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ENGINEERING ANALYSIS

J-3 PAYLOAD SYSTEM CHECKOUT CONSOLE

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1.0 INTRODUCTION

The J-3 Payload System Checkout Console is used at A/P in System Test and at the launch base in the Payload Checkout Trailer. The console simulates the Agena orbital vehicle for performing the System Functional Test of the J-3 Payload System. The console:

a) Provides power for the tests.

b) Simulates Agena commands.

c) Monitors payload response to commands.

d) Monitors payload bus voltage and current under static and dynamic loading conditions.

e) Measures TM data points by selection.

f) Interfaces with AGE recorders for recording TM data.

Existing J-1 System Checkout Consoles were capable of performing the above functions for the J-1 system. Accordingly, the J-3 Program Ground Rules specified modification of the existing consoles to accommodate the J-3 system.

2.0 SYSTEM DESCRIPTION

2.1 Console Description

The J-3 Payload System Checkout Console consists of a three-bay, slope-front enclosure mounted on casters and containing the following assemblies:

a) Power Supply, 115 VAC 400 Hz, -Behlman-Invar	Model 161A
b) Power Supply, +28 VDC Unreg. 50A, - Perkin	Model TVR 28-50
c) Power Supply, +28 VDC Reg., 10A, - Kepco Lab.	Model SC 32-10A
d) Power Control Panel	T8-2656
e) Command Control Panel	T8-2664
f) T/M Monitor Panel	T8-2674
g) Interface Test Panel	T8-2681
h) Patch Panel	T8-2651
i) Digital Voltmeter - Non-Linear Systems	Model V-44

The panel arrangement of the console is shown in Figure 1. Figure 2 is a block diagram of the console.

2.2 Associated Equipment

When used at A/P System Test to perform the functional system test, the console is used with:

a) Automatic Programmer Console	T8-1428
b) Pyro Resistance and Continuity Checker	T8-2750
c) Pyro Load Test Console	T8-2710
d) Sanborn Recorder Console	Model 850
e) Dymec Console	T8-2300
f) Frequency Standard, James Knight	FS 1100T

g) Miscellaneous test aids and cable assemblies.

Figure 3 is a block diagram of the in-house test interconnections between the console and the associated test equipment as used at A/P for the functional system test.

The Automatic Programmer Console provides a tape programmed test sequence. The CTI tape reader and tape handling unit operate conversion relays, which send commands through the J-3 System Console to the payload. The J-3 System Console contains a mode selector switch with which to control the test sequence manually from switches on the system console or automatically from the Automatic Programmer Console.

The Pyro Continuity and Resistance Test Console connects directly to the unit under test. The Pyro Load Test Console connects to the unit under test and to the J-3 System Console, which provides the commands and the power for the load test. The Pyro Continuity and Resistance Test Console measures resistance and checks the continuity. The Pyro Load Test Console measures the stray voltage and loads each pyro circuit in the payload. The J-3 System Console generates the necessary commands for these tests.

3.0 FUNCTIONAL DESCRIPTION

3.1 Power

3.1.1 The J-3 system console provides the power to the payload when under test. The Power Control Panel controls this power and provides a

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power distribution system to the payload at the proper interface connector pins. In order that the panel may accomplish the distribution function, the design provides the capability to turn power on and off manually; distribute power to the payload pyro bus, unreg. bus, and 400 Hz bus; protect the branches; indicate the status of lines and loads; measure voltages and currents by panel meters; and monitor the measured values at test points or interface with AGE recorders for recording them.

3.1.2 The console power distribution trees are shown in Figures 4 and 5. For simplification, the figures show only the protection and the loads on each branch and do not attempt to show the control and switching functions. The details of the system may be seen by referring to T8-2660.

All 24 VDC unregulated power is switched and protected by five branch circuit breakers. Two breakers, CB 1 and CB 2 with 15A elements each, in parallel supply the payload 24 VDC unreg. bus. Two others, CB 3 and CB 4 with 10A elements each, in parallel supply the payload pyro power. The fifth breaker supplies the console power, consisting of relay power, status light power, and Pyro Load Test Console status light power.

The 115 VAC power requirement is less than 1A. Consequently, no overload protection is provided. The 115 VAC power is switched on by SW-2, a pushbutton switch, and is interrupted in case of an instrument failsafe by relay K2. Single-phase power from the console power supply is branched, as shown in Figure 6, to provide the ØA and ØC power to the payload. Current in each phase is monitored on the Power Control Panel by panel meters and test points.

3.1.3 The 24 VDC unreg. power to the payload is backed up, in the event of a power failure, by the Emergency Power Back-Up -- a battery power supply cart. Voltage from both the 24 V unreg. power supply and the back-up are applied as bucking voltages to the element of a line circuit breaker on the cart. In normal operation, the 24 V unreg. passes through the breaker contacts which are between the console power supply and the console Power Control Panel. If a power failure should occur, the current from the back-up would open the circuit breaker and supply 24 V unreg. to the payload from the batteries.

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3.1.4 A failsafe circuit, partly in the console and partly in the Boston equipment, protects the CR Instruments in case either one "fails safe." The wiring for the failsafe circuit is shown in Figures 7 and 8. The failsafe signal is a ground signal, originating at the payload 24 V unreg. return, and is activated by either instrument closing the shuttle overtravel switch. When a failsafe occurs, the console removes the Operate command to both CR instruments by opening the Pad Operate Command (AP Cmmd. 3) line in the console and automatically sending SPC 28. Concurrently, the Boston equipment gives a Stow signal to the failed instrument. After 10 seconds (adjustable between 5 and 20 seconds), the console removes all power to the payload by removing 24 VDC unreg. and 115 VAC power from the interface. Indicating lights on the console indicate "Fail Safe No. 1" (or No. 2), "Fail Safe On," and command status.

3.2 Pyrotechnics

3.2.1 For pyrotechnic checkout, the console is used with the Pyro Resistance and Continuity Tester Console and the Pyro Load Test Console. The J-3 system console provides commands to both these consoles and circuit breaker status light power to the load test console. Relay power for the pyro commands originates in the system console at the 24 VDC bus. Pyro loading power originates at the console 24 VDC bus and is provided to the payload via interface pyro connector J-20 pins D, L, and K. A typical pyro checkout circuit is shown in Figure 9. A discussion of this circuit is included in this report in lieu of a separate engineering analysis report on the Pyro Load Test Console.

3.2.2 The primary purpose of the Pyro Load Test Console is to demonstrate that, when a firing signal is applied, sure-fire current passes through each squib signaled. Sure-fire current for the M-11 squib, used in the payload, is 2.0 A. The resistance of the pyro circuit of Figure 9 is as follows:

Fusistor:	1.8 ohms
Circuit Breaker:	1.0
Wiring:	0.2 (estimated)
Total:	3.0 ohms

At 24 V pyro firing voltage, the circuit resistance would limit firing current to 8.0 A. This is 8 times the 1A breaker element rating. At 800% of rated load the circuit breaker will break in 15 ms or less. The circuit satisfies the most severe requirements of applicable specifications, which state that the circuitry shall limit to 20 milliseconds maximum the time during which the firing current exceeds three amps.

3.3 Commands

3.3.1 The Command and Control Panel contains the necessary switches and status lights to command the payload during test. A mode selector switch permits operation in "manual" or "automatic" mode. In manual mode the commands are initiated by switchlights and selector switches. In automatic mode the commands are initiated by a CTI punched tape reader on the Automatic Programmer Console. The commands are listed in the console requirements specification, T3-6-067.

3.3.2 Stored Program Commands (SPC or Brush) are ground signals completed to 24 V unreg. return through a mode control relay and either a selector switch and switchlight on the command panel or the brush of the tape reader.

3.3.3 The Real Time Commands (RTC) are also called ANA (S-Band) or UNCLE (UHF) commands, depending upon the ground command transmitter wavelengths. The circuit of Figure 10 is typical for ANA or UNCLE commands. The signals are 24 VDC signals which terminate in the payload at relay coils in the Command Box.

Any one of eight ANA commands, or any one of eight UNCLE commands, can be sent manually by selecting the command on the ANA or the UNCLE command selector switch and pushing an Execute switch. Commands for recovery events can also be given manually by selecting the command on a selector switch and pushing an Execute switch.

3.3.4 A description of the manner in which the payload accepts and processes the commands to control the operation of the payload is contained in Engineering Analysis Report for the J-3 Command Subsystem, T9-6-042.

3.4 Monitor Function

3.4.1 The console monitor function is accomplished by readouts and controls on the Power Control Panel, Command Panel, and T/M Monitor Panel of the console, and by the associated Sanborn recorders and Dymec Console.

3.4.2 The Power Control Panel contains meters and status lights for monitoring payload power. Unreg voltage and current and 400 Hz voltage, ϕA current, and ϕC current are monitored on the meters and test points. Status lights indicate Power On at the unreg 400 Hz and pyro busses, as well as instrument fail safe.

3.4.3 The Command Panel monitors command status by meters and lights. The meters, together with a selector switch and Execute switch, monitor (by a units and fives code), the stepper switch position at the last command received. The status of commands initiated by individual switch-lights is monitored by the switchlights.

3.4.4 The T/M Monitor Panel contains four DC voltmeters with 24-position selector switches for monitoring T/M data. Three meters each display, individually, 20 data points from each of commutator rings A and B, for a total capability of 120 data points. The fourth meter displays continuously monitored data that is not on the commutator. A "Patch 1" or "Patch 2" preselector switch permits individual display of 46 data points on this meter.

3.4.5 Any TM data point can be recorded on a Sanborn recorder by patching the point in the console patch panel.

3.4.6 The Dymec Console measures and records the time periods and rates generated in the payload during the functional system test. It receives C.F. signals from the CR instruments and measures their frequency, recording the values on magnetic tape and printing them out on the digital printer. The console also receives and records up to 25 voltage outputs of the Slope programmer.

4.0 ANALYSIS

4.1 Reliability

As noted in paragraph 1.0, the J-3 Payload System Checkout Console

is a modified J-1 Payload System Checkout Console. In the existing J-1 configuration the console has a record of successfully testing a number of payloads which have subsequently been successfully flown. This record establishes confidence in the design philosophy of the console and in the hardware from which it is made. Modifications to the console are made with high-quality parts made for the aerospace industry by leading manufacturers; and are selected from the LMSC Preferred Parts List or conform to applicable military specifications.

4.2 Failure Modes

A payload, during its life through test and flight, is subject to three categories of failure modes:

a. "Critical Failure Mode," or one which results in the termination of the mission primary objective

b. "Major Failure Mode," or one which results in damage to the payload due to a failure of the checkout console

c. "Minor Failure Mode," or one which results in a departure from established standards or specifications but has no significant bearing on the effective use or operation.

From these definitions, it can be seen that under the conditions in which the system checkout console is used only "major" failure modes need be considered. It is an important function of the system console, in the event of a failure in the payload, to protect the payload from further damage. This function may be best analyzed by discussing the protective features of the constituent circuits.

4.2.1 The power control circuit contains the circuit breakers that protect the payload from overload or short circuits in the 24 VDC unreg. circuits.

Two circuit breakers with 15A elements each, or a total of 30A, supply the unreg bus. The element rating selected is the minimum available which would hold in during normal operating loads. The breaker is also capable of sustaining the instrument starting surge without tripping.

The firing current in individual pyro circuits is limited to 8.0 A, as described in paragraph 3.2.2. The maximum number of simultaneous squib firings required by the payload sequence of events is 10. Thus, the maximum pyro load test current would be 80 A. The 28 VDC power supply, being current-limited, will put out a maximum of 55 A. This is ample to load the 10 squibs to sure-fire current. The circuit breaker element rating of 20 A will trip at 55 A in 20 ms. These breakers provide a back-up to the individual Pyro Load Test Console breakers which trip in 15 ms or less.

The console power, which is protected by circuit breaker CB 5 with an element rating of 15 A, consists of the following estimated loads:

Console Status Lights:	4.2 A	
Console Control Relays:	7.0	(Includes 6 A load during in-flight reset)
Load Test Console Lights:	3.0	
Total:	14.2 A	

The 15 A element is adequate to protect the circuit.

4.2.2 The failsafe circuit performs the important function of preventing a major failure mode by protecting a failed instrument from damage. Operation of the failsafe circuit is described in paragraph 3.1.4. The primary operation for the protection of a failed-safe instrument is the immediate stopping of the instrument by the Stow signal. This signal is provided by Boston equipment in the payload. Once the failed instrument is stowed, it is safe from damage. Control and indicating features of the console serve as backup devices and provide controls for the removal of power from the interface. Lights indicate the failed safe condition to the operators. The initiation of BR 28 command, the interruption of A/P Command 3, and the removal of power from the interface are accomplished either automatically or manually by the console.

4.2.3 The command circuits are 24 VDC relay control circuits. Figure 10 shows the command circuitry. A major failure mode is not likely to occur in a relay control circuit. Although highly improbable, the payload could be damaged by an operator giving commands out of sequence. One possibility is to operate the system in the "A" Mode after "A" to "B" Transfer. Although

this is highly unlikely during normal operation, this situation can arise if "Failsafe" occurs during the "B" mission. Attention to test procedures is required. The System Test Console does not have any features to automatically prevent out-of-sequence commanding because of the extensive effort required. The system console does have an "automatic mode" of commanding using punched tape program which greatly reduced human error.

Operational failures could occur by the failure of a relay to function. If a relay fails to operate, or a stepper switch fails to step, the command has not been received. Command verification is provided on the console by the command readout selector switch. TM data, indicating command status, can also be monitored on Sanborn recorders patched to the console.

The console UHF and S-Band command circuits do not actually simulate the signals transmitted by the Agena vehicle. The Agena commands are pulses. The console commands are pulses only to the extent that the Command Execute switch is a momentary contact switch which can be "pulsed" by an operator. For a meaningful checkout of the stepper switches, which are stepped by the Command Pulses, an AGE pulse generating devise to simulate the Agena Command has been built.

4.2.4 The monitor function is described in paragraph 3.4. Monitor circuits provide the necessary display and readout (of the condition of the unit under test) to warn the operators of any test anomalies which might result in damage to the unit. There are no failure mechanisms in the monitor circuits which might cause a major failure mode.

4.3 Conclusions and Recommendations

4.3.1 The J-3 System Checkout Console is a satisfactory equipment. It is designed to perform the system functional test of a payload system and to protect the payload under test. It will satisfactorily perform this function.

4.3.2 The Model TVR 28-50 power supply, because of its 55 A maximum current-limited output, has a marginal capability for short-circuit protection. When in use, the current limiter should always be set for maximum current.

Circuit breaker elements with the lowest rating consistent with the operating current have been installed.

4.3.3 The S-Band command pulse simulation discussed in paragraph 4.2.3 is required to check out the stepper switches.

POWER CONTROL PNL T8-2666-501	COMMAND PANEL T8-2664-501	BLANK
DIGITAL VOLTMETER V44		TM MONITOR PANEL T8-2674-501
BLANK		
BLANK	DRAWER	INTERFACE TEST PANEL T8-2681-501
DIGITAL RANGE SEL V44		
AC/DC CONVERTER 125E *	24 VDC UNREG SUPPLY	
115V AC POWER SUPPLY 161A		PATCH PANEL ASSY T8-2651-501
28VDC REG SUPPLY SC32-10A	TVR-28-50 (50A.)	

* PART OF DIGITAL VOLTMETER SYSTEM

J-3 SYSTEM

Figure 1 -- CONSOLE ARRANGEMENT

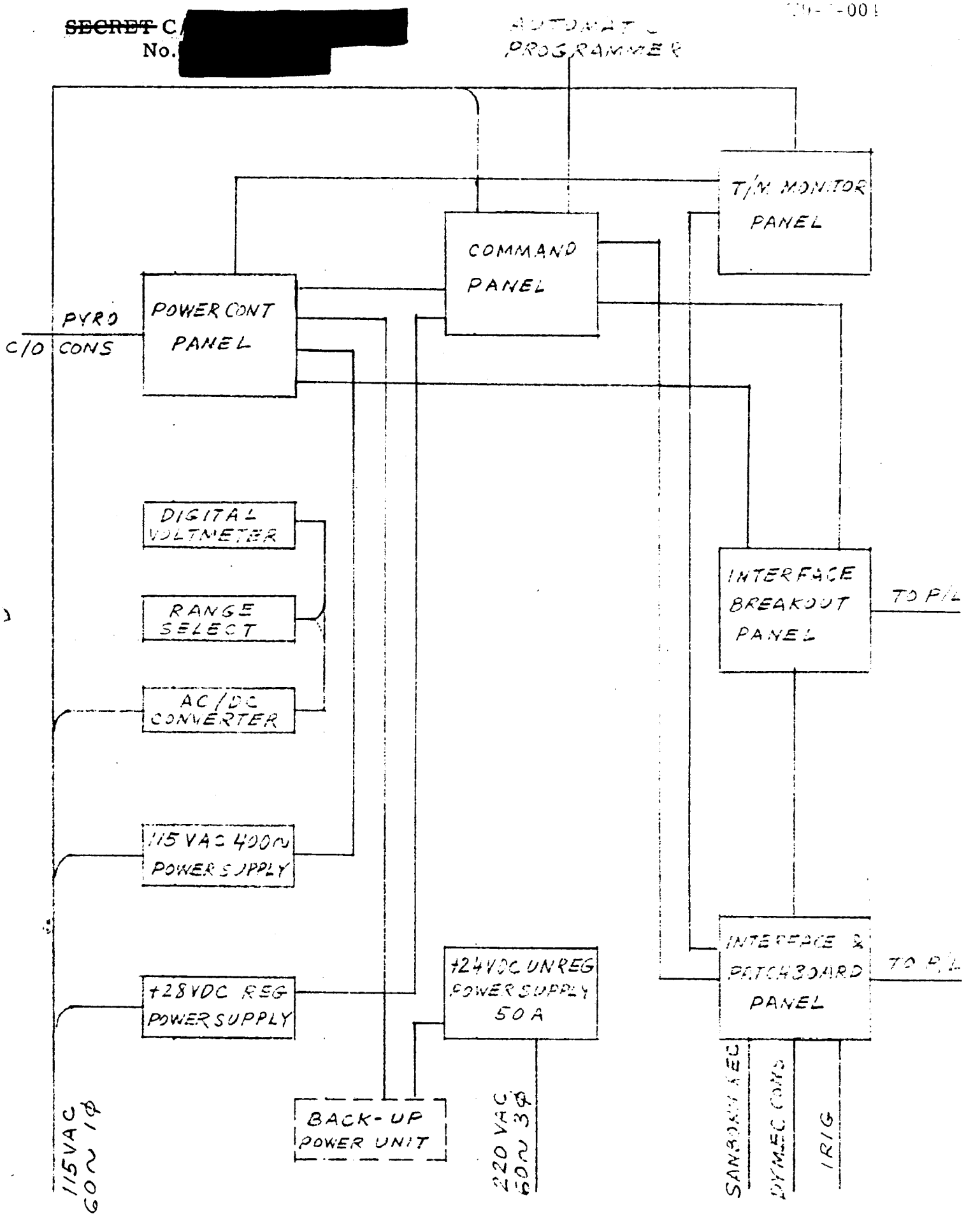

Figure 2--J-3 SYSTEM C/O CONSOLE

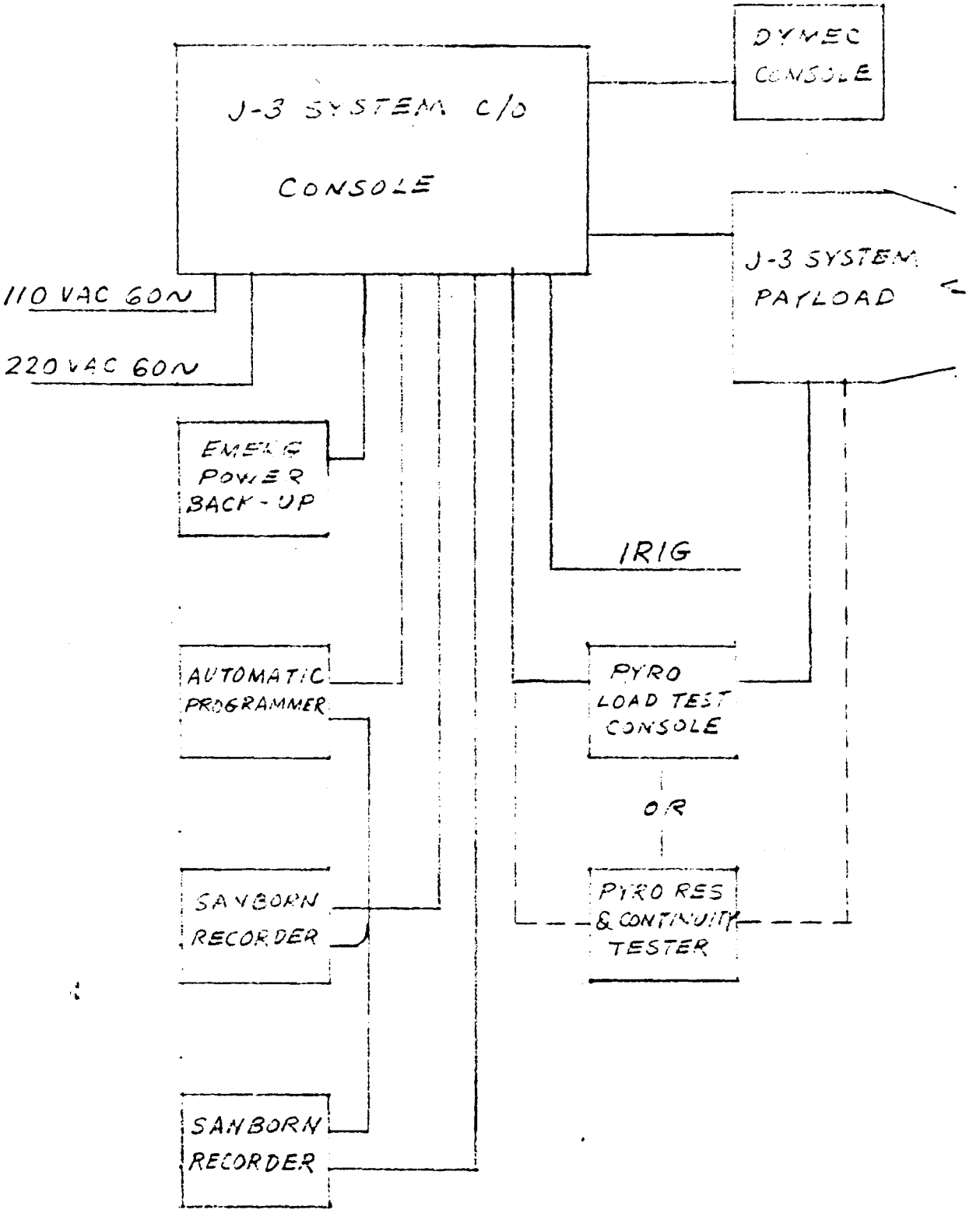

Figure 3 -- FUNCTIONAL TEST
BLOCK DIAGRAM

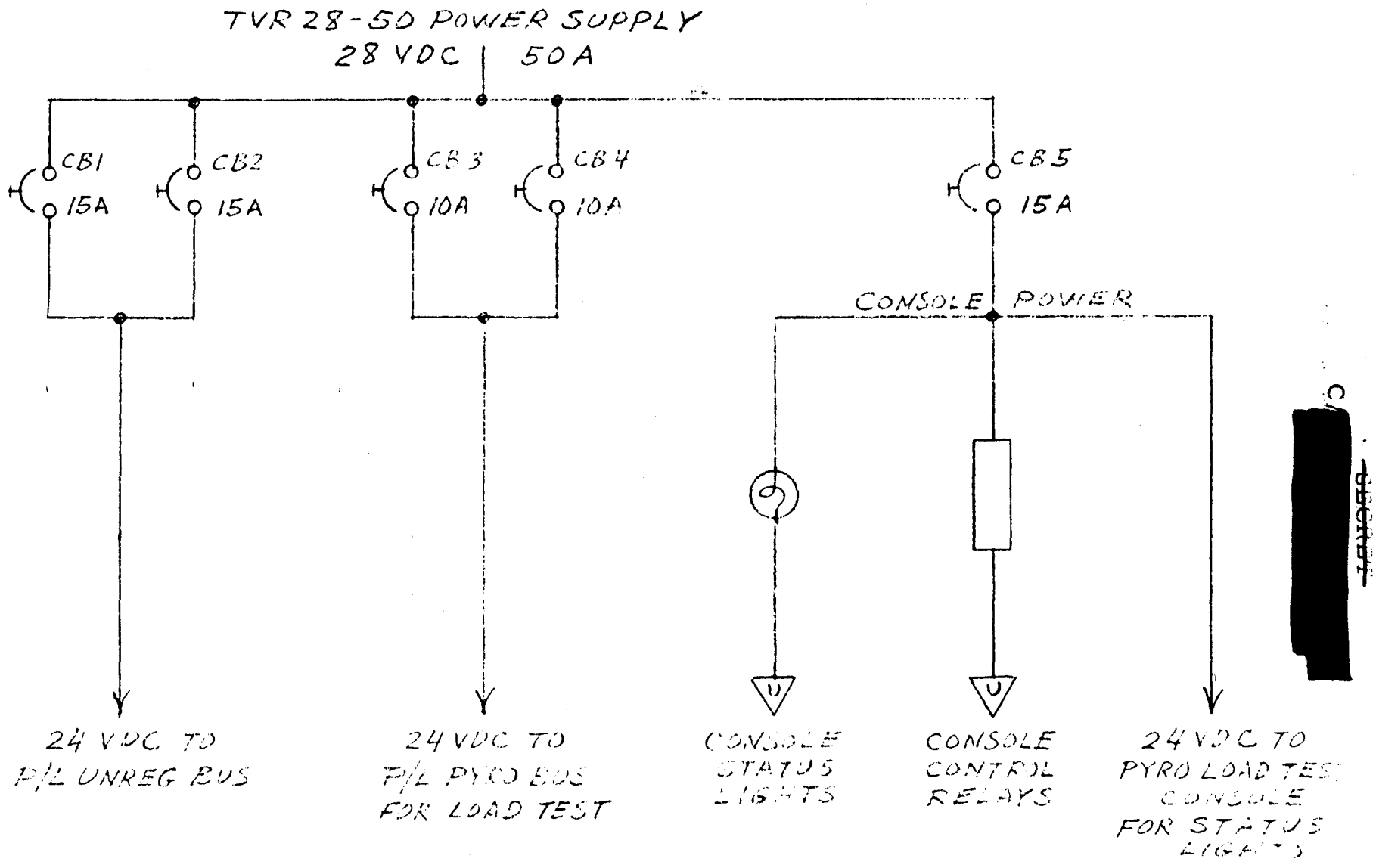

Figure 4 -- POWER DIAGRAM - 24 VDC UNREG

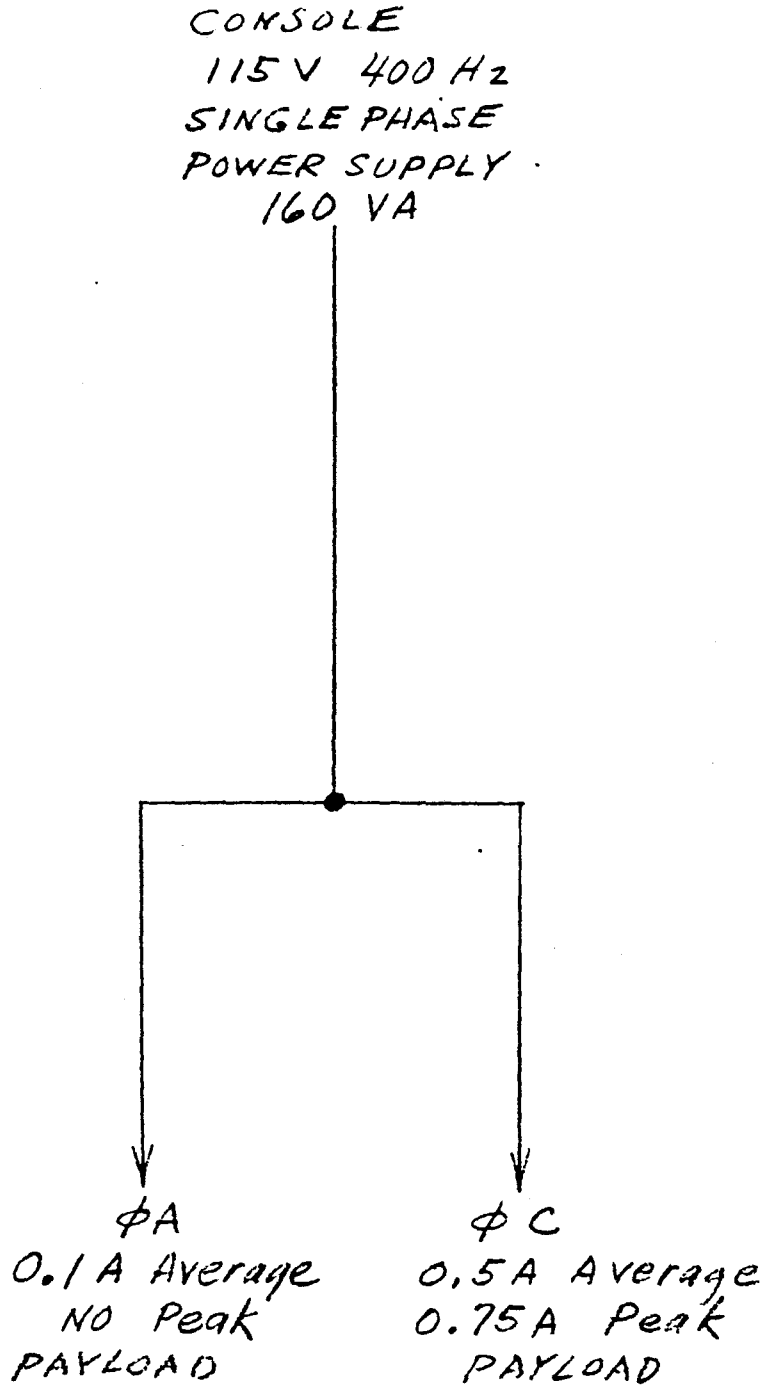

Figure 5-- POWER DIAGRAM
115 V 400 Hz

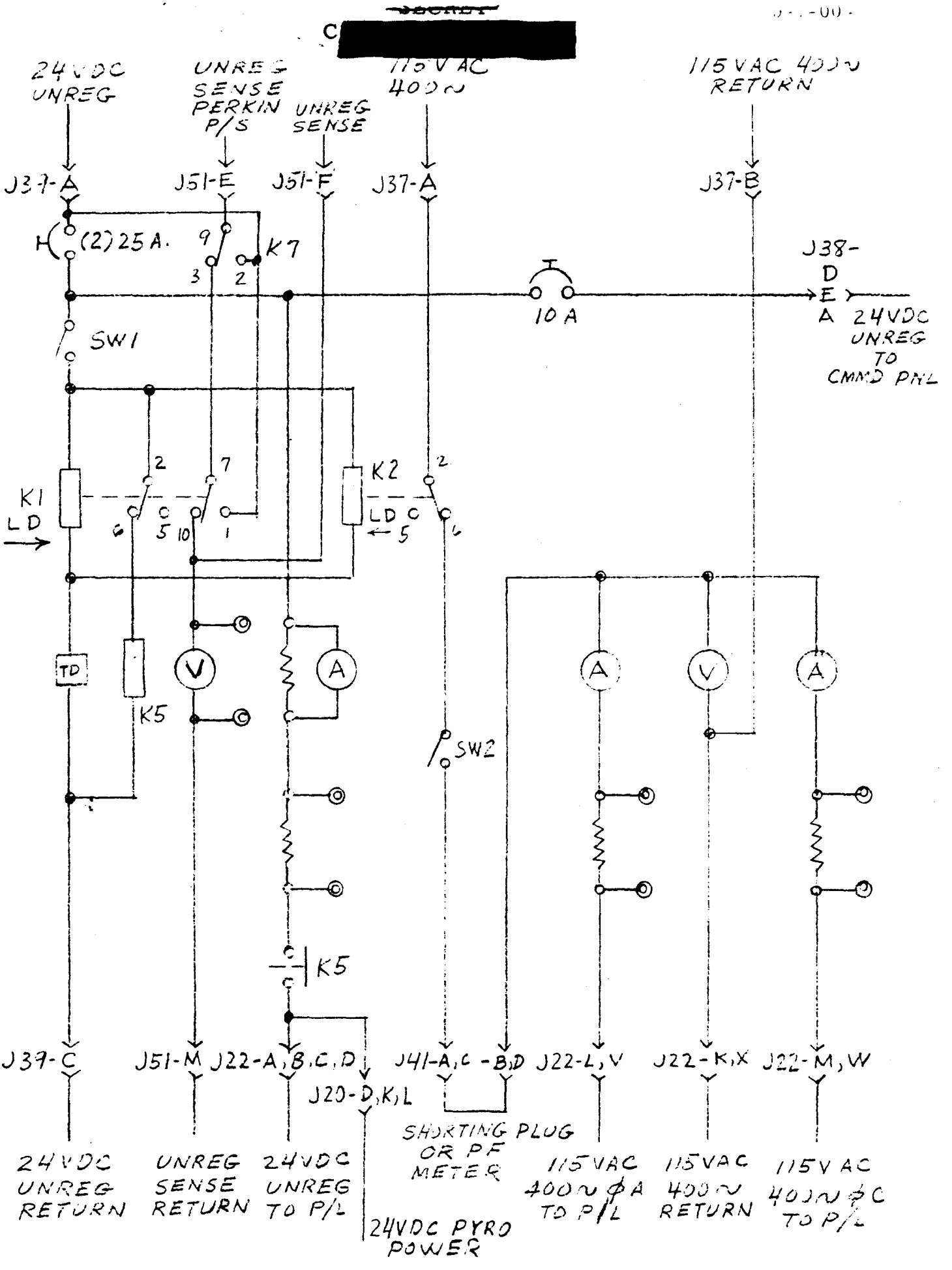

Figure 6 -- POWER CONTROL CIRCUIT

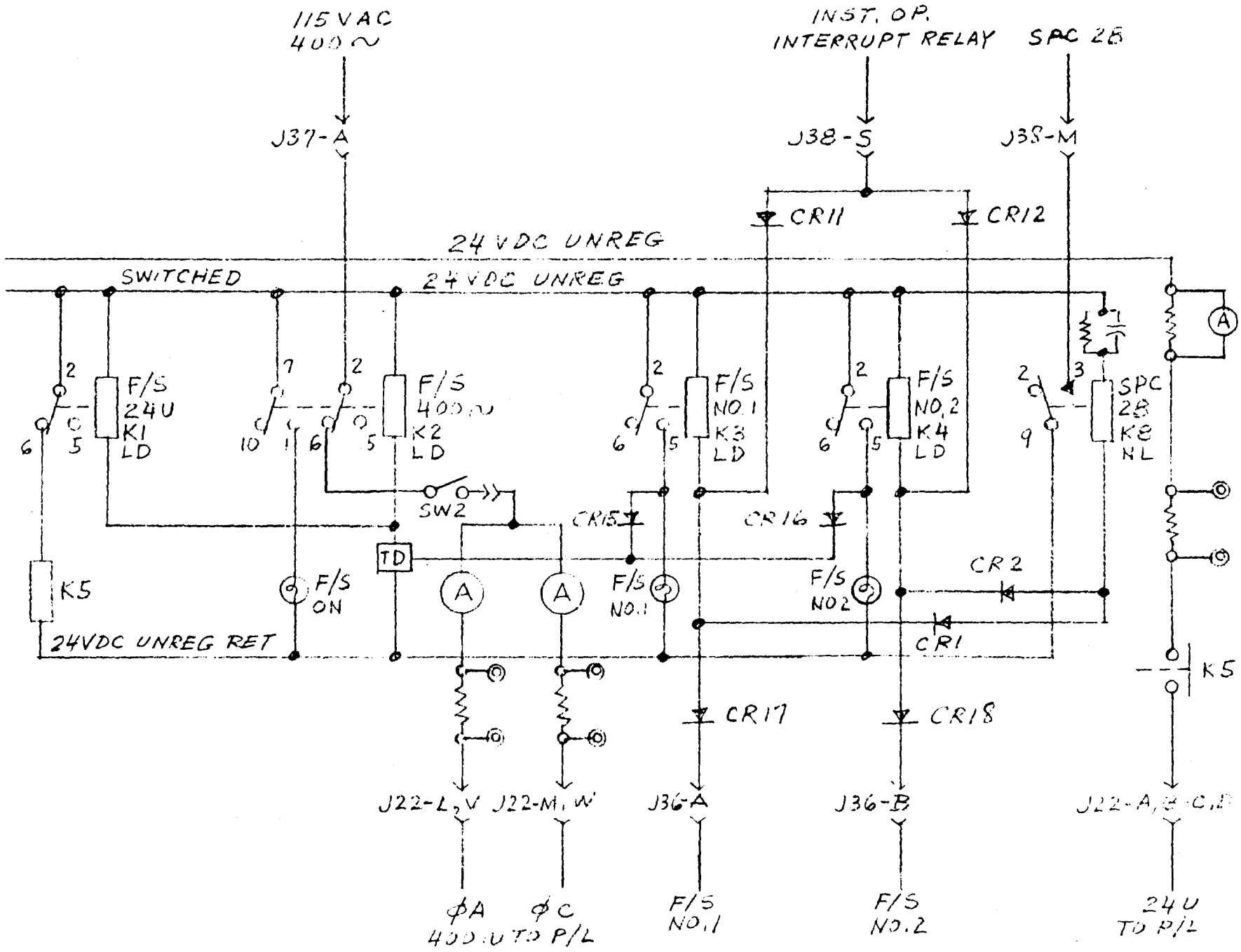

Figure 7 -- FAIL SAFE CIRCUIT
POWER CONTROL PANEL

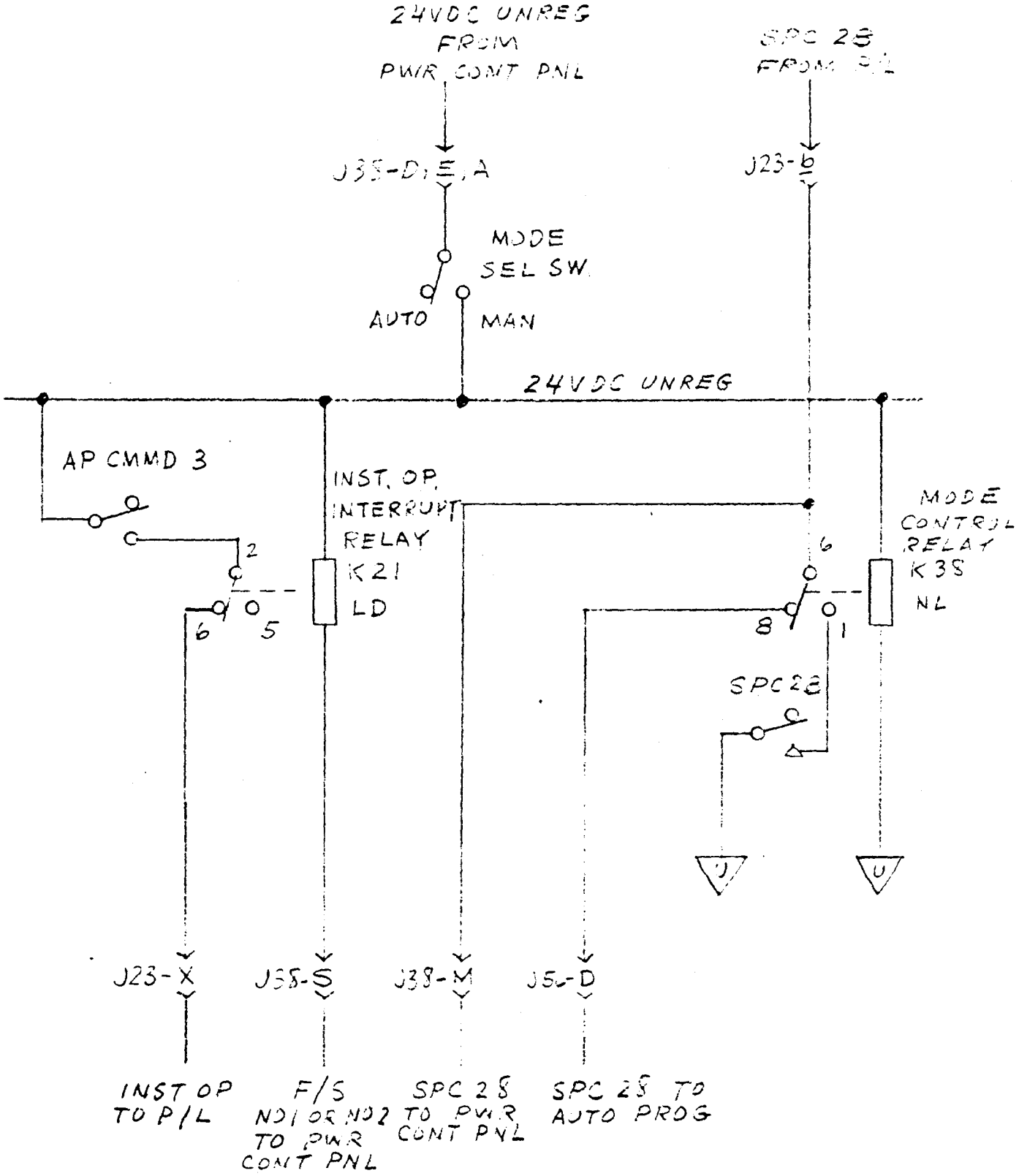

Figure 8 -- FAIL SAFE CIRCUIT COMMAND PANEL

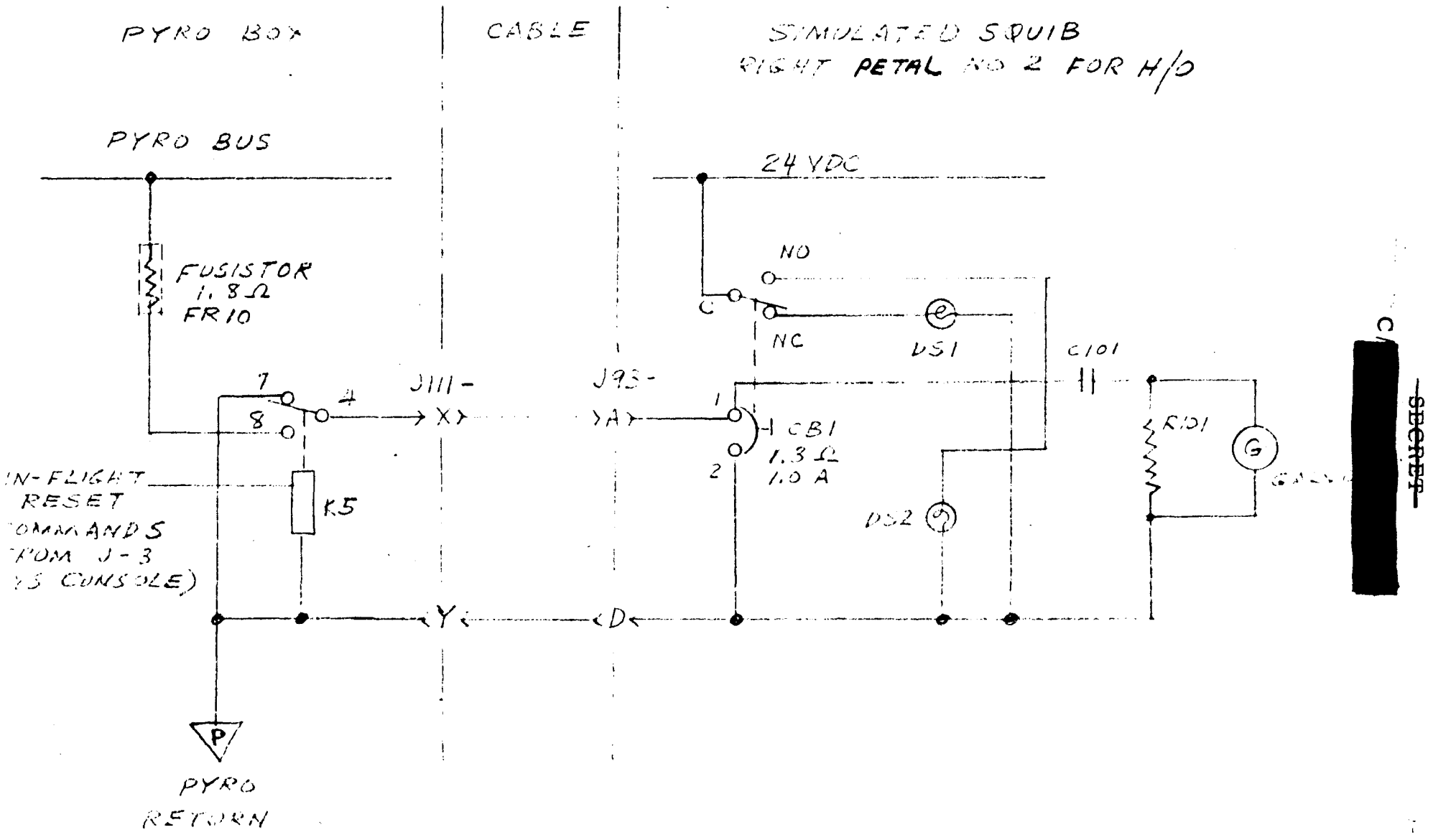

Figure 9 -- PYROTECHNIC TEST CIRCUIT WITH PYRO LOAD TEST CONSOLE

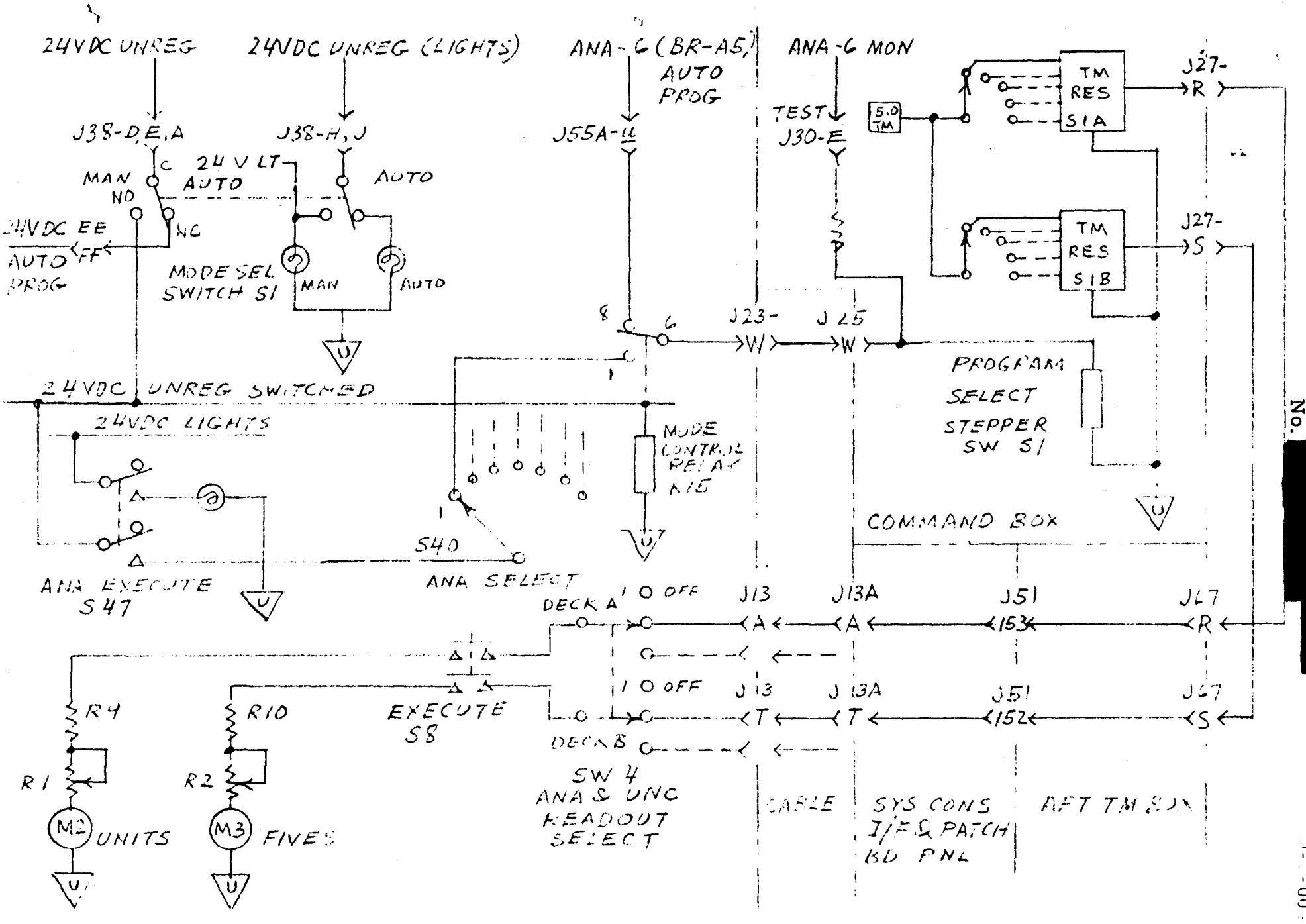

Figure 10-- COMMAND CIRCUIT (ANA DC UNC CMND)