OPERATION PROCEDURES

M903
NEPHELOMETER

ROM Version 2.37.20DE
Pressure and Temperature Compensation
Rh Sensor

Radiance Research

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1. General Information

The M903 (v2.37) portable nephelometer is a light weight, low power instrument designed for portable operation as well as general environmental monitoring. It measures the light scattering extinction coefficient (σ_{sp}) using the geometry of a standard integrating nephelometer. Pressure and temperature sensors automatically correct for changes in air Rayleigh scattering. Rh also is monitored and recorded. The light source is a variable rate flashlamp with a wavelength defining optical filter (530 nm). The optical and electrical background noise is sufficiently low to allow measurement of σ_{sp} (for particles) from less than 10 percent of air rayleigh ($\sigma_{sp} < .001$ km^{-1}) to greater than $\sigma_{sp}=1$ km^{-1}. The electronics are computer based, providing flexible menu driven programming of the instrument operation using panel display/switches or a serial port. Data averages can be stored internally in battery RAM and retrieved at any time using a PC. The instrument has several unique features:

1.1. Operation is simple and flexible: A menu driven panel display allows user setup; zero and span; selection of one of three default operating setups and examination of internal operating parameters for trouble shooting. Each setup can be customized through the serial port for more complex or specialized applications.

1.2. Power consumption low. The instrument operates on 2.5 - 3 watts at 12 VDC (230 ma) input voltage. A 12 volt DC wall converter or batteries can be used to provide power. Power can be reduced (ca. 100 ma) by limiting drive to the chopper motor and panel display back lighting.

1.3. A fixed brightness span chopper automatically corrects for span drift.

1.4. Pressure and temperature are measured in the scattering volume and are used to correct for changes in air Rayleigh background.

1.5 Relay contacts for clean air or span gas control are installed and controlled through real time serial port commands.

1.6. The electronics are computer based, allowing flexibility in averaging times, time constants, flash rate, background and dark current correction, output ranges, etc.

1.7. RS-232 serial port provides real time information on instrument internal operation as well as scattering coefficient. An internal clock and instrument operational parameters are set through the port and stored in battery maintained static RAM. The serial port can be connected directly to a terminal or to a modem for remote communication over a telephone line. Data logger access is pass word protected when connected to a modem.

1.8. The internal data logger has a built in real time clock and battery supported RAM that will store scattering coefficient averages and operating parameters. The current version will store about 2 weeks of 5 minute averages before down loading is necessary. Averaging periods up to 1 hour are user selected. Any computer with a serial port and terminal software can be used to down load stored data as ASCII characters.

1.9. The instrument weighs about 6 lbs, has a small scattering volume with a rapid exchange rate using a small fan and allows for measurements with no heating of the aerosol sample.

2. System Specifications

2.1. Measurement

• Parameter	Light scattering extinction coefficient
• Ranges	0 to >1 km^{-1}
• Lower Detection	< .001 km^{-1} ($1x10^{-6}m^{-1}$) at 30 sec average
• Outputs	4 Analog (0 to 5 VDC) and RS 232 serial, Baud rate selectable, 9600, 4800, 2400, 1200
• Time constant	Adjustable: 2 sec to several minutes

2.2. Measurement Characteristics

• Principle	Integrating nephelometer
• Electronics	Computer based, MD68HC11 @ 8 Mhz Operating parameters, diagnostics through serial port 3 sets of default operating parameters selected with panel switches
• Optics	No lenses. Reference brightness measurement and chopper stabilized span. Chopper rate adjustable (typical, 20% duty cycle)
• Wavelength	530 nm
• Pressure	Microswitch absolute, 1%
• Temperature	Thermistor, .2%
• Rh	Vaisala, 2%

2.3. Physical Characteristics

• Sample Volume	0.44 liter
• Weight	About 2.6 kg depending on application configuration
• LxWxD	56 cm x 13 cm x 17 cm

2.4. Power

• Operating voltage	12 VDC {1 amp supplied)
• Power usage	2.5 - 3 watts (230 ma @ 12VDC) w/o fan at maximum flash rate; less power at lower flash rates. The supplied fan is 0.8 watts.

2.5. Internal Data Storage

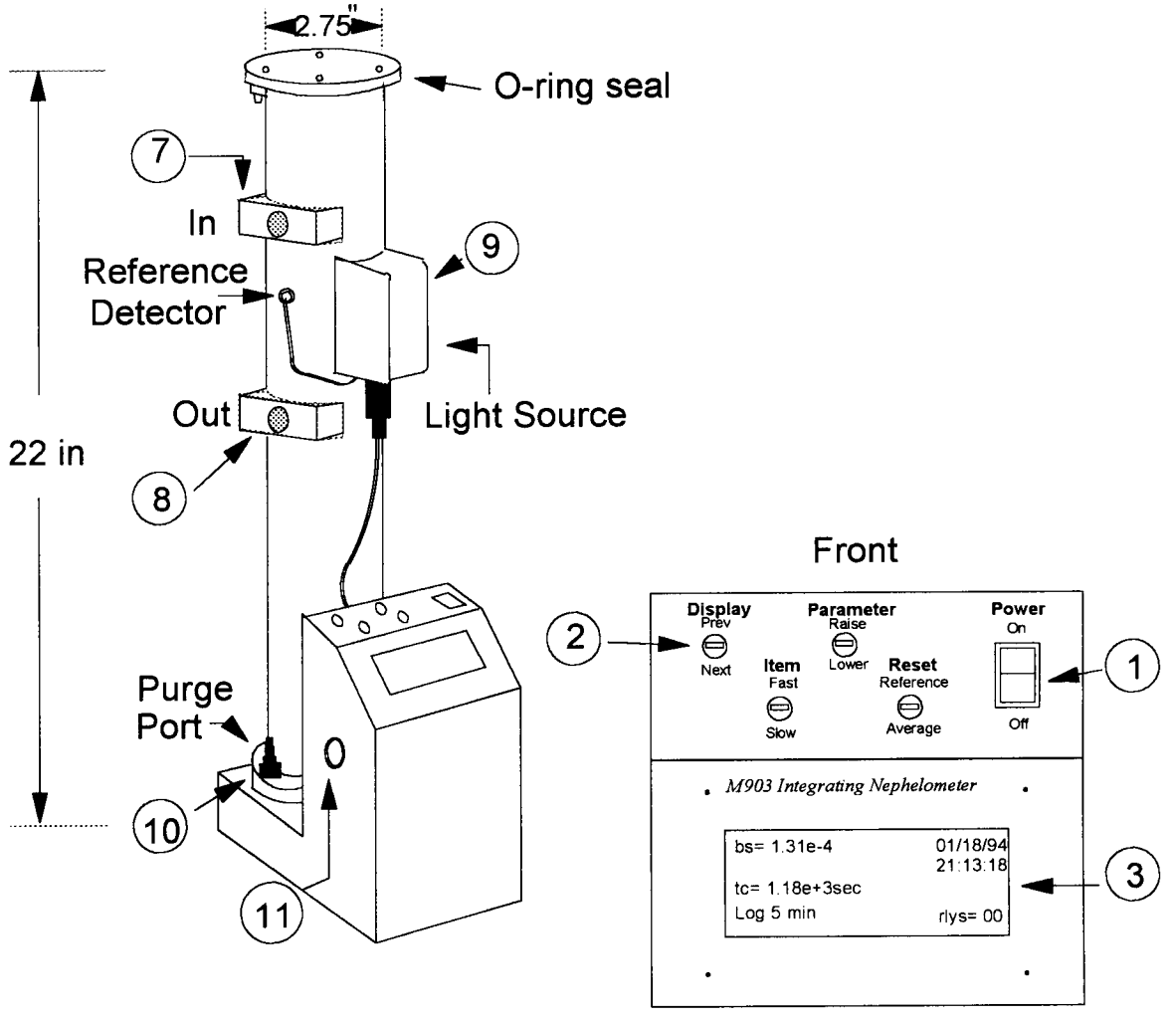
- Selected averaging periods: 20 sec to 1 hr
- Diagnostic parameters, zero and span settings and time stored in RAM
- Internal clock
- 21 days of 5 min averages can be stored before downloading; longer or shorter depending on averaging period.

3. Identifying Parts (see figure 1)

1. Power switch
2. Switches to change display modes and operating parameters - used in conjunction with panel display.
3. 20 x 4 back lighted panel display.
4. Analog outputs - DB9p connector - pins 1-4 outputs (0-5 vdc), pins 6-9 grounds.
5. Serial connector - DB9s connector (direct PC connection).
6. Power connector - 5.5 mm OD, 2.1 mm ID, center positive (12 VDC).
7. Aerosol inlet - Threaded 1/2 inch NPT.
8. Outlet - Vacuum source, threaded 1/2 inch NPT.
9. Flash lamp assembly - flash lamp and flash lamp circuit board are installed in aluminum cover.
10. Purge port - used for clean air and span gas sources.
11. Connector for Rh sensor.
12. Aux. Fan Power.

Figure 1.

M903 Integrating Nephelometer - Rh sensor version



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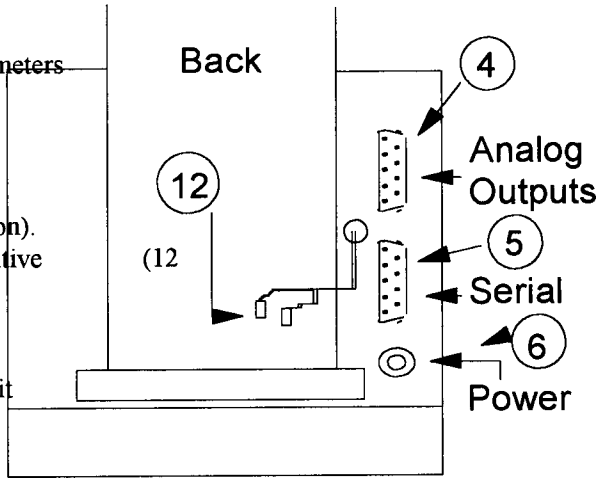


4. Unpacking

4.1 Contents

4.1.1 Nephelometer - Inlet and outlet are capped and the purge line is taped. When shipping always cover these ports to keep foreign material out of the optics.

4.1.2 Rh sensor

4.1.3 DB-9p to DB-9s serial ribbon cable. A DB-9 or DB-25 adapter may be needed if the host computer has a 25 pin serial connector (Radio Shack).

4.1.4 DB-9s connector for analog signals.

4.1.5 12 VDC wall converter power supply (800 ma or 1000 ma).

4.1.6 Operation Instructions.

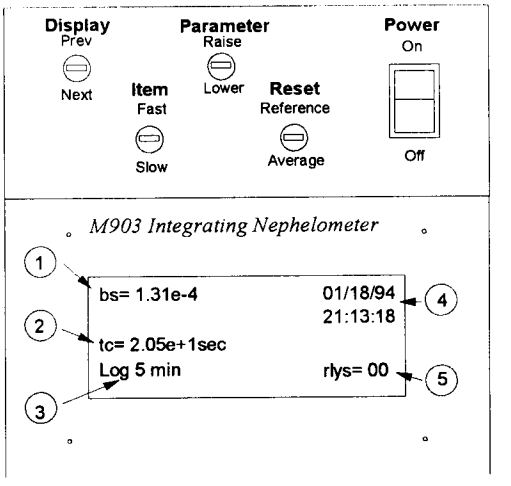
5. Operation

5.1. Basic Startup

Note: σ_{sp}, bs and bscat are used interchangeably for the extinction coefficient for light scattering.

The unit is operated by applying power to the power jack either with the supplied wall converter or a battery pack and turning the power switch to *on*. The flash from the strobe lamp can be observed through the top (inlet) port.

The panel meter displays the following information:

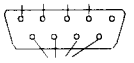


1. bs=1.31e-4 Scattering coefficient in units m^{-1}.
2. tc = 2.05e+1sec Data average time constant in seconds.
3. Log 5 min Operation Mode:
   Log 5 min - 5 minute data averages are being stored internally.
   Fast - time constant and flash rate set by Fast mode parameters.
   Slow - time constant and flash rate set by Slow mode parameters.
4. Time and Date
5. Relay contact status: 0=open, 1=closed - each digit represents one set of relay contacts. Relays are controlled by serial commands (see sec. 7.1). Each set of contacts can be independently opened or closed with single character commands.

   e.g. rlys= 01 relay 1 open, relay 2 closed **Note: only for units with relays installed**.

note: Operation modes *Log, Fast* and *Slow* each contain default operating parameters that can be changed through the serial port to contain any allowable time constants or flash rates or data logger averaging period (*Log* only). These are convenient labels that can be selected using the panel switches.

Four analog outputs are available on the DB-9p connector as 0 to 5 VDC signals. The outputs will extend 0.2 vdc below zero and above 5 vdc.



Chnl #	DB9 pin	Signal	Range
1	1	Scat Coef	0 to $2x10^{-4}m^{-1}$
2	2	Scat Coef	0 to $10^{-3}m^{-1}$
3	3	Internal Calibrator	0 to $10^{-3}m^{-1}$
4	4	Lamp Reference	3 to 5 VDC
	6-9	grounds	

If a ribbon cable is attached to the analog connector, the output channels will be on wires 1, 3, 5 and 7 and the grounds on wires 2, 4, 6 and 8 (red wire #1). All the grounds are tied together.

5.2 Conversion of analog outputs to light scattering coefficient

Analog output voltages - Conversion to light scattering coefficient (σ_{sp})

Channel	Volt Range	σ_{sp} Range	Volt Conversion
1	0 - 5 VDC	0 - $2x10^{-4}$ m^{-1}	σ_{sp}= Volts/5 x $(2x10^{-4})$ m^{-1}
2	0 - 5 VDC	0 - $1x10^{-3}$ m^{-1}	σ_{sp}= Volts/5 x $(1x10^{-3})$ m^{-1}
Cal	0 - 5 VDC	0 - 10^{-3} m^{-1}	Cal= Volts/5 x $(1x10^{-3})$ m^{-1}

e.g. 0.5 VDC on the 'Chnl 2' terminal is equivalent to

$$\sigma_{sp} = 0.5 / 5 \times 10^{-3}\ m^{-1} = 1 \times 10^{-4}\ m^{-1}$$

5.3. Operation of Panel Display

The panel display and display switches are used to monitor the instrument operation and change certain operation parameters. There are eight screens that are user accessible. The panel display is menu driven and individual menus or operation screens are accessed with the **Display** switch. Zero and span adjustments are set from the screens as well as default mode selection; internal operation data such as detector dark current, lamp reference and calibrator brightness can be monitored from the display as well.

5.3.1. Switch Description

Each of the four switches are spring loaded momentary in both directions.

Display - *Prev , Next*

Selects menu or information screens. Pressing the switch up or down determines the order in which the screens are displayed. Scanning through the screens does not affect the operation of the nephelometer.

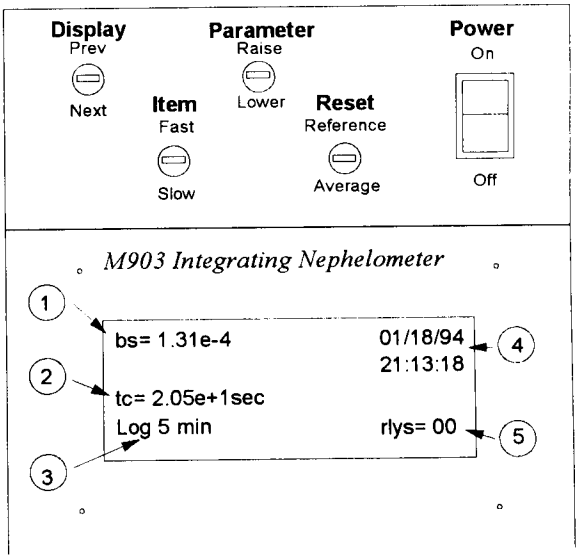
Item - *Fast, Slow* **Parameter** - *Raise, Lower* **Reset** - *Reference, Average*

Note: Item switch may be labeled **Item** - *Set, Select,* but the operation is the same.

These switches perform different functions depending on which screen is selected. The following is a description of the individual screens and the switch operation for each screen. The descriptions are in the order of the **Display**-*next* switch operation.

5.3.2. Main Screen (Invoked on power up)

1. Scattering coefficient, units m^{-1}
2. Scattering coef. time constant , units sec
3. Operation mode: If logger mode the averaging period is included.
   Possible modes: *Log, Fast, Slow*
4. Date and time
5. Relay status {Only on units with relay control)



Switch Operation for Main

(Only switches which perform a function are listed)

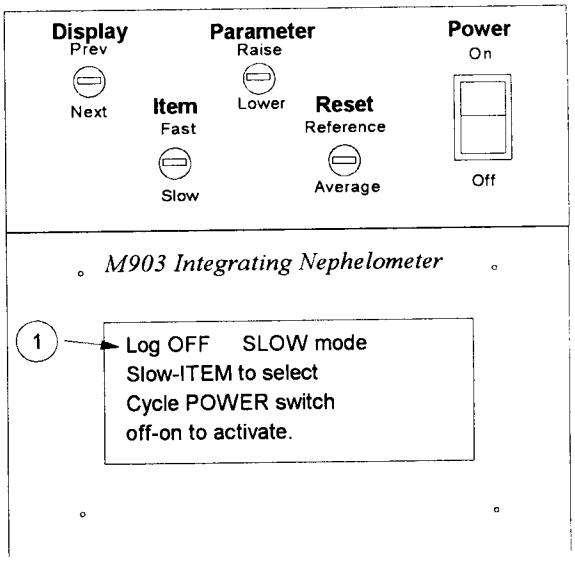
Reset- *average* Resets time constant averaging. When changing from clean air to span gas allows the display to approach the correct value without waiting through several time constants. After pressing Reset, new data will not be displayed until an internal calibrator cycle is completed (a few seconds). 'bs' will appear noisy for a few seconds then stabilize as the average fills with new data.

5.3.3. Mode Change Screen

Allows changing to one of three default parameter setups.

1. Indicates current mode. Possible modes are *Fast, Slow* or *Log*. In *Log* mode the scattering data is stored internally.

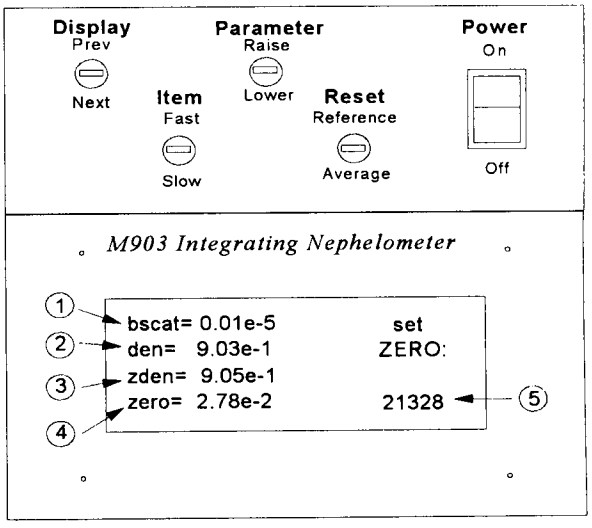
Item - *slow* Toggles between modes. Power must be cycled 'on' an 'off' to activate a mode change. Note: 'SET' shown in the display is actually the *slow* (or down) position of the **Item** switch.



5.3.4. Zero Calibration Screen

Allows setting the instrument zero when particle free air is flowing through the instrument.

1. Current scattering coefficient (same as 'bs' on Main)
2. Current air density $(P/T)(T_0/P_0)$ where (T_0/P_0) is Temperature and pressure at standard conditions, T_0=273°K, P_0=1013 mb.
3. Air density during zeroing. Current air density is copied into **zden** when zero is set.
4. Background suppression as fraction of calibrator extinction coefficient.
5. Internal 16 bit number that is adjusted for zero offset.



Switch Operation

Reset *- average* Resets time constant average.

Parameter *-raise, lower*

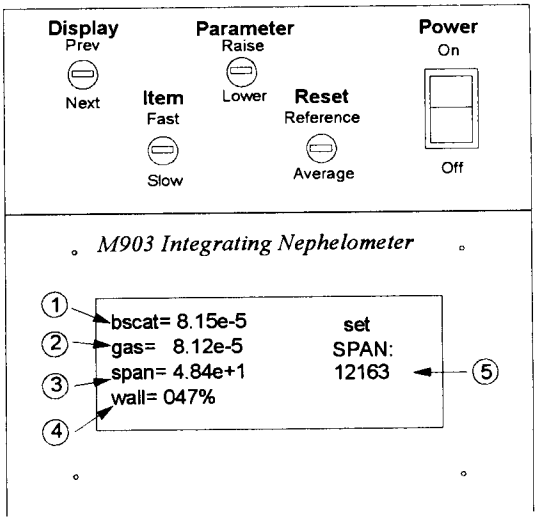
Increases or decreases zero offset With clean air, adjust **Parameter** until bscat <0.05e-5. Use with **Item** switch for rapid change. Copies *den* to *zden*.

Item*- fast, slow* When held in conjunction with the ***Parameter*** switch allows the zero to adjust more rapidly; up for rapid change and down for moderate change.

5.3.5. Span Calibration Screen

Allows setting the instrument span when a calibration gas is flowing through the instrument.

1. Current scattering coefficient (same as 'bs' on Main)
2. Theoretical coefficient of span gas at local pressure and temperature.
3. Ratio of internal calibrator to air Rayleigh coef.
4. Background noise (usually wall scatter) as a fraction of air Rayleigh coefficient.
5. Internal 16 bit number that is adjusted for span gain.



Reset *- average* Resets time constant average.

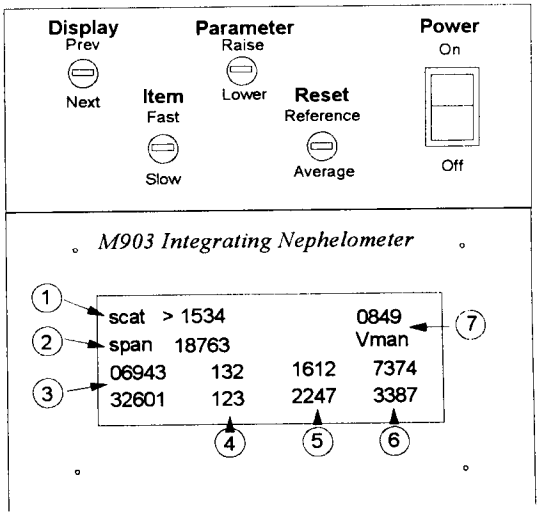
Parameter *-raise, lower*

Increases or decreases span gain. With span gas, adjust Parameter until bscat = calibration gas constant (gas). Use while holding *Item* switch for rapid change.

Item*-fast, slow* When held in conjunction with the *Parameter* switch allows the span to adjust more rapidly; up for rapid change and down for moderate change.

5.3.6 Photomultiplier Adjust and Diagnostic Screen

This screen allows setting the photomultiplier high voltage and also to view internal operating signals within the nephelometer such as dark current, lamp reference output and analog to digital conversion parameters. The high voltage is factory set and normally should **not** be changed unless a cold setup or output range change is being attempted.



1. AtoD conversion of Photomultiplier signal - Calibrator non engaged.
2. AtoD conversion of Photomultiplier signal - Calibrator engaged.
3. Smoothed total of 1. and 2. (upper) Reference brightness of flashlamp - should be between 30,000 and 60,000 (lower).
4. Dark current of Photomultiplier (upper) and flashlamp (lower) - should be steady, rapid variation of photomultiplier dark current indicates a light leak.
5. AtoD conversion times in 1/2 usec steps for Photo-multiplier and reference detector.
6. AtoD conversion for reference voltage - should be steady.
7. Photomultiplier high voltage in volts.

Reset-Reference Switches between VAUTO and VMAN. **Leave in VMAN.** VAUTO allows the high voltage to change dynamically for certain sampling applications.

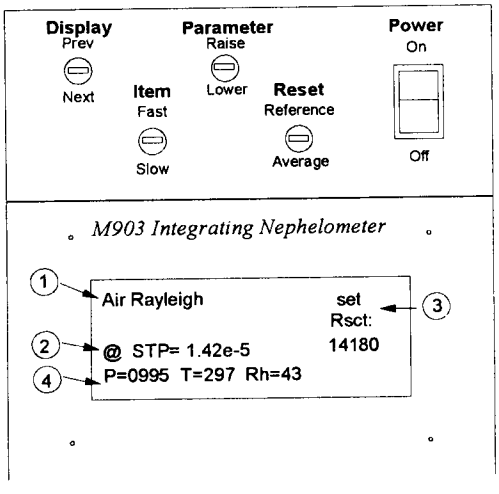
Item - fast Holding the *Reset* switch up displays signal 1-6 in real time without any smoothing.

Parameter-Raise,Lower - Adjusts high voltage on the photomultiplier tube. **Factory adjusted and normally should not be adjusted.**

5.3.7. Set Air Rayleigh Scattering Coefficient-Pressure, Temperature and Rh Display

Used to set the air Rayleigh scattering coefficient at standard conditions, P=1013 mb, T=273°K. This should not ever have to be reset, however, this screen allows the coefficient to be changed if there were a new determination of wavelength.

1. Air Rayleigh set screen
2. Air Rayleigh scattering coefficient at λ=530 nm and at standard pressure and temperature.
3. Internal 16 bit number adjusted used to set coefficient.
4. Pressure (mb), temperature (^{0}K), and Rh (%)



Parameter -raise, lower Sets Air Rayleigh coefficient.

Item- fast, slow When held in conjunction with the *Parameter* switch allows the zero to adjust more rapidly; up for rapid change and down for moderate change.

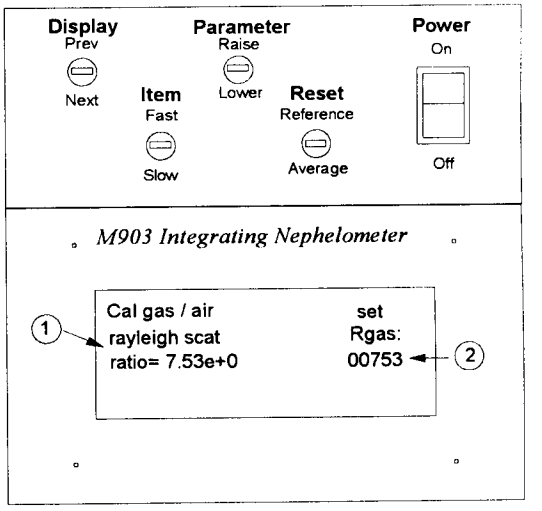
5.3.8. Calibration Gas Screen

Allows setting the ratio of coefficients for calibration span gas to Air Rayleigh. A table of values is shown in sec. 6.3., Table 1, for several span gases. When this value is set for the calibration gas used, the correct scattering coefficient for the calibration gas is shown on the Span Adjust screen at local pressure and temperature conditions. Calibration is accomplished by adjusting the span so that the indicated scattering coefficient matches the calculated value when sampling calibration gas.

1. Ratio of calibration gas to Air Rayleigh scattering coefficients. 7.53 is for R-22 refrigerant.
2. Adjustment value set with **Parameter** switch.

***Parameter** -raise, lower* Sets ratio.

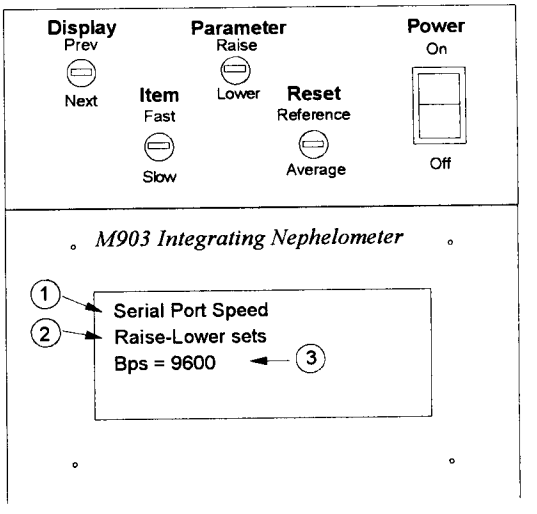
***Item**- fast, slow* When held in conjunction with the *Parameter* switch allows the zero to adjust more rapidly; up for rapid change



5.3.9. Serial Port Adjust Screen

Allows setting the serial port baud rate to 9600, 4800, 2400 or 1200. Default is 9600.

1. Serial port set-up screen
2. The **Parameter**-*raise, lower* changes rate
3. Current baud rate setting



5.4. Startup Parameters

Default Operating Parameters for selected mode.

Log mode:	flash rate	2 hz time constant	32 sec
	stored data averaging period	5 min	
Slow mode:	flash rate	2.5 hz	
	time constant	26 sec	
Fast mode:	flash rate	4 hz	
	time constant	26 sec	

These default constants can be changed through the serial port. See 'parameter setup' in 'serial port operation'.

5.5. Begin Ambient σ_{sp} Measurements: (if not calibrated, follow calibration procedure prior to use, sec. 6)

1. Power switch *off* - Apply power to the unit using the supplied power jack.

2. Connect vacuum to outlet port (lower port). If using the aux. fan, it connects directly to the outlet port using 1/2 in. PVC pipe (supplied). Fan power is supplied by a separate 12VDC wall converter.

3. Power *on* - Unit should start flashing after about 2 secs (visible through the inlet port). Analog outputs will come up according to time constant selected; serial output is available at any time. Each flash produces a string of serial data (see 'Serial Port Operation').

   The Main screen is displayed on the front panel.

6. Calibration

Calibration is accomplished by filling the instrument with gases of known but different scattering coefficients and adjusting the zero and span constants for the appropriate scattering values (bs or bscat) on either the display screen or analog output. Particle free air is used as a zero reference scatterer and one of several gases can be used as an upscale scatterer. The traditional span gases have been refrigerant R-12 ($CCl_2F_{2)}$ or refrigerant R-22 ($CHClF_2$) (i.e.. Freons), however, more recently, other gases such as R-134, SF_6 and CO_2 are being used.

6.1 Supplies

1. Clean air source: A small pump with a filter supplying about 10-20 lpm.
2. Span gas

6.2 Procedural Time

Calibration time depends on the signal averaging time selected since that is the time required for the output to stabilize. However, pressing the *Reset* switch to *average* periodically will decrease the stabilization time. Calibration can be done while in any of the three parameter modes (Fast, Slow or Log), however, the Fast mode will decrease the stabilization time since the flash rate is usually higher and time constant shorter than the other modes. The procedure should take only 5 to 10 minutes.

6.3 Procedure

Note: If Span gas is different from Refrigerent-22 (default) go to 'Calibration Gas Screen' (sec 5.3.7.) and set the Span gas / Air ratio for the calibration gas used (see Table 1 for ratios for several different gases). This ratio, along with pressure and temperature is used to calculate the correct span coefficient shown on the 'Span set screen' as 'gas'. The air Rayleigh coefficient at STP is indicated in the Air Rayleigh screen and shouldn't need to be changed.

1. Any of the operation modes can be used during calibration, however, the outputs in the **Fast** mode will stabilize quicker. To change to the **Fast** mode, use the ***Display*** switch to change to the Mode menu then use ***Item-slow*** to change to **Fast**. Turn the power switch 'off' then 'on'.

2. Turn off the sample source. Block the Outlet(lower) (e.g.with tape) and partially restrict the Inlet (e.g. tape) to allow some flow since the chamber is nearly air tight.

3. Blow clean air through the purge port located at the bottom of the column (about 10 lpm; the rate is not too important, however, more flow will purge more thoroughly). It's important that the entire column is purged and remains full of particle free air during setting of the zero.

4. Press ***Display*** until the **Zero** screen is displayed.

5. Press and release ***Reset-average*** to check that the bscat value on the screen and wait briefly while the bscat value stabilizes. Adjust the zero offset by holding the ***Item*** switch up (fast adjust) or down (slower) while operating the ***Parameter*** - *raise*, or *lower* to add or subtract offset. Adjust until bscat < | 0.05e-5|. Allow to stabilize. Note: 0.05e-5=5x10^{-7}.

6. Press Display until the **Span** screen is displayed.

7. Blow span gas through the purge port. It is especially important that the entire column is filled since the refractive index of any span gas is different from air.

8. Repeat (6.) except adjust span until 'bscat' = 'gas' value shown on 2nd row of the screen. This value is calculated from the 'span gas / Air' ratio and current air density determined from pressure and temperature. Wall scattering is shown as a percent of air Rayleigh. If Wall scatter gets excessively high, above 100%, the neph needs cleaning or realignment of optics.

9. Zero may have to be reset if span was significantly wrong. Return to normal operation.

Table 1

Span Calibration Values

σ_{sp} at λ = 530 nm (Pressure 1013 mb)

	Cal gas / Air	σ_{sp}(T=273°K)	σ_{sp}(T=293°K)
Refrigerant-12 (minus air)	15.3	20.4x10^{-5} m^{-1}	19.0x10^{-5} m^{-1}
Refrigerant-22 (minus air)	7.53	9.31x10^{-5} m^{-1}	8.68x10^{-5} m^{-1}
Refrigerant-134(minus air)	7.35	9.06x10^{-5} m^{-1}	8.44x10^{-5} m^{-1}
SF_6 (minus air)	6.74	8.19x10^{-5} m^{-1}	7.63x10^{-5} m^{-1}
CO_2 (minus air)	2.61	2.30x$10^{-5}$$m^{-1}$	2.14x$10^{-5}$$m^{-1}$
Air Rayleigh		1.427x10^{-5} m^{-1}	1.330x10^{-5} m^{-1}

7. Terminal Operation using Serial Port

The serial port connector is a DB-9s. The port can be connected directly to a PC using a straight through male to female DB-9 (9 pin) connector (no null modem adapter). If the PC has a 25 pin connector then a 9 to 25 pin adapter will be needed. Terminal software such as PROCOMM will be necessary to communicate with the nephelometer. Default communication parameters for the PC should be set to: **9600 baud, 8 bits, 1 stop bit, no parity.**

1. Connect the nephelometer serial port to a PC and invoke terminal software with the above communication parameters.

2. In all modes, the screen will begin listing for each flash the scattering coefficient, internal calibrator coefficient, pressure, temperature, Rh, and relay status. Additonal data can be appended by pressing A-G; 'space' returns to default listing. Pressing I-O lists appended data without default listings; 'space' returns to default. 'H' stops all listings.

Default Listing

Column 1	2	3	4	5	6
1.190e-04	2.313e-04	1005	301	47	00
1.190e-04	2.319e-04	1005	301	47	00
1.190e-04	2.325e-04	1005	301	47	00
1.190e-04	2.325e-04	1005	301	47	00
1.191e-04	2.325e-04	1005	301	47	00
1.192e-04	2.325e-04	1005	301	47	00
1.193e-04	2.325e-04	1005	301	47	00
1.194e-04	2.325e-04	1005	301	47	00
1.194e-04	2.325e-04	1005	301	47	00
1.195e-04	2.325e-04	1005	301	47	00

Col 1 - bscat, units m-1
Col 2 - Calibrator coef, units m-1
Col 3 - Pressure, mb
Col 4 - Temperature, °K
Col 5 - Rh, percent
Col 6 - Relay status:

Status	Relay 1	Relay 2
00	open	open
01	open	closed
10	closed	open
11	closed	closed

7.1. User - Serial Port Commands

1. 'S' or 's' invokes drop down menu for changing operating parameters.

2. Relay commands: 'W' - relay 1 open **Note: Only for units with relays installed.**
'X' - relay 1 closed

'Y' - relay 2 open
'Z' - relay 2 closed

7.2. Menu to Change Default Operation and Down load Stored Averages

1. To invoke the menu at any time during listings, press **S** or **s**. The following menu will appear on the screen. The menu contains a list of single letter commands used to set the clock, download stored data, enter parameter change menus for the various modes and exit into a selected operation mode.

Main Menu

```
T - Displays the current time
T [YY[MM[DD]]]hhmm - start/set the clock
T STOP - stop and power down clock
R - Download:  verbose format since last M command
S -            short format
A -            verbose format, entire data store
B -            short format, entire data store
M - Marks all data as read
E - Test and zero the data RAM, reset record #
X - Enters the FAST response mode setup menu
Y -          SLOW response
Z -          DATA LOGGER
Q - Hang-up and restart in logger mode
V -                    Fast mode
W -                    Slow mode
?, H - This message
```

Description of Menu Items:

Main Menu - All commands are activated by pressing the 'enter' key (<cr>).

T <cr> - displays current time and data

T 9401171525 <cr> - sets clock to 15:25 1/17/94

T STOP - stops the clock and removes power drain on RAM battery, used for instrument storage.

R - Downloads to screen (and serial port) all data stored since the last mark (M) command in verbose format (see data logger section)

S - Same as 'R' but in a shorter format more compatible with spread sheets.

A - Downloads to screen all stored data, marked or not in verbose format

B - Same as 'A' but in a shorter format more compatible with spread sheets.

M - Marks all data as read without erasing; any data stored subsequently will not be marked.

E - Erases entire data storage, verifies RAM and resets record#.

X - Enters Fast mode parameter setup menu (described below).

Y - Enters Slow mode parameter setup menu (described below).

Z - Enters Data logger setup menu (described below)

Q - Exits menu and starts Nephelometer in logger mode

V - Exits menu and starts Nephelometer in Fast mode.

W - Exits menu and starts Nephelometer in Slow mode.

?, H - Either symbol will reprint this menu to the screen.

7.3 Menu to change operation mode parameters (X,YorZ from Main Menu)

Fast, Slow Parameter Setup Menu

Current value	Type to change	Range min-max	Description
002	A	001-002	Signal filter order
002	B	001-002	Calibrator filter order
006	C	000-012	Signal avg time, 2^n flashes
006	D	000-012	Calib avg time, 2^n flashes
050	E	020-255	Flash interval, 10ms steps
035	F	002-255	Signal shutter dwell time, flashes
010	G	002-100	Calibrator shutter dwell time
129	H	002-255	Record interval, 2-60 sec, add 128 for minutes

Note: Item 'H' is in the Log Mode menu only

Description of Mode Menus (Fast, Slow and Data Logger) Currently stored constants for each parameter are listed under 'Current Value' ; the range of valid constants are listed under 'Range'.

A - Sets the signal averaging algorithm
1 = single pole exponential
2 = dual slope (approaches correct value more quickly but can have a small sinusoidal component. - recommended)

B - Same as 'A' but for the span calibrator output.

C - Signal averaging period based on flash rate; averaging period in 2^n flashes, n= 0 to 12.
e.g. if flashing at 5 hz and n=7 then signal time constant is 2^7 / 10 = 26 sec.

D - Same as 'C' but for the span calibrator output.

E - Flash slow down interval - sets flash rate by inserting wait states between flashes
if n=20 then flash rate = 5 hz
if n=50 then flash rate = 1/(.01n) hz = 1/.5 = 2 hz

F - Signal dwell time: related to the number of flashes the signal is measured before the span calibrator is inserted.

G - Calibrator dwell time: number of flashes the span calibrator path is open.
e.g. if signal dwell = 30 and calibrator dwell = 10 then the calibrator is in 10 of each 40 flashes.

H (*Data logger menu only*) - Averaging period for stored averages in seconds or minutes.
e.g. n=30 then 30 second averages are taken; for minutes add 128 (e.g. for 30 min averages set n=128+30 or n=158.
Note: Averaging periods should not be set shorter than one complete calibrator in/out cycle. For Default parameters F=35, G=10 (55 flashes) @ 2 Hz flashrate , a complete cycle would be 27 secs. For short averaging periods, F and G should be made smaller and the flash rate increased.

To change a value, type the command letter + space + new value <cr>. More than one parameter ca n be entered on a line. e.g. to change E to 40(2.5 hz flash rate) and H to 133(5 min logger average) enter the following:
E 40 H 133 <cr> where <cr> is the Enter key - another <cr> returns to the main menu.

7.4. Default Operating Parameters

Default Parameter Constants

Item	Fast	Slow	Data Logger
A	2	2	2
B	2	2	2
C	6	6	6
D	6	6	6
E	25	40	50
F	35	35	35
G	10	10	10
H	-	-	133

Fast Mode - Flash rate 4 hz
Signal Time Const. 16 sec
Calib. Time Const. 1 min
Slow Mode- Flash rate 2.5 hz
Signal Time Const. 26 sec
Calib. Time Const. 2 min
Logger- Flash rate 2 hz
Signal Time Const. 32 sec
Calib. Time Const. 2 min

To Change parameter (1) enter appropriate menu (2) enter item 'letter' plus 'space' plus 'parameter <cr>. Several items can be entered on a line. e.g. A 1 C 8 G 20 <cr> would change A to 1, C to 8 and G to 20.

8. Data Acquisition

8.1. Storing Data

If an averaging period different from the current period is desired, select a new period from the data logger menu (Z command in main menu). See terminal operation section for accessing the parameter menu for the logger.

Exit the Main menu with the 'Q' command to enter the Log mode or change to the Log mode using the panel display switches on the nephelometer. Data will be averaged and stored in battery supported static RAM according to the averaging parameters. Analog outputs and serial port still operate in this mode. Data RAM will hold about 2 weeks of 5 min averages; more for longer periods and less for shorter periods; there are over 4000 records available for data storage. Memory is a continuos loop, so after 21 days (for 5 min averages), new averages will write over the oldest data. If the unit is turned off then used at a later date, new data will be stored starting at the memory location last accessed during data storage. Therefore, previously stored data will not be lost.

8.2. Download data

Connect serial port to PC (see terminal operation) and press upper case **S** to invoke the Main menu. From the main menu initiate a download with one of the following commands **A,B,R,**or **S**; the terminal software should be set to receive an ASCII download file:

a. A <cr> - downloads entire memory area in verbose format.
b. B <cr> - downloads entire memory in short format.
c. R <cr> - downloads all memory not previously marked as read (with 'M' command) in verbose format.
d. S <cr> - Same as 'R' but short format.
e. M <cr> - After downloading with A, B, R or S invoking 'M' will mark all data as having been read but not erasing (A or B will still down

load marked data). Any subsequently stored data will be unmarked and only this data will be downloaded with a future 'R' or 'S' command.

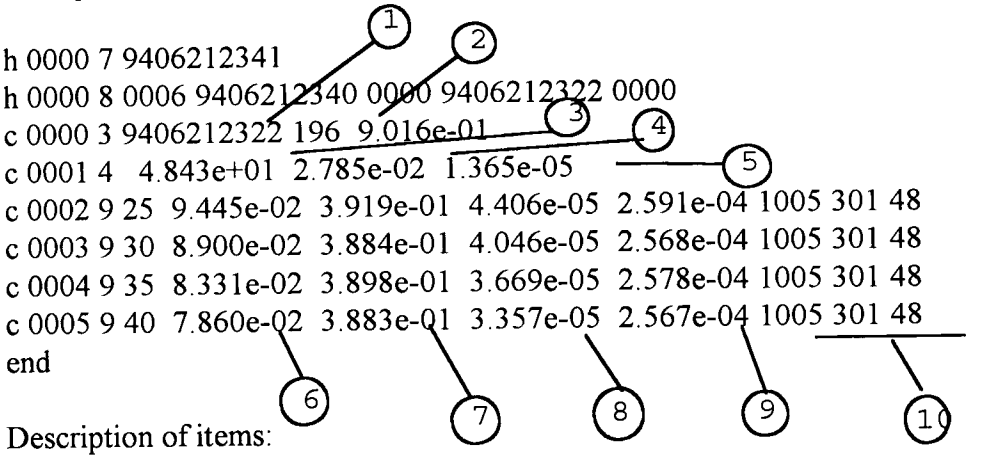
Note: Press *$* to stop download at any time.
^S and ^Q will stop and start scrolling during download. (^ = Ctrl key)

Sample from a downloaded file with 15 min averages

Verbose Format

R or **A** menu Item {**A** downloads entire memory storage area}
{**R** downloads entire storage area since last **M** command}

Example of partial download (Verbose format):



Description of items:

1. Date - (YYMMDDHHmm) year, month, day, hour of measurement. In this example, 9103202300 is 2300 hr 3/20/91.
2. Reference brightness level (8 bit)
3. Span setting
4. Zero setting
5. Air Rayleigh coefficient
5. 15 min average period for the above hour. In the example, 15 would be the 15 min average for 1900 - 1915.
6. Raw scattering averages for that 15 min period as a fraction of calibrator. Span and zero are not applied to these values. These would not normally be used.
7. Raw internal calibrator average. Format is the same as 6.
8. Scattering coefficients are for the 15 min period indicated in units m^{-1}. For example, 3.596e-04 is 3.596×10^{-4} m^{-1}.
9. Internal calibrator in extinction units. This value shouldn't change very much since the calibrator is a fixed brightness object. Any change usually indicates a change in span gain in the system.
10. Pressure (mb), Temperature (°K), Rh (%).

Short Format -Suitable for Spreadsheets

S and **B** Menu item example {**B** downloads entire data store area}
Usual download mode{**S** downloads data since last **M** command}

Example for short format download:

1	2	3	4	5	6	7	8	9	10	11	12
0044	94	06	21	23	10	00	6.242e-05	2.595e-04	1005	301	48
0047	94	06	21	23	11	30	6.412e-05	2.553e-04	1005	301	48
0048	94	06	21	23	11	00	6.581e-05	2.551e-04	1005	301	48
0051	94	06	21	23	12	30	6.342e-05	2.565e-04	1005	301	48
0052	94	06	21	23	12	00	6.068e-05	2.602e-04	1005	301	48
0055	94	06	21	23	13	30	6.259e-05	2.538e-04	1005	301	48
0056	94	06	21	23	13	00	5.986e-05	2.527e-04	1005	301	48
0059	94	06	21	23	14	30	5.799e-05	2.631e-04	1005	301	48
0060	94	06	21	23	14	00	5.897e-05	2.593e-04	1005	301	48
0063	94	06	21	23	15	30	5.721e-05	2.560e-04	1005	301	48
0064	94	06	21	23	15	00	5.270e-05	2.639e-04	1005	301	48
0067	94	06	21	23	16	30	5.765e-05	2.486e-04	1005	301	48

Col 1 - Record Number
Col 2 - Year
Col 3 - Month
Col 4 - Day
Col 5 - Hour
Col 6 - Ending minute of record
Col 7 - Ending second of record
Col 8 - Average σ_{sp}
Col 9 - Average Internal Calibrator Coef
Col 10- Pressure, mb
Col 11- Temperature, °K
Col 12- Rh, %

8.3. Modem Operation - Logger Mode Only
(Modem operation software is disabled except on request. Notify *Radiance* to activate modem software. Modem software is disabled to simplify the operation of the serial port when not needed).

For operation using a modem the baud rate should be set based on the capabilities of the sending and receiving modems (usually 2400 baud). All other parameters are the same (8 bits, 1 stop, no parity). The serial connector on the nephelometer has to be moved from p3 to p2 in order to use the modem commands. Carrier detect and data terminal ready (DTR) are not available on p3.

The following describes the process for remote communication via a modem line:

1. DTR (data terminal ready) is asserted to the modem for about 1 or 2 sec after power is applied to the nephelometer and anything on the RXD line is ignored as long as no carrier is present.

2. Once the modem answers a call and detects a carrier, CD (carrier detect) is asserted to the nephelometer. The nephelometer begins listening for the first letter (lower case **p**) of the pass word (**plax**) at 9600 baud - case is important!! The caller types lower case **p**'s until the screen echoes that character. This allows the nephelometer to find the correct baud rate (9600/4800/2400 or 1200 baud). After **p** is echoed to the screen, the caller then types the rest of the pass word **lax <enter>**. If the correct pass word is not detected within 70 sec, DTR will be dropped for 1 or 2 sec to hang-up the line - this is protect against hackers corrupting the nephelometer data.

3. When the correct pass word is detected, the current scattering coefficient and calibration coefficient is transmitted to the caller's screen - a pair of values after each flash of the flash lamp.

4. Typing any ASCII character (except **s** or **q**) will cause additional data to be transmitted to the screen following each flash. Depending on the character sent, this additional data can be used to determine the health of the nephelometer, diagnose problems, check the clock, etc. Typing a 'space' will stop the extra output. Typing a **q** will hang-up the phone by dropping DTR for about 2 sec; the logger will continue to operate and take averages. Typing an **s** will stop the logger and list the control menu on the screen. From this menu the caller can set the clock, down load stored averages, erase memory, and change operating parameters for any of the operation modes. Once the logger is stopped, it can be restarted only by hanging up the phone (typing **q**).

5. If the caller hangs-up without invoking **q** the nephelometer will still reset the modem and restart the data logger provided the modem is setup properly.

Modem Setup Parameters

Any modem that follows the Hayes protocol will work. The modem setup parameters should be set as follows:

1. The modem should be set in dumb mode (if possible) with no command echo or result codes. Blind mode is best.

2. CD (carrier detect) output must be set to follow the carrier, that is, turned on when the carrier is present and off when it is not.

3. The modem must be set to autoanswer when DTR is 'on' and hang-up and reset when DTR is temporarily dropped.

ATe0q1&c1&d3s0=1 usually does this. AT&w0 usually stores the current settings in the modem non volatile memory.

Modem operation can be simulated by connecting the nephelometer directly to a computer using a 9 pin null modem connector and operating the nephelometer in logger mode. Set the terminal software parameters as described above; the baud rate can be set to either 9600, 4800, 2400 or 1200 baud. Follow the procedure for entering the pass word - typing lower case p's until they are echoed to the screen, then type 'plax' or 'lax'. The output will behave as described above for modem operation.

9. Maintenance

9.1. Cleaning:

1. Power 'off'. Remove the for 6-32 socket screws from the dark trap at the top of the column. The dark trap is sealed with an 'O'-ring and may require tapping with a sharp edge to pop the assembly loose from the body. If either aluminum surface is damaged be sure to knock off any burrs with a file or the 'O'-ring won't seal properly. Blow out the scattering chamber; don't use too much air pressure since the chopper could be damaged. Check carefully with a flashlight for spider webs, especially around the aperture hole. Even the smallest filament in the scattering cone can cause extremely high scattering background.

The unit can be operated with the dark trap removed to check operation of the chopper **but only in subdued light.** Bright light can cause excessive detector currents and destroy the photomultiplier tube.

Install the dark trap, being careful to align the baffle with the lamp.

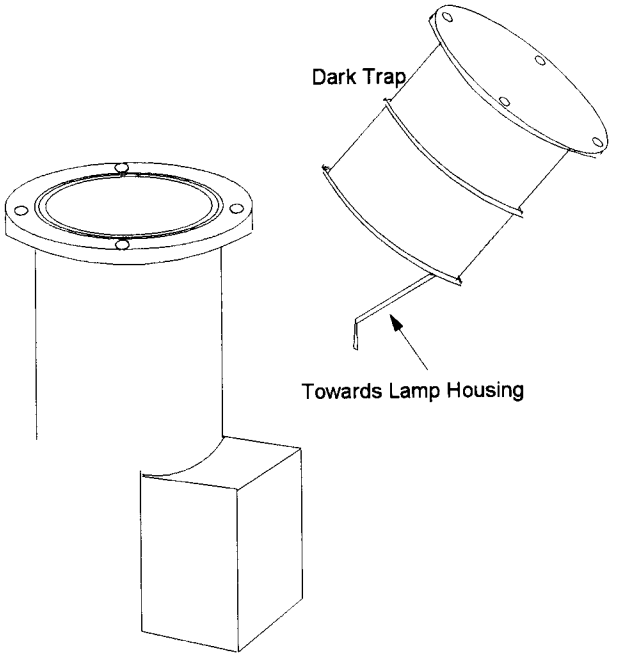


Figure. Removing Dark Trap for Cleaning

9.2. Changing Flash Lamp Assembly

Caution!! There is approximately 400vdc stored in a 2.2uf capacitor inside the flash lamp assembly cover so disconnect power before removing the cover.

1. Remove the two 8-32 screws securing the flash assembly cover and remove the cover.
2. Remove the four 4-40 socket screws holding the lamp assembly and remove. You may have to pry the assembly away from the gasket with a screw driver.
3. The lamp is connected to the flash circuit board with a 6 pin Amp connector.
4. Unplug the Amp connector and replace lamp with new assembly (see figure below).
5. Reverse the order to replace the lamp assembly.