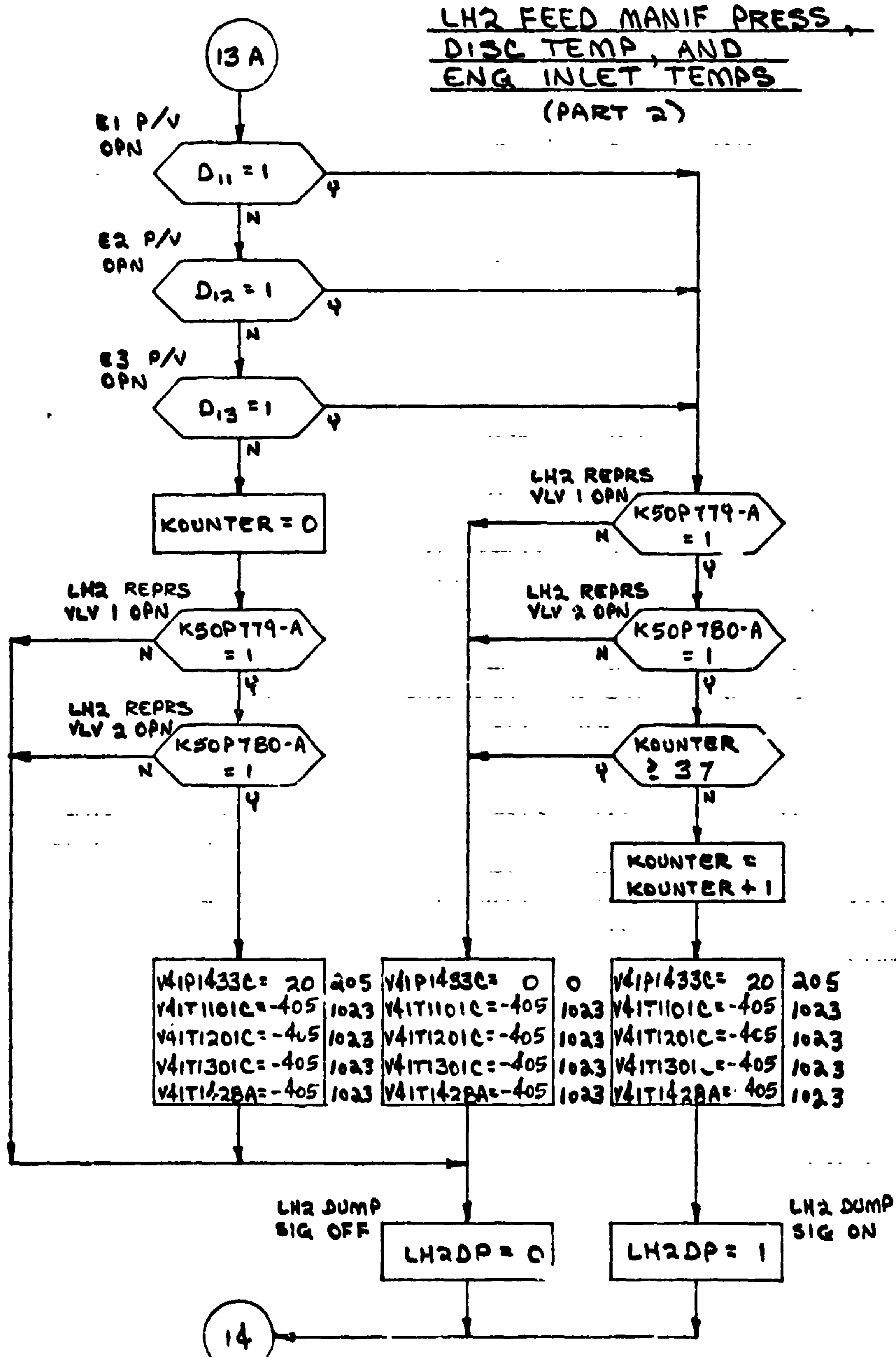
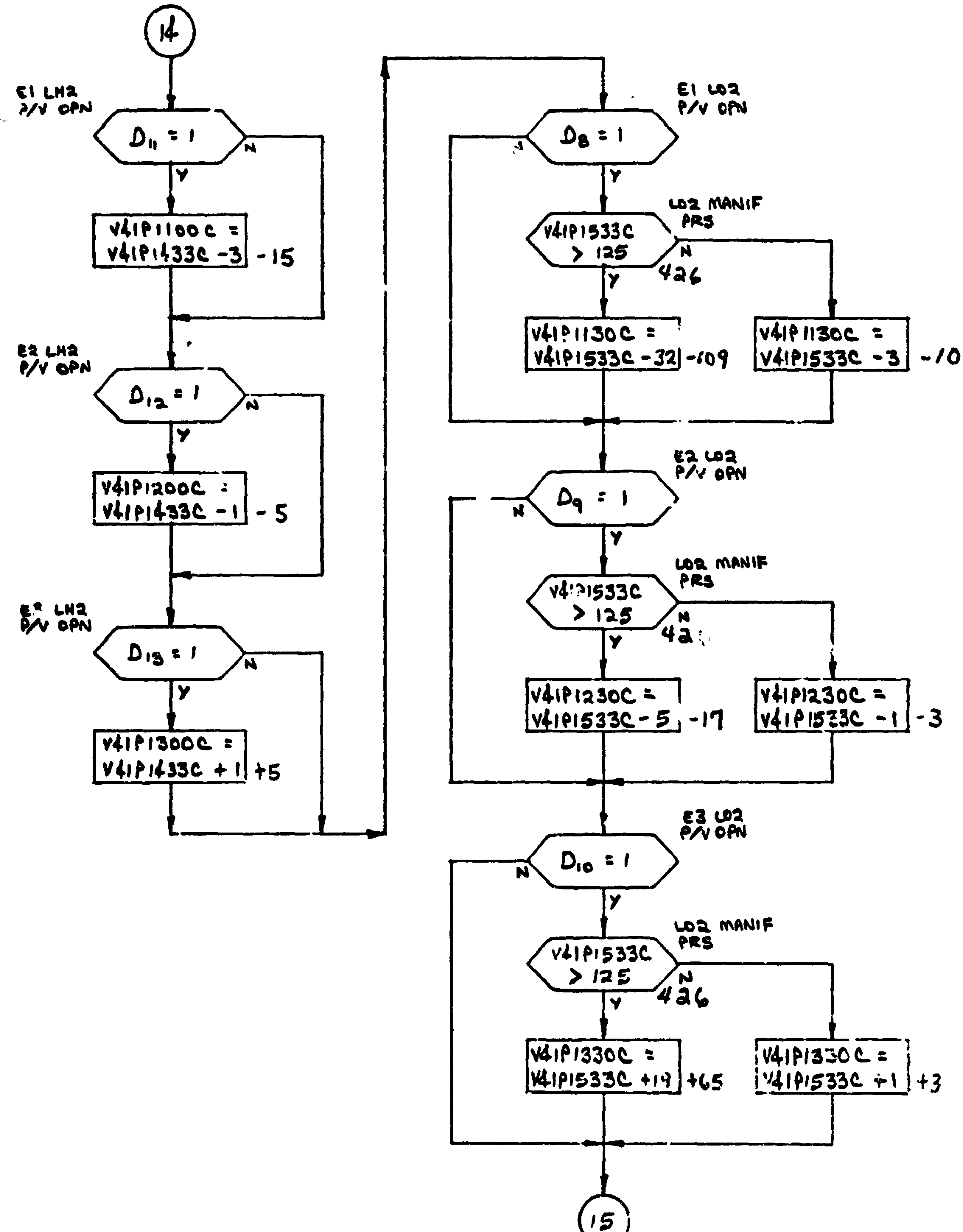


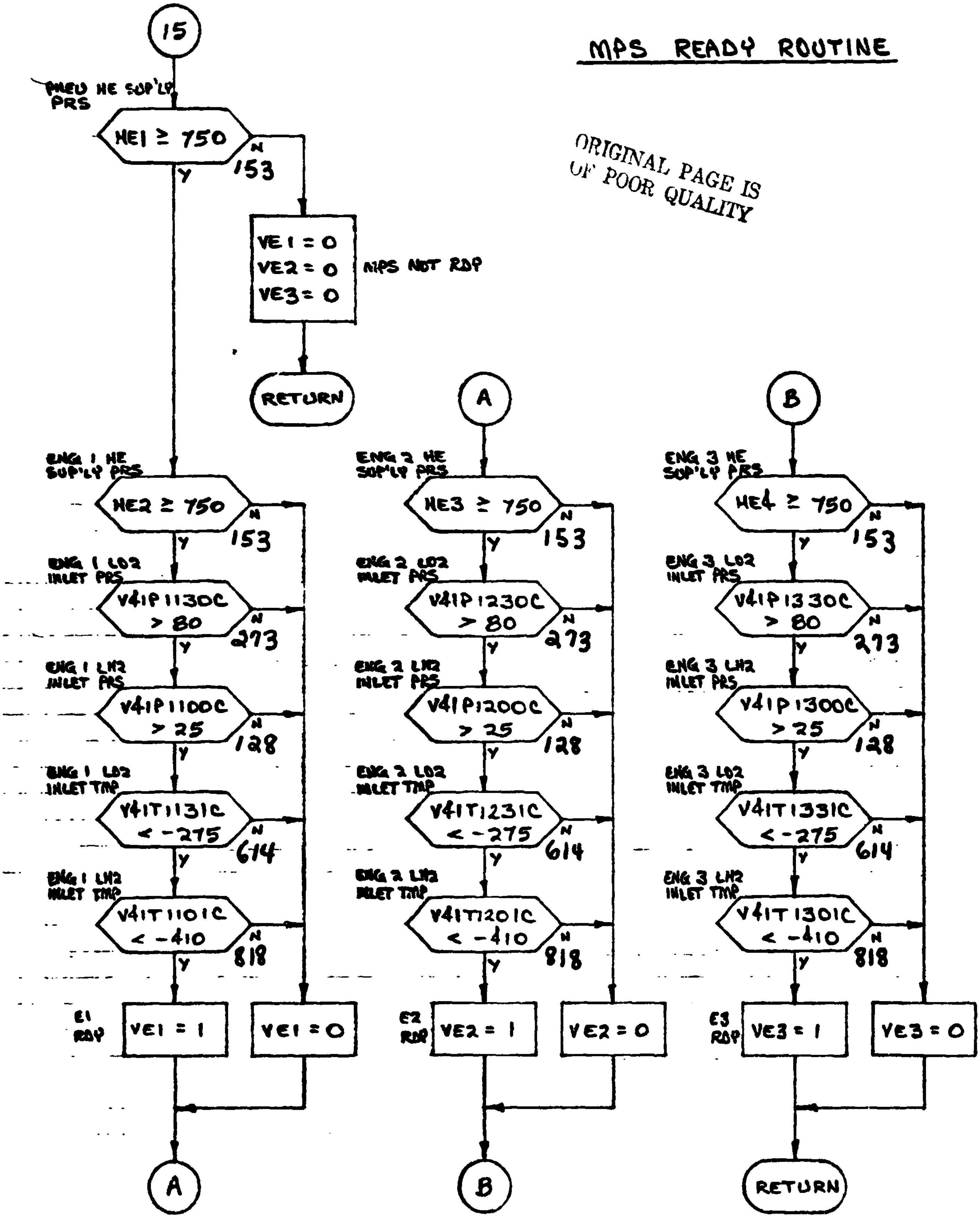
LH2 FEED MANIF PRESS, DISC TEMP, AND ENG INLET TEMPS
(PART 1)
13
LH2 FEED DISC VLV OPN
D2=1
V41P1433C= 55 563
V41T1101C= -423 286
V41T1201C= -419 450
V41T1301C= -413 696
V41T1428A= -428 82
PNEU HE PRS OK
V41P1605A ≥ 740
757
RTLSDP = 0
LH2DP = 0
14
RTLS REPRS VLV 1 OPN
K50P790-A =1
RTLS REPRS VLV 2 OPN
K50P791-A =1
RTLS DUMP VLV 1 OPN
K50P750-A =1
RTLS DUMP VLV 2 OPN
K50P748-A =1
DUMP 1 OPN
50P750-A =1
RTLS DUMP VLV 2 OPN
K50P748-A =1
V41P1433C= 0 0
V41T1101C=-405 1023
V41T1201C=-405 1023
V41T1301C=-405 1023
V41T1428A=-405 1023
V41P1433C= 25 256
V41T1101C=-405 1023
V41T1201C=-405 1023
V41T1301C=-405 1023
V41T1428A=-405 1023
V41P1433C= 15 153
V41T1101C=-405 1023
V41T1201C=-405 1023
V41T1301C=-405 1023
V41T1428A=-405 1023
RTLSDP = 0
13A
RTLSDP = 0
RTLSDP = 1
LH2DP = 0
14


LH2 FEED MANIF PRESS, DISC TEMP, AND ENG INLET TEMPS (PART 2)
13 A
E1 P/V OPN
D11 = 1
E2 P/V OPN
D12 = 1
E3 P/V OPN
D13 = 1
KOUNTER = 0
LH2 REPRS VLV 1 OPN
K50P779-A = 1
LH2 REPRS VLV 2 OPN
K50P780-A = 1
KOUNTER ≥ 37
KOUNTER = KOUNTER + 1
V41P1433C = 20 205
V41T1101C = -405 1023
V41T1201C = -405 1023
V41T1301C = -405 1023
V41T1428A = -405 1023
V41P1433C = 0 0
LH2 DUMP SIG OFF
LH2DP = 0
LH2 DUMP SIG ON
LH2DP = 1
14

ENGINE INLET PRESSURES



MPS READY ROUTINE



4.0 INPUT STIMULI/OUTPUT MEASUREMENT TABLES

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4.1 STS INPUT TABLE

STIMULI INPUT TO [illegible] ODEL - TABLE 4.1

IDENTIFICATION NUMBER	NOMENCLATURE (V41K____)		SOURCE	STATES/RANGE		
				LO	HI	UNITS
K50P700-A	ENG 1 LH2 PRE-VLV OPEN	(1119X)	FS	0	1	STATE
K50P701-A	ENG 1 LH2 PRE-VLV CLOSE	(1122X)				
K50P703-A	ENG 2 LH2 PRE-VLV OPEN	(1219X)				
K50P704-A	ENG 2 LH2 PRE-VLV CLOSE	(1222X)				
K50P706-A	ENG 3 LH2 PRE-VLV OPEN	(1319X)				
K50P707-A	ENG 3 LH2 PRE-VLV CLOSE	(1322X)				
K50P709-A	ENG 1 LO2 PRE-VLV OPEN	(1136X)				
K50P710-A	ENG 1 LO2 PRE-VLV CLOSE	(1139X)				
K50P712-A	ENG 2 LO2 PRE-VLV OPEN	(1236X)				
K50P713-A	ENG 2 LO2 PRE-VLV CLOSE	(1239X)				
K50P715-A	ENG 3 LO2 PRE-VLV OPEN	(1336X)				
K50P716-A	ENG 3 LO2 PRE-VLV CLOSE	(1339X)				
K50P721-A	LH2 RECIRC PUMP VLV OPEN	(1111N)				
K50P729-A	LO2 POGO ACCUM VLV 1 CLOSE	(1815X)				
K50P731-A	LO2 POGO ACCUM VLV 2 CLOSE	(1825X)				
K50P733-A	LO2 OVBD BLEED VLV CLOSE	(1584X)				
K50P734-A	LO2 OTBD FILL VLV OPEN	(1518X)				
K50P735-A	LO2 OTBD FILL VLV CLOSE	(1515X)				
K50P737-A	LO2 INBD FILL VLV OPEN	(1501X)				
K50P738-A	LO2 INBD FILL VLV CLOSE	(1512X)				
K50P740-A	LH2 TOPPING VLV OPEN	(1411X)				
K50P742-A	LH2 INBD FILL VLV OPEN	(1401X)				
K50P743-A	LH2 INBD FILL VLV CLOSE	(1412X)				
K50P745-A	LH2 OTBD FILL VLV OPEN	(1391X)				
K50P746-A	LH2 OTBD FILL VLV CLOSE	(1393X)				
K50P748-A	LH2 FEED RTLS OTBD VLV OPEN	(1913X)				
K50P750-A	LH2 FEED RTLS INBD VLV OPEN	(1923X)				
K50P752-A	LO2 RELIEF SHUT-OFF VLV CLOSE	(1547X)				
K50P754-A	LH2 RELIEF SHUT-OFF VLV CLOSE	(1447X)				
K50P756-A	LO2 FEED DISC VLV OPEN	(1521X)				
K50P757-A	LO2 FEED DISC VLV CLOSE	(1524X)				
K50P759-A	LH2 FEED DISC VLV OPEN	(1413X)				
K50P760-A	LH2 FEED DISC VLV CLOSE	(1416X)	FS	0	1	STATE

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STIMULI INPUT TO S MODEL - TABLE 4.1

IDENTIFICATION NUMBER	NOMENCLATURE (V41K____)	SOURCE	STATES/RANGE LO	STATES/RANGE HI	STATES/RANGE UNITS
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	GH2 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)	FS			
HE1	PNEU HE SUPPLY PRESS	OPR		5000	PSIA
HE2	ENG 1 HE SUPPLY PRESS				
HE3	ENG 2 HE SUPPLY PRESS				
HE4	ENG 3 HE SUPPLY PRESS	OPR		5000	PSIA

STIMULI INPUT TO S MODEL - TABLE 4.1

IDENTIFICATION NUMBER	NOMENCLATURE (V41K____)		SOURCE	STATES/RANGE		
				LO	HI	UNITS
K50P86-A	E1 HE INTERCONNECT "IN" VLV OPN	(1162X)	FLT SYS	0	1	STATE
K50P87-A	E2 HE INTERCONNECT "IN" VLV OPN	(1262X)	↓	↓	↓	↓
K50P88-A	E3 HE INTERCONNECT "IN" VLV OPN	(1362X)				
K50P89-A	E2 HE PNEU XOVR VLV OPN	(1613X)				

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[illegible] RECIRC PUMP SPEED	11183	572	0	0					RPM
*V41P1130C	ENG 1 LO2 INLET PRESS	0	0	17	58	123	419	152	518	PSIA
*V41T1131C	ENG 1 LO2 INLET TEMP	-290	307	-255	1023					DEGF
V41X1134X	ENG 1 LO2 PRE-VLV OPEN	1	1	0	0					STATE
V41X1135E	ENG 1 LO2 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 LO2 INLET PRESS	0	0	15 154	51 525	19	65	150	512	PSIA
*V41T1231C	ENG 2 LO2 INLET TEMP	-286	389	-255	1023					DEGF
V41X1234X	ENG 2 LO2 PRE-VLV OPEN	1	1	0	0					STATE
V41X1235E	ENG 2 LO2 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 LO2 INLET PRESS	0	0	1 39	3 133	19 156	65 532	21 174	72 593	PSIA
*V41T1331C	ENG 3 LO2 INLET TEMP	-279	532	-255	1023					DEGF
V41X1334X	ENG 3 LO2 PRE-VLV OPEN	1	1	0	0					STATE
V41X1335E	ENG 3 LO2 PRE-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	
*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 0	153 0	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	LO2 INBD FILL VLV CLOSED	1	1	0	0					STATE
V41X1510E	LO2 INBD FILL VLV OPEN	0	0	1	1					STATE
V41X1513E	LO2 OTBD FILL VLV OPEN	0	0	1	1					STATE
V41X1514X	LO2 OTBD FILL VLV CLOSED	1	1	0	0					STATE
*V41T1528A	LO2 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	LO2 FEED DISC VLV OPEN	1	1	0	0					STATE
V41X1530X	LO2 FEED DISC VLV CLOSED - A	0	0	1	1					STATE
*V41P1533C	LO2 ENG MANIFOLD PRESS	155	529	20	68	0	0			PSIA
V41X1534X	LO2 FEED DISC VLV CLOSED - B	0	0	1	1					STATE
V41X1542E	LO2 FEED LINE RLF SHUT-OFF VLV CLOSED	0	0	1	1					STATE
V41X1580X	LO2 OVBD BLEED VLV CLOSED - A	1	1	0	0					STATE
V41X1581X	LO2 OVBD BLEED VLV CLOSED - B	1	1	0	0					STATE
V41X1587E	LO2 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	LO2 ACCUM RECIRC VLV 1 OPEN	1	1	0	0					STATE
V41X1818E	LO2 ACCUM RECIRC VLV 1 CLOSED	0	0	1	1					STATE
V41X1821X	LO2 ACCUM RECIRC VLV 2 OPEN	1	1	0	0					STATE
V41X1828E	LO2 ACCUM RECIRC VLV 2 CLOSED	0	0	1	1					STATE
V41X1919X	LH2 RTLS OTBD DRAIN VLV CLOSED	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 $GSIU_{CTS}$ 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	
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
VE3	ENG 3 PLUMBING READY DISCRETE	0	0	1	1					STATE
LO2DP	LO2 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

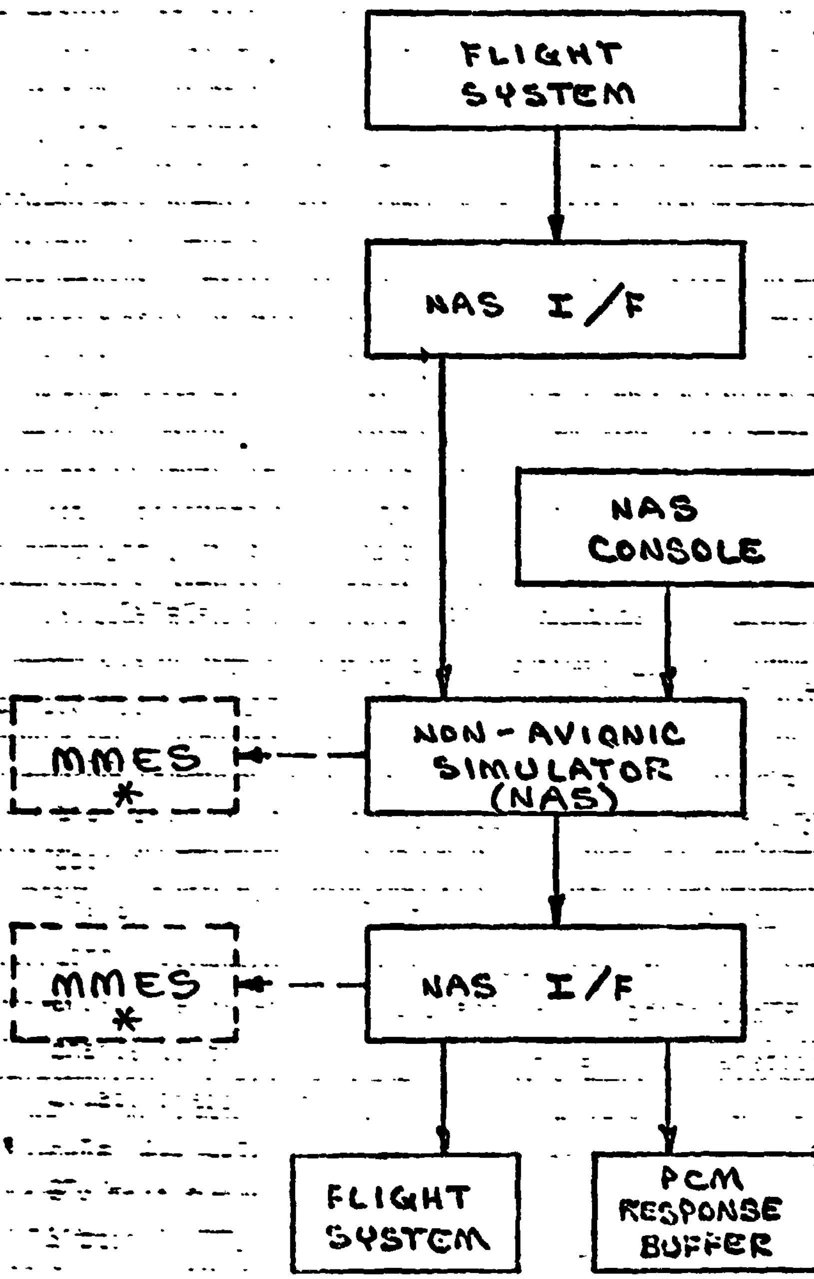
This model simulates those functions of the Main Propulsion System (MPS) components that are in the Orbiter, namely valve positions, system pressures, and system temperatures. To simplify the model, only those component functions needed to support testing of the Shuttle Avionics System are provided.

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 discretes (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 LO2 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 prevalves while the engine is ignited.



* - APPLIES ONLY WHEN MMES IS USED IN GTS

FIGURE 3 - GTS SYSTEM DATA FLOW

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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:

PHASE	PRESSURE VALUE (PSIA)
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 - LO2 Feed Disconnect Valve

D2 - LH2 Feed Disconnect Valve

D3 - LH2 Recirculation Disconnect Valve

D4 - LO2 Outboard Fill and Drain Valve

D5 - LO2 Inboard Fill and Drain Valve

D6 - LH2 Outboard Fill and Drain Valve

D7 - LH2 Inboard Fill and Drain Valve

D8 - Engine 1 LO2 Prevalve

D9 - Engine 2 LO2 Prevalve

D10 - Engine 3 LO2 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:

NOMINAL NUMBER	NOMENCLATURE
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

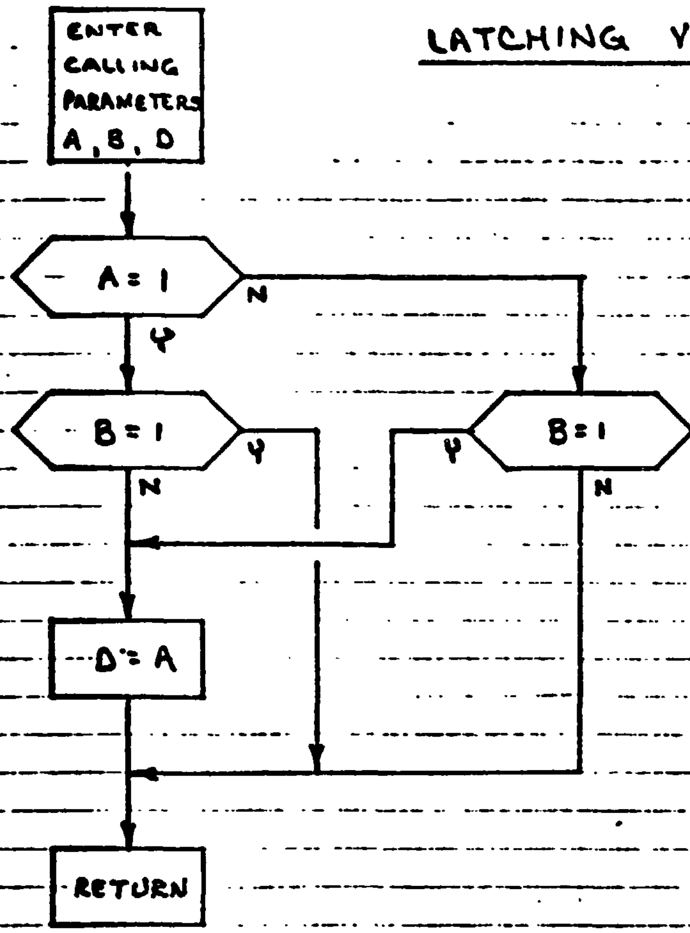
Following Main Engine Cut-Off or External Tank separation, an LO2 signal, an LH2 signal, and an RTLS signal are needed by the Vehicle Dynamics Math Models to compute the changes in vehicle forces and mass properties while MPS residual propellants are discharged overboard. The three signals are generated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

LO2DP	LO2 DUMP SIGNAL
LH2DP	LH2 DUMP SIGNAL
RTLSDP	RTLS DUMP SIGNAL

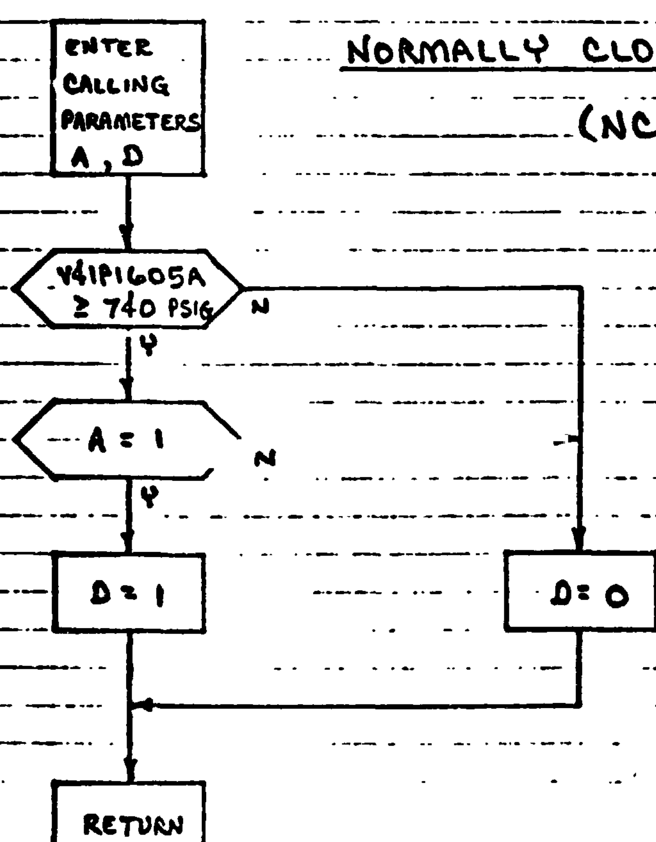
A state of (1) indicates a dump is in progress.

13.0 GTS LOGIC FLOW DIAGRAMS

LATCHING VALVE ROUTINE (LVR)

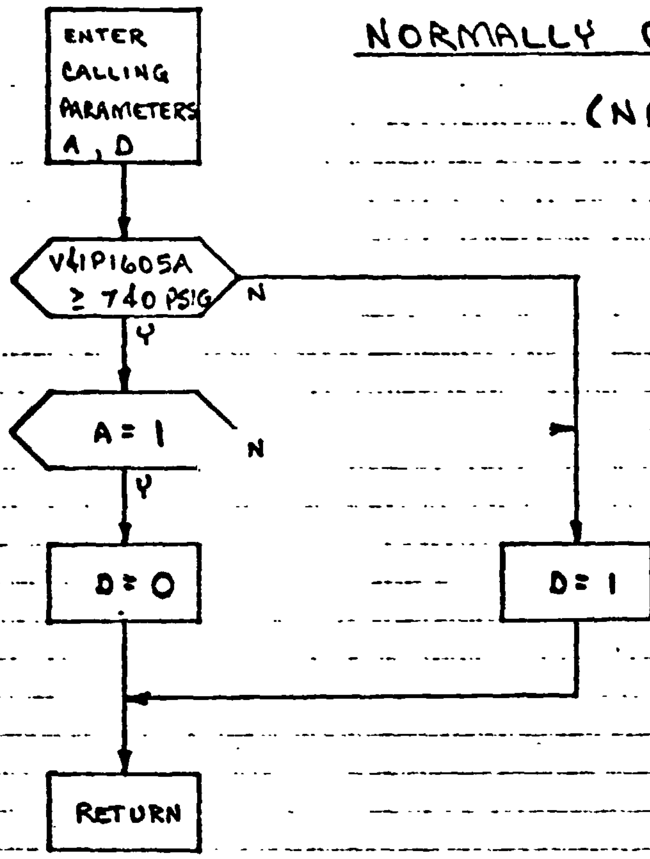


NORMALLY CLOSED VALVE ROUTINE (NCVR)

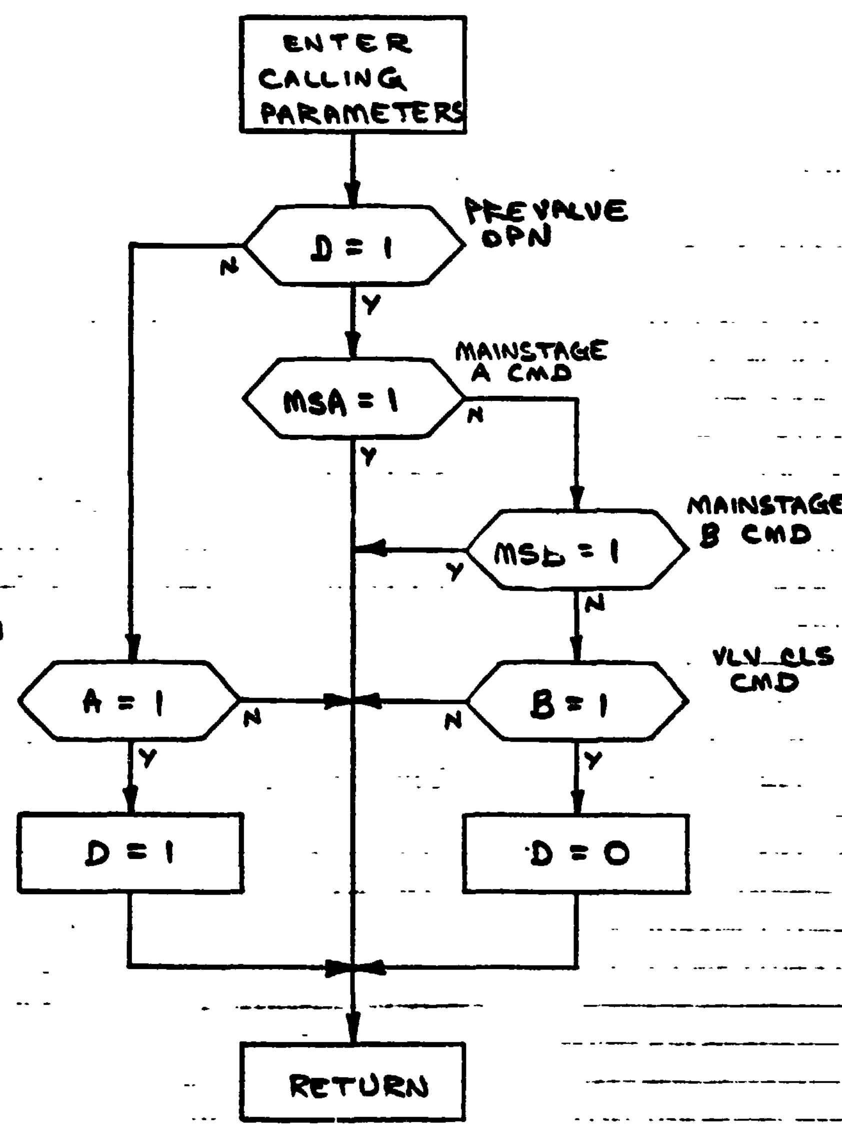


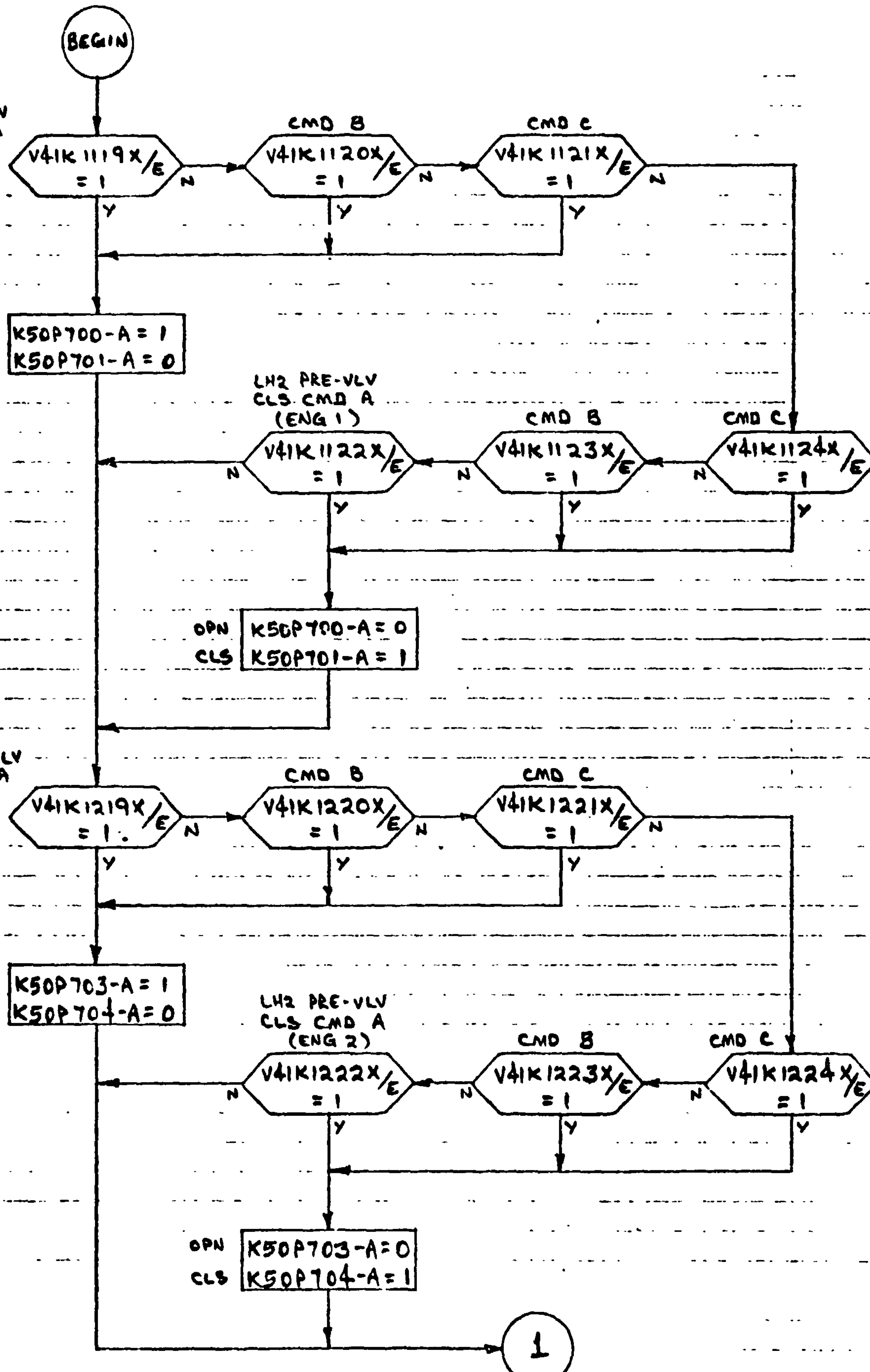
NORMALLY OPEN VALVE ROUTINE

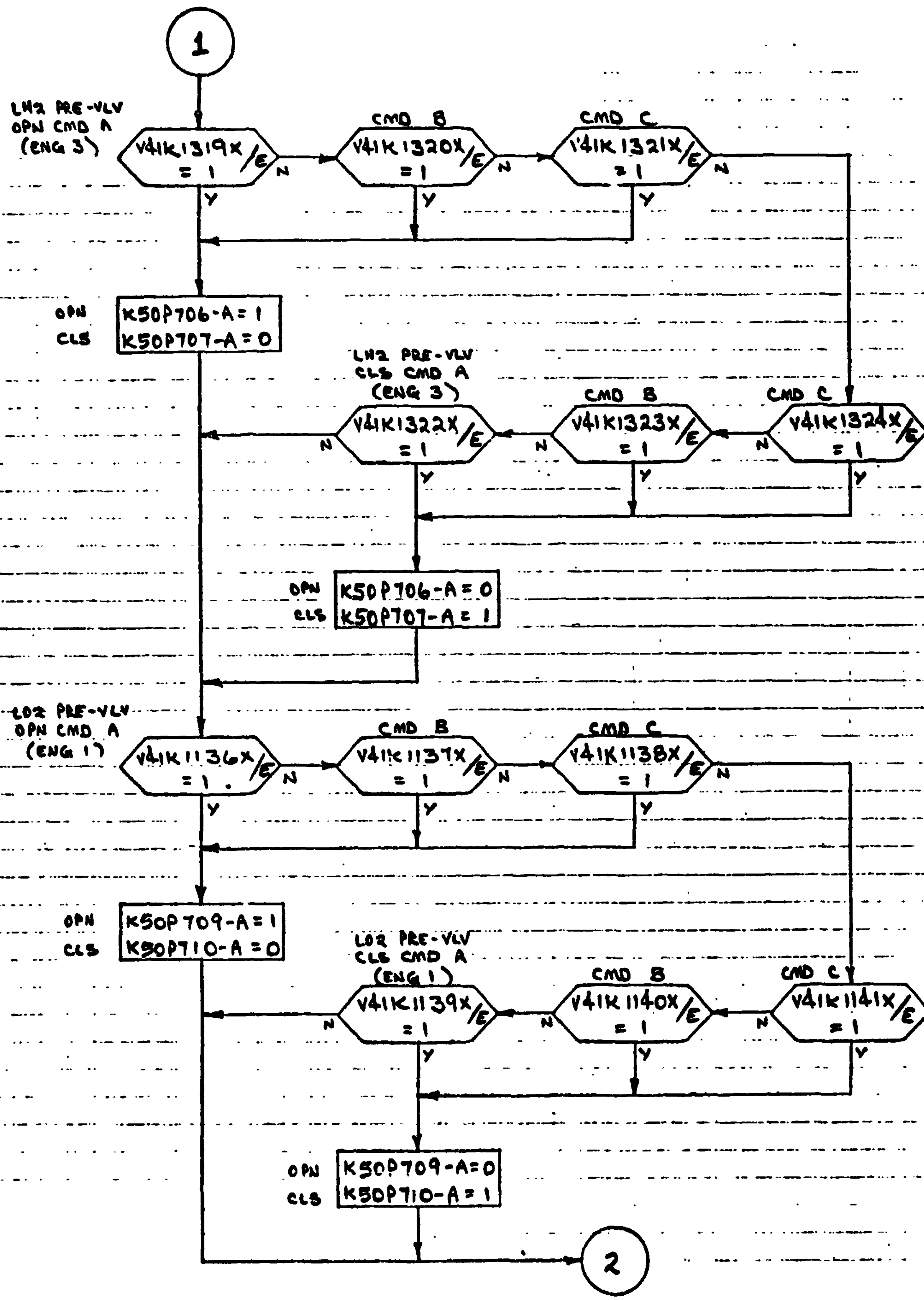
(NØVR)

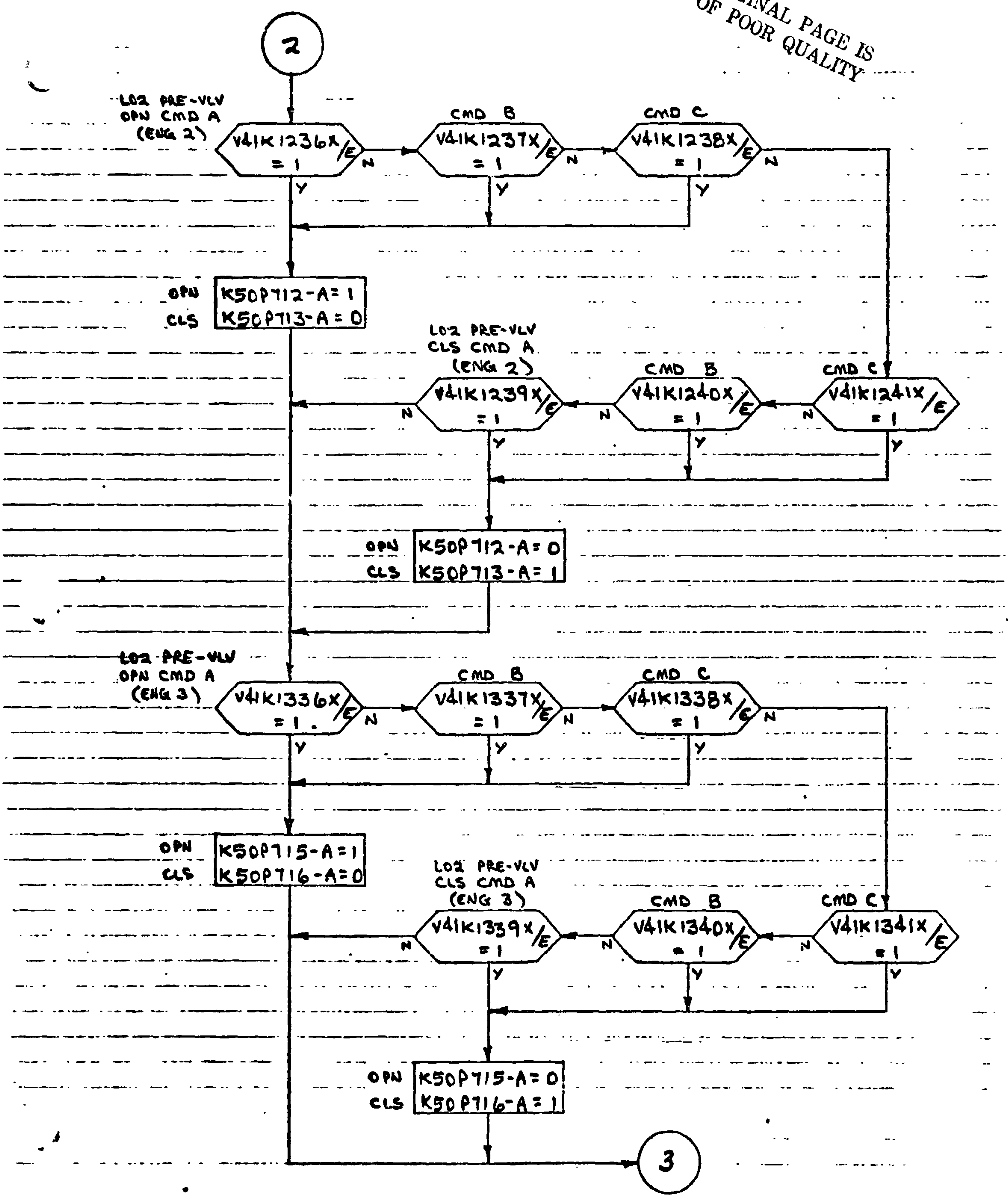


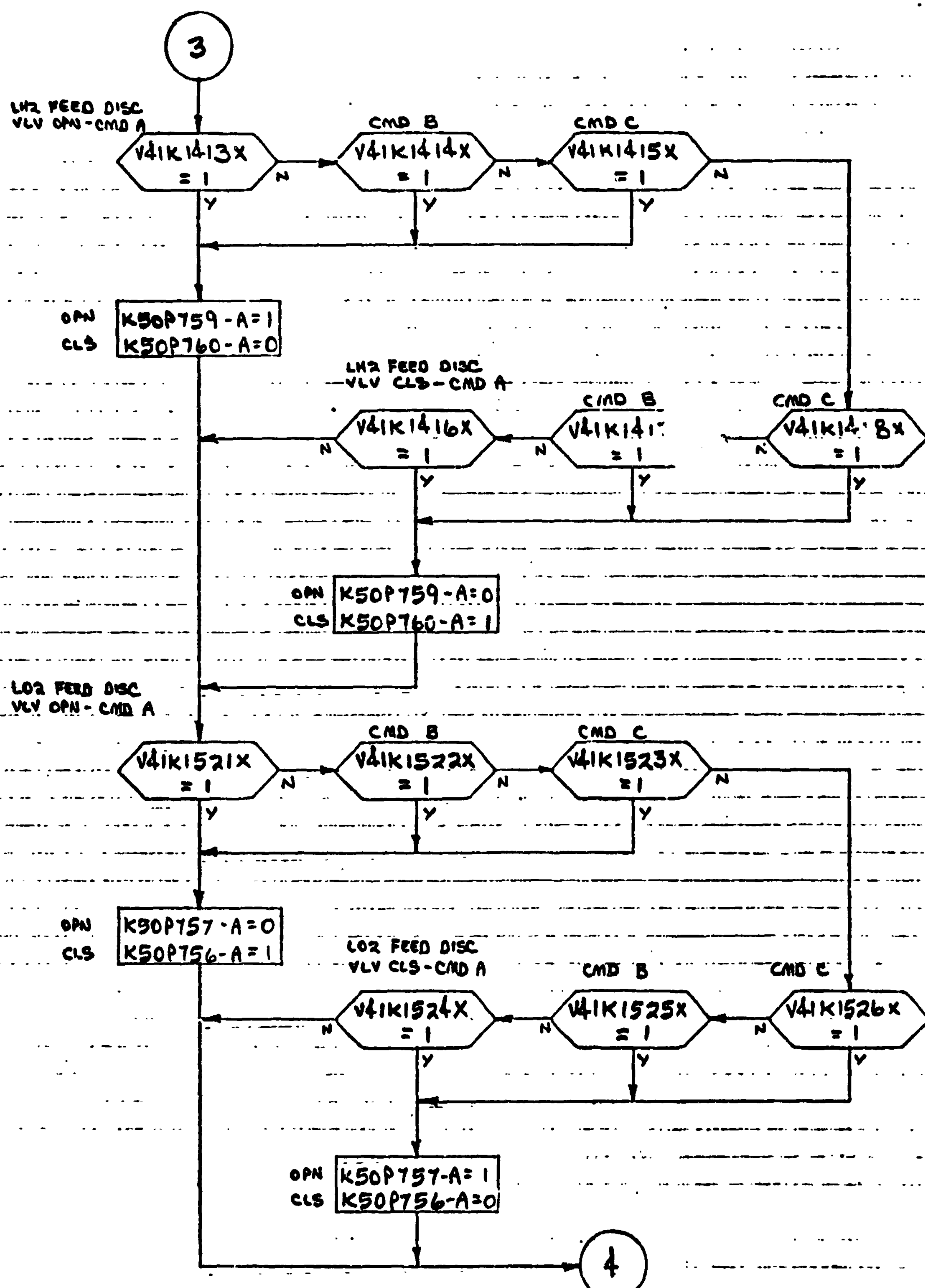
ENGINE PREVALVE ROUTINE (EPR)

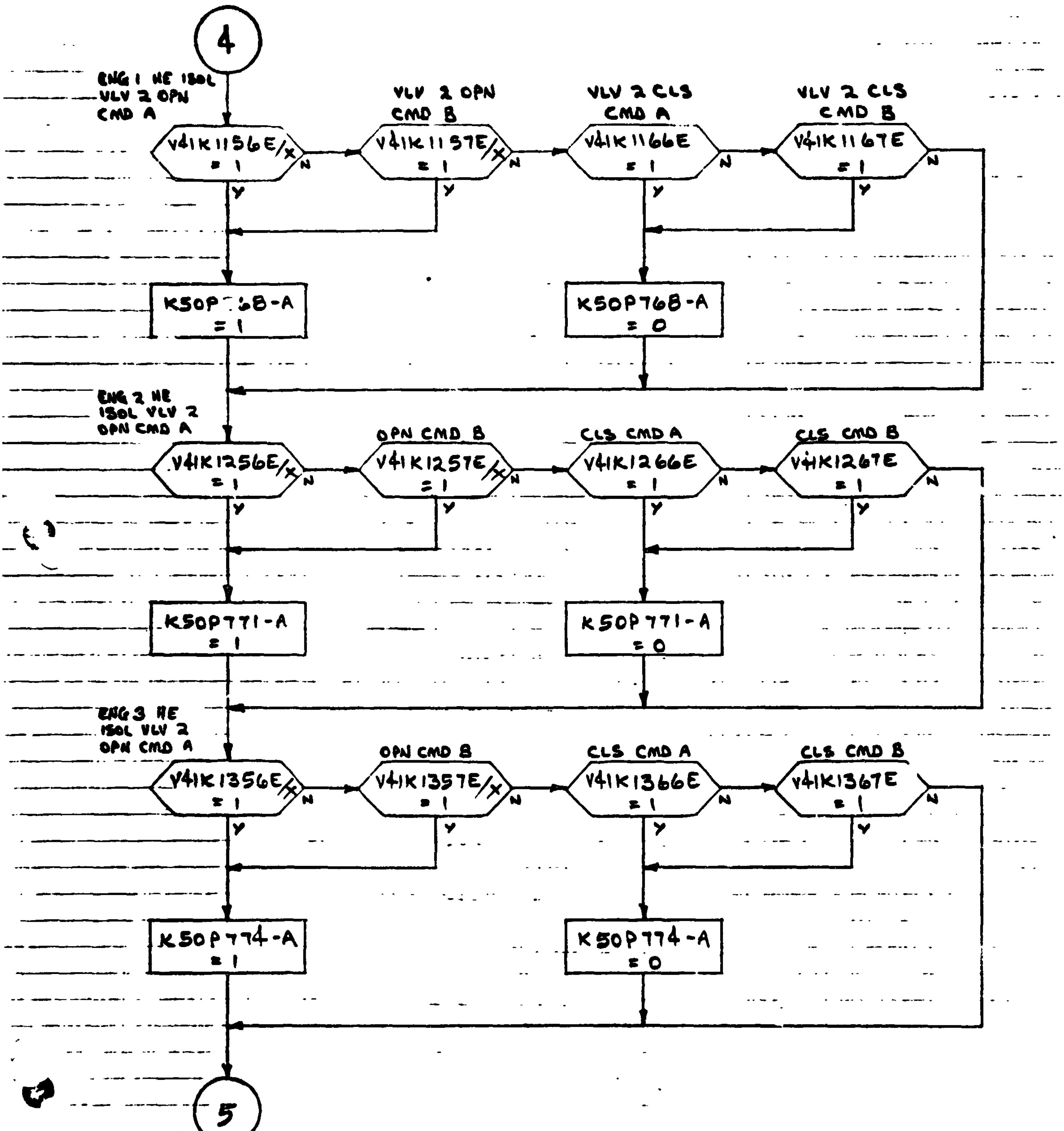


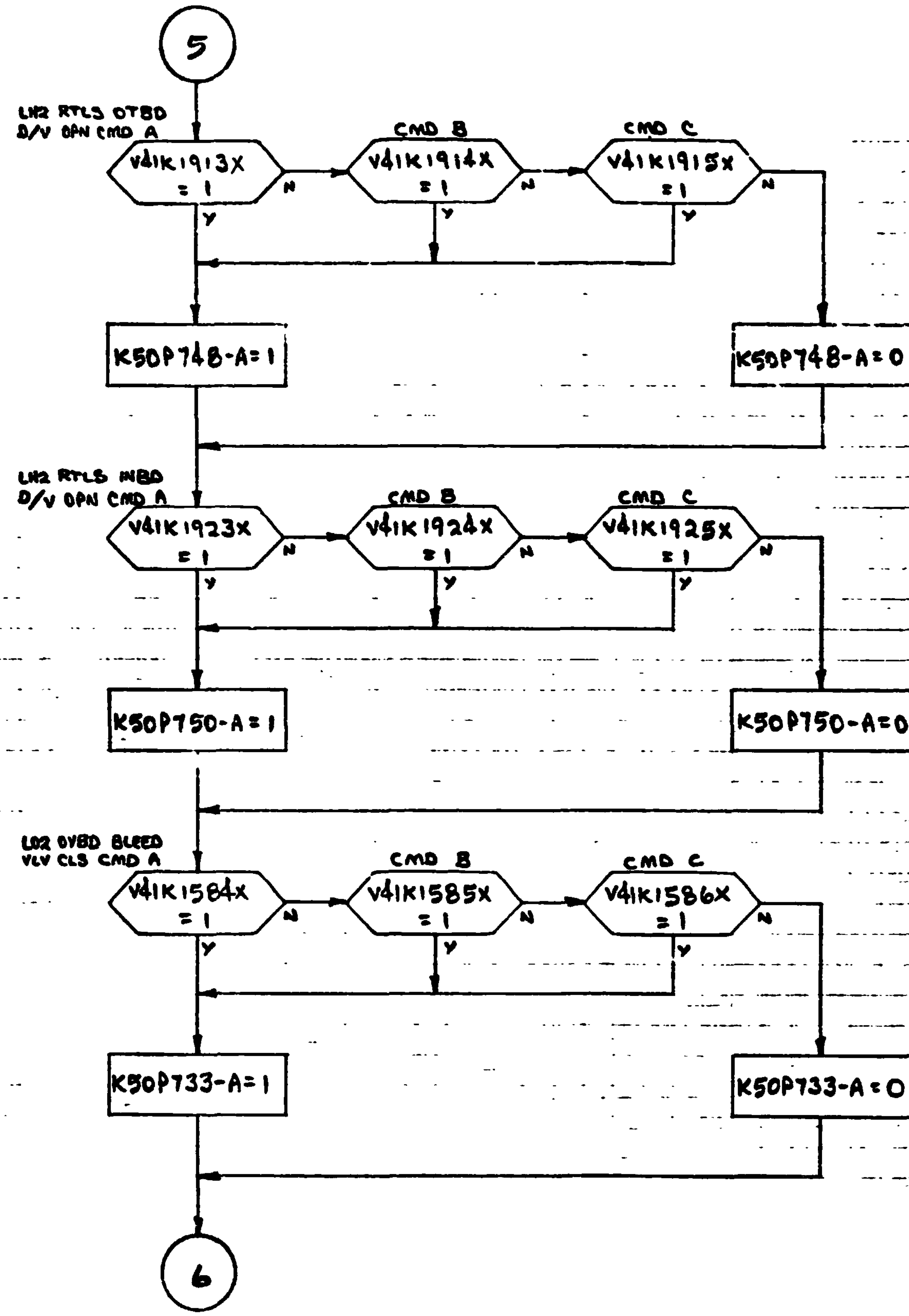

BEGIN
LH2 PRE-VLV OPN CMD A (ENG 1)
V41K1119X/E = 1
CMD B
V41K1120X/E = 1
CMD C
V41K1121X/E = 1
N
Y
OPN K50P700-A = 1
CLS K50P701-A = 0
LH2 PRE-VLV CLS CMD A (ENG 1)
V41K1122X/E = 1
CMD B
V41K1123X/E = 1
CMD C
V41K1124X/E = 1
OPN K50P700-A = 0
CLS K50P701-A = 1
LH2 PRE-VLV OPN CMD A (ENG 2)
V41K1219X/E = 1
CMD B
V41K1220X/E = 1
CMD C
V41K1221X/E = 1
OPN K50P703-A = 1
CLS K50P704-A = 0
LH2 PRE-VLV CLS CMD A (ENG 2)
V41K1222X/E = 1
CMD B
V41K1223X/E = 1
CMD C
V41K1224X/E = 1
OPN K50P703-A = 0
CLS K50P704-A = 1
1


1
LH2 PRE-VLV OPN CMD A (ENG 3)
V41K1319X = 1
E
CMD B
V41K1320X = 1
CMD C
V41K1321X = 1
Y
N
OPN K50P706-A = 1
CLS K50P707-A = 0
LH2 PRE-VLV CLS CMD A (ENG 3)
V41K1322X = 1
V41K1323X = 1
V41K1324X = 1
OPN K50P706-A = 0
CLS K50P707-A = 1
LO2 PRE-VLV OPN CMD A (ENG 1)
V41K1136X = 1
V41K1137X = 1
V41K1138X = 1
OPN K50P709-A = 1
CLS K50P710-A = 0
LO2 PRE-VLV CLS CMD A (ENG 1)
V41K1139X = 1
V41K1140X = 1
V41K1141X = 1
OPN K50P709-A = 0
CLS K50P710-A = 1
2

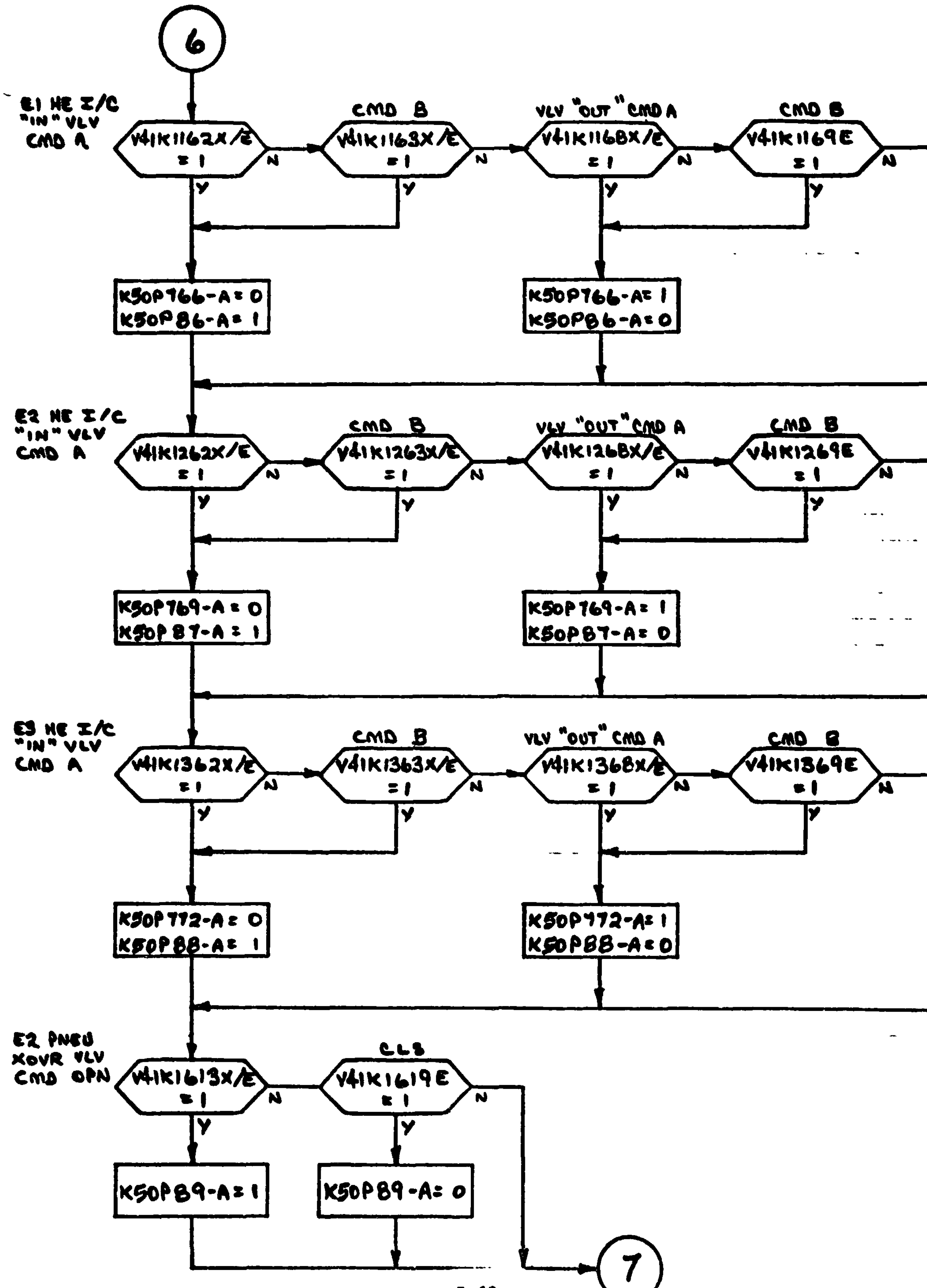

2
LO2 PRE-VLV OPN CMD A (ENG 2)
V41K1236X = 1
E
CMD B
V41K1237X = 1
CMD C
V41K1238X = 1
N
Y
OPN K50P712-A = 1
CLS K50P713-A = 0
LO2 PRE-VLV CLS CMD A (ENG 2)
V41K1239X = 1
CMD B
V41K1240X = 1
CMD C
V41K1241X = 1
OPN K50P712-A = 0
CLS K50P713-A = 1
LO2 PRE-VLV OPN CMD A (ENG 3)
V41K1336X = 1
CMD B
V41K1337X = 1
CMD C
V41K1338X = 1
OPN K50P715-A = 1
CLS K50P716-A = 0
LO2 PRE-VLV CLS CMD A (ENG 3)
V41K1339X = 1
CMD B
V41K1340X = 1
CMD C
V41K1341X = 1
OPN K50P715-A = 0
CLS K50P716-A = 1
3

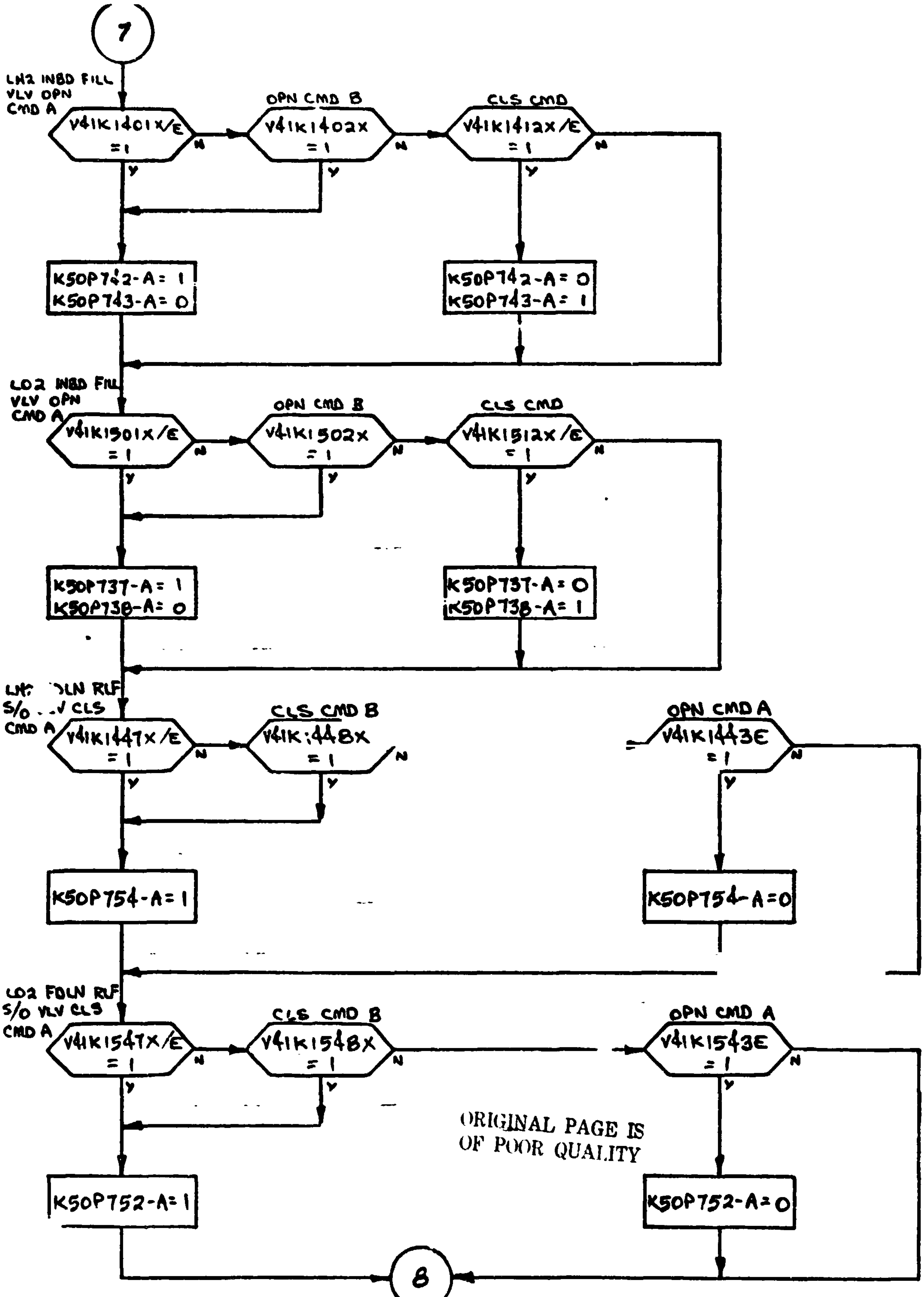

3
LH2 FEED DISC
VLV OPN-CMD A
V41K1413X = 1
CMD B
V41K1414X = 1
CMD C
V41K1415X = 1
OPN K50P759-A=1
CLS K50P760-A=0
LH2 FEED DISC
VLV CLS-CMD A
V41K1416X = 1
CMD B
CMD C
OPN K50P759-A=0
CLS K50P760-A=1
LO2 FEED DISC
VLV OPN-CMD A
V41K1521X = 1
CMD B
V41K1522X = 1
CMD C
V41K1523X = 1
OPN K50P757-A=0
CLS K50P756-A=1
LO2 FEED DISC
VLV CLS-CMD A
V41K1524X = 1
CMD B
V41K1525X = 1
CMD C
V41K1526X = 1
OPN K50P757-A=1
CLS K50P756-A=0
4


4
ENG 1 HE ISOL VLV 2 OPN CMD A
V41K1156E/X = 1
VLV 2 OPN CMD B
V41K1157E/X = 1
VLV 2 CLS CMD A
V41K1166E = 1
VLV 2 CLS CMD B
V41K1167E = 1
K50P768-A = 1
K50P768-A = 0
ENG 2 HE ISOL VLV 2 OPN CMD A
V41K1256E/X = 1
OPN CMD B
V41K1257E/X = 1
CLS CMD A
V41K1266E = 1
CLS CMD B
V41K1267E = 1
K50P771-A = 1
K50P771-A = 0
ENG 3 HE ISOL VLV 2 OPN CMD A
V41K1356E/X = 1
OPN CMD B
V41K1357E/X = 1
CLS CMD A
V41K1366E = 1
CLS CMD B
V41K1367E = 1
K50P774-A = 1
K50P774-A = 0
5



5
LH2 RTLS OTBD
D/V OPN CMD A
V41K1913X
= 1
CMD B
V41K1914X
= 1
CMD C
V41K1915X
= 1
N
Y
K50P748-A=1
K50P748-A=0
LH2 RTLS INBD
D/V OPN CMD A
V41K1923X
= 1
CMD B
V41K1924X
= 1
CMD C
V41K1925X
= 1
K50P750-A=1
K50P750-A=0
LO2 OVBD BLEED
VLV CLS CMD A
V41K1584X
= 1
CMD B
V41K1585X
= 1
CMD C
V41K1586X
= 1
K50P733-A=1
K50P733-A=0
6


6
E1 HE I/C "IN" VLV CMD A
V41K1162X/E = 1
CMD B
V41K1163X/E = 1
VLV "OUT" CMD A
V41K1168X/E = 1
CMD B
V41K1169E = 1
K50P766-A = 0
K50P86-A = 1
K50P766-A = 1
K50P86-A = 0
E2 HE I/C "IN" VLV CMD A
V41K1262X/E = 1
CMD B
V41K1263X/E = 1
VLV "OUT" CMD A
V41K1268X/E = 1
CMD B
V41K1269E = 1
K50P769-A = 0
K50P87-A = 1
K50P769-A = 1
K50P87-A = 0
E3 HE I/C "IN" VLV CMD A
V41K1362X/E = 1
CMD B
V41K1363X/E = 1
VLV "OUT" CMD A
V41K1368X/E = 1
CMD B
V41K1369E = 1
K50P772-A = 0
K50P88-A = 1
K50P772-A = 1
K50P88-A = 0
E2 PNEU XOVR VLV CMD OPN
V41K1613X/E = 1
CLS
V41K1619E = 1
K50P89-A = 1
K50P89-A = 0
Y
N
7



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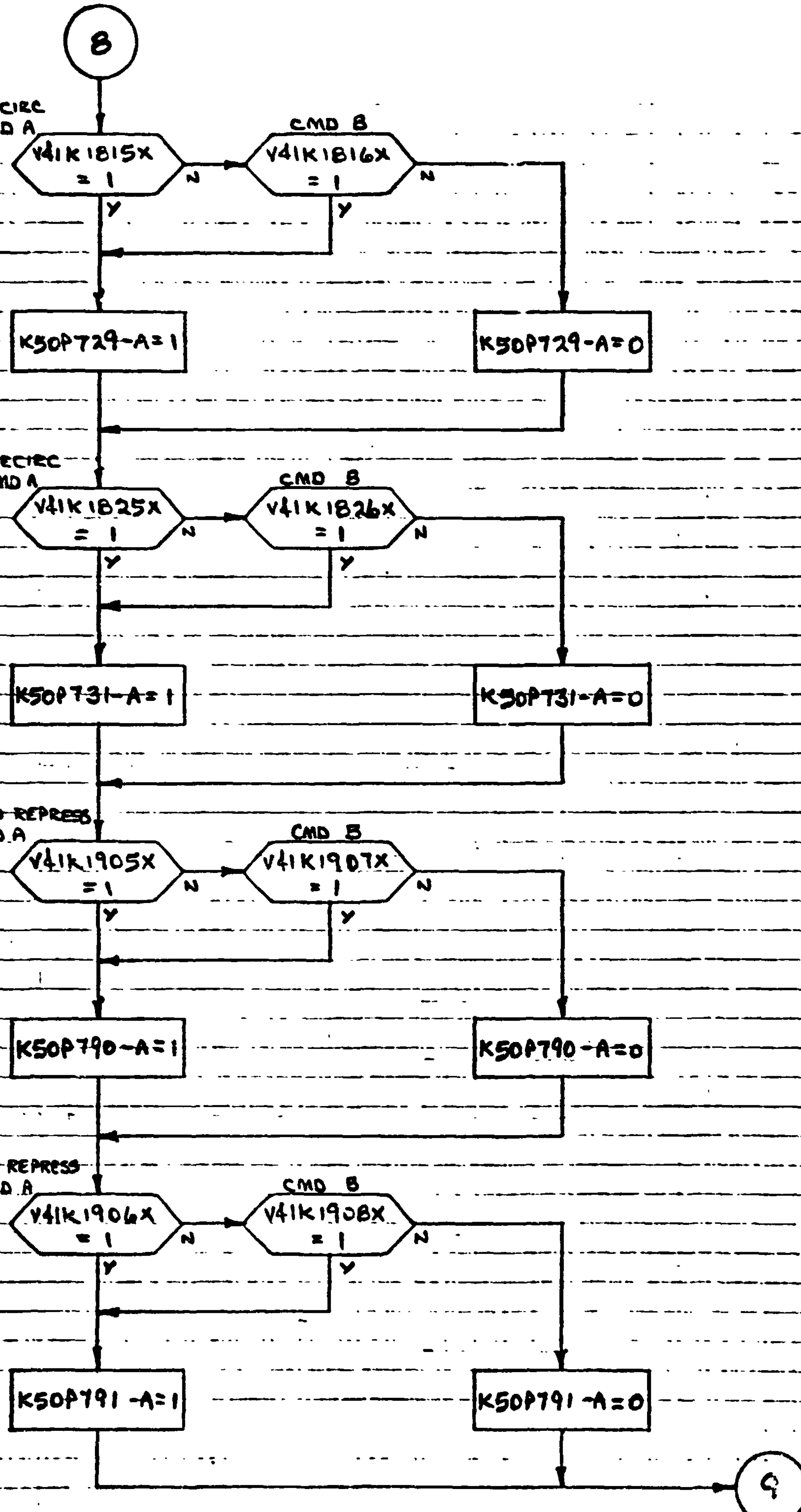
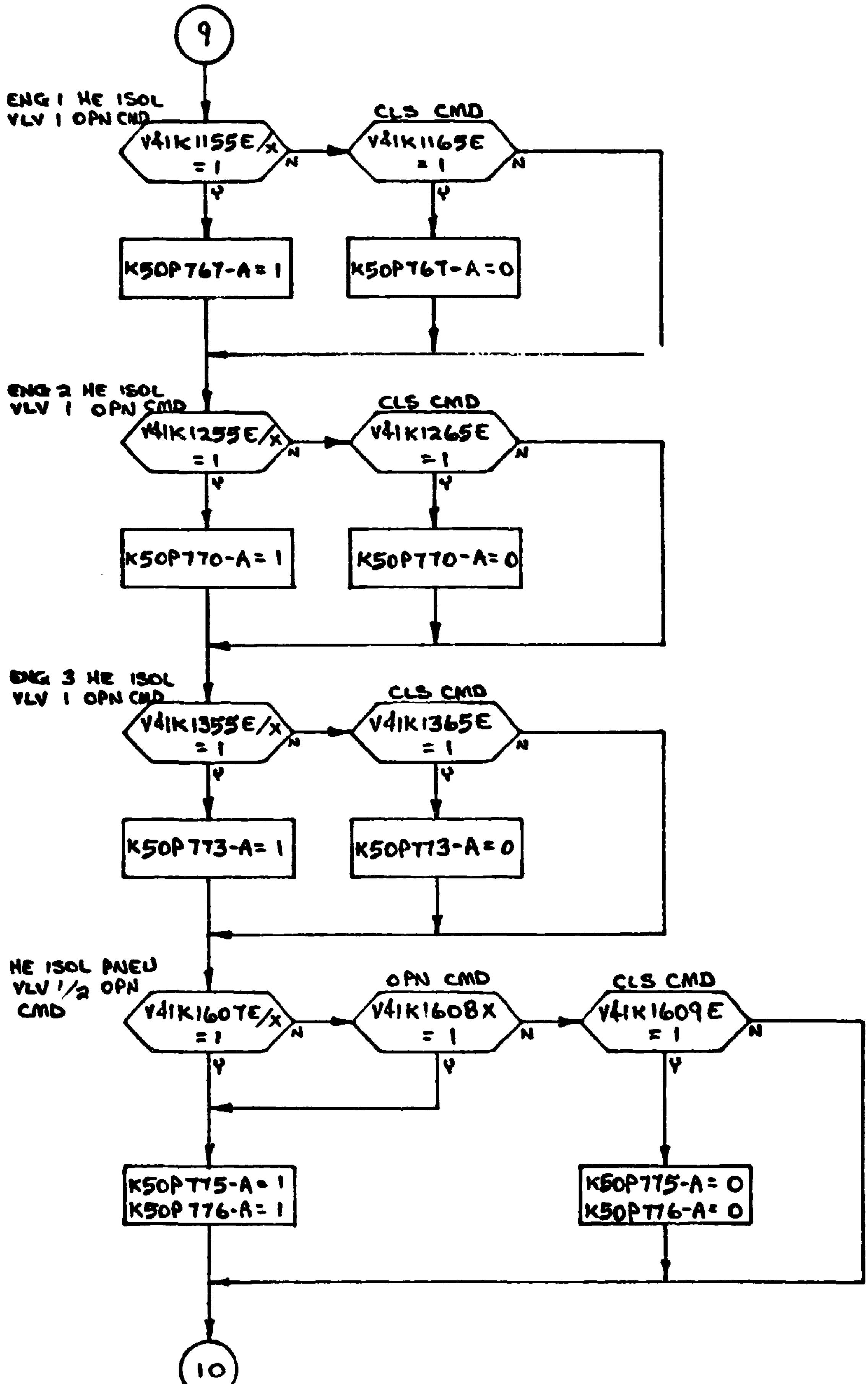
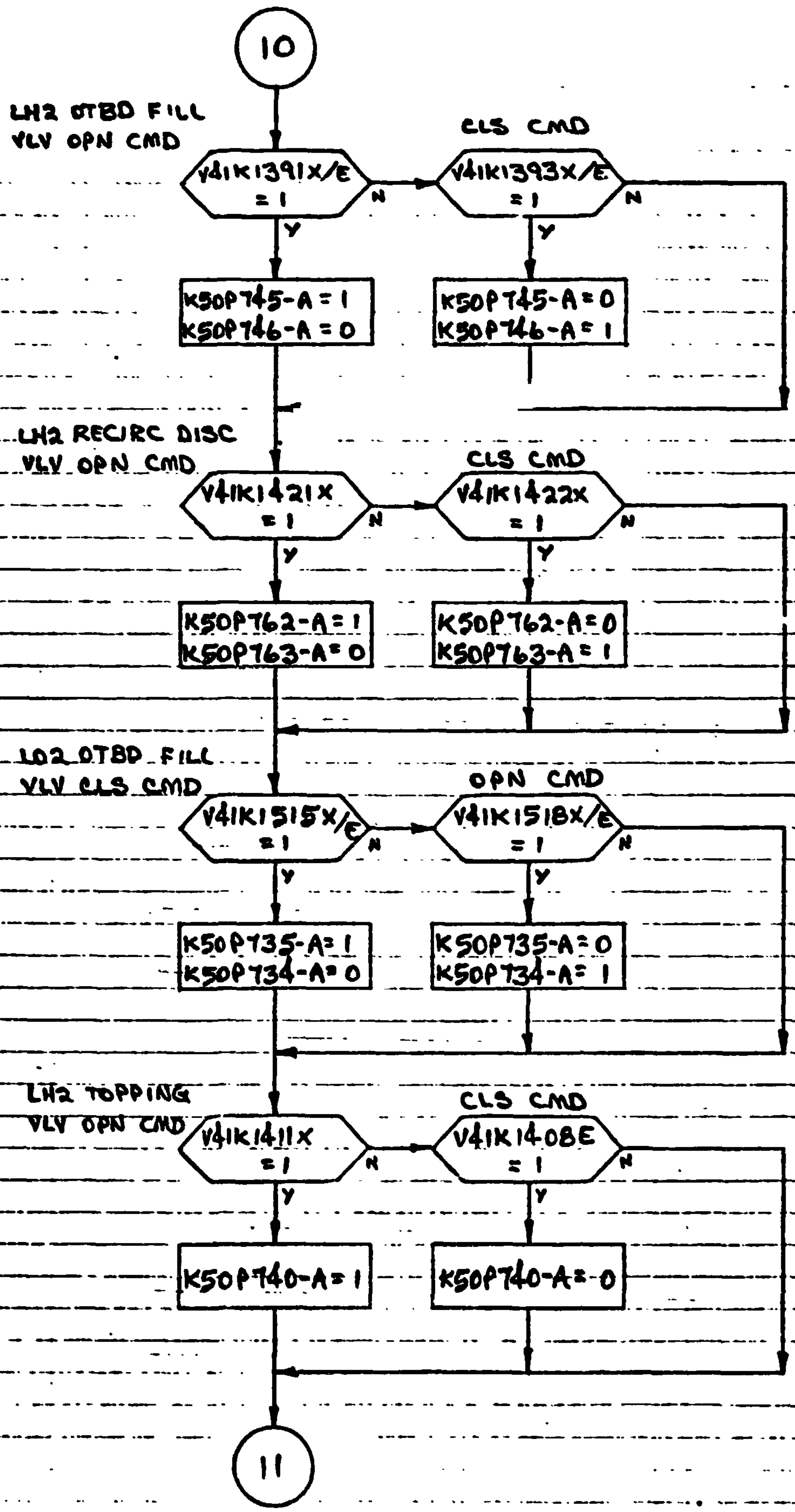
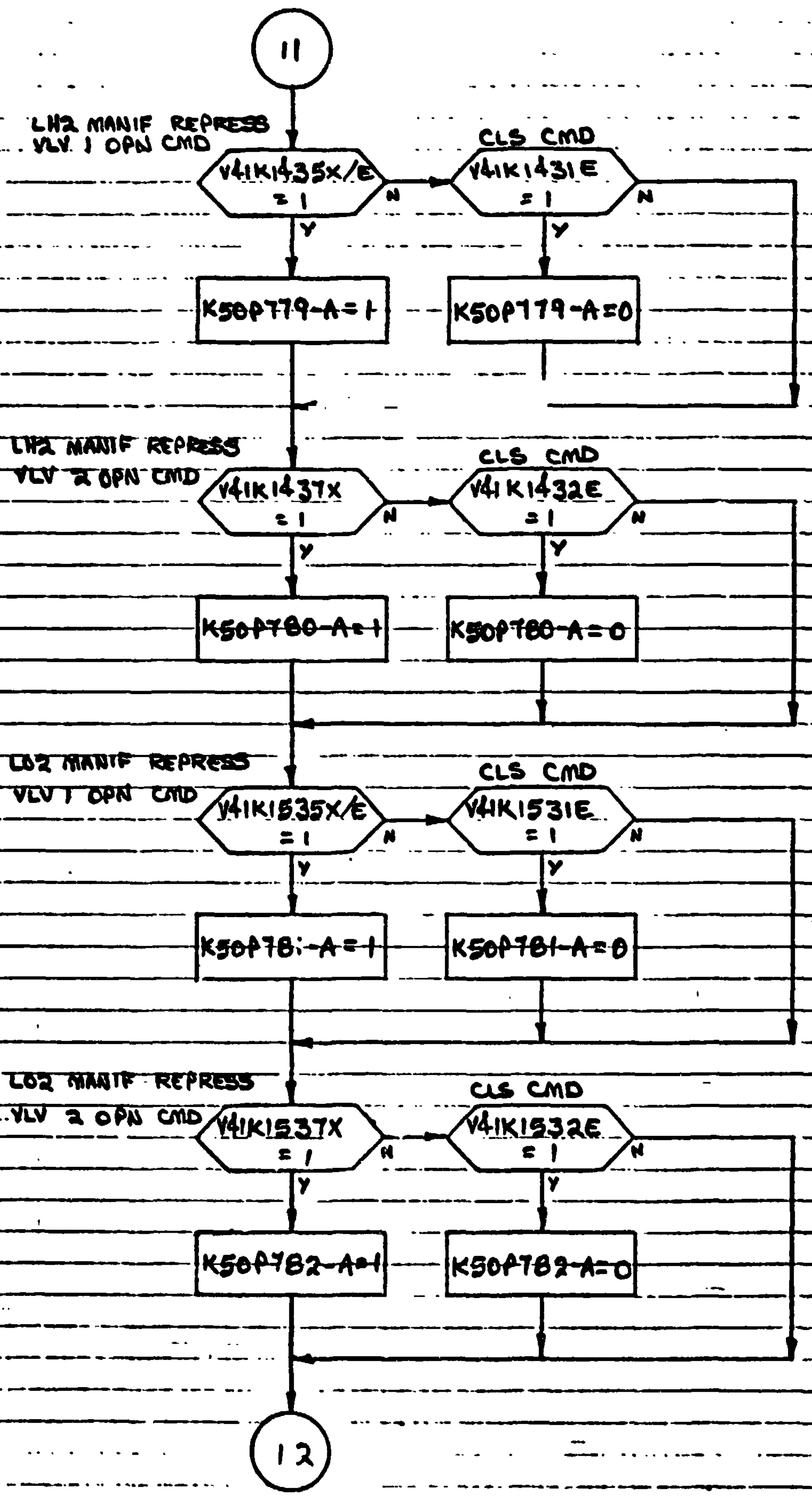
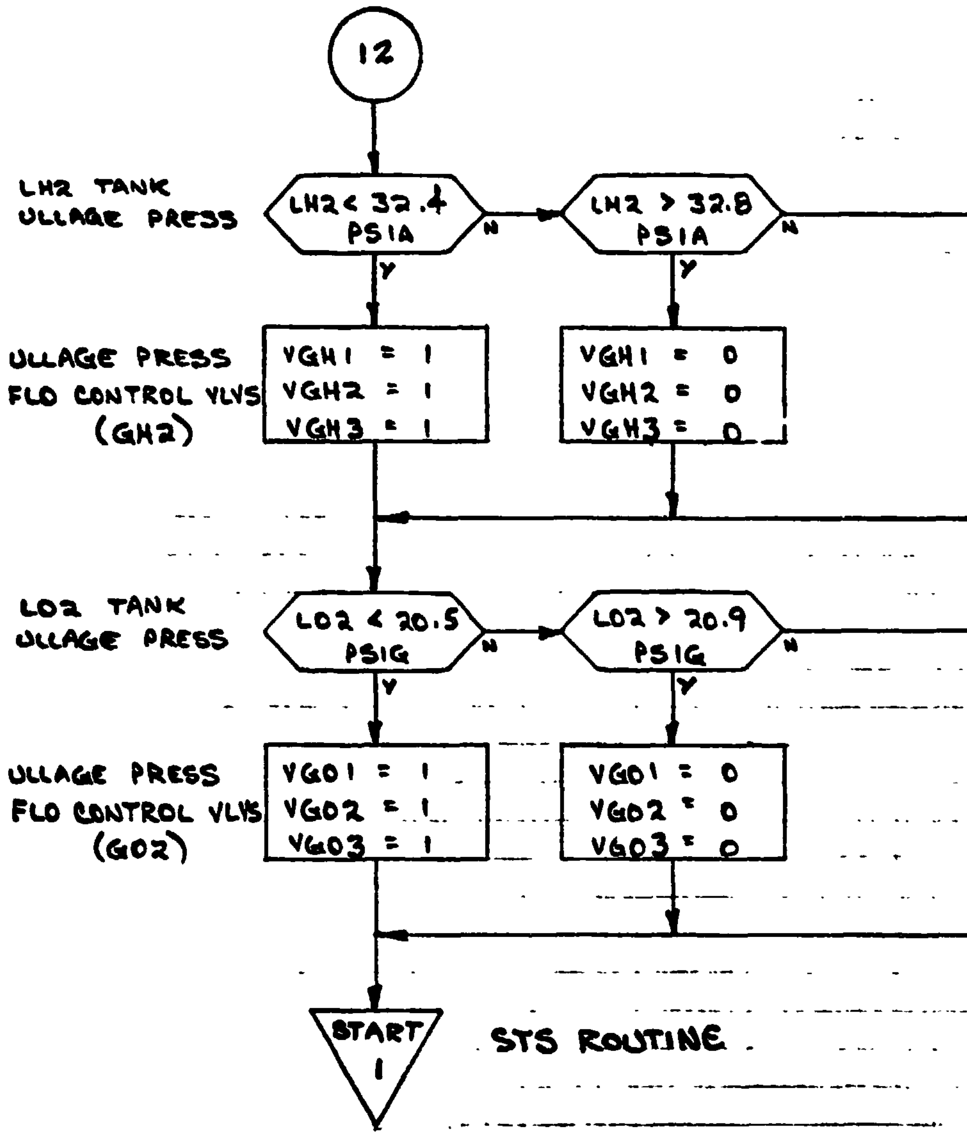

8
LO2 ACCUM RECIRC
VLV 1 CLS CMD A
V41K1815X
= 1
N
Y
CMD B
V41K1816X
= 1
N
Y
K50P729-A=1
K50P729-A=0
LO2 ACCUM RECIRC
VLV 2 CLS CMD A
V41K1825X
= 1
N
Y
CMD B
V41K1826X
= 1
N
Y
K50P731-A=1
K50P731-A=0
LH2 RTLS MAN REPRESS
VLV 1 OPN CMD A
V41K1905X
= 1
N
Y
CMD B
V41K1907X
= 1
N
Y
K50P790-A=1
K50P790-A=0
LH2 RTLS MAN REPRESS
VLV 2 OPN CMD A
V41K1906X
= 1
N
Y
CMD B
V41K1908X
= 1
N
Y
K50P791-A=1
K50P791-A=0
9


9
ENG 1 HE ISOL VLV 1 OPN CMD
V41K1155E/X = 1
CLS CMD
V41K1165E = 1
K50P767-A = 1
K50P767-A = 0
ENG 2 HE ISOL VLV 1 OPN CMD
V41K1255E/X = 1
CLS CMD
V41K1265E = 1
K50P770-A = 1
K50P770-A = 0
ENG 3 HE ISOL VLV 1 OPN CMD
V41K1355E/X = 1
CLS CMD
V41K1365E = 1
K50P773-A = 1
K50P773-A = 0
HE ISOL PNEU VLV 1/2 OPN CMD
V41K1607E/X = 1
OPN CMD
V41K1608X = 1
CLS CMD
V41K1609E = 1
K50P775-A = 1
K50P776-A = 1
K50P775-A = 0
K50P776-A = 0
10



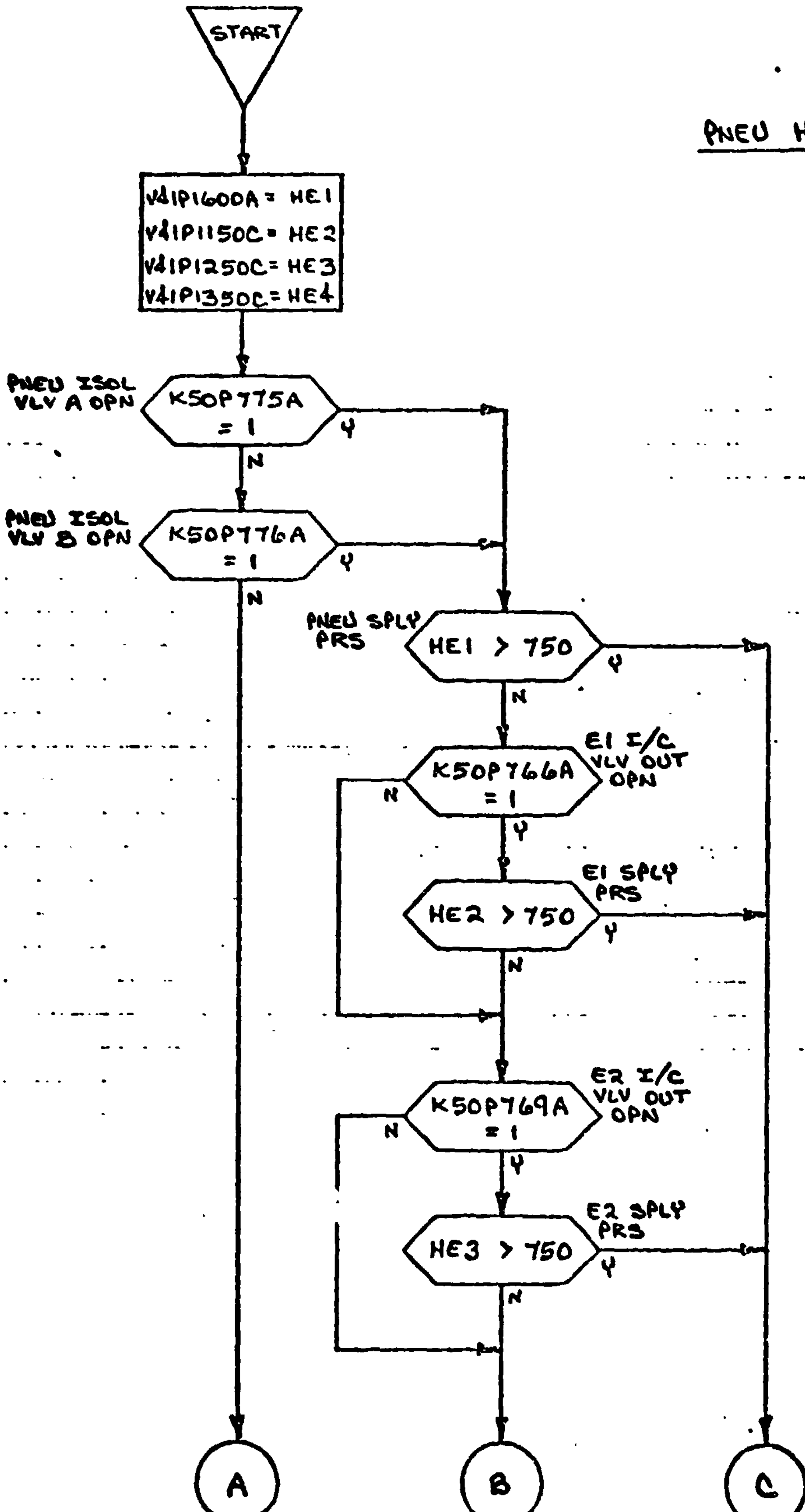
10
LH2 OTBD FILL VLV OPN CMD
V41K1391X/E = 1
CLS CMD
V41K1393X/E = 1
K50P745-A = 1
K50P746-A = 0
K50P745-A = 0
K50P746-A = 1
LH2 RECIRC DISC VLV OPN CMD
V41K1421X = 1
CLS CMD
V41K1422X = 1
K50P762-A = 1
K50P763-A = 0
K50P762-A = 0
K50P763-A = 1
LO2 OTBD FILL VLV CLS CMD
V41K1515X/E = 1
OPN CMD
V41K1518X/E = 1
K50P735-A = 1
K50P734-A = 0
K50P735-A = 0
K50P734-A = 1
LH2 TOPPING VLV OPN CMD
V41K1411X = 1
CLS CMD
V41K1408E = 1
K50P740-A = 1
K50P740-A = 0
Y
N
11


11
LH2 MANIF REPRESS VLV 1 OPN CMD
V41K1435X/E = 1
CLS CMD
V41K1431E = 1
K50P779-A=1
K50P779-A=0
LH2 MANIF REPRESS VLV 2 OPN CMD
V41K1437X = 1
CLS CMD
V41K1432E = 1
K50P780-A=1
K50P780-A=0
LO2 MANIF REPRESS VLV 1 OPN CMD
V41K1535X/E = 1
CLS CMD
V41K1531E = 1
K50P781-A=1
K50P781-A=0
LO2 MANIF REPRESS VLV 2 OPN CMD
V41K1537X = 1
CLS CMD
V41K1532E = 1
K50P782-A=1
K50P782-A=0
12
Y
N



12
LH2 TANK ULLAGE PRESS
LH2 < 32.4 PSIA
LH2 > 32.8 PSIA
N
Y
ULLAGE PRESS FLO CONTROL VLVS (GH2)
VGH1 = 1
VGH2 = 1
VGH3 = 1
VGH1 = 0
VGH2 = 0
VGH3 = 0
LO2 TANK ULLAGE PRESS
LO2 < 20.5 PSIG
LO2 > 20.9 PSIG
ULLAGE PRESS FLO CONTROL VLVS (GO2)
VGO1 = 1
VGO2 = 1
VGO3 = 1
VGO1 = 0
VGO2 = 0
VGO3 = 0
START 1
STS ROUTINE

PNEU HE PRESS



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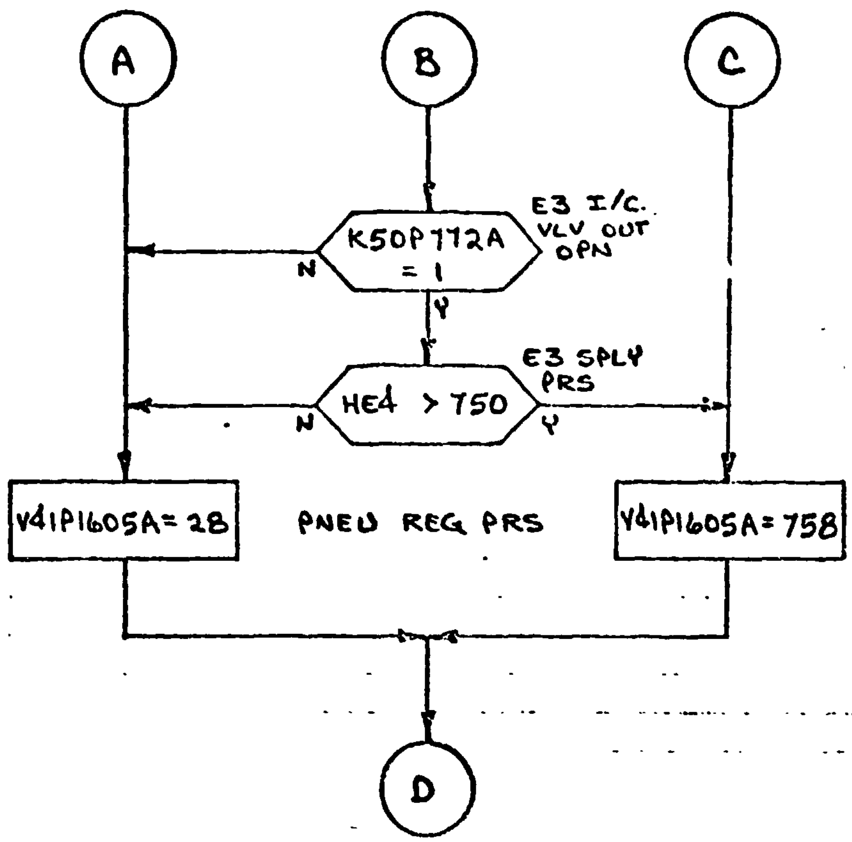
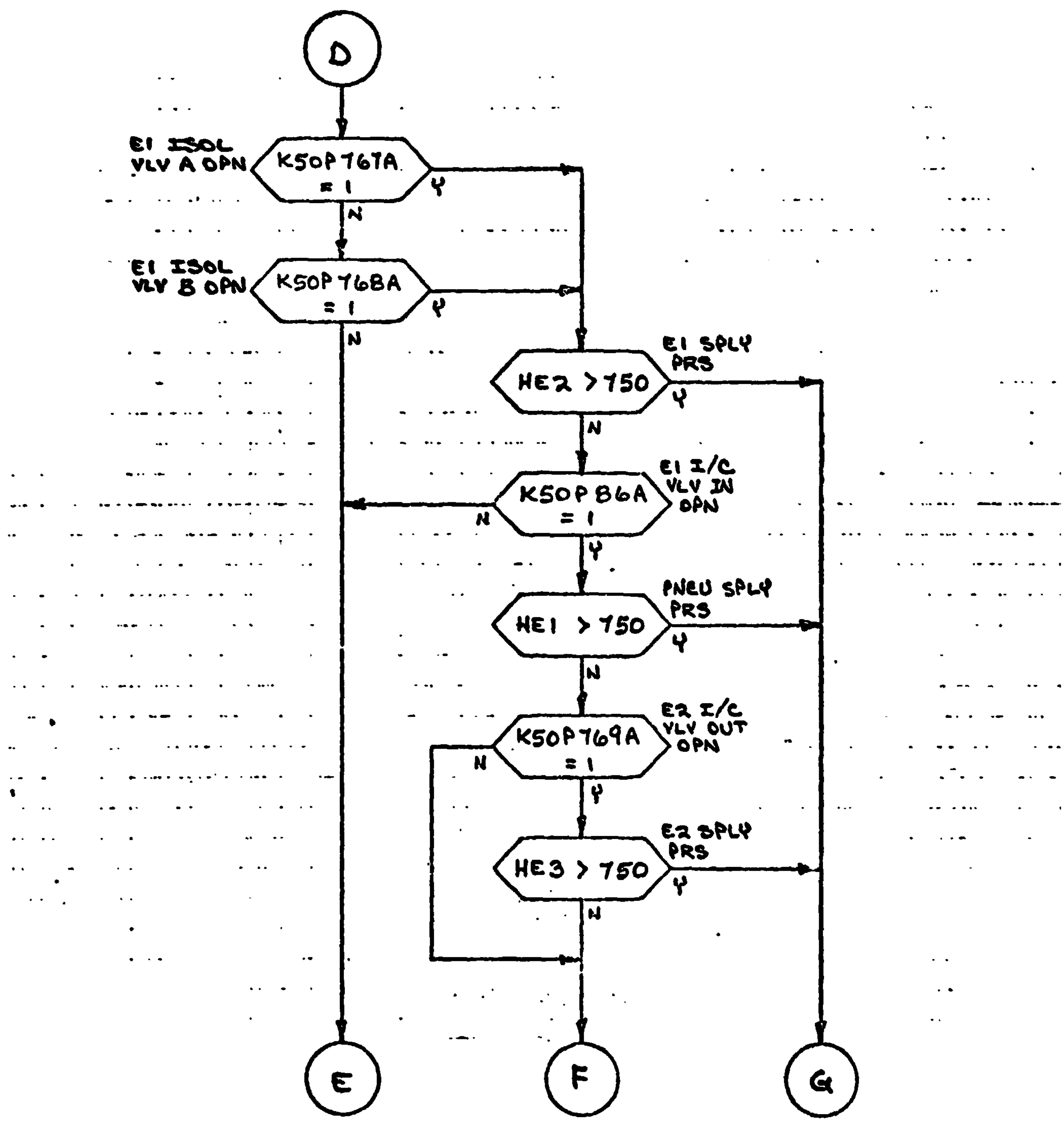
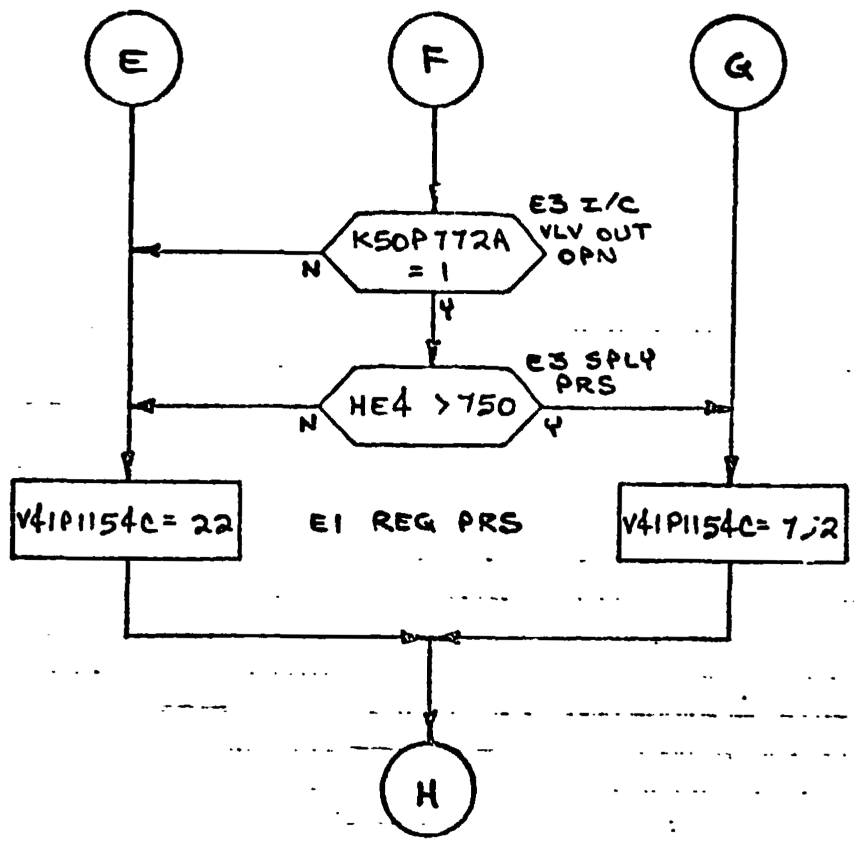

A
B
C
K50P772A = 1
E3 I/C. VLV OUT OPN
N
Y
HE4 > 750
E3 SPLY PRS
N
Y
V41P1605A = 28
PNEU REG PRS
V41P1605A = 758
D

E1 HE PRESS

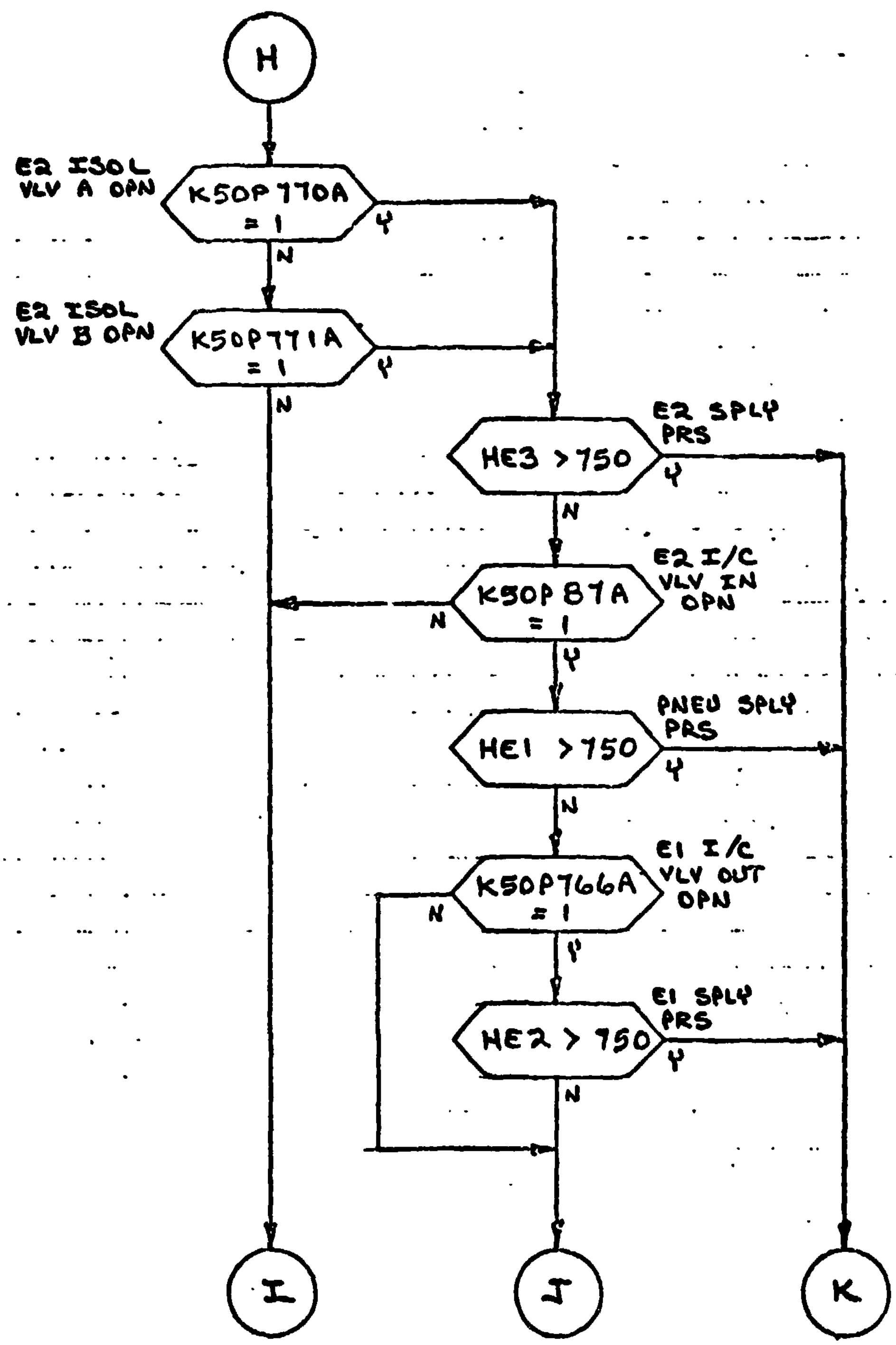

D
E1 ISOL VLV A OPN
K50P767A = 1
E1 ISOL VLV B OPN
K50P768A = 1
E1 SPLY PRS
HE2 > 750
E1 I/C VLV IN OPN
K50P86A = 1
PNEU SPLY PRS
HE1 > 750
E2 I/C VLV OUT OPN
K50P769A = 1
E2 SPLY PRS
HE3 > 750
Y
N
E
F
G

E1 HE PRESS

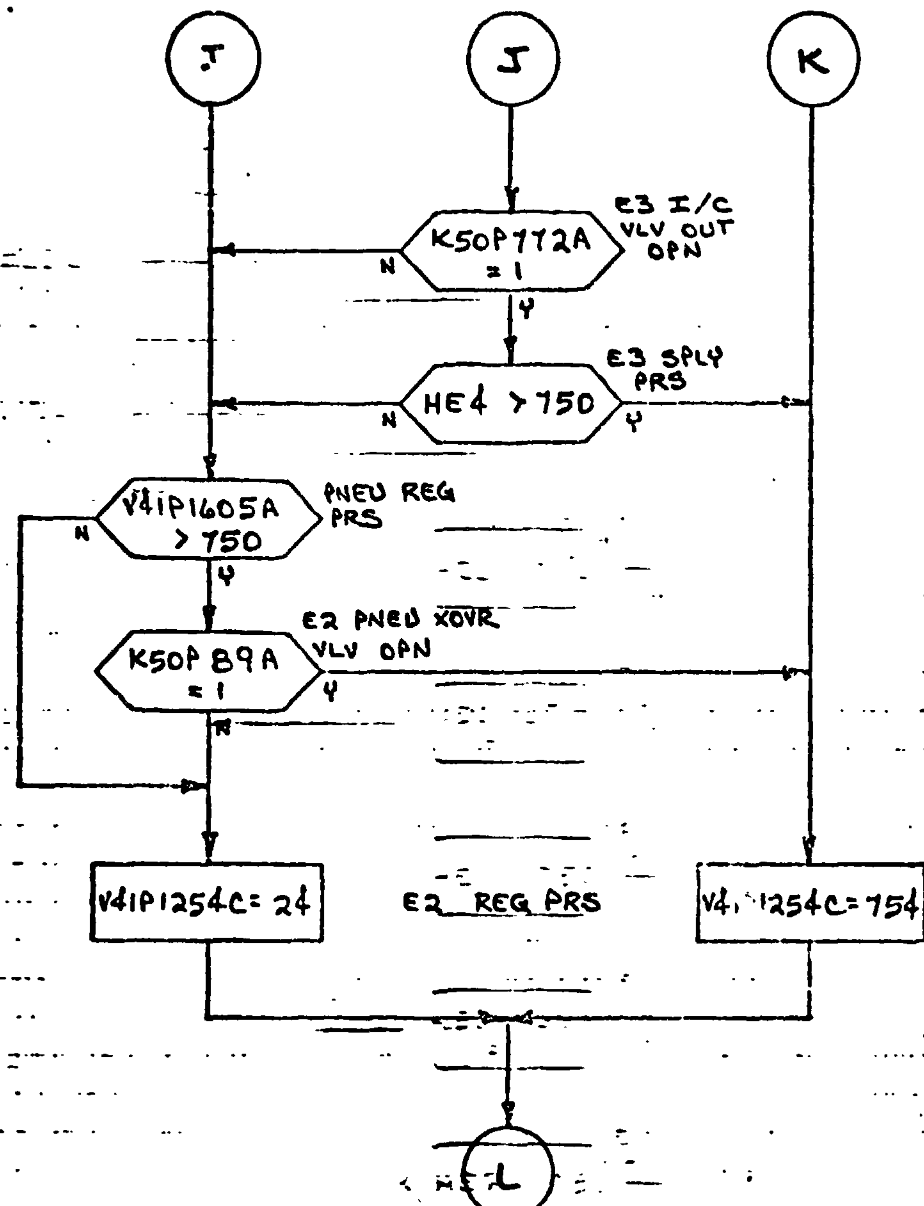


E
F
G
K50P772A = 1
E3 I/C VLV OUT OPN
N
Y
HE4 >750
E3 SPLY PRS
N
Y
V41P1154C= 22
E1 REG PRS
V41P1154C=
H

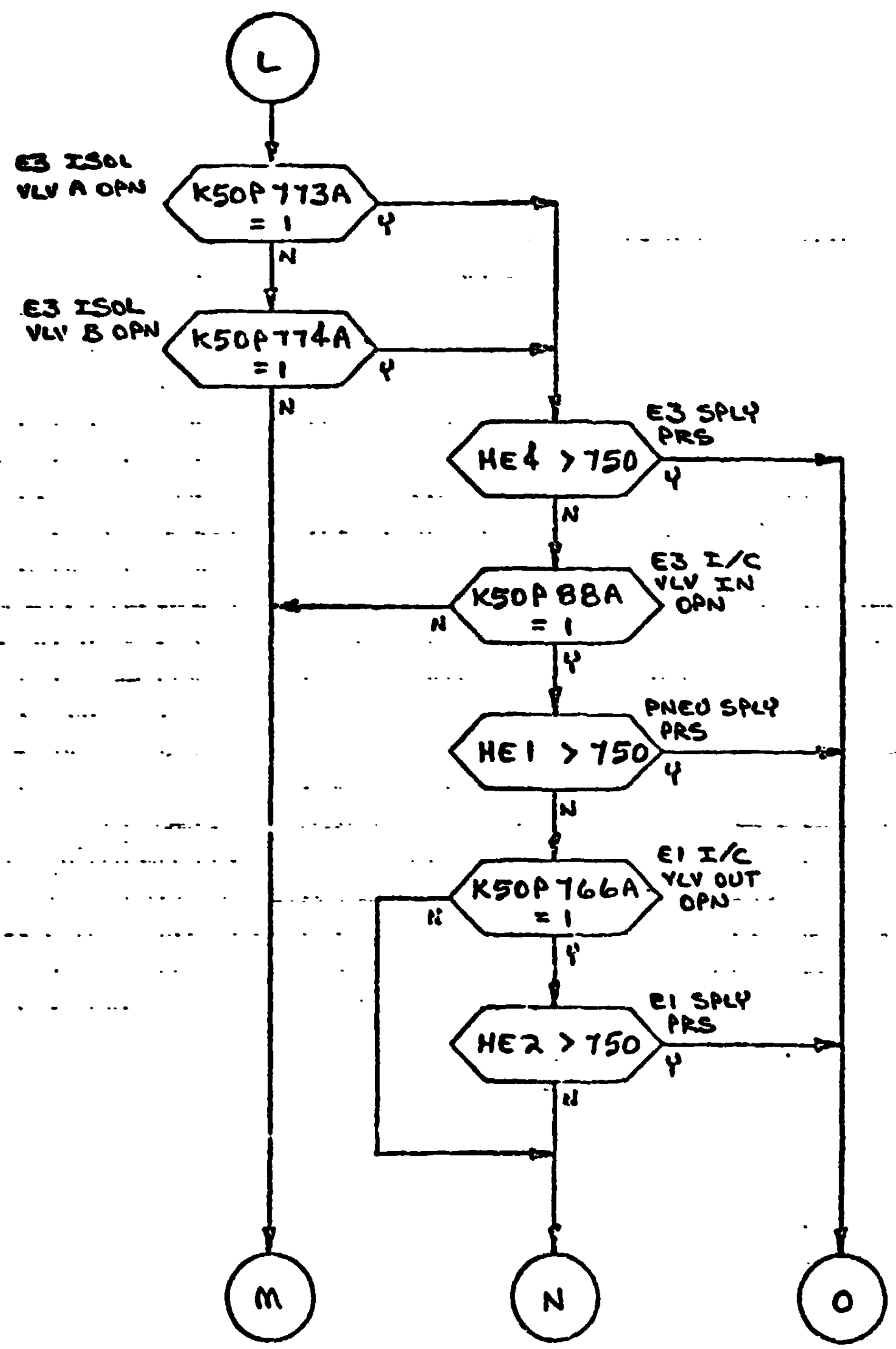
E2 HE PRESS


H
E2 ISOL VLV A OPN
K50P770A = 1
E2 ISOL VLV B OPN
K50P771A = 1
E2 SPLY PRS
HE3 >750
E2 I/C VLV IN OPN
K50P87A = 1
PNEU SPLY PRS
HE1 >750
E1 I/C VLV OUT OPN
K50P766A = 1
E1 SPLY PRS
HE2 > 750
Y
N
I
J
K

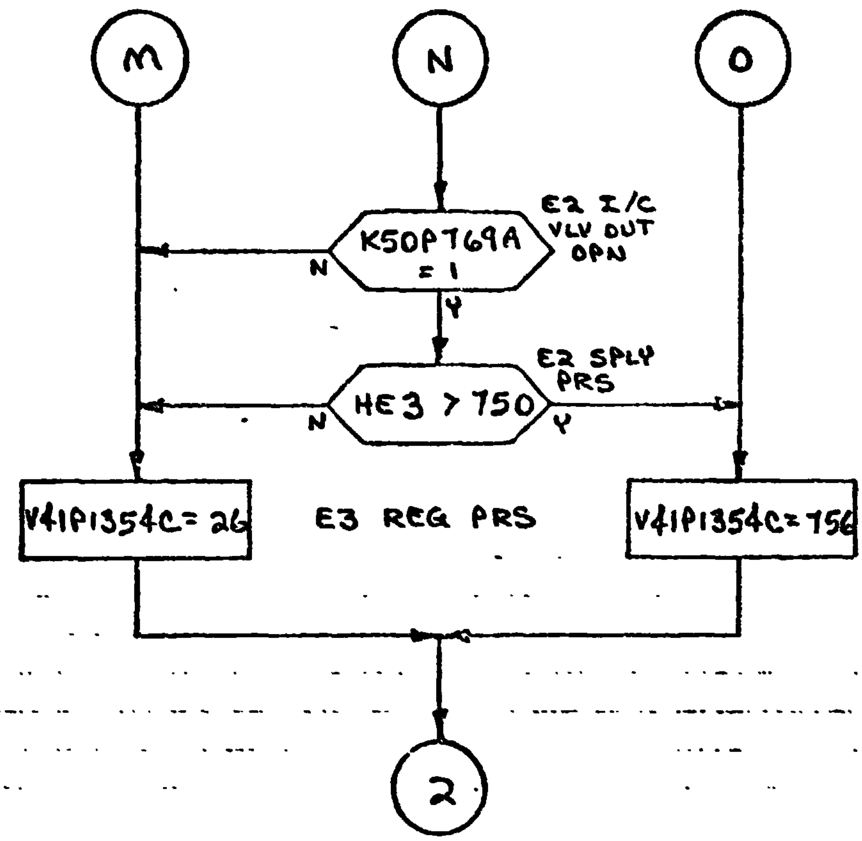
E2 HE PRESS

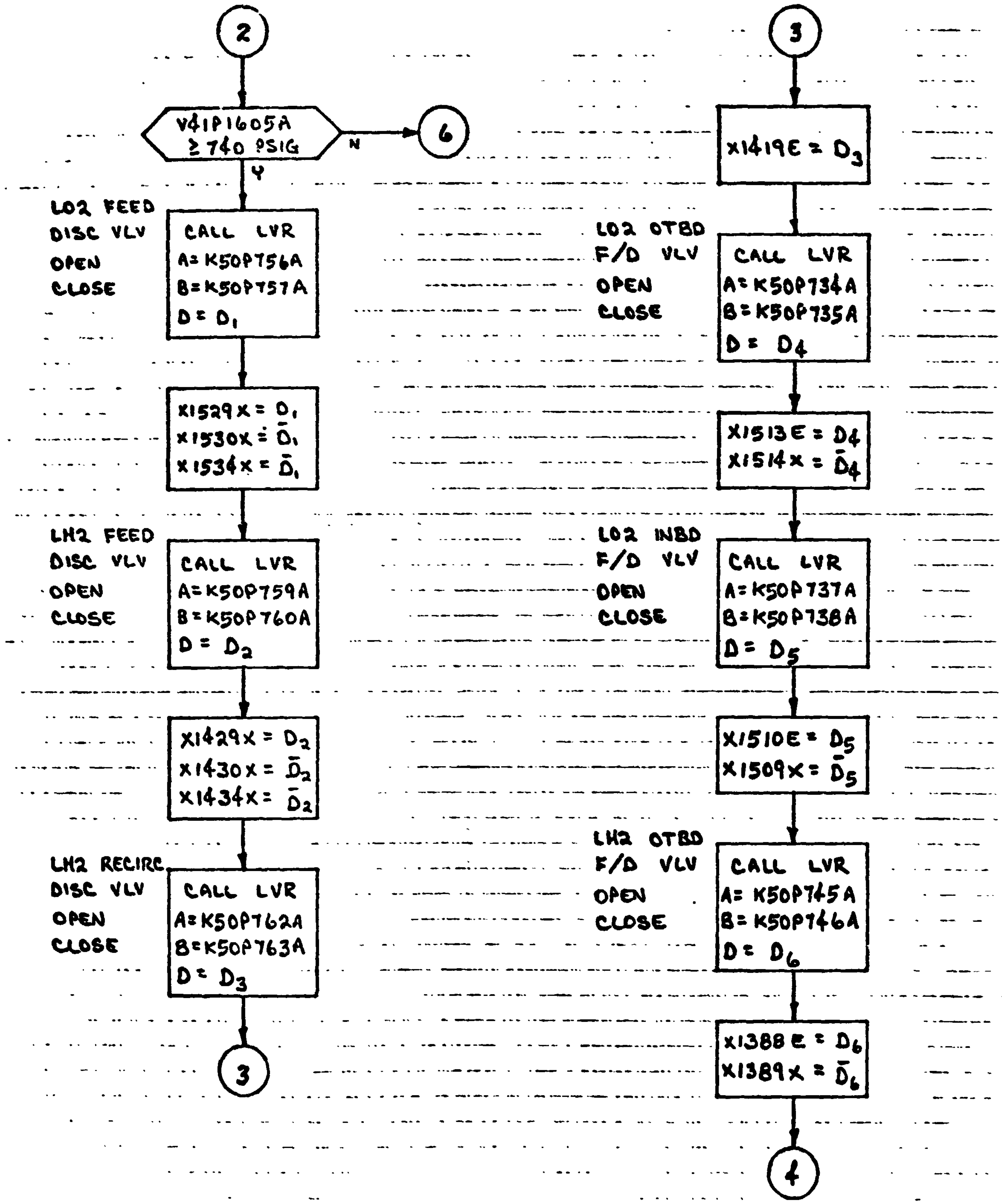

J
J
K
K50P772A = 1
E3 I/C VLV OUT OPN
N
Y
HE4 > 750
E3 SPLY PRS
V41P1605A > 750
PNEU REG PRS
K50P89A = 1
E2 PNEU XOVR VLV OPN
V41P1254C = 24
E2 REG PRS
L

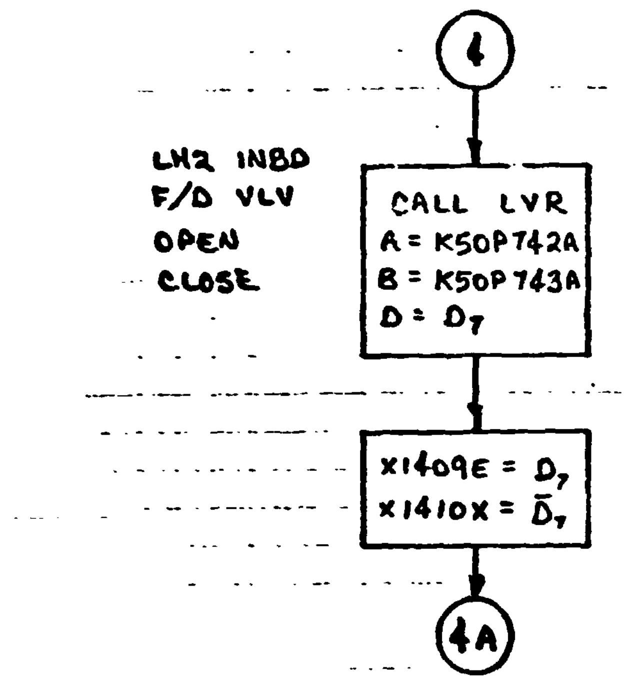
E3 HE PRESS


L
E3 ISOL VLV A OPN
K50P773A = 1
E3 ISOL VLV B OPN
K50P774A = 1
E3 SPLY PRS
HE4 > 750
E3 I/C VLV IN OPN
K50P88A = 1
PNEU SPLY PRS
HE1 > 750
E1 I/C VLV OUT OPN
K50P766A = 1
E1 SPLY PRS
HE2 > 750
M
N
O

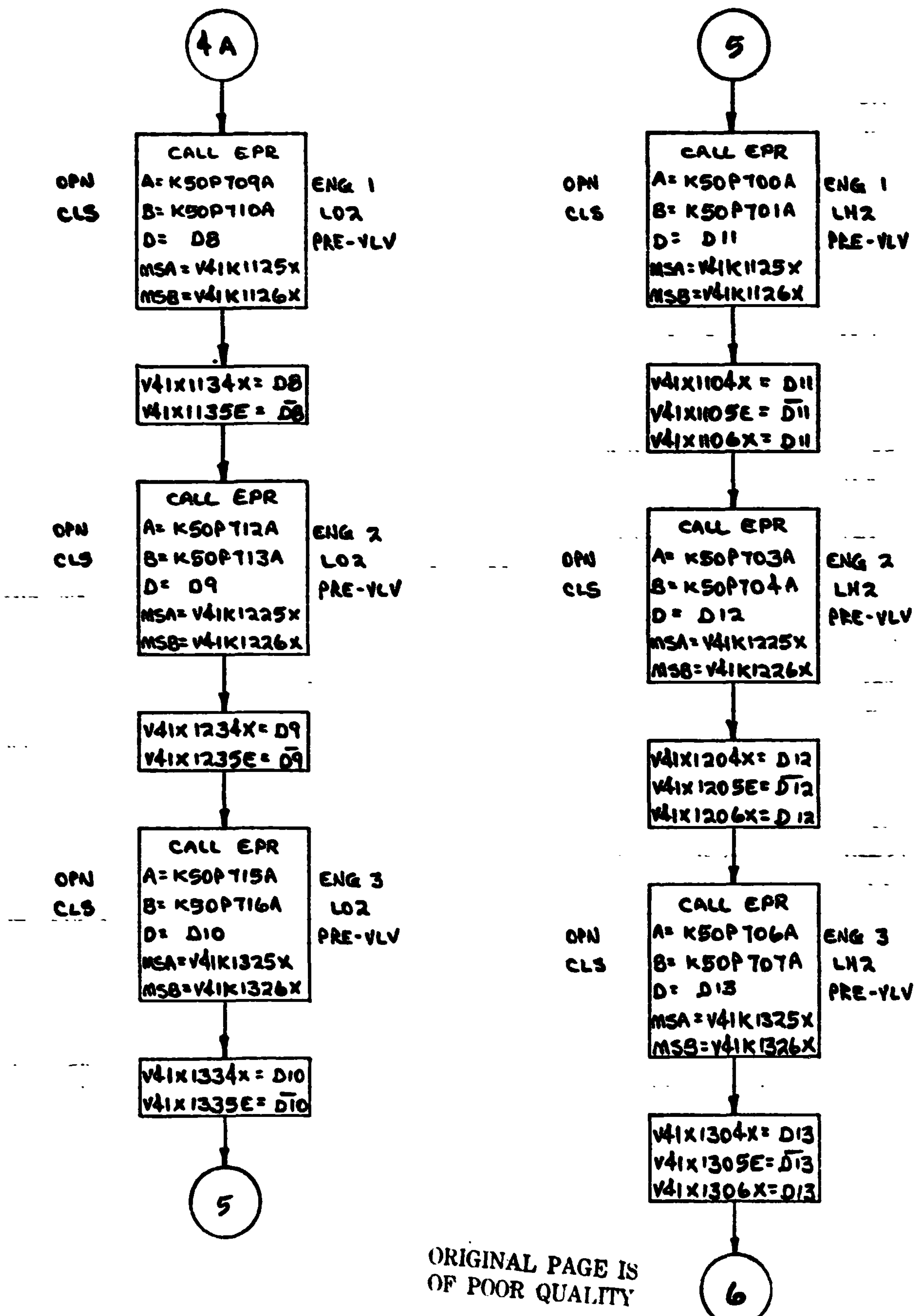
E3 HE PRESS


M
N
O
K50P769A = 1
E2 I/C VLV OUT OPN
N
Y
HE3 > 750
E2 SPLY PRS
N
Y
V41P1354C= 26
E3 REG PRS
V41P1354C= 756
2


2
V41P1605A ≥ 740 PSIG
N
6
Y
LO2 FEED DISC VLV
OPEN
CLOSE
CALL LVR
A= K50P756A
B= K50P757A
D = D1
X1529X = D1
X1530X = D̄1
X1534X = D̄1
LH2 FEED DISC VLV
OPEN
CLOSE
CALL LVR
A= K50P759A
B= K50P760A
D = D2
X1429X = D2
X1430X = D̄2
X1434X = D̄2
LH2 RECIRC DISC VLV
OPEN
CLOSE
CALL LVR
A= K50P762A
B= K50P763A
D = D3
3
3
X1419E = D3
LO2 OTBD F/D VLV
OPEN
CLOSE
CALL LVR
A= K50P734A
B= K50P735A
D = D4
X1513E = D4
X1514X = D̄4
LO2 INBD F/D VLV
OPEN
CLOSE
CALL LVR
A= K50P737A
B= K50P738A
D = D5
X1510E = D5
X1509X = D̄5
LH2 OTBD F/D VLV
OPEN
CLOSE
CALL LVR
A= K50P745A
B= K50P746A
D = D6
X1388E = D6
X1389X = D̄6
4



4
LH2 INBD
F/D VLV
OPEN
CLOSE
CALL LVR
A = K50P742A
B = K50P743A
D = D7
X1409E = D7
X1410X = D̄7
4A



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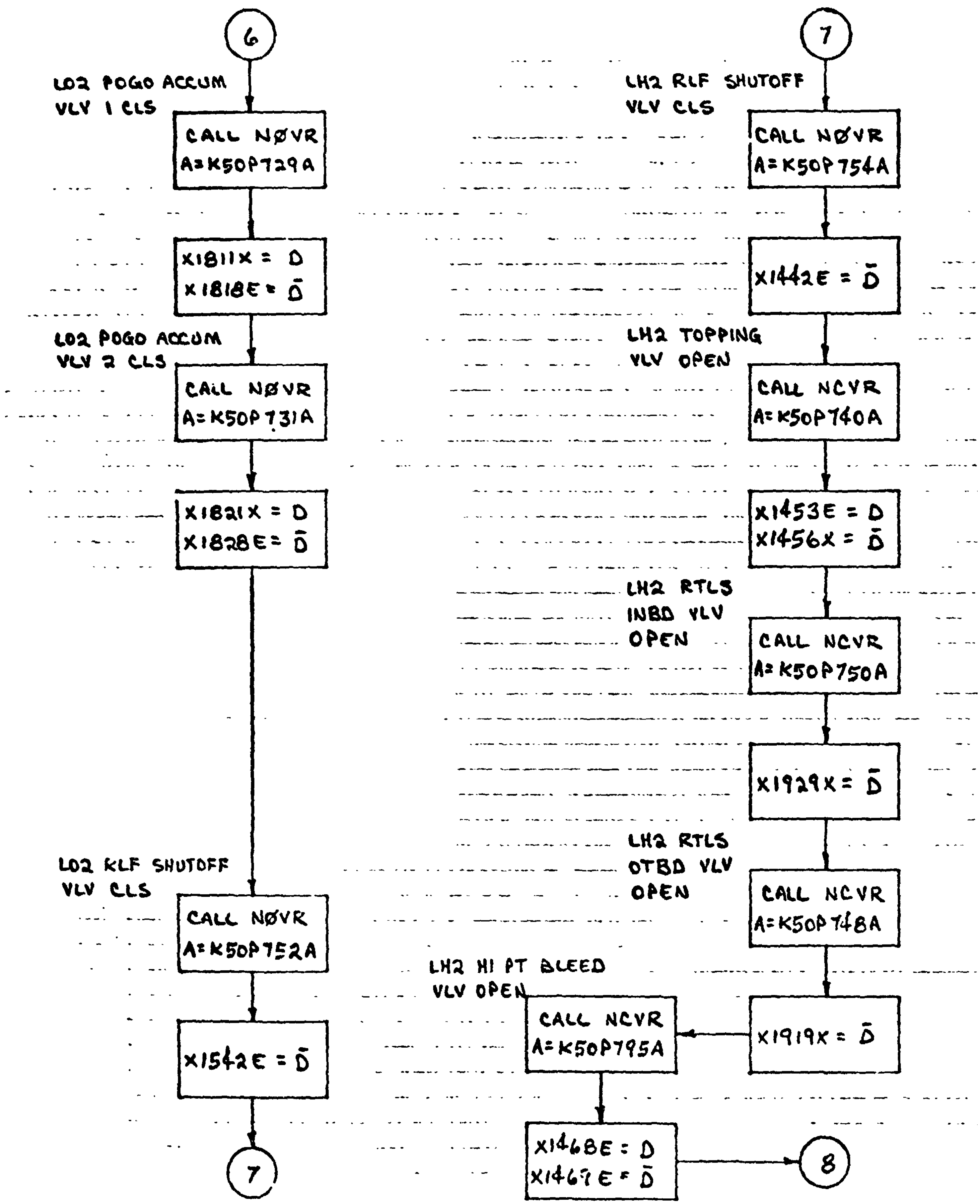
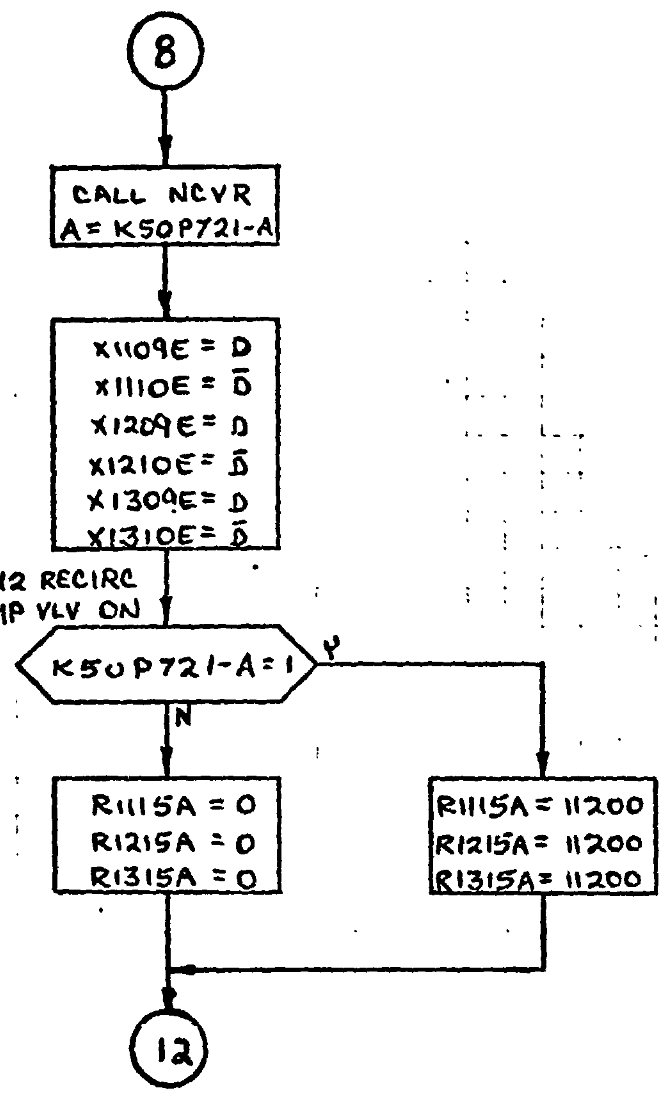
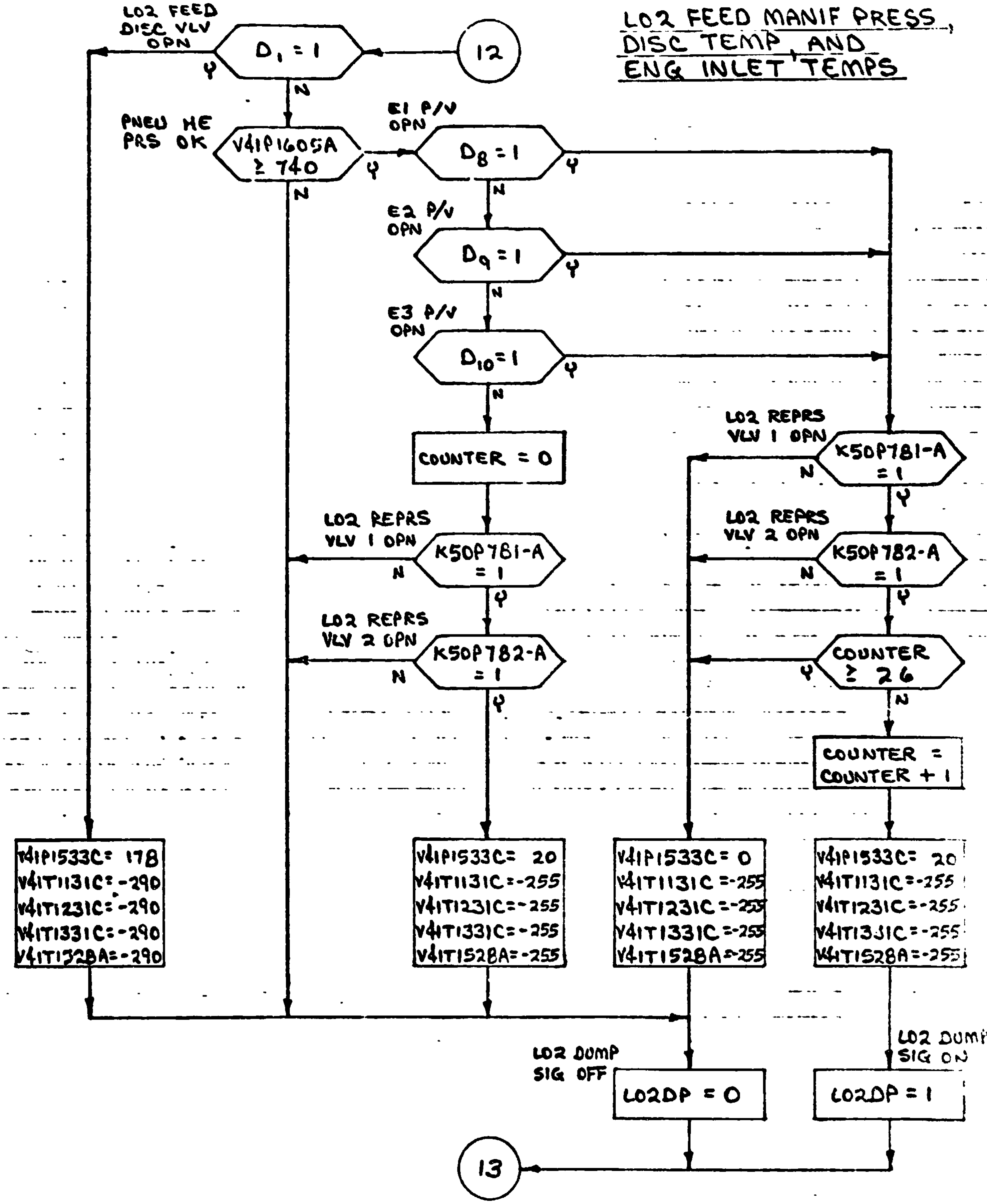
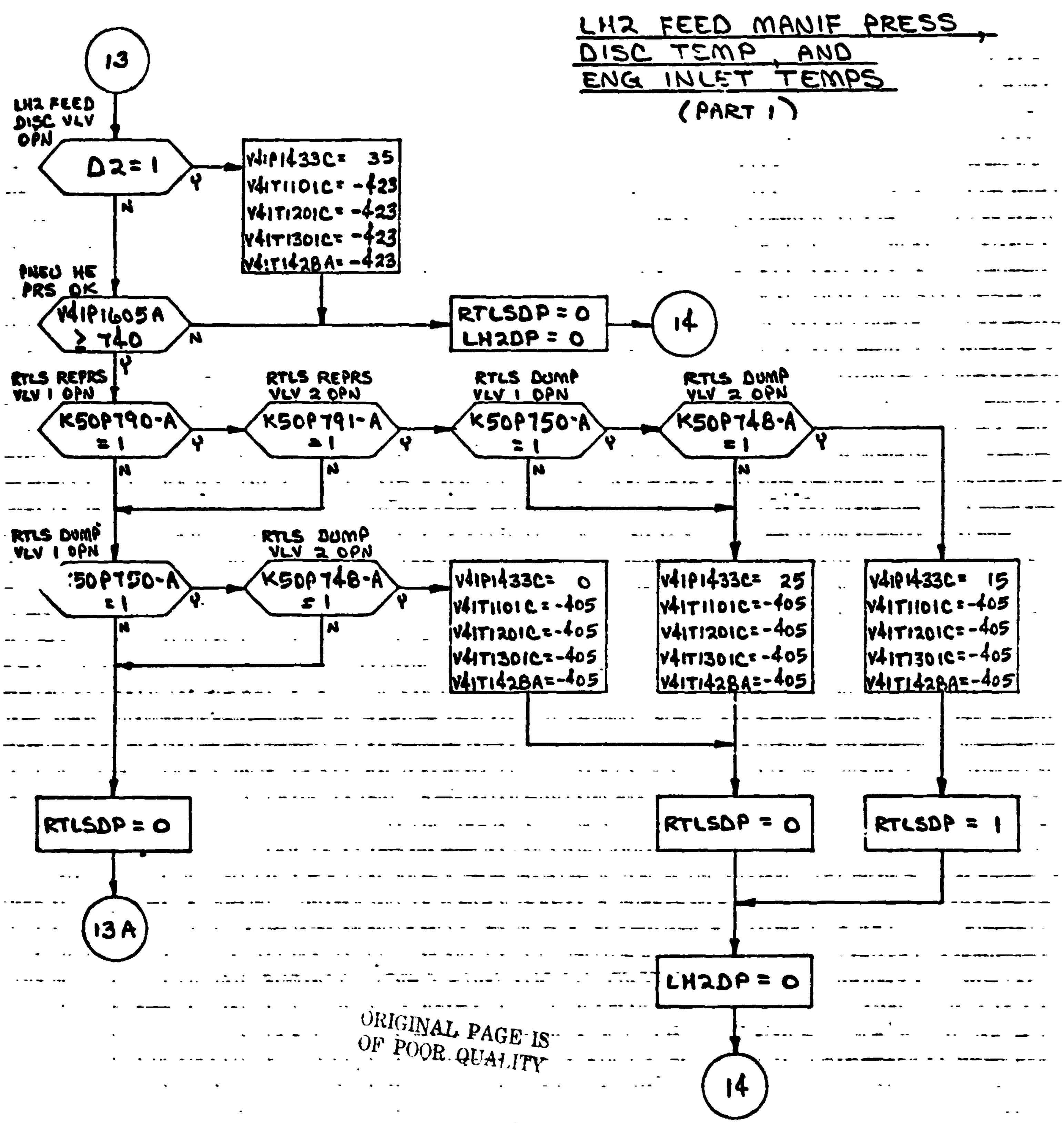

6
LO2 POGO ACCUM VLV 1 CLS
CALL NØVR A=K50P729A
X1811X = D X1818E = D̄
LO2 POGO ACCUM VLV 2 CLS
CALL NØVR A=K50P731A
X1821X = D X1828E = D̄
LO2 RLF SHUTOFF VLV CLS
CALL NØVR A=K50P752A
X1542E = D̄
7
7
LH2 RLF SHUTOFF VLV CLS
CALL NØVR A=K50P754A
X1442E = D̄
LH2 TOPPING VLV OPEN
CALL NCVR A=K50P740A
X1453E = D X1456X = D̄
LH2 RTLS INBD VLV OPEN
CALL NCVR A=K50P750A
X1929X = D̄
LH2 RTLS OTBD VLV OPEN
CALL NCVR A=K50P748A
X1919X = D̄
LH2 HI PT BLEED VLV OPEN
CALL NCVR A=K50P795A
X1468E = D X1469E = D̄
8


8
CALL NCVR
A= K50P721-A
X1109E = D
X1110E = D̄
X1209E = D
X1210E = D̄
X1309E = D
X1310E = D̄
LH2 RECIRC
PMP VLV ON
K50P721-A=1
Y
N
R1115A = 0
R1215A = 0
R1315A = 0
R1115A = 11200
R1215A = 11200
R1315A = 11200
12

LO2 FEED MANIF PRESS, DISC TEMP, AND ENG INLET TEMPS





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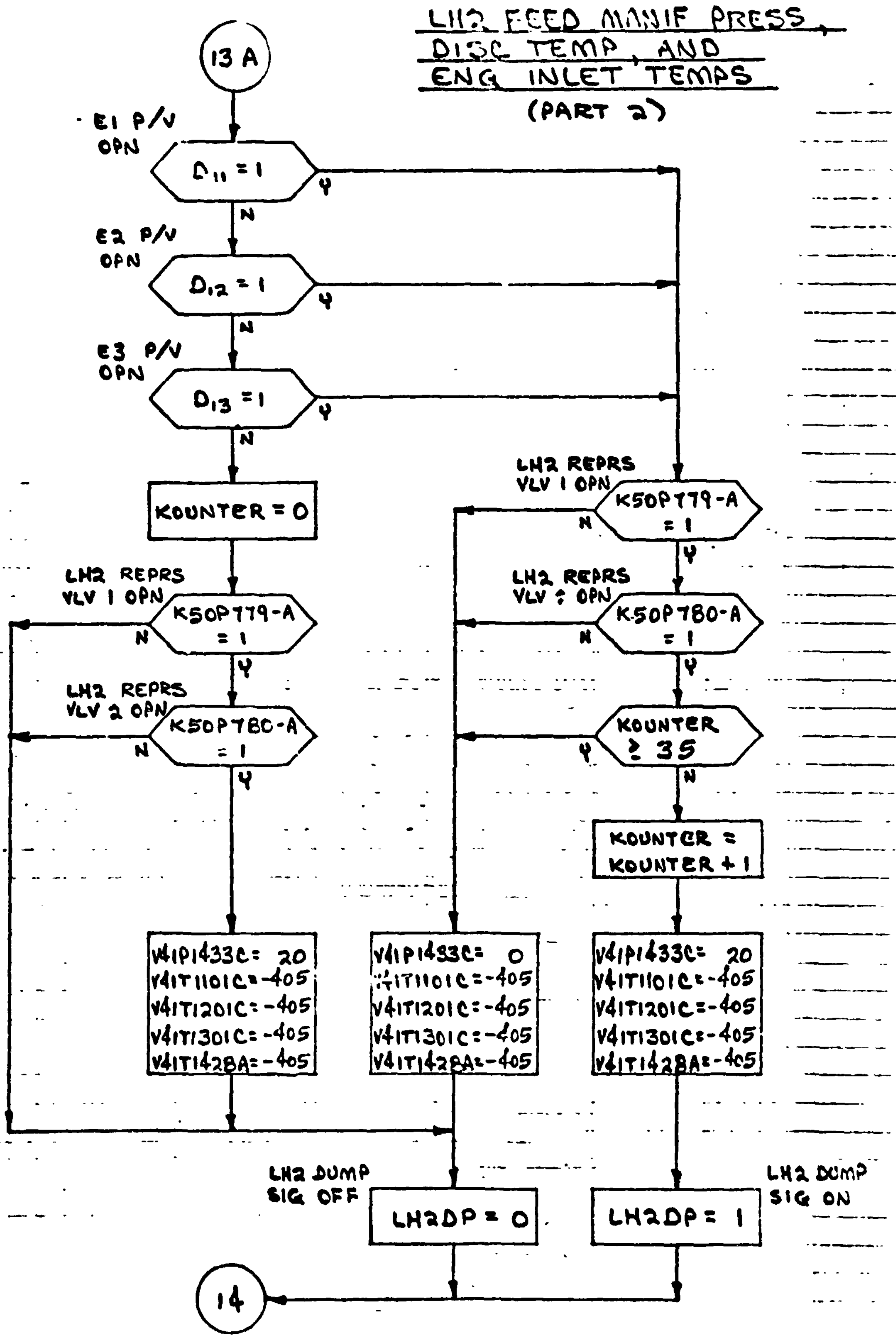
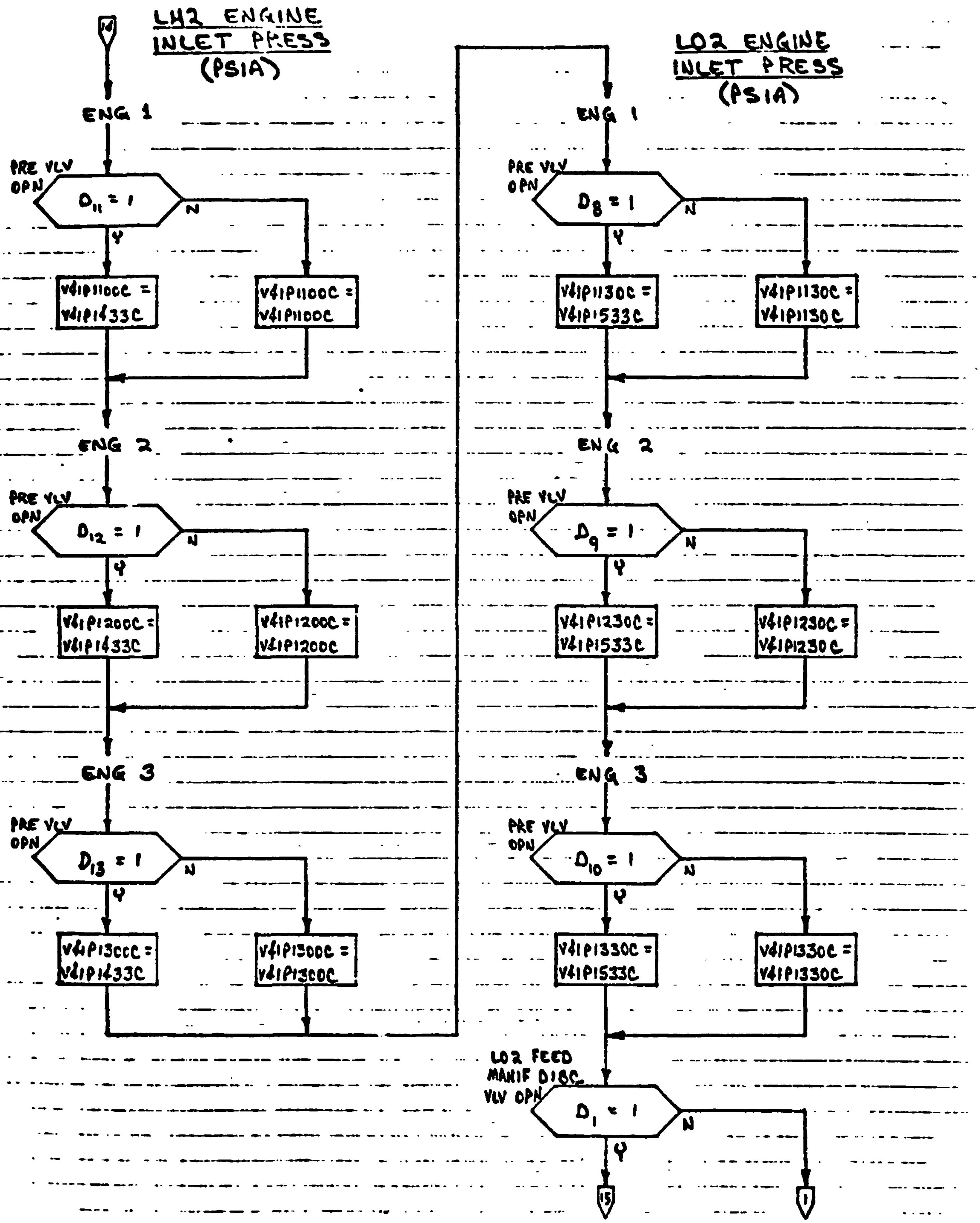
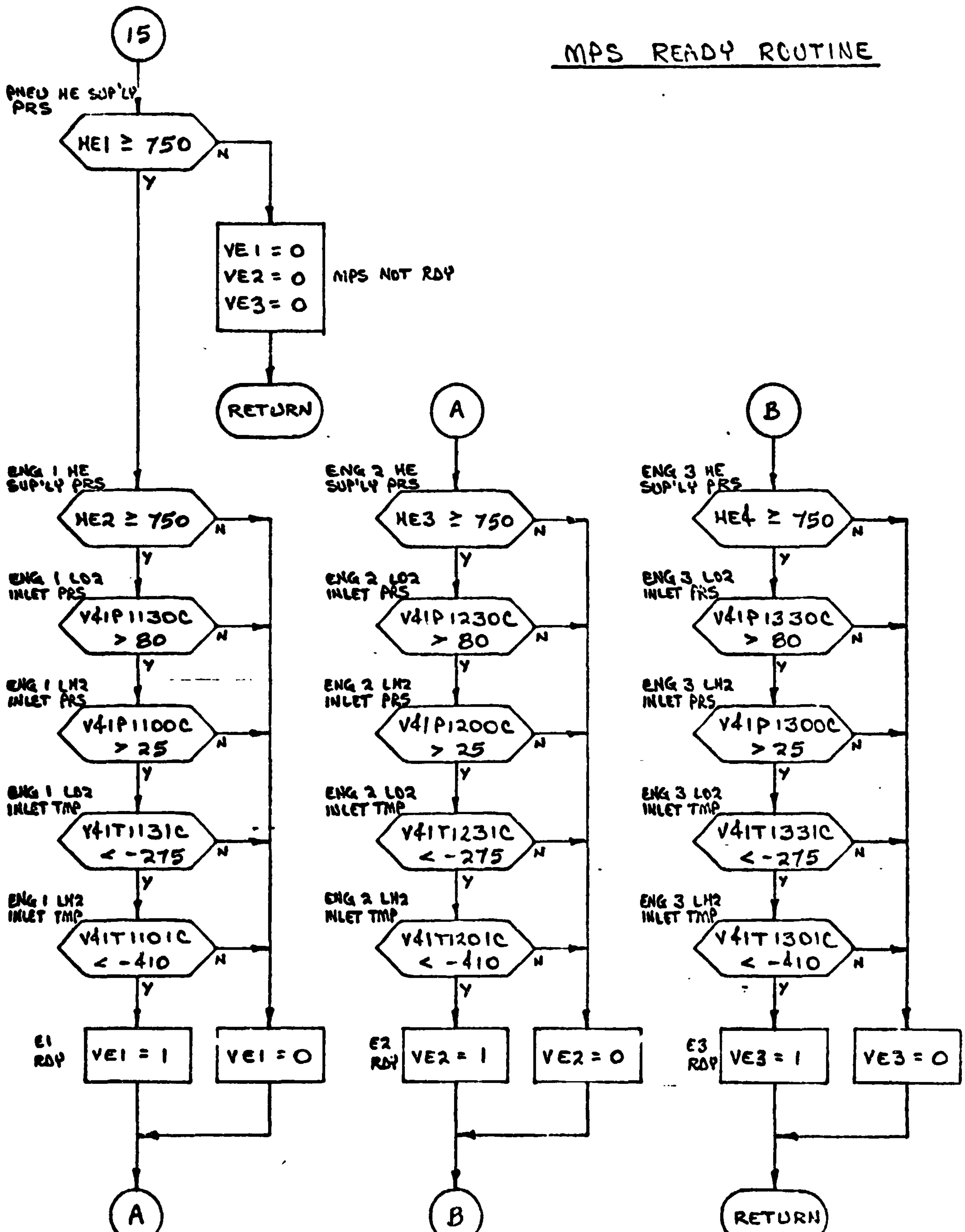


LH2 FEED MANIF PRESS, DISC TEMP, AND ENG INLET TEMPS
(PART 2)
13 A
E1 P/V OPN
D11 = 1
E2 P/V OPN
D12 = 1
E3 P/V OPN
D13 = 1
KOUNTER = 0
LH2 REPRS VLV 1 OPN
K50P779-A = 1
LH2 REPRS VLV 2 OPN
K50P780-A = 1
KOUNTER ≥ 35
KOUNTER = KOUNTER + 1
V41P1433C= 20
V41T1101C=-405
V41T1201C=-405
V41T1301C=-405
V41T1428A=-405
V41P1433C= 0
LH2 DUMP SIG OFF
LH2DP = 0
LH2 DUMP SIG ON
LH2DP = 1
14


LH2 ENGINE INLET PRESS (PSIA)
ENG 1
PRE VLV OPN
D11 = 1
V41P1100C = V41P1433C
V41P1100C = V41P1100C
ENG 2
PRE VLV OPN
D12 = 1
V41P1200C = V41P1433C
V41P1200C = V41P1200C
ENG 3
PRE VLV OPN
D13 = 1
V41P1300C = V41P1433C
V41P1300C = V41P1300C
LO2 ENGINE INLET PRESS (PSIA)
ENG 1
PRE VLV OPN
D8 = 1
V41P1130C = V41P1533C
V41P1130C = V41P1130C
ENG 2
PRE VLV OPN
D9 = 1
V41P1230C = V41P1533C
V41P1230C = V41P1230C
ENG 3
PRE VLV OPN
D10 = 1
V41P1330C = V41P1533C
V41P1330C = V41P1330C
LO2 FEED MANIF DISC VLV OPN
D1 = 1
Y
N
15
17



MPS READY ROUTINE
15
PNEU HE SUP'LY PRS
HE1 ≥ 750
Y
N
VE1 = 0
VE2 = 0
VE3 = 0
MPS NOT RDY
RETURN
ENG 1 HE SUP'LY PRS
HE2 ≥ 750
ENG 1 LO2 INLET PRS
V41P1130C > 80
ENG 1 LH2 INLET PRS
V41P1100C > 25
ENG 1 LO2 INLET TMP
V41T1131C < -275
ENG 1 LH2 INLET TMP
V41T1101C < -410
E1 RDY
VE1 = 1
VE1 = 0
A
ENG 2 HE SUP'LY PRS
HE3 ≥ 750
ENG 2 LO2 INLET PRS
V41P1230C > 80
ENG 2 LH2 INLET PRS
V41P1200C > 25
ENG 2 LO2 INLET TMP
V41T1231C < -275
ENG 2 LH2 INLET TMP
V41T1201C < -410
E2 RDY
VE2 = 1
VE2 = 0
B
ENG 3 HE SUP'LY PRS
HE4 ≥ 750
ENG 3 LO2 INLET PRS
V41P1330C > 80
ENG 3 LH2 INLET PRS
V41P1300C > 25
ENG 3 LO2 INLET TMP
V41T1331C < -275
ENG 3 LH2 INLET TMP
V41T1301C < -410
E3 RDY
VE3 = 1
VE3 = 0
RETURN

14.0 INPUT STIMULI/OUTPUT MEASUREMENT TABLES

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14.1 GTS INPUT TABLE

STIMULI INPUT TO [illegible] 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 L[illegible] 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	FLT SYS	0	1	STATE

STIMULI INPUT TO MPS 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 LO2 PRE-VLV OPN CMD A				
V41K1236E	ENG 2 LO2 PRE-VLV OPN CMD A				
V41K1237X	ENG 2 LO2 PRE-VLV OPN CMD B				
V41K1237E	ENG 2 LO2 PRE-VLV OPN CMD B				
V41K1238X	ENG 2 LO2 PRE-VLV OPN CMD C				
V41K1238E	ENG 2 LO2 PRE-VLV OPN CMD C				
V41K1239X	ENG 2 LO2 PRE-VLV CLS CMD A				
V41K1239E	ENG 2 LO2 PRE-VLV CLS CMD A				
V41K1240X	ENG 2 LO2 PRE-VLV CLS CMD B				
V41K1240E	ENG 2 LO2 PRE-VLV CLS CMD B				
V41K1241X	ENG 2 LO2 PRE-VLV CLS CMD C				
V41K1241E	ENG 2 LO2 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	FLT SYS	0	1	STATE

STIMULI INPUT TO MP ODEL - TABLE 14.1

IDENTIFICATION NUMBER	NOMENCLATURE	SOURCE	STATES/RANGE LO	HI	UNITS
V41K1319X	ENG 3 LH2 PRE-VLV OPN CMD A	FLT SYS	0	1	
V41K1319E	ENG 3 LH2 PRE-VLV OPN CMD A				STATE
V41K1320X	ENG 3 LH2 PRE-VLV OPN CMD B				
V41K1320E	ENG 3 LH2 PRE-VLV OPN CMD B				
V41K1321X	ENG 3 LH2 PRE-VLV OPN CMD C				
V41K1321E	ENG 3 LH2 PRE-VLV OPN CMD C				
V41K1322X	ENG 3 LH2 PRE-VLV CLS CMD A				
V41K1322E	ENG 3 LH2 PRE-VLV CLS CMD A				
V41K1323X	ENG 3 LH2 PRE-VLV CLS CMD B				
V41K1323E	ENG 3 LH2 PRE-VLV CLS CMD B				
V41K1324X	ENG 3 LH2 PRE-VLV CLS CMD C				
V41K1324E	ENG 3 LH2 PRE-VLV CLS CMD C				
V41K1325X	ENG 3 MAINSTAGE CMD A				
V41K1326X	ENG 3 MAINSTAGE CMD B				
V41K1336X	ENG 3 LO2 PRE-VLV OPN CMD A				
V41K1336E	ENG 3 LO2 PRE-VLV OPN CMD A				
V41K1337X	ENG 3 LO2 PRE-VLV OPN CMD B				
V41K1337E	ENG 3 LO2 PRE-VLV OPN CMD B				
V41K1338X	ENG 3 LO2 PRE-VLV OPN CMD C				
V41K1338E	ENG 3 LO2 PRE-VLV OPN CMD C				
V41K1339X	ENG 3 LO2 PRE-VLV CLS CMD A				
V41K1339E	ENG 3 LO2 PRE-VLV CLS CMD A				
V41K1340X	ENG 3 LO2 PRE-VLV CLS CMD B				
V41K1340E	ENG 3 LO2 PRE-VLV CLS CMD B				
V41K1341X	ENG 3 LO2 PRE-VLV CLS CMD C				
V41K1341E	ENG 3 LO2 PRE-VLV CLS CMD C				
V41K1355E	ENG 3 HE ISOL VLV 1 OPN CMD				
V41K1356E	ENG 3 HE ISOL VLV 2 OPN CMD A				
V41K1357E	ENG 3 HE ISOL VLV 2 OPN CMD B				
V41K1355E	ENG 3 HE ISOL VLV 1 CLS CMD				
V41K1366E	ENG 3 HE ISOL VLV 2 CLS CMD A				
V41K1367E	ENG 3 HE ISOL VLV 2 CLS CMD B				
V41K1391X	LH2 OTBD FILL VLV OPN CMD				
V41K1391E	LH2 OTBD FILL VLV OPN CMD	FLT SYS	0	1	STATE

STIMULI INPUT TO MPS 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				
V41K1401X	LH2 INBD FILL VLV OPN CMD A				
V41K1401E	LH2 INBD FILL VLV OPN CMD A				
V41K1402X	LH2 INBD FILL VLV OPN CMD B				
V41K1411X	LH2 TOPPING VLV OPN CMD				
V41K1412X	LH2 INBD FILL VLV CLS CMD				
V41K1412E	LH2 INBD FILL VLV CLS CMD				
V41K1413X	LH2 FEED DISC VLV OPN CMD A				
V41K1414X	LH2 FEED DISC VLV OPN CMD B				
V41K1415X	LH2 FEED DISC VLV OPN CMD C				
V41K1416X	LH2 FEED DISC VLV CLS CMD A				
V41K1417X	LH2 FEED DISC VLV CLS CMD B				
V41K1418X	LH2 FEED DISC VLV CLS CMD C				
V41K1421X	LH2 RECIRC DISC VLV OPN CMD				
V41K1422X	LH2 RECIRC DISC VLV CLS CMD				
V41K1431E	LH2 MANIF REPRESS VLV 1 CLS CMD A				
V41K1435X	LH2 MANIF REPRESS VLV 1 OPN CMD				
V41K1435E	LH2 MANIF REPRESS VLV 1 OPN CMD				
V41K1437X	LH2 MANIF REPRESS VLV 2 OPN CMD				
V41K1443E	LH2 FEEDLINE RLF S/O VLV OPN CMD A				
V41K1447X	LH2 FEEDLINE RLF S/O VLV CLS CMD A				
V41K1447E	LH2 FEEDLINE RLF S/O VLV CLS CMD A				
V41K1448X	LH2 FEEDLINE RLF S/O VLV CLS CMD B				
V41K1501X	LO2 INBD FILL VLV OPN CMD A				
V41K1501E	LO2 INBD FILL VLV OPN CMD A				
V41K1502X	LO2 INBD FILL VLV OPN CMD B				
V41K1512X	LO2 INBD FILL VLV CLS CMD				
V41K1512E	LO2 INBD FILL VLV CLS CMD				
V41K1515X	LO2 OTBD FILL VLV CLS CMD				
V41K1515E	LO2 OTBD FILL VLV CLS CMD				
V41K1518X	LO2 OTBD FILL VLV OPN CMD				
V41K151	LO2 OTBD FILL VLV OPN CMD	FLT SYS	0	1	STATE

STIMULI INPUT TO [illegible] MODEL - TABLE 14.1

IDENTIFICATION NUMBER	NOMENCLATURE	SOURCE	STATES/RANGE		
			LO	HI	UNITS
V41K1521X	LO2 FEED DISC VLV OPN CMD A	FLT SYS	0	1	STATE
V41K1522X	LO2 FEED DISC VLV OPN CMD B				
V41K1523X	LO2 FEED DISC VLV OPN CMD C				
V41K1524X	LO2 FEED DISC VLV CLS CMD A				
V41K1525X	LO2 FEED DISC VLV CLS CMD B				
V41K1526X	LO2 FEED DISC VLV CLS CMD C				
V41K1531E	LO2 MANIF REPRESS VLV 1 CLS CMD				
V41K1535X	LO2 MANIF REPRESS VLV 1 OPN CMD				
V41K1535E	LO2 MANIF REPRESS VLV 1 OPN CMD				
V41K1537X	LO2 MANIF REPRESS VLV 2 OPN CMD				
V41K1543E	LO2 FEEDLINE RLF S/O VLV OPN CMD A				
V41K1547X	LO2 FEEDLINE RLF S/O VLV CLS CMD A				
V41K1547E	LO2 FEEDLINE RLF S/O VLV CLS CMD A				
V41K1548X	LO2 FEEDLINE RLF S/O VLV CLS CMD B				
V41K1584X	LO2 OVBD BLEED VLV CLS CMD A				
V41K1585X	LO2 OVBD BLEED VLV CLS CMD B				
V41K1586X	LO2 OVBD BLEED VLV CLS CMD C				
V41K1607E	HE ISOL PNEU VLV 1/2 OPN CMD				
V41K1609E	HE ISOL PNEU VLV 1/2 CLS CMD				
V41K1613X	PNEU XOVR NO. 2 OPN CMD				
V41K1613E	PNEU XOVR NO. 2 OPN CMD				
V41K1619E	PNEU XOVR NO. 2 CLS CMD				
V41K1700X	REPLACE LH2 ULLAGE PRESS #1 XDCR				
V41K1701X	REPLACE LH2 ULLAGE PRESS #2 XDCR	FLT SYS	0	1	STATE

STIMULI INPUT TO . S MODEL - TABLE 14.1

IDENTIFICATION NUMBER	NOMENCLATURE	SOURCE	STATES/RANGE LO	HI	UNITS
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	FLT SYS	0	1	STATE
LH2	LH2 TANK ULLAGE PRESS	MMES	12	42	PSIG
LO2	LO2 TANK ULLAGE PRESS	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/[illegible]		
			LO	HI	[illegible]
V41K1155X	E1 HE ISOL VLV 1 OPN CMD	FLT SYS	0	1	STAT
V41K1156X	E1 HE ISOL VLV 2 OPN CMD A				
V41K1157X	E1 HE ISOL VLV 2 OPN CMD B				
V41K1162X	E1 HE INTERCONNECT "IN" VLV OPN CMD A				
V41K1162E	E1 HE INTERCONNECT "IN" VLV OPN CMD A				
V41K1163X	E1 HE INTERCONNECT "IN" VLV OPN CMD B				
V41K1163E	E1 HE INTERCONNECT "IN" VLV OPN CMD B				
V41K1168X	E1 HE INTERCONNECT "OUT" VLV OPN CMD A				
V41K1168E	E1 HE INTERCONNECT "OUT" VLV OPN CMD A				
V41K1169E	E1 HE INTERCONNECT "OUT" VLV OPN CMD B				
V41K1255X	E2 HE ISOL VLV 1 OPN CMD				
V41K1256X	E2 HE ISOL VLV 2 OPN CMD A				
V41K1257X	E2 HE ISOL VLV 2 OPN CMD B				
V41K1262X	E2 HE INTERCONNECT "IN" VLV OPN CMD A				
V41K1262E	E2 HE INTERCONNECT "IN" VLV OPN CMD [illegible]				
V41K1263X	E2 HE INTERCONNECT "IN" VLV OPN CMD B				
V41K1263E	E2 HE INTERCONNECT "IN" VLV OPN CMD B				
V41K1268X	E2 HE INTERCONNECT "OUT" VLV OPN CMD A				
V41K1268E	E2 HE INTERCONNECT "OUT" VLV OPN CMD A				
V41K1269E	E2 HE INTERCONNECT "OUT" VLV OPN CMD B				
V41K1355X	E3 HE ISOL VLV 1 OPN CMD				
V41K1356X	E3 HE ISOL VLV 2 OPN CMD A				
V41K1357X	E3 HE ISOL VLV 2 OPN CMD B				
V41K1362X	E3 HE INTERCONNECT "IN" VLV OPN CMD A				
V41K1362E	E3 HE INTERCONNECT "IN" VLV OPN CMD A				
V41K1363X	E3 HE INTERCONNECT "IN" VLV OPN CMD B				
V41K1363E	E3 HE INTERCONNECT "IN" VLV OPN CMD B				
V41K1368X	E3 HE INTERCONNECT "OUT" VLV OPN CMD A				
V41K1368E	E3 HE INTERCONNECT "OUT" VLV OPN CMD A				
V41K1369E	E3 HE INTERCONNECT "OUT" VLV OPN CMD B				
V41K1408E	LH2 TOPPING VLV CLS CMD	KYBD			
V41K1432E	LH2 MANIF REPRESS NO. 2 CL CMD				
V41K1532E	LO2 MANIF REPRESS NO. 2 CL CMD				
V41K1607X	PNEU VLV HE ISOL VLV 1 OP CMD	FLT SYS			
~~V41K1608X~~	~~PNEU VLV HE ISOL VLV 2 OP CMD~~	~~FLT SYS~~			

10.2 GTS OUTPUT TABLE

MEASUREMENT OUTPUT FROM MPS MODEL - TABLE 14.2

IDENTIFICATION NUMBER	NOMENCLATURE	DESTINATION	STATES/RANGE LO	HI	I.C.	UNITS
V41P1100C	ENG 1 LH2 INLET PRESS	FS	0	200	0	PSIA
V41T1101C	ENG 1 LH2 INLET TEMP		-430	-405	-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 INLET PRESS		0	300	0	PSIA
V41T1131C	ENG 1 LO2 INLET TEMP		-305	255	-290	DEGF
V41X1134X	ENG 1 LO2 PRE-VLV OPEN		0	1	1	STATE
V41X1135E	ENG 1 LO2 PRE-VLV CLOSED		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	FS	0	1	1	STATE

MEASUREMENT OUTPUT FROM MODEL - TABLE 14.2

IDENTIFICATION NUMBER	NOMENCLATURE	DESTINATION	STATES/RANGE			
			LO	HI	I.C.	UNITS
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	RPM
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[illegible]	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

MEASUREMENT OUTPUT OF PS MODEL - TABLE 14.2

IDENTIFICATION NUMBER	NOMENCLATURE	DESTINATION	STATES/RANGE			
			LO	HI	I.C.	UNITS
V41X1580X	LO2 OVBD BLEED VLV CLOSED - A	FS	0	1	1	STATE
V41X1581X	LO2 OVBD BLEED VLV CLOSED - B		0	1	1	STATE
V41X1587E	LO2 OVBD BLEED VLV OPEN		0	1	0	STATE
V41P1600A	LO2 PNEU VLV HE SUPPLY PRESS		0	5000	4000	PSIA
V41X1811X	LO2 ACCUM RECIRC VLV 1 OPEN		0	1	1	STATE
V41X1818E	LO2 ACCUM RECIRC VLV 1 CLOSED		0	1	0	STATE
V41X1821X	LO2 ACCUM RECIRC VLV 2 OPEN		0	1	1	STATE
V41X1828E	LO2 ACCUM RECIRC VLV 2 CLOSED		0	1	0	STATE
V41X1919X	LH2 RTLS OTBD DRAIN VLV CLOSED		0	1	1	STATE
V41X1929X	LH2 RTLS INBD DRAIN VLV CLOSED	FS	0	1	1	STATE
VGH1	ENG 1 GH2 FLOW CONTROL VLV POSN - LO	MMES	0	1	0	STATE
VGH2	ENG 2 GH2 FLOW CONTROL VLV POSN - LO		0	1	0	STATE
VGH3	ENG 3 GH2 FLOW CONTROL VLV POSN - LO		0	1	0	STATE
VG01	ENG 1 GO2 FLOW CONTROL VLV POSN - LO		0	1	0	STATE
VG02	ENG 2 GO2 FLOW CONTROL VLV POSN - LO		0	1	0	STATE
VG03	ENG 3 GO2 FLOW CONTROL VLV POSN - LO		0	1	0	STATE
VE1	ENG 1 PLUMBING READY DISCRETE		0	1	0	STATE
VE2	ENG 2 PLUMBING READY DISCRETE		0	1	0	STATE
VE3	ENG 3 PLUMBING READY DISCRETE	MMES	0	1	0	STATE
V41P1605A	PNEU HE REG OUT PRESS	FS	0	1000	750	PSIG
V41X1468E	LH2 HI POINT BLEED VLV OPEN	FS	0	1	1	STATE
V41X1469E	LH2 HI POINT BLEED VLV CLOSED	FS	0	1	0	STATE
V41T1428A	LH2 FEED MANIFOLD DISC TEMP	FS	-430	-405	-423	DEGF
V41T1528A	LO2 FEED MANIFOLD DISC TEMP	FS	-305	-255	-290	DEGF
LO2DP	LO2 DUMP SIGNAL	FDS	0	1	0	STATE
LH2DP	LH2 DUMP SIGNAL	FDS	0	1	0	STATE
RTLSDP	RTLS DUMP SIGNAL	FDS	0	1	0	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.

NAS CRT DISPLAY FORMAT

PROGRAM ______ FORTRAN-FAP CODING DATE ______
CODED BY ______ PAGE ____ OF ____
FOR C PUNCH ______ VERIFY ______ TABULATE ______ EXECUTE ______ IDENTIFICATION

STATEMENT NUMBER	FORTRAN STATEMENT		COMMENTS		
587641					XX:XX:XX
	HYD/APU S/S		MPS X-E-MS		
	58P0114C HYD SUP PRESS A SYS 1	2950	K1700X LH2 1	REPL	
	58P0115C HYD SUP PRESS B SYS 1	2950	K1701X LH2 2	REPL	
			K1702X LH2 3	REPL	
	58P0214C HYD SUP PRESS A SYS 2	2950	K1750X LO2 1	REPL	
	58P0215C HYD SUP PRESS B SYS 2	2950	K1751X LO2 2	REPL	
			K1752X LO2 3	REPL	
	58P0314C HYD SUP PRESS A SYS 3	2950			
	58P0315C HYD SUP PRESS B SYS 3	2950	VE1XXX E-1	READY	
			VE2XXX E-2	READY	
	PYRØS ET SEP		VE3XXX E-3	READY	
	76K6909B ET/ØRB SEPN ARM	ARM	K1125X MPS 1	MNSTG	
	76K6913B ET/ØRB SEPN FIRE	FIRE	K1225X MPS 2	MNSTG	
	76V7079B ET/ØRB P/C A VØLT	5.0	K1325X MPS 3	MNSTG	

NOTE: WRITE NUMBERS 10, LETTERS IØULZC, SYMBOLS /.,*

FIGURE 4

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

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FIGURES

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(H20 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

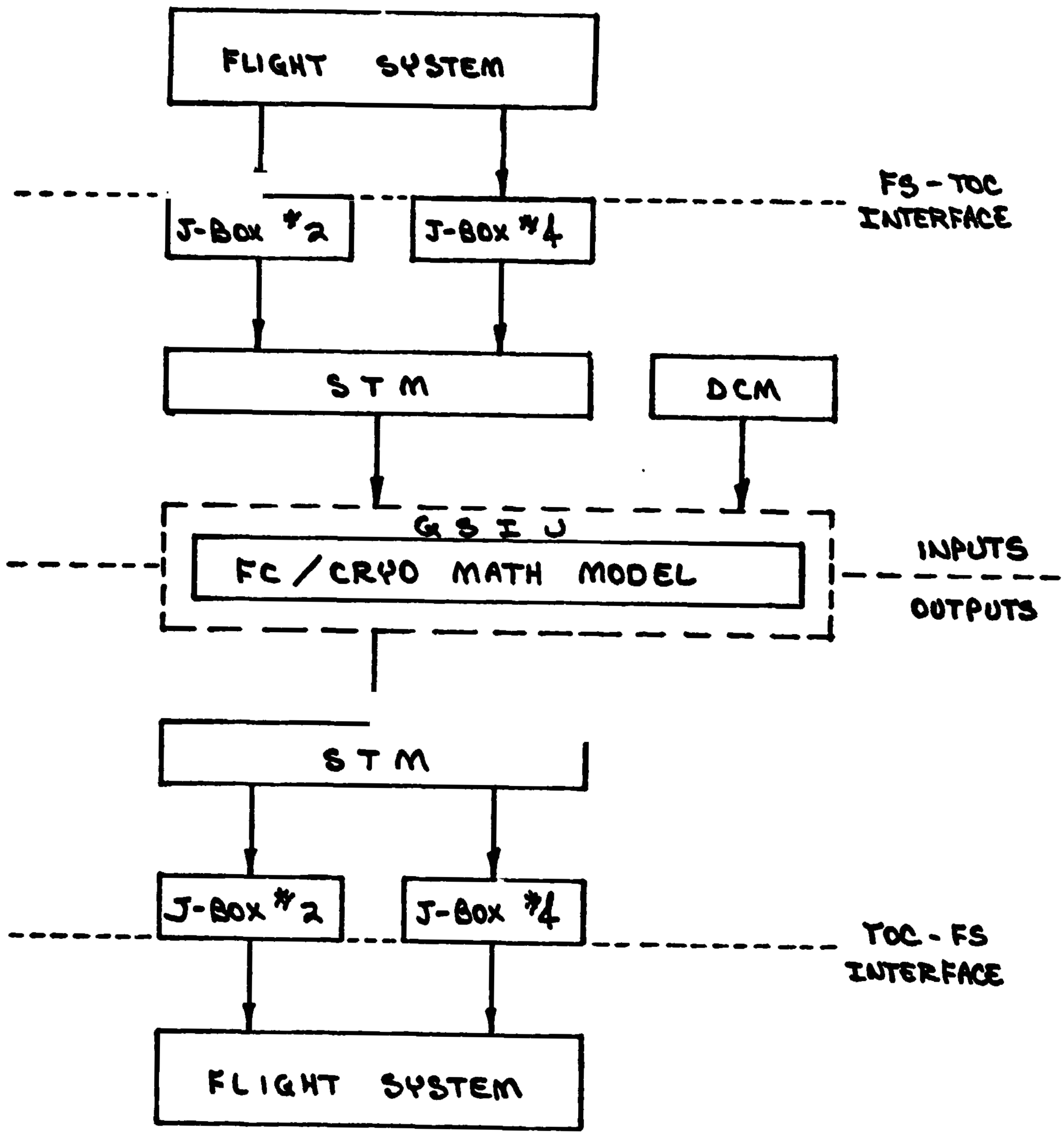
2.1.1 Fuel Cell/Cryogenics System

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 continouous 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

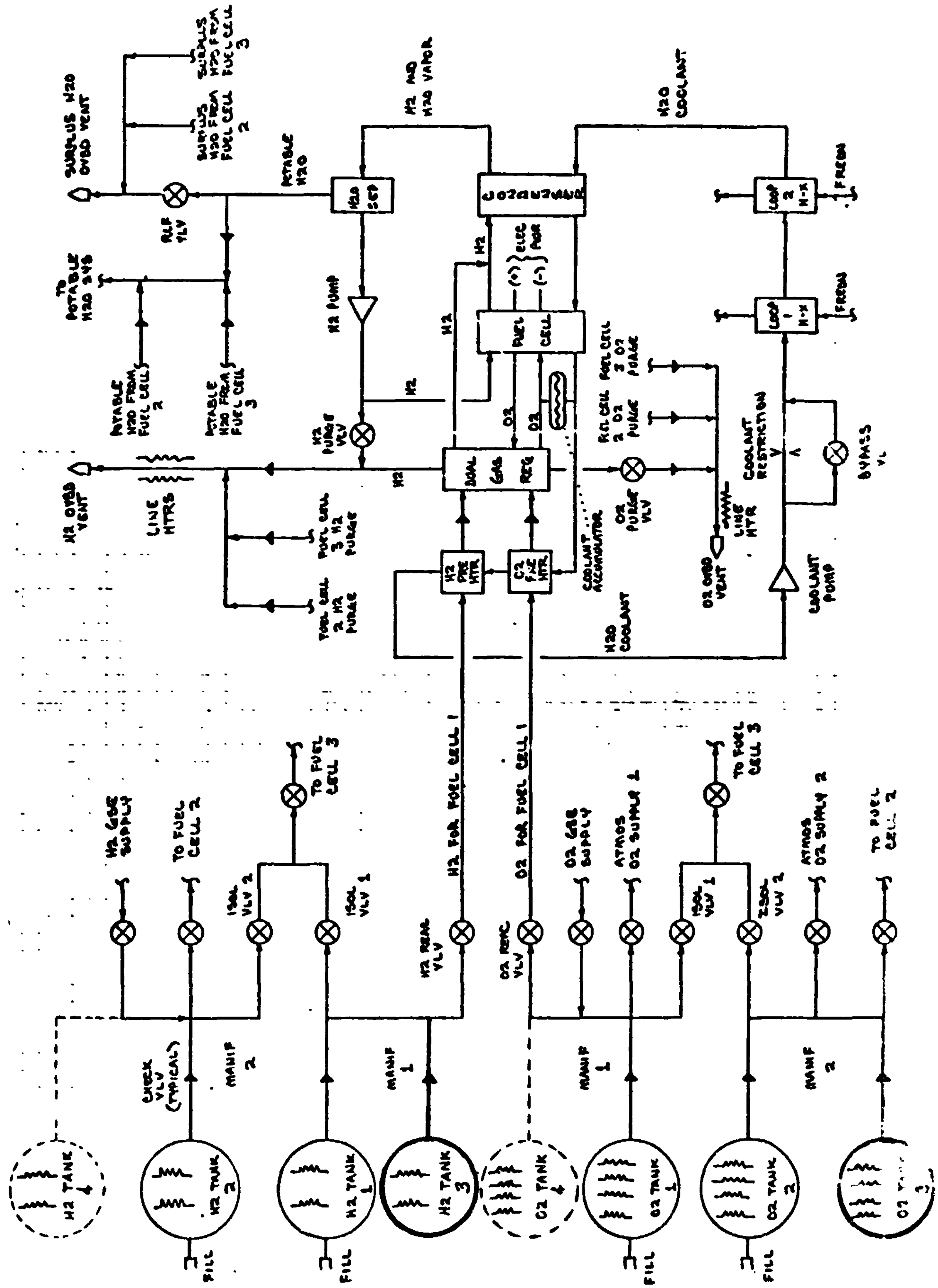
In preparing the requirements for the non-avionics system math models, the following ground rules were observed:

- 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



FUEL CELL / CRYO SUBSYSTEM SCHEMATIC

FIGURE 2

- 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.

```
K  40  PXXX - X
|  |    |     |
|  |    |     └──── PIN NUMBER (FLIGHT CABLE)
|  |    └────────── CONNECTOR NUMBER (P FOLLOWED BY 3 or 4 DIGITS)
|  └─────────────── AREA DESIGNATOR
└────────────────── STIMULI DESIGNATOR
```

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

NAME	FUNCTION	STATE 0	STATE 1
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:

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

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:

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

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

SO X = 3.846529

And

$$FS_{EU} = 443.167 + 851.956X - 143.904X^2 + 12.246X^3$$
$$FS_{EU} = 443.167 + 851.956(3.848) - 143.904(3.848)^2 + 12.246\ (3.848$$
$$FS_{EU} = 2288.017$$

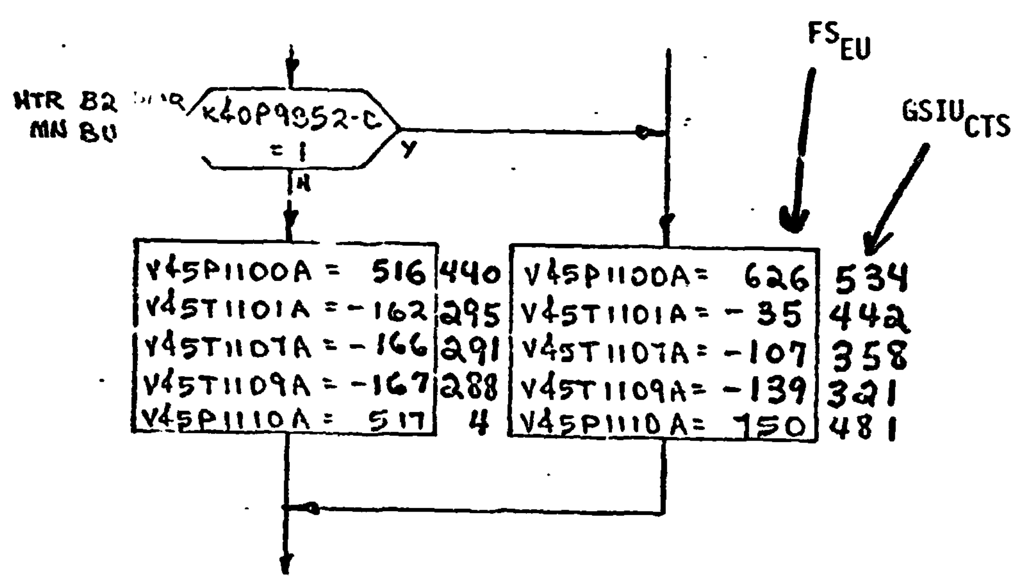
Hence when 787 GSIU counts is inserted for measurement no. V63R̈100A, a value of 2288.017 FS_{EU} will result.

2.6.2 RANGE LIMIT CONVERSION METHOD

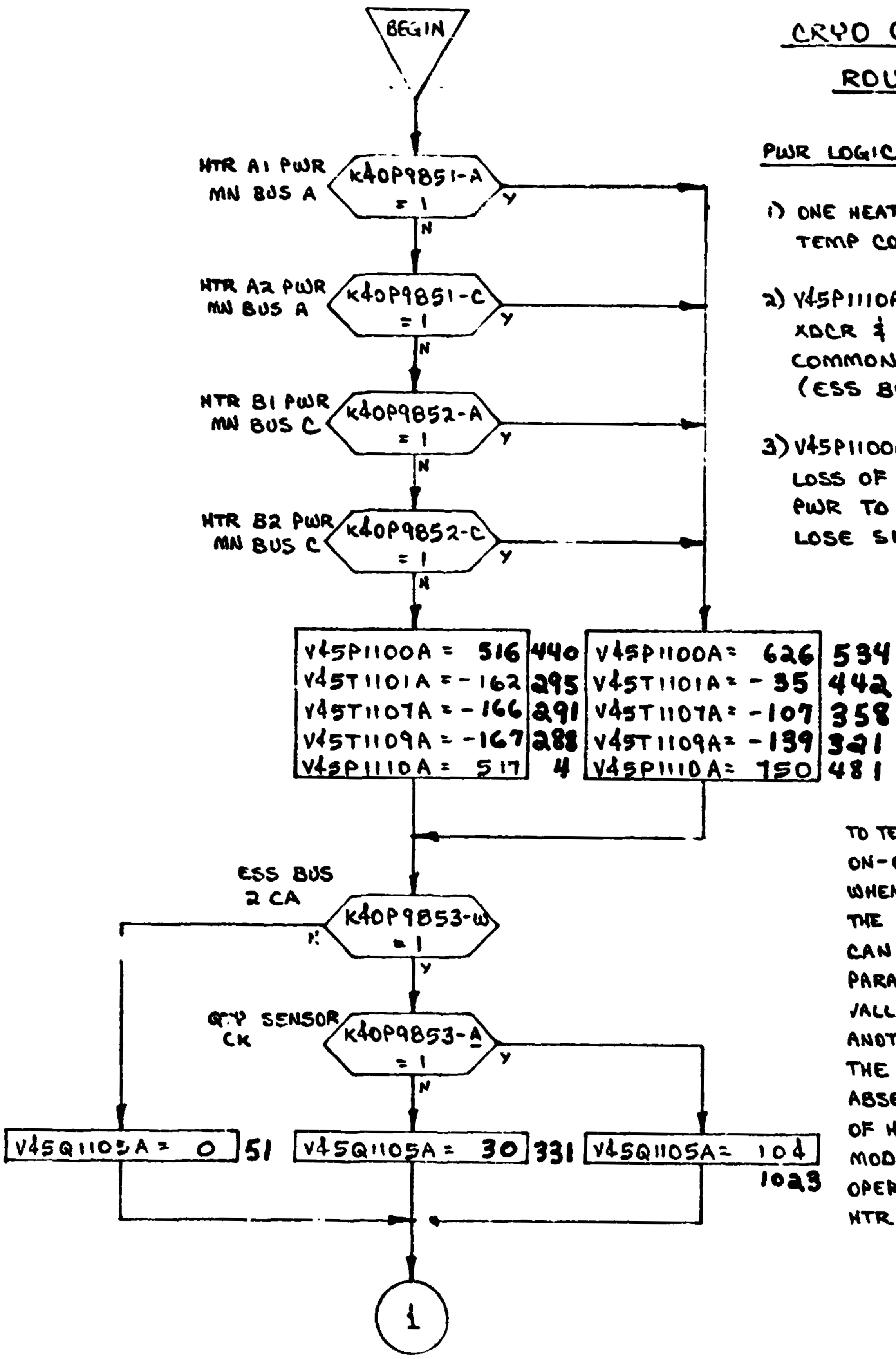
NONE.

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) V45P1110A 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, TOC 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.

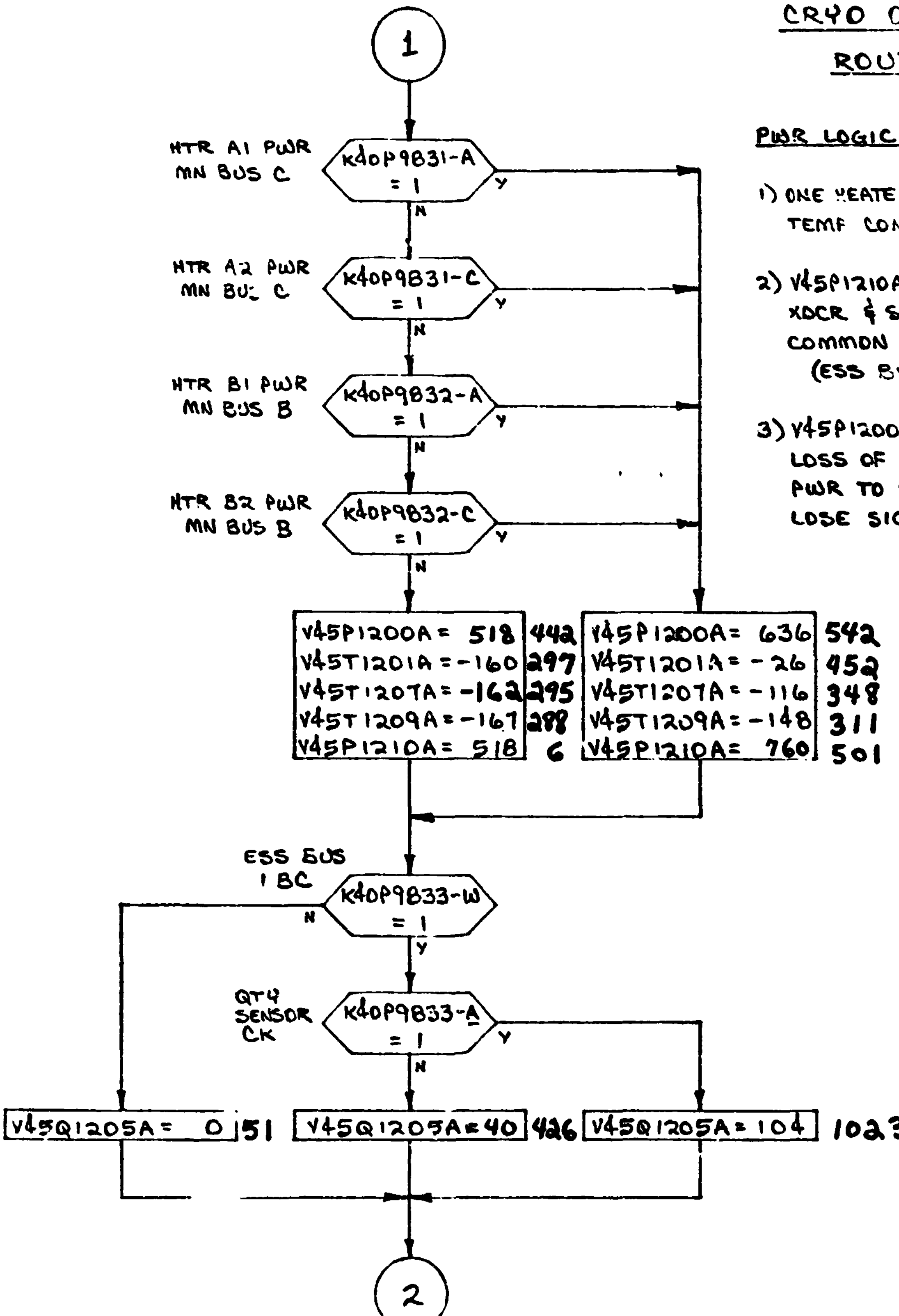
CRYO O2 TANK 2 ROUTINE

PWR LOGIC:

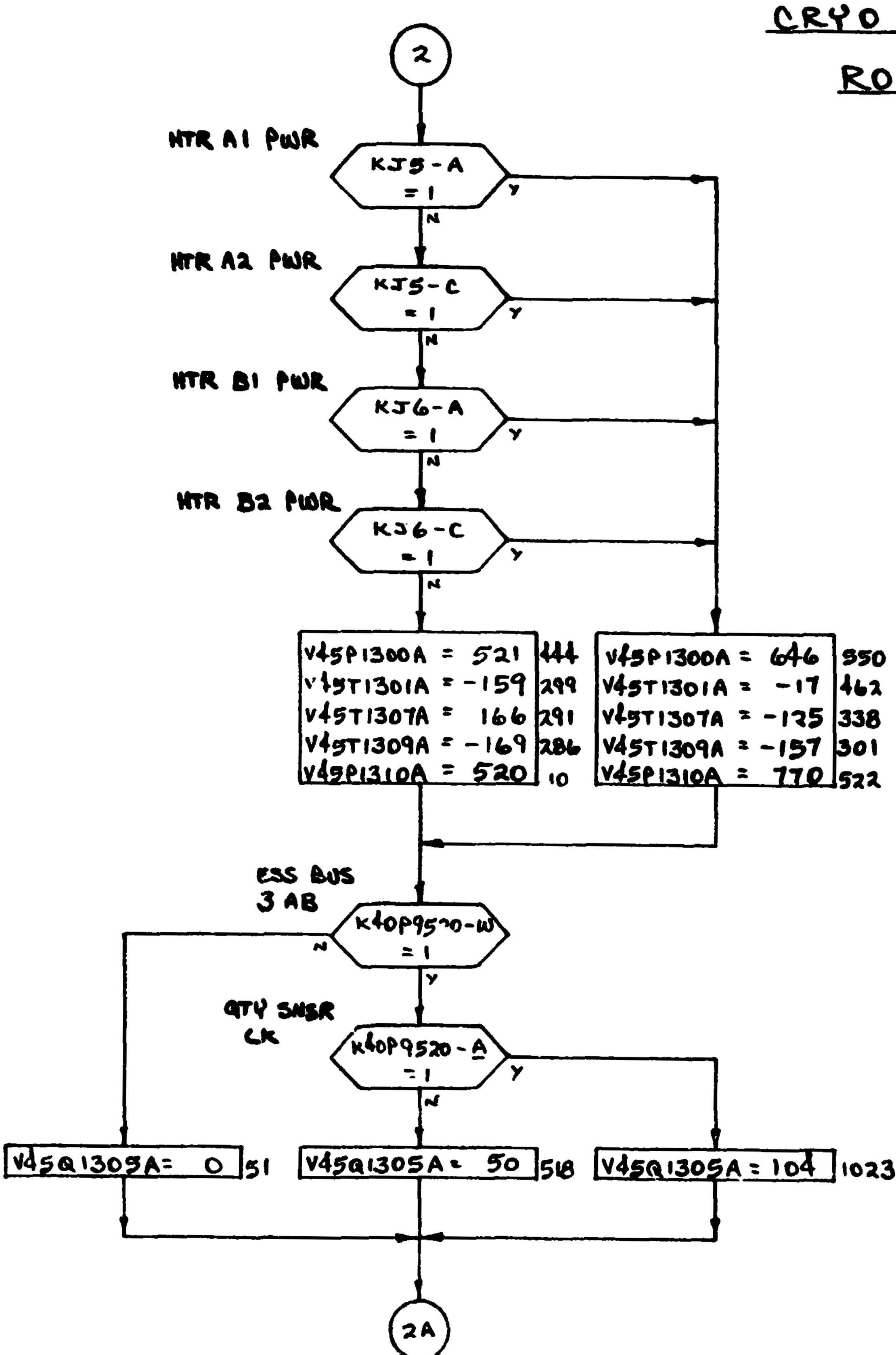
1) ONE HEATER GIVES POSITIVE TEMP CONTROL.

2) V45P1210A PRESS PWR TO XDCR & SIGNAL AMP IS COMMON IN SC A2. (ESS BUS 1BC)

3) V45P1200A PRESS R[illegible] LOSS OF MNC AND MNB PWR TO SC OF3 TO LOSE SIGNAL.

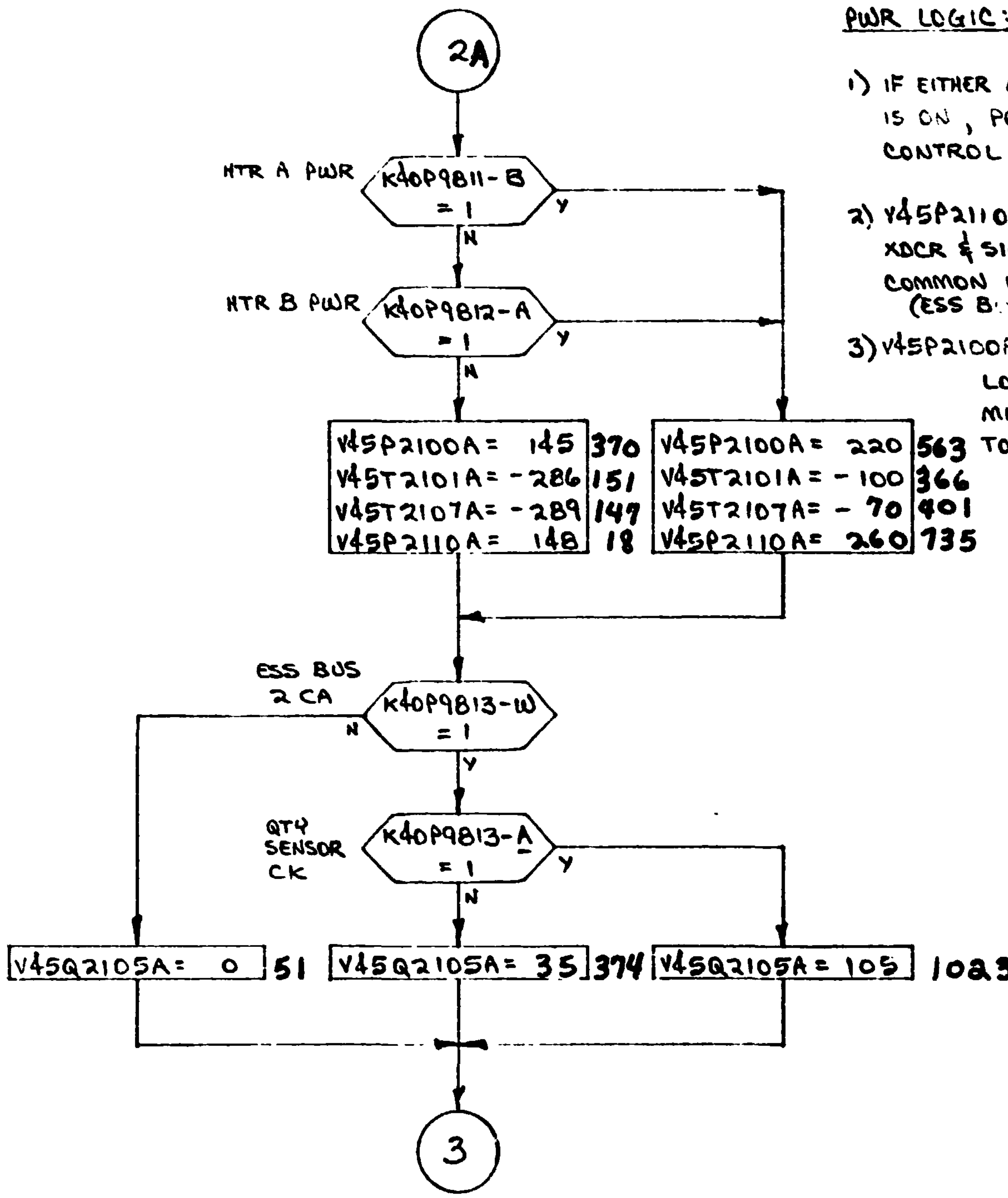


CRYO O2 TANK 3
ROUTINE



CRYO H2 TANK 1

ROUTINE



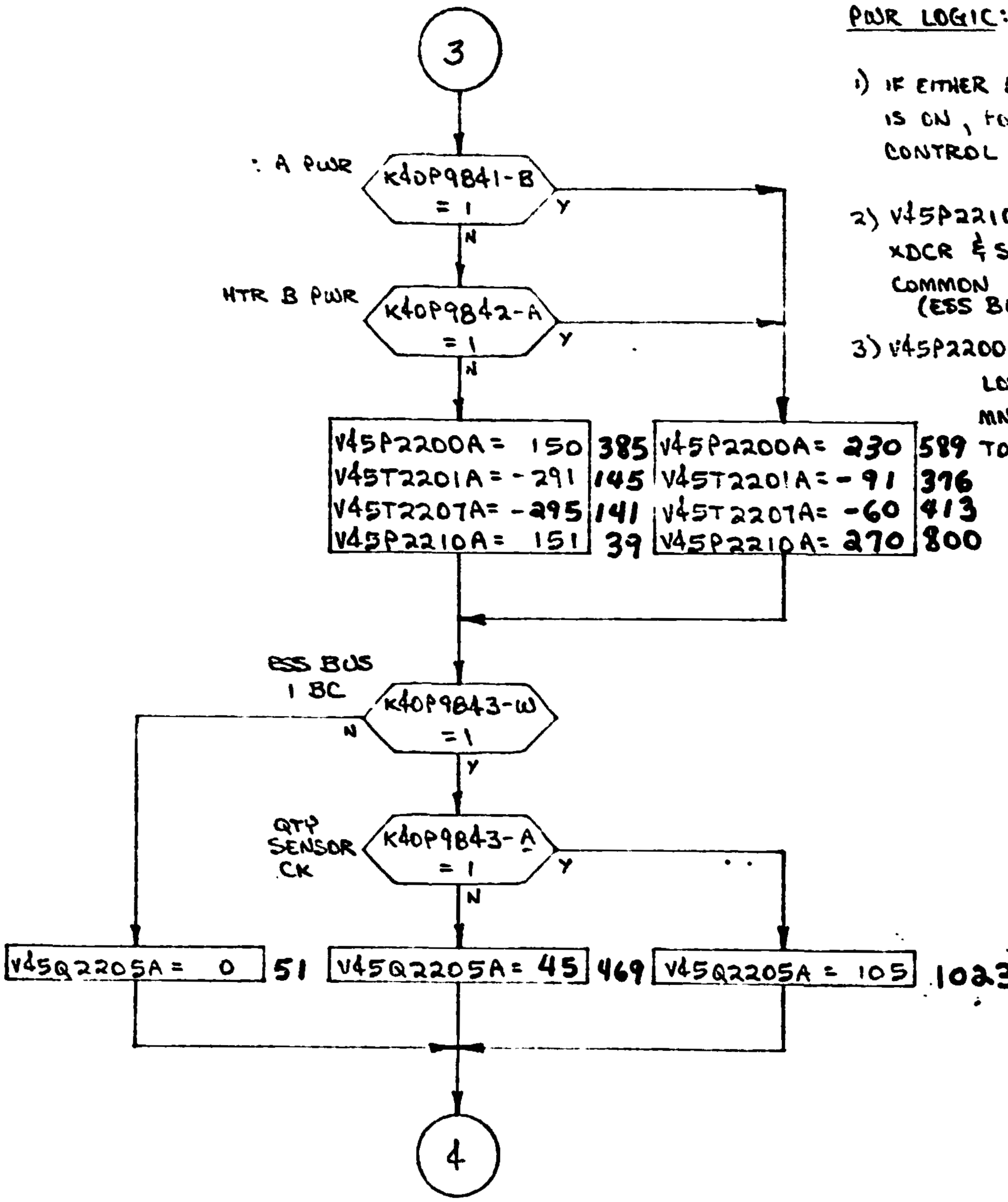
PWR LOGIC:

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 R[illegible] LOSS OF MNA AND MNB PWR TO SC OF1 TO LOSE SIGNAL.

CRYO H2 TANK 2
ROUTINE



PWR LOGIC:

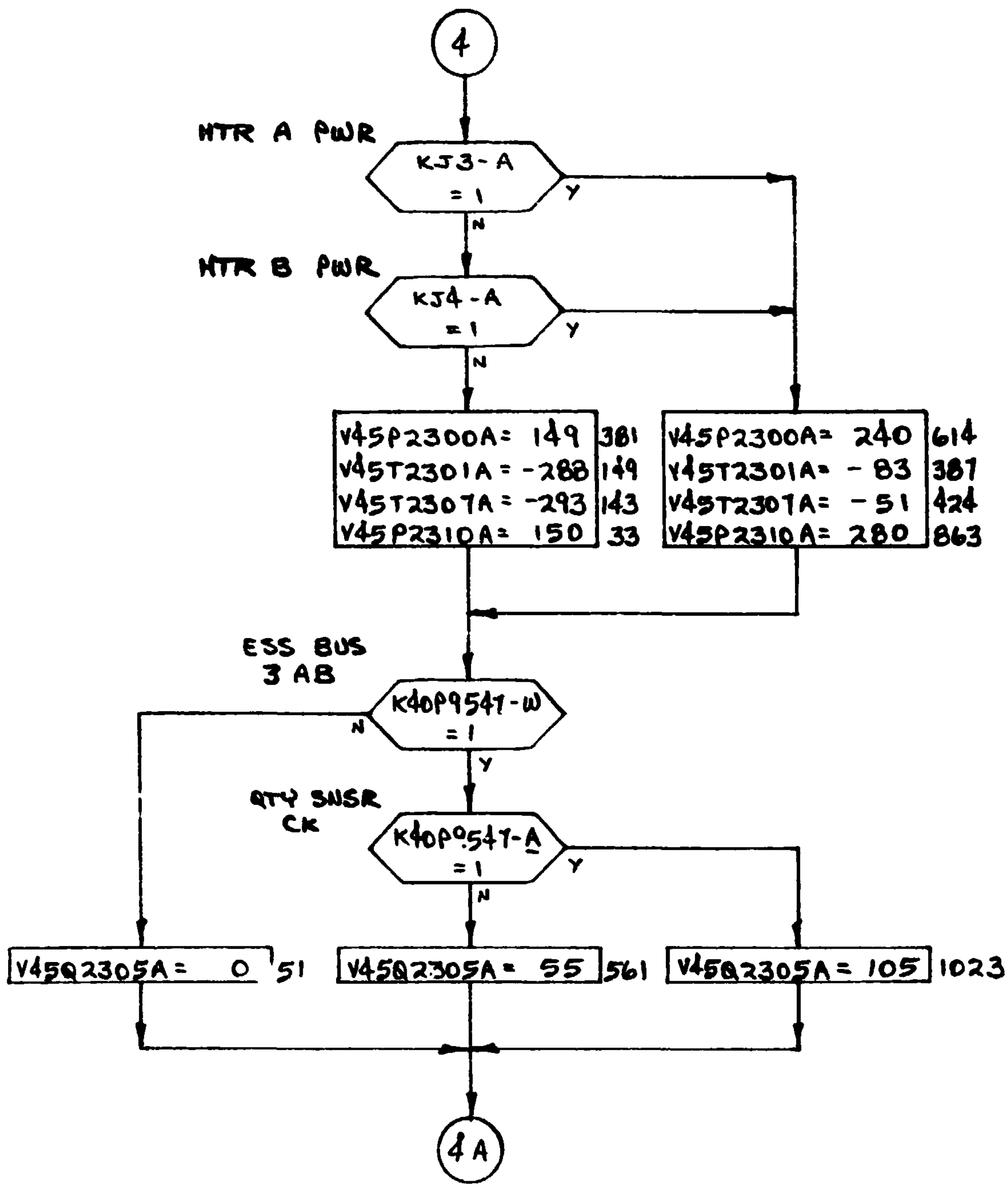
1) IF EITHER B-PWR OR C-PWR IS ON, POSITIVE TEMP CONTROL.

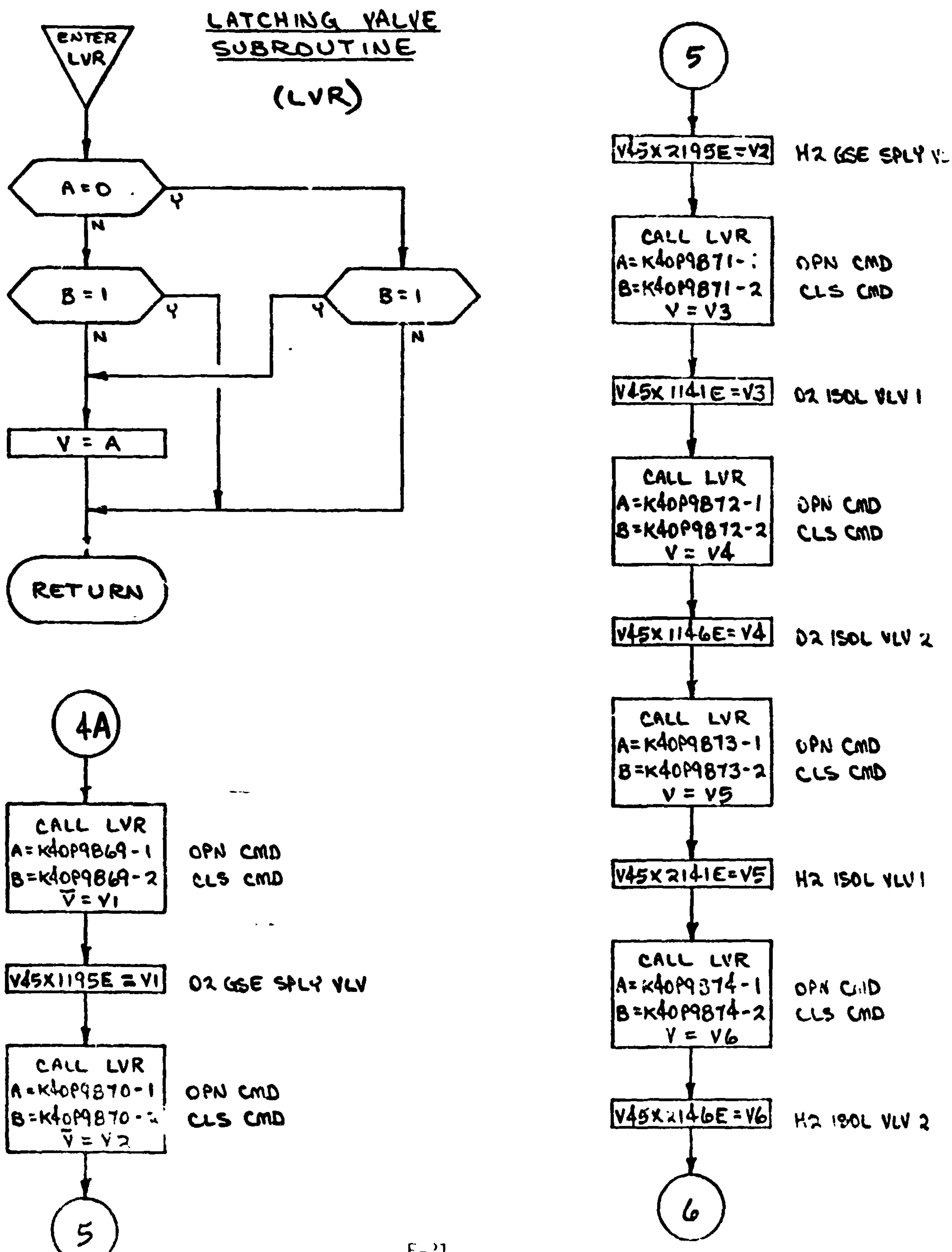
2) V45P2210A PRESS PWR TO XDCR & SIGNAL AMP IS COMMON IN SC A1. (ESS BUS 1BC)

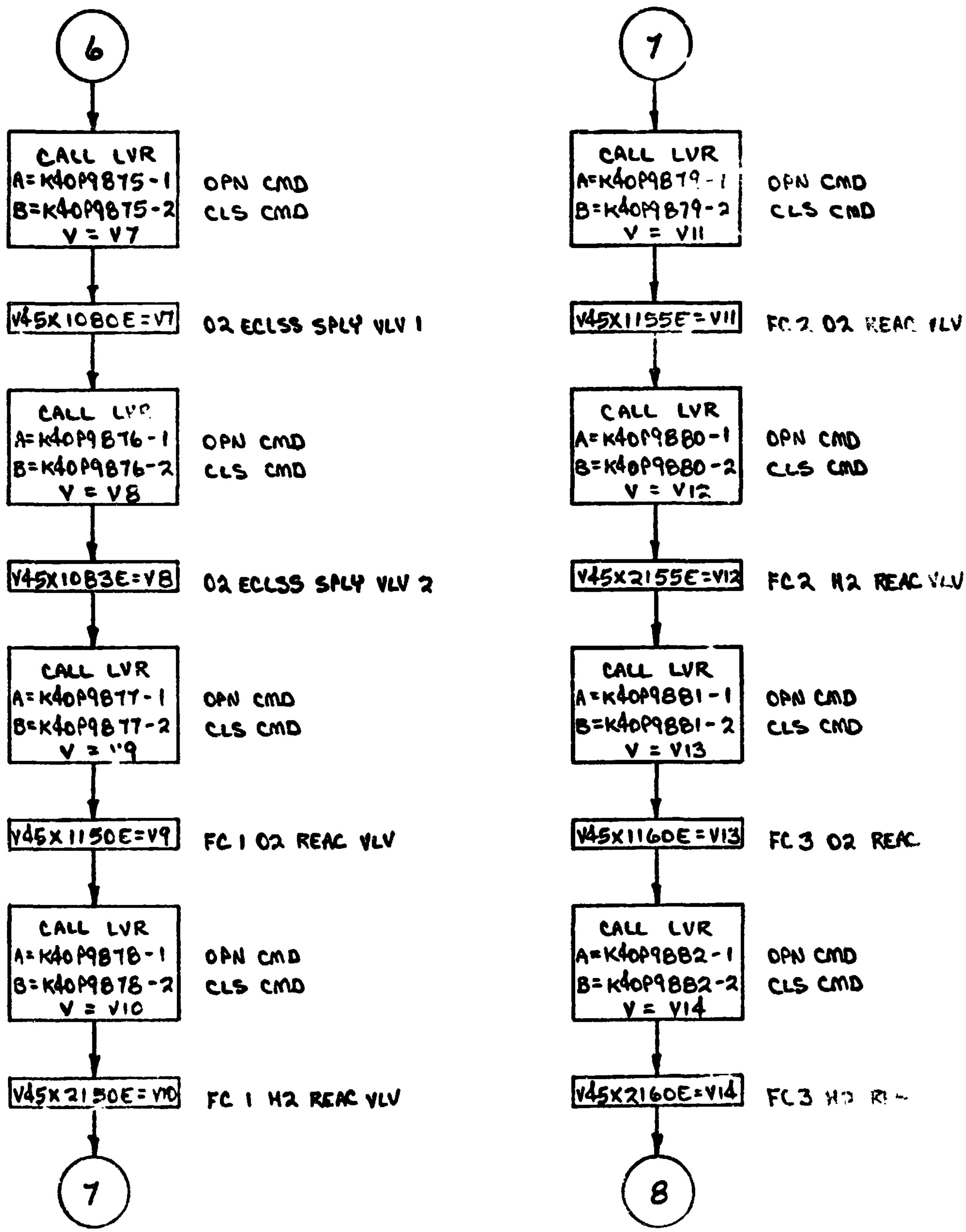
3) V45P2200A PRESS REQUIRES LOSS OF MNB AND MNC PWR TO SC OF3 TO LOSE SIGNAL.

CRYO H2 TANK 3

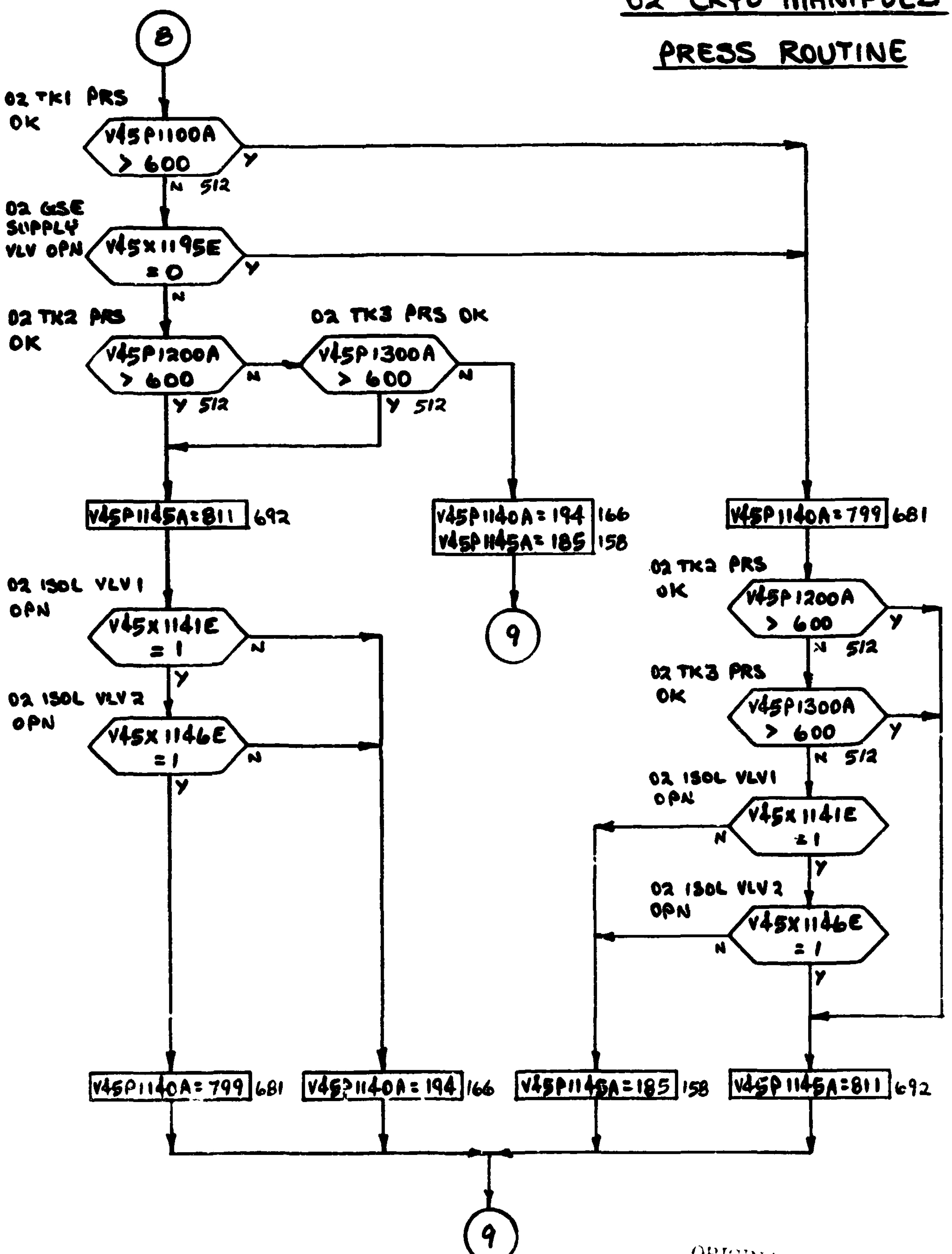
ROUTINE



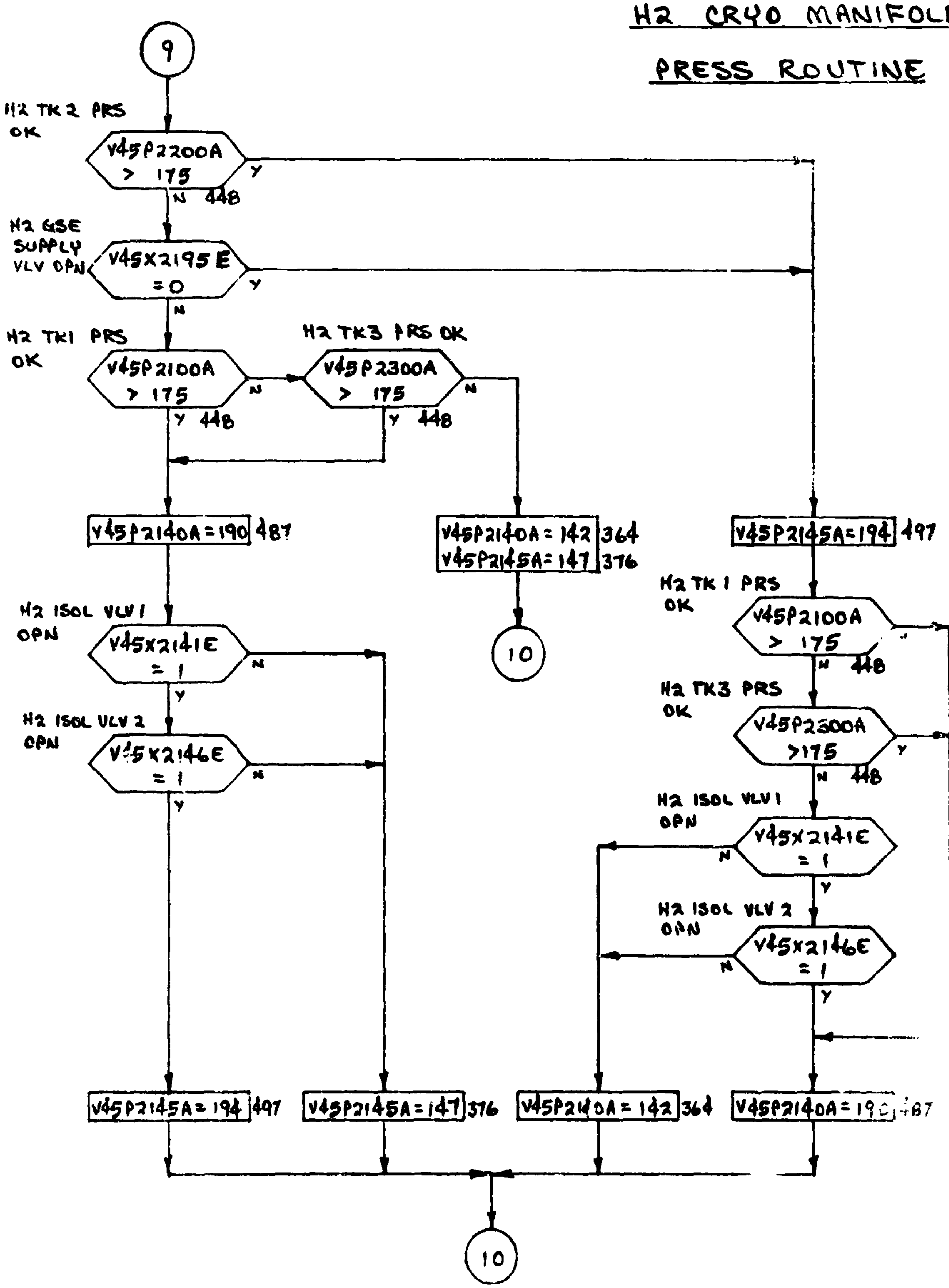

LATCHING VALVE SUBROUTINE
(LVR)
ENTER LVR
A = 0
Y
N
B = 1
Y
N
B = 1
Y
N
V = A
RETURN
4A
CALL LVR
A = K40P9869-1
B = K40P9869-2
V = V1
OPN CMD
CLS CMD
V45X1195E = V1
O2 GSE SPLY VLV
CALL LVR
A = K40P9870-1
B = K40P9870-2
V = V2
OPN CMD
CLS CMD
5
5
V45X2195E = V2
H2 GSE SPLY
CALL LVR
A = K40P9871-1
B = K40P9871-2
V = V3
OPN CMD
CLS CMD
V45X1141E = V3
O2 ISOL VLV 1
CALL LVR
A = K40P9872-1
B = K40P9872-2
V = V4
OPN CMD
CLS CMD
V45X1146E = V4
O2 ISOL VLV 2
CALL LVR
A = K40P9873-1
B = K40P9873-2
V = V5
OPN CMD
CLS CMD
V45X2141E = V5
H2 ISOL VLV 1
CALL LVR
A = K40P9874-1
B = K40P9874-2
V = V6
OPN CMD
CLS CMD
V45X2146E = V6
H2 ISOL VLV 2
6

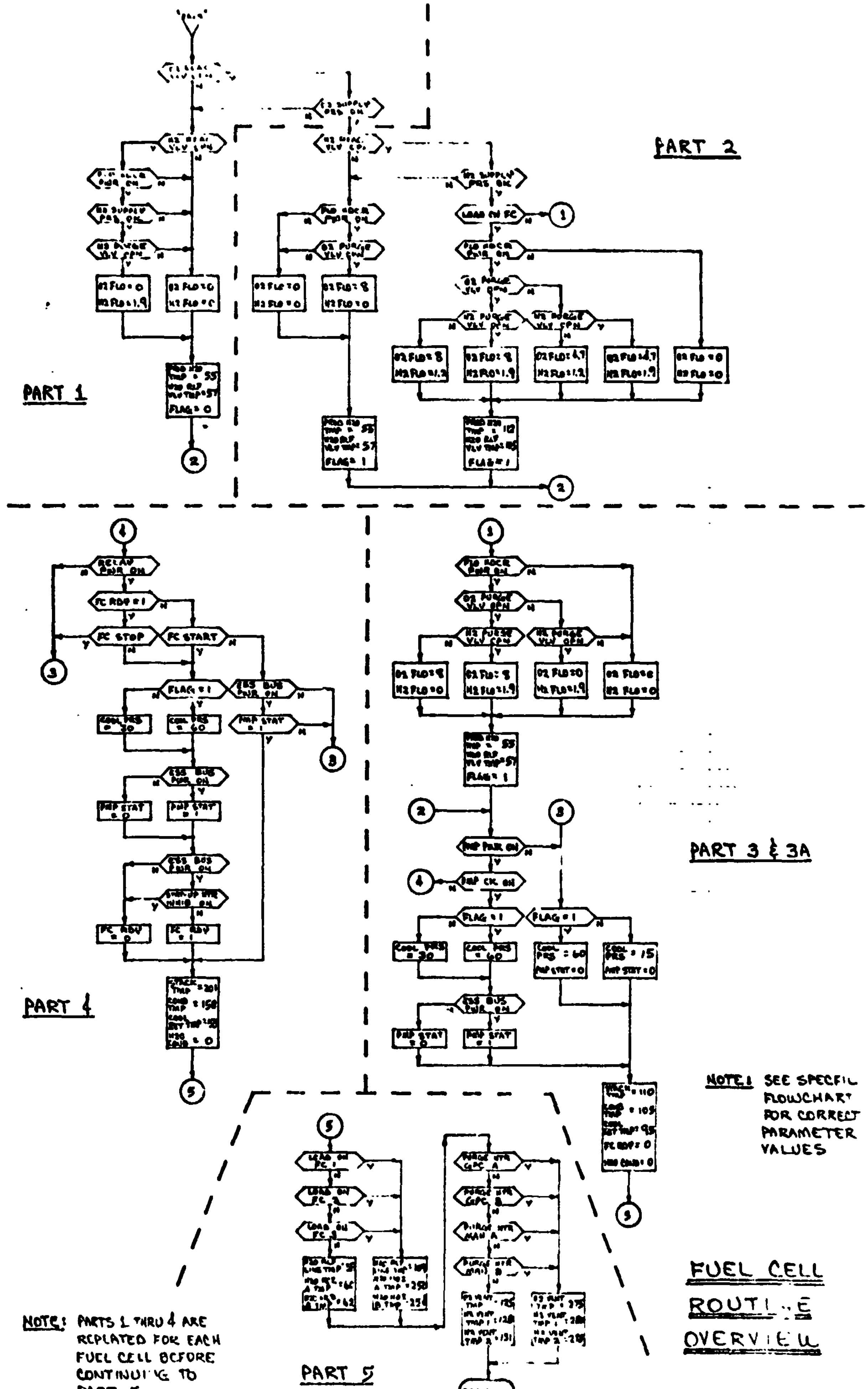

6
CALL LVR
A=K40P9875-1
B=K40P9875-2
V = V7
OPN CMD
CLS CMD
V45X1080E=V7
O2 ECLSS SPLY VLV 1
CALL LVR
A=K40P9876-1
B=K40P9876-2
V = V8
OPN CMD
CLS CMD
V45X1083E=V8
O2 ECLSS SPLY VLV 2
CALL LVR
A=K40P9877-1
B=K40P9877-2
OPN CMD
CLS CMD
V45X1150E=V9
FC 1 O2 REAC VLV
CALL LVR
A=K40P9878-1
B=K40P9878-2
V = V10
OPN CMD
CLS CMD
V45X2150E=V10
FC 1 H2 REAC VLV
7
7
CALL LVR
B=K40P9879-2
V = V11
OPN CMD
CLS CMD
V45X1155E=V11
CALL LVR
A=K40P9880-1
B=K40P9880-2
OPN CMD
CLS CMD
V45X2155E=V12
FC 2 H2 REAC VLV
CALL LVR
A=K40P9881-1
B=K40P9881-2
V = V13
OPN CMD
CLS CMD
V45X1160E=V13
FC 3 O2 REAC
CALL LVR
A=K40P9882-1
B=K40P9882-2
V = V14
OPN CMD
CLS CMD
V45X2160E=V14
FC 3
8

O2 CRYO MANIFOLD PRESS ROUTINE



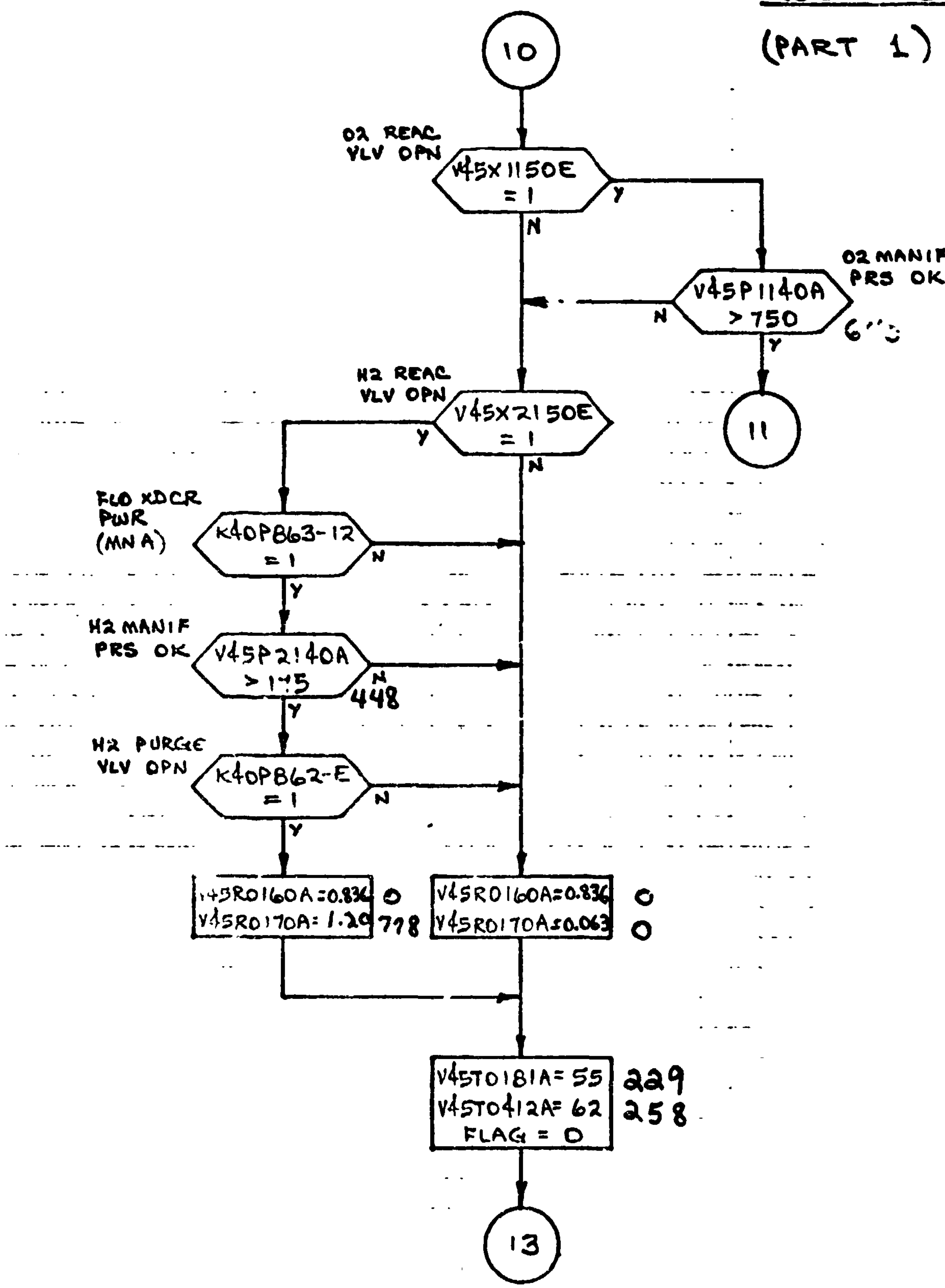
H2 CRYO MANIFOLD PRESS ROUTINE



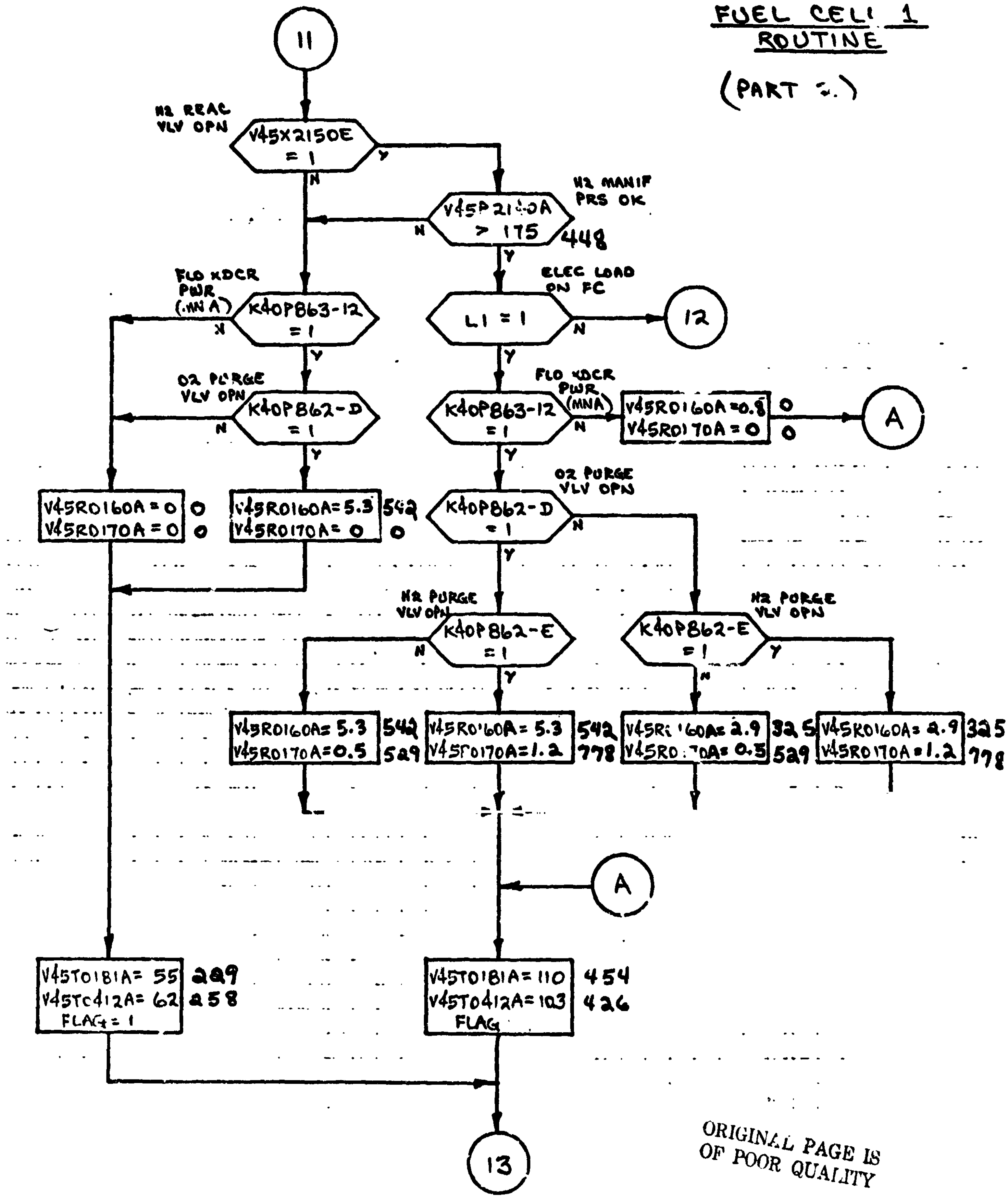

PART 1
PART 2
PART 3 & 3A
PART 4
PART 5
NOTE: SEE SPECIFIC FLOWCHART FOR CORRECT PARAMETER VALUES
NOTE: PARTS 1 THRU 4 ARE REPEATED FOR EACH FUEL CELL BEFORE CONTINUING TO PART 5.
FUEL CELL ROUTINE OVERVIEW

FUEL CELL 1 ROUTINE

(PART 1)



FUEL CELL 1
ROUTINE
(PART 2)



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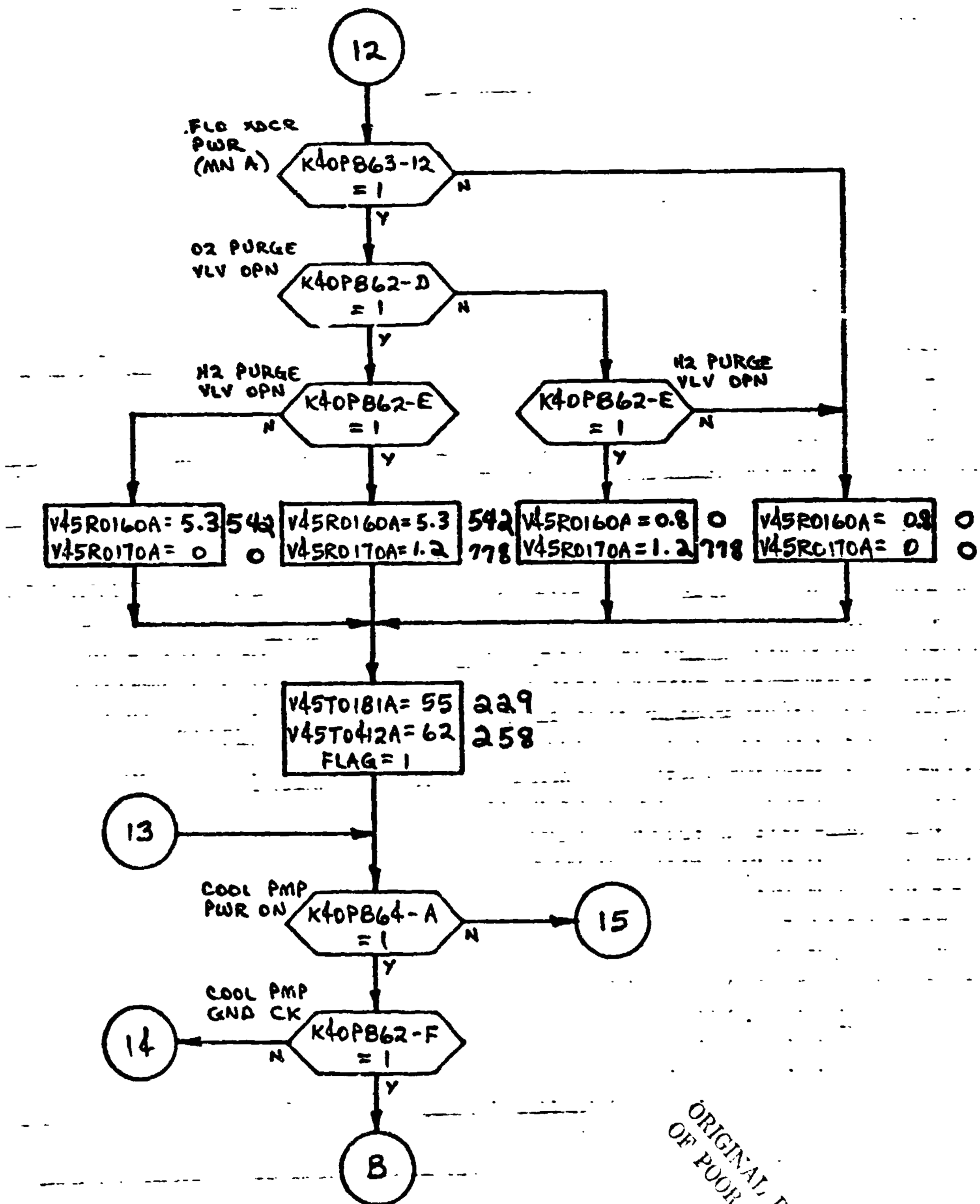
OF POOR QUALITY

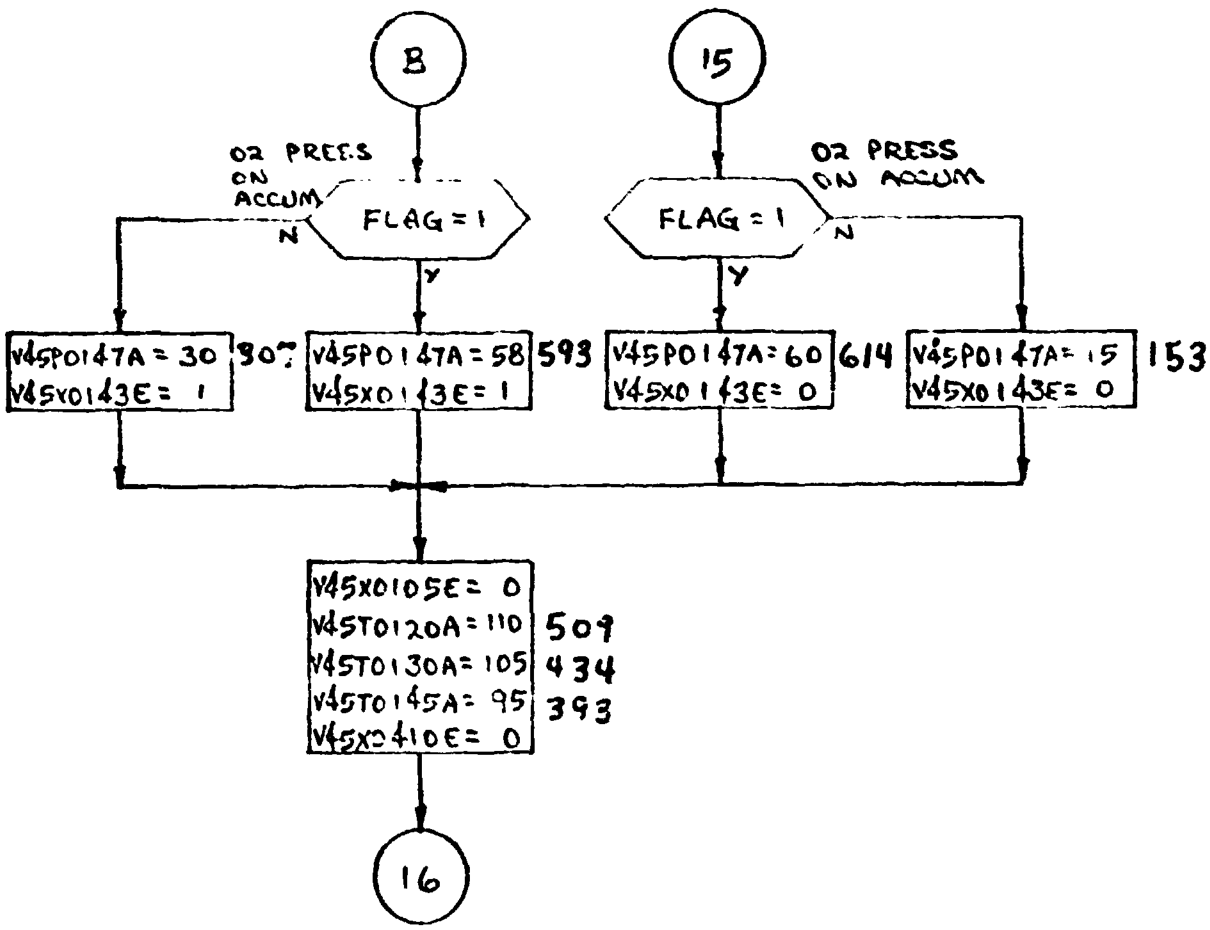
FUEL CELL 1
ROUTINE
(PART 3)



C-4

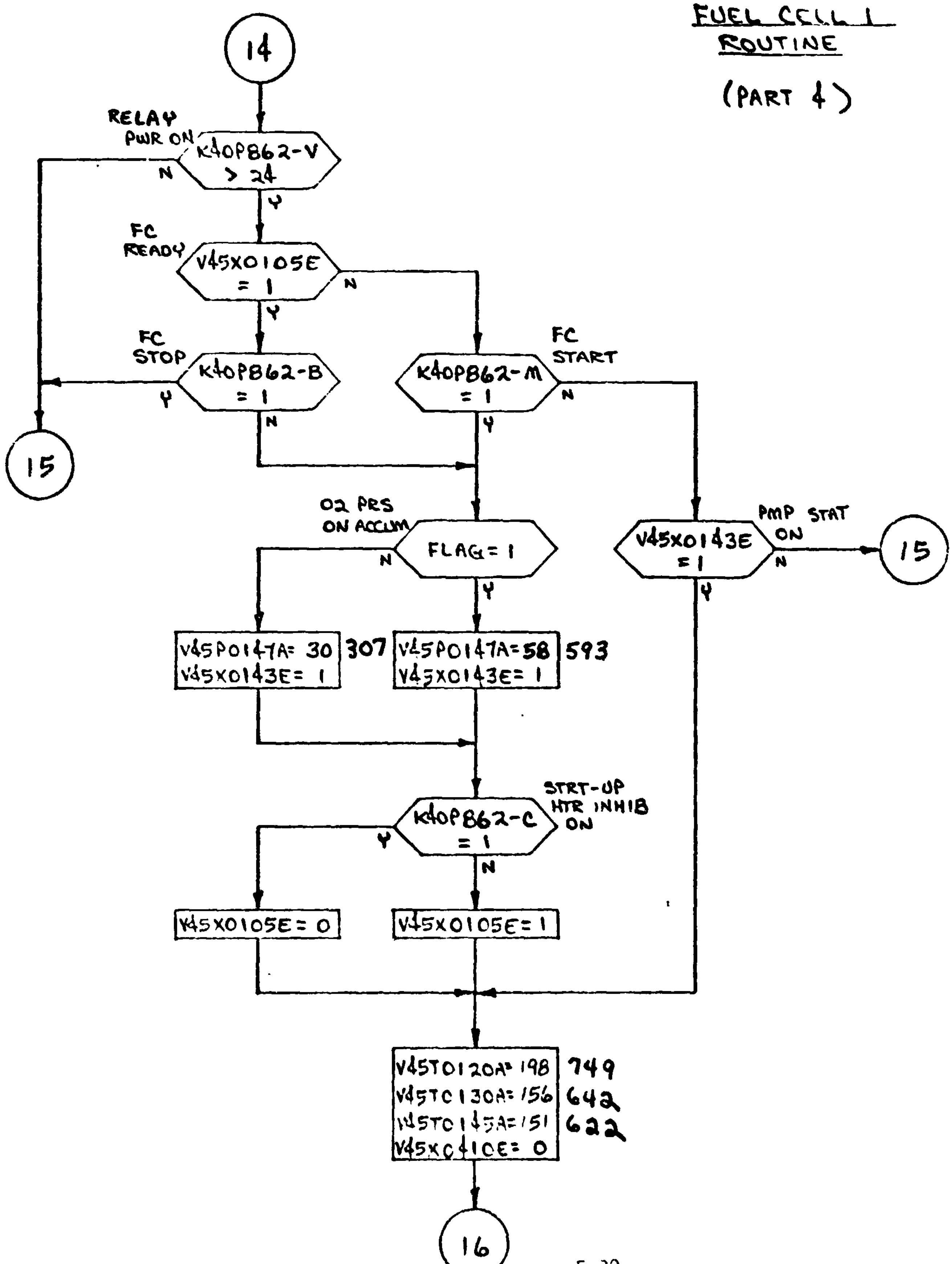
FUEL CELL 1
ROUTINE

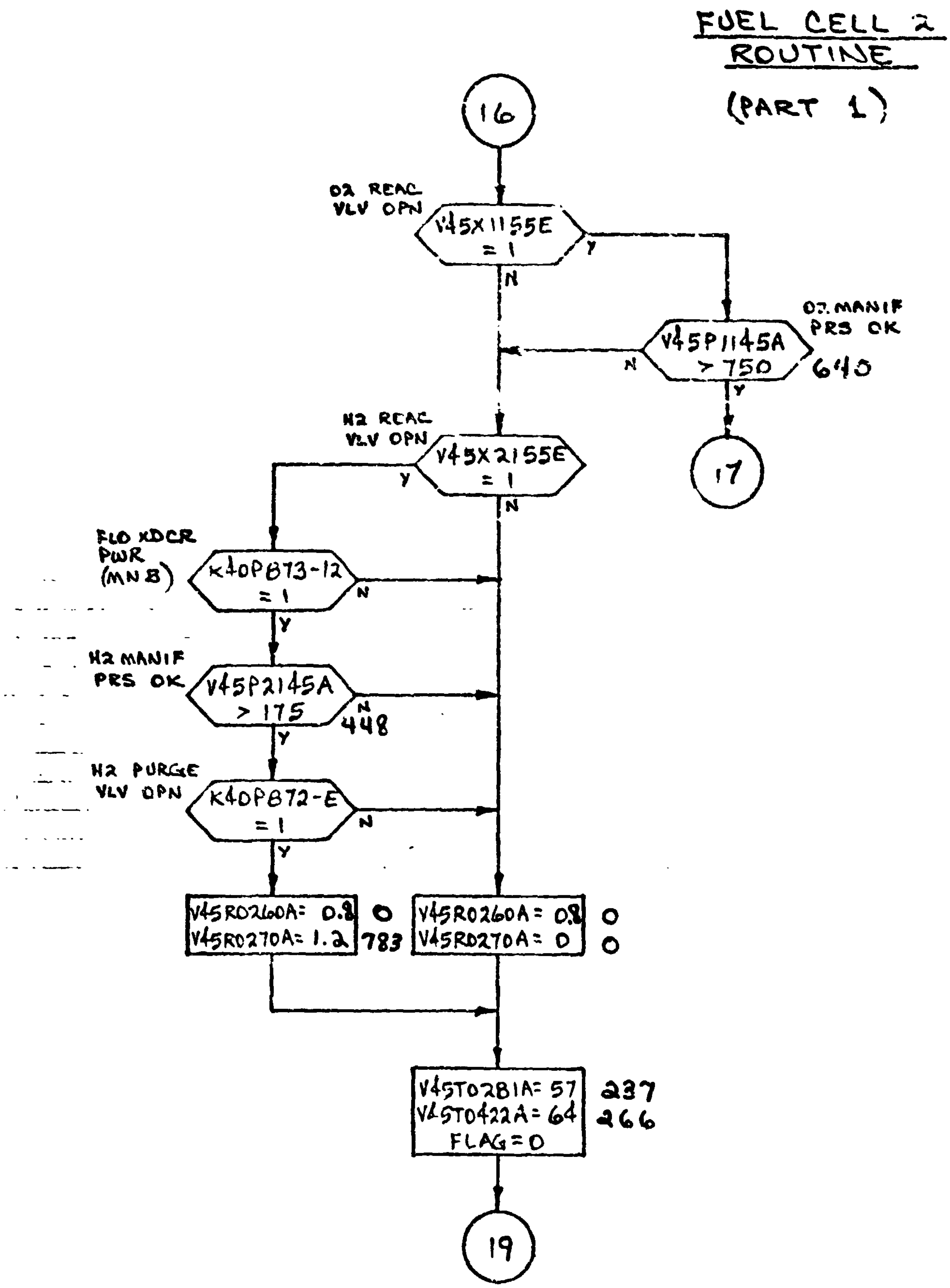
(PART 3A)



FUEL CELL 1
ROUTINE

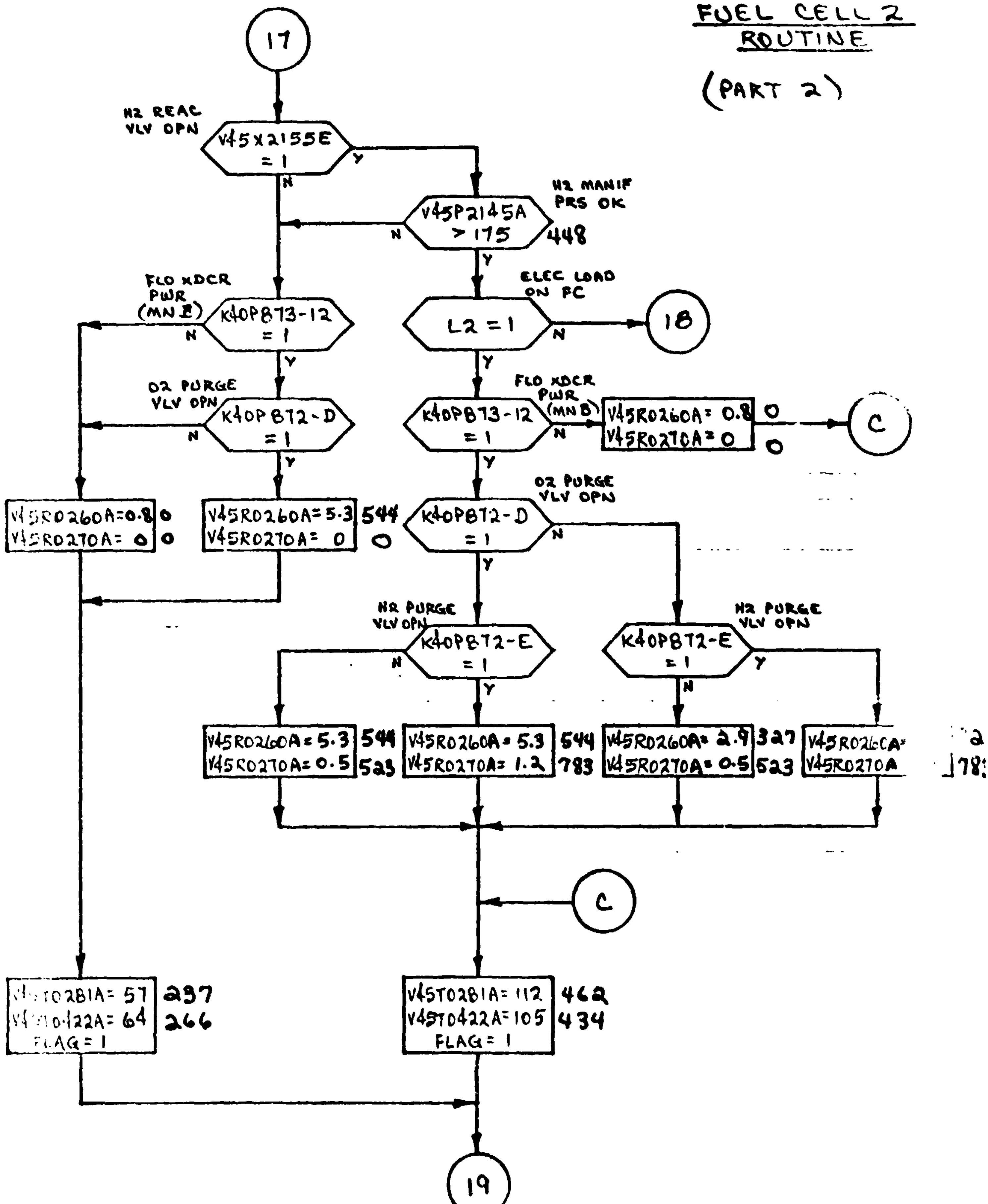
(PART 4)




FUEL CELL 2 ROUTINE
(PART 1)
16
O2 REAC VLV OPN
V45X1155E = 1
Y
N
O2 MANIF PRS OK
V45P1145A > 750
640
N
Y
17
H2 REAC VLV OPN
V45X2155E = 1
Y
N
FLO XDCR PWR (MN B)
K40P873-12 = 1
N
Y
H2 MANIF PRS OK
V45P2145A > 175
N
448
Y
H2 PURGE VLV OPN
K40P872-E = 1
N
Y
V45R0260A= 0.8
0
V45R0270A= 1.2
783
V45R0260A= 0.8
0
V45R0270A= 0
0
V45T0281A= 57
237
V45T0422A= 64
266
FLAG=0
19

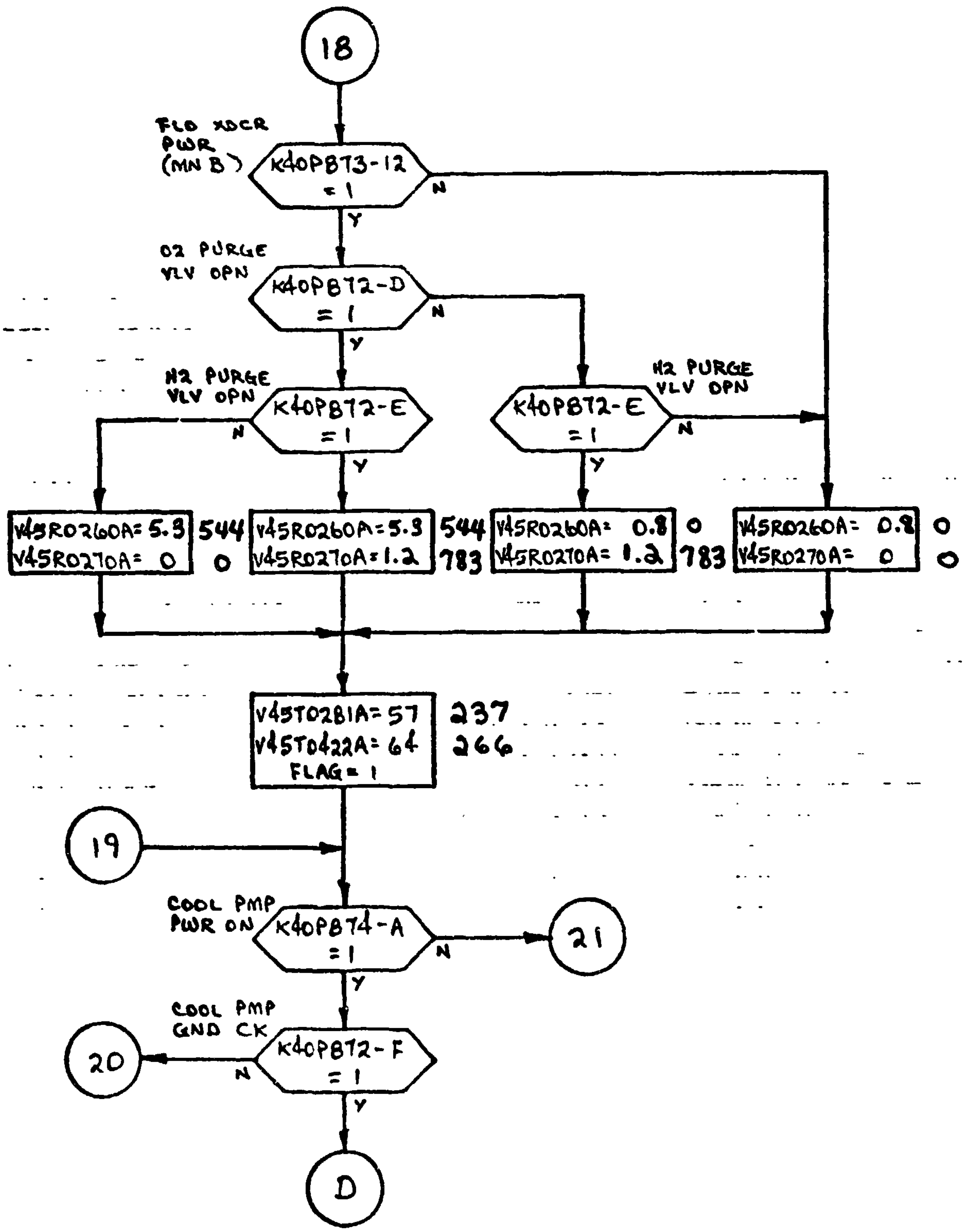
FUEL CELL 2 ROUTINE

(PART 2)



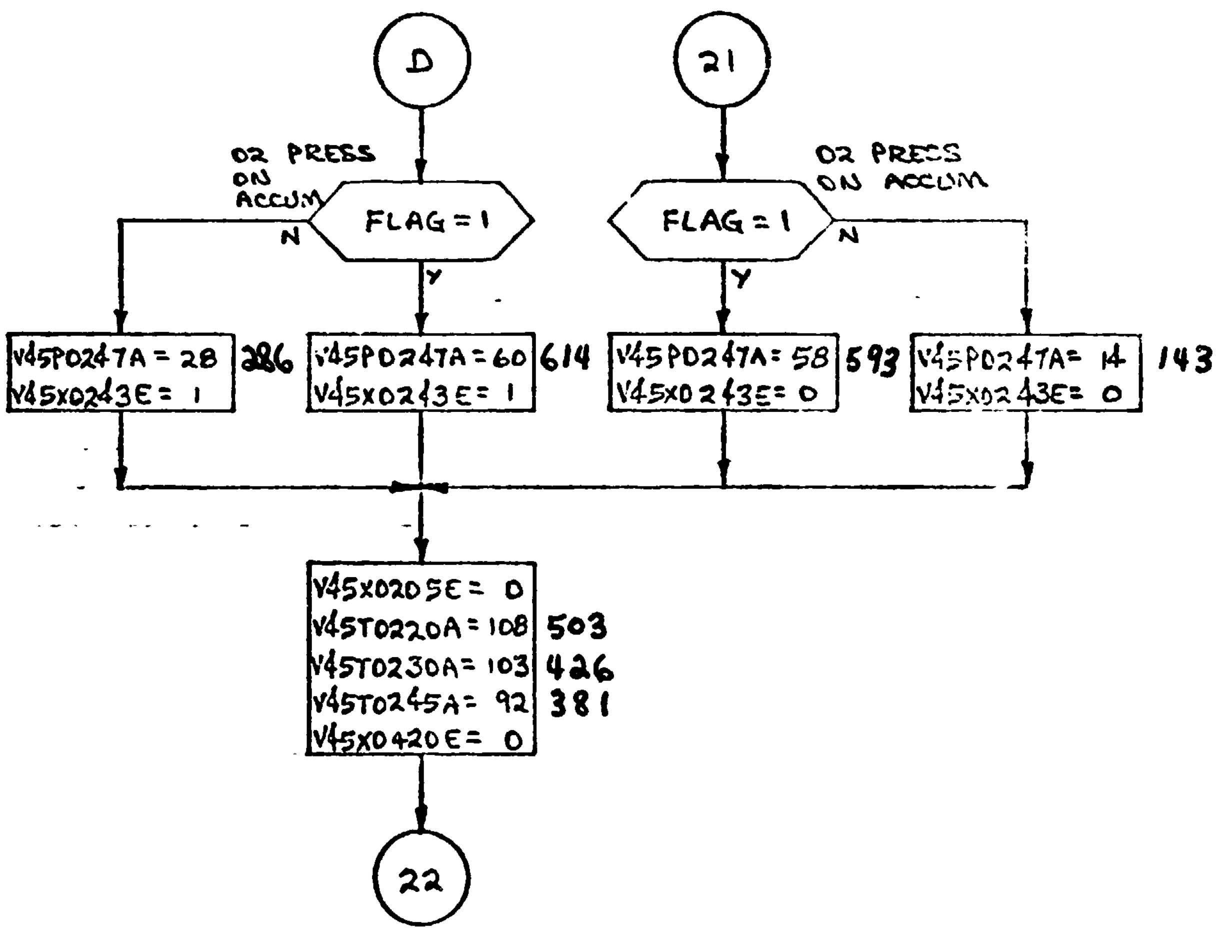
FUEL CELL 2 ROUTINE

(PART 3)



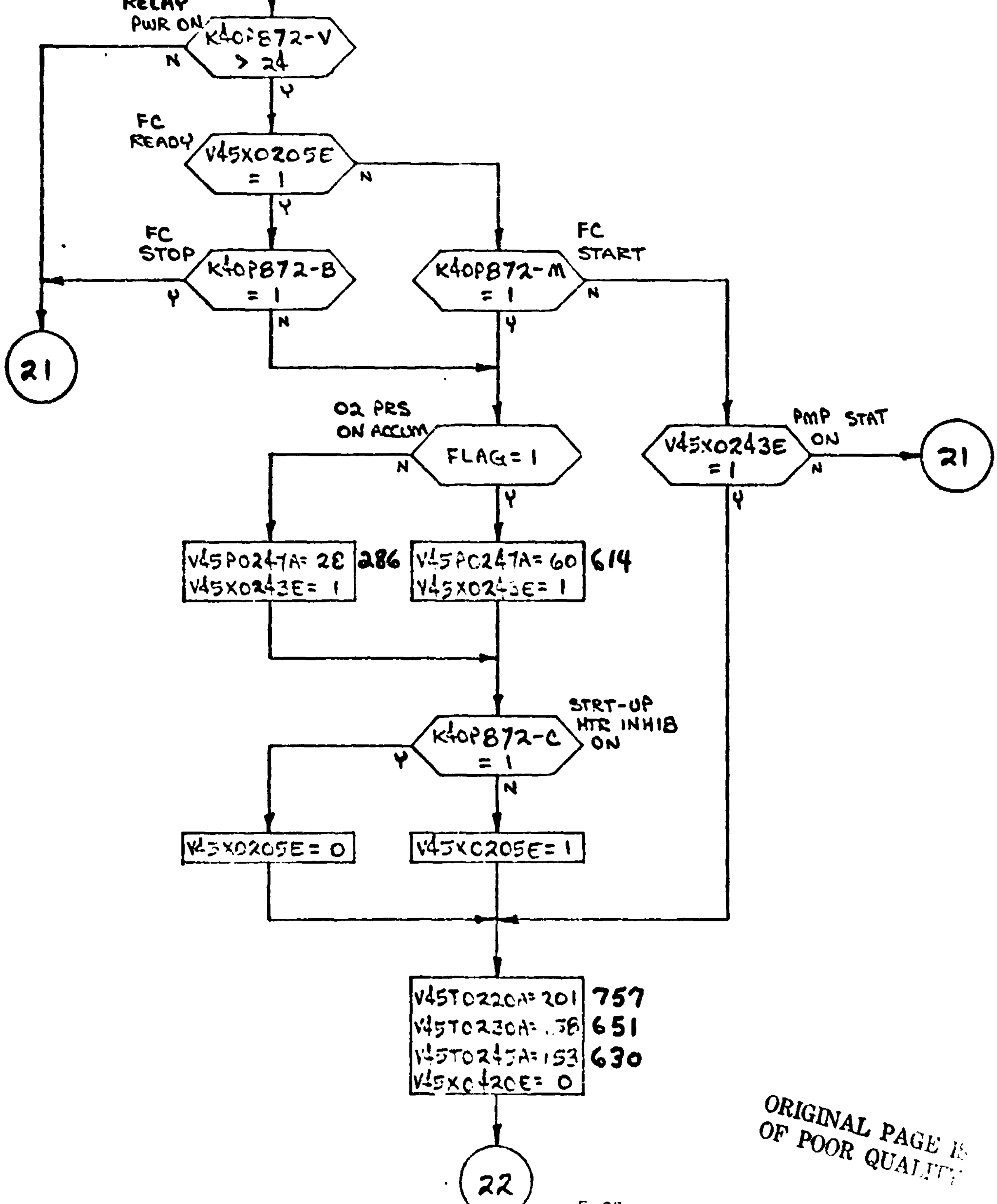
FUEL CELL 2
ROUTINE

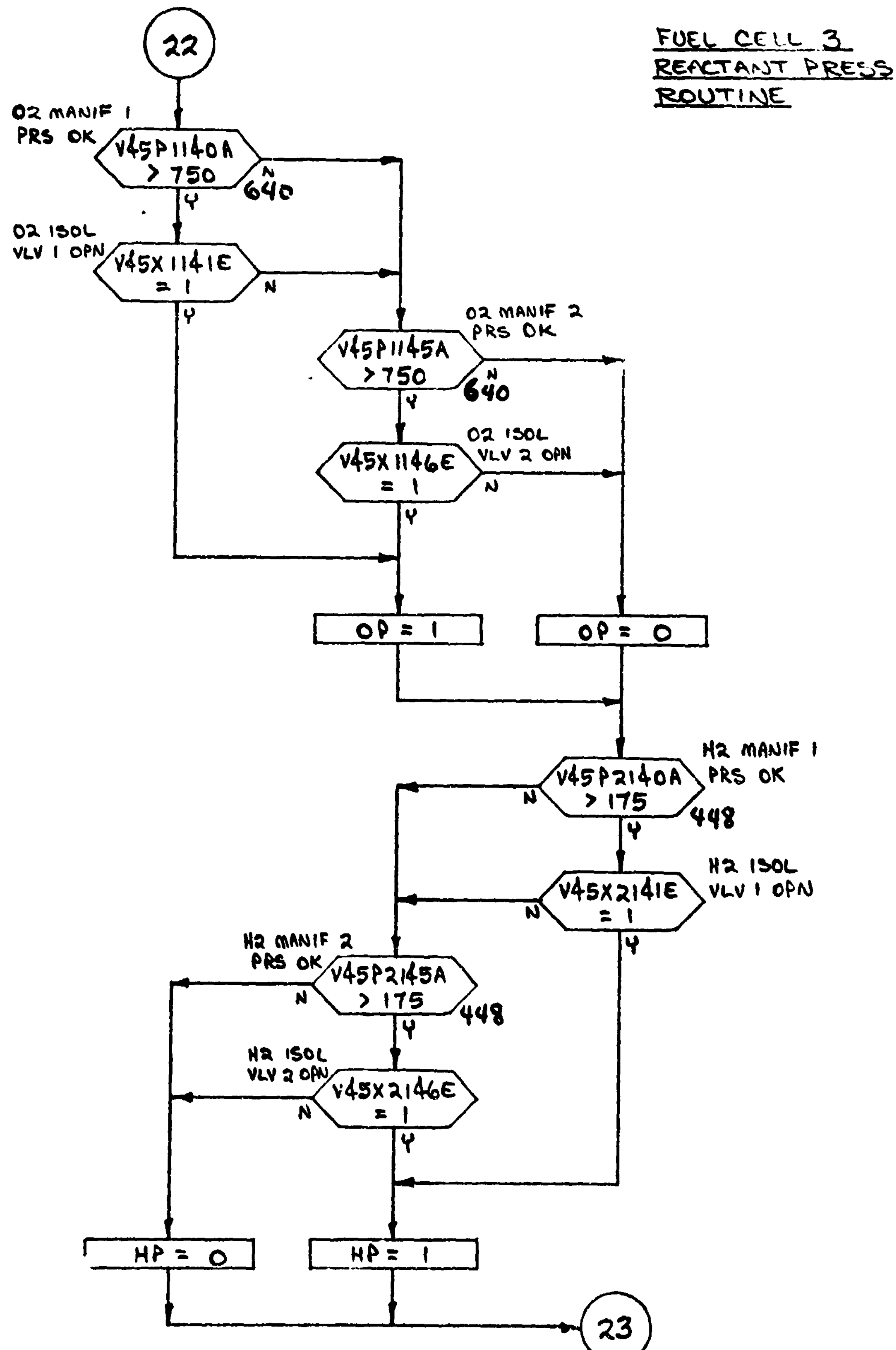
(PART 3A)



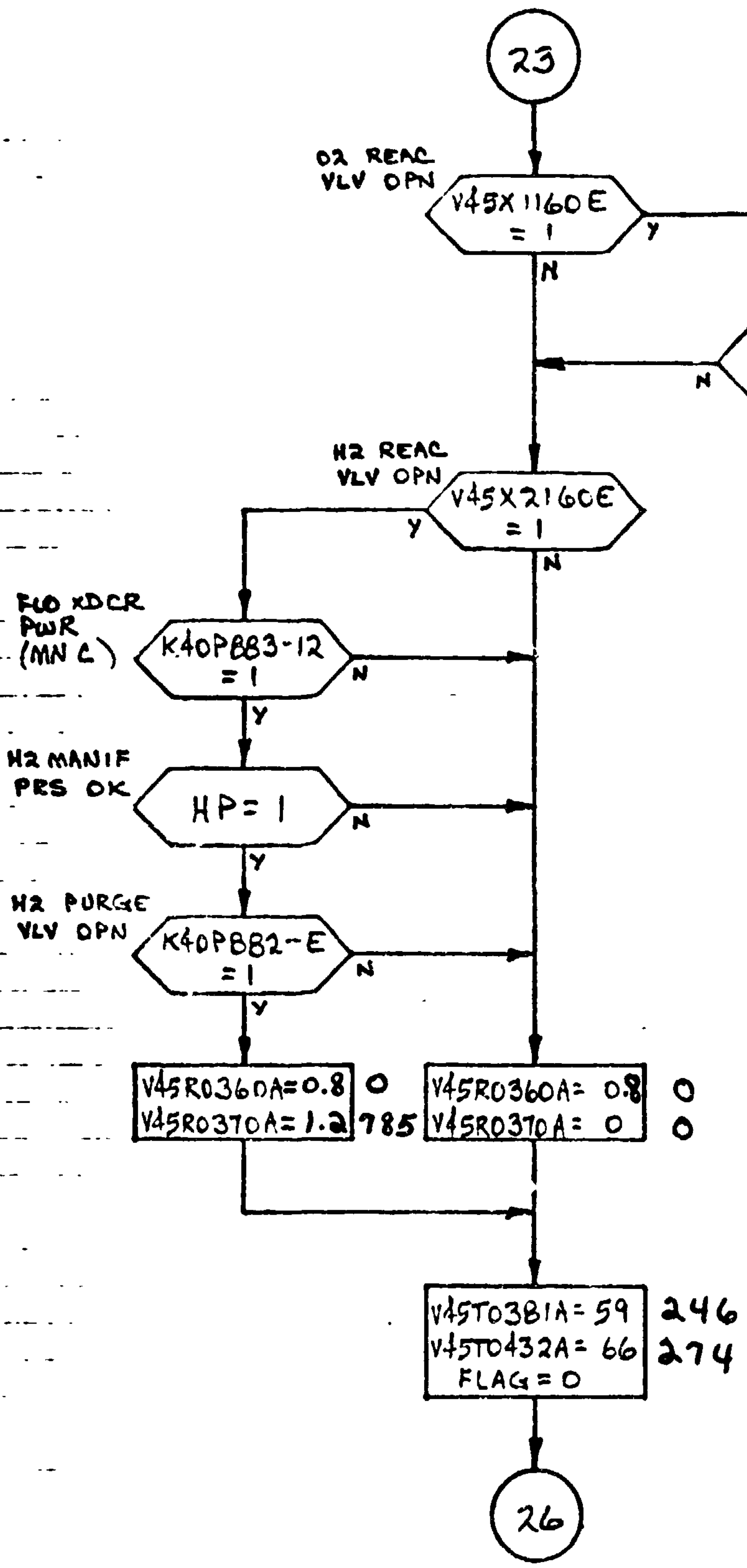
FUEL CELL 2 ROUTINE

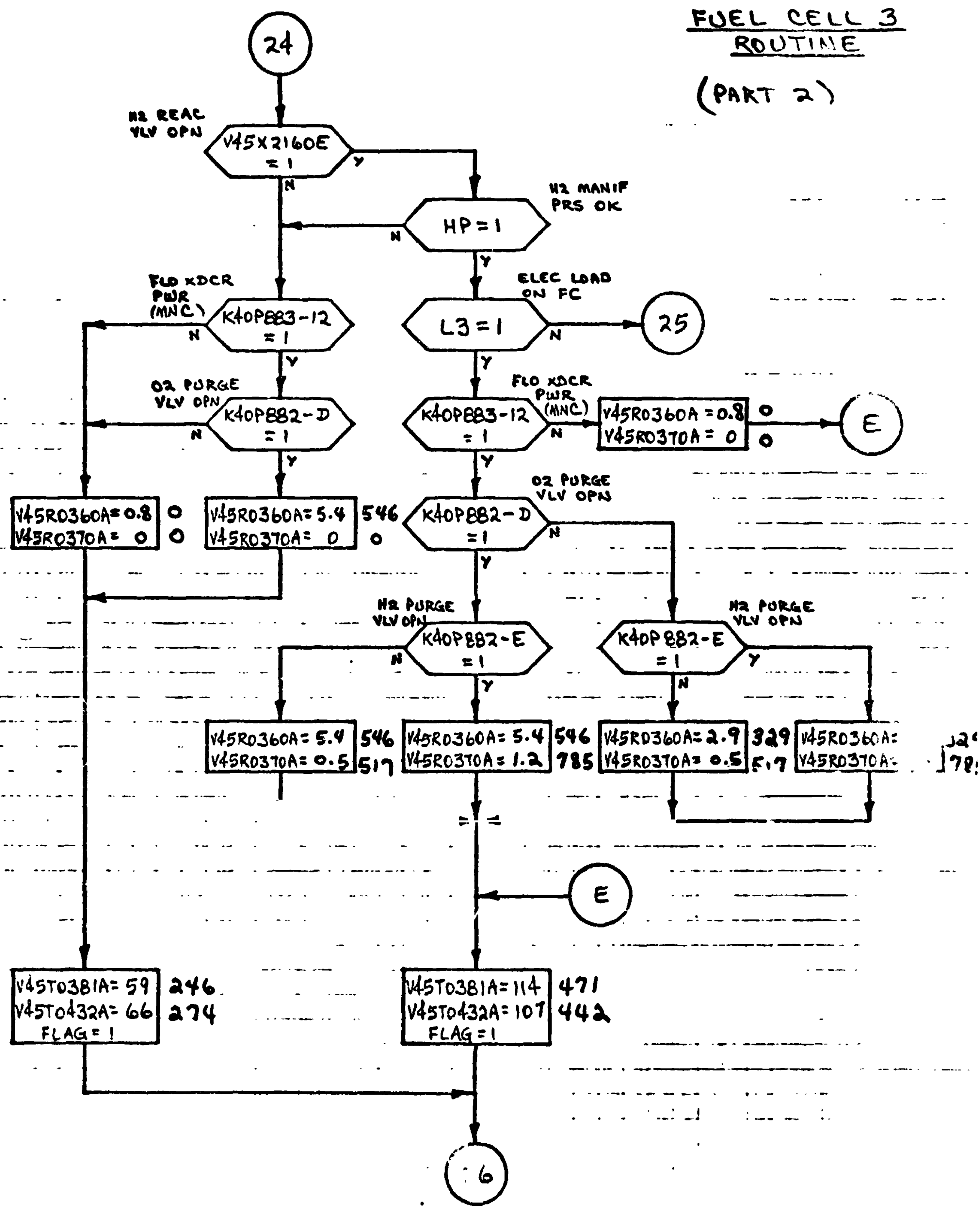
(PART 4)




FUEL CELL 3
REACTANT PRESS
ROUTINE
22
O2 MANIF 1
PRS OK
V45P1140A
> 750
N
640
Y
O2 ISOL
VLV 1 OPN
V45X1141E
= 1
N
Y
O2 MANIF 2
PRS OK
V45P1145A
>750
N
640
Y
O2 ISOL
VLV 2 OPN
V45X1146E
= 1
N
Y
OP = 1
OP = 0
H2 MANIF 1
PRS OK
V45P2140A
> 175
N
448
Y
H2 ISOL
VLV 1 OPN
V45X2141E
= 1
N
Y
H2 MANIF 2
PRS OK
V45P2145A
> 175
N
448
Y
H2 ISOL
VLV 2 OPN
V45X2146E
= 1
N
Y
HP = 0
HP = 1
23

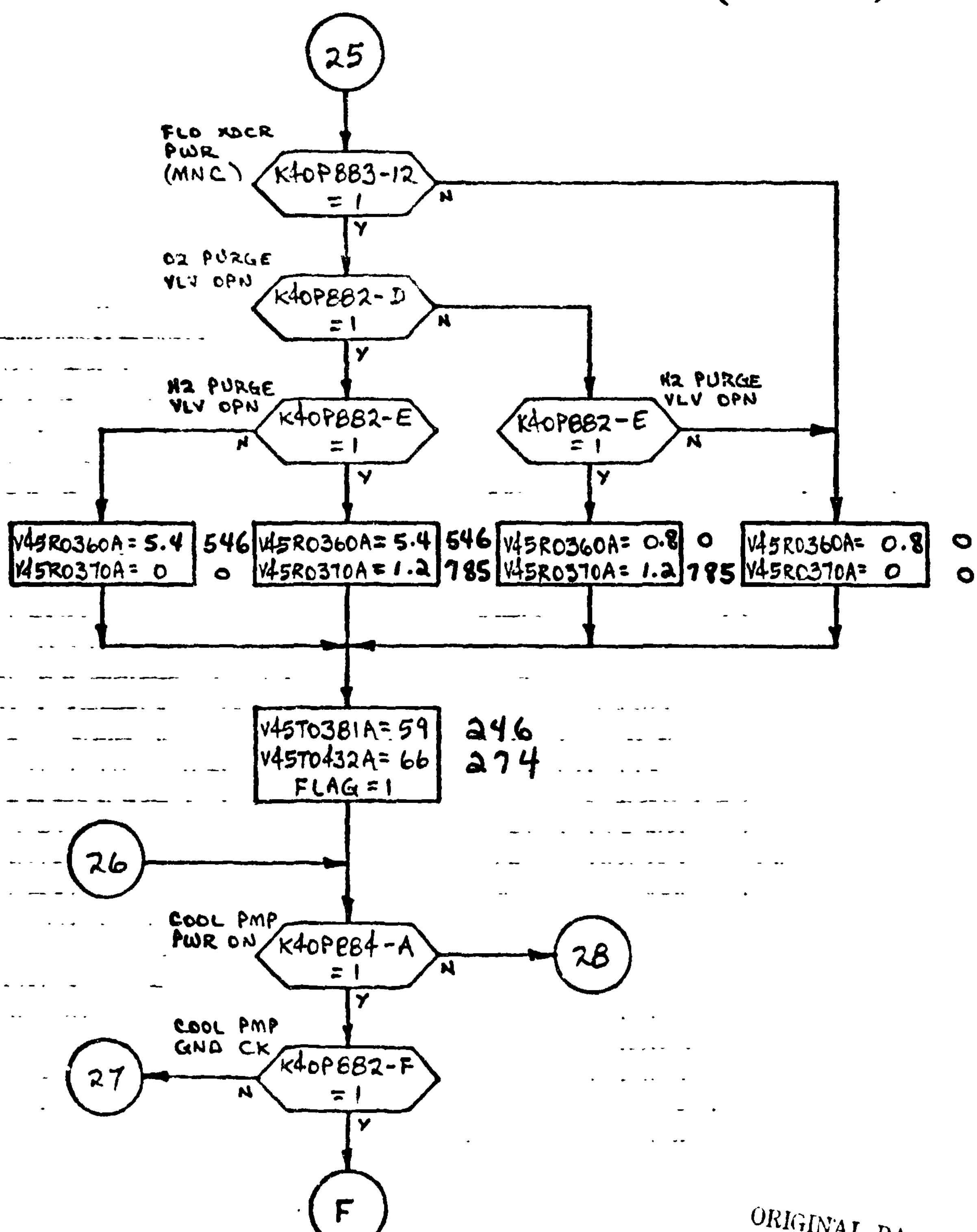
FUEL CELL 3
ROUTINE
(PART 1)





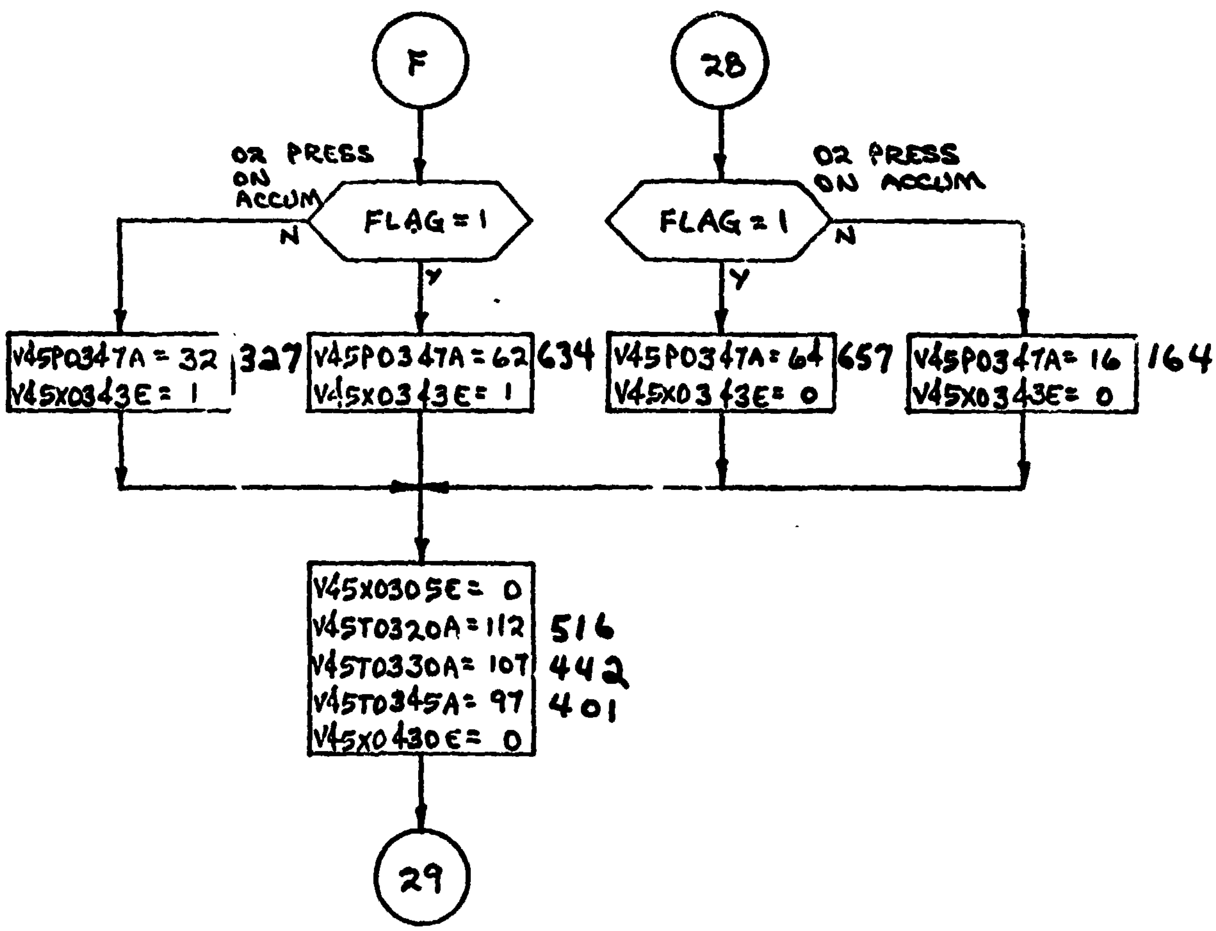
FUEL CELL 3 ROUTINE
(PART 2)
24
H2 REAC VLV OPN
V45X2160E = 1
H2 MANIF PRS OK
HP = 1
FLO XDCR PWR (MNC)
K40P883-12 = 1
ELEC LOAD ON FC
L3 = 1
25
O2 PURGE VLV OPN
K40P882-D = 1
FLO XDCR PWR (MNC)
K40P883-12 = 1
V45R0360A = 0.8 0
V45R0370A = 0 0
E
V45R0360A = 0.8 0
V45R0370A = 0 0
V45R0360A = 5.4 546
V45R0370A = 0 0
O2 PURGE VLV OPN
K40P882-D = 1
H2 PURGE VLV OPN
K40P882-E = 1
H2 PURGE VLV OPN
K40P882-E = 1
V45R0360A = 5.4 546
V45R0370A = 0.5 517
V45R0360A = 5.4 546
V45R0370A = 1.2 785
V45R0360A = 2.9 329
V45R0370A = 0.5 517
E
V45T0381A = 59 246
V45T0432A = 66 274
FLAG = 1
V45T0381A = 114 471
V45T0432A = 107 442
FLAG = 1

FUEL CELL 3
ROUTINE
(PART 3)



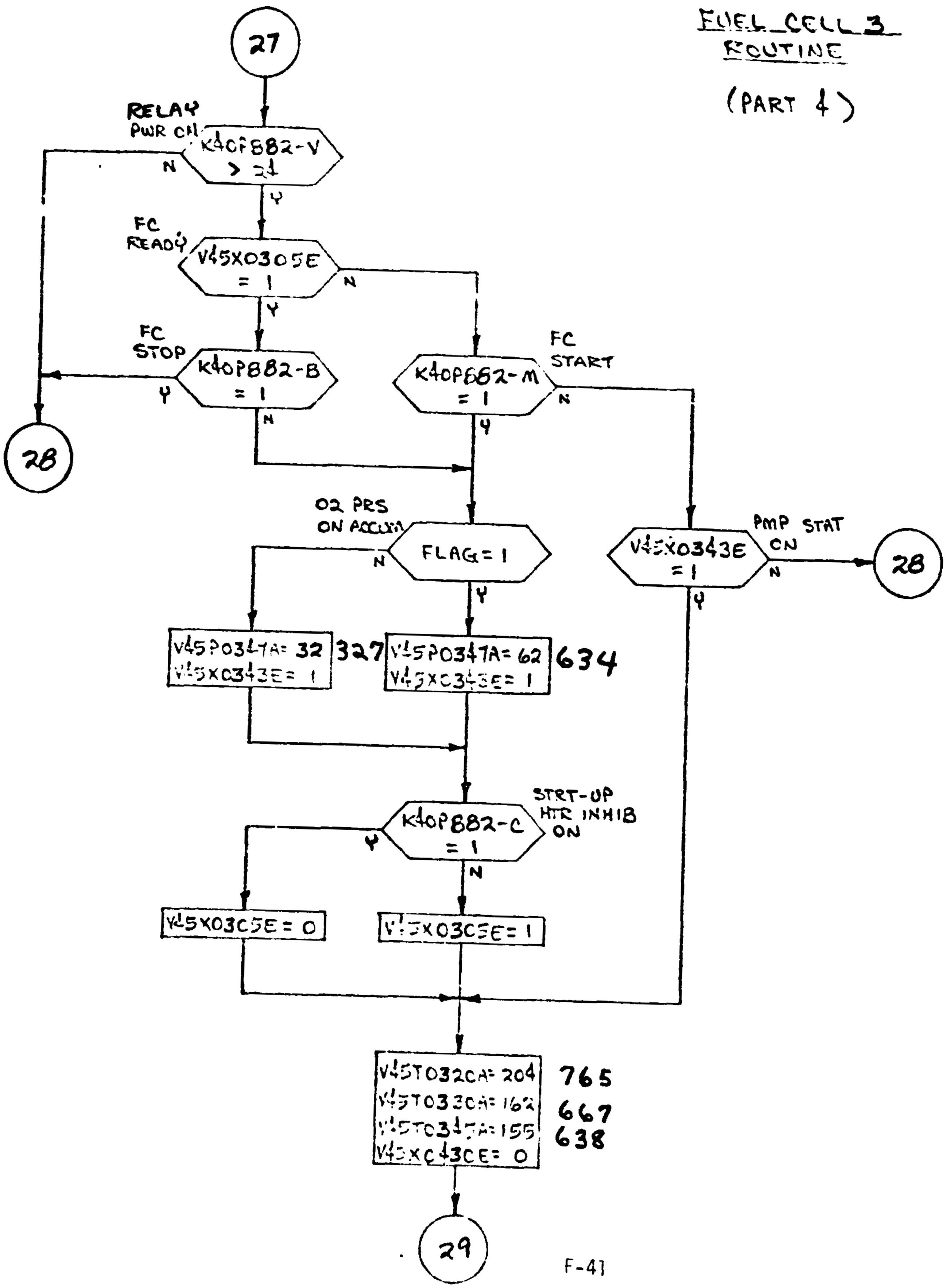
FUEL CELL 3
ROUTINE

(PART 3A)



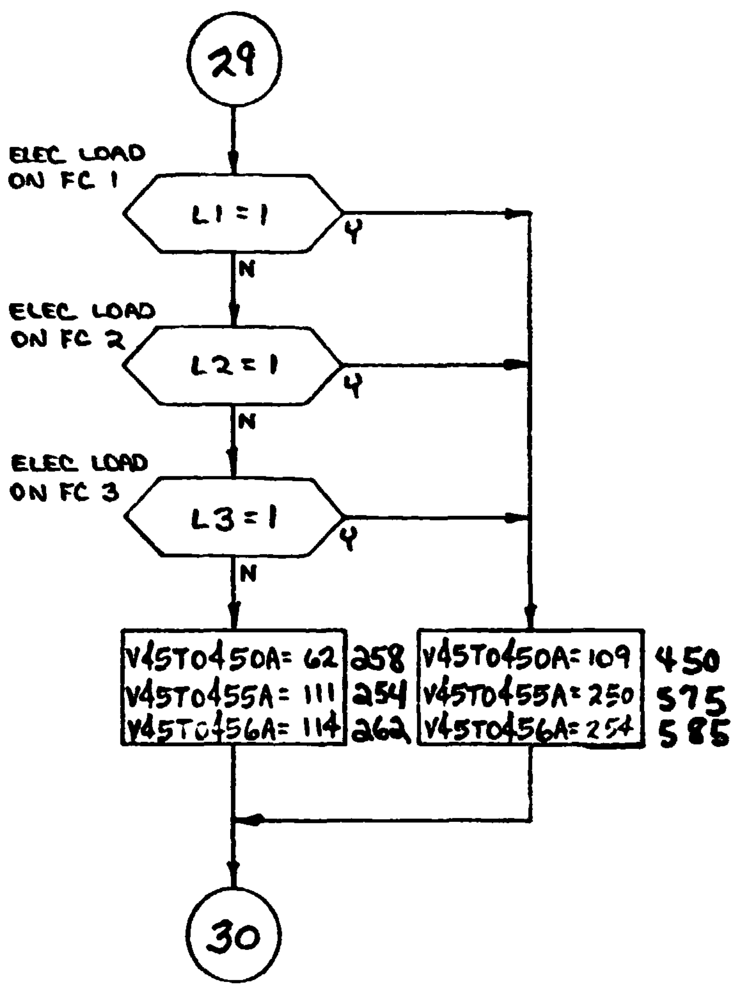
FUEL CELL 3
ROUTINE

(PART 4)

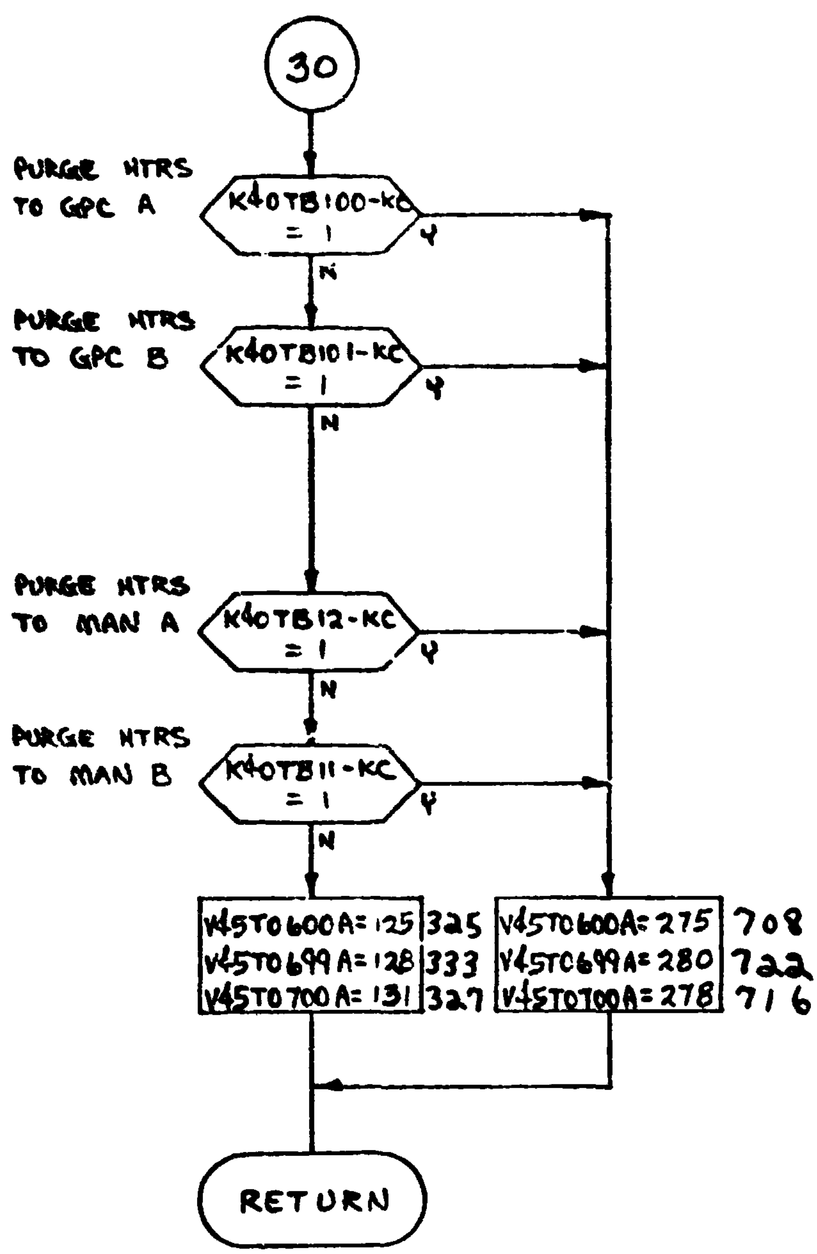


FUEL CELL
ROUTINE

(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	32	327	64	657	PSIA
V45R0360A	FC 3 02 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 H20 LINE TEMP	59	246	114	471					DEGF
V45X0410E	FC 1 H20 CONDITION	0	0	1	1					STATE
V45T0412A	FC 1 H20 RELIEF VLV TEMP	62	258	103	426					DEGF
V45X0420E	FC 2 CONDITION	0	0	1	1					STATE
V45T0422A	FC 2 H20 RELIEF VLV TEMP	64	266	105	434					DEGF
V45X0430E	FC 3 H20 CONDITION	0	0	1	1					STATE
V45T0432A	FC 3 H20 RELIEF VLV TEMP	66	274	107	442					DEGF
V45T0450A	H20 RELIEF LINE TEMP	62	258	109	450					DEGF
V45T0455A	H20 RELIEF NOZZLE TEMP A	111	254	250	575					DEGF
V45T0456A	H20 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
V45T1[illegible]A	PRSD 02 TANK 1 FLUID TEMP	-35	442	-162	295					DEGF

TABLE 1 - STIMULI INPUTS TO FUEL CELL/CRYO MODEL

IDENTIFICATION NUMBER	NOMENCLATURE	SOURCE	STATES/RANGE LO	STATES/RANGE HI	STATES/RANGE UNITS
K40P862-B	FC 1 STOP A/STOP B	FS	0	1	STATE
K40P862-C	FC 1 START-UP HTR INHIBIT		0	1	
K40P862-D	FC 1 02 PURGE VLV OPEN		0	1	
K40P862-E	FC 1 H2 PURGE VLV OPEN		0	1	
K40P862-F	FC 1 K7 PUMP CHECK		0	1	
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	
K40P872-D	FC 2 02 PURGE VLV OPEN		0	1	
K40P872-E	FC 2 H2 PURGE VLV OPEN		0	1	
K40P872-F	FC 2 K7 PUMP CHECK		0	1	
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	
K40P882-D	FC 3 02 PURGE VLV OPEN		0	1	
K40P882-E	FC 3 H2 PURGE VLV OPEN		0	1	
K40P882-F	FC 3 K7 PUMP CHECK		0	1	
K40P882-M	FC 3 START		0	1	STATE
K40P882-V	FC 3 RELAY POWER	FS	0	1	STATE

TABLE 1 - Continued.

IDENTIFICATION NUMBER	NOMENCLATURE	SOURCE	STATES/RANGE		
			LO	HI	UNITS
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	02 TANK 2 HTR A1 POWER		0	1	STATE
K40P9831-C	02 TANK 2 HTR A2 POWER		0	1	STATE
K40P 9832-A	02 TANK 2 HTR B1 POWER		0	1	STATE
K40P9832-C	02 TANK 2 HTR B2 POWER		0	1	STATE
K40P9833-A	02 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	02 TANK 1 HTR A1 POWER		0	1	STATE
K40P9851-C	02 TANK 1 HTR A2 POWER		0	1	STATE
K40P9852-A	02 TANK 1 HTR B1 POWER		0	1	STATE
K40P9852-C	02 TANK 1 HTR B2 POWER		0	1	STATE
K40P9853-A	02 TANK 1 QTY CHECK SIGNAL		0	1	STATE
K40P9869-1	02 GSE SUPPLY VLV OPEN		0	1	
K40P9869-2	02 GSE SUPPLY VLV CLOSE		0	1	
K40P9870-1	H2 GSE SUPPLY VLV OPEN		0	1	
K40P9870-2	H2 GSE SUPPLY VLV CLOSE	FS	0	1	STATE

TABLE 1 - Co 'inued.

IDENTIFICATION NUMBER	NOMENCLATURE	SOURCE	STATES/RANGE		
			LO	HI	UNITS
K40P9871-1	02 MANIFOLD 1 VLV OPEN	FS	0	1	STATE
K40P9871-2	02 MANIFOLD 1 VLV CLCSE		0	1	
K40P9872-1	02 MANIFOLD 2 VLV OPEN		0	1	
K40P9872-2	02 MANIFOLD 2 VLV CLOSE		0	1	
K40P9873-1	H2 MANIFOLC 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 - C[illegible]ued.

IDENTIFICATION NUMBER	NOMENCLATURE	SOURCE	STATES/RANGE		
			LO	HI	UNITS
K40P9882-1	H2 SUPPLY VLV OPEN - FC 3	FS via STM	0	1	STATE
K40P9882-2	H2 SUPPLY VLV CLOSE - FC 3		0	1	STATE
K40TB11-KC	H2/02 PURGE HTRS - MAN B		0	1	STATE
K40TB12-KC	H2/02 PURGE HTRS - MAN A		0	1	STATE
K40TB100-KC	H2/02 PURGE HTRS - GPC A		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	02 TANK 1 QTY XDCR PWR (ESS BUS 2CA)	FS via STM	0	1	STATE
K40P9833-W	02 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	O2 TANK 3 HTR A1 PWR	FS	0	1	STATE
KJ5-C	O2 TANK 3 HTR A2 PWR		0	1	
KJ6-A	O2 TANK 3 HTR B1 PWR		0	1	
KJ6-C	O2 TANK 3 HTR B2 PWR		0	1	
K40P9520-A	O2 TANK 3 QTY CHECK SIGNAL		0	1	
K40P9520-W	O2 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	2.88	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 02 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 H20 LINE TEMP	59	246	114	471					DEGF
V45X0410E	FC 1 H20 CONDITION	0	0	1	1					STATE
V45T0412A	FC 1 H20 RELIEF VLV TEMP	62	258	103	426					DEGF
V45X0420E	FC 2 CONDITION	0	0	1	1					STATE
V45T0422A	FC 2 H20 RELIEF VLV TEMP	64	266	105	434					DEGF
V45X0430E	FC 3 H20 CONDITION	0	0	1	1					STATE
V45T0432A	FC 3 H20 RELIEF VLV TEMP	66	274	107	442					DEGF
V45T0450A	H20 RELIEF LINE TEMP	62	258	109	450					DEGF
V45T0455A	H20 RELIEF NOZZLE TEMP A	111	254	250	575					DEGF
V45T0456A	H20 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) K=1		VALUE 2 (HI/LOW) K=2		VALUE 3 (OFF) K=3		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	[illegible]	0	51			PCNT
V45T1307A	PRSD 02 TANK 3 HTR ASSY 1 TEMP	-125	338	-166						DEGF
V45T1309A	PRSD 02 TANK 3 HTR ASSY 2 TEMP	-157	301	-169	286					DEGF

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MEASUREMENT OUTPUT FROM FC/CRYO MODEL - TABLE 2

MEASUREMENT I. D.	MEASUREMENT NAME	I.C.		VALUE 1 (NOMINAL) K=1		VALUE 2 (HI/LOW) K=2		VALUE 3 (OFF) K=3		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	[illegible]					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	143					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

FIGURES

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 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 ARS/H_2O 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/H_2O 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 generator (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.

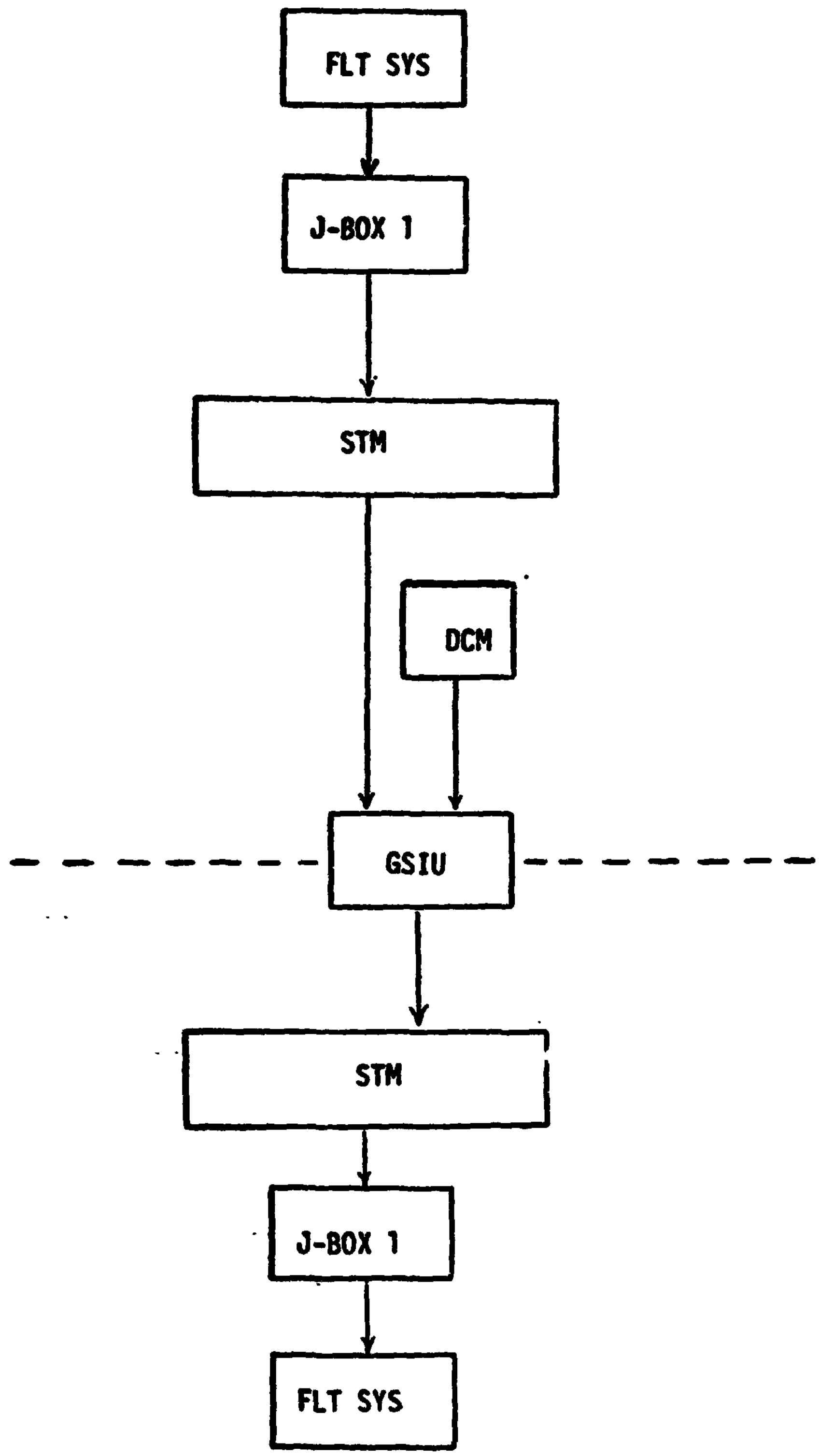


Figure 2-1.– Input/output data flow

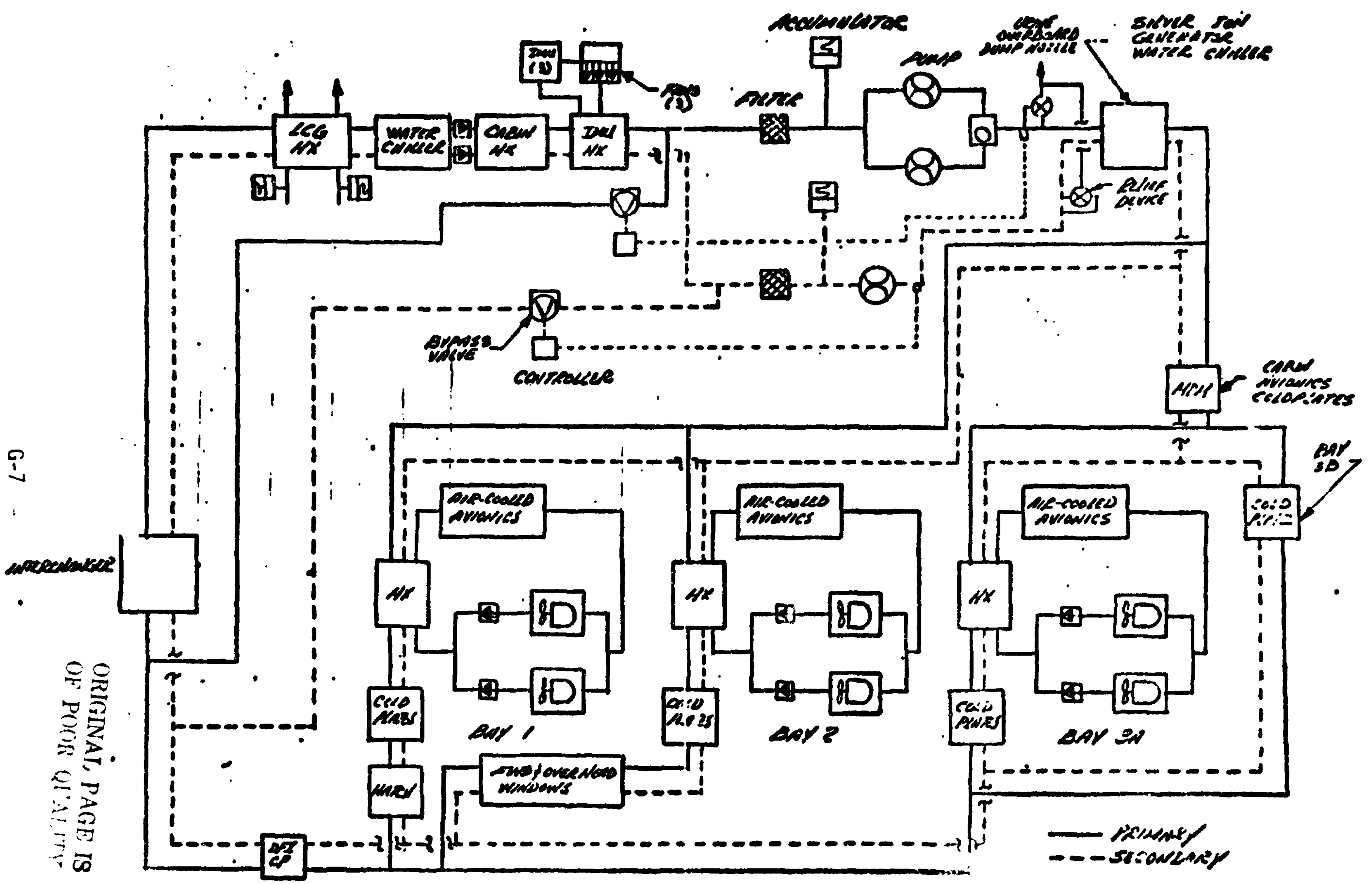


Figure 2-2.— ARS ~ water coolant loops - Orbite 102.

ORIGINAL PAGE IS OF POOR QUALITY

- 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.

- 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 ± 2.5°F by bypassing coolant around the water/freon interchanger. For different phases of the mission, the bypass valve will be controlled as follows:

- 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.

- 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.

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

K 9 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 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

Measurements will be initialized with the values found in the IC (Initial Condition) column of Table 2. Stimuli will be initialized as follows:

STIMULI	INITIAL VALUE
K90P27-1	1
K90P33-1	1
K90P22-1	1
K90P5-1	1
K90P6-1	1
K90P14-1	1
K90P9-1	1
K90P19-1	1
K90P43-1	1
K81P155-1	1

STIMULI	INITIAL VALUE	
T1	38	All other stimuli will be initialized to 0.
T2	38	
R1	300	
R2	300	
L1 = 1	1	
L2 = 1	1	

2.4 TERMINATION REQUIREMENTS

None.

2.5 UNIQUE REQUIREMENTS

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

T_1 - Cabin H_x in TEMP - LOOP 1

T_2 - Cabin H_x in TEMP - LOOP 2

R_1 - H_2O INTCHGR flow rate - LOOP 1

R_2 - H_2O 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:

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

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:

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

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

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

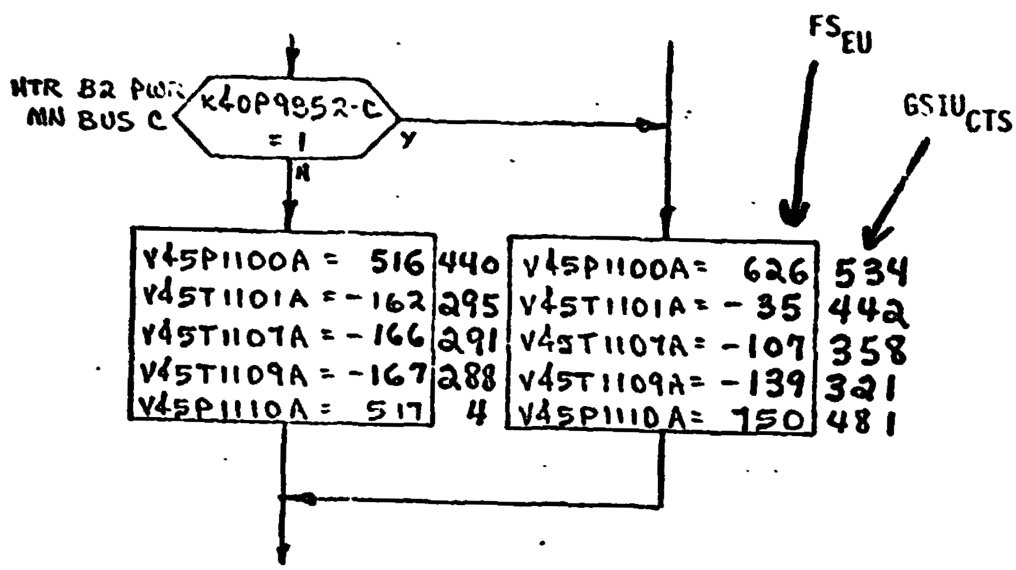
High = Range high limit

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.

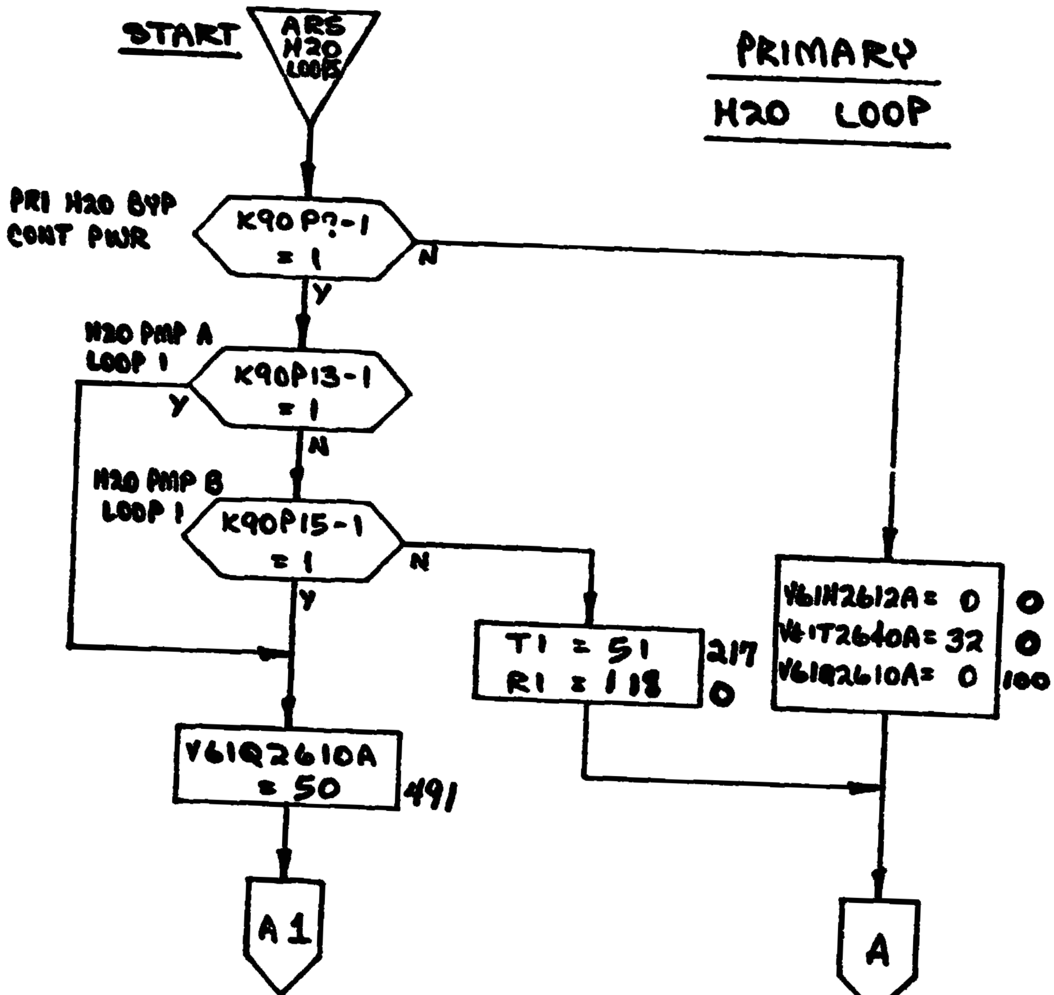
MEASUREMENT ID	RANGE LOW	RANGE HIGH	FS	CTS
V61P2540A	0	30	5.2	177
V61Q2551A	0	100	51	522
V61H2612A	0	100	2	20
V61H2712A	0	100	95	972

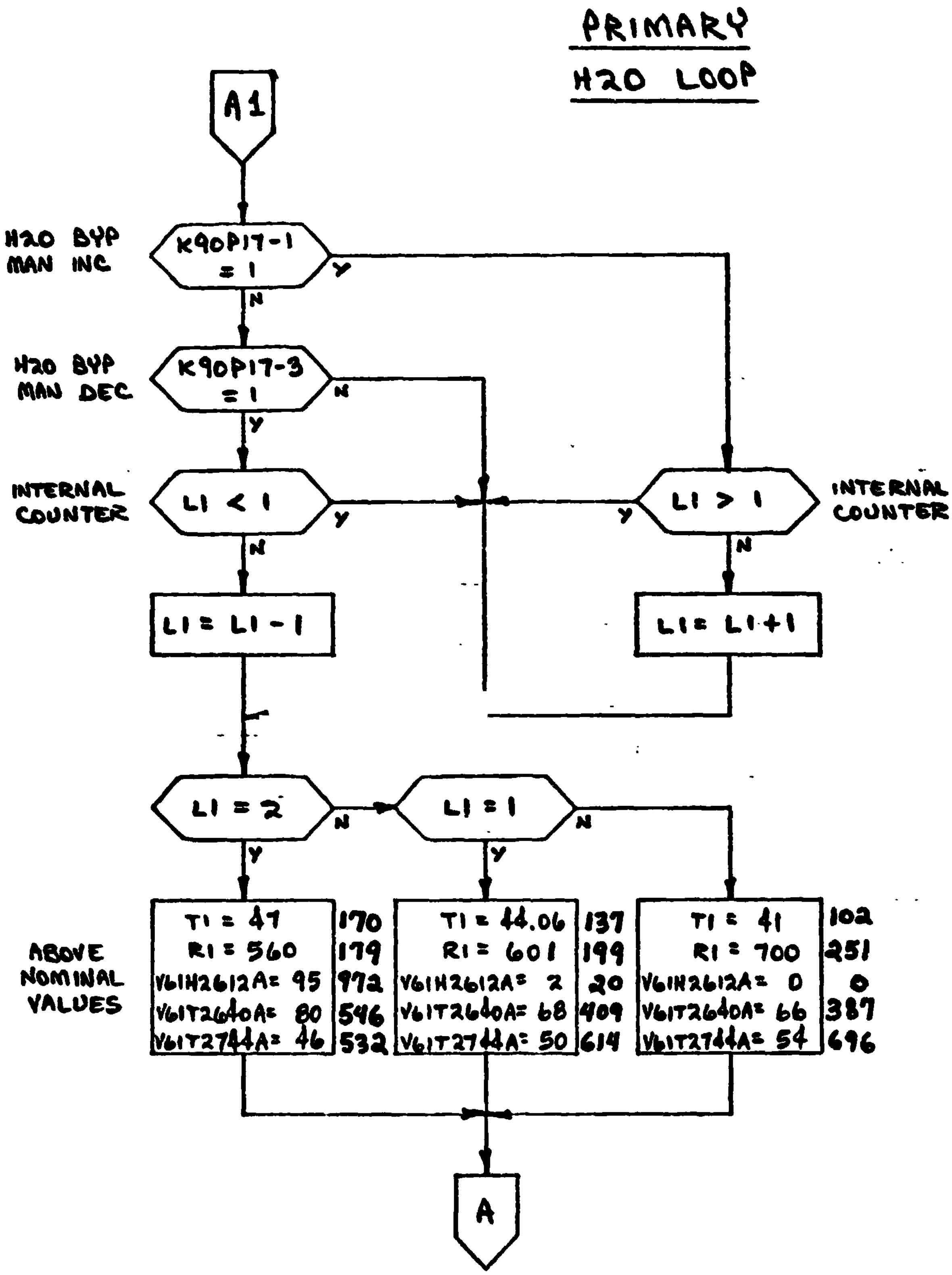
3.0 LOGIC FLOW DIAGRAMS

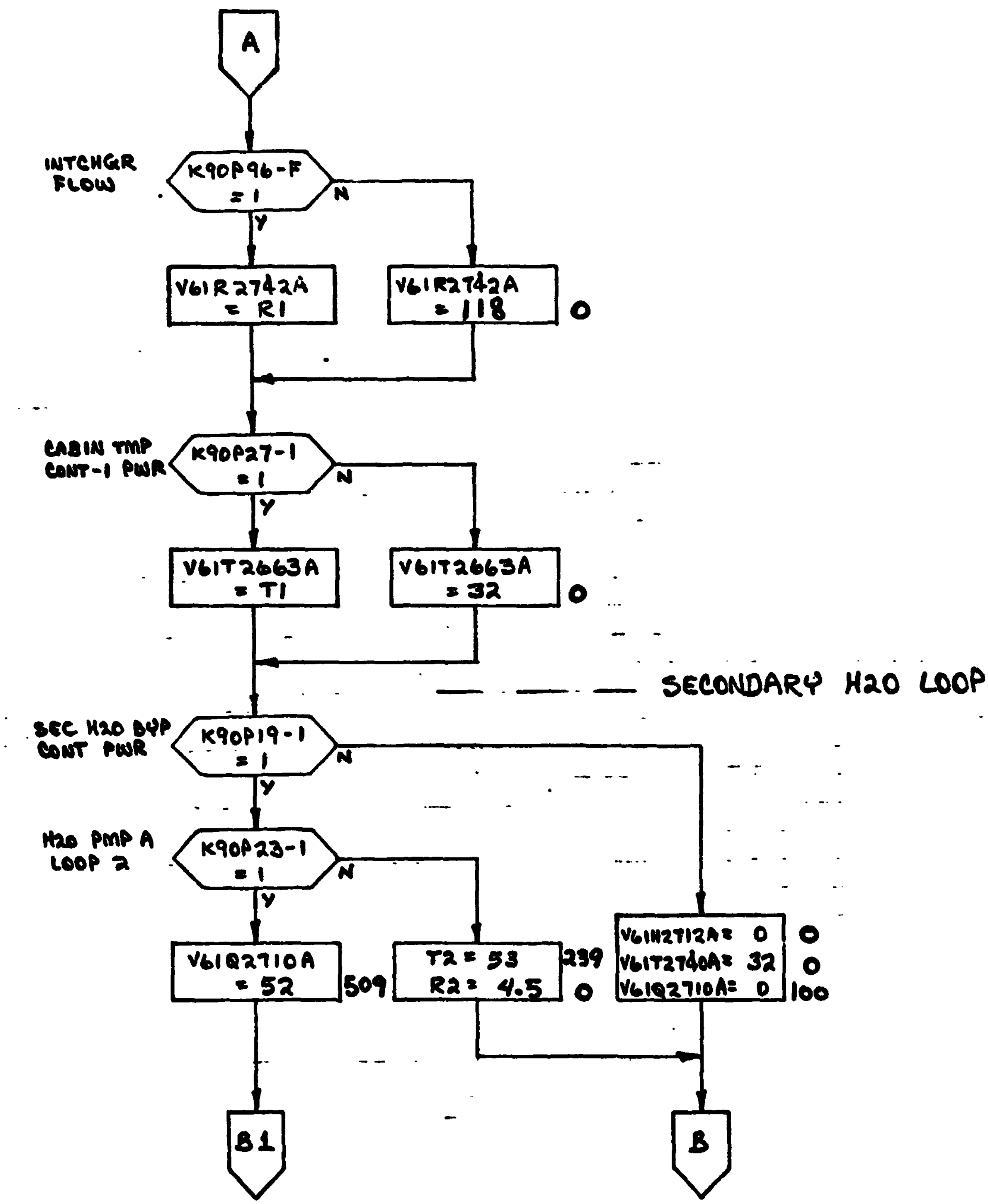
The logic flow diagram is made up of interconnected lines, boxes, decisions, and offpage connectors. Notice that where analog measurements are listed in boxes and decisions, the value inside the box is in flight system engineering units (FS_{EU}) while the corresponding GSIU count value is listed outside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

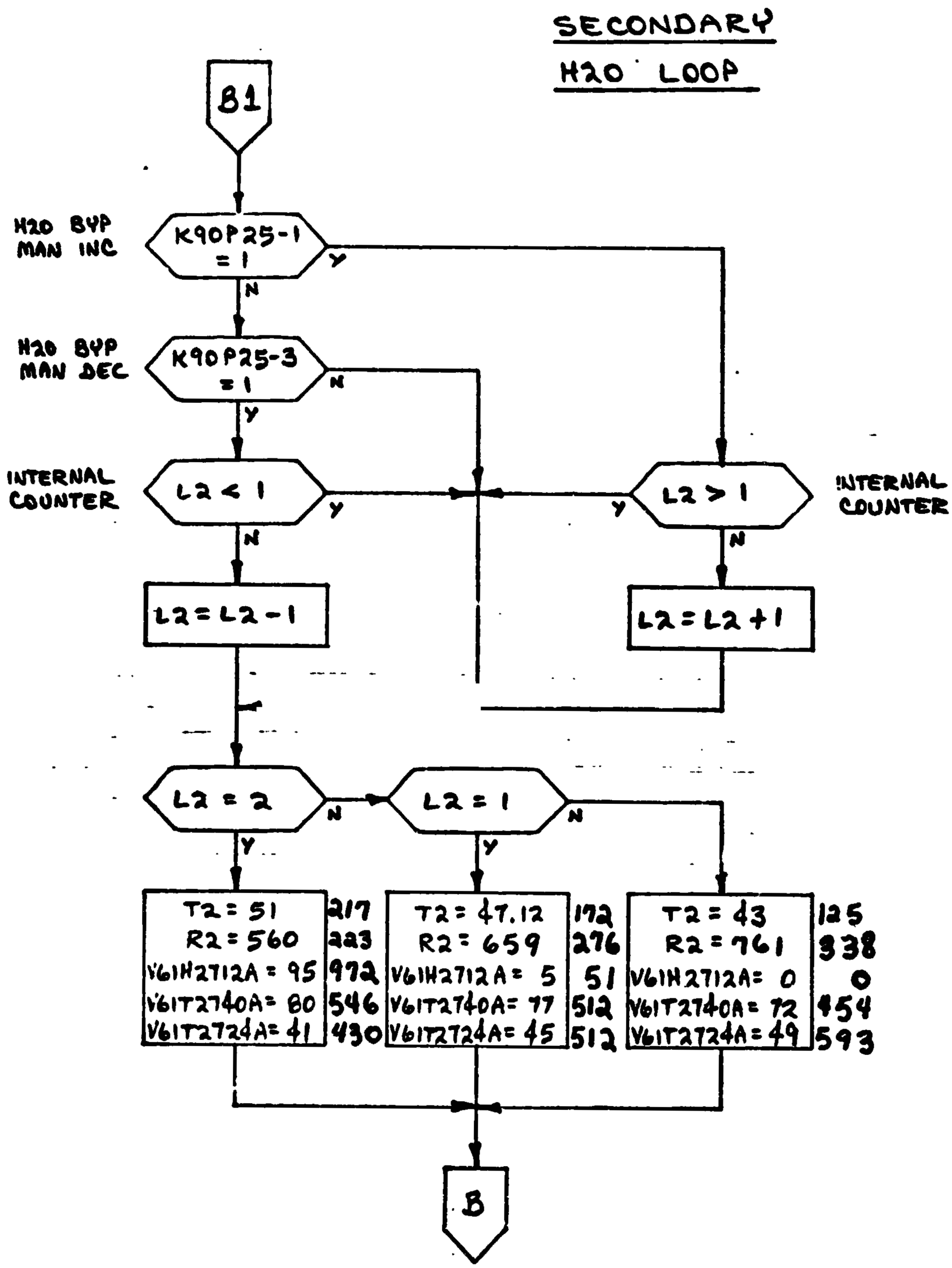


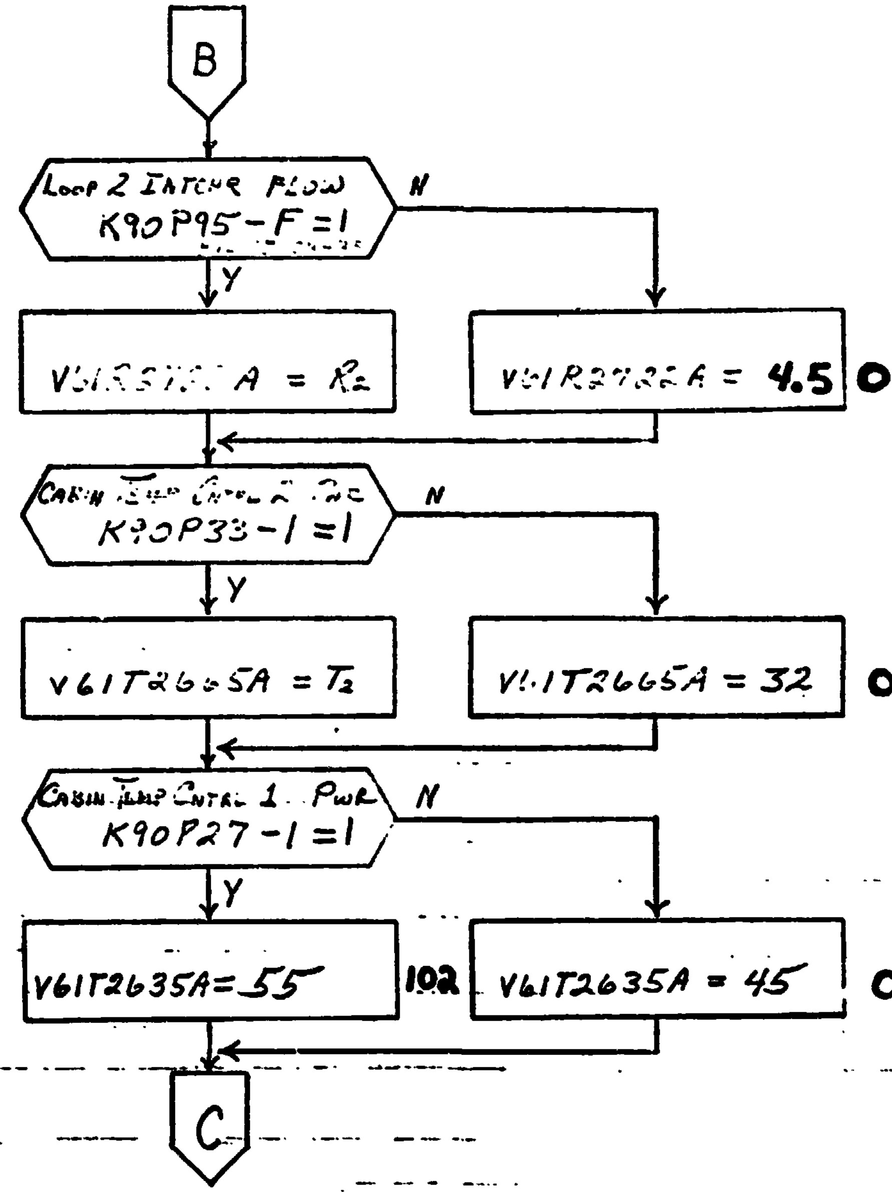
shows that V45P1100A is set equal to 626 FS_{EU} which is equivalent to 534 $GSIU_{CTS}$ shown outside the box.

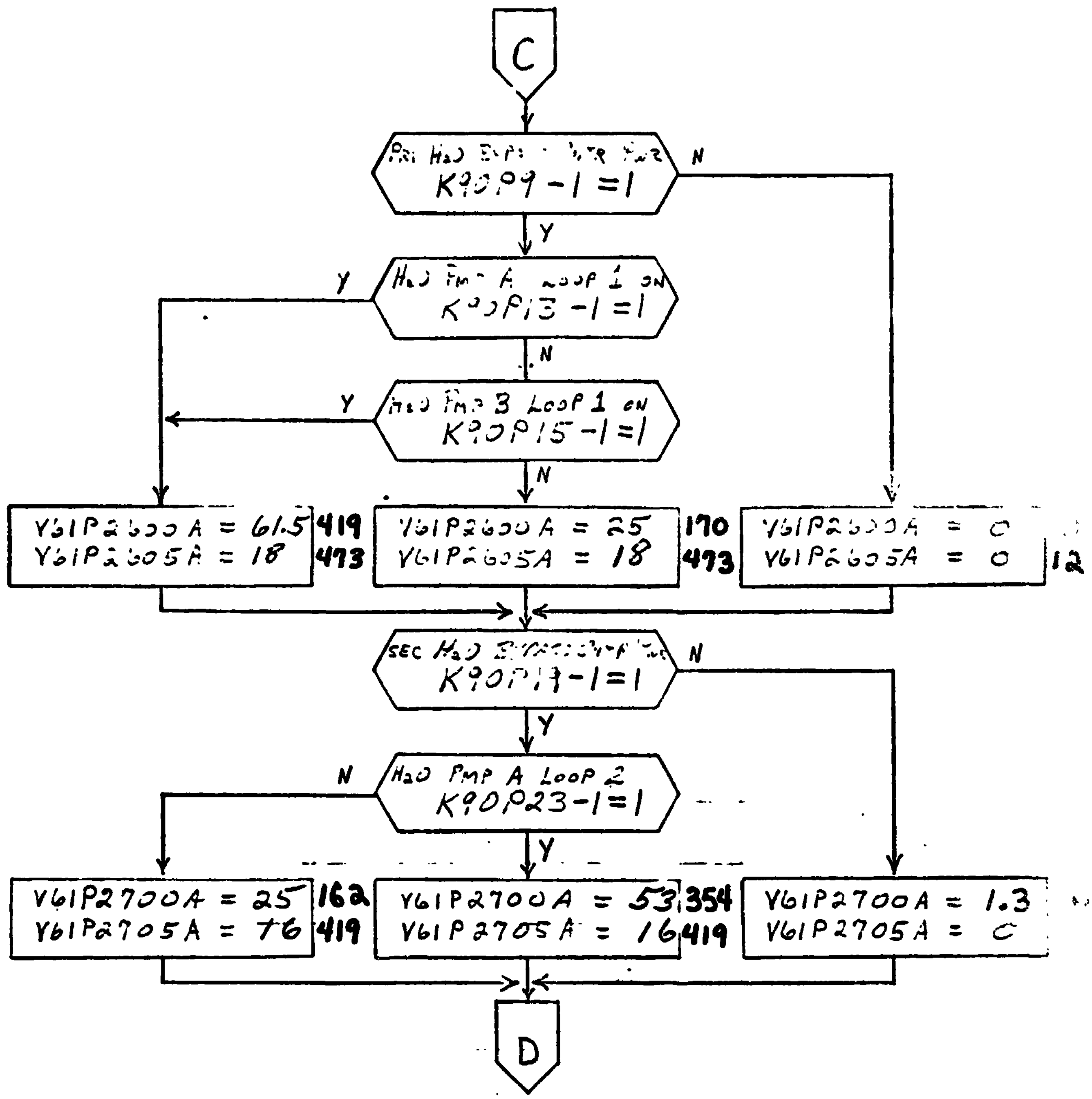

START
ARS H2O LOOPS
PRIMARY
H2O LOOP
PRI H2O BYP CONT PWR
K90P?-1 = 1
N
Y
H2O PMP A LOOP 1
K90P13-1 = 1
Y
N
H2O PMP B LOOP 1
K90P15-1 = 1
N
Y
T1 = 51 217
R1 = 118 0
V61H2612A = 0 0
V61T2640A = 32 0
V61Q2610A = 0 100
V61Q2610A = 50 491
A1
A

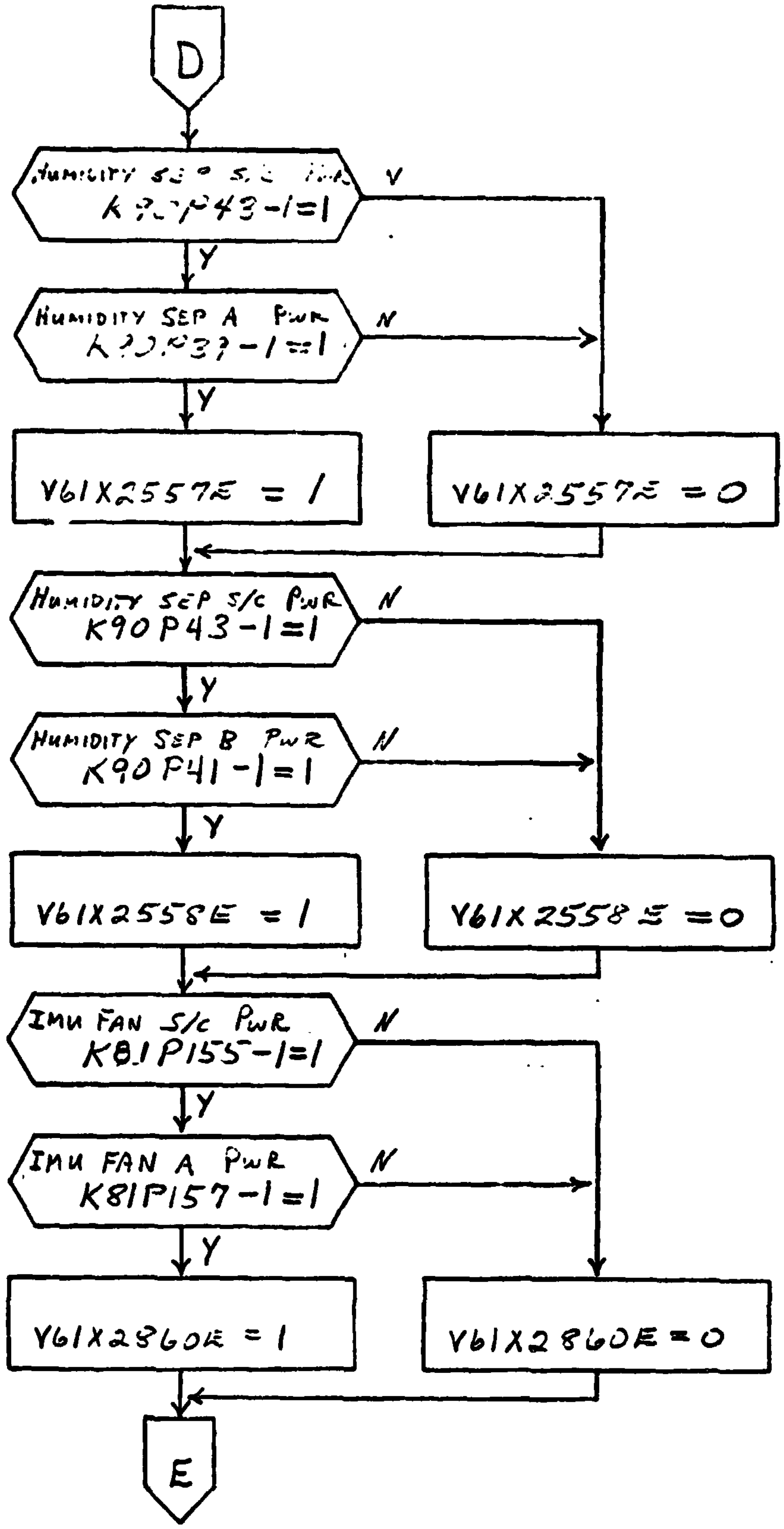

PRIMARY
H2O LOOP
A1
H2O BYP
MAN INC
K90P17-1
= 1
Y
N
H2O BYP
MAN DEC
K90P17-3
= 1
N
Y
INTERNAL
COUNTER
L1 < 1
Y
N
L1 = L1 - 1
L1 > 1
INTERNAL
COUNTER
Y
N
L1 = L1 + 1
L1 = 2
N
Y
L1 = 1
N
Y
ABOVE
NOMINAL
VALUES
T1 = 47
R1 = 560
V61H2612A = 95
V61T2640A = 80
V61T2744A = 46
170
179
972
546
532
T1 = 44.06
R1 = 601
V61H2612A = 2
V61T2640A = 68
V61T2744A = 50
137
199
20
409
614
T1 = 41
R1 = 700
V61H2612A = 0
V61T2640A = 66
V61T2744A = 54
102
251
0
387
696
A

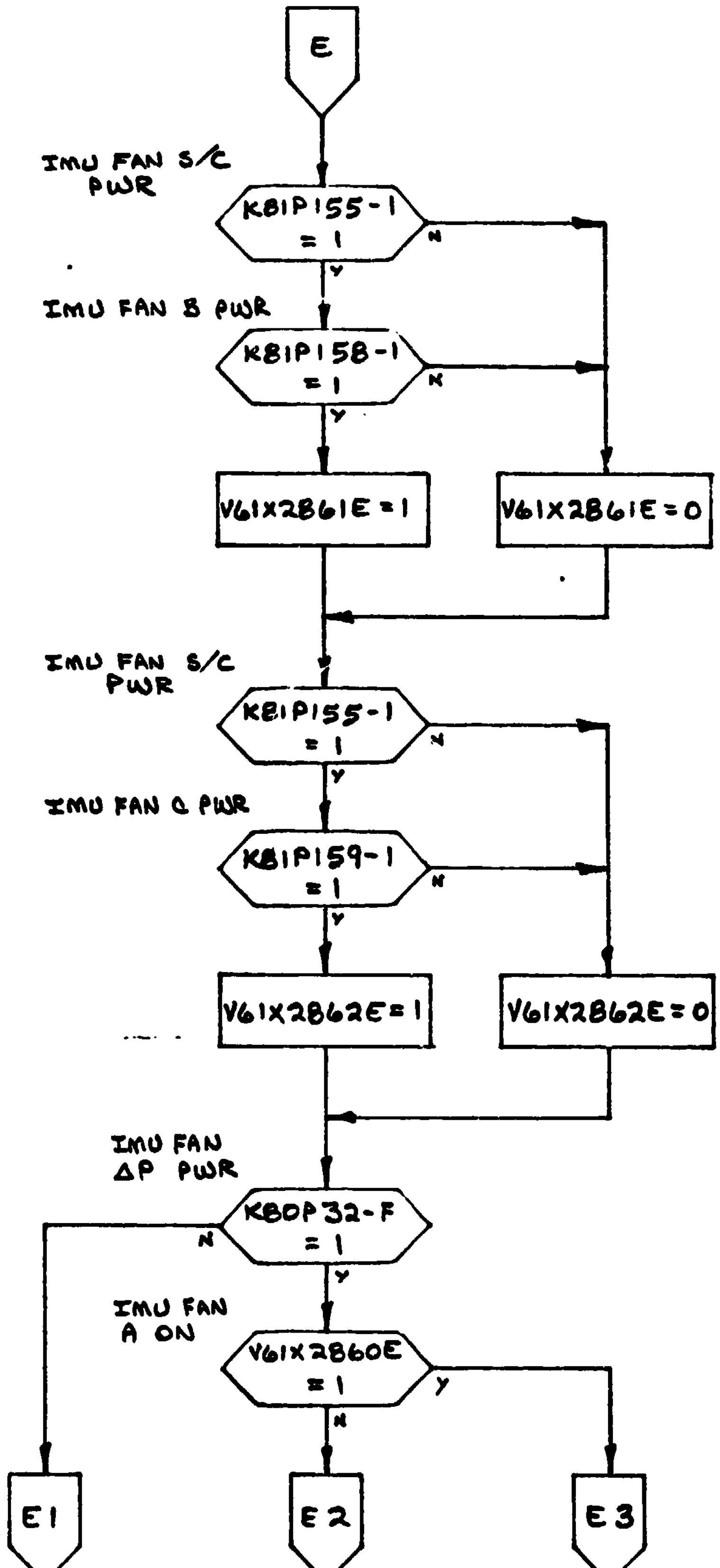

A
INTCHGR FLOW
K90P96-F = 1
N
Y
V61R2742A = R1
V61R2742A = 118
0
CABIN TMP CONT-1 PWR
K90P27-1 = 1
N
Y
V61T2663A = T1
V61T2663A = 32
0
SECONDARY H2O LOOP
SEC H2O BYP CONT PWR
K90P19-1 = 1
N
Y
H2O PMP A LOOP 2
K90P23-1 = 1
N
Y
V61Q2710A = 52
509
T2 = 53
R2 = 4.5
239
0
V61H2712A = 0
V61T2740A = 32
V61Q2710A = 0
0
0
100
B1
B

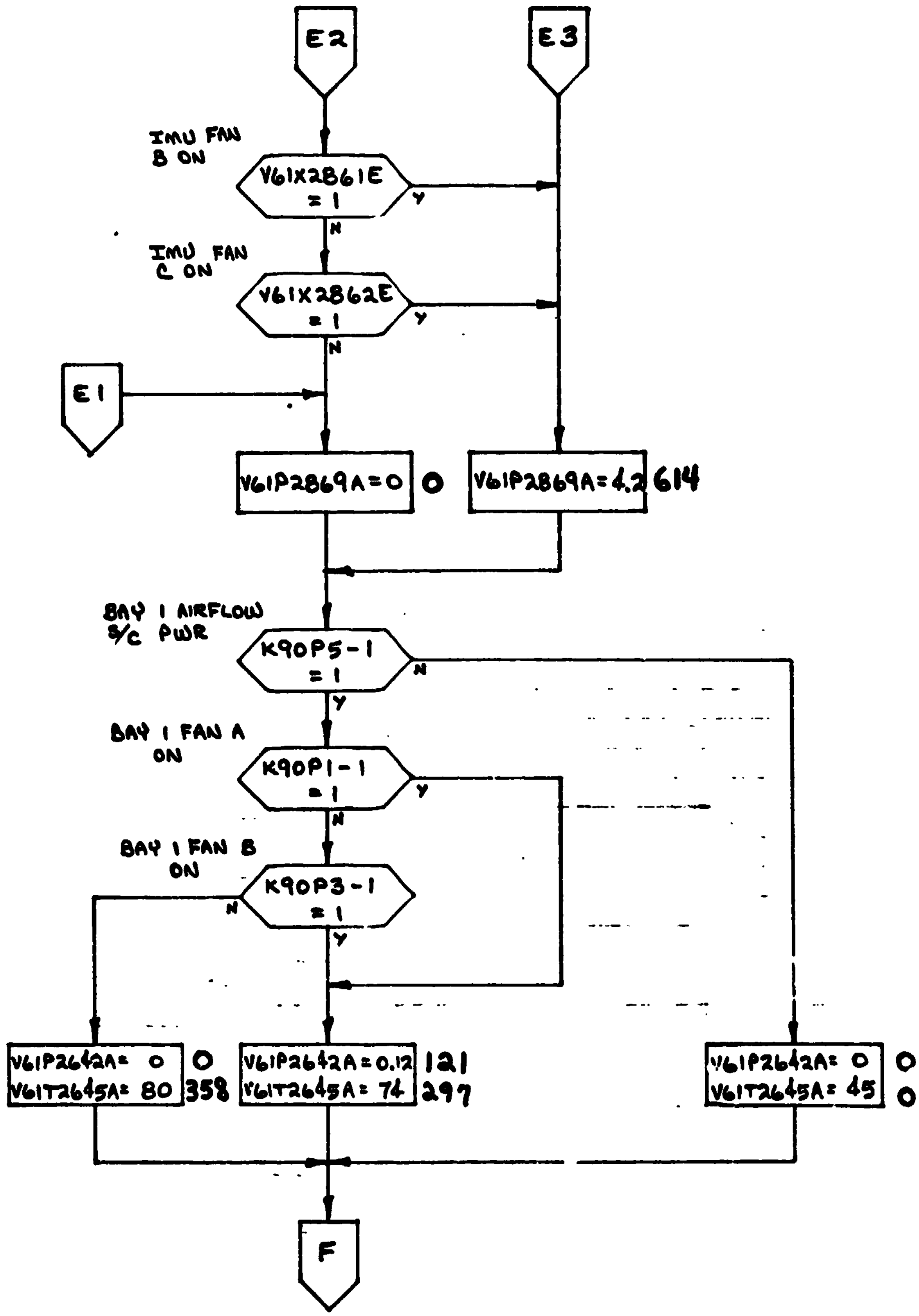

SECONDARY
H2O LOOP
B1
H2O BYP
MAN INC
K90P25-1 = 1
Y
N
H2O BYP
MAN DEC
K90P25-3 = 1
N
Y
INTERNAL
COUNTER
L2 < 1
Y
N
L2 > 1
INTERNAL
COUNTER
Y
N
L2 = L2 - 1
L2 = L2 + 1
L2 = 2
N
Y
L2 = 1
N
Y
T2 = 51
R2 = 560
V61H2712A = 95
V61T2740A = 80
V61T2724A = 41
217
223
972
546
430
T2 = 47.12
R2 = 659
V61H2712A = 5
V61T2740A = 77
V61T2724A = 45
172
276
51
512
512
T2 = 43
R2 = 761
V61H2712A = 0
V61T2740A = 72
V61T2724A = 49
125
338
0
454
593
B

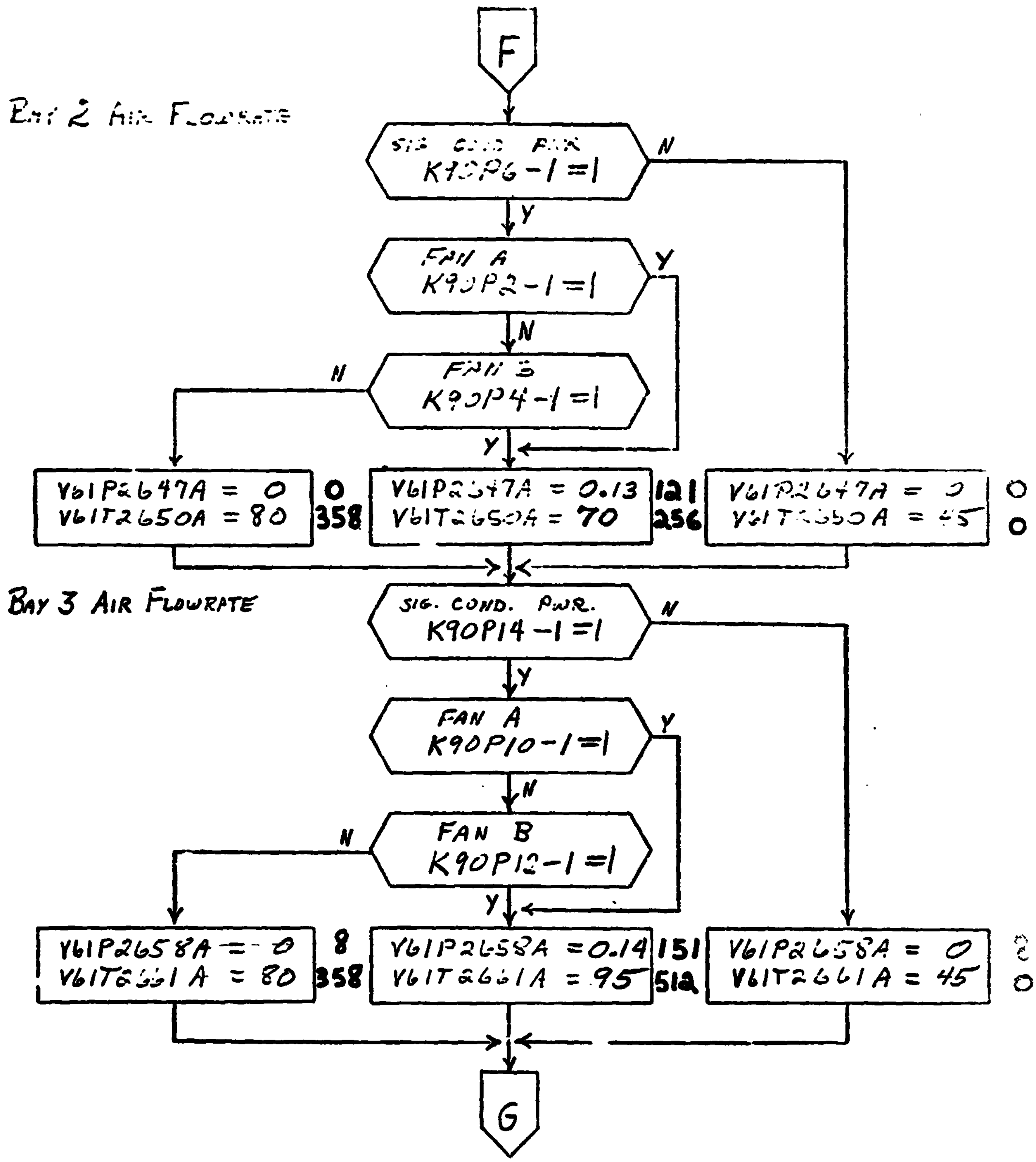

B
Loop 2 INTCHR FLOW
K90P95-F =1
N
Y
= R2
= 4.5
O
K90P33-1 =1
N
Y
V61T2665A = T2
= 32
O
Cabin Temp Cntrl 1 Pwr
K90P27-1 =1
N
Y
V61T2635A=55
102
V61T2635A = 45
O
C


C
K90P9-1=1
H2O PMP A LOOP 1 ON
K90P13-1=1
H2O PMP B LOOP 1 ON
K90P15-1=1
Y61P2600A = 61.5 419
Y61P2605A = 18 493
Y61P2600A = 25 170
Y61P2605A = 18 493
Y61P2600A = 0
Y61P2605A = 0 12
SEC H2O
K90P17-1=1
H2O PMP A LOOP 2
K90P23-1=1
Y61P2700A = 25 162
Y61P2705A = 76 419
Y61P2700A = 53 354
Y61P2705A = 16 419
Y61P2700A = 1.3
Y61P2705A = 0
D
Y
N


D
HUMIDITY SEP A PWR
V61X2557E = 1
V61X2557E = 0
HUMIDITY SEP S/C PWR
K90P43-1=1
HUMIDITY SEP B PWR
K90P41-1=1
V61X2558E = 1
V61X2558E = 0
IMU FAN S/C PWR
K81P155-1=1
IMU FAN A PWR
K81P157-1=1
V61X2860E = 1
V61X2860E = 0
E


E
IMU FAN S/C PWR
K81P155-1 = 1
N
Y
IMU FAN B PWR
K81P158-1 = 1
N
Y
V61X2861E = 1
V61X2861E = 0
IMU FAN S/C PWR
K81P155-1 = 1
N
Y
IMU FAN C PWR
K81P159-1 = 1
N
Y
V61X2862E = 1
V61X2862E = 0
IMU FAN ΔP PWR
K80P32-F = 1
N
Y
IMU FAN A ON
V61X2860E = 1
Y
N
E1
E2
E3


E2
E3
IMU FAN
B ON
V61X2861E
= 1
Y
N
IMU FAN
C ON
V61X2862E
= 1
Y
N
E1
V61P2869A=0
0
V61P2869A=4.2
614
BAY 1 AIRFLOW
S/C PWR
K90P5-1
= 1
N
Y
BAY 1 FAN A
ON
K90P1-1
= 1
Y
N
BAY 1 FAN B
ON
K90P3-1
= 1
N
Y
V61P2642A= 0
V61T2645A= 80
0
358
V61P2642A=0.12
V61T2645A= 74
121
297
V61P2642A= 0
V61T2645A= 45
0
0
F



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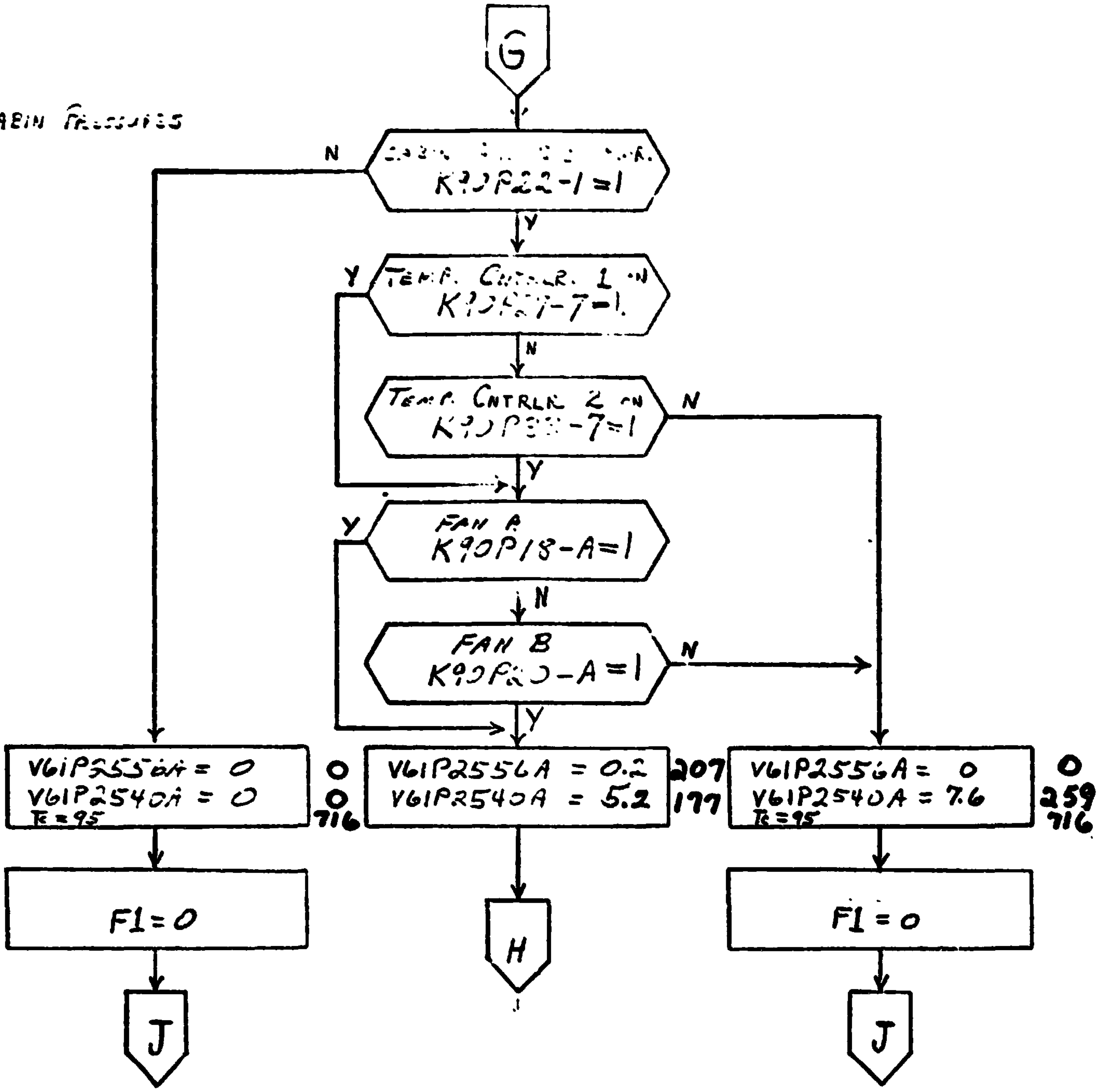
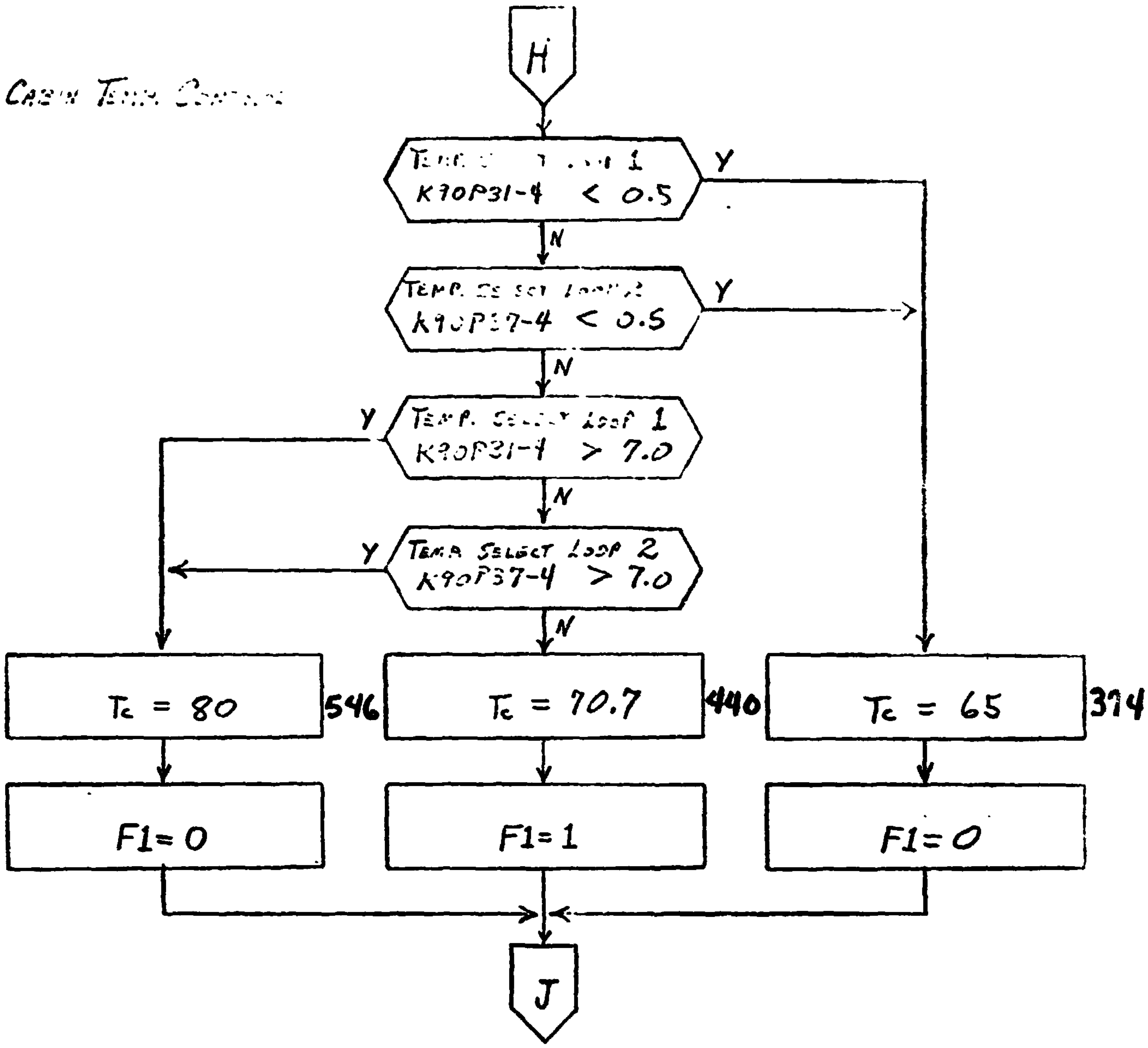
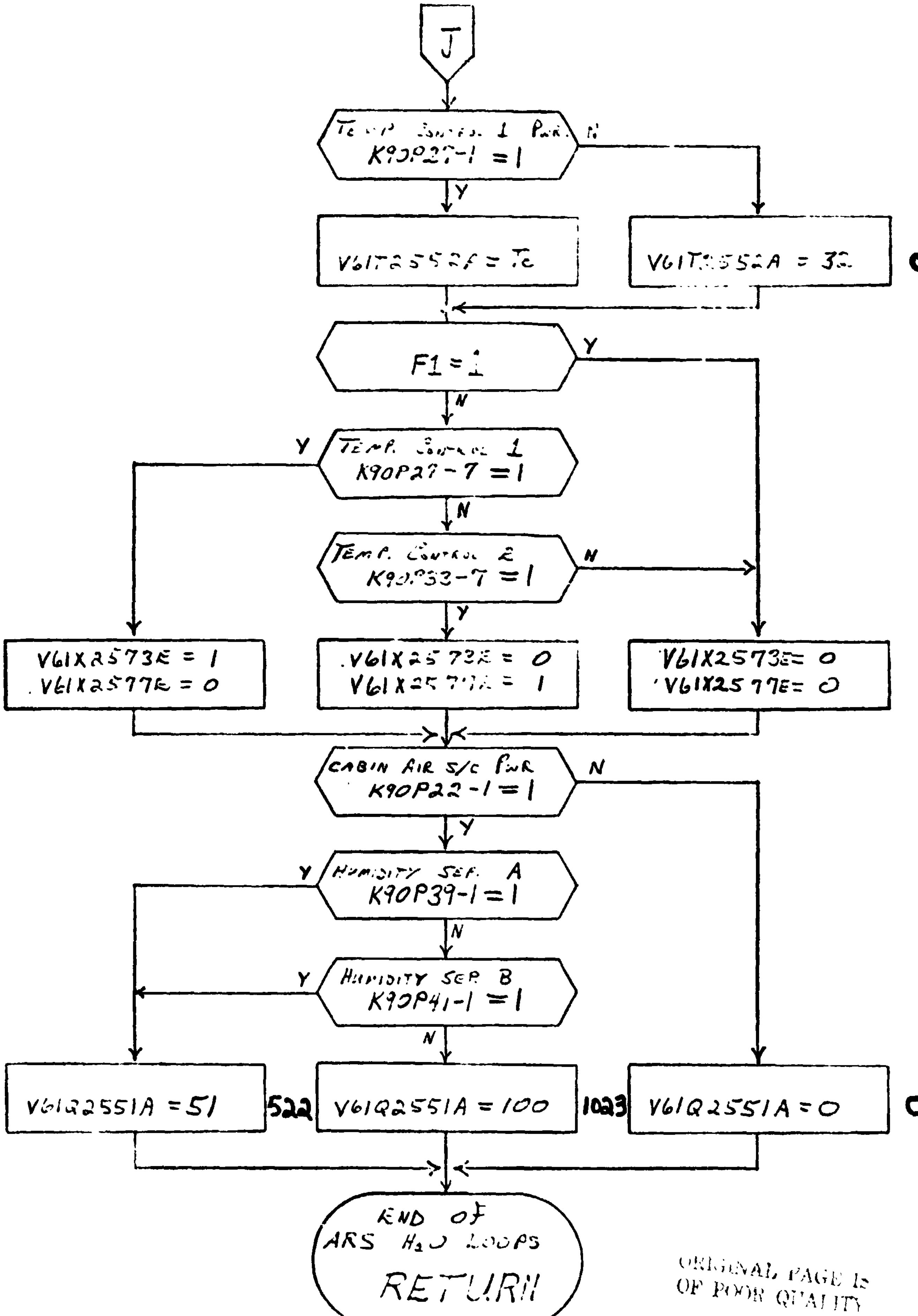
CABIN PRESSURES



Cabin Temp. Control





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4. TABLES

4.1 INPUT STIMULI LIST

Table 1 lists input stimuli to the ARS/H_2O Loops model in terms of ID numbers, nomenclature, stimuli source, address, and range of parameter.

TABLE 2-1.— STIMULI (?UT TO ARS-H_2O LOOPS

IDENTIFICATION NUMBER	NOMENCLATURE		SOURCE	STATES/RANGE		
				LO	HI	UNITS
V61K2120E	CABIN TEMP. CNTRL - LOOP 1 ON	K90P27-7	FS via STM	0	1	STATE
V61K2121E	CABIN TEMP. CNTRL - LOOP 2 ON	K90P33-7		0	1	
V61K2450E	HUMIDITY SEPARATOR A ON	K90P39-1		0	1	
V61K2455E	HUMIDITY SEPARATOR B ON	K90P41-1		0	1	
V61K2566A	CABIN TEMP SELECTOR - LOOP 1	K90P31-4		0	7.5	VDC
V61K2567A	CABIN TEMP SELECTOR - LOOP 2	K90P37-4		0	7.5	VDC
V61K2585E	CABIN FAN A ON	K90P18-A		0	1	STATE
V61K2590E	CABIN FAN B ON	K90P20-A		0	1	
V61K2601E	H_2O PUMP A - LOOP 1 ON	K90P13-1		0	1	
V61K2606E	H_2O PUMP B - LOOP 1 ON	K90P15-1		0	1	
V61K2701E	H_2O PUMP - LOOP 2 ON	K90P23-1		0	1	
V61K2747E	H_2O BYPASS MNL-INCR - LOOP 1	K90P17-1		0	1	
V61K2748E	H_2O BYPASS MNL-DECR - LOOP 1	K90P17-3		0	1	
V61K2770E	AV. BAY 1 FAN A ON	K90P1-1		0	1	
V61K2775E	AV. BAY 1 FAN B ON	K90P3-1		0	1	
V61K2780E	AV. BAY 2 FAN A ON	K90P2-1		0	1	
V61K2785E	AV. BAY 2 FAN B ON	K90P4-1		0	1	
V61K2790E	AV. BAY 3 FAN A ON	K90P10-1		0	1	
V61K2795E	AV. BAY 3 FAN B ON	K90P12-1		0	1	
V61K2847E	H_2O BYPASS MNL-INCR - LOOP 2	K90P25-1		0	1	
V61K2848E	H_2O BYPASS MNL-DECR - LOOP 2	K90P25-3		0	1	

TABLE 2-1. Continued.

IDENTIFICATION NUMBER	NOMENCLATURE		SOURCE	STATES/RANGE		
				LO	HI	UNITS
V61K2849E	IMU FAN A	K81P157-1	FS via STM	0	1	STATE
V61K2852E	IMU FAN B	K81P158-1		0	1	
V61K2855E	IMU FAN C	K81P159-1		0	1	
N/A	CABIN TEMP. CNTRLR 1 PWR	K90P27-1	PNL L4-Cb 117	0	1	
N/A	CABIN TEMP. CNTRLR 2 PWR	K90P33-1	PNL L4-CB 119	0	1	
N/A	INTCHGR FLOW - H_2O LOOP 1 PWR	K90P96-F	PNL 014-CB 35	0	1	
N/A	INTCHGR FLOW - H_2O LOOP 2 PWR	K90P95-F	PNL 015-CB-35	0	1	
N/A	AV. BAY 1 S/C POWER	K90P5-1	PNL L4-CB-127	0	1	
N/A	AV. BAY 2 S/C POWER	K90P6-1	PNL L4-CB-118	0	1	
N/A	AV. BAY 3 S/C POWER	K90P14-1	PNL L4-CB 120	0	1	
N/A	H_2O BYPASS CNTRLR - PRI	K90P9-1	PNL L4-CB 121	0	1	
N/A	H_2O BYPASS CNTRLR - SEC	K90P19-1	PNL L4-CB 93	0	1	
N/A	IMU FAN S/C POWER	K81P155-1	PNL L4-CB 81	0	1	
N/A	CABIN AIR S/C POWER	K90P22-1	PNL L4-CB 94	0	1	
N/A	HUMIDITY SEP S/C POWER	K90P43-1	PNL L4-CB 80	0	1	
N/A	IMU FAN ΔP POWER	K80P32-F	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/H_2O 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					
V61X2573E	CABIN TEMP CTL FULL HX-LOOP 1	0	0	1	1					
V61X2577E	CABIN TEMP CTL FULL HX-LOOP 2	0	0	1	1					
V61P2600A	H_2O PUMP OUT PRESS - PRI	61.5	419	0	0	25	170			PSIA
V61P2605A	H_2O PUMP IN PRESS-PRI	18	473	0	12					PSIA
V61Q2610A	H_2O ACCUM QTY-PRI	50	491	0	100					PERCENT
*V61H2612A	H_2O BYPASS VLV. POS.-PRI	2	20	0	0	95	972			PERCENT
V61T2635A	CABIN HX OUT TEMP.	55	102	45	0					DEG.F.
V61T2640A	H_2O 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 [illegible] the range limit conversion method of calculating FS_{EU} from GSIU$_{CTS}$ as discussed in section [illegible]

MEASUREMENT OUTPUT FROM AR/H_2O 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 53	0 239	43	125	51	217	DEG.F.
V61P2700A	H_2O PUMP OUT PRESS-SEC.	53	354	1.3	0	25	162			PSIA
V61P2705A	H_2O PUMP IN. PRESS-SEC.	16	419	0	10					PSIA
V61Q2710A	H_2O ACCUM. QTY-SEC.	52	509	0	100					PERCENT
*V61H2712A	H_2O BYPASS VLV. POS.-SEC	95	972	0	0	5	51			PERCENT
V61R2722A	H_2O INTCHGR. FLOW - LOOP 2	659	276	4.5	0	560	223	761	338	PPH
V61T2724A	H_2O INTCHGR. OUT TEMP.-LOOP 2	45	512	41	430	49	593			DEG.F.
V61T2740A	H_2O PUMP OUT TEMP - LOOP 2	77	512	32	0	72	454	80	546	DEG.F.
V61R2742A	H_2O INTCHGR. FLOW - LOOP 1	118	0	560	179	601	199	700	251	PPH
V61T2744A	H_2O 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_2O

*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

CONTENTS

TABLES

FIGURES

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 - H_2O 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. [illegible] 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 progr.m in which case the model output rate shall oe 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).

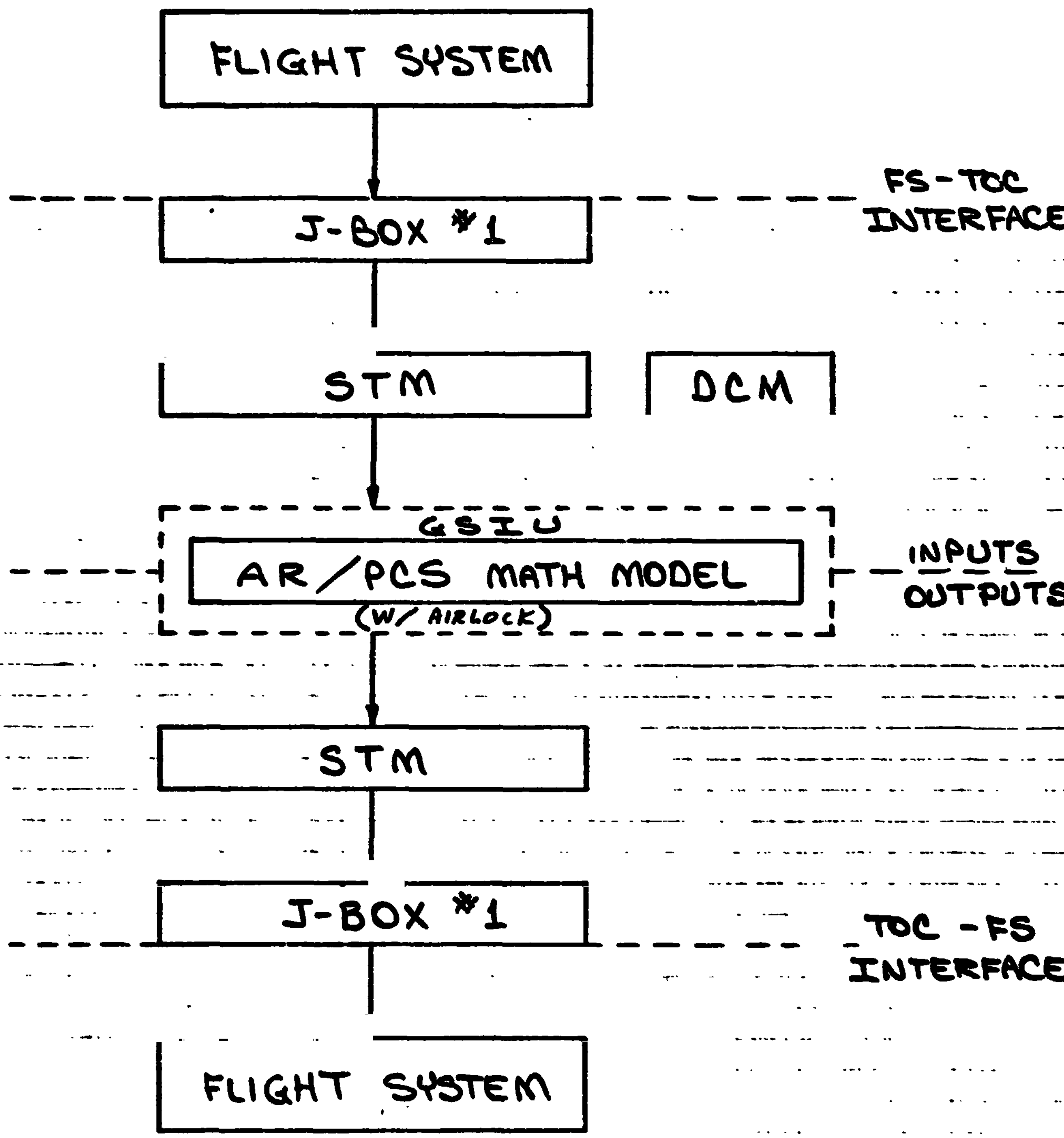
1) The Flight System (FS) via the Signal Termination Module (STM).

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

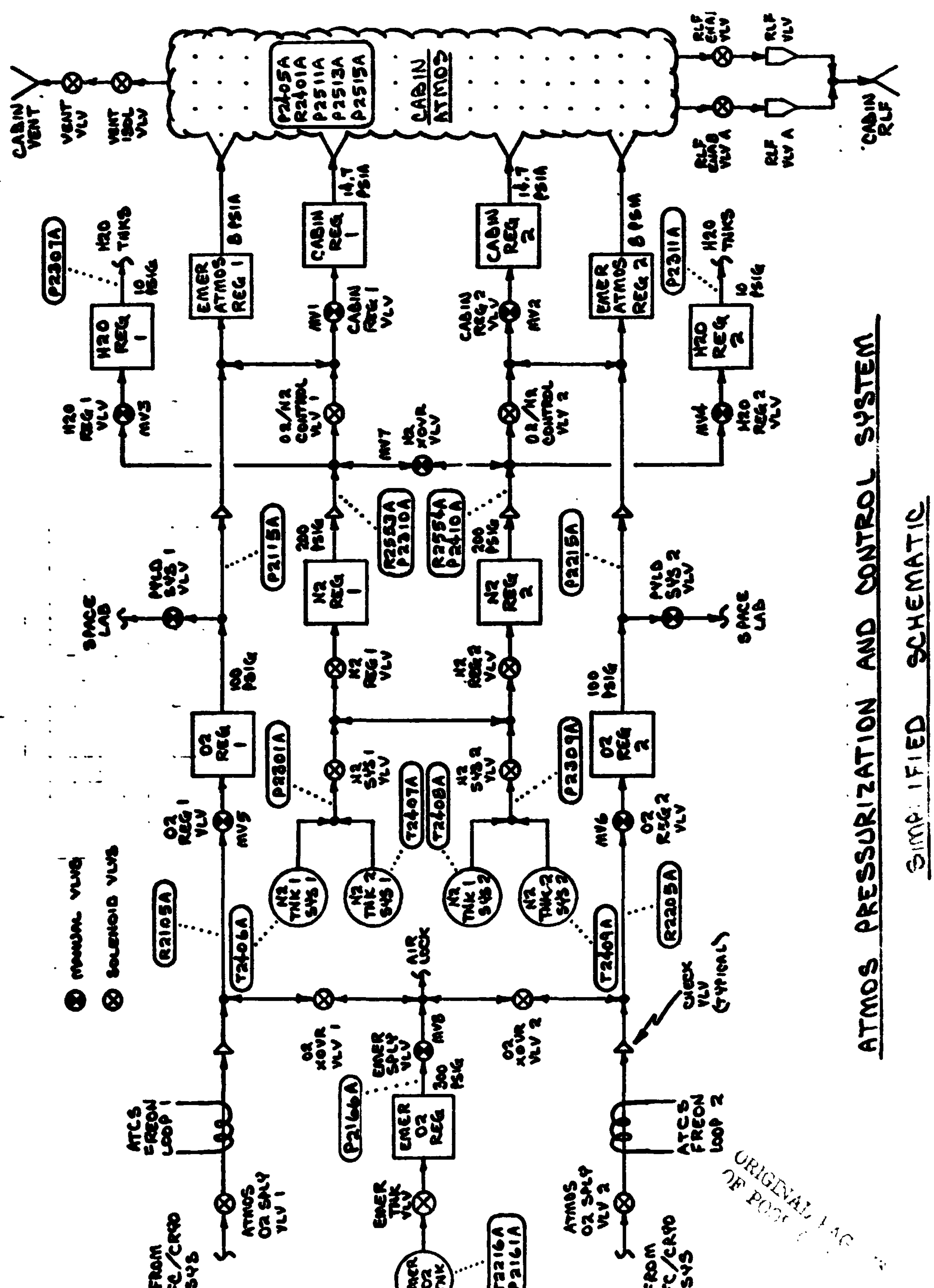

ATMOS PRESSURIZATION AND CONTROL SYSTEM
SIMPLIFIED SCHEMATIC
CABIN ATMOS

FIGURE 2

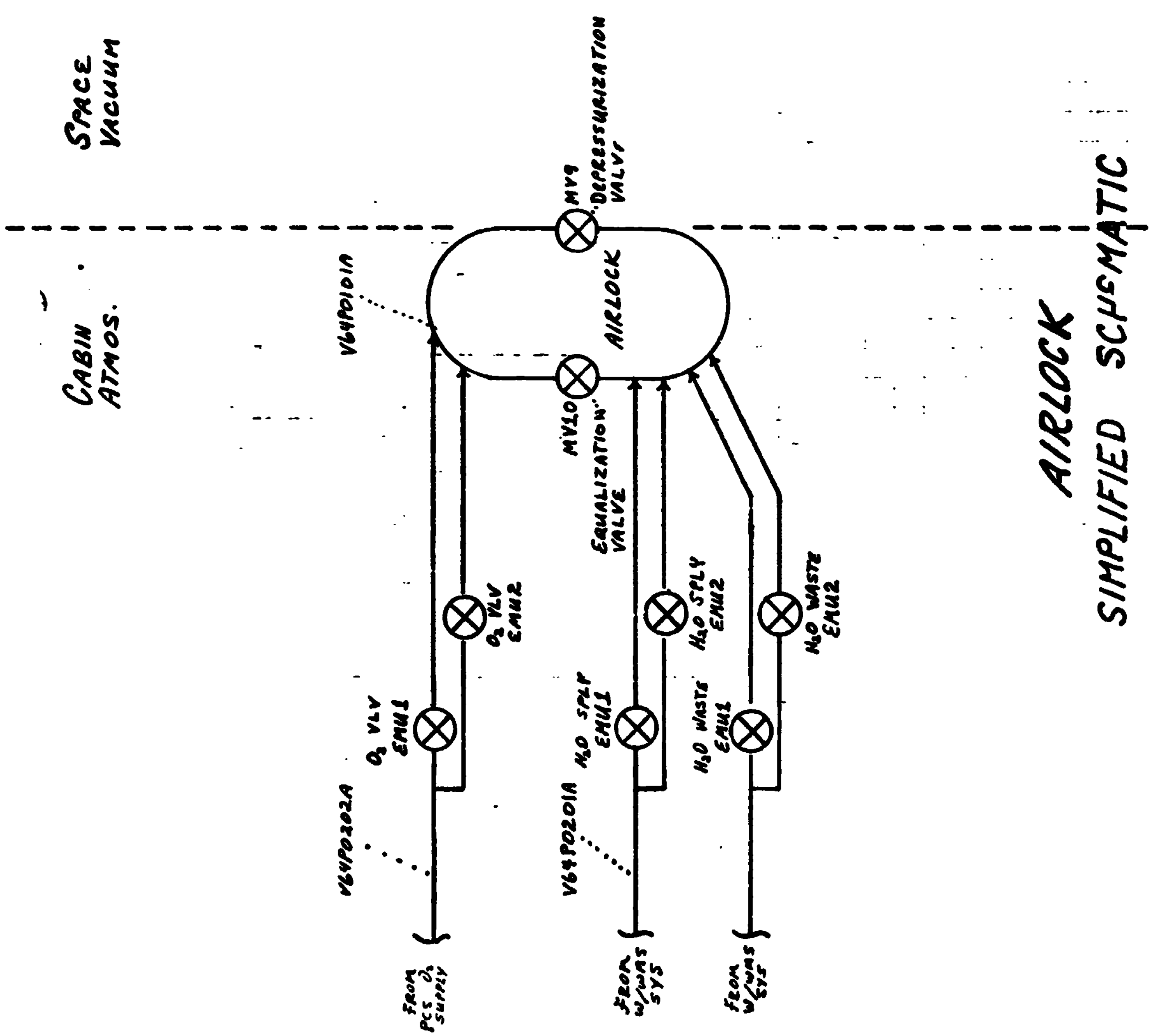

AIRLOCK
SIMPLIFIED SCHEMATIC
SPACE VACUUM
CABIN ATMOS.
MV9 DEPRESSURIZATION VALVE
AIRLOCK
V64P0101A
MV10 EQUALIZATION VALVE
O_2 VLV EMU1
O_2 VLV EMU2
H_2O SPLY EMU1
H_2O SPLY EMU2
H_2O WASTE EMU1
H_2O WASTE EMU2
V64P0202A
V64P0201A
FROM PCS O_2 SUPPLY
FROM W/WMS SYS
FROM W/WMS SYS

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 values 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.

K 80 PXXX - X

- X — PIN NUMBER (FLIGHT CABLE)
- PXXX — CONNECTOR NUMBER (P FOLLOWED BY 3 OR 4 DIGITS)
- 80 — AREA DESIGNATOR
- K — STIMULI DESIGNATOR

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 uplined 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:

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

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

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:

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

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

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

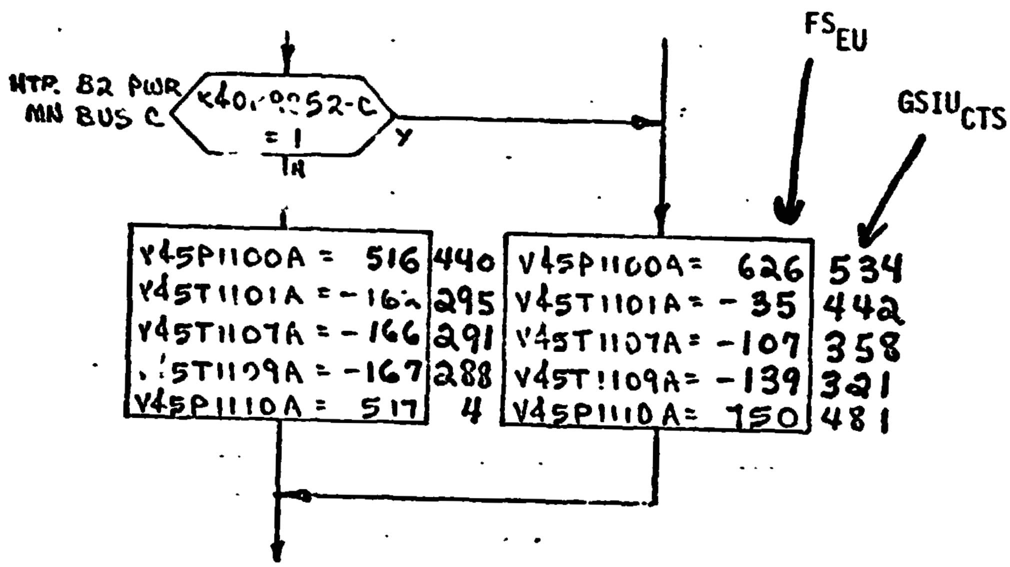
High = Range high limit

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

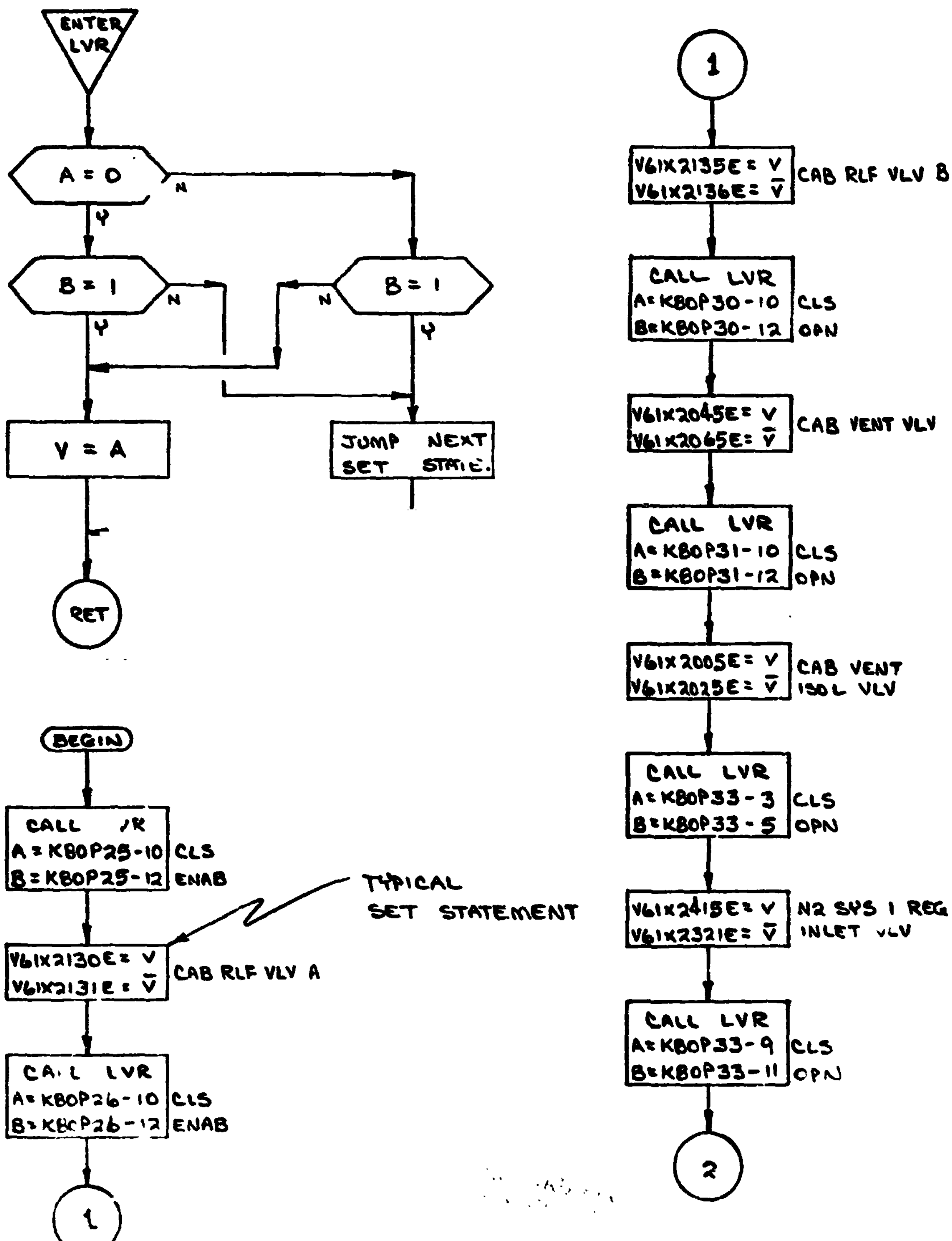
The logic flow diagram is made up of interconnected lines, boxes, decisions, and offpage connectors. Notice that where analog measurements are listed in boxes and decisions, the value inside the box is in flight system engineering units (FS_{EU}) while the corresponding GSIU count value is listed outside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

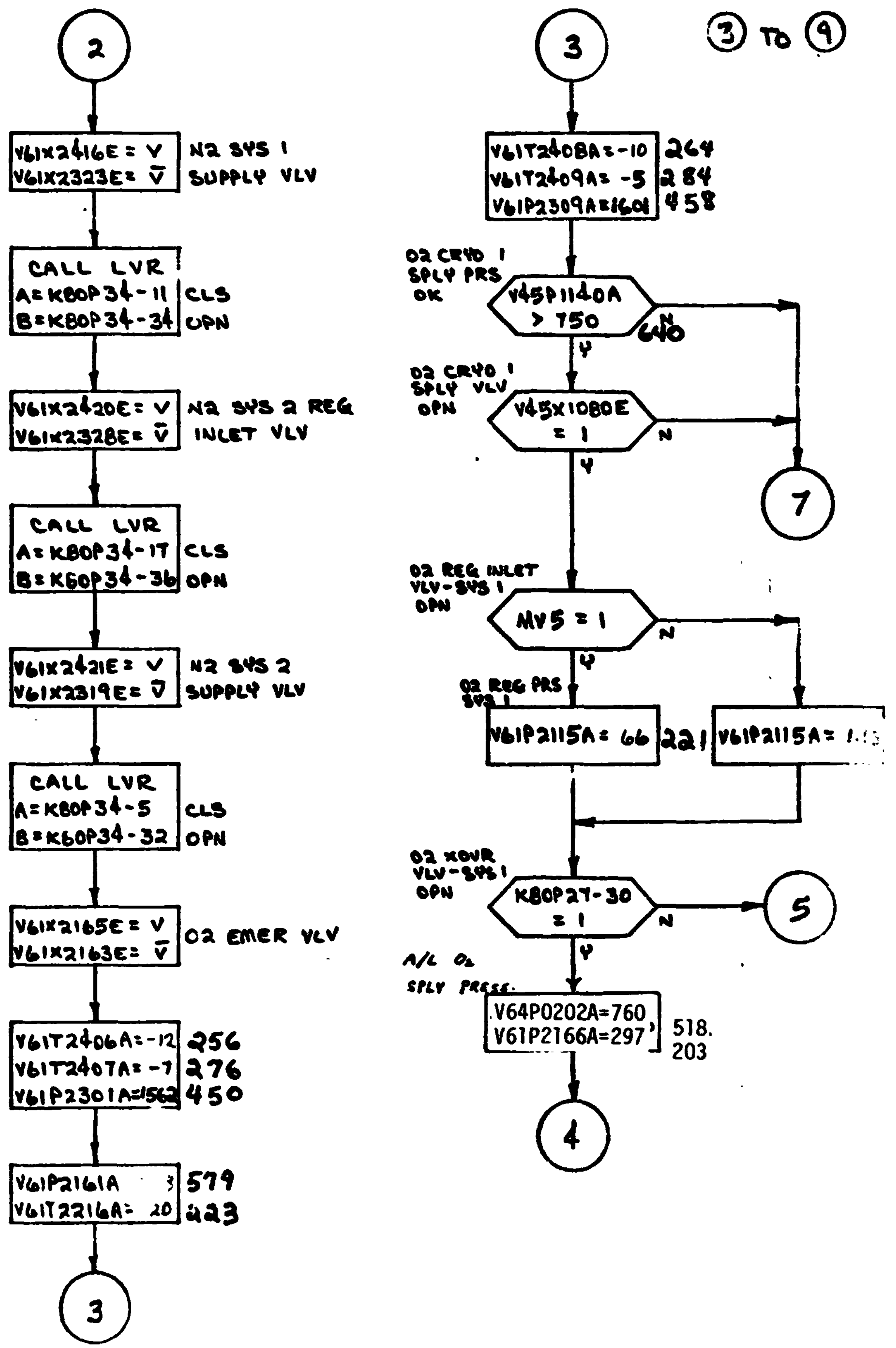
LVR

BEGIN TO 3



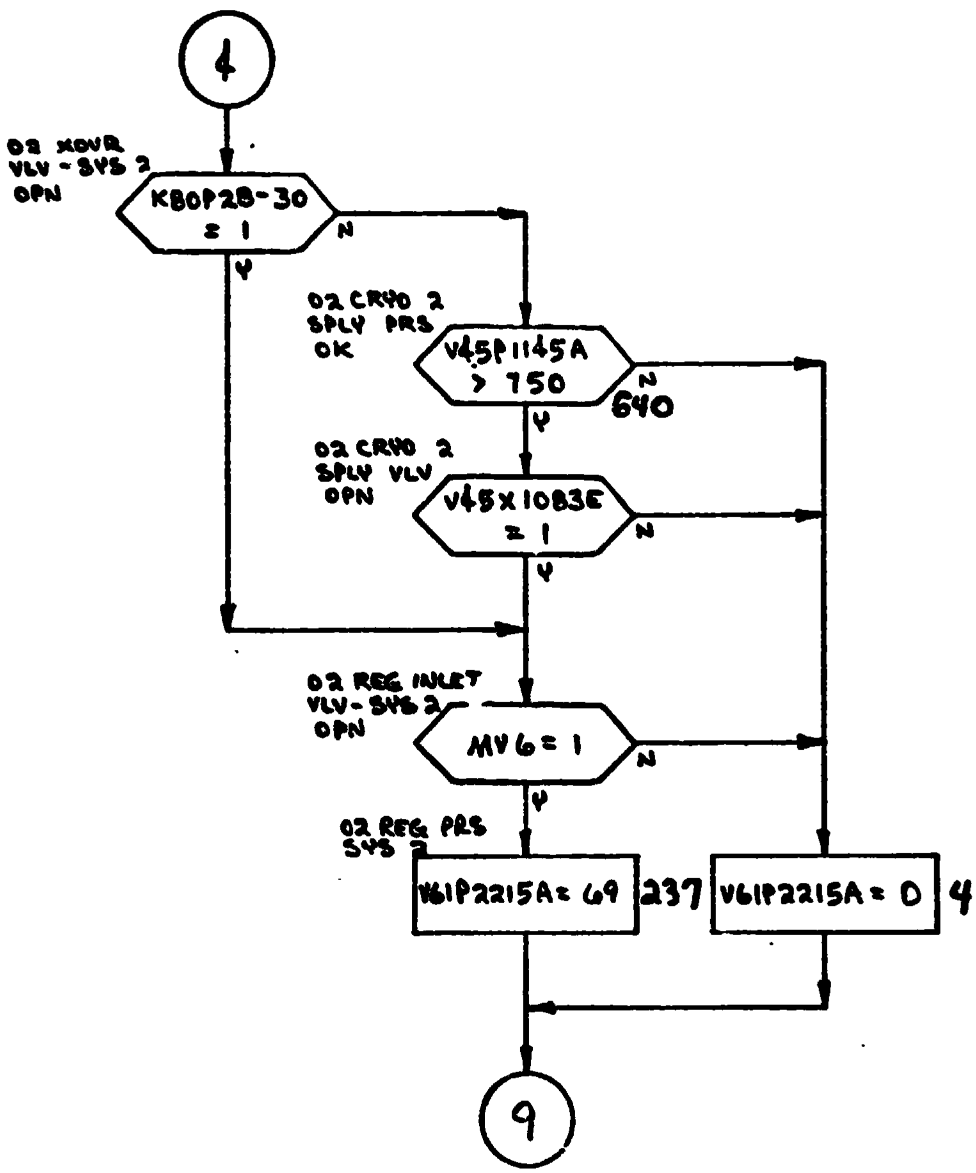
O2 PRESSURES

(3) TO (9)

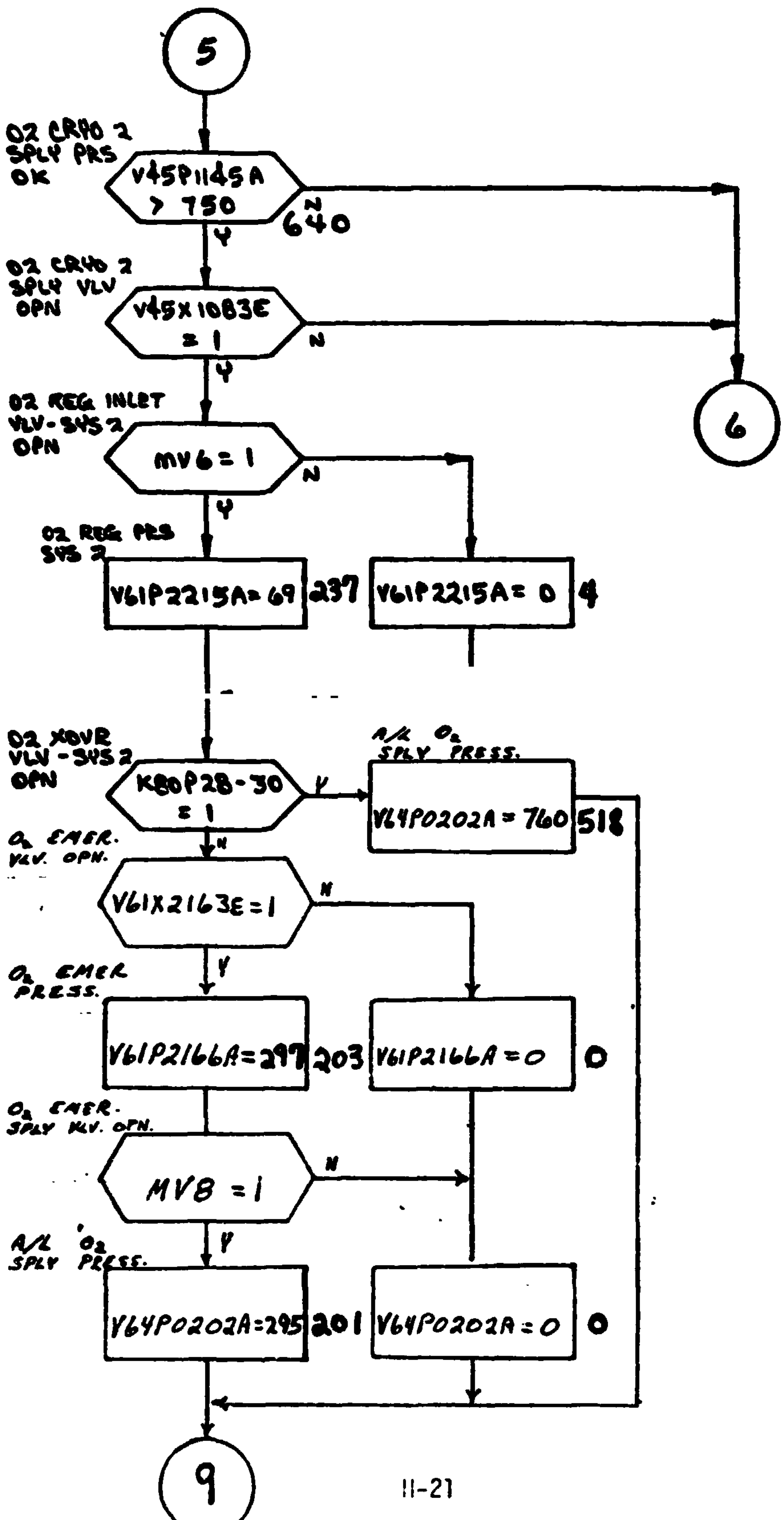


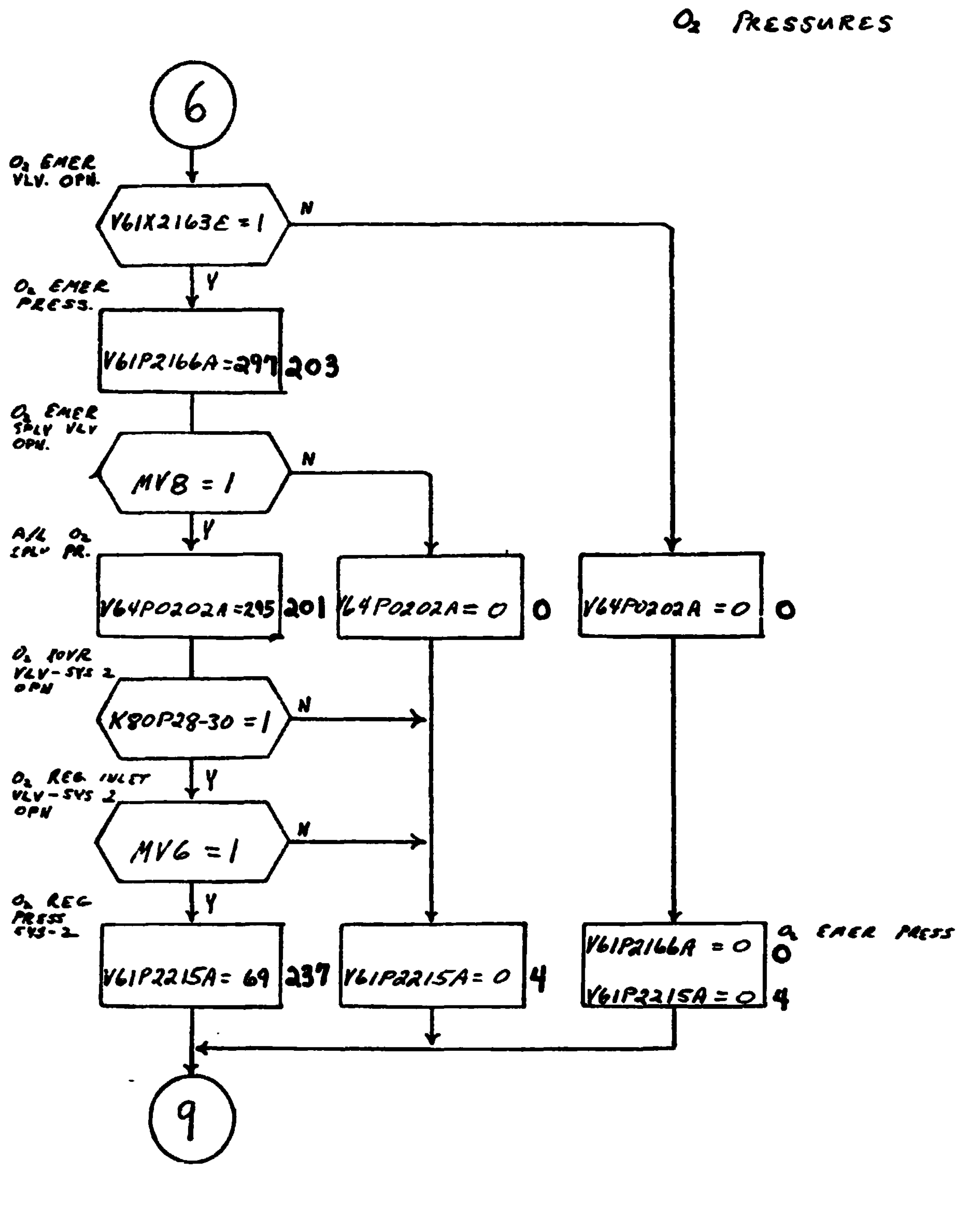
O2 PRESSURES

3 TO 9 .



O2 PRESSURES
3 TO 9

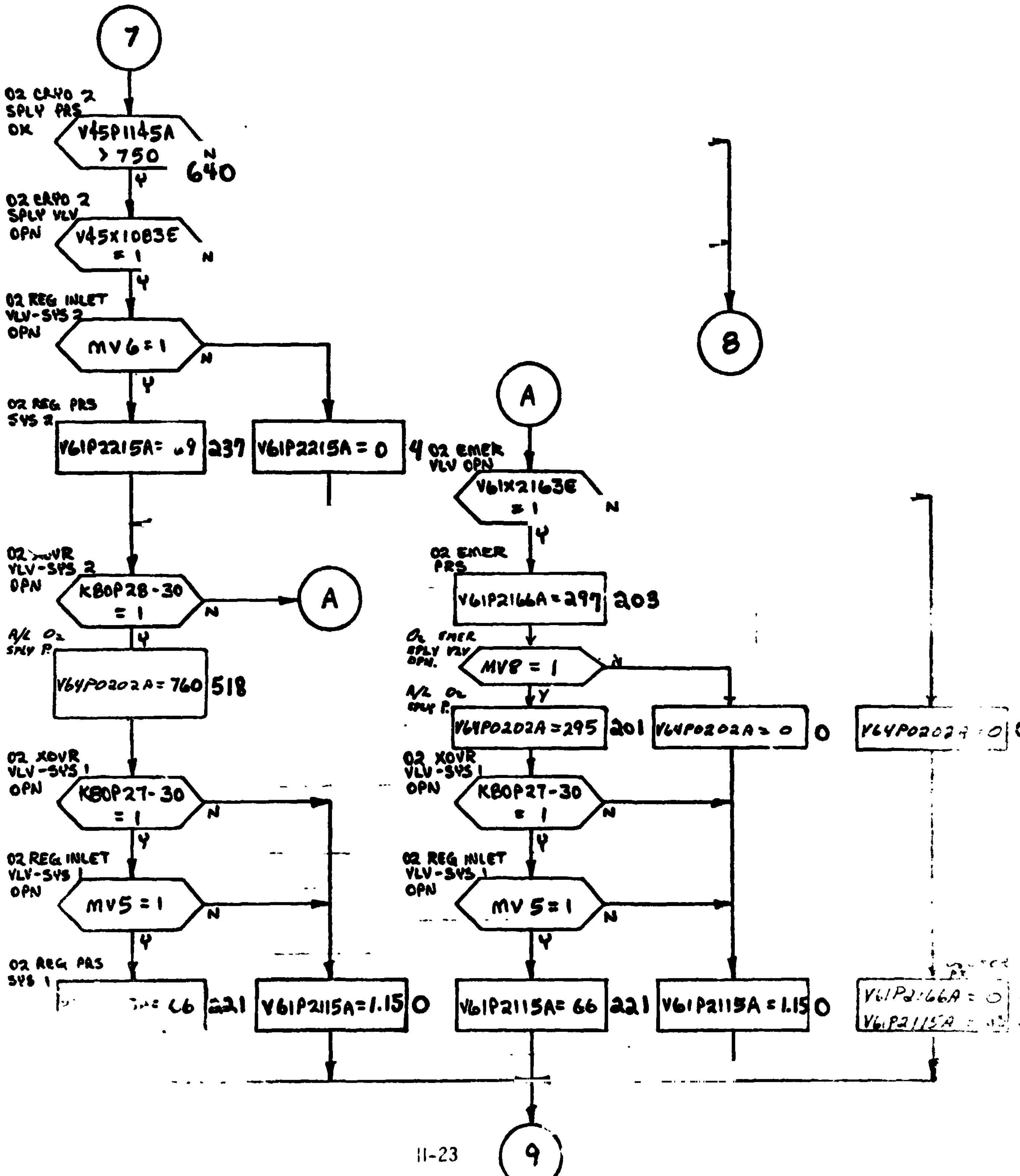




O_2 PRESSURES
6
O_2 EMER VLV. OPN.
V61X2163E = 1
N
Y
O_2 EMER PRESS.
V61P2166A = 297 203
O_2 EMER SPLY VLV OPN.
MV8 = 1
N
Y
A/L O_2 SPLY PR.
V64P0202A = 295 201
V64P0202A = 0 0
V64P0202A = 0 0
O_2 XOVR VLV-SYS 2 OPN
K80P28-30 = 1
N
Y
O_2 REG INLET VLV-SYS 2 OPN
MV6 = 1
N
Y
O_2 REG PRESS SYS-2
V61P2215A = 69 237
V61P2215A = 0 4
V61P2166A = 0 0
V61P2215A = 0 4
O_2 EMER PRESS
9

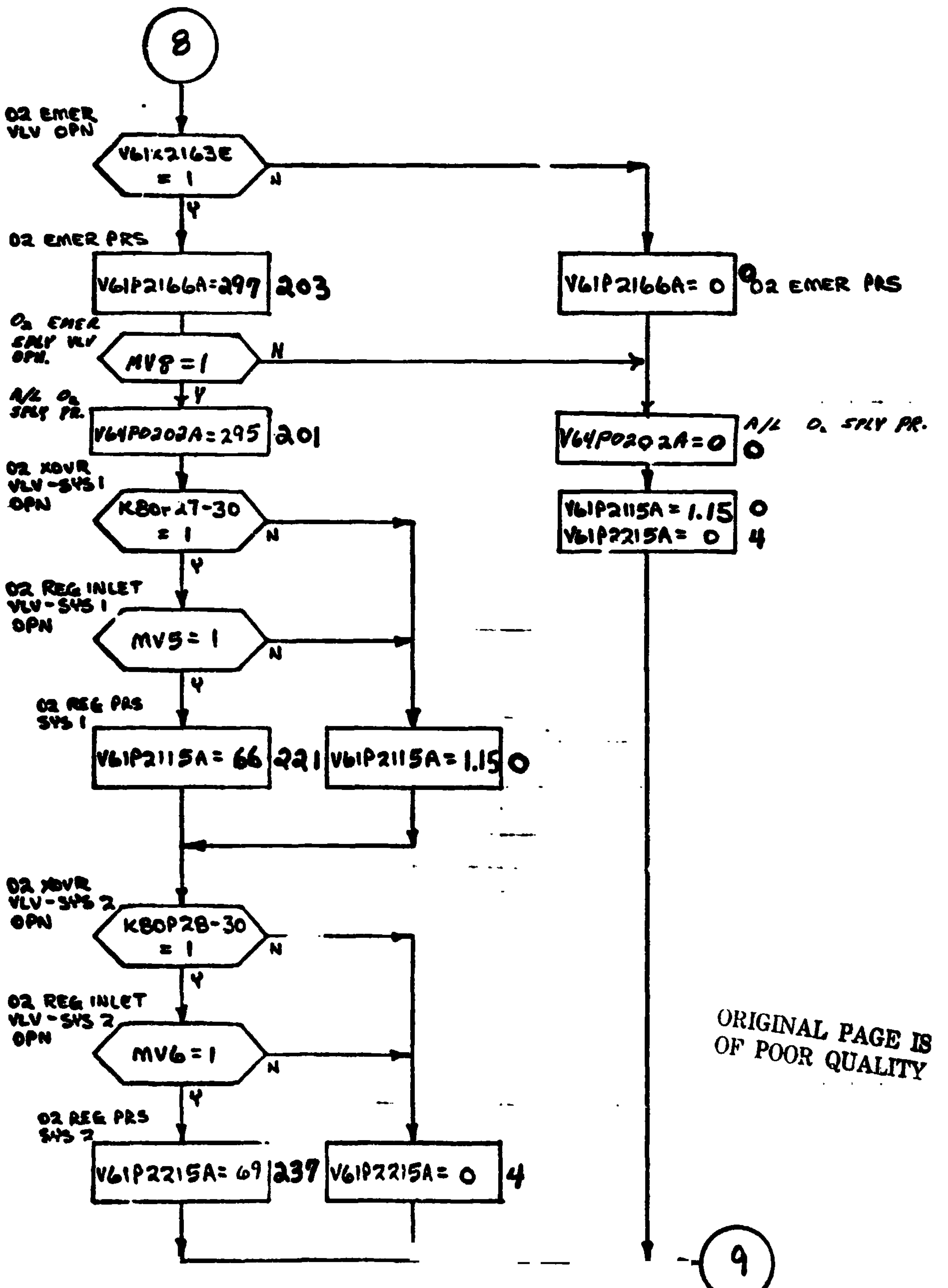
O2 PRESSURES

3 TO 9



O2 PRESSURES

3 TO 9



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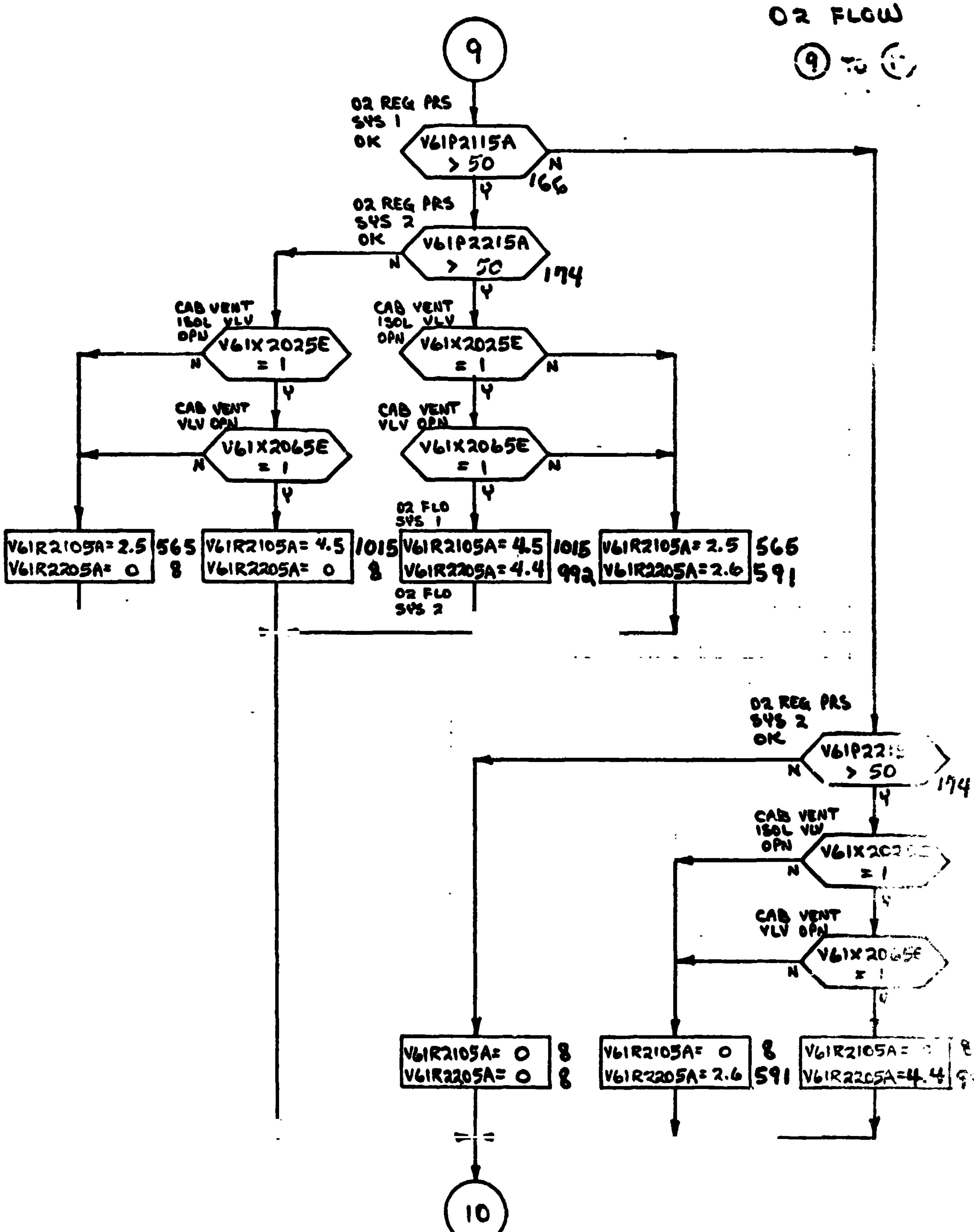
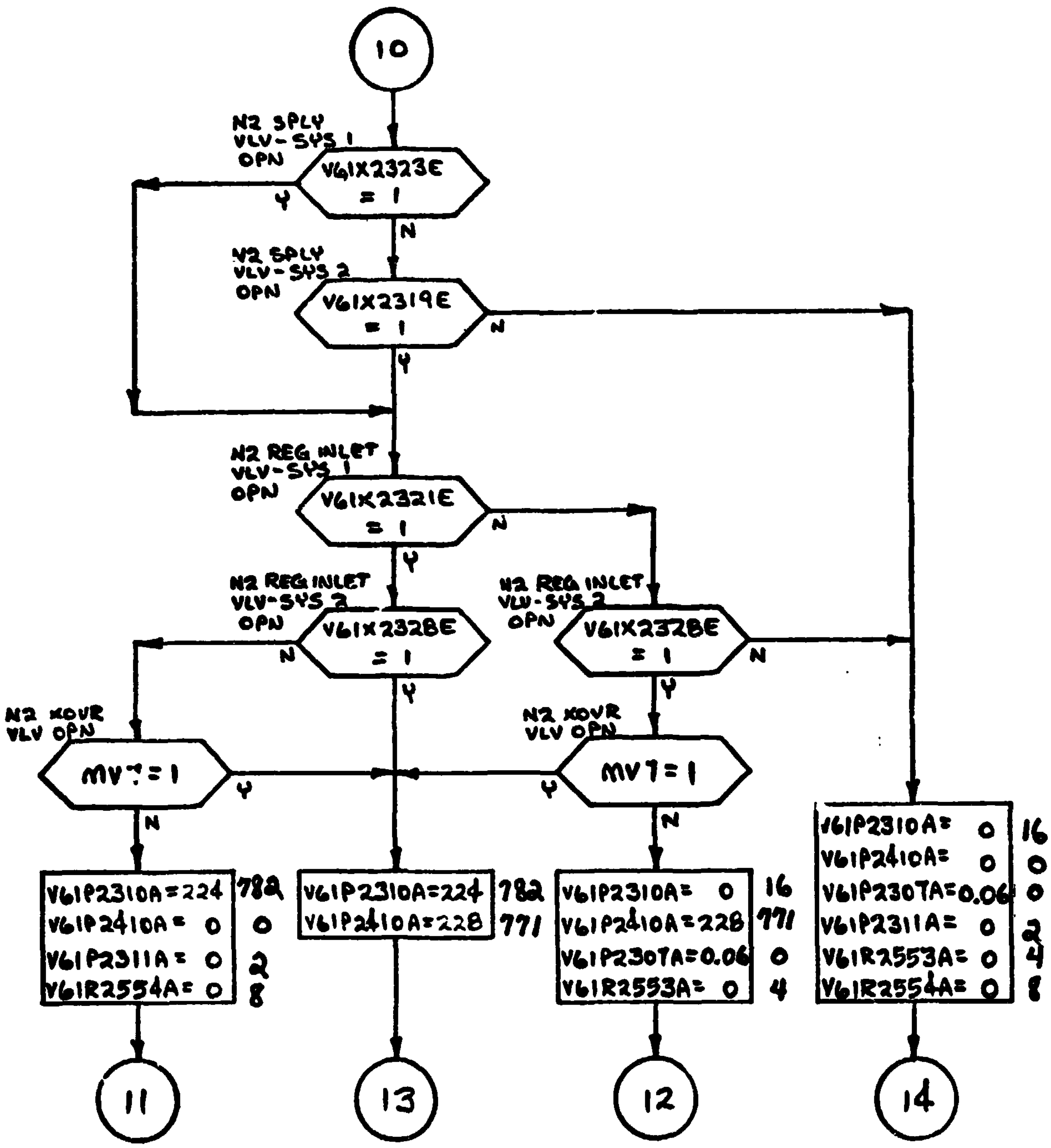
O2 FLOW

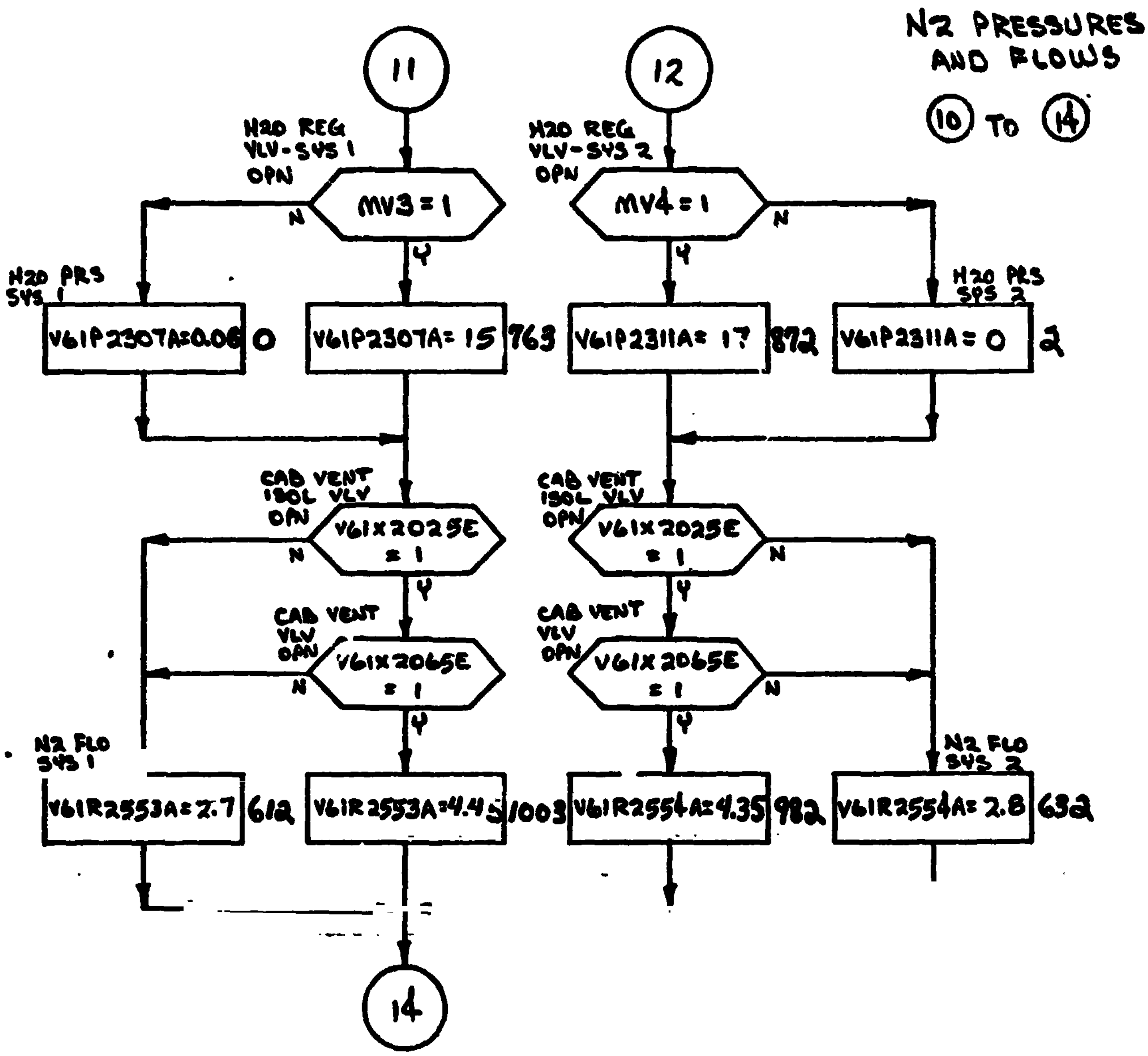
9 TO 10



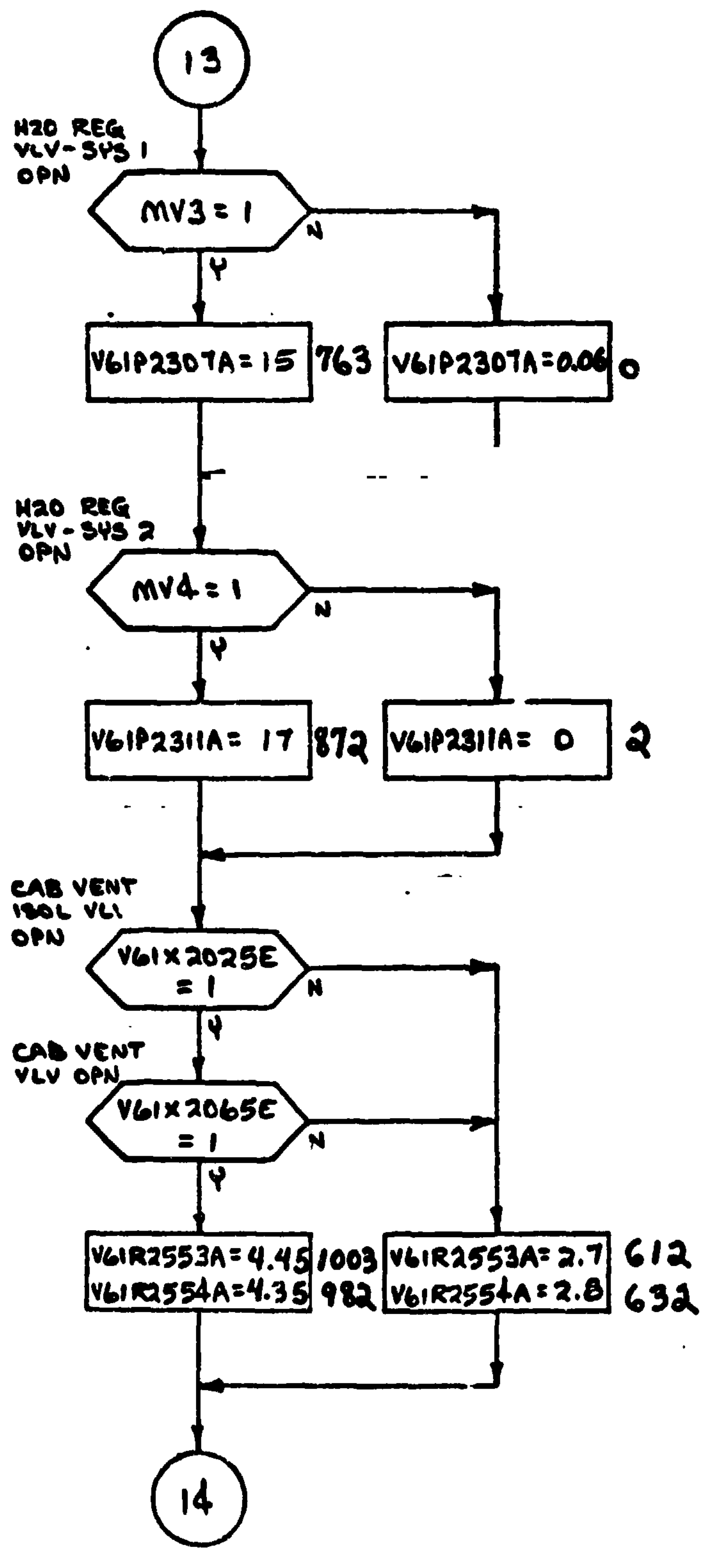
N2 PRESSURES AND FLOWS

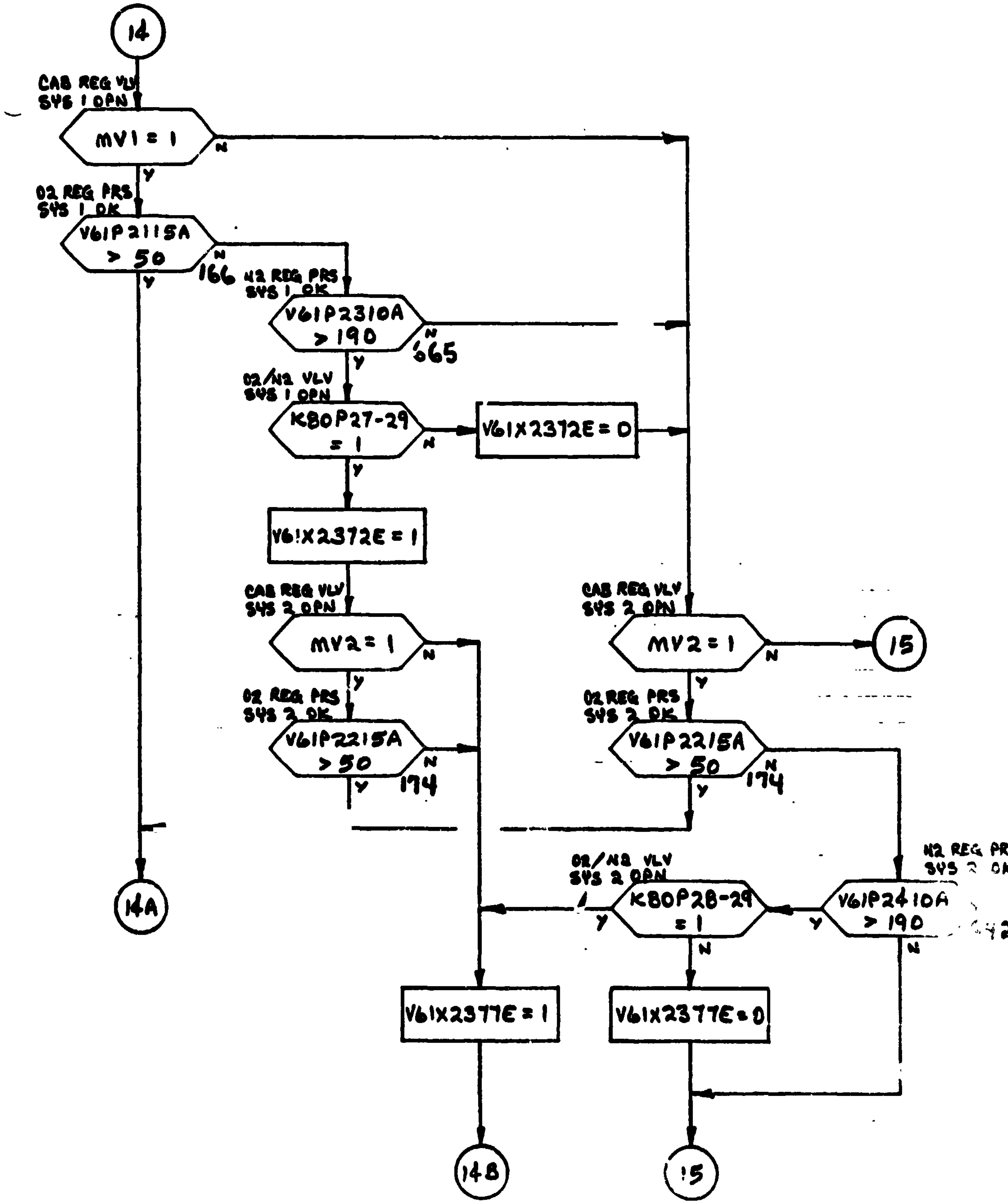
10 TO 14

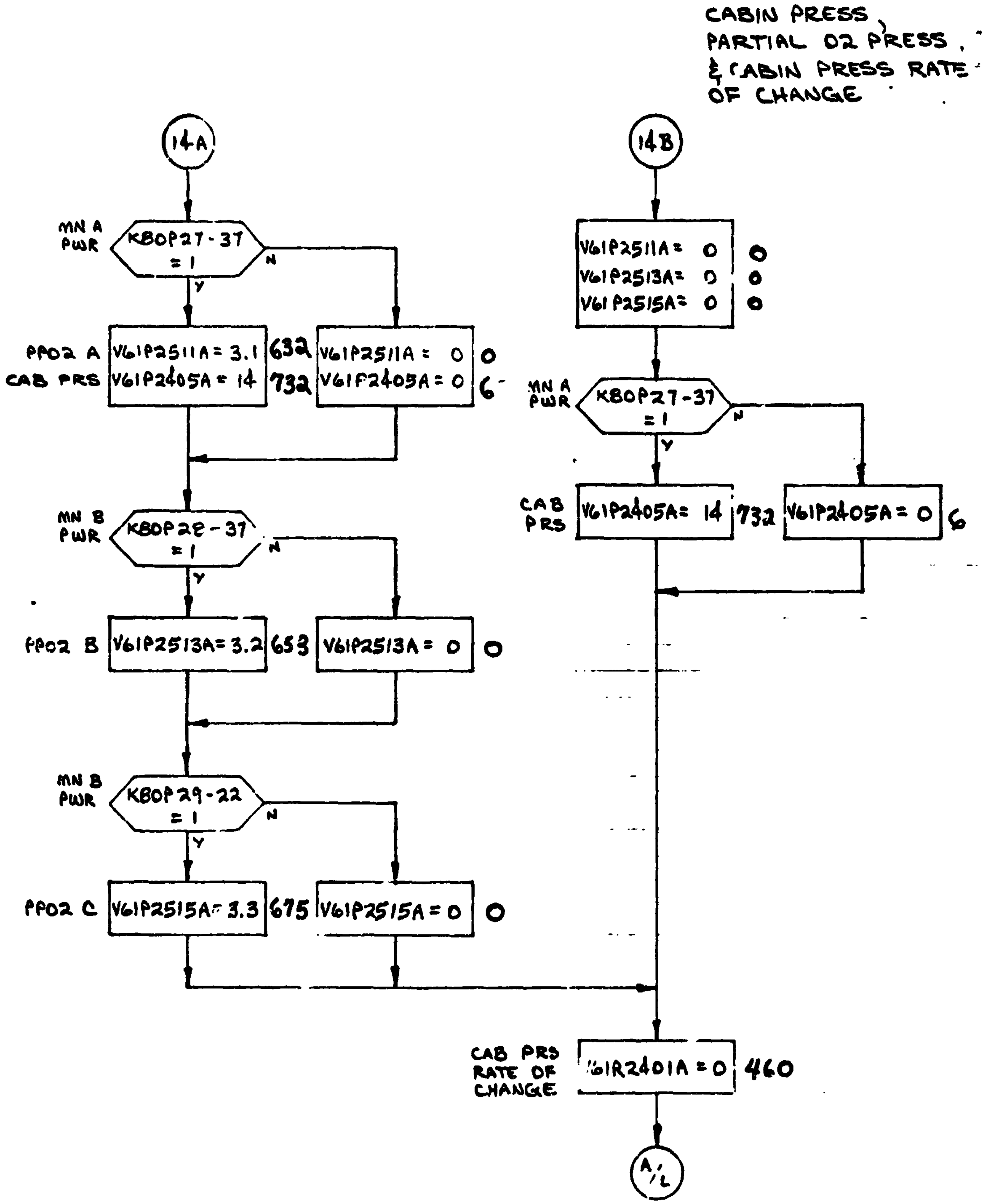


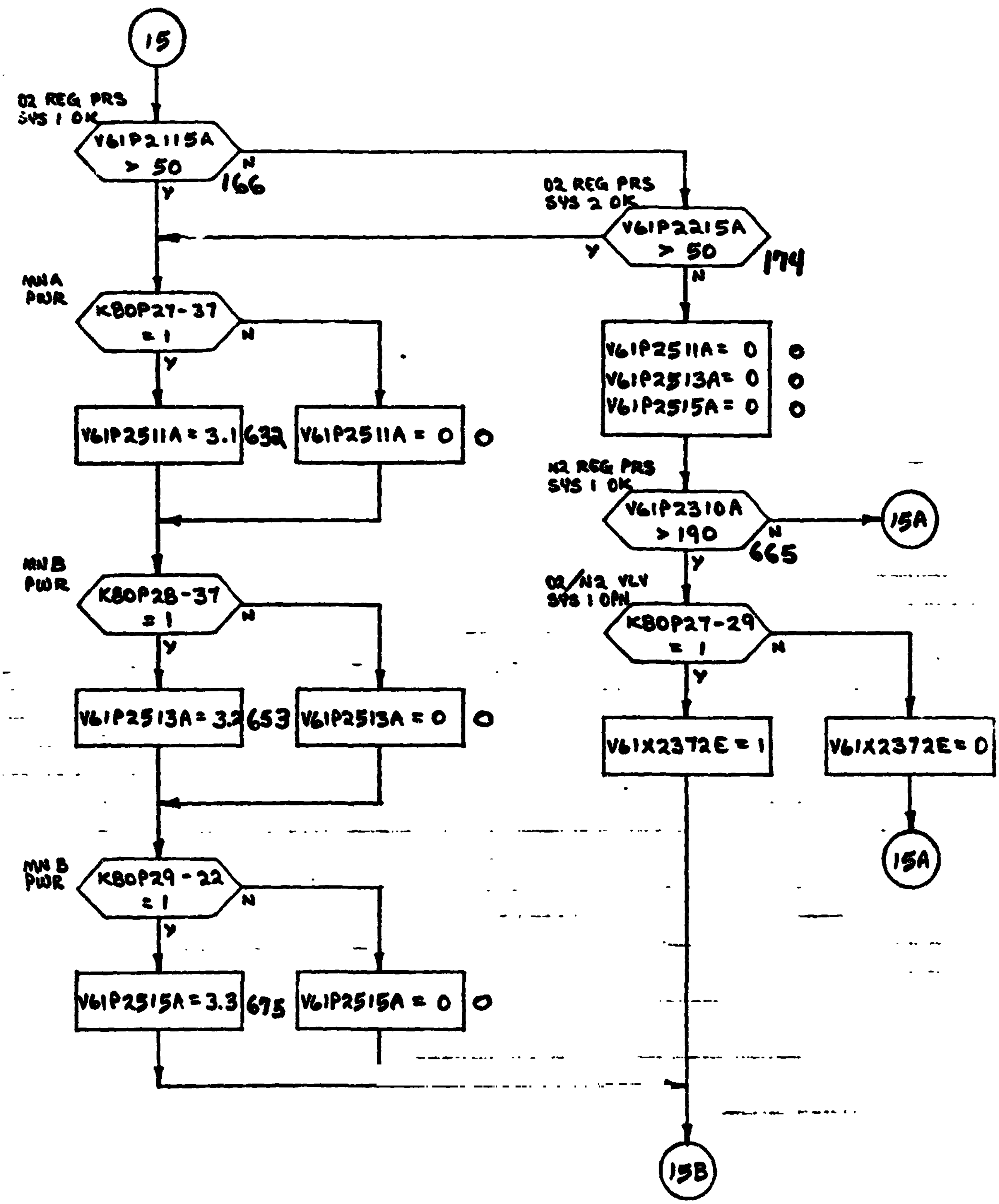

N2 PRESSURES
AND FLOWS
10 TO 14
11
12
H2O REG
VLV-SYS 1
OPN
MV3 = 1
H2O REG
VLV-SYS 2
OPN
MV4 = 1
N
Y
H2O PRS
SYS 1
V61P2307A=0.06
0
V61P2307A= 15
763
V61P2311A= 17
872
H2O PRS
SYS 2
V61P2311A= 0
2
CAB VENT
ISOL VLV
OPN
V61X2025E
= 1
CAB VENT
VLV
OPN
V61X2065E
= 1
N2 FLO
SYS 1
V61R2553A=2.7
612
V61R2553A=4.45
1003
V61R2554A=4.35
982
N2 FLO
SYS 2
V61R2554A= 2.8
632
14

N2 PRESSURES
AND FLOWS
10 TO 14



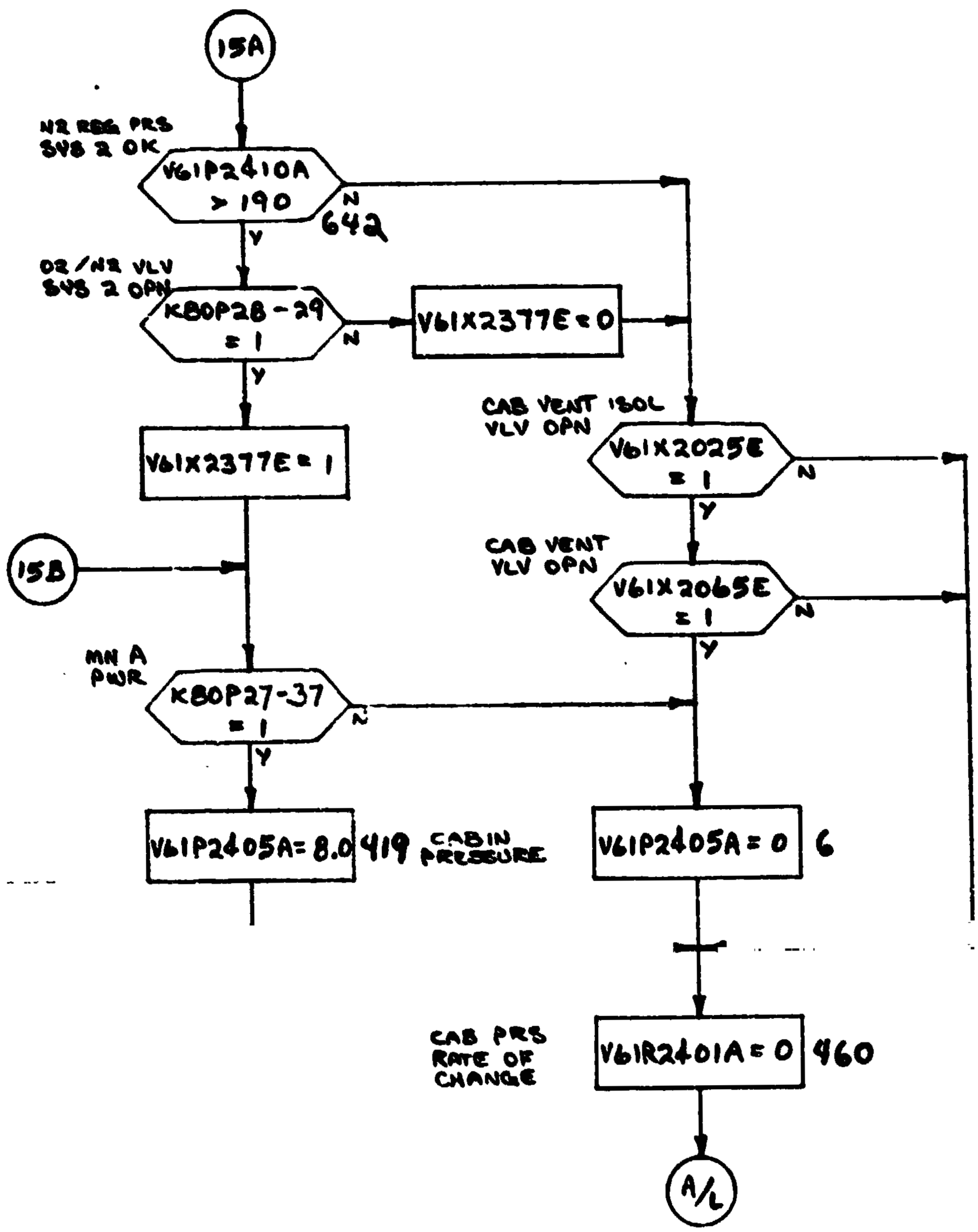

14
CAB REG VLV SYS 1 OPN
MV1 = 1
O2 REG PRS SYS 1 OK
V61P2115A > 50
166
N2 REG PRS SYS 1 OK
V61P2310A > 190
665
O2/N2 VLV SYS 1 OPN
K80P27-29 = 1
V61X2372E = 0
V61X2372E = 1
CAB REG VLV SYS 2 OPN
MV2 = 1
O2 REG PRS SYS 2 OK
V61P2215A > 50
174
CAB REG VLV SYS 2 OPN
MV2 = 1
15
O2 REG PRS SYS 2 OK
V61P2215A > 50
174
14A
O2/N2 VLV SYS 2 OPN
K80P28-29 = 1
N2 REG PRS SYS 2 OK
V61P2410A > 190
V61X2377E = 1
V61X2377E = 0
14B
15


CABIN PRESS, PARTIAL O2 PRESS, & CABIN PRESS RATE OF CHANGE
14A
MN A PWR
KBOP27-37 = 1
N
Y
PPO2 A
CAB PRS
V61P2511A = 3.1
V61P2405A = 14
632
732
V61P2511A = 0
V61P2405A = 0
0
6
MN B PWR
KBOP28-37 = 1
N
Y
PPO2 B
V61P2513A = 3.2
653
V61P2513A = 0
0
MN B PWR
KBOP29-22 = 1
N
Y
PPO2 C
V61P2515A = 3.3
675
V61P2515A = 0
0
14B
V61P2511A = 0
V61P2513A = 0
V61P2515A = 0
0
0
0
MN A PWR
KBOP27-37 = 1
N
Y
CAB PRS
V61P2405A = 14
732
V61P2405A = 0
6
CAB PRS RATE OF CHANGE
V61R2401A = 0
460
A/L


15
O2 REG PRS SYS 1 OK
V61P2115A > 50
166
O2 REG PRS SYS 2 OK
V61P2215A > 50
174
V61P2511A = 0
V61P2513A = 0
V61P2515A = 0
0
0
0
N2 REG PRS SYS 1 OK
V61P2310A > 190
665
15A
O2/N2 VLV SYS 1 OPN
K80P27-29 = 1
V61X2372E = 1
V61X2372E = 0
15A
MN A PWR
K80P27-37 = 1
V61P2511A = 3.1
632
V61P2511A = 0
0
MN B PWR
K80P28-37 = 1
V61P2513A = 3.2
653
V61P2513A = 0
0
MN B PWR
K80P29-22 = 1
V61P2515A = 3.3
675
V61P2515A = 0
0
15B
Y
N

EMERGENCY
CABIN PRESS,

& PRESS RATE OF
CHANGE



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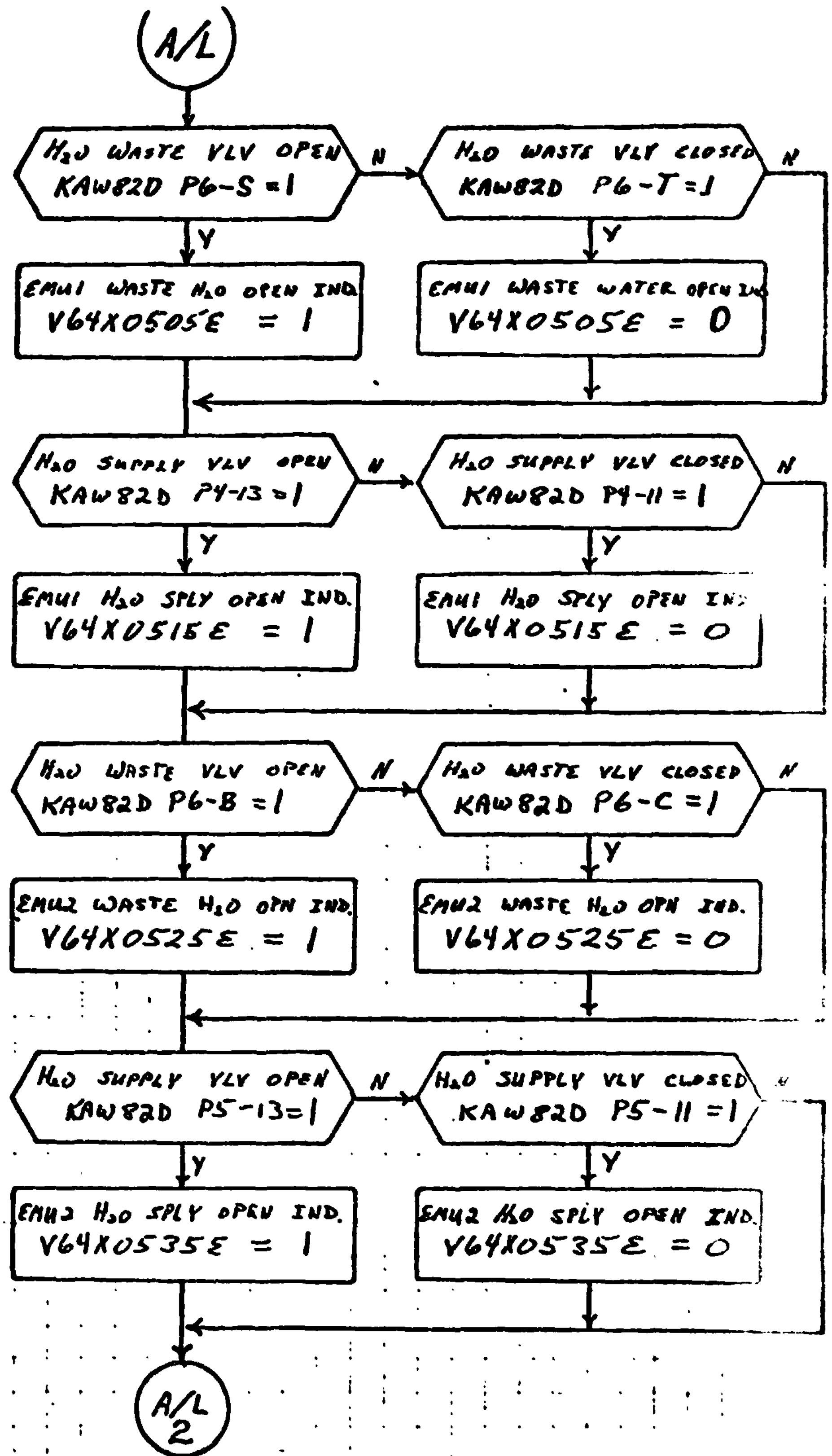
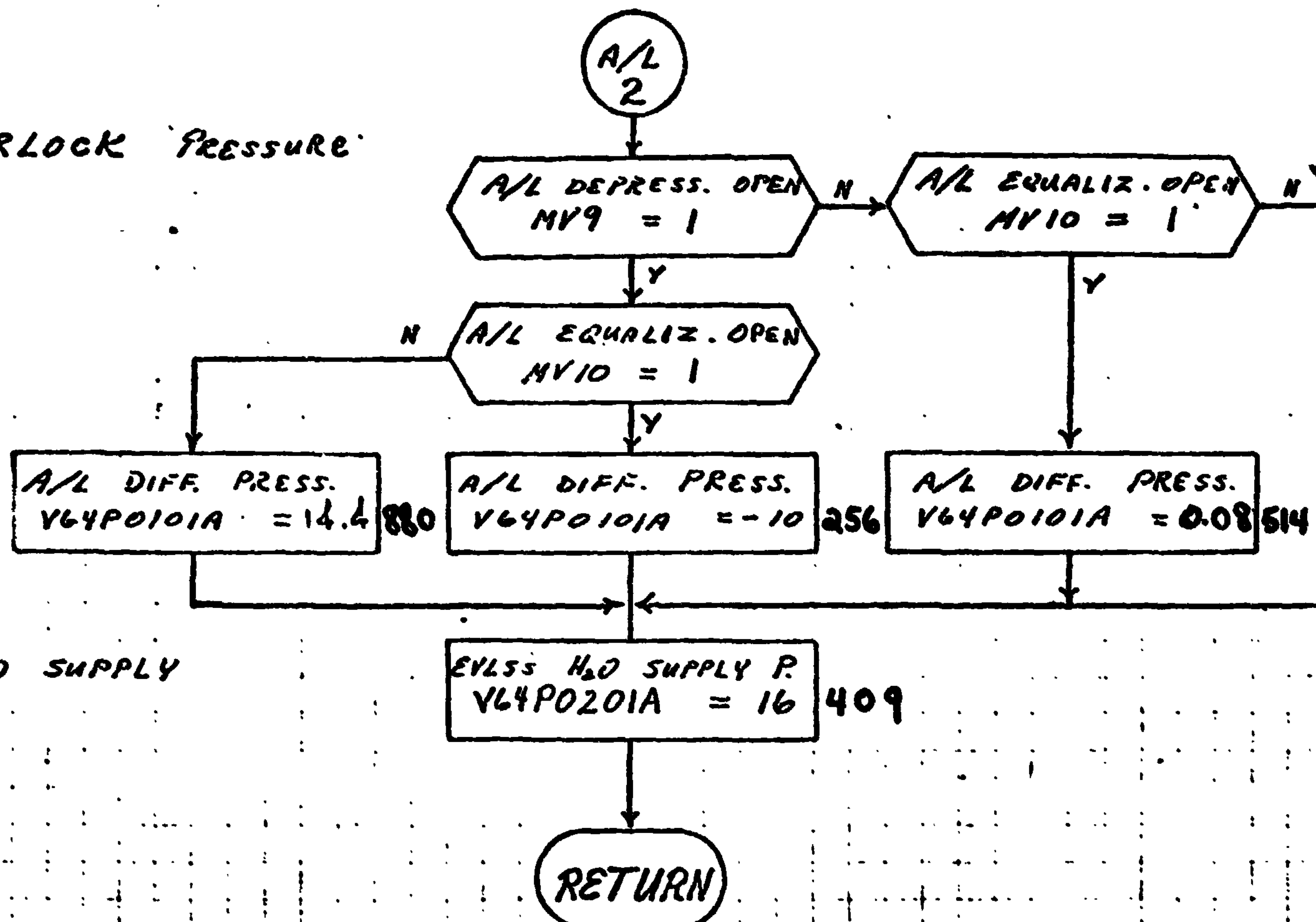
AIRLOCK EMU1

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	O2/N2 Cont VLV SYS 1-Open, Auto	FLT SYS	0	1	State
K80P27-30	O2/SYS 1 XOVR VLV CMD-Open	FLT SYS	0	1	State
K80P28-29	O2/N2 Cont VLV SYS 2-Open, Auto	FLT SYS	0	1	State
K80P28-30	O2 SYS 2 XOVR 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	O2 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	O2 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 O2 REG Inlet VLV CMD-Open	DCM OPER	0	1	State
MV6	SYS 2 O2 REG Inlet VLV CMD-Open	DCM OPER	0	1	State
MV7	N2 XOVR VLV CMD-Open	DCM OPER	0	1	State
MV8	O2 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	UNITS
KAW82D	P6-S	EMU 1 WASTE H_2O VLV - OPEN	FLT SYS	0	1	STATE
KAW82D	P6-T	EMU 1 WASTE H_2O VLV - CLOSED	FLT SYS	0	1	STATE
KAW82D	P4-13	EMU 1 H_2O SUPPLY VLV - OPEN	FLT SYS	0	1	STATE
KAW82D	P4-11	EMU 1 H_2O SUPPLY VLV - CLOSED	FLT SYS	0	1	STATE
KAW82D	P6-B	EMU 2 WASTE H_2O VLV - OPEN	FLT SYS	0	1	STATE
KAW82D	P6-C	EMU 2 WASTE H_2O VLV - CLOSED	FLT SYS	0	1	STATE
KAW82D	P5-13	EMU 2 H_2O SUPPLY VLV - OPEN	FLT SYS	0	1	STATE
KAW82D	P5-11	EMU 2 H_2O SUPPLY VLV - CLOSED	FLT SYS	0	1	STATE

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 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	
V61X23[illegible]	N2 SYS 1 Reg Inlet VLV-Open	1	1	0	0					STATE
V61X23[illegible]E	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	02/N2 CNTLR VLV-SYS 1 Open	1	1	0	0					STATE
V61X2377E	02/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	02 Partial Press-A	3.1	632	0	0					PSIA
V61P2513A	02 Partial Press-B	3.2	653	0	0					PSIA
V61P2515A	02 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 I. 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
V61X21[illegible]E	Cabin Press RLF VLV A-Enabled	1	1	0	0					STATE
V61X2135E	Cabin Press RLF VLV B-CLOSED	0	0	1	1					STATE
V61X2136E	Cabin Press RLF VLV B-ENABLED	1	1	0	0					STATE
V61P2161A	EMER O2 Tank Press	2058	579							PSIA
V61X2163E	O2 EMER VLV-Open	0	0	1	1					STATE
V61X2165E	O2 EMER VLV-Close	1	1	0	0					STATE
V61P2166A	EMER O2 Supply Press	297	203	0	0					PSIA
V61R2205A	SYS 2 O2 Flowrate	0	8	2.6	591	4.4	992			LB/HR
V61P2215A	O2 REG Press SYS 2	0	4	69	237					PSIA
V61T2216A	EMER O2 Tank Temp	-20	223							DEGF
V61P2301A	SYS 1 N2 Supply Press	1562	450							PSIA
V61P2307A	SYS 1 N2 17 PSI Press	15	763	0.06	0					PSIG
V61P2309A	SYS 2 N2 Supply Press	1601	458							PSIA
V61P2310A	SYS 1 N2 200 PSI Press	224	782	0	16					PSIA
V61P2311A	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	
	-AIRLOCK-									
V64P01[illegible]A	AIRLOCK DIFFERENTIAL PRESS	14.4	880	-10	256	0.08	514			PSID
*V64P0201A	EVLSS H20 SUPPLY PRESS	16	409							PSIG
*V64P0202A	EVLSS 02 SUPPLY PRESS	760	518	295	201	0	0			PSIA
V64X0505E	EMU 1 H20 WASTE-OPEN	0	0	1	1					STATE
V64X0515E	EMU 1 H20 SUPPLY-OPEN	0	0	1	1					STATE
V64X0525E	EMU 2 H20 WASTE-OPEN	0	0	1	1					STATE
V64X0535E	EMU 2 H20 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-B-10100-1/JSC-11174, Space Shuttle Systems Handbook OV-102.

VS70-610202, Schematic Diagram-Atmosphere Revitalization/Pressure Control System.

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

SD76-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

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 - H_2O 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):

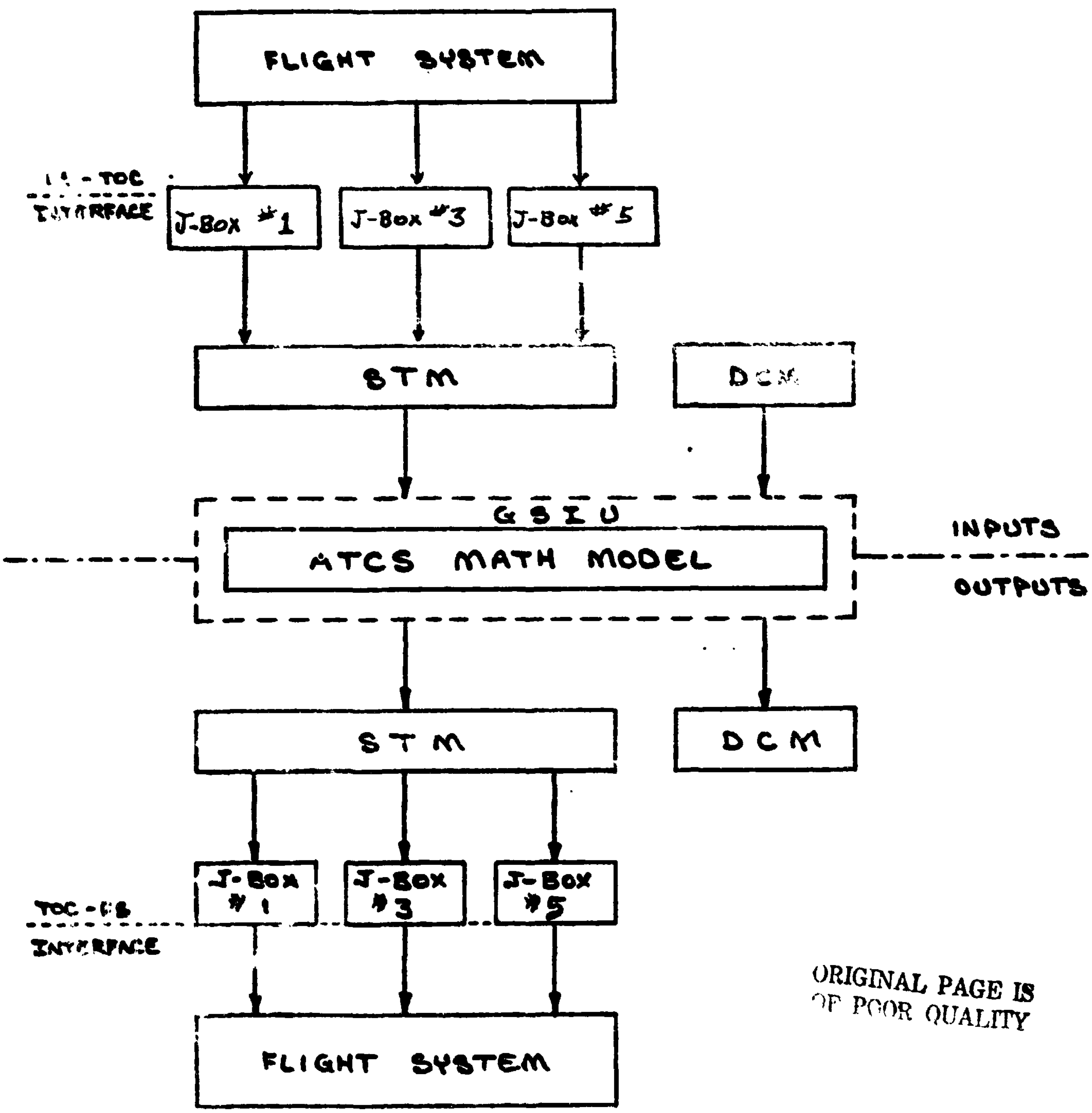
1) The Flight System (FS) via the Signal Termination Module (STM).
2) The TOC DCM.

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

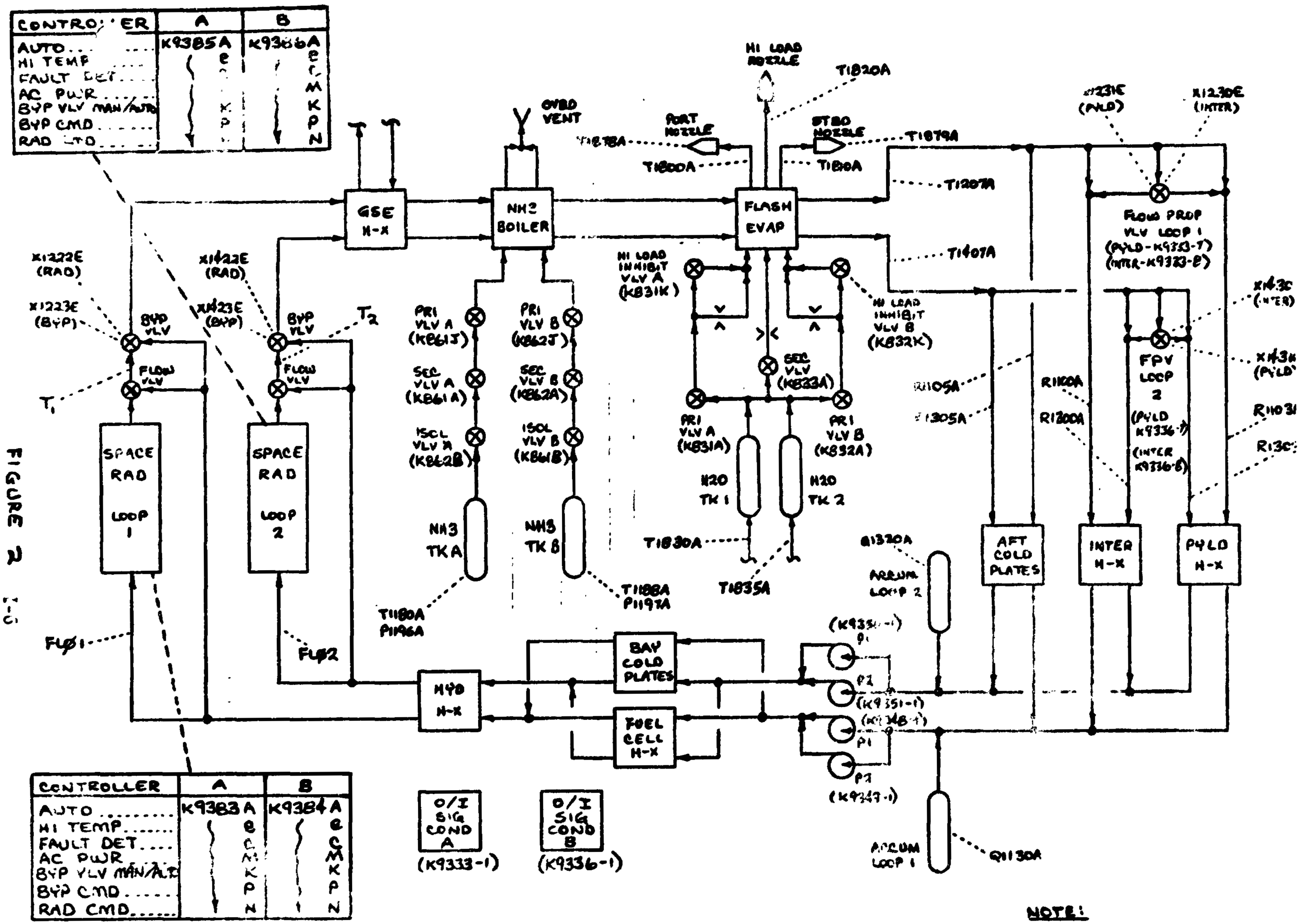
The stimuli identification for those stimuli which have their sources at the flight system via the STM are coded in terms reference Avionics Test Article (ATA) interface connector and pin number according to the following format.

```
K  50  PXXX - X
|  |    |     |
|  |    |     └──────── PIN NUMBER (FLIGHT CABLE)
|  |    |
|  |    └────────────── CONNECTOR NUMBER (P FOLLOWED BY 3 or 4 DIGITS)
|  |
|  └─────────────────── AREA DESIGNATOR
|
└────────────────────── STIMULI DESIGNATOR
```

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:



FREON COOLANT LOOPS

NOTE:
K DESIGNATES STIMULUS

FIGURE 2

I-6

- 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:

	FLAGS		
PHASE	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 calcula*e 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:

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

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

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

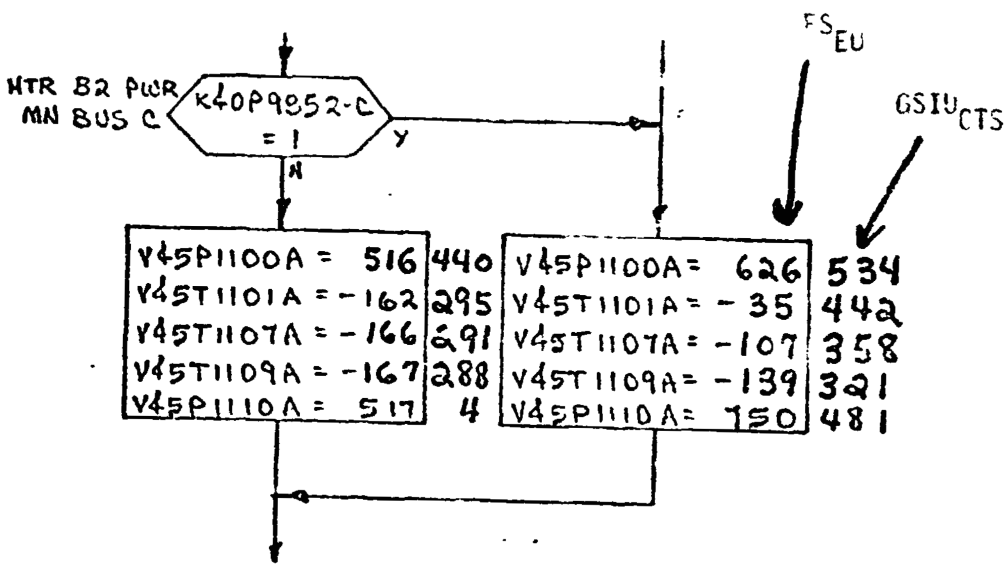
High = Range high limit

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

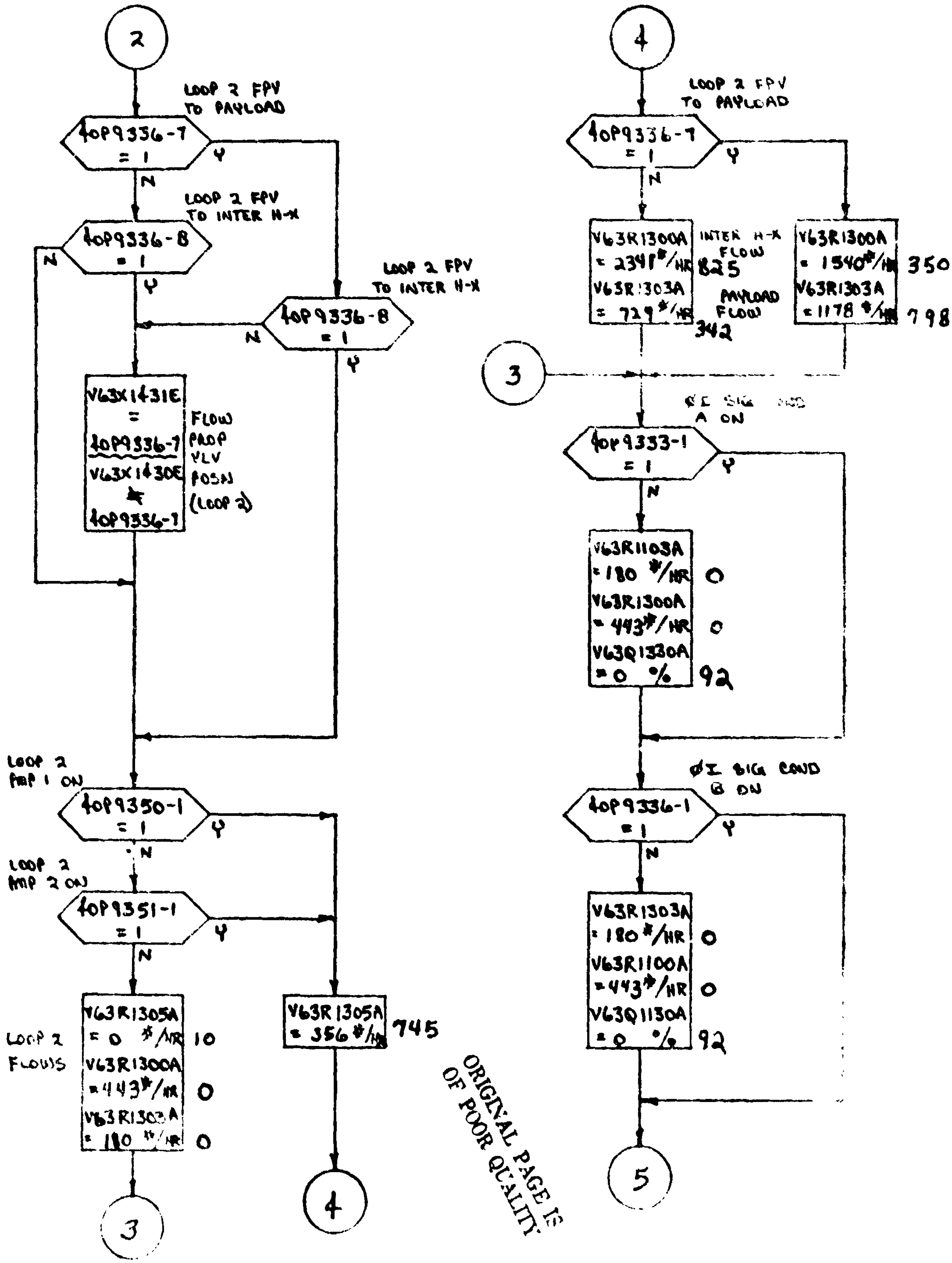
3.0 LOGIC FLOW DIAGRAMS

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



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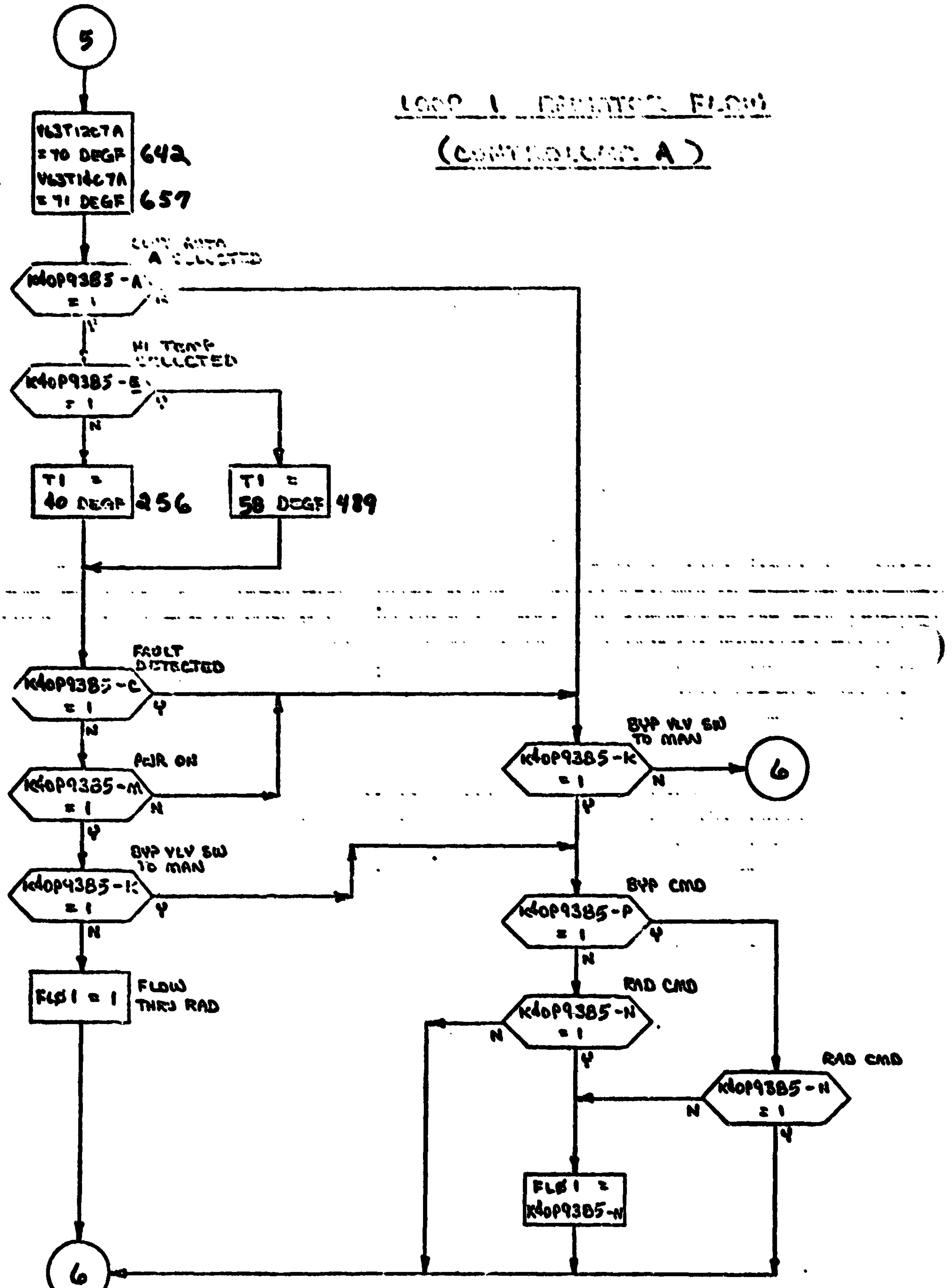
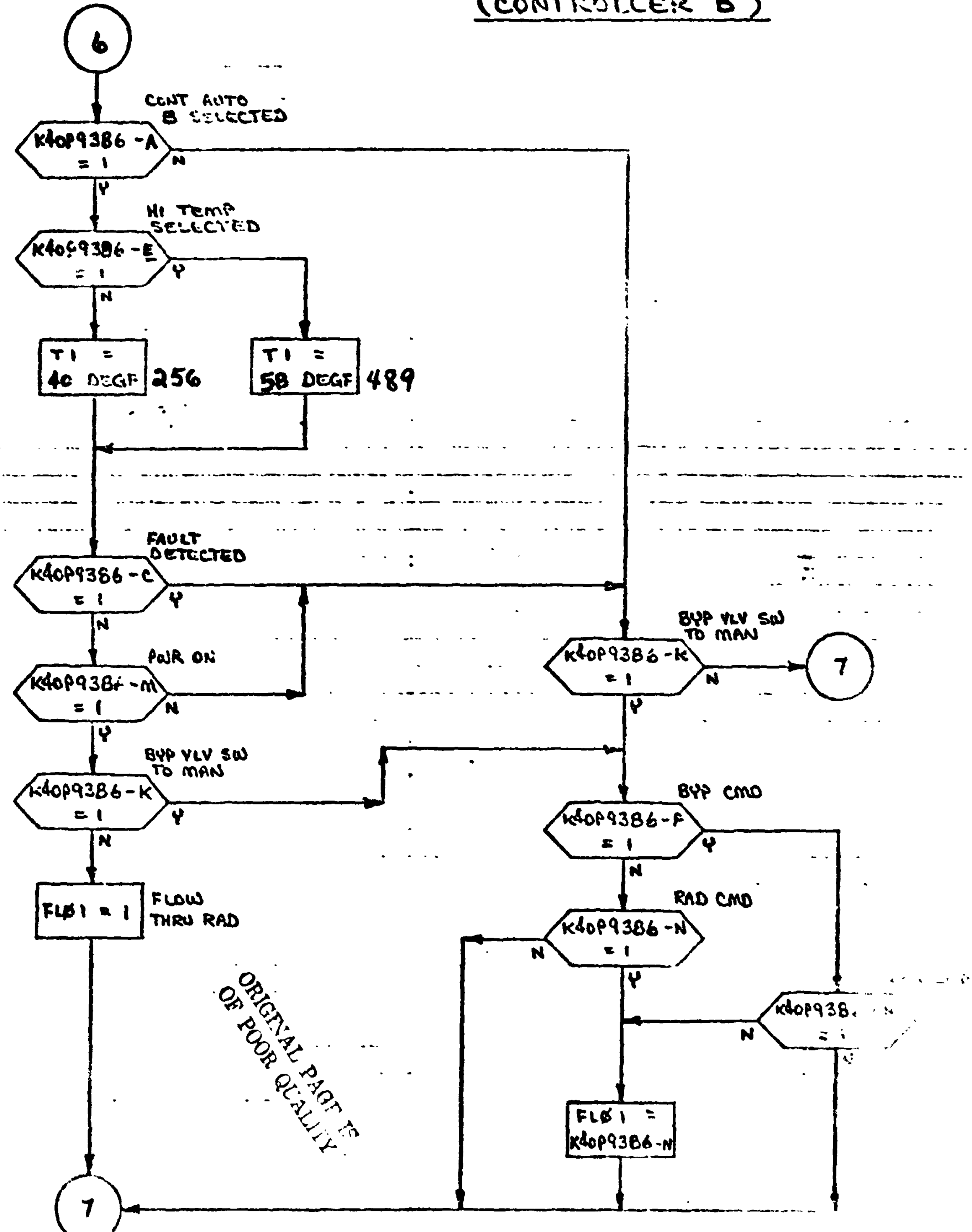
LOOP 1 RADIATOR FLOW

(CONTINUATION A)



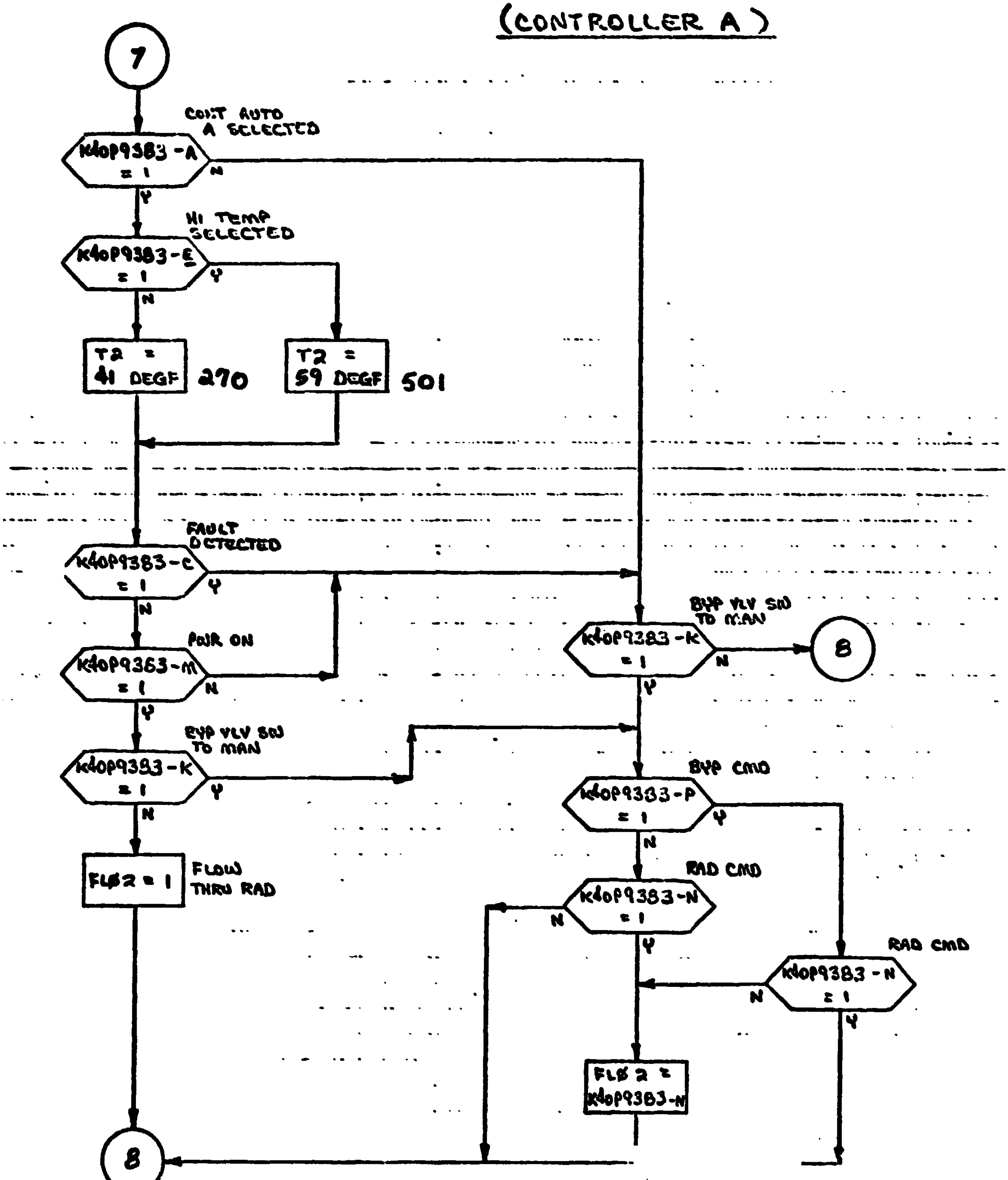
LOOP 1 RADIATOR FLOW

(CONTROLLER B)



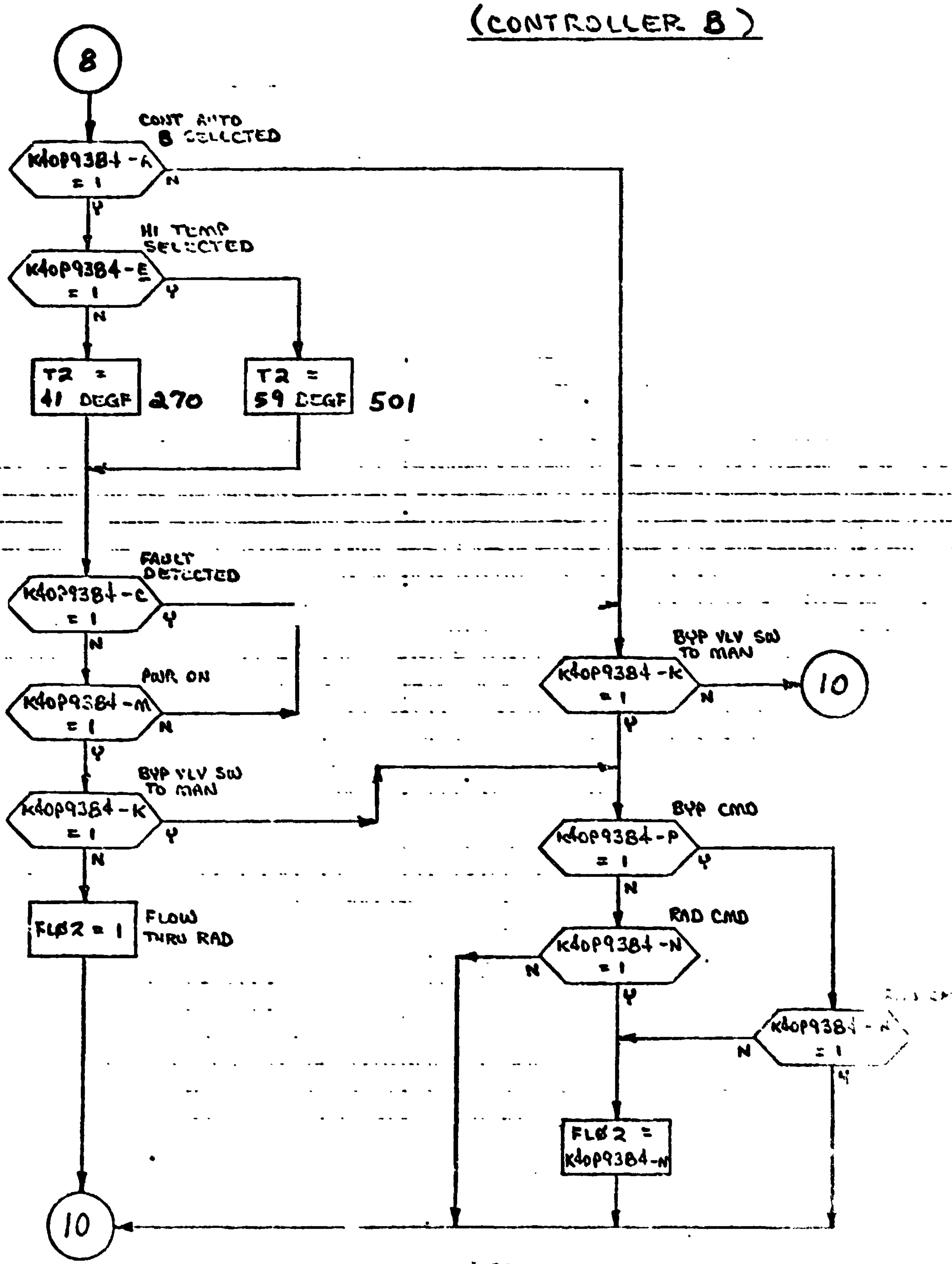
LOOP 2 RADIATOR FLOW

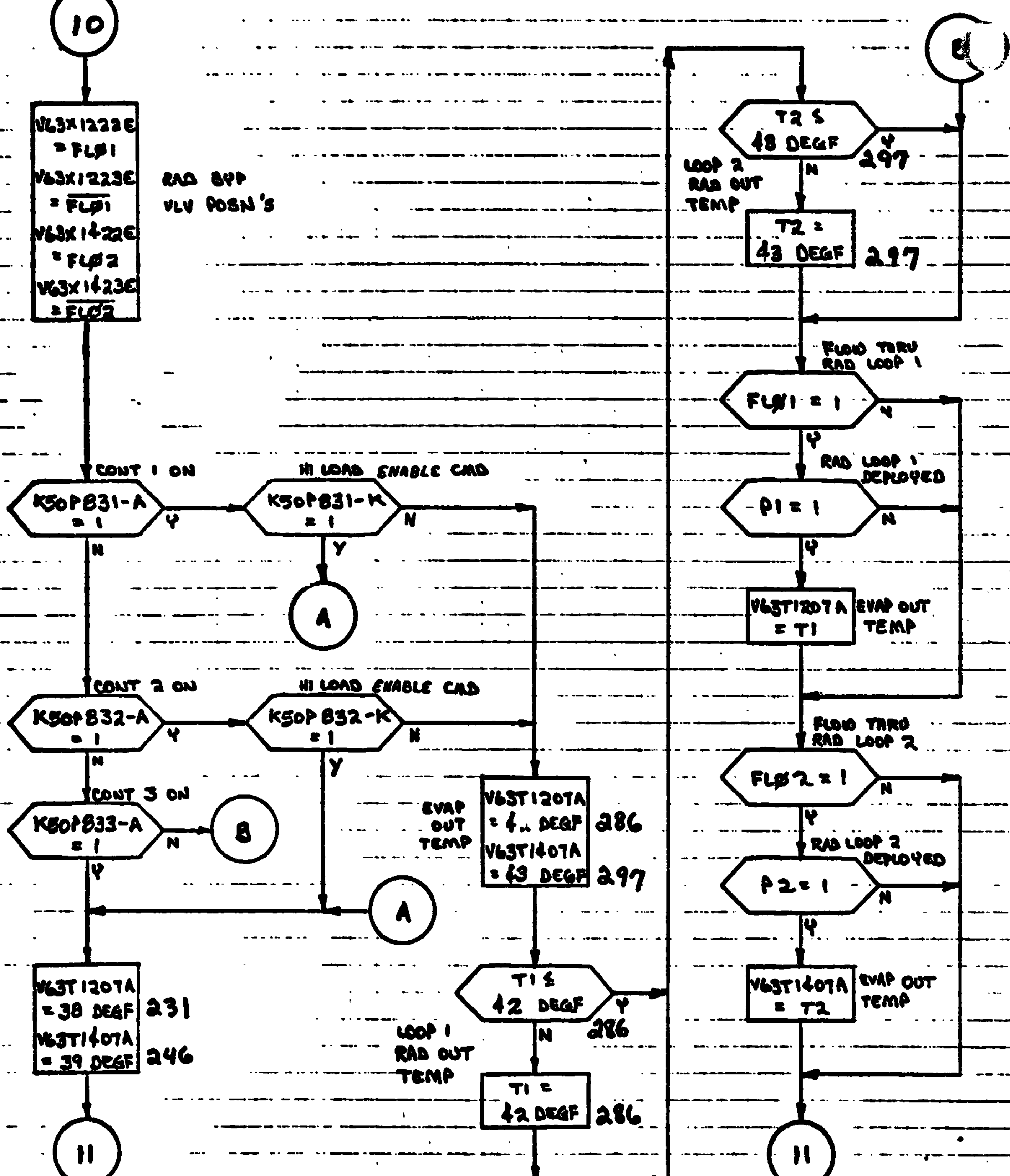
(CONTROLLER A)



LOOP 2 RADIATOR FLOW

(CONTROLLER B)





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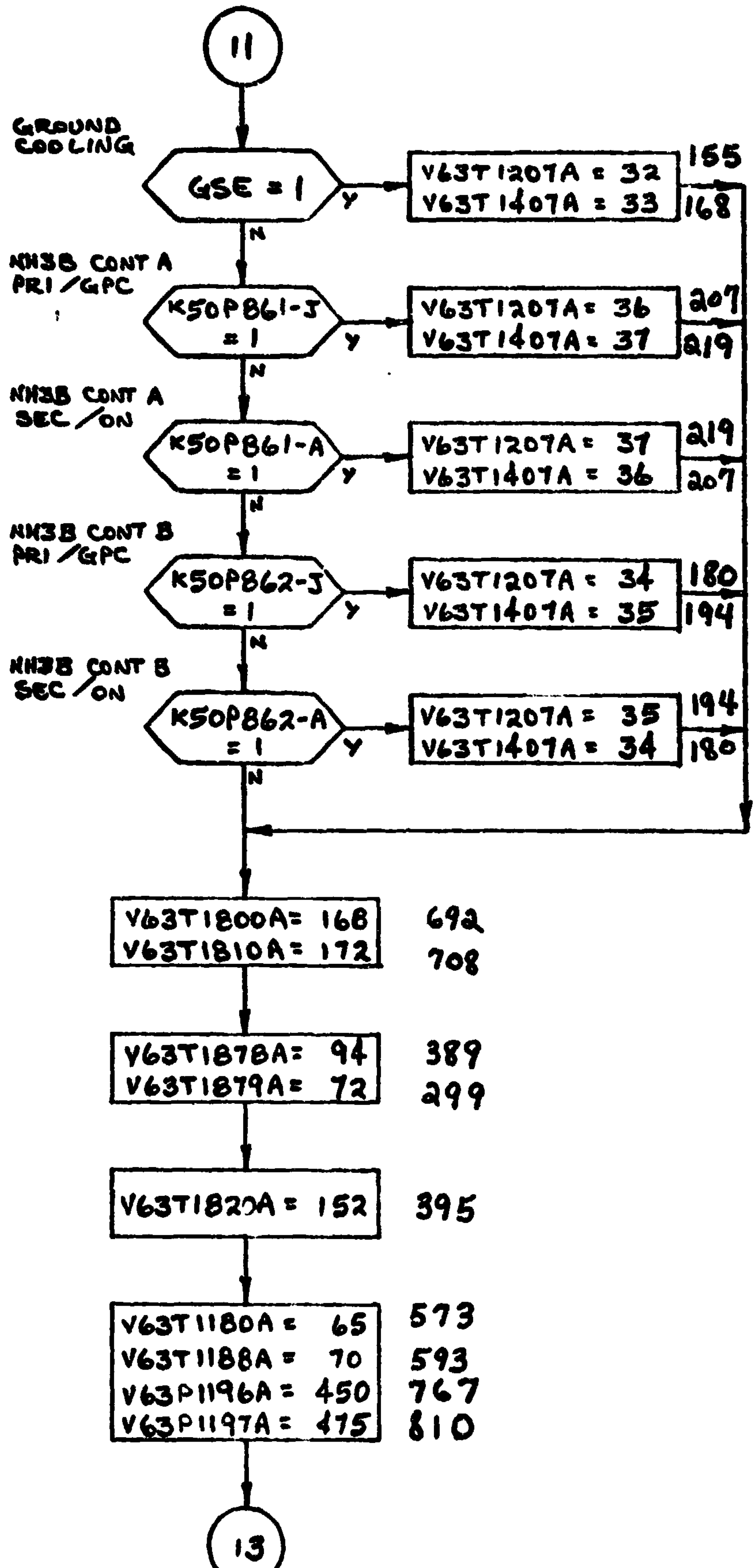
11
GROUND COOLING
GSE = 1
V63T1207A = 32
V63T1407A = 33
155
168
NH3B CONT A PRI/GPC
K50PB61-J = 1
V63T1207A = 36
V63T1407A = 37
207
219
NH3B CONT A SEC/ON
K50PB61-A = 1
V63T1207A = 37
V63T1407A = 36
219
207
NH3B CONT B PRI/GPC
K50PB62-J = 1
V63T1207A = 34
V63T1407A = 35
180
194
NH3B CONT B SEC/ON
K50PB62-A = 1
V63T1207A = 35
V63T1407A = 34
194
180
Y
N
V63T1800A = 168
V63T1810A = 172
692
708
V63T1878A = 94
V63T1879A = 72
389
299
V63T1820A = 152
395
V63T1180A = 65
V63T1188A = 70
V63P1196A = 450
V63P1197A = 475
573
593
767
810
13

13

V63T1208A	=	100.7	739
V63T1209A	=	80	514
V63T1408A	=	109	820 DFI MEAS.
V63T1409A	=	96	616 ADDED BY
V63T1801A	=	160	415 REV. A.
V63T1802A	=	164	426
V63T1821A	=	156	405
V63T1870A	=	85	546
V63T1871A	=	89	571
V63T1872A	=	86	552
V63T1873A	=	90	577
V63T1874A	=	87	559
V63T1875A	=	91	583
V63T1876A	=	88	565
V63T1877A	=	92	591
V63T1890A	=	256	661
V63R9159A	=	420	878

RETURN

4.0 TABLES

TABLE 1 - STIMULUS ?UT TO ATCS MODEL

IDENTIFICATION NUMBER	NOMENCLATURE	SOURCE	STM ADDRESS		STATES/RANGE		
			CELL	CHANNEL	LO	HI	UNITS
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

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TABLE 1 - STIMULUS INPUT . ATCS MODEL

IDENTIFICATION NUMBER	NOMENCLATURE	SOURCE	STM ADDRESS		STATES/RANGE		
			CELL	CHANNEL	LO	HI	UNIT
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			lb/hr
V63R1103A	FCL 1 PYLD H-X FLOWRATE	701	321	180	0	1152	759			lb/hr
V63R1105A	FCL 1 COLDPLATE NETWORK FLOWRATE	348	728	0	10					lb/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 40 35	231 256 194	42 34 36	286 180 207	70 58 37	642 489 219	DEGF
V63T1208A	FCL 1 RAD OUTLET TEMP	100.7	739							DEGF
V63T1209A	FCL 1 RAD INLET TEMP	80	514							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			lb/hr
V63R1303A	FCL 2 PYLD H-X FLOWRATE	729	342	180	0	1178	798			lb/hr
V63R1305A	FCL 2 COLDPLATE NETWORK FLOWRATE	356	745	0	10					lb/hr
V63Q1330A	FCL 2 ACCUMULATOR QUANTITY	65	622	0	92					PCNT
V63T1407A	FCL 2 EVAP OUT TEMP	33	168	39 41 34	246 270 180	43 35 36	297 194 207	71 59 37	657 501 219	DEGF
V63T1408A	FCL 2 RAD OUTLET TEMP	109	820							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 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_2O FDLN TEMP 1-L	85	546							DEGF
V63T1871A	FLASH EVAP H_2O FDLN TEMP 1-R	89	571							DEGF
V63T1872A	FLASH EVAP H_2O FDLN TEMP 2-L	86	552							DEGF
V63T1873A	FLASH EVAP H_2O FDLN TEMP 2-R	90	577							DEGF
V63T1874A	FLASH EVAP H_2O FDLN TEMP 3-L	87	559							DEGF
V63T1875A	FLASH EVAP H_2O FDLN TEMP 3-R	91	583							DEGF
V63T1876A	FLASH EVAP H_2O FDLN TEMP 4-L	88	565							DEGF
V63T1877A	FLASH EVAP H_2O 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

5.0 <u>REFERENCES</u>:

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

FIGURES

J.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 (H20 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 Oribter. 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)

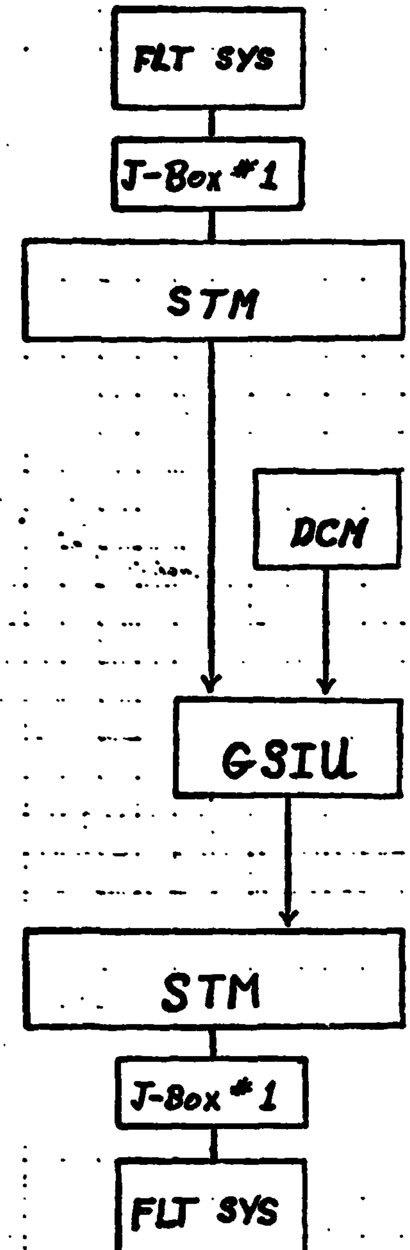
The SDS consists of several detector head (detector) assemblies. Each detector head shall sense any significant increase in the gaseous or particulate products of combustion or decomposition within the cabin or avionics bays. The logic device shall use the input and send a signal to appropriate warning 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

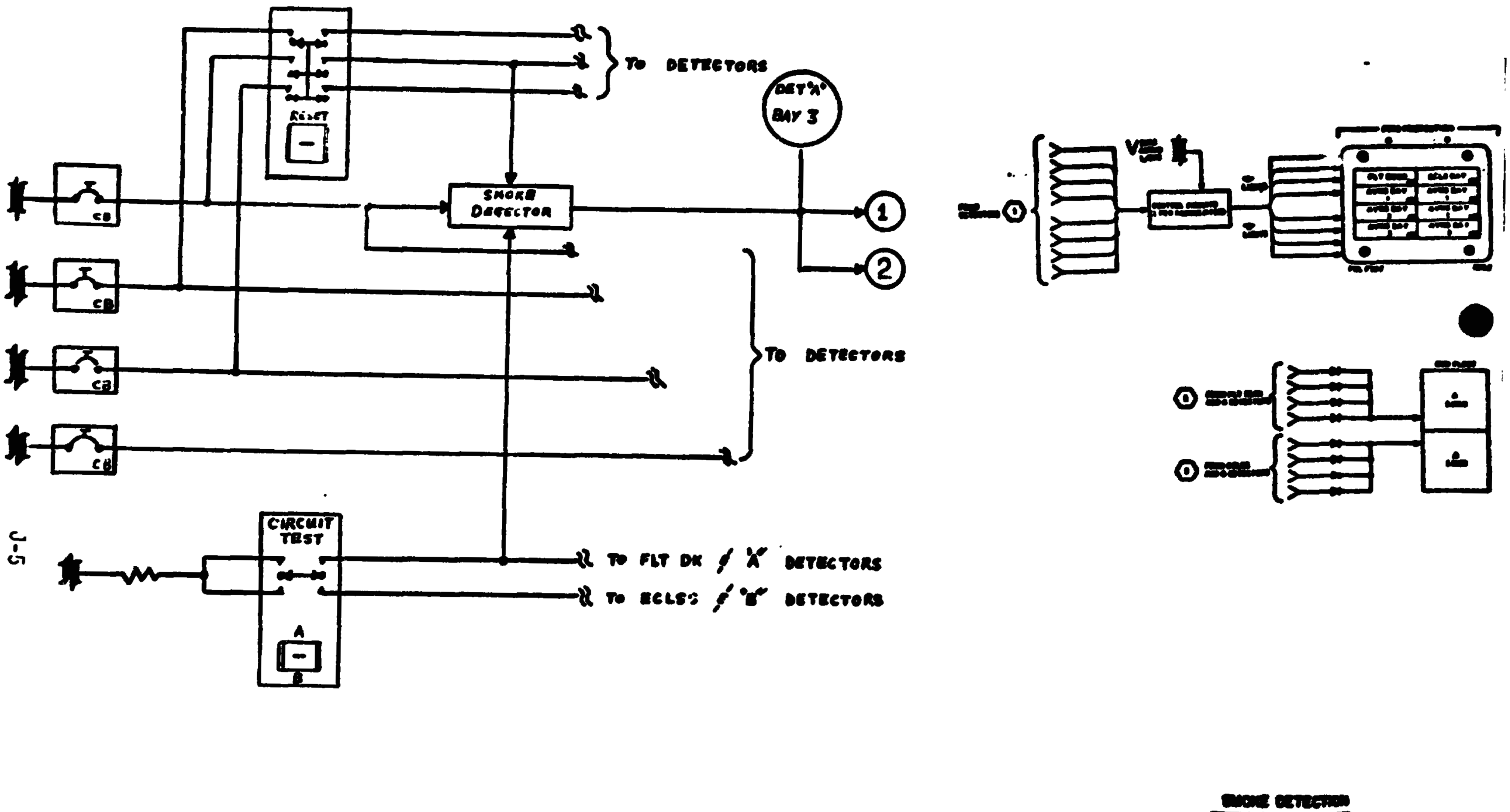

TO DETECTORS
DET "A" BAY 3
SMOKE DETECTOR
RESET
CB
CB
CB
CB
TO DETECTORS
CIRCUIT TEST
A
B
TO FLT DK / "A" DETECTORS
TO ECLSS / "B" DETECTORS
SMOKE DETECTION

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

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

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:

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

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

SO X = 3.846529

And

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

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

$$FS_{EU} = 2288.017$$

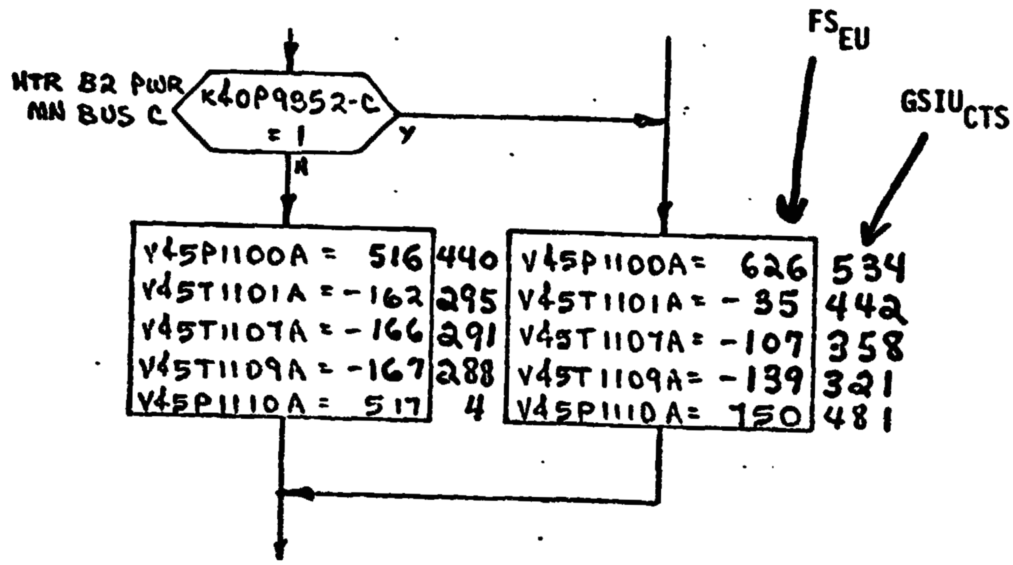
Hence when 787 GSIU counts is inserted for measurement no. V63R1100A, a value of 2288.017 FS_{EU} will result.

2.6.2 PANGE LIMIT CONVERSION METHOD

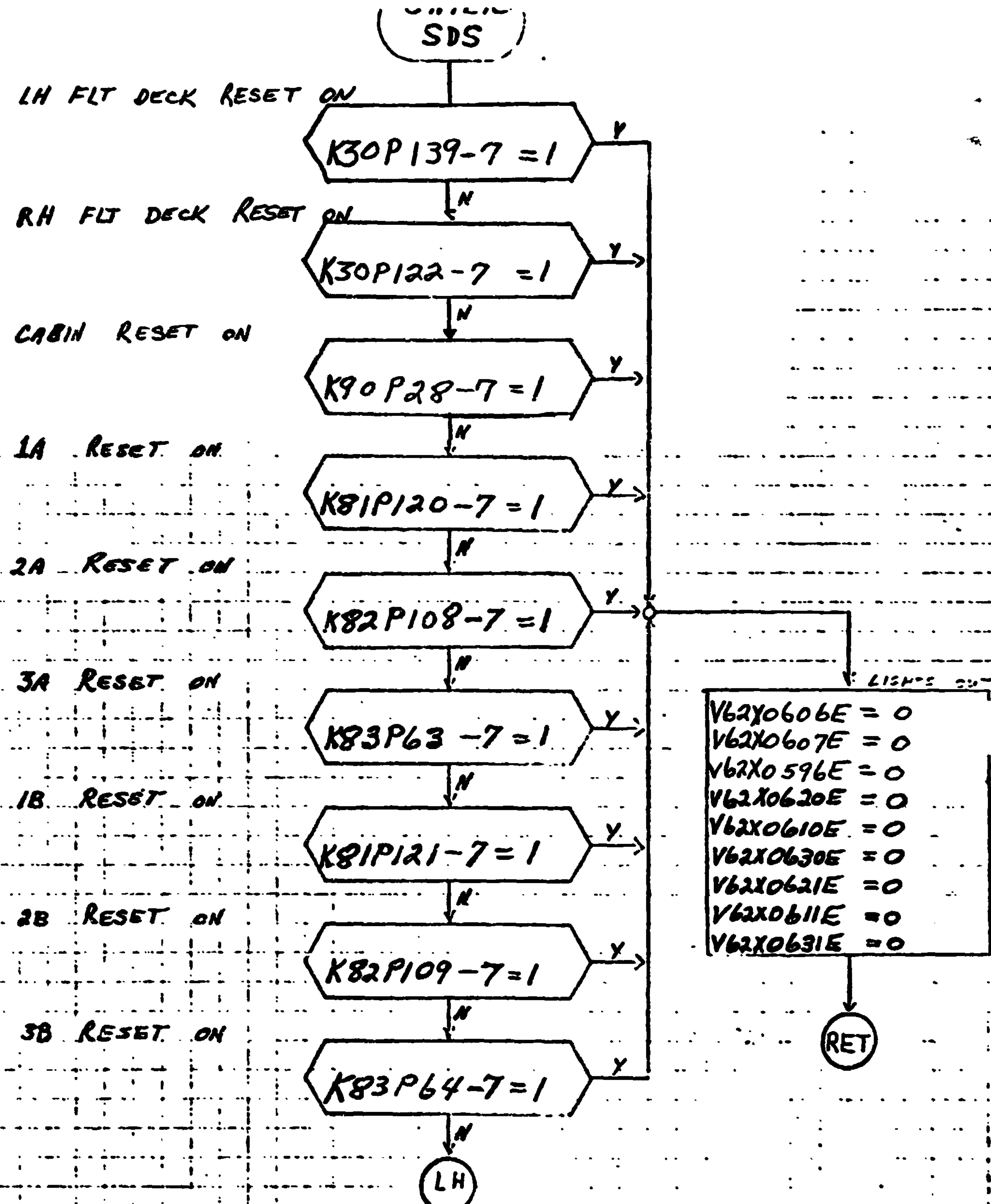
NONE.

3.0 LOGIC FLOW DIAGRAMS

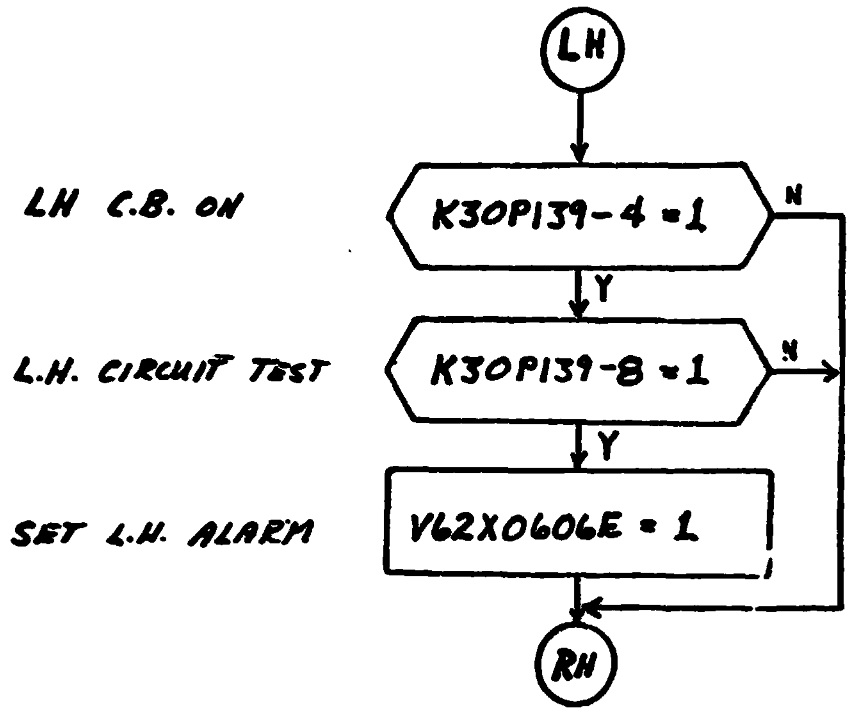
The logic flow diagram is made up of interconnected lines, boxes, decisions, and offpage connectors. Notice that where analog measurements are listed in boxes and decisions, the value inside the box is in flight system engineering units (FS_{EU}) while the corresponding GSIU count value is listed outside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

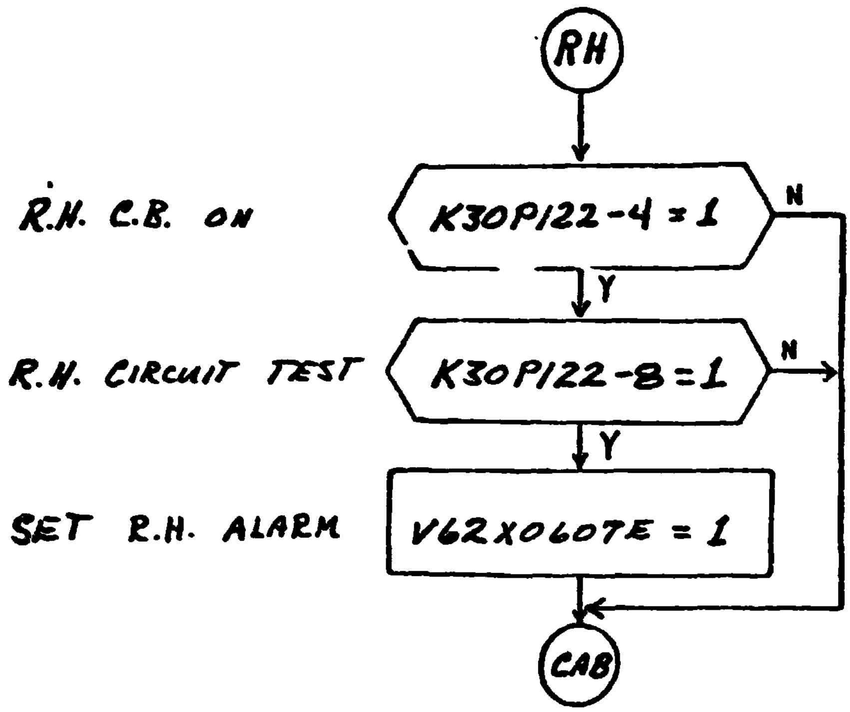


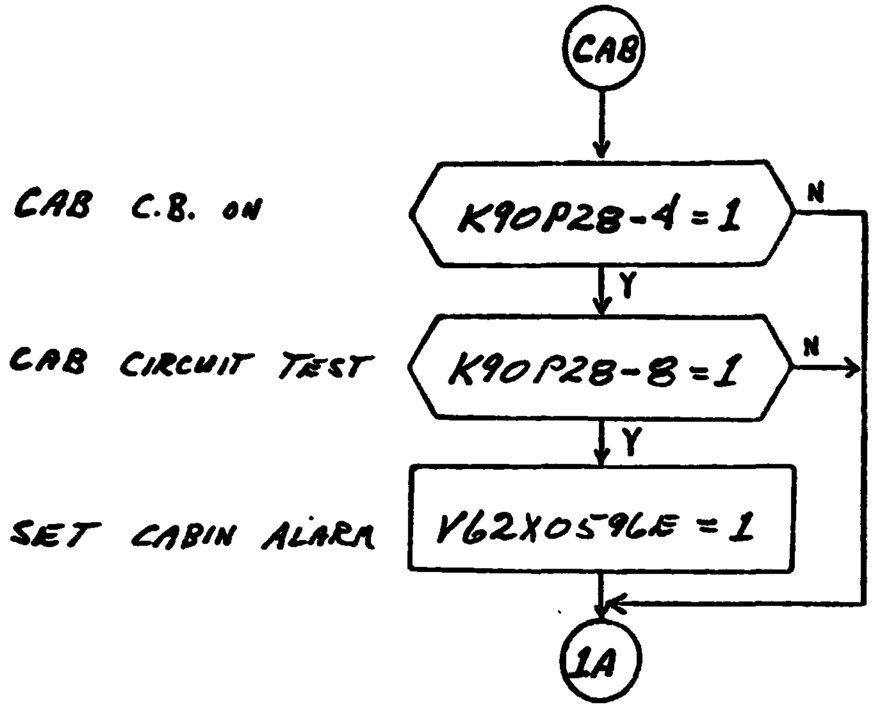
shows that V45P1100A is set equal to 626 FS_{EU} which is equivalent to 534 $GSIU_{CTS}$ shown outside the box.

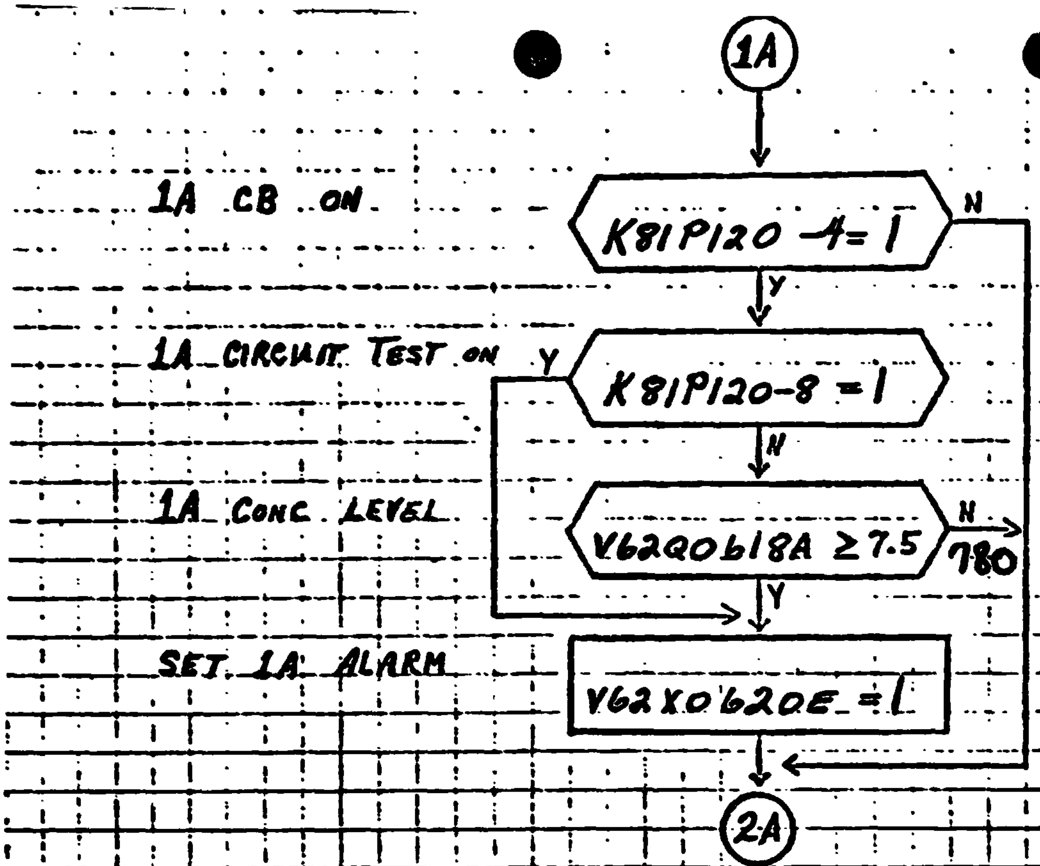


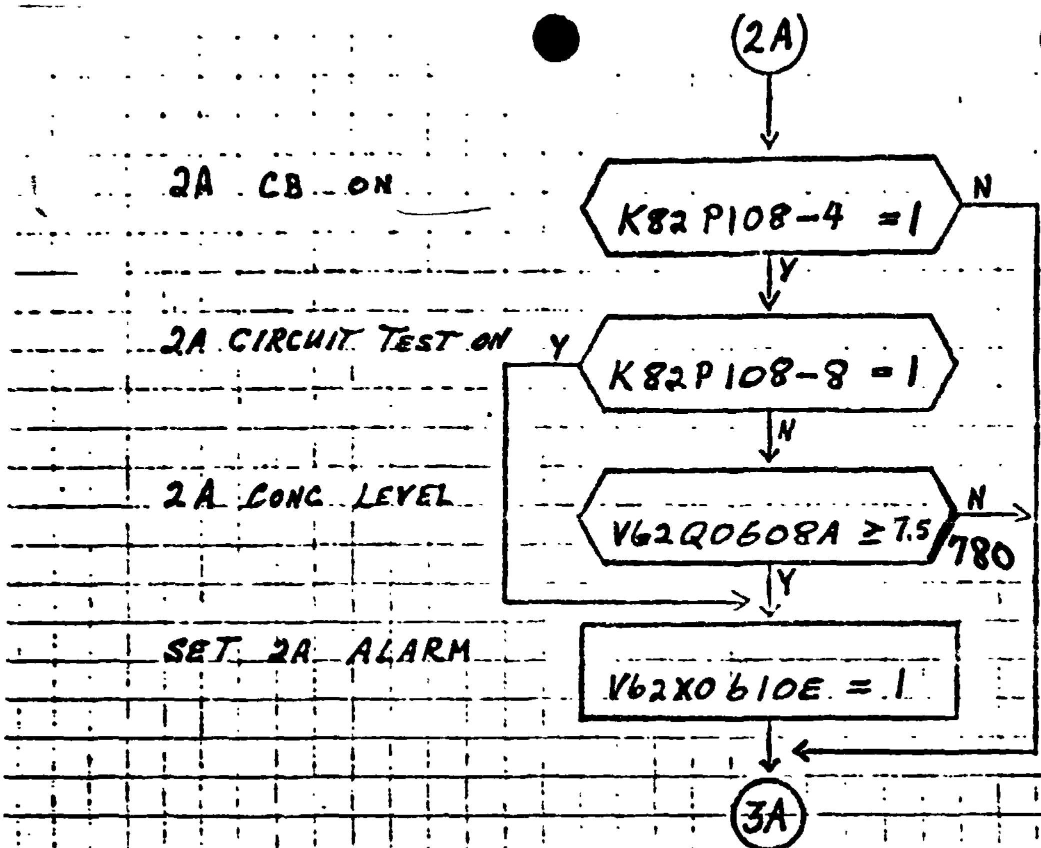
ORIGINAL PAGE IS
OF POOR QUALITY

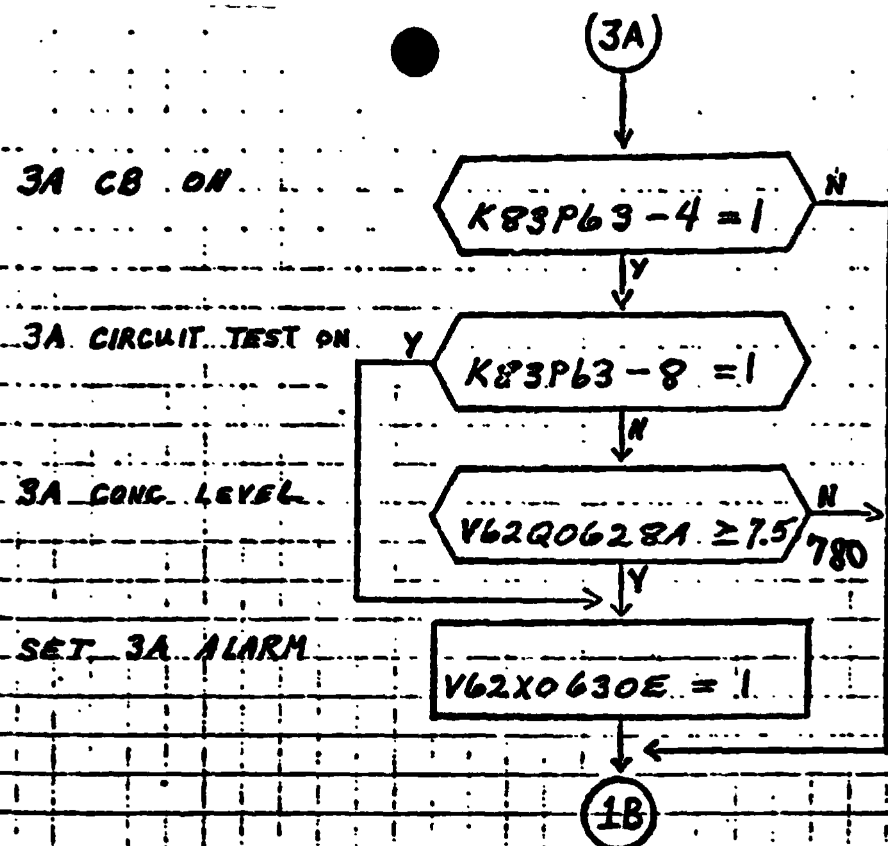

LH
LH C.B. ON
K30P139-4 = 1
N
Y
L.H. CIRCUIT TEST
K30P139-8 = 1
N
Y
SET L.H. ALARM
V62X0606E = 1
RH

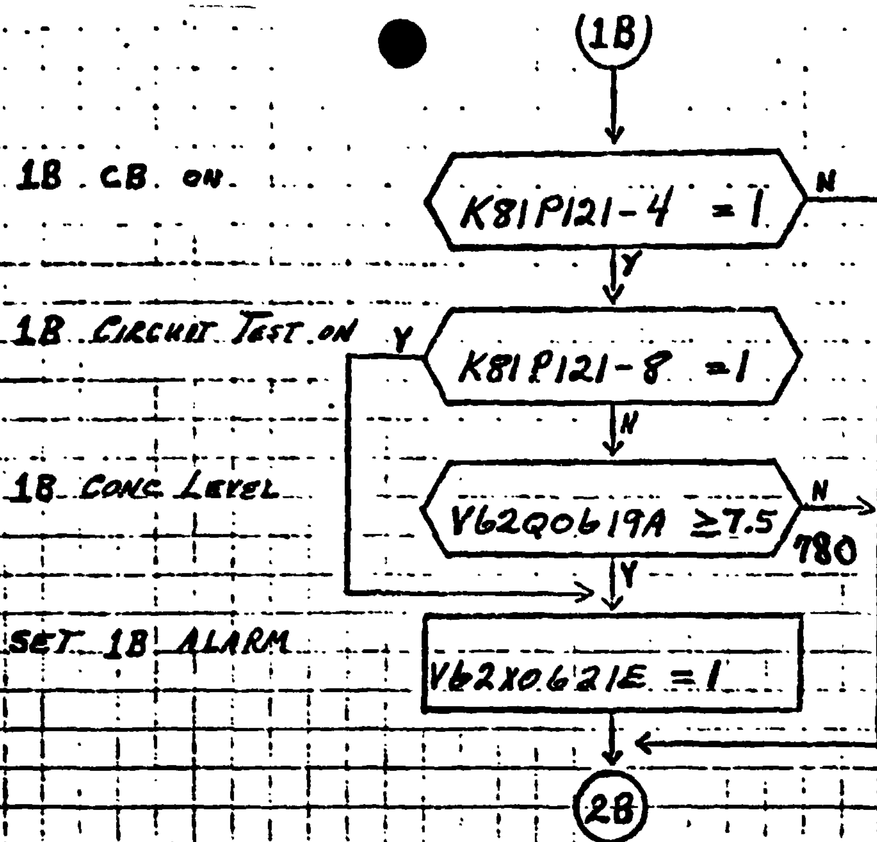

RH
R.H. C.B. ON
K30P122-4 = 1
N
Y
R.H. CIRCUIT TEST
K30P122-8 = 1
N
Y
SET R.H. ALARM
V62X0607E = 1
CAB

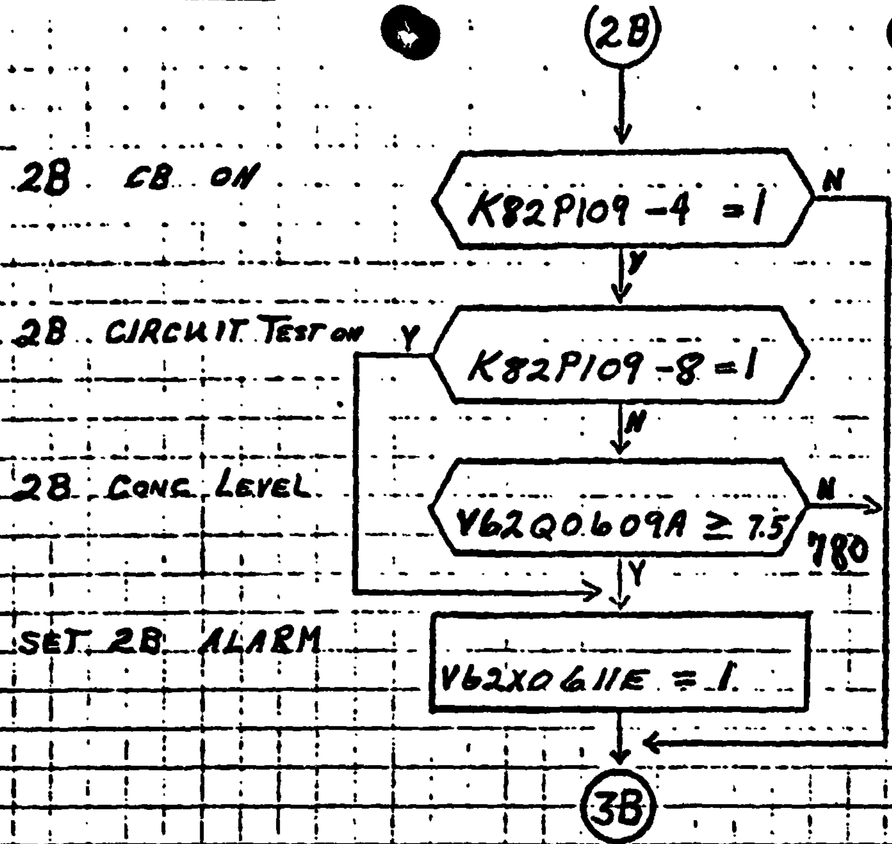

CAB
CAB C.B. ON
K90P28-4 = 1
N
Y
CAB CIRCUIT TEST
K90P28-8 = 1
N
Y
SET CABIN ALARM
V62X0596E = 1
1A

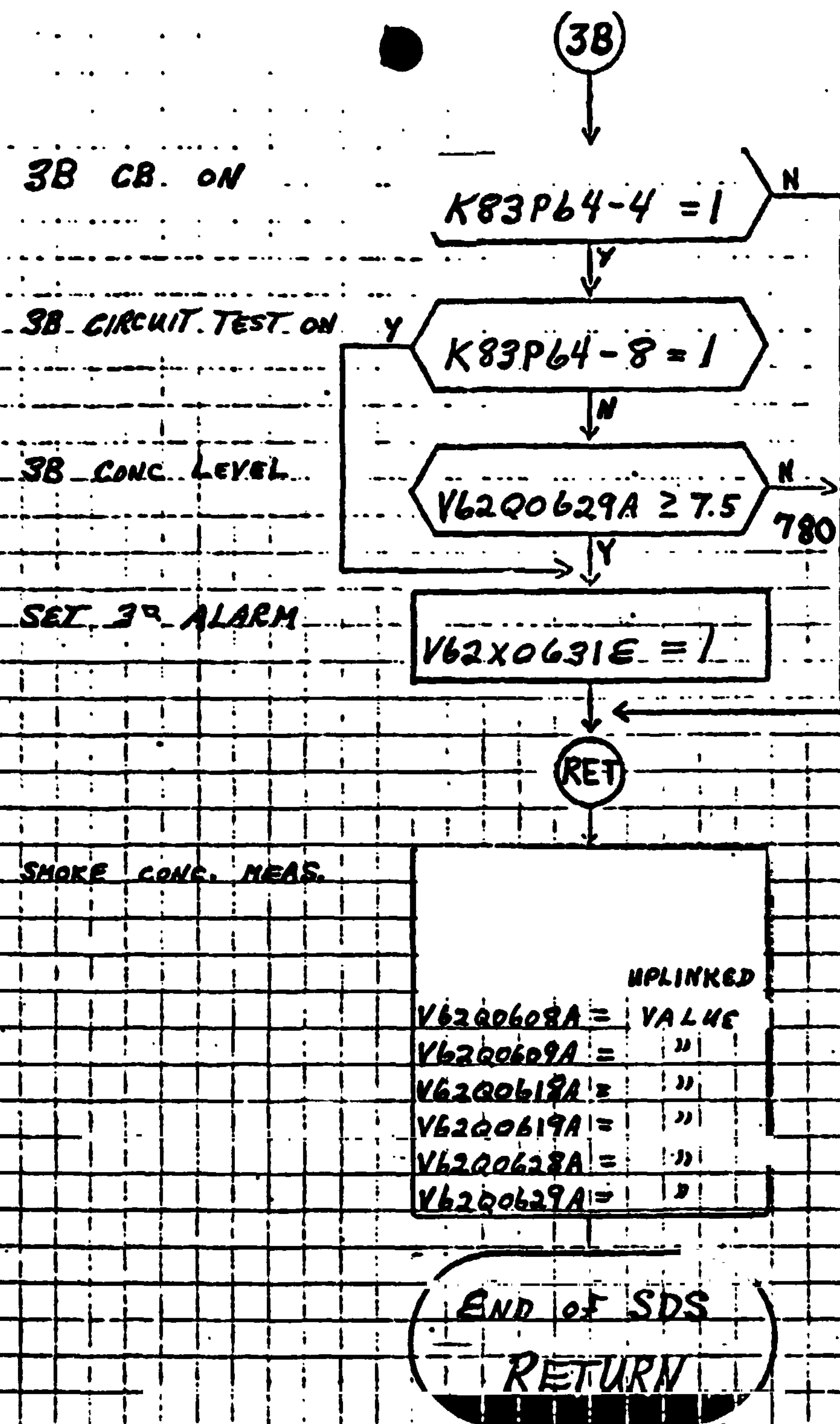

1A
1A CB ON
K81P120 -4= 1
N
Y
1A CIRCUIT TEST ON
Y
K81P120-8 = 1
N
1A CONC LEVEL
V62Q0618A ≥ 7.5
N
780
Y
SET 1A ALARM
V62X0620E = 1
2A


2A
2A CB ON
K82P108-4 =1
N
Y
2A CIRCUIT TEST ON
K82P108-8 =1
Y
N
2A CONC LEVEL
V62Q0608A ≥ 7.5
N
780
Y
SET 2A ALARM
V62X0610E = 1
3A


3A
3A CB ON
K83P63-4 = 1
N
Y
3A CIRCUIT TEST ON
Y
K83P63-8 = 1
N
3A CONC LEVEL
V62Q0628A ≥ 7.5
N
780
Y
SET 3A ALARM
V62X0630E = 1
1B


1B
1B CB ON
K81P121-4 = 1
N
Y
1B CIRCUIT TEST ON
Y
K81P121-8 = 1
N
1B CONC LEVEL
V62Q0619A ≥7.5
N
780
Y
SET 1B ALARM
V62X0621E = 1
2B


2B
2B CB ON
K82P109 -4 =1
N
Y
2B CIRCUIT TEST ON
Y
K82P109 -8 =1
N
2B CONC LEVEL
V62Q0609A ≥ 7.5
N
780
Y
SET 2B ALARM
V62X0611E = 1.
3B



38
3B CB. ON
K83P64-4 = 1
N
Y
3B CIRCUIT TEST ON
Y
K83P64-8 = 1
N
3B CONC LEVEL
V62Q0629A ≥ 7.5
N
780
Y
SET 3B ALARM
V62X0631E = 1
RET
SMOKE CONC. MEAS.
UPLINKED
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	V62K0802E SMOKE DETECTION CIRCUIT TEST 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	V62K0806E SMOKE DETECTION CIRCUIT TEST 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	V62K0815E - SMOKE DETECTION RESET 1B/3A		0	1	
83P63-7	BAY 3/DETECTOR A			0	1	
83P64-7	BAY 3/DETECTOR B	V62K0816E SMOKE DETECTION RESET 3B/2A/L&R FLT.D.		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	V62K0817E SMOKE DETECTION RESET 1A/2B/CABIN		0	1	
82P109-7	BAY 2/DETECTOR B			0	1	
90P28-7	CABIN		FS VIA STM	0	1	STATE

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	[illegible] 1/DETECTOR A MN C PWR [illegible]EL 016/CB7		0	1	
82P1[illegible]-4	[illegible]AY 2/DETECTOR B MN C PWR PANEL 016/CB7		0	1	
82P108-4	BAY 2/DETECTOR A MN A PWR PANEL 014/CB8		0	1	
83P64-4	BAY 3/DETECTOR B MN A PWR PANEL 014/CB8		0	1	
83P63-4	PAY [illegible]/DETECTOR A MN B PWR PAN[illegible] 015/CB7		0	1	
81P121-4	BAY 1/DETECTOR B MN B PWR PANEL 015/CB7	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 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
V62Q0609A	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
V62Q0628A	SMOKE DET. CONC. A AV. BAY 3	1.91	743							MG/M^3
V62Q0629A	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					
V62X0596E	SM DET SIG CABIN	0	0	1	1					
V62X0620E	SM DET SIG 1A	0	0	1	1					
V62X0610E	SM DET SIG 2A	0	0	1	1					
V62X0630E	SM DET SIG 3A	0	0	1	1					
V62X0621E	SM DET SIG 1B	0	0	1	1					
V62X0611E	SM DET SIG 2B	0	0	1	1					
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

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FIGURES

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/H_2O 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.

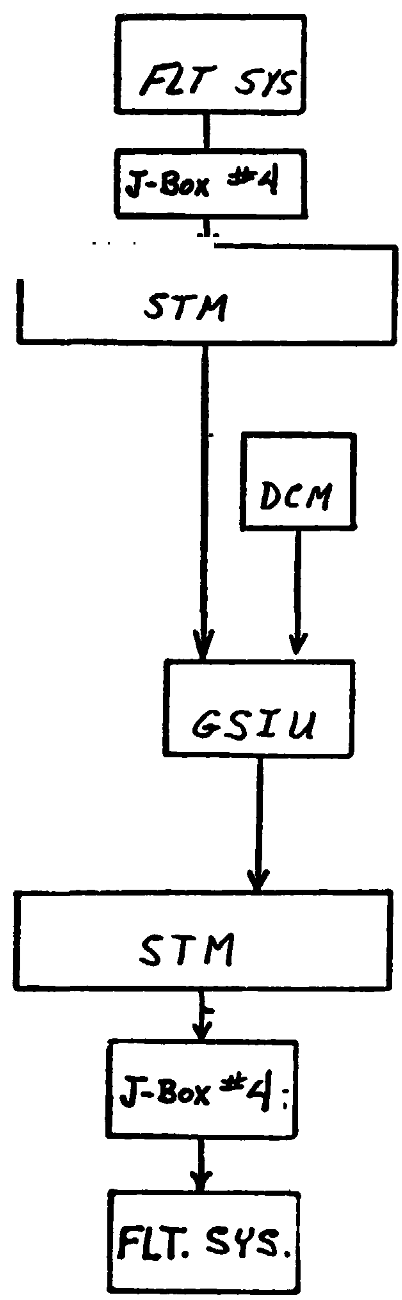
The model receives stimuli from one source, the flight system via the Signal Termination Module (STM); the model provides output parameter values to the flight system via the STM. Figure 2-1 illustrates the data flow in and out of the model. Tables 2-1 and 2-2 list the input stimuli and output measurements.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

2.1 FUNCTIONAL CHRACTERISTICS

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

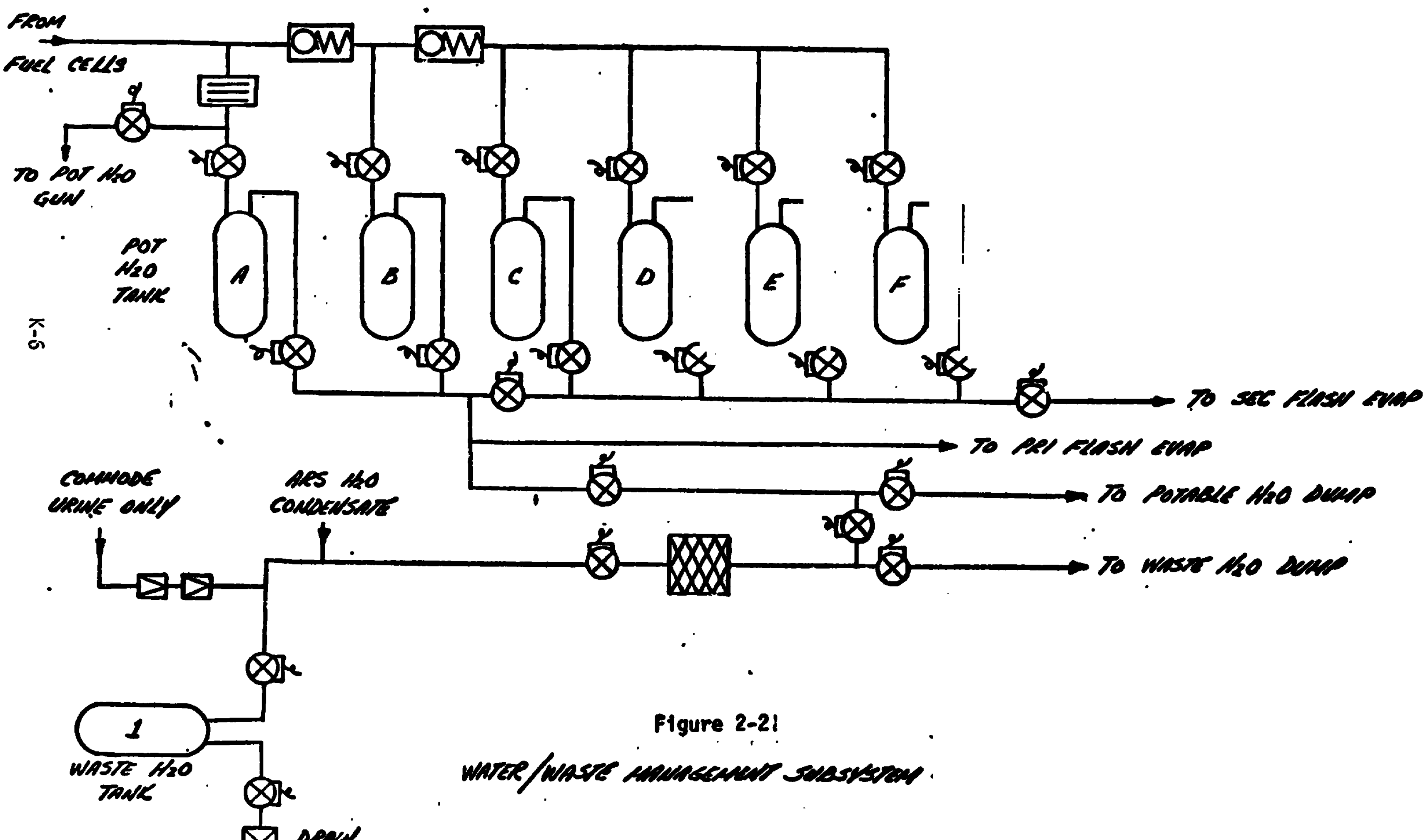


Figure 2-21

WATER/WASTE MANAGEMENT SUBSYSTEM

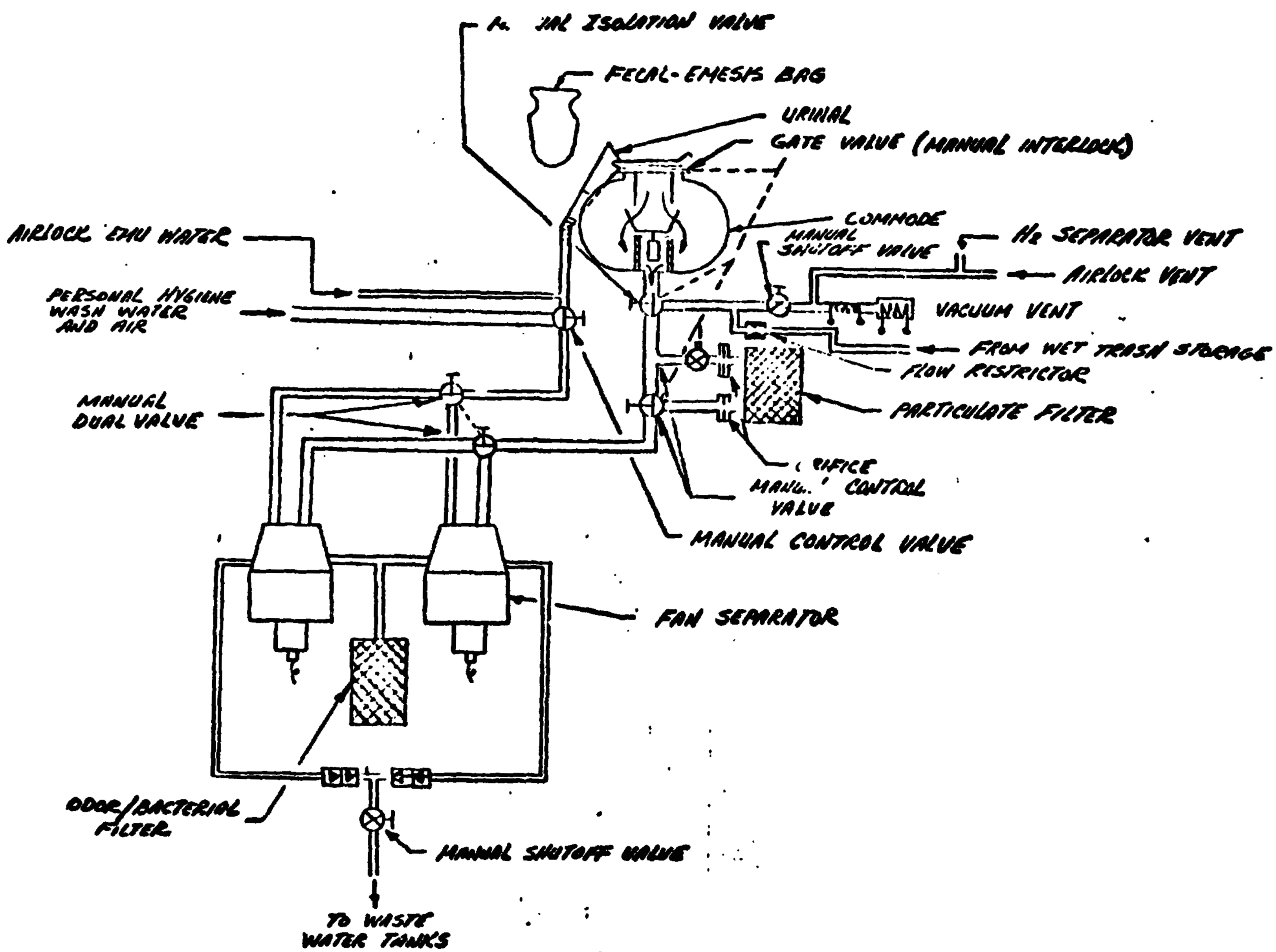


Figure 2-3

WASTE MANAGEMENT SUBSYSTEM - WASTE COLLECTOR

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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.

```
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 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 conver 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 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:

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

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

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

And

$$FS_{EU} = 443.167 + 851.956X - 143.904X^2 + 12.246X^3$$
$$FS_{EU} = 443.167 + 851.956(3.848) - 143.904(3.848)^2 + 12.246\ (3.848)^3$$
$$FS_{EU} = 2288.017$$

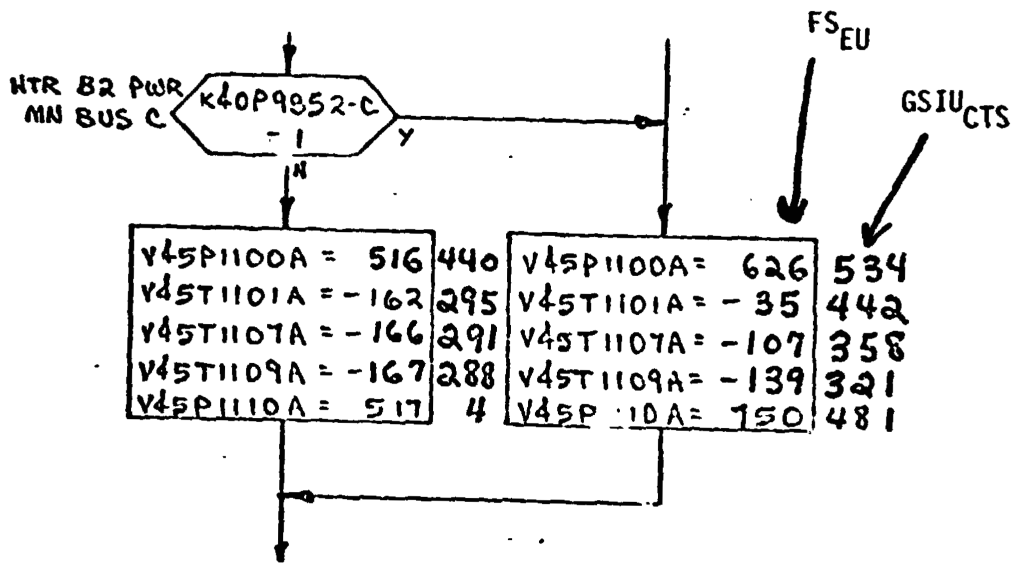
Hence when 787 GSIU counts is inserted for measurement no. V53R1100A, a value of 2288.017 FS_{EU} will result.

2.6.2 RANGE LIMIT CONVERSION METHOD

NONE.

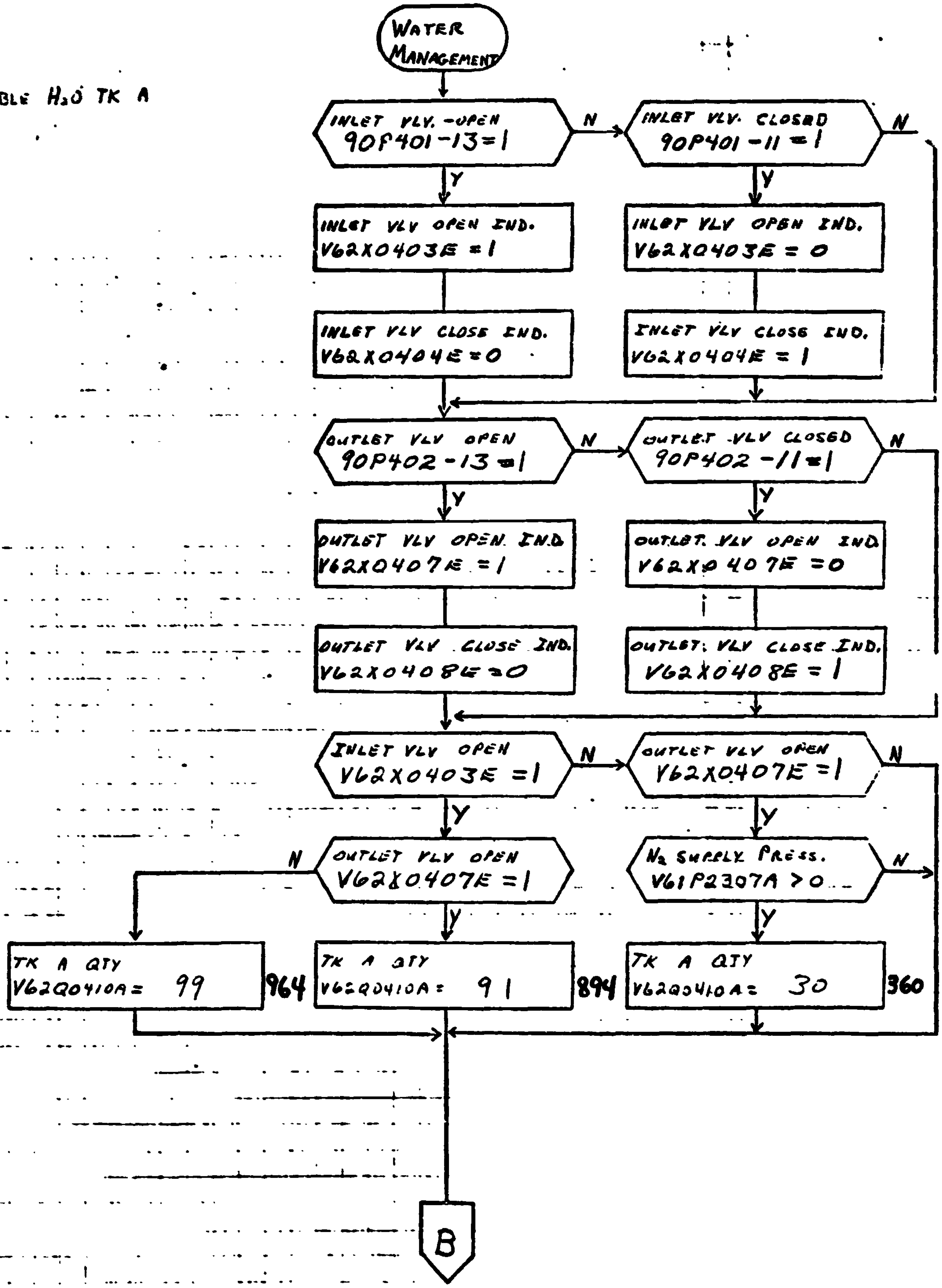
3.0 LOGIC FLOW DIAGRAMS

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,

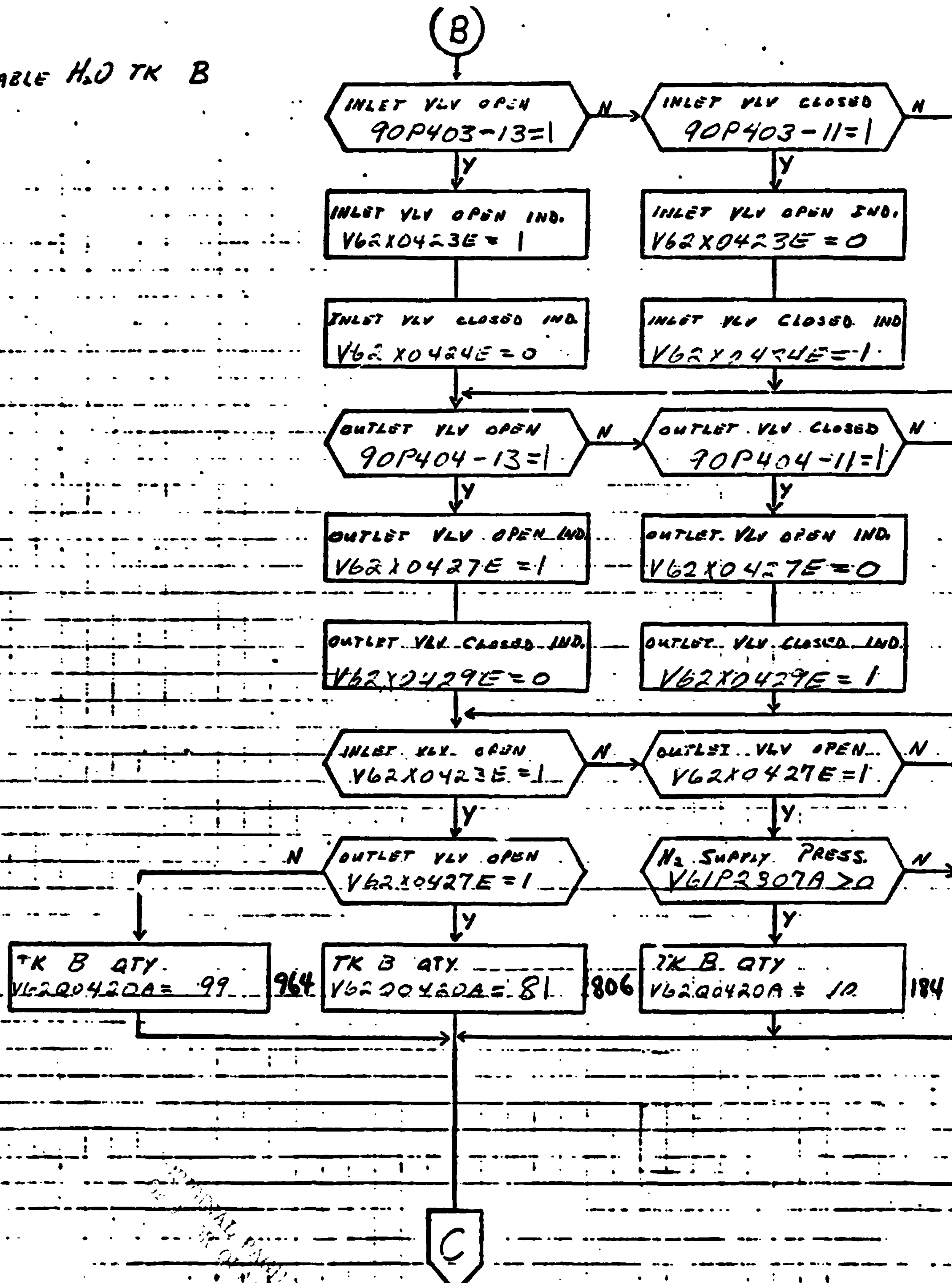


shows that V45P1100A is set equal to 626 FS_{EU} which is equivalent to 534 $GSIU_{CTS}$ shown outside the box.

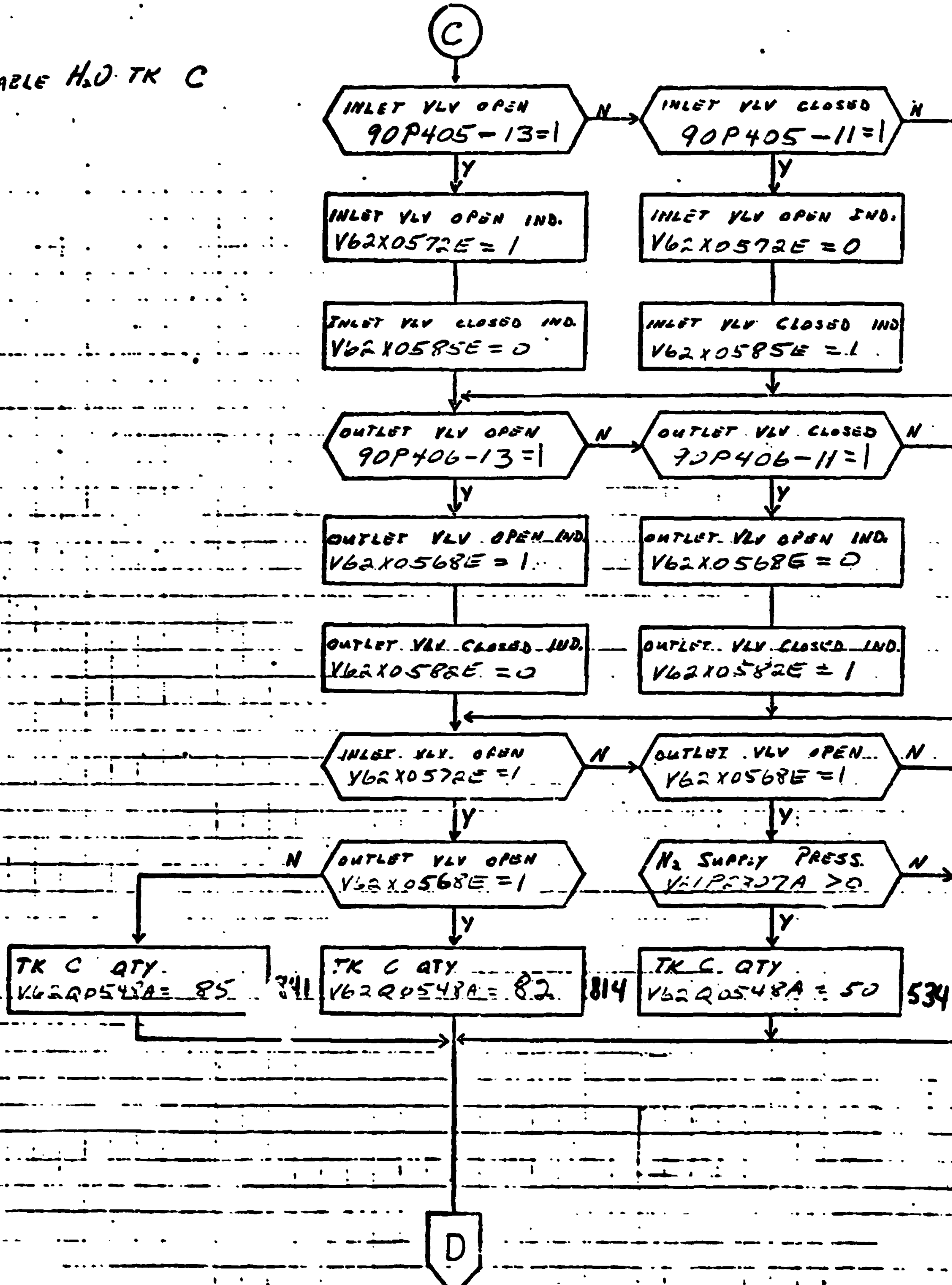
POTABLE H_2O TK A



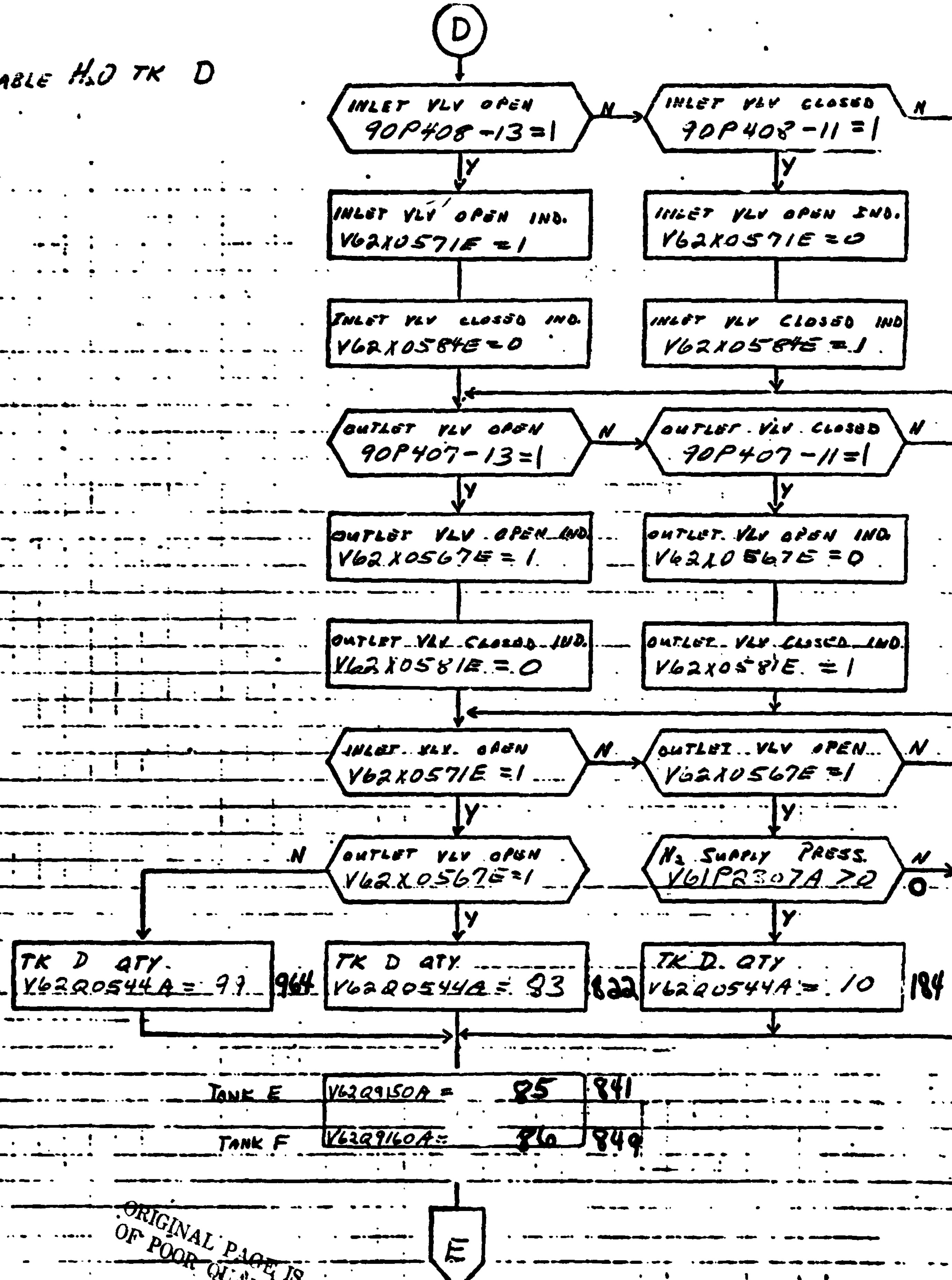
POTABLE H_2O TK B

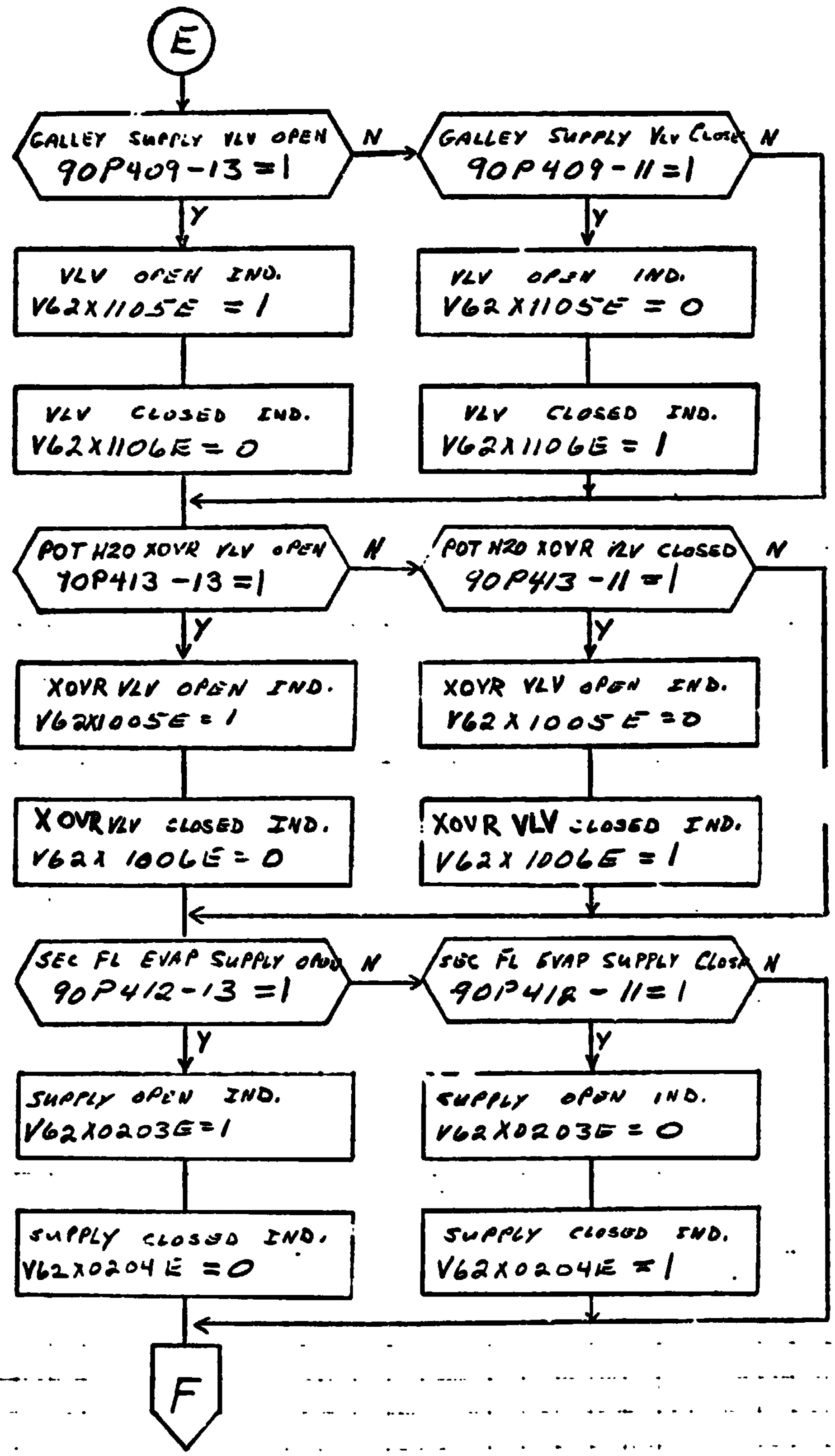


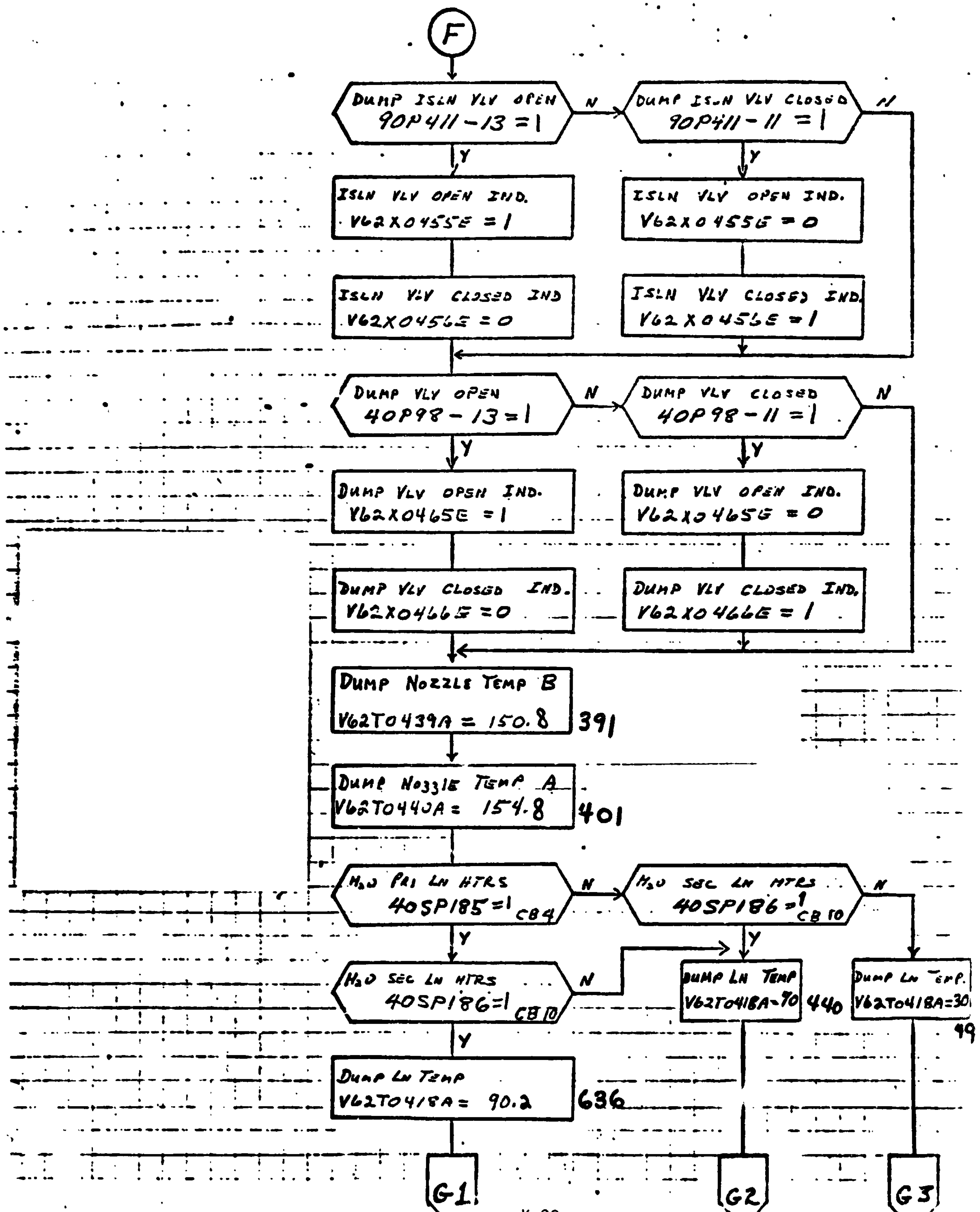
POTABLE H_2O TK C

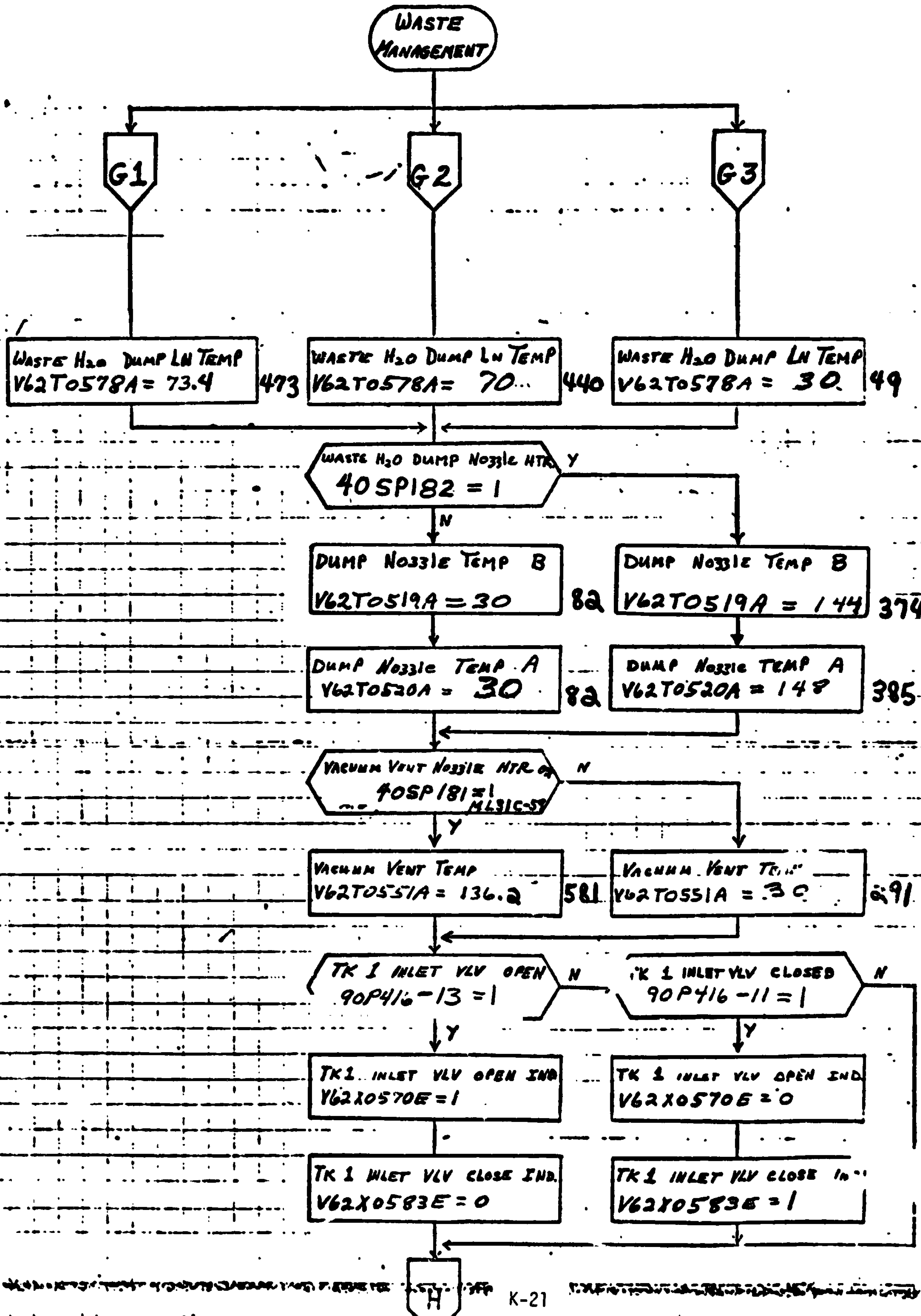


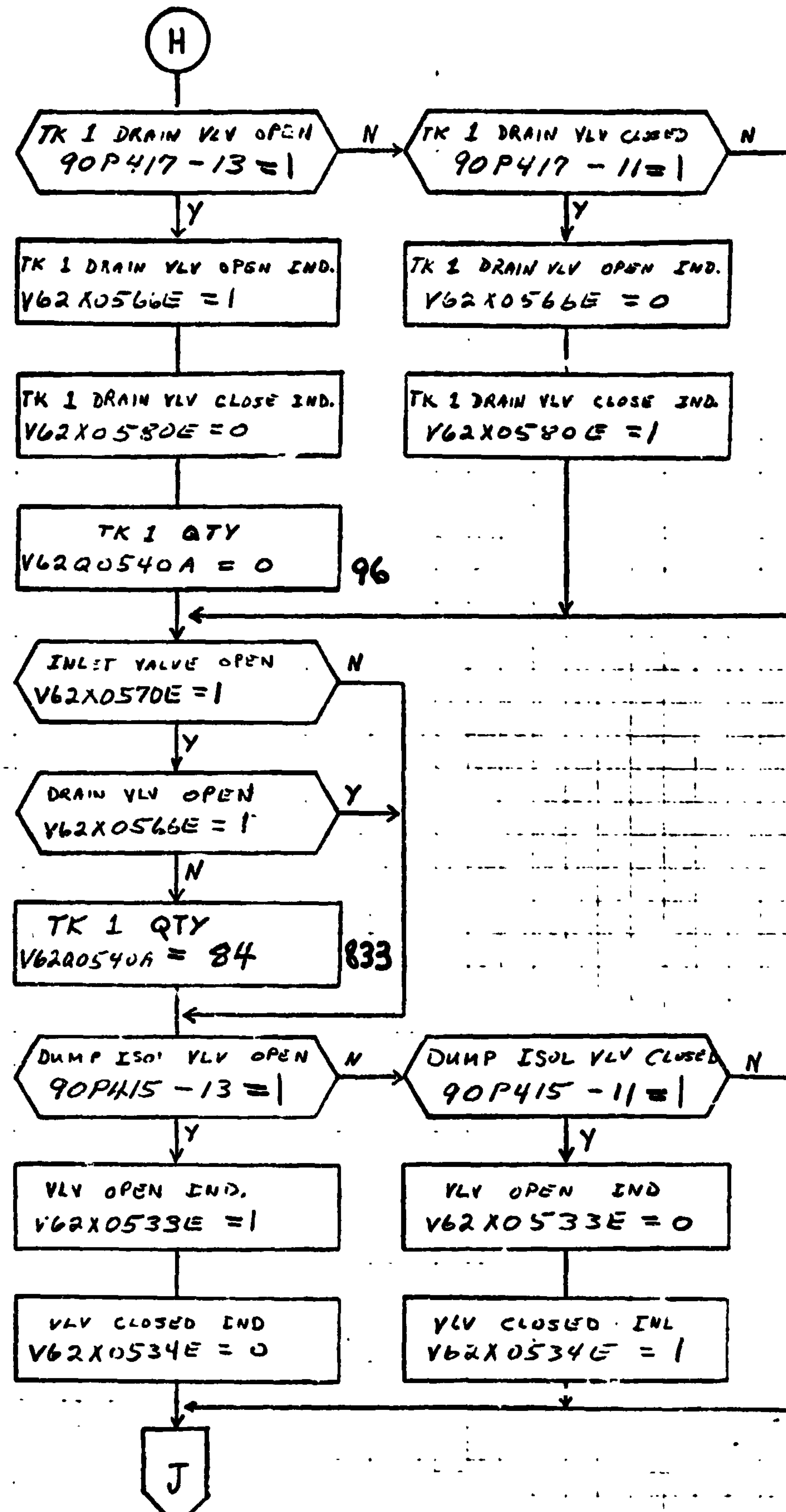
POTABLE H_2O TK D

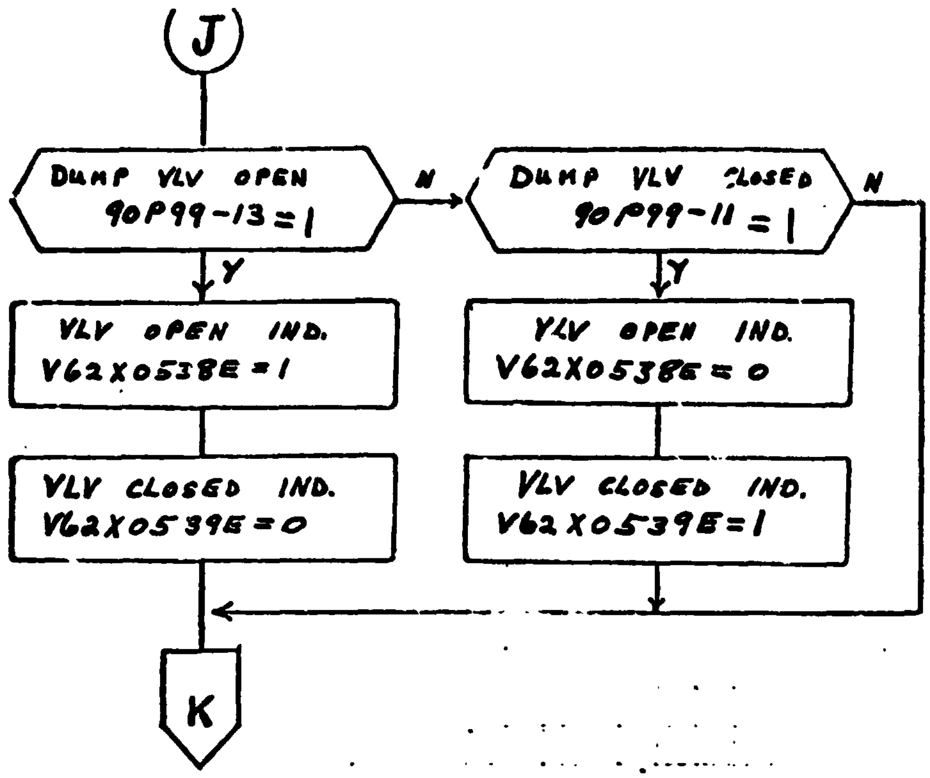


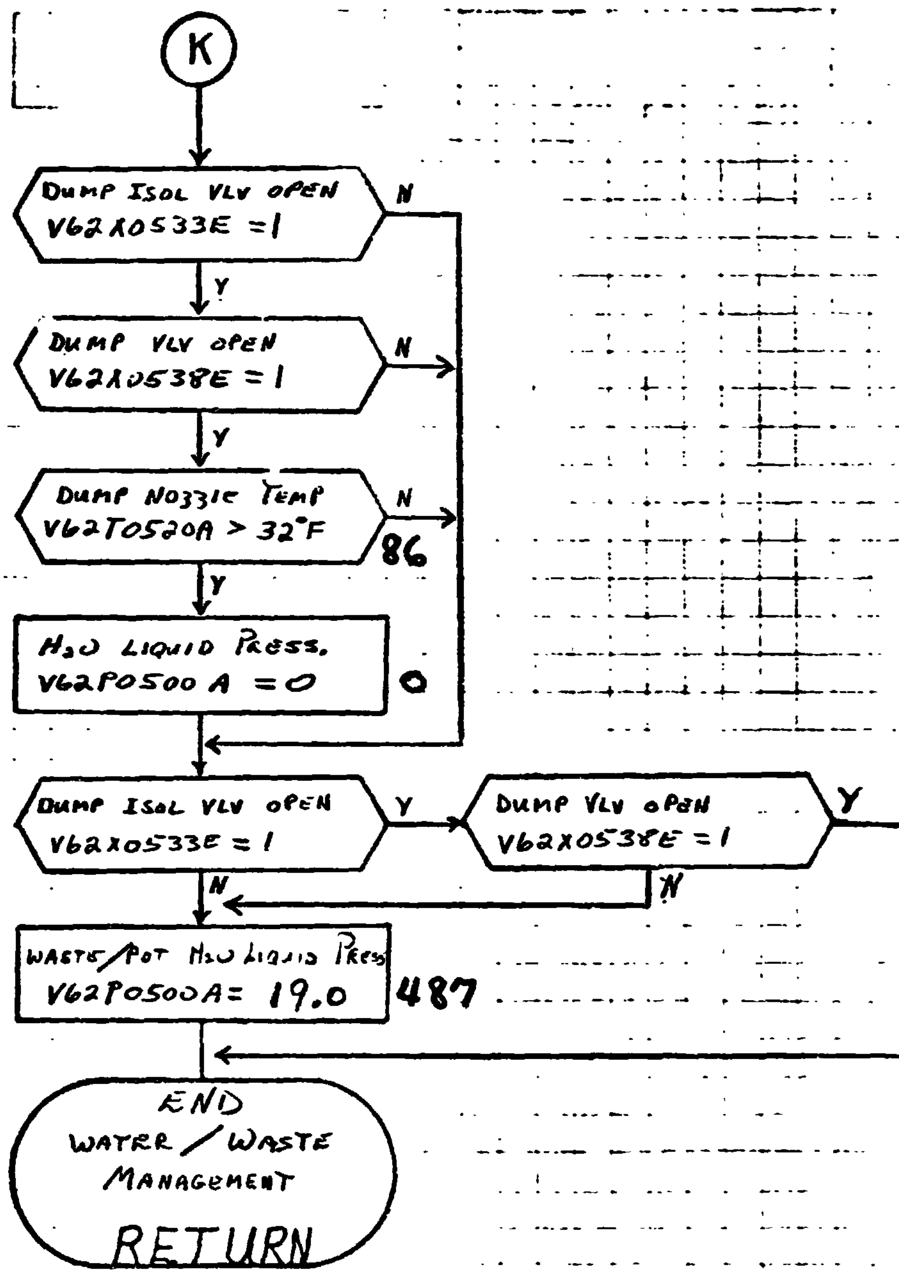

E
GALLEY SUPPLY VLV OPEN
90P409-13 =1
N
GALLEY SUPPLY VLV CLOSE
90P409-11=1
N
Y
VLV OPEN IND.
V62X1105E = 1
VLV OPEN IND.
V62X1105E = 0
VLV CLOSED IND.
V62X1106E = 0
VLV CLOSED IND.
V62X1106E = 1
POT H2O XOVR VLV OPEN
90P413 -13 =1
N
POT H2O XOVR VLV CLOSED
90P413 -11 =1
XOVR VLV OPEN IND.
V62X1005E = 1
XOVR VLV OPEN IND.
V62X1005E = 0
XOVR VLV CLOSED IND.
V62X1006E = 0
XOVR VLV CLOSED IND.
V62X1006E = 1
SEC FL EVAP SUPPLY OPEN
90P412-13 =1
SEC FL EVAP SUPPLY CLOSE
90P412 - 11=1
SUPPLY OPEN IND.
V62X0203E=1
SUPPLY OPEN IND.
V62X0203E = 0
SUPPLY CLOSED IND.
V62X0204E =0
SUPPLY CLOSED IND.
V62X0204E =1
F


F
DUMP ISLN VLV OPEN 90P411-13=1
DUMP ISLN VLV CLOSED 90P411-11=1
ISLN VLV OPEN IND. V62X0455E=1
ISLN VLV CLOSED IND V62X0456E=0
ISLN VLV OPEN IND. V62X0455E=0
ISLN VLV CLOSED IND. V62X0456E=1
DUMP VLV OPEN 40P98-13=1
DUMP VLV CLOSED 40P98-11=1
DUMP VLV OPEN IND. V62X0465E=1
DUMP VLV CLOSED IND. V62X0466E=0
DUMP VLV OPEN IND. V62X0465E=0
DUMP VLV CLOSED IND. V62X0466E=1
DUMP NOZZLE TEMP B V62T0439A = 150.8
391
DUMP NOZZLE TEMP A V62T0440A = 154.8
401
H2O PRI LN HTRS 40SP185=1 CB4
H2O SEC LN HTRS 40SP186=1 CB10
H2O SEC LN HTRS 40SP186=1 CB10
DUMP LN TEMP V62T0418A = 90.2
636
DUMP LN TEMP V62T0418A=70
440
DUMP LN TEMP. V62T0418A=30
49
G1
G2
G3
Y
N


WASTE MANAGEMENT
G1
G2
G3
WASTE H2O DUMP LN TEMP V62T0578A = 73.4
473
WASTE H2O DUMP LN TEMP V62T0578A = 70
440
WASTE H2O DUMP LN TEMP V62T0578A = 30
49
WASTE H2O DUMP NOZZLE HTR 40SP182 = 1
Y
N
DUMP NOZZLE TEMP B V62T0519A = 30
82
DUMP NOZZLE TEMP B V62T0519A = 144
374
DUMP NOZZLE TEMP A V62T0520A = 30
82
DUMP NOZZLE TEMP A V62T0520A = 148
385
VACUUM VENT NOZZLE HTR 40SP181 = 1
MLS1C-57
N
Y
VACUUM VENT TEMP V62T0551A = 136.2
581
VACUUM VENT TEMP V62T0551A = 30
291
TK 1 INLET VLV OPEN 90P416-13 = 1
N
Y
TK 1 INLET VLV CLOSED 90P416-11 = 1
N
Y
TK1 INLET VLV OPEN IND V62X0570E = 1
TK 1 INLET VLV OPEN IND V62X0570E = 0
TK 1 INLET VLV CLOSE IND. V62X0583E = 0
TK 1 INLET VLV CLOSE IND V62X0583E = 1
H


H
TK 1 DRAIN VLV OPEN
90P417-13=1
N
TK 1 DRAIN VLV CLOSED
90P417-11=1
N
Y
Y
TK 1 DRAIN VLV OPEN IND.
V62X0566E =1
TK 1 DRAIN VLV OPEN IND.
V62X0566E =0
TK 1 DRAIN VLV CLOSE IND.
V62X0580E =0
TK 1 DRAIN VLV CLOSE IND.
V62X0580E =1
TK 1 QTY
V62Q0540A = 0
96
INLET VALVE OPEN
V62X0570E =1
N
Y
DRAIN VLV OPEN
V62X0566E = 1
Y
N
TK 1 QTY
V62Q0540A = 84
833
DUMP ISOL VLV OPEN
90P415-13=1
N
DUMP ISOL VLV CLOSED
90P415-11=1
N
Y
Y
VLV OPEN IND.
V62X0533E =1
VLV OPEN IND
V62X0533E =0
VLV CLOSED IND
V62X0534E = 0
VLV CLOSED IND
V62X0534E = 1
J


J
DUMP VLV OPEN
90P99-13=1
N
DUMP VLV CLOSED
90P99-11=1
N
Y
Y
VLV OPEN IND.
V62X0538E=1
VLV OPEN IND.
V62X0538E=0
VLV CLOSED IND.
V62X0539E=0
VLV CLOSED IND.
V62X0539E=1
K


K
DUMP ISOL VLV OPEN
V62X0533E =1
N
Y
DUMP VLV OPEN
V62X0538E = 1
N
Y
DUMP NOZZLE TEMP
V62T0520A > 32°F
N
86
Y
H2O LIQUID PRESS.
V62P0500 A = 0
0
DUMP ISOL VLV OPEN
V62X0533E = 1
Y
DUMP VLV OPEN
V62X0538E = 1
Y
N
N
WASTE/POT H2O LIQUID PRESS
V62P0500A= 19.0
487
END
WATER / WASTE
MANAGEMENT
RETURN

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

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

IDENTIFICATION NUMBER	NOMENCLATURE	SOURCE	STATUS/RANGE		
			LO	HI	UNITS
V62K0401E	POT. H_2O TK A INLET VLV OPEN 90P401-13	FS VIA STM	0	1	STATE
V62K0402E	POT. H_2O TK A INLET VLV CLOSE 90P401-11	FS VIA STM	0	1	STATE
V62K0405E	POT. H_2O TK A OUTLET VLV OPEN 90P402-13	FS VIA STM	0	1	STATE
V62K0406E	POT. H_2O TK A OUTLET VLV CLOSE 90P402-11	FS VIA STM	0	1	STATE
V62K0421E	POT. H_2O TK B INLET VLV OPEN 90P403-13	FS VIA STM	0	1	STATE
V62K0422E	POT. H_2O TK B INLET VLV CLOSE 90P403-11	FS VIA STM	0	1	STATE
V62K0425E	POT. H_2O TK B OUTLET VLV OPEN 90P404-13	FS VIA STM	0	1	STATE
V62K0426E	POT. H_2O TK B OUTLET VLV CLOSE 90P404-11	FS VIA STM	0	1	STATE

STIMULI INPUT TO I/WMS) MODEL-TABLE 2-1

IDENTIFICATION NUMBER	NOMENCLATURE	SOURCE	STATES/RANGE		
			LO	HI	UNITS
V62K0450E	POT. H_2O DUMP ISLN VLV OPEN 90P411-13	FS VIA STM	0	1	STATE
V62K0452E	POT. H_2O DUMP ISLN VLV CLOSE 90P411-11	FS VIA STM	0	1	STATE
V62K0460E	POT. H_2O DUMP VLV OPEN 40P98-13	FS VIA STM	0	1	STATE
V62K0462E	POT. H_2O DUMP VLV CLOSE 40P98-11	FS VIA STM	0	1	STATE
V62K0530E	WASTE H_2O DUMP ISLN VLV OPEN 90P415-13	FS VIA STM	0	1	STATE
V62K0531E	WASTE H_2O DUMP ISLN VLV CLOSE 90P415-11	FS VIA STM	0	1	STATE
V62K0535E	WASTE H_2O DUMP VLV OPEN 90P99-13	FS VIA STM	0	1	STATE
V62K0536E	WASTE H_2O DUMP VLV CLOSE 90P99-11	FS VIA STM	0	1	STATE
V62K0541E	WASTE H_2O DUMP NOZZLE 40SP182	FS VIA STM	0	1	STATE

STIMULI INPUT TO .../WMS) MODEL-TABLE 2-1

IDENTIFICATION NUMBER	NOMENCLATURE	SOURCE	STATES/RANGE		
			LO	HI	UNITS
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 (W/WMS) MODEL-TABLE 2-1

IDENTIFICATION NUMBER	NOMENCLATURE	SOURCE	STATES/RANGE		
			LO	HI	UNITS
V62K0770E	POT. H_2O TK C INLET VLV OPEN 90P405-13	FS VIA STM	0	1	STATE
V62K0771E	POT. H_2O TK C INLET VLV CLOSE 90P405-11	FS VIA STM	0	1	STATE
V62K0774E	POT. H_2O TK C OUTLET VLV OPEN 90P406-13	FS VIA STM	0	1	STATE
V62K0775E	POT. H_2O TK C OUTLET VLV CLOSE 90P406-11	FS VIA STM	0	1	STATE
V62K1000E	POT. H_2O XOVR VLV OPEN 90P413-13	FS VIA STM	0		STATE
V62K1002E	POT. H_2O 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_2O LN HTRS -- PRI 40SP185	FS VIA STM	0	1	STATE
N/A	H_2O 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
V62X0403E	POT. H_2O TK A INLET VLV OPEN IND	0	0	1	1					STATE
V62X0404E	POT. H_2O TK A INLET VLV CLOSE IND	1	1	0	0					STATE
V62X0407E	POT. H_2O TK A OUTLET VLV OPEN IND	0	0	1	1					STATE
V62X0408E	POT. H_2O TK A OUTLET VLV CLOSE IND	1	1	0	0					STATE
V62Q0410A	POT. H_2O TK A QTY	91	894	30	360	99	964			PCT
V62T0418A	POT. H_2O DUMP LINE TEMP	90.2	636	30	49	70	440			DEGF
V62Q0420A	POT. H_2O TK B QTY	81	806	10	184	99	964			PCT
V62X0423E	POT. H_2O TK B INLET VLV OPEN IND	0	0	1	1					STATE
V62X0424E	POT. H_2O TK B INLET VLV CLOSE IND	1	1	0	0					STATE
V62X0427E	POT. H_2O TK B OUTLET VLV OPEN IND	0	0	1	1					STATE
V62X0429E	POT. H_2O TK B OUTLET VLV CLOSE IND	1	1	0	0					STATE
V62P0430A	POT. H_2O STORAGE INLET PRESS.	35	716							PSIA
V62T0439A	POT. H_2O DUMP NOZZLE TEMP. B.	150.8	391							DEGF
V62T0440A	POT. H_2O DUMP NOZZLE TEMP	154.8	401							DEGF
V62X0455E	POT. H_2O DUMP ISOL VLV OPEN IND	0	0	1	1					STATE
V62X0456E	POT. H_2O DUMP ISOL VLV CLOSE IND	1	1	0	0					STATE
V62X0465E	POT. H_2O DUMP VLV OPEN IND.	0	0	1	1					STATE
V62X0466E	POT. H_2O DUMP VLV CLOSE IND.	1	1	0	0					STATE
V62P0500A	WASTE/POT. H_2O LIQUID PRESS	19.0	487	0	0					PSIG
V62T0519A	WASTE H_2O DUMP NOZZLE TEMP. B.	144	374	30	82					DEGF
V62T0520A	WASTE H_2O DUMP NOZZLE TEMP.	148	385	30	82					DEGF

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	
V62X0533E	WASTE H_2O DUMP ISOL VLV OPEN IND	0	0	1	1					STATE
V62X0534E	WASTE H_2O DUMP ISOL VLV CLOSED IND	1	1	0	0					STATE
V62X0538E	WASTE H_2O DUMP VLV OPEN IND	0	0	1	1					STATE
V62X0539E	WASTE H_2O DUMP VLV CLOSED IND	1	1	0	0					STATE
V62Q0540A	WASTE H_2O 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_2O TK C QTY	82	814	50	534	85	841			PCT
V62T0551A	VACUUM VENT TEMP	136.2	581	30	291					DEGF
V62X0566E	WASTE H_2O 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_2O 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_2O TK C INLET VLV OPEN IND	0	0	1	1					STATE
V62T0578A	WASTE H_2O 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_2O TK 2 OUTLET VLV CLOSE IND	1	1	0	0					STATE
V62X0582E	POT. H_2O 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_2O TK C INLET VLV CLOSE IND	1	1	0	0					STATE
2X1005E	POT. H_2O XOVR VLV OPEN IND	0	0	1	1					STATE
V62X1006E	POT. H_2O XOVR VLV CLOSE IND	1	1	0	0					STATE
V62X1105E	POT. H_2O GALLEY SUPPLY VLV OPEN IND	0	0	1	1					STATE
V62X1106E	POT. H_2O GALLEY SUPPLY VLV CLOSE IND	1	1	0	0					STATE
V62Q9150A	POT. H_2O TANK E QTY	85	841							PERCENT
V62Q9160A	POT. H_2O 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

TACLE OF CONTENTS

FIGURES

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 absense 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

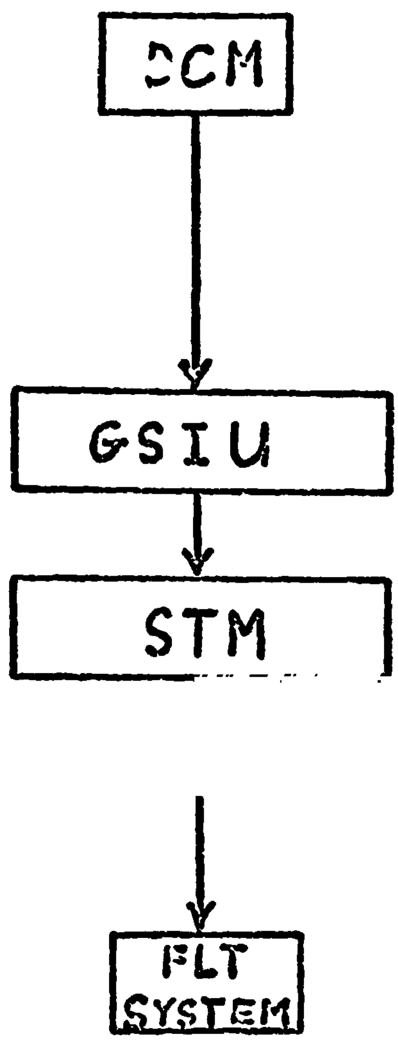
Parameters will be initialized with the values found in the IC (Initial Condition) column of Table 1.

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:

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

$$\text{GSIU counts} = \left[3.846\left(\frac{1023}{5}\right)\right]$$, 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:

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

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

SO X = 3.846529

And

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

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

$$FS_{EU} = 2288.017$$

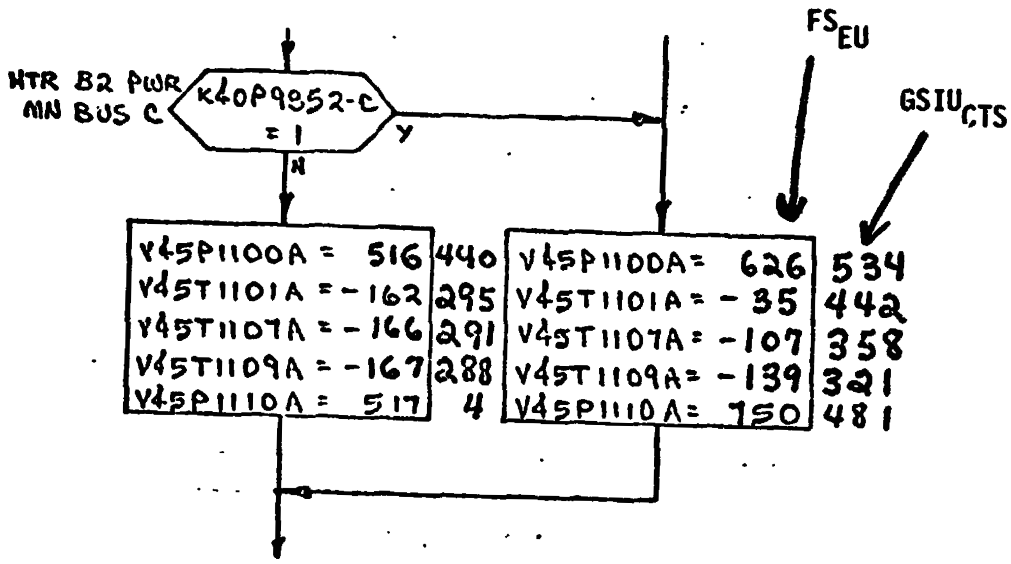
Hence when 787 GSIU counts is inserted for measurement no. V63R1100A, a value of 2288.017 FS_{EU} will result.

2.6.2 RANGE LIMIT CONVERSION METHOD

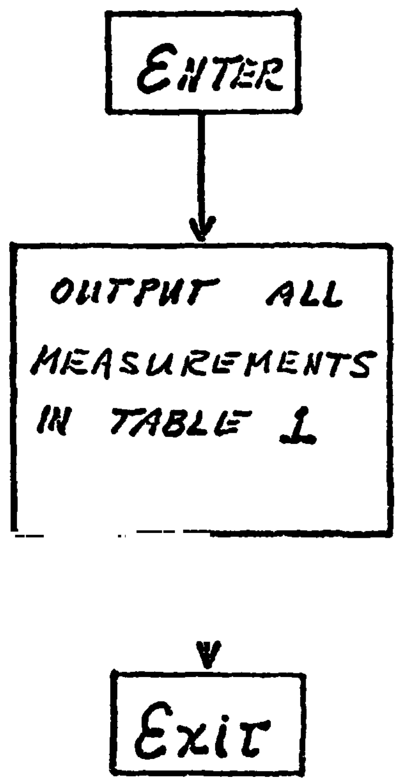
NONE.

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.



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 FTG 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 FTG 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							DEGF
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 Internal 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.