INSTRUCTION MANUAL

MODEL 700
MASS FLOW CALIBRATOR

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SAFETY MESSAGES

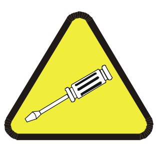
Your safety and the safety of others is very important. We have provided many important safety messages in this manual. Please read these messages carefully.

A safety message alerts you to potential hazards that could hurt you or others. Each safety message is associated with a safety alert symbol. These symbols are found in the manual and inside the instrument. The definition of these symbols is described below:

GENERAL WARNING/CAUTION: Refer to the instructions for details on the specific danger.

CAUTION: Hot Surface Warning

CAUTION: Electrical Shock Hazard



TECHNICIAN SYMBOL: All operations marked with this symbol are to be performed by qualified maintenance personnel only.

CAUTION

The M700 Calibrator should only be used for the purpose and in the manner described in this manual.

If you use the M700 Calibrator in a manner other than that for which it was intended, unpredictable behavior could ensue with possibly hazardous consequences.

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1 INTRODUCTION

1.1 Preface

Teledyne API is pleased that you have purchased the Model 700. We offer a full one year warranty (see Section 1.2), and we at Teledyne API will be pleased to provide you with any support required so that you may utilize our equipment to the fullest extent.

The Teledyne API Model 700 keyboard/operator interface with its "talking keys" makes the Teledyne API a very user-friendly system. We hope you will not experience any problems with the Teledyne API Model 700, but if you do, the built-in tests and diagnostics should allow you to quickly and easily find the problem. In addition, our full time customer service department is always available to answer your questions.

1.2 How To Use This Manual

This manual is intended to help the user operate the M700 easily and precisely per the user’s needs. This operational manual includes many typical examples for easy reference and application for first time users or even experienced users. There are mainly two modes of operation in the M700. The manual step mode (Section 5.2) requires someone to be present to initiate the calibration procedure, but it offers flexible operation. The automatic sequence mode (Section 5.3) on the other hand is convenient, as it allows automatic control whether it is initiated manually by the built-in software timer, remote contact closures or via the RS-232 interface. Like other Teledyne API Analyzers, the M700 supports extensive remote control capabilities through the RS-232 serial port, including most of the manual mode operations.

The first time user could follow Section 2 GETTING STARTED for the initial source gas setup, ozone bench setup and the initial operation to generate zero/span calibration gases. Additional help is provided by the easy-to-follow examples in Section 5.2. Using these examples will help the user navigate through the software menus as quickly and comfortably as possible. Caution and warning notes are included wherever they are needed.

The M700 can be interfaced with a variety of data acquisition systems such as a data logger, modem or computer. In order to set up your Model 700 with remote control from a central site the user would refer to Section 2 (installation), Section 5 (explains how to program and setup the calibration sequences and initiate them by using external sources) and Section 7 (explains, in detail, most of the RS-232 communication and control information).

This manual should provide most of the information the user needs to operate the M700, however, if you encounter any difficulty while using the M700 we suggest you call our customer service department.

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2 GETTING STARTED

2.1 Installation

1. Verify that there is no apparent shipping damage. If damage has occurred, please advise the shipper first, then Teledyne API.

CAUTION
To avoid personal injury, always use two persons to lift and carry the Model 700.

2. Remove the instrument cover and check the voltage and frequency label on the rear panel and compare that to your local power before plugging in the M700. Do not plug in the power cord if the voltage or the frequency is not correct.
3. Check for internal shipping damage, and generally inspect the interior of the instrument to make sure all circuit boards, glassware, and other components are in good shape.
4. Replace the instrument cover. The instrument should not be operated with cover off.
5. When installing the M700, allow at least 4” (100mm) clearance at the back and at least 1” (25mm) clearance at each side for proper venting.

2.2 Electrical and Pneumatic Connections

2.2.1 Source Gas Connection

1. Refer to Figure 2-1 to locate the rear panel pneumatic connections.
2. Attach the zero air source line to the port labeled Diluent In. Diluent Air should be dry (approximately -20°C Dew Point) and the pressure between 25 PSI to 30 PSI at a flow in excess of 10 SLPM (20 SLPM option).

NOTE
If zero air source is not from the API M107, then the zero air source must provide pressurized zero air continuously at 250 cc/min for the ozone generator purge flow and/or perm tube oven purge flow.

NOTE

Use fittings provided to connect the zero air source line. First finger tighten. Then using the proper tool, make an additional 1 and ¼ turn.

3. Connect the gas source line to the ports labeled CYL 1 through 4. Source gas delivery pressure should be regulated between 25 PSI to 30 PSI. See Section 2.3, step 1 for the source gas port set up.
4. Connect the TEST GAS OUTPUT port to the calibration manifold. Use thin wall (0.03 inch wall thickness preferred) 1/4 inch Teflon tubing. A maximum length of 3 meters is recommended.

NOTE

The calibration manifold provides a pneumatic interface between the calibration system and other devices (or systems) which use the calibration gas output. The manifold must have one or more ports for connections to such external devices or systems, and it must be designed so that all ports of a multiport manifold provide identical concentrations. The vent of the manifold should be large enough to avoid any appreciable pressure drop, and it must be located sufficiently downstream of the output ports to assure that no ambient air enters the manifold due to eddy currents or back diffusion. The manifold's excess gas should be vented to a suitable vent outside of the room. The manifold must be made of glass, teflon or other relatively inert material, and it should be kept as clean as possible to avoid loss of sample gas. Figure 2-3 illustrates a typical manifold.

5. Attach the VENT OUTPUT PORT to a suitable vent outside of room at atmospheric pressure.

2.2.2 Electrical Connections

1. Refer to Figure 2-1 to locate the rear panel electrical connections.
2. If desired, connect the control output, control input, and status output. Each group (the control output, control input, and status output) has 12 channels in which the first 4 channels are connected to the corresponding 8-pin connector (refer to Figure 2-1). The remaining 8 channels of each group are connected through the 50-pin connector (refer to Figure 2-2). Refer to Section 4.2.7 RS-232 Interface and the electrical schematic 01565 in the Appendix Section for more detailed information.
3. If desired, also connect the recorder analog output to a strip chart recorder (refer to Figure 2-2) and the 9-pin RS-232 connector to a host computer.
4. Connect the power to the correct voltage line.
5. Turn to Section 2.3 INITIAL OPERATION.

CAUTION

High voltages present inside case.

DO NOT look at the UV lamp.

UV light could cause eye damage.

Always use safety glasses (plastic glasses will not do).

Connect the vent out port on the rear panel to a suitable vent outside the room.

CAUTION

Do not operate with cover off.

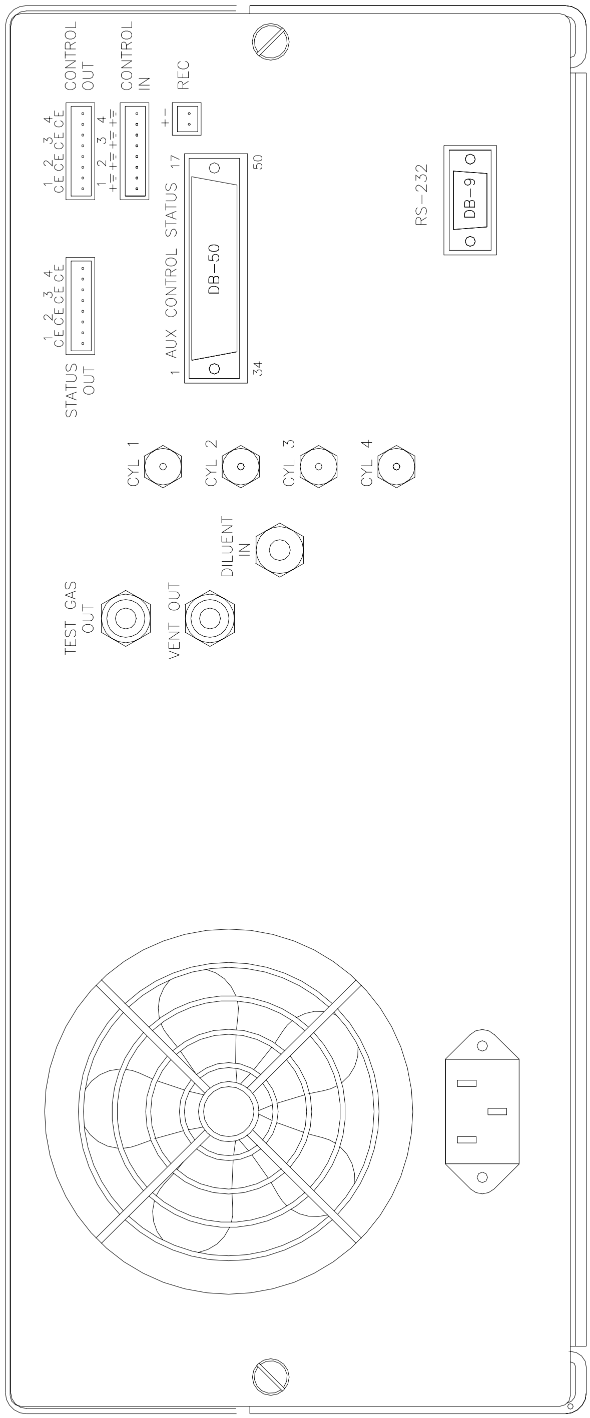
Before operation check for correct line voltage and frequency on Serial Number Sticker.

Do not operate without proper chassis grounding.

Do not defeat the ground wire on power plug.

Turn off analyzer power before disconnecting or connecting electrical subassemblies.

Always replace shipping screws when transporting the Analyzer.



STATUS OUT PIN ASSIGNMENTS

CH NO.	PIN NO.	ASSIGNMENT
1	1	SO1C
	2	SO1E
2	3	SO2C
	4	SO2E
3	5	SO3C
	6	SO3E
4	7	SO4C
	8	SO4E

FOR ADDITIONAL 8 STATUS OUT CHANNELS, SEE FIGURE 2.3

CONTROL IN PIN ASSIGNMENTS

CH NO.	PIN NO.	ASSIGNMENT
1	1	CI1+
	2	CI1−
2	3	CI2+
	4	CI2−
3	5	CI3+
	6	CI3−
4	7	CI4+
	8	CI4−

FOR ADDITIONAL 8 CONTROL IN CHANNELS, SEE FIGURE 2.3

CONTROL OUT PIN ASSIGNMENTS

CH NO.	PIN NO.	ASSIGNMENT
1	1	CO1C
	2	CO1E
2	3	CO2C
	4	CO2E
3	5	CO3C
	6	CO3E
4	7	CO4C
	8	CO4E

FOR ADDITIONAL 8 CONTROL OUT CHANNELS, SEE FIGURE 2.3

Figure 2-1: Rear Panel

ADDITIONAL STATUS CONTROL OUTPUT

(50 PIN CONNECTOR)

ADDITIONAL CONTROL OUT
PIN ASSIGNMENTS

CH NO.	PIN NO.	ASSIGNMENT	
5	1	C05C	
	2	C05E	
6	3	C06C	
	4	C06E	
7	5	C07C	
	6	C07E	
8	7	C08C	
	8	C08E	
9	9	C09C	
	10	C09E	
10	11	C010C	
	12	C010E	
11	13	C011C	
	14	C011E	
12	15	C012C	
	16	C012E	

ADDITIONAL STATUS OUT
PIN ASSIGNMENTS

CH NO.	PIN NO.	ASSIGNMENT	
5	34	S05C	
	35	S05E	
6	36	S06C	
	37	S06E	
7	38	S07C	
	39	S07E	
8	40	S08C	
	41	S08E	
9	42	S09C	
	43	S09E	
10	44	S010C	
	45	S010E	
11	46	S011C	
	47	S011E	
12	48	S012C	
	49	S012E	

ADDITIONAL CONTROL IN
PIN ASSIGNMENTS

CH NO.	PIN NO.	ASSIGNMENT	
5	18	CI5+	
	19	CI5−	
6	20	CI6+	
	21	CI6−	
7	22	CI7+	
	23	CI7−	
8	24	CI8+	
	25	CI8−	
9	26	CI9+	
	27	CI9−	
10	28	CI10+	
	29	CI10−	
11	30	CI11+	
	31	CI11−	
12	32	CI12+	
	33	CI12−	

RS−232 PORT
PIN ASSIGNMENTS

PIN NO.	ASSIGNMENT
1	
2	TX(RX) DATA
3	RS(TX) DATA
4	
5	SIG GROUND
6	DSR
7	
8	CTS
9	

RECORDER OUTPUT
PIN ASSIGNMENTS

PIN NO.	ASSIGNMENT
1	+
2	−

Figure 2-2: Interface Pin Assignments

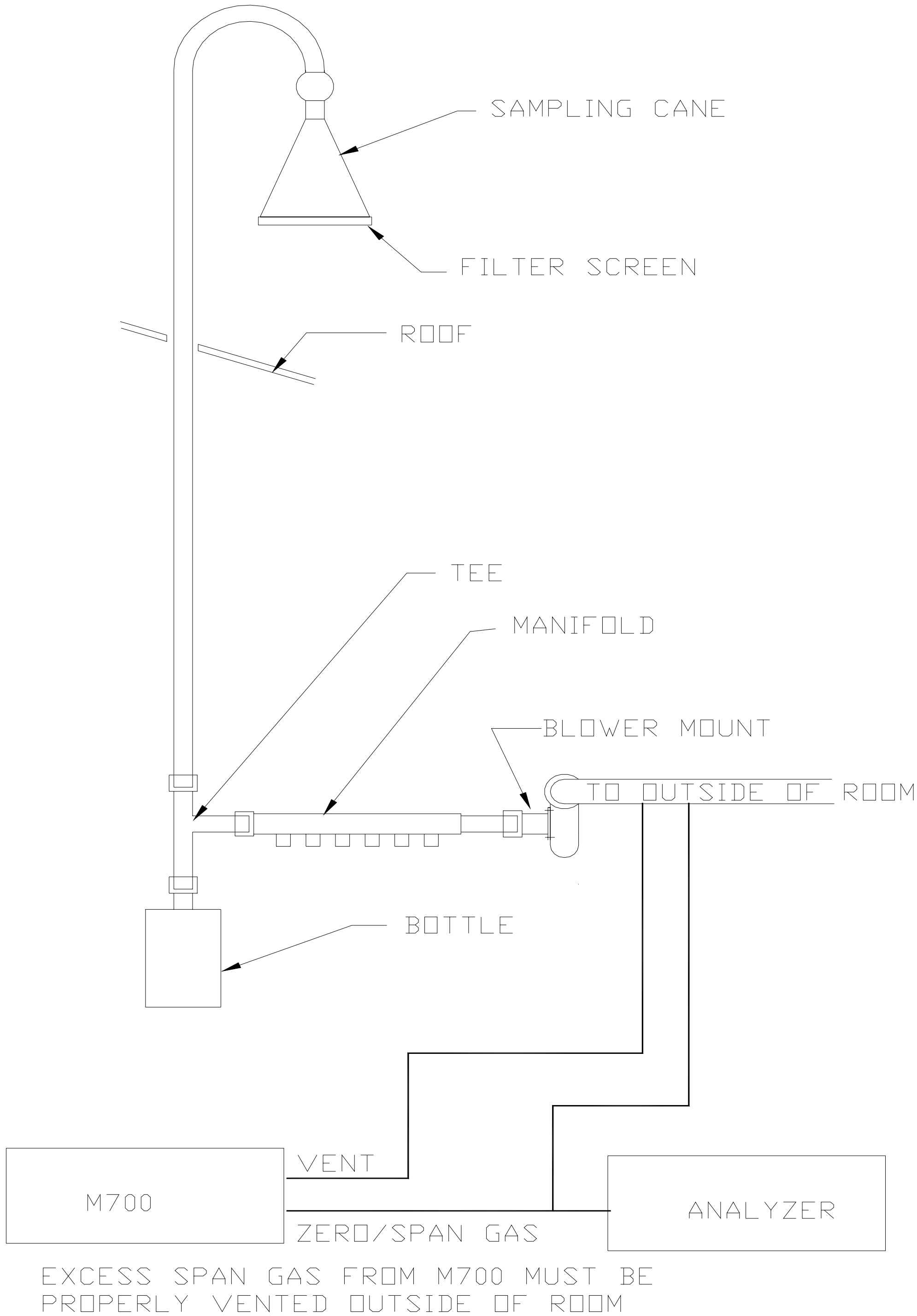


Figure 2-3: Typical Calibration Manifold

2.3 Initial Operation

1. Turn on the instrument power.
2. The display should immediately light up displaying the instrument type (M700) and the CPU memory configuration. If you are unfamiliar with the M700, we recommend that you preview Section 4 and 5 before proceeding. A diagram of the software menu trees can be found in Figure 5-1 and Figure 5-2.
3. The M700 requires about 30 minutes for all internal components to reach a stable operating temperature. If the permeation tube is installed, it requires 48 hours at 50°C to reach a stable output. We recommend operating the unit at temperature for 48 hours before any calibration checks or adjustments are made with the permeation tube.
4. While waiting for the instrument to reach the proper temperature, check for correct operation by using some of the M700 diagnostic and test features.

   The following procedures show how to manually set up the M700 calibrator for the correct port assignments to setup the O_3 generator and to generate zero or span gas of a desired concentration. Section 5 provides detailed information regarding operation.

Step 1 - Set up the source gas port for cylinder assignment and concentration:

Step Number	Action	Comment
1.	Press SETUP-GAS-CYL-PRT1	This key sequence allows the user to assign a gas type for the PORT 1 - see Figure 2-4. Press ADD to set up if NONE is shown. Press NONE button until desired gas name is displayed. After selecting the desired source gas unit, enter the concentration of the source gas cylinder. You can add more than one type of gas (multi-blended gas) cylinder by pressing ADD or can delete the set up by pressing DEL. Pressing PREV or NEXT allows to scroll previous gas set up for the same port. You can also edit the set up by pressing EDIT. For concentrations greater than 999.9 ppm enter PPT (parts per thousand) or the percentage. *Do not assign identical name for another port. See Note below.* If you want to delete the setup, select the gas type and press DEL. If only one gas type is previously setup for the port and NONE selection has been deleted, then you must add NONE before deleting the gas type (otherwise DEL button is not shown).
2.	Press EXIT	Pressing EXIT stores the PORT 1 source gas information. This information is used to calculate the precise concentration. Repeat steps 1 and 2 per each port, if it is desired to assign other source gases for remaining ports.
3.	Press EXIT-EXIT-EXIT	The M700 returns to the main menu.

NOTE

The M700 has default gas type names of NONE, H2S, NO, NO_2, NH_3, SO_2, CO, and HC for a gas type selection. If the User is using more than two different concentrations of the same gas type, including permeation tube gas, the user must define the source gas names before entering the concentration. The user can assign up to four user defines names for the same type of gas since the M700 provides four gas inlet ports. The M700 will store these names entered as valid names as well as the default names listed on the previous page. This library of source gases is used whenever a gas type selectionis needed for source gas port setup or calibration gas setup.

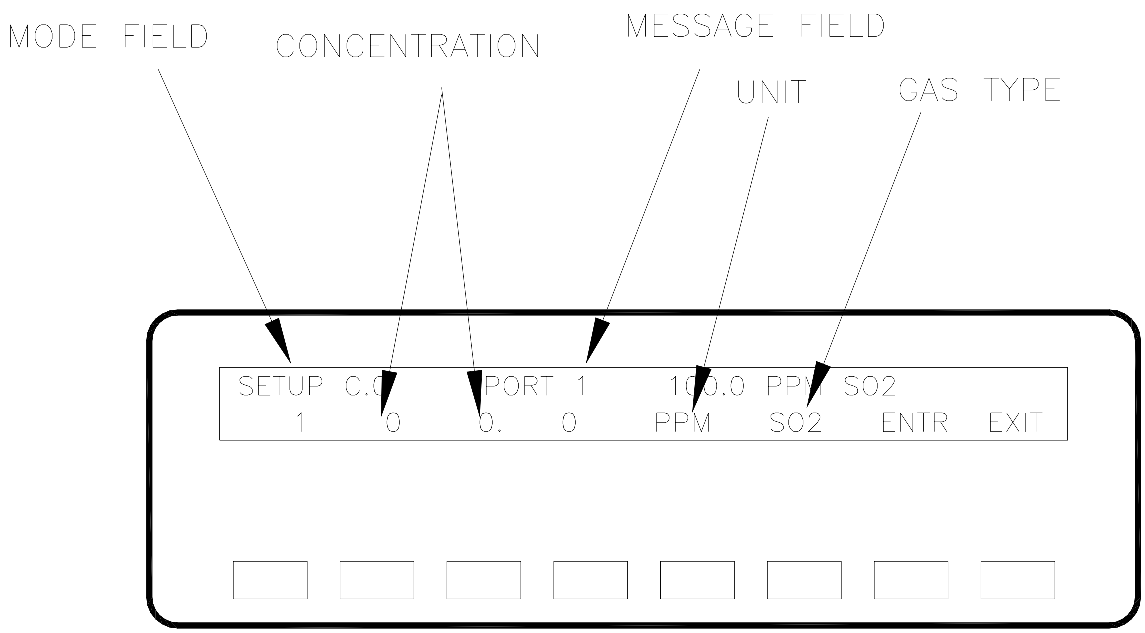


Figure 2-4: Illustration of Source Gas Setup Display

> **NOTE**
>
> **If you do not need to create a different name, skip this section.**

Pressing SETUP-GAS-USER-EDIT brings up the gas name editing menu, which displays the default gas names and four user-definable (i.e. USR1, USR2, etc) entries in the format:

`“GAS:NONE MS:64.1”`

NONE is a user defined gas name.

MS is a Molar Mass of the gas.

For example, SO_2 is 64.1. It is used to convert the value between PPM - Mg/M^3 relationship

Press NEXT until the gas name to be edited is shown. The ENAB will enable user name if set ON. Press NAME to edit the gas name as follow. Press MASS to enter the Molar Mass value of the source gas under the user name.

Any gas name can be edited by pressing each button under the digit cycles through the following sequence of digits: ‘-’ ’A-Z’ ’0-9’. Each field can have up to four alphanumeric digits. A dash (-) indicates a blank space. Although it is valid to have blank spaces (dashes) between characters, it treats the first blank as the end of the string, so that anything after the first blank space is discarded. Therefore, the first digit should always be an alphanumeric entry and not a ‘-’. The name may be a single character name or as many as four characters. Press each key until desired name is entered, Press ENTR. These user-defined names will be added into the default name list for the gas section setup.

If you have the same type of gas, but two different concentrations, assign each a different name (for example, CO1 and CO2, COA and COB or COL and COH). Perm tube names are NO_2 and SO_2 by default, therefore, use different names for cylinder gas sources of NO_2 and SO_2 to avoid gas name conflicts. If the same name is used for the perm tube and a source gas port the M700 will generate the calibration gas from the cylinder gas source.

Permeation tube gas source setup; If you do not have a permeation tube option installed, omit this procedure. Press SETUP-GAS-PERM, then enter the permeation rate in ng/min. @ 50°C. Select a gas type and press ENTR. The perm tube setup will not allow user-defined names.

Step 2 - Set up the O_3 generator for desired operation and control.

If you do not have the O_3 generator option installed, omit this procedure. If you have an O_3 generator then press SETUP-GAS-O3-MODE to select one of the O_3 generator lamp control modes. The BNCH mode is recommended if the photometer (option) is installed. The BNCH mode means the photometer bench is used for the feedback control of the O_3 generator. The REF mode is recommended if the O_3 generator is installed without the photometer. The REF mode means reference detector feedback control. The CNST means constant lamp drive voltage without the CPU feedback control and is typically only used in trouble shooting.

Step 3 - Generate zero air:

Step Number	Action	Comment
1.	Press GEN - AUTO	Press the gas type button until ZERO appears, press ENTR. M700 will start to generate dry zero air at 5 SLPM.
2.	Press STBY	This stops the M700 from generating zero air and returns the instrument to the standby mode.

Step 4 - Generate span gas:

Step Number	Action	Comment
1.	Press GEN - AUTO	This key sequence allows the user to select the gas type and the concentration. Press gas type button until a desired gas name appears, select the unit, and enter the concentration of span gas desired. (The factory set flow is 5 SLPM. See note below)
2.	Press ENTR	The M700 will start to generate a precise concentration of the span gas.
3.	Press STBY	This stops the M700 from generating span gas and returns the instrument to the standby mode.

NOTE

The factory set flow is at 5 LPM. To change the flow, press SETUP-MORE-FLOW, enter the desired flow and press ENTR. This is the total output flow.

The M700 handles flows in three ways.

1. Without operator intervention the M700 using a 5 LPM total output flow does the calculations to determine the required concentration gas flow and diluent flow.
2. The M700 allows the operator to change the total flow and the M700 will calculate the other flows required (SETUP-MORE-FLOW). Once the flow is changed, then the new flow value becomes the total flow for all the gas concentration generated.
3. The M700 allows the operator to set both the diluent flow and gas cylinder concentration flow (thereby, also determining the total flow), see Manual Mode in Section 5.2.

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3 SPECIFICATIONS, WARRANTY

3.1 Specifications

Dilution System	
Flow Measurement Accuracy	±1% F.S.
Repeatability of Flow Control	±0.2% F.S.
Linearity of Flow Measurement	±0.5% F.S.
Flow Range of Diluent Air	0 to 10 SLPM 0 to 20 SLPM (optional)
Flow Range of Cylinder Gases	0 to 100 cc/min. 0 to 50 cc/min. (optional) 0 to 200 cc/min. (optional)
Dilution Ratio (typical)	50:1 to 2000:1 ratio
Zero Air Required	10 SLPM @ 30 PSIG 20 SLPM @ 30 PSIG (optional)
CAL gas input ports	4
Zero Gas Input Ports	1
Response Time	60 Sec. (98%)
Ozone Generator Module	
Ozone Generator Output:	
MAX Output	6 ppm LPM
MIN Output	100 ppb LPM
Response Time:	180 Sec. (98%)
General Specifications	
Input Pressure	20 - 30 PSIG
Temp. Range	5 - 40°C
Humidity	0 - 95% RH, non-condensing
Weight	60 lbs
Dimension HxWxD	7”x17”x24” (18cm x 43cm x 61cm)
Environmental Conditions	Installation Category (Overvoltage Category) II Pollution Degree 2
Maximum Operating Altitude	10,000 ft
Power	115V~60Hz, 220V~50Hz, 240V~50Hz, 250 Watts
Power	230v~50Hz, 2.5A; Electrical ratings for CE MARK

U.V. PHOTOMETER MODULE (option)

Full Scale Range	User Selectable 100 ppb to 10 ppm
Precision	1.0 ppb
Linearity	1.0% of reading
Rise/Fall Time	<20 sec.
Response Time(98%)	180 sec.
Zero Drift	<1.0 ppb / 7 days
Span Drift	<1% / 24 hours <2% / 7 days
Test Channel Analog Output (selectable)	+/-100 mV, 1, 5[1], 10v; resolution of 1 part in 1024 of selected voltage or current range
Digital Control Outputs	12 (opto-isolated)
Digital Control Inputs	12 (opto-isolated)
Digital Status Outputs	12 (opto-isolated)
RS-232 (standard)	

[1] 5 V is recommended since the MFC control voltage is 5 volts (see Section 9.2.1).

3.2 Warranty

WARRANTY POLICY (02024c)

Prior to shipment, Teledyne API equipment is thoroughly inspected and tested. Should equipment failure occur, Teledyne API assures its customers that prompt service and support will be available.

COVERAGE

After the warranty period and throughout the equipment lifetime, Teledyne API stands ready to provide on-site or in-plant service at reasonable rates similar to those of other manufacturers in the industry. All maintenance and the first level of field troubleshooting is to be performed by the customer.

NON-TELEDYNE API MANUFACTURED EQUIPMENT

Equipment provided but not manufactured by Teledyne API is warranted and will be repaired to the extent and according to the current terms and conditions of the respective equipment manufacturers warranty.

GENERAL

Teledyne API warrants each Product manufactured by Teledyne API to be free from defects in material and workmanship under normal use and service for a period of one year from the date of delivery. All replacement parts and repairs are warranted for 90 days after the purchase.

If a Product fails to conform to its specifications within the warranty period, Teledyne API shall correct such defect by, in Teledyne API's discretion, repairing or replacing such defective Product or refunding the purchase price of such Product.

The warranties set forth in this section shall be of no force or effect with respect to any Product: (i) that has been altered or subjected to misuse, negligence or accident, or (ii) that has been used in any manner other than in accordance with the instruction provided by Teledyne API or (iii) not properly maintained.

THE WARRANTIES SET FORTH IN THIS SECTION AND THE REMEDIES THEREFORE ARE EXCLUSIVE AND IN LIEU OF ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR PARTICULAR PURPOSE OR OTHER WARRANTY OF QUALITY, WHETHER EXPRESSED OR IMPLIED. THE REMEDIES SET FORTH IN THIS SECTION ARE THE EXCLUSIVE REMEDIES FOR BREACH OF ANY WARRANTY CONTAINED HEREIN. TELEDYNE API SHALL NOT BE LIABLE FOR ANY INCIDENTAL OR CONSEQUENTIAL DAMAGES ARISING OUT OF OR RELATED TO THIS AGREEMENT OF TELEDYNE API'S PERFORMANCE HEREUNDER, WHETHER FOR BREACH OF WARRANTY OR OTHERWISE.

TERMS AND CONDITIONS

All units or components returned to Teledyne API should be properly packed for handling and returned freight prepaid to the nearest designated Service Center. After the repair, the equipment will be returned, freight prepaid.

4 M700 CALIBRATOR

4.1 Principle of Operation

The M700 Calibrator can generate diluted calibration gas including ozone, gas phase titration (NO2) from gas cylinders, or from a permeation tube source gas. Each concentration is generated precisely by mixing the gas with diluent zero air in which the mixing ratio is controlled by the mass flow controller.

The diluent air mass flow controller has a range of 10 SLPM (20 SLPM option), and the gas mass flow controller has a range of 100 cc/min. (0-50 cc/min., 0-200cc/min. options). The mass flow controllers assure a precise mixing ratio for accurate and precise calibration gas generation using the state-of- the-art electronic closed-loop control. The CPU calculates both the required gas and diluent air flow rate as determined by the following equation and controls the corresponding mass flow controllers accordingly.

$$C_f = C_i \times \frac{GAS_{flow}}{GAS_{flow} + AIR_{flow}}$$

C_f = final concentration of diluted gas

C_i = source gas concentration

GAS_{flow} = gas flow rate

AIR_{flow} = diluting air flow rate

The principle of GPT is based on the rapid gas phase reaction between NO and O_3 which produces stoichiometric quantities of NO_2 as shown by the following equation:

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

Given that the NO concentration is known for this reaction, the resultant concentration of NO_2 can be determined. Ozone is added to excess NO in a mixing glass volume, and the chemiluminescent analyzer detects the changes in NO concentration. After the addition of O_3, the observed decrease in NO concentration on the NO channel is equivalent to the concentration of NO_2 produced. The amount of NO_2 generated can be varied by adding varying amounts of O_3 from the O_3 generator.

It has been determined empirically that the NO-O_3 reaction goes to completion (<1% residual O_3) if the NO concentration in the reaction chamber (ppm) multiplied by the residence time (min.) of the reactants in the chamber is $\geq$2.75 ppm-min. The M700 is designed to satisfy the complete reaction based on U.S.E.P.A. guidelines.

The M700 has a built-in ozone generator as an option in order to generate a dynamic range of ozone concentration. The O_3 generator has up to three different modes of lamp feedback control depending upon the option installed. If only the O_3 generator is installed, then the constant lamp control mode or reference detector control mode can be selected by the user. If the photometer option is included, then the bench feedback mode can be used to generate precise ozone concentration.

The permeation tube consists of a small container of liquid, with a small outlet of PTFE. The gas slowly permeates through the PTFE at a rate in the nanogram/min range. If the tube is kept at constant temperature, usually about 50°C, the device will provide a stable source of gas. The permeation tube concentration is determined by the permeation tube specific output (ppb @ 1 slpm @ 50°C), the permeation tube temperature (°C), and the air flow across it (slpm). The specific output is a fixed function of the permeation tube and is noted on the shipping container.

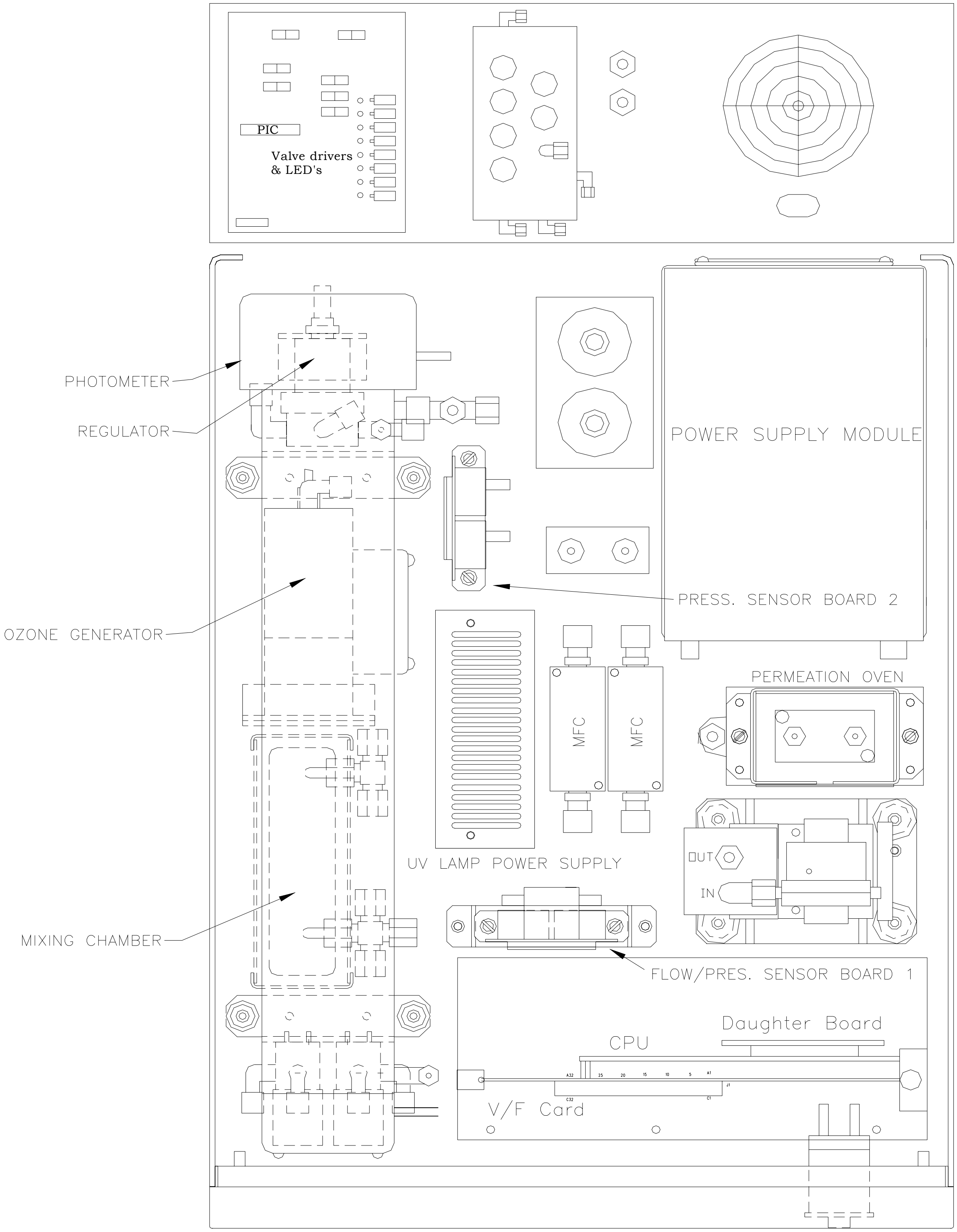


Figure 4-1: M700 Layout

4.2 Instrument Description

4.2.1 Pneumatic System

The M700 calibrator pneumatic system consists of the precision dilution system and valve manifold (refer Figure 4-2 for pneumatic diagram).

As stated previously, the precision dilution system generates diluted calibration gas, including ozone and gas phase titration (NO_2), from gas cylinders, or from a permeation tube. Each type of gas is generated precisely by mixing that gas with diluent zero air in which the mixing ratio is electronically controlled by the mass flow controller.

Two glass volumes are carefully selected per the U.S.E.P.A. guideline to optimize gas mixing for the gas phase titration method. If options such as the ozone generator, permeation oven, or the photometer are used, then the flow is controlled by critical flow orifices. The orifices never need adjustment. Each critical flow orifice maintains precise volumetric control as long as the critical pressure ratio is maintained between the upstream and the downstream orifice.

The input valve manifold consists of four gas port valves and one diluent air valve which are used to select the gas type and to provide a separate gas shut-off at the upstream of the mass flow controller. Each valve is rated for up to 40 PSI and therefore both the diluting zero air pressure and the gas pressure should be between 25 to 30 PSI and never more than 35 PSI in order to avoid unwanted gas mixing. A three way valve is added in series at the downstream of the mixing glass volume to prevent delivering unwanted calibration gas out to the sampling manifold and to also serve as the shut-off valve in order to do the pneumatic leak check. The input valve manifold also has the capability to purge out the pneumatic system with clean zero air if needed without disturbing the mass flow controller.

4.2.2 Pneumatic Sensor Board

There are two pressure sensor boards installed in each M700. One board consists of two pressure sensors to measure the pressure of the diluent zero air and the source gas pressure. The other board is dedicated for as many as two pressure sensors and one mass flow sensor depending upon option requirements (refer to Figure 9-4). All these pressure and flow measurements are displayed in the test menu.

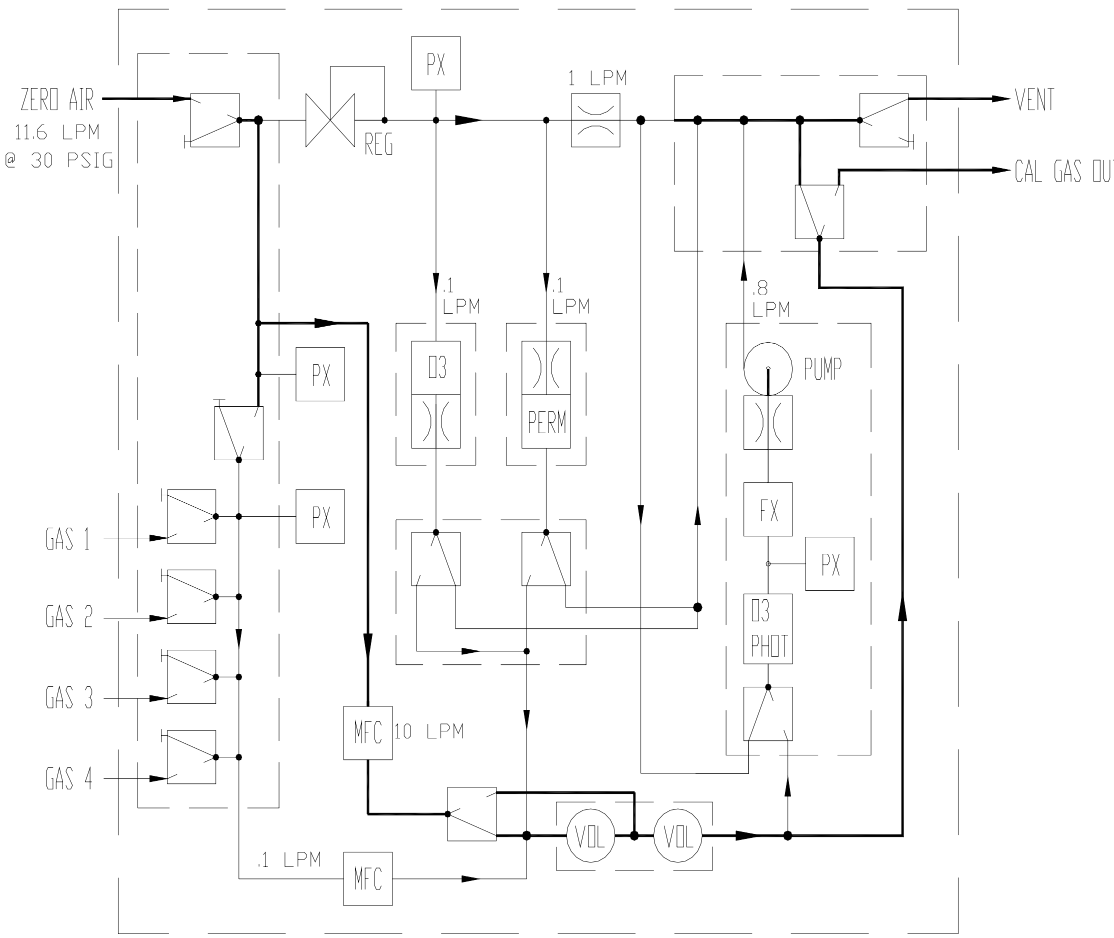


Figure 4-2: Pneumatic Diagram

4.2.3 Computer Hardware and Software

The M700 Calibrator is operated by a field proven 8088 micro computer. The computer's multitasking operating system allows it to do instrument control, monitor test points, provide an analog test output, interface with dataloggers or analyzers, and provide a user interface via the display, keyboard and RS-232 port. These operations appear to be happening simultaneously but are actually done sequentially based on a priority queuing system maintained by the multi-tasking operating system. The operations are queued for execution only when needed, therefore the system is very efficient with the 8088's operations.

The M700 Calibrator is a true computer based instrument. The microprocessor does most of the instrument control functions such as temperature control, mass flow control, ozonator control, and the valve driver controls including interfacing with dataloggers or analyzers. If the ozone photometer option is ordered, then it measures actual real time ozone gas concentration and provides feedback to control the ozonator for precise concentration of ozone calibration gas. The M700 features powerful software and hardware features while still offering user friendly and flexible operation.

4.2.4 V/F Board

The V/F board is multifunctional, consisting of A/D input channels, digital I/O channels, and analog output channels for the mass flow controllers and a test output. The computer interfaces all of the analog and digital data and outputs all the control functions through the V/F board.

4.2.5 Front Panel

The front panel of the M700 is shown in Figure 4-3. The front panel consists of a 2-line by 40-character alphanumeric display, 8 pushbuttons, 3 status LED's and power switch. The M700 is designed as a computer controlled instrument, therefore all major operations can be controlled from the front panel display and keyboard.

The display is divided into 3 fields. The **mode** field in the upper left, the **message** field in the top center and the MENU field which occupies the entire bottom line of the display.

The mode field indicates the current mode of the calibrator. The message field displays TEST values or warning messages. The test functions allow the user to quickly access many important internal operating parameters of the M700. This provides a quick check on the internal health and proper operation of the instrument. The MENU field is divided into 8 areas which indicates the current function of each of the 8 pushbuttons (see Section 5 for detailed MENU information).

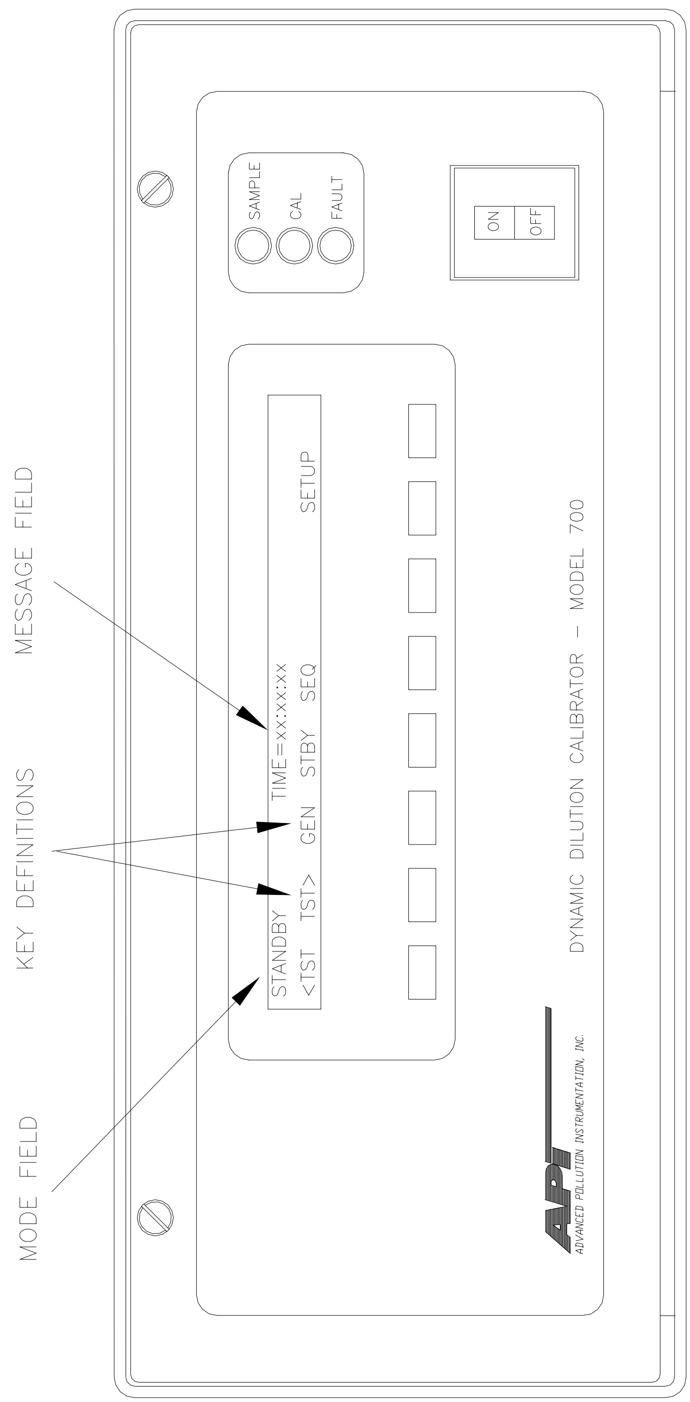


Figure 4-3: Front Panel

4.2.5.1 Status LED’s

The three status LED’s to the right of the display indicate the general status of the Model 700 Calibrator. The green LED indicates the standby mode. The yellow LED indicates the calibration status. The red indicates the fault status. Table 4-1 summarizes the meaning of the status LED’s.

Table 4-1: Status LED’s

LED	State	Meaning
Green	Off On	Calibrator is in standby mode Calibrator is in standby mode
Yellow	Off On Blinking	No automatic timers are enabled No sequence is executing, but an automatic timer is enabled A sequence is executing (but not necessarily initiated by a timer)
Red	Off Blinking	No warnings exist Warnings exist

4.2.5.2 Power Switch

The power switch has two functions. The rocker switch controls overall power to the instrument. In addition, it includes a circuit breaker. If attempts to power up the M700 result in the circuit breaker tripping, the power switch automatically returns to the off position, and the instrument will not power up.

4.2.5.3 Power Supply Module

The power supply module (PSM) supplies AC and DC power to the rest of the instrument. It consists of a 4 output linear DC power supply and a 24 volt switching power supply. In addition, it contains the switching circuitry to drive the DC operated valves and several switched AC loads to operate the photometer, pump and permeation tube oven.

4.2.6 I/O Interface

The M700 is capable of interfacing with external units such as a datalogger or a host computer. This Section describes the RS-232, contact closure input/output, and status output interface information.

4.2.7 RS-232 Interface

The M700 uses the RS-232 communications protocol to allow the instrument to be connected to a variety of computer based equipment. The RS-232 protocol has been used for many years and is field proven. Care should be taken when specifying connectors, and wiring diagrams that attach the M700 to various devices.

RS-232 Connection Examples

Example 1

Connecting the M700 (using supplied cable) to an IBM-PC AT compatible computer (DB-25 external connector, or DB-25 end of DB-9 to DB-25 Adapter).

In this case, the PC is wired as DTE and the analyzer is wired (through supplied cable) as DCE, therefore a null modem is not needed. The wiring is “straight through” i.e. pin 1 to pin 1, pin 2 to pin 2, etc. Therefore, all you have to do here is adapt the connector on the analyzer cable (male DB-25) to the DB-25 male on the PC. A female to female DB-25 “gender changer” (cable or adapter) will complete the connection.

Example 2

Connecting the M700 to a serial printer.

In this case it will be necessary to determine whether the printer is DCE or DTE. Some printers can be configured for either DCE or DTE by jumper or DIP switch settings. Consult the user manual for your type of printer. If the DB-25 connector pinout shows that data is output on pin 2 (from the printer), then it is DTE and the Teledyne API analyzer should set the jumpers to DCE mode. If pin 2 of the printer DB-25 is an input to the printer, then set the jumpers of the analyzer to DTE mode.

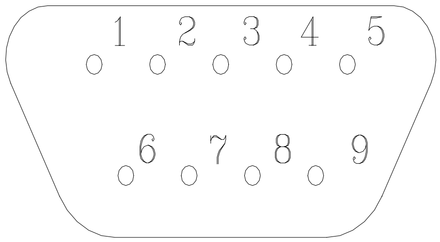
Example 3

Connecting the M700 to a modem.

The modem is always configured as DCE. Therefore setting the jumpers as DTE will be required to interface with the modem.

Data Communications Software for a PC.

You will need to purchase a software package so your computer can transmit and receive information from the M700’s serial port. There are many such programs, we use PROCOMM at Teledyne API. Once you set up the variables in PROCOMM and your wiring connections are correct, you will be able to communicate with the analyzer. Make sure the analyzer is set up for 2400 baud or other desired baud rate (SETUP-MORE-COMM-BAUD) and that PROCOMM is set up as described in the “RS-232 Pin Assignments” Figure 4-4.



PIN ASSIGNMENTS

PIN	FUNCTION
2	TX DATA*1
3	RX DATA*1
5	SIG GROUND
6	DSR
7	RTS
8	CTS

RS-232 CONFIGURATION PARAMETERS

2400 BAUD DEFAULT*2
8 DATA BITS
1 STOP BIT
NO PARITY

*2 SETTABLE 300,1200,2400, 9600 BAUD

*1 JUMPER SETTABLE ON REAR PANEL CONNECTOR BOARD

Figure 4-4: RS-232 Pin Configuration

4.2.8 Status Output Interface

The status outputs are provided to report the M700 conditions via contact closures (optoisolator type) on the rear panel. There are a total of 12 outputs. The first four outputs are wired via an 8 pin connector (see Figure 2-1) labeled “STATUS OUT”. Label C is for “+” and label E is for “-”. The remaining 8 outputs are wired via a 50 pin (DB-50) connector with CONTROL INPUTS and CONTROL OUTPUTS (see Figure 2-1). The pin assignments are listed below.

Table 4-2: Status Output Via 8 Pin Connector

Output #	Pin #	Definition	Condition
1	1,2	POWER OK	CLOSED IF SYSTEM POWER OK
2	3,4	SYSTEM OK	CLOSED IF SYSTEM OK
3	5,6	CAL ACTIVE	CLOSED IF CALIBRATOR IS ACTIVE OPEN IF CALIBRATOR IS IN STANDBY MODE
4	7,8	DIAG MODE	CLOSED IN DIAGNOSTIC MODE

Table 4-3: Status Output Via 50 Pin Connector

Output #	Pin #	Definition	Condition
5	34,35	TEM ALARM	CLOSED IF ANY TEMP WARNING
6	36,37	PRESS ALARM	CLOSED IF ANY PRESS WARNING
7	38,39	SPARE	
8	40,41	SPARE	
9	42,43	SPARE	
10	44,45	SPARE	
11	46,47	SPARE	
12	48,49	SPARE	

When interfacing the optoisolators to external devices, a current limiting resistor must be installed in series with the output pins in order to limit the current. The optoisolators can handle up to 50 Ma DC current. Figure 4-5 shows a typical interfacing example of status control output using the optoisolator circuit.

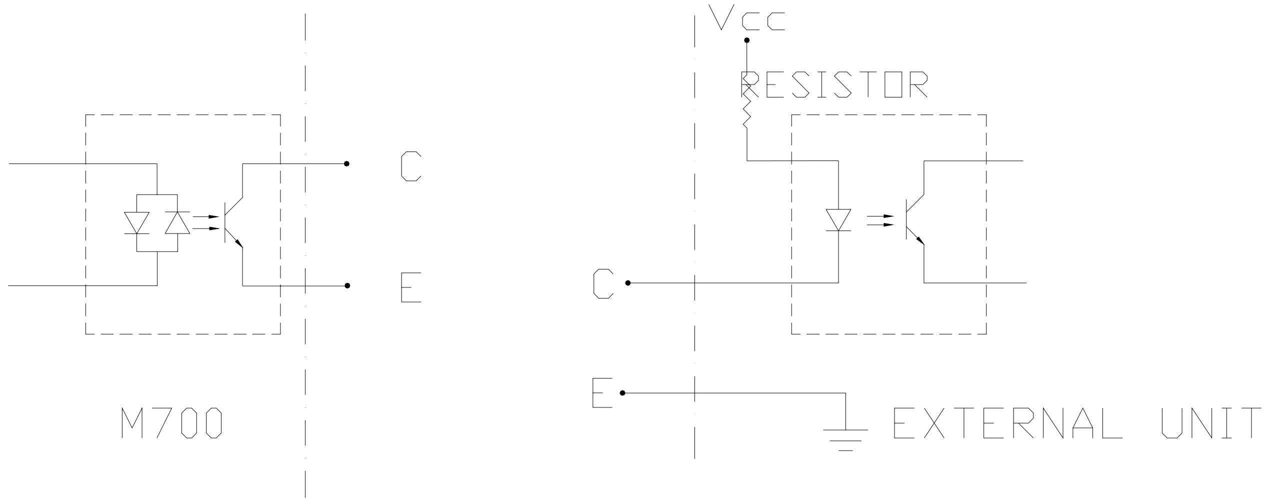


Figure 4-5: Interfacing Contact Closure Output

4.2.9 Contact Closure Control Input Interface

The M700 calibration sequence can be initiated using external control inputs. There are 12 optoisolator type control inputs available and can initiate up to 4096 different sequences with the contact closure inputs. The first four outputs are wired via an 8 pin connector (see Figure 2-1) labeled “CONTROL IN”. The remaining 8 outputs are wired via a 50 pin connector. Section 5.3.3 discusses in detail the control input setup.

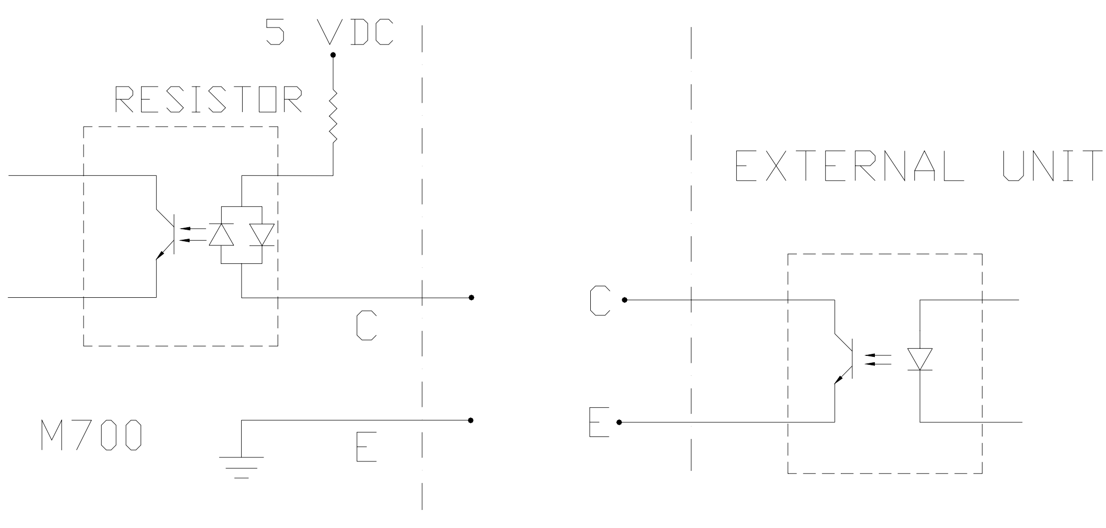


Figure 4-6: Interfacing Contact Closure Input

Figure 4-6 shows an example of a control input interfacing circuit. The input current through the LED is limited by a built-in resistor to prevent damaging due to over-current. Once the desired input channels are properly connected, the user can set up each input to perform specific instructions.

4.2.10 Contact Closure Control Output Interface

The contact closure output interface provides 12 optoisolator outputs to control external devices. The circuit description is identical to the Figure 4-5 Status Output Interface. Up to 4096 different sequence outputs can be setup using these 12 optoisolators. The first four optoisolator outputs are wired via an 8 pin connector (see Figure 2-1) labeled “CONTROL OUT”. The remaining 8 outputs are wired via a 50 pin connector.

As seen in Section 4.2.10, if sequence is initiated by any initiation sources, then the M700 can flag out through any one of the programmed control outputs. This output can be used to synchronize the M700 calibration sequence and the external control unit (i.e. datalogger). See Section 5.3.4 for Contact Closure Output Setup.

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5 M700 OPERATION

This section covers the software features of the M700 Calibrator which is designed as a computer controlled calibrator for easy and yet powerful and flexible operation. All major operations are controlled from the front panel display and keyboard through a user friendly menu. The front panel menu is covered in the first subsection. The remaining sections cover the M700 operation which is divided into three major subsections; manual operation, automatic operation, and remote operation. Each subsection contains a typical example with clear explanations. For installation and initial operation, please see “Section 2 Getting Started”.

5.1 Index to Front Panel Menus

The next several pages contain two different styles of indexes that will allow you to navigate through the M700 software menus. Figure 5-1 shows a “tree” menu structure to let you see at a glance where each key mnemonic is located and Section 5.1.1 Main Menu is a reference to the section of the manual that describes the purpose and function of the mnemonics in more detail.

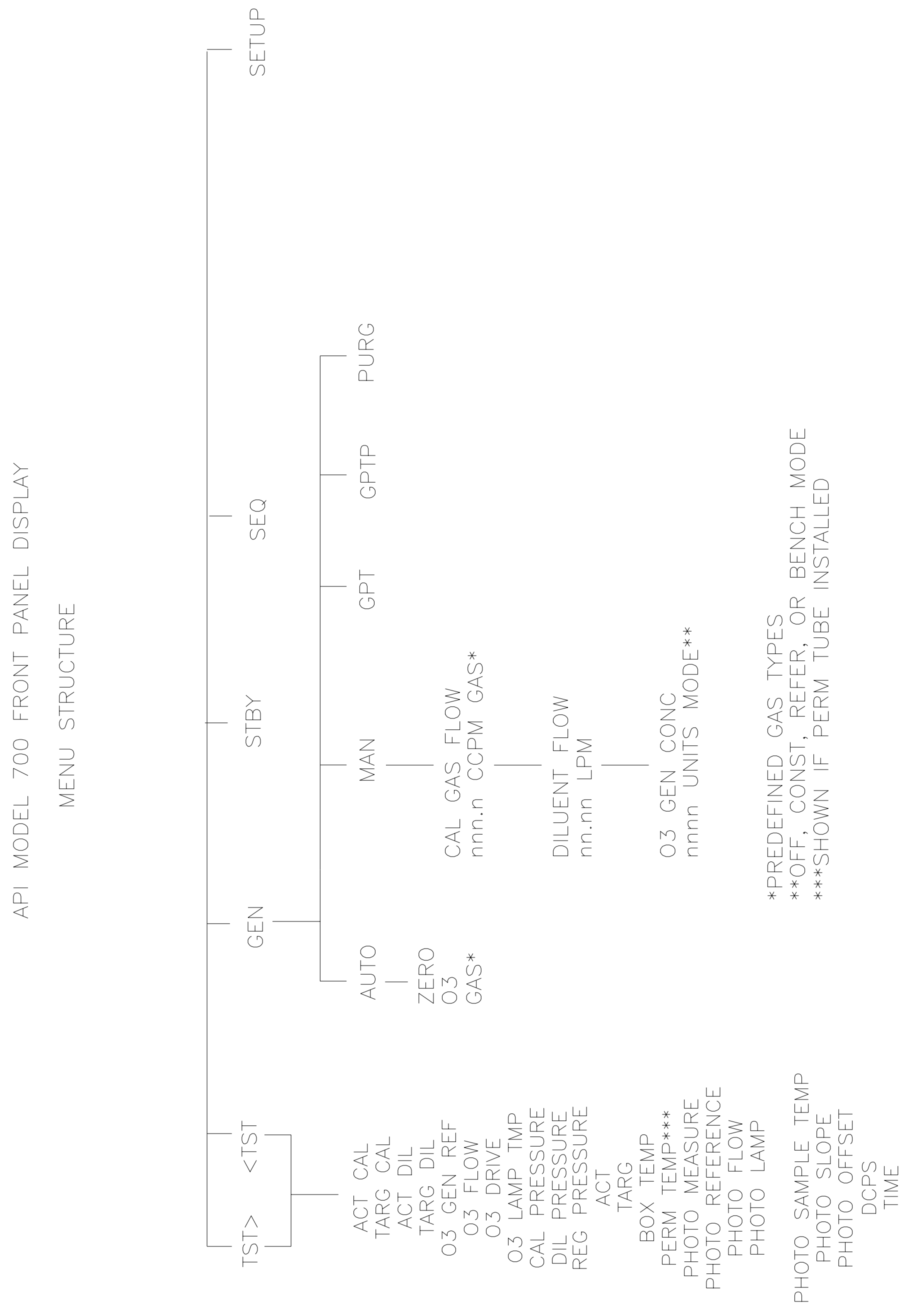

Figure 5-1: Main Menu

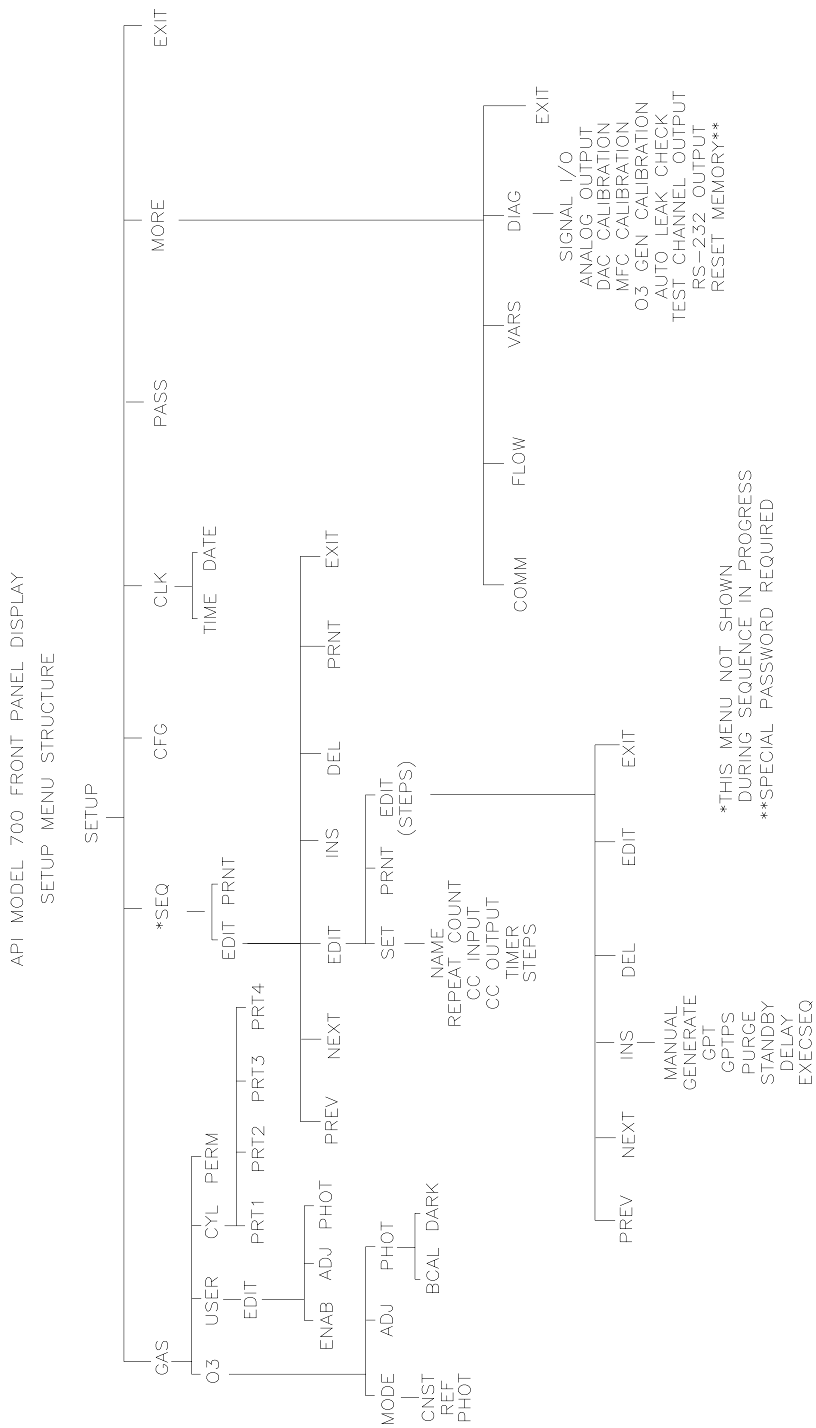

Figure 5-2: Setup Menu

5.1.1 Main Menu

Table 5-1: M700 Main Menu Structure

Menu Level					
Level 1	**Level 2**	**Level 3**	**Level 4**	**Description**	**Reference Section**
TEST TST>				Test functions. These buttons allow the user to scroll up or down to display desired test measurements.	5.1.3, Table 9-1
GEN				Generate mode. Allows the user to generate a specific type of gas manually.	5.2.1
	AUTO			Simple manual step to generate a desired type of gas and concentration including zero air.	5.2.2
	GPT			Gas Phase Titration (GPT) step is to generate the desired concentration of NO_2 gas.	5.2.3
	GPTP			This GPT Preset step will simulate GPT without generating NO gas. It will perform only ozone generation to determine precise ozone value in order to assure precise NO_2 value during an actual GPT.	5.2.4
	MAN			Advanced manual steps to generate a desired type of gas and concentration by entering a target source gas flow and a diluent air flow.	5.2.5
	PURG			Will purge-out the residual gas from the previous generate step in the pneumatic system.	5.2.6
STBY				Stops generate mode and returns the M700 to standby mode.	Example 5.1 & 5.10
SEQ				Sequence mode. Can manually start preset calibration sequences. User must setup the sequences prior to using this feature.	5.2.7
SETUP				The SETUP menu - see next table	

5.1.2 Setup Menu

Table 5-2: M700 Setup Menu Structure

Menu Level					
Level 1	**Level 2**	**Level 3**	**Level 4**	**Description**	**Reference Section**
GAS				Configures source gases	
	CYL			Defines cylinder gas ports 1 - 4	2.3
		PRT1		Defines gas type and concentration for port 1	2.3
		PRT2		Defines gas type and concentration for port 2	2.3
		PRT3		Defines gas type and concentration for port 3	2.3
		PRT4		Defines gas type and concentration for port 4	2.3
	USER			User defined gas type name	2.3
		EDIT		Edit or create source gas name	2.3
			ENAB	Enable gas name setup	2.3
			NAME	Gas name setup	2.3
			MASS	Molar Mass value entry	2.3
	PERM			Permeation tube setup	2.3 & 6.2
	O3			Ozone generator/photometer (optional) setup	2.3
		MODE		O_3 generator control feedback mode; CNST, REF, BNCH	2.3
		ADJ		Adjust O_3 generator output	9.2.6
		PHOT		O_3 photometer setup	6.1
			BCAL	Photometer bench calibration menu	6.1
			DARK	Bench detector dark calibration menu	9.2.7

(table continued)

Table 5-2: M700 Setup Menu Structure (Continued)

Menu Level					
Level 1	**Level 2**	**Level 3**	**Level 4**	**Description**	**Reference Section**
SEQ				Configures sequences. It will create a database to perform calibration sequences.	5.3.1
	EDIT			Edit or create sequence database	5.3.1
		NEXT		Scroll to next sequence number for editing	5.3.1
		INS		Create sequence database	5.3.1
		DEL		Delete sequence from the database	5.3.1
		EDIT		Edit steps of the existing sequence	5.3.1
		PRNT		Print steps of the specified sequence	5.3.1
	PRNT			Print sequence database	5.3.1
CFG				Display software configuration	
CLK				Time of day clock setup	
	TIME			Set time of the day	
	DATE			Set date	
PASS				Setup password enable or disable	5.1.4
MORE				Access more advanced features - see next table	
	COMM			Communications menu	
		BAUD		RS-232 baud rate	
		ID		Instrument ID number	
	FLOW			Sets target total output flow rate of the instrument which is the sum of the gas flow and diluent air flow.	2.3
	VARS			Edits variables for special operation of the instrument	7.5
	DIAG			Diagnostic menu	9.1.3

5.1.3 Test Functions

NOTE

In any of the following TEST functions, if a value of XXXX is displayed, it indicates an off scale reading and therefore is meaningless.

Table 5-3: Test Measurement Description

Test Measurement	Definition
ACT CAL=x.xxxx LPM	Actual calibration gas flow rate
TARG CAL=x.xxxx LPM	Target calibration gas flow rate
ACT DIL=x.xxx LPM	Actual diluent air flow rate
TARG DIL=x.xxx LPM	Target diluent air flow rate
[2]O3 GEN REF= xxxx MV	O_3 generator reference detector reading
[2]O3 FLOW=x.xxxx LPM	Flow rate through O_3 generator
[2]O3 GEN DRIVE= xxxx MV	O_3 generator lamp drive voltage
[2]O3 LAMP TEMP= xx.x C	O_3 generator lamp temperature
CAL PRESSURE= xx.x PSIG	Source (cylinder) gas pressure
DIL PRESSURE= xx.x PSIG	Diluent air pressure
REG PRESSURE=xx.x PSIG	Regulator pressure
ACT= xxxx ppb gas	Actual concentration of calibration gas
TARG= xxxx ppb gas	Target concentration of calibration gas
BOX TEMP= xx.x C	Internal chassis temperature
[1]PERM TEMP=xx.x C	Perm tube oven temperature

(table continued)

Table 5-3: Test Measurement Description (Continued)

Test Measurement	Definition
[1]PERM FLOW=x.xxxx LPM	Perm tube oven flowrate
[3]PHOTO MEASURE=xxxx.x MV	Photometer measure reading
[3]PHOTO REFERENCE=xxxx.x MV	Photometer reference reading
[3]PHOTO FLOW= x.xxxx LPM	Photometer sample flow
[3]PHOTO LAMP= xx.x C	Photometer lamp temperature
[3]PHOTO SPRESS= xx.x IN-HG-A	Photometer sample pressure
[3]PHOTO STEMP= xx C	Photometer sample temperature
[3]PHOTO SLOPE= x.xxxx	Photometer slope
[3]PHOTO OFFSET=x.xxx	Photometer offset
DCPS= xxxxx MV	DC power supply
TIME= xx:xx:xx	Real time clock

[1]Shown if perm tube option is installed.

[2]Shown if ozone generator is installed.

[3]Shown if photometer option is installed.

Actual Calibration Gas Flow - ACT CAL

This is the actual flow of the calibration gas through the mass flow controller. The actual gas flow should be the same value as the target flow.

Target Calibration Gas Flow - TARG CAL

This is the target flow of the calibration gas through the mass flow controller. This target flow is computed by the M700 based on the total flow requirement, the source gas cylinder concentration, and the desired calibration gas output concentration.

Actual Dilution Air Flow - ACT DIL

This is the actual flow of the diluting zero air through the mass flow controller. This actual zero air should be the same value as the target dilution air flow. This diluent zero air should be free of contaminants to assure the quality of the calibration gas.

Target Dilution Air Flow - TARG DIL

This is the target flow of the diluting zero air computed which is typically near the total flow needed. The total flow is the flow provided from the TEST GAS OUT PORT on the rear panel of the M700 which includes diluent flow and source gas flow.

Ozone Generator Reference Reading - O_3 GEN REF

This is the reading from the reference detector of the ozone generator. This value is used to control the ozone output when the reference feedback mode is selected during the ozone generate mode.

Ozone Generator Flow - O_3 FLOW

The flow through the ozone generator is controlled by the critical orifice to assure constant flow. The critical upstream pressure is maintained constant by the precision pressure regulator at the upstream of the orifice.

Ozone Generator Drive Voltage - O_3 GEN DRIVE

This is the lamp control voltage from the CPU to generate a target ozone concentration. This voltage is generated as a feedback voltage using three different modes depending on the option ordered.

Ozone Lamp Temperature - O_3 LAMP TEMP

This is the temperature reading of the ozone generator. This temperature is controlled by the CPU in order to maintain stable lamp temperature and ozone output.

Pressure Calibration Gas - CAL PRESSURE

This is the measurement of the source gas gauge pressure. Typically it should read between 25 - 30 PSIG.

Pressure Diluent Air - DIL PRESSURE

This is the measurement of the diluent air inlet gauge pressure. Typically it should read between 25 - 30 PSIG.

Regulator Pressure - REG PRESSURE

This is the measurement of the regulator pressure which controls the flow rate of the critical orifices of the O_3 generator and perm tube oven. Nominal pressure is 20 PSIG.

Actual Output Concentration - ACT

This is the actual concentration of the diluted calibration gas measured from the feedback voltages of the mass flow controllers. The concentration is computed based on the measurement of the flow through the mass flow controllers using the following equation.

$$C_f = C_i \times \frac{GAS_{flow}}{GAS_{flow} + AIR_{flow}}$$

Equation 5.1

C_f = output concentration of diluted gas

C_i = source gas concentration

GAS_{flow} = gas flow rate

AIR_{flow} = diluting air flow rate

Target Output Concentration - TARG

The target concentration is a user entered concentration. The M700 calculates the gas and air flow rates using the above equation. Generating unusually low or high concentrations may result in inaccurate calibration gas. Do not go below 5% or above 95% of the mass flowmeter range.

Box Temperature - BOX TEMP

This TEST function measures the temperature inside the chassis of the M700. Typically it reaches 2 to 10°C higher than the ambient temperature.

Permeation Oven Temperature - PERM TEMP

This permeation option has an oven for the perm tube based gas (typically SO_2 or NO_2) generation. The oven temperature is normally 50°C. The actual temperature is stable to ±0.1°C although it is normal to see the temperature on the front panel move ±0.3°C due to the proximity of the temperature sensor to the heater.

Photometer Measurement - PHOTO MEASURE

This is the measure channel reading of the photometer. If the photometer option is installed, it will sample the diluted ozone gas to control the ozone gas concentration precisely. It will display XXXX during the STANDBY mode.

Photometer Reference - PHOTO REF

This is the reference channel reading of the photometer. It is used to calculate the ozone gas concentration. It will display XXXX during the STANDBY mode.

Photometer Flow Rate - PHOTO FLOW

This is the sample flow rate through the photometer. Typically it is 800 cc/min when the photometer is operating. The pump and the photometer valve are operated only when it is needed during ozone generate mode and if bench mode is selected.

Photometer Lamp - PHOTO LAMP

This is the temperature of the source lamp in °C. This temperature is controlled to 52°C to maintain a stable lamp output.

Photometer Sample Pressure - PHOTO SPRESS

The photometer sample pressure is measured by the solid state sensor. This value is used to compensate for the sample pressure variation.

Photometer Sample Temperature - PHOTO STEMP

The photometer sample temperature is measured to compensate for the sample temperature variation.

Photometer Slope - PHOTO SLOPE

The slope is a gain term which determines the steepness of the calibration curve of the photometer.

Photometer Offset - PHOTO OFFSET

The offset parameter compensates for the dark current of the photometer.

DC Power Supply - DCPS

The DCPS voltage is a composite of the 5 and ± 15 VDC voltages in the Power Supply Module. This is meant to be a quick indicator to show if the PSM is working correctly. The nominal value is 2500 mV ± 200 mV.

Time - TIME

This is a real time clock reading of the M700 internal clock.

5.1.4 Password Protection

The Teledyne API M700 Calibrator provides password protection of the calibration and setup functions to prevent incorrect adjustments to the instrument. There are three levels of passwords. When prompted for a password, any of the valid passwords can be entered, but the CPU will limit access to the functions allowed for that password level. Each level allows access to the functions of all the levels below plus some additional functions. The table below lists the password levels and the functions allowed for each level.

Table 5-4: Password Levels

Password	Level	Functions Allowed
No password	0	GEN, SEQ,STBY,MSG, CLR
818, 101	1	SETUP, DAIG (low level), VARS (easy)
717	2	Photometer Bench Cal.

NOTE

The 818 password can be disabled. To do this, press SETUP, enter 818, press PASS, and select “OFF”. If the wrong password is entered, the M700 will beep when “enter” is pressed.

5.2 Manual Operation

The M700 can be operated manually through the front panel keyboard to generate the desired type of gas, the concentration, and even the specific flow rates. It can generate single step calibration gas or multiple steps in sequence from the preprogrammed sequence database. Ample numbers of easy to follow examples are also shown for quick application.

5.2.1 Generate Mode

This mode will allow the user to manually generate the desired type of gas and concentration at specific flow rates. The types of gas include NO, NO_2, SO_2, CO, HC, O_3, or ZERO gas. Installation and initial source gas port setup procedures are discussed in Section 2.3. Table 5-1 shows a brief description of each key function.

5.2.2 Auto

This is a simple (AUTO implies simple rather than automatic) manual step to generate desired calibration gas. This AUTO function offers easy and flexible manual operation. The user needs to enter the concentration of the calibration gas, select the proper unit and the type of gas. Press GEN-AUTO, enter the concentration desired by using the keys under each digit, select the unit by pressing a key under the unit display field. Select a valid gas type using the key under the gas field. Press ENTR. Notice that only valid gas names will be shown as configured in Section 2.3. Refer to the examples on the following pages.

The total flow rate of the calibration gas is the value under SETUP-MORE-FLOW menu. The M700 will compute the source gas flow rate and diluent flow rate to generate precise concentrations of calibration gas. The CPU will store the last setup making it easy to restore for future use.

The following examples show how to use the AUTO key function.

Example 5.1: Generate single step of 400 ppb of NO span gas until the operator terminates it by pressing STBY.

NOTE
No gas source port must be predefined as in Section 2.3, Step 1.

Step Number	Action	Comment
1.	Press GEN - AUTO	This key sequence allows the user to select the type and concentration of span gas. Enter 400.0. Select ppb for the unit and NO gas. The factory set flow is at 5 LPM (see note).
2.	Press ENTR	The M700 will start to generate 400 ppb of NO span gas.
3.	Press STBY	This stops the M700 from generating span gas and returns the instrument to standby mode.

NOTE
The total output flow of the instrument is assumed to be factory set at 5 LPM. This flow rate can be edited by pressing SETUP-MORE-FLOW and entering the desired flow rate in LPM.

Example 5.2: Generate zero air for 15 minutes, then change to 200 ppb of O_3 span gas for another 15 minutes.

Step Number	Action	Comment
1.	Press GEN - AUTO	This key sequence allows the user to select the type and concentration of span gas. Select ZERO gas (unit and concentration are ignored for zero air). The factory set flow is at 5 LPM.
2.	Press ENTR	The M700 will start to generate zero air. Wait for 15 minutes.
3.	Press GEN - AUTO	Pressing AUTO will allow a change to ozone span gas. Enter 200.0 using the keys under each digit. Select the ppb for the unit and O_3 gas using keys under each field. The factory set flow is at 5 LPM. Wait for 15 minutes.
4.	Press STBY	This stops the M700 from generating span gas and returns the instrument to standby mode.

Example 5.3: Generate 400 ppb of NO gas for 15 minutes, then change to GPT mode by mixing with 200 ppb of O_3 gas to generate 200 ppb of NO_2 gas for another 15 minutes.

The NO gas generation followed by the GPT will allow the user to determine the NO_2 converter efficiency.

Step Number	Action	Comment
1.	Press GEN - AUTO	This key sequence allows the user to select the type and concentration of span gas. Enter 400.0 using the keys under each digit. Select ppb for the unit and NO gas using the keys under each field. The factory set flow is at 5 LPM (see note in example 5.1).
2.	Press ENTR	The M700 will start to generate NO calibration gas. Wait for 15 minutes.
3.	Press GEN - GPT	Enter 400.0 using the keys under each digit for NO concentration and press ENTR. Enter 200.0 using the keys under each digit for O_3 concentration and press enter. The factory set flow is at 5 LPM. Wait for 15 minutes.
4.	Press STBY	This stops the M700 from generating span gas and returns the instrument to standby mode.

The above examples show only a few of the possible combinations. The operator can generate the desired calibration gas manually by using any combination of available gas types, including O_3 (option), Permeation tube (option), and zero air.

5.2.3 GPT

GPT (Gas Phase Titration) involves mixing a known concentration of O_3 gas with an excess of NO gas in order to generate NO_2 calibration gas. Since it is a 1 to 1 mixing ratio, the NO_2 concentration produced from the complete mixing reaction will be identical to the O_3 concentration. The M700 GPT mixing volume is designed according to the U.S.EPA guidelines to ensure complete mixing reaction. This GPT procedure is particularly useful to determine NO_2 converter efficiency.

Pressing GPT will allow the user to enter the desired NO and O_3 concentrations.

NOTE

Enter an NO concentration greater than O_3 concentration, preferably by a factor of 2 as shown in example 5.3, to ensure the NO gas concentration is in excess of the O_3 concentration.

Example 5.4: Generate 200 ppb of NO_2 by mixing 400 ppb of NO and 200 ppb of O_3 for 15 minutes.

Step Number	Action	Comment
1.	Press GEN - GPT	Enter 400.0 for NO concentration.
2.	Press ENTR	Enter 200.0 for O_3 concentration. The factory set flow is at 5 LPM.
2.	Press ENTR	Wait for 15 minutes.
3.	Press STBY	This stops the GPT mode and returns the instrument to the standby mode.

Example 5.5: Generate 200 ppb of O_3 gas for 15 minutes, then change to the GPT mode by mixing 200 ppb of O_3 gas with 400 ppb of NO gas to yield 200 ppb of NO_2 gas for another 15 minutes.

Step Number	Action	Comment
1.	Press GEN - AUTO	This key sequence allows the user to select the type and concentration of span gas. Enter 200.0 using the keys under each digit. Select ppb for the unit and O_3 gas using the keys under each field. The factory set flow is at 5 LPM (see note in example 5.1).
2.	Press ENTR	The M700 will start to generate O_3 calibration gas. Wait for 15 minutes. Determine the actual O_3 concentration from either O_3 Analyzer (i.e. Teledyne API M400) or built-in photometer (option).
3.	Press GEN - GPT	Enter 400.0 using the keys under each digit for the NO concentration and press enter. Enter 200.0 using the keys under each digit for O_3 concentration and press enter. The factory set flow is at 5 LPM. Wait for 15 minutes. Determine the actual NO_2 concentration from NO_x Analyzer (i.e. Teledyne API M200).
4.	Press STBY	The stops the M700 from generating span gas and returns the instrument to the standby mode.

Assuming the NO_2 gas phase titration efficiency is 100%, the actual O_3 concentration should be the same as the actual NO_2 concentration.

5.2.4 GPTPS (Requires Photometer Option)

This GPTPS (Gas Phase Titration Preset) is a extra feature to simulate GPT in order to determine accurately the NO_2 concentration prior to the actual GPT. Since GPT is a one to one mixing ratio between NO and O_3 gas, the NO_2 concentration produced from the complete mixing reaction will be identical to the O_3 concentration. Therefore once the actual O_3 concentration is determined accurately, the expected NO_2 concentration can be predicted as well. GPTPS procedure is virtually identical to GPT procedure as shown in the following example 5.6.

Example 5.6: Perform GPTPS for 15 minutes, then change to GPT mode by mixing 200 ppb of O_3 gas with 400 ppb of NO gas to yield 200 ppb of NO_2 gas for another 15 minutes. This example is practically identical to the Example 5.5 except GPTPS step is used instead of the O_3 gas generation.

Step Number	Action	Comment
1.	Press GEN - GPTPS	Enter 400.0 using the keys under each digit for NO concentration and press enter. Enter 200.0 using the keys under each digit for O_3 concentration and press enter. The factory set flow is at 5 LPM (see note in example 5.1).
2.	Press ENTR	The M700 will start to generate O_3 calibration gas instead of mixing NO gas with O_3 gas. Wait for 15 minutes. Determine the actual O_3 concentration from either an external O_3 Analyzer or the built-in photometer (option).
3.	Press GEN - GPT	Simply press enter NO gas. Again press enter for O_3 setup. The factory set flow is at 5 LPM. Wait for 15 minutes. Determine the actual NO_2 concentration from the NO_x Analyzer.
4.	Press STBY	This stops the M700 from generating span gas and returns the instrument to the standby mode.

5.2.5 MAN

This manual generation mode (GEN-MAN) provides complete parameter control to generate a user defined calibration gas concentration with user entered flow rates.. Unlike the AUTO mode, this MAN mode allows one to enter both the gas flow rate and diluent air flow rate thereby allowing the control of the mixing ratio and total calibration gas flow rate to generate a defined output calibration gas. In addition the user also needs to select the ozone generator mode by selecting either OFF or one of the feedback modes if the user needs to generate ozone gas for O_3 calibration gas or GPT.

Press GEN-MAN. The display will prompt the user to enter the gas flow rate. Enter the gas flow rate desired, press ENTR. The unit shown is LPM(liter per minute) with a resolution of 0.1 cc/min.. Enter 0.0000 for either zero air or the ozone calibration gas and the reason for entering 0.0000 is to assure that the cylinder gas is not mixed with the zero air or O_3. For other gas types including GPT, enter desired gas flow rate in LPM. Enter diluent air flow rate in SLPM in order to dilute the source gas, press ENTR. Select OFF to disable ozone generator or select either CNST, REF, or BNCH to enable the ozone generator and select the desired control mode (depending on the option installed). Select a feedback control mode only if you need to generate ozone calibration gas or GPT.

NOTE

It is not recommended to enter the flow rate below 5% or above 95% of mass flow controller's full scale.

Step Number	Action	Comment
1.	Press GEN - MAN	This key sequence allows the user to enter the flow rate of the source gas in SLPM unit. Select desired gas type. Select ZERO if user needs to generate O_3.
2.	Press ENTR	Display shows user must enter the gas flow rate. Enter gas flow rate calculated using the following equations .
3.	Press ENTR	Display shows user must enter the diluent air flow rate. Enter diluent air flow rate calculated using the following equations.
4.	Press ENTR	Display now shows user must setup O_3 concentration and the control mode. Select OFF if you don't need to generate O_3. For O_3 generation, select BNCH if the photometer is installed, otherwise Select REF. For GPT, select REF.
5.	Press ENTR	The M700 will start to generate the calibration gas.
6.	Press STBY	This stops the M700 generating span gas and returns the instrument to standby mode.

Use the following equations to determine the gas and diluent air flow rates.

Since the total gas flow is defined by the user depending on system requirement;

$$Totalflow = GAS_{flow} + AIR_{flow}$$ **Equation 5.2**

Equation 5.2 will be slightly different if O_3 generator is used since the O_{3flow} is a constant value and is displayed as a TEST MEASUREMENT on the front panel. Typical value is 105 cc/min.;

$$Totalflow = AIR_{flow} + O_{3\,flow}$$ **Equation 5.3**

For the case of the GPT, it will be;

$$Totalflow = AIR_{flow} + O_{3\,flow} + GAS_{flow}$$ **Equation 5.4**

And from the Equation 5.1 in Section 5.1.3, GAS_{flow} should be;

$$GAS_{flow} = \frac{C_f \times totalflow}{C_i}$$ **Equation 5.5**

Once GAS_{flow} is obtained from the above Equation 5.5, the AIR_{flow} can be found from Equation 5.2, 5.3, or 5.4 depending on the gas type.

For example: Calculate the gas and diluent air flow rates if the cylinder gas concentration is 100 ppm of SO_2, desired concentration is 400 ppb of SO_2, and the total test gas flow needed is 5000 cc/min.

1. cylinder gas flow = (400 ppb x 5000 cc/min)/ 100,000 ppb

   which yields 20 cc/min.

2. Since the total flow rate 5000 cc/min. is the total sum of the diluent air and the cylinder gas flow rates, the diluent air flow rate is simply the difference between this total flow and the cylinder gas flow rate.

   Air flow = 5000 cc/min. - 20 cc/min.

   which yields 4980 cc/min..

Example 5.7: Generate a single step of 400 ppb of SO_2 span gas, until the operator terminates it by pressing STBY. Assume the cylinder source gas concentration is 100 ppm of SO_2 and the total flow rate is 5000 cc/min.. Notice that this example is similar to the example 5.1

First, calculate the cylinder gas flow rate and diluent air flow rate as shown in the above example using equations 5.2 and 5.5.

1. Using equation 5.5; gas flow = (400 ppb x 5000 cc/min)/ 100,000 ppb

   which yields 20 cc/min. or .0200 SLPM.

2. From equation 5.2; air flow = total flow - gas flow

   = 5000 cc/min. - 20 cc/min.

   which yields 4980 cc/min. or 4.9800 SLPM.

Note these values and continue with the following procedures:

Step Number	Action	Comment
1.	Press GEN - MAN	This key sequence allows the user to enter the flow rate of the source gas in SLPM unit. Select SO_2 for the gas type.
2.	Press ENTR	Display prompts user to enter the gas flow rate. Enter 0.0200.
3.	Press ENTR	Display prompts user to enter the diluent air flow rate. Enter 4.9800.
4.	Press ENTR	Display now prompts user to setup O_3 concentration and the control mode. In this example it is not needed to generate O_3, therefore select OFF for O_3 control mode - see note below.
5.	Press ENTR	The M700 will start to generate 400 ppb of SO_2 span gas.
6.	Press STBY	Stops generating span gas and returns the instrument to standby mode.

NOTE

Select OFF for the O_3 control mode if you are generating a gas other than O_3. If you need to generate the O_3 calibration gas, you must select ZERO gas instead of SO_2 in step 1. The reason for selecting ZERO gas instead is to assure that the SO_2 is not mixed with the O_3. Then enter the concentration value, unit, and select one of the control modes – see example 5.8.

Example 5.8: Generate 400 ppb of O_3 for 15 minutes. The total flow rate is 5000 cc/min..

First, calculate the gas flow rate and air flow rate as shown in the above example using equations 5.3 and 5.5. Take a reading from the TEST MEASUREMENT of O_3 FLOW on the front panel. Note that the O_3 flow is controlled by the critical orifice and typical value is 105 cc/min. Assuming the O_3 flow is 105 cc/min;

1. From equation 2; air flow = total flow - gas flow

   =5000 cc/min. - 105 cc/min.

   which yields 4895 cc/min. or 4.8950 SLPM.

Note these values and continue with the following procedures:

Step Number	Action	Comment
1.	Press GEN - MAN	This key sequence allows the user to enter the flow rate of the source gas in SLPM unit. **Select ZERO for the gas type. Do not select other type of gas.**
2.	Press ENTR	Enter 0.0000 for the gas flow. Do not enter other value.
3.	Press ENTR	Display prompts the user to enter the diluent air flow rate. Enter 4.8950.
4.	Press ENTR	Display now prompts the user to setup the O_3 control mode. Select BNCH if photometer (option) is installed. Select REF otherwise. See note below.
5.	Press ENTR	Enter 400.0 for O_3 concentration.
6.	Press ENTR	The M700 will start to generate 400 ppb of O_3. Wait 15 minutes.
7.	Press STBY	Stops generating span gas and returns the instrument to standby mode.

NOTE

If you need to generate the O_3 calibration gas, you must select ZERO gas and select one of the control modes. The BNCH mode is recommended if the photometer is installed. The BNCH mode means the photometer bench is used for the feedback control of the O_3 generator. The REF mode is recommended if the O_3 generator is installed without the photometer. The REF mode means reference detector feedback control. The CNST means constant lamp drive voltage without the CPU feedback control.

MAN mode can be used as a sequence of steps with specific flow rates of air and gas.

5.2.6 PURGE

Purge will purge-out the residual gases from the previous generated steps. The M700 opens the pressurized zero air inlet valve and adjusts both the diluent air mass flow controller (MFC1) and the source gas mass flow controller (MFC2) to maximum flows, 10 SLPM and 100 SCCPM accordingly, to flush out the pneumatic system of the M700. This purging air is vented through the VENT OUT PORT of the rear panel. Press PURGE to start purging and press STBY to stop purging.

CAUTION

This PURGE feature does not stop automatically. The user must manually press STBY to stop purging.

5.2.7 Sequence Mode

Multiple steps of instructions (sequences) can be initialized manually by using a database of preprogrammed steps. This feature is particularly convenient to generate multiple steps of gases. Proceed using the following steps to allow one to initiate a sequence manually.

Step Number	Action	Comment
1.	Press SEQ	Enter pre-programmed (see Section 5.3.1 for sequence setup) sequence ID number. The factory set flow is 5 LPM.
2.	Press ENTR	The M700 will start to generate multiple steps of calibration gas according to the preprogrammed sequence instructions. Each step of the sequence contains information on concentration, unit, gas type, and duration of each step. Once the complete sequence is performed, the M700 will terminate the sequence and return to the standby mode. The operator can terminate manually any time while the sequence is in progress by pressing the STBY key.

NOTE

If the user attempts to initiate a sequence ID number that does not exist, nothing will happen and the action will simply be ignored. This applies to any initiation source.

Whenever a new sequence is initiated from any source, it immediately terminates any sequence in progress and starts the new one.

5.3 Automatic Operation

The M700 can generate calibration gas automatically using a preprogrammed sequence with multiple instruction steps. Once these sequence databases are created, then various sources can initialize execution of a sequence, including the front panel buttons, the contact closure inputs, the RS-232 interface, the automatic timers, and even another sequence. In this section, programming sequence will be discussed in the first part of the section. The sequence can be programmed through the RS-232. The automatic timer based sequence will be discussed in the second part of the section. In Section 5.3.2, the auto-sequence operation initiated from remote sources will be covered in detail with example. Once a sequence is defined and given a number the user can control a complete sequence from the front panel (i.e. 5.2.2).

5.3.1 Sequence Setup

A sequence is a database of single or multiple steps of information in which each step contains an instruction to generate a desired calibration gas. Each single step is actually an instruction, as seen in Section 5.2.1 AUTO, to generate a single type of calibration gas. These steps are grouped under a user defined ID number which can be used to call up an automatic calibration sequence. A sequence can contain other ID numbers to create nested (up to 5 levels) sequences or can be repeated up to 100 times, or even do an infinite loop.

NOTE

If the user attempts to generate a source gas type that does not exist, nothing will happen and the action will simply be ignored. This applies to any initiation source. See Section 2.3, step 1 for source gas port setup.

To setup a sequence do the following;

Step Number	Action	Comment
1.	Press SETUP-SEQ-EDIT-INS	This will allow the user to define the properties for the sequence. Up to 50 different sequences can be created and a sequence can have up to 500 steps.
2.	Press SET	Press SET repeatedly to select NAME, REPEAT COUNT, CC INPUT, CC OUTPUT, TIMER, and STEPS. -NAME - Up to 10 characters long name allowed. Press INS to add character. -REPEAT COUNT - Number of times to execute the same sequence repeatedly. 1 - 100 is allowed or 0 to execute indefinitely. -CC INPUT - specifies a contact closure input to initiate the sequence remotely using 12 optoisolators inputs capable of generating 4096 different inputs. -CC OUTPUT - specifies contact closure output that is set when this sequence executes using 12 optoisolators outputs capable of generating 4096 different outputs combination. -TIMER - Enables or disables the automatic timer to initiate this sequence using built in clock. - STEPS - Indicates number of steps in the sequence. You can edit this property to insert, delete, or edit the steps such as GENERATE, GPT, etc as following.

(table continued)

Step Number	Action	Comment
3.	Press SET until STEPS is shown, then press EDIT-INS	Scroll up or down by pressing PREV or NEXT key to display GENERATE, GPT, GPTPS, PURGE, STANDBY, DELAY, EXECSEQ, and MAN. Select a desired mode and enter concentration, unit, and the gas type. Press ENTR. -GENERATE-ENTR offers selection of gas type, concentration, and the unit. -GPT-ENTR allows to enter NO gas concentration and O_3 gas concentration. -GPTPS-ENTR allows GPT preset which will setup in an identical way as GPT. -PURGE-ENTR will purge-out the residual gases of the previous generated steps in the pneumatic system. -STANDBY-ENTR puts calibrator into standby mode. A STANDBY step is automatically inserted prior to any other steps. Most sequences should end with a STANDBY step, but if a sequence is to be executed by another sequence as a nested one, then it should not end with a STANDBY-see examples 5.10 and 5.13. -DELAY-ENTR adds a delay. -EXECSEQ-ENTR executes another sequence by its ID number. It allows one to create a nested sequence to be executed within another sequence. It can be nested to only 5 levels. -MAN-ENTR step allow to control gas flow, diluent flow, O_3 concentration, and O_3 generator feedback mode. This MAN mode can generate single gas or mixture of two gases (i.e. GPT). Once ENTR is pressed, then the display changes to request the duration of the step in minutes (delay). Enter from 0.1 up to 120.0 and press ENTR. **Note that two lines of steps make a complete instruction and a sequence may contain multiple instructions.**
4.	Press EXIT-EXIT-EXIT-EXIT	The M700 returns to main menu.

The above table shows in general how to create a sequence of multiple instructions. Many combinations of steps can be created as the following examples show.

Example 5.9: Create a sequence named “AB” that contains steps to generate zero air for 15 minutes. Parameters like Repeat count, CC input, CC output, and timer are ignored for this example 5.9.

Step Number	Action	Comment
1.	Press SETUP-SEQ-EDIT-INS, then press EDIT	The display will show NAME: [0] to be edited. Press INS two times to create 2 characters. Press button under [0] until “A” is shown. Press CH> to move to next character. Press [0] button again until “B” is shown. Press ENTR
2.	Press SET until STEPS is shown. Then press EDIT-INS (zero air step)	Scroll up or down by pressing PREV or NEXT key to display “**Insert STEP:GENERATE”** and press ENTR. Display should change showing concentration, unit, and gas name. Select ZERO gas type (unit and concentration are ignored for zero air) and press ENTR. Now the display changes to show the duration of the zero air step. Enter 15.0 for the delay time and press ENTR.
3.	Press EXIT-EXIT-EXIT-EXIT	The M700 returns to main menu mode.

Example 5.10: Edit (allows the user to change the program) sequence name AB to CD. Sequence name AB will be removed from the sequence database. Edit sequence CD to delete the STANDBY step. Deleting STANDBY step will result in continuing the last step of the sequence indefinitely.

Step Number	Action	Comment
1.	Press SETUP-SEQ-EDIT	Scroll up or down by pressing PREV or NEXT key to access sequence name AB on the display.
2.	Press EDIT-EDIT	The display will show NAME: [A]B to be edited. Press button under [A] until “C” is shown. Press CH> to move to next character. Press [B] button again until “D” is shown. Press ENTR
3.	Press SET until STEPS is shown. Then press EDIT	Scroll up or down by pressing PREV or NEXT key to display line of step that shows STANDBY (which should be the last line of the steps).
4.	Press DEL (delete)	Press YES. M700 will delete the STANDBY step from the sequence.
5.	Press EXIT-EXIT-EXIT-EXIT-EXIT	The M700 returns to main menu mode.

STANDBY step at the end of a sequence : Once the sequence name is created, then the M700 automatically inserts a STANDBY step. A sequence always should end with a STANDBY step unless it is needed to continue the very last step of the sequence indefinitely. A sequence without a STANDBY step will exit the sequence mode, but will continue generating the last step of the sequence indefinitely until STBY is pressed manually. However, if a sequence contains a nested sequence, then the nested sequence should not end with STANDBY since this is not the end of the sequence. (see example 5.13)

NOTE

Notice that the sequence that has the REPEAT number of zero (0) will continue an indefinite loop of all of the steps in a sequence. While the sequence without a STANDBY step at the end will continue only the last step of the sequence indefinitely.

Example 5.11: Create a sequence ID number 11, a sequence database that contains steps to generate zero air for 15 minutes, 400 ppb of NO gas for 15 minutes, 200 ppb of O_3 gas for 15 minutes, and GPT mixing 400 ppb of NO gas and 200 ppb of O_3 gas which will yield 200 ppb of NO_2 for 15 minutes. Finally purge the calibration system for 3 minutes. Set Repeat Count to 1 (which means sequence is done only once). The factory set flow is at 5 LPM. To change the flow, press SETUP-MORE-FLOW, enter the desired flow and press ENTR.

Step Number	Action	Comment
1.	Press SETUP-SEQ-EDIT-INS, then press EDIT	The display will show NAME: [0] to be edited. Press INS two times to create 2 characters. Press button under [0] until “1” is shown. Press CH> to move to next character. Press [0] button again until “1” is shown. Press ENTR
2.	Press SET until STEPS is shown. Then press EDIT-INS (zero air step)	Scroll up or down by pressing PREV or NEXT key to display “**Insert STEP:GENERATE”** and press ENTR. Display will change to request concentration, unit, and gas type. Select ZERO gas type (unit and concentration are ignored for zero air) and press ENTR. Now display changes to show the duration of the zero air step. Enter 15.0 and press ENTR.
3.	Press INS (NO gas step)	Scroll up or down by pressing PREV or NEXT key to display “**Insert STEP:GENERATE”** and press ENTR. Select NO gas and enter 400. Select ppb for the unit press ENTR. Enter 15.0 for the duration and press ENTR.
4.	Press INS (O_3 gas step)	Select “**Insert STEP:GENERATE”** and press ENTR. Select O3 and enter 200. Select ppb for the unit press ENTR. Enter 15.0 and press ENTR.
5.	Press INS (GPT step)	Select “**Insert STEP:GPT”** and press ENTR. Enter 400 for NO concentration and press ENTR. Enter 200 for O_3 concentration and press ENTR. Enter duration of 15.0 and press ENTR.
6.	Press INS (PURGE step)	Select “**Insert STEP:PURGE”** and press ENTR. Enter duration of 3.0 and press ENTR.
7.	Press EXIT	Returns to previous level.
8.	Press SET until REPEAT COUNT is shown	Pressing EDIT will allow to enter the number of repetitions for the sequence name “11”. Enter 1(default value). **Do not enter 0 (zero) unless you want an infinite loop of this sequence.**
9.	Press EXIT-EXIT-EXIT-EXIT	M700 returns to main menu mode.

Example 5.12: Edit sequence ID number 11 to add 40 ppm of CO gas generation for the duration of 15 minutes prior to generating NO gas.

Step Number	Action	Comment
1.	Press SETUP-SEQ-EDIT	Scroll up or down by pressing PREV or NEXT key to search for sequence number 11. Then press EDIT.
2.	Press SET until STEPS is shown. Press EDIT	Scroll up or down by pressing PREV or NEXT key to display line of step that generates 400 ppb of NO gas.
3.	Press INS (CO gas step)	Scroll up or down by pressing PREV or NEXT key to display **Insert STEP:GENERATE** and press ENTR. Select CO gas and enter 40. Select **ppm** for the unit and press ENTR. Enter 15.0 and press ENTR. The M700 will automatically adjust the numbering of the steps.
4.	Press EXIT-EXIT-EXIT-EXIT-EXIT	The M700 returns to main menu mode.

Example 5.13: Edit ID number 11 to form a nested sequence by inserting sequence name "CD" (created in examples 5.9 and edited in 5.10) immediately after NO gas generation step.

Step Number	Action	Comment
1.	Press SETUP-SEQ-EDIT	Scroll up or down by pressing PREV or NEXT key to search for sequence number 11. Then press EDIT
2.	Press SET until STEPS is shown. Press EDIT	Scroll up or down by pressing PREV or NEXT key to display line of step that generates 200.0 ppb of O_3.
3.	Press INS	Scroll up or down by pressing PREV or NEXT key to display **Insert STEP:EXECSEQ** and press NEXT (or PREV) until sequence name "CD" is shown. Press ENTR.
4.	Press EXIT-EXIT-EXIT-EXIT-EXIT	The M700 returns to main menu mode.

Printing the sequence database; To print the entire database of all the sequences (using the RS-232 interface) press SETUP-SEQ-PRNT.

There is also a PRNT button in each individual sequence (i.e. SETUP-SEQ-EDIT-EDIT-PRNT) as well. This will print the currently displayed sequence and not the entire database of sequences. For example, to print sequence name “11” (Example 5.11) press SETUP-SEQ-EDIT. Then select “SEQ 11, 14 STEPS” by pressing NEXT or PREV buttons. Press EDIT-PRNT . This will print out sequence 11 .

Example of a sequence (not the entire database) print-out;

NAME:	11
REPEAT COUNT:	1
CC INPUT:	DISABLED
CC OUTPUT:	DISABLED
TIMER:	DISABLED
STEPS:	14

1. GENERATE 0.0 PPB ZERO
2. DELAY 15.0 MIN
3. GENERATE 40.0 PPM CO
4. DELAY 15.0 MIN
5. GENERATE 400.0 PPB NO
6. DELAY 15.0 MIN
7. EXECUTE SEQUENCE CD
8. GENERATE 200.0 PPB O_3
9. DELAY 15.0 MIN
10. GPT 400 PPB NO, 200 PPB O_3
11. DELAY 15.0 MIN
12. PURGE
13. DELAY 3.0 MIN
14. STANDBY

5.3.2 Timer Controlled Auto-Sequence

Once the sequence database is created, then the M700 can initiate this sequence from a built-in software automatic timer. This feature supports up to 12 automatic timers for executing sequences. This means sequences can be tied to any one of 12 different starting times. Each timer can be setup for any existing sequence and it can be turned on or off.

To setup timer, press SETUP-SEQ-EDIT. Use PREV or NEXT buttons to scroll to the desired sequence, and then press EDIT. Use SET button to move to the TIMER property. The automatic timer is initially disabled, so the current property setting will appear as shown below.

SETUP D.3	**TIMER:DISABLED**	
<SET SET> EDIT PRNT		**EXIT**

To enable the automatic timer for this sequence, press **EDIT**. You should see the following display.

SETUP D.3	**TIMER**	**ENABLE:OFF**
OFF		**ENTR EXIT**

Change the setting to *ON* and press **ENTR**. The timer is now enabled and two additional properties will appear in the list of sequence properties: “TIMER START” and “TIMER DELTA.” The “TIMER START” property specifies the first date and time that the sequence should begin executing. Enter the date and time using a series of two menus shown below. The first menu edits the starting date.

SETUP D.3	**TIMER**	**START:24-APR-98**
2 4 APR 9 8		**ENTR EXIT**

The software assumes that 2-digit years from 70 through 99 are 4-digits years 1970 through 1999 and that 2-digit years from 0 through 69 are 4-digit years 2000 through 2069.

The second menu edits the starting time (hours and minutes).

SETUP D.3	**TIMER**	**START:00:00**
0 0 :0 0		**ENTR EXIT**

The “TIMER DELTA” property specifies the amount of time between each sequence execution, in days, hours, and minutes. You enter the delta time using a series of two menus shown below. The first menu edits the number of days between each sequence execution.

SETUP D.3	**TIMER**	**DELTA:1 Days**
0 0 0		**ENTR EXIT**

The second menu edits the number of hours and minutes between each sequence execution.

SETUP D.3	**TIMER**	**DELTA:00:00**
0 0 :0 0		**ENTR EXIT**

Setting a delta of 0 days and 0 hours and minutes effectively disables a timer. The days, hours, and minutes are all added together to form the total delta time.

If any one of 12 timers is turned ON, then the AUTO LED(yellow) on the front panel will be ON. If OFF is selected, then the corresponding timer is deactivated regardless of its previous setup information. The timer setup is stored in the EEPROM for the setup protection.

NOTE

If the user attempts to initiate a sequence name that does not exist, nothing will happen and the action will simply be ignored. This applies to any initiation source.

Whenever a new sequence is initiated from any source, it immediately terminates any sequence in progress and starts the new one.

5.3.3 Contact Closure Input Setup

The M700 can be operated using external control sources to initiate an auto-sequence calibration. Remote contact closure operation will operate the calibrator in a slave mode and external control sources such as a data logger will control the calibration sequences.

To configure the contact closure inputs press **SETUP-SEQ-EDIT**, press **PREV** and **NEXT** to move to the desired sequence, and then press **EDIT**. Use the **<SET** and **SET>** buttons to move to the “CC INPUT” property. The contact closure inputs are initially disabled, so the current property setting will appear as shown below.

SETUP D.3	**CC INPUT: DISABLED**	
<SET SET> EDIT PRNT		**EXIT**

To enable the contact closure inputs for this sequence, press **EDIT**. You should see the following display.

SETUP D.3	**CC INPUT ENABLE:OFF**	
OFF		**ENTR EXIT**

Change the setting to ON and press **ENTR**. You should see the following display.

SETUP D.3	**CC INPUT:[0]00000000000**	
<CH CH>	**[0]**	**ENTR EXIT**

Edit the contact closure input pattern as a string of characters, with each character representing one contact closure input. You can press the **<CH** and **CH>** buttons to move the cursor to a different character in the string; you can press the **[0]** button to change the character under the cursor. You can set a character to a 0 or a 1 only. A value of 0 indicates that the contact closure input is open; a value of 1 indicates that it's closed.

When the external contact closure inputs match the pattern for this sequence, the sequence will be executed. For example, suppose you want to trigger the sequence when the first contact closure input is closed. You would set the input pattern as shown below.

SETUP D.3	**CC INPUT:[1]00000000000**		
<CH CH>		**[1]**	**ENTR EXIT**

Suppose you want to trigger the sequence when the second contact closure input is closed. You would set the input pattern as shown below.

SETUP D.3	**CC INPUT:0[1]0000000000**		
<CH CH>		**[1]**	**ENTR EXIT**

Suppose you want to trigger the sequence when the first and second contact closure inputs are closed. You would set the input pattern as shown below.

SETUP D.3	**CC INPUT:1[1]0000000000**		
<CH CH>		**[1]**	**ENTR EXIT**

The most left 4 digits correspond to the 4 pair of control inputs on the rear panel. The remaining 8 digits are configured on the 50 pin connector. See Figure 2-1.

NOTE

If the user attempts to initiate a sequence name that does not exist, nothing will happen and the action will simply be ignored. This applies to any initiation source.

Whenever a new sequence is initiated from any source, it immediately terminates any sequence in progress and starts the new one.

5.3.4 Contact Closure Output Setup

Configuring the contact closure outputs is very similar to configuring the inputs. Begin by pressing **SETUP-SEQ-EDIT**, press **PREV** and **NEXT** to move to the desired sequence, and then press **EDIT**. Use the **<SET** and **SET>** buttons to move to the “CC OUTPUT” property. The contact closure outputs are initially disabled, so the current property setting will appear as shown below.

SETUP D.3	**CC OUTPUT:DISABLED**		
<SET SET> EDIT PRNT			**EXIT**

When the contact closure outputs are disabled, they are not changed when the sequence executes. To enable the contact closure outputs for this sequence, press **EDIT**. You should see the following display.

SETUP D.3	**CC OUTPUT ENABLE:OFF**		
OFF			**ENTR EXIT**

Change the setting to *ON* and press **ENTR**. You should see the following display.

SETUP D.3	**CC OUTPUT:[0]00000000000**		
<CH CH>		**[0]**	**ENTR EXIT**

As you can see, configuring the contact closure outputs is virtually identical to configuring the inputs, except that each character in the pattern represents one contact closure output instead of an input. The most left 4 digits correspond to the 4 pair of control outputs on the rear panel. The remaining 8 digits are configured on the 50 pin connector. See Figure 2-1.

Whenever this sequence executes, the contact closure outputs will be set according to the pattern. For example, suppose you want to set the first contact closure output when the sequence executes. You would set the output pattern as shown below.

SETUP D.3	**CC OUTPUT:[1]00000000000**		
<CH CH>		**[1]**	**ENTR EXIT**

Suppose you want to set the first and second contact closure outputs when the sequence executes. You would set the output pattern as shown below.

SETUP D.3	**CC OUTPUT:1[1]0000000000**		
<CH CH>		**[1]**	**ENTR EXIT**

5.3.5 Sequence Setup through RS-232

The Model 700 Calibrator features a powerful RS-232 interface for controlling the calibrator from a host computer. Because of the dual nature of the RS-232 interface, the message format has been carefully designed to accommodate both printers and host computers. Refer to Section 4.2.7 RS-232 Interface for interfacing a M700 to a RS-232 device. Refer also to Section 7 for additional RS-232 information.

5.3.6 Creating the Sequence Script

The first step is to create a *script* file containing the desired sequence configuration somewhat like a computer program, as shown in the example below.

```
Seqlistbegin
seqbegin
name “CD”
repeatcount 1
ccinput “100000000000”
ccoutput “100000000000”
timer enabled
timerstart 01/01/1998 00:00
timerdelta 001:00:00
stepbegin
generate 100 ppb so2
delay 10.0
generate 200 ppb so2
delay 10.0
generate 300 ppb so2
delay 10.0
generate 400 ppb so2
delay 10.0
standby
stepend
seqend
seqbegin
name “11”
seqend
seqlistend
```

5.3.7 Sequence Configuration Script Syntax

In the syntax descriptions below, underlined words are keywords and must be spelled exactly as shown. Items in angle braces (< >) are required, but do not include the angle braces in the script. Items in square braces ([ ]) are optional. Upper and lower case doesn't matter except in the case of the sequence name. You can include lower case letters in the sequence name and they will be retained. Line indentation doesn't matter, and you can put multiple statements on a single line. However each line must not exceed 100 characters in length.

Seqlistbegin

[<zero or more sequence definitions (see syntax below)>]

seqlistend

The simplest script consists of just seqlistbegin followed by seqlistend, which defines no sequences. If you view the sequence configuration using the M700 front panel, the sequences will appear in the same order that they appear in the script.

5.3.8 Sequence Definition Syntax

With the exception of the name property, which must always be supplied, you only need to include the properties that you want to change from the default setting.

With the exception of the name property, which must always appear first, you may specify the properties in any order.

Seqbegin

name <sequence name in double quotes>

[<zero or more sequence properties (see table)>]

[<sequence steps (see syntax below)>]

seqend

Model 700 Sequence Property Syntax		
Syntax	**Description**	**Example**
NAME <name>	User-defined name for the sequence, 1–10 characters long, in double quotes.	Name "AB"
REPEATCOUNT <number>	Number of times to execute the sequence. 1–100: the sequence is executed that many times. 0: the sequence is executed indefinitely.	repeatcount 1
CCINPUT DISABLED	Disables the contact closure inputs for this sequence.	ccinput disabled
CCINPUT <pattern>	Specifies the pattern of 12 contact closure inputs that triggers this sequence and enables the contact closure inputs. Pattern must be exactly 12 characters long, consist only of the digits 0 and 1, and be enclosed in double quotes.	ccinput "100000000000"
CCOUTPUT DISABLED	Disables the contact closure outputs for this sequence.	ccoutput disabled
CCOUTPUT <pattern>	Specifies the pattern of 12 contact closure outputs that is set when this sequence executes and enables the contact closure outputs. Pattern must be exactly 12 characters long, consist only of the digits 0 and 1, and be enclosed in double quotes.	ccoutput "100000000000"
TIMER ENABLED	Enables the automatic timer.	Timer enabled
TIMER DISABLED	Disables the automatic timer.	Timer disabled
TIMERSTART[1] <MM/DD/YYYY HH:MM>	The date and time that the sequence begins executing. Format of date and time is month / date / year hour : minute.	Timerstart 1/1/1998 23:59
TIMERDELTA[1] <DDD:HH:MM>	The number of days, hours, and minutes between each sequence execution. Up to one year.	Timerdelta 366:23:59

[1]You may specify these properties, and they will be stored in the sequence, even if the automatic timer is not enabled.

5.3.9 Sequence Steps Syntax

stepbegin

<one or more step definitions (see table)>

stepend

The sequence step syntax is identical to that of the calibrator commands shown in the instrument’s help screen, which you can obtain using the “?” command. When the sequence executes, the steps will be executed in the order that they appear in the configuration script.

<table>
<tr><th colspan="3">Model 700 Sequence Property Syntax</th></tr>
<tr><th>Syntax</th><th>Description</th><th>Example</th></tr>
<tr><td>GENERATE ZERO</td><td>Generates zero air.</td><td>generate zero</td></tr>
<tr><td>GENERATE <conc> <units>[1] <gas>[1]</td><td>Generates a concentration of specified gas and units.</td><td>Generate 100.0 ppb SO_2</td></tr>
<tr><td>GPT <NO conc> <NO units>[1] < O_3 conc> < O_3 units>[1]</td><td>Generates a GPT consisting of NO and O_3.</td><td>GPT 100.0 ppb 100.0 ppb</td></tr>
<tr><td>GPTPS <NO conc> <NO units>[1] < O_3 conc> < O_3 units>[1]</td><td>Generates a GPT-preset consisting of NO and O_3.</td><td>GPTS 100.0 ppb 100.0 ppb</td></tr>
<tr><td>PURGE</td><td>Generates a purge.</td><td>Purge</td></tr>
<tr><td>STANDBY</td><td>Stops generating gas and puts calibrator in standby mode.</td><td>Standby</td></tr>
<tr><td>EXECSEQ <name></td><td>Executes a sequence by name. Enclose name in double quotes. The name is not case-sensitive.</td><td>EXECSEQ “def”</td></tr>
<tr><td>DELAY <minutes></td><td>Generates a delay of the specified minutes.</td><td>Delay 10.5</td></tr>
<tr><td>MANUAL <calgas>[1] <calflow> <dilflow> <OFF | CONST | REF | BENCH>
[< O_3 generator set point>]</td><td>Generates gas under manual control using the specified gas, flows, and O_3 generator setting. If the O_3 generator mode is OFF, do not specify the O_3 generator set point. If the mode is CONST, the O_3 generator set point is mV. If the mode is REF or BENCH, the O_3 generator set point is PPB.</td><td>Manual SO_2 0.05 1.95 off</td></tr>
</table>

[1]Unit and gas names should not be placed in quotes.

5.3.10 Uploading the Sequence Configuration Script

Once the sequence configuration script is created, you simply transmit it to the M700 as you would any other command. If you were using a terminal emulator program on a PC, you would "upload" the script as a text file. **The uploaded configuration completely replaces the existing one.**

You cannot upload the sequence configuration script if the M700 is executing a sequence. You must place the M700 in standby mode using the "c standby" command before you can upload the script.

5.3.11 Downloading the Sequence Configuration Script

You can "download" the current sequence configuration in script format using the command "c print script." Once you've downloaded the script, you can modify it, and then upload it. Downloading the current configuration as a script is the easiest way to get one started and to review the script syntax.

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6 OPTIONAL HARDWARE/SOFTWARE

6.1 Photometer Option

The Photometer is used as part of a feedback to the ozone generator control to assure stable O_3 output. The Photometer is operated only during the O_3 generating mode. The pump and photometer valve are operated only when it is needed during the ozone generate mode and with the bench mode selected. During the GPT mode, the photometer's pump and valve are disabled since the photometer feedback is not used.

6.1.1 Principle of Operation

The detection of ozone molecules is based on absorption of 254 nm UV light due to an internal electronic resonance of the O_3 molecule. The Model 700 Photometer uses a mercury lamp constructed so that a large majority of the light emitted is at the 254nm wavelength. Light from the lamp shines down a hollow glass tube that is alternately filled with sample gas, then filled with zero gas. The ratio of the intensity of light passing through the zero gas to that of the sample forms a ratio I/I_0. This ratio forms the basis for the calculation of the ozone concentration.

The intensity of light is converted into a voltage by the detector/preamp module. The voltage is converted into a number by a voltage-to-frequency (V/F) converter capable of 80,000 count resolution. The digitized intensities, along with the other variables, are used by the CPU to compute the concentration using the above formula.

Every 8 seconds the M700 Photometer completes a measurement cycle consisting of a 2 second wait period for the sample tube to flush, followed by 2 seconds of measuring the average light intensity to determine I. The sample valve is switched to admit zero gas for 2 seconds followed by 2 seconds measuring the average light intensity to obtain I_0. Measurement of the I_0 every 8 seconds minimizes instrument drift due to changing intensity of the lamp due to aging and dirt. The sample pump of the photometer runs only during O_3 generation mode.

6.1.2 Photometer Calibration

Since the accuracy of the calibration standards obtained by this calibration procedure depends entirely on the accuracy of the photometer, it is very important that the photometer is operating properly and accurately. The fact that the photometer makes a ratio measurement (I/I_o) rather than an absolute measurement eases this task. The calibration of the photometer can be verified by periodic (recommended every 3 months) intercomparison between a Model 700 photometer and a reference standard.

Table 6-1: Photometer Zero/Span Calibration Procedure

Step Number	Action	Comment
1.	Press SETUP-GAS-O3-PHOT-BCAL-CAL-ZERO	This key sequence will allow one to calibrate the photometer. (Must enter Special password 717 for BCAL step.)
2.	Press ENTR	The M700 will start to generate zero gas. Allow the photometer to sample zero gas for approximately 10 minutes. Note the front panel display momentarily changes to the main menu.
3.	Press ZERO-ENTR	Press YES to calibrate the photometer's zero. This will set the zero calibration of the photometer. Press NO otherwise.
4.	Press EXIT	The M700 will stop generating zero gas and the display returns to the photometer calibration menu.
5.	Press CAL-SPAN-ENTR	Enter the desired concentration and press ENTR to generate O_3 span gas. Allow the M700 to sample span gas for approximately 10 minutes.
6.	Press SPAN	Enter the actual O_3 concentration measured by the reference standard (or reference ozone analyzer) and press YES to calibrate the photometer's span. This will set the span calibration of the photometer. Press NO otherwise.
7.	Press EXIT	The M700 will stop generating span gas and the display returns to the photometer calibration menu.
8.	Press EXIT-EXIT-EXIT-EXIT-EXIT	The front panel display returns to the main menu.

A well-designed properly built photometer is a precision instrument, and once it is operating adequately, it is likely to continue to do so for some time, particularly if the photometer is stationary and is used under laboratory conditions.

6.2 Permeation Oven Option

The permeation tube source gas is an alternative method to generate stable gas such as SO_2, NO_2, etc. The permeation tube consists of a small container of a liquefied gas, with a small window of PTFE which the gas slowly permeates through at a rate in the nanogram/min .range. If the tube is kept at constant temperature, usually about 50°C, the device will provide a stable source of gas for a year or more.

The permeation tube concentration is determined by the permeation tube specific output (ng/min @ 50°C), the permeation tube temperature (°C) and the air flow across it (slpm). The specific output is a fixed function of the permeation tube and is noted on the shipping container.

The temperature is set at 50.0°C. Check SETUP-MORE-VARS and scroll to the IZS-TEMP variable to verify that the temperature is properly set. It should be set to 50°C with over-and-under temperature warnings set at 49°C and 51°C. There is a 105cc/min flow across the permeation tube at all times to prevent build-up of the gas in the tubing.

This permeation tube source gas is diluted with zero air to generate desired concentration of the specific gas. The gas concentration can be calculated using following equation;

$$C = \frac{P \times Km}{F}$$

where

P = permeation rate, ng/min @ 50°C.

Km = (24.46)/molecular weight, where 24.46 is the molar volume in liters @ 25°C, 760mmHg . Km for SO_2 = 0.382, NO_2 = 0.532, H_2S = 0.719, and NH_3 = 1.436.

F = total flow rate(sum of 105cc/min and diluent flow), cc/min.

C = concentration, ppm.

Permeation tubes require 48 hours at 50°C to reach a stable output. We recommend waiting this long before any calibration checks, adjustments, or conclusions are reached about the permeation tube. Once the M700 has stabilized, the response to the permeation tube is not expected to change more than ± 5% if the zero air is provided for an Teledyne API Model 701 or other dry zero air source.

Teledyne API recommends that you purchase replacement permeation tubes from:

VICI METRONICS
2991 Corvin Drive
Santa Clara, CA 95051 USA
Phone 408-737-0550 Fax 408-737-0346

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7 RS-232 COMMUNICATIONS

The Model 700 Calibrator features a powerful RS-232 interface which is used both for reporting test results and for controlling the calibrator from a host computer. Because of the dual nature of the RS-232 interface, the message format has been carefully designed to accommodate both printers and host computers.

All message outputs from the Model 700 have the following format:

“X DDD:HH:MM IIII MESSAGE<CRLF>”

The “X” is replaced by any of the characters listed below and indicates the message type (see table below).

Table 7-1: RS-232 Message Types

Character	Message Type
R	DAS report
W	Warning
C	Calibration
D	Diagnostic
T	Test measurement
V	Variable value
?	HELP screen

The “DDD:HH:MM” is a time-stamp indicating the day-of-year (“DDD”) as a number from 1 to 366, the hour of the day (“HH”) as a number from 00 to 23, and the minute (“MM”) as a number from 00 to 59.

The “IIII” is a 4-digit Analyzer I.D. number.

The “MESSAGE” field contains variable information such as warning messages, test measurements, DAS reports, etc.

The “<CRLF>” is a carriage return-line feed combination which terminates the message and also makes the messages appear neatly on a printer.

The uniform nature of the output messages make it easy for a host computer to parse them.

Input messages to the Model 700 have a format which is similar to that for output messages:

“X COMMAND<CRLF>”

The “X” indicates the message type as shown above in Table 7-1 and “COMMAND” is the command type, each of which is described individually below.

The “<CRLF>” is used to terminate the command. Typing “<CRLF>” a few times by itself is a good way to clear the input buffer of any extraneous characters.

7.1 Warnings

Whenever a warning message is displayed on the display, it is also sent to the RS-232 output. These messages are very helpful when trying to track down a system problem. The message format is:

`“W DDD:HH:MM IIII WARNING MESSAGE<CRLF>”`

An example of an actual warning message is:

`“W 194:11:03 0000 CAL GAS PRESSURE WARN<CRLF>”`

Warnings may be cleared via the RS-232 interface by issuing a command of the form:

`“W COMMAND<CRLF>”`

where “COMMAND” indicates which warning message to clear. For example, to clear the “CAL GAS PRESSURE WARN” message, the host computer can issue the command:

`“W WCALPRESS <CRLF>”`

Attempting to clear a warning which is not active has no effect. The following table lists the command to use to clear each possible warning message.

Example of other warning commands are:

`W LIST`	List currently active warnings
`W CLEAR ALL`	Clear all current warnings

Table 7-2: RS-232 Warning Message Clear Commands

Command	Warning Message Cleared
"W WSYSRES"	SYSTEM RESET
"W WRAMINIT"	RAM INITIALIZED
"W WPEMTEMP"	PERM TUBE TEMP WARNING
"W WPHOTOREF"	PHOTO REFERENCE WARNING
"W WO3GENREF"	O3 GEN REFERENCE WARNING
"W WCALPRESS"	CAL GAS PRESSURE WARNING
"W WWDILPRESS"	DILUENT PRESSURE WARNING
"W WPHOTOLTEMP"	PHOTO LAMP TEMP WARNING
"W WO3GENTEMP"	O3 GEN LAMP TEMP WARNING
"W WREGPRESS"	REGULATOR PRESSURE WARNING
"W WI2CDET"	I2C INTERFACE NOT DETECTED
"W WVFDET"	V/F CARD NOT DETECTED
"W WMFCFLOW"	CAL GAS/DILUENT FLOW WARNING

7.2 Calibration

This subset of messages is concerned with controlling the calibrator remotely. To do a remote calibration via the RS-232 interface, the host computer should issue a message with the following format:

“C COMMAND<CRLF>”

CAUTION

This C COMMAND feature does not stop automatically unless user issues C STANDBY to stop.

NOTE

If the user attempts to initiate a sequence ID or a gas type that does not exist, nothing will happen, the action will simply be ignored. This applies to any initiation source.

Whenever a new sequence is initiated from any source, it immediately terminates any sequence in progress and starts the new one.

The commands are summarized in the table below:

Command Message	Meaning
"C GENERATE conc units gas"	Generate calibration gas including zero. Conc means the gas concentration, units for the unit of gas, and gas for the type of gas (see note below).
"C GPT noConc noUnits O3Conc O3Units"	Generate GPT. NoConc means concentration of the NO gas, noUnits for the unit of gas, O_3Conc for O_3 gas concentration, and O_3Units for the unit of O_3 gas.
"C GPTPS noConc noUnits O3Conc O3Units"	Generate GPT-Preset. NoConc means concentration of the NO gas, noUnits for the unit of gas, O_3Conc for O_3 gas concentration, and O_3Units for the unit of O_3 gas.
"C PURGE"	Initiate purge mode.
"C EXECSEQ sequenceNumber"	Execute sequence number (see note below).
"C MANUAL calGas gasFlow dilFlow off/const/ref/bench[O3 mV / PPB]"	Generate calibration gas including zero. This command functions the same way as the "C GENERATE" except it allows for control of the flow rate of both the gas and diluent air. calGas means calibration gas type, gasFlow for flow rate of the gas in SLPM*, dilFlow for flow rate of the diluent air in SLPM*; and OFF, CONST, REF, and BENCH are the ozone generator mode. These first four parameters are always required. If the ozone generator mode is not OFF, then the last parameter is also required, and is interpreted as mV if the mode is CONST, and PPB if the mode is REF or BENCH (photometer option).
"C STANDBY"	Stops generating calibration gas and initiates standby mode. **The user must issue this command to terminate any calibration mode initiated** except when "C EXECSEQ" command is used since the sequence contains STANDBY as an end instruction
***** All of the flow rates are in units of SLPM. Even in units of SLPM enough significant digits are provided to enter flows to a resolution of 0.1 SCCPM.	

Whenever the calibrator generates the calibration gas it issues a report to the RS-232 output. The table below shows examples of the status reports.

Report
“C DDD:HH:MM IIII SEQ 123, CYCLE 1 OF 1”
“C DDD:HH:MM IIII 100.0 PPB SO2“
“C DDD:HH:MM IIII STANDBY”

The first line in the table above shows the sequence number and cycle(repetition) being executed. (If the sequence is programmed to repeat indefinitely, the “OF 1”part of the message is omitted.)

For example, when a control issues the command to generate zero gas

“C GENERATE 0 PPB ZERO<CRLF>”

The CPU will send the status report to the RS-232 output

“C DDD:HH:MM IIII GENERATE 0.0 PPB ZERO<CRLF>”

7.3 Diagnostics

The diagnostics mode can be entered from the RS-232 port as well as from the front panel. The diagnostics commands available are listed below.

Table 7-3: RS-232 Diagnostic Commands

Command	Function
“D LIST”	List all I/O signal values.
“D name”	Examine I/O signal[1.]
“D name=value”	Set I/O signal[2]
“D LIST NAMES”	List all diagnostic test names[3]
“D ENTER name”	Execute diagnostic test
“D EXIT”	Exit diagnostic test

[1] May examine an I/O signal at any time.

[2] Must issue the “D ENTER SIG” command before using this command to set an I/O signal. The previous I/O signal state will be restored when the “D EXIT” command is issued.

[3] Only SIG and LEAK can be executed remotely.

These commands may be used whether the diagnostics have been entered from the keyboard (SETUP-MORE-DIAG) or the RS-232 (“D ENTER name”).

In addition to the above commands, three special diagnostics commands have been added to provide complete control over a remote calibrator. These commands may be executed no matter what mode the instrument is in.

Whenever the diagnostic mode is entered or exited, a report is issued to the RS-232 output. The table below summarizes the diagnostic reports.

Table 7-4: RS-232 Diagnostic Reports

Report
“C DDD:HH:MM IIII ENTER DIAGNOSTIC MODE”
“C DDD:HH:MM IIII EXIT DIAGNOSTIC MODE”

7.4 Test Measurements

All the test measurements which can be displayed by pressing the TEST button are also available to the host computer via the RS-232 interface. The host computer can issue a request for a test measurement, and then the CPU will send the current value of the test measurement to the RS-232 output. The format of the test measurement message is:

`“T DDD:HH:MM IIII TEST MEASUREMENT<CRLF>”`

For example, the format of the TARG CAL in LPM would be:

`“T 194:11:29 0000 TARG CAL=1.0000 LPM <CRLF>”`

To request a test measurement, the host must issue a command of the form:

`“T MEASUREMENT<CRLF>”`

To list all test functions issue the command “T LIST”.

The table below lists all the commands and the corresponding test measurements which will be returned. Refer to Section 5.1.3 for the description of the test measurements.

Table 7-5: RS-232 Test Measurement Request Commands

Command	Test measurement
"T ACTCALFLOW"	ACT CAL=x.xxxx LPM
"T TARGCALFLOW"	TARG CAL=x.xxxx LPM
"T ACTDILFLOW"	ACT DIL=x.xxx LPM
"T TARGDILFLOW"	TARG DIL=x.xxx LPM
"T O3GENREF"	[2]O3 GEN REF= xxxx mV
"T O3GENFLOW"	[2]O3 FLOW= x.x LPM
"T O3GENDRIVE"	[2]O3 GEN DRIVE= xxxx mV
"T O3GENTEMP"	[2]O3 LAMP TEMP= xx C
"T CALPRESS"	CAL PRESSURE= xx.x PSIG
"T DILPRESS"	DIL PRESSURE= xx.x PSIG
"T ACTCONC"	ACT= xxxx.x ppb gas
"T TARGCONC"	TARG= xx.x ppb gas
"T BOXTEMP"	BOX TEMP= xx C
"T PERMTEMP"	[1]PERM TEMP=xx C
"T HPOTOMEAS"	[3]PHOTO MEASURE=xxxx.x mV
"T PHOTOREF"	[3]PHOTO REFERENCE=xxxx.x mV
"T PHOTOFLOW"	[3]PHOTO FLOW= x.x LPM
"T HPOTOLTEMP"	[3]PHOTO LAMP= xx C
"T PHOTOSPRESS"	[3]PHOTO SAMPLE= xx.x IN-HG-A
"T PHOTOSTEMP"	[3]PHOTO SAMPLE= xx C
"T PHOTOSLOPE"	[3]PHOTO SLOPE= x.xxxx
"T PHOTOOFFSET"	[3]PHOTO OFFSET=x.xxx
"T x"	DCPS= xxxxx mV
"T TESTCHAN"	TEST CHANNEL= xxx.x mV
"T CLKTIME"	TIME= xx:xx:xx

[1]Shown if perm tube option installed.

[2]Shown if ozone generator installed.

[3]Shown if photometer option is installed.

7.5 Viewing and Modifying Variables

The most powerful feature of the RS-232 interface is the ability of a host computer to view and modify the Analyzer's internal variables. Just as the operator modifies the variables by means of the setup mode, the host computer modifies them by means of the RS-232 interface.

To view a variable's value, the host computer issues a command of the following format:

```
"V VARIABLE<CRLF>"
```

The CPU will respond by sending a message of the following format to the RS-232 output:

```
"V VARIABLE=VALUE WARNLO WARNHI[DATALO-DATAHI] <CRLF>"
```

CAUTION

Before changing the settings on any variables, please make sure you understand the consequences of the change. The variables should only be changed by skilled maintenance people since they can potentially interfere with the performance of the calibrator.

In both cases "VARIABLE" is the name of the variable that is being viewed. "VALUE" is the current value of the variable. "WARNLO" and "WARNHI" are the low and high warning limits, respectively, but may not appear for all variables since some variables do not have warning limits. "DATALO" and "DATAHI" are the low and high data entry limits respectively. The CPU will not set a variable's value or warning limits to values which are outside of the data entry limits.

The values in square brackets are not required for all variables. If needed, the values are included on the command line, separated by spaces. For example, to change the instrument ID, the host computer would issue a command like this:

```
"V MACHINE_ID=1234<CRLF>"
```

and the CPU should respond with:

```
"V DDD:HH:MM IIII MACHINE_ID = 1234 (0-9999)<CRLF>"
```

To list the variables issue the command "V LIST<CRLF>". Table 7-6 lists the variable names which are variable through the RS-232 interface and their corresponding button sequences.

Table 7-6: RS-232 Variable Names

Variable Name	Button Sequence	Legal Values
PHOTO_LAMP	SETUP-MORE-VARS	0 - 100 deg C
O3_GEN_LAMP	SETUP-MORE-VARS	0 - 100 deg C
RS232_MODE	SETUP-MORE-VARS	0 - 32767 bits
CLOCK_ADJ	SETUP-MORE-VARS	-60 - +60 sec/day
CURR_TIME	SETUP-MORE-VARS	00:00-23:59
CURR_DATE	SETUP-MORE-VARS	xx/xx/xx

8 MAINTENANCE, ADJUSTMENT

NOTE

The operations outlined in this chapter are to be performed by qualified maintenance personnel only.

The M700 Calibrator system should be visually inspected to verify that the system is in order. Compare the configuration and plumbing connections to the flow diagram in the associated instruction manual. Verify that all connections are sound and there are no flow restrictions. Look for any obvious or possible leaks, and correct them. Check for cleanliness of the mixing glass, manifold, and lines.

8.1 Cleaning Orifice and Orifice Filter

Options such as the ozone generator, permeation oven, or the photometer flows are controlled by the critical flow orifices. The orifices never need adjustment. The critical flow orifice maintains precise volumetric control as long as the critical pressure is maintained between upstream and downstream of the orifice. The sample flow across the internal pneumatic system is fixed by the critical flow control orifice and has no adjustment. The following procedures are identical for each type of orifice assembly (see Figure 4-1 for location of each assembly).

1. Turn off the instrument power.
2. Remove the assembly.
3. With a toothpick or paper clip, remove the spring, filter, o-ring , orifice, and the o-ring from each port.
4. Discard the filter.
5. Check the orifice by looking it at the light to see that the orifice itself is open. If it is not open, try cleaning the orifice with a strand of fine wire or immersing in a solvent such as methyl alcohol, or do both.
6. If the orifice will not open, replace it.
7. Replace o-rings if they are deformed or suspected not to seat properly.
8. To replace the orifice, start with the o-ring, then orifice(jeweled end faces upstream), o-ring, filter, and finally the spring.
9. Retape the fittings with TFE tape, install and tighten.
10. Leak check.

8.2 Leak Check Procedure

Finding a leak source is often a time consuming process. In order to ease the problems associated with finding a leak, as an option Teledyne API has incorporated an Auto Leak Check procedure in the instruments diagnostics. This procedure, in most cases, is run simply by pressing the front panel buttons to select the routine and then running the routine. This makes it a simple process to incorporate a leak check on a regular basis; thereby, discovering leaks before they are a problem. The exception to this is a M700 with the Photometer option installed. In this case it will be necessary to bypass the internal bench sample pump.

The leak check procedure is performed in two stages. During the first stage; lasting one minute or 17% of the test, the Vent Valve and Output Valve are closed and the Purge Valve and Input Valve are opened, pressure is tested and if it does not reach 25 PSIG the test is aborted with a “LEAK CHECK FAILED” message. If the pressure does reach 25 PSIG the test continues by closing the Input Valve and monitoring pressure decay. If pressure decay exceeds 5 PSIG within five minutes the test will end with a “LEAK CHECK FAILED” message.

AUTO LEAK CHECK procedure:

If you do not have the photometer option skip to step 3.

1. Remove the fitting with Tygon tubing from the brass tee at the rear of the photometer.

NOTE
This procedure bypasses the photometer sample pump and flow sensor. Since these pumps may have internal leaks it is necessary to bypass them.
The flow sensor could be damaged if subjected to 30 PSIG, this technique is required to ensure no damage to the instrument occurs.

2. Remove the fitting from the pressure side of the sample pump and attach it to the fitting at the rear of the photometer where the fitting was just removed.
3. Ensure a source of clean, dry air at 30 to 35 PSIG is connected to the DILUENT IN port at the rear of the M700.
4. Press SETUP-MORE-DIAG. Select AUTO LEAK CHECK. Press ENTR.
5. At the 16% complete point, record the pressure reading from the M700 display. (this will allow you to determine the severity of any leak that might occur.)
6. At test completion the final pressure will be displayed. Any leak greater than 2 PSIG at this point would indicate a leak of sufficient severity to warrant finding and repairing it.

The AUTO LEAK CHECK only pressurizes the M700 for the first 16% or 1 minute of the test making it difficult to use it to find leaks. A method to pressure test the instrument is:

1. From the main menu, press SETUP-MORE-DIAG-ENTR-ENTR-NEXT. Ensure OFF indicator is present. Press JUMP-7-ENTR-OFF-OFF-ENTR. Press JUMP-53-ENTR-OFF-OFF-ENTR. Press NEXT-OFF-OFF-ENTR. You have now closed the Vent and Output valves and opened the Purge and Input valves. This will apply the clean, dry air at 30 to 35 PSIG from the DILUENT IN port throughout the calibrator.

2. Apply bubble type leak detector to all seals and fittings until the leak(s) is(are) located.

3. Tighten seal/fitting until leak stops.

4. Cleanup any excess bubble solution.

5. Press EXIT-NEXT-NEXT-NEXT-NEXT-ENTR. This will restart the AUTO LEAK CHECK.

6. Repeat these procedures until no more leaks exist.

Following table illustrates the valve actuation during different modes of operation including leak check procedure. Refer Figure 4-2 Pneumatic Diagram, Table 9-5 Power Supply LED indication, and Appendix D for schematic 1565 during valve actuation.

Table 8-1: Pneumatic Valve Actuation

Valve	Standby Mode	Gen Conc Mode	Bench O_3 Gen Mode	Ref O_3 Gen Mode	Gen GPTPS	Gen GPT Mode	Gen Perm Mode	Gen Zero Mode	Purge Mode	Auto leak 0 - 16%	Auto leak 17 - 100%
Inlet	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	OFF
Gas	OFF	ON	OFF	OFF	OFF	ON	OFF	OFF	OFF	OFF	OFF
Purge	OFF	OFF	OFF	OFF	ON	OFF	OFF	OFF	ON	ON	ON
GPT	OFF	OFF	OFF	OFF	ON	ON	OFF	OFF	OFF	OFF	OFF
O_3	OFF	OFF	ON	ON	ON	ON	OFF	OFF	OFF	OFF	OFF
Perm	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF
Ref/ Meas	OFF	OFF	SWITCH	OFF	SWITCH	OFF	OFF	OFF	OFF	OFF	OFF
Cal	OFF	ON	ON	ON	OFF	ON	ON	ON	OFF	OFF	OFF
Vent	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	ON	ON

8.3 Replacing the Permeation Tube (Option)

The permeation tube is contained in the oven at the rear - center of the instrument, refer to Figure 8-1 for its location.

1. Turn off the power to the M700.
2. Remove the two pneumatic fittings and the rubber insulation from the top of the assembly.
3. Remove the oven cover by removing three screws holding down the cover.
4. Remove the old permeation tube. Install the new permeation tube in the same chamber with the membrane facing UP.
5. Re-assemble the oven and turn on the instrument power.

The permeation tube requires 48 hours at 50°C to reach a stable output. We recommend waiting this long before any calibration checks, adjustments, or conclusions are reached about the permeation tube.

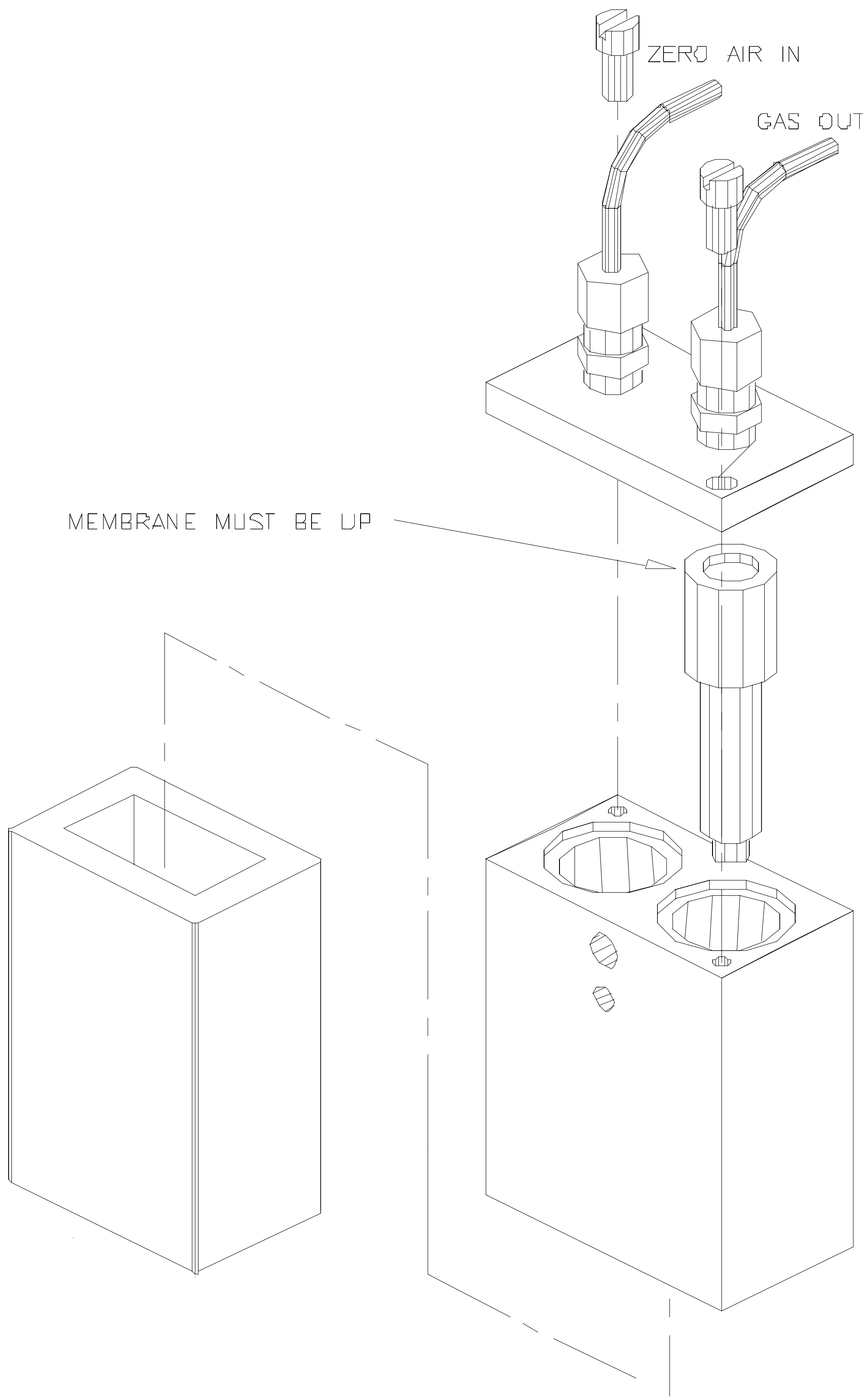

Figure 8-1: Permeation Tube Oven

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9 TROUBLESHOOTING

NOTE

The operations outlined in this chapter are to be performed by qualified maintenance personnel only.

9.1 Operation Verification - Diagnostic Techniques

The Teledyne API ozone analyzer contains two levels of diagnostics: Test measurements which can be viewed at all times (except when in setup) by pressing **TEST**, and lower level diagnostic operations which can only be performed by pressing **SETUP-MORE-DIAG**.

9.1.1 Test Measurements

Test measurements can be viewed at any time except when in setup. To view a different test measurement, simply press the **TEST** button. Table 5-3 lists the test measurements which are available. Viewing these test measurements does not interfere with the operation of the Model 700 in any way, so they may be viewed freely.

9.1.2 Fault Diagnosis with WARNING Messages

When a system warning occurs, a warning message is displayed and the FAULT LED (red) blinks. A warning indicates that something in the system needs to be checked or adjusted. Failure by the operator to respond to a warning may result in poor system performance. Warnings should be taken seriously.

When a warning is displayed, the **MSG** and **CLR** buttons will appear on the menu line (when not in setup mode). Pressing **MSG** will scroll through the warning messages if there is more than one. **CLR** will clear the currently displayed warning message, and if there are no more warning messages remaining, the **MSG** and **CLR** buttons will disappear and the FAULT LED will be turned OFF. If after pressing **CLR**, warning messages still exist, the FAULT LED will continue to blink and the **MSG** and **CLR** buttons will remain on the menu line.

If after clearing a message, the warning condition for that message still exists, the message will reappear after a period of time which depends on how frequently the condition is checked by the CPU (usually every few seconds). If a warning message reappears every time after **CLR** is pressed, the problem should be solved and the Analyzer restarted. Some problems may be temporary and may not reappear after **CLR** is pressed (e.g. temperature too high, too low, etc.).

To ignore the warning messages and display the test measurement again, simply press **TEST**. The warning messages will remain active and may be viewed again by pressing **MSG**.

Table 9-1: Front Panel Warning Messages

Message	Description
SYSTEM RESET	System was powered on or reset. This warning occurs every time the instrument is powered up, as in a power failure. It can also occur if the RAM or EEPROM is reset.
RAM INITIALIZED	RAM was erased and re-initialized. The RAM contains temporary data used by the M700. No setup variables are stored in the RAM.
CAL GAS PRESSURE WARNING	Calibration gas pressure above 30 psig or below 25 psig. If the gas pressure is above 33 psig or below 15 psig, the CPU will shut-off the valve system for the safety.
DILUENT PRESSURE WARNING	Diluent air pressure above 30 psig or below 25 psig. If the air pressure is above 33 psig or below 15 psig, the CPU will shut-off the valve system for the safety.
REGULATOR PRESSURE WARNING	Regulator pressure is below 15 PSIG or above 25 PSIG.
CAL GAS/DILUENT FLOW WARNING	Calibration gas or diluent air flow rate through each corresponding mass flow controller is less than 10% of full scale.
V/F CARD NOT INSTALLED	V/F card was not detected on power up. This probably means 1. Board not seated in socket 2. Defective board.
PHOTOMETER LAMP TEMPERATURE WARNING(option)	Photometer lamp temperature is below 51°C or above 61°C.
O3 GENERATOR LAMP TEMPERATURE WARNING(option)	O_3 generator temperature is below 43°C or above 53°C.
PHOTO REFERENCE WARNING(option)	Photometer reference reading is below 2500 mV or above 5000 mV.
O3 GENERATOR REFERENCE WARNING(option)	O_3 generator reference reading is below 50 mV. This warning is set only during reference feedback mode.
PERM TUBE TEMPERATURE WARNING(option)	The perm tube temperature is below 49°C or above 51°C.

9.1.3 Fault Diagnosis Using DIAGNOSTIC Mode

The diagnostic tests are used to help diagnose a problem and should only be used by skilled maintenance people since they can potentially interfere with the performance of the calibrator. Table 9-2 lists the diagnostic tests which are available. To get into the diagnostic test mode, press **SETUP-MORE-DIAG**. By default, software shows the setup password (818). If user simply press ENTR, then only first five diagnostic tests are shown.

Table 9-2: Summary of Diagnostic Modes

Message	Description
SIGNAL I/O	Gives access to the digital and analog inputs and outputs on the V/F board. The status or value of all of the signals can be seen. Some of the signals can be controlled from the keyboard. NOTE - some signals can be toggled into states that indicate warnings or other faults. These settings will remain in effect until DIAG mode is exited, then the M700 will resume control over the signals.
ANALOG OUTPUT	Causes a test signal to be written to the analog output DAC's. The signal consists of a scrolling 0%, 20%, 40%, 60%, 80%, 100% of the analog output value. The scrolling may be stopped by pressing the key underneath the % display to hold that value.
DAC CALIBRATION	The analog output is created by 4 digital-to-analog converters. Two (DAC 0 and DAC 1) are dedicated for Mass Flow Controllers. DAC 2 is for the O_3 generator control output, and DAC 3 is for the test channel output. This selection starts a procedure to calibrate these outputs. Refer to Section 9.1.4 for a detailed procedure.
TEST CHANNEL OUTPUT	Recorder output on the rear panel is used for the test channel output. See Section 9.1.4. See Figure 2-1.
AUTO LEAK CHECK	This diagnostic feature is part of an option with supporting hardware. It performs the automatic leak check (refer Section 8.2).
RS-232 OUTPUT	Causes a 1 second burst of data to be transmitted from the RS-232 port. Used to diagnose RS-232 port problems. See Section 9.2.4 for RS-232 port diagnostic techniques.

9.1.4 Test Channel Analog Output

Many of the TEST functions have an analog voltage associated with them. As a diagnostic aid, it is possible to route any one of the various test voltages out the 4th analog output port (DAC 3). To route an analog test measurement to test channel output, press SETUP-MORE-DIAG and select "TEST CHANNEL OUTPUT". Press PREV or NEXT buttons to scroll to the desired measurement and press ENTR.

Table 9-3: Test Channel Output

#	Name	Description	Scaled Range
0	NONE		
1	O3 PHOTO MEAS	Photometer detector measure reading	0 – 5000 mV
2	O3 PHOTO REF	Photometer detector reference reading	0 – 5000 mV
3	O3 GEN REF	O_3 generator reference detector reading	0 – 5000 mV
4	SAMPLE PRESSURE	Photometer sample pressure	0 - 40" Hg
5	SAMPLE FLOW	Photometer sample flow rate	0 - 1 l/m
6	SAMPLE TEMP	Photometer sample temperature	0 - 75°C
7	PHOTO LAMP TEMP	Photometer lamp temperature	0 - 75°C
8	O3 LAMP TEMP	O_3 generating lamp temperature	0 - 75°C
9	CHASSIS TEMP	Chassis temperature	0 - 75°C
10	DCPS VOLTAGE	DC power supply	0 – 5000 mV
11	O3 PHOTO CONC	O_3 photometer concentration	0 - 500 ppb

When a measurement other than NONE is selected, an additional test measurement appears on the display, which has the format" TEST=XXXXX.X MV' and shows the mV value currently being output to the test analog output port.

There is a setup variable accessible through the RS-232 which controls which test measurement is selected. This variable is called TEST_CHN_ID where ID is from 0 - 10 as shown in the table above.

9.1.5 Factory Calibration

This factory calibration procedure is at the factory when the instrument is first set-up.

NOTE

The operations outlined in this chapter are to be performed by qualified maintenance personnel only.

9.1.5.1 ADC/DAC Calibration Procedure

Due to the stability of modern electronics this procedure should not have to be performed more than once a year or whenever a major sub-assembly is exchanged or whenever analog output voltage range is changed. It is very important that the following procedure is done carefully since the accuracy of the dilution system is absolutely dependent on the accuracy of the MFC and its control voltages.

Notice that the factory set control voltage range is ± 5 volt since the MFC control input voltage is 0 to 5 volt to cover full scale flow range. After this procedure is completed, a MFC Calibration Procedure should be performed per Section 9.1.5.2.

To calibrate the DAC's on the V/F board, do the following:

1. Press SETUP-MORE-DIAG-ENTR, then scroll down to the D/A CALIBRATION diagnostic mode, then press ENTR to start the calibration procedure.
2. Press ADC to start the calibration. The M100A display will read "ADJUST ZERO A/D= XX.X mV", where XX.X mV is the target voltage which should be coming out the DAC # 3. Put the probe of a voltmeter (recommend to use 4 1/2 digits meter) on the recorder output terminals + and - on the M700 rear panel. The value displayed on the front panel and the voltmeter reading should be the same (± 0.5 mV). If they are not, adjust the zero pot (R27; refer Figure 9.1) on the V/F board until the two values are the same (± 0.5 mV). Note that the voltmeter reading does not change while adjusting the zero pot (R27). When the voltmeter shows the same value as the value displayed on the front panel, press ENTR. DAC #3 is the recorder (test) output.
3. The M700 display will now show a new voltage in the same format as above. This voltage will be about 90% of the full scale DAC output range. Now the value displayed on the front panel and the voltmeter reading should be same (± 3 mV). If they are not, adjust the gain pot (R31) on the V/F board until the two values are the same (± 3 mV). Press ENTR. The DAC #3 is now calibrated and will be used as a voltage reference for calibrating the ADC.
4. Next, the analyzer goes through a procedure which calibrates the other 3 DAC's. When completed press EXIT to return to upper level menus.

Next setup is recommended to verify the quality of the ADC/DAC calibration.

5. Pressing SETUP-MORE-DIAG-ENTR-NEXT, and select ANALOG OUTPUT. Verify the quality of ADC/DAC calibration by measuring the test channel output voltage. The signal consists of a scrolling 0%, 20%, 40%, 60%, 80%, 100% of the analog output value. The scrolling may be stopped by pressing the key underneath the % display to hold that value and will display within the square bracket([%]). Press key once again to continue scrolling or press EXIT to terminate. The exact voltage values depend on the DIP switch settings on the analog output buffer amplifiers.

9.1.5.2 MFC Calibration Procedure

The MFC (Mass Flow Controller) is using advanced electronic technology to control precise flow rates. It is recommended to check the MFC calibration every 6 months or when ADC/DAC FACTORY CALIBRATION (Section 9.1.5) is performed or major subassembly is replaced.

NOTE

Following calibration procedure can potentially interfere the performance of the M700 calibrator and must be performed only be skilled maintenance people.

Before proceeding the calibration, it is important to verify that the actual flow rate and the control voltage applied to MFC are accurate.

1. Verify the accuracy of each MFC control voltage by measuring the voltage across TP10 and TP3 on the V/F card for the MFC2 (air) or TP9 and TP3 for the MFC1 (gas) while performing the analog test procedure described in Section 9.1.5.1, step 5. It is recommended to use a Digital Voltmeter with more than 4 digits display. If the control voltage differs more than 25 mV respect to the expected voltage, then should perform the ADC/DAC calibration procedure per Section 9.1.5.1.

2. Once the accuracy of the control voltage is achieved, then verify actual flow rate through each MFC. Use a Master Standard Flowmeter with better than 1% of accuracy in order to determine the actual flow accurately through a MFC. For safety, use zero air to check the flowrate and always properly vent the gas to a suitable vent outside of the room.

Pressing SETUP-MORE-DIAG, and entering password 818 (default), will allow to scroll MFC CALIBRATION. Press ENTR. Then select MFC1 (10 SLPM by default) for the diluent air MFC or MFC2 (0.1 SLPM by default) for the gas MFC, press ENTR. The display will show very first line of the built-in 20 lines calibration table. Each line can be used to test the control voltage and the flow rate through the MFC or can be used to edit the calibration table according to the test result. DRV means the drive voltage to the MFC and FLOW means the expected flow rate through the MFC. Pressing OFF-ON will turn off or on the MFC by applying the drive voltage to allow gas flow through MFC. While applying the drive voltage, measure the actual flow. Take 10 readings consecutively and get the average value. If the actual flow rate differs more than 2 % of the expected flow rate, then press FLOW button and edit the value by entering the average value. Continue this step to test the drive voltage and actual flow rate for the remaining lines of the calibration table. Edit them accordingly if needed.

If any change has been made to the table, then pressing EXIT will cause to prompt as following messages:

	SAVE CHANGES?	
YES	**NO**	**CANC**

Pressing YES will save the changes made; NO will exit without saving the changes; and CANC will not exit, and resume editing the table. If no changes have been made to the table, then pressing EXIT exits the menu immediately.

There is a button called PRNT which will print the linearization table on the RS-232 interface.

9.1.5.3 Ozone Generator Calibration

The ozone generator can be calibrated against the external ozone analyzer to determine the ozone generator's output. Calibration of the generator allows the operator to enter the desired calibration concentration directly in ppb.

NOTE

Following calibration procedure can potentially interfere the performance of the M700 calibrator and must be performed only by skilled maintenance people.

The external ozone analyzer should be calibrated from an external ozone source before doing this procedure.

Press SETUP-MORE-DIAG, enter the password 818 and scroll to select O3 GEN CALIBRATION to start the calibration process. The M700 will apply lamp drive voltages of: 0.5 V, 0.6 V, 0.7 V, 0.8 V, 0.9 V, 1.0 V, 1.25 V, 1.5 V, 2.0 V, 3.0 V, 4.0 V, and 5.0 V.

1. For each test point, the machine outputs the lamp drive setting and waits 5 minutes for the readings to stabilize. Then it takes current reference detector value, the flow rate, and the O_3 concentration. If the photometer option is installed, the M700 will get the concentration from it; otherwise, the M700 will beep at three second intervals until the user enters the O_3 concentration reading from the external O_3 analyzer.

2. During calibration, the analyzer displays % completion so that you monitor the progress of the calibration. Full calibration will take 60 minutes(12 points x 5 minutes/point).

3. You can abort calibration by pressing **EXIT**. This will not restore the table contents already computed, however. If you **EXIT** within the first 10 minutes of the calibration, the table will not be modified.

Following a complete O_3 generator calibration, this calibration table will be stored in the EEPROM. If the RAM is erased or a new PROM is installed, this concentration table will be loaded from the EEPROM into RAM.

9.2 Troubleshooting

9.2.1 Voltage/Frequency (V/F) Board

The V/F Board consists of 16 analog input channels, each software addressable, 8 digital inputs, and 24 digital outputs, each line independently addressable, and 4 independent analog output channels. The analog input channels are connected to V/F converter capable of 80,000 counts, which is approximately 16 bit resolution. Commands from the SBC40 computer and digitized values from the V/F section of the board are sent via the STD bus interface. The schematic for the board is in the Appendix 00514.

The overall operation of this board is quite complex. To fully check out in all of its operational modes is not recommended in the field. Therefore, a few of simple tests are described here that test one analog input channel, the 4 analog output channels, one digital input, and one digital output.

1. V/F board analog input test.

Each analog channel is routed through a programmable 16 channel multiplexer. Chances are that if one channel works, they all work.

1. Turn on the power.
2. Press TEST key on front panel keyboard until DCPS test is displayed.
3. The value displayed should read 2500 ± 200 mV

If the M700 passes this test, it has successfully digitized a 2500 mV composite voltage output from the Power Supply Module. The signal should also be quiet ± 25 mV.

1. Analog output channel test.

In the DIAGNOSTIC menu on the front panel, there is a test that outputs a step voltage to the 4 DAC channels. The test can be useful in diagnosing faults in the V/F board.

1. Turn on the instrument.
2. Enter the SETUP-MORE-DIAG menu.
3. Scroll to select the ANALOG OUTPUT test. This causes the M700 to output a 5 step voltage pattern to the 4 DAC channels. DAC channel 3 is routed through the REC connector of the rear panel . The status of the test is shown on the front panel display. The scrolling can be stopped at any voltage by pressing the key below the changing percentage display. The values are 0-20-40-60-80-100% of whatever voltage range has been selected. For example the voltages would be 0, 1, 2, 3, 4, 5 V.

4. Use a DVM on the recorder output channel to confirm the correct voltage.

If the voltages step, but are the wrong values, the V/F board may be out of calibration. See Section 9.1.5 for information on how to calibrate the V/F board.

NOTE

Although several different output voltage ranges can be selected by the DIP switch setting on the V/F board, mass flow controller input voltage is required for 0 to 5 volt. Therefore it is recommended to set this output voltage range to ± 5 volt range for full range flow control. See Figure 9-1 for the DIP switch settings.

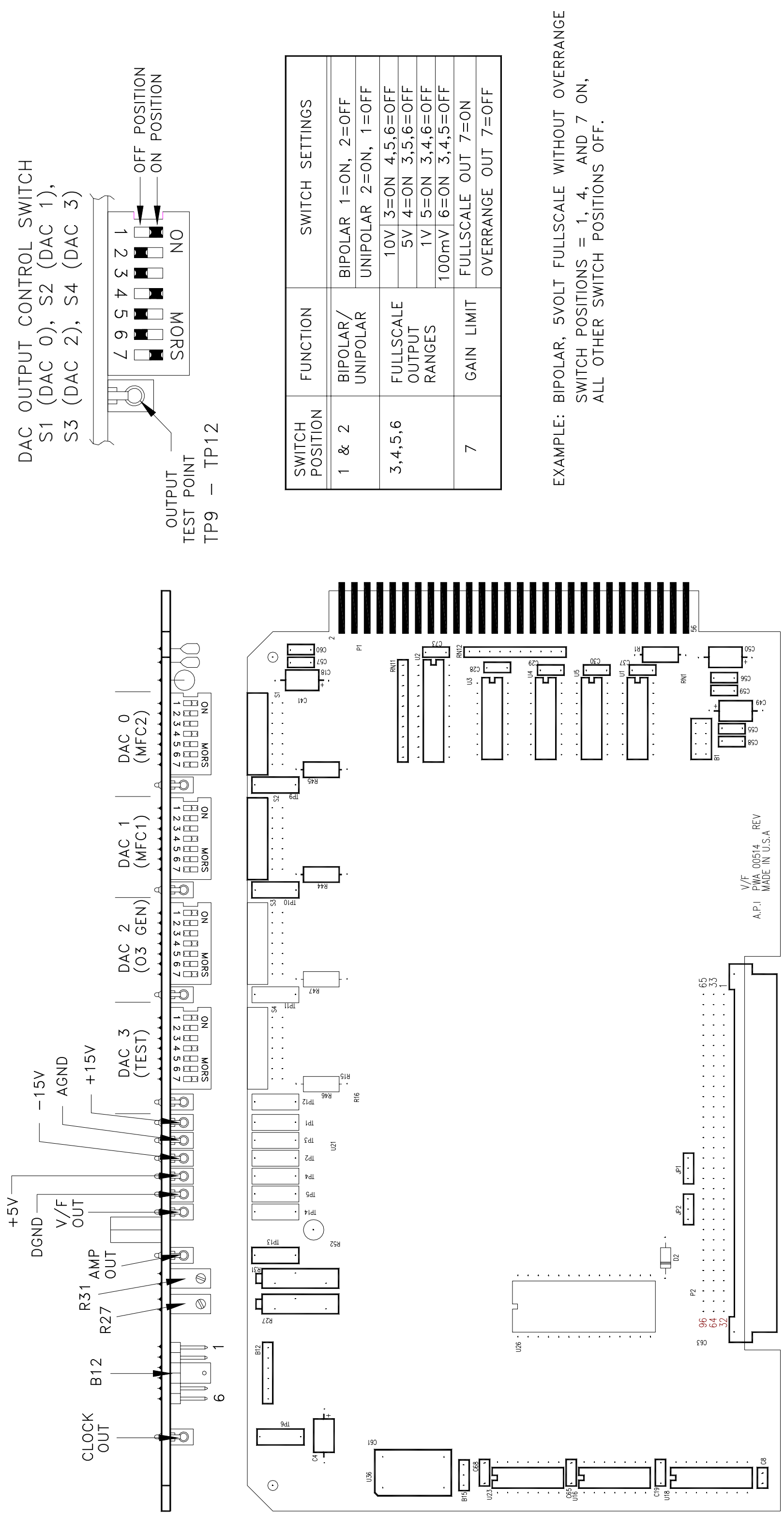


Figure 9-1: V/F Board Jumper

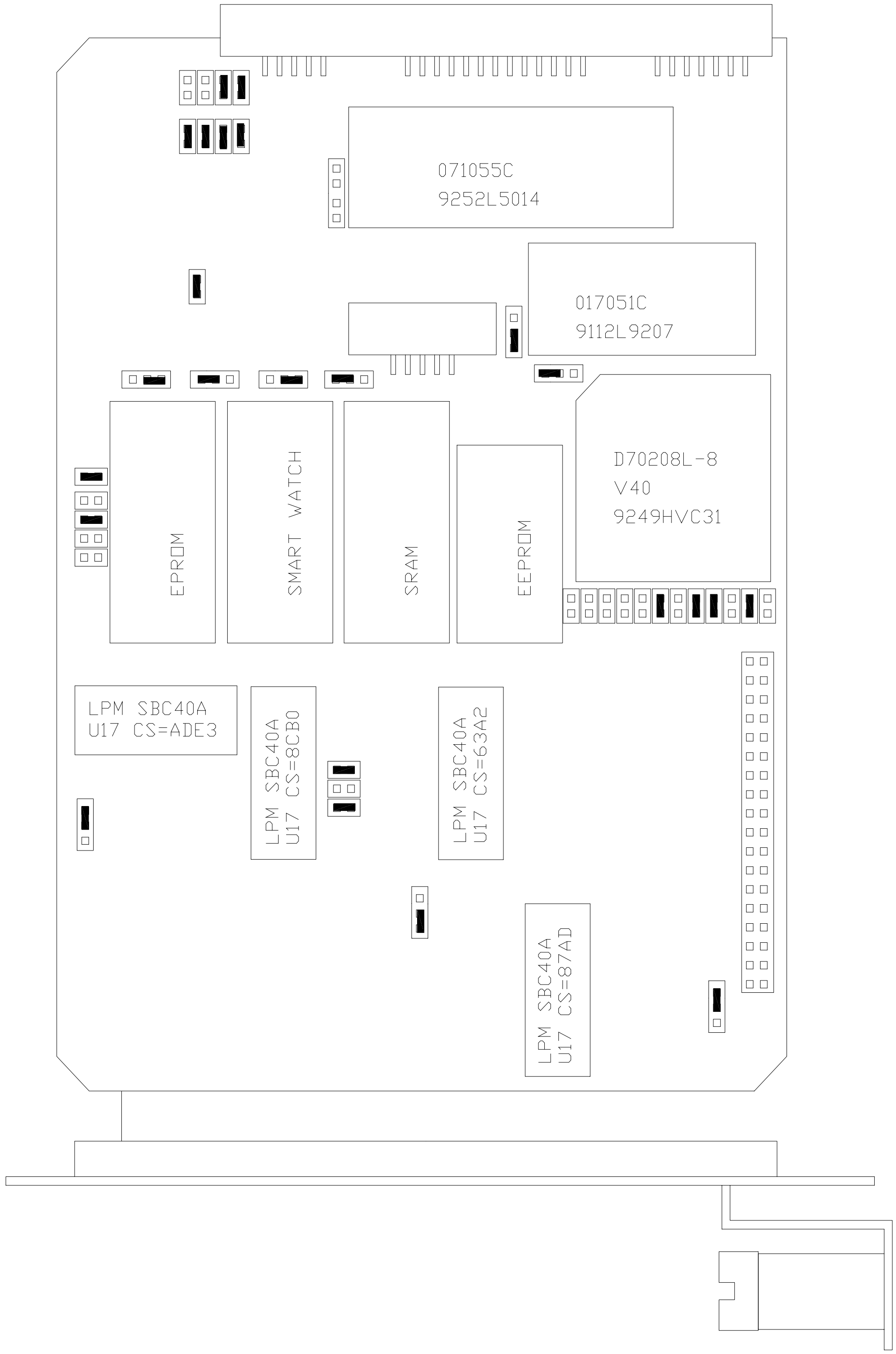


Figure 9-2: CPU Board Jumper

9.2.2 Power Supply Module

Table 9-4: Power Supply Module Subassemblies

Module	Description
Linear Power Supply Board	The linear power supply board takes multiple voltage inputs from the power transformer and produces +5, +15, -15, +12 VDC outputs. The outputs are routed to two external connectors, P2 and P3. See Figure 9-4. The +5 is used for operating the CPU. The ± 15 is used in several locations for running op-amps and IC's. The +12 is used for operating fans and valves.
Switching Power Supply	The switching power supply supplies +24 VDC at 4 A to the UV lamp power supply module. There is a load resistor on the Switch Board to keep the output stable when little current is required from the supply.
Switch Board	Switch Board has many different functions. It takes logic signals from the V/F board and uses them to switch 4-115 VAC and 4-12 VDC loads. The board also contains the instrument central grounding tie point. It routes unswitched AC and DC power as needed. Connector J2 programs the power transformers to take 115, 220, or 240 VAC inputs
Power Transformers	There are potentially 2 input power transformers in the instrument. The multitap transformer T1 is in every M700 and supplies input power for the Linear Power Supply board described above. A second transformer T2 is added if 220 or 240 VAC input is required. Input power selection is done via a programming connector P2 which provides the proper connections for either foreign or domestic power.
Circuit Breaker/Power switch	The front panel contains a combination circuit breaker - input power switch which is connected to the PSM. If an overload is detected the switch goes to the OFF position. Switching the power back on resets the breaker also.

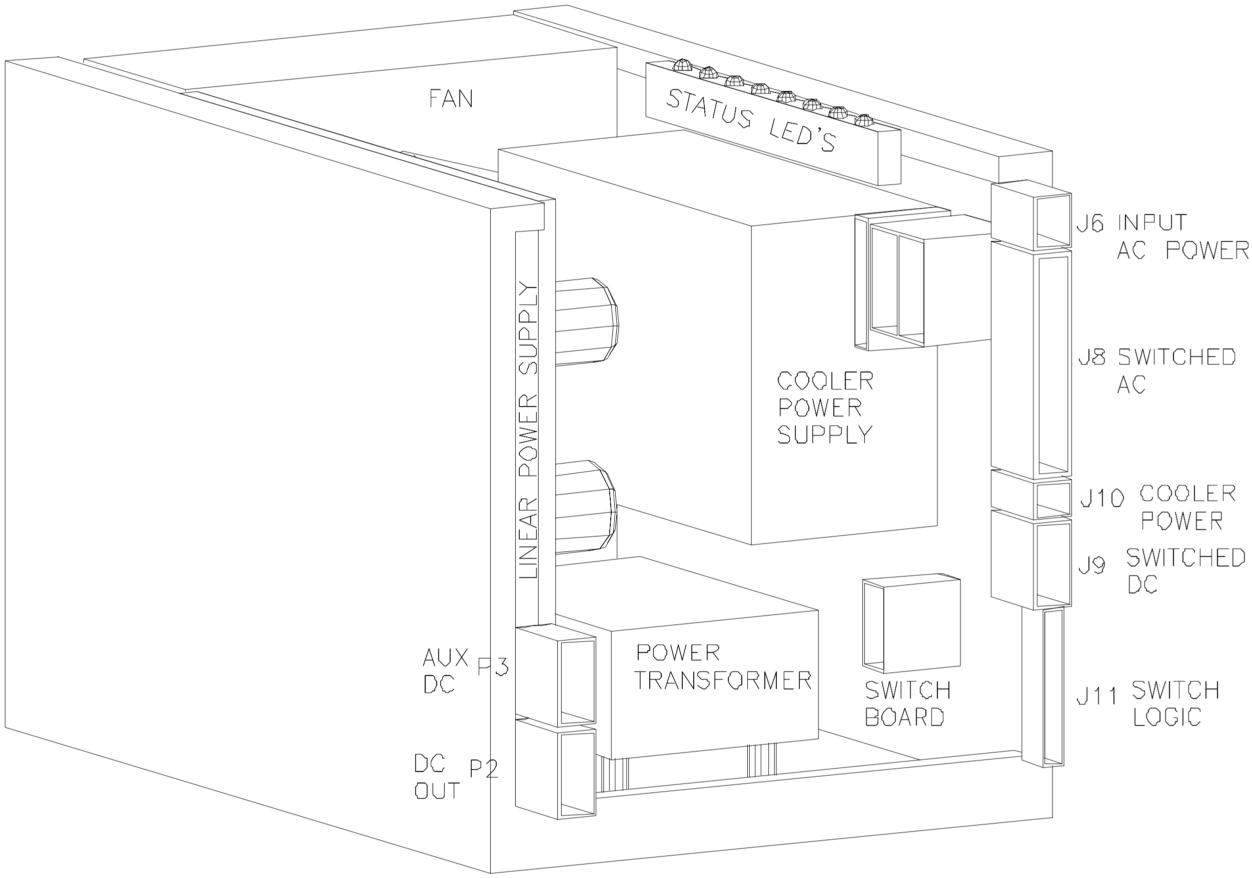


Figure 9-3: Power Supply Module

PSM Diagnostic Procedures

The Linear Power Supply board can be tested by checking the DCPS - TEST function on the front panel. It should read 2500 mV ± 200 mV. If the value is outside this range, individual output voltages can be tested on connector P3, see Schematic in the Appendix for pinouts.

The Switch Board can be tested by observing the diagnostic LED's along the top edge of the board. The following Table 9-4 describes the typical operation of each LED. No. 1 LED starts from the rear of M700.

Table 9-5: Power Supply Module LED Operations

No.	Function	Description
1	Photometer Valve	photometer's I/I_o switching valve.
2	Output Valve	3-way output valve. Normally closed.
3	Spare	
4	GPT valve	3-way valve. Energized when GPT is selected.
5	Pump on/off	Turns the photometer sample pump on/off
6	Photometer lamp heater	Photometer lamp heater
7	Permeation oven heater	Permeation oven heater.
8	O_3 generator heater	O_3 generator heater.

9.2.3 Flow/Pressure Sensor

There are two flow/pressure sensor boards installed in the M700. Each flow/pressure sensor board consists of up to 2 pressure sensors and one flow sensor. See Figure 9-4 for a diagram of this board. From these sensors pressure and flow rate values are measured and displayed on the front panel TEST functions. Refer Table 5-4. They are:

First sensor board located at front center of the chassis;

1. Photometer sample gas pressure (absolute) - measured directly S1, adjust R1
2. Regulator air pressure (gauge) - measured directly S2, adjust R2
3. Photometer sample Flow - measured directly S3, adjust R3

To adjust the sample flow, proceed as followings;

1. Remove the 1/4" fitting from the bench.
2. Scroll to select PHOTO FLOW of the TEST functions.
3. Using independent flow meter verify the flow rate into the bench.
4. Adjust R3 of the flow/pressure board to match the front panel display to the flow rate of independent flow meter.
5. If not able to adjust then replace the flow sensor.

To adjust the photometer sample pressure, proceed as followings;

1. Remove the 1/4" fitting from the bench.
2. Scroll to select PHOTO SAMPLE= xx.x IN-HG-A of the TEST functions.
3. Adjust R1 of the flow/pressure board to read current ambient barometric pressure(typical value at sea level is 29.9 Hg-In).
4. If not able to adjust then replace the pressure sensor.

To adjust the regulator pressure, proceed as followings;

1. Scroll to select REGULATOR PRES of the TEST functions.
2. Adjust R2 of the flow/pressure board to match the front panel display to the pressure(gauge) of independent pressure gauge.
3. Adjust the regulator to read 20 PSIG of the TEST function.

Second sensor board located at the rear center.

1. Gas(source) pressure(gauge) - measured directly S1, adjust R1

2. Diluent air pressure(gauge) - measured directly S2, adjust R2

To adjust the gas(source) pressure, proceed as followings;

1. Scroll to select CAL PRESSURE of the TEST functions.
2. Adjust R1 of the flow/pressure board to match the front panel display to the pressure(gauge) of independent pressure gauge.
3. If not able to adjust then replace the pressure sensor.

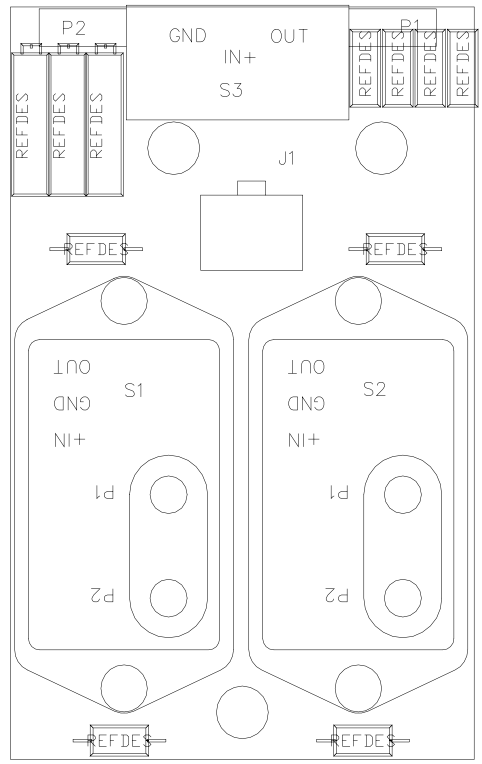
To adjust the diluent air pressure, proceed as followings;

1. Scroll to select DIL PRESSURE of the TEST functions.
2. Adjust R2 of the flow/pressure board to match the front panel display to the pressure(gauge) of independent pressure gauge.
3. Adjust the regulator to read 20 PSIG of the TEST functions.

The above pressure and flow readings are filtered to produce the front panel readings. Several minutes may be required for a steady reading if observing the TEST functions.

FLOW AND PRESSURE READOUT ADJUSTMENT INSTRUCTIONS:

1. SELECT THE DESIRED TEST FUNCTION ON THE FRONT PANEL.
2. ADJUST THE APPROPRIATE POT PER THE TABLE BELOW UNTIL THE CORRECT READING IS OBSERVED ON THE FRONT PANEL.

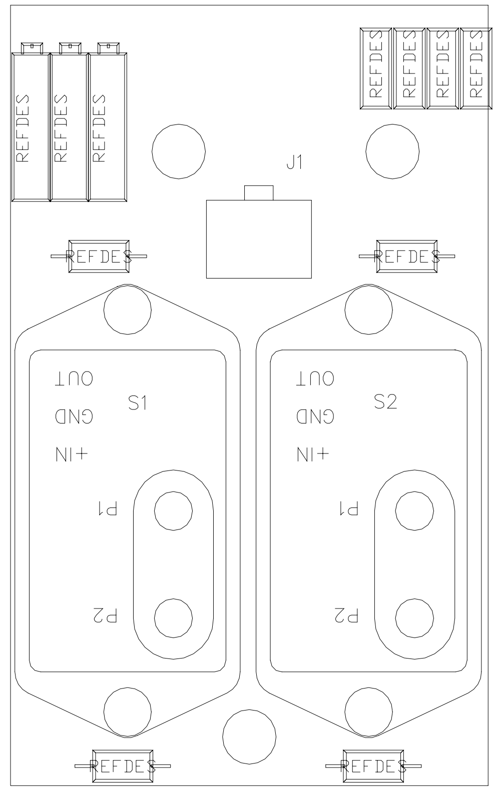


SENSOR, TESTPOINT, ADJUSTMENT	M700 FUNCTION	VOLTAGE NOM.
S1, TP1, R1	PHOTO PRESSURE	8V
S2, TP2, R2	REGULATOR PRESSURE	8V
S3, TP3, R3	PHOTO FLOW	10V

Figure 9-4: Flow/Pressure Sensor Board 1

PRESSURE READOUT
ADJUSTMENT INSTRUCTIONS:

1. SELECT THE DESIRED TEST FUNCTION ON THE FRONT PANEL.
2. ADJUST THE APPROPRIATE POT PER THE TABLE BELOW UNTIL THE CORRECT READING IS OBSERVED ON THE FRONT PANEL.



SENSOR, TESTPOINT, ADJUSTMENT	M700 FUNCTION	VOLTAGE NOM.
S1, TP1, R1	GAS PRESSURE	8V
S2, TP2, R2	DILUENT AIR PRESSURE	8V

Figure 9-5: Pressure Sensor Board 2

9.2.4 RS-232 Diagnostic Procedures

There are several features of the M700 to make connecting to RS-232 and diagnosing RS-232 faults easier.

There are two LED's on the rear panel Connector Board which are connected to pin 2 and 3 of the DB-9 connector on the board. If the jumper block is in the DCE position (default) the red LED is connected to pin 3 of the DB-9 connector. When data is transmitted by the M700 the red LED will flicker, indicating data present on this line. When the M700 is running, the LED will normally be ON, indicating logic low. A one second burst of data can be transmitted over the port by a command in the DIAGNOSTIC menu. Press SETUP-MORE-DIAG, scroll to select RS232 and press ENTR to transmit a burst of lower case "w"'s.

The green LED is connected to pin 2, if the jumper block is in the default DCE position, this is the pin on which the M700 receives data. It is ON if jumpers are set properly and outside device is connected properly. This LED gets its power from the outside device. When data is being transmitted by the outside device to the M700 this LED will flicker.

When you are attempting to configure the RS-232 port, if either of the LED's go out when the cable is connected, that generally means that there is a grounding problem. Check the relative ground levels of pin 5 on the DB-9.

9.2.5 UV Lamp Power Supply Adjustment

Perform following procedure only if photometer is installed. Ozone generating lamp power supply does not need any adjustment. Adjust the drive power of the photometer lamp power supply as follows:

1. Remove the cover of the lamp power supply. Attach a DVM across the test point PT10 and TP7, and adjust the pot (RV1) until the DVM reads 20 volts ± 1 volt.
2. Adjust the positioning of the photometer source lamp, as follows:
   a) At the front panel of the instrument, Press the **TEST** key until PHOTO REFERENCE=XXXX.XmV is displayed.
   b) Loosen the lamp retaining thumb-screw and rotate the lamp until the PHOTO REF reading on display is 4500 mV ± 320 mV. Re-tighten the thumb-screw. (Note that the full range of lamp adjustment can be achieved within ¼ revolution of the lamp. Note also that the PHOTO REF display is updated approximately once every six seconds, and slow rotation of the lamp is needed for proper adjustment.)

3. Adjust the UV Detector Pre-Amp gain as follows:

   a) Remove the access cap on the Detector cover at the front end of the optical bench, and adjust the pot (R7) until the PHOTO REF reading on the display is 4500 mV ± 50 mV.

   b) If it is still not possible to achieve a 4500 mV PHOTO REF reading, increase the UV lamp drive power by adjusting the lamp power supply as described in Step 1.

4. DO NOT, however, allow the voltage measured across the test points to exceed 22 volts.

5. Re-calibrate the automatic Detector Dark Current compensation by pressing **SETUP-GAS-O3-PHOT-DARK** at the front panel. See Section 9.2.7 for dark current adjustment procedure.

9.2.6 Ozone Generator Lamp Setup

This procedure only needs to be done if the lamp is replaced or if the lamp is accidentally moved. The procedure adjusts the lamp for optimum operation of the ozone generator and its feedback circuit.

1. Enter the SETUP menu by pressing SETUP-GAS-O3-ADJ. This causes the lamp drive circuit to output a constant 2.5 V.

2. If you are installing a new lamp, allow approximately 30 min for lamp output to stabilize.

3. Select the "O3 GEN REF" Test function on the front panel display. Loosen the O_3 generating lamp and rotate until the reading on the display is 2500 mV ± 500 mV.

CAUTION

UV light present. Do not pull the lamp from the O_3 generator assembly.

4. Re-tighten the hold-down screws securing the ozone lamp to the ozone generator assembly.

5. Remove access cap from the ozone generator preamp cover and adjust the pot to refine the front panel reading to 2500 mV ± 25.

The O_3 generating lamp and feedback circuit are now set up. Proceed to Section 9.1.5.3 to finish calibration of the ozone generator.

9.2.7 Dark Current Signal Adjust Procedure

The photometer's detector dark current changes little as the detector ages. Therefore this procedure should not need to be performed more than once per year or whenever a major sub-assembly is changed (such as a new UV lamp or UV lamp power supply).

To calibrate the dark current signal, press SETUP-GAS-O3-PHOT-DARK.

1. M700 will turn off the photometer lamp. Wait 2 minutes for stable O_3 detector readings.

2. Press CAL.

3. Press EDIT and verify the value is 100 ± 25mV.

This offset will then be stored and subtracted from all future photometer O_3 detector readings.

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10 MODEL700 SPARE PARTS & SPARES KITS

NOTE

Use of replacement parts other than those supplied by Teledyne API may result in non-compliance with European Standard EN61010-1.

Table 10-1: Teledyne API M700 Spare Parts List Basic (Include O_3 and GPT)

Part No.	Description
00276-05	ASSY, CPU
00402-07	ASSY, PRESSURE SENSOR BOARD
00402-08	ASSY, PRESSURE/FLOW BOARD
00514-03	ASSY, V/F CARD
00535-00	ASSY, DETECTOR PREAMP, PHOTOMETER
00535-01	ASSY, DETECTOR PREAMP, O3 GENERATOR
00594-02	O_3 GENERATOR
00704	ASSY, KEYBOARD
01930	CE ASSY, KEYBOARD
00728	DISPLAY
01139-01	ASSY, POWER SUPPLY MODULE
01139-.3	ASSY, POWER SUPPLY MODULE, CE 230V 50Hz
01383	GPT REACTION VOLUME
01454	MASS FLOW CONTROLLER, 100 CCM
01455	MASS FLOW CONTROLLER, 10 LPM
01509	ASSY, UV LAMP POWER SUPPLY
01564	ASSY, VALVE DRIVER BOARD
01236	FAN
FM007	PRESSURE REGULATOR
HE018	HEATER, 50W (IZS)
00612-01	OZONE LAMP

(table continued)

Table 10-1: Teledyne API M700 Spare Parts List Basic (Include O_3 and GPT) (Continued)

Part No.	Description
OP012	UV DETECTOR
PS013	POWER SUPPLY, SWITCHING
SW006	THERMAL SWITCH
SW019	PRESSURE SENSOR, 30 PSIG
VA023	VALVE, 2-WAY, INLET MANIFOLD
VA032	VALVE, 2-WAY, INLET MANIFOLD, ANGAR
VA020	VALVE, 3-WAY, SS

Table 10-2: Teledyne API M700 Spare Parts List Photometer

Part No.	Description
00176-04	FLOW CONTROL
00329	THERMISTOR ASSY
00329-04	THERMISTOR ASSY
00402-09	ASSY, PRESSURE/FLOWBOARD
00508	ABSORPTION TUBE
00526-01	UV LAMP ASSY
00535-00	ASSY, DETECTOR PREAMP, PHOTOMETER
00566-01	OPTICAL BENCH
00611	ASSY, HEATER/THERMISTOR
FM004	FLOW METER, 0-1000 CC
HW094	SHOCKMOUNT, BENCH
HW123	SHOCKMOUNT, PUMP
PU020	PUMP, 115 VAC 60 Hz
PU022	PUMP REBUILD KIT
SW008	PRESSURE TRANSDUCER
VA023	SOLENOID VALVE, 3 WAY TEFLON

Table 10-3: Teledyne API M700 Spare Parts List PermTube

Part No.	Description
HE017	Heater, Reaction Cell, 12 W
OR046	O-Ring, Perm Oven
VA024	Valve, 3-Way, Vent

Table 10-4: Teledyne API MODEL 700 Level 1 Spares Kit

Part No.	Description	
01690	M700 Level 1 Spares Kit	
Includes:		**Qty**
01383	GPT Reaction Volume	1
01236	Fan	1
HE002	Heater, 50w (IZS)	1
OP005	Ozone Lamp	1
VA023	Valve, 2-Way, Inlet Manifold	1

Table 10-5: Teledyne API MODEL 700 Level 1 Photometer Spares Kit

Part No.	Description	
01689	M700 Level 1 Photometer Spares Kit	
Includes:		**Qty**
00329	THERMISTOR ASSY	1
00329-04	THERMISTOR ASSY	1
00508	ABSORPTION TUBE	1
00526-01	UV LAMP ASSY	1
00611	ASSY, HEATER/THERMISTOR	1
PU022	PUMP REBUILD KIT	

Table 10-6: Teledyne API MODEL 700 Expandables Kit

Part No.	Description
	None Required

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APPENDIX A M700 FINAL TEST VALUES

Test Values	Observed Value	Units	Nominal Range	Reference Section
O3 FLOW		LPM	0.100-0150	5.1.3
CAL PRESSURE		PSIG	25 - 30	2.2.1, 4.2.1
DIL PRESSURE		PSIG	25 - 30	2.2.1, 4.2.1
REG PRESSURE		PSIG	20 ± 0.3	
BOX TEMP		°C	8-48	5.1.3
PERM FLOW		LPM	0.100 - 0.150	
PERM TEMP		°C	50 ± 0.3	6.2
PHOTO MEASURE		mV	4000 – 4500	5.1.3, 6.1.1
PHOTO REFERENCE		mV	4300 – 4500	5.1.3, 6.1.1
PHOTO FLOW		LPM	0.800 ± 0.050	5.1.3
PHOTO LAMP		°C	52 ± 1	5.1.3
PHOTO SAMPLE		IN-HG-A	30 ± 2	5.1.3
PHOTO SAMPLE		°C	5 – 40	5.1.3
PHOTO SLOPE		-	1 ± 0.1	5.1.3
PHOTO OFFSET		PPB	0 ± 100	5.1.3
DCPS		mV	2500 ± 200	9.2.2

Factory Installed Options	Option Installed
Power Voltage/Frequency	
Rack Mount, w/ Slides	
Rack Mount, w/ Ears Only	
Photometer	
Leak Check	
Permeation Tube Oven	
O3 Generator	
Gas Mass Flow Controller (100 cc/min or 50 cc/min)	
Air Mass Flow Controller (10 LPM or 20 LPM)	

PROM # ______________________ Serial # ______________________

Date ______________________ Technician ______________________

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APPENDIX B SEQUENCE SETUP

Table B-1: Sequence Setup

SEQUENCE ID # _____________ DATE:_______

CCINPUT______________ CCOUTPUT________________

Step #	Mode[1]	Conc.	Gas Type	Duration
Example	**Generate**	**400 PPB**	**SO_2**	**10 MIN**
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				

[1] MODE TYPE: GENERATE, GPT, GPTPS, DELAY, PURGE, STANDBY, MAN, EXECSEQ, AND BLEND. Note; Table B.1 is intended as a general example.

Table B-2: Source Gas Setup

Port #	Gas Type	Gas Name	Concentration

Table B-3: PermTube Gas Setup

Perm Tube Gas Type	Gas Name	Permeation Rate @ 50°C

Table B-4: Contact Closure I/O Setup

Sequence #	CCINPUT	CCOUTPUT
Example: 1	**010100000**	**100000000**

Table B-5: Auto-Timer Calibration Setup

Timer #	Sequence ID #	Start Day	Start Time	Delta Day	Delta Time
Example	**sequence 11**	**25 APR 95**	**23:00**	**1**	**1:00**
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					

APPENDIX C MAINTENANCE SCHEDULE FOR M700

Table C-1: Maintenance Schedule for M700

Date instrument received:_____________________

Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Maintenance Interval
Inspect Bench Tube													Quarterly clean as needed
Leak Check													Quarterly and after maintenance/repair
Calibrate O_3 Bench													Quarterly
Inspect Tubing for Dirt, etc													Every 6 months
Clean Orifices and Replace Filters and O-rings													Annually
Check O_3, PERM, and Bench Flows													Annually after cleaning orifices
Record O_3, and PERM Flows in Software													Annually after measuring flows
Check MFC Flows													Every 6 months

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APPENDIX D ELECTRICAL SCHEMATICS

Table D-1: Electrical Schematics Index

Drawing No.	Name
00402	Sensor Board Assembly
00403	Sensor Board Schematic
00514	V/F Board Assembly
00515	V/F Board Schematic
00705	Keyboard Assembly
0113917	Power Supply Wring Diagram
01217	Dual UV Lamp Assembly
01218	Dual UV Lamp Schematic
01479	M700 Motherboard Schematic
01562	M700 Valve/Status Assembly
01564	M700 Valve/Status Assembly
01565	M700 Valve/Status PCB Schematic
01930	Keyboard Assembly - CE
01931	Keyboard Schematic - CE
02222	Switch Board Assembly
02223	Switch Board Schematic
02230	DC Power Supply Assembly
02231	DC Power Supply Schematic