PORTACOUNT

Operation and Service Manual

July 1989
P/N 1980048

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Service policy

Knowing that inoperative or defective instruments are as detrimental to TSI as they are to our customers, our service policy is designed to give prompt attention to any problems. If any malfunction is discovered, please contact your nearest sales office or representative, or call TSI's Customer Service department at (612) 483-4711.

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About this manual

The *PORTACOUNT Operation and Service Manual* tells you how to operate and maintain the PORTACOUNT. Read it thoroughly before using the instrument.

Once you are familiar with its contents, use the *Operator Guide* for day-to-day operations.

- Chapter I and Chapter II explain how to set up the PORTACOUNT and, briefly, how to operate it.
- Chapter III describes the parts and functions of the PORTACOUNT in detail.
- In-depth explanations of each of the three operating modes are given in Chapters IV, V, and VI.
- Chapters VII, VIII, and IX cover the serial interface, optional printer, and optional AC adapter.
- Chapters X and XI cover maintenance and troubleshooting.
- Appendix A describes the theory of operation. Appendix B lists the various printer control codes. Appendix C explains the printer's serial interface. Appendix D explains the signal connections for the PORTACOUNT's serial interface. Appendix E shows how to change the output level of the serial interface.

References to front panel keypads on the MODEL 8010 PORTACOUNT, along with the instrument's data readout, are represented in this manual by the sans serif typeface called Helvetica Light.

Example 1: To switch off the PORTACOUNT, simultaneously press ENABLE and OFF (from *Switching the PORTACOUNT on and off* in Ch. II).

Example 2: The format is a.bEc where a.b is the mantissa and c is the exponent (from *Reading the display* in Ch. VI).

To call attention to an important note or comment, a black four-pointed star ✦ is used.

Introduction

The PORTACOUNT is a highly versatile, portable, particle-counting instrument. It can accurately measure respirator fit factors, filter penetrations, and particle concentrations. Respirator fit factors and filter penetrations are measured using ambient air particles as the challenge aerosol.

Based on the technology of continuous-flow condensation nucleus counters, the PORTACOUNT counts individual airborne particles from sources such as smoke, dust, and engine exhaust. It does so by growing particles that are too small to be otherwise detected to an easily detectable size. In the Count Mode, the PORTACOUNT measures the concentration of these airborne particles. In the Fit-Test Mode, the instrument measures the concentration of these particles inside and outside a respirator and calculates the fit factor. In the Sequential Mode, the instrument measures the concentration on either side of a filter and calculates the filter penetration.

Various accessories can be used with the PORTACOUNT to enhance its operation; they include a portable printer, digital datalogger, and fit-testing software.

I
Setup

The PORTACOUNT is easy to set up. First, use the component lists to be sure no items are missing; next, identify the various parts in the labelled photographs. Then follow the setup instructions to prepare the instrument and its accessories for operation.

Unpacking

The following items are included with the PORTACOUNT; if any are missing or damaged, notify TSI immediately.

Qty	Item	Part No.	
1	PORTACOUNT with twin-tube assembly	8010 8010-1	(115V) or (220V)
1	Carrying case	1319024	
2	Battery pack	8903	
1	Stand	1206214	
1	Charger	2613026 2613028	(115V) or (220V)
48	Alcohol bottles with material safety data sheet and 8 syringes	800362	
1	HEPA filter	1602066	
1	Operator Guide	1980013	
1	Operation and Service Manual	1980012	
2	Hose adapters with tubes	⅛″ to ¼″ ⅛″ to 3⁄16″	

If a MODEL 8902 Printer was also purchased, the following parts are included.

Qty	Item	Part No.	
1	Printer	8902 8902-1	(115V) or (230V)
1	Printer cable	8906	
1	AC adapter	2613029 2613030	(115V) or (230V)

If a MODEL 8018 Adapter was also purchased, the following parts are included.

Qty	Item	Part No.
1	Electronics Module	800387
1	Power Supply	2613042 (115V) or 2613043 (230V)

Figure I-1 is a photograph showing the PORTACOUNT and its accessories.

Included at the front of this manual is a registration card. Please complete it and mail it promptly. This allows TSI to support your instrument and inform you of product updates.

Figure I-1. PORTACOUNT and accessories

Parts identification

Figures I-2 and I-3 identify the main parts of the PORTACOUNT. Become familiar with them before proceeding with the setup.

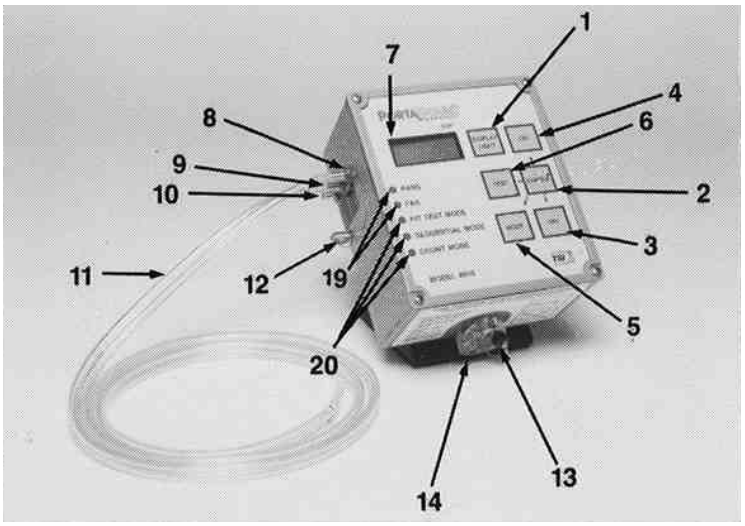

Figure I-2. Front of PORTACOUNT

1. DISPLAY LIGHT keypad
2. ENABLE keypad
3. OFF keypad
4. ON keypad
5. MODE keypad
6. TEST keypad
7. Display
8. Ambient port
9. Sample port
10. Exhaust port
11. Twin-tube assembly
12. Serial interface connector
13. Alcohol fill cap
14. Alcohol fill indicator

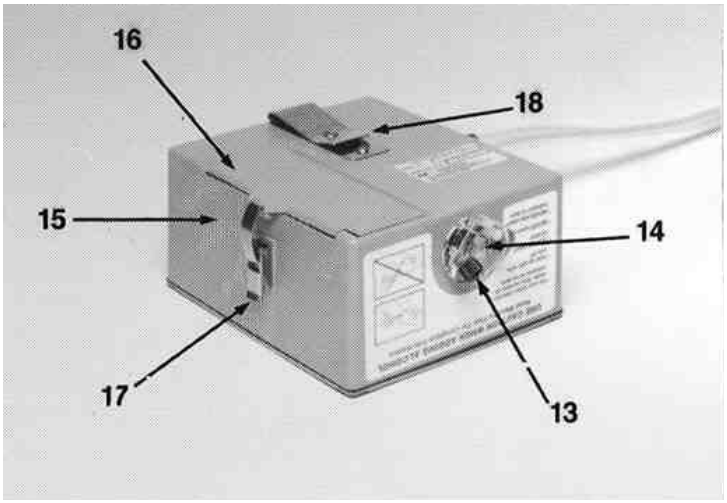

Figure I-3. Back of PORTACOUNT

15. Battery compartment
16. Battery cover
17. Latch clip
18. Belt clip

The twin-tube assembly

The PORTACOUNT is shipped with the twin-tube assembly attached. If the tubes are detached, attach the tube labelled A to the Ambient port and attach the tube labelled S to the Sample port as shown in figure I-4.

Remove the two plugs from the other end of the twin-tube assembly.

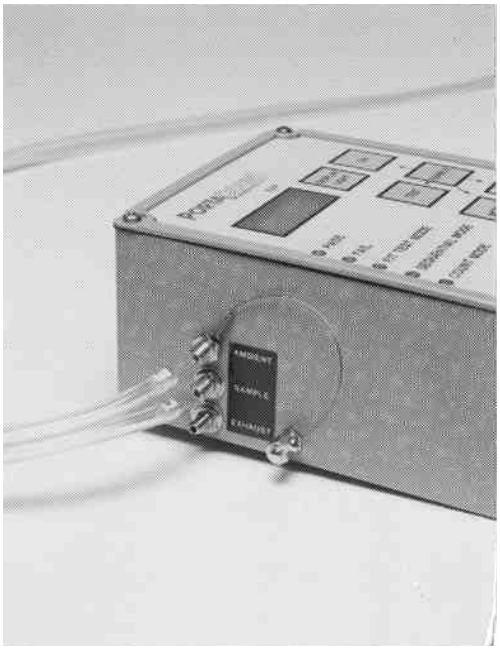

Figure I-4.
Twin-tube assembly connections

Installing the battery pack

Two battery packs are supplied; both are fully charged. To install a battery pack in the PORTACOUNT, follow these four steps:

Step 1. Open the latch clip and remove the battery cover (fig. I-5).

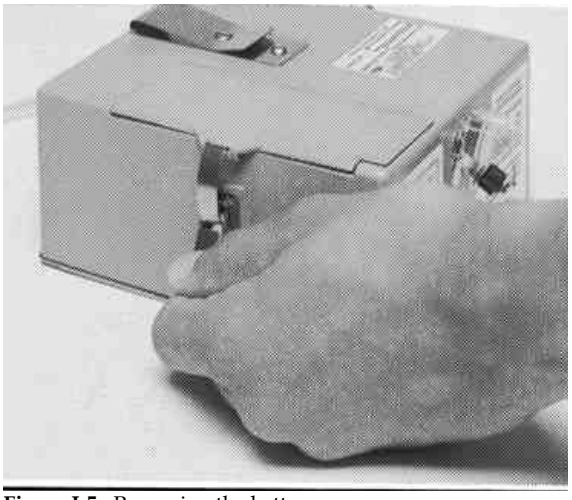

Figure I-5. Removing the battery cover

Step 2. Plug the battery connector into the battery pack. The connector fits only one way (fig. I-6).

Figure I-6. Plugging in the battery connector

Step 3. Insert the battery pack into the battery compartment in the orientation shown (fig. I-7).

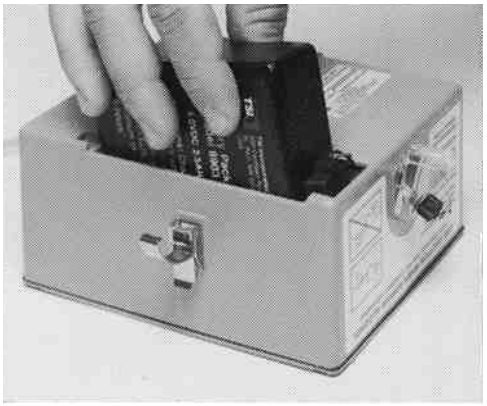

Figure I-7. Installing the battery pack

Step 4. Replace the battery cover and fasten the latch clip.

Adding alcohol

Alcohol should be added when the PORTACOUNT is first received new from TSI and whenever the alcohol indicator turns white. The instructions below describe how to add alcohol to the PORTACOUNT. Do not add alcohol if the fill indicator is dark. If the fill indicator is white, fill the PORTACOUNT using the procedure below. During operation, when the fill indicator first begins to turn white, the PORTACOUNT will operate approximately 45 minutes before the low particle count 'E--E' message appears.

WARNING:

- ❏ PORTACOUNTs should always be shipped dry as a precaution against inadvertent flooding. To dry a PORTACOUNT you should run it in COUNT mode until the alcohol fill indicator is a solid white color. This may take several hours.
- ❏ *Never* add alcohol to the PORTACOUNT when the fill indicator is dark. *Do not* continue to add alcohol once the fill indicator has turned from white to dark. ***Caution:*** Alcohol is extremely flammable. *Do not* fill near open flame or source of ignition.
- ❏ *Never* fill the PORTACOUNT with alcohol other than 100% reagent grade iso-propyl alcohol.

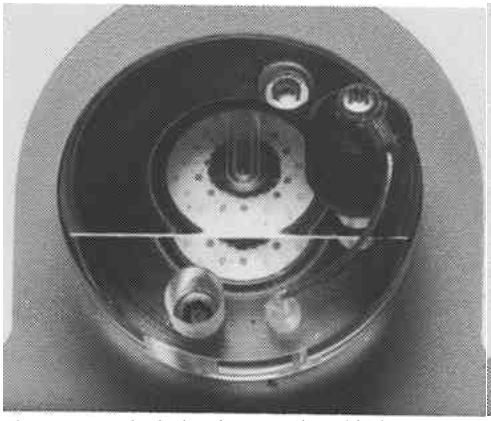

Figure I-8. Alcohol indicator white (dry)

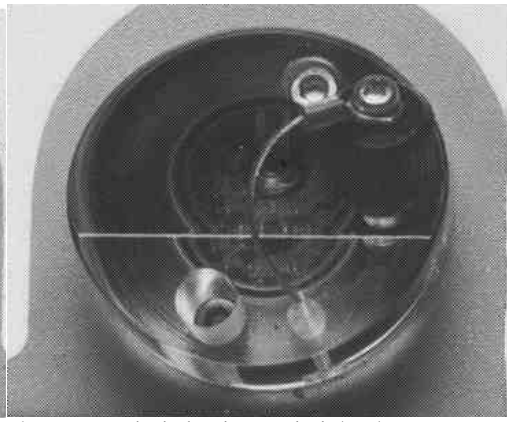

Figure I-9. Alcohol indicator dark (wet)

Step 1. Turn the PORTACOUNT off and remove the alcohol fill cap (fig. I-10).

Figure I-10. Removing the alcohol fill cap

Step 2. Open a disposable TSI alcohol bottle by twisting the top off. Place the short plastic tube stub onto the end of a syringe and then connect the other end of the tube stub to the neck of the alcohol bottle (fig. I-11).

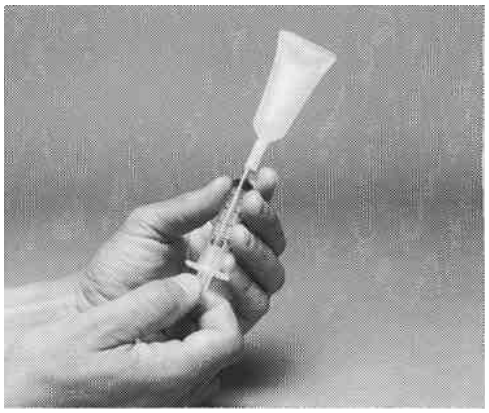

Figure I-11. Filling the syringe

Step 3. Draw about 5 cc of alcohol into the syringe. Remove the tube stub from the syringe. If the alcohol bottle is not empty you may recap it and store it for later use.

Step 4. Insert the end of the syringe into the alcohol fill port on the PORTACOUNT. Make sure the syringe is inserted at the correct angle. The syringe will remain in place without support if the angle is correct (fig. I-12).

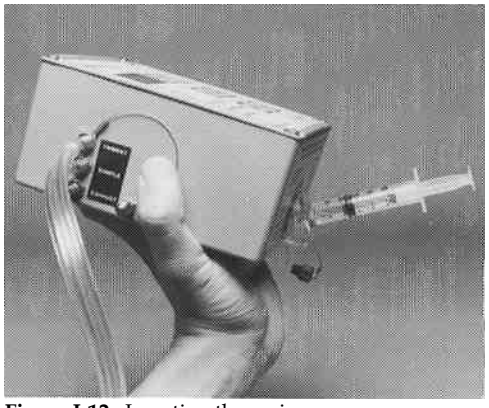

Figure I-12. Inserting the syringe

Step 5. While observing the alcohol fill indicator, gently and slowly inject alcohol into the PORTACOUNT. *Stop filling the moment the indicator turns dark.* This may happen before the syringe is empty. Observe the following precautions while filling (fig. I-13):

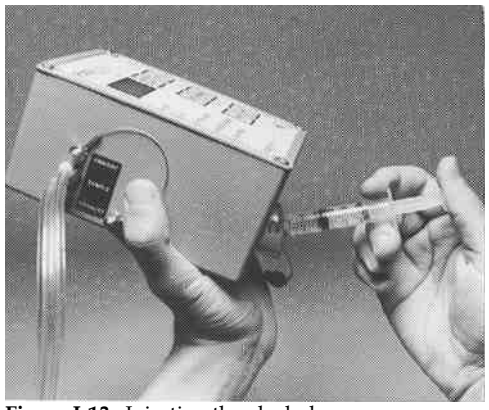

Figure I-13. Injecting the alcohol

- *Never* fill when the PORTACOUNT is on.
- *Never* tip the PORTACOUNT backwards further than horizontal while filling (see figs. I-14 and I-15).
- *Never* inject air into the PORTACOUNT fill port.
- *Never* fill the PORTACOUNT if the alcohol indicator is dark. Stop filling the moment the alcohol indicator changes from white to dark.

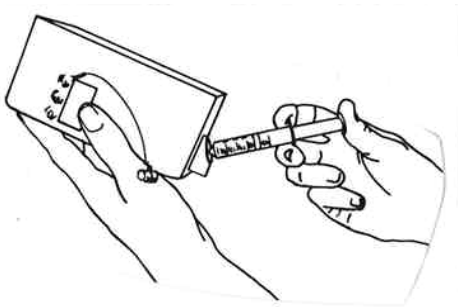

Figure I-14. Correct angle for filling

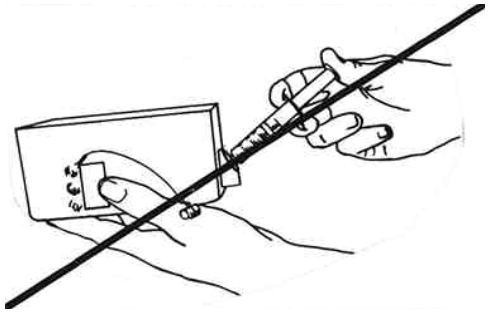

Figure I-15. Wrong angle for filling

Note: The PORTACOUNT will consume alcohol at the approximate rate of one cc per hour.

Connecting the printer

To connect the printer to the PORTACOUNT, follow these five steps:

Step 1. Unscrew the cap from the PORTACOUNT serial interface connector.

Step 2. Screw the small end of the printer interface cable to the serial interface connector (fig. I-16).

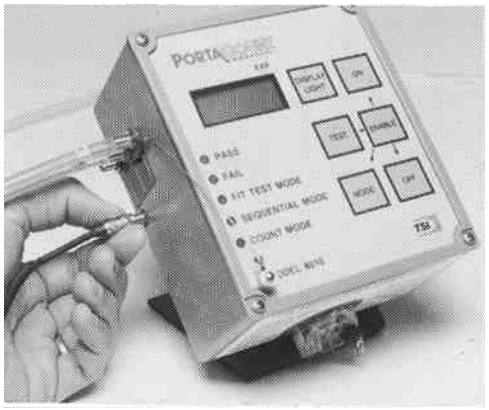

Figure I-16. Connecting the printer interface cable to the PORTACOUNT

Step 3. Plug the other end of the printer interface cable into the connector on the back of the printer (fig. I-17).

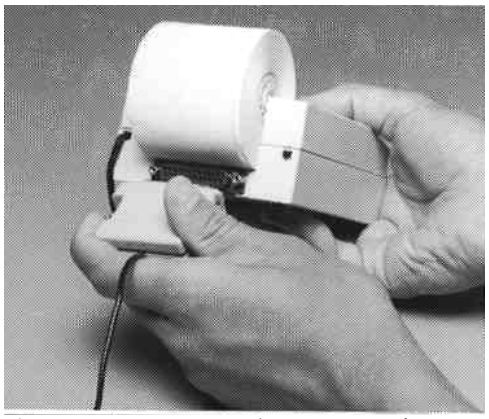

Figure I-17. Connecting the printer interface cable to the printer

Step 4. Plug the cable from the printer's AC adapter into the cable from the printer. Ignore any polarity designation. Polarity is not important (fig. I-18).

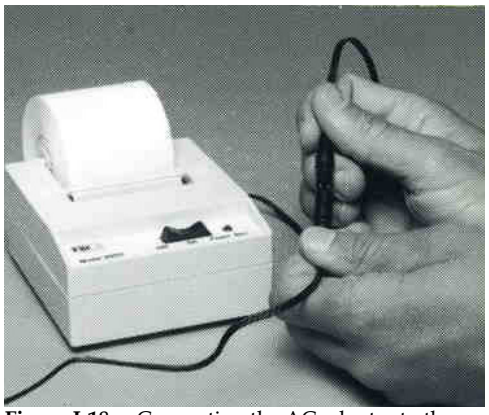

Figure I-18. Connecting the AC adapter to the printer

Step 5. Plug the printer's AC adapter into a nearby wall outlet.

The printer is now ready for operation.

II
Operation

This chapter provides brief instructions on how to operate the PORTACOUNT. Subsequent sections provide more detail.

Caution:	Operate the instrument on the stand provided or hold it in an upright position. If you run it in an inverted position, alcohol may clog the nozzle or coat the optics.

Switching the PORTACOUNT on and off

To switch on the PORTACOUNT, simultaneously press ENABLE and ON. The LCD display counts down from 60 seconds while the instrument warms up. After warm-up, the PORTACOUNT is in the Fit-Test Mode. (If LO appears on the display, see *Error Messages* at the end of this chapter.)

The PORTACOUNT has three operating modes. In the Fit-Test Mode, the instrument can perform quantitative respirator fit tests. In the Sequential Mode, it can be used to test filter penetration. In the Count Mode, it can be used as a stand-alone particle counter. To select a mode, simultaneously press ENABLE and MODE until the indicator light next to the desired mode comes on.

To switch off the PORTACOUNT, simultaneously press ENABLE and OFF.

The Fit-Test Mode

This section briefly describes how to operate the PORTACOUNT in the Fit-Test Mode. See Chapter IV for detailed instructions.

To perform a quantitative respirator fit test, follow these three steps:

Step 1. Attach the free end of the twin-tube, marked S, to the sample port on the respirator.

Step 2. Simultaneously press ENABLE and TEST, the E then flashes. After completing the first test cycle, the fit factor appears in scientific notation and a PASS or FAIL indication is given. The PORTACOUNT continues testing and updating the displayed fit factor every 80 seconds. Perform each exercise for 80 seconds synchronized with the PORTACOUNT.

Step 3. To end a test, simultaneously press ENABLE and TEST again. The overall fit factor is displayed and an overall PASS or FAIL indication is given.

- If you leave the PORTACOUNT running for 10 minutes without starting a test, the instrument automatically switches off to conserve battery life.

The Sequential Mode

This section briefly describes how to operate the PORTACOUNT in the Sequential Mode. See Chapter V for detailed instructions.

To perform a test in the Sequential Mode, follow these three steps:

Step 1. A 1 appears on the display when the PORTACOUNT is in the Sequential Mode. Sample the upstream (high) concentration and simultaneously press ENABLE and TEST. The 1 then disappears. An E then appears and flashes until the end of the upstream test period (30 seconds).

Step 2. When the flashing stops and a 2 is displayed, proceed to the downstream (low) concentration sampling location.

Step 3. After waiting at least 30 seconds for the instrument to purge itself, simultaneously press ENABLE and TEST. The E again flashes. At the end of the downstream test period (30 seconds), the filtration factor is displayed.

- In the Sequential Mode, sampling is done through the Sample port; the Ambient port is not used.

The Count Mode

This section briefly describes how to operate the PORTACOUNT in the Count Mode. See Chapter VI for detailed instructions.

In the Count Mode, the PORTACOUNT automatically displays the concentration measured through the Sample port in particles per cubic centimeter. When initially sampling in the Count Mode, the display is updated every second. To switch to the 15-second averaging mode, simultaneously press ENABLE and TEST. The display then shows the average concentration every 15 seconds. To return to the 1-second averaging mode, simultaneously press ENABLE and TEST again.

The PORTACOUNT switches between the 1-second and the 15-second averaging modes each time you press ENABLE and TEST simultaneously.

Lighting the display

To light the display, press and hold the DISPLAY LIGHT keypad.

Error messages

The PORTACOUNT's display can indicate two error messages: E--E and LO.

E--E message. The 'E--E' Message will be displayed if the ambient particle concentration is not sufficient for respirator fit testing.* There are several possible reasons that can cause this message to appear.

- There may not be sufficient particles in the air for fit testing. This can be caused by such things as special HEPA filtered ventilation systems or, on rare occasions, unusual weather such as several days of heavy rain.
- The PORTACOUNT may be low on alcohol. See the Maintenance section of this manual.
- The PORTACOUNT may be flooded with too much alcohol. See the Adding Alcohol section in this manual and the Troubleshooting section in this manual.
- The twin tube on the PORTACOUNT may be blocked. Check for obstructions.
- The flow may be blocked by dirt or debris inside the PORTACOUNT. This would require factory service.
- The switching valve that diverts the flow between the ambient and sample tubes may not be functioning. This would require factory service.

LO message. A LO message appears when the battery pack voltage drops to an inadequate level. Replace the battery pack with a fully charged battery pack when this message appears. The PORTACOUNT will automatically turn itself off one minute after the LO message appears.

See Chapter XI for detailed information on the causes and solutions of error messages.

Switching the printer on and off

To switch on the printer, push down the right side of the power switch; it will return to the center ON position. To switch off the printer, push down the left side of the power switch.

Advancing printer paper

To advance the paper in the printer, push down and hold the right side of the power switch.

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*625 particles/cm^3 on PORTACOUNTs with Rev. A and earlier firmware
1500 particles/cm^3 on PORTACOUNTs with Rev. B, C, and D firmware
1000 particles/cm^3 on PORTACOUNTs with Rev. E firmware

III
Description of Parts and Functions

Front panel membrane switch

The membrane switch, part of the front panel, includes the display window and six keypads (18, fig. III-1). The keypads are explained below.

DISPLAY LIGHT (1, fig. III-1)
Switches on the display lighting when pressed while the PORTACOUNT is operating.

ENABLE (2, fig. III-1)
Controls the operation of the instrument when pressed simultaneously with the OFF, ON, TEST, and MODE keypads.

OFF (3, fig. III-1)
Switches off the instrument when pressed simultaneously with the ENABLE keypad.

ON (4, fig. III-1)
Switches on the instrument and begins the warmup cycle when pressed simultaneously with the ENABLE keypad.

MODE (5, fig. III-1)
Selects the Fit-Test, Sequential or Count Mode when pressed simultaneously with the ENABLE keypad.

TEST (6, fig. III-1)
Performs several different functions when pressed simultaneously with the ENABLE keypad. In the Fit-Test Mode, it either starts or stops a test. In the Sequential Mode, it starts either of the two samples. In the Count Mode, it switches between the 1- and 15-second averaging modes.

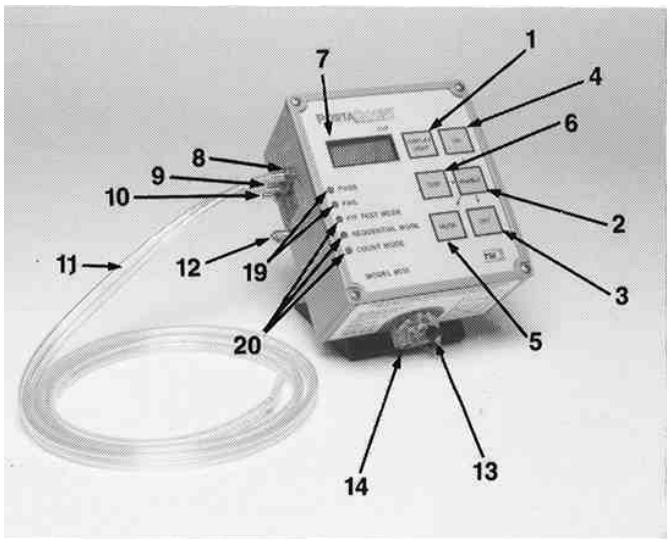

Figure III-1.
Parts and functions of the PORTACOUNT

Display

The PORTACOUNT contains a liquid crystal display (LCD) on the front panel (7, fig. III-1). Under daylight conditions, the LCD is highly visible; under nighttime conditions, the display is backlighted. The LCD displays six items of information:

Fit factor
This is the result of a respirator fit-test measurement. The fit factor (FF) value is displayed as a.bEc which corresponds to $a.b \infty 10^{c}$; thus 2.5E3 means $2.5 \infty 10^{3}$, or 2500.

Filtration factor
This is the result of a Sequential Mode test; it too is displayed as a.bEc. Filtration factor is the inverse of filter penetration.

Particle concentration
In the Count Mode, the concentration of the aerosol drawn through the Sample port is displayed as a.bEc, in particles per cubic centimeter. In the 1-second averaging mode, the display is updated each second, indicating the concentration measured during the previous second. In the 15-second averaging mode, the concentration is updated every 15 seconds, indicating the average concentration measured during the previous 15 seconds.

Low battery indication
LO appears on the display if the battery voltage drops below 3.5 volts. It means the battery pack needs charging. The PORTACOUNT will turn itself off one minute after the LO message appears.

Low particle count indication
If the measured ambient particle concentration is less than 1000* particles per cubic centimeter in the Fit-Test Mode or the Sequential Mode, E--E appears on the display. Instrument problems can cause this message if they reduce the instru-

*625 particles/cm^3 on PORTACOUNTs with Rev. A and earlier firmware
1500 particles/cm^3 on PORTACOUNTs with Rev. B, C, and D firmware

ment's ability to count particles. However, the message usually means that the PORTACOUNT is either flooded or low on alcohol. See Chapter I *Setup* and Chapter XI *Troubleshooting*.

Warm-up time
When the PORTACOUNT is switched on, the warm-up time (60 seconds) counts down on the display.

Indicator lights

Pass/fail lights. In the Fit-Test Mode, the two lights indicate PASS or FAIL at the end of each test cycle as well as after ENABLE and TEST are pressed to end a test (19, fig. III-1). The pass/fail level is determined by DIP switches inside the instrument.

Mode lights. These lights indicate the PORTACOUNT's current operating mode (20, fig. III-1).

The twin-tube assembly

The sampled aerosols are drawn into the PORTACOUNT through the twin-tube assembly (11, fig. III-1). The tubes are connected to the instrument at the sampling ports; they are labelled accordingly: S is the Sample port, and A is the Ambient port.

Sampling and exhaust ports

There are three barbed ports on the left side of the PORTACOUNT cabinet. In the Fit-Test Mode, the aerosols are sequentially sampled from the Ambient and Sample ports (8 and 9, fig. III-1). In the Sequential Mode and Count Mode, the samples are always drawn from the Sample port. The pump exhaust exits through the Exhaust port (10, fig. III-1).

Battery compartment

The battery pack is installed at the back of the PORTACOUNT in the battery compartment (14, fig. III-2). A connector in the battery compartment plugs into the battery.

Battery cover. A removable plastic cover fits over the battery compartment (15, fig. III-2).

Latch clip. A latch clip holds the battery cover in place (16, fig. III-2).

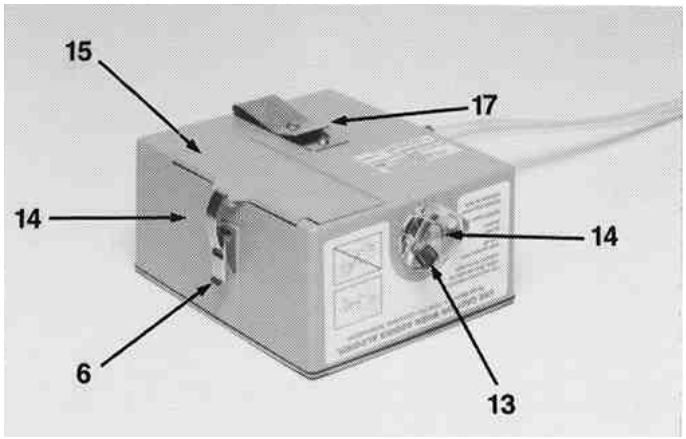

Figure III-2.
Parts and functions of the PORTACOUNT

Alcohol fill cap

The alcohol fill cap at the bottom of the PORTACOUNT (13, fig. III-1) unscrews to reveal the alcohol fill port.

Serial interface connector

The connector on the side of the PORTACOUNT outputs serial data to a datalogger, computer, or printer (12, fig. III-1).

Belt clip

The belt clip on the back of the PORTACOUNT (17, fig. III-2) can also be used to hold the PORTACOUNT on its stand.

Alcohol fill indicator

The alcohol fill indicator (21, fig. III-1) turns white when the PORTACOUNT is low on alcohol. It is dark colored when the alcohol level is adequate.

IV
The Fit-Test Mode

Chapter IV, *The Fit-Test Mode*, along with the following two chapters, are critical to the operation of the PORTACOUNT. They explain the instrument's three modes of operation: Read them carefully.

The PORTACOUNT quantitatively measures respirator fit by comparing the concentration of particles outside the respirator to the concentration of particles inside the respirator. The two concentrations are measured and the fit factor is calculated and displayed automatically.

WARNING:	The PORTACOUNT is designed to operate using the particles and concentrations that occur in ambient air. Using the PORTACOUNT with generated aerosols (DOP, corn oil, smoke, etc.) will dirty the optics, requiring factory service. The PORTACOUNT should be used with a diluter when sampling with generated aerosols. TSI recommends using the PORTACOUNT only with ambient air.

To measure the fit factor, it is necessary to sample air from within the respirator. This is accomplished by using a respirator with a sampling port. Almost all respirator manufacturers can supply respirators with sampling ports for quantitative fit-testing purposes.

Caution:	To achieve proper results in fit testing, the respirator being tested must be equipped with a HEPA filter(s). The test subject should not smoke for at least 30 minutes before the test.

When measuring respirator fit, it is important that any particles measured inside the respirator actually leaked around the face seal into the respirator and did not originate from some other source. Therefore, the respirator being fit-tested should be equipped with a HEPA filter(s). If a HEPA filter is not used, particles that leak through the filter will be sampled inside the respirator, giving a low measured fit factor. It is also important that the test subject not smoke before the fit test. Tests have shown that smokers exhale smoke for up to 30 minutes after smoking. The smoke particles are then sampled inside the respirator, resulting in lower measured fit factors.

- ✦ If the PORTACOUNT is to be used for testing respirators in a positive-pressure mode, precautions must be taken to ensure the supplied air is particle-free. This can be accomplished by installing a HEPA filter in the air supply line.

The integral blower in a powered air purifying respirator (PAPR) could generate some particles which would need to be eliminated as well.

Zero-checking the PORTACOUNT

The PORTACOUNT should be zero-checked each day it is used to ensure that there are no leaks in the instrument or in the sampling system. If fit tests are performed with leaks, the fit factors will be measured low.

Zero-checking the PORTACOUNT is easy. Follow the three-step procedure listed below.

Step 1. Attach the supplied HEPA filter to the Sample hose (labelled S) on the twin-tube assembly. The arrow on the filter indicates the direction of flow (fig. IV-1).

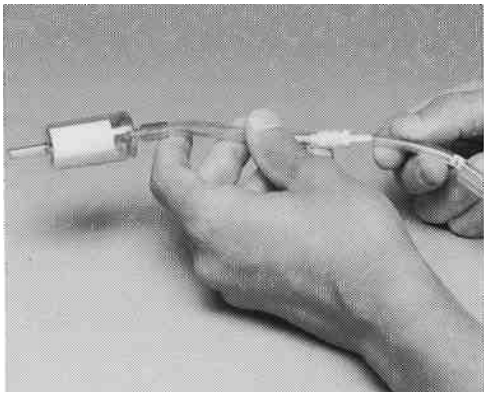

Figure IV-1. Zero-checking the PORTACOUNT

Step 2. Set the instrument to the Count Mode.

Step 3. Watch the display. The concentration should go to zero within 30 seconds. If not, there is a leak that must be found and eliminated before performing fit tests.

Test sequence

In the Fit-Test Mode, the PORTACOUNT automatically samples both the ambient air and the particles inside the respirator. An internal switching valve automatically switches between the two sampling ports. In each 80-second test cycle, both an ambient sample and a respirator sample are taken. Also, time is allowed for purging the sensor between each of the samples.

Caution:	The twin-tube assembly is designed to purge properly in the time allowed in the test sequence. Lengthening the tubes may cause problems with purging the sensor and the tubes between samples.

The test starts when you press the ENABLE and TEST keypads. The first test cycle lasts 9 seconds longer than subsequent test cycles since an extra ambient air sample is taken. Table 1 shows the test sequence for the PORTACOUNT in the Fit-Test Mode.

TABLE 1. Test sequence in the Fit-Test Mode

Action	Time	Notes
Purge	4 seconds	Test started
Ambient sample	5 seconds	
Purge	11 seconds	
Respirator sample	60 seconds	
Purge	4 seconds	
Ambient sample	5 seconds	
Display fit factor		First cycle completed
Purge	11 seconds	
Respirator sample	60 seconds	
Purge	4 seconds	
Ambient sample	5 seconds	
Display fit factor		Second cycle completed
Purge	11 seconds	
•	•	
•	•	
•	•	
Respirator sample	60 seconds	
Purge	4 seconds	
Ambient sample	5 seconds	
Display fit factor		*n*th cycle completed
Display overall fit factor		Test completed

The test cycle repeats until you stop the test by pressing the ENABLE and TEST keypads. The overall fit factor is then displayed.

Reading the display

The fit factor is displayed in scientific notation using a two-digit mantissa and one-digit exponent. The format is a.bEc where a.b is the mantissa and c is the exponent. This corresponds to $a.b \infty 10^c$.

To convert from scientific notation, multiply the two-digit mantissa by 10 raised to the *c* power; thus, $1.2E4 = 1.2 \infty 10^4 = 1.2 \infty 10{,}000 = 12{,}000$. Table 2 shows the value of 10^c for various values of c.

TABLE 2. Values of 10^c

Exponent (c)	10^c	Multiplier
0	10^0	1
1	10^1	10
2	10^2	100
3	10^3	1,000
4	10^4	10,000
5	10^5	100,000

Calculating the fit factor

Fit factor is defined as the concentration outside the respirator divided by the concentration inside the respirator.

In the PORTACOUNT, the ambient concentration is measured for 5 seconds and the respirator concentration for 60 seconds in each test cycle. Because ambient concentration can vary over time, the PORTACOUNT calculates the fit factor by taking the average of the ambient concentrations measured before and after the respirator sample and then dividing by the concentration measured in the respirator. This is why the first test cycle is longer than additional test cycles in the Fit-Test Mode. It is necessary to measure the required additional ambient concentration sample before the first fit factor can be calculated.

Both the ambient and respirator concentrations are determined by integration. The integrated concentrations are determined by the total number of particles counted during the sample periods.

Fit factor is actually calculated by:

$$FF = \frac{C_B + C_A}{2C_R} \tag{1}$$

where FF = fit factor
C_B = particle concentration in the ambient sample before the respirator sample
C_A = particle concentration in the ambient sample after the respirator sample
C_R = particle concentration in the respirator sample.

If no particles are counted in the respirator sample, the PORTACOUNT automatically adds one particle. This prevents dividing the ambient concentration by zero and obtaining a fit factor of infinity.

At the end of a fit test, the overall fit factor is calculated and displayed, based on the individual fit factors for each test cycle and calculated according to ANSI Z88.2 (1980). Equation 2 gives the calculation:

$$Overall\ \ FF = \frac{100}{s/n} \tag{2}$$

where s = sum of the penetrations for each test cycle in percent
n = number of test cycles.

Written in expanded form, equation 2 yields equation 3:

$$Overall\ \ FF = \frac{100}{(\%P_1 + \%P_2 + \%P_3 + \ldots + \%P_{n-1} + \%P_n)/\ n} \tag{3}$$

where $\%P$ = penetration in percent for each test cycle.

Multiplying both the numerator and denominator by n and dividing the numerator and denominator by 100 yields equation 4:

$$Overall\ \ FF = \frac{n}{p_1 + p_2 + p_3 + \ldots + p_{n-1} + p_n} \tag{4}$$

where p = penetration for each test cycle

Since fit factor is the inverse of penetration, equation 4 can be written as:

$$Overall\ \ FF = \frac{n}{\frac{1}{FF_1} + \frac{1}{FF_2} + \frac{1}{FF_3} + \ldots + \frac{1}{FF_{n-1}} + \frac{1}{FF_n}} \tag{5}$$

where FF = fit factor for each test cycle
n = number of test cycles.

Equation 5 is used to calculate the overall fit factor in the PORTACOUNT.

Pass/fail indication

At the end of each test cycle, a pass/fail indication is given for that cycle. Either a green light comes on next to PASS on the front panel, or a red light comes on next to FAIL. PASS means that the measured fit factor is greater than or equal to the set pass/fail level.

At the end of a fit test when the overall fit factor is displayed, an overall pass/fail indication is given. PASS means that the overall fit factor is greater than or equal to the set pass/fail level.

Setting pass/fail levels

The PORTACOUNT is shipped from the factory with the pass/fail level set at '100', although it can be set to many different levels. To set a different level, follow these four steps:

Step 1. Make sure the instrument is switched off. Using a slotted screwdriver, remove the four screws on the front cover.

Step 2. Carefully lift the front cover to expose the printed circuit board and DIP switches (fig. IV-2).

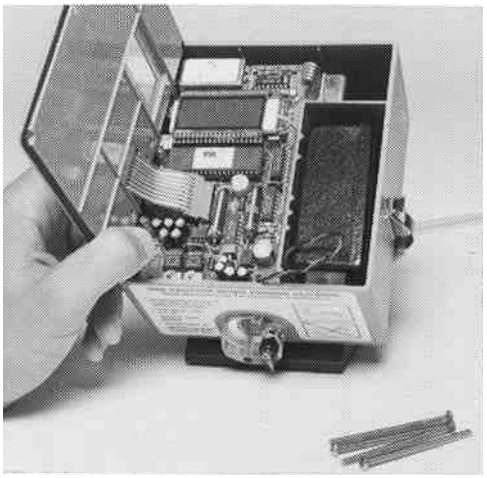

Figure IV-2. Removing the front cover

Step 3. Set the DIP switches to the desired pass/fail level. Table 3 gives the settings for the different levels (fig. IV-3).

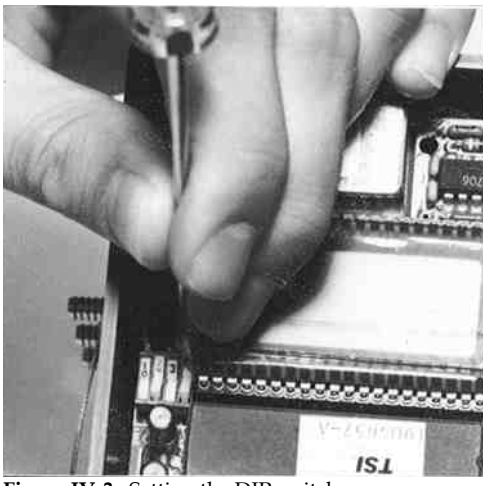

Figure IV-3. Setting the DIP switches

Step 4. Replace the front cover and four screws, making sure the membrane switch remains connected.

TABLE 3. Pass/fail level settings

Fit Factor	SW1	SW2	SW3	SW4
0*	off	off	off	off
Factory Setting 100	off	off	off	on
250	off	off	on	off
500	off	off	on	on
1000	off	on	off	off
1250	off	on	off	on
1667	off	on	on	off
2000	off	on	on	on
4000	on	off	off	off
5000	on	off	off	on
6667	on	off	on	off
10,000	on	off	on	on
Reserved	on	on	off	off
Reserved	on	on	off	on
Reserved	on	on	on	off
Reserved	on	on	on	on

*Setting the pass/fail level to zero effectively disables the pass/fail indication: The pass indicator will always light. This setting can be used when the desired pass/fail level is not available or when the PORTACOUNT is used with the optional fit-test software and microcomputer.

V
The Sequential Mode

In the Sequential Mode, the PORTACOUNT is used to manually take two samples in sequence. This mode is useful for testing filter banks or similar items where it is not possible to simultaneously connect the twin-tube assembly to the upstream and downstream sides of the item being tested. The Sequential Mode lets you sample the concentration upstream of a filter, and then move to the downstream side and sample the concentration. The PORTACOUNT then calculates and displays the filtration factor.

Test sequence

In the Sequential Mode, the PORTACOUNT sequentially measures and stores two concentrations (typically upstream and downstream of a filter), and then calculates and displays the filtration factor. The Sample port is used for both samples. The PORTACOUNT samples for 30 seconds during each of the two concentration measurements and stores the total number of particles counted in each sample.

When the instrument is switched to the Sequential Mode, a 1 appears on the display. It means that the instrument is ready to take the first, or upstream, sample. Press the ENABLE and TEST keypads to start the first test cycle.

When this cycle is completed, a 2 appears on the display. It means that the instrument is ready to take the second, or downstream, sample. Press ENABLE and TEST to start the second test cycle. At the conclusion of the second test cycle, the filtration factor is calculated and displayed. Table 4 lists the test cycle in the Sequential Mode.

- ✦ No purge time is programmed into the test cycle in the Sequential Mode. To ensure accurate measurements, it is important that you allow the PORTACOUNT to draw a sample from the desired sampling location for at least 30 seconds before starting a measurement cycle. This ensures that the PORTACOUNT and twin-tube assembly are properly purged.

TABLE 4. Test sequence in the Sequential Mode

Action	Time	Notes
Display 1		Ready for first sample
Upstream sample	30 seconds	
Display 2		Ready for second sample
Downstream sample	30 seconds	
Display filtration factor		Test completed

- ✦ To conserve battery life, the PORTACOUNT automatically switches off if it is left running for 10 minutes in the Sequential Mode without starting a test. This is also done if more than 10 minutes elapse between the time of the first (upstream) sample and the start of the second (downstream) sample.

Reading the display

The filtration factor is displayed in scientific notation using a two-digit mantissa and one-digit exponent. The format is a.bEc where a.b is the mantissa and c is the exponent. This corresponds to $a.b \infty 10^c$.

To convert from scientific notation, multiply the two-digit mantissa by 10 raised to the *c* power; thus, $1.2E4 = 1.2 \infty 10^4 = 1.2 \infty 10{,}000 = 12{,}000$. Table 2 shows the value of 10^c for various values of c.

Calculating the filtration factor

The filtration factor, which is defined as the particle concentration upstream of the filter divided by the particle concentration downstream of the filter, is equivalent to the inverse of *filter penetration*.

In the PORTACOUNT, each of the concentrations is sampled for 30 seconds. Both the upstream and downstream concentrations are determined by integration. The concentrations are determined by the total number of particles counted during the sample periods. Since the flowrate is the same for both samples, it cancels out in the calculation. The filtration factor is then calculated by equation 6:

$$FF = \frac{NP_U}{NP_D} \tag{6}$$

where FF = filtration factor
NP_U = number of particles counted in the upstream sample
NP_D = number of particles counted in the downstream sample.

If no particles are counted in the downstream sample, the PORTACOUNT automatically adds one particle to prevent dividing the upstream concentration by zero and obtaining a filtration factor of infinity.

To calculate penetration from the filtration factor, use the following equation:

$$p = \frac{1}{FF} \tag{7}$$

where p = penetration.

Percent penetration is then calculated by

$$\%P = p \times 100 = \frac{100}{FF} \tag{8}$$

where $\%P$ = percent penetration.

VI
The Count Mode

In the Count Mode, the PORTACOUNT directly measures and displays the concentration of the aerosol being drawn through the Sample port in units of particles per cubic centimeter. It can accurately measure concentrations as high as 500,000 particles per cubic centimeter.

Averaging modes

In the Count Mode, there is a 1-second and a 15-second averaging mode. In the 1-second mode, the PORTACOUNT calculates and displays the particle concentration every second. In the 15-second mode, the PORTACOUNT calculates and displays the concentration every 15 seconds. To switch between modes, simultaneously press the ENABLE and TEST keypads while in the Count Mode.

Reading the display

The particle concentration is displayed in scientific notation using a two-digit mantissa and one-digit exponent. The format is a.bEc, where a.b is the mantissa and c is the exponent. This corresponds to $a.b \infty 10^c$.

To convert from scientific notation, multiply the two-digit mantissa by 10 raised to the *c* power; thus, $1.2E4 = 1.2 \infty 10^4 = 1.2 \infty 10{,}000 = 12{,}000$. Table 2 shows the value of 10^c for various values of c.

Calculating the concentration

The particle concentration is displayed in units of particles per cubic centimeter. Because the PORTACOUNT is a single-particle counting instrument, the concentration measurement is a direct measurement and does not require calibration.

The particle concentration is calculated by dividing the number of particles counted by the volume of air. The volume of air is the flowrate multiplied by the sampling time. Depending on which averaging time is used, the sampling time is either 1 or 15 seconds. The flowrate through the PORTACOUNT sensor is 0.1 liter per minute, or 1.67 cubic centimeters per second. The resulting equation for calculating particle concentration then becomes:

$$\frac{NP}{ST \times 1.67} \tag{9}$$

where NP = number of particles counted during the sampling time
ST = sampling time (either 1 or 15 seconds).

This means that in the 1-second averaging mode, a single particle would be measured as 0.6 particles per cubic centimeter; in the 15-second averaging mode, a single particle would be measured as 0.04 particles per cubic centimeter. These concentrations represent the minimum resolution of the PORTACOUNT in the Count Mode.

WARNING: The alcohol indicator must be dark for the reading in Count Mode to be accurate.

VII
Serial Interface

The PORTACOUNT includes a serial interface that can be set internally to transmit at either RS-232-C or TTL voltage levels. When shipped from the factory, it is set to transmit at RS-232-C voltage levels.

The PORTACOUNT can be interfaced directly to a printer, microcomputer, or digital datalogger via the serial interface. Table 5 shows the communication parameters for the serial interface.

TABLE 5. Communication parameters of the serial interface

Baud rate	1200
Start bits	1
Data bits	8
Stop bits	1
Parity	none
Handshaking	none
Encoding	ASCII

Serial interface outputs

The output of the serial interface varies with each of the operating modes. In general, however, it outputs a description, a value, and measurement units each time data is transmitted. Descriptions of the output follow for each operating mode and for the error messages.

The fit factors and concentrations are output in scientific notation with a three-digit mantissa and a one-digit exponent. The format is a.bdEc, where a.bd is the mantissa and c is the exponent. This corresponds to $a.bd \infty 10^c$.

To convert from scientific notation, multiply the three-digit mantissa by 10 raised to the *c* power; thus, $1.23E4 = 1.23 \infty 10^4 = 1.23 \infty 10{,}000 = 12{,}300$. Table 2 shows the value of 10^c for various values of c.

Each message output through the serial interface is followed by a carriage return and a line feed.

The Fit-Test Mode. The serial interface outputs a new test message and the pass/fail level at the beginning of each test. The fit factor and pass/fail indication are output at the end of each test cycle. Each of the measured ambient and respirator concentrations are output too. The overall fit factor and pass/fail indication are output at the end of a test. Table 6 shows the serial interface output for a fit-test with two test cycles.

TABLE 6. Serial interface output in the Fit-Test Mode

NEW TEST	PASS = 1.00 E2	Test started
Ambient	1.10 E4 #/cc	
Mask	5.43 E1 #/cc	
Ambient	1.12 E4 #/cc	First cycle completed
FF	2.04 E2 PASS	First fit factor
Mask	4.79 E1 #/cc	
Ambient	1.09 E4 #/cc	Second cycle completed
FF	2.31 E2 PASS	Second fit factor
Overall FF	2.16 E2 PASS	Overall fit factor

The Sequential Mode. In the Sequential Mode, the serial interface outputs the measured upstream and downstream concentrations, and then the calculated filtration factor. Table 7 shows a sample serial interface output in the Sequential Mode.

TABLE 7. Serial interface output in the Sequential Mode

Upstream	1.26 E4 #/cc
Downstream	4.73 E1 #/cc
FF	2.66 E2

The Count Mode. In the Count Mode, the serial interface outputs the measured concentrations in particles per cubic centimeter. In the 1-second averaging mode, the concentration is output as follows:

```
Conc.        1.28 E4 #/cc
```

In the 15-second averaging mode, the concentration is output as follows:

```
Avg. Conc.   1.28 E4 #/cc
```

- ✦ In the 1-second averaging mode, the MODEL 8902 Printer cannot print fast enough to keep up with the serial interface. Only every other value will be printed.

Error messages. The serial interface also outputs the two error messages. When the E--E message appears, the serial interface outputs a low-particle-count message along with the measured ambient concentration. The serial interface output reads as follows:

```
Ambient      Low Particle Count
1.67 E0 #/cc
```

When the LO message appears, the serial interface outputs a low battery-power message. The serial interface output reads as follows:

```
Low Battery
```

Interfacing to a microcomputer

A TSI MODEL 8905-9 or 8905-25 Interface Cable is used to connect the PORTACOUNT to an IBM or IBM-compatible microcomputer that has an RS-232-C interface port. Note that the microcomputer can read the PORTACOUNT serial interface only if its RS-232-C port is properly initialized.

Two methods are available; both require a MODEL 8905-9 or 8905-25 Interface Cable, or their equivalents. One method is accomplished from within a BASIC language computer program, using the OPEN command. Before PORTACOUNT communications begin, execute the following BASIC statement:

```
OPEN "COM1:1200,N,8,1" AS #1
```

The other method for initializing the RS-232-C port uses the DOS MODE command. Before PORTACOUNT communications begin, execute the following DOS command:

```
MODE COM1:1200,N,8,1
```

The following sample BASIC program reads the PORTACOUNT output and displays it on the screen:

```
10   '*** PROGRAM TO READ AND DISPLAY PORTACOUNT OUTPUT ***
20   '
30   CLS                          'CLEAR SCREEN
40   OUT 1021,96                  'CLEAR STATUS PORT
50   OPEN "COM1:1200,N,8,1" AS #1 'OPEN COMMUNICATIONS
60   INPUT #1,A$                  'INPUT DATA IN STRING FORMAT
70   PRINT A$                     'PRINT RESULTS
80   GOTO 60                      'LOOP BACK FOR MORE DATA
```

- If you plan to write your own programs to communicate with the PORTACOUNT, keep in mind that no "handshaking" takes place between the microcomputer and the PORTACOUNT. This means that the PORTACOUNT transmits data whenever it is ready, regardless of the microcomputer's readiness to receive data. To make certain no data is lost, be sure that the program is *receiving* when the PORTACOUNT is *transmitting*. This is fairly easy to do since the PORTACOUNT transmits at predictable intervals. To see firsthand what the transmission intervals are, connect the PORTACOUNT to a microcomputer and run the sample BASIC program listed above; or, connect the PORTACOUNT to a serial printer, such as the MODEL 8902. Refer to Chapter IV of this manual for the test-cycle timing in the Fit-Test Mode. The concentration data is output approximately 2 seconds after the end of each sample in the test cycle, and the fit factor is output approximately 2 seconds after the ambient concentration.

VIII
Printer

The optional MODEL 8902 Printer is compact, portable, and extremely versatile. It can print out PORTACOUNT data wherever testing is being performed. It can also be connected to a microcomputer through a serial interface port.

Using the printer

To activate the printer, press and release the right side of the power switch. It will return to the center ON position. The power LED comes on and a READY message is printed, indicating that its internal microprocessor is operating properly. When you switch off the printer, be sure to wait at least 3 seconds before switching it on again.

The printer stores characters for printing until one of two events occur: (1) Its character-holding buffer becomes full; (2) It receives a line feed (hexadecimal 0A) or a carriage return code (hexadecimal 0D).

When either occurs, the printer prints out the contents of its character buffer. If the buffer is empty when the carriage return is received, the paper simply advances one line, leaving a blank line in the printout. The PORTACOUNT serial output automatically provides the required line feeds and carriage returns to operate the printer properly.

The printer has a graphics mode and a reverse-field mode. Note that printing with patterns having high dot density wears out the print head faster. It is recommended that you use patterns in which dot density is equal to that of ordinary alphanumerics.

Caution: During operation, do not subject the printer to temperatures below 23˚F [5˚C] or above 104˚F [40˚C], or to sudden changes in temperature. Never place the printer where it is exposed to direct sunlight.

WARNING:
- ❑ Never apply power while you are plugging or unplugging an input connector.
- ❑ Do not print without paper and/or ribbon; you may damage the print head.

The self-test mode

The three steps of the printer's self-test mode are performed as follows:

WARNING:	Perform the self-test only after inserting paper into the printer.

Step 1. Depress the right side of the power switch until it reaches the paper feed position.

Step 2. Hold the switch in the paper feed position until the LED comes on and the printer starts to operate. Release the switch.

Step 3. There are two ways to stop the printer. Either turn the power switch to the OFF position during printing (and wait 3 seconds before depressing the power switch to ON again), or simply allow printing to continue until it stops automatically.

Changing the ribbon

When printing becomes faint, replace the cartridge ribbon. Spare cartridge ribbons are available as part of the MODEL 8904 Printer Supplies Kit.

- ✦ If the printer is used infrequently, the print impression sometimes weakens because the ribbon dries out. If the print is difficult to read and you suspect a dry ribbon is the cause, press the POWER switch to the PAPER FEED position to advance the ribbon to a better inked portion.

To replace the cartridge ribbon, follow these six steps:

Step 1. With the printer switched off, push down on the left side of print mechanism cover and remove the cover (fig. VIII-1).

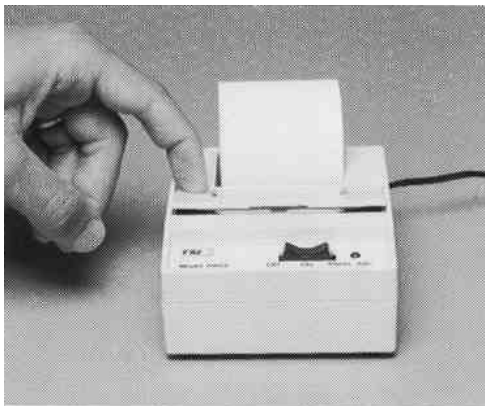

Figure VIII-1. Removing the print mechanism cover

Step 2. Push down on the right side of the cartridge ribbon (marked PUSH) and remove the cartridge (fig. VIII-2).

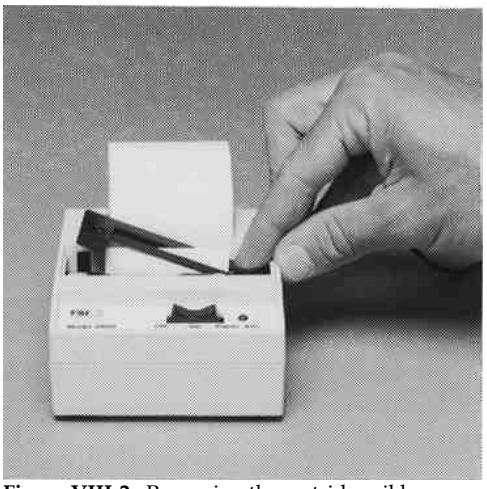

Figure VIII-2. Removing the cartridge ribbon

Step 3. Install the new cartridge ribbon. Be sure the cartridge is inserted firmly to prevent weak or irregular printing. For best printing results, be careful to properly seat and align the cartridge (fig. VIII-3).

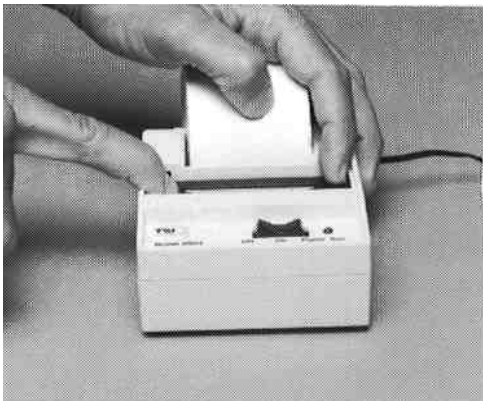

Figure VIII-3. Installing the cartridge ribbon

Step 4. Turn the cartridge knob (marked by an arrow) clockwise to remove any slack from the ribbon (fig. VIII-4).

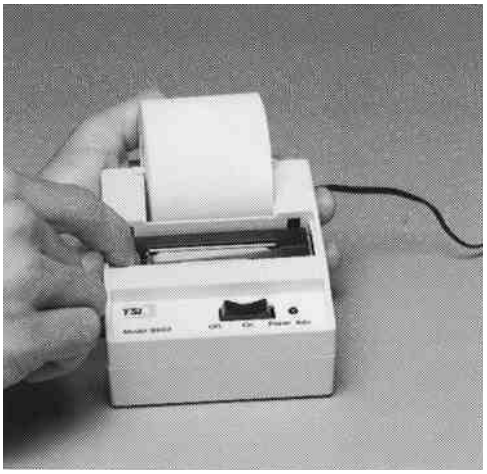

Figure VIII-4. Removing slack from the ribbon

Step 5. Replace the print mechanism cover.

Step 6. Replace the printer paper.

The cartridge ribbon may also be replaced with paper in the printer. By holding the cartridge ribbon as shown in figure VIII-5, you can slide the cartridge over the paper and into the printer compartment. Be sure the paper slides between the ribbon cartridge and the ink ribbon.

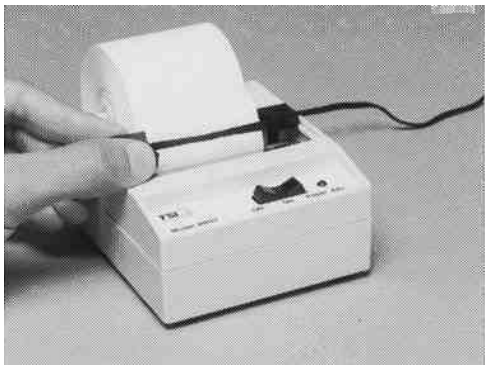

Figure VIII-5.
Installing the cartridge ribbon with paper in the printer

- ✦ If you get ribbon ink on the printer's plastic case, wipe it off immediately. Once dried, it is difficult to remove.

Installing a paper roll

Spare paper rolls are available as part of the MODEL 8904 Printer Supplies Kit. To install a new roll of paper, follow these eleven steps:

Step 1. Unroll several inches of the new paper roll.

Step 2. If jagged, cut a straight edge on the paper roll to ease its entry into the printer.

Step 3. Be sure the printer is switched off. Slide the paper through the slot connecting the paper compartment and the printer compartment. You can slide it in about ¼-inch before it stops (fig. VIII-6).

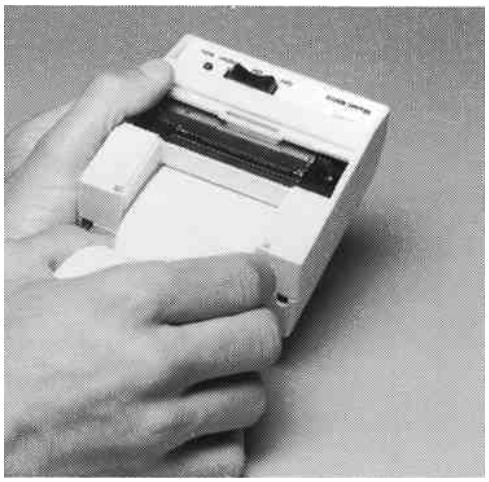

Figure VIII-6. Inserting paper into the printer

Step 4. Press and release the right side of the power switch and wait a few seconds.

Step 5. While holding the paper in place, press the power switch to the PAPER FEED position. A rubber roller then pulls the paper into the printer compartment. Hold the switch in the PAPER FEED position until about 1 inch of paper emerges from the top of the printer mechanism. Then release the power switch (fig. VIII-7).

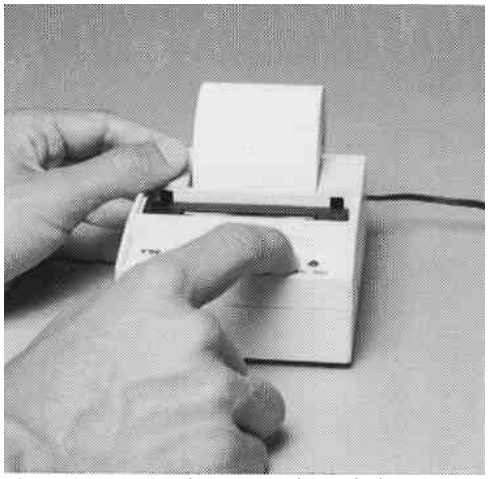

Figure VIII-7. Feeding paper through the printer

Step 6. Now pull the paper through the printer until several inches are exposed (fig. VIII-8).

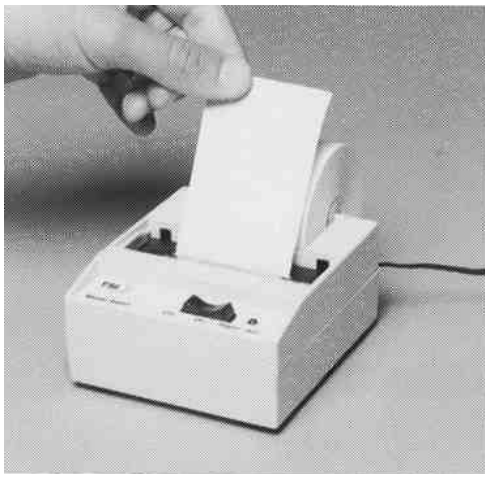

Figure VIII-8. Pulling paper through the printer

Step 7. Slide the paper through the slot in the printer cover (fig. VIII-9).

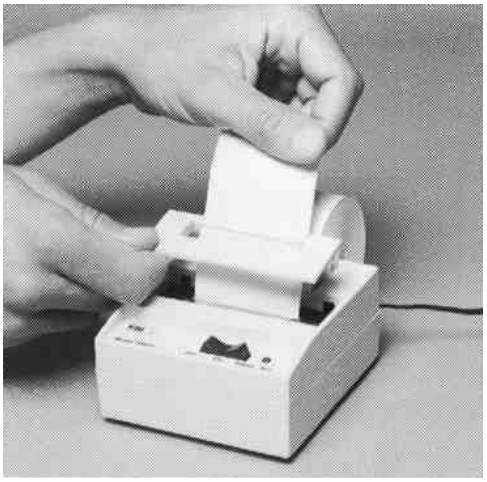

Figure VIII-9. Sliding paper through the printer cover

Step 8. Push the back of the printer cover down and into place (fig. VIII-10).

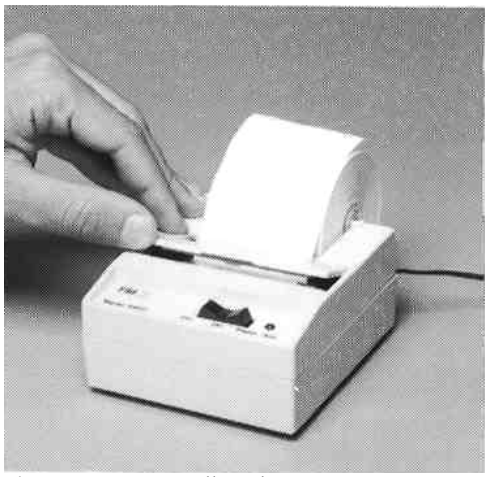

Figure VIII-10. Installing the printer cover

Step 9. Press down the front of the printer cover to lock it in place (fig. VIII-11).

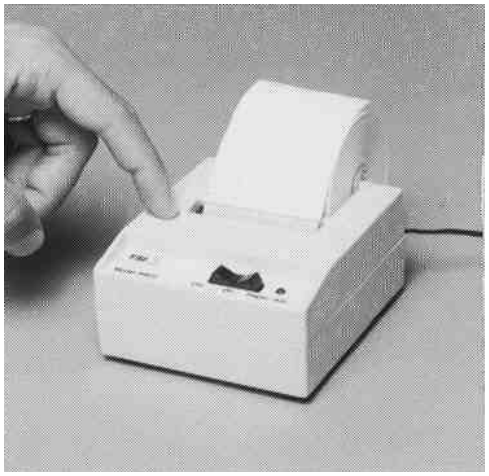

Figure VIII-11. Locking down the printer cover

Step 10. Put the paper spindle into the paper roll and press the roll with the spindle into the clips near the back of the printer (fig. VIII-12).

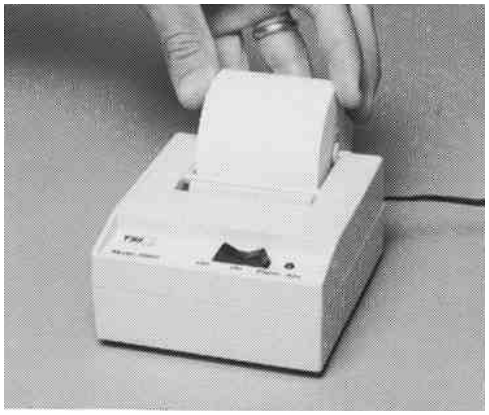

Figure VIII-12. Installing the paper spindle

Step 11. Rotate the roll to take up any slack. Make sure it turns freely. If not, the paper will jam and perhaps damage the printing mechanism.

The paper roll installation process is now complete.

Removing a paper roll

To remove a roll of paper, follow these four steps:

WARNING:	Do not pull the paper out of the back of the printer. The printing mechanism will be damaged.

Step 1. Use the paper feed switch to advance the paper about one inch beyond the paper cutter (fig. VIII-13).

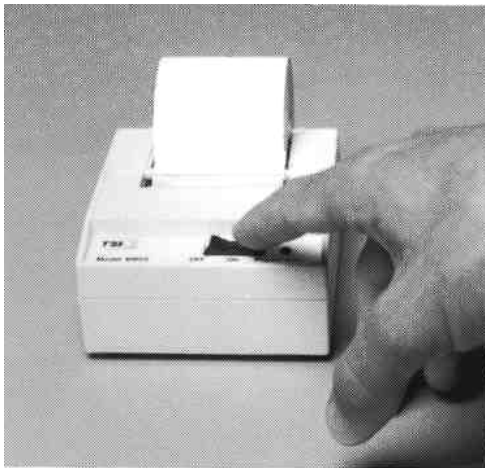

Figure VIII-13. Advancing the paper

Step 2. Lift the paper roll away from the printer housing.

Step 3. With a scissors, cut the paper that is fed to the printer. Make the cut as square as possible to ease reloading (fig. VIII-14).

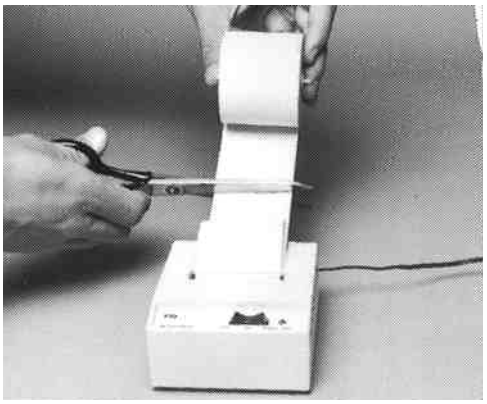

Figure VIII-14. Cutting the paper

Step 4. Pull the remaining paper through the printer mechanism. Be sure to pull out the paper from the front (paper cutter side).

The paper roll removal process is now complete.

IX
AC Adapter

Installation Instructions

Note: The MODEL 8018 AC Adapter is an optional accessory and may not have been purchased with your PORTACOUNT.

The MODEL 8018 AC Adapter consists of two parts; a power supply that converts 115 volts AC (or 220 volts AC for 220 volt AC Adapters) to 5 volts DC and an electronics module that contains circuitry for noise and spike suppression. The noise and spike suppression are needed to protect the sensitive laser diode inside the PORTACOUNT (fig. IX-1).

Figure IX-1. Model 8018 AC Adapter

Step 1. Remove the battery cover and battery from your PORTACOUNT. Store the battery cover in the PORTACOUNT carrying case so that it will be available in case you need to use batteries again in the future.

Step 2. Connect the battery connector from inside the PORTACOUNT to the electronics module as shown in figure IX-2. Make sure the polarity is correct. The connector should mate easily, you should not need to force it into place.

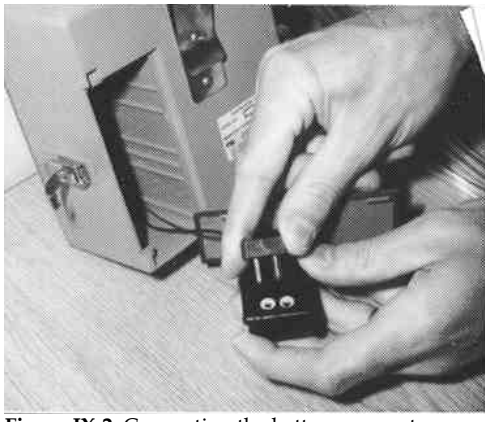

Figure IX-2 Connecting the battery connector

Step 3. Insert the electronics module into the battery compartment and latch the cover in place.

Step 4. Plug the small connector from the power supply into the socket located on the outside of the cover. The label on the connector marked "UP " refers to the top of the PORTACOUNT. The socket has been located so that the stand may still be used to hold the PORTACOUNT (fig. IX-3).

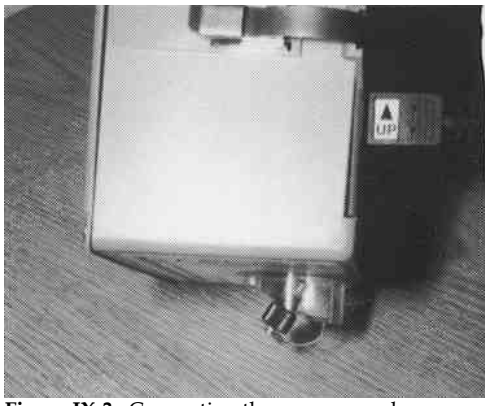

Figure IX-3. Connecting the power supply

Step 5. Plug the power supply into an AC outlet. Make sure you use a 115 volt AC outlet for 115-volt power supplies and a 220-volt AC for 220-volt power supplies. Your PORTACOUNT is now ready for use without batteries.

X
Maintenance

Adding alcohol

Alcohol should be added when the PORTACOUNT is first received new from TSI and whenever the alcohol indicator turns white. The instructions below describe how to add alcohol to the PORTACOUNT. Do not add alcohol if the fill indicator is dark. If the fill indicator is white, fill the PORTACOUNT using the procedure below. During operation, when the fill indicator first begins to turn white, the PORTACOUNT will operate approximately 45 minutes before the low particle count 'E--E' message appears.

WARNING:

- ❏ PORTACOUNTs should always be shipped dry as a precaution against inadvertent flooding. To dry a PORTACOUNT you should run it in COUNT mode until the alcohol fill indicator is a solid white color. This may take several hours.
- ❏ *Never* add alcohol to the PORTACOUNT when the fill indicator is dark. *Do not* continue to add alcohol once the fill indicator has turned from white to dark. ***Caution:*** Alcohol is extremely flammable. *Do not* fill near open flame or source of ignition.
- ❏ *Never* fill the PORTACOUNT with alcohol other than 100% reagent grade iso-propyl alcohol.

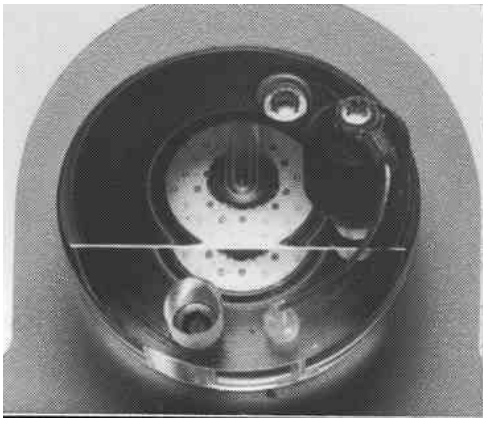

Figure X-1. Alcohol indicator white (dry)

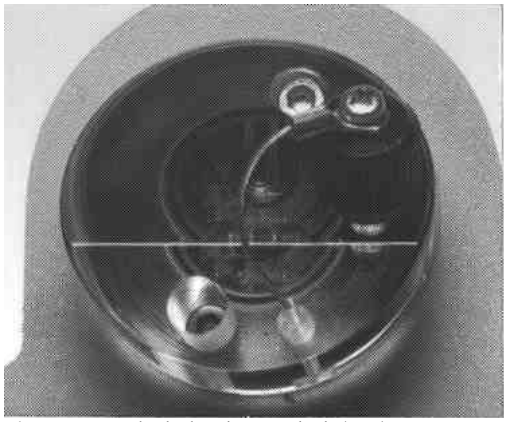

Figure X-2. Alcohol indicator dark (wet)

Step 1. Turn the PORTACOUNT off and remove the alcohol fill cap (fig. X-3).

Figure X-3. Removing the alcohol fill cap

Step 2. Open a disposable TSI alcohol bottle by twisting the top off. Place the short plastic tube stub onto the end of a syringe and then connect the other end of the tube stub to the neck of the alcohol bottle (fig. X-4).

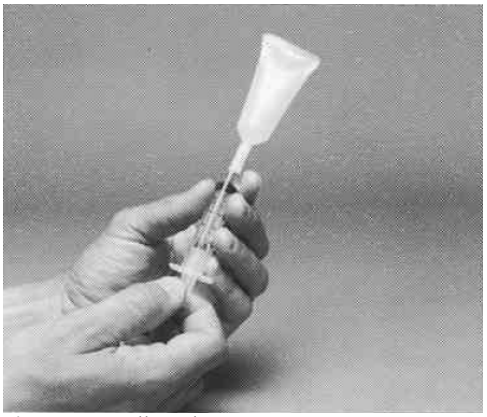

Figure X-4. Filling the syringe

Step 3. Draw about 5 cc of alcohol into the syringe. Remove the tube stub from the syringe. If the alcohol bottle is not empty you may recap it and store it for later use.

Step 4. Insert the end of the syringe into the alcohol fill port on the PORTACOUNT. Make sure the syringe is inserted at the correct angle. The syringe will remain in place without support if the angle is correct (fig. X-5).

Figure X-5. Inserting the syringe

Step 5. While observing the alcohol fill indicator, gently and slowly inject alcohol into the PORTACOUNT. *Stop filling the moment the indicator turns dark.* This may happen before the syringe is empty. Observe the following precautions while filling (fig. X-6):

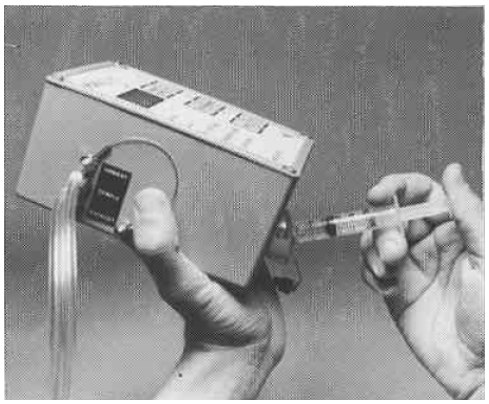

Figure X-6. Injecting the alcohol

- *Never* fill when the PORTACOUNT is on.
- *Never* tip the PORTACOUNT backwards further than horizontal while filling.
- *Never* inject air into the PORTACOUNT fill port.
- *Never* fill the PORTACOUNT if the alcohol indicator is dark. Stop filling the moment the alcohol indicator changes from white to dark.

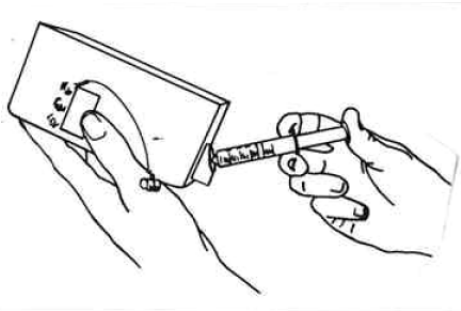

Figure X-7. Correct angle for filling

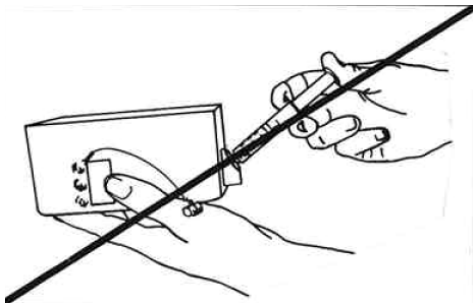

Figure X-8. Wrong angle for filling

Note: The PORTACOUNT will consume alcohol at the approximate rate of one cc per hour.

Charging battery packs

To charge a PORTACOUNT battery pack, follow these three steps:

Step 1. Remove the battery charger and a battery pack from the carrying case.

Step 2. Plug the battery connector (from the battery charger) into the battery pack. The connector fits only one way.

Step 3. Plug the charger into an outlet. Charge the battery pack for at least six hours to fully charge the battery.

- ♦ Battery packs should not be stored in discharged condition. This can affect their ability to take a charge.

Changing battery packs

Under normal conditions, a fully charged battery pack will last for about 5 hours of operation. A LO message appears when the battery's voltage drops too low; at that point, change the battery pack. Follow this five-step procedure:

Step 1. Open the latch clip and remove the battery cover (fig. X-9).

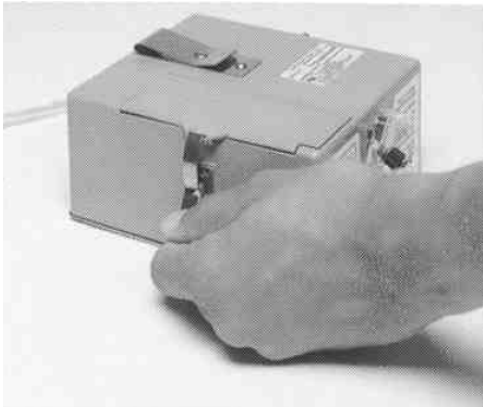

Figure X-9. Removing the battery cover

Step 2. Remove the battery pack from the battery compartment and unplug the battery connector.

Step 3. Plug the battery connector into the new battery pack. The connector fits only one way (fig. X-10).

Figure X-10. Plugging in the battery connector

Step 4. Insert the battery pack into the battery compartment in the orientation shown (fig. X-11).

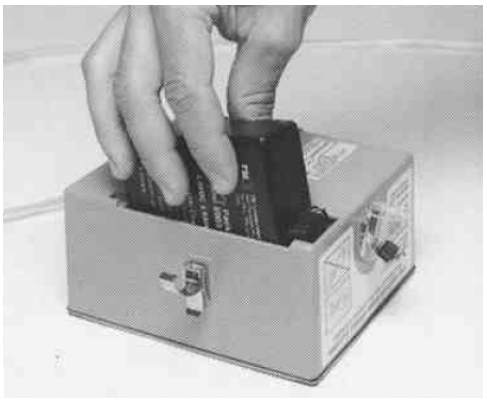

Figure X-11. Installing the battery pack

Step 5. Replace the battery cover and fasten the latch clip.

The battery pack replacement process is now complete.

Storage and shipment

Short-term storage. For periods of less than 14 days, no special preparations are necessary other than making sure the PORTACOUNT is stored in an upright position. This is a precaution to avoid the possibility of having alcohol pool inside the optics section of the PORTACOUNT resulting in a flooded instrument. Note that the cut-out inside the PORTACOUNT carrying case is designed to hold the PORTACOUNT in an upright position while the case is being carried or stored vertically.

Long-term storage or shipment. For periods longer than 14 days or when preparing the PORTACOUNT for shipment, it is essential that any alcohol inside the instrument be allowed to evaporate. *Shipping a wet PORTACOUNT will result in a flooded instrument.*

To dry the PORTACOUNT, run it in Count Mode until the alcohol indicator is a *solid white* color. This may take several hours. *Do not ship the PORTACOUNT when the indicator is dark.*

Shipping. When shipping the instrument, follow the long-term storage procedures.

XI
Troubleshooting

Table 8 lists a series of symptoms, their possible causes and recommended solutions for the PORTACOUNT. Table 9 does the same for the MODEL 8902 Printer. If your symptom is not listed, or if none of the solutions solves your problem, please contact TSI.

TABLE 8. Troubleshooting the PORTACOUNT

Symptom	Possible Causes	Solution
Does not switch on	Battery pack is discharged.	Replace the discharged battery pack with a charged pack.
	Battery connector is unplugged.	Plug the battery connector into the battery pack.
	Battery pack is not installed.	Install the battery pack.
	Membrane switch is disconnected.	Open the front cover and plug the membrane switch into the PORTACOUNT electronics.
	AC adapter not plugged in.	Connect AC adapter.
LO message appears	Battery pack is discharged.	Replace the discharged battery pack with a charged pack.
Fit factor of 1 or very low	Alcohol fill cap is loose or missing.	Tightly close the alcohol fill cap.
	Respirator is not equipped with HEPA filters.	Install HEPA filter for fit for fit testing.
	Twin-tube assembly is disconnected.	Connect the twin-tube assembly to the PORTACOUNT .
	Twin-tube assembly is not connected to respirator sampling port.	Connect the twin-tube assembly to the respirator sampling port.
	Twin-tube assembly leaks.	Repair or replace the twin-tube assembly.
	Respirator has loose filters or a malfunctioning outlet valve.	Repair the respirator.
	Switching valve is not functioning.	Have valve replaced.

TABLE 8. Troubleshooting the PORTACOUNT (continued)

Symptom	Possible Causes	Solution
E--E message appears	Ambient particle concentration is low.	In the Count Mode, check whether the concentration is less than 1000* particles/per cubic centimeter. If so, move the instrument to an area having higher concentration.
	PORTACOUNT is flooded with alcohol.	Run overnight in Count Mode to dry the optics.
	Alcohol level is low.	Add alcohol to the PORTACOUNT.
	Switching valve is not functioning.	Have switching valve replaced.
	Plugs are still in the end of the twin-tube assembly.	Remove the plugs from the end of the twin-tube assembly.
	Wrong tube is connected to respirator.	Connect the proper tube to the respirator (labelled S).
	Twin-tube assembly is kinked, pinched, or blocked.	Straighten out the twin-tube assembly or remove the obstruction.
	Hoses are reversed on twin-tube assembly.	Connect the hoses properly to the PORTACOUNT .
	Downstream sample is taken during first sampling period in the Sequential Mode.	Measure the upstream concentration during the first sampling period in Sequential Mode.
Fails zero check	Alcohol fill cap is loose or missing.	Tightly close the alcohol fill cap.
	Rubber O-ring is missing from the alcohol fill cap.	Replace the rubber O-ring on the alcohol fill cap.
	Twin-tube assembly leaks.	Repair or replace the twin-tube assembly.
	Switching valve is not functioning.	Have switching valve replaced.
	Filter leaks.	Repeat the test with a different filter.
	Ends of twin-tube assembly are poorly sealed.	Cut off the bad ends on the twin-tube assembly.
	Twin-tube assembly is disconnected.	Connect the twin-tube assembly to the PORTACOUNT.

*625 on PORTACOUNTs with Rev. A or earlier firmware
*1500 on PORTACOUNTs with Rev. B, C, or D firmware

TABLE 8. Troubleshooting the PORTACOUNT (continued)

Symptom	Possible Causes	Solution
Suspicious readings optics.	PORTACOUNT is flooded with alcohol.	Run overnight to dry the
	PORTACOUNT leaks.	Zero-check the PORTACOUNT and fix any leaks.
	Alcohol level is low.	Add alcohol to the PORTACOUNT.
	Alcohol fill cap is loose or open.	Tightly close the alcohol fill cap.
	Respirator is not equipped with HEPA filters.	Install HEPA filters for fit tests.
	Twin-tube assembly is kinked, pinched, or blocked.	Straighten out the twin-tube assembly or remove the obstruction.
	Respirator is faulty.	Fix or replace the respirator.
Alcohol visible in twin-tube assembly or coming out of exhaust port	PORTACOUNT is flooded with alcohol.	Run overnight in Count Mode to dry the optics.
Particle count is zero or near zero	PORTACOUNT is flooded with alcohol.	Run overnight in Count Mode to dry the optics.
	Alcohol level is low.	Add alcohol.
	Twin-tube assembly is blocked.	Remove the blockage.

TABLE 9. Troubleshooting the MODEL 8902 Printer

Symptom	Possible Causes	Solution
Does not switch on	AC adapter is not plugged into outlet.	Plug the AC adapter into an outlet.
	Outlet is switched off or does not have power.	Plug the AC adapter into a powered outlet.
	AC adapter is not connected to the printer.	Connect the AC adapter to the printer.
Does not print	Printer cable is not connected to the printer and the PORTACOUNT.	Connect the printer cable to the printer and PORTACOUNT.
	Baud rate is incorrectly set on the printer.	Set the baud rate on the printer to 1200.
	Printer is not switched on.	Switch on the printer.
Prints incorrectly	Baud rate is incorrectly set on the printer.	Set the baud rate on the printer to 1200.

Appendix A
Theory of Operation

The PORTACOUNT is based on a miniature, continuous-flow condensation nucleus counter (CNC). A CNC takes particles that are too small to be easily detected, grows them to a larger, easily detectable size, and then counts them.

The idea of CNCs is not new. As early as 1888, Aitken described a dust counter that grew particles to detect them. In 1943 the Nolan-Pollack photoelectric CNC was described. In the 1950s and 1960s, commercial, automatic CNCs were available. However, none were of the continuous-flow type, and the PORTACOUNT is the first highly portable continuous-flow CNC.

The PORTACOUNT grows submicrometer particles to supermicrometer alcohol droplets and then measures the concentration of the alcohol droplets. This makes the PORTACOUNT sensitive to particles having diameters as small as 0.02 micrometer, but insensitive to variations in particle size, shape, composition, and refractive index. Thus, quantitative fit testing can be performed with virtually any aerosol, including ambient air.

The flow path through the PORTACOUNT is shown in figure 33. Aerosol is drawn through the instrument by a diaphragm vacuum pump operating at a flowrate of 0.7 liter per minute. The flow enters the instrument through either the ambient port or the sample port. The switching valve determines which port is used. The outlet of the switching valve leads to the saturator end cap where the flow splits. A flowrate of 0.1 liters per minute enters the saturator and passes through the condenser, nozzle, and sensing volume. The remaining 0.6 liter per minute passes through the excess air line and is remixed with the sampled flow downstream of the sensing volume.

The PORTACOUNT sensor consists of a saturator, condenser and optical elements. The saturator is lined with an alcohol-soaked felt. A thermoelectric device (TED) is mounted between the saturator and condenser. The TED transfers heat from the condenser to the saturator, cooling the condenser and heating the saturator to just above the ambient temperature. After passing through the saturator the aerosol—now saturated with alcohol vapor—enters the condenser tube. The alcohol vapor condenses on the particles, causing them to grow into droplets. The droplets then pass through the nozzle and into the sensing volume.

The focussing optics in the sensor consist of a laser diode, a collimating lens, and a cylindrical lens. The optics focus the laser light into a sensing volume (1.2-mm wide by 13-µm thick) just above the nozzle.

Each particle passing through the sensing volume scatters light. The light is collected by a pair of lenses in the receiving optics and focussed onto a photodiode. The photodiode generates an electrical pulse from the scattered light from each droplet that passes through the sensing volume. The particle concentration is determined by counting the number of pulses generated.

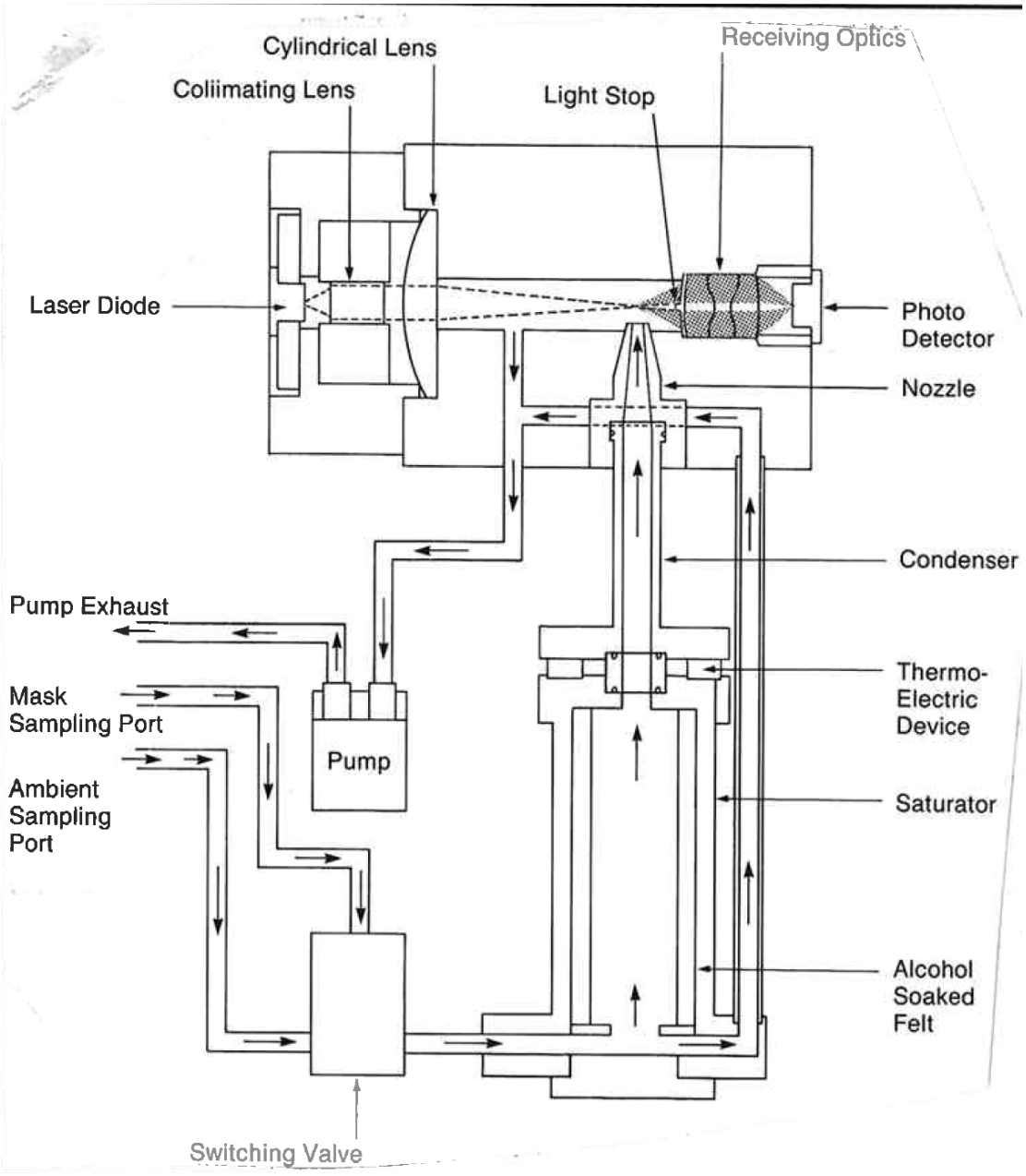

Figure A-1. Schematic of PORTACOUNT

Appendix B
Printer Control Codes

According to the American Standard Code of Information Interchange (ASCII), there are 32 control codes in addition to the codes for the printed characters. Although control codes are sent as data, the receiving device interprets them as abbreviated "instructions," communication-status messages, etc.

The MODEL 8902 Printer recognizes 13 of the control codes, as listed in Table 10, and ignores the rest.

TABLE 10. Control codes for the Model 8902 Printer

Function	Abbreviation	Code	
		Hex	Decimal
Back Space	BS	08	08
Line Feed	LF	0A	10
Carriage Return	CR	0D	13
Double Height	S0	0E	14
Double Width	SI	0F	15
Dot Graphics	DC2	12	18
User Programmable Character	DC3	13	19
Inhibit Line Space	DC1	11	17
Stop Reverse Field	CAN	18	24
Reverse Field	EM	19	25
24-column Mode	GS	1D	29
32-column Mode	RS	1E	30
40-column Mode	US	1F	31

Appendix C
Printer's Serial Interface

The MODEL 8902 Printer contains an RS-232-C serial interface. Table 11 lists the signal connections for the printer.

Figure 34 shows the pin arrangement of the serial connector. Unlisted pins are not used. Table 12 defines the voltage levels used on the signals; Table 13 defines the serial data format; and Table 14 gives the signal connections for the printer's serial interface.

TABLE 11. Signal connections for the Model 8902 Serial Interface

Pin No.	Signal	Direction	Description
1	Chassis ground	--	Cable shield
2	(RD) Received data	To printer	Printer data input line
5	(CTS) Clear to Send	From printer	Signal (equivalent to Busy) indicating that printer is ready for operation and can receive data
7	(SG) Signal	--	Signal ground

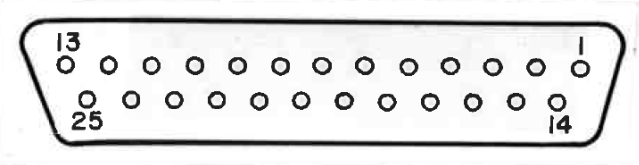

Figure C-1. Pin arrangement of the serial connector

TABLE 12. Serial interface voltage levels

Received data:	Mark = OFF = Logic "1" = -25V to -3V Space = ON = Logic "0" = +25V to +3V
Clear to send:	Busy = OFF = Logic "1" = -14V to -8V Not Busy = ON = Logic "0" = +5V

TABLE 13. Serial data format

Start bits	1
Data bits	8
Stop bits	2 or 1

TABLE 14. Signal connections for the printer's serial interface

Model 8902 Printer		PORTACOUNT
Pin 2	———	center pin
Pin 7	———	shield
Pin 5	not used	
Pin 1	not used	

The MODEL 8902 Printer operates at four different baud rates: 300, 600, 1200, and 2400. To select a baud rate, set the DIP switches under the paper roll. Table 15 shows the DIP switch settings for various baud rates. The MODEL 8920 Printer is shipped from the factory with the baud rate set to 1200.

TABLE 15. Baud rate switch settings

Baud Rate	Switch 1	Switch 2
300	OFF	OFF
600	ON	OFF
1200	OFF	ON
2400	ON	ON

Appendix D
PORTACOUNT's Serial Interface Connections

The interface cable that connects the PORTACOUNT to the microcomputer must be properly wired to allow proper communications. The following two figures show the proper configurations for IBM PC® and IBM-compatible microcomputers. Figure D-1 shows the serial interface signal connections for 25-pin, RS-232-C connectors and figure D-2 shows the signal connections for 9-pin connectors.

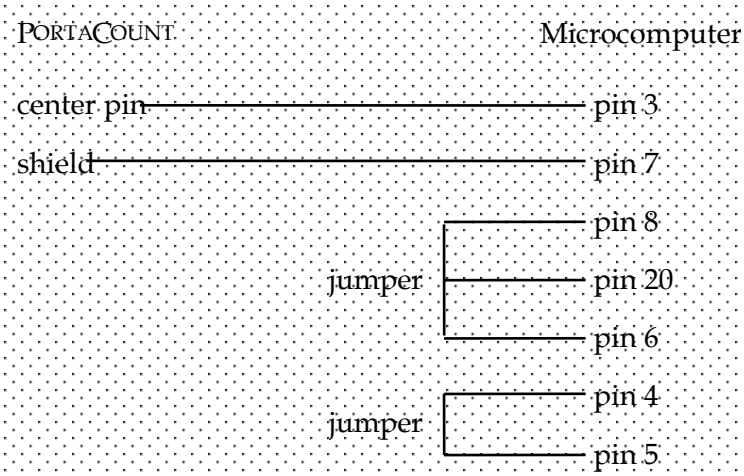

Figure D-1. 25-pin, RS-232-C serial interface signal connections

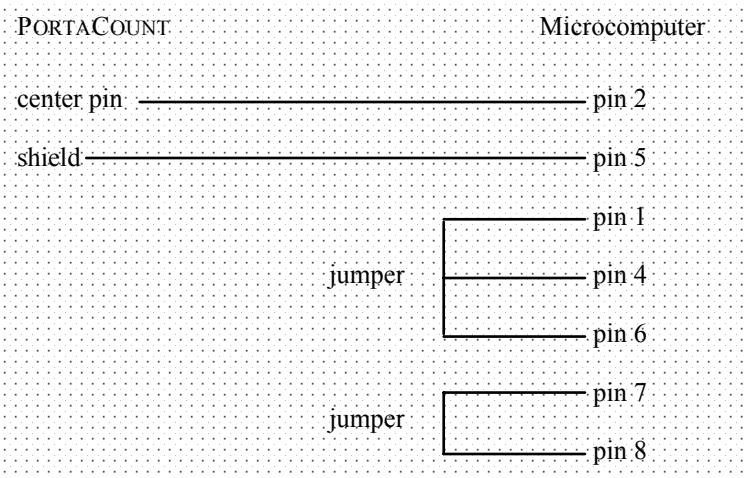

Figure D-2. 9-pin serial interface signal connections

Appendix E
Changing the Output Level of the PORTACOUNT's Serial Interface

The PORTACOUNT's serial interface can be set internally to transmit at either RS-232-C or TTL voltage levels. When shipped, the interface is set to operate at RS-232-C voltage levels. This is correct for the majority of applications. It is possible, however, to set the serial interface to operate at TTL voltage levels. To do so, follow these four steps:*

WARNING:	This is a complex procedure. Do not attempt it unless you have a thorough knowledge of electronics assembly techniques. TSI is not responsible for damage that may be done to the PORTACOUNT while attempting this procedure.

Step 1. With the battery pack disconnected, remove the front cover from the instrument.

Step 2. Using a sharp knife, carefully cut through the trace on the printed circuit board that is marked by an arrow (fig. E-1).

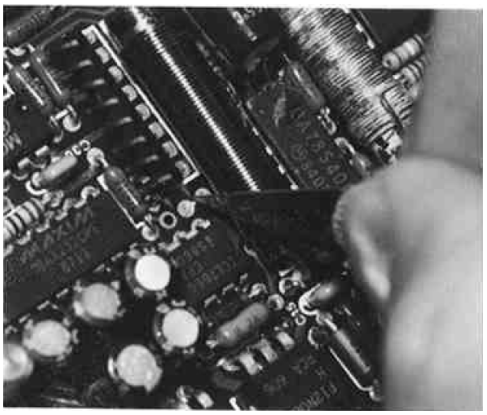

Figure E-1. Cutting through the trace on the printed circuit board

*This procedure is for Rev. A and newer printed circuit boards. For the earlier version of the printed circuit board, the procedure varies slightly. The arrows are not marked on the printed circuit board, and in step 2, instead of cutting the trace, the jumper wire across the location is removed.

Step 3. Solder a jumper wire between the two pads marked by an arrow directly to the left of the trace that was cut through in step 2 (fig. E-2).

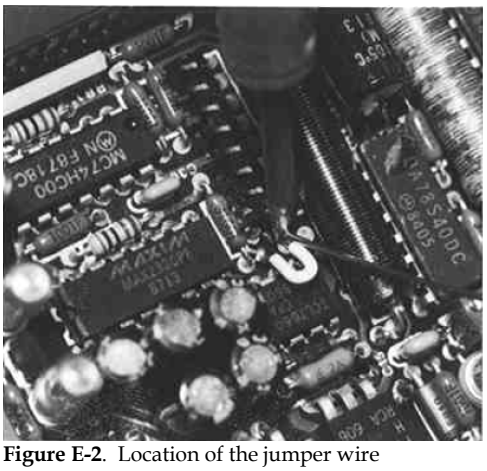

Figure E-2. Location of the jumper wire

Step 4. Install the front cover on the PORTACOUNT, making sure the membrane switch is properly plugged into the printed circuit board.

To switch back from TTL to RS-232-C voltage levels, follow these four steps:*

WARNING:	This is a complex procedure. Do not attempt it unless you have a thorough knowledge of electronics assembly techniques. TSI is not responsible for damage that may be done to the PORTACOUNT while attempting this procedure.

Step 1. With the battery pack disconnected, remove the front cover from the instrument.

Step 2. Remove the jumper wire between the two pads marked by an arrow (fig. E-3).

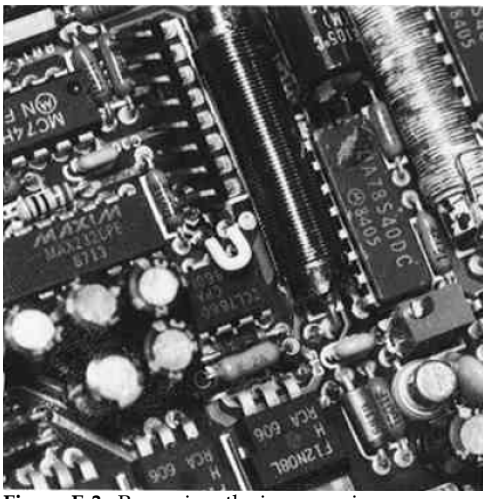

Figure E-3. Removing the jumper wire

*This procedure is for Rev. A and newer printed circuit boards. On the earlier version, the arrows are not marked on the printed circuit board.

Step 3. Install a jumper wire between the two pads (marked by an arrow) directly to the right of the arrow referred to in step 2 (fig. E-4).

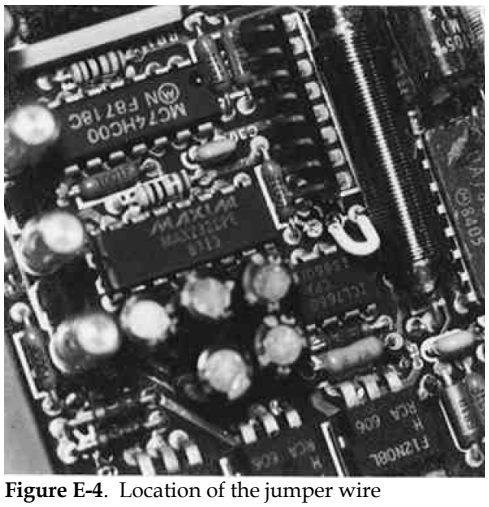

Figure E-4. Location of the jumper wire

Step 4. Install the front cover on the PORTACOUNT, making sure the membrane switch is properly plugged into the printed circuit board.