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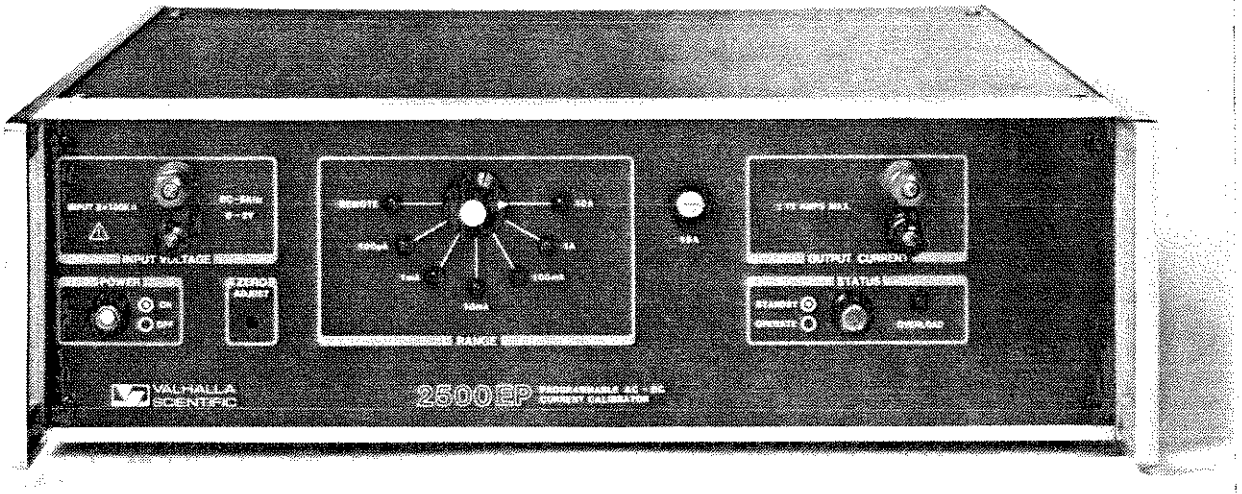
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2500EP

AC-DC Current Calibrators

Operating and Maintenance Manual



VALHALLA SCIENTIFIC

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San Diego, CA 92121
(619) 457-5576
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REV. 3-88

CERTIFICATION

Valhalla Scientific, Inc. certifies that this instrument was thoroughly tested and inspected and found to meet it's published specifications when it was shipped from the factory. Valhalla Scientific, Inc. further certifies that it's calibration measurements are traceable to the National Bureau of Standards to the extent allowed by NBS's calibration facility.

WARRANTY

The warranty period for this instrument is stated on your invoice and packing list. Please refer to these to determine appropriate warranty dates. We will repair or replace the instrument during the warranty period provided it is returned to Valhalla Scientific, Inc. freight prepaid. No other warranty is expressed or implied. We are not liable for consequential damages. Permission and a return authorization number must be obtained directly from the factory for warranty repair returns. No liability will be accepted if returned without such permission.

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Drawings :

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2500-604	1 sheet	Main PCB Assembly
2500-405	2 sheets	Final Assembly

Parts Lists :

2500-604	5 sheets	Main PCB Assembly
2500-405	4 sheets	Final Assembly

FIGURES

Figure 10-1 Functional Block Diagram

SECTION I

UNPACKING AND INSTALLATION

1.1 Unpacking

If the shipping carton is damaged, request that the carriers' agent be present when the 2500EP/N is unpacked. If the 2500EP/N appears damaged when unpacked then notify the carriers' agent who should authorize repairs before the 2500EP/N is returned to Valhalla Scientific or Service Center. Even if the 2500EP/N appears undamaged it may have suffered internal damage in transit that may not be evident until the 2500EP/N is operated or tested to verify performance. If the 2500EP/N fails to meet the performance specifications in Section II then notify the carriers' agent and Valhalla Scientific or Service Center. Retain the shipping carton for the carriers' inspection, DO NOT RETURN EQUIPMENT TO VALHALLA SCIENTIFIC OR ANY OF ITS SERVICE CENTERS PRIOR TO OBTAINING AUTHORIZATION TO DO SO.

1.2 Initial Adjustments

The only adjustments required prior to operation of the 2500EP/N are the correct selection of the local power source voltage and to verify that the correct fuse for this voltage is fitted. The supply voltages and fuses are listed below:

105 to 128VAC 50/60Hz	5 Amp fuse
210 to 256VAC 50/60Hz	3 Amp fuse

ENSURE THAT THE CORRECT SELECTION IS MADE PRIOR TO APPLYING POWER TO THE 2500EP/N.

1.3 Instructions for Bench Use

The 2500EP/N is delivered for operation in bench use and special instructions for use in this manner are not required. However, before connecting the 2500EP/N to the AC power source the user should verify that the power cord is equipped with a three-terminal connector (see the Safety Precautions in 1.5).

1.4 Instructions for Rack Mounting

Optional rack mounting brackets are available for mounting the 2500EP/N in a standard 19" equipment rack. These are listed in Section III of this manual. The size and weight of the 2500EP/N dictate that the unit should be supported on both sides along its entire length (by the use of "trays" or "slides"). If it is to be transported while mounted in a rack then it MUST BE SUPPORTED SO AS TO PREVENT UPWARDS or DOWNWARDS MOVEMENT.

The user should note that the specifications of the 2500EP/N become degraded at high temperatures thus it is recommended that sufficient room be allowed for airflow around the 2500EP/N. This may be achieved by placing at least 1.75" high blank panels above and below the 2500EP/N in the rack and ensuring that there are no obstructions within 5" of either the air inlet or outlet on the rear panel of the 2500EP/N.

Under no circumstances should the air temperature surrounding the 2500EP/N be allowed to exceed 50C while in operation or 70C while not in operation.

1.5 Safety Precautions

The power connector should be a three-contact device meeting the safety requirements of the area in which the 2500EP/N is to be used, and should only mate with a three-contact connector where the third contact provides a ground connection. If power is provided through an extension cable then the ground connection must be continuous through this cable to the 2500EP/N.

FAILURE TO PROVIDE A CONTINUOUS GROUND CONNECTION TO THE 2500EP/N MAY RENDER THE UNIT UNSAFE FOR USE.

SECTION II

SPECIFICATIONS

2.1 2500EP Accuracy

Range	Full Scale Output[1]	Input for F.S. [1]	Accuracy (180 days at 20 to 30C) DC	DC - 5KHz[2]
100uA	200uA	2V	0.01% + 40nA	0.05% + 200nA[3]
1mA	2mA	2V	0.01% + 400nA	0.05% + 2uA
10mA	20mA	2V	0.01% + 4uA	0.05% + 20uA
100mA	200mA	2V	0.01% + 40uA	0.05% + 200uA
1A	2A	2V	0.01% + 400uA	0.05% + 2mA
10A	10A	1V	0.01% + 4mA	0.05% + 20mA

[1] : DC or RMS AC.
[2] : Add 0.01% of range x compliance voltage x frequency (KHz) for compliance voltages greater than 2V RMS.
[3] : Add 0.5% of output above 1KHz.

2.2 2500EN Accuracy

Range	Full Scale Output[1]	Input for F.S. [1]	Accuracy (180 days at 20 to 30C) DC	DC - 500Hz
100uA	200uA	20V	0.01% + 40nA	0.05% + 200nA
1mA	2mA	20V	0.01% + 400nA	0.05% + 2uA
10mA	20mA	20V	0.01% + 4uA	0.05% + 20uA
100mA	200mA	20V	0.01% + 40uA	0.05% + 200uA
1A	2A	20V	0.01% + 400uA	0.05% + 2mA
10A	10A	10V	0.01% + 4mA	0.05% + 20mA

[1] : DC or RMS AC.

2.3 General Specifications

Input Impedance	: 100Kohms (10Mohms for 2500EN)
Output Capacitance	: 500pF
Compliance Voltage	: 10V peak reducing linearly to 7V peak at 10A RMS
Short Term max. Output	: 12A RMS for 2 minutes maximum (25% max. duty cycle)
Max. Input Voltage	: 3V peak (30V peak for 2500EN) without damage
Output Protection	: Fuse protected at 15A RMS
Common Mode Voltage	: Input:Output : 10V peak max.
	: Either to Ground : 100V peak max.
CMRR (Input:Output)	: 60dB RTI at DC linearly decreasing to 40dB at 5KHz
Temperature Range	: Operating : 0 to 50C
	: Storage : -40 to 70C
Humidity	: 70% RH max. at 45C, non-condensing
Temperature Coefficient	: 0.1 x accuracy specification per degree C
Dimensions	: 15" (381mm) L x 17" (432mm) W x 5.25" (133mm) H
Weight	: 30Lbs (14Kg) net, 40Lbs (18Kg) shipping

SECTION III

OPTIONS AND ACCESSORIES

3.1 General
The following options are available for the 2500EP/N PROGRAMMABLE AC-DC CURRENT CALIBRATOR.

3.2 Option "R2"
This option allows the 2500EP/N to be mounted in a standard 19" equipment rack enclosure.

3.3 Option "BBL"
This option is a 48" long shielded cable terminated at both ends with high performance 3/4" spaced banana plugs.

3.4 Option "SP-2"
This option provides a selection of the most likely parts to fail during the first two years of operation.

SECTION IV

FRONT PANEL CONTROLS AND CONNECTORS

4.1 General

This section outlines the use of each of the front panel controls and connectors, the user is advised to read Section VI to obtain full descriptions of the method to operate the 2500EP/N.

4.2 "INPUT VOLTAGE" Section

The polarity and amplitude of the output current of the 2500EP/N is directly proportional to that of the applied input signal at these terminals.

4.3 "POWER" Section

This switch controls the power to the 2500EP/N. When in the "ON" position (depressed, with yellow dot showing) and with AC power supplied, the 2500EP/N will be operational. When in the "OFF" (not depressed) position the 2500EP/N will be unpowered.

4.4 "ZERO" Section

This allows access to the input zero adjustment. The user should note that the 2500EP/N should have been powered for at least one hour prior to making any adjustments. The zero may be adjusted on any range, but the use of the 1mA range with a 1Kohm load is recommended. The user should also note that the 2500EP/N should be in OPERATE when making this adjustment.

4.5 "RANGE" Section

This switch selects a range (overriding any externally selected range) or selects for remote control of the range. The present current range is always indicated by the illuminated LED.

4.6 "OUTPUT CURRENT" Section

This section contains the output current terminals for the 2500EP/N. The user should also note the 15A fuse mounted to the immediate left of this section.

4.7 "STATUS" Section

This section contains the STANDBY/OPERATE switch and the OVERLOAD LED. Whenever the switch is in the depressed (yellow dot showing) position the 2500EP/N is in the STANDBY condition, the input terminals are open circuited and replaced by an internal short circuit. Also a 10Kohm load is placed across the output terminals. When this switch is in the out (no dot showing) position the 2500EP/N is in the OPERATE condition and operates normally. The OVERLOAD indicator illuminates when the output compliance voltage exceeds the capabilities of the 2500EP/N.

SECTION V

REAR PANEL CONTROLS AND CONNECTORS

5.1 General
The functions of the rear panels controls and connectors are described in the following paragraphs.

5.2 "REMOTE CURRENT RANGE PROGRAMMING" Connector
This connector contains the connections to the internal range selection relays, allowing the user to remotely control the 2500EP/N range if desired. The use of this connector is described in Section VII of this manual.

5.3 Power Connector
This is the AC power connector.

5.4 Fuseholder
This is the AC power fuse, the user should ensure that the rating of the fuse is correct for the AC voltage supply being used.

5.5 AC Power Voltage Selection Switch
This slide switch selects either 115V or 230V nominal AC power voltage. Note that the rating of the power fuse should be changed if this switch is changed. The voltage setting of this switch can be checked by noting whether "115" or "230" is visible on the switch.

5.6 Rear Panel Terminals
These terminals are internally wired in parallel with the front panel terminals and may be used in exactly the same manner as those.

SECTION VI

MANUAL OPERATION

6.1 General

The following paragraphs describe the manual operation of the 2500EP/N and should be used (along with Section IV) when using the unit. The user is advised to fully read both this section and Section IV before attempting to operate the 2500EP/N manually.

6.2 Applying AC Power

Before applying AC power to the 2500EP/N the user is advised to ensure that the front panel POWER switch is in the OFF position (no dot showing), that the front panel STATUS switch is in the STANDBY position (yellow dot showing) and that no equipment is connected to the input or output terminals of the 2500EP/N.

After applying AC power and placing the POWER switch in the ON (yellow dot showing) position, the user should note that the internal fan will commence operation, and that the LED pointed at by the RANGE switch pointer should be illuminated. Should either of the above fail to occur then the AC power should be removed and the 2500EP/N placed aside for maintenance.

6.3 Connections

The polarity and level of the output current is directly proportional to that of the input voltage applied. A zero input voltage will cause the 2500EP/N to produce zero output current. As the input is increased positively, the output current will increase positively (if the STATUS switch is in the OPERATE position). With the 1mA range selected and input voltage of +1V DC (+10V DC for the 2500EN) will yield an output current of 1mA DC. An input voltage of 1V AC (10V AC for the 2500EN) will yield and output current of 1mA AC with the same frequency and phase as the input signal applied. The user should note that the size of the wires connected to the output terminals must be carefully chosen to ensure that the voltage drop across them while carrying the current will not yield problems with excessive compliance voltage, also the use of a twisted pair is recommended for currents above 1mA and frequencies above 100Hz to reduce the inductance of these wires as much as possible, also to reduce the compliance voltage requirement from the 2500EP/N. At very low currents individual leads must be used for the output connections because otherwise the load will be "shunted" by the parallel capacitance between these wires. The following wire gauges are recommended :

Current	Wire Gauge
10A	16AWG or heavier
1A	18AWG or heavier
<100mA	20AWG or heavier

Whenever a load is to be connected (or disconnected) the user should ALWAYS place the 2500EP/N STATUS switch in the STANDBY position prior to the removal or connection of the load to the output terminals.

6.4 Range Selection

The range of currents provided by the 2500EP/N may be simply selected by rotating the front panel RANGE switch until the pointer points at the required current. The user should note that the LED pointed at should always be illuminated. It is recommended that the STATUS switch be placed in the STANDBY position prior to altering the position of the range switch to prevent transients or misplacement of the range switch from causing damage to the load.

6.5 Zero Adjustment

A zero adjustment has been provided in the 2500EP/N and may be accessed by the user through the hole in the front panel labelled "ZERO ADJUST". The user is advised to ensure that the 2500EP/N has been operational for at least one hour prior to performing an output zero adjustment. The following procedure is recommended :

a) Ensure that the STATUS switch is in the STANDBY position (yellow dot showing).

b) Remove all connections from both input and output terminals.

c) Place a short circuit between the input terminals.

d) Select the 1mA range on the 2500EP/N.

e) Connect a 1Kohm +/- 5% resistor across the output terminals and monitor the voltage across this resistor with a DVM having at least 10uV resolution.

f) Select OPERATE on the 2500EP/N STATUS switch (no dot showing).

g) Adjust the zero control for an indication on the DVM of < +/- 100uV.

6.6 Overload Indicator

The LED labelled "OVERLOAD" on the front panel of the 2500EP/N will illuminate whenever the 2500EP/N is unable to provide the requested output current due to excessive output compliance voltage requirements. Whenever this LED is illuminated the output current from the unit is in error and should not be relied upon for accuracy. If the user finds that the load is not excessive for the current requested and the wires connected the load to the output terminals of the 2500EP/N are not excessively resistive (or inductive for AC current) then the user should check the fuse on the front panel of the 2500EP/N.

6.7 AC Accuracy Considerations

When using the 2500EP/N the user must be aware of the effects of parallel capacitance and series inductance on the overall accuracy.

6.7.1 Parallel Capacitance Effects

Any resistance or capacitance in parallel with the load will "steal" current from the load, thus producing an apparent error in the output current of the 2500EP/N.
As an example, if the 100uA range of the 2500EP/N is to be used to drive a 10Kohm load at 5KHz and the voltage across the load is to be monitored by a DVM having 100pF input capacitance, the cabling being 5ft of RG58A/U. The total parallel capacitance across the 10Kohm load is thus 50pF (the 2500EP/N) plus 100pF (the DVM) plus 150pF (the cabling). This 300pF will cause an error of 0.45% in the current flowing through

the 10Kohm load. The actual equation for the effect of parallel capacitance is as follows:

$$\text{Error (\%)} = 100 \times \left(\left(1 / \text{SQRT} \left(1 + (2 \times \text{pi} \times f \times R_L \times C)^2 \right) - 1 \right) \right.$$

Where R_L is the load resistance in Ohms
C is the parallel capacitance in Farads
pi is 3.141592654
f is the frequency in Hertz

6.7.2 Series Inductance Effects

Any internal inductance within the load will cause the loads' impedance to increase with frequency and thus cause apparent errors in the output current of the 2500EP/N.
As an example, if the 10A range of the 2500EP/N is to be used to drive a 0.1ohm resistor which has 0.5uH series inductance internal to it then the voltage across the resistor will be 1.23% higher than expected at 5KHz. As can be seen in this example very low levels of inductance are required within the current shunt used to test the 2500EP/N in order to correctly evaluate the high frequency performance. The use of specially manufactured high frequency shunts is necessary for resistances below 5 ohms.
The actual equation for the error caused by this internal inductance is as follows:

$$\text{Error (\%)} = 100 \times \left(\left(\text{SQRT} \left(1 + \left(2 \times \text{pi} \times f \times L_S \right)^2 / R_L^2 \right) \right) - 1 \right)$$

Where R_L is the load resistance in Ohms
L_S is the series inductance in Henries
pi is 3.141592654
f is the frequency in Hertz

The user should also note that there is "second order" effect of total load inductance causing an increasing compliance voltage requirement upon the 2500EP/N at higher frequencies. This causes the specification of the 2500EP/N to be modified by the output compliance modifier shown within the specifications in Section II of this manual.

SECTION VII

REMOTE OPERATION

7.1 General

Remote control of the 2500EP/N ranges is achieved by placing the front panel RANGE switch in the REMOTE position (REMOTE LED illuminated) and then selecting the required range by means of signals applied to the rear "REMOTE CURRENT RANGE PROGRAMMING" connector. When the front panel RANGE switch is not in the REMOTE position these signals are ignored.

7.2 Connector Signal Description

Pin Number	Signal Name	Description
1	10A	+5V selects 10A range
2	1A	+5V selects 1A range
3	100mA	+5V selects 100mA range
4	10mA	+5V selects 10mA range
5	1mA	+5V selects 1mA range
6	100uA	+5V selects 100uA range
7	0V	Common for range command pin signals
9,12	OVLD	Contact closure when 2500EP/N in overload
8,10,11,13,14	No connection	

The range control signals (pins 1 to 6) require a drive current of nominally 10mA and must be within +4V to +6V above pin 7 to select the required range. The circuitry connected to these pins is fully isolated from the other circuitry within the 2500EP/N and may be up to 100V peak from either ground or the output of the 2500EP/N.

The contact closure between pins 9 and 12 is also completely isolated and is rated at 0.1A/100V. The user should note that this contact closure is available whether the 2500EP/N is being remotely commanded or not.

The user should note that the selected range is indicated on the front panel by the illumination of the LED corresponding to the selected range. Selection of no range for extended periods of time is not recommended, selection of more than one range is permitted but will yield unspecified output currents (it is recommended that a short "overlap" period be implemented when changing ranges).

SECTION VIII

CALIBRATION PROCEDURE

8.1 General

The following paragraphs describe the overall calibration procedure for the 2500EP/N. It is assumed that the user is familiar with the normal operation of the unit and that Section VI has been read.

8.2 Calibration Philosophy

The maintenance of the specifications of the 2500EP/N is achieved by the periodic calibration of the unit. The 2500EP/N may be calibrated at any desired interval, 180 days being recommended. The following equipment will be required :

a) DC Voltage Standard having an output of 1V with an accuracy of < 0.003%.

b) DVM having at least 10uV resolution and < 0.003% accuracy at 1V DC.

c) Precision DC Current Shunt Resistors with < 0.003% accuracy of the following values: 0.1 ohm, 1 ohm, 10 ohms, 100 ohms, 1 Kohm, 10 Kohm. It is recommended that the 0.1 ohm and 1 ohm resistors be of substantial proportions to ensure that the accuracy is maintained at the current levels required (10A and 1A respectively).

d) A 1Kohm +/- 5% general purpose resistor.

8.3 Adjustment Required Following Maintenance

This adjustment is only required following component replacement, but may be performed at any time if desired. The user should note that the 2500EP/N will require full re-calibration following the use of this adjustment.

a) Select STANDBY on the front panel STATUS switch.

b) Select the 1A range on the front panel RANGE switch.

c) Short the output terminals together.

d) Connect a DVM having <1mV DC sensitivity at zero between the rear end of R7 and the rear end of R8.

e) Connect a DC voltage source between the input LO terminal of the 2500EP/N and the output LO terminal of the 2500EP/N. Set the voltage source to 0V output.

f) Alternating the output of the DC voltage source between 0V and 10V, adjust RV3 for no change in the DVM reading (within 1mV).

8.4 Periodic Calibration

Periodic calibration of the 2500EP/N is achieved by performing the following steps in the order given. Before attempting to calibrate the 2500EP/N the user should ensure that the unit has been operating for at least one hour continuously. The equipment used is listed in paragraph 8.2 above.

8.4.1 Output Zero Calibration

a) Select the 1mA range on the front panel RANGE switch.

b) Short the input terminals to the 2500EP/N.

c) Select OPERATE on the front panel STATUS switch.

d) Connect the output terminals to the 1Kohm +/- 5% resistor.

e) Connect the input of the DVM across the 1Kohm resistor.

f) Adjust RV1 (front panel ZERO OFFSET adjustment) for an indication of < +/- 100uV on the DVM.

8.4.2 Range Calibration Adjustments

Each range of the 2500EP/N is calibrated in the same manner. The precision current shunt to use, and the adjustment resistor reference, for each range is given in the table below the procedure.

a) Select STANDBY on the front panel STATUS switch.

b) Connect the voltage source to the input terminals of the 2500EP/N and select an output of 1V DC (10V DC for a 2500EN).

c) Connect the required current shunt to the output terminals of the 2500EP/N.

d) Connect the DVM across the voltage sense terminals of the current shunt.

e) Select OPERATE on the front panel STATUS switch.

f) Adjust the required adjustment resistor to obtain a DVM indication within 0.9995 and 1.0005V.

Range	Current Shunt	Adjustment Resistor
10A	0.1ohm	RV4
1A	1ohm	RV5
100mA	10ohm	RV6
10mA	100ohm	RV7
1mA	1Kohm	RV8
100uA	10Kohm	RV9

SECTION IX

MAINTENANCE AND TROUBLESHOOTING

9.1 General

The following paragraphs provide the information required to perform the required periodic maintenance and also basic guidelines for troubleshooting the 2500EP/N.

9.2 Periodic Maintenance

The 2500EP/N requires little periodic maintenance, that which is required is discussed in the following paragraphs.

9.2.1 Cleaning

It is recommended that the 2500EP/N be operated in a clean environment, however if the environment is "dusty" then periodic cleaning of the unit will be required.

On the rear panel of 2500EP/N there are two filters designed to prevent dust from entering the unit through the air intake or outlet. These filters will require periodic cleaning as follows:

a) Ensure that AC power is removed from the 2500EP/N.

b) Remove each filter, by pulling out the plastic central cover and removing the filter element.

c) Clean each filter by blowing with compressed air. If the filters have become excessively dirty then replacement filter elements may be ordered from Valhalla Scientific Inc. under part number 5-10494.

d) Replacement is the reverse of the above, observing the correct orientation of the central cover.

Loose dirt or dust, which is collected on the exterior surface of the 2500EP/N may be removed with a soft cloth or brush. Any remaining dirt may be removed with a soft cloth dampened in a mild soap and water solution. **Do not use abrasive cleaners.**
The front panel may be cleaned with a soft cloth and a "Windex" type cleaner. **Do not use petroleum based cleaners on the front panel.**

If required, the interior of the 2500EP/N may be cleaned by blowing with dry compressed air.

If the 2500EP/N has become "heavily" contaminated with dirt or by other contaminants(s) then it is recommended that the unit be completely overhauled (contact your local Valhalla Scientific Service Center for details).

9.3 Troubleshooting

The following paragraphs give basic procedures for troubleshooting and component replacement in the 2500EP/N.

9.3.1 Component Replacement

The 2500EP/N accuracy and reliability can only be maintained if the following precautions are taken when changing a component:

a) Only use the specified component or exact equivalent. Spare parts can be ordered from your nearest Valhalla Scientific Service Center by the Valhalla part number listed in the parts list in section XIV of this manual. Please provide the type and serial number of the unit with your order.

b) Only use 63/37 rosin core electronic grade solder with a 50W (or lower) maximum power soldering iron.

c) Always use extreme care when removing or inserting components.

9.3.2 Finding the Faulty Component

It is not possible to anticipate all failure modes of the components in the 2500EP/N, therefore the servicing technician should be familiar with the contents of Section X of this manual. Experience has shown that malfunctions are often the result of misinterpretation of the specifications or operating procedures of the unit. Check to be sure that the cables and other test equipment are in good order before attempting to fault find the 2500EP/N. Various portions of the circuitry in the 2500EP/N have a very large power capability, thus operating the unit for extended periods of time while faulty may irrevocably damage the unit. Also note that a physically damaged component usually means that another component has failed and damaged it, this is often the best method of fault finding the 2500EP/N.

A KNOWLEDGE OF CIRCUIT OPERATION IS A PREREQUISITE FOR EFFICIENT FAULT FINDING IN THE 2500EP/N.

SECTION X

THEORY OF OPERATION

10.1 General

This section contains an explanation of the operation of the circuitry within the 2500EP/N. The schematics referenced are in the rear of this manual.

The functional description of paragraph 10.2 is intended to assist the user in gaining a general understanding of the units' operation and refers to Figure 10-1 at the rear of this section.

Paragraph 10.3 contains detailed circuit descriptions which are intended to provide the user with sufficient information on circuit operation to permit efficient troubleshooting.

10.2 Functional Description

10.2.1 Input Amplifier

The input amplifier is a unity gain differential amplifier. This convert the differential input at the 2500EP/N input terminals to a single ended voltage to drive the error amplifier. Circuitry is also provided to protect the input amplifier from accidental overloads.

10.2.2 Error Amplifier

The error amplifier is a very high gain, differential stage that compares the input signal (from the input amplifier) with the signal from the range switching circuitry, producing an error signal which drives the output amplifier. With an output load connected, negative feedback drives the difference between the two error amplifier inputs to zero.

10.2.3 Output Amplifier

The output amplifier is a current booster stage capable of driving up to +/- 12 Amps into the load.

10.2.4 Range Switching

The range switching circuitry selects one of the six precision current shunts for the load current to pass through. The shunts are selected to produce 1V drop for each current range (e.g. 10Amp range uses a 0.1ohm shunt etc.).

10.2.5 Overall Operation

The operation of the unit is as follows:

A one volt signal applied between the input terminals of the unit will cause the input amplifier to produce an output voltage of 1V referred to the internal 0V of the unit. This is supplied to the error amplifier, which will drive the output amplifier to produce current flow through the load until the feedback voltage from the range switching is also 1V, the error amplifier now controls the output amplifier to maintain the output current at the required value.

10.2.6 Overload Indicator

The overload indicator circuitry detects when the error amplifier output is beyond the linear range (i.e. the output amplifier could not deliver the requested current through the load).

10.3 Detailed Circuit Descriptions

10.3.1 Input Amplifier

The input amplifier is formed by the amplifier IC3 with feedback elements formed by R5, R6, R7, R8 and RV3. This forms a conventional unity gain differential amplifier stage with zero offset capability provided by RV1 and CMRR adjustment provided by RV3.
Zener diodes D1 and D2 protect the input amplifier from excessive input voltages and D3 and D4 prevent the error amplifier from being overdriven.

10.3.2 Error Amplifier

The error amplifier is formed by amplifier IC4 with R9 and C9 providing frequency compensation for this stage.

10.3.3 Range Switching

The required current shunt for the range is selected by means of relays RLA, RLB, RLC, RLD, RLE and RLF. Each relay selects the required shunt R33, R35, R37, R39, R41 or R43 respectively, note that each range also uses the shunts for every higher current range. Note also that the relays switch both the current path and the voltage sense path to the error amplifier.

10.3.4 Output Amplifier

The output amplifier consists of five pairs of complementary emitter followers (TR5 through TR14) driven by TR3 and TR4, these in turn are driven by voltage controlled current sources formed by TR1 and TR2 and associated circuitry. The output stage is defined by the diodes D9, D10 and D11 along with the 1 ohm emitter resistors of the output stage.

10.3.5 Overload Detection

The output of the error amplifier (IC4) is also presented to a pair of limit comparators formed by portions of IC5. These combine to illuminate the LED (DS1) whenever the error amplifier out is above approx. +12V or below approx. -12V.

10.3.6 Power Supplies

The AC line voltage is stepped down by transformer T1, rectified by diodes D12, D13, D14 and D15 then filtered by capacitors C18 and C19 to provide the basic +/- 20V rails required by the output amplifier stage. These rails are regulated by IC1 and IC2 to provide smoothed +/- 15V rails for the remaining circuitry.

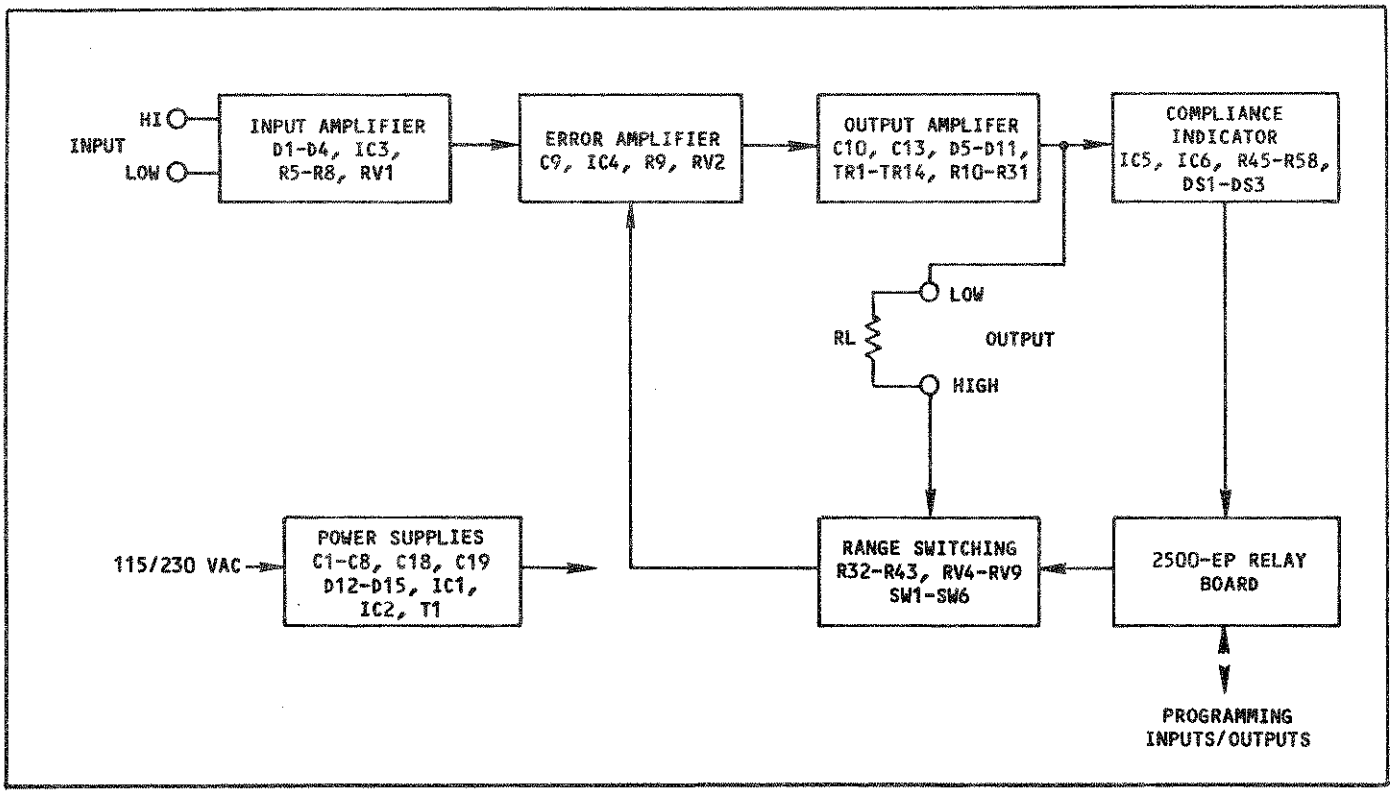


Figure 10-1 2500-EP Block Diagram

SECTION XI

USEFUL HINTS

11.1 Driving Inductive Loads

The 2500EP/N has been designed to have a very wide bandwidth and still remain stable when driving inductive loads, however the user must realize the following problems when driving inductive loads :

a) This type of load presents higher impedance of load the higher the frequency. This means that there is no attenuation of any high frequency noise which may be present. The user may wish to shunt the load with a suitable capacitor (usually 100pF is sufficient) to provide a conductive path for high frequency current noise.

b) Many loads have self-resonant frequencies within the bandwidth of the 2500EP/N (typically 1MHz) which may cause apparent oscillation problems. This may usually be cured by shunting the load with a capacitor/resistor combination to lower the Q of this self-resonance.

c) Almost ALL LOADS ARE INDUCTIVE TO SOME EXTENT, and the largest problem is caused by the leads from the 2500EP/N to the load (always use twisted pairs if at all possible).

11.2 Thermal Considerations

The 2500EP/N is a linear amplifier, providing a very quiet and stable source of current, this entails the potential for a large amount of internal power dissipation (up to 600 Watts). The user is cautioned not to operate the 2500EP/N at full load for extended periods of time without the cover being present (otherwise there will not be sufficient airflow within the 2500EP/N internal circuitry to efficiently cool the unit), and also to ensure that there is freedom of airflow around the unit (particularly around the fan intake and outlet. In an equipment rack the user MUST ENSURE THAT THE HOT AIR FROM THE 2500EP/N IS ALLOWED TO ESCAPE FROM THE RACK, otherwise it will become trapped and will be taken back into the air intake of the 2500EP/N, causing overheating and thus reduced reliability.

The user should also note that the air from the outlet at the rear of the 2500EP/N is at a temperature above the normal operating range of most instrumentation, thus it is recommended that a "baffle" be incorporated between this air and the other equipment in the rack to prevent this air from overheating other equipment.

NOTES: (UNLESS OTHERWISE SPECIFIED)

REVISIONS				
ECO	LTR	DESCRIPTION	DATE	APPROVED
0182	B	ROD # R8-R60, C18	10/21/83	
REV. C SEE E.C.O #444			6-15-84	
SEE SHEET 2				

FRONT PANEL

REAR PANEL

POWER SUPPLY DISTRIBUTION						
IC	+15V	+15VA	+15VB	-15V	-15VA	-15VB
3	—	7	—	—	4	—
4	—	—	7	—	—	4

FIRST USED	NOT USED	LAST USED
C1	C16,17	C30
D1	—	D31
IC1	—	IC5
R1	61,53-60	RV1
DS1	—	DS1
RLA	—	RLN
TR1	—	TR15

TOLERANCES: X = ± 30' ; XX = ± .03 ; XXX = ± .010

MATERIAL

FINISH

BREAK ALL SHARP CORNERS AND EDGES, MACH SURFACES 64

DRAWN JM	2-83	Valhalla Scientific Inc. SAN DIEGO, CA
CHECKED RW	10-83	
APPR RW	10-83	
STK NO		

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MAIN BOARD SCHEMATIC 2500EP

SCALE	CODE IDENT	SIZE	DRAWING NO	REV
	53504	D	2500 - 074	G

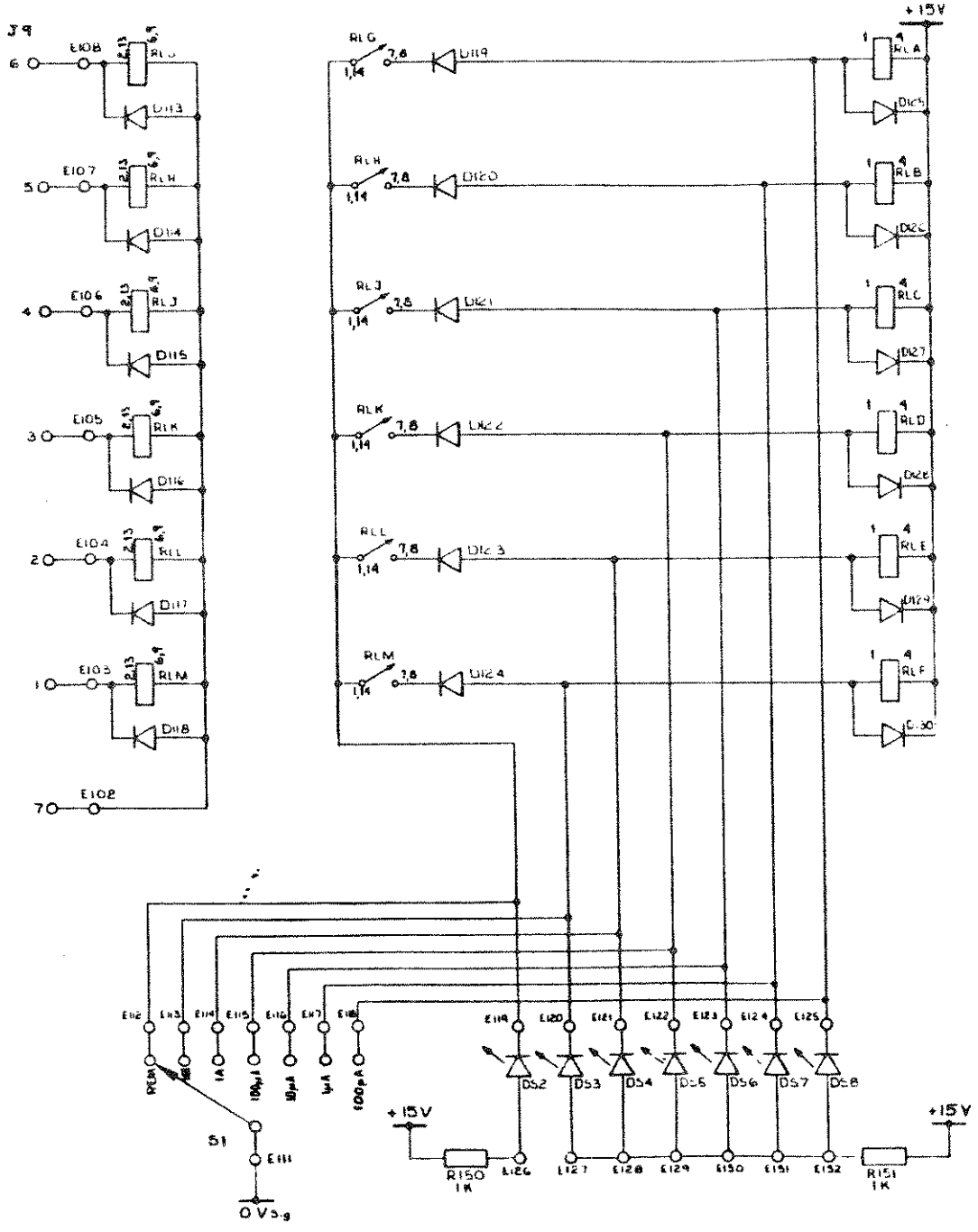
SHEET 1 OF 2

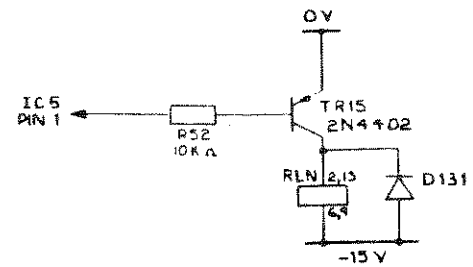
NOTES: (UNLESS OTHERWISE SPECIFIED)

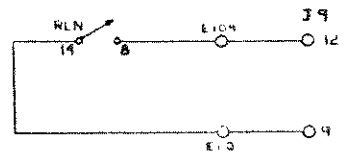
ALL UNMARKED DIODES ARE IN4148.

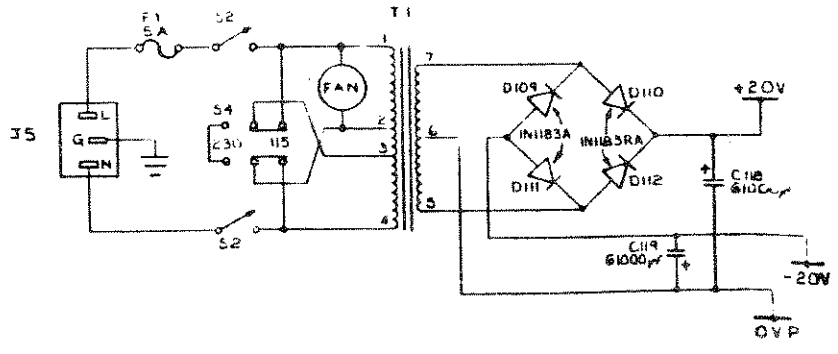
REVISIONS				
ECO	LTR	DESCRIPTION	DATE	APPROVED
718	D	REDESIGN 2500EP RDN	8-5-85	
768	E	RENUMBERED RDN	8-23-85	
776	F	INCORPORATED DESIGN CHANGES	9-6-85	
792	G	UPDATED THE TR15. RDN	5-10-86	

CONTACTS FOR RLA THRU RLF ARE ON SHEET 1 OF 2.









FIRST USED	NOT USED	LAST USED
C118		C119
IC5		IC5
DS2		DS8
R150		R151
D109		D119
S1		S4
F1		F2
T1		T1
J5	J1,2,3,4,7,8	J9

TOLERANCES
X = ± 30
XX = ± 03
XXX = ± 010

BREAK ALL SHARP CORNERS AND EDGES MACH SURFACES 94 ✓

MATERIAL

FINISH

DRAWN RDN 5-22-85
CHECKED [illegible] 6-26-85
APPR [illegible] 6-26-85
STK NO

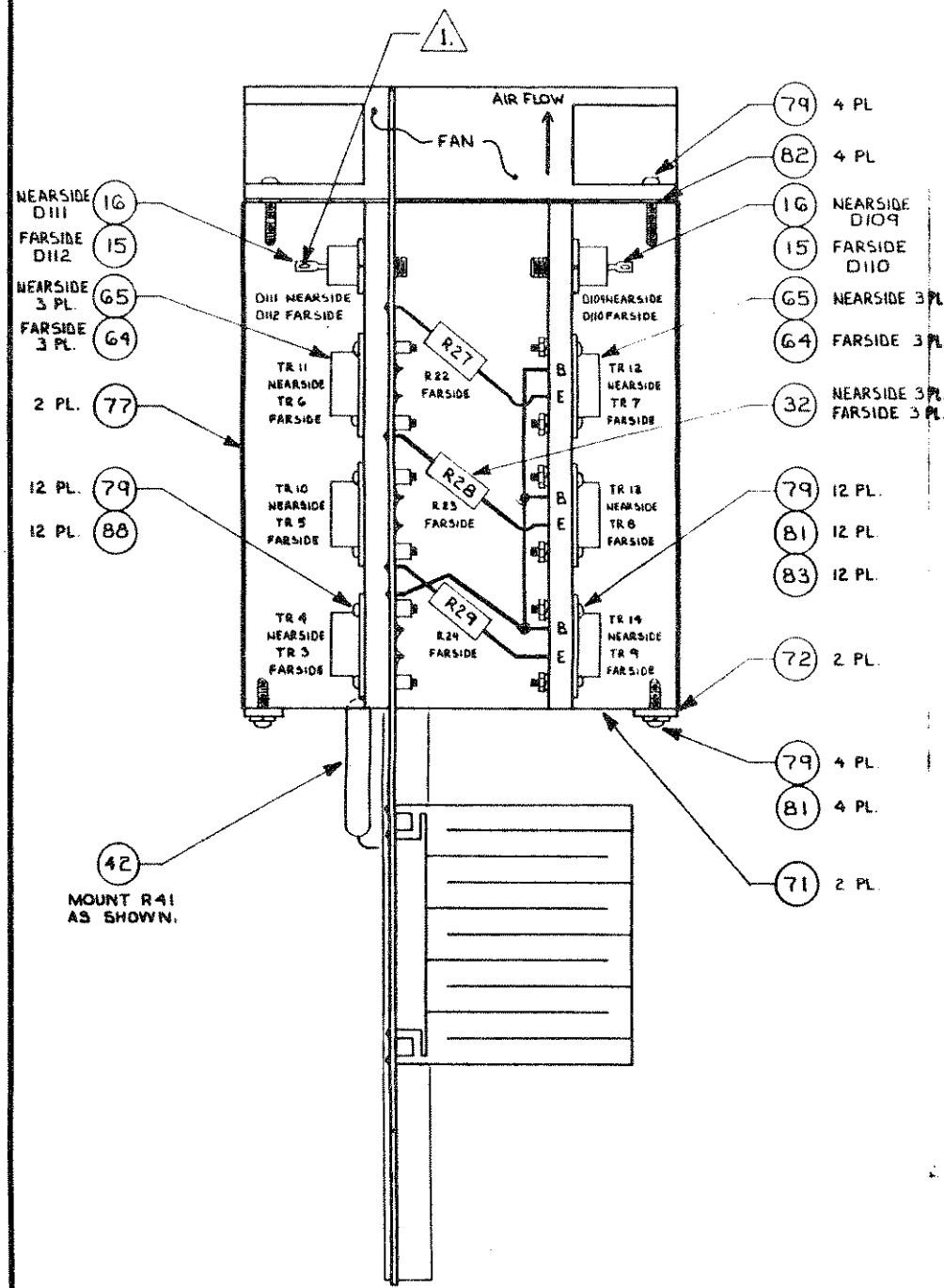
Valhalla Scientific Inc.
SAN DIEGO CA

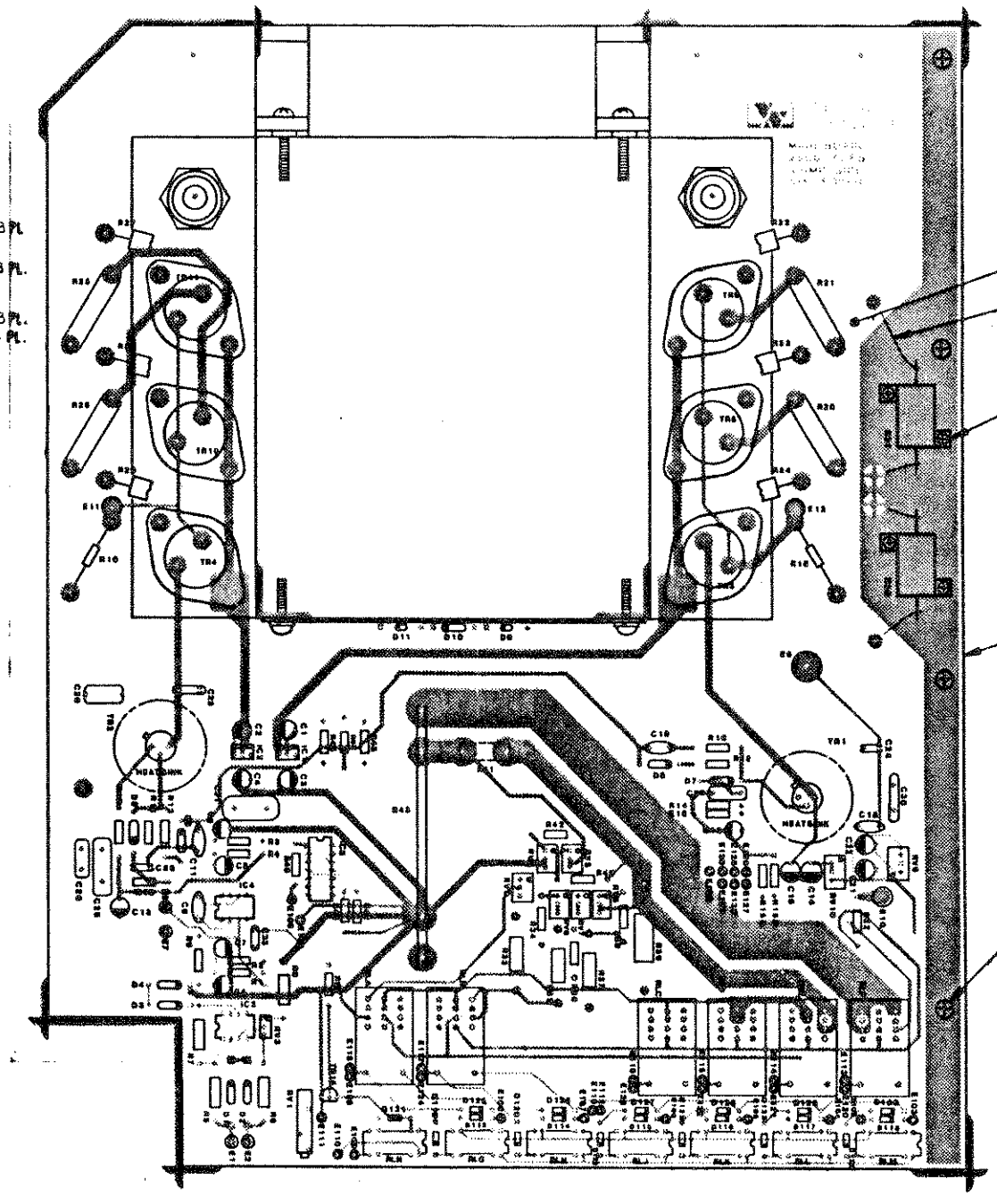
MAIN BOARD SCHEMATIC 25

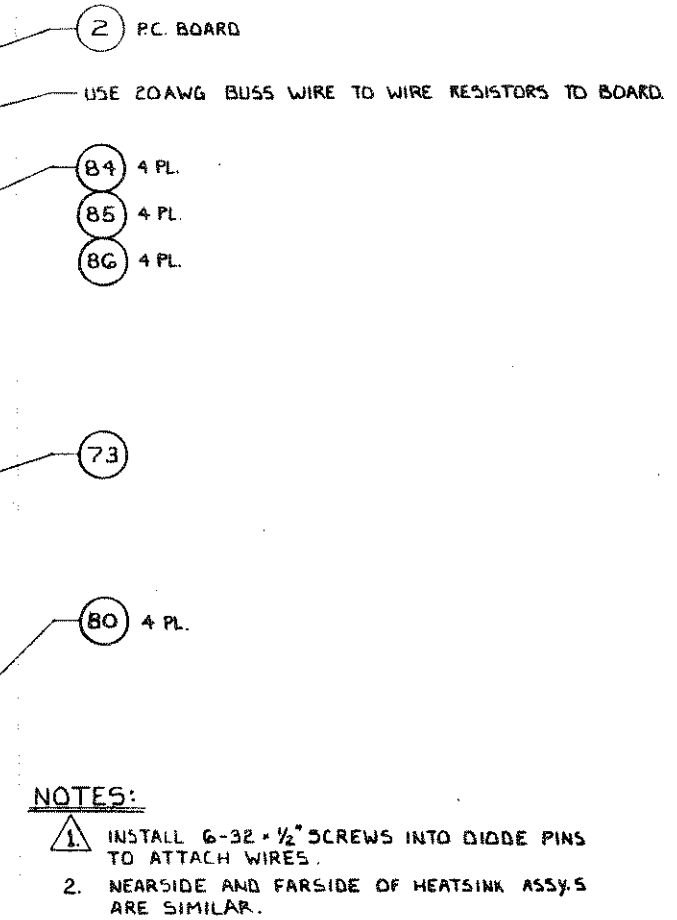
SCALE NONE
SHEET 2 OF 2
CODE IDENT 53504
SIZE D
DRAWING NO 2500-074

NOTES: (UNLESS OTHERWISE SPECIFIED)

REVISIONS				
ECO	LTR	DESCRIPTION	DATE	APPROVED
718	A	REDESIGNED RDN	6-12-85	
768	B	RENUMBERED DRAWING. RDN	8-26-85	
776	C	CHANGED R1415 ON P/L MAS	9-9-85	
792	D	CHANGES TO STOP OSCILLATING. RDN	5-7-86	







NOTES:

1. INSTALL 6-32 × ½" SCREWS INTO DIODE PINS TO ATTACH WIRES.
2. NEARSIDE AND FARSIDE OF HEATSINK ASSY.S ARE SIMILAR.
3. INSTALL ITEMS 80 (12 PER) FIRST.
4. HEATSINK INSULATORS ARE TO BE TAPED ON TO HEATSINKS.

DASH NO	QTY REQD	NEXT ASSEMBLY	USED ON

TOLERANCES
X° = ± 30'
.XX = ± .03
.XXX = ± .010

BREAK ALL SHARP CORNERS AND EDGES, MACH SURFACES 63

MATERIAL

FINISH

DRAWN RDN	6-12-85	
CHECKED TDJ	11/20/85	
APPR TDJ	11/20/85	
STK NO		

Valhalla Scientific Inc.
SAN DIEGO, CA

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MAIN P.C.B. ASSEMBLY

SCALE	CODE IDENT	SIZE	DRAWING NO	REV
1=1	53504	D	2500-604	D

SHEET 1 OF 5

ECO	LTR	REVISIONS DESCRIPTION		DATE	APPROVED
718	A	RELEASED + UPDATED NEW VERSION RDN		6/20/85	
745	B	UPDATE DRAWING; MATCH BALLOON # TO P/L		8/15/85	
791	C	MADE PARTS LIST CHANGE	MAS	11/5/85	
792	D	CHANGED LED'S, LINE 25.	RDN	3-14-86	

2PLS (58)

2PL (51) (58)

4PL (44) (56) (61)

6

4PL (44) (55)

17

NOTICE FLAT PART OF SHAFT

LOCATING WASHER #2

LOCATING TAB

LOCATING WASHER #1

SW1 INSTRUCTIONS

NUT 3/8 x 32 (60)

FRONT PANEL

INTERNAL STAR WASHER

LOCATING WASHER #1

LOCATING WASHER #2

NUT PROVIDED W/SWITCH.

MOUNTING OF SW1

C116

C119

BOTTOM

BOTTOM

(65) 24 PLS

(9) SPD W/CHASSIS

(7) DRILL PER DWG 2500E-213

(49) 8 PLS

(12) FS2

(45) 4 PLS

2 NUTS SUPPLIED WITH EACH BINDING POST

J3 RED

J4 BLACK

F2

S1

DS1

DS2

DS3

DS4

DS5

DS6

DS7

DS8

RED, J1

BLK, J2

(28) S3

(3)

(5)

(43) 4PLS.

(56) 4PLS.

(50)

(9) SPD W/CHASSIS

(63) 6 PLS

(9) SPD W/CHASSIS

(9) SPD W/CHASSIS

(9) SPD W/CHASSIS

BOTTOM (9)

8 PLS (44)

4PL (42) (54) (15)

2PL (64)

S2 (28)

(8) FRONT PANEL

WIRING INFO FOR LEDS

TO MAIN BOARD

E101 E102 E103 E104 E105 E106 E107 E108

DS1 DS2 DS3 DS4 DS5 DS6 DS7 DS8

E100 E119 E120 E121 E122 E123 E124 E125

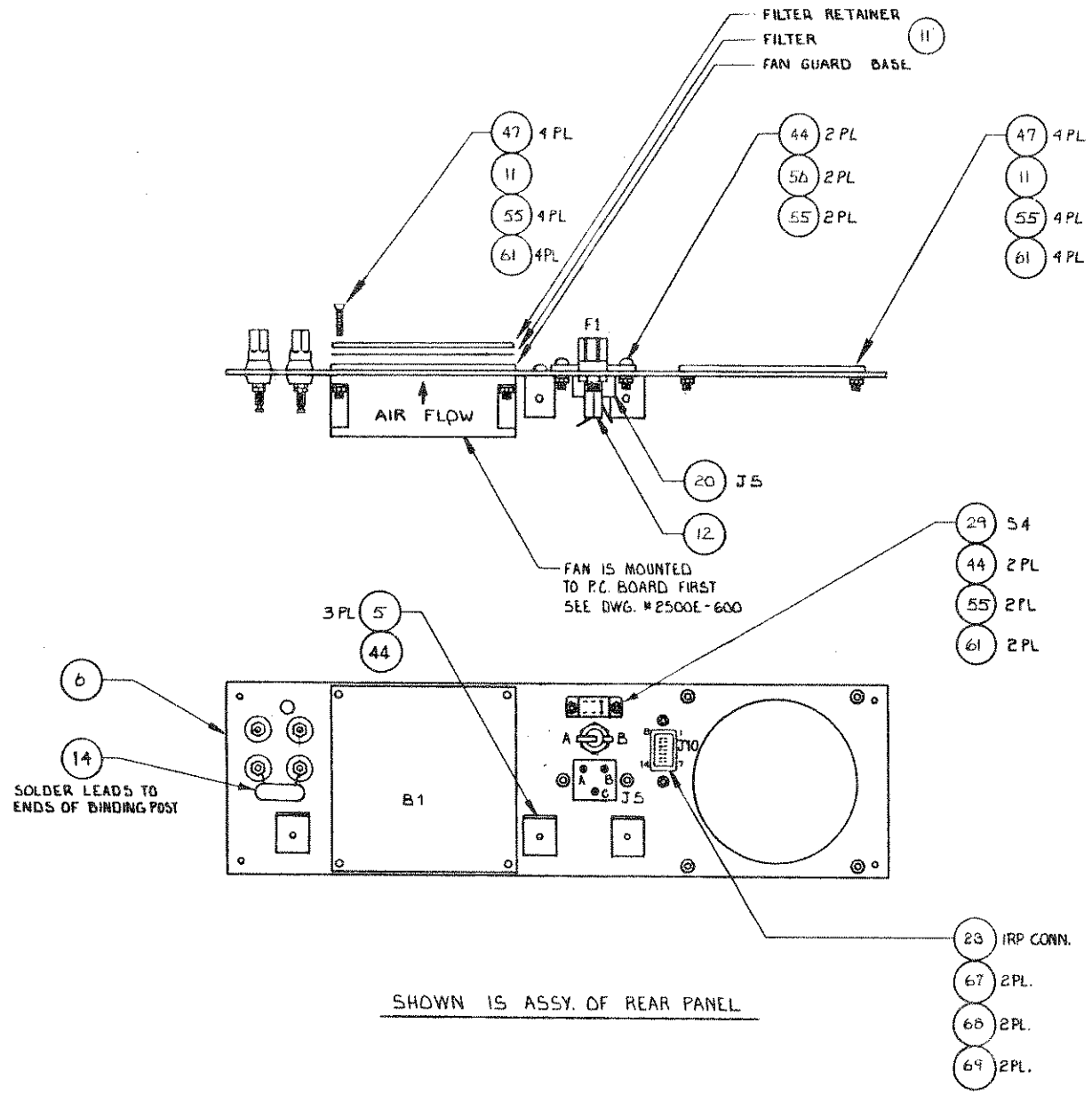
LED'S ARE MOUNTED ON FRONT PANAL.

TO MAIN BOARD

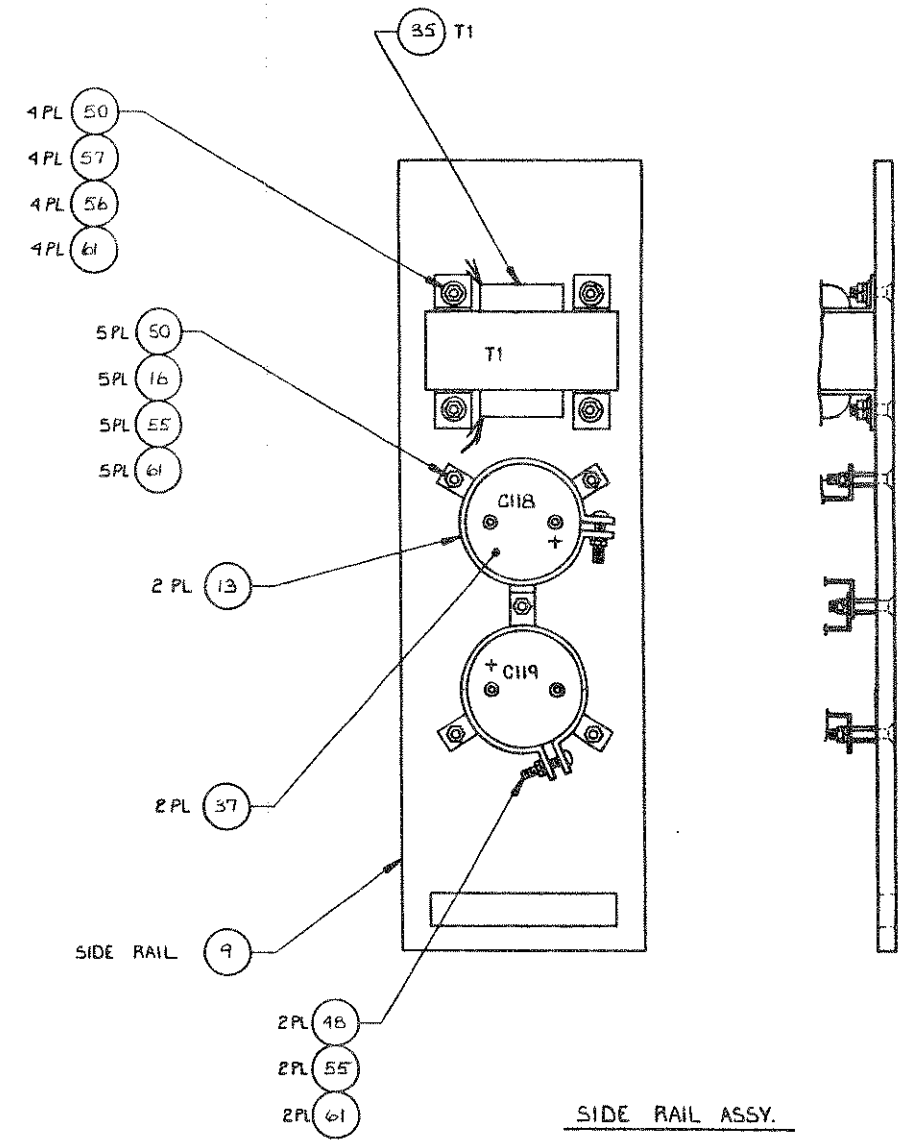
3. FOR WIRING SEE 2500E-051
2. FOR SCHEMATIC SEE 2500E-075

MATERIAL	DRAWN RDN	Valhalla Scientific Inc. SAN DIEGO, CALIFORNIA	
	CHECKED		
	APPR.		
FINISH		2500EP FINAL ASSEMBLY	
	SCALE NONE	CODE IDENT NO. 83504	SIZE D — DRAWING NO. 2500 -405 — REV. D
	SHEET 5 OF 6		

REVISIONS				
ECO	LTR	DESCRIPTION	DATE	APPROVED
		SEE SHEET 5		



SHOWN IS ASSY. OF REAR PANEL



SIDE RAIL ASSY.

MATERIAL	DRAWN C.R.E 1/62	Valhalla Scientific Inc. SAN DIEGO, CALIFORNIA		
	CHECKED			
	APPR.			
FINISH		2500 EP FINAL ASSY.		
	SCALE NONE	CODE IDENT NO 93504	SIZE D	DRAWING NO 2500 - 405 REV. D
	SHEET 6 OF 6			

Valhalla Scientific Inc.	PARTS LIST	FINAL ASSEMBLY	MODEL 2500 EP	DWG NO 2500-405	REV D

#	REF DES	VALHALLA PART NO	DESCRIPTION	CODE IDENT	MFG PART NO	QTY. I	QTY. N	I	N		REMARKS
1											
2											
3			P.C. BOARD ASSY.	VALHALLA	2500-604	1					
4											
5		4-10051	MTG. BRACKET	VALHALLA	2500-208	4					
6		4-10377	REAR PANEL	VALHALLA	2500-225	1					
7		4-10347	SIDE RAIL, MODIFIED	VALHALLA	2500-213	1					
8		4-10604	2500EP FRONT PANEL	VALHALLA	2500-105	1					
9		4-10223	CASE 51/4 2500EP	TDJ	B-525-15-1700H	1					
10											
11		5-10493	FILTER FAN GUARD 4½"	AFP	FF450A/30or45PPI	2					
12	FS1,FS2	5-10018	FUSE HOLDER	LITTLE FUSE	345061	2					
13		5-10062	CAPACITOR MTG. BRACKET	CDE	VR12	2					
14	C32	2-60003	1Uf,100V,MYLAR			1					
15		5-10015	RUBBER FEET WHITE	ACCUR RUBBER	2089 W1017	4					
16		5-10217	SPACER,1/4HEX,1/4 LG.	SMITH	2300	5					
17		5-10291	PLUG HOLE .357 BLK.	SMITH	3091	1					
18	J2,4,6,8	5-10020	BINDING POST BLK.	SUPERIOR	BP30BC	4					
19	J1,3,7,9	5-10021	BINDING POST RED	SUPERIOR	BP30RC	4					
20	J5	5-10063	POWER RECPT.	SWITCH CRAFT	EAC301	1					
21		5-10019	CABLE TIE 4"x1/8"	PANDUIT	WRN-4	50					
22		5-10441	TIE WRAP,BLOCK,SMALL	PANDUIT	ABMM-AT	9					
23	J10	5-10089	CONN.FEMALE 14PIN W/BAIL	AMPHENOL	5740140	1					

NOTES:

Valhalla Scientific Inc.	PARTS LIST	FINAL ASSEMBLY	MODEL 2500EP	DWG NO 2500-405	REV D

#	REF DES	VALHALLA PART NO	DESCRIPTION	CODE IDENT	MFG PART NO	QTY. I	QTY. N	I	N		REMARKS
24											
25	DS1-8	5-01028	LED,RED,PANEL MTG.	H.P.	HLMP3301	8					
26											
27	S1	5-03031	ROTARY SW,2POLE,12WAY	CENTRAL	FA-203-3F000	1					
28	S2-S3	5-03061	POWER SWITCH	SCHADOW	ZFNE2BUEE110101063	2					
29	S4	5-03017	SWITCH SLIDE 115/230	SWITCH CRAFT	46256LFR	1					
30		5-10202	KNOB COLLECT BLK,SLVR,CAP	ALCO	AS1-352-W3-302	1					
31		5-10203	SKIRT,BLK,POINTER	ALCO	AW5-382	1					
32	F1	5-04009	FUSE 5A	LITTLE FUSE	312-005	1					
33	F2	5-04012	FUSE 15A	Bussman	AGC15	1					
34											
35	T1	4-20009	POWER TRANSFORMER	53504	2500-011	1					
36											
37	C118,119	2-40003	CAP,ELEC,61000mf/40V	SANGAMO	DCM613U0400D2B	2					
38											
39	R44	1-01061	RES,10K,1/4w	81349	RC07GF103J	1					
40											
41											
42			SCREW,PHIL,PAN,S.S.		6-32x3/4"	4					
43			SCREW,PHIL,PAN,S.S.		6-32x1/2"	4					
44			SCREW,PHIL,PAN,S.S.		6-32x3/8"	26					
45			SCREW,PHIL,PAN,BLK.		6-32x3/8"	4					
46											

NOTES:

REV 03-07-88

Valhalla Scientific Inc.	PARTS LIST	FINAL ASSEMBLY	MODEL 2500EP	DWG NO 2500-405	REV D

#	REF DES	VALHALLA PART NO	DESCRIPTION	CODE IDENT	MFG PART NO	QTY. I	QTY. N	I	N		REMARKS
47			SCREW,PHIL,FLAT,82°		6-32x1"	8					
48			SCREW,PHIL,PAN,S.S.		6-32x1"	2					
49			SCREW,PHIL,FALE,S.S.,82°		6-32x3/8"	8					
50			SCREW,PHIL,FLAT,S.S.,82°		6-32x5/8"	9					
51			SCREW,PHIL,PAN,S.S.		10-32x7/16"	2					
52											
53											
54			WASHER,FLAT		#6	4					
55			WASHER,SPLIT LOCK		#6	26					
56			WASHER,INTERNAL STAR		#6	15					
57			WASHER,FLAT		#10	4					
58			WASHER,INTERNAL STAR		#10	4					
59											
60			NUT 3/8x32			1					
61			STANDARD HEX NUT		6-32	25					
62											
63	SUPPIED WITH CASE		SCREW,PHIL,OVAL,CAD		6-32x3/8"	6					
64			SCREW,PHIL,OVAL,CAD		6-32x1/2"	2					
65			TINNERMAN NUT		6-32	24					
66											
67			SCREW,PHIL,PAN,S.S.		3-56x3/8"	2					
68			WASHER SPLIT LOCK		#4	2					
69			STANDARD HEX NUT		3-56	2					

NOTES:

Valhalla Scientific Inc. | **PARTS LIST** | FINAL ASSEMBLY | MODEL 2500EP | DWG NO 2500-405 | REV D

#	REF DES	VALHALLA PART NO	DESCRIPTION	CODE IDENT	MFG PART NO	QTY. I	QTY. N	I	N		REMARKS
70											
71			WIRE,BLACK		12 AWG.	9'					
72			WIRE,GREEN		12 AWG.	5'					
73			WIRE,BLACK		14 AWG.	1'					
74			WIRE,RED		16 AWG.	5'					
75			WIRE,BLACK		16 AWG.	5'					
76			WIRE,GREEN		16 AWG.	6"					
77			WIRE,GREEN		14 AWG.	1'					
78			WIRE,BLACK		20 AWG.	6'					
79			WIRE,BROWN		20 AWG.	5'					
80			WIRE,RED		20 AWG.	8'					
81			WIRE,ORANGE		20 AWG.	7'					
82			WIRE,YELLOW		20 AWG.	7'					
83			WIRE,GREEN		20 AWG.	7'					
84			WIRE,BLUE		20 AWG.	7'					
85			WIRE,VIOLET		20 AWG.	7'					
86			WIRE,GRAY		20 AWG.	6					
87			WIRE,WHITE		20 AWG.	6'					
88			RING LUG		#6 16 AWG.	1					
89			RING LUG		#8 22 AWG.	7					
90			RING LUG		#6 12AWG.	7					
91			RING LUG		#8 12 AWG.	6					
92			RING LUG		#10 12 AWG.	2					

NOTES:

REV 03-07-88

Valhalla Scientific Inc.	PARTS LIST	MAIN PCB ASSY.	MODEL 2500EP	DWG NO 2500-604	REV D

#	REF DES	VALHALLA PART NO	DESCRIPTION	CODE IDENT	MFG PART NO	QTY. I	QTY. N	I	N		REMARKS
1											
2	A1	4-30152	P.C.BOARD (MAIN)	53504	2500-704	1					
3											
4	C1-8,12,13	2-30011	4.7uF,35V,TANT.BEAD			10					
5	C9	2-20014	20pF,500V,MICA	81349	CM05FD200J03	1					
6	C10,11	2-20007	150pF,500V,MCIA	81349	CM05FD151J03	2					
7	C14,15	2-30016	47uF,25V,TANT.BEAD			2					
8	C18	2-20020	300pF,500V,MICA	81349	CM05FD301J03	1					
9	C21,22	2-30003	47uF,10V,TANT.BEAD			2					
10											
11	D1,2	3-20031	DIODE,ZENER,4.7V,10%,5w		1N5337A	2					
12	D3-6	3-20005	DIODE,ZENER,6.2V,10%		1N5234	4					
13	D7,8,10,113-131	3-20000	DIODE,SIGNAL		1N4148	22					
14	D9,11	5-01005	SINGLE LED, RED,SMALL	H.P.	5082-4480	2					
15	D110,112	3-20011	DIODE,RECTIFIER,10A		1N1183A	2					
16	D109,111	3-20012	DIODE,RECTIFIER,10A(REVERSE)		1N1183RA	2					
17											
18											
19	IC1	3-30036	REG.,+15V,0.5A,T0202		78M15CP	1					
20	IC2	3-30037	RES.,-15V,0.5A,T0202		79M15CP	1					
21	IC3	3-30315	OP-AMP,PRECISION FET	B-B	OPA103CM	1					
22	IC4	3-30170	OP-AMP,LOW NOISE		OP-07DP	1					
23	IC5	3-30133	QUAD COMPARATOR		LM339N	1					

NOTES:

REV 03-07-88

Valhalla Scientific Inc.	PARTS LIST	MIAN BOARD ASSY.	MODEL 2500EP	DWG NO 2500-604	REV D

#	REF DES	VALHALLA PART NO	DESCRIPTION	CODE IDENT	MFG PART NO	QTY. I	QTY. N	I	N		REMARKS
24											
25	R1-4	1-01007	10 ohm,5%.1/4w	81349	RC07GF100J	4					
26	R5-8	1-20034	50K ohm,.05%,5PPM	GOLDSTAR	GS711-50K.05%-5PPM	4					
27	R9-11,32	1-01043	1.5K ohm,5%,1/4w	81349	RC07GF152J	2					
28	R12,13	1-01063	15K ohm,5%,1/4w	81349	RC07GF153J	2					
29	R14,15	1-01037	680 ohm,5%,1/4w	81349	RC07GF	2					
30	R16,17	1-01015	47 ohm,5%,1/4w	81349	RC07GF470J	2					
31	R18,19	1-01033	470 ohm,5%,1/4w	81349	RC07GF471J	2					
32	R20-29	1-30001	1 ohm,8w	OHMITE	1500 BROWN DEVIL	10					
33	R30,31	1-30034	25 ohm,5%,15w	DALE	RH10	2					
34	R33	1-20051	8.95 ohm,0.1%,5PPM	GOLDSTAR	GS805-8K95-1%-5PPM	1					
35	R34	1-10072	6.49K ohm,1%	81349	RN60C6492F	1					
36	R35	1-20050	909 ohm,0.1%,5PPM	GOLDSTAR	GS809-909R-.1%-5PPM	1					
37	R36	1-10071	6.49K ohm,1%	81349	RN60C6491F	1					
38	R37	1-20049	90.9 ohm,1%,5PPM	GOLDSTAR	GS809-90R9-1%-5PPM	1					
39	R38	1-10070	649 ohm,1%	81349	RN60C64R9F	1					
40	R39	1-10048	9.09,1%,5PPM	GOLDSTAR	GS811-9R09-1%-5PPM	1					
41	R40	1-10069	64.9 ohm,1%	81349	RN60C64R9F	1					
42	R41	1-20047	0.909,0.1%,LOLLIPOP	GOLDSTAR	R0004	1					
43	R42	1-10068	7.15 ohm,1%	81349	RN60C7R15F	1					
44	R43	1-20046	0.101 ohm,0.1% (patato masher)	GOLDSTAR	R0003	1					
45	R45,48	1-10067	3.01K,1%,50PPM,1/4w	81349	RN60C3011F	2					
46	R49	1-01041	1K ohm,5%,1/4w	81349	RC07GF102J	1					

NOTES:

Valhalla Scientific Inc. | **PARTS LIST** | MAIN PCB ASSY | MODEL 2500EP | DWG NO 2500-604 | REV D

#	REF DES	VALHALLA PART NO	DESCRIPTION	CODE IDENT	MFG PART NO	QTY. I	QTY. N	I	N		REMARKS
47											
48	R61,152	1-01061	10K ohm,5%,1/4w	81349	RC07GF103J	2					
49	R46,R47	1-10056	12.1K,1%,50PPM,1/4w		RN60C1212F	2					
50	R150,151	1-01037	680 ohm,5%,1/4w	81349	RC07GF680J	2					
51	RLG,H,J-M	5-03012	RELAY,REED,5V COIL,DIL	SIGMA	191TE1A1-5S	6					
52	RLA-F	5-03019	RELAY, CRADLE, 4 FORM C	P&B	R10-E2-Z4-J1.OK	6					
53	RLN	5-03070	RELAY,REED,1 FORM A,12V	CLAIRE	PRMA1A12	1					
54	RV10	1-50012	10K ohm,(TOP ADJUST)		68WR10K	1					
55	RV1	1-50035	50K ohm,(END ADJUST)	BECKMAN	89PR50K	1					
56	RV3,5,9	1-50014	100 ohm,(TOP ADJUST)	BECKMAN	68WR100 ohm	3					
57	RV4	1-50018	10 ohm,(TOP ADJUST)	BECKMAN	68WR10 ohm	1					
58	RV6	1-50013	1K ohm,(TOP ADJUST)	BECKMAN	68RW1K	1					
59	RV7	1-50012	10K ohm,(TOP ADJUST)	BECKMAN	68WR10K	1					
60	RV8	1-50024	100K ohm,(TOP ADJUST)	BECKMAN	68WR100K	1					
61											
62	TR1	3-10002	PNP TRANSISTOR(TO-5)		2N4036	1					
63	TR2	3-10007	NPN TRANSISTOR(TO-5)		2N2102	1					
64	TR3,5-9	3-10008	NPN TRANSISTOR(TO-3 STEEL)		2N3055	6					
65	TR4,10-14	3-10009	PNP TRANSISTOR(TO-3 STEEL)		2N6246-8	6					
66	TR15	3-10013	NPN TRANSISTOR (TO-92)		2N4401	1					
67											
68											
69											

NOTES:

Valhalla Scientific Inc. | **PARTS LIST** | MAIN PCB ASSY. | MODEL 2500EP | DWG NO 2500-604 | REV D

#	REF DES	VALHALLA PART NO	DESCRIPTION	CODE IDENT	MFG PART NO	QTY. I	QTY. N	I	N		REMARKS
70											
71		4-10049	HEATSINK	53504	2500-206	2					
72		4-10065	HEATSINK BRACKET	53504	2500-211	2					
73		4-10050	2500E GROUND BRACKET	53504	2500-207	1					
74											
75	XTR1,2	5-10207	HEATSINK,TO-5		209CB	2					
76	FAN	5-10059	FAN,11VAC,50-60Hz	ROTRON	MU2A1	1					
77		5-10233	HEATSINK INSULATOR	53504	2500-212	2					
78											
79			SCREW ,PHIL,PAN, .S.S		6-32x3/4"	32					
80			SCREW,PHIL,PAN,S.S.		6-32x5/8"	4					
81			WASHER,SPLIT LOCK		#6	16					
82			WASHER FLAT		#6	4					
83			NUT,RADIO HEX		6-32	12					
84			SCREW,PHIL,PAN,S.S.		2-56x5/8"	4					
85			WASHER,SPLIT LOCK		#2	4					
86			NUT,RADIO HEX		#2	4					
87											
88		5-10005	STANDOFF 3/16"	88249	1530B-3/16"	12					
89											
90			WIRE BUS		22AWG	18"					
91			CLEAR SLEEVING		22AWG	12"					
92											

NOTES:

Valhalla Scientific Inc. | **PARTS LIST** | MAIN PCB ASSY. | MODEL 2500EP | DWG NO 2500-604 | REV D

#	REF DES	VALHALLA PART NO	DESCRIPTION	CODE IDENT	MFG PART NO	QTY. I	QTY. N	I	N		REMARKS
93	C23	2-10000	0.005uF,100V,CERAMIC			1					
94	C20	2-60002	0.1uF,250V,MYLAR			1					
95											
96											
97	C30	2-10004	0.02u,500V,CERAMIC DISC.			1					
98	C24,29	2-10006	0.01uF,50V,CERAMIC DISC.		8121-050-651-103M	2					
99	C25,31	2-60001	0.22u,100V,MYLAR			2					
100	C33	2-10005	50pF,500V,CERAMIC DISC.			1					
101	C27	2-20011	1000p,500V,MICA		CM06FD102J03	1					
102	C28	2-20012	10p,500V,MICA		CM05FD100J03	1					
103											
104											
105											
106											
107											
108											
109											
110											
111											
112											
113											
114											
115											

NOTES:

REV 03-07-88

Federal Supply Codes for Manufacturers (cont.)

81095
Triad Transformer Corp.
Venice, California

81312
Winchester Electronics
Div. of Litton Industries Inc.
Oakville, Connecticut

81483
International Rectifier Corp.
Los Angeles, California

81741
Chicago Lock Co.
Chicago, Illinois

82389
Switchcraft Inc.
Chicago, Illinois

82877
Rotron Inc.
Woodstock, New York

82879
ITT Royal Electric Div.
Pawtucket, Rhode Island

83003
Varo Inc.
Garland, Texas

83298
Bendix Corp.
Eatontown, New Jersey

83330
Herman H. Smith, Inc.
Brooklyn, New York

83594
Burroughs Corp.
Plainfield, New Jersey

83740
Union Carbide Corp.
New York, New York

84171
Arco Electronics
Great Neck, New York

84411
TRW Electronic Components
Ogallala, Nebraska

84613
Fuse Indicator Corp.
Rockville, Maryland

84682
Essex International Inc.
Peabody, Massachusetts

86684
Radio Corp. of America
Harrison, New Jersey

88219
Gould Inc.
Trenton, New Jersey

88245
Litton Systems Inc.
Useco Div.
Van Nuys, California

88419
Cornell-Dubilier Electronic Div.
Fuquay-Varian, North Carolina

89730
G.E. Co.
Newark, New Jersey

90201
Mallory Capacitor Co.
Indianapolis, Indiana

56365
Square D Co.
Chicago, Illinois

90303
Mallory Battery Co.
Tarrytown, New York

91094
Essex International Inc.
Newmarket, New Hampshire

91293
Johanson Mfg. Co.
Boonton, New Jersey

91506
Augat Inc.
Attleboro, Massachusetts

91637
Dale Electronics Inc.
Columbus, Nebraska

91662
Elco Corp.
Willow Grove, Pennsylvania

71468
Gremar Mfg. Co., Inc.
ITT Cannon/Gremar
Santa Ana, California

91802
Industrial Devices, Inc.
Edgewater, New Jersey

91833
Keystone Electronics Corp.
New York, New York

91929
Honeywell Inc.
Micro Switch Div.
Freeport, Illinois

92194
Alpha Wire Corp.
Elizabeth, New Jersey

93332
Sylvania Electric Products
Woburn, Massachusetts

94988
Wagner Electric Corp.
Tung-Sol Div.
Newark, New Jersey

95146
Alco Electronic Products Inc.
Lawrence, Massachusetts

95275
Vitramon Inc.
Bridgeport, Connecticut

95303
RCA Corp.
Receiving Tube Div.
Cincinnati, Ohio

95348
Gordo's Corp.
Bloomfield, New Jersey

95712
Bendix Corp.
Franklin, Indiana

97913
Industrial Electronic
Hardware Corp.
New York, New York

97945
Penwalt Corp.
SS White Industrial Products Div.
Piscataway, New Jersey

98278
Malco A. Microdot Co., Inc.
Connector & Cable Div.
Pasadena, California

98291
Sealectro Corp.
Mamaroneck, New York

98388
Royal Industries
Products Div.
San Diego, California

98978
IERC
Burbank, California

99120
Plastic Capacitors, Inc.
Chicago, Illinois

99217
Bell Industries Elect.
Burbank, California

99392
STM
Oakland, California

99515
ITT Jennings Monrovia Plant
Monrovia, California

99779
Use 29587
Bunker-Ramo Corp.
Landsdowne, Pennsylvania

99942
Centrelab Semiconductor
El Monte, California

Federal Supply Codes for Manufacturers (cont.)

18612
Vishay Intertechnology Inc.
Malvern, Pennsylvania

18722
R C A
Mountaintop, Pennsylvania

18927
GTE Sylvania Inc.
Titusville, Pennsylvania

21604
Bucheye Stamping Co.
Columbus, Ohio

21845
Solitron Devices Inc.
Riveria Beach, Florida

22767
ITT Semiconductors
Palo Alto, California

23936
Pamotor Div
Burlingham, California

24355
Analog Devices Inc.
Norwood, Massachusetts

24655
General Radio
Concord, Massachusetts

25088
Siemen Corp.
Isilen, New Jersey

25403
Amperex Electronic Corp.
Slatersville, Rhode Island

25684
Victoreen Instrument Co., Inc.
Oak Lawn, Illinois

27014
National Semiconductor Corp.
Santa Clara, California

27556
IMB Electronic Products
Santa Fe Springs, California

27264
Molex Products
Downers Grove, Illinois

28213
Minnesota Mining & Mfg. Co.
St. Paul, Minnesota

28480
Hewlett Packard Co.
Palo Alto, California

29083
Monsanto Co., Inc.
Santa Clara, California

29604
Stackpole Components Co.
Raleigh, North Carolina

30323
Illinois Tool Works, Inc.
Chicago, Illinois

30983
Electra/Midland
San Diego, California

32539
Mura Corp.
Great Neck, New York

32897
Erie Technological Products, Inc.
Carlisle, Pennsylvania

32997
Bourns Inc
Riverside, California

33173
General Electric Co
Owensboro, Kentucky

34333
Silicon General
Westminister, California

34335
Advanced Micro Devices
Sunnyvale, California

34802
Electromotive Inc.
Kenilworth, New Jersey

37942
P.R. Mallory & Co., Inc.
Indianapolis, Indiana

43543
Nytronics Inc.
Geneva, New York

44655
Ohmite Mfg. Co.
Skokie, Illinois

49671
RCA Corp.
New York, New York

49956
Raytheon Company
Lexington, Massachusetts

50088
Mostek Corp.
Carrollton, Texas

50579
Litronix Inc.
Cupertino, California

51605
Scientific Components Inc.
Linden, New Jersey

53021
Sangamo Electric Co.
Springfield, Illinois

53504
Valhalla Scientific, Inc.
San Diego, California

54294
Cutler-Hammer Inc.
Selma, North Carolina

55026
Simpson Electric Co.
Elgin, Illinois

56289
Sprague Electric Co.
North Adams, Massachusetts

58474
Superior Electric Co.
Bristol, Connecticut

63743
Ward Leonard Electric Co., Inc.
Mount Vernon, New York

65092
Weston Instruments Inc.
Newark, New Jersey

70563
Amperite Company
Union City, New Jersey

70903
Belden Corp.
Geneva, Illinois

71279
Cambridge Thermionic Corp.
Cambridge, Massachusetts

71400
Bussmann Mfg.
Saint Louis, Missouri

71450
CTS Corp.
Elkhart, Indiana

71468
ITT Cannon Electric Inc.
Santa Ana, California

71482
Clare, C.P. & Co.
Chicago, Illinois

71590
Centrelab Electronics
Milwaukee, Wisconsin

71707
Coto Coil Co., Inc.
Providence, Rhode Island

71744
Chicago Miniature Lamp Works
Chicago, Illinois

71785
TRW Electronics Components
Chicago, Illinois

72005
Wilber B. Driver Co.
Newark, New Jersey

72259
Nytronics Inc.
Pelham Manor, New Jersey

72619
Dialight Div.
Brooklyn, New York

72982
Erie Tech. Products Inc.
Erie, Pennsylvania

73138
Beckman Instrument Inc.
Helipot Division
Fullerton, California

73445
Amperex Electronic Corp.
Hicksville, New York

73734
Federal Screw Products, Inc.
Chicago, Illinois

73899
JFD Electronics Co.
Brooklyn, New York

73949
Guardian Electric Mfg. Co.
Chicago, Illinois

74276
General Instrument Corp.
Neptune, New Jersey

74306
Piezo Crystal Co.
Carlisle, Pennsylvania

74970
Johnson E.F., Co.
Waseca, Minnesota

75042
TRW Electronics Components
IRC Fixed Resistors
Philadelphia, Pennsylvania

75378
CTS Knights Inc.
Sandwich, Illinois

75382
Kulka Electric Corp.
Mount Vernon, New York

75915
Littlefuse Inc.
Des Plaines, Illinois

76055
Mallory Controls
Frankfort, Indiana

76493
J.W. Miller Company
Los Angeles, California

76854
Oak Industries Inc.
Crystal Lake, Illinois

77342
Potter & Brumfield Div.
Princeton, Indiana

77638
General Instrument Corp.
Rectifier Division
Brooklyn, New York

78488
Stackpole Carbon Co.
Saint Marys, Pennsylvania

78553
Eaton Corp.
Cleveland, Ohio

80031
Electro-Midland Corp.
Mepco Div.
Norristown, New Jersey

56289
Sprague Products
North Adams, Massachusetts

80294
Bourns Inc., Instrument Div.
Riverside, California

81073
Grayhill, Inc.
La Grange, Illinois

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