

**COMBUSTION ANALYZER
MODEL 2000**

INSTRUCTION MANUAL

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LIST OF ABBREVIATIONS

ATEMP	Ambient (room) Temperature
CO	Carbon Monoxide
CO ₂	Carbon Dioxide
COMB	(Gaseous) Combustibles
DISPLAY PTR	Display Pointer
EFFI	Combustion Efficiency
IN. H ₂ O	Inches of Water (Draft measurement).
MGM	Milligrams (of pollutant) per cubic meter (of stack gas)- dry basis.
NOX	Oxides of Nitrogen (Nitric oxide measurement)
OXY	Oxygen
OXY_REF	Oxygen reference basis for correction of toxic gas concentration
PPM	Parts per million (Volume basis-dry)
PRHT	Preheated Air Temperature
SO ₂	Sulfur Dioxide
STEMP	Stack Temperature
X-AIR	% Excess Air
#/B	Lbs. (of pollutant) per million BTU (of fuel)
%	Percent by volume dry basis

LIST OF OPTIONS

The ENERAC model 2000 has been designed as a modular system, permitting the installation in the field of all the various available options. This manual describes the complete instrument equipped with all the options. The available options on the model 2000 are as follows:

1. 4" SEIKO Printer
2. Plotter Printer capability (Requires Printer)
3. Oxides of nitrogen (NOX) measurement capability
4. Sulfur dioxide (SO₂) measurement capability
5. Internal 99 test storage option
6. Internal modem for telephone communication
7. Emissions option. (Performs calculations in mg/m³ or lbs./MMBTU corrected to any oxygen reference)
8. CD-ROM or 3.5" diskette with custom program (ENERCOM for Windows) for MS-DOS personal computer
9. 24", 36" or 48" inconel probe option
10. Custom fuel option. (Either at the factory, or remotely programmable, if the ENERAC is equipped with a modem or as a menu selection on SHARP computer).

Any combination, or all of these options are available to meet the customer's requirements. There is also a variety of cables and attachments available for special connections to the ENERAC (see Appendix C).

Please note that options 1, 2, 3, 4, 5, 6, and 7, if installed in the field, must be activated from the factory via a remote connection to your ENERAC.

The factory telephone number is: (516) 997-2100

ENERAC REPROGRAMMING DISKETTE

This diskette contains three files that you may need, in case customized, information, that is currently stored in your ENERAC'S memory is either accidentally erased or corrupted. This diskette has customized information for your ENERAC only, it cannot be used with other ENERAC'S.

The ENERAC Model 2000 is carefully designed for protection against a variety of electric or mechanical disturbances that may cause accidental writes to its memory. Such sources can be electromagnetic noise due to ignition systems or communication equipment operation in the vicinity, sudden power surges or drains caused by large electric motors, or line problems, or even dropping the instrument while it is on, causing momentary loss of connection in a critical circuit.

However, since the unit is portable and is commonly used in a hostile industrial environment, it is still possible (though unlikely) that it's memory may accidentally be corrupted.

You can tell if the memory has been corrupted by observing the display and the printer for any strange characters that may appear.

To restore the ENERAC'S memory in case of accidental corruption using the diskette, follow the instructions outlined in the file "README.DOC".

Following a memory refresh, the instrument should be calibrated using span gas. Make sure you also reset time & date.

CHAPTER 1

FUNDAMENTALS

The ENERAC Model 2000 is designed as a rugged and reliable and portable service tool for use as follows:

- To assist the boiler operator in getting maximum performance out of his boiler or furnace.
- To be used as a management tool to assist the plant manager with keeping records and controlling costs.
- To monitor compliance with environmental regulations.

The ENERAC Model 2000 is the most complete instrument of its kind and uses the latest electronic and sensor technology available to get maximum performance. It measures 2 temperatures, 5 different stack gases, draft and smoke. It computes efficiency of combustion as well as excess air and carbon dioxide. In addition, it computes all emissions parameters. It stores, prints and plots data. It communicates with a variety of other computers located near by via its RS-232 port, or remotely by telephone connection. It has a library of 15 fuels and over 100 diagnostic and help messages and can operate either on its rechargeable batteries or AC current.

ENERAC has years of experience in the manufacture and marketing of combustion analyzers. The model 2000 is based on this experience, together with the latest innovations in electronic and sensor technology. It also expresses our basic conviction that communications and artificial intelligence are the basic ingredients of the instrument of the future.

The instrument operates basically as follows:

You insert the probe in the stack of an operating boiler or furnace. A pump located inside the instrument draws a small sample of the stack gas. A number of sensors analyze the contents of the stack gas and its temperature and calculate and display the results. The results can also be printed, stored or send to another computer either by direct connection or by the telephone lines. The boiler operator makes the required adjustments based on the analysis of the stack conditions to optimize

performance.

A. UNPACKING THE INSTRUMENT

Every ENERAC model 2000 includes as standard equipment:

One Combustion Analyzer model 2000 (includes a roll of printer thermal paper).
One stack probe.

1. One condensation trap with (or without) desiccant.
2. One detachable AC power cord.
3. One smoke chart and 30 pieces of smoke paper.
4. One extra disposable filter.
5. One instruction manual.
6. (Optional) Special hose and disposable desiccant-filter for sulfur dioxide measurements.

NOTE: Every ENERAC sold has stored in its memory information regarding manufacturing and sensor dates, as well as product identification, serial number of unit, version and original customer.

IMPORTANT ADVICE

Most stack gases are hot, full of moisture, corrosive and laden with particles of soot.

To make sure that your instrument will give you a long time of trouble free performance, please observe the following recommendations.

- Never use the instrument without the condensation trap inserted between the probe and the unit (use no desiccant for SO₂ measurements!).

- Replace the disposable filter as soon as it becomes noticeably discolored.
- Replace the desiccant (if equipped) when it turns pink- white.
- Do not expose the probe tip to open flame.
- Do not rest the hose of the stack probe on a hot boiler surface.
- Allow the probe tip to cool off before packing the probe.
- At the end of a measurement remove the water collected from the condensation trap and shake the hose vigorously to drain any remaining moisture from it.
- Avoid draining the battery completely.
- In dusty environments cover the printer slot with the velcro cover and, if possible, cover the faceplate of the instrument. **THE PRINTER WILL BE DAMAGED, IF EXPOSED TO DUST!**
- For sulfur dioxide measurements avoid any condensation in the probe.

CHAPTER 2

BASIC INSTRUMENT OPERATION

It is possible to master the basic operation of the instrument in a few minutes by following the procedure outlined below. Please refer to the other sections of this manual for a description of the more advanced features.

There are 20 push buttons on the face plate of the instrument. These buttons are clustered into 4 basic groups. The most important is the group that contains the eight operating buttons (plus the display pointer) and is located at the center of the faceplate. There is a group of three buttons on the left side that, when pressed, will display the three foreground fuels. There are four buttons on the right hand side of the face plate that are used for printing, storing, outputting information and displaying time.

Finally there is a group of four buttons located below the display that are used for setting various parameters and customizing the instrument.

For simple measurements you only need to use the basic 8 buttons.

A. STARTING UP THE INSTRUMENT

1. Unlock the instrument case. Remove the water trap and probe from their compartments. If the case temperature is less than 40 degrees Fahrenheit, wait a few minutes for it to warm up.
2. Insert the water trap into the opening provided that is located on the hinged side of the faceplate. Connect the gas fitting that is located at the tip of the disposable filter of the water trap to the "GAS IN" input of the instrument. Make sure the fittings are locked to avoid a gas leak.
3. Connect the hose end of the stack probe to the top of the water trap and the phone plug end to its corresponding jack on the faceplate (the one labeled TEMP.PROBE).
4. Turn the instrument on. The " BATTERY OK" light should turn on. The Display should read:

"Press ENTER to AUTOZERO"

Press the ENTER key. The following message will appear on the display:

"DO NOT INSERT PROBE"

and immediately afterwards:

"WARMING UP XXX SEC"

and count down.

5. At the end of the warm up period a number of messages will appear. If everything is OK with the unit, the following message will eventually appear:

"INSERT PROBE IN STACK"

(If a "...AUTOZERO ERROR" message appears, see Appendix A for help).

You are now ready to get started with your measurements.

B. READING THE CONTENTS OF THE STACK GASES & TEMPERATURES

1. Insert the probe in the stack. Push the Fuel button that corresponds to the fuel of your choice.

(IF YOUR FUEL IS NOT ONE OF THE THREE FUELS THAT ARE DISPLAYED WHEN PRESSING ON OF THE FUEL BUTTONS, SEE CHAPTER 6 FOR INSTRUCTIONS ON SETTING FUELS).

2. You can now read on the display any two stack parameters that you wish simply by operating any of the eight basic buttons shown in Fig.1.
3. Use the "DISPLAY PTR." button to display any combination of the stack

parameters that you wish to view simultaneously. See fig.2.

NOTE:

THE DISPLAY IS DIVIDED INTO TWO HALVES. YOU CAN DISPLAY ANY STACK PARAMETER ON EITHER SIDE BY USING THE "DISPLAY PTR" BUTTON AND OBSERVING THE SIDE OF THE DISPLAY TO WHICH ONE OF THE DISPLAY PTR. LEDS IS POINTING.

THE BUTTONS "TEMP/ST-RM", "CO2/X-AIR", "OXY/NOX" AND "CO/SO2" ARE TOGGLES. YOU DISPLAY THE ALTERNATE PARAMETER BY PRESSING THE SAME BUTTON AGAIN.

C. THE DRAFT TEST

1. If you wish to read the stack draft (i.e. the pressure inside the stack relative to the ambient pressure outside), push the "DRAFT" button. The current value of the stack draft will appear on the display measured in inches W.C. This is a continuous real time measurement!

CAUTION: To make sure that your reading of the draft is accurate please observe the following precautions:

- (1) Auto zero the instrument with the unit aspirating air before every draft measurement to obtain a correct zero reading.
- (2) Make sure the ENERAC filter is reasonably clean and there are no obstructions or water collected in the hose. Make sure the smoke paper opening on the probe is shut tight.

The display reading of draft is also stored in the ENERAC'S memory and its value will be printed by the printer at the time when the "TEXT" button is pushed.

D. THE SMOKE TEST

1. If you wish to take a measurement of the smoke using the smoke spot

method, push the "SMOKE" button. The pump will stop and the following message will appear on the display:

"INSERT SMOKE PAPER"

The instrument is waiting for you to take out a piece of the smoke paper and insert it in the cut out provided in the probe handle (see fig.3). To do this you must first loosen the thumbscrew to make room for the paper and then screw it back tightly so that there is no leak. When you are ready, push any button. The smoke test will begin and the display will read:

"SMOKE TEST XXX SEC"

and will count down. At the end of the test the pump will stop again and the following message will appear:

"REMOVE SMOKE PAPER"

Remove the smoke paper as instructed. Tighten the thumbscrew to avoid any leaks and push any button to continue with your measurements. Take out the smoke chart that comes with the instrument and compare the paper's discoloration with the standard shades of grey on the chart. The number corresponding to the closest match is the smoke number.

E. SULFUR DIOXIDE MEASUREMENT

Sulfur dioxide is a difficult gas to handle, because it dissolves readily in water and also, has a tendency to "stick" to the walls of many surfaces. In order to get quick and accurate readings you must be sure the hose is dry at all times.

It is a good idea, to read the SO_2 concentration as soon as you insert the probe in the stack and before any appreciable condensation occurs in the hose and water trap.

Never allow any condensation to appear in the hose, because it will slow down the response of the sulfur dioxide sensor by several minutes.

Make sure you order disposable filters with a fluorocarbon binder for replacement!

F. SHUTTING OFF THE INSTRUMENT

1. Remove the probe from the stack and shake it vigorously to get rid of any water accumulated. DO NOT TOUCH THE HOT TIP.
2. Remove and drain the condensation trap.
3. Allow the instrument to run for two minutes aspirating ambient air to purge any remaining gases.
4. Turn the unit off and store the condensation trap and probe in their compartments.
5. Do not forget to give the batteries a fresh charge before using it next time.

IMPORTANT NOTE:

IF YOU ACCIDENTALLY TURN THE INSTRUMENT OFF WHILE THE PROBE IS IN THE STACK (OR, IF FOR ANY REASON THE INSTRUMENT LOCKS UP AND THE BUTTONS BECOME INOPERATIVE), TURN THE ENERAC OFF AND ON AGAIN. WHEN THE MESSAGE

“Press ENTER to AUTOZERO”

APPEARS ON THE DISPLAY, PRESS ANY KEY OTHER THAN THE "ENTER" KEY. THE ENERAC WILL BYPASS THE AUTOZEROING PROCEDURE AND YOU CAN CONTINUE WITH YOUR MEASUREMENTS.

CHAPTER 3

POWER REQUIREMENTS

The ENERAC model 2000 can be operated by using either its own rechargeable battery, or by plugging it to a suitable AC outlet.

A. BATTERY OPERATION

The instrument's battery pack consists of a single 6 Volt rechargeable sealed lead acid cell. The cell is housed inside the power supply section of the unit and is rated at 4.8 AH. This means that it will operate the instrument for approximately 4 hours on a single charge. Operation time can be extended to 6-7 hours, if the printer is used sparingly.

The "BATTERY OK" light located above the ON-OFF switch, shows the condition of the battery.

As long as the batteries are in GOOD CONDITION, the "BATTERY OK" LED will stay ON.

1. When the battery BEGINS TO WEAKEN the light will start to FLASH. Don't operate the unit for more than 5 minutes after the "BATTERY OK" light begins to flash, even though you may be still able to read the display.
2. When the battery BECOMES VERY WEAK, the instrument will be AUTOMATICALLY shut off by a battery monitoring circuit to prevent the battery from becoming totally depleted.
3. There is a very small drain on the battery, even when the instrument is turned off. Sensor bias and the internal clock circuits stay on and will eventually drain the battery completely after 8-10 months.

TURN THE INSTRUMENT OFF, PLUG THE AC CORD AND CONTINUE YOUR MEASUREMENTS!

OR

TURN THE INSTRUMENT OFF AND CHARGE THE BATTERY FOR 4

HOURS.

4. When the battery is DISCHARGED COMPLETELY the light will go out.

To recharge the batteries plug the instrument to any convenient AC outlet (120 V. for domestic units, 220 V. for export units). The "CHARGE" light will turn on indicating that the batteries are being charged. (If the batteries are completely discharged, the CHARGE light will not turn on immediately. The battery will start charging slowly and only when sufficient charge has been stored, will the CHARGE light turn on indicating the start of a rapid charge cycle.) The "CHARGE" light will go off, as soon as the batteries have received a complete charge. It takes approximately 4 hours only to give a fresh charge to discharged batteries (instrument off). (Approximately six hours are needed, if the battery is completely discharged).

B. AC OPERATION

Before plugging the instrument to an AC outlet, make sure the outlet voltage is the right one for the instrument. Domestic units operate on 110-125 V. 60 Hz. Export units have a modified connection to their internal transformers so that they can be used with 220-240 V. The power line module (i.e. the ON-OFF switch assembly) includes the AC socket, the ON-OFF switch, a 1.0 Amp.fuse and an EMI/RFI filter for compliance with the FCC regulations.

The fuse can be reached by simply lifting the AC module's plastic cover using a small screwdriver.

When the unit is operating on AC, the batteries receive small charge.

CAUTION:

If your AC power is subjected to frequent "brownouts", or, if you are operating large motors in the vicinity, you should avoid using the ENERAC on AC power.

Even though the unit has built in protection, AC lines with frequent problems may eventually cause corruption of data stored in its memory. If this occurs, "rebooting" from the factory will be required.

CHAPTER 4

FLOW DESCRIPTION & SENSORS

During operation, the metal tube of the probe (see fig.3) is inserted into the stack. A small pump located inside the unit draws a sample of the stack gases into the instrument for analysis.

The gas sample flows through the following sections, sequentially: the probe, the water trap and the sensor housing. Their function is described below.

A. THE PROBE

The probe consists of an inconel tube , an aluminum handle and a 10' length of hose and thermocouple wire.

The inconel tube is the only part that is inserted into the stack. It can withstand temperatures up to 2000 degrees F. Standard tube length is 13". Longer lengths are available on request. Inside the tube there is an inconel sheathed type K thermocouple wire. It monitors the stack temperature.

The tube must be inserted into the stack, with its tip as near to the center of the stack as possible. It must be inserted at least 12" below any dampers to avoid errors.

To insert the tube into the stack, drill a 3/8" hole on the wall of the stack. Do not insert the tube into a thermowell. The tube threads into the probe handle for easy replacement.

The probe handle is made of aluminum bar stock and has two functions. It is used for gripping the probe and it is designed to hold the smoke paper during a smoke test (see fig.3).

MAKE SURE THAT THE THUMBSCREW IS ALWAYS SCREWED TIGHTLY AGAINST THE OPPOSITE FACE SO THAT THERE ARE NO AIR LEAKS AT THE PROBE.

A 10' braided latex hose guides the stack gases from the probe handle to the water

trap. Other lengths are available on request. However, for every 10' of added hose length the response time increases by approx. 10 sec.

DON'T KINK THE HOSE OR REST IT AGAINST A HOT SURFACE.

The phone plug that is located at the end of the probe, is inserted into the temperature input of the instrument. It is the location of the cold junction of the thermocouple. The stack temperature displayed is the difference between the probe tip and phone plug temperatures plus the ambient temperature measured independently.

B. THE WATER TRAP

The water trap consists of a clear plastic cylindrical assembly and a disposable filter. The plastic assembly is divided into two compartments.

The bottom compartment is used to collect the condensate accumulating in the hose. It will take at least two hours for the compartment to fill up with water under normal operating conditions. There is a small drain plug at the bottom of the condensation trap. Drain the water collected after each use.

The upper compartment of the water trap may be empty, or filled with a desiccant material. The purpose of this material is to remove any additional moisture present in the stack gases in order to avoid any condensation on the sensor surfaces. The color of the desiccant will gradually change as the instrument is being used. The desiccant should be replaced, when its color changes to pink-white. For further details, see the section on maintenance.

NOTE:

Use DESICCANT #1 (Silica Gel), if your instrument has no NOX or SO₂ measurement capability. Use DESICCANT #2 (Drierite), if you measure NOX. Use NO desiccant, if you are measuring SO₂!

The stack gases that are exiting the water trap pass through a disposable fiberglass filter. The function of the filter is to trap particles of soot and fly ash that may be traveling with the gases. Replace the filter when it gets noticeably discolored. (The filter casing of the SO₂ measuring units has a greenish hue!).

The water trap and filter are designed to function unattended for a few hours of

continuous operation. If the excess moisture and particulates are removed from the gas stream by some other means, then it is possible to operate the instrument continuously for a long time.

C. THE SENSOR HOUSING.

The stack gases, after exiting the filter, are drawn in to the instrument, where the sensors are located. All the sensors are mounted for convenience and easy access on a plastic "sensor housing". The gases pass first through the CARBON MONOXIDE sensor then through the OXYGEN sensor. They enter a cavity inside the housing whose function is to reduce the pressure fluctuations caused by the action of the pump. There are small openings for the pressure sensor and for the NOX and SO₂ sensors (environmental units). The pump discharges the gases into the area, where the combustibles sensor is located and from there they are discharged to the atmosphere through an opening on the face plate of the unit.

D. THE SENSORS

1. **Temperature sensing.**

The instrument uses two temperature sensors.

- (1) THERMOCOUPLE. The first one is a thermocouple junction. It is located at the tip of the probe and measures the stack temperature. It measures the ambient temperature. The thermocouple junction is type K with a capability of measuring temperatures from 0 to 2000 degrees F. The instrument linearizes the thermocouple output for high accuracy measurements.
- (2) AMBIENT TEMPERATURE SENSOR. This is an integrated circuit type temperature sensor. It is located inside the probe's 1/4" plug. It is used to measure the room temperature.

2. **Pressure sensing.**

The pressure sensor is mounted inside the unit and is located on the right hand side of the sensor housing. It is a highly sensitive piezoresistive sensor

intended for pressures from +10" to -40" of water. It uses the probe as a gas conduit to monitor stack draft. For this reason the pump will stop during a draft measurement to avoid additional erroneous pressure drops due to flow resistance. The exhaust must also be plugged to avoid any back leakage from the exhaust opening.

3. **Smoke sensing**

Smoke density is measured by comparing the discoloration of a piece of special filter paper with a standard chart of different shades of grey. The chart is supplied with the instrument. Use only the paper supplied with the unit, because it has the correct flow resistance and color.

4. **Gas sensing.**

(1) Carbon Monoxide Sensor.

This is a sealed electrochemical cell. It consists of three platinum electrodes and an electrolyte. Carbon monoxide gas diffuses through a tiny hole on the face of the sensor. It reacts with oxygen present inside the cell to form carbon dioxide. The reaction produces an electric current proportional to the concentration of the gas. Sensor life is estimated at 2 years. It is possible to saturate the sensor by exposing it to concentrations in excess of 10000 PPM. This will not harm the sensor but it will take time for it to recover.

(2) Oxygen Sensor

This is a two electrode electrochemical cell. It has a silver cathode and a lead anode. Oxygen diffuses through a tiny hole and reacts with the lead. The reaction produces an electric current. The unit software linearizes the current vs. oxygen response. The cell becomes exhausted when all the lead is consumed. It takes about a year for this to happen. Disconnecting the cell when not in use will extend its life by six months.

(3) NOX Sensor

This is an electrochemical cell similar to the carbon monoxide sensor

with the important exception that it needs a constant bias voltage. This voltage is supplied to the sensor even when the instrument is turned off. It draws a small amount of current and will drain the batteries completely in about 10 months. For this reason the unit should always be given a fresh charge once every 2-3 months. The sensor will respond primarily to Nitric Oxide (NO). It exhibits a very small cross sensitivity to NO₂.

(4) Sulfur Dioxide Sensor

This is an electrochemical cell similar to the carbon monoxide sensor. It has a range of 0 to 2000 PPM. Its life is estimated at two years.

5. **Combustibles Sensor**

This is a semiconductor type sensor. It is based on the principle of molecular adsorption on the surface of the sensor. Molecules of a combustible gas stick to the surface of the sensor and change its electrical resistance. This change in resistance depends on the concentration of the gas. The software take care of linearization and compensation. This type of sensor shows greater sensitivity than the catalytic types for low combustible gas concentrations (below 0.1%). It should last for years, unless it is damaged by abuse or catalyst poisoning. Combustible sensors need a minimum amount of oxygen to operate properly. Since stack gases may contain little or no oxygen, it is necessary to admit a small amount of air at the sensor's surface. There is a small opening at the bottom of the housing that admits the required air.

CHAPTER 5

CUSTOMIZING YOUR INSTRUMENT (USING THE "SET" KEY)

One of the nicest features of the ENERAC Model 2000 is the ability to customize each unit to best meet the specific needs of the application.

By customization we mean the ability to set certain parameters such as fuels, degrees F or C, alarm levels, emissions units, plotting coordinates etc. and do it only once, without having to repeat such procedures every time the instrument is turned on. This information is stored in the instrument and will be retained, even if all power is removed including the battery.

Of course, any parameters that have been previously set can be changed by the customer by following the procedures outlined below.

When the instrument is turned on for the first time, it assumes a certain configuration (called the DEFAULT CONDITIONS), that was originally stored at the factory. (For example the default CO alarm level is 50 PPM, the default fuel #1 is #2 oil etc.

A. THE "SETTING" GROUP OF BUTTONS

To customize your unit you will have to use the four buttons located near the top of the faceplate. These buttons are labeled "SET", "UP", "DOWN" and "ENTER".

1. The "SET" key.

You use the "SET" button to get in or get out of the SETTING MODE.

When the LED located directly above the "SET" button is off, you are in the normal measurement mode and all the operating buttons (outside the setting group) function as labeled. When the "SET" LED is on, you are in the setting mode. The operating buttons assume now the "SETTING" function indicated immediately above or below them. (The action is similar to that of the 2nd function in a calculator).

To set any one parameter, push the "SET" button. The "SET" LED will turn on and the following message will appear on the display:

"SET MODE ; PRESS KEY"

You must now press the button corresponding to the parameter you wish to set. An explanation of the meaning of the operating buttons in the setting mode follows below. See also fig.4.

2. The "UP" & "DOWN" keys.

The "UP" and "DOWN" buttons are used to increment and decrement the parameter that you are setting. The increment/decrement interval is preset and depends on the parameter being set. (For example, the incr./decr. interval for setting combustibles in ash is 5%). The range over which a parameter can be set is also fixed.

You also use the "UP" and "DOWN" buttons not only for changing the numerical entries, but also for selecting various modes (i.e. You select between STORE, PRINT, DUMP, ERASE, etc when you are in the "SET" "STORE" mode).

3. The "ENTER" key.

The "ENTER" button functions either as a "shift" key or as an "enter" key.

When you are in the setting mode, a blinking cursor will appear on the display in front of the parameter that you are currently setting. However, some functions require the setting of more than one parameter. (For example setting the time/date requires setting the minutes, hours, day, month etc). Use the "UP" and "DOWN" key to select the appropriate blinking digit or parameter and then use the "ENTER" key to "shift" over to the next digit or parameter that requires setting. You can also use the "ENTER" button to get out of the setting mode ("SET" LED will turn off).

(There are two additional specialized functions of the "ENTER" button. If you encounter a "...AUTOZERO ERROR" message during start up, you can use the "ENTER" button to continue with the warm up procedure. (CAUTION: Disregard any display readout of the malfunctioning

parameter!). The second application deals with span gas calibration and is explained later).

B. HOW TO SET YOUR FUELS

Selecting the proper fuel is important for the computation of carbon dioxide, excess air and combustion efficiency. It also enters in the computation of toxic gas concentrations when expressed in lbs./ million BTU (#/B).

There is an LED in front of each of the three fuel buttons. The one that is on indicates the fuel that the machine is currently using to compute efficiency, CO₂ etc.

When you turn the instrument on for the first time, you will have in the foreground the following fuels:

Fuel #1: #2 OIL
Fuel #2: #6 OIL
Fuel #3: NATURAL GAS

These fuels are set at the factory, unless the customer has ordered a custom fuel.

Each time you turn the instrument on, it will default to Fuel #1. Of course, fuel #1 will be the fuel that you have chosen to store in that position.

The instrument has a library of 15 fuels. You can select any three of these fuels and place them in any of the three fuel positions (buttons).

Assume you wish to have fuel PROPANE as Fuel #2. Proceed as follows:

1. Push the "SET" button and observe "SET" LED turn on.
2. Push Fuel #2 button. The current fuel will be displayed.
3. Scan the Fuel Library by pushing repeatedly the "UP" or "DOWN" buttons, until the display shows:

"PROPANE 21680 BTU/LB"

4. Push the "SET" or "ENTER" button and observe the "SET" LED turn off. PROPANE is now fuel #2 and you are back in the normal measuring mode.

The fuels that the fuel buttons are set for are retained even after the instrument has been turned off, so that you will not have to repeat any setting procedure every time you turn the unit on.

C. CHANGING DEGREES F OR C AND FOR PREHEATED AIR

The instrument can be set to display and print all temperatures either in degrees Celsius or Fahrenheit.

It can also compute the combustion efficiency for boilers that use preheated air for combustion. The efficiency formula takes into account the energy of the preheated air in order to give a more accurate figure of the actual combustion efficiency.

IF YOU DO NOT USE PREHEATED AIR, LEAVE THE PREHEAT SETTING TO ITS DEFAULT VALUE OF 0 C (OR 32 F).

To change the temperature scale (F or C) proceed as follows:

1. Push the "SET" button and observe "SET" LED turn on.
2. Push the "TEMP/ST-RM" button. The following message will be displayed:

"PREHEAT TEMP: XXX F"

3. Push the "ENTER" button. The blinking cursor will shift to the letter F (or C).
4. Push the "UP" or "DOWN" button once. The letter F will change to C (for Celsius).
5. Push the "SET" button to get out of the setting mode.

If you use preheated air, first take its temperature using the stack probe. As an example, assume the preheat air temperature is 372 degrees F.

- Push "SET" button and observe "SET" led turn on.
- Push the "TEMP/ST-RM" button. The following message will be displayed:
"PREHEAT TEMP: XXX F"

- Use the "UP" button until the display reads:

"PREHEAT TEMP: 370 F"

- Push the "SET" button again to exit the setting mode.
The instrument ignores any set preheat temperature that is less than the ambient temperature.

Remember to reset your preheat temperature back to 32 degrees F., if the unit is going to be used in different conditions!

D. HOW TO SET THE EMISSIONS MEASUREMENTS

If you press the "SET" "OXYGEN" keys in sequence, you will be in the "emissions" SET mode. The display will read:

"SEL: PPM OXY_REF: TRUE%"

The above mode selection means that the toxic gas sensors (Carbon monoxide, Oxides of Nitrogen and Sulfur dioxide) will read the respective gas concentrations in parts/million. The display "TRUE%" indicates that there is no correction for oxygen and the readings will be actual concentrations. This is the DEFAULT setting from the factory.

There are two functions of the "SET EMISSIONS" key.

1. Selection of measuring units

You can select to read the three toxic gas concentrations in any of the following units:

PPM	Parts/million (Volumetric)
MGM	Milligrams/cubic meter
#/B	Lbs./ million BTU of fuel

To choose the desired units toggle the "UP" button until the proper units are displayed.

2. Selection of Oxygen Correction factor.

Many environmental regulations require that concentrations of pollutants be measured, corrected to some reference oxygen value other than the actual concentration at the time of the measurement. Typical oxygen reference values are 3%, 7% or 15%.

To select the desired oxygen reference value enter the "SET EMISSIONS" mode as described above. Press the "ENTER" key so that the cursor blinks in the OXY_REF side of the display. Toggle the "UP" or "DOWN" button until the desired value of the reference oxygen is displayed. (Range is 0-20% in 1% increments.

To return to uncorrected measurements toggle the OXY_REF values until you see "TRUE%" on the display.

Return to the measurement mode by pressing the "ENTER" key again and observing the "SET" LED go off.

E. HOW TO SET THE CARBON MONOXIDE ALARM

The instrument is provided with an audio and visual alarm that will be activated, if a preset threshold of Carbon monoxide is exceeded.

The audio alarm consists of a beeping sound occurring every second to alert the user. The visual alarm consists of the flashing simultaneously of both display pointer LEDs.

To set the CO alarm proceed as follows:

1. Push the "SET" button and observe the "SET" LED turn on.
2. Push the "CO/SO2" button. The following message will be displayed:

"CO ALARM: XXXX PPM"
3. Use the "UP" and "DOWN" buttons to set the alarm threshold to your desired value.
4. Push the "SET" button to exit the setting mode.

NOTE: If you have the emissions option your CO ALARM function will always be

set for the same units as those selected for measuring the toxic gas concentrations!

F. HOW TO SET THE COMBUSTIBLES IN ASH

When solid fuels such as coal are burned, they leave a residue called ash. Ash drops through the stoker gratings to the bottom of the boiler. However, some unburned fuel also drops through the grating and is discarded with the ash. This unburned fuel represents potential energy not utilized. The ENERAC model 2000 will take into account this loss of energy in its Efficiency formula, if the % of unburned fuel in the ash residue is entered into the instrument.

The default value of combustibles in ash is zero.

The Combustion efficiency for gaseous, liquid and wood fuels is not affected by any setting of the combustibles in ash parameter, since the instrument assumes that there should be no ash with combustibles for such fuels.

The Combustion efficiency for all coal fuels listed in the fuel library will, however, be affected by a setting of the combustibles in ash other than zero. Be careful to remember, that when you are setting combustibles in ash for a certain fuel you are also setting the same value for all coal fuels.

To set the combustibles in ash proceed as follows:

1. Push the "SET" button and observe "SET" LED turn on.
2. Push the "COMBUSTIBLES" button. The following message will be displayed:

"COMB IN ASH 0%"

3. Use the "UP" and "DOWN" buttons to set the display to the desired value of combustibles in ash.
4. Push the "SET" button to exit the setting mode.

G. SETTING THE SPAN CALIBRATION

This key is used to perform span calibrations of the sensors.

See chapter 11 of this manual for a complete description of how to set the span and carry out a calibration of the unit using span gas.

H. HOW TO SET THE DURATION OF THE SMOKE TEST

The duration of the smoke test depends on the gas flow rate through the smoke paper. The greater the flow rate the shorter the duration of the test will have to be.

Before a unit leaves the factory, its flow rate is measured accurately and the duration of the test is set to correspond to that particular flow rate. This is the default "smoke flow" setting for your instrument. It should require no adjustment until, either the pump's performance changes, or you have a partially clogged filter, or you encounter unusual draft conditions.

To check the accuracy of the smoke test, first insert a piece of smoke paper into its proper position in the probe. Make sure you have no leaks. Turn on the instrument and take a low pressure drop flowmeter (such as the Gilmont #12) and connect it to the tip of the probe. Measure and record the indicated flow rate. For example assume the flowmeter reads 800 cc/min.

To set the "Smoke Flow" to this value, proceed as follows:

1. Push the "SET" button and observe the "SET" LED turn on.
2. Push the "SMOKE" button. The following message will appear:

"SMOKE FLOW XXX ML/M"

3. Use the "UP" or "DOWN" buttons to set the display to the same value as the recorded flow rate (i.e.800 cc/m).
4. Push the "SET" button to exit the setting mode.

You now have a calibrated smoke density measuring instrument!

The stored setting will be retained even after the instrument has been turned off.

I. HOW TO SET THE TIME AND THE DATE

The instrument's internal clock displays and records time (24 hour mode only) in hours, minutes and seconds. It displays and records the date in the American convention of month #, day #, year#.

To set the time or date proceed as follows:

1. Push the "SET" button and observe "SET" LED turn on.
2. Push the "TIME/DATE" button. The following type of message will appear on the display as an example:

" 12:46:35 05/27/87 "

3. Use the "UP" or "DOWN" buttons to set each digit to the correct value and then use the "ENTER" button to shift to the next digit. (If you make a mistake and have to go back to a previous digit you must restart the procedure).
4. Push the "SET" button to exit the setting mode at any time, or the "ENTER" button at the end of the last digit.

J. HOW TO SET THE PLOTTER'S SCALES

1. Setting the ordinate (vertical scale).

There are three vertical scales (ordinates) that can be chosen from in the printer's plotter mode. These scales are numbered:

- (1) for Full Scale (0-100% of max. reading).
- (2) for Half scale (0-50% of max. reading).
(Exception: For toxic gas readings of CO, NOX, SO2 scale is 0-500 ppm or mgm and 0-0.500 #/B)
- (3) for Quarter scale (0-25% of max, reading).
(Exception: For toxic gas readings of CO, NOX, SO2 scale is 0-200 ppm or mgm and 0-0.200 #/B). (Scale #4 has a different function!)

The full scale values (100%) of the stack parameters are:

Stack temperature: 1090 C	2000 F	Ambient temperature: 90 C	200 F
Carbon monoxide: PPM	2000	Oxygen:	25%
Combustibles:	2.50%	Carbon dioxide:	40%
Excess Air:	1000%	Efficiency:	100.0%
Oxides of nitrogen: PPM	2000	Sulfur dioxide: PPM	2000

The one half and one quarter scales are 1/2 and 1/4 fractions of the values listed above. (Example: If stack temperature is in the 300-700 degree F range, use scale #2. If oxygen is less than 5%, use scale #3).

For units with the emissions option enabled the full scale readings on CO, NOX and SO₂ are 2000 MGM(milligrams/cub.met.) and 1.000 #/B (lbs./million BTU).

2. Multiple plots.

To obtain a simultaneous plot of three fixed parameters:

Carbon Monoxide	-- Range 0-500 PPM,
Oxygen	-- Range 0-12.5%,
Combustion Efficiency	-- Range 75-100%

toggle the "UP" key until the display indicates:

"SCALE: 4 TIME: 1 SEC"

The ENERAC printer will mark the graph of carbon monoxide with the letter C, the graph of oxygen with the letter O, the graph of efficiency with the letter E.

This type of plot is very significant in tuning boilers, because it shows the

effect of reducing excess air on efficiency and build up of carbon monoxide, simultaneously!

Instruments having the emissions option enabled will create four parameter plots instead of three parameter plots. The fourth parameter added is NOX and its range plotted is 0-200 PPM (or MGM). The letter N indicates the plot of NOX.

3. Setting the chart speed.

The chart speed (actually its reciprocal) is selected in seconds per event (dash). The fastest speed is 1 event/sec. and the slowest 1 event/min. There are 59 chart speeds to choose from. (Example: A chart speed of 20 means a point will be plotted every 20 seconds).

To set the desired scale and speed for the chosen stack parameter proceed as follows:

- (1) Push the "SET" button and observe the "SET" led turn on.
- (2) Push the "PLOT" button. The following message will be displayed:

"SCALE: 1 ; TIME 1 SEC"

and the cursor will blink at the scale position.

- (3) Use the "UP" or "DOWN" buttons to select among the three scales 1,2 or 3.; then use the "ENTER" button to shift the cursor to the time position.
- (4) Use the "UP" or "DOWN" buttons to select the desired chart speed (measured in seconds elapsed between events or dots).
- (5) Push the "SET" button to exit the setting mode.

K. SETTING THE STORAGE PARAMETERS

Read chapter 8 for an explanation of how to use the storage button.

L. HOW TO SET YOUR TELEPHONE COMMUNICATIONS

See chapter 9 on communications for an explanation of how to set up and dial a phone number.

CHAPTER 6

USING THE PRINTER

The ENERAC model 2000 is equipped with a 4" SEIKO thermal printer.

DUST WILL EASILY DAMAGE THE PRINTER!

**AVOID EXPOSING THE PRINTER TO A VERY DUSTY ENVIRONMENT!
USE THE PROTECTIVE PIECE OF "velcro" TO COVER THE SLOT EVEN
WHEN THE INSTRUMENT IS PRINTING.**

Do not use any ordinary paper or thermal paper other than the one supplied, to avoid damaging the printer heads. Thermal paper is a specially treated paper and must be protected from excessive heat or moisture. See the section on maintenance for directions on paper replacement.

There is a special sensor mounted on the back of the printer that monitors the paper. If there is no paper in the printer the printer will not operate.

There are two switches on the faceplate for advancing the paper. The "PAPER FEED" switch will advance the paper one line at a time, if pushed. The "FORM FEED" switch will advance the paper one page at a time, if pushed. See fig.5 for details on the printer section.

There are four different types of printouts that you can get from the printer. (i.e. There are four different ways to use the printer). These are described below.

A. OBTAINING A PRINTOUT OF "CURRENT" STACK PARAMETERS

This is the most basic printer operation. You get a printout of all stack parameters together with the time, date and fuel description. The values printed are those last read by the instrument at the moment that the "TEXT" button was depressed.

To obtain a "current" printout proceed as follows:

1. Make sure that the "PRINTER LED" is on (see fig.5). If it is not, use the

- "OUTPUT MODE" button to toggle the "PRINTER LED" on.
2. Make sure that you ARE NOT in the setting mode ("SET" LED is off).
 3. Push the "TEXT" button. The printer will start operating. It takes about 20 seconds to complete the printing.
 4. Use the "PAPER FEED" switch to advance the paper, so that it can be easily cut.

While the printer is in the process of printing you may use any other buttons to display any parameters you desire. The basic function of the "OUTPUT MODE" switch is to direct information either to the printer or to the output connectors (RS-232 or Modular phone connector). You cannot direct information simultaneously to printer and outputs!

B. OBTAINING PRINTER PLOTS

See chapter 5 for a description of how to set the plot parameters.

You can use the printer as an analog chart recorder to obtain a continuous plot of any stack parameter vs. time. The printer prints horizontal bars, so that the printout looks more like a step chart rather than one continuous line. The resolution of the vertical scale is better than 1% of full scale (i.e. there are 120 different positions for the bar mark).

There are three vertical scales available and sixty chart speeds ranging from 1 dot/sec to 1 dot/min. See chapter 6 paragraph I for directions on setting the plotter scales.

The plot always begins with a printout of the time and date, followed by the parameter being plotted, the chart speed and the vertical scale.

To get a plot of a stack parameter proceed as follows:

1. Select the proper scale and chart speed, by using the "SET" button as explained in chapter 6, I.
2. Push one of the eight basic buttons that corresponds to the stack parameter you wish to have plotted. (This will place the desired parameter on the "ACTIVE" part of the display).
3. Push the "PLOT" button. This will start the plot.

4. When you wish to stop the plot, push the "PLOT" button again.

The instrument remembers the last plotting scale and chart speed used even after it has been turned off. It will use the same settings the next time you do a plot, unless you change the settings.

When using the fast speeds, keep in mind that the instrument needs 20-30 seconds to respond fully to any changes to the stack parameters.

You can also obtain a multiple plot of carbon monoxide, oxygen and combustion efficiency, simultaneously by setting the plotting scale to #4. (See chapter 5).

C. PRINTING THE CONTENTS OF STORED MEASUREMENTS

The instrument is capable of storing the complete results of up to ninety nine different measurements (see chapter 8). These ninety nine storage compartments are called buffers (the display calls them TEST#XX) and are numbered from 1 to 99.

You can get a printout of any one stored measurement (i.e TEST), or you can get a printout of all ninety nine stored measurements sequentially, if you wish.

If you wish to get a printout of one stored measurement (for example Test#7) proceed as follows:

1. Make sure the "PRINTER" LED is on. (If it is not, use the "OUTPUT MODE" button to turn it on).
2. Push the "SET" key to turn the "SET" LED on. The following message will appear:

"SET MODE; PRESS KEY"

3. Push the "TEXT" button. This will activate the storage mode (as long as the "SET" LED is on) and the following message will appear on the display:

"TEST #1; FUNC=STORE"

4. Use the "UP" or "DOWN" key to set the Test# to the desired value (7 in

the example). Display reads:

"TEST#7; FUNC=STORE"

5. Push the "ENTER" button to shift the blinking cursor to the function location.
6. Push the "UP" button a few times until the display reads:

"TEST#7; FUNC=PRINT"

7. Push the "ENTER" button. The printer will start printing the contents of stored test measurement #7.

If you wish to obtain a complete printout of all the ninety nine tests at once, proceed as follows:

- Carry out steps 1,2 and 3 outlined above.
- Push the "ENTER" button to shift the cursor to the function area.
- Use the "UP" button a few times until the display reads:

"TEST#1; FUNC=PRNT ALL"

- Push the "ENTER" button. The printer will start printing in sequence the entire contents of all ninety nine stored tests.

REMINDER: The printer WILL NOT PRINT any stored locations (i.e.test#) that are EMPTY.

D. PRINTING EXTERNAL (OUTSIDE) MESSAGES

The ENERAC model 2000 is designed to communicate with external devices such as computers or terminals. During such communication it may be important (especially when communicating by telephone), for the remote device to send messages or instructions to the operator of the instrument.

After establishing communication via either the RS-232 port or the modular phone connector you can have your messages printed by the ENERAC printer by sending the PRNT command followed by quotation marks, then the message ending with

quotation marks. For examples if you send the message:

```
PRNT "REDUCE EXCESS AIR TO 30%"
```

the printer will print:

```
REDUCE EXCESS AIR TO 30%
```

You can send to the printer up to 40 characters at a time with each PRNT command.

CHAPTER 7

STORING YOUR MEASUREMENTS

You can save the results of a boiler performance test by using the storage capabilities of the ENERAC model 2000. This is a very useful feature, especially if you have to test a number of boilers in sequence, or you wish to compare previous with current measurements.

The information that you save, will be retained in the instrument's memory, even after the instrument has been shut off. It will be retained, even if the battery is removed from the unit (The instrument's memory is powered from its own tiny cells that should last at least 3 years).

Of course, you have the capability of erasing any test results that you no longer need and replacing them with new ones.

You can store up to ninety nine different test results in the instrument's memory. These are defined as :

TEST#1-99.

Each test contains complete information on all stack parameters including date and time, exactly as it would have appeared, if you had obtained a printout by pushing the "TEXT" button. In addition, it includes the BOILER I.D. # that you entered before storing the test.

A. THE STORAGE FUNCTIONS

The storage function can perform the following eight operations:

1. **"STORE"** This operation will store all the current values and source identification number. These will be stored in the test (storage) compartment whose number appears currently on the display (provided it is empty!).

2. **"DUMP"** This operation will send to the RS-232 output the

contents of the test# that is currently appearing on the display. (If you have an internal modem and you have established a telephone link, the information will be sent to the modular phone connector).

3. **"DUMP ALL"** This operation will send to the RS-232 output, or to the modem, the entire contents of all eighty tests stored, in sequence. The instrument will ignore any empty storage buffers.
4. **"PRINT"** This operation will cause the printer to print the contents of the test whose number appears currently on the display. (If it is empty, nothing will be printed).
5. **"PRINT ALL"** This operation will cause the printer to print the contents of all seventy five tests, in sequence starting with test#1. The instrument will not print empty storage locations.
6. **"ERASE"** This operation will permanently erase the contents of the test whose number appears currently on the display. You cannot overwrite a used test# (i.e. if there are data stored in that buffer, you must erase it first).
7. **"WIPE ALL"** This operation will erase permanently the contents of all fifty storage locations.
8. **"QUIT"** This operation takes you out of the storage function, without executing any of the above functions.

B. HOW TO STORE YOUR DATA

Fig.6 shows a chart of the required sequence of operations for storing in the ENERAC's memory and for retrieving the results of combustion tests.

To store a single complete combustion test in the ENERAC's memory proceed as follows:

1. Push the "SET" button and observe "SET" LED turn on.
2. Push the "TEXT" button. The following message will appear on the display:

"TEST#1; FUNC=STORE"

3. Use the UP/DOWN buttons until the desired Test # appears on the display. (You can select up to 99 different tests).
4. Push the ENTER button to shift the blinking cursor to the letter "S" of the function STORE.
5. Push the ENTER button again. The display will read:

"BOILER #01; FUNC=STORE"

6. Use the UP/DOWN buttons until the number associated with the boiler you are testing appears on the display. (You have a selection of 99 different boilers you can identify!)
7. Press the ENTER button again. The current stack parameters will be instantly stored in memory.

C. RECOVERING YOUR STORED DATA

You can recover your stored combustion tests, either by having them printed on the ENERAC's printer or by sending them out via the RS-232 port or the telephone line.

To recover your data proceed as follows:

1. Push the "SET" button and observe "SET" LED turn on.

2. Push the "TEXT" button. The following message will appear on the display:

"TEST#1; FUNC=STORE"

3. After selecting the proper TEST# (if you wish to recover only one test result), press the ENTER button to move the cursor over to FUNC location.
4. Use the UP/DOWN buttons until one of the following functions appears on the display: "DUMP", "DUMP ALL", "PRINT", "PRINT ALL".
5. Press the ENTER button. The stored result, or results will be sent to the selected output device.

D. ADDITIONAL STORAGE

Because of the ENERAC's capabilities, you are not limited to storing only the results of 50 tests. You can use the RS-232 output to connect to an outside computer.

The most convenient way to obtain unlimited storage capability is to use the ENERAC's ENERCOM™ FOR WINDOWS software with any PC computer using Windows.

Some of the capabilities of this software include:

1. Calculation of maximum, minimum and average values over a preselected period.
2. Storage and retrieval of data and plots from the computer in a variety of formats.
3. Programming custom fuels into the ENERAC.
4. Obtaining multiple plots & bar graphs.
5. Letting multiple alarms and monitoring their duration.

CHAPTER 8

COMMUNICATIONS

One of the most important recent developments in portable instruments is their ability to communicate directly with other instruments or computers. When good communications capability is paired with the development of artificial intelligence, the result is a very powerful system that can literally replace a consultant's visit to the plant and assure optimum performance of the monitored equipment at all times.

The ENERAC model 3000 has been designed with this concept in mind. It is capable of communicating directly with a computer in any of the following ways:

1. Through its RS-232 port.
2. Through the telephone line by using the modular phone output.

We strongly recommend using the ENERCOM™ for Windows program to communicate with any computer that is equipped with Windows™ software. This program offers unlimited storage capacity, automatic computation of maximum, minimum and average values over customer specified periods, presettable alarms and duration for any parameter, programming custom fuels, displaying bar graphs of the emission parameters and obtaining multiple plots of all stack parameters.

Enerac is a leading innovator in the field of combustion emissions measurements is committed to this concept and will be introducing so called "Expert Programs" that will be able to perform remote diagnosis and recommend steps to improve boiler performance.

The instrument is provided with two output ports. The RS-232 port is standard. The modular phone port is optional and will become operational if you have purchased the internal modem option. If you do not have this option, you can have your local distributor install it and call the factory to activate it remotely.

Please keep in mind that you can communicate with one output at a time. The ENERAC always defaults to the RS-232 when it is not communicating. This

means that the RS-232 is always on line, unless you originate a telephone call, or the ENERAC detects an incoming call on the telephone line. In that case, the modem automatically takes control, and the RS-232 is temporarily disabled. When the telephone communication is over, or the phone line disconnected, the RS-232 port will automatically be reactivated.

A. HOW TO ESTABLISH COMMUNICATIONS

If two human beings want to communicate with each other they must meet two requirements: First they must position themselves so that they can hear each other (i.e. place one's mouth near the other's ear and vice versa) and second they must speak the same language. The same is true for communication between machines. They must be connected properly to each other and they must agree to speak the same language.

The description below assumes that you have an external computer and that you wish the ENERAC to communicate with it and that the computer is equipped with a RS-232 port. It is also assumed that you have some kind of communications program installed on your computer.

NOTE: An RS-232 port is a special type of serial port. You cannot use a TTL serial port or a parallel port on your computer.

NOTE: If your computer does not have a communications program installed and if you have an IBM PC compatible computer, you can obtain such a program from Enerac for a modest fee.

1. HOW TO CONNECT YOUR COMPUTER DIRECTLY TO THE RS-232

The RS-232 port on the ENERAC is a male 25 pin D type connector. You will need a serial cable to connect to your computer. Cable lengths can be as long as 300 ft. You can get such cables from any computer store or from Enerac, if you wish.

Computers have their outputs configured for a certain type of connection known as DTE or DCE (a DTE device transmits on pin 2 and receives on pin

3, the opposite is true for a DCE). The ENERAC can be set to function as either one. Its default condition (i.e. the way it has been set at the factory) is as a DTE. For two machines to have their pins connected properly they must be of opposite type (i.e. one DTE the other DCE). Therefore make sure your machine is a DCE. (If you are not sure, use a voltmeter to measure the voltage on pin #3 of your computer's connector. It should be negative 5V. or more with respect to pin#7, ground).

If your computer is a DTE device, the easiest way to establish communication with the ENERAC, is to purchase a small attachment called a null modem. Null modems are available in any computer store.

Some computers also need an additional signal to be present in one of the other pins, before they start communicating with each other. This is called hardware handshaking. The ENERAC does not need such a signal. If your computer needs one, the ENERAC can supply it on any pins that your computer wishes to see it. The default pin on which this signal is supplied in the ENERAC as set at the factory is pin 20 (known as the DTR pin).

If both the above conditions are satisfied you have met the first requirement for successful communication. (CALL ENERAC, IF YOU NEED HELP).

The second requirement for successful communication deals with establishing a common language between the two machines.

There are two conditions for a common language. Speed of transmission and data format must be the same. The ENERAC model 2000 uses the following speed and data format:

SPEED: 1200 BAUD
START BITS: 1
DATA BITS: 8
STOP BITS: 1
PARITY: NONE

You must set your computer to the same values as those listed above.

(The ENERAC is capable of using any other speed up to 19200 baud and

different data formats. Consult Enerac for instructions).

This completes the connection requirements.

NOTE: The ENERAC model 2000 will communicate via its serial port with a computer provided it has been turned on and gone through the AUTOZERO procedure WITHOUT BEING HALTED by an "... AUTOZERO ERROR" message. If such an error message appears on the display and you still wish to establish communication, by pass it by pressing the "ENTER" key!

2. HOW TO ESTABLISH A TELEPHONE CONNECTION

If your ENERAC is equipped with an internal modem, use the following procedure to establish a successful telephone communication link with a remote computer:

NOTE: You need to have available a direct phone line. If your telephone is connected to a special communications system, such as MERLIN™, you will need to purchase from your phone company a special device called a modem adaptor in order to communicate with the ENERAC.

- (1) Connect the modular phone adaptor to the ENERAC's phone socket.
- (2) Disconnect your telephone from its wall outlet and connect it to one of the two sockets of the phone adaptor.
- (3) Use any modular phone cable to establish a connection between the wall telephone socket and the unused adaptor socket.

You are now ready to establish communication.

3. HOW TO RECEIVE TELEPHONE CALLS

As soon as the telephone connections have been made in the manner described above, the ENERAC will set its in the "autoanswer" mode. This means that it will automatically answer any remote computer that dials the telephone number to which the ENERAC is connected. The operator's presence near the ENERAC is not required.

If there is no incoming call, or if the call is disconnected, the ENERAC's RS-232 port will be enabled and can be used with any nearby computer, even if the ENERAC is connected to the phone line. If, however, a call comes in, the ENERAC will disable its RS-232 port and establish automatically communication with the calling computer.

You can still operate the ENERAC's buttons including the "TEXT" button in order to read stack parameters, while simultaneously maintaining a telephone connection with a remote computer.

As long as you are maintaining a telephone connection, the following message will appear every 30 seconds on the display:

"MODEM ON LINE"

to remind you that you are still connected to the phone line.

4. HOW TO DIAL A REMOTE COMPUTER

Proceed as follows in order to originate a call by the ENERAC to a remote computer. (The remote computer must be connected to its own modem).

- (1) Press the "SET" button and observe "SET" LED turn on.
- (2) Press the "OUTPUT" mode button and observe the "OUTPUT" LED turn on. The following message will appear on the display:

"DIAL#;CARRIER? PRESS KEY"

- (3) Pick up the telephone receiver and dial the telephone number of the remote computer that you wish to establish communication with.
- (4) Listen on the receiver first for the phone to start ringing and then for a high pitched whistle, that indicates the presence of a "carrier". The whistling sound means that the remote computer has answered your call.
- (5) Press any button, then hang up the telephone. You have now established connection and are ready to send and receive messages.

As a reminder that you are still connected on the phone, the following message will appear every 30 seconds:

"MODEM ON LINE"

Remember that you can still display stack parameters on the ENERAC's display while communicating over the telephone.

B. THE ENERAC'S COMMUNICATION LANGUAGE

Once communication has been established, you can now proceed with data transfers and the execution of commands. There are two ways to exchange information between the ENERAC and an external computer or terminal. The first is a data dump and the second is an information exchange between the two devices.

1. DUMPING DATA TO A REMOTE COMPUTER

In this mode you just send data from the ENERAC to a waiting computer by simply pushing the appropriate buttons.

To send a record of all the stack parameters currently being monitored by the ENERAC while the probe is in the boiler's stack proceed as follows:

- (1) Make sure the "SET" LED is off.
- (2) Establish a successful connection either via the RS-232 or the telephone.
- (3) Observe that the "OUTPUT" LED turn on.
- (4) Push the "TEXT" button. A complete record of all current stack measurements is sent to the computer.

To send a record of the measurements that have been previously stored in the ENERAC proceed as follows":

- (1) Carry out steps 1, 2, and 3 above.
- (4) Push next the "SET" button, "SET" LED must be on.
- (5) Push the "TEXT" button, the following message will appear:

"TEST #1 FUNC=STORE"

(6) If you wish to send all the data stored, push the "ENTER" button to shift the blinking cursor to the FUNC area.

(7) Use the "UP" button until the following message appears:

"TEST #1 FUNC=DUMP ALL"

(8) Push the "ENTER" button. All measurements stored in the ENERAC's memory are sent out in sequence.

Use the "DUMP" function, if you wish to transmit only one set of data (corresponding to the TEST#).

2. TWO WAY COMMUNICATION

The ENERAC is also capable of responding to requests for data and to commands sent by the remote computer. For this purpose it has a vocabulary of COMMANDS that the computer can send and to which it will respond. There are two kinds of commands: Those designed for general use and those reserved for technical purposes in order to determine from remote locations the performance of the instrument. All commands consist of four letter words (these are usually abbreviations of the complete word). If the command is followed by a question mark, it means that it is a request for information (i.e. it will cause the ENERAC to respond to the command by sending to its output port the specific information requested). If a command is followed by a quotation mark it will cause the ENERAC to store the data between quotes in its memory. This is the way to reprogram the instrument from a remote location. This feature makes possible the introduction of new fuels, if desired, or remote control of parameters or even the introduction of additional features and improvements without having to ship the instrument to the factory or dismantling it.

A list of commands intended for general use follows:

THE COMMAND SET

COMMAND	FUNCTION
ATEM?	Sends to the external computer the ambient temperature of the instrument.
CASH?	ENERAC returns the present value of combustibles in ash stored in its memory.
CDOX?	ENERAC returns present value of carbon dioxide.
CMNX?	ENERAC returns present value of carbon monoxide.
COAM?	ENERAC returns present set value of the carbon monoxide alarm.
COMB?	ENERAC returns present value of combustibles.
DATE?	ENERAC returns present date.
DATE XX/XX/XX	Stores in ENERAC new date.
DRFT?	ENERAC returns the present value of draft.
DUMP?	ENERAC returns results of all tests stored in its memory.
EFFI?	ENERAC returns present value of combustion efficiency.
EXAR?	ENERAC returns present value of excess air.
FL01?	ENERAC returns the fuel currently stored in location 01
.....
.....
FL15?	ENERAC returns the fuel currently stored in location 15
COMMAND	FUNCTION

FUEL?	ENERAC returns the current fuel used.
LOGO?	ENERAC returns current LOGO (default value "ENERAC 3000").
MODE?	ENERAC returns the current Emissions mode (units) and the oxygen correction factor.
MODE X	(Emissions option). Causes ENERAC to switch units of emissions gas measurements (CO, NO, NO ₂ , NOX, SO ₂) as follows: X=P PPM (Volumetric) X=M MGM (milligrams/cub.meter) X=# #/B (Lbs./million BTU) X=G GBH (Grams/brake hp-hour)
NOXY?	ENERAC returns present value of nitric oxide (NO).
OPTI?	Returns ENERAC's current option setting. (There are 16 available options).
OXRF XX	(Emissions option). Causes ENERAC to set the oxygen correction factor to any number as follows: XX=0-20 (%) (In 1% steps) XX=TRUE (No correction for oxygen)
OXYG?	ENERAC returns the present value of oxygen.
PRHT?	ENERAC returns the present value of the combustion air temperature.

COMMAND

FUNCTION

PRNT"X..XX"	Sends to the ENERAC printer the message "X..XX" up to 40 characters long. To send more characters repeat the command.
PUMP?	ENERAC returns pump status, ON or OFF.
PUMP0	Turns the ENERAC main pump off. (The probe air flow pump stays on!)
PUMP1	Turns the ENERAC main pump on. The instrument begins to draw a sample.
SO2X?	ENERAC returns present value of sulfur dioxide.
SMFL?	ENERAC returns the currently stored value of the smoke test flow rate.
STEM?	ENERAC returns present value of the stack temperature.
TEXT?	ENERAC returns a complete record of all current stack parameters.
TEXT	Commands the ENERAC to print on its printer all the current stack parameters including time, date, fuel and "mode".
TIME?	ENERAC returns the current time.
TIME"XX:XX:XX"	Stores in ENERAC new time.
WARN?	ENERAC will return any warning messages currently activated.

A remote computer executing the commands TEXT? and WARN? in a continuous loop will perform as a remote continuous readout device of a source's

performance.

The commands "PUMP0" and "PUMP1" allow the ENERAC to be left unattended at the combustion source site for long periods by remotely turning the main pump off and on, periodically, as needed. However, keep in mind that the probe pump air flow pump will be running continuously and its life is rated at 3000 hours.

You can type more than one commands at a time to a maximum number of commands that will not exceed 40 characters (including spaces). To send more than one command, separate each command by SPACE-SEMICOLON- SPACE.

We strongly recommend using the ENERCOM™ for WINDOWS software package to take advantage of the ENERAC's communications capability.

C. ENERAC SOFTWARE.

You can use any communications program such as PROCOMM™ or WINDOWS™ TERMINAL to communicate with the ENERAC. You can, however, enhance considerably the performance of the ENERAC, by using the special ENERCOM™ FOR WINDOWS software that is supplied with every model 3000 analyzer. These software allows you to:

1. Monitor all emissions parameters simultaneously.
2. Record maximum, minimum, average and standard deviation for all emissions parameters.
3. Set alarms for every emissions parameter including recording the time duration that alarms have been exceeded.
4. Plot bar graphs and time plots of all parameters.
5. Select a variety of saving and printing options.

Consult the manual for ENERCOM™ FOR WINDOWS for details on the available software.

CHAPTER 9

THE ENERAC'S COMPUTATIONS

A. SIMPLIFIED DESCRIPTION

The heart of the ENERAC model 2000 is an INTEL 16 bit single chip microcontroller . (A microcontroller is a special purpose microprocessor). A second 8 bit microcontroller takes care of the printer requirements and releases the main processor from these tasks. The unit's clock speed is a very fast 12 Mhz.

The system can accommodate 64K bytes of memory. The instrument uses a total of 38K bytes (or the equivalent of 15 full type written pages) for its code. Of these, 6K bytes are stored inside the microcontroller and 32K bytes in permanent memory (2 16kx8 EPROMS). The instrument also uses an additional 16Kbytes of read or write memory (2 8kx8 battery backed SRAM).This large amount of read/write memory for a dedicated instrument is intended for enhanced remote reprogramming capability and for storage.

There is a 10 bit analog to digital conversion of the sensor outputs, that yields better than 1 part in 1000 resolution.

There are two printed circuit boards (there may be a third one if the internal modem is present). The main board is a high density six layer board. The power supply board is housed inside the separate power supply module to minimize noise.

The basic ENERAC has all the connectors present so that any option can be installed, without having to ship the instrument to the factory.

B. HOW EFFICIENCY IS COMPUTED

The ENERAC has stored in its memory a complete library of mathematical functions that it uses to carry out all the needed computations. It uses these functions to linearize thermocouple, oxygen sensor and combustibles sensor outputs and to compute combustion efficiency, carbon dioxide and excess air.

The ENERAC uses a unique (and the most complete) formula to compute

combustion efficiency. It is based essentially on measuring all the heat loss mechanisms. Most of the heat is lost up the stack. In the case of coal fuels some potential heat is also lost by the amount of combustibles found in the ash residue.

The heat lost up the stack falls into the following three categories:

1. Heat carried away by the (dry) stack gases nitrogen, carbon dioxide and oxygen.
2. Heat lost by the water vapor that is formed during combustion. The heat lost by the water vapor can be broken into two categories.
 - (1) Heat lost in converting the water vapor into steam at the boiling temperature of water.
 - (2) Additional heat lost in heating the steam formed to the temperature of the stack gases.
3. Available heat lost by any combustible (i.e. unburned) gases escaping through the stack.

The ENERAC measures all three heat losses. If the fuel is coal, it will also allow you to enter the % combustibles in the ash residue to obtain a more accurate value for the combustion efficiency.

In addition, for high efficiency boilers (i.e. boilers operating with stack temperatures below water vapor condensation), the ENERAC will account for the reduced heat loss, arising from partial condensation of the water vapor and compute the combustion efficiency correctly.

C. EXCESS AIR & CO₂ COMPUTATION

Carbon dioxide and excess air are calculated by the ENERAC and are functions of the oxygen concentration and type of fuel used. There is no carbon dioxide sensor in the unit. Consequently, carbon dioxide values are only valid for combustion systems.

D. EMISSIONS CALCULATIONS

The toxic gas sensors measure concentrations in PPM (parts per million) on a

volume to volume basis. However, there are two other sets of units used for toxic gas emissions. The first is milligrams per cubic meter (abbreviated as MGM). The other system of units is pounds of pollutant per million BTU of fuel burned. The ENERAC is programed to carry out the required calculations automatically in any of the above listed units.

Some regulations also specify that toxic gas concentrations

be referenced to certain oxygen levels, such as 3% or 7%. The ENERAC can be programed by the customer to carry out these computations automatically.

All calculations including sensor linearizations are executed using floating point arithmetic, not look up tables, for greater accuracy and reduced memory overhead.

CHAPTER 10

MAINTENANCE

There are three items on the instrument that will require occasional replacement (i.e. replacing them every few weeks depending on instrument usage). These items are the disposable filter, the desiccant material and the printer paper.

You will also probably have to replace the oxygen sensor once a year.

Finally, the carbon monoxide, NOX and sulfur dioxide sensors will probably need replacement every two years.

After 3-4 years you may have to replace the combustible sensor, the pressure sensor and the pump, depending on use and abuse of the instrument.

All replacement items mentioned are easily accessible. They are either located outside the instrument, or they can be reached by opening the hinged plate.

A. REPLACING THE DISPOSABLE (FIBERGLASS) FILTER

The disposable filter is located outside the instrument on the water trap assembly (see fig.3). It must be replaced if it becomes noticeably discolored. Failure to replace a partially blocked filter will cause longer response times and probable clogging of the tiny sensor openings, resulting in sensor failure.

To replace a used filter, remove the clamps that secure it to the hose assembly of the watertrap. Take a new filter. Observe the correct flow direction (i.e. towards the instrument). Connect the new filter to the hose assembly and secure it with the clamps.

NOTE:

Units with SO₂ measurement capability must be equipped with a fluorocarbon based disposable filter (casing color is pale green).

B. REPLACING THE DESICCANT AND DRAINING THE WATERTRAP

The desiccant is the blue crystalline material located inside the upper compartment of the watertrap. As this material absorbs water vapor, its color changes to pink and finally to white-pink as it becomes saturated with water. It should be replaced with fresh desiccant when it is used up.

To replace the desiccant, unscrew the Watertrap cover carefully and empty the desiccant compartment. Fill it with fresh desiccant and screw the cover back tightly so that there are no air leaks.

Used desiccant can be restored by placing it in 200 degree F oven for 20 minutes. This, however, cannot be repeated more than two or three times, because of gradual soot accumulation.

To drain the watertrap from water accumulated in the bottom, simply remove the red plastic plug and shake the watertrap. Don't forget to replace the plug.

NOTE:

If your instrument has NO oxides of nitrogen OR sulfur dioxide measurement capability, use DESICCANT #1 (Silica Gel).

If your instrument is equipped to measure oxides of nitrogen, but NO sulfur dioxide, use DESICCANT #2 (Drierite) only.

If your instrument can measure sulfur dioxide, you must use NO desiccant, or insert any other substance in the water trap compartment!!

C. REPLACING THE PRINTER PAPER

The ENERAC's printer uses a special paper called thermal paper. ALWAYS USE THE PROPER TYPE OF THERMAL PAPER. If the wrong paper is inserted, the printer may not operate at all or the printer's thermal heads may be damaged. If you notice that the printer is printing incomplete letters, this is an indication that one or more of the printer heads have been damaged. In that case you have to

order a complete head assembly from the company and install it yourself.

Do not leave thermal paper exposed to heat or humidity, because it will gradually turn yellow.

When there are only 3 ft. of paper left in the roll, you will see a red line appearing on the left border. This is a warning that there is little paper left and order a new roll.

There is a paper sensor located behind the printer. The printer will operate as long as the sensor's beam is interrupted by the paper. When there is no paper, the sensor disables the printer to avoid damaging the thermal heads.

To insert a new roll of paper, open the hinged side of the faceplate. Pull out the steel rod that holds the paper. Insert a new roll of paper and gently press the rod back against the clamps. Take out about 3" of paper and pass it through the rear of the printer making sure that it goes between the paper sensor's openings. Use the little thumbwheel located on the right hand side of the printer to slowly push the paper through the printer. Once the paper is through you can insert it into the cutout on the faceplate. Use the "PAPER FEED" switch to advance the paper.

D. SENSOR REPLACEMENT

1. Replacing the oxygen sensor

The oxygen sensor is an electrochemical cell and has a limited life. It should last approximately one year.

The oxygen sensor's date code is stored in the instrument when it is manufactured. After a year you will start seeing the following message appear on the display:

"OXY SENSOR OUTDATED"

This message is telling you that the sensor is still functioning properly, but you should not expect it to last much longer. It is time to order a new sensor.

When finally the message,

"OXY AUTOZERO ERROR"

appears on the display, it means that the sensor is no longer functioning satisfactorily and should be replaced.

Before replacing an oxygen sensor, however, open the hinged plate and take a look at the cables leading to the sensor housing. Make sure that no wires have accidentally been disconnected.

If the ERROR message appears for the first time, try operating the unit, for a few hours in a clean environment in case the sensor got wet. If this doesn't work, you must replace the oxygen sensor.

To replace the oxygen sensor, open the hinged plate. Remove the six captive screws that secure the cover to the sensor housing. See fig.3. Pull out the housing cover. The sensor is the small battery like device attached to the cover. Unscrew the sensor wires and remove the old sensor. Take a new sensor and attach it to the cover. Carefully screw the sensor leads observing the proper polarity. Place back the cover and tighten the six screws so that housing is air tight. Make sure you don't damage the gasket. Close the hinged plate. Wait 10 minutes. Turn the instrument on. If everything is OK, it should warm up without the "OXY AUTOZERO ERROR" message appearing. If it appears, turn the unit off wait 5 minutes and turn it back on. If the error message still appears, open the hinged plate and examine the wires to the sensor. Make sure you have attached the wires with the correct polarity.

2. Replacing the carbon monoxide sensor

The carbon monoxide sensor is an electrochemical cell. Its expected life is about 2 years.

During manufacture the sensor's date code is stored in the instrument. After two years the following message will begin appearing on the display during warmup:

"CO SENSOR OUTDATED"

Its purpose is to warn you that even though the sensor is still functioning properly, it is now two years old and you should consider replacing it soon.

When finally the following message appears:

“CO AUTOZERO ERROR”

it means that the CO sensor has stopped functioning and must be replaced with a new one.

However, before replacing a malfunctioning sensor, let the ENERAC run for 2 hours in a clean environment, (you will have to push the "ENTER" button to continue). Sometimes a malfunction message appears, if the sensor got wet or it had been saturated with carbon monoxide during a measurement. Restart the unit again. If the error message still appears, replace the sensor.

To replace the sensor open the hinged plate. See fig.3 for the location of the CO sensor. Take out the three screws that secure the sensor to the housing. Notice the three wires attached to the sensor. Observe carefully the pins to which they are connected. Disconnect the wires and remove the old sensor.

Take a new CO sensor. Notice that the new sensor has two pins shorted. Remove the shorting spring. Attach the three wires to the corresponding pins on the sensor and mount the sensor on the housing. Make sure to locate the O-ring carefully in its groove, so that there are no air leaks. Wait 15 minutes. Turn the instrument on and AUTOZERO the unit.

3. Replacing the NOX & SO₂ sensors

These are also electrochemical sensors with an expected life of two years. See fig.3 for their location. The sensors are labeled, so that you can distinguish between them. Follow the instructions for replacing the CO sensor.

CHAPTER 11

CALIBRATION

Every instrument must occasionally be calibrated against some known parameter in order to make sure that its accuracy has not deteriorated.

The display readout is always a linear function of the source excitation (i.e. gas concentration or temperature etc.). You therefore need only two points on the straight line to calibrate a parameter over its entire range. Usually, the first point chosen is the zero value (called zeroing the instrument). The second point has to be set by using some known value of the parameter being calibrated (i.e. using for example 200 PPM certified carbon monoxide gas to set the display to read 200). Sometimes the second point is not needed, if the slope of the parameter is known and is always the same (for example for the stack temperature the slope of the curve is well known and you don't need a span calibration).

Traditionally, both zeroing and span (i.e. second point) calibration was done manually, by rotating suitable potentiometers until the display was set to read first zero in ambient air and then the correct value using span gas.

With the introduction of microprocessors, it became a simple matter for instruments to zero themselves automatically upon start up, without having to use any adjustments. However, this simplification requires caution. The instrument must be started in a true "zero" environment. Otherwise it will assume as "zero" non zero conditions and give erroneous readings. (Example: Never autozero the ENERAC, if the probe tip is still hot from a recent measurement.)

The ENERAC carries out this improvement in automatic calibration procedure one step further. It does away with all potentiometric span adjustments. You just tell it the value of the calibrating parameter that you are using and the instrument adjusts itself automatically.

The ENERAC will "auto zero" itself every time you start the instrument, provided you push the ENTER key. Span calibration will be carried out on request.

You should carry out a span calibration every 3-4 months to maintain an accuracy within specifications.

A. AUTO ZEROING THE INSTRUMENT

Every time you turn the instrument on, you should wait for 2 minutes for the ENERAC to warm up. At the end of the warmup period the ENERAC reads the output of all sensors and sets them all to zero with the exception of the oxygen that it sets to 21.0% and the ambient temperature that it reads directly. Consequently, it is very important that at the moment of "zeroing" the probe tip is at room temperature and the environment is clean from traces of carbon monoxide or other gases.

NOTE:

In practice AUTOZEROING is only needed once at the beginning of a day of measurements. The ENERAC will not have sufficient zero drift during in 24 hours to require additional autozeroing procedures. You can bypass the AUTOZERO procedure by pressing any key other than the "ENTER" key, when prompted to do so by the display.

If the instrument has not been used for quite some time, it is a good idea to give it a longer warmup period (the combustibles sensor is the only sensor, that may need a little more time). To do this turn the unit off at the end of its initial warmup and then turn it immediately back on.

If you accidentally shut off the unit while the probe is still in the stack, TURN THE UNIT BACK ON AND BYPASS THE AUTOZEROING PROCEDURE BY PRESSING ANY KEY OTHER THAN THE "ENTER" KEY WHEN THE MESSAGE "Press ENTER to AUTOZERO" APPEARS.

B. SPAN CALIBRATION OF THE INSTRUMENT

Once every 3-4 months you should perform a span calibration of the instrument. The parameters that require a span calibration are: Carbon Monoxide, Combustibles and Draft. For the environmental version of the ENERAC you will need also a span calibration of the NOX and Sulfur Dioxide parameters. There is, finally, a span calibration for the ambient temperature sensor.

You can carry out all span calibrations in sequence or just one only, if you wish.

You can use your own gas calibration system, or you can use the convenient gas calibration kit supplied by Enerac. (information is listed on APPENDIX D).

1. Span calibration using the Enerac kit.

The gas calibration system supplied by Enerac is shown in Fig. 9B. The kit comes with a gas bottle containing a mixture of 200 PPM carbon monoxide and 0.1% methane. For NOX and SO₂ calibrations you must order extra gas bottles containing the desired type of span gas. All three gas bottles and apparatus fit in a small carrying case for easy transportation to the field.

Follow the instructions supplied with the kit for proper span calibration.

For span calibration of the DRAFT and AMBIENT TEMPERATURE follow the directions in section B below.

2. Span calibration using your own gas

If you wish to use your own gas to perform span calibrations you must take certain precautions, in order to calibrate the sensors properly.

To carry out a span calibration follow the steps below:

- (1) We suggest that you set up your calibration apparatus as shown in fig.9.

Notice that you need a number of certified gas bottles, a manometer for pressure calibration, a small flowmeter and a sample stack tube (2" diam by 12" high).

The Carbon Monoxide gas should be in the range 50-500 PPM 2% accuracy with the balance nitrogen.

The Combustible gas should be in the range 0.07%-0.2% methane, 2% accuracy with the balance nitrogen.

The NOX span gas should be in the range 10-500 PPM, 2% accuracy with balance nitrogen.

The sulfur dioxide span gas should be in the range of 30-500 PPM, 2% accuracy, balance nitrogen.

- (2) Turn the instrument on, press ENTER to autozero and wait until the message

‘INSERT PROBE IN STACK’

appears on the display.

- (3) Push the "SET" button and observe "SET" LED turn on.
- (4) Push the "DRFT" button. The following message will appear:

“CMB SPAN GAS: 0.11%”

- (5) (If you wish to skip the Combustibles calibration push the "ENTER" button. The display will read:

"PUSH ENTER KEY!!"

Push any button, except the "ENTER" button and the unit will skip the combustibles calibration and proceed to the next one.)

- (6) To carry out the combustibles span calibration, use the "UP" or "DOWN" buttons until the display reads the same combustibles value as that printed on the combustibles (methane) gas bottle label. Then press the "ENTER" button. The display will read:

"PRESS ENTER KEY!!"

- (7) Open the span gas valve, set your gas flow to 200-600 cc/min above the pump flow. Remove the cap from the top of the sample stack tube to vent the excess gas. (The purpose of this is to maintain reasonably steady pressure near ambient for more accurate results). Press the "ENTER" key. The following message will appear on the display:

"FEED GAS NOW and WAIT"

- (8) Make sure you keep the gas flow reasonably constant. At the end of two minutes the unit will record and store the combustibles sensor output and define it as the value that you set earlier.

When you see the message:

"CO SPAN GAS: 200 PPM"

it means that you are finished with the combustibles span calibration and the instrument is prompting you to perform the CO calibration next. Shut off the gas!

- (9) To carry out the CO (carbon monoxide) span calibration follow the procedure outlined above for the combustibles calibration.

If you wish to skip the CO calibration proceed as in step 5. The following message will appear on the display:

"NOX SPAN GAS: 100 PPM"

prompting you to carry out this calibration.

The next calibration in line is sulfur dioxide and the following message will appear on the display;

"SO2 SPAN GAS: 200 PPM"

If you wish to carry out any of these calibrations, proceed as outlined in steps 6, 7 and 8. At the end of either step the following message will appear on the display:

"DRAFT SPAN: -05.0 in"

- (10) To obtain a span calibration of the draft sensor disconnect the gas bottle from the apparatus. Close the opening at the top of the sample tube using a suitable plug. Use the "UP" key to select a suitable draft calibration span between 5" and 10". Press the "ENTER" key.

The display will read:

"PUSH ENTER KEY"

and the pump will be on. Very slowly start closing the intake valve of the apparatus and observe the manometer reading climbing. Set the valve opening as soon as the manometer is reading the same pressure as that selected on the display.

Press the "ENTER" key again. The draft sensor will be calibrated to the value shown on the display.

You can easily check the accuracy of your calibration, by partially restricting the valve and measuring and comparing the draft with the manometer readout.

- (11) The final span calibration is the ambient temperature. Following the DRAFT calibration the following message will appear on the display:

"ATEMP OFFSET +0 C"

This calibration allows you to make minor corrections so that the ENERAC will read the exact ambient temperature.

At the end of the span calibration procedure the following message will appear on the display:

"WAIT TWO MINUTES!!"

The instrument is now purging any traces of remaining gas. At the end of the two minute period it will perform an "auto zero" and it will be ready by displaying any two stack parameters.

- (12) If there is something wrong with any of the sensors during span calibration, (i.e. if the sensor's output is not within the expected range) the instrument will display the message:

"CALIBRATION FAILED"

and will not calibrate for this sensor.

NOTE:

IF you wish to exit the span calibration procedure at any time, simply press the "SET" key and observe the "SET LED" turn off.

Whenever the message "FEED GAS NOW AND WAIT" appears, the ENERAC is inside a software loop and will not respond to any commands from the keyboard or communicate with the serial port.

APPENDIX A

ERROR MESSAGES & TROUBLESHOOTING

The ENERAC model 2000 is always going through a self checking procedure every time it is turned on. If there is a problem with the ENERAC, it will most probably due to one of the following four causes:

1. Sensor failure, or open sensor wire.
2. Discharged battery, or blown fuse.
3. Clogged filter, or damaged probe.
4. Thermal printer head failure.

It is highly unlikely that anything else will go wrong with the instrument, short of physical damage caused by abuse.

A. SENSOR FAILURE MESSAGES

If one of the sensor messages printed below, appears on the display, the instrument will stop its autozeroing procedure and wait for you to act. You have two options: You can either turn the unit off and look for the cause of the malfunction, or you can push the "ENTER" button to continue with the calibration. Thus, by pushing the "ENTER" button you can proceed to take measurements. Keep in mind, however, to discard all readouts of the parameter that did not autozero properly!

WARNING: THE AUTOZERO ERROR MESSAGES WILL ALWAYS APPEAR, IF YOU MISTAKENLY AUTOZERO THE INSTRUMENT WITH THE PROBE IN THE STACK!

ERROR MESSAGE

WHAT TO DO

"CONNECT PROBE-RESTART"

1. Make sure probe thermocouple is connected to unit.

"STEMP AUTOZERO ERROR"

1. Check t'couple electrical resistance (~10 ohms).

"OXY AUTOZERO ERROR"

1. Make sure wires to sensor are connected

properly.

2. Voltage on sensor wires must be >40 mV.
If not wait a day in case sensor got wet.

"CO AUTOZERO ERROR"

1. Check wiring connections.
2. Wait 24 hours in case sensor saturated from excess CO.

"COMB AUTOZERO ERROR"

1. Sensor needs additional warm up period.
Restart unit.
2. Sensor response is out of original specs.
Sensor is probably OK. Check with calibration gas.
3. Sensor is damaged by excessive moisture
Or combastible gas.

"DRAFT AUTOZERO ERROR"

1. Check wiring connections.
2. Check for clogged filter, or kinked hose.

"NOX AUTOZERO ERROR"

1. Allow sensor to recover from over exposure to gas concentrations.

"SO2 AUTOZERO ERROR"

1. Allow a few hours for the sensor to recover from over exposure to gas.
2. When replacing sensor check the wiring connections.

B. WARNINGS

The ENERAC has been designed to perform a number of diagnostic tests, while carrying out stack measurements.

If, during operation, it detects any conditions that will jeopardize the integrity of the instrument or its readings, it will warn the operator by displaying every 30 seconds a message that describes the nature of the warning. These messages, if activated can also be monitored remotely by using the WARN? command.

A list of the warning messages follows:

WARNING MESSAGE

WHAT TO DO

"AMBIENT TEMP TOO HIGH"	Check connection of thermocouple plug to instrument. Remove ENERAC from immediate vicinity to avoid sensor failure because of high ambient temp.
"STEMP HIGH EXTRACT PROBE"	Remove probe from stack to avoid damage to the thermocouple.
"CO HIGH EXTRACT PROBE"	Remove probe to avoid temporary failure of The CO sensor.
"REPLACE BLOCKED FILTER"	Excessive suction pressure. Check filter or hose for kinks.
"CALIBRATION FAILED"	Sensor did not respond to the span gas. Check sensor wiring or replace sensor.
"CO EXCEEDS ALARM"	The CO in the stack exceeds the preset alarm value.
"PRINTER PROBLEM"	Check printer paper, or printer connections.
"RS-232 PROBLEM"	Improper initialization at start up. Ignore unless you require serial communication. In that case, turn unit off then back on again. Bypass autozero.
"MODEM ON LINE"	A reminder that the ENERAC is still connected to the phone line.
"...SENSOR OUTDATED"	Sensor still functions, but expected life is now limited.
"...OVER....."	Value of stack parameter exceeds upper range limit.

"OPTIONAL... "

This option is not available in your unit.
Contact the factory.

C. ELECTRICAL FAILURE

SYMPTOM

WHAT TO DO

No lights, no display.

1. Plug AC cord. If still nothing:
2. Check connector from Power supply to PC board.
3. Check fuse.

Battery will not charge.

1. Check fuse and CHARGE LED.
2. Check voltage across battery. If <6 V. after full charge, replace battery.

D. PROBE PROBLEMS

SYMPTOM

WHAT TO DO

Oxygen too high in stack.

1. Check for kinked hose.
2. Check for clogged filter.
3. Tighten thumbscrew on probe handle.
4. Check for high draft.
5. Tighten housing cover.

Response too slow.

1. Check for clogged filter.
2. Check the type of desiccant and hose you use for NOX & SO₂ measurements!

E. PRINTER PROBLEMS

SYMPTOM

WHAT TO DO

Printer does not run

1. Make sure there is paper in the printer.
2. Make sure paper goes through paper check sensor.

Missing dots on letters

1. Replace thermal head.

APPENDIX B

MODEL 2000 SPECIFICATIONS

PHYSICAL:

1. CASE: 18"X13"X6" Aluminum carrying case with lock. Weight: 15 lbs.
2. PROBE: 13"L.x3/8"OD. Inconel probe with aluminum handle and 10 ft. braided hose std. (Other sizes optional.) (Condensation trap is included).

ELECTRICAL:

1. BATTERY: 6V. rechargeable sealed lead-acid cell. Four hour continuous battery operation . Quick 4 hour recharge.
2. AC : 120V. 60 Hz. std. (220V. 50 Hz. optional), 1A.

DISPLAY:

0.5"High by 24 Character single line LCD with backlight illumination and adjustable viewing angle.

MEASURED PARAMETERS:

- | | |
|--------------------------|---|
| 1. AMBIENT TEMPERATURE | IC sensor. Degrees F or C.
Range: 0-150 degrees F
Resolution: 1 degree F or C.
Accuracy: 3 degrees F. |
| 2. STACK TEMPERATURE | Type K thermocouple. Degrees F or C
Range: 0-2000 degrees F (-1100 C).
Resolution: 2 degrees F.(1 C.)
Accuracy: 5 degrees F. |
| 3. OXYGEN | Electrochemical cell. Life 1 year.
Range: 0-25%
Resolution: 0.1%
Accuracy: 0.2% |
| 4. NITROGEN OXIDES (NOX) | Electrochemical cell.Life 2 years.
Range: 0-2000 PPM.
Resolution: 2 PPM
Accuracy: 5% of reading. |

- | | |
|-------------------------|--|
| 5. CARBON MONOXIDE | Electrochemical cell. Life 2 years.
Range: 0-2000 PPM
Resolution: 2 PPM
Accuracy: 5% of reading. |
| 6. SULFUR DIOXIDE | Electrochemical cell. Life 2 years.
Range: 0-2000 PPM.
Resolution: 2 PPM
Accuracy: 5% of reading. |
| 7. COMBUSTIBLES (GASES) | Semiconductor sensor. Life indefinite.
Range: 0-2.50%
Resolution: 0.01%
Accuracy: 10% of reading in CH ₄ gas |
| 8. DRAFT | Piezoresistive sensor.
Range: +10.0 to -40.0 inches water.
Resolution: 0.1" water.
Accuracy: 5% of reading. |
| 9. SMOKE. | Smoke spot method, 0-9 smoke numbers in unit increments.
Automatic timing. |
| 10. TIME/DATE | Time in hours, minutes, seconds. Date in month, day, year format. |

COMPUTED PARAMETERS:

- | | |
|--------------------------|---|
| 1. COMBUSTION EFFICIENCY | Heat loss method. Unique four loss factors computation. (dry gas, water vapor, gaseous combustibles, combustibles in ash)
Range: 0-100%
Resolution: 0.1%
Accuracy(4 loss): 1% (above H ₂ O condensation), 2% (below H ₂ O) |
|--------------------------|---|

condensation)

- | | |
|---|---|
| 2. CARBON DIOXIDE | Range: 0-40%
Resolution: 0.1%
Accuracy: 5% of reading. |
| 3. EXCESS AIR | Range: 0-1000%
Resolution: 1%
Accuracy: 10% of reading |
| 4. EMISSIONS 1
(CO, NOX, SO ₂) | Range: 0-2500 milligrams/cubic
meter
Resolution: 2 mg/m ³
Accuracy: 5% of reading |
| 5. EMISSIONS 2
(CO, NOX, SO ₂) | Range: 0.000-0.999 lbs./million BTU
Resolution: 0.001 lbs./MMBTU
Accuracy: 7% of reading |

(Oxygen correction factor for emissions adjustable 0-20% in 1% steps plus TRUE)

PRINTER.

SEIKO 4",40 char. per line thermal printer with form feed and line feed buttons and with end of paper override.

Operates in any of three modes:

1. TEXT MODE. 25 line printout of instant. values of all measured parameters. (time req.20 sec.)
2. PLOT MODE. Any one parameter vs. time plotted. 3 ordinate scales: full, half,quarter. Time scale: Selectable,1 sec/dot-1 min/dot in 1 sec/dot intervals. 3 parameter plot CO-OXYGEN-EFFICIENCY, single scale.
3. EXTERNAL PRINT MODE. Prints messages sent via RS-232 port.

STORAGE:

1. INTERNAL 99 individually selectable buffers hold one complete set of measurements each in non volatile

memory. Buffer contents can be sent to printer or RS-232 port.

COMMUNICATIONS:

1. RS-232 PORT Full RS-232c port (DTE), 1200 baud, half duplex, 1 start bit, 8 data bits, 1 stop bit, no parity.
2. TELEPHONE PORT Internal 1200 baud modem connects to a modular phone line for remote communication. (A 50 word command set sends instructions to the unit for remote control and troubleshooting).
3. SOFTWARE ENERCOM™ for Windows™ software . 3 1/2" diskette includes MONITOR, ALARMS, FUEL PROGRAMMING, BAR GRAPHS and LINE PLOTS.

MISCELLANEOUS:

1. FUELS 15 fuels, 3 in foreground, 12 in background standard. Custom fuels available on request.
2. CO ALARM Selectable 0-2000 PPM in 10 ppm steps.
3. COMBUSTIBLES IN ASH Presetable 0-100% in 5% steps.
4. MESSAGES One hundred diagnostic and help messages.
5. CALIBRATION Optional Autozero on start up. Software span calibration CO, NOX, SO₂, combustibles and draft.

APPENDIX C

INSTALLATION INSTRUCTIONS FOR MODEL 2000 OPTIONS

A. PRINTER INSTALLATION. (REQUIRES SOLDERING)

To install the printer some soldering experience is required.

Open the printer package. (It includes the printer, a controller chip, four screws and a roll of thermal printer paper).

Loosen the thumbscrew on the ENERAC's faceplate and open the hinged plate. Carefully insert the controller chip in its socket with pin #1 located on the upper right hand side (i.e. letters on chip upside down). Make sure that all pins are properly inserted in their sockets.

Place the printer on its supports and use the four screws that are supplied to secure it to the threaded standoffs.

Remove the insulating tape from the flexible 25 pin connector and carefully solder all 25 connector pins to the front of the printer.

Connect the four wire connector to its appropriate header on the PC board.

Call the factory to have the printer option enabled.

B. MODEM INSTALLATION

Handle the modem board with care.

Open the ENERAC hinged plate and locate the two modem cables. One cable is a 20 conductor cable and the other is a 2 conductor cable. They are already connected to the ENERAC PC board and their ends should be located under the printer paper.

Take the modem board locate the 20 pin and the 2 pin header on it and rotate it, so that the 20 pin header is located on the right hand side (when looking at the ENERAC).

Slide the modem board underneath the ENERAC PC board (below the printer paper) and connect the 2 conductor cable to the modem board 2 pin header. Orientation is not important, just make sure both pins are connected to the cable!

Connect the 20 conductor cable to the modem board 20 pin header making sure that the conductor originating on the left hand side of the ENERAC PC board (red stripe) terminates on bottom side of the modem board header. Make sure that all 20 header pins are inserted in the cable socket!

Remove the paper that covers the adhesive pads, slide the modem board underneath and to the left of the thermal paper and press it firmly to the bottom of the instrument case.

The modem is ready to answer any incoming call.

Contact the factory to have the dialing function of the modem enabled!

C. CO SENSOR REPLACEMENT (MODEL 2000)

Make sure the instrument is turned off!

Raise the ENERAC's hinged plate and locate the CO sensor on the side of the white plastic sensor housing.

Disconnect the three sensor wires.

Remove the three screws that secure the sensor to the housing.

Look into the opening in the sensor housing where the CO sensor was attached and see if there is a teflon shoulder washer wedged in the opening. (If there is no washer, you must install the one that comes with the replacement sensor.

Open the small package that contains the shoulder washer and the small circular white membrane. Place the membrane over the opening and place the shoulder washer over the membrane, the flat part of the washer resting on the membrane. Slowly push the membrane-washer assembly into the opening, wedging the washer into the hole as far as it will go. Make sure the membrane does not slide to one side of the hole!)

Place the O-ring in its groove and secure the new sensor with the three screws.

Remove the shorting spring from the two sensor terminals.

Connect the three sensor wires to the sensor pins observing the correct color code. (R-Red, G-Green, B-Black).

Close the hinged plate and wait 5 minutes.

Turn the instrument on and go through the AUTOZERO.

Span calibrate the CO sensor following the instructions in your manual.

D. NOX SENSOR INSTALLATION

To install a new NOX sensor, raise the ENERAC's hinged plate exposing the bottom side of the white plastic sensor housing.

Remove the metal disk cover that is located nearest to you (when facing the ENERAC) from the sensor housing. Don't loose the O-ring! Make sure that the O-ring is located properly in its groove. Place the NOX sensor on top of the O-ring with all three sensor pins facing towards the pump. Secure the sensor with the three screws provided.

Locate the three wire NOX sensor cable near the base of the pump. (It is the cable with the ORANGE, BLUE and WHITE wires). Cut the black nylon tie wrap that holds the cable near the pump and remove the insulation tubing from the the three conductor pins.

Connect the three wires to the NOX sensor pins as follows:

ORANGE	wire to Sensor pin marked G
WHITE	wire to Sensor pin marked B.
BLUE	wire to Sensor pin marked R.

Close the ENERAC faceplate and contact the factory to have the NOX measurement option enabled and the date code of your sensor inserted!

NOTE: If you have purchased a precalibrated NOX sensor, the factory will enter

into the ENERAC the sensor's span sensitivity, so that no gas calibration is required after installing the new sensor.

E. SO₂ SENSOR INSTALLATION

To install a new SO₂ sensor, raise the ENERAC's hinged plate exposing the bottom side of the white plastic sensor housing.

Remove the metal disk cover that is located nearest to the pump (when facing the ENERAC) from the sensor housing. Don't loose the O-ring!

Make sure that the O-ring is located properly in its groove. Place the SO₂ sensor on top of the O-ring with all three sensor pins facing towards the pump. Secure the sensor with the three screws provided.

Locate the three wire SO₂ sensor cable near the base of the pump. (It is the cable with the GREEN, WHITE/BLACK AND RED/BLACK wires). Cut the black nylon tie wrap that holds the cable near the pump and remove the insulation tubing from the the three conductor pins.

Connect the three wires to the SO₂ sensor pins as follows:

GREEN	wire to Sensor pin marked G.
WHITE/BLACK	wire to Sensor pin marked B.
RED/BLACK	wire to Sensor pin marked R.

Close the ENERAC faceplate and contact the factory to have the SO₂ measurement option enabled and the date code of your sensor inserted!

NOTE: If you have purchased a precalibrated SO₂ sensor, the factory will enter into the ENERAC the sensor's span sensitivity, so that no gas calibration is required after installing the new sensor.

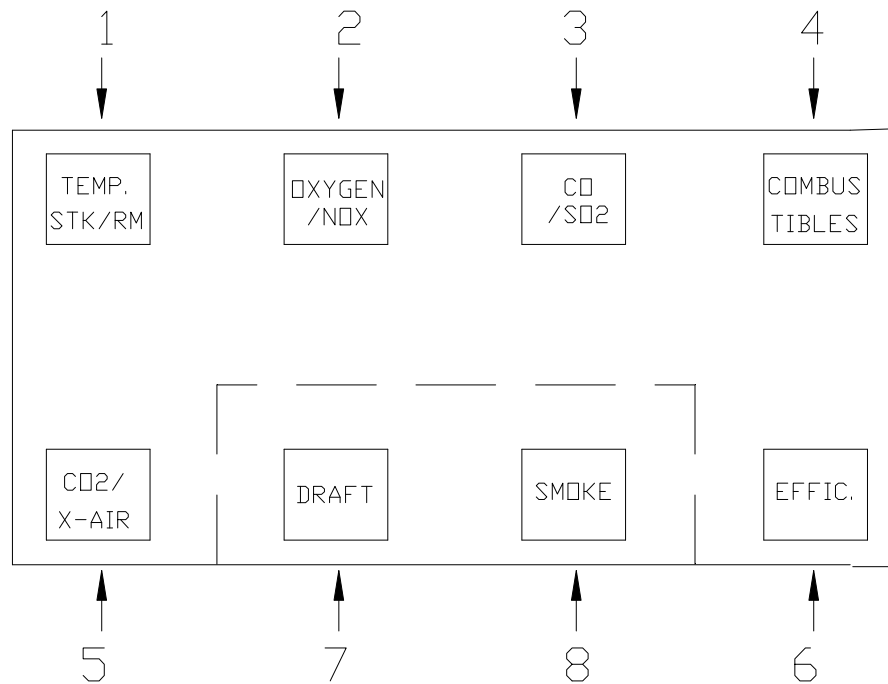
F. STORAGE OPTION INSTALLATION

You must have a modem to enable this option, remotely. No hardware installation is required. Just contact the factory.

G. PLOTTER OPTION INSTALLATION

You must have a modem to enable this option, remotely. You must have a printer already installed in the ENERAC. No hardware installation is required. Just contact the factory.

THE BASIC OPERATING BUTTONS



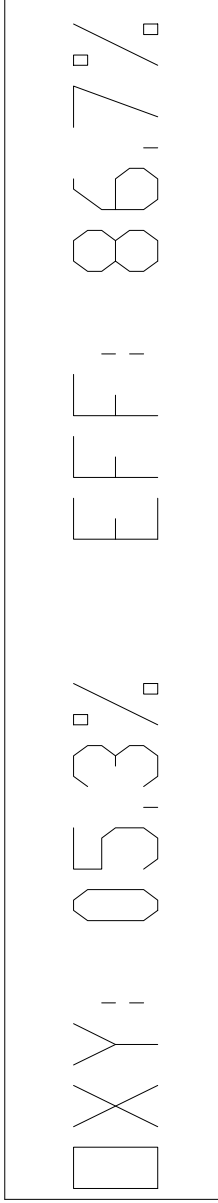
INSTANTANEOUS READOUTS

1. SWITCH TOGGLES BETWEEN AMBIENT & STACK TEMPERATURES
2. SWITCH TOGGLES BETWEEN OXYGEN & OXIDES OF NITROGEN
3. SWITCH TOGGLES BETWEEN CARBON MONOXIDE & SULFUR DIOXIDE
4. SWITCH DISPLAYS GASEOUS COMBUSTIBLES
5. SWITCH TOGGLES BETWEEN CARBON DIOXIDE & EXCESS AIR
6. SWITCH DISPLAYS COMBUSTION EFFICIENCY

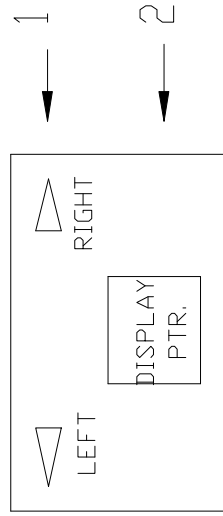
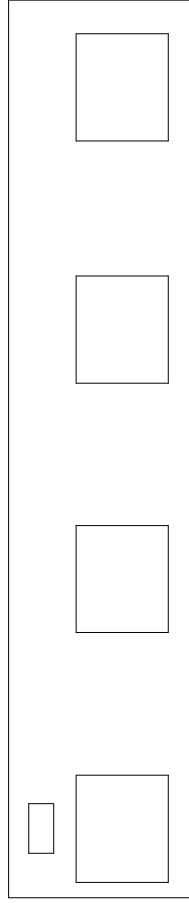
TIME MEASUREMENTS

7. SWITCH EXECUTES DRAFT MEASUREMENT
8. SWITCH EXECUTES SMOKE SPOT TEST

FIG. 1



VIEWING
ANGLE



1. LEADS INDICATE ACTIVE HALF OF DISPLAY WHEN THE NEXT BUTTON IS PUSHED. ALSO WHICH PARAMETER WILL BE PLOTTED.
2. SWITCH TOGGLES DISPLAY "ACTIVE" SIDE LEADS
3. POTENTIOMETER ADJUSTS VIEWING ANGLE OF DISPLAY.

DISPLAY BACKLIGHTING SWITCH IS LOCATED UNDER THE HINGE PLATE ON PC BOARD

FIG. 2

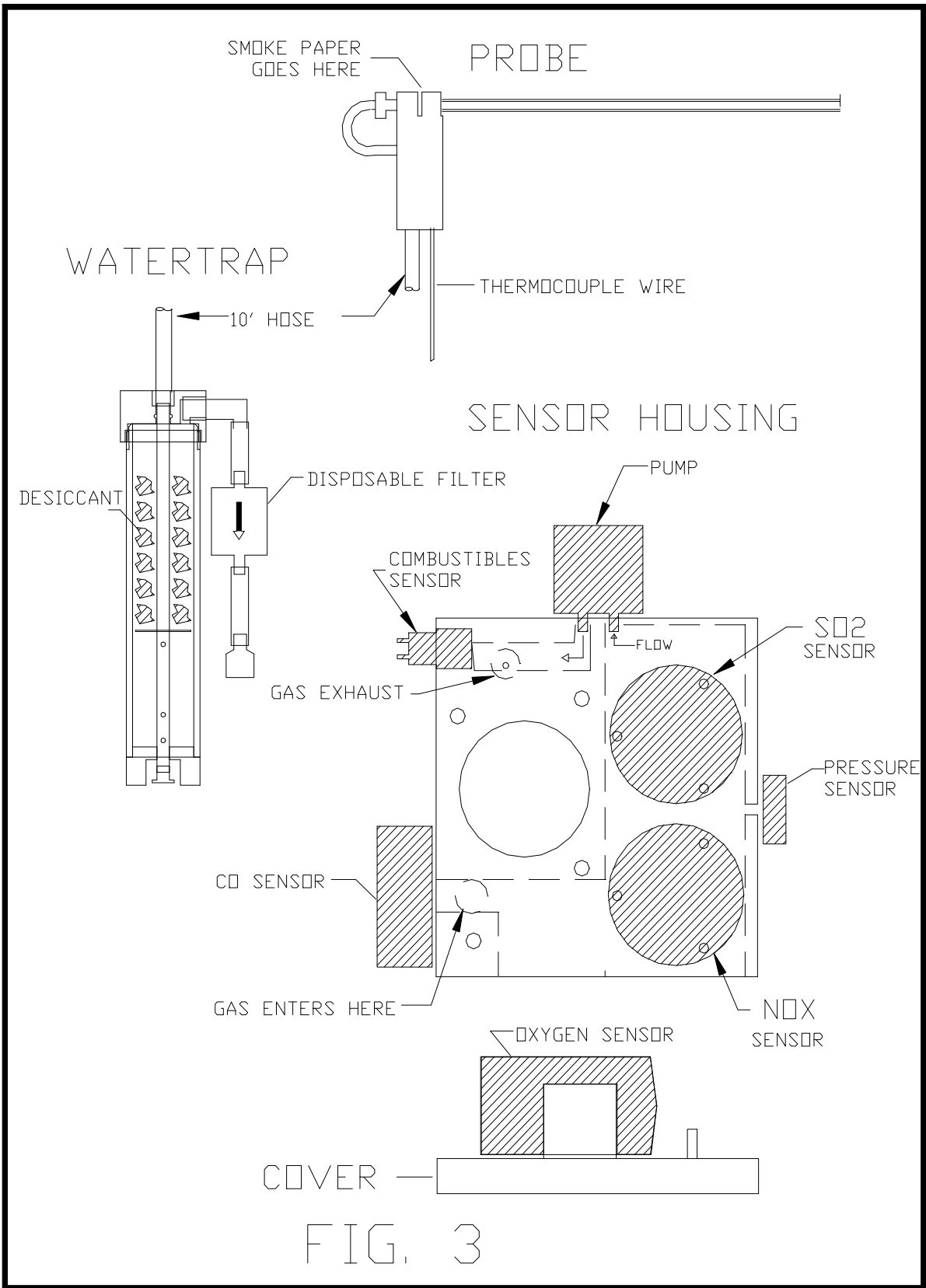
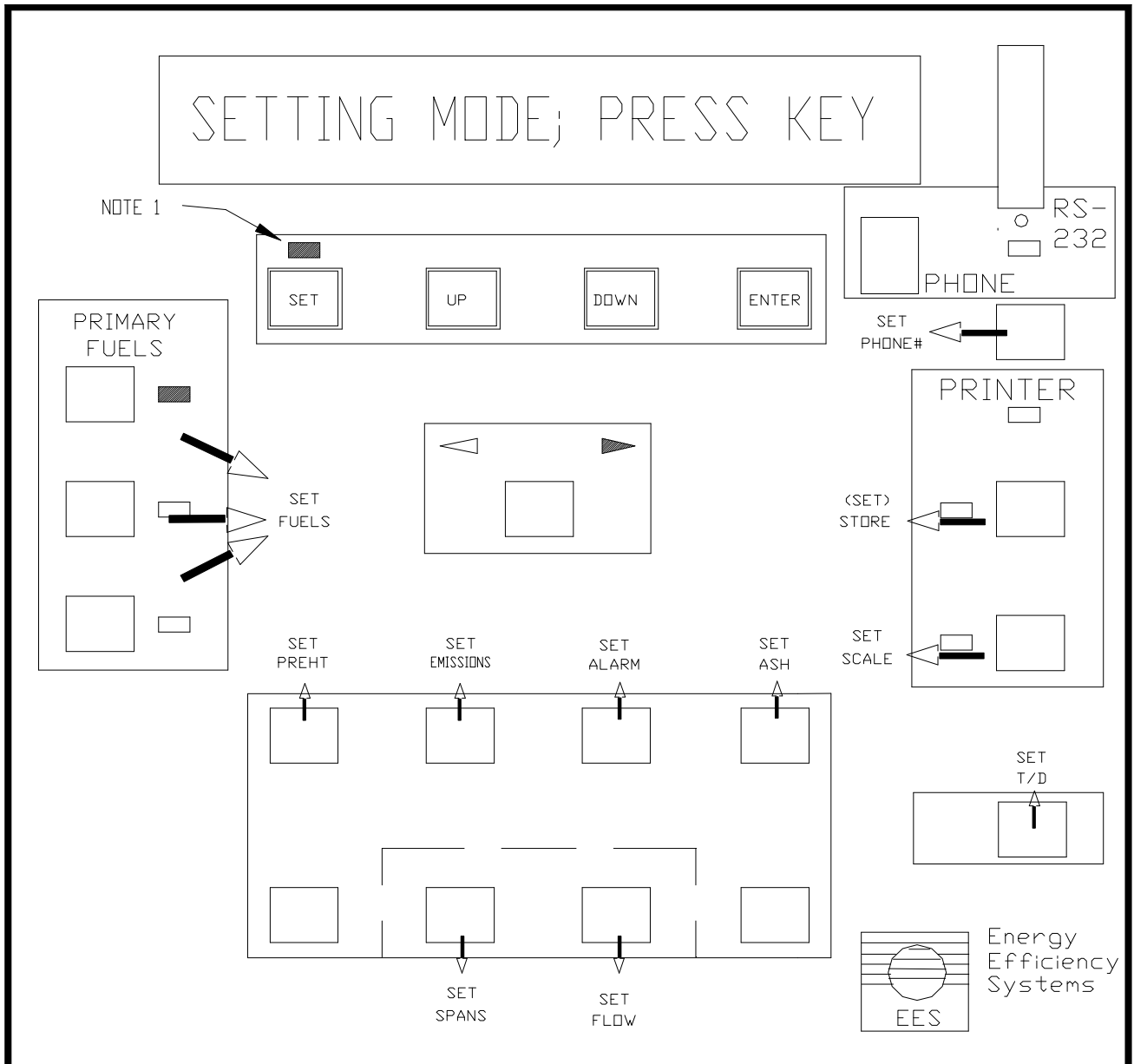


FIG. 3

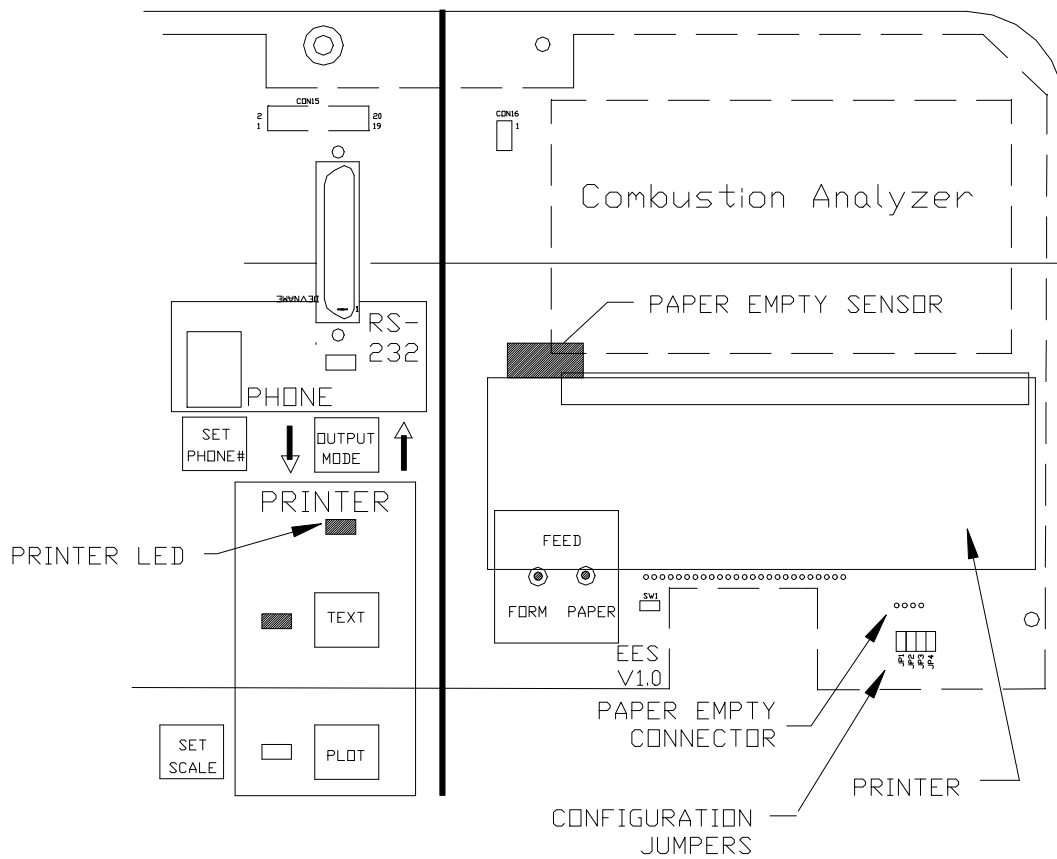


NOTE 1: LED ON-SETTING MODE; LED OFF-MEASURING(NORMAL) MODE

"SET" BUTTON: TOGGLES BETWEEN SETTING & MEASURING MODE
 "UP" & "DOWN" BUTTON: INCREMENTS/DECREMENTS VALUE OF PARAMETER BEING SET.
 "ENTER" BUTTON: SHIFTS CURSOR TO THE NEXT DIGIT TO BE SET.
 ARROWS SHOW THE CORRESPONDENCE BETWEEN BUTTONS & SETTING PARAMETERS.
 TO SET A PARAMETER PUSH "SET" BUTTON FIRST TO TURN "SET" LED ON.

FIG. 4

PRINTER OPERATION



1. PRINTER LED MUST BE ON TO OPERATE THE PRINTER
2. "OUTPUT MODE" SWITCH TOGGLES(CONTROLS) PRINTER/OUTPUT OPERATION
3. PUSH "TEXT" BUTTON TO GET PRINTOUT OF CURRENT VALUES
4. PUSH "PLOT" BUTTON TO START PLOTTING "ACTIVE" PARAMETER
5. PUSH "PLOT" BUTTON AGAIN TO STOP PLOTTING
6. "PAPER FEED" SWITCH ADVANCES PAPER BY ONE LINE

NOTE: COMPONENTS LOCATED UNDER FACEPLATE ARE SHOWN DASHED

FIG. 5

PUSH THIS BUTTON

DISPLAY READS

SET

SET MODE;PRESS KEY

TEXT

TEST #1 FUNC=STORE

UP ○ ○ ○ ○ ○ UP

TEST #7 FUNC=STORE

ENTER

TEST #7 FUNC=STORE

UP ○ ○ ○ ○ ○ UP

TEST #7 FUNC=PRINT

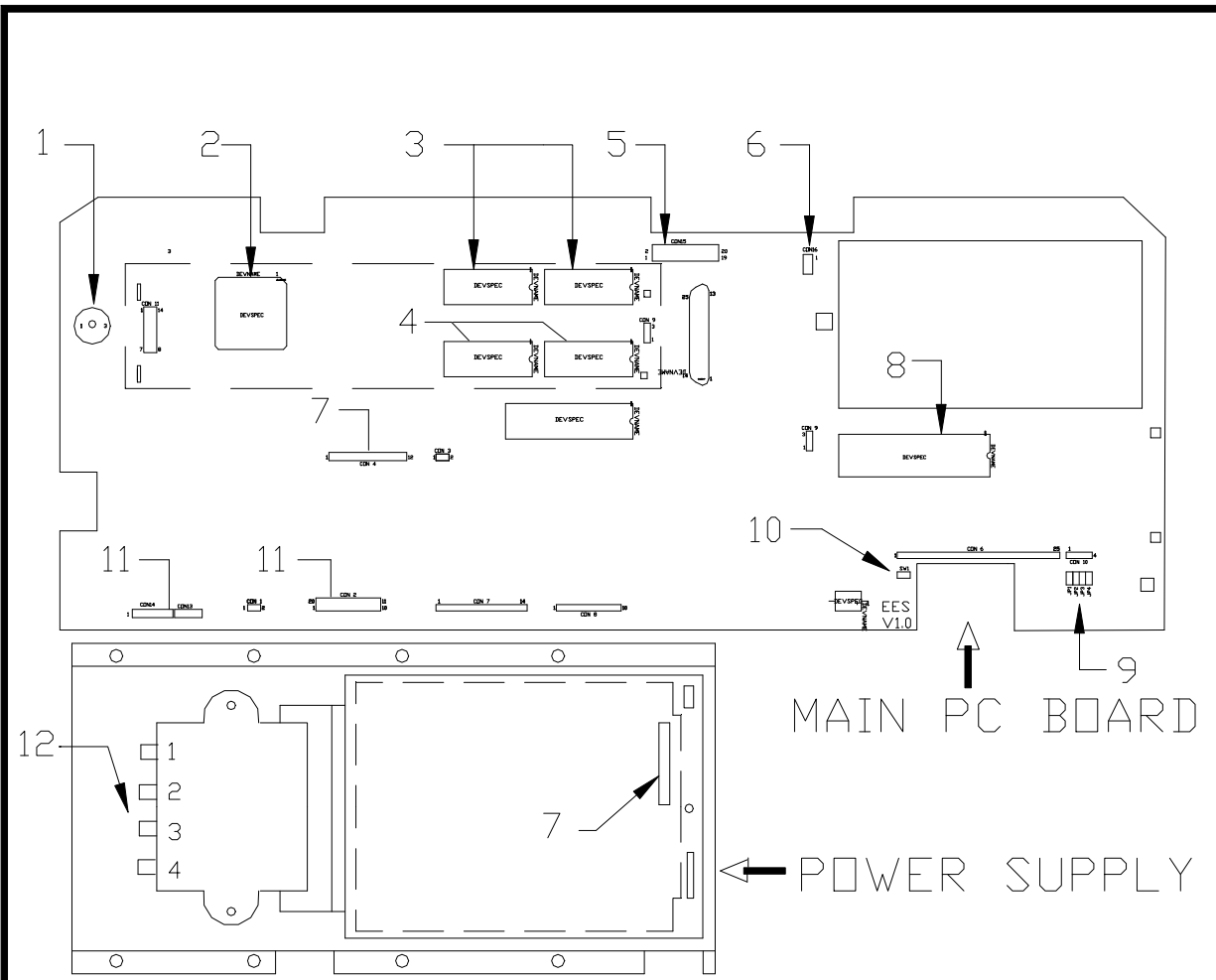
ENTER

PRINTER OPERATES

ANY BUTTON

THIS EXAMPLE SHOWS HOW TO PRINT DATA STORED IN TEST #7.

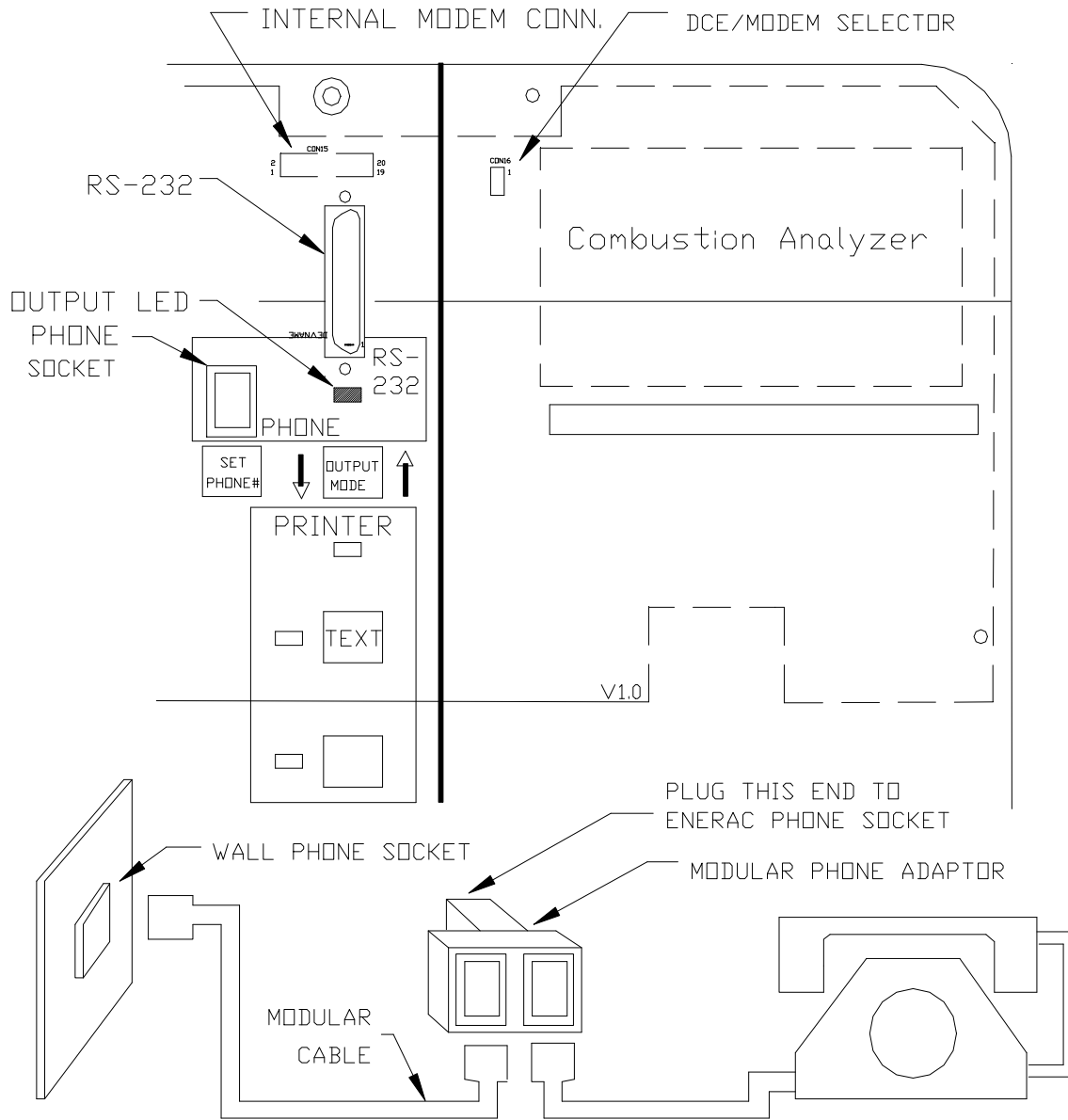
FIG. 6



- | | |
|---|---|
| <ul style="list-style-type: none"> 1. VIEWING ANGLE ADJUSTMENT 2. INTEL 16 BIT MICROCONTROLLER 3. (2) 16KX8 EPROMS 4. (2) 8KX8 SRAMS 5. INTERNAL MODEM CONNECTOR 6. MODEM/RS-232 SELECTOR | <ul style="list-style-type: none"> 7. BOARD POWER CONNECTOR 8. 8 BIT MICROCONTROLLER 9. PRINTER CONFIGURATION SWITCH 10. DISPLAY BACKLIGHTING SWITCH 11. SENSOR CONNECTORS 12. POWER TRANSFORMER 120V./220V. WIRING ARRANGEMENT |
|---|---|

FIG. 7

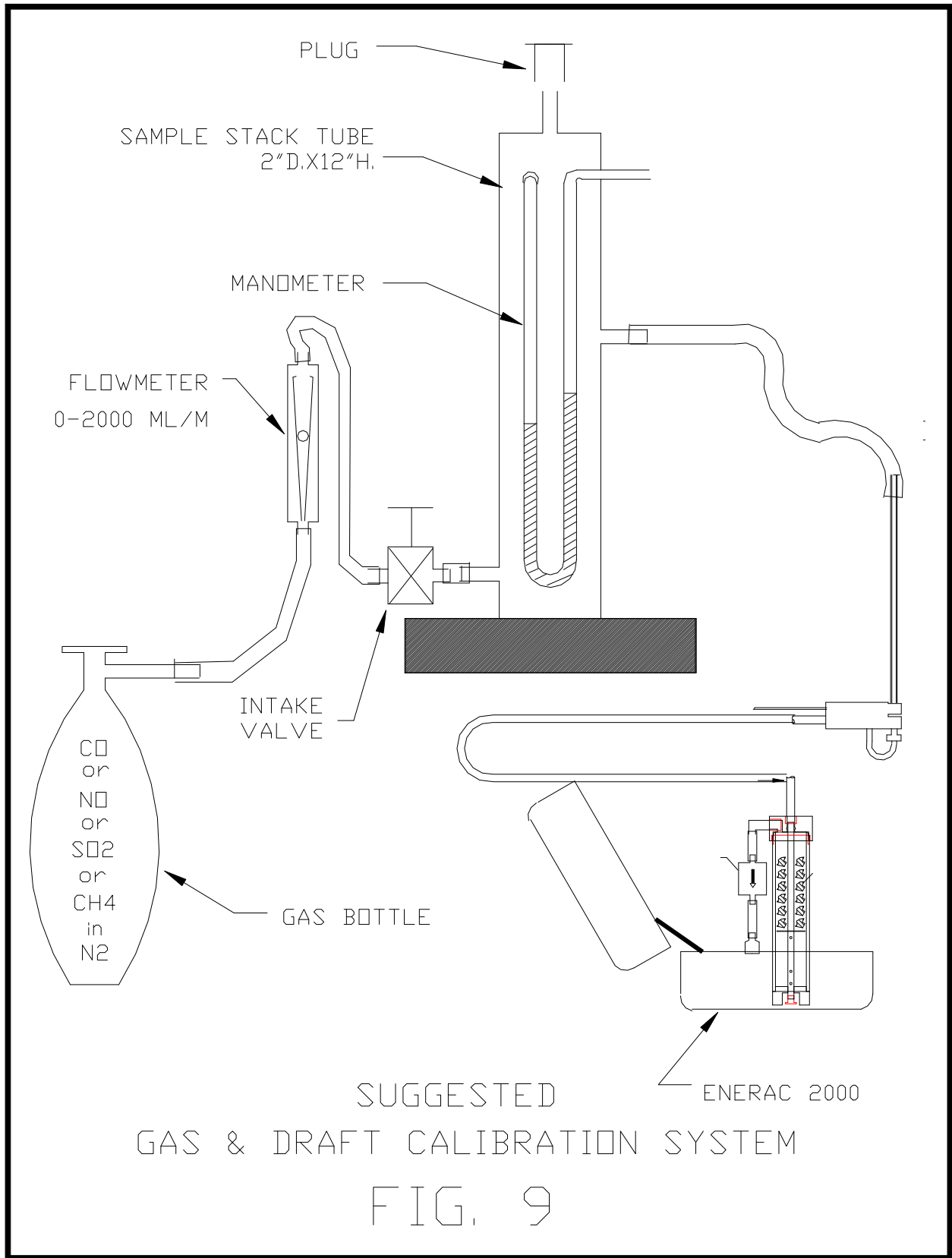
OUTPUT OPERATION

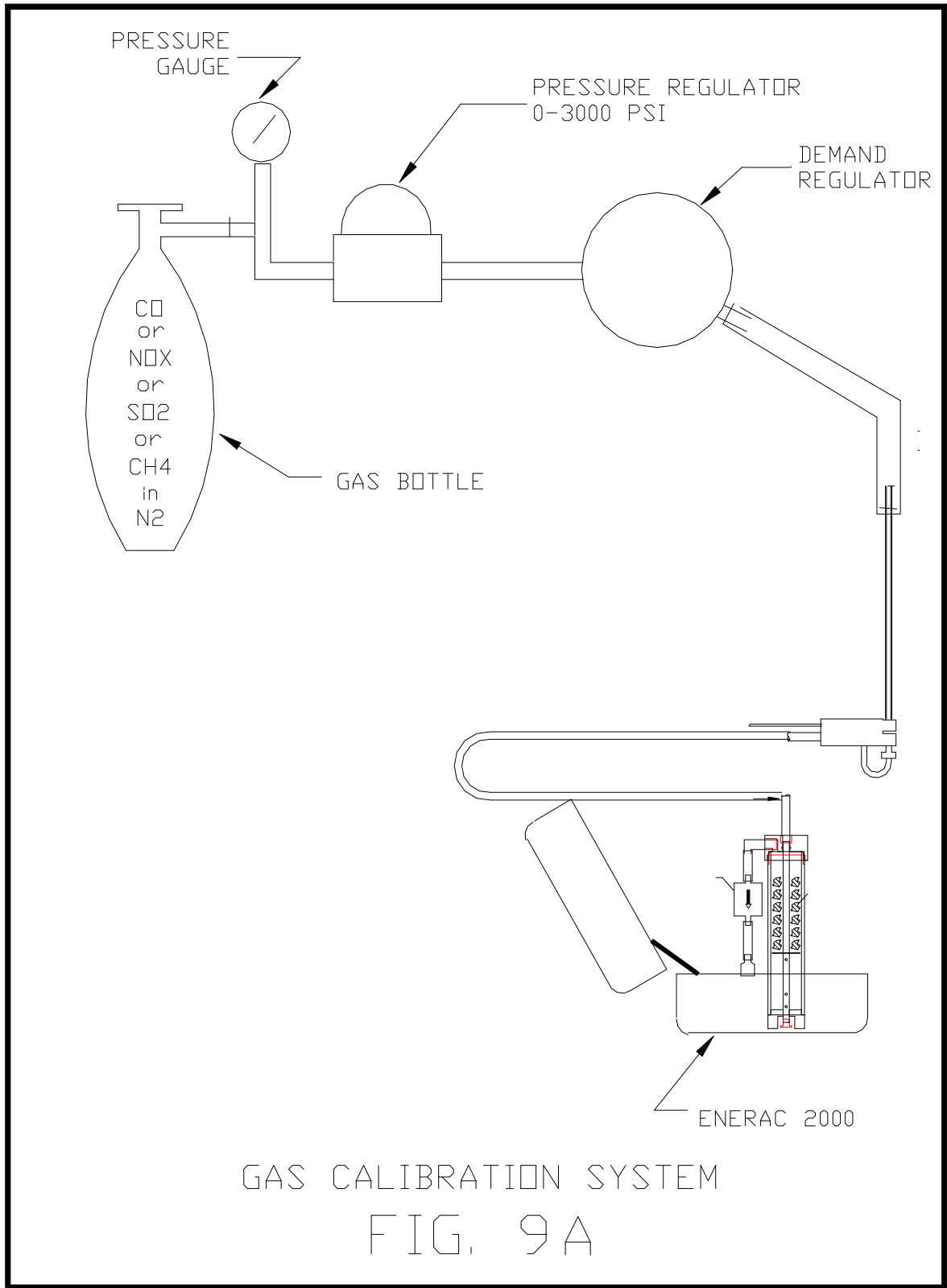


1. OUTPUT LED MUST BE ON TO ACTIVATE EITHER OUTPUT
2. PHONE OUTPUT IS OPERATIONAL IF THERE IS AN INTERNAL MODEM
3. CONNECT EXTERNAL COMPUTER TO RS-232 PORT
4. PUSH "TEXT" BUTTTON TO SEND CURRENT VALUES TO RS-232

NOTE: COMPONENTS LOCATED UNDER FACEPLATE ARE SHOWN DASHED

FIG. 8





GAS CALIBRATION SYSTEM
FIG. 9A