STUDENT STUDY GUIDE

AIR TRAINING COMMAND

MISSILE LAUNCH/MISSILE OFFICER

LAUNCH CONTROL SYSTEM AND EQUIPMENT

LAUNCH CONTROL SYSTEM OPERATION AND CHECKOUT

March 1962

Course OZR1821B/3121B-4
Technical Training

FOR INSTRUCTIONAL PURPOSES ONLY

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LAUNCH CONTROL SYSTEM AND EQUIPMENT

OBJECTIVE

To familiarize the student with the purpose, location, and construction of the launch control equipment.

INTRODUCTION

The primary purpose of the launch control system is to monitor, control, and provide rapid sequencing of the subsystems required for the "F" silo missile launch. It is designed to do this at the fastest rate possible with the highest degree of success.

The countdown is initiated at the launch control console, and if necessary, a hold is permitted at the "ready-for-commit" portion of the countdown for a period of one hour. There isn't any arbitrary hold point except by delaying the start of the commit sequence, which is that portion of the countdown where the final preparation for launch is enabled.

EQUIPMENT IDENTIFICATION

Main items of Launch Control Equipment:

ITEM	LOCATION
1. Launch Control Console	LCC
2. Relay Logic Units	Level 3
3. Launch Signal Responders	Level 3
4. Umbilical Junction Box	L/P
5. AC-Power Distribution Box	Level 3
6. DC-Power Distribution Box	Level 3
7. Emergency Battery	Level 3

EQUIPMENT DESCRIPTION AND FUNCTION

The following is a general description of the launch control equipment. A more detailed discussion is presented later.

Launch Control Console

The launch control console is the only console used in launching the missile. It has several functional groups of indicators which provide information that cannot be incorporated in the countdown sequence display. This information is necessary for the safety of the missile and for support of required decisions. The console is designed for operation by one man. It is composed of 13 areas called Panels. They are:

Panels	Color of Indicators
1. Select Target Panel	Amber, Green
2. Timer Panel	White
3. Gage Pressure Panel	Red, Green
4. Power and Sensing Panel	Amber, Red
5. Standby Status Panel	Red, Green
6. Countdown Ready Panel	Red, Green
7. (4) Countdown Panels	Amber, Green
8. Abort Panel	Amber, Green
9. Ready State Panel	----
10. Commit Panel	(Amber, Red) & (Amber, Green)
11. Test Panel	
12. Communication System Panel	White
13. Public Address System Panel	White

Within each area are lights, or switches, which denote the condition or status of a particular missile. Two color indicators are used throughout, although in some cases both colors are not used. The basic color combinations are amber/green, green/red, and amber/red.

Each indicator is capable of displaying two lines of 14 letters and spaces each. The bulbs are replaced from the front of the panel without the use of special tools. Lamp test is by means of two master lamp test pushbuttons labeled "Lamp Test 1" and Lampt Test 2". These buttons activate a pair of lamp busses which are coupled to the bulbs by means of diodes mounted within the indicators. The bulbs are identified by the numbers "1" and "2", and if an indicator does not have a response to "Lamp Test 1" then the "1" bulb shoud be replaced. Color coding requirements for lamp test are thus avoided. The same indicator arrangement is employed on the logic units.

The more important functions of the launch console are as follows:

1. The selection of either target A or B.
2. The insertion of down and cross range guidance corrections.
3. The monitoring of the subsystems required for launch.
4. The monitoring and control of missile pressurization.
5. The initiation of the countdown sequence.
6. The initiation of the commit sequence.
7. The initiation of the abort sequence.
8. A display of the countdown sequence.
9. A display of the commit sequence.
10. A display of the abort sequence.

The launch control console is located on level two of the launch control center.

Logic Units #1 and #2 Location: Level 3

Each logic unit contains the necessary electronic and electrical circuitry to monitor and control all missileborne and ground support subsystems during both standby and countdown.

The sequencing of subsystems and components are controlled by the logic unit which in turn receives responses from these subsystems. These responses are interlocked in the logic unit as required and displayed on the front panels to provide information for fault isolation and local control operations.

Launch Signal Responder Location: Level 3

The prime purpose of the Launch Signal Responder (LSR) is to check the proper operation of the logic units and launch control console. Other uses of the LSR may include exercising the logic units between missile rotation periods and exercising the launch crew.

For the above operations the LSR will simulate all the ground support and missileborne equipment; however, only to such an extent as to fulfill its prime purpose, that of checking the logic units.

The LSR's are capable of simulating a countdown that for all practical purposes is true in sequence and time.

The LSR's are checked out by its associated self-test panels when the launch control system is in the standby mode.

DC Power Supply & Distribution Unit Location: Level 3

This unit contains a 28 volt, 600 ampere transformer rectifier power supply, power distribution busses, emergency battery ampere-hour monitor and relays for umbilical ejection power. The rectifier bus and the emergency battery tie directly into the standby bus.

Emergency Battery Location: Level 3

The emergency battery consists of 21 cells, each of 240 ampere-hour capacity. The battery is used to supply DC power for shutdown of the missile systems if the normal 28V DC power supply fails. The battery must be connected before a countdown can be initiated.

400 CPS Power Supply (AF type MD-2) Location: Level 3

This unit is a 10 KW, 120/208 volt, 400 CPS output, synchronous drive motor-generator. It supplies 400 CPS power to the AC power distribution box for distribution to the various 400 CPS loads. It is monitored by sensors in drawer A29 of the relay logic unit #2.

AC Power Distribution Box Location: Level 3

This unit contains relays and receptacles for distribution of 400 CPS power to missileborne and ground loads. It also supplies 60 CPS power to the missile-borne heaters during standby, countdown, and checkout. Another function it performs is that of monitoring the SPGG heaters.

Other launch control items of importance include cable kits, junction boxes, interface connections, and missile ground power system.

Cabling:

The Launch Control System has been developed with a minimum number of pieces of equipment which are directly interconnected by cables. Cable distribution units and power distribution units are not utilized because they would be purely static equipment and would contribute nothing to a tactical system once the design is firmed. Hence the system is composed solely of active equipment and a pre-established set of cables.

All the subsystems interconnection functions that previously have been accomplished by jumpers in cable distribution units are accomplished by fixed harness connections within the two logic units. This means that the factory

acceptance procedure also tests the subsystem signal interchanges. Site electrical OGE installation and activation then consists only of installing the cable kit, setting the OGE in place, mating the connectors, and running validation tests.

The validation tests consists of running a simulated countdown into the launch signal responder (LSR), and verifying by each subsystems local (Manual) controls at the logic units, that their proper subsystem end components are controlled.

The launch control equipment is directly interconnected to other OGE, the missile, the facility, the inertial guidance and re-entry vehicle ground control equipment by cable kits consisting of about 100 cables. These cable kits handle all functions including power, sequencing controls, checkout provisions, and equipment grounding, but excludes the umbilical and communication cables.

The majority of the cables utilize connectors on both ends. Terminals are employed where existing OGE or facility designs employ them. Terminals are also used in the DC negative power return busses and in the equipment grounding due to amperage and resistance requirements.

Umbilical Junction Box

The umbilical junction box is located on the launch platform directly below the flame bucket. The box contains the ARMA amplifier fidelity link which is cooled by air from the pod cooling unit.

The umbilical junction box provides means to accomplish the following:

1. For standby and countdown, connect the OGE to the missile.
2. For LSR mode, disconnect the missile and tie in the LSR to the logic units.
3. For checkout mode, tie the checkout trailer (MAPCHE) through the umbilical cables to the missile and provide AC and DC power to the missile from the missile power control unit, checkout.

The junction box accomplishes the above by acting as a termination point for the following cables:

1. Cable Kit, Missile Umbilical. This kit provides electrical connections from the missileborne subsystems to the OGE via the junction box. The kit contains the following cables:

   a. Guidance Signal

   b. Guidance Power

   c. Propulsion Booster

   d. Autopilot

   e. Static Ground

   f. Missile Power and P/U

   g. Propulsion and P/U

2. Cable Kit, Missile Umbilical. This kit consists of cables connecting the various units on the launch platform to each other and to the umbilical junction box.

3. Cable Kit, L/P Umbilical Loop. This kit consists of cables connecting OGE to the missile and launch platform equipment via the umbilical junction box.

Checkout Cable Junction Box

This unit is located next to the umbilical junction box. The unit (commonly referred to as the MAPCHE stub-up box) provides an interface for the MAPCHE trailer, tying the trailer to the umbilical junction box.

Crib Cable Kit

This kit connects the various OGE items on the crib in the missile silo to each other, and to the facility items.

LCC/Crib Interconnecting Cable Kit

This kit connects OGE items in the launch control center to the OGE on the crib in the missile silo via the interconnecting LCC/Crib tunnel.

Launch Control/OGE/Missile Interface Connections

The silo launch control system is electrically connected to, and controls and/or monitors the following units:

1. Facility Items
2. IRSS Console (GFE) (OSTF-2 and 65-T2 only)
3. Re-Entry Vehicle
4. R/V Prelaunch Monitor and ELEC. simulator CAB.
5. Countdown cabinets 1A1 and 2A2 (ARMA)
6. Alignment Group 2A1 and 2A2 (ARMA)
7. TSC Cabinet (ARMA) (OSTF-2 only)
8. TSC Amplifier (ARMA) (OSTF-2 only)
9. Pressurization Control Unit
10. Pneumatic Distribution Unit
11. Hydraulic Pumping Unit
12. Helium Charge Unit
13. Pod Air Conditioner
14. Launch Platform

15. Launcher
16. Missile
17. MAPCHE Trailer
18. Pneumatic C/O Trailer
19. ARMA Fidelity Link Amplifier (In Umbilical Junction Box)

Block Diagram (Figure 1) of the launch control system in Tactical (Standby Mode)

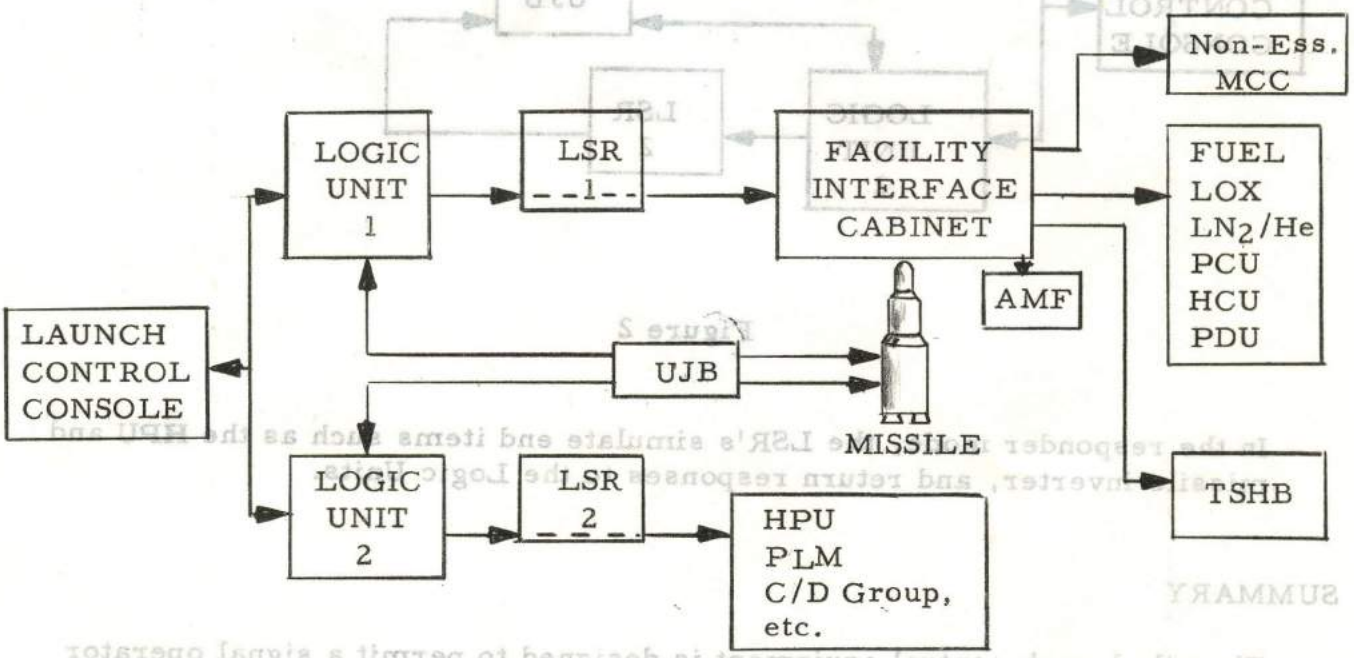


Figure 1

Note that in the block diagram, signal flow to the OGE is via the LSR's. Signals to the missile are via the umbilical junction box directly from the logic units.

Block Diagram (Figure 2) of the launch control system in the Responder Mode:

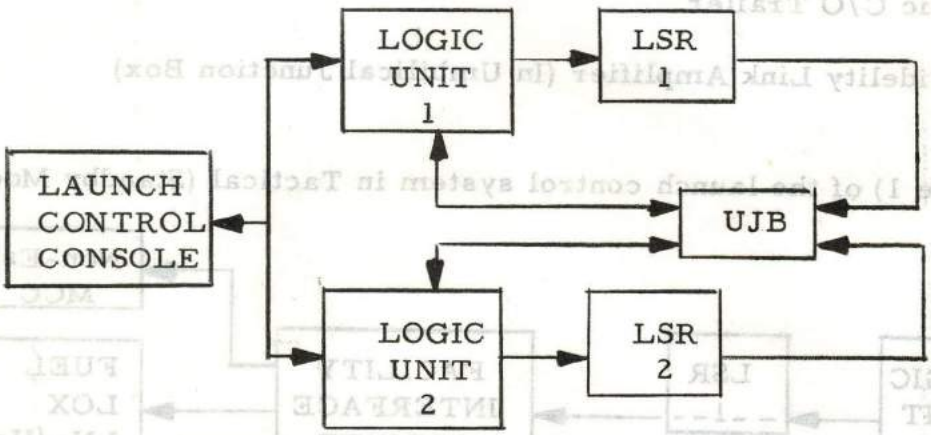


Figure 2

In the responder mode, the LSR's simulate end items such as the HPU and missile inverter, and return responses to the Logic Units.

SUMMARY

The silo launch control equipment is designed to permit a signal operator to countdown and launch the missile. The countdown is based upon a strictly tactical situation. The launch control presents only the summary displays required to launch the missile and to provide the state of the countdown or standby condition. Detailed breakdown of the console displays is contained on the front panels of the logic units.

The sequencing of subsystems and components are controlled by the logic units which in turn monitor the processes of missileborne and AGE subsystems.

The launch signal responders are used to check the proper operation of the logic units and launch control console.

QUESTIONS

1. What is the purpose of the launch control system?

2. List the units of launch control equipment.

3. What units are electrically connected to the launch control system?

4. Where is the launch control console located?

5. What is the prime purpose of the logic units?

6. What is the prime purpose of the signal responders?

7. Where is the umbilical junction box located?

8. Are any missileborne or AGE subsystems connected to the launch control equipment during checkout? Explain.

9. What type of displays are presented on the launch control console?

ELECTRICAL CIRCUITRY OPERATION

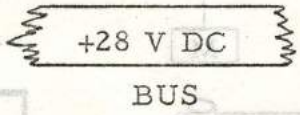
Relays

A relay is one form of an electrical switch. There are four main types of relays found in the logic units and launch signal responders:

1. The standard relay.
2. The time delay pickup relay (TDPU).
3. The time delay drop out relay (TDDO).
4. The magnetic latching relay.

The standard relay energizes whenever voltage is applied, and de-energizes when voltage is removed. The mechanical operation is as follows: (Figure 3)

Step 1. Assume a source of electrical power is available to a bus:



Step 2. Assume an electrical lead is attached to this bus, and connects to a relay via a switch.

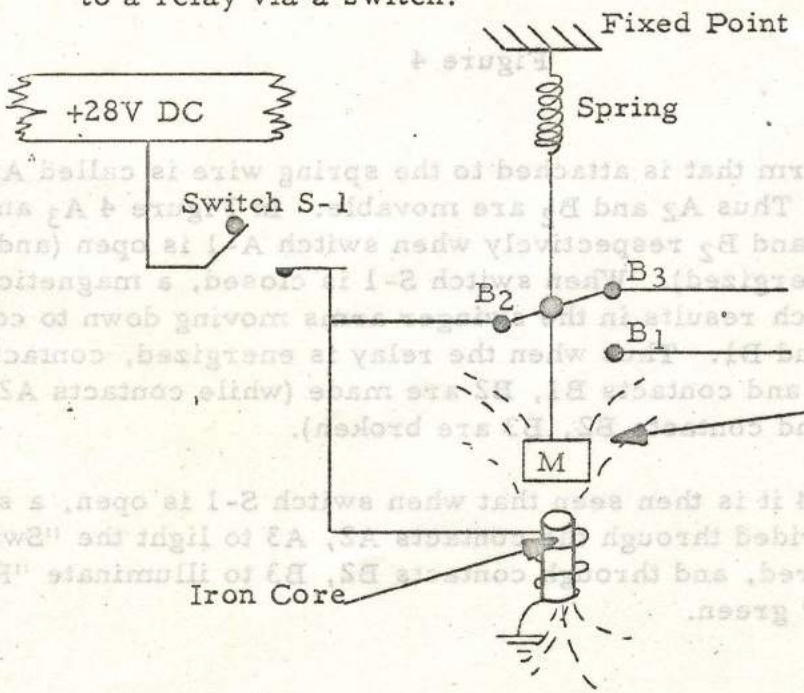


Figure 3

By wrapping a wire several hundred times around an iron core one has made a basic solenoid. Whenever voltage is applied to the wire, a magnetic field is created about the iron core, and is strongest at the poles. If a metal slug were placed near a pole of the solenoid, it would be attracted by the magnetic field. By attaching a spring to the metal slug, when the relay is energized the slug is attracted downward. When the magnetic field collapses, the spring returns the metal slug to its original position. By attaching more electrical leads to the spring wire, and allowing a movable connection one has a basic standard relay.

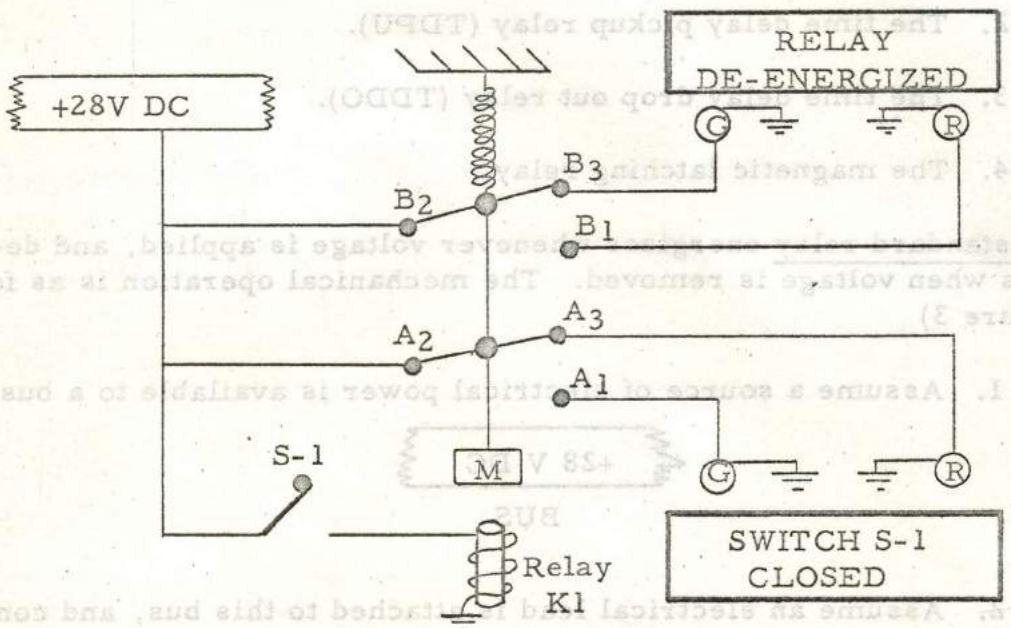


Figure 4

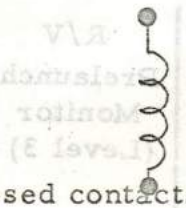
The swinger arm that is attached to the spring wire is called A_2, B_2 respectively. Thus A_2 and B_2 are movable. In Figure 4 A_3 and B_3 connect to A_2 and B_2 respectively when switch A-1 is open (and the relay is de-energized). When switch S-1 is closed, a magnetic field is created which results in the swinger arms moving down to connect to points A1 and B1. Thus when the relay is energized, contacts A1, A2 are made, and contacts B1, B2 are made (while contacts A2, A3 are broken, and contacts B2, B3 are broken).

From Figure 4 it is then seen that when switch S-1 is open, a series circuit is provided through the contacts A2, A3 to light the "Switch Closed" light red, and through contacts B2, B3 to illuminate "Relay De-energized" green.

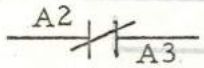
When S-1 is closed, and the relay is energized, contacts A2, A3 break and contacts B2, B3 break, while contacts A2, A1 make, and contacts B2, B1 make. The "Relay De-energized" light illuminates red, the "Switch Closed" light illuminates green.

A standard relay operates essentially in the same manner. However, instead of just two sets of contacts, they may have as many as six.

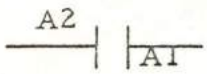
In the launch control schematic diagrams, certain symbols are used to represent relays and contacts. A standard relay is represented by this symbol:

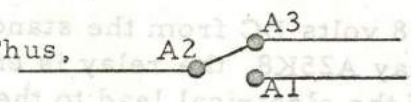


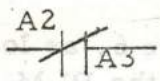
A set of normally closed contacts (all relay contacts are drawn in the de-energized position) are represented by the symbol:

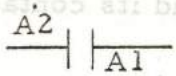


and normally open contacts by:



Thus, 

is represented by 

and by 

Replacing the symbols stated in Figure 4 light circuit:

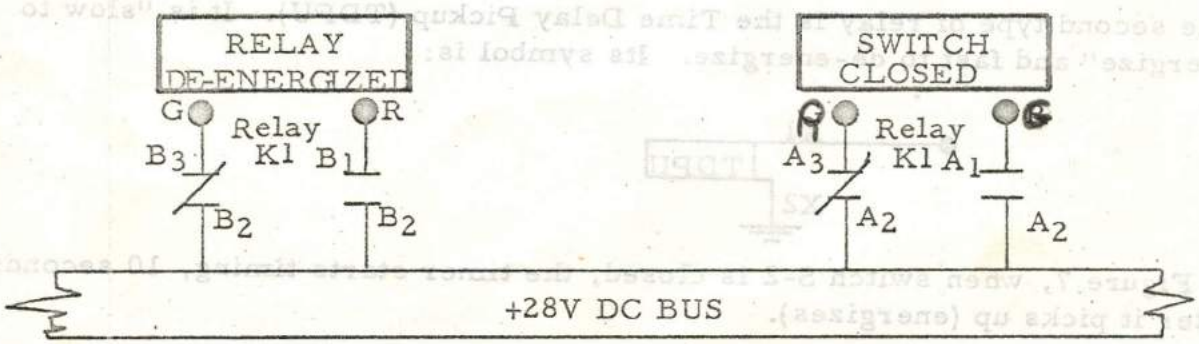


Figure 5

Thus, when relay K1 is energized, both lights will illuminate red. (Figure 5)

Another important point is that whatever is written along the relay, or the relay contacts, when that statement is true, the relay is energized and the contacts change position.

EXAMPLE:

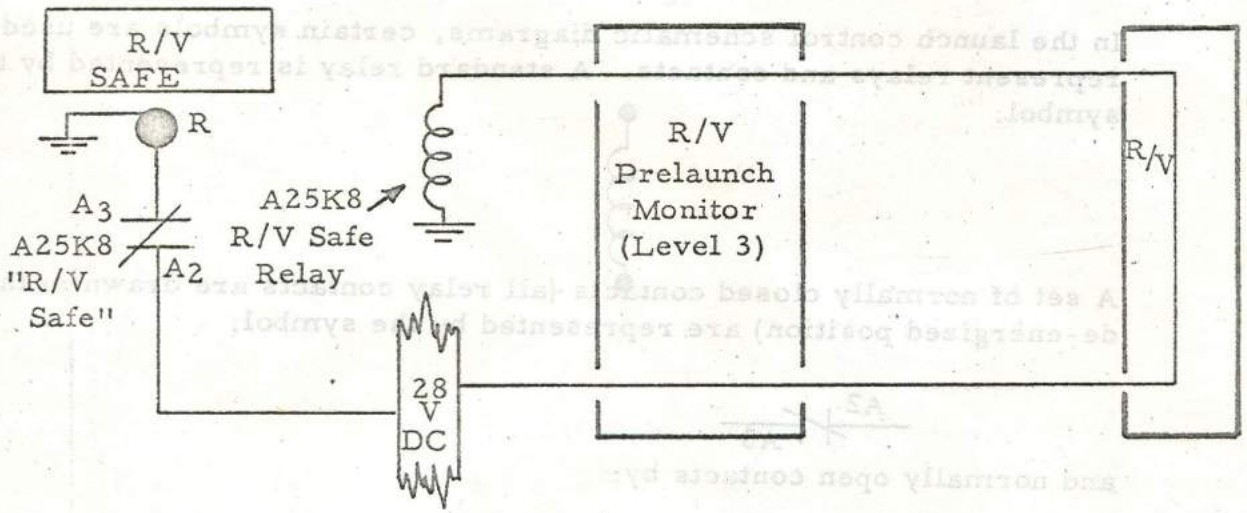
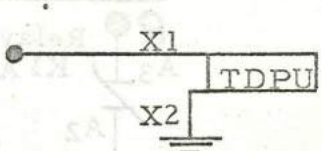


Figure 6

In Figure 6, as long as there is a steady 28 volts DC from the standby bus through the PLM, and R/V and back to relay A25K8, the relay is energized and the R/V Safe Light is extinguished. If the electrical lead to the relay A25K8 is broken, the relay de-energizes, and its contacts A3, A2 provide a path to illuminate the R/V Safe light red.

Thus, an R/V not safe condition illuminates the light red. An R/V safe condition keeps the light extinguished.

The second type of relay is the Time Delay Pickup (TDPU). It is "slow to energize" and fast to de-energize. Its symbol is:



In Figure 7, when switch S-2 is closed, the timer starts timing, 10 seconds later it picks up (energizes).

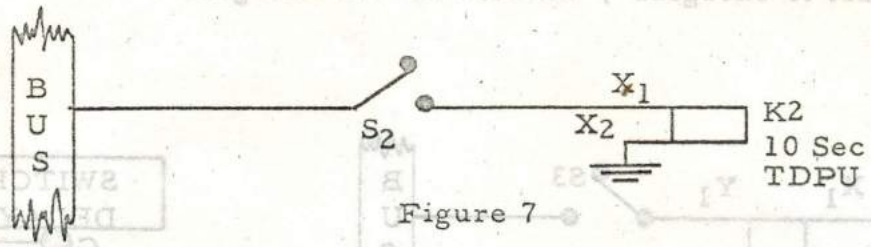


Figure 7

The relay de-energizes immediately whenever S-2 is reopened.

EXAMPLE:

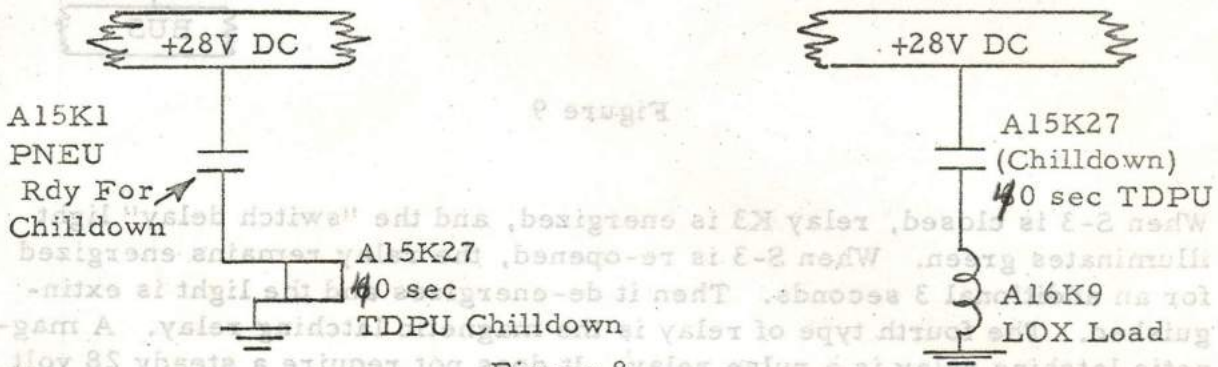
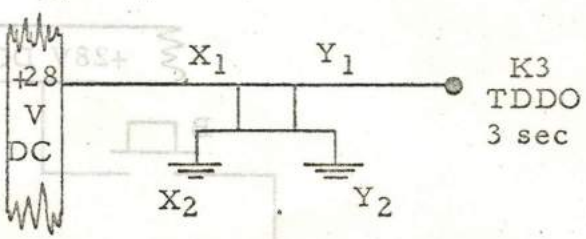


Figure 8

When the pneumatics ready for chilldown relay is energized, (Figure 8) and if it remains energized, 60 seconds later A15K27, the 60 second TDPU relay energizes, which in turn energizes A16K9, the "LOX Load" relay.

The third type of relay is the time delay dropout, TDDO. It has two leads, an X_1 and a Y_1 side.



The X_1 side is always "on". When Y_1 receives +28V DC signal the relay energizes. When the +28V DC signal is removed, the relay de-energizes 3 seconds later. (Figure 9)

The relay is "fast to energize", but slow to "de-energize".

EXAMPLE:

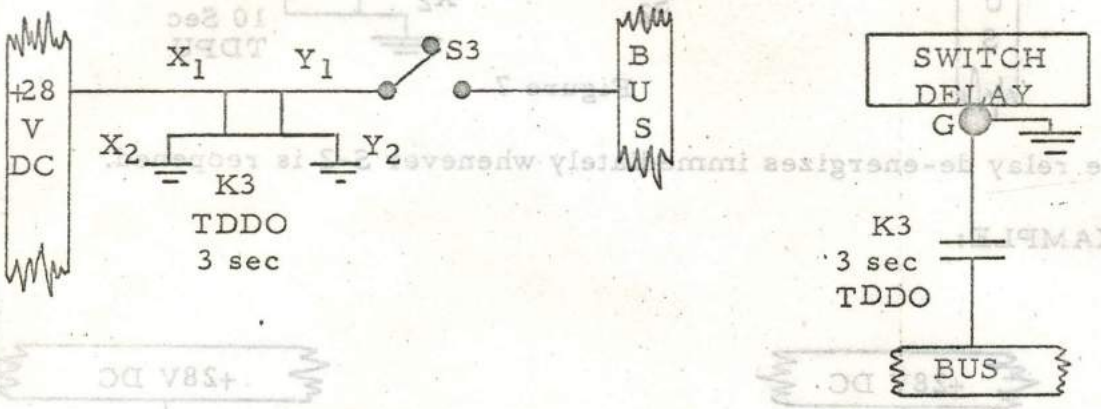
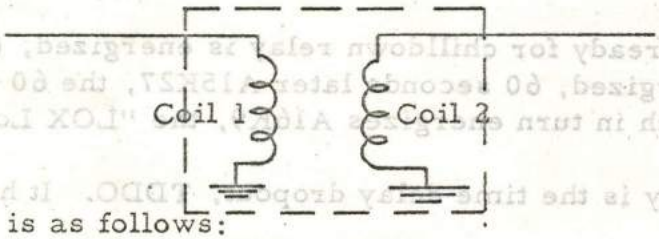


Figure 9

When S-3 is closed, relay K3 is energized, and the "switch delay" light illuminates green. When S-3 is re-opened, the relay remains energized for an additional 3 seconds. Then it de-energizes and the light is extinguished. The fourth type of relay is the magnetic latching relay. A magnetic latching relay is a pulse relay. It does not require a steady 28 volt DC signal, just a "burst" or pulse of electricity. Its symbol is:



Its operation is as follows:

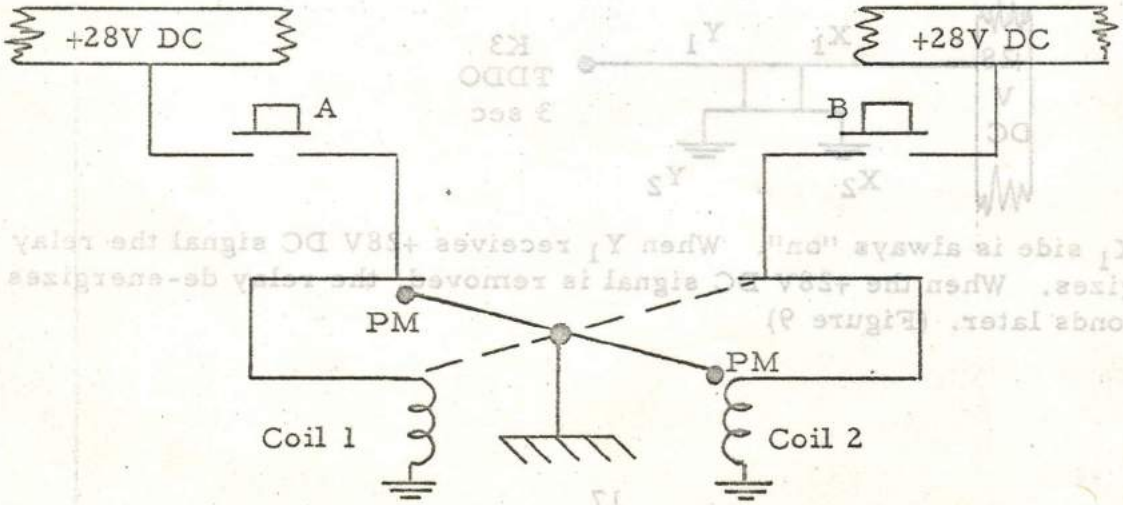
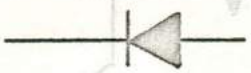


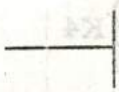
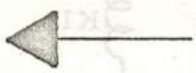
Figure 10

When pushbutton B is depressed, (Figure 10), coil 2 is energized, which sets up a magnetic field which repels the permanent magnet, and the arm "flips". Similarly for "A".

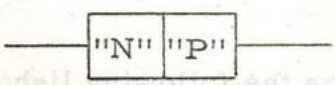
DIODES

Diodes are used in the launch control system as voltage limiters, and as current "directors".

The symbol  is a standard diode, where

 represents "N" type material, and 

represents "P" type material.

 corresponds to 

Potential Barrier

Since "N" type material is said to have an excess of electrons, and "P" type a deficiency of electrons, a negative voltage impressed on the "N" type repels the electrons, decreases the potential barrier, and the diode conducts. If a positive voltage were impressed at the "N" wafer, the two would attract, the potential barrier would increase, and the diode would not conduct (sufficiently). (Remember, like charges repel, unlike charges attract.)

Therefore in the following circuits, (Figure 11) K2 WILL NOT CONDUCT, K4 WILL CONDUCT AND WILL ENERGIZE.

Electron flow is always against the arrow in a standard diode. Diodes are drawn in the electrical schematic in terms of current flow, i.e. from positive to negative. Therefore in circuit tracing, from the +28V DC power bus you may go through a diode if you go with the arrow.

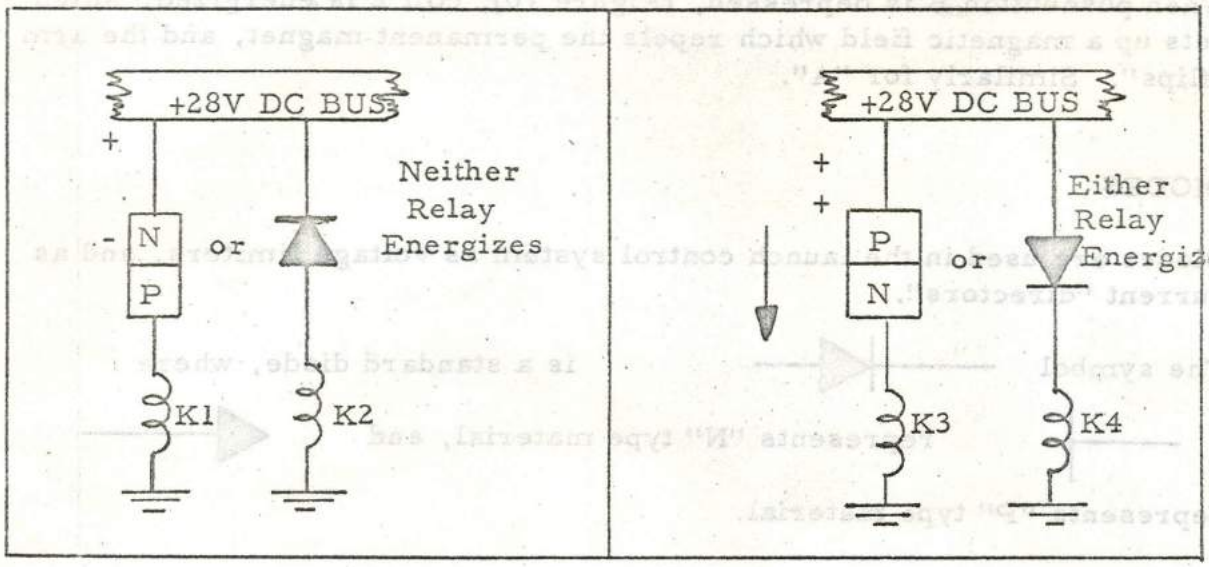
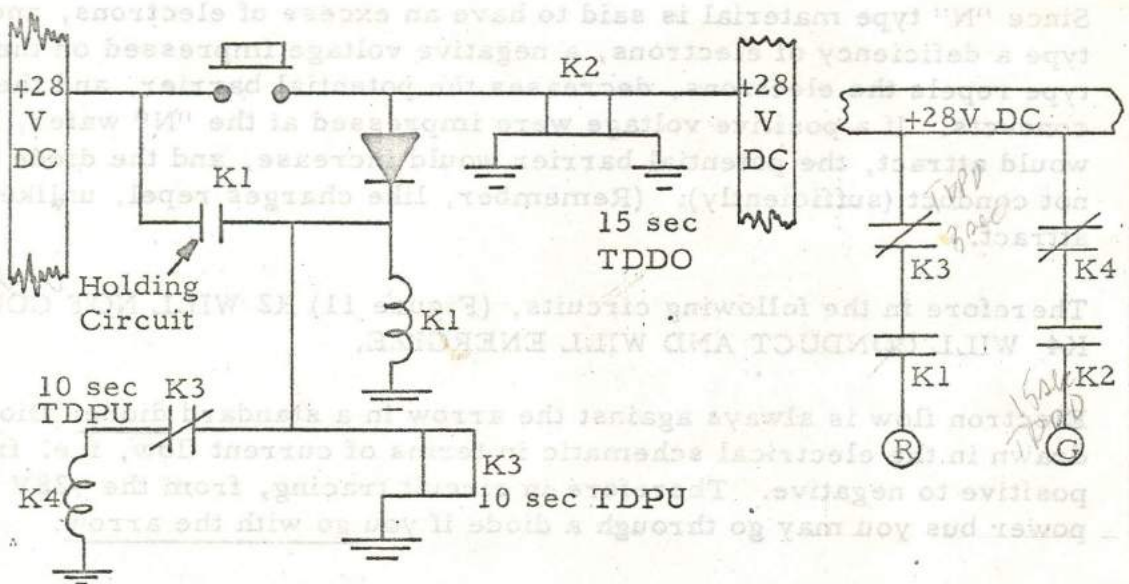


Figure 11

Analyze the following light circuit:



Assume the pushbutton has been depressed and released.

Figure 12

QUESTIONS (Refer to Figure 12)

1. What is the function of the diode?

2. When will the light illuminate red?

PUSH BUTTON

3. When will the light illuminate green?

10 sec later

4. When will the light extinguish?

after 15 sec or for 5 sec

LOGIC UNITS

The Logic Units (Figures 89-92) are located on level 3 in the silo. A logic unit is a device containing relays, sensors, switches, and indicators to provide monitor, control and rapid sequencing. Sheet one of blueprints show light and switch locations and indicate relay locations. The blueprints are similar to a 'road map' for location purposes.

Construction

Logic units No. 1 and No. 2 are palletized rack type structures. Each logic unit is equivalent in size and design to four conventional relay rack cabinets and is capable of containing 24 chassis.

The basic cabinet consists of the chassis mounting assembly, a transverse stiffener bulkhead mounting the chassis electrical receptacles and wiring harness, a light weight housing to cover the harness, air plenums, and a mounting base. The cooling air is delivered into an air plenum above the chassis mounting assembly, then down through two of the hollow structural walls between the vertical columns of chassis.

Each logic unit drawer is given the prefix A. Drawer A1 through A24 are in relay logic unit #1. Drawers A25 through A48 are in relay logic unit #2. A 3/4 inch torque nut on the face of each panel is used to secure the drawer to the cabinet. Index pins in the cabinet prevent insertion of any drawer except the one to be utilized. A lever located about half-way in the drawer allows complete removal of the drawers. Relays in the logic units, are given the prefix 600, such as 600A25K8, indicating drawer A25 (R/V sequencer), the 8th relay. "600" indicates logic unit. The responders are similar, using the prefix 609. As an example 609A45K9, a relay in the hydraulics responder.

Controls and Indicators

The following sequencers have remote/local switches: PLCU, FUEL, LOX, LN2/He, A/P, HYDRAULICS.

On local control, certain functions may be performed such as "transducer

checks", automatic valve operation, etc. On local control, the local power indicator illuminates amber. The pneumatic sequencer has a local/remote switch, but it is used in conjunction with the pod air conditioning. Remote control is a requirement to start countdown on all sequencers having Local/Remote switches.

All but two sequencers have a system in standby indicator which monitors the subsystem that the sequencer is controlling. For example, the Hydraulics sequencer SYSTEM IN STANDBY light monitors that the HPU is ready to start countdown. The exceptions are the countdown and facility sequencers.

The following is a brief description of their functions.

Function of the Individual Logic Unit Sequencers:

1. Logic Unit #1 PLCU (Figure 93) (Drawers A1, A2)

   a. Controls loading of fuel during transfer of fuel from catchment tank or fuel tanking truck.

   b. Monitors level of fuel upon initiation of countdown for a 3 second period, or during a transducer check prior to the start of countdown.

   c. Controls the closing of certain valves during LOX loading, and also controls the topping of LOX.

2. Fuel Tanking Control (Figures 94, 95) (Drawers A3, A4)

   a. Use to transfer fuel from catchment tank or fuel tanking trucks after missile is lowered in the silo.

   b. Fuel is pumped by means of electrically controlled valves controlled from the fuel sequencer.

   c. Two pair of sensors, one pair at 99.6% and one pair at 100.4% of missile fuel tank fullness.

      (1) When the fuel comes in contact with the 99.6% sensor, the PLCU signals the F1 valve to close. Opening or closing the F1 switch will not operate F1 valve once fuel is above 99.6% sensor.

(2) The 100.4% sensor sends indication that fuel level is too high.

3. Pneumatic System Control Sequencer (Figures 96, 97, 98) (Drawers A8, A9, A10)

a. Control PCU valves so that proper pressures are maintained in the missile during standby, loading, and unloading conditions.

b. Phase I (Standby) — 12 PSI in Missile fuel tank; 4 PSI in Missile LOX tank

c. Phase II (Propellant Loading) — 63 PSI in Missile fuel tank; 4 PSI in Missile LOX tank

d. Phase III (Flight Pressure) — 63 PSI in Missile fuel tank; 27 PSI in Missile LOX tank

e. Pod air conditioning is set to Remote Control here.

4. LOX System Control (Figures 99, 100) (Drawers A14, A15, A16)

a. Monitors automatic LOX valves.

b. Controls automatic valves during countdown and commit sequence to assure missile with sufficient supply of liquid oxygen.

c. Operates automatic valves in local control for checkout purposes.

d. Monitors pressure need for loading LOX.

e. Loading of the LOX storage and topping tanks is accomplished manually by operating the fill valves (L-7, L-6) which will close automatically by a float switch when the tank is full.

5. Facilities System Control (Figure 101) (Drawer A20)

a. Monitors and controls thrust section blower.

b. Monitors and controls non-essential power motor control center.

c. Monitors if a nuclear blast is detected.

d. Monitors if proper summary commands are received by the C/D sequencer from the missile lift sequencer and facilities sequencer.

e. Causes blast covers to close upon receipt of "missile lift commit start" signal.

f. Turns on non-essential power again after "site hard" signal is received. (Turns off at missile power internal.)

g. Turns heaters off a few seconds after "missile away", and the blast dampers are re-opened.

h. Turns on and then off the purge flows to remove GO2, GN2 fumes before the silo doors are opened.

6. Missile Lift Sequencer (Figure 102) (Drawer A21)

a. Monitors AMF Logic Racks

b. Controls AMF Logic Racks

7. LN2/Helium System Control (Figure 103) (Drawer A22, A23)

a. Fills missile helium spheres during countdown.

b. Loads LN2 at fast rapid load rate (6 min.) then at a reduced rate. (Medium and fine loads.)

c. Monitors and controls the LN2/He transfer system.

d. Vents inflight helium bottles through HCU.

e. Ambient bottle is vented through HCU via the heat exchanger and PDU after a 2-hour time delay.

LOGIC UNIT #2

8. R/V Control (Figure 104) (Drawer A25)

   a. Monitors R/V for

      (1) Safe condition

      (2) Power Available

      (3) Tactical Condition

   b. Controls R/V target selection upon signal from Launch Control officer's console (via Guidance sequencer).

   c. Monitors MK III's Battery Temperature during C/D.

9. Missile Power System Control Sequencer (Figures 105, 106) (Drawers A26, A27, A28, A29)

   Functions:

   a. Control application of A/P heater power.

   b. Control application of MGS power.

   c. To control and monitor positions of the power changeover switch.

   d. To monitor ground AC and DC voltages.

   e. Activates missile battery at start of countdown.

   f. Starts Missile Inverter 5 minutes after start of countdown, or at end of LOX Rapid Loading, whichever occurs first.

   g. Monitors Missile AC and DC.

   h. Initiates Commit Sequence when electrical power has been transferred to Missile power.

i. Shuts Inverter off if run 5 minutes without starting the Commit Sequence.

10. Guidance Control (Figure 107) (Drawer A31)

a. Monitors Arma C/D group which in turn monitors the MGS.

b. Upon receipt of target selection command from console, it selects target A, or B for the MGS. (Target constants boards.)

c. Upon command, it generates a signal to "GO AIG" to the MGS, thus upon return signal that MGS is "on inertial" it enables the engine start command.

d. Commands MGS to go on Memory upon receipt of a signal from the Facility Sequencer that a nuclear blast has been detected, or Missile Power Internal during the Commit Sequence.

11. Autopilot System Control Sequencer (Figures 108, 109) (Drawers A32, A33, A34, A35, A36)

a. Monitors A/P Flight Programmer (F/P).

b. Monitors A/P Heaters (P/Y rate, displacement gyro fine heaters).

c. Initiates command to arm F/P in the commit sequence.

d. Controls F/P on local operation.

e. Monitors A/P gyros for drift during countdown for 90 seconds.

f. Monitors engine position during countdown.

g. Has certain checkout capabilities for the A/P system.

h. Monitors that gyro spin motors are running during countdown.

12. Hydraulic System Control (Figure 110) (Drawer A38)

a. Monitors Hydraulic Pumping Unit

(1) Valve position

(2) Return pressure in S/B.

(3) Output pressure in countdown.

b. Controls the starting and stopping of the HPU.

c. Has local control for checkout purposes.

d. Extracts 130 cubic inches of hydraulic fluid from Missile Hydraulic System during the Commit Sequence (at Commit Internal).

13. Engine System Control (Figures 111) (Drawer A39, A40)

a. Fires Initiators, Ignitors.

b. Cuts off engines if Missile not away 5 seconds after the Ignition Start command is generated.

c. "System Power ON" is the only requirement for this sequencer in Standby.

14. Countdown System Control (Figure 113) (Drawers A44, A45, A46, A47)

a. Monitors the L/C System.

b. Controls the L/C System.

c. Provides majority of display lights on the console with necessary relay logic.

d. Contains the countdown clock.

Those chassis or drawer numbers omitted are "spares" or blank chassis, or do not have any indicators or controls.

LAUNCH SIGNAL RESPONDER OPERATION

The most important concept associated with the theory of launch signal responders (Figures 114 - 117) is that of major and minor commands. Before introduction to the responder operation can be made, a discussion of command signals is necessary.

There are two kinds of command signals in the launch control system, and they are called Major and Minor Commands. Major commands are electrical signals which initiate in one of the logic unit sequencers and terminate in another. In the standby mode position of the LSR transfer switches, major commands exist strictly within the logic units. They do not leave the logic units. In the responder mode, the major commands still perform their functions within the logic units but are now enabled to be monitored by major command relays in the LSR's. Minor commands are electrical signals which leave the logic unit and terminate at an end item such as a valve, or a motor, or come from the end item to the logic units.

There are two types of major commands:

Major incoming
or
Major outgoing

There are two types of minor commands:

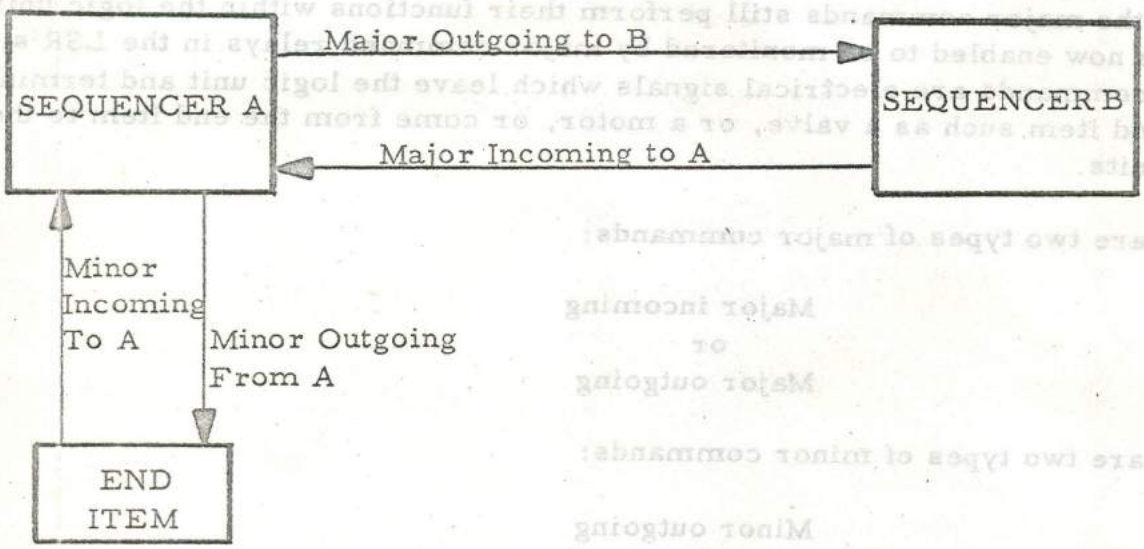
Minor outgoing
or
Minor incoming

Major incoming commands are major commands incoming in a particular sequencer. In the responder mode, all major incoming commands to a particular sequencer are monitored by the respective responder in the form of "green" indicators called Major incoming commands. Thus, "Pneumatics ready for Chilldown" is a major incoming command to the LOX sequencer from the pneumatics sequencer. Therefore, in the responder mode, the LOX responder will have a green illumination in a light called "Pneumatics Ready for Chilldown", if the signal is present.

Major outgoing commands are major commands outgoing from a sequencer to another sequencer. In the above example, "Pneumatics Ready for Chill-down" was seen to be a major incoming command to the LOX sequencer, and by definition it was a major outgoing command from the pneumatics sequencer.

Simply, major commands exist between logic unit sequencers, outgoing from one sequencer, incoming to another.

Minor command to end items from a logic unit sequencer are called minor outgoing commands. Minor commands incoming to a sequencer from end items are called minor incoming commands; or responses. The Countdown and Propellant Level Control Sequencers do not generate minor outgoing commands.



BLOCK DIAGRAM OF MAJOR & MINOR COMMANDS TACTICAL MODE

Figure 13

With respect to sequencer A, (Figure 13), the arrow going to sequencer B represents a major outgoing command from A to B.

The arrow coming to sequencer A from B represents a major incoming command to A from B.

The arrow going from sequencer A to the end item represents a minor outgoing command from A. The arrow going to sequencer A from the end item represents a minor incoming (response) command to sequencer A. An end

item for all practical purposes is a piece of operational ground equipment, or a missile system, or a component. It is "something" outside of the logic unit. There are about 82 major incoming command monitored by the launch signal responders.

In Tactical Mode (Figure 14)

Normally two seconds after the start of countdown when the A/P gyros are started, the A/P sequencer sends a major outgoing command called "A/P ON", which is a major incoming command to the hydraulics sequencer. "A/P ON" then leaves the hydraulic sequencer and becomes a minor outgoing command to start the HPU. When the HPU reaches its operating pressure of 2000 PSI + or -250 PSI P.S. 49 sends a minor incoming command to the hydraulics sequencer signifying hydraulic pressure is okay. It then becomes a major outgoing command from the hydraulic sequencer and a major incoming command to the A/P sequencer where this signal is used to enable engine position monitoring.

(See Figure 14) In Responder Mode, the "A/P ON" major incoming command is monitored by the hydraulics responder for being present (in the monitor section). Also when the "A/P ON" signal leaves the hydraulics sequencer to go to the HPU, it now instead goes to the simulation section of the hydraulics responder, where a TDPU relay starts to time out. At the end of 5 seconds it returns the minor incoming command "Hydraulic pressure" to the hydraulic sequencer. As far as the hydraulic sequencer is concerned, all it "knows" is that it received a 28V DC signal from an end item. In this case, the simulation section acts as the end item (P.S. 49) and sends a response to the hydraulics sequencer. Thus the hydraulics sequencer receives a response (either from the end item in tactical mode, or from the simulation portion of the responder in responder mode) and generates a major outgoing command to the A/P sequencer.

Thus in the responder mode:

> The launch signal responder serves to monitor the major and minor commands of the logic units, and it simulates end item respondes.

Typical Responder Chassis (Figures 118-153)

The responder is divided basically into two panels:

A self-test panel which is used in the tactical mode to checkout the responder major and minor command relays, and the internal circuitry. A simulated countdown panel which is checked out in the self-test mode, but serves its true function in the responder mode, that of monitoring for the presence of major and minor commands of the logic unit, and the simulation of end items.

Basic components of the self-test panel:

1. Test power switch (applies power for the self-test).
2. Major outgoing command test switch (energizes the responders major outgoing command relays).
3. Step pushbutton (enables stepping of a test counter).
4. Test Counter (enables stepping of the system counter and shows position or step of test stepping switch).
5. Test Reset pushbutton (resets the test counter).
6. Stop Reset Pushbutton (de-energizes a stop relay).
7. Fault insertion switches (in responder mode they are used to simulate faults in the end items).

Basic components of the simulated countdown section:

1. System Status light (indicates red for malfunction, green if satisfactory conditions exist, and is extinguished during certain steps).
2. Major incoming command indicators (illuminate green when the command is present).

3. System counter (advances digital readout when the homing relay and advance relay are energized. Shows position or step of system stepping switch).

4. Responder Power switch (applies power to the responder).

5. Stepping Switch (a rotary switch with associated wafers and wiper arms).

6. Stepping coil (enables stepping of the stepping switch when the advance relay is energized and the stop relay is de-energized).

7. Advance command wafer (monitors major incoming and minor commands by permitting signal flow to the advance relay).

8. Advance relay (energizes when certain major incoming and minor commands are present or absent according to a predetermined matrix).

9. Present Command Wafer (allows monitoring by the minor command fault relay (TDDO) of the previous path of the advance command wafer).

10. Minor (and major incoming) command fault relay. (A TDDO relay that is normally energized when there aren't any faults in the step it is monitoring. If a fault occurs, it de-energizes, and its contacts energize a "stop" relay.)

11. STOP Relay (energizes whenever the commands being monitored are not in the correct sequence or are not available).

12. Homing Wafer and homing relay (returns all wiper arms to the zero position when power is turned off then on again, if the wiper arms are not already on zero. Also on the zero position of the wafer, it enables the minor command fault realy (TDDO) to energize).

13. Too Early, Too Late wafers and their respective relays (monitor major outgoing commands for being either too early or too late).

14. The simulation section receives minor outgoing commands from the logic unit sequencer and provides a response back to the sequencer.

15. Lamp test pushbuttons for determing lamp operation.

16. Relay Matrix (a relay tree made up of the contacts of the major incoming and minor command relays. This "tree" then enables the Advance Command section to initiate stepping action, and the present command section to monitor for sequence and relay operation).

LAUNCH CONTROL CHECKOUT

The major "tools" used in analyzing malfunctions of the logic units to a drawer level are:

1. SYSTEM STATUS INDICATOR LIGHT ("RED" for malfunction).

2. MAJOR INCOMING COMMAND LIGHT (Green indicates command is present, thereby reducing the number of relays to check if a malfunction occurs).

3. SYSTEM COUNTER (tells what step should be used to analyze the malfunctions).

In actual practice, there are four parts to be considered when a checkout with the responders is desired. They are:

1. A self-test of the LSR's prior to initiating the simulated countdown. (Performed in "Standby Mode").

2. A check of the light circuitry by means of the lamp test and countdown responder prior to simulated countdown (performed in "responder mode").

3. An actual simulated countdown in real time with No faults inserted. If a red light illuminates, this would indicate a malfunction.

4. An actual simulated countdown in real time with faults inserted, and in this case, if a light stays green when it should illuminate red, it indicates malfunctioning circuitry.

Let a particular logic unit subsystem sequencer be considered. Basically it generates the following categories of signals:

a. Minor Outgoing Commands.

b. Major Outgoing Commands.

c. Signals for operating lights on the control panel.

It receives major incoming commands, and it receives responses from the end components. The major incoming commands are the signals which will start the logic sequence of the sequencer; later on during the countdown cycle the responses may sometimes initiate such a sequence.

As a result of the logic sequence, the sequencer will generate its outgoing signals.

System Matrix

Keeping in mind that the main function of the Logic Unit is to operate the AGE and Airborne equipment correctly and in proper sequence, it will be clear that ultimately the minor commands are the main product of the Logic Units. Therefore, a proper operation of the Logic Units means that the minor commands are generated correctly and in proper sequence during the countdown cycle.

The countdown cycle however, has a permissive progress and the sequencing progress of the various subsystems in respect to each other may differ from case to case, and will also depend on the individual settings of certain time delay relays in each sequencer.

Launch Control Checkout is accomplished primarily by the launch signal responders. Three functions of the LSR's during checkout are:

1. Checking the minor commands against a preestablished subsystem matrix.

2. Checking that a step takes place by the correct initiating signal only.

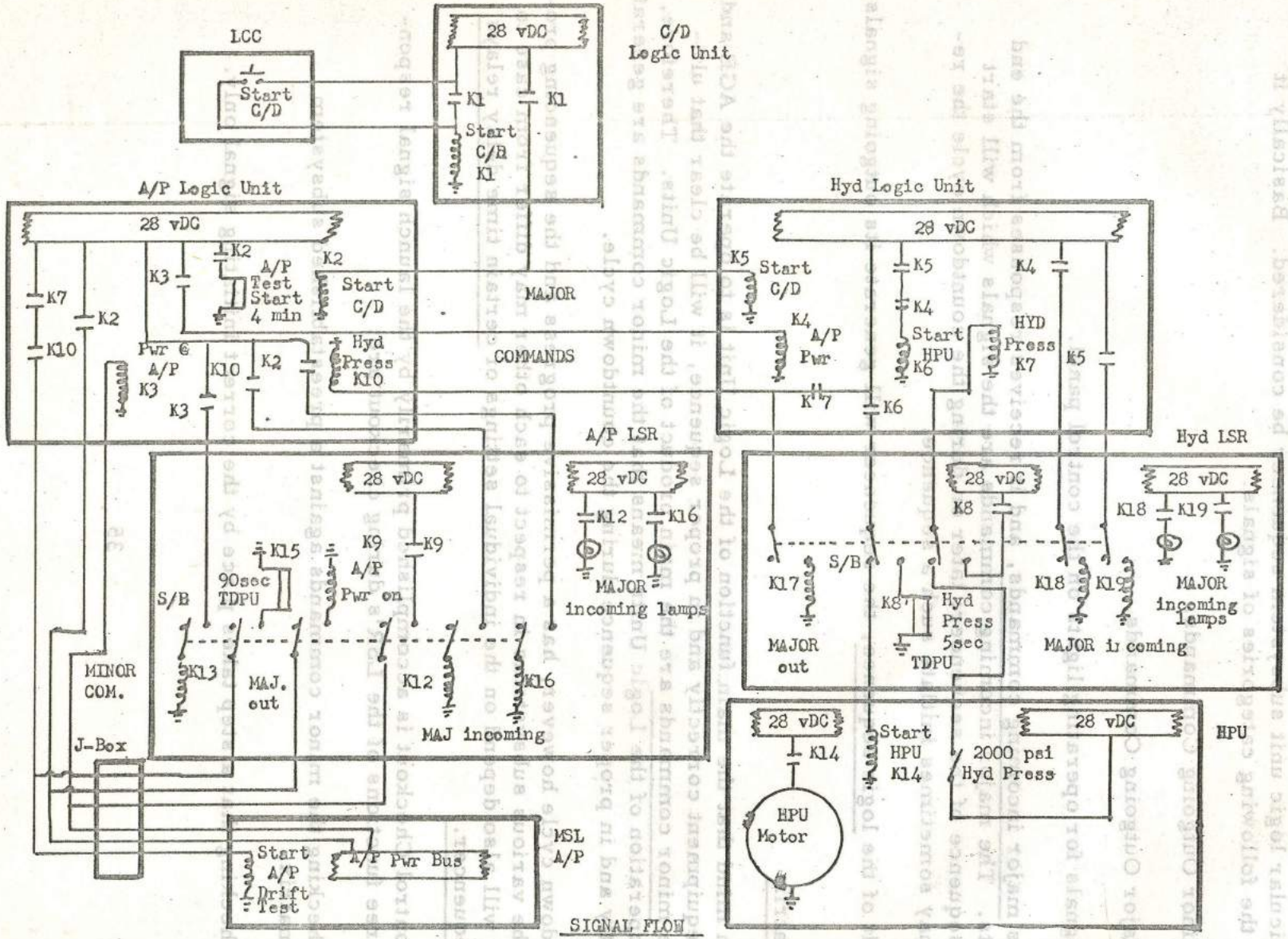


Figure 14

3. Checking that the major commands are generated at the proper steps only.

The responder monitors the major incoming commands, the major outgoing commands, the minor outgoing commands, and simulates the end item responses.

Minor Command Fault Check

The function of the responder is to check that voltage at the tree branches 1, 2, 3, ETC., of Figure 15 appears correctly, continuously, and in correct sequence. For this purpose, a telephone type stepping switching is used. The present command wafer checks on the continuity of a minor command combination by means of a minor command fault relay, and a time delay relay which drops out if the voltage disappears for a period exceeding 500 milli-seconds. The advance command wafer takes care of the stepping procedure of the switch.

Suppose the sequencer is in step 3 of its cycle. In that case the wiper will be in position 3. The minor command fault relay checks on the continuity of voltage from branch 3 of the relay tree. Suppose now the sequencer cycles to step 4. The voltage of branch 3 disappears and will appear at 4. Since point 4 of the tree is wired to position 3 of the advance command wafer and the stepping switch is still in position 3, the advance command relay will pick up, energizing the switch stepping relay, and ultimately resulting in a step of the switch. The minor command fault relay, which, due to its time delay, remained picked up during the stepping period, will now be connected to point 4 of the present command wafer, and will again receive voltage but now from point 4 of the tree.

If a minor command combination appears out of sequence, the stepping switch will not advance and the minor command fault relay will drop out after 500 milliseconds.

Major Outgoing Command Check

A major command generated in the sequencer will energize a major outgoing command relay in the responder (see Figure 16). The check on these commands are made with the same stepping switch as used for the minor commands. As mentioned previously, a major outgoing command will be related to a certain step.

TYPICAL RESPONDER STEPPING SWITCH

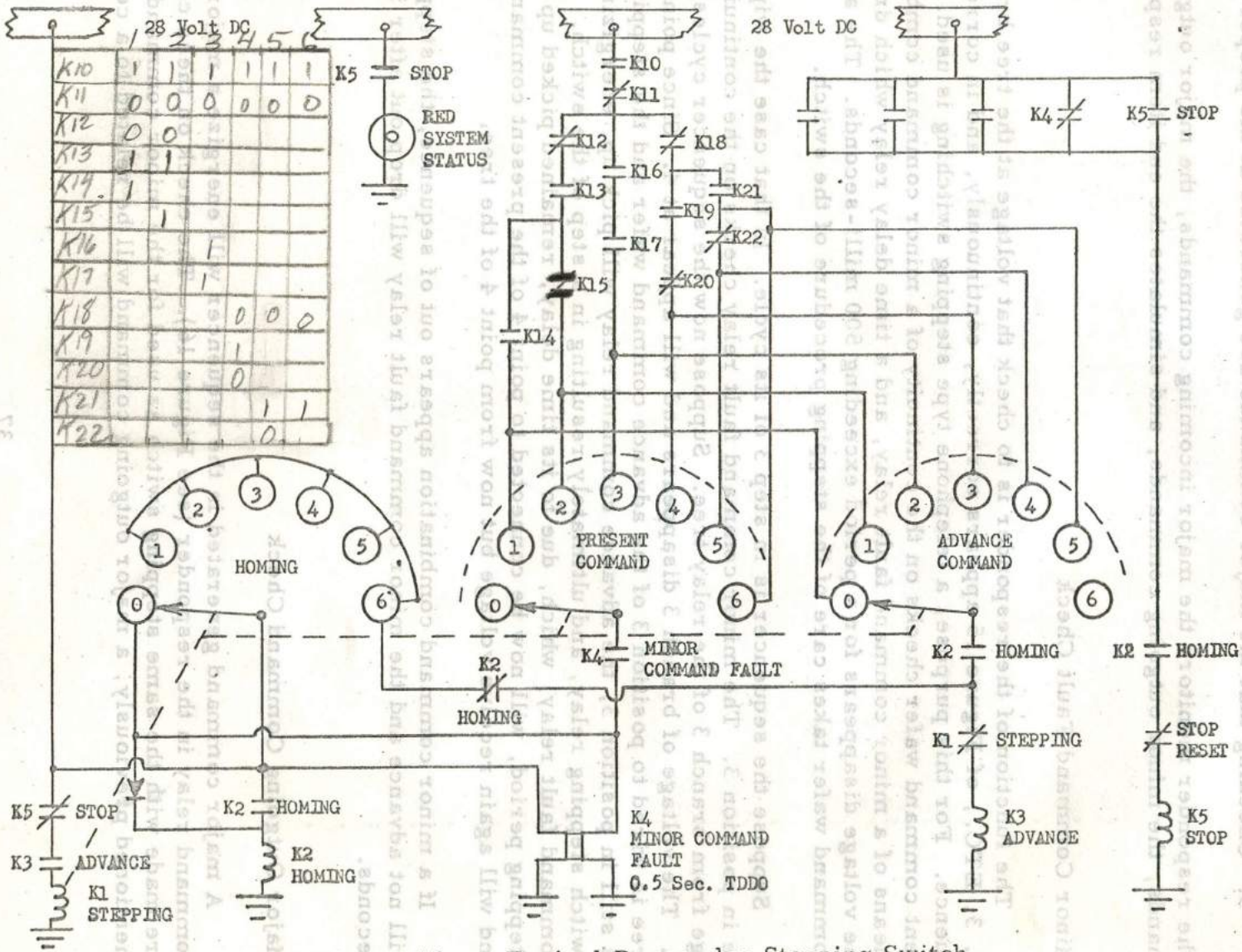


Figure 15 - Typical Responder Stepping Switch

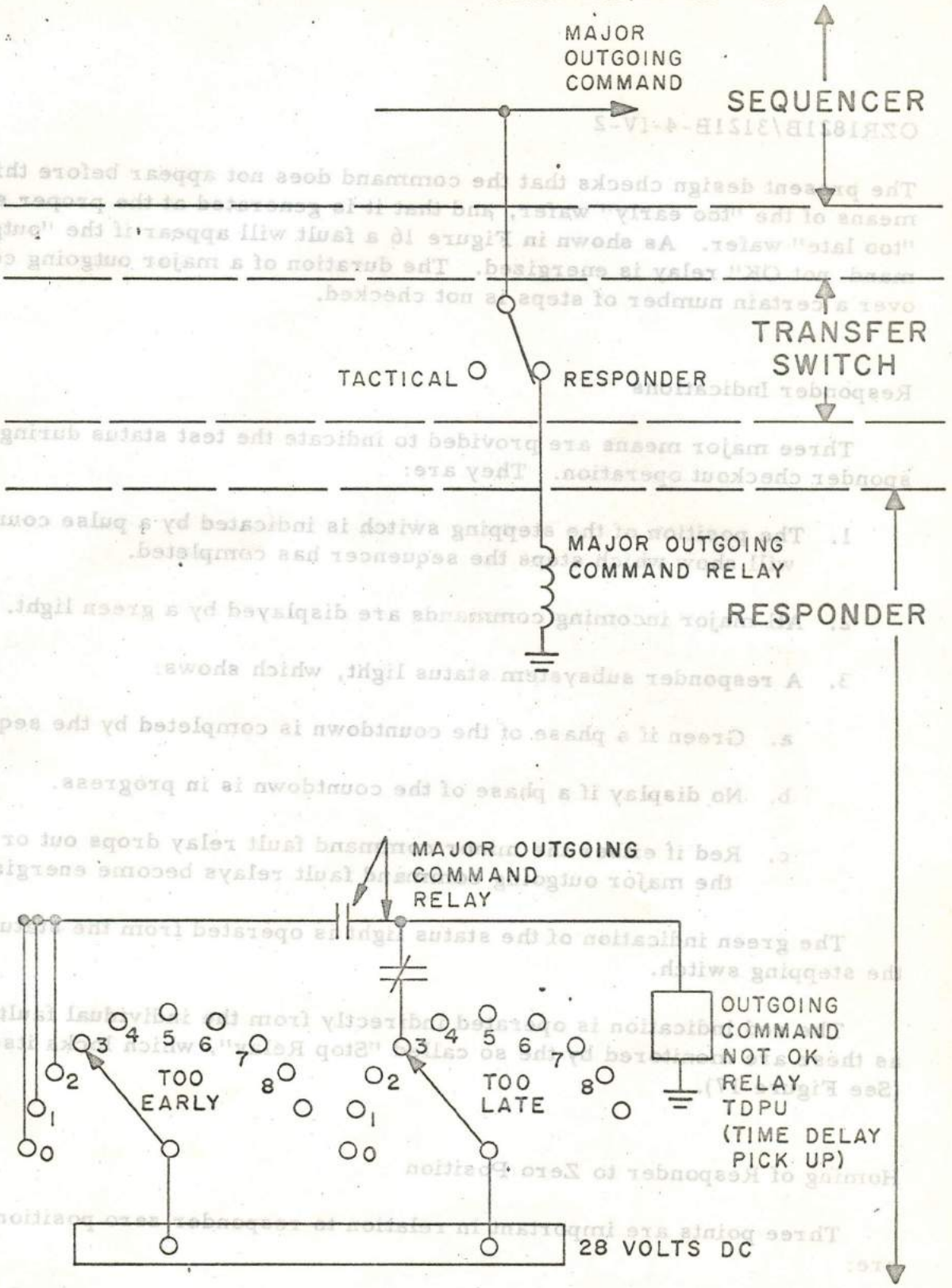


Figure 16 - Major Outgoing Command Check

The present design checks that the command does not appear before this step by means of the "too early" wafer, and that it is generated at the proper step by the "too late" wafer. As shown in Figure 16 a fault will appear if the "outgoing command not OK" relay is energized. The duration of a major outgoing command over a certain number of steps is not checked.

Responder Indications

Three major means are provided to indicate the test status during the responder checkout operation. They are:

1. The position of the stepping switch is indicated by a pulse counter, which will show which steps the sequencer has completed.

2. All major incoming commands are displayed by a green light.

3. A responder subsystem status light, which shows:

   a. Green if a phase of the countdown is completed by the sequencer.

   b. No display if a phase of the countdown is in progress.

   c. Red if either the minor command fault relay drops out or one of the major outgoing command fault relays become energized.

The green indication of the status light is operated from the status wafer of the stepping switch.

The red indication is operated indirectly from the individual fault relays, as these are monitored by the so called "Stop Relay", which locks itself in. (See Figure 17).

Homing of Responder to Zero Position

Three points are important in relation to responder zero position, they are:

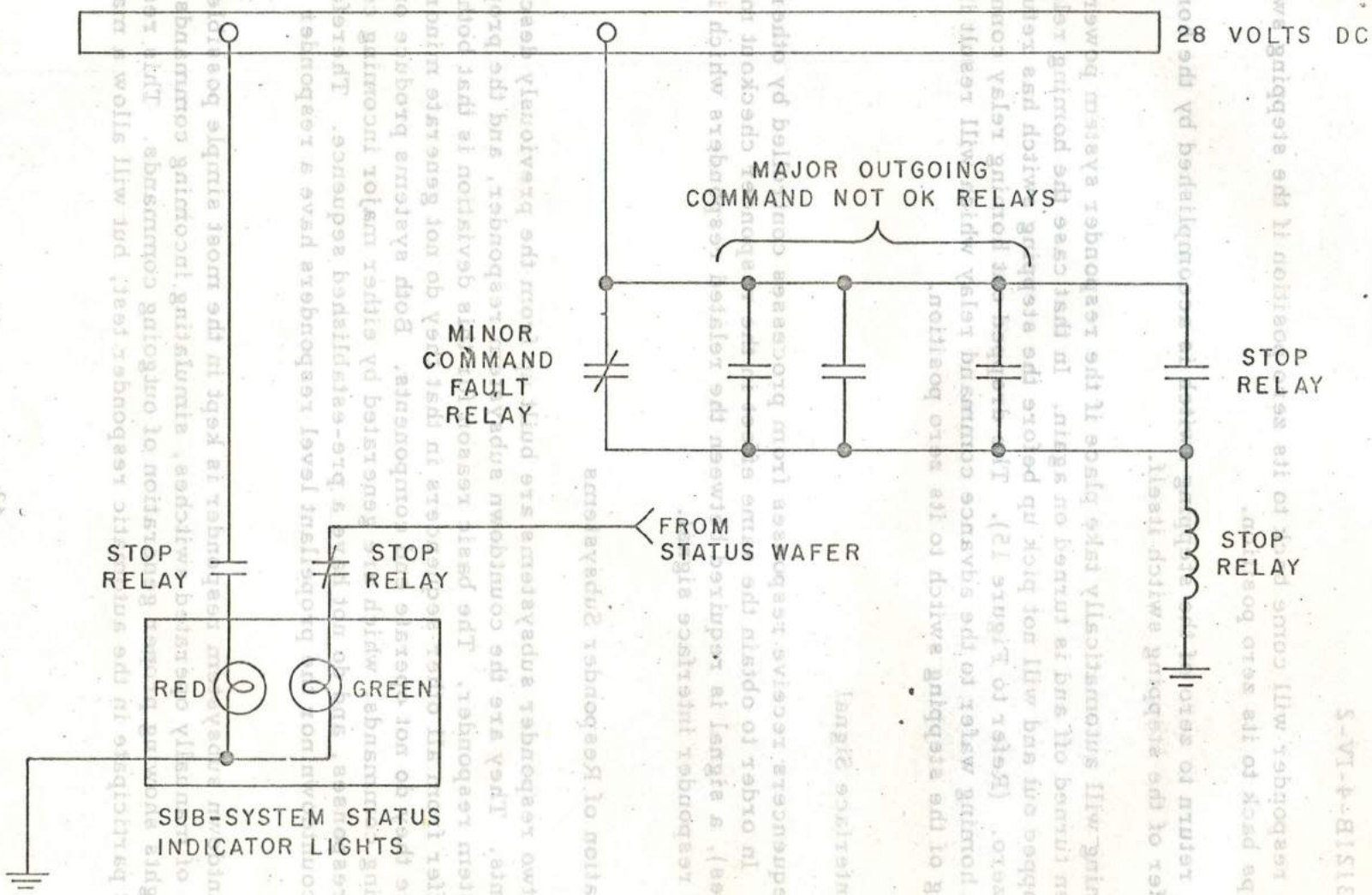


Figure 17 - Subsystem Status Indicator

1. The responder will come back to its zero position if the stepping switch steps back to its zero position.

2. The return to zero of the stepping switch is accomplished by the homing wafer of the stepping switch itself.

3. Homing will automatically take place if the responder system power has been turned off and is turned on again. In that case the homing relay has dropped out and will not pick up before the stepping switch has returned to zero. (Refer to Figure 15). The dropped out homing relay connects the homing wafer to the advance command relay which will result in stepping of the stepping switch to its zero position.

Responder Interface Signal

Some sequencers receive responses from processes controlled by other sequencers. In order to obtain the same effect in the responder checkout mode (in such cases), a signal is required between the related responders which is defined as a responder interface signal.

Design Deviation of Responder Subsystems

All but two responder subsystems are built up from the previously described basic elements. They are the countdown subsystem responder, and the propellant level subsystem responder. The basic reason for this deviation is that both sequencers differ from all other sequencers in that they do not generate minor commands, since they do not operate end components. Both systems produce only major outgoing commands, which are generated by either major incoming commands or process responses, and do not have a pre-established sequence. Therefore, neither the countdown nor the propellant level responders have a responder stepping switch.

The countdown subsystem responder is kept in the most simple possible form and consists of manually operated switches, simulating incoming commands, and indication lights showing proper generation of outgoing commands. This responder does not participate in the automatic responder test, but will allow a manual

check prior to such an automatic test, according to a written procedure. In the propellant level responder, only a major outgoing command check is made. This responder has a normal simulation part.

The countdown responder does not have a subsystem test feature. The propellant level responder has a test stepping switch which performs a gross check on the proper operation of the relays.

Preparation for Checkout of Responders

See that all ground and airborne systems are in "tactical mode" and in "standby condition". Next, transfer into "responder mode" using the following steps:

1. Transfer the missile pressurization from the pneumatic subsystem to an auxiliary pressurization unit, since the responder mode operation will interfere with the normal standby pressurization.

2. Turn off subsystem power on all sequencers except re-entry vehicle and guidance.

3. Switch cables connecting the logic units with the umbilical junction box (at the junction box end) from the "Standby Mode" to the "Responder Checkout Mode" connections. (This does not apply to re-entry vehicle and guidance).

4. Rotate transfer switches in the bottom section of the responder units from "Standby" to "Responder" mode.

5. Obtain "Launch Enable" signal from Squadron Command Post (if checkout is to include a commit sequence).

Countdown Sequencer Pre-Check

Upon completion of the 5 steps under "Preparation for Checkout", the logic and responder units are ready for a responder checkout operation. The first part of this will consist of a manual check of the countdown system since this

responder, as explained before, does not participate in the automatic checkout procedure. For this check, the subsystem power has to be turned on at the countdown responder.

Check the sequencer according to a written procedure. The check will consist of manually operating switches in a certain sequence and by observing the indication of certain lights on the front panel of the countdown responder chassis and Launch Control Console. Upon successful completion of the test, return all switches to the position they occupied prior to "Preparation for Checkout".

Automatic Checkout Start

To start the automatic checkout, the following steps have to be taken:

1. Turn on responder subsystem power on all responders.
2. Turn on sequencer subsystem power on all sequencers.

All subsystems should now obtain their "Standby" condition, resulting in green standby lights on the Launch Control Console. This green display for some subsystems will be reached via a red one first, which will set off the alarm and require the actuation of the alarm reset button on the control panel. All responder status lights shall display green. Each responder system counter shall indicate the number corresponding with the subsystems final step number for "Standby".

Simulated Countdown

Simulated countdown can be started after completing "Automatic Checkout" and is initiated in the same way as a real countdown, by actuating the "Start Countdown" button on the Launch Control Console. If all systems operate properly, the status lights will progress to "Ready" and "Ready for Commit" will illuminate green. All responder status lights, which at the start of the countdown cycle lost their display, shall show green again. Each system counter will display a pre-established number for each subsystem. In a similar way the "commit" cycle can be completed, and will be initiated also from the control panel. The responder design also permits an "Abort" cycle, but only from the "Ready for Commit" and the "Missile Away" points.

Re-Setting the Responder Mode Operation to Zero

In order to reset a once started or completed responder checkout operation to its zero position, the following steps have to be taken:

1. Turn off all sequencer subsystem power.
2. Turn off all responder subsystem power.

The logic and responder units are now ready again for a responder mode checkout start as described under "Automatic Checkout Start". The responder system stepping switch remains in its last or ultimate position after the power has been turned off, however, as described before, it will return to zero position as soon as the power is turned on again.

Fault Indication

If during a particular cycle of the responder mode operation all responder status lights become green, all subsystems have performed this cycle satisfactorily. If one or more green indications are missing after a pre-established period of time, or one or more subsystems show a red status light, this means that the cycle was not performed satisfactorily.

Fault Location

Fault detecting facilities, in relation to the responders, are the status lights, the system counter, the major incoming command lights, and the major command matrix. For the subsystems not showing a green responder status light, the counter reading and the major incoming commands that have been received (indicated by lights) are compared with the major command that should have generated.

The following cases can be distinguished:

1. Counter reading agrees with the major incoming commands combination.

   a. No status light display indicates sequencer is alright, but did not continue due to lack of further required major incoming commands.

b. Red status light, indicates sequencer is at fault.

2. Counter reading disagrees with major incoming commands combination.

In this case, first the correctness of the disagreeing incoming commands have to be checked by going back to the generating subsystems and comparing them with their switch and counter reading. Depending on whether the generating systems are satisfactory or at fault, it can be concluded whether the original sequencer is correspondingly at fault or alright.

In case any of the sequencers fault during the responder checkout mode, one or more of the status lights will not come on green and some may turn red. By a procedural check of those subsystems which do not have a green status light, the system which is at fault can be determined.

SUMMARY

The prime purpose of the launch signal responders is to check the proper operation of the launch control logic units and launch control console. This is accomplished by checkint the outputs of the sequencers to a pre-established, fixed control relay matrix.

When the LSR is in the responder mode, logic unit control is removed from the subsystems, and the logic units are connected to the responders so all logic unit sequencers may be checked out in a simulated countdown.

LSR operation is performed by a stepping switch connected to the pre-established, fixed control relay matrix. The stepping switch advances automatically as long as the logic sequence is correct. A counter indicates each position of the responder stepping switch.

For proper operation of the responders, a specific written procedure must be followed prior to exercising the launch control logic units.

If a malfunction occurs in any of the sequencers during the responder checkout mode, one or more of the responder SYSTEM STATUS lights will not come on green and some may turn red. The system at fault can be determined by a procedural check of those subsystems that do not have a green SYSTEM STATUS light.

QUESTIONS

1. How do the launch signal responders check the logic unit sequencer output?

2. What do the responder relay trees represent?

3. Define a major incoming command.

4. Define a major outgoing command.

5. Define a minor outgoing command.

6. What signals are simulated by the LSR?

7. What commands are not included in the relay tree?

8. What is the function of the advance command section of the stepping switch?

9. What is the function of the present command section of the stepping switch?

10. What is the purpose of the homing section of the stepping switch?

11. What causes the SYSTEM STATUS light to illuminate red?

12. Why is an LSR subsystem self-test performed?

13. What responders deviate from the standard type employed?

14. Why is it necessary to transfer the missile to an auxiliary pressurization unit prior to starting a responder checkout?

15. How are responder stepping switch positions indicated?

LAUNCH CONTROL SYSTEM OPERATION AND CHECKOUT

OBJECTIVE

To acquaint the student with the general operation of launch control equipment.

F SILO COUNTDOWN SEQUENCE

The following discussion describes the processes taking place during the countdown and commit sequences.

On energizing the start countdown relay, the following events immediately occur: (a) The engine valve (controlled by AC power distribution unit) and thrust section (controlled by the facilities subsystem) heaters are turned on; (b) The AC and DC power busses in the missile are energized from the ground power system; (c)The missile battery is activated and a two minute timer is started to allow the battery sufficient time to build-up to full load carrying capabilities; (d) The R/V battery heater is turned on by the start countdown signal to the R/V Pre-launch Monitor; (e) The guidance system starts a series of tests on its airborne computer and also calibrates the airborne accelerometers; (f) The autopilot gyro spin motors are started and simultaneously a four minute timer is started to prevent the initiation of the autopilot test until the autopilot gyros have been allowed to reach their proper running speed; (g) The fuel line below the airborne fill and drain valve is drained of fuel; (h) The Hydraulic Pumping Unit is started and within ten seconds the proper booster and sustainer pressures are attained; (i) The rapid loading (100 GPM) of LN_2 is started and continued until a six minute timer runs out, at which time a medium flow of LN_2 is maintained for an additional 30 seconds. LN_2 is then fine loaded until the start of the commit sequence.

After a two second warmup period, the fuel level control units are activated to check if the level of fuel within the missile propellant tanks is within tolerance. A three second check period is allowed during which time the fuel level signal

sensed is electrically locked up. Unless both fuel "low" probes indicate wet, and one and/or both fuel "high" probes indicate dry, the "Fuel Level" indicator is illuminated Red and an alarm sounds signifying to the officer that a malfunction exists and the countdown must be aborted. The fuel level check is limited to a three second period for two reasons: (1) The design of the fuel level control units prevents them from operating continuously during standby, and (2) the raising of pressure in the missile fuel tank from standby to flight pressure will cause the fuel probes to become uncovered.

After the missile fuel level check timer runs out (5 seconds after the start of the countdown), the PCU is set to regulate pressures in the missile to approx. 63 PSIG in the fuel tank, and 4 PSIG in the LOX tank (regulated by placing the LOX boiloff valve on automatic). When the missile pressures reach their required setting, a one minute timer is started in the LOX system in conjunction with the initiation of the LOX line chilldown process. This timer allows sufficient time for the LOX storage tank to build up to chilldown pressure and thus force the LOX through the LOX loading lines up to the missile LOX fill and drain valve. When the chilldown timer runs out, the LOX storage tank pressure is raised to allow a rapid transfer (5000 gpm) of LOX into the missile. This process continues until the 95% LOX missile probes indicate wet, at which time the rapid load valve is closed and fine LOX loading beings and continues until the 99% LOX probes indicate wet. Then, the airborne LOX fill and drain valve is closed and the line is drained. At the same time the LOX level at 99% is maintained by topping LOX thru the booster pump inlets. Topping is stopped everytime the 99. 25% LOX probes become wet andthe stop topping timer runs out. This on-off process maintains the LOX level between 99. 25% and 100% until the commit sequence is initiated.

After a forty (40) second warm-up period, the LOX level control units are activated to monitor the condition of the missile LOX level probes. If a wet condition is noted within 2 minutes after the initiation of the LOX rapid loading, a probe failure is inferred and displayed on the LCC by the "LOX level sensing" indicator.

After the two minute battery activate timer completes its delay, the missile DC voltage is checked. If it is in tolerance, it is summarized along with heaters on, engine missile bus energized and missile AC and DC busses energized to illuminate the "Engine/Missile Power Ready" summary indicator.

The helium loading which was delayed for two minutes to allow the LN2 to cool the inflight helium bottles, is now started. The helium load complete signal is electrically locked-up the first time the proper pressure (approx. 3000 PSIG) is sensed in the bottles, however, helium loading is continued until the commit sequence starts to allow sufficient helium to be stored in the bottles for use during the missile's flight.

After a four minute delay to allow the autopilot gyros to attain proper running speed, the autopilot engine position and gyro displacement tests are initiated by opening the gyro nulling loops and monitoring the displacement of the engines and the gyros. If a malfunction is not detected during the ninety (90) second test, the nulling loops are closed and the autopilot system is ready for commit.

After approximately five minutes, the R/V battery temperature comes into tolerance, and shortly thereafter, the guidance system completes its computer tests and indicates it is ready for commit. These ready signals, along with autopilot ready and target selection complete and satisfactory are summarized to illuminate the "Flight Control and R/V Ready" indicator.

The missile inverter is started at the completion of LOX rapid load, or at the run out of the five minutes start inverter timer (whichever occurs first). This step is actually in anticipation of an immediate missile commit sequence, and is employed to enable the launch sequence to be performed within the specified time as it allows the commit sequence to be shortened by the one minute warm-up period required prior to applying full load to the inverter. Inasmuch as the inverter has a short lift time, a five minute cutoff timer is also started with the inverter to shut it off if the commit sequence is not initiated within the five minute period. In this case the minimum countdown time criteria is assumed to cease applying as a deliberate hold has been made, and the inverter is then allowed a warmup time by adding the minute time delay to the start of the commit sequence. When all systems have sequenced and the four ready summaries are present, the conditions required for "Ready for Commit" are satisfied.

The "Ready for Commit" summary and the removal of the "Launch Disable" signal electrically enables the commit start control on the commit patch. This control is mechanically guarded by a covered metal cup which is drilled to

accept a sealing wire. The criteria established by the Nuclear Weapons System Safety Board require that this control be safety sealed whenever a tactical warhead is installed on the missile and the missile is connected to the launch controls. This is a procedural control to be established by the Air Force. The commit sequence is started by breaking the seal and pressing the control. This causes a relay to pick up and electrically lockup. The subsystem ready conditions then cannot stop the sequence, however, the Flight Control R/V, Hydraulic-Pneumatic, and Battery activated ready summaries are again checked by means of a ladder circuit prior to engine start command so that a missile will not be launched with a NO-GO in these subsystems.

The commit start signal goes to the Ground Power control subsystem which in turn restarts the inverter if it has been stopped and transfers the missile to internal power. After a delay of 200 milliseconds, if the AC voltage and frequency are in specification on internal power, the missile is locked on internal and the subsystem sends a signal back to the countdown system that missile power is on internal. This signal energizes a relay known as "Start Commit". (This is not a power bus and should have the applied load minimized). This signal then is sent out to the various subsystems and causes each of these to start their commit sequences.

Upon receipt of the "start commit" signal the following events occur: (a) helium loading is stopped; (b) LN2 fine loading is stopped; (c) the LOX fine topping and rapid topping valves are opened and a 50 second timer is started. The topping valves will remain open until the timer runs out or when the 100% sensor is wet, whichever occurs first; (d) the guidance system is placed on its memory mode; (e) the silo roof is opened; (f) the silo crib is locked in place; (g) the collimator tube is retracted; (h) the non-essential power bus is de-energized; (i) any change in targets is blocked; (j) the pressurization control subsystem, on receipt of the commit signal, closes the boil-off valve, then raises the missile tanks to flight pressures. When both the missile fuel and liquid oxygen tanks are within the flight pressure limits, the missile is changed over to internal pneumatic supply and control. If the internal regulation does not maintain the proper pressure limits the system transfers back to external control and locks up in such a manner as to prevent transferring back to internal. The "Hyd-Pneu LN/He" status light will also turn red on this fault. If the pneumatics are satisfactorily on internal control a signal to this effect is sent back to the countdown system where it completes the commit internal ladder. This signal is then sent to the hydraulic subsystem to evacuate the booster and sustainer hydraulic evacuation chambers.

The Autopilot subsystem starts arming the flight programmer on receipt of the commit internal signal. The flight programmer arming motor circuit is of such a nature that it must be driven to the fully armed position before it can be disarmed. For this reason the Autopilot subsystem has a circuit which will positively sequence the arming even if the commit signal is lost. A signal is sent back to the countdown subsystem when the flight programmer is fully armed.

The missile lift commit start summary signal then starts the raising of the missile lifting platform. When the lifting platform reaches ground level and is locked in place, it sends a signal to the countdown sequence to complete the commit lock-up ladder and generate commit lock-up.

This summary, when complete, simultaneously locks out the "Abort" control, locks the pneumatics to internal, and sends the command to put the Guidance on inertial. This summary in effect has locked all systems in the committed state and monitors that they remain so for one second while the Guidance system is going to inertial. When the Guidance subsystem replies back that it is on inertial and the summary has remained unbroken the command is given to start the engines. At the same time the summary is electrically locked up to prevent its drop out. When the engines start, the thrust builds up and the missile lifts off the launcher. The lift off is monitored and generates the signal to eject all umbilicals. At the time the engine start command is given a five second timer is started. This timer, on running out, sends an engine cutoff command which will automatically abort the flight if insufficient thrust has developed to cause the lift off. On the other hand if the umbilicals have ejected the command has no effect as it then has lost control over the engines. This same engine cutoff timer reactivates the "Abort" control which was blocked earlier.

Abort Sequence

The launch sequence can be aborted at any time prior to the generation of the commit lock-up signal.

The following discussion will cover an abort sequence initiated prior to commit lock-up.

Pressing the abort button immediately removes all commit signals and causes the following events to take place; (a) the blast covers, air intakes and exhausts in the missile silo and launch control center are opened; (b) the autopilot flight programmer is disarmed; (c) power is transferred from internal to external; (d) the missile lifting platform is lowered.

When the platform reaches its down position, it is locked in place and the silo roof is closed making the site "hard".

At this time, the non-essential power bus is again energized and the PCU is set to stage II pressure regulation. When pressures in the missile are at stage II, the sub-cooled inflight helium bottles are vented; guidance is returned to standby; and the missile LOX drain sequence is started in conjunction with a 25 minute LOX drain complete timer. At the completion of the timing cycle, the hydraulic pumping unit is shut down and the missile is returned to standby pressures by the PCU. The missile AC and DC busses are then de-energized and the countdown signal is removed. The R/V battery heater is now turned off, and after a two hour delay the thrust section heater is shut off and the ambient inflight helium bottle is vented. These last two events are delayed to allow sufficient time for the residual LOX in the missile to boil-off.

LAUNCH CONTROL CONSOLE INDICATIONS

The Select Target Panel (Figure 18) displays the type of R/V in the silo ("HIGH" for MKIV, "LOW" for MKIII), and the selection of target A or B. The target select pushbuttons are enabled to select either target A or B except when the guidance system is on memory, or after the start of the commit sequence. One target or the other is normally always selected. A green target selected light is an acknowledgment that the R/V burst has been selected, and that the target constants board is selected. There are also two spotting boxes used to insert a down and cross range correction to the guidance system if required. (Figure 19)

These CROSS RANGE CORRECTION AND DOWN RANGE CORRECTION dials are fine targeting correction controls. These are required to make allowance for atmospheric conditions at the target. The setting value will vary from 000-999 and reads out decimally in the center of a 10-turn dial. The value of the correction is computed elsewhere and transmitted with the target selection commands to the Launch Control Officer.

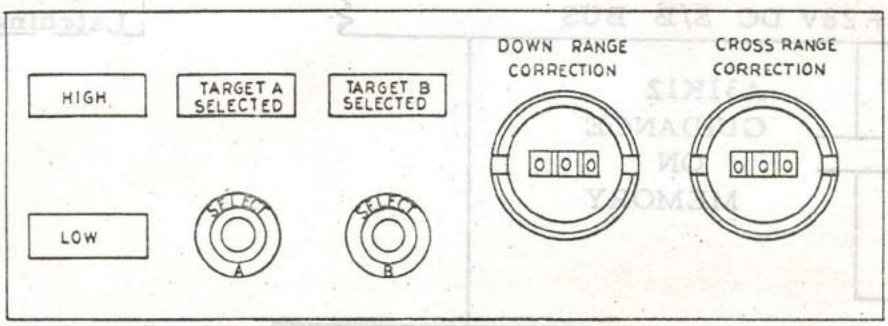


Figure 18 - Select Target Panel

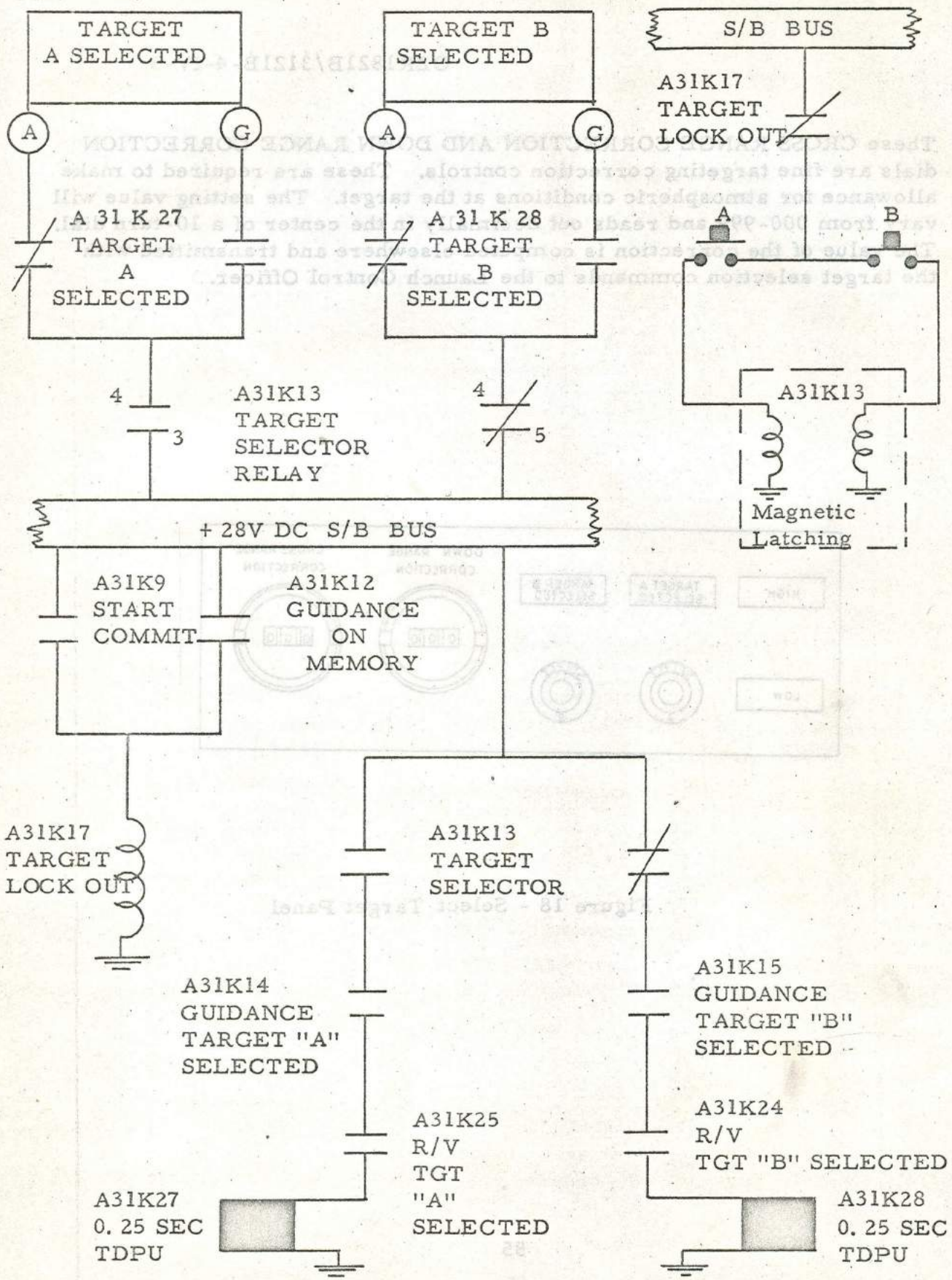


Figure 19 - Target Selected

The TIMER PANEL is at the top center of the console. The indicator is a part of the console, and the rest of the clock subsystem is supplied by Kellog Switchboard and Supply Corporation (KSS). The following signals form the clock logic.

1. In countdown
2. Abort start
3. Ready for commit
4. Commit start
5. Missile away
6. Inverter shutdown

The countdown clock uses four fixed-time points and sequences between them by means of logic based upon the signals listed. The basic sequence is to turn on at the start of countdown (time point 1) and countdown in time. The countdown of time continues to the time of commit (point 3), at which point the countdown stops and holds until "commit start." If "ready for commit" occurs before the clock reaches point 3, the clock jumps ahead to point 3. If the missile inverter is turned off because of too long a hold at "ready for commit", the clock must set back to point 2 to allow more time for the commit sequence. After "commit start", the clock counts down to zero time (point 4), holding at this point until the missile away signal is present. When the missile away signal appears the clock steps ahead to zero time, if not already there, and counts increasing (+) until time 59:59. At this time the clock turns off if not turned off before by other action. If "abort start" appears or "in countdown" disappears, the clock turns off. The Timer Panel as mentioned above will be primarily for V. A. F. B.

The gage and pressure panel (Figure 20) displays the pressure status of both propellant tanks and the pressure across the bulkhead between them, and also provides manual control of the emergency pressurization system.

The three meters are driven by airborne transducers and indicate the pressures in the LOX tank, the difference between them and the fuel tank respectively. There are pushbuttons for controlling missile tank pressurization when the pneumatics system is placed in emergency.

When the LOX raise button is depressed, PCU valve 135 opens to enable raising missile LOX tank pressure. When the LOX lower button is depressed, PCU valve 137 opens to enable venting of the Missile LOX tank. If both buttons were depressed simultaneously, pressure control is disabled. Similarly, when the fuel raise button is depressed, PCU valve 134 is opened, raising missile fuel tank pressure. When the fuel lower button is depressed, PCU valve 136 is opened, venting missile fuel tank pressure. If both were depressed simultaneously, fuel tank pressure control would be disabled.

There are eleven ways to enable emergency pressurization (Figure 20) : one way is manual, by depressing the emergency pushbutton. The other ten ways are automatic, and deal with emergency pressurization condition such as over-pressurization of the missile LOX tank, or exceeding the lower limit for the missile fuel tank.

The automatic pushbutton returns the PCU to the normal pressurization mode after emergency conditions have been corrected.

The "Pressure Mode" light illuminates red when the pneumatics system is in emergency, and illuminates green when the pneumatics system has returned to normal pressurization of the missile tanks.

In standby, the missile tank pressures should be approximately 12 PSI in the fuel tank, and 4 PSI in the LOX tank. In countdown when the "stop check fuel" command is generated, the boiloff valve is enabled to open, and phase II of the pressurization system is scheduled. When the fuel tank reaches 53 PSI, but does not exceed 67 PSI, and the LOX tank is below 17 PSI, the missile tanks are said to be in phase II. After missile power is transferred to the internal side of the power change, the boiloff valve is disabled to vent, and phase III is initiated. Pressure in the LOX tank is now increased to about 27 PSI (the fuel tank remaining at about 63 PSI). These conditions enable pneumatics - internal, when the booster helium shut off valve 802 opens to allow the inflight bottles to pressurize the missile tanks via missile borne regulators. With the missile away signal, the meters return to zero.

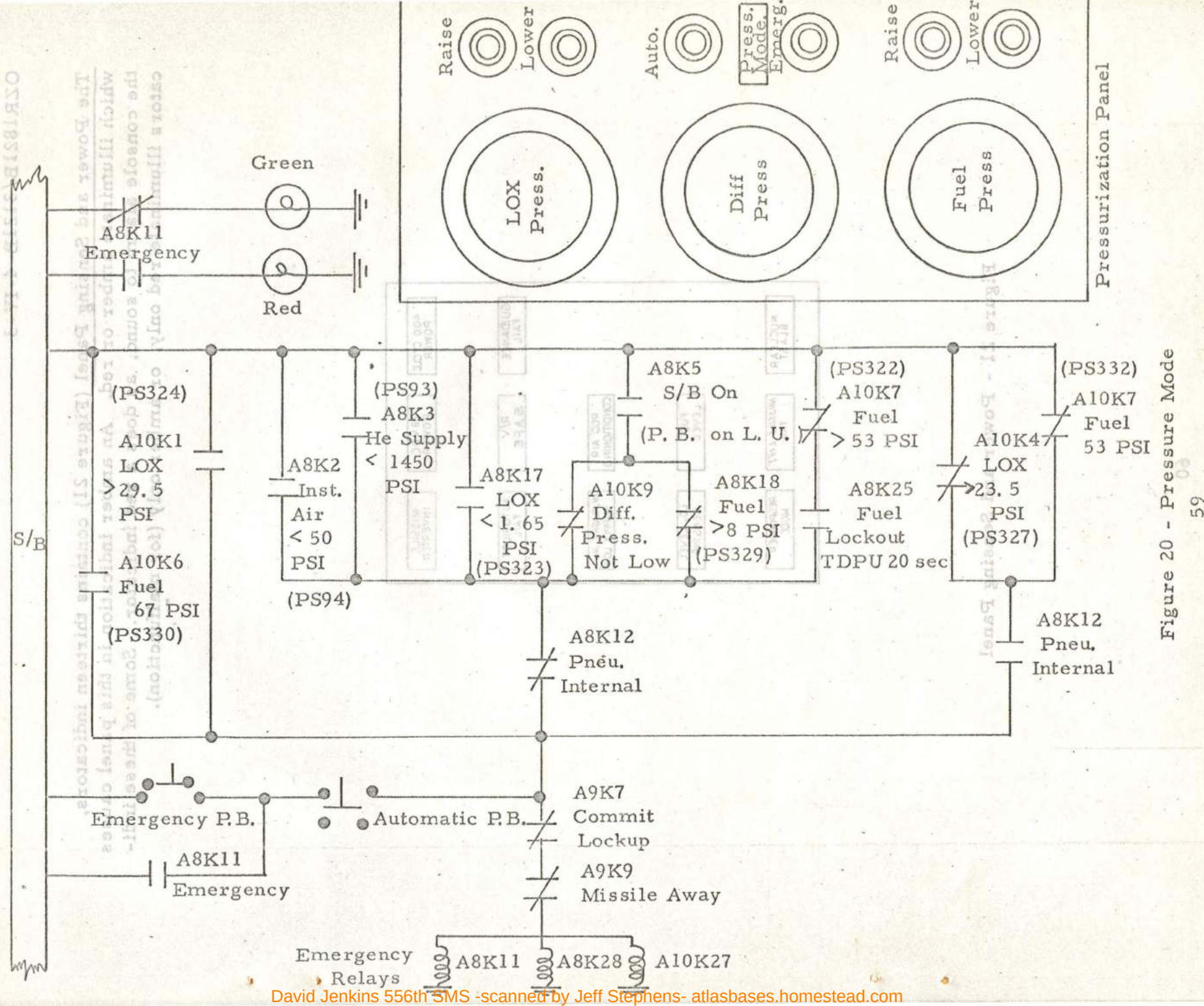


Figure 20 - Pressure Mode

The Power and Sensing Panel (Figure 21) contains thirteen indicators, which illuminate amber or red. An amber indication in this panel causes the console alarm to sound, as does a red indicator. Some of these indicators illuminate red only, or amber only (for malfunction).

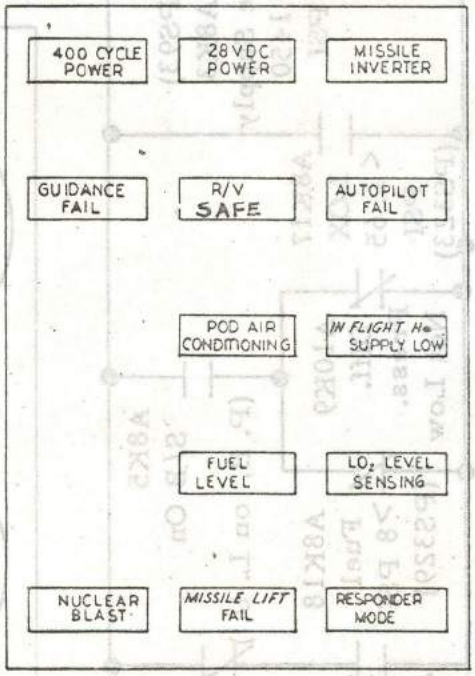


Figure 21 - Power and Sensing Panel

The "400 cycle power" (Figure 22) light monitors the motor generator for voltage and/or frequency. Either being out of tolerance would cause a red illumination.

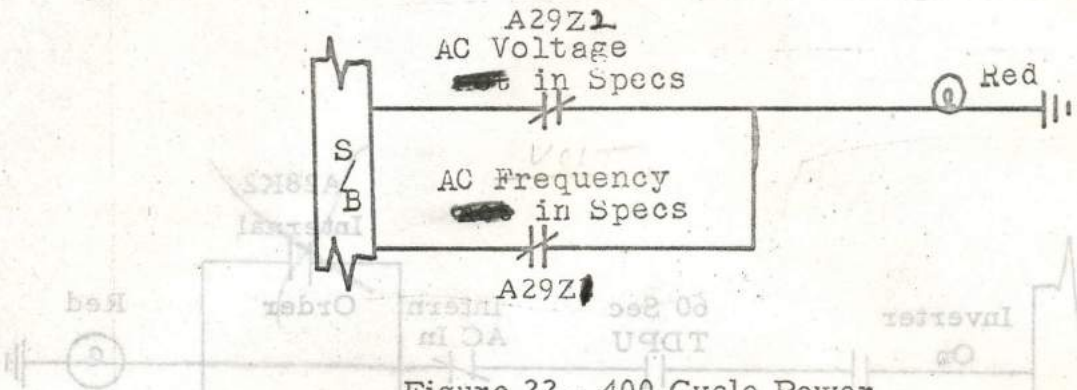


Figure 22 - 400 Cycle Power

The "28 V DC Power" (Figure 23) light illuminates amber if the transformer rectifier cooling fan is off, or if more than 40 ampere hours have been used up on the emergency battery. A Red illumination if the standby bus is out of tolerance.

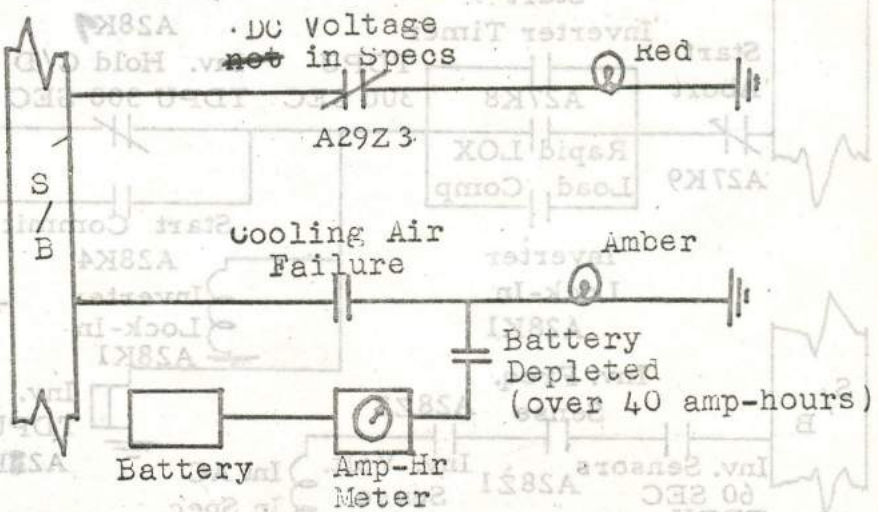


Figure 23 - 28 V DC Power

The "Missile Inverter" (Figure 24) is enabled to illuminate red for an inverter voltage or frequency malfunction during countdown, after the inverter has been allowed to warmup for 60 seconds (prior to the start of the commit sequence or after the order to transfer to missile power internal via the power changeover switch).

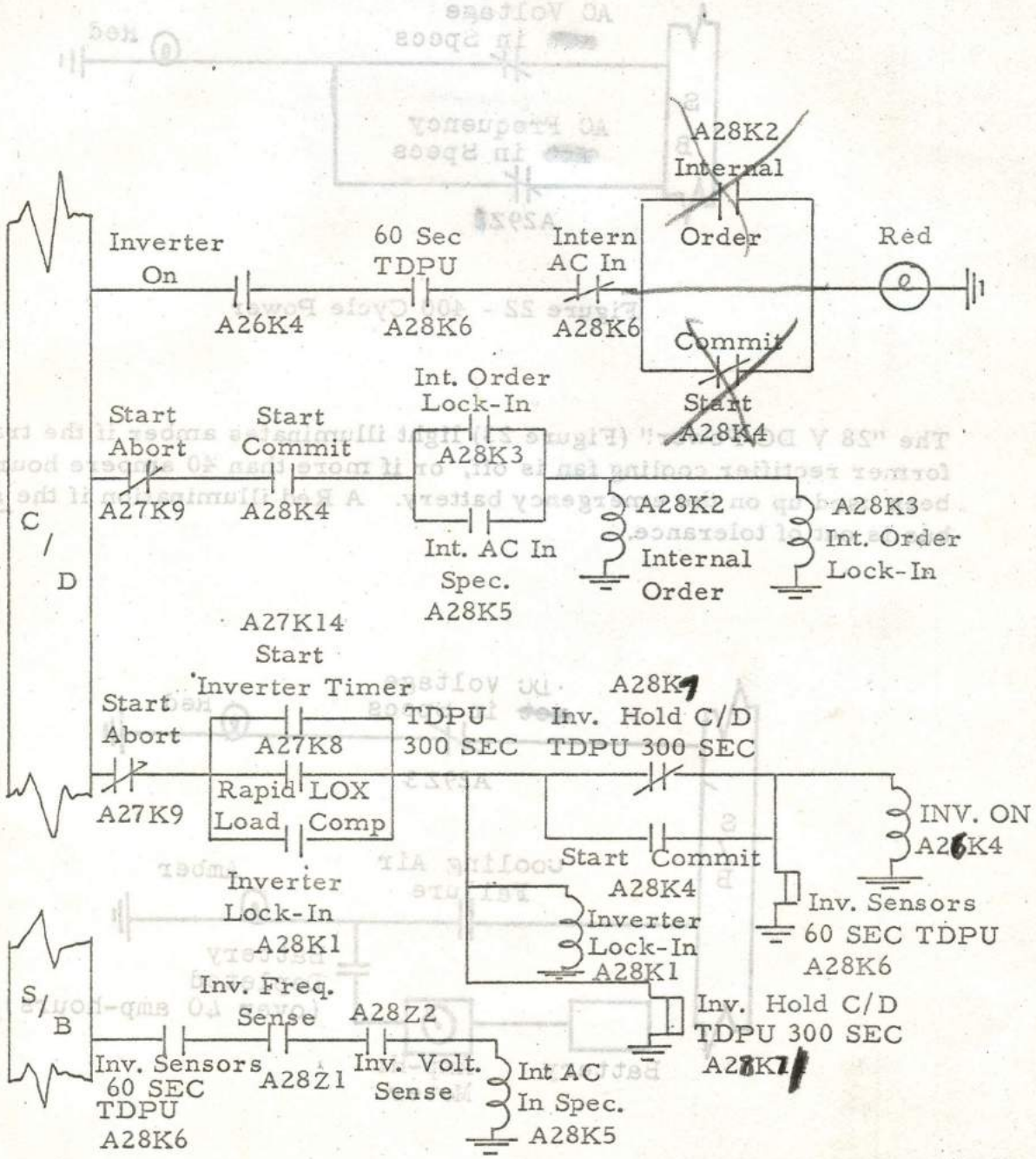


Figure 24 - Missile Inverter

The "Guidance Fail" (Figure 25) light illuminates amber if a nuclear blast has been detected and an 1800 second timer has run out, or if a marginal malfunction exists in the guidance system. It illuminates red if a major malfunction is present in the missile guidance set, or the Arma count-down racks.

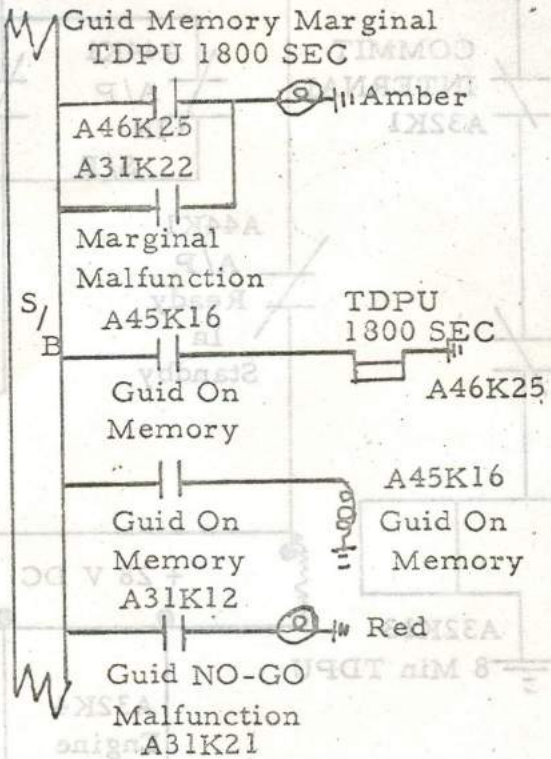


Figure 25 - Guidance Fail

The "R/V Safe" (Figure 26) light illuminates red if there is discontinuity in the re-entry vehicle as monitored by the pre-launch monitor unit.

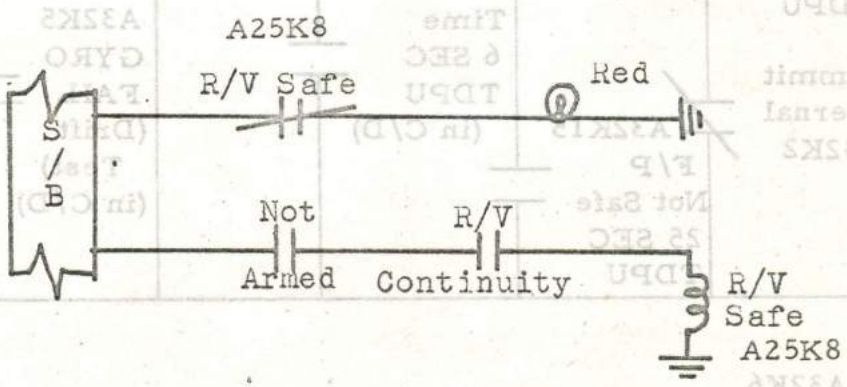


Figure 26 - R/V Safe

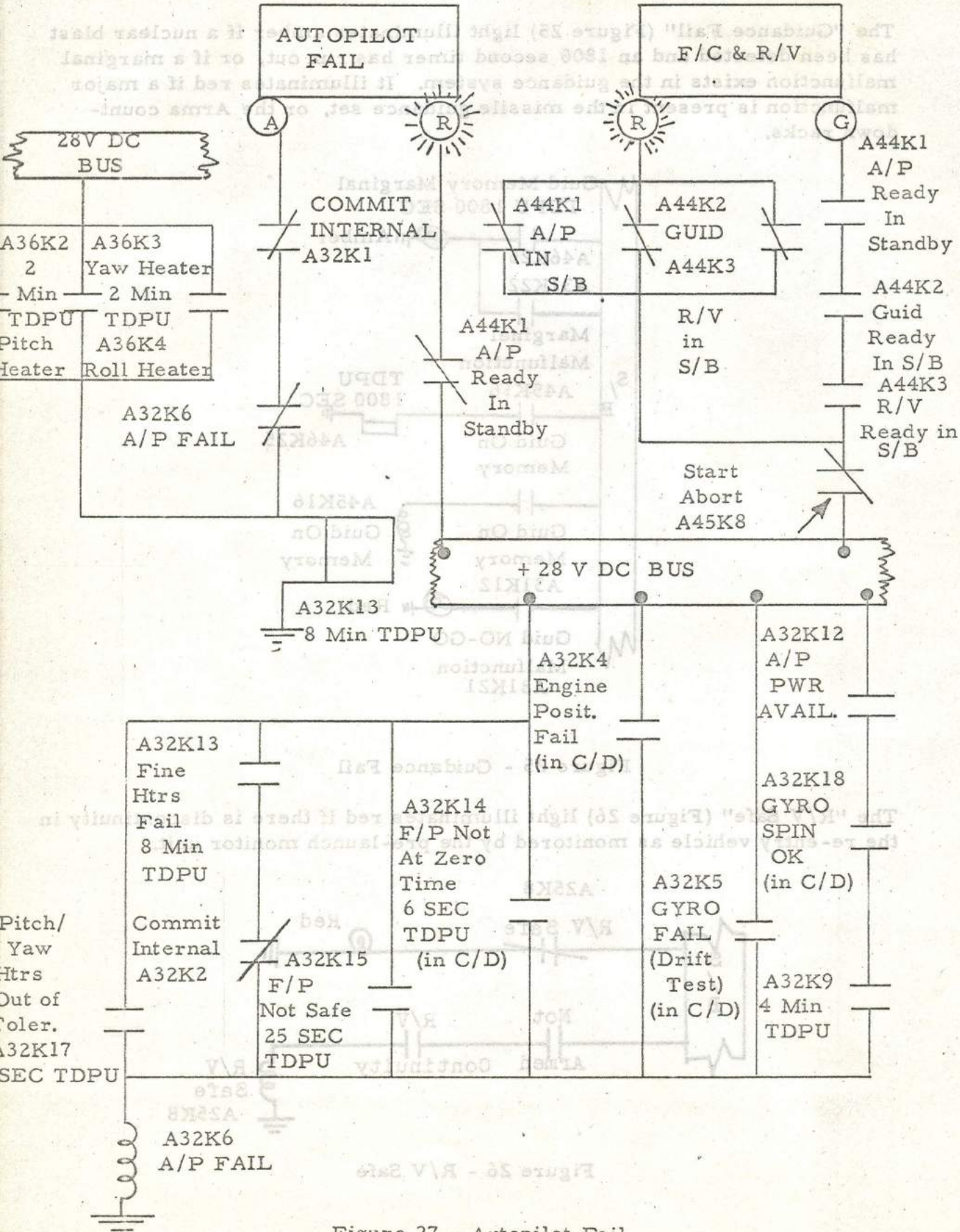


Figure 27 - Autopilot Fail

The "A/P Fail" (Figure 27) light illuminates amber if one or more of the displacement gyro fine heaters is out of tolerance for more than 2 minutes but less than 10 minutes (prior to commit internal). It illuminates red if the fine heaters remain out of tolerance for more than 10 minutes (prior to commit internal). It also illuminates red if the A/P sequencer is on local control or if the pitch/yaw rate gyro heaters are out of tolerance for more than one second, or if the flight programmer is not safe prior to commit internal. During countdown, it could also illuminate red if the engine thrust chambers are not at a null position (providing hydraulic pressure is in tolerance), or if the flight programmer is not at zero time, or if the gyro spin motors are not running (after a 4 minute warmup period), or if the signal amplifier output of the A/P displacement gyros exceed a tolerance during the 90 SEC. A/P drift test, or if the flight programmer fails to disarm in the abort sequence.

The "Pod Air Conditioning" (Figure 28) light illuminates amber if pod air-conditioning is out of tolerance (temperature, humidity, rate of flow) provided the "standby on" pushbutton on the pneumatics sequencer has been depressed with a missile on the launcher platform.

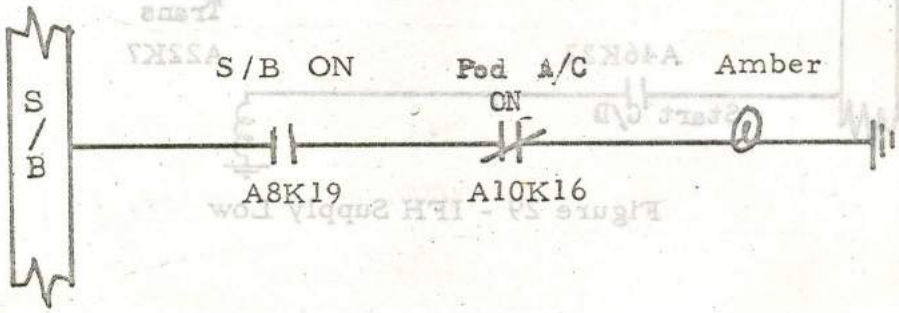


Figure 28 - Pod Air-conditioning

The "Inflight Helium Supply Low" (Figure 29) light illuminates red prior to commit internal if helium pressure is below 1450 PSI in the supply bottles. It illuminates amber in countdown if both bottles 1 and 2 go below 4000 PSI.

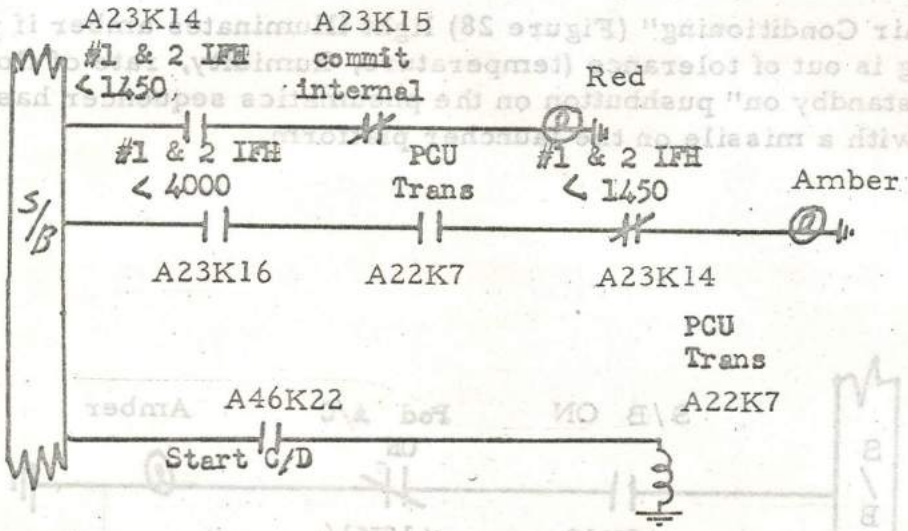


Figure 29 - IFH Supply Low

The "Fuel Level" (Figure 30) light illuminates red if a transducer check is being made via the PLCU in local control and fuel level is too high (above 100.4%) or too low (below 99.6%) after a 2 second amplifier warmup period. In countdown, after the 2 SEC warmup, the fuel sensors are monitored for a too high or low level for a 3 second period. If this light illuminates red during the 3 second time stated, it will remain red, and the countdown cannot proceed into the commit sequence. After 5 SEC from the start of the countdown, if the fuel level was monitored and no malfunction existed, the light is disabled and the check of the fuel level is stopped.

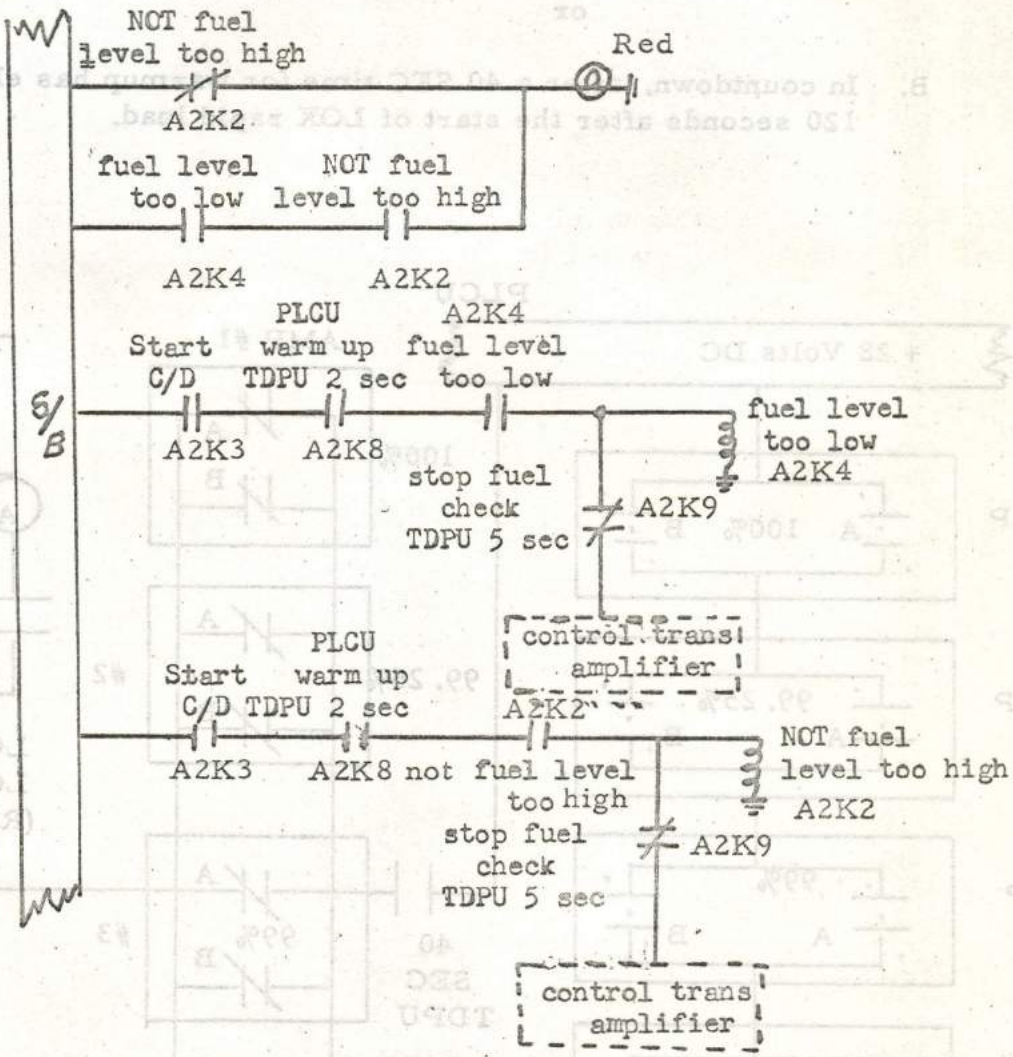


Figure 30 - Fuel Level Indicator

The "LOX Level Sensing" (Figure 31) light illuminates amber if a single LOX level sensor fails at any level, and red if a double failure occurs at any level (95%, 99%, 99.25%, and 100%), provided the following exists.

A. When the PLCU is on Local Control and a 40 second warmup time has elapsed

or

B. In countdown, after a 40 SEC time for warmup has elapsed until 120 seconds after the start of LOX rapid load.

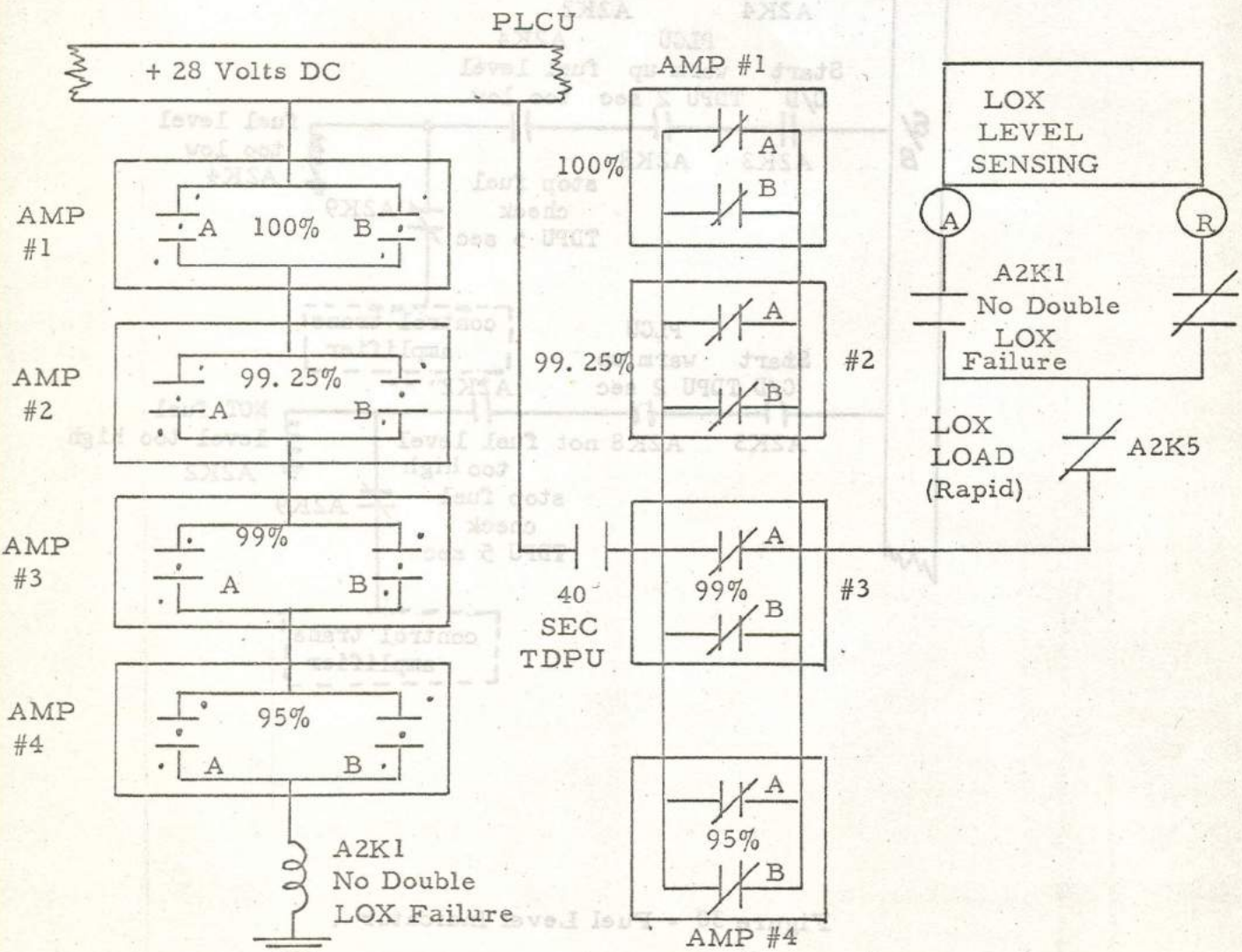


Figure 31 - LOX Level Sensing

The "NUCLEAR BLAST" (Figure 32) light illuminates amber if a nuclear blast has been detected near the silo. This condition also causes guidance to go on memory and an 1800 second timer to start timing.

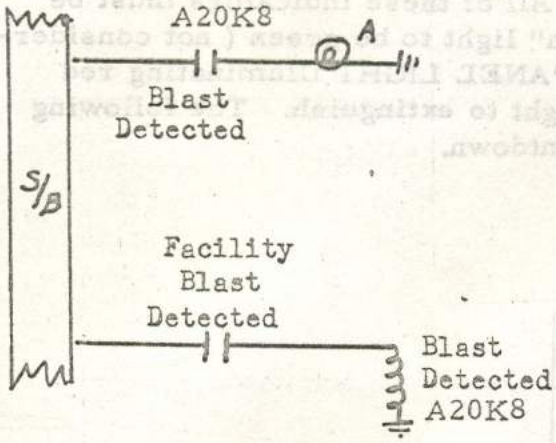


Figure 32 - Nuclear Blast

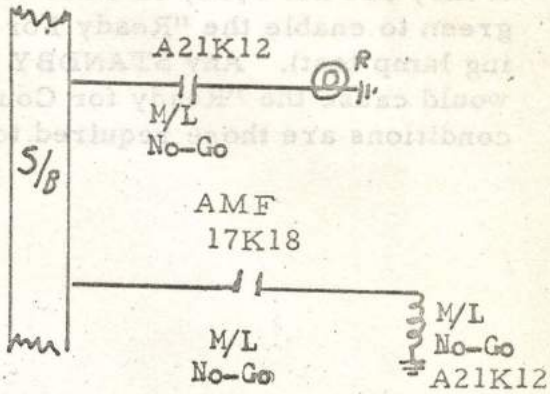


Figure 33 - N/L NO-GO

The "Missile Lift" (Figure 33) fail illuminates red if a malfunction exists in the AMF system. There are 31 conditions monitored by this light. The more important are as follows:

Seq. #1 receiver ready, horizontal and vertical crib locks unlocked, doors fully closed (site hard), launcher platform down and locked, N2 Recharger ready, Hyd. Dist. unit ready, vent valves open. AIG pod handling fixture retracted, manual valves ready, Pwr. Pack drain valves closed, return pressure ready (AOK), pump motors ready in standby, AMF logic circuitry okay, actuators 1, 2, 3 & 4 ready, work platforms 1, 2 & 3 retracted, L/P drive control shifted to high, GOX vent mechanism extended.

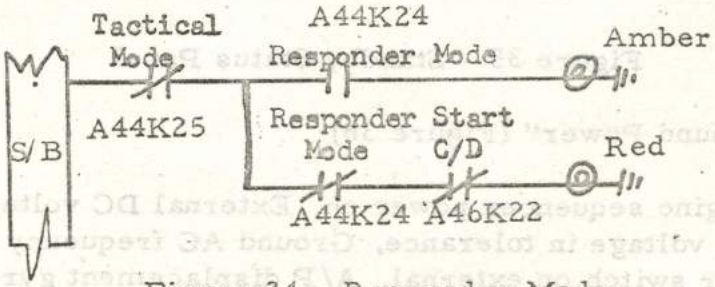


Figure 34 - Responder Mode

The "Responder Mode" (Figure 34) light normally is extinguished when the launch control system is tactical (standby) mode. It illuminates amber when the 8 LSR transfer switches are placed in the responder mode and the proper cables have been repositioned at the umbilical junction box. It illuminates red if the LSR transfer switches are not all placed in the tactical mode or the responder mode, or if the cables are not correctly positioned in standby.

The STANDBY STATUS PANEL (Figure 35) monitors all of the relay logic unit sequencers which in turn monitor their respective sub systems. These lights illuminate green if the subsystems are ready to start countdown, red if they are not ready to start countdown. All of these indicators must be green to enable the "Ready For Countdown" light to be green (not considering lamp test). Any STANDBY STATUS PANEL LIGHT illuminating red would cause the "Ready for Countdown" light to extinguish. The following conditions are those required to start countdown.

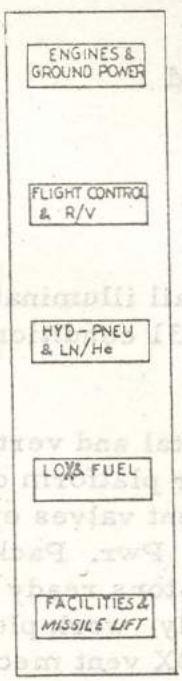


Figure 35 - Standby Status Panel

"Engines and Ground Power" (Figure 36)

(For standby) Engine sequencer power on, External DC voltage in tolerance, Ground AC voltage in tolerance, Ground AC frequency in tolerance, Power changeover switch on external, A/P displacement gyros initially in tolerance for 5 seconds, emergency battery connected, power supply on in DC power distribution box, booster #1, #2, SPGG Heaters within limits, sustainer SPGG heater within limits, missile guidance set power on, missile ground power sequencer power on.

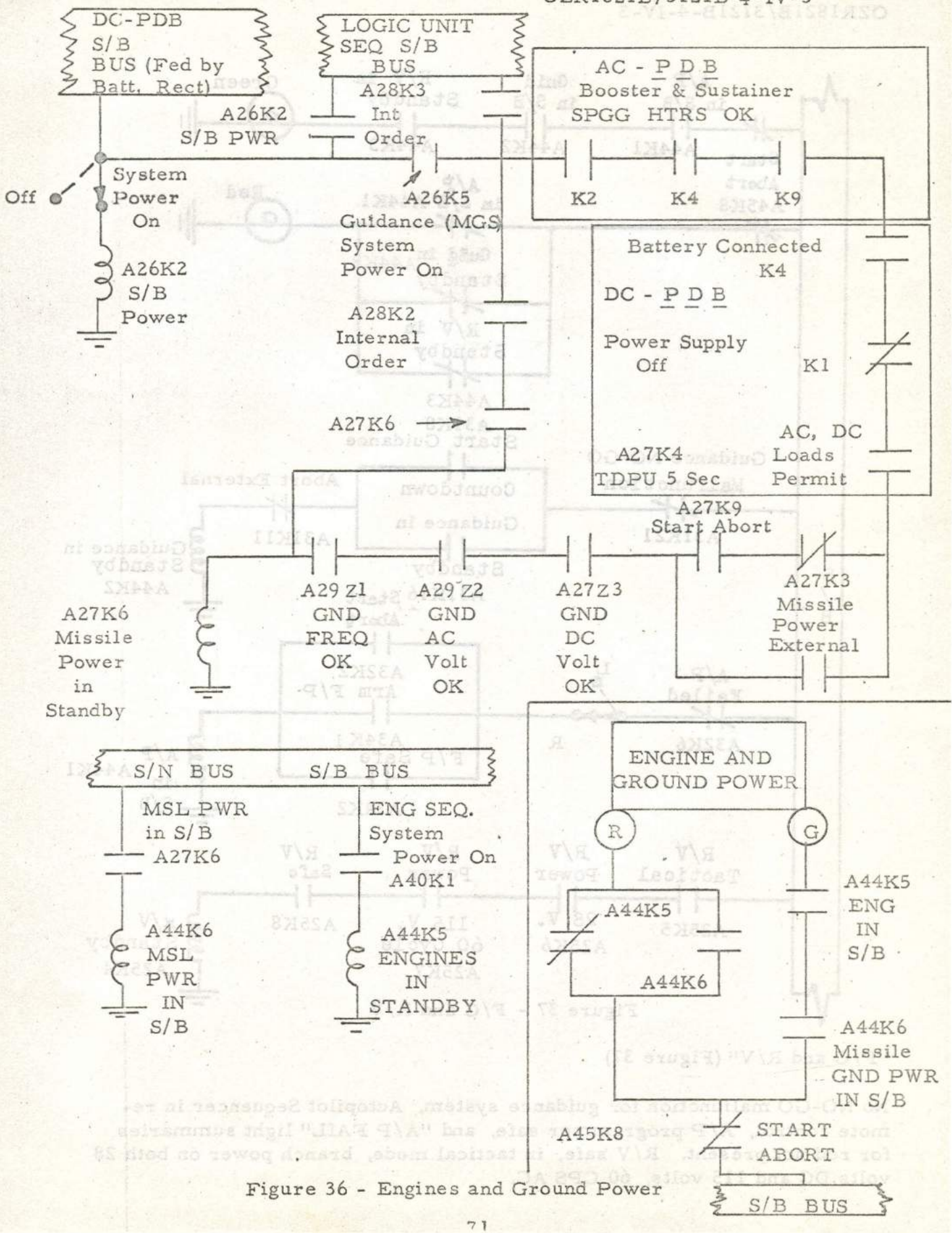


Figure 36 - Engines and Ground Power

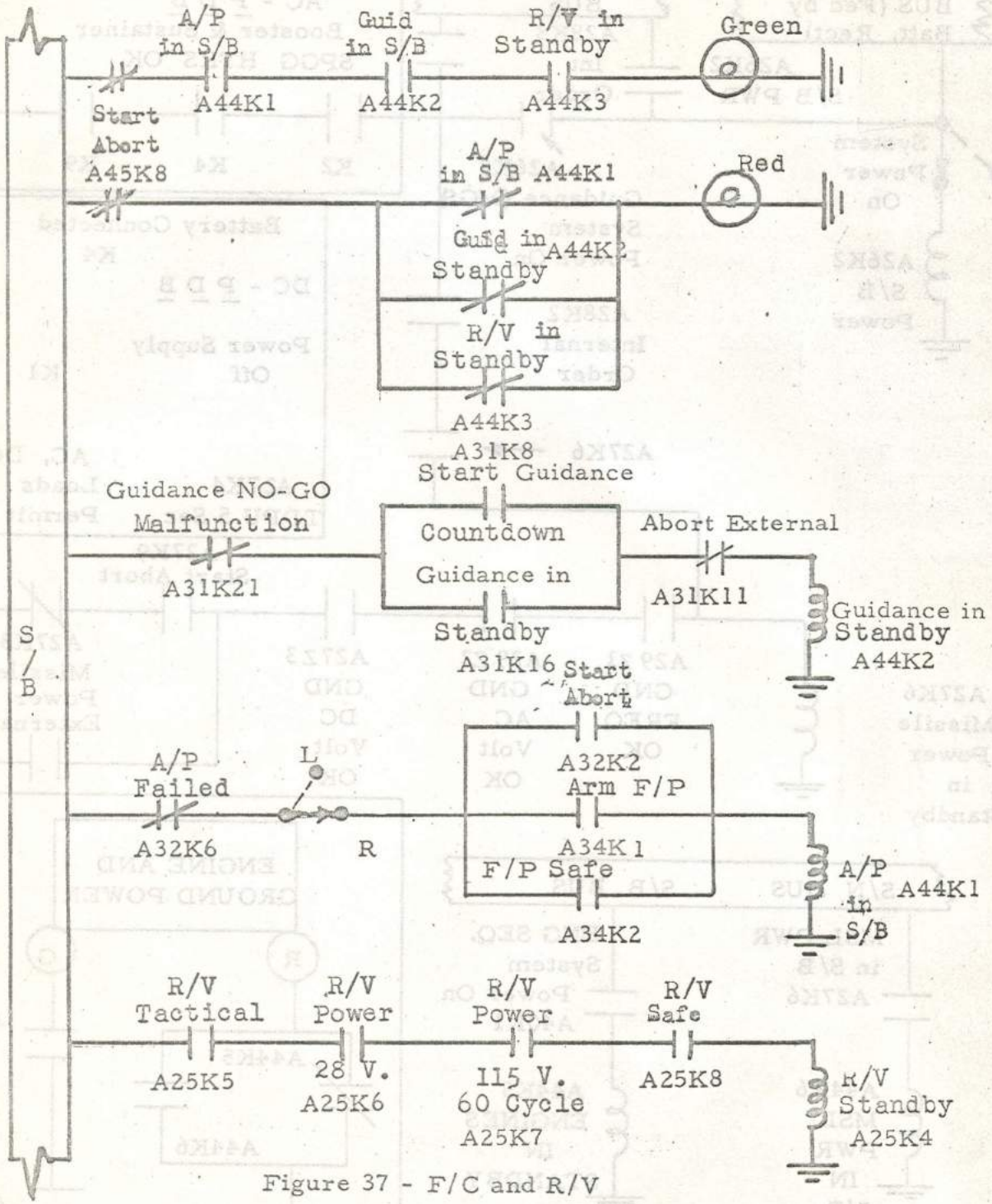


Figure 37 - F/C and R/V

"F/C and R/V" (Figure 37)

No NO-GO malfunction for guidance system, Autopilot Sequencer in remote control, A/P programmer safe, and "A/P FAIL" light summaries for red not present. R/V safe, in tactical mode, branch power on both 28 volts DC and 115 volts, 60 CPS AC.

"Hyd-Pneu-LN2/He" (Figure 38)

Hydraulics. Hydraulic system power on, 28 volts DC and 480 volts 60 CPS AC, Phase A, B & C on. HPU Booster and sustainer section on remote control, V-54 not via flowmeter, return pressure greater than 80 PSI. Booster and sustainer reservoir shutoff valve V55 open. Hydraulics sequencer in remote control.

Pneumatics. In Phase I, automatic valves ready, not locked out from changing over to airborne helium spheres.

Automatic valves ready summary:

Helium charge unit valves ready (305 closed, 308 open (vent). PCU Valves 117 open, 118 closed, 119 open, 120 closed, 107 and 108 open.

LN2/He - LN2/He not in manual transfer, Number 1 and 2 helium supply greater than 4000 PSI and also #1 and 2 Helium supply bottles greater than 1450 PSI, then either valve 14 open and 15 closed, or 15 open and 14 closed. Pneu. dist unit ready in standby; V7, 8, 37, 26, 52, 54, 13 closed, V-50 open. LN2 Valves 213, 214, 215 closed, V-201 open.

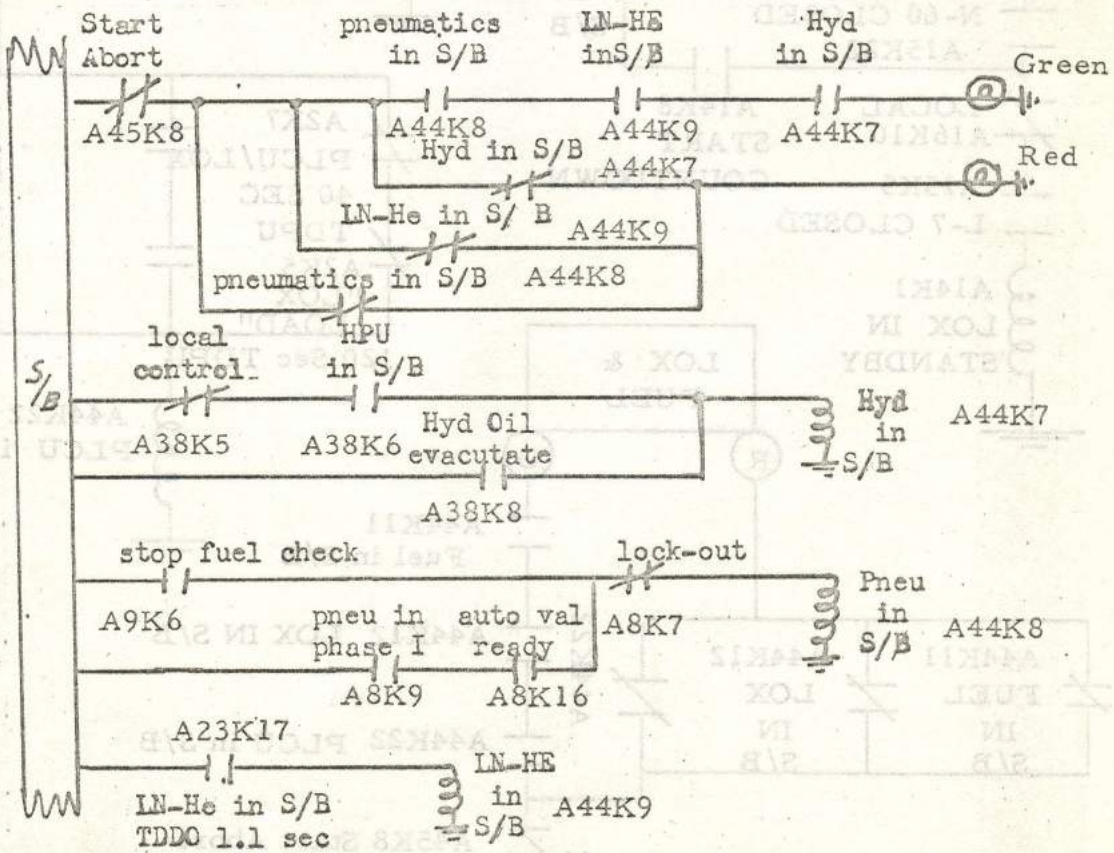


Figure 38 - Hydraulic Pneumatic LN/He

"LO2 and Fuel" (Figure 39)

Fuel: On remote control and the A/B F&D valve closed.

LO2: On Remote, N-4 open, L-1 closed, L-2 closed, L-16 closed, N-60 closed, L-7 closed.

PLCU: Fuel on Remote, LO2 on Remote.

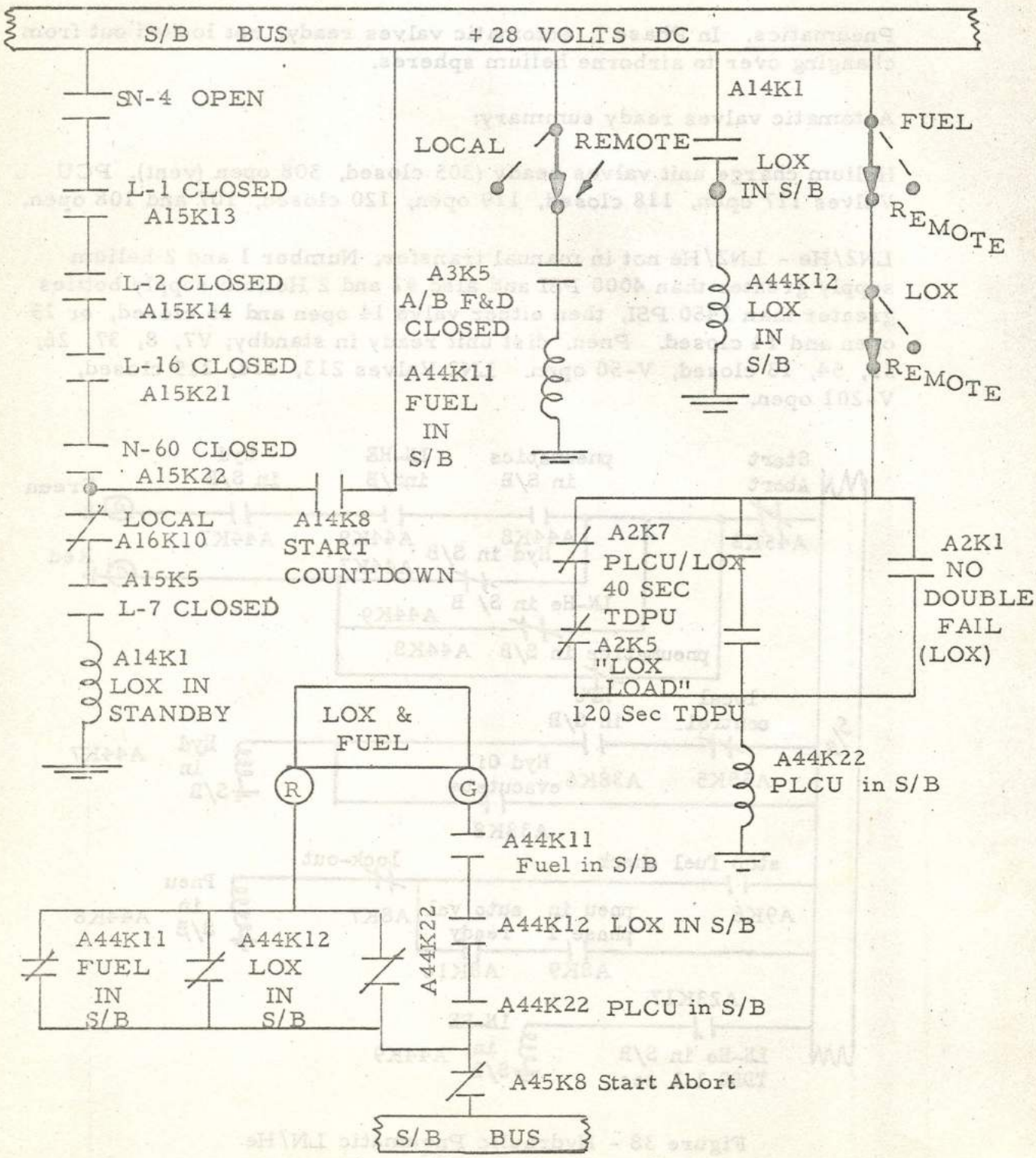


Figure 39 - LO2 and Fuel

"Facilities and Missile Lift" (Figure 40)

Facilities: System power on (Drawer A20)

Missile Lift: Same conditions as the MISSILE LIFT FAIL light in the Power and Sensing Panel (No AMF malfunctions).

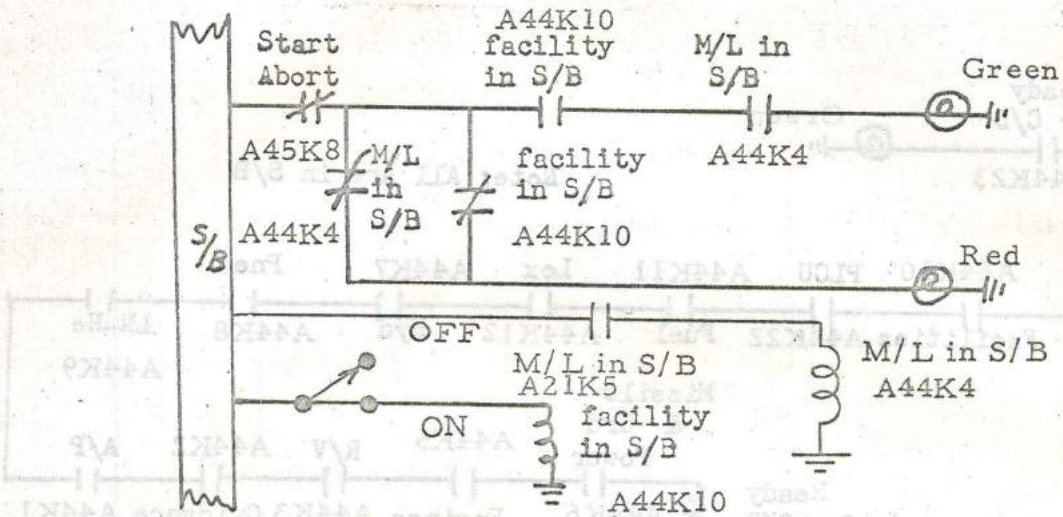


Figure 40 - Facilities and Missile Lift

Countdown Ready Panel

The countdown ready panel (Figure 41) contains one light, READY FOR COUNTDOWN, and a pushbutton START countdown indicating the weapon system is ready to go into a countdown. The pushbutton, when depressed, starts the countdown.

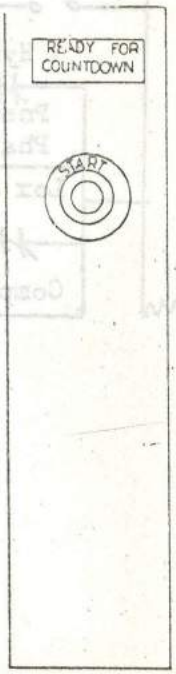


Figure 41 - Countdown Ready Panel

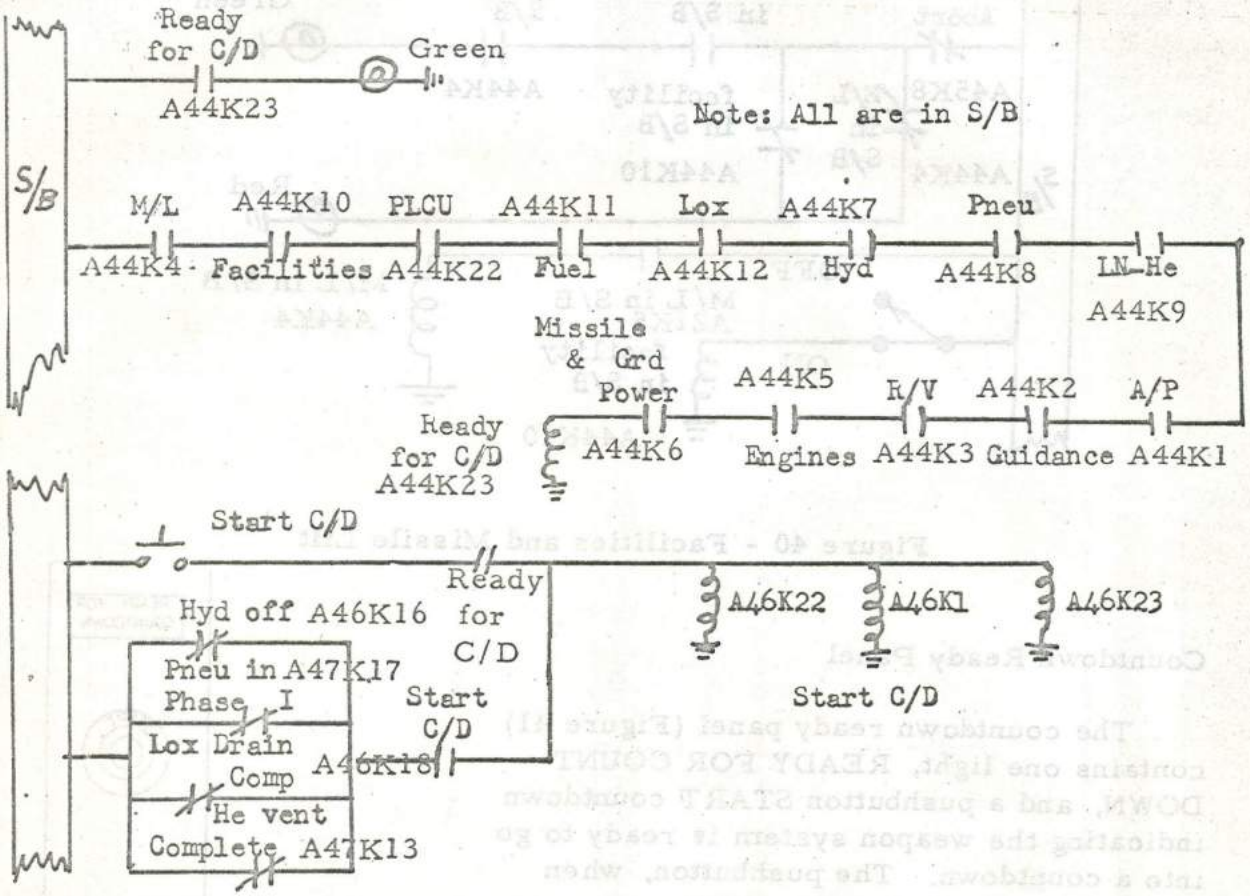


Figure 42 - Ready for C/D

The purpose of the Countdown Status Panel (Figure 43) is to inform the launch operator of the progress of the countdown sequence. The failure of an indicator to illuminate amber or green at the proper time could signify that a system has malfunctioned or is not progressing at a satisfactory rate.

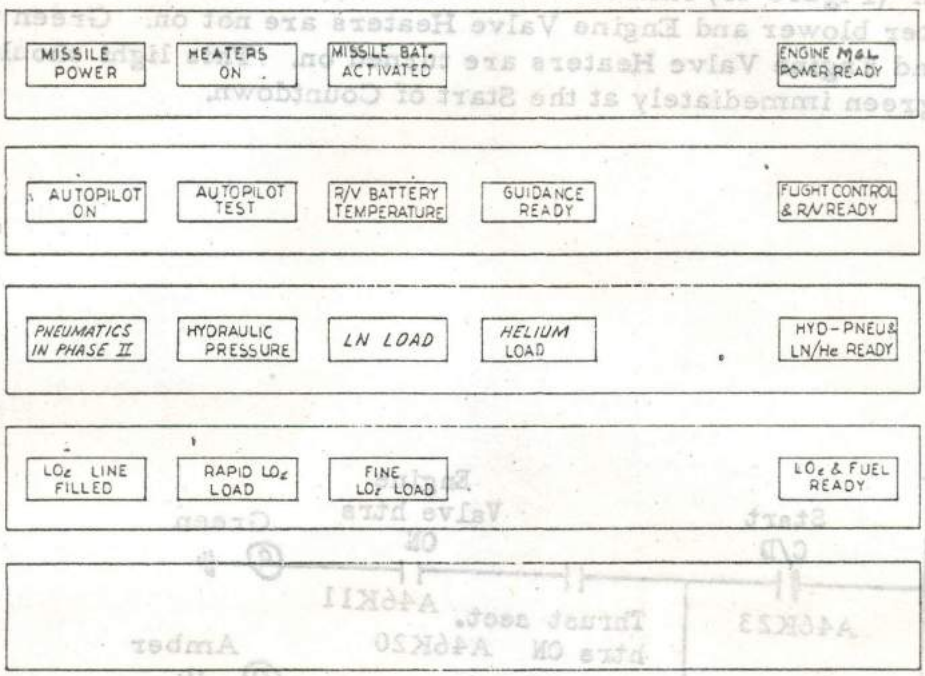


Figure 43 - Countdown Status Panel

COUNTDOWN PANEL
(Eng/Msl. Power Section) Figure 44

"Missile Power": Amber at start of countdown. Normally green 2 SEC later when AC and DC has been applied to the missile.

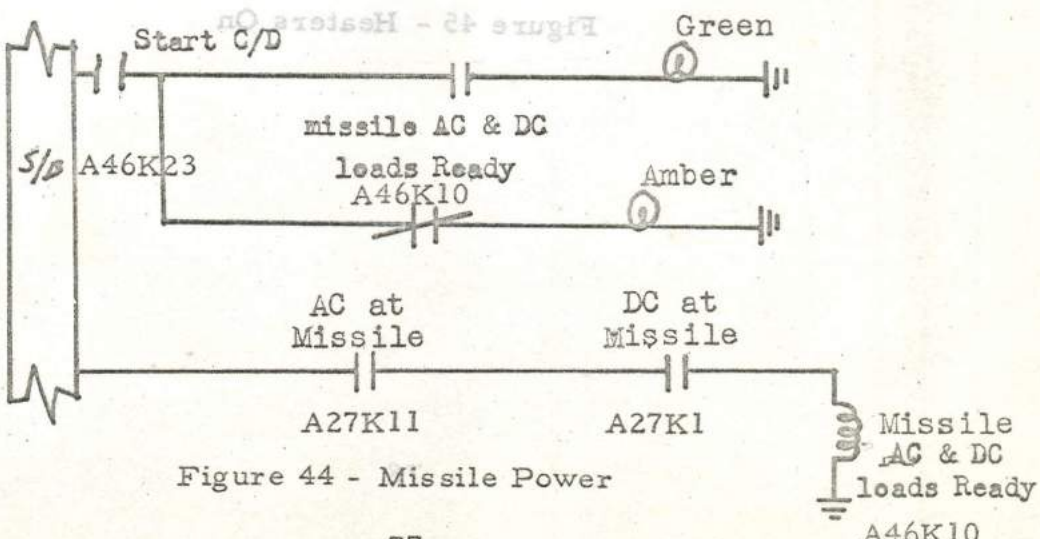


Figure 44 - Missile Power

"Heaters On" (Figure 45) Amber when countdown has started and the thrust section heater blower and Engine Valve Heaters are not on. Green when the TSHB and Engine Valve Heaters are turned on. This light should illuminate green immediately at the Start of Countdown.

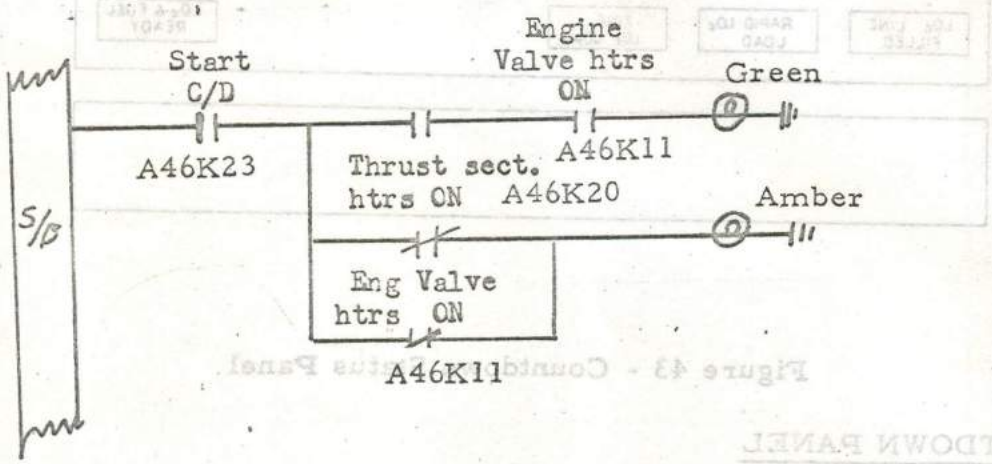


Figure 45 - Heaters On

"Missile Battery Activated": (Figure 46) Amber when the 'activate battery' signal is sent to the main missile battery, 2 seconds after start of countdown. Green when battery voltage is in tolerance (normally 2 minutes after the start of countdown). Could revert to amber condition if battery goes out of tolerance.

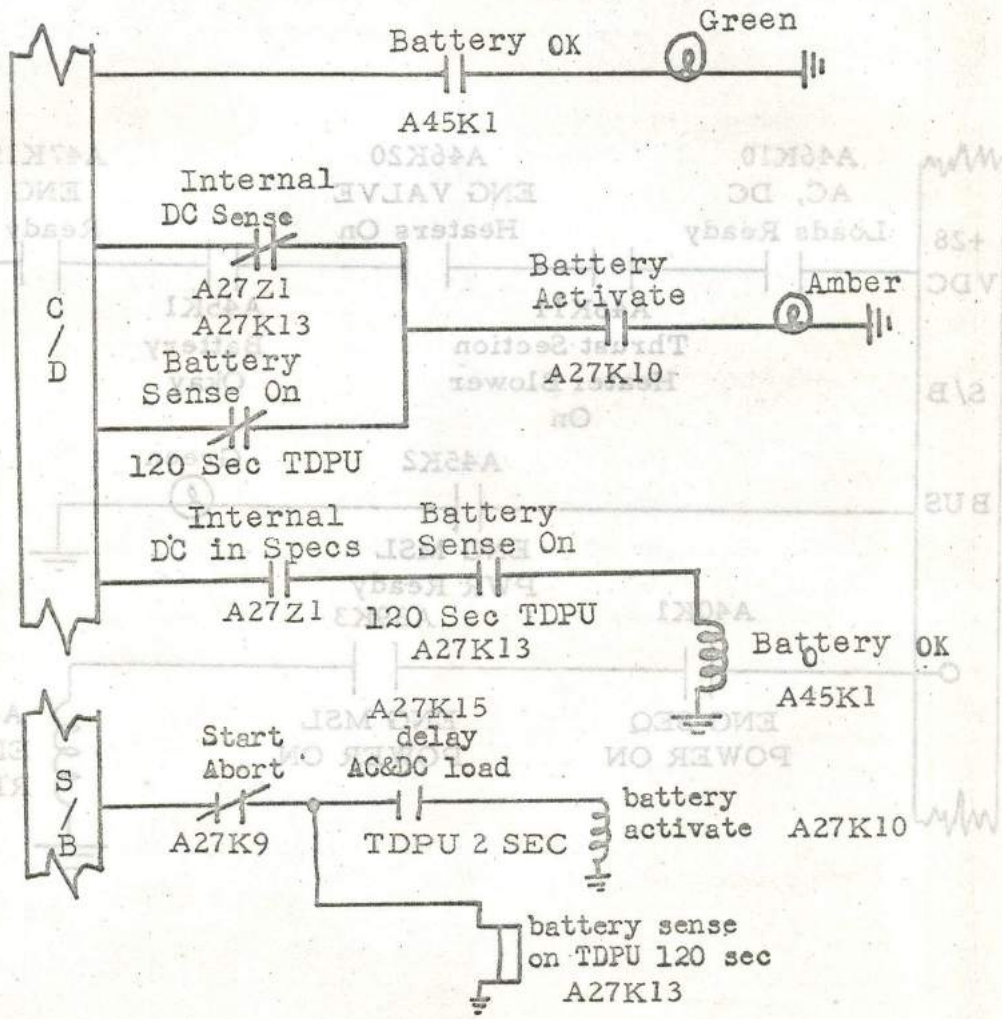


Figure 46 - Missile Battery Activated

"Engine/Missile Power Ready": (Figure 47) Illuminates green when AC, DC is present at missile, the rocket engine relay box has power applied to it, the TSHB and engine valve heaters are on, the missile battery is in tolerance, and the engine sequencer system power is on.

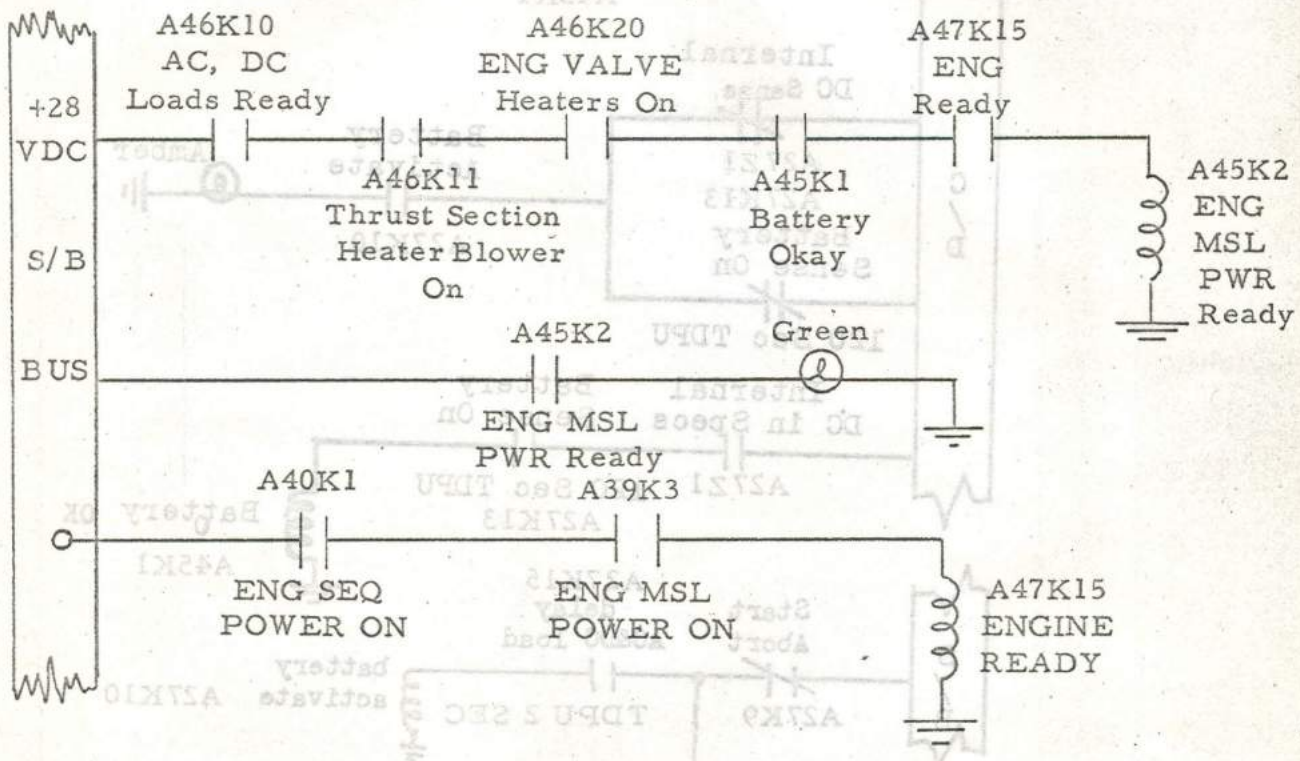


Figure 47 - Engine/Missile Power Ready

COUNTDOWN PANEL
(F/C and R/V Section)

"A/P ON": (Figure 48) Normally illuminates amber when the A/P gyros have 400 CPS applied to them, and a 4 minute warmup timer has not "run out". Green when the A/P gyros have warmed up for 4 minutes. Spin Motor Rotation detection is now enabled.

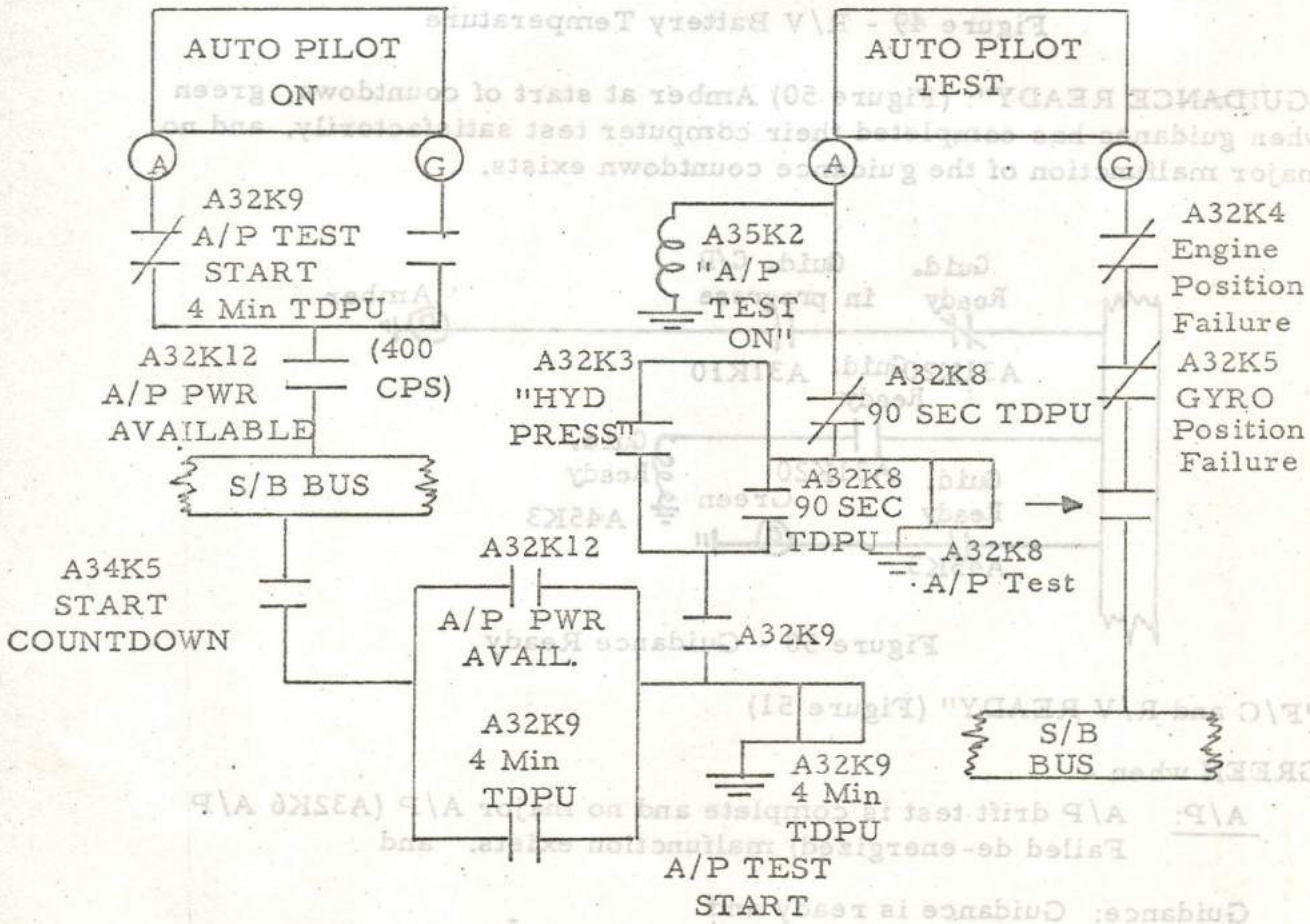


Figure 48 - Autopilot On and Autopilot Test

"A/P TEST": (Figure 48) Illuminates amber when the A/P gyros have completed their 4 minute warmup cycle, and hydraulic pressure is at 2000 + or - 250 PSI, Green 90 seconds later providing a 90 SEC timer has timed out, and that the engines are nulled, and the A/P gyros have not drifted excessively. (The A/P gyros are checked for drift during the A/P drift test of 90 SEC.)

"R/V BATTERY TEMPERATURE": (Figure 49) If MKIV is installed, should go green at start of countdown.

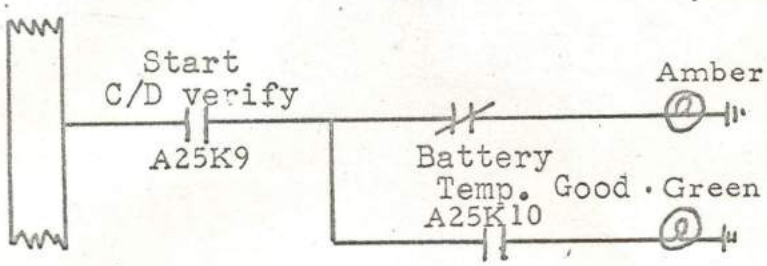


Figure 49 - R/V Battery Temperature

"GUIDANCE READY": (Figure 50) Amber at start of countdown, green when guidance has completed their computer test satisfactorily, and no major malfunction of the guidance countdown exists.

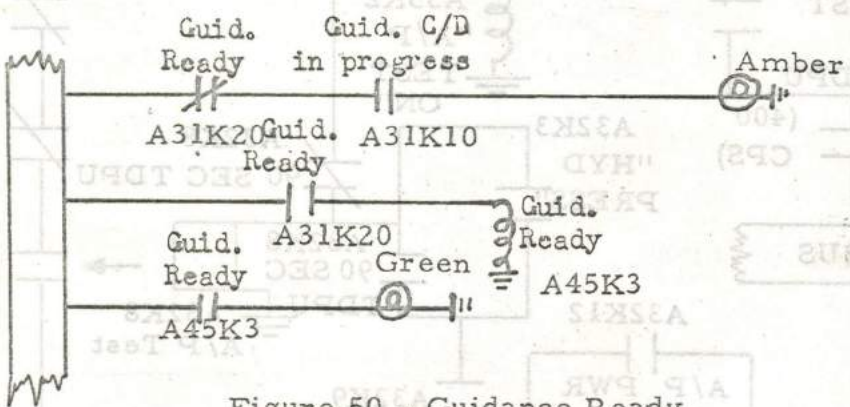


Figure 50 - Guidance Ready

"F/C and R/V READY" (Figure 51)

GREEN when -

A/P: A/P drift test is complete and no major A/P (A32K6 A/P Failed de-energized) malfunction exists. and

Guidance: Guidance is ready and

R/V: (MKIV) The R/V is safe, branch power is on, R/V is tactical, the PLM has acknowledged the start (Start C/D Verification) of countdown, and burst is selected.

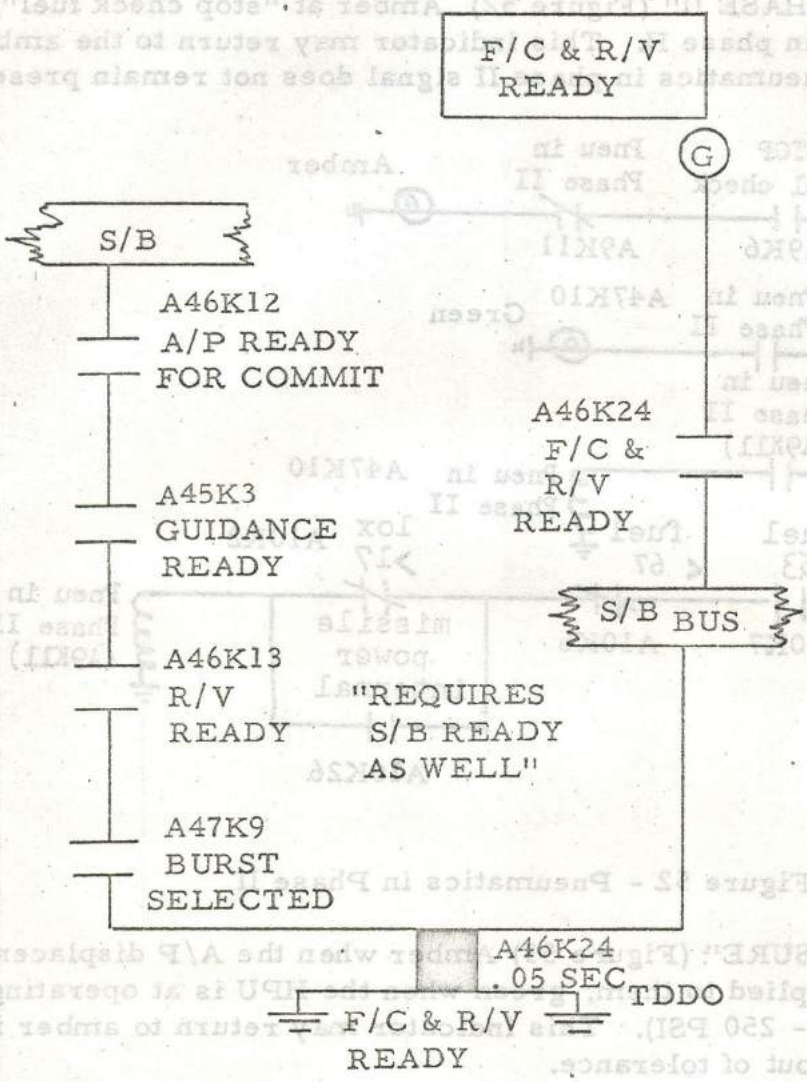


Figure 51 - F/C and R/V Ready

COUNTDOWN PANEL
(Hyd-Pneu-LN2/He Section)

"PNEUMATICS IN PHASE II" (Figure 52) Amber at "stop check fuel", green when pneumatics is in phase II. This indicator may return to the amber illumination if the pneumatics in phase II signal does not remain present.

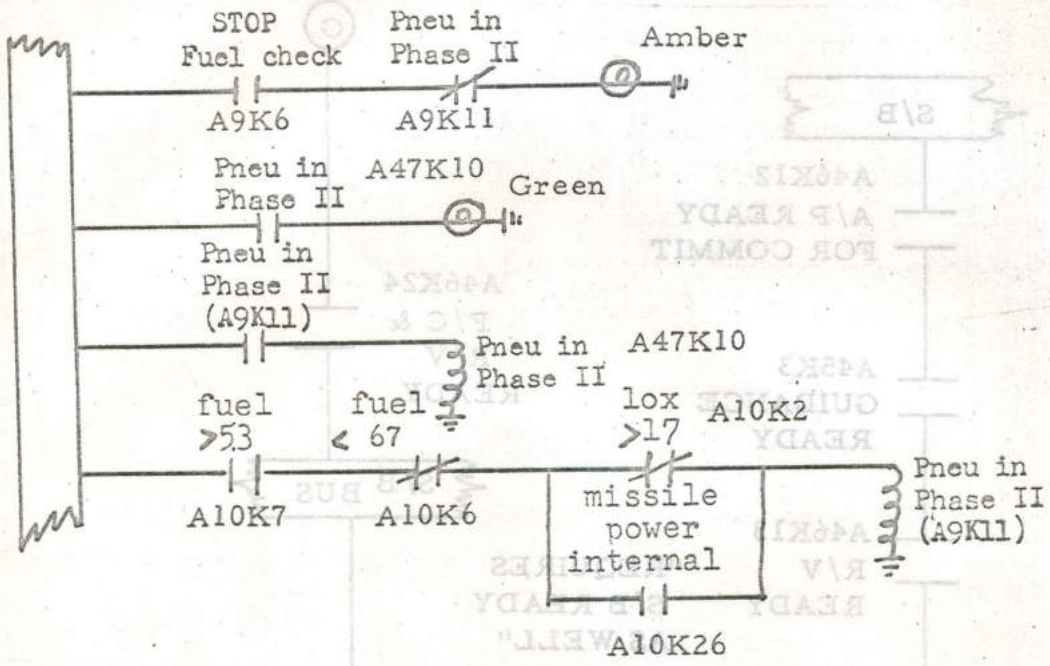


Figure 52 - Pneumatics in Phase II

"HYDRAULIC PRESSURE": (Figure 53) Amber when the A/P displacement gyros have power applied to them, green when the HPU is at operating pressure (2000 + or - 250 PSI). This indicator may return to amber if HPU pressure goes out of tolerance.

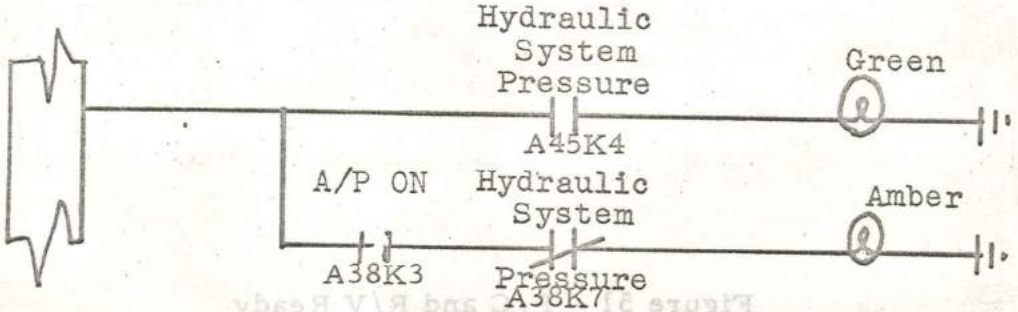


Figure 53 - Hydraulic Pressure

"LN2 LOAD": (Figure 54) Amber at start of countdown when LN2 loading is initiated and valves 213, 214 have opened. Green six minutes later when LN2 Loading is complete (a six minute TDDO drops out, V213, 214 are still open, and LN2 storage tank pressure is greater than 75 PSI initially - when these conditions exist LN2 loading is said to be complete and the summary once met is "locked in").

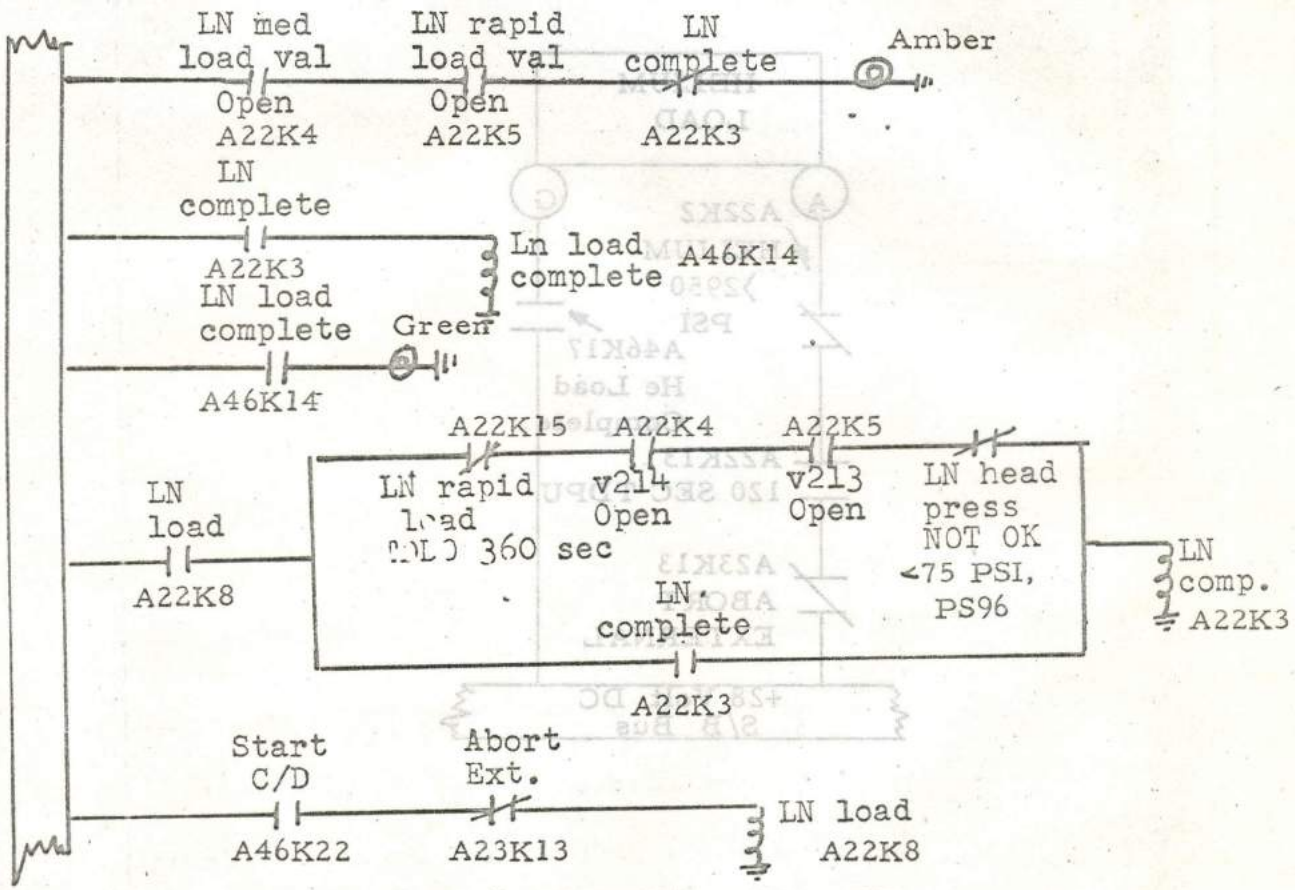


Figure 54 - LN Load

"HELIUM LOAD": (Figure 55) Amber 2 minutes after the start of countdown. Will remain amber until greater than 2950 PSI is reached in the inflight helium spheres as monitored by pressure switch 321. Once 2950 PSI is reached the light will illuminate green, and "lock-in", even though pressure may decay below 2950 PSI.

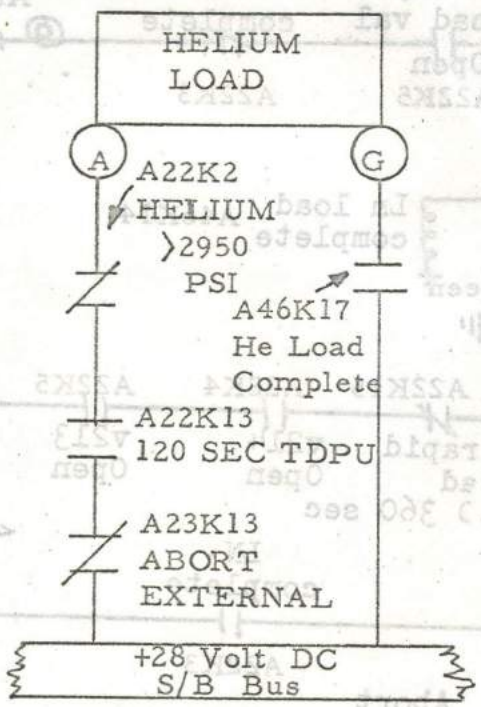


Figure 55 - Helium Load

"HYD-PNEU-LN2/He": (Figure 56) Green when the HPU is at operating pressure, the pneumatics system is in phase II, an HCU bottle is greater than 4500 PSI, LN2 loading is complete, and initially there was greater than 2950 PSI in the shrouded spheres. (But will be replenished by the mass controller, VII).

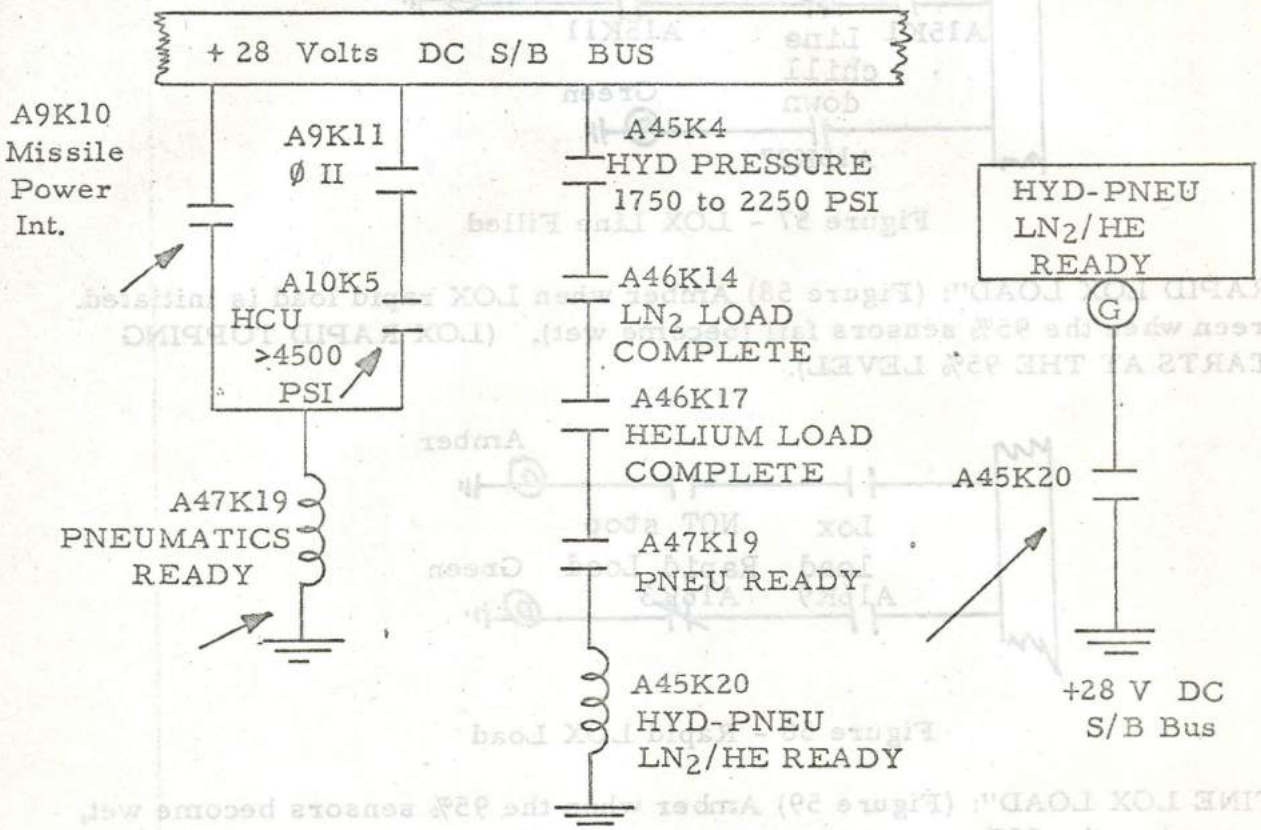


Figure 56 - Hyd-Pneu-LN2/He Ready

COUNTDOWN PANEL
(LOX and Fuel Section)

"LOX LINE FILLED": (Figure 57) Amber when the pneumatics system is ready for chilldown, and the chilldown 60 SEC timer has not run out. Green when the 60 SEC chilldown timer (TDPU) energizes.

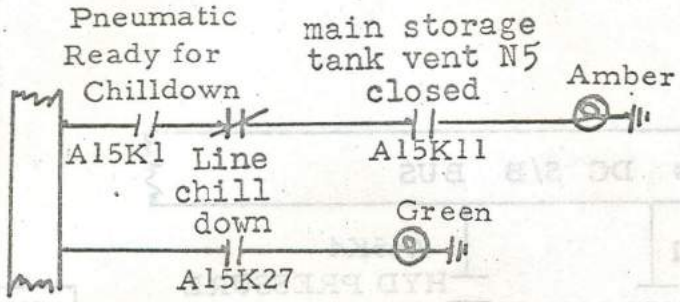


Figure 57 - LOX Line Filled

"RAPID LOX LOAD": (Figure 58) Amber when LOX rapid load is initiated. Green when the 95% sensors fail (become wet). (LOX RAPID TOPPING STARTS AT THE 95% LEVEL).

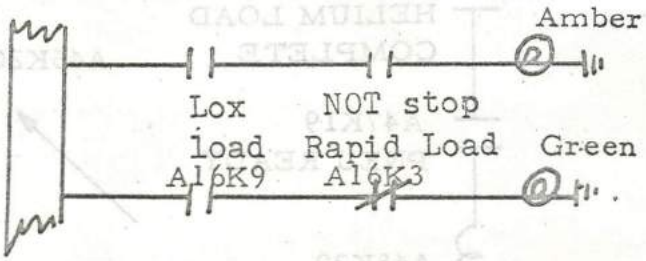


Figure 58 - Rapid LOX Load

"FINE LOX LOAD": (Figure 59) Amber when the 95% sensors become wet, green when the 99% sensors become wet. (A 50-second line drain starts at 99% and also a 40 second commit delay timer is started).

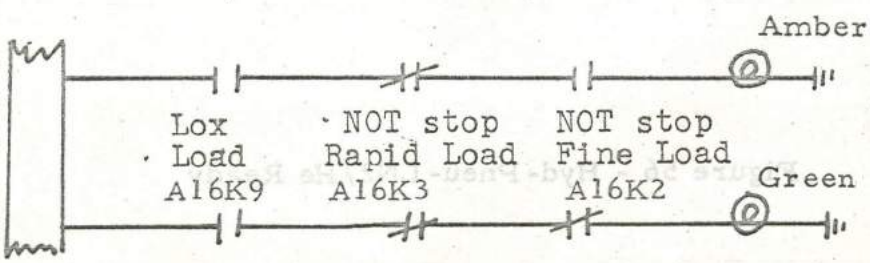


Figure 59 - Fine LOX Load

"LOX & FUEL READY": (Figure 60) Green

LOX: Has passed the 99. 25% sensors at least once, a 40 second timer has energized, and the airborne fill and drain valve is closed.

FUEL: The fuel level check during the 5 SEC period at the start of countdown was satisfactory.

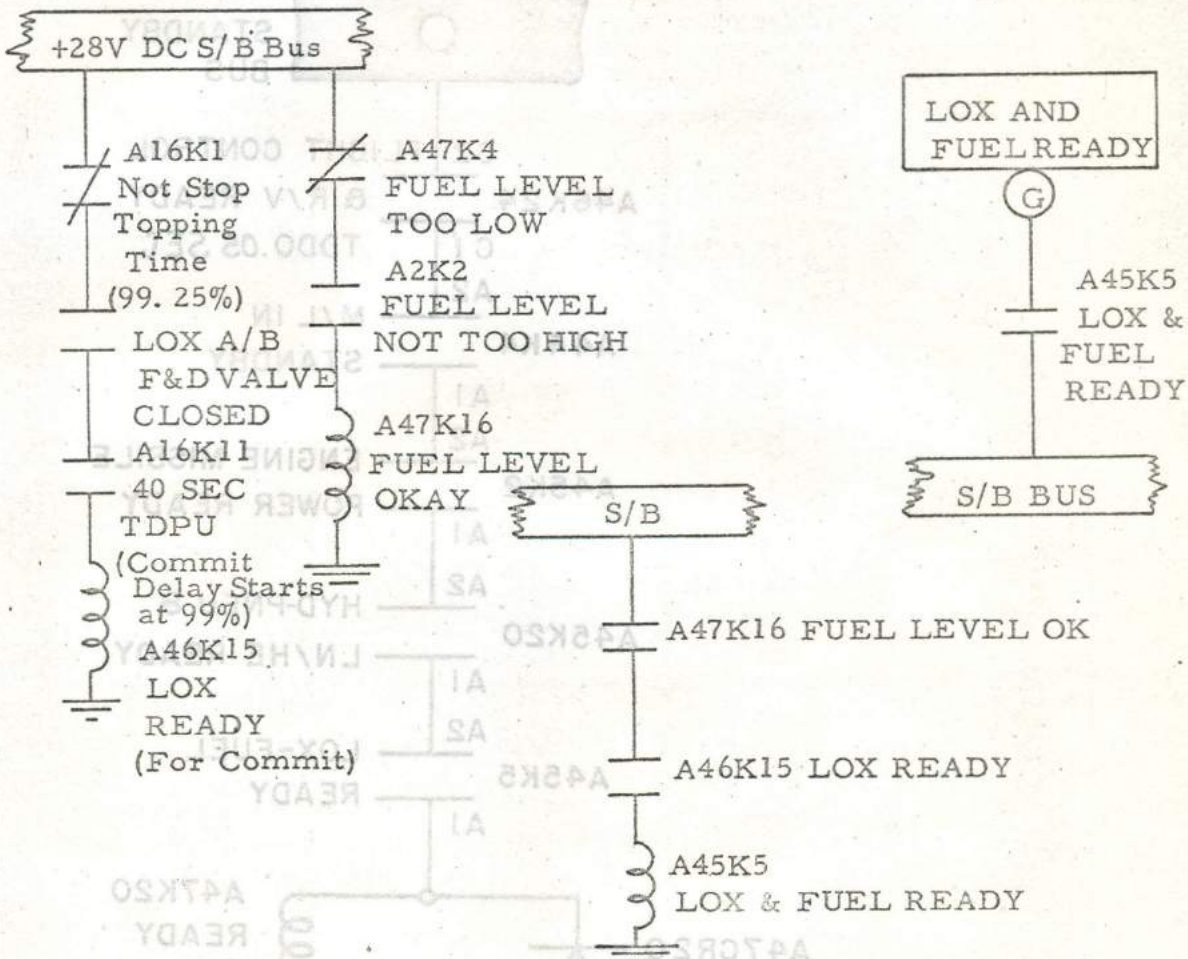


Figure 60 - LOX and Fuel Ready

COMMIT PANEL (Figure 61)

The "Ready For Commit" (Figures 62 and 63) light will illuminate green when all of the 'ready' lights are green (due to proper summaries) in the countdown panels, and the missile lift system has maintained its ready in standby summary conditions.

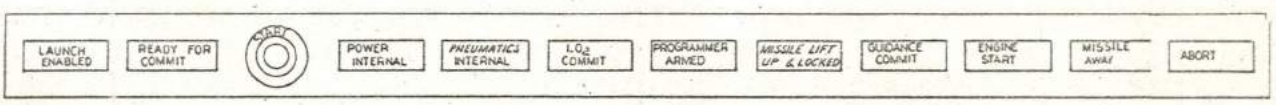


Figure 61 - Commit Panel

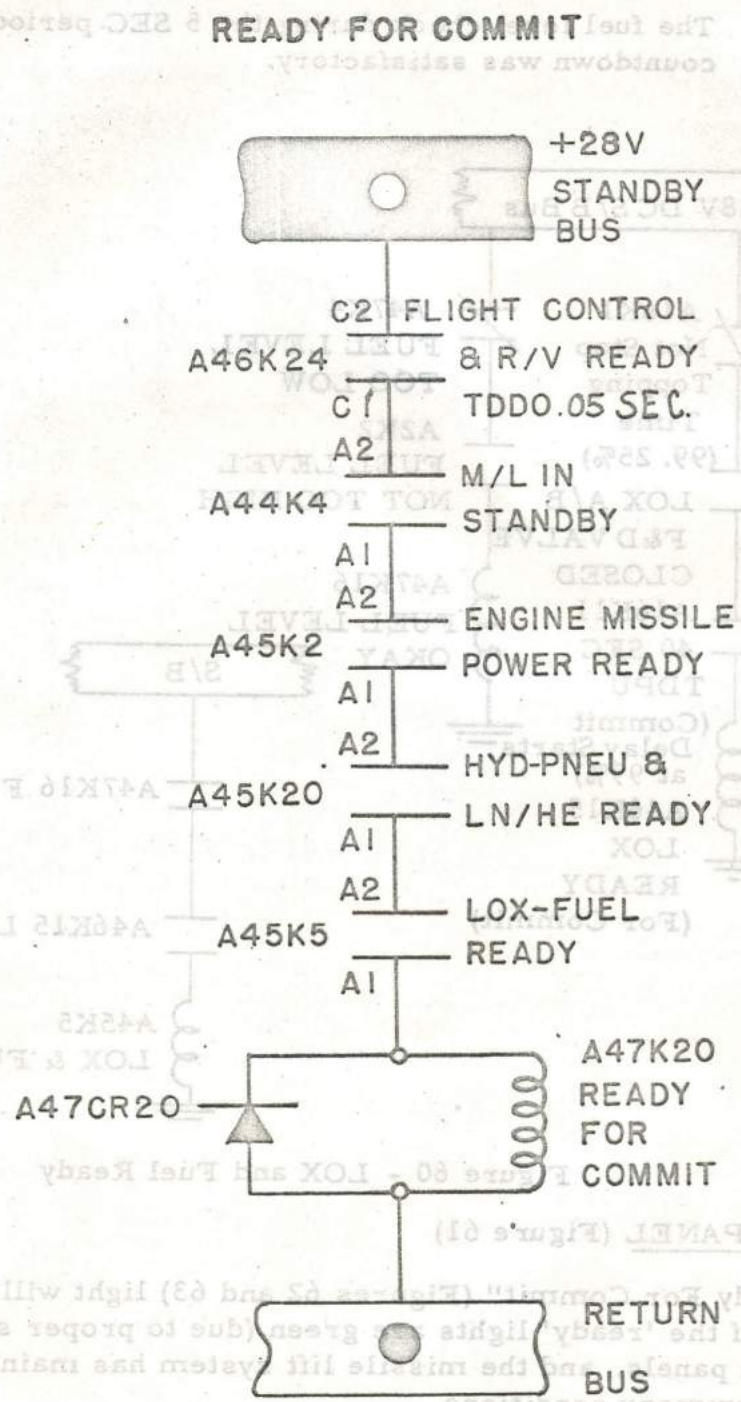


Figure 62 - Ready For Commit

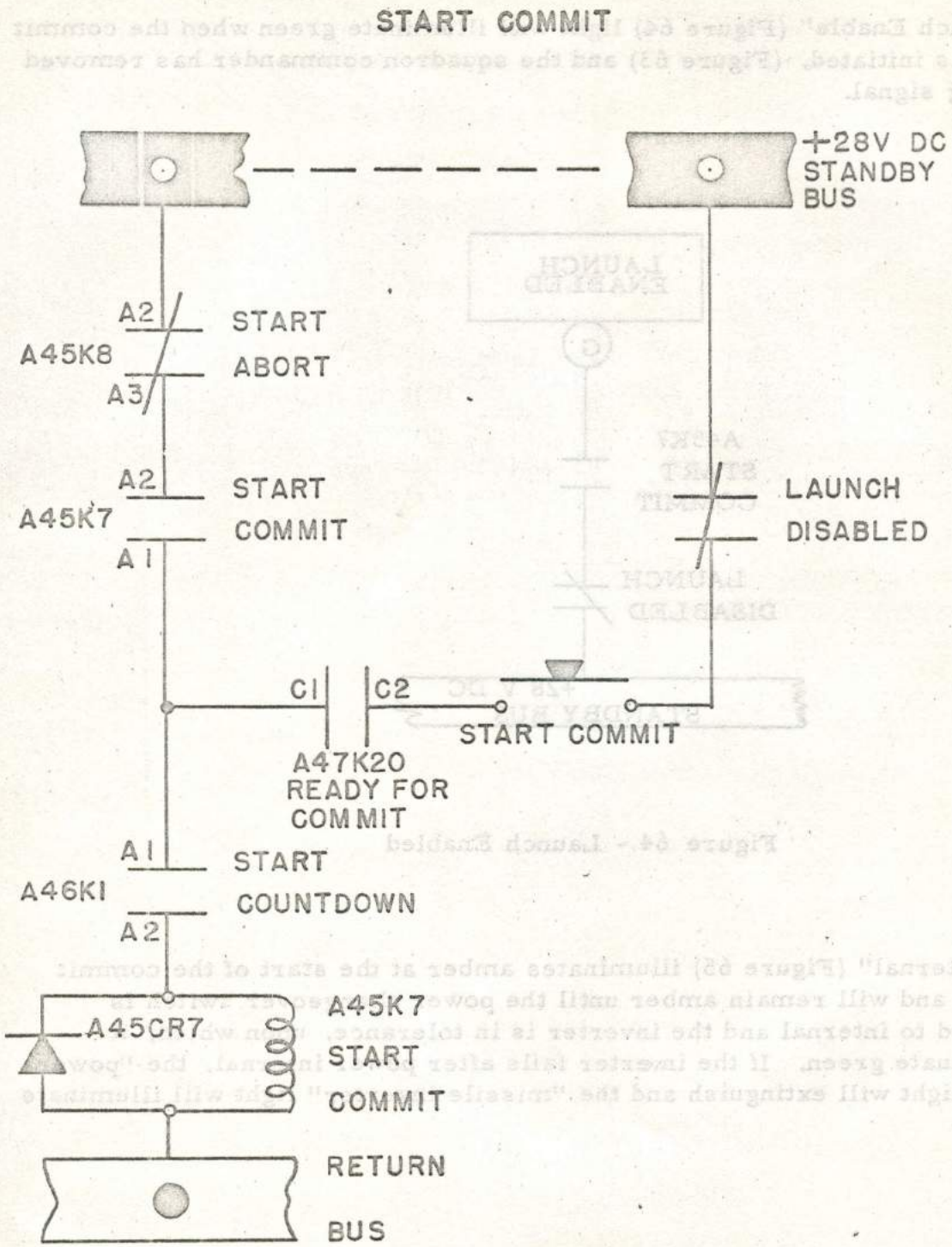


Figure 63 - Start Commit

The "Launch Enable" (Figure 64) light will illuminate green when the commit sequence is initiated, (Figure 63) and the squadron commander has removed a disabling signal.

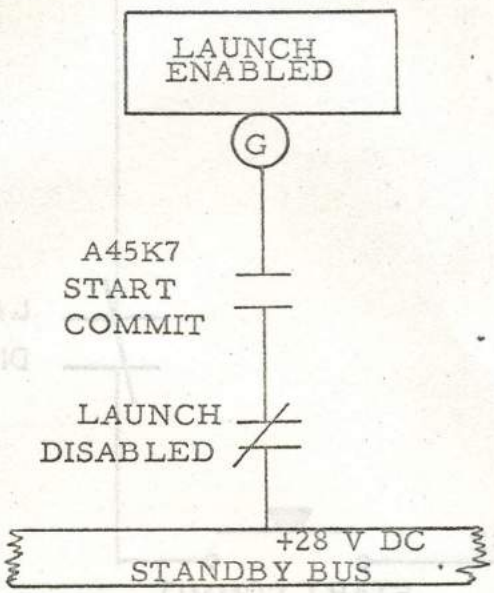


Figure 64 - Launch Enabled

"Power Internal" (Figure 65) illuminates amber at the start of the commit sequence, and will remain amber until the power changeover switch is transferred to internal and the inverter is in tolerance, upon which, it will illuminate green. If the inverter fails after power internal, the "power internal" light will extinguish and the "missile inverter" light will illuminate red.

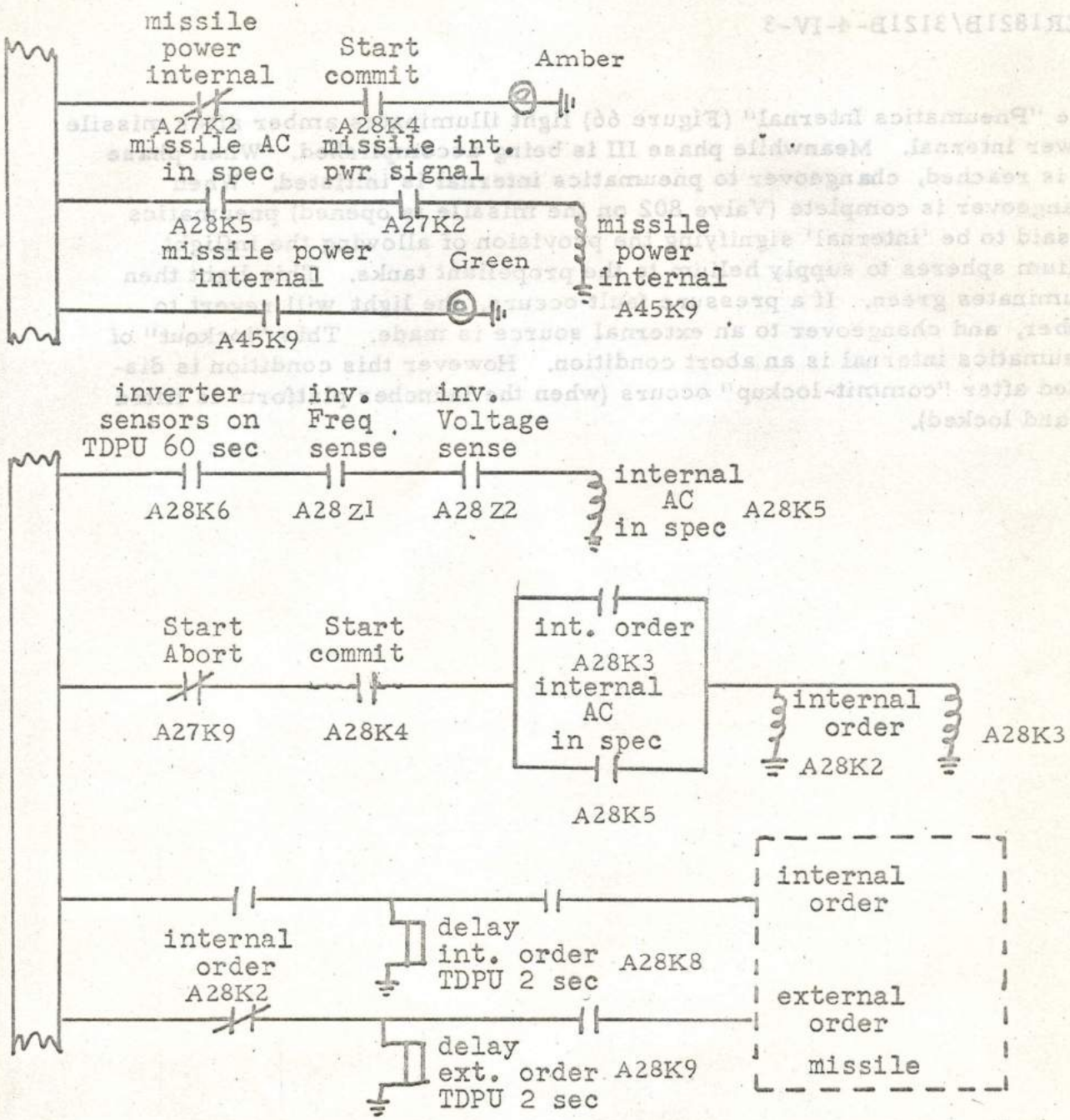


Figure 65 - Power Internal

The "Pneumatics Internal" (Figure 66) light illuminates amber after missile power internal. Meanwhile phase III is being accomplished. When phase III is reached, changeover to pneumatics internal is initiated. When changeover is complete (Valve 802 on the missile is opened) pneumatics is said to be 'internal' signifying the provision of allowing the inflight helium spheres to supply helium to the propellant tanks. This light then illuminates green. If a pressure fault occurs, the light will revert to amber, and changeover to an external source is made. This "lockout" of pneumatics internal is an abort condition. However this condition is disabled after "commit-lockup" occurs (when the launcher platform is lifted up and locked).

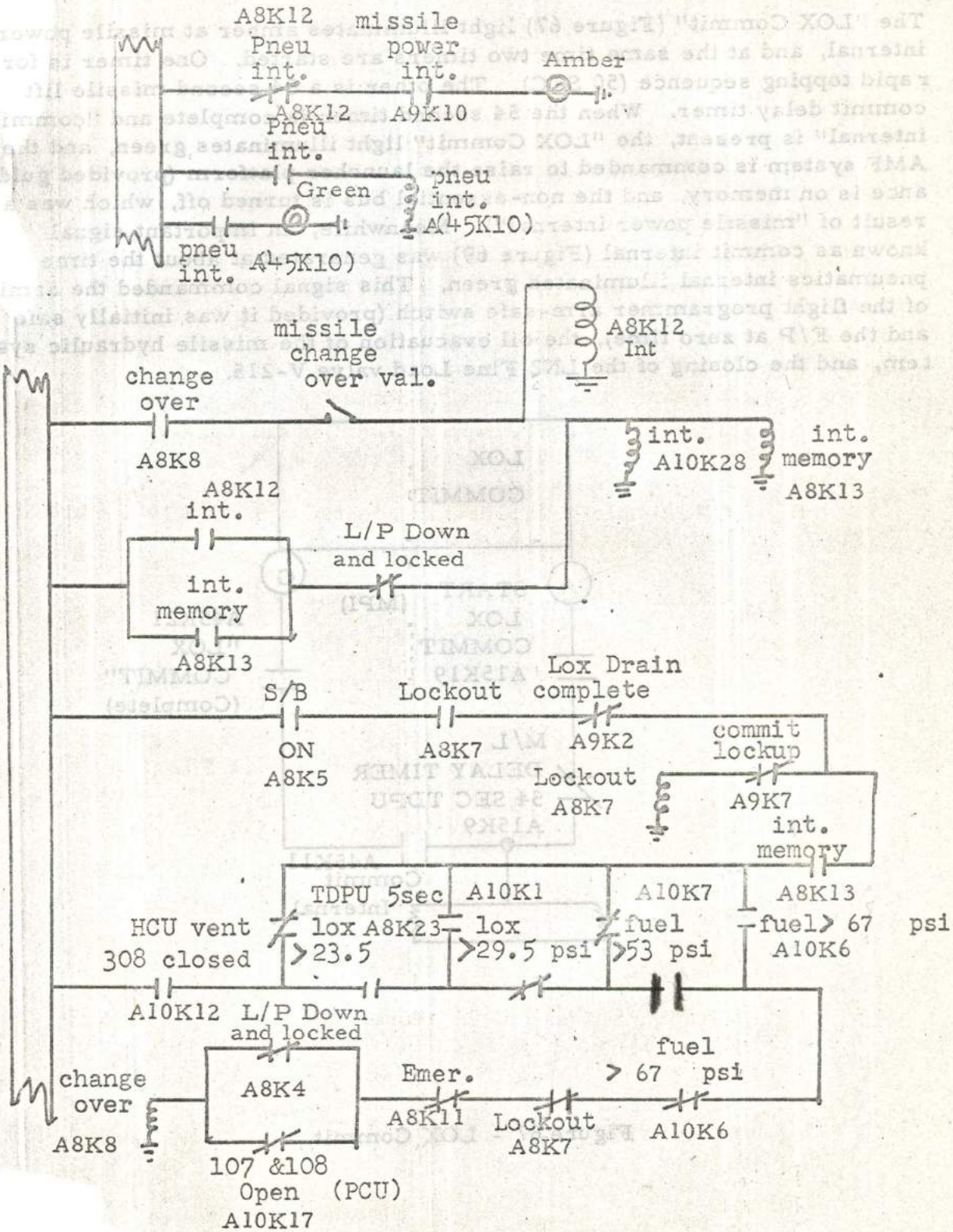


Figure 66 - Pneumatics Internal

The "LOX Commit" (Figure 67) light illuminates amber at missile power internal, and at the same time two timers are started. One timer is for the rapid topping sequence (50 SEC). The other is a 54 second missile lift commit delay timer. When the 54 second timer is complete and "commit internal" is present, the "LOX Commit" light illuminates green, and the AMF system is commanded to raise the launcher platform (provided guidance is on memory, and the non-essential bus is turned off, which was a result of "missile power internal"). Meanwhile, an important signal known as commit internal (Figure 69) was generated at about the time pneumatics internal illuminated green. This signal commanded the arming of the flight programmer arm-safe switch (provided it was initially safe and the F/P at zero time), the oil evacuation of the missile hydraulic system, and the closing of the LN2 Fine Load valve V-215.

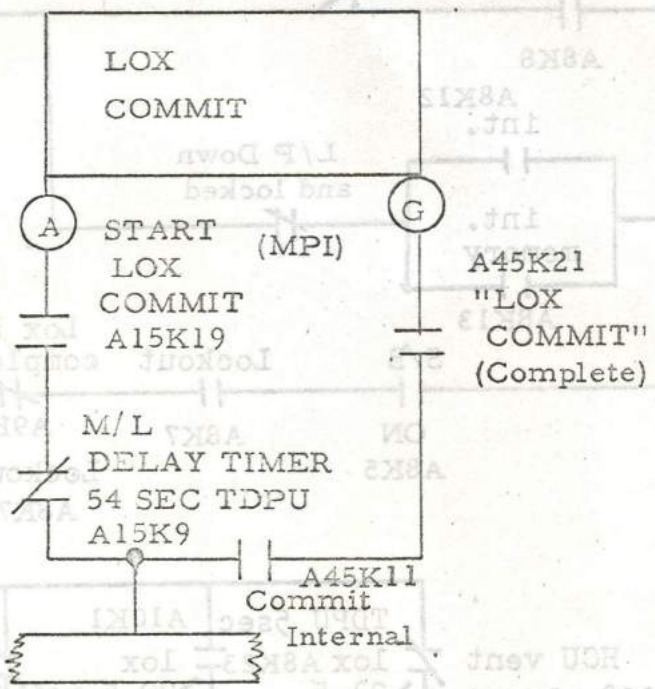


Figure 67 - LOX Commit

The "PROGRAMMER ARMED" (Figure 68) light illuminated amber just after "Pneumatics-Internal" illuminated green, signifying the arming of the F/P. In about 15 seconds, the F/P should have fully armed, which in turn would cause the "PROGRAMMER ARMED" light to illuminate green. The arming of the F/P is not a requirement for raising the launcher platform, but it is one of the requirements for "Commit Lockup", another important commit sequence command signal.

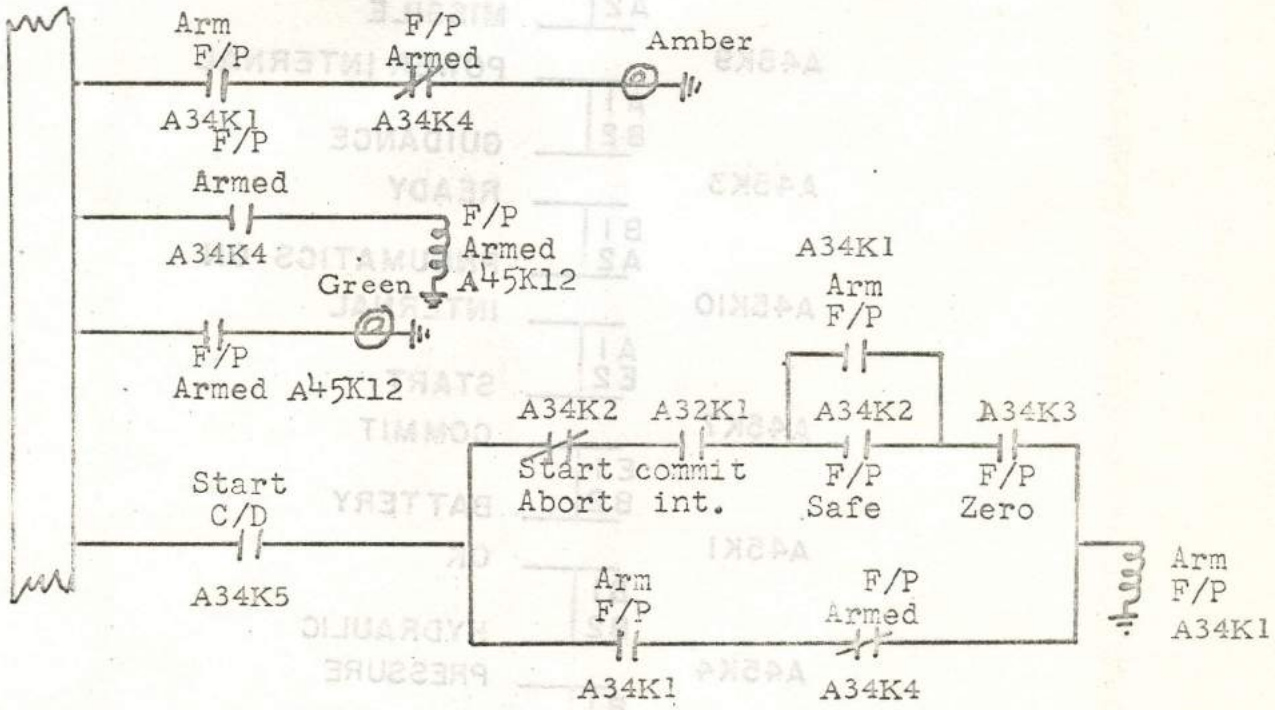


Figure 68 - Programmer Armed

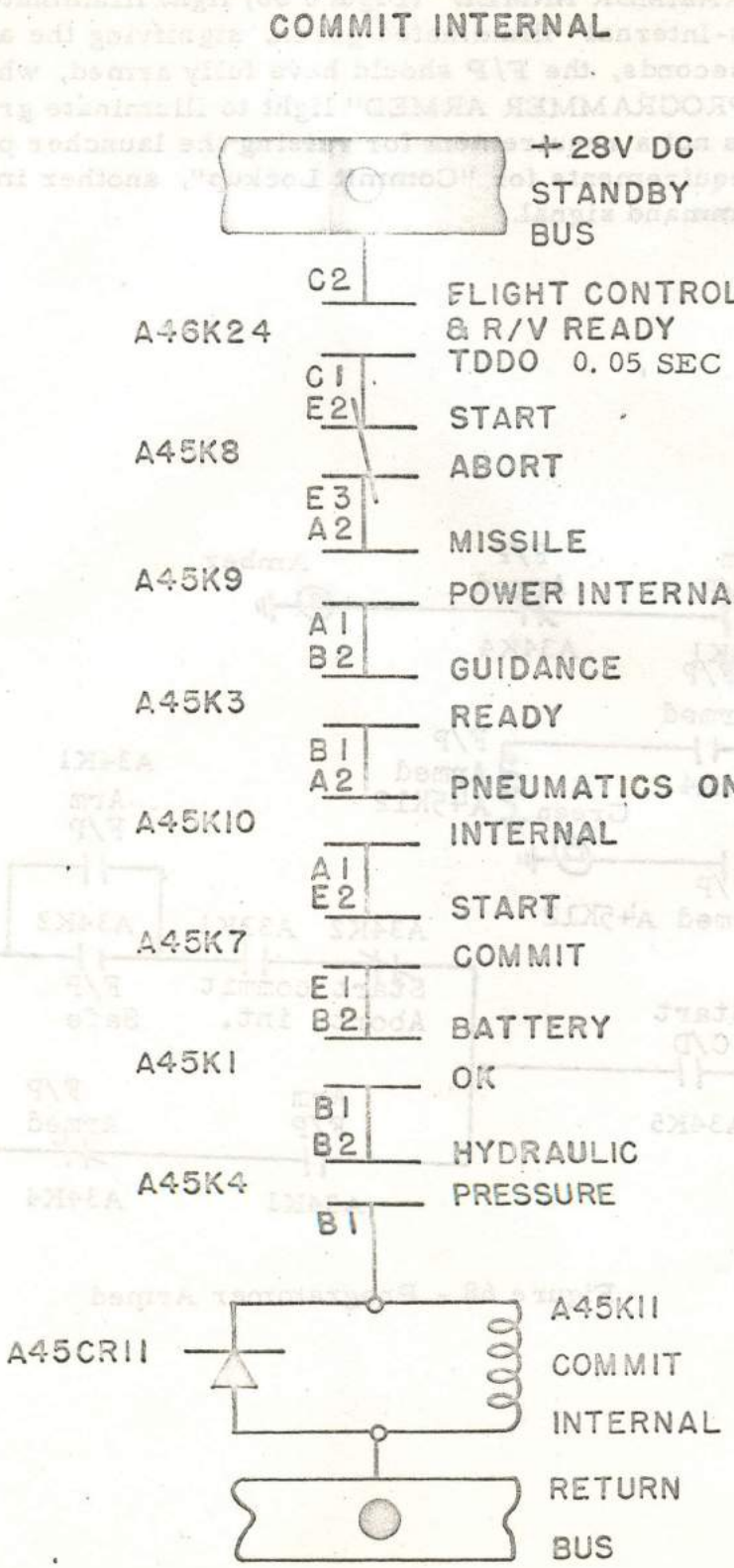


Figure 69 - Commit Internal

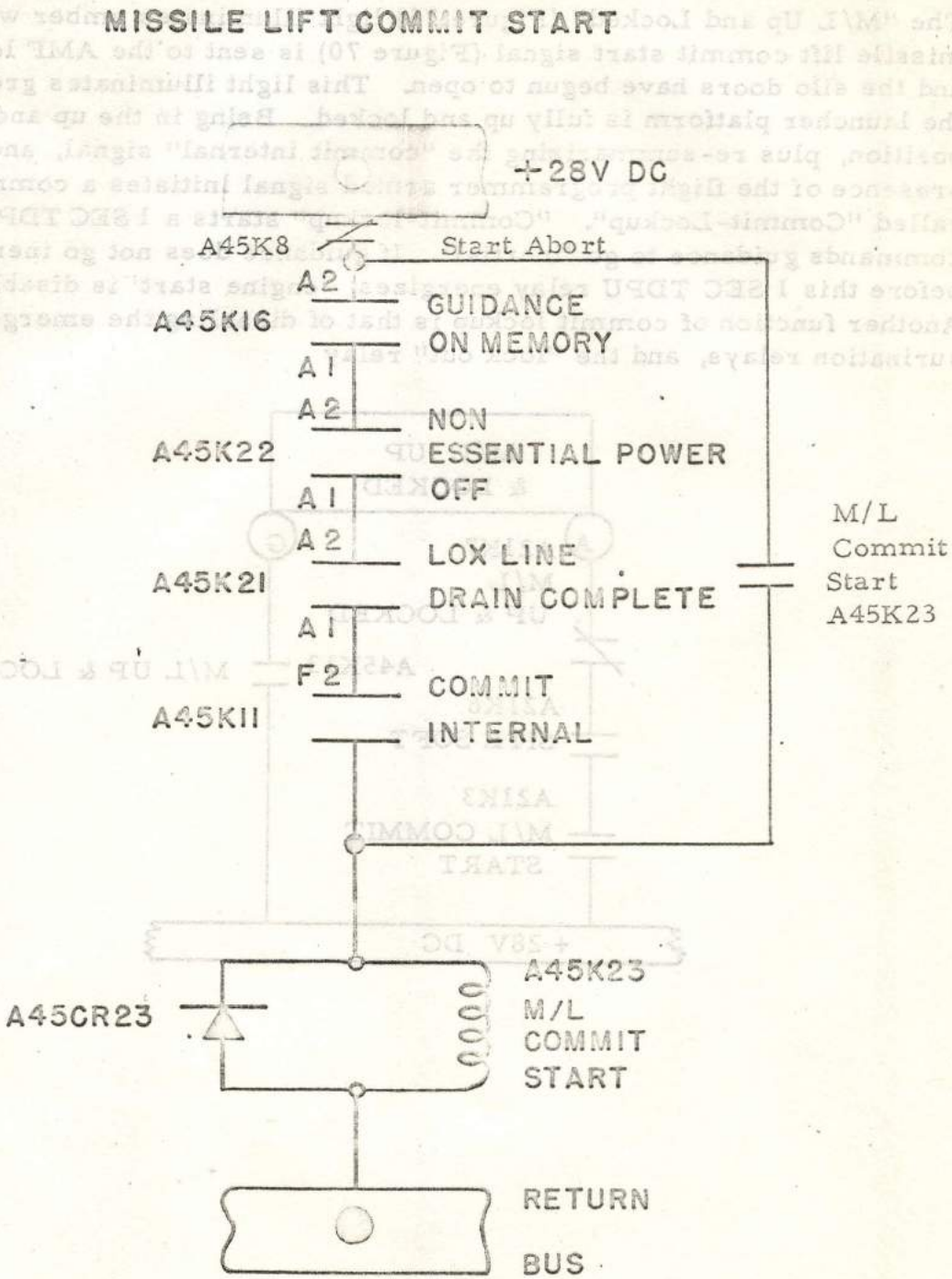


Figure 70 - Missile Lift Commit Start

The "M/L Up and Locked" (Figure 71) light illuminates amber when the missile lift commit start signal (Figure 70) is sent to the AMF logic racks, and the silo doors have begun to open. This light illuminates green when the launcher platform is fully up and locked. Being in the up and locked position, plus re-summarizing the "commit internal" signal, and the presence of the flight programmer armed signal initiates a command called "Commit-Lockup". "Commit-lockup" starts a 1 SEC TDPU, and commands guidance to go 'inertial'. If guidance does not go inertial before this 1 SEC TDPU relay energizes, 'engine start' is disabled. Another function of commit lockup is that of disabling the emergency pressurization relays, and the "lock out" relay

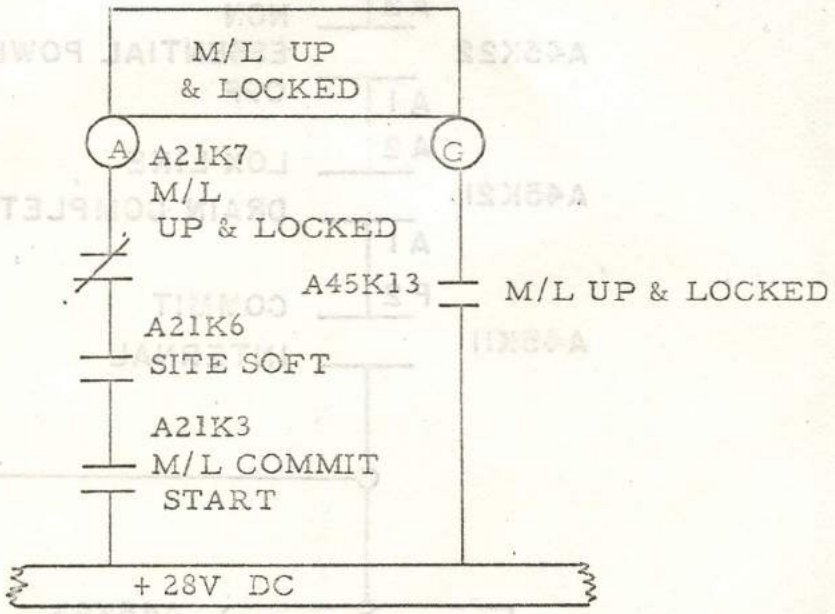


Figure 71 - M/L Up and Locked

"Guidance Commit" (Figure 72) illuminates amber when the guidance system is on memory. Normally, missile power internal places guidance on memory. Commit lockup will command guidance to go inertial and when guidance has gone inertial within one second, the lamp is green.

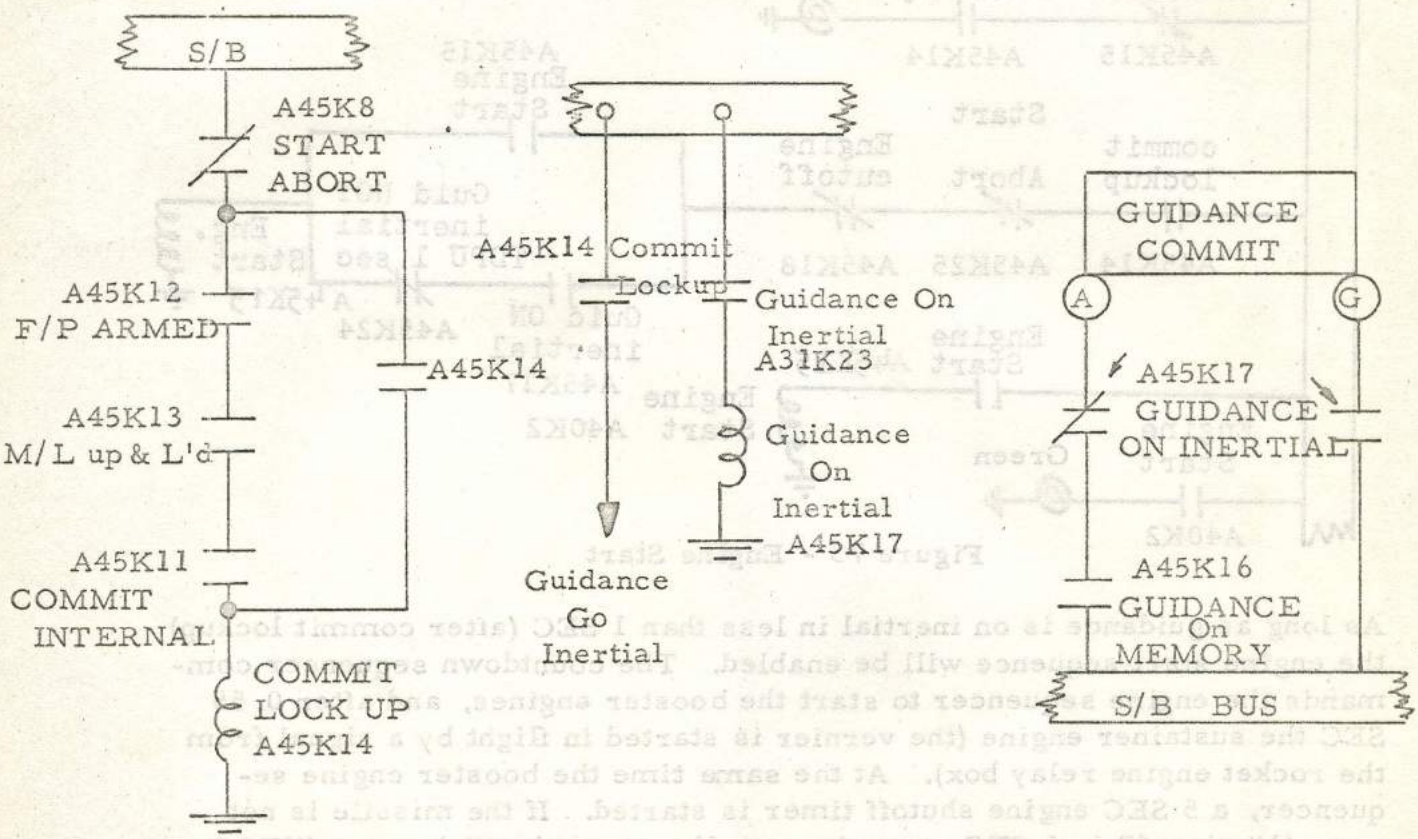


Figure 72 - Guidance Commit

The "Engine Start" (Figure 73) light illuminates amber when commit lockup is generated until engine start is initiated. When the engine sequencer sends the engine start signal to the rocket engines, this light would then illuminate green. In actual practice, one should never see the "Engine Start" light illuminate amber because the "Engine Start" sequence, if normal, is very rapid.

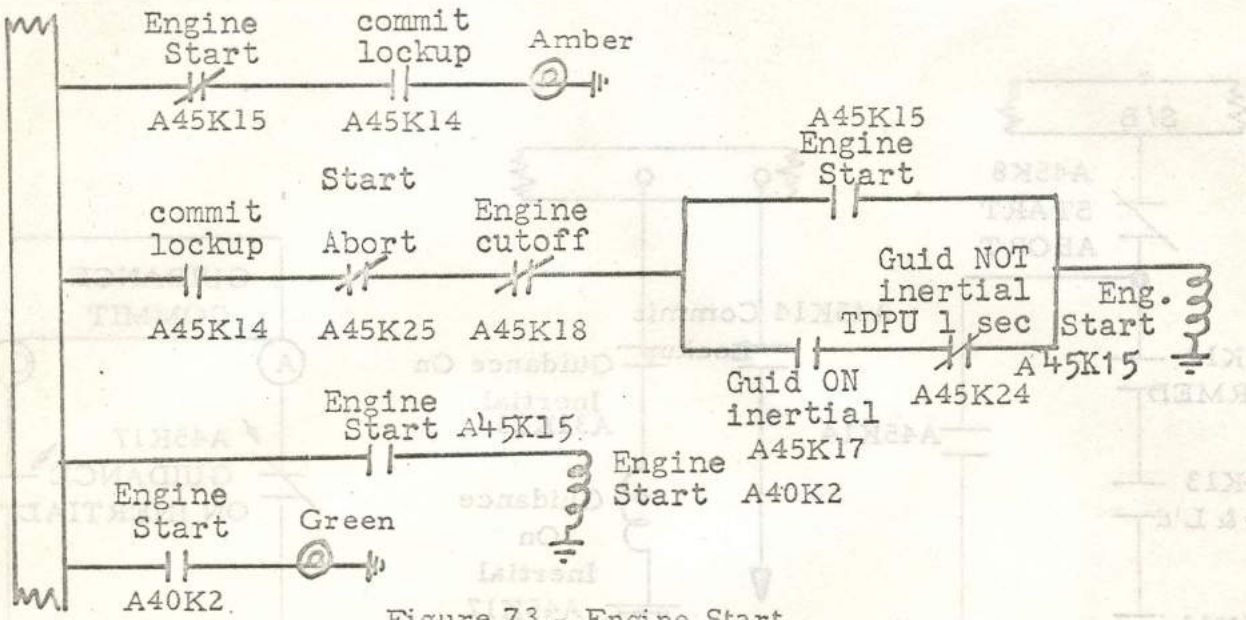


Figure 73 - Engine Start

As long as guidance is on inertial in less than 1 SEC (after commit lockup) the engine start sequence will be enabled. The countdown sequencer commands the engine sequencer to start the booster engines, and after 0.55 SEC the sustainer engine (the vernier is started in flight by a signal from the rocket engine relay box). At the same time the booster engine sequencer, a 5 SEC engine shutoff timer is started. If the missile is not away (1" riseoff) in 5 SEC an engine cutoff command will be sent (VECO, SECO, BECO) to shut down all engines. The abort sequence is enabled before "commit-lockup" and after the 5 SEC engine shutoff timer runs out (The ABORT sequence is disabled during this short time of about 5 1/2 seconds).

The "Missile Away" (Figure 74) light illuminates green when the "1 inch" microswitch on the launcher platform detects 1 inch of missile movement upward. If the missile is 'away', this light will remain green even though the abort sequence is initiated.

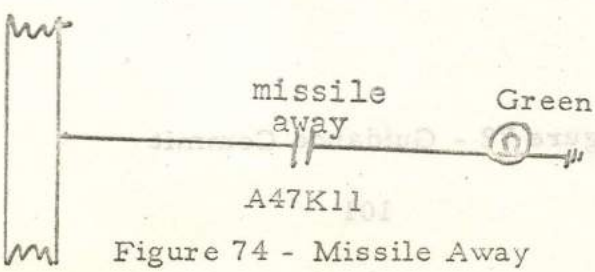


Figure 74 - Missile Away

The "Abort" light (Figure 75) illuminates amber if, when a 4 minute time has expired since the LOX 54 SEC TDPU relay energized and the "commit-lockup" signal has not generated. It illuminates red if guidance does not go inertial in the one second allotted time, or if the missile is not away in 5 seconds after the engine start signal to the boosters was generated.

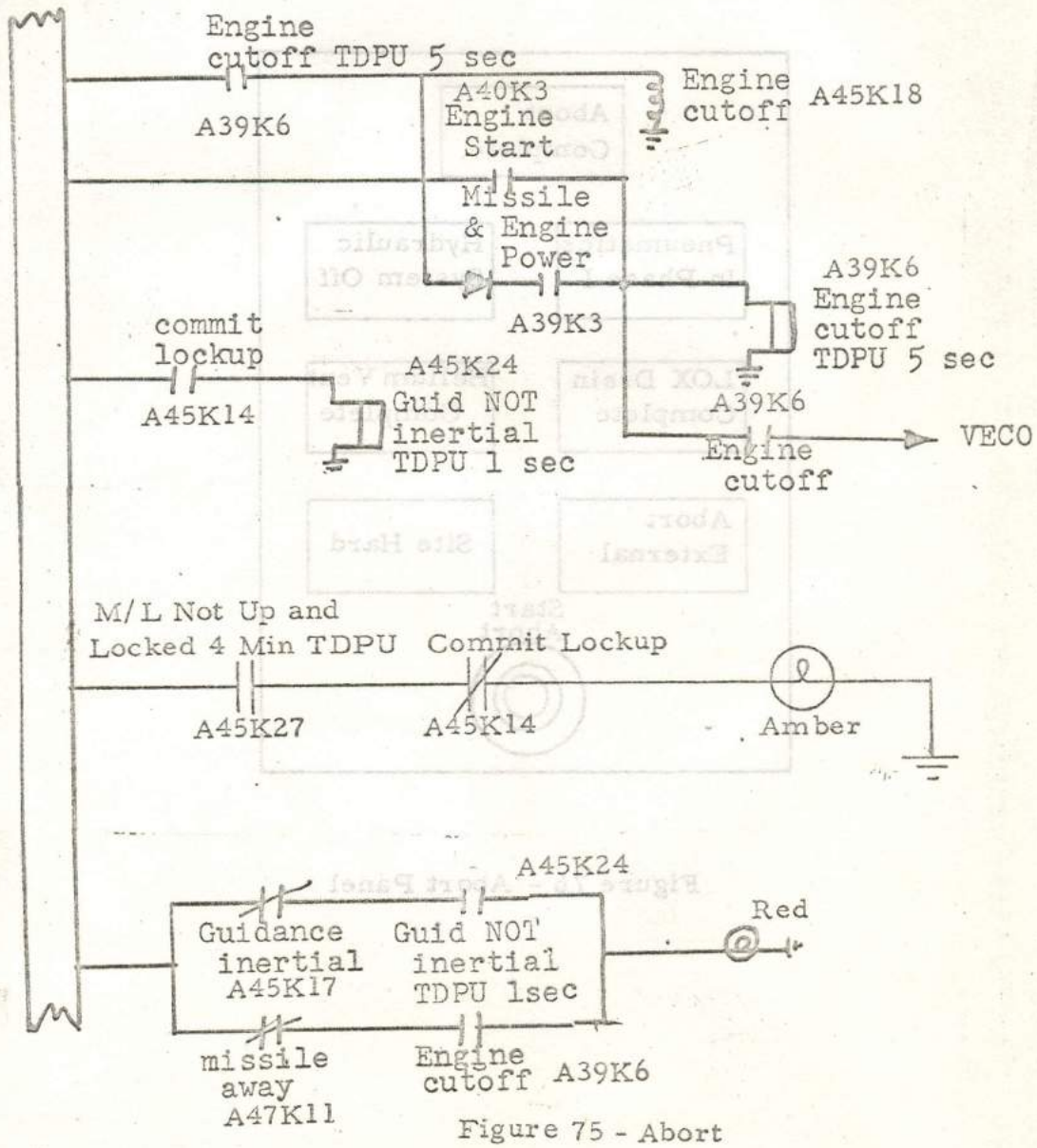


Figure 75 - Abort

The ABORT PANEL: (Figure 76) The lights in the abort panel illuminate amber or green for lamp test. When the Abort pushbutton is depressed during countdown, the abort sequence is initiated, the indicators in the abort panel are enabled to illuminate.

The following discussion is for "Missile Not Away".

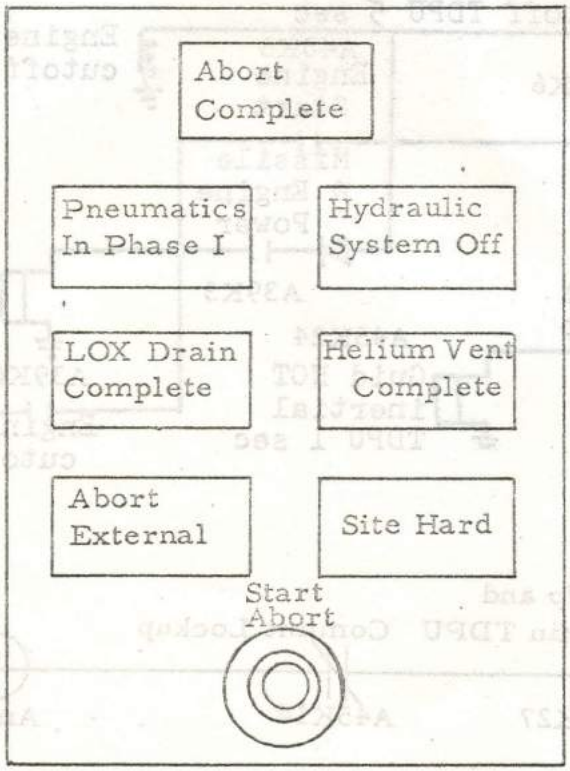


Figure 76 - Abort Panel

The start abort signal (Figure 77) causes: the AMF system to begin lowering the launcher platform, the inverter to shutoff, the power change-over switch to go back to "external".

"Site Hard" (Figure 78) illuminates amber when the L/P has started to lower (if it was not down and locked). It illuminates green when the launcher platform is down and locked, doors fully closed and crib locks retracted.

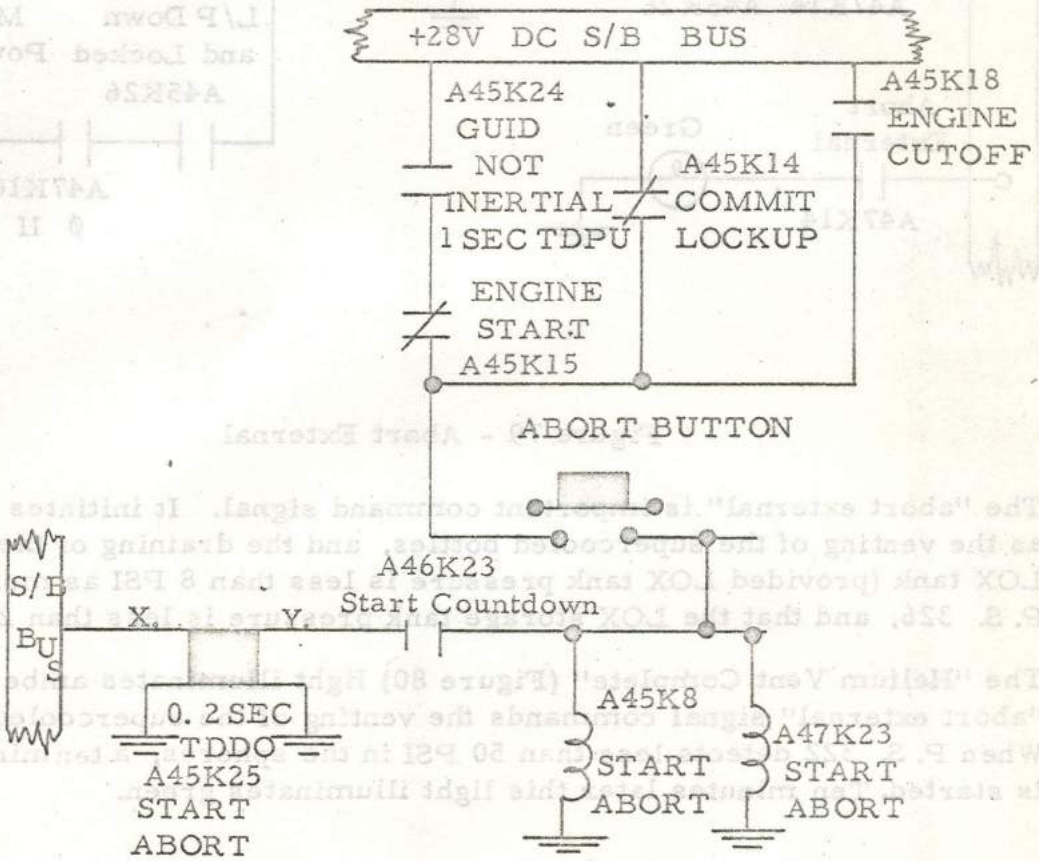


Figure 77 - Start Abort

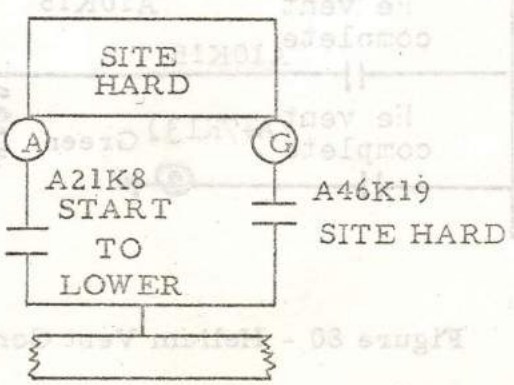


Figure 78 - Site Hard

"ABORT EXTERNAL" (Figure 79) light illuminates amber when the launcher platform is down and locked, and illuminates green when pneumatics is returned to phase II, the L/P is down and locked, and missile electrical power is external.

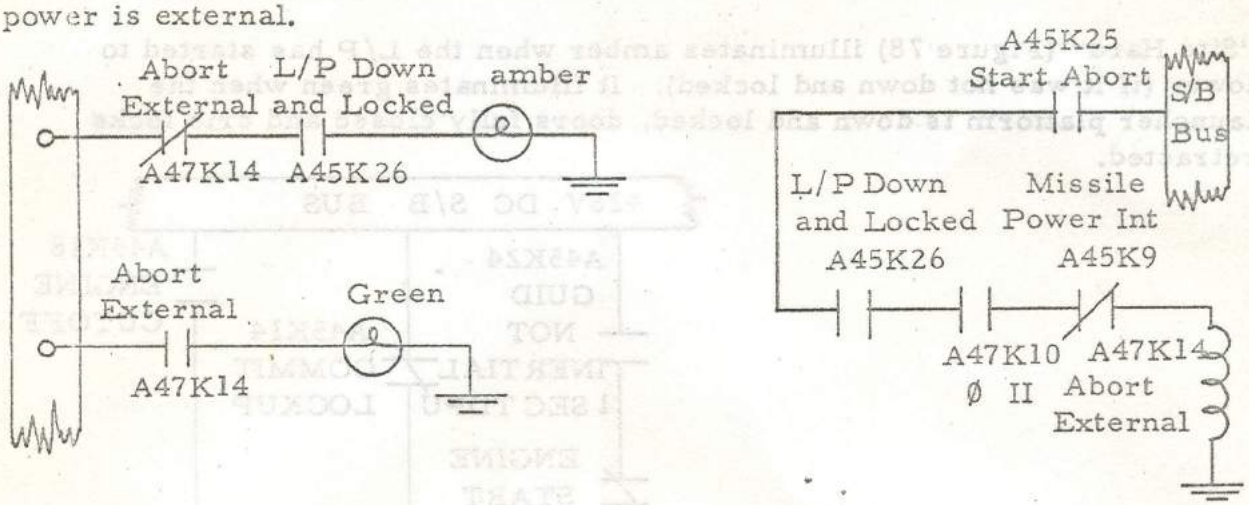


Figure 79 - Abort External

The "abort external" is important command signal. It initiates such events as the venting of the supercooled bottles, and the draining of the missile LOX tank (provided LOX tank pressure is less than 8 PSI as monitored by P. S. 326, and that the LOX storage tank pressure is less than 25 PSI).

The "Helium Vent Complete" (Figure 80) light illuminates amber when the "abort external" signal commands the venting of the supercooled bottles. When P. S. 322 detects less than 50 PSI in the spheres, a tenminute timer is started. Ten minutes later this light illuminates green.

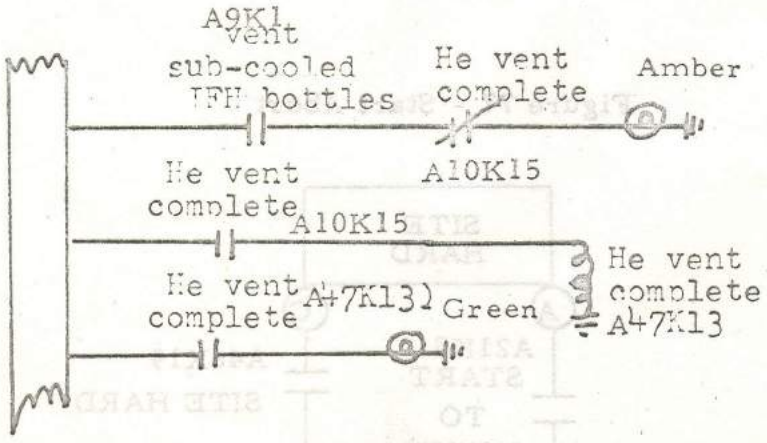


Figure 80 - Helium Vent Complete

The "LOX Drain Complete" (Figure 81) light illuminates amber when valve L-16 is initially opened. It illuminates green 1500 seconds later, signifying drain complete.

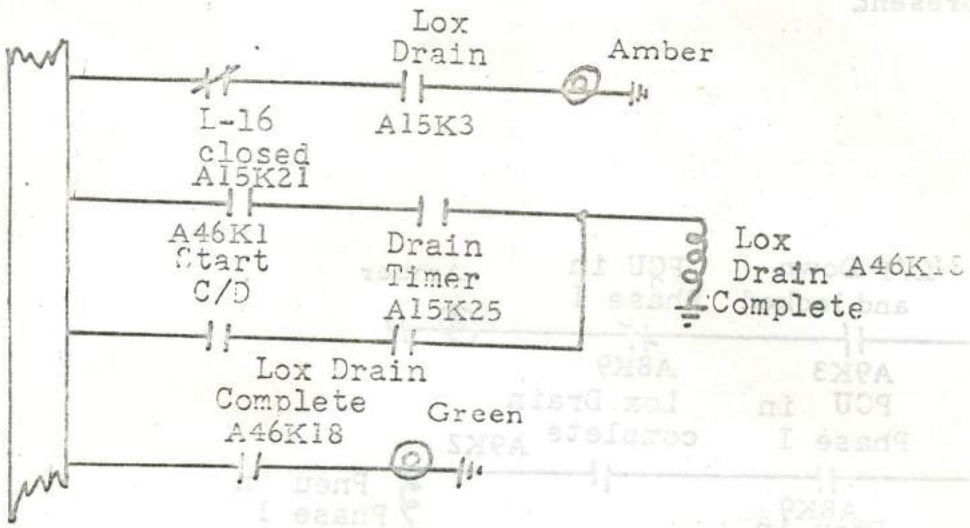


Figure 81 - LOX Drain Complete

+/1260 sec

When LOX drain is complete (1500 SEC), the signal "LOX drain complete" shuts off the HPU, and commands the return to phase I. (45MIN)

The "Hydraulics System Off" (Figure 82) light illuminates amber when LOX drain is complete. The HPU is turned off, and when pressure decays to less than 1750 PSI, it illuminates green. Time from amber to green is about 4 to 5 seconds.

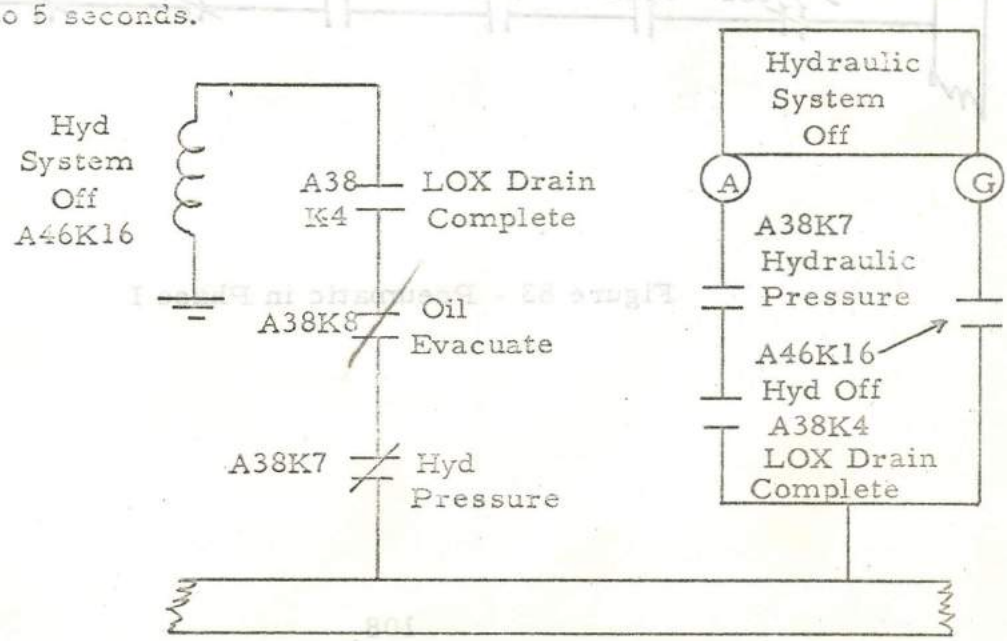


Figure 82 - Hydraulic System Off

The "Pneumatics in phase I" (Figure 83) light illuminates amber at when the L/P is down and locked. It illuminates green when phase I pressures are present.

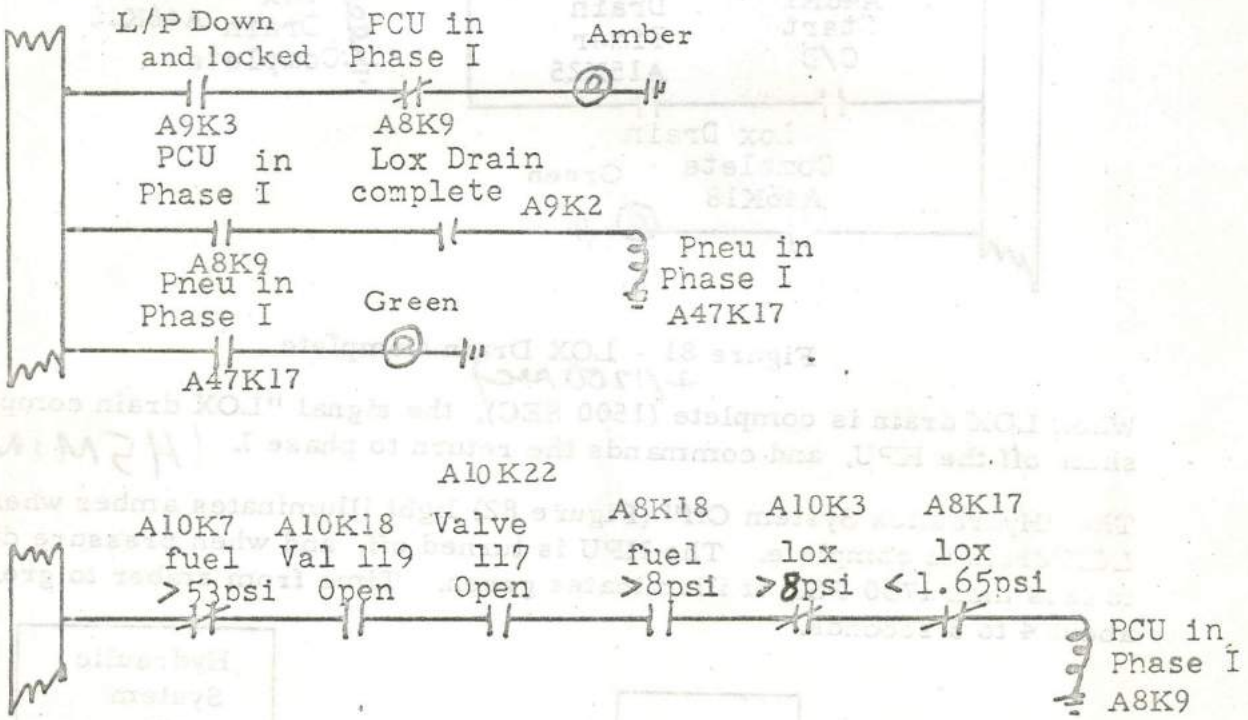


Figure 83 - Pneumatic in Phase I

The "ABORT COMPLETE" (Figure 84) light illuminates amber at the start of the abort sequence, and green when the abort is complete (not in countdown, not ready to start countdown). Not in countdown indicates the start countdown relays de-energized during the abort sequence. Four conditions would cause this: hydraulics off, LOX drain complete, Helium vent complete, pneumatics in Phase I.

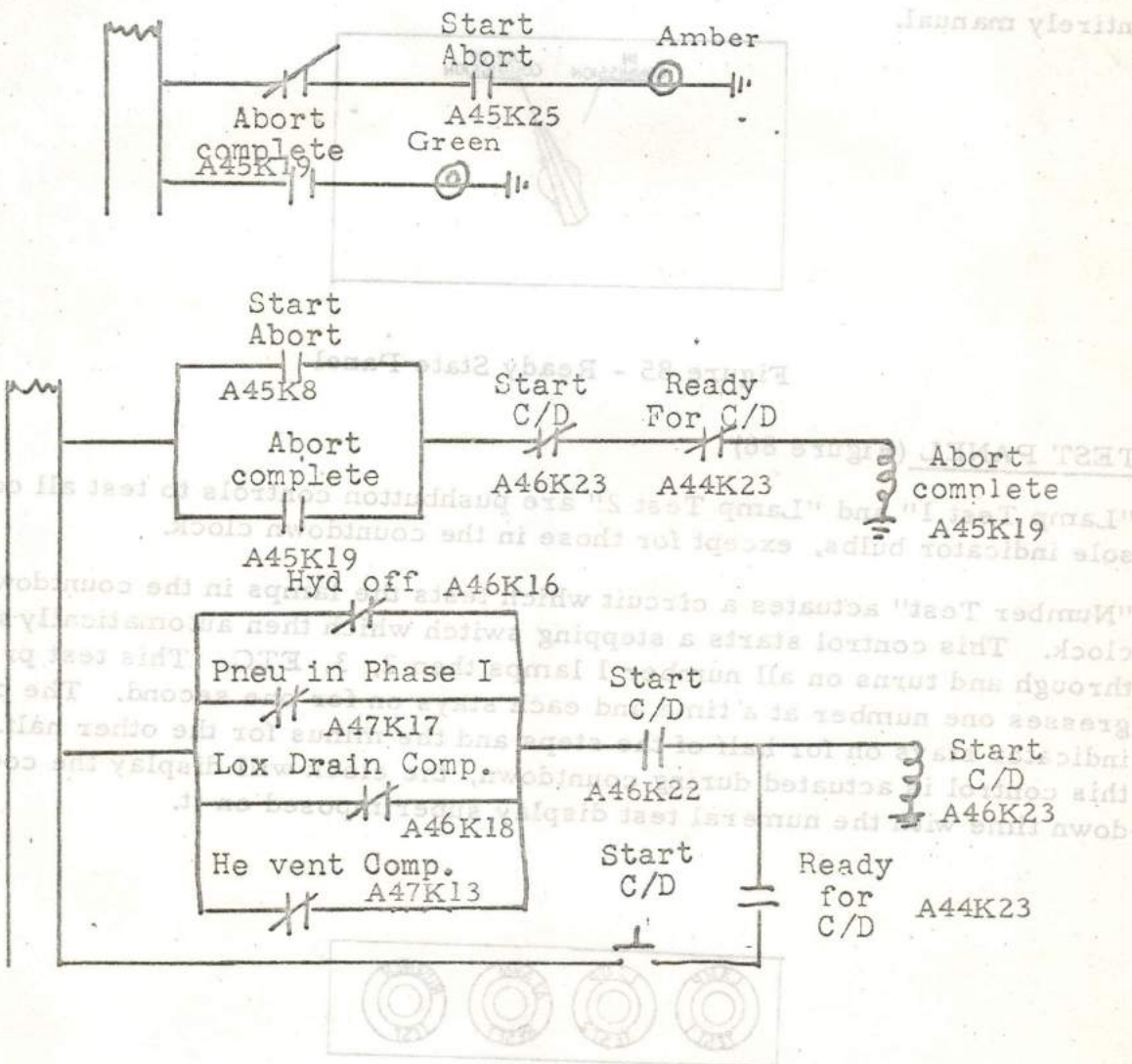


Figure 84 - Abort Complete

READY STATE PANEL (Figure 85)

This panel is at the lower left corner of the console, consists of a switch which sends a signal to the Squadron Command indicating the "readiness to launch" status of the complex. The signal controls indicators on a display panel at that location.

The signal "In Commission" means that the complex is ready at any time to go into countdown. "Out of Commission" means that the site is incapable of completing a countdown at this time.

The setting of the selector in this panel is done by the launch operator and is based on his knowledge of the complex's condition. The process is entirely manual.

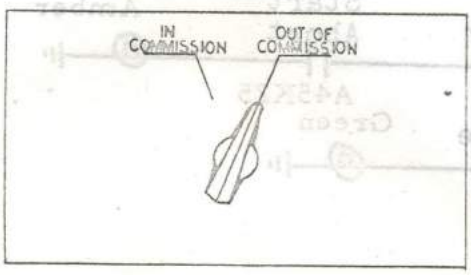


Figure 85 - Ready State Panel

TEST PANEL (Figure 86)

"Lamp Test 1" and "Lamp Test 2" are pushbutton controls to test all console indicator bulbs, except for those in the countdown clock.

"Number Test" actuates a circuit which tests the lamps in the countdown clock. This control starts a stepping switch which then automatically steps through and turns on all number 1 lamps then 2, 3, ETC. This test progresses one number at a time and each stays on for one second. The plus indicator stays on for half of the steps and the minus for the other half. If this control is actuated during countdown, the clock will display the countdown time with the numeral test display superimposed on it.

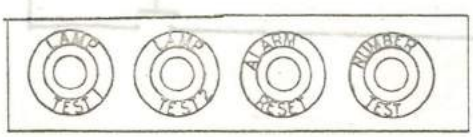


Figure 86 - Test Panel

The "Alarm Reset" control silences the console alarm after it is turned on. However, the indicator displaying the malfunction will remain on until the malfunction has been corrected. The alarm will sound for a malfunction in the power and sensing panel, a red "pressure mode" light in the gage pressure panel, a red light in the standby status panel, or a red abort light in the commit panel.

COMMUNICATIONS SYSTEM PANEL (Figure 87)

The communications system panel is the large horizontal area at the bottom center of the console. This group provides the various communications required by the Launch Control Officer.

PANEL	FUNCTION
OPS	Squadron operations - the duty officer for the Squadron Commander
AOPS	Alternate Squadron Operations - an alternate operations officer located in one of the complexes.
JC	Maintenance Job Control - the central maintenance control at the Squadron Maintenance Area (SMA).
CSC	Central Security Control - a central control point to insure the security of the various parts of the squadron - located at the SMA.
GH	Gatehouse - the personnel and vehicle entry point to the particular missile launch complex.
DIAL 1 DIAL 2	These are the two conventional dial lines available at the console.
APCHE	Automatic Programmed Checkout Equipment - this is a direct line within the complex connecting to the mobile checkout trailer when it is present.

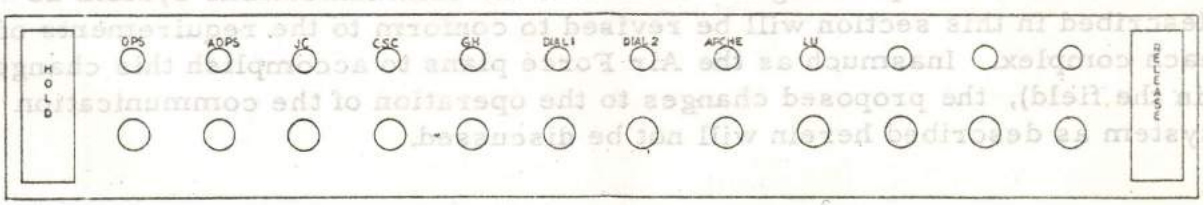


Figure 87 - Communications System Panel

LU — Logic Units - This is a direct line to a group of three communications panels located beside the various Logic Units, Launch Signal Responders, and inertial guidance and re-entry vehicle ground electrical control units.

The last two channels are intended to support the rapid information required to bring a site to a tactical configuration if checkout is in progress when an alert occurs.

Twelve illuminated line selector pushbuttons are located across the bottom portion of this panel. The same number of telephone type indicator lamps are situated immediately above these pushbuttons. The two end controls "Hold" and "Release" are bar knob pushbutton switches. The remainder of the associated communications circuits are located elsewhere in the console; the dial is in the right leg, the headset jacks (two sets) are in the left leg.

The operation of these controls is as follows: Assume that the console operator desires to dial a number, he presses the line selector pushbutton for "Dial 1". The pushbutton is a momentary control and, as such, returns to its normal position on being released, however, the button illuminates indicating the line is selected. The operator then proceeds to dial his number and conduct his conversation. Now assume that a call comes in from "GH" during this conversation, the line selector for "GH" flashes and the ringer sounds. The operator desires to retain his "Dial 1" connection while answering "GH" so he presses the "Hold" control at the left end of the panel. The "Dial 1" call is thereby placed on hold and the upper hold indicator illuminates and the line selector light turns off. The operator then presses the "GH" line selector pushbutton and it becomes steadily illuminated indicating that it is now selected. He conducts his conversation then "hangs up" by pressing the "Release" control at the right end of the panel. The "GH" selector pushbutton light turns off showing that the line has been released. The operator then returns to "Dial 1" by pressing that line selector, which again becomes illuminated while the hold light turns off. On completing his call he again "hangs up" by pressing the release control. This causes the "Dial 1" selector light to turn off.

Present Air Force planning indicates that the communications system as described in this section will be revised to conform to the requirements of each complex. Inasmuch as the Air Force plans to accomplish this change (in the field), the proposed changes to the operation of the communication system as described herein will not be discussed.

PUBLIC ADDRESS PANEL (Figure 88)

The public address panel is at the extreme lower right corner of the console. This panel consists of five illuminated pushbuttons of the same type used in the communications panel. The signals from this panel are handled by the communications system.

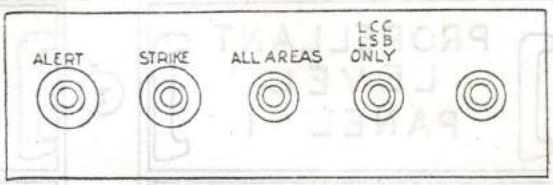


Figure 88 - Public Address Panel

The ALERT and STRIKE buttons put special tone signals on the PA system. The alert signal is used to signify that an alert situation exists and the complex should make ready for countdown, if not already in that condition. The strike signal is used to indicate that the complex is going into countdown immediately. The alert control is guarded by an open face cup that is yellow inside. The strike control has a similar cup colored red inside.

The ALL AREA control permits the operator to speak through all speakers on the PA system, both inside and outside of the buildings. The LCC/LSB control restricts the PA system to only those outlets inside the launch control center and silo. To speak over the PA system, the operator depresses the proper one of the two controls and speaks into his regular communications headset-mike while the control button is depressed.

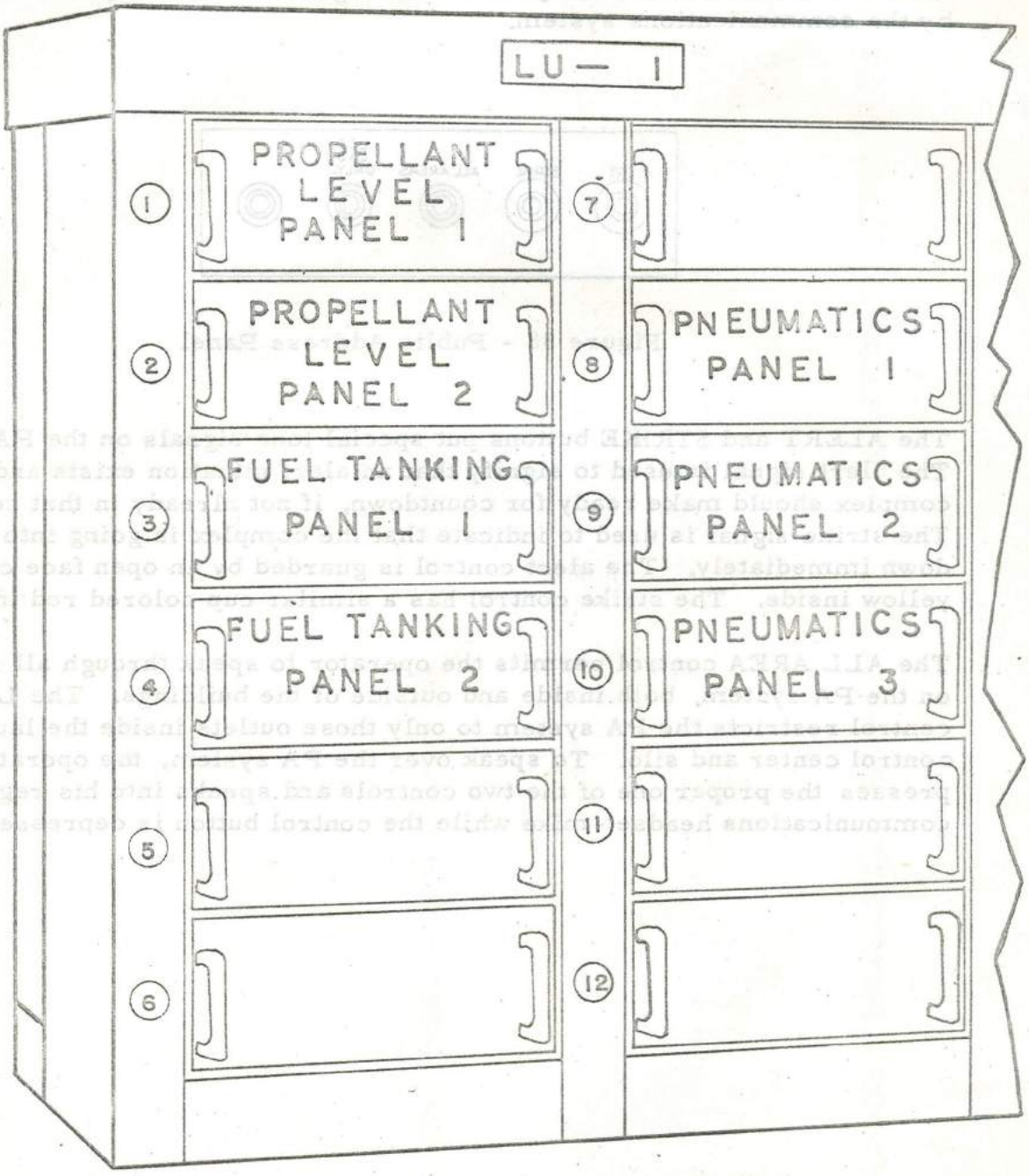


Figure 89 - Logic Unit-1 (Left Half)

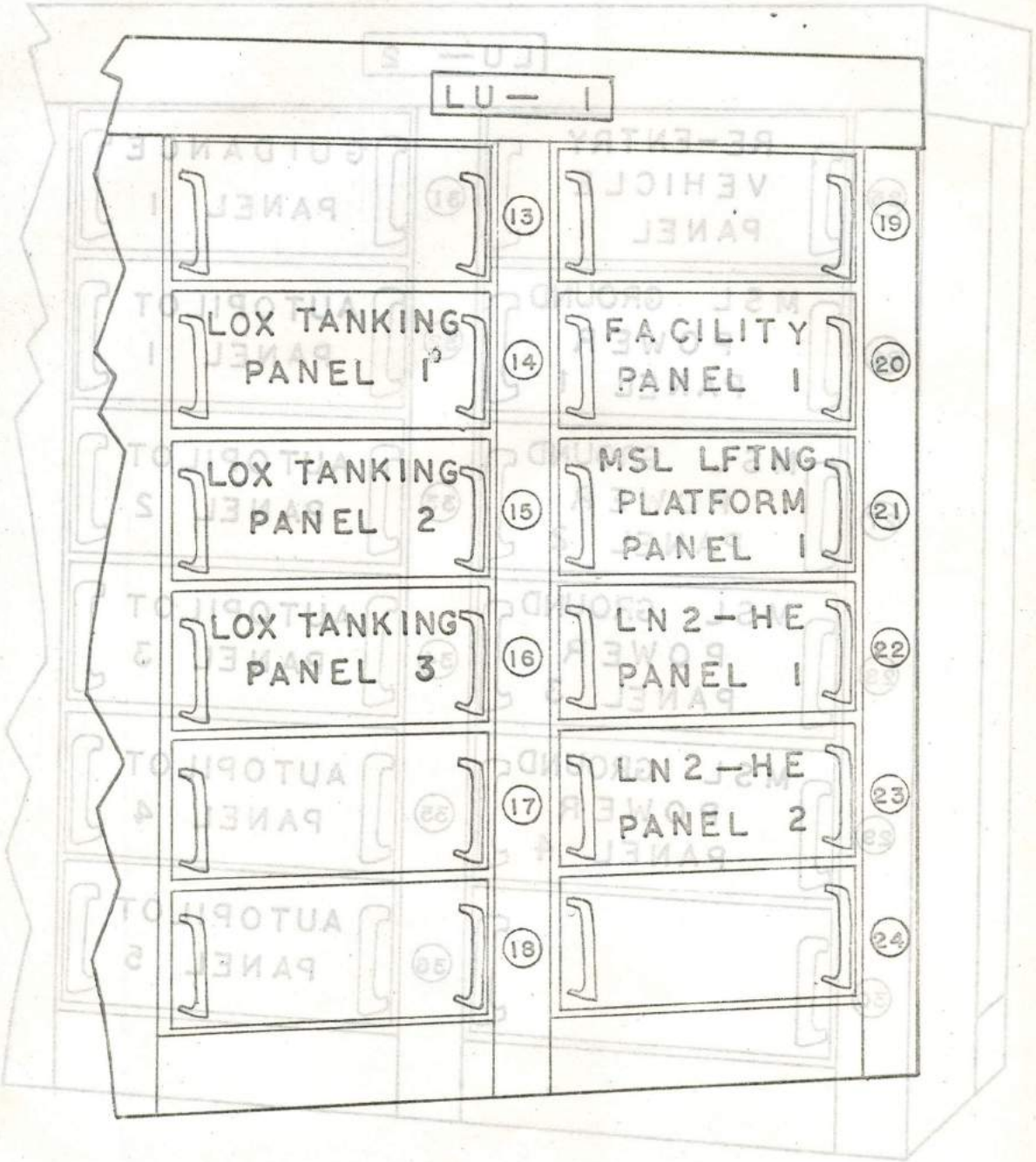


Figure 90 - Logic Unit-1 (Right Half)

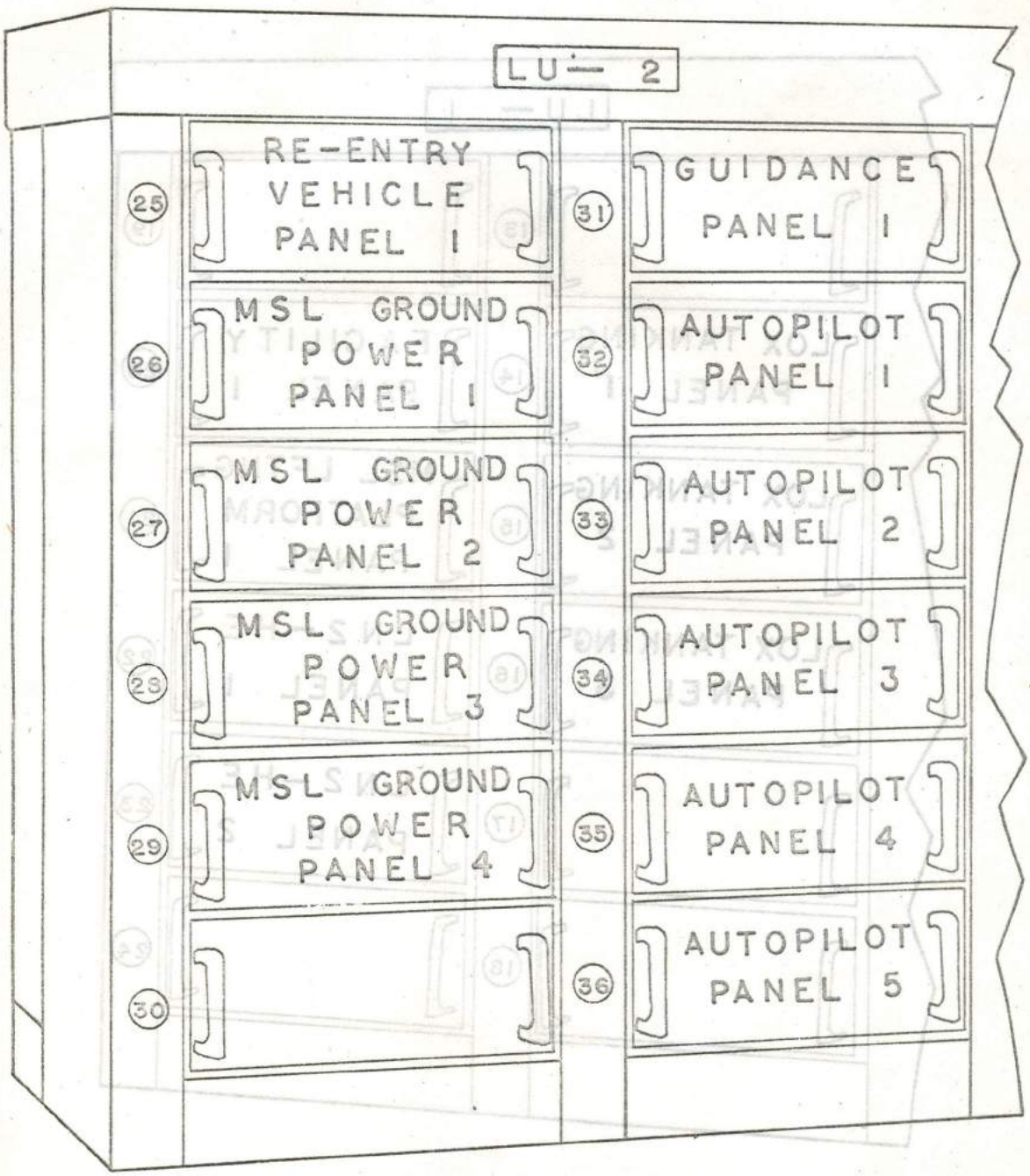


Figure 91 - Logic Unit-2 (Left Half)

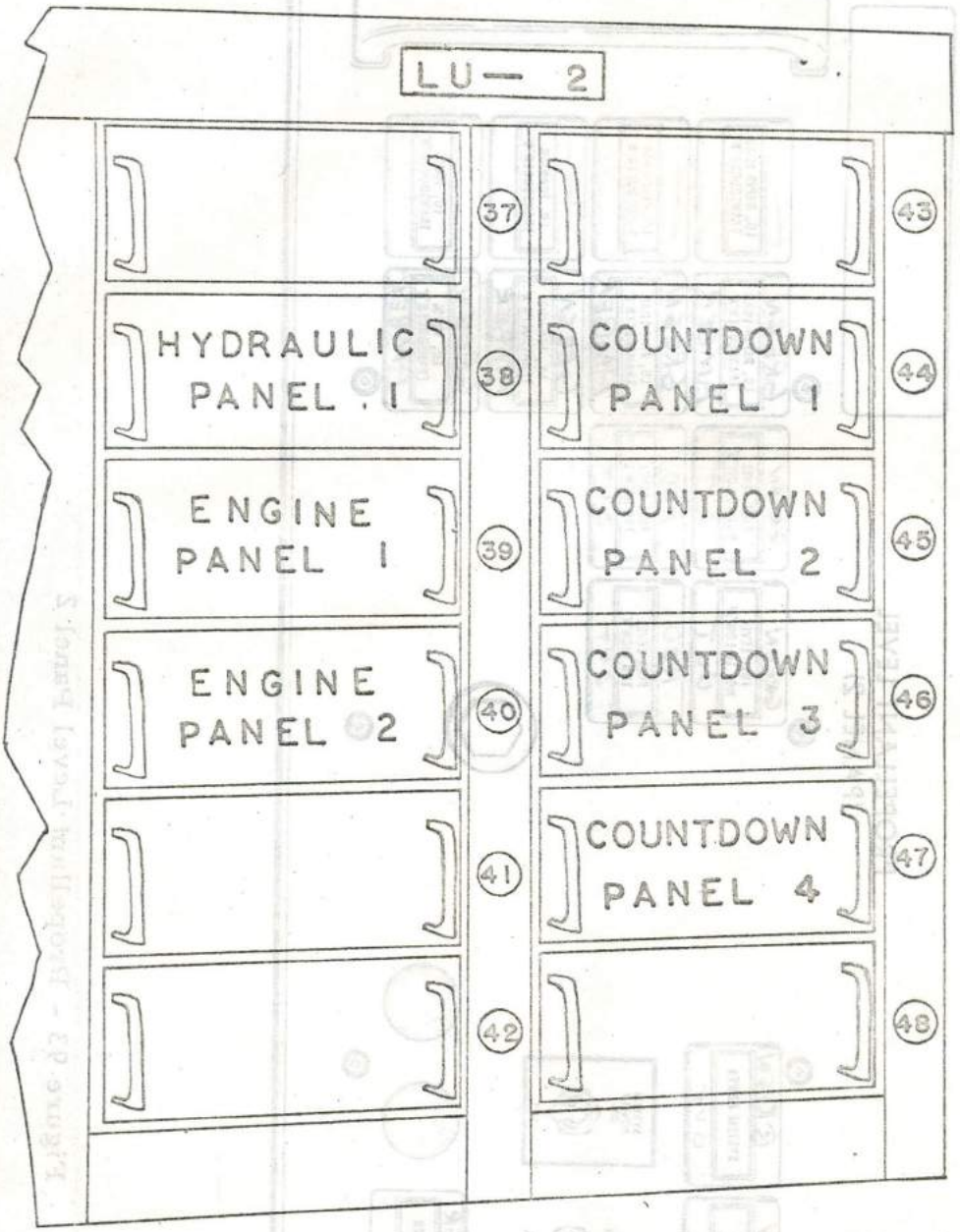


Figure 92 - Logic Unit-2 (Right Half)

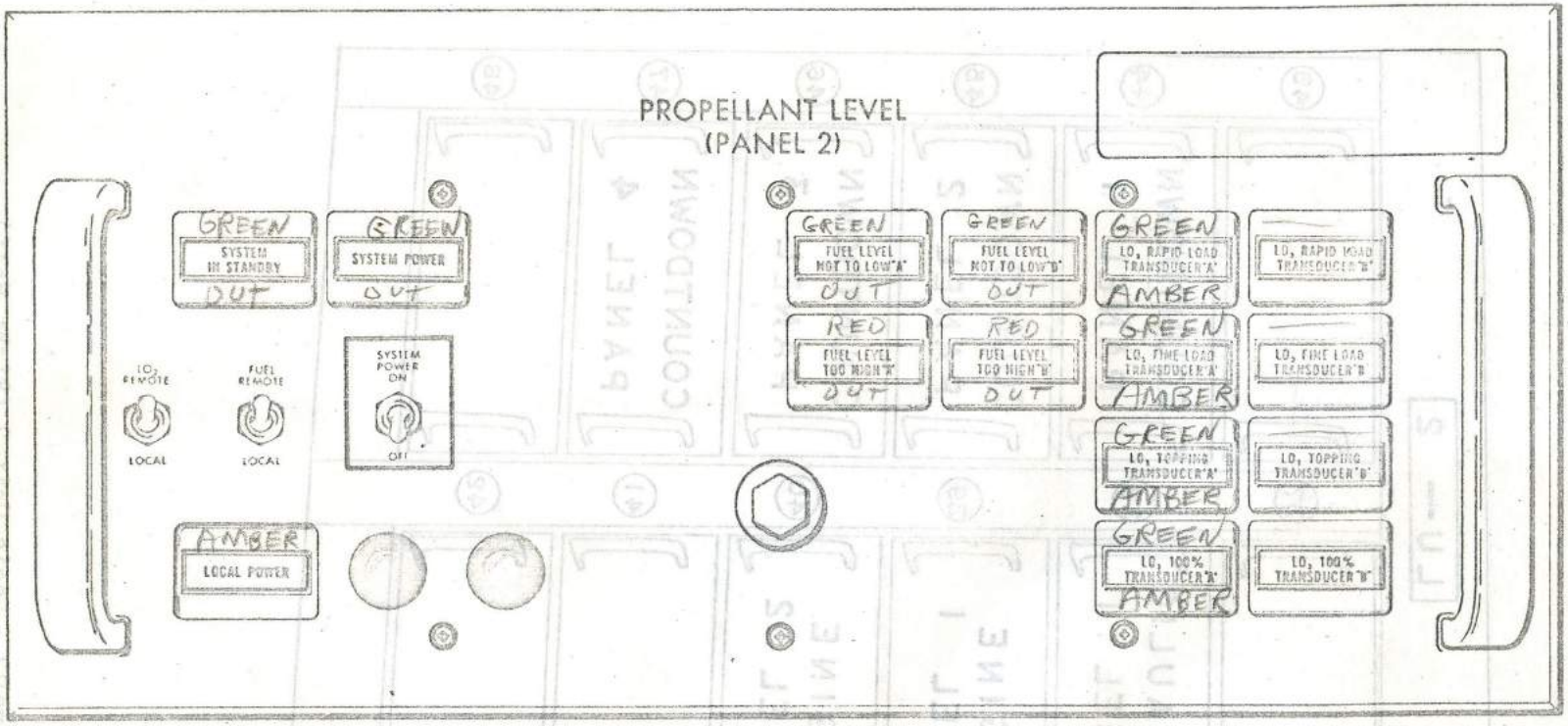


Figure 93 - Propellant Level Panel 2

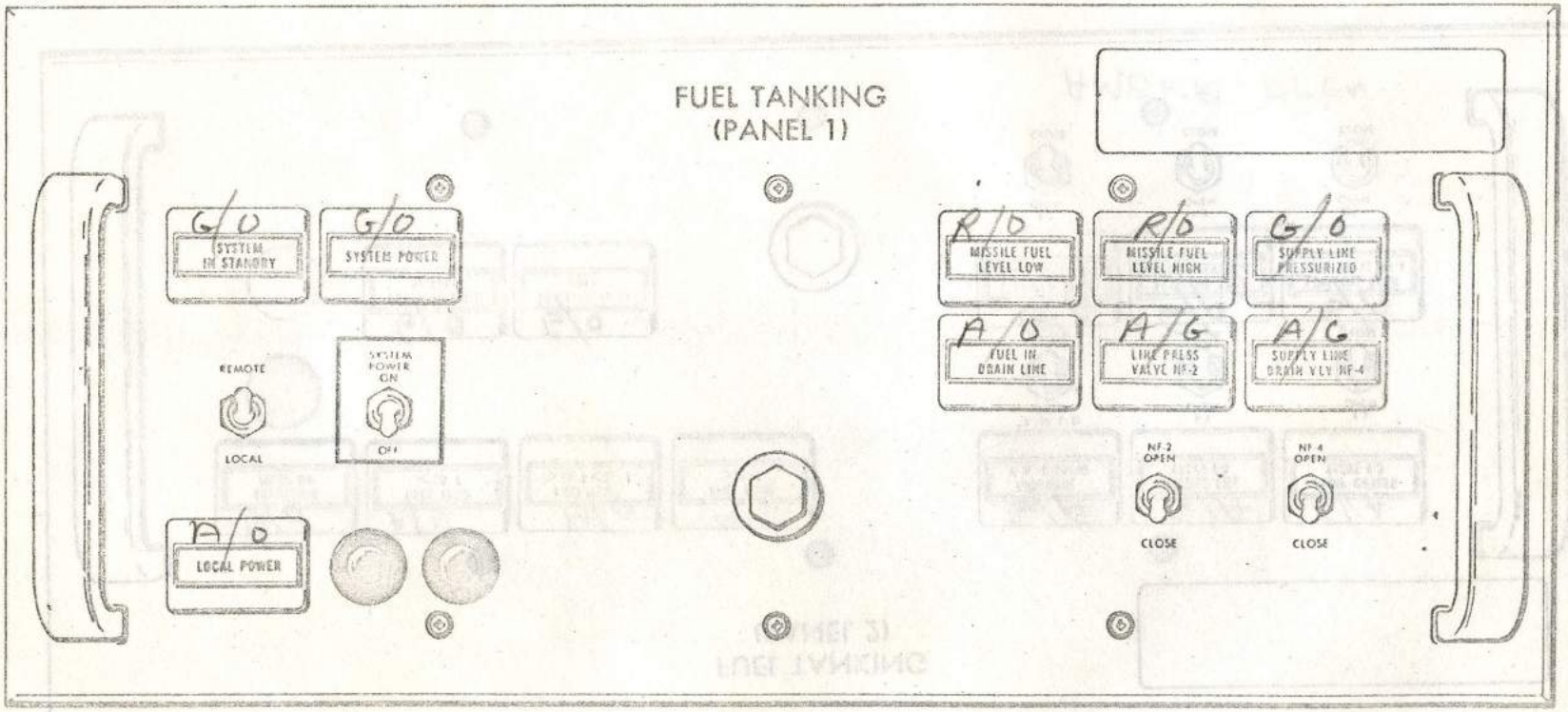


Figure 94 - Fuel Tanking Panel 1

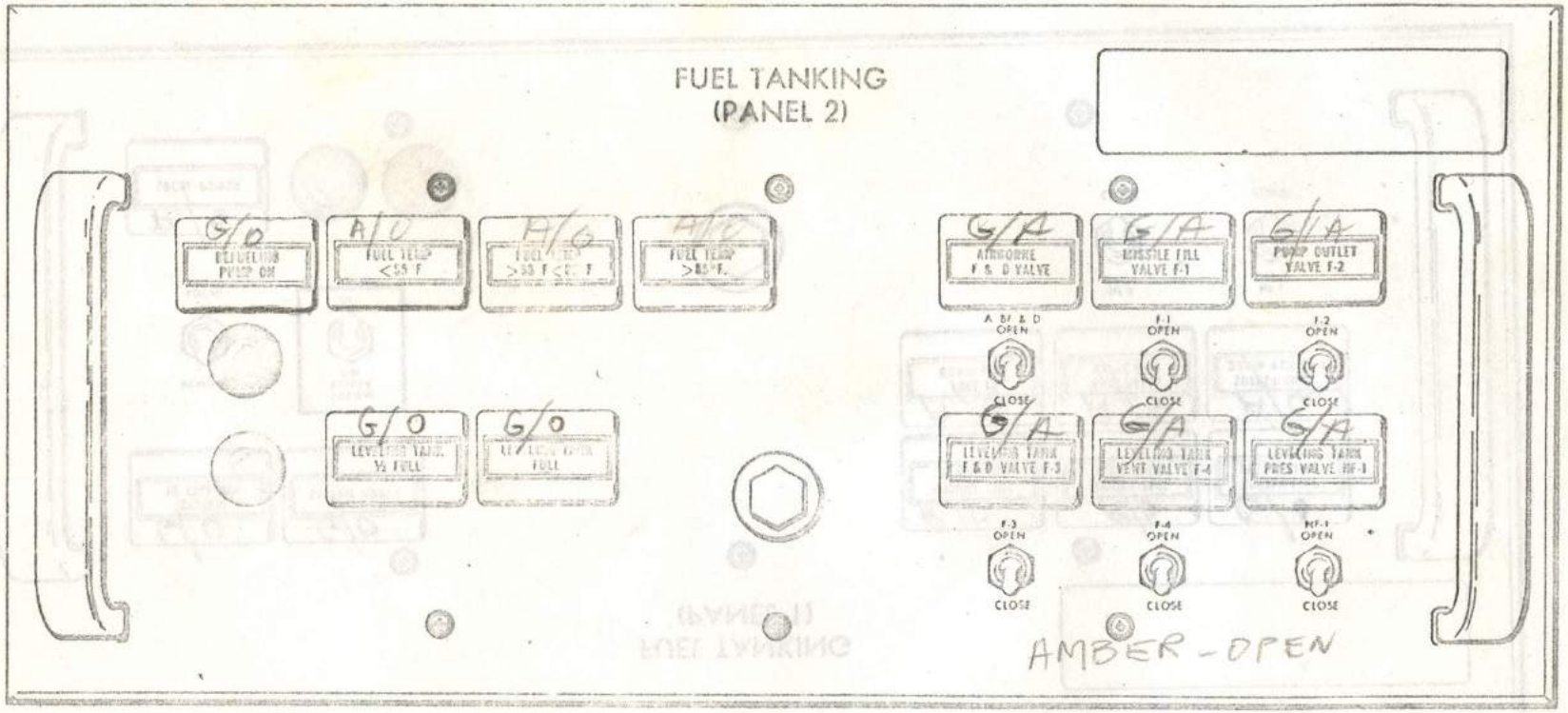
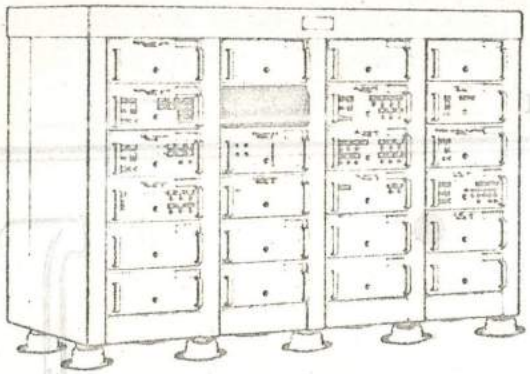


Figure 95 - Fuel Tanking Panel 2



RELAY LOGIC UNIT NO. 1

PNEUMATICS
(PANEL 1)

G/O
SYSTEM
IN STANDBY

G/O
SYSTEM POWER

SYSTEM
POWER
ON
OFF

STANDBY
STARTED

R/O
INSTRUMENT AIR
< 50 PSIG

R/O
HELIUM SUPPLY
< 1450 PSIG

R/O
LO2 LESS THAN
1.65 PSIG

R/O
EMERGENCY

G/O
BOIL OFF
VALVE CLOSED

G/O
AUTOMATIC
VALVES READY

R/O
FUEL BELOW
8 PSIG

G/O
PNEUMATICS
IN PHASE I

R/O
INT. REGULATORS
LOCK OUT

A/O
VENT AMBIENT
H.P.H. BOTTLES

Figure 96 - Pneumatics Panel 1

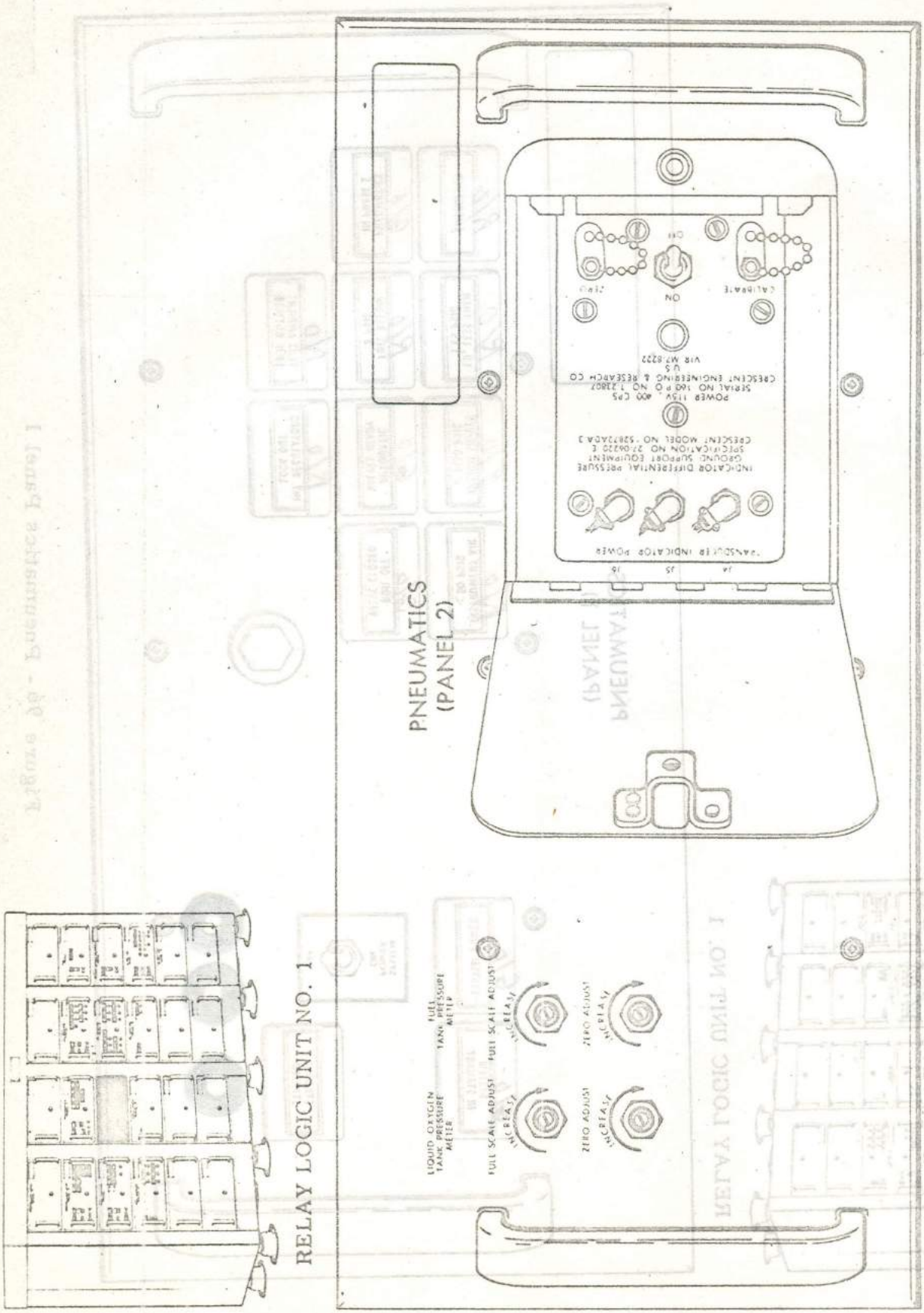


Figure 97 - Pneumatic Panel 2

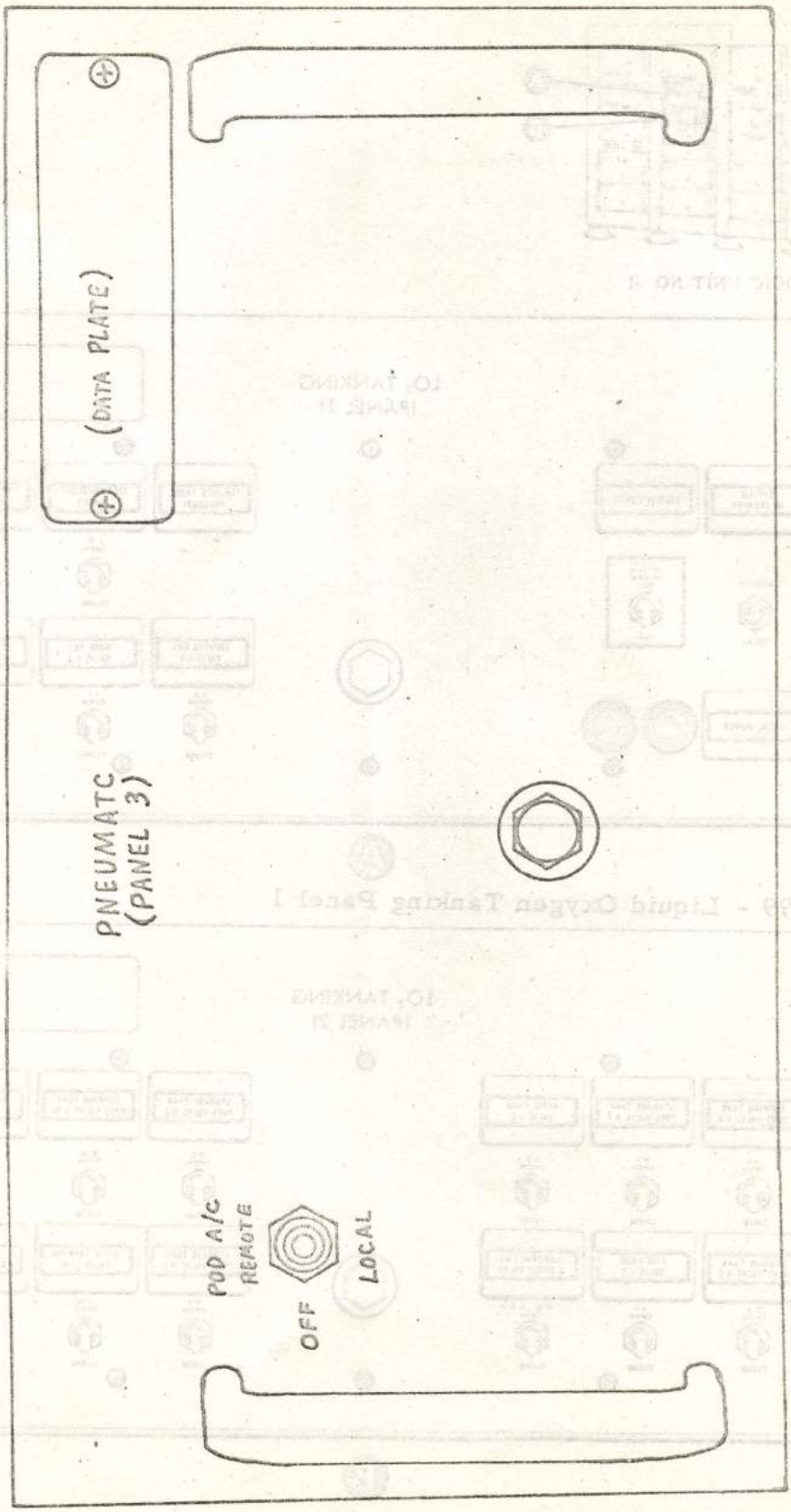
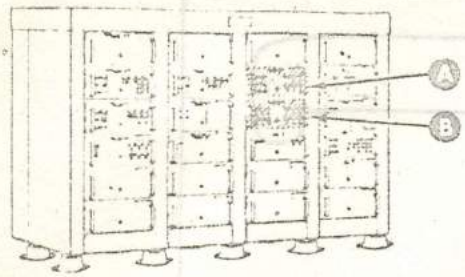


Figure 98 - Pneumatics Panel 3



RELAY LOGIC UNIT NO. 1

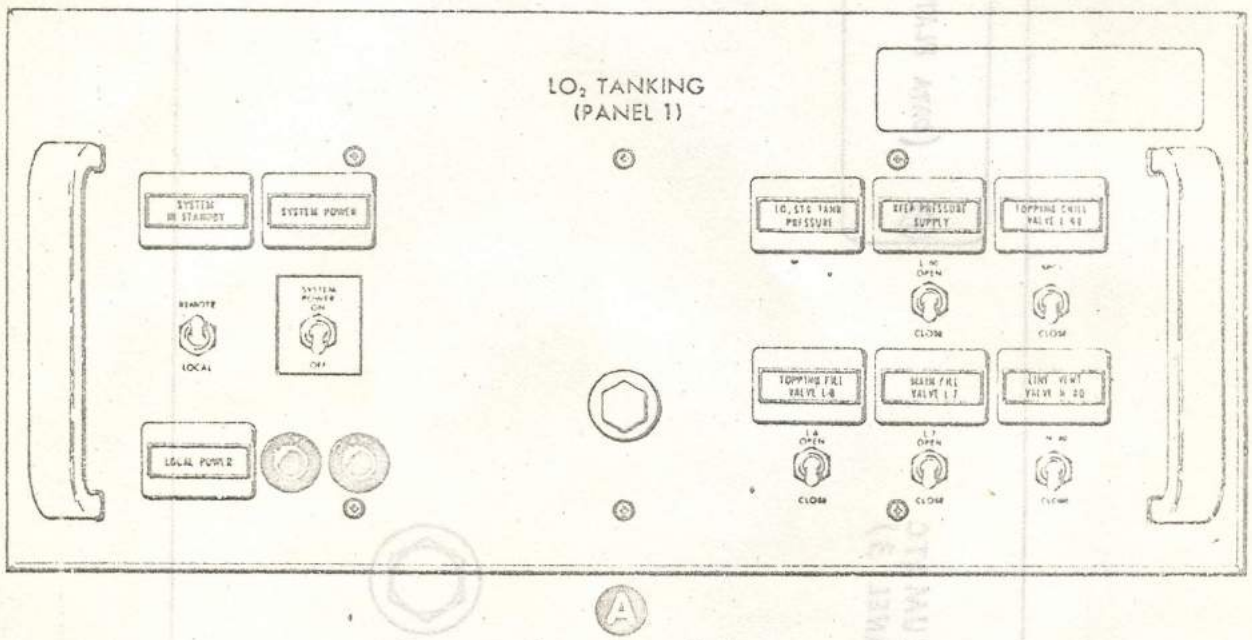


Figure 99 - Liquid Oxygen Tanking Panel 1

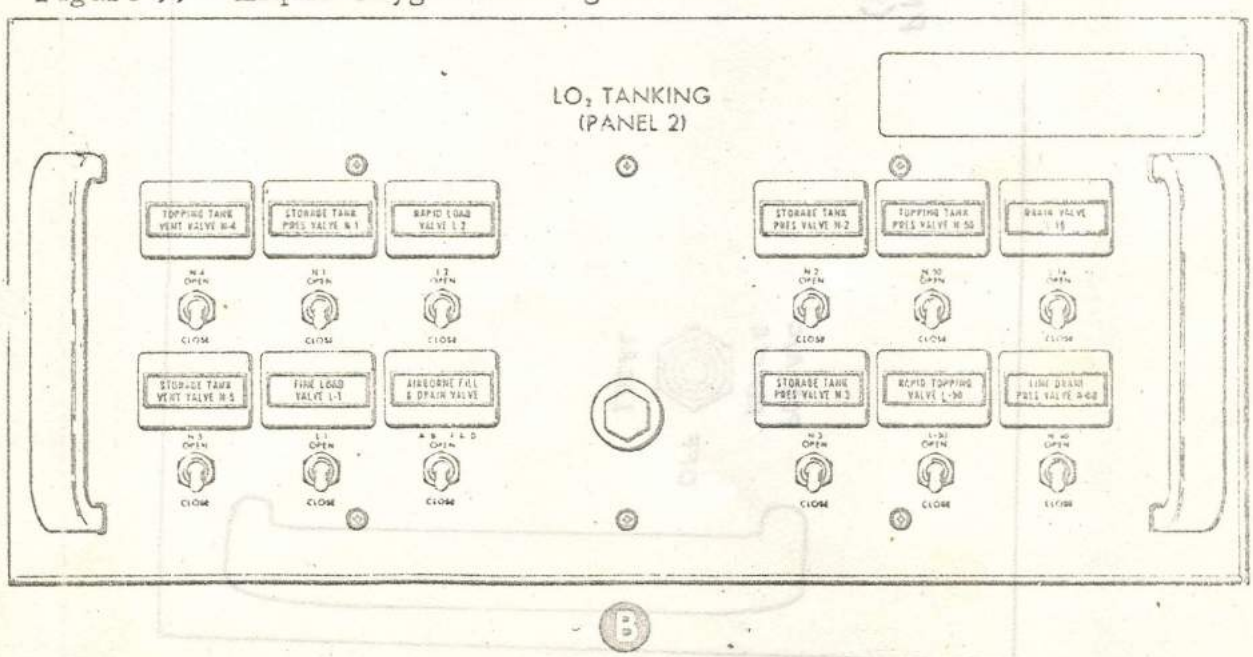
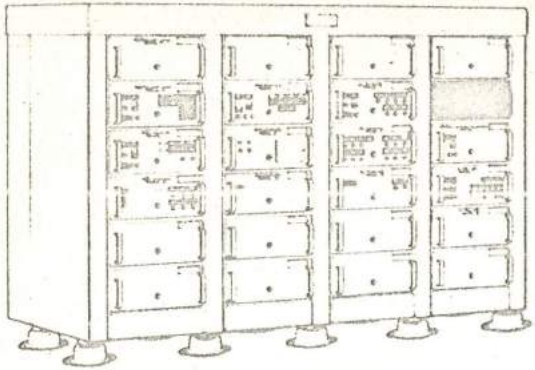


Figure 100 - Liquid Oxygen Tanking Panel 2



RELAY LOGIC UNIT NO. 1

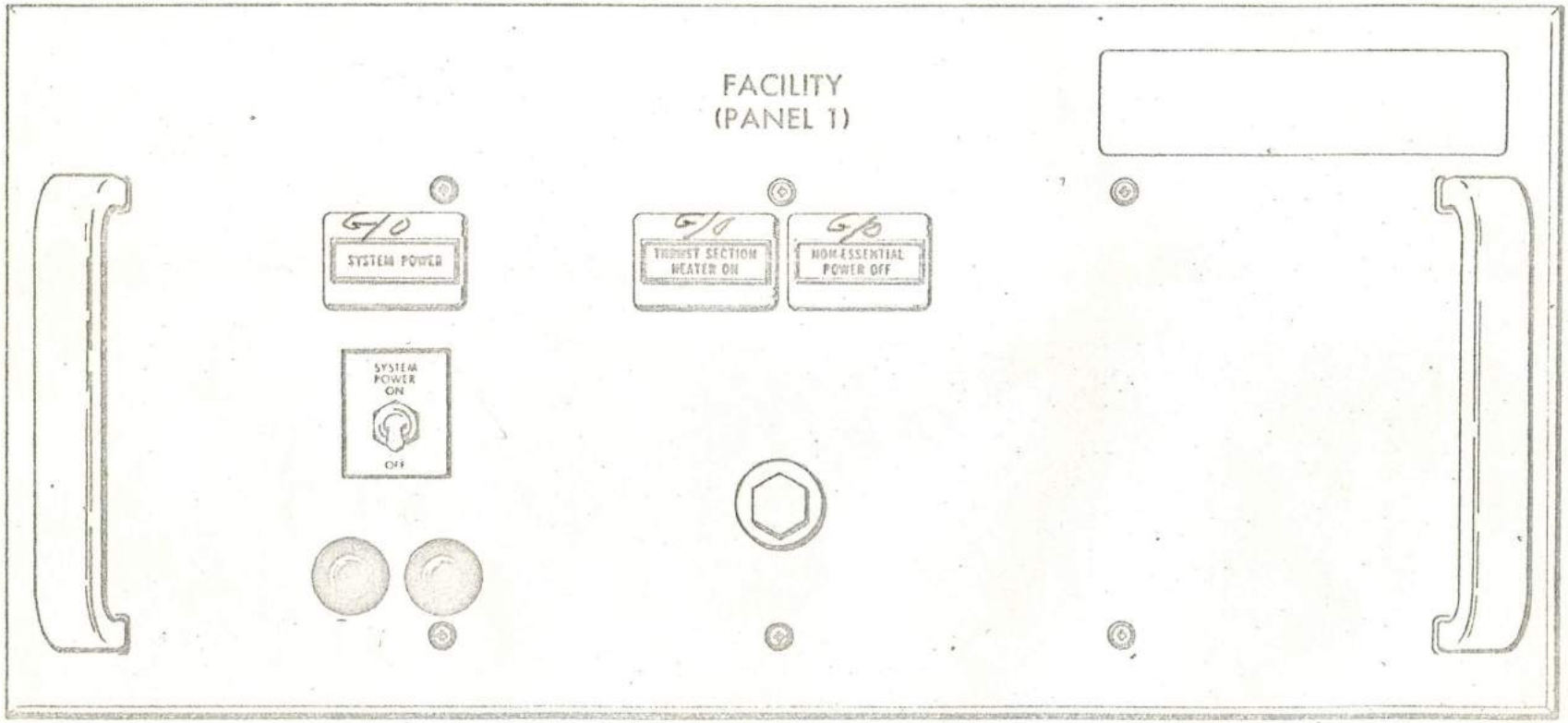


Figure 101 - Facility Panel 1

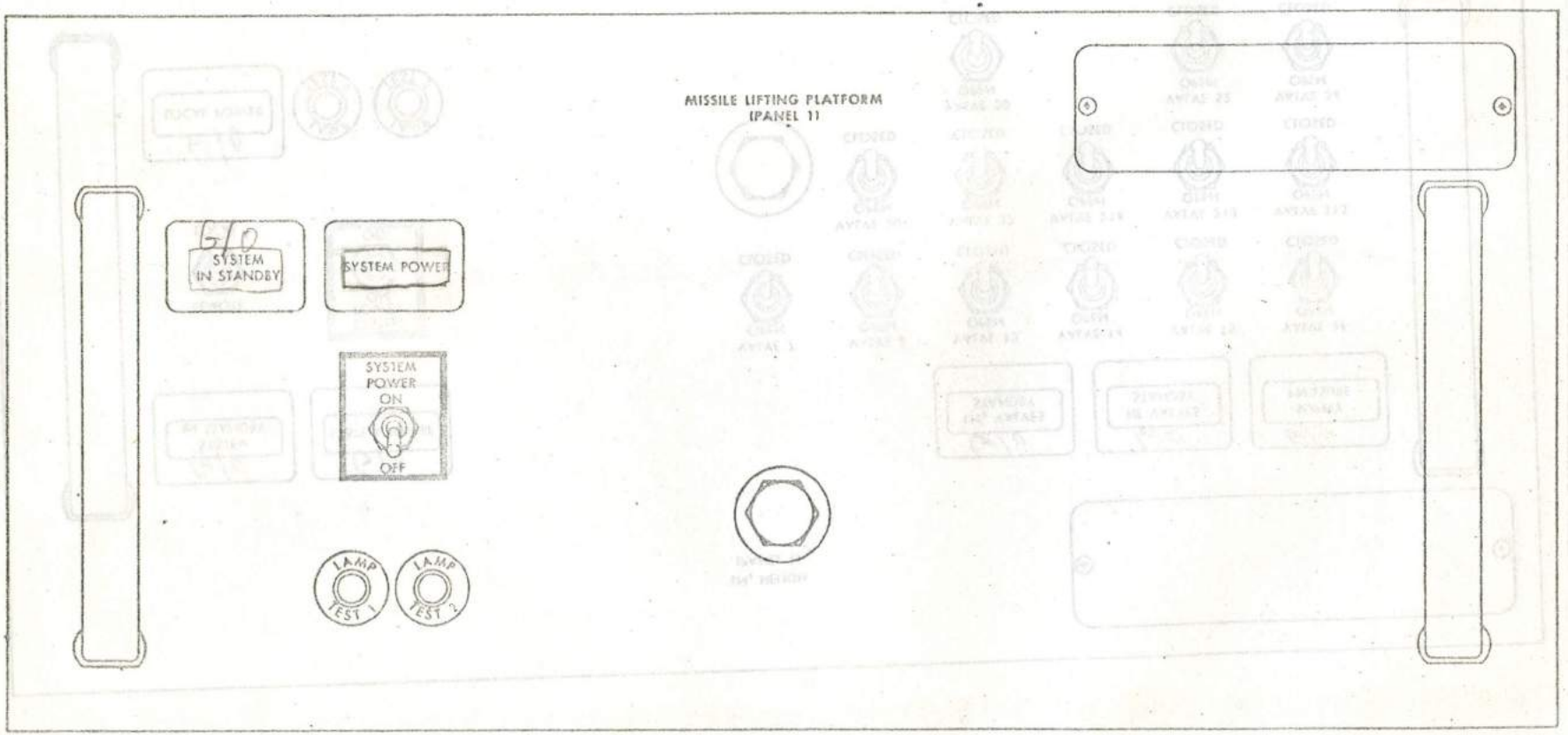


Figure 102- Missile Lifting Platform Panel 1

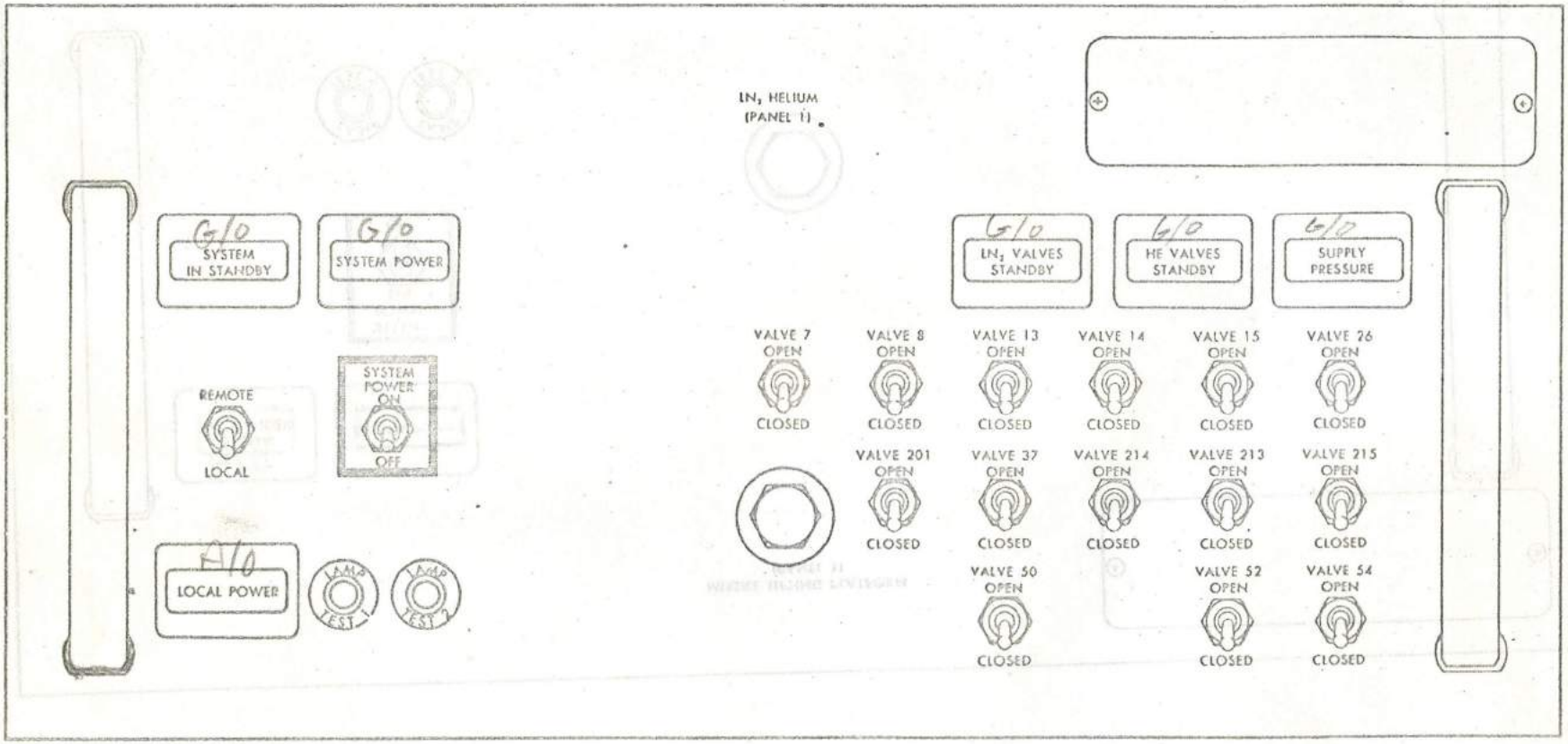


Figure 103- LN2/Helium Panel 1

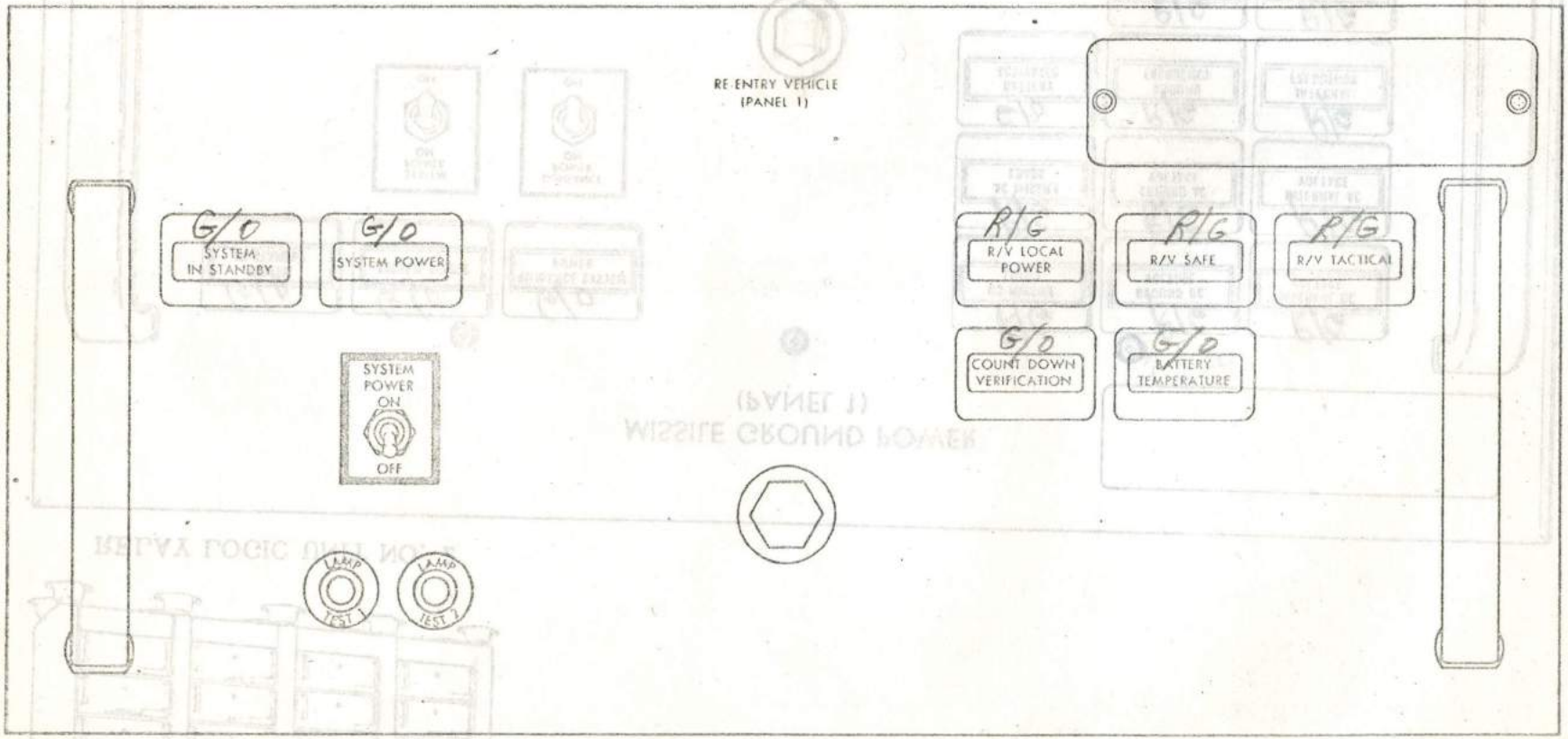
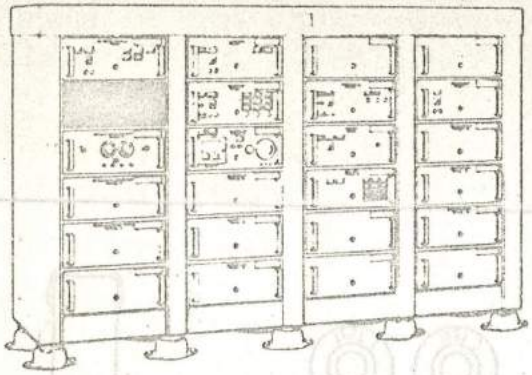


Figure 104 - Re-Entry Vehicle Panel 1



RELAY LOGIC UNIT NO. 2

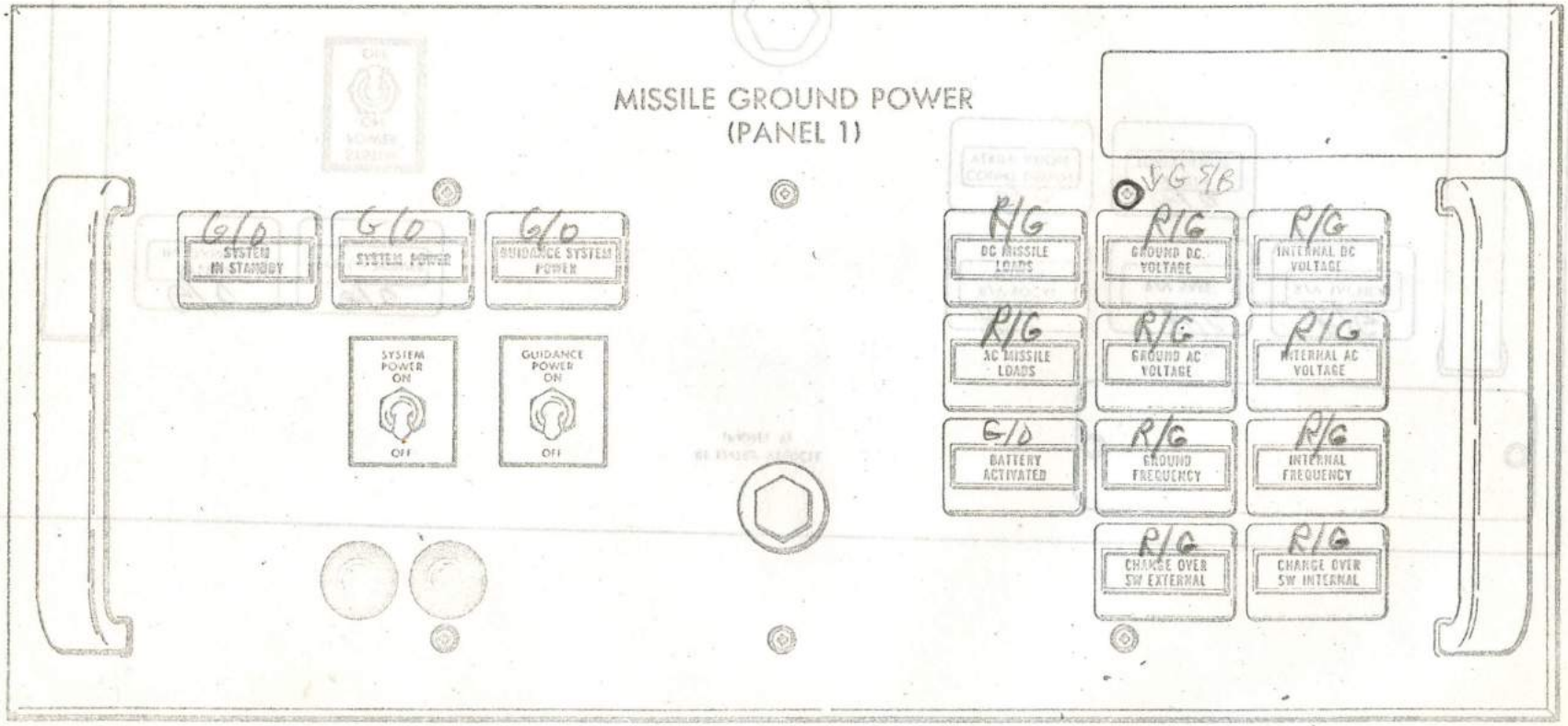
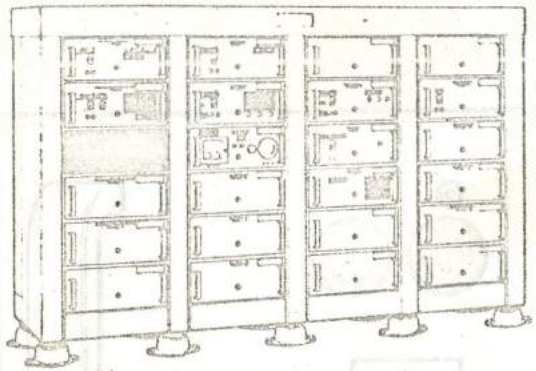


Figure 105- Missile Ground Power Panel 1



RELAY LOGIC UNIT NO. 2

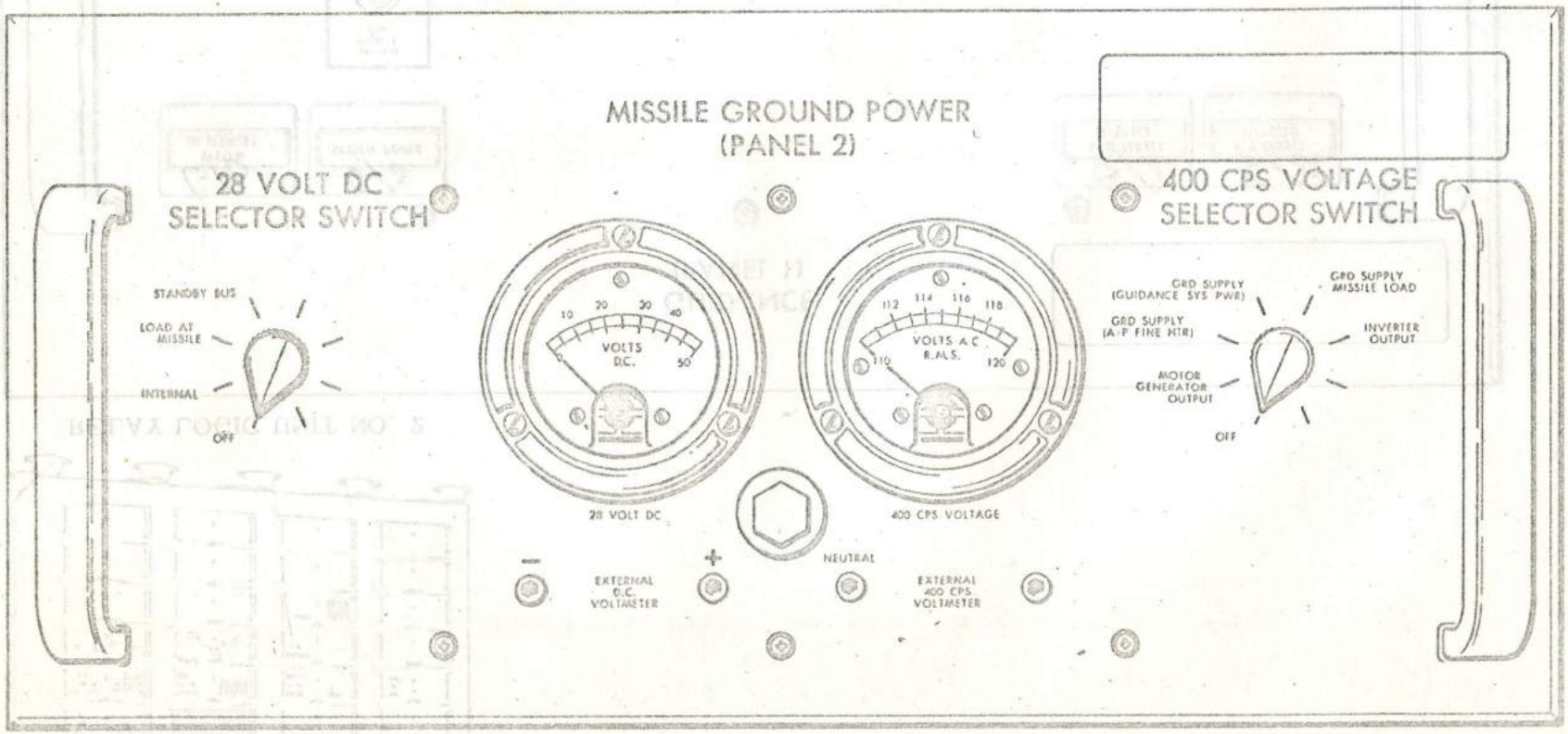
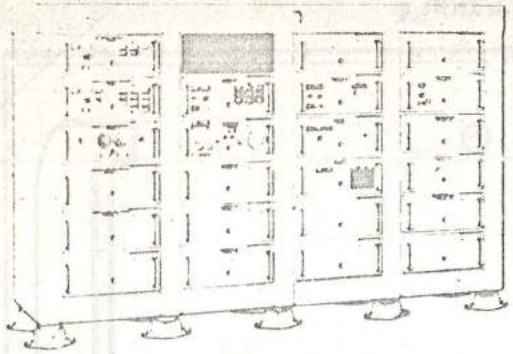


Figure 106- Missile Ground Power Panel 2



RELAY LOGIC UNIT NO. 2

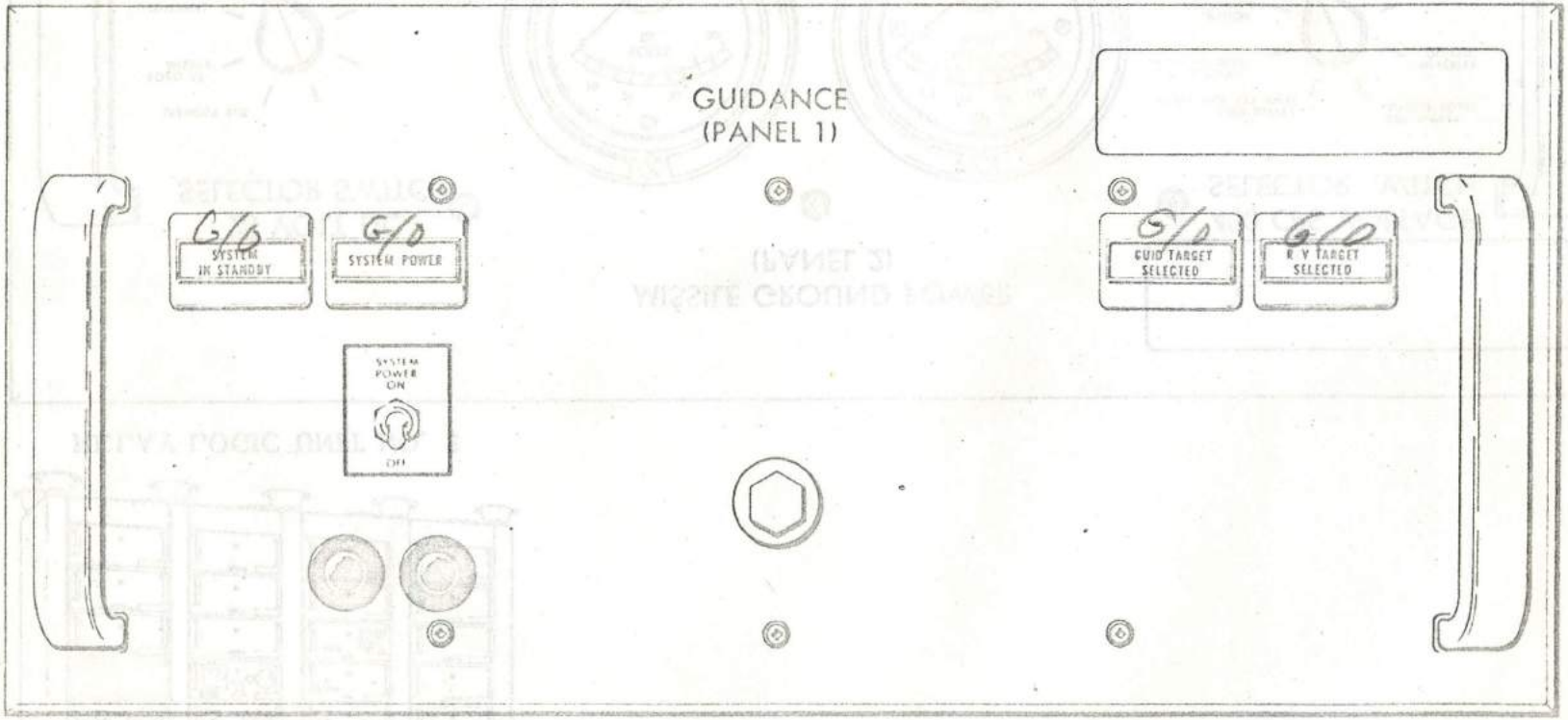


Figure 107- Guidance Panel 1

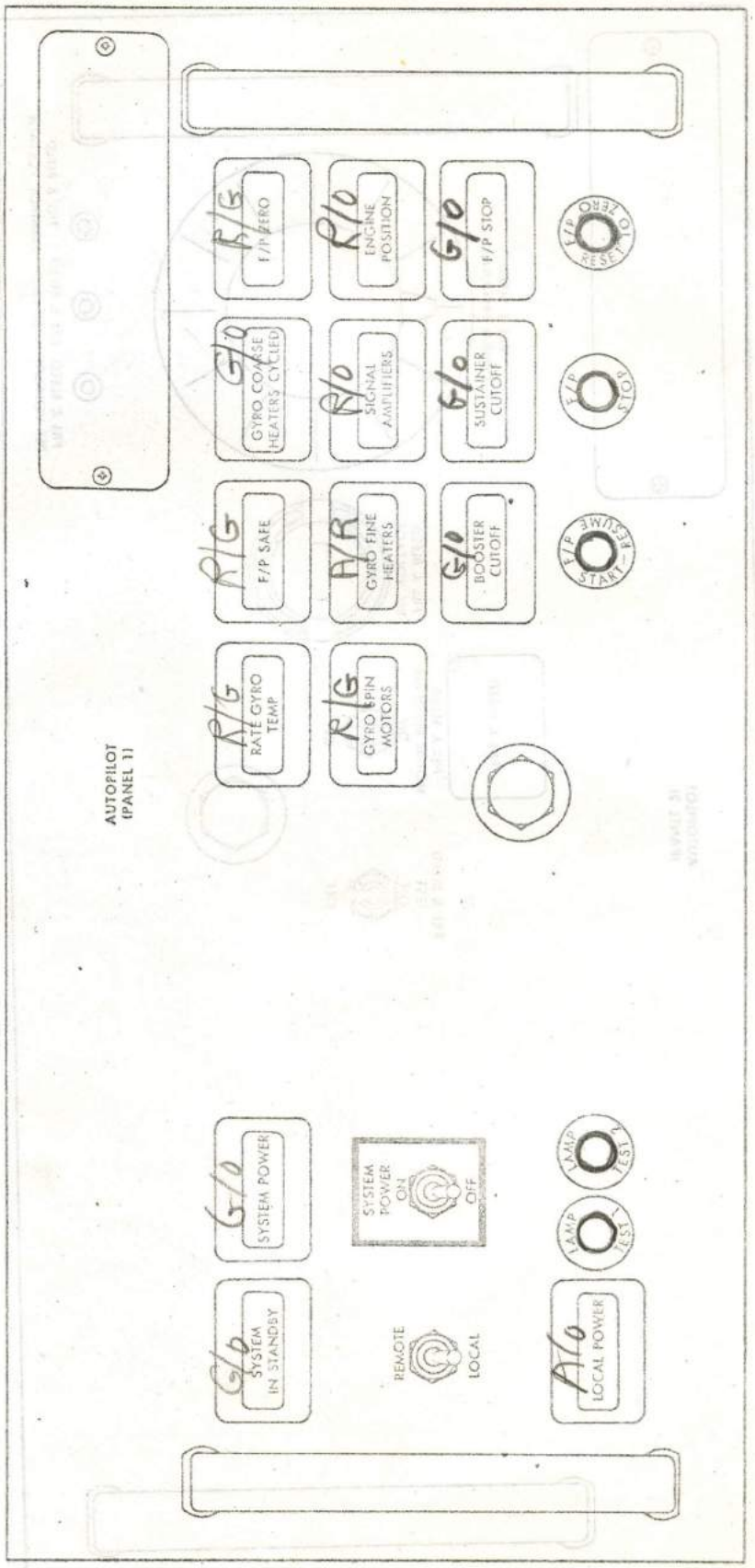


Figure 108- Autopilot Panel 1

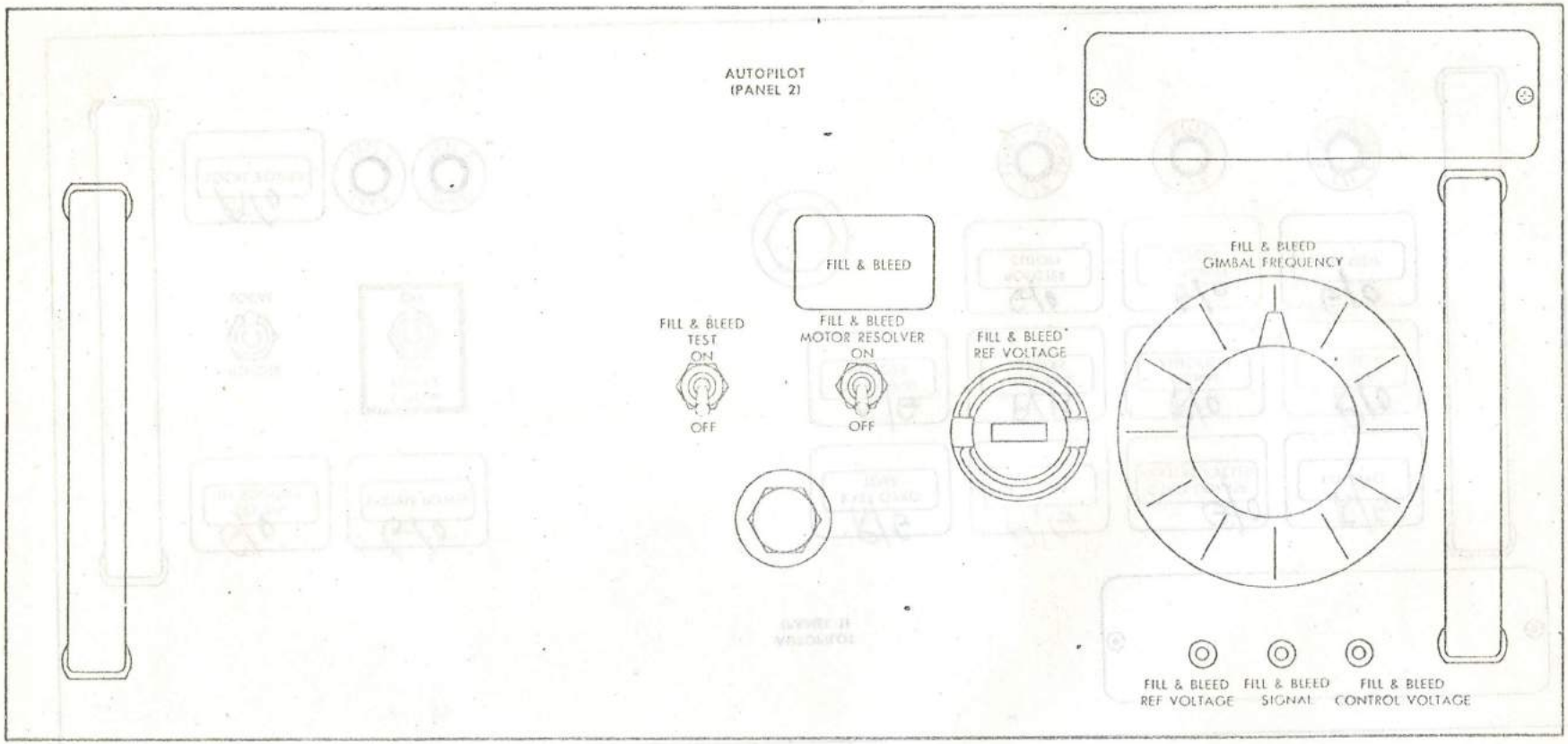


Figure 109- Autopilot Panel 2

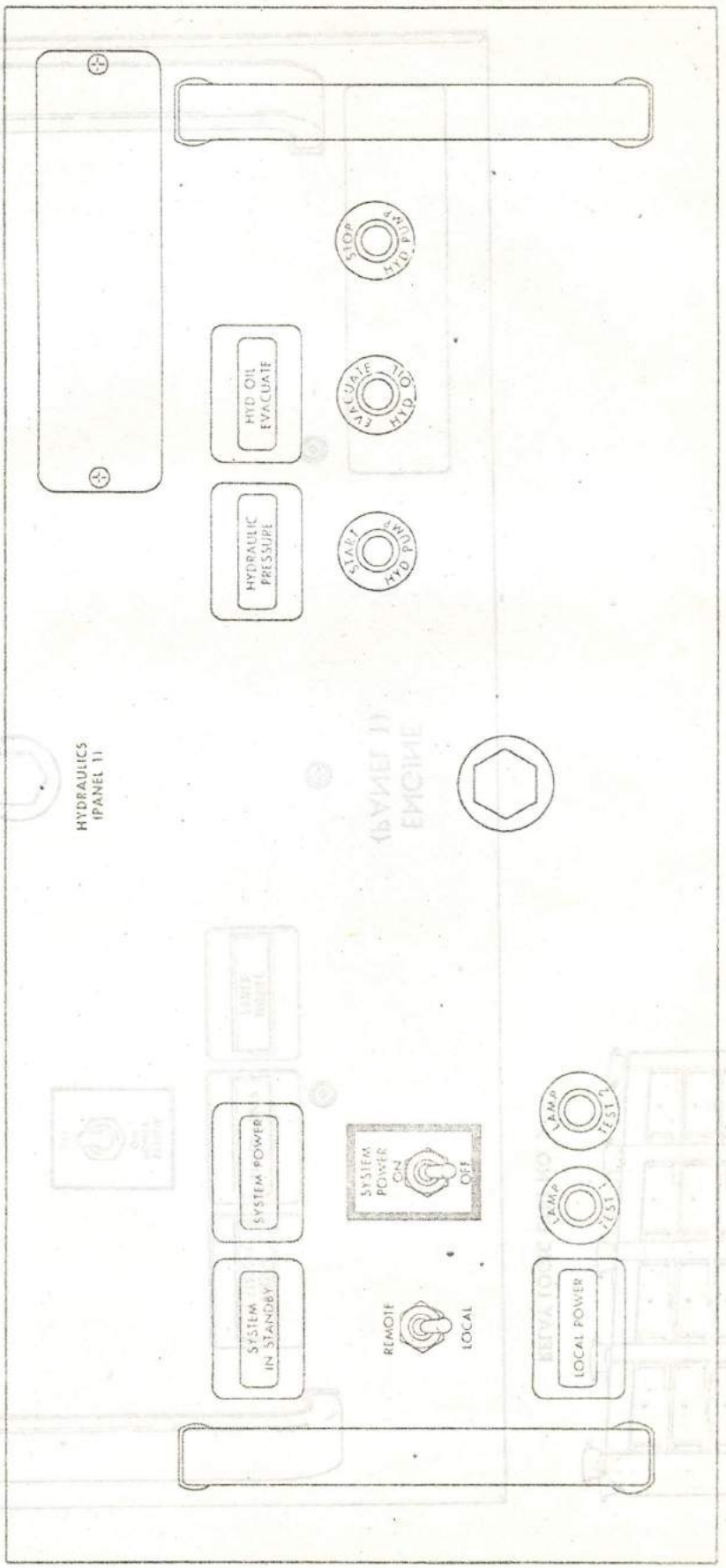


Figure 110- Hydraulic Panel 1

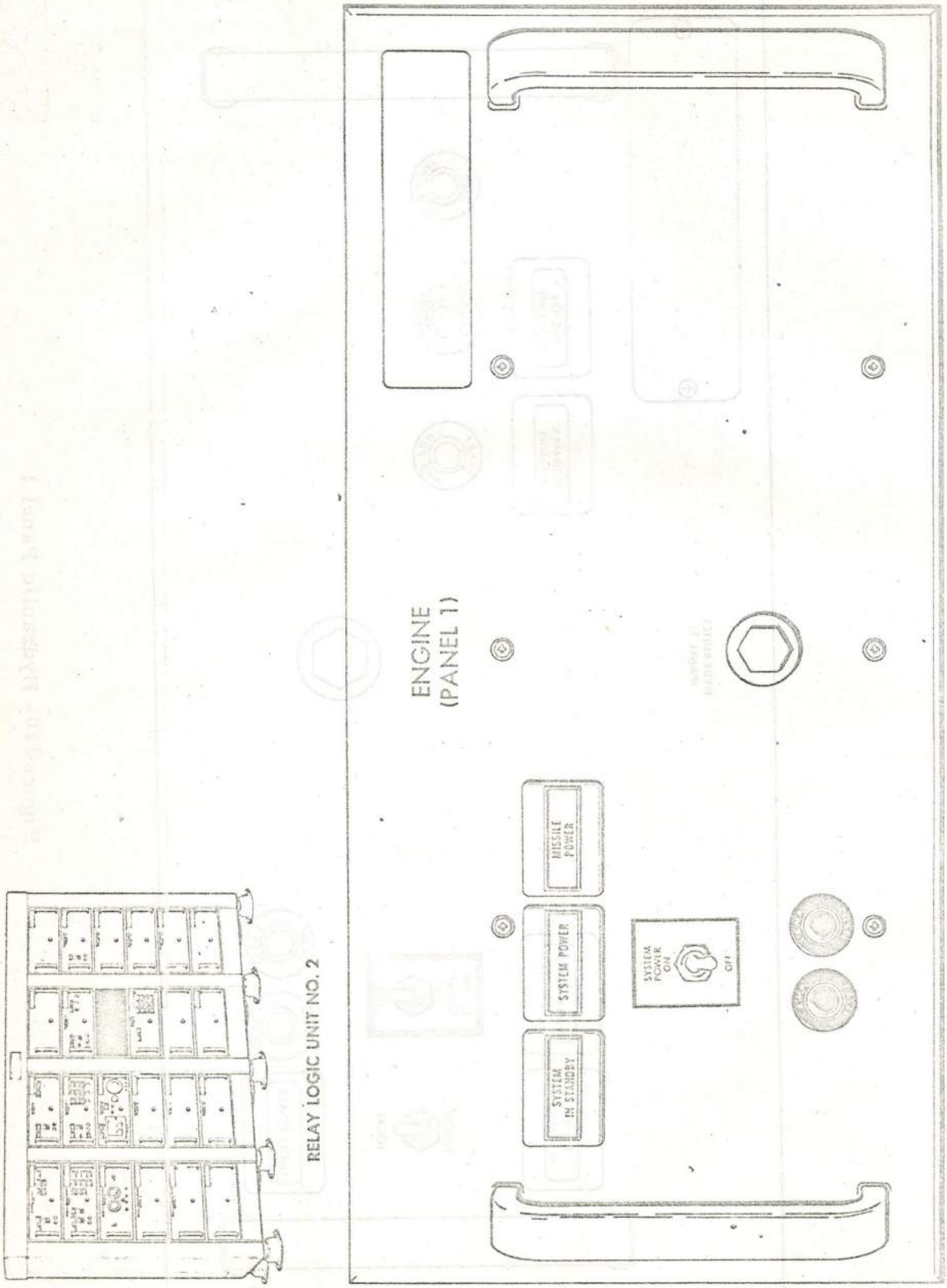
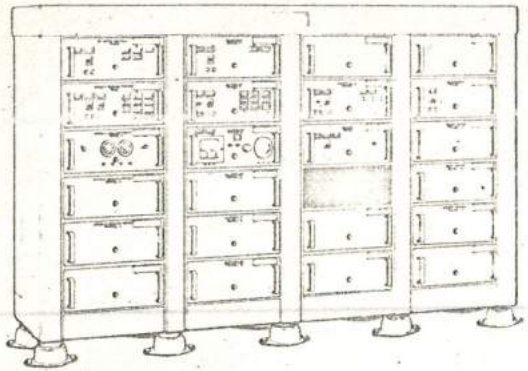


Figure 111 - Engine Panel 1



RELAY LOGIC UNIT NO. 2

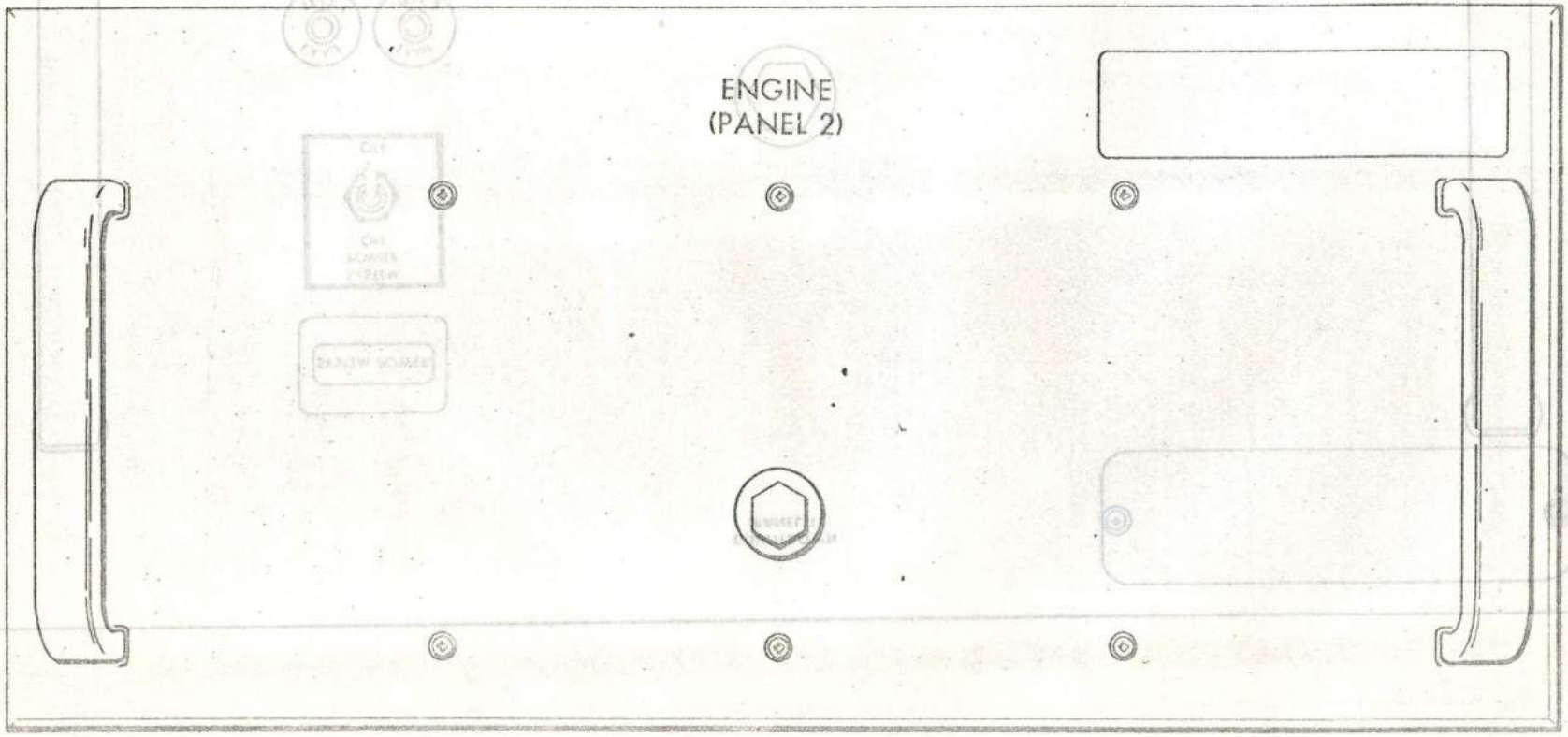


Figure 112- Engine Panel 2

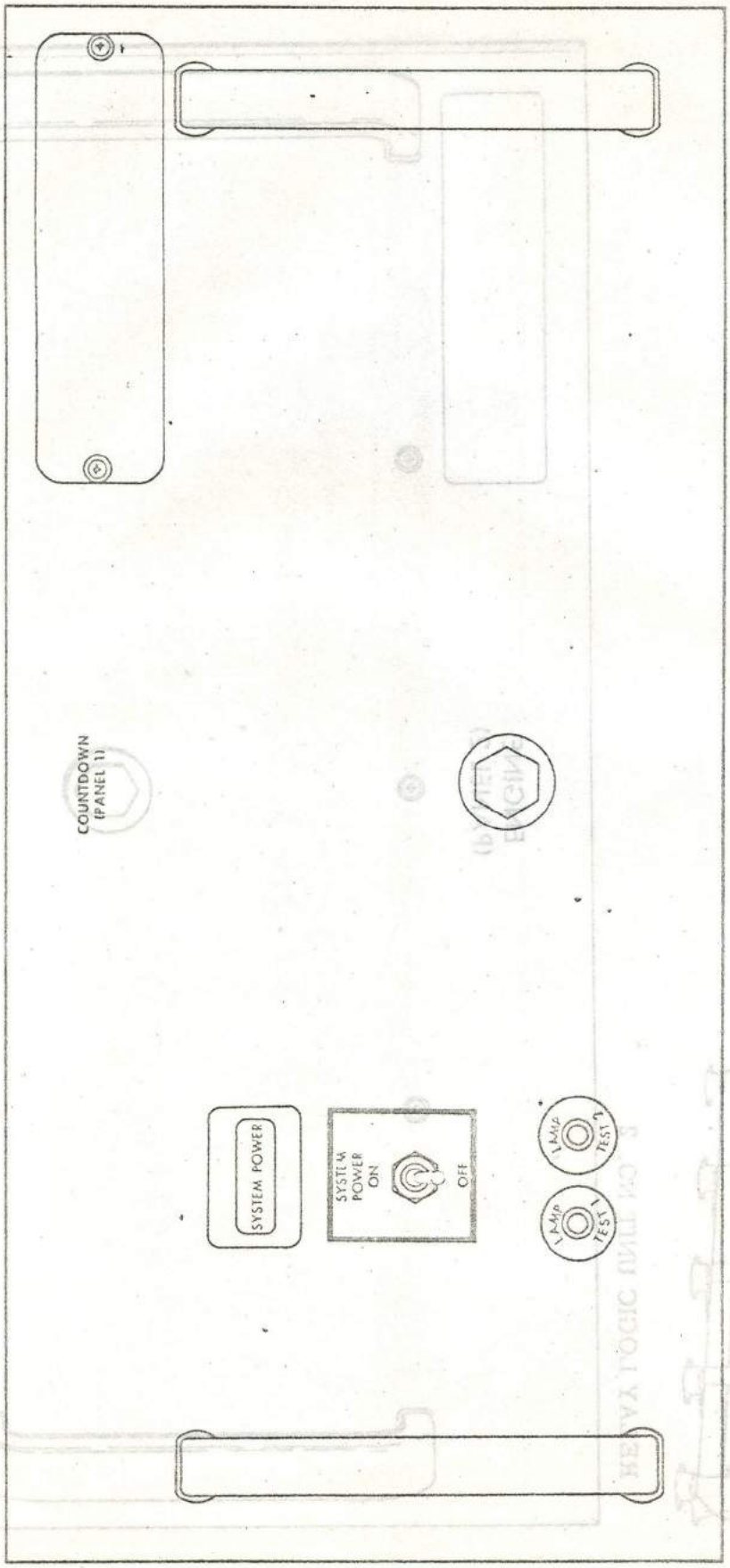


Figure 113- Countdown Panel 1

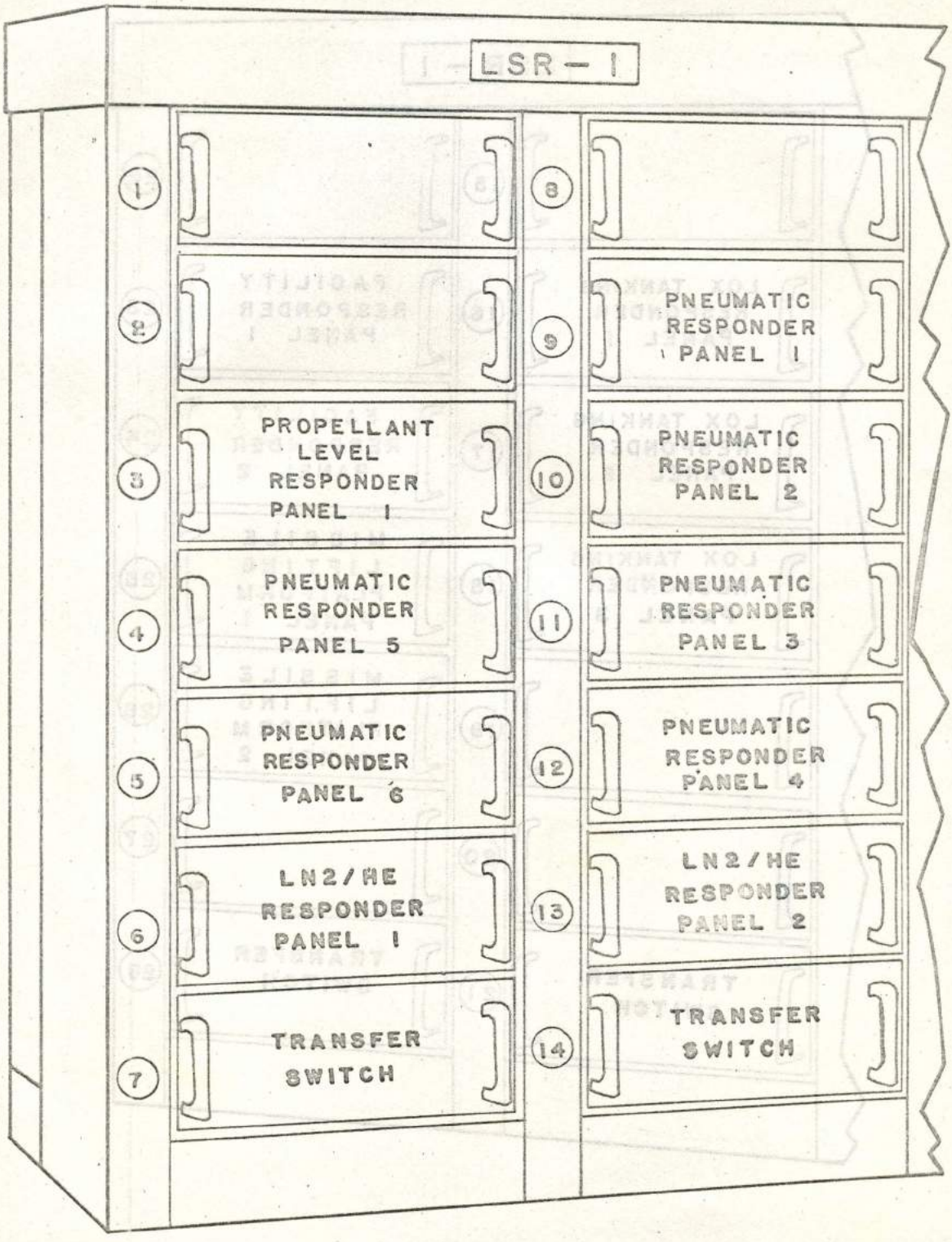


Figure 114-Launch Signal Responder -1 (Left Half)

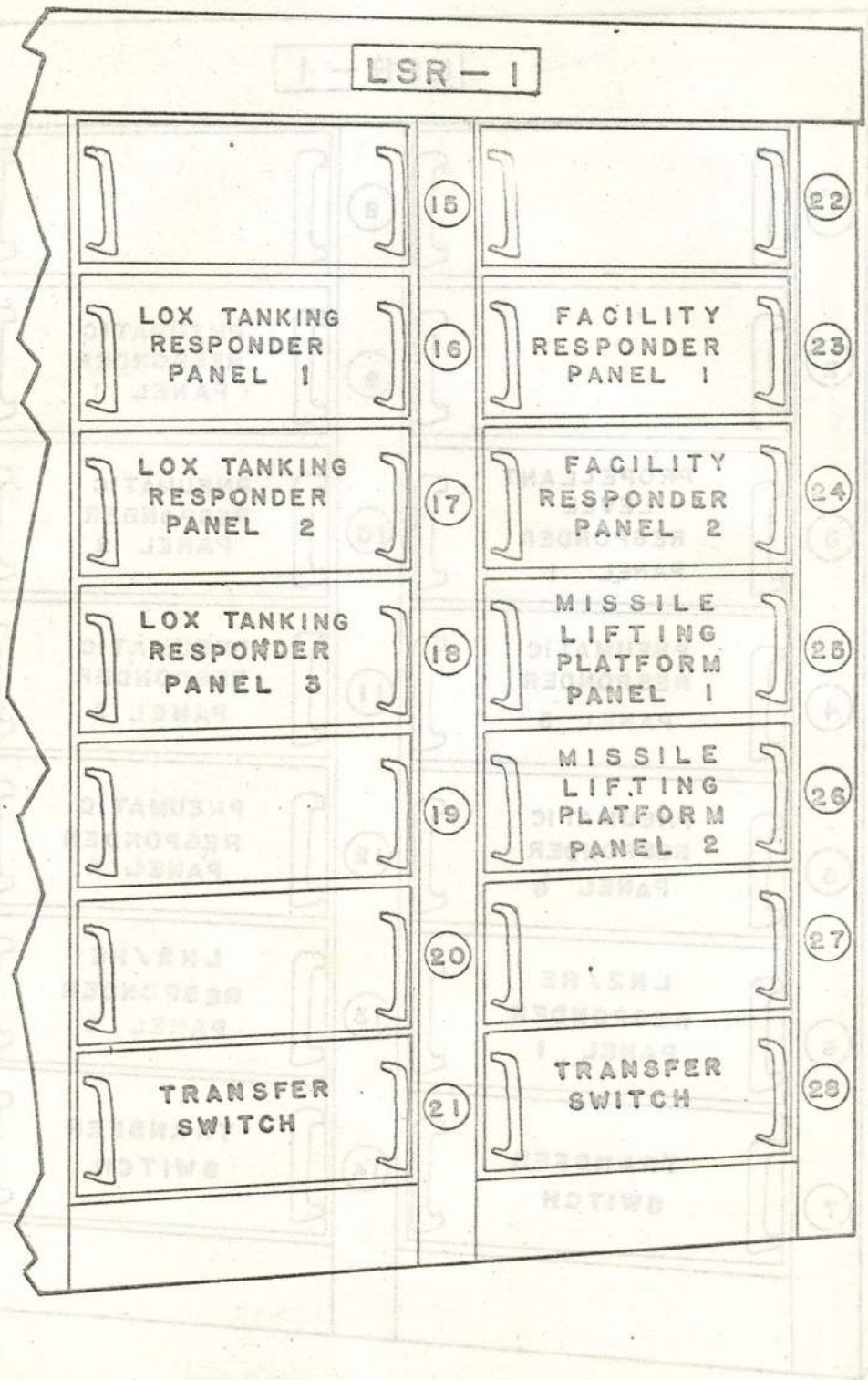


Figure 115 - Launch Signal Responder - 1 (Right Side)

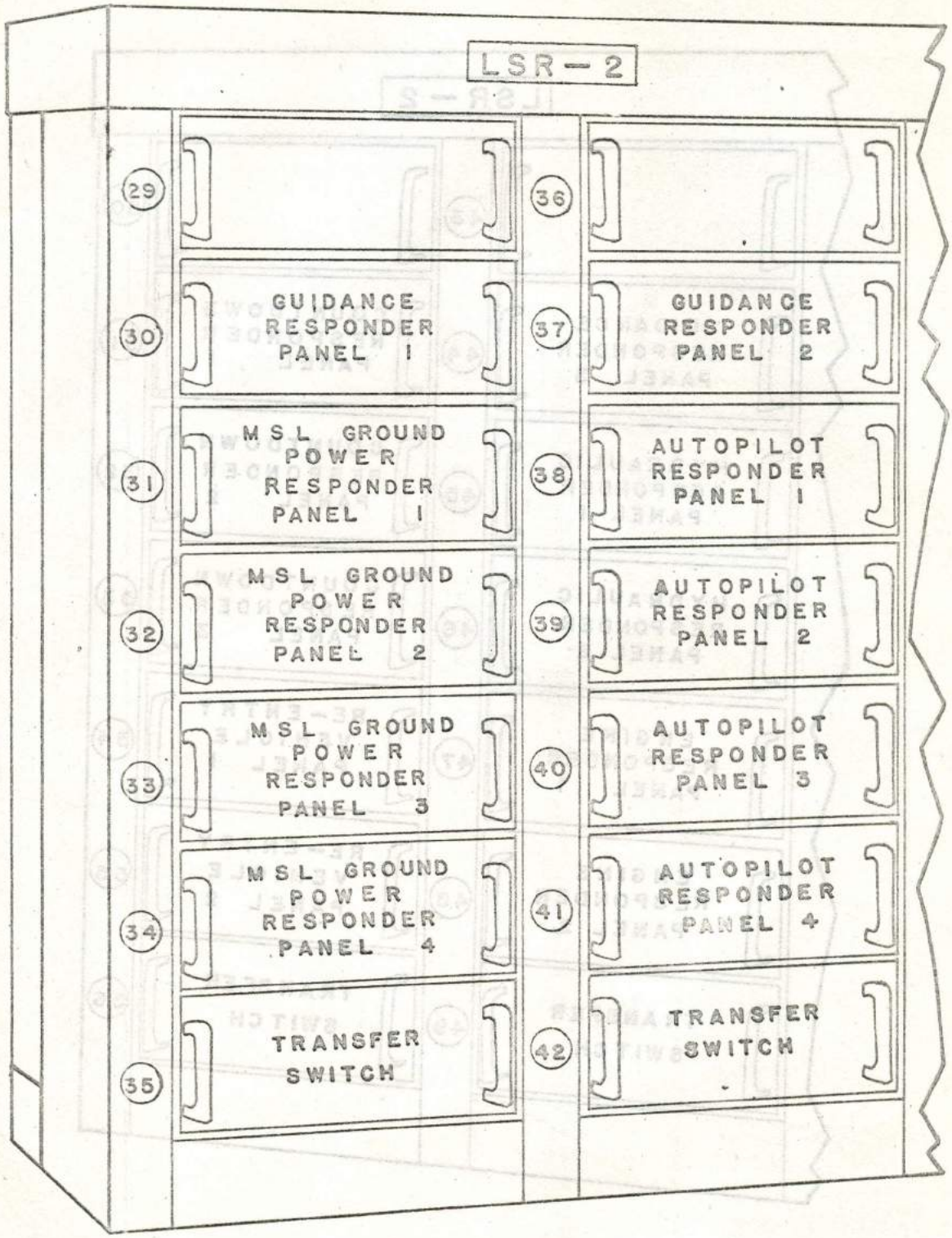


Figure 116-Launch Signal Responder -2 (Left Half)

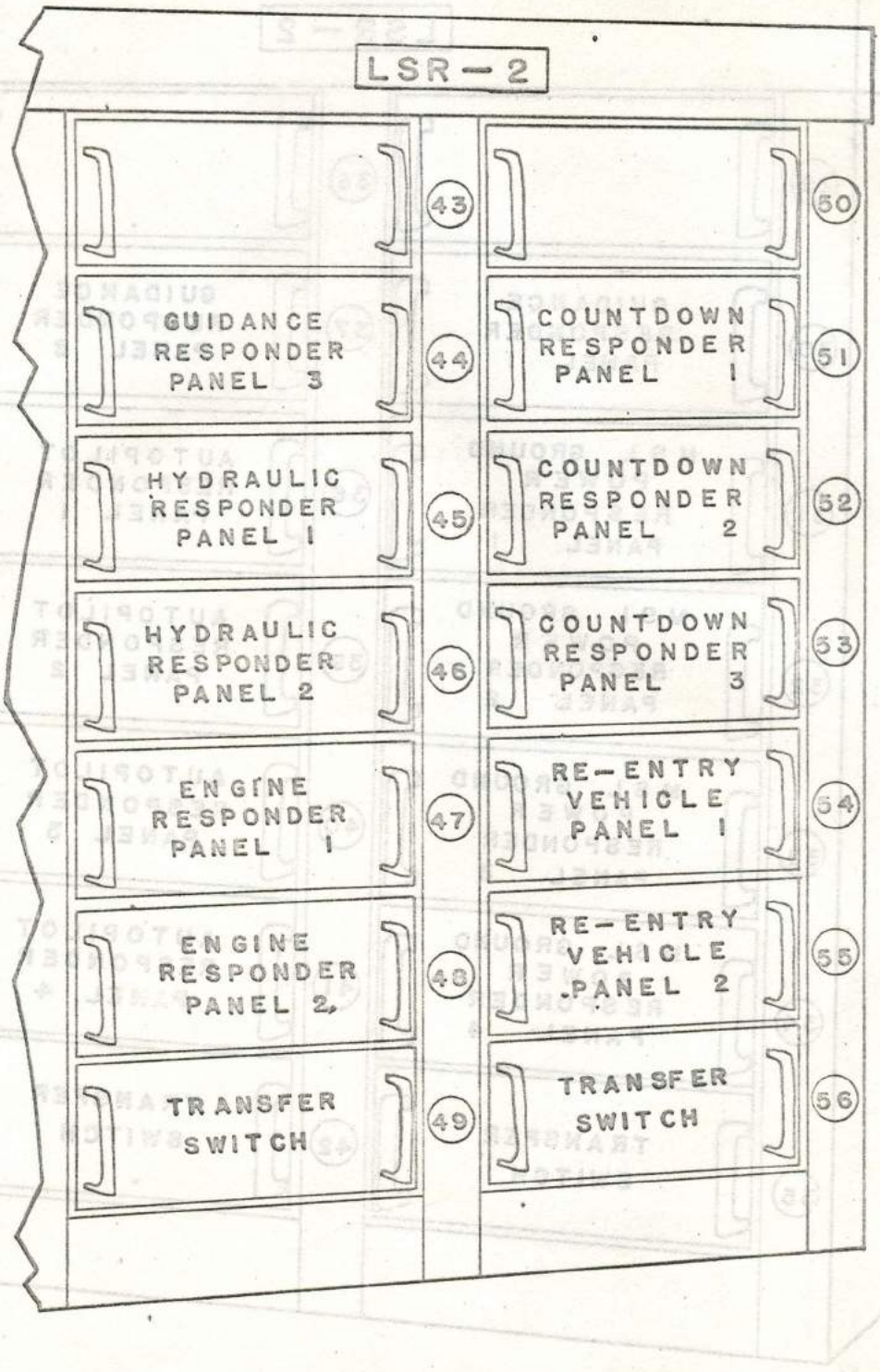


Figure 117 - Launch Signal Responder - 2 (Right Half)

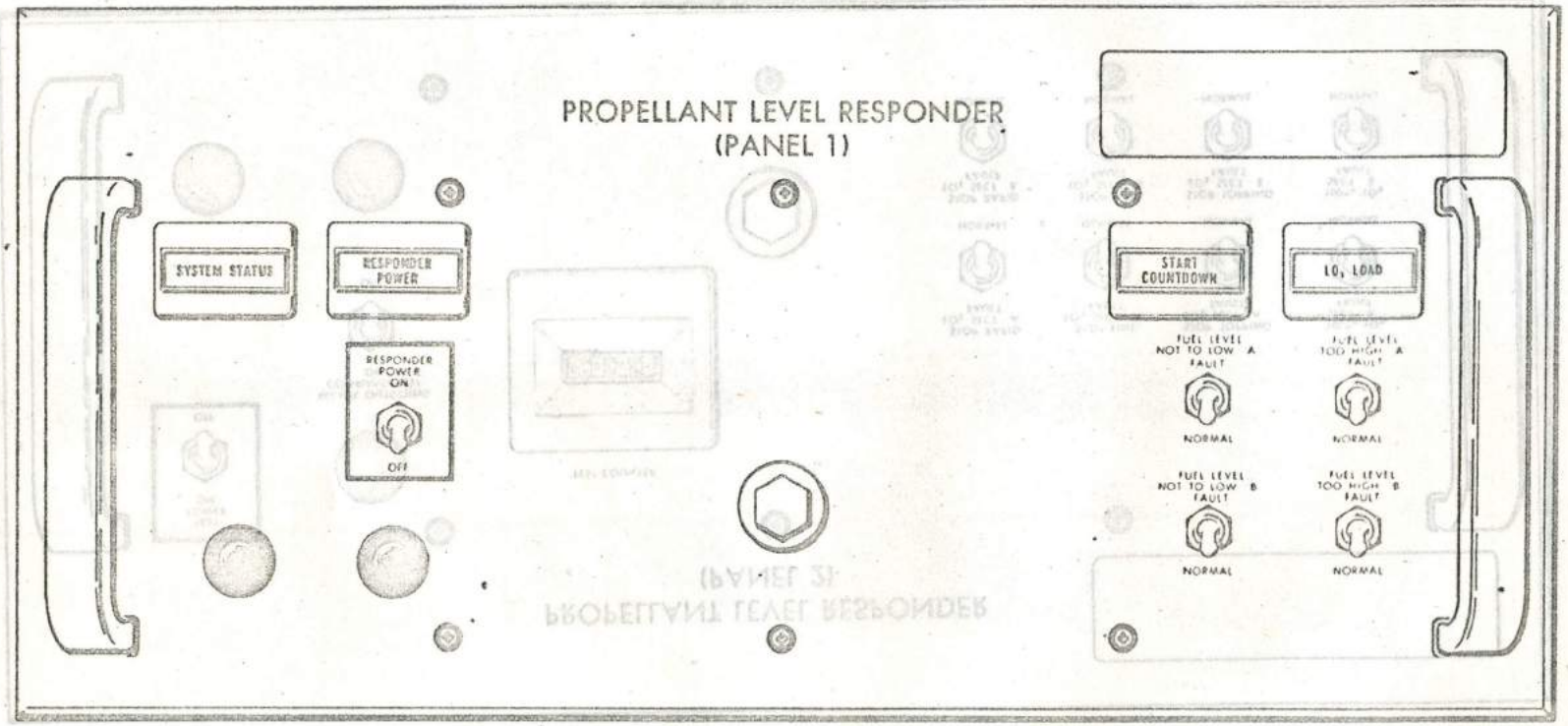


Figure 118- Propellant Level Responder (Panel 1)

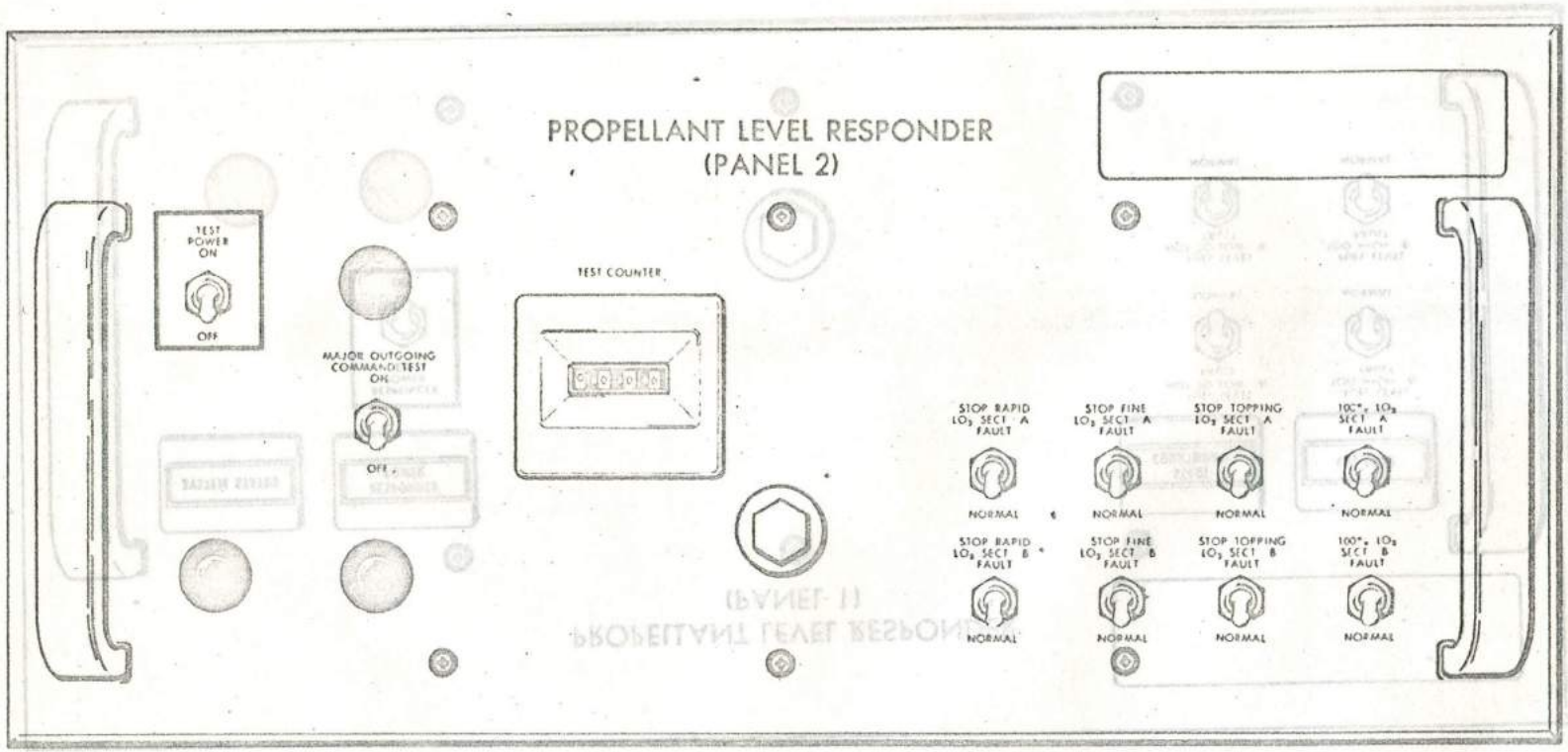


Figure 119 - Propellant Level Responder (Panel 2)

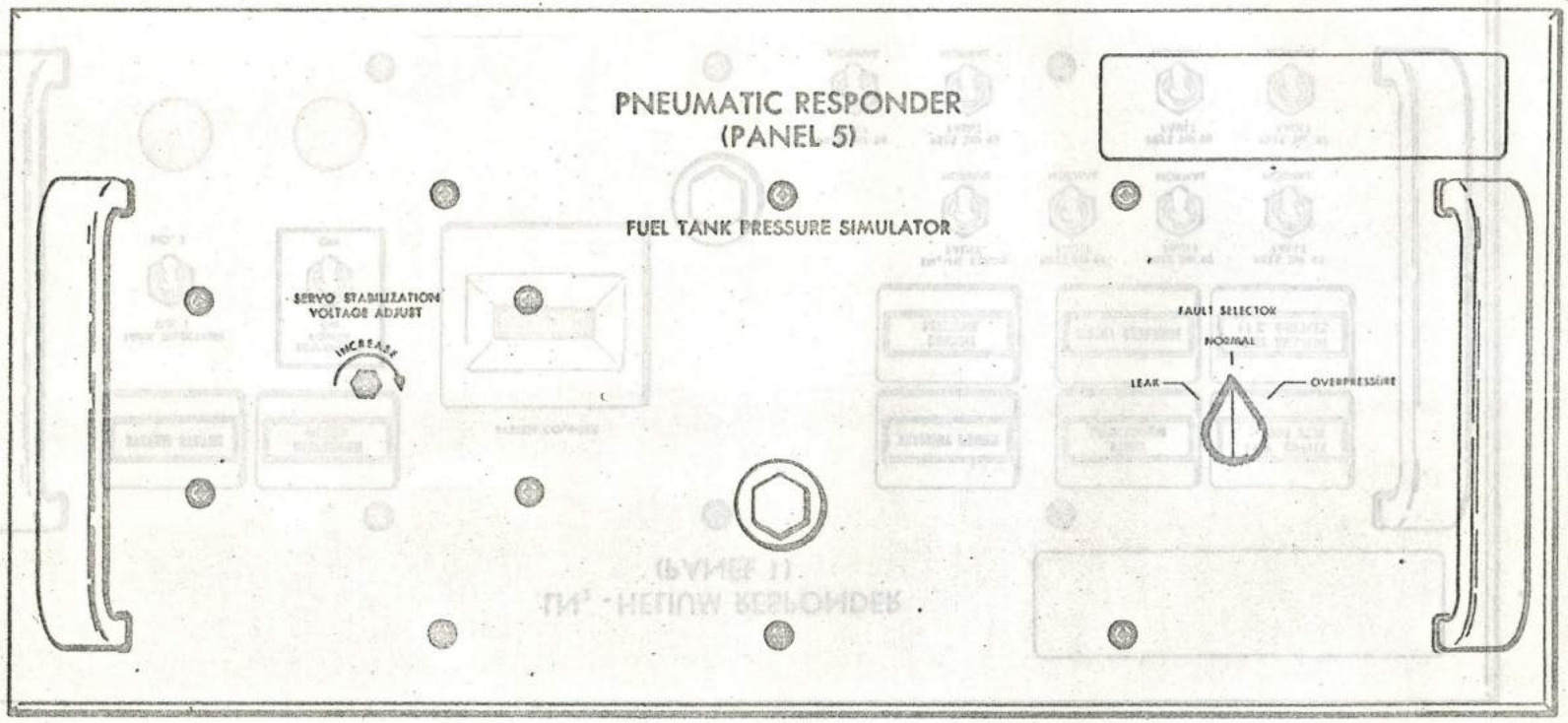


Figure 120 - Pneumatic Responder (Panel 5)

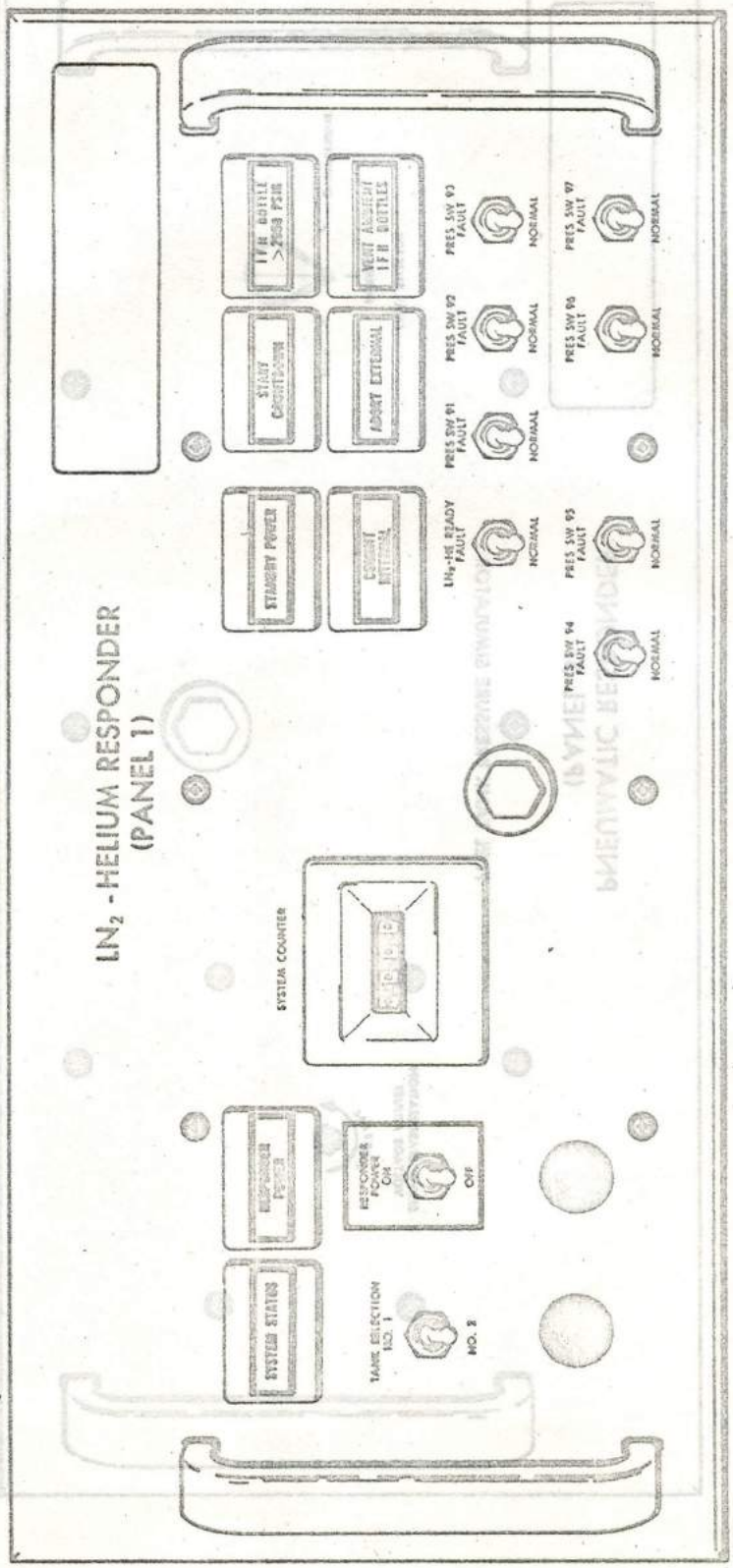
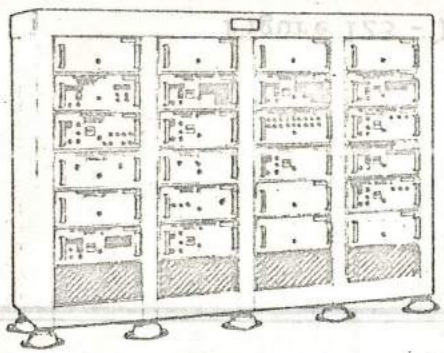
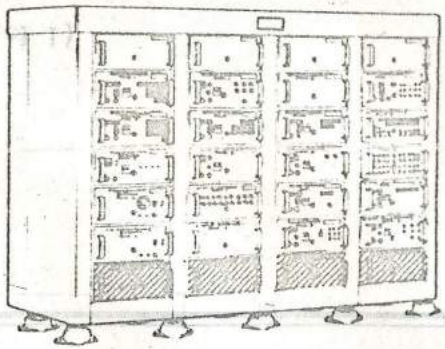


Figure 121 - LN_2-Helium Responder (Panel 1)



SIGNAL RESPONDER NO. 1



SIGNAL RESPONDER NO. 2

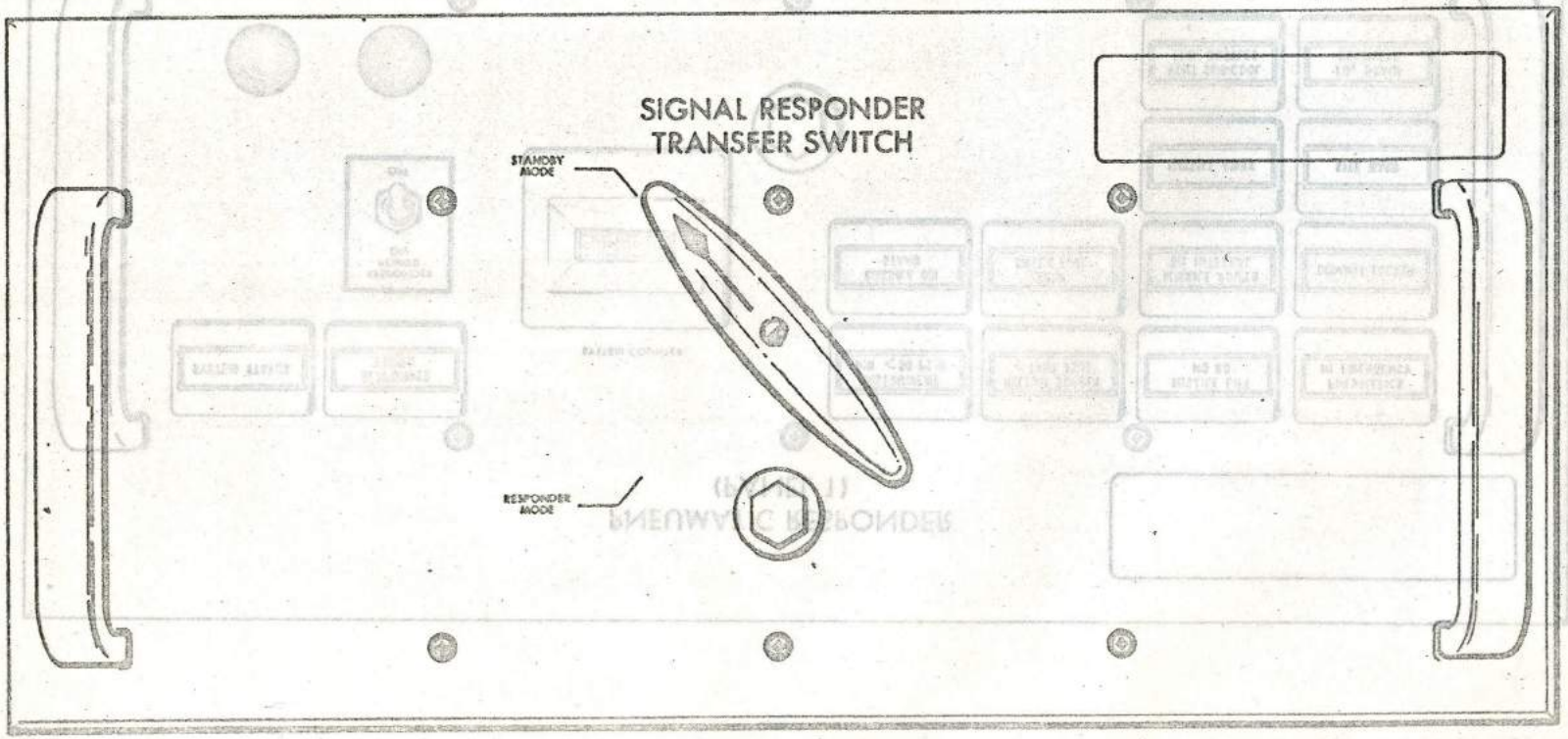


Figure 122 - Signal Responder Transfer Switch

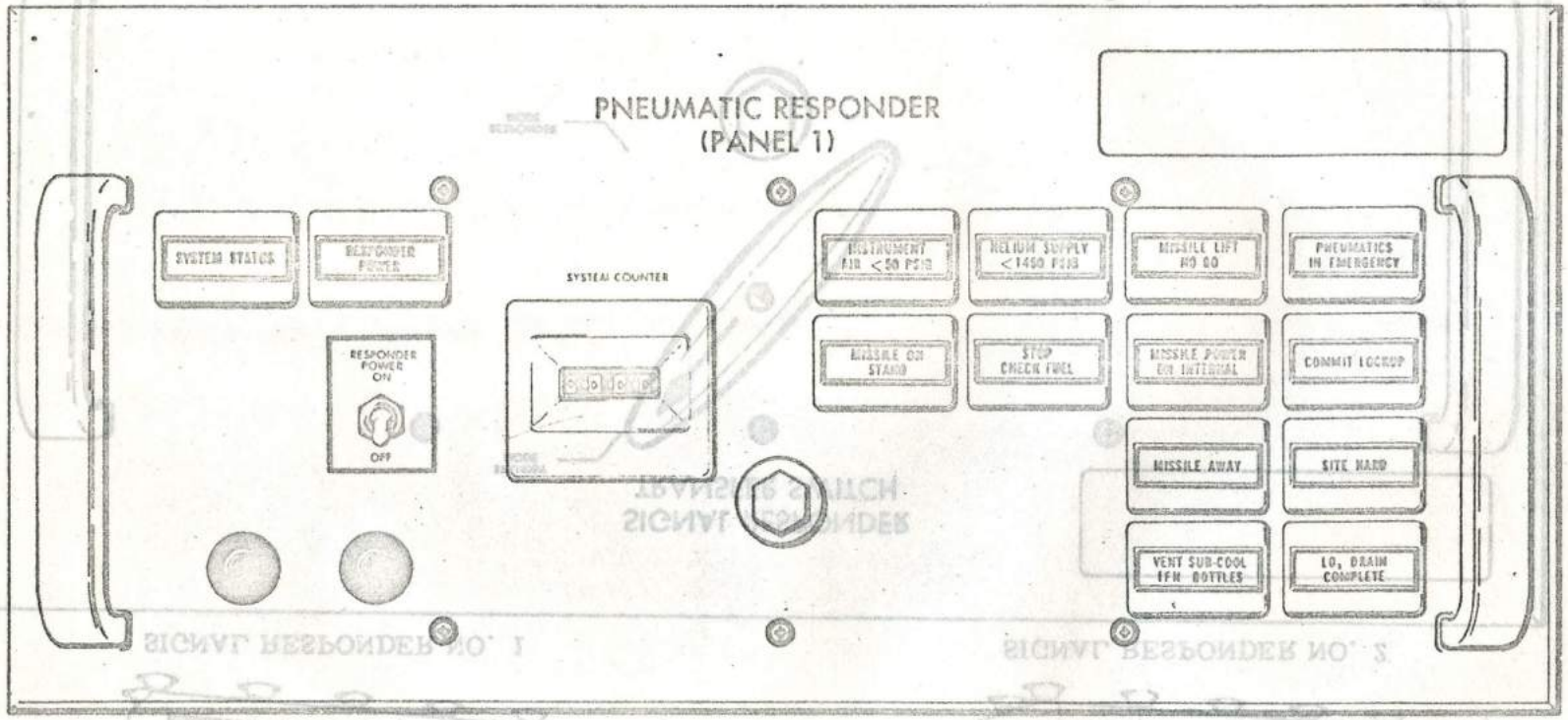


Figure 123 - Pneumatic Responder (Panel 1)

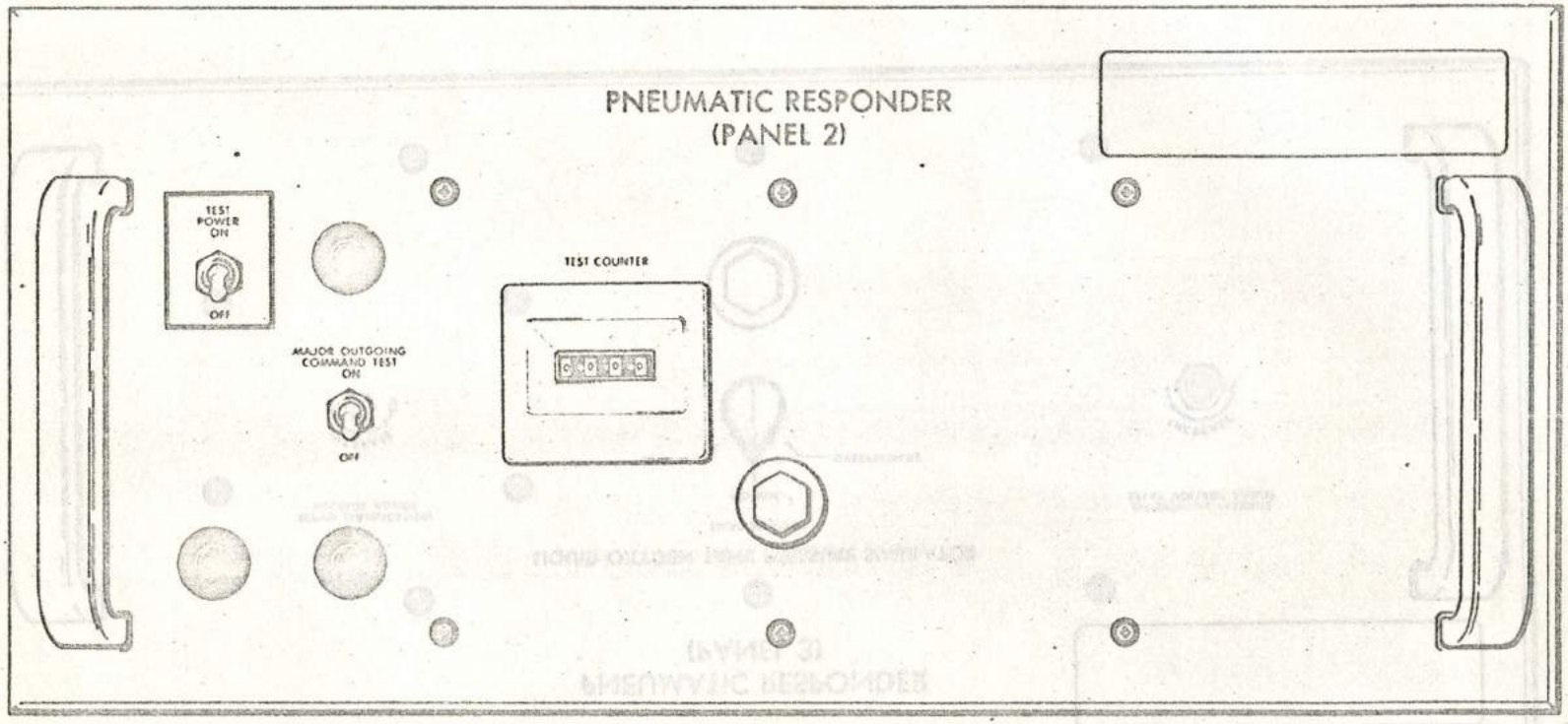


Figure 124 - Pneumatic Responder (Panel 2)

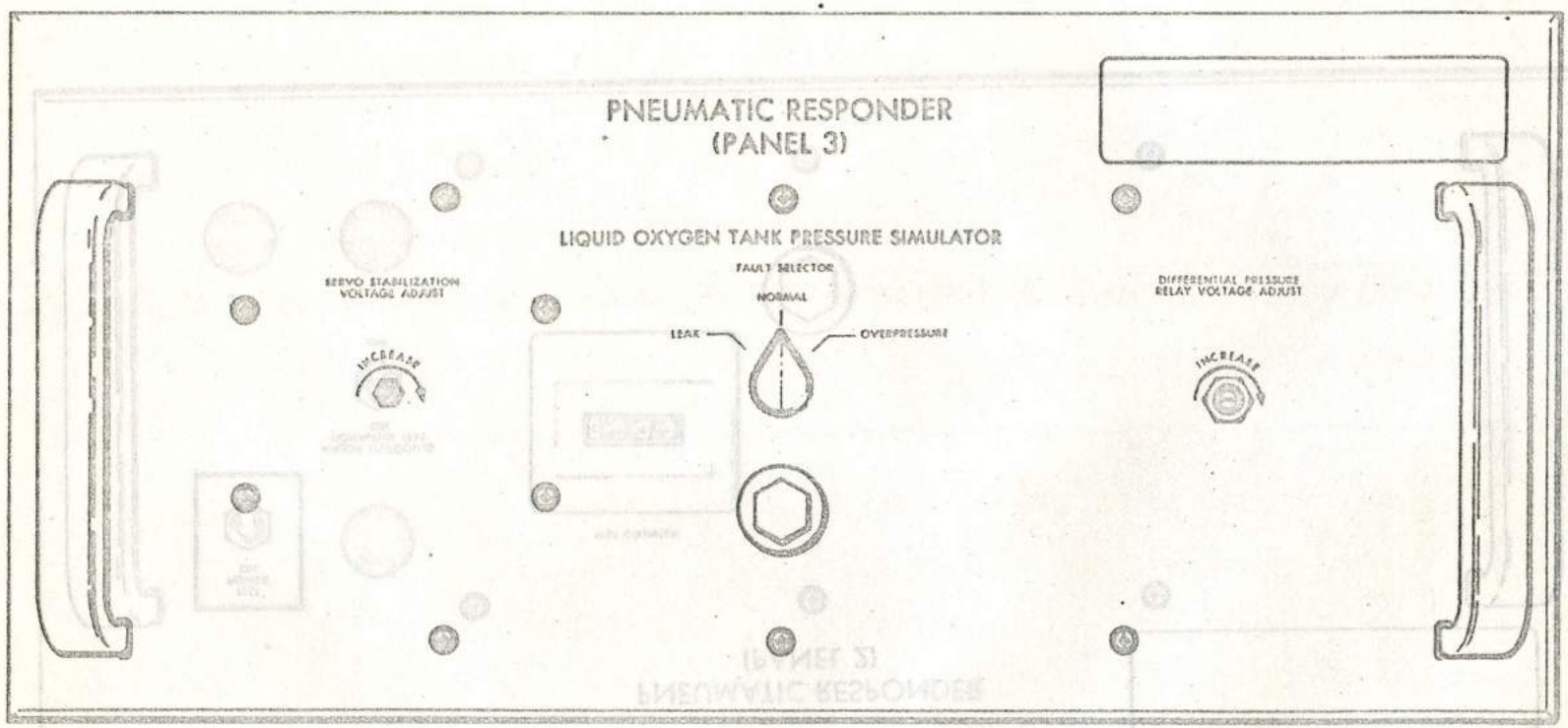


Figure 125 - Pneumatic Responder (Panel 3)

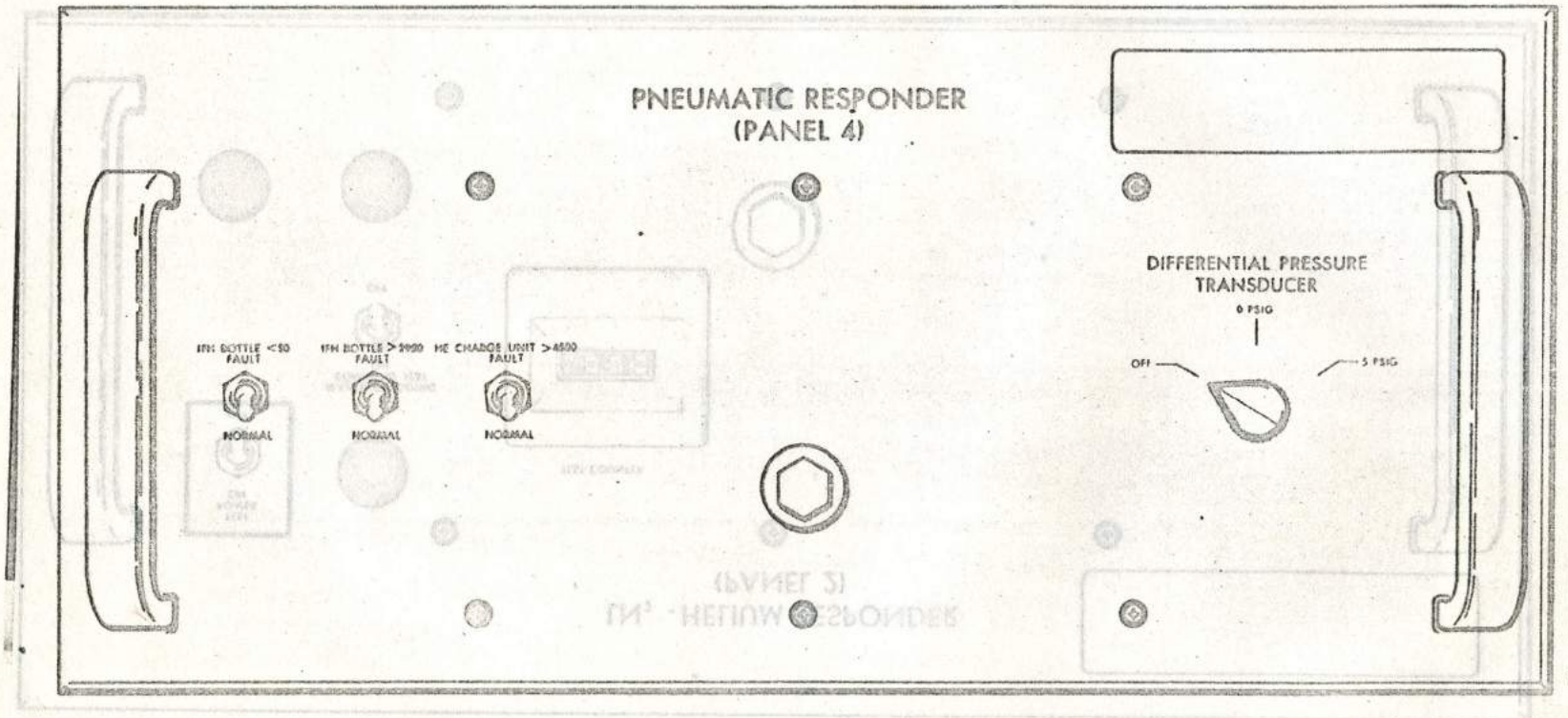


Figure 126 - Pneumatic Responder (Panel 4)

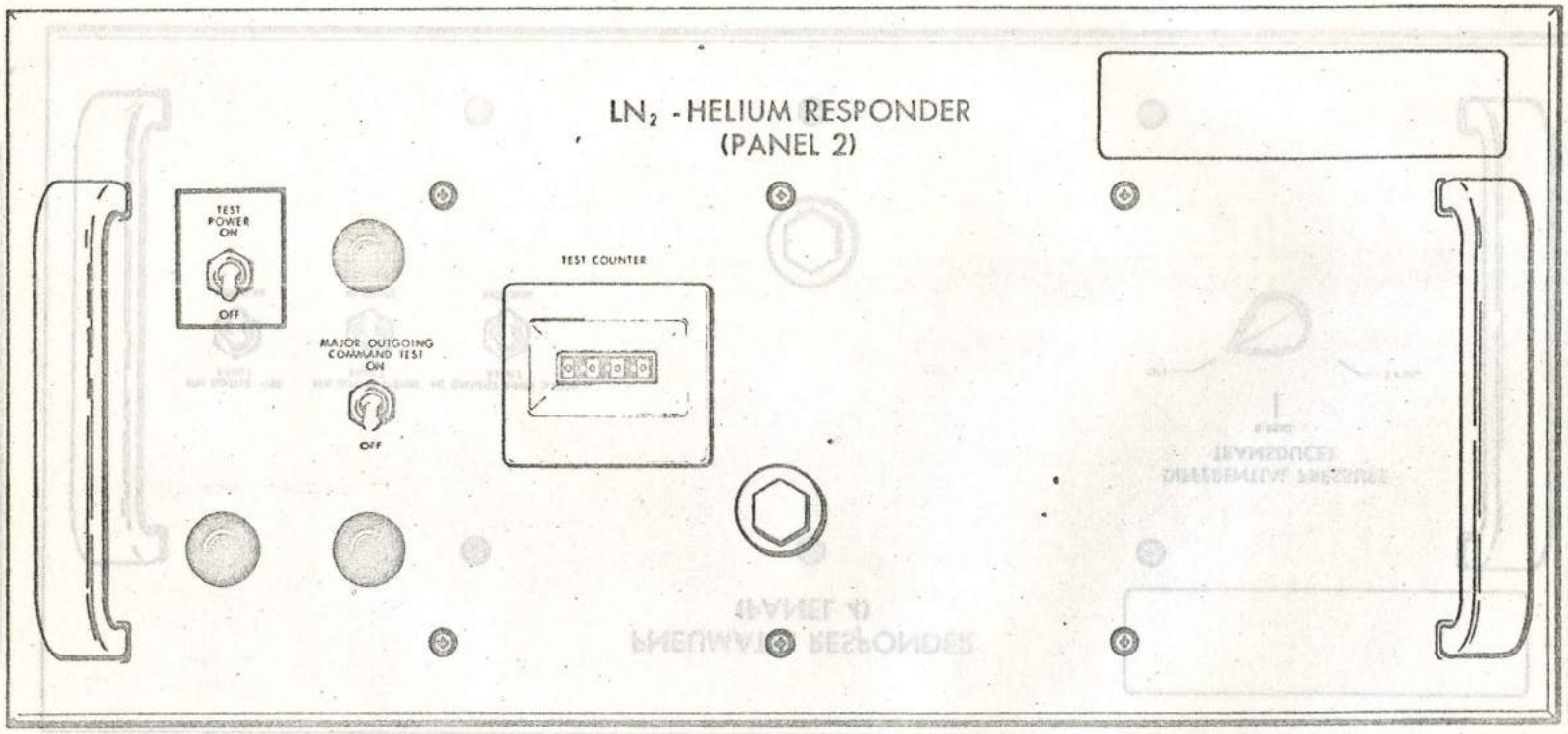


Figure 127 - LN_2- Helium Responder (Panel 2)

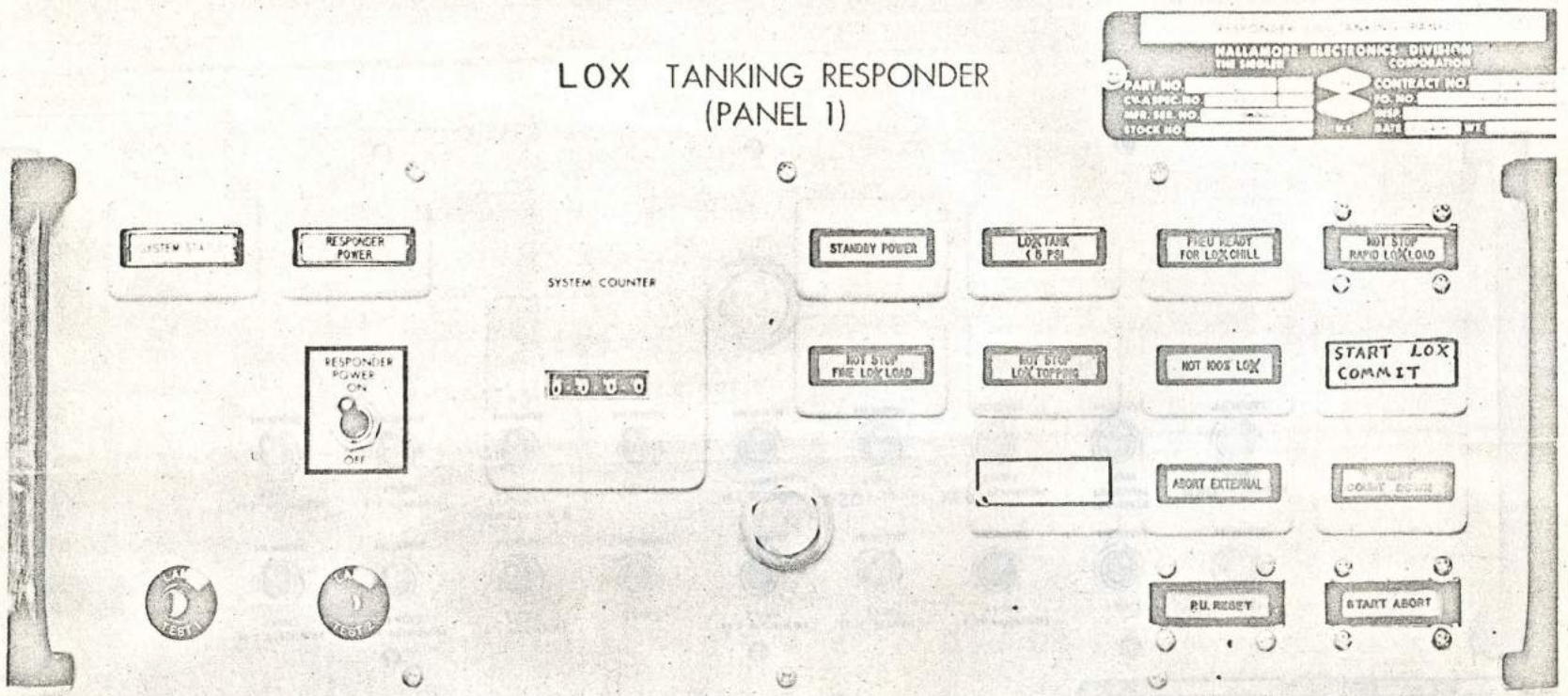


Figure 128 - LOX Tanking Responder (Panel 1)

Figure 129 LOX Tanking Responder (Panel 2)

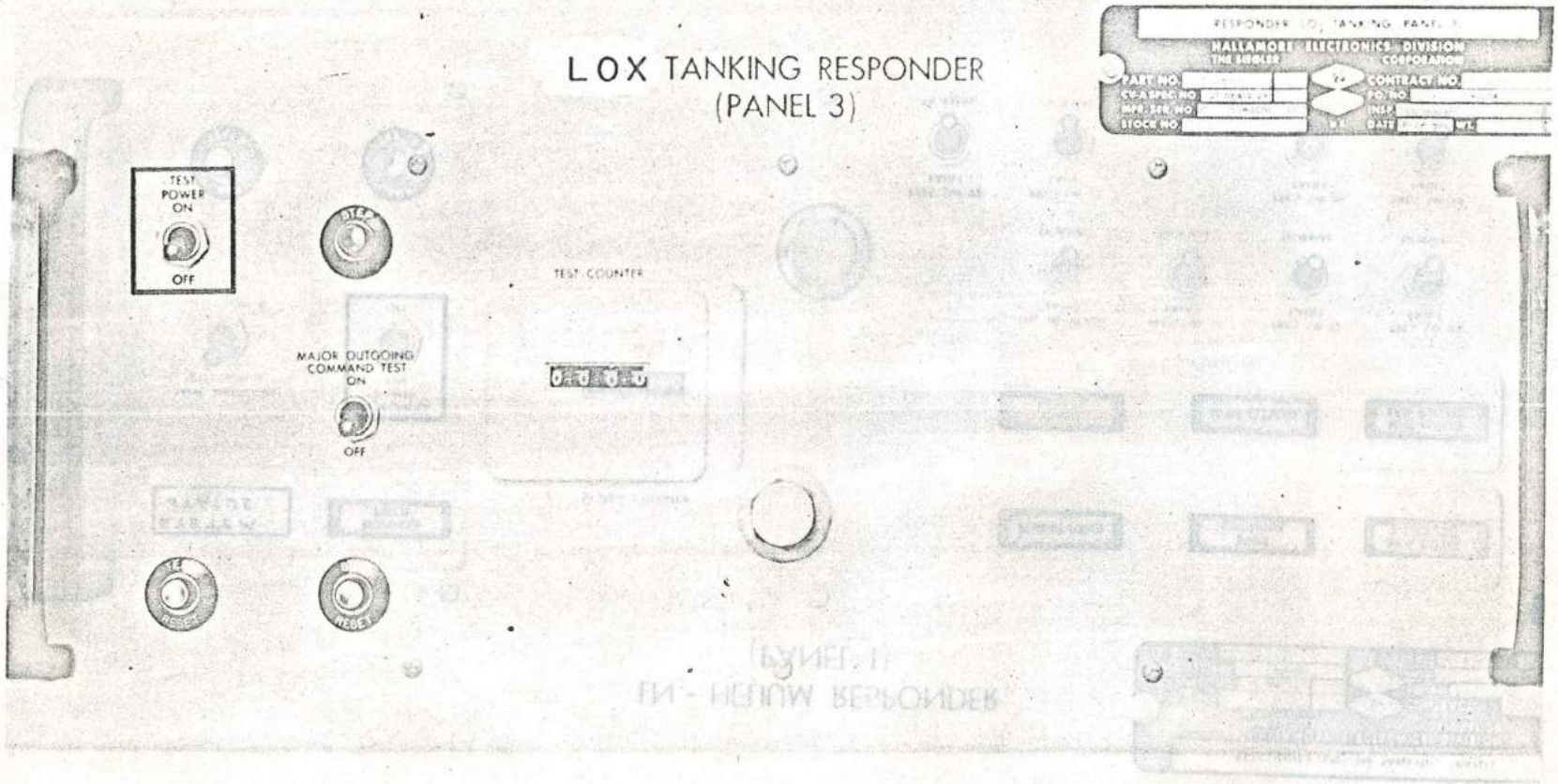


Figure 130 - LOX Tanking Responder (Panel 3)

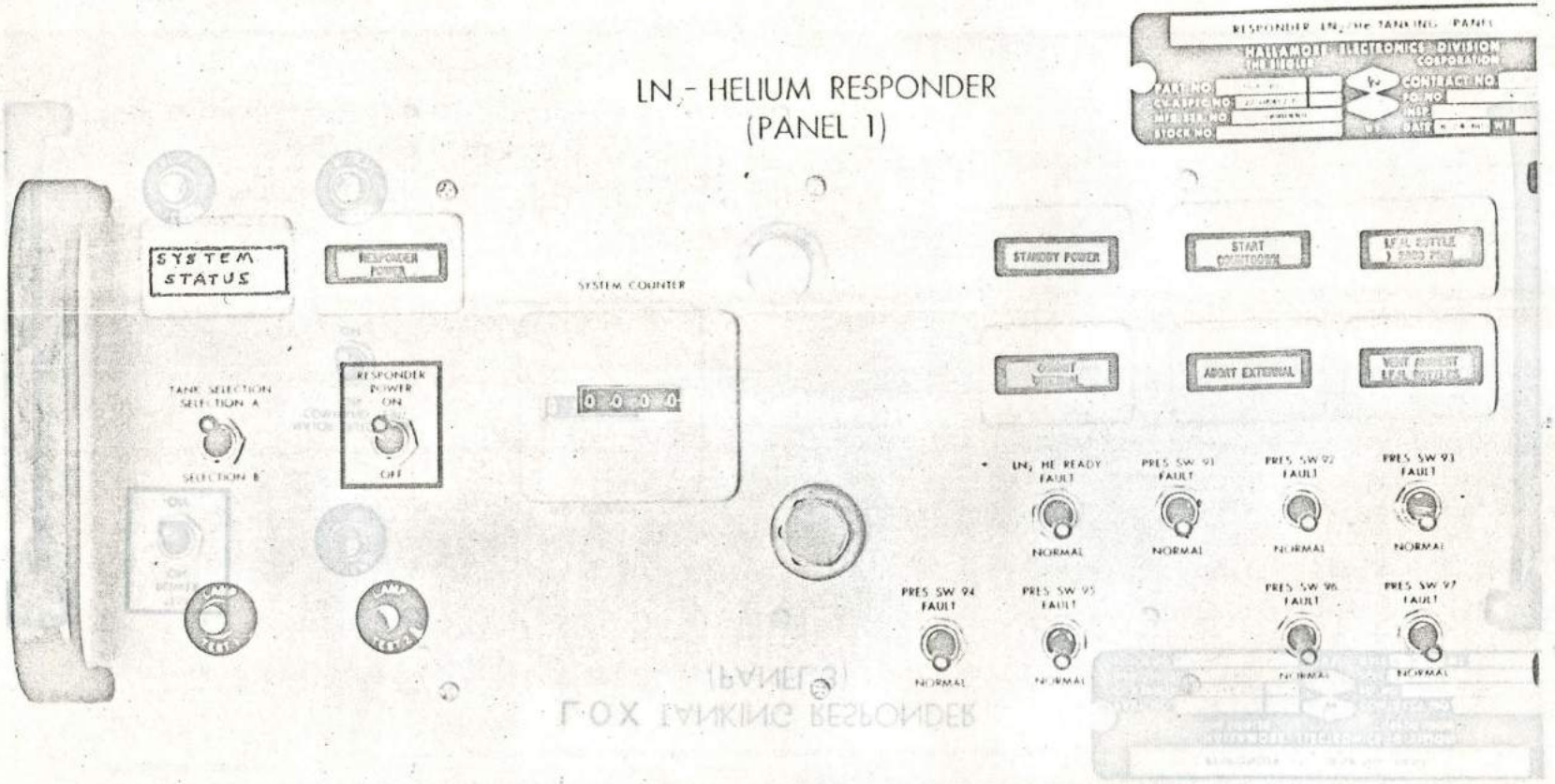


Figure 131 - LN_2 - Helium Responder (Panel 1)

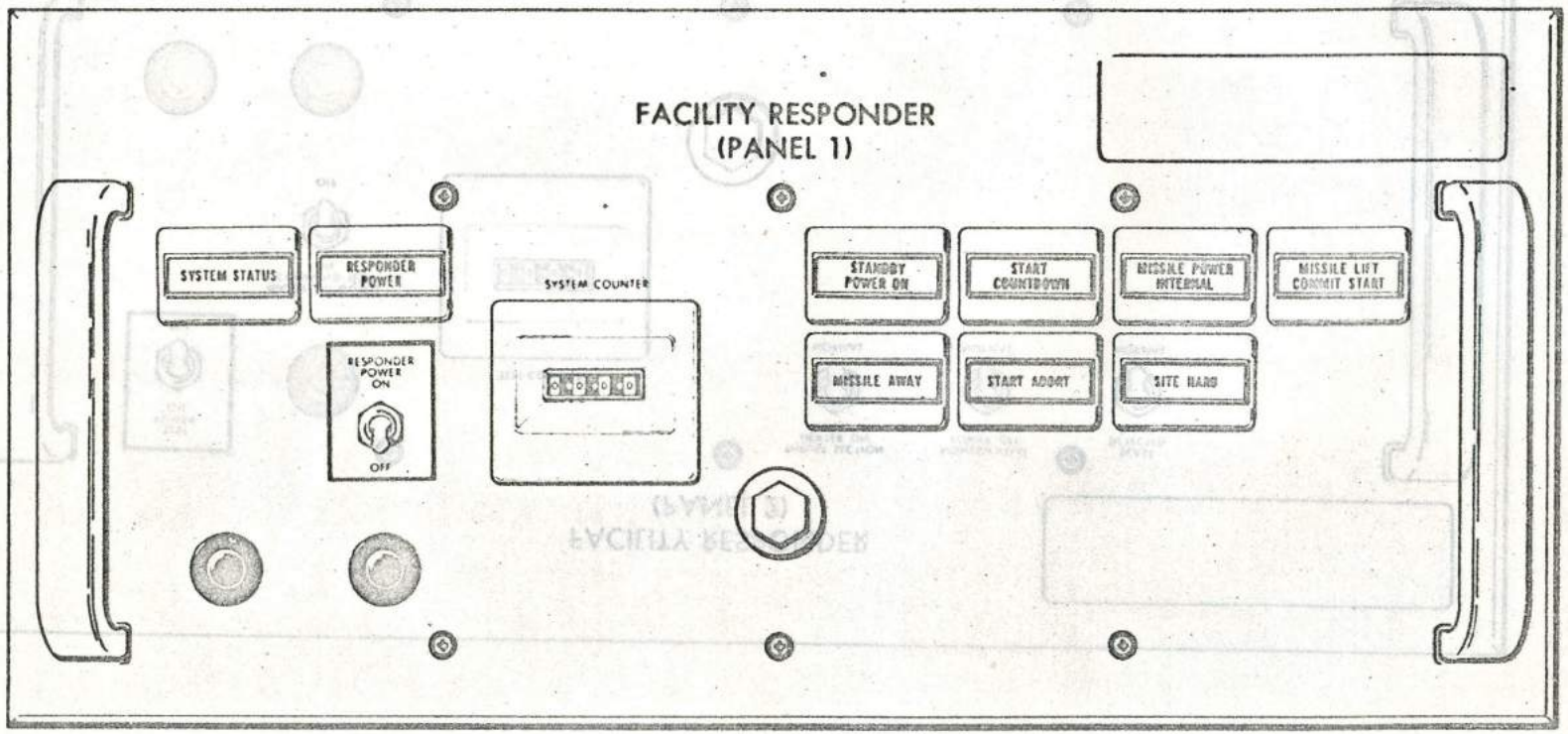


Figure 132 - Facility Responder (Panel 1)

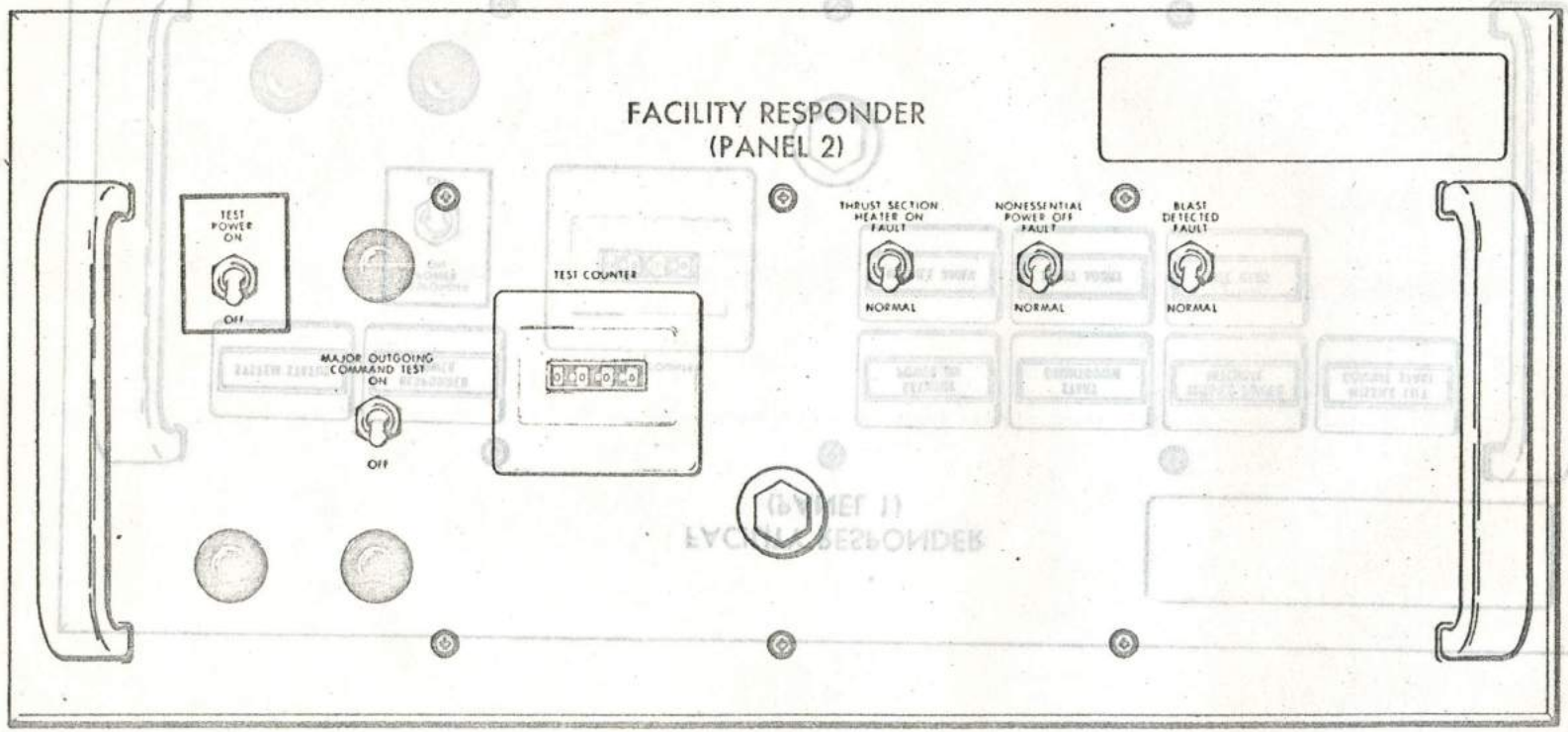


Figure 133 - Facility Responder (Panel 2)

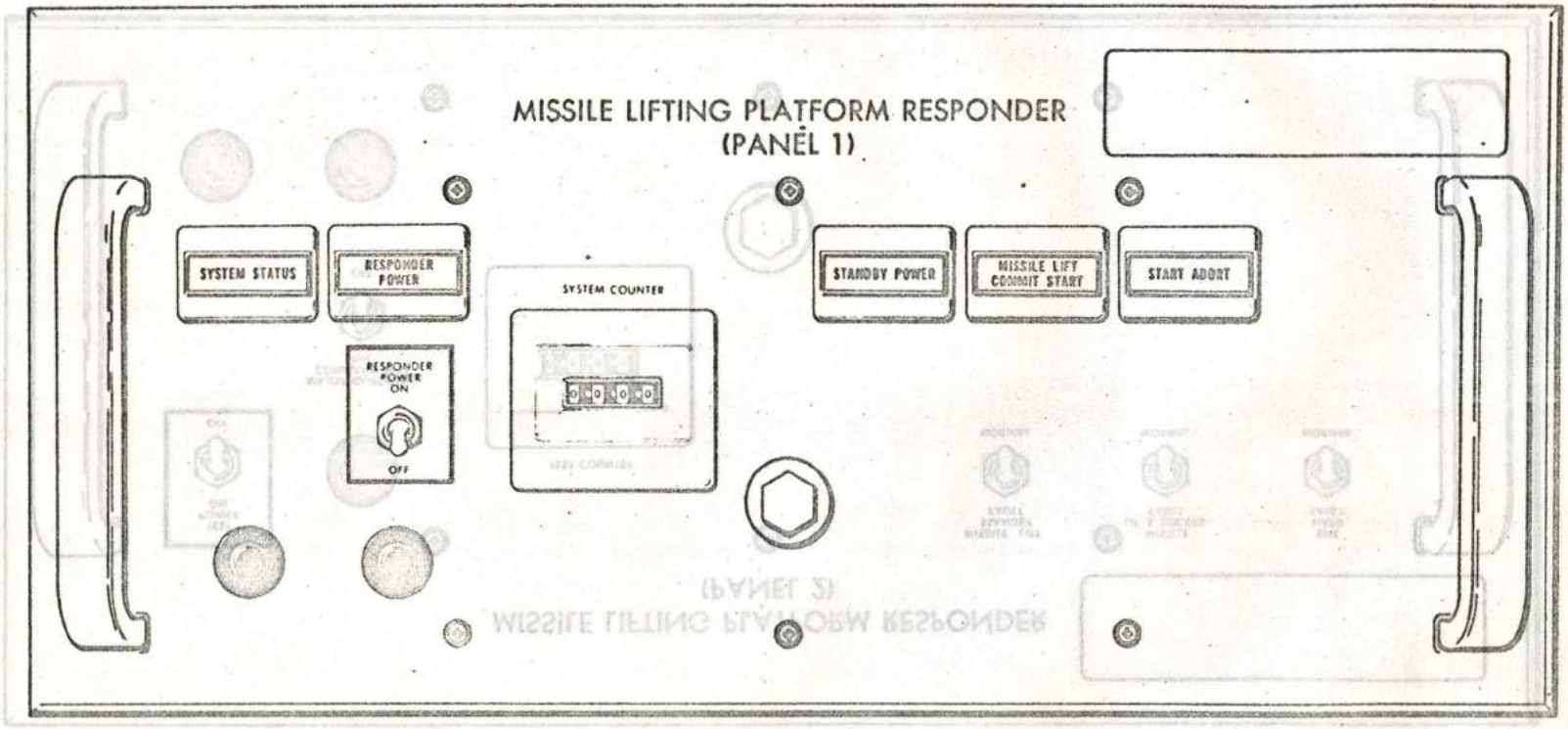


Figure 134 - Missile Lifting Platform Responder (Panel 1)

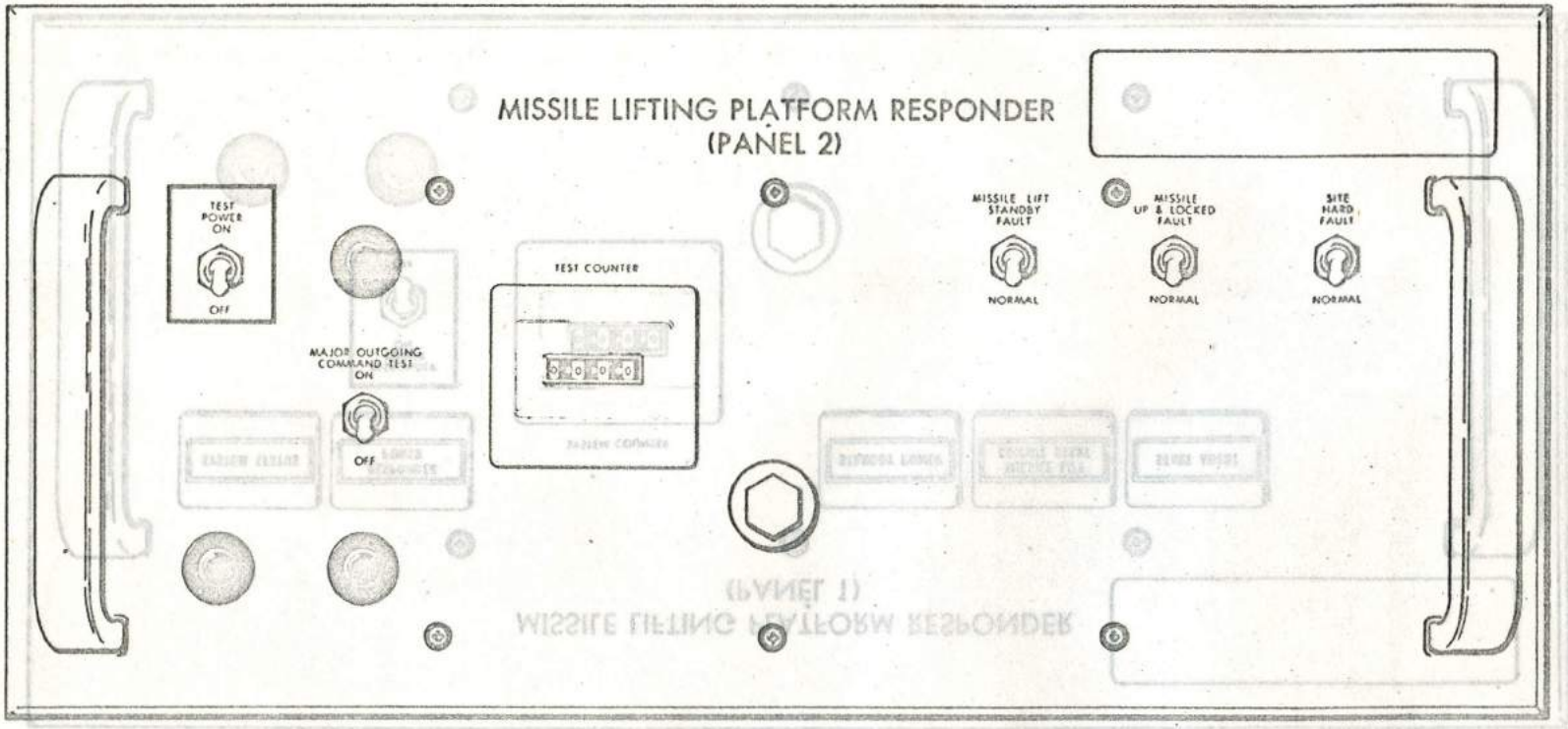


Figure 135 - Missile Ground Power Responder (Panel 2)

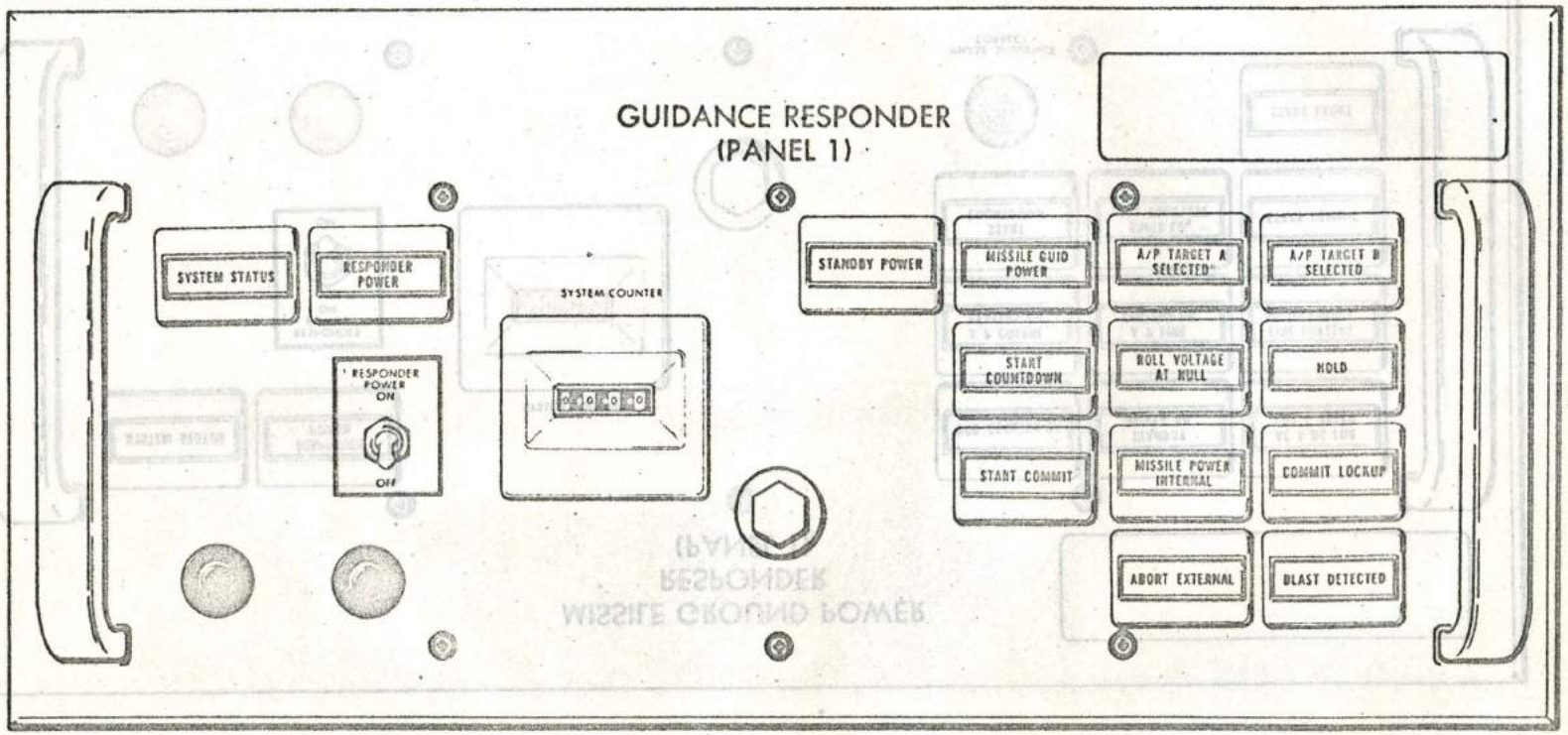


Figure 136 - Guidance Responder (Panel 1)

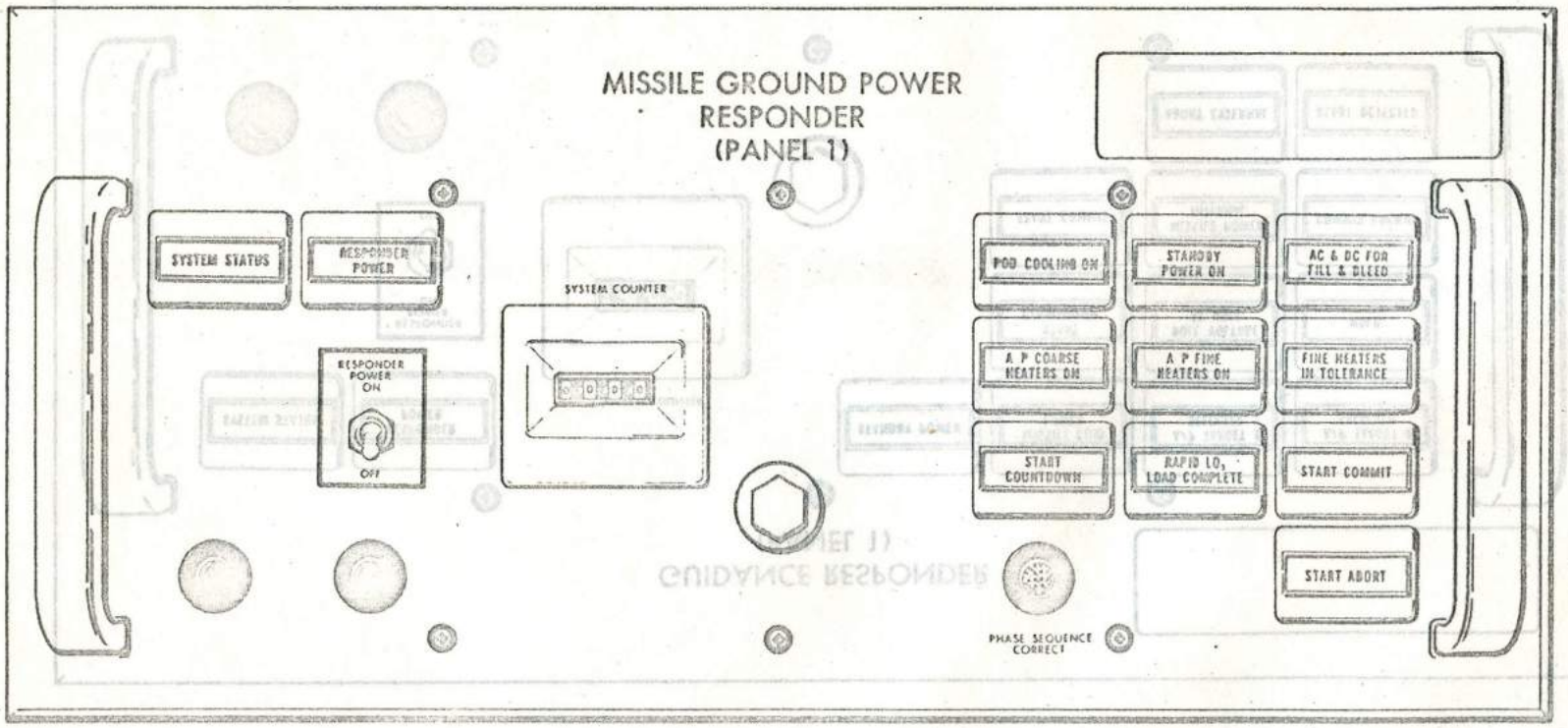


Figure 137 - Missile Ground Power Responder (Panel 1)

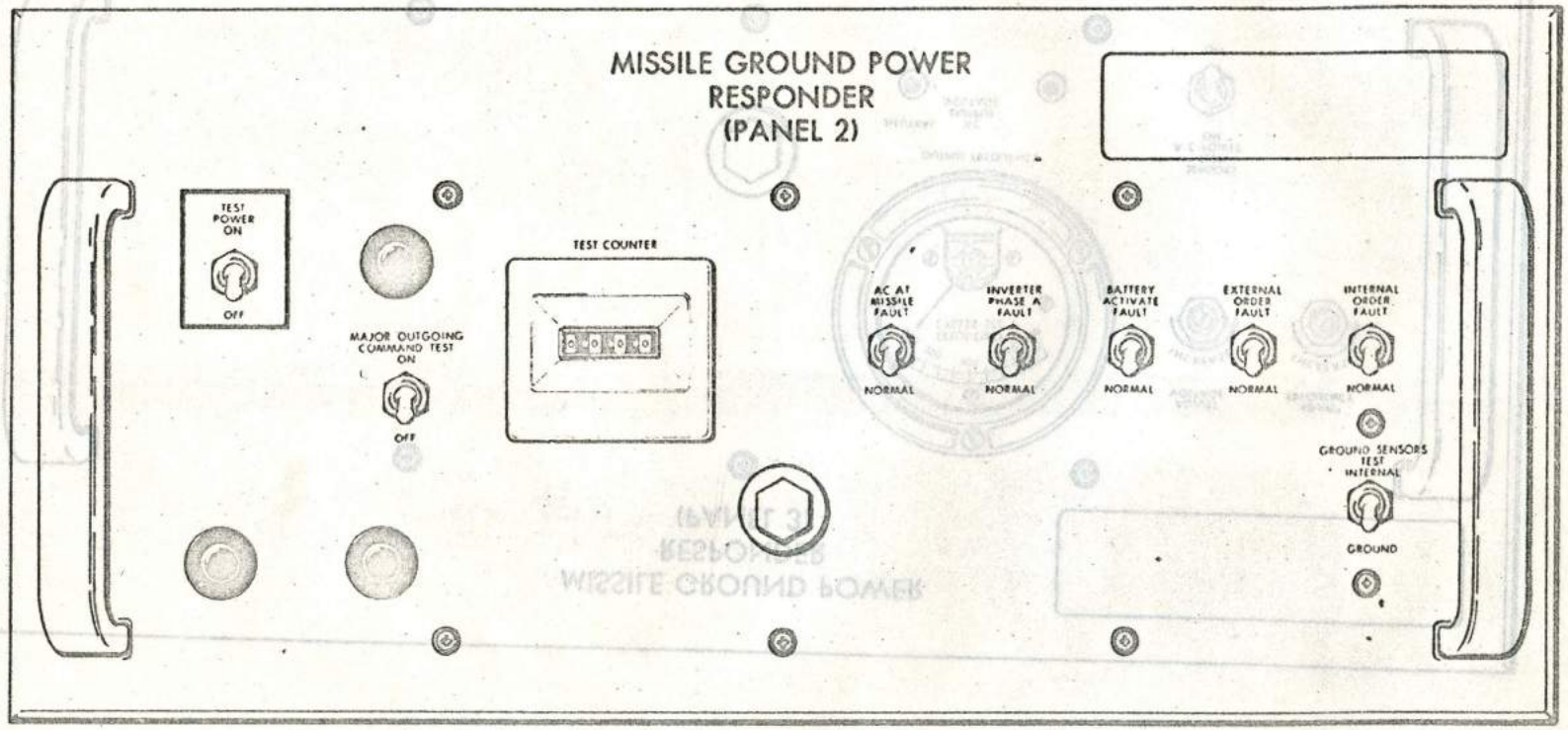


Figure 138 - Missile Lifting Platform Responder (Panel 2)

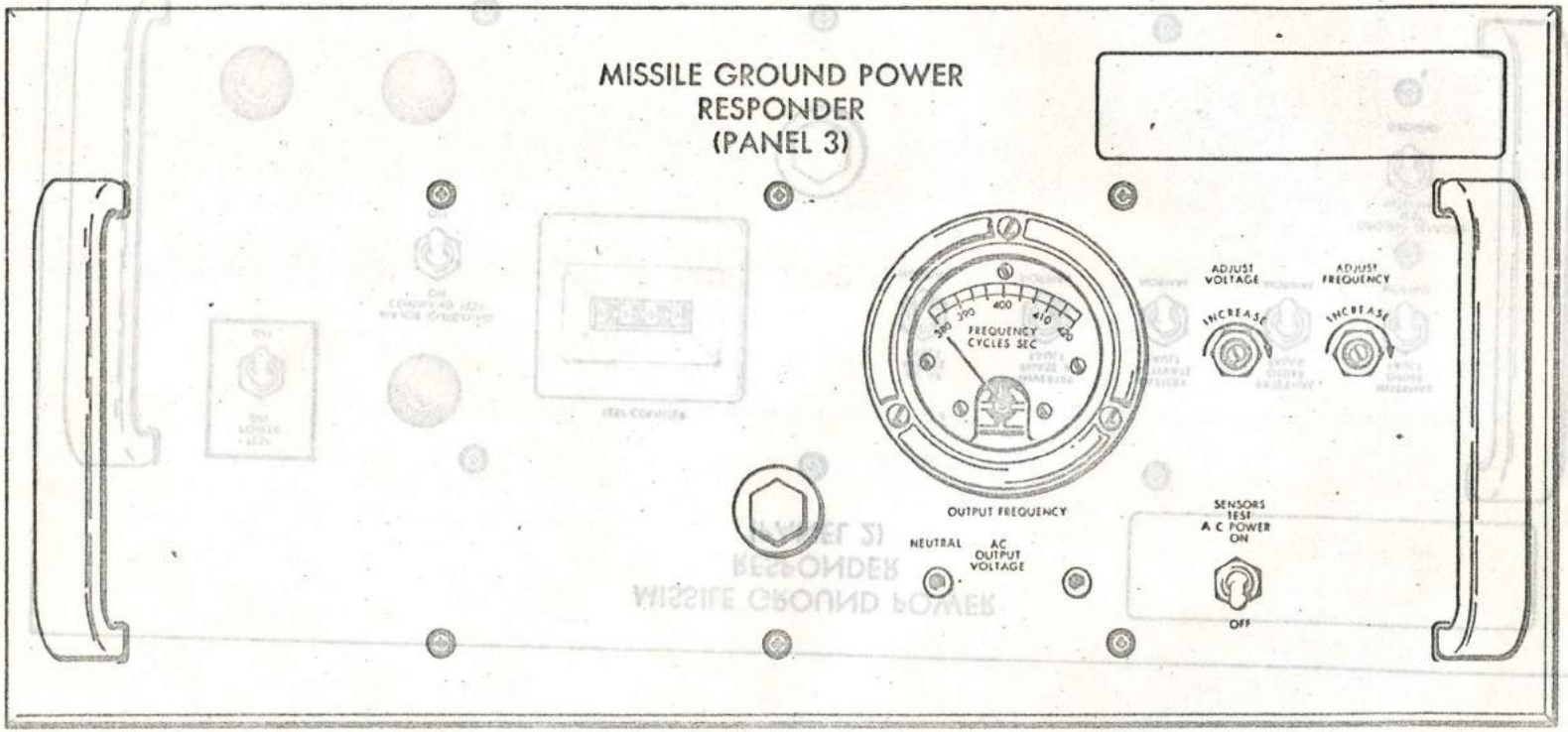


Figure 139 - Missile Ground Power Responder (Panel 3)

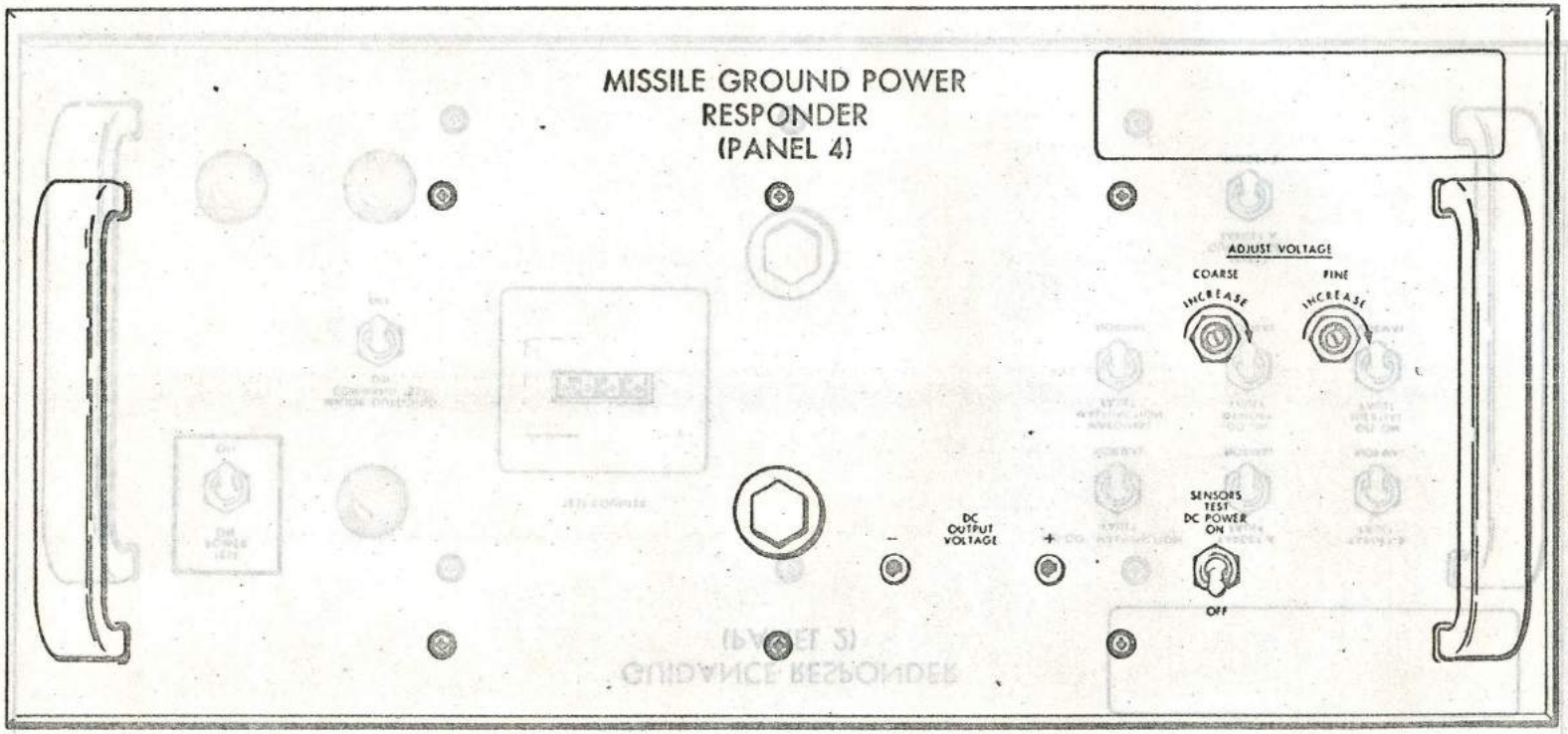


Figure 140 - Missile Ground Power Responder (Panel 4)

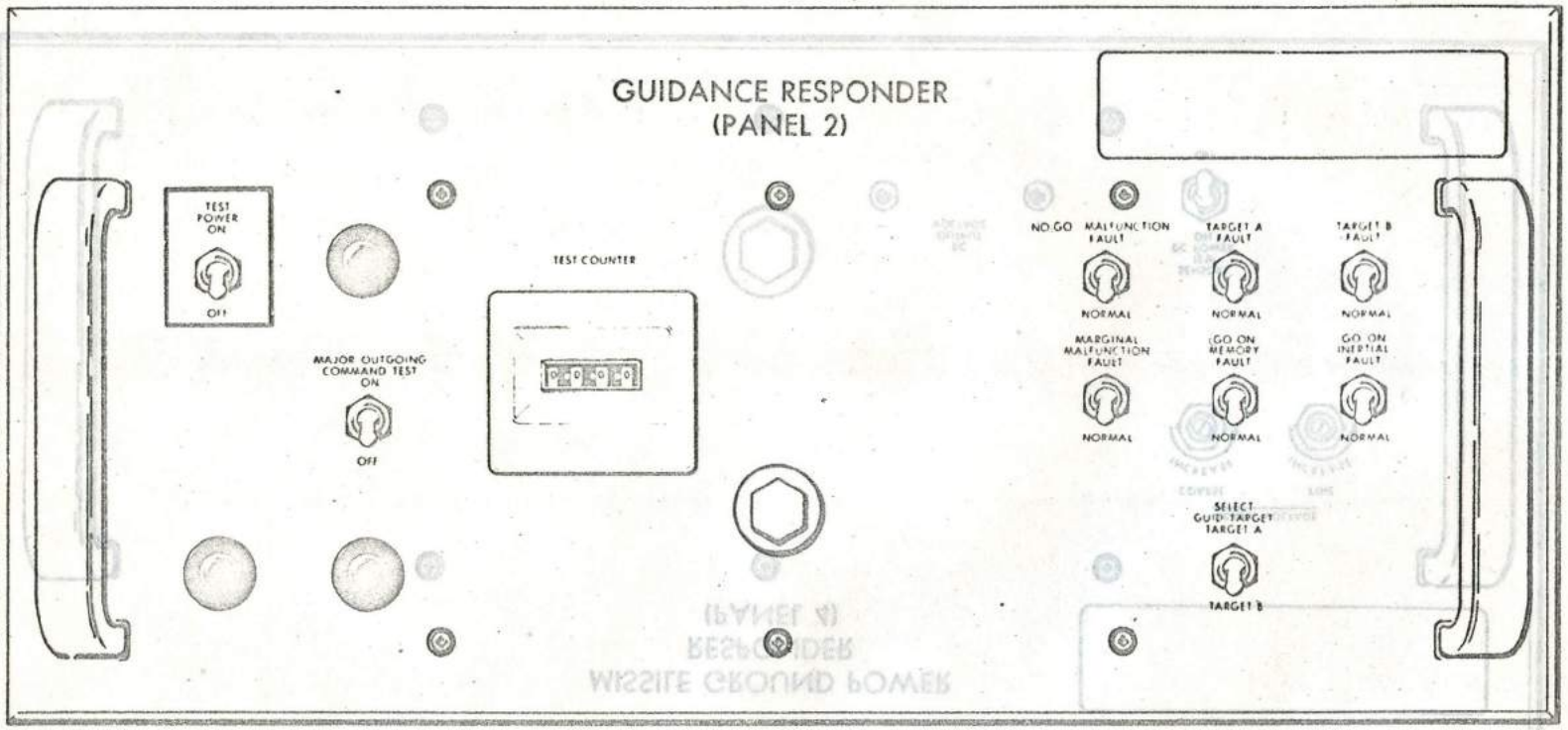


Figure 141 - Guidance Responder Panel 2

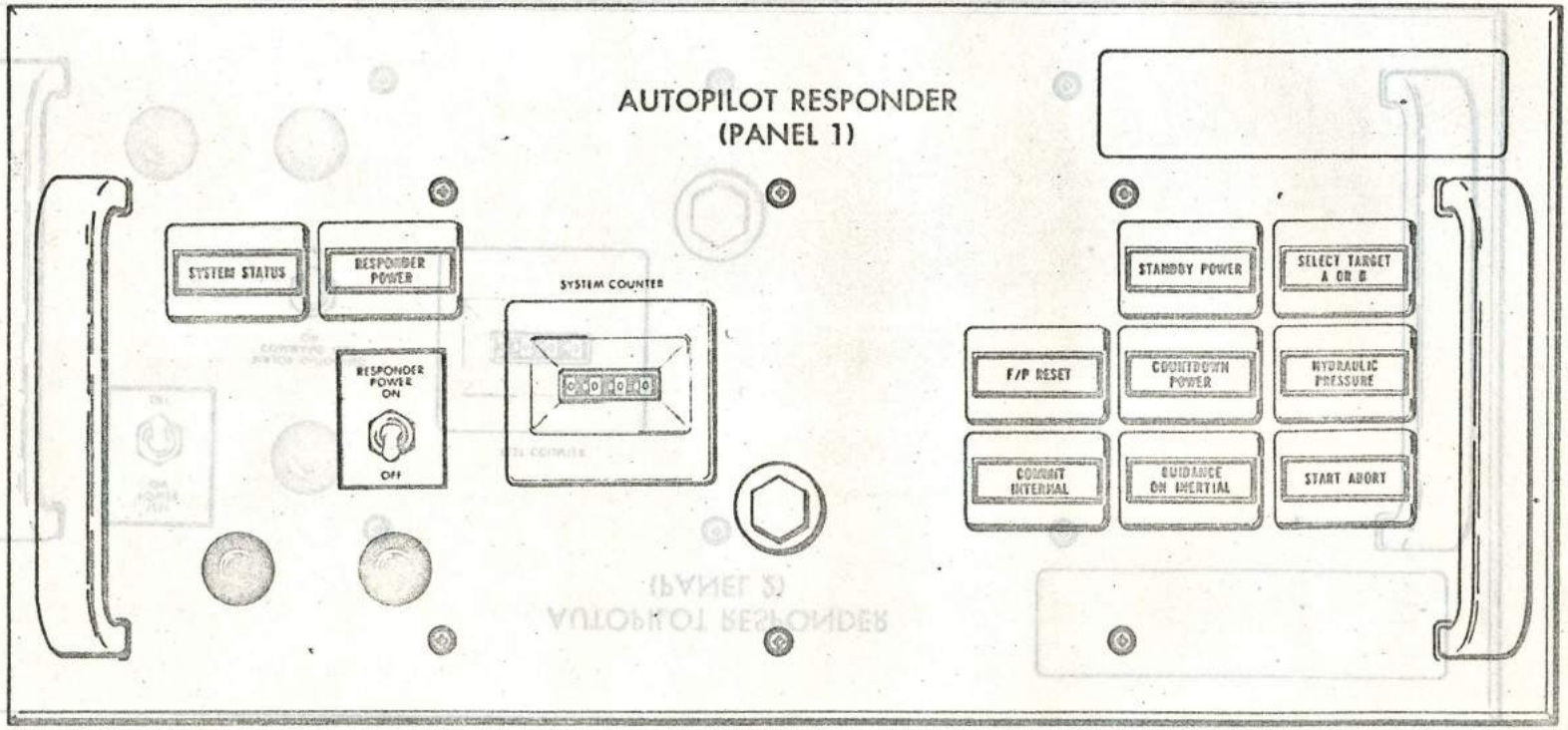


Figure 142 - Autopilot Responder (Panel 1)

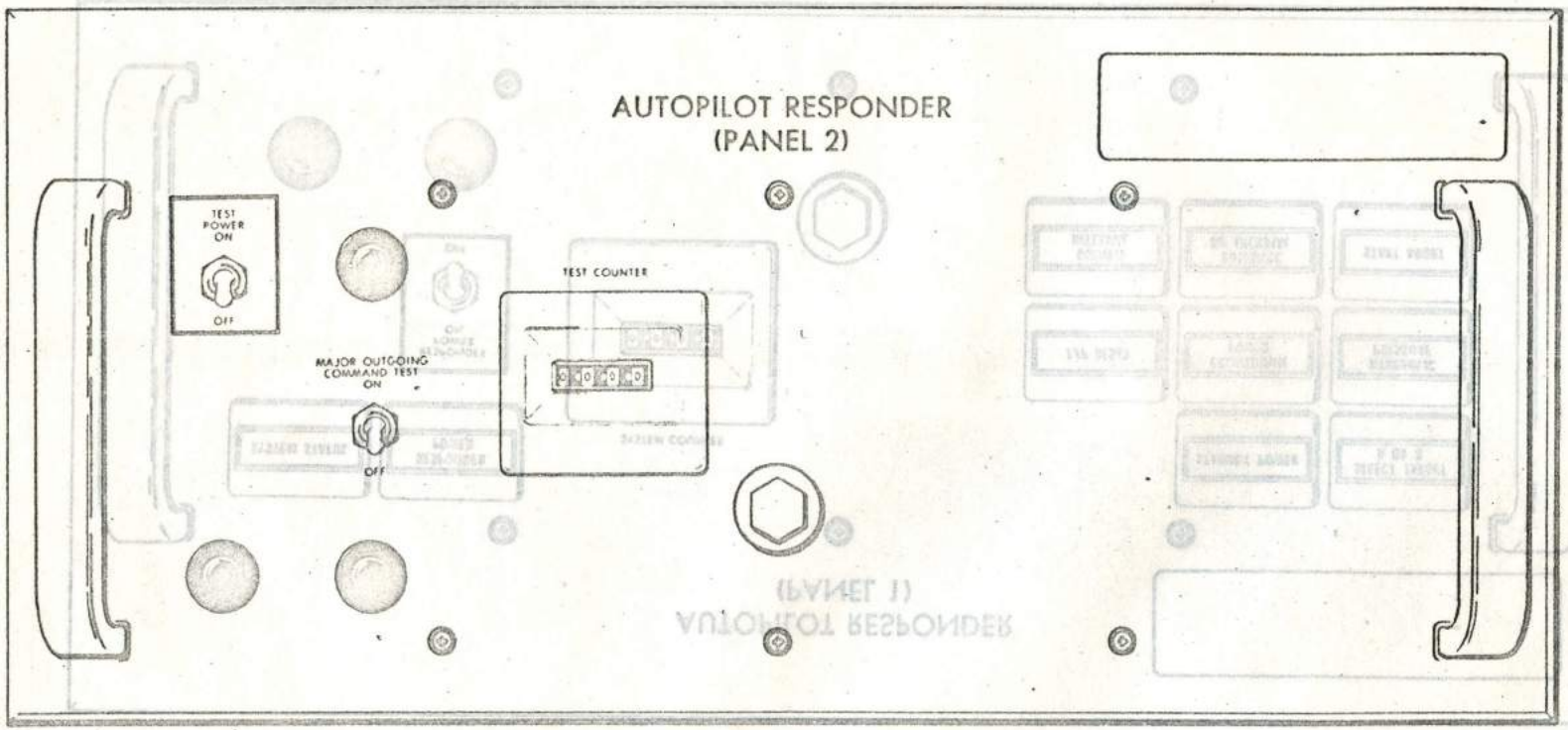


Figure 143 - Autopilot Responder (Panel 2)

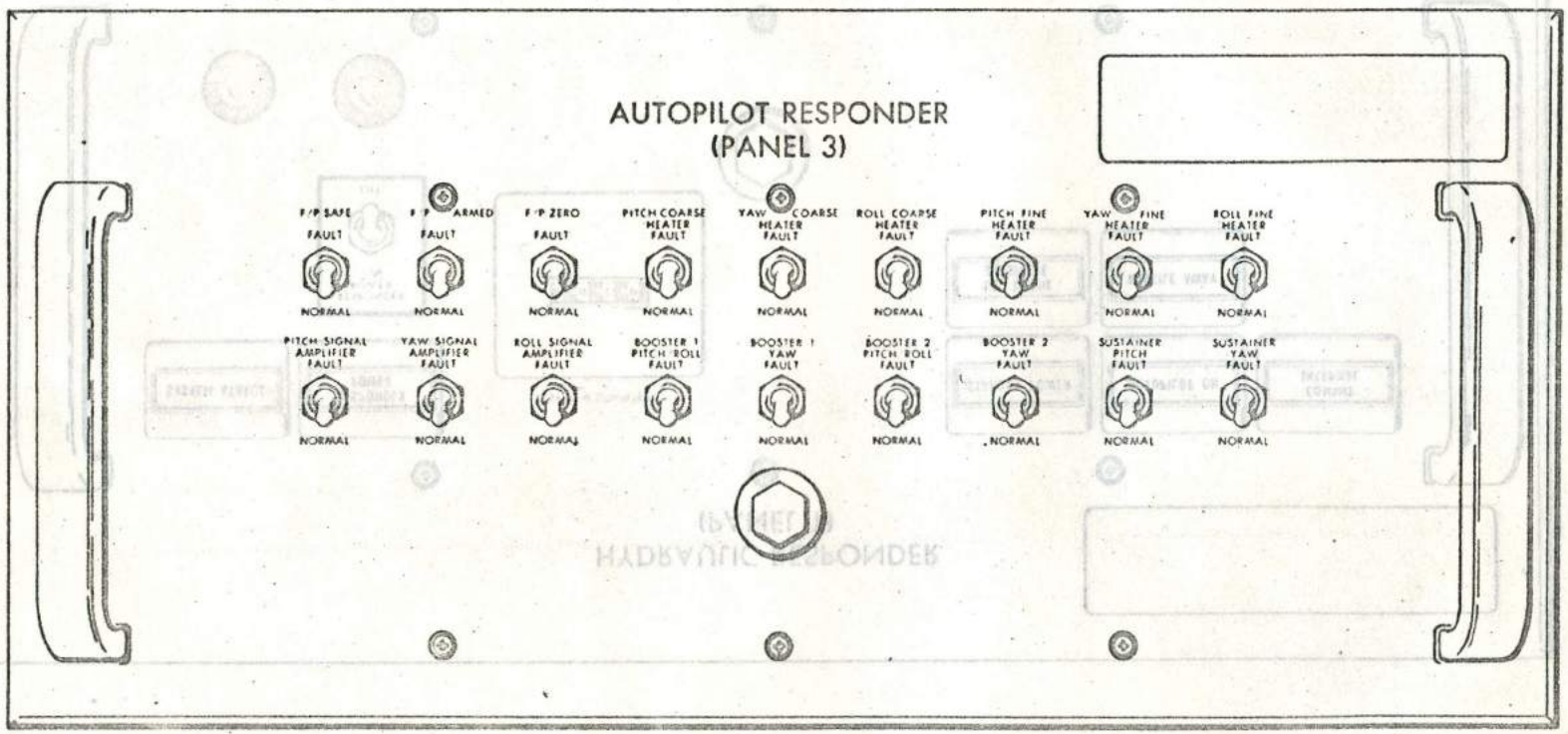


Figure 144 - Autopilot Responder (Panel 3)

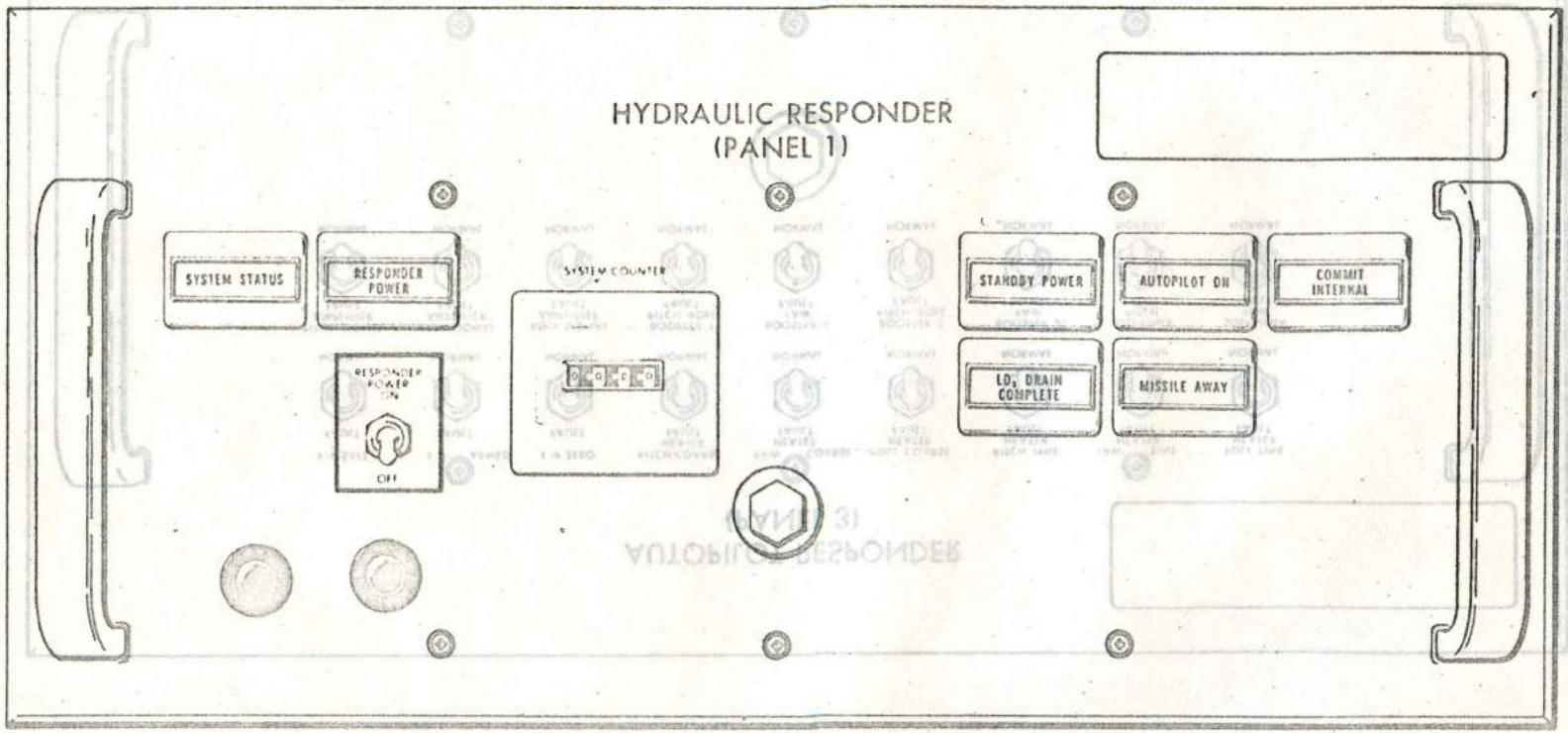


Figure 145 - Hydraulic Responder (Panel 1)

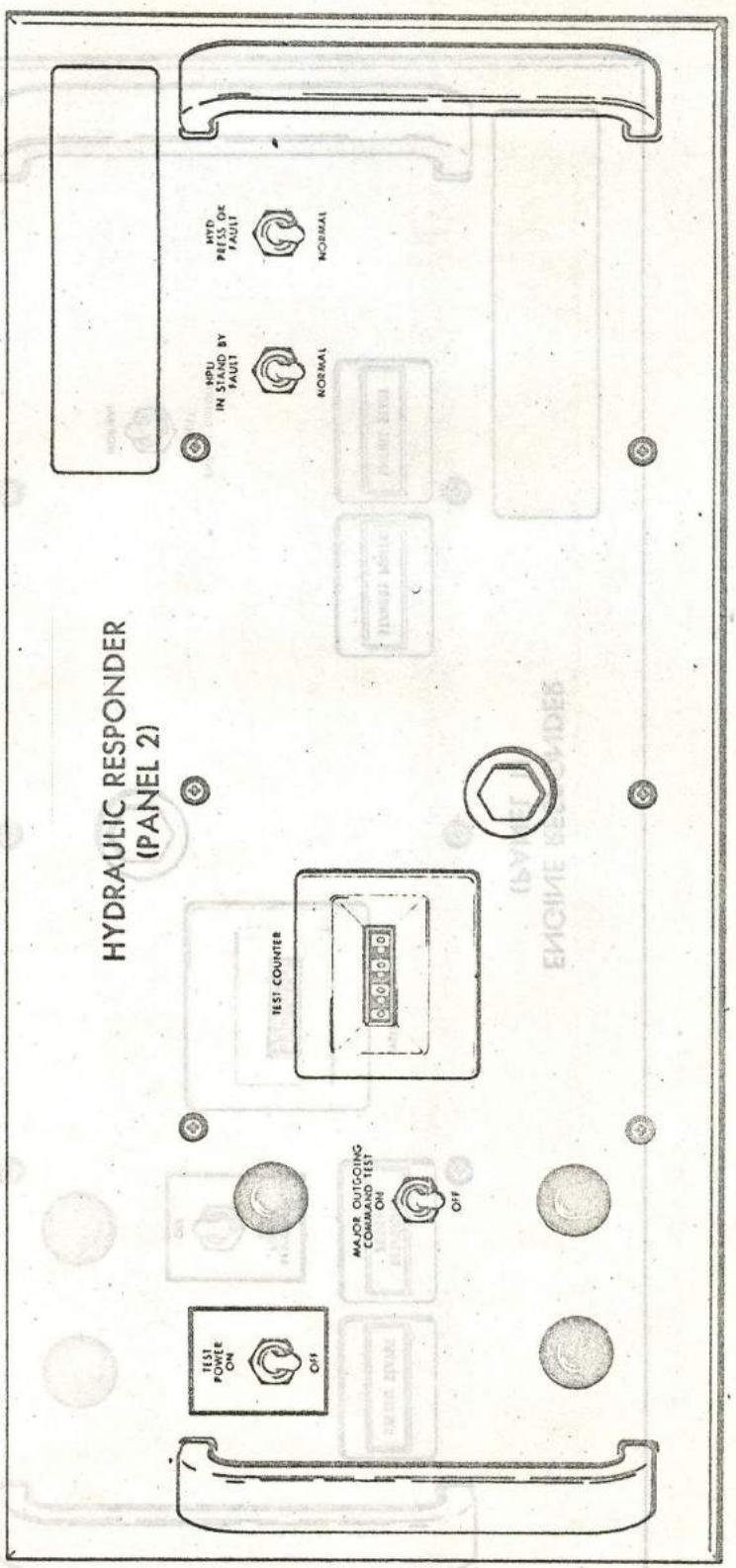


Figure 146 - Hydraulic Responder (Panel 2)

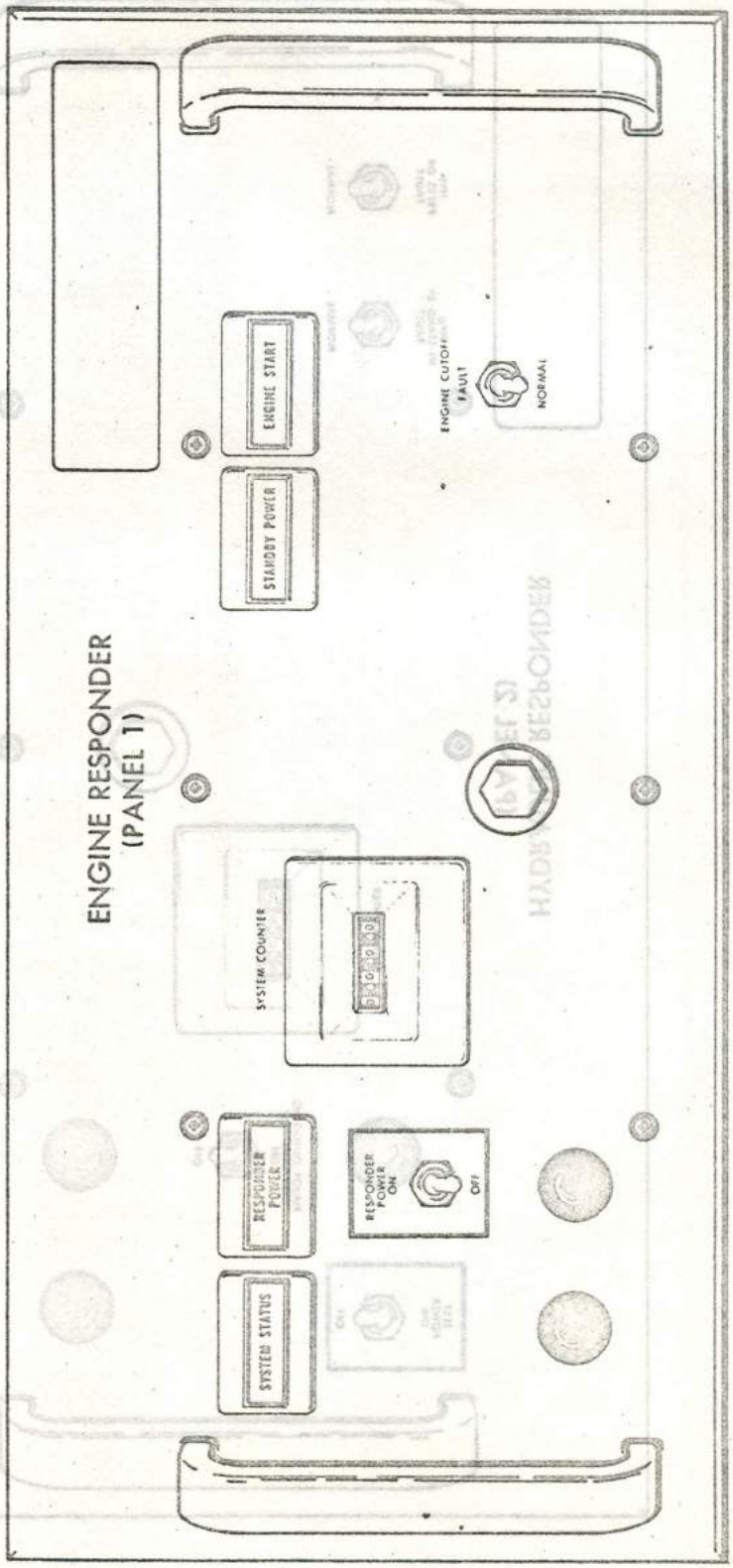


Figure 147 - Engine Responder (Panel 1)

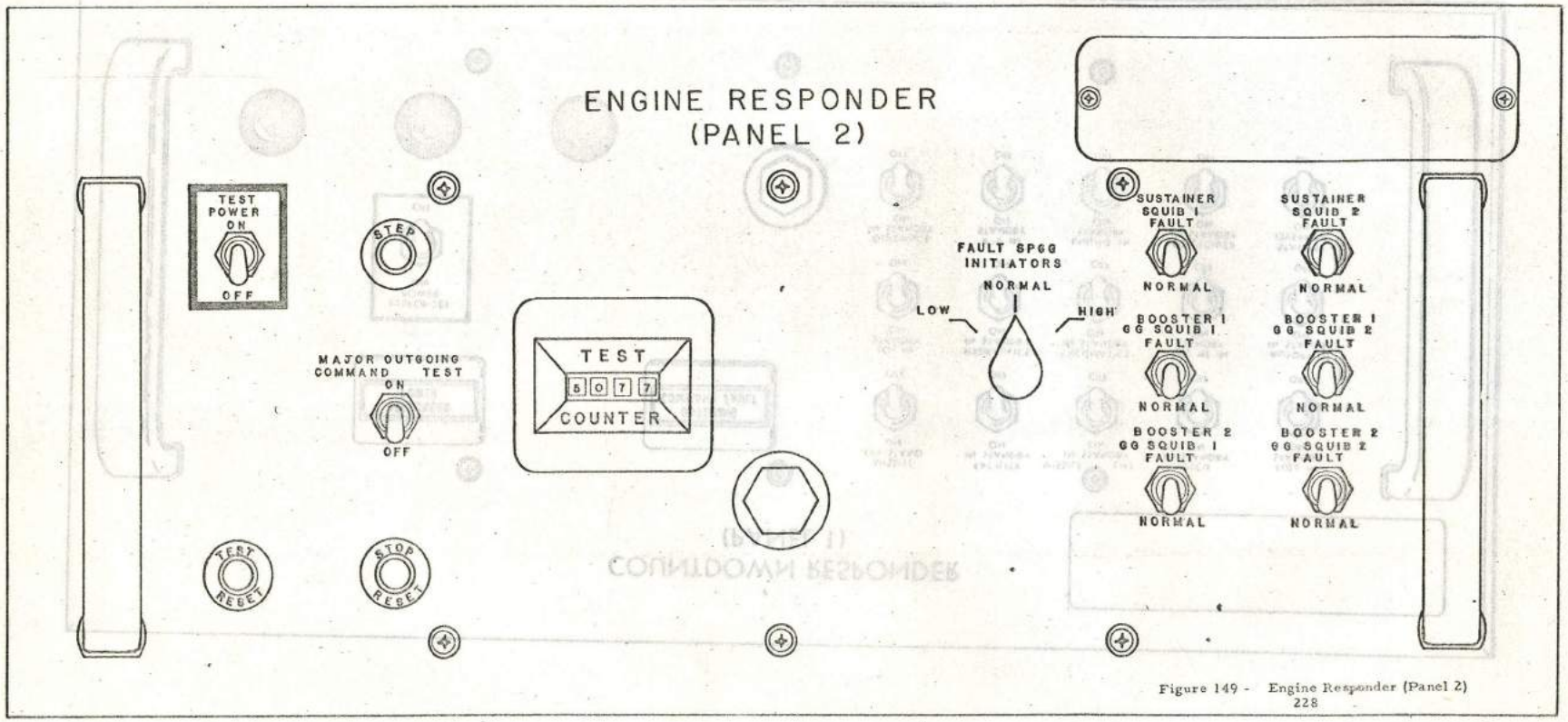


Figure 149 - Engine Responder (Panel 2)
228

Figure 148 - Engine Responder Panel 2

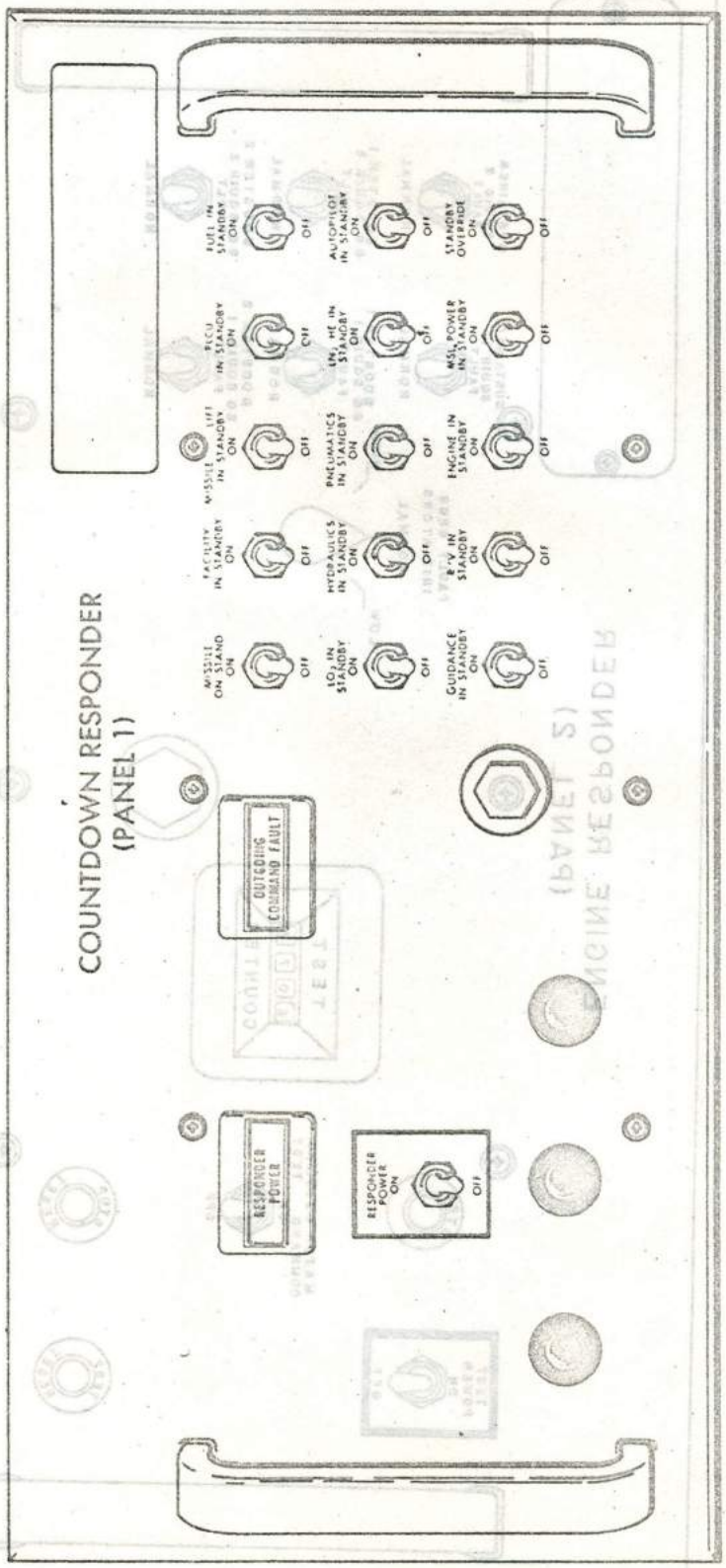


Figure 149 - Countdown Responder (Panel 1)

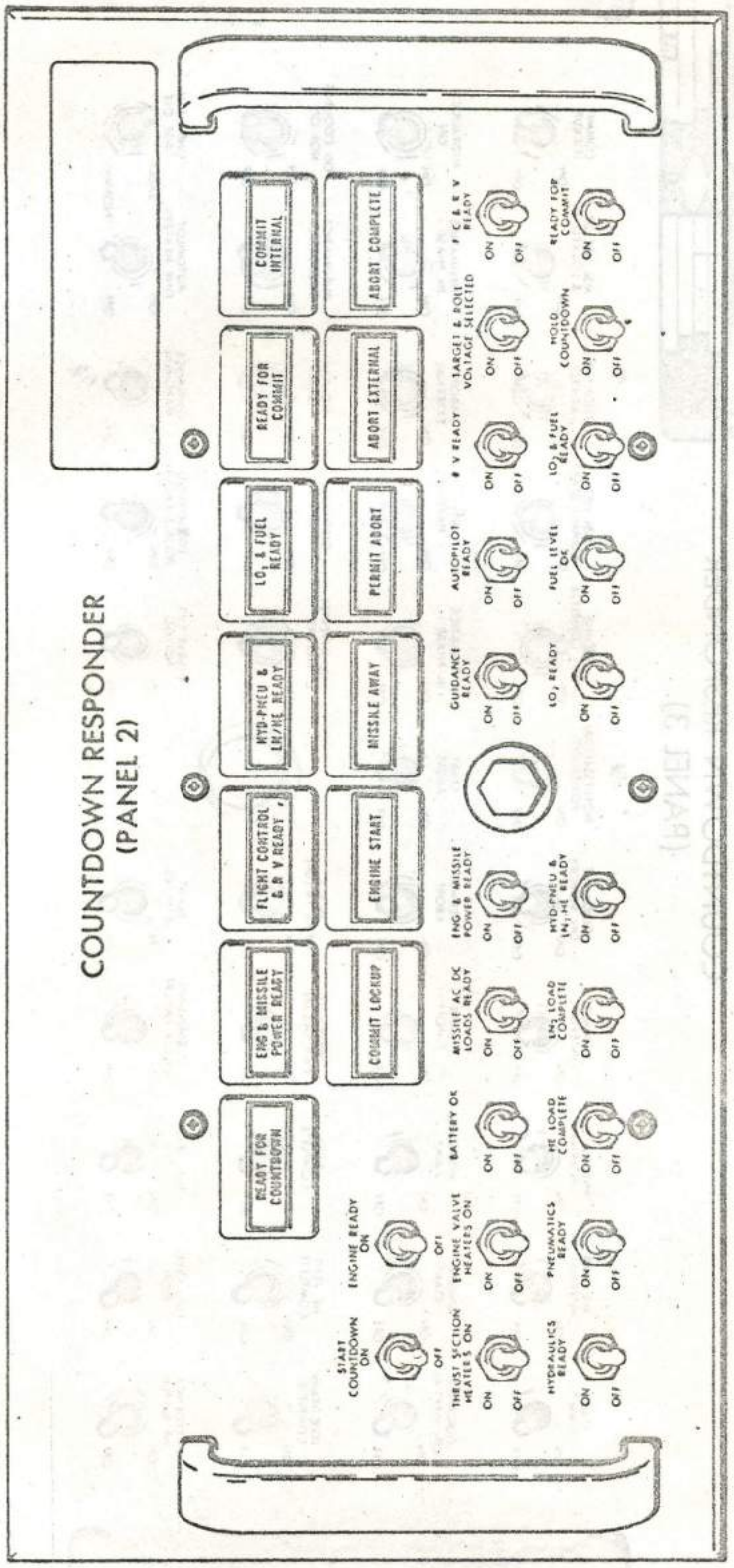


Figure 150 - Countdown Responder (Panel 2)

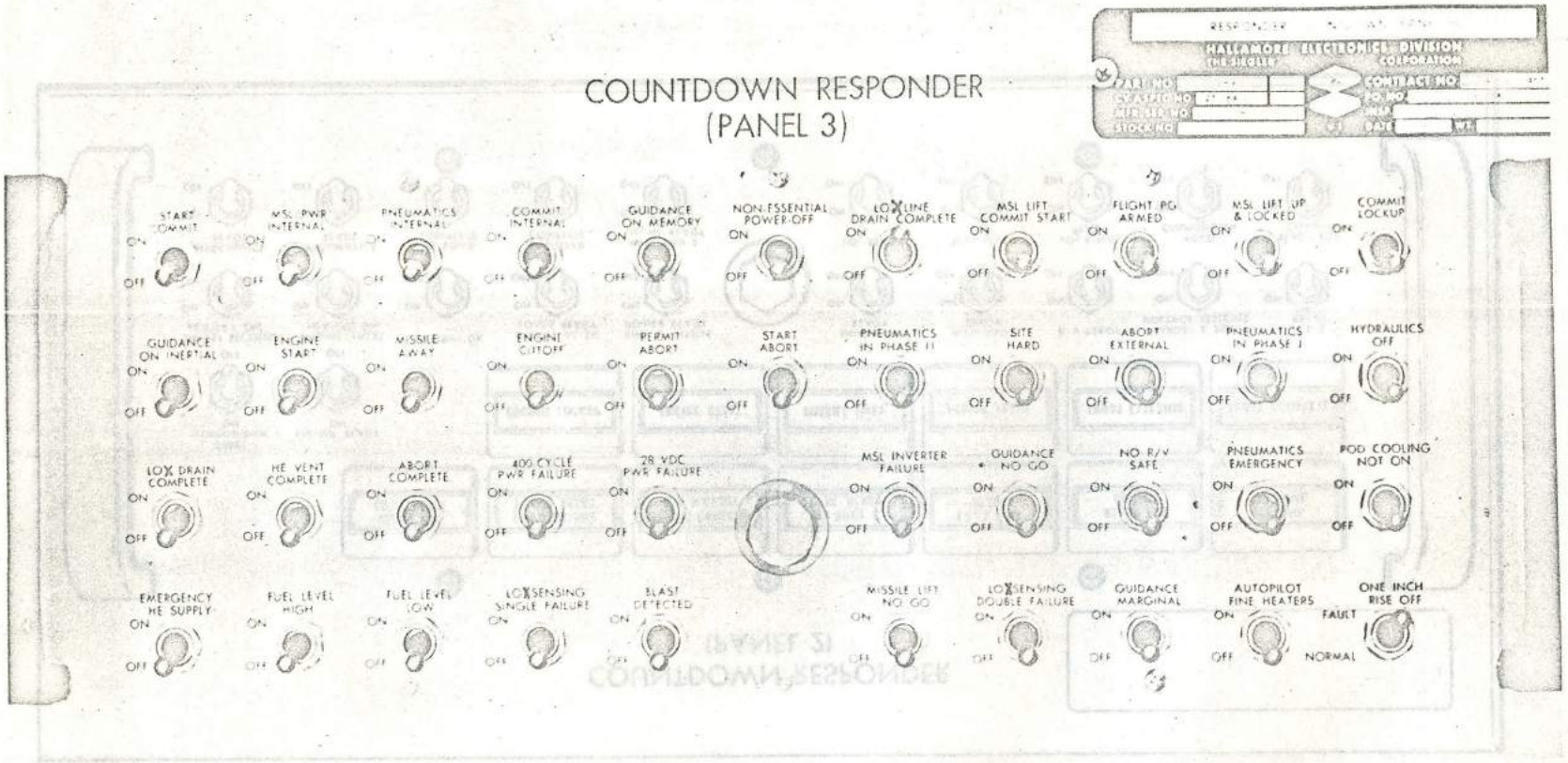


Figure 151 - Countdown Responder (Panel 3)

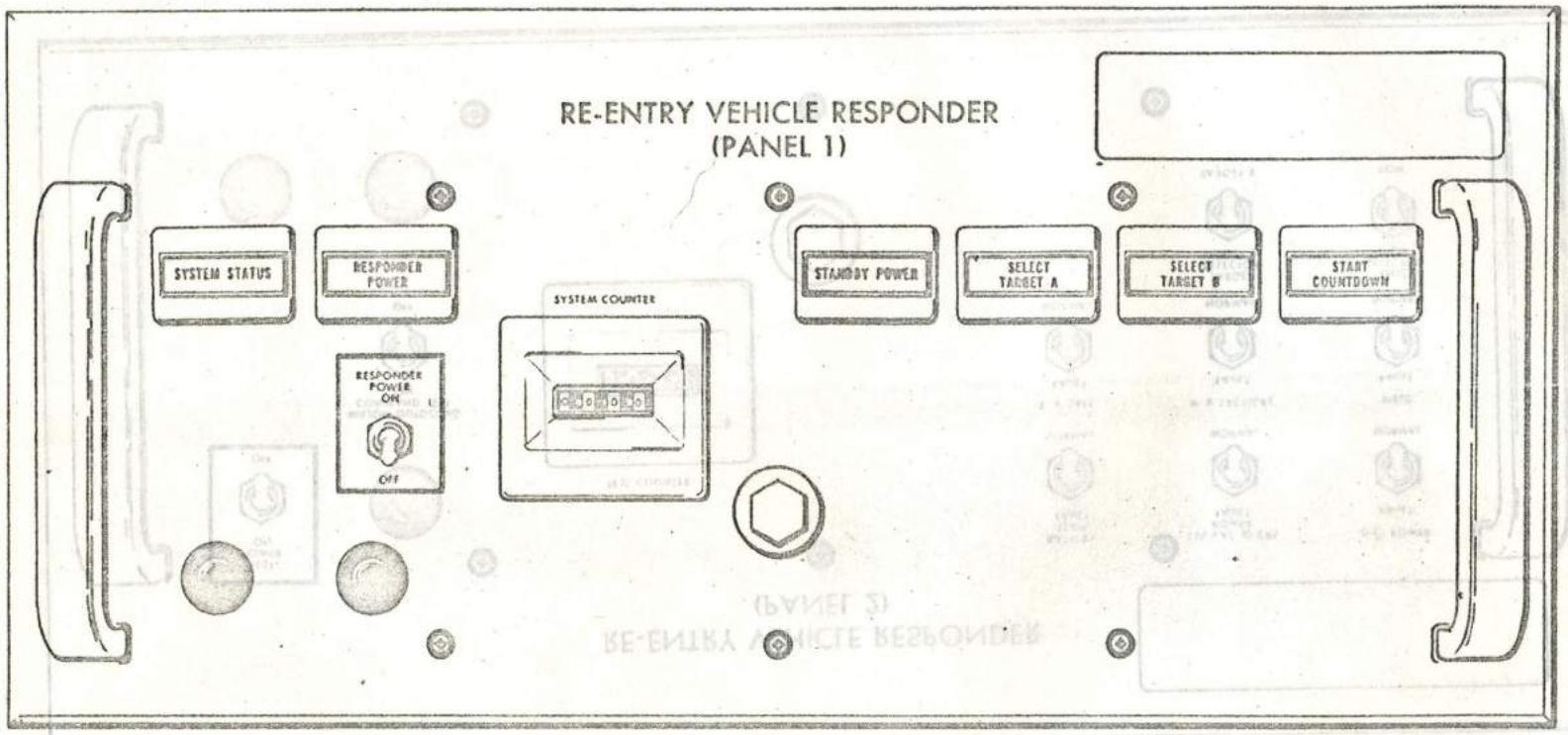


Figure 152 - Re-Entry Vehicle Responder (Panel 1)

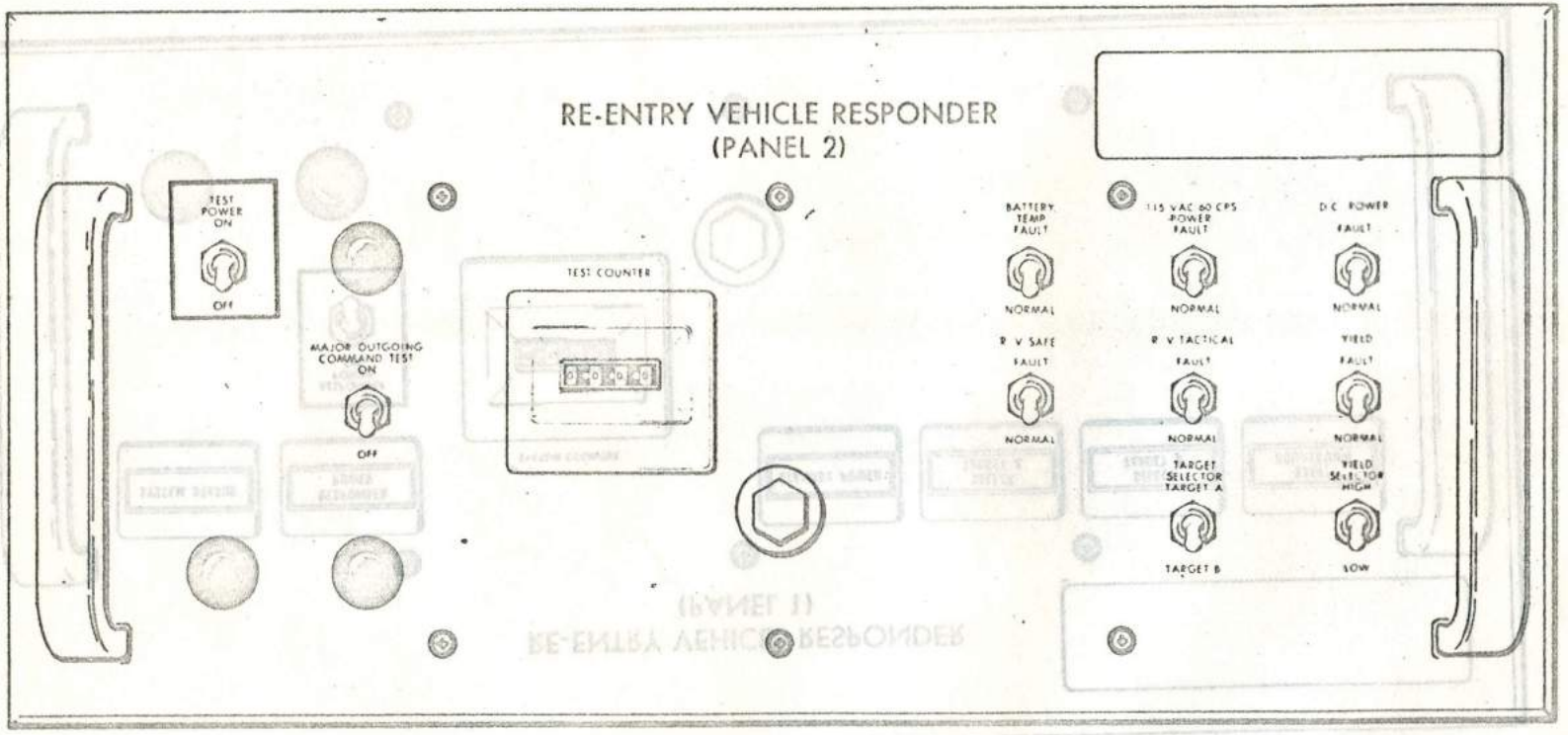


Figure 153- Re-Entry Vehicle Responder (Panel 2)

DEFINITIONS

1. Logic Unit - A master control device containing the necessary circuitry to control the launching or abort sequences of all missile and all OGE subsystems.

2. Subsystem Sequencer - A functional division of the Launch Control logic units into subsystems such as:

   Pneumatic Subsystem sequencer.

   LOX Subsystem sequencer.

3. End Component - A piece of OGE or missile equipment (outside the logic units) which controls a process upon receiving commands from the subsystem sequencer.

4. Process - A process is defined as a series of actions or changing conditions controlled by the end components such as:

   Pressurizing

   Filling with LOX or fuel

   Activating a battery

   Heating gyros

5. Launch Signal Responder (LSR) - A device containing the necessary circuitry to simulate the OGE and missile end components, and check the sequence of operation of the logic units.

6. Responder subsystem - A functional breakdown of the LSR by subsystem analogous to the subsystem sequencers.

7. Major Command - An interface signal between sequencers in the launch control logic units.

8. Major Incoming Command - A major command received by a subsystem sequencer.

9. Major Outgoing Command - A major command sent out by a subsystem sequencer.

10. Minor Command - A control signal to an end component in the missile or OGE.

11. Process Condition - A term which defines the status of the process such as:

    LOX tank full

    Pressure rising

    Doors open complete

    Elevator rising

12. Response - A signal from an end component indicating a specific condition of the end component, or of a process condition.

13. LSR Interface Signal - An interface signal between LSR subsystem analogous to the major commands in the logic units.

14. Subsystem Sequencer Step - A term describing a discrete change in one or more of the minor commands which will be maintained over a definite period of time.

15. Subsystem Sequencer Step Number - Steps will be numbered in time sequential order.

16. Subsystem Sequencer Step Name - The name of a process and whether it is being pre-conditioned started, or stopped.

17. Internal Sub-Routine - A logic operation generated and used entirely within a subsystem sequencer to initiate a subsystem sequencer step.

18. Subsystem Matrix - A subsystem matrix is a rectangular arrangement of terms describing the position of the subsystem's end components at each subsystem sequencer step, in vertical columns and in horizontal rows.

19. LSR Relay Matrix - LSR relay matrix is a subsystem matrix representing the end components position in terms of relay operations.

20. Subsystem Sequencer Status - A term describing one of the three phases of the launching sequence, or the abort sequence:

    Standby
    Countdown
    Commit
    Abort

21. Major Commands Routed Through Sequencer - This term refers to major incoming commands that are not used to initiate any change in a subsystem sequencer, but are changed in meaning (by the addition of a relay contact or contacts) and transmitted to another subsystem sequencer.

SUMMARY:

The launch control equipment associated with the "F" Series Atlas missile is made up of five units. These units are the launch control console, logic unit NO. 1, logic unit NO. 2, launch signal responder unit NO. 1, and launch signal responder unit NO. 2.

The launch control console is the only console necessary to complete a launching sequence. This console consists of all controls and status indications necessary for one operator to launch the missile. The console is located in the launch control center.

The units responsible for monitoring and controlling all missile-borne and OGE subsystems during standby and countdown are known as logic units one and two. These units, referred to as sequencers, are located on the third level of the silo.

Two other units, known as launch signal responder NO. 1 and launch signal responder NO. 2, are responsible for checking the proper operation of the Relay Logic Units and the Control Panel. They may also be used to exercise the logic units between missile rotation periods, as well as exercising the launch crew.

QUESTIONS:

1. What are the two primary purposes of the launch control system?

2. Give two reasons why it is not possible to "hold" at just any arbitary point during countdown.

3. At what point during countdown is a "hold" possible?

4. How long can a "hold" continue?

5. What are the main pieces of launch control equipment?

6. How many men are necessary to operate the launch control console?

7. How many areas are there on the launch control console? What name is given to the areas?

8. What color combinations are used in the launch control console indicators?

9. How is a "target selection" made on the launch control console?

10. What are the "color" possibilities of the target patch indicators?

11. What is the purpose of the HIGH-LOW indicators in the target patch?

12. What is the purpose of the pressurization patch?

13. With which patch is the audible alarm associated? How do you silence the alarm?

14. What is the purpose of the standby status patch?

15. Give a purpose for the countdown status patch.

16. What does the signal "In Commission" mean?

17. Who sets the "Commission" selector in the readiness patch?

18. In which patch are the lamp test buttons located?

19. What are the two purposes of the relay logic units?

20. How many logic units are there? How many panels in each unit?

21. What are the two operating modes that are possible with the logic unit sequencers?

22. What three categories of signals can a subsystem sequencer generate?

23. What chassis drawers does logic unit NO. 1 contain? Logic unit NO. 2?

24. What is the purpose of the launch signal responders?

25. What two steps must be followed in order to perform an LSR check?

26. Give three functions of the LSR's during checkout.

27. What steps must be followed in preparing for a responder checkout?

28. At what point during countdown is the inverter started?

29. When does the autopilot subsystem start arming the flight programmer?

30. What summary is necessary to get a "Missile Battery Activated" AMBER?

31. What summary will cause a "Hydraulic Pressure" GREEN?

32. What does a "LOX Commit" AMBER indicate?

33. If a start abort signal is present, will the "Programmer Armed" indicator illuminate AMBER?

34. What will cause a "Missile Away" GREEN indication?

35. What summary is necessary to give an "Abort Complete" GREEN indication?

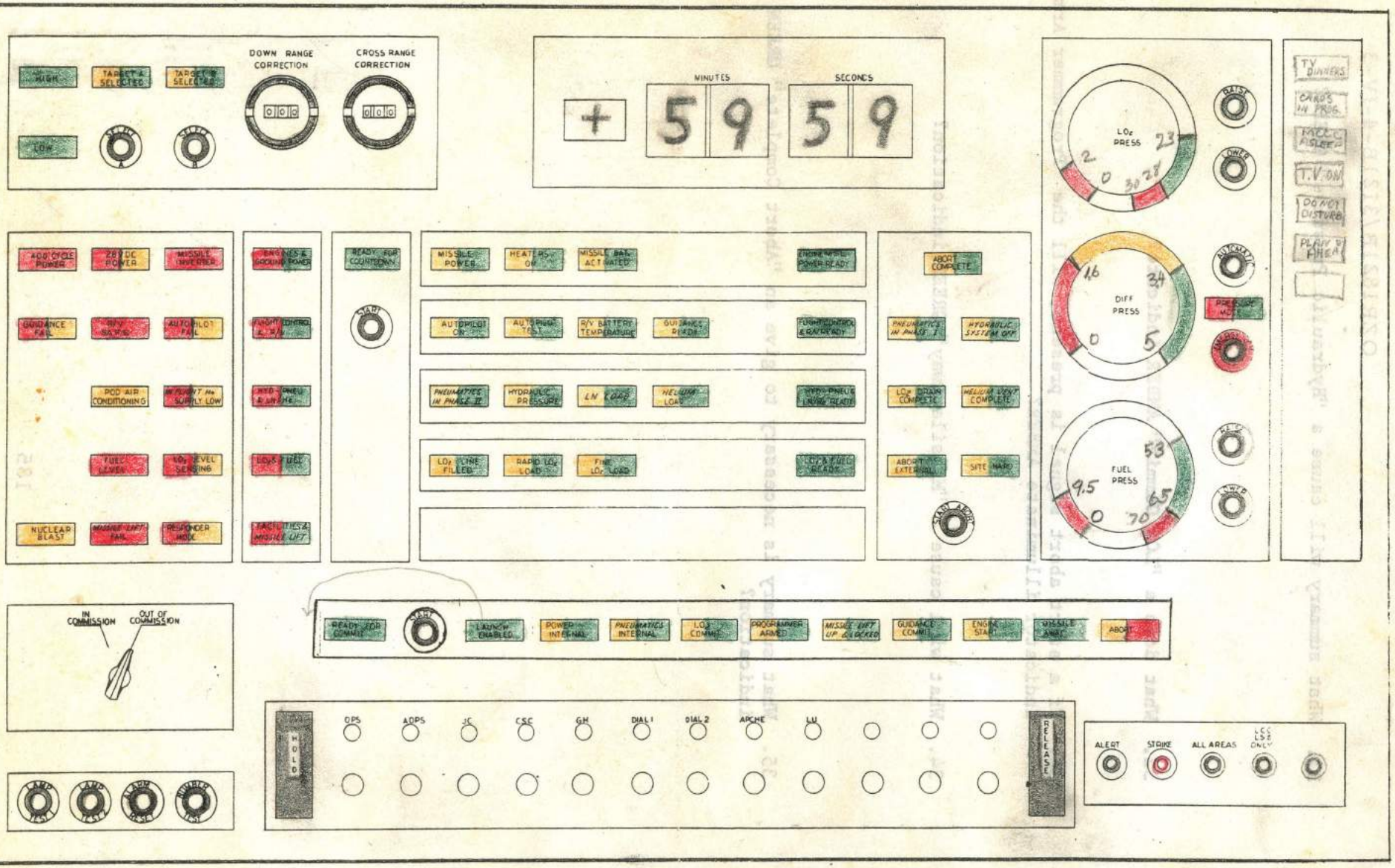


Figure 154 - Launch Control Console - Silo