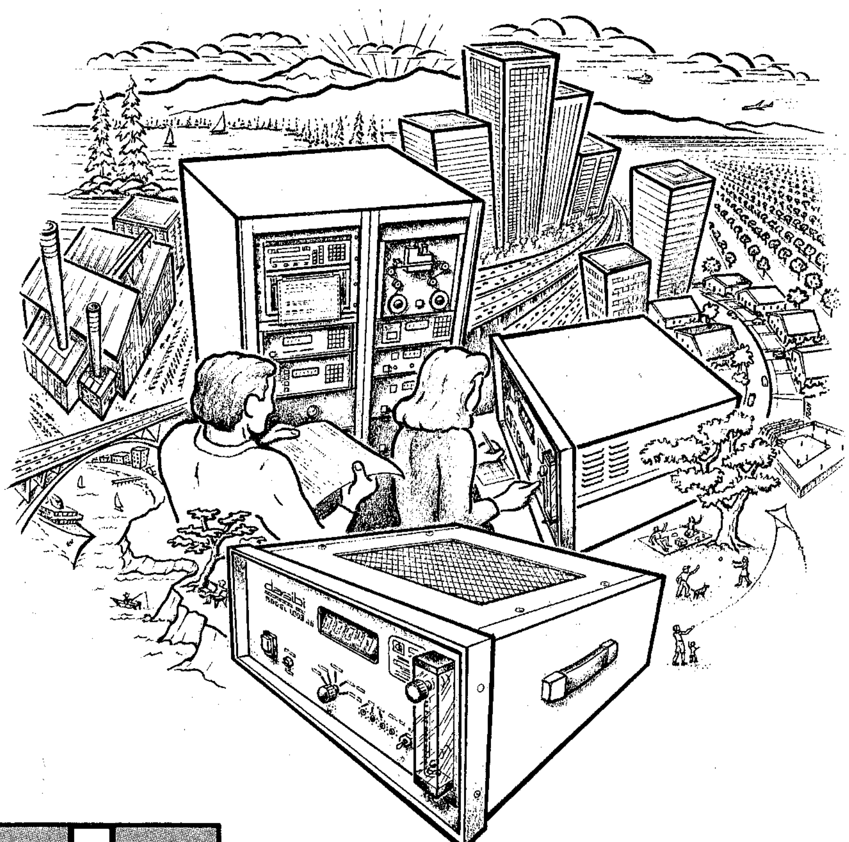
SERIES 1008
U.V. PHOTOMETRIC OZONE ANALYZER

(MODELS 1008-AH, 1008-PC, 1008-PS,
1008-RS & 1008-HC)

OPERATING AND MAINTENANCE MANUAL



dasibi
ENVIRONMENTAL CORP.

Preface

This Operating & Maintenance (O&M) manual contains information for use by operating personnel of the Dasibi Environmental Corporation (Dasibi) Series 1008 Ultraviolet (UV) Photometric Ozone Analyzer, also referred to herein as the unit or instrument. This information includes descriptions of installation, theories of operation, basic operation, calibration, preventive & corrective maintenance procedures and troubleshooting techniques for the unit.

Experience indicates that the user will obtain maximum performance and utility from the instrument when time has been spent studying the information provided herein. It is therefore recommended that this manual be fully reviewed before proceeding with installation and commissioning of the unit.

Dasibi continually strives to remain current with the latest electronic developments. Hardware/software improvements are incorporated into its products as soon as development and testing have been accomplished. Sometimes, due to printing and shipping requirements, these changes are not immediately incorporated into the manuals, but are rather presented as individual technical update pages provided in Appendix C. Information about modifications that have taken place since the copyright date listed on the front page of this manual, are detailed there; It is highly recommended that this section be reviewed for any unit purchased.

Modifications that have occurred since the last copyright date of this manual will be carried in Appendix C until they may be permanently entered into the manual. If no update pages are included in this section, then this manual is correct as printed. Any feature described in this section that is applicable to the unit shipped with this manual will have an asterisk (*) hand-written next to its listing in the Table of Contents when this manual is inspected before shipment. Although every effort is made to keep the manual accurate and up-to-date, it is possible that errors have been made. If an error in the manual is found, or further information or assistance is desired, please contact Dasibi's sales department.

Dasibi Environmental Corporation
506 Paula Avenue
Glendale, CA 91201
Phone #: (818) 247-7601 **Fax #: (818) 247-7614**

 Any modifications made to the unit without prior, written consent of Dasibi may void the following warranty.

Warranty

This warranty covers two specific areas that may occur after delivery to the original purchaser by Dasibi, or by an authorized Dasibi representative:

1) Defective instrument operation according to guaranteed performance specifications.

2) Defects in materials or workmanship.

The warranty is applicable, provided that inspection and analysis by Dasibi discloses that any defects in instrument performance or defects in materials and workmanship developed under normal and proper use, and that the instrument was maintained and operated in accordance with the operations and service manuals supplied with the instrument. Dasibi will be released from all obligations under this warranty in the event repairs or modifications to the instrument have been made by persons other than Dasibi's own representatives, unless such repairs were made with the prior, written consent of Dasibi.

Any item claimed to be defective must be returned to Dasibi, transportation charges prepaid, and will be re-shipped to the customer collect, unless the item is actually' found to be defective, in which case, Dasibi will pay transportation charges.

Defective Instrument Operation

Dasibi agrees to correct any unit that does not function within the limits of the published performance specifications, either by repair or, at the option of Dasibi, by replacement, for one year after delivery to the original purchaser, the only exception being consumable items.

Defective Materials or Workmanship

Dasibi agrees to correct any defects in materials or workmanship in any unit either by repair or, at the option of Dasibi, by replacement, subject to the following conditions:

1. Dasibi extends to the original purchaser a two year warranty on all Dasibi-manufactured electronic parts and a one year warranty on all Dasibi-manufactured mechanical parts.

2. Dasibi extends to the customer whatever dated warranty is given to Dasibi by the suppliers of component items purchased by Dasibi and incorporated into the instrument.

3. This warranty does not cover expendable items, because their duration and performance may vary from case-to-case.

Claims for Damaged Shipments and Shipping Errors

Damaged Shipments

Merchandise should be inspected immediately upon receipt as described in Section One of this manual. A packing list is supplied with every shipment, and all items received should be checked against this list. If there appears to be shipping damage, both the carrier and Dasibi should be notified immediately (if the instrument appears to have only operational problems not associated with shipping damage, only Dasibi should be notified).

Claims for Shipping Discrepancies

It is important to check the contents of all shipments promptly against the packing list. Dasibi reserves the right to disavow all claims of deficiency that are not promptly reported.

If a claim is to be made, report the following:

1. Sales Order Number
2. Purchase Order Number
3. Model Number
4. Serial Number
5. Date Received

In addition, the following documents may be necessary to support a claim for shipping damage:

1. Copy of original invoice
2. Copy of packing list
3. Original freight bill and bill of lading
4. Photos of damaged equipment and container (if possible)

Conditions of Shipment

F.O.B. DESTINATION means that Dasibi pays all expenses and assumes all risks until actual delivery of the merchandise at the point agreed upon with the buyer.

F.O.B. GLENDALE means that the purchaser will pay all expenses and assumes all risks of merchandise damage.

Procedure For Returns/Repairs

1) Contact Dasibi to describe the problem. Obtain a return authorization number from the sales/service department. This number aids Dasibi in "tracking" returned items and in determining whether or not the item is still under warranty, or considered out-of-warranty.

2) **Warranty Items:** Please enclose a written description of the exact problem as accurately as possible. If strip charts or other such test documents are available, please include copies of them in the return shipment as they will help in the swift troubleshooting of described problems.

   Out-of-Warranty Items: Providing a written description of the exact problem as accurately as possible, guarantees that Dasibi technicians will only perform repair work on the requested areas. If additional repairs/upgrades are desirable, Dasibi customer service will notify the customer to first obtain approval.

3) Upon receipt of an out-of-warranty item, Dasibi will draft an estimate of the repair work required (there is no charge for this). The estimate will contain probable replacement parts/assemblies and the respective costs of each. In addition, there will be an estimate of "hands on" labor time.

4) Dasibi's service department will contact the customer with the initial estimate. Dasibi will not complete the required work until proper authorization from the customer is obtained. Because of the nature of some problems, though, some repair work may have to be performed before authorization is obtained in order to draft the initial estimate.

5) If repair work is going to exceed the initial estimate, Dasibi will draft an estimate revision, provide an explanation for the additional work required, and submit this to the customer for re-approval. Once such approval is either given, or denied, work will commence. This prevents any unauthorized work from being performed.

6) Dasibi will ship repaired out-of-warranty items back to the customer with appropriate strip charts and quality control reports verifying performance, along with a detailed listing of all replaced parts and assemblies. Dasibi will return any replaced component upon customer request only.

Operating Warning Information

*** DANGER ***

TOXIC EXHAUST GAS

Route exhaust gas from rear panel outlet to outside vent or laboratory fume hood through tubing with an O.D. of 1/4-inch and an I.D. of 1/8-inch or greater.

*** DANGER ***

ELECTRICAL SHOCK HAZARD

There exists HIGH VOLTAGE within portions of the circuitry of this analyzer. Please refer to material within this manual before performing any servicing inside the unit, itself.

EPA Designation

The Dasibi Model 1008-AH, -PC, and -RS UV Photometric Ozone Analyzers have been designated by the United States Environmental Protection Agency as reference methods for the measurement of ambient air concentrations of ozone pursuant with the requirements of 40 CFR Part 53 (published in the Federal Register, Volume 40, page 7049, February 18, 1975).

Designated Reference Method Number:	EQOA-0383-056
EPA Designation Date:	March 10, 1983

The Dasibi Model 1008-AH, -PC, and -RS UV Photometric Ozone Analyzers meet EPA designated equivalent method requirements when operated under the following conditions:

Concentration Ranges:	0 - 0.5 ppm and 0 - 1.0 ppm
Line Voltage Range:	105 - 125 vac
Temperature Range:	20° C - 30° C

The analyzers must be operated and maintained according to the Operating and Maintenance Manual to conform to the EPA Designation requirements.

EC Declaration of Conformity

Name of Manufacturer: Dasibi Environmental Corporation

Address of Manufacturer: 506 Paula Avenue
Glendale, CA 91201
U.S.A.

Declares that the products:

Product Name: Series 1008 U.V. Photometric Ozone Analyzers

Model Numbers: 1008-AH, 1008-HC, 1008-PC, 1008-PS, 1008-RS

Conforms to the following Product Specifications/Standards:

EMC: EN50081-1
EN50082-1
IEC 801-2

Relevant Directives:

EMC Directive (89/336/EEC)

Authorized Signatory

Date of issue:
December, 1996

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1.0 INTRODUCTION

1.1 Purpose and Organization of Manual

This O&M manual presents operating and service information for the Dasibi Model 1008-AH, -PC, -RS, and -HC UV Photometric Ozone Analyzers. Past experience indicates that the user will obtain maximum performance from the instrument when time has been spent studying this information. It is therefore recommended that this manual be reviewed before installing, operating or servicing the analyzer.

The information is presented in seven sections which include a description of the instrument design and operating theory, as well as discussions of its installation, operation, and maintenance. Appendices include specialized information on the 1008-HC (high concentration) unit, general instrument calibration procedures, update information to this manual (when applicable), and general references for further information. For each section, the information is presented as descriptive text, followed by the referenced figures, in order, at the end of the section. The information presented is outlined in Table l-l, below.

TABLE 1-1
Outline of Organization of Manual

Section	Topics Covered
1	General instrument description, performance specifications, and physical characteristics.
2	Instrument installation.
3	Instrument description.
4	Theory of operation.
5	Routine operation.
6	Maintenance procedures.
7	Replacement parts lists.
Appendix A	Model 1008-HC (high concentration) information.
Appendix B	Instrument calibration.
Appendix C	Manual update information (as appropriate).
Appendix D	References

Included with this manual is the final factory quality control report for the analyzer, which includes'recorder traces with zero and span gas that were obtained during final factory testing prior to its shipment. These data are of great value in determining if the analyzer, as received by the user, has experienced any change in performance due to shipping problems. The user is encouraged to recheck the performance of the instrument immediately after installation by running a zero and span record to·ensure that the factory results can be duplicated.

1.2 Description of Instrument

1.2.1 Functional Description

The basic analyzer is a self-contained instrument which measures the concentration of ozone in ambient air. This is accomplished by measuring the absorption of ultraviolet (UV) light in a sample of gas flowing through the optics bench (often called an absorption cell) contained in the instrument. The instrument is designed to provide a highly stable measurement capability for extended periods without repeated adjustments, and it operates over a wide range of ambient conditions without adverse effects *on* measurement accuracy.

The analyzer is a component in a system whose end purpose is to provide a continuous stream of high quality, .non-ambiguous, ozone concentration data. The feasibility of this system is predicated on good design, proper system maintenance and frequent performance checks.

The analyzer is available in four different configurations which are discussed briefly below and presented in detail in Section 3.0.

1.2.1.1 Basic Air Monitor (Model 1008-AH)

This configuration of the analyzer is used to determine the level of ozone in ambient air and has been designated by the U.S. EPA as an equivalent method. This configuration represents the "basic" analyzer.

1.2.1.2 Monitor With Internal Zero/Span Checks (Model 1008-RS)

The addition to the basic analyzer of an internal ozonator, selection valve, scrubber, pump, and flowmeter allows both zero and span gases to be generated and utilized within the analyzer for manual or remote self-check purposes.

1.2.1.3 Ozone Calibration Standard (Model 1008-PC or 1008-PS)

The basic analyzer may be configured as a UV photometer calibrator in accordance with EPA regulations (commonly referred to as a transfer standard, or the Model 1008-PC). This configuration includes an ozonator, valve, scrubber, pump, and flow meter.

The catalytic converter used in the transfer standard may be removed, and the sample handling system modified to incorporate use of an additional internal manifold used in conjunction with an external zero air source (commonly referred to as a primary standard, or Model 1008-PS).

1.2.1.4 High Concentration Monitor (Model 1008-HC)

Model 1008-HC is electronically and functionally identical to Model 1008-AH except that it measures much higher ozone concentrations (from 0 to 10 percent by weight, or 0 to 60,350 ppm by volume). The special features are described in Appendix A.

1.2.2 Physical Characteristics

The physical characteristics of the analyzer are presented in Table l-2.

TABLE l-2
Physical Characteristics
Dasibi Model 1008

Dimensions:	W - 17.20 in (43.69 cm) H - 5.25 in (13.34 Cm) D - 22.50 in (57.15 Cm)
Weight (including pump):	28 lbs (12.73 kg)
Power:	105-125V AC, 50/60 Hz 220-240V AC, 50/60 Hz 100V AC, 50/60 Hz
Options:	Rack mounting, RS232C interface, dual ozone output generator, Isolated Analog Output or 4/20 mA Output.

1.2.3 Operation

Sample gas is continually supplied to the optics bench by a self-contained pump and sample handling system. The intensity of the UV light beam traversing the optics bench is attenuated in proportion to the concentration of ozone present in the sample as prescribed by the Beer-Lambert Law (Beer's Law). This signal is detected and processed digitally for presentation by the readout system.

Two reference subsystems ensure a high degree of measurement stability by correcting for variations in source intensity and detector response, and interference components in the sample gas. Self-zeroing and interference removal is accomplished by comparison of alternate sample and reference measurements. Because of the operation of these reference, zeroing and interference removal subsystems, there is virtually no span or zero drift. These features are described in detail in Sections 3.0 and 4.0.

All operating controls are contained on the front panel. The ozone concentration is indicated on the digital display mounted on the front panel and is also provided at rear panel terminals as an analog signal. The various operational and sample gas inlet connections, filters and conditioning elements are also mounted on the rear panel for accessibility and ease of replacement.

1.2.4 Maintenance

All systems are designed for reliability and ease of maintenance. Electronic components are mounted on plug-in printed circuit boards, so that equipment operation can be restored quickly in the event of a component failure.

1.2.5 Performance

The performance specifications of the analyzer and optional ozone generator are presented in Tables 1-3 and 1-4, respectively. The instrument will operate within these specifications under the conditions listed.

TABLE 1-3
Analyzer Performance Specifications
Dasibi Model 1008

Range:	0-0.5, 0-1.0 ppm* (instrument can read higher than 1 ppm)
Noise:	±0.001 ppm
Flow Rate:	2 l/min (nominal)
Precision:	0.001 ppm
Linearity:	±0.001 ppm
Temperature Range:	0-45° C
Pressure Range:	0.66-1.20 atm (500-900 torr)
Zero Drift:	
Display & digital outputs:	Zero
Analog outputs:	±0.5% of digital reading
Span Drift:	
Display & digital outputs:	Zero
Analog Outputs:	±0.5% of digital reading
Zero Offset:	Adjustable to 9 ppb in steps of 1 ppb or to 90 ppb in steps of 10 ppb (specify when ordering)

Response Time (99% final value):	50 Seconds 20 Seconds (No Averaging)
Cycle Time:	Updated reading every 10 seconds
Ozone Concentration Corrections:	
Temperature	±0.3° C .
Pressure	±0.003 atm (2 torr)
Analog Output	Standard 1 volt for 1 ppm (with any 3 digits of display selectable). Other ranges available.
Digital Outputs:	
Display	5 Digits
RS-232C	Optional

* The instrument does not have a range switch, but reads continuously from 0.001 ppm to 1.000 ppm. It meets the EPA designated range requirements for 0.5 and 1.0 ppm.

TABLE 1-4

Ozone Generator Performance Specifications
Dasibi Models 1008-PC & 1008-RS

output:	0.040-1.000 ppm @ 5-6 l/min
Stability:	±0.002 ppm @ 0.500 ppm
Response Time:	
Manual Control	2 Minutes
Automatic Control	5-10 Minutes (1008-PC)
Drift:	
Manual Control	1% per week
Automatic Control	Zero (1008-PC)

Notes :

The Automatic Control (Digital Feedback) of the ozone generator by the UV Photometer only applies to Model 1008-PC.

The UV Photometer is used in conjunction with the ozone generator only in Model 1008-PC in order to provide a w Photometric system to be used for the calibration of other ozone analyzers not necessarily operating on the principle of UV Photometry. For more details, see Reference 11.

2.0 INSTALLATION

2.1 General

This section of the manual describes installation of the instrument. It is advisable to read this section before installation is begun. The information presented includes receiving. inspection, and pneumatic, electrical, and recorder connections.

2.2 Receiving Inspection

The instrument was carefully inspected and packed prior to shipment. After the instrument has been delivered, please check the following:

1. Verify that the package contents are complete as ordered.
2. Inspect the instrument for external physical damage due to shipping such as scratched or dented panel surfaces, broken knobs or connectors, etc.
3. Remove the instrument cover and remove all interior foam packing and save for future shipments. Make note of how the foam packing was installed.
4. Inspect interior of instrument for damage, broken components, loose circuit boards, etc. Make sure that all of the circuit boards are completely secured (loose boards could short-out the motherboard). If no damage is evident, the instrument is ready for installation and operation. If any damage due to shipping is encountered, please contact Dasibi (see preface page iv, "Claims for Damaged Shipments and Shipping Errors").
5. If shipping damage is found, and it becomes necessary to return the instrument, please repack it in the same way it was delivered (using both the Dasibi shipping container and the internal foam packing material).
6. The Dasibi shipping box and interior packing materials are specifically made for shipment of the unit. This material should be retained for future possible re-shipment to Dasibi in case subsequent service or warranty conditions should occur.
7. If it becomes necessary to return the instrument to Dasibi at some future time, and the original shipping materials and container cannot be found or were not saved, please contact the Dasibi sales office <u>before re-shipment</u>, with the model number of your instrument, and we can sell you the appropriate shipping container and materials to prevent damage to the instrument during shipping. <u>It is not recommended that the instrument be shipped using shipping materials and containers unsuited for the purpose</u>.

2.3 Installation

The installation of the instrument consists of connecting the sample tubing to the sample gas inlet fitting located on the rear panel shown in Figures 2-1, 2-2, 2-3, and 2-4. In addition to the pneumatic fitting, the primary power and the recorder signal connections are also located on the back panel.

2.3.1 Gas Sampling Requirements

The sample inlet line connection should be made with 1/4 inch (0.64 cm.) O.D. Teflon tubing (not supplied). Remove the nut on the inlet bulkhead connector and slip it over the end of the tube. Insert this into the connector marked INLET and tighten the nut finger-tight. This connector is off-white in color, because it is made of Kynar, a fluoroplastic similar to Teflon which does not react with ozone.

CAUTION
To avoid damage to the fitting, do not over-tighten.

The entrance of the sampling system should have provision for a water drop-out, or some way to ensure that water (i.e., rain) cannot enter the system. It should be placed as far as possible from any sources that could contaminate the sample.

Since the analyzer is an optical instrument, it is possible that particulate in the gas sample could cause interference in the ozone readings, although the sampling/referencing cyclic operation of the instrument is designed to eliminate such interference.

However, in order to avoid frequent cleaning of the optics and flow handling components, it is recommended that the Teflon filter (that comes standard on the inlet port) should be installed in the inlet line, especially if the monitoring site is in the area of high particulate concentrations. It has been determined that a 0.5 micron Teflon filter will not degrade the ozone concentration in the air sample if the filter is clean. However, if dirt builds up on the filter, it will destroy some of the ozone in the sample. Therefore, if a filter is to be used, it must be changed regularly (see Maintenance Schedule Check List, Tables 6-2 and 6-3) and should be held in a Teflon filter holder.

Some users feel that filter maintenance may not be reliably performed and that this will put an unknown factor into the data, and they prefer to monitor without the use of a filter. If a filter is used, all calibrations should be done with the filter in-line so that any effect the filter may have on the sample will be included in the span. Sample air should be drawn through a standard glass or Teflon manifold with enough flow to ensure the sample residence time in the filter is less than 10 seconds.

The instrument does not use any reagents and is safe to vent into a working area. The exhaust is actually ambient air with some ozone removed. For this reason, the exhaust should also be Prevented from reentering the sample system.

2.3.2 Electrical Connection

The instrument is designed to operate on standard, single phase AC electrical power, 50-60 Hz and 105-125 or 220-240 volts. A three conductor power cable is supplied with the instrument. The round pin on the plug is the ground lead and is connected to the instrument chassis. To provide protection to personnel when operating the instrument on a two wire receptacle, use a three prong adapter plug and connect the pigtail wire to the power outlet box or to a nearby ground such as a water pipe.

HAZARD WARNING

Operating the instrument without a proper third wire ground is a dangerous electrical practice.

If a DC to AC inverter is used as the power source, it should be capable of delivering 125 watts within the specified line frequency and voltage ranges and should have a sine wave output. Some inverters have a square wave output which will cause the instrument to malfunction.

NOTE

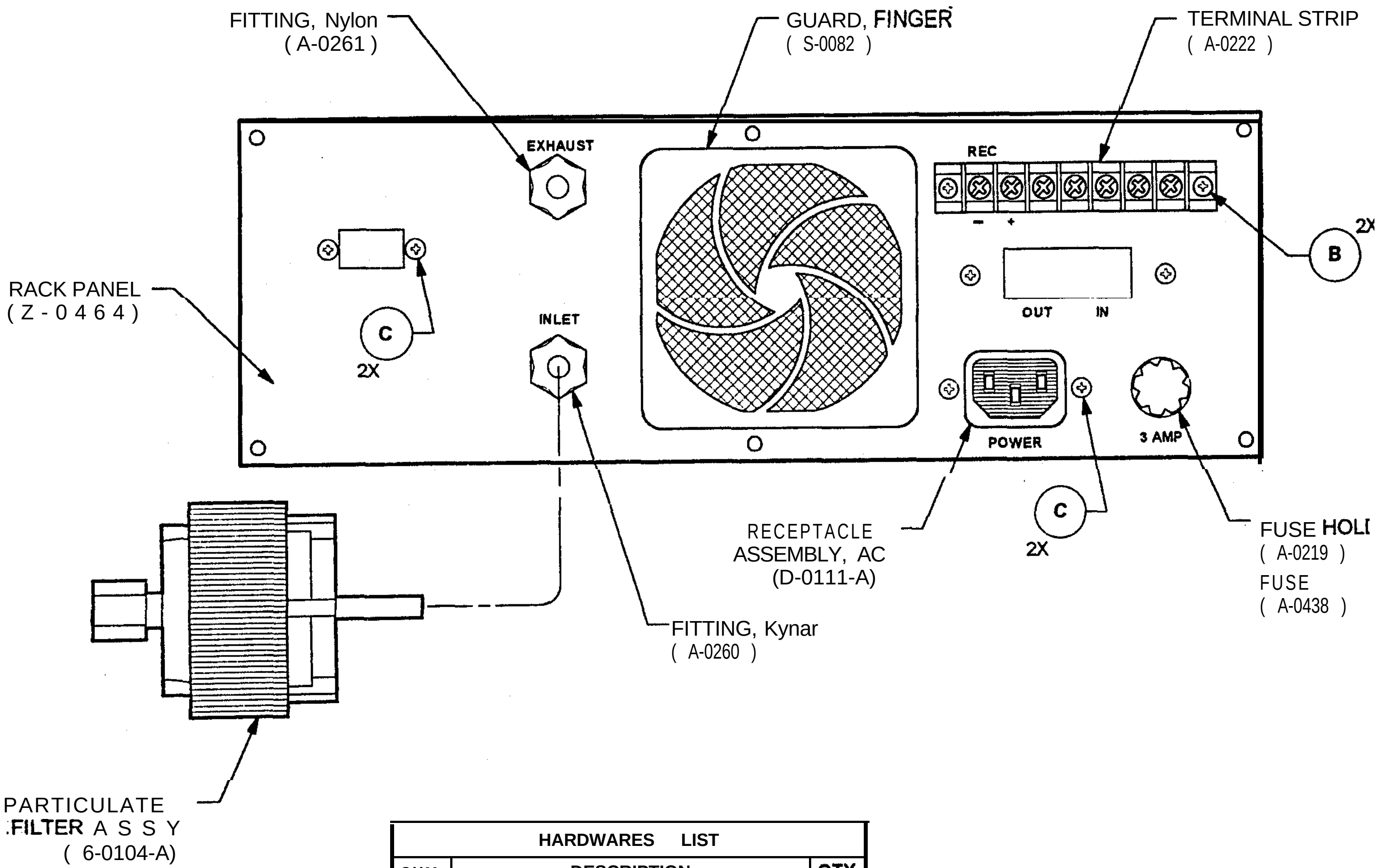
This equipment should not be used in the presence of high electric and magnetic fields (>0.1V/m and >0.1A/m 50 Hz - 1 Ghz) due to the very sensitive nature of its detection system.

2.3.3 Recorder Connection

If a strip chart recorder is used, it should be connected so that the high side of the recorder is connected to the RECORDER terminal marked (+) on the rear of the instrument. The low side is connected to (-) which is chassis grounded.

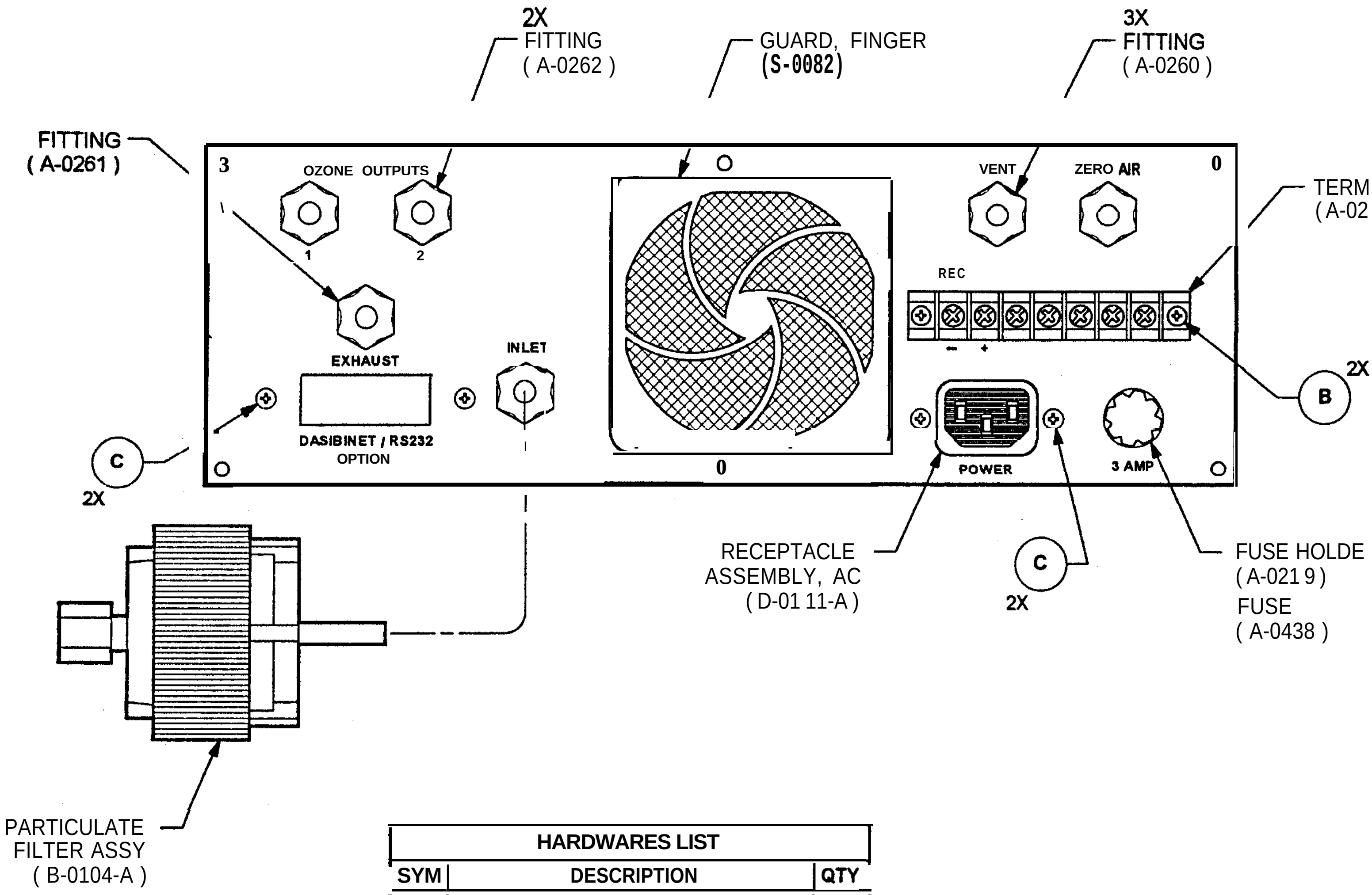
The nominal analog output is 1.000 volts for 1.000 ppm. Other, more sensitive ranges can be used, e.g., 100 mv for 1.000 ppm, or 10 mv for 1.000 ppm. This requires an adjustment of the RECORDER SPAN potentiometer on the front panel of the instrument or a specific request when ordering.

All recorder and remote control connections should be kept as short as possible (not greater than 10m) and always use a braided screened multicore cable where the braided screen is only connected at the 1008 instrument rear ground/0V terminal, the far end of the cable screen being left unconnected and insulated. The screen MUST NOT be used as a 0Volt return path for recorder or control signal lines.



HARDWARES LIST		
SYM	DESCRIPTION	QTY
A	6-32 X 5/8" Flat Head Screw w/ nut & washer	4
B	4-40 X 1/2" Pan Head Screw w/ nut & washer	2
C	4-40 X 3/8" Pan Head Screw w/ nut & washer	4
D	HEAT SHRINK TUBING	AIR
E	SPIRAL WRAP	A/R

Figure 2-1 Back Panel (Model 1008-AH)



HARDWARES LIST		
SYM	DESCRIPTION	QTY
A	6-32 X 5/8" Flat Head Screw w/ nut & washer	4
B	4-40 X 112" Pan Head Screw w/ nut & washer	2
C	4-40 X 3/8" Pan Head Screw w/ nut & washer	4
D	HEAT SHRINK TUBING	A/R
E	SPIRAL WRAP	A/R

Figure 2-2 Back Panel (Model 1008-PC)

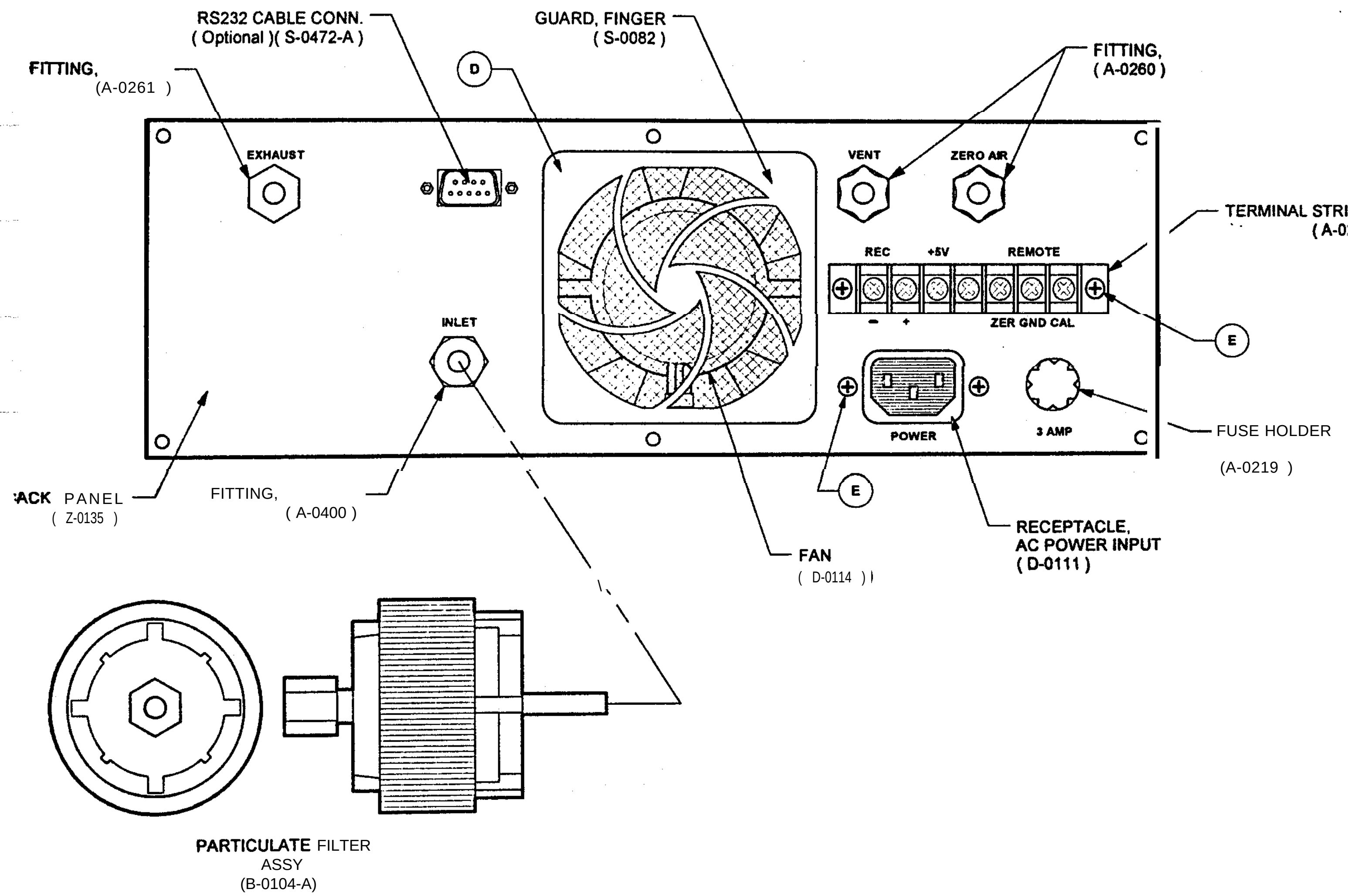
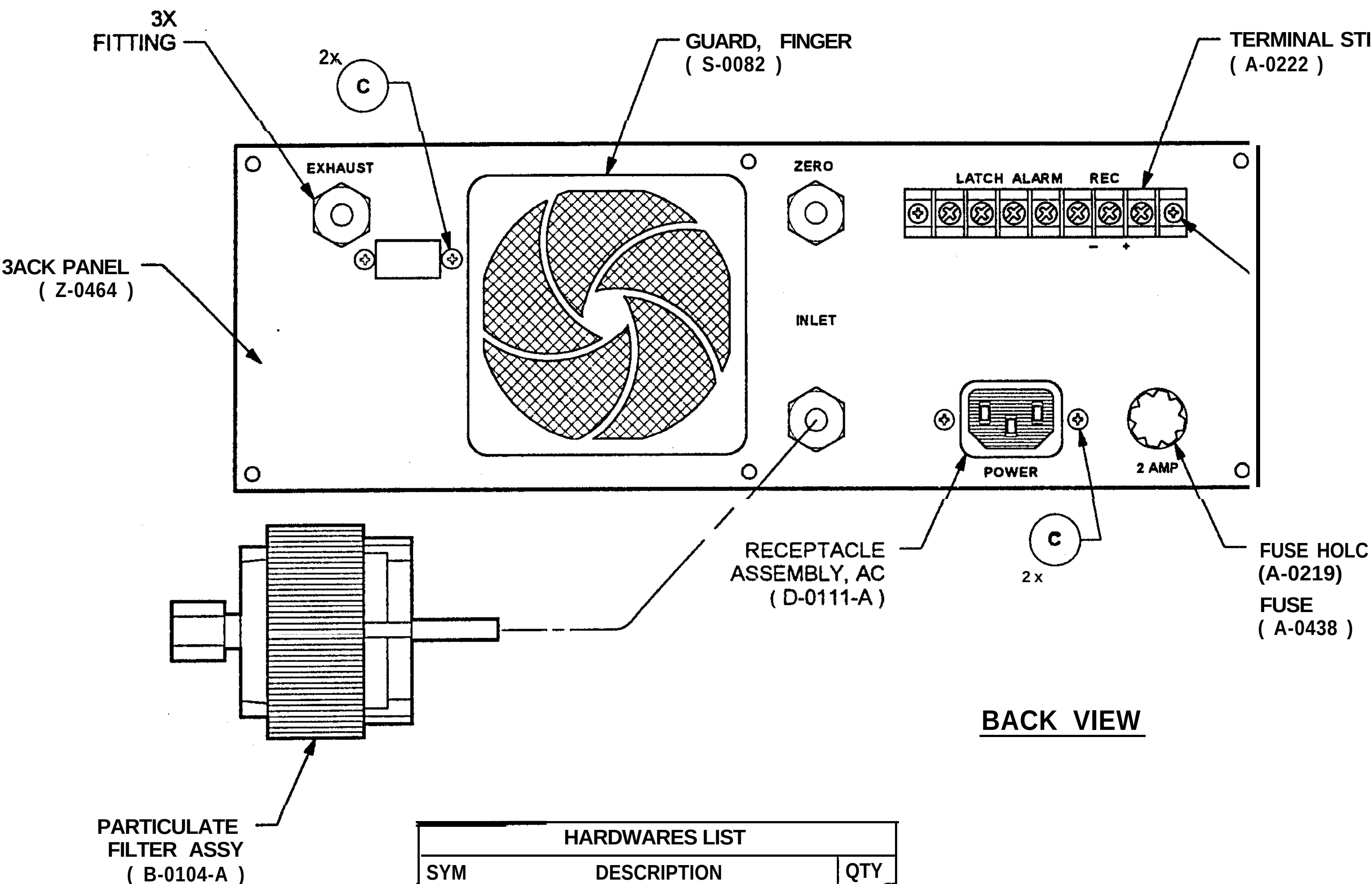


Figure 2-3 Back Panel (Model 1008-RS)



HARDWARES LIST		
SYM	DESCRIPTION	QTY
A	6-32 X 7/8" Flat Head Screw w/ nut & washer	4
B	4-40 X 112" Pan Head Screw w/ nut & washer	2
C	4-40 X 318' Pan Head Screw w/ nut & washer	4
D	HEAT SHRINK TUBING	A/R
E	SPIRAL WRAP	A/R

Figure 2-4 Back Panel (Model 1008-HC)

3.0 INSTRUMENT DESCRIPTION

3.1 General

This section provides a brief physical and operational description of the instrument. Further operating details and theory are provided in Section 4.0, Principle of Operation. The two sections should be read together to obtain a full overview of the instrument's construction and capabilities. Section 5.0 describes instrument adjustments for routine operation.

3.2 Optical

3.2.1 Lamp

The source of UV radiation is a low pressure, cold cathode, mercury vapor lamp with 92% of its output concentrated at the 253.7 nm. emission line, where absorption by ozone is maximized. Emission at wavelengths shorter than 200 nm is eliminated by an Ozone-free quartz shielding around the source. Presence of the shielding prevents any emission at 185 nm, an emission line which generates ozone.

3.2.2 Detector

The detector is a "solar blind" Cesium Telluride vacuum diode with a broad passband centered near 253.7 nm. The total optical selectivity of the lamp and detector together is such that better than 99.5% of the detector current is due to 253.7 nm. light.

3.2.3 Optics Bench

The optics bench (absorption cell) is a 71 cm. folded chamber consisting of stainless steel tubes and quartz windows to physically isolate the gas from the lamp and detectors, and quartz mirrors mounted in a triangular optical block to reflect the UV light through 180°.

3.3 Pneumatic

3.3.1 Gas Valve(s)

The gas valve is a dual-input/single-output teflon diaphragm valve. It is operated by a plunger actuated by a +24 V solenoid, which is turned on and off by a signal from the electronic sub-system timing circuitry. It is connected in such a way as to perform the function of either switching the sample gas or the reference gas into the absorption cell. There may be up to two valves in the unit, depending upon its configuration. In the Model 1008-RS, there is a second valve used for remote activation, allowing the unit to perform remote zero and/or span "self-checks". The 1008-RS remote valve would be located nearer the back panel.

Required replacement parts for the gas valve, such as O-rings and diaphragms, etc. are available from Dasibi. However, because of the calibration requirements after re-assembly, it is strongly recommended that the user does not attempt to service or replace parts associated with the gas valve (see following note).

NOTE

If any users wish to service the gas valve, or disassemble and/or replace any parts for whatever reason, they are hereby notified that they do so at their own risk.

3.3.2 Flowmeter

The analyzer's front panel flow indicator is plumbed between the output port of the optics bench and the instrument exhaust port. The flow rate is determined by the flush delay time and the ozone scrubber requirements (the ozone measurement is independent of flow rate). For a given flush delay time, T, a lower limit of the flow rate is defined by the need to flush the system completely during time T. This lower limit is 1.5 l/min. An upper flow rate limit of approximately 3.5 l/min is defined by the rate of the reaction of ozone to diatomic oxygen in the catalytic scrubber: higher flows will not give the scrubber time to do its job.

If the unit is a Model 1008-PC, 1008-PS or 1008-RS, there will be two flow meters on the front panel. The second one, for the ozone generating subsystem, has an upper range of 6 liters per minute and would be located on the left side of the front panel (when looking at the unit from the front).

3.3.3 Pump(s)

The pump, which pulls sample through the system, is an AC diaphragm vacuum pump utilizing a Teflon coated synthetic rubber diaphragm. It is capable of 15 inches of water vacuum at 2.5 l/min, which is much more than adequate for the analyzer's requirements.

If the unit purchased is a Model 1008-PC, 1008-PS or 1008-RS, there will be a second pump for the ozone generator's flow. This pump, which is also an AC diaphragm vacuum pump utilizing a Teflon coated synthetic rubber diaphragm, is capable of more than 5.5 liters per minutes of flow.

3.3.4 Fittings and Tubing

In order to maintain sample integrity, all fittings and tubing in contact with ozone containing sample are Teflon or Kynar. Kynar is a fluoroplastic, off-white in color, with chemical properties similar to Teflon, but superior in mechanical strength. All other fittings are nylon, and tubing is either tygon or Teflon.

3.3.5 Ozone Scrubber

The ozone scrubber is a two-piece aluminum assembly that contains a replaceable cartridge. All consumable elements in this cartridge (copper screens coated with manganese dioxide (MnO_2)) are inserted into the cartridge at the factory.

The MnO_2 catalyzes the reaction of ozone to diatomic oxygen, and does not itself react with the sample. Thus, the sample entering the absorption cell after passing through the filter is preserved intact except for the ozone.

Since the ambient air sample may contain a number of substances in addition to ozone which to some extent will absorb 253.7 nm UV light (such as benzene), it is imperative that these substances be of the same concentration during the reference and the sample cycles. The single-cell design used in the instrument does provide equal concentrations of these substances.

If the unit purchased is a Model 1008-PS (a special version of the 1008-PC, called a "primary standard"), the ozone scrubber assembly is removed and an additional manifold is installed to be used with an external zero air source. This zero air is used for the reference portion of the measurement cycle.

3.4 Electronic

3.4.1 Mother Board (Figures 3-1 and 3-2)

The mother board provides all the circuit interconnections for the instrument, and has a minimum of electronic components mounted on it. This approach reduces electronic troubleshooting to simply interchanging boards. The major components mounted on the mother board are the power transformer T1, bridge rectifier, filter capacitors, and connectors. The power transformer provides the various voltages for the electronic circuitry of the instrument. The unregulated DC voltages supplied by T1 are:

1) +B, for either +15 V or +12 V, used for analog circuits, PROM's, and the DAC's.

2) -B, for either -15 V or -12 V, used for analog circuits and the DAC's.

3) +5 V, for the digital circuits.

4) -5 V, for the PROM's.

5) +24 V, for the pumps, heaters, UV lamps, and the solenoid valve.

All the boards that plug into the mother board use on-card regulators. The regulated voltages utilize integrated circuits for a high order of regulation.

The boards described in section 3.4.2 to 3.4.7, use the common DAS-80 Bus (shown in Figure 3-3). This common bus structure enables the *user* to plug any of these boards into any DAS-80 Bus connector, provided that the board components face the front of the instrument.

3.4.2 Electrometer Assembly (Figures 3-4 and 3-5)

3.4.2.1 Physical Description

The electrometer assembly consists of a universal adapter board (Figures 3-4a1 and 3-4a2) which plugs directly into the Mother Board by means of an edge card connector. Electronic sub-assemblies contained on the adapter board include two independent, detachable electrometer circuit boards for both the sample and control channels. These circuit boards are attached to the Adapter Board by means of individual, multi-pin connectors. In addition, a separate, detachable Temperature Circuit Board is also included in a similar manner on the Adapter Board.

The Adapter Board, and its associated circuit boards, may be removed from the Mother Board as a unit, and the individual circuit boards may then be removed from the Adapter Board for repair or replacement. Input signals from the remote detectors and the temperature sensor are supplied directly to the appropriate circuit boards by means of integral, multi-pin connectors mounted on the circuit boards, themselves. The signal leads are therefore also individually detachable from the electrometer assembly. Thus, the electrometer assembly is of completely modular design for flexibility in configuration, and ease of maintenance, trouble-shooting, and repair or replacement of sub-assemblies or components.

The operation of the sample and control channels and the Temperature Board are described next. Options exist **for** the signal processing circuit boards, and these are also discussed.

3.4.2.2 Signal Detection and Processing

Two separate functions are accomplished by the sample and control channel circuit boards, respectively:

1) Measuring the signal from the sample detector for both the sample gas (measurement) cycle. and the zero gas (reference) cycle.

2) Controlling the timing of the sample gas and zero gas signal measurement cycles. As described in Section 4.0, it is essential that the time interval during the **"up"** counts for the zero gas reference cycle be exactly the same as the time interval for the **"down"** counts for the sample gas measurement cycle.

3.4.2.2.1 Sample Channel

The low-level current output from the UV sample detector in the optics bench is measured by the sample channel circuit board Containing an electrical circuit called an electrometer. The electrometer converts the extremely low-level detector current to a frequency which is directly proportional to the magnitude of this current. -This frequency is applied, in turn, as a pulse train to the input of an integrating counter (totalizer) remotely located in the logic circuitry section which totalizes the pulses obtained during each measurement and reference cycle. Subsequent signal processing of these pulses accumulated in the totalizer yields the ozone concentration for presentation on the numeric display on the front panel of the instrument and as an analog voltage at the output terminals on the back panel. The signal processing methodology employed by the electronics section of the analyzer to calculate ozone concentration from the pulses obtained during the sample gas and zero gas cycles, respectively, is described in Section 4.0.

For this electrometer, the sample frequency should be in the range of 450 KHz to 480 KHz for an input clock frequency of 1.0 MHz (common for most analyzers). To adjust for proper sample frequency, set the mode selector switch to SAMP/TEMP with T/P off. The number appearing on the front panel numeric display will be 0.10 of the internal sample frequency (consider, in this case, the decimal point as a comma). The sample frequency is changed by adjusting the position of the UV lamp in the Light Source Block which alters the input light level to the optics bench. This is accomplished by loosening the dual thumbscrews which hold the lamp in place. The lamp is pulled out of the housing to decrease the frequency or pushed into the housing to increase the frequency. Alternatively, the lamp may also be rotated to change the frequency. It takes only very small movements of the lamp to make large frequency changes, and one thumbscrew should be tightened while making a frequency reading. After the proper frequency has been established, tighten the second thumbscrew.

This process can be made considerably less tedious if a frequency counter is available. However, verification that the frequency counter correctly counts square wave pulses must be made by comparing its count with the displayed value. Both the sample and control frequencies can be continuously monitored at test points on the Mother Board. If this method is used, the display readouts can be disregarded because the test points (labeled SAMPLE and CONTROL) provide the frequencies directly.

3.4.2.2.2 Control Channel

The timing for the sample gas and zero gas signal measurement cycles is provided by the control channel circuit board. A fixed-frequency oscillator/counter is generally utilized for this purpose. The fixed-frequency output of this circuit board is also applied as a pulse train to the input of a separate integrating counter also located in the logic circuitry section. The frequency produced by the control channel circuit, and the resulting pulses accumulated in the control channel counter, provide the necessary clock function. This method of sample and zero gas measurement cycle timing is totally adequate for a stable UV lamp and lamp drive (short-term drift less than 100 Hz/min).

For specified analyzers, the control channel. frequency may be generated by a circuit board containing an electrometer which functions much like the sample channel electrometer. The input current to this control electrometer is provided by a separate control detector. The source of UV radiation for the control detector is the same UV lamp in the optics bench used for the sample channel. For this control detector, however, the radiation is not attenuated by absorbing gases because it is positioned in a location separate from the optics bench and in direct view of the W lamp. It only responds to changes in radiation due to the lamp, itself. The control channel output frequency is therefore not constant, but varies slightly if the intensity of the UV lamp varies. For this reason, the total pulses accumulated in the control channel counter no longer represent a direct clock function for measurement cycle timing, but are modulated by the radiation flux from the UV lamp. This provides a method of adjusting, or "trimming," measurement cycle times to account for variations in UV lamp intensity during the measurement process itself. This is discussed in more detail in Section 4.0.

Once the sample frequency has been set, it may be necessary to reset the control frequency. The control frequency should be set in the same range as the sample: 450 KHz to 480 KHz. To adjust the control frequency, Set the function switch to CONT/PRESS, again with T/P off. The control frequency can be increased by loosening the set screw which holds the control detector in the detector housing. The control detector is the 1 inch diameter cylinder aligned perpendicular to the long optic tube. Loosening the set Screw requires a 1/16th inch allen wrench. For fine adjustments, move the detector into the housing to increase the frequency and pull it out to decrease the frequency. There is also a coarse adjustment screw located in the middle of the detector block which varies the Size of the light aperture between the UV lamp and the control detector.

3.4.2.2.2.1 Integrating Electrometer (Figures 3-5a1 and 3-5a2)

This electrometer totally eliminates the unexplained drift (and the frequent re-calibrations required) by all other electrometers. While this electrometer may exhibit a minute increase in noise over the VFC electrometers, it is the one used for all sample channel electrometers; it is NOT recommended for the control channel because its extreme accuracy is of minimal benefit as a control frequency source, and the lower noise of the VFC electrometer is much more desirable to the operation of the control function.

This electrometer saturates at 1/2 the input clock frequency and is totally linear up to saturation. Due to lamp drift, however, it is recommended that the frequency should never be set to a value higher than 96 percent of the saturation frequency. For a 1.0 MHz input frequency (common to most analyzers), this translates into 480 KHz, or lower. There is NO absolute lower frequency limit, but if the frequency drops below 300 KHz, an error message will be displayed.

3.4.2.2.2.2 Fixed-FrequencyElectrometer (Figures 3-5d1 & 3-5d2)

For standard 1008 analyzers, this simple circuit provides all the timing that is required by the control channel, while also keeping expense as low as possible. A slide switch on the board allows selection of the output frequency to either 250 KHz for Model 1003 analyzers or to 500 KHz for Model 1008 analyzers.

3.4.2.2.2.3 652 VFC Electrometer (Figures 3-5b1 and 3-5b2)

Although this electrometer is still subject to drift and requires re-calibration, it is 10 times more linear than the older 650 VFC Electrometer design and is not as subject to temperature and humidity variations as other VFC electrometers. It is offered as an option for the control channel side of 1008 electrometers.

It is intended to switch over to the 653 VFC as soon as it becomes available (and in all probability long before any "advance information" is released), and this board will then be given the 653 VFC designation to reinforce the fact that Dasibi remains on the cutting edge of technology. Although this electrometer does not currently use the 653 VFC, but rather the 652 VFC, Dasibi has been promised first receipt of the 653 VFC as soon as it performs as promised.

This electrometer saturates at 1/2 the input clock frequency and is totally linear up to saturation. Due to lamp drift, however, it is recommended that the frequency should never be set to a value higher than 96 percent of the saturation frequency. For a 1.0 MHz input frequency (common to most analyzers), this translates into 480 KHz, or lower. There is NO absolute lower frequency limit, but if the frequency drops below 300 KHz, an error message will be displayed.

3.4.2.2.2.4 Temperature Sensor Board (Figures 3-5e1 and 3-5e2)

Using the two-trim adjustment, the temperature circuit has an accuracy of ±0.3° C over a temperature range of 0-50° C, when calibrated at 25° C. This eliminates the need to perform two-point calibrations using ice baths, high temperature standards, etc.

This temperature circuitry features an integrated temperature transducer which produces an output current proportional to absolute temperature. Laser trimming at the wafer level in conjunction with extensive final testing ensures that the sensors are interchangeable.

This circuit is so accurate that some NBS thermometers are actually referenced to it. Since a 1 percent error in ozone reading requires a 3.0° C error in temperature, the maximum ozone reading error due to the temperature from the temperature circuit will never exceed 0.20 percent, worst-case.

3.4.3 CPU Board (Figures 3-6, and 3-7)

The CPU board has on it a central processing unit (CPU), a real time clock, an asynchronous reset circuit, a 1.0 MHz system clock, and buffers for the data, address, and control busses. The CPU controls the entire instrument with the exception of the asynchronous reset circuit. If for some reason the CPU becomes stuck in an unintentional program loop, the reset circuit puts the CPU back into the proper operation on a first priority basis. The real time clock works in conjunction with the CPU to do all the timing required for the operate and frequency modes.

3.4.4 Memory Board (Figures 3-8 and 3-9)

The memory board consists of the address decode circuits, 4K bytes of read only memory (ROM) and 256 bytes of random access memory (RAM).

3.4.5 Counter Board (Figures 3-10 and 3-11)

The counter board contains the sample and control channel integrators. These integrators consist of six cascaded 4-bit BCD up-down counters, driven through dual four-input NAND gates by the sample and control frequencies. The counters have BCD parallel outputs as well as "carry" and "borrow" outputs for cascading.

During the reference cycle, the solenoid valve is switched so that the reference gas enters the optics bench. After a four second flush time, both of the integrators are enabled for 1.5 seconds. The sample integrator counts the sample frequency pulses and the control integrator counts the control frequency pulses. The CPU then stores the count of the sample integrator, resets it to zero, switches the solenoid valve to the sample gas containing ozone, and waits another four seconds. This is the end of the reference cycle and the beginning of the sample cycle.

After another four second flush time, the CPU again enables the integrators. This time the sample integrator counts up as before but the control integrator counts down from its previous up count. When the control integrator reaches zero, it toggles a flip-flop which stops both integrators. The CPU then stores the count of the sample integrator, resets both integrators, and switches the solenoid valve to the reference gas, thus repeating the cycle.

3.4.6 D/A Board (Figures 3-12 and 3-13)

The analog output is obtained by converting complemented BCD information from the CPU to a DC voltage by means of a weighted ladder network, precision switches and an output buffer amplifier. The complete D/A converter and buffer amplifier is housed in an encapsulated module. The input to the D/A converter depends on which 3 digits of the display are selected by the Digit Selector Switch: the recorder output will always follow the selected 3 digits of the front panel display no matter what mode the instrument is in.

The D/A converter has a 10 volt capability, but this is normally scaled down by a feedback resistor. If the full scale output is 1 volt, then the output is 0 to +0.999 V for 0 to 0.999 ppm. This value can be scaled down by turning the analog span control on the front panel until the desired full-scale range is achieved. The D/A board also has on it the Digit Selector Switch, Zero Offset Switch, Recorder Zero Offset Pot, and the Span Switches.

3.4.7 I/O Board (Figures 3-14 and 3-15)

The I/O board multiplexes eight different analog signals into a 10 bit analog to digital converter. At this time only three of the eight channels are used:

1. Source Block Heater Voltage
2. Pressure Amplifier Output
3. Temperature Amplifier Output

The Span and Zero Pots, R6 and R10 respectively, are adjusted so that a O-10 V input corresponds to a OOOH-3FFH binary output.

3.4.8 Display Board (Figures 3-16 and 3-17)

The displays and the update LED are driven by the CPU through two I/O ports. These I/O ports also carry signals for Mode Selector, solenoid drive circuit, and the Temperature and Pressure Mode Switch.

3.4.9 LDHC Board (Figures 3-18 and 3-19)

This board has on it all the drive circuits for the analyzer. These include the lamp drive, lamp heater, and the solenoid drive.

3.4.10 Ozone Control Board (Model 1008-PC, Figures 3-20 & 3-21)

This board is used in conjunction with the built-in ozone generator in the Model 1008-PC. It contains the ozone generator lamp drive and heater and the regulators for the ozone generator and drive pump.

3.4.11 Ozone Control Board (Model 1008-RS, Figures 3-22 & 3-23)

This board is used in conjunction with the built-in ozone generator in the Model 1008-RS. It contains the ozone generator lamp drive and heater.

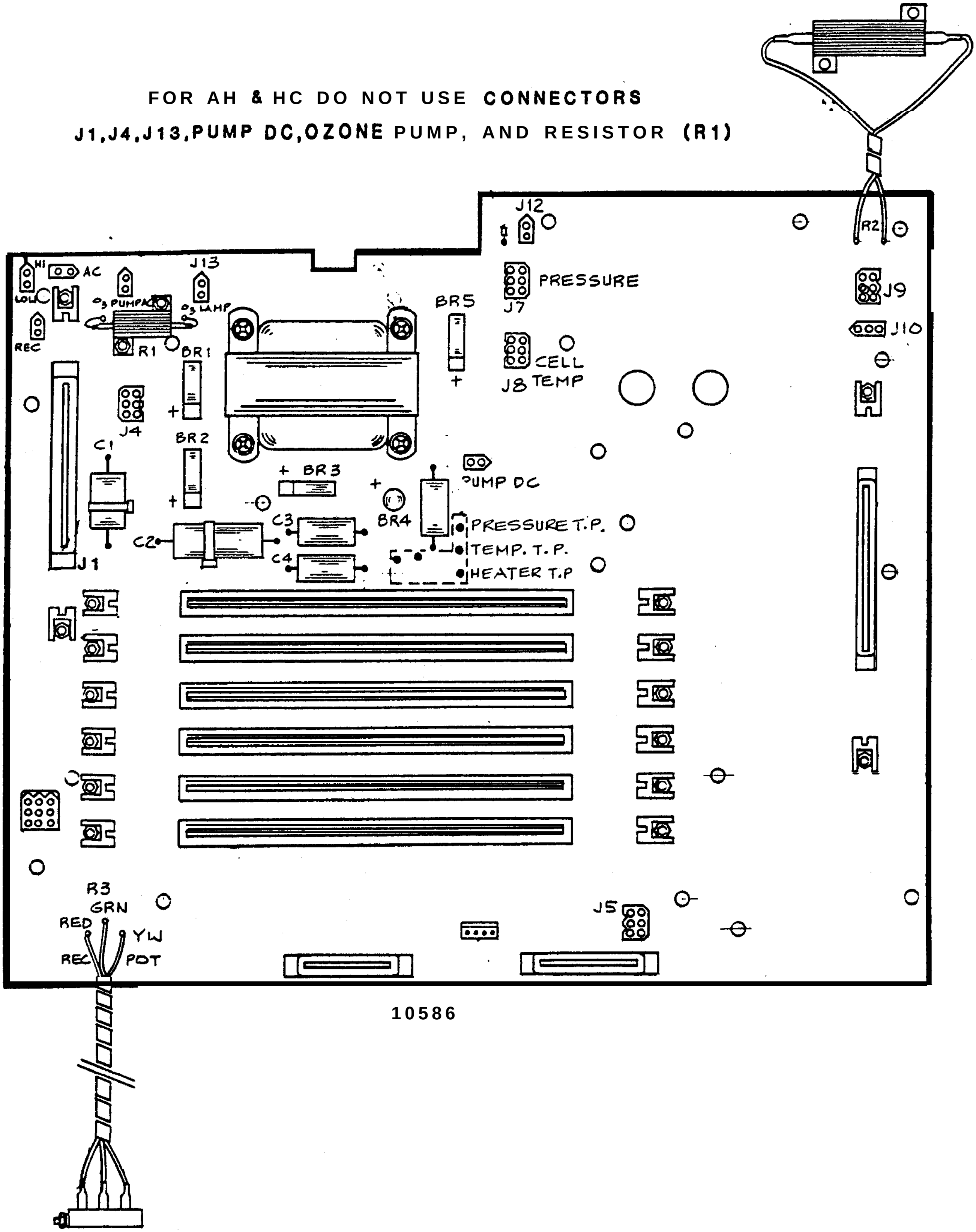


Figure 3-la Motherboard Assembly (Model 1008-AH, -PC, and -HC)

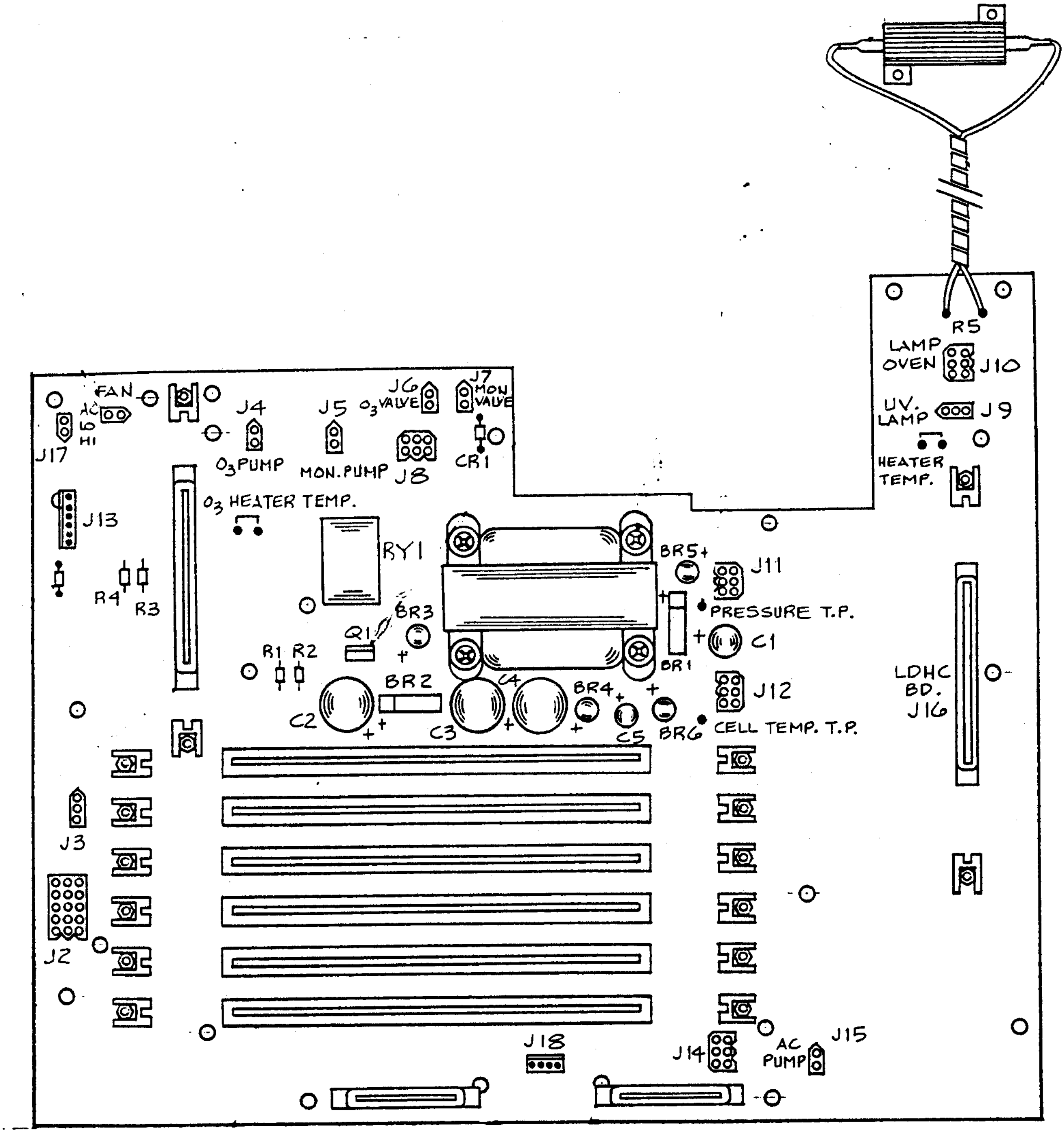


Figure 3-1b Motherboard Assembly (Model 1008-RS)

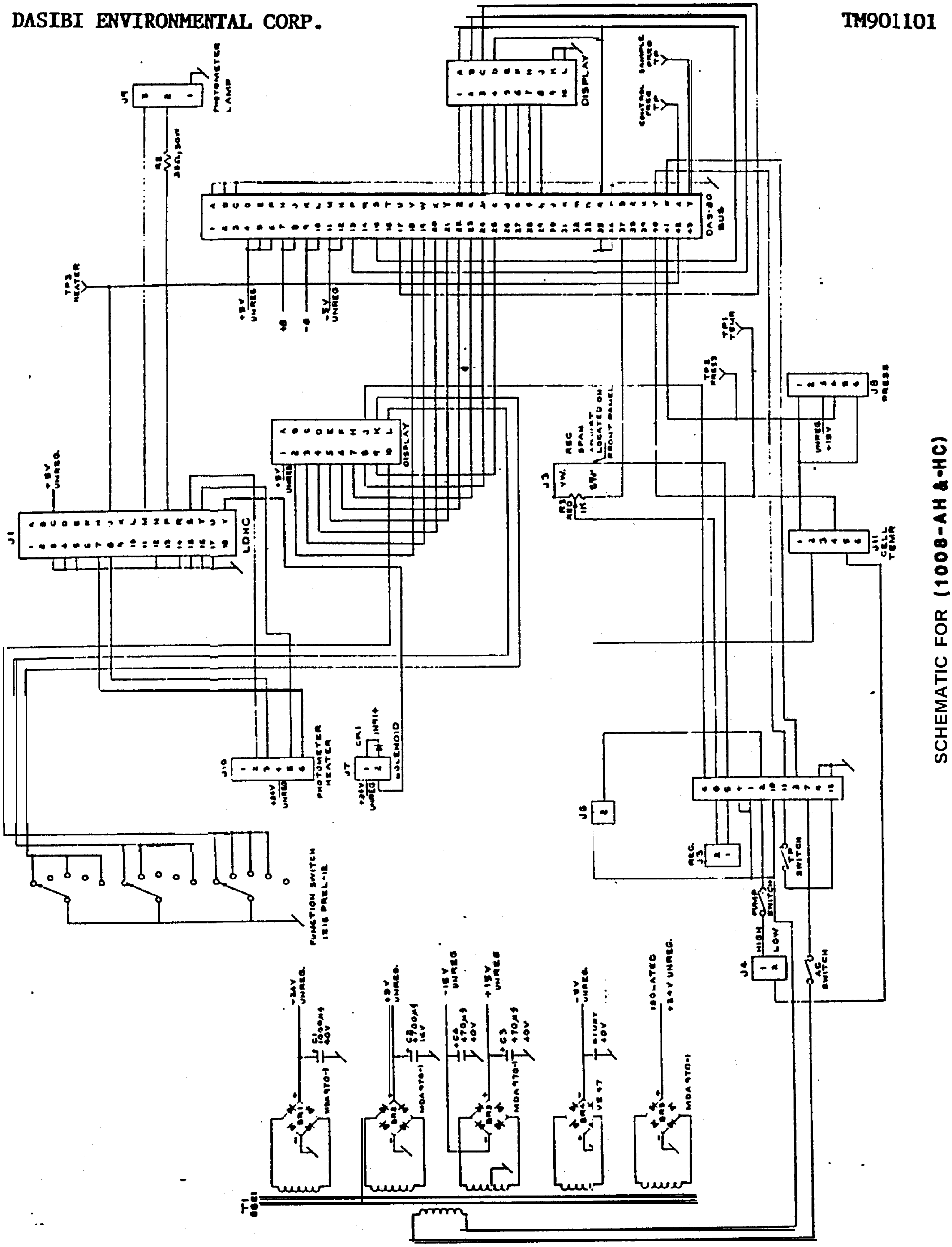


Figure 3-2a Motherboard Schematic Diagram (Model 1008-AH and HC)

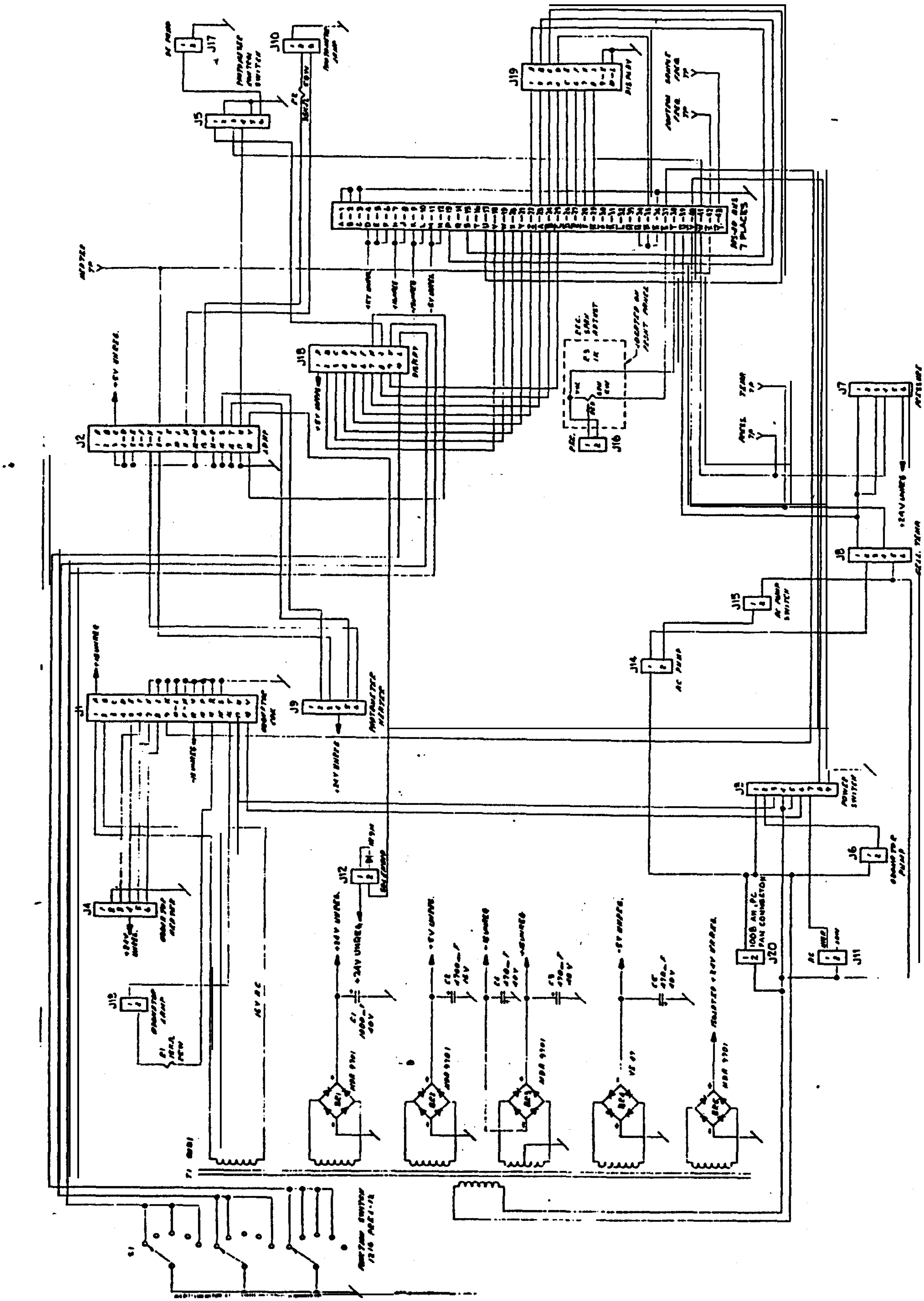


Figure 3-2b Motherboard Schematic Diagram (Model **1008-PC)**

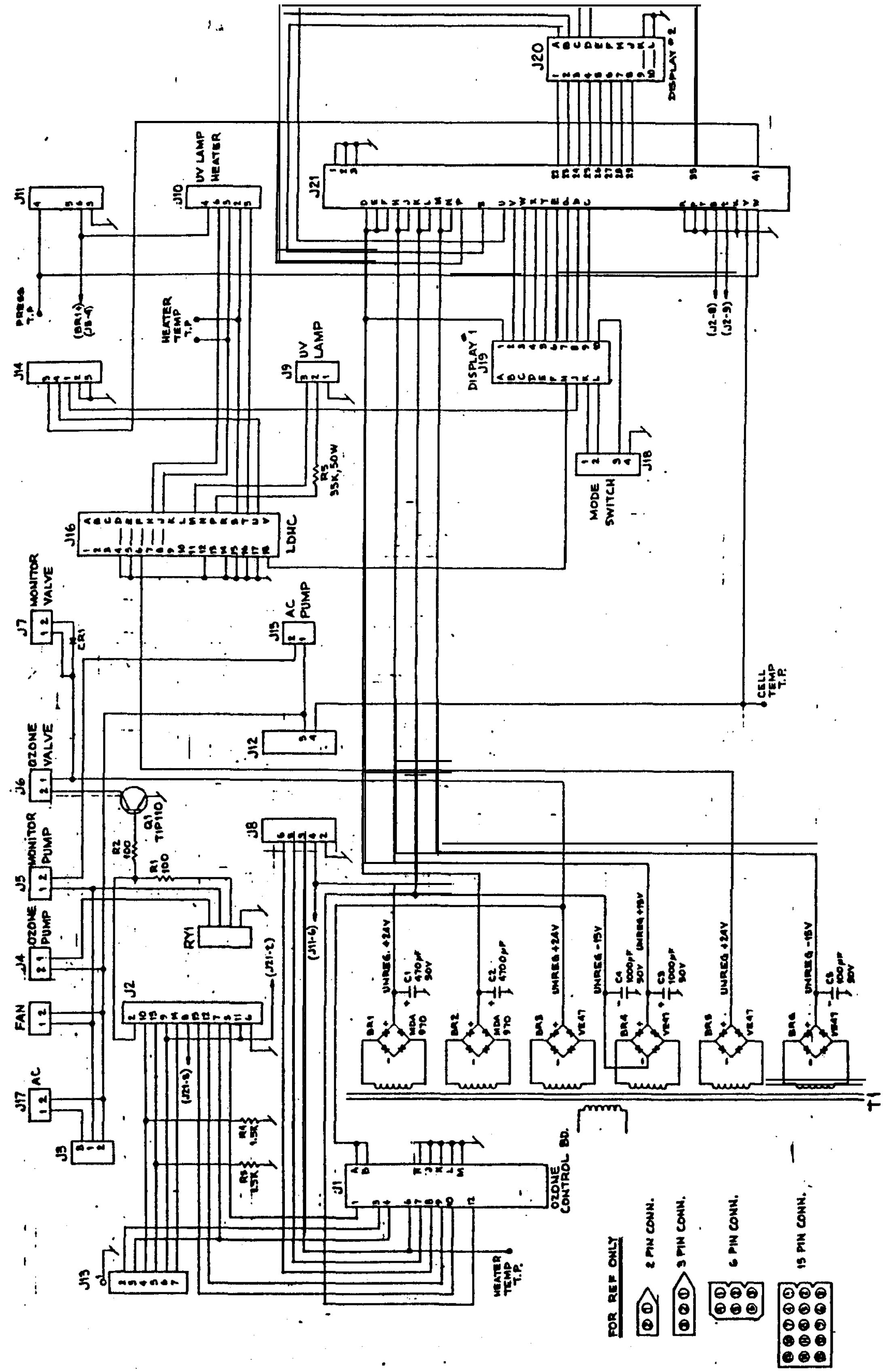
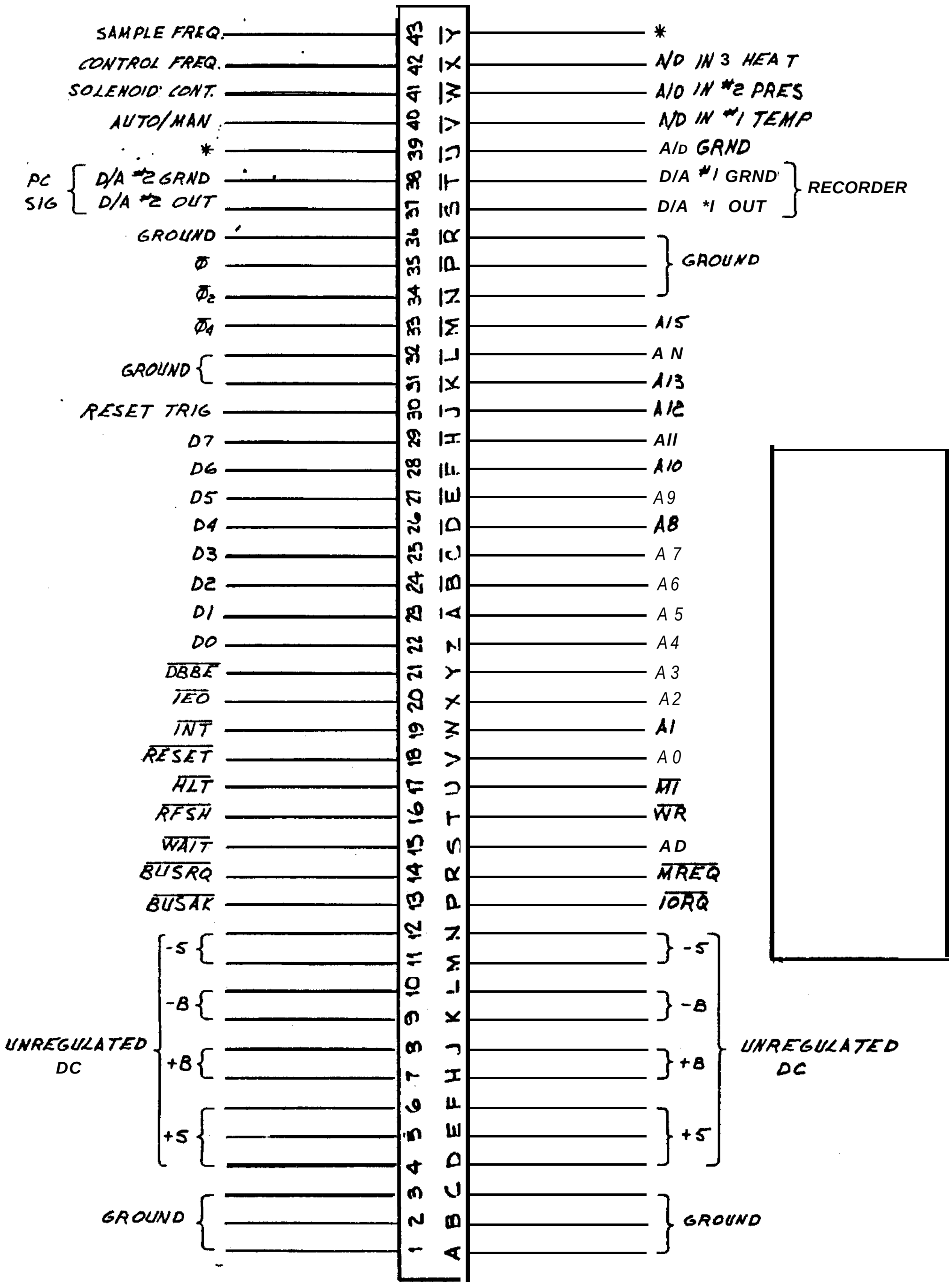


Figure 3-2c Motherboard Schematic Diagram (Model 1008-RS)



* - SPARES

NOTE: DAS-80 BUS USES A 2 ROW 43 PIN .156" CENTERS EDGEBOARD CONNECTOR

Figure 3-3 DAS-80 Bus Schematic Diagram

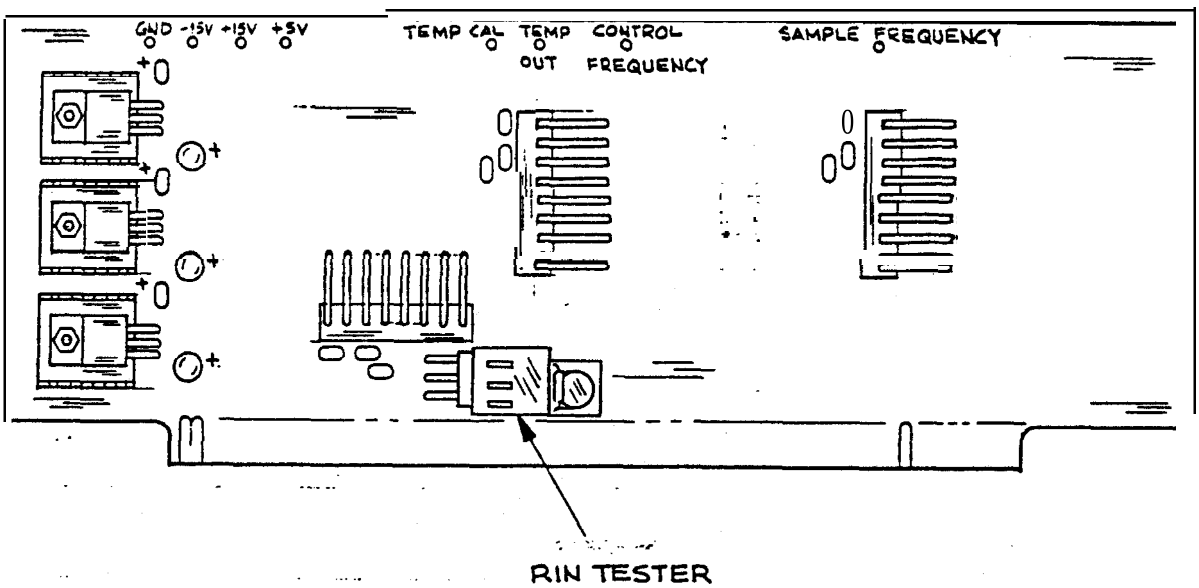


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Figure 3-4al Universal Adapter Board Assembly

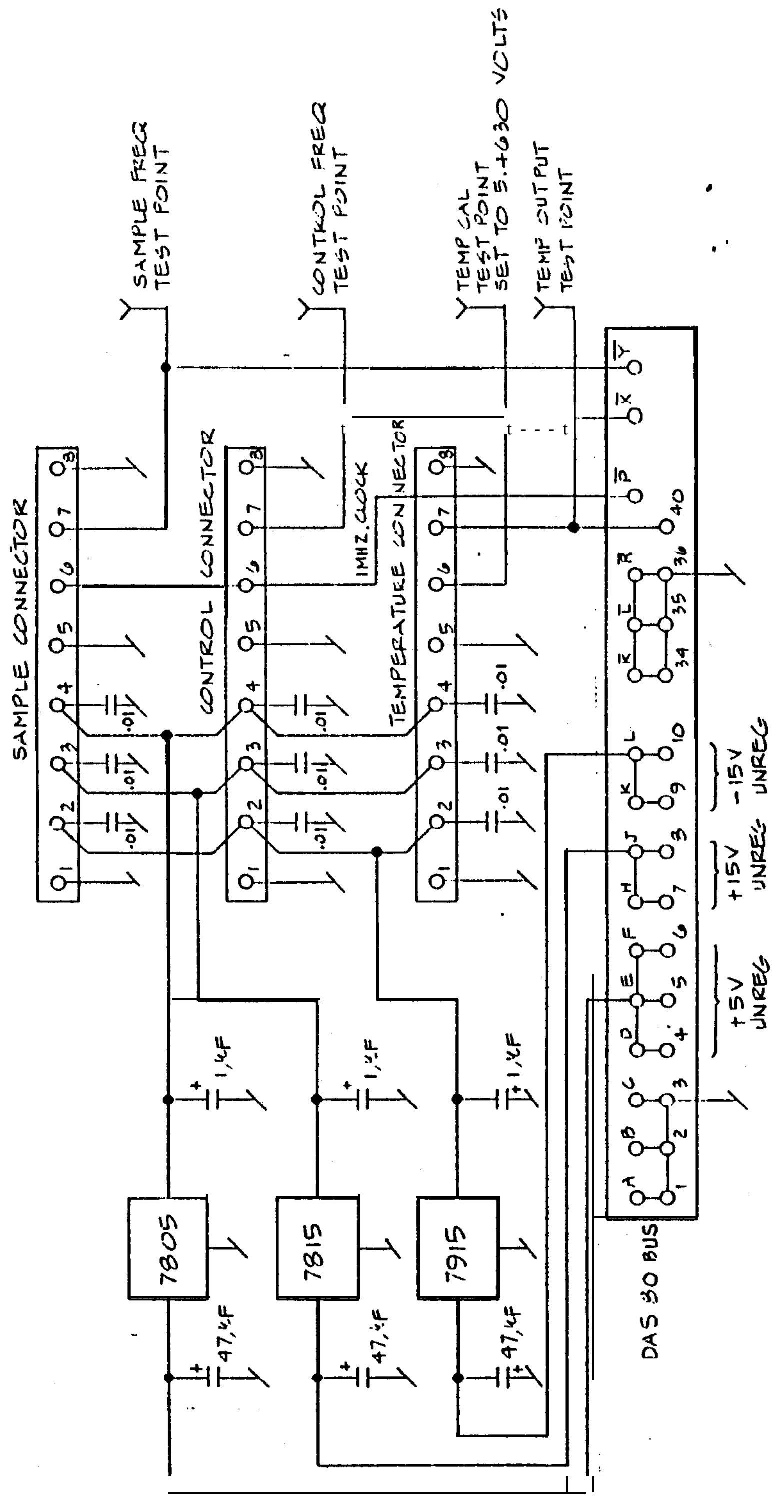


Figure 3-4a2 Universal Adapter Board Schematic Diagram

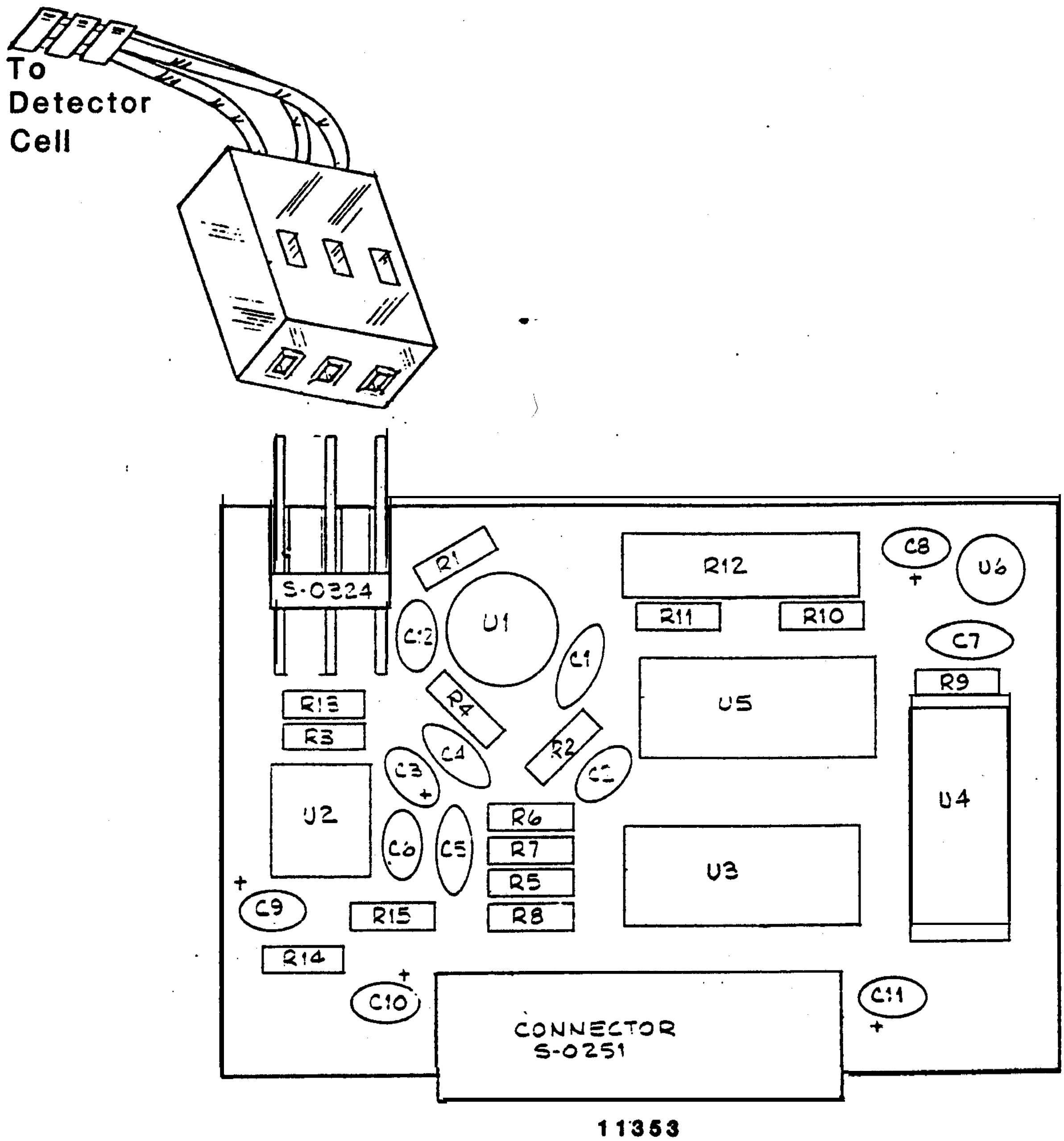


Figure 3-5a1 Integrating Current Electrometer Assembly

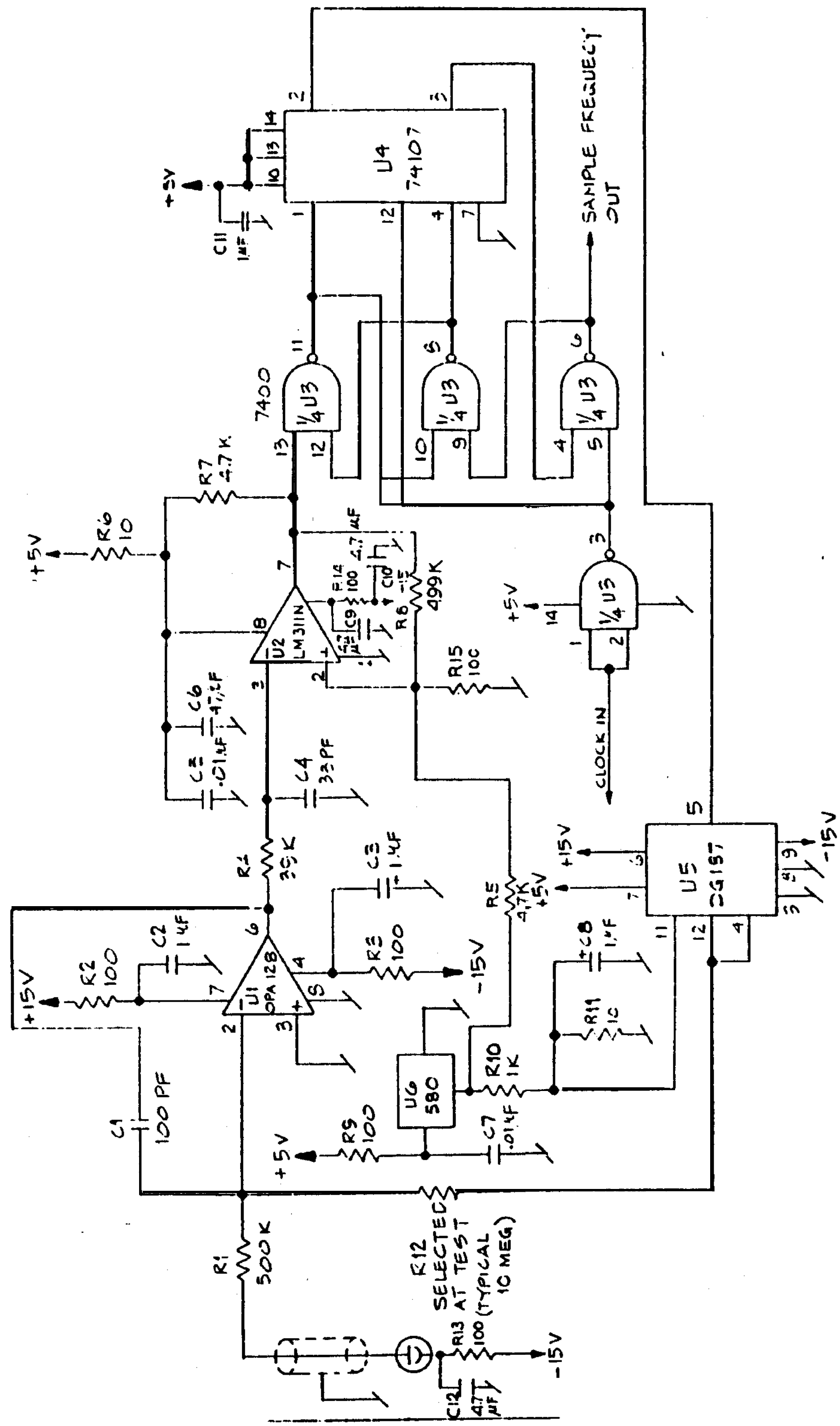


Figure 3-5a2 Integrating Current Electrometer Schematic Diagram

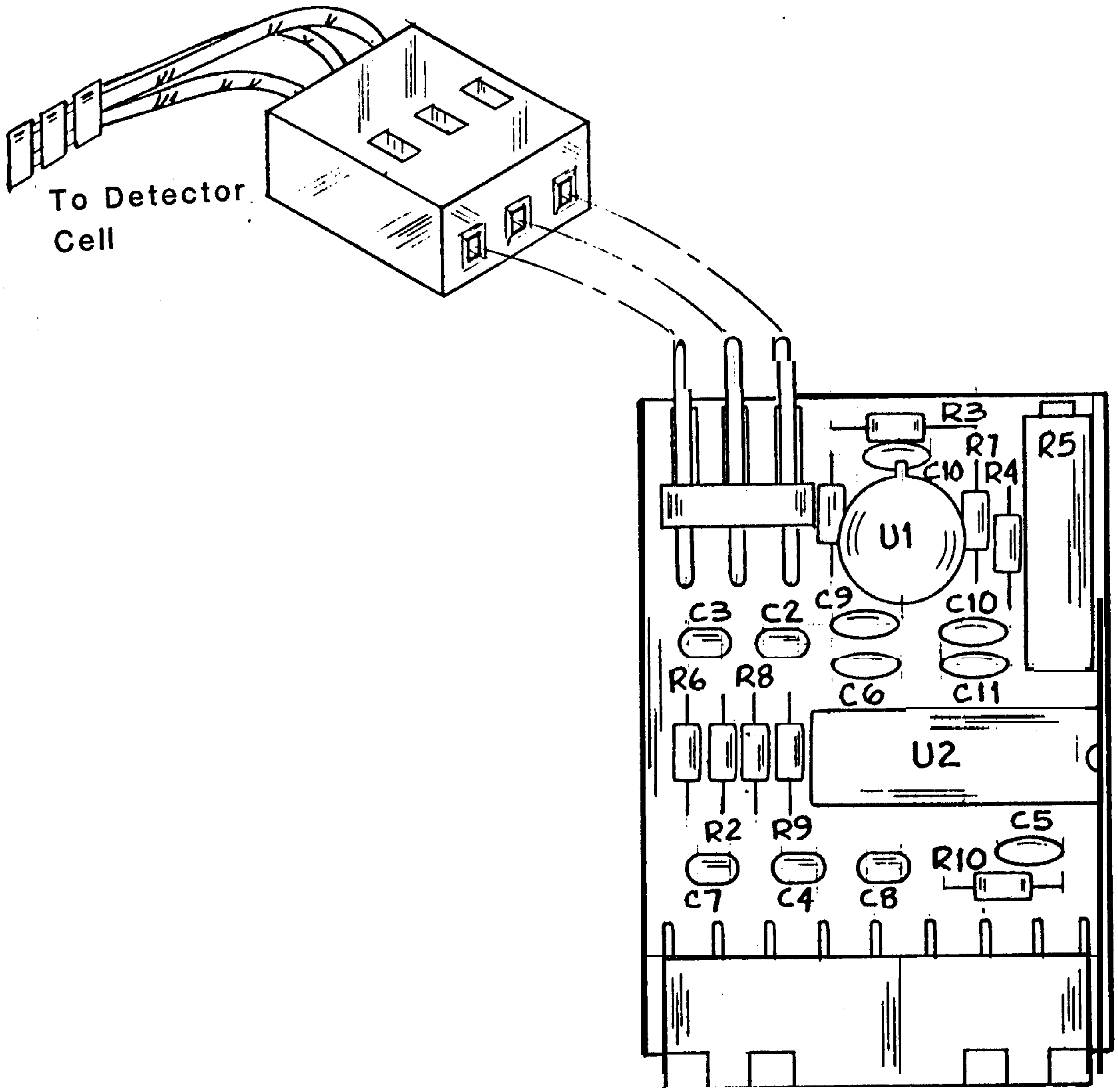


Figure 3-5bl 652 VFC Electrometer Assembly

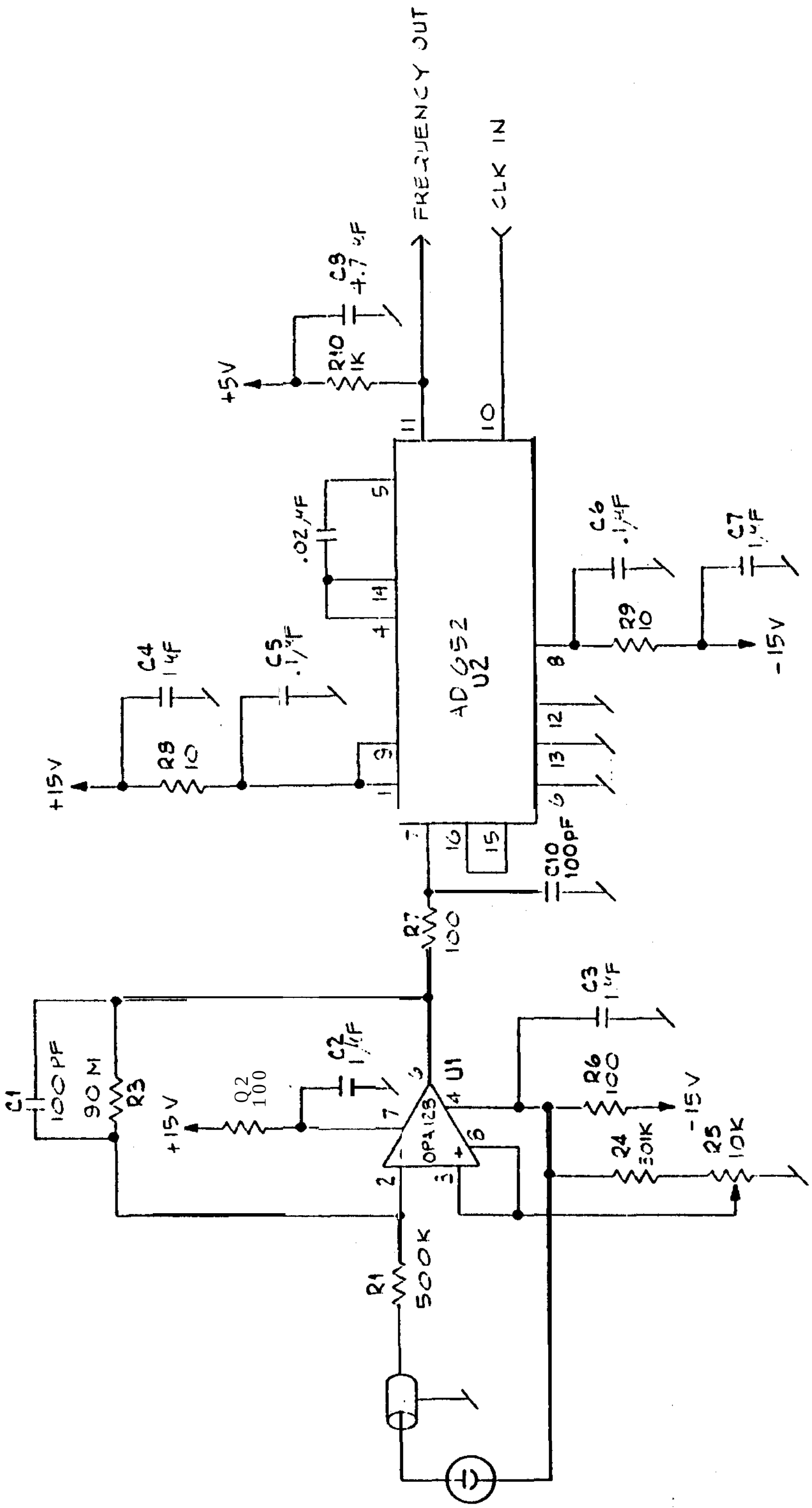


Figure 3-5b2 652 VFC Electrometer Schematic Diagram

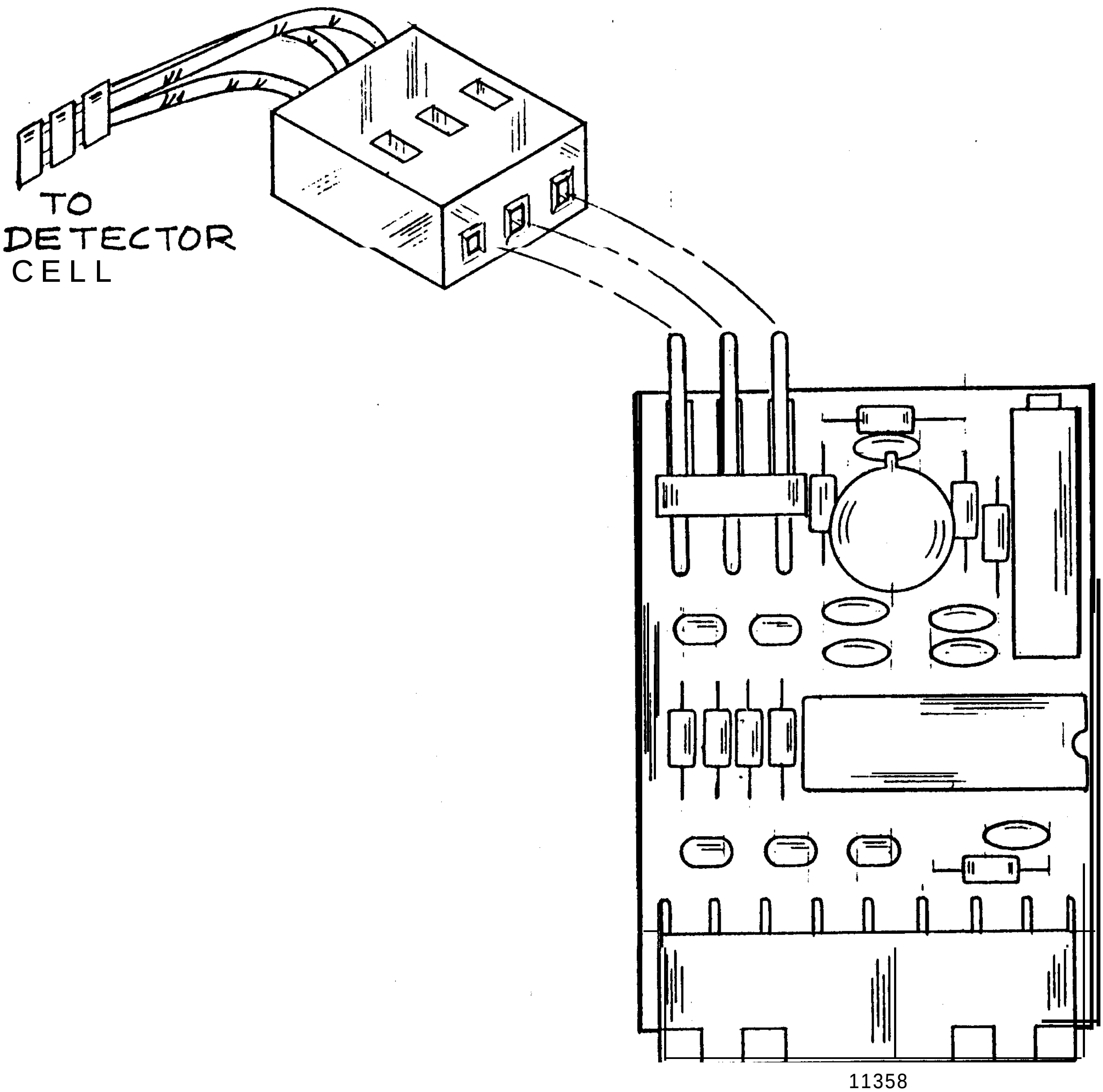


Figure **3-5cl** 650 VFC Electrometer Assembly

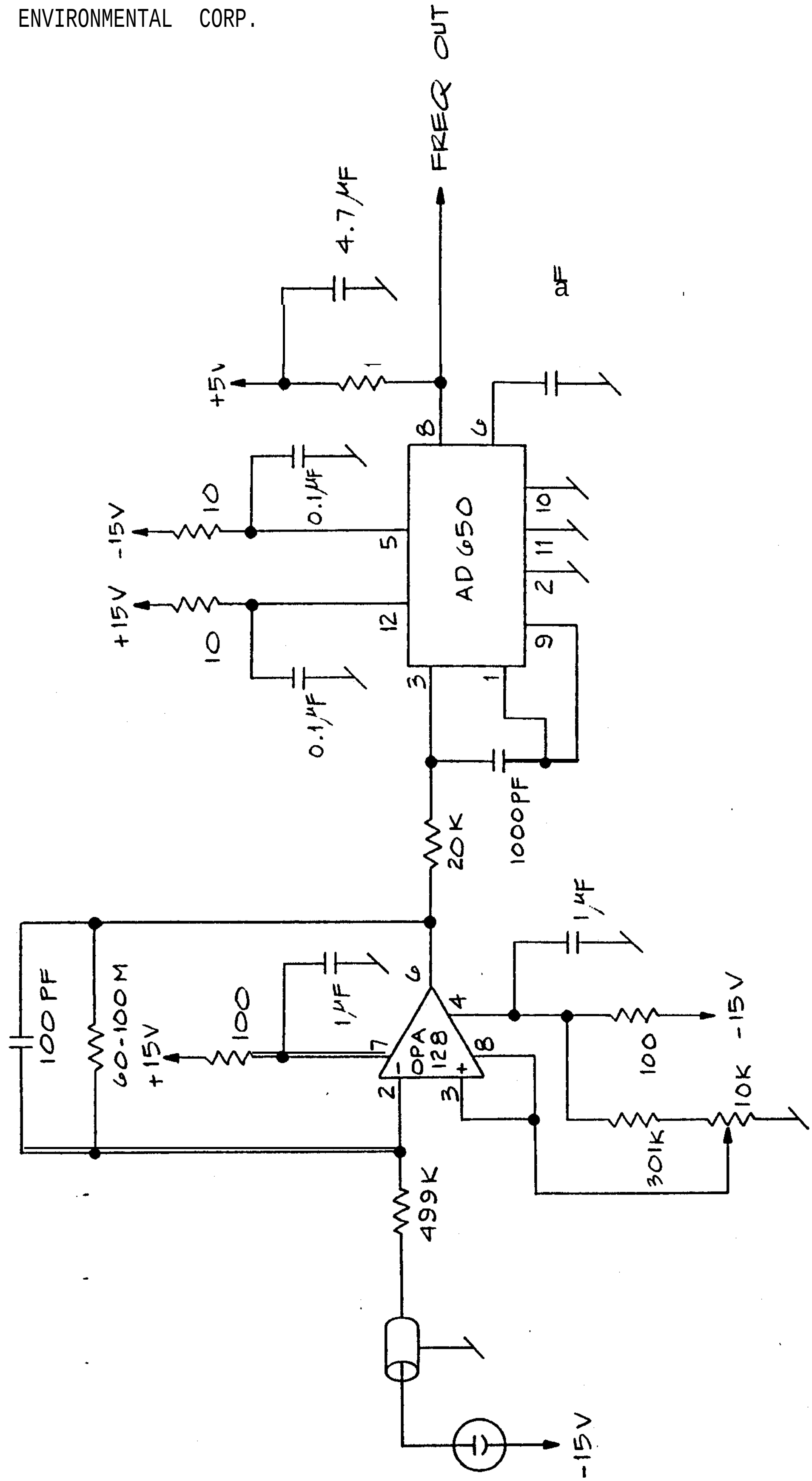


Figure 3-5c2 650 VFC Electrometer Schematic Diagram

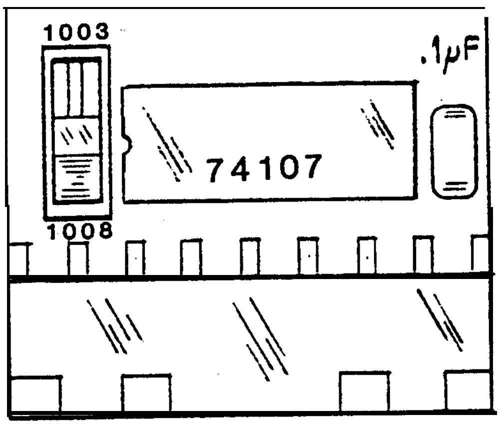


Figure 3-5d1 Fixed Frequency Oscillator Assembly

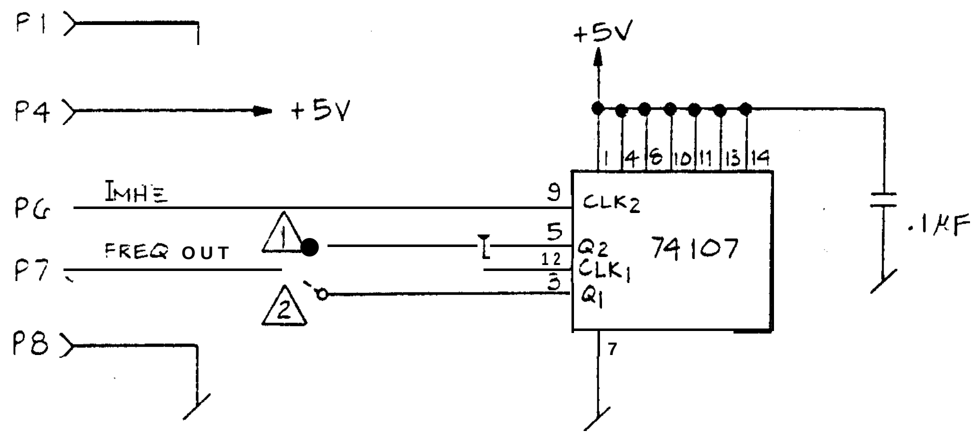


Figure 3-5d2 Fixed Frequency Oscillator Schematic Diagram

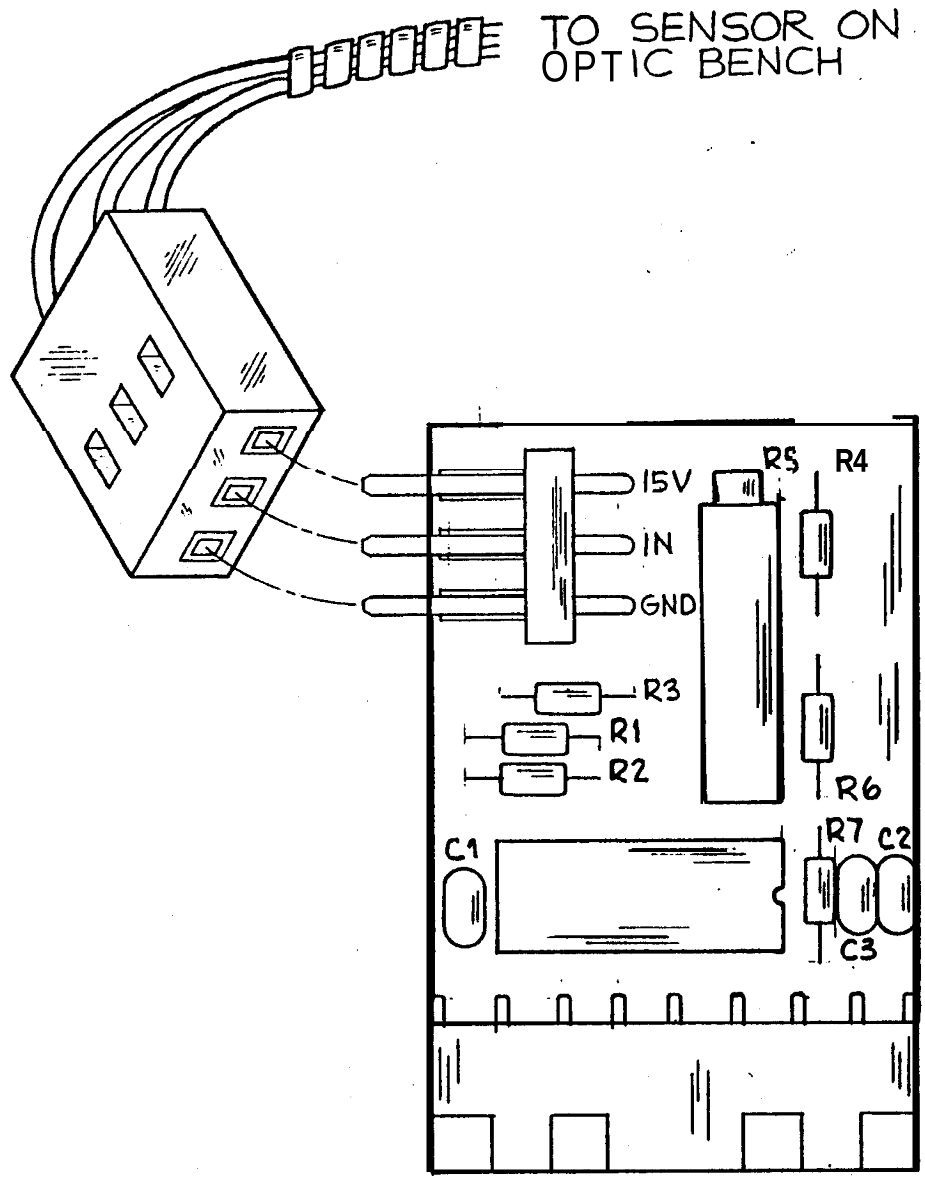
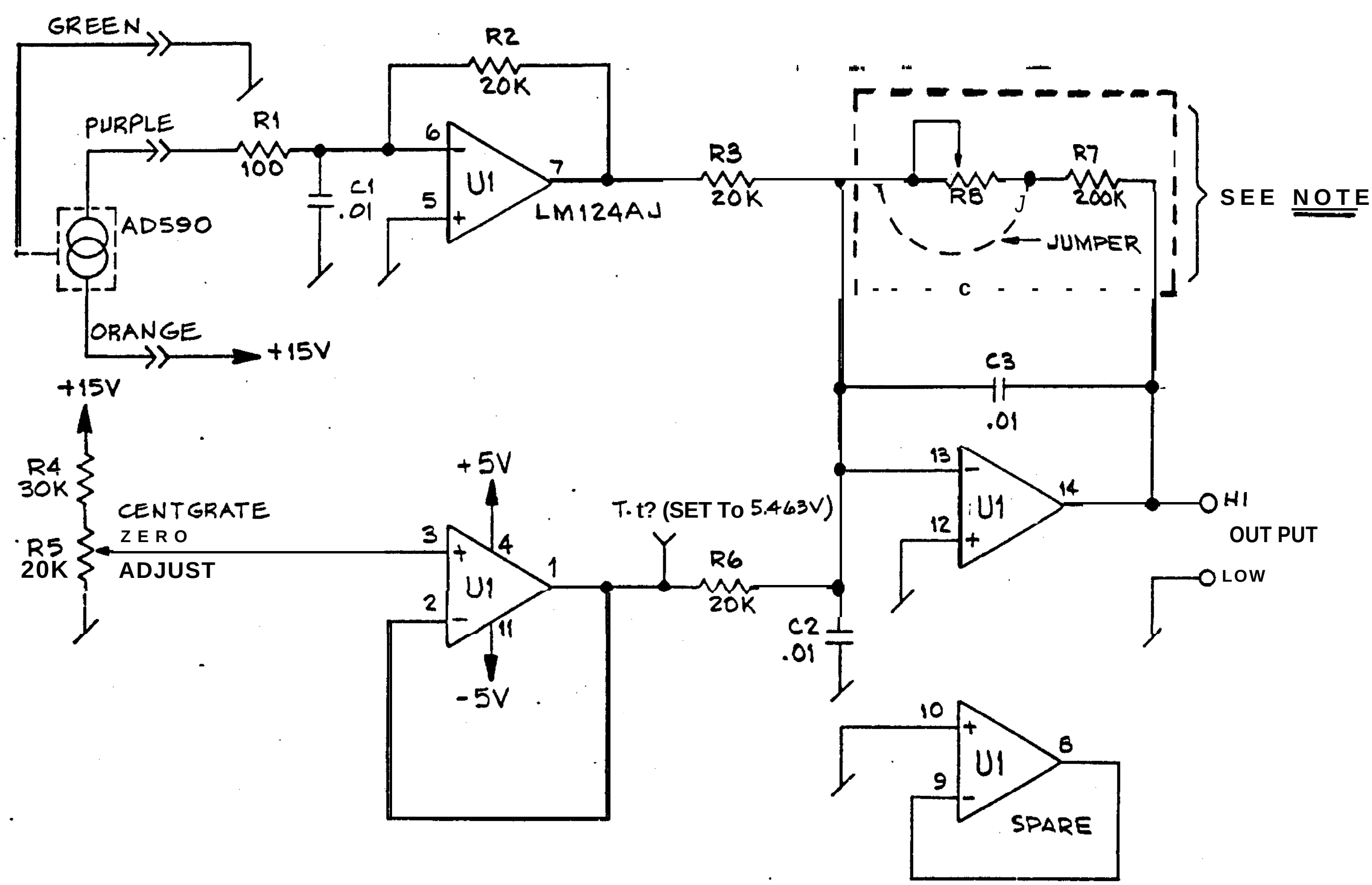


Figure 3-5el Temperature Circuit Board Assembly



NOTE: UNIT COMES WITH R8 (SPAN POT) JUMPERED AND R7 AS 200K±0.1%. UNIT WILL BE WITHIN 1% OF CORRECT TEMPERATURE CONFIGURED AS SUCH. IF CUSTOMER WISHES TO PROVIDE SPAN ADJUSTMENT, CHANGE R7 10 190KΩ, CUT JUMPER, AND ADD 20K POT POQ R8.

Figure **3-5e2** Temperature Circuit Board Schematic Diagram

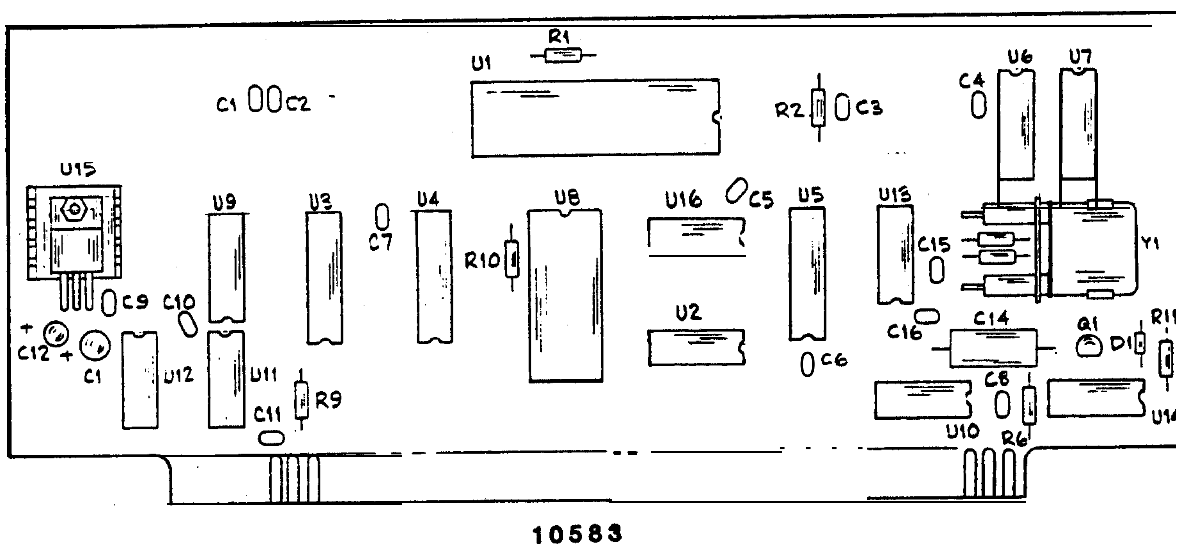


Figure 3-6 CPU Board Assembly

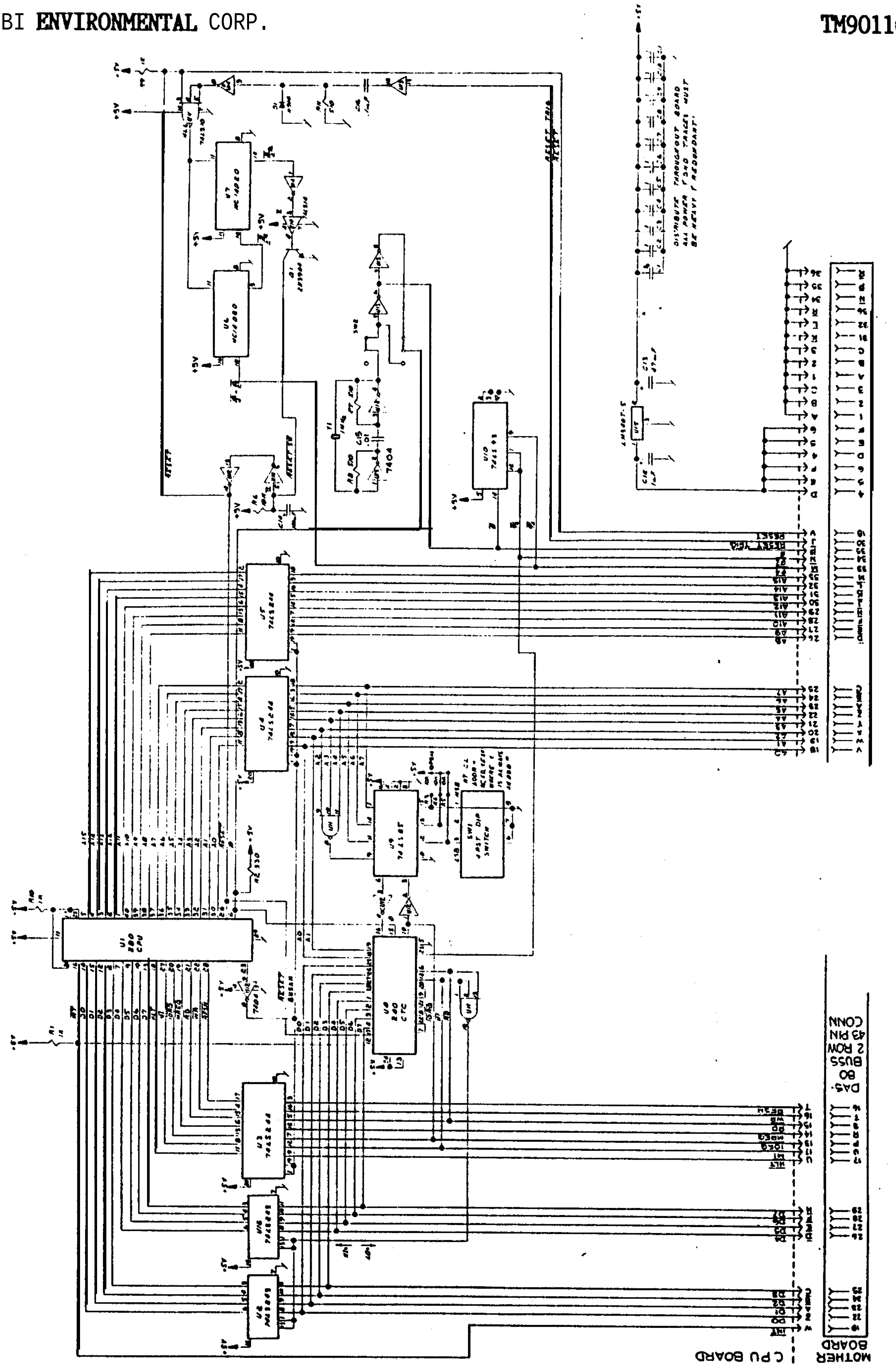


Figure 3-7 CPU Board Schematic

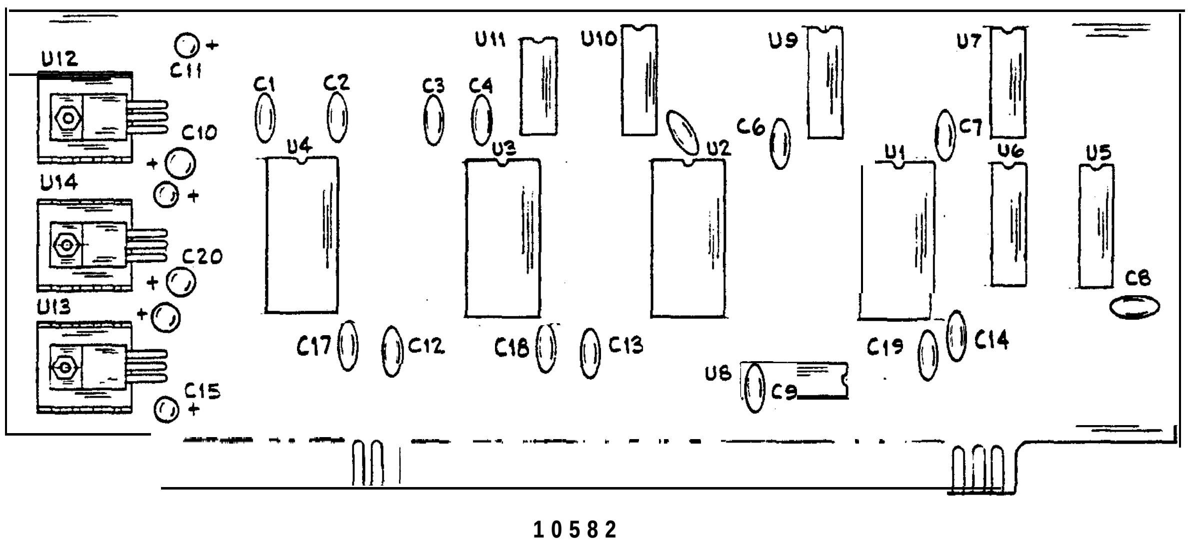


Figure 3-8 Memory Board Assembly

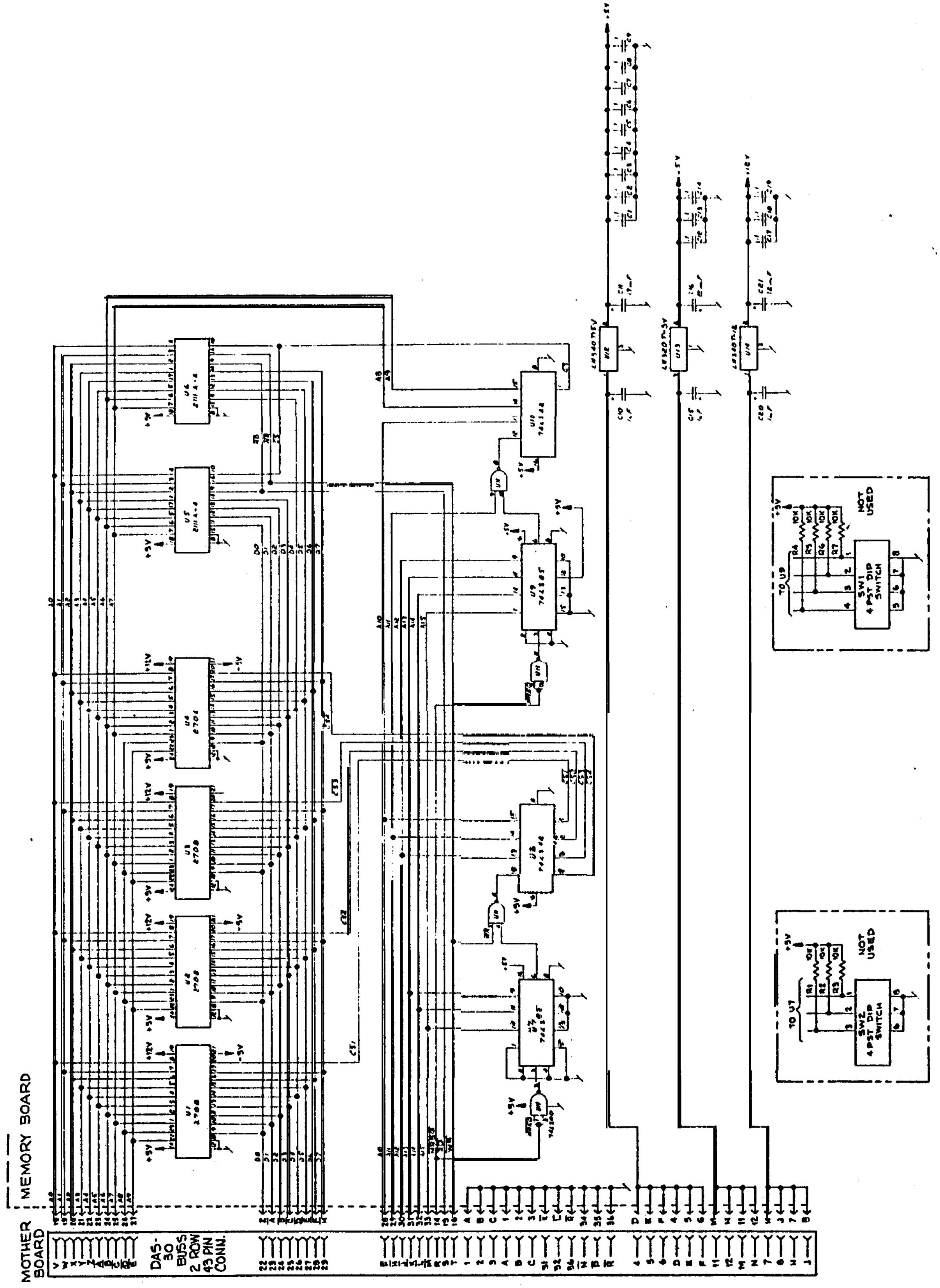


Figure 3-9 Memory Board Schematic Diagram

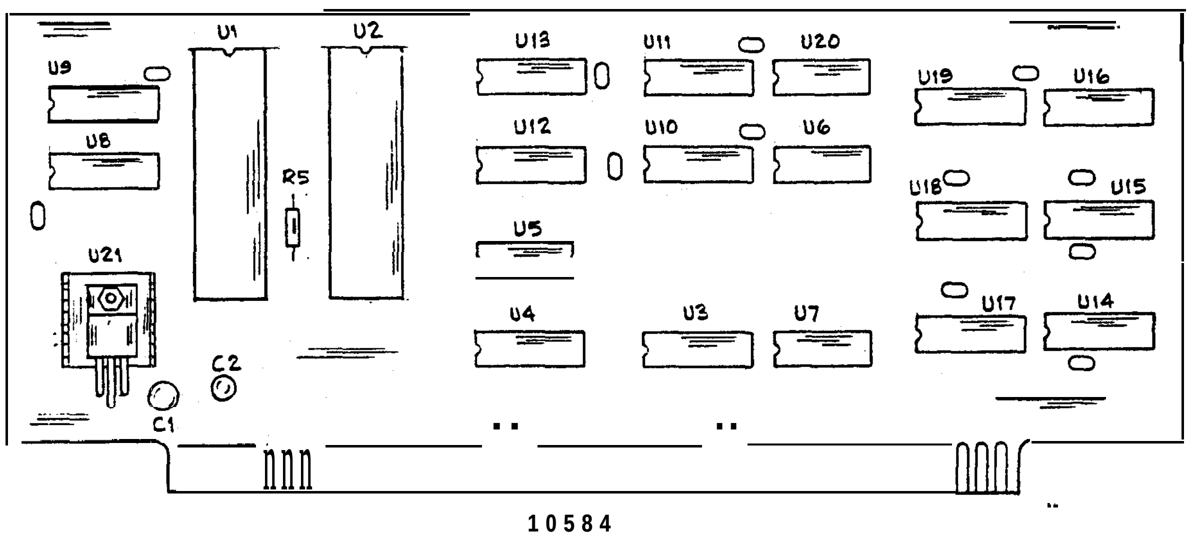


Figure 3-10 Counter Board Assembly

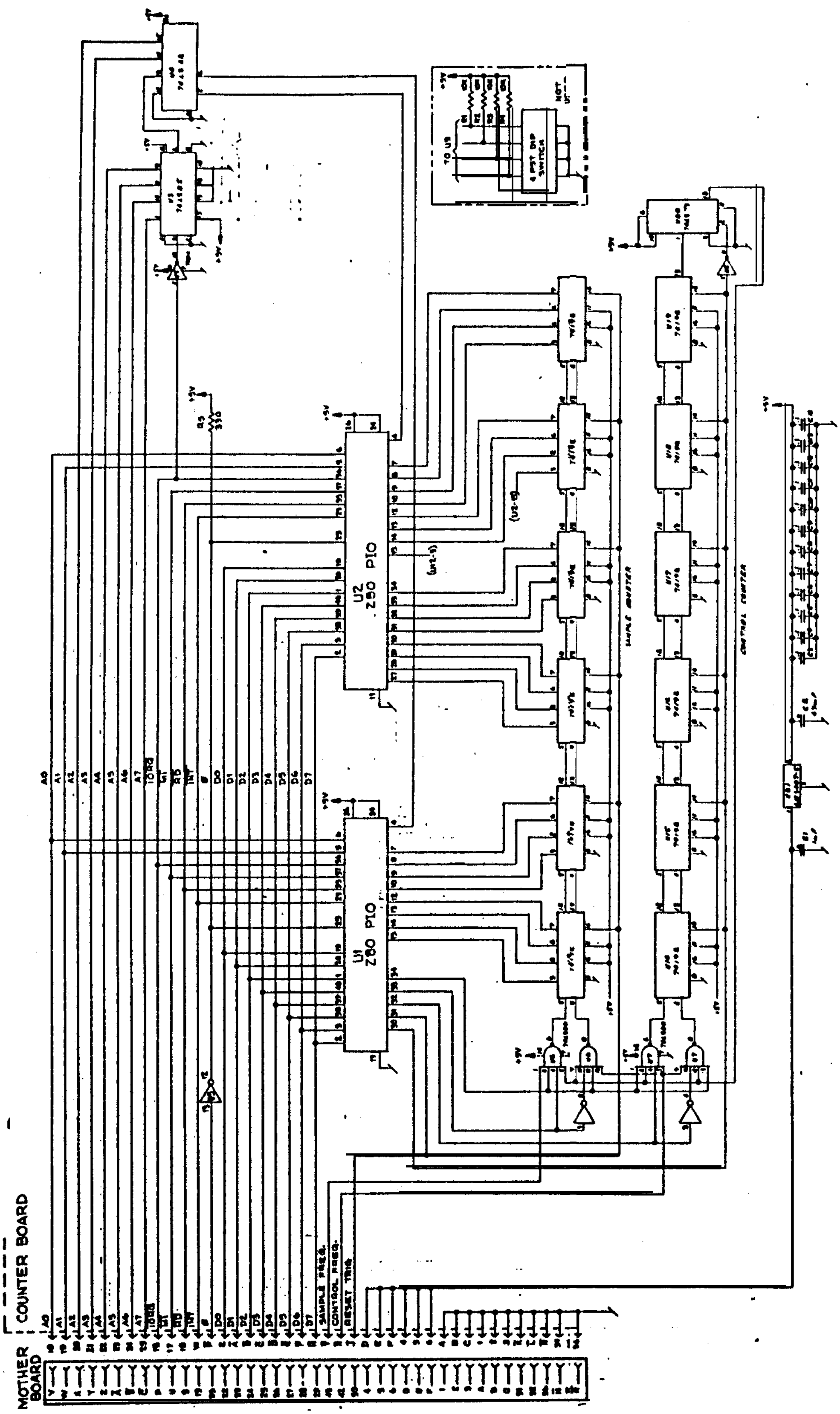


Figure 3-11 Counter Board Schematic Diagram

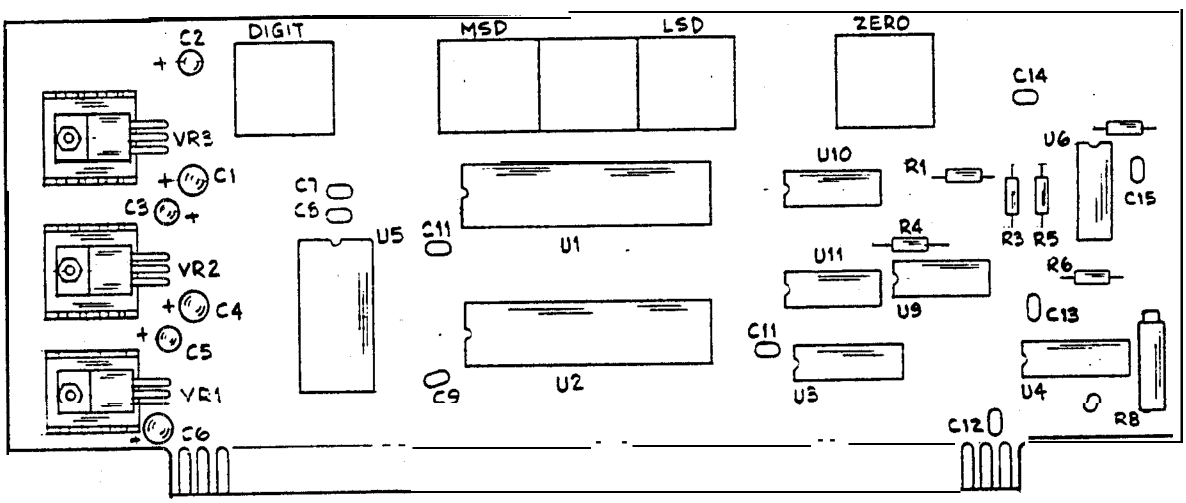


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Figure 3-12 D/A Board Assembly

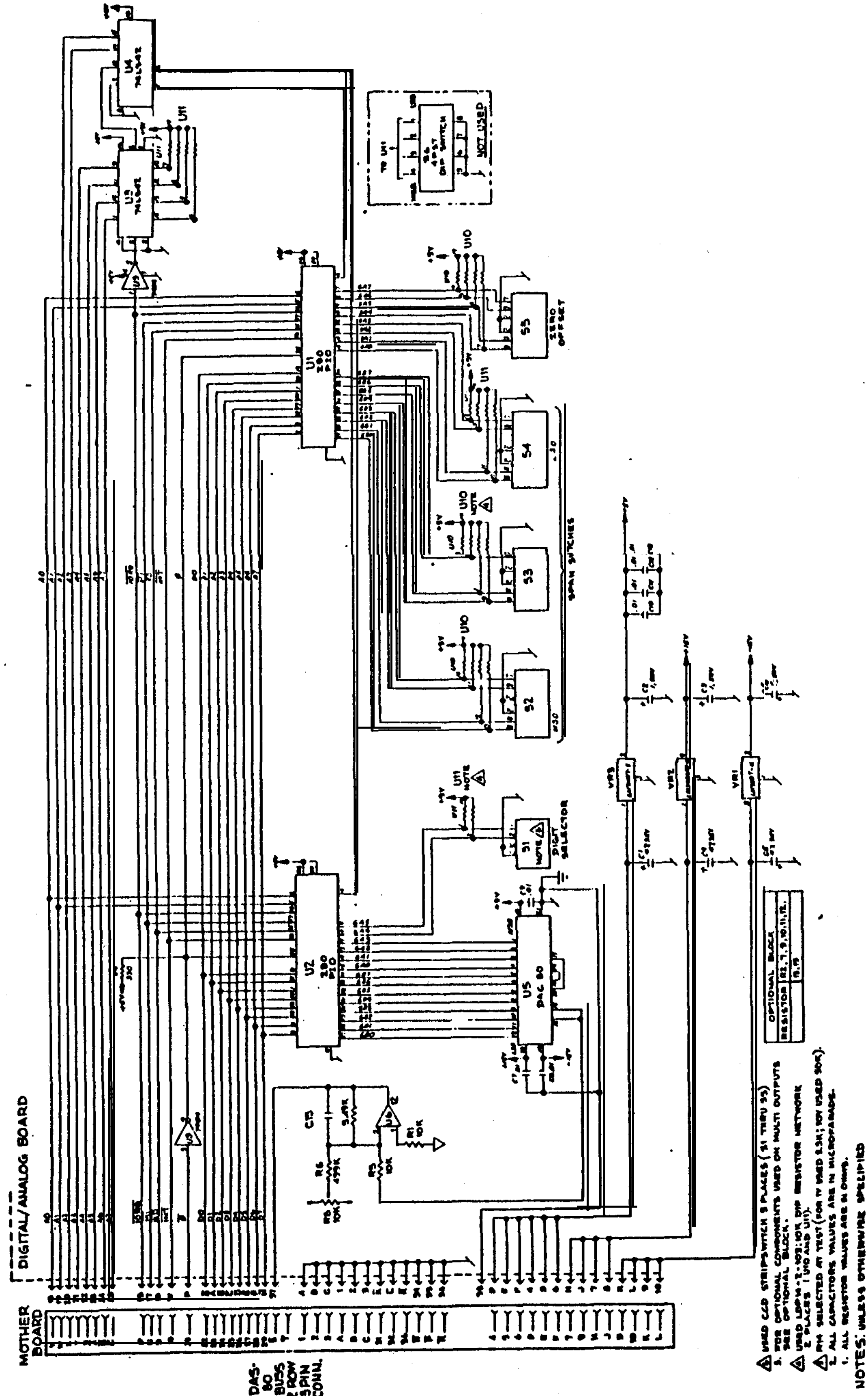

Figure 3-13 D/A Board Schematic Diagram

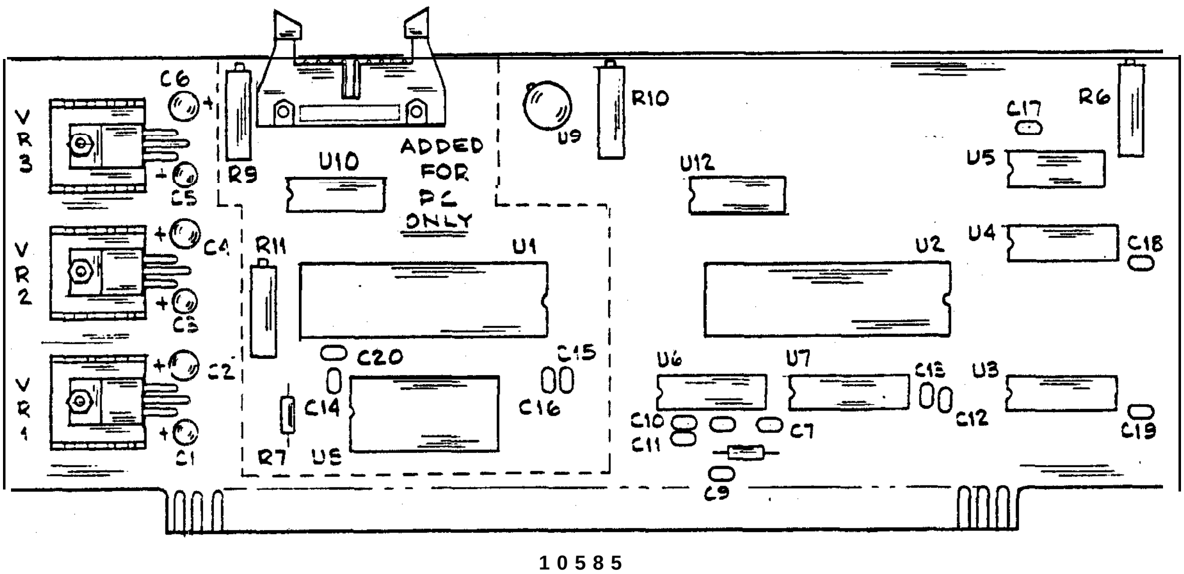

Figure **3-14** I/O Board Assembly

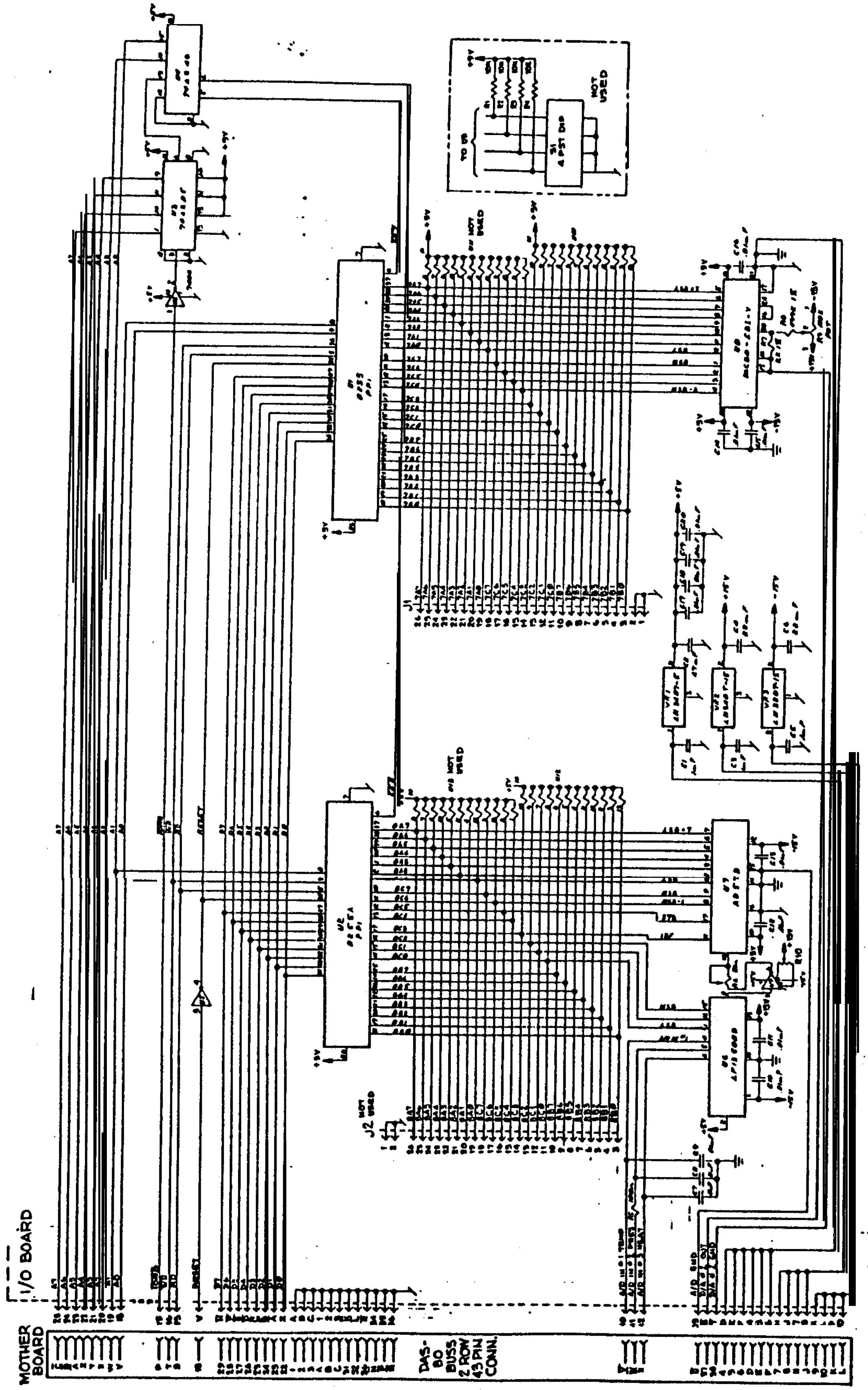

Figure 3-15 I/O Board Schematic Diagram

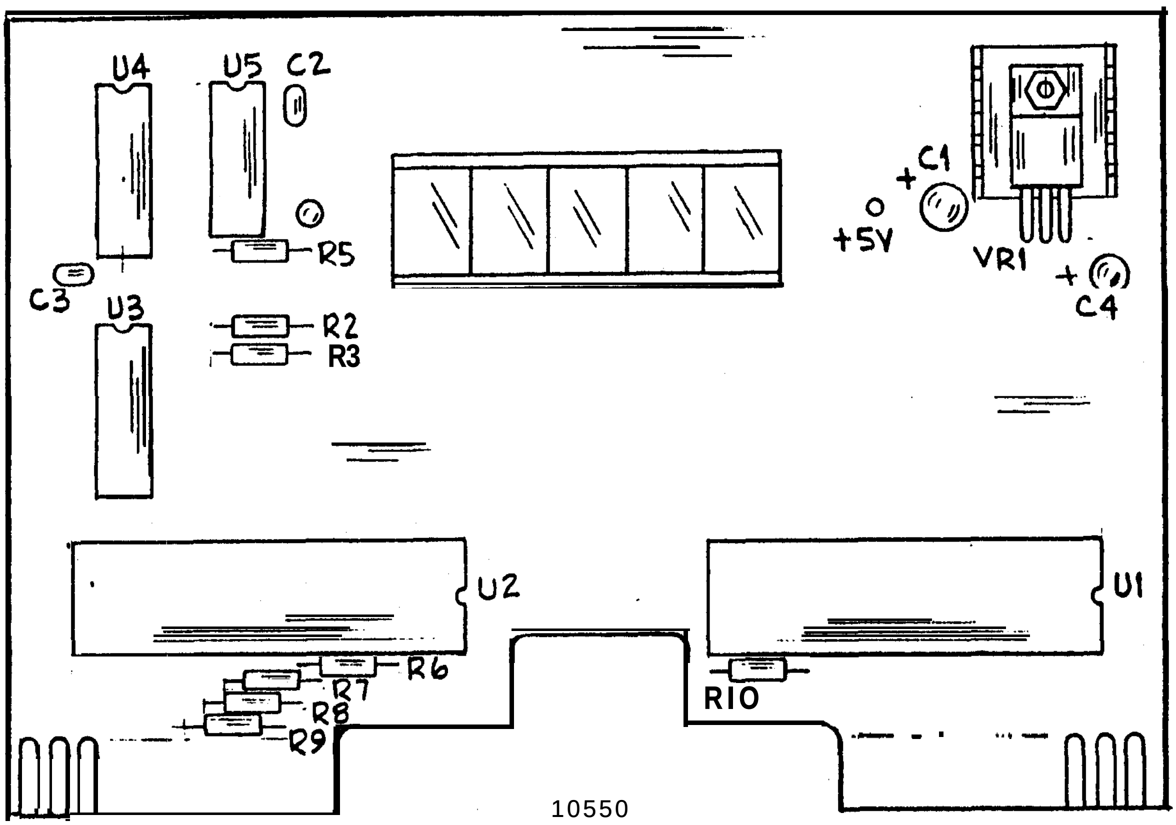

Figure 3-16 Display Board Assembly

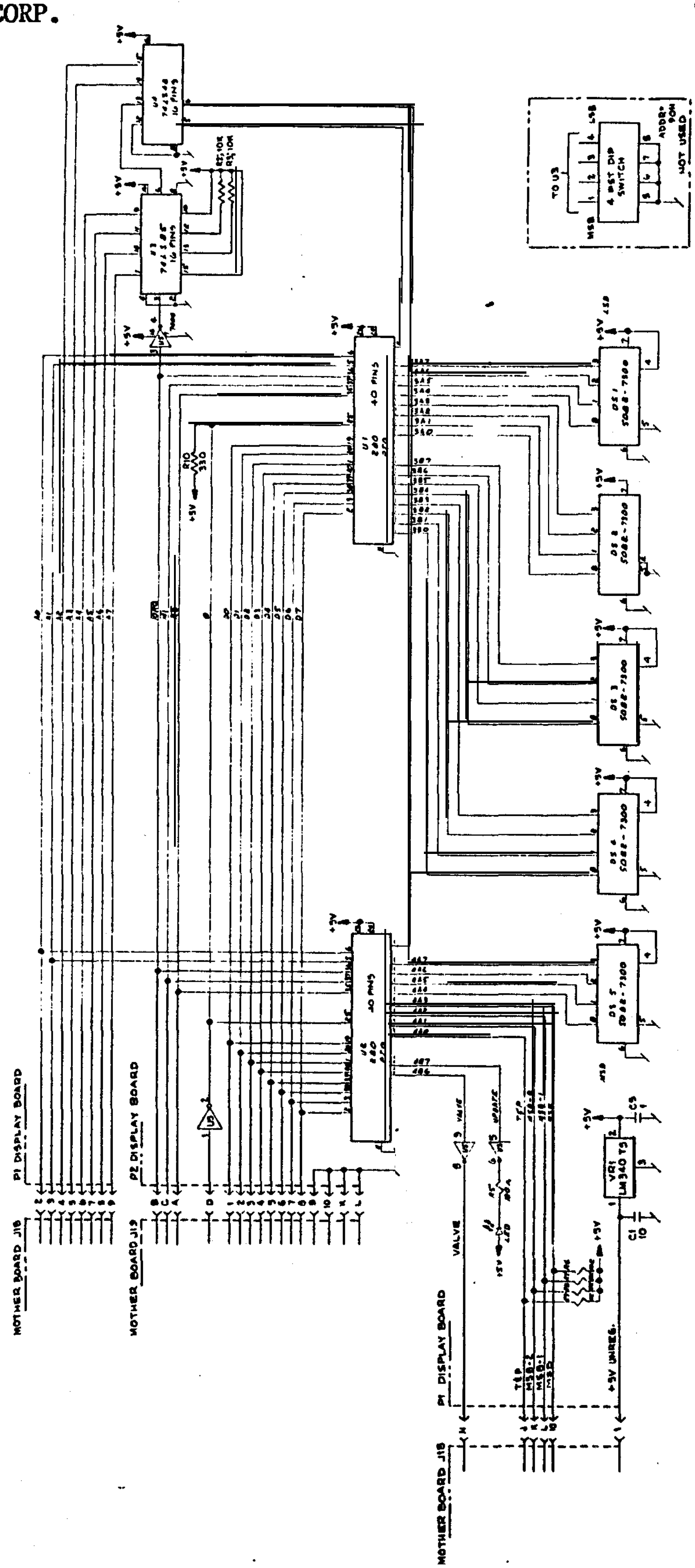

Figure 3-17 Display Board Schematic Diagram

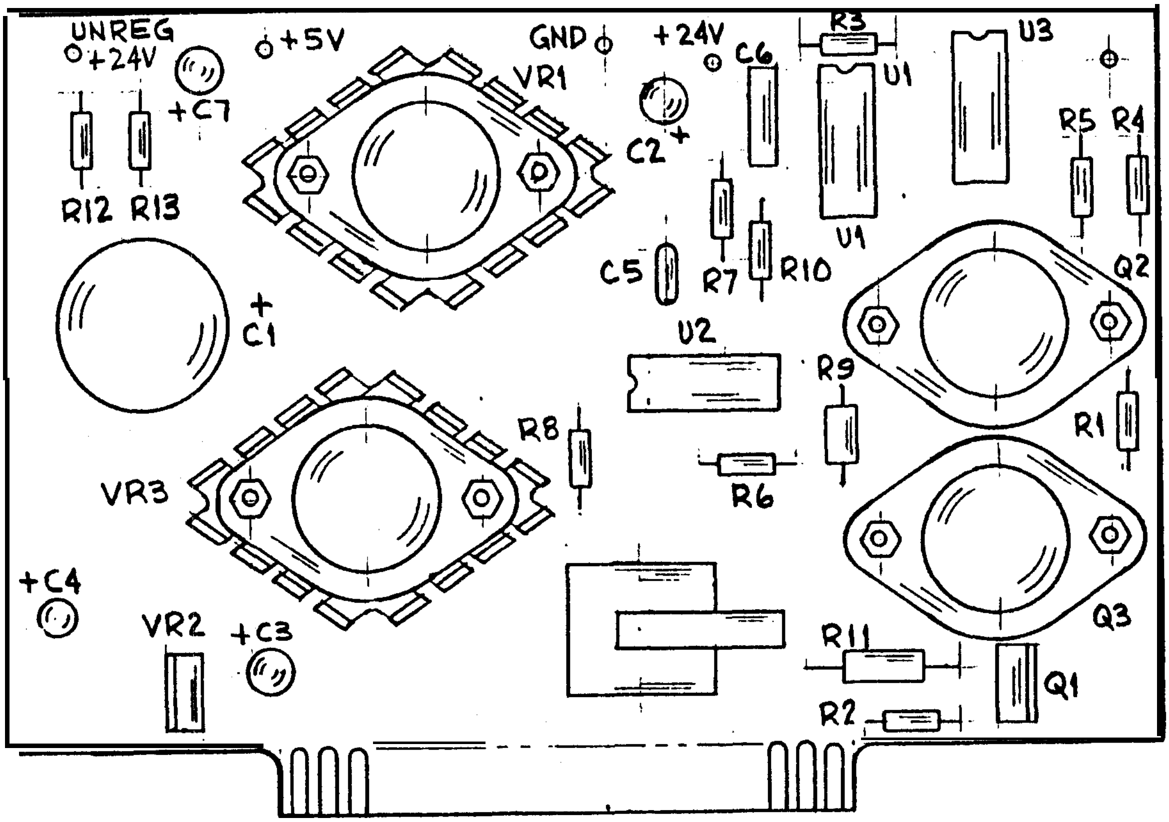

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Figure 3-18 Lamp Drive Heater Control Board Assembly

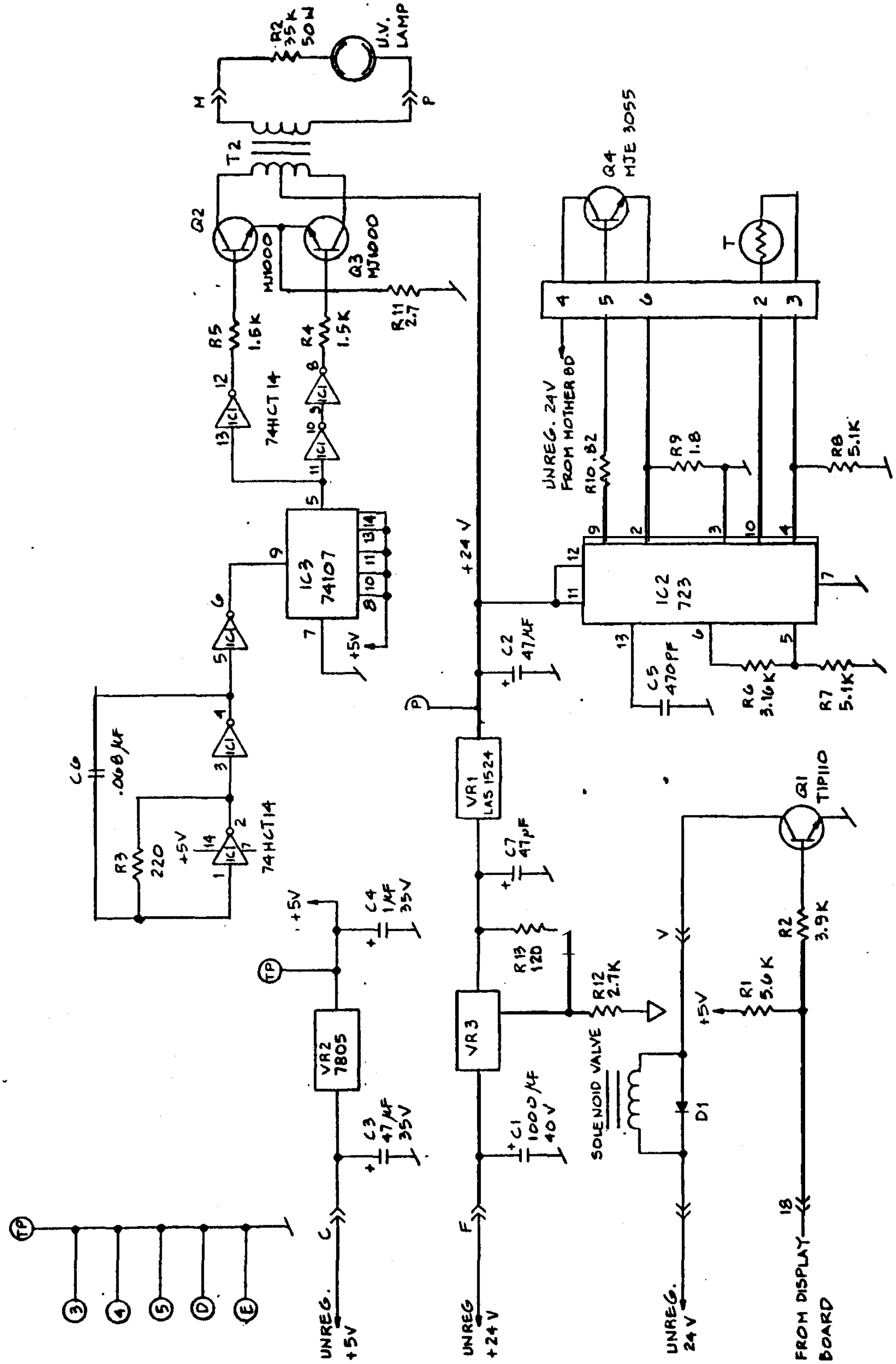


Figure 3-19 Lamp Drive Heater Control Board Schematic Diagram

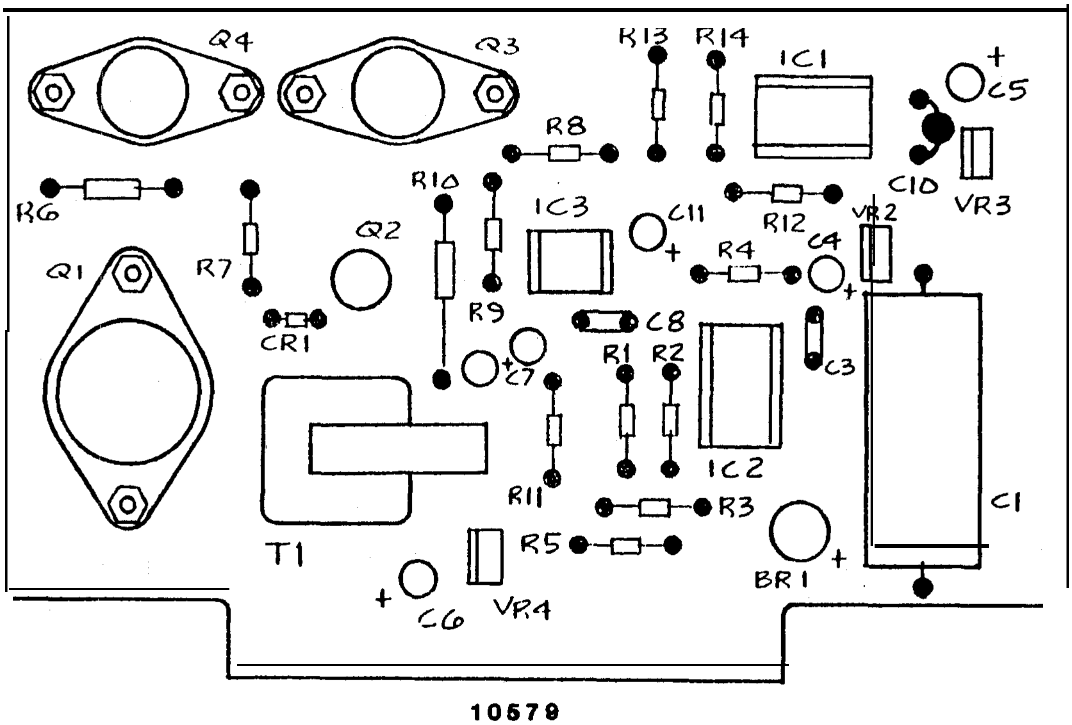


Figure 3-20 Ozone Control Board Assembly (PC)

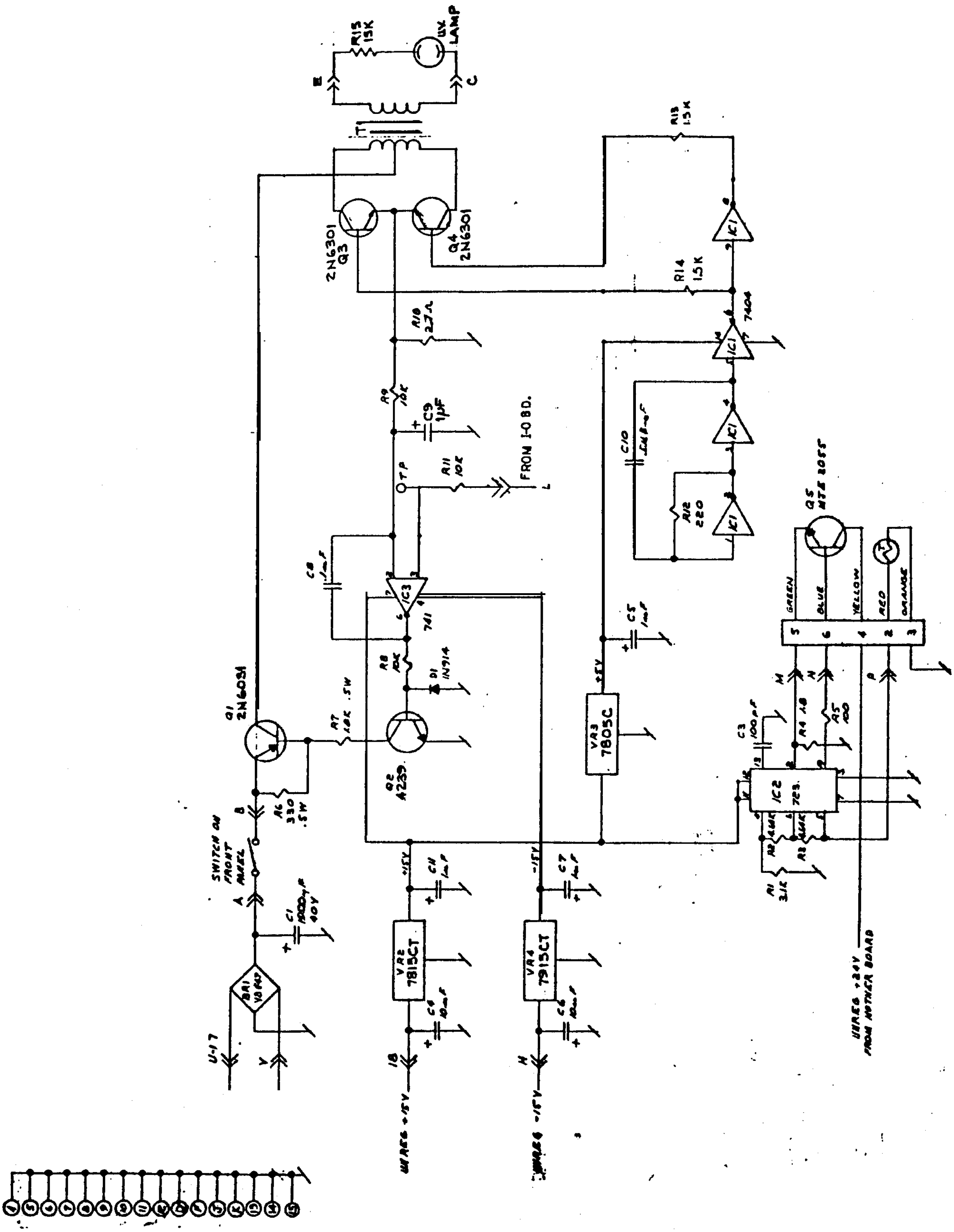


Figure 3-21 Ozone Control Board Schematic Diagram (PC)

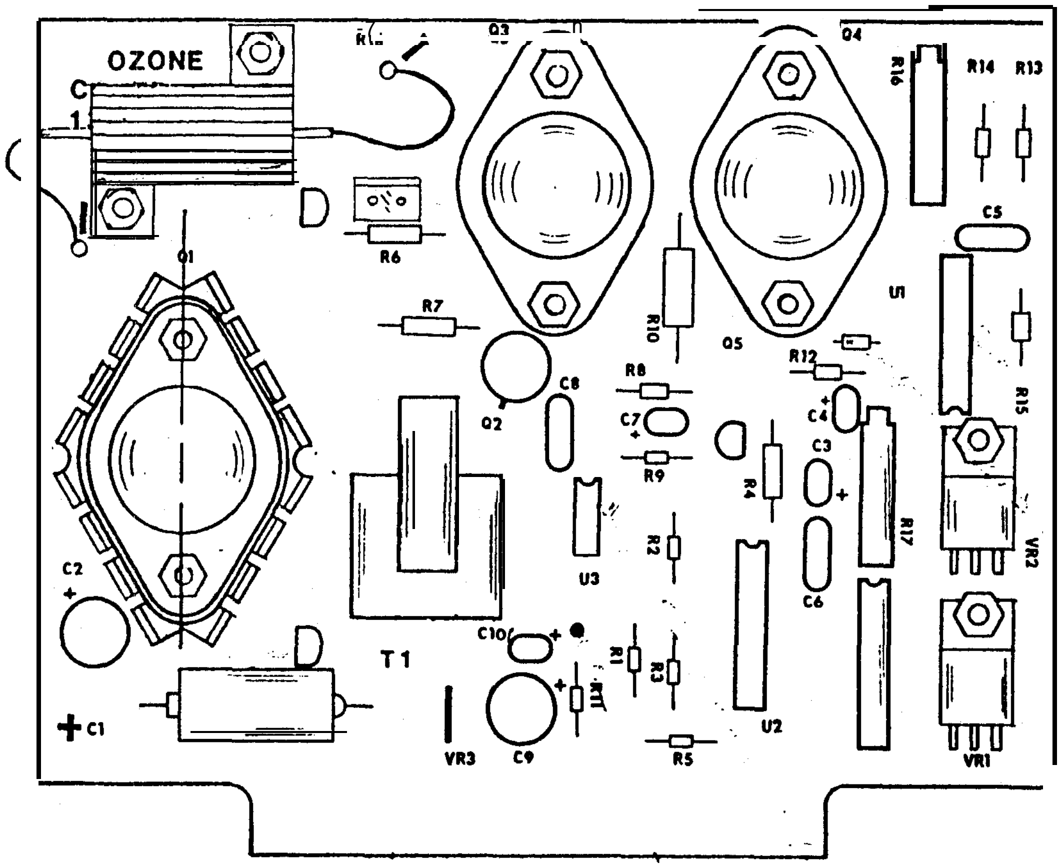


Figure 5-22 Ozone Control Board Assembly (RS)

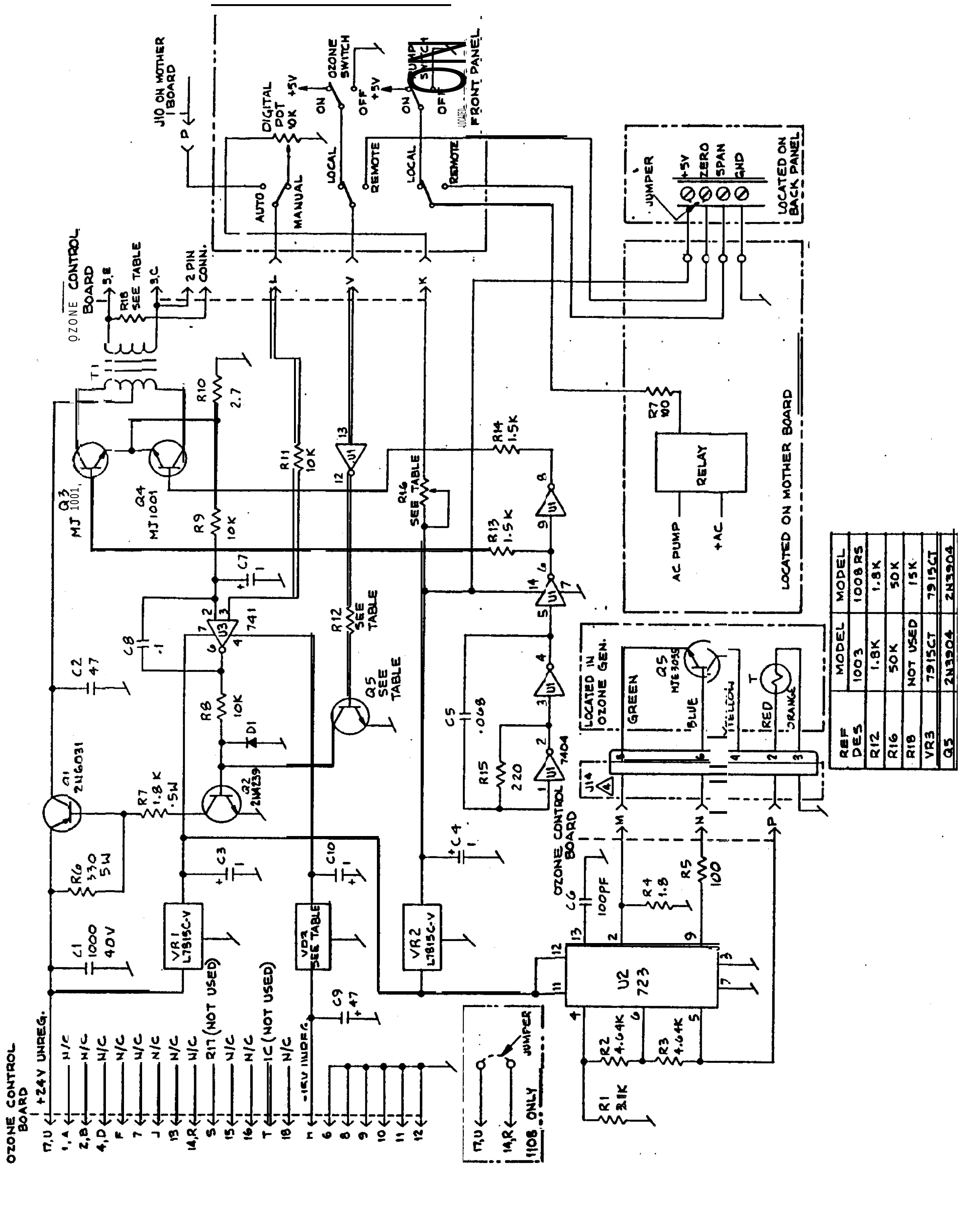
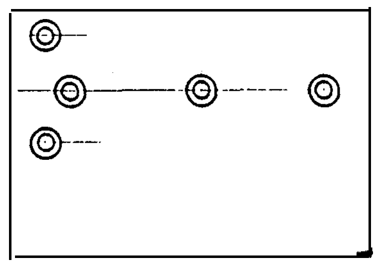


Figure 5-23 Ozone Control Board Schematic Diagram (RS)



BACK SIDE

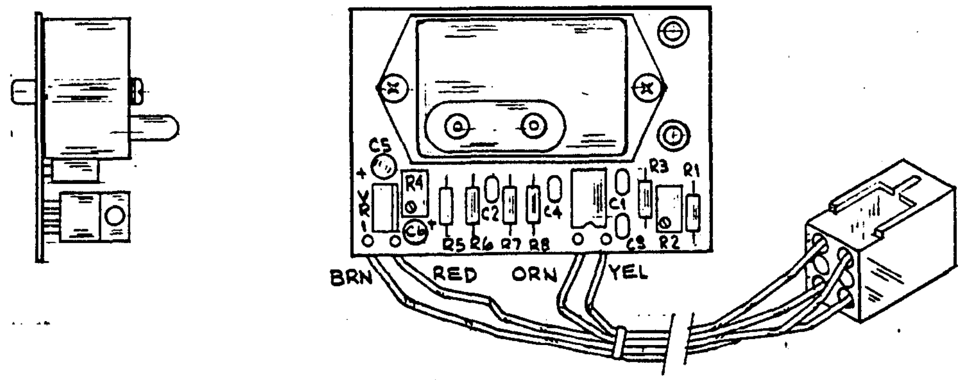
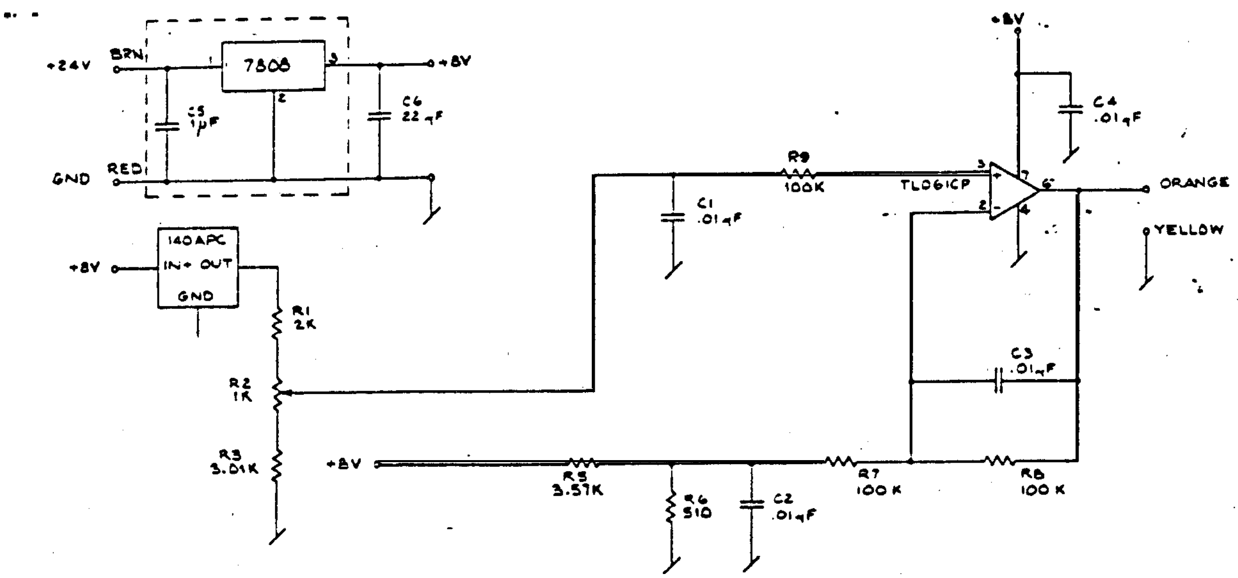


Figure 3-24 Pressure Sensor Board Assembly Diagram



'Figure 3-25 Pressure Sensor Board Schematics Diagram

4.0 PRINCIPLES OF OPERATION

4.1 General

This section describes the operating principles and the data processing techniques used by Dasibi 1008 ozone analyzers. These analyzers utilize "monochromatic ultraviolet (UV) absorption spectrophotometry" to provide an electrical. signal which is proportional to the ozone concentration. This signal is subsequently used for data processing and concentration read-out.

This section is also intended to furnish the reader with a comprehensive understanding and a high level of confidence about the gas concentration readings obtained from the analyzers. A discussion of the theory of operation and method of measurement is presented. Also, adjustments to instrument operation and application of corrections to the data to allow for Standard Temperature and Pressure conditions (STP) (as well as to convert to different engineering units) are given.

4.2 Symbols Used

A	=	absorption coefficient of ozone (308.3 $[cm^{-1}][atm^{-1}]$ at 253.7 [nm] wavelength and STP)
a	=	approximate ozone concentration for linear form of Beer's law
C	=	ozone concentration as partial pressure [atm]
c	=	ozone concentration in desired units
CF,,	=	temperature and pressure conversion factor to STP
e	=	natural logarithm (2.71828)
I	=	intensity of UV radiation during measurement cycle (with ozone present in sample gas)
I,	=	intensity of UV radiation during reference cycle (with ozone removed from sample gas, i.e., zero gas)
K	=	proportionality factor relating concentration, C, to concentration, c, and correcting from ambient conditions to STP
K_{STP}	=	proportionality factor relating concentration, C, to concentration, c, at STP
L	=	optics bench path length [cm]
$[M]_i$	=	Molecular weight of gas of interest, (i.e., ozone)
$[M]_b$	=	Molecular weight of background gas.
P	=	ambient pressure [atm]
R	=	instrument Reading
S	=	instrument Span Number
SF	=	instrument Scale Factor
STP	=	Standard Temperature and Pressure (0° [C], 1 [atm])
T	=	ambient temperature [°K]

For the discussion in this section only, units are enclosed in square brackets, i.e., [ ], to avoid alphabetical confusion with the various constants and variables that are also used. Commonly accepted English and/or metric units are used, thus, [l] is liters, [m] is meters, [in] is inches, [sec] is seconds, etc.

4.3 Description of Instrument Operation

4.3.1 General

Dasibi analyzers are self-contained instruments which measure the concentration of ozone in a sample of ambient (background) gas, such as air, oxygen, nitrogen, etc. This instrument is a monochromatic, UV absorption spectrophotometer, specific for ozone. Control of instrument function and data processing is performed automatically by the electronic system, and only minimal front-panel adjustments are required for proper operation.

4.3.1.1 Principle of Operation

A fixed quantity of "zero gas" and the same quantity of "sample gas" are drawn-in alternately to the optics bench in the instrument by utilizing a pump and sample handling system. The zero (reference) gas is ambient gas, but with the ozone "scrubbed" (removed): the sample gas is the pure, unaltered ambient gas, with the ozone still present. The optics bench is often referred to as an "absorption cell," since absorption of the W light (radiation) by various constituents in these gas samples: i.e., ozone (as well as unwanted background constituents) takes place there.

A stable W light source is placed at one end of the optics bench, and the level of UV radiation transmitted across the optics bench is measured by a UV detector which is placed at its opposite end. Alternate, consecutive measurements of the absorption of W radiation during the zero gas (reference) cycle and the sample gas (measurement) cycle are made by the photometer. A continuous record of ozone concentration is then obtained by the sequential sampling of a group, or "stream," of such "measurement pairs" of alternate reference and measurement cycles for which the instrument's timing circuitry has been designed.

Continuous auto-zeroing and removal of interferences are accomplished by this paired measurement technique, which may be thought of as "gas chopping." Some people have been surprised by Dasibi's claim of absolute interference removal and no zero drift. A familiar technique to achieve automatic zero stability for normal spectrophotometer operations involves chopper stabilization, or "light chopping." The technique of gas chopping achieves the same zero stability, with the added advantage of inherently eliminating all interferences.

Span stability is achieved by ensuring that the reference and measurement cycle times for each measurement pair are identical - by utilizing a special **"clock/counter"** control circuit (much like a stopwatch) which is set by each reference cycle time interval, controls the subsequent measurement cycle time interval, and then is reset for the next measurement pair. A fixed-frequency oscillator is generally utilized for this purpose which is completely adequate for a stable lamp and lamp drive.

Any variations that might be caused by short term lamp drift resemble **"noise,"** but operational experience with many Dasibi ozone analyzers over many years indicate that this noise is minimal, WELL BELOW the 1 percent span drift specified. However, short term drift in the intensity of the UV lamp during any given measurement pair can be compensated, if desired, by an optional, optical subsystem.

For this, an alternate, control detector (external to the optics bench and sample photometer) is arranged to independently monitor the UV lamp intensity directly. This provides a method of adjusting, or **"trimming,"** the control clock/counter if short term drift (variations) in the intensity of the lamp should occur. Long term drift in lamp intensity between measurement pairs is unimportant (whether the control detector is used *or not)* due to the very nature of the paired measurement technique (unless, of course, the lamp totally fails, or its output falls below analyzer cut-off). Because of the operation of the zeroing,, interference removal and control subsystems, there is VIRTUALLY NO Span or Zero Drift in instrument readings under any conditions or for any instrument configuration.

Appropriate signal processing of each individual measurement pair by the electronic system yields the instantaneous ozone concentration (i.e., within the update cycle of the instrument) in accordance with the Beer-Lambert law (Beer's law). A complete, general discussion of Beer's Law is beyond the scope of this document, but a comprehensive discussion can be found in Reference # 14 listed in Appendix D. The signal processing methodology utilized by the Dasibi ozone analyzer to obtain gas concentration values utilizing the measurement pairs mentioned (as well as the practical aspects of Beer's law) above is discussed in detail in Section 4.7.

4.3.1.2 Calibration

When operated according to this O&M manual, the analyzer will provide accurate data. However, continued data quality assurance will depend upon periodic calibration and zero and span check programs. Appendix B describes these programs as well as the procedures required for a complete calibration. The information presented is sufficient to perform the calibration, but for more information, the user is referred to References 13 and 11 listed in Appendix D. For detailed guidance in setting up a quality assurance program, refer to References 12 and 13) listed in Appendix **D.**

Zero and span checks should be performed once each month during continuous monitoring operations. A complete calibration should be performed at least once every three months or whenever a major disassembly of components occurs. The analyzer is intended to be a component in a system whose end purpose is to provide high quality gas concentration data. The accuracy and reliability of this system is predicated on good design, proper system maintenance, and appropriate calibration and zero and span checks.

4.4 UV Photometer

A photometer is a device **which quantitatively** determines the amount of light crossing a prescribed area. The *W* photometer in the Dasibi ozone analyzer consists of a stable *W* light source which is placed at one end of the optics bench, and a suitable *W* detector (sample detector) which is placed at the opposite end. The detector provides an electrical output which is directly proportional to the amount of *W* radiation striking its sensitized surface. The intensity of the UV radiation traversing the optics bench is attenuated by the ozone present in the sample gas during the measurement cycle in accordance with Beer's law. This attenuated signal is detected and compared with the unattenuated signal from the previous reference cycle. The two signals are processed digitally by the electronics for presentation directly as ozone concentration.

The UV light source is a low pressure, cold cathode mercury vapor lamp with 92 percent of its output concentrated at the 253.7 [nm] emission line. The absorption of UV radiation by ozone has been found to be maximum at this wavelength. The absorption coefficient of ozone, A, has been determined to be 308.3 $[cm^{-1}]$ $[atm^{-1}]$ at this wavelength by at least five separate investigators using more than one independent method. Emission at wavelengths shorter than 200 [nm] is eliminated by a Vycor optical filter around the lamp, which prevents any emission at 186 [nm], an emission line which actually generates ozone. The detector is a **"solar blind"** Cesium Telluride vacuum photodiode with a broad **passband** centered near 253.7 [nm]. The total optical selectivity of lamp and detector is such that better than 99.5 percent of the system response is due to 253.7 [nm] light. This results in a monochromatic instrument.

The optics bench is a sealed chamber to contain and physically isolate the sample gas. Quartz windows allow the beam of *W* radiation to pass through the chamber from the lamp to the detector, both of which are mounted externally. For monitors with long optical paths that must be **"folded"** to fit in the instrument (all of the 1008 analyzers, except the **1008-HC),** quartz mirrors are mounted in a triangular optical block to bend the *W* radiation through **180°.**

4.5 Sample Handling System

The sample handling system includes the gas inlet and exhaust ports, an optics bench (the W absorption cell), a solenoid actuated gas selection valve, a source of zero air (either a catalytic converter or a zero air manifold), a flowmeter, and a pump.

The reference cycle is implemented by use of either the catalytic converter (which selectively converts ozone in the sample gas to oxygen, but does not affect any of the other constituents) or a zero air manifold. During this cycle, the gas selection valve routes ambient gas through the catalytic converter or selects gas from the zero air manifold (to obtain the ozone-free, zero gas sample) and then directs this gas into the optics bench for measurement by the photometer. During the measurement cycle, the gas selection valve bypasses the catalytic converter or zero air manifold and routes the sample gas directly into the optics bench for measurement by the photometer.

The gas selection valve is a 3-way (dual-input/single-output) valve constructed from inert materials. It is solenoid operated by a signal from the electronic system timing circuitry. It is connected in such a way as to perform the function of routing either the sample gas or zero gas alternately into the optics bench.

The catalytic converter (for analyzers so equipped) catalyzes a reaction which converts ozone in the sample gas to diatomic oxygen, but does not otherwise overtly react with the sample gas. Thus, the sample gas entering the optics bench after passing through the catalytic converter is preserved predominately intact except for the removal of ozone, which has been converted into oxygen (which does not, itself, absorb UV radiation). However, since the sample gas may contain other substances (interferences) in addition to ozone which will absorb some W radiation, it is important that these substances be of the same concentration for both the reference and measurement cycles (which is ensured with this scrubber for all practical requirements).

The front panel flowmeter is plumbed between the output port of the optics bench and the pump. The ozone measurement is relatively independent of flow rate. However, an upper limit for the flow rate which may affect instrument concentration readings is the decreased pressure (from ambient) occurring in the optics bench due to the increased pressure drop in the sample supply lines resulting from an excessively high flow rate. Also, setting the flow rate higher than required consumes the functional elements contained in the catalytic converter at a faster rate, so that they must be replaced more often.

On the other hand, for a given flush delay time, a lower limit for the flow rate is defined by the need to completely flush the optics bench between update cycles. This lower limit is approximately 1.0 [l]/[min] for a 20 second update cycle. Therefore, we recommend a minimum flow of 1.5 [l]/[min] to ensure that the bench is totally flushed. For more rapid update cycles (i.e., shorter flush time) the flow rate must be increased in inverse proportion to the update cycle time, and for less rapid update cycles, it may thus be reduced.

The sample gas is drawn into the instrument by a vacuum pump located downstream of the optics cell. For instruments with internal pumps (standard in every 1008 except the 1008-HC), the pump has excess vacuum versus flow capabilities to provide sufficient margin for all requirements of the flow system. In order to maintain sample gas integrity, all internal surfaces in contact with the sample gas upstream of the optics bench are manufactured from materials which minimize sample gas degradation.

4.6 Electronic System

The sample detector in the photometer converts the UV radiation striking its surface to a low-level current by the photoelectric effect. This current is directly proportional to the incident radiation. The detector dark current is so small in this application that it can be ignored. The current from the detector is applied to the input of an electrometer which converts it to a frequency. This frequency, in turn, is directly proportional to the input current and thus also to the intensity of the UV radiation transmitted through the optics bench.

The control circuit consists of either a fixed-frequency oscillator or a control detector electrometer, either of which provides a clock function (the control timing for the reference and measurement cycles associated with the sample circuit). Analyzers that have the control detector and associated electrometer are continuously and directly monitoring the w lamp intensity during both the reference and measurement cycles. This detector is contained in an independent optical path not associated with the optics bench, and is in direct view of the lamp. Its output is not affected by absorption due to ozone or any interferences. The physical process of converting the w radiation intensity to frequency for the control detector and electrometer is similar to the process described above for the sample detector and electrometer. The control frequency, in this case, is only a function of the lamp intensity and varies only if the lamp intensity varies (drifts).

The signal frequencies from the sample circuit (sample photometer, detector, and electrometer) and the control circuit (fixed-frequency oscillator or control detector and electrometer) are each applied as a train of pulses to the inputs of separate counters where the pulses are totalized independently. This totalizing is actually an integration or averaging process. Figure 4-l is a block diagram of this arrangement.

A complete measurement cycle is performed as follows:

1) The sample and control totalizers are set to zero and the gas valve is switched so that zero gas enters the optics bench. A pre-determined amount of time is allowed to pass while the new amount of zero gas is allowed to flush out the previous amount of sample gas. The w radiation transmitted through the zero gas is then measured by allowing the sample and control counters to totalize until the sample totalizer counts reach a pre-determined value, S, the "Span Number." The counts then residing in the control totalizer are proportional to S and are retained in memory. For a fixed-frequency control circuit, these counts will be directly proportional to the time elapsed. For a control circuit utilizing a control detector and electrometer, the counts are modulated, or "trimmed" from this value if the output intensity of the UV lamp either increased or decreased during this time interval.

2) The gas valve switches again, and now an amount of sample gas with ozone present is brought into the optics bench. The flushing of the optics bench described above is again repeated to remove the previous amount of zero gas and replace it with the sample gas. Another measurement is then taken, with the counts from the sample and control circuits arranged to subtract from those previously accumulated in the sample and control totalizers, respectively. The control totalizer is allowed to count down to zero, ensuring that the same total amount of time (or total UV radiation for the case of an analyzer with a control detector and electrometer) was utilized for the measurement and reference cycles. If the radiation level from the UV lamp did not vary during the "up" and "down" cycles for an analyzer with a control detector and electrometer, or if the control circuit contained the fixed-frequency oscillator instead of the control detector and electrometer, then the frequency from the control circuit acts much like a "clock," so that the "up" and "down" cycles would then be of exactly the same length.

3) The counts now remaining in the sample totalizer (termed R in the following discussion), correspond to the difference between the reference cycle "up" counts (with no ozone present) and the measurement cycle "down" counts (with ozone). If there is no ozone in the sample gas, the sample totalizer "down" counts will be the same as the previous "up" counts and R will be zero. However, R will have a positive value if ozone was present in the sample gas, since the total measurement cycle "down" counts in the sample totalizer will be less than what it was for the reference cycle "up" counts (the ozone would have attenuated the radiation during the measurement cycle).

The following section explains how the analyzer utilizes the values of S and R to obtain the ozone concentration from Beer's law. So far, the discussion has involved a functional description of analyzer operation. The following discussion involves the quantitative relationship of the measured radiation intensities in Beer's law obtained during the reference and measurement cycles. It provides quantitative values for adjusting the analyzer's Span Number to obtain ozone concentrations in various, desired units. It also provides the corrections necessary to convert the concentration data from ambient to standard conditions of pressure and temperature. This discussion requires some mathematical expertise by the reader.

4.7 Measurement of Ozone Concentration

4.7.1 Theory

As previously described, the analyzer measures ozone concentration directly by the attenuation of UV radiation by ozone molecules in the optics bench. The ozone concentration is obtained by measuring the relative intensity of transmitted W radiation for a '*measurement pair" consisting of a consecutive zero gas cycle and a sample gas cycle. The exact algorithms utilized by the instrument's signal processor to obtain concentration are presented next. The degree to which the UV radiation is attenuated depends on the optics bench path length, the absorptivity of the ozone molecules, and the number of ozone molecules present.

The quantitative relationship between these factors is shown below by Beer's law. For this form of Beer's law, the values for the two W radiation intensities, I and I_o, can be in any arbitrary (although consistent) set of units, because they always appear as a ratio. For the case of the Dasibi ambient ozone analyzer, they are calculated on the basis of the "down" counts and the "up" counts in the sample totalizer for the sample and zero cycles, respectively. The operating and calculation procedures are described in detail in Sections 4.7.3 and 4.7.4, respectively. First, consideration is given to expressing the concentration in the desired units in Section 4.7.2.

Beer's law is normally written as:

$$\frac{I}{I_o} = e^{-(ALC)} \qquad \textbf{(4-1)}$$

The units for ozone concentration, C, are partial pressure of ozone, in atmospheres, which is a fractional basis of the total gas volume for expressing concentration. For 100 percent ozone at STP, the concentration, C, would be 1.0 [atm]. For a different volumetric fraction of ozone in the sample gas (the usual case), C **would be different than one atmosphere, For instance, for 1 [ppm]** ozone (by volume), C would be 10^{-6} [atm] at STP.

However, "atmospheres," is not the manner in which gas concentrations are normally expressed, and users of Dasibi ozone analyzers are generally interested in employing more conventional units, such as [ppm] (by volume or weight), [percent] (by volume or weight), [mg]/[m^3], etc. Also, for relative concentration units expressed in terms of weight, such as [ppm] (by weight) or [percent] (by weight), the molecular weights of both the gas of interest -and the background gas must be utilized in order to calculate correct results. In addition, concentration is usually desired at conditions of standard temperature and pressure, and under most ambient monitoring situations, conditions are not usually standard, so corrections to the data must be made.

For this reason, the above form of Beer's law is rewritten to include a proportionality factor, K, which relates the concentration in partial pressure, C (upper-case), with more conventional units for the concentration, c (lower-case). That is, K will be used as a concentration conversion factor. In addition, the gas law corrections are included in K which may (or may not, at the operator's discretion) be used to automatically correct the concentration readings displayed by the instrument to standard conditions of temperature and pressure.

It should be clearly understood that concentration, C, expressed here as an upper-case letter, refers to the concentration from Beer's law in the form given in Eqn. (4-l) in the units of atmospheres. The concentration, c, expressed here as a lower-case letter, is the equivalent concentration, but expressed in any desired set of units more convenient for the user. C and c are related linearly by K, and different quantitative values for K are required for each of the desired units of interest for c. A discussion of the methodology for calculating K is presented in Section 4.7.2. **Thus,** utilizing the proportionality factor, K, the relationship between c and C is given by:

$$c = KC, \text{ so that}$$

$$C = \frac{c}{K}$$

Substituting this form for the concentration into Beer's law results in:

$$\frac{I}{I_o} = e^{-\left(\frac{ALc}{K}\right)} \qquad (4\text{-}2)$$

Solving Eqn. '(4-2) for the concentration, c, yields:

$$c = \left(\frac{K}{AL}\right)\left(\ln\left[\frac{I_o}{I}\right]\right) \qquad (4\text{-}3)$$

4.7.2 Calculation of Proportionality Factor, K

4.7.2.1 General

This section presents the method of calculating the proportionality factor, K, used in Beer's law expressed in Eqn. (4-2) or (4-3). K is comprised of two terms, a concentration conversion factor at standard temperature and pressure, K_{STP}, and a temperature and pressure correction factor, CF_{TP}, so that in general:

$$K = (K_{STP})(CF_{TP}).$$

Determination of the concentration conversion factor, K_{STP}, is discussed in Section 4.7.2.2. It presents selected numerical values of K_{STP} utilizing example calculations as well as summarized in tabular form for various common units of concentration at STP.

Determination of the temperature and pressure correction factor, CF_{TP}, is discussed in Section 4.7.2.3. This factor will allow K to be corrected to STP from ambient conditions, which will cause the instrument to display the concentrations at standard conditions. Some people prefer to have the instrument display the concentration data at ambient conditions and perform their own temperature and pressure corrections manually. For this situation, assume CF_{TP} = 1, and adjust the instrument using K = K_{STP} only. The instrument will then read in the units desired, but at the conditions of ambient temperature and pressure. The corrections to standard conditions must be performed manually by appropriate data reduction procedures later using the actual value of CF_{TP}.

As described in Section 4.7.3, the instrument is adjusted to read directly in the desired units (corrected for ambient temperature and pressure, if desired), by using K to establish and set the Span Number, S.

4.7.2.2 Concentration Conversion Factors at STP, K_{STP}

This discussion assumes a two component gas system only. That is, the concentration of a single component gas of interest, i, is to be determined in a single background gas, b. Where appropriate, properties and characteristics of the gas of interest are indicated as $( )_i$ and of the background gas as $( )_b$. The background gas may be a single component, itself (as for the case of oxygen or nitrogen), or it may be a mixture, such as air. However, the background gas will be treated as if it were a sinsle component by using commonly accepted values for its combined, average properties (such as the average "molecular weight" determined for air). Here, the gas of interest is ozone, and the background gas can be air, oxygen, nitrogen, etc. only dilute solutions of ozone in the background gas are considered.

Table 4-l presents some relevant physical constants and properties for various gases that will be useful for this discussion.

TABLE 4-1
Useful Physical Constants and Gas Properties
(Reference 15)

puantitv		Value
1.	Molar gas volume	22.414 [l][atm]/[mole]
2.	Absolute zero temperature	-273.15' [C]
3.	Molecular wt of ozone	47.9982 [g]/[mole]
4.	Molecular wt of dry air	28.964 [g]/[mole]
5.	Molecular wt of oxygen (O_2)	32.0000 [g]/[mole]
6.	Molecular wt of nitrogen (N_2)	28.0134 [g]/[mole]

7. Furthermore, various useful conversion factors and derived gas properties are calculated and presented below:

1 [m^3] = 1000 [l]

Density of dry air at STP:
= (28.964 [g]/[mole])(1000 [l]/[m^3])(1 [atm])/22.414 [l][atm]/[mole]
= 1292.2 [g]/[m^3]

Density of ozone at STP:
= (47.9982 [g]/[mole])(1000 [l]/[m^3])(1 [atm])/22.414 [l][atm]/[mole]
= 2141.4 [g]/[m^3]

Density of oxygen (O_2) at STP:
= (32.0000 [g]/[mole])(1000 [l]/[m^3])(1 [atm])/22.414 [l][atm]/[mole]
= 1427.7 [g]/[m^3]

Density of nitrogen (N_2) at STP:
= (28.0134 [g]/[mole])(1000 [l]/[m^3])(1 [atm])/22.414 [l][atm]/[mole]
= 1249.8 [g]/[m^3]

The following relationship is given for expressing relative concentration units by weight fraction, c', rather than volume fraction, c. K_{STP} is first determined for the volume fraction units and then modified to weight fraction units, K'_{STP}, by this relationship.

Assuming a dilute solution of the gas of interest, i, in the background gas, b:

$$c' = \left(\frac{[M]_i}{[M]_b}\right)(c)$$

Since K_{STP} is proportional to c, it is then also the case that:

$$K'_{STP} = \left(\frac{[M]_i}{[M]_b}\right)(K_{STP}) \qquad (4\text{-}6)$$

4.7.2.2.1 K_{STP} for concentration, c, in [ppm] (by volume)

For a concentration, c, of one part per million by volume, c = 1, and the fractional concentration, C = 1/1000000 = 10^{-6}.

Since K_{STP} = c/C, then $K_{STP} = 1/10^{-6}$ = 1000000 [ppm]/[atm].

4.7.2.2.2 K_{STP} for concentration, c, in [percent] (by volume)

For a concentration, c, of one percent by volume, c = 1, and the fractional concentration, C = 1/100 = 10^{-2}.

Since K_{STP} = c/C, then $K_{STP} = 1/10^{-2}$ = 100 [percent]/[atm].

4.7.2.2.3 K_{STP} for concentration, c, in [ppm] (by weight)

From 5.2.2.1, $K_{STP} = 10^6$ for [ppm] (by volume). Therefore, from Eqn. (4-4) (and dropping the prime sign):

In air: K_{STP} = (47.9982/28.964)(1000000)
= 1.657 x 10^6 [ppm]/[atm].

In oxygen: K_{STP} = (47.9982/32.0000) (1000000)
= 1.500 x 10^6 [ppm]/[atm].

In nitrogen: K_{STP} = (47.9982/28.0134)(1000000)
= 1.713 x 10^6 [ppm]/[atm].

4.7.2.2.4 K_{STP} for concentration, c, in [percent] (by weight)

From 5.2.2.2, $K_{STP} = 10^2$ for percent by volume. Therefore, from Eqn. (4-4) (and dropping the prime sign):

In air: K_{STP} = (47.9982/28.964)(100)
= 1.657 x 10^2 [percent]/[atm].

In oxygen: K_{STP} = (47.9982/32.0000) (100)
= 1.500 x 10^2 [percent]/[atm].

In nitrogen: K_{STP} = (47.9982/28.0134)(100)
= 1.713 x 10^2 [percent]/[atm].

4.7.2.2.5 K_{STP} for concentration, c, in [g]/[m^3]

c = (2141.4 [g]/[m^3]/[atm])(C [atm]).
But c = KC = (K_{STP}) x (C) for CF,, = 1 (i.e., at STP), so that:

K_{STP} = 2141.4 [g]/[m^3]/[atm].

Here, concentration, c, is in absolute units and is independent of the composition of the background gas. The values for K_{STP} calculated above are summarized in Table 4-2. Using these values, two examples, to demonstrate how to convert from one set of units to the other (in dry air), are given below. Conversions for other units and gases are accomplished in a similar manner.

1 [percent (by wt in dry air)] = 2141.4J165.7
= 12.92 [g]/[m^3], and

1 [percent (by wt in dry air)] = (1000000)/165.7
= 6035 [ppm] (by volume in dry air).

TABLE 4-2
Summary of Concentration Conversion Factors, K_{STP}

Desired Units	K_{STP} [desired units]/[atm]
[ppm] (by volume in any background gas)	1000000
[percent] (by volume in any background gas)	100.0
[ppm] (by wt in dry air)	1657000
[ppm] (by wt in oxygen)	1500000
[ppm] (by wt in nitrogen)	1713000
[percent] (by wt in dry air)	165.7
[percent] (by wt in oxygen)	150.0
[percent] (by wt in nitrogen)	171.3
[g]/[m^3]	2141.4

4.7.2.3 Correction Factor for Temperature and Pressure, CF_{TP}

In order to correct K for ambient conditions to those at STP, the gas laws must be utilized. Because of the definition of STP for the absorption coefficient (i.e., 1 [atm], 0° [C]), STP is defined as 1 [atmosphere] and 273.15' [K].

Thus,

$$CF_{TP} = \frac{T}{(273.15)\,(P)}\ .$$

4.7.3 Specific Measurement Considerations

Now, the two UV radiation intensities for Beer's law in the form given in Eqn. (4-3) will be related to the counts for the **Span, S,** and the Reading, R. S is entered into the instrument manually by the operator in accordance with the procedure presented below. R is obtained in the sample totalizer and displayed as the instrument reading after each pair of zero and sample cycle measurements are made.

With reference to the discussion in Section 4.4 regarding the zero and sample cycle counting procedures, it can be seen that the **"up"** counts in the sample totalizer, S, are proportionalto I_o, and the **"down"** counts, S - R, are proportional to I. Thus, Beer's law **can** be expressed for **Dasibi's** measurement and data processing methodology as:

$$c = \left(\frac{K}{AL}\right)\left(\ln\left[\frac{1}{S - R}\right)\right. ,$$

or, dividing each variable in both the numerator and the denominator of the logarithmic term by S in order to obtain a non-dimensional form in R/S, yields Eqn. (4-5):

$$c = \left(\frac{K}{AL}\right)\left(\ln\left[\frac{1}{1 - \frac{R}{S}}\right]\right. \qquad \text{4-5)}$$

which is the exact form to determine ozone concentration from instrument counts. For R/S small **(i.e., "small" as** discussed below), Eqn. (5-5) can be further simplified using a standard series expansion of the logarithmic term to yield an approximate concentration, a:

$$\mathbf{a} = (K/AL)\ (R/S). \qquad (4\text{-}6)$$

By setting the Span such that:

S = K/AL

in Eqn. **(4-6),** the approximate concentration, a, will be given directly by:

a = R, the Reading displayed by the instrument, itself.

The Reading, R, is arranged to be presented on the instrument's numeric display on the front panel and on the recorder output terminals on the rear panel. Thus, the instrument is direct reading when the appropriate Span number has been properly set for the optics bench path length and desired concentration units (with optional corrections for STP conditions), and the quantity R/S is sufficiently small.

To obtain the exact concentration, c, from the approximate concentration, a, a calculation must be performed by dividing Eqn. (4-5) by Eqn. (4-6) to obtain:

$$\frac{c}{a} = \frac{c}{R} = \left(\frac{S}{R}\right)\left(\ln\left[\frac{1}{1-\frac{R}{S}}\right]\right) \qquad (4\text{-}7)$$

Eqn. (4-7) can be easily solved, since both R and S are known. For example, for several representative values of R/S, c/R is given in Table 4-3. The user must solve Eqn. (4-7) for his particular set of Readings and Span numbers. The table also shows the error in the reading (given by 1 - c/R, expressed as percent) if the correction is not made, and it shows the value of R/S (R/S = 0.0198) below which this error is 1 percent or less, which thus defines R/S "small."

TABLE 4-3
Representative Values for
Concentration Calculation Corrections Due To
Non-linearity Due In Beer's Law

R/S	c/R	(1 - c/R)x100 [percent]
0.0001	1.0000	0.00
0.0010	1.0005	0.05
0.0100	1.0050	0.50
0.0198	1.0100	1.00
0.1000	1.0536	5.36

The 1008 analyzers contain a microprocessor which solves the exact form of Beer's law, Eqn. (4-5), so that concentration corrections are not necessary. However, from Table 4-3, the error in ozone reading (1 - c/R) is only 1 percent for a value of R/S of 0.0198. For lower R/S, the error becomes smaller, but for larger R/S, the error is also larger. Below 1 percent error, concentration corrections are made at the option of the operator, but for errors exceeding 1 percent, corrections are required.

All analyzers function perfectly as described above to the point at which the ozone concentration is sufficiently high to totally extinguish the UV radiation that strikes the sample detector. This "cut-off" point will vary according to the path length of a given optics bench as well as the ozone concentration (total number of ozone molecules present). The relationship between path length and ozone concentration required for cut-off is given in Table 4-4.

TABLE 4-4
Analyzer Cut-off Characteristics

Bench Length	Ozone Concentration		
[cm]	[ppm]	[percent] (by wt)	[g/m^3]
0.0762	70,000	11.6000	150.00
0.300	7,000	1.1600	15.00
71.000	70	0.0116	0.15

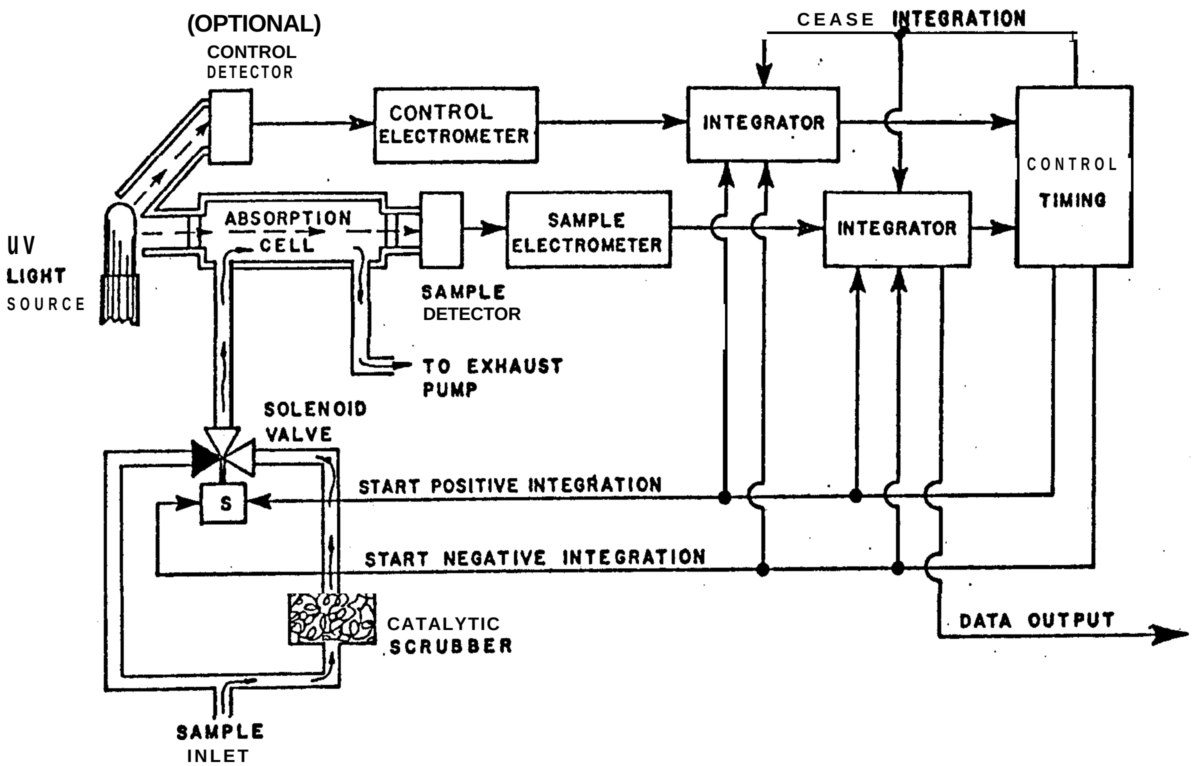


Figure 4-1 Block Diagram, Optic and Pneumatic Subsystems

5.0 OPERATION

5.1 Controls and Indicators

This section contains information for the operation of the front panel controls and indicators. Also described are the turn-on procedure, error code definitions, recorder operation, and shutdown procedure.

1) POWER switch - Push button switch used for turning the instrument ON or OFF.

2) ANALOG SPAN pot - Used for adjusting the recorder output voltage gain.

3) DISPLAY - User interface for obtaining visual readings. An LED indicates a new valve.

4) MODE SELECTOR switch - Used for selecting different instrument operating modes.

   a) ZERO position - All zeros are displayed and the recorder output is set to zero.

   b) SPAN position - The photometer SPAN and ZERO OFFSET are displayed.

   c) OPERATE position - See T/P switch described below.

   d) SAMP/TEMP position - See T/P switch description below.

   e) CONT/PRESS position - See T/P switch description below.

5) T/P Switch - This switch affects only the OPERATE, SAMP/TEMP, and CONT/PRESS modes.

   a) In the OPERATE mode, the T/P Switch works as follows:

      i) OFF - Ozone readings are referenced to STP if the ANALYZER SPAN is set to 308.

      ii) ON - Ozone readings are automatically corrected for temperature and pressure changes.

   b) In the SAMP/TEMP mode, the T/P switch operates as follows:

i) OFF - The sample frequency is displayed. The displayed value is updated every 1.5 seconds and corresponds to one ten thousandth of the actual frequency. To determine the frequency in KHz, move the decimal point one place to the right (i.e. a reading of 42.301 would be 423.01 KHz).

ii) ON - Temperature is displayed in °C.

c) In the CONT/PRESS mode, the T/P switch operates as follows:

i) OFF - A fixed control frequency of 500 KHz is displayed. The control frequency is displayed in the same manner as the sample frequency - see i) under SAMP/TEMP mode above.

ii) ON - The pressure is displayed in atmospheres.

6) VALVE Switch - Controls the photometer's valve.

a) In the OPERATE mode, the VALVE Switch works as follows:

i) OFF - The solenoid is de-energized. The valve remains in the reference gas position.

ii) ON - The solenoid switching cycle is enabled. The valve Cycles between the reference gas and sample gas every 10 seconds.

b) In any other mode (except the OPERATE mode) the VALVE Switch works as follows:

i) OFF - The solenoid is de-energized. The valve remains in the reference gas position.

ii) ON - The solenoid is energized. The valve remains in the sample gas position.

7) PUMP switch - Turning the photometer's pump ON or OFF.

8) FLOWMETER - Indicates the rate of flow in l/min through the analyzer. The flow should be between 1.5-3.0 l/min.

9) FLOW CONTROL - Used for adjusting the analyzer flow.

5.1.1 Ozone Generator (1008-PC and -RS; Figures 5-2 & 5-3)

1) FLOW METER - Indicates the rate of flow in l/min through the O_3 generator. The flow should be between 5-6 l/min.

2) FLOW CONTROL - Adjusts the ozone generator flow.

3) OZONE Switch - Used for turning ON the ozone generating lamp. Whenever using the photometer in conjunction with an external ozone generator, it is recommended that the ozone generating lamp be switched OFF. This will increase the life of the lamp.

4) PUMP Switch - Turns the ozone generator pump ON or OFF.

5) OZONE Adjust - Three thumbwheels that give the operator control of the O_3 generator's concentration (1008-PC).

6) OZONE Adjust - Two push button numbers that give the operator control of the ozone generator's level of concentration (1008-RS only).

NOTE

There is no direct correlation between the numerical value of this pot and the concentration of ozone being produced. Any correlation observed will be merely a coincidence.

7) AUTO/MAN Switch - In the Manual mode, increasing the OZONE ADJ Switch will increase the ozone concentration. Because of the instability of the photometer during the first 30 minutes of warm-up, it is recommended that the switch be in the MANUAL position for this period. In the AUTO mode, the ozone generator is put into feedback with the photometer. The operator selects the desired ozone concentration using the OZONE ADJ Switch (1008-PC only).

NOTE

When in the "Auto" mode, turning the thumbwheel digits to "000" will not completely shut off the ozone generating lamp. The "Ozone" switch must be turned off as well. If it is not, ozone generation may occur sporadically, as the internal computer attempts to create this low level of ozone dialed into the thumbwheel.

8) REMOTE/LOCAL Switch - Gives the user the capability of operating the ozone generator locally or by remote command (1008-RS only).

5.2 Remote "Zero" or "Span" Operation for the Model 1008-RS

The Model 1008-RS is designed to be remotely switched into a zero and/or span-check mode upon contact closure via datalogger. To activate either of these modes from the back panel, the operator must have the front panel first switched to the "remote" position. Then the operator must short between the screw labeled "+5 V" and the desired function. The unit will remain in these modes until the shorts are removed by the datalogger.

To activate the "zero" mode, simply short between the "+5V" screw and the "Zero" screw and the pump and valve will be activated (thus, allowing the zero air source attached to the "Zero" back panel port to be sampled by the analyzer). To activate the "span" mode, though, the operator must <u>also</u> short between the "+5V" screw and the "Span" screw. By doing this, the internal ozonator lamp is enabled to generate a level of ozone as determined by the front panel "O3 Adjust" thumbwheel switch.

5.3 Start Up

5.3.1 Turn On

Connect the instrument as described in Section 2.0 and turn on the power switch (remember to open the instrument and check for loose PC boards first). The front panel will be lit up as soon as power is applied.

5.3.2 Error Code

If the instrument is in the OPERATE Mode when it is first turned on, or if an error ever occurs while in the OPERATE Mode, an error code is generated, consisting of the number 3. This is displayed since the sample frequency is below 300,000 Hz.

Only applicable the error code is displayed: all other digits are blanked. The error code is only functional in the OPERATE Mode and does not affect the RECORDER OUTPUT (i.e., the RECORDER OUTPUT continues to give ozone information when the error code is being displayed).

5.3.3 Warm Up

The instrument should be given thirty minutes to warm up from the time it is first turned on. If the error code is still displayed after 30 minutes warm up, refer to the maintenance section.

5.4 Recorder Operation

The recorded voltage on the back panel of the instrument is derived from a 12 bit digital to analog converter (DAC). Therefore, only three digits of any displayed value are recorded. See Section 6.6.3, Recorder Adjustments.

5.5 Shut Down

If the analyzer will not be used for an extended period of time, turning it off will extend the life of the pump, valve, and the UV light source. To do so, push the power button to the OFF position.

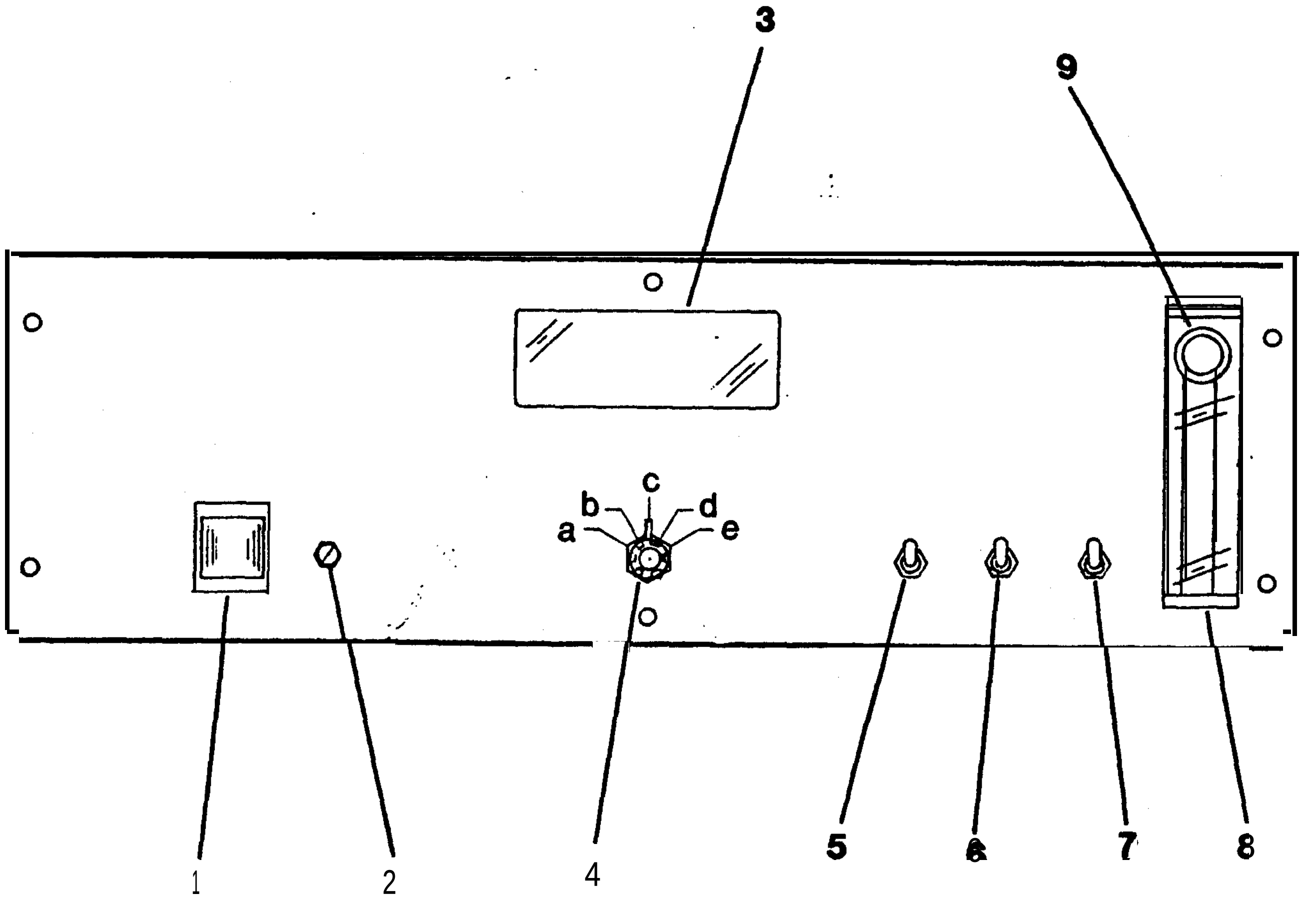


Figure 5-1 Analyzer Controls and Indicators

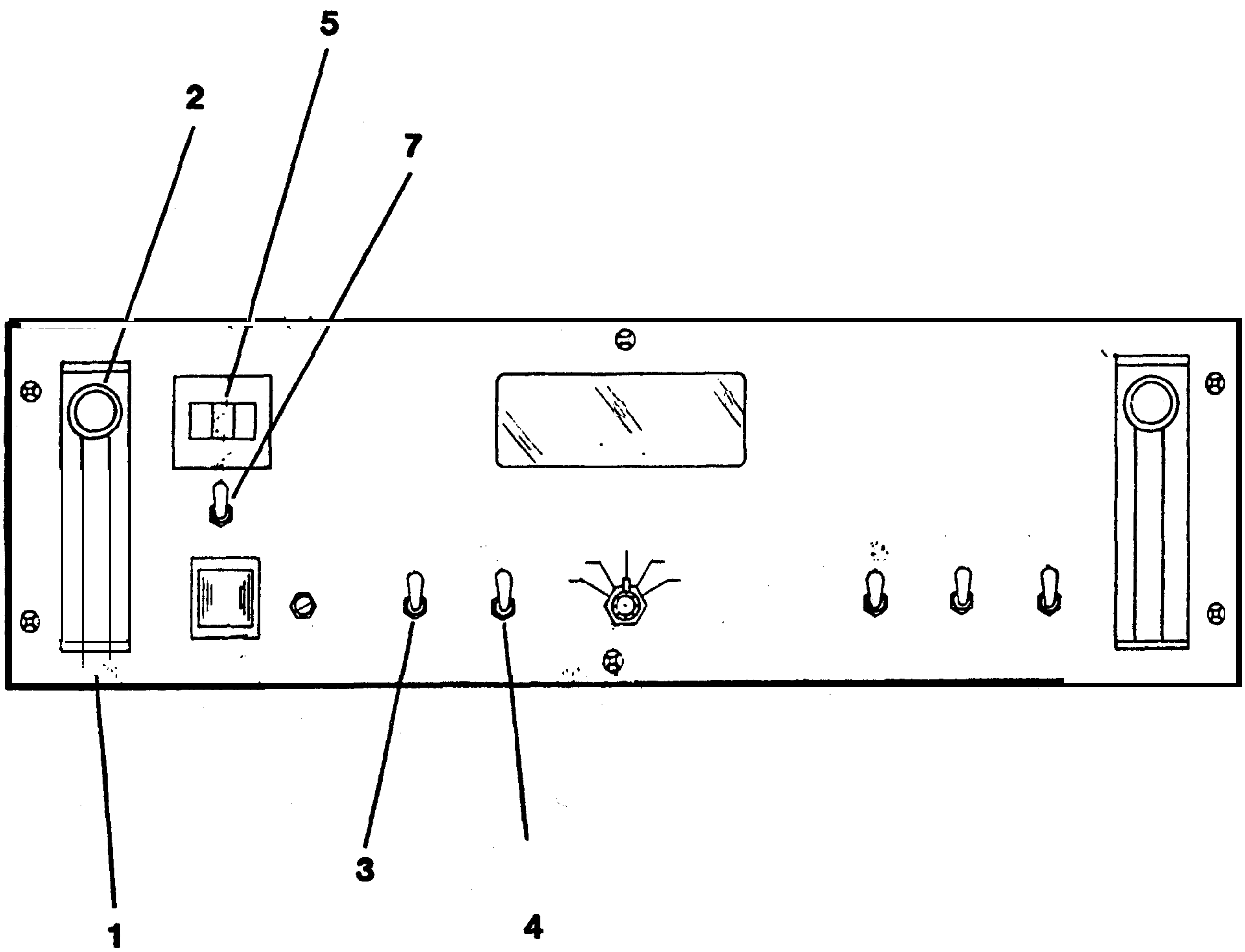


Figure 5-2 Ozone Generator Controls and Indicators (PC)

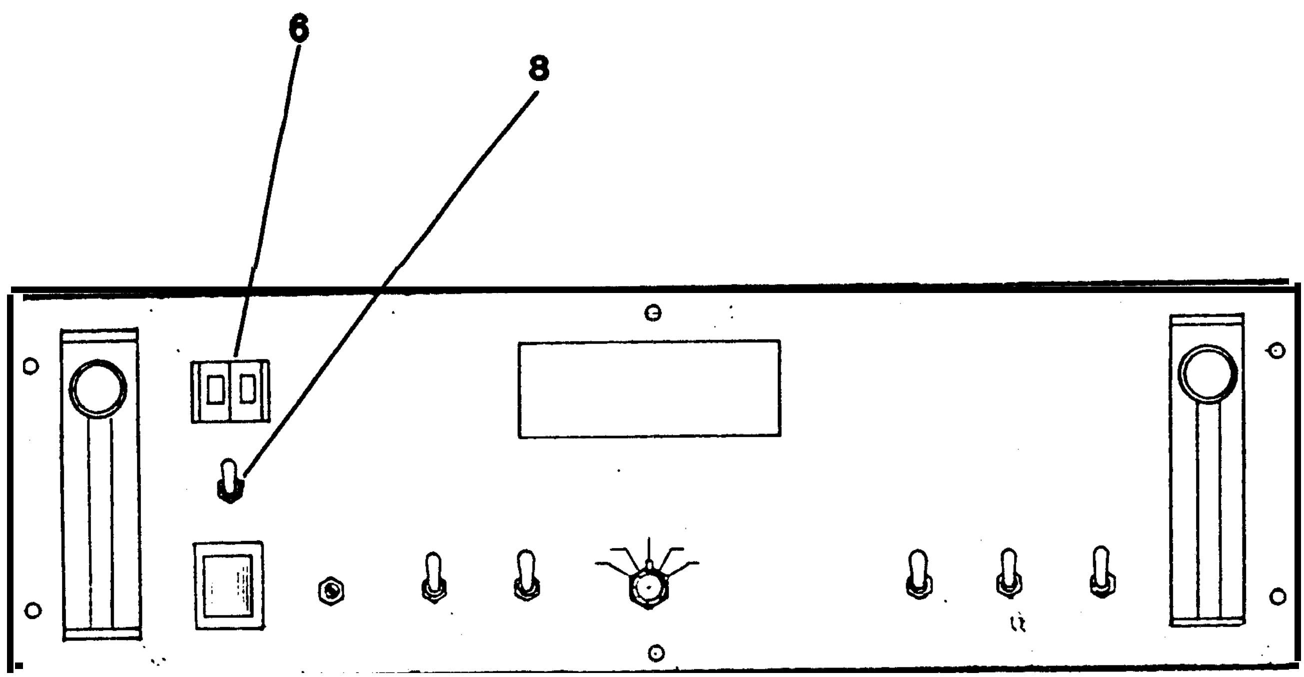


Figure 5-3 Ozone Generator Controls and Indicators (RS)

6.0 MAINTENANCE

6.1 General

Test equipment required to perform maintenance is listed, and preventive maintenance and maintenance schedules are detailed. An introduction to corrective maintenance explains the general approach to trouble isolation. Performance checks are described. Detailed adjustments and optics cleaning procedures are covered.

6.2 Test Equipment Required

1) Oscilloscope - frequency response, DC to 2 MHz

2) Frequency Meter - frequency response up to 2 MHz

3) Power Supply - adjustable, 0-10 volts

4) Voltmeter

5) Barometer - accurate to ±0.001 atm.

6) Thermometer - accurate to ±0.1° C

6.3 Preventive Maintenance

Preventive maintenance is a quality control procedure and MUST be done periodically in order to maintain the integrity of the instrument.

6.3.1 Maintenance Schedules

It is highly recommended that a log be kept with the instrument, since the maintenance schedules are done according to total hours of "instrument ON" time.

6.3.2 Scrubber Cartridge Replacement (Figure 6-l)

The precise life span of the ozone scrubber is directly proportional to the level and characteristics of the pollutants flowing through it. The higher the concentration of the pollutants, or the "harsher" their characteristics (such as sulfuric acid), the less the life span of the scrubber will be. Dasibi recommends initial replacement of the scrubber cartridge every four months, until an "average" life span can be determined based upon experience with actual operating conditions at each installation site.

To replace the scrubber cartridge, the scrubber assembly must first be removed from the instrument. To accomplish this, loosen the two Kynar nuts from both ends of the scrubber assembly and remove it from the chassis.

While holding the cartridge with the heads of the four thumbscrews facing up, remove the thumbscrews. Gently lift-off the top end cap to expose the cartridge assembly. There are O-rings on each side of the cartridge to provide the pneumatic seal. Remove both of the O-rings along with the cartridge assembly and discard all.

Position each of the replacement O-rings into the end caps. It is important that the outer edges of the O-rings touch the wall of the end caps to ensure an adequate seal. If there is any clearance between the O-ring and the wall, stretching the O-ring about a quarter of an inch will take-up the slack.

Insert the replacement cartridge into the end cap with the four threaded holes and set the other end cap on top of it, paying attention to the orientation of the Kynar fittings. Start the thread of all four thumbscrews before tightening any one of them. To prevent the end cap from "cocking," rotate each screw alternately one turn, until each is finger-tight. DO NOT overtighten these screws.

To re-install the scrubber assembly in the instrument chassis, reverse the process described above for removal from the chassis. It is NOT necessary to use a wrench on the Kynar nuts (unless they have been damaged previously).

6.3.3 Cooling Fan Filter Pad Cleaning (Figure 6-2)

It is important that the instrument has an adequate air supply through the cooling fan at the back panel. To ensure this, the filter pad must be maintained clean.

It is suggested that the filter pad be cleaned weekly. However, this will depend upon the operating environment, and this can de determined by experience for each installation site.

To clean the filter pad, *remove* the outside cover by gently prying-up the locking tabs with a flat blade screwdriver. Remove the filter pad and wash in a mild solution of liquid detergent in warm water. Rinse thoroughly in clear water and allow the filter pad to dry before re-installing.

Replace the filter pad and outside cover in the opposite order indicated above, making sure that the curved struts in the cover are aligned with those in the fan housing. The cover snaps in place with the locking tabs in the appropriate slots in the fan housing.

6.4 Corrective Maintenance

6.4.1 Trouble Isolation

The approach to trouble isolation is shown in Figure 6-3. Once a general problem area has been determined, the user is referred to the appropriate block diagram, flowchart, and accompanying paragraphs to further diagnose the malfunction.

6.5 Performance Checks

6.5.1 Sample Flow Check

Tap the analyzer flowmeter to make sure the float is not stuck and is actually reading the proper value. The flowmeter should read about 2 **l/min.** If it does not, see Section 6.6.1, Analyzer Flow Adjustments.

6.5.2 Span Check

Turn the mode switch to SPAN. Record the displayed value from the front panel. The first three digits MUST read 30.8 and the last two depend on what zero offset has been selected. If it does not, see Section 6.6.2, Span Adjustments.

6.5.3 Recorder Span Check

With the MODE switch still in the SPAN position, read the analog value from the recorder. If the display reads 30.800, then the recorder should read 0.800 or 80% of full scale. If it does not, adjust to the proper value (see Section 6.6.3, Recorder Adjustments). If the last three digits of the SPAN number are higher than the maximum full scale value for the recorder, switch the SPAN number to a lower value, check the recorder, and then switch the SPAN value back to its original setting.

NOTE

The SPAN number must be set to 30.8 when in the OPERATE mode.

6.5.4 Zero Check

Set the mode switch to ZERO. The front panel display should **read 00.000.** Check the recorder to make sure that it ***is*** reading zero. If it is not, adjust the recorder to zero or the instrument zero as described in Section 6.6.3, Recorder Adjustments. If a recorder zero adjustment is made, repeat Section 6.5.3, Recorder Span Check.

6.5.5 Control Frequency Check

1) Front panel controls should be set as follows:

  a) MODE Switch set to CONT/PRESS.
  b) T/P Switch set to OFF.

2) Record the value. It should be 500 KHz, or 50.000 on the display, unless the optional control detector is installed; in which case, this value should be above 200 Khz.

6.5.6 Sample Frequency Check

1) Front Panel Controls should be set as follows:

   a) MODE Switch set to SAMP/TEMP.
   b) T/P Switch set to OFF.
   c) VALVE Switch set to OFF.

2) Record the value. If it is below 35.0, see Section 6.7, Optics Cleaning Procedures.

6.5.7 Temperature Check

1) Disconnect all gas lines from the back panel.

2) Front panel controls should be set as follows:

   a) MODE Switch set to SAMP/TEMP.
   b) T/P Switch set to ON.
   c) Analyzer PUMP Switch set to OFF.
   d) VALVE Switch set to OFF.

3) Connect the leads of a digital voltmeter between the GROUND test point and the TEMP CAL test point on the 1008 Universal Electrometer Adapter Board Assembly. Adjust the trimpot on the Temperature Circuit Board until the voltmeter reads 5.463 volts.

4) After the appropriate stabilization period, the display should read approximately 30° C.

5) If this reading is not observed, carefully remove the temperature sensor by unscrewing the Kynar nut at the output of the optics bench. Remove the nut from the sensor. Tape the sensor to the bulb of a mercury thermometer. If the instrument was just turned on, allow 30 minutes warm-up, otherwise allow 10 minutes for the temperature to stabilize. The display and the thermometer should agree to within ±0.3° C; if not, there is a problem with the temperature sensor, and the factory should be consulted.

6.5.8 Pressure Check

1) Disconnect all lines from the back panel.
2) Front panel controls should be set as follows:

   a) MODE Switch set to CONT/PRESS.
   b) T/P Switch set to ON.
   c) Analyzer PUMP Switch set to OFF.

3) Compare the displayed *value* with the barometer: if they do not agree, see Section 6.6.8, Pressure Adjustments.

6.5.9 System Leak Check

1) Remove the sample line from the SAMPLE INLET on the back panel.

2) Front panel controls should be set as follows:

   a) MODE Switch set to CONT/PRESS.
   b) T/P Switch set to ON.
   c) Analyzer PUMP Switch set to ON.
   d) VALVE Switch set to ON.
   e) Analyzer flowmeter set to 2 **l/min.**

3) Plug the SAMPLE INLET (a finger may be used). The flow, as indicated on the flowmeter, should drop to zero. If it does not, there is a leak in the system.

6.5.10 Solenoid Valve Leak Check

1) Remove the sample line from the SAMPLE INLET on the back panel.

2) Remove the *ozone* scrubber, and locate the Kynar elbow on the solenoid valve. This is the ZERO AIR INLET.

3) Front panel controls should be set as follows:

   a) MODE Switch set to CONT/PRESS.
   b) T/P Switch set to ON.
   c) Analyzer PUMP Switch set to ON.
   d) VALVE Switch set to OFF.
   e) Analyzer flowmeter set to 2 **l/min.**

4) Plug the ZERO AIR INLET (a finger may be used). The flow, as indicated on the flowmeter, should drop to zero. If it does not there is leak in the system.

5) If no leaks were found, reconnect all in-cabinet plumbing and repeat Section 6.5.9, System Leak Check.

6.6 Adjustment Procedures

6.6.1 Flow Adjustments

The flow should be adjusted to 2.0 **l/min** with the flow control valve on the flowmeter. Flow is not critical since the instrument is flow independent. However, it should not be less than 1.5 **l/min** nor greater than 3.5 **l/min.**

6.6.2 Span Adjustments

The ozone readings are proportional to the span number electronically set into the instrument by the SPAN Selector Switches on the D/A board. Since this number never changes once set, there is no span drift. The recommended span number is 308.3 atm^{-1} cm^{-1} (refer to Reference #9 in Appendix D of this manual for additional information about the determination of this span number).

To use this span simply dial the numbers 3, 0, and 8 in that order (left to right) on the switches. To verify the span number, switch the MODE switch to SPAN. The reading should be 30.8XX. Where XX is the zero offset.

6.6.3 Recorder Adjustments

1) Digit Selector

The DIGIT SELECTOR Switch determines which group of three digits on the display go to the RECORDER OUTPUT. Normally the three digits following the decimal point are of the most interest. These digits correspond to ozone concentrations in the range of 0 to 999 ppb. These digits are selected by setting the DIGIT SELECTOR Switch on the left side of the D/A board to position "1". However, if the ozone concentration ever exceeded 999 ppb the most significant digit would not show up on the recorder chart. For example, if the ozone concentration was 1.018 ppm, the recorder would read 0.018 ppm if the DIGIT SELECTOR Switch was set to position "1". Switching the DIGIT SELECTOR Switch to position "2" will make the chart read 1.01 ppm (and by switching to position "3" the chart would read 01.0 ppm).

2) Recorder Zero Offset

The RECORDER ZERO OFFSET Pot is located on the D/A board between the DIGIT SELECTOR Switch and the SPAN Switches. This pot is initially adjusted at the factory and normally is not used unless the operator cannot zero the recorder with the recorder's controls. Turn the MODE SELECTOR Switch to ZERO. When the digital display is reading all zeros, the strip chart recorder should read zero.

3) Recorder Span Adjustment

The nominal analog output is one volt per ppm. Other more sensitive ranges can be used, e.g. 100mV per ppm or 10mV per ppm. This requires an adjustment of the ANALOG SPAN Pot on the front panel of the instrument, or a specific request when ordering.

6.6.4 Zero Offset Adjustment

The zero offset is designed to allow the operator to use the instrument with a fixed zero offset, if desired. The offset is adjustable from 0 to 9 ppb in steps of 1 ppb by use of the right hand digital selector switch on the D/A board. The control is labelled ZERO. The offset adjustment does not affect the span or linearity but simply adds a fixed number to all readings. To verify the zero offset, set the MODE Switch to SPAN. The last or second to the last digit (depending on the option ordered) on the display should correspond to the number selected on the ZERO Thumbwheel Switch.

The simplest procedure to make this adjustment is to turn the sample flow OFF with the analyzer PUMP Switch. Set the ZERO Thumbwheel Switch to 5 and the MODE Switch to OPERATE. The average of the numbers which are read out will be 5 PPB plus or minus the instrument offset. (For example, suppose that the instrument offset is -3 ppb. Following the above procedure the operator will observe an average of 00.002 on the display. Thus 2 ppb will be the total reading offset which should be subtracted from all subsequent readings to obtain the true ozone reading.) This total offset can be canceled with the ZERO Switch for direct readings.

6.6.5 Light Level Adjustments

Turn the MODE Switch to SAMP/TEMP, and set both the T/P Switch and the VALVE Switch to the OFF position. The number displayed in this position is 1/10,000 of the internal sample frequency. The sample frequency is proportionalto the amount of light transmitted through the optics bench.

The instrument is designed to operate over a wide range of light levels. Set the frequency at a point which will allow maximum operating time before new adjustments must be made. The optimum points for setting the frequency are between 48.0 to 45.0. As previously mentioned, these numbers are not critical, and an instrument would still operate properly if they were 30.0, or even in the extreme, 15.0. However, if the frequency has dropped from 45.0 to 30.0, for example, the amount of accumulated dirt which would cause this would begin to destroy the ozone as it passed through the system, causing low readings for that reason. Therefore, before making light level adjustments, the optics must be cleaned (see Section 6.7, optics Cleaning Procedure).

HAZARD WARNING

Ultra Violet light can cause burns of the cornea. Use glasses to view the lamp or look at it for only a couple of seconds at a minimum distance of 0.5 meters.

To adjust the proper frequency (light level), the thumbscrews which hold the lamp in place should be loosened and the lamp pulled out of the housing to decrease the frequency, or pushed into the housing to increase the frequency (Figure 6-4). Alternatively, the lamp may be rotated to change the frequency. It takes very small movements of the lamp to make large frequency changes, and the thumbscrews should be tightened to take a frequency reading.

6.6.6 Analog Voltage Adjustments

The analog to digital converter (ADC) on the I/O board measures the voltages from the photometer lamp heater and the temperature and pressure sensors. The ADC is set at the factory so that a O-10 V input corresponds to a OOOH-3FFH binary output. This can be checked and adjusted as follows:

1) Turn the instrument OFF.

2) Locate the connector labelled CELL TEMP on the motherboard next to the Temperature Bridge Amplifier. Make a note as to which pin on the connector has a solid red wire attached and then unplug the connector.

3) Put a piece of wire into the socket where the red wire was connected. This is the input for the temperature signal. A O-10 V signal corresponds to O-50° C.

CAUTION

Be careful not to touch any of the other pins on this connector when the instrument is turned ON. Some of the pins in this connector have 115 VAC.

4) Connect a +10V power supply to the temperature signal input. Adjust the power supply voltage to 7.5 volts.

5) Put the MODE Switch in the SAMP/TEMP position and set the T/P Switch to ON.

6) Turn the instrument ON. After the displayed value has stabilized, it should read 37.5' C. If it does not, adjust the ADC span pot, R6, on the I/O board.

7) Disconnect the power supply and short the temperature signal input to ground.

8) After the displayed value has stabilized, it should read zero. If it does not, adjust the ADC zero pot, R10, on the I/O board. If a zero adjustment is made, repeat steps 1 through 8.

6.6.7 Pressure Adjustments

The only adjustment required for the pressure measurement is the SPAN. The SPAN Pot is located on the Pressure Amplifier mounted on the optics bench. Perform span adjustment as follows:

1) The instrument should be set up as described in Section 6.5.8, Pressure Check before continuing this procedure.

2) Adjust the pressure SPAN Pot until the barometer and the displayed value compare. If after adjusting the SPAN Pot, the readings do not compare, see Section 6.6.6, Analog Voltage Adjustments.

6.7 Optics Cleaning Procedure

1) Turn power off to the instrument and remove its cover.

2) Remove the LDHC board.

3) Loosen the top knurled retaining nut and remove the absorption tube (Figure 6-4).

4) Loosen the bottom knurled retaining nut and remove to clean both absorption tubes. The absorption tubes may be cleaned by inserting a Kim Wipe, and pushing it through the tube using a length of Teflon tube, or an optics cleaning rod (refer to Section C.7 in Appendix C).

5) The mirrors may be cleaned in place, using a Q tip, thereby eliminatinq the need to disassemble the optical relay block. If the procedure is not satisfactory, proceed as follows:

   a) Remove the triangular optical relay block by loosening two screws. This may be done by inserting a screwdriver through the access hole in the side of the chassis. Hold the block to prevent it from dropping to the bottom of the case and damaging the mirrors.

   b) Remove the two screws holding each mirror cover plate.

   c) Carefully remove the two mirrors and clean with a soft tissue. If further cleaning efforts are required, a solvent may be used, provided it does not leave a film on the mirrors. Isopropyl alcohol is recommended. Handle the mirrors at the edges, to prevent fingerprints.

   d) Before re-inserting the mirrors, thoroughly clean the optical relay block. After cleaning the mirrors and the block, carefully reseat each mirror in the block. If the mirrors are installed in a cocked position, mirror breakage will result.

e) Assemble the mirror, O-ring and cover plate, using the two cover plate tie-down screws. Tighten each screw gradually, so as to apply pressure on the mirror evenly, to avoid cracking the mirrors.

f) Re-install the triangular optical relay block. The recessed holes on the block should face out.

6) The windows may be cleaned in place, using a Q-tip, thereby eliminating the need to disassemble the I/O block. If unsatisfactory, proceed as follows:

a) Remove the lamp heater electrical connector.

b) Remove the screw holding the window assembly block, and clean each of the two windows with a soft tissue (Kim Wipes are recommended). Upon disassembly, hold the block in place to avoid accidentally dropping and breaking the windows. Re-install the two windows and reconnect the block using the tie-down screw.

c) Re-insert the lamp heater electrical connector.

7) Re-install the bottom absorption tube. A light film of Stopcock grease may be used on the threaded tube section to prevent galling the Aluminum. Special care should be taken to avoid contaminating the absorption tube inner surfaces with lubricant.

8) Re-install top absorption tube (note comments in # 7).

9) Perform Section 6.5.9, System Leak Check.

6.8 Teflon Particulate Filter Pad Replacement (Figure 6-5)

The unit is delivered with a particulate filter holder assembly attached to the sample inlet port on the rear panel. The Teflon pad inside of this assembly reduces the amount of particulate matter that will enter the instrument, thus preventing problems from occurring, while reducing the frequency with which the optics cell must be cleaned. This pad should be replaced periodically; how often, is dependent upon the flow rate used and the concentration of particulate matter in the air stream. A "trial and error" method of determining how often this pad should be replaced must be conducted by the end user, much in the same manner as for the replacement of the unit's ozone scrubber. To remove the Teflon filter pad for replacement, follow these instructions:

1. Remove the Filter Holder Assembly located on the Sample inlet port by loosening the nut on the Sample port fitting and pulling the assembly off.

2. Use the two green wrenches that were delivered with the unit's manual to grasp the two clamps on either side of the filter assembly. Move the wrenches in opposite directions to unscrew the clamps: this may require quite a bit of torque as the seal may be very tight (in order to prevent leaks).

3. Remove the Teflon filter element.

4. Install the new filter element making sure it is centered on the filter holder's "grid".

5. Start the re-seal of the filter holder's clamps by turning the inlet clamp clockwise. Once it is as tight as it can be made by hand, turn it 1/4 turn using the wrenches.

6. Re-apply power and check the flow of the instrument.

7. If a leak exists in the filter holder, turn tighten the clamps further, using the wrenches, until the leak disappears.

TABLE 6-l
Maintenance Schedule**

Section	Performance Checks	Frequency (Hrs. of Operation)
6.5.1	Sample Flow Check	24 hrs*
6.5.2	Span Check	168 hrs
6.5.3	Recorder Span Check	168 hrs
6.5.4	Zero Check	168 hrs
6.5.5	Control Frequency Check	168 hrs
6.5.6	Sample Frequency Check	168 hrs
6.5.9	System Leak Check	168 hrs
6.8	Teflon Particulate Filter Pad Replacement	168 hrs
6.5.10	Solenoid Valve Leak Check	720 hrs
6.5.7'	Temperature Check	720 hrs
6.5.8	Pressure Check	720 hrs
6.5.9	Scrubber Cartridge Replacement	125 hrs (recommended)

* Or each day of which an operator is in attendance.
** See Tables 6-2 and 6-3 for check lists.

(1 st YEAR OF OPERATION)		
Section	Performance Check	Performance Time Schedule
6.5.1	Sample Flow Check	Performed each Check
6.5.2	Span Check	Performed Weekly
6.5.3	Recorder Span Check	Performed Weekly
6.5.4	Zero Check	Performed Weekly
6.5.5	Control Frequency Check	Performed Weekly
6.5.6	Sample Frequency Check	Performed Weekly,'

Maintenance Check List (A)

Section	Performance Check	Performance Time Schedule
6.5.9	System Leak Check	Performed Weekly
6.5.10	Solenoid Leak Check	Performed Monthly
6.5.7	Temperature Check	Performed Monthly
6.5.8	Pressure Check	Performed Monthly

TABLE 6-3
Maintenance Check List (B)

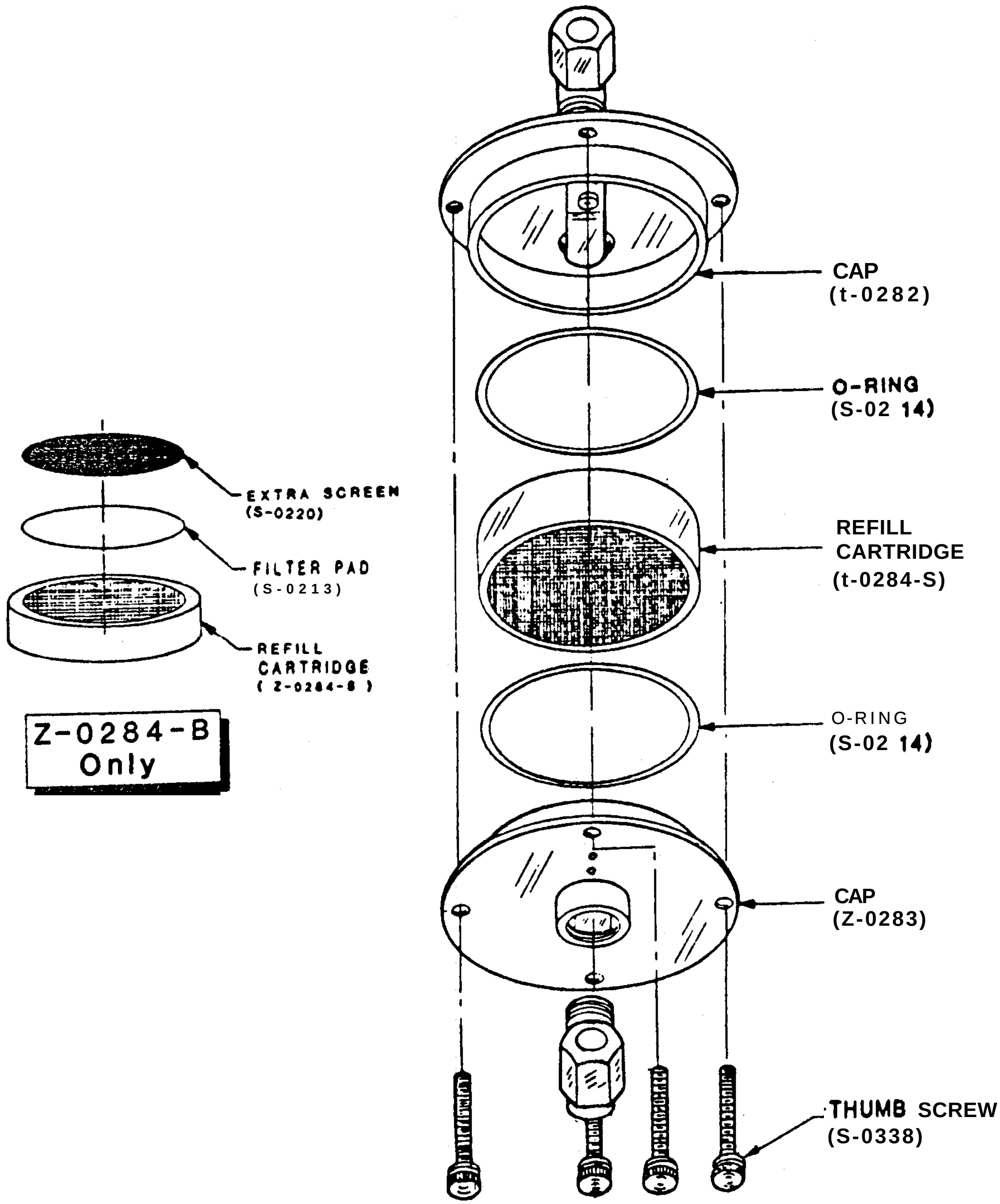


Figure 6-1 Scrubber Cartridge Replacement

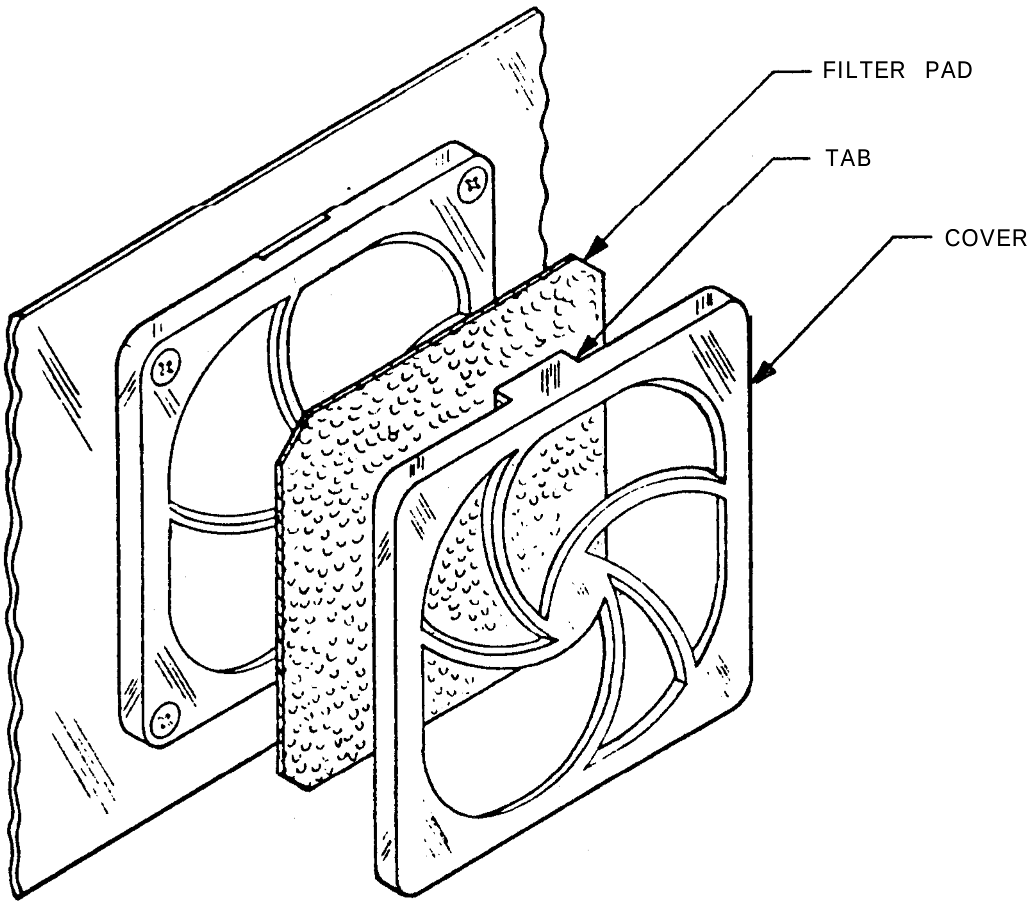


Figure 6-2 Cooling Fan Filter Pad Removal

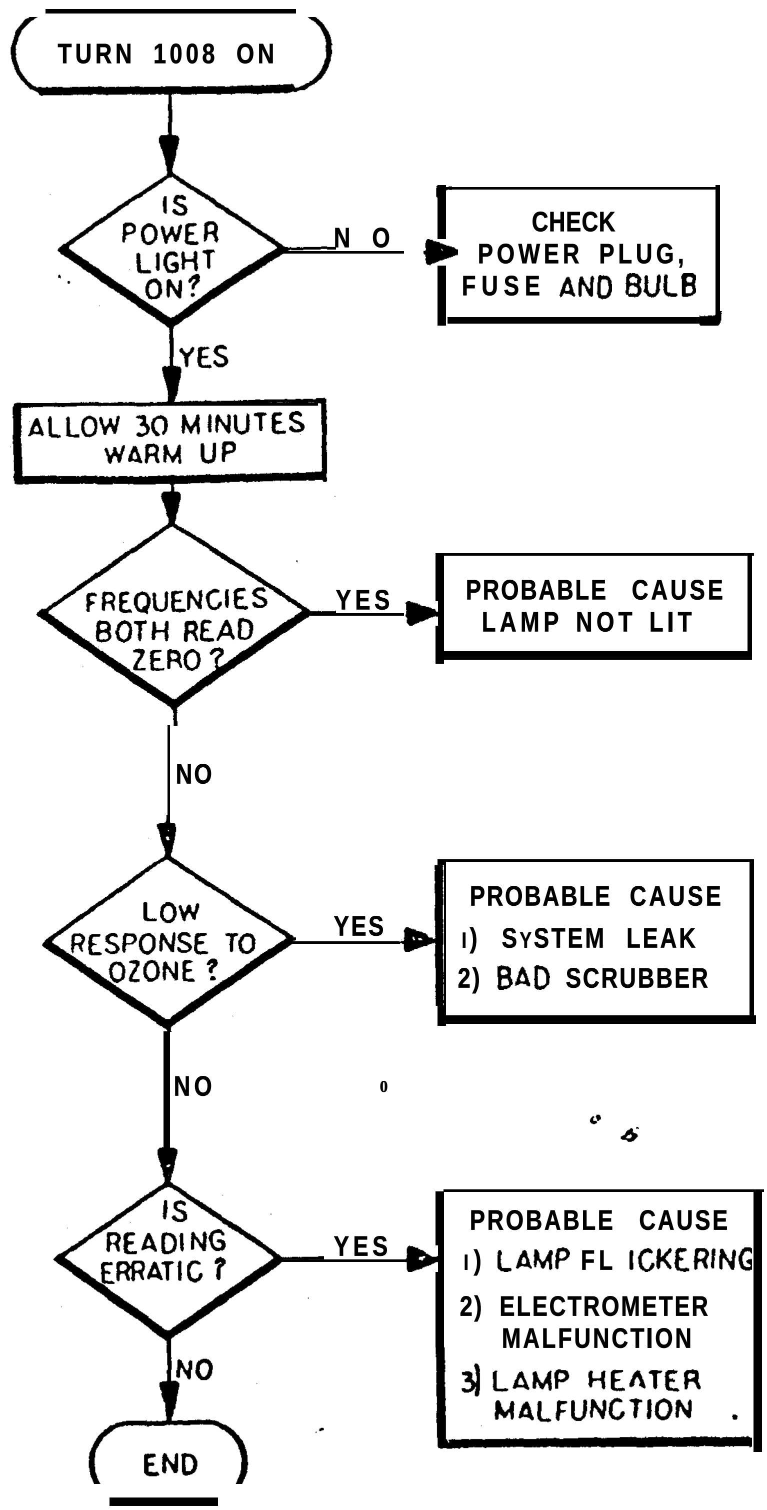


Figure 6-3 Trouble Isolation Flow Chart

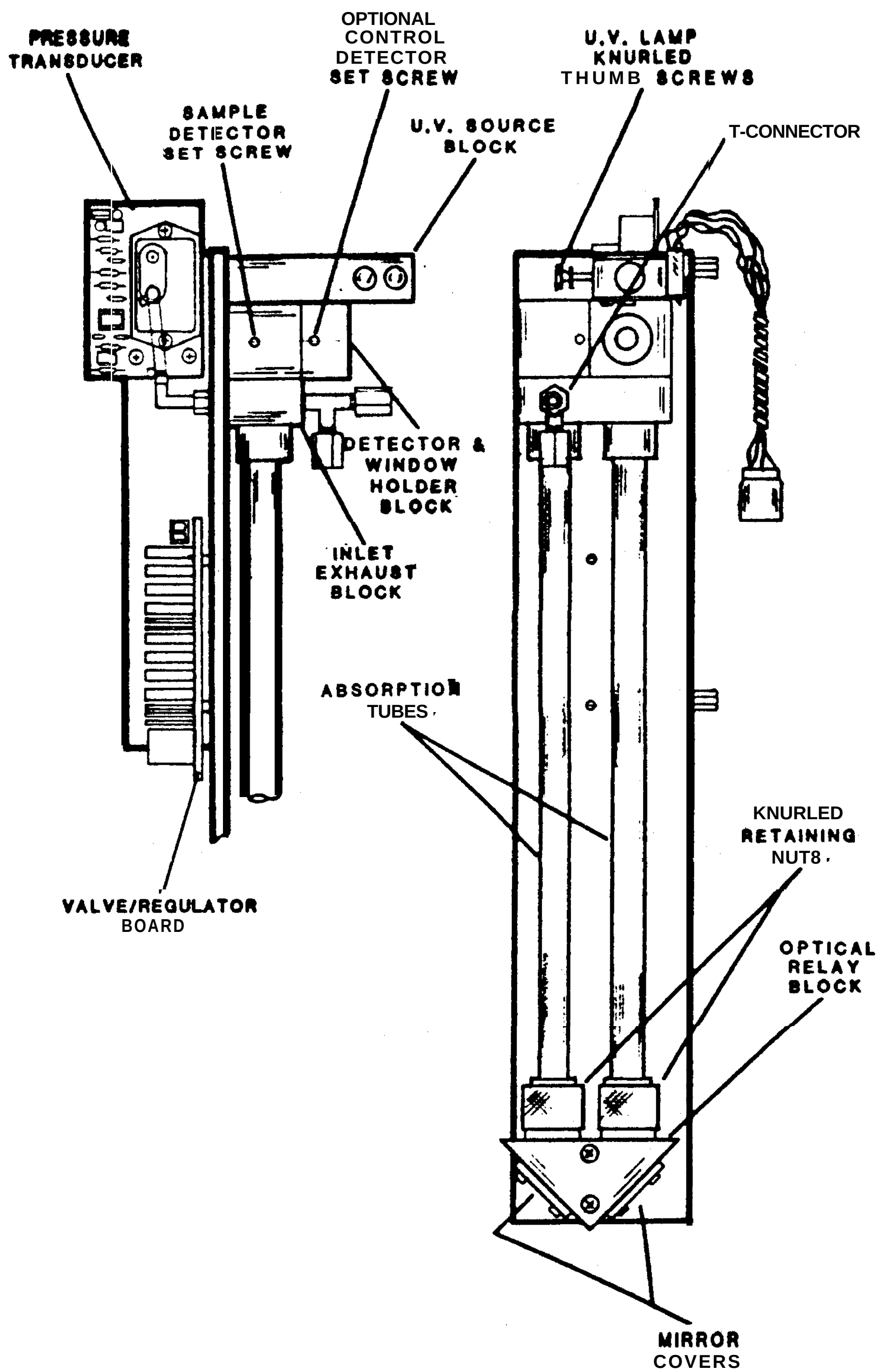


Figure 6-4 Optics Assembly

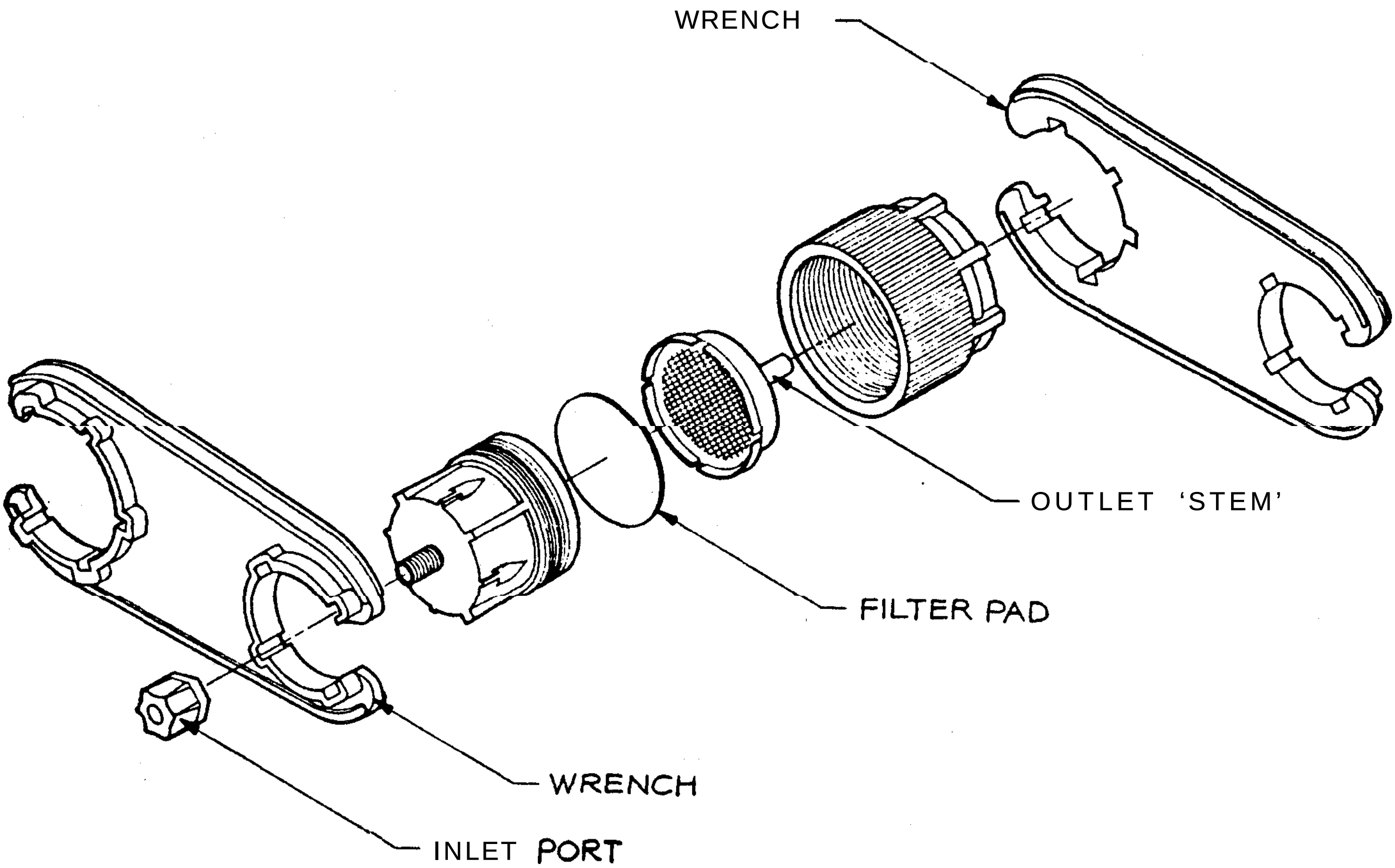


Figure 6-5 Teflon Particulate Filter Pad Replacement

7.0 REPLACEMENT PARTS LISTS

7.1 General

This section contains a list of major components in the instrument. Electronic boards are listed as complete assemblies. A more detailed parts list can be obtained on request.

7.2 Ordering Information

All inquiries regarding ordering spare parts should be addressed to:

Dasibi Environmental Corporation
506 Paula Avenue
Glendale, CA 91201
Phone: (818) 247-7601 or Fax: (818) 247-7614

7.3 Service Kit for One Year of Operation:

For All 1008 Models:

Fifty (50) Teflon Filter Pads	A-0000

For Models 1008-AH, 1008-PC & 1008-RS Only:

Two (2) Ozone Scrubber Refill Cartridges	Z-0284-S

For Model 1008-RS Only:

If Unit is Purchased With On-Board Zero Air Source Option:

Five (5) Refill Packages (.3 lbs/pkg)	S-0189

For Model 1008-HC Only:

One (1) O-Ring for Optics Bench	S-0370
One (1) O-Ring for Optics Bench	S-0369
Three (3) Internal Filter Refill (.5 lbs/pkg)	S-0189

If Unit is Purchased With Reference Measurement Charcoal Filter:

Three (3) Refill Packages (.3 lbs/pkg)	S-0189

7.4 Service Kit for Two Years of Operation:

For All 1008 Models:

One Hundred (100) Teflon Filter Pads	**A-0000**

For Models **1008-AH,** IOOS-PC, IOOS-PS **&** IOOS-RS Only:

Two (2) O-Rings for Absorption Tubes	A-0205
Two (2) O-Rings for Optics Bench Mirrors	S-0346

For Models **1008-AH, 1008-PC, 1008-PS &** IOOS-RS **(110 Volt)** Only:

One (1) U.V. Lamp Assembly	A-0204-S

For Models **1008-AH, 1008-PC &** IOOS-RS Only:

Five (5) **Ozone** Scrubber Refill Cartridges	Z-0284-S

For Models IOOS-PC, IOOS-PS **& 1008-RS** Only:

One (1) Ozone Generator Pump Repair Kit	R-0089

For Models IOOS-PC, IOOS-PS **&** IOOS-RS **(110** Volt) Only:

One (1) Ozone Generator Lamp Assembly	c-0120-s

For Models **1008-AH** & IOOS-RS Only:

One (1) Photometer Pump Repair Kit	R-0089

For Models IOOS-PC **&** IOOS-PS Only:

One (1) Photometer Pump Diaphragm	R-0005

For Model IOOS-RS Only:

If Unit is Purchased With On-Board Zero Air Source Option:

Ten (10) Refill Packages (.3 lbs/pkg)	S-0189

For Model IOOS-RS, 220 Volt, Only:

One (1) U.V. Lamp Assembly	A-0204-RS
One (1) Ozone Generator Lamp Assembly'	**C-0120-RS**

For Model **1008-HC** Only:

One (1) O-Ring for Optics Bench	s-0370
One (1) O-Ring for Optics Bench	S-0369
Seven (7) Internal Filter Refill (.5 lbs/pkg)	S-0189

If Unit is Purchased With Reference Measurement Charcoal Filter:

Seven (7) Refill Packages (.3 lbs/pkg)	S-0189

If Unit is Purchased With Internal Pump:

One (1) Photometer Pump Repair Kit	R-0089

7.5 **Replacement Component/Assembly Stock Numbers***

Description	**110 Volt**	**220 Volt**

Mechanical Parts/Assemblies:

For All 1008 Configurations:

Description	110 Volt	220 Volt
Power cord	A-0224	Same as 110V
Function Switch Assembly	S-0396-A	"
Flowmeter Assembly (O-3 LPM)	A-0271-1	"
Photometer Valve Assembly	S-0438-A	"
Replacement Diaphragm	R-0092	"
Back Panel Fan	D-0114	"
Particulate Filter Holder (W/Filter Inside)	B-0104-A	"

For Models 1008-AH, 1008-PC, 1008-PS & 100%RS Only:

Description	110 Volt	220 Volt
Optics Bench Assembly (Does Not Include Lamp)	Z-0022-08/09	Same as 110V
Relay Block Assembly	Z-0125-A	"
Light Source Block Assembly	Z-0032-A	"
Absorption Tube Assembly (One)	Z-0378-A	"
Optics Bench Mirror	A-0210	"
Optics Bench Window	A-0209	"
O-Ring (Inlet Block)	A-0212	"
O-Ring (Detector Block)	A-0205	"
Optics Cleaning Rod Handle	S-0366	"
Optics Cleaning End Rod	S-0367	"
Optics Cleaning Middle Rod	S-0368	"
Optics Cleaning Rod Assembly Holding Clips	S-0382	"
Maintenance Tool: 1/16" Allen Wrench	s-0415	"

For Models 1008-AH, 1008-PC & 1008-RS Only:

Description	110 Volt	220 Volt
Ozone Scrubber Assembly	Z-0284-A	Same as 110V

For Models 1008-PC, 1008-PS & 1008-RS Only:

Description	110 Volt	220 Volt
Thumbwheel (Manual 03 Adj.)	A-0460	Same as 110V
Analog Output Potentiometer	A-0175	"
Flowmeter Assembly (O-6 LPM)	A-0271-2	"

For Models 1008-AH & 1008-HC Only:

Description	110 Volt	220 Volt
Fuse	A-0220	A-0109
Power Switch Assembly	B-0098-B	B-0098-B-220V
Pump Switch Assembly (Photometer)	A-0173-A	"

Description	110 Volt	220 Volt

Mechanical Parts/Assemblies (Continued):

For Models **1008-PC & 1008-PS** Only:

Power Switch Assembly	B-0098	Specify 220V
Thumbwheel Assembly (Auto 03 Adj.)	A-0443-B	Same as 110V
0, Generator Pump Assembly	A-0218K-110V	A-0218K-220V
Photometer Pump Assembly	A-0218-A	Same as 110V
Elbow Fitting	R-0003	"
Tee Fitting	R-0004	"
Ozone Generator Assembly (W/O Lamp)	Z-0271-PC	"
Ozonator Lamp O-Ring	A-0213	"
Side Blower Assembly	A-0226-A .	A-0319-A

For Model **1008-AH:**

Photometer Pump Assembly	A-0218J-110V	A-0218J-220V

For Model **1008-RS** Only:

Power Switch Assembly	B-0098-A	B-0098-RS
Pump Switch Assembly (Photometer)	A-0173-A	A-0173-RS
"Remote" Valve Assembly	A-0203-S	A-0203-R
Replacement O-Ring	R-0006	Same as 110V
Replacement Upper Diaphragm	R-0013	"
Replacement Lower Diaphragm	R-0014	"
Photometer Pump Assembly	A-0218J-110V	A-0218J-RS
0, Generator Pump Assembly	A-0218K-110V	A-0218K-RS
Ozone Generator Assembly (Does Not Include Lamp)	Z-0271-A	Same as 110V
Ozone Generator O-Ring	A-0213	"

For Model **1008-HC** Only:

Optics Bench Assembly (Does Not Include Lamp)	Z-0100-B	Same as 110V
Optics Cell Spacing Shim	S-0423	"
Light Source Block Assembly	Z-0032-A	"
Optics Bench Window	A-0209	"
Internal Filter Assembly	Z-0109-D	"

Pneumatic Parts/Assemblies:

For All 1008 Configurations:

1/4" Teflon Tubing (Price/Foot)	N-0034	Same as 110V
1/4" Tygon Tubing (Price/Foot)	s-0021	"

Description	110 Volt	220 Volt
Electronic Parts/Assemblies:		
For All 1008 Configurations:		
CPU/Memory Board Assembly	S-0372-A	Same as 110V
LED	A-0177	"
I.C. (U1)	A-0058	"
I.C. (U2)	S-0325	"
RAM (U3)	s-0400	"
I.C. (U4)	A-0057	"
I.C. (U5)	S-0218	"
I.C. (U6)	A-0276	"
Crystal (U7)	s-0373	"
I.C. (U8)	s-0371	"
I.C. (U9)	N-0071	"
I.C. (U10)	A-0159	"
I.C. (U11)	A-0155	"
I.C. (U12)	A-0165	"
I.C. (U13)	A-0281	"
I.C. (U14)	A-0287	"
D/A Board Assembly	A-0428-A	"
I.C. (U1 & U2)	A-0063	"
I.C. (U3)	A-0283	"
I.C. (U4)	A-0281	"
Converter (U5)	B-0067	"
I.C. (U6)	A-0437	"
I.C. (U9)	A-0159	"
Display Board Assembly	A-0430-A	"
LED	A-0177	"
I.C. (U1 & U2)	A-0063	"
I.C. (U3)	A-0283	"
I.C. (U4)	A-0281	"
I.C. (U5)	A-0159	"
Counter Board Assembly	A-0429-A	"
I.C. (U1 & U2)	A-0063	"
I.C. (U3)	A.-0283	"
I.C. (U4)	A-0281	"
I.C. (U5)	A-0159	"
I.C. (U6 & U7)	A-0276	"
I.C. (U8 thru U19)	A-0285	"
I.C. (U20)	A-0282	"
LDHC Board Assembly	A-0432-B	"
Transformer (T1)	A-0148	"
Transistor (Q2 & Q3)	A-0129	"
Regulator (VR2)	T-0442	"
I.C. (U1)	A-0159	"
I.C. (U2)	**A-0154**	"
I.C. (U3)	A-0168	"

Description	110 Volt	220 Volt
Electronic Parts/Assemblies (Continued):		
Valve/Regulator Board	S-0444-A	Same as 110V
Regulator (VR1)	A-0531	"
Regulator. (VR2)	A-0138	"
Regulator (VR3)	T-0442	"
I.C. (U1)	c-0041	"
Pressure Sensor Board Assembly	A-0435-A	"
Switch	A-0475	"
I.C. (U1)	A-0483	"
Temperature Sensor Board Assembly	S-0238-A	"
Op Amp	S-0247	"
Electrometer Adapter Board Assembly	S-0265-A	"
RIN Tester Assembly	S-0263-A	"
Sample Channel Electrometer Board	S-0266-A	"
Op-Amp (U1)	A-0530	"
I.C. (U2)	A-0340	"
I.C. (U3)	A-0155	"
I.C. (U4)	A-0168	"
I.C.(U5)	S-0245	"
I.C.(U6)	S-0246	"
Control Channel Electrometer Board Assembly	S-0260-A	"
I.C.	A-0168	"
Detector Assembly Only	A-0263-B	"
Detector (Specify Sample or Control Channel)	A-0263	"
For Models **1008-AH, 1008-PC, 1008-PS & 1008-RS** Only:		
Temperature Sensor Assembly	A-0370-A	"
For Models **1008-AH, 1008-RS & 1008-HC** Only:		
I/O Board Assembly	S-0025-A	Same as 110V
I.C. (U2)	A-0409	"
I.C. (U3)	A-0283	"
I.C. (U4)	A-0281	"
I.C. (U5)	A-0159	"
I.C. (U6)	A-0030	"
Converter (U7)	A-0406	"
I.C. (U9)	B-0035	"
For Models **1008-AH & 1008-HC** Only:		
Mother Board Assembly	A-0433-A	A-0433-A-220V
Main Transformer	s-0022	S-0022A
Potentiometer	A-0175	Same as 110V

Electronic Parts/Assemblies (Continued):

For Models **1008-PC & 1008-PS** Only:

Description	110 Volt	220 Volt
Mother Board Assembly	A-0433-P	A-0433-P-220V
Main Transformer	S-ob22	S-0022A
Potentiometer	A-0175	Same as 110V
I/O Board Assembly	S-0025-B	"
I.C. (U1 & U2)	A-0409	"
I.C. (U3)	A-0283	"
I.C. (U4)	A-0281	"
I.C. (U5)	A-0159	"
I.C. (U6)	A-0030	"
Converter (U7)	A-0406	"
Converter (U8)	B-0067	"
I.C. (U9)	B-0035	"
Ozone Control Board Assembly	A-0431-A	"
Transformer (T1)	A-0148	"
Transistor (Q1)	B-0050	"
Transistor (Q2)	B-0049	"
Transistor (Q3 & Q4)	A-0418	"
I.C. (IC1)	A-0159	"
I.C. (IC2)	A-0154	"
I.C. (IC3)	B-0042	"

For Model **1008-RS** Only:

Description	110 Volt	220 Volt
Mother Board Assembly	A-0433-R	A-0433-R-220V
Main Transformer	s-0022	S-0022A
Potentiometer	A-0175	Same as 110V
Relay(RY1)	A-0217	"
Ozone Control Board Assembly	A-0099-A	"
Transformer	A-0148	"
Transistor (Ql)	B-0050	"
Transistor (Q2)	B-0049	"
Transistor (Q3 & Q4)	A-0129	"
Regulator (UR1)	A-0151	"
Regulator (UR2)	A-0347	"
Regulator (UR3)	A-0082	"
I.C. (U1)	A-0159	"
I.C. (U2)	A-0154	"
I.C. (U3)	B-0042	"

For Model **1008-HC** Only:

Description	110 Volt	220 Volt
Temperature *Sensor* Assembly	A-0370-C	Same as 110V

Description	110 Volt	220 Volt

Components For Options:

For All 1008 Configurations:

4-20 mA Output Board Module (U2)	S-0228	Same as 110V
Isolated Analog Output Board I.C.(U1)	S-0227	"
Detector Block Assembly (Retrofit)	Z-0119-A	"
RS232 Board Driver I.C.	T-0156	"
Dual Detector Control Channel Electrometer Board	S-0287-A	"
I.C.(AD652)	S-0289	"
Op-Amp	A-0530	"
Dual Detector Assembly (Pair)	A-0263-C	"
Control Detector Assembly (Only)	A-0263-D	"
Temperature Sensor Circuit (Used with Blue Box)	S-0345-A	"
Temperature Sensor Assembly (Used with Blue Box)	A-0370-B	"

* Please consult factory for additional stock numbers.

APPENDIX A

MODEL 1008-HC INFORMATION

A.1 General

The information in this appendix applies only to Model 1008-HC, which measures much higher ozone concentrations than Models 1008-AH, 1008-PC, and 1008-RS. The normal range of Model 1008-HC is from 0 to 10 percent by weight (O-60,350 ppm by volume). Even though it is electronically identical to the other models, there are some pneumatic and optical differences the user should be aware of:

1. Model 1008-HC usually does not contain a sample pump.

2. Model 1008-HC does not use a built-in ozone scrubber as its zero reference; it uses some of the air or oxygen (or ambient air) used to generate ozone. For this reason there is an inlet port on the rear of the instrument labelled "zero".

3. The length of the optical cell in Model 1008-HC is 0.076 cm. instead of 71 cm. For this reason the flow rate need not be 2.0 l/min, but a flow rate of 0.5-1.0 l/min is sufficient.

4. Because most large scale ozone generators operate with positive pressure, the absolute pressure sensor in Model 1008-HC measures up to 30 psig, with the same voltage range.

NOTE

If the ozone sample and the zero air (carrier gas) are not under positive pressure, a pump can be used to pull in the sample and reference gases. The suction side of the pump <u>must</u> be connected to the port **labelled "exhaust".** In order to protect the pump from high ozone levels (usually 1% or more) a <u>molecular sieve</u> cartridge (300-400 cc volume) <u>must</u> be connected between the exhaust port of the analyzer and the suction side of the pump. If a molecular sieve cartridge is not necessary because the pump is resistant to high ozone, then the exhaust of the pump <u>must be vented safely</u>. Figure A-l shows a typical connection of Model 1008-HC to the gas stream of an ozone generator.

A.2 Assembly of Sample Cell

Under conditions of normal operation, the sample cell windows will eventually become contaminated with dirt and particulate from the sample gas and must be cleaned periodically. The schedule for such cleaning has been described under Section 6.0, Maintenance. Here, the disassembly of the sample cell, the cleaning of windows, and the reassembly of the cell are described.

To remove the cell from the instrument, disconnect the inlet and outlet lines at the Swagelock fittings on the cell block. Loosen the detector set screws and remove the detectors. Remove the two screws holding the cell block to the cell base.

Figure A-2 shows the components that are contained in the sample cell. Remove the four screws holding the window plate. All of the components in the cell are now free to be removed. Carefully allow them to slide out of the cell onto a cloth placed on the workbench.

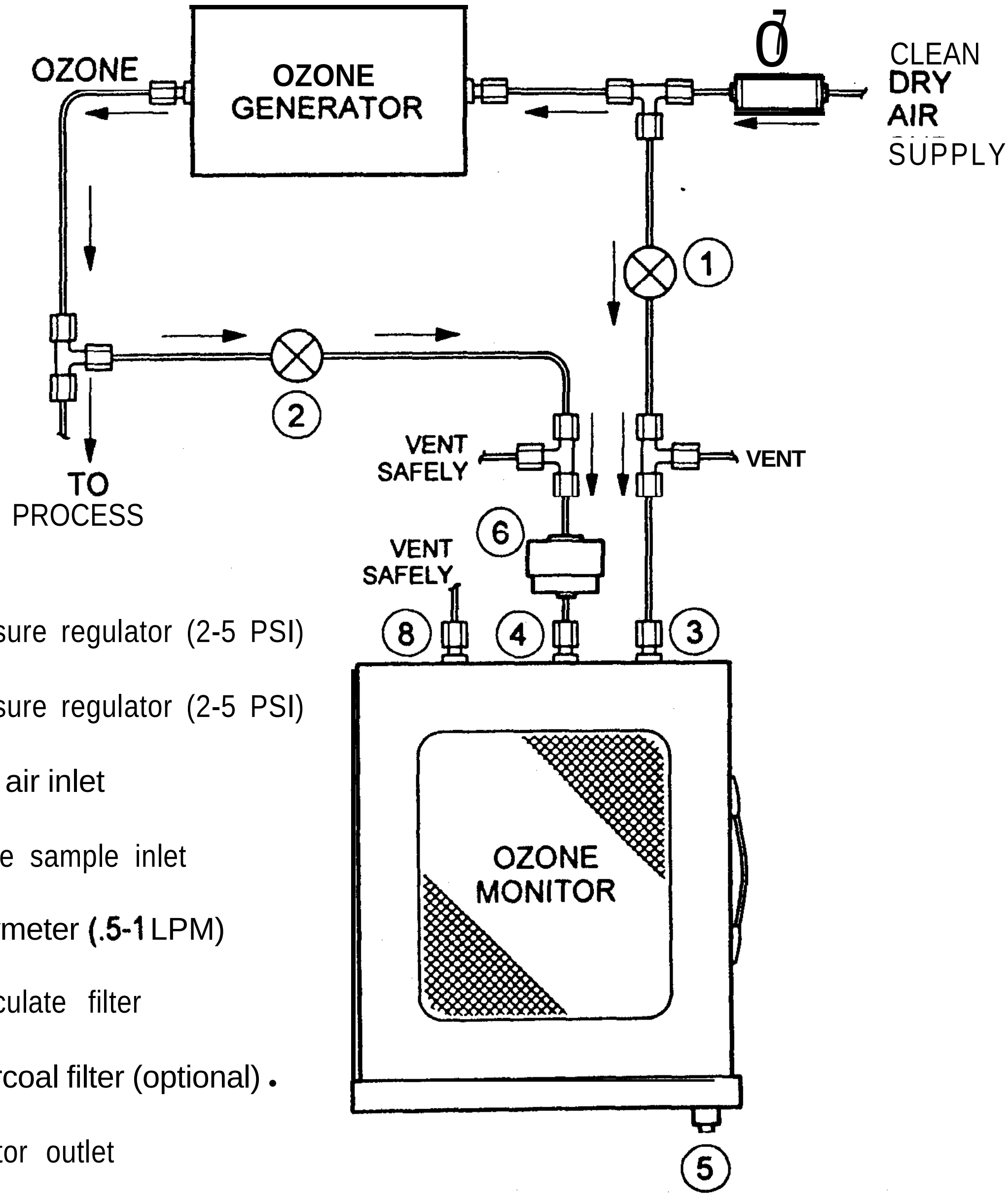
Wipe all of the components clean with a lint-free cloth. Clean the quartz windows with alcohol, being careful to hold them only by their edges after cleaning to avoid contamination with fingerprints. It is advised to wash your hands before the actual cleaning and reassembly of the cell are performed.

After cleaning, the components are replaced in the sample cell in the order shown in Figure A-2. The only critical item here is that the path length spacer must be properly aligned so that the sample flow may pass freely through the sample cell. Figure A-2 shows the sample flow as a heavy dotted line. After reassembly, the notch, on the gap between the two .0298" shims (for the L = .0298" path length instrument) must be aligned with the flow path direction as indicated on the figure.

When all of the components are in place in the sample cell, visually check through the sample inlet port that the path length spacer gap is properly aligned. Screw the window plate back down onto the cell block for a tight sealing of the o-rings.

Leak check the re-assembled unit by attaching a 10 psi source of gas to the exhaust fitting. Hold your finger over the sample gas inlet port and using "snoop" or other substance, ensure that the unit does not leak at this pressure. If it does, visually check the status of the o-rings to verify that they are worn out.

After a successful leak check, the unit is ready for replacement in the instrument. Replace the sample gas inlet, and attach the optics block to the cell base with the two screws. Re-attach the exhaust line to the Swagelock fitting and install the detectors and tighten in place with the set screws. The instrument is now ready for operation. After the unit has warmed up it may be necessary to readjust the sample frequency.



1. Pressure regulator (2-5 PSI)
2. Pressure regulator (2-5 PSI)
3. Zero air inlet
4. Ozone sample inlet
5. Flowmeter (.5-1 LPM)
6. Particulate filter
7. Charcoal filter (optional) •
8. Monitor outlet

• Item for this point is only required when the clean dry air supply is not available. All fittings and lines (possibly 1/4" OD) should be either teflon or stainless steel or combination of both.

Figure A-l Connection of Model 1008-HC to Ozone Generator

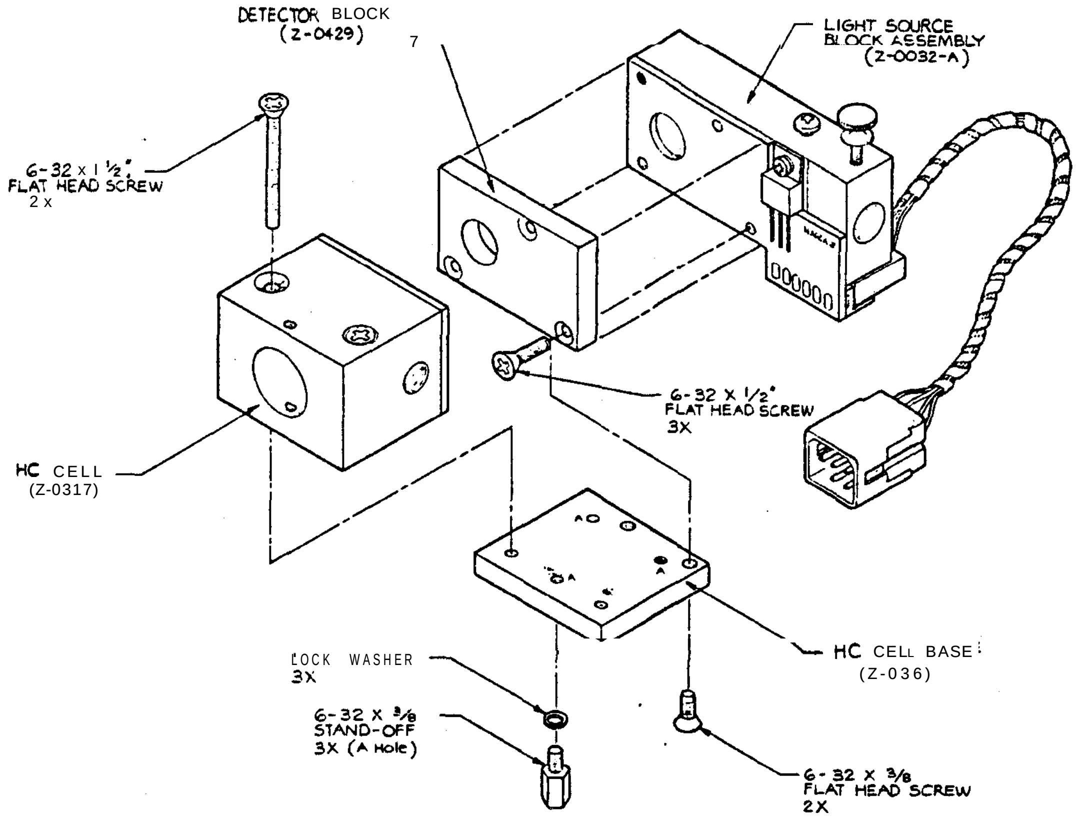


Figure A-2 Model **1008-HC** Sample Cell Components

APPENDIX B

INSTRUMENT CALIBRATION

B.l General (New W Calibration Procedure)

The new W calibration procedure is quite simple. After generating a stable, ozone concentration with an ozone generator, the operator assays it by passing all or a portion of the gas flow through the cell of a W photometer. The photometer readings are then used in a formula to calculate the ozone concentration, which is **effectively** a **primary** ozone standard. Most commercially available photometers do the photometric calculations automatically, and some may also make temperature and pressure corrections automatically. The primary burden on the operator is to insure that:

1) The photometer is operating correctly.

2) The apparatus is set up properly, is clean and leak-free.

3) The calculations are complete and accurate.

While none of these is particularly difficult, EPA has prepared a Technical Assistance Document which explains these tasks and provides other detailed information about the procedure (Reference #9 in Appendix D). The photometer is obviously of critical importance to the procedure and must have a precision within 0.005 ppm or 3% of the concentration, whichever is greater. While a calibration photometer can be assembled from laboratory components, EPA recommends the purchase of a commercial photometer which is either designed specifically for this calibration procedure or which can be readily adapted to it. Such a photometer and ozone generator system is the Dasibi Model 1008-PC (Fig. B-l).
W Photometers of the type used in ambient ozone analyzers are likely to be suitable as calibration photometers. Conversion of an ambient UV analyzer to a calibration photometer is covered in the Technical Assistance Document. However, it is important to differentiate between the use of a UV photometer as an ambient analyzer and its use as a calibration photometer. This distinction is predicated more on operational differences than on any specific physical differences. The new calibration procedure requires that a photometer used for calibration must be:

1) Dedicated **exclusively** to such use.

2) Must be maintained under meticulous conditions.

3) Must be used only with clean calibration gases.

W analyzers used for ambient monitoring should always be calibrated with an independent calibration photometer or a certified transfer standard. A W analyzer should not be considered to be **"self-calibrated"** even though it contains a UV photometer which meets the specifications of the W calibration procedure.

B.2 Calibration Procedure

The calibration procedure is based on the photometer's assay of ozone (O_3) concentrations in a dynamic flow system. The concentration of 0, in an absorption cell is determined from a measurement of the amount of 254 nm light absorbed by the sample. This determination requires knowledge of:

1) The absorption coefficient (A) of 0, at 253.7 nm.

2) The optical path length (L) through the sample.

3) The transmittance of the sample at a wavelength of 253.7 nm.

4) The temperature (T) and pressure (P) of the sample.

The transmittance is defined as the ratio I/I,, where I is the intensity of light which passes through the cell and is sensed by the detector when the cell contains an 0, sample, and I, is the intensity of light which passes through the cell and is sensed by the detector when the cell contains zero air. It is assumed that all conditions of the system, except for the contents of the absorption cell, are identical during measurement of I and I,. The quantities defined above are related by the Beer-Lambert absorption law as presented next:

$$\text{Transmittance} = \frac{I}{I_0} = e^{-(ALC)}, \quad (1)$$

where,

A = absorption coefficient of 0, at 253.7 nm (308.3 atm^{-1} cm^{-1} at 0° C and 760 mm Hg)
C = 0, concentration in atmospheres
L = optical path length in cm

In practice, a stable 0_ generator is used to produce O_3 concentrations over the required range. Each 0, concentration is determined from the measurement of the transmittance (I/I_0) of the sample at 253.7 nm with a photometer of path length L and calculated from the equation:

$$C(atm) = \left(\frac{1}{AL}\right)\left(\ln\left[\frac{I_O}{I}\right]\right) \quad (2a)$$

or,

$$c(ppm) = \left(\frac{10^6}{AL}\right)\left(\ln\left[\frac{I_O}{I}\right]\right) \quad (2b)$$

The calculated O_3 concentrations must be corrected for O_3 losses which may occur in the photometer and for the **temperature** and pressure of the sample. This procedure is applicable to the calibration of ambient air O_3 analyzers, either **directly** or by means **of** a **transfer** standard certified by this **procedure.** Transfer standards must meet the requirements and specifications set forth in Reference 8, as provided in Appendix D.

A complete *w* calibration system consists of an ozone generator, an **appropriate** source of zero air, and other components as necessary. The configuration must provide ***a* stable *ozone*** **Concentration at the system output and allow the photometer to** accurately assay the output concentration to the precision specified for the photometer.

Figure B-2 shows a commonly used **configuration** and serves to illustrate the calibration procedure which follows. Other configurations may require appropriate variations in the **procedural** steps. All connections between components in the calibration system downstream of the O_3 generator should **be of glass, Teflon,** or other relatively inert materials. Additional information regarding the assembly of a *w* photometer calibrating apparatus is given in Reference 9 (Appendix D).

For certification of transfer standards which provide their own source of O_3, the transfer standard may replace the O_3 generator and possibly other components shown in Figure B-2 (refer Reference 8 of Appendix D).

The photometer consists of a low-pressure mercury discharge **lamp,** (optional) collimation optics, an absorption cell, a detector, and signal-processing electronics, as illustrated in Figure B-2. It must be capable of measuring the transmittance, I/I_o at a wavelength of 253.7 nm with sufficient precision that the **standard** deviation of the concentration measurements does **not** exceed 0.005 ppm or 3% of the concentration.

Because the low-pressure mercury lamp radiates at several wavelengths, the photometer must incorporate suitable means to ensure that no O_3 is generated in the cell by the lamp, and that at least 99.5% of the radiation sensed by the detector is 253.7 nm radiation. (This can be readily achieved by prudent **selection** of **optical filter** and detector response characteristics). The length of the light path through the absorption cell must be known with an accuracy of at least 99.5%. **In** addition, the cell and associated plumbing must be designed to minimize **loss** of O_3 from contact with cell walls and gas handling components. See Reference 9 in Appendix D for additional **information.**

Air Flow controllers: Devices capable of regulating air flows as necessary to meet the output stability and photometer precision requirements.

Ozone Generator: Device capable of generating stable levels of O_3 over the required concentration range.

Output manifold: The output manifold should be constructed of glass, Teflon, or other relatively inert material, and should be of sufficient diameter to ensure a negligible pressure drop at the photometer connection and other output ports. The system must have a vent designed to insure atmospheric pressure in the manifold and to prevent ambient air from entering the manifold.

Two-wav valve: Manual or automatic valve, or other means to switch the photometer flow between zero air and the 0, concentration.

Temoerature indicator: Accurate to ±1° C.

Barometer or pressure indicator: Accurate to ±2 torr.

Zero air: The zero air must be free of contaminants which would cause a detectable response from the 0, analyzer, and it should be free of NO, C_2H_4, and other species which react with 0,.

A procedure for generating suitable zero air is given in Reference 9 (Appendix D). As shown in Figure B-2, the zero air supplied to the photometer cell for the I, reference measurement must be derived from the same source as zero air used for generation of the ozone concentration to be assayed (I measurement). When using the photometer to certify a transfer standard having its own source of ozone (Reference 8, Appendix D).

B.2.1 Procedure

General Operation: The calibration photometer must be dedicated exclusively to use as calibration standard. It should always be used with clean, filtered calibration gases, and never used for ambient air sampling. Consideration should be given to locating the calibration photometer in a clean laboratory where it can be stationary, protected from physical shock, operated by a responsible analyst, and used for a common standard for all field calibrations via transfer standards.

Preparation: Proper operation of the photometer is of critical importance to the accuracy of this procedure. The following steps will help to verify the proper operation. The steps are not necessarily required prior to each use of the photometer. Upon initial operation of the photometer, these steps should be carried out frequently, with all quantitative results or indications recorded in a chronological record either in tabular form or plotted on a graphical chart. As the performance and stability record of the photometer is established, the frequency of these steps may be reduced, consistent with the documented stability of the photometer.

Instruction manual: Carry out all set-up and adjustment procedures or checks as described in the operation or instruction manual associated with the photometer.

System Check: Check the photometer system for integrity, leaks, cleanliness, proper flow rates, etc. Service or replace filters and zero air scrubbers or other consumable materials, as necessary.

Linearity: Verify that the photometer manufacturer has adequately established that the linearity error of the photometer is less than 3%, or test the linearity by dilution as follows:

Generate and assay an O_3 concentration near the upper range limit of the system (0.5 or 1.0 ppm), then accurately dilute that concentration with zero air and reassay it. Repeat at several different dilution ratios. Compare the assay of the diluted concentration divided by the dilution ratio, as follows:

$$E = \left(\frac{A_1 - A_2/R}{A_1}\right) \times 100\% \qquad (3)$$

where,

E = linearity error, percent

A_1 = assay of the original concentration

A_2 = assay of the undiluted concentration

R = dilution ratio (i.e., flow of original concentration divided by the total flow).

The linearity error must be less than 5%. Since the accuracy of the measured flowrates will affect the linearity error as measured this way, the test is not necessarily conclusive. Additional information on verifying linearity is contained in Reference 9, Appendix D.

Intercomnarison: When possible, the photometer should be occasionally intercompared, either directly or via transfer standards, with calibration photometers used by other agencies or laboratories.

Ozone losses: Some portion of the O_3 may be lost upon contact with the photometer cell walls and gas handling components. The magnitude of this loss must be determined and used to correct the calculated O_3 concentration. This loss must not exceed 5%. Some guidelines for quantitatively determining this loss are discussed in Reference 9, Appendix D.

B.2.2 Assay of O_3 Concentrations

1. Allow the photometer to warm up and stabilize.

2. Verify that the flowrate through the photometer absorption cell, F, allows the cell to be flushed in a reasonably short period of time (2 liter/min is a typical flow). The precision of the measurements is inversely related to the time required for flushing, since the photometer drift error increases with time.

3. Ensure that the **flowrate** into the output manifold is at least 1 **liter/min** greater than the **flowrate** required by the photometer and any other flow demand connected to the manifold.

4. Ensure that the **flowrate** of zero air, F, is at least 1 **liter/min** greater than the **flowrate** required by the photometer.

5. With zero air flowing in the output manifold, actuate the **two-**way valve to allow the photometer to sample first the manifold zero air, then F. The two photometer readings must be equal $(I = I_o)$.

NOTE

In some commercially available photometers, such as the Dasibi Model **1008-PC,** the operation of the two-way valve and various other operations are carried out automatically by the photometer.

6. Adjust the 0, generator to produce an 0, concentration as needed.

7. Actuate the two-way valve to allow the photometer to sample the ozone concentration until the absorption cell is thoroughly flushed and record the stable measured value of I,,.

8. Actuate the two-way valve to allow the photometer to sample the ozone concentration until the absorption cell is thoroughly flushed and record the stable measured value of I.

9. Record the temperature and pressure of the sample in the photometer absorption cell. (See Reference 9 for guidance).

10. Calculate the 0, concentration from Equation (B-l). An average of several determinations will provide better precision.

$$(O_3)_{OUT} = \left(\frac{10^6 \times 760 \times T}{ALPD \times 273.15}\right)\left(\ln\left[\frac{I_O}{I}\right]\right) \qquad \text{(B-1)}$$

where:

$(O_3)_{OUT}$ = 0, concentration, ppm

A = absorption coefficient of 0, at 253.7 4nm (308.3 atm^{-1} cm^{-1} at 0° C and 760 mm Hg)
L = optical path length, cm
T = sample temperature, $^\circ K$
P = sample pressure, mm Hg
D = correction factor for 0, losses = (1 - fraction 0, lost).

NOTE

Some commercial photometers, such as **Dasibi Model 1008-PC** automatically evaluate Equation (B-l), except for D. It is the operator's responsibility to verify that the information required for Equation (B-l) is obtained, either automatically by the photometer or manually. For **"automatic"** photometers which evaluate the logarithmic term of Equation (B-l) based on a linear approximation, a manual correction may be required, particularly at higher O_3 levels. **See** the photometer instruction manual and Reference 9, Appendix D for guidance.

11. Obtain additional 0, concentration standards as necessary by repeating steps 6 to 10.

Certification of transfer standards: A transfer is certified by relating the output of the transfer standard to one or more ozone standards as determined according to Section B.2.2. The exact procedure varies depending on the nature and design of the transfer standard. Consult Reference 8, Appendix D for guidance.

B.2.3 Calibration of the Analyzer

Models **1008-AH,** -PC, **-RS** are calibrated using ozone standards obtained directly according to Section B.2.2 or by means of a certified transfer standard.

1. Analyzer's controls (refer to Figure 5-1)

   a. POWER Switch (1) - ON
   b. MODE SELECTOR Switch (4) - OPERATE position
   c. T/P Switch(s) - OFF
   d. VALVE Switch (6) - OFF
   e. PUMP Switch (7) - OFF

   Allow sufficient time (20-30 minutes) for the 0, analyzer and the photometer or transfer standard to warm-up and stabilize. Connect the analyzer inlet port to the manifold of your calibration system (see Figure B-3) via **1/4** Teflon tubing.

2. Offset the analyzer to **+9** ppb in order to observe negative readings. This can be done via the right hand side thumbwheel switch on the D/A board (see Figure 3-12). Observe the readings on the display for 3-5 minutes. The average reading should be 9 ppb + l-2 ppb. This verifies that the **optical-**electronic system is working well; we call this **"no** flow **zero".** Turn on the valve and the pump (see Figure **5-1),** adjust the flow meter to 2 l/min, and allow the analyzer to sample zero air until a stable response is obtained on the recorder. Record the stable zero air response as **"Z".**

3. Generate an O_3 concentration standard of approximately 80% of the desired upper range limit (URL) of the O_3 analyzer (400 or 800 ppb). Allow the O_3 analyzer to sample this O_3 concentration standard until a stable response is obtained on recorder.

4. Adjust the O_3 analyzer's span control (see No. 2, Figure 5-1) to obtain a recorder response as indicated in the following equation:

$$\text{Recorder Response (\% Scale)} = \left(\frac{(O_3)_{OUT}}{URL} \times 100\%\right) + Z$$

where,

URL = upper range limit of the O_3 analyzer, ppm

Z = recorder response with zero air, percent scale. Record the O_3 concentration and the corresponding analyzer response. If substantial adjustment of the span control is necessary, recheck the zero and span adjustments by repeating steps 2 to 4.

5. Generate several other O_3 concentration standards (at least 5 others are recommended) over the scale range of the O_3 analyzer by adjusting the O_3 source. For each concentration standard, record the O_3 and the corresponding analyzer response.

6. Plot the O_3 analyzer responses versus the corresponding O_3 concentrations and draw the O_3 analyzer's calibration curve or calculate the appropriate response factor (see Figures B-3 and B-4).

7. The various O_3 concentrations required in step 5 may be obtained by dilution of the O_3 concentrations generated in steps 3 and 5. With this option, accurate flow measurements are required. The dynamic calibration system may be modified as shown as Figure B-3 to allow for dilution air to be metered downstream of the O_3 generator. A mixing chamber between the O_3 generator and the output manifold is also required. The flowrate through the O_3 generator (F_O) and the dilution air flowrate (F_D) are measured with a reliable flow or volume standard traceable to NBS. Each O_3 concentration generated by dilution is calculated from:

$$(O_3)_{OUT}' = (O_3)_{OUT} \times \left(\frac{F_O}{F_O + F_D}\right)$$

where,

$(O_3)_{OUT}'$ = diluted concentration, ppm
F_O = flowrate through the O_3 generator, l/min
F_D = diluent air flowrate, l/min.

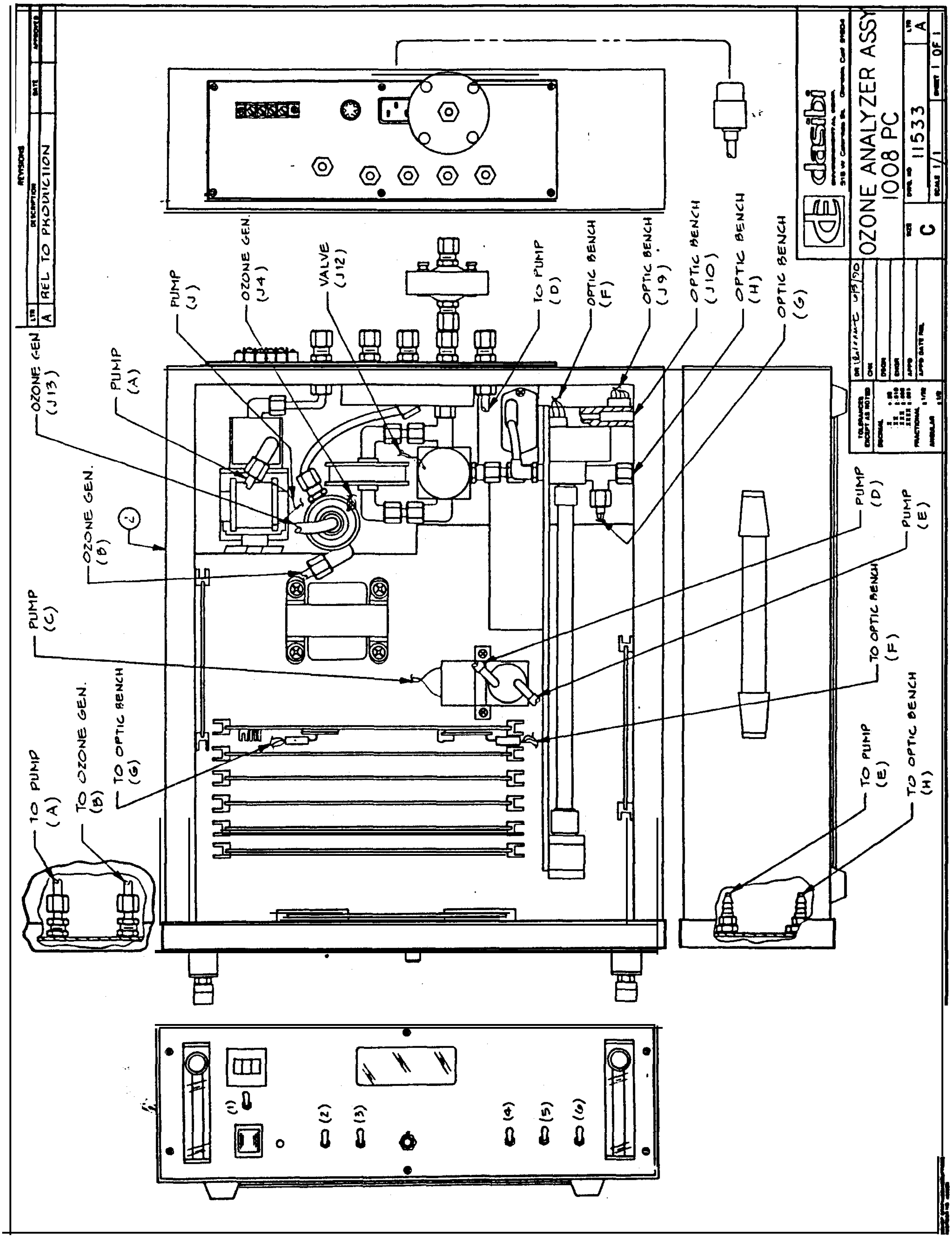


Figure B-l Ozone Generator and Photometer System Schematic

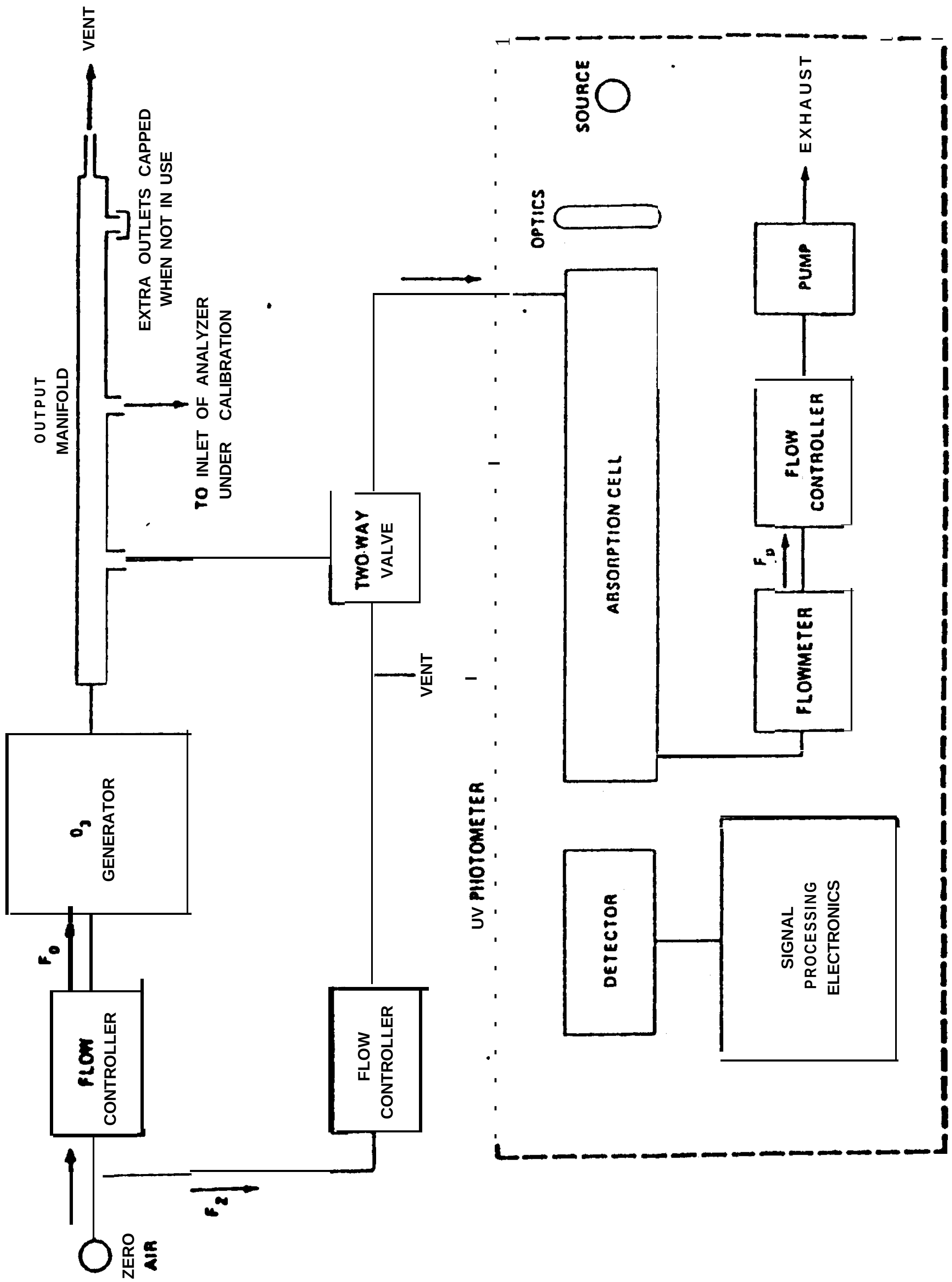


Figure B-2 Schematic Diagram of a Typical UV Photometric Calibration System

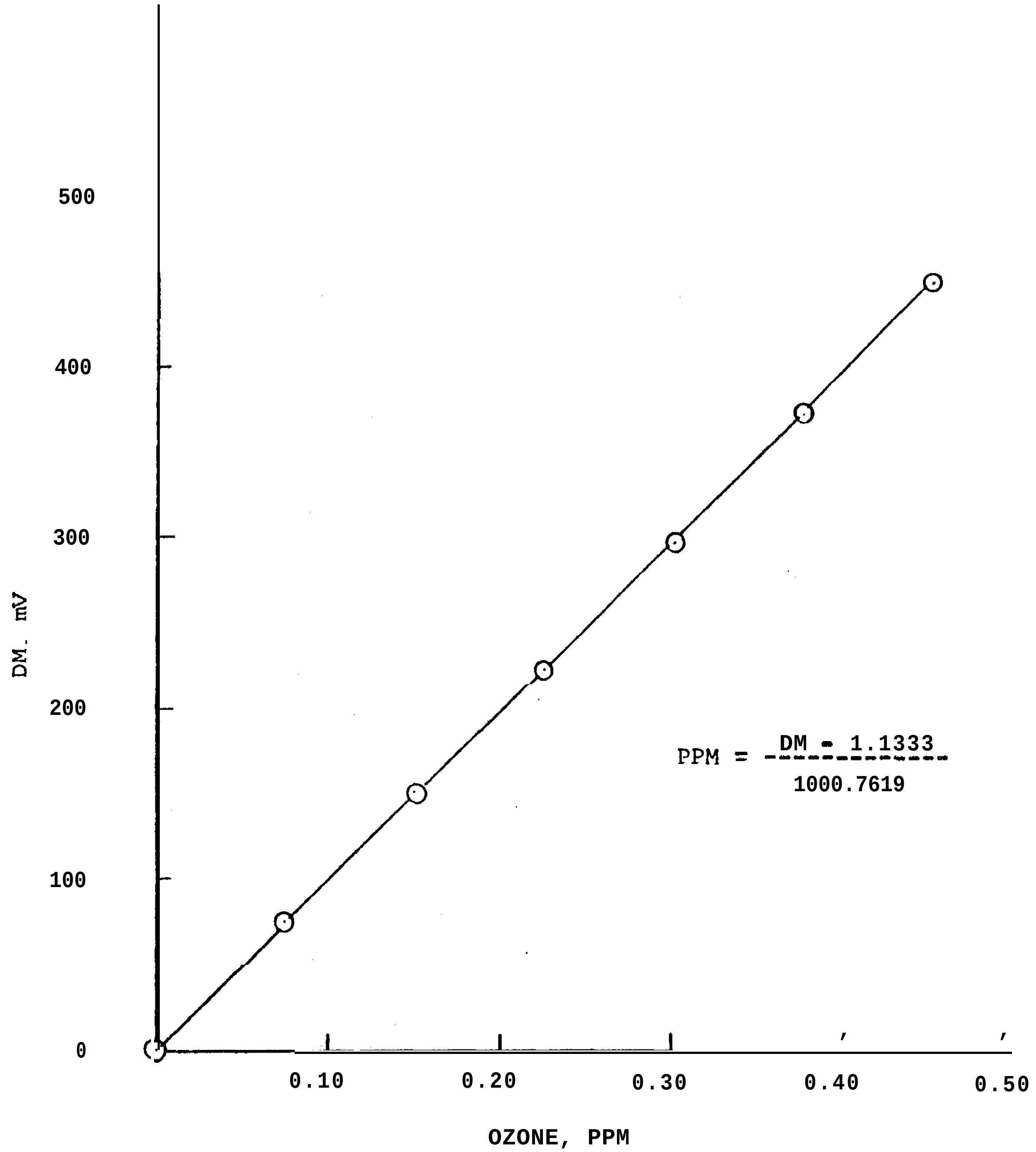


Figure B-3 Typical Calibration Curve, 0 - 0.5 ppm Range

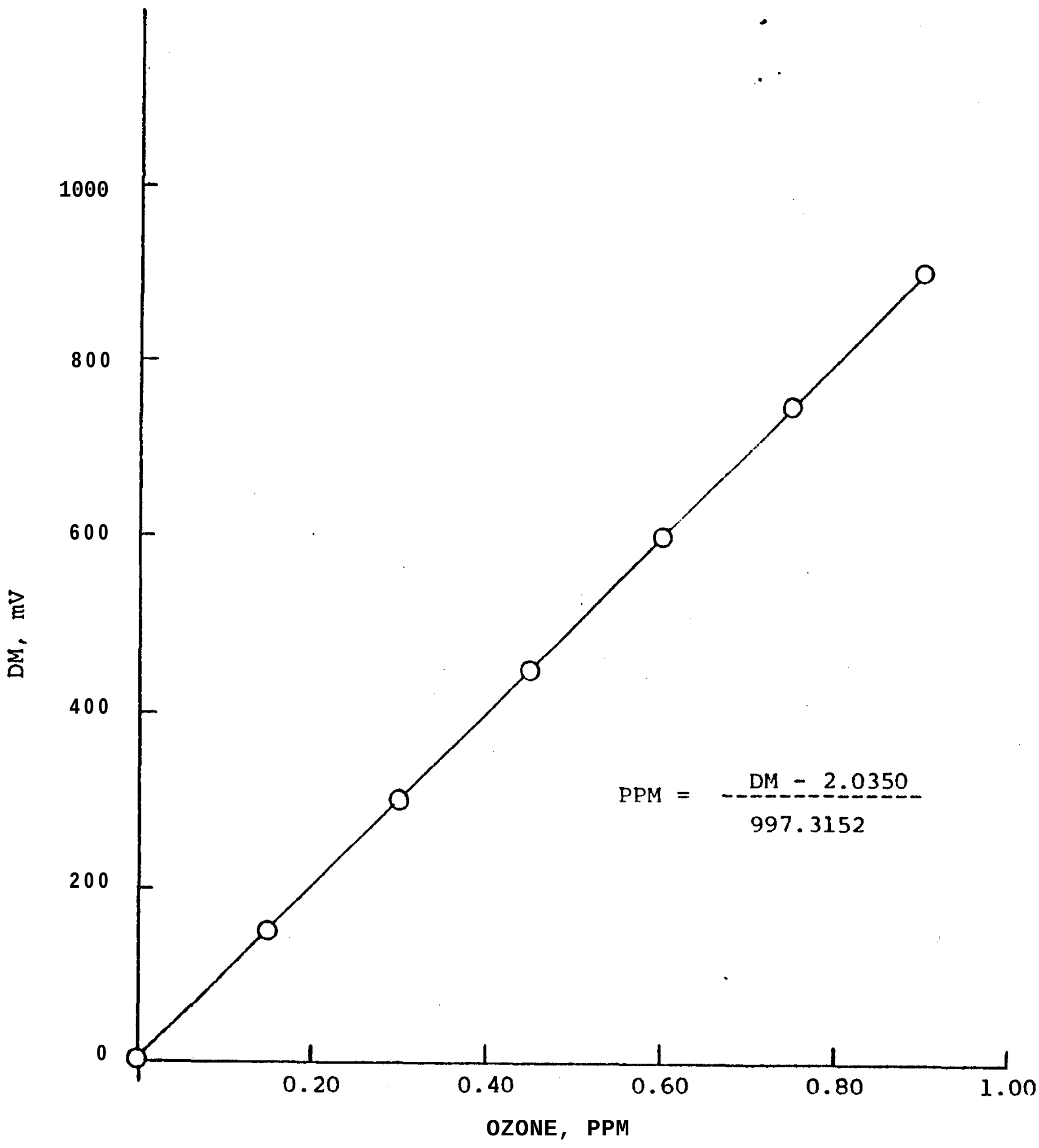


Figure B-4 Typical Calibration Curve, 0 - 1.0 ppm Range

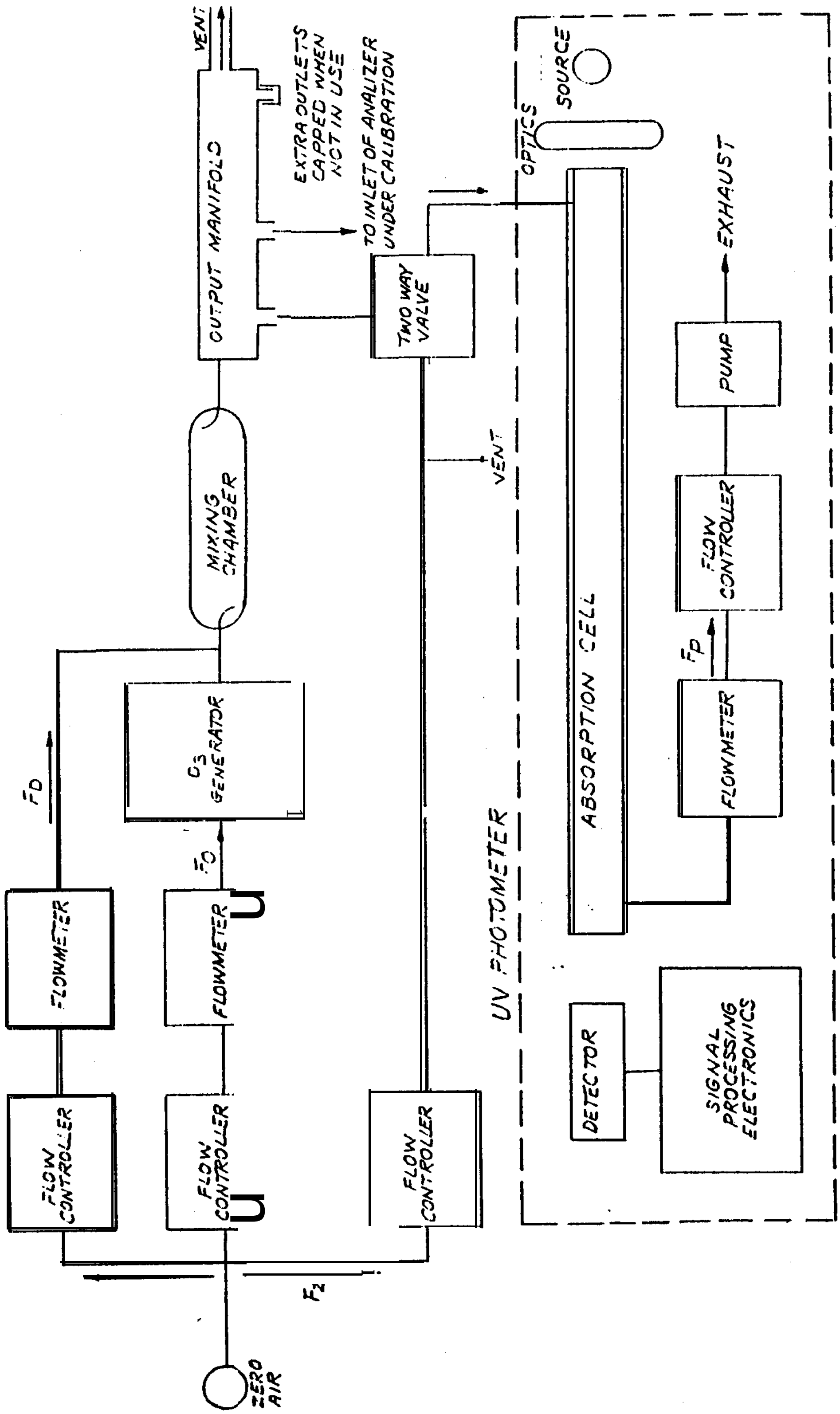


Figure B-5 Schematic Diagram of a Typical UV Photometric Calibration System (Option 1)

APPENDIX C

MANUAL UPDATE INFORMATION

c.1 RIN Tester Description

This assembly is stored on a connector that is located near the bottom of the electrometer adapter board (refer to Figure 3-4al). Its purpose is to aid in troubleshooting a noisy photometer after the noise has been determined not to be in the optics.

This tool functionally separates the lamp/lamp drive circuit from the electrometer section. Therefore, if the analyzer remains noisy using the RIN tester, the problem can be traced to the electrometer/logic circuitry. On the other hand, if the noise disappears (which is usually the case), then the lamp/lamp drive circuitry should be checked.

NOTE

> Certain kinds of dirt (such as lint) in the optics can cause noise even with the pump and valve turned off. Therefore, we recommend thoroughly cleaning the optics section before using the RIN tester.

c.1.2 RIN Tester Check

If the analyzer is exhibiting noise levels outside the specified parameters, first clean the optics section (see Section 6.7). If the noise persists after performing this procedure, turn off the power to the analyzer and unplug the detector assembly from the sample channel electrometer.

However, if your unit also contains a control detector assembly (a specified option), then a determination of which electrometer is most likely at fault, must be made first. This can **be** accomplished by switching the front panel mode switch to **"SAMP FREQ"** for a few minutes and recording the values indicated on the front panel. Next, switch to the **"CONT FREQ"** mode for a few minutes and record these values. If one frequency is substantially more unstable than the other, then that channel's electrometer **becomes** the suspected **"faulty"** electrometer and its detector assembly would be disconnected. If not, then start out by disconnecting the sample electrometer detector.

After the detector assembly has been disconnected, unplug the RIN tester from its holder on the adapter board and install it in place of the removed detector assembly. Apply power to the analyzer, turn the front panel switch to the appropriate frequency mode and adjust the potentiometer on the RIN tester until the desired frequency is obtained.

If the noise persists, this indicates that a check of the electrometer/logic circuitry should be made. If the noise disappears, then check the lamp/lamp drive circuitry

NOTE

The RIN tester is, by nature, slightly more noisy than the lamp/detector combination when they are functioning properly. Thus, the noise level observed when the RIN tester is in place is not necessarily a completely accurate indication- of the electrometer's noise level.

c.2 Flow Restrictor Option

The end user has the option of requesting use of a flow restrictor to stabilize the flow through the photometer. The restrictor would be located at the outlet of the photometer flow meter. The restrictor in this instrument is designed to provide approximately 2 liters per minute through the photometer. The use of different pumps with time may vary this exact flow, but as long as the flow rate falls between 1.5 LPM and 3.5 LPM, there will be no problems.

The end user should be cautioned that use of such a flow restrictor requires periodic maintenance to prevent "clogging". Such an occurrence will result in too low of a flow rate if proper maintenance is not performed. Dasibi recommends the use of the particulate filter holder that comes standard on the unit's sample port. This will reduce the amount of particulate matter flowing through the instrument. Dasibi also recommends cleaning the restrictor whenever cleaning of the optics bench **absorption tubes** occurs.

To do this, simply pull the tygon tubing off of the flow restrictor, and unscrew the nut holding the restrictor. Once freed, run a piece of wire through the restrictor to loosen any matter that may have collected. Then reverse the process to replace the restictor. Make sure you perform a leak check every time this is performed.

c.3 Rapid Response Software Option

The unit may be fitted with a special E-Prom containing software that does not perform any averaging. This increases the response time of the unit from 50 seconds to 20 seconds. The unit, however, would be quality-controlled to insure the noise level of the unit would still be well within Dasibi specifications.

c.4 CPU/Memory Board (Figures C-l and C-2)

The CPU/Memory Board consists of four (4) main sections, the Central Processing Unit (CPU), the Counter/Timer Circuit, the Memory, and the Watchdog Timer circuitry. Each of these sections is described next.

The Central Processing Unit (CPU) is a Z80A, running at 1.0 MHZ. It controls the operation of the entire instrument including reading the switch settings, controlling the valve, reading the temperature, pressure and light sensors, computing the concentration, and outputing the results.

The Counter/Timer Circuit (CTC), is used for all non-critical timing in the system. These include flush time, "count up" time, and time between successive measurements. After the preset time expires, the CTC generates an interrupt, signaling the CPU to proceed with the next operation(s).

The Memory, consists of 8K Bytes of EPROM and 2K Bytes of RAM. The program is stored in ROM, along with all constants required for the calculations and unit conversions. The RAM is used to store sensor readings, and intermediate results during calculations.

The Watchdog Timer is designed to expire and reset the unit. In normal operation, the CPU repeatedly restarts the timer, preventing it from expiring and resetting the CPU. If an error occurs that causes the CPU to become stuck, the Watchdog timer will expire, resetting the unit. In the "SPAN" mode, the CPU does not restart this timer, allowing verification of the watchdog timer and reset circuitry.

C.5 Optional RS232 Board (Figures C-5, C-6 & C-16)

The optional RS232 Board allows the communication between a 1008 ozone analyzer and an external computer, terminal, or datalogger. This board contains all the circuitry required to provide a Full-Duplex interface and is intended to be used to display and/or capture ozone measurements, as well as provide internal diagnostic information from the analyzer.

Because of the vast amount of confusion about RS232 interface, Dasibi would like to present a brief overview on the subject. Put simply, RS232 is an interface specification that defines signal voltage levels, signal slew rates, line capacitance and so forth. It is extremely important not to spell out exactly what the RS232 standard <u>does</u> specify, but rather what it <u>does not</u> specify. The RS232 specification does not stipulate how many signals are required, nor what signals are to appear on what lines (i.e. the simplest RS232 interface could contain as few as 2 wires, one for the signal and one for ground).

With RS232, one can only transmit about 50 feet on the best coax and remain within the specifications due to the line capacitance. But since communications are taking place daily over vastly greater distances, some of what RS232 does provide, may be misunderstood by some end users. Since every different manufacturer has had a different version of what RS232 consists of, or which signals other than Txd, Rxd, and Gnd, should appear on what signal lines (Pin Numbers), Dasibi has opted to comply with the most standard RS232 interface in existence today; that of the IBM AT personal computer.

The 1008 monitor is pin-to-pin compatible with the IBM AT 9-pin interface; there is no need to switch any wires at all, including Rxd & Txd (simply connect Pin 1 to Pin 1, Pin 2 to Pin 2, etc.). There are only 2 signals, (i.e. 3 wires), that are "required" to interface to the 1008 monitor (it is conceivable that one could skip the signal line Rxd, Pin 2, if satisfied with half-duplex operation). The required wires are Pins 2, 3, and 5. The addition of any extra signals/wires provides no benefit to the end user and Dasibi recommends not using them unless the configuration and/or software requires them. The following list defines the Dasibi-to-IBM 9-pin interface:

Dasibi Sisnal Name:	#Pin	IBM AT Sisnal Name:
No Connection	- 1 -	Received Line Signal Detect
TxD Transmitted Data	- 2 -	RxD Received Data
RxD Received Data	- 3 -	TxD Transmitted Data
DSR Data Set Ready	- 4 -	DTR Data Terminal Ready
Signal Ground	- 5 -	Signal Ground
DCD Data Carrier Detect	- 6 -	DSR Data Set Ready
CTS Clear To Send	- 7 -	RTS Request To Send
RTS Request To Send	- 8 -	CTS Clear To Send
No Connection	- 9 -	Ring Indicator

NOTE

Both 1008 input pins numbers 7 and 4 have pull-up resistors on them so the operator can leave them floating. If not used, the 1008 monitor will stop transmitting when either of them becomes false. If one of them is held in the false state for any appreciable time, the 1008 monitor will skip transmission of that data packet and resume data transmission on the next update that both lines are free.

If a 25 pin connector is going to be used, the following table lists the most common 9-pin-to-25-pin adapter wiring:

9pin	25pin	
1	8	DCD
2	3	RxD
3	2	TxD
4	20	DTR
5	7	Gnd
6	6	DSR
7	4	RTS
8	5	CTS
9	22	

The RS232 section of this board (there are other features available on this multi-functional board) consists of a 2.5 Mhz crystal oscillator for generation of the baud rate, a serial I/O unit (USART) for communicating with the CPU, and level shifters for converting the TTL level signals into the RS232 levels.

To avoid affecting the ozone monitor's main task (that of measuring ozone), the board is used in a polled fashion, where the CPU periodically checks the port for input (which may cause a slight delay in responding to keyboard inputs). The set up for the RS232 is as follows:

Data Bits	7 bits - ASCII format
Parity	None
Stop Bits	1
Baud Rate	9600

The Baud Rate is set to 9600 bps, 7 data bits, no parity, 1 stop bit. The unit will probably work, however, with either even or odd parity, and 1.5 or 2 stop bits depending on the software the computer uses. The 1008 powers-up in the log mode. Typing a **"D"** (either upper or lower case), will put the unit into the "diagnostic display **mode".** Typing any other key will return the unit-to the log-mode. Only 2 of the RS232 signals are mandatory (plus ground). These are Rxd and Txd:

The computers line labeled **"Rxd"** is wired to pin 2
The computers line labeled **"Txd"** is wired to pin 3
Signal Gnd is wired to pin 5

The commands available via RS232 are as follows:

F Turns off RS232 display.

D Full system display as shown next:

```
   Dasibi 1008 Ozone Monitor
          .[illegible] ppm
FAULT: 0 MODE: 5  SPAN: 308
OFFSET:+9PPB
TEMP: 31.7 C
PRESS: 0.979 ATM
CONT FREQ: 500000 Hz
SAMP FREQ: 480000 Hz
```

Typing any other key produces the **"Log Mode".** This mode displays the front panel readings and the error code if it is not zero (no error). For example:

```
13.567 ppm    02
-1.678 ppm    02
 0.008 ppm    07
 0.009 ppm
 0.008 ppm
```

The following are the error codes currently implemented. The column labeled CPU refers to the error code(s) found on the CPU/Memory Board error display which are described in Section C.16.1.

CPU	RS232	
0	00	No Fault
1	01	Not currently used.
2	02	Sample frequency is above 481,250 Hz less than 300,000 Hz.
3	04	Control frequency is less than 300,000 Hz.
4	08	CPU Reset occurrence.
5	10	Not currently used.
6	20	Not currently used.
7	40	Heater Voltage below 4.10 Vdc.
8	80	User error - either the front panel mode switch is not in the operate position, or the T/P switch is in the off position.

In the case of a single error, the value in the table above will be displayed. In the case of multiple errors, the "lowest" error will be displayed on the CPU/Memory Board's display (since the lower the number, the more significant the error), and the "sum" of the errors will be displayed in hexadecimal format in the RS232 data. For example, the sum of the errors 2, 3, and 7 will result in a Hexadecimal display of "46". The calculated concentration will be displayed though, even if errors are present.

C.6 Internal Timer (Optional)

An internal timer may be procured for the instrument to allow automatic zero or span functions. Once the selected time is achieved on the internal clock, the unit will automatically allow itself to sample zero air, and then generate ozone for an internal span check for a user-selectable duration.

The internal timer on the angle plate of the U.V. photometer. To set the time, or adjust for changes in time due to daylight savings, follow these procedures:

1) Open the hinged touch sensor door. Before setting, or whenever the timer is without power for more than *one* minute, the clock display will show 12:00 a.m..

2) Slide the function switch to the "SET CLOCK" position.

3) Press the "HRS" button until the display shows the correct hour. Push and hold the button for rapid advance. Make sure that the AM/PM indicator on the display is correct.

4) Press "MIN" button until the display shows the proper minutes.

5) When you have the current correct time, press the "ENTER" button to begin time keeping. The display should blink once when the "ENTER" button is pushed.

To set the program for internal automatic zero and span, follow these steps:

1) Slide the function switch to the "Program" position. The number 0.001 should appear on the display.

2) Push the "Event" button until the number "1" appears above "Event" on the display.

3) Push the on/off button until the arrow at the right side of the display points to the "ON" setting.

4) Push the "HRS" button until the hour you want the event to happen appears. Make sure that the AM/PM indicator on the left side of the display shows the correct setting.

5) Push the "MIN" button until the exact time you want the event to occur appears.

6) Push the "ENTER" button to store the event you have just programmed in the Timer's memory.

7) Slide the function switch to one of the "AUTOMATIC FIXED".

Now, the duration of the zero and span must be set on the two potentiometers on the RS232 Board the board furthest back on the Mother Board Bus directly behind the Electrometer Board configuration. To do this follow these steps:

1) Locate the "zero" potentiometer on the RS232 Board. Looking at the front of the board, it is the potentiometer on the left.

2) The time must be set according to the "blinking" frequency of the LED located to the left of the potentiometer. This LED is set to blink 1/128 of the duration of the zeroing event. Thus, to find out how long the zero will last, use the following formula:

LED Frequency = X min * 60(seconds) / 128

Thus, if the LED blinks about once every 7 seconds, then the zero check will iast for approximately 15 minutes. To increase the zero duration, turn the potentiometer clockwise, to decrease the time, turn it counter-clockwise.

4) To set the span duration, simply follow step number two for the right side potentiometer.

REMOTE ELECTRICAL INSTALLATION NOTES:

When installing a Model 1008 with internal timer, the user must be sure **not** to hook up more than one timing.device. In other words, if the internal timer is to used, do not hook up an external datalogger to perform remote zero and span functions.

All connections should be made at the rear panel, which contains a terminal block with several screws for different functions. For connections involving external dataloggers, use of the three right-hand side screws (looking at the terminal block) is necessary. To activate a function, simply "close" the contact between the +5V screw and the desired function ("zer" for zero check and "cal" for span check).

NOTE

The contact closure should be "floating" in relationship to the other equipment's power.

If the internal timer is to be used for. the automatic zero/span checks, then the connection should be made between the "Z" on the terminal block and the "zer" and between the "C" and the "cal". There should be no connections to the +5V.

TUBING CONNECTIONS FOR INSTALLATION:

On the back panel, there are two nylon fittings. These should be exhausted safely. One kynar outlet port labelled "vent" is for the connection between the unit to be calibrated and the calibrator. The "zero" inlet port should be connected to an appropriate *zero* air source.

C.7 Optics Cleaning Rod Assembly

A maintenance tool has been added to the standard 1008 unit to aid in the cleaning of absorption tubes in the optics cell for prevention of particulate matter build up. This tool is particularly helpful in the field where teflon tubing (which can also be used) may not be available.

The cleaning rod assembly components are clipped to the angle of the optics bench. The first rod on top of the other, includes a tip with a hole in the middle of it. This hole is provided for a Kim Wipe (or other such material) to be run through the tubes for dislodging all particulate matter. The bottom rod is provided to connect to the end of the top rod in order to create a length long enough to easily pass through the absorption tubes.

To use, simply disconnect both rods, screw the bottom rod into the top rod, slide a Kim Wipe into the tip of the top rod and push it through the absorption tubes. Reverse these instructions when the cleaning is completed.

C.8 Dual Ozone Output Option For Model 1008-RS (Figure C-4)

This option allows the unit to create two levels of ozone upon remote or manual command (referred to as "precision" for the lower ozone output and "span" for the higher level). This. option requires additional components on the Ozone Generator Board and special labels on the back panel terminal block.

To activate any desired function from the back panel while in the remote mode, short between the screw labeled "+5v" and the desired function. The two different levels of ozone generated are determined by the voltage divider combination of either the pot labeled R16 or the pot labeled R17 on the Ozone Generator Board and the digital front panel pot.

When the screws labeled "+5v" and "PRE" (precision) are shorted between them, pot R17 is switched into the circuit by a relay regardless of the status of any of the other controls (including the remote/local switch on the front panel). When this short is removed, pot R16 is switched into the circuit: again, regardless of the status of any of the other controls.

To actually generate ozone in the remote mode, however, you must also short between "+5v" and "ZERO" to activate the pump and valve, <u>and</u> also short between "+5v" and "SPAN" to enable the lamp. With both of these terminals activated, you then select either the "SPAN" or "PRE" concentration by the status of the "PRE" terminal.

In the local mode, the "PRE" terminal functions the same way as in the remote mode. The "SPAN" and the "ZERO" terminals, however, are now replaced by the front panel toggle switches.

C.9 1/16" Allen Wrenches

Dasibi is in the process of adding a 1/16" allen wrench into the Model 1008 unit as a tool to aid in standard unit maintenance procedures. The wrench would be housed inside of the optic bench's detector block in a slot, covered by a screw.

The tool can be removed by simply loosening the screw so that the head of the wrench is loosened, and pulling the wrench out. This wrench is used primarily for tightening, or loosening, the set screws in the detector block for the sample detector (and/or control detector, if present in the analyzer - it is also used for adjusting the control detector's aperture in cases where the control detector is being saturated by too much light hitting its surface). The wrench can be used for the removal of the front panel function switch's knob (required when removing the function switch for servicing).

C.10 On-Board Zero Air Filter For Models 1008-RS, PC & HC

The Models 1008-RS, 1008-PC & 1008-HC can be purchased with an on-board zero air filter assembly to allow automatic self-zero checks for the RS's, on-board zero air capabilities for use in the ozone generating sub-section of the Model 1008-PC and for the reference measurement air flow for the Model 1008-HC. This assembly (Z-0109-E) contains approximately .3 lbs of activated charcoal and should last for between 12-20 hours of use. The life of this charcoal can be maximized by setting the flow rate used through the ozone generator to 3.5 LPM, as this is the minimum flow rate required.

C.11 "KNF" 5-Liter Pumps Replace "ASF" Pumps

For many years, Dasibi Environmental has utilized 5-liter pumps manufactured by a company called "ASF". In an effort to increase the quality of the 5-liter pumps utilized in the "PC" or "RS" versions of the 1008 ozone analyzers, a switch has been made to pumps manufactured by a company called "KNF".

One side effect of this change has been the required use of a charcoal filter up-stream of the internal ozone generator. In all new units sold utilizing the KNF 5-liter pump, this charcoal filter is located at the outlet port of the ozone generator's flowmeter. All 5-liter KNF pumps purchased as replacement pumps will be shipped with these charcoal filters. The charcoal filter may or may not require replacement whenever a pump is replaced, though. The life expectancy of the charcoal filter will be dependent upon the characteristics of the zero air flowing through it. If the zero air contains pollutants (such as NO, or SO,), then the filter will become consumed much faster. If pure zero air is utilized through the ozone generating subsystem, then the filter could conceivably last forever.

To replace a charcoal filter already installed, simply loosen and disconnect the nut located on the outlet side of the filter and which extends from the tubing attached to the inlet port of the ozone generator. Pull the filter free and install a new one. Once the connection of the tubing is made, perform a leak check.

C.12 Pyrex Optics Tubes Changed to Stainless Steel Tubes

Dasibi is in the process of switching from the use of pyrex "absorption" tubes in the optics cell to stainless steel tubes in Models 1008-AH, PC and RS. These new tubes are completely retrofittable into any older 1008 analyzer without any modifications necessary. The *new* tubes are stock number Z-0378-A for each assembly (two per optics cell). The optics tube cleaning procedure described within this manual remains exactly the same and cleaning should be performed as regularly as with the pyrex tubes.

C.13 Dual Analog Output Option (Figure C-3)

There is an option available for the Model 1008 in which a second analog output range is added to the unit. The option consists of adding another potentiometer to the front panel, additional wiring to the terminal strip located on the back panel and slight modifications to the unit's D/A Board (refer to Figure C-3). Standard unit analog output is 1 volt; if the requested range(s) are different, the front panel potentiometers will be marked accordingly, as will the back panel terminal strip.

C.14 Changing the Unit's Analog Output Range

The analog output range of the 1008 can be modified very easily. Simply change resistor R14 on the unit's D/A Board to establish any of the following ranges:

Ranse	R14 Resistor Value	Dasibi Stock # For Resistor
1 PPM = .1 V	510 ohm	A-0059
1 PPM = .5 V	3 K	A-0410
1 PPM = 1.0 V	5.5 K	D-0015
1 PPM = 2.0 V	10 K	A-0010
1 PPM = 5.0 V	27 K	A-0012
1 PPM = 10.0 V	50 K	A-0005

C.15 New "Latching" Photometer Valve (Figs.C-7, 8, 9, 10 & 11)

Dasibi has changed the type of valve used in conjunction with the U.V. photometer in the 1008 series (but <u>not</u> the "remote" valve used in the Model 1008-RS) to a "latching" valve as opposed to the "energized/de-energized" (on/off) valve used since the introduction of the 1008 series. What is meant by "latching" is that the valve receives a "momentary" electrical pulse to change state. Once toggled into the appropriate state, the electrical signal is removed and the valve then stays in that state (rather than being either on or off depending on whether voltage is applied).

Therefore the terms "on" and "Off" no longer have any relevance when discussing the state of this valve. Instead, reference will now be made to either "Sample" or "Reference" pulses. After receiving one of these pulses, the valve will then be in a position that allows that particular gas to enter the optics bench. Thus, after receiving a "Sample Pulse", the valve will be in such a state that the sample gas will be fed directly into the optics cell (without going through the scrubber first): obviously, the "Reference Pulse" is when the valve diverts the air flow through the scrubber before it enters the optics cell.

This modification does not affect the principles/theory of operation in any way. It simply takes advantage of new '*state-of-the-art" components that have only recently been introduced to the market. The benefits of this new valve are two-fold:

1) First, and perhaps foremost, this new valve totally eliminates the "magnetic offset" present in use of the previous valve design. Since there is absolutely no magnetic field present when the monitor performs either its sample or reference frequency measurements, there will be absolutely no difference between those frequency measurements resulting from the magnetic field of the valve. Thus, the laborious task of rotating the lamp and/or detector(s) to find their "null" points is no longer necessary.

2) Secondly, the design of this new valve is such, that the restriction to air flow is dramatically reduced over that of the previous design to the point where, at 2 LPM, it is virtually non-existent. What this means is that the user can now rebuild/recondition the valve without the need to spend hours of time "balancing" the port restrictions, nor the need for expensive flow test equipment used to perform such tasks.

The only expendable/replaceable part of this valve, is the Viton diaphragm. To repair this valve, it is not necessary to remove the entire valve body from the instrument. Simply remove the top four screws holding the solenoid to the valve body and lift the solenoid off. Then either clean the body and/or replace the Viton diaphragm and replace the solenoid. (To clean the valve, however, it is very advantageous to remove the body).

For cleaning, first remove the solenoid as described above and then clean it using a small nylon bottle brush and isopropyl alcohol. After re-assembly, run the valve on about 800 ppb of ozone for about two hours to cleanse any residual alcohol and/or other substances.

Due to the change in operation of this valve, a design change has had to be made to certain circuitry inside the unit. Used in conjunction with this new valve, is a "Valve/Regulator Board". This board is attached to the side of the optics cell (directly beneath the optics cleaning tools) and serves two functions:

1) The new valve plugs directly into this board instead of plugging into the Mother Board.

2) The regulators that used to be mounted on the unit's LDHC Board are now mounted on this board. The reason for this modification is that this moves the regulators (which need to be "cooled") closer to the air flow of the instrument. The result is increased stability of the regulators, which in turn, increases the stability of the lamp output, which in turn increases the stability of the unit itself.

The diagram and schematics for the Valve/Regulator Board are provided at the end of this section. Since the regulators have been detached from the LDHC Board, this board has been essentially "stripped-down". In place of the regulators is a wiring connection that extends from the LDHC to the Valve/Regulator Board. A diagram and schematic for the stripped-down version of the LDHC Board is also provided at the end of this section.

C.16 New Features of the CPU/Memory Board

One of the primary reasons for the introduction of the CPU/Memory Board was to increase the memory space of the 1008 series of analyzer in order to allow new software features to be added to the instrument. These additions will occur over throughout the year of 1993 and will be carried in Appendix B until the next version of the 1008 manual is written.

The following sections will describe the first three new features added to the CPU/Memory Board since its inception.

C.16.1 "Diagnostic LED":

There is a single LED on top of the board, which will display a number continuously, depending upon the operational status of the unit, as well as the importance of the fault. If, for instance, two faults are present in the unit, only the more important of the two will be displayed. The lower the number, the higher the importance of the fault. Descriptions of the fault numbers that can be displayed are provided here:

0	=	No faults.
1	=	Not used yet.
2	=	Sample Frequency is not above 300 Khz, or is not below 480 Khz.
3	=	Control Frequency is not above 300 Khz, or is not below 480 Khz.
4	=	Lamp heater voltage is incorrect.
5	=	Not used yet.
6	=	Not used yet.
7	=	CPU reset occurrence.
8	=	Displayed whenever any front panel switch not in the correct position for proper operation.

These fault displays can be very useful in determining the cause of problems that may occur in the unit. They are not designed to diagnose the problem completely, but rather, save the end user time and effort in determining the **"possible"** causes. The fault numbers not currently being utilized should be available by the end of 1993.

C.16.2 "Selectable Averaging Switch":

This switch is mounted next to the LED display and allows the end user to change the number of readings being averaged every cycle. Currently, there are only two possible averaging possibilities:

0 = No averaging occurs; the cycle time of the instrument is 20 seconds.

1-9 = Averaging of five consecutive readings occurs; the cycle time of the instrument is 50 seconds.

C.16.3 **"Mode Switch":**

This switch is mounted below the LED display and allows the end user to change the output range of the display. Currently, there are only six mode possibilities:

0 = Parts Per Billion (PPB)
1 = mg/m^3
2 = % Weight in Oxygen Stream (For Model 1008-HC only)
3 = % Weight in Air Stream (For Model 1008-HC only)
4 = Parts-Per Ten-Thousand (For Model 1008-HC only)
5 = g/m^3 (For Model 1008-HC only)

C.17 DasibiNet Interface (Figures C-12, C-13, C-14 & C-15)

Dasibi has introduced a new concept for use in its Ambient Air Monitoring System, Model 1000. It is called "DasibiNet" and it essentially allows the end user to obtain valuable diagnostic information from each of the system's internally-mounted air monitoring instruments. Since the Model 1008-AH is the unit that provides ozone measurements for the System 1000, it has had the capability added to its list of available options.

DasibiNet is a multi-drop network in which diagnostic signals from more than one Dasibi instrument may be "linked" together utilizing just one telephone line: this line can then be attached to a modem for remote accessibility of a central computer system (as opposed to having several telephone lines connected to a site for such information).

This feature affects the configuration of the Model 1008-AH in two ways. First of all, there is an additional P.C. Board attached to the unit's back panel. This board, the Network Interface Board, allows the 1008 to be linked to the single network line and contains "In" and "Out" ports for connection of two telephone jacks'. There is another P.C. Board located in the Mother Board Bus where' the RS232 Board would usually be located. This board, the DasibiNet Board, attaches to the Network Interface Board on the back panel via cable connection. Diagram and schematics for these boards are provided at the end of this section.

C.18 New Back Panel Design For Models 1008-PC & -PS (Fig.C-17)

Dasibi has re-designed the back panel for Models 1008-PC and 1008-PS. This new design allows use of a fan on the back panel for either of these units in order to decrease internal instrument temperature.

Before this re-design, the only air flow inside the monitor was provided by a blower located on the side of the chassis next to the ozone generator's pump. In order to increase air flow throughout the interior of the unit (and consequently reduce the temperature inside), it was determined that a fan mounted in the same manner as on the other 1008 models, would be much more efficient. This modification does not affect the functionality of either models: it will only affect the location of the ports on the back panel. A diagram of this new design is provide in Figure C-17.

C.19 Error Code "3" Removed From Front Panel Display

The error code number "3" (which was a diagnostic code that indicated whenever the sample frequency was below 400 Khz) has been removed from the front panel display since this diagnostic code (as well as several others) is now indicated by an LED located on the unit's CPU/Memory Board (refer to Sections C.4 and C.16).

C.20 Special Application Note for Model 1008-PS

The unit purchased with this manual is referred to as the "Model 1008-PS" in order to distinguish it from the from the Dasibi transfer standard, referred to as the "Model 1008-PC". The front panel is labelled "1008-PC" for both units because end users many times wish to re-configure a primary standard into a transfer standard at a later date, or vice-versa; modification of one type to another is performed by simply removing the zero air manifold (or adding it), adding an internal ozone "scrubber" (or removing it) and modifying the plumbing accordingly.

Purchasers of the Model 1008-PS will notice a 3' piece of 1/4" O.D. Teflon tubing provided in the plastic bag containing the unit's manual. This tubing is provided to help balance the air pressure of the sample inlet and zero reference inlet air streams. Since primary standards utilize a customer-selected external zero air source for the "reference" half of the measurement cycle, a pressure imbalance may occur in which a negative offset is created in the unit. Consequently, Dasibi provides a piece of Teflon tubing that will be connected to the "Vent" port of the zero air manifold to prevent this occurrence. Please follow the instructions provided next:

1) After the unit has been checked-in and installed per the instructions in Sections 1 & 2 in this manual, simply connect the tubing to the "Vent" port of the zero air manifold located on the unit's back panel by removing the port's nut, sliding the tube through it and then re-connecting the nut back onto the fitting.

2) Attach a flow meter with a range of up to at least 6 LPM to the other end of this tubing.

3) Referring to the operational instructions provided in Section 5 of this manual, operate the unit so that it is sampling zero air.

4) Adjust the zero air supply until it provides a minimum of 3 LPM on the external flow meter whenever the photometer's valve is providing the reference half of the measurement cycle.

5) Remove the flow meter, but leave the tubing in place for continued pressure balancing.

C.21 Design Modification to the Model 1008-HC

Dasibi has modified the design of the Model 1008-HC High Concentration Ozone Analyzer in an effort to increase the longevity of several components utilized inside this 1008 configuration. The longevity of such components has been affected by the continual stream of high concentrations of ozone flowing through the instrument. The design modifications are described next:

Addition of Ozone Scrubber Filter:

An O_3 scrubber filter assembly has been installed directly downstream of the optics cell. This filter has been added to remove most of the O_3 in the air stream as it exists the measurement cell in order to protect the components located downstream of the cell. The materials contained inside of the assembly (Dasibi "ozone scrubber **refill"** stock number **S-0134A-B)** should be replaced periodically; how often will depend upon the flow rate, the frequency of analyzer usage and the level of O_3 flowing through it. Dasibi recommends replacing it every 300 hours of use until such time as an average replacement time period can be determined by the end user. Figure C-18 shows how the assembly is constructed.

Addition of Mounting Plate For Pressure Sensor:

A mounting plate has been installed into the Model **1008-HC** in order to locate it closer to the outlet of the charcoal filter assembly. This sensor was previously located upstream of the optics cell and was exposed to the high concentrations of ozone flowing through the instrument. By locating it directly downstream of the charcoal filter outlet port, the sensor's measurements are still accurate, while being protected from the harsh air flow.

Addition of Back Panel Fan:

A fan has been added to the Model 1008-HC's back panel in order to improve air circulation inside of the unit. This feature was not provided before because there was no real heat generation inside of the chassis that required improved air circulation. However,- by both adding a charcoal filter and moving the pressure sensor closer to the optics cell, an internal pump may be purchased (optionally) for use in the Model 1008-HC.

Change in Components' Materials:

All of the fittings utilized on the back panel of the Model 1008-HC have been changed from Kynar material, to longer-lasting stainless steel fittings. In addition, since the charcoal filter assembly has been added, use of tygon tubing replaces the use of Teflon. Tygon tubing is much easier to work with than is Teflon tubing (due to its increased flexibility).

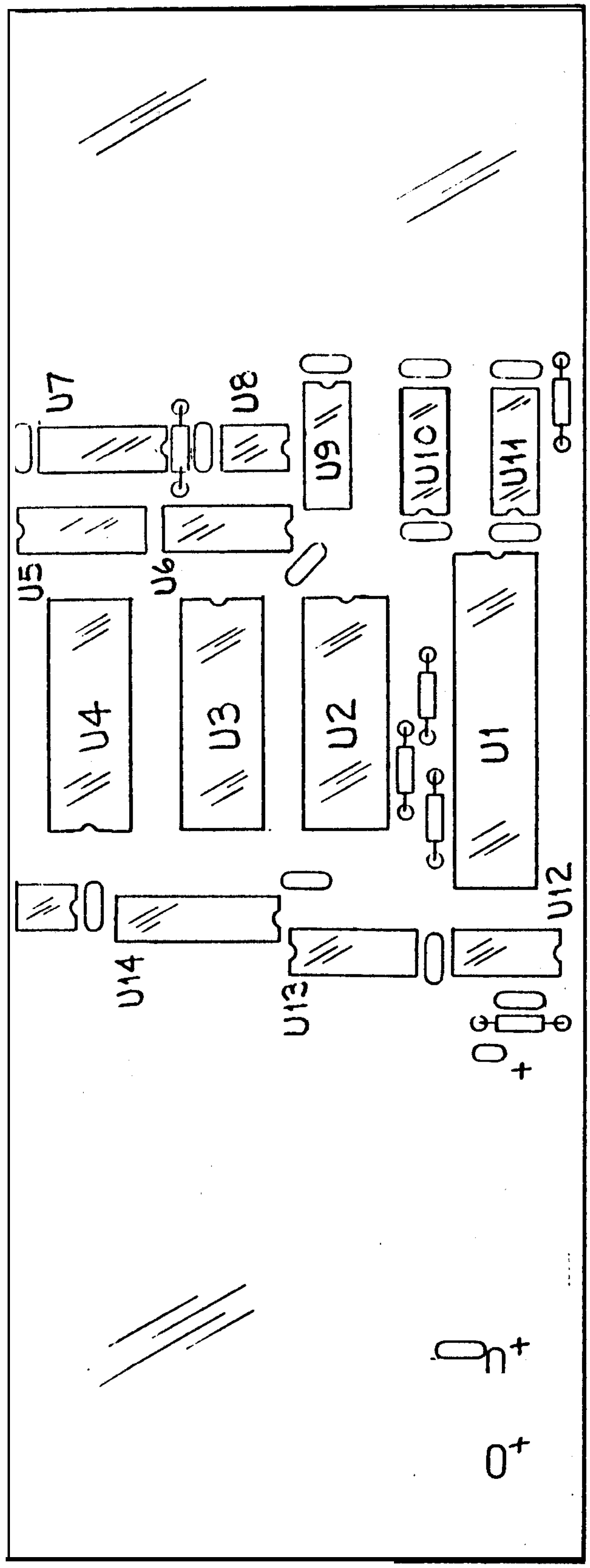


Figure C-l CPU/Memory Board Diagram

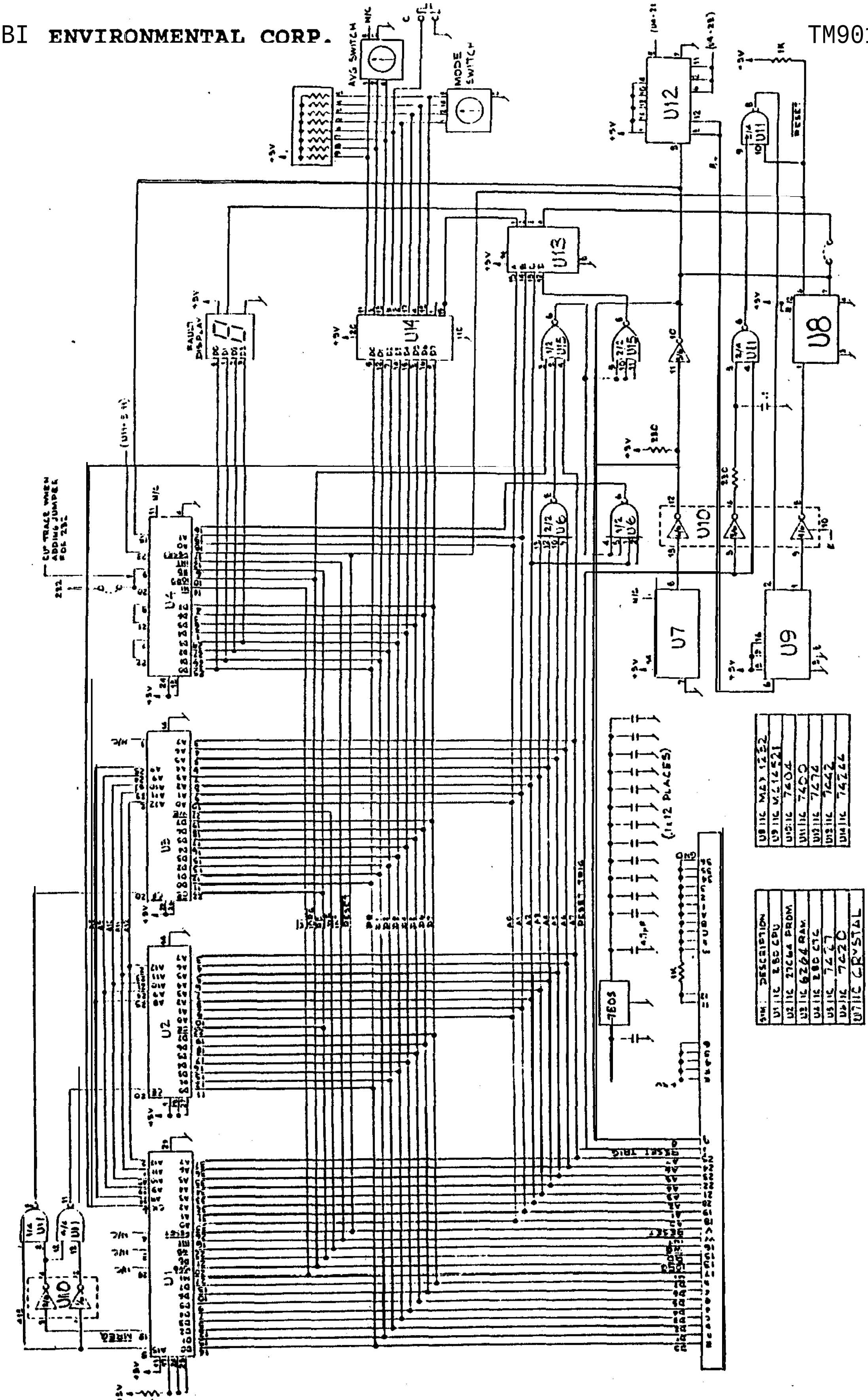
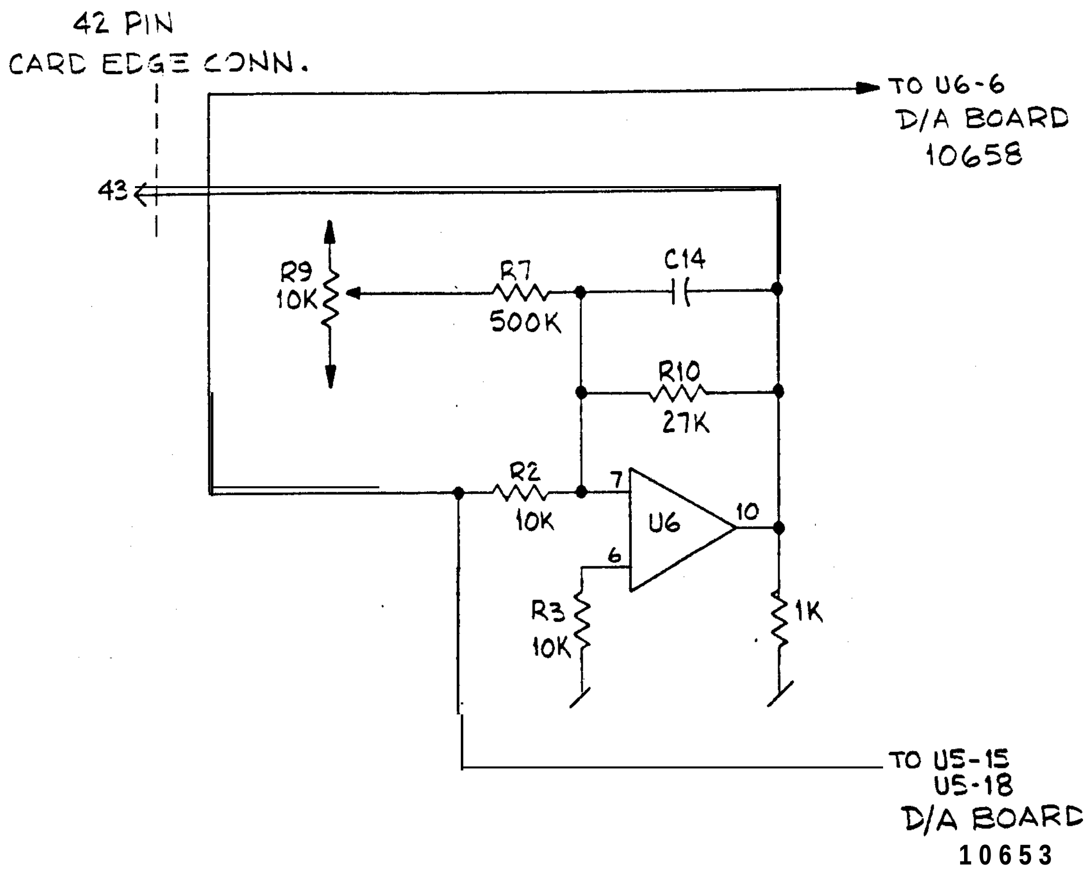


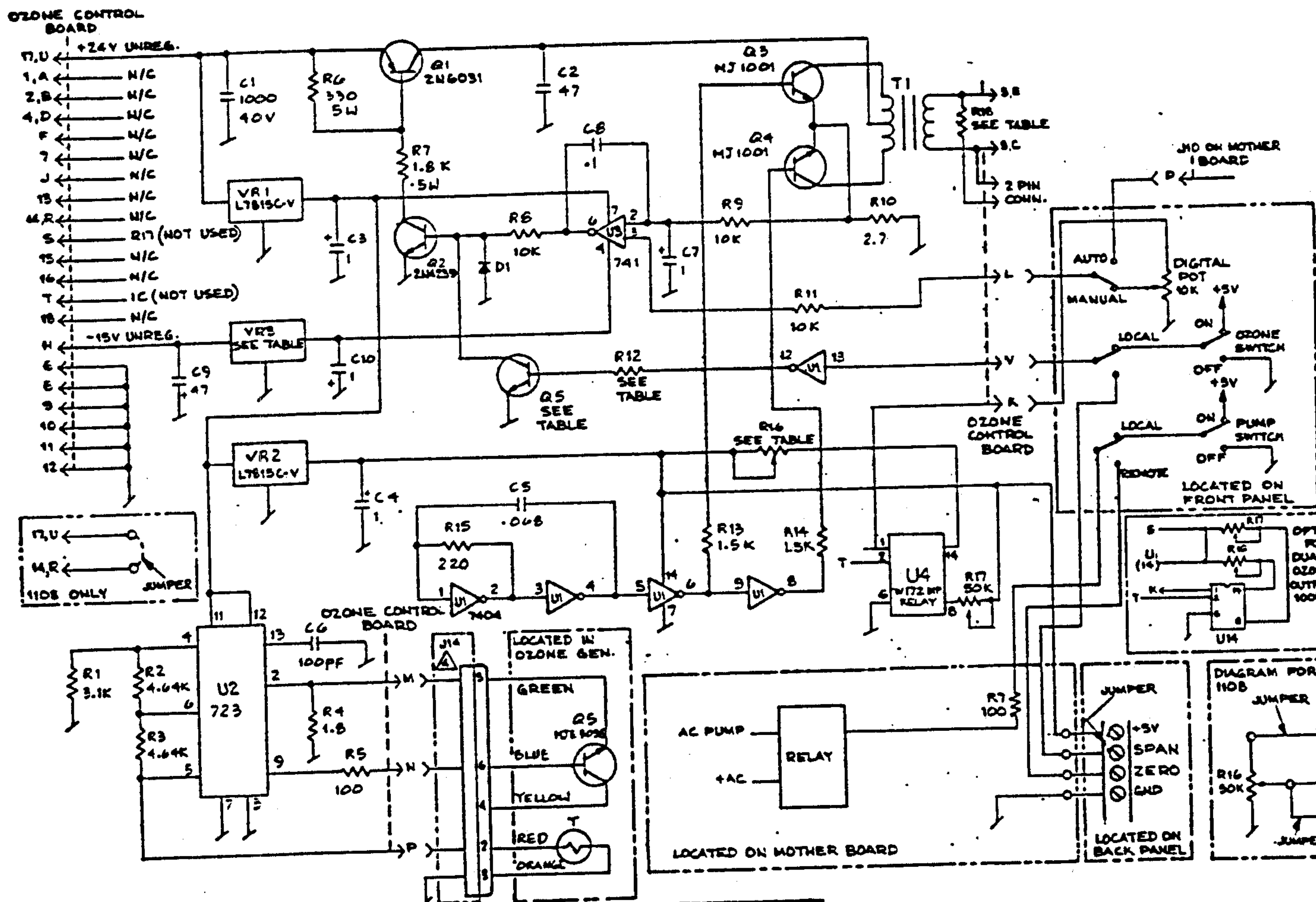
Figure C-2 CPU/Memory Board Schematics



3; TO BE USED WITH DASIBI PRINTED CIRCUIT BOARD D/A 10658.
2. CAPACITOR VALUES ARE IN MICROFARADS.
1. RESISTORS VALUES ARE IN OHMS.

NOTES:

Figure C-3 D/A Board Dual Analog Schematics Modification



REF DES	MODEL 1003	MODEL 1003 RS	MODEL 1108
R12	1.8K	1.8K	NOT USED
R16	50K	50K	SEE DIAGRAM
R18	NOT USED	15K	15K
VR3	7915CT	7915CT	JUMPER
Q5	2N3904	2N3904	NOT USED

4. (triangle) J14 IS LOCATED ON THE MOTHER BD.
3. RESISTORS ARE IN OHMS.
2. CAPACITORS ARE IN MICROFARADS.
1. (triangle) SWITCH NOT INCLUDED IN MODEL 1003-PC MODEL 1003-PC WIRED DIRECTLY TO MANUAL.

NOTES: UNLESS OTHERWISE SPECIFIED

Figure C-4 Dual Ozone Output Option Schematics

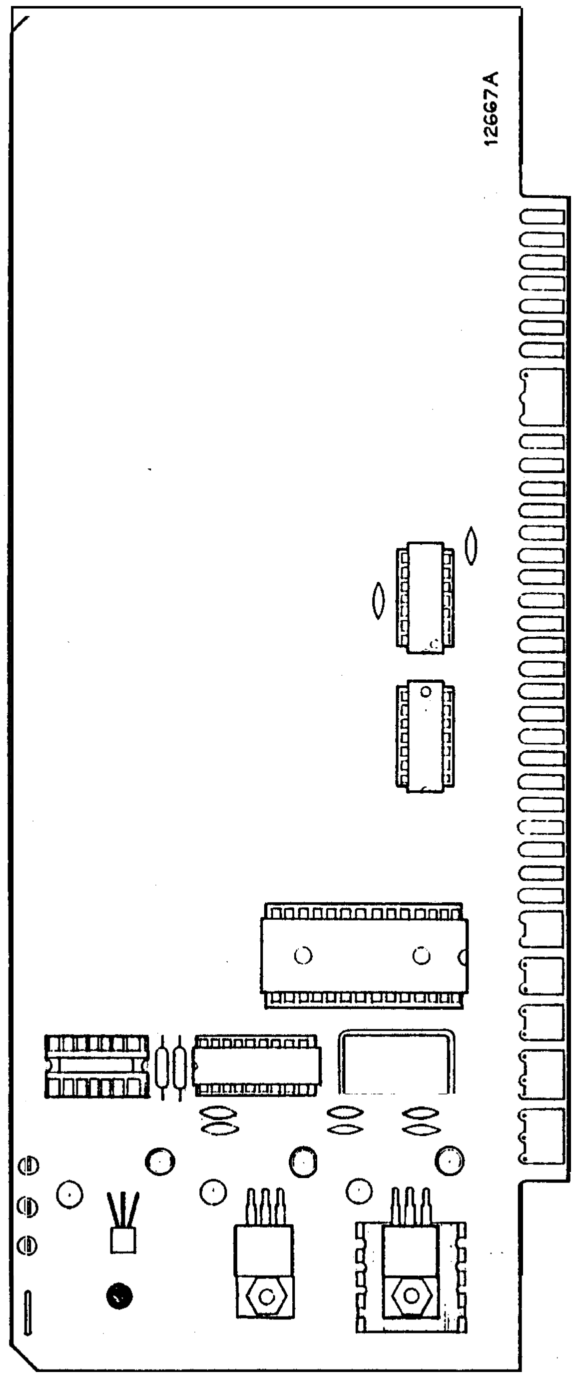


Figure C-5 Optional RS232 Interface Board Diagram

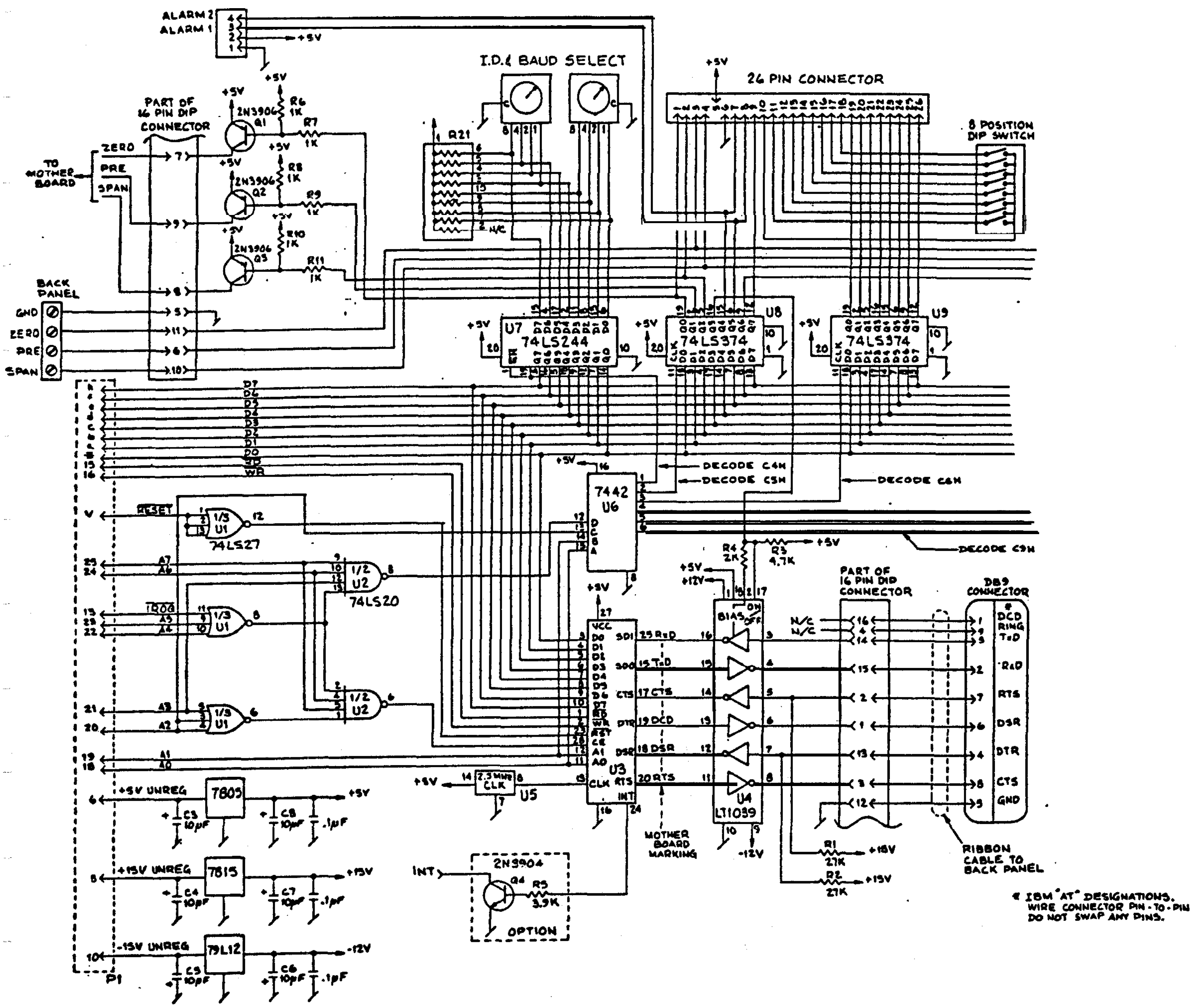


Figure C-6 Optional RS232 Interface Board Schematics (A)

1008-RS	
HOLE	FITTING
A	(2)
B	(4)
C	(2)

1008-AH	
HOLE	FITTING
A	(1)
B	(3)
C	(2)

1008-PC	
HOLE	FITTING
A	(1)
B	(1)
C	(2)

1008-HC	
HOLE	FITTING
A	(1)
B	(1)
C	(2)

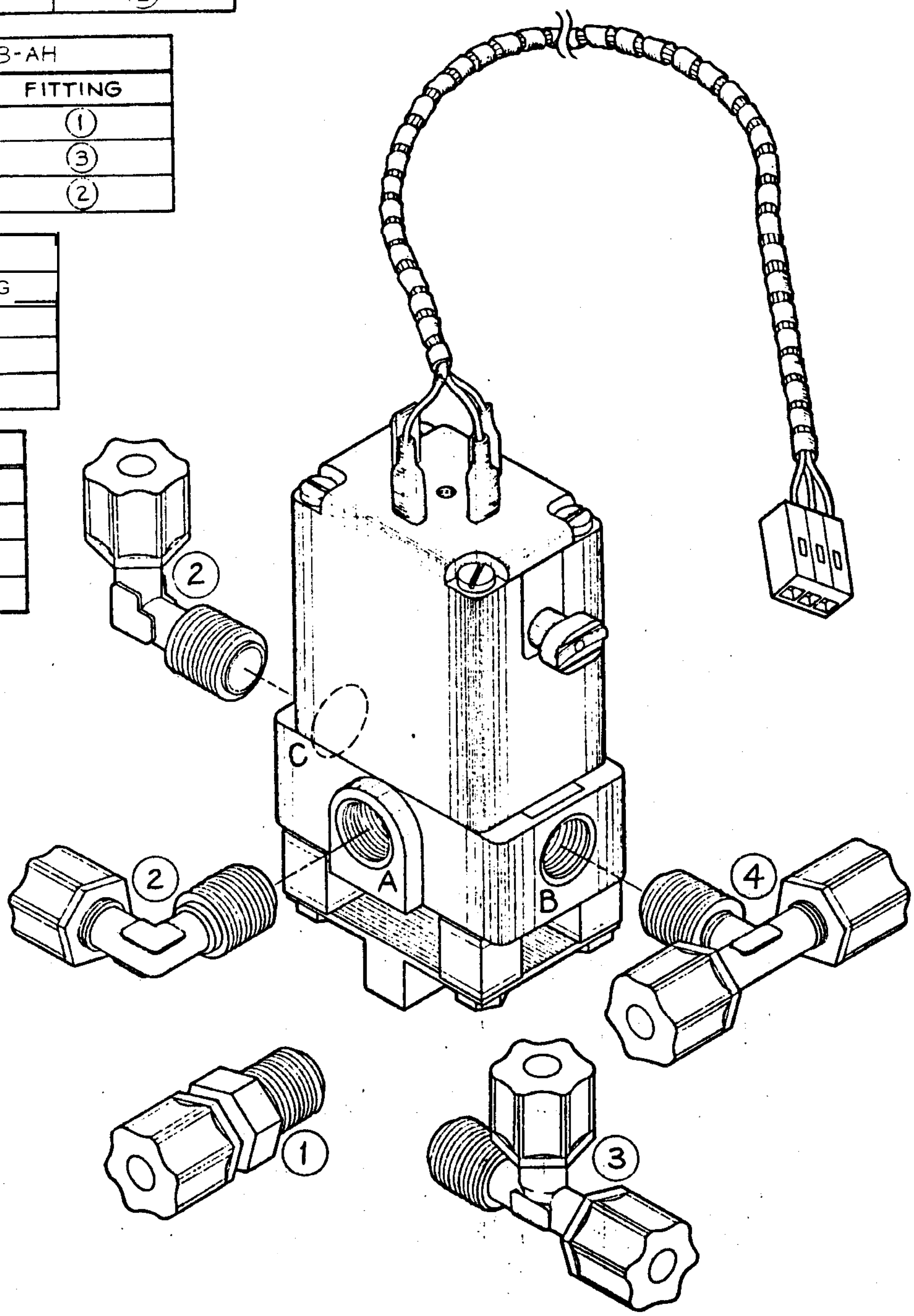


Figure C-7 New "Latching" Valve Diagram

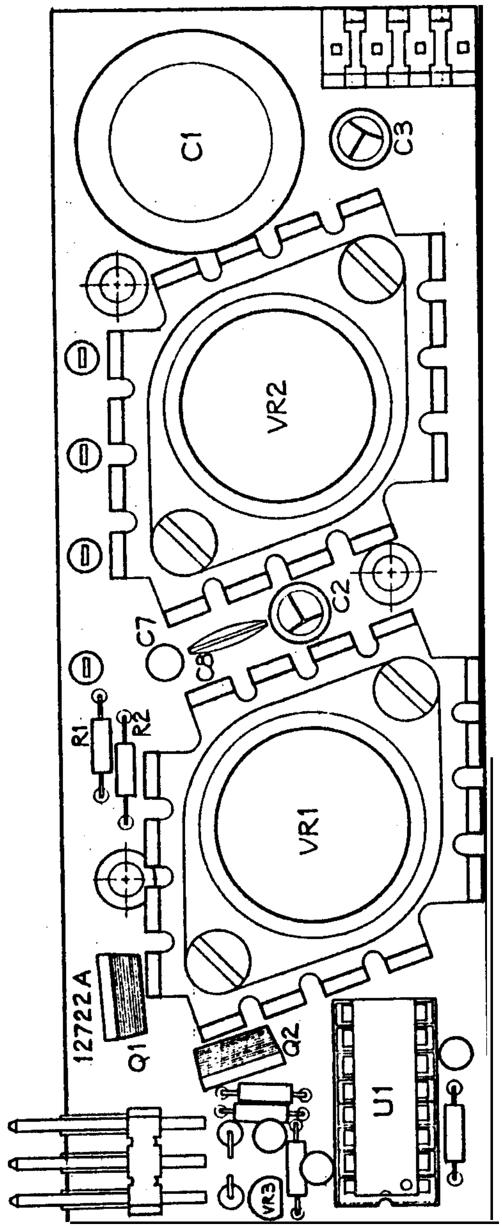


Figure C-8 New Valve/Regulator Board Diagram

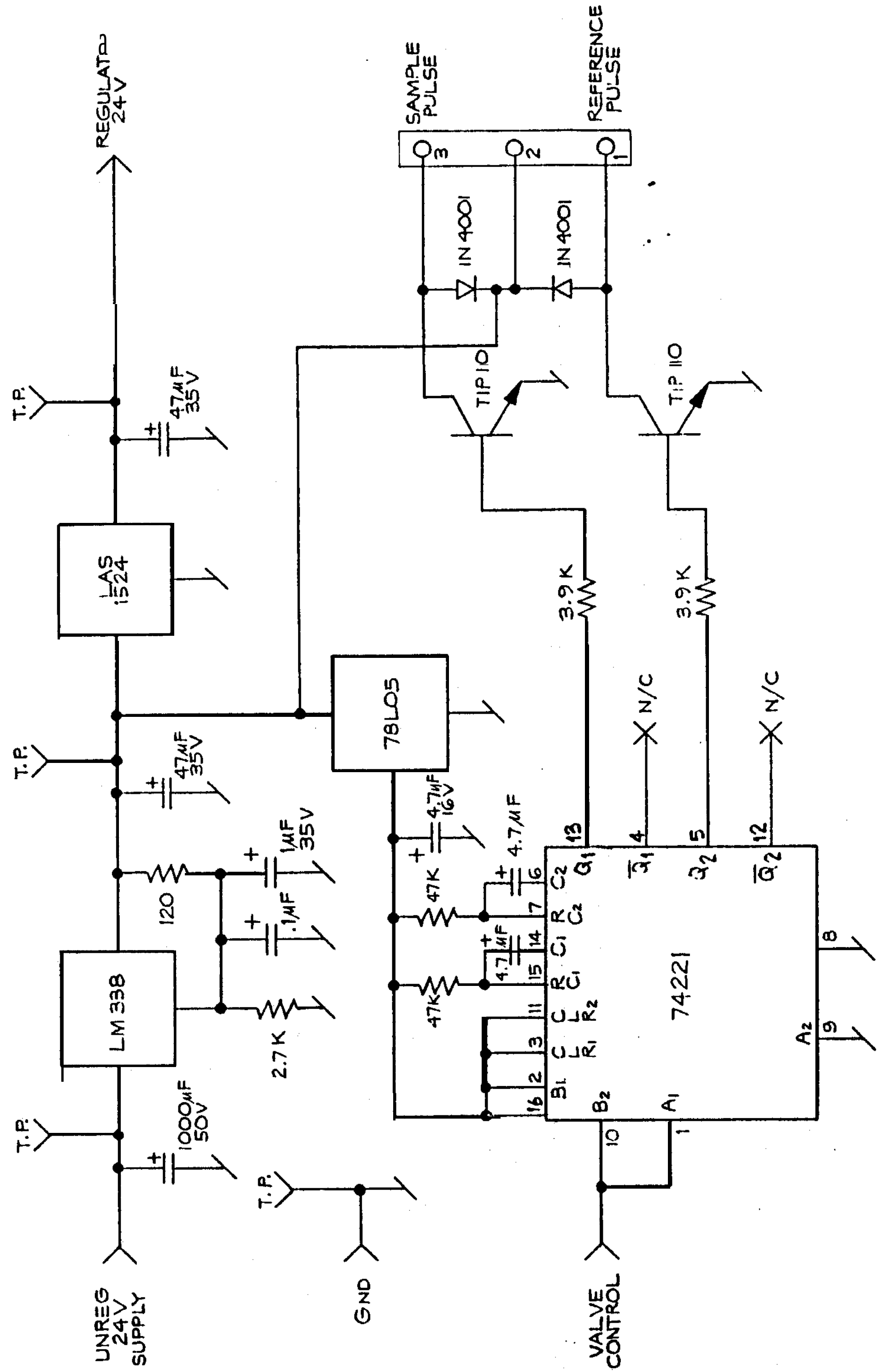
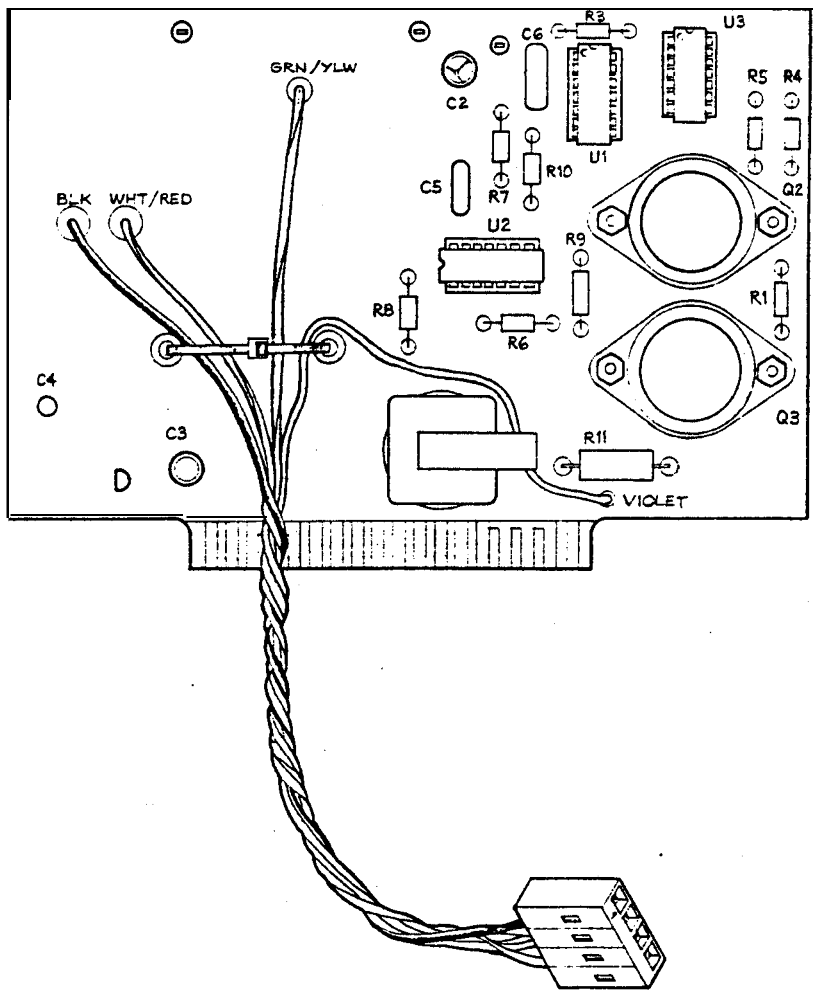


Figure C-9 New Valve/Regulator Board Schematics



PIN 1 - BLACK
PIN 2 - GREEN/YELLOW } (18 GAUGE)
PIN 3 - WHITE / RED
PIN 4 - VIOLET (22 GAUGE)

Figure C-10 Stripped-Down LDHC Board Diagram

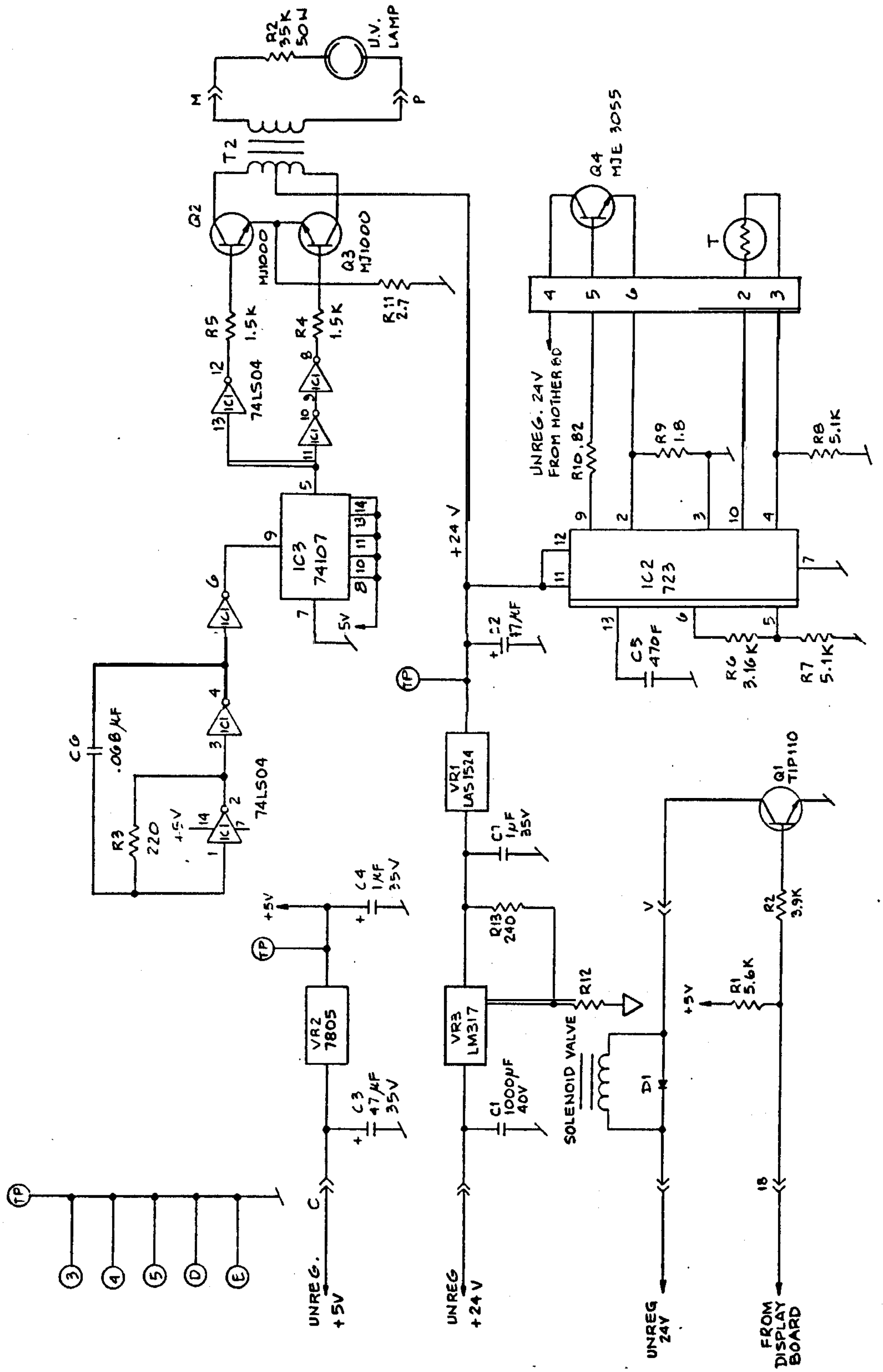


Figure C-11 Stripped-Down LDHC Board Schematics

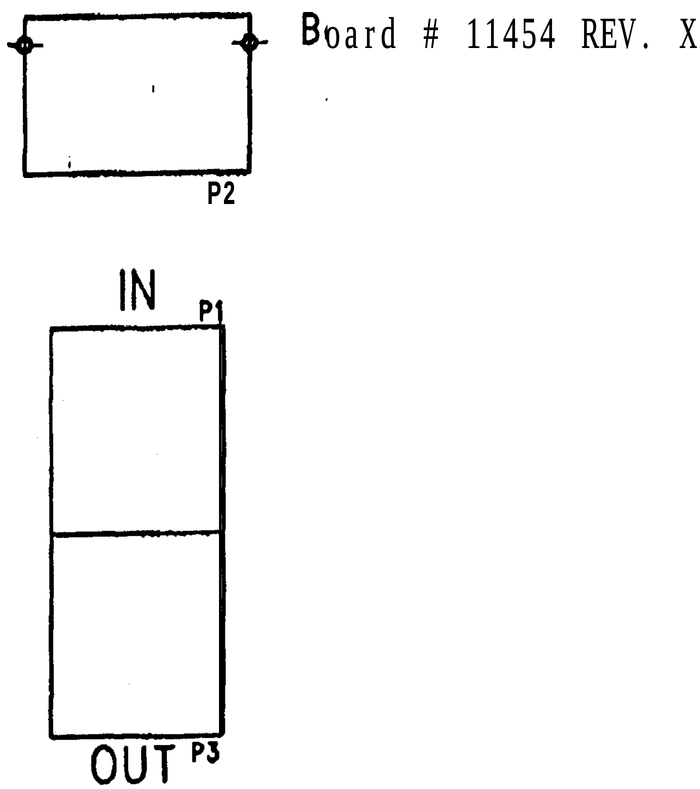


Figure C-12 Network Interface Board Diagram

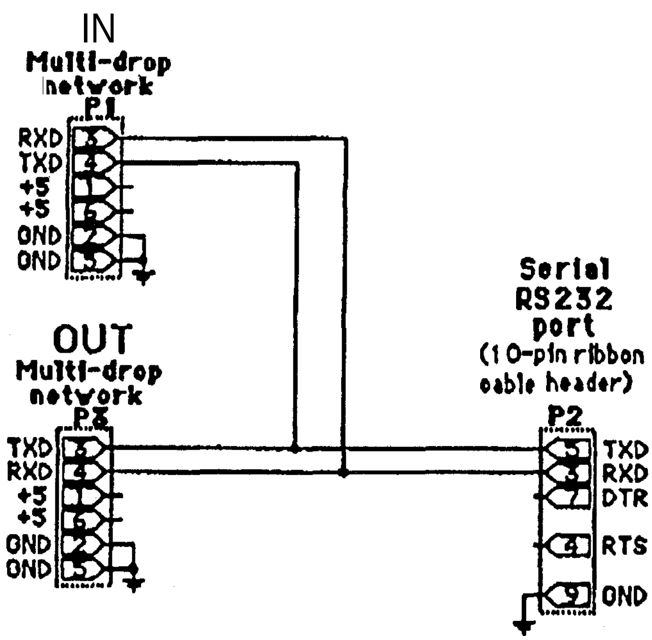


Figure C-13 Network Interface Board Schematics

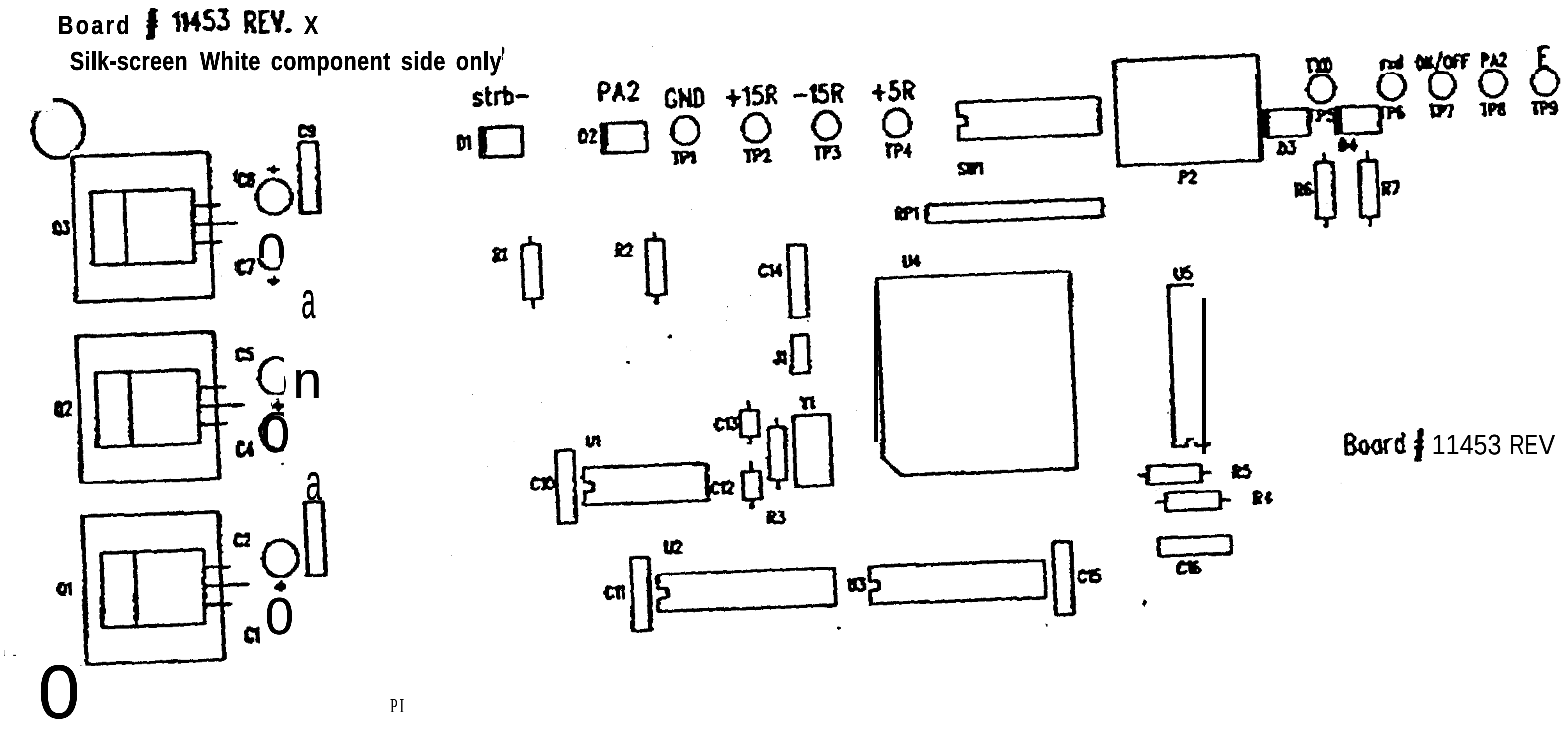


Figure C-14 DasibiNet Board Diagram

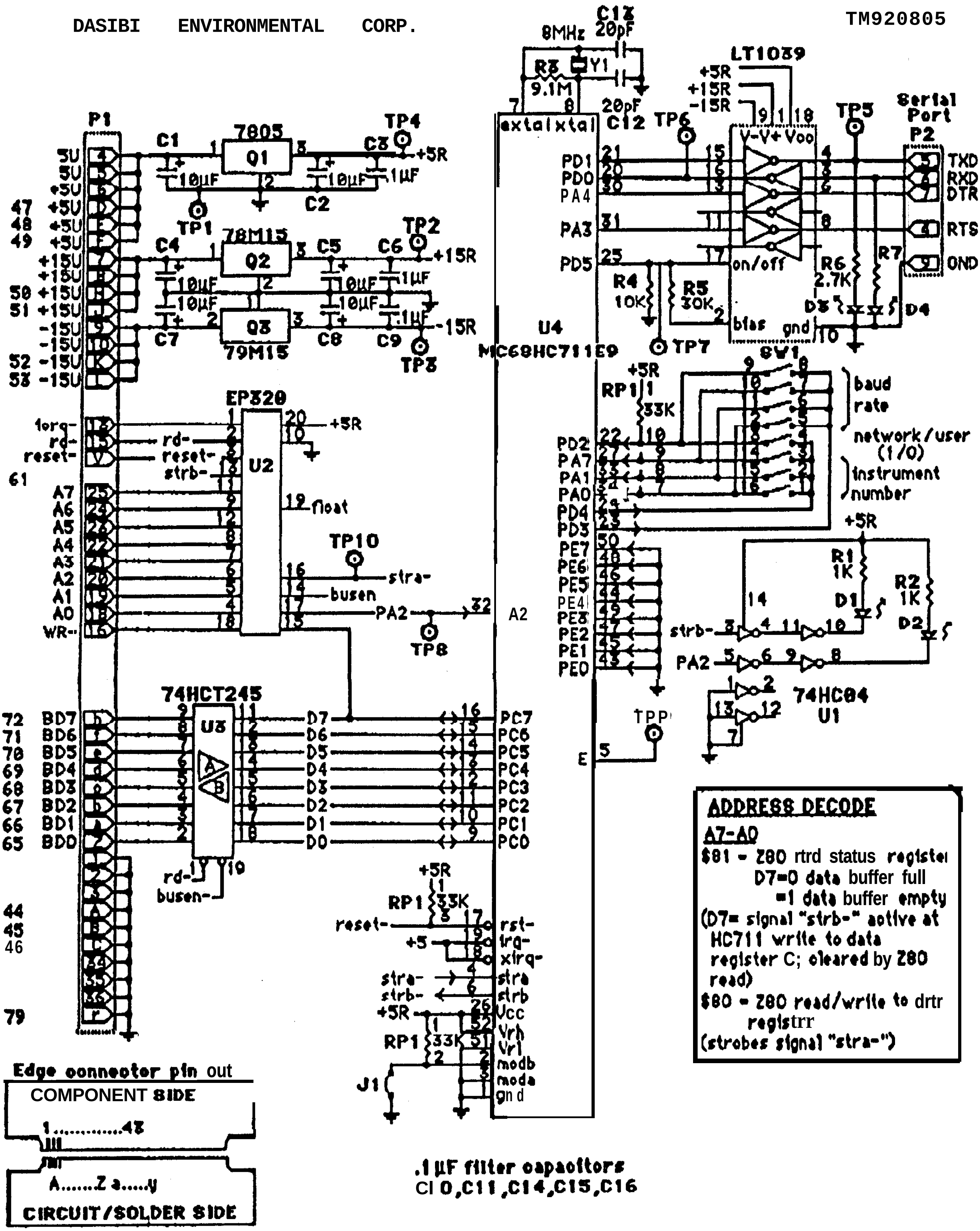


Figure C-15 DasibiNet Board Schematics

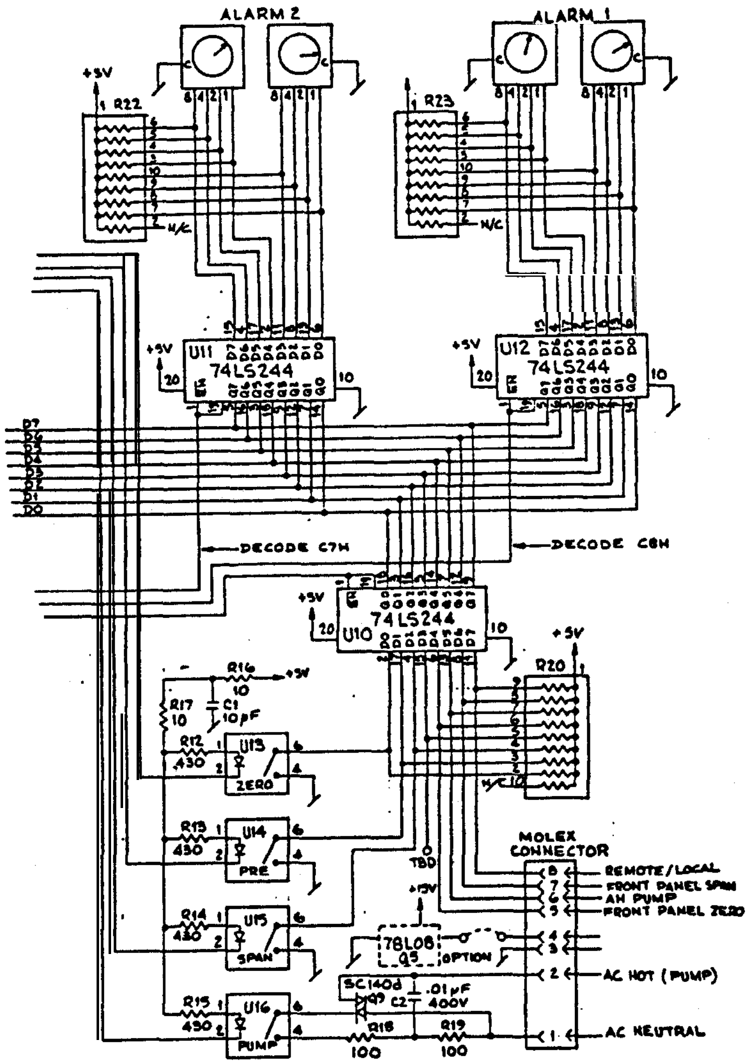


Figure C-16 RS232 Board Schematics (B)

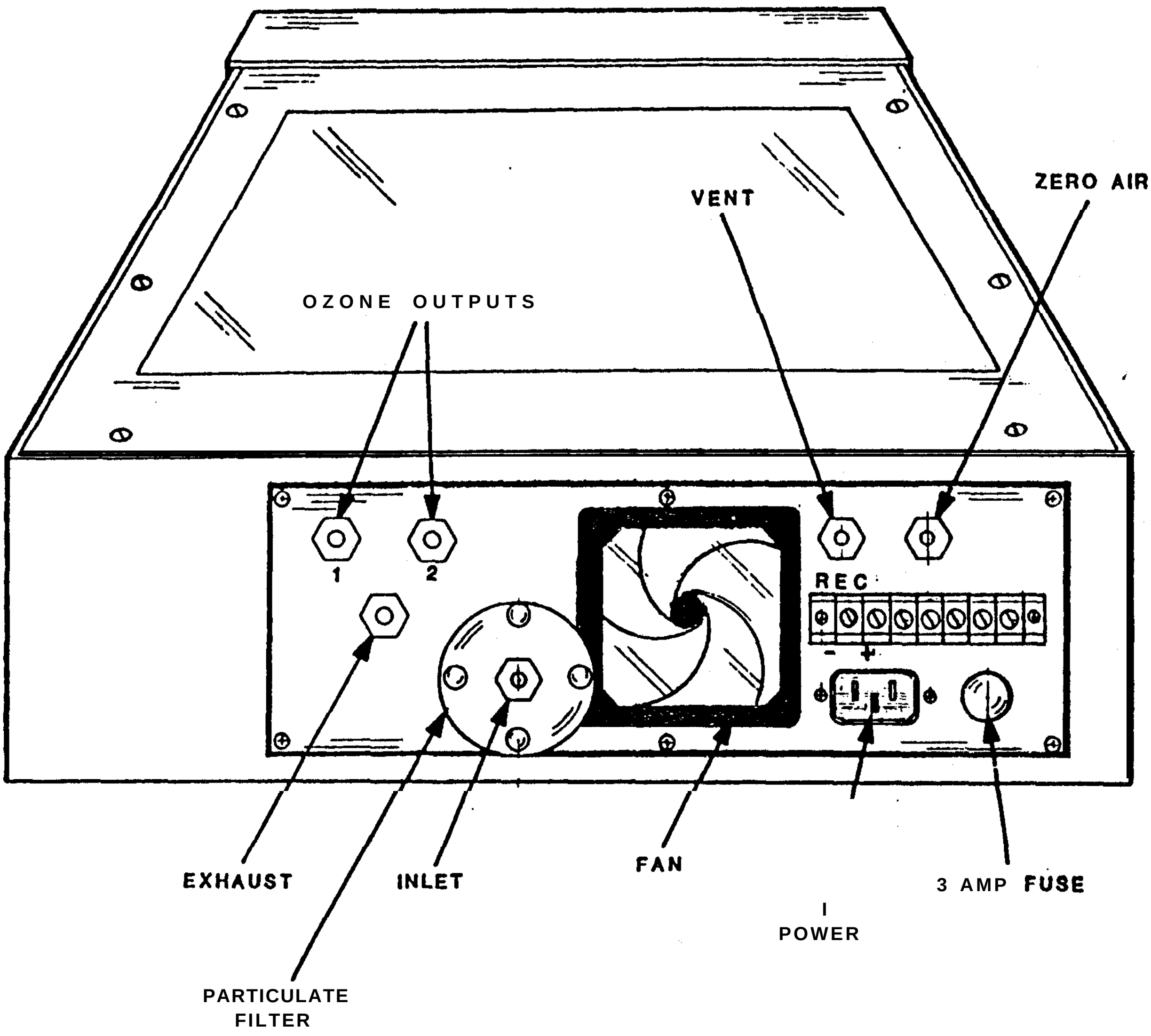


Figure C-17 New Back Panel Design For Models 1008-PC & 1008-PS

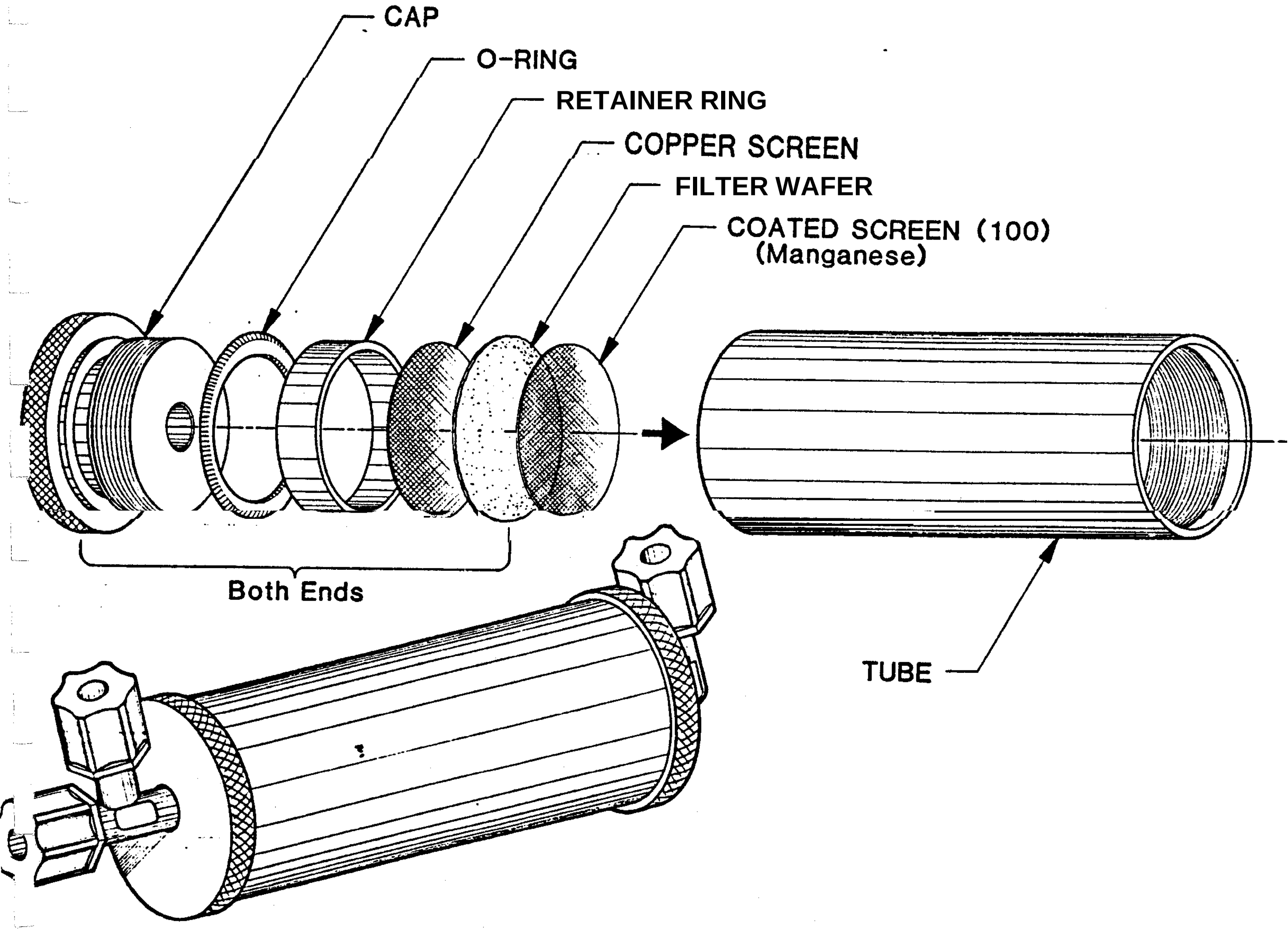


Figure C-18 Construction of 1008-HC Ozone Scrubber Assembly

APPENDIX D

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***** End of Manual *****