


**OPERATION AND MAINTENANCE MANUAL
FOR MODEL 301 FID AND 301M FID ANALYZER**

gasanalyzers.com



California Analytical
Instruments, Inc.

1312 West Grove Avenue, Orange, CA 92865 - 714 974-5560 - Fax 714 921-2531
Website: www.gasanalyzers.com

Table of Contents

| | |
|---|------|
| 1. INTRODUCTION | 1-5 |
| 1.1. Overview..... | 1-5 |
| 1.2. Unpacking Instructions | 1-5 |
| 1.3. Reporting Damage | 1-5 |
| 1.4. Contact Information | 1-5 |
| 1.5. Warranty Certificate..... | 1-6 |
| 1.6. Possible Explosion Hazard..... | 1-7 |
| 1.7. Electrical Shock Hazard | 1-7 |
| 1.8. Fuel Requirements | 1-7 |
| 1.9. Potential Sample Pump Damage | 1-7 |
| 1.10. FACTORY QA CHECKOUT SHEET | 1-8 |
| 2. FEATURES AND PRINCIPLES OF OPERATION | 2-9 |
| 2.1. Description..... | 2-9 |
| 2.2. Product Specifications Model 301 FID | 2-10 |
| 2.3. FID OPTIONS..... | 2-10 |
| 3. INSTALLATION | 3-11 |
| 3.1. General..... | 3-11 |
| 3.2. Site and Mounting..... | 3-11 |
| 3.3. Electrical | 3-11 |
| 3.4. Remote Range Operation..... | 3-12 |
| 3.5. Required Gases and Gas Handling Equipment..... | 3-13 |
| 3.6. Gas Connections | 3-14 |
| 3.7. Sampling Requirements | 3-14 |
| 3.8. Pressure and Flow Rate | 3-15 |
| 3.9. Sample Gas By-Pass Outlet..... | 3-15 |
| 3.10. Exhaust Port | 3-15 |
| 4. DESCRIPTION AND FUNCTION COMPONENTS | 4-16 |
| 4.1. Model 301 FID Analyzer Front Panel | 4-16 |
| 4.2. Model 301 FID Analyzer Rear Panel | 4-18 |
| 5. Major Internal Components | 5-19 |
| 5.1. Model 301 FID Interior Layout..... | 5-19 |
| 5.2. MAIN CIRCUIT BOARD | 5-21 |
| 5.3. MAIN AMPLIFIER BOARD..... | 5-22 |
| 5.4. Burner Assembly | 5-23 |
| 5.5. Automatic Ignite Board | 5-24 |
| 5.6. Diagnostic Board | 5-25 |
| 5.7. EPC and Dual Temperature Control Board | 5-26 |
| 5.8. EPC Hydrogen and CH ₄ Cutter Control Board Components | 5-27 |
| 5.9. Valve Driver Board | 5-28 |
| 6. Operation | 6-29 |
| 6.1. Start-Up Procedure..... | 6-31 |
| 6.2. Shutdown Procedure..... | 6-31 |
| 7. FUNCTIONAL DESCRIPTION | 7-32 |
| 7.1. Operating Principle..... | 7-32 |
| 7.2. Burner Assembly | 7-32 |
| 7.3. Methane Cutter (Non-Methane Hydrocarbons) | 7-32 |
| 7.4. Flow System | 7-33 |

| | | |
|------|---|-------|
| 8. | ELECTRONICS | 8-34 |
| 8.1. | Main Circuit Board | 8-34 |
| 8.2. | Main Amplifier Board | 8-34 |
| 8.3. | Automatic Ignite Board | 8-34 |
| 8.4. | Diagnostic Board | 8-34 |
| 8.5. | EPC/Dual Temperature Control Board | 8-34 |
| 8.6. | EPC Hydrogen/Cutter Temperature Control Board | 8-35 |
| 8.7. | Valve Driver Control Board | 8-35 |
| 9. | DISASSEMBLY-GENERAL INFORMATION-TROUBLESHOOTING | 9-36 |
| 9.1. | Oven Burner Assembly Filter Unit/Filter Removal | 9-36 |
| 9.2. | Electronic Boards/Removal | 9-36 |
| 9.3. | Electronics | 9-36 |
| 9.4. | Flow System/Fuel and Burner Air Supply | 9-37 |
| 9.5. | Sample Supply | 9-37 |
| 10. | TROUBLESHOOTING GUIDE | 10-38 |
| 11. | FLOW DIAGRAMS AND SCHEMATICS | 11-39 |

Table of Figures

| | |
|--|------|
| Figure 3-1 AC Power Switch, Connector, and Fuse | 3-11 |
| Figure 3-2 EMI Suppressor..... | 3-12 |
| Figure 4-1 Model 301 FID Analyzer Front Panel | 4-16 |
| Figure 4-2 Model 301M FID Analyzer Front Panel with CH ₄ Cutter..... | 4-16 |
| Figure 4-3 Model 301 FID Analyzer Rear Panel | 4-18 |
| Figure 5-1 Model 301 FID Interior Layout..... | 5-19 |
| Figure 5-2 Model 301 FID Main Circuit Board | 5-21 |
| Figure 5-3 Model 301 FID Amplifier Board | 5-22 |
| Figure 5-4 Model 301 FID Burner Assembly..... | 5-23 |
| Figure 5-5 Model 301 FID Automatic Ignite Board..... | 5-24 |
| Figure 5-6 Model 301 FID Output Diagnostic Circuit Board..... | 5-25 |
| Figure 5-7 Model 301 FID EPC and Dual Temperature Control Board | 5-26 |
| Figure 5-8 Model 301 FID EPC Hydrogen and CH ₄ Cutter Control Circuit Board | 5-27 |
| Figure 5-9 Model 301 Valve Driver Board..... | 5-28 |

Tables

| | |
|--------------------------------|------|
| Table 3-1 I/O Connections..... | 3-13 |
|--------------------------------|------|

1. INTRODUCTION

1.1. Overview

Thank you and congratulations! You have just purchased one of the most reliable gas analyzers in the world. Before using the analyzer, please familiarize yourself with its operation by reading this manual. If you have any questions, please do not hesitate to call California Analytical Instruments for assistance. We want you to be a member of our thousands of satisfied customers.

1.2. Unpacking Instructions

Open the shipping container and carefully remove the analyzer from the packing materials. Inspect the instrument for any sign of damage. Remove the retaining screws and lift off the cover panel. Visually check for proper seating of parts and or connectors. If all internal components appear to be normal replace the cover and secure it with the screws previously removed.

1.3. Reporting Damage

Should there be any apparent damage either to the inside or outside of the instrument due to shipping or handling, notify the shipper immediately. Retain the shipping container or packing materials for inspection by the shipper.

1.4. Contact Information

California Analytical Instruments, Inc.
1312 West Grove Avenue
Orange, CA 92865
714 974-5560
Fax 714 921-2531
Website: www.gasanalyzers.com

1.5. Warranty Certificate

Subject to the exceptions and upon the conditions stated below, California Analytical Instruments (CAI) warrants that the products sold under this sales order shall be free from defects in workmanship and materials for one year after delivery of the product to the original Buyer by CAI and if any such product should prove to be defective within such one year period, CAI agrees, at its option, either (i) to correct by repair or, at CAI's election, by replacement with equivalent product any such defective product, provided that investigation and factory inspection discloses that such defect developed under normal and proper uses, or (ii) to refund the purchase price. The exceptions and conditions mentioned above are as follows:

- a) components or accessories manufactured by CAI that by their nature are not intended to or will not function for one year are warranted only to give reasonable service for a reasonable time. What constitutes reasonable time and reasonable services shall be determined solely by CAI. A complete list of such components and accessories is maintained at the factory;
- b) CAI makes no warranty with respect to components or accessories not manufactured by it; in the event of defect in any such component or accessory CAI will give reasonable assistance to Buyer in obtaining from the respective manufacturer whatever adjustment is authorized by the manufacturer's warranty;
- c) any product claimed to be defective must be returned to the factory transportation charges prepaid and CAI will return the repaired or replaced product freight collect;
- d) if the product claimed to be defective requires on-site repair, such warranty labor will be provided at no charge; however, transportation and living expenses will be charged to Buyer;
- e) if the product is a consumable or the like, it is warranted only to conform to the quantity and content and for the period (but not in excess of one year) stated on the label at the time of delivery or 90 days;
- f) CAI may from time to time provide a special printed warranty with respect to a certain product, and where applicable, such warranty shall be deemed incorporated herein by reference;
- g) CAI shall be released from all obligations under all warranties, either expressed or implied, if any product covered hereby is repaired or modified by persons other than its own authorized service personnel unless such repair by others is made with the written consent of CAI.

IT IS EXPRESSLY AGREED THAT THE ABOVE WARRANTY SHALL BE IN LIEU OF ALL WARRANTIES OF FITNESS AND OF THE WARRANTY OF MERCHANTABILITY AND THAT CAI SHALL HAVE NO LIABILITY FOR SPECIAL OR CONSEQUENTIAL DAMAGES OF ANY KIND OR FROM ANY CAUSE WHATSOEVER ARISING OUT OF THE MANUFACTURE USE, SALE, HANDLING, REPAIR, MAINTENANCE OR REPLACEMENT OF ANY OF THE PRODUCTS SOLD UNDER THIS SALES ORDER. SOME STATES DO NOT ALLOW THE EXCLUSION OR LIMITATION OF INCIDENTAL OR CONSEQUENTIAL DAMAGES, SO THAT THE ABOVE LIMITATIONS OR EXCLUSIONS MAY NOT APPLY. THIS WARRANTY GIVES YOU SPECIFIC LEGAL RIGHTS, AND YOU MAY HAVE OTHER RIGHTS, WHICH VARY FROM STATE TO STATE.

Representations and warranties made by any person, including dealers and representatives of CAI which are inconsistent or in conflict with the terms of this warranty, shall not be binding upon CAI unless produced in writing and approved by an expressly authorized officer of CAI.

Danger

1.6. Possible Explosion Hazard

Do not apply power to the analyzer or attempt to ignite the burner until performing ALL leak checks and until determining the analyzer environment to be non-hazardous.

Use this analyzer in a **NON-HAZARDOUS** environment.

This analyzer uses a fuel that contains a **FLAMMABLE LEVEL OF HYDROGEN**. Any leakage from this fuel can result in an explosion. Carefully check the fuel supply system, both inside and outside the analyzer for leaks upon installation, before initial start-up, during any maintenance: or after the integrity of the system is broken.

This analyzer has not been designed for use with a hazardous sample.

Tampering or use of substitute components may cause a safety hazard. Use only factory authorized replacement parts.

1.7. Electrical Shock Hazard

Do not operate without the cover secured. Servicing requires access to live electrical components that can cause death or serious injury. Refer servicing to qualified service personnel. For safety and proper performance, connect this instrument to a properly grounded three-wire receptacle.

Caution

1.8. Fuel Requirements

The factory configured the Model 301 FID for either 100% Hydrogen or 40%/60% Hydrogen/Helium Fuel. Please make sure to use the **CORRECT** fuel.

Use of **INCORRECT** fuel will **DAMAGE** the instrument and could cause an **EXPLOSION**.

1.9. Potential Sample Pump Damage

For applications that require injection of calibration gas via the sample port of the analyzer, it is **MANDATORY** that pressures do not exceed **2.0 PSIG** pressure.

DAMAGE SUSTAINED BY THE PUMP WHEN OVER PRESSURED IS NOT COVERED BY THE CAI WARRANTY.

Plug Removal: Do not operate this analyzer UNTIL REMOVING the red plastic ¼ inch plugs from the sample/zero/span/fuel fittings on the rear panel.

1.10. FACTORY QA CHECKOUT SHEET

FID SERIAL NUMBER:

FACTORY AIR PRESSURE SETTING:

FACTORY FUEL PRESSURE SETTING:

FACTORY SAMPLE PRESSURE SETTING:

2. FEATURES AND PRINCIPLES OF OPERATION

2.1. *Description*

The CAI Model 301 FID Heated Total Hydrocarbon Analyzer uses a highly sensitive flame ionization detector (FID) gas analyzer for measuring gas concentrations in industrial and vehicle emission applications.

The CAI Model 301M FID Total Hydrocarbon Analyzer is exactly the same instrument as the Model 301 FID, except that it contains a catalyst that switches in and out of the sample stream, with the front panel switch or via a contact closure, to analyze the methane content of the sample. This catalyst (Methane Cutter) removes all hydrocarbons from the sample stream except methane.

A self-contained temperature controlled oven maintains the sample capillaries and the flame ionization detector (FID burner) at a constant temperature to eliminate any signal drift due to variations of the temperature in the analyzers environment. The oven temperature is factory set at 85° C.

A nine-position range-selector switch is located on the front panel of the analyzer. This switch allows the operator to select between any one of eight full-scale ranges (0-10/30/100/300/1,000/3,000/10,000 ppm) or the remote range selection mode. The instrument provides a 0-10VDC and a 4-20 mADC analog output signal that is scaled for the selected operating range.

2.2. Product Specifications Model 301 FID

ANALYSIS METHOD: Flame Ionization Detector (FID)

TOTAL RANGES: 0- 10, 30, 100, 300, 1,000, 3,000, 10,000, 30,000 ppm Carbon

EIGHT OPERATING RANGES: Switch Selectable from the Front Panel or Remote Range Change.

RESOLUTION: 0.01 ppm Carbon

REPEATABILITY: Better than 0.5% of Full Scale

LINEARITY: Better than 1% of Full Scale to 10,000

Better than 1% of Full Scale above 10,000

O₂ EFFECT: Less than 1% of Full Scale

CH₄ EFFECT: Less than 1.2 Times Propane

RESPONSE TIME: 90% of Full Scale in 1.5 seconds

SAMPLE FLOW RATE: 3.0 L/min. \pm 1.5 L/min.

EXTERNAL SAMPLE FILTER: 40 micron required

INTERNAL SAMPLE FILTER: 0.1 micron Replaceable Filter

NOISE: Less than 0.5% of Full Scale

ZERO & SPAN DRIFT: Less than 1% of Full Scale per 24 hours

ZERO & SPAN ADJUSTMENT: Ten Turn Potentiometer

FLOW CONTROL: Electronic Proportional Pressure Valve

FUEL REQUIREMENTS: 40% H₂
60% He 120 cc/min. or 100% H₂ at Specified Flow (See section 1.10)

Specifications subject to change without notice

AIR REQUIREMENTS: Less than 1 ppm THC. See Individual Sheet for Specific Flow Rates

DISPLAY: 3½ Digit Panel Meter.

DIAGNOSTICS: 3½ Digit Meter with seven Position Switch

Collector Voltage +15 VDC

Fuel Pressure Oven Temperature

Air Pressure Burner Temperature

Sample Pressure

ANALOG OUTPUT: 0-10 VDC and 4-20 mADC

FUEL/AIR CONTROL: Forward Pressure Regulator & Capillaries

IGNITION: Momentary Push-Button With Flame-On Indicator (Manual or Remote Control)

FLAME OUT INDICATOR: Automatic Fuel Shut Off

AMBIENT TEMPERATURE: 5 to 45 Degrees C

SAMPLE TEMPERATURE: 0 to 50 Degrees C

WARM-UP TIME: 1 Hour

FITTINGS: 1/4 Inch Tube

POWER REQUIREMENTS: 115/230 (\pm 10%) VAC 50/60 Hz; 600 Watts

DIMENSIONS: 5¼ H x 19 W x 24 D (Inches)

RELATIVE HUMIDITY: Less than 90% RH

WEIGHT: 38 Pounds

2.3. FID OPTIONS

- Methane Cutter (Reads Only Methane in Sample)
- Specify Fuel Type
- 19 Inch Rack Mount Slides
- Remote In-Line Filter

3. INSTALLATION

3.1. General

The design of the instrument is for industrial applications. These installation instructions are for a typical site. Direct any questions regarding specific installation situations to Technical Service of California Analytical Instruments, Inc.

3.2. Site and Mounting

NOTE: Observe the following precautions carefully:

1. Select a site free from direct sunlight, radiation from a high temperature surface, or abrupt temperature variations.
2. This analyzer is not suitable for outdoor installation. If installed outdoors, shelter the instrument from wind and rain.
3. Select a site where the air is clean. Avoid exposing the instrument to corrosive or combustible gases.
4. The instrument must not be subject to severe vibration. If severe vibration is present, use isolation mounts.
5. The design of the instrument is for rack mounting. Optional rack mount slides are available.
6. Do not install near equipment emitting electromagnetic interference (EMI).

NOTE: A rear supporting brace or equivalent is required if the optional rack mount slides were not purchased.

3.3. Electrical

Connect all wiring at the rear of the instrument. Table 4-1 on the following page show the connect outputs, etc. Connect the AC power to the power/fuse/switch as shown below in Figure 3-1.

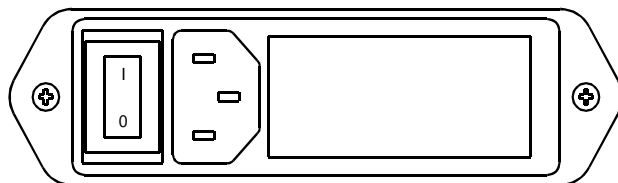


Figure 3-1 AC Power Switch, Connector, and Fuse.

NOTES: A defective ground may affect the operation of the instrument. Connect the output voltages per Table 3-1. Shielded wiring is recommended for output signals.

CAUTION: Electromagnetic interference (EMI) may affect the operation of the instrument. Do not install the instrument near electrical noise (such as high frequency furnaces, electric welding machines, etc.). A separate power line must be used if the instrument must be installed at such locations. Control the noise from a relay or solenoid valve by the use of an EMI suppressor (RC circuit) across the power wiring close to the noise-generating component (see Figure 3-2).

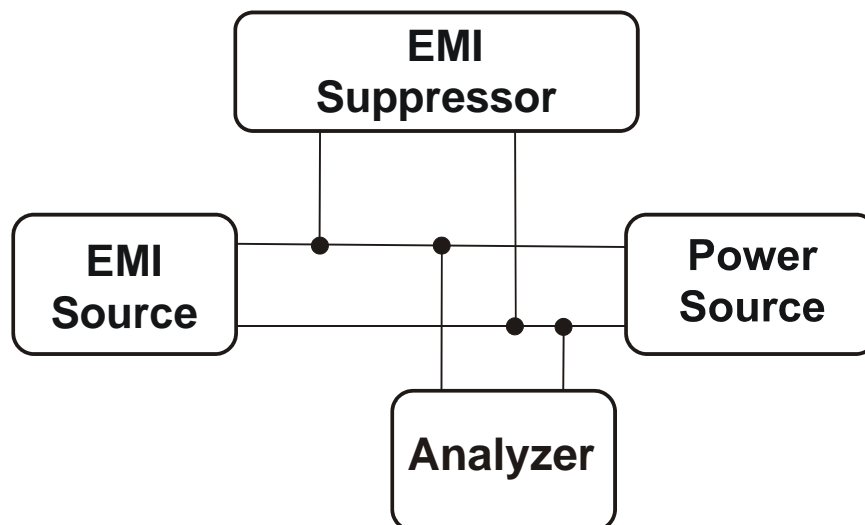


Figure 3-2 EMI Suppressor.

NOTE: Locate the EMI Suppressor close to the noise source.

3.4. Remote Range Operation

Obtain remote range identification and range selection by the rear panel connections. When selecting a range the corresponding control line pulls low to zero VDC. Ranges not selected will remain at approximately 5 VDC.

Selecting remote range control on the front panel switch provides a contact closure at the rear panel connector. Remote range selection and FID ignite is made by connection of the control wire at the rear panel connector. A contact closure at the rear panel connector indicates FID "Flame On."

NOTE: Shielded wiring is recommended for output signals.

Table 3-1 I/O Connections

| | | | |
|------------------------------------|-------------------------|-------------------|---|
| 1. V Out Common | 9. Zero Select** | 17. R1 ID/Control | 25. Remote Range Control |
| 2. | 10. Span Select** | 18. R2 ID/Control | 26. Remote Range Common |
| 3. 0- 10 VDC | 11. Flame On Output | 19. R3 ID/Control | 27. 5 VDC |
| 4. I Out Common | 12. Flame On Common | 20. R4 ID/Control | 28. DC Common |
| 5. I Out (4-20 MADC) | 13. Ignite On | 21. R5 ID/Control | * Only available on models 301M-FID. |
| 6. THC/CH ₄ Common* | 14. Ignite Common | 22. R6 ID/Control | |
| 7. Select THC or CH ₄ * | 15. Sample Select** | 23. R7 ID/Control | ** Only available on models supplied with a built-in sample pump. |
| 8. Oven Temp (1mv per degree C) | 16. Z/S/Sample Common** | 24. R8 ID/Control | |

3.5. Required Gases and Gas Handling Equipment

- 1) Air (zero and burner air, < 1 ppm C) in pressurized cylinder.
- 2) Fuel 40% H₂/60% He or 100% H₂ in pressurized cylinder. (As Specified)
- 3) Standard span gas(es) near full-scale concentration (typically 80-95% of the analyzers measuring range) with an air balance, in a pressurized, certified cylinder.
- 4) Pressure regulators for zero and span gas cylinders.
- 5) Corrosive resistant gas tubing.
- 6) Pump — if not supplied as an analyzer option.

The sample gas must be supplied to the analyzer at an inlet pressure of 6-25 PSIG (8 PSIG nominal.) The flow will then be regulated at approximately 2.5 LPM.

DAMAGE SUSTAINED BY THE PUMP WHEN OVER PRESSURED IS NOT COVERED BY THE CAI WARRANTY.

3.6. Gas Connections

The tubing from the sampling system to the gas analyzer should be corrosive resistant material such as Teflon® or stainless steel. Do not use rubber or soft vinyl tubing even when the gases sampled are non-corrosive, since readings may be inaccurate due to gas absorption into the piping material. To obtain fast response, the tube should be as short as possible. Optimum tube internal diameter is 0.16 inch (4 mm). Instrument couplings are ¼-inch tube. A sample-gas outlet fitting is located on the rear panel (¼-inch tube). Keep pressure at this outlet at atmospheric level. Vent this gas from the instrument.

NOTE: *Teflon® is a registered trademark of E. I. du Pont de Nemours and Company.*

NOTE: *Be sure tubing and joints are clean. Dust entering the instrument may cause it to malfunction.*

3.7. Sampling Requirements

- 1) Filtration.
 - a) Eliminate all Dust. Use filters as necessary.
 - b) Internal: The instrument includes an internal 0.1 micron filter located at the sample inlet on the back of the analyzer. This fiberglass filter is easily replaceable.
- 2) The sample gas should be dried to a dew point of 20° C or less.
- 3) Presence of Corrosive Gases.
 - High concentrations of corrosive gases such as Cl₂, F₂, HCl, etc. present in the sample gas will shorten the useful service life of the instrument.
- 2) Gas Temperature.
 - The Model 301 FID is factory set at 85° C.

3.8. Pressure and Flow Rate

An internal pressure regulator controls the burner air entering the instrument. The air cylinder pressure should be set at 20 PSIG. The air regulator is factory set for proper air/fuel ratio as indicated on the QA Check Sheet and as included in this manual.

| | | |
|--------|---------------------------------|------------------|
| Fuel | ± 0.5 PSIG of Indicated Setting | See section 1.10 |
| Air | ± 0.5 PSIG of Indicated Setting | See section 1.10 |
| Sample | ± 0.2 PSIG of Indicated Setting | See section 1.10 |

NOTE: Do not operate the FID sample pump with sample lines that have more than 2 PSIG pressure. If using sample lines to introduce zero/span gases, do not exceed 2 PSIG at sample pump.

A factory set precision electronically controlled proportional flow controller controls the sample and fuel entering the instrument. For proper flow control, set the sample gas and fuel entering the instrument at a pressure between 6 and 25 PSIG at a flow rate of 4 ± 1.5 liters/min. If ordered, the internal heated sample pump automatically maintains this pressure. The calibration (span and zero-gas) cylinder-pressures should be set at 20 PSIG.

3.9. Sample Gas By-Pass Outlet

A sample-gas by-pass outlet-connector is located on the rear panel (¼ Inch Tube). Keep pressure at this outlet at atmospheric level. ANY backpressure may cause an error in reading. Vent this gas away from the instrument.

3.10. Exhaust Port

The exhaust port on the back of the analyzer is the exhaust vent for the burner assembly. It **is not** acceptable to have **ANY BACKPRESSURE** applied to the exhaust port. It is recommended to vent this exhaust separately from the sample-gas by-pass outlet.

Water is a by-product of combustion. Water droplets accumulate at the exhaust port. Any tubing connected to the exhaust port must be installed on a continuous “down-hill” slope of at least 3 inches per feet.

4. DESCRIPTION AND FUNCTION COMPONENTS

4.1. Model 301 FID Analyzer Front Panel

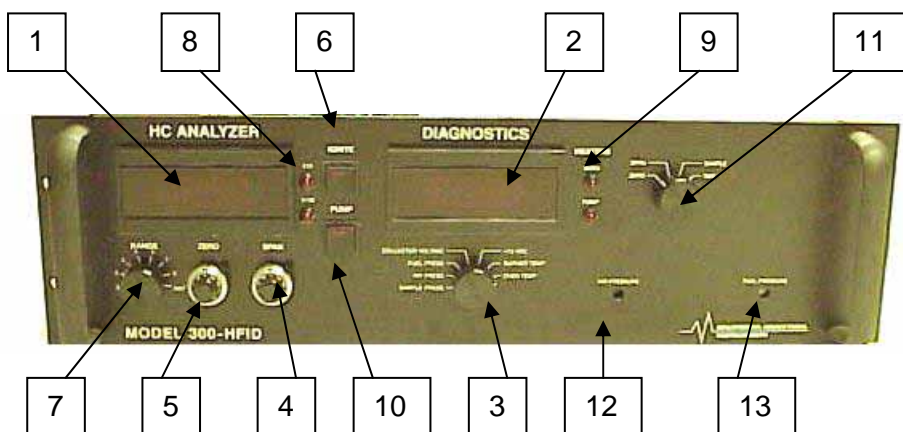


Figure 4-1 Model 301 FID Analyzer Front Panel



Figure 4-2 Model 301M FID Analyzer Front Panel with CH₄ Cutter

- 1) **Digital Indicator (3 1/2 Digits):** Displays analyzer output.
- 2) **Digital Indicator (3 1/2 Digits):** Displays diagnostic functions.
- 3) **Diagnostic Switch:** Eight Position Switch Displays:

| | |
|-------------------------|------------------------|
| Collector Voltage (DCV) | Plus 15 VDC Supply |
| Fuel Pressure (PSIG) | Cutter Temperature (C) |
| Air Pressure (PSIG) | Burner Temperature (C) |
| Sample Pressure (PSIG) | Oven Temperature (C) |
- 4) **Span Control:** Sets fine gain of instrument. (Adjust while span gas is flowing through instrument.)
- 5) **Zero Control:** Sets zero level of instrument. (Adjust while zero gas is flowing through instrument.)

- 6) **Ignite Switch:** Depressing the momentary push-button ignite switch starts the burner ignites sequence. The illuminated LED in the switch and a contact closure on the rear panel connector indicates Burner ON condition. Remote ignite may be accomplished via a contact closure on the rear panel connector.
- 7) **Range Switch:** Allows selection of ranges 1 through 8 or remote. The remote position allows for remote computer control of ranges via a contact closure on the rear panel connector.
- 8) **Multiplier LED's:** Meter Reading Times 10 or 100.
- 9) **Heated Cycle Switch:** Indicates Pump, Oven, and Cutter Heaters are cycling.
- 10) **Pump Switch (Optional):** Turns On Heated Internal Sample Pump
- 11) **Sample/Zero/Span/Remote Switch (Optional):** Activates Internal Solenoids.
- 12) **Air Pressure Adjust:** Adjusts Air Pressure (See Factory Settings Sheet).
- 13) **Fuel Pressure Adjust:** Adjusts Fuel Pressure (See Factory Settings Sheet).
- 14) **Methane Cutter Switch (Optional):** Selects between the CH₄, THC and Remote modes of operation. .

4.2. Model 301 FID Analyzer Rear Panel

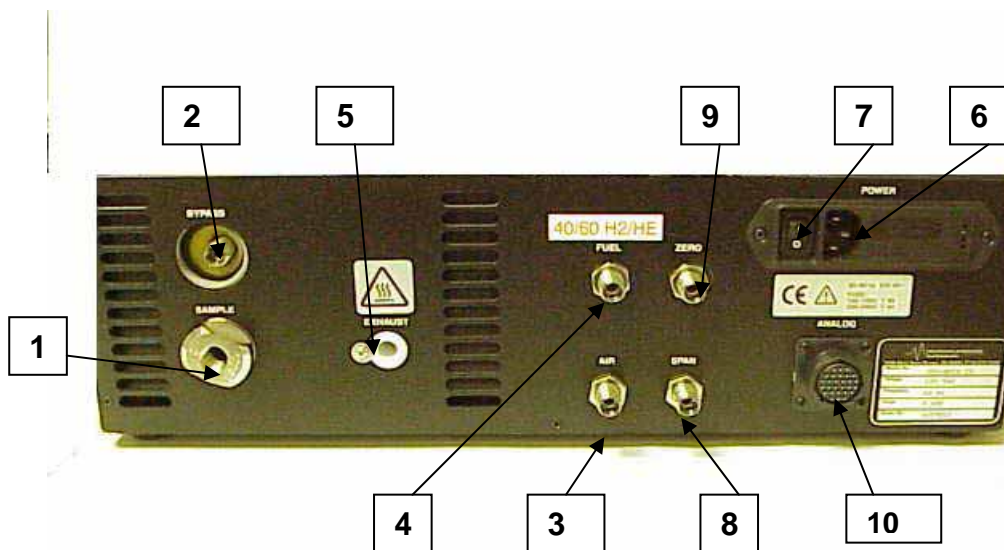


Figure 4-3 Model 301 FID Analyzer Rear Panel

- 1) **Sample Gas Inlet:** Feeds sample gas to the analyzer. Threaded ¼ Inch Tube. Fitting also contains a heated filter.
- 2) **Sample Gas By-Pass Outlet (Vent):** Exhaust for sample. Threaded ¼ Inch Tube.
- 3) **Burner Air Inlet:** For feeding hydrocarbon free air to the burner. See Figure 5-4. Threaded ¼ Inch Tube.
- 4) **Fuel Inlet:** For feeding fuel to the burner. See Figure 5-4. Threaded ¼ Inch Tube.
- 5) **Burner Outlet (Vent):** Exhaust for burner (No fitting required).
- 6) **Power Entry Module:** Power cord connection, power switch, fuse compartment.
- 7) **Rear Panel Power ON/OFF Switch:** Turns ON/OFF line power to instrument.
- 8) **Span Gas Inlet (Optional):** Inputs Span Gas to Optional Solenoids.
- 9) **Zero Gas Inlet (Optional):** Inputs Zero Gas to Optional Solenoids.

5. Major Internal Components

5.1. Model 301 FID Interior Layout

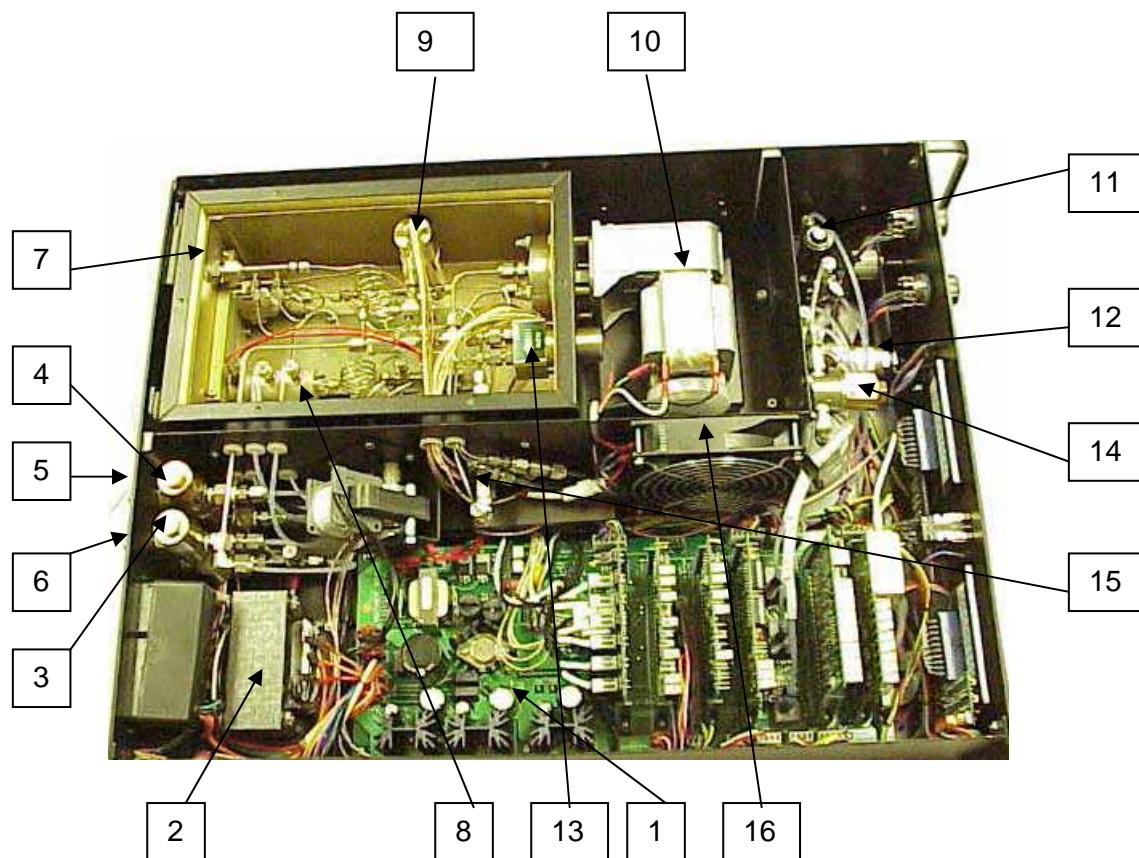
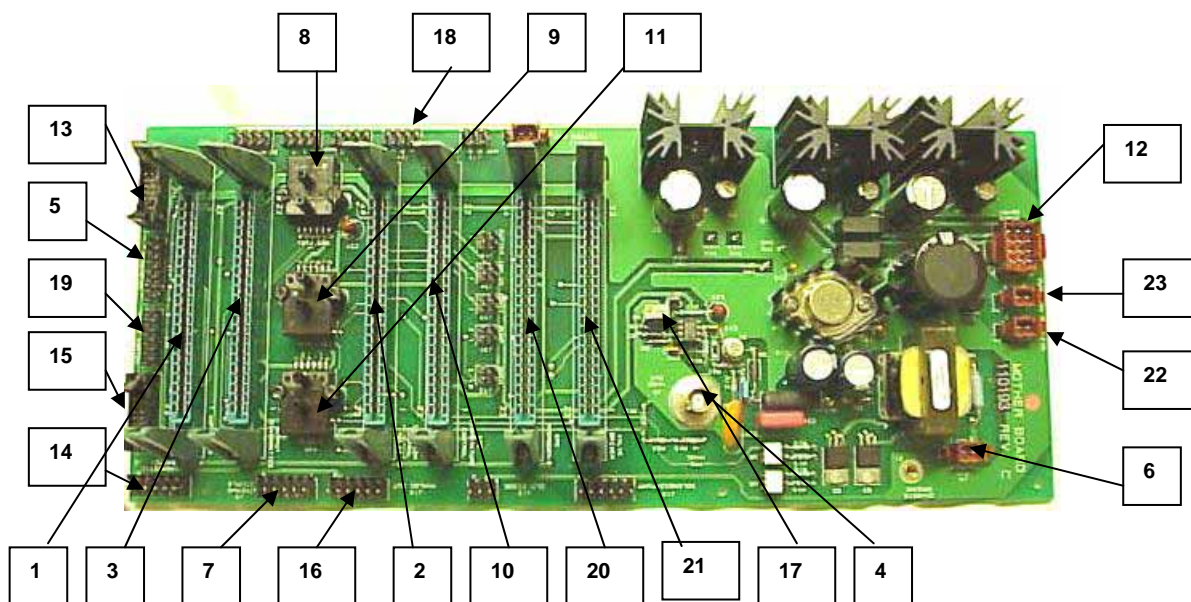


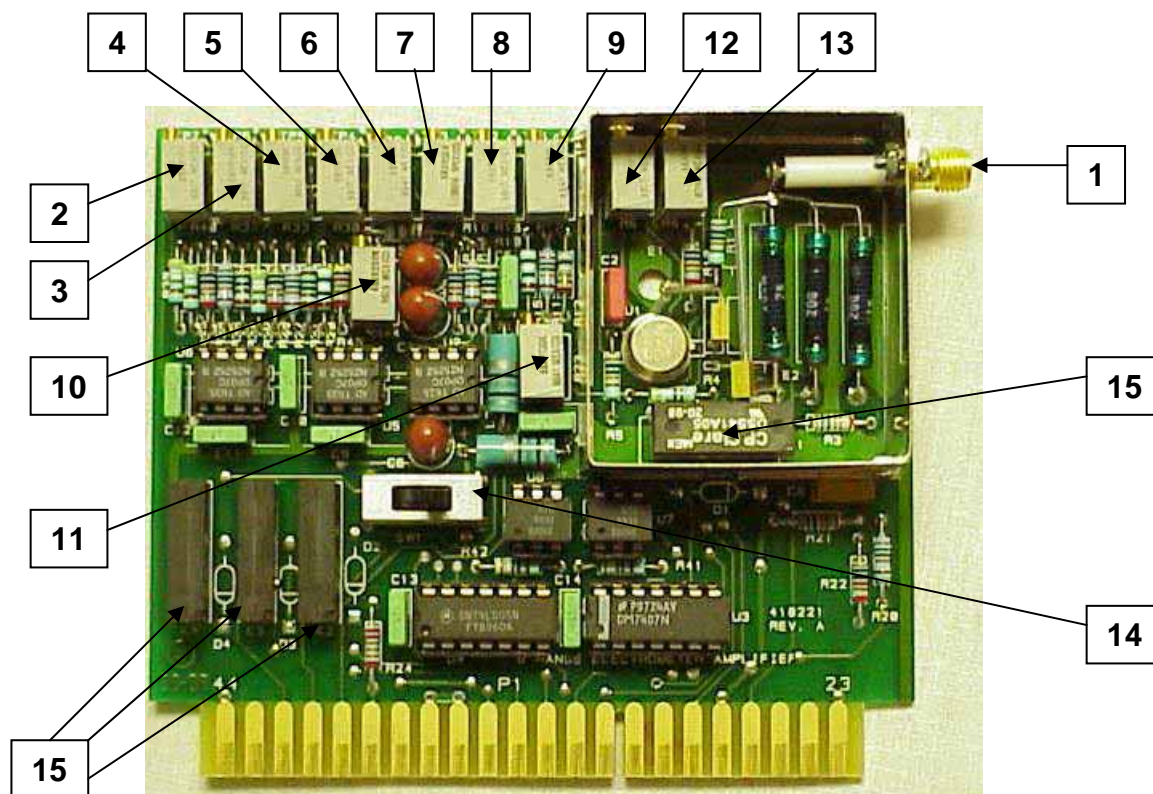
Figure 5-1 Model 301 FID Interior Layout

- 1) **Mother Board:** Includes components for all power supplies and connector for the individual plug in boards. See Figure 5-2 for board locations.
- 2) **Power Transformer:** Converts line voltage to several lower AC voltages and delivered to the main circuit board.
- 3) **Zero Solenoid Valve (Optional):** Allows Zero Calibration Gas To Flow to Burner.
- 4) **Fuel Solenoid Valve:** Automatic Fuel Shut Off.
- 5) **Air Solenoid Valve:** Automatic Air Shut Off.
- 6) **Span Solenoid Valve (Optional):** Allows Span Calibration Gas To Flow to Burner.
- 7) **Heated Oven:** Maintains Sample Components at Set Temperature (Cover Removed).
- 8) **Burner Assembly:** FID Burner.
- 9) **Methane Cutter (Optional):** Removes ALL THC, except Methane.
- 10) **Heated Sample Pump/Motor (Optional):** Provides sample to Burner Assembly.
- 11) **Fuel Proportional Control Valve:** Regulates Pressure to Fuel Orifice.
- 12) **Air Pressure Regulator:** Regulates Pressure to Air Orifice.
- 13) **Sample Proportional Control Valve:** Regulates Sample Pressure to Burner.
- 14) **Fuel Bleed Valve to Cutter (Optional):** Adds Fuel to Cutter.
- 15) **THC/Methane Solenoid Valve (Optional):** Switches between THC and CH₄.
- 16) **Instrument Circulation Fan:** Provides Internal Air Circulation.

5.2. MAIN CIRCUIT BOARD**Figure 5-2 Model 301 FID Main Circuit Board**

- | | |
|-------------------------------------|--|
| 1. Amplifier Board Location: J12 | 13. Diagnostic Meter Connection: J11 |
| 2. Ignite Board Location: J16 | 14. Diagnostic Switch Connection: J8 |
| 3. Diagnostic Board Location: J7 | 15. Analog Meter Connection: J15 |
| 4. Collector Voltage Connection: J5 | 16. Analog Output Connection: J10 |
| 5. Zero & Span Pot Connection: J14 | 17. Collector Voltage Potentiometer: R8 |
| 6. Burner, Igniter Connection: J4 | 18. Proportional Valve Connection: J24 |
| 7. Burner, Oven & Cutter TC's: J9 | 19. Range Switch Connection: J36 |
| 8. Fuel Pressure Connection: SW3 | 20. H2 & Cutter & Temp Board Location: J23 |
| 9. Air Pressure Connection: SW4 | 21. Valve Driver Control Board: J25 |
| 10. EPC/Temp Control Board: J21 | 22. Oven Circulating Fan Location: P1 |
| 11. Sample Pressure Connection: SW2 | 23. Pump Fan Location: P2 |
| 12. Transformer Connection: J1 | |

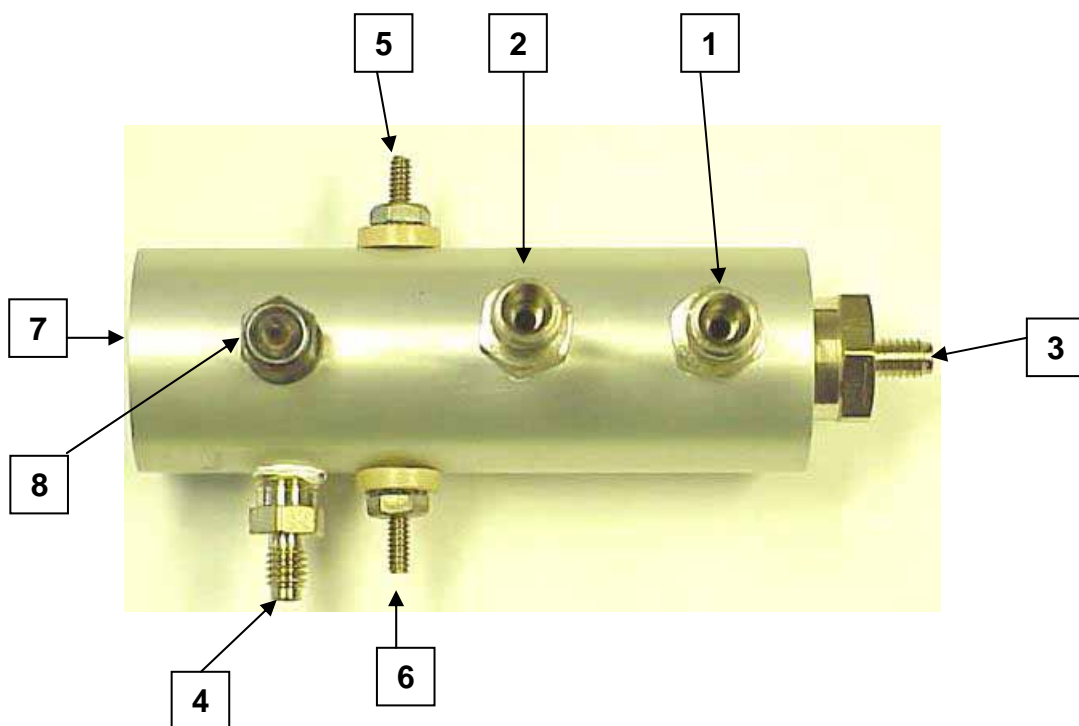
5.3. MAIN AMPLIFIER BOARD



NOTE: Cover removed from high impedance section.

Figure 5-3 Model 301 FID Amplifier Board

- | | |
|---------------------------------------|--------------------------------------|
| 1. Input Connection: SMA Connector | 9. Signal Attenuator Adjust: R13 |
| 2. Amplifier Gain Adjust: R40 | 10. Filter Time Constant Adjust: R44 |
| 3. Amplifier Zero Adjust: R37 | 11. Coarse Zero Adjust: R23 |
| 4. Gain Signal Attenuator Adjust: R33 | 12. Amplifier Zero Adjust: R6 |
| 5. Amplifier Zero Adjust: R30 | 13. Amplifier Gain Change Adjust: R9 |
| 6. Signal Attenuator Adjust: R26 | 14. PPM/% Switch: SW1 |
| 7. Coarse Gain Adjust: R18 | 15. Range Change Relays: K1-K4 |
| 8. Amplifier Zero Adjust: R16 | |

5.4. Burner Assembly**Figure 5-4 Model 301 FID Burner Assembly**

- | | |
|----------------------------|------------------------------------|
| 1. Fuel Inlet | 5. Collector Voltage Connection |
| 1. Air Inlet | 6. Burner Output Signal Connection |
| 2. Sample Inlet | 7. Burner Exhaust |
| 4. Thermocouple Connection | 8. Glow Plug |

5.5. Automatic Ignite Board

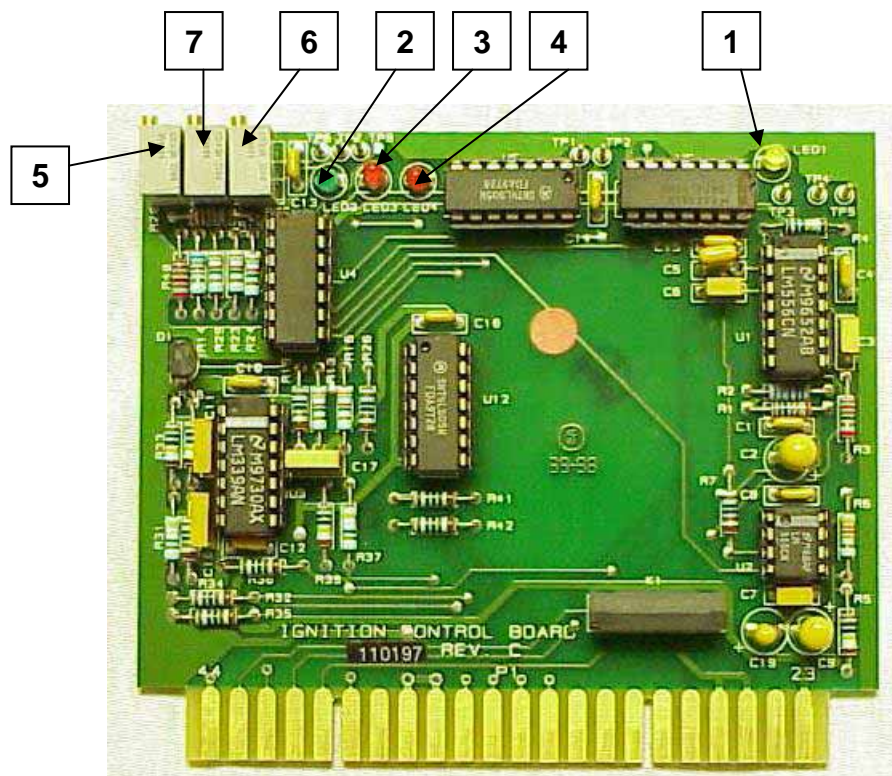


Figure 5-5 Model 301 FID Automatic Ignite Board

- | | |
|---------------------------------|--|
| 1. Glow Plug: LED 1 | 5. Fuel Low Pressure Limit Adjust Pot: R20 |
| 2. Air Solenoid ON: LED 2 | 6. Air Low Pressure Limit Adjust Pot: R22 |
| 3. Fuel Solenoid ON: LED 3 | 7. Burner Flame Temp Limit Adjust Pot: R21 |
| 4. Ignite ON (Burner TC): LED 4 | |

5.6. Diagnostic Board

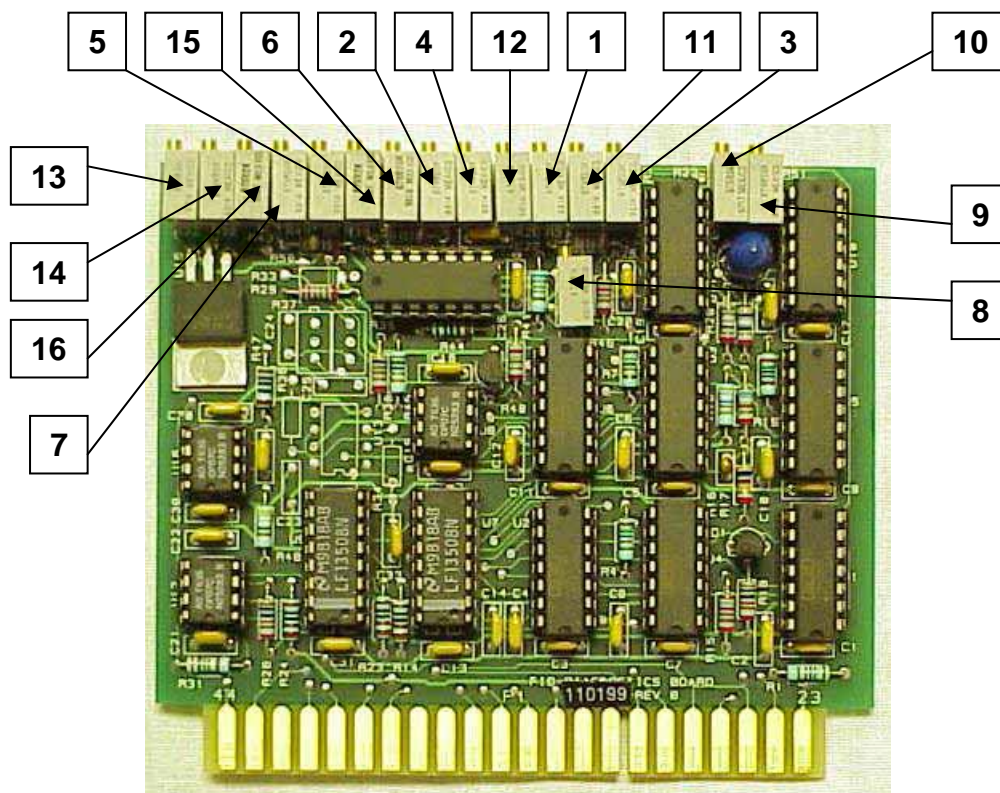
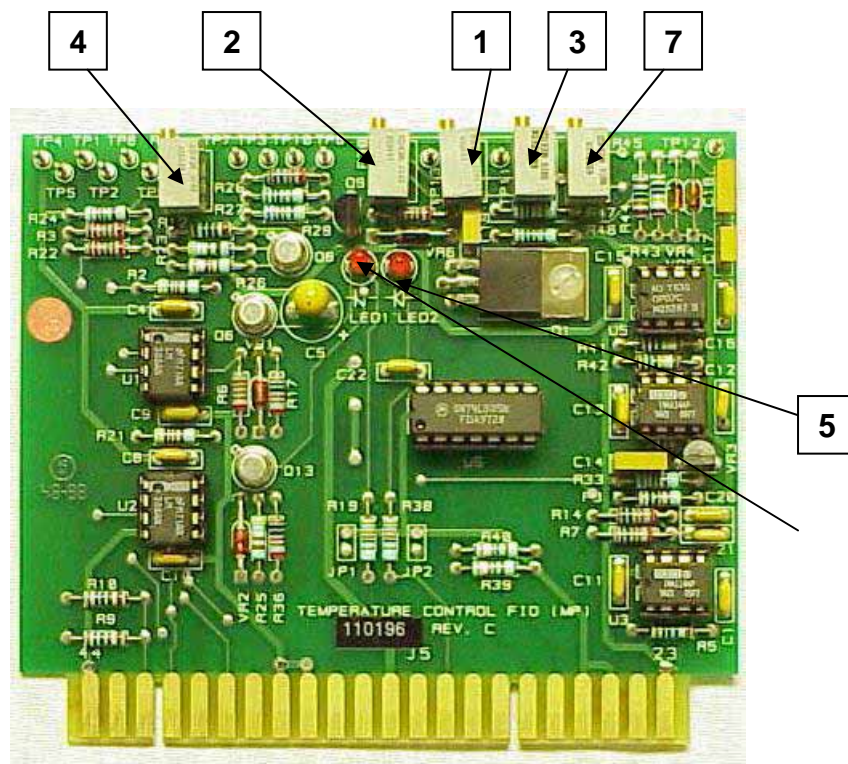


Figure 5-6 Model 301 FID Output Diagnostic Circuit Board

- | | |
|---------------------------------|---|
| 1. Fuel Pressure Zero Pot: R9 | 9. Burner TC Zero Pot: R51 |
| 2. Fuel Pressure Span Pot: R8 | 10. Burner TC Span Pot: R22 |
| 3. Air Pressure Zero Pot: R3 | 11. Oven TC Zero Pot: R27 |
| 4. Air Pressure Span Pot: R2 | 12. Oven TC Span Pot: R26 |
| 5. Sample Pressure Zero Pot: R6 | 13. Analog Voltage Output Zero Pot: R32 |
| 6. Sample Pressure Span Pot: R5 | 14. Analog Voltage Output Span Pot: R30 |
| 7. Cutter TC Zero Pot: R49 | 15. Analog Current Output Zero Pot: R39 |
| 8. Cutter TC Span Pot: R53 | 16. Analog Current Output Span Pot: R43 |

5.7. EPC and Dual Temperature Control Board**Figure 5-7 Model 301 FID EPC and Dual Temperature Control Board**

- | | |
|------------------------------------|--------------------------------------|
| 1. Sample Pressure Cal Pot: R4 | 5. Oven Heater Indicator: LED2 |
| 2. Sample Pressure Adjust Pot: R30 | 6. Pump Heater Indicator: LED1 |
| 3. Sample Pressure Gain Pot: R11 | 7. Amplifier Zero Offset Adjust: R45 |
| 4. Oven & Pump Temp Adjust: R20 | |

5.8. EPC Hydrogen and CH₄ Cutter Control Board Components

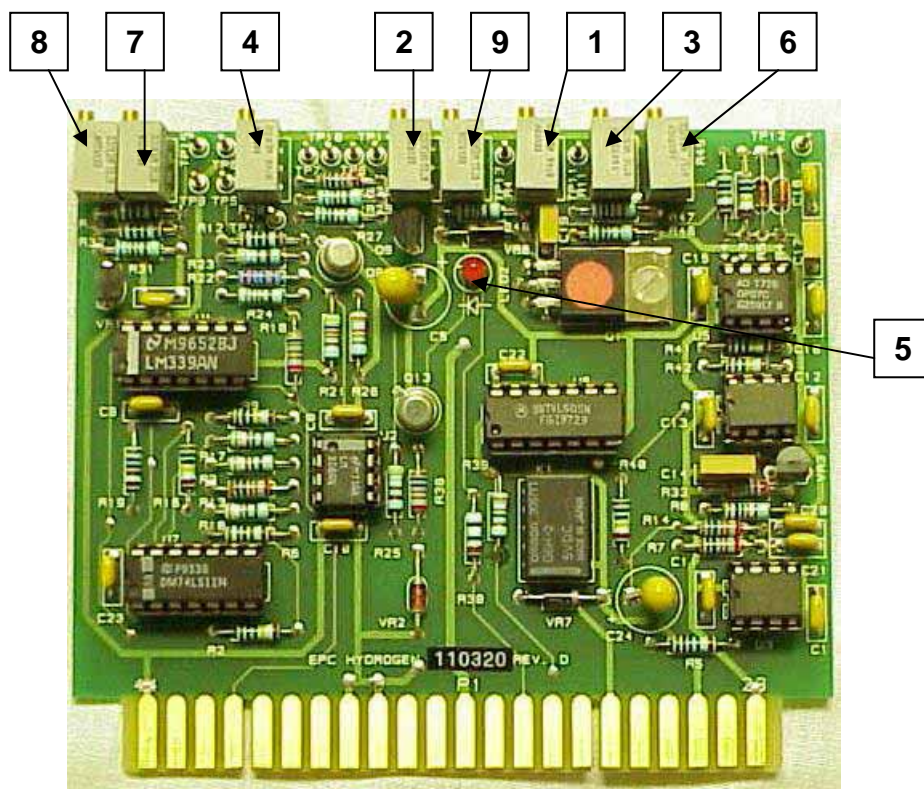
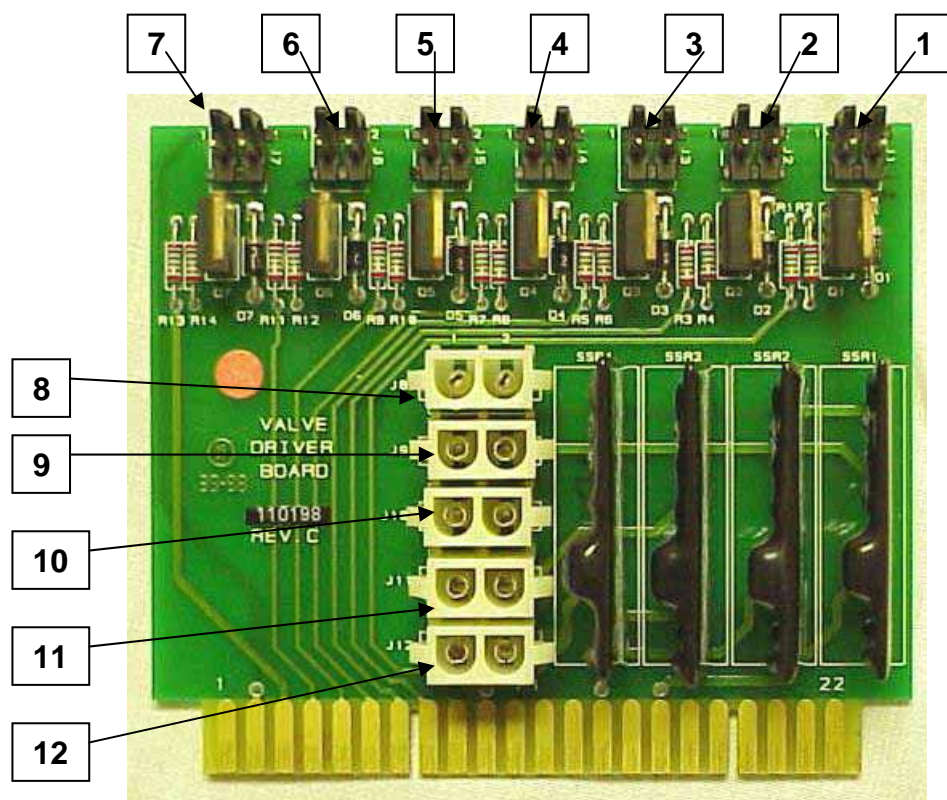


Figure 5-8 Model 301 FID EPC Hydrogen and CH₄ Cutter Control Circuit Board

- | | |
|--|---------------------------------------|
| 1. Hydrogen Pressure Cal Pot: R4 | 6. Amplifier Offset Adjust: R45 |
| 2. Hydrogen Pressure Ignition Pot: R15 | 7. Cutter H2 Low Temp Adjust: R34 |
| 3. Hydrogen Pressure Gain Pot: R11 | 8. Cutter H2 Low Pressure Adjust: R37 |
| 4. Cutter Temp Adjust: R20 | 9. Not Used |
| 5. Cutter Heater Indicator: LED2 | |

NOTE: Control the final hydrogen pressure after ignition by the front panel potentiometer.

5.9. Valve Driver Board**Figure 5-9 Model 301 Valve Driver Board**

- | | |
|--|-----------------------------------|
| 1. Fuel Solenoid Connection: J1 | 7. Spare: J7 |
| 2. Burner Air Solenoid Connection: J2 | 8. AC Power Connection: J8 |
| 3. Zero Air Solenoid Connection: J3 | 9. Pump Heater Connection: J9 |
| 4. Span Gas Solenoid Connection: J4 | 10. Oven Heater Connection: J10 |
| 5. THC/CH ₄ Solenoid Connection: J5 | 11. Cutter Heater Connection: J11 |
| 6. Cutter H2 Solenoid Connection: J6 | 12. Pump On/Off Control: J12 |

6. Operation

- 1) Check that the external plumbing and wiring are connected correctly, as described in Section III of this manual.
- 2) Power On: Turn ON the power switch on the rear panel. The digital panel meters should illuminate.
- 3) Introduce Fuel & Burner Air: Adjust the cylinder output pressures to 20 PSIG. Upon initial installation, loosen the fuel inlet connection to allow the air to bleed from the fuel line. This should only take 5 to 10 seconds. Firmly re-connect the fuel line.
- 4) Ignition (After Oven at 50 Degrees C): Press the momentary ignite button. This will initiate the automatic ignite sequence.
 - a) An electronic proportional control valve that opens and flows fuel at an initial, factory set, high flow rate, controls the fuel pressure. This creates a very rich fuel mixture that saturates the burner with fuel.
 - b) After 3 seconds of fuel, the burner air solenoid opens and the ignite glow plug is energized. This cycle repeats for five sequences OR until the burner lights as indicated when the thermocouple reaches a factory set temperature to indicate ignition.
 - c) After detecting ignition, the burner ON light in the momentary push button is illuminated and a contact closure is completed on the rear connector. Reduce the burner fuel flow to maintain a more efficient flame. This sequence can be started by a remote (Computer) contact closure.
 - d) The sequence will not succeed if the ignition control board senses insufficient fuel or air pressure. The fuel valve and air solenoid will shut off if the burner thermocouple senses a flame out OR lack of either fuel or air pressure.
 - e) To meet the drift and repeatability specifications, allow the instrument to warm up for approximately one hour. It is preferable, but not essential, that zero airflow through the instrument during warm-up.
- 5) Fuel and Air Pressure Settings:
 - a) Observe the fuel and air pressure pressures by placing the diagnostic switch in the respective positions.
 - b) They should agree with the factory set pressure settings indicated on the QA Checkout Sheet (Section 1.10) and within the tolerances indicated in section 3.8.
 - c) If necessary, reset the air and fuel pressures by adjusting the front panel potentiometers or regulator.
- 6) Flame Optimization: The fuel and air flow-rates are controlled using state-of-the-art pressure control and internal critical flow capillaries. This maintains flame optimization if the fuel and air pressures are within ± 0.5 PSIG of the respective settings, indicated above.

- 7) Zero Adjustment:
 - a) After the one-hour warm-up period, flow zero gas through the instrument sample or optional zero inlet.
 - b) Adjust the zero control on the front panel until the digital panel meter or recorder reading reads exactly zero.
- 8) Span Adjustment:
 - a) Flow span gas through the instrument sample or optional span inlet.
 - b) Adjust the span control on the front panel until the digital panel meter, or recorder, reading is at the value specified for the span gas concentration.
- 9) Sample Pressure Check:
 - a) With sample or span gas flowing through the instrument, place the diagnostic switch in sample position.
 - b) The inlet sample pressure must be above 6 PSIG for the meter to read original factory setting ± 0.2 PSIG, unless the instrument has an internal sample pump, then pressure is automatically controlled. (See Factory Settings Sheet)
- 10) Methane ONLY Operation (optional): Switch the CH₄ cutter in and out of the sample stream to measure total hydrocarbons or methane only.

6.1. Start-Up Procedure

- 1) Sampling System: Prepare and check the sample system.
 - a) Check the sample pressure and by-pass flow and verify agreement with the factory QA Checkout sheet, (± 0.2 PSIG).
 - b) Failure to meet the sample pressure may be due to a dirty filter. See Section 9 for replacement procedure.
- 2) Air & Fuel Pressure:
 - a) Check the fuel and air pressures for agreement with the factory QA Checkout sheet, (± 0.5 PSIG).
 - b) Readjust pressures as required.
 - c) Note: Cylinder pressures should be set at 20 PSIG.
- 3) Zero & Span Calibration:
 - a) Check zero and span adjustment daily.
 - b) While flowing zero gas check the zero reading and readjust, if necessary, using the front panel zero control.
 - c) While flowing span gas check the span reading and readjust, if necessary, using the front panel span control.

6.2. Shutdown Procedure

- 1) Turn off all gas supply cylinders.
- 2) Disconnect the sample line from the inlet port on the back of the analyzer.

Do NOT turn off the pump or analyzer at this time.

- 3) Allow the analyzer to draw in room air for approximately 5 minutes. This will flush out the analyzer of any remaining sample that may condense in the sample system.
- 4) Turn off the pump switch and THEN the analyzer.
- 5) Back-flush the heated sample line (and filter) of any sample before disconnecting power.

7. FUNCTIONAL DESCRIPTION

7.1. *Operating Principle*

The California Analytical Model 301 FID Total Hydrocarbon Analyzer uses the flame ionization detection-method of determination of total carbon (C) in a sample gas.

The detector is a burner in which a regulated flow of sample gas passes through a flame sustained by a regulated flow of hydrocarbon free air and fuel gas 40% H₂/60% He or 100% H₂, as specified. Within the flame, the hydrocarbon components of the sample undergo an ionization process that produces electrons and positive ions. A 250 volt (-250 VDC) polarized electrode ring collects these ions, causing a very low current to flow. A precision amplifier amplifies this low current. This current flow is directly proportional to the carbon content of the sample.

The instrument includes a temperature controlled sample oven. The oven maintains the capillaries and FID Burner Assembly at an elevated temperature (85°C) to minimize signal drift due to changes in the temperature of the analyzers environment.

7.2. *Burner Assembly*

Unique regulated flow systems deliver the sample, combustion air and fuel to the burner where they are mixed and pass through the burner tip. Energizing a standard glow plug accomplishes ignition. The dual ring electrode functions as electrodes and are connected to a precision high voltage regulated 250 volt DC power supply and a precision amplifier. The small ionization current flowing between electrodes is directly proportional to the carbon atoms in the sample stream.

7.3. *Methane Cutter (Non-Methane Hydrocarbons)*

The cutter uses a temperature controlled metal oxide catalyst to oxidize all hydrocarbons in the sample except methane. The cutter catalyst assembly uses a cartridge heater and an Resistance Temperature Detectors (RTD) with electronic proportional circuitry to maintain the catalyst converter at the factory set value of approximately 280°C.

The operator may first elect to measure to the total hydrocarbon content of the sample by selecting the THC Mode of operation. When the CH₄ mode is selected, the cutter catalyst assembly is placed in the path of the sample, resulting in the measurement of only the methane. Subtraction of the CH₄ measurement from the THC measurement will yield the non-methane hydrocarbon content of the sample.

The analyzer can be alternately be cycled between the THC to CH₄ mode of operation via the mode selector switch on the front of the analyzer, or remotely via a contact closure.

7.4. Flow System

The basic function is to deliver highly regulated flows of sample, fuel, and air to the burner assembly. The air pressure regulator delivers the appropriate pressure to critical flow capillary. The control of the fuel is via a precision, electronically controlled proportional flow controller through a critical capillary. This control accurately pre-determines the flame characteristics. The pressures settings recorded in Section 1.10 were determined during a factory performed flame optimization.

The sample flow to the burner is via a precision, electronically controlled proportional flow controller through a critical capillary. The sample pressure is factory set during the flame optimization procedure. A close-coupled by-pass capillary minimizes "dead volume" and improves response time. This by-pass flow is factory set by the capillary and flows approximately 3 liters/Min. Internal pressure transducers monitor sample inlet pressure, regulated fuel and air pressures. The values are available via the diagnostics meter.

8. ELECTRONICS

8.1. Main Circuit Board

The main circuit board contains the instrument power supplies and edge connectors for the required control boards. A single transformer is used to allow operation from 110/220 VAC at 50/60 Hz. Change a small circuit board from the back panel of the instrument to convert from 110 to 220 VAC.

This main board also contains the plug-in connectors for all the additional electronic circuitry in the instrument, providing ease of maintenance. The board also contains clearly marked test points for diagnostic purposes, including +15, -15, + 24 and -250 VDC, + 5, etc.

8.2. Main Amplifier Board

The main amplifier board contains the low noise low trans-impedance amplifier used to amplify the ionization current produced in the burner. The amplifier changes the current to a representative voltage and scales the output. This board contains a coarse zero and span potentiometers that work in conjunction with the front panel controls. This amplifier also contains the nine range electronic components, which sets the instrument's eight operating ranges.

8.3. Automatic Ignite Board

The automatic ignite circuit board contains the logic circuitry required to perform an automatic ignite function. The front panel momentary ignite switch is used to begin the ignite sequence. LED's on the board give visual indication of the operation of the air solenoid, fuel solenoid, and glow plug.

8.4. Diagnostic Board

The diagnostic circuit board contains the logic circuitry required to convert the instrument transducers output signals for presentation via a 7-position switch to the diagnostic digital panel meter.

8.5. EPC/Dual Temperature Control Board

This board contains the circuitry required to control the oven, and pump temperature. It contains the logic circuitry required for precision control of the sample proportional flow controller.

A single potentiometer controls the temperature of both the pump and oven. A pressure transducer measures the sample pressure directly at the entrance of the burner capillary. The electronically controlled proportional control valve automatically adjusts to maintain this pressure at the factory setting.

8.6. EPC Hydrogen/Cutter Temperature Control Board

This board, when fully populated, contains the circuitry required to temperature control the THC cutter, control the hydrogen solenoid, and provide pressure control for the hydrogen electronic control valve. To assure proper cutter operation, a small amount of burner fuel is introduced to the cutter and the solenoid is activated only when proper temperature and pressures are satisfied. As with the EPC/Dual Temperature Control Board, an EPC valve is used to accurately control the burner fuel pressure. During the ignition process, the fuel pressure is increased to facilitate ignition. After ignition, this pressure is reduced to factory setting to optimize the burner.

8.7. Valve Driver Control Board

This board, when fully populated, contains the seven amplifiers and four solid-state relays necessary to electrically control the instrument solenoid valves and AC devices.

Take EXTREME CAUTION, as either 120 or 220 VAC instrument supply voltages are located on both sides of this board.

9. DISASSEMBLY-GENERAL INFORMATION-TROUBLESHOOTING

9.1. *Oven Burner Assembly Filter Unit/Filter Removal*

- 1) Shut off ALL gas flow. **CAUTION:** The filter housing may be hot.
- 2) Remove power from the instrument.
- 3) Remove the sample line.
- 4) When the filter has cooled, use one wrench to hold the filter body and a second wrench to remove the filter holder assembly.
- 5) Remove and replace the filter. Re-install.

9.2. *Electronic Boards/Removal*

- 6) Shut off ALL gas flow.
- 7) Remove power from the instrument.
- 8) Remove the top cover retaining screws.

Slowly remove the individual plug-in circuit boards.

9.3. *Electronics*

For ease of service, ALL electrical connections terminate on the main circuit board using plug-in connectors. The following information may be of use to the electronic technician:

- 1) The digital panel meters are powered by 5 VDC from the main circuit board. If the instrument seems to operate properly, output analog voltage, etc., except the meter display, refer to the main circuit board schematic and check the 5 volt section, 3 terminal regulators, capacitors, etc.
- 2) The ± 15 VDC supplies from the main circuit board must be operating properly. If any of these are not operational, refer to the main circuit board schematic and check the 15 volt section, 3 terminal rectifiers, capacitors, etc.
- 3) The -250 VDC burner collector voltage supply from the main circuit board is operating properly as indicated by the diagnostic meter. If this voltage is not between -200 and -300 VDC, refer to the main circuit board schematic and check the HVDC section, 3 terminal regulators, capacitors, transistors, op amps, etc.
- 4) The 4 VAC burner glow plug voltage supply from the main circuit board is operating properly as indicated by the sequencing LED on the ignite board, during the ignite cycle. If this LED not illuminating, refer to the main circuit board schematic and check the 4 VAC section, transformer, etc.

9.4. Flow System/Fuel and Burner Air Supply.

Capillary protection micro-screen metal filters are contained in the respective solenoid output fittings. If difficulty occurs during the lighting sequence, **TEMPORARILY** remove these filters when proceeding with diagnostic activity. It is necessary to replace contaminated filters.

These flows are controlled by adjustable forward-pressure devices that require 20 PSIG cylinder supply pressure and are factory set at the pressures indicated on the QA Check Sheet. These pressures may be monitored by the diagnostics meter during the ignite sequence or after the flame is ignited. The burner flow-rate from the orifices is very low and will require a bubble flow meter to determine proper flow rates. After the pressures have been properly set, if clogged lines are suspected replace the delivery lines containing the orifices.

NOTE: *Depending upon the amount of moisture contained in the sample gas, problems may develop in re-igniting the burner. If this should occur, perform the following procedure:*

- 1) Remove the Teflon sleeve from the burner exhaust on the rear panel.
- 2) Through a Teflon line, direct a flow of clean DRY gas into the burner exhaust port. A good source to utilize would be the instrument burner-air supply. Reduce the pressure on this air supply and direct the clean air into the rear of the burner from approximately 2-4 inches. Let clean air flow for approximately 1 minute. **DO NOT** insert this line directly into the burner.
- 3) Restore all gas lines and, with the Teflon sleeve removed, attempt to light the burner.
- 4) If the burner will still not light, contact the factory.

9.5. Sample Supply

An inline SMALL filter is contained in the heated oven, however an external sample orifice protection sintered metal filter is highly recommended for trouble-free operation.

An optional remote in-line filter assembly is available from CAI. If difficulty occurs with erratic sample flow, **TEMPORARILY** remove this filter when proceeding with diagnostic activity. It is necessary to replace contaminated filters.

An adjustable electronic proportional pressure valve controls the sample flow. This pressure may be monitored by the diagnostics meter at any time. The instrument has an internal sample pump and is factory set per the QA Check Sheet.

10. TROUBLESHOOTING GUIDE

| SYMPTOM | CAUSE | REMEDY |
|---|---|---|
| Downscale indication with flame out. | Electrical leakage in burner. | Check Burner voltage. |
| Burner will not ignite. | Air and/or Fuel Pressures improperly adjusted. Improper operation of glow plug. | Depress Ignite button, and with diagnostic switch verify all pressures per manual. Adjust regulators as required. (IF OK) Depress Ignite button, and from rear of instrument, check for red glow from plug at burner vent. (IF OK) If plug glows, bleed off fuel line to instrument for 5 seconds. (IF OK) Check glow plug connections. (IF OK) Check for 3 VAC at plug connections. If OK, replace plug. (IF OK) View ignite board LED's for proper sequence. Replace board if necessary. (IF OK) Check for 4 VAC at plug connections. If no voltage, replace transformer. (IF OK) Check switch continuity. Replace if necessary. (IF OK) Replace fuel and/or air critical orifices. |
| Noisy Signal. | Sample pressure under regulator control limit of 6 PSIG. Water or contamination in burner. | Check and adjust as required. Change fuel and/or air supply. Replace external tubing. Check burner voltage. |
| Loss of Sensitivity. (Not enough gain) | Contamination in fuel/air or sample flow system. | Verify air & fuel pressures to be set per calibration sheet. (IF OK) Verify sample pressure to be set per calibration sheet. (IF OK) Verify by-pass flow to be at 3 Liters/Min. ± 1.5 . (IF OK) Verify 250 volt DC collector voltage. (± 15 Volts) (IF OK) Carefully remove burner signal co-ax cable. Touch center conductor and watch for up scale reading. (IF OK) Remove and clean sample critical orifice. (IF OK) Check Co-Ax cable for continuity. |

11. FLOW DIAGRAMS AND SCHEMATICS

