# Environics®

## SERIES 100 MULTI GAS CALIBRATOR

## OPERATING AND SERVICE MANUAL

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Edition: 1/90
Revision: 3

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# Environics

## Operating Manual Addendum

| SYMBOLS USED | PUBLICATION | MEANING |
|---|---|---|
|  | ISO 3864, No. B.3.1 | CAUTION (Refer to accompanying documents).<br>Refer to specific WARNINGs and CAUTIONs in Operating Manual. |
|  | IEC 417, No. 5019 | PROTECTIVE CONDUCTOR TERMINAL |
|  | IEC 417, No. 5007 | ON (SUPPLY) |
|  | IEC 417, No. 5008 | OFF (SUPPLY) |

## POWER CONNECTION

The main power disconnect for the unit shall be the power cord that is plugged into the rear of the unit. The instrument is totally enclosed at all times with a top and bottom cover for safety.

**WARNING**

DISCONNECT POWER CORD FROM REAR OF UNIT BEFORE SERVICING.

Series S-100
Multi-Gas Calibrator

Environics, Inc.
69 Industrial Park Road East
Tolland, Connecticut 06084

Equipment summary - Type: ( x ) Measurement; ( ) Control; ( ) Laboratory

Marked electrical rating (including any applicable tolerance or fluctuations):

115VAC, 50-60 Hz, 2A
230VAC, 50-60 Hz, 1A

| | |
|---|---|
| Connection to Supply: Connected | Standard IEC Inlet Coupler/Cord |
| Environmental rating: | Standard |
| Temperature: | 15-30 deg C |
| Humidity: | <95% RH @ 15-30 deg C |
| Altitude: | up to 2000 Meters |

Equipment function/feature/description:
S-100 was designed for precision Multi-Gas Calibrations with Ozone
Mode of operation:
Concentration Mode, Flow Mode, Program Mode, Calibrate Mode

Degree of mobility:
( )Permanently Connected; (X) Other Cord Connected

Overall size/weight: 65 lbs

# I. INTRODUCTION

## I.A. GENERAL THEORY AND OPERATION

The Environics Series 100 Computerized Multi-Gas Calibrator is designed for single or multi-point calibration of continuous ambient air quality measurement systems. This includes monitors for Ozone ($O_3$), Sulfur Dioxide ($SO_2$), Nitrogen Dioxide ($NO_2$), Nitric Oxide (NO), Carbon Monoxide (CO) and Methane ($CH_4$). The Series 100 may also be used for the precise blending of gases for laboratory analytical use and calibration of gas analytic devices.

The basic Series 100 instrument, for blending and dilution of cylinder gases, consists of a single chassis supporting two mass flow controllers, a mixing chamber, and a complete electronics package. One flow controller is for high flows of dilution gas such as zero air or nitrogen; the other controller is for low flows in controlling analyte or calibration (span) gas. Each flow controller is factory calibrated using an NBS traceable primary standard at points across its range of flow. The Series 100's microcomputer fits a least squares line through these data points to compensate for flow controller inaccuracy and non-linearity.

In order to calibrate monitors for hydrocarbons, nitric oxide, sulfur dioxide and carbon monoxide, high concentration cylinders of these gases are connected to inlet ports on the unit together with appropriate diluent gas supplies. The instrument software allows the user to blend/dilute or generate gas standards using front panel selection of simple input and output parameters.

The Series 100 unit incorporates the ability to perform gas phase titration of nitric oxide with ozone for the generation of nitrogen dioxide. With this feature the chassis supports an ozone generation module, a reaction chamber and appropriate electronics.

Ozone calibration is done by producing known concentrations of $O_3$ from this ozone generator. This generator is voltage controlled and thermally stable, using a low pressure mercury vapor lamp and a precision optical feedback circuit.

The other useful and innovative functions which are part of the Series 100 unit are described in detail in this manual.

Environics is pleased to have supplied you with a quality product utilizing state-of-the-art electronic technology and significant user benefits. Your purchase is supported by a knowledgeable factory service team ready to assist you in the use of this instrument.

## I.B. INSTRUMENT DESCRIPTION

### I.B.1. Rear Panel

The standard rear panel configuration of the Environics Series 100 is shown below.

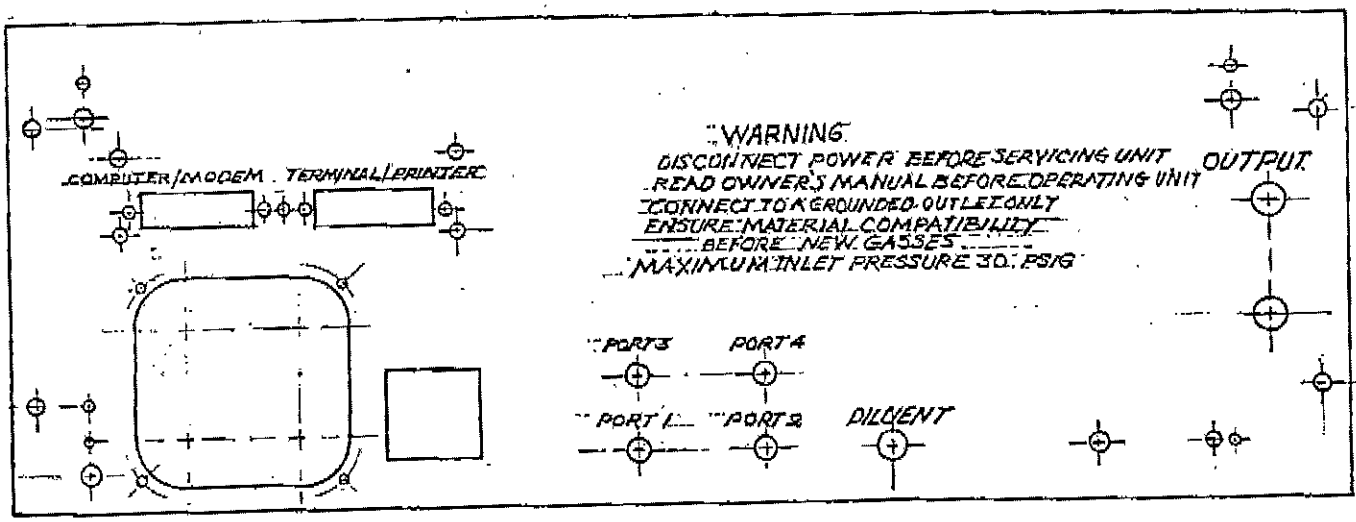



ILLUSTRATION I

Four (4) gas inlet ports (1/8 inch compression type fittings) are provided and labelled GAS PORT 1 through 4. This allows for the connection of four separate analyte (span) gas cylinders.

CAUTION! MAXIMUM GAS INLET PRESSURE IS 30 POUNDS PER SQUARE INCH. OVER PRESSURIZATION OF THE SERIES 100 MAY DAMAGE THE SOLENOIDS AND WILL VOID THE WARRANTY. OVER PRESSURIZATION WILL CAUSE THE SOLENOIDS TO LEAK AND MAY RESULT IN RISK OF PERSONAL INJURY.

A 1/4 inch compression type fitting (labelled DILUENT AIR) is provided for inlet of diluent gas. This gas is usually zero air.

There is a 1/4 inch compression type fitting (labelled OUTPUT) for conveying the blended/diluted gas to an instrument being calibrated, an injection valve, storage container or other use point.

CAUTION! BEFORE CALIBRATING ANY MONITOR OR GAS ANALYTIC DEVICE BE SURE TO CONSULT MANUFACTURER'S SPECIFICATIONS WITH RESPECT TO CALIBRATION GAS FLOW RATES. OVER PRESSURIZING A MONITOR OR GAS ANALYZER DURING CALIBRATION MAY DAMAGE IT.

The fuse holder contains a fuse of the size shown on the top of the holder. The fuse should be replaced with a fuse having the same rating as shown.

I.B.2 Rear Panel - Optional Items

a. Status Board

The rear panel of the Series 100 instrument may contain a 20 pin terminal block and Status Board.

The status board consists of 8 independent status lines, 2 analog outputs (after the necessary connections are made inside the unit), and a +24 volt supply. The terminal block on the back of the instrument is numbered consecutively from 1 through 20, left to right. An example of the pinout of the terminal block is listed below. (Please refer to the specific description packaged with your instrument for the exact functions and pin numbers).

| Pin numbers | Description |
|---|---|
| 1-2 | Active in the Zero mode |
| 3-4 | Active in the Blend mode |
| 5-6 | Active in the Gas Phase Titration Mode |
| 7-8 | Active in the Ozone mode |
| 9-10 | Not used |
| 11-12 | Not used |
| 13-14 | Recovery mode timer output |
| 15-16 | Not used |
| 17-18 | Can be tied to internal test points |
| 19-20 | +24 volts and ground |

b. RS-232 Serial Data Interface

The Series 100 may be ordered with two-25 pin female connectors for an RS-232 Serial Data Interface. The COMPUTER/MODEM "port/connector" provides for a remote communication to and operation of the instrument through a PC or modem. The PRINTER/TERMINAL "port/connector" allows for the down loading of data to a serial printer.

I.B.3. Front Panel

All of the Series 100 functions are accessed and controlled by the user from the front panel of the device - See Illustration II.

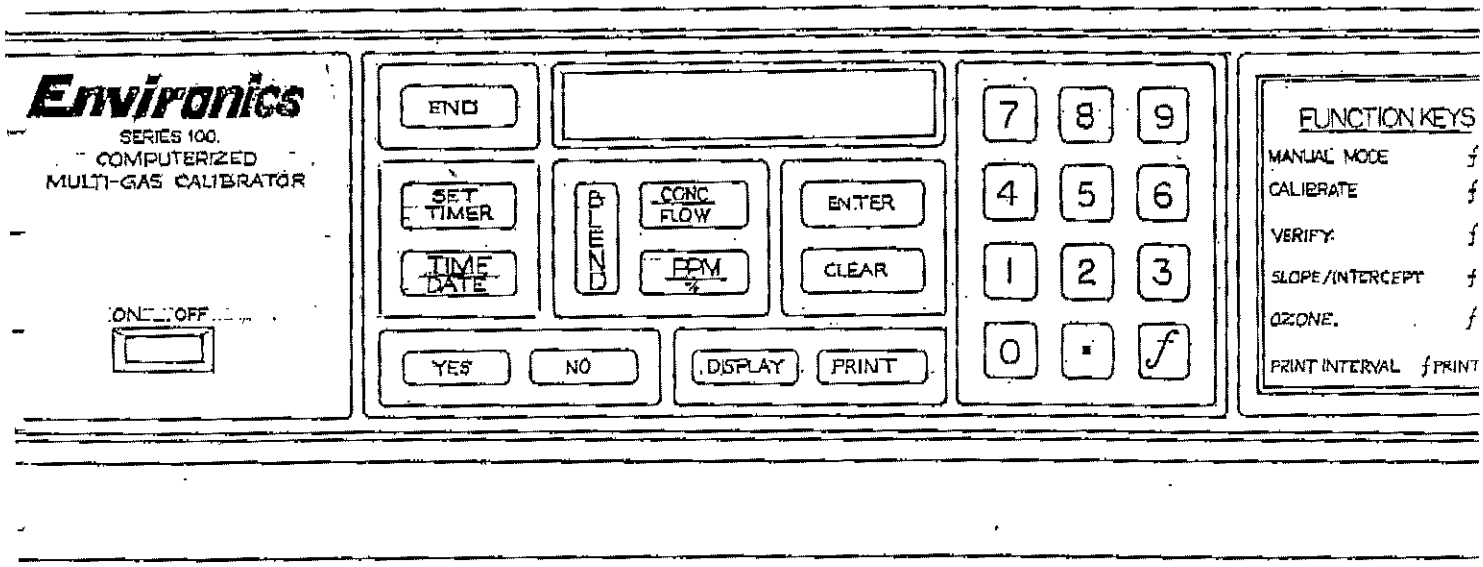



ILLUSTRATION II

In addition to the POWER ON/OFF switch, the front panel consists of a number of touch sensitive membrane switches and a 16 character LED display. A brief description of each follows (additional information on keyboard functions is provided in Section II-Instrument Operation.)

| | |
|---|---|
| ON/OFF | Power Switch - (NOTE! THE STANDARD UNIT OPERATES ON 115 V ONLY; 230V VOLTAGE OPTIONAL. Operating the Series 100 at an incorrect line voltage will damage the instrument and void the warranty. Check line voltage before plugging in. Turning the machine "off", then "on" returns it to the READY state for beginning a new sequence. |
| END | Allows the user to "end" a sequence at any time, returning the instrument to a READY state. |
| SET TIMER | Accesses the routine which allows programmable automatic blends/dilutions or manual flows, etc. over a seven (7) day period. |
| TIME-DATE | Allows the user to set/reset the time and the date in the Series 100's memory for dating and controlling the SET-TIMER routine and for optional printout. |
| BLEND | Enters BLEND routine to deliver precise concentrations at the flow selected. The Series 100 instrument can blend from cylinder gases (such as carbon dioxide or zero air for the analyte and diluent gases respectively) with or without the addition of the ozone generator for gas phase titration for calibration of Ozone and $NO_x$ monitors. |
| CONC/FLOW | In the BLEND routine, the LED will display the output gas concentration (OGC=_____ppm or %) Pressing this switch will change the LED to show total flow (MFT=_____sccm.) |
| PPM/% | Converts LED reading of cylinder gas concentration and output gas concentration to PPM from % (or from % to PPM.) |
| YES NO | Many of the Series 100 functions require the user to input either a "yes" or "no" in response to LED prompts to continue or end a routine. |
| ENTER | Enters user input data into microcomputer in response to LED prompts for information. |

DISPLAY — Permits the user to monitor the performance of the Series 100 during a routine. For example, in a BLEND routine with Gas Phase Titration, by pushing the display button, the total mass flow (MFT), diluent flow through mass flow controller #1 (MF1), analyte (span) gas flow through controller #2 (MF2), the ozone concentration and ozone block heater temperature are displayed in sequence.

PRINT — Turns the printer output ON (or OFF)

NUMERICAL KEYPAD — Permits entry of quantitative parameters (concentrations, flows, etc.) in response to LED prompts in conjunction with the ENTER key. Also used to select functions (see below).

The keypad is used to gain access to seven (7) additional Series 100 operating modes or functions. They are:

f 0 — MANUAL MODE
Allows the user to manually select and enter flow commands to both flow controllers. The user also has the option in this mode to turn ON the ozone generator for manual input of flows for gas phase titration.

f 1 — CALIBRATE FLOW
Permits the user to re-calibrate either flow controller by measuring, then entering via the numerical keypad, true flow (as determined by a primary standard) versus the commanded flow. Up to 20 points of input data, entered into the microcomputer will result in a new least squares line for the flow controller being calibrated.

f 2 — VERIFY FLOW
Allows user verification of each individual flow controller's output. The true flow (as determined by primary standard) is measured and compared to the flow commanded.

f 3 — SLOPE/INTERCEPT
Provides the user with a LED display of the least squares SLOPE and INTERCEPT values based on the current calibration points stored in microcomputer memory for each flow controller. This routine also allows the user to "force" a new least squares fit without underlying calibration points.

f 4 GENERATE OZONE
Initiates precise generation of ozone. Together with diluent air the Series 100 will provide low ppb levels of ozone for calibration of ozone monitors.

f 5 CALIBRATE OZONE
For linear response of the Series 100 ozone generator, this mode allows the user to enter commanded levels of ozone versus actual ozone concentrations as determined by an independent ozone monitor. Five (5) pairs of data points are entered from the lowest to highest required ozone concentration.

f PRINT PRINT SETUP
Sets the print interval and initiates printing out of information such as BLEND routine data through optional RS-232 serial data interface. BLEND routine information includes time, date, inlet port, cylinder gas concentration, output gas concentration and flow through each flow controller. Calibration data points including SLOPE and INTERCEPT values may also be printed.

I.B.4. Internal Components
The basic internal components of the Environics Series 100 Computerized Multi-Gas Calibrator are shown in the following Illustration III (see next page).

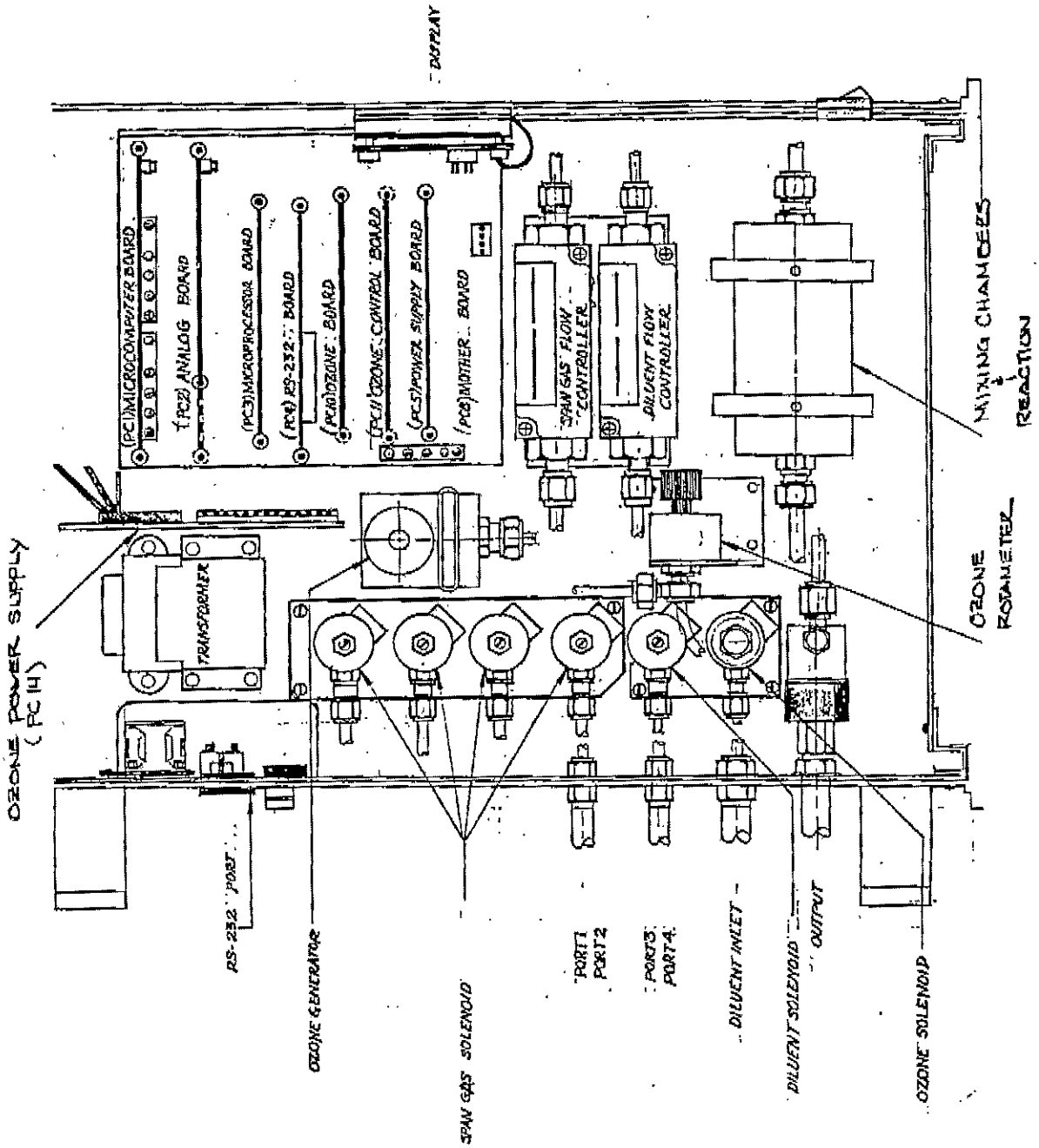



ILLUSTRATION III

## II. INSTRUMENT OPERATION

The Environics Series 100 Computerized Multi-Gas Calibrator is shipped to you completely assembled and ready to use. You may begin using the instrument simply by unpacking the unit, removing any packing materials and connecting it to a diluent (e.g. zero air) source and appropriate analyte span gas cylinders. Once you have finished reading this Operating Manual, you are then ready to do precise gas blends or generate gas standards for calibration purposes.

### II.A. UNPACKING AND SET-UP

The Series 100 should be removed from its shipping container. (Note! Inspect shipping package for any signs of damage and if any, report it immediately to the carrier.) Remove any shipping material. Place the unit on a suitable work surface for easy access to the rear panel. Any damage to the unit itself should be reported to your local Environics Sales Representative.

II.A.1. Remove the top cover and inspect for any visible signs of damage before plugging in the unit. In particular check for loose electronic boards and check all connections. Remove internal packing material.

II.A.2. Power Connection

WARNING! OPERATING THE SERIES 100 AT AN INCORRECT LINE VOLTAGE WILL DAMAGE THE INSTRUMENT AND VOID THE WARRANTY. CHECK LINE VOLTAGE BEFORE PLUGGING IN. LINE VOLTAGES BETWEEN 100-130 V AC (OPTIONAL 200-260 V AC) ARE ACCEPTABLE.

Plug in the 3 prong grounded plug to an appropriate outlet. The standard unit allows for normal 115 V AC (50-60 Hz) only; nominal 230 V AC (50-60 Hz) input is optional.

After confirming the proper supply voltage the front panel rocker switch may be placed in the "ON" position. The LED display should indicate "READY" and the instrument should emit two beeps (one delayed slightly). If it does, turn the rocker switch to the "OFF" position and continue with connection of gases.

IF THERE IS NO DISPLAY CONSULT THE TROUBLESHOOTING GUIDE SECTION III.A.

II.A.3. Gas Connection

Connect a source for diluent gas (zero air) to the inlet port labelled DILUENT and the analyte (span) gas cylinder(s) to ports labelled GAS PORT 1, GAS PORT 2, GAS PORT 3 and GAS PORT 4. The DILUENT inlet is a 1/4 inch compression type fitting; all other ports are 1/8 inch compression type.

A MINIMUM OF 10 PSI INLET PRESSURE IS REQUIRED FOR BOTH DILUENT AND GAS PORT 1-4. AN INLET PRESSURE OF 20 PSI IS PREFERRED; A MAXIMUM PRESSURE OF 30 PSI SHOULD NOT BE EXCEEDED. SUPPLY RATES SHOULD BE ADJUSTED TO MEET THE FLOW CONTROLLER SIZING (E.G. AT LEAST 10 SLPM SHOULD BE AVAILABLE TO A 10 SLPM FLOW CONTROLLER.)

CAUTION! OVER PRESSURIZATION OF THE SERIES 100 MAY DAMAGE THE SOLENOIDS AND WILL VOID THE WARRANTY. DO NOT CONNECT THE DILUENT AND ANALYTE GAS SOURCES TO THE SERIES 100 UNTIL YOU HAVE SET THE REGULATORS ON THESE SOURCES TO O PSI. THEN SLOWLY INCREASE PRESSURE OBSERVING THE MINIMUMS AND MAXIMUMS SHOWN ABOVE. ALL UNUSED PORTS MUST BE CAPPED.

The Environics Series 100 flow controllers were calibrated with zero air at a standard temperature of 77 F (25°C) and a pressure of 760 mm Hg. Other temperature and pressure calibration standards may be specified when ordering.

All wetted surfaces of the Series 100 are glass, stainless steel (SS 316) or Teflon; flow controller seals are Viton. The user should verify the compatibility of their diluent or span gases with these materials. Contact Environics to discuss revised internal materials for special gas conditions. (Refer to Appendix IV.C Gas Compatibility).

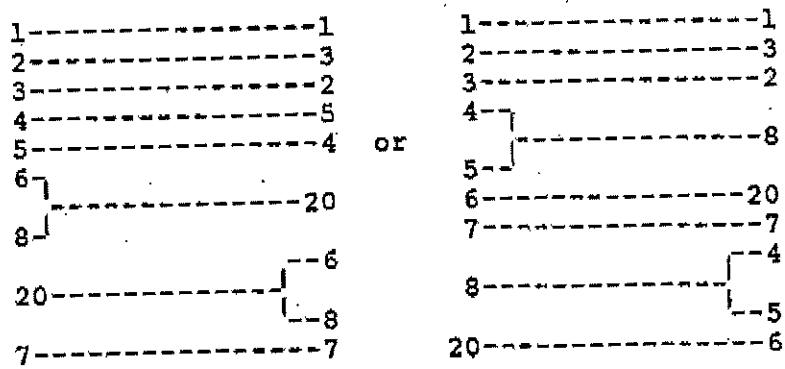
II.A.4. RS-232 Connection (optional)

a. Computer/Modem

The Environics Series 100 unit can be interfaced with any commercially available modem having minimum capabilities of 0-300 bps. The Series 100 itself has a selectable baud rate of 300 through 9600 bps. This is selected on the RS-232 board (part 100-PC4-D4) using the programming jumper labeled PJ5. Set the Series 100 baud rate to match your modem before using. Computer/Modem cables to connect the Series 100 device to the modem should be serial style 25 pin connectors (male to male). The cable must have nine (9) conductor cables extended at pins 1 through 8, and at pin 20.

b. Computer

When interfacing directly to a computer a null modem is required. The null modem adapter is to conform to either of the following pin diagram.




For IBM computers, you will require a male to female cable and a null modem adapter, or a null modem cable having male to female connections.

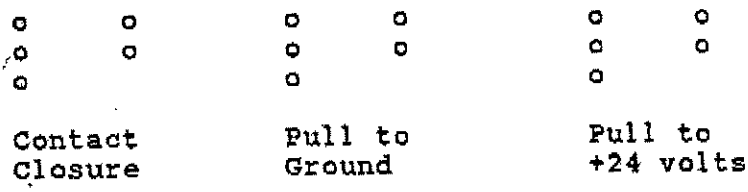
c. Printer/Terminal

The Environics Series 100 unit can be attached to any serial data printer. RS-232 cables (male to male) used to interface from the machine to the printer must have, as a minimum, nine (9) conductor cables extended at pins 1 through 8, and at pin 20. Also acceptable is 25 conductor cable extending all 25 pins. The Series 100 baud rate for the printer is user selectable from 300 to 9600 bps. This is selected on the RS-232 board (piece 100-PC4-D4) using programming jumper PJ6. Set the baud rate to match the printer before operation.

## II.A.5 Status Board

The status board consists of 8 independent status lines, 2 analog outputs and a +24 volt supply. The terminal block on the back of the instrument is numbered consecutively from 1 through 20 left to right. Numbers 1-16 are used as the status lines, 17-18 are used to monitor any point inside of the unit (after the necessary connections are made inside the unit) and 19-20 supply +24 volts on pin 19 and ground on pin 20.

The 8 independent status lines each are available on two screws on the terminal block. The output may be configured for a contact closure, pulled to ground or pulled to +24 volts. Each status line is configured through jumpers as shown below:




The status lines are independently configured, i.e. status line 1 (#1 and #2) may be a contact closure, status line 2 (#3 and #4) may be pulled to ground and status line 3 (#5 and #6) may be pulled to +24 volts upon activation.

Below is a list of the terminal block screws which correspond to the various status lines:

| | Contact Closure | Pulled to Ground | Pulled to +24 volts |
|---|---|---|---|
| Status line #1 | 1-2 | 1 | 2 |
| Status line #2 | 3-4 | 3 | 4 |
| Status line #3 | 5-6 | 5 | 6 |
| Status line #4 | 7-8 | 7 | 8 |
| Status line #5 | 9-10 | 9 | 10 |
| Status line #6 | 11-12 | 11 | 12 |
| Status line #7 | 13-14 | 13 | 14 |
| Status line #8 | 15-16 | 15 | 16 |

Pins 17 and 18 are connected to the test points labelled TP1 and TP2 on the status board inside of the unit. By tying these test points to the desired point in a circuit it is possible to monitor that portion of the circuit. Pin 19 is tied to +24 volts through a 1 amp fuse on the status board. Pin 20 is tied to ground. The 24 volts is available whenever the instrument is turned on.

An LED (Light Emitting Diode) array is incorporated on the status board as a debugging feature. The top LED indicated that +5 volts is supplied to the board, the second LED is for +24 volts, the third LED is for the first status output (terminals 1-2), the fourth LED is for the second status output (terminals 3-4)... the tenth and last LED is for the eighth status output (terminals 15-16).

## II.B. Primary Functions

Once the gases are connected at the rear of the unit, inlet pressures set as required (refer to Section II.A.3) and the unit is plugged in, you are ready to turn on the instrument and initiate any of its functions.

### II.B.1 BLEND (WITHOUT OZONE GENERATION)

In this mode, the user can rapidly generate precise gas calibration standards or blends from two gas sources attached to the rear of the unit. These are an analyte gas of known concentration and a diluent gas, usually zero air.

This BLEND routine (Illustration IV), is initiated by pressing the BLEND function key. In quick succession the interactive software prompts the user by requesting the gas port to be used for input of analyte (span) gas, cylinder gas concentration (CGC) of analyte gas, total output gas flow (MFT) and output gas concentration (OGC). With this input date entered by the user, the Series 100 will automatically deliver the gas concentration and the total flow selected.

NOTE! Zero air must be used as the diluent gas for accurate flows and dilutions.

In using a blend routine without Ozone, the user must enter a value of 0.0 ppm for the Ozone concentration when prompted by the computer for this input data.

During this routine the user may observe the mass flow through each controller as well as the total mass flow (MFT) without interrupting the BLEND sequence. See DISPLAY-Section II.C.2. Also see f PRINT - Section II.C.7. to obtain a printout of BLEND parameters.

The following are application examples of the BLEND routine.

Example 1:
It is desired to blend a span gas of 55 ppm Sulfur Dioxide ($SO_2$) in air with a diluent of zero air. The desired concentration of the blended output gas is 1 ppm to be delivered to the analytical device manifold at the rate of 5000 cc/minute. For this example, the Environics Series 100 instrument has internal flow controllers of 20 SLM (MF1) for diluent and 99.9 SCCM (MF2) for span gas.

| STEP | LED PROMPT | PRESS/INPUT DATA | NEW LED PROMPT | COMMENTS |
|---|---|---|---|---|
| 1 | READY | BLEND | ENTER GAS PORT<br><br>PORT=____ | Enter BLEND routine<br><br>Displays last port used |
| 2 | PORT=____ | ENTER to accept or key in new gas port; then ENTER | CYL.GAS CONC?<br><br>CGC=___PPM or % | |
| 3 | CGC=___PPM or % | ENTER to accept or key in new cylinder gas conc in PPM or (%); then ENTER | OUTPUT GAS FLOW<br><br>MFT=___CC/M | |
| 4 | MFT=____CC/M | ENTER to accept or key in new total mass flow; then ENTER | OUTPUT GAS CONC.<br><br>OGC=___PPM or % | |
| 5 | OGC=___PPM or % | ENTER to accept or key in new output gas conc. in PPM (or) %;then ENTER | OGC=___PPM (or%) | Series 100 blends gases at requested flow and conc. |

ILLUSTRATION IV-BLEND MODE

| Step | Led Prompt | User Input |
|---|---|---|
| 1 | READY | BLEND |
| 2 | PORT=_____ | Enter port number to which span gas cylinder is connected |
| 3 | <O3>=_____ | Enter 0.0 for Ozone Conc. |
| 4 | CGC=_____PPM | Enter cylinder gas concentration of 55 ppm |
| 5 | MFT=_____CC/m | Enter total output flow of 5000 sccm |
| 6 | OGC=_____PPM | Enter output gas concentration of 1.0 ppm |
| 7 | OGC=_____PPM | None required, the unit displays output gas concentration |

Example 2:

As in example 1, the cylinder gas concentration is 55 ppm and total flow is 5000 cc/m. With the unit output at 1 ppm, the user wants to change the output concentration to 0.75 ppm.

| Step | Led Prompt | User Input |
|---|---|---|
| 1 | OGC=1.___PPM | Clear |
| 2 | OUTPUT GAS CONC? | |
| | OGC=1. PPM | 0.75 |
| 3 | OGC=0.75 PPM | Unit displays output concentration |

This example shows how easy it is to do multi-point calibration of analyzers from a single gas cylinder.

Example 3:

Span gas cylinder is 113 ppm Nitric Oxide (NO) in an air balance. The diluent is a zero air source. Total flow rate is set by the user at 10,000 cc/m; MF1 is 20 SLM; MF2 is 99.9 SCCM. The desired output concentration is 4 ppm.

| Step | LED Prompt | User Input |
|---|---|---|
| 1 | READY | Blend |
| 2 | PORT=____ | Enter port number to which "NO" cylinder is connected |
| 3 | <O3>=_____ | Enter 0.0 for Ozone concentration |
| 4 | CGC=_____PPM | Enter cylinder gas concentration of 113 ppm |
| 5 | MFT=_____CC/M | Enter total flow rate of 10000 SCCM |
| 6 | OGC=_____PPM | Enter output concentration of 4 ppm |
| 7 | "MF2 OUT OF RANGE" | |

In example 3, the user has called for an output concentration and/or flow rates exceeding the 99.9 cc/m capacity of the MF2 flow controller. It will be necessary for the user to change either or both the requested total flow (MFT) or output gas concentration (OGC). Changing the total flow from 10,000 cc/m to 2800 cc/m or less will allow normal instrument performance; changing the output concentration to 1.1 ppm or less is an alternate solution to clear this error message.

Example 4:

Span gas cylinder is 5480 ppm of methane ($CH_4$) in air; the diluent is zero air. It is desired to dilute this cylinder down to 10 ppm at a flow rate of 6000 cc/m. The Series 100 unit is equipped with an MF1 of 20 SLM and a MF2 of 99.9 sccm.

| Step | LED Prompt | User Input |
|---|---|---|
| 1 | READY | Blend |
| 2 | PORT=_____ | Enter port number to which the methane cylinder is attached |
| 3 | <O3>=_____PPM | Enter 0.0 for Ozone concentration |
| 4 | CGC=_____PPM | Enter cylinder gas concentration of 5480 |

| | | |
|---|---|---|
| 5 | MFT=_____CC/M | Enter total flow rate of 6000 sccm |
| 6 | OGC=_____PPM | Enter output concentration of 10 ppm |
| 7 | OGC=10.___PPM | DISPLAY |
| 8 | MFT=6000.___CC/M | DISPLAY |
| 9 | MF1=5989.1__CC/M | DISPLAY |
| 10 | MF2=10.9____CC/M | DISPLAY |
| 11 | <O3>=0.0___PPM | DISPLAY |
| 12 | OZBLK=_____DEG C | DISPLAY |
| 13 | OGC=10.____PPM | |

In this example, the user, by pressing the "DISPLAY" button on the front panel of the Series 100 instrument will display the total mass flow (MFT) and the flow through the individual flow controllers (MF1 and MF2, the ozone concentration and the ozone generator temperature before returning to display the output gas concentrations.

It is important to note that at the flow rates and output concentration selected, flow through MF2 is at 10.9 cc/m. Environics considers the 10 percent level to be the lower range of acceptable performance for any flow controller (e.g. 10 percent level for 100 cc/m controller is 10 cc/m; 10 percent level for 5 l/m controller is 500 cc/m). Below the 10 percent level performance accuracy of the flow controller is greatly reduced. Users are encouraged to only use the flow controllers where flow rates will be between 10 percent and 90 percent of scale.

II.B.2. MANUAL

In the MANUAL mode, shown in Illustration V, the Environics Series 100 allows the user to override the microcomputer to manually select and enter a desired rate of flow for each mass flow controller. (NOTE: This routine may also be used for gas phase titration in which flows and ozone concentration are selected by the user. This is discussed on page 24 and shown in Illustration VII.

In the MANUAL mode, the computer generated least squares line is still used by the instrument to deliver voltage signals regulating the demanded flow. Individual flows through each controller are separately selected and each is operated independently.

As is always the case, flow controllers are designated as MF1 for diluent flow and MF2 for analyte (span) gas. In the MANUAL mode the user can:

a. Calculate on his own the necessary flows of diluent and span gas (plus ozone concentration if appropriate-see page 24) to give the required output gas concentration;

b. Purge the instrument (zero check) being calibrated with diluent air only (shutting down MF2 and directing only diluent through MF1);

c. Dose the instrument with undiluted span gas (close down MF1) for a span (calibration) check.

The following examples provide a more detailed explanation of the MANUAL mode.

Example 5:

A span gas cylinder is 6170 ppm of "CO" in balance gas air. Diluent is a zero air source. It is desired to dilute this cylinder down to approximately 320 ppm. The user has determined that diluent and span gas flow rates of 950 and 50 sccm respectively will result in the desired output gas concentration.

| Step | LED Display | User Input |
|---|---|---|
| 1 | READY | f 0 |
| 2 | MANUAL? Y/N | Yes |
| 3 | PORT=_____ | Enter port number of span gas |
| 4 | <O3>=_____PPM | Enter 0.0 for Ozone concentration |

| STEP | LED PROMPT | PRESS/INPUT DATA | NEW LED PROMPT | COMMENTS |
|---|---|---|---|---|
| 1 | READY | f and 0 | MANUAL MODE? Y/N | |
| 2 | MANUAL MODE? Y/N | YES | ENTER GAS PORT<br>PORT=_____ | |
| 3 | PORT=_____ | ENTER to accept or key in new gas port; then ENTER | [03]=_____PPM | Required Ozone Concentration |
| 4 | [03]=___PPM | Enter 0.0 for Ozone Conc. | ENTER SPAN GAS<br>MF2=_____CC/M | Span gas flow |
| 5 | MF2=___CC/M | ENTER to accept or key in new gas port; then ENTER | ENTER DILUENT<br>MF1=_____CC/M | Diluent flow command |
| 6 | MF1=___CC/M | ENTER to accept or key in new diluent flow; then ENTER | MF1=_____CC/M | Actual diluent flow |
| 7 | MF1=___CC/M | DISPLAY | MF2=_____CC/M | Actual span gas flow |
| 8 | MF2=___CC/M | DISPLAY | MF1=_____CC/M | |

ILLUSTRATION V-MANUAL MODE (f0)

| | | |
|---|---|---|
| 5 | MF2=_____CC/M | 50 |
| 6 | MF1=_____CC/M | 950 |

Example 6:

As in example 5 above, except the user wants to zero check the instrument with 2000 cc/minute of zero air.

| Step | LED Display | User Input |
|---|---|---|
| 1 | READY | f 0 |
| 2 | MANUAL? Y/N | Yes |
| 3 | PORT=_____ | Enter port number of span gas |
| 4 | <O3>=_____PPM | Enter 0.0 for Ozone Concentration |
| 5 | MF2=_____CC/M | 0 |
| 6 | MF1=_____CC/M | 2000 |

## II.B.3. OZONE GENERATION

The Environics Series 100, in addition to its ability to accurately dilute gases, incorporates an Ozone generation module.

Zero air, free of contaminants, is directed into the unit. A portion of this air flow is diverted into the ozone oven where it is exposed to U.V. light of a 184nm specific wavelength. Light intensity within the generator is held constant by a very stable, current controlled, mercury vapor lamp. To insure stability, the U.V. lamp has a precision photoptical feedback circuit which automatically adjusts the supply voltage to compensate for degradation in the lamp due to aging.

The Ozone generation routine is shown in Illustration VI. As shown, the user initiates the ozone generation routine by pressing keys f 4 on the keypad. The instrument will then ask for user responses to total diluent flow (MF1) and ozone concentration ( $O_3$ conc.). With this input data the unit will begin ozone generation.

Prior to its shipment to you, the Ozone Generation unit in the Series 100 was factory calibrated for linear operation across the expected range of performance of the unit. This underlying calibration data is based upon measurement of the actual ozone concentration output of the unit versus user commanded concentrations. This calibration is normally done between 0.100 ppm and 0.5 ppm at 5 liters of dilution air (or 1/2 the rated maximum flow of MF1, whichever is the greater). Other calibration references are possible. Please refer to the calibration sheet enclosed with the unit to confirm the factory calibration references. [PLEASE REFER TO SECTION II.C.8 FOR ADDITIONAL INFORMATION ON THE OZONE CALIBRATION MODE.]

Once this underlying calibration data has been developed using a primary standard, the user will know the actual ozone concentrations being generated by the unit.

The Series 100 is set-up to direct a constant flow of zero air through the generator. IT IS RECOMMENDED THAT 500 +/- 10 SCCM BE DIRECTED THROUGH THE GENERATOR. THIS FLOW IS CONTROLLED THROUGH USE OF THE INTERNAL ROTAMETER.

It is now possible to do a multi-point calibration check of an ozone analyzer. The user simply keys in the appropriate ozone concentration and flow to deliver a repeatable, stable ozone for instrument calibration. The following examples provides a better look at this mode:

| STEP | LED PROMPT | PRESS/INPUT DATA | NEW LED PROMPT | COMMENTS |
|---|---|---|---|---|
| 1 | READY | f and 4 | GENERATE OZONE? | |
| 2 | GENERATE OZONE? | YES | ENTER DILUENT<br>MF1=___CC/M | |
| 3 | MF1=___CC/M | ENTER to accept or key in new total flow; then ENTER | ENTER [03] CONC.<br>[03] = ___PPM | Required Ozone Conc. |
| 4 | [03] = ___PPM | ENTER to accept or key in new Ozone Conc. in PPM; then ENTER | [03] =___PPM | Display of Ozone Conc. |
| 5 | [03] =___PPM | DISPLAY | OZ BLK=___DEG C | Ozone oven temp |
| 6 | OZ BLK=___DEG C | DISPLAY | MF1=___CC/M | Total flow |
| 7 | MF1=___CC/M | DISPLAY | MF2=___CC/M | Display 0.0 |
| 8 | MF2=___CC/M | DISPLAY | [03]=___PPM | |

ILLUSTRATION VI-OZONE GENERATION (f4)

In Example #7, the user wishes to generate 1.0 ppm of ozone in 15 liters per minute of dilution air. NOTE! For Ozone generation to be valid, the total flow during any blending must equal the flow during Ozone calibration.

Example 7:

| Step | LED Prompt | User Input |
|---|---|---|
| 1 | READY | f 4 |
| 2 | GENERATE OZONE? | Yes |
| 3 | MF1=_____CC/M | 15000 CC/M |
| 4 | <O3> CONC=____PPM | 0.5 ppm |
| 5 | <O3> CONC= 0.50 PPM | DISPLAY |
| 6 | OZ BLK=_____DEG C | DISPLAY |
| 7 | MF1=15000.__CC/M | DISPLAY |
| 8 | MF2= 0.00 CC/M | DISPLAY |
| 9 | <O3> CONC=0.50 PPM | |

Example 8:

| Step | LED Prompt | User Input |
|---|---|---|
| 1 | <O3> CONC=0.5 PPM | CLEAR |
| 2 | <O3> CONC=0.5 PPM | 0.2 PPM |
| 3 | <O3> CONC= 0.2 PPM | |

In Example 7, the user has requested, and the instrument will deliver, 0.5 ppm of ozone in 15 liters of diluent zero air. In Example 8 the user has initiated a second ozone data point ($O_3$ = 0.2 ppm) with diluent flow unchanged.

THE OZONE BLOCK TEMPERATURE MUST BE BETWEEN 49°C AND 51°C FOR PROPER AND COMPLETE FORMATION OF OZONE.

## II.B.4 Blend with Gas Phase Titration (GPT)

In addition to its ability to provide for the precise diluting of gases from cylinder, and the generation of precise quantities of ozone, the Environics Series 100 has the capability to perform the gas phase titration of nitric oxide and ozone for the generation of nitrogen dioxide. The Flow Schematic for this routine is shown on page 22.

As has been explained in Section II.B.3, ozone is formed by exposing zero air to U.V. light of a specific wavelength. The Series 100 contains an ozone generator. Light intensity within this generator is held constant by a very stable current controlled mercury vapor lamp and a precision optical feedback circuit.

The Series 100 is set-up to direct a constant flow of zero air through the generator. IT IS RECOMMENDED THAT 500 +/- 10 SCCM BE DIRECTED THROUGH THE GENERATOR. THIS FLOW IS CONTROLLED THROUGH USE OF THE INTERNAL ROTAMETER.

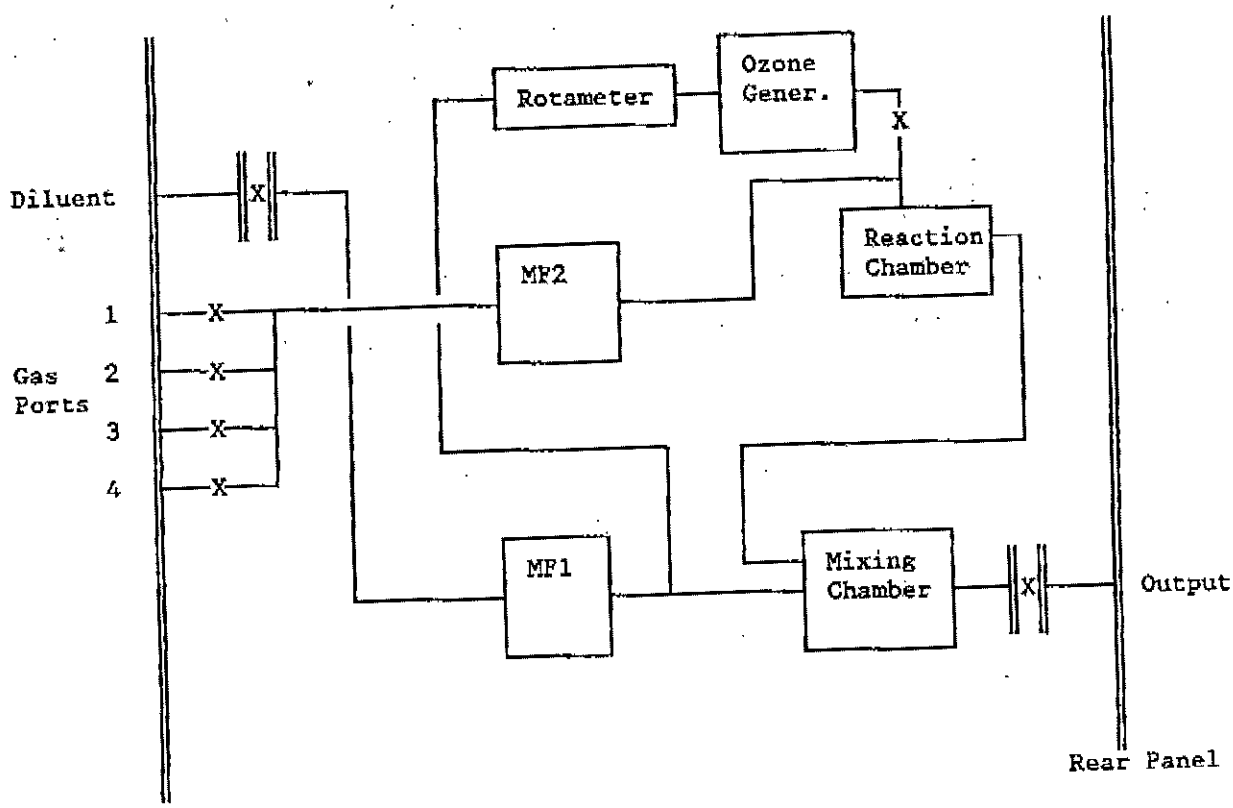
Gas phase titration (GPT) of nitric oxide (NO) with Ozone ($O_3$) is expressed by the following chemical reaction:

$$NO + O_3 \text{ ----------> } NO_2 + O_2$$

The nature of the reaction is such that when the "NO" concentration is known, the concentration of $NO_2$ can be determined. In the Series 100 during GPT, $O_3$ is added to excess NO producing $NO_2$. The decrease in "NO" concentration is equivalent to the concentration of $NO_2$ produced. The amount of $NO_2$ generated is varied by adding increased amounts of ozone from the generator.

For Example:

1000 ppb NO + 200 ppb $O_3$ ---> 200 ppb $NO_2$ + 200 ppb $O_2$ + 800 ppb NO




Series 100--Flow Diagram-Gas Phase Titration

The Ozone and GPT routine is shown in Illustration VII. The interactive software routine initially asks for the user specification of the gas port to which the "NO" cylinder is attached (NOTE: This cylinder should contain 50 to 200 ppm NO in Nitrogen. These cylinders should be prepared and analyzed in accordance with the Environmental Protection Agency's 1987 guideline documents.* Consult your gas cylinder supplier for more information and appropriate certificates.

*Procedures for NBS Traceable Certification of Compressed Gas Working Standards used for Calibration and Audit of Continuous Source Emission Monitors, and; Procedures for NBS Traceable Certification of Compressed Gas and Permeation Device Working Standards used for Calibration and Audit of Air Pollution Analyzers.

After the BLEND key has been pressed the user specifies, in response to software prompts, the desired ozone concentration, the concentration of the "NO" cylinder gas, the total output gas flow in cc/m and the output gas concentration.

The zero-air source for diluent flow and ozone must be free of contaminants which might react with the "NO", $O_3$ or $NO_2$ in gas phase titration. Zero air should be capable of being delivered at 20-30 liters/minute at a pressure greater than 20 psi (but less than 30 psi).

After initiation of the output gas flow, and at any time during the routine, the user may observe flow performance through the unit by toggling the DISPLAY button. The instrument will display total mass flow (MFT), diluent flow (MF1), "NO" flow (MF2), the ozone concentration and the ozone block temperature in degrees°C before returning to the output gas concentration (OGC).

The following examples will help the user to more fully understand instrument operation during the gas phase titration sequence.

Example 9:

The span gas cylinder is 126 ppm of "NO" in a balance of zero air. The diluent is a zero air source. The $NO_x$ calibration is to be at 0.82 ppm; the $NO_2$ calibration at 0.5 ppm. The Environics Series 100 has internal flow controllers of 20 SLM (MF1) for diluent and 100 SCCM (MF2) for span gas:

| STEP | LED PROMPT | PRESS/INPUT DATA | NEW LED PROMPT | COMMENTS |
|---|---|---|---|---|
| 1 | READY | BLEND | ENTER GAS PORT<br>PORT=___ | Displays last port used |
| 2 | PORT=___ | ENTER to accept or key in port of "NO" cylinder; then ENTER | ENTER [03] CONC.<br>[03]CONC=___PPM | Required Ozone concentration |
| 3 | [03] CONC=___PPM | ENTER to accept or key in new Ozone Conc. in PPM; then ENTER | CYL. GAS CONC?<br>CGC=___PPM (OR %) | "NO" cylinder concentration |
| 4 | CGC=___ppm (OR %) | ENTER to accept or key in conc. of "NO" cylinder; then ENTER | OUTPUT GAS FLOW<br>MFT=___CC/M | Total flow required |
| 5 | MFT=___CC/M | ENTER to accept or key in new total mass flow; then ENTER | OUTPUT GAS CONC.<br>OGC=___PPM (or%) | Enter value for OGC equal to 03 conc. for 100% GPT, enter value greater than 03 conc. for excess "NO" |
| 6 | OGC=___PPM (or %) | ENTER to accept or key in new output gas conc.; then ENTER | OGC=___ppm (OR %) | |

ILLUSTRATION VII-AUTOMATIC MODE-OZONE GAS PHASE TITRATION

| STEP | LED PROMPT | PRESS/INPUT DATA | NEW LED PROMPT | COMMENTS |
|---|---|---|---|---|
| 7 | OGC=___PPM(or%) | DISPLAY | MFT=___CC/M | |
| 8 | MFT=___CC/M | DISPLAY | MF1=___CC/M | Zero air flow |
| 9 | MF1=___CC/M | DISPLAY | MF2=___CC/M | "NO" flow for GPT |
| 10 | MF2=___CC/M | DISPLAY | [03]=___PPM | Ozone conc. |
| 11 | [03]=___PPM | DISPLAY | OZ BLK=___DEG C | Ozone oven temp. |
| 12 | OZ BLK=__DEG C | DISPLAY | OGC=___PPM(or%) | Output gas conc. |

ILLUSTRATION VII-AUTOMATIC MODE-OZONE GAS PHASE TITRATION

| Step | LED Prompt | User Input |
|---|---|---|
| 1 | READY | BLEND |
| 2 | PORT=____ | Enter Port # of NO cylinder |
| 3 | <O3> CONC=___PPM | 0.50 |
| 4 | CGC=____PPM | 126; Then ENTER |
| 5 | MFT=____CC/M | 15,000; Then ENTER |
| 6 | OGC=____PPM* | 0.82; Then ENTER |

*NOTE: In this example, the excess "NO" method is used to specify the output gas concentration; in the excess "NO" method, the output concentration is the SUM of the NO plus the $NO_2$ concentrations. The $O_3$ concentration being delivered by the ozone generator is .50 ppm. A user specification of OGC=0.82 PPM will insure complete reaction of NO with $O_3$ to form .5 ppm of $NO_2$ and 0.82 ppm of $NO_x$ (NO at .32 ppm plus .5 ppm of $NO_2$)].

Example 10:

As in previous Example 9 except the calibration is to be at .25 ppm of $NO_2$ and 0.42 of $NO_x$.

| Step | LED Prompt | User Input |
|---|---|---|
| 1 | READY | BLEND |
| 2 | PORT=____ | Specify "NO" Cylinder Port |
| 3 | <O3> CONC=___PPM | .25 PPM; Then ENTER |
| 4 | CGC=____PPM | 126; Then ENTER |
| 5 | MFT=____CC/M | 15,000; Then ENTER |
| 6 | OGC=____PPM | .42 ("NO @ .17 PPM AND .25 PPM OF $NO_2$) |

II.B.4.

a. MANUAL GAS PHASE TITRATION
In the MANUAL mode, the Series 100 will allow the user to override the microcomputer and to manually select flow rates and ozone concentration. The computer generated least squares line is still used by the instrument to regulate flow. Each flow controller is operated separately. See Illustration VIII.

Example 11:

A cylinder containing 126 ppm of "NO" is attached to port number 1. It is desired to do a manual GPT. The $NO_2$ calibration is at 0.5 ppm; the $NO_x$ calibration is at 0.82 ppm.

| Step | LED Display | User Input |
|---|---|---|
| 1 | READY | f 0 |
| 2 | MANUAL? Y/N | YES |
| 3 | PORT=____ | ENTER PORT=1 |
| 4 | <03> CONC=____ | ENTER 0.50 |
| 5 | MF2=____CC/M | 97 CC/M |
| 6 | MF1=____CC/M | 14,903 CC/M |

| STEP | LED PROMPT | PRESS/INPUT DATA | NEW LED PROMPT | COMMENTS |
|---|---|---|---|---|
| 1 | READY | f and 0 | MANUAL? Y/N | |
| 2 | MANUAL? Y/N | YES | ENTER GAS PORT<br>PORT=___ | |
| 3 | PORT=___ | ENTER to accept or key in port for "NO" cylinder; then ENTER | ENTER [03] CONC.<br>[03] CONC=___PPM | Required Ozone Concentration |
| 4 | [03] CONC=___PPM | ENTER to accept or key in new Ozone conc. in PPM; then ENTER | ENTER SPAN GAS<br>MF2=___CC/M | Required flow of "NO" gas |
| 5 | MF2=___CC/M | ENTER to accept or key in new flow through MF2; then ENTER | ENTER DILUENT<br>MF1=___CC/M | Zero air flow |
| 6 | MF1=___CC/M | ENTER to accept or key in new diluent flow through MF1; then ENTER | MF1=___CC/M | |

ILLUSTRATION VIII-MANUAL MODE-03 GENERATION GAS PHASE TITRATION

| STEP | LED PROMPT | PRESS/INPUT DATA | NEW LED PROMPT | COMMENTS |
|---|---|---|---|---|
| 7 | MF1=___CC/M | DISPLAY | MF2=___CC/M | "NO" Cylinder flow |
| 8 | MF2=___CC/M | DISPLAY | [03] CONC.=__PPM | Ozone Conc. |
| 9 | [03]=___PPM | DISPLAY | OZ BLK=___DEG C | Ozone oven temperature |
| 10 | OZ BLK=___DEG C | DISPLAY | MF1=___CC/M | Diluent Flow |

ILLUSTRATION VIII-MANUAL MODE-03 GENERATION GAS PHASE TITRATION

## II.B.5 Set-Timer

One of the most powerful functions within the Series 100 instrument is the SET-TIMER sequence. Initiation of SET-TIMER allows the user to program the unit for a seven (7) day period of automatic, unattended BLENDS or MANUAL operations. It is possible for the user to establish two (2) individual programs, either of which may consist of up to twenty (20) different routines (a routine being defined as a complete BLEND or MANUAL operation). Each program can be set to begin at times specified by the user. Either program can be set to run more than once each day depending on their length. Each of the seven (7) days (Monday through Sunday) are programmed by the user to run none, one or both of the established programs. NOTE! The user is limited to a maximum of eighteen (18) start times, that is the number of Program #1 starts plus the number of Program #2 starts must be less than or equal to 18.

The following diagram illustrates the basic structure of the SET-TIMER function:

| Display or Keypad Entry | |
|---|---|
| SET-TIMER | Initiation of Set-Timer function via keypad |
| CHANGE ROUTINES? | User establishes up to twenty (20) routines (R1 through R20). Each routine is a complete BLEND or MANUAL function of the Series 100. |
| CHANGE PROGRAM 1?<br>CHANGE PROGRAM 2? | User establishes the order in which each routine (R1 through R20) is to be run in each of two (2) programs. |
| CHANGE SEQUENCE? | User establishes the sequence in which the unit will run either of the two (2) programs. User goes through Monday to Sunday sequences in which Programs 1 or 2 are to be run and start times for program initiation. |
| STEP TIME | User establishes the length of time each routine is to be run (from 1 to 99 minutes). |
| AUTO | Series 100 now in automatic mode. |

A more detailed logic flow for each segment of the SET-TIMER function is contained in the following illustrations:

| | |
|---|---|
| CHANGE ROUTINE? | Illustration IX |
| CHANGE PROGRAM? | Illustration X |
| CHANGE SEQUENCE? | Illustration XI |

The SET TIMER routine allows for the automatic operation of the Environics Series 100 which has been programmed to sequence through steps established by the user.

There are actually four (4) separate parts to the SET-TIMER routines:

CHANGE ROUTINES?
CHANGE PROGRAM 1?
CHANGE PROGRAM 2?
CHANGE SEQUENCE?

II.B.5.a. CHANGE ROUTINES?

In the first part of the SET-TIMER routine the user established up to twenty (20) individual "routines". A "routine" is one complete BLEND OR MANUAL function in which the user inputs port, cylinder gas concentration, total flow, output gas concentration and appropriate ozone concentration in the case of a BLEND; or port, diluent flow, span flow and appropriate ozone concentration in the case of a MANUAL routine. Each routine is assigned a number from 1 to 20 in the CHANGE ROUTINES? segment.

Example 12:

| LED PROMPT | USER INPUT REQUIRED |
|---|---|
| R1 Mode = Blend and Ozone concentration | Port #, CGC, MFT, OGC |
| R2 Mode = Manual | Port #, MF1, MF2, and Ozone concentration |

The user then continues to build a series of up to 20 different routines by responding to the computer prompts. Each BLEND Routine will require user specification of gas ports, cylinder gas concentrations, total flows, output concentrations and Ozone concentrations. Each MANUAL routine will require gas port, gas flows and Ozone concentration.

| STEP | LED PROMPT | PRESS/INPUT DATA | NEW LED PROMPT | COMMENTS |
|---|---|---|---|---|
| 1 | READY | SET TIMER | ANY CHANGES? | |
| 2 | ANY CHANGES? | YES | CHANGE ROUTINES? | If NO, unit will go to READY |
| 3 | CHANGE ROUTINES? | YES | R1MODE = BLEND? | The following is a BLEND example |
| 4 | R1MODE = BLEND? | YES if routine 1 is to be a BLEND; NO if routine is to be MANUAL; then ENTER | ENTER GAS PORT<br>R1PORT=____ | |
| 5 | R1PORT=____ | ENTER to accept or key in new port number; then ENTER | ENTER [03] CONC.<br>R1[03] CONC.=___PPM | Enter 0.0 for Ozone if not in GPT mode |
| 6 | R1[03] CONC.=___PPM | ENTER to accept or key in new Ozone Conc.; then ENTER | CYL. GAS CONC.<br>R1CGC=____PPM(or%) | |
| 7 | R1CGC=___PPM(or%) | ENTER to accept or key in new cylinder gas conc. in PPM or %; then ENTER | OUTPUT GAS FLOW<br>R1MFT=____CC/M | |

ILLUSTRATION IX-SET TIMER-"CHANGE ROUTINE"

| STEP | LED PROMPT | PRESS/INPUT DATA | NEW LED PROMPT | COMMENTS |
|---|---|---|---|---|
| 8 | R1MFT=____CC/M | ENTER to accept or key in new total mass flow; then ENTER | OUTPUT GAS CONC.<br>R1OGC=__PPM(or%) | |
| 9 | R1OGC=__PPM(or%) | ENTER to accept or key in new output gas conc.; then ENTER | ANOTHER? (Y/N) | |
| 10 | ANOTHER? (Y/N) | YES | R2MODE=MANUAL? | MANUAL mode example |
| 11 | R2MODE=MANUAL? | YES if routine 2 mode is MANUAL; NO if routine 2 mode is BLEND; then ENTER | ENTER GAS PORT<br>R2PORT=____ | |
| 12 | R2PORT=____ | ENTER to repeat or key in new gas port #; then ENTER | ENTER [03] CONC.<br>R2[03] CONC=__PPM | |

ILLUSTRATION IX-SET TIMER-"CHANGE ROUTINE"

| STEP | LED PROMPT | PRESS/INPUT DATA | NEW LED PROMPT | COMMENTS |
|---|---|---|---|---|
| 13 | R2[03] CONC=___PPM | ENTER to repeat or key in new Ozone conc.; then ENTER | ENTER DILUENT<br>R2MF1=____CC/M | |
| 14 | R2MF1=_____CC/M | ENTER to accept or key in new diluent flow; then ENTER | ENTER SPAN GAS<br>R2MF2=____CC/M | |
| 15 | R2MF2=____CC/M | ENTER to accept or key in new span gas flow; then ENTER | ANOTHER? (Y/N) | |
| 16 | ANOTHER? (Y/N) | YES | R3MODE=_____ | |
| 17 | R3MODE=_____ | BLEND or MANUAL | | Software will proceed through the remaining routines. The user must select inputs for each if desired. |

ILLUSTRATION IX-SET TIMER-"CHANGE ROUTINE"

II.B.5.b.& c. CHANGE PROGRAM 1?/CHANGE PROGRAM 2?

After the user has established his "reference library" of up to twenty (20) routines in the CHANGE ROUTINES? segment, it is then possible to move to either of the CHANGE PROGRAM 1? or CHANGE PROGRAM 2? segments. These segments are nothing more than user selection of the order in which each of the previously established routines is to be run.

Each of the two (2) programs can contain up to twenty steps identified as Step 1 through Step 20. The user simply picks from this "reference library" of routines (see example no. 7) any routine from 1 to 20. For instance Step 1 in Program 1 can be any reference routine R1=___ to R20=___. In this manner the user can select the order in which a BLEND or MANUAL routine is completed. As the user goes through each program, a Routine number from 1 to 20 is assigned to each program step 1 to 20. Routines can be repeated and used in any order as shown in Example 13.

Example 13:

PROGRAM 1

Step 1 = R12
Step 2 = R1
Step 3 = R4
Step 4 = R5
Step 5 = R20
Step 6 = R18
Step 7 = R16
Step 8 = R2
Step 9 = R6
Step 10= R8
Step 11= R10
Step 12= R12
Step 13= R14
Step 14= R13
Step 15= R11
Step 16= R9
Step 17= R7
Step 18= R5
Step 19= R3
Step 20= R1

PROGRAM 2

Step 1 = R20
Step 2 = R10
Step 3 = R19
Step 4 = R9
Step 5 = R18
Step 6 = R8
Step 7 = R17
Step 8 = R7
Step 9 = R16
Step 10 = R6
Step 11 = R15
Step 12 = R5
Step 13 = R10
Step 14 = R12
Step 15 = R14
Step 16 = R16
Step 17 = R18
Step 18 = R20
Step 19 = R1
Step 20 = R2

In this example some routines are used more than once and the order of routines chosen to meet customer needs for calibration flows. A program does not have to consist of twenty (20) steps as shown. Any number of steps is acceptable. The user defines the length of the program by inserting a Step = 0 at that point where the program should end.

| STEP | LED PROMPT | PRESS/INPUT DATA | NEW LED PROMPT | COMMENTS |
|---|---|---|---|---|
| 1 | CHANGE PROGRAM 1? | YES | ENTER ROUTINE #<br><br>STEP 1 = R___ | If NO, unit defaults to CHANGE PROGRAM 2 |
| 2 | STEP 1 = R___ | Input routine number 1-20 | ENTER ROUTINE #<br><br>STEP 2 = R___ | At any time, input of R=0, unit defaults to next program |
| 3 | STEP 2 = R___ | Input routine number 1-20 | ENTER ROUTINE #<br><br>STEP 3 = R___ | |
| 4 | STEP 3 = R___ | Input routine equal to 0 | CHANGE PROGRAM 2? | |
| 5 | CHANGE PROGRAM 2? | YES to CHANGE PROGRAM 2; NO to go to CHANGE SEQUENCE? | ENTER ROUTINE #<br><br>STEP 1 = R___ | |
| 6 | STEP 1 = R___ | Input routine number 1-20 | ENTER ROUTINE #<br><br>STEP 2 = R___ | |
| 7 | STEP 2 = R___ | Input routine number 1-20 | CHANGE SEQUENCE? (Only if R = 0) | See ILLUSTRATION XI for this routine |

ILLUSTRATION X-SET TIMER-"CHANGE PROGRAM?"

II.C.5.d. CHANGE SEQUENCE?

Once the user has established the reference library of routines (CHANGE ROUTINES?) and has set-up the order in which routines are to be run in either of two separate programs (CHANGE PROGRAM 1?/CHANGE PROGRAM 2?) it is now possible to establish the order in which the programs are to run. This is accomplished by the CHANGE SEQUENCE? segment, the fourth and last part of the Set-Timer function.

In the CHANGE SEQUENCE? segment, the user can:

1. Establish the day or days either or both of the two (2) programs are to automatically run;

2. Establish the time in each day at which the program(s) selected are to begin; and

3. Establish the universal commands for the length of all of the routines.

NOTE! A Maximum of eighteen (18) different start times are available in any one week period. DO NOT attempt to run the programs with more than 18 different start times.

By responding YES to the LED prompt CHANGE SEQUENCE? it is possible to enter a seven (7) day calendar (beginning with Monday and ending with Sunday.) The user has the option of inserting a program (or programs) on each day and establishing the time that the program(s) is to be begin.

By responding NO to the CHANGE SEQUENCE? prompt the user enters that portion of the software which determines the length of time each of the 20 routines will be run by the machine. Please note that this choice of time is universal. That is all routines, regardless of being a BLEND or MANUAL routine, will run for the same length of time established by the user. The user can set these up to 99 minutes in length (if the user has set up 20 routines, however, the maximum length of each routine can only be 72 minutes in a 24 hour day.) NOTE! THIS STEP TIME MUST BE AT LEAST 1 MINUTE IN LENGTH.

Important: It is the user's responsibility to ensure that programs do not overlap.

| STEP | LED PROMPT | PRESS/INPUT DATA | NEW LED PROMPT | COMMENTS |
|---|---|---|---|---|
| 1 | CHANGE SEQUENCE? | YES | DAY=MONDAY<br>ANY PROGRAMS? | If NO, unit defaults to Step #14 |
| 2 | ANY PROGRAMS? | YES | START TIME=___:___<br>CHANGE TIME? | If NO, unit defualts to next day |
| 3 | CHANGE TIME? | YES | ENTER HOUR<br>HOUR=_____ | System displays current hour; if NO unit defaults to Step #6 |
| 4 | HOUR=_____ | ENTER to accept or key in new hour 1-24; then ENTER | ENTER MINUTES<br>MINUTES=_____ | System displays current minutes |
| 5 | MINUTES=_____ | ENTER to accept or key in new minutes 1-59;then ENTER | START TIME=___:___<br>CHANGE TIME? | |
| 6 | CHANGE TIME? | NO | ENTER PROGRAM #<br>PROGRAM=_____ | User selects #1 or #2 |
| 7 | PROGRAM=_____ | ENTER to accept or key in new program #1 or #2;then ENTER | DAY=MONDAY<br>MORE PROGRAMS? | |

ILLUSTRATION XI-SET TIMER-"CHANGE SEQUENCE?"

| STEP | LED PROMPT | PRESS/INPUT DATA | NEW LED PROMPT | COMMENTS |
|---|---|---|---|---|
| 8 | MORE PROGRAMS? | YES | START TIME=__:__<br>CHANGE TIME? | If NO, unit defaults to next day |
| 9 | CHANGE TIME? | Key in YES or NO<br>See Steps #3,4,<br>5 or 13 | ENTER PROGRAM#<br>PROGRAM=____ | |
| 10 | PROGRAM=____ | ENTER to accept or key in new program #1 or #2;then ENTER | DAY=MONDAY<br>MORE PROGRAMS? | |
| 11 | MORE PROGRAMS? | NO | DAY=TUESDAY<br>ANY PROGRAMS? | If YES, unit defaults to Step #13 |
| 12 | ANY PROGRAMS? | YES | START TIME=__:__<br>CHANGE TIME? | If NO, unit defaults to next day |

ILLUSTRATION XI-SET TIMER-"CHANGE SEQUENCE?"

| STEP | LED PROMPT | PRESS/INPUT DATA | NEW LED PROMPT | COMMENTS |
|---|---|---|---|---|
| 13 | CHANGE TIME? | YES or NO | | See Step #3 if YES<br>See Step #6 if NO<br>User sets the Program and start time for each day |
| 14 | STEP TIME=___:___<br>CHANGE TIME? | YES | ENTER MINUTES<br>MINUTES=_____ | This is universal spec. by user of length of time each routine is to run. All routines will run for length specified. Time must be 1 minute in length |
| 15 | MINUTES=_____ | ENTER to acccept or key in new minutes 1-59; then ENTER | ENTER SECONDS<br>SECONDS=_____ | |
| 16 | SECONDS=_____ | ENTER to accept or key in new seconds 1-59; then ENTER | STEP TIME=___:___<br>CHANGE TIME? | |
| 17 | CHANGE TIME? | NO | ANY CHANGES? | |
| 18 | ANY CHANGES? | NO | AUTO DAY TIME | Displays current time and date |

ILLUSTRATION XI-SET TIMER-"CHANGE SEQUENC?"

# II. INSTRUMENT OPERATION

## II.C. OTHER FUNCTIONS

In addition to the three (3) primary Environics Series 100 routines already described, there are additional functions which can be accessed from the front keypad of the unit. These functions are listed on the right front panel of the machine and are described in greater detail in this section.

### II.C.1. Time/Date

This mode allows the user to initialize the Series 100 unit to the current DATE and TIME.

The DATE is expressed by the unit as the current day (Monday through Sunday) as well as the numerical day, month and year (e.g. 21/2/88 for February 21, 1988). TIME is expressed in military time hours (1 through 23) and minutes (1 through 59). TIME/DATE, once initialized, is retained by the on-board computer clock.

The sequence for initializing TIME/DATE is shown in Illustration XII ).

### II.C.2. Display

Pressing the DISPLAY key while the Series 100 is running in either the BLEND, MANUAL, CALIBRATE or VERIFY mode permits the user to "view" internal machine functions. Repeated pressing of the DISPLAY key will cycle through all pertinent data for that function. The sequence of steps for the DISPLAY mode while the Series 100 is in the BLEND mode are shown in illustration XIII.

### II.C.3. Print

The gas mixing parameters and calibration data can be down loaded to a standard serial interface printer through the optional RS-232 Serial Data Interface. Pressing the PRINT key toggles the print function ON (or OFF), pressing it again turns the printer OFF (or on). The interval at which information is sampled and sent to the printer is selected by the user through the f PRINT function (See Section II.C.7.)

### II.C.4. Calibrate Flow (Function f1)

The Calibrate mode (Illustration XIV) allows the user to individually calibrate each flow controller from the front panel using a suitable primary standard.

| STEP | LED PROMPT | PRESS/INPUT DATA | NEW LED PROMPT | COMMENTS |
|---|---|---|---|---|
| 1 | READY | TIME/DATE | DATE=_____<br>CHANGE DATE? | Displays current day, month & year |
| 2 | CHANGE DATE? | YES | ENTER WEEKDAY<br>WEEKDAY=____ | If no, unit defaults to step #7<br>Displays day of week |
| 3 | WEEKDAY=___ | ENTER to accept or key in new weekday 1-7 (monday=1,tuesday=2) then ENTER | ENTER DAY<br>DAY=____ | Displays current day |
| 4 | DAY=___ | ENTER to accept or key in new day 1-31; then ENTER | ENTER MONTH<br>MONTH=____ | Displays current month |
| 5 | MONTH=___ | ENTER to accept or key in new month 1-12; then ENTER | ENTER YEAR<br>YEAR=____ | Displays current year |
| 6 | YEAR=___ | ENTER to accept or key in new year,ie 87 for 1987;then ENTER | DATE=_____<br>CHANGE DATE? | Displays set date |

ILLUSTRATION XII-TIME/DATE

| STEP | LED PROMPT | PRESS/INPUT DATA | NEW LED PROMPT | COMMENTS |
|---|---|---|---|---|
| 7 | CHANGE DATE? | NO | TIME:__:__:__<br>CHANGE TIME? | Displays current time |
| 8 | CHANGE TIME? | YES | ENTER HOUR<br>HOUR=____ | If NO, unit goes to READY<br>Displays current hour |
| 9 | HOUR=__ | ENTER to accept or key in new hour 1-23; then ENTER | ENTER MINUTES<br>MINUTES=____ | Displays current minutes |
| 10 | MINUTES=__ | ENTER to accept or key in new minutes, 1-59; then ENTER | TIME=__:__:__<br>CHANGE TIME? | Displays set time |
| 11 | CHANGE TIME? | NO | READY | If YES, unit defaults to #8 |

ILLUSTRATION XII-TIME/DATE

| STEP | LED PROMPT | PRESS/INPUT DATA | NEW LED PROMPT | COMMENTS |
|---|---|---|---|---|
| 1 | OGC=___PPM(or%) | DISPLAY | MFT=___CC/M | Displays total mass flow |
| 2 | MFT=___CC/M | DISPLAY | MF1=___CC/M | Displays flow through MF1 |
| 3 | MF1=___CC/M | DISPLAY | MF2=___CC/M | Displays flow through MF2 |
| 4 | MF2=___CC/M | DISPLAY | [03] =___PPM | Displays Ozone concentration |
| 5 | [03]=___PPM | DISPLAY | OZ BLK=___DEG C | Displays Ozone generator temp. |
| 6 | OZ BLK=___DEG C | DISPLAY | OGC=___PPM(or%) | Returns to display output gas conc. |

ILLUSTRATION XIII-DISPLAY FUNCTION (BLEND ROUTINE W/OZONE)

The instrument software permits the user to enter twenty (20) points of data consisting of commanded flow versus actual flow (as measured by the primary standard) through either flow controller. The user goes sequentially through the full operating range of the controller. At the end of the routine, after the twentieth point has been entered the microcomputer fits a new least squares line through the data.

The Calibrate mode is normally used when: 1) Flow controllers are either changed or serviced; 2) the VERIFY FLOW mode (see Section II.C.5) shows significant differences between actual vs commanded flow or; 3) operating conditions (temperature/ pressure) vary markedly from original calibration parameters.

NOTES!

- o Any flow within the range of the flow controller may be selected.
- o Flows should be selected to be equally distributed across the full scale of the meter. It is recommended that data points at 10, 30, 50, 70 and 90% of full scale be selected. As many as four (4) flows should be commanded at each location and measured by the primary standard.
- o Be sure to enter all twenty (20) data points for each flow controller. Unless the twentieth point is entered and the response NO given to the prompt ANOTHER?, the least squares calculation is not made and the calibration is incomplete.
- o The Series 100 must be calibrated using zero air (GAS CONSTANT of 1.00.) only.

II.C.5 Verify (Function f2)

The VERIFY mode (Illustration XV) permits the user to verify the output of each flow controller as measured by a suitable primary mass flow standard connected to the machine.

By entering the inlet port and desired output gas flow the routine allows for measurement of delivered gas flow through the selected flow controller.

The "true" flow, as measured by the primary standard is compared to the "commanded" output flow of the Series 100. The percent full scale bias error should be less than 1 percent at any point; if greater the flow controllers may require re-calibration (see CALIBRATE, Section II.C.4.)

| STEP | LED PROMPT | PRESS/INPUT DATA | NEW LED PROMPT | COMMENTS |
|---|---|---|---|---|
| 1 | READY | f and 1 | CALIBRATE? (Y/N) | |
| 2 | CALIBRATE?(Y/N) | YES | ENTER FLOW METER<br>FLOW METER=___ | if NO, unit returns to READY |
| 3 | FLOW METER=___ | ENTER to repeat or key in new number then ENTER | ENTER GAS PORT<br>PORT=___ | Only if MF2 |
| 4 | PORT=___ | ENTER to repeat or key in new port #; then ENTER | 20 POINT CALIB<br>ENTER ALL POINTS<br>ENTER INPUT FLOW<br>X1=___CC/M | |
| 5 | X1=___CC/M | ENTER to repeat or key in new flow; then ENTER | MF1(or MF2)=___ | Flow readout |
| 6 | MF1(or MF2)=___ | ENTER | ENTER TRUE FLOW<br>Y1=___CC/M | Enter command flow |
| 7 | Y1=___CC/M | Enter true flow from primary standard | ENTER INPUT FLOW<br>X2=___CC/M | |

ILLUSTRATION XIV-CALIBRATE FLOW (f1)

| STEP | LED PROMPT | PRESS/INPUT DATA | NEW LED PROMPT | COMMENTS |
|---|---|---|---|---|
| 8 | X2=___CC/M | ENTER to repeat or key in new flow; then ENTER | MF1(or MF2)=___ | Flow readout |
| 9 | MF1(or MF2)=___ | ENTER | ENTER TRUE FLOW<br>Y2=___CC/M | Command flow |
| 10 | Y2=___CC/M | Enter true flow from primary standard | ENTER INPUT FLOW<br>ETC. | |
| 11 | REPEAT THROUGH DATA POINTS 3-20 | | | |
| 12 | Y20=_____CC/M | Enter true flow from primary standard | ANOTHER? Y/N | |
| 13 | ANOTHER? Y/N | NO | CALCULATING<br>SLOPE=_____<br>INTERCEPT=____<br>READY | If YES, unit returns to step #5<br>New Slope<br>New Intercept |

| STEP | LED PROMPT | PRESS/INPUT DATA | NEW LED PROMPT | COMMENTS |
|---|---|---|---|---|
| 1 | READY | f and 2 | VERIFY? (Y/N) | |
| 2 | VERIFY? (Y/N) | YES | ENTER FLOW METER<br>FLOW METER=___ | If NO, unit returns to READY |
| 3 | FLOW METER=___ | ENTER to accept or key in new controller number; then ENTER | ENTER GAS PORT<br>PORT=____ | Only if MF2 being verified |
| 4 | PORT=____ | ENTER to accept or key in new gas port #; then ENTER | OUTPUT GAS FLOW<br>MF1(or MF2)=___CC/M | |
| 5 | MF1(or MF2)=___CC/M | ENTER to accept or key in new flow; then ENTER | MF1(or MF2)=___CC/M | Controller chosen delivers gas flow requested |
| 6 | MF1(or MF2)=___CC/M | DISPLAY | MF2(or MF1)=___CC/M | Status of other controller |
| 7 | MF2(or MF1)=___CC/M | DISPLAY | MF1(or MF2)=___CC/M | Returns to original controller |
| 8 | MF1(or MF2)=___CC/M | CLEAR | OUTPUT GAS FLOW<br>MF1(or MF2)=___CC/M | |

ILLUSTRATION XV-VERIFY FLOW (f2)

II.C.6. Slope/Intercept (Function f3)

The SLOPE/INTERCEPT mode (Illustration XVI) allows the user to examine the actual slope and intercept values of the least squares fit.

The routine also permits the user to "force" a fit by directly inputting a slope and intercept value without underlying calibration data.

WARNING!
THERE IS A TWO LEVEL ENTRY INTO THIS FUNCTION TO PREVENT ACCIDENTAL CHANGES IN SLOPE AND INTERCEPT SINCE A CASUAL CHANGE IN EITHER PARAMETER SIGNIFICANTLY AFFECTS INSTRUMENT ACCURACY.

II.C.7. Print Interval (Function f PRINT)

The PRINT Interval mode (Illustration XVII) permits the user to select the interval in minutes and seconds at which the Series 100 updates the printer via its RS-232 Serial Data Interface during a BLEND or MANUAL function.

II.C.8 Ozone Calibration (Function f 5)

The Environics Series 100 Computerized Multi-Gas Calibrator is capable of linear operation over the entire available range of ozone generation through the use of special hardware and software features which allow the user to precisely control the amount of ozone produced. This is done by entering a series of commanded values for the ozone concentration generated by the S-100 (the X value) and observing the actual output ozone concentration (the Y value) as measured by an independent ozone monitor. Once the ozone output has stabilized, the actual concentration is entered as the Y value. This procedure is then repeated for four (4) additional ozone concentrations. After the five X-Y pairs have been entered, the unit is calibrated. The S-100 will perform an interpolation routine for any point which does not coincide with one of the five actual calibration points. Any desired output ozone concentration will now match the value entered on the keypad in the ozone generation mode. For best results after calibration, the instrument should be used for ozone concentrations between the lowest and highest Y values, i.e. between Y1 and Y5.

The ozone calibration routine is shown in Illustration XVIII. As shown, the user initiates the ozone calibration routine by pressing keys "f" and "5" on the keypad. The instrument will then ask for confirmation to calibrate. After displaying two temporary information messages, it will request the diluent flow followed by a request for the first ozone value, i.e. the lowest desired ozone concentration(the X value). It will then display the mathematically calculated ozone concentration,

| STEP | LED PROMPT | PRESS/INPUT DATA | NEW LED PROMPT | COMMENTS |
|---|---|---|---|---|
| 1 | READY | f and 3 | SLOPE INTCPT? | |
| 2 | SLOPE INTCPT? | YES | ABORT? (Y/N) | If YES, unit returns to READY |
| 3 | ABORT? (Y/N) | NO | ENTER FLOW METER | |
| | | | FLOW METER=___ | Flow controller selection |
| 4 | FLOW METER=___ | ENTER to accept or key in new controller #; then ENTER | ENTER NEW SLOPE | |
| | | | SLOPE=____ | Display of current slope |
| 5 | SLOPE=___ | ENTER to accept or key in new slope; then ENTER | ENTER NEW INTCPT | |
| | | | INTCPT=____ | Display of current intercept |
| 6 | INTCPT=___ | ENTER to accept or key in new intercept; then ENTER | CHANGE SIGN? | |
| 7 | CHANGE SIGN? | YES OR NO | INTECPT=____ | If YES, unit will change sign of intercept, if NO un returns to READY |

ILLUSTRATION XVI-SLOPE/INTERCEPT (f3)

| STEP | LED PROMPT | PRESS/INPUT DATA | NEW LED PROMPT | COMMENTS |
|---|---|---|---|---|
| 1 | READY | f and PRINT | PRINT? (Y/N) | |
| 2 | PRINT? (Y/N) | YES | TIME=___:___<br>CHANGE TIME? | Display of current time interval in minutes/seconds |
| 3 | CHANGE TIME? | YES | ENTER MINUTES<br>MINUTES=____ | If NO, unit returns to READY |
| 4 | MINUTES=___ | ENTER to accept or key in new interval; then ENTER | SECONDS=____ | Display of seconds interval |
| 5 | SECONDS=___ | ENTER to accept or key in new interval; then ENTER | PRINT=ON<br>READY | |

ILLUSTRATION XVII-PRINT SEQUENCE (f PRINT)

based on internal flow measurements, which should be within a few percent of the entered X value. The output is observed via an independent ozone monitor. (NOTE: If a specific output value is desired, "CLEAR" is pressed and a new ozone concentration value either higher or lower is entered. This trial and error sequence is repeated until the output concentration measured by the $O_3$ monitor is at the desired level. After an X value is entered, the unit will then ask for the true concentration observed on the ozone monitor (the Y value). The first pair of calibration points are now stored. This sequence is repeated for increasing ozone concentration until all five X-Y pairs are entered. At the first prompt the user may end the calibration routine or may check and/or modify any of the points. When the ozone calibration is complete, the "END" key returns the user to the "READY" mode.

| STEP | LED PROMPT | PRESS/INPUT DATA | NEW LED PROMPT | COMMENTS |
|---|---|---|---|---|
| 1 | READY | f and 5 | CALIBRATE OZONE? | |
| 2 | CALIBRATE OZONE? | YES | 5 POINT CAL.<br>ENTER ALL POINTS<br>ENTER DILUENT | Require five Ozone measurement |
| | | | MF1=____CC/M | Zero air flow |
| 3 | MF1=____CC/M | ENTER to accept or key in new diluent flow; then ENTER | ENTER INPUT CONC.<br>X1=___PPM | |
| 4 | X1=___PPM | Key in desired Ozone Conc.; then ENTER | ENTER TRUE CONC.<br>Y1=___PPM | Measured Ozone |
| 5 | Y1=____PPM | Enter true Conc. in PPM as measured by Ozone Monitor | ENTER INPUT CONC.<br>X2=____PPM | |
| 6 | X2=____PPM | Repeat procedure using true measured Ozone Conc. | | |
| 7 | Y5=____PPM | Key in last data point | ANOTHER? (Y/N) | |
| 8 | ANOTHER? (Y/N) | NO | READY | |

ILLUSTRATION XVIII-OZONE CALIBRATION (f5)

# III. SERVICE AND MAINTENANCE

## III.A. Troubleshooting

The Environics Series 100, with few moving parts and a durable electronics package should provide a high level of reliability. In the event that there is a failure the following troubleshooting guide may be useful in isolating and solving the problem.

WARNING!

DISCONNECT POWER WHEN WORKING ON UNIT. DUE TO RISK OF INJURY OR ELECTRIC SHOCK, DISCONNECT POWER CORD FROM WALL WHENEVER SERVICING THE UNIT. EXTREME CAUTION SHOULD BE USED IF IT IS NECESSARY TO WORK INSIDE THE UNIT WITH THE POWER CONNECTED.

CAUTION!

USE STATIC DISCHARGE EQUIPMENT. THE ELECTRONIC CIRCUIT BOARDS CONTAIN STATIC SENSITIVE COMPONENTS. ALWAYS USE STATIC DISCHARGE EQUIPMENT WHEN HANDLING CIRCUIT BOARDS.

This section contains a logical, systematic approach to isolating problems to a particular board or assembly within the instrument

### III.A.1. Power Problems

a. Unit does not function, that is there is no READY display when the instrument is turned on.

1) Blown fuse

a) Replace the fuse with one of equal rating.

2) No power to instrument

a) Verify that the proper voltage is applied to the instrument.

3) Loose wires to Motherboard

a) Check all the wiring for loose connections

4) Loose Boards

a) Check and re-seat all of the electronic boards

b. Unit does not function, no READY display, one beep

1) Improper voltage

a) Apply the proper voltage to the instrument

2) Loose boards or connections

a) Check and re-seat all of the electronic boards

3) Defective transformer

a) Replace the transformer

c. Unit does not function, no READY display, continuous beep

1) Improper voltage

a) Apply the proper voltage to the instrument

2) Loose boards or connections

a) Check and re-seat all of the electronic boards

3) Defective Microcomputer Board (100-PC1-D1)

a) Replace PC1

III.A.2. Display Problems

a. No Display

1) No power to display

a) Verify that the power cable between the display and the motherboard (100-PC8) is properly connected.

b) Verify that the voltage between the outside pin and the inside pin on the cable mentioned above is 5.0 volts +/- 0.2 volts.

2) No display communication

a) Verify that the ribbon cable between the two display boards is properly connected.

b) Verify that the ribbon cable between the display and 100-PC1 is properly connected.

c) Defective data communication drivers on PC1; replace PC1.

3) Defective display

a) Replace the display

b. Missing segments in the display

1) Communication problems

a) Verify that the ribbon cable between the two display boards is properly connected

b) Verify that the ribbon cable between the display and 100-PC1 is properly connected.

2) Defective display

a) Replace the display.

c. Display "vanishes" during the data entry

1) Loose boards or connections

a) Check and re-seat all of the electronic boards and wire connections.

III.A.3. Keypad(Membrane) Problems

a. Keypad does not respond

1) Keypad improperly connected

a) Verify that the ribbon cable from the keypad is properly connected to the Microcomputer Board 100-PC1.

2) Defective keypad

a) Replace the keypad/front panel.

3) Microcomputer or Microprocessor board lock up

a) Cycle power to the instrument

4) Loose boards or connections

a) Check and reseat all electronic boards

b. Keypad responds incorrectly

1) Keypad improperly connected

a) Verify that the ribbon cable from the keypad is properly connected to the Microcomputer Board 100-PC1

c. Certain keys do not respond, other keys respond properly

1) Keypad improperly connected

a) Verify that the ribbon cable from the keypad is properly connected to the Microcomputer Board 100-PC1

2) Defective keypad

a) Replace the keypad/front panel

d. Keypad "freezes" during data entry

1) Loose boards or connections

a) Check and re-seat all electronic boards.

2) Low line voltage

a) Check line voltage

III.A.4. Flow Controller Problems

a. No flow through either flow controller

1) No pressurized gas connected to the instrument

a) Verify that the inlet pressure is between 15-30 psi at the proper inlets.

2) Scale factors are incorrect

a) Verify that the Range (the maximum flow rate of the mass flow controller) is correct. Press "f" and "8" on the keypad and verify that the range is correct for each flow controller.

3) The Slope is incorrect

a) Verify that the Slope for each flow controller is correct; both slopes should have a value close to 1.0. Press "f" and "3" on the keypad and answer the appropriate prompts until the slope portion is reached. If the Slope value displayed is incorrect, re-enter the slope values provided with the calibration reference sheet sent with each instrument.

4) The Intercept is incorrect

a) Verify that the Intercept values for each flow controller are correct; both intercept values should be within 10% of the maximum flow rate

through each flow controller. Press "f" and "3" on the keypad and answer the appropriate prompts until the Intercept portion of the routine is reached. If the displayed values are incorrect re-enter the intercept values from the calibration reference sheet sent with the instrument.

5) Faulty analog board

a) Generate 50% of the maximum flow rate for the flow controller in question. Verify that the voltage on pin 14 on the Analog board 100-PC2 is 2.5 volts on J2 for the diluent flow controller (MF1) and J3 for the analyte flow controller (MF2). If it is not, replace the Analog board.

6) Faulty flow controller

a) Generate 50% of the maximum flow rate for the flow controller in question. Verify that the voltage on pin 6 on the Analog board is 2.5 volts on J2 for the diluent flow controller (MF1) and J3 for the analyte controller (MF2). If the voltage is not near 2.5 volts, replace the flow controller(s).

7) Output port blocked or restricted

a) Check output port

8) Bent or "kinked" tubing

a) Check all of the internal and external tubing.

b. No flow through one of the mass flow controllers

1) No pressurized gas hooked up to the correct port

a) Verify that the inlet pressure is between 15-30 psi at the inlet port.

2) Scale factor in incorrect

a) Verify that the Range (the maximum flow rate of the mass flow controller) is correct. Press "f" and "8" on the keypad and verify that the range is correct for the respective controllers.

3) The Slope is incorrect

a) Verify that the slope for the controller in question is correct. The slope should be close

to the value of 1.0. Press "f" and "3" on the keypad and answer the appropriate prompts until the slope portion is reached. If the Slope values are incorrect re-enter the Slope values given on the calibration reference sheet provided with the unit.

4) The Intercept is incorrect

a) Verify that the Intercept for the controller in question is correct; the Intercept value should be within 10% of the maximum flow rate through the controller. Press "f" and "3" on the keypad and answer the appropriate prompts until the intercept portion is reached. If the Intercept values are incorrect re-enter the values given on the calibration reference sheet provided with the unit.

5) Faulty Analog board

a) Generate 50% of the maximum flow rate for the flow controller in question. Verify that the voltage on pin 14 on the Analog board 100-PC2 is 2.5 volts on J2 for the diluent controller (MF1) and J3 for the analyte controller (MF2). If it is not, replace the Analog board.

6) Faulty flow controller

a) Generate 50% of the maximum flow rate for the controller in question. Verify that the voltage on pin 6 is 2.5 volts on the Analog board 100-PC2 is 2.5 volts on J2 for the diluent controller (MF1) and J3 for the analyte controller (MF1). If the voltage is not near 2.5 volts, replace the controller.

7) Leak in system

a) Perform an internal leak check on the instrument. Check all of the plumbing connections both inside and outside the instrument.

8) Solenoid malfunction

a) Check all electrical connections between solenoids and Microcomputer board 100-PC1.

b) Solenoid coil failure or diaphragm problems; replace solenoids

c) Contamination in the solenoids; check and clean.

c. Gas Flows not stable

1) Erratic pressure regulation

a) Replace the inlet pressure regulator.

2) Defective mass flow controller

a) Verify the flows through the controller in question.

b) Calibrate the controller.

c) Replace the controller if it cannot be calibrated properly.

3) Flow controller is being used outside of its range

a) Do not use the flow controller at less then 10% or more than 90% of its full scale range.

4) Loose boards or connections

a) Check and re-seat all of the electronic boards and all cable connections.

d. Flows are not accurate

1) Leak in the system

a) Find the leak and repair. Refer to the leak test procedure in Section III.C

2) Flow Controller out of calibration

a) Calibrate the controller in question.

3) Defective mass flow controller

a) Replace the controller in question if it cannot be properly calibrated.

III.A.5. Ozone Generation Problems

a. Ozone output is inaccurate

1) Instrument is out of calibration

a) Calibrate Ozone-See Section II.C.8.

b. No Ozone Generation

1) No flow through system

a) Verify that a source of zero air is available at the input to the instrument at a regulated pressure of 15-30 psi. The supply rate should be greater than the maximum flow of the diluent controller, MF1.

b) Verify that the flow rate through MF1 during ozone generation is at least 3000 sccm.

2) No flow through Ozone Generator

a) Turn the knob on the internal rotameter to the desired ozone generator flow. This value is typically set at the factory to 500 Sccm. If 500 sccm cannot be reached, or is unstable, refer to Section III.A.1. for flow controller troubleshooting.

3) Ozone lamp does not turn on

a) Generate 1.0 PPM of Ozone in the CALIBRATE OZONE mode by pressing "f" and "5". If ozone is being generated, proceed to step #4 below. If no ozone is generated, verify that TP5 (O3 gain) on board 100-PC10 is between 3 and7 volts when 1 PPM is commanded in this mode. Replace the Ozonator board (PC10) if this voltage is not between 3 to 7 volts.

b) Verify that the voltage at TP9 (DET) is equal to the voltage at TP5 (O3 GAIN). Continue to the next step if they are <u>not</u> equal.

c) Measure the voltage at TP7 on the lamp driver board (100-PC14). This is the board with the large black heat sink. If the voltage is between 10 to 24 volts, replace the Ozone producing lamp. If the voltage is less than 3 volts, replace board 100-PC14. It will be necessary to recalibrate the Ozone generation of the unit after this board is replaced.

4) Ozone generation is not in calibration

a) Calibrate Ozone--See Section II.C.8

c. Ozone is unstable or drifts over time

1) Oven temperature is not 50°C

2) Flows are not stable

a) Verify that the flows are stable. Recalibrate or replace the flow controller(s) if the flows

are not stable. The stability of the diluent flow controller can be visually checked by looking at the "ball" in the rotometer.

3) Ozone lamp problem

a) Replace the lamp and recalibrate the Ozone--See Section II.C.8.

## III.B ROUTINE MAINTENANCE

Maintenance on a periodic schedule should be performed on the Environics Series 100 Gas Calibrator in order to reduce equipment malfunction and maintain the accuracy and reliability of the instrument. The following section provides information for performing this maintenance. Since the use of the unit may vary between locations, it may be necessary to adjust the maintenance schedule accordingly.

**WARNING!**

**DISCONNECT POWER WHEN WORKING ON THE UNIT. DUE TO RISK OF INJURY OR ELECTRICAL SHOCK, DISCONNECT THE POWER CORD FROM THE WALL WHENEVER SERVICING THE UNIT. EXTREME CAUTION SHOULD BE USED IF IT IS NECESSARY TO WORK INSIDE THE UNIT WITH THE POWER CONNECTED.**

**CAUTION**

**USE STATIC DISCHARGE EQUIPMENT WHEN SERVICING THE INSTRUMENT. THE ELECTRONIC BOARDS CONTAIN STATIC SENSITIVE COMPONENTS. ALWAYS USE STATIC DISCHARGE EQUIPMENT WHEN HANDLING CIRCUIT BOARDS.**

In order to replace parts in the unit it might be necessary to slide the chassis back for easier access. To do this, disconnect the power and:

1. Remove the four screws on the back panel;
2. Loosen (do <u>not</u> remove) the four chassis screws;
3. Slide the chassis back approximately 3 inches;
4. Disconnect the keypad and LED display cables;
5. Disconnect the ON/OFF switch;
6. Slide chassis back to the desired position.

The items which require most of the routine maintenance in this instrument are the mass flow controllers. It is <u>always</u> recommended that zero air and <u>not</u> ambient air be run through both of the flow controllers. This should be done for several minutes to clear away any loose particles or residue that may have entered the system. This should be done as often as the environmental conditions and the types and quality of the gases being used require. A flow verification should be done after this zero air cleansing and a zero adjustment may be necessary.

The outside of the instrument should be cleaned with a soft cloth using a mild soap and water solution. Care should be taken not to touch any of the electronics. Abrasive cleaners should be avoided. It may be necessary to remove the fan guards to clean the fan blades.

Dust inside the instrument should be removed as this could interfere with proper operation of the unit under certain conditions. The circuit boards can be cleaned using a vacuum or air gun.

Prior to putting the unit back in service after routine maintenance, complete the following check list:

Inspect power cords and internal wiring;

Check all fittings for tightness, leak check if possible;

Check all tubing for splits, kinks or cuts.

## III.C LEAK CHECK

All Environics Series 100 units are helium leak checked prior to shipment as part of final quality control procedures. Leak specifications for the unit are approximately 1 X $10^{-5}$ sccm at the time of checking.

There are a variety of ways to do a leak check on the instrument. The first method is of course to repeat the helium leak check as was done at the factory. This however may not always be practical in the field.

In the field, we recommend doing the following.

1. Cap the outlet port on the instrument;

2. Apply air to one of the ports, either diluent or analyte.

3. Command 80% of the full scale value of the flow controller being checked. It would be useful to do a "zero" check on the flow controllers.

4. After approximately 10 minutes the display should read less than 2 sccm.

5. If the displayed flow is in excess of this value, apply a soap solution to the fittings to determine the cause of the leak.

# III. SERVICE AND MAINTENANCE

## III.D PC Board Function and Description

### III.D.1. 100-PC1 Microcomputer Board

FUNCTION: Provides the interface between the operator and the microprocessor through the keypad and the 16 character LED display on the front panel. This board also controls the operation of all of the various solenoids and converts the analog mass flow controller response signals to binary numbers for processing.

THEORY OF OPERATION: U1, which is an EPROM version of the Motorola 6805 microcomputer reads the keypad by strobing the rows via U4 ( a 3 to 8 decoder ) and U5 and U6 (buffers) and reading the columns after an interrupt is generated. This interrupt is generated whenever any key is pressed. By knowing the column and row which was activated, it can deduce which key was pressed.

Other inputs to PC1 include the analog voltages and the corresponding error signal which is read by the analog-to-digital converter (ADC) on the microcomputer. An "AC low" input, which originates on the power supply board signals that the input voltage has reached an unacceptable low level.

### III.D.2. 100-PC2 Analog Board

FUNCTION: Converts the digital signals from the microprocessor on PC3 to analog voltages for commanding the flow rates of the mass flow controllers. This board also filters the response of the flow controllers and sends these to the microcomputer on PC1 for processing.

THEORY OF OPERATION: U3 is a digital to analog converter (DAC), which under microprocessor command, controls the flow through the mass flow controllers.The microprocessor talks to the DAC via the address, data and control lines on the motherboard. U1 and U2 act as voltage and current buffers between the two. Q1 is a +5 volt reference which is fed to the ADC's voltage reference input and to other parts of the circuit via voltage follower operational amplifier (U4). Pins 17 and 15 on U3 correspond to the current output of the DAC for MF1 and MF2 respectively, which is proportional to the commanded flow requested by the user. U5 and U6 are current to voltage converters since the mass flow controllers require a voltage signal to operate properly. U9 and U8 and their corresponding hardware components buffer, amplify and filter the computer command signal for use by the flow controller. P8 and P6 are used to zero the operational amplifiers at a command flow of zero. P7 and P5 are used as a minor gain adjustment. The command output for the flow controller is available on pin 14 of the 15 pin "D" connector and on TP1 or

TP3. The response of the flow controller enters the analog board on pin 6 of the 15 pin connector. The dual diode and capacitor act as a filter and protection device for each input. This signal then branches off to two places, the signal MFx and to the error detection signal MFEx. U7 and its associated circuitry provide a signal to the microprocessor which is an amplification of the difference between the command voltage and the response voltage. The two error signals and the two response signals are sent to the microcomputer for further mathematical computations.

III.D.3. 100-PC3 Microcomputer Board

FUNCTION: This board performs the necessary arithmetic calculations and data processing for the unit. This board also provides the commands to the analog board and handles the communication protocol between all of the various boards in the system.

THEORY OF OPERATION: U5, the 6803, is the "brain" of the instrument. It performs most of the data processing, stores the variable instrument information in the non-volatile random access memory (RAM), controls and reads the real time clock, and generates much of the control logic which is used to interface with all of the other boards in the system. The real time clock and the non-volatile RAM are both contained in U13. A highly structured sequence of 64 cycles is used to gain access to time information and temporarily disconnect the mated memory from the system bus. Information transfer into and out of the clock is achieved by using address bits A0 and A2 and the control signals. The odds of the necessary pattern occurring inadvertently during normal operation is less that 1 in $10^{+9}$.

III.D.4. 100-PC4 RS-232 Board

FUNCTION: Provides a serial RS-232 interface between an external instrument and the Environics unit.

THEORY OF OPERATION: The RS-232 interface board consists of two (2) UARTs (Universal Asynchronus Receiver/Transmitter) which accept data from either the Environics software or from an external source and formats them according to the proper protocol. When serial data is received from an outside source (eg: a computer) the UART converts this serial data to an eight bit parallel data byte which can be processed by the Environics unit. When the resident software communicates to the outside world, it sends data via the eight bit parallel data bus to the UART where it is converted to a serial data stream. The baud rate, the rate at which information is transferred, is controlled by the jumpers on the board. A crystal, XL1, oscillates at 153.6 KHz and is divided down to various frequencies by the counter U3. One of these

frequencies is then selected by the jumpers to be the baud rate. U5, U6 and U7 are level shifters which convert the data from the RS-232 specifications to logic levels or from logic levels to the RS-232 specifications depending on the direction of the data.

When any serial commands or requests are sent from an external source, this data is temporarily stored in the UART until the microprocessor reads the UART's internal buffer. The microprocessor is sent and interrupt signal, /IRQ, whenever there is any data in this buffer.

### III.D.5. 100-PC5 Power Supply

FUNCTION: Provides a filtered, regulated +15 and -15 volts for the analog circuitry, +5 volts for the digital logic, and an unregulated +12 volts for solenoid control. It also provides an AC low signal to indicate that the main power supply is low or has been shut off.

THEORY OF OPERATION: The Power Supply board requires two inputs. The first is a rectified input with a DC input of approximately 15 to 18 vo9lts with an AC component of 1 to 4 volts. After passing the filter capacitors C1, C2 and C3, the voltage is regulated by Q1, an adjustable regulator. Adjusting P1 results in a change of output voltage. P1 is set at the factory such that the output of the regulator is 5.00 volts DC. C5 acts as filter and D2 protects the circuit against any reverse bias voltage. The second required input is an AC voltage which is rectified by DB1 on the power supply board. After passing by the filter capacitors C6, C7, C8 and C9, the two voltage regulators, Q2 and Q3, regulate the voltage to +15 and -15 volts for use by the analog circuitry elsewhere in the instrument. C10, C11, C14 and C15 act as an output filter for the +15 and -15 volts output. D4 and D5 provide reverse bias protection. An AC low voltage input signal is generated by U11 and its associated circuitry which provides a signal to the microprocessor that the AC line voltage is dangerously low.

### III.D.6. 100-PC6 Display Adapter

FUNCTION: To provide an interface between the microcomputer and the front panel 16 segment LED display.

THEORY OF OPERATION: All of the power, data and control lines pass from the microcomputer board (PC1) to the display via the ribbon cable and the display adapter board. The display adapter is mounted on the back of the LED display and it buffers all of the signals and converts a serial data stream on "D7" to a parallel address for the display (A0 through A3).

III.D.7. 100-PC7 RS-232 Connector

FUNCTION: To provide a path for the serial communications and the printer signals from the instrument to two industry standard DB25 25 pin connectors.

THEORY OF OPERATION: Both the printer and serial communication (computer) signals are interfaced from the RS-232 board (PC5) to the outside world via a ribbon cable and the RS-232 Connector board. This board is mounted on the back panel of the instrument and it separates the computer from the printer signals and routes them to their respective DB25 connectors.

III.D.8. 100-PC8 Motherboard

FUNCTION: To provide a transfer medium for all of the power, address, data and control lines.

THEORY OF OPERATION: The power comes in on J6 and is delivered to J5, the power supply connector. The power supply distributes power to all of the other boards and to the display via J7. All of the other power, address, data and control lines are connected via runs on the PC board to the respective PC board connectors, J1, J2, J3, J4, J10 and J11.

III.D.9. 100-PC10 Ozonator Board

FUNCTION: The two main functions of the ozonator board are to provide communication between the main microprocessor and the ozone generator and to measure and control the temperature of the ozone generator.

THEORY OF OPERATION: Other microprocessors, located on PC1 and PC3, communicate with U7 (68705 microcomputer) via the address, data and control bus on the motherboard (PC8). U2 (AD584) provides a voltage reference to a variable gain amplifier, U1. Adjusting P6 on the board varies the gain of U1 which changes the negative voltage reference (-Vref). The digital-to-analog converted (DAC), which is under microprocessor control, outputs a current which is proportional to the commanded value and -Vref. U9 then converts this current to a voltage (which can be measured on TP5). This is the voltage which acts as the ozone lamp intensity controller. U11 is a comparator/driver which compares the lamp intensity output with the commanded voltage and increases or decreases the lamp driver to insure that the lamp drive exactly equals the command voltage. This optical feedback circuit resolves the problem of long term and short term lamp drift. The voltage at TP4 (the lamp drive voltage) should be between -3.0 and -12.0 volts for proper operation.

U12 is a current-to-voltage amplifier which converts the low current of the photodiode to a detector output voltage which can be measured on TP9. If the feedback circuit is functioning properly,TP9 and TP5 (the command voltage) should be equal. If the voltage at TP9 is less than the voltage at TP5, then there is a problem with either the lamp or the lamp driver board, 100-PC14.

U18 acts as the temperature controller for the ozone generator. R42 and R43 act as a fixed voltage divider which form two legs of a bridge. R44 and the thermistor, which is located inside the ozone generator form the other legs of the bridge. Therefore, in the equilibrium state, the voltages at pins 4 and 5 on U18 will be equal. U18 will drive transistor Q11 on the ozone generator which will in turn allow current to pass through the heater coil, thereby heating the generator. Once the thermistor TR1 reaches a value as determined by the resistor bridge, the temperature controller will regulate the temperature within one (1) degree celsius. U19 is a voltage follower which buffers the thermistor from the rest of the circuitry, acts as an amplifier with a fixed gain and a variable offset adjustment. When the generator reaches equilibrium temperature, P2 can be adjusted to change the displayed temperature as seen on the front panel. This voltage then passes through and integrated switch, U10, where it goes through one last voltage follower before it is read by the microcomputer, U7. The diode array, D1, and its associated circuitry, as a voltage clamp to protect the analog-to-digital (ADC) input on the microcomputer. The voltage as seen by the ADC will always be within the range of -0.1 to +4.9 volts

### III.D.10. 100-PC11 Ozone Control Board

FUNCTION: Provides the interface between the microprocessor and the ozonator board via a ribbon cable on the top of PC11 and PC10.

THEORY OF OPERATION: The ozone control board acts as an interface by decoding the address lines to act as the chip and board select lines. This board buffers all of the address lines with line drivers U2 and U3. The data lines are buffered by U10, a bidirectional line driver.

### III.D.11. 100-PC14 Lamp Driver Board

FUNCTION: The Lamp Driver Board accepts an analog input signal from the ozonator board (PC10) and powers the mercury vapor ozone producing lamp proportional to the level of the input.

THEORY OF OPERATION: The Lamp Driver Board generates its own +24, +15, -15 and +5 volt power supply. An AC signal is rectified by DB1 and DB2 for use as an input to the +24 volt

regulator (VR1) and the +15/-15 volt regulators (VR3) and (VR4) respectively. a DC signal is regulated by VR5 to produce the +5 volt supply.

A universal timer chip (555) generates a 20 KHz signal which is converted to a 10 KHz 50% duty cycle square wave by a D flip-flop (U2) for use as the high frequency input needed for proper operation of the lamp. The outputs which are generated are Q and /Q which are 180 degrees out of phase. These signals are then fed to U3, an open collector driver which drives the first stage amplifiers, Q7 and Q9. Q7 drives the second stage amplifier Q12 which pulls current through the "upper half" of the transformer T1. Q9 drives the other second stage amplifier Q16 which pulls current through the "lower half" of the transformer T1. In this way, a 10KHz 50% duty cycle square wave is stepped up through the transformer T1 to produce a 10 KHz 50% duty cycle at a voltage which is far greater but proportional to the input voltage at the center tap of the transformer.

The input voltage at the center tap of the transformer is controlled by the voltage at J1-9. This signal originates on the ozonator board (PC10) and is dependent on the light intensity detector in the ozone generator. With a positive voltage on J1-9, the first stage drive circuit Q3 is shut down which in turn shuts down the second stage drive control circuit, Q2. A negative voltage, and thereby a negative current, turns on the first stage which turns on the second stage drive control circuit in proportion to the current at J1-9. At maximum drive current, the voltage at the transformer centertap input is approximately 23 volts. If the voltage at TP7, which is the transformer center tap, is 23 volts, the circuit is in saturation and is not controlling the lamp. The lamp is being properly controlled when the voltage at TP7 is approximately 10 to 21 volts.

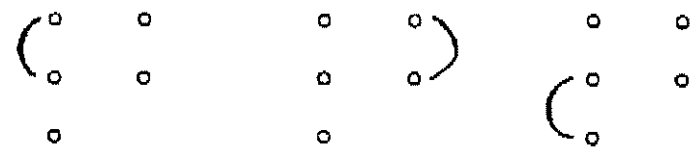
### III.D.12. 100-PC16 Status Board

FUNCTION: The Status Board examines the state of the solenoids in the instrument and sets a "status bit" corresponding to the configuration of the board.

THEORY OF OPERATION: This board uses U1 and U2 as a comparator to compare the solenoid voltage against a reference voltage of 2.5 volts. The outputs of the comparators are active low, i.e. the output goes low (0.0 to 1.2 volts) when the corresponding solenoid is energized. The PAL (Programmable Array Logic) chip, U3, which controls the status bits is factory programmable to meet the customers requirements. The PAL uses the status of the solenoids as its inputs and performs an AND/OR function on these to generate the proper

output. For example, if the customer requests that a status bit be active when the instrument is in the zero mode, the PAL will set this bit when it detects that the diluent and output solenoids are active and the ozone and the four port solenoids are inactive. U4 is used as a buffer between the TTL logic PAL and the reed relay to drive the display and the status bit. The 10 segment LED display on the board is used as a debugging and diagnostic feature. The top two LED's indicate that a +5 volts and +24 volts are both supplied to the board. There are two sets of test points "+5V" and "+24V" which allow the user to verify these voltages with a voltmeter. The remaining eight LED's correspond directly to the eight status bits.

The 8 independent status lines are each available on two screws on the terminal block which is mounted on the rear panel of the instrument. The terminal block is numbered sequentially from left to right, 1 through 20. Numbers 1 to 16 are used as the status lines, 17 and 18 are used to monitor any point inside the unit (after the necessary connections are made inside the unit). Each status line may be configured through jumpers as shown below:



| Contact Closure | Pull to Ground | Pull to +24 Volts |
|---|---|---|

The 8 status lines are independently configurable, i.e. status line #1 may be a contact closure, status line #2 may be pulled to ground and status line #3 may be pulled to +24 volts upon activation.

Below is a list of the terminal block screws which correspond to the various status lines:

| | Contact Closure | Pulled to Ground * | Pulled to +24 Volts * |
|---|---|---|---|
| Status Line #1 | 1-2 | 1 | 2 |
| Status Line #2 | 3-4 | 3 | 4 |
| Status Line #3 | 5-6 | 5 | 6 |
| Status Line #4 | 7-8 | 7 | 8 |
| Status Line #5 | 9-10 | 9 | 10 |
| Status Line #6 | 11-12 | 11 | 12 |
| Status Line #7 | 13-14 | 13 | 14 |
| Status Line #8 | 15-16 | 14 | 16 |

*Note: When the status line is pulled to ground or +24 volts, pin 20 is used as the common reference ground.

As an option when the PAL is configured, the user may elect to forfeit one of the status bits to be used as a "recovery timer". This timer is activated when the flow through the system is de-activated. It uses the 555 integrated timer chip to perform this function. R4 and C22 act as the main timing components with P1 used as the timer adjustment. The "recovery time" is set by adjusting P1 and measuring the voltage at TP3, the "control voltage". The following chart determines the proper voltage setting for the desired recovery time:

| Control Voltage | Recovery time |
|---|---|
| 1.0 volts | 1.5 minutes |
| 1.8 volts | 2.0 minutes |
| 2.5 volts | 3.0 minutes |
| 3.0 volts | 4.0 minutes |
| 3.4 volts | 5.0 minutes |
| 3.7 volts | 6.0 minutes |
| 3.9 volts | 7.0 minutes |
| 4.1 volts | 8.0 minutes |
| 4.4 volts | 9.0 minutes |

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# IV. APPENDIX

## IV.A. WARRANTY

1. Subject to exceptions stated below, Environics agrees to correct, either by repair or, at our option, replace any Series 100 Computerized Multi-Gas Calibrator that does not function within the limits of its published performance specifications for one (1) year after delivery at the site of the original purchaser.

2. This warranty requires that the instrument be maintained and operated in accordance with the Instruction and Use Manual supplied with the instrument and that the defects occurred under normal use.

3. Expendable items (fuses, lamps, etc.) are excluded from this warranty.

4. Requests for warranty service must be received by Environics within the warranty period.

5. Repair and service performed after expiration of the original one (1) year warranty period shall be charged to the purchaser at the parts, labor and shipping charges then prevailing.

6. The warranty given herein is exclusive and Environics shall have no liability under any warranty express or implied. Environics does not warrant merchantability or fitness for any particular purpose to the articles covered hereunder. Statements made by any person or representative of Environics, which are inconsistent with the terms of this warranty shall not be binding on Environics unless confirmed in writing by an officer of the company or a duly authorized manager.

   Environics assumes no obligation of any kind with regard to design modifications not authorized by Environics or repairs made by other than authorized service personnel.

7. Environics will only pay shipping charges for units found to be defective.

# IV. APPENDIX

## IV.B. INSTRUMENT SCHEMATICS/WIRING DIAGRAM/PARTS LIST-

# IV. APPENDIX

## IV.C. GAS COMPATIBILITY

The "wetted" surfaces of the standard Environics Series 100 Computerized Multi-Gas Calibrator are as follows:

| | |
|---|---|
| Inlet Ports & Fittings: | Type 316 Stainless Steel |
| Tubing: | Teflon |
| Mixing Chamber: | Teflon |
| Flow Controllers: | Type 316 Stainless Steel w/Viton Seals |
| Solenoids (Span Gas): | Type 303 Stainless Steel |
| Solenoid (Diluent): | Type 303 Stainless Steel |

It is important for you to have determined the compatibility of the gases being used with the Environics unit. Failure to confirm that a gas or gas blend is not compatible with the unit provided to you will void the warranty provided for the unit.

Since use applications and conditions of use are outside of Environics' control, Environics makes no warranty or representation regarding the results which may be obtained by the user.

# IV. APPENDIX

## IV.D. CALIBRATING A MASS FLOW CONTROLLER

Mass flow controllers operate on a thermal principle that depends on the mass flow of the gas and on its heat capacity to gage the temperature within a heated conduit. Since these controllers measure the true mass flow, they have the advantage of not requiring corrections for changes of temperature and pressure. Flow rate values are usually given in standard cubic centimeters per minute, which are measures of the volume occupied by a mass of air at standard temperature and pressure, as specified by the manufacturer.

Since mass flow controllers are not volume displacement devices, they require calibration at least quarterly against a displacement device such as a bubble meter or a wet test controller, (servicing as a secondary calibration standard.)

The flow controllers can only be calibrated within the accuracy of the secondary calibration standard. When using these standards be sure to compensate for temperature and pressure. The Series 100 is initially calibrated by Environics to a Standard Temperature and Pressure of 77°F and 760 mm Hg (unless specified otherwise.) The pressure is adjusted to sea level. Depending on the type of device used, compensation for gas temperature, test device back pressure and relative humidity may be required. Follow the instructions for use of your flow calibration standard and incorporate all compensations during the calibration.

The procedure for a full calibration of the TYLAN flow controllers is contained in their manual enclosed with your unit.

# IV. APPENDIX

## E. Replacement of Mass Flow Controllers

If for any reason a mass flow controller is replaced, the following procedure should be used to electronically "tune" the flow controller and the Series 100 electronics package:

1. With the unit off and unplugged, physically switch the flow controllers. Mass flow controller number 1 (diluent) connects to connector J2 on the Analog board (100-PC2-D2) while mass flow controller number 2 (span gas) connects to connector J3 on the analog board (100-PC2-D2). Be sure there are no leaks in the plumbing when connecting the new flow controller.

2. Plug in the Series 100 and turn on the unit.

3. Set the flow controllers size in the computers memory by pressing f 8 and answering the prompts. The computer is asking for the maximum range of the flow controller.

4. Allow the flow controllers to warm-up a minimum of 30 minutes.

5. Zero the flow controller per the Tylan manual.

6. Calibrate the flow controller per the Tylan manual Do not become alarmed at slight display inaccuracies as these will be adjusted later.

7. Adjust the display. The adjustment for the display is located on the analog board, (100 PC2-D2). Adjust P1 for flow controller 1 and P2 for flow controller 2. First monitor the display at 20 percent and 100 percent of full flow to determine if the display needs adjusting and if so, how much. The adjustment shifts the entire display higher or lower but the display may be slightly non-linear so a compromise may have to be made such as having the 20 percent range slightly low and the 100 percent range a little high. The user may wish to adjust the display so it is most accurate at the flow most often used. Once you determine how much to adjust, make that adjustment. Repeat the procedure of looking at both ends of the scale then adjusting until the desired accuracy is reached.

8. The flow controller is now ready for use.

# IV. APPENDIX

## F. Zeroing a Flow Controller

An unfortunate reality with flow controllers is zero drift; therefore the flow controllers must be periodically rezeroed. When rezeroing use the following procedure.

1. Allow the Series 100 to warm up for 30 minutes (minimum).

2. Disconnect all input gases and the output from the Series 100.

3. Connect a DC Voltmeter to the Series 100 electronics on the analog board, (100-PC2-D2). For flow controller number 1 connect the meter to PJ7 and connect the positive (red) probe to the A side of PJ7. For flow controller number 2 connect the meter to PJ5. Connect the black probe to the B side and the red probe to the A side. For both flow controllers the programming jumpers which are on PJ5 and PJ7 must remain in the A position during the procedure. To connect the red probe to the A position remove the programming jumper, connect the probe, then replace the jumper. A small probe should be used such as an E-2 hook brand mini-hook.

4. Adjust the zero adjusting screw on the flow controller to achieve a meter reading of negative .010 volts to negative .050 volts. With a slight negative the drift will generally stay below zero and will keep the Series 100 display reading zero. If the flow controller zero drift is positive, then a reading may result on the display of the Series 100.

5. After making the adjustment, view the meter for one or two minutes to assure that the adjustment is maintained.

6. Remove the probes making sure that the programming jumper is securely placed in the A position of PJ5 and PJ7.

This procedure should take place whenever the unit is serviced or every 4 months. This procedure should also be performed whenever a positive reading is observed or there is a display with no gas input.