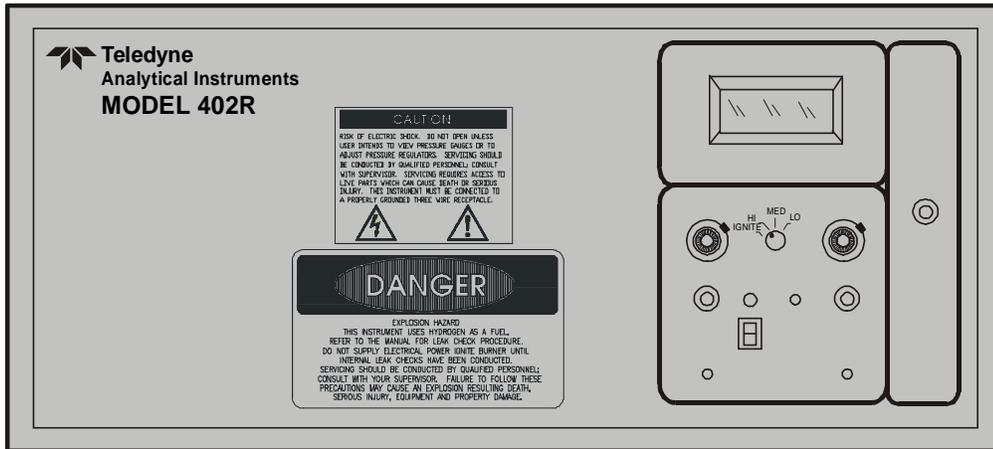

INSTRUCTION MANUAL

MODEL 402R-EU

TOTAL HYDROCARBON ANALYZER



	DANGER	
<p>HIGHLY TOXIC AND OR FLAMMABLE LIQUIDS OR GASES MAY BE PRESENT IN THIS MONITORING SYSTEM.</p> <p>PERSONAL PROTECTIVE EQUIPMENT MAY BE REQUIRED WHEN SERVICING THIS SYSTEM.</p> <p>HAZARDOUS VOLTAGES EXIST ON CERTAIN COMPONENTS INTERNALLY WHICH MAY PERSIST FOR A TIME EVEN AFTER THE POWER IS TURNED OFF AND DISCONNECTED.</p> <p>ONLY AUTHORIZED PERSONNEL SHOULD CONDUCT MAINTENANCE AND/OR SERVICING. BEFORE CONDUCTING ANY MAINTENANCE OR SERVICING CONSULT WITH AUTHORIZED SUPERVISOR/MANAGER.</p>		

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ECO: #99-0323
08/06/1999

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Warranty

This equipment is sold subject to the mutual agreement that it is warranted by us free from defects of material and of construction, and that our liability shall be limited to replacing or repairing at our factory (without charge, except for transportation), or at customer plant at our option, any material or construction in which defects become apparent within one year from the date of sale, except in cases where quotations or acknowledgements provide for a shorter period. Components manufactured by others bear the warranty of their manufacturer. This warranty does not cover defects caused by wear, accident, misuse, or neglect. We assume no liability for direct or indirect damages of any kind and the purchaser by the acceptance of the equipment will assume all liability for any damage which may result from its use or misuse.

We reserve the right to employ any suitable material in the manufacture of our apparatus, and to make any alterations in the dimensions, shape or weight of any parts, in so far as such alterations do not adversely affect our warranty.

Important Notice

This instrument is intended to be used a tool to gather valuable data. The information provided by the instrument may assist the user in eliminating potential hazards caused by the process that the instrument is intended to monitor; however, **it is essential that all personnel involved in the use of the instrument or its interface with the process being measured be properly trained in the process itself, as well as all instrumentation related to it.**

The safety of personnel is ultimately the responsibility of those who control process conditions. While this instrument may be able to provide early warning of imminent danger, it has no control over process conditions, and can be misused. In particular, any alarm or control system installed must be tested and understood, both as to how they operate and as to how they can be defeated. Any safeguards required such as locks, labels, or redundancy must be provided by the user or specifically requested of Teledyne.

The purchaser must be aware of the hazardous conditions inherent in the process(es) he uses. He is responsible for training his personnel, for providing hazard warning methods and instrumentation per the appropriate standards, and for ensuring that hazard warning devices and instrumentation are maintained and operated properly.

TET/AI, the manufacturer of this instrument, cannot accept responsibility for conditions beyond its knowledge and control. **No statement expressed or implied by this document or any information disseminated by the manufacturer or his agents is to be construed as a warranty of adequate safety control under the user's process conditions.**

IN ORDER TO AVOID HAZARDOUS CONDITIONS, DAMAGE TO THE INSTRUMENT, AND TO ASSURE PROPER OPERATION, THE USER SHOULD READ THIS MANUAL BEFORE INSTALLING AND OPERATING THE 402R-EU



THIS INSTRUMENT SHOULD ONLY BE MAINTAINED BY SUITABLY TRAINED AND QUALIFIED PERSONNEL.



IF USED OUTSIDE OF THE SPECIFICATIONS (SEE APPENDIX A), THE INSTRUMENT MAY BE DAMAGED AND HAZARDOUS CONDITIONS MAY BE PRODUCED.

Model 402R-EU complies with all of the requirements of the Commonwealth of Europe (CE) for Radio Frequency Interference, Electromagnetic Interference (RFI/EMI), and Low Voltage Directive (LVD).

The following International Symbols are used throughout the Instruction Manual for your visual and immediate warnings and when you have to attend CAUTION while operating the instrument:



STAND-BY, Instrument is on Stand-by, but circuit is active



GROUND
Protective Earth



CAUTION, The operator needs to refer to the manual for further information. Failure to do so may compromise the safe operation of the equipment.



CAUTION, Risk of Electric Shock

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Introduction

The Teledyne Electronic Technologies/Analytical Instruments (TET/AI) Model 402R-EU Total Hydrocarbon Analyzer meets or exceeds all of the requirements of the Commonwealth of Europe (CE) for Radio Frequency Interference and Electromagnetic Interference (RFI/EMI) protection and Low Voltage Directive (LVD). The analyzer is designed to measure the quantity of hydrocarbons present in a positive pressure sample as equivalent methane.

1.1 Principle of Operation

The sample gas is mixed with a fuel (normally a composition of hydrogen and nitrogen) and burned in an atmosphere of “blanket air”. The ions formed in the burning process cause an electrical conduction between two electrodes in the combustion chamber (or detector cell) that is amplified by a highly sensitive electrometer-amplifier circuit. The electrical output of the electrometer-amplifier is directly proportional to the quantity of flame ionizable hydrocarbons present, and is linear over the range of 0-10,000 PPM methane.

1.2 Analyzer Description

The information contained in this manual describes individual analyzers of the Model 402R-EU standard series. In cases of special design, other factors may apply requiring additional or supplementary information. These special considerations will be described in detail on specific application pages labelled Addenda, in each manual. When the Model 402R-EU is a part of a larger system, it is subordinate to that system, and specific installation and operation conditions of that system will apply. Consult system sections of the manuals for those applications, where conditions specific to those systems will be detailed.

To best suit the needs of the purchaser, specialized designs are available. Details of the design differences may be found in the various drawings (outline, assembly, schematic, wiring, and piping diagrams) in the drawings section at the rear of the manual. The standard analyzer is housed in a sheet steel equipment case that has been designed for flush-mounting in a 19" rack.



CAUTION: *Since the measured component for the 402R-EU is hydrocarbon content, and since hydrocarbon lubricants and conditioners as well as synthetic plastics are common to instrumentation supply processes, utmost precaution must be taken at all times to specify hydrocarbon-free gases, regulator diaphragms and supplies.*

1.3 Sampling System

All components used to control the sample and supporting gases, as well as the combustion portion of the detector cell, are located inside, behind the electronics control panel. The basic analyzer consists of an isothermal chamber containing the pressure regulators, pressure gauges and flow restrictors. The temperature within the chamber is maintained at 125°F by a heating element. The regulated temperature of the chamber insures stable gas flow. An optional sample selector module is an integral gas selector panel inside the instrument enclosure for conveniently switching between sample and calibration gases. When installed, it is part of the isothermal chamber. The bypass flow is also controlled from this optional panel.

1.3.1 Input Porting

The analyzer is equipped with ports for the introduction of air, fuel, zero, span, and sample gas.

1.3.2 Sample Flow Control System

Stable sample flow is achieved by maintaining a constant pressure across a restrictor through the use of a back-pressure regulation system, which includes an adjustable regulator, pressure gauge, throttle valve, and flowmeter. The throttle valve and flowmeter are included so that the bypass flow required by the back-pressure regulator can be limited. Without these controls, a high sample point pressure would result in unnecessary sample waste through the back-pressure regulator.

The components of the system are arranged so that no dead volume is present in the sample path to the detector cell. This guarantees rapid response to changes in hydrocarbon concentration—a fact that can be dem-

onstrated when zero and span gas are exchanged during the standardization procedure.

The restrictors used in the system look alike; however, they are not interchangeable.

1.3.3 Fuel and Blanket Air Systems

The fuel and blanket air systems use similar components. Stable flow is achieved by maintaining a constant pressure across restrictors upstream from the cell. Each system incorporates an adjustable pressure regulator, pressure gauge, and restrictor. A flame out light is included to indicate when the flame fails. A fuel shut-off solenoid valve, mounted on the line that supplies hydrogen, stops the fuel flow in case of flame failure. This valve is located in line with the fuel port; except for instruments using hydrogen as the sample gas. In this case, the sample is used as fuel and the valve is located in line with the sample port. See Figure 1-1A for a flow schematic for instruments equipped with a sample selector module. Figure 1-1B shows the flow schematic for instruments without the optional gas selector module.

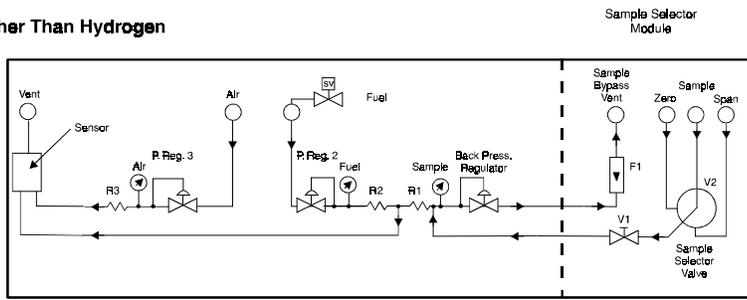
1.3.4 Flame Ionization Detection Cell

The sample and fuel are combined within a tee fitting located in the isothermal chamber. The mixed gas is emitted from a burner within the sensor assembly. Blanket air is introduced into the sensor (or cell) by means of a separate fitting that is located in the base section of the assembly. The upper half of the assembly houses the anode-igniter, collector, and flame guard thermistor. The cell is located at the left hand front area inside the enclosure for easy access. See Figure 1-2.

1.4 Applications

- Monitoring the purity of oxygen, argon, nitrogen and other gases in the manufacture of microcircuits.
- Monitoring hydrocarbon contamination in air liquefaction and other gas production processes.
- Gas purity certification.
- Detecting trace hydrocarbons in ambient air.
- Detecting atmospheric pollutants.
- Cryogenics.
- Monitoring for fuel leakage or toxic solvents.
- Monitoring hydrocarbons in a wide range of process streams.

Sample Gas Other Than Hydrogen



Hydrogen as Sample Gas

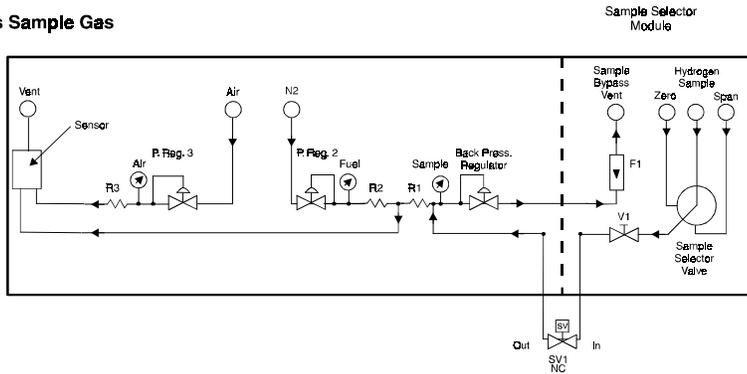
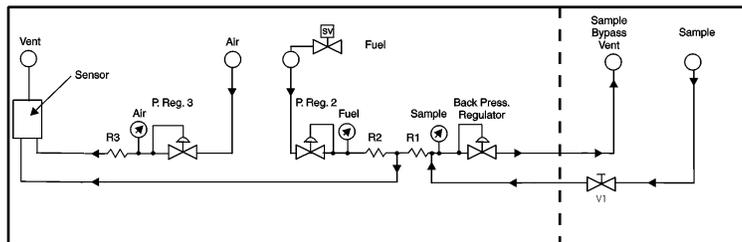


Figure 1-1A: Schematic Flow Diagram With Gas Selector Panel

Sample Gas Other Than Hydrogen



Hydrogen as Sample Gas

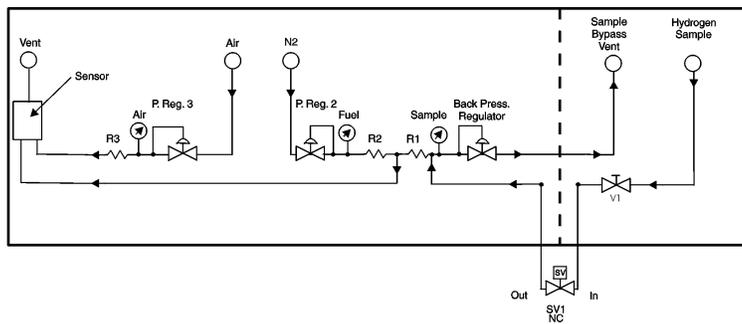


Figure 1-1B: Schematic Flow Diagram Without Gas Selector Panel

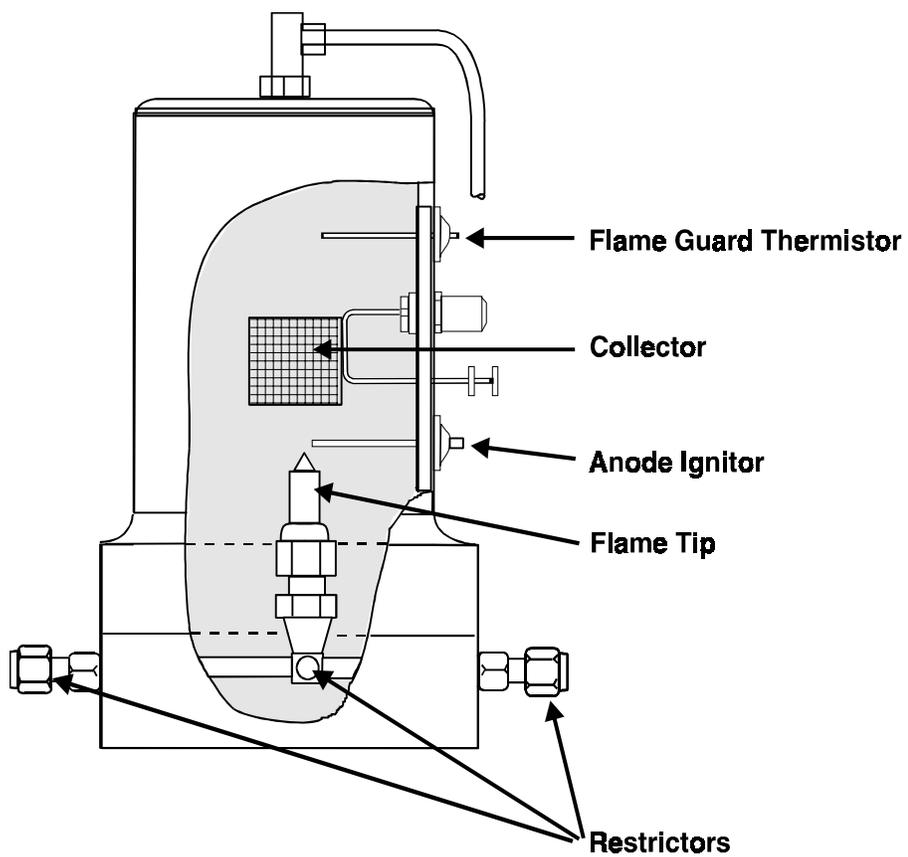


Figure 1-2: Flame Ionization Cell

Operational Theory

2.1 Electronics

The analyzer features semiconductor circuitry throughout. Integrated (IC) circuits are employed in the highly sensitive electronic circuits of the instrument to reduce circuit component requirements and increase reliability. Aside from the necessary power transformers, three fuses, and electrical controls, all circuitry is mounted on plug-in type printed circuit cards. The circuitry has been sectionalized so that spare circuit cards can be employed without the use of expensive test equipment or the services of a highly-trained technician. With spare circuit cards available for replacement, you will only need a multimeter to isolate and remedy an electronic malfunction.

All the electronic PC board units (except the electrometer-amplifier) plug into an interconnecting unit called the motherboard. See Figure 2-1 for motherboard location.

WARNING: *The PCBs in the 402R-EU contain dangerously high voltages. Ensure that all power to the instrument has been removed before disconnecting or handling any of the PCBs. (See Section 1 Page VII: "PROCEDURE FOR REMOVAL OF INTERNAL INACCESSIBLE SHOCK HAZARDS").*



The only electromechanical devices used are the control and fuel shut-off relays in the flame guard circuit.

The isothermal chamber components including the detector cell are interconnected with the electronics chassis by means of plug-in cables.

The bulk of the electronic circuitry is located behind the hinged door of the analyzer. Access to the interior of the analyzer is gained by rotating

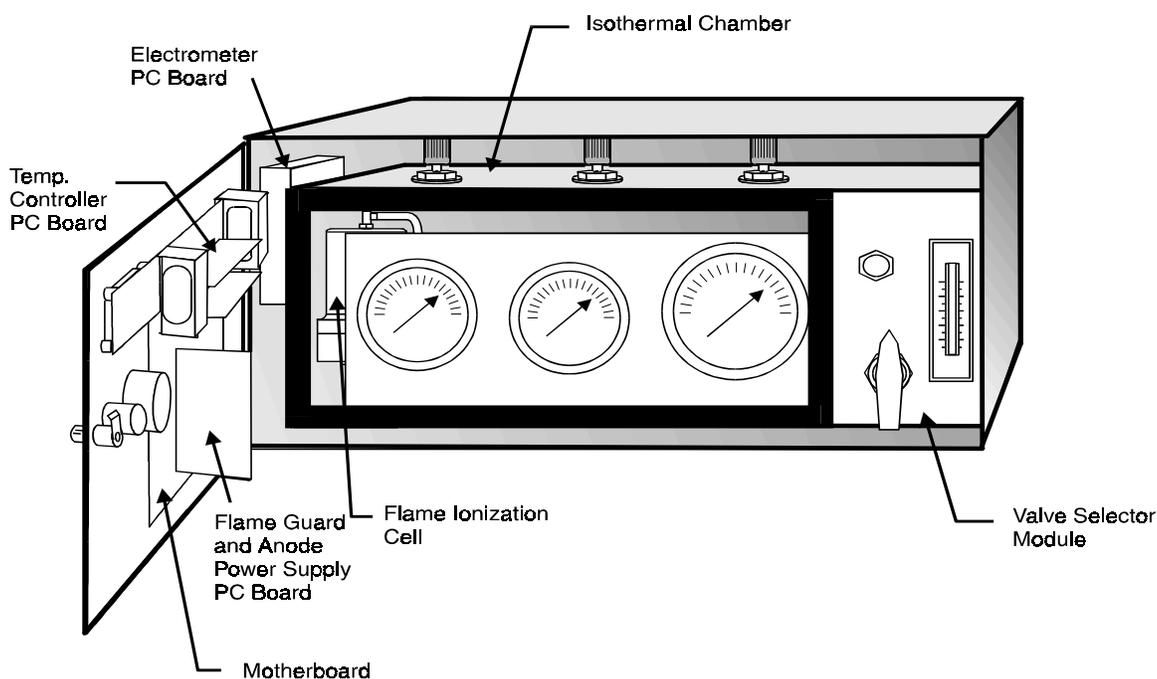


Figure 2-1: View Inside 402R-EU Cabinet
(with internal door cover removed)

the doorknob located on the upper right-hand side of the hinged door, and swinging it out.

To gain access to the electronics mounted on the inside of the door, the cover must be removed.

WARNING: *No user serviceable parts are located in this area and hazardous voltage exist in this area. Therefore this cover should only be removed by suitably trained service personnel. (See Section 1 Page VII: "PROCEDURE FOR REMOVAL OF INTERNAL INACCESSIBLE SHOCK HAZARDS").*



While reading the following descriptive subsections, refer to Figure 2-1 and the schematics, electronics chassis component layout and wiring diagrams in the drawings section at the rear of the manual. In addition, detailed descriptions of the various plug-in printed circuit boards are provided in the printed circuit board description section of the manual. Any specialized information unique to your instrument will be detailed in an Addendum and included at the front of this manual.

2.1.1 Detection Cell

The upper section of the stainless steel flame ionization cell houses the cylindrical collector electrode, the high voltage (+260 VDC) anode-igniter coil, and the sensing thermistor of the flame guard circuit (see cell wiring diagram and Figure 2-1).

WARNING: *Dangerous high voltage exists at the anode igniter coil (+260 VDC). Do not attempt to disconnect the igniter coil cable or disassemble any of the flame ionization cell components without first applying the following procedure in Section 1 Page VII: "PROCEDURE FOR REMOVAL OF INTERNAL INACCESSIBLE SHOCK HAZARDS", then disconnect plug P3 from receptacle J3.*



The collector is interconnected with the electrometer-amplifier PC board by a coaxial cable. Although the cable and fittings are intended for coaxial service, the cable is actually being used as a shielded single-conductor connection.

The anode-igniter, as its name implies, serves two functions. When the selector switch is held in the ignite position, the coil becomes an electrical heating element that glows red hot and ignites the hydrogen fuel. When the switch is released, the heater circuit is broken, and the coil is connected to the +272 volt DC terminal of the anode-flame guard power supply PC board. In this configuration, the necessary potential difference is established between the coil (anode) and collector to promote ionization of the burned hydrocarbons. The coil functions as the high voltage anode in all three range positions of the selector switch.

The thermistor acts as the sensor in the flame guard circuit. Its ambient temperature resistance is in the 100 K Ω region. When the flame is ignited, its resistance is reduced by a factor of 100. The thermistor is coupled to a semiconductor control circuit on the anode-flame guard power supply PC board, which will be described in a following section.

The cell electrodes of both the anode-igniter and flame guard thermistor are connected to the electronics chassis by means of a plug-in cable.

The electrode section of the cell may be removed for inspection by turning off the power, disconnecting the electrode lead plug, and removing the screws which retain the electrode assembly in the sensor body.

2.1.2 Electrometer-Amplifier

The collector cable is coupled directly to a coaxial fitting located on the electrometer-amplifier PC board. The plug-in PC board is located on

the side panel next to but outside of the isothermal chamber. See Figure 2-1, and consists of an electrometer amplifier and an operational amplifier. This circuit is a very high-gain, current-to-voltage converter circuit, having an input impedance measuring in the billions of ohms. It is static sensitive and highly susceptible to contamination. Special care must be taken in handling this PC board.

Refer to Section 5-4: *Electrometer-Amplifier PC Board* for more information concerning the electrometer-amplifier and the other printed circuits that follow.

2.1.3 Differential Power Supply

The positive and negative operating voltage required by the electrometer-amplifier is furnished by a regulated, differential power supply circuit. The output of the power supply as referenced to chassis ground is positive 15 (± 1) VDC, and negative 15 (± 1) VDC. Regulation is better than 1% of the rated voltage.

2.1.4 Anode Power Supply

The high voltage anode power supply components are mounted on the anode power supply printed circuit board. High voltage regulation is achieved through the use of series-connected zener diodes. The simplicity of this circuit's design can be attributed to the extremely low current demand of the anode circuit. The positive output voltage is nominally 250 volts. Output tolerance is ± 22 volts from the specified 250 volts.

2.1.5 Flame Guard Circuit

A thermistor-controlled, transistorized switching circuit is employed to operate a relay in the event of a flameout condition. A panel indicator light and fuel shut-off solenoid valve are operated by the relay to alarm personnel that a flameout condition has occurred. The fuel shut-off solenoid valve stops the hydrogen flow.

2.1.6 Flame Ignition Circuit

The flame ignition circuit includes the anode-igniter electrode (in the detector cell), a transformer, and the momentary IGNITE position of the selector switch.

2.1.7 Proportional Temperature Control Circuit

The temperature of the isothermal chamber containing the sampling components is regulated by a thermistor-directed electronic circuit. The thermistor and heating element are located in the chamber, and the balance of the circuit components are mounted on the temperature controller printed circuit board. A temperature limit switch protects the isothermal

chamber against excessive temperature, which may occur if the temperature controlling system fails.

2.1.8 Output

The electrometer-amplifier output is connected to a span potentiometer, whose slider is connected to a 3½ digit digital panel meter (DPM) a voltage-to-current (E-to-I) converter, as well as optional output circuits which may be utilized, such as alarm comparators. Description of optional circuits employed can be found in the Printed Circuit Board Description section of Chapter 5.

Installation

The analyzer should be panel mounted (unless otherwise designed) in an upright position in a sheltered area that is not exposed to the following conditions:

1. Direct sunlight.
2. Drafts of air.
3. Temperatures below 55 °F or above 110 °F.

Subject to the specified conditions, the analyzer should be installed as close to the sample point as is possible.

An outline diagram of the analyzer can be found in the drawings at the rear of the manual. After the cutout has been made in the equipment panel, TET/AI recommends that the case be used as a template to lay out the mounting holes. Such a procedure will compensate for sheet metal tolerance errors.

Special statistical information will be covered on the Specifications page in the Appendix. All pertinent dimensions, connecting points, and piping details can be found in the drawings section as part of the outline, input-output, and piping diagrams. These drawings are specific to the instrument or system to which the manual applies.

3.1 Electrical Requirements and Connections

WARNING: *Follow the procedure in Section 1 Page VII: "PROCEDURE FOR REMOVAL OF INTERNAL INACCESSIBLE SHOCK HAZARDS" before performing any maintenance, except for adjusting the pressure regulator.*



All electrical connections are made at the terminal block located on the rear panel of the 402R-EU, except primary power, (see the "Input-Output Diagram"). Before making any electrical connections, you must

detach the EMI/RFI Block Cover by removing four screws. Then, after making the connections, ensure that the Block Cover is securely remounted over the terminal block to insure EMI/RFI protection of the 402R-EU.

NOTE: Some features displayed on the terminal strip may not be present in your system, i.e., no alarms.

3.1.1 Primary Power

The standard version of the 402R-EU is designed and specified to function properly for mains (line) voltage in the range 115VAC $\pm 10\%$ at 50Hz or 60Hz. For the 230V version this range of voltages is 230VAC $\pm 10\%$ at 50Hz or 60Hz.

Subjecting the 402R-EU to mains (line) voltages which are either higher than or **lower than these ranges** can cause permanent damage to the 402R-EU.

If the unconditioned mains (line) voltages are expected to exceed these ranges, the use of some form of voltage conditioner (such as an uninterruptible power supply) should be used to protect the 402R-EU.

A source of single phase, 115V $\pm 10\%$ (or 230V $\pm 10\%$), 50 or 60 Hz power will be required to operate the analyzer electronics. The nominal volt-amp consumption of the analyzer is 150VA..

The primary power is connected to an IEC connector in the power entry module at the rear of the 402R-EU. This power entry module also contains the EMI/RFI line filters and holds the two 5mm x 20mm main (line) fuses. These fuses may be replaced by using a small bladed screwdriver to pry out the cover plate (marked "USE ONLY 250V FUSES"). This cover plate is the outside surface of the fuse carrier. The line fuses used are manufactured by LITTELFUSE INC., their part number: 21501.6. ***Only this manufacturer, and manufacturer's part number fuse may be used for replacement.*** This is a 250V, 1.6A fuse with a current interrupting rating of 1500A and a nominal melting I^2t rating of 3.9 A² Sec.

The main (line) cord used to power the 402R-EU must contain a safety ground wire and this must be connected to a safety earth ground such as a proper cold water pipe ground. In addition to this safety ground connection the 402R-EU, a safety ground wire (green - yellow, AWG #16) must be connected to the protective earth ground 8-32 screw marked with:



This ground wire must be connected to this screw by a ring-lug with external star lock washers on both sides of the lug. After the lug and

lockwasher are put on the screw, the screw must be screwed into the 402R-EU case firmly to assure that the lockwasher next to the case cuts through the paint on the case to the metal of the case. The other end of this wire must be connected to an approved safety ground (protective ground).

After connecting this wire to the 402R-EU and before connecting this wire to the safety ground, check that the resistance from this wire to the case of the 402R-EU is less than 1.0 ohms. If the resistance is greater than or equal to 1.0 ohm:

1. Remove the screw, lug and star washers,
2. Scrape away the paint on the case in that area,
3. Reconnect the screw, lug and star washers,
4. And recheck the resistance.

The ground pin on the IEC power connector and the protective earth ground screw are both protective conductor terminals and functional earth terminals. Both must be grounded for personnel safety and for proper functioning of the equipment. A lack of grounding will result in erratic instrument performance.

3.1.2 Voltage Output Signal

The output signal is available at the terminal block on the rear of the analyzer case (see the "Input-Output Diagram"). A 2-conductor shielded cable must be used to interconnect the analyzer with an auxiliary indicating and/or recording instrument. Connect the shield at the analyzer end only. Connecting both ends of the shield can produce a ground loop and erratic performance. Polarize the signal connections as shown on the "Input-Output Diagram".

Auxiliary indicating and/or recording equipment must have an input impedance of no less than 10K Ω . A self-balancing potentiometer is ideally suited as an auxiliary indicator.

An isolated 4-20mA current output is also provided.

3.2 Gas Connections

The analyzer gas connection diagram identifies the various gas connection points as to function and location. Figure 3-1 shows the gas connection points for instruments with or without the optional gas selector

module. Gas connections to the instrument are made at the $\frac{1}{8}$ " or $\frac{1}{4}$ " stainless steel tube fittings provided on the rear panel. Note that the Purge and Sensor Vent fittings are $\frac{1}{4}$ " while all other gas connections are $\frac{1}{8}$ ".

Before tubing is connected to the system, it must be decontaminated to rid it of hydrocarbon deposits. Using a small torch, heat each length of tubing, while passing nitrogen through it, until it glows red. Begin at the nitrogen source end and proceed down the length of the tube, "chasing" the red glow (and hydrocarbon deposits) down to the open end of the tube. Cap tubing while not in use with suitable non-contaminating caps.

All sample, calibration, and supporting gas lines which deliver into the analyzer must be decontaminated before connection; vent lines do not.

When connecting the various gas lines to the system, be absolutely certain that no "dead ends" are left; that is, no unused branch lines should be left capped off, where pockets might form of material that is not representative of the current contents of the line, or which might keep contaminants from being purged out of the system.

3.2.1 Supporting Gases

Normally, four supporting gases of different composition (see Chapter 4: *Equipment*) will be required to operate the analyzer. The recommended composition of these gases is specified in the Application Data section of the Appendix. The gases should be supplied from cylinders that are equipped with the type of regulator specified in the aforementioned sections.

CAUTION: *Under no circumstances should you employ a regulator that is not equipped with a metallic diaphragm anywhere in the system. The regulators should be inspected prior to installation to be sure that they are oil-free. Failure to comply with these directives will result in a constant drift in analyzer output, as organic compounds will outgas into the plumbing system at a rate that is related to the ambient temperature. Use 316 stainless steel, dual-stage regulators only in fuel, sample, and blanket air lines; shutoff valves should be used downstream from each regulator.*



Place the supply cylinders as close to the analyzer as possible, and interconnect them to the analyzer with **new** tubing. Be sure that all plumbing connections are free of leaks.

NOTE: *Use only stainless steel tubing within the analyzer and throughout the system. Consult the assembly, piping, outline drawings, and any Addenda included with this manual to determine if special conditions apply.*

3.2.2 Sample Gas

An **oil-free, metallic diaphragm** regulator must be installed as close to the sample point as possible. Use new tubing in the installation. The output pressure of the regulator should be **30 psig**, whenever possible, to match the settings of other regulators on the support gas tanks; sample inlet pressure must exceed the operating sample pressure by at least **10 psig** and provide at least **1 SCFH** bypass flow. In any case, the zero and span gas regulators should be set to match the sample pressure regulator—as the back-pressure regulator within the analyzer ultimately determines the sample flow to the detection cell. Refer to Chapter 4: *Sampling*.

3.2.3 Effluent

All the gases introduced into the detection cell vent from one fitting at the rear of the analyzer. TBE/AI recommends that the cell be permitted to vent directly to the atmosphere wherever possible.

If a vent line is required, the installation **must include a drop-out pot** to collect the water that is formed by the burning of the hydrogen fuel. The vent line must be constructed so that water and dirt cannot collect in it.

3.2.4 Sample Bypass Vent

The sample bypassed by the back-pressure regulation system vents from a separate port at the rear of the analyzer. If a vent line is required, it must be installed so that water and dirt cannot accumulate in it.

3.2.5 Fuel and Air Connections

The fuel used to provide combustion should be a gas mixture comprised of 40% H₂ and 60% N₂. The fuel is mixed with air to provide a combustion source for the analyzer. Connect the fuel and air sources to the instrument according to the gas connection diagram included at the back of this manual.

NOTE: *For applications where the sample gas is hydrogen, the sample gas is doubles as the fuel for combustion and is diluted with nitrogen. Connect a nitrogen source (40 psig) to the fuel inlet port. See Figure 3-1.*

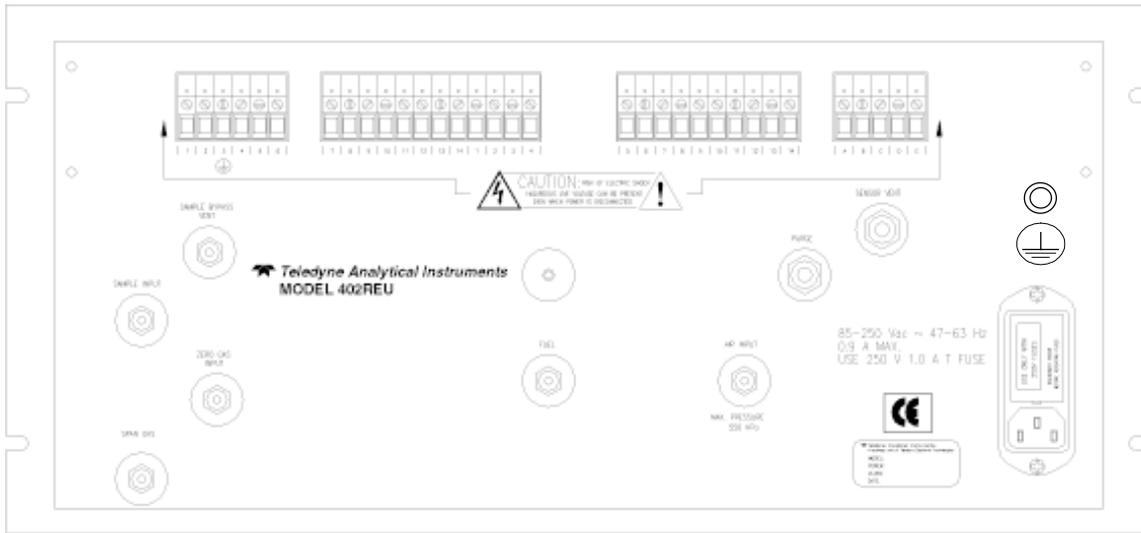


Figure 3-1: Rear Panel of Model 402R-EU With Gas Connections

3.2.6 Fuses

The fuses used in Table 1, should be used in the instrument to avoid hazardous conditions and avoid damage to the instrument.

REFERENCE DESIGNATOR	TELEDYNE A. I. PART NO.	MFG. (LITTELFUSE) PART NO.	CURRENT RATING (A)	USED IN 402R-EU VOLTAGE VERSION	USE DESCRIPTION
F1	F1361	21501.6	1.6	115 / 230 VAC	MOTHER PCB
F2 & F3	F1361	21501.6	1.6	115 / 230 VAC	MAINS (LINE)
F4	F1378	218.200	0.200	115 VAC	TRANSFORMER T-1212
F4	F1374	218.125	0.125	230 VAC	TRANSFORMER T-1212
F5	F1358	218.500	0.500	115 / 230 VAC	TRANSFORMER T-1213
F6	F1375	218.800	0.800	230 VAC	TRANSFORMER T-1211

Table 1 - Fuses in 402R-EU

Operations

4.1 Equipment

The following supporting gases and hardware will be required to operate the (standard) analyzer:

1. **Fuel:** A cylinder containing a 40% hydrogen, 60% nitrogen composition will be required to supply the fuel for the flame ionization burner. The cylinder is to be equipped with an **oil-free metallic diaphragm regulator (dual stage)**.

NOTE: *When hydrogen is the parent gas in the application, an auxiliary source of fuel may not be required. See the Appendix: Specifications for specific recommendations.*

2. **Blanket Air:** A cylinder of **water-pumped** (low hydrocarbon) compressed air will be required to maintain the proper atmosphere within the cell. The cylinder is to be equipped with an **oil-free, dual stage**, metallic diaphragm regulator. Less than 1% of the full scale reading (in the selected measurement range) of hydrocarbon contamination is advisable, if the instrument's accuracy is to be realized.
3. **Zero Gas:** A cylinder of the parent (or background) gas, containing less than 10% full scale (of the narrowest range) hydrocarbon impurity, will be required to zero standardize the analyzer. For example, if 10 PPM is the narrowest range of the instrument, then the zero gas impurities are to be less than 1 PPM. The cylinder is to be equipped with an **oil-free**, dual stage, metallic diaphragm regulator.

4. **Span Gas:** A cylinder containing a composition consisting of the parent gas and a specified (see Appendix: Specifications) amount of methane will be required to standardize the sensitivity setting of the analyzer. The cylinder is to be equipped with an **oil-free**, dual stage metallic diaphragm regulator.
5. **Sample Pressure Regulation:** An **oil-free**, metallic diaphragm regulator must be installed at the sample point when possible; see Section 4-9: *Sampling*.

4.2 Preliminary Power-Off Check List

Make the following checks of the installation before proceeding further into the start-up procedure:

1. Check to see that the sample and supporting gas installation is in accordance with the specifications called for in the installation and application sections of the manual. Be sure that the supporting gases are of the proper composition and are connected to the correct fittings at the rear of the analyzer.
2. Check to see that the electrical connections conform to the instructions contained in the installation section and on the input-output diagram.

NOTE: Ensure that the Terminal Block Coverplate is securely in place to maintain RF/EMI protection.

3. The digital meter requires no adjustments. If you feel that your digital readout needs adjustment and you are not familiar with the procedures required, consult TET/AI before making any adjustments.
4. Open the door and check to see that the printed circuit boards and cables are firmly seated in their respective sockets.

NOTE: The boards and cable plugs are keyed so that they cannot be inserted incorrectly in either the wrong position or the wrong connector.

5. Confirm that recorder and alarm connections are properly made.

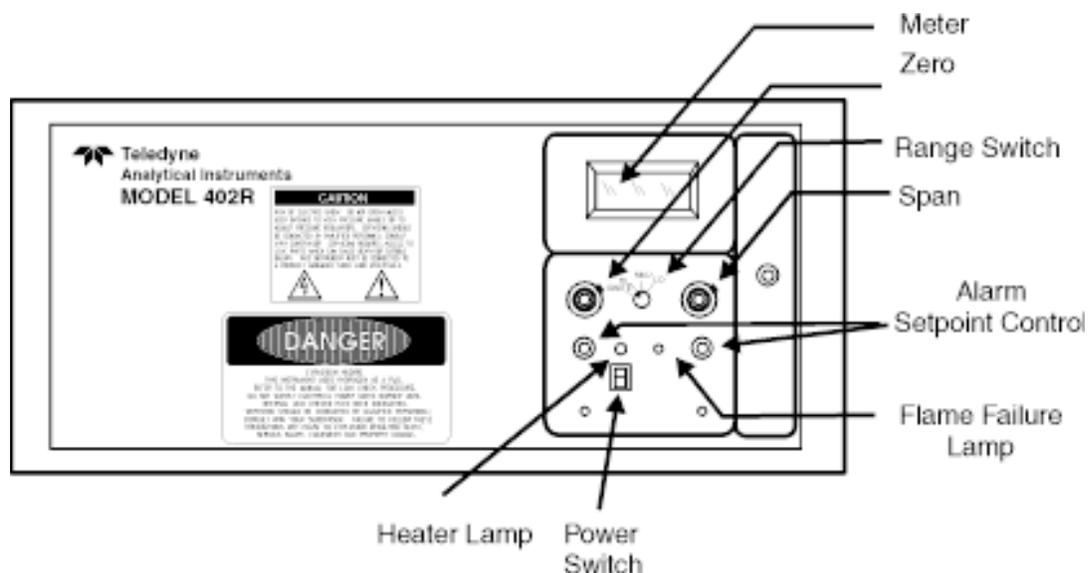


Figure 4-1: Front Panel of Model 402R-EU Total Hydrocarbon Analyzer

4.3 Preliminary Electronic Adjustment

After the foregoing preliminary checks and adjustments have been made, turn the analyzer and recorder (if applicable) switches on (see Figure 4-1) and make the following checks and adjustments:

4.3.1 Meter-Recorder Alignment

If the application involves the use of an auxiliary recording and/or indicating device, the following procedure should be used to check and adjust the output circuit so that the meter and recorder are in close agreement:

1. Set the analyzer span control so that the dial indicates the number recorded in the Application Data sheet in the Appendix under "Start-up Span Setting".
2. Place the selector switch in the "LO" position.
3. Adjust the door-mounted zero control until the meter **stabilizes** at a full scale indication.
4. Check the recorder reading. If the recorder's input sensitivity coincides with the analyzer's output specification (see Appendix: Specifications), the recorder should be at a balance at its full scale marker.

5. If the meter and recorder do not agree, open the electrical control panel, and locate the span potentiometer's slider terminal. Under full scale conditions 1000 millivolts ± 1 mv should be present. Using a digital multimeter set for about 2 volts, measure between the slider and ground. If necessary, adjust the span potentiometer until 1000 mv (± 1 mv) is obtained, and verify that all output devices agree; adjustment of devices which read incorrectly may be required. If a remote indicator panel or device is used, check that as well.

4.4 Placing the System in Operation

1. Turn the power switch to the ON position.
2. Place the range switch in the "HI" (widest) range position.
3. Allow at least 2 hour warm-up (heat up sensor & sample system) after making the air adjustment described below.
4. **DO NOT attempt to ignite the flame yet.** Condensation will occur.

4.5 Activating the Support Gases

4.5.1 Air

1. Set the air tank regulator to **30 psig**.
2. Adjust the instrument air regulator until the air pressure gauge reads the recommended air pressure. See Figure 4-2.
3. Air should thus be flowing through the sensor during the warm-up (see step 3 above).

After the air is flowing through the sensor and a 1 hour warm-up has been completed, activate the following gases:

4.5.2 Zero Gas

1. Set the gas selector valve to the ZERO position.

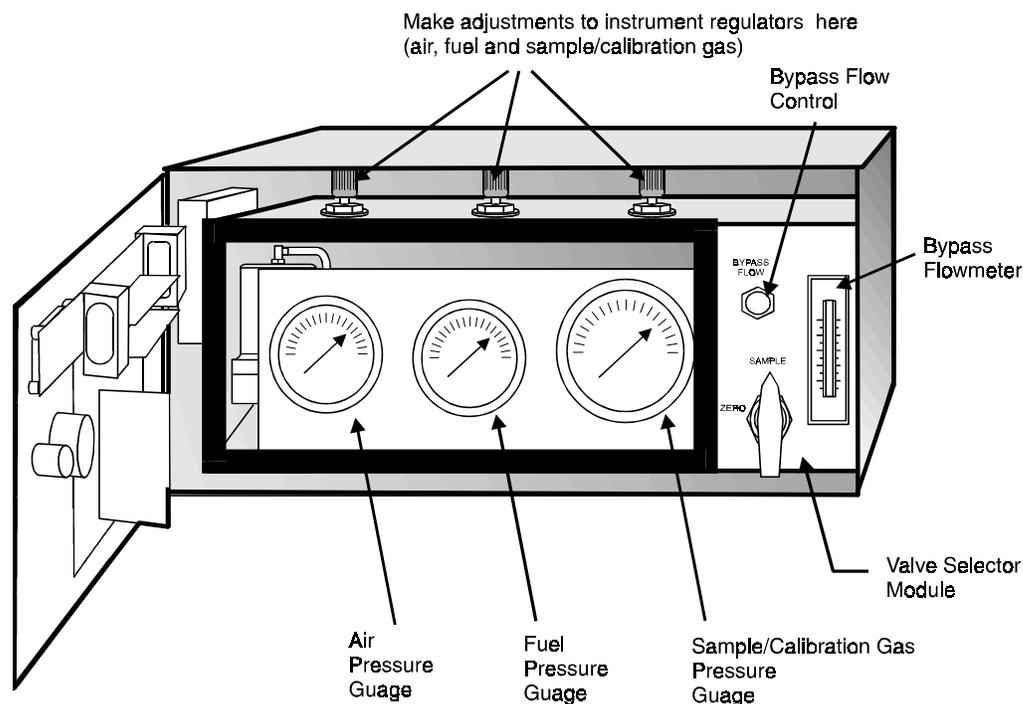


Figure 4-2: Setting the Air, Fuel and Sample Pressure

2. Set the zero gas tank regulator to **30 psig** (or a pressure which matches the sample pressure) and adjust the instrument sample regulator until its (sample) pressure gauge reads the recommended sample pressure (except that zero gas is flowing rather than sample). See Figure 4-2.
3. Adjust the bypass flow to **0.3-1.0 SCFH**.

4.5.3 Span Gas

1. Set the gas selector valve to the SPAN position.
2. Set the span gas tank regulator to **30 psig** or to match the sample pressure.
3. Observe that the instrument sample pressure gauge still reads the recommended sample pressure and that the bypass flowmeter reads from **0.5 to 1.0 SCFH**.

4.5.4 Fuel

1. Make sure that the valve on the regulated side of the fuel tank is closed.
2. Open the main valve on the tank and set the fuel tank pressure regulator to **30 psig** (or to match sample pressure).
3. To avoid pressure shock to the instrument fuel regulator, **slowly** open the secondary valve until it is wide open.
4. Set the instrument fuel regulator to the recommended pressure. See Figure 4-2.

NOTE: *When adjusting fuel settings, the front panel switch must be held in the IGNITE position.*

4.6 Flame Ignition

Observe that after 1 hour preheating of the sensor, the amber heater lamp is blinking (indicating that the temperature controller is maintaining the temperature setpoint) and the red flame failure lamp is on. See Figure 4-1.

With the gas selector valve in the SPAN position and the range switch in the highest range, turn the range switch to the IGNITE position and release as soon as the meter is upscale (or off scale) and the red flame failure light turns off, indicating flame on (no flame failure).

Limit the time that the switch is held in the IGNITE position to intervals of about **5 seconds**, with similar intervals of time between ignite cycles, until the flame stays lit (and the light stays off). Such a procedure will prevent damage to the anode-igniter electrode through overheating.

4.6.1 Verification of the Flame Guard Circuit

The operation of the flame guard circuit has been checked at the factory, but should be re-verified during start-up. Employ the following procedure, once ignition of the flame has been achieved:

1. Turn off the fuel at the supply cylinder.
2. Observe the fuel pressure gauge on the analyzer control panel. The gauge indication will decay as the fuel in the line is exhausted. When the gauge reading reaches the vicinity of **5 lbs**, the flame will be extinguish as the fuel solenoid shuts off

the fuel supply. Within 5–30 seconds the flame out indicator light will come on.

3. Open the cylinder supply valve and re-ignite the flame.

4.6.2 Ignition and/or Flame Guard Circuit Failure

If the flame ignition or guard circuits do not operate as described in the above two sections, proceed as directed in Chapter 5: *Maintenance & Troubleshooting*.

4.7 Calibration

Switch the gas selector valve to ZERO and observe that the meter drives downscale. Switch the range switch to the LOW range and adjust the zero control such that an on scale indication is observed. A recording should be made so that the stabilization progress of the instrument can be observed. After a stable reading is obtained:

1. “Zero” the analyzer by adjusting the zero control until the meter reads the methane concentration indicated on the zero gas tank, if other than 0 PPM; otherwise set the meter to zero.
2. After a stable zero reading is obtained, “span” the analyzer.
 - a. Switch the range switch to the range which gives the highest resolution of the span gas used (usually the high range), and observe that the meter reads zero.
 - b. Switch the gas selector valve to SPAN and observe that the meter drives upscale. Wait until stable ready is obtained.
 - c. Adjust the span control until the meter reads the methane concentration indicated on the span gas tank.
 - d. Repeat this procedure to confirm proper calibration.

3. After completion of calibration, shut off the main valves on the zero and span gas tanks to avoid losing gas to minute leaks, etc.

4.8 Stabilization Period

After the proper gas flow rates have been established and the flame ignited, the analyzer should be permitted to operate on zero gas until the isothermal chamber temperature comes to equilibrium, and, more importantly, until the user is satisfied that the analyzer is operating in a stable fashion in the absence (or near absence) of hydrocarbons.

Run the analyzer at the span setting found after calibration (and the selector switch in the low position) on zero gas until a stable recording is obtained. If time permits, allow the instrument to run for 24 hours. If all lines are free of hydrocarbons, the recorder should chart a closed circle from the point where temperature equilibrium was reached. The recording should have no more than 1% noise, and there should be no more than 2% diurnal indicated.

4.9 Sampling

After a satisfactory recording is obtained on zero gas (see Calibration, above), make sure that the process gas sample is in a condition acceptable to the analyzer, or contamination of the sample system may occur.

The gas must be dry, free of particulates, and at a temperature not to exceed 120 °F.

Incoming sample pressure should be regulated to **30 psig**. In case the sample pressure is lower than 30 psig, make sure that the incoming sample pressure exceeds the recommended sample pressure as read on the instrument sample pressure gauge by at least 10 psig and is capable of maintaining a stable bypass flowrate of **0.5-1.0 SCFH**. The use of a sample pump is otherwise indicated.

NOTE: *Your analyzer may be designed with a low pressure input option for sample pressures as low as 5 psig.*

If a sample pump is required, one must be selected which does not emit chemicals visible to the analysis, and should have, if at all possible, metal bellows and valves. **Rubber diaphragms and valves are not acceptable.**

Set the process sample regulator to **30 psig**.

Switch the gas selector switch to SAMPLE and set range switch to a range which comfortably accommodates the process fluctuations in sample hydrocarbon concentration. Sample flow should now be established.

NOTE: *On standard instruments, the hydrocarbon concentration of a mixture of different species of hydrocarbons will be indicated as if it were only methane, unless the instrument is specifically calibrated to read a different species.*

4.10 Routine Operation

The pressure gauges and bypass flow rate should be checked on a daily basis to insure continuous flow. The large cross-sectional area of the sintered disc restrictors should eliminate the possibility of particulate matter stopping or restricting flow. Nevertheless, even with the design safeguards, the condition of the system should be checked daily. Any change in fuel or sample flow rate will result in a change in signal output.

Since the only moving parts in the system are the fuel shut-off solenoid valve and the flame guard relay, no routine maintenance is required to keep the electrical portion of the analyzer operative. The relay is designed to operate continuously in an energized condition. In the event of failure, the relay is a plug-in device.

4.10.1 Verification of Calibration

Repeat the zero and span standardization until no further adjustment of either control is necessary to produce repeatable readings when switching from zero to span conditions.

Whenever a change is made in the pressure settings of either the air, fuel, or sample regulators of the instrument, **the instrument must be recalibrated.**

IMPORTANT: *The accuracy of the analysis can be no better than the user's knowledge of the hydrocarbon content of the standardization gases.*

These gases should be procured from a supplier who will certify their composition. If a wide discrepancy exists between the span setting recorded in the manual and that finally reached through the use of span gas, you should investigate either the zero or span gas composition, or both. If

such is the case, have the compositions of these gases laboratory-analyzed before relying on the information obtained from the analyzer.

4.10.2 Supporting Gases

The supporting gases (particularly the fuel and air) should be procured well in advance of their need. TET/AI suggests that the gases be replaced when their pressure gauges indicate that the supply is down to 100 psi. Most cylinder regulators operate marginally in very low pressure ranges.

IMPORTANT: Whenever the fuel or air supply is replaced, the analyzer must be restandardized. Any hydrocarbons present in these gases will alter the instrument's calibration and must be compensated for through restandardization (see Section 4-8: Stabilization Period.)

Maintenance & Troubleshooting

WARNING: *There are dangerous high voltages within the instrument.*



There are no user serviceable parts within the cover on the inside of the door, inside the isothermal chamber (sample system), and on the Electrometer-Amplifier PC Board. Work in these areas shall only be performed by authorized suitably trained personnel.

Before starting any of these maintenance and troubleshooting procedure, whenever possible apply procedures provided in Section 1 Page VII: "PROCEDURE FOR REMOVAL OF INTERNAL INACCESSIBLE SHOCK HAZARDS". When the 402R-EU must be turned on during any of these maintenance and troubleshooting procedures, be careful and work with the ONE HAND RULE (SECTION 1, PAGE VIII). After the need to have the instrument turned on passes, apply procedure in section , page VI and then proceed.

CAUTION: *Many of the electrical parts within the 402R-EU are susceptible to damage from the electrostatic discharge. Therefore, ESD safe procedures shall be followed during servicing of the 402R-EU.*



If the analyzer is suspected of incorrect operation, always evaluate performance with zero or span gas flowing in the sample path. Never attempt to evaluate performance on sample gas. If analyzer sensitivity is questionable, use the span gas. For all other evaluations, use the zero gas and low range for maximum sensitivity. The important consideration is to control as many variables as possible. Using cylinder-supplied gases of known hydrocarbon content eliminates the possibility of introducing an unknown variable.

Do not overlook the seemingly obvious. Check to see that power is available for the instrument (and of the proper voltage, etc.), and that connections are correct. Also verify that support/calibration gases are not depleted.

5.1 Measuring Circuit Electrical Checks

If the analyzer performs erratically on zero gas, the trouble can be related to either the integral gas control systems, or the electronics. To isolate the problem, the two systems must be separated. To isolate the electronics, employ the following procedure:

1. Open the door and disconnect the collector cable from the electrometer-amplifier, leaving it attached to the cell. (Consult schematic and assembly drawings for circuitry and location, also see Figure 2-1.) **Do not use a twisting motion**—instead, pull the cable straight up through the hole in the cover. With this cable disconnected, the electronic circuitry is completely isolated from the gas control system and cell.
2. Select the lowest measurement range (for maximum sensitivity) and adjust the zero control until the readout device indicates above midscale. (The span control should already be set; see Section 4.8: *Stabilization Period.*)

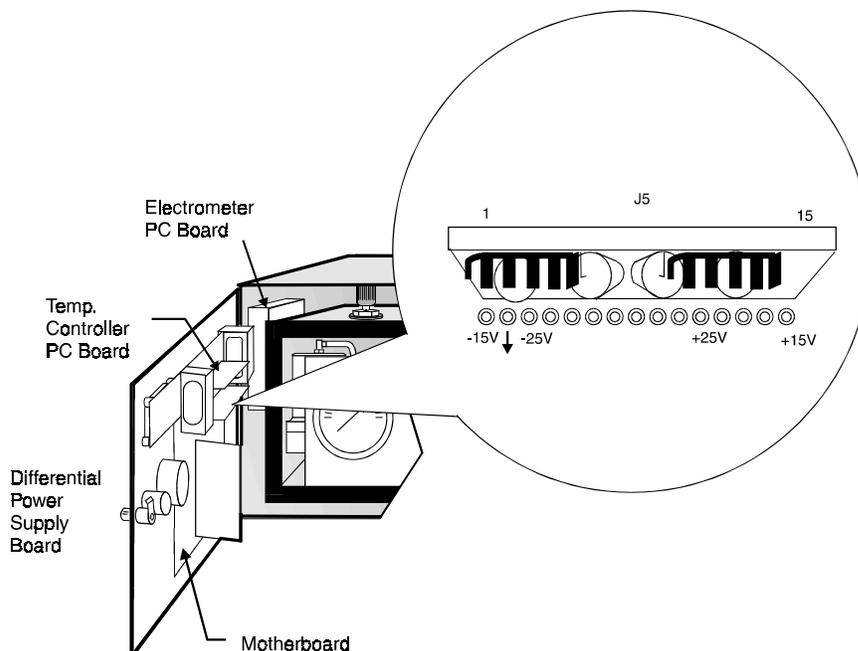


Figure 5-1: Checking the Differential Power Supply

5.1.1 Loss of Zero Control

If the zero cannot be controlled as directed above, a failure has occurred in either the differential power supply or the electrometer-amplifier. Use the following procedure to isolate the fault:

With a digital voltmeter (DVM) set to read 15 VDC, check the positive and negative 15 V output of the power supply as follows:

(See schematic and assembly drawings for the differential power supply PC board. Additional information can be found in the printed circuit board description section at the end of this chapter.)

1. Connect the **negative** voltmeter lead to the common (pin 2) and the **positive** lead to pin 15 of connector J5. The measured voltage should be 15 ± 1 volt. See Figure 5-1.
2. Then connect the **positive** DVM lead to pin 1 of connector J5. Measured voltage should be -15 ± 1 volt.

If correct readings are not obtained at both points, the differential power supply has failed, and the printed circuit card must be replaced. If correct readings are noted, the electrometer-amplifier has failed, and that printed circuit card must be replaced.

NOTE: TET/AI recommends that spares for each of the printed circuits be kept on hand so that service can be restored immediately. The faulty circuit card should be returned to the factory for repair. Unless personnel knowledgeable in electronics are available, do not tamper with the circuits.

5.1.2 Anode Voltage Check

If the output can be adjusted by the zero control (the above section, step 2), the cell anode voltage should be verified as follows:

WARNING These procedures should be carried out only by suitably trained personnel familiar with high voltage circuit boards. The anode-igniter unit and associate circuitry involve dangerously high voltages.



Refer to the cell wiring diagram. Using a voltmeter set to measure 299 VDC, check the voltage on terminal four on the terminal strip TS6 on the (mother) PCB, as follows:

1. Connect the **negative** voltmeter lead to ground and the **positive** lead to TS6 terminal 4. Be careful not to short the circuit by touching both an electrode and the cell body simultaneously. The reading obtained should be 250 ± 22 VDC.

2. Apply procedure given in Section 1, Page VI of this manual, then unplug P3 from J3 of the anode-igniter cable.
3. Reconnect the mains (line) cord to the 402R-EU and turn it ON.
4. Measure the voltage between socket "3" of J3 and ground and then reapply the same procedure as provided in section 1, page VI of this manual.
5. If the voltage was 250 ± 22 VDC, then check the anode-ignitor cable and the sensor for low electrical resistance to ground or other problems. Else, if the voltage was not 250 ± 22 VDC, then replace the flame guard and anode power supply Pc Board.

WARNING: Do not touch capacitor C1 or C2, resistor R1 or R2, diodes D1, ZD2 or ZD3 or their related circuit foils. A shock hazard may exist. Note and follow the turn off procedure given in Section 1 Page VII: "PROCEDURE FOR REMOVAL OF INTERNAL INACCESSIBLE SHOCK HAZARDS".



Carefully remove the circuit board without touching any connections which might lead to C1 or C2. After removal, discharge the two capacitors by placing a jumper wire across each.

3. The anode voltage may also disappear or be greatly diminished when condensation inside the sensor has occurred, shorting the ignitor to the sensor body across the wet insulator. This usually occurs when the flame is turned on, if the sensor has not been preheated for at least 1 hour.

5.1.3 Electronic Stability

If the checks outlined above indicate that conditions are normal, allow the analyzer to run electronically with the collector cable disconnected for several hours in the lowest range, and with the zero control adjusted so that the recorder is reading midscale. If all is normal electronically, a noise-free (pen width) recording, showing absolutely no instability, should be obtained for as long as the analyzer is allowed to run in this configuration. If the recording obtained is noisy or erratic, replace the electrometer-amplifier PC board.

5.1.4 Printed Circuit Board Replacement

Whenever the differential power supply temperature controller or electrometer-amplifier printed circuit boards are replaced (or repaired), instrument performance should be rechecked. The replacement circuit boards are tested and adjusted at the factory before they are sent, and in most cases, no recalibration will be required.

If performance is not adequate, then the analyzer must be restandardized as described in Section 4-7: *Calibration* before being placed back in service.

Whenever the flame guard and anode power supply printed circuit board has been replaced, the flame guard circuit must be recalibrated (see Section 5.3.1: *Flame Guard Circuit Calibration*) and the analyzer must be restandardized.

If the instrument performs as outlined in this section, the problem is not related to the measuring circuit electronics.

5.1.5 Collector Cable

Before reconnecting the collector cable, check the continuity of the center wire of the cable with an ohmmeter by measuring between the center pins at each plug on the lowest resistance scale of the meter. Flex the cable while making this measurement to be sure that there is not an intermittent open circuit. If there is, replace the cable. Do not attempt to repair the cable, as special tooling is required to disassemble and reassemble the cable plugs.

5.2 Temperature Control Electronic Check

If the heating circuit fails, the output of the analyzer will tend to drift with changes in ambient temperature. Such a failure will be more evident in the low range. If the temperature environment surrounding the analyzer is closely regulated, failure in this circuit might go unnoticed after the initial failure. If the environment follows day and night temperature changes, the analyzer will show a diurnal, bi-directional drift when operated on zero gas. The magnitude of the drift will be a function of the temperature differential experienced by the analyzer. To check the circuit, employ the following procedure:

Consult the 402R-EU schematic and assembly drawings, as well as the temperature control PC board schematic and assembly drawings at the rear of the manual for circuit details and component placement. See also Figures 5-2 and 5-3 for the location of the Temperature Controller PC Board.

1. An indicator light on the control panel cycles on and off with the heating element; the light is on when the heater is on, and vice versa. Failure of the light to come on at all when the cell compartment is cold indicates a problem in the temperature sensing or control circuitry or the wiring that interconnects the

thermistor to the circuit. If the light stays on constantly, but the compartment does not heat up, then a problem with the heating element or connecting wiring is indicated.

2. Apply procedure for removal of internal inaccessible shock hazards, mentioned in section 1, page VI of this manual
3. Check the sensing thermistor by measuring the resistance between its connecting wires. See Figure 5-2. Disconnect one of the thermistor wires from terminal strip TS-2 (terminals 1 and 2) on the mother board and measure resistance between that

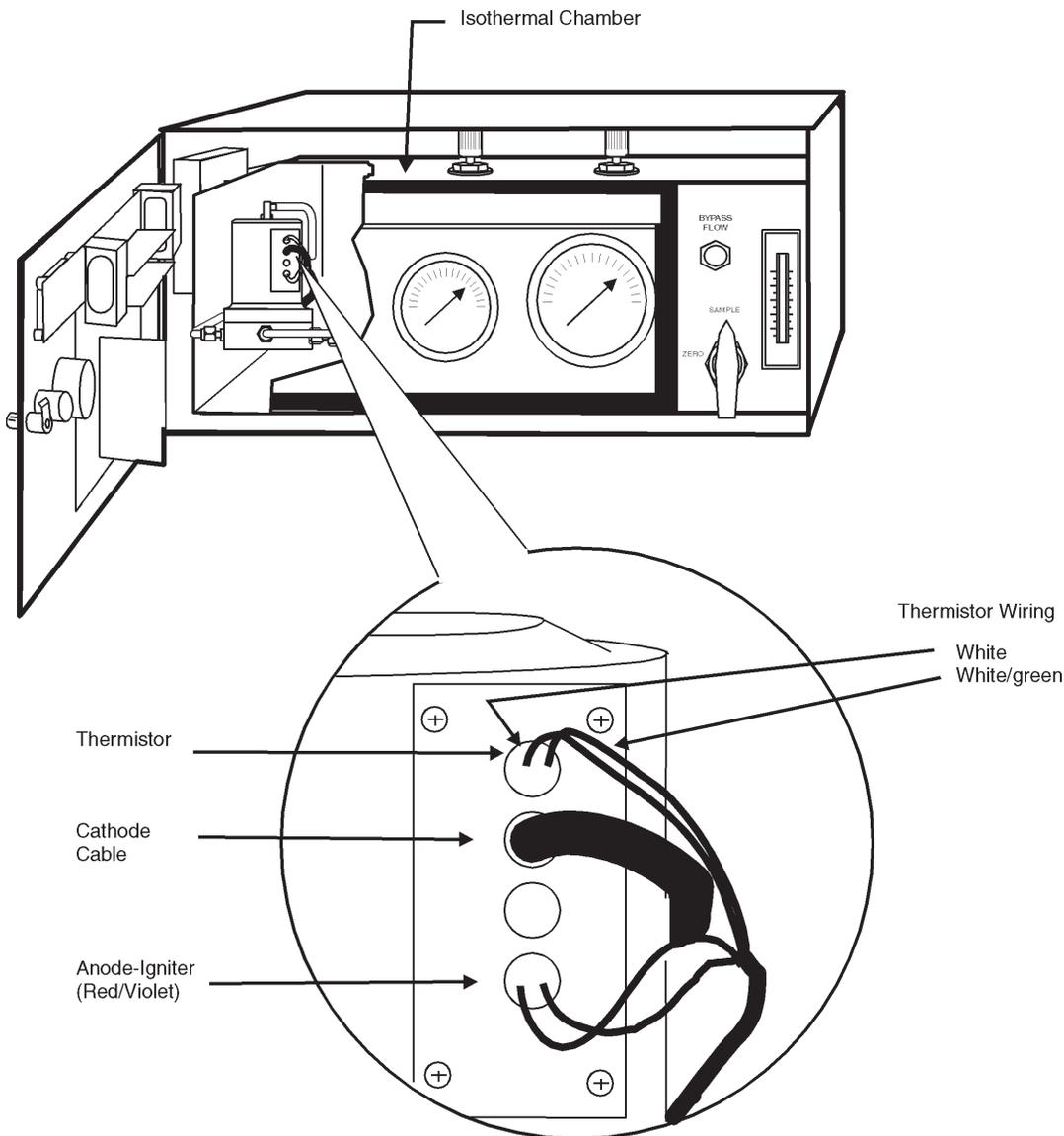


Figure 5-2: Identification and Location of Thermistor and Wires

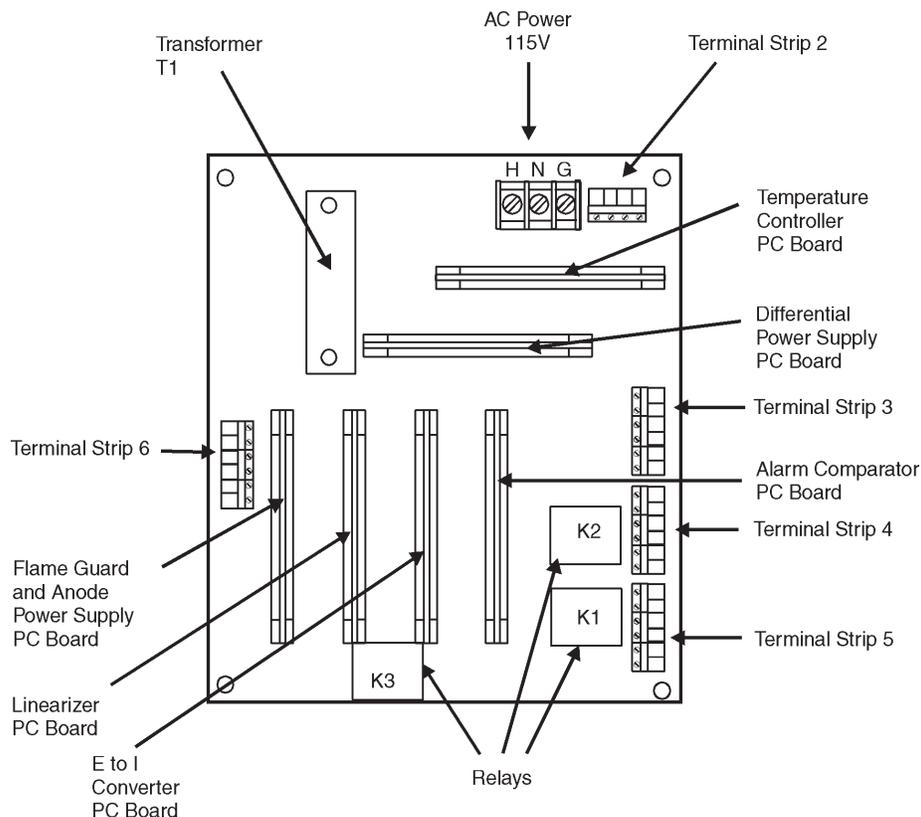


Figure 5-3: Motherboard

wire and the remaining undisturbed terminal. See Figure 5-3. Resistance of the thermistor varies with its surrounding temperature. A reading of between $10\text{K}\Omega$ and $20\text{K}\Omega$ at around $25\text{ }^\circ\text{C}$ may be measured. (Under very cold conditions, the resistance could be as high as $50\text{K}\Omega$; under hot conditions, just a few thousand ohms.) If the thermistor measures anywhere in this range, it is most likely OK. Otherwise, if the circuit is open, check the wires leading to the thermistor.

4. Check the heating element by measuring its resistance. Disconnect one of the heater wires from either terminal 3 or terminal 4 of TS-2 on the motherboard which is shown in Figure 5-3, and check the resistance between that wire and the remaining undisturbed terminal. If a reading of $288\Omega \pm 10\%$ is found, then the heating element is most likely OK. If an open circuit is found, check the heater wires and a possible connector between the heater and TS-2. If no problems are found, and the heater circuit is open, then replace the heater element.

NOTE: *If any of the components located inside the isothermal chamber has failed, the instrument must be removed for service. The sample selector module can be unplugged for service. All other components can be reached without instrument removal.*

5. If no problems are found with either the thermistor or the heater circuits, then replace the temperature control board.

5.3 Ignition and/or Flame Guard Circuit Checks

If the flame guard circuit will not hold the flame-out lamp off when the ignition procedure is employed (see Chapter 3: *Flame Ignition*), perform the following procedure to isolate the problem (consult the system schematic for details of the circuit):

1. Disconnect connector J3 (4 sockets) from connector P3 (4 pins). These are one of the large pairs of connectors just outside of and to the left of the isothermal chamber. See Figure 5-2.
2. Check the flame guard sensing thermistor by measuring the resistance between pins 1 and 2 of P3. The nominal resistance at 25°C is 100K, resistance readings at about 25°C of greater than 250K or less than 40K indicate that the thermistor is defective and should be replaced.
3. Check the anode-igniter coil for continuity by measuring between pins 3 and 4 of the disconnected cable plug P3. The ohmmeter should indicate a maximum resistance of 1Ω.
4. If either step 2 or 3 does not check as indicated, remove the electrode assembly of the detection cell and return it to the factory for repair. If the quartz flame tip is damaged, the top section of the cell may be removed by disconnecting the vent line, and removing the screws around its flange. Return the unit complete with attached electrode cable. If steps 2 and 3 both check out properly, reconnect the anode-igniter cable (connect J3 to P3).

5. Observe the K3 relay operation as the selector switch is moved in and out of the IGNITE position (see Figure 5-3). If the relay does not energize in the IGNITE position, remove it and check it for an open coil (pins 13 and 14). The nominal resistance is 650Ω . If the coil checks OK, remove the flame guard power supply board and check the forward and backward resistance of its transient suppression diode by measuring pins 13 and 14 of the relay socket. A multimeter should be set to the “diode test” setting. The positive lead from the multimeter shall be connected to socket number 13 on the relay socket and the negative lead to socket 14. In this direction the multimeter should indicate approx. 0.6 V and it should indicate an overload when the lead connections are reversed. If these readings are not obtained, then the diode (“D1” on the mother PCB) must be replaced.

NOTE: *If, after replacing a defective diode, the circuit still does not work properly, the flame guard circuit components have been damaged, and the flame guard PC board must be replaced.*

6. If the preceding steps check out correctly, the flame guard portion of the circuitry on the flame guard/anode power supply PC board is either defective or needs recalibrating. Use the following procedure to determine which problem exists:

IMPORTANT: *If the circuit proves defective, the analyzer will have to be restandardized (see Chapter 3: Stabilization Period) after the board is replaced. (See section 5.1.4: Printed Circuit Board Replacement.)*

5.3.1 Flame Guard Circuit Calibration

1. With the selector switch in the high position, introduce span gas into the sample path of the analyzer. Verify that all control panel pressure readings are correct, and that the bypass flowrate is **0.5 SCFH or greater**.
2. Operate the selector switch in and out of the IGNITE position until the presence of fuel is assured.
3. Observe the panel meter. If the meter reads up scale when the selector switch is returned to the high position, **ignition of the**

flame has occurred. If ignition failure is indicated (the meter will read zero when the switch is in the high range), then refer to Section 5.3: *Ignition and/or Flame Guard Circuit Checks* to check the ignition circuit.

4. If ignition is verified, adjust the miniature potentiometer on the flame guard anode power supply board until it is over 75% of its travel clockwise (but not fully clockwise or counter-clockwise), and repeat the ignition procedure. If the sensing thermistor is intact (see step 2 under Section 5.3), and a fault does not exist on the PC board, the flame guard circuit should hold the flame-out indicator light in the off condition. If it does not, replace the circuit board. If it does (or after a new board is installed and the preceding steps completed), proceed with the remaining steps of this section.
5. Turn the potentiometer slowly counter-clockwise until the flame-out indicator light just comes on. Turn the potentiometer **gradually** clockwise again (while repeating the ignition procedure) until the light remains off. This adjusts the sensitivity of the flame guard circuit. If properly adjusted, the flame guard circuit should illuminate the flame-out indicator light within 10-20 seconds after flame failure. This can be easily tested by turning off the fuel and checking the light.

5.4 Sampling System

If the procedures outlined above do not correct the problem, the fault must be related to the gas control systems. Plugged or faulty regulators, plugged restrictors, or leaks within the system can cause erratic performance. TET/AI recommends that the factory or an authorized representative be contacted before attempting any repairs to the sample or supporting gas systems within the analyzer.

5.5 Printed Circuit Board Descriptions

The electronics circuitry of the analyzer is designed with the latest integrated circuit technology. The individual circuits which are required to process the incoming signal and condition it to provide the various outputs, alarms, indicators, etc., are built upon separate plug-in printed circuit

boards and interconnected via a motherboard, which contains the connectors into which the circuit boards are inserted.

The layout of the motherboard changes very little, in spite of the fact that it is used in a wide variety of instruments. This allows a universal approach to its use, and the circuit boards which are used can thus remain the same in varied applications.

The circuit board connectors on the Mother Board are labeled J1 through J6 and are used in totally standard instruments to connect and hold plug-in printed circuit boards in the following configuration:

- J1: Flame guard-anode power supply
- J2: Not used for the standard Model 402R
- J3: E-to-I converter (isolated)
- J4: Alarm comparator (dual)
- J5: Differential power supply
- J6: Temperature control

In addition, connector J1 is used with the Model 402R-EU; J1 plugs onto the electrometer amplifier PC board. These are shown in Figures 5-2 and 5-3.

The alarm comparator is an optional circuit; it has two (dual) adjustable setpoints at which an alarm or indicator is activated. Alarm circuits normally employ relays to provide contacts which may be connected, via terminal strip, to auxiliary signal devices.

Consult the following pages for detailed descriptions of the plug-in circuits used with the Model 402R.

5.5.1 Flame Guard and Anode Power Supply Printed Circuit Board

Schematic No. B-67810

Assembly Dwg. No. B-67797

Anode Power Supply: The high voltage anode power supply components (except for transformer) are mounted on the flame guard and anode power supply printed circuit board. High voltage regulation is

achieved through the use of series-connected zener diodes. The simplicity of this circuit's design can be attributed to the extremely low current demand of the anode circuit. The positive output voltage is nominally 250 volts. Output tolerance is ± 22 volts from the specified 250 volts, due to variation in components from unit to unit.

Flame Guard Circuit: A thermistor-controlled, transistorized switching circuit is employed to operate a relay in the event of a flame-out condition. A panel indicator light is turned on by the relay to alarm personnel that a flame-out condition has occurred.

The controlling thermistor is located within the upper section of the sensor cell assembly. The electronic circuit components are mounted on the same printed circuit board as the anode power supply. The relay is located on the motherboard and the indicator light on the control panel.

The thermistor is located in the circuit so that it controls the bias on the switching transistor. The circuit is factory set so that with the flame burning, the bias on the transistor is such that it conducts and holds the K3 relay energized. When energized, the relay extinguishes the Flame Out indicator light. Conversely, if the flame goes out, bias to the switching transistor is lost, the relay drops out, and the Flame Out light receives power through normally closed contacts.

During ignition, the flame heats the thermistor, holding the relay in the energized condition and the indicator light off. If the Flame Out light comes on as the switch returns from its momentary IGNITE position, then the flame is not burning, and the ignition procedure must be repeated.

Millivolt Output Resistors: Resistors R5 and R6 on this PC board are selected per application. They are used to convert the voltage signal obtained from the wiper of the span potentiometer into an auxiliary millivolt output.

5.5.2 Regulated Differential Power Supply Printed Circuit Board

Schematic No. B-33129

Assembly Dwg. No. A-9306

The purpose of this power supply circuit is to provide the DC voltage requirements of the various electronic circuits within the analyzer or system. An input voltage of 40-50 VAC at card pins 8 and 10 (center-tapped to ground at pin 14) is converted to a non-regulated +24 VDC at pin

12, -24 VDC (non-regulated) at pin 4, regulated +15 VDC at pin 15, and regulated -15 VDC at pin 1.

The circuit board can be easily tested (by verifying the voltages while in operation) as follows:

Regulated \15 volts:

1. Connect the **negative** voltmeter lead to the common (pin 2) and the **positive** lead to pin 15 of the card connector. The measured voltage should be 15 ± 0.5 volt. Refer to Figure 5-1.
2. Then connect the **positive** DVM lead to pin 1 of the card connector. Measured voltage should be -15 ± 0.5 volt.

Non-regulated \24 volts:

1. With the negative lead of the DMM still connected to pin 2 (ground), connect the positive lead to pin 12, and verify 24 volts (nominal).
2. Then connect the positive lead to pin 4 and verify -24 volts (nominal).

Input Voltage 40-50 VAC:

Using a voltmeter set to measure at least 50 VAC, test the voltage between the circuit card pins 8 and 10; voltage should measure ca. 30-50Vrms. Voltage from either pin 8 or pin 10 to ground should measure half the voltage found across pins 8 and 10.

5.5.3 Proportional Temperature Controller Printed Circuit Board

Schematic No. B-30974

Assembly Dwg. No. B-30868

The temperature of the chamber to be controlled is regulated by a thermistor-directed electronic circuit. The thermistor and heating element are located in the chamber, and the balance of the circuit components are mounted on the temperature controller printed circuit board, which plugs into a connector on the motherboard.

The control temperature is determined by the value of resistor R3 on the temperature controller printed circuit board, selected (at the time of

manufacture) from the chart on schematic B-30974 to provide the desired control point.

The thermistor used in the circuit is a negative temperature coefficient (NTC) device; as the chamber temperature increases, the resistance of the thermistor decreases, and vice versa.

The resistance of the thermistor in the circuit is compared with the value of resistor R3; when their resistance is equal, or when the resistance of R3 is less than that of the thermistor, the heating circuit is activated.

When a temperature deficiency is sensed by the thermistor, integrated circuit A1, acting as a zero-crossing switch, applies a pulsed signal to triac Q1, which in turn applies full wave power to the heating element.

IC A1 employs a diode limiter, a zero-crossing (threshold) detector, an on-off sensing amplifier (differential comparator), and a Darlington output driver (thyristor gating circuit) to provide the basic switching action. The DC operating voltages for these stages are provided by an internal power supply, with resistor R1 and capacitor C1 added externally.

The on-off sensing amplifier in this circuit is configured as a free-running multivibrator. This scheme adds proportional control, which takes over when the comparator inputs are at the design differential voltage.

Initially, when cold, the thermistor resistance is large, and the voltage at pin 13 is larger than that at pin 9. As the temperature of the controlled chamber begins to rise, the resistance of the thermistor decreases, thus reducing the voltage at pin 13. During this warm-up time the thyristor gating circuit is continuously delivering gate current from pin 4, thus maintaining constant fullwave AC power to the heater.

When the temperature reaches the selected control point, pin 13 voltage is about the same as pin 9 voltage, and proportional control takes over. The rate at which thyristor (triac) Q1 conducts and allows power to be delivered to the heater is determined by the combination of components R2 & R3, R4, C3, R5, and the thermistor resistance at the control temperature. Consequently, the balance point of the bridge formed by this combination of components can be altered by the selection of R3, causing the circuit to seek a temperature at which the thermistor resistance balances the bridge.

Because IC A1 triggers the thyristor at zero-voltage points in the supply voltage cycle, transient load current surges and radio frequency interference (RFI) are substantially reduced. In addition, use of the zero-voltage-switch reduces the rate of change of on-state current (di/dt) in the thyristor.

5.5.4 Electrometer-Amplifier PC Board

Schematic No. B-34436

Assembly Dwg. No. C-34434

The ions formed in the process of burning hydrogen in the presence of hydrocarbon components of the sample gas cause an electrical conduction between two electrodes in the combustion chamber (or detector cell) that is amplified by a high sensitivity and high input impedance electrometer-amplifier circuit. The electrical output of the electrometer-amplifier is directly proportional to the quantity of flame ionizable hydrocarbons present.

The electrometer amplifier PC board is not located on the motherboard, as are the other plug-in printed circuit boards; rather, it is mounted to the backplate assembly and interconnected to the electronics circuitry by means of a single card edge connector, so that the ease of replacement of a plug-in board is maintained. The high input impedance requires a shield, or cover, which is removable for access, as well as a shielded input conductor. Interconnection with the collector is made by a coaxial cable. Although the cable and fittings are intended for coaxial service, the cable is actually being used as a shielded single-conductor connection. The collector cable plugs into a coaxial connector on the electrometer amplifier PC board, which is located at the rear cover.

The circuit consists of an electrometer amplifier and an operational amplifier. It is a very high-gain, current-to-voltage converter circuit, having an input impedance measuring in the billions of ohms. It is static sensitive and highly susceptible to contamination, and special handling precautions must be taken.

Because of its high impedance, the input circuitry to the electrometer has had careful design consideration. The glass resistors (R2 and R3) in the input gain circuit (see schematic) are installed on Teflon-insulated stand-offs, instead of directly to the printed circuit, to eliminate the possibility of leakage currents.

To eliminate any possibility of contamination of the insulating materials employed, the completed PC board is ultrasonically cleaned in laboratory grade alcohol. **Under no circumstances should the parts described be handled with bare fingers.** A freshly-scrubbed finger, stroked along

one of the glass resistors, would deposit enough skin oil to completely upset the range division of the attenuator circuit.

Resistor R3 is a 1000M Ω resistor used in the feedback circuit of the amplifier. R2 has a resistance of 100,000M Ω and is used in series with the zero potentiometer slider. This circuit is used to nullify any offset signal introduced by the signal electrode. Trimmer P1 is used to nullify the offset signal generated by the electrometer amplifier.

The output of the circuit is standardized against gases with known hydrocarbon concentrations by setting the zero and span control potentiometers, located on the door, so that the meter and/or recorder indicates the hydrocarbon concentration of the gas being used.

The positive and negative operating voltage required by the electrometer amplifier is furnished by a regulated differential power supply circuit, a plug-in printed circuit board which plugs into a connector on the motherboard.

The stability of the electrometer circuit can be tested as follows:

1. Disconnect the collector cable.
2. Turn the span control about midway between clockwise and counter-clockwise.
3. Place the selector switch in the low range position.
4. Offset the zero control so that the recorder reads at some point upscale, and record a 24 hour chart.

Electrometer-Amplifier PC Board Adjustments:

1. **Input Zero Adjustment:** Connect DMM (millivolt range) between ground and the wiper of the zero potentiometer. Adjust the zero pot until the DMM reads zero.
2. **Absolute Zero Adjustment:** Disconnect the input cable from the tower (sensor assembly). With zero millivolts input to the circuit, open the plug of P1 trimmer on the electrometer-amplifier cover. Using a DMM, measure the the signal between the clockwise terminal of the span pot and ground, and adjust P1 in the electrometer-amplifier board to obtain zero reading on the DMM.

The electrometer-amplifier circuit is now nulled.

5.5.5 Comparator Alarm Printed Circuit Board

Schematic No. B-33128

Assembly Dwg. No. A-9309 (dual)

The comparator alarm circuit consists simply of an operational amplifier used to turn a transistor on or off according to logic wiring, in response to an increasing process signal. The transistor, in turn, in its “turned on” state, activates a contact relay to provide switching contacts accessible at the interconnection terminal strip.

For the number 1 alarm circuit, potentiometer P3 sets a reference voltage at strapping point B on the circuit board. The process signal is present at strapping point A. Depending upon the strapping configuration (jumper placement), IC A1 can be used in its inverting or non-inverting mode to control relay K1 by means of NPN transistor Q2.

When in its inverting mode (jumpers JP3 and JP4 installed), A1 receives the positive signal voltage at its inverting input (pin 2) and the positive reference voltage at its non-inverting input (pin 3). When the voltage at pin 2 is more positive than that at pin 3, A1’s output goes low (negative), and the transistor is turned off, de-energizing relay K1. Thus, K1 is energized when the signal is below the point set by P3 (Alarm setpoint 1) and de-energized above the setpoint.

In its non-inverting mode (jumpers JP1 and JP2 installed), A1 switches to a negative output when the signal voltage (now applied to pin 3) is less than the reference voltage (pin 2), to a positive output if the signal output is greater, and vice versa. Once again, when A1’s output is positive, Q2 is turned on, energizing K1; negative A1 output turns off Q2, de-energizing K1. Thus configured, the alarm relay is energized “above setpoint”, or when the signal is greater than the reference.

For number 2 alarm circuits, setpoint potentiometer P4 is used to adjust alarm setpoint #2. IC A2, transistor (PNP) Q4, and alarm relay K2 are added to make up the second alarm. Transistor Q4 (PNP) acts in the reverse manner from Q2 (NPN), turning on with a negative A2 output, off with positive. Installing jumpers JP7 and JP8 configures the second alarm to energize below alarm 2 setpoint (P4), and installed jumpers JP5 and JP6 causes the alarm to energize above setpoint.



**IF USED OUTSIDE OF THESE SPECIFICATIONS
THE INSTRUMENT MAY BE DAMAGED AND
HAZARDOUS CONDITIONS MAY BE PRODUCED.**

Appendix

Specifications

- Ranges:** 0-10, 0-100, 0-1000ppm hydrocarbon standard (methane equivalent)
(0-1ppm low range is optional.)
- Sensitivity:** 1% of full scale
- Accuracy:** $\pm 2\%$ of full scale at constant temperature
(Applies to standard ranges.)
- Response Time:** 90% in less than 15 second
- Operating Temperature:** 41°F to 110°F (5°C to 43.3°C)
- Fuel:** Mixture of 40% hydrogen, 60% nitrogen recommended
(Other mixtures are possible. Contact TET/AI for applications assistance.)
- Sensor Type:** Flame Ionization Detector with Flame Guard
- Signal Output:** Internal - Digital Panel Meter
External - 0-1VDC, 4-20mA DC Isolated
- Power Requirement:** 115VAC $\pm 10\%$ 50/60 Hz
230VAC $\pm 10\%$ 50/60Hz
90VA nominal, 150VA maximum
- Enclosure:** 19" (48.3cm) Rack-Mounted Steel Enclosure
19" (48.3cm) W x 8.75" (22.2cm) H x 15.5" (39.4cm) D

Application Data

Model Number: _____

Serial Number: _____

Ranges Of Analysis: _____

Output Signal: _____

Start-Up Span Setting: _____

Control Panel Pressure Settings: _____

Comments: _____

Blanket Air: _____

Fuel: _____

Sample: _____

Bypass Flowrate: A minimum of **0.25 SCFH** is indicated on the integral flowmeter

Recommended Support Gases: The accessory gases should **all** be laboratory analyzed and certified as to their hydrocarbon content.

Blanket Air: Water pumped, hydrocarbon free, compressed air.

Fuel: A hydrocarbon-free composition of 40% hydrogen and 60% nitrogen.

Zero Gas: Water pumped, hydrocarbon free (certified)

Span Gas: _____ ppm methane in _____ (certified)

The span gas contains a known amount of methane impurity. The span gas **must** be certified as to its methane equivalent impurity.

IMPORTANT: For the best possible results, zero and span gases that are representative of the parent (or background) gas should always be used.

This is particularly true in applications where the analyzer is being used to analyze a number of different samples with varying concentrations of oxygen. The geometry and temperature of the flame will be somewhat dependent on the oxygen content of the sample. Alterations in the flame configuration will lead to differences in output readings. The application calls for this analyzer to be used on oxygen, air, and a composition of oxygen and nitrogen. For the best possible results, TAI recommends that zero and span gases representative of each of these samples be used to standardize the analyzer.

Recommended Spare Parts List

Qty.	P/N	Description
1	B67797	PC board, Flame guard & anode power supply
1	C34434	PC board, Electrometer-amplifier
1	B30868	PC board, Temperature control
1	A9306	PC board, Differential power supply
1	B29600	PC board, E/I Converter (isolated)
1*	A10045	PC board, Alarm comparator (single)
1*	A9309	PC board, Alarm comparator (dual)
1	A46128	Coaxial cable
1	R179	Relay
1	L79	Lamp, neon
6	F1361	Fuse, 1.6A, Littelfuse P/N 21501.6, only used for F1, F2 and F3.
4	F1358	Fuse 0.5A, Littelfuse P/N 218:500 only, used for F5
4	F1375	Fuse 0.8A, Littelfuse P/N 218.800 only, used for F6, and used for 230VAC version.
4	F1378	Fuse 0.2A, Littelfuse P/N 218.200, only used for F4, and used for 115VAC version only.
4	F1374	Fuse 0.1-5A, Littelfuse P/N 218.125 only, used for F4, and used for 230VAC version only.
1	L156	Lens, red
1	L154	LED, red
1	A33748	Thermistor assembly

* Optional—will not be present if not specified at time of order.

A minimum charge of US \$20.00 is applicable to spare parts orders.

IMPORTANT: Orders for replacement parts should include the part number and the model and serial number of the system for which the parts are intended.

Send orders to:

Teledyne Electronic Technologies
 Analytical Instruments
 16830 Chestnut Street
 City of Industry, CA 91749-1580
 Telephone: (626) 934-1500
 TWX: (910) 584-1887 TDYANYL COID
 Fax: (626) 961-2538
 Web: www.teledyne-ai.com
 or your local representative

Drawing List

C-66897	Outline diagram
B-67695	Input-output diagram
B-67698	Piping diagram
B-67691	Gas connection diagram w/sample select module (optional)
B-67692	Gas connection diagram w/o sample select module (optional)
D-67924	Schematic, 402R, 19" rack standard
B-34436	Schematic, Electrometer PC board
B-67810	Schematic, Flame guard, anode power supply PC board
B-33129	Schematic, Power supply PC board
B-30974	Schematic, Temp. controller PC board
B-29602	Schematic, E to I converter, isolated
B-33128	Schematic, Alarm PC board (optional)
B-34609	Schematic, digital meter, 2½ digit standard
D-67923	Wiring diagram, 19" rack standard

Assemblies

D-68011A,B,C,D	Assembly, gas control module
D-67685	Assembly, door (115V version)
D-67809	Assembly, sensor
B-68234	Assembly, sensor plug
A-46128	Assembly, signal cable
B-67881	Cable Assembly, heater

PC Board Assemblies

C-67789	PCB Assy, motherboard, basic
C-34468	PCB Assy, motherboard, 402DPM (version)
B-67797	PCB Assy, anode power supply, flame guard
A-9306	PCB Assy, power supply
A-9309	PCB Assy, alarms (optional)
B-29600	PCB Assy, E to I converter, isolated
B-30868	PCB Assy, temperature controller, 110V
C-34434	PCB Assy, electrometer
B-34592	PCB Assy, digital meter, standard, 2½ digit