Date	E.C.O. No.	Rev.

Next Assy	Used On
	PC-320

REV.	DESCRIPTION	APPR.
A	DOCUMENTATION RELEASE	
B	INCORP. ECO. #11966	5/19/83

UNIVERSAL PROCEDURE FOR THE FIELD CALIBRATION OF THE HIAC AUTOMATIC PARTICLE SIZE ANALYZER MODEL PC-320.

1 - KIT -
4 CAL'S

312-428-7794 (STEVE ZIGGS)
415-325-7811 (CURTIS)

Item No.	Qty.	Nomenclature Or Description	Ref. Desig.	Part No.

Unless Otherwise Specified Dimensions Are In Inches
Tolerances: .xxx ± .010 .xx ± .02 x/x ± 1/32
63
Angles ± 0° 30′
Material:

Drafting | Date
Designer
Engineer 6/24
Approval

Dwg. Title: Procedure, Calibration, Field PC-320

Size: A | Scale: ----- | Sht. 1 of 14 | Dwg. No. 20000 899 | Rev. B

HIAC

PACIFIC SCIENTIFIC COMPANY
HIGH ACCURACY DIVISION
141 Spring Street
Claremont, California 91711
U.S.A.

HIAC/ROYCO STOCK NO. 20001106

2001745
MAINT MANUAL

OPERATION AND MAINTENANCE MANUAL

FOR

HIAC MODEL PC-320

AUTOMATIC PARTICLE SIZE ANALYZER

HIAC/ROYCO

All Hiac/Royco products are warranted against defects in materials and workmanship. This warranty applies for one year from date of delivery, or in the case of certain major components listed in the operating manual, for specified period. We will repair or replace products which prove to be defective during the warranty period provided they are returned to Hiac/Royco. No other warranty is expressed or implied. Hiac/Royco is not liable for consequential damages. Your authorized Hiac/Royco Field Engineer is ready to assist you and you are welcome to contact directly the Hiac/Royco Service Department:

CUSTOMER SERVICE
HIAC/ROYCO INSTRUMENTS
Division of Pacific Scientific
141 Jefferson Drive, Menlo Park, Calif. 94025
415/325-7811

NOTE

7/1/79

RECENT OPERATIONAL CHANGES

A. WHEN OPERATING THE PC-320 WITH AUTOMATIC BOTTLE SAMPLER (ABS) - WITH PART NUMBERS 80026901 THROUGH 80026909 - REFER TO APPENDIX A FOR OPERATING INSTRUCTIONS.

B. WHEN OPERATING THE PC-320 WITH THE CP-100 CALCULATING PRINTER REFER TO APPENDIX B FOR OPERATING INSTRUCTIONS.

Next Assy.	Used on	Effect.	Rev	Description	Date	Appr.
80014400	320/326	SN 326 & up	A	Documentation Release	11-15-77	AWR
80014400	320/326	SN 326 & Up	B	INC. ECO 11663 Fig.6-14	12-15-77	DR
80014400	320/326	SN 326 & Up	C	INC. ECO 11745	6/6/78	DR

Drafting	Date	Dwg. Title	
Designer		MANUAL, OPERATORS AUTOMATIC PARTICLE SIZE ANALYZER PC-320	
Engineer A. Russell	11-15-77		
Approval Dennis H. Ross	NOV 16 77		

Size	Scale	Sht.	Dwg. No.	Rev.
A	---	1 of 107	20001106	C

HIAC®

PACIFIC SCIENTIFIC COMPANY
HIAC INSTRUMENTS DIVISION
4719 W. Brooks St.
Montclair, California 91763
U.S.A.

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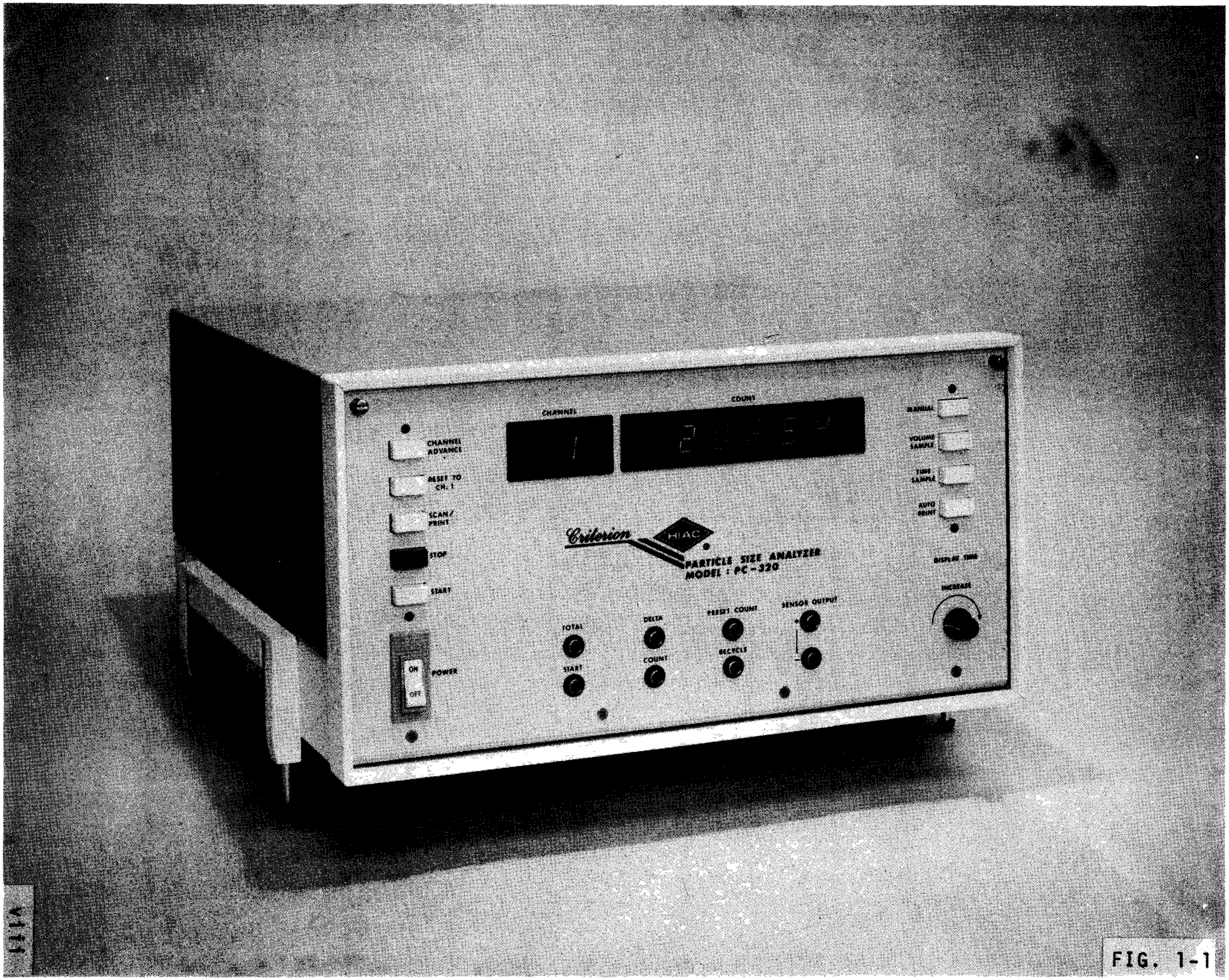

CHANNEL
COUNT
CHANNEL ADVANCE
RESET TO CH. 1
SCAN/PRINT
STOP
START
POWER
ON
OFF
Criterion
HIAC
PARTICLE SIZE ANALYZER
MODEL : PC-320
TOTAL
START
DELTA
COUNT
PRESET COUNT
RECYCLE
SENSOR OUTPUT
MANUAL
VOLUME SAMPLE
TIME SAMPLE
AUTO PRINT
DISPLAY TIME
INCREASE

FIG. 1-1

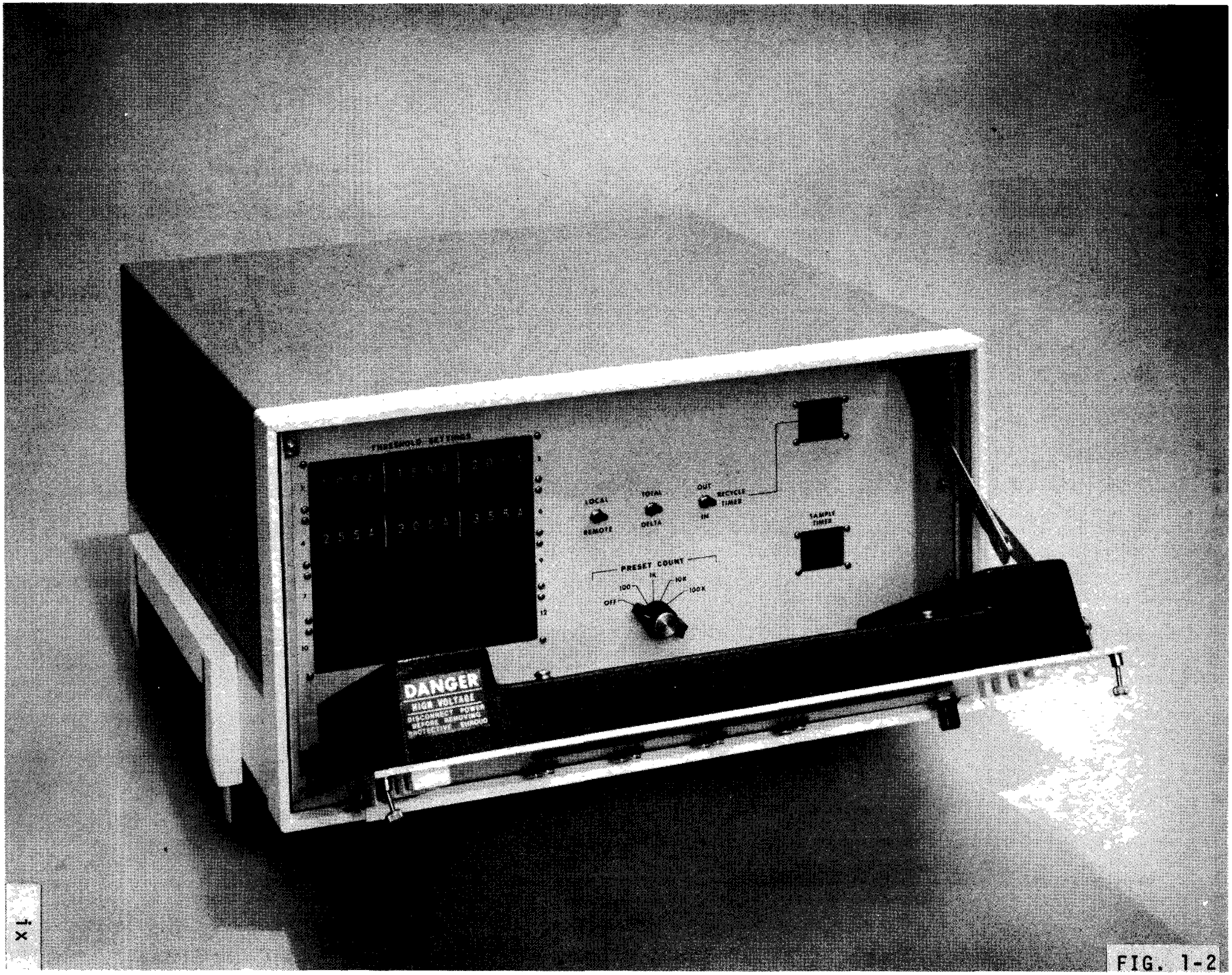

LOCAL
REMOTE
TOTAL
DELTA
OUT
IN
RECYCLE
TIMER
SAMPLE
TIMER
PRESET COUNT
OFF
100
1K
10K
100K
DANGER
HIGH VOLTAGE

FIG. 1-2

SECTION I
INTRODUCTION

1-1. GENERAL

1-2. This manual contains operational and maintenance instructions for the HIAC Model PC-320 "Criterion" Particle Size Analyzer and associated accessories.

1-3. This manual is intended for the use of the instrument operator to operate and maintain the Model 320. A spare parts list and block diagrams are included to aid personnel in replacement of components and troubleshooting.

1-4. PURPOSE OF EQUIPMENT

1-5. The Model 320 has been designed to provide high-speed, precise particle size distribution analyses on a wide variety of materials suspended in liquids or gasses, or of dry powders capable of being suspended in a liquid or gas.

1-6. TYPICAL APPLICATIONS

1-7. Typical applications include

a. Hydraulic Fluid cleanliness monitoring for hydraulic systems in aircraft, construction and farm machinery, numerically controlled machines, computers, etc.

b. Filter testing and evaluation.

c. Turbine lubricating oil cleanliness monitoring.

d. Parenteral fluid cleanliness monitoring.

e. De-ionized water and solvent cleanliness monitoring for semi-conductor manufacturing.

f. Precision parts and components cleanliness testing.

g. Production testing of lubricating oils, hydraulic fluids, solvents, foods and beverages, pharmaceutical products, viscose, and virtually all liquids where a knowledge of the presence or absence or the size distribution of particulate matter is necessary.

h. Particle size distribution of powdered materials such as photocopy toners, alumina, diamonds, pharmaceuticals, polymers, pigments, various chemicals, etc.

1-8. GENERAL SYSTEM DESCRIPTION

1-9. The Model 320 is a 3, 6, 9, or 12-channel Automatic Particle Size Analyzer with independently adjustable thresholds (size discriminators) for each channel. Each channel counts the number of particles whose size reaches or exceeds the size represented by each individual threshold. Data output is in the form of a front panel digital display which reads each channel in sequence at a rate selected by the operator. Readout is in the form of number of particles per unit time or per unit volume of sample analyzed.

1-10. The Model 320 operates on AC power (100/115/230 VAC ± 10% 47-63Hz) and is packaged in a portable cabinet, 18 inches x 9.5 inches x 18 inches, and weighs approximately 40 pounds. The instrument can also be mounted in a standard relay rack. Power consumption is 40 watts maximum.

1-11. LIMITED WARRANTY POLICY

1-12. All equipment sold by HIAC Division, Pacific Scientific Company is warranted to be free from defects in material and workmanship. Provisions of HIAC Instruments Division Limited Warranty are detailed on pages 1-3 and 1-4.

HIAC/ROYCO
INSTRUMENTS DIVISION

PACIFIC SCIENTIFIC

WARRANTY POLICY

LIMITED WARRANTY

HIAC/ROYCO Instruments Division, Pacific Scientific Company warrants to the original purchaser in the country of delivery that all equipment sold by an authorized representative, shall be free, under normal use and maintenance, from any defect in material and workmanship for a period of one year from date of delivery, subject to the following conditions, exclusions, obligations and limitations:

a) The following purchased products are specifically excluded from the terms and provisions of this warranty:

1. Stand-alone products not manufactured by HIAC/ROYCO and not possessing a HIAC/ROYCO logo. Such products are covered by the original manufacturer. In the event of failure, HIAC/ROYCO will give reasonable assistance to the purchaser in obtaining from the respective manufacturer whatever adjustment is reasonable in the light of the manufacturer's own warranty.

b) Any material or workmanship found to be defective by HIAC/ROYCO within the one year warranty term shall be remedied without charge for parts or labor.

c) When an instrument, component or accessory is claimed to be defective, HIAC/ROYCO shall determine whether or not the item shall be returned by purchaser to a HIAC/ROYCO service center:

HIAC/ROYCO Eastern Sales & Service, 137 Moody Street
Waltham, MA 02154 — 617/891-5320

HIAC/ROYCO Service Center, U.S. Highway North 130
Willingboro, NJ 08046 — 609/871-2220

HIAC/ROYCO Midwest Sales & Service, 700 Willow Lane
West Dundee, IL 60118 — 312/428-7794

HIAC/ROYCO Instruments, Inc., 141 Jefferson Drive
Menlo Park, CA 94025 — 415/325-7811

HIAC/ROYCO Instruments GmbH, Heidenheimerstrasse 8 - Postfach 120
7250 Leonberh, West Germany

PACIFIC SCIENTIFIC, Inc., Hauptstrasse 132 - P.O. Box 69
CH-4450 Sissach, Switzerland

141 Jefferson Drive, Menlo Park, California 94025, (415) 325-7811

Any item required to be returned by purchaser to a HIAC/ROYCO service center must be shipped prepaid. If upon receipt the item is determined to be defective by HIAC/ROYCO, the repaired or replacement item will be returned to the purchaser shipping charges prepaid (U.S.A. and Europe only). If the item is found by HIAC/ROYCO not to be defective, the item will be returned by HIAC/ROYCO freight collect.

d) Purchaser may elect to have warranty repair or replacement performed in its plant, if possible, in which case purchaser shall pay all transportation and expenses for HIAC/ROYCO personnel and equipment.

e) This warranty shall not apply to or include any of the following; Repair or replacement required as a result of (i) accident, (ii)misuse or neglect, (iii) lack of reasonable and proper maintenance, (iv) repairs improperly performed or replacements improperly installed, (v) use of replacement parts or accessories not conforming to HIAC/ROYCO's specifications which adversely affect performance and/or durability, (vi) alterations or modifications not recommended or approved in writing by HIAC /ROYCO and/or (vii) wear and deterioration occasioned by the use of the equipment.

The liability of HIAC/ROYCO under this warranty is limited solely to the remedying of defects in material and workmanship at a HIAC/ROYCO authorized repair facility during customary business hours. This warranty does not cover inconvenience of loss of use of the equipment. HIAC/ROYCO shall not be liable for any other expense, loss or damage, whether direct, incidental, consequential or exemplary arising in connection with the sale or use of or inability to use the equipment for any purpose.

HIAC/ROYCO makes no other warranty of any kind, expressed or implied. ALL IMPLIED WARRANTIES, INCLUDING THOSE OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, WHICH EXCEED THE OBLIGATIONS AND TIME LIMIT STATED IN THIS WARRANTY ARE HEREBY DISCLAIMED BY HIAC/ROYCO AND EXCLUDED FROM THIS WARRANTY.

The foregoing statements of warranty are exclusive and in lieu of all other remedies.

Representations and warranties made by any person, including representatives of HIAC/ROYCO, which are inconsistent or in conflict with the terms of this warranty shall not be binding upon HIAC/ROYCO unless in writing and signed by an officer of HIAC/ROYCO.

This warranty shall be governed by the laws of the State of California.

ADDENDUM: <u>SERVICE CONTRACTS</u>

In addition to our standard warranty, HIAC/ROYCO Service and Calibration programs provide for the services of a factory-trained and supervised field engineer at scheduled intervals, to perform preventive maintenance and prime calibration at your facility. For information on the program, contact HIAC/ROYCO Customer Service.

SECTION II
UNPACKING & LONG TERM STORAGE

2-1. GENERAL

2-2. This section contains general instructions on unpacking the HIAC Model PC-320.

2-3. UNPACKING

a. Carefully open the packing carton by cutting the tape with a knife. Lift the PC-320 along with the two foam end-blocks out of the carton. Remove the end-blocks and place the instrument on a stable base.

b. Carefully open the second carton. This carton will contain two smaller inner cartons each containing small parts and accessories.

c. Verify the contents of all of the cartons against the included packing list and invoice. Check all packing material to see that no small parts are discarded.

d. Retain all cartons and packing materials.

e. Inspect the unpacked instrument and accessories for possible damage during shipment and notify HIAC and the shipping company of any damage in accordance with paragraph 1-13.

2-4. LONG-TERM STORAGE OF ELECTRONIC EQUIPMENT

2-5. Wherever possible, equipment should be stored in an air-conditioned environment where temperature changes are kept to a minimum.

2-6. When equipment has to be stored for long periods, it is desirable to operate it once a year for an hour or two to prevent degradation of electrolytic capacitors and the like. If this is not possible, the following procedure should be followed when the equipment is to be activated.

2.7. The instrument should be plugged into a variable transformer ("Variac" or equivalent). With the power switch in the "ON" position, the voltage should be increased in 10 volt steps, each level being maintained for approximately thirty seconds. When the nominal input voltage has been reached, the equipment should be left on for at least eight hours to stabilize. At the end of this period, the standard checkout procedure should be followed, after which the instrument should be ready for use.

SECTION III
THEORY OF OPERATION

3-1. GENERAL

3-2. This section contains the theory of Sensor and instrument operation supported by System Block Diagram, Section XI.

3-3. SENSOR THEORY (Refer to Section VI for more details)

3-4. All HIAC Sensors operate on the light blockage principle. Particles in fluid suspension flow through a channel past a window whose area is known accurately. A collimated light beam shines through the fluid at right angles to the direction of flow, and passes through the window to fall on a photodiode.

3-5. The output of the photodiode goes to a preamplifier in the Sensor and thence to the main particle counter. There, a peak level detector generates a signal which controls a servo loop which maintains the output level of the Sensor preamplifier at -10V when there is no particle in the window.

3-6. When a particle of projected area "a" passes across the window, it partially blocks the light beam, the reduction being a/A where "A" is the area of the window. Since the preamplifier output without a particle is 10V, the amplitude of the pulse produced by the particle is Eo

particle area

$$\text{where } E_o = \frac{a}{A} \times 10V \text{ -----------eq 1}$$

window area

3-7. It is customary to specify particle size in terms of equivalent spherical diameter, i.e. the diameter of a sphere whose projected area is the same as the particle.

Substituting $\Pi d^2/4$ for "a" in eq 1

$$E_o = \frac{\Pi d^2}{4A} \times 10V$$

$$= \frac{d^2}{A} \times 7.854V \text{ -------eq 2}$$

3.8. The voltage corresponding to the appropriate particle size is dialed into the "threshold set" controls for each channel in the HIAC Particle Size Analyzer.

3-9. Every HIAC Sensor is calibrated against spherical particles of known size and a copy of the calibration curve is furnished with the unit (figure 6-10).

3-10. THEORY OF OPERATION

3-11. The signal from the Sensor is applied to a negative peak level detector and through buffer amplifiers to a bank of analog comparators.

3-12. The peak level detector senses the maximum negative excursion of the signal from the Sensor corresponding to clean fluid with no particle in the window. This signal is stored in an RC circuit with a long time constant and compared with an internally generated +10V reference signal. The difference between the two signals is amplified and used to adjust the Sensor lamp voltage until a -10V base level is achieved.

3-13. A bank of analog comparators (one per channel) is employed to sort the train of pulses from the Sensor according to size. The output signal from the Sensor is applied to one input of each comparator, while a reference signal (a known fraction of the -10V base level) is applied to each comparator. When the input signal is more positive than the preset threshold voltage of an analog comparator, its output changes level, producing a standard amplitude output pulse. From this point on, standard digital circuitry is employed to manipulate the data.

3-14. A six-digit BCD counter accumulates the pulses from each channel. When the instrument is in the TOTAL mode, each channel counts all particles larger than the threshold, while in the DELTA mode, each channel counts particles between two adjacent thresholds.

3-15 The BCD outputs form the counters go to a scanner which upon command transmits them one channel at a time to the front panel display and to a rear panel connector for printout if desired.

3-16 A dual monitor circuit is provided to provide visual warning of possible malfunction of the Sensor due to partial (or complete) blockage of the window and/or fluid passage. The -10V base level from the Sensor is compared with an independent reference voltage. If it is above or below its correct value by more than 150 mv, the (+) or (-) lamps on the front panel will be illuminated. When the concentration of the sample being tested is 20% to 30% above the maximum concentration rate of the Sensor, the lamps will flash at a 5HZ rate. This is the "Overconcentration" alert signal. Under normal conditions, both lamps will be out.

3-17 DATA PRESENTATION - PC-320

3-18 Data from the PC-320 are displayed on the front panel one channel at a time and are accessible simultaneously at the printout connector (J14) in parallel BCD format.

3-19 When the Scan/Print switch is in the "Scan" position, depressing the "Print" switch scans the data one channel at a time at a rate determined by the setting of the "Display Time" control. In the "Print" mode, an automatic PRINT command from the PC-320 indicates that Channel 1 data are ready for printing. A return signal from the printer or external data processor, signifying acceptance of the data will step the display to Channel 2 and the cycle will repeat until all channels have been scanned, whereupon a "Paper Advance" signal from the PC-320 is available for use an an "End of Message" signal.

3-20 Data are accessible in parallel BCD format; columns 6 & 7 carry channel identification information, while columns 13 through 18 carry the contents of the PC-320 channel registers. Positive logic is employed and signal levels are TTL compatible. (Note: The nominal 5 v supply in the PC-320 is normally set for 5.75 v which poses no problem when used with the HIAC PO 500/600 printers which can accept 15 v positive inputs without damage. The supply voltage may be lowered to 5 v if desired. The only effect on the PC-320 will be a reduction in brightness of the front panel data display).

3-21. Table 3-1 identifies the pin assignments for connector J14.

TABLE 3-1

CONNECTIONS TO PRINTOUT CONNECTOR (J14) FOR
PC-320/6+6 (S/N 151 AND ABOVE)

PRINT COL. NO.	BIT #	SIGNAL/DATA	PIN #
5	Q1	Symbol "Ch"	51
	Q2		55
	Q4		53
	Q8		57
6	Q1	Channel I.D. MSD	43
	Q2		47
	Q4		45
	Q8		49
7	Q1	Channel I.D. LSD	35
	Q2		39
	Q4		37
	Q8		41
8	Q1	Not used in PC-320	3
	Q2	Configuration	7
	Q4		5
	Q8		9
9	Q1	Data from J15	27
	Q2		31
	Q4		29
	Q8		33
10	Q1	Data from J15	11
	Q2		15
	Q4		13
	Q8		17

CONNECTIONS TO PRINTOUT CONNECTOR (J14) FOR
PC-320/6+6 (S/N 151 AND ABOVE)

PRINT COL. NO.	BIT #	SIGNAL/DATA	PIN #
11	Q1	Data from J15	38
	Q2		42
	Q4		40
	Q8		36
12	Q1	Not used in PC-320 Configuration	19
	Q2		23
	Q4		21
	Q8		25
13	Q1	Count Data MSD	22
	Q2		26
	Q4		24
	Q8		20
14	Q1	Count Data 2nd MSD	30
	Q2		34
	Q4		32
	Q8		28
15	Q1	Count Data 3rd MSD	6
	Q2		10
	Q4		8
	Q8		4
16	Q1	Count Data 4th MSD	14
	Q2		18
	Q4		16
	Q8		12

CONNECTIONS TO PRINTOUT CONNECTOR (J14) FOR
PC-320/6+6 (S/N 151 AND ABOVE)

PRINT COL. NO.	BIT #	SIGNAL/DATA	PIN #
17	Q1	Count Data 5th MSD	46
	Q2		50
	Q4		48
	Q8		44
18	Q1	Count Data LSD	54
	Q2		58
	Q4		56
	Q8		52
		Ground	61
		-15VDC	62
Print Command - A positive transition (0 to +5V) indicates that Ch 1 data is present			59
Channel Advance - A negative transition (+5V to 0) applied to this pin will step the Data to Ch 2			2
The sequence - Print Command out, Channel Advance in - continues until all channels have been scanned.			
Paper Advance - A positive transition (0 to +5V) indicates that the last channel has been scanned.			60
Print Red - Not used in PC-320 configuration			1

SECTION IV

DESIGN PHILOSOPHY AND SYSTEM CONTROLS

4-1. GENERAL

4-2. This section contains a discussion of the Model 320 design philosophy and a description of all system controls. System controls will be best understood by referring to the Front, Sub, and Rear Panel diagrams in Section XI.

4-3. DESIGN PHILOSOPHY

4-4. Unlike all previous particle counters, the PC-320 was designed to be the nucleus of a particle size analysis system, rather than just a particle counter to which accessories could be connected.

4-5. The system logic is therefore configured in such a way that regardless of the mode of operation, all accessories are controlled by the PC-320. This means that once the initial set up adjustments have been made, a single push-button controls the system.

4-6. Labeled rear panel connectors provide for standard accessories such as an Automatic Bottle Sampler, Digital Printer, etc. In addition, an auxiliary accessory connector makes available a wide variety of internal signal and control lines to accomodate accessories still to be announced and to permit the user to use the PC-320 as part of a larger system.

4-7. PHYSICAL DETAILS

4-8. Every effort has been made to apply the basic principles of Human Engineering. Operational controls and Indicators are grouped in a logical manner on the front panel; set-up controls, size threshold adjustments, etc. are found on the sub-panel, while all cable connectors etc. are located on the rear panel.

4-9. Except for display circuitry which is on a printed circuit board attached to the front panel, all the electronic circuits are on PCB's which plug into a card cage accessible through the rear panel.

4-10. Each PCB functions as a complete sub-system rather than being simply a sub-assembly of convenient size. This permits the instrument to be expanded up to twelve channels simply by plugging in the appropriate number of circuit cards and threshold controls.

4-11. In a twelve channel configuration there is a full complement of nine circuit cards made up as follows: (Refer to Block Schematic diagram, Figure 11-2).

a. PCB #1 incorporates the buffer amplifier, the peak level detector, the Sensor lamp control circuitry and the auxiliary monitor system.

b. PCB #2 and #3 are identical; each containing six analog comparators with their associated Total/Delta Mode circuitry. PCB #3 is identical to #2 except that two IC's are removed. In the six plus six system, PCB's #2 and #3 are identical and contain all IC's.

c. PCB #4, 5, 6, and 7 each have three six-digit counters along with the appropriate portion of the scanner.

d. PCB #8 contains all the system control logic and scanning circuitry.

e. PCB #9 contains the display and printer buffer drivers and PO 600 line 3 enabling commands.

f. PCB on sample timer contains a two-position slide switch for proper timer synchronization with power line frequency. Switch should be in left position for 60Hz power line frequency and in right hand position for 50 cycle power line frequency.

4-12. SYSTEM CONTROLS -- FRONT PANEL

ON/OFF POWER----------------This switch controls AC power to the unit. It also includes a curcuit breaker for overload protection and an integral lamp that lights when switch is energized.

COUNT Display--------------This 6-digit display provides a direct readout of the number of particles in any one channel or, when used in conjunction with CHANNEL ADVANCE or SCAN/PRINT provides a direct sequential readout from all channels.

CHANNEL Display------------This 2-digit display indicates the number of the channel being displayed on the COUNT display. When used in conjunction with CHANNEL ADVANCE or SCAN/PRINT, will readout sequentially at all channels.

CHANNEL ADVANCE------------This momentary push button switch, when depressed, advances the channel and count displays sequentially up to the maximum number of channels. This command may be used at any time during operation or may be set at any one channel during operation.

RE-SET TO CH 1-------------This momentary push button switch, when depressed, re-sets the COUNT display and CHANNEL display to channel 1. This command functions on MANUAL channel advance only, and not on AUTO/PRINT or SCAN/PRINT modes where the re-set is automatic.

SCAN/PRINT-----------------This momentary push button switch, when depressed, initiates automatic sequential scanning of the CHANNEL and COUNT displays and returns the displays to channel one after scanning. This command may be repeated any number of times to repeat the scan. The AUTO/PRINT switch must be at the "OUT" position when using SCAN/PRINT.

STOP-----------------------This momentary push button switch immediately stops the counting cycle and sampling operation. It also triggers the Auto/Print cycle, if engaged.

START----------------------This momentary push button switch, when depressed, initiates the sampling and counting operation.

4-13. OPERATIONAL MODES -- FRONT PANEL

MANUAL---------------------This interlocking push button switch, when depressed, selects the manual mode of operation. When the START button is depressed when in the manual mode, the sample count is initiated immediately and counting continues until the STOP button is depressed.

VOLUME SAMPLE--------------This interlocking push button switch, when depressed, selects the metered volume sample mode when the AUTOMATIC Bottle Sampler is used. This allows the counter to analyze a pre-selected volume of sample.

TIME SAMPLE----------------This interlocking push button switch,
(Optional) when depressed, selects the timed sample mode. The time, from 1 to 99 seconds, is selected from the SAMPLE TIMER located on the sub-panel.

AUTO/PRINT-----------------This alternate action switch, when engaged, overrides the SCAN/PRINT button and causes the instrument to automatically scan all channels immediately after the operation cycle is completed. The optional printer must be employed to enable this mode to function.

DISPLAY TIME---------------This potentiometer, when rotated, increases or decreases the display time in the Scan/Print mode.

4-14. FUNCTION LIGHT DISPLAYS -- FRONT PANEL

TOTAL----------------------TOTAL display light, when illuminated, indicates that all counts are displayed on a cumulative basis.

DELTA----------------------DELTA display light, when illuminated, indicates that all counts are displayed on a differential basis.

PRE SET COUNT--------------PRE SET COUNT light, when illuminated, indicates that the instrument is set to stop counting when channel 1 reaches a PRE SET COUNT level and that the pre-set count selector on the sub-panel is in an operational position.

SENSOR OUTPUT-------------The (+) or (-) lamp, when continuously illuminated indicates a blocked sensor or any condition when insufficient light is reaching the photodiode. When flashing off and on, the lamps indicate that the sample is overconcentrated and requires dilution.

START---------------------START light, when illuminated, indicates that the START button has been depressed and the sampling operation has been initiated.

COUNTING------------------COUNTING light, when illuminated, indicates that the instrument is accumulating particle count data.

RECYCLE-------------------RECYCLE light, when illuminated, indicates that the optional RECYCLE/ TIMER switch is operating and the instrument running in a time mode.

4-15 SUB-PANEL CONTROLS AND COMPONENTS

THRESHOLD SETTINGS--------This series of thumbwheel switches is used to adjust the calibration numbers for each channel and thereby set the thresholds against the calibration chart.

LOCAL/REMOTE Switch-------This toggle switch is used to select direct operation in LOCAL position or to allow a remote start button or computer control and acquisition through accessories connector J15 when in REMOTE position.

TOTAL/DELTA Switch--------This toggle switch is used to select between a cumulative count display or a differential count display.

RECYCLE TIMER (OUT/IN)----This toggle switch engages or disengages the RECYCLE TIMER. The time interval between counts may be set from the thumbwheel switch in one minute increments from 1 to 99 minutes. The front panel TIMING light when illuminated indicates that the RECYCLE TIMER sequence is in operation.
(Optional)

SAMPLE TIMER--------------This thumbwheel switch sets the time, in SECONDS, of particle counting. Counts may be taken in 1 second increments from 1 to 99 seconds. When used in conjunction with the RECYCLE TIMER, continuous monitoring sequences may be set.
(Optional)

PRE-SET COUNT-------------This 5-position rotary switch, when engaged at a specific count level, causes the count cycle to stop when channel 1 has reached either 100, 1,000, 10,000 or 100,000 counts. This will allow direct readout in the form of cumulative count % greater than channel 1.

4-16. BACK PANEL COMPONENTS

J14 PRINTOUT--------------This connector is used to connect the accessory Digital Printer PO 500/600 to the PC-320 (J-14 Connector) using appropriate cable.

J-15 ACCESSORIES-----------This connector is used to connect accessory equipment to PC-320.

J-16 ANALOG SIGNAL---------Used when it is desired to operate another HIAC counter in parallel will be the PC-320.

J-17 SENSOR----------------This connector is used to connect "CM" and "E" series Sensor to PC-320 using cable #80001100 or #20000239.

J-18 A.B.S.----------------This connector is used to connect the HIAC Automatic Bottle Sampler (Connector J704) to PC-320 (J-18 Connector) using cable #20000209.

J-19 CRO-------------------Used to monitor the sensor output with an oscilloscope.

LAMP VOLTAGE ±-------------These two test points are used to check the Sensor lamp voltage with a 0-10 volt dc voltmeter.

ACCESS Panel---------------This panel, when open provides access to printed circuit boards.

CHANNEL Selector-----------This thumbwheel selector located on PCB #8 is used to select the total number of channels to be displayed on the CHANNEL and digital COUNT displays. The access panel must be removed to locate this selector.

4-17. SENSOR FLOW RATE AND CONCENTRATION LIMITS

4-18. All analyses must be performed within the flow rate ranges listed in Table 4-1. The 60, 90, 120, 150, and 300μm Sensors, although capable of use over wide flow rate ranges, are somewhat sensitive to flow rate variations, and therefore must be used only at the flow rate (±10%) listed on the calibration curve for each Sensor. If flow rates other than those listed on the calibration curve are required, the Sensors must be re-calibrated at the required flow rates.

4-19. When any Sensor is used on-line and/or operated on a time basis, it is essential that the flow rate through the Sensor be constant at all times. Any flow rate variations will result in a variation in the volume of sample passed through the Sensor for the given time period.

[illegible] listed in Table 4-1. Coincidental particle passage will occur at concentration levels higher than the stated concentration limit and result in a particle count lower than the true count. In some cases, the concentration may be so high that the count readout may indicate that the concentration level is within limits. To avoid this possibility, an overconcentration indicator is provided. An overconcentration condition will be indicated by a rapid flashing off and on of the Sensor Output lamps on the 320 Front Panel. If the particle concentration in any one sample is higher than the concentration limit, the sample should be diluted with an appropriate diluent or solvent. High concentration sensors with higher limits are available on special order from HIAC. The concentration limits and flow rates for these special Sensors are also listed in Table 4-1.

Table 4-1. Sensor Flow Rate and Concentration Limits

STANDARD SENSORS EB and CMB Series			HIGH CONCENTRATION SENSORS EH and CMH Series		
Max. Size	Flow Rate Range (ml/min)	Concentration Limit (Particles/ml)	Max. Size	Flow Rate Range (ml/min)	Concentration Limit (Particles/ml)
60	8 ±0.8	12,400	60	6 ±0.6	30,000
90	20 ±5	5,600	90	10 ±5	12,000
120	40 ±10	3,100	120	20 ±5	7,500
150	100 ±50	2,000	150	50 ±20	4,000
300	225 ±100	500	300	100 ±50	1,250
600	75 -1200	120	600	50 -600	300
1000	10-3300*	35	1000	10-3300*	35
2500	10-21000*	6	2500	10-21000*	6

* Available as E Series only.
Cannot be used with Automatic Bottle Sampler due to minimum flow rate specification.

SECTION V

OPERATING INSTRUCTIONS

5-1.0 GENERAL

5-1.1 This section contains operating instructions for the Model PC-320. The front panel controls and displays, inner panel controls, and back panel components are described in Section IV. Refer to Section XIII for connections and cable block diagrams. Operation with the Automatic Bottle Sampler is outlined in paragraph 8-34 or Appendix A.

5-2.0 PREPARATION FOR USE

5-2.1 Operation of the PC-320 and its associated components is uncomplicated and requires only a minimum of set-up time prior to operation.

5-2.2 Connect Sensor to connector (J17) located on PC-320 rear panel.

5-2.3 If Automatic Bottle Sampler is employed, connect that unit to the PC-320 as described in para. 8-34 or Appendix A (newer ABS units). Turn ABS Pump Switch to off position.

5-2.4 Connect PC-320 AC power cord to appropriate AC outlet.

5-2.5 Turn on power by depressing power switch into ON position. The front panel SENSOR OUTPUT lamps will extinquish in a few seconds. This is imperative! If either light remains illuminated refer to the Trouble Shooting Section IX.

5-2.6 Set channel thresholds in accordance with sensor calibration graph. For example; if channel 1 is to be set at 5µm, find 5µm on the horizontal axis of the graph. Note where the 5µm line intersects the calibration curve. Note where that point intersects the horizontal scale. Read the threshold setting for that point on the vertical axis. That number is then entered into channel 1 by adjusting the thumbwheel switches to read that number. Set each channel threshold for particle size of interest.

5-2.7 Select data presentation mode. If cumulative counts (counts greater than each successive size) are desired, place TOTAL/DELTA Switch into TOTAL position. If differential counts (counts within each threshold range) are desired place switch into DELTA position.

5-2.8 SELECT TIMER OPERATION: If unit is operated with Automatic Bottle Sampler place RECYCLE TIMER into OUT position. If on-line or automatic operation is desired place this switch into IN position.

5-2.9 SELECT PRE-SET COUNT MODE: If a specific total count is desired place PRE-SET COUNT Switch to the desired total count. If Pre-Set Count Mode is not desired place the switch into OFF position.

5-2.10 SELECT OPERATION MODE:

a) MANUAL MODE: This mode is used when the counting period is controlled completely by the operator. Engaging the front panel MANUAL Mode Switch enables the STOP and START buttons to control the unit. Data printout is achieved at the moment STOP is commanded when the AUTO PRINT Switch is engaged. Initiating START will instantly enable the unit for Data Acquisition. This is indicated by the panel lights START and COUNT being illuminated.

b) VOLUME SAMPLE MODE: This mode is used when the counting period is controlled by volume metering tube in the AUTOMATIC BOTTLE SAMPLER. (Refer to paragraph 8-34 or Appendix A for detailed operation.) Engaging this front panel switch and placing the ABS Selector Switch to AUTO achieves this condition. Depress START will turn on the pump. The front panel START light will indicate this. When the fluid sample passes the ABS lower "Light Block", the COUNT light will illuminate. Passing the upper "Light Block" stops the count and shuts off the pump. Depressing the STOP button overrides the ABS and resets the ABS circuits. (Previous counts on the display will reset to 0 when the count light comes on.)

NOTE: During any of the sampling modes, if the SENSOR OUTPUT lights come on or blink, possible sizing error may be experienced. Investigate if the situation persists.

c) TIME SAMPLE MODE: This mode is used when the counting period is controlled by the SAMPLE TIMER. Engaging this front panel switch and pre-setting the timer is allthat is required. Initiating START will instantly enable the unit for Data Aquisition. This is indicated by the panel lights START and COUNT illuminating. Depressing STOP will override the Sample Timer Mode and reset the time to 0.

5-3.0 INITIATE COUNT

5-3.1 To initiate count cycle sample fluid must be presented to the sensor via Automatic Bottle Sampler, continuous flow, or On-Line Sampling device. The count cycle will begin when the START switch is depressed and will continue until STOP switch depressed if in MANUAL Operation

Mode, pre-set count is reached if in PRE-SET COUNT Mode, selected sample time reached if in TIME SAMPLE Mode, or pre-set sample volume reached if in VOLUME SAMPLE Mode.

5-4.0 OBSERVE AND RECORD COUNT DATA

5-4.1 After completion of count cycle the particle counts at each channel for the selected operation mode are displayed on the COUNT Display and the channel identification is shown in the CHANNEL Display. Counts in channel 1 are displayed at the end of the count cycle. To observe other channels and their counts, depress the CHANNEL ADVANCE Switch. If an automatic printer is employed, the counts will be automatically printed at the end of the count cycle when the AUTO PRINT Switch is depressed. Additional printings will be made by depressing the SCAN/PRINT Switch.

SECTION VI

SENSOR THEORY AND CALIBRATION

6-1 GENERAL

6-2 SENSOR THEORY INTRODUCTION

This section contains a discussion of sensor theory, calibration theory, methods, and materials. The HIAC PC-320 is shipped factory calibrated against spherical latex by the noise compensation method and/or with non-spherical AC Fine Test Dust in accordance with methods specified by the International Standards Organization (ISO/4402), American National Standards Institute (ANSI/B93.28) and the National Fluid Power Association (NFPA/T2.9.6).

6-3 GENERAL DESCRIPTIONS

All HIAC Sensors operate on the light blockage principle. Particles in fluid suspension flow through a channel past a window whose area is accurately known. A collimated light beam shines through the fluid at right angles to the direction of flow, and passes through the window to fall on a photodiode. The output of the photodiode is modified by a preamplifier and sent to the particle counter. This is illustrated in Fig. 6-1.

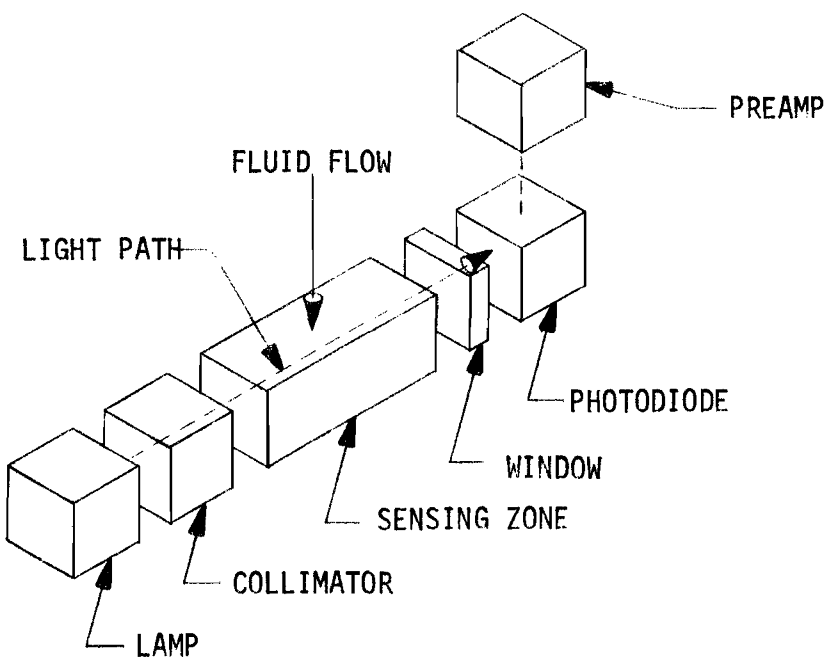


FIGURE 6-1
SENSOR BLOCK DIAGRAM

When a particle of projected area "a" passes through the sensing zone, it partially blocks the light beam. The reduction in light falling on the photodiode is a/A where "A" is the area of the window. Since the preamplifier output without particles present is known, E_k, the amplitude of the pulse produced by the particle is Eo.

$$\text{where} \quad Eo = \frac{a}{A} E_k$$

The peak amplitude of the pulse is proportional to the particle's area and the width is proportional to the particle's velocity as it passes through the sensing zone.

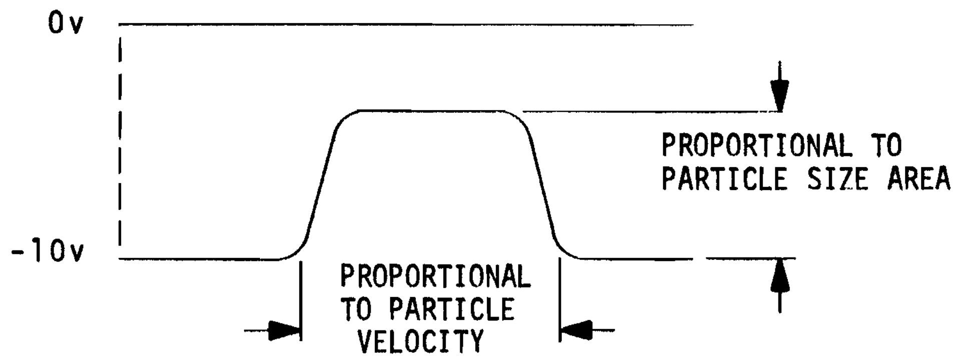


FIG. 6-2: PULSE GENERATED BY A PARTICLE

It is customary to specify particle size in terms of equivalent circular diameter, i.e. the diameter of a circle whose area is the same as the projected area of the particle.

Substituting $d^2/4$ for "a" in above equation

$$Eo = \frac{\pi d^2}{4A} E_k, \quad \text{where} \quad E_k = 10 \text{ volts}$$

$$= \frac{7.854\ d^2}{A} \quad \text{volts}$$

This is illustrated in Fig. 6-3 which shows a microscope measurement versus equivalent HIAC measurement. As can be seen the equivalent HIAC measurement shows these particles as being different by the ratio of their projected areas. This method is certainly a realistic approach to measuring the actual size of particles.

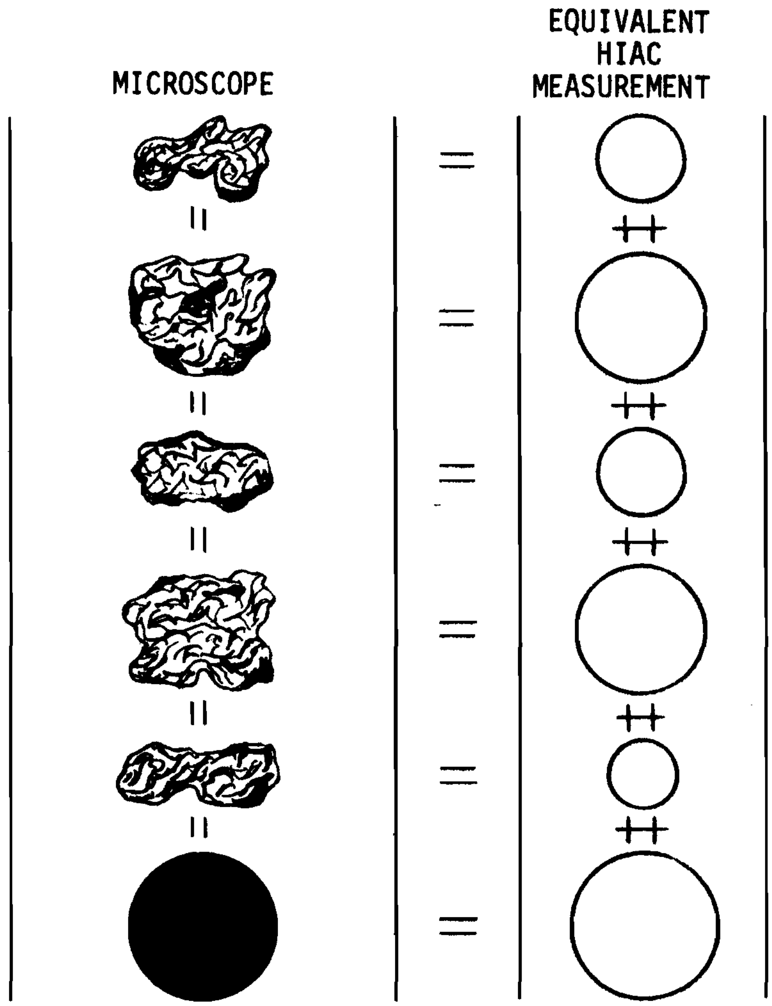


Fig. 6-3 : Illustration of Equivalent Circular Diameter

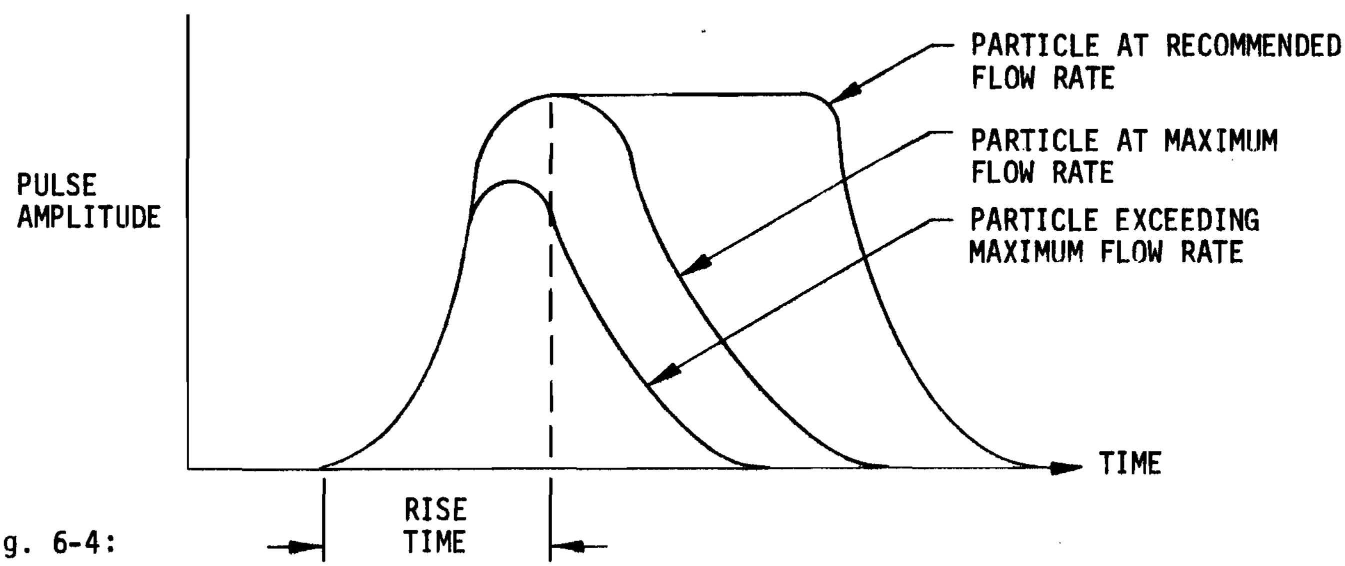


Fig. 6-4:

Simplified Diagram Showing Effect of Particle velocity, therefore flow rate on particle amplitude.

6-4 SENSOR CONSTRAINTS

The following are important concepts to understand which are applicable to all sensors using an electro-optic principle.

Flow Rate:

The maximum flow rate is determined by the bandwidth of the preamplifier, i.e. when the rise time of the pulse approaches that of the preamplifier the amplifier is bandwidth limited. Exceeding the maximum flow rate will result in the pulse amplitude being reduced in size (see Fig. 6-4) which will cause the measured particle diameter to be smaller than the actual diameter.

Concentration:

There is a maximum concentration limit (particles/ml) which is determined so that the particles flow through the sensor one at a time. Experience has shown that one particle for every 10 sensing volumes represents maximum concentration. The smaller the sensing volume, the higher the maximum concentration.

Uniformity of Light in the Sensing Zone;

The light projected through the sensing zone should be completely uniform and parallel so that a particle produces a uniform pulse regardless of its location in the sensing zone. This is illustrated in Fig. 6-5.

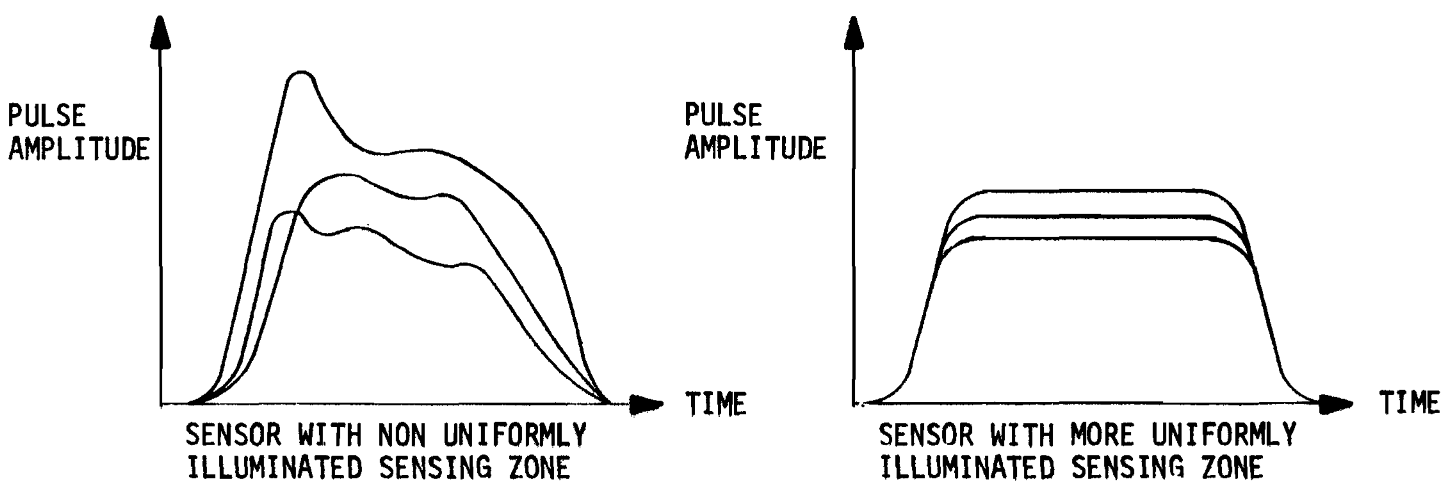


Fig. 6-5: SIMPLIFIED DIAGRAM SHOWING EFFECT OF 3 IDEALLY MONOSIZED PARTICLES PASSING THROUGH A UNIFORMLY OR NON-UNIFORMLY ILLUMINATED SENSING ZONE.

Noise:

The lower limit of detection of particle size is primarily determined by noise generated by the electronic components. (Refer to Sec. 6-6).

Vibration:

Vibration of the optical components, particularly the lamp filament, results in optical variations which show up as particle counts. HIAC sensor optical components are rigidly mounted in a compact mechanical configuration to minimize vibration.

External Noise Pickup:

Sensitive amplifier circuits detecting low level signals may be subject to external radiated energy. HIAC sensors are shielded to minimize this type of noise pickup. This is particularly important in an industrial environment where heavy machinery generates electrical noise.

6-5 STANDARD MODEL SENSORS (Type CMH, CMB)

HIAC manufactures a small, compact, high concentration sensor which has been the "work-horse" of industry for many years. It is a tried and proven sensor which meets the necessary requirements described in the previous section. This sensor is shown in Fig. 6-6.

HIAC has a continuing program of sensor development. If the standard sensors do not satisfy your requirements, please contact your HIAC representative.

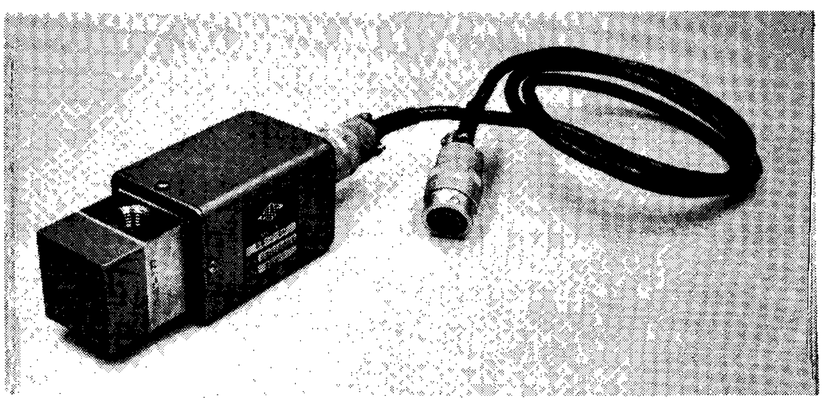


Fig. 6-6.
Standard Type CMH, CMB Sensor

HIAC Sensors utilize the well proven light blockage principle of operation. Their compact and efficient design provides collimated light which ensures a uniform zone of illumination and accurate sizing. Their broad-banded frequency response (to 70 KHz) minimizes the error attributable to flow rate variances. They are provided with an individual multi-point calibration curve, derived from spherical standards, traceable to NBS, or with optional calibration using irregular material, ACFTD, per ISO standard ISO/4402.

CMB Series Standard Sensors are recommended for fluids with moderate numbers of particles or contaminants to be tested. Larger flow rates offer faster test intervals and better flushing of fluid lines.

CMH Series High Concentration Sensors are recommended for very high particle count fluids, which normally would require dilution with clean fluids prior to testing. Flow rates are slower than comparable standard sensors.

6-6 NOISE COMPENSATION

The output of the sensor consists of pulses produced by the particles passing through the microcell plus electrical noise generated in the electronic circuitry. For a given configuration, the magnitude of the noise is constant and this noise level sets a lower limit to the signal which can be detected and measured. In all HIAC particle size analyzers, because all circuits are direct coupled, the pulses and noise add algebraically. Extensive tests have shown that it is possible to take advantage of the noise pulse to extend the measuring range of the sensor by a factor of 2:1 at the low end, e.g. a sensor which originally covered a range of 2-60um may now be used down to 1um. A more detailed description of the technique will be found in Section 6-7.

6-7 CALIBRATION WITH MONOSIZED SPHERES

Spherical calibration is performed to generate calibration numbers (mv) corresponding to the size of mono-sized spherical particles having accurately known diameters. This will allow the preparation of a particle size/calibration number (mv) plot from which all calibration information may be taken.

The standard spheres are not perfectly monosized but do have an extremely narrow gaussian particle size distribution which has been pre-determined and verified by a variety of instrumental and microscopic methods. The median particle size is defined as that point where one-half of the particles are greater and one-half are smaller than that size. A plot of the size distribution of a 10.3um spherical standard in the form of cumulative count percent greater than stated size produces a curve similar to that in Fig. 6-7 with the 50% point at 10.3um.

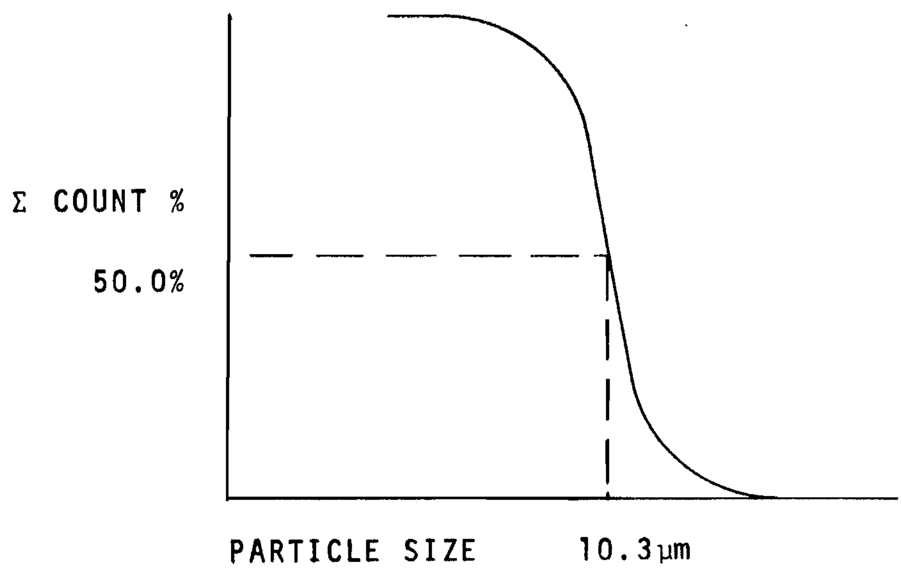


FIG. 6-7 ILLUSTRATION OF PARTICLE HALF-COUNT

HALF-COUNT CALIBRATION METHOD

The factory calibration procedure utilizes what is termed the "half-count method" which is used to determine the precise point where half of the particles are greater and half are smaller than a given threshold and that threshold will, in the example case of the 10.3um particle, represent 10.3um. A total particle count at some point well below the median particle size is taken in channel 1 and a second threshold is then adjusted to the point where it counts one-half of the particles found in channel 1. The position of the second threshold is now set at the median size of the particulate system. This is illustrated in Fig. 6-8.

The vertical lines in Figure 6-8 represent the pulses generated from the 10.3um spherical standard. Threshold 1 (channel 1) is placed at about 5.0um and a total count of 1,000 is observed. Threshold 2 (channel 2) is then adjusted to the point where it counts 500 particles. The voltage level required to trigger channel 2 is then read directly from threshold setting #2 (channel 2).

This procedure is repeated with at least three other monosized spherical particles of appropriate size to the sensor being calibrated.

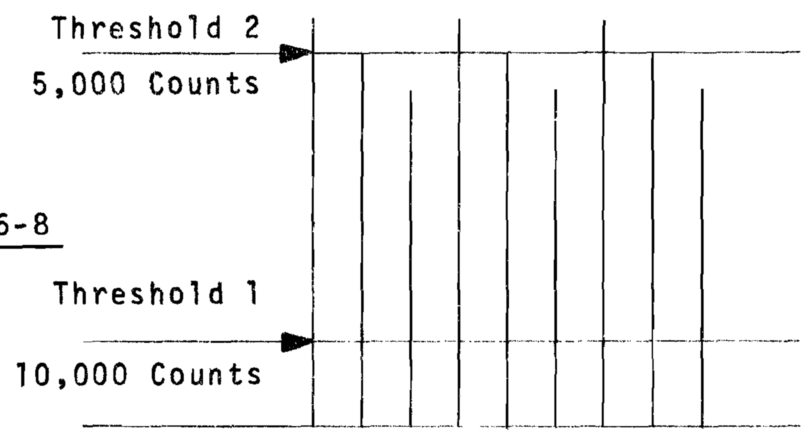


Figure 6-8

NOISE LEVEL DETERMINATION

As noted in Section 6.6 - Noise Compensation, the system has a measurable noise component which is compensated for in the calibration process. This noise component is easily determined by the following process.

With the sensor connected to the PC-320, set the instrument to the TIMER mode with the SAMPLE TIMER set for 30 seconds. (If the PC-320 does not have a sample timer, use a stop watch and run the instrument in the MANUAL mode.) Starting with Channel #1 threshold set at 040A, and the remaining thresholds set at 100B or greater, increase the setting until the count rate drops to about one count second, i.e. 30 counts during the 30 second test period. The threshold setting recorded corresponds to the peak noise output of the sensor.

Note, that when using the "half-count method" of calibration, the threshold setting for channel 1 should be set at least 5 mv (050A) above the noise level setting.

CALIBRATION CURVE DERIVATION

The calibration curve is developed using the Sensor Calibration plot paper.

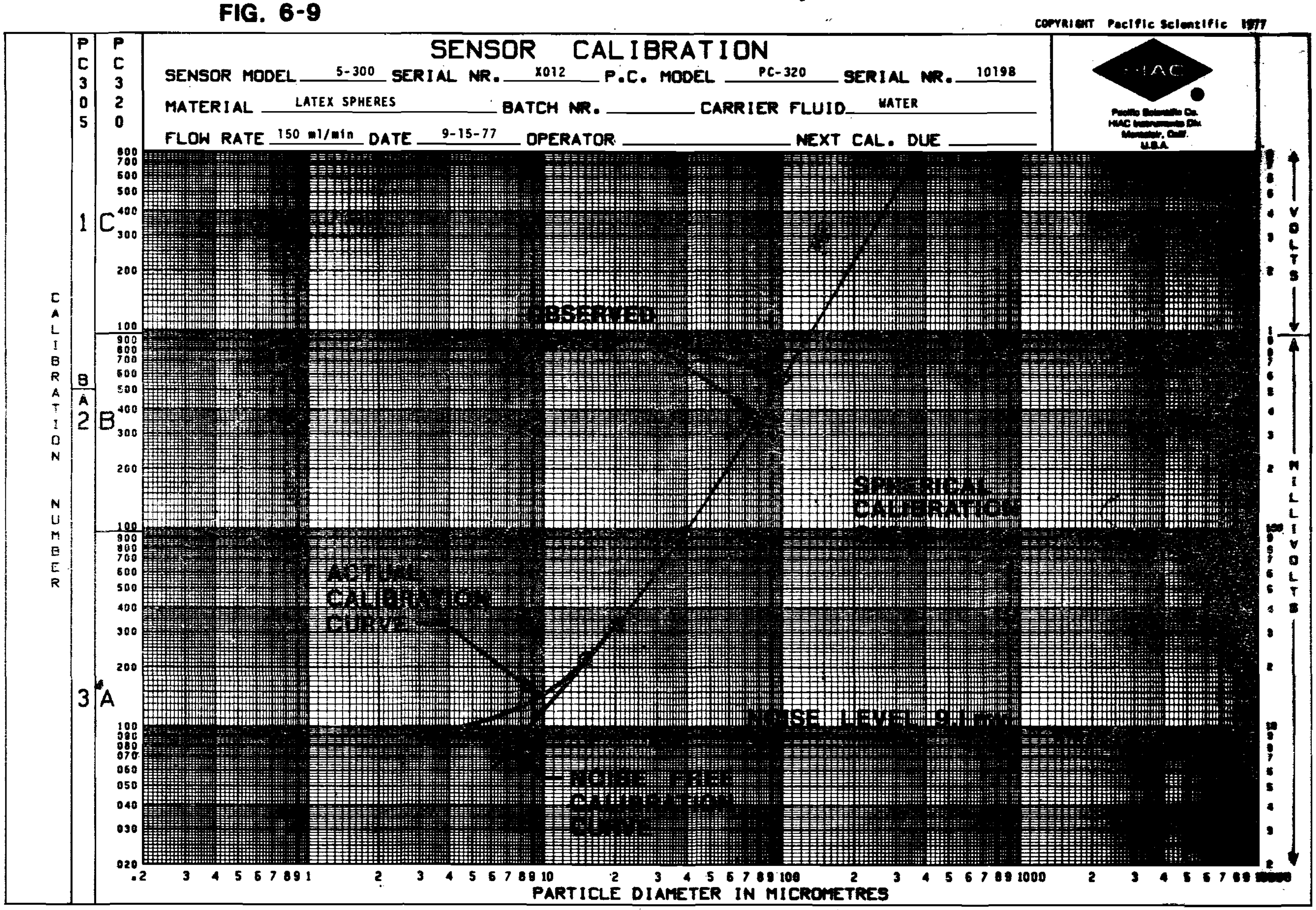
The first step is to draw a horizontal line at the level representing the noise level. In the example shown as Fig. 6-9, the noise level is at 091A which corresponds to 9.1 mv.

When the half-count method was performed a set of theshold settings corresponding to known monosized spheres was determined. To correct these threshold settings for noise, subtract the noise threshold from each of the half-count thresholds to determine the calibration numbers. Plot these data points on the plot paper, i.e. calibration number vs. particle diameter. A best fit straight line drawn through these data points produces the noise free calibration curve.

To produce the actual noise compensated calibration curve, select data points along the noise free curve and add the noise component to these data points. A best fit curve to these new points matches the noise free curve at the large diameter end, but becomes asymptotic to the horizontal noise level line at the small diameter end.

This calibration curve may now be used to set the PC-320 to distinguish class sizes with boundaries determined by the threshold switch settings. Simply set the appropriate threshold switch at the calibration number corresponding to the required diameter.

FIG. 6-9


COPYRIGHT Pacific Scientific 1977
SENSOR CALIBRATION
SENSOR MODEL 5-300 SERIAL NR. X012 P.C. MODEL PC-320 SERIAL NR. 10198
MATERIAL LATEX SPHERES BATCH NR. CARRIER FLUID WATER
FLOW RATE 150 ml/min DATE 9-15-77 OPERATOR NEXT CAL. DUE
HIAC
Pacific Scientific Co.
HIAC Instruments Div.
Montclair, Calif.
U.S.A.
PC305
PC320
CALIBRATION NUMBER
1 C
2 B
3 A
BA
OBSERVED
SPHERICAL CALIBRATION CURVE
ACTUAL CALIBRATION CURVE
NOISE LEVEL 9.1mv
NOISE FREE CALIBRATION CURVE
VOLTS
MILLIVOLTS
PARTICLE DIAMETER IN MICROMETRES

COMPUTER AIDED DERIVATION

The noise compensated calibration curve can be described by the equation:

$$Vs = Ad^k + Vn$$

where:
- Vs = Signal pulse height (mv)
- A = Intercept constant of straight line portion of curve.
- d = Particle diameter (um)
- k = Slope constant of straight line portion of curve.
- Vn = Noise level (mv)

A computer program has been developed by HIAC to assist their technicians in the development of the calibration curve. The operator simply enters the noise level and the threshold values with their corresponding particle diameters as determined using the "half-count method", and the computer supplies a plotted calibration curve.

In addition, the computer outputs parameters which give insight into the integrity of the calibration process. The slope constant, k, is ideally 2.000, while the "goodness of curve fit" is ideally 1.000.

All of this information, as well as data describing the sensor and calibration materials, is provided to the user on the calibration curve, Fig. 6-10.

PACIFIC SCIENTIFIC 1977

SENSOR CALIBRATION

FIG. 6-10

20000817

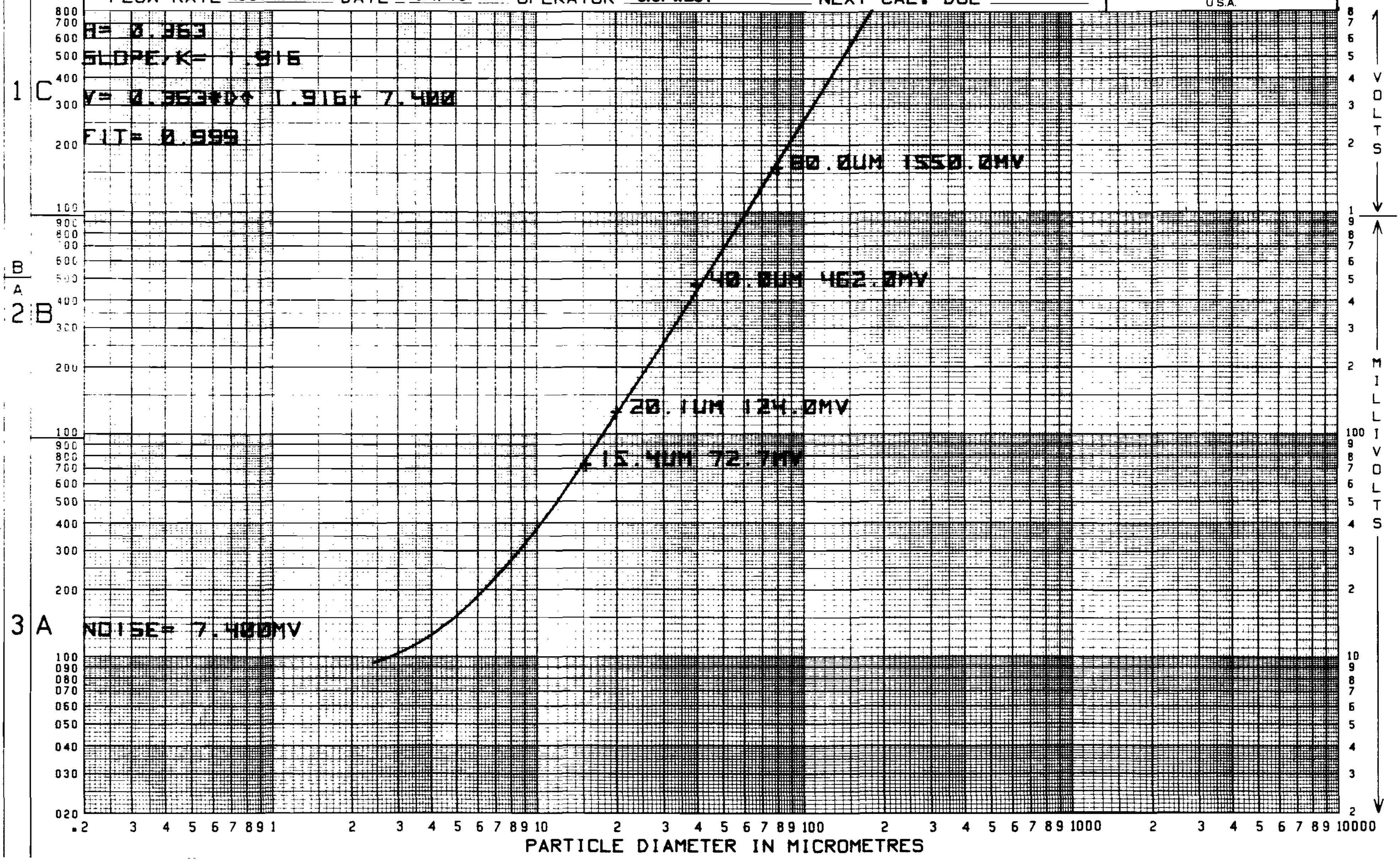
SENSOR MODEL CMB-150 SERIAL NR. 812 P.C. MODEL 320 SERIAL NR. ______

MATERIAL MONOSIZED SPHERES IN H_2O BATCH NR. ______ CARRIER FLUID DISTILLED WATER

FLOW RATE 100 ml./min. DATE 5-11-79 OPERATOR G.C. WEST NEXT CAL. DUE ______

HIAC ®

Pacific Scientific
HIAC Instruments Div.
Montclair, Calif.
U.S.A.



6-8 TRACEABILITY TO NBS

The spherical calibration method has been found to be extremely precise and can be verified by the use of the National Bureau of Standards Standard Reference Material 1003. The HIAC factory standard instrument was calibrated against the mono-sized spheres and that unit was then used to analyze the NBS standard. The data were then coverted to a weight % distribution to allow direct comparison to NBS. Both the HIAC curve and the NBS curve were found to be almost identical as in Fig. 6-11. Where NBS indicates a median size of 15.8um, HIAC indicates a median size of 15.6um.

6-9 CALIBRATION WITH NON-SPHERICAL "AC" FINE TEST DUST (ACFTD)

ACFTD calibration is performed to generate calibration numbers corresponding to non-spherical particles having an accurately known size distribution. The stated sizes of the non-spherical particles are based on microscopically determined greatest dimension and thereby differ considerably from the spherical diameters used in the spherical calibration.

ACFTD has for many years been a standard particulate material for use in fluid power contamination control and filter evaluation applications. The material has been studied by a wide variety of techniques and much documented data has been collected. Calibration of the HIAC Particle Counter with ACFTD was pioneered by Oklahoma State University and the method has been adopted as a standard by the American National Standards Institute (ANSI/B93.28), the National Fluid Power Association (NFPA/T2.9.6), and International Standards Organization (ISO/4402). This is the only particulate standard approved by any standards organization for the calibration of Automatic Particle Counters.

ACFTD was chosen as a standard because it is one of the few known materials having a precisely known log-normal particle size distribution which is easily reproducible and

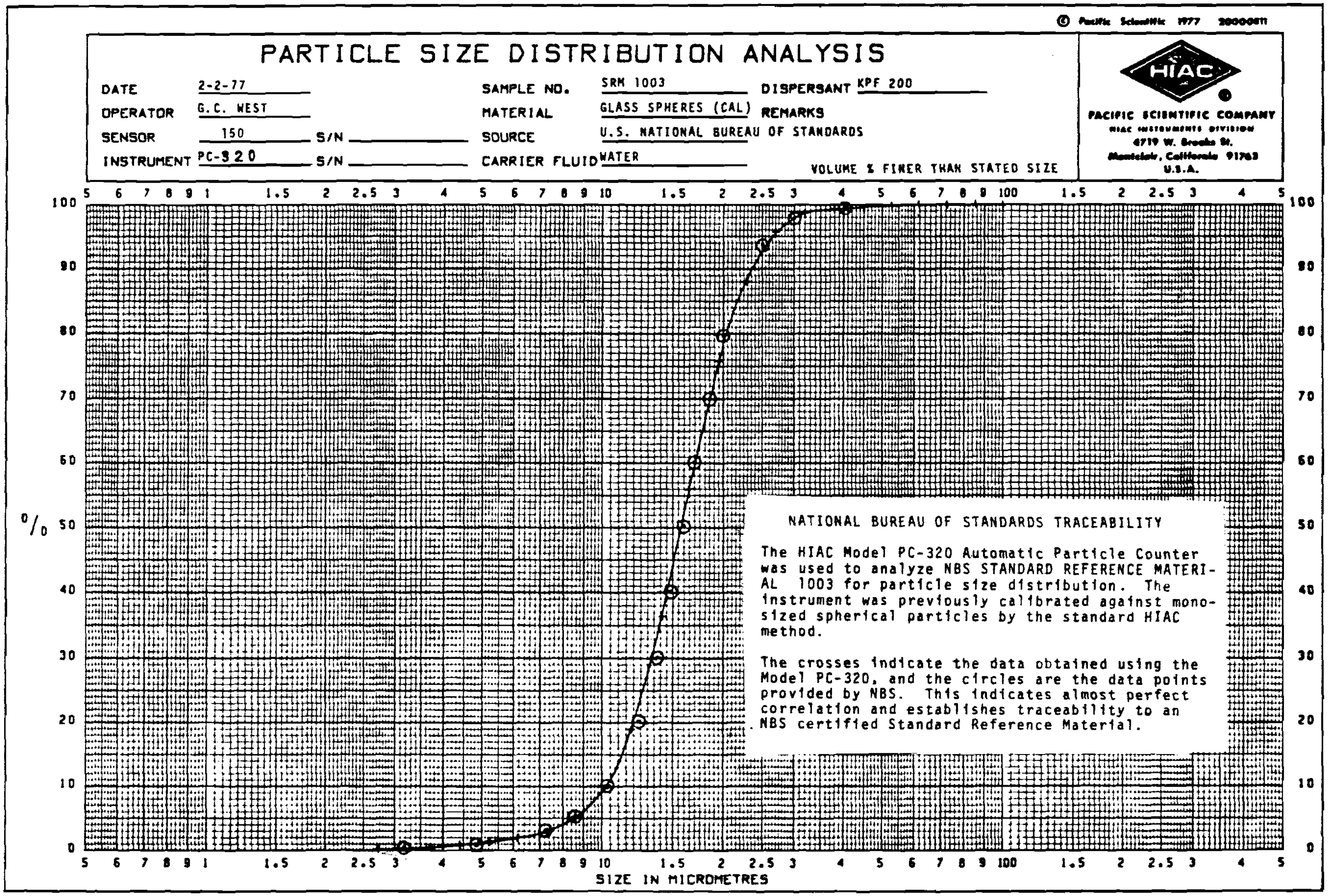


FIGURE 6-11
DATA PLOT
COMPARISON TO NBS DATA

U. S. Department of Commerce
John T. Connor, Secretary
National Bureau of Standards
A. V. Astin, Director

Certificate of Calibration

Standard Reference Material 1003

Calibrated Glass Spheres

(5 to 30 Microns)

This standard sample of microscopically measured beads is issued for use in calibrating equipment and in evaluating methods for measuring particle size in the 5 to 30 micron range.

The values given are based on measurements of 10,000 particles, of which 96 percent by volume are spheres. Four particle-size distributions are given with this sample in the form of graphs. These graphs represent a distribution according to volume (figure 1), a distribution according to weight (figure 2), and two Stokes' law distributions (figures 3 and 4). The volume distribution permits comparison with electronic particle counters which respond according to the volume of the particle. The weight distribution permits comparison with ultrafine sieves, and the Stokes' law distributions permit comparison with certain types of sedimentation and elutriation methods.

Four distributions instead of one arise from the fact that some of the beads contain spherical gas voids which are large enough to affect the weight and sedimentation rate of the bead. Void diameters have been measured and corrections applied. The diameters given in the weight and volume distribution (figures 1 and 2) are actual physical diameters. Those given in the Stokes' law distributions (figures 3 and 4) are diameters corresponding to an equivalent distribution of solid spheres, which, on a weight basis, would settle at the same rate as the actual sample. Comparison of figures 3 and 4 shows the effect of a comparatively large change in the density of the sedimentation medium on the calculated Stokes' law distribution of the sample.

The vertical lines in the graph are an estimate of reproducibility based on three times the standard error of the mean for ten samples of 1,000 beads each of which represents ten subsamples of 100 beads. This corresponds to less than ±4 percent of the particle diameter for particles smaller than 20 microns with somewhat greater uncertainty for particles larger than this size.

The average specific gravity of the beads for purposes of weight-to-volume conversions is 2.39 ±0.01. The specific gravity of the solid glass for Stokes' law calculations is 2.54 based on measuremens of a single prism of the same glass. The specific surface computed from microscopic measurements is 1730 ±50 cm^2/g, which corresponds with a specific-surface mean diameter of 14.5 ±0.4 microns. The sample contains between 500,000 and 600,000 particles per milligram.

Two bottles of beads are provided. It is recommended that each bottle be shaken vigorously for a minute before sampling, and beads be taken from a number of places in each. When the results of the two bottles are analyzed separately, there should be no systematic difference between the two sets of results in excess of the reported reproducibility limits of the sample.

The surface of the glass in these beads can react with atmospheric moisture, which, with time, tends to make them more difficult to disperse. Direct exposure to relative humidities above 90 percent will produce a noticeable effect on dispersibility within three days, whereas the effect is exceedingly slow at relative humidities less than 50 percent, and can be minimized, if not eliminated entirely by storing the beads in a desiccated atmosphere.

W ngton, D. C. 20234
July 1, 1965.

W. Wayne Meinke, Chief,
Office of Standard Reference Materials

Figure 6-12

readily available in large quantities. The particles are non-spherical with a length to width aspect ratio of 2.7:1 and closely resemble the type and shape of particles found as contaminants in hydraulic systems.

Theoretically, a material having a log-normal distribution will always produce analytical samples of the same particle count if exactly the same weight/unit volume of suspending media are prepared. This was researched by Dr. E. C. Fitch at Oklahoma State University and Dr. Erwin Kirnbauer of Pall Filter Corporation. According to Fitch and Kirnbauer, a concentration of 5.0 mg/L of ACFTD suspended in MIL-H-5606 hydraulic fluid would produce the following particle counts at each size level:

TABLE 6-1

>5.0um	=	25,830/10ml
>10.0um	=	7,190/10ml
>20.0um	=	1,270/10ml
>30.0um	=	375/10ml
>40.0um	=	143/10ml

It seems at first glance that it would be difficult, if not impossible, to closely reproduce particle counts based on weighted samples. The reproducibility was verified by the analysis of successive preparations of 50 different samples of 5.0 ml/L of ACFTD in MIL-H-5606 hydraulic fluid. All particle counts were obtained on a standard HIAC Model 320 equipped with an Automatic Bottle Sampler and a 5-150um Sensor at a flow rate of 60.0 ml/min. The data from each sample was found to be easily reproducible within the limits of instrument precision and/or normal statistical variations as in Table 6-2.

TABLE 6-2

Size	Expected Count/10ml	Average of HIAC Counts/10ml	% Dev.
>5.0um	25,830	25,385	1.7
>10.0um	7,195	7,170	0.4
>20.0um	1,270	1,290	1.2
>30.0um	375	337	8.9
>40.0um	143	143	0.0

Further studies were performed by OSU to correlate counts found by optical microscopy to those found on the HIAC unit. The following Table 6-3 is a comparison of data between the microscope and the HIAC unit based on 3 ml samples.

TABLE 6-3
Number of Particles Larger Than
Indicated Size in a 3 ml Sample

Diameter	10 mg/litre Contaminant Level		% Diff.	5 mg/litre Contaminant Level		% Diff.
(Microns)	Microscope	HIAC		Microscope	HIAC	
10	4500	4252	5.5	2250	1920	14.7
15	1900	1873	1.5	950	974	2.5
20	870	805	7.5	435	422	3.0
25	450	465	3.2	225	228	1.0
30	258	274	5.9	129	153	15.7
35	150	128	14.7	75	61	18.7
40	88	88	0.0	44	43	2.0

From Test Report 66-3, Fluid Power Controls Laboratory
Oklahoma State University, Stillwater, Oklahoma.

This can be considered excellent correlation considering the fact that it is virtually impossible to achieve better than 30% reproducibility on the microscope.

When applying the ACFTD procedure to the calibration of a HIAC Particle Counter, the dust is analyzed at 5 size ranges simultaneously. If the particle counts in any of the 5 size ranges differ from the standard expected particle counts, the instrument thresholds are adjusted to the point where the actual counts agree with the expected counts within a few percent. The voltage level (calibration number) required to trigger each threshold is then determined. Since the voltage output (calibration number) is directly proportional to the size of the particle measured, a log-log plot of particle size versus voltage level is prepared as in Fig. 6-13. Please note the absolute linearity of the voltages versus particle size curve. This indicates that the HIAC counter does indeed size a 10.0um particle with the same precision as a 40.0um particle and that the particle counts determined by Fitch and Kirnbauer are in agreement with HIAC's output. This gives a rather high degree of confidence in the ACFTD calibration material and method. The use of the noise compensated calibration curve indicates the same linearity in the noise compensated region.

PACIFIC SCIENTIFIC 1977

SENSOR CALIBRATION

FIG. 6-13

20000817

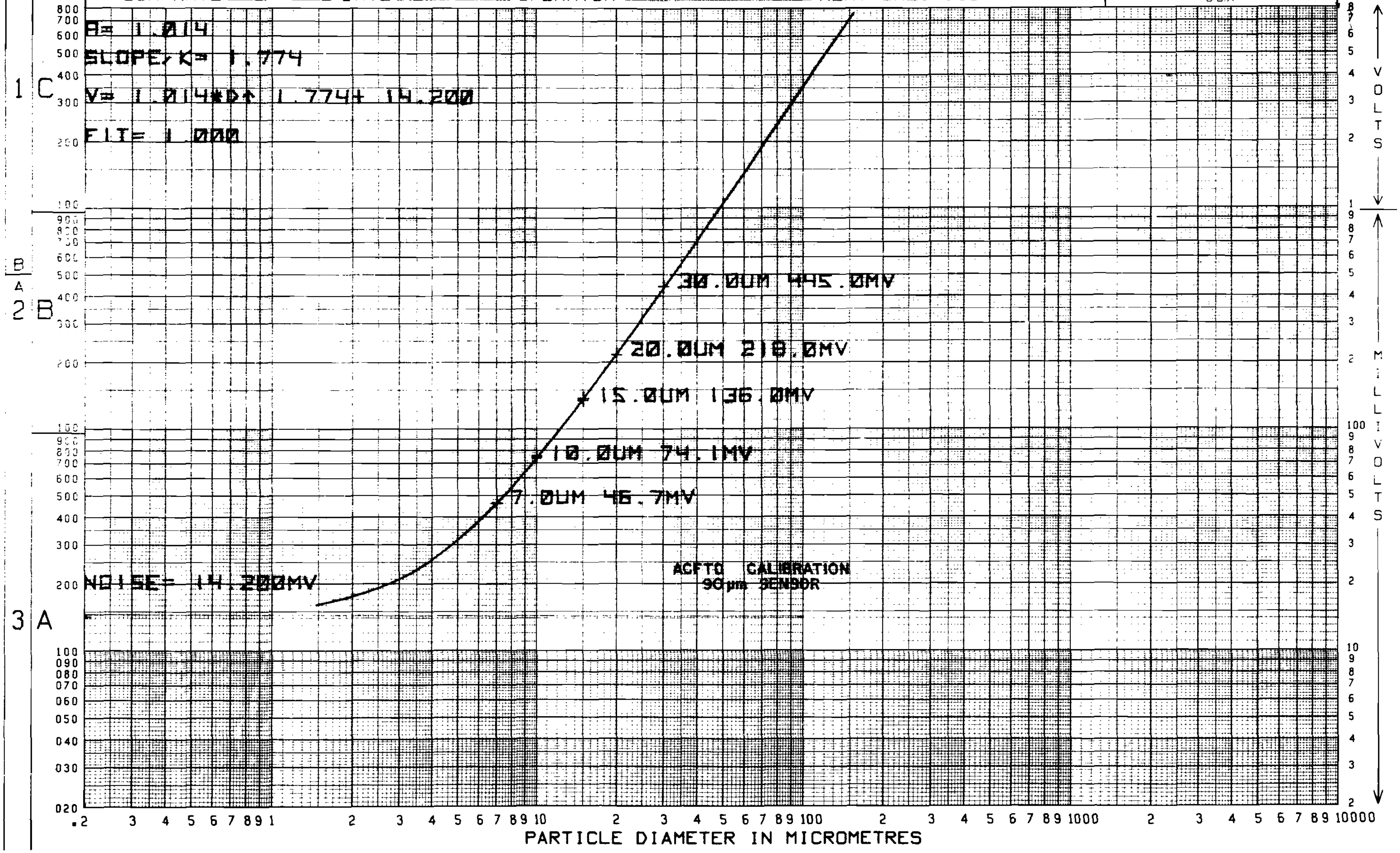
Pacific Scientific
HIAC Instruments Div.
Montclair, Calif.
U.S.A.

PC 305 | PC 320

SENSOR MODEL CMB-90 SERIAL NR. 672 P.C. MODEL 320 SERIAL NR. ______

MATERIAL ACFTD BATCH NR. ______ CARRIER FLUID MIL-H-5606

FLOW RATE 20 5 ml./min. DATE 5-11-79 OPERATOR G.C. WEST NEXT CAL. DUE ______



6-10 CHOICE OF CALIBRATION METHOD

Since each calibration method, either standard spheres or ACFTD, is based on a different parameter of the standard particles, the calibration curves from each will be different. The particle counter user must decide which method is best for his particular application. It should be kept in mind that, although the calibration curves are different and will produce different data, both methods are correct but are merely based on different parameters of the standard particles. If we look at a 5.0um sphere, as in Fig. 6-14 and compare it to a 5.0um ACFTD particle, we can easily see that the ACFTD particle is much smaller in cross-sectional area than the sphere.

Figure 6-14

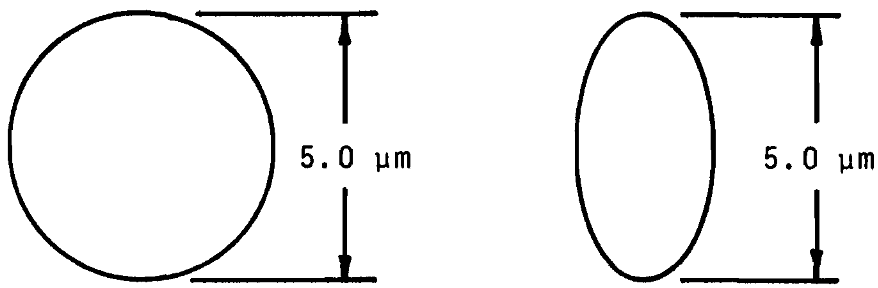


Figure 6-15 represents a log-log plot of both spherical and ACFTD calibration comparing the two methods. The two curves are completely parallel differing by a factor of 1.54:1. To convert from spherical size to ACFTD size, multiply the spherical diameter by 1.54. To convert ACFTD to spherical diameter, multiply by 0.65. To convert the spherical calibration number at any particular size to ACFTD calibration number, multiply by 0.45 and to convert ACFTD to spherical calibration number, multiply by 2.20. It should be noted that this work was performed on a linearily calibrated instrument, however, the same relationship has found utilizing the noise compensated method.

This experimental data confirms the theoretical relationship between ACFTD and spherical diameter. It has been reported many times in technical literature that ACFTD has a length to width aspect ratio of 2.7:1. The ACFTD particle is, of course, not a perfect rectangle nor is it a perfect ellipse but falls somewhere in between. If we calculate the area of a rectangle having a 2.7:1 aspect ratio, we have:

$$A = L \times W$$

$$A = 2.7\text{um} \times 1.0\text{um}$$

$$A = 2.7\text{um}^2$$

The diameter of a circle having an area of 2.7um^2 is:

$$A = \frac{\pi d^2}{4}$$

$$d = \frac{\sqrt{4A}}{\pi}$$

$$d = 1.85\text{um}$$

When comparing the diameter of the circle to the length of the rectangle, we have:

$$\frac{1.85}{2.7} = 0.68$$

Our experimental factor was found to be 0.65.

If, then, we consider the ACFTD particle to be an ellipse, we can calculate its area by:

$A = \pi ab$ when a and b are the semi-axis of the ellipse.

$A = \pi 1.35\ (.5) = 2.12\text{um}^2$.

The diameter of a circle having an area of 2.12um^2 is:

$$d = \sqrt{\frac{2.12\ (4)}{\pi}} = 1.64\text{um}$$

Comparing the diameter of the circle to the length of the ellipse, we have:

$$\frac{1.64}{2.7} = 0.61$$

Again, this is very close to the 0.65 factor found experimentally.

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SENSOR CALIBRATION

FIG. 6-15

HIAC® Pacific Scientific, HIAC Instruments Div, Montclair, Calif. U.S.A.

SENSOR MODEL 5-150 SERIAL NR. 168 P.C. MODEL 320 SERIAL NR. 255

MATERIAL ____ BATCH NR. ____ CARRIER FLUID ____

FLOW RATE 60ml./min. DATE 7-10-79 OPERATOR G.C. WEST NEXT CAL. DUE ____

SIZE COMPARISON
µm

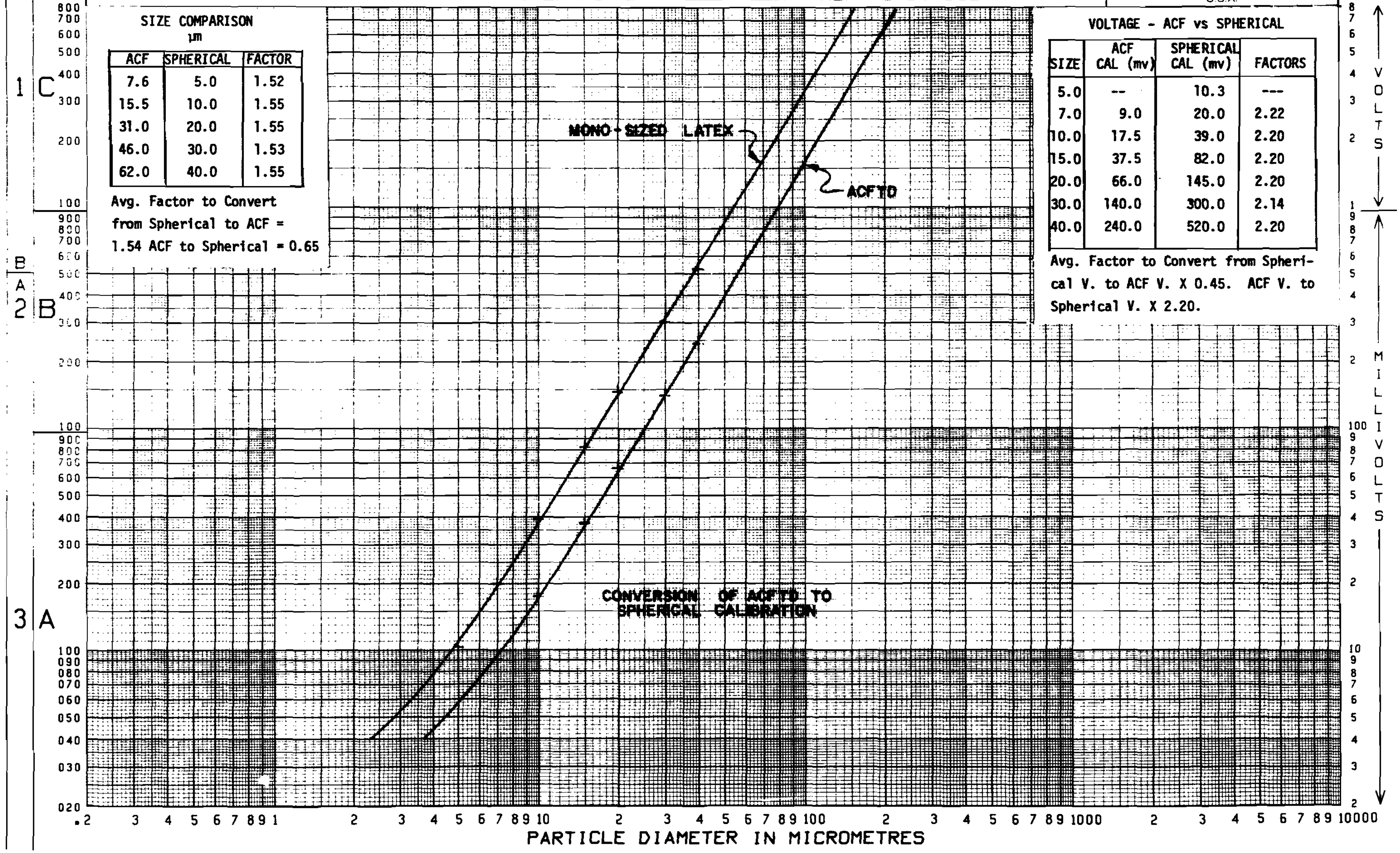
ACF	SPHERICAL	FACTOR
7.6	5.0	1.52
15.5	10.0	1.55
31.0	20.0	1.55
46.0	30.0	1.53
62.0	40.0	1.55

Avg. Factor to Convert from Spherical to ACF = 1.54 ACF to Spherical = 0.65

VOLTAGE - ACF vs SPHERICAL

SIZE	ACF CAL (mv)	SPHERICAL CAL (mv)	FACTORS
5.0	--	10.3	---
7.0	9.0	20.0	2.22
10.0	17.5	39.0	2.20
15.0	37.5	82.0	2.20
20.0	66.0	145.0	2.20
30.0	140.0	300.0	2.14
40.0	240.0	520.0	2.20

Avg. Factor to Convert from Spherical V. to ACF V. X 0.45. ACF V. to Spherical V. X 2.20.



If the ACFTD particle is considered to be midway between an ellipse and a rectangle, we have:

$$\frac{0.68 + 0.61}{2} = 0.645$$

6-11 CALIBRATION AND FLOW RATE

The calibration curve, Fig. 6-10, is valid only for the flow rate listed in Table 4-1. Other flow rates may be used, however, the instrument/Sensor combination must be re-calibrated at the flow rate at which the unknown sample will be analyzed, and conversely, all samples must be analyzed at the calibration flow rates. This re-calibration may be performed with Calibration Kits available from HIAC.

6-12 FIELD CALIBRATION KITS AND PROCEDURES

Calibration kits based on distributed spherical latex or ACFTD are available from HIAC for field re-calibration purposes. The calibration procedure and method for developing the calibration graph is included with the Calibration Kit.

6-13 FREQUENCY OF FIELD CALIBRATION

Proper analytical practice suggests that calibration of any analytical instrument be performed at periodic intervals dependent upon the degree of precision required for any particular application. The calibration of a HIAC Sensor/Particle Counter system should not drift noticeably under normal operating conditions, however, there could be a minor shift if any components are changed or modified. It is recommended that the HIAC instrument be re-calibrated at the following times:

a. Every 90 days (or less) to assure stable calibration.
b. After changing light source.
c. After physical adjustment of light source.
d. After changing or repairing pre-amp board in Sensor assembly.
e. Whenever a new uncalibrated Sensor is installed.

6-14 THEORETICAL CALIBRATION

An alternate calibration method based on the theoretical relationahip between particle size and nominal Sensor dimensions may be used if high sizing precision is not required. Theoretical calibration will permit highly reproducible data although the actual particle size may be somewhat different than the theoretical size. Cross checking between several different HIAC instruments may be difficult to achieve by the theoretical method. The calibration numbers used in this method may be taken directly from the theoretical calibration chart, Table 6-4.

EB-60/CMB-60			EB-90/CMB-90			EB-120/CMB-120		
PARTICLE SIZE d (MICRONS)	CALIBRATION NUMBER	MULTIPLIER	PARTICLE SIZE d (MICRONS)	CALIBRATION NUMBER	MULTIPLIER	PARTICLE SIZE d (MICRONS)	CALIBRATION NUMBER	MULTIPLIER
2	85	A	3	89	A	4	88	A
3	190	"	4	159	"	5	138	"
4	338	"	5	248	"	6	198	"
5	527	"	6	358	"	7	270	"
6	760	"	7	487	"	8	353	"
7	104	B	8	636	"	9	446	"
8	135	"	9	804	"	10	551	"
9	171	"	10	993	"	11	667	"
10	211	"	11	120	B	12	794	"
11	256	"	12	143	"	14	108	B
12	304	"	14	194	"	15	124	"
13	357	"	15	226	"	16	141	"
14	414	"	16	255	"	18	179	"
15	475	"	18	323	"	20	220	"
16	540	"	20	398	"	25	334	"
17	610	"	25	623	"	30	496	"
18	685	"	30	896	"	35	675	"
19	762	"	35	122	C	40	882	"
20	845	"	40	159	"	45	112	C
25	132	C	45	202	"	50	138	"
30	190	"	50	249	"	60	198	"
35	260	"	55	301	"	70	270	"
40	338	"	60	358	"	80	353	"
45	428	"	65	420	"	90	446	"
50	527	"	70	488	"	100	551	"
55	639	"	75	560	"	110	667	"
60	760	"	80	637	"	120	794	"
			85	720	"			
			90	805	"			

EB-150/CMB-150			EB-300/CMB-300		
PARTICLE SIZE d (MICRONS)	CALIBRATION NUMBER	MULTIPLIER	PARTICLE SIZE d (MICRONS)	CALIBRATION NUMBER	MULTIPLIER
5	85	A	10	85	A
6	122	"	11	102	"
7	166	"	12	122	"
8	216	"	13	143	"
9	274	"	14	166	"
10	338	"	15	190	"
11	409	"	16	216	"
12	486	"	17	245	"
13	570	"	18	274	"
14	662	"	19	306	"
15	760	"	20	338	"
20	135	B	25	527	"
25	211	"	30	760	"
30	304	"	35	104	B
35	414	"	40	136	"
40	540	"	45	171	"
45	692	"	50	211	"
50	845	"	55	256	"
55	102	C	60	304	"
60	122	"	65	357	"
65	143	"	70	414	"
70	166	"	75	475	"
75	190	"	80	540	"
80	216	"	90	685	"
90	274	"	100	845	"
100	338	"	125	132	C
110	409	"	150	190	"
120	486	"	175	260	"
130	570	"	200	338	"
140	662	"	225	428	"
150	760	"	250	527	"
			275	640	"
			300	760	"

Table 6-4

Theoretical Calibration Charts

SECTION VII

OPERATIONAL, TECHNIQUE, AND APPLICATION SUGGESTIONS

7-1. GENERAL

7-2. This section contains a discussion of some basic suggestions to consider when operating the HIAC PC-320. Many problems can be traced directly to unfamiliarity with general contamination control and/or particle technology principles. HIAC personnel have gained many man-years of experience in this field and our Engineering and Applications Engineering Departments are always eager to answer any questions or to assist instrument users upon request.

7-3. The PC-320 requires little or no warm-up time for electronic circuits to stabilize. The instrument will be ready for operation within 3 - 5 minutes after turning on power.

7-4. The Sensor lamp is illuminated at all times when the PC-320 power is on. To prolong the life of the Sensor lamp, turn off the PC-320 power when the instrument is not in use. If it is desired to maintain instrument power for long intervals while not analyzing samples, the Sensor cable may be disconnected to disable the Sensor lamp.

7-5. SAMPLE CONTAINERS

A. Clean sample containers must be used at all times to avoid contamination of the sample. Often times when the sample particle count is higher than expected, it is due to the use of dirty containers. Containers may be made of any material compatible with the sample to be analyzed, however, high quality glass has been found to be the most useful. The glass bottles should have a wide mouth and be free of bottom ridges which can trap particles. HIAC recommends the use of HIAC Clean Bottles, part #90240003 (0723-3) which are cleaned by ultra-sound and ultra-clean mechanical methods to NAS specification 1638, Class 0 or better as follows:

NAS 1638 Class 0

SIZE(μm)	5-15	15-25	25-50	50-100	>100
Number of Particles/ml	2.5	0.44	0.08	.02	0

HIAC has monitored clean bottles from all other commercial sources and none have been found by HIAC to reach this specification.

B. Clean bottles may be prepared in the laboratory by thorough washing with soap and water, ultrasonic immersion, and rinsing with clean filtered distilled water. Compressed air drying methods must not be used.

C. Bottle closures such as screw caps, snap-caps, rubber stoppers, glass stoppers, etc. are a serious source of contamination. A clean film of nylon or mylar should always be used between the bottle and closure. Nylon film is available from HIAC part #10000156 (0724). Commercial plastic wrapping material may be used in emergency situations although they are often times too dirty. Metal foils must not be used.

D. Bottles must be dry or free of liquids which are immiscible with the sample to be analyzed.

E. Bottles may be rinsed prior to use with clean sample fluid or other clean fluid miscible with the sample. The HIAC Bottle Flush Stand model BF-100 has been found to be extremely useful for this procedure.

7-6. CLEAN FLUIDS

It is often helpful to maintain a supply of clean fluid to be used as a diluent for overconcentrated samples as well as for bottle flushing. The HIAC BF-100 Bottle Flush Stand, with a capacity of 4.5 gallons and 0.9μm high volume filtration, may be used.

7-7. SAMPLING TECHNIQUES

A. Sample ports and valves are a source of sample contamination. When sampling, open the valve and allow enough fluid to flow through the valve to flush it thoroughly before sample collection. Close the valve only after the sample bottle has been removed. Do not open, close, or adjust the valve during the sample collection procedure.

B. When sampling from closed containers such as pharmaceutical bottles, oil cans, etc, take precautions to avoid contamination from closure removal or penetration. All tools, syringes, etc, should be flushed with clean fluid if they are to come into contact with the sample.

C. When transferring samples from a container to a clean bottle for analysis, allow a portion of the sample to wash the lip of the container before sample collection. It is best to analyze the sample directly in the container if possible, and avoid transfer.

D. All sample containers should be well shaken prior to sampling to assure representative sampling.

E. If dilutions are required always use clean volumetric glassware.

7-8. BUBBLES

All particle counters see bubbles as particles and cannot differentiate between the two; therefore, bubbles must be avoided or removed by any of the following methods:

a. Subjection to ultrasonics.
b. Subjection to reduced pressure.
c. Subjection to high pressure.
d. Allowing the sample fluid to remain stationary long enough for the bubble to rise to the surface.

7-9. FLOW RATE

A. The EB and CMB series Sensors are essentially insensitive to flow rate variations when used within the limits outlined in Section IV and listed in Table 4-1. When the instrument is operated on a time basis, it is important that constant flow rates are used throughout the counting cycle.

B. Some low boiling point fluids, such as Freon, may de-gas at points of pressure reduction when flowing through the Sensor/Volume Metering system. When working with these fluids, it is best to work with a higher inlet pressure and a micrometer restrictor valve downstream of the Sensor to set flow rates.

C. Some low viscosity fluids require fairly low (e.g. 2-5 psi) positive pressures to maintain the proper flow rates with smaller sized Sensors. The previously mentioned micrometer restrictor valve may be used or the use of a low pressure regulator may be necessary. Consult your HIAC service representative for details.

D. Some high viscosity fluids such as 30 weight oil or viscose may require a high pressure pump/pressure cylinder system to provide a workable flow rate. Temperature elevation to reduce viscosity may also be used.

E. Flow rates should be measured from time to time with a stopwatch and A.B.S. volumeter.

F. Causes of flow rate changes

1. Viscosity change by temperature differential or dilution.
2. Improper setting or malfunction of pressure regulator.
3. Partial blockage of Sensor or flow system.

7-10. HIGH HUMIDITY CONDITIONS

In areas of high humidity it is possible that condensation will occur within the pressure cylinder when alternating between high and low pressures. This will result in abnormally high or inconsistant particle counts if the condensed water droplets fall into the sample. Condensation can be eliminated by the use of a dessicator in the pressure line between the pump and pressure cylinder. The dessicator is available as an option from HIAC (P/N 20000409).

7-11. CALIBRATION

Calibration is discussed thoroughly in Section VI and that section should be reviewed from time to time. It is important to understand the differences in calibration methods and materials. Much of the confusion in the entire field of fine particle technology is a result of the many different definitions of particle size in use. All of the calibration methods are correct in their own right but do produce different data because they are all based on different particle parameters.

7-12. DATA PRESENTATION

A. Cumulative data (Total count mode) is expressed as total number of particles greater than each stated size (threshold). Differential data (Delta count mode) is expressed as the number of particles between each size level. Examples:

CUMULATIVE COUNT (TOTAL COUNT MODE)		DIFFERENTIAL COUNT (DELTA MODE)	
>5µm	10,000	5-10µm	2,000
>10µm	8,000	10-15µm	4,000
>15µm	4,000	15-20µm	3,000
>20µm	1,000	20-30µm	750
>30µm	250	30-40µm	230
>40µm	20	>40µm	20

Note

In Delta mode the last channel is always cumulative.

B. The data sheet format in Figure 7-1 has been found to be useful.

DATE________________

HIAC PC-320

HIAC Division

PACIFIC SCIENTIFIC COMPANY

PARTICLE SIZE ANALYSIS DATA SHEET

COMPANY________________________ INSTRUMENT HIAC PC-320________S/N________

SAMPLE________________________ SENSOR________________________S/N________

SOURCE________________________ CALIBRATION (Spherical)________ACFTD________

SAMPLE VOLUME________________________

OPERATOR________________________ml

Ch. No.	Particle Size µm	Cal. No.	Count Total	Mode Delta	PARTICLE COUNTS n 1	n2	n 3	n 4	n5	$\overline{n}$	$\overline{n}$/___ml
1											
2											
3											
5											
6											
7											
8											
9											
10											
11											
12											

Figure 7-1

7-13. SENSOR MAINTENANCE AND CLEANING

7-14. It is important that the Sensor be kept as clean as possible to assure maximum performance. Partial or complete Sensor blockages will occur if particles larger than the sensing zone are allowed to enter the Sensor. These blockages may be removed by attaching a fluid filled syringe to the Sensor outlet adapter and backflushing the fluid through the Sensor. If backflushing isn't successful, a cleaning probe may be inserted directly into the outlet side of the Sensor to push the particles out through the inlet side.

7-15. The Sensor may develop a film over the windows over a period of time if fluids, expecially water, are allowed to dry in the Sensor. Most liquids, even if filtered, will leave some residue when dried. The automatic base level control will compensate for the film accumulation, however eventually the film must be removed to eliminate the possibility of window size reduction. Film accumulation may be avoided by simply not allowing the Sensor to dry. Clean fluid may be left in the Sensor at all times. When water is used, it must be distilled. A wetting agent such as Eastman Kodak Photo-Flow/200 has been found to be useful.

7-16. If Sensor drying is necessary, water may be removed by cycling isopropanol, methanol, or ethanol through the Sensor. The final drying agent is Freon T.F. If oils are to be removed, solvent such as Stoddard's solvent or Freon T.F. may be used. Solvents for specific fluids may be used at any time providing they are compatible with the Sensor materials; i.e., stainless steel, glass, Buna N, and epoxy. Chemical reaction between solvents should be considered to avoid the possibility of precipitate formation which may cause Sensor problems.

Caution:

Do not use acetone or strong soluents, MEK, strong acids and bases with the standard CMB, CMH sensor, Special Acid and Solvent sensors are abailable from HIAC.

SECTION VIII

ACCESSORIES

8-1. GENERAL

8-2. This section contains a description of, and installation and operation procedures for the various accessories available for the HIAC PC-320 Particle Size Analyzer.

8-3. RECYCLE TIMER

8-4. The Recycle Timer is a thumbwheel switch used to set the time interval in minutes, between automatic particle counting procedures when the PC-320 is used in the timing mode with the Sample timer. The Sample timer resets and starts the Recycle timer. At the pre-set time, the Recycle Timer stops, sending a command to the start/stop function which STARTS the PC-320 again for another timed count. If the Auto/Print switch is depressed, Print Out will occur automatically at the end of each cycle. The Recycle Timer option will cause the instrument to function continuously until the STOP command button is depressed and the recycle switch is returned to OFF.

8-5. FIELD INSTALLATION OF RECYCLE TIMER KIT (#20000246)

Note

Recycle Timer ON/OFF switch is standard and is factory installed in all PC-320 units at time of manufacture. Field installation is only possible on instruments with a previous sample timer.

8-6. INSTALLATION PROCEDURE

A. Turn OFF all power by placing ON/OFF switch in OFF position.

B. Remove top cover by removing two screws at top of Back panel.

C. Open Front panel to expose inner panel.

D. Remove Recycle Timer hole plug by removing four screws.

E. Unpack Recycle Timer module, cable, and hardware.

F. Connect multi-colored cable (19002352) to connector socket J1 of Sample timer board on back of inner panel with arrow pointing up.

G. Connect remaining connector of multi-colored cable to socket J1 of Recycle Timer board.

H. Using #2 size hardware supplied with kit, install Recycle Timer module onto inner panel.

I. Replace cover, but do not tighten screws.

J. Turn power on by placing ON/OFF Power switch to ON position.

K. Test Recycle Timer as per instructions included.

L. Turn off power and replace two screws in top cover back panel.

8-7. DIGITAL PRINTER PO-500/600

8-8. The HIAC Model PO-500/600 is an eighteen column digital printer using a print drum with thirteen positions per column. One complete line of data is printed in a single revolution of the print drum (approximately 370 milliseconds).

8-9. Figure 1 shows the print drum format. Each vertical position of a given column is selected for printout by means of a binary coded number 0 through 12. Except for columns 5 and 12, which are reserved for symbols, the digits 0 through 9 are selected by the same numbers in binary coding which are identical with BCD (1248) coded numbers. The other three positions are selected by binary coded numbers 10, 11 and 12.

8-10. Connections to the printer are made via two connectors on the Rear Panel, J1 which has 63 pins and J2 which has 28. Pin assignments are listed in Tables 1 and 2. Connector J1 accepts data from the particle counter, while J2 is for use with a 24-hour clock or a stop watch (9m 59s max.). PO-500/600 specifications are listed in paragraph 8-28 to 8-33.

POSITION	CODE	COLUMN NUMBER																	
NUMBER	8421	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
12	1100	S						R	A	T	I	O							%
11	1011	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	1010							.	.	.	.				.	.	.	.	
9	1001	9	9:	9	9		9	9	9	9	9	9		9	9	9	9	9	9
8	1000	8	8:	8	8	$\Delta\bar{n}$	8	8	8	8	8	8	Δ	8	8	8	8	8	8
7	0111	7	7:	7	7	n	7	7	7	7	7	7	T	7	7	7	7	7	7
6	0110	6	6:	6	6	V	6	6	6	6	6	6	°C	6	6	6	6	6	6
5	0101	5	5:	5	5	W	5	5	5	5	5	5	°F	5	5	5	5	5	5
4	0100	4	4:	4	4	P	4	4	4	4	4	4	V	4	4	4	4	4	4
3	0011	3	3:	3	3	Δ	3	3	3	3	3	3	mV	3	3	3	3	3	3
2	0010	2	2:	2	2	T	2	2	2	2	2	2	μm	2	2	2	2	2	2
1	0001	1	1:	1	1	Ch	1	1	1	1	1	1	A	1	1	1	1	1	1
0	0000	0	0:	0	0	A	0	0	0	0	0	0	B	0	0	0	0	0	0

Figure 8-1 - Print Drum Format

TABLE 8-1

PIN ASSIGNMENTS - CONNECTOR J1

FOR PO-500 S/N 019 & ON AND ALL PO-600's

COLUMN	BIT	PIN #	COLUMN	BIT	PIN #
5	1	51	12	1	19
	2	55		2	23
	4	53		4	21
	8	57		8	25
6	1	43	13	1	22
	2	47		2	26
	4	45		4	24
	8	49		8	20
7	1	35	14	1	30
	2	39		2	34
	4	37		4	32
	8	41		8	28
8	1	3	15	1	6
	2	7		2	10
	4	5		4	8
	8	9		8	4
9	1	27	16	1	14
	2	31		2	18
	4	29		4	16
	8	33		8	12
10	1	11	17	1	46
	2	15		2	50
	4	13		4	48
	8	17		8	44
11	1	38	18	1	54
	2	42		2	58
	4	40		4	56
	8	36		8	52

Print command	59	Ground	61
Print Red Enable	1	Data Change Inhibit	2
Paper Advance after Last Line	60	-15V DC	62
		N.C.	63

TABLE 8-1A

PIN ASSIGNMENTS - CONNECTOR J1 FOR PO-500 S/N 001-018

COLUMN	BIT	PIN #	COLUMN	BIT	PIN #
5	1	58	12	1	27
	2	59		2	35
	4	60		4	29
	8	61		8	37
6	1	34	13	1	40
	2	44		2	30
	4	43		4	32
	8	42		8	38
7	1	36	14	1	46
	2	26		2	45
	4	28		4	47
	8	18		8	48
8	1	53	15	1	31
	2	54		2	41
	4	55		4	39
	8	56		8	33
9	1	24	16	1	15
	2	22		2	25
	4	16		4	23
	8	14		8	17
10	1	9	17	1	1
	2	4		2	10
	4	2		4	8
	8	7		8	3
11	1	5	18	1	20
	2	12		2	6
	4	21		4	13
	8	19		8	11

Print Command	49
Print Red Enable	51
Advance Paper after Last Line	50
Ground	52
Data Change Inhibit Signal	57

TABLE 8-2
PIN ASSIGNMENTS - CONNECTOR J2

FUNCTION	COLUMN	BIT	PIN #
MSD Hours	1	1	9
		2	13
		4	11
		8	15
LSD Hours	2	1	4
		2	8
		4	6
		8	2
MSD Minutes	3	1	12
		2	16
		4	14
		8	10
LSD Minutes	4	1	1
		2	5
		4	3
		8	7
Data Change Inhibit Signal			28
Ground			26

DUAL 6 PRINTOUT FORMAT

		Line	Color
09:31Δ	031B0167.0	3	Black
09:31	005 000003	2	Black
09:31Ch06	050°C000501	1	Red
09:31Δ	031B0096.1	3	Black
09:31	005 000011	2	Black
09:31Ch05	050°C001057	1	Red
09:31Δ	031B0080.8	3	Black
09:31	005 000107	2	Black
09:31Ch04	050°C008642	1	Red
09:31Δ	031B0049.3	3	Black
09:31	005 000720	2	Black
09:31Ch03	050°C035497	1	Red
09:30Δ	031B0040.1	3	Black
09:30	005 002451	2	Black
09:30Ch02	050°C098301	1	Red
09:30Δ	031B0028.2	3	Black
09:30	005 006983	2	Black
09:30Ch01	050°C197542	1	Red

(Optional Printout ° F)

Figure 8 - 2

8-11. OPERATION WITH PC-320

8-12. When operated on a 12-channel PC-320, the printout is on a single channel per line basis as follows:

Ch. 12	000000
Ch. 11	000001
Ch. 10	000003
Ch. 09	000020
Ch. 08	000095
Ch. 07	000150
Ch. 06	000875
Ch. 05	001565
Ch. 04	007510
Ch. 03	018623
Ch. 02	085123
Ch. 01	126931

8-13. Columns 9 through 11 are available to print relevant digital data with identification symbols in column 12 as shown in Figure 8.1.

8-14. OPERATION WITH PC-326 (6+6) (See para. 8.35-43)

8-15. The PC-326 is designed primarily for measuring the efficiency of filters at six different particle sizes. Two Sensors are used, one upstream of the filter and one downstream. Because of the high particle concentrations involved, the sample fluid may require dilution above and below the filter.

8-16. An additional P.C. Board incorporating a digital calculator is added to the PO-500 Printer, making it a Model PO-600. For each particle size threshold, a three line print format is used. First the printer displays the actual particle count above the filter, then the actual count below the filter. For the third line, the

(8-16. continued)
calculator divides line one by line two, multiplies the quotient by a composite dilution factor (dialed in via digital thumb switches) and then prints out the result which is the filter efficiency factor (B) for the particle size involved. (9999.9 Max.)

8-17. Provision is also made to print out data pertaining to oil temperature, oil flow through the filter and pressure drop across the filter. This requires that the user provide suitable transducers with digital output signals. Refer to paragraph 8-48 through 8-53.

8-18. NOTE

If the Sensor below the filter sees no particles in a given channel, the calculator will reject the data since it cannot divide by zero. When this occurs, the printout assumes a two-line format, thus:

09:30Δ	B000000	Black
09:30Ch.06	050°C000482	Red

8-19. CALCULATION OF COMPOSITE DILUTION RATIO

8-20. Figure 8-3 is a Schematic Diagram of the filter test hook-up. Sensor "A" is upstream of the filter and Sensor "B" is downstream. F_{A1} etc. are flow rates measured at the points indicated.

8-21. The fluid ahead of the filter is diluted before entering Sensor "A" and the dilution ratio is:

$$D_A = \frac{F_{A2}}{F_{A2} - F_{A1}}$$

Similarly, below the filter, the dilution ratio is:

$$D_B = \frac{F_{B2}}{F_{B2} - F_{B1}}$$

(8.21. continued)

For a given particle size, let the number of particles counted in time t by the two sensors be N_{MA} & N_{MB}.

8-22. These particles were suspended in undiluted sample volumes given by $(F_{A2} - F_{A1})t$ and $(F_{B2} - F_{B1})t$ respectively, so the particle concentration above & below the filter are given by $C_A = N_{MA}/(F_{A2} - F_{A1})t$ and $C_B = N_{MB}/(F_{B2} - F_{B1})t$

8-23. The filter efficiency B is defined as the ratio of particle concentration above and below the filter.

Hence $$B = \frac{C_A}{C_B} = \frac{N_{MA}}{N_{MB}} \times \frac{F_{B2} - F_{B1}}{F_{A2} - F_{A1}}$$

8-24. The factor $(F_{B2} - F_{B1})/(F_{A2} - F_{A1})$ is referred to as the composite dilution factor which must be dialed into the thumb wheel switches located on the Front Panel of the Printer.

(Note that the dials will accept only integers from 1 through 99)

8-25. PAPER REPLACEMENT PROCEDURE

1. Turn off Printer.
2. Undo (4) screws on Front Panel, remove panel.
3. Put fingers under slide that print head sits on and pull forward as far as plate will go.
4. Tilt print head forward. Do not let head drop hard.
5. Remove thumb screw on left side bracket. Pull roller out.
6. Put new roll of paper on roller, replace on brackets, replace thumb screw and tighten down snug. (See Figure 8-4)
7. Thread tape under head as shown in Figure 8-5 and tilt head to upright position.

(8-25. continued)

8. Pull down paper guide as shown in Figure 8-4.
9. Push head back in cabinet, turn on unit and push paper advance button to advance tape through head about 3 inches.
10. Thread tape through paper guide and close paper guide so that it snaps.
11. Turn off unit, put Front Panel back after feeding tape through opening in panel. Tighten (4) screws.

8-26. RIBBON REPLACEMENT PROCEDURE

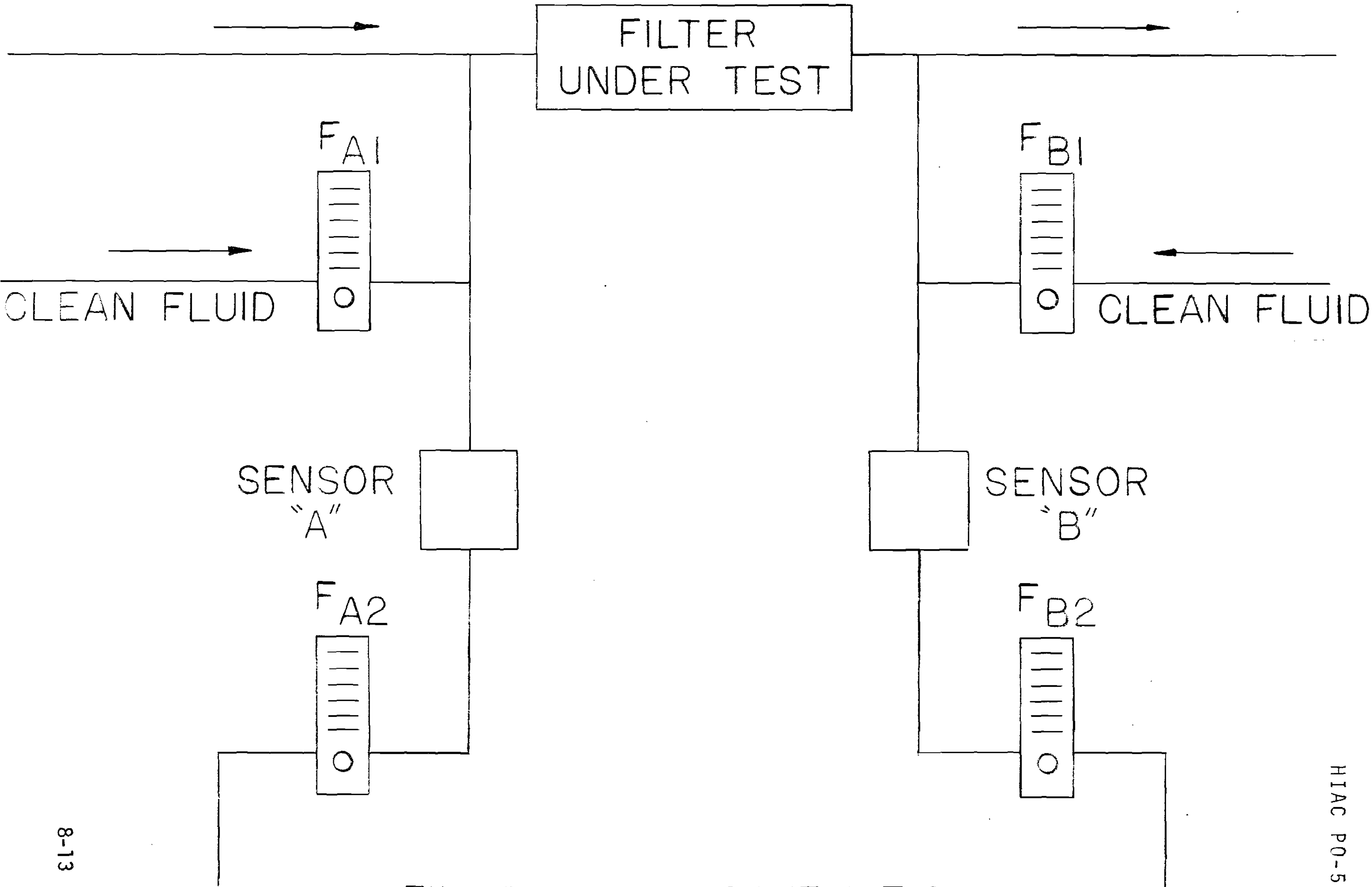
NOTE: A) Ribbon automatically reverses itself when it runs down.

B) The ribbon must be threaded on print head as shown in Figure 8-5 (bottom) or it will not work.

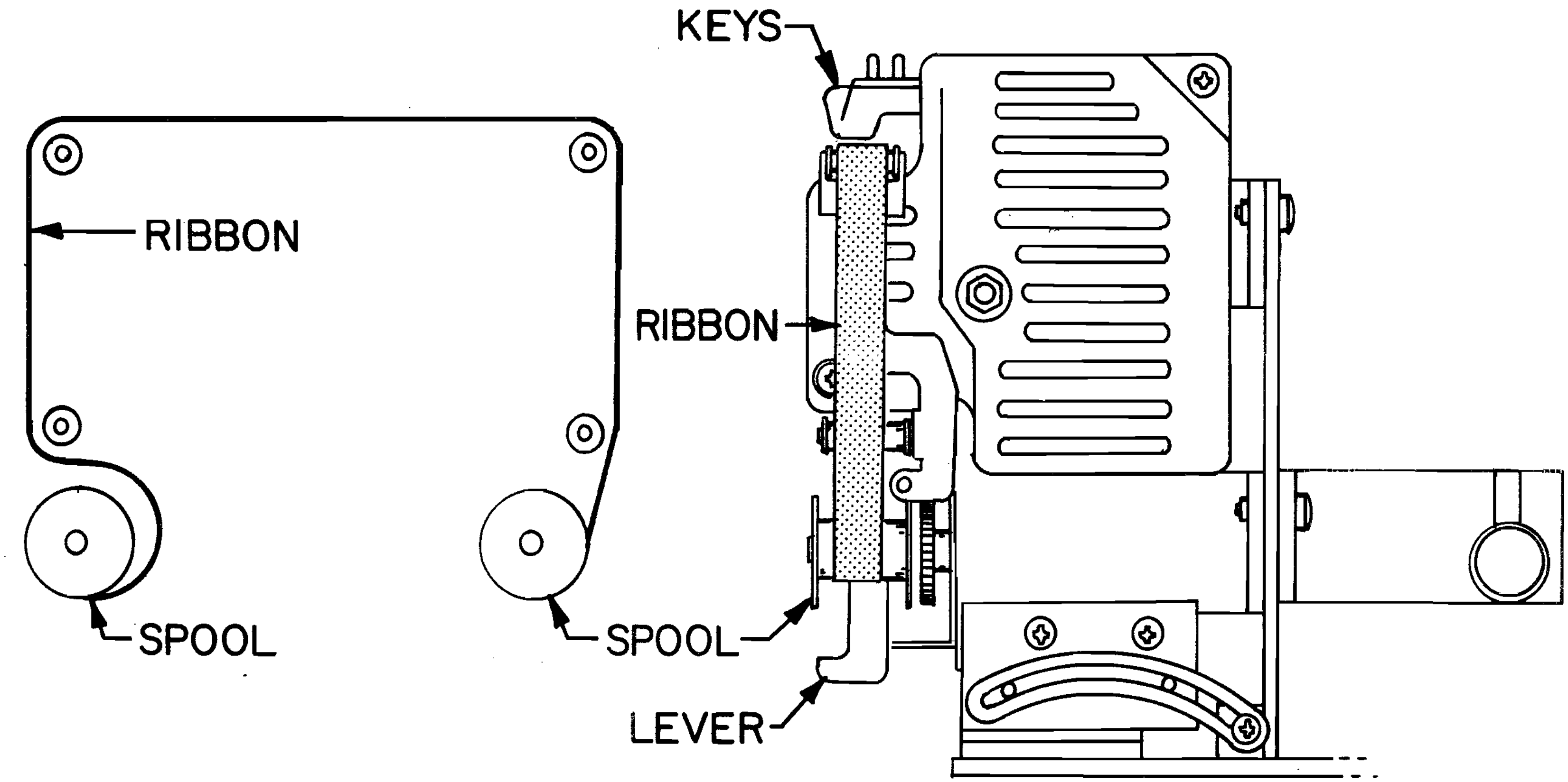
C) The black on the ribbon must be facing forward.

8-27. REPLACING RIBBON

1. Turn off unit.
2. Undo (4) screws on Front Panel and remove panel.
3. To remove ribbon spools, push lever underneath each spool down and pull spool off. Remove ribbon and spools. (See Figure 8-5, top)
4. To replace ribbon/spools, put ribbon under keys on top of print head and down over rollers on each side. Push levers down from previous step and replace spool each side part way. Take up slack on ribbon, push down levers again and push spool on all the way.
5. Turn on unit and test.
6. Turn off unit.
7. Replace Front Panel threading paper through hole in panel. Tighten (4) screws.



FILTER TEST SCHEMATIC
FIG. 8-3



FRONT VIEW

SIDE VIEW

FIG. 8-4

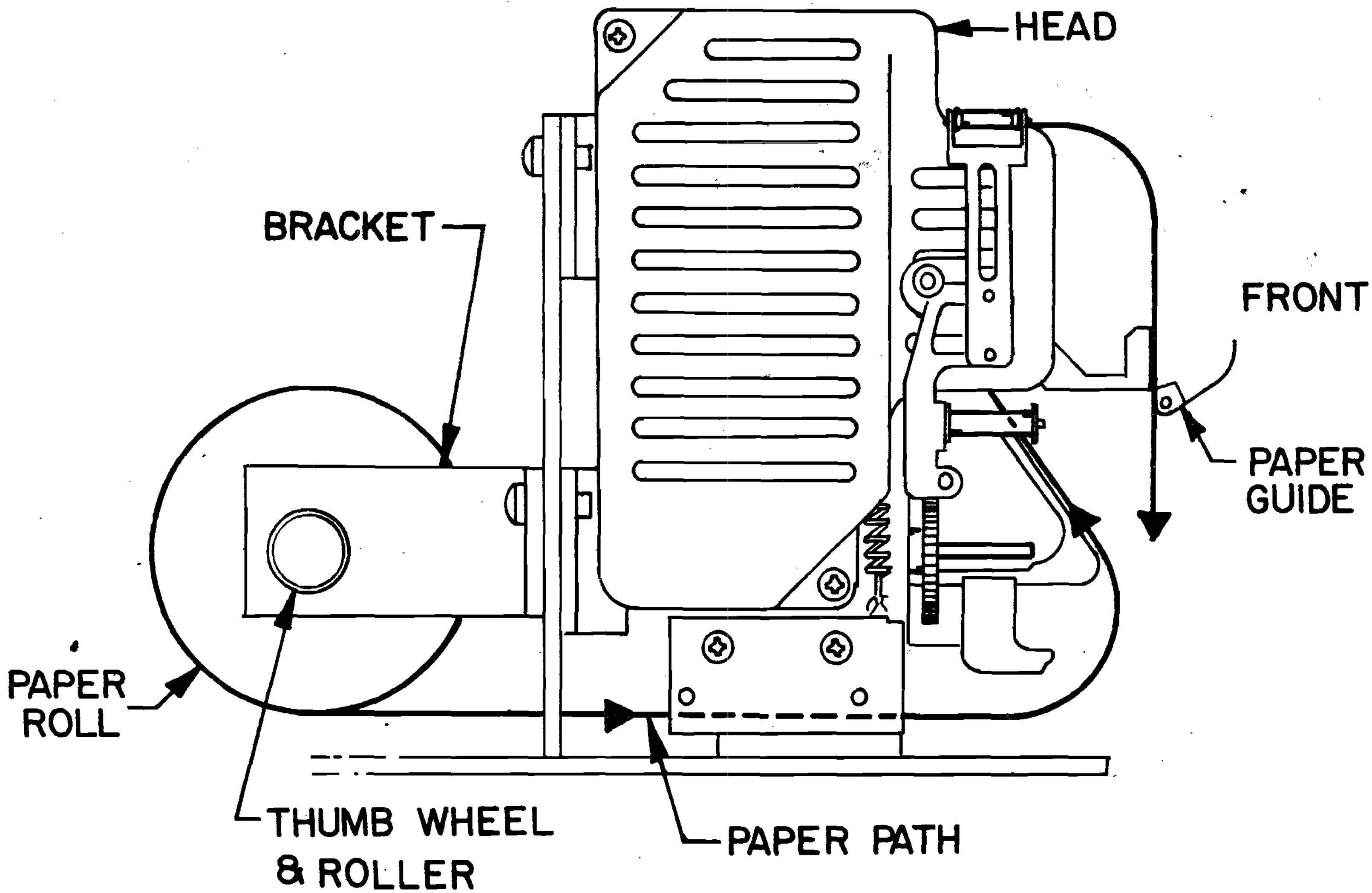

HEAD
BRACKET
FRONT
PAPER GUIDE
PAPER ROLL
THUMB WHEEL & ROLLER
PAPER PATH

FIG. 8-5

8-28. DIGITAL PRINTER SPECIFICATIONS (Model PO-500/600)

8-29. Number of Columns---------------------18
Number of Positions per Column--------13
Priting Speed (nominal)--------------- 2.5 lines per second
Printing Colors-----------------------Black and Red
Input Data Format---------------------Parallel BCD (8421) positive logic, TTL compatible.

8-30. INPUT COMMANDS
Print Red-----------------------------Active low enable, 0V, coincident Print Pulse and 100ms wide.
Print---------------------------------Positive transition, 0 to +5V
Paper Advance after last line of Data-Positive transition, 0 to +5V

8-31. SIGNALS FROM PRINTER
Data Change Inhibit Signal------------+5V level for duration of print cycle.

8-32. FRONT PANEL CONTROLS
Power ON/OFF
Paper Advance
Power Requirements--------------------115/230V ±10%AC 50/60Hz 40W
Size----------------------------------6-3/4" X 8-1/2" X 15-1/2"
Weight--------------------------------14-1/2 lbs.

8-33. REPLACEMENT SUPPLIES
Paper---------------------------------Printing Calculator roll 2-1/4" W by 2-3/4" D.
Ribbon (Black & Red)------------------Nylon or Vinylon fibered ribbon 13mm (0.5") wide 6m (250") long
Ribbon Spool--------------------------35mm diameter

8-34. AUTOMATIC BOTTLE SAMPLING SYSTEM (ABS)

A. Description

The Automatic Bottle Sampling System is designed to provide a means of metering a known volume of sample through the Sensor and to generate start/stop count signals to the PC-320. The metered volume may be adjusted by setting photo-electric level detectors on the units volumeter. The operating cycle is initiated by depressing the start switch on the PC-320 Front panel when the function mode is in the Volume Sample position. Figure 8-6 is a block diagram of the ABS system. Figure 8-7 pictures the ABS Front panel with controls. Fig. 8-8 is a Hydraulic Schematic of the ABS.

B. Installation

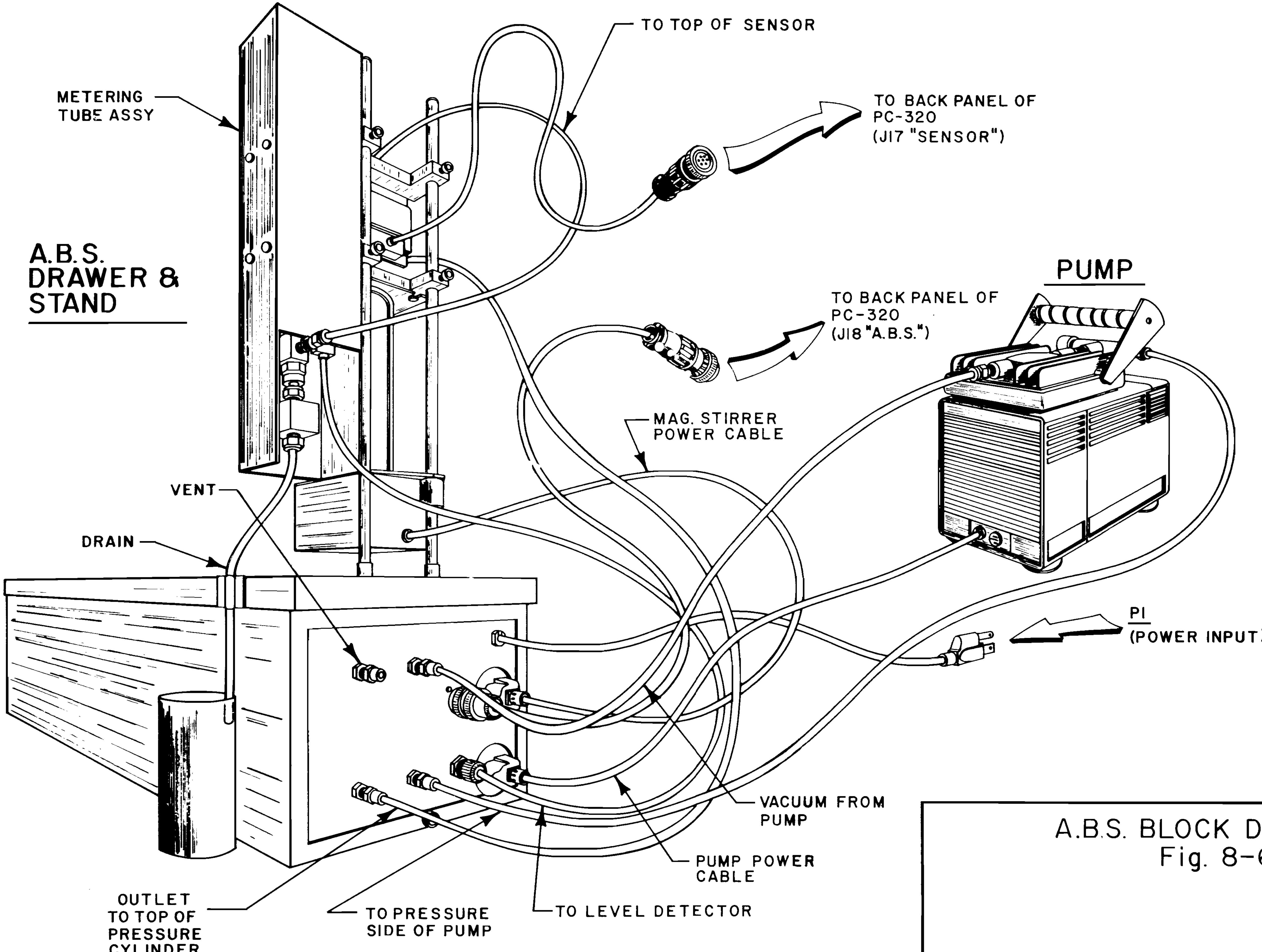
1. Place the ABS Control Cabinet next to the PC-320 with the Front panel control facing the operator. The ABS may be on either side of the PC-320.

2. Insert Sensor Mount Assembly support rods into feet on top of Control Cabinet Assembly. Tighten wing nuts on support feet so rods are held securely.

3. Unlatch Magnetic Stirrer base from Pressure Cylinder. Use Allen wrench provided to loosen Magnetic Stirrer support (left hand rod) and lower stirrer.

Note

> The Metering Tube Housing for the SMALL (1-10ml) metering tube fits directly above the Sensor. Three mounting bars are required for the SMALL tube: the Top mounting bar is on back of the



A.B.S. BLOCK DIAGRAM
Fig. 8-6

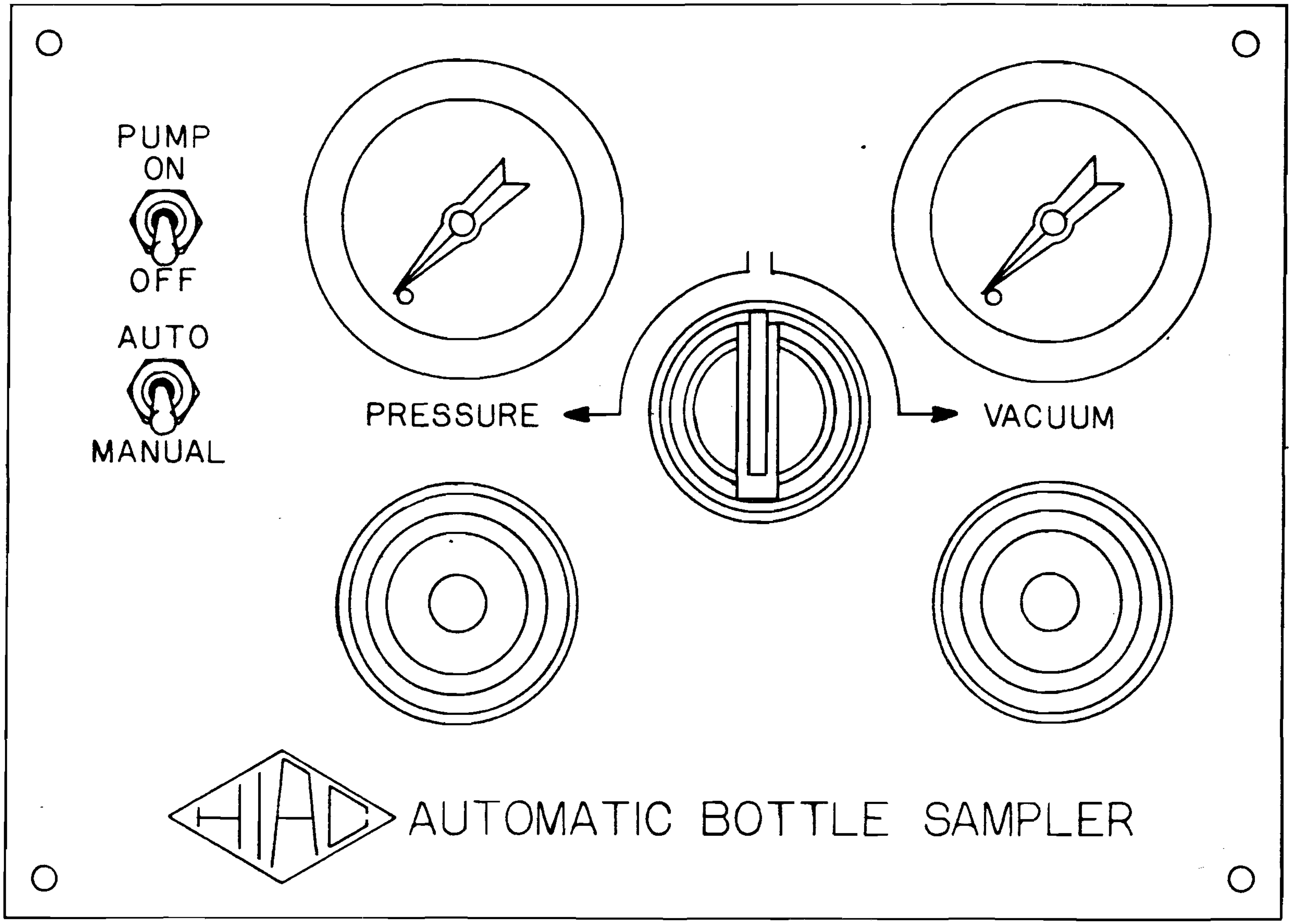
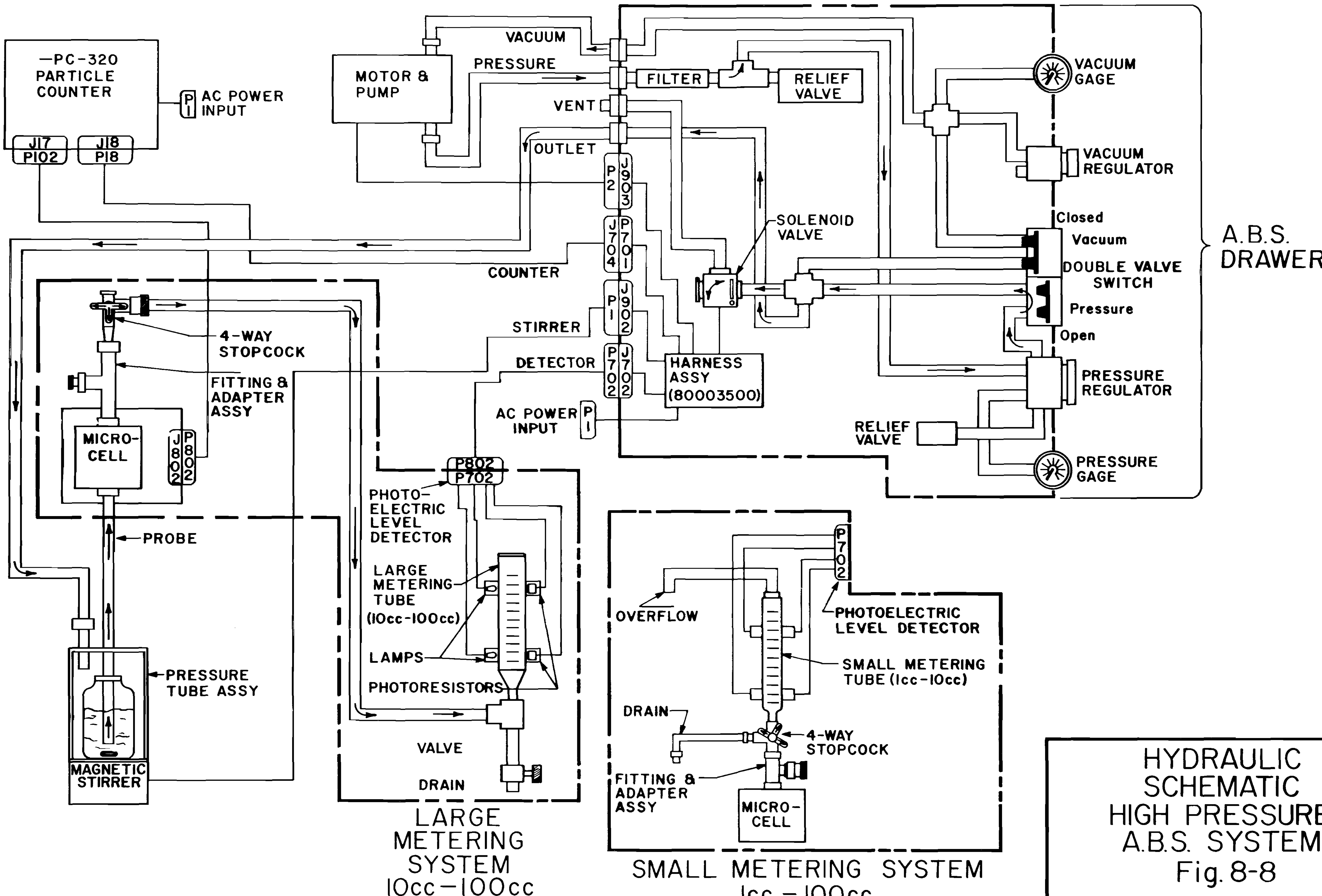


Figure 8-7 Automatic Bottle Sampler, Front Panel



HYDRAULIC SCHEMATIC HIGH PRESSURE A.B.S. SYSTEM
Fig. 8-8

8-19A

SMALL Metering tube housing; the Sensor attaches to the Middle mounting bar; the lower mounting bar is used only to position the Pressure Cylinder under the Sensor.

4. Holding Sample Volume Metering Tube assembly securely, loosen two knurled knobs on back of top mounting bar and slide assembly up to accommodate Sensor.

5. Insert Sensor into Sensor mounting brackets and position Sensor fluid passage directly above Sensor probe.

6. Slightly loosen knurled knobs, holding Pressure Cylinder beneath lower mounting bar.

7. Loosen knurled nut on top of Pressure Cylinder.

8. Raise probe and insert into Sensor inlet passage. Tighten Microcell nut securely.

9. Adjust Pressure Cylinder mounting bar up until Sensor probe is to desired depth in Pressure Cylinder.

Note

Front holes in mounting bars are not used for this setup.

10. Tighten the following:

a. Knurled nut on top of Pressure Cylinder.

b. Knurled knobs holding Pressure Cylinder beneath lower mounting bar.

c. Screws on Sensor mounting bracket.

11. Position Magnetic Stirrer approximately 1 inch below Pressure Cylinder by moving positioner stop up and tightening. Connect Magnetic Stirrer power cord to "Stirrer" receptacle on rear of drawer.

12. The Sensor Outlet Adapter is the same, except for the HOSE, for both the Large Metering Tube and the Small Metering Tube. Remove the Sensor Outlet Adapter assembly from its packing envelope and separate the Check Valve Body and "O" ring from the 4-Way Stopcock and the Hose Assembly.

13. Take the Check Valve Body with "O" ring and insert the "O" ring into the top outlet of the Sensor Microcell.

14. Insert the tapered male Luer fitting of the 4-Way Stopcock into the upper female adapter of the Check Valve Body.

15. Connect the Male Adapter on the Hose assembly to the horizontal female Luer fitting of the 4-Way Stopcock.

16. Connect the other end, with Nut or Connector, of the Hose assembly to the Tee inlet of the Large Metering Tube.

17. For SMALL Metering tube assembly (1-10 cc), while holding the Sample Metering tube assembly, slide the assembly down, and insert male Luer of the 1-10 cc Sampling Tube into the top female Luer fitting of the 4-Way Stopcock.

CAUTION

Use caution when inserting Sampling Tube into Stopcock. Glass Luer tip is easily broken.

18. For the Small Metering Tube, the other end, with no attachment, of the Hose assembly should be inserted into the 3/8 inch O.D. polyurethane drain tube located on the side of the mounting bars.

19. Verify Overflow Tube is connected from top of 1-10 ml Sampling Tube to 3/8 inch O.D. polyurethane Overflow Tube located on the side of the mounting bars.

20. Attach 30 inch Hose (black nylon) from top of Pressure Cylinder to OUTLET on rear of drawer.

21. Attach Level Detector Cable to DETECTOR receptable on rear panel of drawer and to rear of Sample Volume Metering Tube assembly.

22. Connect ABS to P.C. cable to COUNTER receptacle on rear of drawer and to J18 ABC receptacle on rear of PC-320 counter.

23. Connect Sensor Cable to mating connector on rear of Sensor and to mating SENSOR connector on rear of counter (J17).

24. Connect one of the seven foot hoses (black nylon) to the pressure side of pump (Side with relief valve). Connect other end to Pressure fitting on rear of drawer.

25. Connect other seven foot hose to vacuum side of pump. Connect other end to vacuum fitting on rear of drawer.

26. Connect pump power cord to PUMP receptable on rear of drawer.

27. Connect ABS power cord to applicable 115 VAC or 230 VAC outlet in accordance with label on rear of drawer.

28. Connect Counter power cord to applicable 115 VAC or 230 VAC outlet in accordance with label on rear of counter.

C. To establish pressure settings for proper flow rate

Note

To adjust pressure or vacuum regulators, the red locking ring should be pulled forward. When the proper setting is reached, the red locking ring should be pushed back.

1. Obtain a stop watch. (A wrist watch with sweep second hand may be used, as flow rate need only be ±10% as volume is accurately metered).

2. Set upper level detector on Metering Tube to measure the desired sample volume per minute. (For example: If flow rate is to be 50 ml/minute, set volume to 50 ml).

3. Turn Selector Valve to PRESSURE.

4. Place operation switch to AUTO.

5. Place Pump switch to ON. This will turn the ABS internal power on and the metering tube light blocks.

6. Place bottle of type of fluid to be tested in Pressure Cylinder.

7. Position Magnetic Stirrer assembly under Pressure Cylinder, raise, and clamp.

8. Set the switches on the PC-320 Counter as follows:

SWITCH	PANEL	TO
POWER ON/OFF	Front	ON
MODE	Front	VOLUME SAMPLE - Depressed
LOCAL/REMOTE	Sub-Panel	LOCAL
TOTAL/DELTA	Sub-Panel	TOTAL
RECYCLE TIMER IN/OUT	Sub-Panel	OUT

9. Sampling: When using either the LARGE or the SMALL Sampling tube, the Check Valve will always allow proper flow when Sampling but will block reverse flow through the Sensor.

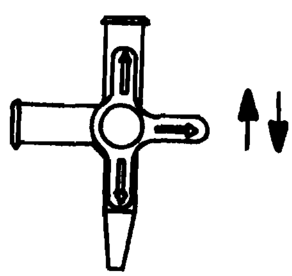
10. Sampling when using the LARGE volume Metering Tube (10-100 cc): The 4-Way STOPCOCK arrows should be pointing horizontal with the perpendicular arrow pointing down. Verify drain valve on Sample Metering Tube Housing is closed (handle pointing to left).

11. Sampling when using the SMALL volume Metering Tube (1-10 cc): The 4-Way STOPCOCK arrows should be pointing vertically with the perpendicular arrow pointing to the right.

Note

Fluid path through Stopcock is indicated by handle arms in alignment with Luer connectors.

SAMPLE Position



12. Depress START switch on PC-320 to apply pressure and initiate sample flow.

Note

The readout resets to zero
when particle count commences.

13. Adjust pressure regulator for some arbitrary pressure. (Best estimate as to correct value for desired flow rate).

14. The instant fluid reaches the lower level detector in the Sample Metering Tube, start the stop watch (this instant can be determined by observing The Count Light.

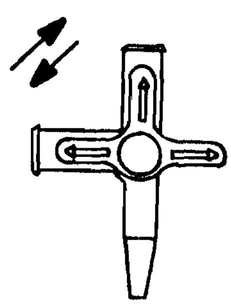
15. The instant that fluid reaches the upper level detector, stop the stop watch. (This can be determined by observing when counting stops). The Air Pump will be turned off, and the Pressure Cylinder will be vented (both automatically) to relieve the pressure and stop the fluid flow. Open the drain valve to empty the Sample Metering Tube.

16. Drain: For LARGE Metering Tube (10-100 ml), turn handle (on Lower part of Metering Tube Housing) DOWN to drain Metering Tube. Then turn handle to point toward LEFT to close drain and be ready for next Sampling.

17. For SMALL Metering Tube (1-10ml), turn 4-Way Stopcock perpendicular arrow UP, with both other arrows horizontal, to drain Metering Tube. To close drain and prepare for next Sampling, turn handle 90 degrees CW, (refer to direction of flow chart provided).

18. Fluid path is indicated by hand arms in alignment with Luer connectors:

DRAIN Position



19. Before starting the next run verify that there is sufficient fluid remaining in the sample bottle to complete the next run. If not, refill the sample bottle or replace with another sample.

20. Readjust pressure and repeat this procedure until the time is one minute. This will then be the correct pressure to obtain the proper flow rate for this fluid.

D. Sample De-aerating

Note

During handling or agitation, liquid samples may entrain air bubbles. As these would be counted, they must be removed before a run is started. A vacuum system is provided to accelerate this de-aerating where necessary.

1. Place sample bottle in Pressure Cylinder.

2. Rotate Magnetic Stirrer Assembly under Pressure Cylinder, raise and clamp.

3. The Check valve will prevent air bubbles from entering through Sensor probe.

4. Turn SELECTOR valve to VACUUM.

5. Place operation switch to MANUAL. The pump will start.

6. Adjust Vacuum Regulator to desired vacuum by turning control knob counter-clockwise to increase vacuum.

7. When the sample is de-aerated (no visible bubbles) release vacuum by turning control knob on vacuum regulator clockwise until vacuum gauge indicates zero.

E. Manual Operation of the Automatic Bottle Sampler

1. Depress MANUAL switch on PC-320 Front panel.

Note: The drain valve may be left open to prevent over flowing of the metering tube.

2. Turn the SELECTOR valve to PRESSURE.

3. Place the OPERATION switch to MANUAL.

4. Place sample bottle in Pressure Cylinder.

5. Rotate Magnetic Stirrer Assembly under pressure Cylinder, raise, and clamp.

6. Place PUMP switch to ON. The pump will start.

7. Check Pressure Gauge to be sure that pressure is correct to establish proper flow rate.

8. Press START button on the PC-320, the count will commence.

9. To stop counting, press STOP switch on Particle Counter.

a. If printout is connected, and AUTO/PRINT is depressed, printout will occur at this time.

10. Place PUMP switch to OFF.

11. Record results.

12. Repeat as desired.

F. Automatic Operation

1. Check to verify that upper level detector on Sample Metering Tube is set for the desired sample volume.

2. Turn SELECTOR valve to PRESSURE.

3. Depress VOLUME SAMPLE switch on Particle Counter.

4. Place OPERATION switch to AUTO and PUMP switch to ON.

5. Place sample bottle in Pressure Cylinder.

6. Rotate Magnetic Stirrer Assembly under Pressure Cylinder, raise, and clamp.

7. Push START switch on PC-320 counter to turn on pump and start sample flow.

8. Check Pressure Gauge to be sure that pressure is correct to establish proper flow rate.

G. Sampling

1. When fluid reaches the lower level detector in the Sample Metering Tube COUNT will start.

2. When fluid reaches the upper level detector in the Sample Metering Tube COUNT will stop, the Air Pump will be turned off, and the Pressure Cylinder will be vented to relieve the pressure and stop the fluid flow.

Note

If printout is connected and AUTO/PRINT is depressed, printout will occur at this time.

3. Open the drain valve to empty the Sample Metering Tube.

4. Record results.

5. If additional runs are to be made from the same bottle, repeat, if there is sufficient sample.

6. When through running from this sample bottle, unclamp Magnetic Stirrer Assembly from Pressure Cylinder, lower, and rotate out of the way.

7. Remove Sample Bottle.

Note

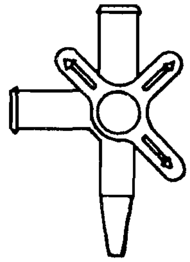
The initial fluid flow necessary to reach the lower Level Detector in the Sample Metering Tube will normally be adequate to flush the tubing ahead of the Sensor. Flushing between samples with clean fluid is optional.

H. Backflush (In case of a blocked Sensor passage)

1. Place beaker (or suitable fluid collector) under Sample Probe.

2. Fill Backflush Syringe with filtered fluid.

3. For SMALL and LARGE Metering Tube, position perpendicular arrow 45 degrees up from horizontal to block 4-Way Stopcock, (refer to direction of flow chart provided). Remove Luer-LOK PLUG on side of check valve body.



4. For SMALL and LARGE Metering Tube, insert Backflush Syringe in place of Luer-LOK PLUG.

5. Push plunger on Syringe to backflush Sensor.

6. Remove Syringe.

I. Proper Care and Cleaning

1. After daily use, the ABS should be flushed with appropriate solutions to clean and dry inner passageways.

2. After using water-based solutions, one cleaning method frequently used is filtered 99% Isopropyl alcohol followed by another flushing with filtered Freon T.F.

3. Oil-based solutions may require the first rinse to be a filtered solvent, such as Stoddard's, followed with filtered Freon T.F.

4. After a thorough flushing a clean empty bottle may be placed in the Pressure Cylinder. Close latches. Open drain valve. Manually operate pump to circulate air through probe and innser passages.

Note

In some cases, it may be helpful to leave clean fluid of the same material as the samples in the Sensor and leave it wet at all times.

5. At end of each day check the following:

a. Clean and dry passageways.

b. Place PUMP switch to OFF. This shuts off the light blocks and the internal power.

8-35. 6+6 CONFIGURATION

8-36. The 6 + 6 configuration, also known as the PC-326, is a special option PC-320 designed to measure filter efficiency at six (6) different size ranges and automatically compute the ratio of the number of particles upstream to the number of particles downstream of a filter (Beta Ratio). The PC-326 is identical with the PC-320 with the following exceptions:

1. The Unit contains modified P.C.B.'s 2,3,8, and 9 to provide logic specific to this design. P.C.B. #1 is not installed.
2. The 6 + 6 system includes a Dual Sensor Control Model SM-100 containing two P.C.B.'s #1, and a Digital Printer Model PO-600.

8-37. Figure 8-9 is a Block Diagram of the 6 + 6 system indicating interconnections for the PC-326, PO-600 (Digital Printer), and SM-100 (Dual Sensor Control). Figure 8-10 pictures the SM-100 Front Panel and Figure 8-11 pictures the PO-600 Front Panel.

8-38. INSTALLATION

1. Place the counter module (PC-326) on a stable vibration free base such as a laboratory bench or table.
2. Place the Dual Sensor Control module (SM-100) on the left side of the PC-326 or directly on top of the PC-326.
3. Place the Digital Printer module (PO-600) on either side of the PC-326 or also directly on top of the PC-326.
4. Connect Sensor #1 to Dual Sensor Control module Rear Panel connector J4 using cable #80001100 or #20000239.
5. Connect Sensor #2 to Dual Sensor Control module Rear Panel connector J2 using a second cable #80001100 or #20000239.
6. Connect Dual Sensor Control to counter module PC-326 by attaching cable #20000513 to connector J5 on Rear Panel of Dual Sensor Control to connector J17 on Rear Panel of counter module.

7. Connect counter module to Digital Printer Model PO-600 by attaching cable #20000594 to connector J14 on counter module to connector J1 on Digital Printer

8. With Front Panel power switch in OFF position, connect the 6+6 system units to the appropriate power source.

8-39. THRESHOLD SETTINGS

8-40. Threshold thumbwheel switches 1 through 6 will be used to set the size levels for Sensor #1. Threshold thumbwheel switch 7 through 12 will be used to set the size levels for Sensor #2. The calibration numbers used for the threshold settings will be taken from the calibration charts for each Sensor.

8-41. OPERATION

8-42. Operation of the PC-326 module is identical to operation of the PC-320. Initial settings should be in accordance with those listed in Section 5-5, a through d. The SENSOR OUTPUT lights function the same as outlined in Paragraph 3-16. Only Sensor #1 section has the overconcentration signal.

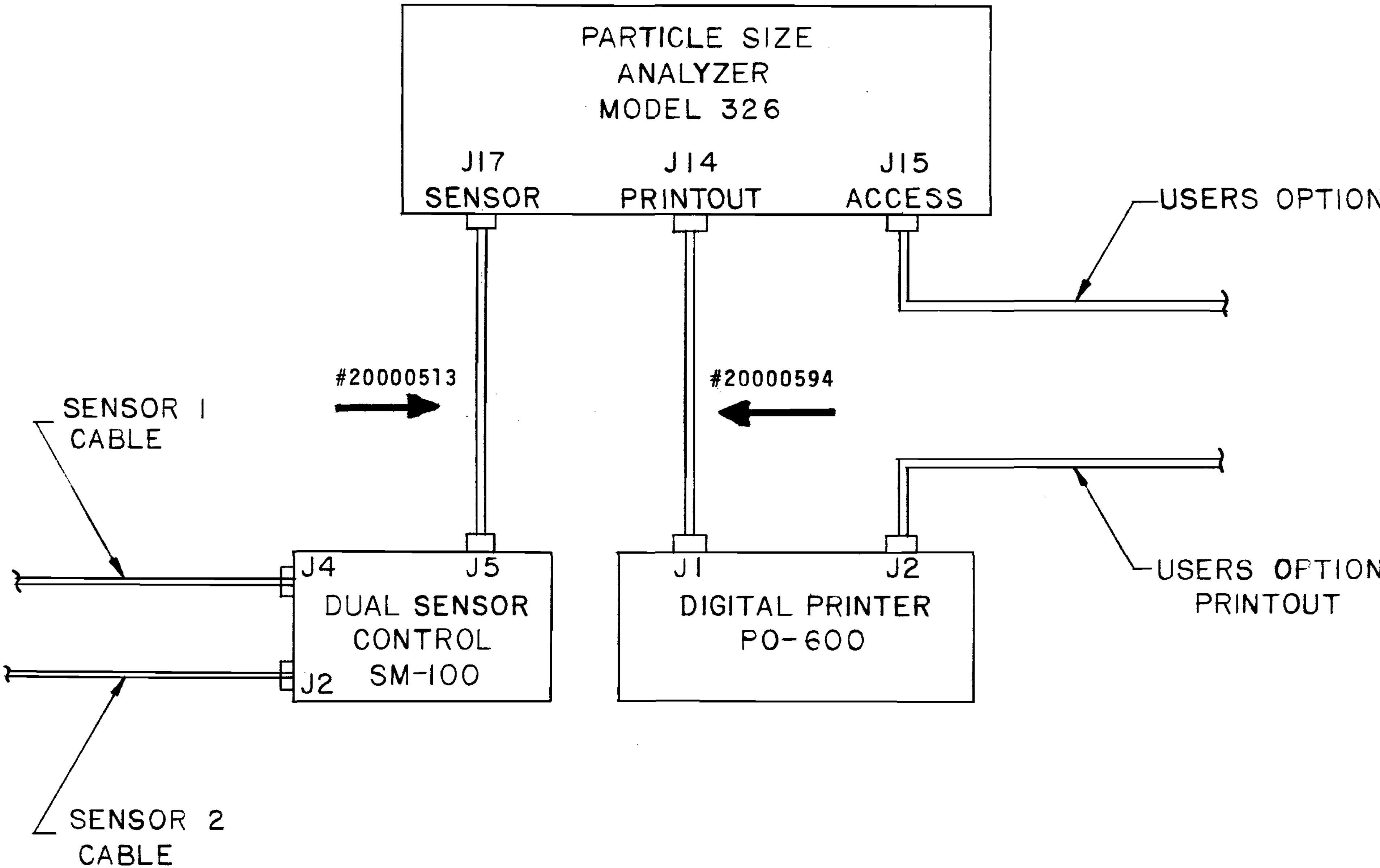
8-43. Further details on the 6 + 6 system regarding operation, readout, and typical applications will be found in the operating manual for the PO-500/600 Digital Printer, paragraphs 8-14 through 8-33.

8-44. ACCESSORIES CONNECTOR (J15) PC-326/6 + 6.

8-45. This connector is provided to facilitate the use of a standard PC-326/6+6 with external accessories to provide additional features and capabilities.

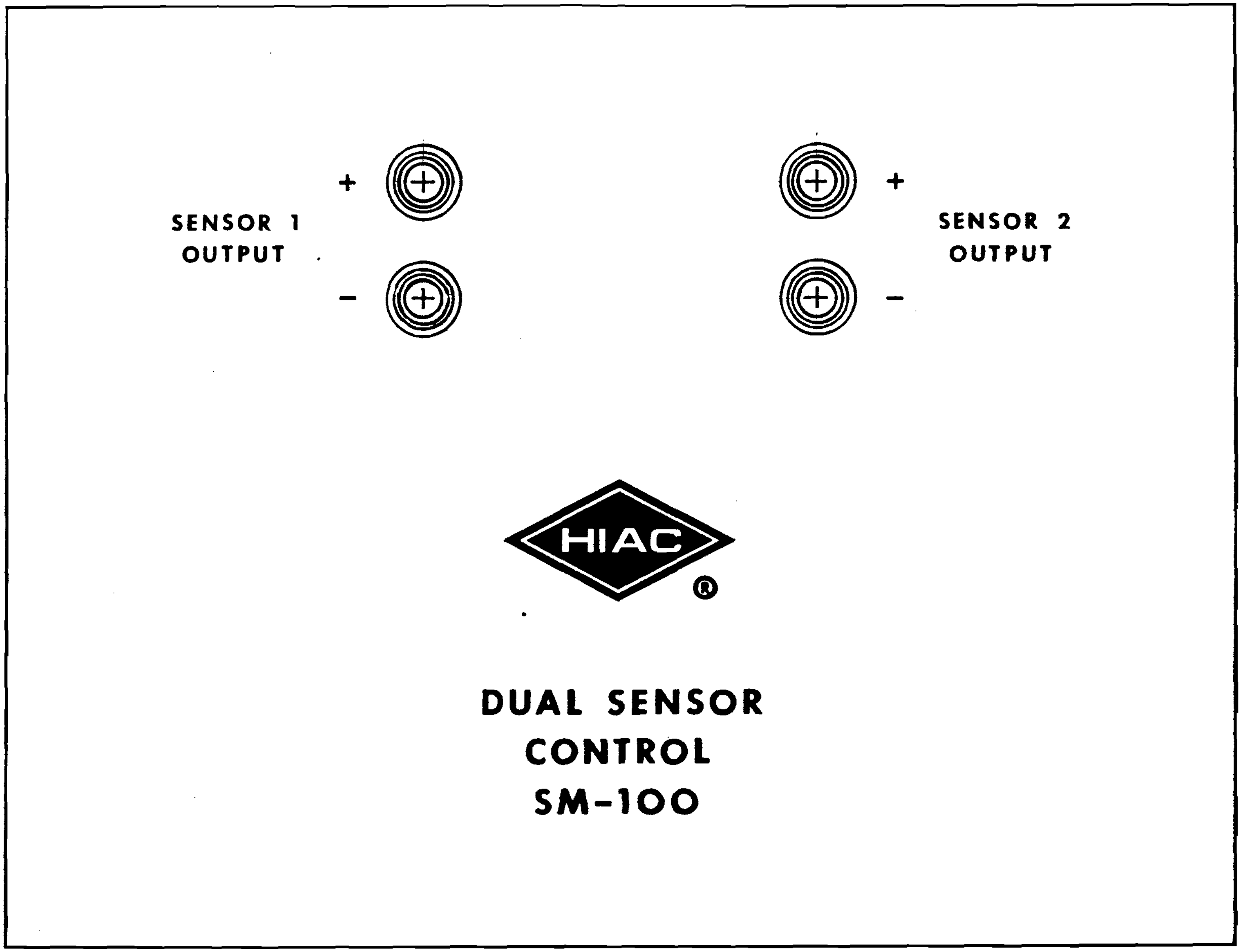
8-46. Internal data and timing signals are made available for outside use, while external data and commands may be applied when remote control of a system is necessary.

8-47. Table 8-3 provides the pin allocations and describes and defines the signals handles by J15.



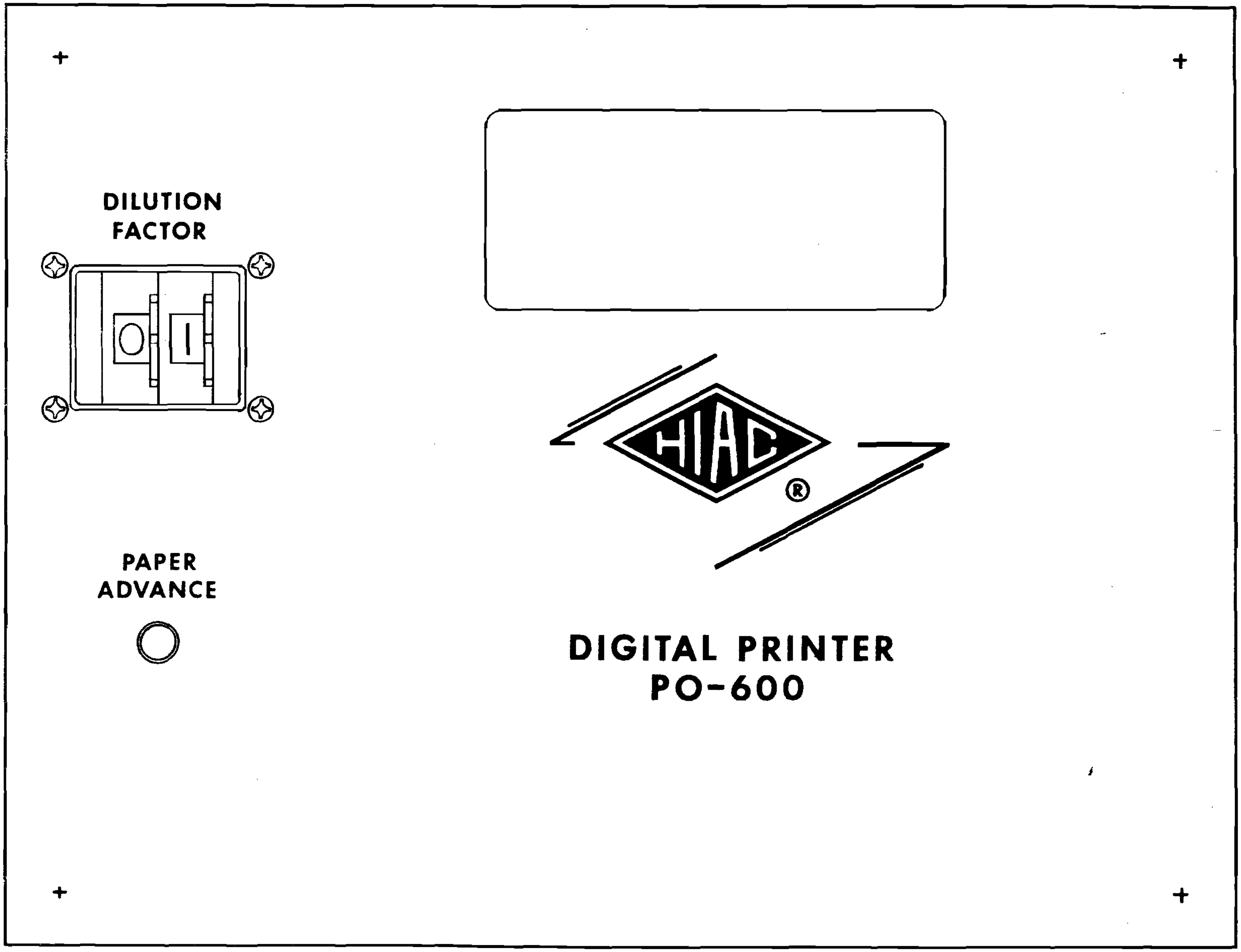
Block Diagram of 6 + 6 System

FIG. 8-9



SM-100 Front Panel

FIG. 8-10



PO-600 Front Panel

FIG. 8-11

TABLE 8-3

CONNECTIONS TO PC-320/326 ACCESSORIES SOCKET (J15)

Pin #	Signal	Characteristics
1	Ground	
2	N.C.	
3	Printer Column # 9 Q1	Accepts BCD inputs for printer. Signals must be TTL compatible. Positive logic.
4	Q2	
5	Q4	
6	Q8	
7	10 Q1	
8	Q2	
9	Q4	
10	Q8	
11	11 Q1	
12	Q2	
13	Q4	
14	Q8	
15	PCB #9 Pin #25	Reserved for possible selective printout scheme

(CONNECTIONS CONTINUED)

n #	Signal	Characteristics
16	$\overline{\text{Print Red}}$	+5V line goes to ground when printer is commanded to print red
17	Print Red	Ground line goes to +5V when printer is commanded to print red
18	"Inhibit" from printer	Ground line goes to +5V when printer is printing
19	"$\overline{\text{Inhibit}}$" from printer	+5V line goes to ground when printer is printing
20	Line 3 "print"	In 6+6 configuration, +5V line goes to ground while line #3 of each channel is printed
21	Line 3 "$\overline{\text{print}}$"	In 6+6 configuration, ground line goes to +5V while line #3 of each channel is printed
22		
23	Channel #1 digital output	+12V pulse ≈2μs wide each time a particle exceeds threshold (total mode) or is between adjacent limits (delta)
24	#2	
25	#3	
26	#4	
27	#5	
28	#6	
29	#7	
30	#8	
31	#9	

(CONNECTIONS CONTINUED)

Pin #	Signal	Characteristics
32	Channel #10 digital output	+12V pulse ≈2μs wide each time a particle exceeds threshold (total mode) or is between adjacent limits (delta)
33	#11	
34	#12	
35	Count Enable Signal	Ground line goes to +12V as long as instrument is counting
36	Remote Start Command	When S23 (Local/Remote Switch) is in "remote", a momentary connection to ground will start the cycle
37	ABS Pump Control	10mA max. current source is enabled as long as pump is running (L.E.D. load limits voltage to approx. +1.3V)
38	"Check Sensor" Signal	+15V line goes to ground when sensor output is low. 10Hz square wave indicates sample overconcentration
39	+12V DC	Current drain must not exceed 100 mA
40	N.C.	
41	Manual Channel Advance (HI)	Ground line goes to +12V while manual channel advance switch is depressed
42	Manual Channel Advance (Lo)	+12V line goes to ground while manual channel advance switch is depressed
43	Manual Reset to Ch. #1	A momentary connection to ground will reset the display to Ch. #1
44	Manual Scan/Print	A momentary connection to ground will initiate scanning or printout of all channels
45	Print Command	+12V line is grounded momentarily to initiate print cycle
46	Paper Advance	+12V line is grounded momentarily to advance paper at end of data printout

(CONNECTIONS CONTINUED)

Pin #	Signal	Characteristics
47	Channel #1 100,000	Ground line goes to +12V when channel #1 MSD = 1
48	Channel #1 10,000	Ground line goes to +12V when channel #1 2^{nd} MSD = 1
49	Channel #1 1,000	Ground line goes to +12V when channel #1 3^{rd} MSD = 1
50	Channel #1 100	Ground line goes to +12V when channel #1 4^{th} MSD = 1
51	N.C.	
52	N.C.	
53	N.C.	
54	N.C.	
55	+5V	Current drain must not exceed 250mA
56	+15V	Current drain must not exceed 100mA
57	-15V	Current drain must not exceed 100mA

HIAC MODEL MLC ACCESSORY

8-48. This accessory is designed for use with the HIAC "6+6" Filter Efficiency Test Unit to permit printout of filter test parameters in addition to the test results.

It is designed to accept digital data in BCD format from three transducers which measure oil temperature, oil flow and differential pressure across the filter under test. This information appears in columns 9, 10 and 11 of the printout in lines 1, 2 and 3, respectively.

Input data must be in BCD format with 5V positive logic (TTL compatible).

DATA INPUT CABLE CONNECTOR

CINCH DC37P

TABLE 8-4

MLC DATA INPUT CONNECTIONS

J3	BCD	TRANSDUCER	PRINTOUT	
20	MSD Q1	PRESSURE	LINE 3	
1	Q2			
2	Q4			
3	MSD Q8			
24	Q1			
23	Q2			
22	Q4			
21	Q8			
28	LSD Q1			
27	Q2			
26	Q4			
25	LSD Q8	PRESSURE	LINE 3	
12	MSD Q1	FLOW	LINE 2	
13	Q2			
14	Q4			
15	MSD Q8			
8	Q1			
9	Q2			
10	Q4			
11	Q8			
4	LSD Q1			
5	Q2			
6	Q3			
7	LSD Q4	FLOW	LINE 2	
32	MSD Q1	TEMPERATURE	LINE 1	RED
31	Q2			
30	Q4			
29	MSD Q8			
36	Q1			
35	Q2			
34	Q4			
33	Q8			
16	LSD Q1			
17	Q2			
18	Q4			
37	LSD Q8	TEMPERATURE	LINE 1	RED
19	GROUND			

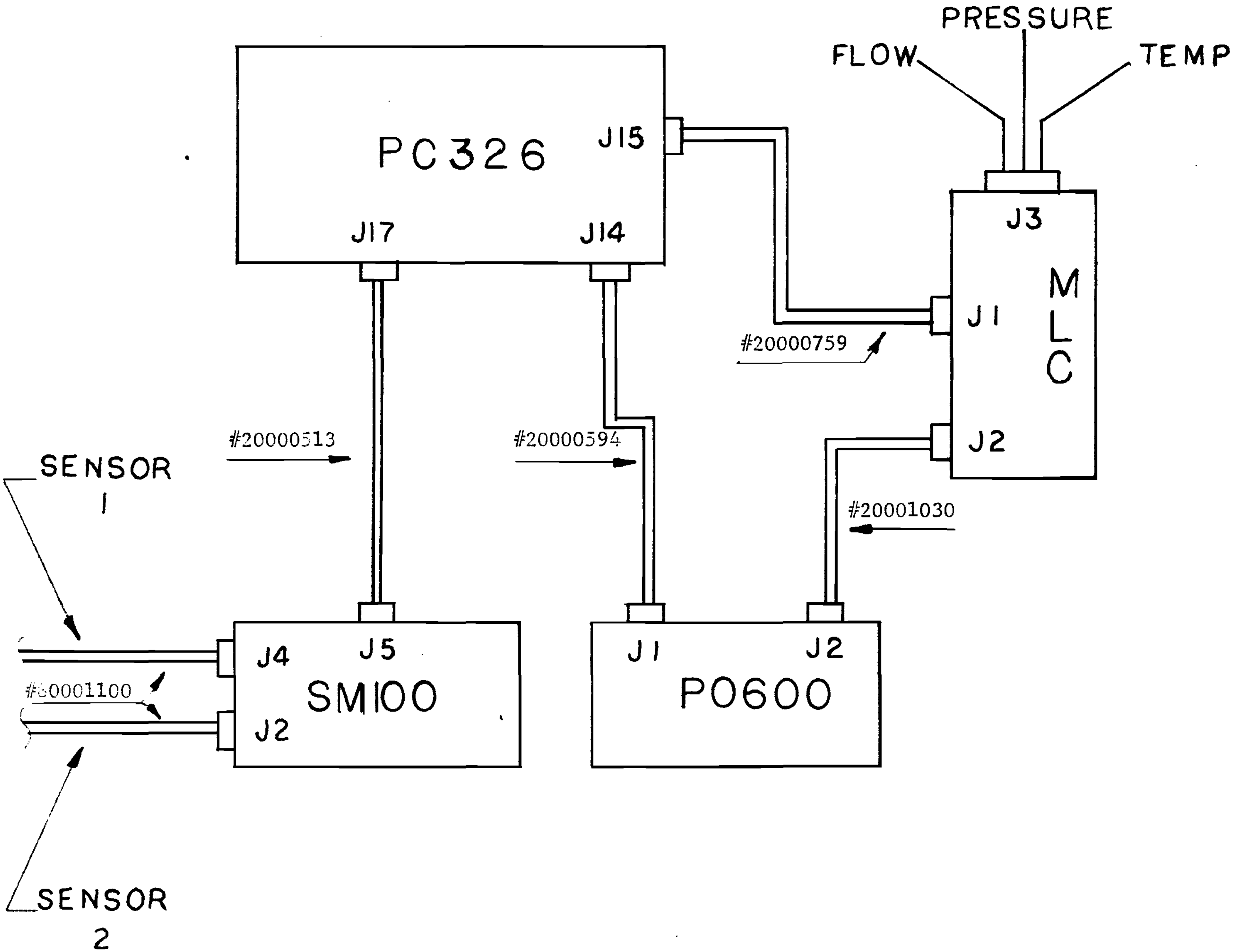

PRESSURE
FLOW
TEMP
PC326
J15
J17
J14
J3
M
L
C
J1
#20000759
J2
#20000513
#20000594
SENSOR
1
#20001030
J4
J5
J1
J2
#20001100
SM100
P0600
J2
SENSOR
2

Figure 8-12.

SECTION IX

TROUBLESHOOTING

9-1. GENERAL

This section contains a routine troubleshooting guide and an extensive troubleshooting guide. Table 9-1 lists routine troubleshooting problems and their probable cause and corrective action. When using this table, always proceed through "Possible Causes" in sequence. Most operational difficulties can be traced to unfamiliarity with the instrument. Table 9-2 is a list of extensive troubleshooting procedures.

Table 9-1. Troubleshooting Table

a. FRONT PANEL DISPLAYS NOT LIT

Problems	Cause and Corrective Action
No line voltage.	Check power source.
Power supply protection device tripped due to line voltage surge.	Turn instrument OFF, then ON again.

b. READOUT DISPLAY OFF OR PARTIALLY LIT

Problem	Cause and Corrective Action
CHANNEL identification not present after instrument is turned on.	Push RESET TO CHANNEL 1 switch.
Improper COUNT display after instrument is turned on.	Push STOP then the START switch to reset instrument.

Table 9-1. Troubleshooting (cont.)

c. SENSOR OUTPUT LIGHTS

Problem	Cause and Corrective Action
(-) LIGHT remains on:	Sensor or Sensor cable connectors not correctly engaged.
	Sensor blocked with particles, backflush. Clean passage thoroughly
	Sample is too opaque. Use high concentration model Sensor or dilute sample.
	Sensor lamp has low light output due to age or is not functioning, replace lamp. (Refer to Extensive Troubleshooting Section). Sensor lamp out of adjustment. Adjust lamp according to Section 9-3. Sensor cable broken.
(+) LIGHT remains on:	Sensor cable broken. Sensor electronics failed.
(-) Light comes on sporadically:	Air bubblesin the sample, deaerate.
(+) (-) lights blinking at a 5HZ rate:	Particle concentration too high for type of Sensor, dilute or use high concentration Sensor.
	Sensor passage partially blocked, clean passage thoroughly.
	Sensor passage blocked, clean thoroughly.

d. INOPERATIVE PUSH BUTTON COMMANDS

Problem	Cause and Corrective Action
Instrument will not:	
START	LOCAL/REMOTE switch in the REMOTE position.
	Push STOP switch to reset starting circuits.
SCAN/PRINT	AUTO PRINT switch is IN, push switch to OUT.
	DISPLAY TIME setting at lower right of Front panel increased too far.
SCAN/PRINT the total amount of channels.	CHANNEL STOP switch on Board #8 at rear of instrument set on incorrect channel.

e. IMPROPER COUNT

Problem	Cause and Corrective Action
Does not decrease progressively with each channel.	TOTAL/DELTA switch in DELTA position.
	THRESHOLD settings not correct.
Two or more channels have approximately the same count.	Sensor operating incorrectly, check SENSOR OUTPUT LIGHTS.
	Sample overconcentrated, dilute or use high concentration sensor.
Stops before STOP command is pushed.	TIME SAMPLE mode switch is depressed.
	PRESET switch is not OFF.

f. TIME SAMPLE MODE (Optional)

Problem	Cause and Corrective Action
Incorrect timing.	SAMPLE TIMER incorrectly set.
	PRESET COUNT switch not in OFF position.
(With optional recycle timer)	RECYCLE TIMER IN/OUT switch is OUT.
	RECYEL TIMER incorrectly set.

g. TIME SAMPLE MODE (Optional)

Problem	Cause and Corrective Action
Incorrect timing.	SAMPLE TIMER incorrectly set.
	PRESET COUNT switch not in OFF position.
(With optional recycle timer)	RECYCLE TIMER IN/OUT switch is OUT.
	RECYCLE TIMER incorrectly set.

h. VOLUME SAMPLE MODE

Used with optional AUTOMATIC BOTTLE SAMPLER (ABS)

Problem	Cause and Corrective Action
Pump does not turn on at START	Check ABS power source.
	ABS PUMP ON/OFF switch is off.
	PC-320 to ABS cable connectors not correctly engaged.

Instrument does not count when fluid passes lower level detector.	Level detecting lights in ABS METERING TUBE are not lit.
	Metering assembly power cord not engaged correctly.
or	ABS metering tube glass walls are dirty. Clean.
Instrument does not STOP automatically when fluid passes upper level detector.	Wrong MODE switch is pushed IN.
	Metering assembly cable incorrectly terminated.
	ABS AUTO/MANUAL switch in MANUAL.
Instrument starts counting at START command.	Wrong MODE switch pushed IN.
	Bubbles in Metering Tube. Clean glass tube.
	Lower Level Detector too low on Metering Tube.
Instrument stops before measurement is completed.	Film has formed on inside and/or outside of Metering Tube, wash Metering Tube and Level Detector surfaces with the prescribed solvents.
	PRESET switch is not OFF.
	Upper Level Detector out of adjustment.

i. PRINTER

Problem	Cause and Corrective Action
Does not print.	Printer cable not engaged correctly, cable MUST be plugged into the TOP rear connector J14 of the PC-320.
	Check power source.
	Defective cable.

Note: ELECTRONICS BOARD REMOVAL AND INSERTION

To gain access to the Electronic Circuit Board, remove the rear cover from the back panel by pulling the two black knobs outward.

Dislodge the board by grasping the Extractor Tab at the board's upper edge and firmly lift up. Slide board out.

To INSERT, slide the board into the guides while holding the Extractor Tab HORIZONTALLY. When it is almost all the way in, jiggle the board in and out until the tab can be partially lowered. (About a 45 degree angle). Firmly push the tab down and the board will slide forward a small amount. Finally, push on the board edge center until it firmly locks into position.

CAUTION

Don't operate unit for over five seconds with a board removed.

9-2. Table 9-2. Extensive Troubleshooting Procedure

a. SENSOR-TYPE E or CM

Determining its correct operation requires two voltage measurements be taken with a DC VOLTMETER capable of reading 10 vdc.

Correct Parameters

LAMP VOLTAGE	Measure between back panel test points lamp voltage (+) and (-), +1.5 vdc to +2.5 vdc.
OUTPUT VOLTAGE	Measure at back panel analog signal (J16) coax connector center, -10.0 vdc.

Measured	Diagnosis
Lamp voltage is 2.5 vdc to 2.8 vdc and Output voltage is less than -10.0 vdc. (0 vdc to -9.8 vdc).	Sensor cell is blocked, cell window is damaged, lamp has darkened with age.

Lamp voltage is over 13 vdc and Output voltage is 0 vdc.	Lamp has failed, wire broken off Sensor lamp terminal, faulty cable.
Lamp voltage is 1.5 vdc to 2.5 vdc and Output voltage is less than -10.0 vdc. (0 vdc to -9.8 vdc).	Check the LAMP SURGE LIMIT current for correct value. Refer to Section (b) - Sensor Lamp current limit circuit.

b. PC-320 INSTRUMENT

Correct Parameters

Sensor Lamp Current Limit Circuit	Correct value is 375 madc to 410 madc. To measure, remove the Sensor and connect a DC Ammeter of 500 madc capability into lamp voltage (+) and (-) test points on back panel.
Internal DC Voltages	Measured at Power Supply Terminals: ±14.8 ±.05 vdc +5.75 ±.05 vdc

Symptom	Diagnosis and Correction
SENSOR LAMP VOLTAGE measures correctly, SENSOR OUTPUT VOLTAGE is LOW, between 0 vdc and -9.8 vdc.	If INTERNAL DC VOLTAGES are verified and SENSOR LAMP current limit value is below minimum, replace Board #1. If INTERNAL DC VOLTAGES and SENSOR LAMP current limit value are verified, replace Board #1.
DIM LIGHTS or NO LIGHTS in the Total, Delta, Preset count front panel sockets.	Dislodge, then re-insert, one at a time, Boards #1 through 9. Replace the Board that allowed lights to return to normal brilliance.

Verify Internal DC Voltages Before Proceeding

COUNT Display has a "0" readout for a specific CHANNEL number or two channels display approximately the same count.	If channels 1 through 6: replace Board #2. If channels 7 through 12: replace Board #3.
CHANNEL identification has a faulty number.	Replace Board #8 or 9; set channel stop switch to correct number.
COUNT Display has missing numbers or does not progress in count for a specific CHANNEL identification.	If channels 1 through 3: replace Board #2 or #4. If channels 4 through 6: replace Board #2 or #5. If channels 7 through 9: replace Board #3 or #6. If channels 10 through 12: replace Board #3 or #7.
COUNT Display has the same missing numbers for ALL CHANNEL identifications.	Replace Board #9.
COUNT Display is very dim or completely dark.	Refer to Section (c).
COUNT Display numbers do not go to "0" when START is pushed or COUNT light goes on.	Replace Board #8. Set channel STOP switch to correct number.

c. UNUSUAL PROBLEMS

In case of an unusual problem, contact your Pacific Scientific Company Representative.

9-3. SENSOR LAMP REPLACEMENT AND ADJUSTMENT

A. Replacement

1. Turn Particle Counter power switch to OFF.

2. If "CM" series Sensor, remove Sensor lamp cover and P.C. Board cover.

3. Remove screws from lamp holder.

4. Unsolder Sensor lamp leads from terminals.

5. Remove lamp holder and install on replacement Sensor lamp.

6. Solder replacement Sensor lamp leads to terminals. If "CM" series Sensor, Sensor lamp leads must be run through hole in microcell.

7. Install screws in lamp holder leaving them loose to allow Sensor lamp movement.

B. Adjustment

1. Connect dc voltmeter (0 to +5) to lamp voltage (+) and (-) test points located on back panel of the particle counter as shown in back panel and card cage diagram.

2. Turn particle counter power switch to ON.

3. Adjust position of Sensor lamp SLOWLY while observing meter. Adjust lamp until meter reading is minimum value (approximately +1.5 to 2.5 vdc). If meter reading drops to zero, stop adjustment until reading returns to normal.

4. Tighten lamp holder screws evenly to secure Sensor lamp.

5. Observe meter reading to verify no change has occurred.

6. Remove meter leads from lamp voltage test points.

7. If "CM" series Sensor, install Sensor lamp cover and P.C. Board cover.

SECTION X

SPARE PARTS LISTS

10-1. GENERAL

10-2. Table 10-1 lists the spare parts included in the PC-320 Minimum Spares Kit SK-10. The Minimum Spares Kit is intended for those users who wish to have on hand the basic easily replaced parts. Table 10-2 lists the spare parts included in the PC-320 Expanded Spares Kit SK-11. The Expanded Spares Kit is intended for those users who require immediate parts replacement or repair and where normal delivery from the factory would result in excessive instrument down-time.

Table 10-1. PC-320 Minimum Spares Kit SK-10
Part #20000269

QTY	DESCRIPTION	PART No.
2	Sensor Lamp Assembly	90430001
2	Panel Lamp (Amber)	19000598
1	Panel Lamp (Red)	19000599
4	Sensor "O" Rings Sub Kit	10000015
2	Ferrules Sets Sub Kit	10000015
4	Allen Wrenches Sub Kit	10000015
1	Sensor Cleaning Probe (2-60μm)	*90060001
1	Sensor Cleaning Probe (3-90μm)	*90060002
1	Sensor Cleaning Probe (4-120μm)	*90060003
1	Sensor Cleaning Probe (5-150μm) and up	*90060004

*When ordering Spares Kit SK-10, specify part number of Sensor for which the kit is to be used to insure that the correct Sensor Cleaning Probe is included. Only one probe is included in the kit.

Table 10-2. PC-320 Expanded Spares Kit, SK-11

Part #20001067

QTY	DESCRIPTION	PART NO.
1	P C Board #1	80015902
1	P C Board #2	80018003
1	P C Board #3	80018004
1	P C Boards #4, #6, or #7	20000101
1	P C Board #8	80010201
1	P C Board #9	80011801

Table 10-3. PC-326 (6 + 6) Expanded Spares Kit, SK-11

Part #20001068

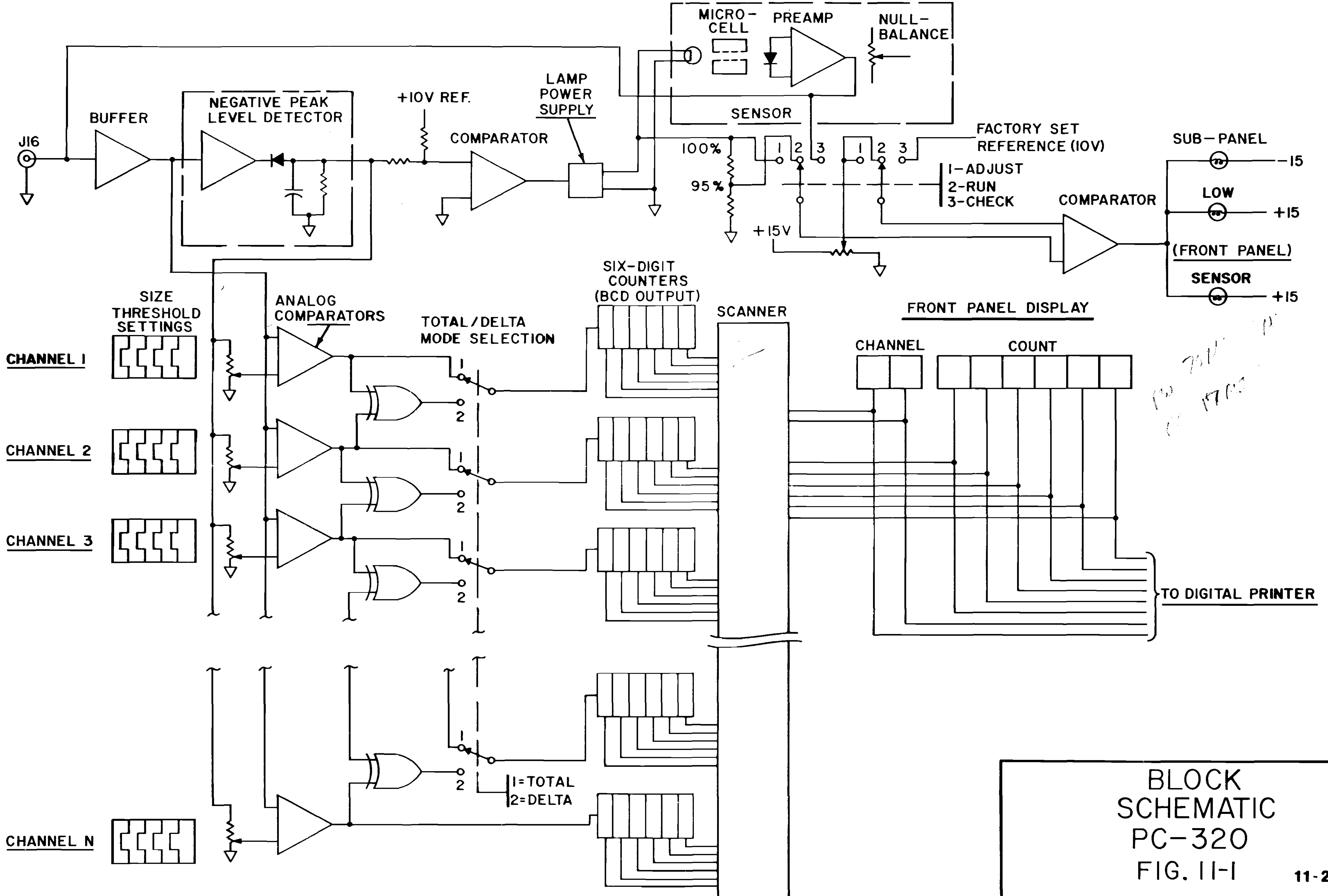
QTY	DESCRIPTION	PART NO.
1	P C Board #1	80015902
1	P C Board #2 or #3	80018005
1	P C Boards #4, #5, #6, or #7	20000101
1	P C Board #8	80010202
1	P C Board #9	80011802

SECTION XI

DIAGRAMS

11-1. GENERAL

11-2. This section contains a block schematic and block diagrams to assist in the installation and operation of the HIAC PC-320.



BLOCK SCHEMATIC
PC-320
FIG. 11-1

APPENDIX A

VOLUME SAMPLING

A-1.0 GENERAL

A-1.1 This section contains a discussion of the system concept, physical description, and operation of the Automatic Bottle Sampler (ABS), Part Number 80026901 to 80026909 in combination with the PC-320 Particle Size Analyzer and is supported by the diagrams at the end of this appendix.

A-2.0 SYSTEM CONCEPT

A-2.1 With the Automatic Bottle Sampler (ABS) the PC-320 system can be made to collect data from samples of constant volume.

A-2.2 The ABS is designed to provide a means of metering a known volume of sample through the sensor and to generate start/stop signals to the PC-320. The metered volume may be adjusted by setting photoelectric level detectors on the unit's volumeter. The sampling cycle is initiated by depressing the START switch on the PC-320 while the operational mode switch is in volume sample. Setting the operational mode switches to any of the other sample mode selections will override the ABS and permit manual or timed operation of the PC-320 as described in the Operations Manual.

A-2.3 The Large Volume Metering system enables sampling of volumes from 10 to 120 ml. Pressure is used to push fluid through the sensor.

A-2.4 The Small Volume Metering system enables sampling of volumes from 0.2 to 10 ml. Vacuum, instead of pressure, is used to produce a regulated flow through the sensor. It is designed for applications where flow rates (2 to 30 ml/min.) are desired, and the fluid used is of low viscosity (less than 70 Saybolt Universal Seconds), such as water, alcohol, or intravenous solutions. It is recommended for use in parenteral and pharmaceutical applications.

A-3.0 ASSEMBLY (LARGE VOLUME)

A-3.1 Refer to the diagrams at the end of this section.

A-3.2 Place the ABS Control Cabinet next to the PC-320. The ABS may be on either side of the PC-320.

A-3.3 Insert the support rods of the Metering Assembly into the clamps on the top of the Control Cabinet. Tighten the wing nuts so that the rods are held securely. Be sure that stirrer lock ring is in place below stirrer.

A-3.4 Unlatch the Magnetic Stirrer from the base of the Pressure Cylinder. Loosen the Magnetic Stirrer Support and lower the Stirrer.

A.3-5 While holding the Tube Assembly securely, loosen the two knurled thumbscrews on the back of the top mounting bar and slide the assembly up near the top of the support bars. Tighten the thumbscrews.

A-3.6 Install the Sensor Clamp Hardware (packaged separately) on the top mounting bar. Refer to the drawings.

A-3.7 Install the sensor in the clamps and position the sensor's fluid passage directly above the Sensor Probe.

A-3.8 While holding the Pressure Cylinder securely, loosen the two knurled thumbscrews on the back of the lower mounting bar and position the cylinder to a height that will allow convenient insertion of the sample bottle into the cylinder. Tighten the thumbscrews.

A-3.9 Using a 9/16 inch wrench, loosen the Probe Clamping Nut.

A-3.10 Raise the probe and insert it into the Sensor's inlet port. The Sensor may have to be repositioned to assure alignment with the probe. Tighten the inlet fitting securely.

A-3.11 Adjust the Tube Assembly (on which the Sensor is mounted) until the Probe is at the desired depth in the Pressure Cylinder.

A-3.12 Tighten the Probe Clamping Nut securely.

A-3.13 Position the Magnetic Stirrer approximately one inch below the Pressure Cylinder. Connect the Stirrer Power Cord to the STIRRER Receptacle on the rear of the Control Cabinet.

A-3.14 Remove the Sensor Outlet Assembly from its packing envelope and separate the Check Valve Body from the 4-way Stopcock and Hose Assembly.

A-3.15 Insert the Check Valve Body, with "O"Ring, into the outlet port of the Sensor and secure.

A-3.16 Insert the tapered male fitting of the 4-Way Stopcock into the upper fitting of the Check Valve Body. Make sure that the plastic hose fitting is attached to the horizontal port of the 4-Way Stopcock.

A-3.17 Connect the other end of the hose to the Tee Fitting of the Metering Assembly.

A-3.18 Attach the 30 inch hose between Tee Fitting on the top of the Pressure Cylinder to the OUTLET Fitting on rear of the Control Cabinet.

A-3.19 Connect one of the seven foot hoses between the pressure side of the pump and the PRESSURE Fitting on the rear of the Control Cabinet.

A-3.20 Connect the other seven foot hose between the vacuum side of the pump and the VACUUM Fitting on the rear of the Control Cabinet.

A-3.21 Connect the Level Detector Cable between the Level Detector Assembly (in the Metering Assembly) and the DETECTOR Connector on the rear of the Control Cabinet.

A-3.22 Connect the Sensor Cable between the sensor and the SENSOR Connector (J-17) on the rear of the PC-320.

A-3.23 Connect the Pump Power Cord to the PUMP Receptacle on the rear of the Control Cabinet.

A-3.24 Connect the ABS Power Cord to an appropriate outlet (115 VAC or 230 VAC) in accordance with the label on the bottom of the Control Cabinet.

A-4.0 ASSEMBLY (SMALL VOLUME)

A-4.1 Refer to the diagrams at the end of this section.

A-4.2 Place the ABS Control Cabinet next to the PC-320. The ABS may be on either side of the PC-320.

A-4.3 Insert the support rods of the Metering Assembly into the clamps on the top of the Control Cabinet. Tighten the wing nuts so that the rods are held securely.

If a Small Volume Assembly is being substituted for the Large Volume Assembly, remove the large volume hardware, except for the Stirrer Assembly, from the support rods and replace with the small volume hardware.

A-4.4 Loosen the Magnetic Stirrer Support and lower the Stirrer.

A-4.5 Install the Sensor Clamp Hardware (packaged separately) on the bottom mounting bar. Refer to the drawings.

A-4.6 Install the sensor in the clamps and position the sensor's fluid passage directly below the Small Volume Assembly's input fitting.

A-4.7 Raise the bottom mounting bar and sensor to engage the fitting. Make sure that the "O"Ring is in the fitting. Secure the fitting. Make sure that the alignment of the glass tube, fittings, and sensor is proper, allowing the light blocks to be adjusted without binding.

A-4.8 Install the probe in the input port of the sensor. Make sure that the "O"Ring is in the probe.

A-4.9 Position the whole Metering Assembly at a level that will accomodate the sample bottle and stirrer.

A-4.10 Position the stirrer so that the probe is at the desired depth in the sample bottle. Connect the stirrer power cord to the STIRRER Receptacle on the rear of the Control Cabinet.

A-4.11 Attach the tube from the Fluid Trap to the OUTLET Fitting on the rear of the Control Cabinet.

A-4.12 Attach the seven foot hose between the vacuum side of the pump and the VACUUM Fitting on the rear of the Control Cabinet.

A-4.13 Connect the Level Detector Cable between the Level Detector Assembly (in the Metering Assembly) and the DETECTOR Connector on the rear of the Control Cabinet.

A-4.14 Connect the Pump Power Cord to the PUMP Receptacle on the rear of the Control Cabinet.

A-4.15 Connect the Solenoid Cable (located near the bottom of the Metering Assembly) to the special outlet box on the PUMP.

A-4.16 Connect the sensor cable between the sensor and the SENSOR Connector (J-17) on the rear of the PC-320.

A-4.17 Connect the ABS Power Cord to an appropriate outlet (115 VAC or 230 VAC) in accordance with the label on the rear of the Control Cabinet.

A-5.0 FLOW RATE ADJUSTMENTS

A-5.1 For best results the sample fluid flow rate should be adjusted to those recommended for the sensor in use.

A-5.2 When adjusting the pressure or vacuum regulators, pull the red locking ring out. When the proper setting is reached, secure the regulator by pushing the red locking ring in.

A-5.3 A stop watch or sweep second hand may be used for timing during the flow rate adjustment.

A-5.4 The theory of the flow rate adjustment procedure is as follows: adjust the pressure or vacuum so that a specified volume is filled in a specified time.

A-5.5 Note that the large volume metering system uses pressure to move the fluid, while the small volume metering system uses vacuum.

A-5.6 Flow rate adjustment for Large Volume Metering System.

a) Set the Metering Tube's upper level detector at 10 ml. above its lower level detector.
b) Set the PRESSURE/VACUUM switch to PRESSURE.
c) Set the AUTO/MANUAL switch to AUTO.
d) Set the ON/OFF switch to ON.

e) Set the OPERATION MODE switch on the PC-320 to VOLUME SAMPLE.

f) Place a bottle of sample fluid in the Pressure Cylinder and position the Magnetic Stirrer Assembly under the cylinder, and raise and clamp.

g) Verify that the STOPCOCK arrows are pointing horizontal with the perpendicular arrow pointing down.

h) Verify that the DRAIN VALVE handle is in the horizontal position.

i) Depress the START switch on the PC-320. The pump will start and fluid will begin to flow.

j) Adjust the PRESSURE REGULATOR to produce an estimated flow rate.

k) Begin timing when the fluid reaches the Lower Level Detector. The display on the PC-320 will start counting.

l) Stop timing when the fluid reaches the Upper Level Detector. The display on the PC-320 will stop counting, the pump will turn off, and the pressure cylinder will be vented.

m) Compare the time with that shown in Table A-1 for the appropriate sensor. Note the change which must be made to make the flow time match that in the table.

n) Drain the tube by turning the DRAIN VALVE handle to the verticle position. When draining is complete, return the handle to the horizontal position.

o) Repeat this procedure until the flow time matches the table value to within $\pm$ 10%.

A-5.7 Flow rate adjustments for Small Volume Metering systems.

a) Set the Metering Tube's Upper Level Detector at 3 ml. above its Lower Level Detector.

b) Set the PRESSURE/VACUUM Switch to VACUUM.

c) Set the AUTO/MANUAL Switch to AUTO.

d) Set the ON/OFF Switch to ON.

e) Set the OPERATIONAL MODE Switch on the PC-320 to VOLUME SAMPLE.

f) Place a bottle of sample fluid under the probe and position the Magnetic Stirrer Assembly.

g) Depress the START switch on the PC-320. The Pump will start and fluid will begin to flow.

h) Adjust the VACUUM REGULATOR to produce an estimated flow rate.

i) Begin timing when the fluid reaches the Lower Level Detector. The display on the PC-320 will start counting.

j) Stop timing when the fluid reaches the Upper Level Detector. The display on the PC-320 will stop counting, the Pump will turn off, the Metering Tube will be vented, and the Tube will drain automatically.

k) Compare the time with that shown in Table A-1 for the appropriate Sensor. Note the change which must be made to make the flow time match that in the table.

l) Repeat this procedure until the flow time matches the table value to within $\pm$ 10%.

TABLE A-1

ABS FLOW RATE ADJUSTMENT

SENSOR	Nominal Flow Rate (ml/min)	Large Volume Time For 10 ml. (Sec)	Small Volume Time For 3 ml (Sec)
CMB 60	8	75	23
CMB 90	20	30	9
CMB 120	40	15	5
CMB 150	100	6	6*
CMB 300	225	15 (50 ml)	**
CMB 600	900	4 (50 ml)	**

* 30 ml/min calibration required

** NOT RECOMMENDED

A-6.0 MANUAL OPERATION

A-6.1 The ABS may be operated in a mode where it acts only as a fluid transport device, rather than a volume sampler. This mode is referred to as the "Manual" Mode. In this mode the Liquid Level Detectors are inoperable.

A-6.2 It is recommended that only the Large Volume Metering System be used in this mode. Since the Small Volume System uses vacuum to move the fluid, even the careful operator runs the risk of getting fluid in the Pump.

A-6.3 Manual Operation of the Large Volume Metering System.

a) Note that in this mode the Level Detectors are inoperable.

b) Set the PRESSURE/VACUUM Switch to PRESSURE.

c) Set the AUTO/MANUAL Switch to AUTO.
d) Set the ON/OFF Switch to ON.
e) Set the OPERATIONAL MODE Switch on the PC-320 to MANUAL.
f) Place a bottle of sample fluid in the Pressure Cylinder and position the Magnetic Stirrer Assembly under the cylinder, and raise and clamp.
g) Verify that the STOPCOCK arrows are pointing horizontal with the perpendicular arrow pointing down.
h) The DRAIN VALVE may be left open to prevent overflow of the Metering Tube.
i) Set the AUTO/MANUAL Switch to MANUAL. The Pump will start and fluid will begin to flow.
j) Check the Pressure Gauge to verify that the correct pressure is established for proper flow.
k) Push the START Switch on the PC-320. Counting will start immediately.
l) Counting will stop when the STOP button is pushed.
m) Set the AUTO/MANUAL Switch to AUTO to stop the Pump and the fluid flow.
n) This procedure may be repeated as desired.

A-6.4 TIME OPERATION

a) Follow instructions as set forth for Manual Operation, except that the TIME SAMPLE Switch on the PC-320 is depressed instead of the MANUAL Switch.

A-6.5 PRE-SET COUNT OPERATION

a) Position PRE-SET COUNT Switch behind front panel of PC-320 to desired count.
b) Follow instructions as set forth for MANUAL OPERATION.
c) Count will automatically stop when channel no. 1 reaches the pre-set count.

A-7.0 AUTOMATIC OPERATION

A-7.1 The ABS may be operated in a mode where the level detectors control the starting and stopping of the particle count, thus producing samples of constant volume. This mode is referred to as the "Automatic" Mode.

A-7.2 Automatic Operation of the ABS.

a) Verify that the Upper and Lower Level Detectors are positioned to produce samples of the desired volume.

b) Set the PRESSURE/VACUUM Switch to the appropriate position for the Metering Tube in use - i.e., Large = Pressure, Small = Vacuum. (See Note A-7.3)

c) Set the AUTO/MANUAL Switch to AUTO.

d) Set the ON/OFF Switch to ON.

e) Set the OPERATIONAL MODE Switch on the PC-320 to VOLUME SAMPLE.

f) Place a bottle of sample fluid in the Pressure Cylinder for Large Volume Systems or under the probe for Small Volume Systems.

g) As required, verify that the STOPCOCK is positioned horizontally and that the DRAIN VALVE is closed.

h) Push the START Switch on the PC-320. The Pump will start and fluid will begin to flow.

i) Check the gauge to verify that the correct pressure or vacuum is established for proper flow.

j) Counting will start when the fluid reaches the Lower Level Detector.

k) Counting will stop when the fluid reaches the Upper Level Detector. Also, the Pump will turn off, the Pressure Cylinder will be vented, or the Small Volume Tube will be drained.

l) Drain the Large Volume Tube by turning the DRAIN VALVE handle to the vertical position. When draining is complete, return the handle to the horizontal position.

m) This procedure may be repeated as desired. The initial fluid flow necessary to reach the Lower Level Detector will normally be adequate to flush the tubing ahead of the sensor. Flushing between samples with clean fluid is optional.

A-7.3 Operational Note

a) If maximum pressure cannot be obtained or if pressure build-up occurs slowly - and the Vacuum regulator knob is full counter-clockwise - adjust the Vacuum regulator knob 2-3 turns from full counter-clockwise position.

b) If a vacuum cannot be achieved in the chamber - and the Pressure regulator knob is full counter-clockwise - adjust the Pressure regulator knob 2-3 turns from full counter-clockwise position.

A-7.4 ABS Maintenance

a) Due to the frequent locking and releasing of the pressure chamber clamp assembly, it is suggested that the screws holding the latch in position, as well as the related chamber support bar screws, be periodically checked for tightness.

A-8.0 STIRRING MECHANISM

A-8.1 During the sampling of a fluid; it is important that, the particles in the fluid remain in suspension. The Stirring Assembly provides this function.

A-8.2 The Stirring Assembly consists of a box with a Non-Magnetic (Aluminum) top on which the sample fluid bottle is placed. The box contains a motor which rotates a magnet under the center of the aluminum plate. The rotating magnet will exert forces on a Stirring Rod which is placed in the sample bottle. This causes the Stirring Rod to rotate thus agitating the sample fluid.

A-8.3 It is of interest to note that the Stirring Rod has two important properties - 1) it does not contain a magnet, but rather will respond to magnetic fields, and 2) the outer surface of the glass covering is very smooth. The first is important because the Rod itself should not attract metal particles, thus trapping them at the bottom of the sample bottle. The second is important because the Rod should neither slough off particles which contaminate the sample or pulverize the sample particles.

A-8.4 Stirring Rods may be obtained from HIAC as Part Number 10000095.

A-8.5 The Stirring Assembly contains its own Power Switch and Stirring Speed Control. Rotating the Speed Control changes the speed of rotation of the Rod thus changing the amount of agitation.

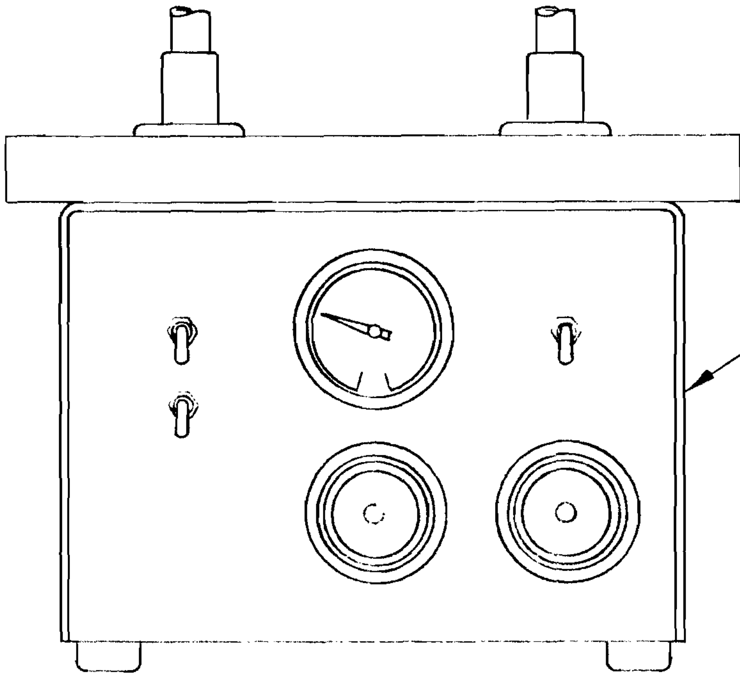
A-9.0 SENSOR MAINTENANCE

A-9.1 It is important that the Sensor be kept as clean as possible to assure maximum performance. Partial or complete Sensor blockage will occur if particles larger than the sensing zone are allowed to enter the Sensor. If backflushing does not prove successful in removing a blockage, remove the Sensor and insert a cleaning proble directly into the outlet side of the Sensor to push the particles out through the inlet side. Compressed air, directed from the outlet side, may also be used to dislodge blockage.

A-9.2 The Sensor may develop a film over the windows over a period of time if fluids, especially water, are allowed to dry in the Sensor. Most liquids, even if filtered, will leave some residue when dried. The automatic base level control will compensate for the film accumulation, however, eventually the film must be removed to eliminate the possibility of window size reduction. Film accumulation may be avoided by simply not allowing the Sensor to dry. Clean fluid may be left in the Sensor at all times. When water is used, it must be distilled. A wetting agent such as Eastman Kodak Photo-Flo-200 has been found to be useful.

A-9.3 If Sensor drying is necessary, water may be removed by cycling isopropanol, methanol, or ethanol through the Sensor. The final drying agent is Freon T.F. If oils are to be removed, solvent such as Stoddard's Solvent or Freon T.F. may be used. Solvents for specific fluids may be used at any time providing they are compatible with Sensor materials, i.e., stainless steel, glass, Buna N, and epoxy. Chemical reaction between solvents should be considered to avoid the possibility of precipitate formation which may cause Sensor problems.

FIGURE A-1
CONTROLS LOCATION DIAGRAM
ABS-CONTROL CABINET



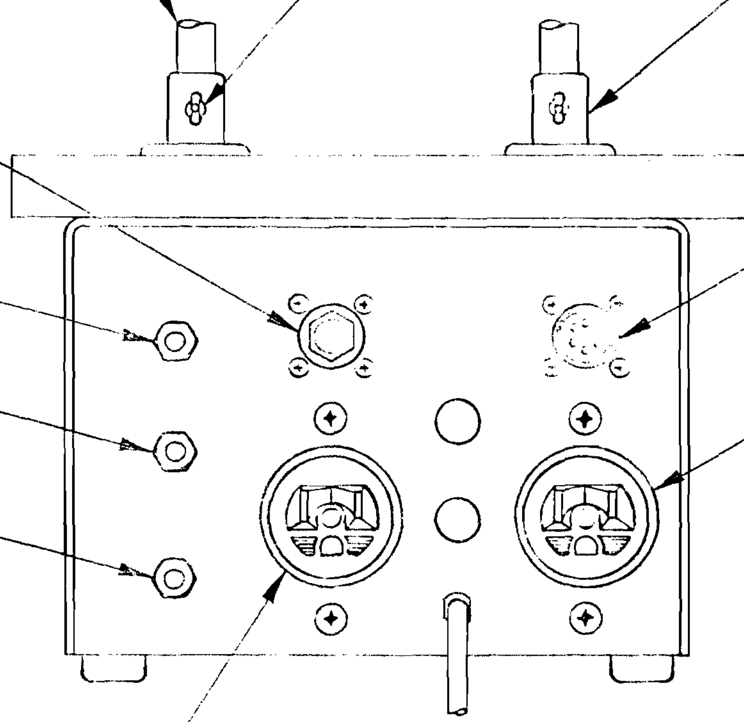


FIGURE A-2
CONTROLS LOCATION DIAGRAM
ABS - LARGE VOLUME METERING SECTION

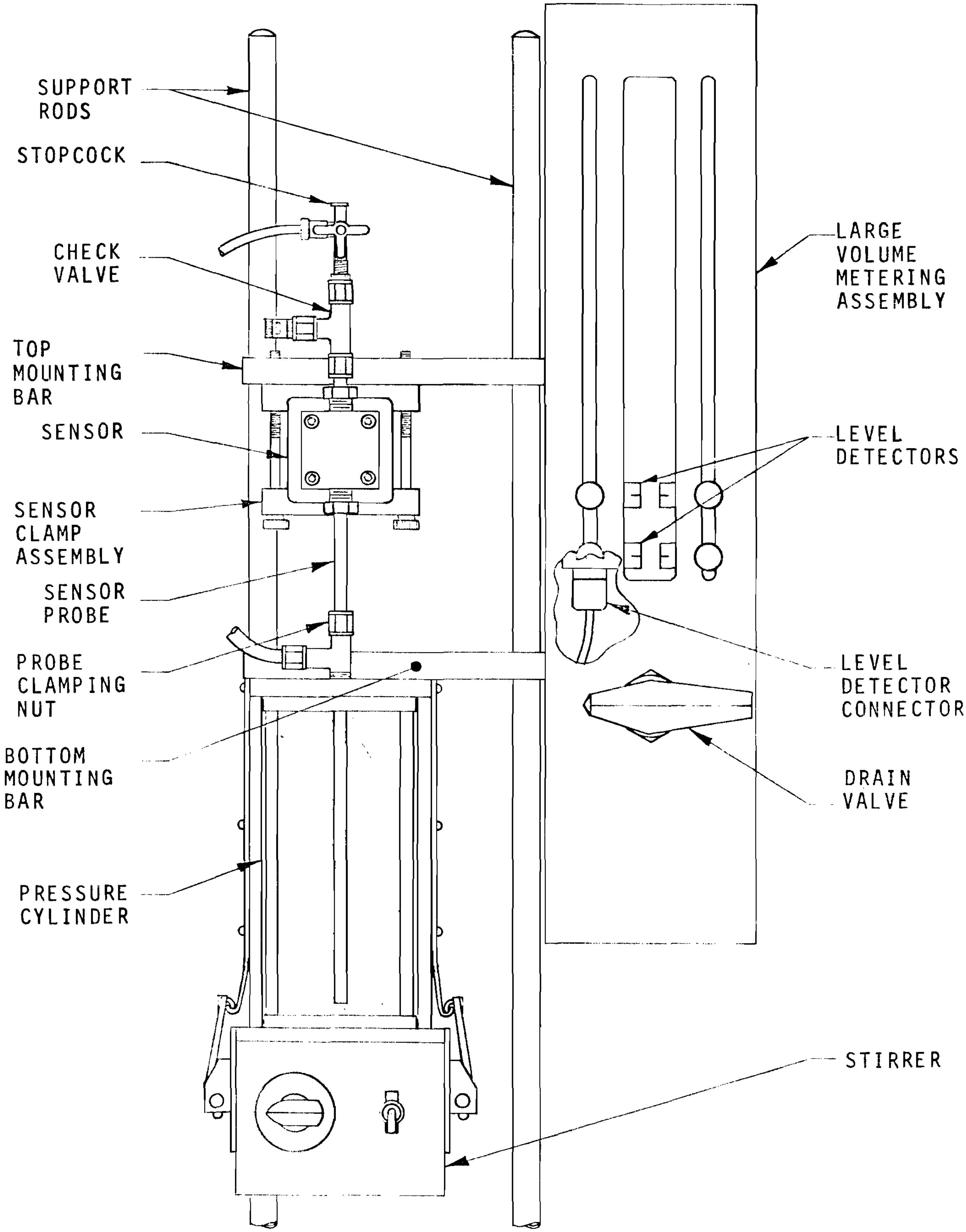
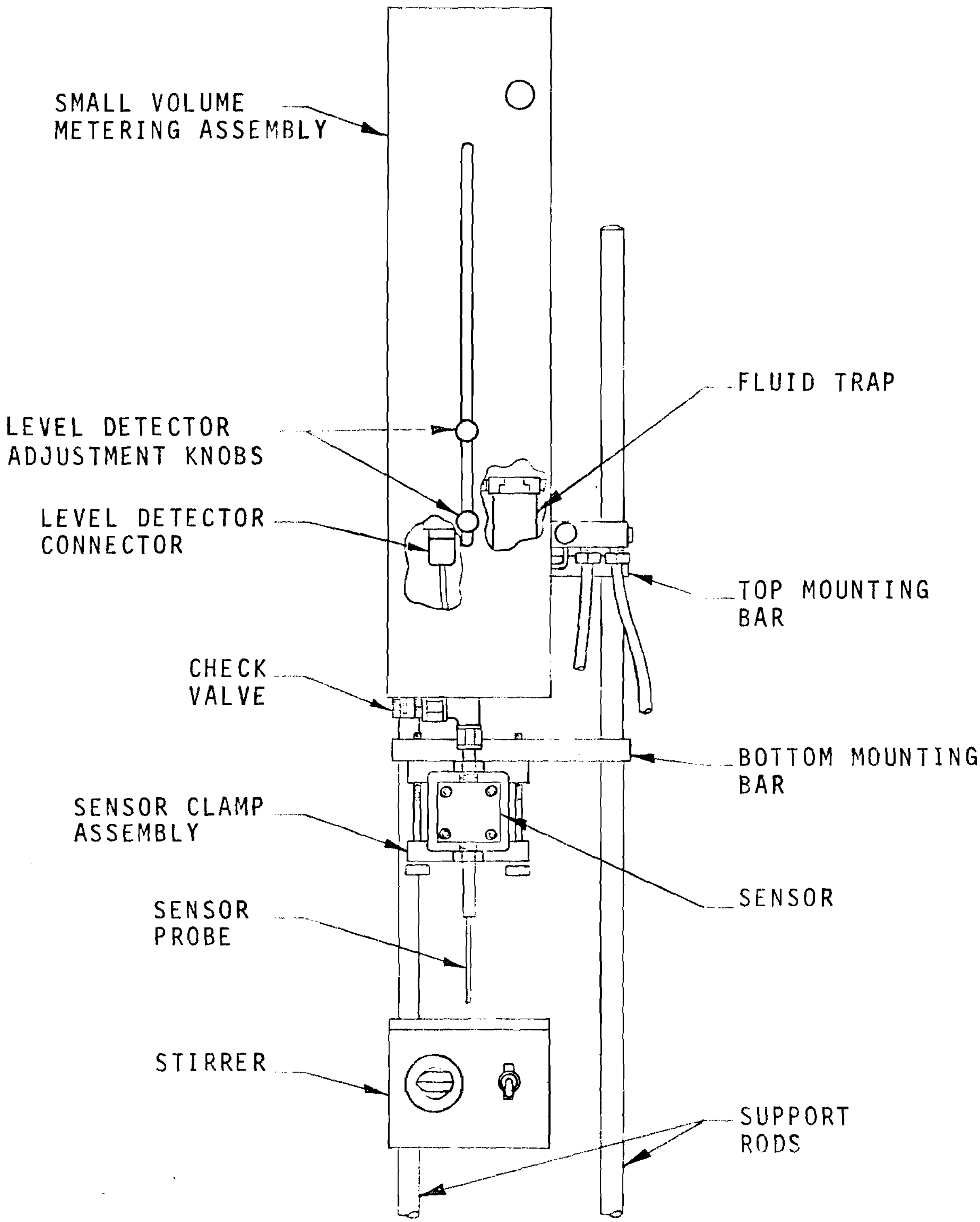
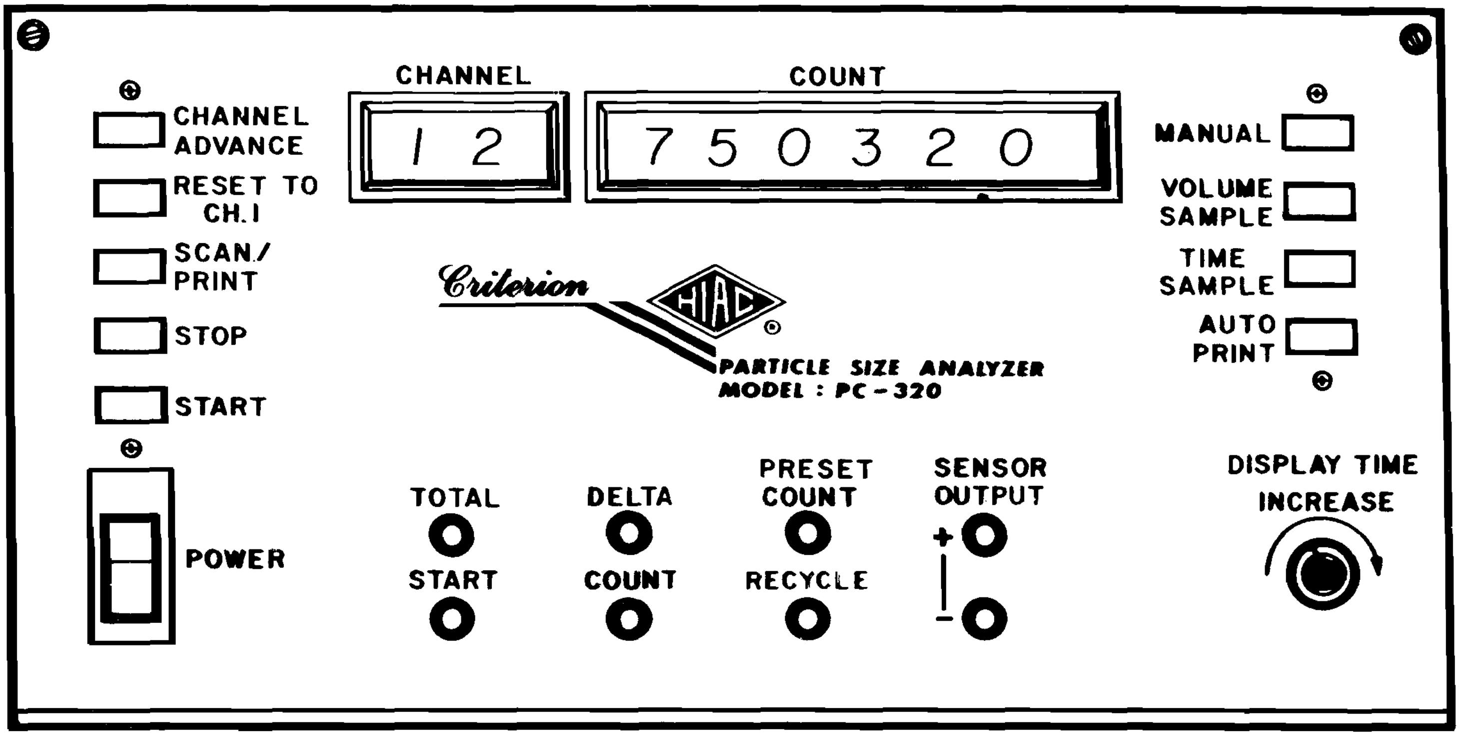


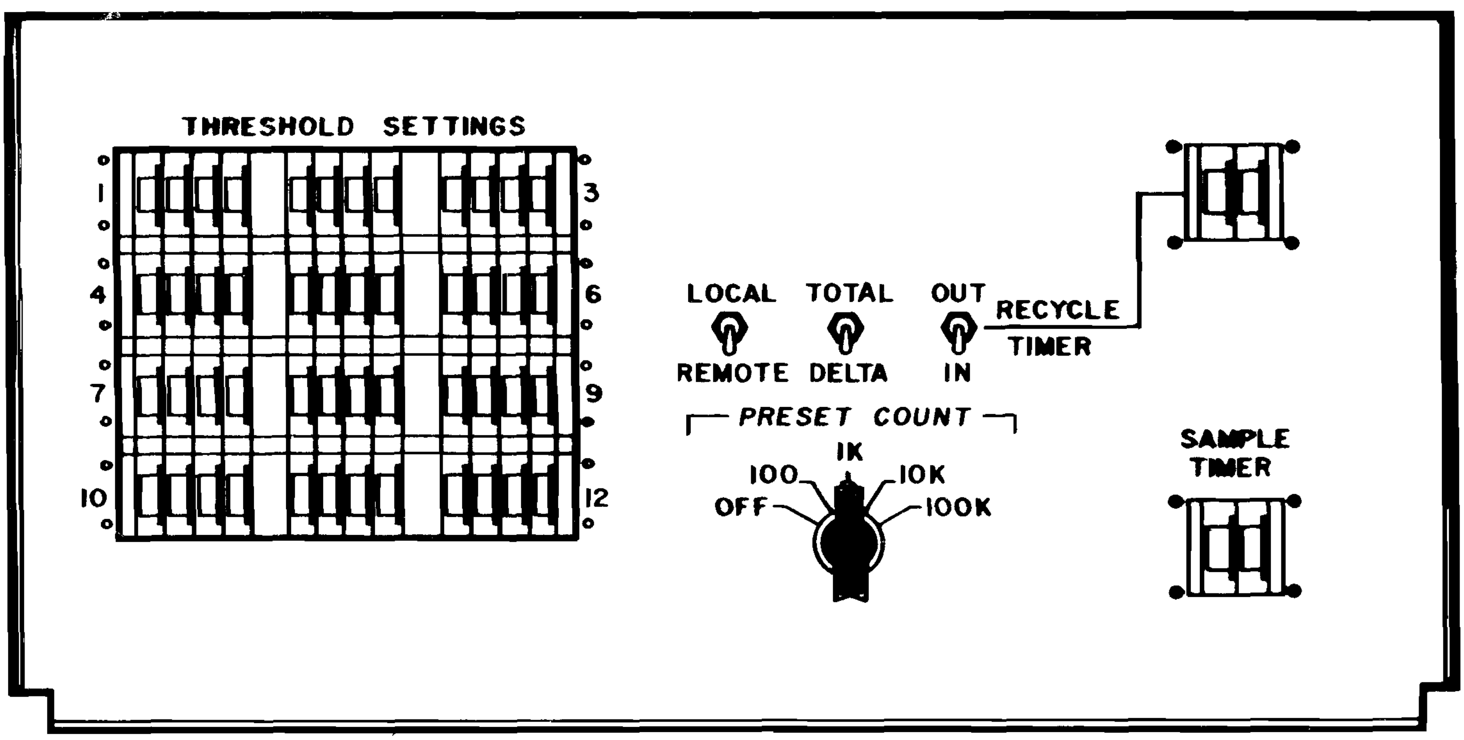
FIGURE A-3

CONTROLS LOCATION DIAGRAM

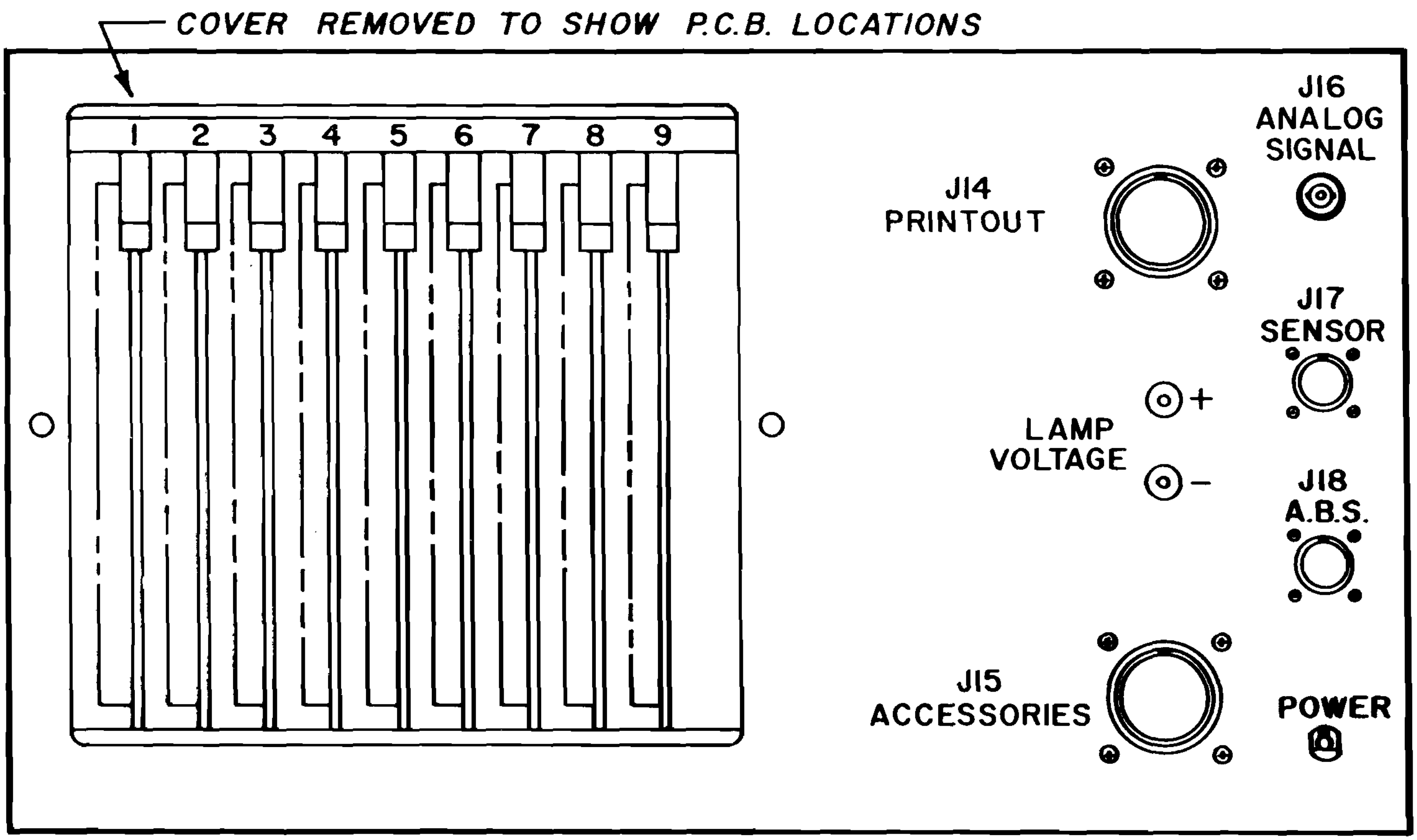
ABS - SMALL VOLUME METERING SECTION







FRONT & SUB-PANEL
PC-320
FIG. 11-2



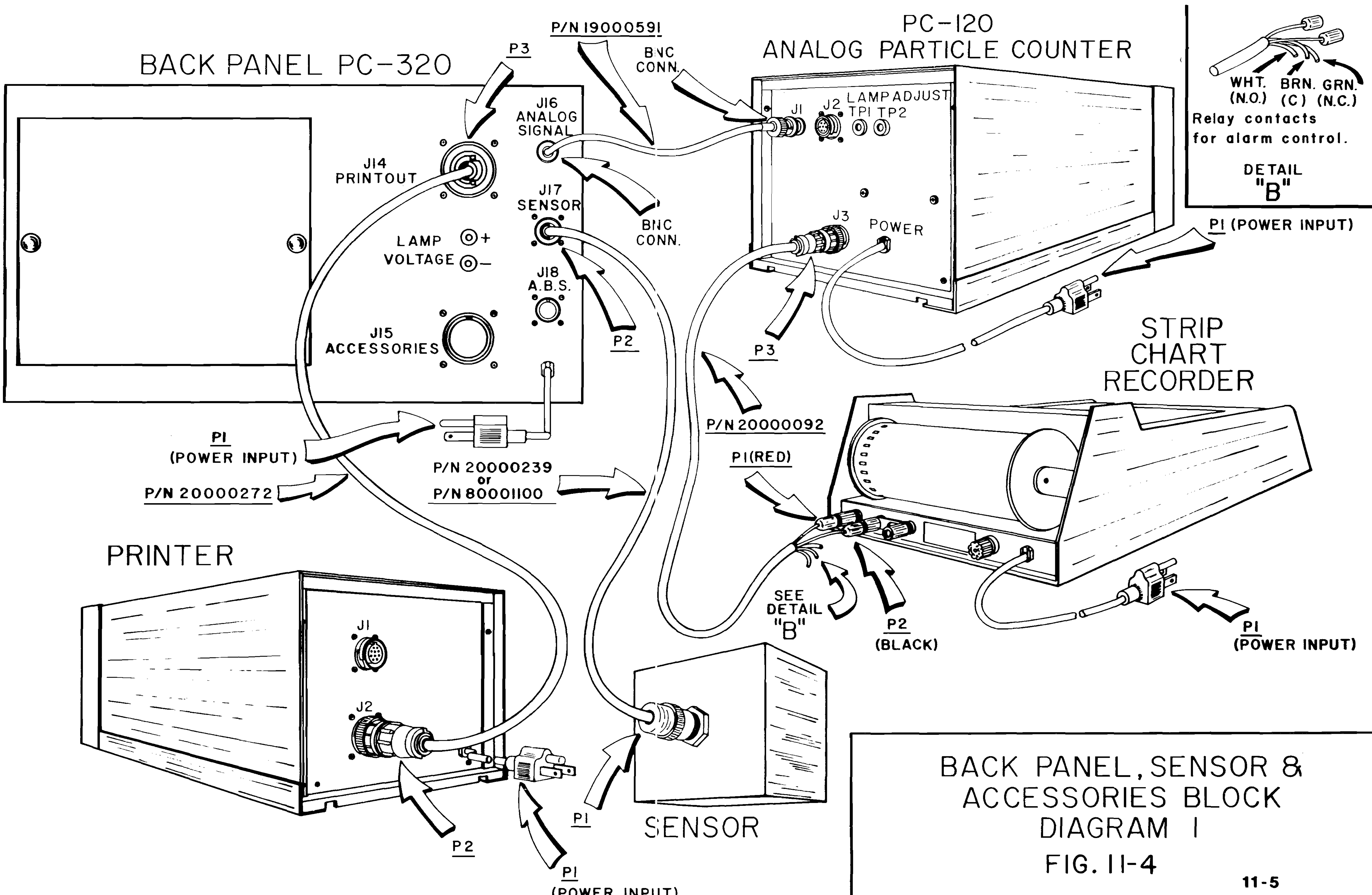
PCB'S

1. ASSY, PCB, SENSOR CONTROL. (80015902)
2. ASSY, PCB, ANALOG COMPARATOR. (80018003)
3. ASSY, PCB, ANALOG COMPARATOR. (80018004)
4.
5.
6. ASSY, PCB, 3CH., 6 DIGIT COUNTER. (2000101)
7.
8. ASSY, PCB, CONTROL LOGIC. (80010201)
9. ASSY, PCB, DISPLAY & PRINTOUT CONTROL. (80011801)

ACCESSORY CONN. (J15)

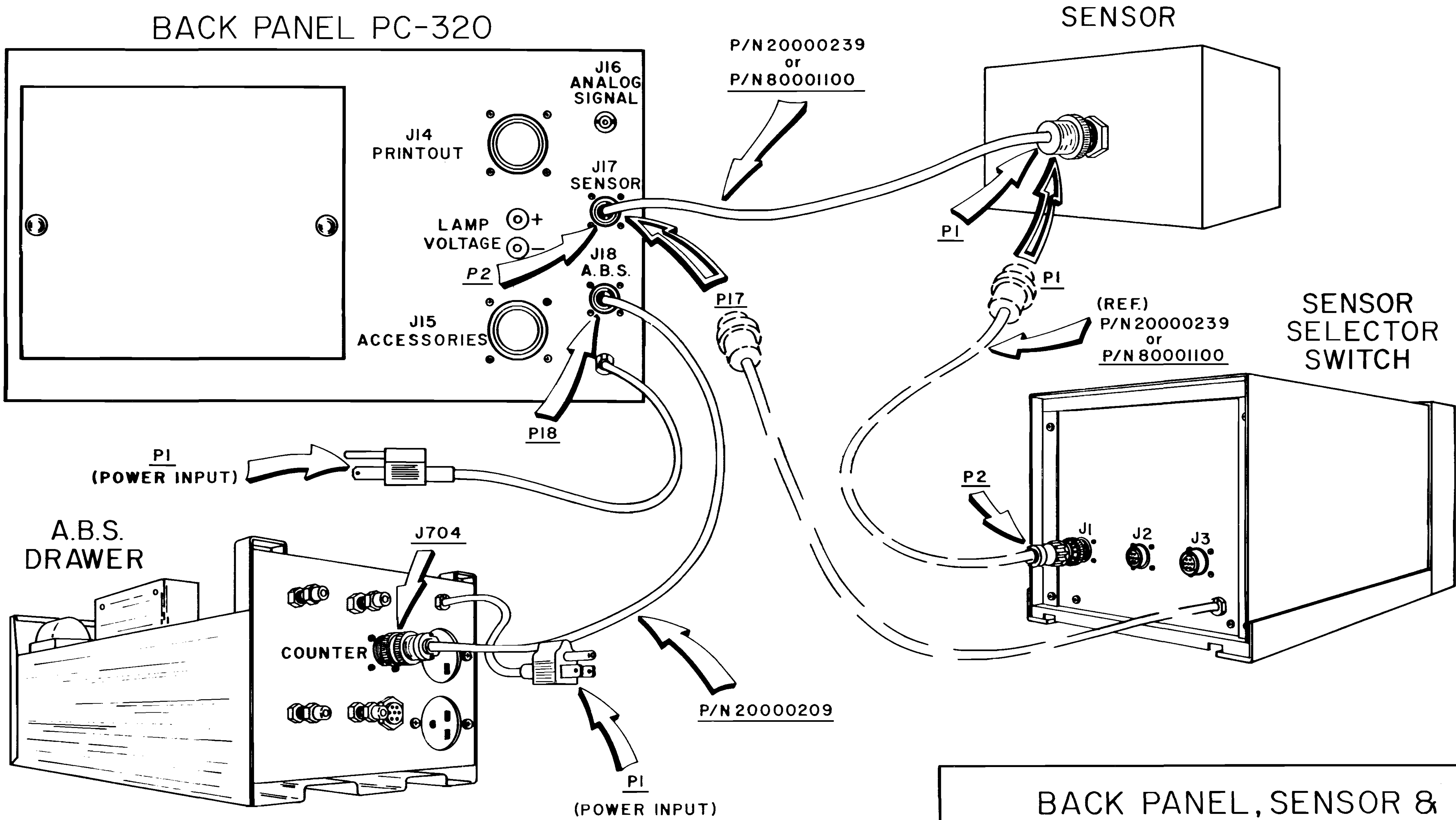
For accessories to be released at a later date.

BACK PANEL & CARD CAGE PC-320 FIG. 11-3



BACK PANEL, SENSOR & ACCESSORIES BLOCK DIAGRAM I

FIG. 11-4



BACK PANEL, SENSOR &
ACCESSORIES BLOCK
DIAGRAM 2

FIG. 11-5

OPERATORS MANUAL

CALCULATOR PRINTER

MODEL CP100

OPERATING INSTRUCTIONS FOR:

CP100-1 PRINT ONLY

CP100-2 PRINTER / STATISTICS PRINTER

HIAC

HIAC INSTRUMENTS DIVISION

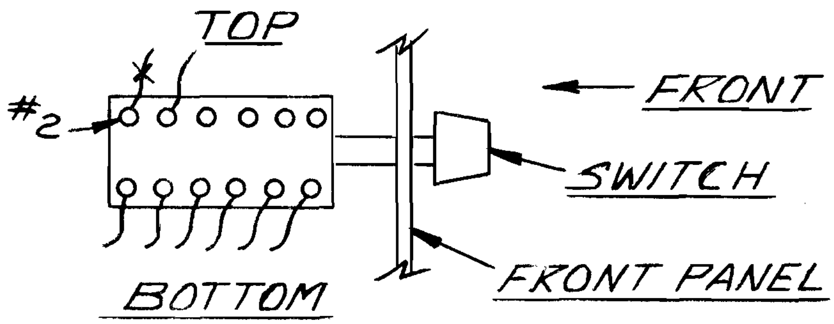
Pacific Scientific

P. O. Box 3007
4719 West Brooks Street
Montclair, California 91763
(714) 621-3965

ADDENDUM

MODIFICATION NOTE FOR PC320 SN10001 Thru 10150

PURPOSE: This modification is to retain the DISPLAY TIME front panel control adjustment when the AUTO PRINT button is engaged to operate the HP97S Printer.



MODIFICATION:

A) Remove front panel cover.

B) Disconnect the wire from the AUTO PRINT switch pin #2, front top pin.

C) Reinstall front panel cover.

INSTRUCTIONS:

A) Set the DISPLAY TIME control approximately 30° CW from the full CCW position.

B) Engage AUTO PRINT. The HP97S will print every time the STOP indicator light comes on.

TROUBLE SHOOTING:

A) Channel and data not printed, increase DISPLAY TIME.

B) Printer not functioning:

1. Verify interface cable #20001305 is correctly connected.
2. Reset per instructions.
3. Verify AUTO PRINT button is engaged.

NOTE: For S/N 10150 & Up use cable #20001271 and proceed as per Operations Manual.

TABLE OF CONTENTS

1.0 INTRODUCTION TO THE CP-100

This system consists of a PC-320 Particle Counter which is interfaced with a Hewlett Packard 97S Programmable Calculator-Printer to provide fast, custom particle size analysis of data and external control of particle processes and other instruments.

1.1 Description & Specifications

This system allows complete flexibility for taking particle count data in up to 12 sizing channels and reducing this data with almost any conceivable mathematical manipulation desired to analyze the results. The system is either operator programmable or may use fixed program for on-line applications by using a pre-programmed magnetic card. The program may be instantly changed

Typical applications include particle size and count averaging and other statistics, instrument calibration and laboratory aid and filter B ratio calculations. Perhaps the most important feature is the output control from the calculator which allows external accessories or processes to be controlled by means of "flag" output signals from the system. The savings in time may shortly pay for the complete system.

The limit of analysis and control is what the system designer, or lab analyst can think up. The HP97S Calculator is easy to program and when disconnected from the counter, may be used as a "stand-alone" programmable calculator useful for all types of scientific or business computations. The system comes complete with programming and operating instructions.

For those who do not wish to write their own programs, the system is supplied with a variety of standard programs.

1.2 Typical Programs Which May be Generated for Use With HP97S Calculator Connected to PC-320 Counters

PRINTOUT OF SAMPLE RUNS

1. Standard Print Mode.
2. Compute and print mean and standard deviation of several sample runs for up to 12 channels.

SENSOR CALIBRATION AND INSTRUMENT AIDS

3. Semi - automated half count of sensors with generation of sensor calibration equation, and sensor calibration curve data.
4. Calculation of PA-520 threshold settings for various dynamic ranges and sizing intervals.
5. Measurement of sensor flow rate with built in clock prior to printout and computation. (Requires special interface modification.)

FILTER B RATIO (6 + 6 COUNTER)

6. Compute and print B ratio of a filter as a function of particle size and dilution ratio, or flow rates.
   Time information and flow rate information may be inputs using an additional multiplexer.

INSTRUMENT & PROCESS CONTROL

7. Automatic control of process or instrument when particle count is not within pre-set bounds.

   These programs will be stored on magnetic program cards. Some of these are available as standard programs. (Refer to HIAC Sale Literature).

2.0 DESCRIPTION OF PC-320 PARTICLE COUNTER

The PC-320 "Criterion" Particle Size Analyzer is the most advanced instrument of its type available on today's market.

It not only measures particles by size and counts them (in as many as twelve different size groups) but does it all automatically.

The PC-320 will operate with full efficiency on liquids of different optical density and color without any special adjustment. In addition it has an integral indicator which warns of any change in sensor operation due to partial window blockage or change in the fluid system.

The "Criterion" Analyzer has a BCD output which will interconnect with data processing equipment or for analog accessories.

Sensors are compact (2" X 2" X 5") with ultra linear calibration. Sensors can be located as far as 1,000 feet from the counter if necessary. In addition, multiple sensor with selector switch can be used. Special sensors for use with corrosive liquids are also available.

In addition, to these features the Model PC-320 is suited to either sample bottle or on-stream analysis. Every unit is factory calibrated and electronic and reference standards are available.

Particles from 1 to 9000 microns can be accurately counted and sized (with the proper sensor). Circuits are of modular construction for easy "plug-in" replacement or service.

2.1 Features of this Counter Are:

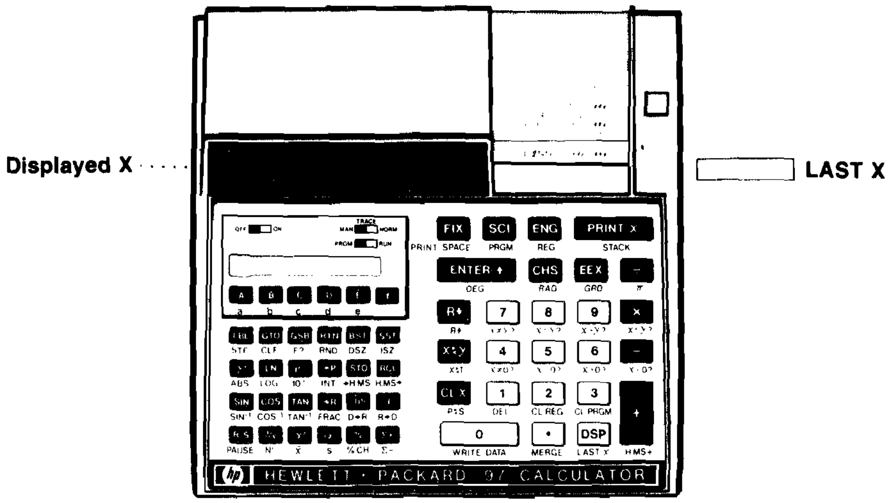
* Designed to be the nucleus of an integrated particle analysis system.
* Six full channels may be expanded to nine or even twelve channels.
* "Direct Dial" size thresholds.
* Full range calibration in every channel.
* Six digit display with built-in timer.
* Sample may be defined by volume, time, or pre-set particle count.
* All solid state construction including photo detector.
* Samples may be run wet or dry with no electrolyte needed.
* Data is available in printout form if required.
* Total/Delta operation with the flip of a switch.

The HP-97 Programmable Printing Calculator

Automatic Memory Stack

Registers

T	0.00
Z	0.00
Y	0.00



Addressable Storage Registers

Primary Registers

	(i) Address
I	25
R_E	24
R_D	23
R_C	22
R_B	21
R_A	20
R_9	9
R_8	8
R_7	7
R_6	6
R_5	5
R_4	4
R_3	3
R_2	2
R_1	1
R_0	0

Protected Secondary Registers

	(i) Address	
R_{S9}	19	n
R_{S8}	18	Σxy
R_{S7}	17	Σy^2
R_{S6}	16	Σy
R_{S5}	15	Σx^2
R_{S4}	14	Σx
R_{S3}	13	
R_{S2}	12	
R_{S1}	11	
R_{S0}	10	

Program Memory

000	
001	51
002	51
003	51
004	51
005	51
220	51
221	51
222	51
223	51
224	51

Figure 1.

3.1 General Operation

The HP97S Programmable Printing Calculator is a versatile and unique calculating instrument. Using the Hewlett-Packard RPN logic system the HP97S slices with ease through the most difficult equations.

As a scientific calculator, the HP97S features a familiar adding-machine style keyboard for rapid data entry wedded to a powerful calculator with dozens of mathematical, statistical, and scientific functions, and a three-way printer for archival permanence to your answers.

As a personal programmable calculator, the HP97S is so easy to program and use that it requires no prior programming experience or knowledge of programming languages. Yet even the most sophisticated computer experts marvel at the programming features of the HP97S.

Some of the Programming Features Are:

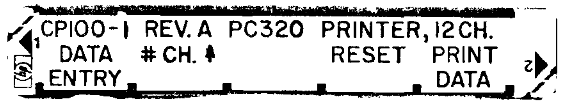
* Magnetic cards that record data or programs-permanently.
* 26 data storage registers.
* 224 steps of program memory.
* Fully merged prefix and function keys that mean more programming per step.
* Easy-to-use editing features for correcting and modifying programs.
* Powerful unconditional and conditional branching.
* Three levels of subroutines, four flags, 20 easily-accessed labels.
* Indirect addressing.
* Printer to record results, list programs, or trace executing programs.

And in addition, the HP97S can be operated from its rechargeable battery pack for <u>complete</u> <u>portability</u>, anywhere.

3.2 Running a Prerecorded Program

The standard programs shipped with your calculator contains prerecorded magnetic cards, and each card contains a program. By using these cards from the Standard Pac you can use your HP97S to perform extremely complex calculations just by following the cookbook-style directions in each pac. Let's try running one of these programs now.

1. Select the Standard Printer Program from the Standard Pac card case.



2. Ensure that the PRGM-RUN Switch is set to RUN.
3. Set the Print Mode switch to MAN. insert side 1 of the Printer Program card, printed side up, into the card reader slot on the front of the calculator as shown. When the card is partially into the slot, a motor engages and passes the card through the calculator and out a similar slot at the rear of the calculator. Let the card move freely.
4. The calculator display should read CRD to prompt you that side 2 of the card must be read in. If CRD does not appear, only one side needs to be read.
5. Now insert side 2 of the Printer Program card, again face up, into the card reader slot on the front of the calculator and permit it to pass through the card reader to the rear of the calculator.
6. If after either pass of the card through the card reader, the display shows ERROR, that side of the card did not read properly. Press CLX, then insert that side of the card into the card reader slot and let it pass through again.
7. When both sides of the card have been read properly, the display will again show the previous answer.
8. Insert the card into the window slot, as shown. The markings on the card should be directly over the keys marked A, B, C, D, E. The markings, or mnemoncis, on the card now identify the function of each of these five keys.

   You are now ready to use the program, but first the general operation of the CP-100 will be described.

4.0 GENERAL FUNCTIONAL OPERATION OF THE CP-100

The functional operation for the CP-100 is outlined in Figure 2. Many variations of this flow chart are possible. The CP-100 may be used for:

1. Sample Computations

and 2. Calibration Assistance

4.1 Sample Computations

4.1.1 Initial Setup - Computing Threshold Settings

REMEMBER: There are two types of cards.

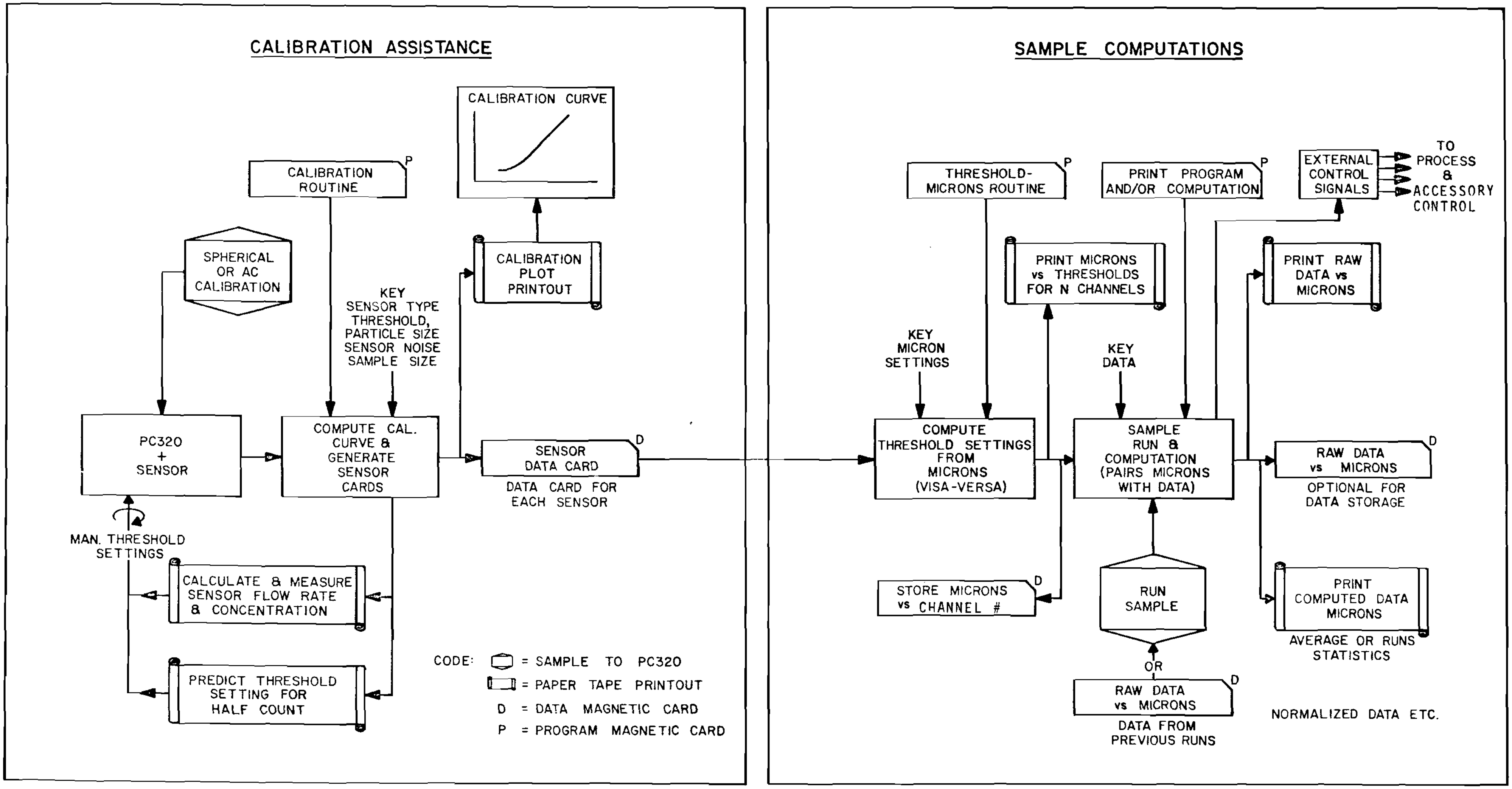
1. Program Cards: Tell the CP-100 what program or series of data manipulations or calculations to make.
2. Data Cards: Contain particle or sensor data which is operated by the program.

The HP97S knows the difference automatically. All you have to do is insert the card.

During calibration, a sensor data card may be prepared which contains information which describes the calibration curve of the sensor being used.

The sensor data (calibration curve) may be used to compute the threshold settings on the PC-320 for a desired micron size without looking at the calibration graph. This is accomplished by entering a threshold to microns subroutine via a program card and then entering desired microns via keyboard. The PC-320 settings will be printed out and stored on a microns vs. channel data card.

The above is initial preparation for using a given sensor and need only be set-up once for a given series of runs.



FUNCTIONAL USES OF CP100 PRINTER PROGRAMMABLE CALCULATOR
CONNECTED TO PC320 PARTICLE COUNTER

Figure 2.

PACIFIC SCIENTIFIC COMPANY
HIAC INSTRUMENTS DIVISION
4719 W. Brooks St.
Montclair, California 91763
U.S.A.

HIAC CP-100

4.1.2 Sample Run & Computation

The desired computational program(s) card(s) are entered. These are the main programs such as standard deviation, population to Delta, percent, etc.

Then the microns vs. channel number data card is entered and then the sample is run. Computations are made and the output may be in four forms.

1. Raw particle count vs. microns or channel number
2. Computed output vs. microns or channel number.
3. Stored data for future use on a data card.
4. External control flags to generate up to (4) distinct go-no-go signals for operating another instrument or controlling an industrial process.

4.2 Suggested Memory Map for Storing Data

The following memory map will utilize the minimum number of program steps for storing data. This technique allows the calculator to operate sequentially from "indirect addressing" feature of the HP97S. (Refer to HP97S Operating Manual - Section 12).

MEMORY MAP OF STORAGE REGISTERS

	REGISTER #		SUGGESTED USE
	Name	Address	Particle Data
	R0	0	
	R1	1	
	R2	2	
	R3	3	
	R4	4	
Primary Registers	R5	5	
	R6	6	
	R7	7	
	R8	8	
	R9	9	
	RS0	10	Particle Data
	RS1	11	
	RS2	12	Channel Microns
Protected Registers	RS3	13	
	RS4	14	
	RS5	15	
	RS6	16	
	RS7	17	
	RS8	18	
	RS9	19	
	A	20	Channel Microns
	B	21	
Other Registers	C	22	
	D	23	
	E	24	Miscellaneous
	I	25	Increment Register

TABLE 1

Now the operation of the Standard Print-Only program will be described.

5.0 EXAMPLE - STANDARD PRINT-ONLY PROGRAM

5.1 Description

This program allows the HP97S Calculator connected to the PC-320 Particle Counter to perform Print-Only functions and store the count data for future use. The PC-320 is run in the normal manner.

5.2 Example - Procedure

a) Turn on CP-100, trace switch in manual position, program switch in run position.

b) Insert program card.

c) PC-320 Auto Print Switch Out - Turn on PC-320 - Reset to Channel 1.

d) Punch keyboard No. of channels; then press key B, which must equal No. of channels used according to indicator on back of board 8. This initializes and clears the CP-100 for the printer mode only. This need not be done again to remain in the print only mode. When the CP-100 is ready to accept new data a 1.000000 appears on the display.

e) Print data from the counter for every sample run by pressing the SCAN/PRINT button or RUN/STOP button. The format looks like Figure 3.

Print Format:

YY.XXXXXX

Y= Channel No.

X= Counts (to 999999)

```
       10.  ***          No. of channel used, Press B

   1.013362 ***
   2.015221 ***
   3.012262 ***
   4.016233 ***
   5.009532 ***          Print Only, Run #1
   6.007432 ***
   7.004326 ***
   8.003218 ***
   9.000356 ***
  10.000072 ***

   1.013549 ***
   2.015364 ***
   3.012836 ***
   4.016335 ***
   5.009211 ***          Print Only, Run #2
   6.007236 ***
   7.004123 ***
   8.003121 ***
   9.000756 ***
  10.000065 ***

   1.015443 ***
   2.015236 ***
   3.012111 ***
   4.011218 ***
   5.005123 ***          Print Only, Run #3
   6.007213 ***
   7.004231 ***
   8.003128 ***
   9.000756 ***
  10.000064 ***

                               ETC.
```

Fig. 3: Print Only Mode Format

f) Continue; repeat b) as many times as desired or until the print statistics mode is used, or until the CP-100 is turned off.

g) To print out the stored data, press Key E. The printout format looks like this example (for 10 channels). (Refer to Fig. 4).

```
                              Stored Data Printout

      1.  ***                 CH #
  19443.  ***                 COUNT

      2.  ***                 CH #
  15236.  ***                 COUNT

      3.  ***                 ETC.
  12111.  ***

      4.  ***
  11210.  ***

      5.  ***
   9125.  ***

      6.  ***
   7213.  ***

      7.  ***
   4231.  ***

      8.  ***
   3120.  ***

      9.  ***
    756.  ***

     10.  ***
     64.  ***
```

Fig. 4: STORED DATA

h) RESET:

The a CRD appears on the display. Run a blank card to store the data or press Reset Key D to prepare for new data. The program may be reset at any time to receive new data by pressing reset Key D. The stored count data is always destroyed by Key D.

User Instructions

CP100-1 REV. A PC-320 PRINTER, 12 CHANNEL

A	B	C	D	E
DATA ENTRY	#CHANNELS↑		RESET	PRINT DATA

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1.	PRINTER ONLY MODE			
	Enter # of channels used.	#CH	B	1.000000
	Ready for count data entry.			
	AUTO: Data enters after sample run.			12.000000
	Nothing need be pressed for			
	repeated runs.			
	MANUAL: Key in data format			
	Channel # . 6 Digits of Count Data i.e.	1.62438	A	2.000000
2.	TO PRINT STORED DATA		E	PRINTS
				CHANNEL#
				& COUNT
				Then
	Enter Blank Card to store data or			CRD
	press CLX to read for new run			
3.	RESET: Use at any time, clears count		D	1.000000
	registers and prepares for new			
	entry from Channel 1			

TABLE 2

USER INSTRUCTIONS - PRINT ONLY

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	[illegible]	[illegible]	
002	DSP0	-63 00	
003	PRTX	-14	CLEAR & STORE
004	CLRG	16-53	
005	P⇄S	16-51	# OF
006	CLRG	16-53	
007	CF3	16 22 03	CHANNELS IN
008	STOE	35 15	
009	SPC	16-11	E
010	DSP6	-63 06	
011	RTN	24	
012	*LBLB	21 12	
013	GSB0	23 00	
014	*LBLb	21 16 12	ENTER # CHANNEL
015	CF3	16 22 03	
016	RCLI	36 46	&
017	1	01	
018	+	-55	PRINT ONLY
019	R/S	51	
020	*LBLA	21 11	
021	PRTX	-14	
022	STOi	35 45	
023	ISZI	16 26 46	
024	RCLI	36 46	
025	RCLE	36 15	
026	X≠Y?	16-32	
027	GTOb	22 16 12	
028	0	00	
029	STOI	35 46	
030	SPC	16-11	
031	GTOb	22 16 12	
032	R/S	51	
033	*LBLE	21 15	
034	DSP0	-63 00	PRINT
035	0	00	
036	STOI	35 46	CHANNEL #
037	SPC	16-11	
038	*LBLe	21 16 15	AND COUNT
039	RCLI	36 46	
040	1	01	
041	+	-55	
042	PRTX	-14	
043	RCLi	36 45	
044	FRC	16 44	CONVERTS DECIMAL
045	EEX	-23	
046	6	06	TO NUMERICA1
047	x	-35	
048	PRTX	-14	COUNT
049	SPC	16-11	
050	ISZI	16 26 46	
051	RCLI	36 46	
052	RCLE	36 15	
053	X≠Y?	16-32	
054	GTOe	22 16 15	
055	SPC	[illegible]	
056	0	[illegible]	

STEP	KEY ENTRY	KEY CODE	COMMENTS
057	STOI	35 46	
058	WDTA	16-61	
059	DSP6	-63 06	
060	GTOb	22 16 12	
061	R/S	51	
062	*LBLD	21 14	
063	DSP6	-63 06	RESET &
064	RCLE	36 15	
065	P⇄S	16-51	CLEAR
066	CLRG	16-53	
067	P⇄S	16-51	REGISTERS
068	CLRG	16-53	
069	P⇄S	16-51	
070	STOE	35 15	
071	GSBb	23 16 12	
072	R/S	51	

TABLE 2
(continued)

REGISTERS

0	1	2	3	4	5	6	7	8	9
COUNT CH. #1	COUNT CH. #2	COUNT CH. #3	COUNT CH. #4	COUNT CH. #5	COUNT CH. #6	COUNT CH. #7	COUNT CH. #8	COUNT CH. #9	COUNT CH. #10

S0	S1	S2	S3	S4	S5	S6	S7	S8	S9
COUNT CH. #11	CH. #12	Free	Free	Free	Free	Free	Free	Free	Free

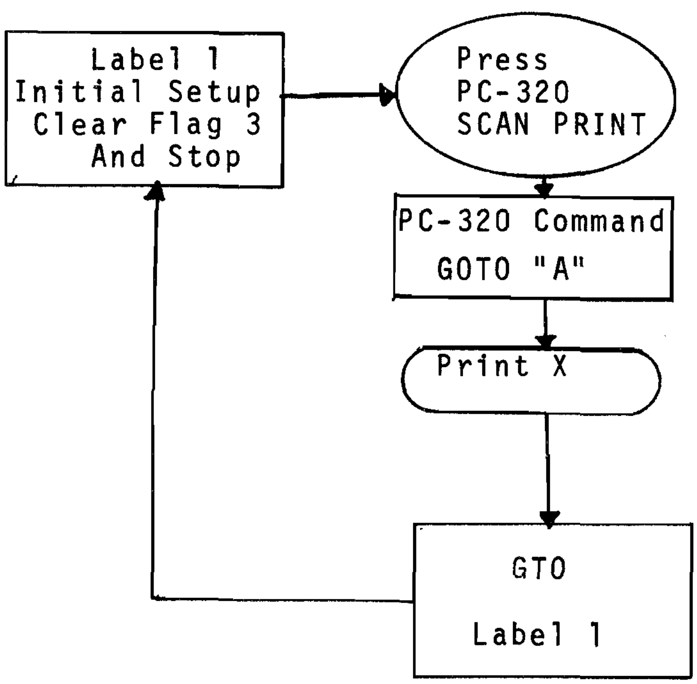
A	B	C	D	E	I
					CHANNEL #

6.0 PROGRAMMING HINTS

A complete description of programming methods is beyond the scope of this manual. Refer to the HP97S instruction manual. However, a few instructions are necessary to make the CP-100 interactive with the PC-320 Counter.

1. Immediately after Count Data is sent from the PC-320 to the CP-100, Label Key A is electronically pressed so that a jump is made to the next Label A in the program. Label A is the Data entry key.

2. Flag 3 is set by data entry and must be cleared before new data can be received from the PC-320. So the program must clear flag 3 to allow the PC-320 to advance to the next data channel. The following diagram illustrates the use of flag 3. (See Fig. 5).



A Simple Print Program

Press Display 6
And Then Return

```
001  *LBL1
002    CF3
003    R/S
004  *LBLA
005   PRTX
006   GTO1
007    R/S
```

Figure 5: Print Program Illustration

Another Example:

This will print 4 successive channels, each time jumping to the next label and if channel 3 exceeds 5198 counts then a flag is set to operate (say) another instrument. This program is a little more complex. (See Fig. 6).

001	*LBL1	Initialize
002	CF3	Clear Flag 3 and Stop
003	R/S	
004	*LBLA	Accept PC-320 Data, CH.1
005	GSB2	Go To Subroutine 2 and Return (See Below)
006	PRTX	Print Data CH.1
007	CF3	Clear Flag 3 and Stop
008	R/S	
009	*LBLA	Accept CH.2
010	GSB2	
011	PRTX	Print CH.2
012	CF3	
013	R/S	
014	*LBLA	Accept CH.3
015	GSB2	
016	PRTX	Print CH.3
017	5	
018	1	5198
019	9	
020	8	
021	X≤Y?	5198≤ Count in Channel 3 ?
022	SF1	Yes: Set Flag 1 For Control of External Instrument
023	CF3	No: Clear Flag 3, Stop, Get Ready for Channel 4
024	R/S	
025	*LBLA	Accept CH.4
026	GSB2	
027	PRTX	Print CH. 4
028	SPC	Space, Finished, Go Back to 1
029	SPC	
030	GTO1	
031	R/S	
032	*LBL2	Subroutine 2
033	FRC	Formats say: 1.012631 to 12631
034	EEX	
035	6	
036	×	
037	RTN	
038	R/S	

Figure 6: Example Program

7.0 OPERATION OF CP100-2 PROGRAM PRINTER/STATISTIC PRINTER

This program allows the HP97S calculator connected to the PC-320 Particle Counter to perform two functions, namely:

1. Print count data only.
2. Print count data from n runs, then determine statistics of average and standard deviation of those n runs.

The PC-320 is run in the normal manner.

8.0 EXAMPLE-PROCEDURE FOR CP100-2

8.1 Initialization

8.1.1 Power On

a) Turn on CP-100, trace switch in manual position, program switch in run position.

b) Insert program card, both sides.

c) PC-320 Auto Print Out - Turn on PC-320 - Reset to Channel 1.

8.1.2 Print Only Mode

a) Punch keyboard No. of channels; then press key B, which must equal No. of channels used according to indicator on back of board 8. This initializes and clears the CP-100 for the printer mode only. This need not be done again to remain in the print only mode.

b) Print data from the counter for every sample run by pressing the SCAN/PRINT button or RUN/STOP button. The format looks like Figure-7.

Print Format:

YY.XXXXXX

Y= Channel No.

X= Counts (to 999999)

10. *** — No. of channel used, Press B

Print Only, Run #1

```
 1.015552  ***
 2.015231  ***
 3.012265  ***
 4.010236  ***
 5.005532  ***
 6.007432  ***
 7.004326  ***
 8.003216  ***
 9.000356  ***
10.000072  ***
```

Print Only, Run #2

```
 1.019545  ***
 2.015564  ***
 3.012236  ***
 4.010335  ***
 5.005211  ***
 6.007626  ***
 7.004123  ***
 8.003121  ***
 9.000736  ***
10.000035  ***
```

Print Only, Run #3

```
 1.019443  ***
 2.015236  ***
 3.012111  ***
 4.011216  ***
 5.005123  ***
 6.007213  ***
 7.004231  ***
 8.003126  ***
 9.000756  ***
10.000064  ***
```

ETC.

Fig. 7: Print Only Mode Format

c) Continue; repeat b) as many times as desired or until the print statistics mode is used, or until the CP-100 is turned off.

8.1.3 Print Statistics Mode

a) Punch keyboard No. of channels; then press key C, which must equal No. of channels used according to indicator on back of board 8. This initializes and clears the CP-100 for the Print Statistics Mode. This must be done every time a series of runs is to be averaged.

b) Data from the counter for every run may be printed by pressing the SCAN/PRINT button or RUN/STOP button. The format looks like Figure-8.

8.1.4 Calculate Statistics

a) To calculate the results of the runs made in 2.1.3, enter number of runs, n, press D and wait while the CP-100 calculates the mean and standard deviation of n runs.

b) The CP-100 will print the statistical computation as shown in Fig. 9.

c) The CRD appears on the display to allow the operator to record this data on a blank card. Merely run both sides of the card through. This data is then stored for future reference or use in other calculations or programs. If no data record is desired, press clear X.

d) To make another series of runs, repeat steps 2.1.3 and 2.1.4.

Print Format

YY.XXXXXX

Y= Channel No.

X= Counts (to 999999)

No. of Channels Used, Press C

```
      10.   ***

1.013562    ***
2.015231    ***
3.012265    ***
4.010230    ***
5.009532    ***
6.007432    ***
7.004326    ***
8.003216    ***
9.000556    ***
10.000072   ***
```

Print Statistics Only, Run #1

```
1.019549    ***
2.015364    ***
3.012856    ***
4.010335    ***
5.009211    ***
6.007256    ***
7.004123    ***
8.003121    ***
9.000756    ***
10.000065   ***
```

Print Statistics Only, Run #2

```
1.019443    ***
2.015236    ***
3.012111    ***
4.011210    ***
5.005123    ***
6.007213    ***
7.004231    ***
8.003120    ***
9.000756    ***
10.000064   ***
```

Print Statistics Only, Run #3

Fig. 8: Print Statistics Mode Format

3.000000	***	Number of Runs, n, Press D
1.	***	Channel No.
71.	***	Std. Dev.
13515.	***	Average Count
2.	***	Channel No.
75.	***	Std. Dev.
15277.	***	Average Count
3.	***	Etc.
416.	***	
12424.	***	
4.	***	
536.	***	
16552.	***	
5.	***	
215.	***	
5283.	***	
6.	***	
345.	***	
7514.	***	
7.	***	
122.	***	
4227.	***	
8.	***	
52.	***	
3156.	***	
9.	***	
113.	***	
623.	***	
10.	***	
4.	***	
67.	***	
11.	***	
0.	***	
0.	***	
12.	***	
0.	***	
0.	***	

Fig. 9: Statistical Computation and Print Out for n, Runs.

User Instructions

HIAC CP-100

#CP100-2 REV. A PC-320 PRINTER - 12 CHANNEL

1				2
AUTO OR MAN. DATA	#CHANNELS PRINT ONLY	#CHANNELS STATISTICS PRINT	#RUNS↑ READ STATISTICS	
A	B	C	D	E

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1.	PRINTER ONLY MODE			
	Enter # of channels used.	#CH	B	1,000000
	Ready for count data entry.			
	AUTO: Data enters after sample run.			12,000000
	Nothing need be pressed for			
	repeated runs.			
	MANUAL: Key in data in format			
	Channel # 6 Digits of Count Data		A	
2.	STATISTICAL PRINTER			
	Enter # of channels used.	#CH	C	1,000000
	Ready for count data entry.			
	AUTO: Data enters after sample run.			12,000000
	Nothing need be pressed for			
	repeated runs.			
	MANUAL: Key in data as in step 1.		A	
	Calculate average and standard deviations.			
	after n runs.			
	Enter number of runs.	n	D	
	Calculates for a few seconds then prints			
	a) Average of n runs for 12 channels.			
	b) Standard deviation of n runs for 12 channels.			
	To make another series of runs, repeat			
	step 2.			
	TABLE 3: USER INSTRUCTIONS			
	PRINTER/STATISTICS			

9.0 PROGRAM MATHEMATICS - CP100-2

This program provides a printer for the PC-320 in two modes:

1. Fast Print Only Mode - Particle Count
2. Statistics Printer Mode - Calculations the average and standard deviation on particle count for, n, samples runs for up to 12 data channels.

STANDARD DEVIATION:

$$S.D. = Sxi = \sqrt{\Sigma X_i^2 - \frac{(\Sigma X_i)^2}{n}}$$

ΣX_i = Summation of count on n runs for the i'th channel

i = 1 to 12

$$\overline{Xi} = \text{Mean} = \frac{\sum_{i}^{n} Xi}{n}$$

TO FAST PRINT ONLY:

Set mode by keying No. of channels used and press B. Data is entered automatically from PC-320 and printed. It is not necessary to press B again for each sample run.

TO PRINT STATISTICS:

Set mode by keying No. of channels used and press C. Data is entered automatically from PC-320. (To enter data manually key in CH #, decimal point, then count and press A). It is necessary to press C for repeared runs. After n runs, key in n, and press D; the statistics are printed. Now for a new set of runs enter CH # and press C again, etc.

HIAC Instruments Division

PACIFIC SCIENTIFIC

IMPORTANT NOTES ON CALIBRATION

The attached procedure gives detailed, step-by-step instructions on calibration of your HIAC particle counter, using a HIAC calibration standards kit. Our experience has shown this method to be extremely reliable for verifying equipment operation and establishing correct sizing.

Most customers have no difficulty calibrating their equipment; we find most customers who do have difficulty can eliminate most problems by following the suggestions on this sheet.

FOR SUCCESSFUL CALIBRATION:

1. Carefully read the entire procedure before trying to calibrate. Follow it through in a "dry run" while directly in front of the equipment. You will probably not be able to obtain a good calibration if you do not practice the steps involved, and understand the procedural steps involved.

2. The basic steps in calibration , most of which are detailed in the procedure. Simplified, they are:

   a. CLEAN the fluid passageways of all foreign matter, and of all contaminated material, prior samples, etc; run filtered freon/alcohol to do this.

   b. Dry the sensor completely (not required for "D" type sensors).

   c. Establish the noise threshold level (not required for "D" type sensors, for PC-305, or for PC-420's using "SB" sensors).

   d. Set the sampler mechanism for a 10 ml sample.

   e. Set the flow rate for the correct value specified; use a stopwatch.

   f. When flow rate and sampling have been set, set each channel as specified in initial threshold settings part of tables. (if you have a previous calibration curve, you may use values derived from that curve instead.)

   g. Run 10 ml samples of calibration fluid; adjust thresholds until you obtain counts within the acceptable tolerances of the correct values.

   h. Plot the particle size vs. threshold values on the supplied graph paper. Find your required values from the resulting curve, and adjust your thresholds for the sizes you use in normal operation.

AC FINE TEST DUST PROBLEMS

We have found that many more customers have problems with ACFTD calibration than with spherical calibrations. Virtually all of these problems can be solved by keeping these points in mind:

1. AC Fine Test appears to fall out of suspension very quickly. Therefore:

   a. AGITATE THOROUGHLY

   b. DEAERATE QUICKLY (We strongly recommend use of ultrasound.)

   c. USE A MAGNETIC STIRRER - Get it to turn as fast as possible, being careful not to create a vortex, cavitation or air bubbles.

   d. Run the samples as quickly as possible. Do not delay the procedure once you have removed the sample from the ultrasonic or once shaken.

   e. Run repetitive samples quickly. Do not allow more than 20-30 seconds to elapse between runs.

2. Water vapor is responsible for extremely high counts, generally in the last half of a sample bottle, and must be eliminated from the system. Even a few drops of moisture will vaporize and perfuse the solution.

   a. All condensation must be removed from the pressure cylinder and probe.

   b. If the sampler has been used with water-based samplers, flush with alcohol then freon before using oil.

   c. You MUST use a dessicant dryer if your humidity is over 25-30%; you SHOULD use one any time you run any oil-based samples.

   d. All glassware or other material inside the sampler MUST be thoroughly dried. This includes the outside of the sample bottles.

3. It is normal for counts to drop off quite a bit toward the bottom of each bottle, starting with the larger sizes.

4. It has been noted that less than one bottle in one hundred will give noticeably different counts from the others in a calibration kit. If you are almost "zeroed in" on the correct values, change bottles, and suddenly find yourself far off the mark; try a third bottle.

IV.

UNIVERSAL PROCEDURE FOR THE FIELD CALIBRATION OF THE HIAC AUTOMATIC PARTICLE COUNTER MODEL PC-320

This field calibration procedure is designed to provide a simple method of verifying the calibration of the PC-320 series HIAC Automatic Particle Size Analyzer. It is based on the use of standard calibration kits which are fluid suspensions of standard materials having accurately known size distributions. The calibration procedure involves the adjustment of threshold levels for the particle sizes of interest until the indicated counts (per unit volume) match those on the certification slip which accompanies each kit.

Three kinds of calibration kits are available

1 - Spheres in water

2 - Spheres in Mil-H-5606 Hydraulic Fluid

This sample 3 - A.C. Fine Test Dust in Mil-H-5606 Fluid

Calibration with AC Fine Test Dust is performed in accordance with ISO 4402.

The kit consists of four 250 ml bottles of standard particles suspended in either water or Mil-H-5606 Hydraulic Fluid; stirring rods; certification slip; graph paper; and this step-by-step procedure. The standard suspension values have been verified at the HIAC Applications Engineering Laboratories.

When plotted on log-log paper, the calibration curves derived from spherical and AC Fine Test Dust have exactly the same shape but are displaced along the size axis. This displacement occurs because of the different definitions of particle size. A sphere is defined by its diameter, while AC Fine Test is sized by its greatest lineal dimension. To convert spherical calibration to ACFTD the particle size must be multiplied by 1.54. Thus a 5μm sphere is equivalent to a 7.7μm ACFTD particle.

WHEN TO RECALIBRATE

Good Analytical practice requires that any instrument should be calibrated at periodic intervals. Recalibration is recommended at the following times:

1. Every six months (or more often).
2. After changing or adjusting the sensor lamp.
3. After changing or repairing sensor electronics.
4. Whenever a new, uncalibrated sensor is installed.

PROCEDURE

1.0 Materials and Equipment

1.1 HIAC Model PC-320 Series Automatic Particle Size Analyzer.

1.2 HIAC Automatic Bottle Sampler (ABS) or other device capable of delivering a 10 ml volume of test fluid through the sensor at the correct flow rate.

1.3 EB, CMB, EH, CMH, E, CM Series sensors: 60µm, 90µm, 120µm, 150µm, 300µm.

1.4 Stop watch or timer with 0.1 second resolution.

1.5 HIAC Field Calibration Kit; spheres in water or Mil-H-5606 Hydraulic Fluid or AC Fine Test Dust in Mil-H-5606 Hydraulic Fluid.

2.0 Peak Noise Level Determintaion

2.1 Attach sensor to Automatic Bottle Sampler (ABS) and connect to PC-320 using appropriate cable. DO NOT allow fluid to enter sensor. If fluid is already in sensor, rinse with an appropriate solvent and allow to dry.

2.2 If the Particle Size Analyser is equipped with a sample timer, depress time sample switch on front panel. If the Particle Size Analyzer does not have a sample timer, use a stop watch to time the operation.

2.3 Adjust sample timer to 30 seconds.

2.4 Set Total/Delta switch to TOTAL position.

2.5 Set Threshold #1 to 040A, or to the noise level determined in a previous calibration.

2.6 Depress Start Switch on 320 front panel and allow the counter to run over the entire thirty second cycle.

2.7 If the count in Channel #1 is greater than 30 ±5, readjust Channel 1 to a higher number and repeat step 2.6 until Channel #1 reads 30 ±5, for 2 consecutive runs.

2.8 Record the resulting threshold #1 setting. This setting corresponds to the peak noise output for the sensor.

2.9 On the log-log graph paper, draw a horizontal line from 0.1-100µm at the peak noise level recorded in Step 2.8. In the example graph attached, the peak noise level calibration number is 097A, (or97mv).

NOTE: Some HIAC PC-320's with serial numbers 10150 and below are designed so that the threshold voltage of the auxiliary amplifier is fixed at 7.5mv (075A). In these instruments, noise readings of less than 075 cannot be made. If these instruments are used with low noise sensors, the peak level noise may be assumed to be 5.0mv or 050A. Should you wish to convert your counter to accept noise compensated calibration, please request a modified PC Board #2.

3.0 Flow Rate Adjustment Procedure

Please refer to the attached table entitled "Calibration Variables, PC-320". The second line from the bottom lists the flow rate range for each sensor. The time required to cycle 10 ml of sample fluid at that flow rate is listed below the range. For example, a 150µm sensor should be run at a flow of 100 ±50 ml/min, and a 10 ml run at 100 ml/min. will take 6 seconds.

3.1 Adjust the level detector blocks on the Automatic Bottle Sampler to 10.0 ml total volume (0-10 or 5-15 ml for example).

3.2 Place one bottle of sample fluid from the calibration kit into the sample stand pressure cylinder and seal by closing clasp locks.

3.3 Depress Volume Sample switch on Analyzer front panel.

3.4 Initiate fluid flow by depressing Start switch on the Analyzer front panel, and using a stop watch, time the flow of 10 ml through the system.

3.5 If the flow rate is outside of the recommended range, adjust the flow rate by increasing or decreasing the air pressure. Increasing air pressure will increase the flow rate.

4.0 Set Channel Thresholds

4.1 Allow a five minute warm-up period before performing the calibration.

4.2 Place the count mode selector in TOTAL position.

4.3 See the Calibration Variable Table to determine the initial calibration number for each of the first five channels for the sensor to be calibrated. For example, with a 150μm sensor, Channel 1 will be set at 5.0μm with a threshold setting of 160A. If you have a prior calibration curve for that sensor, you may use the values specified on that curve instead. Adjust each of the first five channel thresholds to their appropriate settings as listed in the table (Channels 6 and higher should be set at 999C.)

5.0 Count Procedure

5.1 Thoroughly mix one bottle of the standard suspension by vigorous shaking for at least 30 seconds. Dissipate any entrained air from the standard suspension by exposing it to vacuum or to ultrasound. (If using ultrasound, be sure to thoroughly dry the outside of the bottle!)

5.2 Insert a clean magnetic stirring bar into the bottle. Place the bottle on the magnetic stirring base of the bottle sampler (ABS). Turn the stirrer motor on and adjust the stirring speed to a point where it thoroughly agitates the sample but not so fast as to introduce air bubbles. Continue stirring throughout the procedure.

5.3 Raise the bottle into the pressure cylinder by raising the magnetic stirring base into position, and seal by closing clasp locks. Verify that volume sample switch on PC-320 front panel is on. Start flow by pushing the START BUTTON on the analyzer front panel.

5.4 Record the counts for all five channels.

6.0 Threshold Adjustment Procedure

The particle counts in the standard particle suspension are recorded on the Certification Slip included with the Calibration Kit. If the counts obtained in step 5.4 are different from those recorded on the Certification Slip, thresholds must be adjusted. The allowable variation can be found on the "Calibration Variables Table" in the "% Deviation" column for each sensor. For instance, with a 150μm sensor, the channel number 1 count at 5.0μm must be within ±5% of the count recorded on the Certification Slip.

6.1 If the count in any one channel is lower than allowable (with deviation) change the threshold switch setting for that channel to a lower number.

6.2 If the count in any one channel is higher than allowable, adjust the threshold switch for that channel to a higher number.

6.3 Repeat steps 6.1 and/or 6.2 for each of the five channels.

6.4 Continue analyzing 10 ml samples by repeating steps 5.3 through 6.3 until all count are within the allowable range.

6.5 Once the channel thresholds are set within acceptable limits, do not change them!

6.6 Record the channel threshold setting for each channel. These are the calibration numbers for each channel at the specified particle size.

7.0 Preparation of Calibration Graph

7.1 Subtract the peak noise level value from each of the channel threshold settings recorded in step 6.6.

Example:

```
Channel #1 = 15.0µm
Channel Threshold = 814A
Peak Noise Level =  097A
Noise free Cal # =  717A
--------------------------------------------
Channel #2 = 20.0µm
Channel Threshold = 129B = 1290A
Peak Noise Level =          097A
Noise Free Cal #           1190A = 119B
```

7.2 Plot these "noise free" calibration numbers on the vertical axis against particle size on the horizontal axis. Extend the resulting line to the point where it intercepts the horizontal axis. The upper end of the line must stop at maximum size of sensor. (See attached example curve.)

7.3 At Convenient values, (2.5, 3.0, 4.0, 5.0, 8.0, 10.0, 15.0, 20.0 and 30.0µm for example, add the peak noise value to the "noise free" calibration number.

7.4 Plot these new "noise compensated" calibration numbers obtained in step 7.3 on the log-log graph. This will result in an asympotic noise-included graph of particle size versus calibration number. (See example attached.)

8.0 Instrument Recalibration

8.1 Find the particle size desired on the horizontal axis of the graph prepared in Step 7.

8.2 Determine the calibration number by finding where particle size intersects the calibration number on the noise-included curve.

NOTE: Do not use calibration numbers which are less than 2.0 mv above the peak noise level. For example: If the peak noise level is 097A, the lowest point which may be used is 117A. (97 + 20).

8.3 Recalibrate the PC-320 by the procedure outlined in the instruction manual using the calibration numbers derived from this procedure.

HIAC PC-320

	CHANNEL	60 µm SIZE (µm)	60 µm THRESHOLD SETTING	60 µm ± % Dev.	90 µm SIZE (µm)	90 µm THRESHOLD SETTING	90 µm ± % Dev.	120 µm SIZE (µm)	120 µm THRESHOLD SETTING	120 µm ± % Dev.	150 µm SIZE (µm)	150 µm THRESHOLD SETTING	150 µm ± % Dev.	300 µm SIZE (µm)	300 µm THRESHOLD SETTING	300 µm ± % Dev.
SPHERES/H_2O or 5606	1	2.0	175A	5	5.0	330A	5	5.0	250A	5	5.0	160A	5	15.0	250A	5
	2	5.0	500A	5	10.0	100B	5	10.0	620A	5	10.0	400A	5	20.0	400A	5
	3	10.0	170B	10	15.0	200B	10	15.0	120B	10	20.0	130B	10	30.0	840A	10
	4	20.0	590B	10	20.0	350B	10	20.0	210B	10	30.0	280B	15	40.0	140B	15
	5	30.0	130C	10	30.0	800B	10	30.0	410B	15	40.0	480B	15	50.0	215B	20
ACFTD/5606	1	4.0	180A	5	7.0	200A	5	10.0	280A	5	10.0	180A	5	15	115A	5
	2	5.0	220A	5	10.0	450A	5	15.0	540A	5	15.0	380A	5	20	180A	5
	3	10.0	760A	5	15.0	900A	5	20.0	950A	10	20.0	580A	10	30	380A	10
	4	15.0	170B	5	20.0	160B	10	30.0	1[illegible]0B	10	30.0	130B	10	40	630A	20
	5	20.0	260B	10	30.0	360B	10	40	300B	20	40.0	220B	20	50	970A	20
	Flow Rate	EB, CMB - 8 ±.8 mil/min. EH, CMH - 6 ±.6 mil/min. E, CM - 8 ±.8 mil/min.			EB, CMB - 20 ±5 mil/min. EH, CMH - 15 ±4 mil/min. E, CM - 20 ±2 mil/min.			EB, CMB - 40 ±10 mil/min. EH,CMH - 20 ± 5 mil/min. E, CM - 30 ± 3 mil/min.			EB. CMR - 100 ±50 mil./min. EH, CMH - 60 ±30 mil./min. E, CM - 60 ± 6 mil./min.			EB, CMB - 225 ±100 mil/min. EH, CMH - 100 ± 50 mil/min. E, CM - 200 ± 20 mil/min.		
	Time for 10 ml run at Flow Rate	EB, CMB - 75 sec. EH, CMH - 100 sec. E, CM - 75 sec.			EB, CMB - 30 sec. EH, CMH - 40 sec. E, CM - 30 sec.			EB, CMB - 15 sec. EH, CMH - 30 sec. E, CM - 20 sec.			EB, CMB - 6 sec. EH, CMH - 10 sec. E, CM - 10 sec.			EB, CMB - 3 sec. EH, CMH - 6 sec. E, CM - 3 sec.		

CALIBRATION VARIABLES TABLE

CALIBRATION DATA SHEET

PC-320, 420

SENSOR ________ S/N ________ Particle Counter ________ S/N ______

Flow rate ________ ACFTD CONC ________

CHANNEL	SIZE	COUNT/10 ml	THRESHOLD		PEAK NOISE		NOISE FREE CAL NUMBER
1	µm			-		=	
2	µm			-		=	
3	µm			-		=	
4	µm			-		=	
5	µm			-		=	

OPERATOR ________

DATE : ________

PARTICLE SIZE CERTIFICATION

Material SPHERES Lot Number 410

Carrier Fluid H_2O Invoice 4941

Instrument 320 S/N 10173

Sensor 300 S/N 542-L

Flow Rate ——— Sample Volume 10ML

Bottles Clean To NAS 1638 Class ———

ANALYSIS

Size µm	Particle Count/ 10 ml.
> 15.	4,435
> 20.	1,857
> 30.	306
> 40.	80
> 50.	35

OPERATOR S. RUTLEDGE DATE 4-1-77

EXPIRATION DATE 7-1-77

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4719 W. BROOKS ST.
MONTCLAIR, CALIF. 91763
U.S.A.

PARTICLE SIZE CERTIFICATION

Material ACETD Lot Number 404

Carrier Fluid MIL-H 5606 Invoice 4887

Instrument 320 S/N 10173

Sensor 150 S/N 016-L

Flow Rate ——— Sample Volume 10 ML

Bottles Clean To NAS 1638 Class ———

ANALYSIS

Size μm	Particle Count/ 10 ml.
> 10.	7,714
> 15.	2,698
> 20.	1,320
> 30.	430
> 40.	168

OPERATOR S. RUTLEDGE DATE 4-1-77

EXPIRATION DATE 10-1-77

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4719 W. BROOKS ST.
MONTCLAIR, CALIF. 91763
U.S.A.

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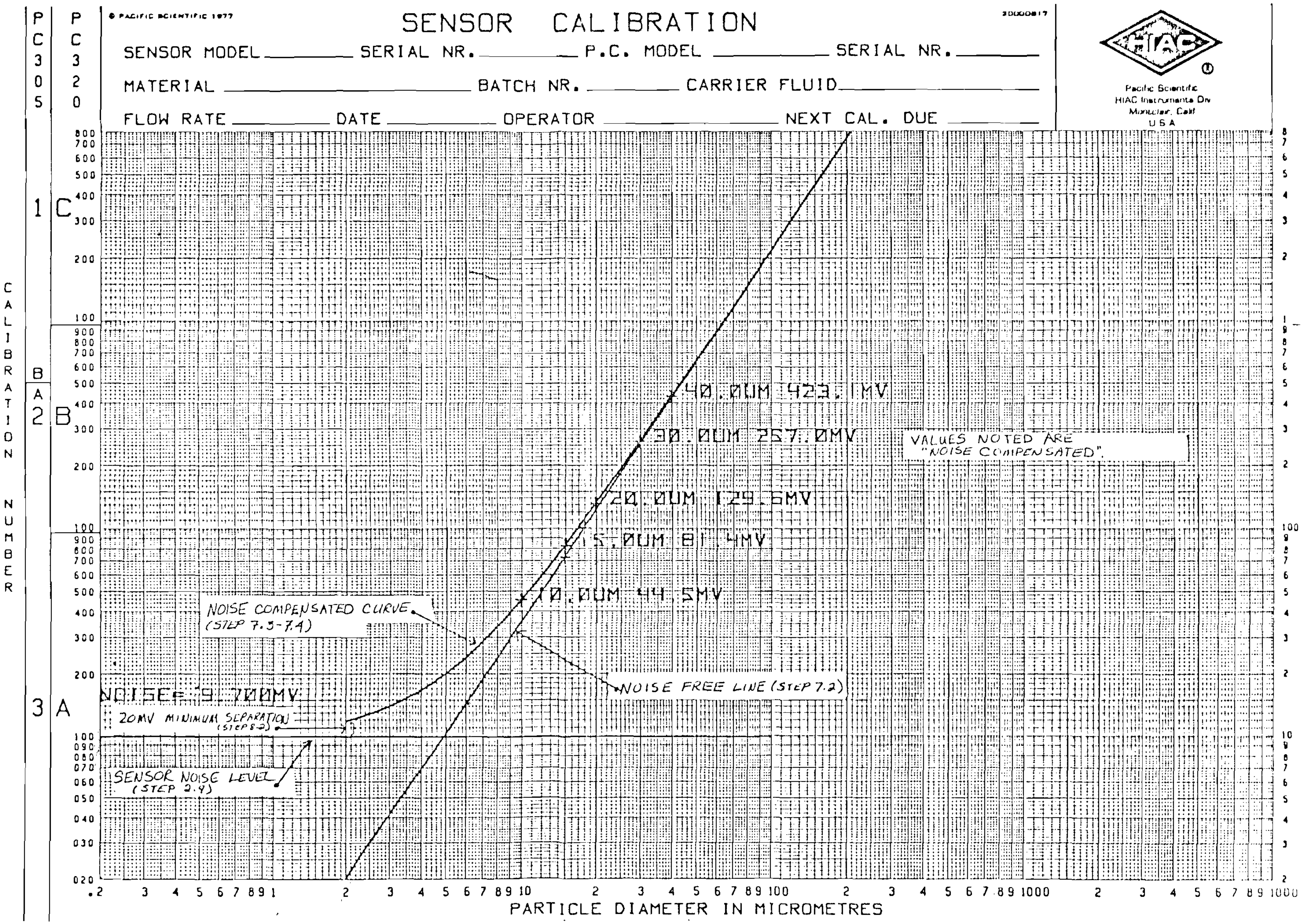

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SENSOR CALIBRATION
20000817
SENSOR MODEL
SERIAL NR.
P.C. MODEL
SERIAL NR.
MATERIAL
BATCH NR.
CARRIER FLUID
FLOW RATE
DATE
OPERATOR
NEXT CAL. DUE
HIAC
Pacific Scientific
HIAC Instruments Div
Montclair, Calif
U S A
PC 305
PC 320
CALIBRATION NUMBER
40.0UM 423.1MV
30.0UM 257.0MV
20.0UM 129.6MV
15.0UM 81.4MV
10.0UM 44.5MV
VALUES NOTED ARE "NOISE COMPENSATED".
NOISE COMPENSATED CURVE (STEP 7.3-7.4)
NOISE FREE LINE (STEP 7.2)
NOISE= 9.700MV
20MV MINIMUM SEPARATION (STEP 8.2)
SENSOR NOISE LEVEL (STEP 2.4)
PARTICLE DIAMETER IN MICROMETRES