MAST/KEYSTONE INC.

727-3A OZONE MONITOR
For Mast 700 Series Test Chambers

PARTS AND CALIBRATION MANUAL

TABLE OF CONTENTS

CONSTRUCTION

I. Body

Front Plate

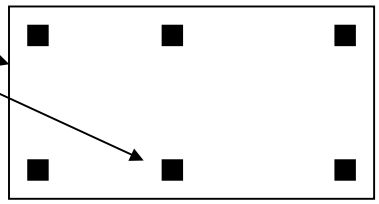
1.....449-968 ..... Front Plate
4.....101-640 ..... Lockwash
4.....104-671 ..... Nut

Back Plate

1.....449-969 ..... Back Plate
4.....101-640 ..... Lockwash
4.....104-671 ..... Nut
.

Chasis

1.....449-970 ..... Chasis
6.....297-900 or 297-240 ..... Sticker legs



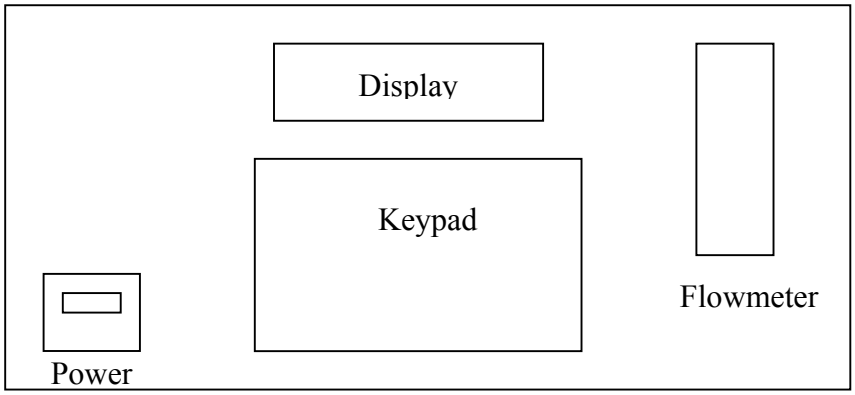
Inferior View

Note: Make sure that the legs don't cover any of the holes.

Cover

1.....449-600 ..... Cover
6.....607003 ..... Adhesive Cable Clamp
8.....102-291 ..... Screw
Note: The cable clamps are to support the front and back plates. They go 0.5 inches from the edge of the cover, three on each side.

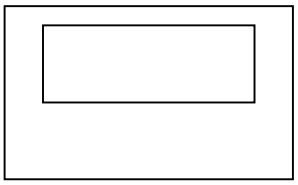
II. Front Plate



Power

1.....297-310..... Switch Assy
1.....297-347..... Button
4∗3/4"...298-079-4..... Heat Shrink

Note: It goes in by applying pressure. Seeing it from the front, it should look like the next figure.



Flowmeter

1.....297-296..... Flowmeter

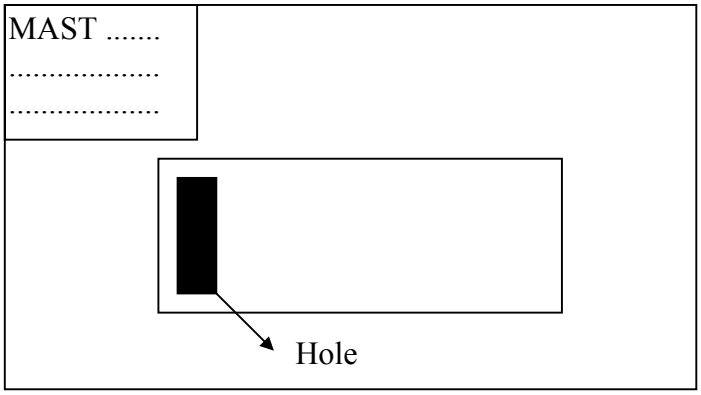
Note: The black supports should be taken off for putting it in. Its easier to rotate them for taking them off.

Note: Range is 0 - 10 SCFH (Standard Cubic Feet per Hour). 1 LPM (Liter per Minute) = 2.11896 SCFH. **It should be above 2 LPM = 4.25 SCFH.**

Keypad

1.....385-652..... Keypad support plate

4.....101-640..... Lockwash
4.....104-671..... Nut

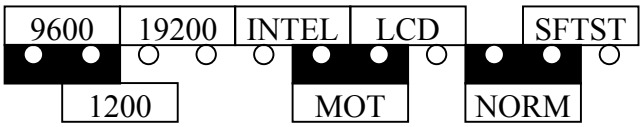


1.....449-900..... Keypad Overlay
Note: It should be cut like 0.5 mm off one of the short sides to fit well.

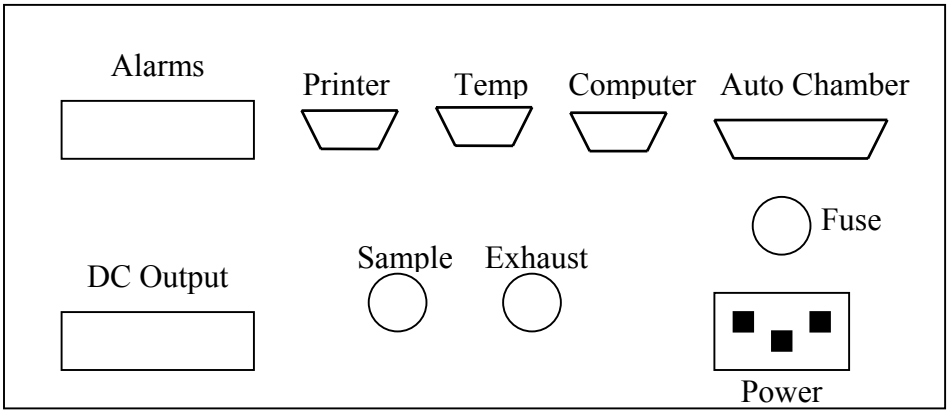
1.....385-621..... Keypad
Note 1: It is a sticker. It sticks to the support plate, and the overlay sticks to it.
Note 2: It hooks to the main PCB by 385-626. The white wire goes in the up most position when hooking it up.

Display

1.....385-620..... Display IEE 03702-020-05220
4.....101-170..... Spacer
4.....104-641..... Nut
Note 1: The DIP switches go in the up side.
Note 2: It goes hooked to the main PCB by 385-634.
Note 3: DIP switch configuration: 9600 bps Motorola Normal (no self test)

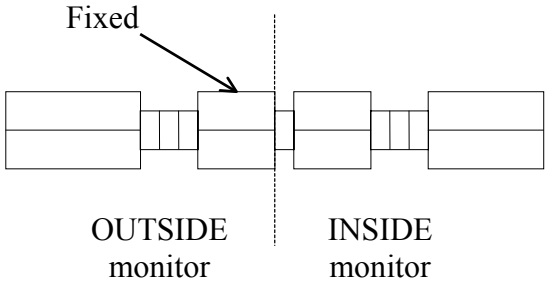


III. Back Plate



Sample Inlet

1.....297-332..... Sample Inlet



Exhaust

1.....298-312..... Exhaust
Note: It goes in the same way as the Sample Inlet.

Temperature Probe

1.....385-627..... Assy Temp cable
2.....385-656..... Jackscrew

Printer and Computer connectors

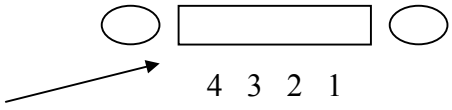
1.....385-624 ..... Printer and Computer Assy
2.....385-656 ..... Jackscrew
Note 1: Printer: 3 cables Computer: 5 cables

Auto Chamber connector

1.....385-625 ..... 25 Pin connector cable Assy
2.....385-656 ..... Jackscrew

Alarms

1.....297-035 ..... Strip Terminal
2.....102-083 ..... Screw
2.....104-664 ..... Nut
2.....101-630 ..... Lockwasher
Note 1: Use screw 102-086 if the strip terminal comes with caps at the ends.
Note 2: Wires coming from JP2 (pins #1,2,3,4) from Main PCB go soldered in the next way:



Strip Terminal View
(from the inside of
the monitor)

1: brown
2: red
3: orange
4: yellow

DC Output

1.....449-987 ..... Assy Strip Terminal
2.....102-083 ..... Screw
2.....104-664 ..... Nut
2.....101-630 ..... Lockwasher
Note 1: Use screw 102-086 if the strip terminal comes with caps at the ends.
Note 2: Pins 1-3 and 2-4 have to be jumped in the Strip Terminal.

Fuse

1.....449-949 ..... Assy Fuse Holder

1.....299-786..... 1 A fuse
1∗1¼"...298-079-7..... Heat Shrink
1∗5/8"...298-079-5..... Heat Shrink

Note 1: Heat Shrink has to be put on the inside part of the fuse holder, to cover all the bare parts.
Note 2: The short wire goes soldered to the Assy Receptacle, to close the power input circuit.

Power

1.....449-948..... Assy Receptacle
2.....102-043..... Screw
2.....104-640..... Nut
2.....101-620..... Lockwasher
1∗½".....298-079-5..... Heat Shrink

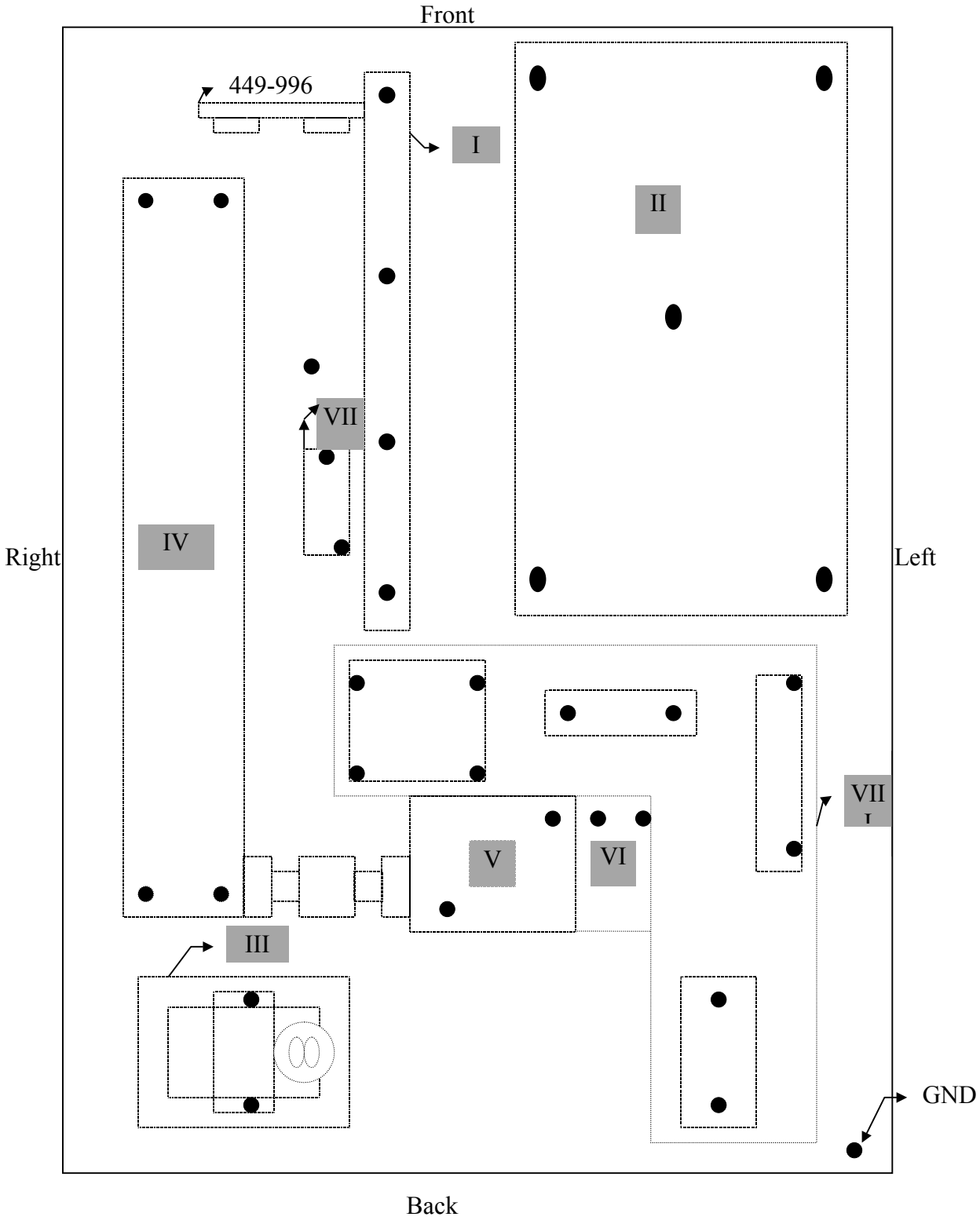
Ground (green cable)
1.....102-082..... Screw
1.....104-665..... Nut
1.....101-630..... Lockwasher

Note: It goes screwed to the chasis, as shown in the chasis figure on next page.

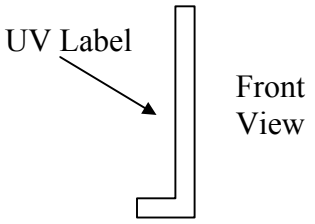
Reset Switch

1.....298-996..... Switch
Note 1: The hole for this switch should be made with a I size bit. Always use smaller bits to start drilling the hole, and then increment the bits size until you get to the I bit.
Note 2: This switch is soldered to the mother board to ground and the left leg of R6.

IV. Chasis



PCB Base (I)



1.....385-653 ..... PCB Support Plate
4.....102-291 ..... Screw
4.....101-640 ..... Lockwasher
1.....737-367 ..... UV Warning Label

Board Supports (II)

5.....607-005 ..... Board Standoff
5.....104-113 ..... Screw
5.....101-630 ..... Lockwasher
Note: The head of the center standoff has to be cut off.

Pump (III)

1.....449-888 ..... Assy pump with clamp
2.....102-083 ..... Screw
2.....104-662 ..... Nut
2.....101-630 ..... Lockwasher

Optical Bench (IV)

1.....451-138 ..... Assy Optical Bench
4.....102-082 ..... Screw
4.....101-630 ..... Lockwasher
Note: The UV light (297-330) goes with the two cables parallel to the absorption tube, so that the filament of the lamp will be in the best position to give more light.

Valve (V)

1.....449-889 ..... Assy Valve
1.....297-335 ..... Fitting
2.....102-082 ..... Screw
2.....101-630 ..... Lockwasher
Note 1: Teflon tape has to be used to put the fitting on.
Note 2: The fittings shouldn't be too tight, because the valve might not function in the right way, causing very noisy readings.
Note 3: The valve by itself is 297-323, and make sure it is NC-C-NO.
Note 4: Add 4 inches to the cable for 727-3A.

Scrubber (VI)

1.....297-315-1..... Scrubber
1.....297-868..... Bracket
2.....102-238..... Screws
1.....102-291..... Screw
1.....101-641..... Lockwasher
Note: The tube lengths are as follows:
727-3 is 2 and 5/8 inches
727-3A is 3 and ¾ inches.

Power Board (VII)

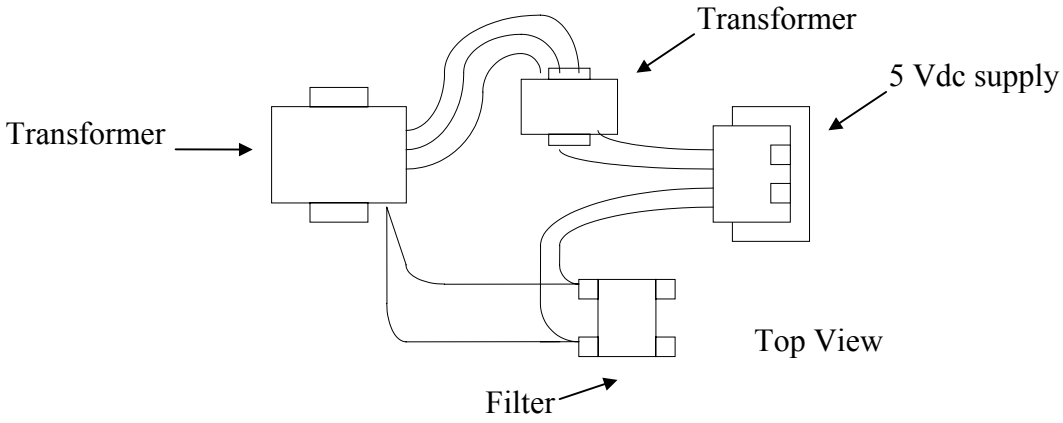
1.....451-001..... Power Supply PCB Assy
4.....101-170..... Supports
8.....102-042..... Screws

40 KΩ resistor
2.....102-042..... Screw
2.....101-620..... Lockwasher
2.....104-642..... Nut
Note: It's easier to put this resistor on before putting the power board on.

Note 1: The electrometer board (449-996) goes plugged into the power board, with the chips facing to the back. The sensor goes into the optical bench.
Note 2: The board goes hooked to the main board through the cable 385-623.

Power Transformers and Filters (VIII)

1.....385-622..... Transformer Assy
10.....102-292..... Screw
10.....101-801..... Lockwasher
10.....104-671..... Nut



Note: The red cable in the 5Vdc power supply goes to the top of the capacitor that is to the right. It is the regulated 5V. The black cable goes to the bottom of the capacitor. It is very important to verify this. The white cable is the 5V unregulated.

Tubing

5 feet.....298-072-3..... Flexible tubing

22.5 inches ..... Top Flowmeter → IN Pump
12.5 inches ..... Bottom Flowmeter → Front Optical Bench
10 inches ..... Sample inlet → Valve
9 inches ..... Exhaust → OUT Pump
8 inches ..... Scrubber

5.....449-955-1..... Tubing

- (2) Inlet → Valve
- (1) Exhast → OUT Pump
- (1) Optical Bench → Valve
- (1) Valve → Scrubber

CALIBRATION

The calibration process should be done in the same order as described in the following pages.

5 Volts Power Supply (727-3A only)

This power supply is part of the 385-622 Transformer Assy. It has to be checked that its output is 5 Vdc. If it is not, the output voltage can be modified with the potentiometer that is in it. This potentiometer is brown, and is located to the right of this unit.

Voltage outputs of the Power Board (727-3A only)

The output voltages of the power board (449-001) should be checked with a DVM. The different voltages should be checked between ground (negative leg of capacitor C**) and the following places:

- Positive leg of C8 ..... +5 Vdc
- Positive leg of C3 ..... +12 Vdc
- Positive leg of C14..... +15 Vdc
- Positive leg of C2 ..... +24 Vdc
- Negative leg of C12 ..... -15 Vdc

A variation of ±5% is admisible in any of the voltages checked

Procedure for checking 727-3A Mother Boards

I. Power Down Circuit

Change potentiometer R1 until voltage of pin 4 of U1 is 1.730 V_{DC} @ 120 V_{AC} (input). This with SPAN and OFFSET set at zero.

II. Counters

Use a frecuency counter in TOTALIZE.

Frequency: count pin 40 (U23) = 2500
..... count pin 40 (U48) = Frequency reading ÷ 10

Operate: count pin 40 (U23) = same ↑ and ↓ (offset = 0)
count pin 40 (U48) = ↑ SW1 , SW2 , SW3 , 0 , SW4 , 0
↓ 115050 (OFFSET = 9)

III. Relays and Alarms (use a Logic Test Probe)

Reley:

	JP2
Lamp	5
Pump	7
Relay 1	9
Relay 2	11

Alarms (pump and light must be on)
.....Alarm 1: test continuity between pins 1-2 (JP2)
.....Alarm 2: test continuity between pins 3-4 (JP2)

IV. Pressure Regulator (JP3)

Pin #1 → PULSES Pin #3 → direction 0 ➔ close 1 ➔ open

V. Analog Output Calibration

1. DVM at bottom of R42 and grond (pin 1 JP8)
2. 0-0-0 → adjust R34
3. 9-9-9 → adjust R33
4. DVM pin 2 JP8
5. 9-9-9 → adjust R41
6. Check.

VI. Temperature Probe Calibration

1. DVM pin 11 of U41. Adjust R30 → OV_{DC}
2. DVM pin 12. Adjust R31 → 1.58869 V_{DC}
3. DVM pin 11. Ajdust R 30 → 0.9211 V_{DC}
4. DVM pin 12. Check 2.2171 V_{DC}

Procedure for checking 727-3A Power Boards

I. Visual Check

Check for correct polarity on capacitors, diode bridges, I.C.'s, connectors...

II. Voltages

Check with a DVM the following voltages to ground(negative pin of C10):

+5 VDC .....(+) C8
+12 VDC.....(+) C3
+15 VDC.....(+) C14
-15 VDC.....(-) C12
+24 VDC.....JP2 (PUMP)

III. Push-Pull Amplifier

R2..... ..... $0.33V_{AC}$ ..... $1.75V_{DC}$
R4 & R7 ..... $1.23V_{AC}$ —— $2.00V_{AC}$ ..... $1.90V_{DC}$ —— $2.04V_{DC}$
Q1 & Q3..... $20.55\ V_{AC}$ ..... $24.27V_{DC}$

Check with a ORC the simetry of the signals in Q1-Q3 and R4-R7 (1 V/DIV & 20µ SEC/DIV).

IV. Check that the valve opens and closes.

The voltage ranges between $30\ V_{DC}$ ~ $0\ V_{DC}$.

V.Power up, in frecuency, and verify that everything works correctly.

Must switch between both cycles.

Low voltage shut-down (727-3A only)

If the input voltage drops below a certain value, the monitor will shut-down to protect all the electronic components. This voltage should be set at around 97 Vac. The way to set it up is as follows:

1. Connect the monitor to the variable voltage generator at 117 Vac.
2. Set the oscilloscope's variable time knob to 5 ms/cm.

3. Observe in the oscilloscope the voltage signal of the leg 5 of U1.
4. Set the potentiometer R1 so that signal is high.
5. Change the setting of the voltage source to 97 Vac.
6. Now change the setting of R1 to the point where the signal observed in the oscilloscope just drops. You will observe a square signal. If the signal observed is low, turn R1 CCW. If it is high, turn it CW.

Analog Output

Note: All voltages are D.C.

727-3 Monitor

1. Remove the analog board.
2. Remove the three IC 74C175, and replace with **Thumbwheel switch plugs**, 1 - 2 - 3 from left to right.
3. Install the analog board with extender board (gnd on extender board should go in the front).
4. Connect **DVM** to bottom end of R18 on analog board and GND (black connected to GND).
5. Turn the monitor on.
6. Set thumbwheels to 0-0-0 and adjust "z" potentiometer so the DVM reading will be zero volts DC.
7. Change Thumbwheels to 9-9-9 and adjust left hand "c" potentiometer so the DVM reading will be 9.99 Volts.
8. Repeat 6-7 if necessary.
9. Shift DVM (+) lead to top of R18.
10. Adjust right hand "c" potentiometer to 0.999 Volts.
11. Shift DVM to red and black wires on analog output.
12. Repeat steps 6-8 until satisfactory results (in step 7, instead of 9.99 V, it should now be adjusted to 0.999 V).

727-3A Monitor

1. Remove U46, U50 and U51.
2. Replace with Thumbwheel Switch, 1 - 2 - 3 from left to right.
3. Connect DVM to bottom of R42 and ground (the ground should be the closest posible to R42, a good place is the top leg of C59).
4. Turn the monitor on.
5. Set the thumbwheel to 0-0-0, and adjust R34 for zero volts DC.
6. Set thumbwheel to 9-9-9, and adjust R33 for 9.99 V DC on DVM.
7. Move DVM to top of R42.

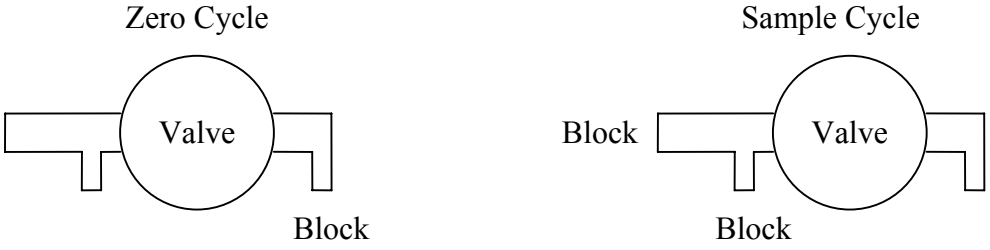
8. Set thumbwheel to 9-9-9, and adjust R41 to 0.999 V dc on DVM.
9. Set thumbwheel to 0-0-0, and re-adjust R34 to zero.

Cleaning the optical system

1. Remove the absorption tube from the optical bench.
2. Look trough it at a light source, and make sure it is clean.
3. If not clean, clean it with a window cleaner detergent.
4. Dry it with a paper tissue, and then with compressed air (the paper tissue can be pulled trough using a small gage wire).
5. Now clean the quartz windows using a Q-Tip. If the absorption tube was real dirty, then it may be necessary to take apart the optical bench, and clean the quartz windows with the same window cleaner liquid used before. Make sure that when replacing the windows, no grease or fingerprints is left on them.

Checking the Valve

1. Remove the scrubber from the system.
2. By using your finger to block the air inputs, make sure the air flow drops to zero in both the zero and the sample cycles, as shown in the next diagram.



3. If the air flow doesn't drop to zero in both cycles, the take the valve apart and clean it. MAKE SURE YOU NOTICE THE WAY ALL THE PARTS GO.
4. To put it back together, use hook a flowmeter to the valve's air output, and electrically connecting the flowmeter, repeat step 2.
5. If it doesn't work, take it apart again and either tighten or untighten the small metal magnet, and repeat steps 4-5 until it works.

Searching for air leaks

With one finger, block the inlet terminal, and make sure that the air flow in the flowmeter drops to zero, both in the sample and normal cycles. If it doesn't drop to zero, then there is a leak. For the proper operation of the monitor, there should be **no leaks**.

If there is an air leak, but you can't find it, and it seems to increase when the distance from the pump to the place where you are blocking the air inlet increases, then the problem might be in the pump. To solve this problem, change the diaphragm of the pump, with a spare diaphragm 297-206.

Setting the Operation Frequency

1. Turn the monitor on, and let it run with the cover on for about an hour, so that it will warm up.
2. Connect the DVM to the leg 1 of IC VFC52BP on electrometer board and GND. The reading of the DVM (Volts DC) is the double of the frequency.
3. Set the voltage between 4.40 V and 4.80 V by moving the UV light up or down.
4. Make sure that the two wires of the UV light run parallel to the optical bench's absorption tube, because it will give a better light output in this way (higher and more constant).
5. Check the frequency in the FREQUENCY mode, so that it is between 220 and 240.
6. If the frequency seems to drop after a while, clean again the optical system, because sometimes there are impurities in the system that cannot be cleaned during the first time that the optical system is cleaned.

Setting the Zero Offset

1. Set the SPAN thumbwheel switches (the first three from top to bottom on the 727-3A or from left to right on the 727-3) to 1-1-5.
2. Set the OFFSET thumbwheel switch (the fourth one) to 0.
3. Connect the charcoal filter to the inlet terminal, and let the monitor run in OPERATE mode for about an hour or until the reading is constant.
4. Set the OFFSET thumbwheel to the reading's value.
5. Repeat until a good zero is obtained in the reading.
6. The OFFSET value should not be more than necessary, even though a good zero is obtained, because the monitor would not function properly.

SPAN Calibration

1. Connect the monitor to the ozone generator and to the chart recorder, and set the generator to about 0.5 ppm. Let the monitor warm up for about an hour.
2. Set the span thumbwheels to match the real ozone concentration. 0.01 ppm is aproximately the same as two positions in the third thumbwheel switch. Let it run for some time to obtain a constant reading.
3. Set the ozone generator to about 1.0 ppm (a little bit less), and set the thumbwheels to match the reading. The variation in the thumbwheels shouldn't be that much.
4. Repeat the procedure at about 0.8 ppm.
5. Set the generator to 0.5, 1.0, 0.8 and 0.5 ppm; and let the monitor run for about an hour in each position, to make sure the readings are accurate and constant.
6. A variation of ±4% is admisible in each reading, but not desirable.

Note: If the span setting is too high, the scrubber is defective. A way to check the scrubber is measuring the frequency with an ozone concentration of about 1 ppm. Then, turn the ozone source off, and measure the frequency again. If the frequency increases, then the scrubber is bad.

Temperature Probe (727-3A only)

1. Hook the temperature probe and turn the monitor on. Let it warm up for about half an hour.
2. Measure Vp with the DVM between the top of D23 and GND (choose the closest ground possible).
3. Solve the following equation:

$$R31 = \frac{802.245 * Vp}{(5 - 0.8650699 * Vp)}$$

4. Connect the DVM to the leg 11 of U41 and GND, and set R30 to zero volts DC on the DVM (or the closest to zero possible).
5. Connect the DVM to the leg 12 of U41, and vary R31 until the reading of the DVM equals $+Vref_0$ (given by the next equation):

$$\mathbf{+Vref_0 = \frac{5 * R31}{(1500 + R31)}}$$

6. Now connect the DVM back to the leg 11, and vary R30 until the reading of the DVM equals **-Vref = 0.33024 * Vp**.
7. Check that the voltage on the leg 12 equals **+Vref = 0.86507 * Vp**.
8. With a real thermometer, get two different temperature values (in °C), and measure Vp for each value. Those will be the two **real** values y1, y2.
9. Now evaluate the two temperatures in the next formula, to obtain the two **formula**

values x1, x2.

$$x = -0.0053483*Vp*Temp[°C] + 0.86507*Vp$$

10. Eval the values $+Vref_0$, +Vref and -Vref obtained before in the next formula:

$$NEW = \frac{(y2 - y1)*Vref}{x2 - x1} + y1 - \frac{(y2 - y1)*x1}{x2 - x1}$$

11. Repeat steps 4 through 7, but setting the new values for $+Vref_0$, +Vref and -Vref obtained from the last formula.

**. If there is no temperature probe, set the next values:
$+Vref_0$ = 1.58869 Vdc
+Vref = 2.2171 Vdc
-Vref = 0.9211 Vdc

The temperature probe can also be set by using the following program, that must be programed in DOS Q-Basic. This program calculates the same values descrived before.

```
10  INPUT VP
20  R31 = 802.245 * VP / (5-0.8650698999999999# * VP)
30  pVrefO = 5 * 3R31 / (1500 + R31)
35  mVref = .33024 * Vp
40  pVref = .86507 * Vp
50  PRINT ("+Vref0"); pVref0
60  PRINT ("-Vref"); mVref
70  PRINT ("+Vref"); pVref
80  PRINT
90  PRINT
100 PRINT
110 PRINT ("ADJUSTMENT")
120 PRINT ("INPUT Temp1, Vin1, Temp2, Vin2")
130 INPUT T1
140 INPUT Y1
150 INPUT T2
160 INPUT Y2
170 X1 = -.0053483 * VP * T1 + .86507 * VP
180 X2 = -.0053483 * VP * T2 + .86507 * VP
190 NpVref = (Y2 - Y1) * pVref / (X2 - X1) + Y1 - (Y2 - Y1) * X1 / (X2 - X1)
200 NmvREF =  (Y2 - Y1) * mVref / (X2 - X1) + Y1 - (Y2 - Y1) * X1 / (X2 - X1)
210 R = 1500 * (NpVref - NmVref) / (5 - NpVref)
220 NpVref0 = 5 * R / (1500 + R)
230 PRINT ("NEW +Vref0"); NpVref0
240 PRINT ("NEW -Vref"); NmVref
250 PRINT ("NEW +Vref"); NpVref
```

Programing the I.C.

The memory used is a 27/C256 type EPROM, part number 610029. Its characteristcs are Vpp = 12.75 V, and ALGO = QUICK.

It is programmed using the AVOCET program, and the procedure is as follows:

FROM DOS:
cd avocet ↵
up.exe ↵

Program
DEFAULT

Load BIN File
Start 0

Target Zone
8000
FFFF
Device Start Adress 0

WIRE CONNECTIONS

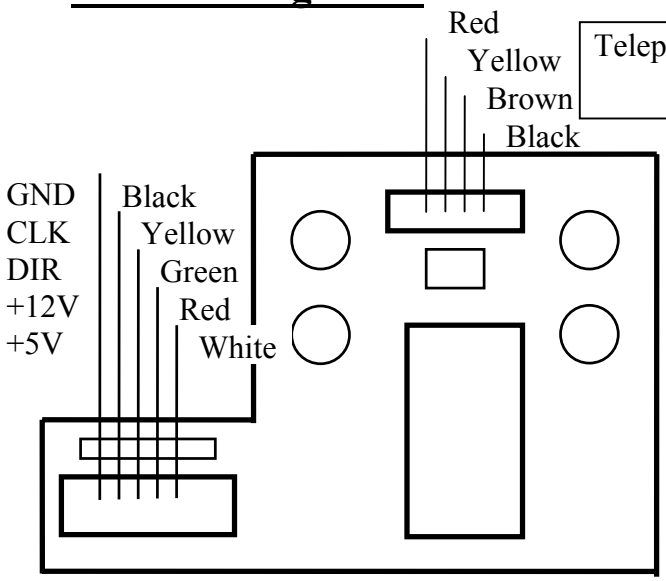
Temperature Probe

The wiring of the temperature probe connector is described in the following table:

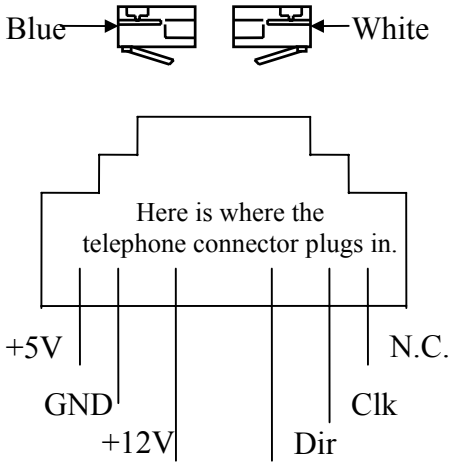
Temperature Probe Connector	9 pin male Connector
+	6
-	5
G	3

The 9 pin male connector is 602096, and it needs a cover.

Pressure Regulator



Telephone connector viewed with the metal pins on top:
blue - yellow - green - red - black - white



9 Pin Conector

Pin	Color	Function
1	red	+12V
3	black	GND
5	white	+5V
6	yellow	Clock
9	green	Dir

(cut blue off)

25 Pin Connector

Pin	Color	Function
12	green	Dir
13	yellow	Clock
22	red	+12V
23	black	GND
24	white	+5V

Jump pins 20-21
(cut blue off)

TROUBLE SHOOTING

Leaks

If there is a leak that can't be found, and it gets bigger the farther away from the pump, the problem might be in the pump itself. Change the inner diaphragm and valves of the pump.

Noisy Readings

Small Magnitude Noise

- Fittings on the valve may be too tight.
- Valve may be defective.
- Input voltage to the valve may be too low. It has to be over 24 Volts dc. CHANGE POWER BOARD.
- Problem with temperature circuit (transistor, termistor, LM723 [regulator], ...) CHANGE OPTICAL BENCH OR POWER BOARD.
- Amplifier on electrometer board may be noisy. CHANGE IT (The amplifier is the I.C. that is on the right side of the board).
- Noise on the traces that go to the analog output. USE JUMPER WIRES.

Large Magnitude Noise

- UV light might be wrong (flickering too much) CHANGE IT
- Electrometer board may be wrong CHANGE IT
- Problem with push-pull amplifier (the one that feeds the UV light) CHANGE POWER BOARD

Too much time to warm up

Heater circuit may be wrong. Probably the heater transistor. CHANGE OPTICAL BENCH OR POWER BOARD

LM723 of heater circuit burns

The heater transistor may be loose, so it doesn't make good contact with the heater block. Put the transistor again with the blue compound and the phenolic washer (101-378).

Over Range Function

This function can be turned on and off by pressing [Relay 2] + [←].