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GUIDE TO OPERATION AND MAINTENANCE OF THE AUTOMATIC PARTICLE SIZE ANALYZER

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Rocketdyne

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Rocketdyne
Rockwell International Corporation
Canoga Park, California

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Abstract: The report contains a description of an Automatic Particle Size Analyzer (APSA) for analyzing the particle size distribution in a freeze crystallizer. The system contains the following electronic and optical instruments: 1) a particle sensor, 2) an amplifier/power supply, 3) a pulse converter, 4) a pulse height analyzer, and 5) a serial printer. The operation, maintenance, and data reduction from use of the APSA are described.

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17b. Identifiers

Automatic particle size analyzer

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GUIDE TO OPERATION AND MAINTENANCE OF THE AUTOMATIC PARTICLE SIZE ANALYZER

By G. R. Schneider, Rocketdyne, Rockwell International Corporation, Canoga Park, California, for Office of Saline Water, J. W. O'Meara, Director; W. Sherman Gillam, Assistant Director, Research; Sidney Johnson, Chief, Applied Science Division

Contract No. 14-30-3000

UNITED STATES DEPARTMENT OF THE INTERIOR . Rogers C. B. Morton, Secretary
James R. Smith, Assistant Secretary for Water and Power Resources

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The Department works to assure the wisest choice in managing all our resources so each will make its full contribution to a better United States—now and in the future.

FOREWORD

This is one of a continuing series of reports designed to present accounts of progress in saline water conversion and the economics of its application. Such data are expected to contribute to the long-range development of economical processes applicable to low-cost demineralization of sea and other saline water.

Except for minor editing, the data herein are as contained in a report submitted by the contractor. The data and conclusions given in the report are essentially those of the contractor and are not necessarily endorsed by the Department of the Interior.

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DESCRIPTION OF SYSTEM

The Automatic Particle Size Analyzer (APSA) consists of the following electronic and optical instruments:

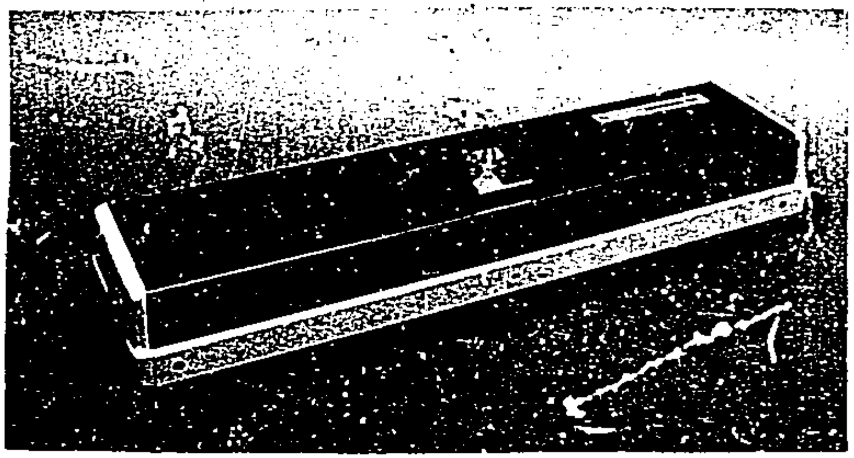
1) A particle sensor (Model 341, Royco)
2) An amplifier/power supply (Model 41, Royco)
3) Pulse converter (Model 171, Technical Instruments Inc.)
4) Pulse height analyzer (Gammascope II-Model 102 Technical Instruments Inc.)
5) Serial printer

Under conditions where the carrier fluid is saturated with gas, as occurs when examining ice particles produced by secondary refrigerant freezing, a degasser unit is required in the particle-fluid sampling line. Although not strictly a part of the APSA, the degasser will be included in the general description to be given of the various components.

These instruments will be described in the following paragraphs in sufficient detail to permit the user to understand their function and operation as part of the APSA system.

PARTICLE SENSOR, AMPLIFIER/POWER SUPPLY

The particle sensor is a low angle light scattering instrument. Photographs of the sensor with and without the cover are given in Fig. 1 with the major components of the instrument identified. Light from the tungsten ribbon lamp is passed through a lens system equipped with light masks that focus a well defined beam of light on the flow channel of the sensor cell. Particles suspended in liquid are passed through the 2000 X 2000 micron flow channel formed between two sapphire windows. Light scattered by the particles into a certain forward angle is focused on the photomultiplier tube (PM-tube) by two condensing lenses; most of the unscattered light is absorbed by light traps. The intensity of light reaching the PM-tube has



1. LENS SYSTEM
2. SENSOR CELL
3. TUNGSTEN LAMP
4. BEAM SPLITTING PRISM
5. 45° MIRROR
6. CHOPPER MOTOR
7. LIGHT PIPE
8. NEUTRAL DENSITY FILTER
9. PM-TUBE
10. POTENTIOMETER

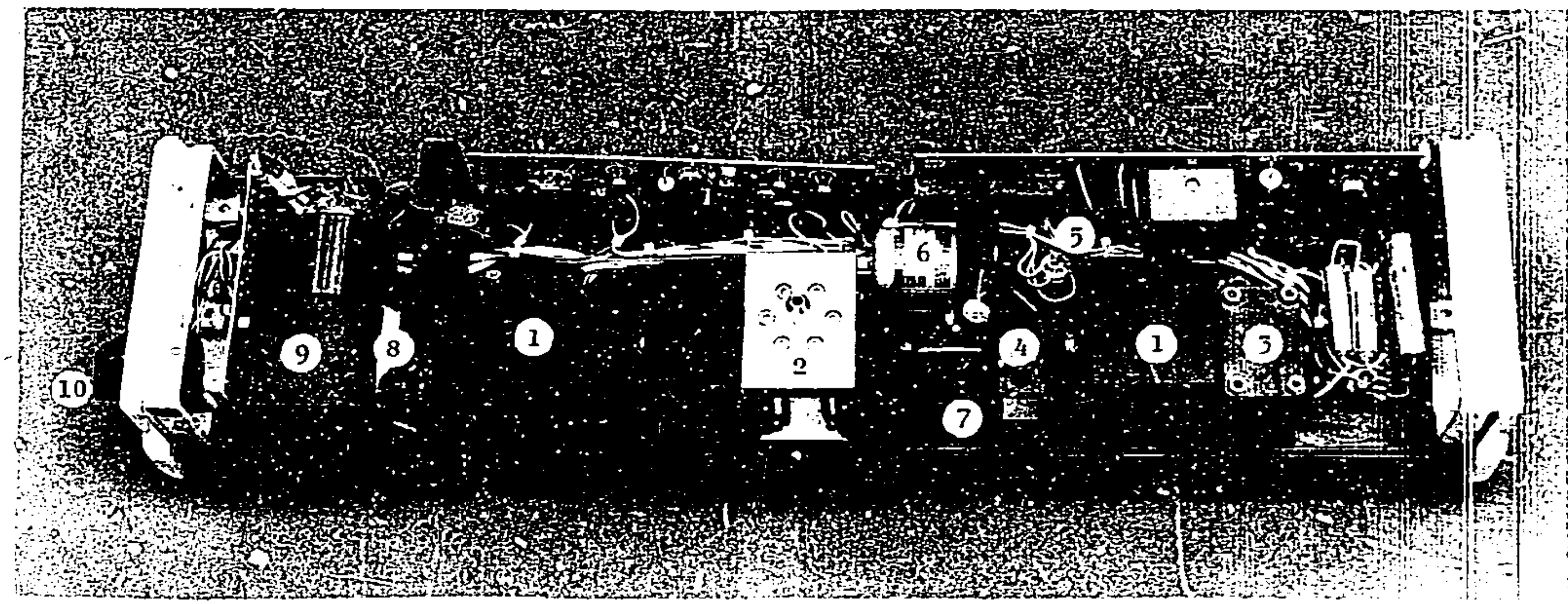


Figure 1 Royco Model 341 Sensor (modified)

been reduced by taping a Wratten neutral density filter (10% transmittance) in front of the PM-tube housing.

A fraction of the light in the main light beam of the sensor is deflected from the main beam by a beam splitting prism and sent to a chopper by reflection from a 45° mirror. When the chopper motor is activated, light pulses passed by chopper enter a light pipe and are directed into the sensor cell at an angle which will ensure that the light will reach the PM-tube.

The signal from the PM-tube is processed by a preamplifier circuit in the chassis of the sensor unit and is then sent to the Model 41 Amplifier/ Power Supply (A/PS) where it is further amplified before being routed to the Pulse Converter. In addition to amplifying signals from the sensor, the A/PS is the power supply for the sensor (the tungsten lamp, the PM-tube, the preamplifier, and the chopper motor). A photograph of the front and rear of the A/PS chassis is shown in Fig. 2. The front panel of the A/PS includes the POWER switch and a red light to indicate when the instrument is turned on. Another switch on the front panel, LAMP ON, controls the power to the tungsten lamp in the sensor unit. Two lights on the front panel, labeled LAMP ON and LAMP OUT, will inform the user as to the condition of the tungsten lamp. The output signal from the model 41 Amplifier/ Power Supply is available from the SENSOR OUTPUT jack on the front panel as well as at OUTPUT J5 and J4 on the back panel.

The A/PS includes circuitry for the internal calibration check of the sensor unit. When the MODE switch on the front panel of the A/PS is in the CAL position, the chopper motor in the sensor is activated. Internal calibration was originally intended by the manufacturer to be done by using the CAL ADJUST knob and the CALIBRATE meter on the A/PS unit. When the MODE switch was in the CAL setting, the CAL ADJUST knob (which controls the voltage to the PM-tube) was adjusted until the needle on the CALIBRATE meter was in the red zone. Because of modification of the sensor this calibration procedure is no longer used. The meter is superfluous, and the CAL ADJUST knob should not be moved. The recommended internal calibration procedure is given in the operation section of this user's manual.

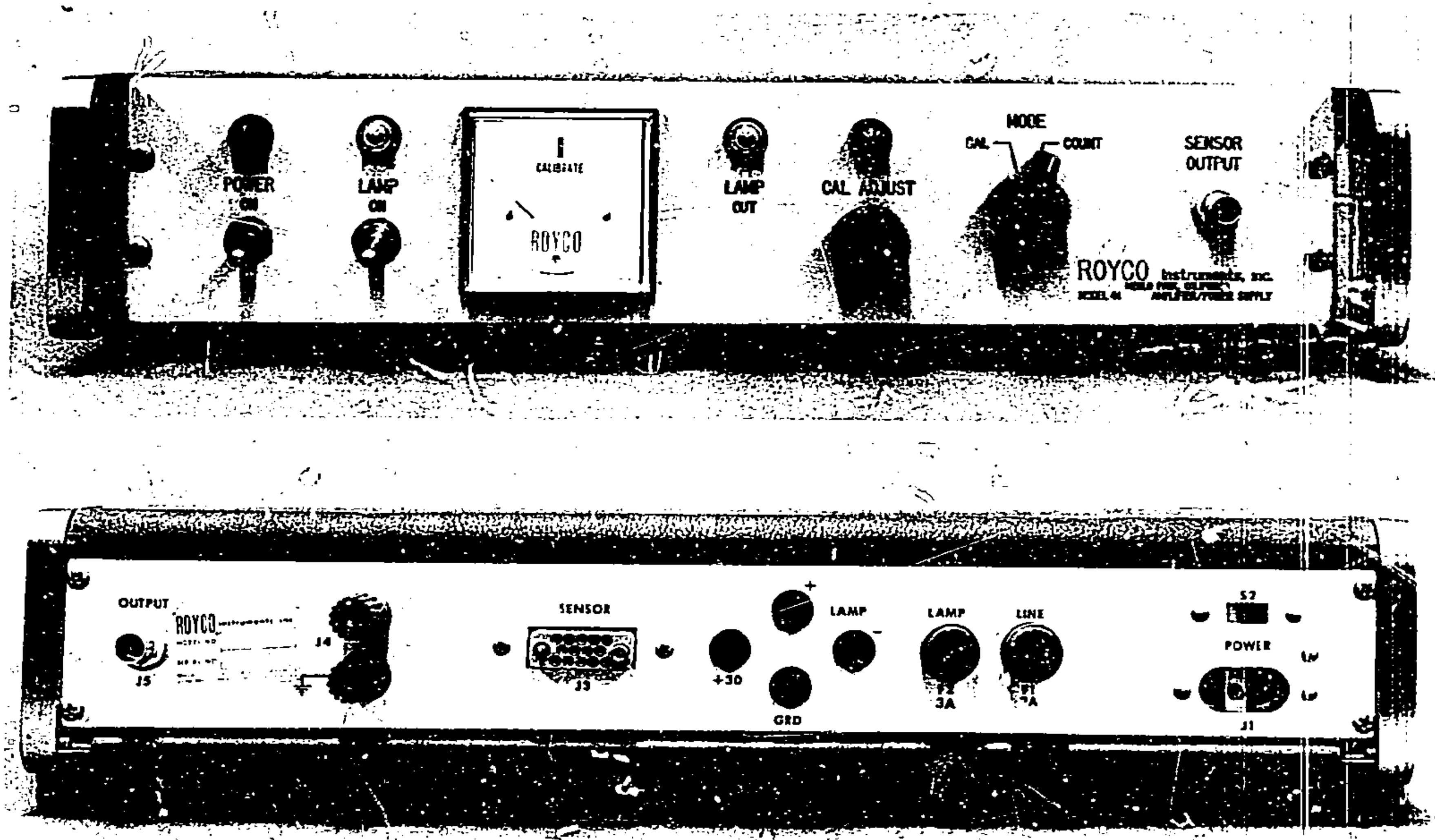


Figure 2. Front and Rear Panels of the Amplifier-Power Supply

PULSE CONVERTER AND PULSE HEIGHT ANALYZER

The 100 channel Pulse Height Analyzer (PHA) was designed to detect pulses with very short rise times. Voltage pulses produced by particles passing through the sensing volume of the Royco model 341 would have a long rise time dependent upon the particle size and flow-rate; most pulses would be viewed by the PHA as merely a slowly drifting dc base voltage. Detection of these "long" pulses is accomplished by using the Pulse Converter, shown in Figure 3, and by operating the PHA in the Mössbauer mode (one of several operating modes which can be chosen on the FUNCTION knob of the PHA). Normally, when operating in the Mössbauer mode, the PHA receives two signals, one from a radiation detector and another from a transducer with a voltage output proportional to the velocity between the Mössbauer source and the absorber. When a nuclear absorption is detected, the pulse transmitted to the PHA opens a gate that allows the PHA to sample the velocity transducer voltage. A count is then stored in one of the 99 channels corresponding to the transducer voltage. Particle size analysis is accomplished in the Mössbauer mode by using the Pulse Converter to produce a voltage output proportional to the maximum voltage perceived during a specified sequence time and then to provide a gating pulse at the end of the sequence. When the signal from the A/PS rises above a selected threshold value, a sequence of events is initiated. For a pre-selected time interval (adjustable to 800,400,200,100, and 50 microseconds), a voltage output is produced which is proportional to the maximum input voltage received up to that time. At the end of the chosen time sequence, a gating pulse is sent to the PHA via the -50 MV connector causing it to sample the voltage output from the Pulse Converter on the ANALOG ±2V connector. At the end of the sequence, the output voltage from the Pulse Converter is reduced to zero and the sequence is ready to start again.

The photograph of the Pulse Converter given in Figure 3 shows four control knobs labeled COARSE GAIN, FINE GAIN, BASE LINE, and DELAY μS. The COARSE GAIN control provides amplification of 2,4, 8 and log X and the FINE GAIN control is for minor adjustment. The threshold voltage required to trigger the timing sequence for particle counting can be adjusted by the 10-turn

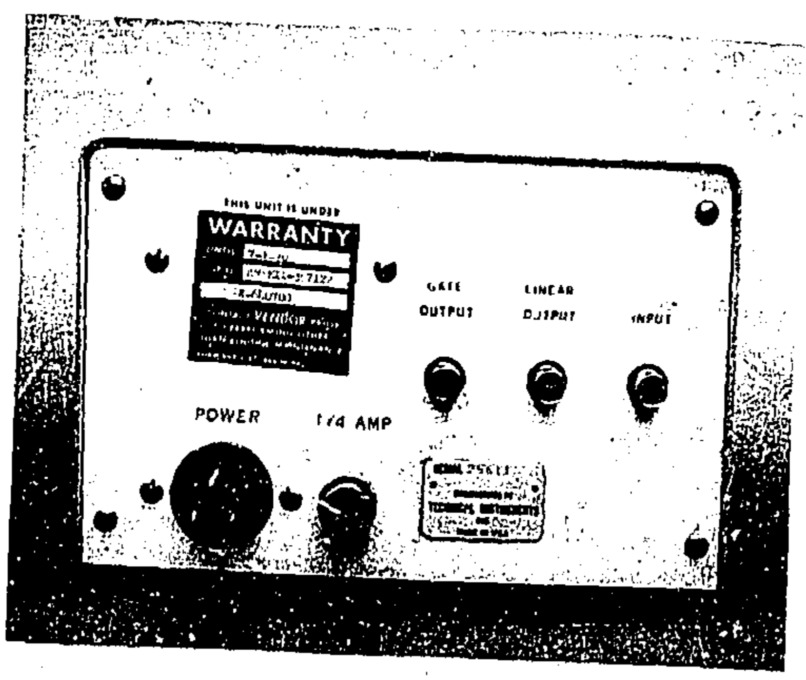


Figure 3. Front and Rear Panels of the Pulse Converter

potentiometer labeled BASE LINE. A threshold value is needed to avoid having a counting sequence triggered by noise in the particle sensor output. It is imperative that only a particle initiate the counting sequence. F... accurate size analysis the peak of the voltage pulse should occur during the sequence time; if noise initiated the sequence, it is possible that a pulse caused by a large particle passing into the sensor volume during the sequence time, could not reach a maximum value before the end of the sequence.

The DELAY μS switch is for selection of the time interval over which the Pulse Converter will monitor a voltage pulse once the instrument timing sequence is triggered by a voltage in excess of the threshold value. An optimum time interval is dictated by the largest particle expected, the flow rate through the sensor flow channel, and the length of the monitored zone in the flow channel.

As shown in Figure 4, the PHA contains a cathode ray tube for display of the particle count on the vertical axis versus channel number on the horizontal axis. The CRT operation is controlled by the five knobs located on the upper right side of the instrument (FOCUS, INTENSITY, VERT. CTR., HORIZ. CTR and HORIZ. SIZE). The count displayed on the vertical direction can be adjusted so that full scale is 100, 400, 1000, 4000, 10,000, 40,000, and 100,000 counts; the memory core will store up to 99,999 counts in each channel. Four control pushbuttons are used when operating the instrument (ACCUMULATE, DISPLAY, READOUT, and STOP). Pressing the DISPLAY pushbutton will cause the instrument to display on the CRT, the information on counts per channel stored in the memory. The ACCUMULATE pushbutton will cause the PHA to accept input data in any of the modes dictated (Mössbauer, multiscaling, etc.), until either a preset accumulation time is reached or another pushbutton is pressed. When in the readout cycle, the instrument will provide signals in either digital or analog form (depending on the position of the PLOT/PRINT switch) for a digital printer or an X-Y plotter. The STOP pushbutton terminates any action of the instrument initiated by the other three pushbuttons. At the end of an experiment, the memory unit can be cleared by pressing a MANUAL RESET button. Shutting off the instrument will not erase the information stored in the memory.

Figure 4A. Front Panel of Pulse Height Analyzer

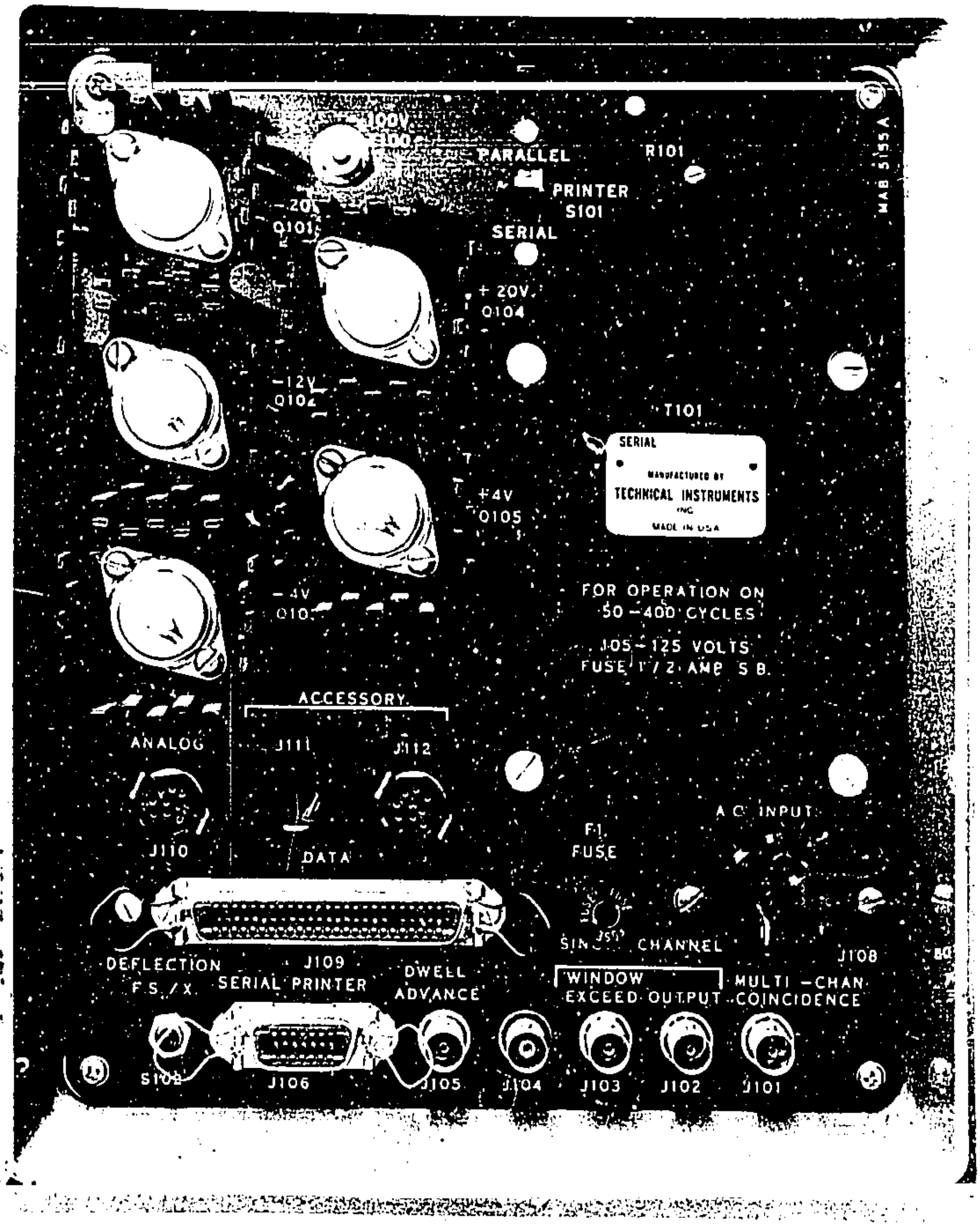


Figure 4B. Rear Panel of Pulse Height Analyzer

A four-position switch is provided for changing the size of the pulse registered in channel 99 (and correspondingly in the other channels). The switch positions are labeled x1, x2, x4, and x8. In the x8 mode for example, information that would have been stored in 12 to 13 channels in the x1 mode can be stored in 99 channels. When the instrument is being used to size ice particles, the x4 position is used to provide the capability of measuring particle sizes up to 2000 microns. If more detail was required on the smaller ice particles, the x8 position could be used. The gain controls on both the Pulse Converter and the PHA, coupled with this expansion switch, provide a high degree of flexibility.

A much more detailed description of what the PHA controls do is given in Appendix A or in the instruction manual prepared by Technical Instruments for the Model 102 Gammascope.

DEGASSING APPARATUS

The particle sensor cannot distinguish ice particles from undissolved solids and gas bubbles. Undissolved material can be kept to a minimum by filtering the brine before adding it to the crystallizer. Gas bubbles, however, arise from the use of a direct contact refrigerant. The brine becomes saturated with dissolved refrigerant that can come out of solution during the sampling process.

Entrained bubbles and dissolved refrigerant are removed from ice-brine samples by placing a degasser in the sample line. The degasser (Fig. 5) consists of two pieces of glassware connected by a 75-millimeter O-ring joint. The top has three standard taper joints, one for the ice-brine sample line, another for the stirrer, and a third for pressure and vacuum connection. The bottom has a vacuum jacketed inner wall to reduce heat transfer rates. The side arm is the line to the particle sensor and the bottom arm is used to drain excess ice-brine mixture from the reservoir before taking another sample.

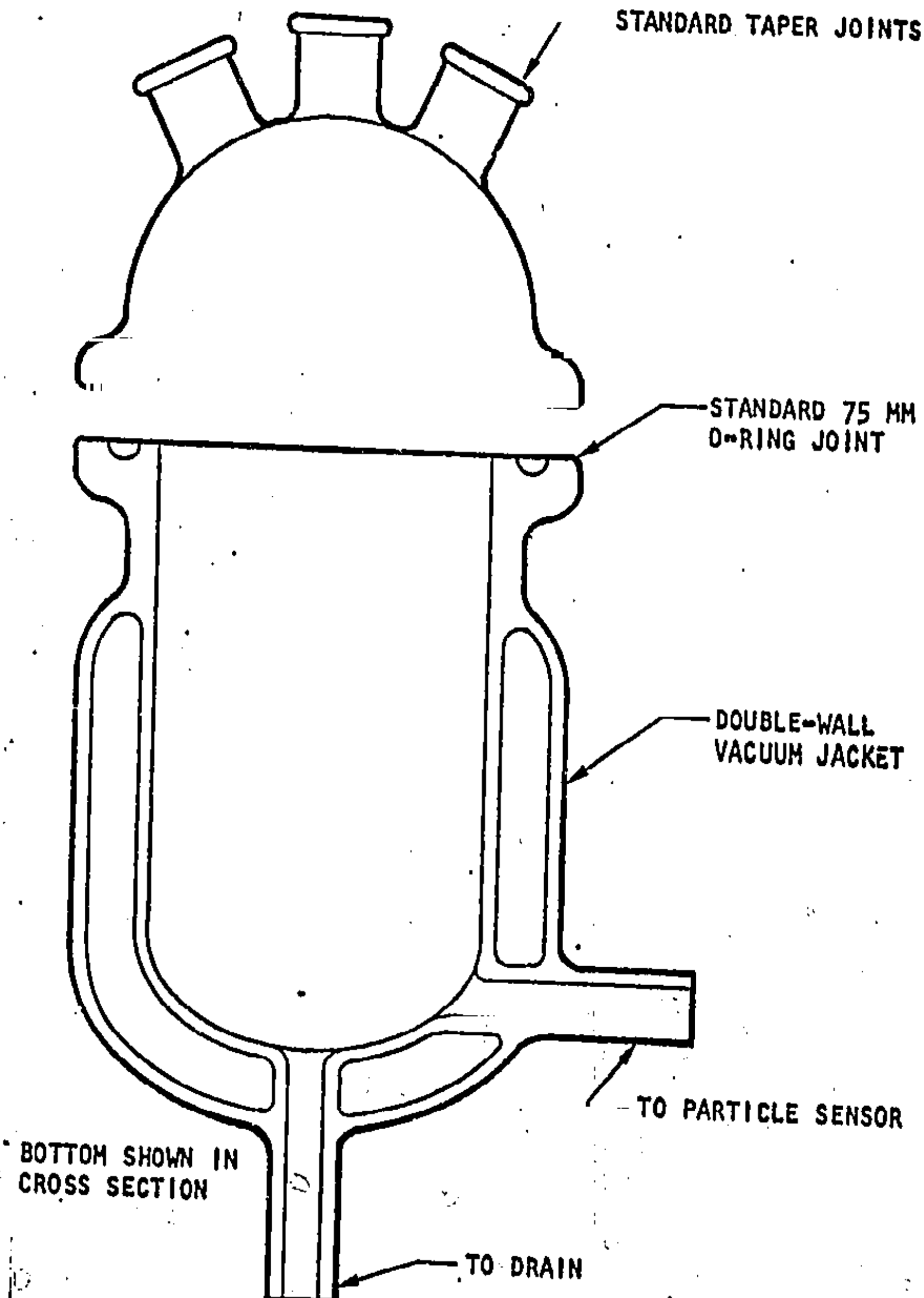


Figure 5. Schematic of Degasser

After the degasser is filled with an ice-brine sample from the crystallizer (300 to 400 milliliters), the mixture is subjected to a vacuum of approximately 5 to 10 cm Hg to remove the refrigerant. After 15 to 20 seconds, the pressure in the degasser is raised to about 2 to 3 psig with nitrogen and the ice-brine sample is passed through the Royco sensor.

The heat transfer rate can be further reduced by enclosing the degasser in a fitted polyethylene bag which will permit crushed ice to be packed around the degasser. The sampling line from the crystallizer to the degasser and from the degasser to the sensor is well insulated and can also be packed in ice before an experiment.

SERIAL PRINTER

At the conclusion of a crystal sizing experiment, the data on elapsed time and counts per channel stored in the memory of the PHA is read out by a solenoid driven Victor Serial Printer. The print out operation is initiated by pressing the READOUT pushbutton on the PHA. The small plastic pushbutton on the printer is a "totalizer". When the pushbutton is pressed, the serial printer will print out the total of the numbers read into it by the PHA. This total will include the number stored in channel 0, which will be the time in hundredths of a minute during which particles were being sized. To find the total number of particles counted, deduct the number printed in channel 0 from the total.

ELECTRICAL CONNECTIONS

The five pieces of electronic equipment comprising the APSA are electrically connected together as described in the following numbered paragraphs. Before completing any connections be sure that the instruments are shut off.

(1) Particle Sensor to A/PS: Connect one plug of the 14-pin connector cable to the jack at the bottom of the Particle Sensor and the Plug at the other end to the jack labeled SENSOR J3 located on the back panel of the A/PS. All power requirements of the sensor unit as well as signals from the sensor to the A/PS are carried by this cable. Line power to the A/PS is supplied to the socket labeled POWER J1 which connects with a 3-hole female plug. The A/PS unit will accept 115 or 230 volts; check the position of the sliding switch S2 directly above the power socket to be sure it is set for the applied line voltage.

(2) A/PS to Pulse Converter: Using a coaxial cable, connect the SENSOR OUTPUT jack on the front of the A/PS to the INPUT jack on the back of the Pulse Converter. Line power is supplied to the Pulse Converter via the socket at its rear panel labeled POWER.

(3) Pulse Converter to PHA: (a) The LINEAR OUTPUT jack at the rear of the Pulse Converter is connected with the jack labeled ± 2V (located at the bottom, near left of the front panel of the PHA) via a coaxial cable. (b) Connect the GATE OUTPUT jack at the rear of the Pulse Converter with the -50 MV jack on the lower left corner of the front panel of the PHA.

(4) <u>PHA to Serial Printer</u>: The terminal on the back of the PHA, labeled SERIAL PRINTER, J106, is connected to the solenoid driven Serial Printer with a cable and 14-pin connectors. Be sure that the sliding switch labeled PRINTER S101 on the back of the PHA is in the position marked SERIAL and the PLOT/PRINT toggle switch in the control section of the front panel of the PHA is in the PRINT position. The line power is provided to the PHA at the socket labeled A.C. INPUT located on the rear panel. Another power line is required for the serial printer.

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(5) PHA to X-Y Plotter: A connector for an X-Y plotter is provided with the PHA. If an X-Y plotter is used, the connector should be plugged in at ANALOG J110 at the rear of the PHA. A tag on the connector cable identifies the function of each of the unterminated wires. Instructions for adjusting the X-Y plotter to the horizontal and vertical limits of the PHA can be found in the Instruction Manual Model 102 Gammascope printed by Technical Instruments Inc.

CONTROL SETTINGS FOR PARTICLE SIZE ANALYSIS

1. Amplifier/Power Supply Model 41 (A/PS)

CONTROL	SETTING
POWER	ON
MODE	COUNT
LAMP	OFF

2. Pulse Converter

CONTROL	SETTING
POWER	ON
COARSE GAIN	LOG
FINE GAIN	108
BASE LINE	40
DELAY μS	400*

3. Pulse Height Analyzer

CONTROL	SETTING
FUNCTION	MOSSB.
(a) Control Section	
DWELL-MILLISEC	EXT.
LIVE-MIN.	∞
ADD/SUB 1	ADD
TEST/USE	USE
ADD/SUB 2	ADD
RESET AUTO	OFF
PLOT/PRINT	PRINT
MAN/AUTO	MAN.
PUSHBUTTON	DISPLAY

(b) Multi-channel Section

EXPANSION	X4
THRESHOLD	0
GAIN	130
UPPER LEVEL	10
BASELINE	195
TEST/OFF	OFF
COINC./ANTI	ANTI

(c) Single Channel Section

WINDOW	1000
THRESHOLD	2
EXT./INT.	INT.

(d) Rear Panel

PARALLEL-SERIAL	SERIAL

*The DELAY μS switch was placed in the 400μ sec. position for the experimental work conducted with the APSA to date. The correct delay time to use is determined by the length of time required for the largest particle expected to travel from a point in the flow channel where it just enters the sensing zone to the point where it is completely in the sensing zone. For very small particles and high flow rates this delay time could be very short; for large particles and low flow rates perhaps 800 μsec. would be required. A delay of 400 μsec. is suitable for particles as large as 2 mm and a channel flow rate of 20 ml/sec.

MECHANICAL CONNECTIONS

Connections between the sampling line, the degasser and the sensor flow cell are shown in Fig. 6. The sample line to the degasser is 3/8 inch diameter stainless steel tube which is connected, via TYGON tubing, to the PYREX tubing leading to the degasser. At the side exit near the bottom of the degasser, a length of TYGON tubing is used to connect the PYREX line with 1/4 inch stainless steel tubing leading to the sensor cell. Both the entrance and exit to the sensor cell are 1/4 inch AN flare fittings. The two valves shown in Fig. 6 are ball valves (HOKE 7115F4B) that open fully with one quarter of a turn.

All sampling tubing and valves should be well insulated and the tubing lengths as short as possible to avoid melting the ice sample. In sampling experiments

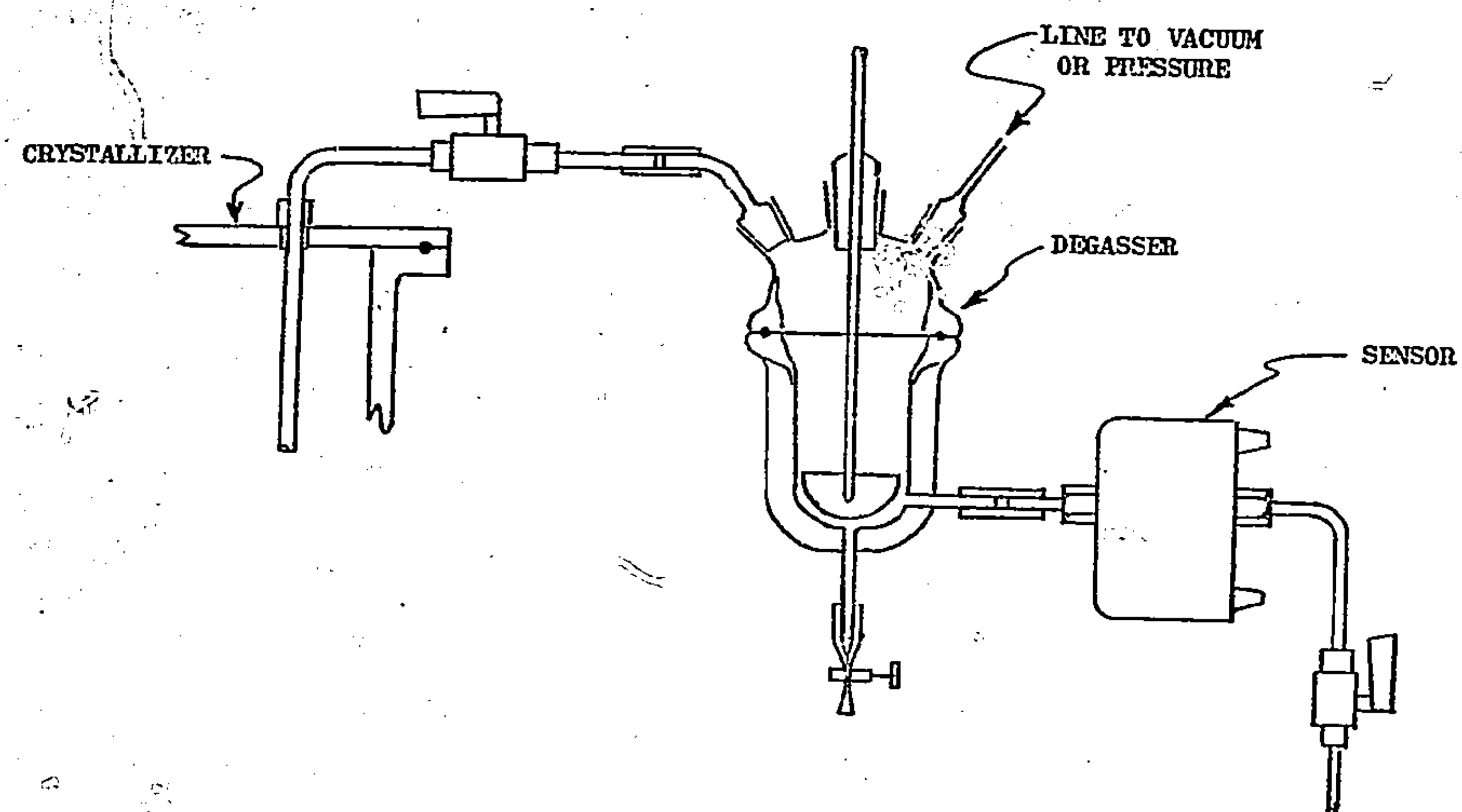

Figure 6. Sampling Line From Crystallizer to Sensor

performed using the APSA, the sampling line was fitted with a trough so that ice could be packed around the insulation.

A combination vacuum and pressurization line are also plumbed into the degasser. The pressure required to force the sample from the degasser through the sensor cell at a reasonable rate should be no more than about 5 psig.

An ice-brine mixture passing through the sensor cell will chill the cell to the point where moisture will condense on the cell exterior. Scattered light from condensate on the windows of the flow cell will interfere with particle sizing. To prevent moisture from condensing on the windows of the sensor cell during an experiment, the particle sensing unit (Royco Model 341) is kept in an atmosphere of dry nitrogen. This can be easily done with two polyethylene bags; one bag is slipped over each end of the instrument and they are sealed together with masking tape. Of course, some cutting of the plastic bags is necessary to get a fit around the connector cable, the flow channel entrance and exit, and the tubing supplying the dry nitrogen atmosphere. Masking tape can also be used to seal these fitted areas.

GENERAL INFORMATION

1. The flow-channel of the sensor should be kept filled with fluid when the instrument is not in use. The fluid can be methanol, or ethanol. For times up to a week, distilled water can be used. This will tend to keep the windows of the flow cell clean and prevent gasket materials from drying out.
2. If the flow cell windows become fouled, they can be cleaned by running a length of pipe cleaner (soaked with water, methanol, ethanol or acetone) back and forth through the flow channel and then flushing the channel with water. Cleaning the windows is simple and should be done frequently.
3. Fill the sensor flow channel with fluid before turning on the tungsten lamp. If the flow channel is empty, contains a large bubble, has very

dirty windows, or if the fluid in the channel contains many dirt particles, a large amount of light will get to the PM-tube. When the signal from the PM tube rises above a certain level, a protective circuit in the A/PS will shut off the tungsten lamp to prevent saturation of the PM-tube. The lamp will be automatically turned on again after 3 seconds and if the PM-tube signal is still too high, the lamp will again shut off for about 3 seconds. An on-off cycling of the indicator lights on the front panel of the A/PS will indicate when this situation occurs. With the flow channel filled with clear water or brine and the tungsten lamp turned on, the signal from the SENSOR OUTPUT jack (or OUTPUT J3 and J4 on the back panel) on the A/PS should be fairly smooth when viewed on an oscilloscope at 20 mvolt/cm and should not cause the Pulse Converter unit to trigger a pulse. If the oscilloscope trace is "rough" and causes the Pulse Converter to trigger timing sequences, then either the fluid in the flow channel contains small bubbles and/or dirt particles, or the flow cell windows should be cleaned.

4. If it is ever necessary to remove the cover from the sensor, be sure the power to the sensor is shut off. Aside from electrical hazards which should be apparent to the user, damage might be done to the PM-tube by exposure to the room lighting.

5. The instrumentation is sensitive to electrical noise. Electrical noise from D.C. motors or various relay switches can be picked up and amplified by the circuitry of the Sensor and the A/PS. The sharp pulses caused by this electromagnetic noise becomes a part of the signal sent to the Pulse Converter and can thus lead to spurious counts on the PHA. If the sensor and A/PS instruments must be operated in an area where they will be subjected to electrical noise, they may have to be shielded. If the electrical noise pulses are small enough to be confined to the first few channels, it is possible to turn up the BASE LINE knob on the Pulse Converter and eliminate them. In so doing, however, all pulses below the BASELINE level will be eliminated and the first few channels of the PHA will record no pulses.

6. On rare occasions the FUNCTION knob of the PHA will improperly set in the detent for the MOSSB. mode. When this happens, the PHA will not register counts in any of the channels. This condition will usually be noticed when the ACCUMULATE button has been pressed but no counts are

observed on the CRT. Turning the function knob slightly to one side or another will cause the switch to click into its proper position.

7. The PHA should not be left in the STOP mode (one of the four push-buttons at the bottom of the front panel of the PHA) for long periods of time. In this mode, a single spot will steadily appear on the CRT and there is a possibility of "burning in" the spot on the CRT.

INTERNAL CALIBRATION

Before using the APSA, the internal calibration of the sensor should be checked. The method provided by the manufacturer for checking the internal calibration has been modified because of several changes in the operation of the sensor. Do not turn the CAL ADJUST knob and pay no attention to the CALIBRATE meter on the front of the A/PS.

The calibration is now conducted as follows:

1. Connect the jack labled SENSOR OUTPUT on the front panel of the A/PS (or OUTPUT J5 on the back panel) to an oscilloscope.
2. Turn the POWER switch on the A/PS to ON and permit the instrument to warm up for about 20 minutes.
3. Turn on the oscilloscope and adjust the vertical scale to 10 or 20 mv/cm and the time scale to about 5 msec/cm.
4. Be sure the flow channel of the sensor cell is filled with the carrier fluid to be used in the size analysis.
5. After the A/PS has warmed up, place the LAMP swich on the A/PS in the ON position. The LAMP OUT light should go out and the LAMP ON bulb should light.
6. Turn the MODE switch on the A/PS to the CAL position. This activates the chopper motor in the sensor.
7. The signal displayed on the oscilloscope should look like the photograph in Fig. 7. The short voltage pulses occurring every 7.5 msec. are used for the calibration. A sinusoidal wave with a period of 3 msec., superimposed on the sharp pulses, is somehow related to the operation of the chopper motor but is not of interest for the calibration.
8. Adjust the potentiometer installed at one end of the sensor unit until

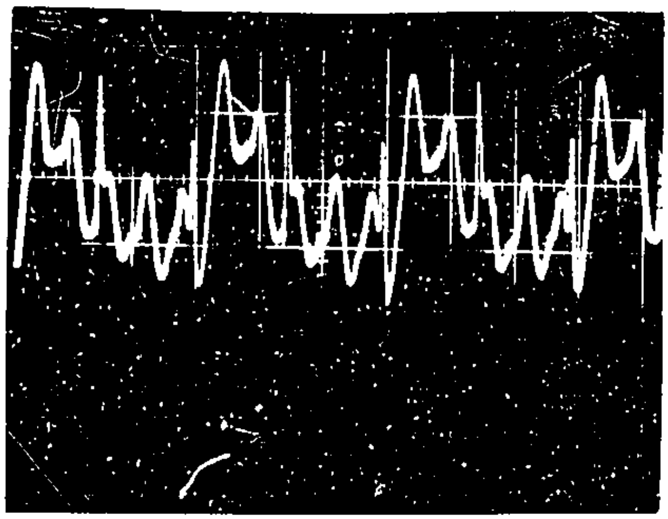

Figure 7. Internal Calibration, PM-tube Output Displayed On Oscilloscope; 20 mv/div. X 5 msec./div.

the calibration pulses have a peak voltage of 36 mv. This adjustment is slightly obscured because the "base line" is a sinusoidal wave.

9. Turn the MODE switch to the COUNT position and turn the LAMP switch off.

. EXPERIMENTAL PROCEDURE FOR THE DETERMINATION OF ICE PARTICLE SIZE DISTRIBUTION

Before proceeding according to the numbered steps given below, be sure the electrical connections, control settings and mechanical connections are correct. Check the internal calibration of the APSA.

1. Turn on the power to all of the instruments and allow them to warm up for about 10 to 20 minutes. Press the DISPLAY pushbutton on the PHA and then the MANUAL reset button to clear the PHA memory.
2. Shut off the ball valves on both sides of the degasser and open the vacuum line to reduce the pressure in the degasser.
3. Turn on the stirrer for the degasser.
4. Open the valve in the sampling line and withdraw an ice-brine sample from the crystallizer (about 300 to 400 ml should be enough).
5. After the ice-brine sample has been under moderately reduced pressure for about 20 seconds, shut off the vacuum line and open the line to pressurize the degasser to roughly 3 to 5 psig.
6. Turn on the tungsten lamp in the sensor unit via the LAMP ON switch on the front panel of the A/PS.
7. Under a pressure between 3 and 5 psig. the ball valve on the exit line from the sensor is opened and the ice-brine mixture is passed through the sensor cell.
8. Immediately after the sample has begun flowing through the sensor cell, press the ACCUMULATE push button at the bottom of the front panel of the PHA. If the intensity knob is turned high enough, the accumulation of counts per channel can be viewed on the CRT as they are recorded by the PHA.
9. When a sufficient count has been obtained or when the sample level in the degasser falls close to the sensor exit line, the STOP button on the PHA is pressed, the tungsten lamp should be shut off and the ball valve

downstream of the sensor should be shut off.

10. Press the READOUT button on the PHA. This will cause the serial printer to record the data stored in the memory core of the PHA.
11. The ice-brine sample remaining in the degasser reservoir can be removed by opening the pinch clamp on the drain line and blowing it out.
12. Enter the numbers printed out by the serial printer into the computer program set up for data reduction, to convert these numbers to particles per 50 μsize interval. The computer programs and instructions in their use are given in the Data Reduction section of this manual.

CALIBRATION OF PULSE CONVERTER AND PHA

The input voltage necessary to excite a specific channel of the PHA is easily determined by using a pulse generator or wave form generator capable of producing pulses with rise times less than the sequence time specified by the DELAY μS switch on the Pulse Converter. A plot of voltage versus channel number for the recommended instrument settings is given in Fig. 8. If, for some reason, the control settings of the Pulse Converter and/or the PHA must be changed, the new relationship of voltage to channel number can be determined by the procedure given in the following numbered steps.

1. Connect the pulse generator output with the Pulse Converter input jack, and with an oscilloscope.
2. Turn on the Pulse Converter, the PHA, and the oscilloscope. Allow about 10 to 20 minutes for them to warm up.
3. Adjust the peak voltage and rise time or frequency of the pulses produced by the pulse generator.
4. Press the ACCUMULATE pushbutton on the PHA and note the channel receiving the counts.
5. With the oscilloscope, measure the peak voltage of the input pulses.
6. Repeat steps 3, 4, and 5 at a sufficient number of peak voltages to obtain a smooth curve of voltage versus channel number.

The new voltage-channel number curve can be used with the calibration curve relating particle size to voltage output from the Power Supply/Amplifier, given in Figure 9, to obtain a correlation of particle size with channel number suitable for the altered control settings. Of course, with altered

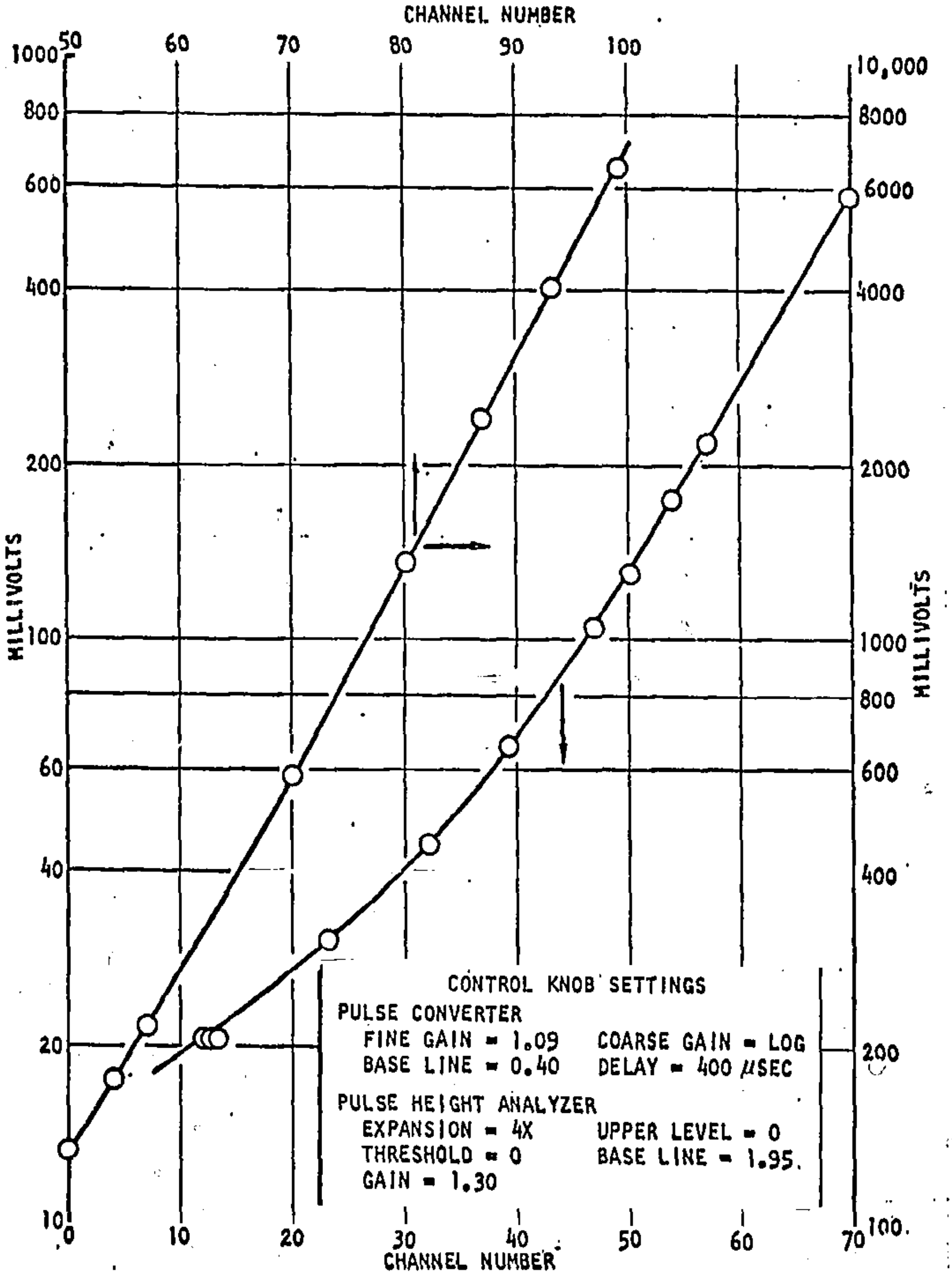

Figure 8. Calibration of Pulse Height Analyzer

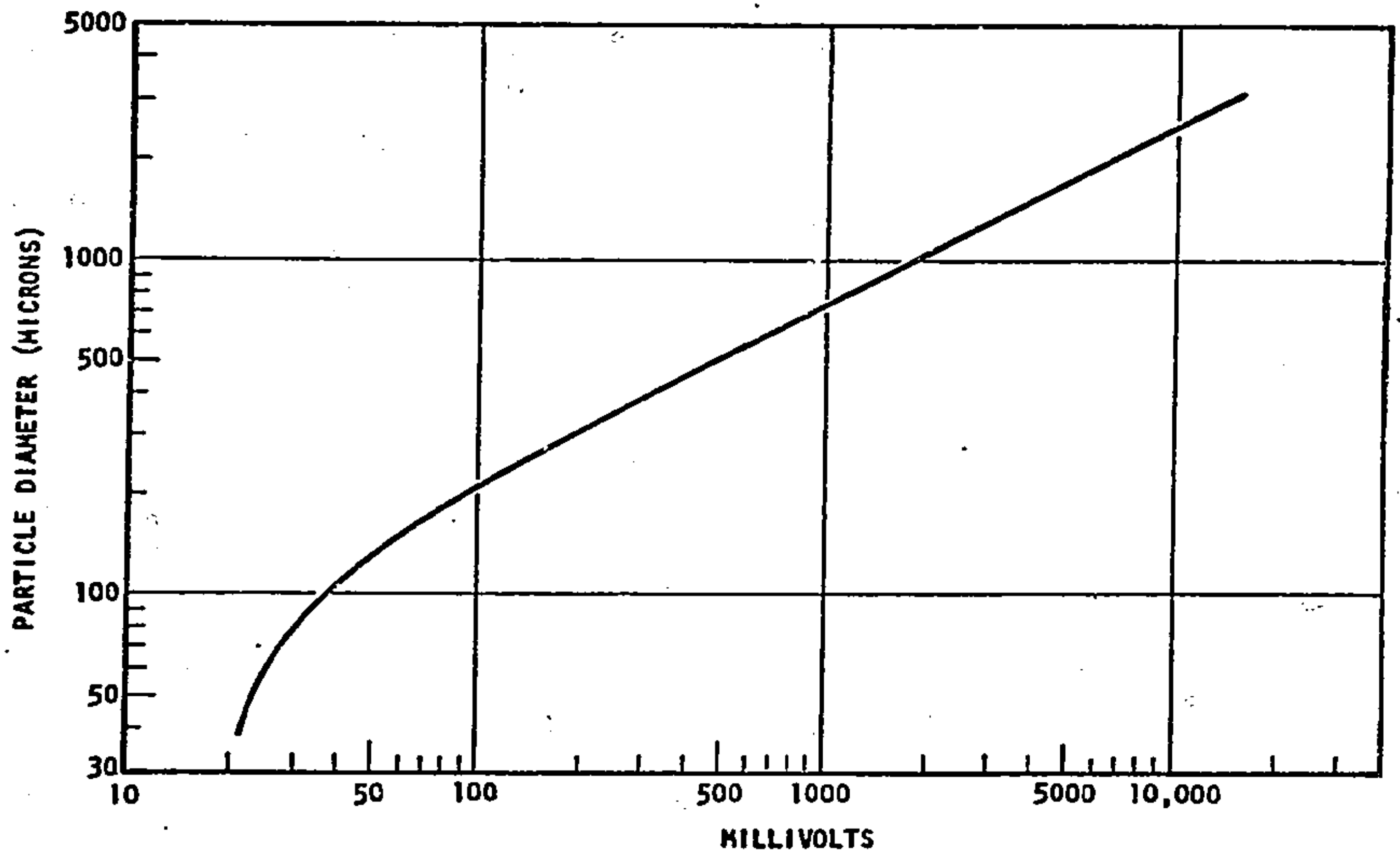

Figure 9. Pulse Converter Input (Millivolts) Versus Particle Size for Ice-Brine System (30 gm NaCl/liter H_2O)

settings, the particle size calibration curve information supplied to the computer program used to reduce the counts per channel to a size distribution will also require alteration. The information on the size calibration curve is supplied to the computer program in the form of fourth order polynomials which were fitted to the curve. A new calibration curve thus requires that new polynomials be used.

DATA REDUCTION

Two computer programs are given in Table 1 and 2 to reduce the counts per channel to particles per size interval. Both programs are written in BASIC language. The program named GEOICE, listed in Table 1, reduces the counts per channel to a size distribution uncorrected for coincidence counting while the program named GEOCUP, listed in Table 2, serves to correct the size distribution for coincidence effects.

To use GEOICE, enter the counts per channel in sequence from channel 1 through 99 on any statement number between 81 and 99. The data presently entered in the program at steps 90 to 96 are for illustration and should be deleted when entering new data. Salt concentration in gms NaCl/liter H_2O is represented by S and is entered in statement number 100. The salt concentration is required to make the correction for the effect of refractive index ratio on the amount of light scattered by a particle. The correction is valid from 0 to 60 gm NaCl/liter H_2O. Information on the calibration of channel number vs particle size has been included in the computer program in statements 230 and 250 in the form of polynomials fitted to the calibration curve.

To use GEOCUP, enter the number of particles per 50 micron interval found from the GEOICE program, in the statements from 71 to 79. In statement 180, enter the total number of particles counted, as A. The time delay used on the Pulse Converter (400 microseconds is shown in the sample listing) is entered in statement 190. The total number of seconds in which the counting was accomplished (channel 0 in the printout from the PHA, multiplied by 0.6 to convert to seconds) is entered in statement 200. The program will iterate through as many cycles as are designated by K1 in step 30. This program is a lengthy one for a timeshare computer (about 16 seconds per cycle) and more than 6 cycles is not usually required. For more information on the particle coincidence problem in the APSA and the mathematics required for correction, the reader is referred to Office of Saline Water Research and Development Progress Report No. 770.

Printouts of the solutions are given in Table 3 and 4. The area and volume of the particles were computed assuming the particles to be spheres.

Table 1. Computer Program, GEOICE, for Determination of Size Distribution from Counts per Channel

```
GEØICE

10 DIM P(110),C(45),G(45),D(45),A(45),V(45)
15 LET T=0
16 LET T2=0
17 LET T3=0
20 FØR I=100 TØ 110
30 LET P(I)=0
40 NEXT I
50 FØR I=1 TØ 100
60 READ P(I)
65 LET T=T+P(I)
70 NEXT I
80 IF P(100)>=0 THEN 470
90 DATA 0,37,36,39,45,43,37,53,38,46,46,37,53,53,57,47,50,60,66,
91 DATA 63,77,68,79,77,89,81,93,95,114,120,139,142,152,158,
92 DATA 208,193,204,193,237,223,306,271,293,302,337,336,331,340,
93 DATA 377,373,373,354,448,429,433,461,427,450,449,408,438,441,
94 DATA 414,448,422,395,412,372,385,407,352,386,377,370,327,306,
95 DATA 263,252,259,278,246,220,205,190,166,158,140,131,107,98,
96 DATA 107,101,87,83,182,149,22,0,0,-1,
100 LET S=60
105 LET P(100)=0
110 FØR I=1 TØ 45
111 READ D(I)
112 NEXT I
113 FØR I=1 TØ 44
114 LET A(I)=(D(I)↑2+D(I+1)↑2)*3.1416/2
116 LET V(I)=(D(I)↑3+D(I+1)↑3)*3.1416/12
117 NEXT I
135 DATA 1,25,50,75,100,125,150,175,200,250,300,350,400,450,
136 DATA 500,550,600,650,700,750,800,850,900,950,1000,1050,1100,
137 DATA 1150,1200,1250,1300,1350,1400,1450,1500,1550,1600,1650,
138 DATA 1700,1750,1800,1850,1900,1950,2000
140 IF S>=10 THEN 170
150 LET F=.012*S+.68
160 GØ TØ 180
170 LET F=.01*S+.7
180 LET F1=SQR(F)
185 LET G(1)=D(1)
190 FØR I=2 TØ 45
200 LET H=F1*D(I)
210 LET Y=LØG(H)
220 IF D(I)>127 THEN 250
230 LET G(I)=.99997-47.9844*Y+34.8851*Y↑2-8.32712*Y↑3+.714687*Y↑4
240 GØ TØ 260
250 LET G(I)=265.97-198.567*Y+52.6411*Y↑2-5.45099*Y↑3+.208198*Y↑4
260 NEXT I
270 FØR I=1 TØ 44
280 LET J=INT(G(I))
290 LET J1=INT(G(I+1))
300 LET R=J1-J
```

Table 1. (Continued)

```
310 LET B=0
320 IF R<1.5 THEN 360
330 FØR N=1 TØ (R-1)
340 LET B=P(J+N)+B
350 NEXT N
360 LET C(I)=((J+1-G(I))*P(J)+(G(I+1)-J))*P(J+R)+B)*1000/T
370 LET A(I)=A(I)*C(I)*1E-8
375 LET T2=T2+A(I)
380 LET V(I)=V(I)*C(I)*1E-12
385 LET T3=T3+V(I)
390 NEXT I
400 PRINT "RANGE","NUMBER","AREA,SQ.CM.","VØL.,CU.CM."
410 FØR I=1 TØ 44
420 PRINT D(I) "TØ" D(I+1),C(I),A(I),V(I)
430 NEXT I
440 PRINT "-----------------------------------------------------"
450 PRINT "TØTAL","1000",T2,T3
460 GØ TØ 480
470 PRINT "CHECK DATA INPUT FØR 99 CHANNELS ,CØUNT IS WRØNG"
480 END
```

Table 2. Computer Program, GEOCUP, for Particle Coincidence Correction

```
GEØCUP

10 DIM C(40),P(40),Q(40),X(40),U(40),D(40),H(40),F(40),B(20)
20 DIM V(20,20),E(20,20),S(20),0(20),Y(20),W(20)
30 LET K1=6
31 DATA 25,75,125,175,225,275,325,375,425,475,525,575,625,675,
32 DATA 725,775,825,875,925,975,1025,1075,1125,1175,1225,1275,
33 DATA 1325,1375,1425,1475,1525,1575,1625,1675,1725,1775,1825,
34 DATA 1875,1925,1975
40 FØR I=1 TØ 40
50 READ X(I)
60 LET U(I)=(X(I)+25)↑2
70 NEXT I
71 DATA 34.1,53.57,90.73,103.25,97.36,93.82,78.65,67.47,55.71,
72 DATA 46.48,40.89,37.05,29.47,22.49,19.66,19.16,15.47,12.95,
73 DATA 10.87,9.1,7.87,6.79,5.56,4.66,4.56,4.41,3.93,3.4,7.13,
74 DATA 6.09,5.84,4.53,1.79,.22,0,0,0,0,0,0,
80 FØR I=1 TØ 40
90 READ P(I)
100 LET H(I)=P(I)
110 LET P(I)=P(I)/1000
120 NEXT I
130 FØR I=1 TØ 20
140 LET S(I)=P(2*I-1)+P(2*I)
150 LET Y(I)=(X(2*I-1)+X(2*I))/2
160 LET 0(I)=(Y(I)+50)↑2
170 NEXT I
180 LET A=20842
190 LET G=4E-4
200 LET T=34.2
210 LET T1=A*T/(T-A*G)
220 LET L=1000*EXP(-T1*G/T)*T1*G/T
230 LET L1=L*(T1*G/T)/2
240 FØR K=1 TØ K1
250 PRINT "K="K
260 LET R3=40
270 LET R4=20
280 FØR I=1 TØ 40
290 LET C(I)=0
300 LET Q(I)=0
310 LET D(I)=0
315 LET F(I)=0
320 NEXT I
330 FØR I=1 TØ 20
350 LET W(I)=0
360 LET B(I)=0
370 NEXT I
380 FØR I=1 TØ 20
390 FØR J=1 TØ 20
400 LET V(I,J)=0
410 LET E(I,J)=0
420 NEXT J
430 NEXT I
440LET J=1
```

Table 2. (Continued)

```
450 LET R=X(J)↑2
460 LET A1=1
470 LET R1=P(J)*L
480 FØR N=J TØ 40
490 LET Q(N)=P(N)*R1*A1
500 LET A1=2
510 LET D(N)=R+X(N)↑2
520 IF D(N)<4E+6 THEN 560
530 LET Q(N)=0
540 LET R3=N
550 LET N=40
560 NEXT N
570 LET R2=J
580 FØR N=J TØ R3
590 FØR I=R2 TØ 40
600 IF D(N)<U(I) THEN 620
610 NEXT I
620 LET C(I)=C(I)+Q(N)
630 LET C(N)=C(N)-Q(N)
640 LET C(J)=C(J)-Q(N)
650 LET R2=I
660 NEXT N
670 FØR I=1 TØ 40
680 LET Q(I)=0
690 LET D(I)=0
700 NEXT I
710 LET J=J+1
720 IF J>40 THEN 740
730 GØ TØ 450
740 FØR I=1 TØ 20
750 LET R=Y(I)↑2
760LET R1=S(I)*L1
770 FØR J=I TØ 20
780 LET V(I,J)=R1*S(J)
790 LET E(I,J)=R+Y(J)↑2
800 IF E(I,J)<4E+6 THEN 830
810 LET V(I,J)=0
820 LET J=20
830 NEXT J
840 NEXT I
850 FØR I=1 TØ 20
860 LET A1=1
870 FØR J=I TØ 20
880 IF V(I,J)=0 THEN 1180
890 FØR N=J TØ 20
900 LET F(N)=V(I,J)*S(N)*A1
910 LET W(N)=E(I,J)+Y(N)↑2
920 IF W(N)<4E+6 THEN 960
930 LET F(N)=0
940 LET R4=N
950 LET N=20
960 IF J>I THEN 990
970 LET A1=3
980 GØ TØ 1000
```

Table 2. (Continued)

```
990 LET A1=6
1000 NEXT N
1010 LET R2=J
1020 FØR N=J TØ R4
1030 FØR M=R2 TØ 20
1040 IF W(N)<O(M) THEN 1060
1050 NEXT M
1060 LET B(J)=B(J)-F(N)
1070 LET B(I)=B(I)-F(N)
1080 LET B(N)=B(N)-F(N)
1090 LET B(M)=B(M)+F(N)
1100 LET R2=M
1110 NEXT N
1120 FØR M=1 TØ 20
1130 LET F(M)=0
1140 LET W(M)=0
1150 NEXT M
1160 LET A1=3
1170 NEXT J
1180 NEXT I
1190 FØR N=1 TØ 19
1200 LET T2=(B(N)-B(N+1))/100
1210 LET Q(2*N)=B(N+1)+75*T2
1220 LET Q(2*N+1)=Q(2*N)-50*T2
1230 NEXT N
1240 LET Q(1)=B(2)+(B(1)-B(2))*1.25
1250 LET Q(40)=B(20)+(B(20)-B(19))*.25
1260 LET F(0)=0
1261 LET R7=0
1270 FØR I=1 TØ 40
1280 LET C(I)=C(I)+Q(I)/2
1290 LET F(I)=C(I)+1000*P(I)+F(I-1)
1300 NEXT I
1310 FØR I=1 TØ 40
1320 LET P(I)=P(I)+(H(I)-(F(I)-F(I-1))*1000/F(40))/1000
1321 IF P(I)>0 THEN 1323
1322 LET P(I)=0
1323 LET R7=P(I)+R7
1330 NEXT I
1331 FØR I=1 TØ 40
1332 LET P(I)=P(I)/R7
1333 NEXT I
1340 FØR I=1 TØ 20
1350 LET S(I)=P(2*I-1)+P(2*I)
1360 NEXT I
1370 NEXT K
1372 FØR I=1 TØ 40
1373 LET F(I)=1000*P(I)+F(I-1)
1374 NEXT I
1380 PRINT "TØTAL TWØ PARTICLE CØINCIDENCE ="L
1390 PRINT "TØTAL THREE PARTICLE CØINCIDENCE ="L1
1400 PRINT "SIZE-RANGE","INIT. DIST.","CØRR. DIST.","DIST. SUM"
1410 FØR I=1 TØ 40
```

Table 2. (Continued)

```
1420 PRINT X(I)-25"TO"X(I)+25,H(I),P(I)*1000,F(I)
1430 NEXT I
1440 LET F(0)=0
1450 LET X(0)=0
1460 FØR I=1 TØ 40
1470 LET H(I)=1000*P(I)*((.005*I)↑3+(.005*(I-1))↑3)/12*3.14159
1480 LET C(I)=1000*P(I)*((.005*I)↑2+(.005*(I-1))↑2)/2*3.14159
1490 LET F(I)=H(I)+F(I-1)
1500 LET X(I)=C(I)+X(I-1)
1510 NEXT I
1515 PRINT "  "
1516 PRINT " "
1520 PRINT "AREA","CUM. AREA","VØLUME","CUM. VØLUME"
1530 FØR I=1 TØ 40
1540 PRINT C(I),X(I),H(I),F(I)
1550 NEXT I
1560 PRINT "TØTAL MASS ØF 1000 PARTICLES ØF ICE ="F(40)*.916
1570 END
```

Table 3. Sample Computed Size Distribution Using GEOICE

GEØICE 21:06 [illegible] 1973

RANGE	NUMBER	[illegible], SQ.CM.	VOL., CU.CM.
1 TØ 25	[illegible]	1.29344E-4	5.35106E-5
25 TØ 50	20.2503	1.02646E-3	7.71899E-7
50 TØ 75	22.7545	2.96537E-3	3.25923E-6
75 TØ 100	30.3163	7.56844E-3	1.14713E-5
100 TØ 125	32.6807	2.12069E-2	4.07292E-5
125 TØ 150	33.0497	2.27469E-2	5.30757E-5
150 TØ 175	51.5209	4.29736E-2	1.17311E-4
175 TØ 200	51.725	5.73325E-2	1.60907E-4
200 TØ 250	97.3922	.156566	6.02374E-4
250 TØ 300	93.8229	.22475	1.04699E-3
300 TØ 350	78.6172	.26242	1.43517E-3
350 TØ 400	67.4739	.299416	1.85791E-3
400 TØ 450	55.7124	.317255	2.26255E-3
450 TØ 500	46.4915	.330456	2.63056E-3
500 TØ 550	40.9615	.35497	3.12004E-3
550 TØ 600	37.0412	.335471	3.70504E-3
600 TØ 650	29.474	.36228	3.78561E-3
650 TØ 700	22.5075	.322612	3.63933E-3
700 TØ 750	19.6442	.324771	3.93364E-3
750 TØ 800	19.1728	.362152	4.68752E-3
800 TØ 850	15.4606	.33039	4.55308E-3
850 TØ 900	12.9542	.311555	4.55531E-3
900 TØ 950	10.3669	.29232	4.51317E-3
950 TØ 1000	9.10273	.27203	4.4265E-3
1000 TØ 1050	7.37826	.260003	.004447
1050 TØ 1100	6.79202	.246719	4.42515E-3
1100 TØ 1150	5.55564	.221006	4.14796E-3
1150 TØ 1200	4.6633	.202356	3.9664E-3
1300 TØ 1250	4.55937	.215035	4.39395E-3
1250 TØ 1300	4.41321	.225472	4.79497E-3
1300 TØ 1350	3.93405	.217059	4.79679E-3
1350 TØ 1400	3.39871	.201936	4.63076E-3
1400 TØ 1450	7.12693	.454796	1.08081E-2
1450 TØ 1500	6.09066	.416413	1.02427E-2
1500 TØ 1550	5.84343	.42705	.01086
1550 TØ 1600	4.52353	.353003	.009271
1600 TØ 1650	1.78789	.148354	4.01983E-3
1650 TØ 1700	.222096	1.95502E-2	5.46859E-4
1700 TØ 1750	0	0	0
1750 TØ 1800	0	0	0
1800 TØ 1850	0	0	0
1850 TØ 1900	0	0	0
1900 TØ 1950	0	0	0
1950 TØ 2000	0	0	0
TØTAL	1000	8.67521	.132555

RUNNING TIME: 4.6 SECS I/Ø TIME : .7 SECS

Table 4. **Sample Computed Size Distribution Corrected for Particle Coincidence Using GEOCUP**

```
GEOCUP    21:20   NR T/S FEB 12, 1973

K= 1
K= 2
K= 3
K= 4
K= 5
K= 6
TOTAL TWO PARTICLE COINCIDENCE = 233.521
TOTAL THREE PARTICLE COINCIDENCE = 37.6366
```

SIZE RANGE	INIT. DIST.	CORR. DIST.	DIST. SUM
0 TO 50	34.1	53.7849	53.7849
50 TO 100	53.57	82.5209	136.306
100 TO 150	90.73	122.994	259.3
150 TO 200	103.25	135.171	394.471
200 TO 250	97.36	110.634	505.104
250 TO 300	93.92	100.294	605.398
300 TO 350	78.65	68.9668	674.365
350 TO 400	67.47	53.3402	727.705
400 TO 450	55.71	48.1354	775.84
450 TO 500	46.48	34.7922	810.633
500 TO 550	40.39	29.4372	840.07
550 TO 600	37.05	29.1791	869.249
600 TO 650	29.47	16.3517	885.601
650 TO 700	22.49	15.3769	900.978
700 TO 750	19.66	12.1529	913.13
750 TO 800	19.16	13.6493	926.78
800 TO 850	15.47	10.0489	936.829
850 TO 900	12.95	8.18816	945.017
900 TO 950	10.87	7.04738	952.064
950 TO 1000	9.1	5.10259	957.167
1000 TO 1050	7.37	4.70763	961.874
1050 TO 1100	6.79	4.33154	966.206
1100 TO 1150	5.56	3.42625	969.632
1150 TO 1200	4.66	2.81827	972.451
1200 TO 1250	4.559	2.76708	975.218
1250 TO 1300	4.41	2.95033	978.168
1300 TO 1350	3.93	2.55021	980.718
1350 TO 1400	3.4	2.15998	982.878
1400 TO 1450	7.13	5.72461	988.603
1450 TO 1500	6.09	4.25187	992.855
1500 TO 1550	5.84	3.68972	996.544
1550 TO 1600	4.53	2.86904	999.413
1600 TO 1650	1.79	.586634	1000.
1650 TO 1700	.22	0	1000.
1700 TO 1750	0	0	1000.
1750 TO 1800	0	0	1000.
1800 TO 1850	0	0	1000.
1850 TO 1900	0	0	1000.
1900 TO 1950	0	0	1000.
1950 TO 2000	0	0	1000.

Table 4. (Continued)

AREA	CUM. AREA	VOLUME	CUM. VOLUME
2.11213E-3	2.11213E-3	1.76011E-6	1.76011E-6
1.62029E-2	1.83151E-2	2.43044E-5	2.60645E-5
6.27895E-2	8.11046E-2	1.40674E-4	1.66936E-4
.132703	.213808	4.02534E-4	5.69472E-4
.178127	.391935	6.84269E-4	1.25374E-3
.24025	.632185	1.1192E-3	2.37294E-3
.230207	.862392	1.26162E-3	3.63456E-3
.236697	1.09909	1.49245E-3	5.12701E-3
.274039	1.37313	1.95485E-3	7.08187E-3
.247296	1.62043	1.96859E-3	9.05046E-3
.255475	1.87595	2.24552E-3	.011296
.303653	2.1796	2.92099E-3	.014217
.200937	2.38059	2.1003E-3	1.63173E-2
.220319	2.60091	2.43536E-3	1.87526E-2
.201018	2.80193	2.48474E-3	2.12374E-2
.257819	3.05975	3.33709E-3	2.45745E-2
.215063	3.27482	2.96261E-3	2.75371E-2
.197109	3.47192	2.8792E-3	3.04163E-2
.189574	3.6615	2.92686E-3	3.33431E-2
.152486	3.81399	2.48118E-3	3.58243E-2
.155474	3.96946	2.65917E-3	3.84835E-2
.157341	4.1268	2.82208E-3	4.13056E-2
.136293	4.2631	2.5581E-3	4.38637E-2
.122294	4.38539	2.39709E-3	4.62608E-2
.130504	4.5159	2.66665E-3	4.89274E-2
.150733	4.66663	3.20553E-3	.052133
.140706	4.80734	3.10947E-3	5.52424E-2
.128336	4.93567	2.94297E-3	5.81854E-2
.365303	5.30098	8.6814E-3	6.68668E-2
.290695	5.59167	7.15037E-3	7.40172E-2
.269649	5.86132	6.65727E-3	8.06745E-2
.223644	6.08497	5.8736E-3	8.67481E-2
4.86773E-2	6.13364	1.31897E-3	.088067
0	6.13364	0	.088067
0	6.13364	0	.088067
0	6.13364	0	.088067
0	6.13364	0	.088067
0	6.13364	0	.088067
0	6.13364	0	.088067
0	6.13364	0	.088067

TOTAL MASS OF 1000 PARTICLES OF ICE = 8.06694E-2

RUNNING TIME: 99.7 SECS I/O TIME : 3.3 SECS

MAINTENANCE

ROYCO MODEL 341 SENSOR AND MODEL 41 A/PS

Preventive maintenance on the Royco equipment is limited to good housekeeping. All motors used in the 341 System equipment have sealed permanently-lubricated bearings. Do not oil them. Corrective maintenance is carried out using the Trouble Shooting Chart shown in Table 5. It is taken from the Royco Operating and Servicing Manual. For any further instructions on the maintenance or repair of the Royco equipment, the user is referred to that manual.

TECHNICAL INSTRUMENTS MODEL 102 GAMMASCOPE (PHA)

Preventive maintenance is limited to good housekeeping. General trouble-shooting procedures for possible typical malfunctions are given in Section 5 of the Instruction Manual for the Model 102 Gammascope.

TABLE 5

ROYCO TROUBLESHOOTING CHART

TROUBLE	POSSIBLE CAUSE	REMEDY
Any equipment Red ON lamp not lit, with POWER switch ON	Fuse blown	Replace; if replacement fuse also blows, contact Royco.
	Power not applied	Check line cord and utility outlet.
	ON lamp burned out	Replace lamp (NE-2D).
No sample flow, with pressure applied	Tubing or cell clogged	Disconnect tubing and blow clear, then purge thoroughly with sample liquid.
Amplifier/power supply White LAMP OFF lamp lit, with LAMP switch ON	Sensor lamp burned out	Replace lamp in 341 sensor.
White LAMP ON and LAMP OFF lamps lit alternately, with LAMP switch ON	Sample cell empty	Turn LAMP switch off until cell is full.
	Air bubbles in sample	Check for bubbles at 341 sensor outlet tubing. Determine source, and eliminate.
	Emulsion in sample	Purge thoroughly with solvents.

APPENDIX A

PULSE HEIGHT ANALYZER CONTROLS

The brief explanation of the purpose of each of the controls on the PHA is based on information compiled in the instruction manual for this instrument. Often the explanations given here are taken directly from the manual. At times, however, they've been abbreviated or elaborated and, it is hoped, clarified.

The FUNCTION switch can select three possible primary operating modes (in addition to OFF), MOSSB: Mössbauer analysis mode, SCALER: the multiscaler mode and, PHA: the pulse height analyzer mode. For performing particle size analyses, the instrument will be operated in the Mössbauer mode.

Upper Front Panel

The six controls labeled FOCUS, INTENSITY, VERT. CTR., HORIZ. CTR., HORIZ. SIZE, and DISPLAY all regulate the cathode ray tube (CRT) display. Since none of these controls effect the pulse counting and sizing process, they can be adjusted to suit the user.

FOCUS:	A single-turn potentiometer controls the sharpness of CRT display.
INTENSITY:	A single-turn potentiometer controls the brightness of the CRT display. Every tenth channel is intensified for ease of identification.
VERT. CTR:	This knob controls the vertical position of the CRT display.
HORIZ. CTR:	The inner single turn potentiometer of dual concentric potentiometers; it controls the horizontal position of the display.
HORIZ. SIZE:	The outer single turn potentiometer of dual concentric potentiometers; it controls the width of the display.
DISPLAY:	An eight-position rotary switch is used to select full-scale count range (Y-axis) of the display. When the count in a

channel exceeds the selected full-scale value the channel display starts at 1 again. This doesn't effect the memory unit or the counting process (unless counts >99999) and the proper display can be found by switching to the next higher range.

PERCENT LIVE TIME METER indicates the percentage time that the instrument is able to process input pulses.

Control Section

DWELL-MILLISEC:	This switch is used in connection with the Multiscaler mode. The positions are the number of milliseconds that each channel is open to accept pulse counts. The position marked EXT is used for the ice particle size analysis.
LIVE-MIN.:	This switch is used to select a preset live time (positions are given in minutes). The instrument will automatically stop accumulating counts at the designated time. At the position marked ∞ the instrument must be stopped manually.
ADD/SUB.: (next to TEST-USE)	ADD - A count is added to channel 0 every 0.01 minutes. SUB. - A count is subtracted from channel 0 every 0.01 minutes until the counts accumulated in channel 0 (from previous ADD mode operation) declines to zero.
TEST/USE:	When the analyzer is in the DISPLAY mode and the TEST/USE switch is in the TEST position, one count is added to each channel during each display cycle. This internal test checks on the proper operation of the read-write memory cycle. The switch would ordinarily be left in the USE position.
ADD/SUB.:	This switch determines whether a count is added to or subtracted from the contents of the memory. Normally this switch is placed in the ADD position.
RESET AUTO:	For this switch to be effective, the MAN./AUTO toggle switch should be in the AUTO position. Then with the RESET AUTO. switch in the up position (automatic reset), continuous accumulate destructive readout cycling will occur, provided that the LIVE-MIN. switch is not set at ∞. With RESET AUTO

in the down position, one accumulate-non-destructive readout cycle will occur, the instrument will STOP, and the data will be retained in the memory cores.

RESET MANUAL: In the DISPLAY mode, pushing the RESET MANUAL button will reset the accumulated counts in each channel to zero.

PLOT/PRINT: This toggle switch is used to select the type of readout. In the PLOT position, signals are provided at connector J 110 on the back of the PHA for an X-Y recorder. In the PRINT position, signals are provided for digital readout devices (serial type printers on J106 and parallel type on J109).

MAN./AUTO.: In the AUTO. position the instrument will accumulate data, readout, and recycle. When in the MAN. position the instrument will accumulate data until preset time on LIVE-MIN. is reached or until manually shut off by pushing the STOP button.

ACCUM: When the ACCUM. pushbutton is pressed, the instrument will accumulate data in any FUNCTION position until either a preset time is reached or the STOP button is pressed.

DISPLAY: Pressing this pushbutton causes the information on counts per channel to be displayed on the CRT. When not accumulating data, the instrument should be left in the display mode to prevent burned spots on the CRT.

READOUT: Pressing this pushbutton causes the instrument to readout information on counts per channel in either digital or analog form depending on the PLOT/PRINT switch position.

STOP: This pushbutton terminates any mode initiated by the ACCUM., DISPLAY or READOUT pushbutton.

Multi-Channel Section

EXPANSION: A four position switch will change the size of the pulse registered in channel 99 (and correspondingly in the other channels). The switch positions are labeled X1, X2, X4, and X8. In the X8 mode for example, information that would have been stored in 12 to 13 channels in the X1 mode can be stored in 99 channels.

THRESHOLD: This single-turn potentiometer determines the level below which pulses will not be registered. In the Mössbauer mode this control does nothing.

UPPER LEVEL: Pulses above the level set by this single-turn potentiometer will not be registered.

GAIN: The ten-turn potentiometer attenuates input signals on the -50MV jack only. This jack is used for the gating signal when operating in the Mössbauer mode. Thus, the GAIN control effects the sizing process only when it reduces the gating signal below some detection limit. At that point all counting will cease.

UPPER LEVEL LAMP: The light above the UPPER LEVEL control will go on when incoming pulses exceed the setting of the UPPER LEVEL control. The lamp may not be visible unless more than 60 pulses/sec. exceed the setting.

BASE-LINE: This ten-turn potentiometer can be used to attenuate incoming pulses. It can, in effect, control the voltage pulse range covered by the 99 channels.

TEST/OFF: In the test position, test pulses from an internal pulse generator can be addressed to any channel by varying the gain control. This procedure is used to verify that the linear amplifier and the height-time converter are working properly. The switch should be left in the OFF position.

COINC./ANTI: The toggle switch should be left in the ANTI position when using the Mössbauer mode for sizing particles.

Single Channel Section

The controls in this section have no effect on the operation of the PHA in the Mössbauer mode. Their function will be briefly described for completeness.

WINDOW: The ten turn potentiometer is used to regulate the upper level of the single-channel window from 100% to 5% of full scale.

THRESHOLD: Variation of the lower level of the single-channel window is accomplished via this ten-turn potentiometer.

EXT./INT. In the EXT. position, a bi-polar signal supplied to the adjacent connector goes directly to the input of the single channel section. In the INT. position, signals fed to the -50MV connector are routed to both the single and the multi-channel section.

Rear Panel

When using the PHA as part of a system to perform a particle size analysis, few of the connectors on the back of the PHA are utilized. However, a brief description of the function of the connectors (taken primarily from the instruction manual for the Model 102 Gammascope) will be given.

PARALLEL-SERIAL: (S101) When the sliding switch is placed on the serial position the instruments will provide readout to a serial printer. For all other digital readout the parallel position is used.

ANALOG (J110): This connector provides a readout of the data stored in the memory of the instrument, for use with an X-Y recorder, a strip chart recorder, or an external oscilloscope.

ACCESSORY (J111 and J112): These connectors supply and accept signals for remote control operations of the analyzer and external equipment. Connector J111 is supplied with a shorting plug by the manufacturer. Pins C and E are shorted together in order that the instrument operate in the accumulate mode. (Connector J111 was damaged and is not mounted on the rear panel).

DATA (J109): This 50 pin connector provides data and control signals for a parallel-entry printer.

A.C. INPUT: The socket accepts a three-hole female plug to provide line power to the instrument.

DEFLECTION F.S./X. (S102): When pressed, this pushbutton causes a full-scale 40 mv signal to be applied to the horizontal input of an associated analog readout device. The deflection can be used to adjust position of channel 99 on the X-axis of the analog display.

SERIAL PRINTER: (J106) Provides an output signal for a serial printer.

DWELL ADVANCE: (J105)	This connector accepts a channel-advance signal from an external time base signal generator.
CONNECTOR (J104):	Not used.
EXCEED (J103):	The connector provides a pulse when an input pulse exceeds the upper level of the Single Channel window.
OUTPUT (J102):	The connector provides an output pulse each time that an input pulse occurs within the Single Channel window.
MULTI-CHAN. : COINCIDENCE (J101)	The connector accepts gating pulses for coincidence and anticoincidence operations.