Rosemount Analytical

MODEL 951A
NO/NOX ANALYZER
INSTRUCTION MANUAL

556383-Y

NOTICE

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PREFACE

SAFETY SUMMARY

To avoid explosion, loss of life, personal injury and damage to this equipment and on-site property, all personnel authorized to install, operate and service the Model 955A should be thoroughly familiar with and strictly follow the instructions in this manual. **Save these instructions.**

If this equipment is used in a manner not specified in these instructions, protective systems may be impaired.

DANGER is used to indicate the presence of a hazard which **will** cause **severe** personal injury, death, or substantial property damage if the warning is ignored.

WARNING is used to indicate the presence of a hazard which **can** cause **severe** personal injury, death, or substantial property damage if the warning is ignored.

CAUTION is used to indicate the presence of a hazard which **will or can** cause **minor** personal injury or property damage if the warning is ignored.

NOTE is used to indicate installation, operation or maintenance information which is important but not hazard-related.

WARNING: ELECTRICAL SHOCK HAZARD

Do not operate without doors and covers secure. Servicing requires access to live parts which can cause death or serious injury. Refer servicing to qualified personnel.

For safety and proper performance this instrument must be connected to a properly grounded three-wire source of power.

WARNING: ULTRA VIOLET LIGHT HAZARD

UV light from the ozone generator can cause permanent eye damage. DO NOT LOOK DIRECTLY AT THE UV SOURCE IN THE OZONE GENERATOR. Use of UV filtering glasses is recommended.

WARNING: OZONE HAZARD

This instrument generates ozone while operating. Ozone is toxic by inhalation and is a strong irritant to the throat and lungs. Ozone is also a strong oxidizing agent. Its presence is detected by a characteristic pungent odor.

The instrument EXHAUST outlet contains ozone and nitrogen dioxide which is toxic by inhalation. The BYPASS outlet contains various oxides of nitrogen, and if the sample source is from the exhaust of an internal combustion engine, it may contain unburned hydrocarbons and carbon monoxide which is highly toxic and, depending on duration of exposure, can cause headache, nausea, loss of consciousness and death.

Avoid any inhalation of the internally generated ozone, sample, EXHAUST and BYPASS discharge. Keep all tubing fittings checked for tightness to avoid internal leaks.

Connect rear panel EXHAUST and BYPASS outlets to outside vent via separate lines 1/4 inch (6.3mm) or larger. Use only Teflon or stainless steel tubing.

WARNING: PARTS INTEGRITY

Tampering or unauthorized substitution of components may adversely affect safety of this product. Use only factory documented components for repair.

CAUTION: AIR FLOW

Do not operate instrument without air flow to the ozonator; plugging of the filter will result.

CAUTION: HIGH PRESSURE GAS CYLINDERS

This instrument requires use of oxygen and a known standard gas in high pressure cylinders. Refer to Handling and Storing High Pressure Gas Cylinders located in the rear of this manual.

SPECIFICATIONS

CATALOG NUMBER	193702 Model 951A NO/NOx Analyzer
RANGES	Selectable fullscale range of 10, 25, 100, 250, 1000, 2500 and 10,000 parts per million
SENSITIVITY	0.1 ppm on 10 ppm range
LINEARITY	±1% of fullscale The specified linearity is obtainable throughout the operating range, contingent upon use of an appropriate combination of oxygen source gas, gas pressure settings and electronic adjustments.
RESPONSE TIME (ELECTRONIC PLUS FLOW)	
STANDARD SAMPLE CAPILLARY	Approximately one second on all ranges except 10 ppm. Approximately three seconds on 10 ppm range.
AUXILIARY SAMPLE CAPILLARY	Five seconds on all ranges. For such applications as monitoring stack sources, where comparatively slow response is desired, an internal switch provides an optional electronic response time of approximately 10 seconds to 90% of fullscale on all ranges.
PRECISION	±5% of fullscale
STABILITY	
ZERO	1% of fullscale in 24 hours
SPAN	1% of fullscale in 24 hours
DETECTOR OPERATING TEMPERATURE	Atmospheric
RECORDER OUTPUT	Selectable output of 10 millivolts, 100 millivolts, 1 volt or 5 volts
AMBIENT TEMPERATURE	40°F to 100°F (4.4°C to 37.7°C)
ELECTRICAL POWER REQUIREMENTS	107 to 127 VAC, 50/60 Hz, 1000 watts
DIMENSIONS	9.0 x 17.8 x 22.0 inches (228.6 x 450.9 x 558.8mm) HxWxD
WEIGHT	76 lbs (34.5 kg)

CUSTOMER SERVICE, TECHNICAL ASSISTANCE AND FIELD SERVICE

For order administration, replacement Parts, application assistance, on-site or factory repair, service or maintenance contract information, contact:

Rosemount Analytical Inc.
Process Analytical Division
Customer Service Center
1-800-433-6076

RETURNING PARTS TO THE FACTORY

Before returning parts, contact the Customer Service Center and request a Returned Materials Authorization (RMA) number. Please have the following information when you call: *Model Number, Serial Number, and Purchase Order Number or Sales Order Number.*

Prior authorization by the factory must be obtained before returned materials will be accepted. Unauthorized returns will be returned to the sender, freight collect.

When returning any product or component that has been exposed to a toxic, corrosive or other hazardous material or used in such a hazardous environment, the user must attach an appropriate Material Safety Data Sheet (M.S.D.S.) or a written certification that the material has been decontaminated, disinfected and/or detoxified.

Return to:

Rosemount Analytical Inc.
4125 East La Palma Avenue
Anaheim, California 92807-1802
USA

TRAINING

A comprehensive Factory Training Program of operator and service classes is available. For a copy of the *Current Operator and Service Training Schedule* contact the Technical Services Department at:

Rosemount Analytical Inc.
Phone: 714-986-7600
FAX: 714-577-8006

DOCUMENTATION

The following Model 951A NO/NOx Analyzer instruction materials are available. Contact Customer Service or the local representative to order.

556383 Instruction Manual (this document)

COMPLIANCES

This product may carry approvals from several certifying agencies, for use in non-hazardous, indoor locations

97-C218

NOTES

1 INTRODUCTION

1.1 OVERVIEW

The Model 951A NO/NOx Analyzer continuously analyzes a flowing gas sample performing one of two switch selectable determinations:

1. Nitric oxide (NO); or
2. Combined nitric oxide (NO) and nitrogen dioxide (NO,) designated NOx. By definition [NOx] = [NO] + [NO_2].

Typical applications include analyzing vehicular exhaust emissions from internal combustion engines and monitoring the effluent from stationary (stack) sources

The analyzer utilizes the chemiluminescent method of detection In the nitric oxide determination, sample NO is quantitatively converted into NO_2 by gas-phase oxidation with molecular ozone produced within the analyzer from air or oxygen supplied by an external cylinder. A characteristic of this reaction is the elevation of approximately 10% of the NO_2 molecules to an electronically-excited state, followed by immediate reversion to the non-excited state accompanied by emission of photons.

The emitted photons impinge on a photomultiplier detector generating a low-level DC current. The current is amplified to drive a front panel meter and an accessory potentiometric recorder if desired.

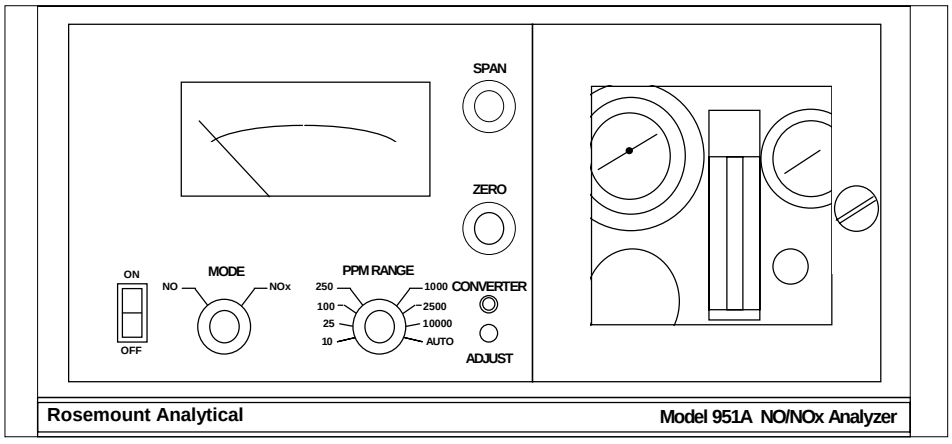


FIGURE 1-1. MODEL 951A NO/NOX ANALYZER

To minimize noise and reduce dark current, the photomultiplier tube is mounted in a thermoelectrically-cooled housing with temperature held constant at about 59°F (15°C). Control circuitry is contained in the 652831 Cooler Temperature Controller/Power Supply Assembly. The power supply circuit provides a high-current source of DC voltage. A thermistor sensor attached to the housing, and an associated switching transistor, control a pass transistor, providing closely regulated on-off control.

Attached to the cooler housing is thermal fuse F3, setpoint 150°F (65°C). This fuse protects the thermoelectric cooler against the overheating that otherwise could occur as a result of excessively high ambient temperature or failure of a fan.

CAUTION: EXCESSIVE HEAT

Do not operate this analyzer without the air duct covering the cooling fins of the thermoelectric cooler. Excessive heat may damage the cooling devices. The cooler indicator lamp DS1 (mounted on the upper left side of the inner flow regulator panel and can be viewed through the window) will cycle on and off until a control point is reached.

Analyzer functioning for the NOx determination is identical to that described above for the NO determination except that, before entry into the reaction chamber, the sample is routed through a converter where the NO_2 component is dissociated to form NO. Instrument response is proportional to total NO in the converted sample, that is the sum of the NO present in the original sample plus the NO produced by dissociation of NO_2.

To minimize system response time an internal sample-bypass feature provides high-velocity sample flow through the analyzer.

The electronic circuitry is modularized, utilizing plug-in printed circuit boards with solid state components and test jacks for easy troubleshooting and replacement.

If desired, the Model 951A may be factory equipped with various optional features in addition to the standard features of the basic instrument. Brief descriptions of the principal options are given in the following section.

1.2 OPTIONS

RANGE I.D.

This option provides contact closure signals that enable a computer or other external device to identify the setting of the front panel PPM RANGE Switch. The Model 7D Thermal Conductivity Analyzer is designed to continuously measure the concentration

of a single component of interest in a flowing gas mixture. The measurement is based on the different thermal conductivity's of the individual components of the sample stream. The method is especially well suited to analysis of two-component sample streams. However, analysis of multi-component streams is possible if the various components of the background gas occur in relatively constant ratio, or have similar thermal conductivity's.

REMOTE RANGE CHANGE

For applications where remote operation of the analyzer is desired, as in an emission test console, the Remote Range Change Option may be used. This option permits either the operator or a computer to override and disable the front panel MODE and PPM RANGE Switches and thus to control selection of: (a) NO or NOx mode, and (b) parts-per-million range.

The unit consists of an electrical plug connector with plug-in logic card and harness for connection to a rear panel terminal strip on the analyzer.

RANGE I.D. AND REMOTE RANGE CHANGE

The Range I.D./Remote Range Change Option is a combination of the Range I.D. and Remote Range Change options. This option is compatible with a user supplied remote control system employing a 24 VDC digital output and input for analyzer range control and analyzer range sense, respectively. It is completely integral within the analyzer and provides a terminal strip on the rear of the analyzer for connections of the user cable.

SAMPLE PUMP

The basic Model 951A is designed to accept pressurized samples. To permit analysis of gases at atmospheric or sub-atmospheric pressure the analyzer may be equipped with an optional, internally mounted sample pump. This option is not available on Low Tempco versions of the 951A. An external, accessory pump can be ordered instead.

NOTES

2 INSTALLATION

2.1 FACILITY PREPARATION

Sections 2.1.1 through 2.1.3 provide information that may be required prior to installation of the analyzer.

2.1.1 OUTLINE AND MOUNTING DIMENSIONS

Significant dimensions are shown in Figure 2-1.

2.1.2 LOCATION

Install analyzer in a clean area, not subject to excessive vibration or extreme temperature variations .

Preferably, the analyzer should be mounted near the sample stream, to minimize sample transport time. A circuit controlled by a thermal switch holds internal temperature of the analyzer to the correct operating temperature for ambient temperatures in the range 40°F to 100°F (4.4°C to 37.7°C). *Temperatures outside these limits necessitate use of special temperature controlling equipment or environmental protection.*

Preferably, the cylinders of air (or oxygen) and span gas should be located in an area of relatively constant ambient temperature.

2.1.3 POWER REQUIREMENTS

Electrical power requirements are 107 to 127 VAC, 50/60 Hz, 1000 watts.

2.2 UNPACKING

Unpack instrument carefully. Preparatory to shipment, the photomultiplier tube housing and the sample pump (if instrument is so equipped) are immobilized with hold down screws, inserted from the bottom of the instrument and marked with red paint for identification. The hold down screws must be removed prior to operation of the instrument. In the event the instrument is ever returned to the factory, these screws must be replaced to ensure safe shipment.

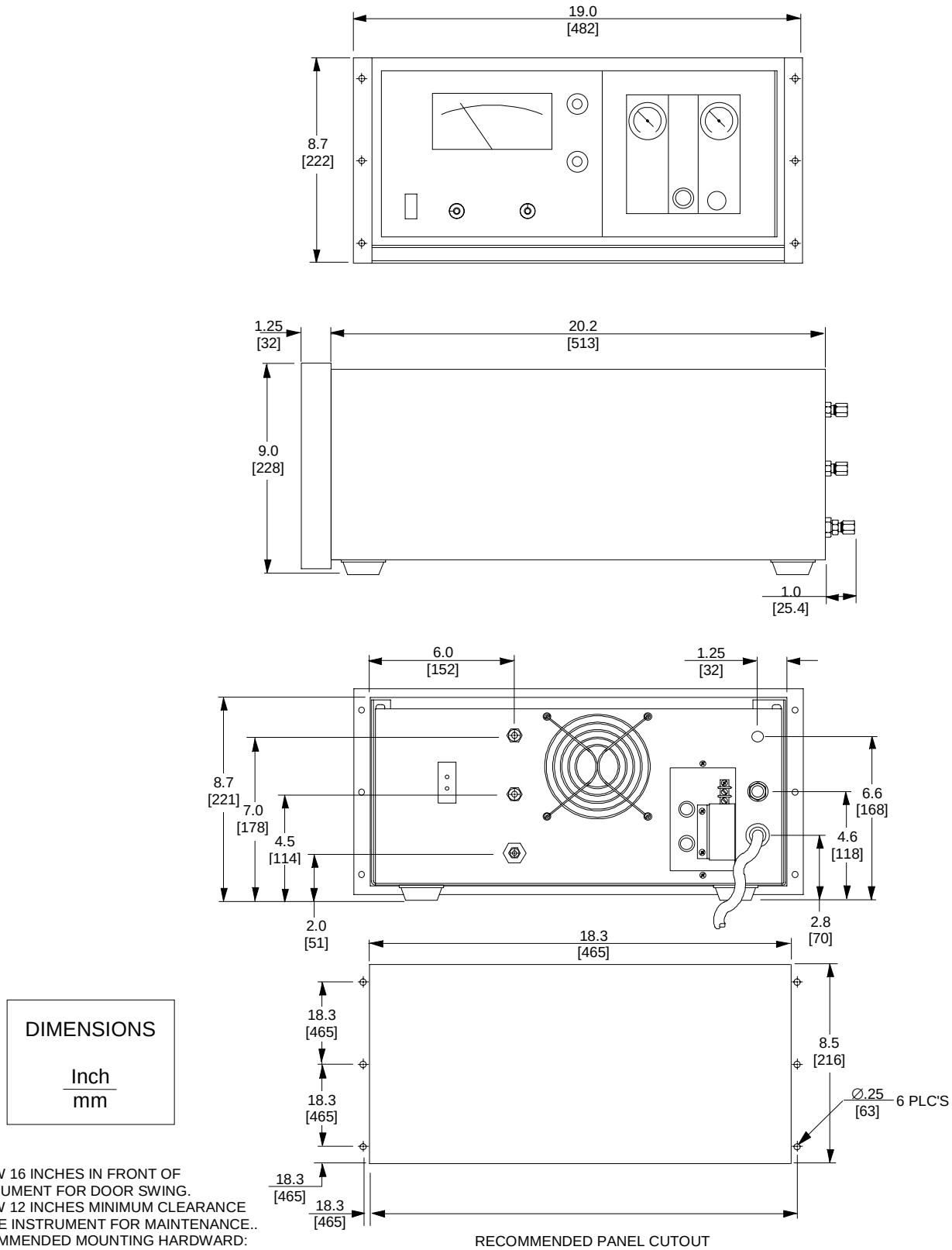


FIGURE 2-1. MODEL 951A OUTLINE AND MOUNTING DIMENSIONS

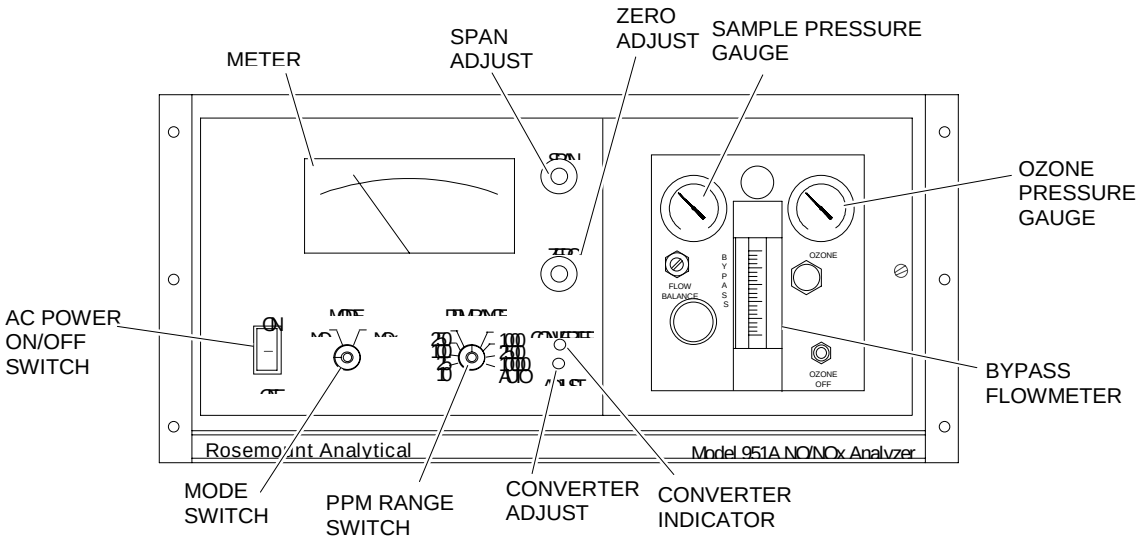


FIGURE 2-2. FRONT PANEL INDICATORS AND CONTROLS

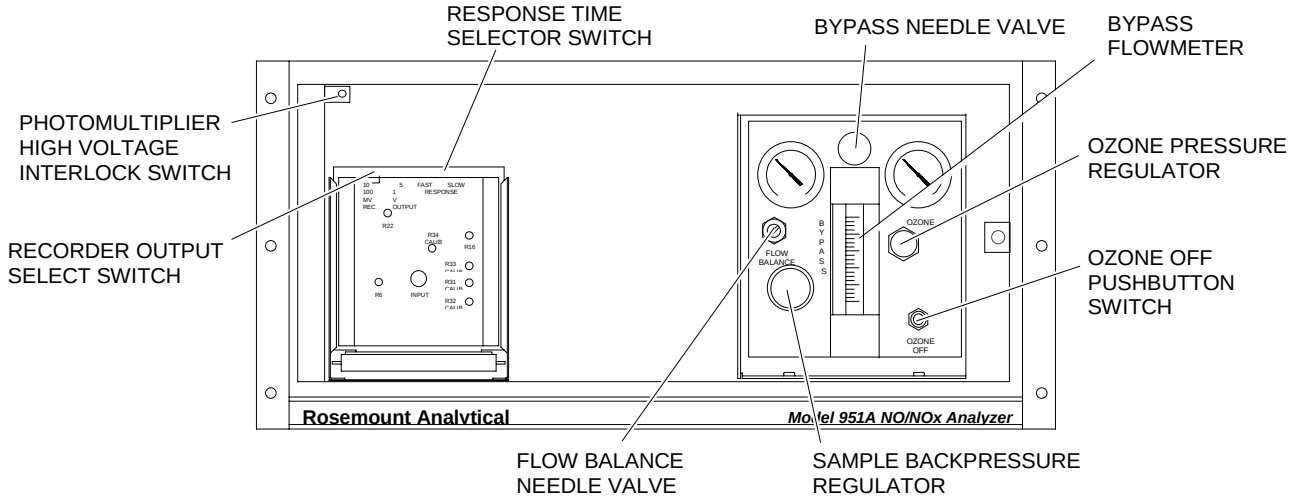


FIGURE 2-3. CONTROLS AND ADJUSTMENTS LOCATED BEHIND SWING OUT FRONT PANEL

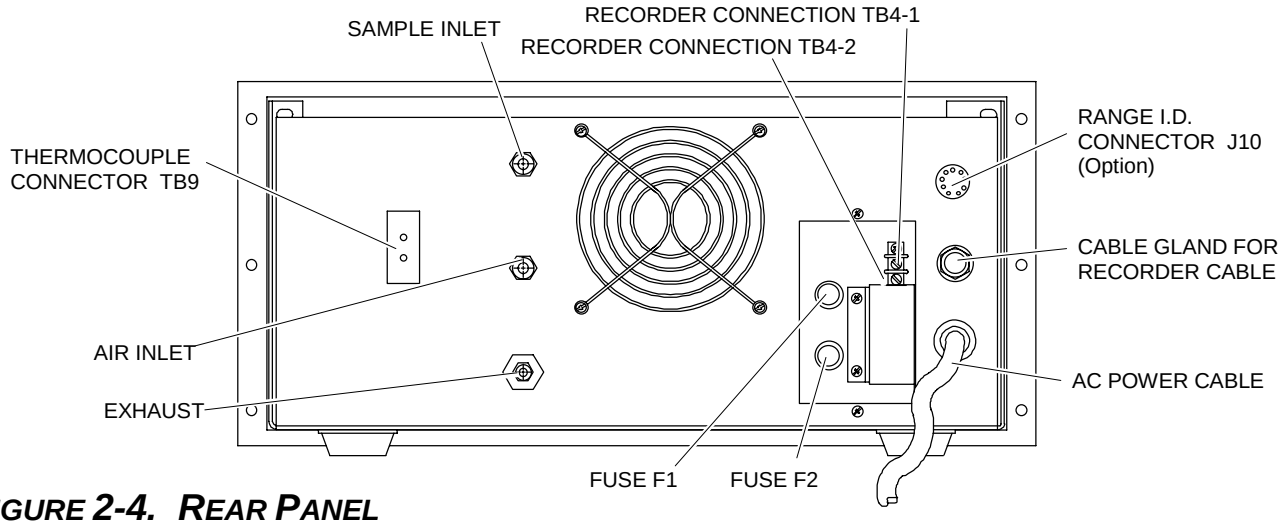


FIGURE 2-4. REAR PANEL

CONTROL	FUNCTION
ON/OFF	Controls AC power to all components in instrument
MODE SWITCH	For selection of NO or NOx
METER	Readout of NO or NOx in ppm as selected with MODE switch. Upper scale is graduated 0 to 100 for use with 10, 100, 1000, and 10,000 ppm ranges. Lower scale is graduated 0 to 25 for use with 25 and 2500 ppm ranges.
PPM RANGE SWITCH	Select fullscale range for meter and recorder
CONVERTER	LED illuminates during application of power to converter heater. When Converter reaches temperature equilibrium, LED will go off and on at intervals of about 2 seconds, indicating correct temperature control.
ADJUST	Through-panel screwdriver adjustment of converter temperature. Should be set for temperature that yields optimum combination of high efficiency for the NO2 to NO conversion and extended life for the catalytic converter. Optimum temperature differs from one instrument to another, see Section 3.3.
ZERO	Set zero point on meter scale or recorder chart. With MODE switch in NO position and zero air supplied to SAMPLE inlet, ZERO Control is adjusted for zero reading.
SPAN	Set upscale calibration point on meter scale or recorder chart. MODE switch is at NO or NOx and suitably pressurized standard gas of accurately known NO/NOx content is supplied to SAMPLE inlet. With PPM RANGE switch set to the appropriate range for the span gas, the SPAN control is adjusted to correct reading on meter or recorder.
SAMPLE BACKPRESSURE REGULATOR AND PRESSURE GAUGE	Adjustment and indication of pressure (and therefore flow) of sample or standard gas routed through sample capillary, and into reaction chamber. Proper setting dependent on operating range. See Table 3-1.
BYPASS FLOWMETER AND NEEDLE VALVE	Bypass flow indication and adjustment for sample or standard gas to SAMPLE inlet. Setting of 2 L/min. is recommended to ensure rapid response and optimum functioning of sample backpressure regulator
OZONE PRESSURE REGULATOR AND GAUGE	Pressure adjustment and indication for air or oxygen supplied to AIR inlet for use as oxygen source for internal ozone generator. Oxygen is usable for all ranges. Air is usable only for 2500 ppm range or lower. Proper pressure setting dependent on operating range, see Table 3-1.
OZONE OFF SWITCH	Removes AC power to ultraviolet source lamp in ozone generator. Power is OFF when switch indicator is red.

TABLE 2-1. MODEL 951A CONTROLS AND ADJUSTMENTS (CONTINUED ON NEXT PAGE)

CONTROL	FUNCTION
FLOW BALANCE NEEDLE VALVE	Use to equalize pressure drop for NO and NOx legs of the internal flow system. Criterion for correct adjustment is an NO2 free nitric oxide standard gas should give equal readings of ppm for NO and NOx modes. An alternate flow balance check , if NO2 free standard gas is unavailable, is to verify that the reading on the SAMPLE pressure gauge is the same for NO and NOx modes.
RESPONSE TIME SELECTOR SWITCH	Select either FAST or SLOW electronic response. When set to FAST, electronic response time (for 0 to 90% of fullscale) is then approximately one second for all ranges except 10 ppm, which is approximately three seconds. When set to SLOW (as in monitoring stack sources), electronic response time 0 to 90% of fullscale) is approximately ten seconds for all ranges.
RECORDER OUTPUT SELECTOR SWITCH	To select output of 10 mV, 100 mV, 1V or 5 V for a potentiometric recorder.
METER MECHANICAL ZERO	Located on rear of meter. With AC power OFF, meter should read zero. If not use screw adjustment on meter.
PHOTOMULTIPLIER HIGH VOLTAGE INTERLOCK SWITCH	When analyzer front panel is open, photomultiplier high voltage power supply is automatically shut off.

TABLE 2-1. (CONTINUED FROM PREVIOUS PAGE)

2.3 GAS REQUIREMENTS

WARNING: HIGH PRESSURE GAS CYLINDERS

This instrument requires use of oxygen and a known standard gas in high pressure cylinders. Refer to Handling and Storing High Pressure Gas Cylinders located in the rear of this manual.

AIR OR OXYGEN

This is used as both (a) oxygen source for generation of the ozone required for the chemiluminescent reaction, and (b) standard gas for zero calibration. Gas for both purposes may be supplied from a single cylinder and routed through a tee. Alternatively, two separate cylinders may be used.

Oxygen is usable in all applications. Air is suitable for the oxygen source only if the desired fullscale operating range is 2500 parts-per-million or less. Breathing grade oxygen or air is recommended. Clean, dried ambient air containing less than 0.1 parts-per-million nitric oxide may be used, provided that its dewpoint is below -10^{o}F (-23^{o}C). If air is insufficiently dried, or contains excessive nitric oxide, instrument response will not be linear to 2500 ppm.

SPAN GAS

This is a standard gas of accurately known composition, used to set an upscale calibration point.

Alternative span gases are:

1. The usual span gas is NO in a background of nitrogen.
2. For span check or adjustment in the NOx mode, the span gas may be NO_2 in a background of air or nitrogen.
3. For convenient calibration in *either* the NO or NOx mode, the span gas may be a cylinder gas mixture consisting of known concentrations of *both* NO and NO_2 in a background of nitrogen.

Note

For maximum calibration accuracy, the concentration of NO and/or NO_2 in the span gas should be as near as possible to that in the sample gas. Also, the span gas should be supplied to the rear panel SAMPLE inlet at the same pressure as the sample gas. To ensure constant pressure, a pressure regulator may be utilized immediately upstream from the SAMPLE inlet.

Preferably, each gas used should be supplied from a tank or cylinder equipped with a clean, non-corrosive type two stage regulator. In addition, a shut-off valve is desirable. If possible, install the gas cylinders in an area of relatively constant ambient temperature.

2.4 SAMPLE REQUIREMENTS

The Sample must be relatively clean and dry before entering the analyzer. In general, before admission to the analyzer, the sample should be filtered to 2 microns and should have a dewpoint below 90°F (32°C). The factory can provide technical assistance if desired .

Proper supply pressures for sample and span gases depend on whether or not the analyzer is equipped with the optional 632748 Sample Pump:

For the basic Model 951A, without sample pump, sample must be supplied to the SAMPLE inlet at a pressure of 5 to 10 psig (34.5 to 69 kPa). This ensures that the normal bypass flow of two liters per minute will be obtainable by adjustment of the BYPASS Needle Valve. (Proper bypass flow is essential for rapid system response and stable flow into reaction chamber.)

For an analyzer *equipped with sample pump,* the acceptable pressure range at the SAMPLE inlet is 0 to 5 psig (0 to 34.5 kPa). The pump pressurizes the sample to between 5 and 10 psig (34.5 to 69 kPa) for supply to the internal flow system.

2.5 GAS CONNECTIONS

1. Remove plugs and caps from all inlet and outlet fittings. See Figure 2-4.
2. Connect EXHAUST outlet to outside vent via tubing with O.D. of 1/4 inch (6.3mm) or larger.
3. Connect external lines from air (or oxygen) cylinder and sample source to corresponding rear panel inlet ports. For sample line, stainless steel tubing is recommended.
4. Adjust regulator on air (or oxygen) cylinder for output pressure of 35 to 40 psig (251 to 276 kPa).

Supply sample gas to rear panel SAMPLE inlet at appropriate pressure: 5 to 10 psig (34.5 to 69 kPa) for basic analyzer without sample pump; 0 to 5 psig (0 to 34.5 kPa) for analyzer with pump.

2.6 ELECTRICAL CONNECTIONS

2.6.1 RECORDER OUTPUT

If a recorder is used, connect leads to terminals marked REC 1 (+) and 2 (-) on TB4 (Figure 2-4). (Note that, within the analyzer, the negative recorder output terminal is connected to ground.)

Set REC OUTPUT Selector Switch SW1 (Figure 2-3) to the recorder span: 10 mV, 100 mV, 1 VDC or 5 VDC.

2.6.2 THERMOCOUPLE CONNECTIONS FOR MEASURING TEMPERATURE OF NO_2 TO NO CONVERTER

Temperature of the NO_2 to NO converter may be monitored by connecting a customer supplied millivolt meter to thermocouple connector TB9 located on the rear panel (Figure 2-4). The position of the thermocouple in the converter bundle will influence the actual temperature readout.

2.6.3 REMOTE RANGE CHANGE

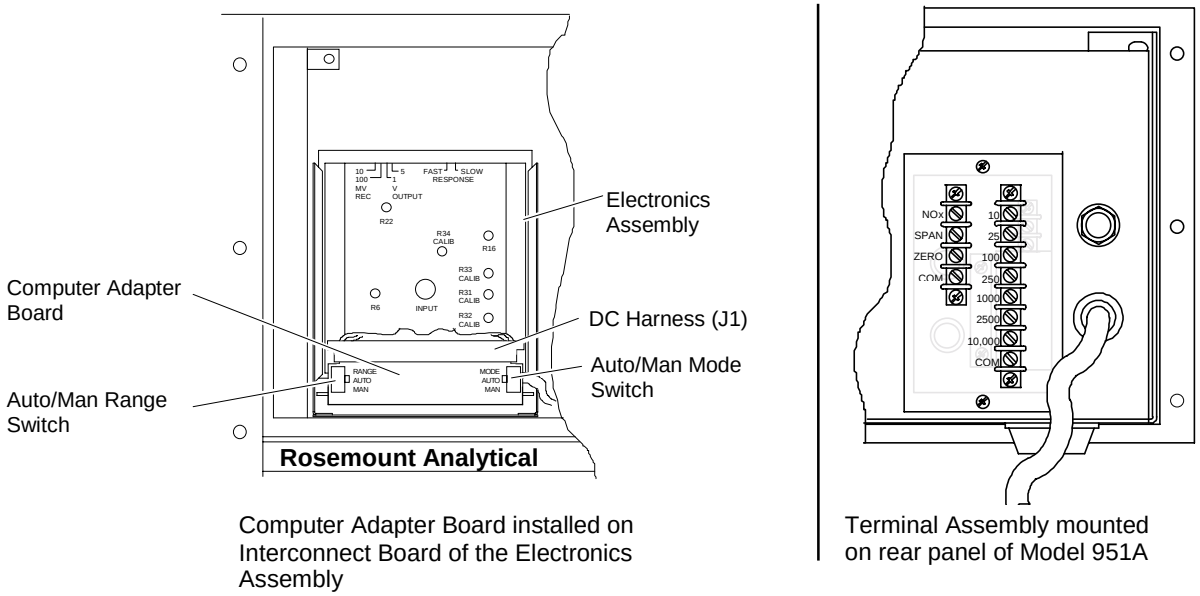
The Remote Range Change Kit, Figure 2-5, consists of a plug-in Adapter Board plus attached harness and rear terminal plate.

The Adapter Board has two two-position slide switches: the MAN/AUTO MODE Switch and the MAN/AUTO RANGE Switch.

The MAN/AUTO MODE Switch provides the choice of local or remote control of the NO/NOx Mode Switching Solenoid Valve, associated with the NO_2 to NO converter. With switch at MAN, the function is under control of the front panel MODE Switch. With switch at AUTO, the front panel MODE Switch is disabled; the function is then remotely controlled, by either the operator or a computer, via contact closure signals applied to terminals on TB5.

The MAN/AUTO RANGE Switch provides the choice of local or remote selection of operating range. With switch at MAN, range selection is under control of the front panel PPM RANGE Switch. With switch at AUTO, the front panel PPM RANGE Switch is disabled; range selection is remotely controlled, by either the operator or a computer, via contact closure signals applied to terminals on TB6.

Control at TB5 and TB6 is accomplished by a contact closure from the terminal marked COM (for common) to the terminal marked with the name of the desired function. Contact closure requirements are 25 mA at 15 VDC.



Computer Adapter Board installed on Interconnect Board of the Electronics Assembly

Terminal Assembly mounted on rear panel of Model 951A

FIGURE 2-5. REMOTE RANGE KIT INSTALLED

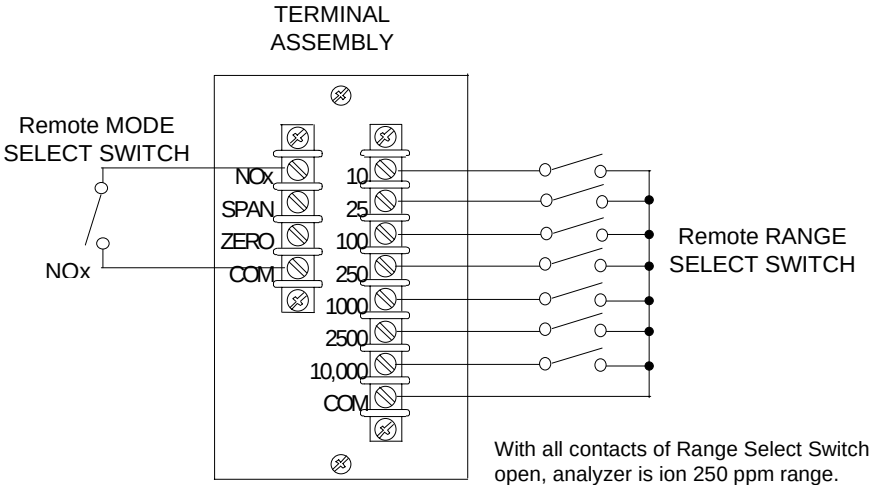


FIGURE 2-6. TYPICAL INTERCONNECTION OF REMOTE RANGE KIT

2.6.4 CONNECTIONS OF THE RANGE I. D. KIT

The Range I.D. option provides contact closure signals that permit a computer or other external device to identify the position selected manually with the front panel PPM RANGE Switch. The cable is connected to PPM RANGE Switch SW1 and extends to connector J10 mounted on the rear of the case (Figure 2-4).

The pin-out connections of J10 are as follows:

Pin A 10 ppm
Pin B 25 ppm
Pin C 100 ppm
Pin D 250 ppm
Pin E 1000 ppm
Pin F 2500 ppm
Pin H 10000 ppm
Pin J Wiper

2.6.5 POWER CONNECTIONS

Connect power cord to an AC source of 107 to 127 volts, 50/60 Hz. If power outlet does not have third (ground) contact, use an adapter to provide proper grounding.

NOTES

3 STARTUP

Preparatory to startup and operation, a thorough familiarization with Table 2-1 and Figures 2-2, 2-3 and 2-4 is recommended. These figures give locations and brief descriptions of operating controls. For more detailed information on controls, refer to Section Five.

3.1 STARTUP PROCEDURE

Following are *detailed* stepwise instructions on startup and calibration. For convenience, *condensed* instructions for startup, routine calibration and normal operation are provided at the front of this manual.

1. With power removed from analyzer, check front panel meter. It should read zero; if not, adjust Mechanical Zero Screw at rear of meter for zero reading.
2. Place front panel PPM RANGE Switch at 1000.

WARNING: OZONE HAZARD

When instrument power is on, the ultraviolet source sample is energized, converting a portion of the oxygen contained with the ozonator into ozone. With normal flow through the ozonator, the ozonized air or oxygen is continuously swept though the ozonator and into the reaction chamber. If flow is stopped, however, the ozone will diffuse and will attack the sintered metallic restrictor element in the tee fitting at the upstream end of the ozonator. Operation of the analyzer with the restrictor element thus rusted will result in the following consequences: Reduced flow of air or oxygen through the ozonator, ozone deprivation within the reaction chamber and non-linear response of the analyzer to NO/NOx.

To prevent such damage, verify that the front panel ozone ON/OFF switch is turned off if flow of feed gas to the air inlet is terminated.

3. Set front panel MODE Switch at NO or NOx. Place POWER Switch at ON. Electrical power is now being supplied to all circuits, including sample pump if analyzer is so equipped. Analyzer will now require approximately one hour for temperature equilibration before ready for calibration.

4. Establish correct pressure for air oxygen:
   a. Verify that pressure regulator on cylinder of air or oxygen is set for supply pressure of 35 to 40 psig (242 to 276 kPa).
   a. On internal gas control panel, Figure 2-3. adjust OZONE Pressure Regulator so that OZONE Pressure Gauge indicates either 20 psig (138 kPa) or 30 psig (207 kPa), depending on the desired operating range.
5. Establish correct flow of sample gas:
   a. Supply sample gas to rear panel SAMPLE inlet.
   b. Adjust SAMPLE Backpressure Regulator so SAMPLE Pressure Gauge indicates the value appropriate to the desired operating range.
   c. Adjust BYPASS Needle Valve for reading of two liters per minute on BYPASS Flowmeter.

Note

Inability to obtain a bypass flow of two liters per minute by adjustment of the BYPASS Needle Valve usually indicates insufficient sample supply pressure at the SAMPLE inlet.

6. Establish correct flow of zero air:
   a. Supply zero air to rear panel SAMPLE inlet.
   b. Note reading on SAMPLE Pressure Gauge. It should be the same as in Step 5b. If not, adjust output pressure regulator on air cylinder as required.
7. Establish correct flow of upscale standard gas:
   a. Supply upscale standard gas to rear panel SAMPLE inlet.
   b. Note reading on SAMPLE Pressure Gauge. It should be the same as in Step 5b. If not, adjust output pressure regulator on cylinder of upscale standard gas as required.

Note

Supply pressures for sample and upscale standard gases must be the same; otherwise, readout will be in error.

The Analyzer is now ready for calibration per Section 3.2.

Max. NOx Level (ppm)	Gas Supplied to Air Inlet	Ozone Pressure Gauge Setting	Sample Pressure Gauge Setting
1000	Air	20 psig (138 kPa) Provides flow of approx. 500 cc/min to ozone generator	4 psig (27.6 kPa) Provides flow of approx. 60 cc/min to reaction chamber
2500	Air	30 psig (207 kPa) Provides flow of approx. 1000 cc/min to ozone generator	
10,000	Oxygen	30 psig (207 kPa) Provides flow of approx. 1000 cc/min to ozone generator	1.5 psig (10.3 kPa) Provides flow of approx. 20 cc/min to reaction chamber

TABLE 3-1. PROPER GAS SUPPLY PRESSURES FOR VARIOUS LEVELS OF SAMPLE NOX

3.2 CALIBRATION

1. Zero Calibration.
   a. Set PPM RANGE Switch for the same range that will be used during sample analysis. Set SPAN Control at about midrange.
   b. Supply zero gas to rear panel SAMPLE inlet.
   c. Adjust ZERO Control for zero reading on meter or recorder, then lock ZERO Control knob.
2. Upscale Calibration.
   a. Set PPM RANGE Switch at the position appropriate to the particular span gas.
   b. Supply upscale standard gas of accurately known NO/NOx content to rear panel SAMPLE inlet.
   c. Place MODE Switch at NO if nitric oxide span gas is used.
   d. Adjust SPAN Control so that reading on meter or recorder is equal to the known parts-per-million concentration of NO or NOx in the span gas. In operation at NOx levels in the range of 2500 to 10000 parts-per-million, the correct reading may not be obtainable, initially, by adjustment of the SPAN Control. The cause is that the reduced sample flow required for linearity results in lowered sensitivity and slower response. To compensate for these effects, make the electronic adjustments of Steps (e) and (f) below.
   e. If necessary, increase sensitivity by raising photomultiplier voltage per Section 6.1, Step 5.
   f. To reduce observed noise, select SLOW position of Response Time Selector Switch SW2, Figure 3-1.
   g. When correct upscale reading is obtained, lock SPAN Control knob.

Calibration is now complete. Before Placing analyzer in operation, however, measure efficiency of the NO_2 to NO converter per Section 3.3.

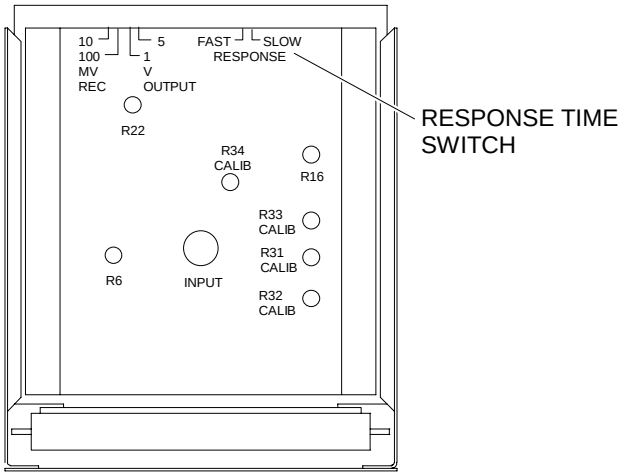


FIGURE 3-1. AMPLIFIER BOARD ADJUSTMENTS

3.3 MEASURING EFFICIENCY OF NO_2 TO NO CONVERTER AND ADJUSTING TEMPERATURE SETPOINT

It is the responsibility of the user to measure efficiency of the NO_2 to NO converter during initial startup and thereafter at intervals appropriate to the application, normally once a month.

The reactant material used in the converter provides the optimum combination of high conversion efficiency and low ammonia interference. Unlike most competitive analyzers, the Model 951A utilizes a reactant material that gradually becomes *more efficient at a given temperature* , and thus after a period of use may permit operation with a lower temperature setpoint than that required initially.

Conversion efficiency in the Model 951A is typically 95% to 98% +, considerably above the 90% minimum accepted by the EPA. Refer to 40 CFR 60, App. A, Method 20, Section 5.6.

3.3.1 TEST SETUP FOR MEASUREMENT OF CONVERSION EFFICIENCY

A typical setup for measurement of conversion efficiency is shown in Figure 3-2A. The test setup includes:

1. A cylinder of nitric oxide standard gas consisting of NO in N_2. The concentration of NO in the standard gas should be about the fullscale value of the range under test. The test sample supplied to the analyzer should contain a concentration of NO

comparable to that in the samples that are to be analyzed. Alternately, a higher concentration NO standard may be used if the test setup includes provision for diluting it appropriately with zero air. Suitable standard gases are available from various suppliers. Stainless steel cylinders are commonly used, but specially treated aluminum is preferred for low parts-per-million NO samples.

2. An ozone generator utilizing an ultraviolet lamp, not a corona discharge. A corona discharge ozone generator is undesirable as it may produce oxygen atoms, which can then combine with atmospheric nitrogen to form NO. The result can be an erroneously high value for the measured conversion efficiency.

3.3.2 TEST PROCEDURE

1. Measure converter temperature by connecting a millivolt meter to terminals 5 (+) and 6 (-) on TB9. Within the analyzer, these terminals are connected to a Type J thermocouple. Note present reading as a reference for comparison with subsequent measurements. The optimum temperature differs from one analyzer to another. but typically is in the range of 660°F to 750°F (350°C to 400°C).
2. Turn front panel CONVERTER ADJUST one turn counterclockwise, to lower temperature setpoint slightly from the original factory setting. Wait 15 minutes for temperature equilibration, then proceed to Step 3.
3. Refer to Figure 3-2. Connect the Model 958 NO_2 Converter Efficiency Tester to the Model 951A, and use the following procedure, adapted from 40 CFR 60, to determine the values to be used in Equation (A):
   a. Attach the NO/N_2 supply at C2. the air supply at C1, and the analyzer inlet connection at C3.
   b. With the variable transformer off, place Model 951A in NO mode and close valve MV1. Open valve MV2 until Model 951A SAMPLE Pressure Gauge reaches operating pressure and BYPASS Flowmeter indicates some bypass flow. Wait until stable readings are obtained at analyzer. Zero and span the analyzer output to indicate the value of the NO concentration being used. This value should be approximately 80% of fullscale. Record this concentration.
   c. Open valve MV1 (air supply metering valve) and adjust to blend enough air to lower the NO concentration (ii) about 10%. Record this concentration.
   d. Turn on the ozonator and increase its supply voltage until the NO concentration of (iii) is reduced to about 20 percent of (ii). NO_2 is now being formed from the NO + O_3 reaction. There must always be at least 10 percent un-reacted NO at this point. Record this concentration.
   e. When a stable reading has been obtained from (iv), place Model 951A in NOx mode. It will now indicate the total NOx concentration. Record this concentration.

f. Turn off the ozonator and allow the analyzer reading to stabilize. This reading is the total NOx concentration of the dilute NO span gas used at step (iii). Record this concentration.

f. Close valve MV1. The NO concentration should be equal to or greater than the reading of (ii). Indicating whether the NO contains any NO_2.

g. Calculate the efficiency of the NO converter by substituting the concentrations obtained during the test into the following equation.

Equation (A)

$$\% \text{ Efficiency} = \left(1 + \frac{\text{v-vi}}{\text{iii-iv}} \right) \text{ X } 100$$

In the example of Figure 3-2B,

$$\% \text{ Efficiency} = \left(1 + \frac{85\text{-}90}{80\text{-}20} \right) \text{ X } 100\% = 92\%$$

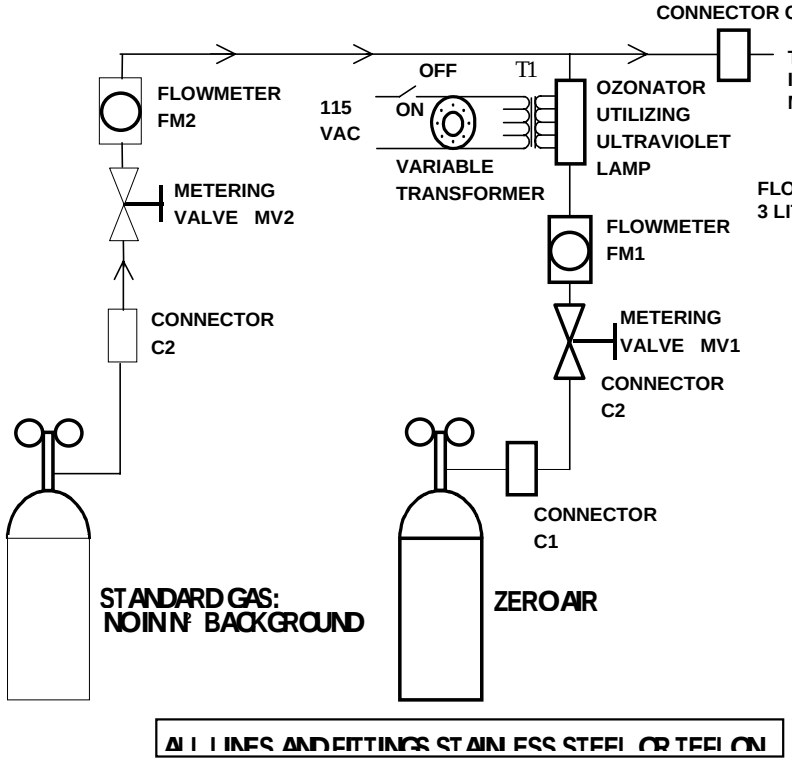
Efficiency checks should be made on each analyzer range, using an NO span gas concentration appropriate to the instrument range.

Note

In the initial measurement, following lowering of the temperature setpoint in Step 2, the efficiency will normally be less than 92%.

4. Turn CONVERTER ADJUST one quarter turn clockwise, thus raising temperature setpoint slightly. Wait 15 minutes for temperature equilibration. Again measure conversion efficiency per Step 3; it should be somewhat improved.

A. TYPICAL TEST SETUP



B. TYPICAL TEST RESULTS

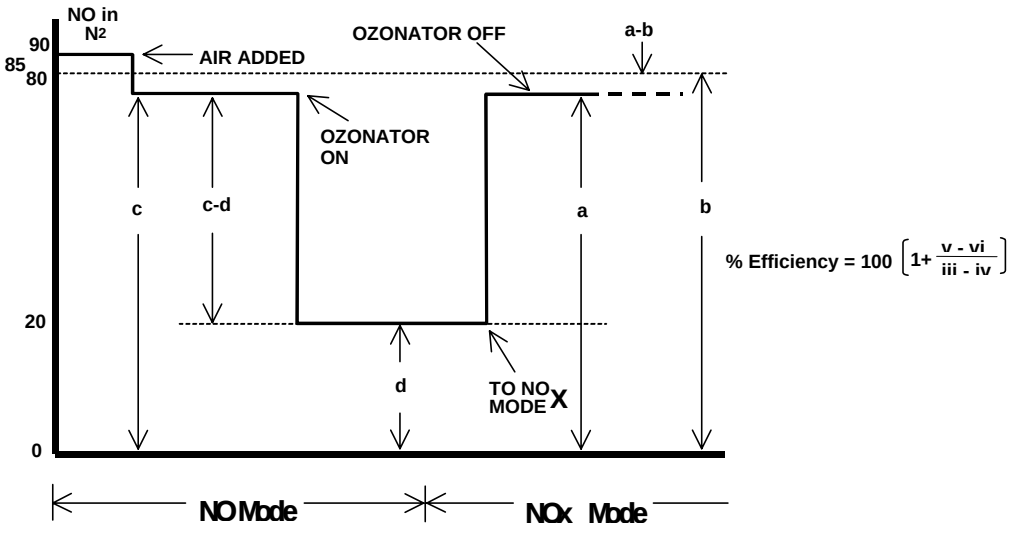


FIGURE 3-2. MEASURING EFFICIENCY OF NO_2 TO NO CONVERTER

5. Repeat Step 4 until either (a) 95% efficiency is attained, or (b) the final one quarter turn clockwise adjustment yields an increase in efficiency of less than 1%. Then proceed to Step 5.
6. Turn CONVERTER ADJUST one-eighth turn counterclockwise, thus lowering temperature setpoint very slightly. Converter temperature is now set at a point on the front edge of the plateau on the efficiency-vs.-temperature curve, Figure 3-3. This setting should provide the optimum combination of high conversion efficiency and low ammonia interference. Wait about fifteen minutes for temperature equilibration, then again measure converter temperature as in Step 1. Compare present temperature with original value. Normally, converter temperature should be in the range of 660°F to 750°F (350°C to 400°C).

Note

Converter temperature is not a direct measure or conversion efficiency. Temperature measurement is for reference purposes only.

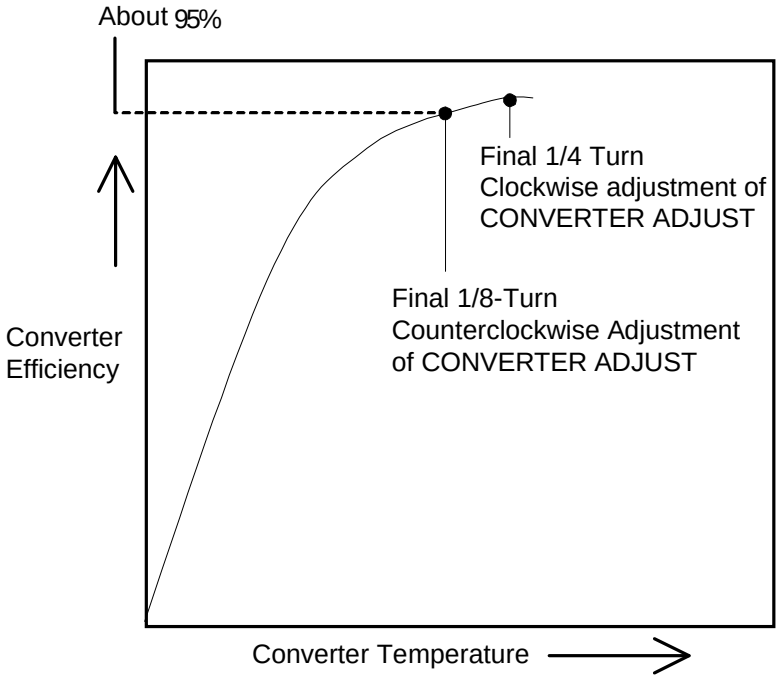


FIGURE 3-3. CONVERSION EFFICIENCY AS A FUNCTION OF CONVERTER TEMPERATURE

3.3.3 SUBNORMAL CONVERSION EFFICIENCY

If a measured conversion efficiency of 95% is unobtainable within the normal temperature range, the most probable cause is depletion of the catalytic material within the converter. However, before concluding that the converter is defective, make sure that the conversion efficiency measurement is accurate. Even though the *measured* efficiency is less than 95%, the *actual* efficiency may be somewhat higher. An apparent subnormal efficiency can be due to a problem external to the analyzer, located either within the *test setup*, or between it and the analyzer. Check for the following:

1. Leakage.
2. Loss of NO_2 between test setup and analyzer. Such loss can occur by reaction with a rubber diaphragm in a pressure regulator or flow controller. Stainless steel diaphragms are preferred. Loss can also occur during passage through filter media.

3.3.4 REPLACEMENT OF CONVERTER

If it is determined that the subnormal conversion efficiency is *real*, and *not* due to measurement error introduced by the test setup, the converter must be replaced per Section 6.2.3. The usual cause of converter failure is destruction of a large part of the catalytic material by excessive heat, due either to excessively high temperature setpoint or failure of the converter temperature control circuit.

3.3.5 CAPILLARIES

Replacement capillaries should be installed finger-tight. Use of a wrench can constrict capillaries, changing flow rate.

3.3.6 TEA SCRUBBER

The TEA Scrubber accessory (PN 635741) can be used to remove residual NO_2 from the NO cylinders. Use of this accessory allows a true calibration of the analyzer.

White crystal deposits on the windows of the reaction chamber and plugging of capillaries and vent are usually due to sample contaminates reacting with the high ozone levels. To eliminate the contaminates, the sampling system should be reworked or a preventive maintenance program developed (if dropout is not excessive). Another source of crystalline formation is contaminated air.

NOTES

4 OPERATION

4.1 ROUTINE OPERATION

After calibrating analyzer per Section 3.2, supply sample to SAMPLE inlet. Place MODE Switch in NO or NOx position, depending on the desired determination. Set PPM RANGE Switch in appropriate position. The instrument will now continuously analyze the sample stream.

The Model 951A is designed for continuous operation. Normally, it is never turned off except for servicing or for a prolonged shutdown. However, if the instrument is to remain idle for an extended period with power on, the recommended practice is to leave the MODE Switch in NO position to de-energize the NO/NOx Mode Switching Solenoid Valve.

4.2 RECOMMENDED CALIBRATION FREQUENCY

After initial startup, or startup following a shutdown, the analyzer requires about one hour for stabilization before it is ready for calibration. Maximum permissible interval between calibrations depends on the analytical accuracy required, and therefore cannot be specified. It is recommended that initially the instrument be calibrated at least once every eight hours, and that this practice be continued until experience or requirements indicate that some other interval is more appropriate.

NOTES

5 THEORY

5.1 PRINCIPLES OF OPERATION

5.1.1 NITRIC OXIDE DETERMINATION BY CHEMILUMINESCENCE METHOD

The chemiluminescence method for detection of nitric oxide (NO) is based on its reaction with ozone (O_3) to produce nitrogen dioxide (NO_2) and oxygen (O_2). Some of the nitrogen dioxide molecules thus produced are initially in an electronically excited state (NO_2^*). These revert immediately to the ground state, with emission of photons. The reactions involved are:

$$NO + O_3 \rightarrow NO_2^* + O_2$$

$$NO_2^* \rightarrow NO_2 + h\nu$$

where

h = Planck's constant

ν = frequency, Hz

As NO and O_3 mix in the reaction chamber, the chemiluminescence reaction produces light emission that is directly proportional to the concentration of NO. This emission is measured by a photomultiplier tube and associated electronic circuitry. Refer to Section 5.3.

5.1.2 NOX DETERMINATION

The NOx determination is identical to the NO determination described in Section 5.1.1 except that, prior to entry into the reaction chamber, the sample is routed through a converter where the NO_2 component is converted into NO. The reaction is:

$$2NO_2 \rightarrow 2NO + O_2$$

Instrument response is proportional to total NO in the *converted* sample, that is, to the sum of the NO originally present in the sample plus the NO resulting from conversion of NO_2. This sum of NO and NO_2 is commonly termed NOx, i.e., ([NOx] = [NO] + [NO_2]).

5.1.3 OZONE GENERATION

Ozone for the chemiluminescence reaction is produced in a flow chamber where a stream of air or oxygen from an external cylinder is exposed to ultraviolet radiation from a source lamp. The reaction is:

$$h\nu \quad 3O_2 \rightarrow 2O_3$$

5.2 ANALYZER FLOW SYSTEM

The analyzer flow system is shown schematically in Figure 5-1 and pictorially in Figure 6-1. Its basic function is to deliver regulated flows of sample or calibration gas and ozonized air or oxygen to the reaction chamber. The discharge from the reaction chamber exits the analyzer via the EXHAUST outlet.

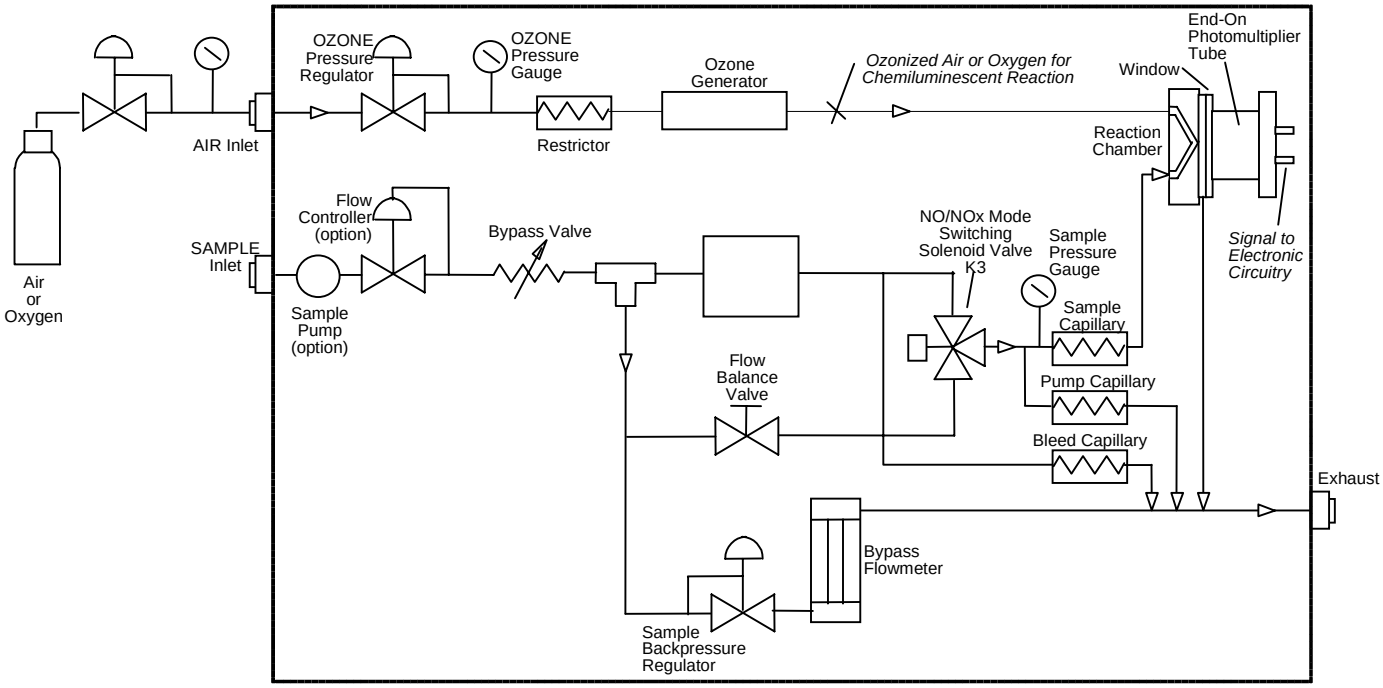


FIGURE 5-1. SCHEMATIC FLOW DIAGRAM OF MODEL 951A

5.2.1 FLOW OF SAMPLE OR STANDARD GAS TO REACTION CHAMBER

Suitably pressurized sample or standard gas is supplied to the rear panel SAMPLE inlet.

Within the analyzer, flow rate of the selected gas into the reaction chamber is controlled by a back-pressure regulator. It provides an adjustable, controlled pressure on the upstream side, where gas is supplied to the calibrated, flow-limiting sample

capillary. The regulator is adjusted for appropriate reading on the SAMPLE Pressure Gauge. For operation at NOx levels below 2,500 parts-per-million, correct setting on the SAMPLE Pressure Gauge is 4 psig (27.6 kPa), resulting in a flow of approximately 60 cc/min to the reaction chamber. For operation at NOx levels in the range of 2,500 to 10,000 parts-per-million, setting on SAMPLE Pressure Gauge should be 1.5 psig (10.3 kPa), resulting in a flow of approximately 20 cc/min to the reaction chamber.

Gas in excess of the flow required for the reaction chamber is discharged through the BYPASS Flowmeter and out the BYPASS outlet. Bypass flow should be two liters per minute to ensure optimum functioning of the SAMPLE Pressure Regulator and rapid system response. *Total* flow of sample or standard gas into the SAMPLE inlet is adjusted by means of the BYPASS Needle Valve (or optional flow controller). Excessive changes, on the order of ±5 psig (±34.5 kPa), in the pressure of the sample or standard gas will affect the bypass flow rate and can affect accuracy.

5.2.2 FLOW OF AIR OR OXYGEN

WARNING: OZONE HAZARD

When instrument power is on, the ultraviolet source sample is energized, converting a portion of the oxygen contained with the ozonator into ozone. With normal flow through the ozonator, the ozonized air or oxygen is continuously swept though the ozonator and into the reaction chamber. If flow is stopped, however, the ozone will diffuse and will attack the sintered metallic restrictor element in the tee fitting at the upstream end of the ozonator. Operation of the analyzer with the restrictor element thus rusted will result in the following consequences: Reduced flow of air or oxygen through the ozonator, ozone deprivation within the reaction chamber and non-linear response of the analyzer to NO/NOx.

To prevent such damage, verify that the front panel ozone ON/OFF switch is turned off if flow of feed gas to the air inlet is terminated.

Suitably pressurized air or oxygen from an external cylinder is supplied to the rear panel AIR inlet. Immediately downstream from the inlet, a regulator and associated gauge provide pressure adjustment and indication for air or oxygen. Proper pressure setting. and the corresponding flow to the ozone generator, will depend on sample NOx level. Refer to Table 3-1.

1. For operation at NOx levels below 1,000 parts-per-million, correct *air pressure* setting on OZONE Pressure Gauge is 20 psig (138 kPa), resulting in a flow of approximately 500 cc/min of air to the ozone generator.
2. For operation at NOx levels in the range of 1,000 to 2,500 parts-per-million, *air pressure* setting on OZONE Pressure Gauge should be 30 psig (207 kPa),

resulting in a flow of approximately 1 liter per minute of air to the ozone generator.

3. For operation at NOx levels in the range of 2,500 to 10,000 parts-per-million, oxygen pressure setting on OZONE Pressure Gauge should be 30 psig (207 kPa), resulting in a flow of approximately 1 liter per minute of *oxygen* to the ozone generator.

Within the ozone generator, a portion of the oxygen in the stream is converted into ozone by exposure to ultraviolet radiation from a lamp source. From the generator, the flow passes into the reaction chamber for use in the chemiluminescence reaction.

5.2.3 FLOW SYSTEM OPERATING MODES

Downstream from the BYPASS Needle Valve, the sample or standard gas flows through either the FLOW BALANCE Needle Valve or the NO_2 to NO converter, depending on the status of NO/NOx Mode Switching Solenoid Valve K3. Status of this valve depends on whether the front panel MODE Switch is in NO or NOx position.

Operation for NO and NOx determination is as follows:

NO DETERMINATION

Sample or standard gas is supplied to the rear panel SAMPLE inlet, passes in turn through the BYPASS Needle Valve, NO/NOx Mode Switching Solenoid Valve K3, the sample capillary, and on to the reaction chamber. Since the NO_2 to NO converter is bypassed, any NO_2 component originally present in the sample *remains* in the NO_2 form and does not contribute to the output signal. (During startup, the FLOW BALANCE Needle Valve is adjusted to equalize flow rated for NO and NOx flow modes.)

NOX DETERMINATION

Sample or standard gas supplied to the rear panel SAMPLE inlet passes in turn through the BYPASS Needle Valve, the NO_2 to NO converter, the solenoid valve, the sample capillary and on to the reaction chamber. With the sample now routed through the converter, the NO_2 component is converted into NO prior to entry into the reaction chamber, and thus will contribute to the output signal.

During startup, the FLOW BALANCE Needle Valve is adjusted to equalize flow rates for NO and NOx flow modes. Criterion for correct adjustment is that an NO_2 free nitric oxide standard gas should give equal readings of parts-per-million for NO and NOx modes.

An alternate method of checking flow balance, usable if NO_2 free standard gas is *unavailable,* is to verify that the reading on the SAMPLE Pressure Gauge is the same for NO and NOx modes. If not, adjust FLOW BALANCE Needle Valve as required.

5.2.4 CONVERTER BLEED FLOW

Even in converter bypass condition (i.e., de-energized state of the solenoid valve), a flow of approximately 100 cc/min of sample or standard gas passes continuously through the converter and the bleed capillary. This bleed flow provides faster response and ensures that the sample within the converter is current. Bleed flow need not be precisely 100 cc/min. However, an excessively low bleed flow will result in impaired response. Conversely, use of excessively high bleed flow may result in failure to obtain the required flow of 60 cc/min for the reaction chamber. Thus the nominal value of 100 cc/min represents a compromise between response time requirements and sample supply.

5.3 ELECTRONIC CIRCUITRY

Photons emitted during the chemiluminescence reaction (Section 5.1.1) impinge on the end-on photomultiplier tube, generating a signal current of approximately 3 x 10^{-10} amperes per parts-per-million concentration of NO in the reaction chamber. This current is measured by an electrometer amplifier.

A functional diagram of the *electronic signal circuitry* is shown in Figure 5-2. For a more detailed presentation of the signal circuitry, plus *control* circuitry for actuation of NO/NOx Mode Switching Solenoid Valve, etc., refer to the overall schematic and pictorial diagrams in the rear of this manual, respectively. Individual circuit boards plug into the Interconnect Board, shown in Figure 7-2.

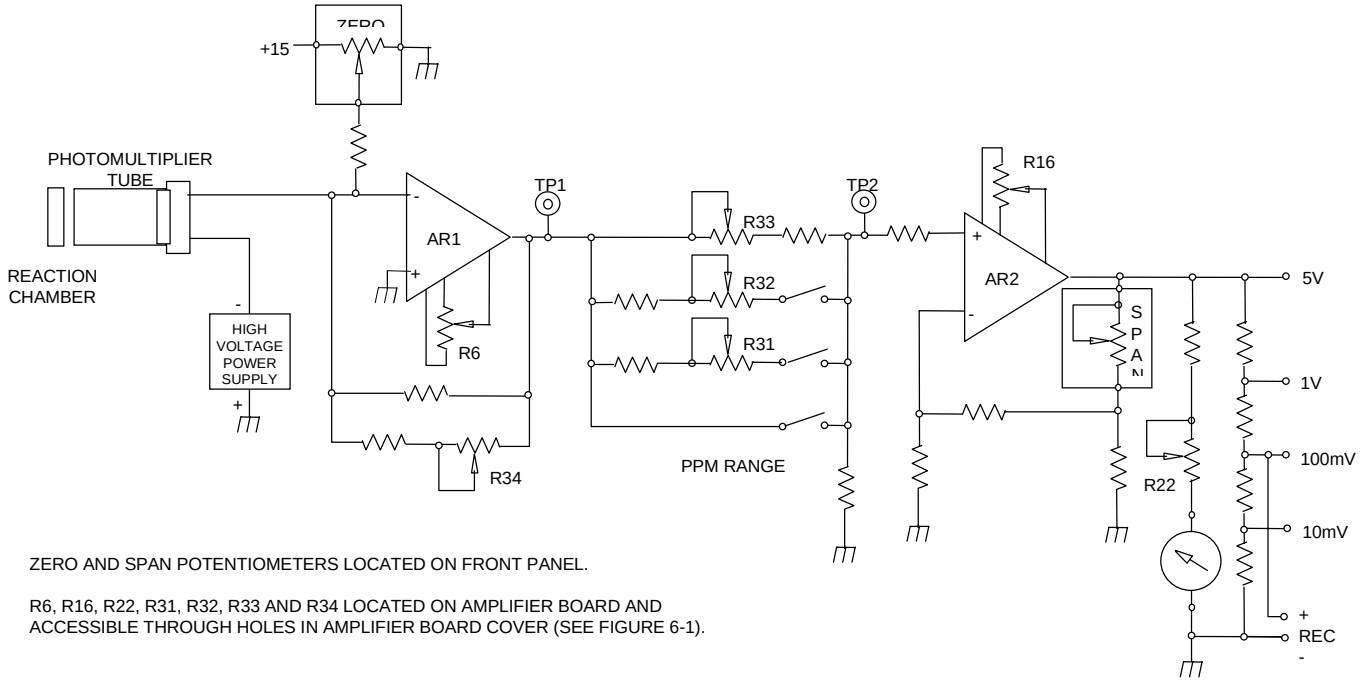


FIGURE 5-2. FUNCTIONAL SCHEMATIC DIAGRAM OF ELECTRONIC SIGNAL CIRCUITRY

As shown in Figure 5-2, the anode of the photomultiplier tube is connected to the inverting input of AR1, and integrated circuit MOSFET amplifier with extremely high input impedance to minimize loading effects, and comparatively low output impedance to match the following stage. The signal from AR1 is directed to integrated circuit amplifier AR2 for additional gain.

The front panel ZERO Control applies an adjustable zero-biasing signal to the input of AR1, to permit setting the zero point on the meter scale or recorder chart.

For adjustment of overall sensitivity, the current measuring circuitry utilizes two front panel controls:

1. The PPM RANGE Switch, associated with AR1, provides a choice of seven fullscale sensitivities, obtained by a combination of high/low feedback selection and output attenuation. Potentiometers R31, R32, R33 and R34 are adjustable to provide inter-range correlation of exactly adjusted integral multiples. Refer to Section 6.1, Step 3.
2. The SPAN Control, associated with AR2, provides continuously variable gain through feedback adjustment. A voltage divider network associated with AR2 provides a selectable output for a potentiometric recorder.

The following sections describe electronic circuitry of individual circuit boards.

5.3.1 AMPLIFIER BOARD AND ASSOCIATED CIRCUITRY

The Amplifier Board provides two stages of amplification utilizing integrated circuit amplifiers AR1 and AR2.

FUNCTIONS ASSOCIATED WITH AR1:

***AR1 Zero Adjust Potentiometer R6*:** This screwdriver adjusted trimming potentiometer, accessible through a hole in the amplifier cover, is used to eliminate voltage offset with AR1. When input signal is zero, output signal also should be zero. Refer to Section 6.1 for proper adjustment procedure.

Front Panel Zero Control: This control applies an adjustable zero-biasing signal to the input of AR1. to permit setting the zero point on the meter scale or recorder chart. The adjustment compensates for a residual amplifier input signal resulting from a combination of background signal and photomultiplier dark current.

Front Panel PPM RANGE: *Switch and Associated Resistor Network.* The PPM RANGE Switch controls sensitivity by a combination of two methods:

Selection of high or low feedback resistance via a transistor switching circuit. Potentiometer R34, adjustable by insertion of a screwdriver through a hole in the amplifier cover, permits establishing exactly the correct ratio between the high and low feedback resistances.

Output attenuation via resistors associated with relays U1, U2 and U3 on the amplifier board. Potentiometers R31, R32 and R33, adjustable by insertion of a screwdriver through the corresponding holes in the amplifier cover, permit inter-range correlation of exactly adjusted integral multiples.

FUNCTIONS ASSOCIATED WITH AR2:

AR2 Zero Adjust Potentiometer R16: This screwdriver adjusted trimming potentiometer, accessible through a hole in the amplifier cover, is used to eliminate voltage offset with AR2.

Front Panel SPAN Control: Provides continuously variable adjustment of AR2 gain.

Response Time Selection Switch SW2: Provides choice of fast or slow response:

With switch in FAST position, electronic response time (for 0 to 90% of fullscale) is approximately one second for all ranges except 10 ppm, approximately three seconds for 10 ppm range.

For such applications as monitoring of stack sources, where slow response is desired, switch is placed in SLOW position. Electronic response time (0 to 90% of fullscale) is then approximately 10 seconds for all ranges. Closure of the switch connects capacitors C7 and C8 across resistor R17, thus increasing the RC time constant.

Recorder Output Selection Switch SW1: The desired recorder output is obtained by closing the corresponding contact on Switch SW1, thus selecting the appropriate tap on a voltage divider connected across the output of AR2.

Meter Span Adjustment Potentiometer R22: Potentiometer R22, adjustable by insertion of a screwdriver through the hole in the amplifier cover, permits adjusting the fullscale span of the meter so that meter readout agrees with recorder readout.

5.3.2 VALVE CONTROL BOARD, FRONT PANEL MODE SWITCH AND ASSOCIATED CIRCUITRY

As shown in Drawings 649834 and 649835, actuation of NO/NOx Switching Solenoid Valve K3, associated with the NO_2 to NO converter, is controlled by front panel MODE Switch SW2 via the valve driver circuit on the Valve Control Board. With MODE Switch in NO position, the solenoid valve is de-energized, placing the converter in bypass condition. With switch in NOx position, the solenoid valve is energized, placing the converter in in-line condition.

Drawing 656313 shows internal circuitry of the Valve Control Board. The valve driver circuit consists of a single-pole, single-throw relay and associated TRIAC element. The relay is used only to switch the gate current for the TRIAC; therefore, power carried by the relay contacts is very small.

Each relay is connected to AC neutral while the associated TRIAC is connected to 115 VAC. When the relay closes, in response to closure of the associated contacts on the MODE Switch, gate current flows through the relay contacts and causes the TRIAC to fire. Resistance of the TRIAC becomes very small, causing application of 115 VAC across the solenoid. When the relay contacts open, the gate current is interrupted and the TRIAC stops conducting. Thus the relay controls the power applied to the solenoid.

5.3.3 ±15 VOLT POWER SUPPLY

The ±15 Volt Power Supply provides power for the various circuits. As shown in Drawing 619710, power transformer T1 has three secondarys that are used as follows:

38 VAC center-tapped secondary - Powers both 15 volt supplies through diode bridge CR1 and filter capacitors C1 and C4.

The adjustable positive regulator, VR1, is set by voltage divider R1, R2 and R3; and its output is applied to pin A of the circuit board and to test point TP1. Potentiometer R2 should be adjusted to +15.5 VDC ±50 mVDC.

The negative DC, regulated by VR2, is applied to pin D of the circuit board.

The center tap is the common reference for both the +15 and the -15 volt supplies and is applied to pin R of the circuit board and test point TP2.

Both outputs are used for individual amplifiers on the various circuit boards and for the zero-biasing circuit associated with the front panel ZERO Control (Section 5.3.1).

90 V secondary - Not used in this instrument.

9.5 VAC secondary - Drives a +5 V supply not used in this instrument.

5.3.4 HIGH VOLTAGE POWER SUPPLY

As shown in Drawings 649834 and 649835, DC high voltage for the photomultiplier tube is provided by the 630922 High Voltage Power Supply. It operates from the ±15 Volt Power Supply (Section 5.3.3).

Drawings 652423 and 654348 shows *internal* circuitry of the high voltage power supply. It consists of a voltage regulator circuit utilizing non-inverting operational amplifier AR1 and a flux-switching DC to AC converter. Potentiometer R4 provides an adjustment range of approximately -650 V to -2100 V for the regulated DC voltage supplied to the photomultiplier. *Nominal* setting is for -900 V; however, during factory checkout of the individual instrument, R4 is adjusted as required for overall system sensitivity. If necessary, R4 is readjusted per Section 6.1, Step 5.

5.3.5 CONVERTER TEMPERATURE CONTROL BOARD AND ASSOCIATED ELEMENTS

The temperature control circuit for the NO_2 to NO converter consists of:

Temperature sensor R3, a platinum resistance element mounted in the converter.

Converter Temperature Control Board.

CONVERTER ADJUST potentiometer R6 mounted on the front panel, Figure 2-2.

Resistive heating element within a lace-on jacket.

During startup, temperature of the platinum sensor is initially below the setpoint selected with the CONVERTER ADJUST potentiometer. Controller now switches to "on" condition, and applies power to the header via TRIAC element Q5. The controller remains in "on" condition until temperature of the platinum sensor has risen sufficiently to come within the range of the proportional band of the controller. The controller then switches alternately off and on during a two-second time base. to maintain the temperature of the heater at the setpoint.

Clockwise rotation of the CONVERTER ADJUST raises the setpoint; counterclockwise rotation lowers it. Setpoint adjustment is explained in Section 3.3.

Note

When installing or reinstalling the lace-on healer jacket on the converter, make sure that the yellow fiberglass sleeve on the temperature sensor leads is exposed and is not enclosed within the jacket. Otherwise, the insulation may burn off the sensor leads, causing short-circuiting of the sensor and temperature runaway or the converter heater.

CONVERTER TEMPERATURE READOUT THERMOCOUPLE

The Converter has an associated Type J thermocouple to permit temperature monitoring. The thermocouple connections, i.e., terminals 5(+) and 6(-) on TB9, are used to measure converter temperature in the range of 660°F to 750°F (350°C to 400°C). The optimum temperature differs from one analyzer to another. Refer to Section 3.3.

Note

Converter temperature is not a direct measure of conversion efficiency. Temperature measurement is for reference purposes only. An exact determination of conversion efficiency is performed by the procedure given in section 3.3.

5.3.6 FAN CONTROL CIRCUIT

The fans in current production instruments run continuously. In older instruments, the fan control circuit consists of thermistor R4, TRIAC switching circuit and blower fan B. When internal temperature of the analyzer reaches approximately 100°F (38°C), the fan is turned on.

5.3.7 REMOTE OPERATION OPTION

The Remote Operation Option, Figure 2-5, consists of a Plug-In Adapter Board with attached harness that terminates on a rear panel plate.

The adapter board has two two-position slide switches: the MAN/AUTO MODE Switch and the MAN/AUTO RANGE Switch.

The MAN/AUTO MODE Switch provides the choice of local or remote control of the NO/NOx Mode Switching Solenoid Valve, associated with the NO_2 to NO converter. With switch at MAN, the function is under control of the front panel MODE Switch (Section 5.3.2). With switch at AUTO, the front panel MODE Switch is disabled; the function is then remotely controlled, by either the operator or a computer, via contact-closure signals applied to terminals on TB5.

The MAN/AUTO RANGE Switch provides the choice of local or remote selection of operating range. With switch at MAN, range selection is under control of the front panel PPM RANGE Switch. With switch at AUTO, the front panel PPM RANGE Switch is disabled; range selection is remotely controlled by either the operator or a computer, via contact-closure signals applied to terminals on TB6.

Control at TB5 and TB6 is accomplished by a contact closure from the terminal marked COM (for common) to the terminal marked with the name of the desired function. Contact closure requirements are 25 mA at 15 VDC.

5.3.8 RANGE I.D. OPTION

The Range I.D. Option provides contact closure signals that permit a computer or other external device to identify the position selected on the front panel PPM Switch. This cable is connected to PPM Switch SW1 and extends to connector J10 mounted on the rear of the case.

6 SERVICE AND MAINTENANCE

WARNING: ELECTRICAL SHOCK HAZARD

Do not operate without doors and covers secure. Servicing requires access to live parts which can cause death or serious injury. Refer servicing to qualified personnel.

For safety and proper performance this instrument must be connected to a properly grounded three-wire source of power.

WARNING: ULTRAVIOLET LIGHT HAZARD

UV light from the ozone generator can cause permanent eye damage. DO NOT LOOK DIRECTLY AT THE UV SOURCE IN THE OZONE GENERATOR. Use of UV filtering glasses is recommended.

WARNING: LIGHT EXPOSURE

The photomultiplier tube must not be exposed to ambient light. Unless appropriate precautions are observed, light can strike the tube upon removal of fittings from the reaction chamber.

6.1 SYSTEM CHECKS AND ADJUSTMENTS

The following procedures may be used to determine the cause of unsatisfactory instrument performance, or to make adjustments following replacement of components. If a recorder is available, use it for maximum convenience and accuracy in the various tests.

METER MECHANICAL ZERO

With electrical power removed from the analyzer, connect a shorting jumper across the terminals of the front panel readout meter. Meter should read zero; if not, adjust screw at rear of meter as required. Remove jumper.

AMPLIFIER ZERO ADJUSTMENTS

Refer to Figure 6-1 for location of Amplifier Board components noted in the following procedure.

1. Open front panel to turn off high voltage; set SPAN Control at 1000; set ZERO Control at 1000. Then perform the following checks and adjustments:
2. With PPM RANGE Switch at 250, obtain zero reading on meter or recorder by screwdriver adjustment of R16, accessible through hole in cover of amplifier board.
3. With PPM RANGE Switch at 1000, obtain reading of 0 (±1 division) on meter or recorder by screwdriver adjustment of R6, accessible through hole in cover of amplifier board.
4. Repeat Step a. If the specified zero readings are unobtainable by adjustment of the corresponding potentiometers, replace amplifier board.

INTER-RANGE ATTENUATION CORRELATION ADJUSTMENTS

Refer to Figure 6-1 for location of Amplifier Board components noted in the following procedure.

1. During the following adjustments, observe the analyzer output on a digital voltmeter or strip-chart recorder. If neither is available, use the front panel meter. Perform the following adjustments:
2. Supply 10 parts-per-million standard to analyzer. Set PPM RANGE Switch at 10. Obtain fullscale reading by adjustment of front panel SPAN Control.
3. Move PPM RANGE Switch to 250. Obtain reading of 4% of fullscale by screwdriver adjustment of R33, accessible through hole in cover of amplifier board.
4. Move PPM RANGE Switch to 25. Obtain reading of 40% of fullscale by screwdriver adjustment of R31, accessible through hole in cover of amplifier board.
5. Move PPM RANGE Switch to 100. Obtain reading of 10% of fullscale by screwdriver adjustment of R32, accessible through hole in cover of amplifier board.
6. Supply 100 parts-per-million standard to analyzer. Adjust front panel SPAN Control for fullscale reading.
7. Move PPM RANGE Switch to 1000. Obtain reading of 10% of fullscale by screwdriver adjustment of R34, accessible through hole in cover of amplifier board.

METER FULLSCALE SPAN ADJUSTMENT

If a recorder is used, and has been properly zeroed, it should agree with the meter reading. If not, obtain agreement by screwdriver adjustment of R22, accessible through hole in cover of amplifier board (Figure 6-1). If agreement *cannot* be obtained, check recorder. If recorder is functioning properly, replace amplifier board.

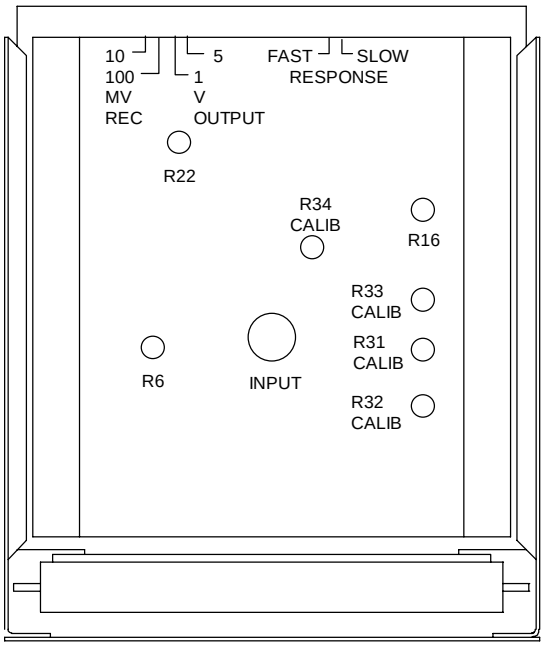


FIGURE 6-1. AMPLIFIER BOARD

OVERALL SENSITIVITY

Principal factors that determine overall sensitivity of the analyzer are: (a) sample flow rate to the reaction chamber, and (b) sensitivity of the photomultiplier tube. If specified fullscale readings are unobtainable by adjustment of the SPAN Control, sensitivity is subnormal. The cause of the reduced sensitivity may be in either the flow system (Section 6.2) or the electronic circuitry (Section 6.3).

If either the High Voltage Board or the Phototube/Reaction Chamber Assembly has been replaced, a readjustment of R4 on the High Voltage Board will probably be required to obtain the correct overall sensitivity. Turn the adjustment in the appropriate direction: *clockwise* to *increase* photomultiplier high voltage and therefore sensitivity; or, *counterclockwise* to *decrease* voltage and sensitivity. Adjustment range is approximately -650 volts to -2100 volts for the regulated DC voltage applied to the photomultiplier. *Nominal* setting is for -1100 volts; however, the adjustment should be set as required for overall system sensitivity.

OZONE OUTPUT

Maximum concentration of NO or NOx which the analyzer will measure with linearity depends on both the ozone generator output and the sample flow rate. If the analyzer seems to be ozone limited at high concentrations of NO or NOx, possible causes are: incorrect sample flow rate, incorrect flow rate through ozone generator, malfunction in ozone generator or associated transformer.

WARNING: TOXIC GAS

Use extreme caution in troubleshooting ozone generator. Ozone is toxic.

CAUTION: OZONE DAMAGE

When instrument power is on, the ultraviolet source sample is energized, converting a portion of the oxygen contained with the ozonator into ozone. With normal flow through the ozonator, the ozonized air or oxygen is continuously swept though the ozonator and into the reaction chamber. If flow is stopped, however, the ozone will diffuse and will attack the sintered metallic restrictor element in the tee fitting at the upstream end of the ozonator. Operation of the analyzer with the restrictor element thus rusted will result in the following consequences: Reduced flow of air or oxygen through the ozonator, ozone deprivation within the reaction chamber and non-linear response of the analyzer to NO/NOx.

To prevent such damage, verify that the front panel ozone ON/OFF switch is turned off if flow of feed gas to the air inlet is terminated.

BACKGROUND CURRENT

With zero air supplied to rear panel SAMPLE inlet, and MODE Switch at either NO or NOx, excessive background current is evidenced by inability to obtain zero meter reading by adjustment of the ZERO Control. If background current is excessive, the cause must be found and corrected. The fault may be in either the electronic circuitry or the sample flow system.

First, establish proper performance of the electronic circuitry. Turn off high voltage by opening door. Turn on analyzer power. Verify that ZERO Control and amplifier are functioning properly. Close door and check for the following:

1. Excessive photomultiplier dark current. To check, shut off all flow to the ozone generator. Supply *cylinder air* to rear panel SAMPLE inlet. With MODE switch at NO, note response on meter or recorder. If background is still excessive, possible causes are: (1) leakage of ambient light to photomultiplier tube, or (2) defective photomultiplier tube.
2. Contamination of reaction chamber or sample flow system. Refer to Sections 6.2.1, 6.2.2 and 6.2.4

NO_2 TO NO CONVERTER TEMPERATURE ADJUSTMENT

Use procedure of Section 3.3

The FLOW BALANCE Control must now be adjusted to equalize pressure drops for the NO and NOx legs of the internal flow system. In the usual method, *NO_2 free* nitric oxide standard gas is supplied to the analyzer and the FLOW BALANCE Control is adjusted for equal reading of parts-per-million for the NO and NOx modes, as explained in Step 9.

An alternate method of flow balance, useable if NO_2 free nitric oxide standard gas is *unavailable* consists of checking SAMPLE pressure reading for NO and NOx modes, as described in Step 10.

FLOW BALANCE USING FRONT PANEL METER INDICATION WITH NO_2 FREE NITRIC OXIDE STANDARD GAS

1. Supply to the SAMPLE inlet a suitable NO_2 free nitric oxide span gas, for example 2500 parts-per-million NO. And NO span gas may be used, since balance is independent of concentration. However, it is *important* that the span gas be entirely free of NO_2; otherwise, the supposed flow balance achieved will be erroneous. A NO span gas known to be free of NO_2 can be purchased as a certified standard gas. Set SAMPLE Pressure Regulator so that SAMPLE Pressure Gauge indicated the value appropriate to the desired operating range. Refer to Figure 3-3. Set BYPASS Needle Valve for reading of 2 liters per minute on BYPASS Flowmeter.
2. Supply to the AIR inlet suitable air or oxygen, depending on the operating range. Refer to Section 2.3. Adjust OZONE Pressure Regulator so that OZONE Pressure Gauge indicates the value appropriate to the desired operating range. Refer to Figure 3-3.
3. Set MODE Switch at NO. Leave ZERO Control at previous setting. Turn PPM RANGE Switch to a setting appropriate to the nitric oxide content of the particular span gas. Adjust SPAN Control for reading of approximately 90% on meter or recorder.
4. Move MODE Switch from NO to NOx; compare meter or recorder readings for the two modes. The NOx reading should be equal to the NO reading. If the readings are within acceptable agreement, the flows are properly balanced.

If the readings for the two modes are not in acceptable agreement, adjust the front panel FLOW BALANCE Control as required.

ALTERNATE FLOW BALANCE METHOD, USING SAMPLE PRESSURE READING FOR NO AND NOX MODES

If NO_2 free nitric oxide standard gas is unavailable, verify that reading on SAMPLE Pressure Gauge is the same for NO and NOx modes. If not, adjust FLOW BALANCE Needle Valve as required.

6.2 SERVICING FLOW SYSTEM

To facilitate servicing and testing, the Model 951A has front, rear and top access.

Refer to Drawings 649958 and 649842 in the rear of this manual for details of flow system.

6.2.1 SAMPLE CAPILLARY

Depending on when the instrument was made, one of two types of capillaries may be present: a) a black tubing with white Teflon inner sleeve, or b) a one-piece black Teflon tubing.

If clogging of sample capillary is suspected, measure flow rate as described below:

1. Turn off instrument power and shut off all gases.
2. Cover and shade the fittings on the reaction chamber with a dark cloth or other light-shielding material. While maintaining the area properly darkened, remove the fitting associated with the sample capillary (red-banded tube) and place a cap over the open fitting to prevent entry of stray light.

Note

If the opened fitting is inadvertently exposed to ambient light, the instrument will temporarily give a highly noisy background reading. If so, this condition may be corrected by leaving the instrument on, with high voltage on, for several hours.

3. With *instrument power off*, supply suitable test gas (dry nitrogen or air) to rear panel SAMPLE inlet.
4. Connect a flowmeter to open end of sample capillary. Per Table 3-1, adjust SAMPLE Pressure Regulator to normal operating setting, and verify that flowmeter indicates appropriate flow.

If flow is correct, restore analyzer to normal operation. If flow is low, the capillary requires cleaning; proceed with the following steps:

1. On NO/NOx Mode Switching Solenoid Valve K3, remove fitting from port associated with sample capillary.
2. Clean capillary with alcohol, then purge with dry nitrogen for one minute. Reconnect capillary to K3.
3. With the photomultiplier still covered, slowly insert the free end of the capillary into the corresponding fitting on the reaction chamber. (If capillary is of the two-piece variety, the bare Teflon tube at the end of the capillary *must* be inserted blindly and rotated until it enters a channeled internal passage, which can be detected by feel. The end of the Teflon tube should *not* project into the interior of the chamber; it should be slightly below the surface of the inner face. If tube is too long, trim back

slightly as required.) Push the capillary in until it bottoms against the internal fitting, then tighten fitting.

Note

After capillary cleaning, instrument readout may be noisy for a short time, but should then become quiet. However, if bare Teflon tube is improperly inserted in Step 7, noisy readout will persist.

6.2.2 OZONE RESTRICTOR AND CAPILLARY

CAUTION: OZONE DAMAGE

When instrument power is on, the ultraviolet source sample is energized, converting a portion of the oxygen contained with the ozonator into ozone. With normal flow through the ozonator, the ozonized air or oxygen is continuously swept though the ozonator and into the reaction chamber. If flow is stopped, however, the ozone will diffuse and will attack the sintered metallic restrictor element in the tee fitting at the upstream end of the ozonator. Operation of the analyzer with the restrictor element thus rusted will result in the following consequences: Reduced flow of air or oxygen through the ozonator, ozone deprivation within the reaction chamber and non-linear response of the analyzer to NO/NOx.

To prevent such damage, verify that the front panel ozone ON/OFF switch is turned off if flow of feed gas to the air inlet is terminated.

With *instrument power off*, supply suitable test gas (dry nitrogen or air) to rear panel AIR inlet. Cover photomultiplier housing with a dark cloth. At the fitting on the reaction chamber, disconnect the ozone tube (yellow banded) and place a cap over the open fitting to prevent entry of ambient light. Connect a flowmeter to open end of ozone tube. Adjust the OZONE Pressure Regulator so that OZONE Pressure Gauge indicates normal operating pressure, as listed in Table 3-1; verify that test flowmeter indicates appropriate flow, as listed in Table 3-1.

Subnormal flow indicates clogging in the flow path that supplies air or oxygen to the ozone generator. This path contains two pressure reducing elements:

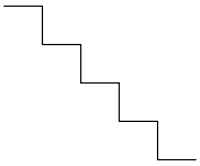
1. A Restrictor, consisting of a metal fitting with internal fritted (metal membrane) restrictor, the fitting is upstream from the inlet port of the ozone generator. If the internal restrictor becomes plugged, the Restrictor must be replaced, as it cannot normally be cleaned satisfactorily.
2. A capillary connected from the outlet of the ozone generator to the ozone inlet of the reaction chamber (coded with a yellow dot). This capillary may be cleaned if desired. Remove the ozone capillary by a procedure similar to that given for the

sample capillary in Section 6.2.1, observing all cautions cited. Clean ozone capillary by same method used for sample capillary.

Test for Ozone Efficiency

Perform the following steps:

1. Span the instrument with sample at 5 lb.
2. Decrease the pressure in 1 lb. steps. The response should be equal steps.



If the steps are not equal, there is an ozone deficiency. The ozone transformer lamp should be checked.

6.2.3 REPLACING NO_2 TO NO CONVERTER

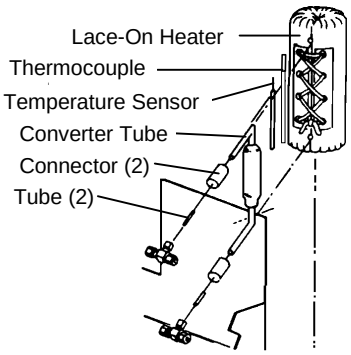
Converter replacement is recommended upon failure to achieve a conversion efficiency of 95% during the test of Section 3.3

To remove and replace converter, refer to Figure 6-2A. Within the outer lace on jacket heater, the converter tube is wrapped in aluminum foil, with the temperature sensor in contact with the glass converter tube. In removing foil, note sensor and thermocouple position to ensure correct repositioning during reassembly. Assemble sensor to replacement converter, as shown in Figure 6-2B, using new aluminum foil.

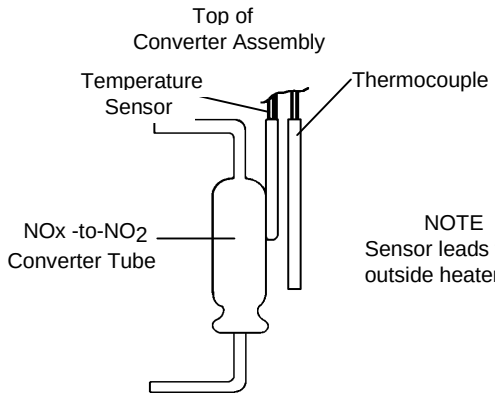
Note

When installing or reinstalling the lace on heater jacket on the converter, make sure that the yellow fiberglass sleeve on the temperature sensor leads is exposed and is not enclosed within the jacket. See Figure 6-2C.

A. EXPLODED VIEW



B. ATTACHING TEMPERATURE SENSOR TO CONVERTER TUBE



NOTE
Orient converter tube as shown and install sensor flush with outside edge of tube as shown.

C. HEATER JACKET PROPERLY INSTALLED ON CONVERTER TUBE

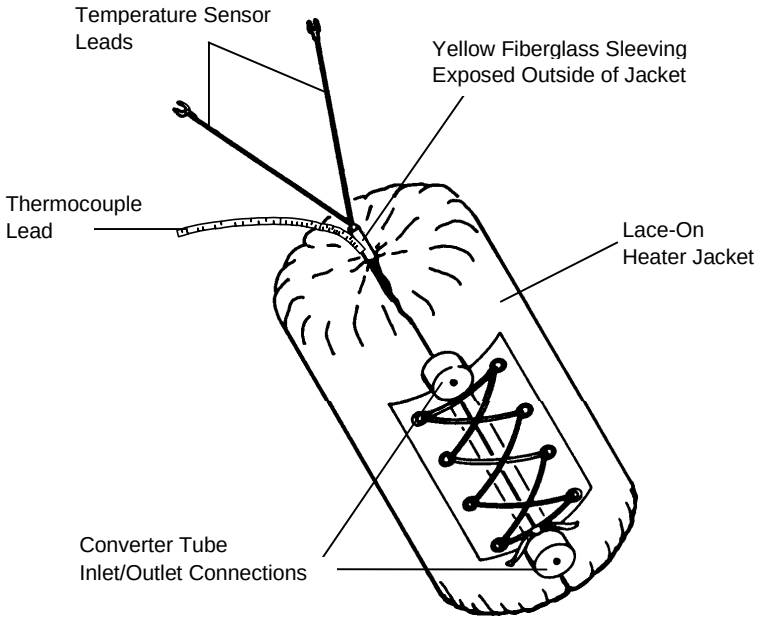


FIGURE 6-2. NO2 TO NO CONVERTER ASSEMBLY

6.2.4 CLEANING REACTION CHAMBER

CAUTION: LIGHT DAMAGE

Photomultiplier will develop temporary electronic noise if exposed to ambient light with high voltage on. Damage may be permanent if exposure occurs with high voltage off. A temporary noisy condition may be corrected by leaving instrument on, with high voltage on, for several hours. The required recovery time depends on intensity and duration of the exposure. Noise level on the most sensitive range usually drops to normal within 24 hours.

If sample gas is properly filtered, the reaction chamber should not require cleaning. In event of carryover or contamination, however, the chamber should be disassembled to permit cleaning the quartz window and the optical filter. The following procedure is recommended.

1. Turn off instrument power and shut off all gases.

2. Cover and shade the Reaction Chamber Photomultiplier Assembly, Figure 6-3, with a dark cloth or other light shielding material.

CAUTION: HAND PROTECTION

Always wear surgical rubber gloves when handling reaction chamber.

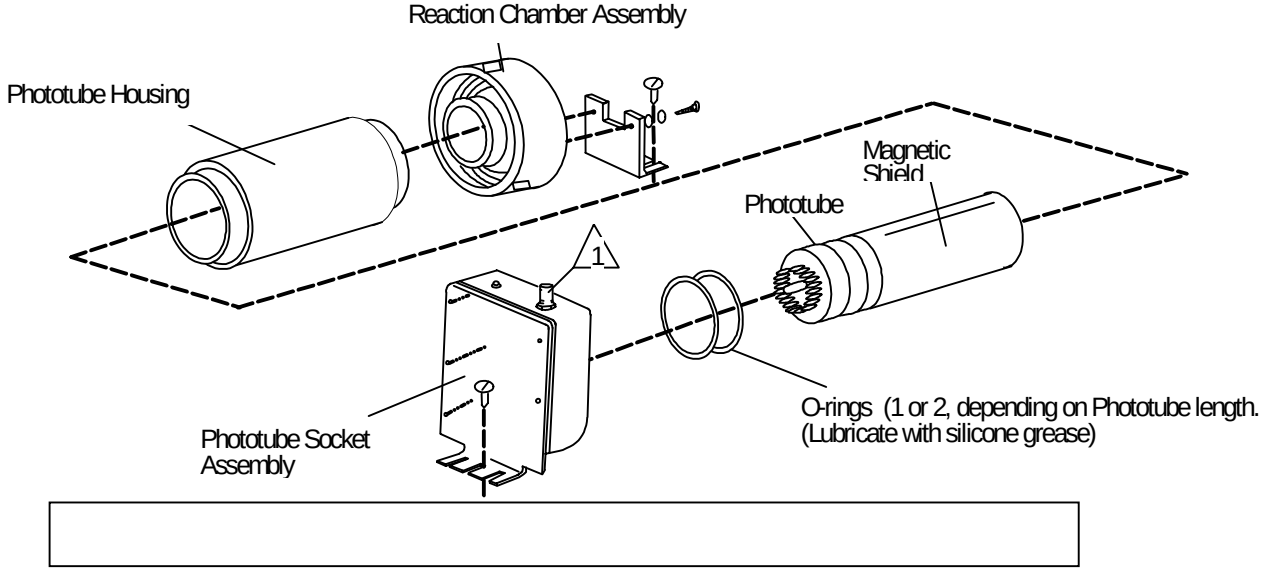


FIGURE 6-3. REACTION CHAMBER/PHOTOMULTIPLIER ASSEMBLY

3. At the front of the Reaction Chamber Photomultiplier Assembly, remove the three screws that secure the reaction chamber mounting bracket. See Figure 6-3. The middle screw is a 1/4-turn quick-release type; the two adjacent screws are the conventional continuous thread type.

4. With reaction chamber now free, detach its three tube fittings. See Figure 6-3.

5. Slide off and remove the reaction chamber from the housing. Take care not to let light enter.

6. Unscrew plastic end cap, Figure 6-4, thus freeing the quartz window and the red plastic optical filter.

7. Clean the reaction chamber by the appropriate one of the following two methods, “a” or “b”. Method “a” is applicable in most cases. Alternate method “b” is applicable when the instrument has shown high residual fluorescence, as indicated by high residual currents on a zero gas and high differentials between zero gas readings obtained with the ozone lamp on and off.

CAUTION: SOLVENT USAGE

For a solvent, use only distilled water, do not use alcohol or acetone.

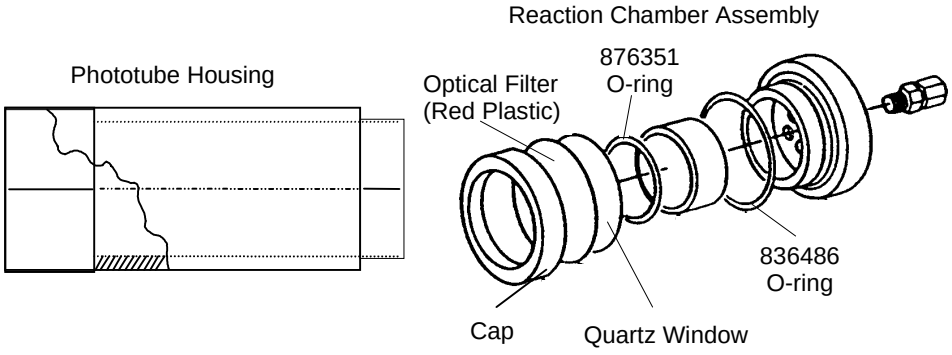


FIGURE 6-4. REACTION CHAMBER ASSEMBLY AND PHOTOTUBE HOUSING

a. Standard Cleaning Procedure

Using a stiff plastic bristle brush, such as a toothbrush, scrub the Teflon surface and gas ports of the reaction chamber with clean distilled water and Alconox detergent (634929). Alconox detergent is included in the shipping kit provided with the Model 951A NO/NOx Analyzer and is also available from Sargent-Welch Scientific Company under its Catalog Number S-19650-A.

Using Alconox and clean, soft facial tissue (NOT industrial wipes), carefully clean the quartz window, vigorously flush reaction chamber and quartz window with clean distilled water. Blow out all possible water from internal passages of reaction chamber. Dry reaction chamber and quartz window in a warm oven at 125°F to 150°F (52°C to 66°C) for 30 to 45 minutes or purge dry the parts with dry cylinder air or nitrogen to eliminate all moisture.

b. Alternate Cleaning Procedure - For High Residual Fluorescence

Holding the reaction chamber by the tube fittings, and using appropriate caution. immerse the white Teflon part of the chamber in 50% concentrated Reagent Grade HCl. After five minutes, rinse thoroughly with deionized water, then air dry as in method “a” above.

8. Place parts in position and press on end cap so that mating threads engage properly, without cross-threading. Turn mating parts in one continuous motion until the parts bottom. Do not over torque.

9. With reaction chamber now assembled, replace and reconnect it in the reverse order of that used for removal.

6.2.5 PHOTOMULTIPLIER TUBE AND HOUSING

The photomultiplier tube operates at high DC voltages (nominal range 600 to 1200 volts) and generates small currents that are highly amplified by the signal conditioning circuitry. It is therefore important that ambient humidity and condensed water vapor be excluded from the interior of the photomultiplier housing. Ambient humidity can result in electrical leakage, evidenced as abnormally high dark current. Water vapor or condensed moisture in contact with the thermoelectrically-cooled photomultiplier may be evidenced by abnormally high noise level during instrument readout on zero air or upscale standard gas.

The Reaction Chamber Photomultiplier Assembly, Figure 6-3, incorporates several features for exclusion of humidity and moisture. The photomultiplier socket assembly is potted with a high impedance compound and is sealed from external influences with epoxy and rubber gasket material. The socket assembly and the reaction chamber are sealed, with o-rings, into opposite ends of the tubular photomultiplier housing. The socket end of the housing may be sealed with either one or two o-rings, depending on the length of the phototube.

In addition, a rolled-up piece of blotter-like desiccant paper is inserted between the shield external to the housing. The desiccant paper ensures hermetic isolation of the housing despite possible minor leakage around the o-rings, and eliminates the effects of any humidity possibly trapped during assembly of the socket and the reaction chamber to the housing. If the photomultiplier housing is exposed to ambient air for a period of tie, the desiccant paper will absorb water. Before reassembly, the paper must then be heated in an oven at about 300°F (149°C) for at least two hours.

Within the housing is a humidity indicator which turns pink in the presence of humidity.

6.2.6 TEFLON LINER IN LAMP HOUSING OF OZONE GENERATOR

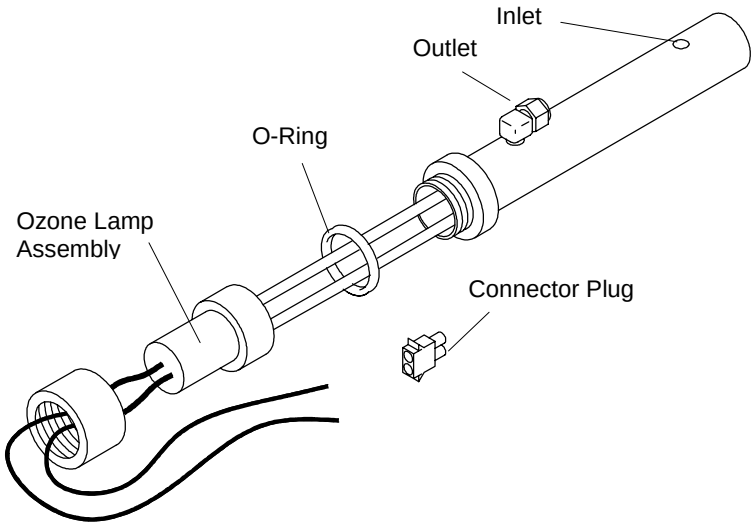
WARNING: MERCURY HAZARD

Handle lamp assembly with extreme caution. Lamp contains mercury vapor.

CAUTION: LAMP DAMAGE

Do not touch lamp. Fingerprints could cause a decrease in lamp output.

A Teflon liner was used inside the ozone lamp housing during early production runs of the Model 951A. A bare lamp housing is now used in lieu of the liner.

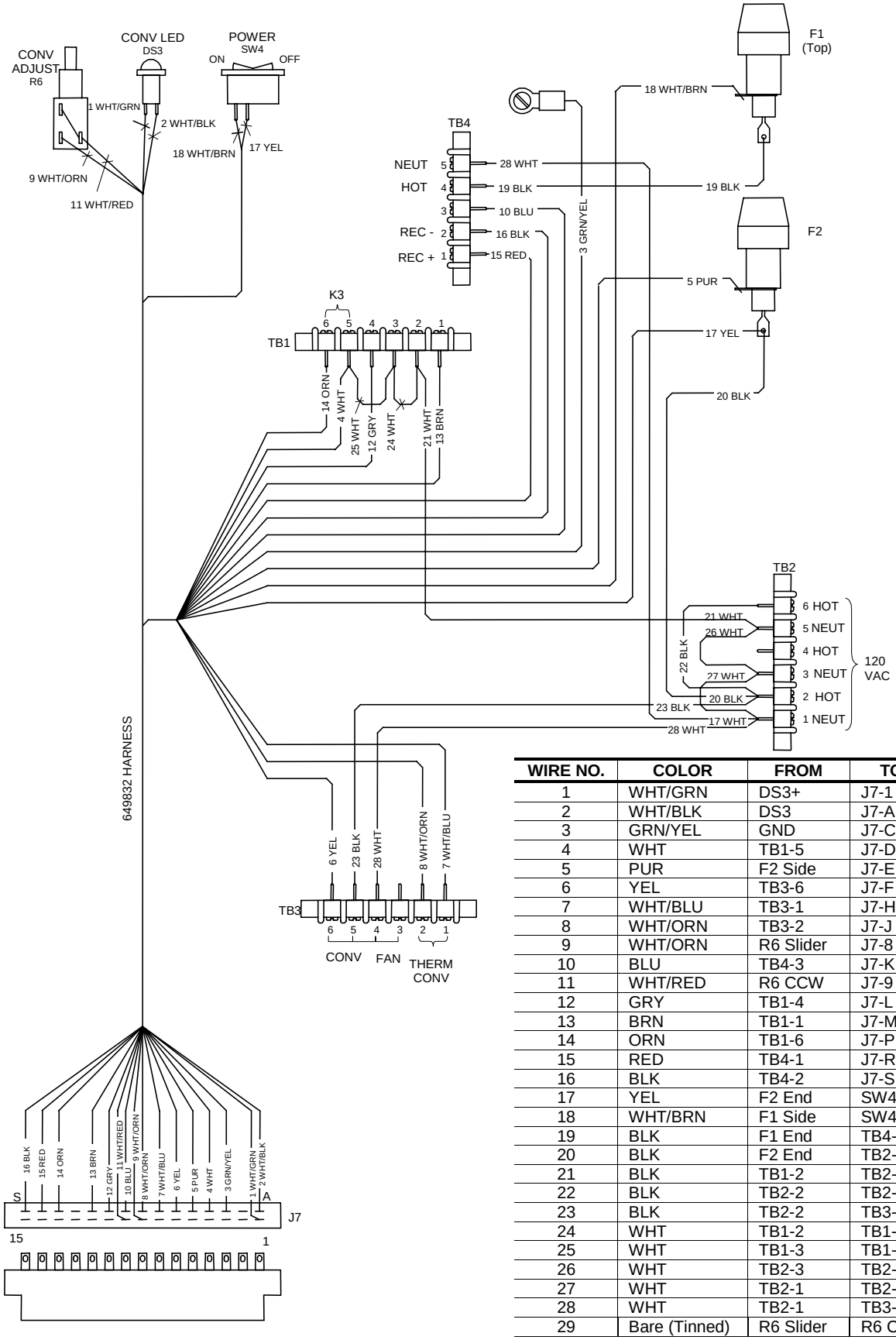


For replacement of lamp only, order Ozone Lamp Kit 658156 (includes O-Ring).
For replacement of complete Ozone Generator, order Kit 654793.
Refer to instructions provided with kit.

FIGURE 6-5. OZONE GENERATOR

6.3 SERVICING ELECTRONIC CIRCUITRY

Refer to the appropriate schematic and pictorial diagrams in the rear of this manual when servicing. The electronic system, Figure 7-2, utilizes plug in printed circuit boards with solid state components. After a malfunction is traced to a particular board, the recommended procedure is to return it to the factory for repair. Your Service Representative will arrange a Returned Goods Authorization.



WIRE NO.	COLOR	FROM	TO
1	WHT/GRN	DS3+	J7-1
2	WHT/BLK	DS3	J7-A
3	GRN/YEL	GND	J7-C
4	WHT	TB1-5	J7-D
5	PUR	F2 Side	J7-E
6	YEL	TB3-6	J7-F
7	WHT/BLU	TB3-1	J7-H
8	WHT/ORN	TB3-2	J7-J
9	WHT/ORN	R6 Slider	J7-8
10	BLU	TB4-3	J7-K
11	WHT/RED	R6 CCW	J7-9
12	GRY	TB1-4	J7-L
13	BRN	TB1-1	J7-M
14	ORN	TB1-6	J7-P
15	RED	TB4-1	J7-R
16	BLK	TB4-2	J7-S
17	YEL	F2 End	SW4
18	WHT/BRN	F1 Side	SW4
19	BLK	F1 End	TB4-4
20	BLK	F2 End	TB2-2
21	BLK	TB1-2	TB2-5
22	BLK	TB2-2	TB2-6
23	BLK	TB2-2	TB3-5
24	WHT	TB1-2	TB1-3
25	WHT	TB1-3	TB1-5
26	WHT	TB2-3	TB2-5
27	WHT	TB2-1	TB2-3
28	WHT	TB2-1	TB3-4
29	Bare (Tinned)	R6 Slider	R6 CW

FIGURE 6-6. TERMINAL CHASSIS ASSEMBLY WIRING DIAGRAM

NOTES

7 REPLACEMENT PARTS

The following parts are recommended for routine maintenance and troubleshooting of your instrument. If the troubleshooting procedures do not resolve the problem, contact your local service office.

7.1 CIRCUIT BOARD REPLACEMENT POLICY

In most situations involving a malfunction of a circuit board, it is more practical to replace the board than to attempt isolation and replacement of the individual component, as the cost of test and replacement will exceed the cost of a rebuilt assembly. As standard policy, rebuilt boards are available on an exchange basis.

Because of the exchange policy covering circuit boards, the following list does not include individual electronic components. If circumstances necessitate replacement of an individual component, which can be identified by inspection or from the schematic diagrams, obtain the replacement component from a local source of supply.

7.2 REPLACEMENT PARTS

621095	±15V Power Supply	
649815	Amplifier Board	
652842	Ballast Transformer, Ozone Generator	
623719	Capillary, Sample	
623743	Capillary, Pump	
634398	Capillary, Bleed	
630960	Coaxial Cable, Amplifier	
632783	Converter Assembly[1]	See Section 7.2.2
861273	Fan	
809374	Fuse 3/4 Amp	
777010	Fuse 5 Amp (Package of 15)	
658992	High Voltage Power Supply Board	
630920	Interconnect Board	
630931	Meter	
654793	Ozone Generator	See Section 7.2.3
658156	Ozone Generator Lamp Kit (Lamp Only)	
657842	Power Supply Board	
632748	Pump (Option)	
635664	Pump Repair Kit	
636343	Reaction Chamber	
902315	Signal Converter 4-20mA (Option)	
641620	Temperature Control Board	
624593	Valve Control Board	

[1] See section noted for components of assembly.

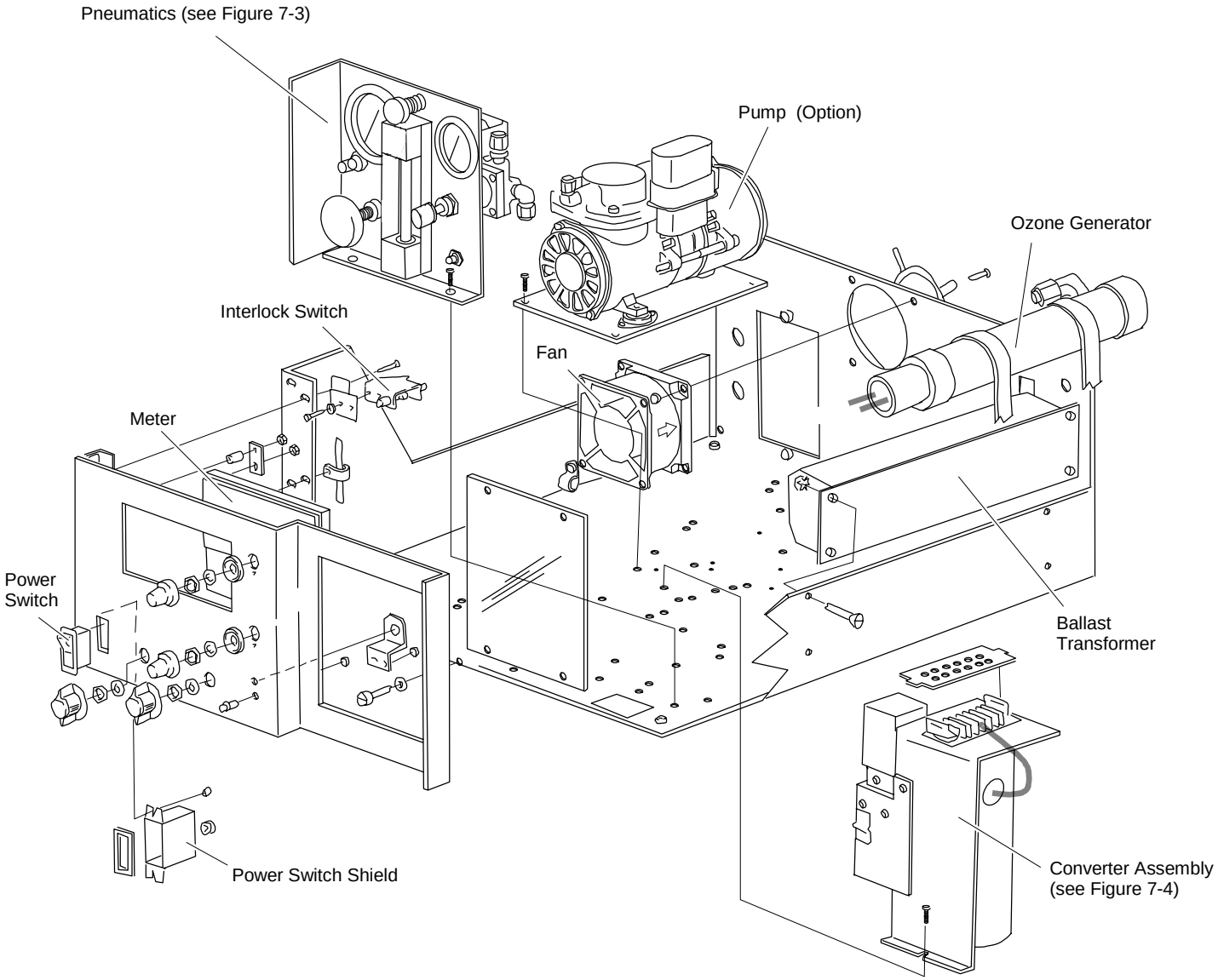


FIGURE 7-1A. MODEL 951A

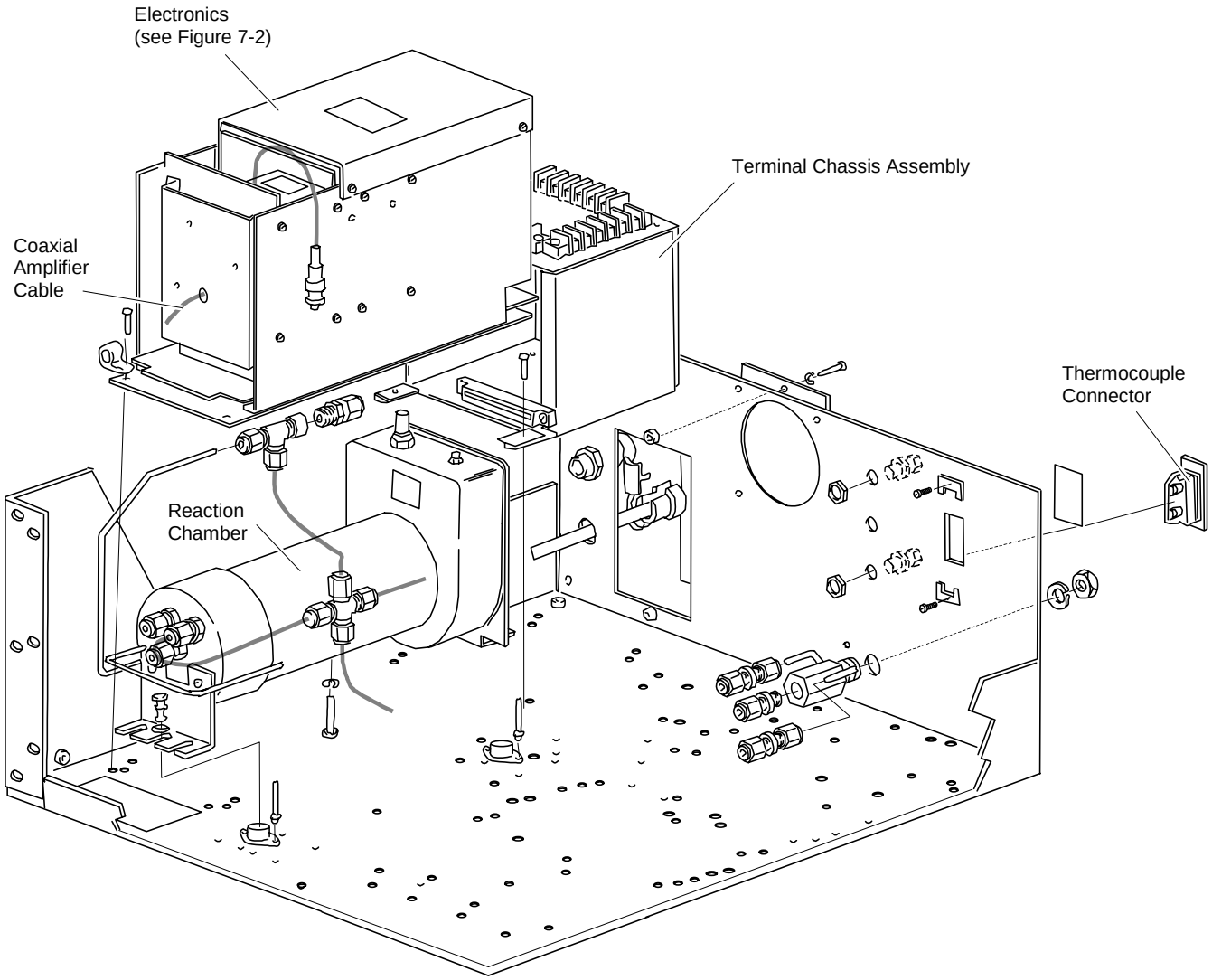


FIGURE 7-1B. MODEL 951A

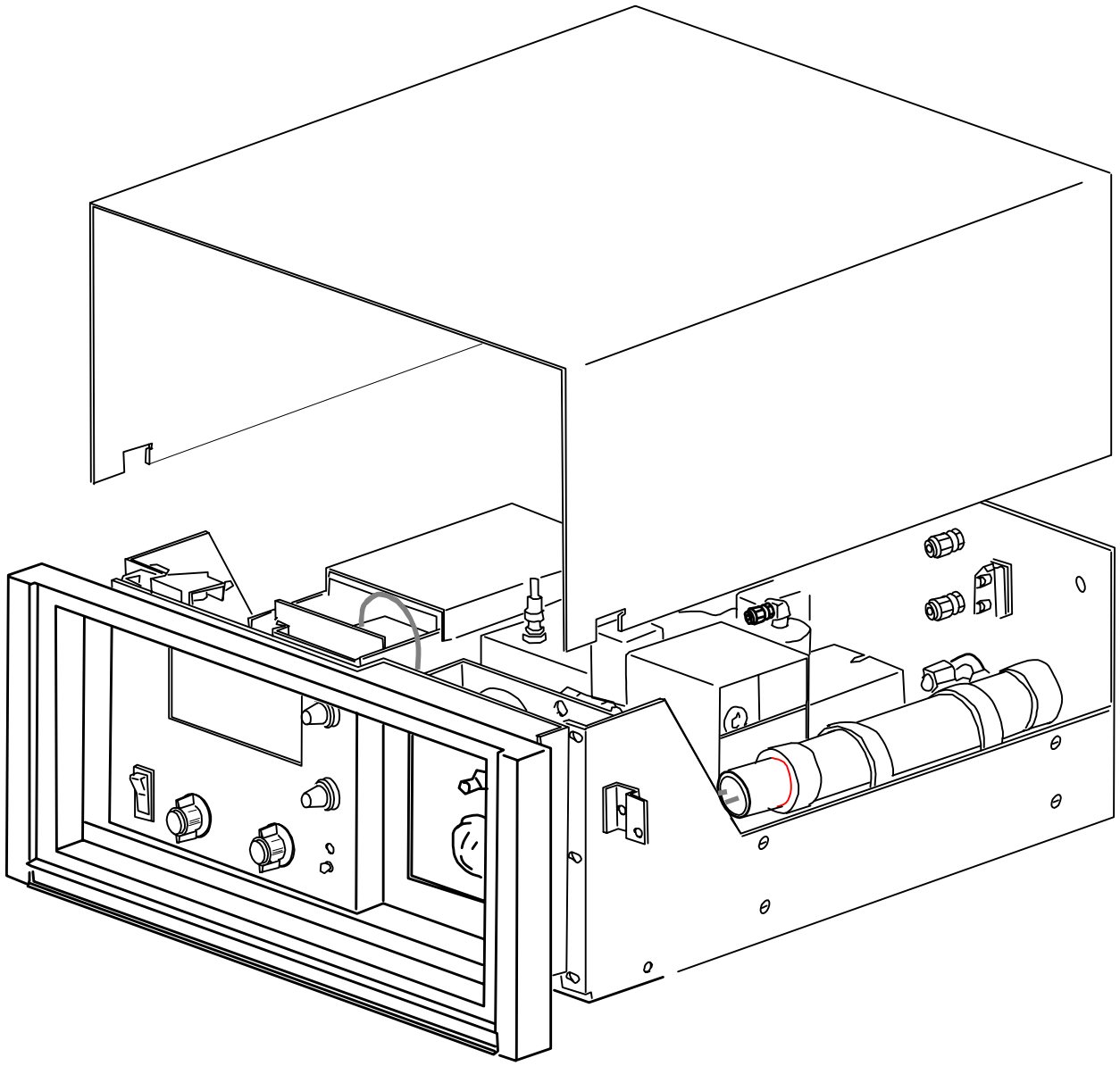


FIGURE 7-1C. MODEL 951A

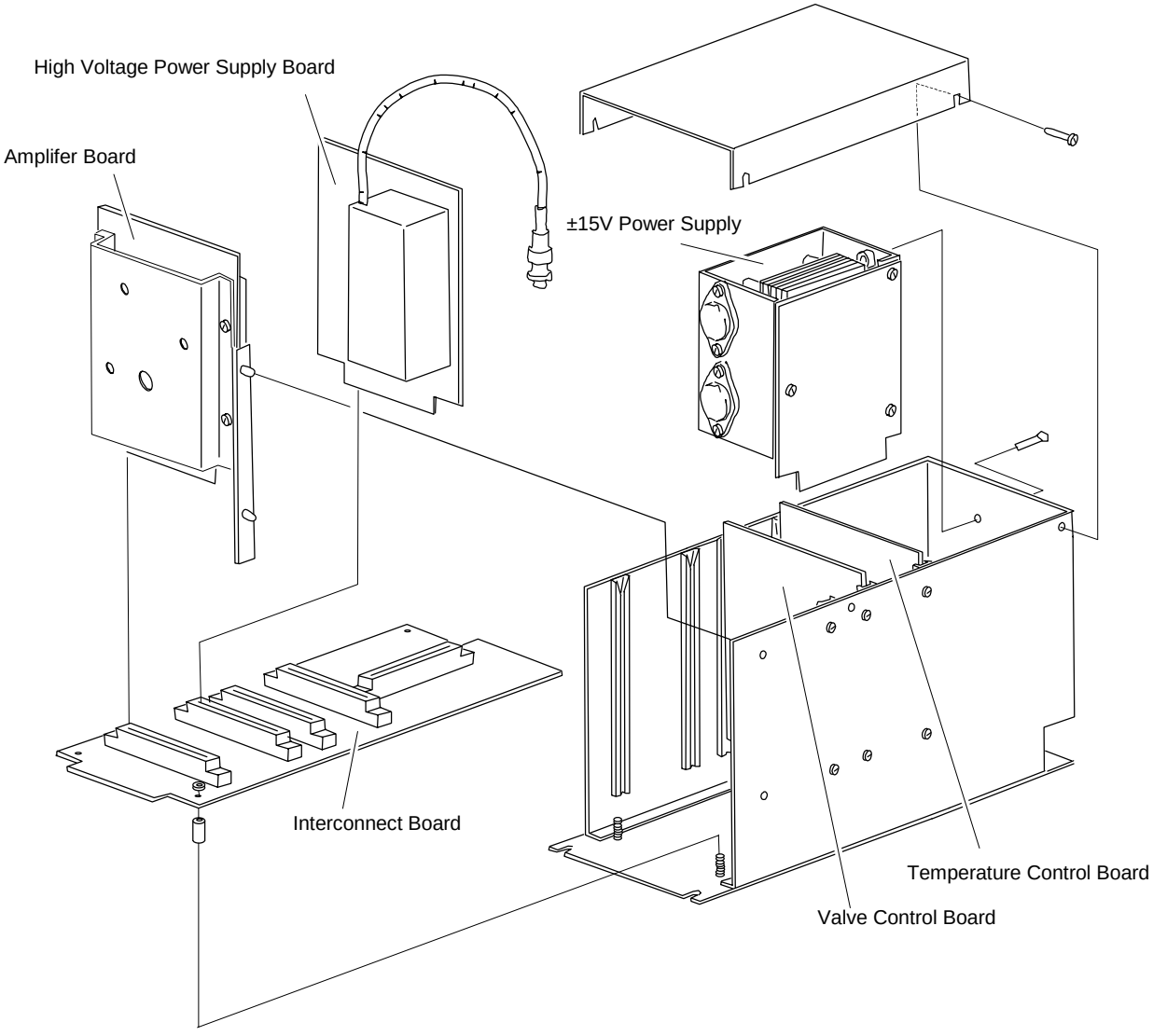


FIGURE 7-2. ELECTRONICS

7.2.1 PNEUMATICS

638614 Pressure Gauge, Ozone
644055 Pressure Gauge, Sample
839906 Flowmeter, Bypass
815187 Backpressure Regulator, Sample
634993 Needle Valve, Bypass
888692 Pressure Regulator, Ozone
652146 Tee Fitting Assembly
107542 Metering Valve, Flow Balance

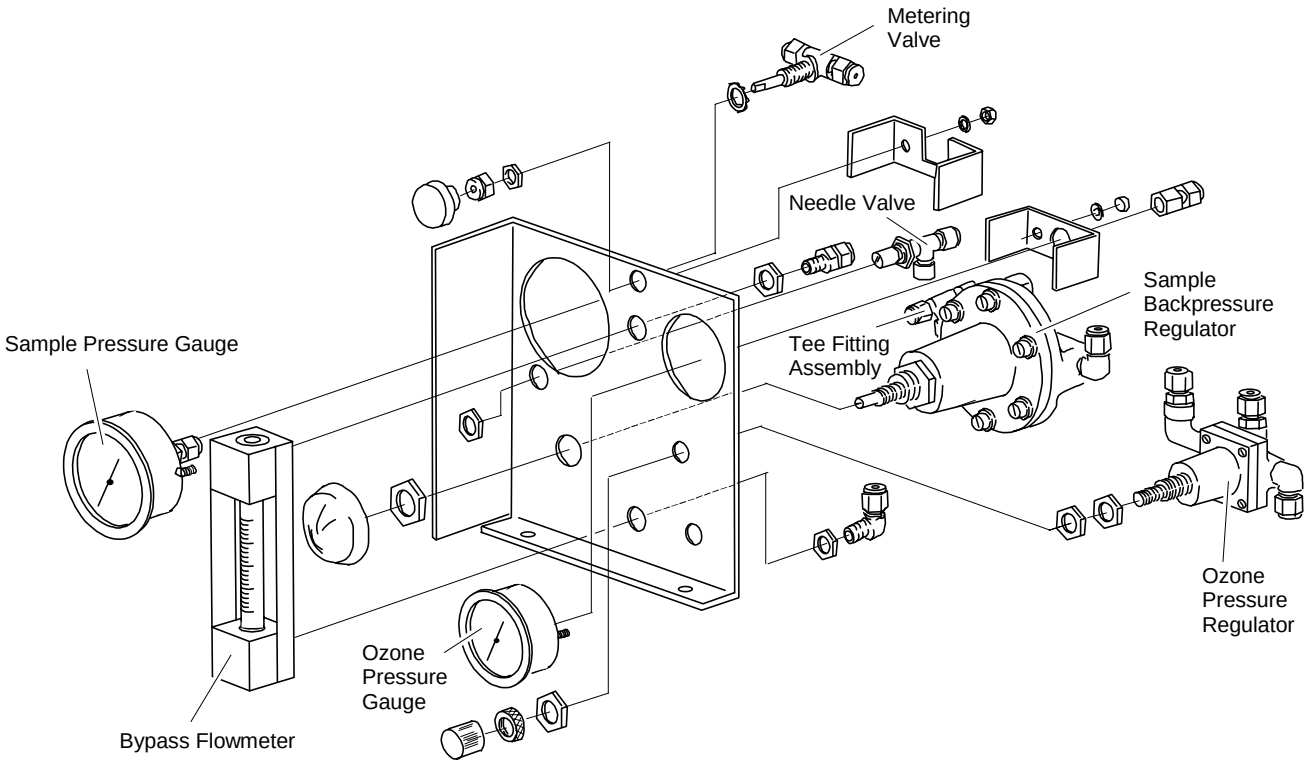


FIGURE 7-3. FRONT PANEL PNEUMATIC COMPONENTS

7.2.2 CONVERTER ASSEMBLY

632782 Sensor
632784 Connector, Tube
632795 Tube, Packed - Aged
617124 Heater Jacket
623848 Thermocouple, Type J
876776 Solenoid Valve - 3-Way
879948 Nut, Teflon 3/32

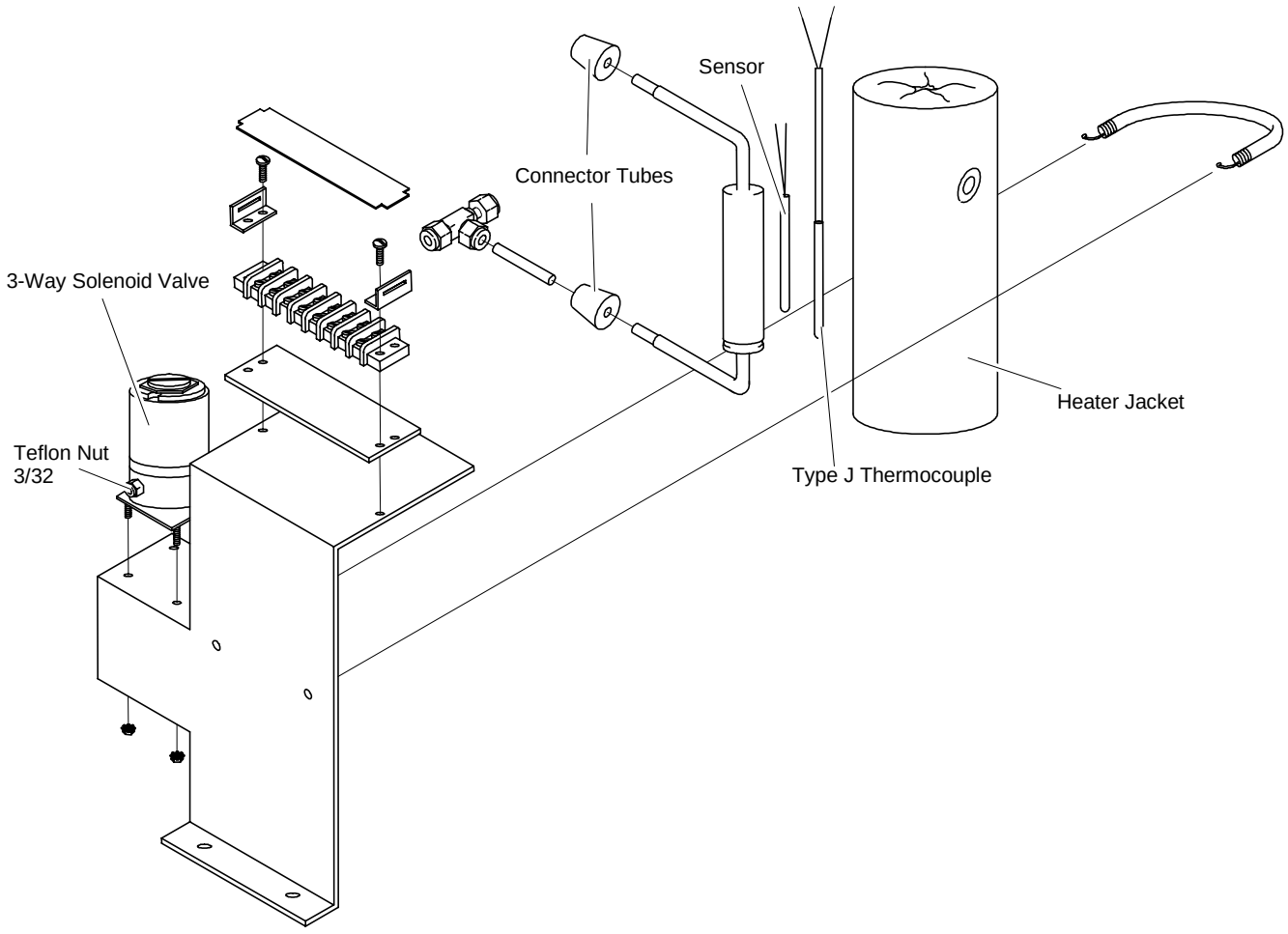
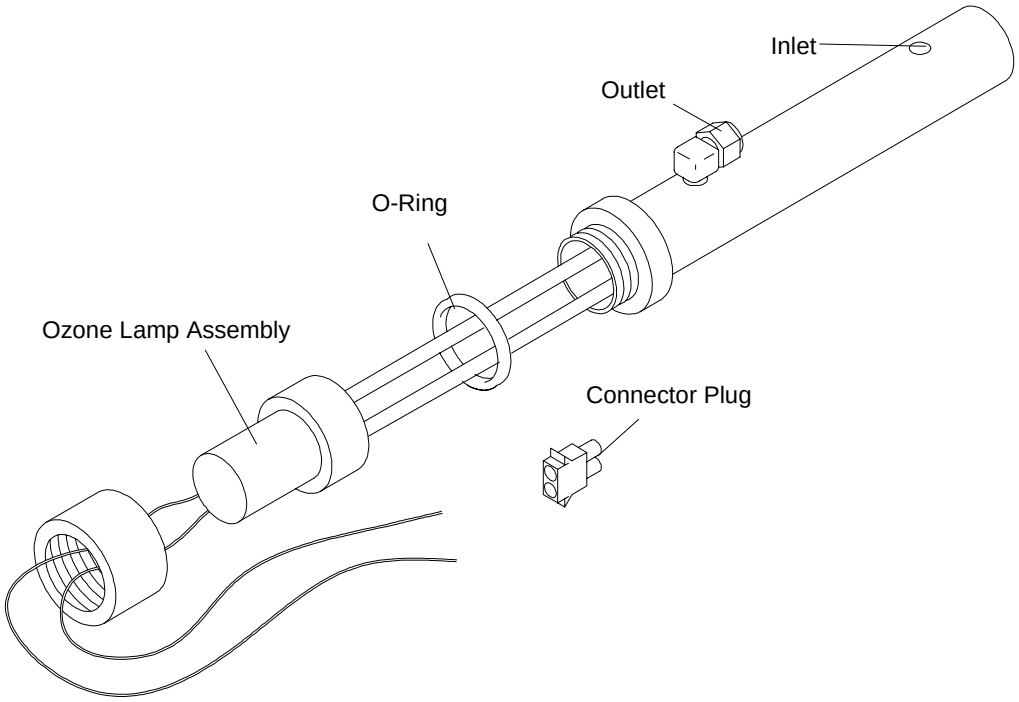


FIGURE 7-4. CONVERTER COMPONENTS



For replacement of lamp only, order Ozone Lamp Kit 658156 (includes O-Ring).
For replacement of complete Ozone Generator, order Kit 654793.
Refer to instructions provided with kit.

FIGURE 7-5. OZONE GENERATOR COMPONENTS

7.2.3 LOW TEMPCO OPTION

652831 Power Supply Assembly
654831 Reaction Chamber
861040 Sensor, Cooler Temperature
884791 Thermistor
654943 Thermoelectric Cooler Assembly
652836 Transformer, Thermoelectric Cooler

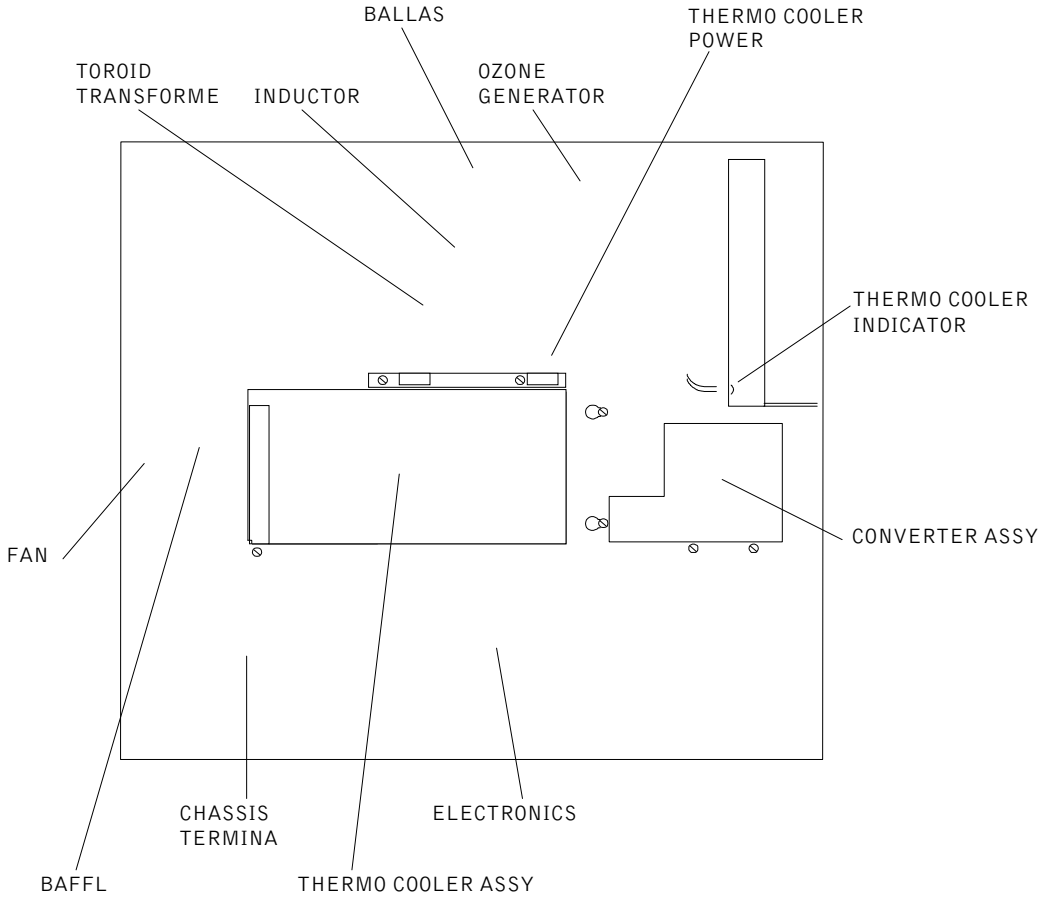


FIGURE 7-6. TEMPCO RETROFIT COMPONENT LOCATION

NOTES