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# AUTOMATED NUTRIENT ANALYSES IN SEAWATER

Terry E. Whitley, Stewart C. Malloy,  
Charles J. Patton, and Creighton D. Wirick

MASTER

February 1981

DEPARTMENT OF ENERGY AND ENVIRONMENT

BROOKHAVEN NATIONAL LABORATORY  
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Printed in the United States of America  
Available from  
National Technical Information Service  
U.S. Department of Commerce  
5285 Port Royal Road  
Springfield, VA 22161

NTIS price codes:  
Printed Copy: A10; Microfiche Copy: A01

## FOREWORD

This report is being prepared with some trepidation because of the inability to describe the "perfect" automated chemistry system. Everyone who operates an automated chemical analyzer whether it is a Technicon AutoAnalyzer or some similar instrument does so with his own individual style. Often different styles originate from the different emphasis needed to solve the questions being asked. For example, some investigations will require the maximum sensitivity with a relatively small number of samples while others might need lower sensitivity with a large number of samples. Therefore, we will not be able to answer all of your questions but we hope to include enough discussion that you may be able to solve most of your problems. Specifically, this manual has been assembled to use as a guide to analyze the nutrient content of seawater samples collected in the marine coastal zone of the Northeast United States and the Bering Sea. Some modifications (changes in dilution or sample pump tube sizes) may be necessary to achieve optimum measurements in very pronounced oligotrophic, eutrophic or brackish areas.

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## 1. THEORY AND MECHANICS OF AUTOMATED ANALYSIS

Automated chemical analyses using colorimetric techniques fall into two basic categories, batch and continuous flow analyses. Several automated batch analyzers have been produced, the most recent of which is the Kem-O-Lab marketed by Coulter Electronics, Inc. This system incorporates a sample transport system, automatic sampling, reagent addition and mixing, incubation, colorimeter reading and printout of results. With 6 analyses about 40 samples can be analyzed per hour. A standard RS232C interface is available for computer interfacing. Currently incubation temperatures are not high enough to complete some chemical reactions and as a result the minimum concentration measured is reported to be about  $1.4 \mu\text{g-at ammonium-N l}^{-1}$ .

Continuous flow analysis (CFA) techniques were developed to improve chemical analysis procedures by allowing a laboratory analyst to measure several parameters on a large number of small samples. Improvements have occurred in the analysis system but the basic operating principles remain the same. Sample and reagents are pumped into a manifold, mixed, and are segmented by air bubbles thus producing tiny discrete parcels of sample (often called slugs) that are separated to reduce sample mixing and drag. Between the samples distilled water washes are used to produce distinct "absorbance peaks" when each of the samples are measured in the colorimeter. The typical shape of a sample peak is a sharp rise from the initial distilled water baseline, then near the top of the peak the absorbance asymptotically approaches a steady state value which produces a plateau (Figure 1-1). The peak drops sharply as the distilled water wash enters the flow cell and the absorbance asymptotically approaches the initial baseline if the wash time between sample peaks is sufficiently long. In some early AutoAnalyzer versions good sample peaks and

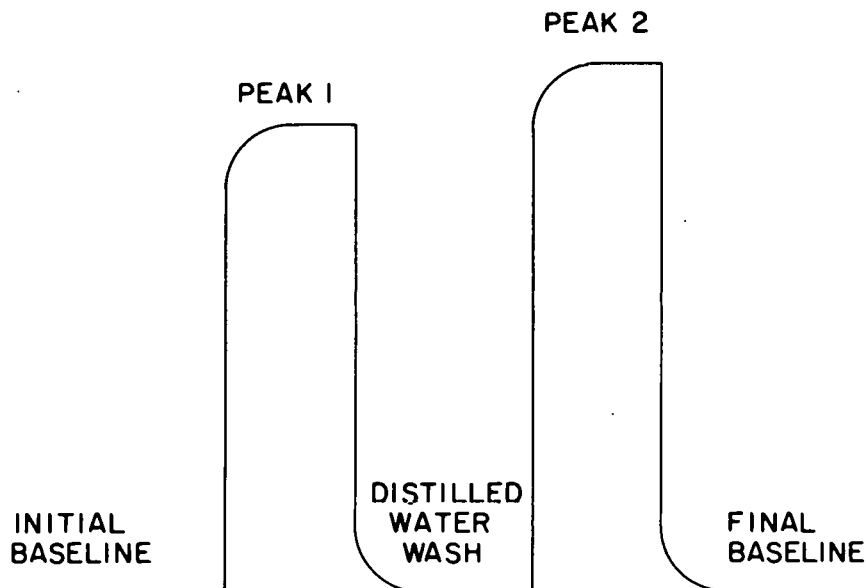


Figure 1-1. Raw AutoAnalyzer Data Showing Peaks

baselines could be obtained but the sample analysis rate was very slow. As sampling rates increased the determination of peak heights became increasingly difficult so attention was focused on understanding the physics involved in continuous flow analysis systems.

A technique known as curve regeneration evolved from the early efforts to relate the shape of peaks observed by the detector of air segmented continuous flow analyzers (AutoAnalyzers) with elementary physical phenomena such as mixing and diffusion. About ten years after Skeggs introduced air segmented continuous flow analysis, Thiers and coworkers showed that the familiar rise and fall curves of CFA peaks were comprised of two parts, the lag phase and the exponential phase (Thiers and Olgeby, 1964; Thiers, Cole and Kinsch, 1967).

The lag phase is characterized by a "damped exponential" or Poisson distribution which can be observed by constructing a histogram of concentrations caused by the leakage of the contents of one segment into those which follow via the thin film of liquid that wets the inside wall of the glass manifold tubing. This thin film deposited by one segment is overtaken and mixed into the next segment and so on. Suppose, for example, that a marker-dye (or sample) could be instantaneously injected into a single segment of the flowing analytical stream in a CFA networks. After a time, by the process described above, the dye would have become incorporated into a number of the succeeding segments and the maximum concentration would not be found in the original dye containing segment, but in one of a number of segments downstream (Figure 1-2). Next suppose that the marker dye (or sample) was continuously pumped

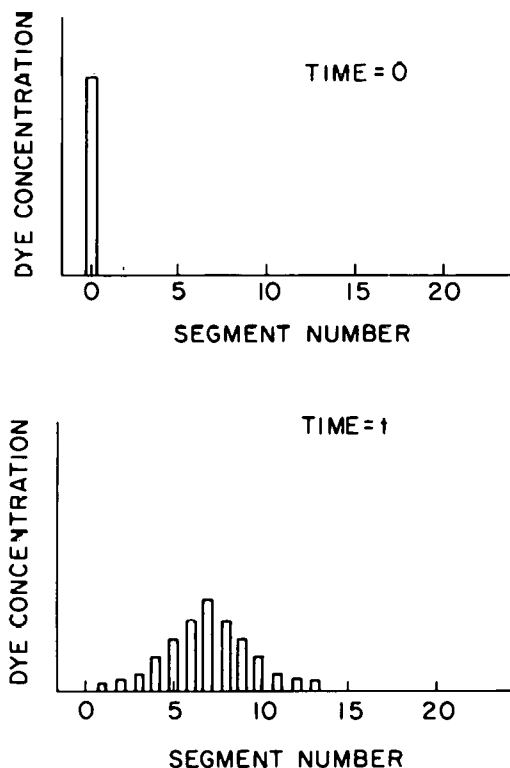


Figure 1-2. Dispersion Effect of a Single Segment of Dye

into the manifold. The concentration of the dye in the liquid segments emerging from the manifold would approach a constant value and when the concentration from one segment to the next no longer varied with time, the system is said to be at steady-state (see Figure 1-3).

The time required to attain steady state is a function of the amount of dispersion which occurs in the entire (sampler to detector) flow network. Thiers' group developed a mathematical model based on the above description and recently Theirs' model has been expanded to allow the prediction of dispersion in the CFA network in terms of experimental conditions. The amount of dispersion in the CFA network can be related to the inside diameter of the manifold tubing, liquid flow rate, bubble segmentation rate, residence time in the flow network, liquid viscosity, surface tension and the sample mass transfer coefficient. Usually the experimenter has control of only the first four variables since the others are largely fixed by the inherent properties of the sample and reagents. In general, dispersion decreases as the inside tubing diameter and dwell time decrease. By assigning values to tubing diameter and dwell time and holding all other variables constant, optimum values can be found for segmentation rate and liquid flow rate (Snyder and Adler, 1976). These types of calculations are useful in designing CFA networks with minimum dispersion.

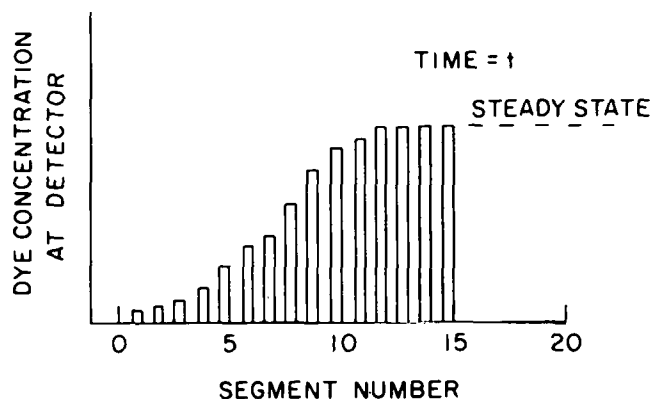


Figure 1-3. Dispersion Effect of a Continuous Input of Dye

The foregoing discussion assumes that the analytical stream is uniformly segmented at all times with gas (air) bubbles. This is not a good assumption since in conventional CFA analyzers, air bubbles must be removed from the analytical stream prior to its passage into the detector's flow cell in order to obtain a stable output signal. Under these conditions, the exponential phase becomes dominant. The Thiers group noted that with standard (debubbling) flow cells a logarithmic plot of absorbance versus time (Figure 1-4) yielded a straight line, after an initial lag period (a). Walker and co-workers seem to have been the first to recognize that since the majority of points on the rise and fall curves were well behaved exponential functions

over most of their range, the steady state detector response can be estimated from the rate of change of the detector using the equation:

$$H_{SS} = H_t + B \frac{dH_t}{dt}$$

where  $H_{SS}$  is the steady state detector output,  $H_t$  the detector output at any time  $t$ , and  $B$  the exponential factor (the negative inverse slope of the line from a plot of  $\ln(H_{SS}-H_t)$  versus  $t$ ) which is concentration independent (Walker et al, 1970; Walker, 1971; Walker et al, 1971). This steady state detector response can be generated to a very good approximation before it is physically achieved. The signal processing required for this transform can be performed in the analog or digital domain. At Brookhaven we convert analog detector signals to digital and regenerate the data in software using most of procedure described by MacAulay et al. (1976). A refinement was suggested for this technique in which the dispersion correction is made proportional to the power of the gradient (Begg, 1974) rather than the nondimensional length of the manifold. This change allows the dispersion coefficient to be empirically determined over a larger range than the technique suggested by Walker (1971).

An alternate method of regeneration has been described by Font (1978) which has been used on both discrete samples and continuous underway data. This post-processing method is based upon obtaining a transfer function for the dispersion in the analysis system which is then used to transform the observed absorbances into regenerated data. We are not convinced that this method has any advantages over the MacAulay et al. (1976) procedure, but it has the disadvantage of post-processing the data hence a slower output rate.

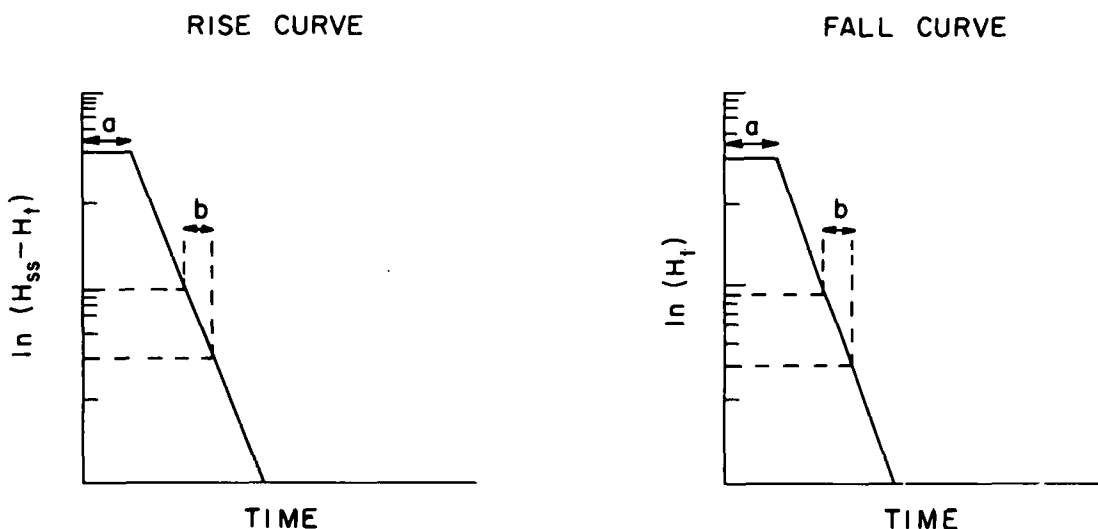


Figure 1-4. Exponential Lag Phases of Rise and Fall Curves of a Peak

## 2. CONTINUOUS FLOW SYSTEM DESCRIPTION

The most serious problem in continuous flow analyses is sample dispersion which can be defined as mixing of a segmented sample stream that occurs along the wall of the tubing. Several factors influence the amount of dispersion of a sample including: 1) tube inside diameter, 2) liquid flow rate, 3) bubble segmentation rate, 4) liquid viscosity, 5) surface tension, 6) time in the flow network, and 7) a sample mass transfer coefficient. Several excellent papers that generally describe these factors are listed in the reference section among which are Snyder et al. (1976); Snyder and Adler (1976); Snyder (1976); Snyder (1980) and Van Den Berg et al. (1980).

For seawater analyses tube inside diameter, liquid flow rate, bubble segmentation rate and length of the flow network are the only variables that can be manipulated to minimize dispersive processes. The trend in Technicon instruments and manifold components has been to use smaller tubes, increase bubble segmentation rate, space bubbles at regular intervals and shorten the length of the flow system. Of course as the dispersion and the length of the systems decreased the sample analysis rate increased markedly. The result is that the AutoAnalyzer I system using 2 mm I.D. tubing would produce satisfactory results for nutrients in seawater at about 20 samples/hour. The AutoAnalyzer II system with 1.5 mm I.D. tubing and a pump III with an air bar can analyze seawater samples at 60-90 samples/hour, especially if peak regeneration processing of the raw data is used. The Technicon SMAC system has 1 mm I.D. tubing, no debubbling in the colorimeter flow cell, and computer control including peak regeneration which can do 150 samples/hour. Ultimately it has been calculated that 600 samples/hour can be analyzed if all dispersion processes are minimized, however, that analysis rate has not been approached by any operating system.

### General Component Description

The automated chemical analyzer is basically composed of modules connected by tubing or electrical connections. The modules used in most systems in chronological order are: sampler, pump, manifold, colorimeter, recorder and data logger or computer. A basic description of these modules and their utility follows.

The sampler is basically a timer and sample changer which starts the sample through the analyzer system and alternates wash solution and samples to give separate "peaks" for each of the samples. The standard AutoAnalyzer sampler will hold 40 cups in the rotary tray. The length of sample time and wash time is governed by a mechanical timer with interchangeable cams. The total sample plus wash time period is set by the speed of rotation of the timer motor hence it is not changeable but the ratio of sample to wash time can be changed within that period of rotation. Several modifications of the standard AutoAnalyzer sampler are desirable to increase operator efficiency and reduce sample contamination (e.g. adapting the sample tray to accept 2 ounce polyethylene bottles instead of the small cups and a selectable electronic timer in which a large number of sample-wash combinations can be programmed). The sampler can also be operated remotely with the computer controlling both the sampling rate and the data logging. See the chapter on Computer Interfacing and Hardware Modifications for further details.

The pump (known as a peristaltic pump) is the work horse of the AutoAnalyzer system. A set of revolving rollers squash plastic tubing and pull sample reagents and air streams into the pump and push them into the manifold section. As in manual (hand) methods it is necessary to add different quantities of sample and various reagents to achieve the proper results. The different quantities are obtained by using various bore sizes for the pump tubes. The wall thickness of all the various pump tube sizes are identical so all the tubes are compressed equally and sealed by each of the rollers. Air is also pumped to generate the bubbles used to segment the sample stream. On most of the later pumps an air bar is used to produce more precise bubble spacings in the manifold. The air bar is a necessary fixture to obtain high quality analyses for a large number of samples. No modifications are necessary on the AutoAnalyzer pump unless a microflow system is desired.

The chemical reactions occur in the manifold where the sample is segmented with air, mixed with reagents, heated if necessary and then sent to the colorimeter. All the pump tubes are connected to small glass fittings or plastic blocks which divide the sample and inject the reagents and air into the sample stream. Small, circular glass coils are then used to mix the sample thoroughly. Several additions of other reagents may be made through platinum or glass injector connectors after the initial mixing. The number of turns in the mixing coils governs time delay before another reagent is added or the sample goes to the colorimeter. If a chemical reaction time is normally too long to come to completion at room temperature, the coils are heated to increase the reaction rate. Basically it is best if all parts of the manifold are constructed with glass which reduces back pressure and chemical reaction with the walls of the coils and allows you to see the sample stream. Another variable to be optimized in the manifold is the internal diameter of the glassware. Basically it is best to use the smallest tubing possible which minimizes mixing and contamination between samples and wash. Glass tubing of 1.5 and 1.0 mm internal diameter are being used on the relatively recent systems.

The AutoAnalyzer II single channel industrial colorimeter (SCIC) measures the transmittance (which is electronically converted to absorbance) of the sample stream after it has been debubbled. The latest models have sample and reference cells even though they are called single channel instruments. The reference cell is normally filled with air and serves to modulate variation in light filament intensity. Narrow pass interference filters are used with the sample and reference cells to produce the desired wavelength of light for specific analysis. The sample stream with bubbles is pushed into the colorimeter. At the debubbler in the colorimeter the nonsegmented sample is pulled through the sample cuvet and back through the pump while the bubbles and a small fraction of the sample stream are vented to a waste line. Several flow cell lengths and diameters are available to optimize sensitivity and to alter sample residence and wash out times in the cuvet. Some problems are produced with smaller diameter flow cells such as a significant refractive index difference between distilled water wash and seawater samples. This refractive index error is normally corrected empirically as described in Section 3. The output of the colorimeter is both 60 mv and 5 volts full scale. Older versions of the colorimeter (AAI) use larger volumes and measure percent transmittance of the samples. The output of the older colorimeter must be amplified using the recorder as provided by Technicon. It is also possible to build or buy a log-amplifier which will linearize the transmittance output of the AAI so it can be recorded on a standard chart recorder.

The recorder receives the analog signal from the colorimeter so that the trace displays the absorbance of the samples as "peaks" and the distilled deionized wash water lowers the trace to separate the peaks from one another. The baseline absorbance obtained with reagents and distilled wash water represents zero concentration. The difference between the peak heights in absorbance units and the baseline absorbance represents the absorbance of the sample.

A data logger also can connect to the output of the colorimeters to digitize the analog output and print this output on paper tape. The data logger is also connected to the sampler to coordinate the sample times and it can be calibrated to display concentrations by inserting the appropriate factor. The data logger is deficient in that it will not correct baseline changes and refractive index corrections, and displays only to paper tape.

A computer is an optional data recording device (as is the data logger) which collects the absorbance values of baselines and sample peaks. The computer is interfaced to the analog output signal of the colorimeter by an analog to digital converter. Absorbance values of the sample peaks are stored in the computer. The computer does the tasks of the data logger but also can correct for baseline changes and refractive index, store data in formatted files, store data on mass storage media (magnetic tape or disks), print a formatted report, display formatted data in tabular or graphic form on a CRT, and calculate chemical factors directly from standard solutions. Given the combination of capabilities that are currently available in the commercial market it is possible to purchase a computer that performs these tasks for less cost than the data logging devices needed to operate five or six AutoAnalyzer channels. The software development of data logging from an automatic analyzer is not difficult if the computer has a high level language such as BASIC. Technicon Corp. is currently marketing an AutoAnalyzer IIC Data Handler and Controller system which is built around a microprocessor. The system description indicates that it produces data listings and can communicate with other computers but there are currently no graphics available with the system.

#### Specific Component Description

The automated analysis system (Figure 2-1) has the capability of processing 8 channels but in practice only 6 analyses are implemented at the present time. The specific modules in the analysis system are:

1. AA II Sampler IV
2. AA II Single Channel Industrial Colorimeter (SCIC)
3. AA II Pump III with single speed
4. Honeywell dual pen recorders with multiple speeds and input spans.
5. Manifold modules constructed from a la carte components.
6. A to D interface with HP 98132A interface card. This device also has a DAC output port which controls the sampler.
7. HP 9845 S desktop computer with internal printer, CRT, real-time clock, I/O read only memory (ROM), GRAPHICS ROM and Mass Storage ROM.

#### HP System Description

- A. HP 9845S: with 62,650 bytes of R/W memory (option 203)  
graphics package (option 370, option 700)  
second tape drive (option 600)  
integral thermal line printed - 8-1/2 paper (option 500)  
standard ASC II keyboard and printer (option 800)



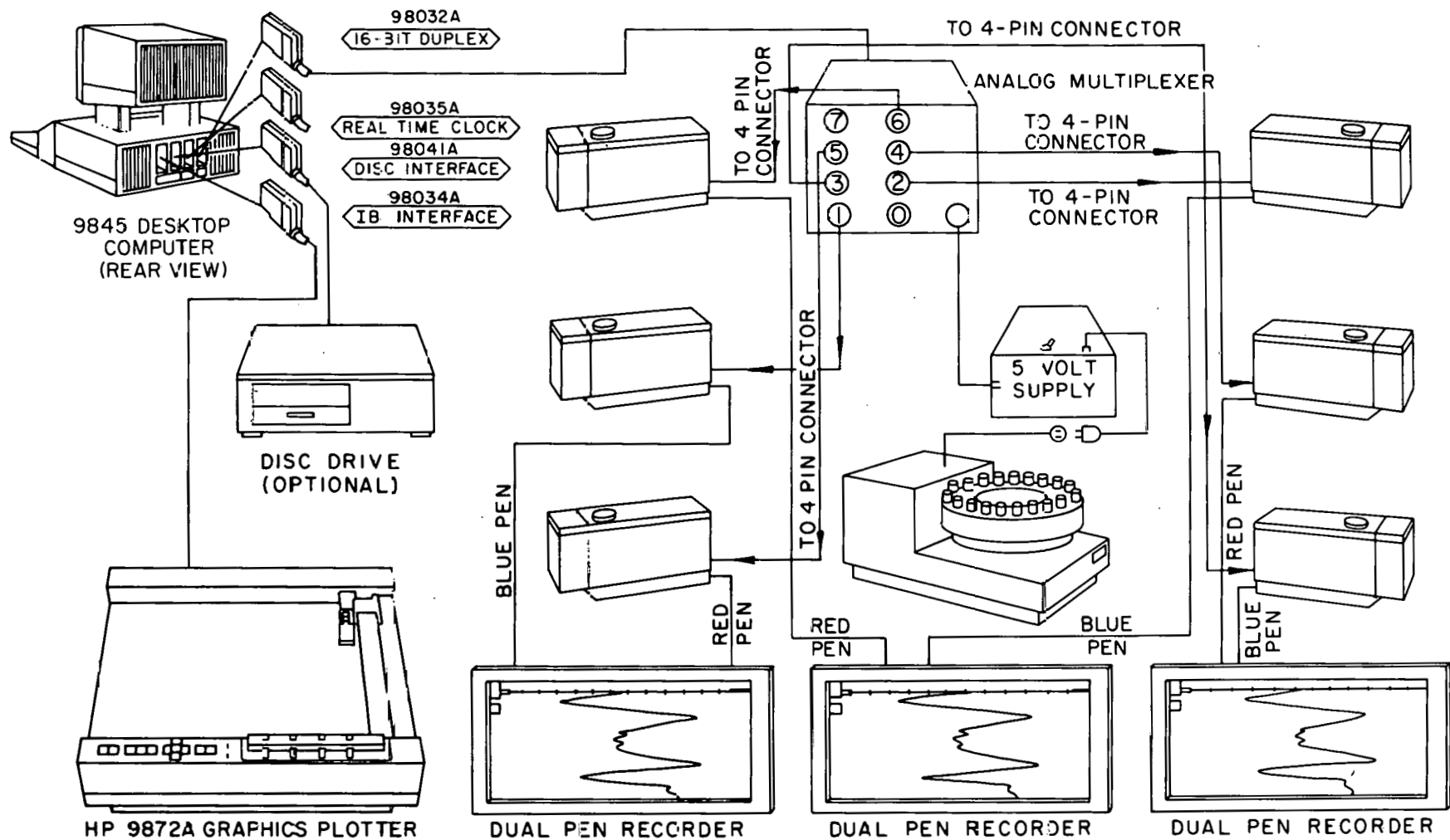


Figure 2-1. Schematic Diagram of Computer-AutoAnalyzer System

- B. ROMs:           mass storage        98431A  
                  graphics           98437A  
                  I/O                   98432A
  
- C. Peripherals: Flexible disk drive    9885M, option 045  
                  Plotter                   9872A, option 045
  
- D. Peripheral Interface Cards:
  - Plotter interface (HP-IB) 98034A
  - Flexible disk interface 98032A, option 485
  - 16-bit parallel I/O       98032A
  - Real time clock           98035A
  - RS-232-C interface        98036A, option 001
  
- E. Other:        Anderson Jacobson, model A242, 300 baud modum  
                  Analog multiplexer constructed by Interscience Instrumentation

#### Configuration

The automated analysis system is operated in both shore-side and ship-board laboratories. The component modules have been configured to occupy a minimum of bench space but still allow easy access for troubleshooting (Figure 2-2). The 6 AutoAnalyzer channels require about 7 feet of bench space that is 3 feet wide and has 2-1/2 feet of overhead clearance above the bench top. The computer requires another 3 feet by 3 feet area but it can be somewhat removed (a few feet).

The analysis system is transported as four separate modules that are attached to plywood bases. A dual channel recorder, 3 colorimeters and a pump are located on each end of the layout while a dual channel recorder and sampler are located in the center. The colorimeters are placed in aluminum frames that are attached securely to the top of the recorders (Figure 2-3). The colorimeters may be easily lifted out of the frames for repairs. The manifolds are attached vertically along the sides of the recorders (Figure 2-4). The pumps are located close to the sampler, reagents and colorimeters so that no long reagent lines are required. Heating coils for the phosphate, ammonium and urea channels are located on the back side of the manifold platens.

The component parts used to construct each of the analysis manifolds were purchased mainly from Technicon. Some costs can be reduced by using parts manufactured by other vendors, however, the quality of these cheaper parts are often not good. Detailed lists of all component parts are located in Appendix B.

As mentioned before all flow lines between the pump and colorimeters should be constructed from glass tubing to reduce back pressures. The glass segments are best joined using heavy walled 1/8 inch tygon tubing. The ends of the glass segments should be butted against each other inside the joints. All reagent lines from the storage bottles to the pump should be small bore teflon or polyethylene tubing. This will reduce start up or shut down time. The small teflon tubing can be joined tightly to the pump tubes using small segments of old pump tubes. Small reagent lines from the pump to the manifold injector fittings can often be made using small teflon tubing.

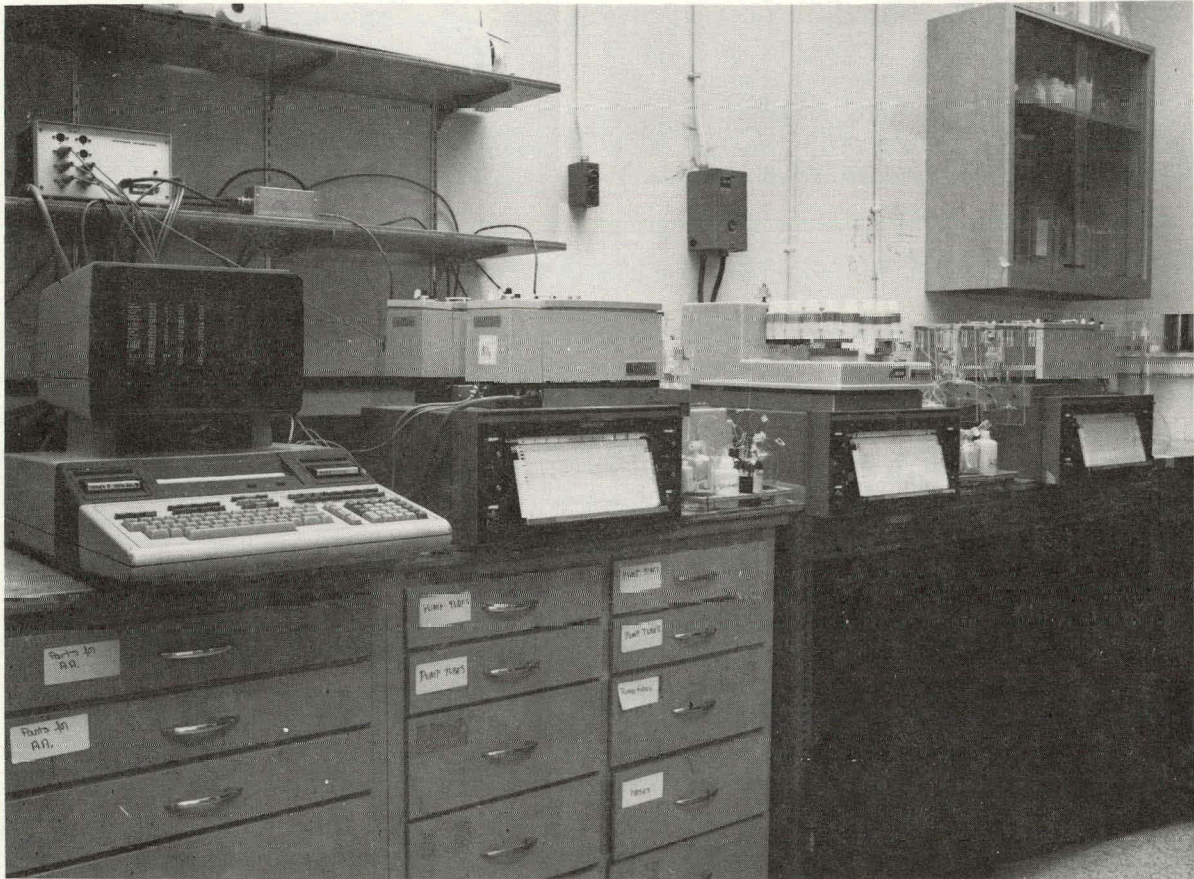


Figure 2-2. AutoAnalyzer on the Laboratory in a Sea-going Configuration

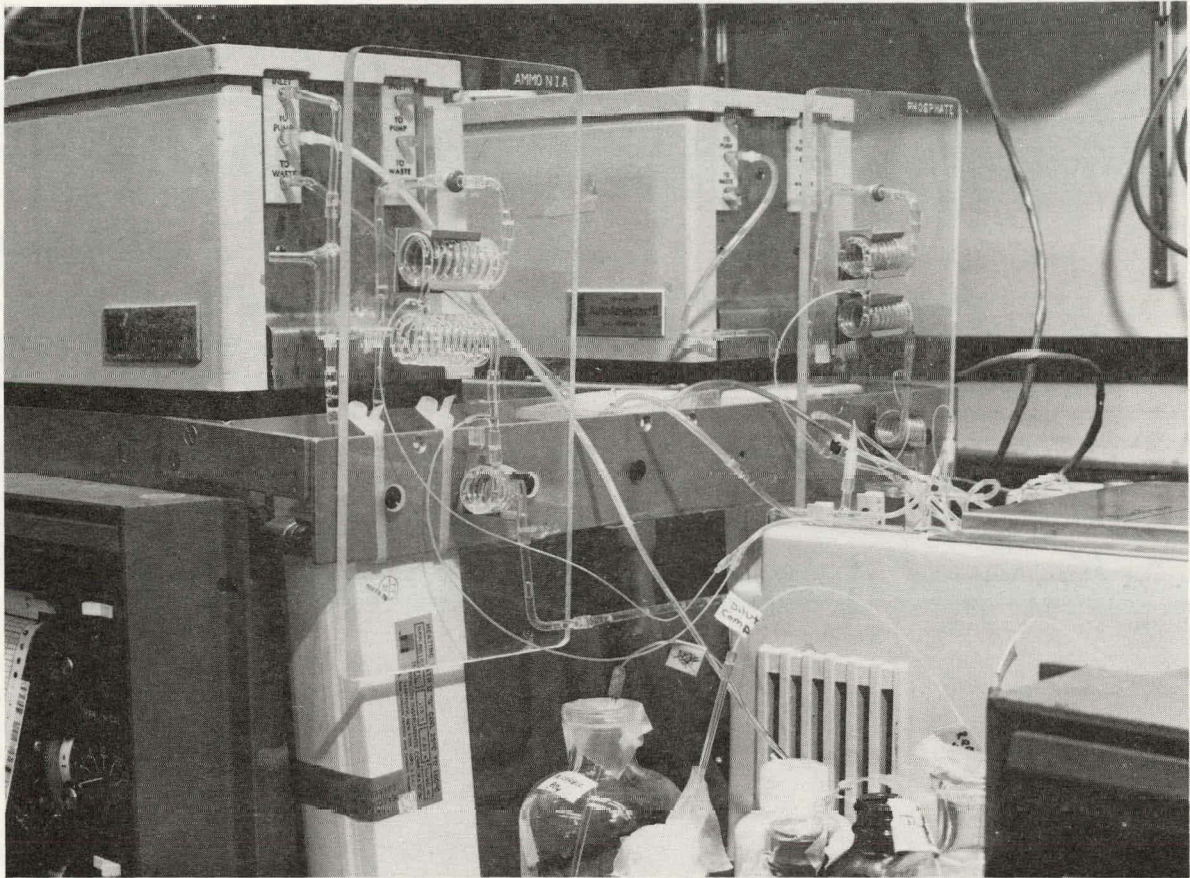


Figure 2-3. Ammonium Manifold Showing Vertical Orientation of Flow Stream and Heating Bath

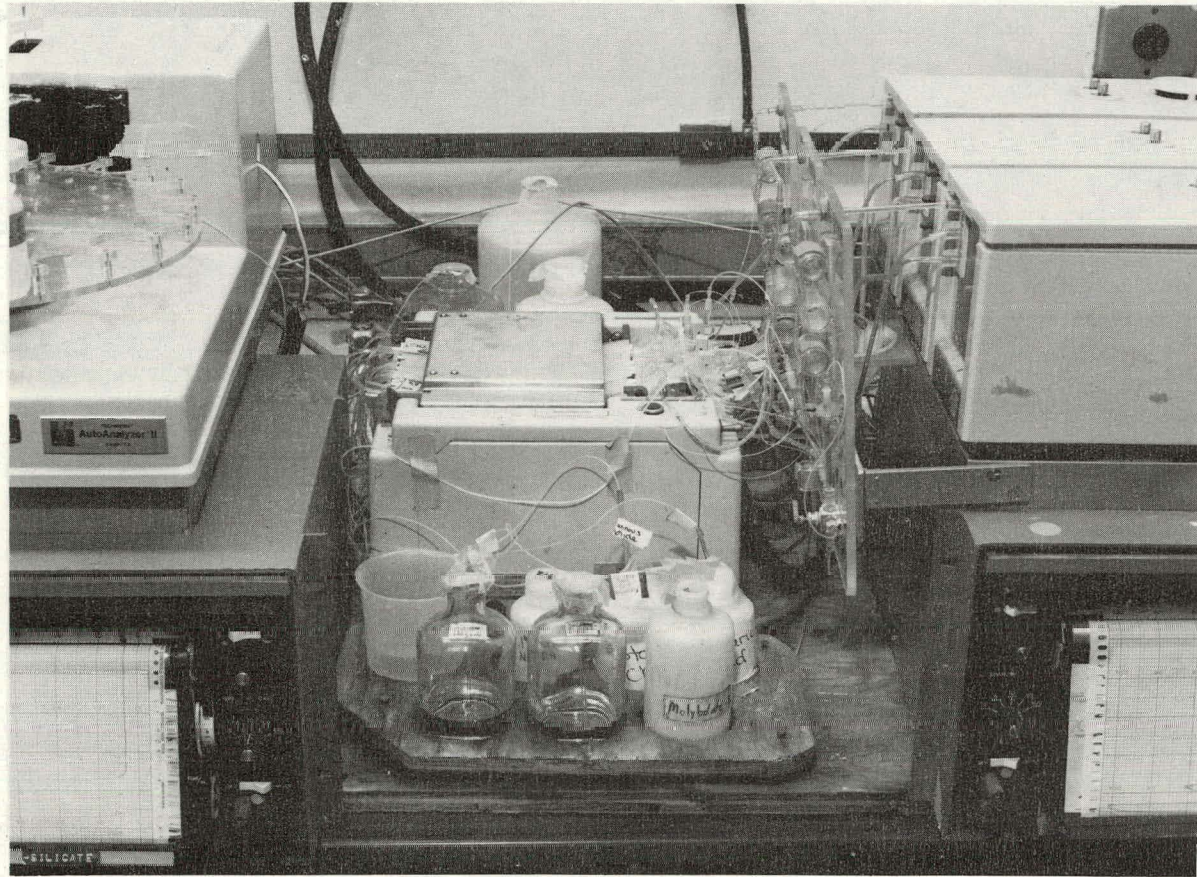


Figure 2-4. Arrangement of AutoAnalyzer Sampler, Pump and Colorimeters which Reduces the Total Length of the Flow System

### 3. OPERATION OF AUTOANALYZER SYSTEM

#### Nutrient Analyses in the Field

Running nutrient samples onboard ship is required by projects which collect a large number of samples or desire the highest precision especially with an analysis like ammonium. Some problems may be encountered with shipboard automated nutrient analyses that are not often present in the shoreside laboratory. It is generally best if the shipboard nutrient analyzer is oriented along the starboard-port axis, located in an area with relatively constant temperature ( $\pm 5^{\circ}\text{C}$ ) and near the centerline of the ship. The colorimeters are temperature sensitive so cold drafts in the middle of a run can increase colorimeter drift. The roll of a vessel produces the same angle of roll at the center line and the outside bulkheads however the vertical displacement is much smaller near the center of the vessel so the segmentation air bubbles are less likely to enter the colorimeter flow cell. The problems created by the tips of air bubbles which quickly dip in and out of flowcells during excessive ship roll are most severe with the 50 mm length flowcells used in ammonium and phosphate analyses.

In terms of operating the AutoAnalyzer at sea there are several additional problems that often arise. The quality of water that comes from ship evaporators can range from nearly perfect with no nutrients to practically straight seawater. It is always best to prepare for lousy shipboard water and bring extra ion exchange columns and several big polyethylene storage jugs.

To successfully analyze for micromolar quantities of nutrients in seawater it is imperative that very pure water is used in reagent and primary standard preparations. Distilled water produced in very good stills is usually contaminated with some nutrients, especially ammonium. Water produced by evaporators aboard ship can often be very pure but it is rarely pure enough to use without further treatment.

Mixed-bed ion exchange resins are most often used to further reduce the small amounts of nutrients contained in distilled or evaporated water. The efficiency of the ion exchange columns is best when flow rates are relatively slow so it is best to fill large 20 to 40 liter polyethylene jugs that have spigots for easy use. The ion exchange columns change colors as the capacity of the resin beads are reached. A convenient method to get the entire use of a column is to connect two columns in series so that the first column pretreats the water for the second column. A flow rate of 200 to 400 ml per minute can be easily obtained. Several brands of ion exchange columns are available and mounting racks can also be purchased. There seems to be no noticeable difference between the several best known brands (e.g. IONXCHANGE cartridges with duplex mounting fixture, Illinois Water Treatment Company, 840 Cedar St., Rockford, IL 61101).

Several spare columns should be taken to sea if good water onboard ship is vital. It is not uncommon for seawater to be accidentally admitted to the shipboard freshwater system. If this happens, a column can often be exhausted in processing 5 to 10 liters. Shipboard contamination and moisture condensation from overhead pipes can also bring disaster if a drop falls in the wrong place.

Another potential source of problems of nutrient samples collected at sea is mistakes in drawing samples from the water bottles especially if it is rough and people are not feeling too well. We have found that it is best to

have nalgene (2 oz.) nutrient sample bottles that are previously numbered with waterproof ink located in a rack under the water sampling bottles or carried in a plastic soda case if a rosette is used. The person who fills the nutrient sample bottles should be very attentive because it is easy to take water from the wrong sampling bottle. Before drawing the samples it is best to place the nutrient sample bottles in numerical order in the rack or sampling case. As each of the nutrient bottles are rinsed and filled they should be checked for proper order, and finally after all the nutrient bottles are filled the numerical order should be checked again while you have the chance to redraw the samples. If an error is made at this step it is nearly impossible to correct it later unless it is a simple error such as filling the bottles in reverse order. Another note of caution - a rosette sampler can collect up to 12 samples on a cast. It is critical that the chief rosette operator check on the number of sample bottles tripped and he should clearly mark the first sample bottle with a tag.

The AutoAnalyzer operator should start analyzing the samples immediately for best results. If a short-term delay is necessary, the samples should be refrigerated in the dark to retard changes in the samples. He should place the nutrient bottles on the sampler tray in numerical order taking notice whether they were systematically arranged in the carrying case. It is important to analyze the surface samples first so that the data logging and later computer transfers can be carried out smoothly.

#### Storage of Nutrient Samples

The best policy is never store nutrient samples for extended periods -- fresh ones are best. There are times, however, when it is not convenient or possible to analyze the samples at sea. There are some differences of opinion on the best storage procedure of nutrient samples and there are a few papers that discuss freezing and pickeling (May, 1960; Proctor, 1962; Marvin and Proctor, 1965; Gilmartin, 1967; Thayer, 1970; Degobbis, 1973;). Generally we have had good results from frozen samples for phosphate, silicate, nitrate and nitrite. Results are sometimes poor on ammonium samples that have been frozen. We have obtained the best results by collecting samples in nalgene (2 oz) bottles that are filled to the shoulder, the caps tightened and quick frozen in an upright position in a salt-ice bath. The samples freeze in 20-30 minutes and then are placed in a nutrient case in a freezer. The tops should be checked at this time to be certain that they are tight. The samples are thawed just minutes before analyzing by placing them upright in a sink with running cold water. A comparison of nitrate concentration in both fresh and frozen samples collected on a cruise indicated that the mean concentrations did not change significantly and the mean difference between all the fresh and frozen samples was  $-0.05 \mu\text{gat } \ell^{-1}$  (Atwood et al., 1979).

Some special samples collected in muddy estuaries, from bottom water samples, or in very dense plankton blooms should be filtered before running the samples on the AutoAnalyzer. To filter such samples pour the sea water from the nalgene (2 oz.) sample bottle into a millipore stainless steel filter funnel that uses a prewashed 25 mm or 47 mm glass fiber filter (Reeve Angel, Gelman, or Whatman, etc.). The gravity flow of the sample through the filter can be used to rinse the sample bottle. After 1/2 oz of sample is used for rinsing, the filter funnel mounted on the top of a bell jar is placed on a base plate (Fischer order No. 9-788) and a vacuum is applied to filter the remaining sample into the sample bottle. (Alternatively the Filter Funnel can

be mounted on a bored rubber stopper which fits a glass side armed cup especially constructed to hold the sample bottle.) This process places the filtered sample back into the original sample bottle and removes any interfering particulate matter. For the smaller samples like pore water from cores it is often better to withdraw the sample into a 10 or 20 cc glass syringe and filter through a previously rinsed 0.45 m membrane filter (Fischer No. 9-730-219) that fits directly on the syringe tip.

#### Starting Up and Shutting Down

1. Fill out AutoAnalyzer data sheet for the station.
2. Place samples in sampler tray in order listed on data sheet.
3. Start pumps with reagents if they have been previously shut down.
4. Turn on colorimeters and recorders and wait until stable baselines are established (approximately 20 minutes). Turn on the computer, the A to D interface box and the sampler control box. Load APILOT program into the computer.
5. The pump may be turned on to rapid pump to help flush the reagents thru. Be sure all reagent tubes are in the proper bottles and that all tubes are connected to the colorimeter etc. Turn on nitrate column.
6. Write on the recorder chart paper the ink color for each of the nutrients being run, the station number, the date and time and the investigator's name if they are special samples.
7. Turn sampler main power switch on.
8. Check distilled water and reagents every 1/2 hour until the samples have all been run.
9. To shut down the A.A. move reagent straws to deionized water and if analyzing silicate leave tartaric acid straw in reagent bottle for 1-2 minutes after removing the other reagents before putting into distilled water. A blue precipitate will form if molybdate and  $\text{SnCl}_2$  are mixed without tartaric acid. The precipitate can be removed with a short flush of the manifold with 0.1 N sodium hydroxide.
10. Turn off nitrate column.
11. After thoroughly flushing all lines with water, turn off pump and release pump tube end blocks.
12. Turn off power of computer, A to D interface, sample box, sampler, recorders and colorimeters if analyses are completed for the day. While on shipboard the colorimeters are usually not turned off if more samples will be run within 4 to 8 hours.

#### Standards

##### I. Primary Standards

Primary standards should be prepared from the best grade reagents available. Transfer a small quantity of these reagents to weighing bottles and dry in an oven for two hours at 100°C. Store the dried reagents in a vacuum desiccator. Weighings should be made to a tenth of a milligram on an analytical balance which has been recently calibrated. Bottles used to store standard solutions (and analytical reagents for that matter) should be initially acid



rinsed with 10% HCl and then rinsed three times with the solution they are to contain. Primary standards preserved with chloroform and stored in the refrigerator are usually stable for a month.

Ammonium - 5 micromole primary standard/ml

Dissolve 0.2674 g (5 m mole) of  $\text{NH}_4\text{Cl}$  in ~800 ml DDW in a 1 liter flask and dilute to the mark with DDW. Transfer to a 500 ml poly bottle, add 3 drops of chloroform, and refrigerate.

Nitrate - 20 micromole primary standard/ml.

Dissolve 1.0111 g (10 m mole) of  $\text{KNO}_3$  in ~400 ml DDW contained in a 500 ml volumetric flask, dilute to the mark, add 3 drops of chloroform, and refrigerate.

Nitrite - 5 micromole primary standard/ml.

Dissolve 0.3450 g (5 m mole) of  $\text{NaNO}_2$  in ~800 ml DDW contained in a 1 liter volumetric flask and dilute to the mark with DDW. Transfer to a 500 ml poly bottle, add 3 drops of chloroform and refrigerate.

Orthophosphate - 5 micromole primary standard/ml.

Dissolve 0.6804 g (5 m mole)  $\text{KH}_2\text{PO}_4$  in ~800 ml DDW and dilute to 1 liter with DDW. Transfer to a 500 ml poly bottle, add 3 drops of chloroform and refrigerate.

Orthosilicic Acid - 20 micromole primary standard/ml.

Add 0.9403 g (5 m mole)  $\text{Na}_2\text{SiF}_6$  to a 500 ml nalgene beaker containing 150 ml DDW and a teflon coated magnetic stirring bar. Stir magnetically at low speed for several hours to effect complete solution. Quantitatively transfer this solution to a 250 ml volumetric flask and dilute to the mark with DDW. Transfer to a poly bottle, add 3 drops of chloroform and refrigerate.

Urea - 5 micromole primary standard.

Dissolve 0.1502g (2.5 m mole) of  $\text{NH}_2\text{CONH}_2$  in ~800 ml DDW in a 1 liter flask and dilute to the mark with DDW. Transfer to a 500 ml polybottle, add 3 drops of chloroform and refrigerate.

## II. Secondary Standards

Secondary standards can be prepared individually or as a mixed standard containing an aliquot of each of the five primary standards. The mixed secondary standard approach is appealing because a single set of working standards prepared from a mixed secondary standard can be used to calibrate all six chemistries simultaneously. In order for this approach to be valid, however, one must assume that each primary standard is pure. In practice, this proves to be a rather poor assumption since the salts used to prepare the primary standards usually contain trace impurities which are often significant at the micromolar concentration range.

For example, assume that the nitrate primary standard contained a small amount of phosphate impurity. It follows that when an aliquot of this nitrate standard was combined with an aliquot of the phosphate primary standard, the analytical concentration of phosphate in the resulting mixed secondary standard would be somewhat higher than its nominal concentration. This error often goes undetected because its only manifestation is a non-zero intercept for the Beer-Lambert calibration plot of absorbance versus nominal phosphate concentration.

For this reason, it is probably best to prepare an individual secondary standard and set of working standards for each analyte. Once this is done, however, the concentrations of the other four analytes in each of the five working standard sets can be determined and appropriate correction factors calculated to apply when mixed standards are used. These factors should remain constant as long as the concentration of the primary standards and their ratios to each other in the mixed secondary standards remain constant. It should be stressed that the errors which result from the use of mixed standards are small (usually 1-5%), but this error source is one of which the analyst should be aware.

In our laboratory, we prepare two sets mixed/working standards combining those primary standards which experience has shown do not contain trace impurities of one another. To make five concentrations of mixed standard series number 1 equivalent to 5, 15, 25, 35, and 45  $\mu\text{g-at/l}$ , pipet 25, 75, 125, 175, and 225  $\mu\text{l}$  each of primary nitrate and silicic acid into 100 ml volumetric flasks. Dilute to the mark with DDW (Table 3-1). These standards constitute the "S-1" series. For work in the Bering Sea and other waters where higher concentrations of silicic acid are normally encountered, double the amount of silicate primary standard to 50, 150, 250, 350, and 450  $\mu\text{l}$  for this series and calculate the standard factor (see STAND) based on these greater values. If urea is to be analyzed it should be included in the "S-1" standard by adding 10, 30, 50, 70, and 90  $\mu\text{l}$  of the primary solution to obtain 0.5, 1.5, 2.5, 3.5, and 4.5  $\mu\text{g-at/l}$  urea standards.

Concentrations of 0.5, 1.5, 2.5, 3.5, and 4.5  $\mu\text{g-at/l}$  of  $\text{NH}_4$ ,  $\text{NO}_2$ , and  $\text{PO}_4$  are obtained by pipetting 20  $\mu\text{l}$  in 200 ml and 30, 50, 70, and 90  $\mu\text{l}$  of the primary solutions per 100 ml DDW as indicated above. This group of mixed standards is designated as the "S-2" series (Table 3-1).

With good quality chemicals, these two mixed/working standards eliminate the need to apply correction factors.

A synchronization standard designated as DO, is prepared by pipetting 225  $\mu\text{l}$  of  $\text{NO}_3$  and  $\text{Si(OH)}_4$  primary standard and 90  $\mu\text{l}$  of  $\text{NO}_2$ ,  $\text{PO}_4$ ,  $\text{NH}_4$ , and urea primary standard into 100 ml distilled water.

There are definite salt effects in some of the analyses, e.g. ammonium. It is therefore highly recommended that if standards are prepared in distilled water, then spike standards in seawater should also be analyzed. This is best accomplished by making a standard addition of primary standard to a surface sample on selected low nutrient stations. With the present ammonium method and manifold (see Cookbook section), we have obtained consistently better reproducibility and linearity with working ammonium standards prepared in low nutrient seawater. The ammonium series run in distilled water yields reduced absorbances and deviation from linearity. We emphasize that these ammonium seawater samples should be utilized for calculating the standard factor.

The merits of preparing standards in distilled water can be debated among a group of seawater chemists for hours. There are difficulties with almost all the choices. Here are some of the arguments.

Table 3-1  
Mixed/Working Standards for Nutrient Analysis

ID	Standard Set No. 1 (NO <sub>3</sub> + Si(OH) <sub>4</sub> )			ID	Standard Set No. 2 (NO <sub>2</sub> + PO <sub>4</sub> + NH <sub>4</sub> )	
	Primary/100 ml DDW		µg-at/l		Primary/100 ml DDW	
S-1-1	25	50*	5.0	S-2-1	10	0.5
S-1-2	75	150*	15.0	S-2-2	30	1.5
S-1-3	125	250*	25.0	S-2-3	50	2.5
S-1-4	175	350*	35.0	S-2-4	70	3.5
S-1-5	225	450*	45.0	S-2-5	90	4.5

If standards are prepared in sodium chloride or spiked seawater instead of DDW, "blanks" are designated as S-1-0 and S-2-0 respectively.

\*Microliters of silicic acid in S-1 standard for Bering Sea work. Equivalent concentrations 10, 30, 50, 70, and 90 µg-at Si(OH)<sub>4</sub>/l.

A. Deionized water standards:

Advantages

1. The quality of the water is usually well known.
2. The quality of the water is not highly variable.
3. The prepared standards are relatively stable with time.
4. Large volumes of water are easily available.

Disadvantages

1. The chemical factors may be different than in salt solution (salt effect).

B. Deionized water-sodium chloride solutions:

Advantages

1. Salt effects on chemical factors are minimized.
2. Sodium chloride solution is easy to prepare and is not expensive.

Disadvantages

1. Ammonium impurity is quite large in sodium chloride.
2. Large quantities of sodium chloride are sometimes required.

C. Artificial Seawater Solution:

Arguments are similar to sodium chloride solution. No known advantages over sodium chloride.

D. Low Nutrient seawater:

Advantages

1. Salt effects are eliminated.
2. In certain regions of the ocean it is easily obtained.

Disadvantages

1. It always contains some nutrients.
2. If not used immediately it must be filtered to remove any particulate matter.
3. Often it is difficult to obtain when working in eutrophic waters.
4. Storage is difficult so large quantities are not easily obtained.

The choice of 1) low nutrient seawater when available or 2) deionized water standards for seawater nutrient samples was made because the ammonium analysis is very important in our scientific programs which are often studying highly variable eutrophic environments. Other choices may be made in oligotrophic waters.

The frequency of analyzing standards has increased in recent years as the analysis rate has increased. When 10 samples per hour was a good analysis rate, it was often difficult to run standards more than once a day. As the

analysis rate has gone to 20, 40 or even 60 samples per hour it is possible to analyze more standards. When the AutoAnalyzer is not busy running nutrient samples between stations, while at sea, it has been a regular procedure to run a set of standards (S1 and S2 standards of 5 concentrations each for a total of 11 samples including the sync sample). We try to run a complete set of standards every six hours if the AutoAnalyzer is running around the clock. Of course, one S1 and one S2 standard is placed at the beginning of each set of station samples which are used to check how well the AutoAnalyzer is operating.

### Running Standards

The determination of nutrient concentration in seawater is a strictly empirical process, i.e. for each analysis chemical factors are calculated using prepared standard concentrations. There are several steps in preparing the standards which produces some uncertainty in the concentrations prepared. It is therefore very advisable that an independent check of standards be made in some way. This is often accomplished by obtaining standard solutions from a commercial manufacturer, government agency, or another marine laboratory.

Several approaches in producing standards have been tried. A commercial firm (Sagami Chemical Research Center, Japan) has manufactured several concentrations of orthophosphate, nitrate, nitrite and silicic acid in solutions of sodium chloride which sell for about \$5 per vial. The orthophosphate, nitrate and nitrite are sealed in glass ampoules and silicate is placed in plastic vials. The solutions are normally only used immediately after opening so a calibration using 3 concentrations of the 3 nutrients would cost about \$45.00. The cost is rather high so these are used only occasionally as a check rather than the routine daily standards. There have been some negative comments about these standards from several laboratories because of possible inaccuracies.

Another approach has been to prepare and freeze standards which are used to compare to fresh standards while at sea. The institutions that use this method have carefully worked out the details of producing, freezing, and thawing the standards in order to obtain highly precise results.

Some distilled water standards can be obtained from government agencies in limited quantities for calibration purposes. The Environmental Protection Agency (EPA) has produced phosphate standards in the past.

### Refractive Index Corrections

The Beer-Lambert law which defines the linear relationship between the absorbance of a species in solution and its concentration is valid only when refractive index (and a number of other solution variables) is constant. When seawater samples are determined relative to a distilled water baseline, this assumption is not satisfied. For this reason, some fraction of the total absorbance measured for seawater plus reagents will reflect refractive index rather than analyte concentration differences relative to the distilled water plus reagents baseline. The magnitude of the refractive index correction is a function of the initial salinity of the sample and the amount of dilution the sample experiences in the manifold. Once determined, the refractive index corrections remain relatively constant if the salinity of the seawater samples remain constant to within  $\sim \pm 2\%$  provided that there is no change in either the manifold or the colorimeter's cell path length or standard calibration control.

To determine refractive index corrections seawater or a sodium chloride solution which closely matches the salinity of the samples expected to be encountered is analyzed after one of the reagents necessary for the formation of the absorbing species in each analysis is omitted. The resulting change in absorbance relative to the distilled water baseline is therefore due only to refractive index changes. Thus the absorbance due to differences in analyte concentration ( $A_c$ ) is equal to the total absorbance ( $A_t$ ) of a sample minus the absorbance due to refractive index changes ( $A_r$ ).

$$A_c = A_t - A_r$$

The suggested reagent omissions for each analysis is presented below. Note that for standards, the refractive index correction is included in the "blank" absorbance determined for the sodium chloride solution or seawater used in their preparation.

#### Determination of Refractive Index

Ammonium. Substitute 1 g NaOH in 200 ml DDW for reagent B. All other reagents unchanged.

Orthosilicic acid. Substitute 80 ml DDW + 120 ml 10% v/v HC for the molybdate reagent. All other reagents unchanged.

Nitrate + Nitrite, Nitrite. Substitute DDW containing Brij-35 wetting agent for the NNED reagent. All other reagents unchanged.

Orthophosphate. Substitute 10% v/v  $H_2SO_4$  containing sodium lauryl sulfate wetting agent for the molybdate reagent. All other reagents unchanged.

Urea. Substitute 1.65 ml DDW for the semicarbazide in the color solution.

#### Carryover Corrections

If dispersion is minimized in the continuous flow analysis channels by reducing the size of the manifold and increasing segmentation by injecting a lot of bubbles, then the peaks obtained will be sharp and will look like square waves. However, when several samples are run close together preceding samples may affect the height of following peaks. This effect is known as "carryover" (Walker et al., 1970; Snyder et al., 1976; Jacklyn et al., 1978) or "sample interaction" (Thiers and Oglesby, 1964; Thiers et al., 1967). Peaks are composed of fall curves and rise curves so carryover can be viewed as the height of the fall curve at the time when the next peak is formed (Walker et al., 1970). The extent of carryover can be calculated as:

$$\text{carryover (C.O.)} = E_1 e^{-p/b}$$

where  $E_1$  is the height of the previous peak,  $p$  is the interval between peaks (sample plus wash time) and  $b$  is the slope of the exponential portion of the rise or fall curve.

In practice we do not correct for carryover in our determination of seawater nutrients. This is mainly the result of not finding a significant interaction between peaks. This was checked by alternately running two low samples and then two high samples.

#### Precision Testing of Peak Reading Program (APILOT)

The use of large numbers of periodic standards has the purpose of maintaining a high degree of accuracy of the results in the nutrient analyses. A further check on the precision of the results can be estimated by running a

number of replicate determinations at high, medium, and low nutrient concentrations. As a result, Table 3-2 was constructed from a data set obtained at sea under normal working conditions. Each sample was individually collected in a separate bottle so the values should represent a "typical" degree of precision.

Table 3-2  
Field Replication Experiments using Natural Seawater.  
Units are:  $\mu\text{g-at liter}^{-1}$

	PO <sub>4</sub>	SiO <sub>4</sub>	NO <sub>3</sub>	NO <sub>2</sub>	NH <sub>4</sub>
<u>Low Conc.</u>					
No. of replicates	11	10	8	17	17
Mean Concentration	0.17	1.36	0.09	0.05	0.09
Std. Dev.	0.02	0.06	0.01	0.01	0.01
95% Confid. Interval	0.02	0.05	0.01	0.006	0.008
<u>Med. Conc.</u>					
No. of replicates	20	20	20	11	8
Mean Concentration	1.09	11.96	19.78	0.26	0.68
Std. Dev.	0.03	0.12	0.10	0.009	0.03
95% Confid. Interval	0.01	0.05	0.05	0.007	0.03
<u>High Conc.</u>					
No. of replicates	17	17	17	10	20
Mean Concentration	3.21	178.23	42.97	1.28	6.38
Std. Dev.	0.02	0.35	0.24	0.006	0.16
95% Confid. Interval	0.02	0.17	0.13	0.005	0.08

#### Comparison of Automated and Manual Data Logging

In addition to the replication tests described in the previous section a comparison of automated peak reading using the "APILOT" program was compared to the manual method of reading the analog strip charts. The natural seawater samples were run at three speeds (20, 40 and 60 per hour) and were recorded with the "APILOT" program. The strip charts were read manually and the peaks were entered into files using the "MANDAT" program. A comparison of each of the sampling rates was made using the "A vs M" program. The output on pages 24-33 were run at 20 samples per hour for both sets of samples, HA016 and HM016. The first page of output lists the absorbances read by the computer (HA016) and the data set 2 was read manually (HM016). A table of differences for the nutrient channel and a plot of those differences versus sample number indicates that only one or two points deviated by more than .03 absorbance units for silicate while the majority of data for phosphate, silicate, nitrate and nitrite differed by 0.01 absorbance units.

Nutrient analyses at faster sampling rates do show divergence between manual and computer determined absorbances if the chemical aspects of the

AutoAnalyzer methods are not optimum. If the nutrient channels are well designed and maintained, then analysis rates of 60 samples per hour produce results that are nearly as precise and accurate as 20 samples per hour.

#### Comparison of Slow and Fast Sample Analysis Rates

A series of natural seawater samples was analyzed at 20, 40 and 60 samples per hour using the "APILOT" program. A comparison of each analysis was made for differences that occurred in going from 20 to 40 analyses per hour and 40 to 60 analyses per hour using the "A vs M" program. The example data set (pages 34-39) shown is a comparison between 20 samples per hour (HY2-20) and 40 samples per hour (HY2-40). The analysis of the data indicates that the phosphate channels gave higher results at 20 samples per hour than 40 per hour which is probably related to some "carryover effect" in that channel. Silicate exhibited no trend while nitrate and nitrite were lower at the slow speed. Finally, ammonium was in need of some work because the differences were quite large and all tended to be high at the slow speed compared to the faster rate.



THIS IS A LIST FOR DATA SET=

1.00

LABEL=HA016

DATE=29AUG78

HR=1240

LAT=N.A.

LON=N.A.

DEPTH= -99

COMMENT=N.A.

NO. SAMPLES= 39

OPERATOR=SCM

CHANNEL=	P04	SI04	N03	N02	NH4	X30N
STATUS=	1	1	1	1	1	1
FACTORS=	.953	4.338	4.941	.859	0.000	5.019
RF'S=	0.000	0.000	0.000	0.000	0.000	0.000
BASE1=	.029	.234	.158	.032	0.000	.103
BASE2=	.123	.294	.176	.028	0.000	.107

NO.	ID							
1	D	0	5.02	4.01	5.89	4.99	0.00	6.36
2	S	23	3.24	2.58	.73	3.04	0.00	.63
3	S	13	.87	5.74	4.72	.14	0.00	5.24
4	H	0	.24	1.98	.21	.14	0.00	.15
5	H	10	.19	1.86	.20	.14	0.00	.15
6	H	20	.33	1.87	.21	.13	0.00	.16
7	H	30	.36	1.88	.20	.14	0.00	.15
8	H	40	.52	1.63	.24	.21	0.00	.20
9	H	50	.47	1.67	.44	.35	0.00	.43
10	H	75	.81	2.16	1.98	.21	0.00	2.15
11	H	100	.96	2.25	2.26	.21	0.00	2.48
12	H	200	1.36	2.73	3.14	.16	0.00	3.50
13	H	400	1.74	4.06	4.29	.17	0.00	4.69
14	H	0	.39	1.65	.22	.17	0.00	.17
15	H	10	.42	1.62	.20	.15	0.00	.16
16	H	20	.48	1.44	.19	.16	0.00	.15
17	H	30	.57	1.70	.22	.19	0.00	.17
18	H	40	.66	1.91	.63	.38	0.00	.66
19	H	50	.78	2.09	1.08	.36	0.00	1.21
20	H	60	0.00	2.69	2.30	.22	0.00	2.59
21	H	75	-1.00	2.29	1.75	.22	0.00	2.00
22	H	100	-1.00	2.50	1.97	.21	0.00	2.22
23	H	125	0.00	6.71	1.78	.27	0.00	2.13
24	H	0	-1.00	1.44	.21	.19	0.00	.17
25	H	10	.52	1.43	.21	.17	0.00	.17
26	H	20	.74	1.74	.64	.39	0.00	.69
27	H	30	1.03	1.80	.95	.47	0.00	1.07
28	H	40	1.12	2.38	1.58	.33	0.00	1.78
29	H	50	1.10	2.29	1.55	.29	0.00	1.76
30	H	60	1.16	2.47	1.75	.26	0.00	1.96
31	H	75	1.22	2.39	1.73	.26	0.00	1.95
32	H	100	1.36	2.75	2.24	.20	0.00	2.52
33	H	0	.53	1.50	.24	.20	0.00	.20
34	H	15	.63	1.45	.31	.29	0.00	.29
35	H	25	.83	1.59	.45	.32	0.00	.47
36	H	35	.95	1.84	.84	.60	0.00	.92
37	H	45	.98	2.00	1.20	.49	0.00	1.35
38	H	55	1.02	2.51	1.55	.44	0.00	1.73
39	H	65	1.20	2.44	1.55	.48	0.00	1.73

THIS IS A LIST FOR DATA SET=

2.00

LABEL=HM016

DATE=29AUG78

HR=1240

LAT=N.A.

LOH=N.A.

DEPTH= -99

COMMENT=N.A.

NO.SAMPLES= 39

OPERATOR=SCM

CHANNEL=	P04	SI04	NO3	NO2	NH4	X3ON
STATUS=	1	1	1	1	0	1
FACTORS=	.953	4.338	4.941	.859	0.000	5.019
RF'S=	0.000	0.000	0.000	0.000	0.000	0.000
BASE1=	.020	.230	.170	.030	0.000	.090
BASE2=	.170	.290	.180	.060	0.000	.110

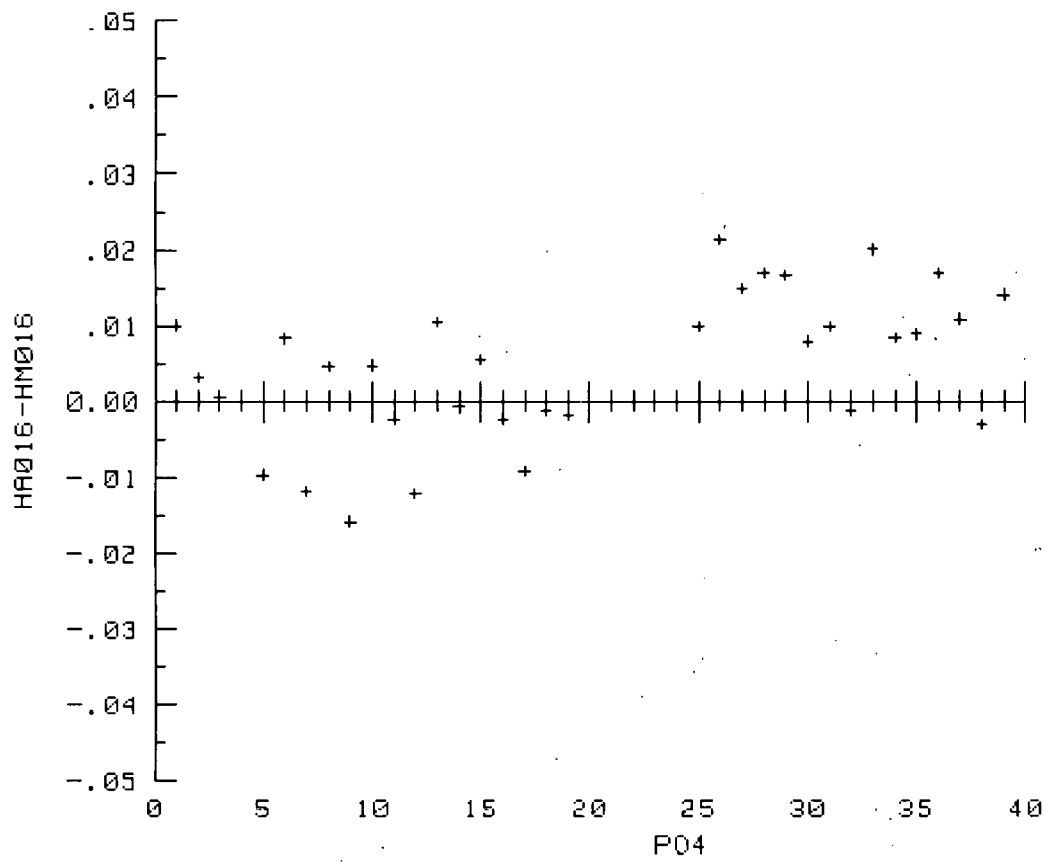
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2	S 23	3.24	2.59	.73	3.06	0.00	.62
3	S 13	.87	5.72	4.73	.14	0.00	5.27
4	H 0	.24	1.97	.21	.13	0.00	.16
5	H 10	.20	1.88	.20	.13	0.00	.13
6	H 20	.32	1.87	.20	.13	0.00	.16
7	H 30	.37	1.88	.20	.13	0.00	.15
8	H 40	.52	1.62	.22	.21	0.00	.19
9	H 50	.49	1.67	.43	.27	0.00	.42
10	H 75	.81	2.18	1.99	.21	0.00	2.17
11	H 100	.96	2.25	2.27	.21	0.00	2.50
12	H 200	1.37	2.72	3.15	.18	0.00	3.51
13	H 400	1.73	4.07	4.30	.18	0.00	4.70
14	H 0	.39	1.67	.21	.18	0.00	.17
15	H 10	.41	1.62	.19	.18	0.00	.16
16	H 20	.48	1.43	.19	.18	0.00	.14
17	H 30	.58	1.70	.19	.20	0.00	.17
18	H 40	.66	1.90	.62	.39	0.00	.67
19	H 50	.78	2.10	1.08	.38	0.00	1.21
20	H 60	0.00	2.70	2.31	.21	0.00	2.61
21	H 75	0.00	2.30	1.77	.22	0.00	2.01
22	H 100	0.00	2.50	1.99	.21	0.00	2.23
23	H 125	0.00	6.72	1.78	.28	0.00	2.13
24	H 0	0.00	1.47	.21	.20	0.00	.18
25	H 10	.51	1.42	.20	.20	0.00	.17
26	H 20	.72	1.76	.63	.39	0.00	.69
27	H 30	1.02	1.81	.95	.48	0.00	1.07
28	H 40	1.10	2.40	1.59	.33	0.00	1.79
29	H 50	1.08	2.29	1.57	.29	0.00	1.77
30	H 60	1.15	2.47	1.77	.27	0.00	1.98
31	H 75	1.21	2.40	1.75	.28	0.00	1.97
32	H 100	1.36	2.71	2.26	.29	0.00	2.53
33	H 0	.51	1.45	.23	.20	0.00	.20
34	H 15	.62	1.43	.31	.30	0.00	.29
35	H 25	.82	1.57	.45	.32	0.00	.47
36	H 35	.93	1.83	.83	.61	0.00	.91
37	H 45	.97	1.98	1.21	.51	0.00	1.35
38	H 55	1.02	2.49	1.56	.46	0.00	1.72
39	H 65	1.19	2.45	1.56	.49	0.00	1.73

THIS IS A TABLE OF MANUAL AND COMPUTER READ ABSORBANCE FOR P04

1=HA016

2=HM016

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5	.19	.20	-.01
6	.33	.32	.01
7	.36	.37	-.01
8	.52	.52	.00
9	.47	.49	-.02
10	.81	.81	.00
11	.96	.96	-.00
12	1.36	1.37	-.01
13	1.74	1.73	.01
14	.39	.39	-.00
15	.42	.41	.01
16	.48	.48	-.00
17	.57	.58	-.01
18	.66	.66	-.00
19	.78	.78	-.00
20	0.00	0.00	0.00
21	-1.00	0.00	-1.00
22	-1.00	0.00	-1.00
23	0.00	0.00	0.00
24	-1.00	0.00	-1.00
25	.52	.51	.01
26	.74	.72	.02
27	1.03	1.02	.01
28	1.12	1.10	.02
29	1.10	1.08	.02
30	1.16	1.15	.01
31	1.22	1.21	.01
32	1.38	1.38	-.00
33	.53	.51	.02
34	.63	.62	.01
35	.83	.82	.01
36	.95	.93	.02
37	.98	.97	.01
38	1.02	1.02	-.00
39	1.20	1.19	.01

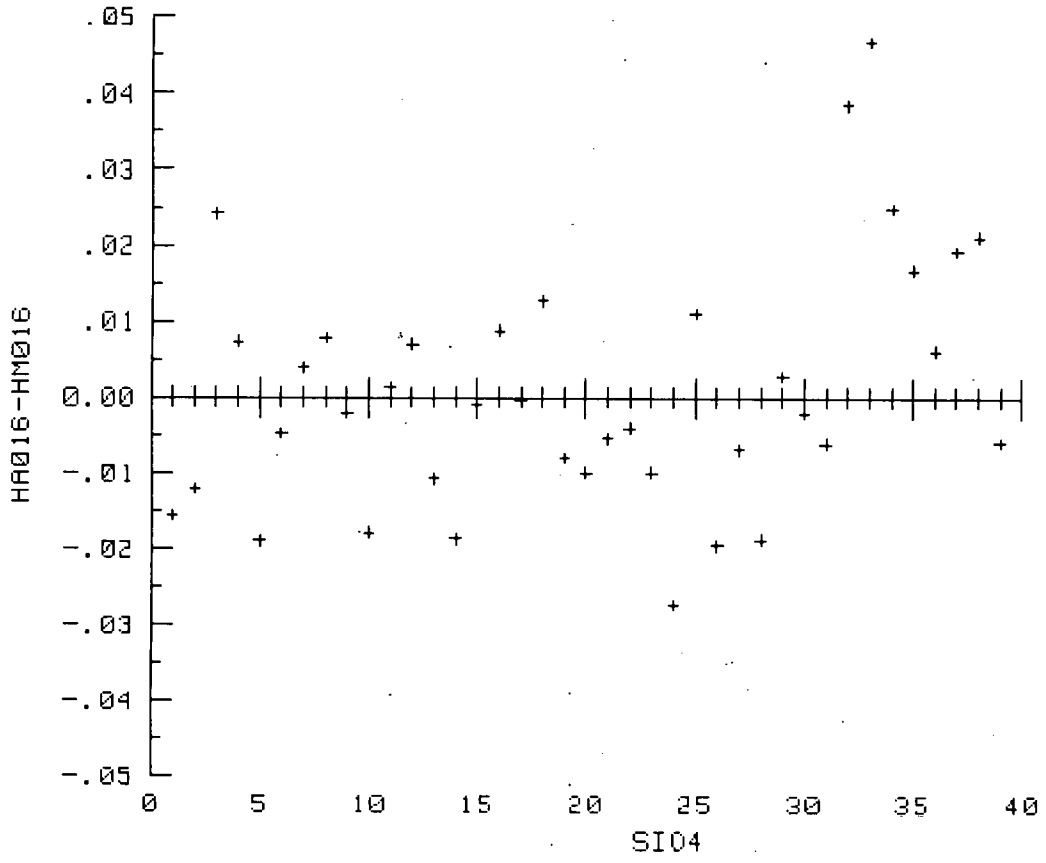


THIS IS A TABLE OF MANUAL AND COMPUTER READ ABSORBANCE FOR SI04

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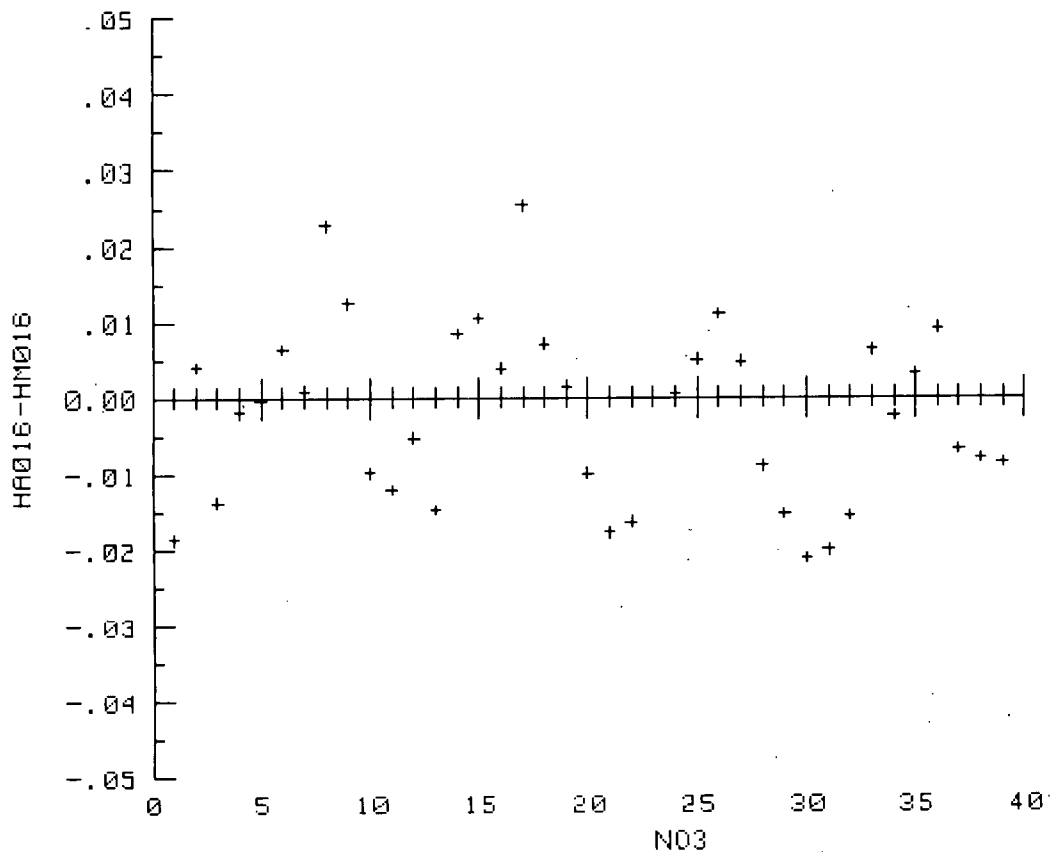
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2	2.58	2.59	-.01
3	5.74	5.72	.02
4	1.98	1.97	.01
5	1.86	1.88	-.02
6	1.87	1.87	-.00
7	1.88	1.88	.00
8	1.63	1.62	.01
9	1.67	1.67	-.00
10	2.16	2.18	-.02
11	2.25	2.25	.00
12	2.73	2.72	.01
13	4.06	4.07	-.01
14	1.65	1.67	-.02
15	1.62	1.62	-.00
16	1.44	1.43	.01
17	1.70	1.70	-.00
18	1.91	1.90	.01
19	2.09	2.10	-.01
20	2.69	2.70	-.01
21	2.29	2.30	-.01
22	2.50	2.50	-.00
23	6.71	6.72	-.01
24	1.44	1.47	-.03
25	1.43	1.42	.01
26	1.74	1.76	-.02
27	1.80	1.81	-.01
28	2.38	2.40	-.02
29	2.29	2.29	.00
30	2.47	2.47	-.00
31	2.39	2.40	-.01
32	2.75	2.71	.04
33	1.50	1.45	.05
34	1.45	1.43	.02
35	1.59	1.57	.02
36	1.84	1.83	.01
37	2.00	1.98	.02
38	2.51	2.49	.02
39	2.44	2.45	-.01



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 2=HM016

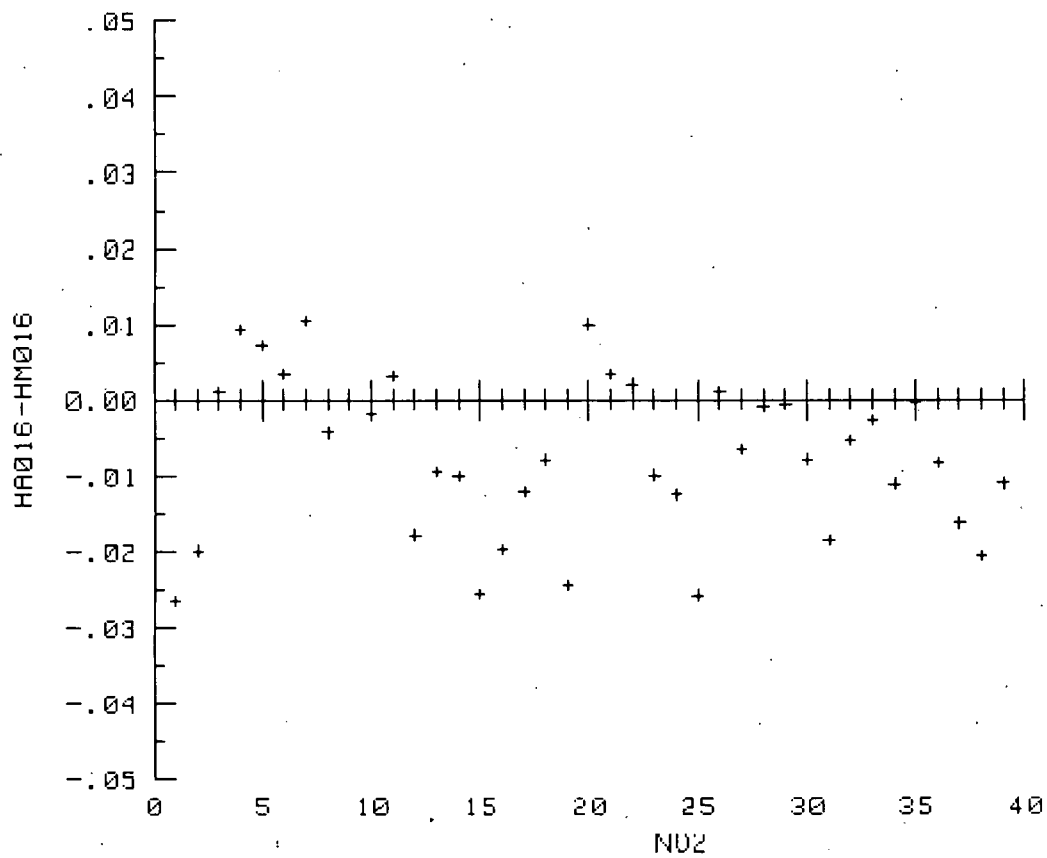
PEAK NO.	1 NO3	2 NO3	1-2
1	5.89	5.91	-.02
2	.73	.73	.00
3	4.72	4.73	-.01
4	.21	.21	-.00
5	.20	.20	-.00
6	.21	.20	.01
7	.20	.20	.00
8	.24	.22	.02
9	.44	.43	.01
10	1.98	1.99	-.01
11	2.26	2.27	-.01
12	3.14	3.15	-.01
13	4.29	4.30	.01
14	.22	.21	.01
15	.20	.19	.01
16	.19	.19	.00
17	.22	.19	.03
18	.63	.62	.01
19	1.08	1.08	.00
20	2.30	2.31	-.01
21	1.75	1.77	-.02
22	1.97	1.99	-.02
23	1.78	1.79	0.00
24	.21	.21	.00
25	.21	.20	.01
26	.64	.63	.01
27	.95	.95	.00
28	1.58	1.59	-.01
29	1.55	1.57	-.02
30	1.75	1.77	-.02
31	1.73	1.75	-.02
32	2.24	2.26	-.02
33	.24	.23	.01
34	.31	.31	-.00
35	.45	.45	.00
36	.84	.83	.01
37	1.20	1.21	-.01
38	1.55	1.56	-.01
39	1.55	1.56	-.01





THIS IS A TABLE OF MANUAL AND COMPUTER READ ABSORBANCE FOR N02  
 1=HA016  
 2=HM016

PEAK NO.	1 N02	2 N02	1-2
1	4.99	5.02	-.03
2	3.04	3.06	-.02
3	.14	.14	.00
4	.14	.13	.01
5	.14	.13	.01
6	.13	.13	.00
7	.14	.13	.01
8	.21	.21	.00
9	.05	.07	.08
10	.21	.21	-.00
11	.21	.21	.00
12	.16	.18	-.02
13	.17	.18	-.01
14	.17	.18	-.01
15	.15	.18	-.03
16	.16	.18	-.02
17	.19	.20	-.01
18	.38	.39	-.01
19	.36	.38	-.02
20	.22	.21	.01
21	.22	.22	.00
22	.21	.21	.00
23	.27	.28	-.01
24	.19	.20	-.01
25	.17	.20	-.03
26	.39	.39	.00
27	.47	.48	-.01
28	.33	.33	-.00
29	.29	.29	-.00
30	.26	.27	-.01
31	.26	.28	-.02
32	.28	.29	-.01
33	.20	.20	-.00
34	.29	.30	-.01
35	.32	.32	-.00
36	.60	.61	-.01
37	.49	.51	-.02
38	.44	.46	-.02
39	.48	.49	-.01



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 DATE=12OCT78  
 HR=0545  
 LAT=N.A.  
 LON=N.A.  
 DEPTH= -99  
 COMMENT=N.A.  
 NO. SAMPLES= 10  
 OPERATOR=CJP

1.00

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FACTORS=	1.234	4.767	4.316	1.028	1.000	1.000
RF/S=	0.000	0.000	0.000	0.000	0.000	0.000
BASE1=	.090	.112	.098	.098	.090	0.000
BASE2=	.122	.131	.112	.115	.161	0.000

NO.	ID							
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3	S	22	1.71	.14	.41	1.56	1.02	0.00
4	H	0	.63	.37	.11	.18	.88	0.00
5	H	5	.65	.37	.10	.18	.82	0.00
6	H	10	.60	.38	.08	.19	1.01	0.00
7	H	15	.64	.39	.09	.18	1.34	0.00
8	H	20	.62	.40	.11	.18	1.27	0.00
9	H	30	.70	1.28	.67	.64	1.12	0.00
10	H	40	.94	2.17	1.25	.96	1.38	0.00

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 HR=0700  
 LAT=N.A.  
 LON=N.A.  
 DEPTH= -99  
 COMMENT=N.A.  
 NO. SAMPLES= 10  
 OPERATOR=CJP

2.00

CHANNEL=	P04	SI04	N03	N02	NH4	X30N
STATUS=	1	1	1	1	1	1
FACTORS=	1.234	4.767	4.316	1.028	1.000	1.000
RF/S=	0.000	0.000	0.000	0.000	0.000	0.000
BASE1=	.115	.127	.100	.121	.110	0.000
BASE2=	.117	.131	.117	.134	.134	0.000

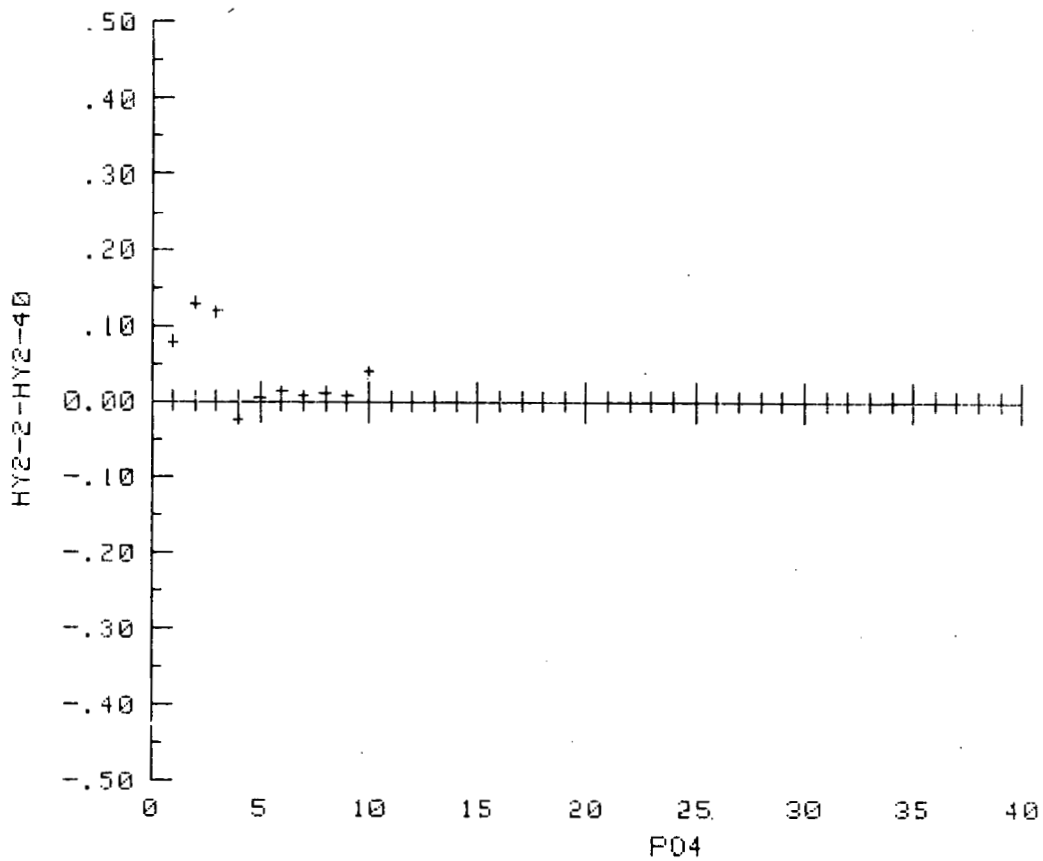
NO.	ID							
1	D	0	3.77	7.35	6.64	3.56	5.17	0.00
2	S	12	.29	2.36	2.78	.14	2.45	0.00
3	S	22	1.59	.15	.44	1.56	.45	0.00
4	H	0	.65	.38	.18	.22	.79	0.00
5	H	5	.64	.38	.17	.21	.96	0.00
6	H	10	.59	.38	.15	.22	.85	0.00
7	H	15	.64	.38	.17	.21	.85	0.00
8	H	20	.61	.40	.17	.21	.98	0.00
9	H	30	.69	1.26	.70	.66	1.07	0.00
10	H	40	.90	2.15	1.28	.98	.95	0.00

THIS IS A TABLE OF MANUAL AND COMPUTER READ ABSORBANCE FOR P04

1=HY2-20

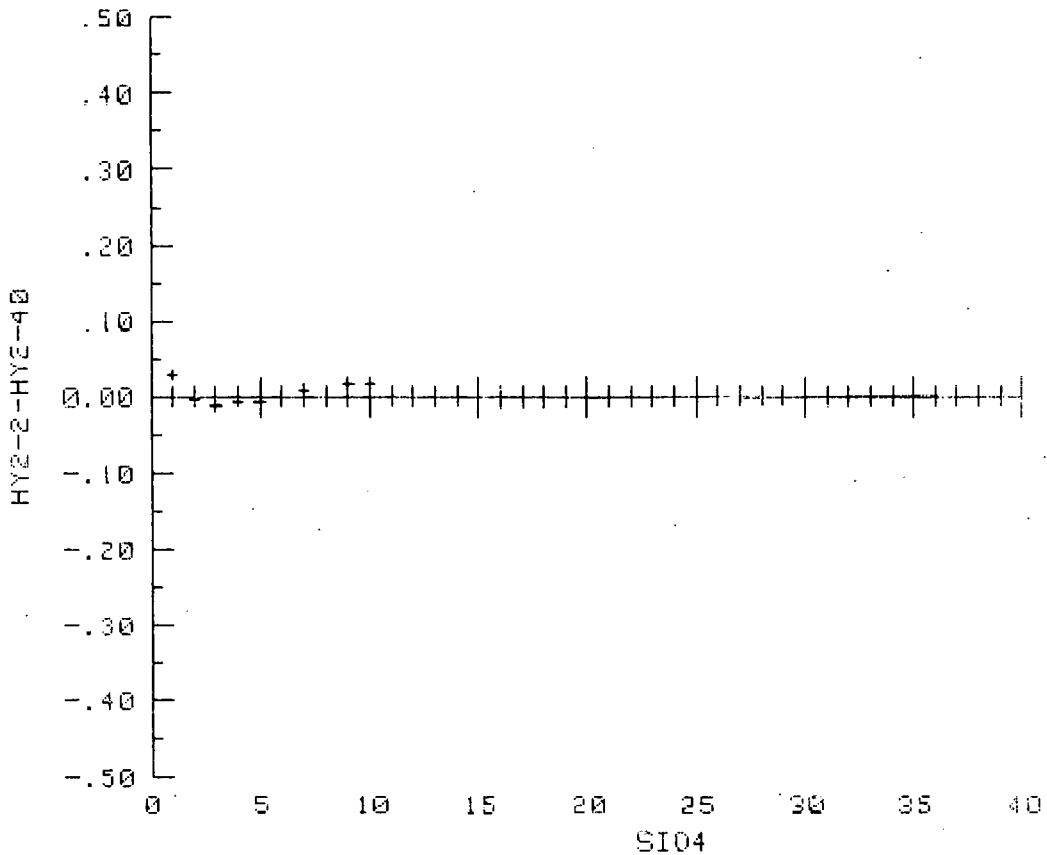
2=HY2-40

PEAK NO.	1 P04	2 P04	1-2
1	3.85	3.77	.08
2	.42	.29	.13
3	1.71	1.59	.12
4	.63	.65	-.02
5	.65	.64	.00
6	.60	.59	.01
7	.64	.64	.01
8	.62	.61	.01
9	.70	.69	.01
10	.94	.90	.04



THIS IS A TABLE OF MANUAL AND COMPUTER READ ABSORBANCE FOR SI04  
 1=HY2-20  
 2=HY2-40

PEAK NO.	1 SI04	2 SI04	1-2
1	7.38	7.35	.03
2	2.35	2.36	-.00
3	.14	.15	-.01
4	.37	.38	-.01
5	.37	.38	-.01
6	.38	.38	-.00
7	.39	.38	.01
8	.40	.40	.00
9	1.28	1.26	.02
10	2.17	2.15	.02

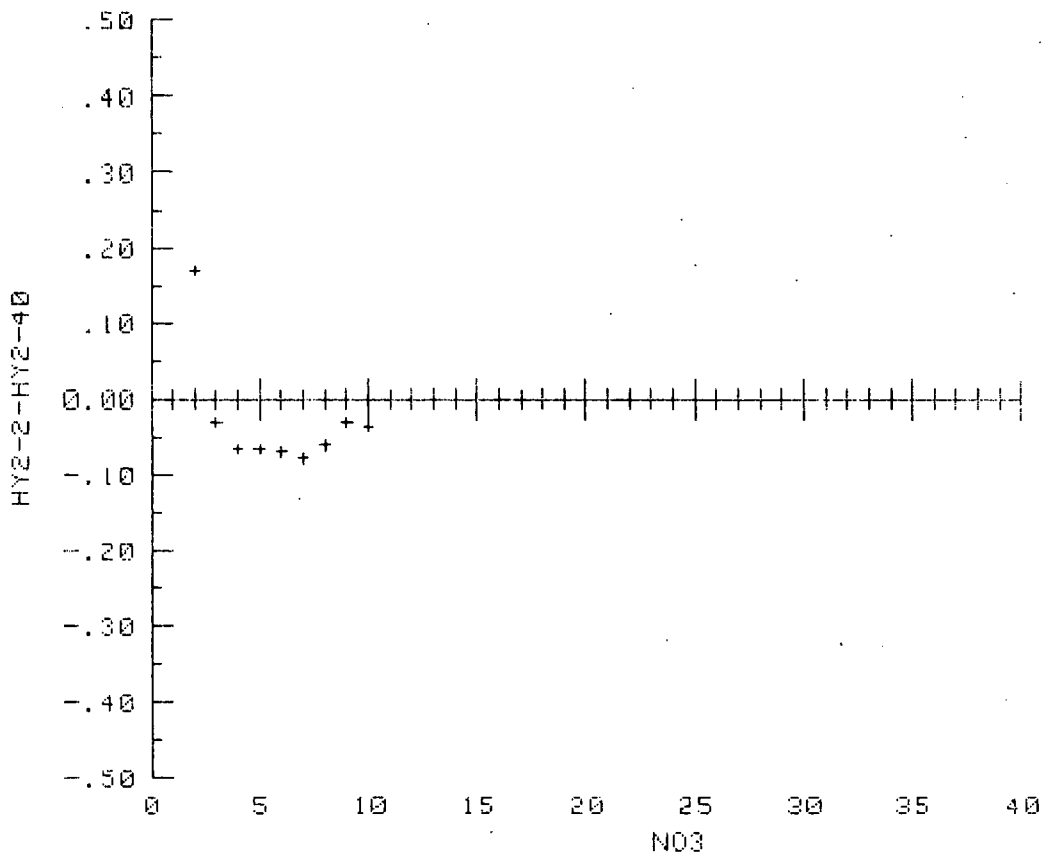


THIS IS A TABLE OF MANUAL AND COMPUTER READ ABSORBANCE FOR N03

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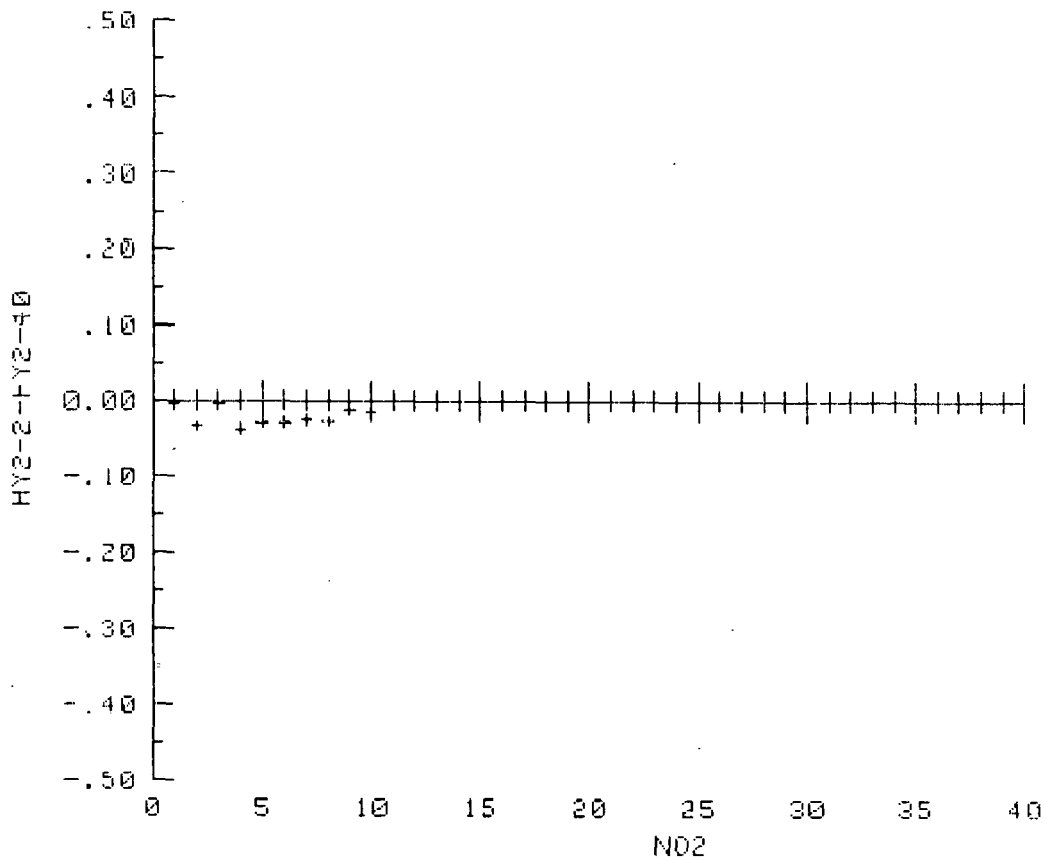
2=HY2-40

PEAK NO.	1 N03	2 N03	1-2
1	7.62	6.64	.98
2	2.95	2.78	.17
3	.41	.44	-.03
4	.11	.18	-.07
5	.10	.17	-.07
6	.08	.15	-.07
7	.09	.17	-.08
8	.11	.17	-.06
9	.67	.70	-.03
10	1.25	1.28	-.03



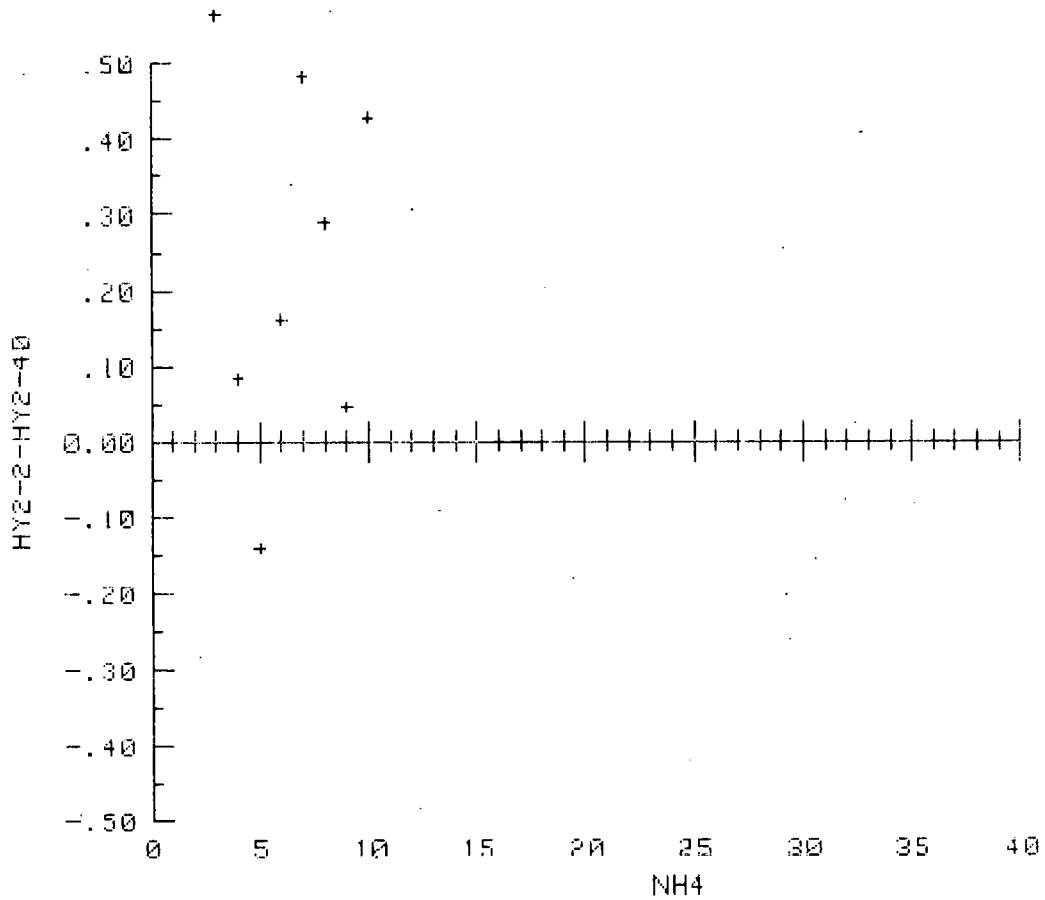
THIS IS A TABLE OF MANUAL AND COMPUTER READ ABSORBANCE FOR NO2  
 1=HY2-20  
 2=HY2-40

PEAK NO.	1 NO2	2 NO2	1-2
1	3.56	3.56	-.00
2	.11	.14	-.03
3	1.56	1.56	-.00
4	.18	.22	-.04
5	.18	.21	-.03
6	.19	.22	-.03
7	.18	.21	-.03
8	.18	.21	-.03
9	.64	.66	-.01
10	.96	.98	-.01



THIS IS A TABLE OF MANUAL AND COMPUTER READ ABSORBANCE FOR NH4  
 1=HY2-20  
 2=HY2-40

PEAK NO.	1 NH4	2 NH4	1-2
1	2.40	5.17	-2.77
2	.42	2.45	-2.03
3	1.02	.45	.56
4	.88	.79	.08
5	.82	.96	-.14
6	1.01	.85	.16
7	1.34	.85	.48
8	1.27	.98	.29
9	1.12	1.07	.05
10	1.38	.95	.43





## Underway Mapping

Underway nutrient mapping is a method of collecting continuous data as the ship steams a designated track. Two variations have been used in analyzing the sample stream that is pumped from a through-hull intake at 2-3 m depth to the ships' laboratory. One method uses a continuous sample with no washes to produce an absorbance analog that can easily be digitized with any scanning data logger (Kelly, Whitley and Dugdale, 1974 and 1975). An alternate method pumps the sample stream into the wash cup of the sampler and deionized water is placed in the sample cups (Wiesenburg, Setser and Bottom, 1978). This approach produces peaks to be read but is not as adaptable to data logging and small scale variability in the data may be more difficult to observe.

The continuous sample method has been employed in most underway nutrient mapping studies and is comparable to techniques normally used for mapping surface water temperature, salinity and chlorophyll fluorescence. A general flow diagram for the system is presented in Figure 3-1. Surface water is sampled continuously at a through-hull fitting and mixing tank assembly. *In situ* sensors can be installed in the mixing tank. Water is then pumped from the mixing tank to the wet laboratory sensor arrays and discrete samples may be collected for calibration purposes. The mixing tank is shown in Figure 3-2.

The through-hull fitting which feeds the mixing tank is usually located at a depth of approximately 3 m. When a ship is underway, surface water is entrained in a slipstream at the bow and flows along the hull. The surface water may flow slightly downward, especially in conditions of appreciable roll. Thus, water sampled at the inlet can originate from anywhere in the upper 3 m of water.

At the outlet from the mixing tank, water is pumped through PVC piping to the ship's wet laboratories. Flow rates are on the order of 60 l/min. The total residence time of water in the system has been estimated by injecting rhodamine-B at the inlet and timing the fluorometer response delay in the laboratory. Residence time is estimated as 15 sec. Water from this piping system is available for chemical, fluorometric and biological sampling in the ship's laboratories.

## Wet Laboratory System

Water can be taken from the piping system by two methods. The first, and somewhat less successful technique, utilizes a standpipe of plastic tubing attached to the laboratory outlet. The standpipe is intended to prevent air bubbles from passing through the AutoAnalyzer or fluorometer array, but it performs unsatisfactorily due to considerable mixing during the long chamber residence time of the water. Exposure of the water to laboratory lighting also affects fluorescence determinations. The second technique employs a large latex tubing termination on the outlet, which is connected directly to the continuous-flow fluorometer. Water emerging from the fluorometer is drained directly to the sink. A small latex tube for the AutoAnalyzer sample is attached to a small "T" connector in the fluorometer inlet tube. The flow through the fluorometer is kept as rapid as can be accommodated by drain facilities (40 l/min) to minimize residence time in the piping system. The small latex tube feeding the AutoAnalyzer is connected to a CRC model 9350/305 continuous dialysis block which contained a Millipore type HA 142 filter. The stream of water (~200 ml/min) flows across the top of the filter membrane

### UNDERWAY SAMPLING DATA FLOW

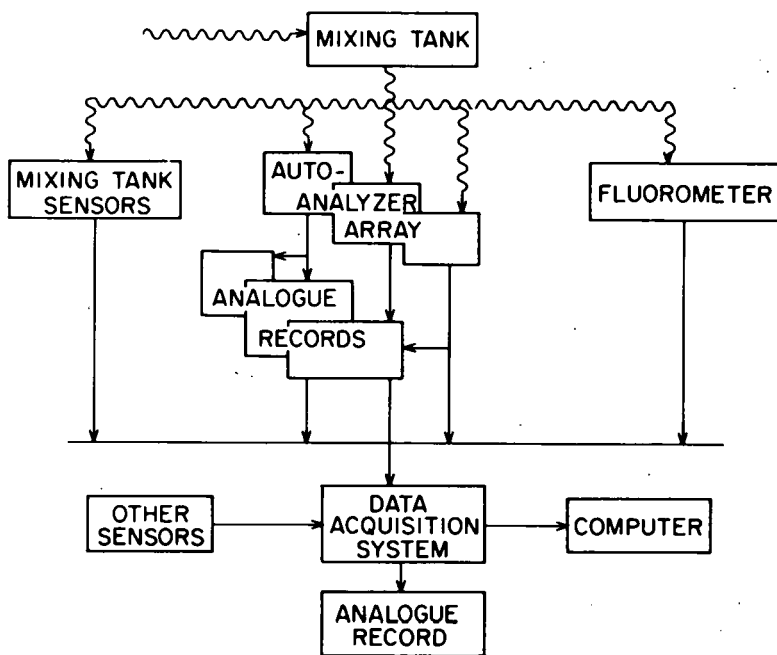


Figure 3-1. Flow Diagram of Total Sampling System. Wavy Lines Indicate Flow of Water, Straight Lines, Electronic Signals

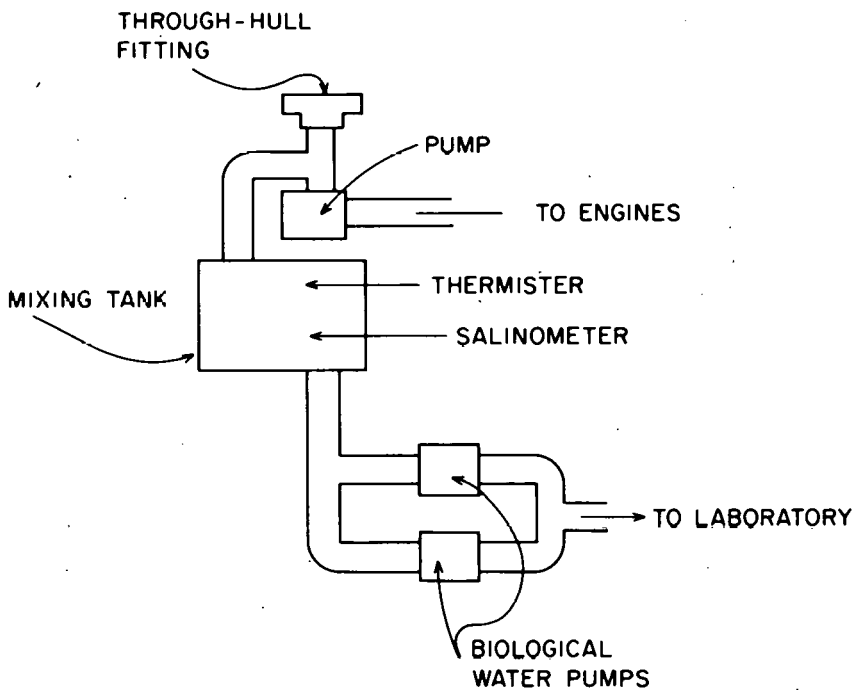


Figure 3-2. Diagram of Mixing Tank Arrangement

while the AutoAnalyzer pumps a continuous sample stream through the filter membrane from a single nipple on the bottom of the dialysis block. A stream divider is used to split the sample stream to the various nutrient analysis manifolds. To prevent air contamination of the copper-cadmium column in the nitrate analysis, a debubbler is used to catch gas bubbles which form as the sample stream warms. A plug of glass wool in the nitrate sample stream helps speed the degassing process. Filtration measurably improved the quality of data in the phosphate and ammonium channels, but no change is noticed with filtered water in the nitrate and silicate analyses. Sample readings logged by a computer are normally collected at one minute intervals.

The continuous operation of an AutoAnalyzer array over long periods requires special considerations regarding operating procedures and monitoring personnel. For instance, the time should be marked on the analog strip charts every 15 minutes to aid in later data corrections. Depending somewhat on the stability of the AutoAnalyzer system at the time, a blank should be determined every 2 to 4 hours to establish baseline drift. Baseline drift may be large on long continuous runs because of reagent and instrument changes. A refrigerator has been used with some success to preserve reagents in our laboratory when runs cover several days or weeks. The timing of blank values should be coordinated with the operation of the ship so that the data of least importance to the survey area is missed during the 10-15 minute period required for the blank determination. Mixed nutrient standards are run either before or after the survey commences. If the survey is longer than 8-12 hours, nutrient standards should be run both before and after the survey. The baseline drift is assumed to be linear, unless clues to the contrary become apparent on the analog output.

The sequence of events which makes up the underway data processing system is shown in Figure 3-3. Raw data from the underway scans are stored as a multivariate time series. The record is a two-dimensional array in which rows represent sequential scans and columns represent different variables. Raw data records can be printed and edited. Editing is especially important for the AutoAnalyzer channels which are subject to spikes and other spurious effects, and is normally done both on the raw voltages from these channels and on the nutrient concentrations calculated from them. All other raw data are converted to correct units before they are entered into the file. AutoAnalyzer channels must be corrected for baseline drift and thus the conversion of these data is delayed until the system encounters a blank determination from which it can update the record. Blanks are flagged in the digital record by the AutoAnalyzer personnel. The raw data file is accessed by the time index as the primary index but initially the time index indicates the time at which the data were acquired rather than the time the ship encountered the water parcel. Some variables such as temperature, salinity, and the meteorological variables are acquired in real-time; but delays due to residence time in the pumping system and the AutoAnalyzer analyses cause the inputs from the AutoAnalyzer channels and the fluorometer, and from any other instruments in the ship laboratories, to be acquired at a lag of several minutes from real-time. This asynchrony must be corrected by shifting certain columns in the array a number of rows equivalent to the delay in the acquisition for the variable.

DATA FLOW-COMPUTATION

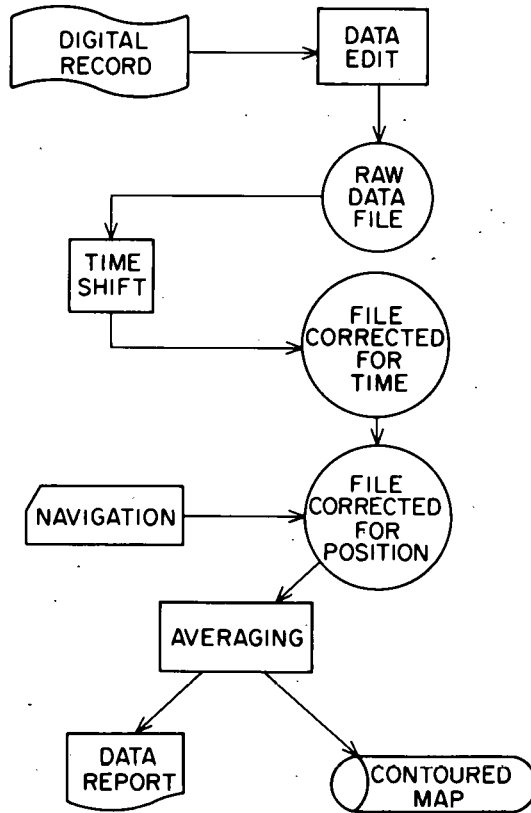


Figure 3-3. Flow Diagram of Computations

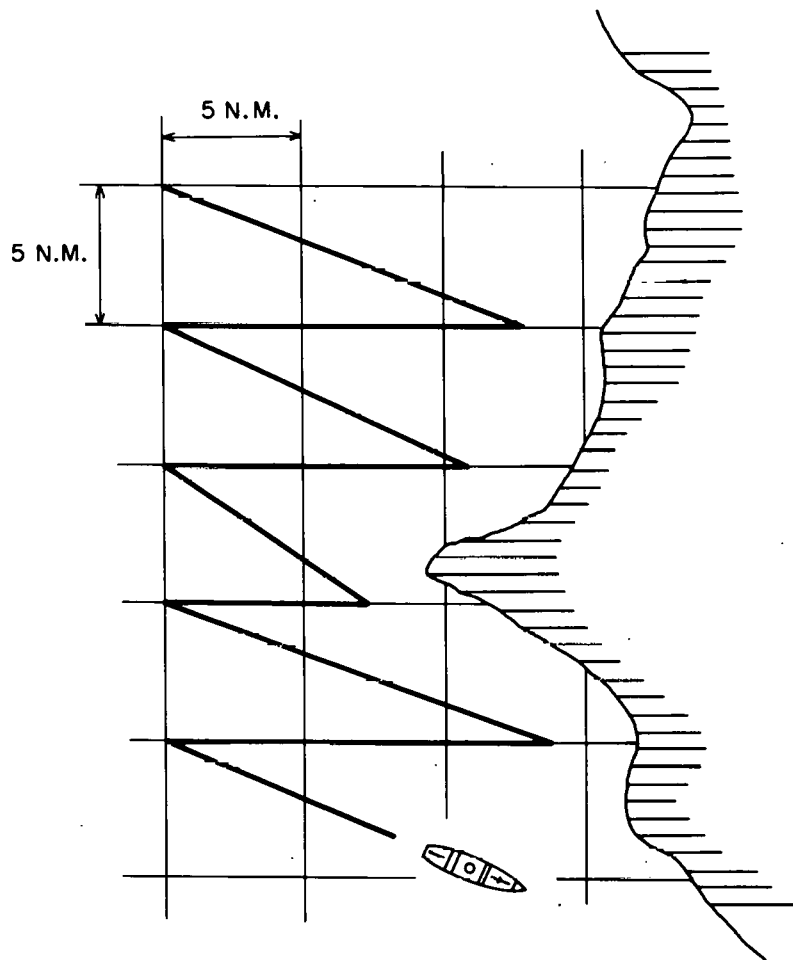


Figure 3-4. Example of Survey Grid and Mapping Pattern

The multivariate time series also can be uniquely mapped into the x, y, z space from which the samples are taken. For the surface sampling system depth, z is assumed constant and equal to 3 meters, and x and y are the geographic coordinates of the ship position. In the system described here, geographic positions are usually determined by entering fixes and their times and by interpolating linearly between them. The ship movement is assumed to be a straight line between fixed positions at a constant speed.

Once the file has been edited, the time shift effected, and navigational information included, the data can be presented in a number of ways. First, the contents of the file can be printed. The data in any single column can be plotted as a time series. Our method of presentation, which has proven quite useful, has been to plot the data in appropriate horizontal positions and contour them to produce a map of the geographic distributions of the measured variables. These surface maps represent an approximation of the two-dimensional fields of the variables. When the data acquisition system is employed in this mapping activity the ship is deployed along a zig-zag course to cover the area of interest as uniformly as possible with a minimum of course changes. The ship typically steams this pattern over a standard grid (Figure 3-4) approximately 20 x 50 nautical miles in size and with a grid point spacing of 5 nautical miles. With the ship underway at 12 knots, scanning data channels once per minute yields a data point spacing of 370 m in the horizontal. This particular sampling pattern is somewhat arbitrary, but it has evolved over a period of years. The contouring program uses a planar least squares interpolation from the randomly located data points to a square grid and contours the grid points. Several contouring methods have been investigated, but the grid interpolation scheme has been chosen because the goal of the contouring procedure was to define the total x, y field of the variables. Most schemes overemphasize the importance of individual data points and honor them exactly at considerable cost to the quality of interpolation to areas between data points. For some applications of automatic contouring techniques, such as topographic mapping, data points are often selected on the basis of their diagnosticity but in the application described here the locations of particular data points are totally fortuitous and the inclusion of a particular data point in the file implies nothing about its relative importance for field definition. Additional discussion concerning underway nutrient mapping are given by Cruzado, 1971; Cruzado and Kelley, 1973; Cruzado, 1974; and in situ mapping by Bernhard and Piro, 1971.

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#### 4. COOKBOOK OF CURRENT NUTRIENT METHODS

This section gives a detailed account of the reagents, manifold configuration and operating instructions for the AutoAnalyzer II system that is currently being used for the analysis of orthophosphate, dissolved silicon (silicate), nitrate plus nitrite, nitrite, ammonium and urea nutrients. Analytical methods change with time as more is learned about the optimum conditions needed for the chemical reactions to occur. As a result this section will need to be updated continually and the description presented here should be considered only our best effort at the time the material was written.

A large number of references are appended (Appendix A) to provide a convenient source of the past information available on manual and automated oceanographic nutrient analyses. Some of the most applicable clinical and analytical chemistry sources are included for completeness.

The chemicals and manifold components are detailed for each analysis in Appendix B. Technicon part numbers are listed for each manifold component and the manufacturers of chemicals are described. In some instances the purity of a few chemicals depends greatly on their source.



## Orthophosphate

Phosphate is determined as phosphomolybdic acid which in its reduced form in the presence of antimony has an absorption maximum at 880 nm. The method reported here is basically an automated version of the Murphy and Riley (1962) procedure. The phosphate manifold is illustrated in Figure 4-1.

### Reagents:

Molybdate solution. Dissolve 17.0 g of ammonium molybdate in 1 liter of DDW contained in a 2 liter volumetric flask. Add 200 ml conc. sulfuric acid slowly and allow the solution to cool under running tap water. Next add 0.37 g of potassium antimonyl tartrate (KAT) which has been previously dissolved in 20 ml of DDW. Dilute to the mark with DDW, transfer to a nalgene bottle, and 2 ml of a 15% w/w solution of sodium lauryl sulfate (SLS).

Ascorbic Acid Solution. Stock solution. Dissolved 6 g of ascorbic acid in 200 ml of acetone and 200 ml DDW. Store this stock solution in the refrigerator. To make the running solution, add 20 ml stock ascorbic acid to 100 ml DDW. Prepare a fresh dilution daily if the autoanalyzer is not run continuously.

Dilution Water. Pipet 0.5 ml SLS in 1000 ml DDW. Prepare daily.

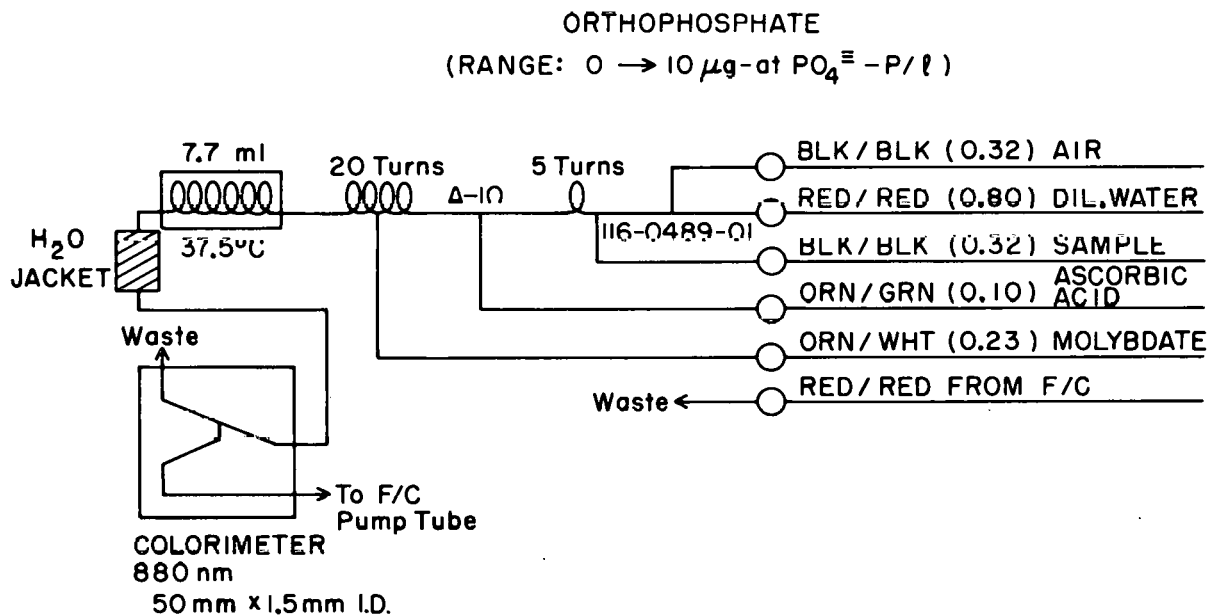


Figure 4-1. Orthophosphate Manifold for AutoAnalyzer 11

## Orthosilicic Acid

Orthosilicic acid is determined by its reaction with molybdate in aqueous acidic solution to form silicomolybdic acid. In this procedure, which is basically that of Armstrong, Stearns and Strickland (1967), stannous chloride is used to reduce silicomolybdic acid to the heteropoly acid which has an absorption maximum at 820 nm. The silicate flow diagram is shown in Figure 4-2. Reagents:

Molybdate. Dissolve 10 g ammonium molybdate in 800 ml DDW and 2.8 ml conc  $H_2SO_4$  contained in a 1 liter volumetric flask - dilute to the mark with DDW - transfer to a 1 liter poly bottle and add 1 ml SLS. DO NOT REFRIGERATE.

Tartaric Acid. Dissolve 100 g of tartaric acid in 950 ml DDW contained in a 1 liter nalgene bottle and dilute to the mark. Add a few drops of Chloroform and store in the refrigerator.

### Stannous Chloride.

- a) Stock solution. Dissolve 40.0 g of stannous chloride in 50 ml conc. HCl, add 50 ml DDW and store in a small narrow-mouthed pyrex reagent bottle. Seal with a rubber stopper and store in the refrigerator.
- b) Running solution. Add 0.5 ml stock solution to 100 ml of DDW contained in a small poly bottle. Prepare fresh daily.

## ORTHOSILICIC ACID

(RANGE: 0-50  $\mu$ g - at  $Si(OH)_4-Si/I$ )

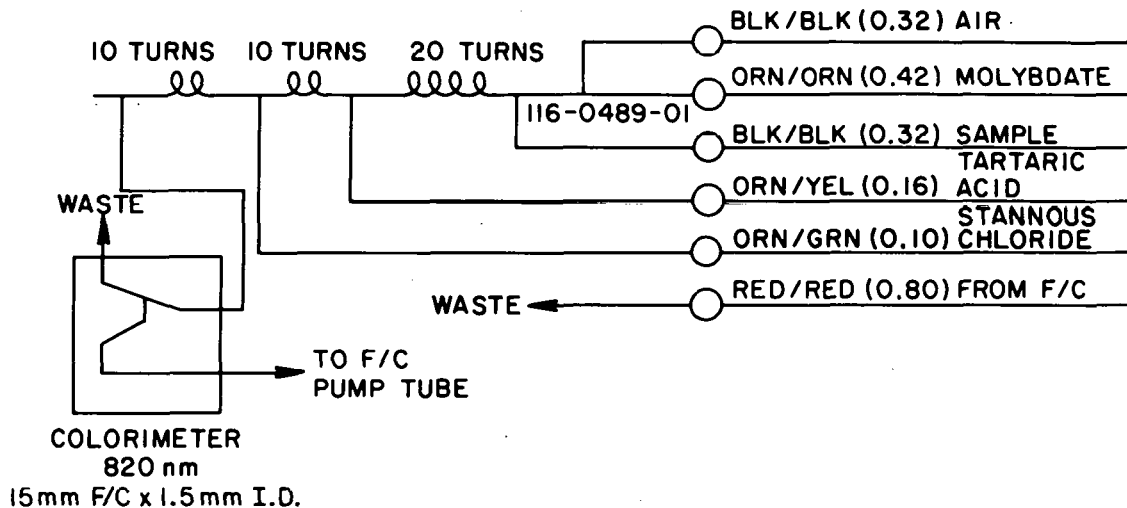


Figure 4-2. Orthosilicic Acid (Silicate) Manifold for AutoAnalyzer II

## Nitrate + Nitrite, Nitrite

Nitrite is determined by the Greiss reaction in which sulfanilamide and N-(1-Naphthyl)ethylenediamine dihydrochloride (NNED) reacts with nitrite in aqueous acidic solution to form an intensely pink diazo dye with an absorption maximum at 540 nm (Bendschneider and Robinson, 1952). Nitrate, after it is reduced to nitrite by passage through a column containing copperized cadmium filings (Wood, Armstrong and Richards, 1967), is determined in an identical manner. Thus the sum of nitrate plus nitrite is determined in the nitrate procedure (Figures 4-3 and 4-4). Note that the cadmium column is quite small so that retention time and dispersive effects are minimized and no loss of efficiency is observed.

### Reagents:

Ammonium Chloride. Dissolve 10 g of ammonium chloride in 2 liter of DDW.

Sulfanilamide. Dissolve 10 g sulfanilamide in a solution of 600 ml DDW and 100 ml conc. HCl contained in a 1 liter volumetric flask. Dilute to the mark with DDW, transfer to a 1 liter nalgene bottle, add 0.5 ml Brij-35 wetting agent and store in the refrigerator.

Nitrite Dilution Water. Add 0.5 ml Brij-35 to 1 liter of DDW.

N-(1-Naphthyl)ethylenediamine dihydrochloride (NNED). Dissolve 1.0 g NNED in 800 ml DDW contained in a 1 liter volumetric flask. Dilute to the mark with DDW, transfer to a 1 liter nalgene bottle, add 0.5 ml Brij-35 wetting agent and store in the refrigerator.

NITRATE + NITRITE

(RANGE: 0 → 15 μg-at / l (50mm F/C)  
 0 → 50 μg-at / l (15mm F/C)

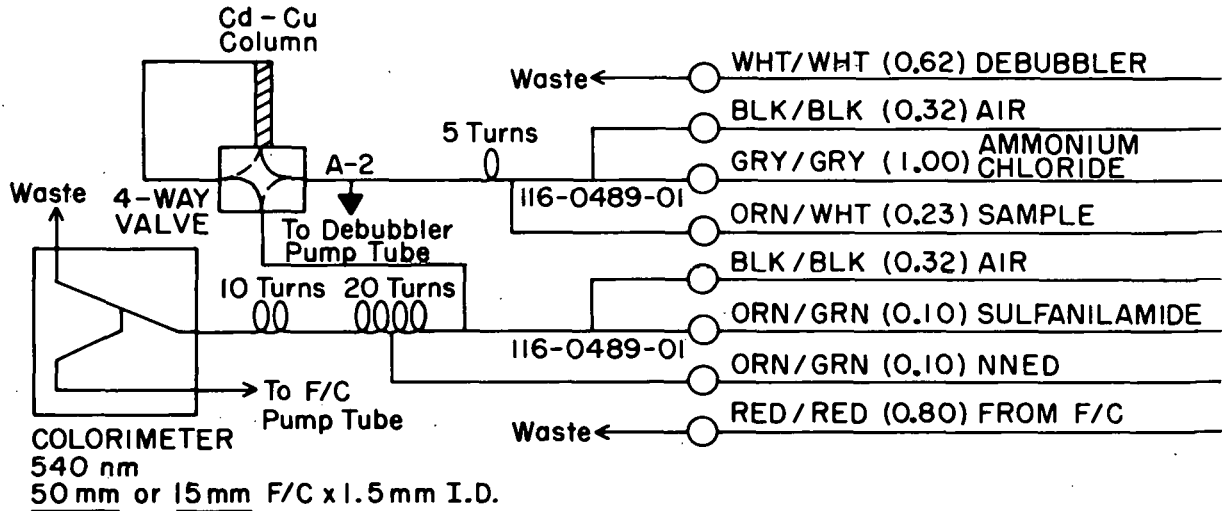


Figure 4-3. Nitrate plus Nitrite Manifold for AutoAnalyzer II

NITRITE

( RANGE: 0 → 10 μg-at NO<sub>2</sub><sup>-</sup> - N / l )

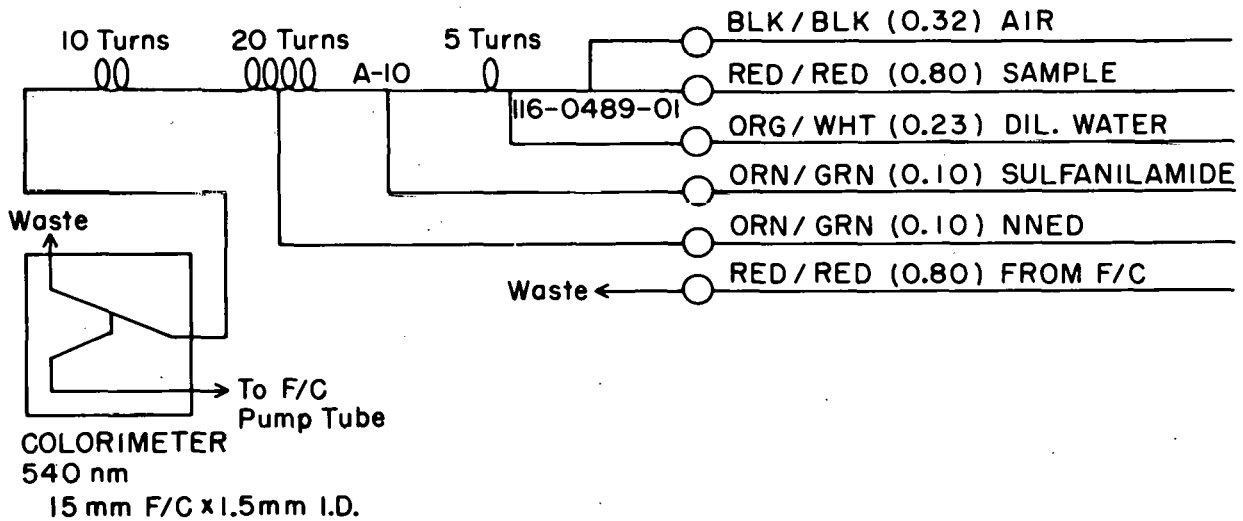


Figure 4-4. Nitrite Manifold for AutoAnalyzer II

Preparation of Nitrate Reduction Column:  
Copperized cadmium filings.

- a) Filings are most easily prepared by holding a coarse file at a 45° angle to a cadmium rod which is turned at slow speed on a lathe.
- b) Sieve the filings and retain the 30-60 mesh fraction.
- c) Remove any ferrous metal from the sieved filings with a magnet.
- d) Next wash the filings with several portions of carbon tetrachloride and dry on filter papers.
- e) Place the dry filings in a small glass beaker and cover with 75 ml DDW.
- f) Add conc. nitric acid drop-wise while stirring until redbrown nitrogen dioxide is evolved copiously. This pits the surface of the filings greatly increasing their surface area.
- g) After about a minute, decant the liquid and rinse thoroughly (9-10 times) with DDW.
- h) Rinse thoroughly with 10% v/v HCl.
- i) Again rinse thoroughly with DDW.
- j) Next treat the prepared filings with 25 ml portions of 2% w/v copper sulfate solution. When the blue color fades from the solution, decant it and add a fresh portion. Continue this procedure until the blue color does not fade (usually 8-10 times). The filings will appear charcoal gray and the supernatant liquid will be turbid at this stage. Rinse 8-10 times with DDW.
- k) Rinse the filings in a 1% w/v ammonium chloride solution until they appear bright silver-gray and the supernatant liquid is clear. The filings are now ready to be packed in the column.
- l) Excess copperized cadmium filings should be stored under seawater containing ammonium chloride in a tightly sealed glass jar where they are stable for at least 1 year.

Packing the column (Figure 4-5B)

- a) With the column (65 mm x 4 mm OD pyrex tube with a constriction at one end) in place on the manifold, attach a small glass funnel to the top of the column by means of a tygon sleeve.
- b) With the system pumping, open the 4-way valve to allow ammonium chloride to fill the column and partially fill the funnel.
- c) Using a rigid wire push a small plug of glass wool to the bottom of the column.
- d) Next add the copperized cadmium filings, a spatula tip full at a time. Tap the side of the column gently with the spatula to ensure proper packing. Continue this process until the filings almost fill the column.
- e) Insert a small plug of glass wool, remove the funnel, and insert an N-6 nipple (Figure 4-5A).
- f) Connect the top of the column to the 4-way valve with a short length of teflon tubing (0.5 mm ID).

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Note: If a large volume of air passes through the column it will have to be repacked. The filings, however, are unharmed, so simply empty them into a small beaker containing ammonium chloride solution and use them to repack the column. Add additional filings if necessary.

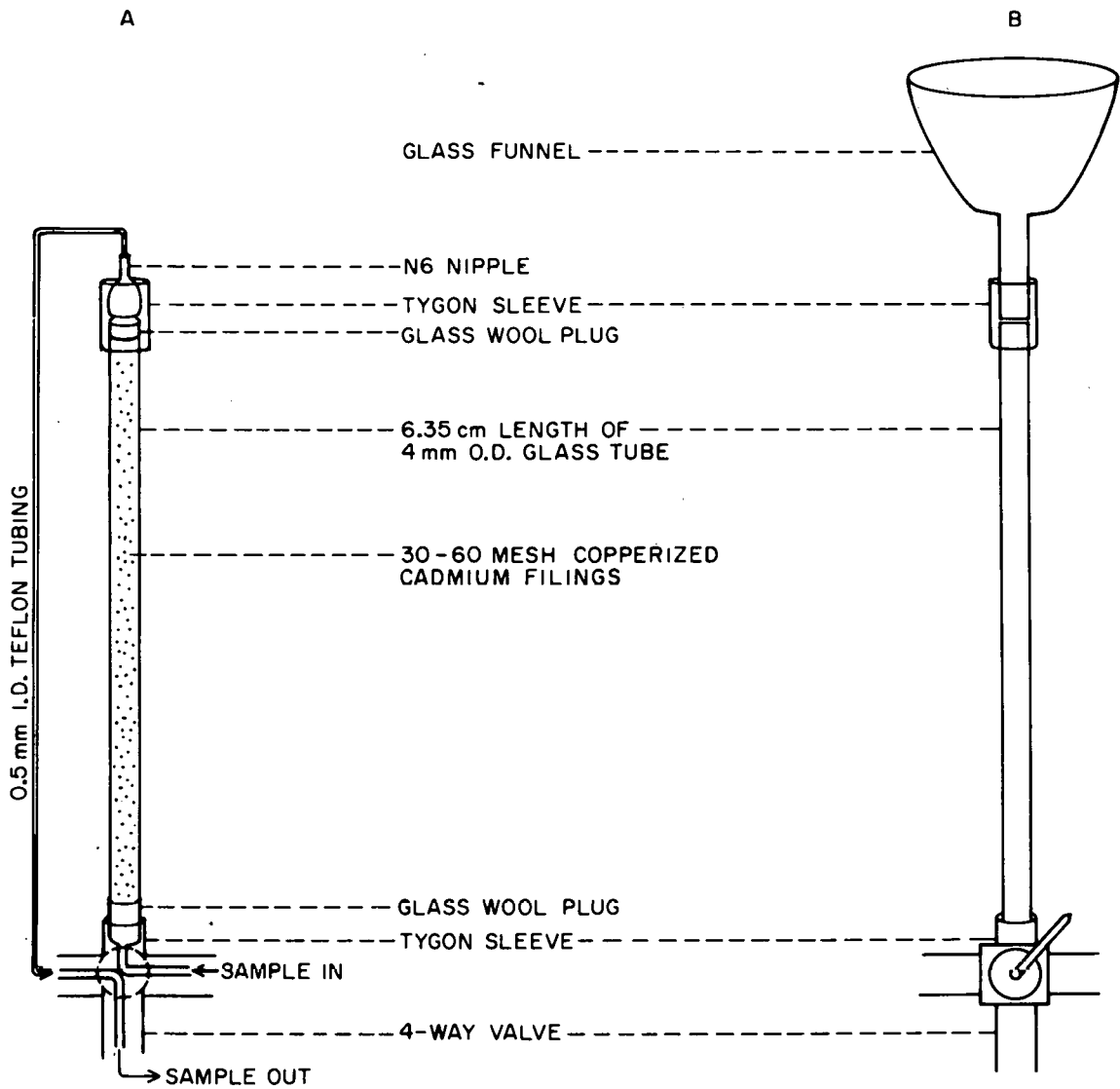


Figure 4-5. A) Cadmium Column for Nitrate plus Nitrite in Running Mode  
 B) Column Ready for Packing with Cadmium Filings

## Ammonium

Ammonium is determined by the Berthelot reaction in which hypochlorous acid and phenol react with ammonium in aqueous alkaline solution to form indophenol blue, an intensely blue chromophore with an absorption maximum at 637 nm. The method presented below is a modification of a procedure reported by Slawyk and MacIsaac (1972). Additional information on the kinetics of the reaction may be found in a paper by Patton and Crouch (1977). Figure 4-6 shows the flow diagram for this method.

Reagents:

### Reagent A.

**Stock Solution.** Dissolve 35.0 g of phenol and 0.40 g of sodium nitroprusside dihydrate in ~800 ml of deionized distilled water (DDW) contained in a 1 liter volumetric flask. Dilute to the mark with DDW, transfer to a 1 liter nalgene bottle and store in the refrigerator.

**Reagent B.** Dissolve 5.0 g sodium hydroxide in 800 ml DDW contained in a 1 liter volumetric flask. Add 50 ml Chlorox and dilute to the mark with DDW. Store in a 1 liter nalgene bottle in the refrigerator.

**Dilution/Complex.** Dissolve 140.0 g sodium citrate and 5.0 g sodium hydroxide in 1 liter DDW and refrigerate.

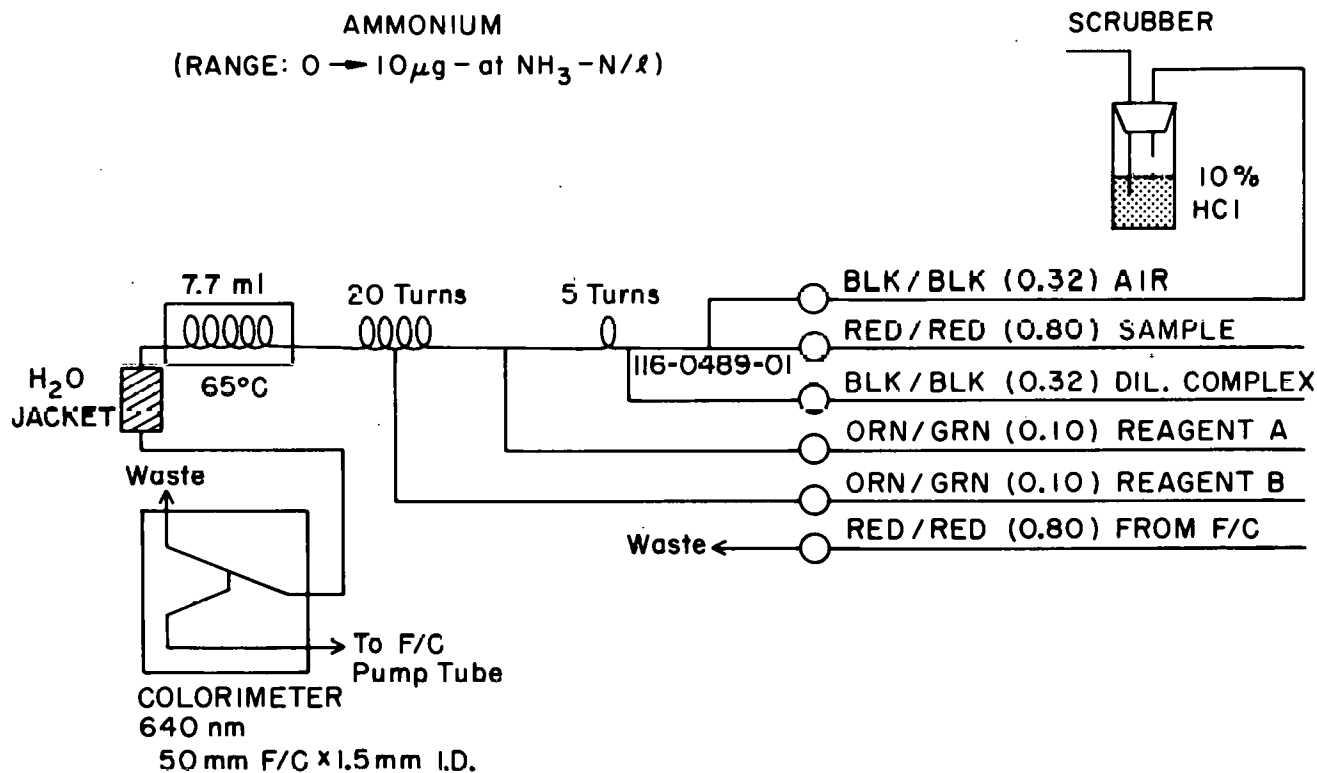


Figure 4-6. Ammonium Manifold for AutoAnalyzer II

Urea

The urea analysis is based on the method of DeManche, Curl, and Coughenower (1973). The pink reaction product is measured at 520 nm after heating at 95°C.

Reagents:

Sodium chloride solution. Dissolve 175 g of NaCl in 500 ml DDW. Add 1 ml Brij-35.

Acid phosphate solution.

a) Stock solution. Dissolve 42.50 g of sodium phosphate, mono basic ( $\text{NaH}_2\text{PO}_4 \cdot \text{H}_2\text{O}$ ) in 500 ml conc.  $\text{H}_2\text{SO}_4$ .

b) Working solution. Add 147 ml of stock acid phosphate to about 100 ml DDW in a 250 ml volumetric flask. Cool under running tap water and make up to the mark with DDW.

Semicarbazide HCl stock. Dissolve 1.2 g semicarbazide HCl in 100 ml DDW. Refrigerate the solution.

Manganous chloride and potassium nitrate solution. Dissolve 15.7 g  $\text{MnCl}_2 \cdot 4\text{H}_2\text{O}$  and 0.30 g  $\text{KNO}_3$  in 100 ml DDW.

Color Reagent. Dissolve 1.65 g of diacetylmonoxime in 65 ml hot DDW ( $\sim 80^\circ\text{C}$ ) and then cool to room temperature. Add 1.65 ml of semicarbazide stock and 33.3 ml of  $\text{MnCl}_2 + \text{KNO}_3$  stock solution. Prepare a fresh solution daily.

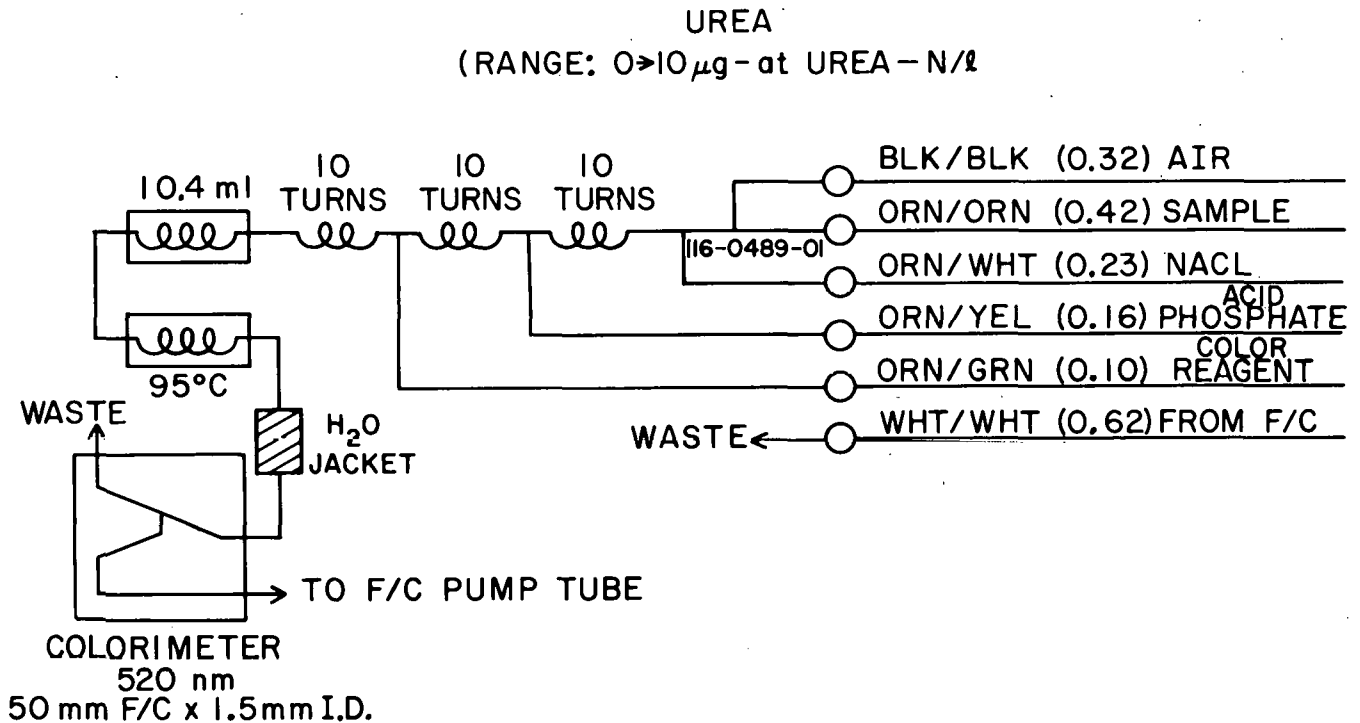


Figure 4-7. Urea Manifold for AutoAnalyzer II



## Chemicals - Storage and Handling

- a. Crystalline stannous chloride, ascorbic acid, and phenol may deteriorate rapidly at room temperature, so these bulk reagents should be refrigerated. We have obtained the best results with the chemicals suggested in the appendix.
- b. Keep prepared reagent solutions refrigerated at all times. Transfer only the amounts of reagents expected to be used in one day of operation to small pyrex or plastic bottles for use at the AutoAnalyzer bench. Table 4-1 below can be used to estimate reagent consumption.
- c. Wipe reagent straws dry with a tissue before placing them in reagent bottles. Seal the top of the reagent bottles with parafilm after the reagent straw is in place. Never release the platten until reagent straws are removed from reagent bottles. These measures prevent cross contamination of reagents.
- d. Wetting agents are essential for proper flow in the AAI system. Brij-35 seldom causes problems. Sodium lauryl sulfate (SLS) on the other hand will precipitate if stored at too low a temperature. Simply place the bottle containing SLS in warm water to redissolve.

Table 4-1  
Approximate Reagent Consumption

Color-code	Pump Tube Flow-rate (ml/min)	Consumption (ml)	
		per 8 hrs.	per 24 hrs.
ORN/GRN	0.10	48	144
ORN-YEL	0.16	77	231
ORN/WHT	0.23	110	330
BLK/BLK	0.32	154	462
ORN/ORN	0.42	202	606
WHT-WHT	0.62	298	894
RED/RED	0.80	384	1152
GRN/GRN	2.00	960	2880

### Glassware

- a. Use only "Type A" pipettes and volumetric flasks. We use continuously adjustable microliter pipettes with disposable plastic tips instead of glass pipettes for mixed standard preparation.
- b. Clean glassware periodically with a mild detergent solution. Always rinse glassware with dil. HCl and DDW just prior to use.

### Plumbing

- a. When the flow stream is unsegmented, use small ID nonwetable tubing such as teflon or polyethylene. Keep the lines as short as possible and use low dead-volume connectors (e.g., stream dividers). Use the same type of tubing to connect reagent straws to pump tubes. Reagent pump tubes are connected to the manifold with extensions made from old pump tubes of matching ID.

- b. Air segmentation of the flow stream and addition of the first reagent should be accomplished in an injector fitting (Technicon 116-0489-01). Subsequent reagent additions should be made either through the platinum side arms provided in some mixing coils or through A-10 fittings. Once the flow stream is segmented use 2 mm ID x 3.6 mm OD glass tubing for transmission to manifolds and colorimeters.

#### Pump Tubes

- a. Only flow-rated pump tubes should be used.
- b. Silicon rubber tubing should be used underneath the air bar.
- c. New pump tubes should be sprayed lightly with a silicone lubricant. This will greatly extend their useful life time. Once a week spray the platten with this same lubricant. Wipe off the excess with a tissue.
- d. Install new pump tubes after 300 hrs. of operation or sooner if necessary.

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## 5. AUTOMATED ANALYZER AND DATA ANALYSIS SOFTWARE

The tasks of using a computer to collect store and process AutoAnalyzer data requires a hardware interface from the colorimeters and software packages to handle the data. The interface hardware will need to be selected for compatibility with the system software on the particular computer used. In our case the Hewlett-Packard 9845S has an interface card (HP98032A 16 bit parallel I/O card) which was connected to an eight channel analog to digital converter (ADC). A single digital to analog converter (DAC) is also utilized simultaneously through the interface card to control the sampler. A specific description of the interface operation can be found in Section 6, Computer Interfacing and Hardware Modifications.

The software written in BASIC language uses nearly all of the techniques described for peak regeneration by MacAulay et al. (1976). In general, peak regeneration calculates the mixing characteristics of an AutoAnalyzer channel and empirically derives coefficients to calculate what a sample reading should be if dispersion did not exist (or at least ideally minimized).

The following short description will acquaint an unfamiliar reader with the purpose and utility of the software operating procedures.

- a. STAND program. This program takes data read by the computer with the APILOT program and calculates chemical factors for each of the analysis channels. After the factors are calculated the absorbances and concentrations of the standards may be plotted. The chemical factors must be manually entered in the APILOT program.
- b. APILOT program. This program reads peaks while samples are being run on the AutoAnalyzer. An initial input of header information, the number of samples being run and an I.D. code for each sample is needed before the run can begin. The program will control the sampler, set initial and final baselines and will log the peak heights using a software peak regeneration routine. Additional features of this program allows a continuous logging of data points which is used in the BFINDD program to calculate factors for peak regeneration. After a sample run is completed table lists of absorbances, concentrations, time between samples and confidence interval of all samples, data edit to correct errors, data save on cassette tape and data fetch from cassette tape can be made. Regenerated peaks may also be observed on the CRT while the data are collected.
- c. MANDAT program. This program allows manual data entry into a file structure identical to APILOT program. This program also features the table lists, data edit, data save on cassette tape and data fetch from cassette tape.
- d. BFINDD program. This program reads a continuous data tape of standards logged with the APILOT program and calculates "B" factors used in the peak regeneration subrouting in APILOT during samples analyses. The routine collapses the raw data and plots both raw and regenerated sample peaks.
- e. CLOCK program. This program sets the time on the real time clock that triggers the interrupt commands that the computer uses to operate the sampler and log the raw data.

- f. AvsM program. This program compares manually read absorbance values in chart units to automatic computer read absorbance values. The manually read raw peaks, baselines and factors are entered via the MANDAT program and saved on cassette tape. The computer read absorbances are generated by the APILOT program and saved on cassette tape. The AvsM program calls both files, tabulates the differences and plots the results of the differences between the two methods.
- g. PLOT program. This program plots the station concentrations of nutrients in an X-Z plot. The input data are taken from the stored station values on cassette tape. The nutrient to be plotted, concentration scales and depth scales of plots are chosen interactively by the operator.
- h. SECS program. This program plots sections or time series stations. The operator requests the stations in the proper order and the program will store all values in memory. Station positions are read from the nutrient file header for proper placement along the transect line. The values for each nutrient can be written at their proper distance and depth along the transect for later hand contouring. Automatic machine contouring with or without numbers is another option available. Contour intervals are selected interactively by the operator. Ratios of nutrients may also be plotted. Integrated concentrations over an operator-selected depth range can be printed and plotted along the transect.

## STAND PROGRAM - OPERATING INSTRUCTIONS

### STEPS FOR USING STAND - Regression of Standards

1. Insert Autoprogram tape into tape drive 15.
2. Type Load "STAND" and then press Execute.  
The step loads the program into the computer's memory. When the small square of light at the lower right hand corner of the cathode ray tube (CRT) is extinguished, the program is fully loaded and ready for use. Remove program tape and put data dape in drive 15.
3. Press RUN. CRT displays HELLO FROM REGRESSION OF STANDARDS, "VARIABLE NAMES ARE PO4, SIO4, N+N, NH4, X3ON. At the bottom of the screen, CRT prompts you with FILE WANTED.
4. Type in your standard run file name and press CONT. Computer finds and reads your standard file. CRT displays file and prompts "DO YOU WANT A COPY OF THE LIST? Y/N."
5. If you want copy of the list type "Y". Thermal printer gives you a hard copy of the list and CRT "DO YOU WANT A COPY OF THE LIST? Y/N". Again, Type "N" and press CONT. CRT displays REGRESSION SECTION at top of screen and prompts with "VARIABLE NAME".
6. Type one variable name: PO4, SIO4, N+N, NO<sub>2</sub>, NH4, or URE and press CONT. Typing an incorrect variable yields incorrect variable BAD CHOICE TRY AGAIN.  
CRT displays TABLE OF DATA FOR REGRESSION  
Label = station name  
NUTRIENT = nutrient chosen  
N = number of sample, ID - identification, CONC = concentration  
ABS = absorbance and prompts DO YOU WANT TO DELETE? Y/N
7. If you want to delete a bad point, type Y and press CONT. CRT prompts WHICH SAMPLE IS TO BE DELETED? NO.
8. Type in sample number to be deleted and press CONT. If there are several numbers to be deleted, eliminate them in descending order. CRT displays standard table as in 6 above minus deleted sample(s) and "DO YOU WANT DELETE? Y/N" If you delete until the number of sample is <2, an "ERROR IN REGRESSION N = " appears. Regression analysis is invalid.
9. If you do not wish to delete, type "N" and press CONT. Computer performs least squares regression on your data. CRT displays TABLE OF DATA FOR REGRESSION as in 6 including calculated INTERCEPT, SLOPE, R\*R, and FACTOR, and prompts DO YOU WANT A LIST OF THE TABLE? Y/N
10. If you want a list, type Y and press CONT. Thermal printer gives hard copy and CRT displays "DO YOU WANT A PLOT? Y/N"
11. If you do not want a list of the table, press N and then CONT. CRT displays DO YOU WANT A PLOT? Y/N (Go to 12 or 14)
12. Type "Y" and then press CONT if you desire a plot of the regression. CRT plots data. Press CONT. CRT prompts DO YOU WANT A HARD COPY OF THE PLOT? Y/N
13. Type Y for the hard copy and then CONT. Hard copy is output to thermal printer. Computer program returns to step 6.
14. Type "N" and press CONT. CRT and computer go back to STEP 6 and prompts for new variable name.
15. If you desire another standard data file, press CONTROL/RESET simultaneously and then RUN to restart STAND.

## STAND PROGRAM - USER DEFINED PARAMETERS

These are program lines that may need to be changed occasionally by doing a program edit of the designated lines.

### Lines

220 Variable names: Order of variable is constant. Channel 6, URE is the experimental channel, however, the name may be changed if so desired.

690 Channel labels: Same as 111 above.

710 Maximum sample concentration for each channel: For Bering Sea, set channel 2 which is silicate to 100.

940 Concentrations of standards: For Bering Sea work set channel 2 which is silicate to 10 i.e. 0,5,5,0,0,5 becomes 0,10,5,0,0,5

950 Same as 750. Set channel 2 to 30 i.e. 0,15,15,0,0,15 becomes 0,30,15,0,0,15

960 Same as 750. Set channel 2 to 50 i.e. 0,25,25,0,0,25 becomes 0,50,25,0,0,25

970 Same as 750. Set channel 2 to 70 i.e. 0,35,35,0,0,35 becomes 0,70,35,0,0,35.

980 Same as 750. Set channel 2 to 90 i.e. 0,45,45,0,0,45 becomes 0,90,45,0,0,45

LABEL=STANS  
 DATE=26JAN81  
 HR=1600  
 LAT= N.A.  
 LON= N.A.  
 DEPTH= -99  
 COMMENT= WORKING STANDARDS  
 NO.SAMPLES= 11  
 OPERATOR=DMV  
 CHANNEL= P04 S104 N+N NO2 NH4 URE  
 STATUS= 1 1 1 1 1 0  
 FACTORS= 1.039 5.720 4.620 .940 1.016 1.000  
 RF'S= 0.000 0.000 0.000 0.000 0.000 0.000  
 BASE1= 0.000 .190 .379 .307 .218 0.000  
 BASE2= 0.000 .183 .391 .308 .220 0.000

NO.	ID						
1	D 0	0.000	8.004	10.000	4.884	5.158	0.000
2	S 11	0.000	1.245	1.716	.327	.450	0.000
3	S 12	0.000	2.983	3.629	.307	.642	0.000
4	S 13	0.000	4.749	5.776	.301	.444	0.000
5	S 14	0.000	6.514	7.904	.300	.420	0.000
6	S 15	0.000	8.217	9.996	.296	.429	0.000
7	S 25	0.000	.189	1.251	.198	4.861	0.000
8	S 24	0.000	.178	.994	.567	4.001	0.000
9	S 23	0.000	.176	.820	3.002	2.731	0.000
10	S 22	0.000	.178	.651	1.960	2.069	0.000
11	S 21	0.000	.173	.482	.875	.960	0.000



TABLE OF DATA FOR REGRESSION

LABEL=STAN5

NUTRIENT=SI04

N	ID	CONC.	ABS
1	S11	5.000	1.056
2	S12	15.000	2.795
3	S13	25.000	4.561
4	S14	35.000	6.327
5	S15	45.000	8.031

INTERCEPT= .183

SLOPE= .175

R\*R= 1.000

FACTOR= 5.720

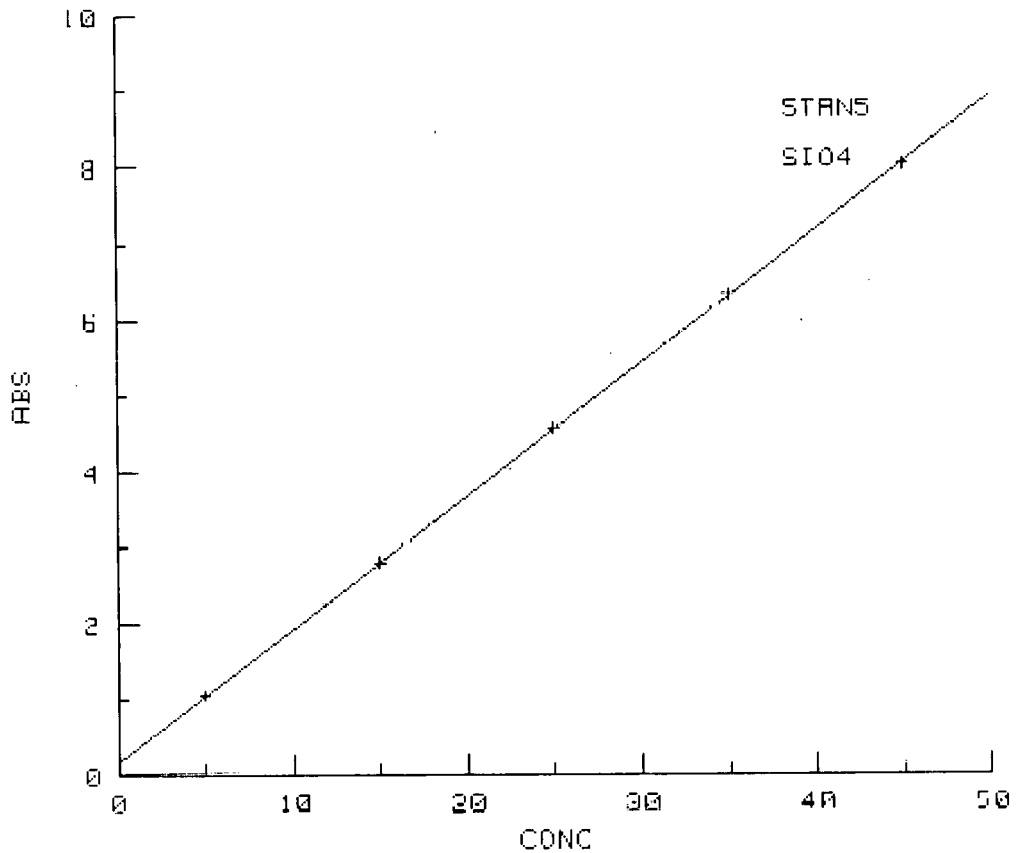


TABLE OF DATA FOR REGRESSION

LABEL=STANS

NUTRIENT=N+N

N	ID	CONC.	ABS
1	S12	15.000	3.248
2	S13	25.000	5.394
3	S14	35.000	7.520
4	S15	45.000	9.611
5	S25	4.500	.865
6	S24	3.500	.607
7	S23	2.500	.432
8	S22	1.500	.262
9	S21	.500	.092

INTERCEPT=-.072

SLOPE=.216

R\*R= 1.000

FACTOR= 4.620

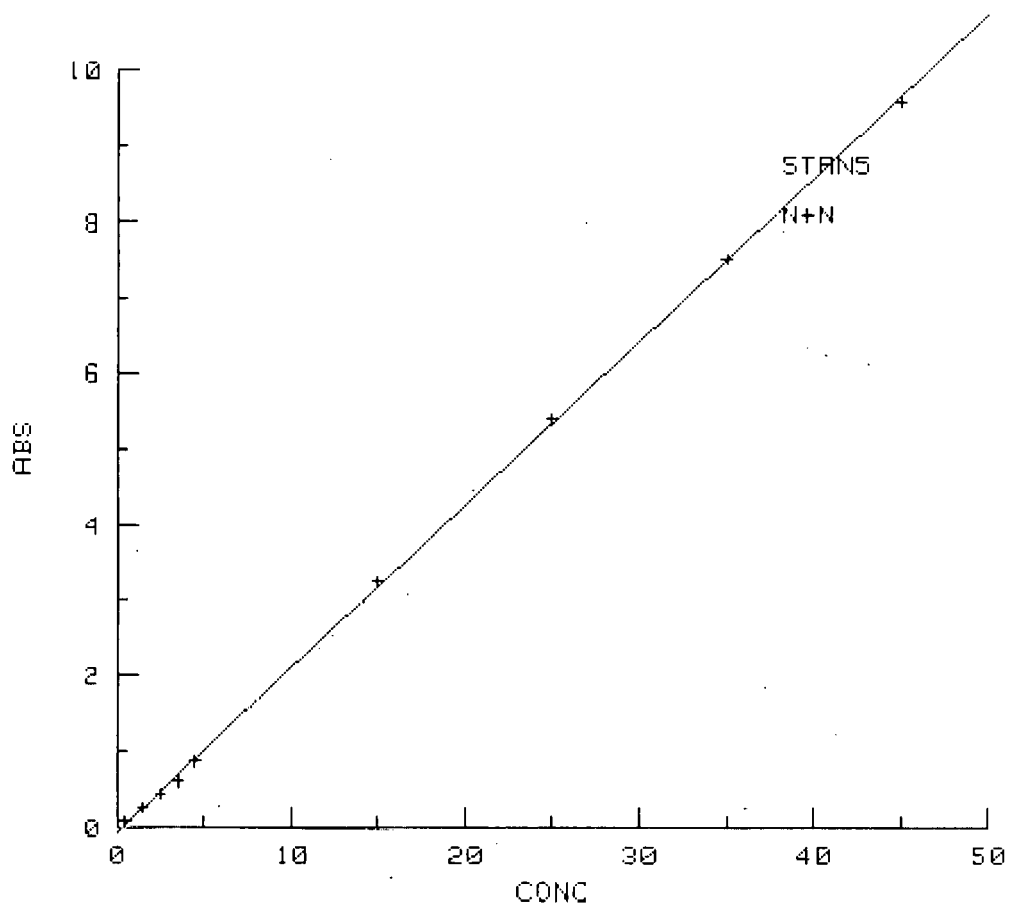


TABLE OF DATA FOR REGRESSION

LABEL=STANS  
NUTRIENT=NO2

N	ID	CONC.	ABS
1	S23	2.500	2.694
2	S22	1.500	1.652
3	S21	.500	.567

INTERCEPT= .043  
SLOPE= 1.063  
R\*R= 1.000  
FACTOR= .940

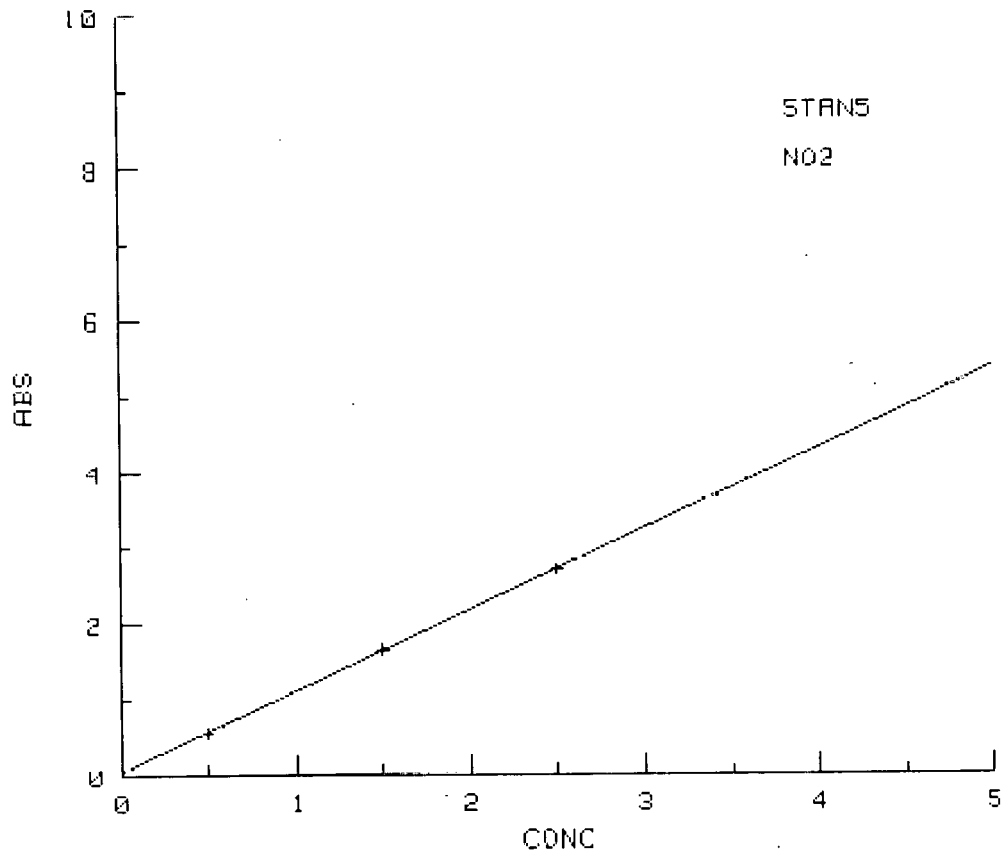


TABLE OF DATA FOR REGRESSION

LABEL=STAN5

NUTRIENT=NH4

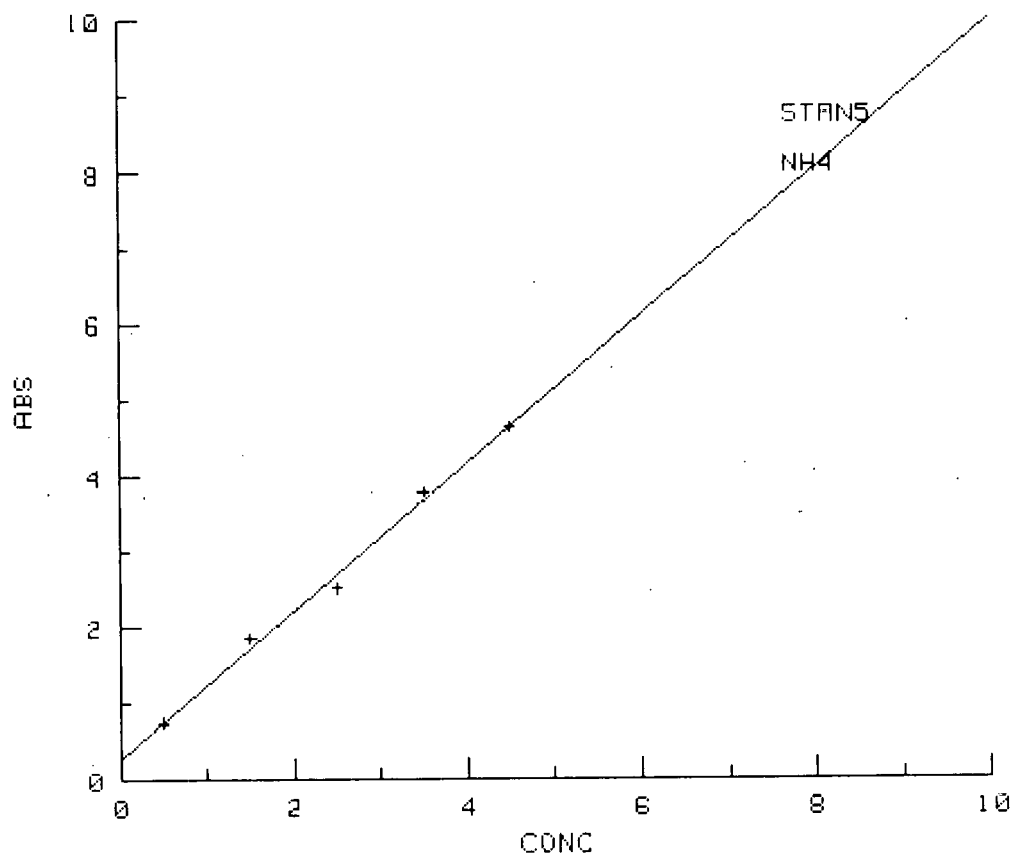
N	ID	CONC.	ABS
1	S25	4.500	4.641
2	S24	3.500	3.782
3	S23	2.500	2.511
4	S22	1.500	1.849
5	S21	.500	.740

INTERCEPT= .271

SLOPE= .974

R\*R= .993

FACTOR= 1.027



INSTRUCTIONS FOR THE AUTOMATIC PEAKING FINDING  
ROUTINE KNOWN AS "APILOT"

1. Have AutoAnalyzer log sheet filled out with station number, date, time, latitude, longitude, sonic depth, sync standard, calibration standards, nutrient sample numbers, and the sample depths from the hydrographic or productivity log sheets. See sample log sheet at the end of this description of APILOT
2. Insert the Auto program tape into tape drive 15.
3. Type LOAD "APILOT" and then press Execute. This step loads the program into the computer's memory. When the small square of light at the lower right hand corner of the cathode ray tube (CRT) is extinguished, the program is fully loaded and ready for use. Press K7 to rewind the Autoprogram tape. After rewinding the tape, remove and place in protective case. Place an initialized data tape in tape drive 15.
4. Press RUN. CRT displays "Hello From Auto Pilot". "I HAVE RUN OFF TO GET THE TIME BACK IN 20 SEC." After pause, "CLOCK TIME IS correct time." CRT then prints "IS DATA FROM TAPE? Y/N"
5. Press "N" and then CONT  
Display prints "DO YOU WANT TO SAVE DATA FILE ON TAPE? Y/N"
6. Press "N" and then CONT. Thermal printer writes on  
KEY 0 INIT  
KEY 1 LIST  
KEY 2 PEAK  
KEY 3 EDIT  
KEY 4 SAVE  
KEY 5 FINI  
KEY 6 FE'CH  

"When in doubt, press CONTINUE, something will happen" CRT displays flashing "WAITING FOR COMMAND". At this point you must set up table for receiving the peaks.
7. Press K0. CRT displays "HELLO FROM INITIALIZE" LABEL [6]? Enter station number as 001, 002, etc. You may wish to identify station type as Hydro, Productivity, Interface, Pump, Benthic, Zooplankton, or Miscellaneous sample run as H, P, I, Q, Z or M respectively. For example H001 indicates station No. 1 is Hydro. Station label cannot contain more than 6 characters - hence [6] after LABEL. (See examples at the end of this section that show the several kinds of tables.)
8. Press CONT after entering the label. CRT displays "DATE [7]?"
9. Type in date as day number (2 characters), month (3 characters), year (2 characters).  
Examples: 01MAR79      21APR79
10. Press CONT after entering date. CRT displays "TIME [4]". Type in the time (4 characters using 24 hour clock)  
Examples: 0014      2341  
Press CONT. CRT displays "LAT? 12A or [CONT]" Enter Latitude (Maximum 12 characters) if available.  
Examples: 40 20.1      56 01.1  
Press CONT. CRT displays "LON? 12A or [CONT]" Enter Longitude (maximum 12 characters) if available.  
Examples: 70 29.6      150 02.1

Press CONT. CRT displays "STATION DEPTH? FLOAT or [CONT]" Enter depth if available.

Examples: 26 1046

Press CONT. CRT displays "COMMENT? 50A or [CONT]" Enter your comment (maximum 50 characters).

Example: TIME SERIES STATION 1

11. Press CONT. CRT displays "OPERATOR [6]?"

12. Enter your initials or name up to 6 characters.

Example: TEW

13. Press CONT. CRT displays "NO. SAMPLES?"

14. Type in the number of samples (including the three standards) for this run and press CONT. CRT displays "DO YOU WANT TO CHANGE THE TABLE? Y/N"

(NOTE: Each individual hydro station should be a separate run, i.e. never set up a tray with 2 or more hydro stations or a hydro and prod station in same run. This prevents a lot of extra work in data processing later.)

15. Press "Y" and then CONT. If you have a mistake in the completed table, type N which takes you back to Step 7. Type in correct parameter and press CONT again and again until computer and you return to step 14 - "DO YOU WANT TO CHANGE THE TABLE? Y/N"

16. Press "N" and then CONT. CRT displays "ENTER SAMP ~, ID OPTIONS = EXIT and LIST)". "NO; ID?"

17. TYPE in sample sequence number, a comma, sample ID, and depth or sample number if it is an experimental sample.

Examples:

4,H0	(seq. no. 4 - hydrography sample, 0 meters)
15,H120	(seq. no. 15 - hydrography sample, 120 meters)
19,P5	(seq. no. 19 - productivity sample, 5 meters)
21,I19	(seq. no. 21 - interface sample, 19 meters)
22,Q10	(seq. no. 22 - pump sample, 10 meters)
23,Z250	(seq. no. 23 - Zooplankton experiment sample, bottle no. 250)
24,B101	(seq. no. 24 - Benthic sample, bottle no. 101)
25,M12	(seq. no. 25 - Miscellaneous sample, bottle no. 12).

NOTE: The first 3 bottles of any run are standards.

Bottle No. 1 is 1,D0

Bottle No. 2 is 2,S1\_\_

Bottle No. 3 is 3,S2\_\_

D0 is a mixed synchronization standard for all channels.

S1\_\_ and S2\_\_ are calibration standards. The \_\_ is a number, 1 to 5, corresponding to the standard concentration (discussed section 3 under standards).

18. Press CONT and repeat Step 17 until all bottle sequences and ID's have been entered. (Note it is very important to run bottles in numerical sequence to avoid data processing problems later).

19. Press "L" and then CONT after entering last sample. CRT displays "HELLO FROM LIST" "1=ABS 2=UG-AT"

20. Press "l" and then CONT to obtain a list of your entered material. CRT displays "DO YOU WANT A HARD COPY? Y/N"

21. If table is correct, press "N" and CONT. CRT displays "ENTER SAMP No., ID, OPTIONS = EXIT or LIST)"

22. Press "E". CRT displays "INITIALIZE FINISHED" "WAITING FOR COMMAND" in flashing characters. (Go to Step 24.)

23. If table is incorrect, press "Y" and CONT. CRT displays "ENTER SAMP No., ID (OPTION = EXIT OR LIST)" "NO., ID?" Type in correct sequence number and ID and press CONT. (Go to Step 19.)
24. Press  $K_7$  to enter check. CRT displays check \_\_, \_\_, \_\_, \_\_, \_\_, \_\_. In check, the time and absorbances for all six channels are displayed. Examine CRT value and strip chart values to see if they correspond. If they are not the same, adjust zero knob on recorder until value is in agreement with CRT value.  
NOTE: The above adjustment assumes recorder has been checked previously against colorimeter to assure full scale is being used.
25. Press  $K_7$  to exit "check". CRT displays "WAITING FOR A COMMAND" in flashing type.
26. Press  $K_2$  if all the channels are ready to run samples. The sampler is controlled by the computer and the channel delay times are entered into the program so the baselines are set automatically for each channel 30 seconds before the first sample reaches the colorimeter.  
So sit back and relax as the peaks are read.
27. At any time you can obtain a table update of the peaks on the CRT by pressing  $K_{11}$ .
28. When all peaks have been read and baselines have flattened, the baselines will automatically be set about one sample time after the last peak. CRT displays "Waiting for Command" in flashing characters.
29. Press  $K_1$  to obtain list. CRT prints "HELLO FROM LIST" "1=ABS, 2=TIME, 2=DELTA TIME, 4=AG-AT, 5=CONFID"
30. Press 1 and then CONT to obtain list of absorbances on CRT. CRT displays also "DO YOU WANT A HARD COPY?"
31. Press "Y" to obtain thermal printer hard copy. CRT displays "WAITING FOR COMMAND"
32. Press  $K_1$  to obtain list. CRT prints "HELLO FROM LIST" "1=ABS, 2=TIME, 3=DELTA TIME, 4=UG-AT, 5=CONFID"
33. Press 4 to obtain a list in UG-AT. CRT displays also "DO YOU WANT A HARD COPY, Y/N?"
34. Press "Y" to obtain a hard copy of list in UG-AT. CRT displays "WAITING FOR COMMAND" in flashing characters.
35. Press  $K_4$  to save the file. CRT displays "HELLO FROM SAVE" "DO YOU WANT TO SAVE THE FILE, Y/N?"
36. Press "Y" and then CONT. CRT display "TAPE DRIVE 14 or 15"
37. Type 15 and then CONT. When file has been save, CRT prints "FILE HAS BEEN SAVE ON T:15"
38. To set up for another run, press CONTROL and RESET simultaneously and then RUN. Go to Step 4.  
Regenerated peaks may be viewed on the CRT after the peak reading routine has been started. The channel number of the analysis you want to view must be entered:  
Cplot=3 Execute will display N+N channel then press  $K_9$ .  
The plot will appear on the screen. To exit, repress  $K_9$ .

Emergency - Instructions for Use of Knobelsdorf Timer with "APILOT"

In the event that the sampler control system fails, it is possible to easily utilize the Knobelsdorf electronic timer using the following steps.

1. Check line 5300 in "APILOT" program for sample: wash time increments. Set the Knobelsdorf timer and "APILOT" program for identical sample and wash times.
2. Set up file structure in "APILOT" in the usual manner and load samples in sample tray. Load a distilled water bottle at the beginning of samples in front of the sync sample but do not enter in computer file. Put turn-off pin next to the last sample bottle.
3. Push key 7 and go into "check" mode.
4. Turn sampler "off" and "on" to start Knobelsdorf timer.
5. When timer goes into the first bottle which is dionized water, turn off "check" and turn on "check" again using key 7.
6. When using a 120 second sample and 60 second wash, exit "check" with key 7 when the counter on the CRT reaches 600.
7. In about 10-15 seconds the sampler will go into a wash cycle. When the needle leaves the sample bottle of deionized water press "PEAK FINDER," key 3, to start data logging.
8. The complete set of readings will be automatically taken. No further instructions are necessary until "WAITING FOR A COMMAND" appears on the CRT after which the data is processed normally.



## APILOT PROGRAM - USER DEFINED PARAMETERS

In most of the programs associated with the computer assisted AutoAnalyzer, there are lines which should or can be edited by the user. These user defined parameters (factors are most frequently changed) are entered immediately after a program has been loaded into the computer's memory.

1. To change a user defined parameter, press EDIT LINE. Type in the line number and press EXECUTE. The CRT will display this line with the blinking cursor to the right of it. Move the cursor to the parameter to be changed and edit it.
2. Press STORE. The edited line is now in the computer's memory. If you don't press STORE the original line will not be retained.
3. Press CONTROL/RESET simultaneously and then RUN. Your edited program is now ready for use.

The common user defined parameters for each AutoAnalyzer program are listed below by line number.

- 5260 The data in this statement indicate whether a channel is on or off. An active channel is "1" while "0" is inactive. If an analysis is not being performed or if a channel is shut down for some reason, change the status to "0". Operating a non-active channel in the on mode can result in cross talk with an active channel.
- 5300 This line lists the regression factors as determined in STAND. The factors should be updated and changed periodically as the standard runs dictate.
- 5320 The refractive index for each channel is usually determined at the beginning of each cruise, stored in the program, and not altered thereafter unless the manifold is modified.
- 5340 This line lists the B factors calculated in the BFIND program. These numbers, used to determine the regenerated peak heights, are also determined at the initiation of a cruise and remain constant if no changes are made in the manifold colorimeter and the sample and wash times.
- 5360 These six numbers are the times at which the initial baseline is set for each channel. These baseline numbers are set about 15 seconds before the sample stream enters the flow cell. They represent the number of seconds required for a sample to be aspirated, traverse the manifold, and just reach the colorimeter with the present system. If the diameter of the sample pump tube is changed by substitution or the sample line from the sampler to the manifold is significantly lengthened or shortened, the initial baseline time should be redetermined.
- 5380 The second and third numbers in this sequence are the sample and wash times, respectively. Standard rates for the present manifold configurations are 120 seconds of sample and 60 seconds of distilled water wash -- approximately 20 samples per hour. If a faster rate is desired, 60 seconds sample and 30 seconds of wash is satisfactory. When recording data on tape for use in BFIND, sample for 180 seconds and wash for 60 seconds.

In addition, some of these user defined parameters can be altered once a program is engaged. They are Refractive index, Factors, and Baselines.

1. Refractive index is defined by the Mnemonic Rf(\*). To change the refractive index of channel No. 3, type, Rf(3)=value calculated for this channel and press EXECUTE. Follow the same procedure for the other channels if needed. This statement will change the value of

Rf(3) for the file at hand and must be reentered for succeeding files. Rf(3) will not be changed on the program tape using this statement.

2. Factor is defined by the Mnemonic F(\*). To change the factor for channel No. 2, type F(2)=value calculated for this channel and press EXECUTE. Follow the same procedure for the other channels if needed.

3. Baselines

- a. Initial or beginning baseline is defined by the Mnemonic B1(\*). To change the initial baseline for channel No. 4, type B1(4)=value determined from strip chart and press EXECUTE. Repeat as needed for the other channels.
- b. Final or end baseline is defined by the mnemonic B2(\*). To change the final baseline for channel No. 5, type B2(5)=value determined from strip chart and press EXECUTE. Repeat as needed for the other channels.

4. Sample Specification

- a. Sample identification is defined by the mnemonic Id\$(\*) and is used to correct minor listing errors.  
Example: Sample 10,H18 is incorrectly listed as 10,B18. Type Id\$(10) = "H". Press Execute.
- b. Sample code is defined by the mnemonic ICODE(\*) and is also used to correct listing errors.  
Example: Sample 13,H425 is incorrectly listed as 13,H5425. Type ICODE(13) = 425. Press execute.

Using these two mnemonics the operator does not have to re-initialize a file in order to correct listing errors.

5. Header Information

The complete list of header mnemonics (see APILOT No. 8-13) for any file are:

L\$ = "Label" (file name)  
Da\$ = "Date"  
Hr\$ = "Hour"

Lat\$ = "Latitude"  
Lon\$ = "Longitude"  
Mess\$ = "Comment"  
Depth = Depth  
Nsamp = No. samples  
Op\$ = "Operator"

Note that mnemonics followed by "\$" require quotes while others do not.

To change any part of the header simply type the mnemonic L\$ = " " and press Execute.

Examples: L\$ = "BIRD" Execute.

Mess\$ = "MESA STATION 23" Execute.

The depth and operator changes do not require the use of parentheses. Hence it is correct to type Depth = 45. Execute.

6. Column Heading

The column headings for the six autoanalyzer channels are defined by the mnemonic A\$(\*) and presented as PO<sub>4</sub>, SiO<sub>4</sub>, N+N, NO<sub>2</sub>, NH<sub>4</sub>, and URE. The sixth channel for urea is not routinely run. Thus it is available for other data. For example, should

you wish to use this column for chlorophyll, type A\$(6) = "CHL". Press Execute. Likewise A\$(6) = "SAL" indicates that the column is reserved for salinity values. The chlorophyll data can be entered manually under the Edit subprogram of APILOT or in MANDAT.

Additional capabilities such as edit, list, tape write and tape read may be performed in APILOT. For detailed instructions of these tasks go to MANDAT program description.

AutoAnalyzer Data

Latitude \_\_\_\_\_

Longitude \_\_\_\_\_

Investigator _____ Experiment _____									
Vessel _____		Station _____		Time _____		Page _____			
Cruise _____		Run No. _____		Date _____		of _____			
Analysis Code	Factor	Std Cal	Blank I	Blank II	Refract. Index	Reagent Blank For Stds			
— PO4	09	_____	_____	_____	_____	_____	_____	_____	_____
— SiO4	10	_____	_____	_____	_____	_____	_____	_____	_____
— N+N	11	_____	_____	_____	_____	_____	_____	_____	_____
— NO2	12	_____	_____	_____	_____	_____	_____	_____	_____
— NH4	13	_____	_____	_____	_____	_____	_____	_____	_____
— Urea	27	_____	_____	_____	_____	_____	_____	_____	_____

Seq.	Depth	Bottle	Ident.	PO4	SiO4	N+N	NO2	NH4	Urea
1	-	DØ	SYN						
2	-	S-1-	STD						
3	-	S-2-	STD						
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									
22									
23									
24									
25									
26									
27									
28									

SAMPLE TIME (SEC)= 120.00  
 WASH TIME (SEC)= 60.00  
 SAMPLING RATE (SEC)= 1.00  
 Y LIMIT= .01000  
 B(\*)=9.00 8.00 13.50 9.50 11.50 7.50

SAMPLE TIME (SEC)= 180.00  
 WASH TIME (SEC)= 60.00  
 SAMPLING RATE (SEC)= 1.00  
 Y LIMIT= .01000  
 B(\*)=9.00 8.00 13.50 9.50 11.50 7.50

LABEL=BFIND  
 DATE=03FEB81  
 HR=1600  
 LATITUDE= N.A.  
 LONGITUDE= N.A.  
 COMMENT=N.A.  
 DEPTH= -99  
 NO. SAMPLES= 11  
 OPERATOR=TEW

CHANNEL	P04	G104	N11	N02	NH4	URE
STATUS=	1	1	1	1	1	0
FACTORS=	1.039	4.911	5.996	1.023	3.498	1.000
RF/S=	.140	.090	.030	.040	.150	0.000
BASE1=	0.000	.531	.327	.217	.227	0.000
BASE2=	-9.990	.580	.333	.210	.210	-9.990

NU.	ID	ABS	ABS	ABS	ABS	ABS	ABS
1	D 0	0.000	9.173	9.998	5.140	4.848	0.000
2	S 15	0.000	8.643	9.995	.228	.479	0.000
3	S 14	0.000	6.874	7.954	.234	.354	0.000
4	S 13	0.000	5.351	5.995	.225	.431	0.000
5	S 12	0.000	3.394	3.784	.230	.332	0.000
6	S 11	0.000	1.730	2.016	1.514	.313	0.000
7	S 25	0.000	.565	1.194	5.160	4.865	0.000
8	S 24	0.000	.562	1.009	4.163	4.298	0.000
9	S 23	0.000	.575	.798	3.017	2.751	0.000
10	S 22	0.000	.577	.605	2.374	1.040	0.000
11	S 21	0.000	.577	.417	.926	1.141	0.000

LABEL=BFIND  
 DATE=03FEB81  
 HR=1600  
 LATITUDE= N.A.  
 LONGITUDE= N.A.  
 COMMENT=N.A.  
 DEPTH= -99  
 NO.SAMPLES= 11  
 OPERATOR=TEW

CHANNEL=	P04	SI04	N+N	NO2	NH4	URE
STATUS=	1	1	1	1	1	0
FACTORS=	1.039	4.911	5.996	1.023	3.498	1.000
RF/S=	.140	.090	.030	.040	.150	0.000
BASE1=	0.000	.531	.327	.217	.227	0.000
BASE2=	-9.990	.580	.333	.210	.210	-9.990

NO.	ID	TIME	TIME	TIME	TIME	TIME	TIME
1	D	0	700.013	625.513	567.513	891.513	0.000
2	S	15	932.513	858.513	801.013	1126.013	0.000
3	S	14	1172.013	1085.513	1044.013	1369.013	0.000
4	S	13	1412.513	1330.013	1287.513	1610.513	0.000
5	S	12	1657.013	1569.026	1524.513	1851.513	0.000
6	S	11	1894.513	1813.012	1763.013	2091.513	0.000
7	S	25	2137.013	2055.513	2000.513	2322.013	0.000
8	S	24	2381.013	2292.013	2241.513	2556.513	0.000
9	S	23	2615.513	2537.513	2481.513	2798.513	0.000
10	S	22	2858.513	2780.013	2730.513	3043.513	0.000
11	S	21	3097.513	3024.513	2964.013	3287.513	0.000

LABEL=BFIND  
 DATE=03FEB81  
 HR=1600  
 LATITUDE= N.A.  
 LONGITUDE= N.A.  
 COMMENT=N.A.  
 DEPTH= -99  
 NO.SAMPLES= 11  
 OPERATOR=TEW

CHANNEL=	P04	SI04	N+N	NO2	NH4	URE
STATUS=	1	1	1	1	1	0
FACTORS=	1.039	4.911	5.996	1.023	3.498	1.000
RF/S=	.140	.090	.030	.040	.150	0.000
BASE1=	0.000	.531	.327	.217	.227	0.000
BASE2=	-9.990	.580	.333	.210	.210	-9.990

NO.	ID	DT	DT	DT	DT	DT	DT	
1	D	0	700.013	625.513	567.513	891.513	0.000	
2	S	15	232.500	233.000	233.500	234.500	0.000	
3	S	14	0.000	233.500	227.000	243.001	243.000	0.000
4	S	13	0.000	240.500	244.500	243.500	241.500	0.000
5	S	12	0.000	244.500	239.013	237.000	241.001	0.000
6	S	11	0.000	237.501	243.987	238.500	240.000	0.000
7	S	25	0.000	242.500	242.501	237.501	230.500	0.000
8	S	24	0.000	244.000	236.501	241.000	234.500	0.000
9	S	23	0.000	234.500	245.500	240.000	242.000	0.000
10	S	22	0.000	243.000	242.500	249.000	245.000	0.000
11	S	21	0.000	239.000	244.500	233.500	244.000	0.000

LABEL=BFIND  
 DATE=03FEB81  
 HR=1600  
 LATITUDE= N.A.  
 LONGITUDE= N.A.  
 COMMENT=N.A.  
 DEPTH= -99  
 NO. SAMPLES= 11  
 OPERATOR=TEW

CHANNEL=	P04	SI04	N+N	NO2	NH4	URE
STATUS=	1	1	1	1	1	0
FACTORS=	1.039	4.911	5.996	1.023	3.498	1.000
RF'S=	.140	.090	.030	.040	.150	0.000
BASE1=	0.000	.531	.327	.217	.227	0.000
BASE2=	-9.990	.580	.333	.210	.210	-9.990

NO.	ID	UG-AT	UG-AT	UG-AT	UG-AT	UG-AT	UG-AT
1	D 0	-9.990	41.980	57.800	4.995	15.644	-9.990
2	S 15	-9.990	39.356	57.784	-.028	.366	-9.990
3	S 14	-9.990	30.645	45.544	-.022	-.066	-9.990
4	S 13	-9.990	23.150	33.794	-.031	.209	-9.990
5	S 12	-9.990	13.517	20.530	-.025	-.134	-9.990
6	S 11	-9.990	5.327	9.926	1.289	-.195	-9.990
7	S 25	-9.990	-.414	4.994	5.020	15.734	-9.990
8	S 24	-9.990	-.448	3.883	4.000	13.754	-9.990
9	S 23	-9.990	-.407	2.618	2.828	8.348	-9.990
10	S 22	-9.990	-.415	1.454	2.171	5.178	-9.990
11	S 21	-9.990	-.438	.326	.691	2.726	-9.990

LABEL=BFIND  
 DATE=03FEB81  
 HR=1600  
 LATITUDE= N.A.  
 LONGITUDE= N.A.  
 COMMENT=N.H.  
 DEPTH= -99  
 NO. SAMPLES= 11  
 OPERATOR=TEW

CHANNEL=	P04	SI04	N+N	NO2	NH4	URE
STATUS=	1	1	1	1	1	0
FACTORS=	1.039	4.911	5.996	1.023	3.498	1.000
RF'S=	.140	.090	.030	.040	.150	0.000
BASE1=	0.000	.531	.327	.217	.227	0.000
BASE2=	-9.990	.580	.333	.210	.210	-9.990

NO.	ID	CONF	CONF	CONF	CONF	CONF	CONF
1	D 0	-.990	.006	.001	.002	.003	-.990
2	S 15	-.990	.008	.001	.001	.001	-.990
3	C 14	-.990	.006	.005	.000	.002	-.990
4	S 13	-.990	.005	.005	.000	.001	-.990
5	S 12	-.990	.002	.003	.001	.001	-.990
6	S 11	-.990	.002	.002	.000	.002	-.990
7	S 25	-.990	.001	.002	.004	.005	-.990
8	S 24	-.990	.002	.001	.002	.002	-.990
9	C 23	-.990	.002	.003	.001	.002	-.990
10	S 22	-.990	.002	.001	.001	.003	-.990
11	S 21	-.990	.001	.003	.078	.003	-.990

INSTRUCTIONS FOR THE USE OF MANDAT  
(Manual Data Entry and Listing)

1. Insert Autoprogram tape into tape drive 15.
2. Type LOAD "MANDAT" and press EXECUTE.  
This step loads the program into the computer's memory. When the small square of light at the lower right hand corner of the cathode ray tube (CRT) is extinguished, the program is fully loaded and ready for use.
3. Press RUN. CRT displays HELLO FROM MANDAT and prompts with flashing WAITING FOR A COMMAND in lower left hand corner of the screen. KEY specifications are output to thermal printer. These are the special Function Keys at upper right hand side of Keyboard.  
KEY 0 = INITIALIZE  
KEY 1 = LIST  
KEY 2 = INPUT DATA  
  
KEY 3 = EDIT  
KEY 4 = SAVE DATA  
KEY 5 = FINISHED  
KEY 6 = FETCH

WHEN IN DOUBT PUSH CONTINUE,  
SOMETHING WILL HAPPEN

I. INITIALIZE

4. Press K<sub>0</sub>. CRT displays HELLO FROM INITIALIZE and prompts for LABEL [6]? Type label for this data up to six characters. Press CONT.
5. CRT prompts for DATE [7]? Type date number as day, month, and year i.e. 06JAN80. Press CONT.
6. CRT prompts for TIME [4]? Type time for 24 day i.e. 1146, 2205. Press CONT. CRT prompts for LAT, LON, DEPTH and COMMENT. Enter as described in step 10 of APILOT program.
7. CRT prompts for OPERATOR [6]? Type name or initials of the AutoAnalyzer operator up to six characters i.e. SCM, PATTON. Press CONT.
8. CRT prompts for NO. SAMPLES? Type number of samples to be entered. Press CONT.
9. CRT prompts BEGIN BASE LINE [6 NO. 5]. Type in the beginning baselines for all six channel.  
Example: 0.75, 1.1, 0.32, 0.41, 0.2, 1.3 Press CONT.
10. CRT prompts FINAL BASE LINE? [6 NO. 5]. Type in the final baseline for all six nutrients. Press CONT.
11. CRT displays list of the parameters entered and prompts DO YOU WANT TO CHANGE FACTORS? Y/N (Go to if you want to change Factors, type Y and press CONT.
12. CRT displays LIST FINISHED and prompts for FACTOR? [6 NO. 5]. Type in the six nutrient factors previously determined in STAND. Press CONT.
13. CRT prompts IS THE TABLE CORRECT? Y/N. Type Y and Press CONT. CRT displays INITIALIZE FINISHED and prompts WAITING FOR A COMMAND.
14. If the table is incorrect, type N and press CONT. Computer program returns to step 4 and prompts for LABEL [6]? Press CONT until you arrive at incorrect parameter. Correct it and press CONT to step to through INITIALIZE to step 13.



## II. INPUT DATA

15. Press  $K_2$  to input data. CRT displays HELLO FROM MAKE and prompts SAMPLE NO., LIST OR EXIT?
16. Type 1 and press CONT. CRT displays SAMPLE NO. = 1.00 and prompts ID, NUT 1, NUT 2, NUT 3, NUT 4, NUT 5, NUT 6?
17. Type in identification of sample usually an H or P followed by a numeral to indicate a Hydro sample or Productivity sample and its depth. Follow the identification with the absorbances of the six nutrients separated by commas as recorded on the strip charts. Press CONT.
18. CRT again prompts for SAMPLE NO., LIST OR EXIT? Repeat the steps above for each sample and press CONT.
19. Type L for List and Press CONT to obtain a complete listing of the input data. CRT prompts for OUTPUT TYPE: 1=ABS, 2=UG-AT/L.
20. Type 1 and press CONT. CRT displays a table of data and prompts DO YOU WANT A HARD COPY, Y/N?
21. Type Y and press CONT to obtain a hard copy of data in absorbance units. CRT again prompts for SAMPLE NO., LIST or EXIT. Repeat steps 19-20 for hard copy in ug-at/l.
22. Type E for exit and press CONT. CRT displays BYE FROM MAKE and prompts in flashing letters WAITING FOR A COMMAND.

## III. SAVE

23. Press  $K_4$  to save the file. CRT displays HELLO FROM SAVE and prompts DO YOU WANT TO SAVE THE FILE, Y/N?
24. Type Y and press CONT. CRT prompts TAPE DRIVE WANTED? 14 or 15?
25. Type 15 if data tape is in that drive and press CONT. Your data is saved on tape 15 and CRT displays FILE HAS BEEN SAVED ON T15. BYE FROM SAVE and prompts WAITING FOR A COMMAND.
26. Press  $K_5$ . FINI FINISHED AND PROGRAM IS ENDED-BYE is printed in flashing letters over the screen. To enter another run press CONTROL/RESET.

## IV. FETCH

27. If data file has been saved previously, retrieve it using FETCH Press  $K_6$ . CRT prompts FILE WANTED.
28. Type file name and press CONT. CRT prompts TAPE DRIVE WANTED? 14 or 15?
29. Type 14 or 15 wherever tape is, press CONT. Your file is read and CRT displays FINISHED READING FILE and prompts WAITING FOR A COMMAND.

## VI. LIST

30. If WAITING FOR A COMMAND is flashing, then press  $K_1$  and CRT prompts OUTPUT TYPE: 1=ABS, 2=UG-AT/L. Obtain a hard copy as in steps 19-20.

## VII. EDIT DATA

### Edit Functions

Should errors be discovered in your data after it has been entered manually, you can correct it using the edit functions.

31. CRT prompts WAITING FOR A COMMAND. Press K<sub>5</sub>. CRT displays HELLO FROM EDIT and prompts ENTER EDIT OPERATION LETTER Add, Replace, Delete, Exit, List.
  - A. To Replace.
    32. Type R and press CONT to replace a value in the data matrix. CRT prompts ROW, COLUMN?
    33. Type respective row and column, press CONT. CRT prompts VALUE REQUIRED. VALUE.
    34. Type corrected absorbance value and press CONT. CRT displays COMMAND IS letter, run, column, absorbance and prompts DO YOU WANT TO EXECUTE, Y/N.
    35. Press Y and press CONT. Computer returns to step 32. Repeat 32-35 as needed. Go to step 42.
  - B. To Delete.
    36. Type D and press CONT to delete a value in the data matrix CRT prompts ROW, COLUMN.
    37. Type respective row and column, press CONT. CRT prompts ROLL REQUIRED. Y/D?
    38. Type D and press CONT. (Entire data column above point of deletion will be moved down one position.) Or type U and press CONT. (Entire data column below point of deletion will be moved up one space.) CRT prompts ENTER EDIT OPERATION LETTER, ADD, REPLACE, DELETE, EXIT, LIST. Repeat 36-38 as needed. Go to step 42.
  - C. To Add
    39. Type A and press CONT to add a value in the data matrix. CRT prompts ROW, COLUMN?
    40. Type respective row and column, press CONT. CRT prompts ROLL REQUIRED. U/D?
    41. Type D and press CONT. (Entire data column will be moved down one space place below point of addition). Or type U and press CONT. (Entire data column will be moved up one space above the point of addition.) CRT prompts ENTER EDIT, OPERATION LETTER, ADD, REPLACE, DELETE, EXIT, LIST. Repeat 39-41 as needed. Go to step 42.
    42. To obtain a display of the edited data, type L and press CONT. CRT prompts OUTPUT TYPE: 1 = ABS; 2 =  $\bar{U}G-AT/L$ .
    43. Type 1 or 2 press CONT. CRT displays data and prompts DO YOU WANT A HARD COPY, Y/N?
    44. Type Y and press CONT. Hard copy is output to thermal printer. Or type N and press CONT. CRT prompts ENTER EDIT OPERATION LETTER, ADD, REPLACE, DELETE, EXIT, LIST.
  - D. To exit edit mode
    45. Type E and press CONT. CRT displayed EDIT FINISHED and prompts with WAITING FOR A COMMAND.
    46. To save this edited file, type PURGE "file name" and press EXECUTE. Follow steps 23-25 of SAVE.

MANDAT PROGRAM - USER DEFINED PARAMETERS

- 2030 Channel labels: The only label which should be changed is "URE." For example, if chlorphyll is being run on channel 6, change URE to CHL.
- 2050 Channel status.
- 2090 Factors: Enter the factors as determined in stand for each channel.
- 2110 Refractive index: Enter the refractive index determined for each channel.

HELLO FROM MANDAT

KEY 0- INITIALIZE  
KEY 1- LIST  
KEY 2- INPUT DATA  
KEY 3- EDIT  
KEY 4- SAVE DATA  
KEY 5- FINISHED  
KEY 6- FETCH

WHEN IN DOUBT PUSH CONTINUE, SOMETHING WILL HAPPEN

LABEL=H4102  
 DATE=03JUN80  
 HR=2245  
 LAT= 54 52.0  
 LON=167 52.7  
 DEPTH= 1527  
 COMMENT= ACROSS SHELF TRANSECT  
 NO.SAMPLES= 14  
 OPERATOR=TEW

CHANNEL=	P04	SI04	N+N	N02	NH4	URE
STATUS=	1	1	1	1	1	0
FACTORS=	.690	9.930	4.969	.740	.975	1.000
RF/S=	.190	.020	.030	.240	.190	0.000
BASE1=	.431	.176	.454	.278	.604	0.000
BASE2=	.418	.225	.534	.299	.672	0.000

NO.	ID	ABS	ABS	ABS	ABS	ABS	ABS
1	D 0	7.50	4.63	8.24	5.25	5.09	0.00
2	S 15	1.60	5.85	9.41	.30	.80	0.00
3	S 25	6.99	.20	1.26	6.09	4.64	0.00
4	H 0	2.04	1.23	2.33	.86	1.04	0.00
5	H 10	2.09	1.45	2.78	.04	1.20	0.00
6	H 20	2.31	1.87	3.36	.85	1.30	0.00
7	H 30	2.47	2.05	3.65	.89	1.97	0.00
8	H 40	2.67	2.14	3.77	.93	2.43	0.00
9	H 50	2.94	2.29	3.97	.90	3.16	0.00
10	H 100	3.32	3.20	5.50	1.17	1.13	0.00
11	H 250	3.76	3.95	6.42	.66	.99	0.00
12	H 500	4.84	6.16	8.87	.59	1.07	0.00
13	H1000	5.25	9.49	9.55	.59	.99	0.00
14	H1525	5.22	18.11	9.29	.59	1.00	0.00

LABEL=H4102  
 DATE=03JUN80  
 HR=2245  
 LAT= 54 52.0  
 LON=167 52.7  
 DEPTH= 1527  
 COMMENT= ACROSS SHELF TRANSECT  
 NO.SAMPLES= 14  
 OPERATOR=TEW

CHANNEL=	P04	SI04	N+N	N02	NH4	URE
STATUS=	1	1	1	1	1	0
FACTORS=	.690	9.930	4.969	.740	.975	1.000
RF/S=	.190	.020	.030	.240	.190	0.000
BASE1=	.431	.176	.454	.278	.604	0.000
BASE2=	.418	.225	.534	.299	.672	0.000

NO.	ID	UG-AT	UG-AT	UG-AT	UG-AT	UG-AT	UG-AT
1	D 0	4.75	44.00	38.50	3.50	4.18	0.00
2	S 15	.68	56.05	44.30	-.17	-.01	0.00
3	S 25	4.40	-.03	3.78	4.12	3.73	0.00
4	H 0	.98	10.18	9.05	.25	.22	0.00
5	H 10	1.02	12.29	11.26	.23	.37	0.00
6	H 20	1.17	16.40	14.16	.24	.46	0.00
7	H 30	1.28	18.21	15.54	.27	1.11	0.00
8	H 40	1.42	19.03	16.09	.29	1.56	0.00
9	H 50	1.61	20.49	17.06	.27	2.27	0.00
10	H 100	1.87	29.54	24.64	.47	.20	0.00
11	H 250	2.18	36.89	29.21	.09	.14	0.00
12	H 500	2.92	58.83	41.38	.04	.22	0.00
13	H1000	3.20	91.88	44.71	.04	.14	0.00
14	H1525	3.18	177.43	43.37	.04	.14	0.00

## INSTRUCTIONS FOR BFIND PROGRAM

The BFIND program calculates "B" factors from standards that are run on the AutoAnalyzer channels with the APILOT program. New "B" factors should be determined when changes are made which could affect the amount of dispersion in any of the channels (e.g. addition of an extra mixing coil or debubbler).

1. In order to save the data in the APILOT program a file must be created on the tape or disk. The number of records needed for the file can be calculated as follows:

1. A 180 second sample and a 60 second wash = 240 sec/sample.
2. One sync sample plus five S1 standards and five S2 standards = 11 samples.
3. Eight values are recorded per second.
4. There are 4 Bytes per value and 256 Bytes per tape record.

The number of records needed to record 11 peaks plus initial and final baselines (2 peaks each) gives a total equivalent to about 15 peaks.

File Length = 15 samples x 240 sec/sample x 8 values/sec x

4 Bytes/value x 1 record/256 Bytes

F.L. = 450 records

So a file is created on tape 15 by: Create "TEST", 450 Execute.

2. After the file has been created and the data have been saved on the tape using the APILOT program, insert the AUTO program tape in tape 15.
3. Type LOAD "BFIND" and then press Execute to load the program.
4. Press RUN. CRT displays "ENTER CHANNEL No." Type in the channel number desired and push CONTINUE. Phosphate=1, Silicate=2, Nitrate plus Nitrite=3, Nitrite=4, Ammonium=5 and Urea =6.
5. CRT displays "MAX NO. OF POINTS." For all eleven peaks enter 2500 and press CONTINUE. For 4 or 5 peaks use 1600 points.
6. CRT displays "FILE NAME." Type TEST and press CONTINUE.
7. CRT displays "FILE DEVICE." Type 2 and press CONTINUE.
8. CRT displays "SAMPLE TIME." Type 180 and press CONTINUE.
9. CRT displays "WASH TIME." Type 60 and press CONTINUE.
10. Raw data will be plotted on the CRT and a cursor displayed. Move cursor between the sync sample and the first peak, press CONTINUE. Now move cursor between peaks 5 and 6, press CONTINUE. This produces a collapsed data set which will automatically be plotted on the CRT.
11. The collapsed data is plotted on the CRT with the cursor near the first peak. Position cursor to a position about 5 seconds after the initial rise of the first peak and press CONTINUE. Position cursor further up the rise but still in the exponential portion of the peak. This position of the cursor is usually very close, therefore little if any movement is necessary, press CONTINUE. Select rise points for all peaks in the same manner. After the last rise is selected, press KO to exit.
12. The cursor will again appear but as a horizontal line this time. Select the peak heights for each peak and press CONTINUE. After the last peak height has been selected, press KO to exit.
13. CRT displays "DO YOU WANT A HARD COPY OF THE GRAPH? Y/N" Enter Y or N and press CONTINUE.
14. A segment table is displayed on the CRT along with "DO YOU WANT TO CHANGE THE E'S?" Enter "N" and press CONTINUE.
15. CRT displays "DO YOU WANT A HARD COPY? Y/N" If the table is desired enter "Y" and press CONTINUE.

16. CRT displays regression plot of  $\ln(E-H)$  versus time. The regression lines should be linear for each of the segments chosen. If the lines are curved then the rise points were chosen incorrectly.
17. CRT displays "DO YOU WANT A COPY OF REGRESSION PLOT? Y/N" If a hard copy is desired enter "Y" and press CONTINUE.
18. CRT displays regression table with intercept, slope, B value and no. of points and a mean "B" value is calculated.
19. CRT displays "DO YOU WANT A HARD COPY? Y/N" Enter "Y" and press CONTINUE.
20. Three notes are listed on the CRT describing the effects of the "B" value on peak regeneration.
21. CRT displays "B VALUE FOR REGENERATION?" For a first approximation take the mean "B" value from regression and subtract one. Enter the B value minus 1 and press CONTINUE.
22. CRT will display regenerated peaks using the "B" value entered.
  - a) If the regenerated peaks have a sharp spike at the beginning, they are probably over-regenerated thus you should lower the "B" value.
  - b) If the peaks are rounded like the raw data, the peaks are probably under-regenerated, thus you should raise the "B" value.
  - c) The tops of the peaks and the valleys should be flat.
23. CRT displays "DO YOU WANT TO DUMP PLOT? Y/N" If a hard copy is desired enter "Y" and press CONTINUE.
24. CRT displays "DO YOU WANT TO TRY REGEN AGAIN? Y/N" If you want to try another "B" value enter "Y" and press CONTINUE.
25. Enter the best "B" value into APILOT program.
26. To determine the "B" value for another channel, press STOP and then press RUN which will return you back to step 4.

## REQUIREMENTS FOR BFIND PROGRAM

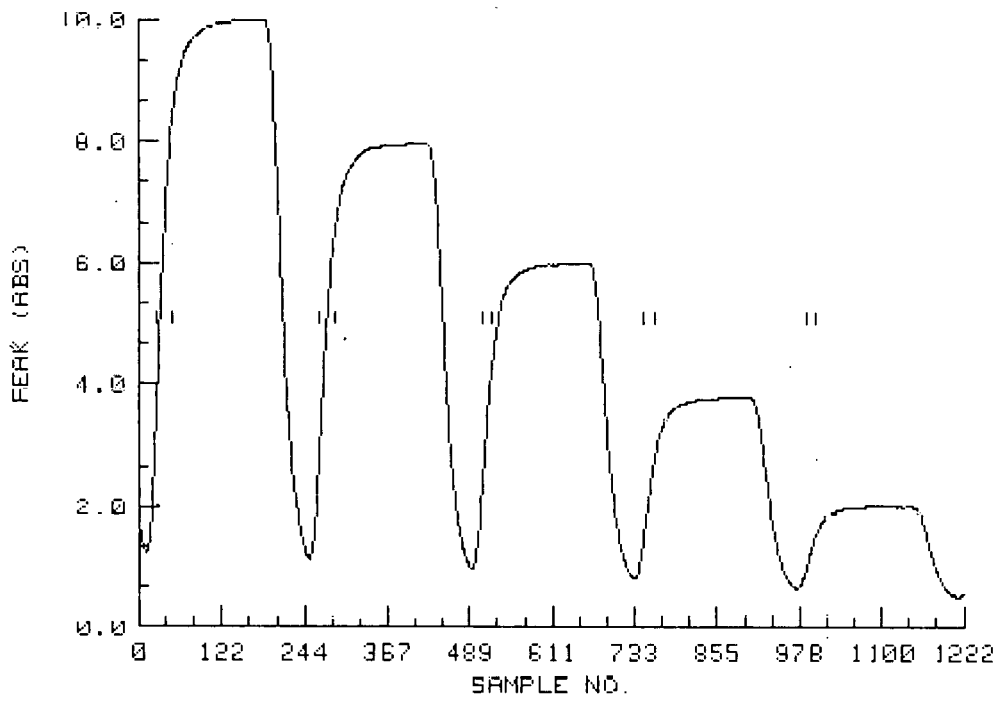
1. Must achieve true steady state
  - a. requires long sample and wash times 180 seconds and 60 seconds, respectively.
2. 3 stds (low, medium, high - i.e. S-1, S-3, S-5) are sufficient.

### Information

1. "B"  $\equiv$  exponential phase constant  
"B" =  $-1/\text{slope}$  of a plot of  $\ln(E-h)$  versus time  
"B" tells you how fast the system approaches steady state. The longer the system takes to reach steady state, the larger "B" will be. Likewise, B reflects the amount of segment to segment mixing (longitudinal dispersion) which occurs in the manifold and colorimeter flow cells. As longitudinal dispersion decreases, B decreases.
2. "A"  $\equiv$  lag phase constant  
"A" = y intercept of a plot of  $\ln(E-h)$  versus time  
"A" indicates (in seconds) the period of time before the rise curve begins to approach steady state exponentially. A is largely influenced by the dwell time of the CF systems. Manifolds with dialyzers and heating baths have longer lag phase than those without.



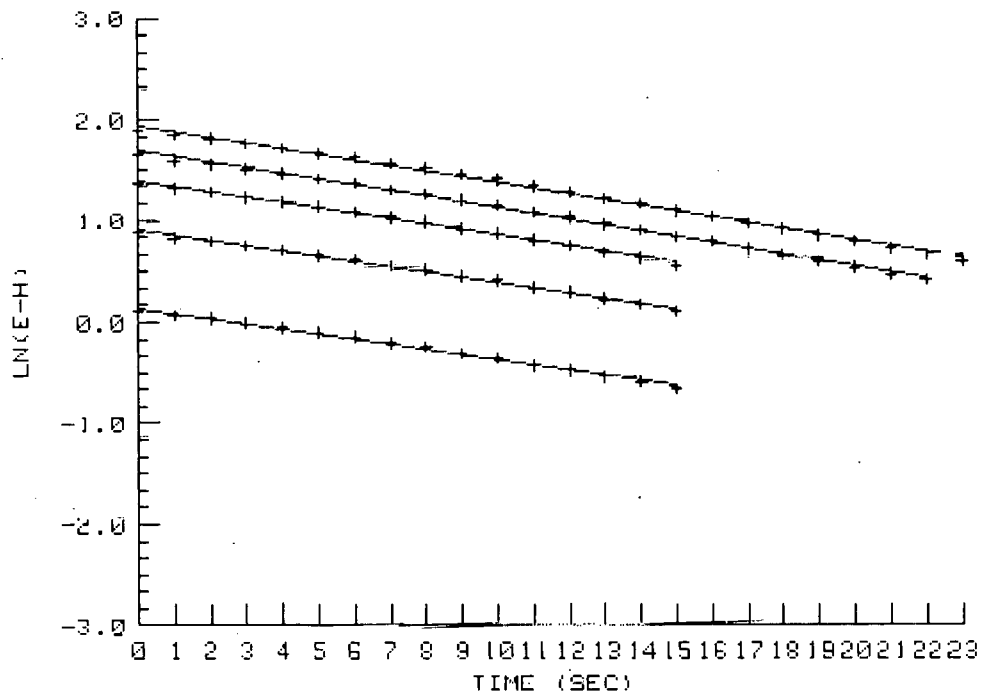
COLLAPSED CHANNEL - 3



SEGMENT TABLE

PEAK	TB	TF	E
1	26	49	9.99026
2	266	288	7.97332
3	506	521	5.99019
4	746	761	3.80930
5	986	1001	2.02205
6	1226	0	2.02205

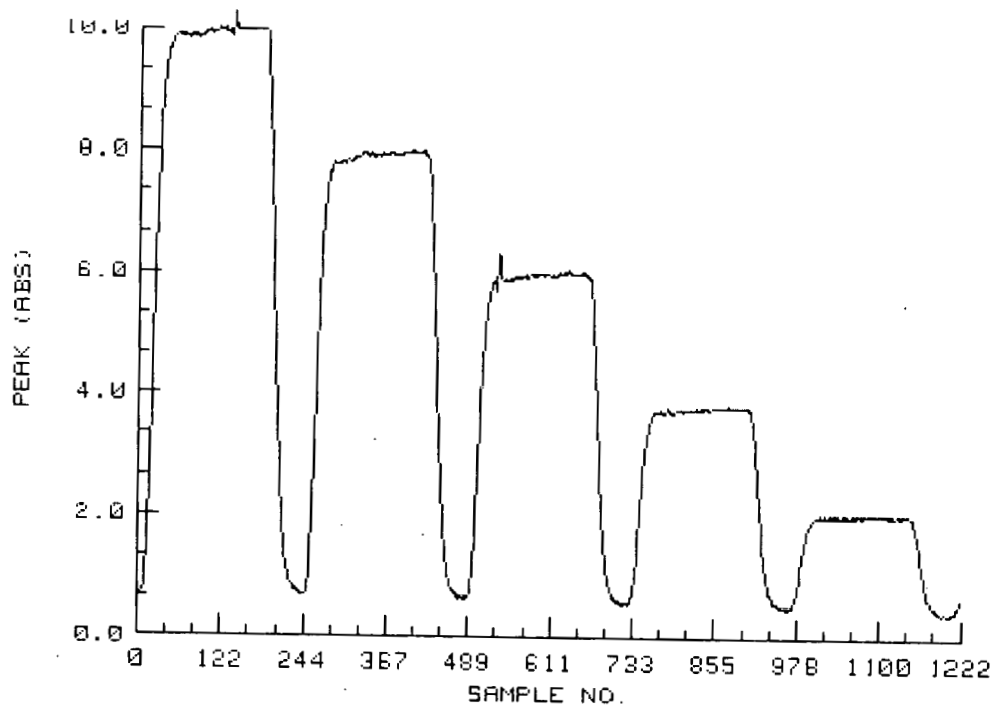
REGRESSION



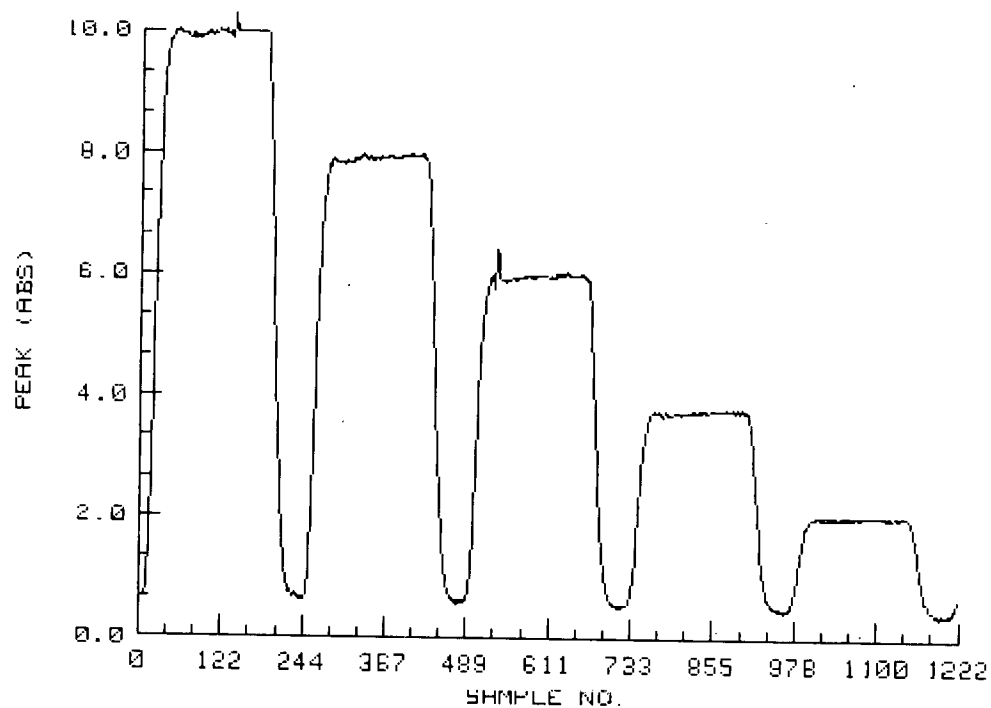
REGRESSION TABLE

SEG	INTC	SLOPE	B	NO.
1	1.94465	-.05719	17.48469	24
2	1.68395	-.05656	17.68058	23
3	1.38489	-.05328	18.76985	16
4	.89838	-.05078	19.69321	16
5	.14061	-.05111	19.56438	16
6	0.00000	0.00000		
			<hr/> 15.53212	

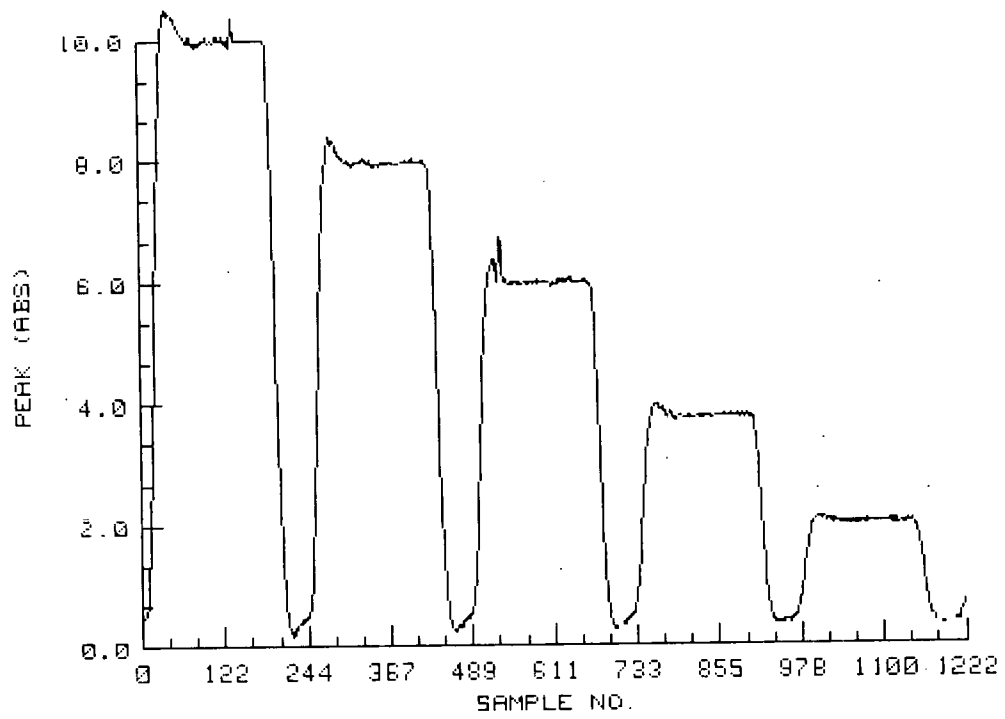
REGEN CHANNEL3 B- 14.50



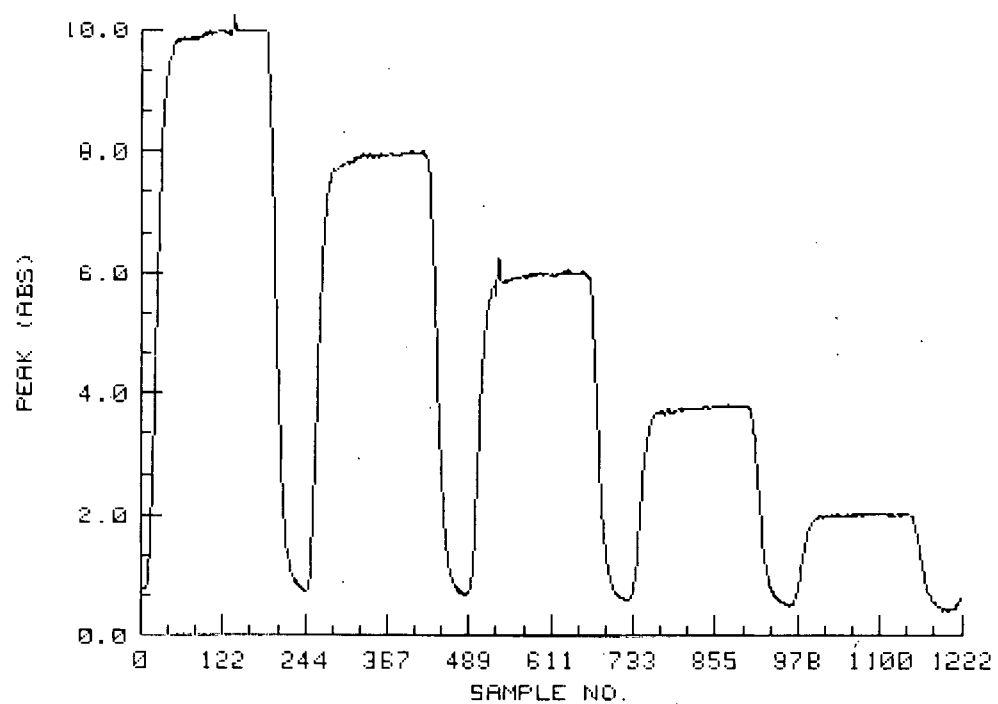
REGEN CHANNEL3 B- 15.50



REGEN CHANNEL3 B- 19.00

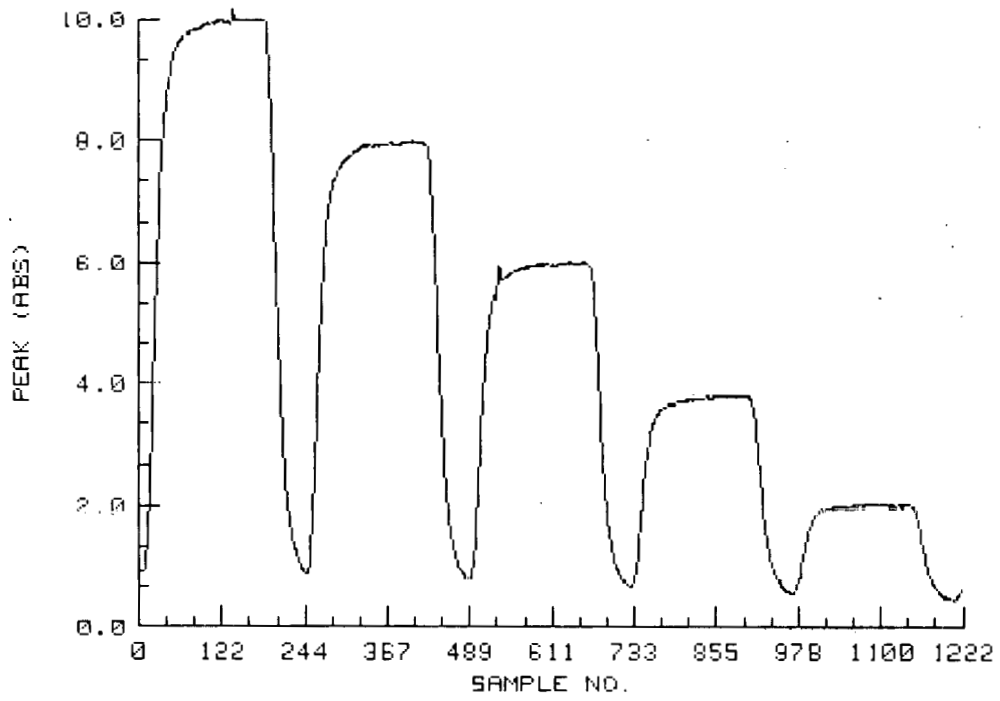


REGEN CHANNEL3 B- 13.50

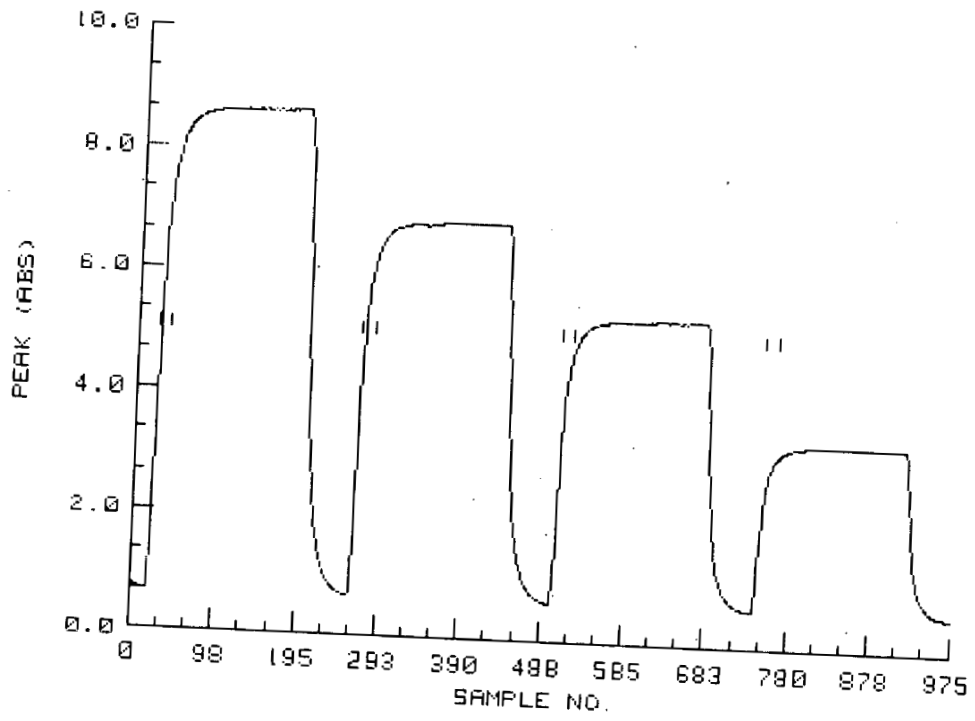




REGEN CHANNEL3 B- 10.00



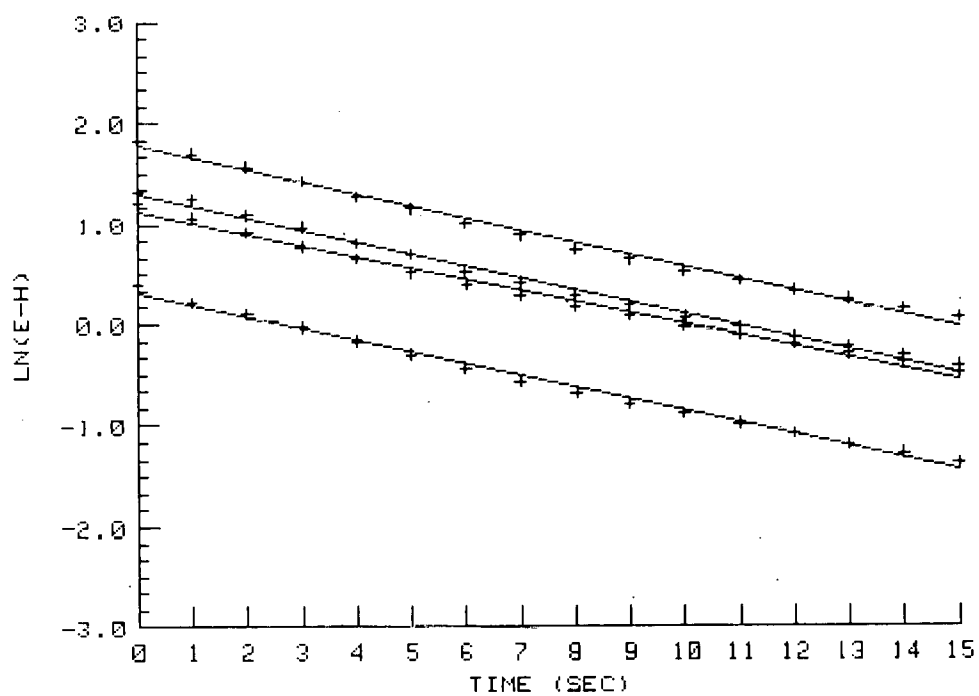
COLLAPSED CHANNEL - 2



SEGMENT TABLE

PEAK	TB	TF	E
1	23	38	8.67662
2	266	281	6.86997
3	503	518	5.38239
4	746	761	3.37267

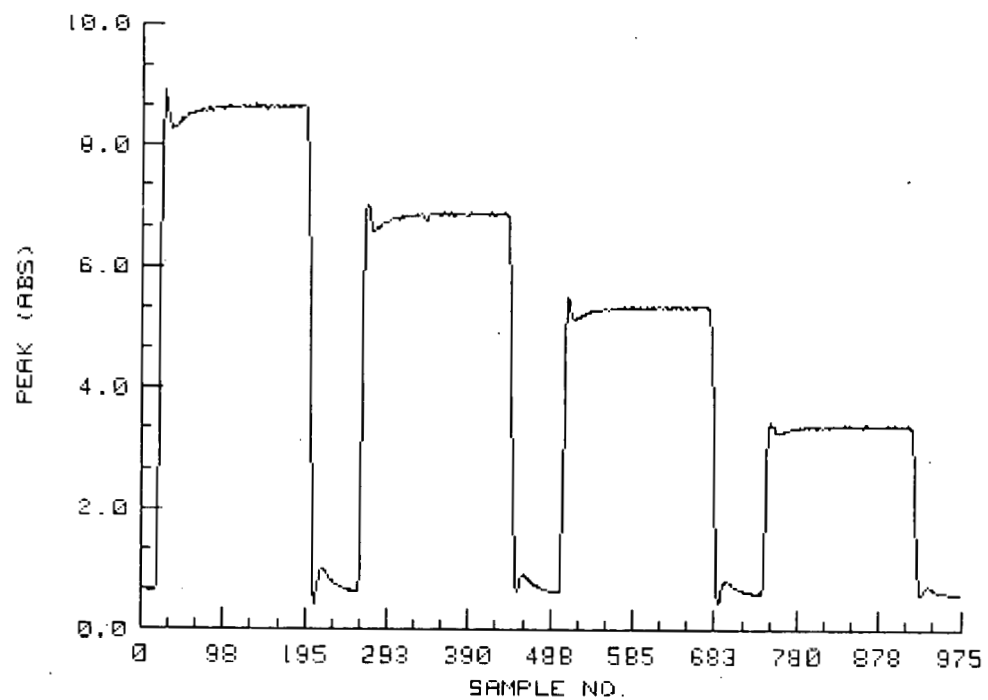
REGRESSION



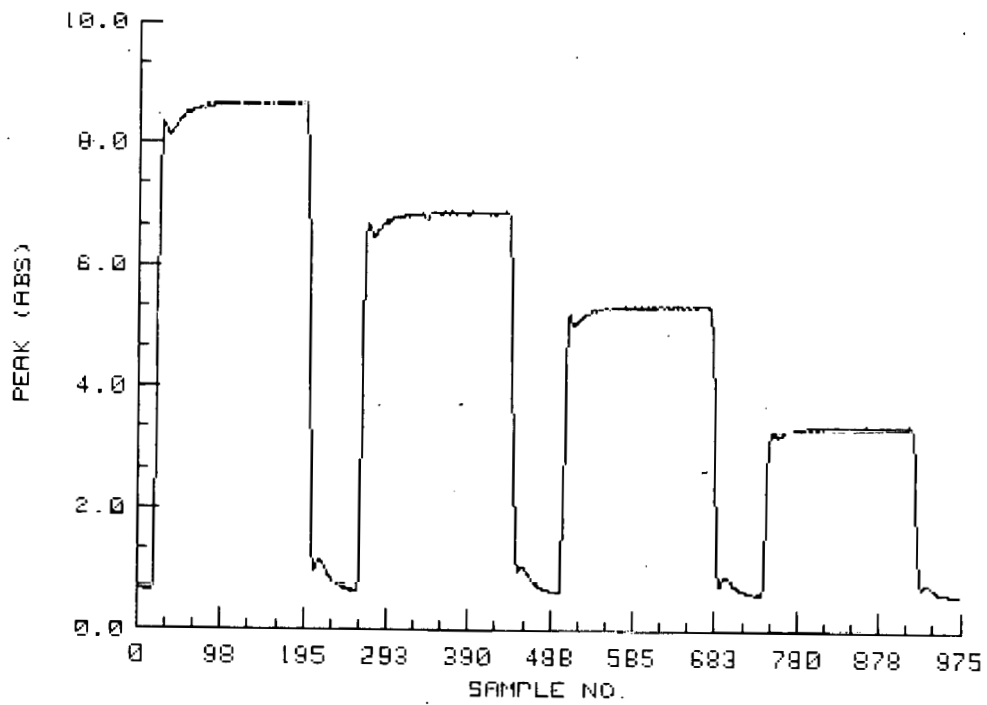
REGRESSION TABLE

SEG	INTC	SLOPE	B	NO.
1	1.77243	-.11902	8.40203	16
2	1.12190	-.11088	9.01879	16
3	1.30532	-.11905	8.39961	16
4	.31217	-.11659	8.57712	16
			<hr/> 8.59939	

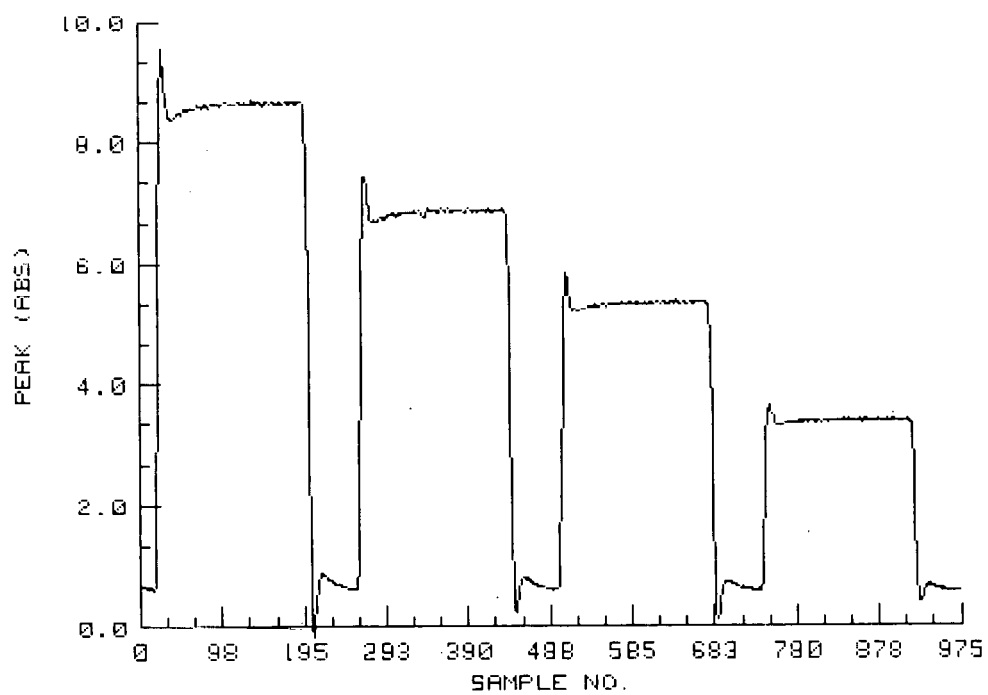
REGEN CHANNEL2 B- 7.50



REGEN CHANNEL2 B- 6.50



REGEN CHANNEL2 B- 0.50





INSTRUCTIONS FOR USE OF CLOCK PROGRAM

1. Insert Autoprogram tape into tape drive 15. Type LOAD "CLOCK" and then press EXECUTE.

This step loads the program into the computer's memory. When the small square of light at the lower right-hand corner of the cathode ray tube (CRT) is extinguished, the program is fully loaded and ready for use.

2. Press RUN, the CRT will display "HELLO FROM PROGRAM CLOCK I AM LOOKING FOR THE TIME BACK IN 20 SEC".

3. The CRT will display "AT THE TIME OF THE TONE IT WAS" \_\_\_\_\_. DO YOU WANT TO CHANGE IT? Y/N" Enter "Y" or "N" and push CONT. If "N" then "CLOCK IS FINISHED" will be displayed. If "Y" then the CRT will ask for input of month, day, hour, minute, and second. Enter each as 2 digits and push CONT.

Example: "MONTH?" 02  
"DAY" 03  
"HOUR" 04  
"MINUTE" 05  
"SECOND" 06

for February 3, 0405 hour, 6 seconds

4. The CRT will display "THE TIME YOU SET IS" \_\_\_\_\_. "DO YOU WANT TO SET IT? Y/N". Enter "Y" or "N" and push CONT. If "Y" then clock will be set at the time you entered while the CRT displays "WORKING AT SETTING CLOCK". After setting the clock is completed the CRT will display THE TIME HAS BEEN SET IT IS \_\_\_\_\_. "CLOCK IS FINISHED".

## INSTRUCTIONS FOR USE OF AvsM PROGRAM

1. Insert Autoprogram tape into tape drive 15. Type Load "AvsM" and then press EXECUTE.  
This step loads the program into the computer's memory. When the small square of light at the lower right-hand corner of the cathode ray tube (CRT) is extinguished, the program is fully loaded and ready for use. Remove the Autoprogram tape and insert your data tape into tape drive 15.
2. Press RUN, CRT prompts "FILE WANTED?" for first data file to be read.
3. Type in the name of the file desired and press CONT. Computer finds and reads your data file from tape and writes table on CRT. CRT displays "DO YOU WANT HARD COPY, Y/N?" Enter "Y" or "N" and press CONT. If "Y" then the table will be written by printer.
4. CRT displays "FILE WANTED?" for second data file to be read.
5. Type in name of the second file desired and press CONT. The table will be displayed on CRT and you will be asked if you want a hard copy as in step 3.
6. CRT displays "CHANNEL WANTED IN PLOT?" Enter channel number and press CONT. (Note: Usually the channels are: 1 =  $PO_4$ , 2 =  $SiO_4$ , 3 =  $NO_3 + NO_2$ , 4 =  $NO_2$ , 5 =  $NH_4$ , 6 = UREA).
7. A table of absorbances for variable and the differences between absorbance values for the two data files will be listed on the CRT. You will be prompted by "DO YOU WANT A HARD COPY OF THE TABLE? Y/N". If a hard copy is wanted enter "Y" and press CONT.
8. If "N" is entered to the hard copy then a graph of the differences between the absorbances will be plotted versus peak number in the AutoAnalyzer run.
9. The CRT will display "DO YOU WANT A HARD COPY OF THE GRAPH? Y/N". If "Y", the printer will produce a copy of the graph and if "N" then the program will return to step 6 and ask for channel number. If a new set of files are desired, then push STOP and RUN which will start the programs with step 2.

THIS IS A LIST FOR DATA SET=

1.00

LABEL=HA001

DATE=25AUG78

HR=1530

LAT=N.A.

LON=N.A.

DEPTH= -99

COMMENT=N.A.

NO. SAMPLES= 22

OPERATOR=CJP

CHANNEL=	P04	S104	N03	N02	NH4	X30N
STATUS=	1	1	1	1	1	1
FACTORS=	.953	4.338	4.941	.859	0.000	5.019
RF'S=	0.000	0.000	0.000	0.000	0.000	0.000
BASE1=	.111	.112	.103	.115	0.000	.117
BASE2=	.073	.193	.137	.171	0.000	.186

NO.	ID							
1	D	0	4.57	9.60	7.92	4.43	0.00	7.78
2	H	0	.61	2.02	.16	.24	0.00	.21
3	H	10	.66	1.45	.14	.21	0.00	.20
4	H	20	.91	1.45	.15	.23	0.00	.21
5	H	30	1.17	2.92	.38	.29	0.00	.45
6	H	40	1.28	3.08	.49	.30	0.00	.57
7	H	0	.74	1.66	.15	.24	0.00	.21
8	H	10	.70	2.03	.14	.25	0.00	.21
9	H	20	1.01	2.52	.27	.29	0.00	.34
10	H	30	1.36	3.58	.70	.35	0.00	.78
11	H	35	1.09	2.90	.39	.32	0.00	.47
12	H	0	.84	1.86	.16	.26	0.00	.23
13	H	10	.73	1.69	.15	.25	0.00	.22
14	H	20	1.19	2.19	.21	.29	0.00	.29
15	H	0	.58	1.63	.15	.26	0.00	.23
16	H	10	.83	1.41	.16	.27	0.00	.24
17	H	20	1.15	2.15	.23	.31	0.00	.32
18	H	30	1.19	3.46	.64	.37	0.00	.75
19	H	40	1.32	3.55	.72	.38	0.00	.82
20	H	45	1.66	3.64	.81	.42	0.00	.93
21	S	11	.73	3.50	1.34	.26	0.00	1.47
22	S	21	1.14	2.37	.27	.92	0.00	.37

THIS IS A LIST FOR DATA SET=

2.00

LABEL=HM001

DATE=28AUG78

HR=1530

LAT=N.A.

LON=N.A.

DEPTH= -99

COMMENT=N.A.

NO.SAMPLES= 22

OPERATOR=CJP

CHANNEL=	P04	SI04	N03	N02	NH4	NOF
STATUS=	1	1	1	1	1	1
FACTORS=	.953	5.579	4.941	.859	0.000	5.019
RF'S=	.180	.040	0.000	.020	.100	0.000
BASE1=	.110	.110	.100	.110	0.000	.120
BASE2=	.090	.187	.130	.180	0.000	.180

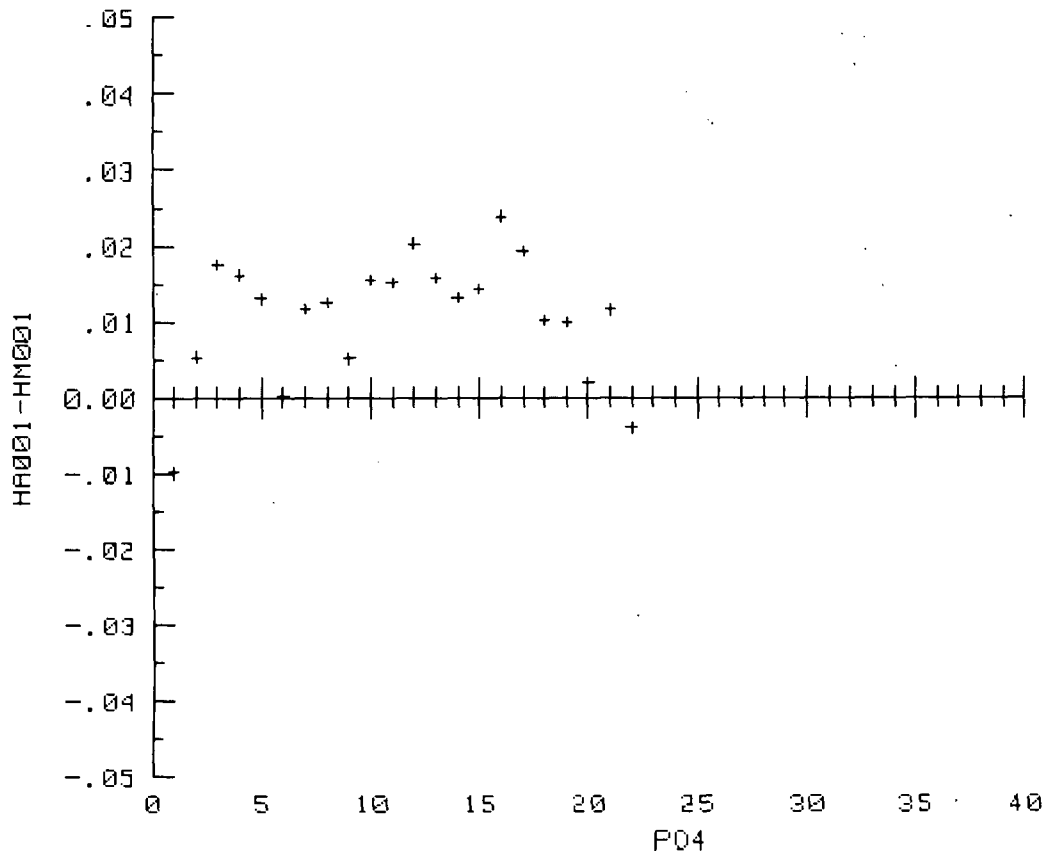
NO.	ID							
1	D	0	4.58	9.62	7.94	4.47	0.00	7.81
2	H	0	.60	2.03	.17	.26	0.00	.22
3	H	10	.64	1.47	.13	.21	0.00	.20
4	H	20	.89	1.47	.14	.23	0.00	.22
5	H	30	1.16	2.94	.39	.30	0.00	.47
6	H	40	1.28	3.11	.50	.31	0.00	.57
7	H	0	.73	1.58	.13	.25	0.00	.21
8	H	10	.69	2.03	.13	.26	0.00	.20
9	H	10	1.00	2.52	.27	.30	0.00	.35
10	H	30	1.34	3.10	.70	.37	0.00	.79
11	H	35	1.07	2.90	.39	.32	0.00	.47
12	H	0	.82	1.89	.15	.27	0.00	.22
13	H	10	.71	1.69	.15	.26	0.00	.22
14	H	20	1.18	2.21	.21	.30	0.00	.30
15	H	0	.57	1.61	.16	.27	0.00	.22
16	H	10	.81	1.45	.17	.28	0.00	.24
17	H	20	1.13	2.19	.22	.31	0.00	.32
18	H	30	1.18	3.47	.65	.38	0.00	.73
19	H	40	1.31	3.57	.71	.38	0.00	.81
20	H	45	1.66	3.62	.81	.42	0.00	.92
21	S	11	.72	3.55	1.35	.28	0.00	1.49
22	S	21	1.14	2.38	.28	.91	0.00	.37

THIS IS A TABLE OF MANUAL AND COMPUTER READ ABSORBANCE FOR P04

1=HA001

2=HM001

PEAK NO.	1 P04	2 P04	1-2
1	4.57	4.58	-.01
2	.61	.60	.01
3	.66	.64	.02
4	.91	.89	.02
5	1.17	1.16	.01
6	1.28	1.28	.00
7	.74	.73	.01
8	.70	.69	.01
9	1.01	1.00	.01
10	1.36	1.34	.02
11	1.09	1.07	.02
12	.84	.82	.02
13	.73	.71	.02
14	1.19	1.18	.01
15	.58	.57	.01
16	.83	.81	.02
17	1.15	1.13	.02
18	1.19	1.18	.01
19	1.32	1.31	.01
20	1.66	1.66	.00
21	.73	.72	.01
22	1.14	1.14	-.00



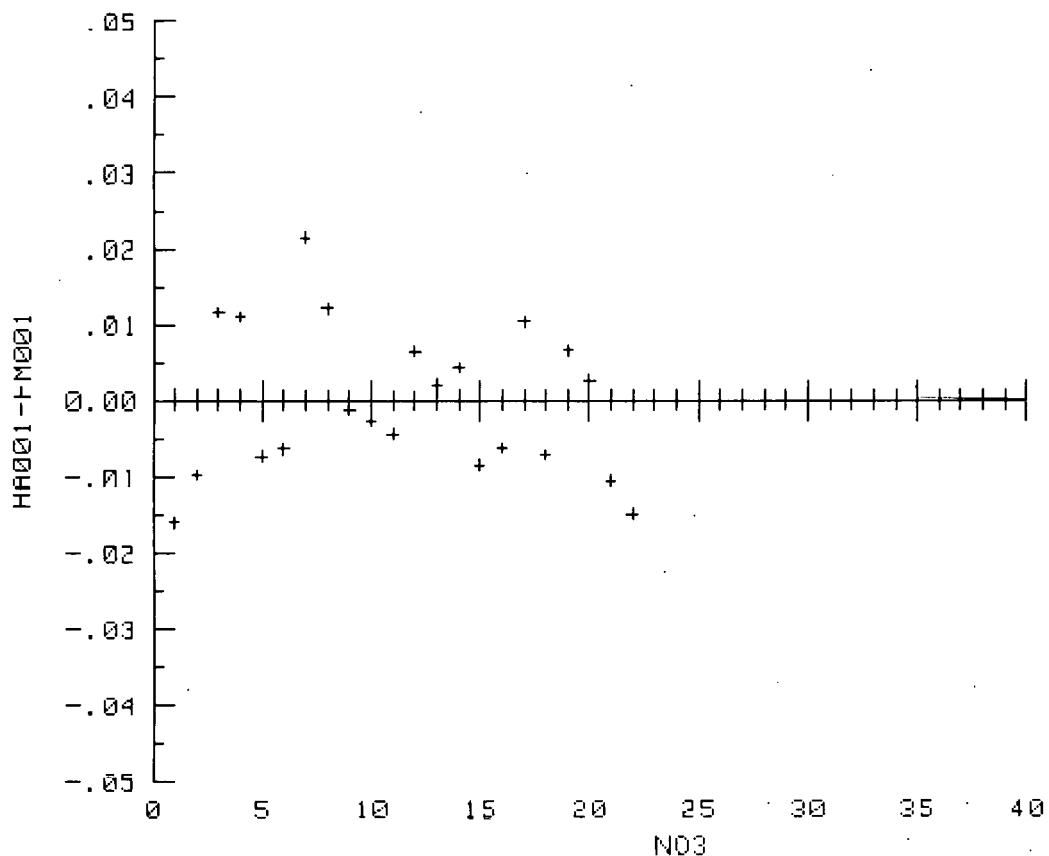


THIS IS A TABLE OF MANUAL AND COMPUTER READ ABSORBANCE FOR NO3

1=HA001

2=HM001

PEAK NO.	1 NO3	2 NO3	1-2
1	7.92	7.94	-.02
2	.16	.17	-.01
3	.14	.13	.01
4	.15	.14	.01
5	.38	.39	-.01
6	.49	.50	-.01
7	.15	.13	.02
8	.14	.13	.01
9	.27	.27	-.00
10	.70	.70	-.00
11	.39	.39	-.00
12	.16	.15	.01
13	.15	.15	.00
14	.21	.21	.00
15	.15	.16	-.01
16	.16	.17	-.01
17	.23	.22	.01
18	.64	.65	-.01
19	.72	.71	.01
20	.81	.81	.00
21	1.34	1.35	-.01
22	.27	.28	-.02



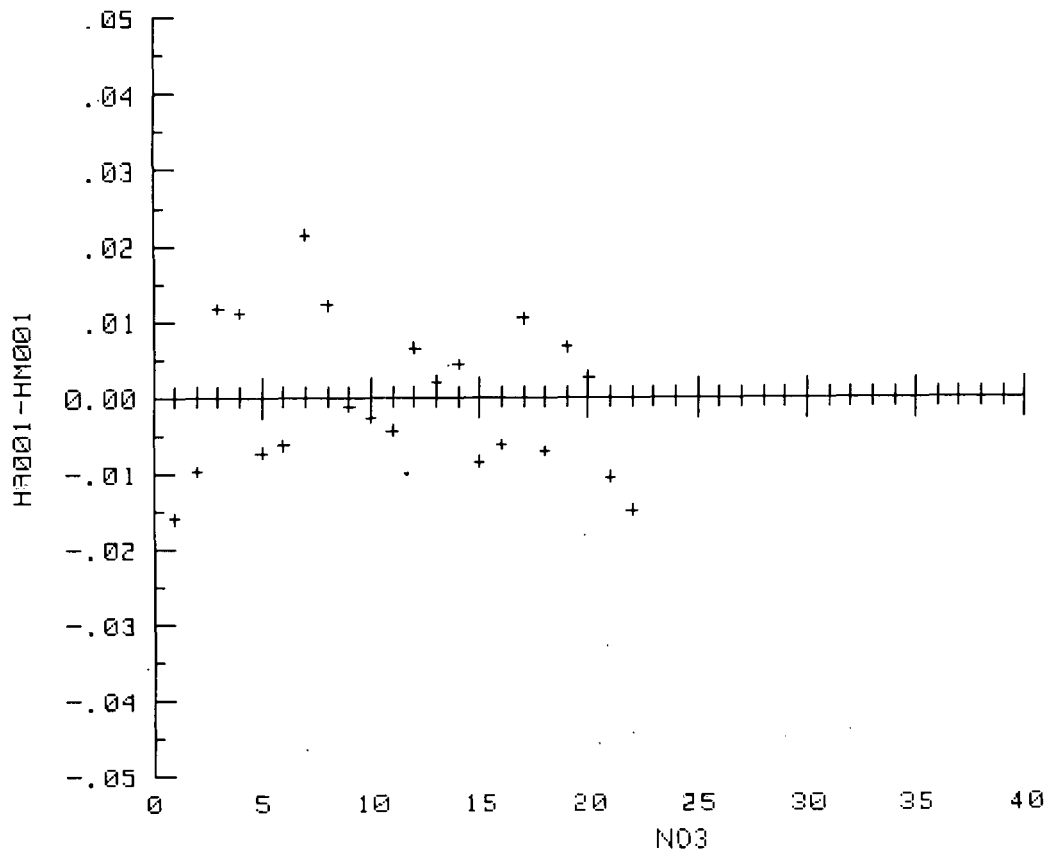


THIS IS A TABLE OF MANUAL AND COMPUTER READ ABSORBANCE FOR NO3

1=HA001

2=HM001

PEAK NO.	1 NO3	2 NO3	1 2
1	7.92	7.94	.02
2	.16	.17	-.01
3	.14	.13	.01
4	.15	.14	.01
5	.38	.39	-.01
6	.49	.50	-.01
7	.15	.13	.02
8	.14	.13	.01
9	.27	.27	-.00
10	.70	.70	-.00
11	.39	.39	-.00
12	.16	.15	.01
13	.15	.15	.00
14	.21	.21	.00
15	.15	.16	-.01
16	.16	.17	-.01
17	.23	.22	.01
18	.64	.65	-.01
19	.72	.71	.01
20	.81	.81	.00
21	1.34	1.35	-.01
22	.27	.20	-.02



## INSTRUCTIONS FOR USE OF PLOT PROGRAM

1. Insert Autoprogram tape into tape drive 15. Type LOAD "PLOT" and then press EXECUTE.  
This steps loads the program into the computer's memory. When the small square of light at the lower right-hand corner of the cathode ray tube (CRT) is extinguished, the program is fully loaded and ready for use. Remove the Autoprogram tape and insert your data tape into tape drive 15.
2. Press RUN. CRT displays HELLO FROM PLOT USING STANDARD FILE. Variable names are PO4, SIO4, N+N, NO2, NH4, URE. CRT prompts FILE WANTED at lower left-hand corner of the screen.
3. Type in the name of the file desired and press CONT. Computer finds and reads your data file from tape. CRT displays "FINISHED READING FILE" and prompts OUTPUT TYPE: 1=ABS  
2=UG-AT/L
4. Type 1 if you desire a listing in absorbance units or type 2 if you desire a listing in  $\mu\text{g-at/liter}$ . Because you will need to know the nutrient concentrations in  $\mu\text{g-at/liter}$  for the plotting routine, it is wise to select 2. Press CONT.  
CRT displays data file and prompts DO YOU WANT HARD COPY, Y/N?
5. Type Y and press CONT. A hard copy is output to the thermal printer. CRT prompts again, DO YOU WANT HARD COPY, Y/N?
6. Type N and press CONT. CRT displays LIST FINISHED and prompts DO YOU WANT A PLOT?, Y/N.
7. Type Y and press CONT. CRT prompts for VARIABLE NAME.
8. Type the variable desired; PO4, SIO4, N+N, NO2, NH4, or URE and press CONT. If variable name is incorrect, CRT displays incorrect variable name IS A BAD CHOICE TRY AGAIN. Type correct name and press CONT.
9. CRT prompts XMIN, XMAX? Type range of concentration desired for this variable, press CONT.
10. CRT prompts DEPTH MIN, DEPTH MAX. Type range of depths desired for this variable, press CONT.
11. CRT plots data for this nutrient variable and prompts DO YOU WANT A HARD COPY OF THE PLOT? Y/N.
12. Type Y and then press CONT to obtain a copy of the plot on the thermal printer. CRT prompts again DO YOU WANT A HARD COPY OF THE PLOT? Y/N.
13. Type N and press CONT. CRT prompts DO YOU WANT A NEW STATION? Y/N.
14. Type N and press CONT and program returns you step to 9 for new variable or type Y and press CONT. Program returns you to step 4 for the selection of a new station.

## PLOT PROGRAM - USER DEFINED PARAMETERS

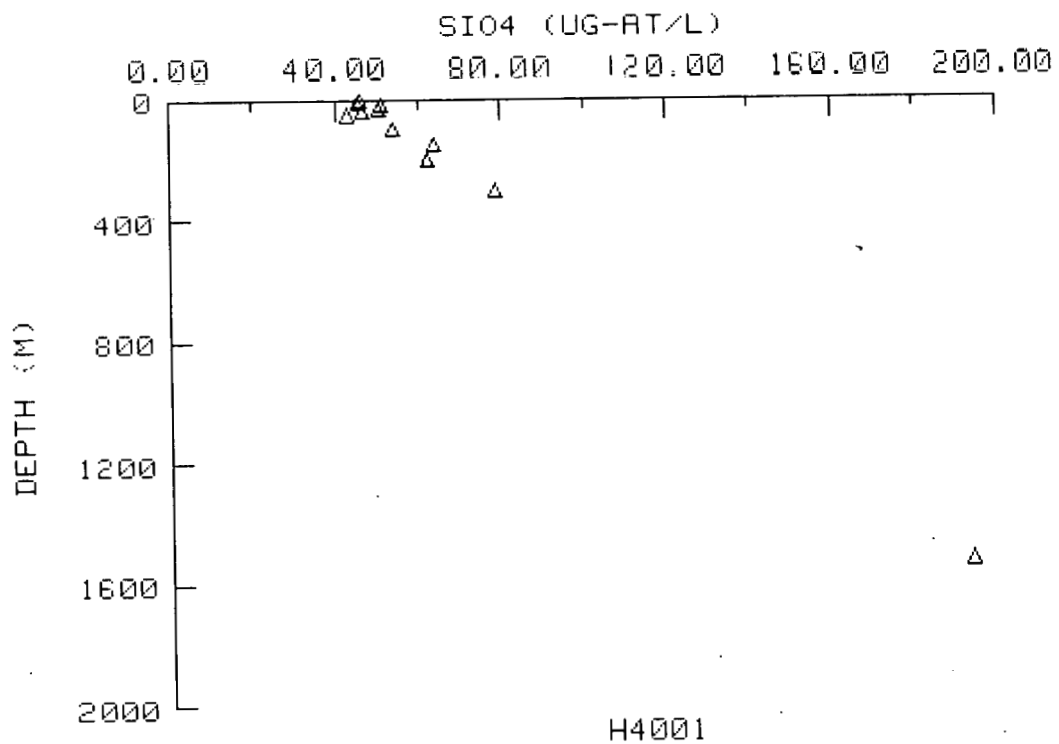
- 120 Variable names: Order of variables is constant. Channel 6, URE, is for experimental work. Change URE to the analysis at hand. For example, change URE to CHL if chlorophyll is being determined.
- 550 Type of sample: For hydro samples, this line specifies that these "H" samples will be plotted. To plot samples identified in the data base by any other letter, enter its I.D. letter here. For example, to plot productivity identified in the data by the letter P, substitute "P" for "H". Only productivity samples will then be plotted when PLOT is called.

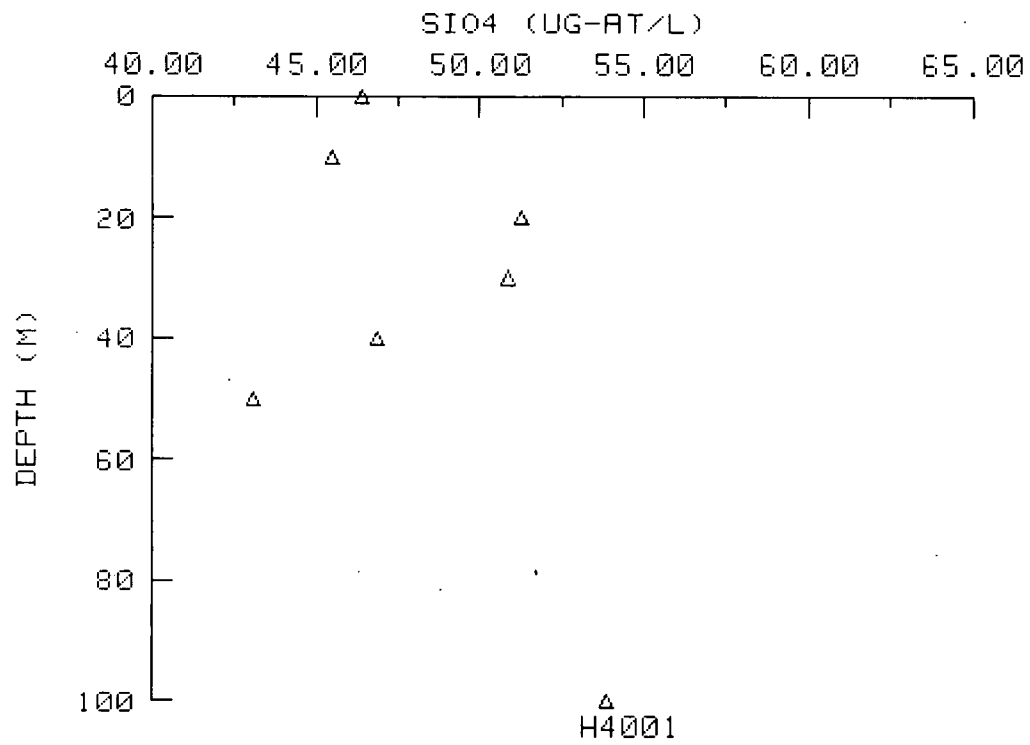
The following three pages are output examples of "PLOT".

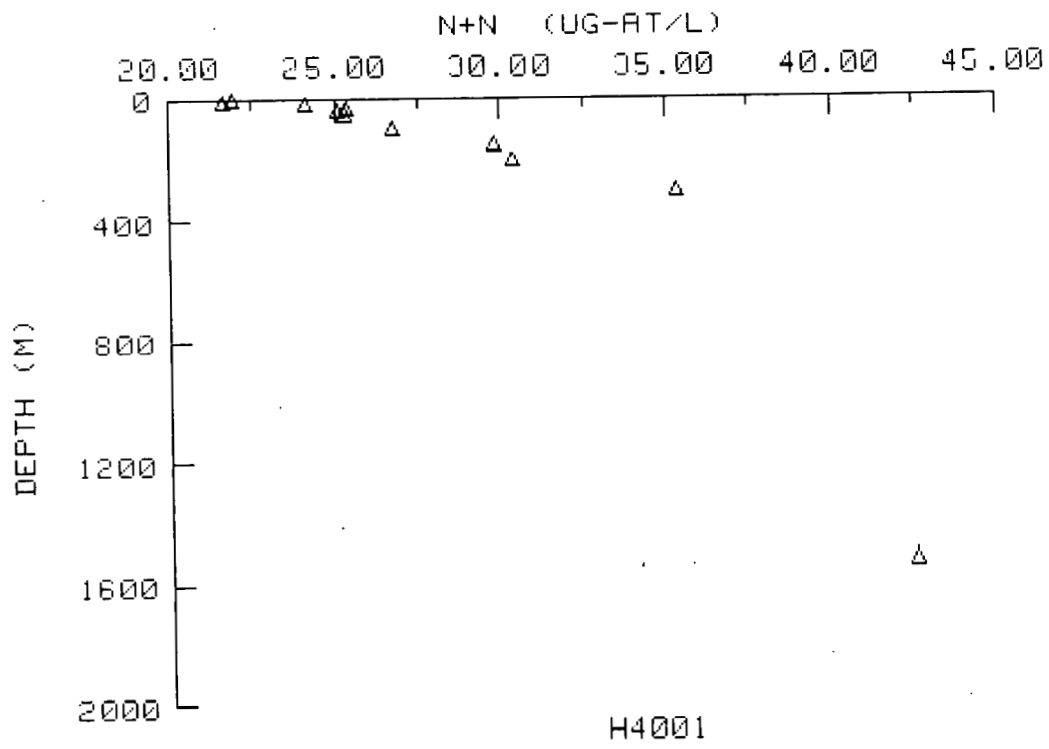
LABEL=H4001  
 DATE=21MAY80  
 HR=2350  
 LAT=54 52.0  
 LON=167 53.0  
 DEPTH= 1527  
 COMMENT=TRANSECT STATION  
 NO. SAMPLES= 14  
 OPERATOR=MR

CHANNEL=	P04	S104	N+N	N02	NH4	URE
STATUS=	1	1	1	1	1	0
FACTORS=	.681	10.401	4.613	.638	.855	1.000
RF'S=	.150	.130	.010	.030	.180	0.000
BASE1=	.369	.427	.215	.375	.322	0.000
BASE2=	.474	.606	.615	.386	.331	-9.990

NO.	ID	UG-AT	UG-AT	UG-AT	UG-AT	UG-AT	UG-AT
1	D 0	5.18	96.92	45.40	3.17	7.47	0.00
2	S 15	.73	94.79	43.90	.02	.10	0.00
3	S 25	4.20	-.89	4.23	4.44	4.44	0.00
4	H 0	1.76	46.38	21.95	.38	.95	0.00
5	H 10	1.86	45.51	21.63	.35	.90	0.00
6	H 20	1.94	51.30	24.13	.35	.99	0.00
7	H 30	2.01	50.88	25.34	.35	1.06	0.00
8	H 40	1.99	46.87	25.12	.35	.99	0.00
9	H 50	2.00	43.13	25.27	.37	.97	0.00
10	H 100	2.09	53.92	26.71	.39	1.06	0.00
11	H 150	2.28	64.06	29.82	.38	.72	0.00
12	H 200	2.33	62.17	30.41	.44	.83	0.00
13	H 300	2.59	78.75	35.31	.22	.75	0.00
14	H1524	3.25	193.99	42.54	.17	.79	0.00







## INSTRUCTIONS FOR SECS

1. Insert Autoprogram tape into tape drive 15. Type LOAD "SECS" and then press EXECUTE.

This step loads the program into the computer's memory. When the small square of light at the lower right-hand corner of the cathode ray tube (CRT) is extinguished, the program is fully loaded and ready for use. Remove the Autoprogram tape and insert your data tape into tape drive 15.

2. Press RUN, CRT prompts "ENTER FILE NAME, STA NO.? TYPE EXIT TO QUIT". Enter file names that are stored on data tape and Station numbers to be used for each station in the section, push CONT. (Note: Be certain the stations are entered in their proper order in the transect). A maximum of 25 stations with 40 depths on each station and 6 channels are the upper limit of storage capacity in the computer.

Example: HY2001, 1 file "HY2001" is called station 1  
HY2002, 3 file "HY2002" is called station 3.

The file name is checked for each request on tape 15 and if not found "INPUT ERROR IN (file name) TRY AGAIN" will be displayed. Type "EXIT" and push CONT to quit requesting files.

3. The CRT will display "DO YOU WANT A HARD COPY?" Y/N" Enter "Y" or "N" and push CONT.
4. The CRT will display "DO YOU WANT TO RUN? Y/N" Enter "Y" or "N" and push CONT.

If "Y" is answered to question then the computer will sequentially retrieve the files from the tape and store them in a 3-dimensional matrix of stations, depths and channel numbers. As the files are stored in the computer the CRT displays that the file has been found.

5. After the last file has been stored, the section length in km will be written on the CRT. This is calculated from the latitude and longitude fixes from each station file. The distance represents the cumulative distance calculated as a great circle between each of the stations. As a result, the cumulative distance between stations may be different than the distance between the two transect end stations.
6. The CRT will then ask for "VARIABLE NAME?" Enter the three or four letter name of the nutrient wanted, press CONT. Other options are: integrations, enter "I" and ratios, enter "R"
7. The CRT will request "SECTION LENGTH?" Enter desired length in km of the section while taking note of the actual length in step 6 above, press CONT.
8. The CRT will request "MAXIMUM DEPTH PLOT?" Enter the deepest depth for the vertical scale desired, press CONT. Note that you do not have to plot all values. If 100 m is requested then all values deeper than 100 m will be disregarded. Bottom depths will be drawn for all or part of the stations if the requested depth is chosen large enough.
9. The CRT will request "Type of Plot 1 = numbers, 2 = numbers + contours, 3 = contours." If you want only number with no lines enter 1 and press CONTINUE. However, you can obtain numbers and contours or just contours by pressing 2 or 3 followed by a CONTINUE. If contours are requested the CRT will display "Contour level value or E to exit." Enter each contour concentration followed by a CONTINUE. Enter E and press CONTINUE to start plot.



10. The section will be drawn from left to right. The bottom contour will be added to the figure automatically if sonic depths have been entered into the files.
11. The CRT will display "DO YOU WANT A HARD COPY OF THE PLOT? Y/N" Enter "Y" or "N" and press CONT.
12. The CRT will display "DO YOU WANT ANOTHER VARIABLE ON THIS SECTION? Y/N". Enter "Y" or "N" and press CONT. If "Y" then go to step 7. If "N" then the program ends. To do another section push STOP and RUN, then start at step 2.

## INTEGRATION

To obtain integrated values in a transect respond to CRT with an "I" and press CONTINUE when "VARIABLE NAME? [6A]" is displayed.

1. CRT will request "WHAT IS THE INTEGRATION MIN?" Enter depth and press CONTINUE.
2. CRT will request "WHAT IS THE INTEGRATION MAX?" Enter depth and press CONTINUE.
3. CRT will request "DO YOU WANT A HARD COPY OF THE INTEGRATED VALUES? Y/N" Enter "Y" and press CONTINUE for a printout of all integrated values in the transect.
4. CRT will request "SECTION LENGTH?" Enter length of x-axis in km and press CONTINUE.
5. CRT will request "MAXIMUM INTEGRATED CONC?" Enter maximum value of y-axis and press CONTINUE.
6. The plot will commence but the CRT will request "VARIABLE MASK? [6 No.'s]" Enter 6 numbers separated by commas for the nutrient channels desired in the plot.  
 Examples: 0,1,1,0,0,0 will plot only channels 2 and 3 (SiO<sub>4</sub> and N+N).  
 1,0,1,0,1,0 will plot channels 1, 3 and 5 (PO<sub>4</sub>, N+N, NH<sub>4</sub>).

If you simply press CONTINUE without entering numbers, all channels will be plotted unless you had previously changed the mask.

## RATIOS

To obtain ratios of variables in a transect respond to CRT with an "R" and press CONTINUE when "VARIABLE NAME? [6A]" is displayed.

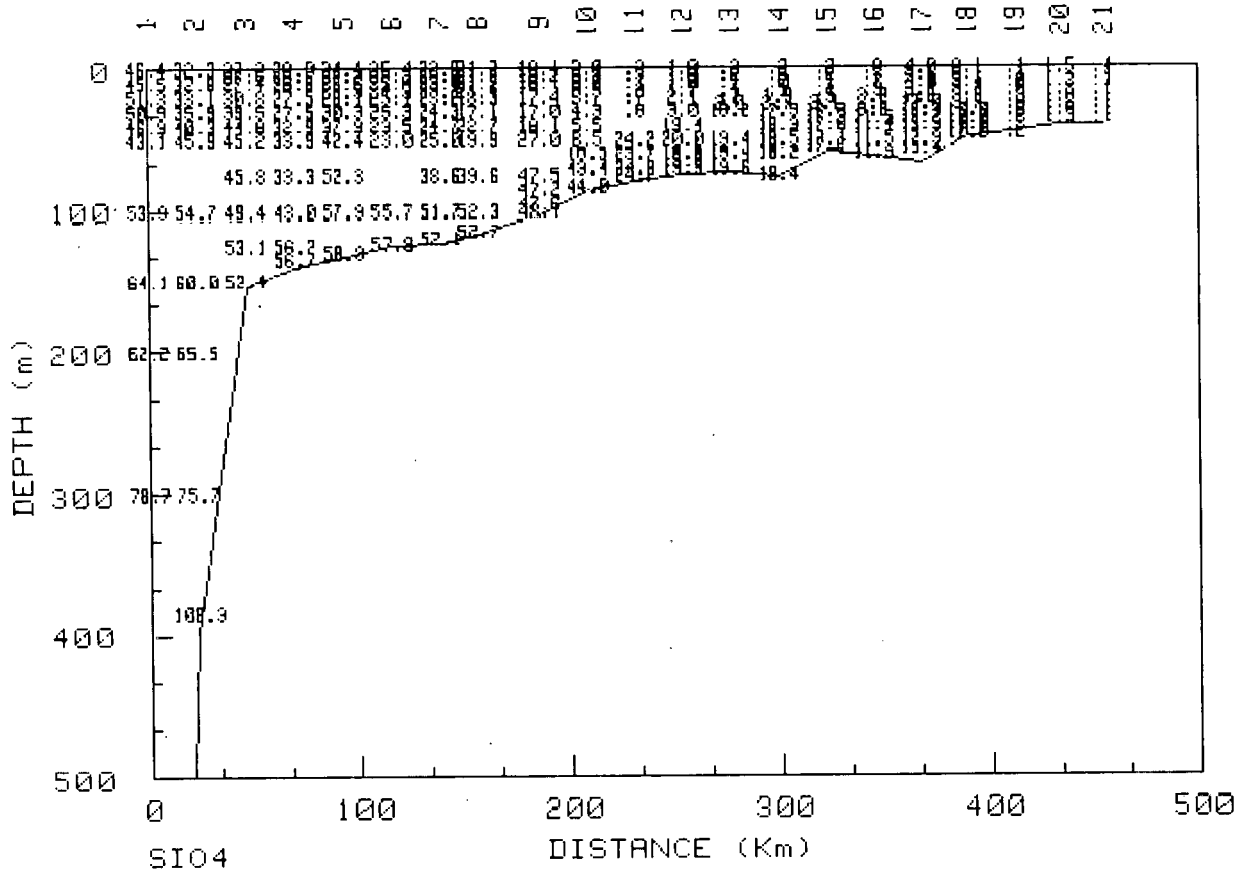
1. CRT will request "SECTION LENGTH?" Enter length in km and press CONTINUE.
2. CRT will request "MAXIMUM PLOT DEPTH?" Enter depth in m and press CONTINUE.
3. CRT will request "WHAT IS THE LABEL FOR THE PLOT? [18]" Enter label from keyboard (maximum of 18 characters) and press CONTINUE.  
 Example: NO<sub>3</sub>/SiO<sub>4</sub>.
4. CRT will request "TYPE OF PLOT 1 = NUMBERS, 2 = NUMBERS + CONTOURS, 3 = CONTOURS." Enter desired number and press CONTINUE. If contours are requested, enter contour levels and press CONTINUE. Enter "E" and press CONTINUE to start the plot.

(Note: For ratios other than NO<sub>3</sub>/SiO<sub>4</sub> the coding must be altered in SECS program lines 3210 and 3220.)

HERE IS A LIST OF FILES YOU HAVE ASKED FOR

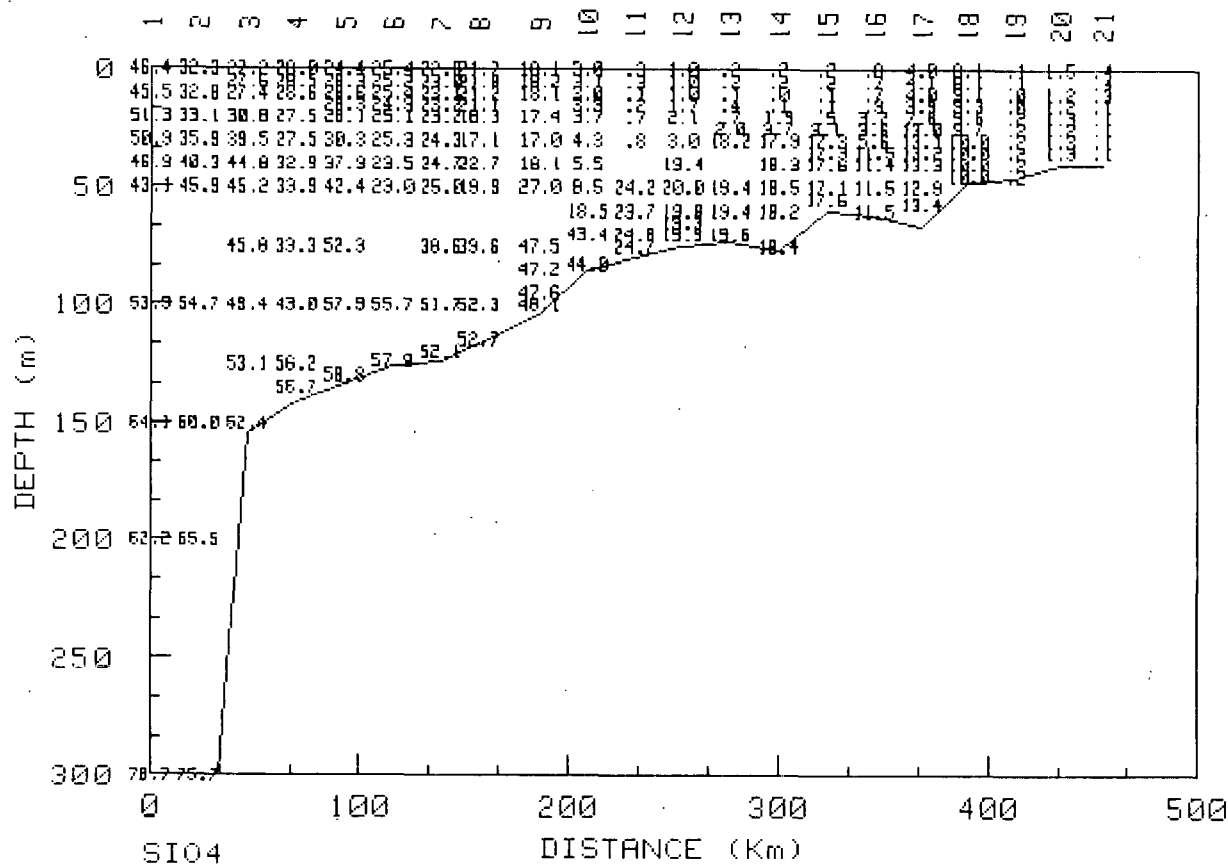
NO.	NAME	STATION
1	H4001	1
2	H4002	2
3	H4003	3
4	H4004	4
5	H4005	5
6	H4006	6
7	H4007	7
8	H4008	8
9	H4009	9
10	H4010	10
11	H4011	11
12	H4012	12
13	H4013	13
14	H4014	14
15	H4015	15
16	H4016	16
17	H4017	17
18	H4018	18
19	H4019	19
20	H4020	20
21	H4021	21

PROBES LEG IV STATIONS

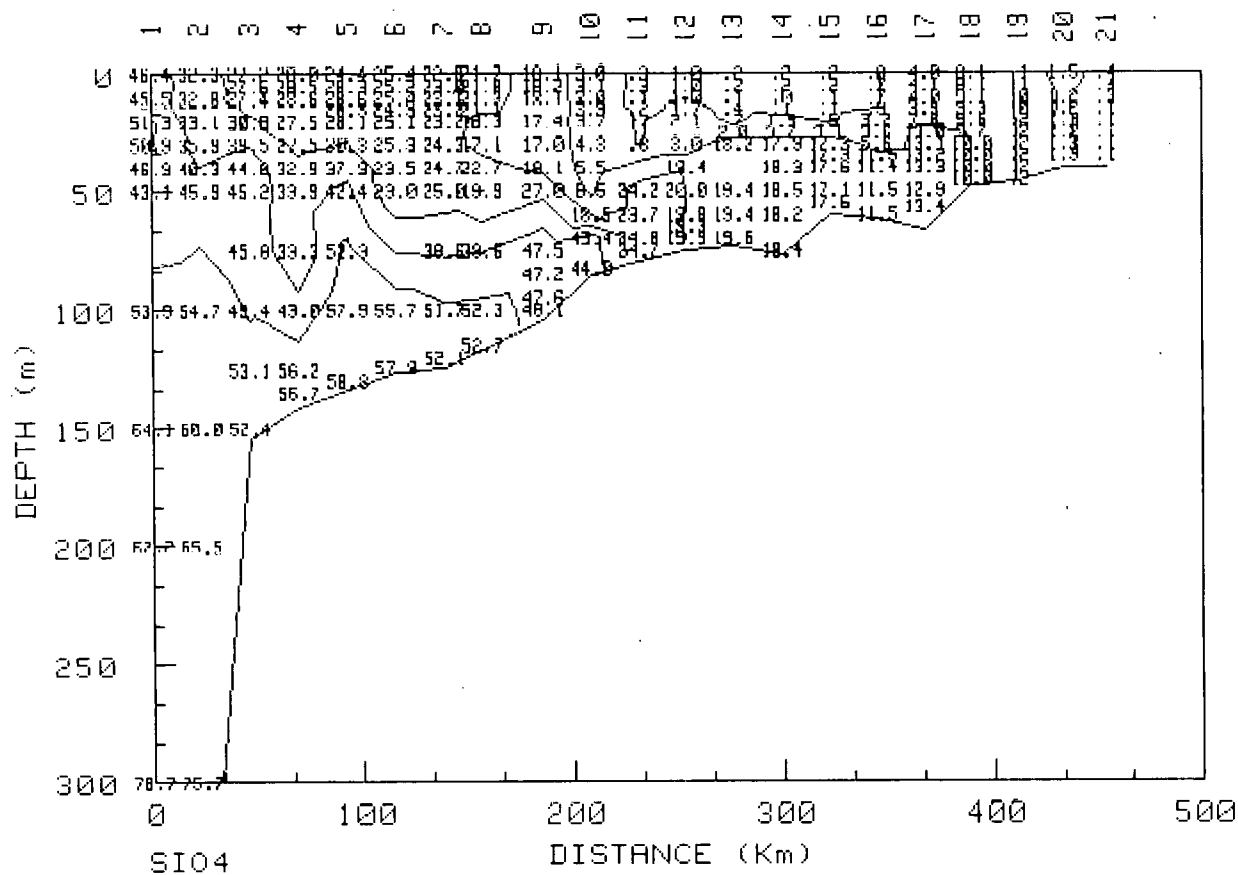


PROBES LEG IV

STATIONS



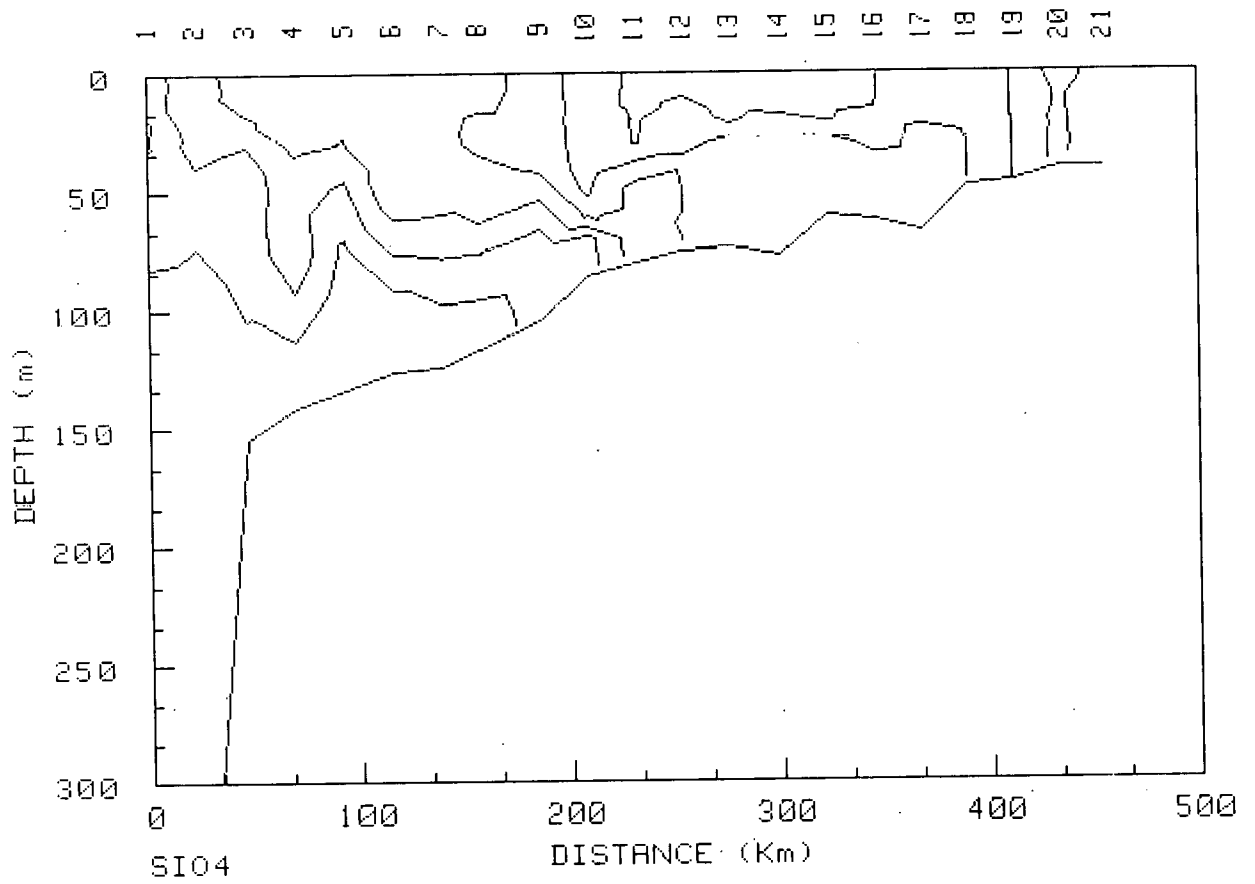
PROBES LEG IV STATIONS





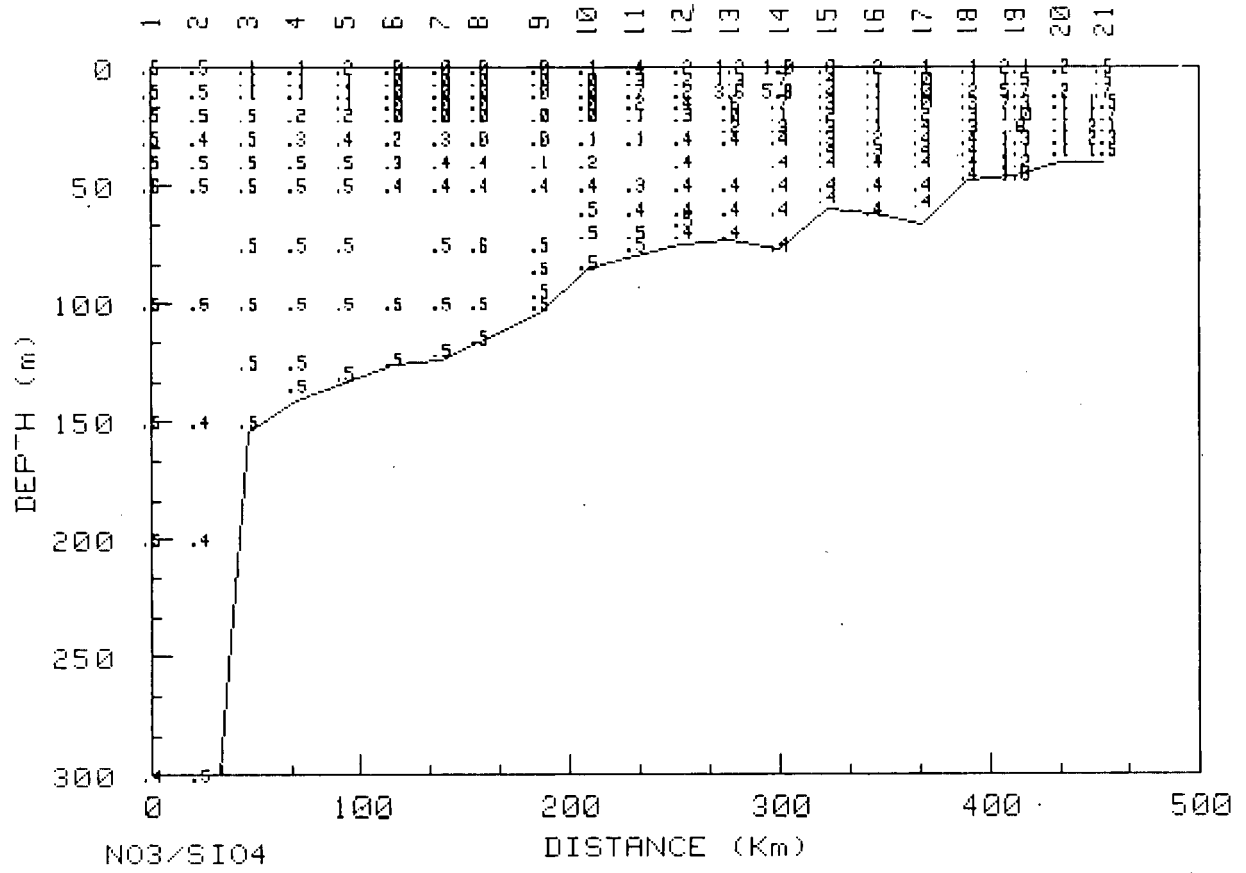
PROBES LEG IV

STATIONS



PROBES LEG IV

STATIONS



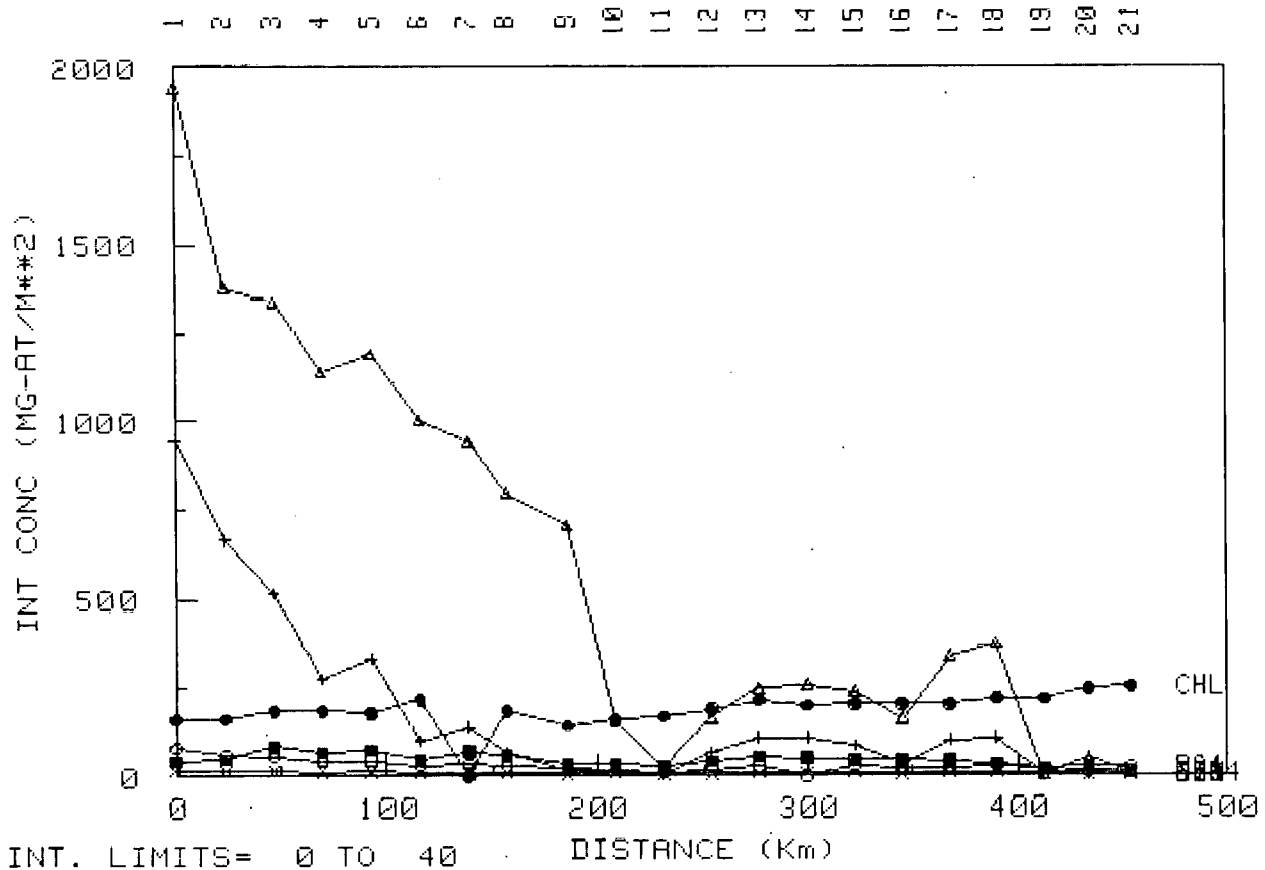


INTEGRATED CONCENTRATIONS (MG-AT/M\*\*2)

STA NO.	INTEGRATED FROM 0 TO 40 m					
	P04	SI04	N+N	N02	NH4	CHL
1	76.81	1943.12	946.29	14.24	39.14	159.84
2	56.84	1381.19	666.28	16.24	47.65	159.84
3	53.16	1338.68	517.37	13.61	82.15	183.15
4	39.38	1141.13	273.12	10.78	63.86	183.15
5	43.19	1191.24	328.03	12.12	72.15	176.29
6	30.02	1000.45	98.24	8.40	43.77	214.07
7	32.46	943.02	137.50	8.19	67.99	0.00
8	25.29	797.00	64.20	7.69	56.35	182.84
9	22.17	705.95	17.35	6.14	32.69	141.52
10	14.50	156.07	14.87	8.44	35.19	158.77
11	10.46	21.54	3.09	5.22	25.65	167.14
12	17.75	163.70	65.09	6.21	39.21	187.80
13	25.28	244.51	106.17	9.09	52.29	209.21
14	0.00	255.83	105.95	7.43	48.48	197.79
15	26.18	238.03	85.70	7.34	44.84	201.12
16	20.23	162.31	35.30	6.44	44.75	201.12
17	22.32	338.65	98.56	9.68	40.01	201.12
18	26.81	373.66	105.90	10.00	32.52	216.34
19	18.87	5.50	8.11	6.26	20.26	216.34
20	28.46	50.59	7.05	5.85	18.01	244.56
21	26.81	7.31	7.56	6.24	15.88	252.32

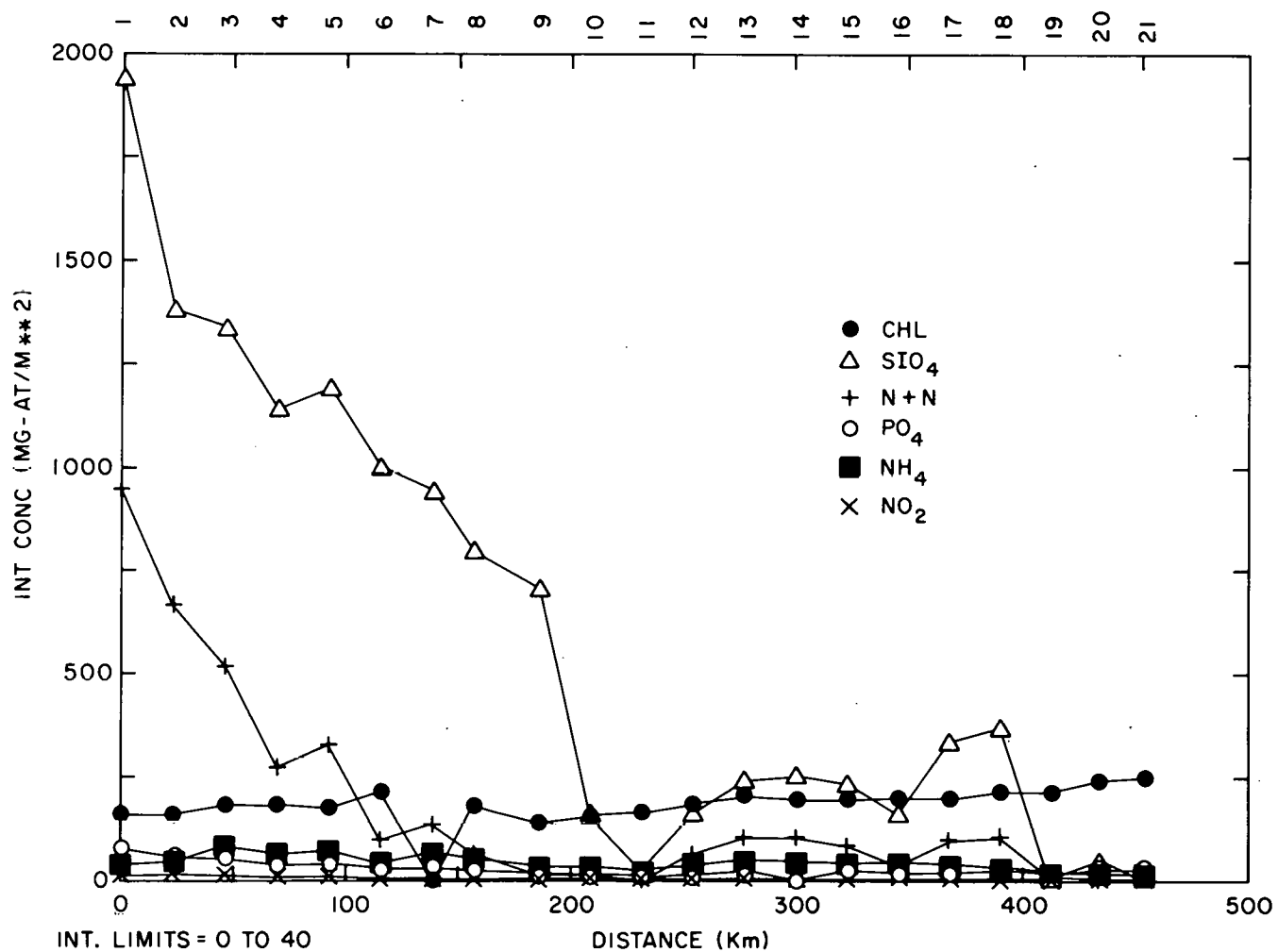
PROBES LEG IV

STATIONS



PROBES LEG IV

STATIONS

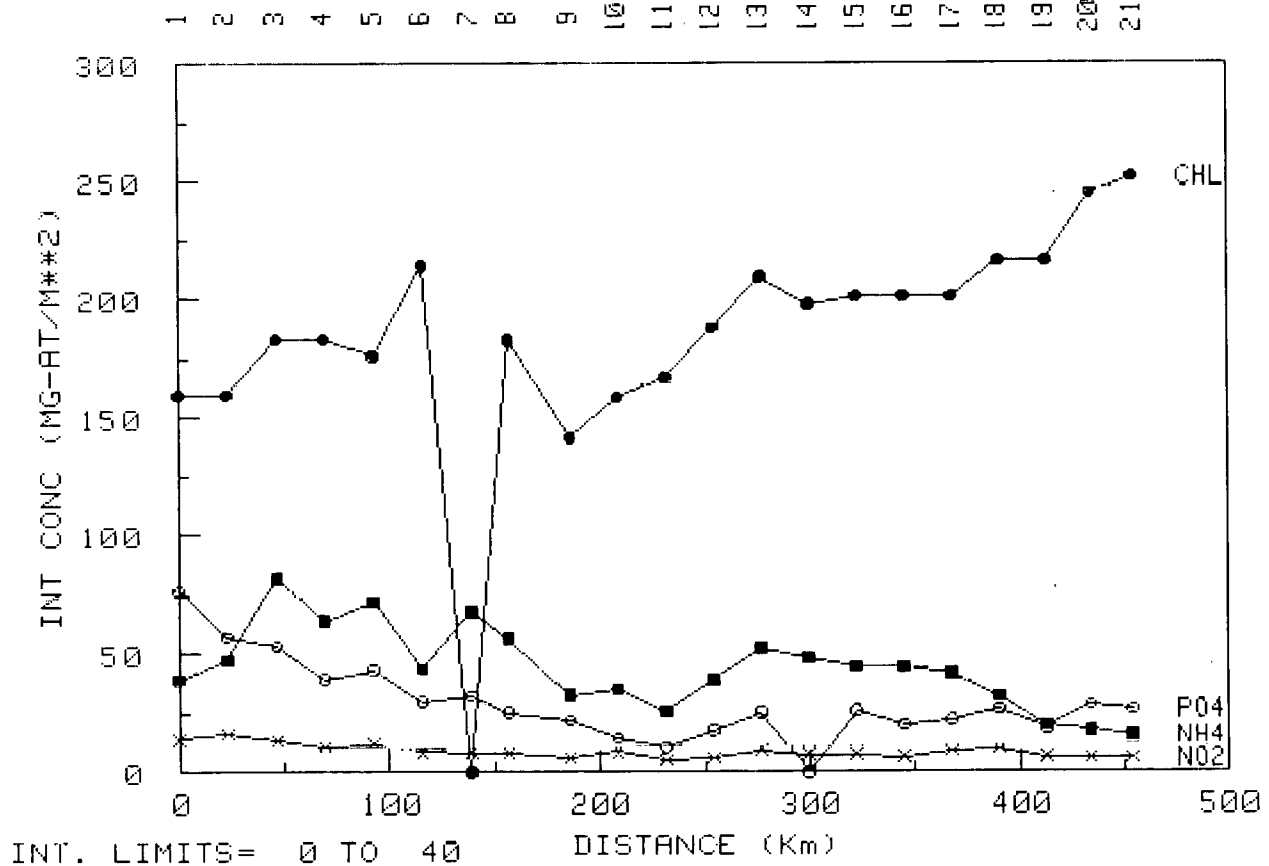


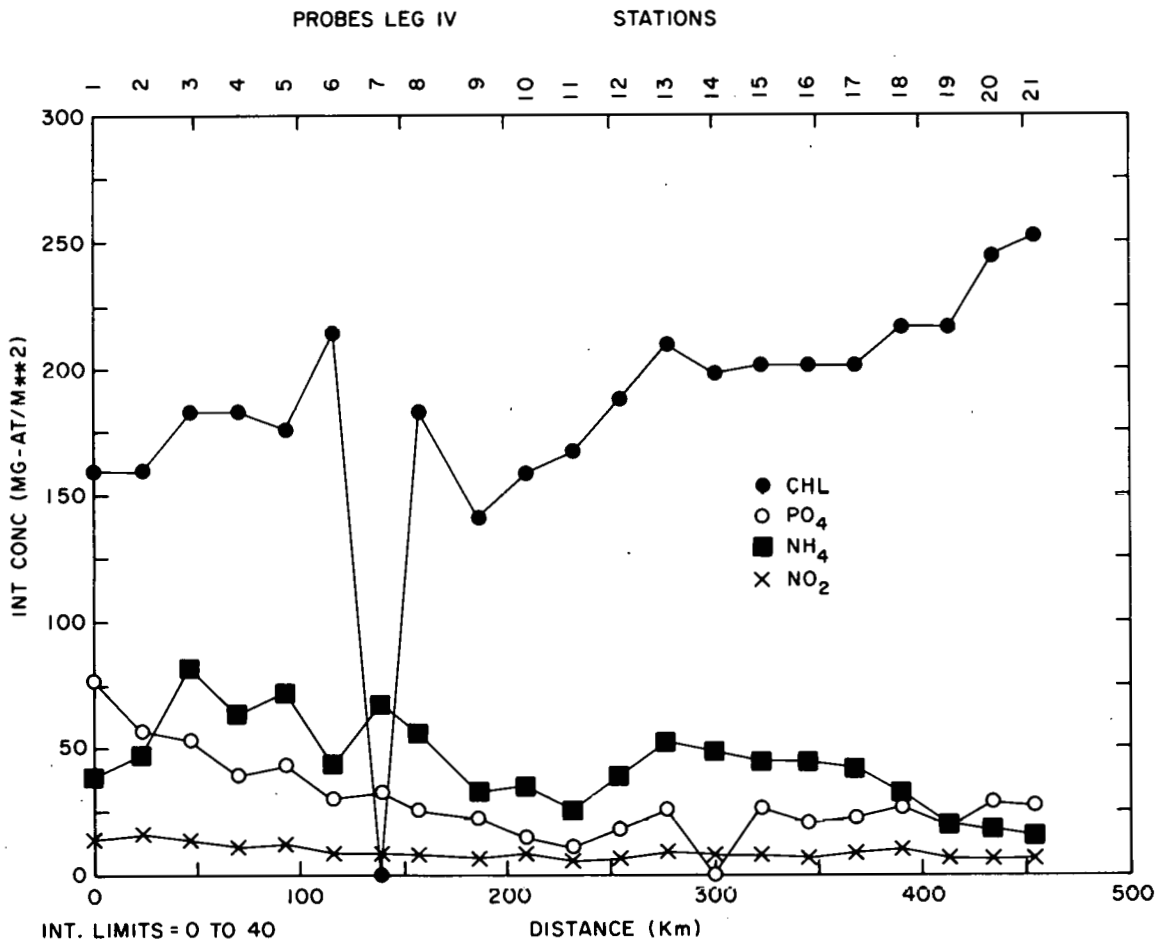
INTEGRATED CONCENTRATIONS (MG-AT/M\*\*2)

STA NO.	INTEGRATED FROM 0 TO 40 m					
	P04	SI04	N+N	N02	NH4	CHL
1	76.81	1943.12	946.29	14.24	39.14	159.84
2	56.84	1381.19	666.28	16.24	47.65	159.84
3	53.16	1338.68	517.37	13.61	82.15	183.15
4	39.38	1141.13	273.12	10.78	63.86	183.15
5	43.19	1191.24	328.03	12.12	72.15	176.29
6	30.02	1000.45	98.24	8.40	43.77	214.07
7	32.46	943.02	137.50	8.19	67.99	0.00
8	25.29	797.00	64.20	7.69	56.35	182.84
9	22.17	705.95	17.35	6.14	32.69	141.52
10	14.50	156.07	14.87	8.44	35.19	158.77
11	10.46	21.54	3.09	5.22	25.65	167.14
12	17.75	163.70	65.09	6.21	39.21	187.80
13	25.28	244.51	106.17	9.09	52.29	209.21
14	0.00	255.83	105.35	7.43	48.48	197.79
15	26.18	238.03	85.70	7.34	44.84	201.12
16	20.23	162.31	35.30	6.44	44.75	201.12
17	22.32	338.65	98.56	8.68	42.31	201.12
18	26.81	373.66	105.90	10.00	32.52	216.34
19	18.87	5.50	8.11	6.26	20.26	216.34
20	28.46	50.59	7.05	5.85	18.01	244.56
21	26.81	7.31	7.56	6.24	15.88	252.32

PROBES LEG IV

STATIONS





## 6. COMPUTER INTERFACING AND HARDWARE MODIFICATIONS

The task of interfacing a desktop computer to control an AutoAnalyzer can be somewhat confusing so some details of the hardware needed are given in this section. Also the hardware in only a few automated nutrient analysis systems completely satisfy all of the reasonable needs or desires of its operator. Part of the dissatisfaction is the development time required for commercial companies to incorporate the newest technological advances into their instruments. Some instrument users have special needs which do not have a large enough market to encourage companies to alter their designs. These mismatches between products and users often stimulate design changes by some users which make their instruments more useful.

### Computer Interfacing

The task of collecting voltage outputs from the 0 to 5 volt telemetry outlet on the AAI colorimeter requires an interface to the computer and an analog to digital (A to D) converter. A 16 bit parallel interface card (HP 98032A) can be purchased directly from Hewlett Packard. The cable from the interface card connects to the 8 channel A to D converter. The colorimeter from each nutrient channel must be connected to one of the 8 A to D ports. Since the computer also commands the sampler, the output of the digital to analog converter (DAC) is connected to the sampler. Additional details about the operation of the interface box follow.

### Description of the Analog Multiplexer Interface to Computer

This interface accepts eight analog inputs within 0...5 volts. All inputs are differential for a minimum of common mode noise. A HP programmable calculator model 9845 or 9825 controls all conversion functions via a 16-bit multiplexer card 98032A by executing the proper commands and codes.

In addition to the input channels one analog output is provided. This output is derived from 8 bits, the full scale being +10V for a binary equivalent of 255. Binary zero corresponds to 0 volts output.

#### Function Description.

Any analog input channel is addressed (selected) sequentially or randomly by setting the binary bit pattern to the Hewlett Packard output bits D08, D09 and D10, D08 being the least significant bit.

Examples:	BITS	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Select Ch. 5		X	X	X	X	X	1	0	1	X	X	X	X	X	X	X	X
Select Ch. 7		X	X	X	X	X	1	1	1	X	X	X	X	X	X	X	X

Note: X Don't care

1 Bit true, 0 Bit false

Addressing is performed by executing an output statement, such as write, write byte and equivalent, depending on the particular I/O configuration of the calculator. The least significant 8 bits (0..7) are used for the analog output. Thus, if the analog output voltage is to remain constant during a channel address operation, these 8 bits must be treated in a special manner:

1. Before output of the address bits:
  - a) "AND" the 7 lsb with "0"
  - b) "OR" the desired bit pattern for the output voltage into the 8 lsb.
  - c) Now output the word.

## 2. Alternate Mode:

- a) Set the bit pattern for the desired output voltage into the output variable.
- b) Multiply the input address channel by 256, E.G.  $3 \times 256$ .
- c) Add this quantity to the variable in step a).
- d) Now output the entire word.

Either method will yield the same results, in this manner the operator maintains full control over input and output operations with a most efficient use of the existing I/O hardware. It is recommended that the above mentioned statements be executed as subroutines that may be called when desired.

## Hardware Description

The 8 input signals pass through shielded "DIN" connectors to an analog multiplexer/conversion module (analog devices mod. DAS1128). This module is programmed to accept unipolar signals from 0 to +5 volts. The conversion protocol is programmed to 12 bits straight binary yielding a resolution of 1 in 4096. The module is internally temperature compensated and contains its own precision reference voltage. After setting the three address inputs, a read statement triggers the conversion start. After the end of the conversion cycle a "FLAG" signal is returned to the 98032A card, indicating a valid byte on the data line. The calculator now accepts the 12 bits and continues with program execution. Since full scale corresponds to all bits "TRUE", the input voltage is obtained by dividing the result into 4095 and multiplying it by 5. The value is now read in volts.

Example: Input Binary Equivalent: 2048  
 $2048 \times 5 / 4095$  yields 2.5 volts.

The input card is programmed such, that the input appears as negative true. The HP9845 does not recognize this hardware programming. Thus, the complement of the input has to be programmed manually. For 9825 operations, this step is unnecessary since it automatically makes the conversion.

## Output Operations

A motorola DAC MC1408L-8 converts the least significant 8 output bits into a constant current, which is calibrated such, that in combination with an OP-AMP A 10 volt full scale is achieved for a binary equivalent of 255. Calibration is obtained through a 1K trim-Pot. A 741 OP-AMP converts the neg. output current into a positive voltage which can be accessed via a rear panel BNC connector. This voltage may be used for oscilloscope displays or plotters.

This interface is self-contained and requires 115V/60HZ only. A fuse (1/2 amp) protects the circuitry. A power switch and a led power indicator are the only front panel controls.

The use of advanced modular electronic packages makes this interface extremely reliable and stable. If required, the module can easily be programmed to accept other input voltages or two output different binary codes.

## Software

The particular software depends on the I/O ROMS installed into the various slots of the calculator. "ROMS" may also be supplied in the form of magnetic tapes from Hewlett Packard that may be updated from time to time. Thus,

no particular program sequence can be specified. However, the operation of the interface is straight forward and it will take only a few programming lines once the I/O operations of the calculator are established. Please refer to the general statements within the "Functional Description".

## Interface Connector Wiring

1	WT/BK/GN	GND	
2			
3			
4			
5			
6			
7	RD/BK	DO10	(20B)
8	RD/GN	DO9	(21B)
9	RD/YL	DO8	(22B)
10	WT/VI	DO7	(5)
11	WT/BU	DO6	(6)
12	WT/GN	DO5	(7)
13	WT/YL	DO4	(8)
14	WT/OR	DO3	(9)
15	WT/RD	DO2	(10)
16	WT/BN	DO1	(11)
17	WT/BK	DO0	(12)
18	WT	GND	
19	WT/GR	PCTL	
20	WT/BK/BN	I/O	
21			
22			
23			
24	WT/BK/OR		
25			

## Interface Connector Wiring (cont)

26	WT/BK/RD	GND	
27		DI15	(GND)
28		DI14	(GND)
29		DI13	(GND)
30		DI12	(GND)
31	WT/BN/GN	DI11	(29T)
32	WT/RD/VI	DI10	(29B)
33	WT/BN/BU	DI9	(30T)
34	WT/BN/RD	DI8	(30B)
35	VI	DI7	(31T)
36	BU	DI6	(31B)
37	GN	DI5	(32T)
38	YL	DI4	(32B)
39	OR	DI3	(33T)
40	RD	DI2	(33B)
41	BN	DI1	(34T)
42	BK	DIO	(34B)
43			
44	GR	PFLG	
45			
46			
47			
48			
49	WR/BK/YL	GND	
50			



## Computer to AutoAnalyzer Sampler Interface

The 9845 computer controls the AutoAnalyzer IV sampler by a digital to analog converter channel (DAC) that was built into the 8 channel A to D constructed by Interscience Instrumentation. The computer generated signal is then passed through a solid state relay which activates the 110VAC relay in the AutoAnalyzer sampler (Figure 6-1). The real-time clock in the computer is therefore used both to control the sampler and collect the digital data at the appropriate times.

The Knobelsdorff timer is used as an emergency back-up for the computer controlled sampler. This timer is programmable so it can be interfaced with the APILOT program if necessary. The emergency instructions are detailed in the APILOT program description in section 5.

### Hardware Modifications

Most of the hardware changes at our laboratory focus on the sampler. For oceanographic purposes the clinical oriented sampler has several deficiencies which can be improved with small changes.

For AutoAnalyzer users who do not have a computer-controlled capability, one of the best low cost additions to a system is a precision electronic timer. This timer plugs directly into existing sockets on the standard AutoAnalyzer sampler IV and allows sample wash ratios to be set in a large number of combinations that are not dictated by the speed of rotation of an electric motor. The electronic timer allows wash and sample time to be set with thumb wheels in increments of 5 or 10 secs. A special rate of 10 and 20 sec intervals can be obtained by contacting the manufacturer. This compact and easy to use device is made by Knobelstorff Instruments Inc., P.O. Box 218, West Hartford, CT 06107 (phone [203] 236-1308) and can be purchased for around \$300. Log amplifiers are also sold by this vendor to linearize outputs from AAI colorimeters.

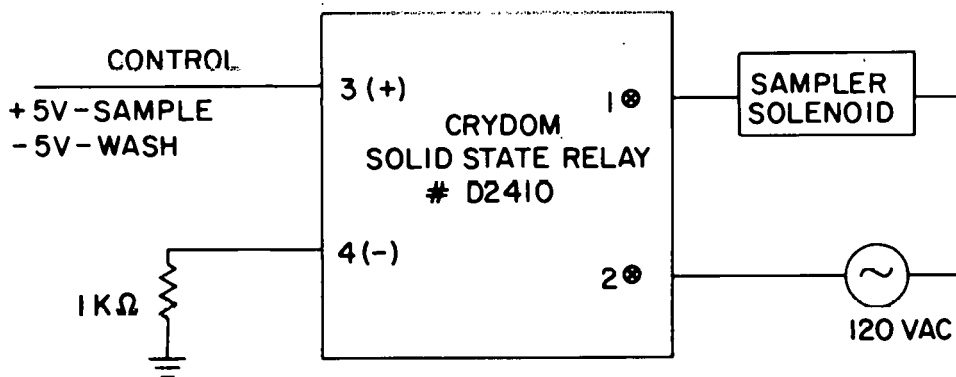


Figure 6-1. Schematic of AutoAnalyzer Sampler Controller that is Interfaced to Computer through DAC Output of the A to D Converter

## Knobelsdorff Precision Sampler Timer Instructions

### Sampler IV Installation

- (1) Turn the Sampler POWER "ON" and move the probe to the sampling position. Switch POWER "OFF."
- (2) Open the cover to expose the TIMING MOTOR+CAM ASSEMBLY.
- (3) Loosen the single screw (next to the cam) and lift the entire assembly UP and OUT of the space it occupied.
- (4) Note the 9-pin jac in the right-hand corner. Plug the TIMER.
- (5) Pull the TIMER CABLE through the "U"-shaped cut in the cam-well cover and dress it between the bottom of the "U" and wash reservoir with the cover closed (in such a way that it will not obstruct the probe entry).
- (6) Now place the TIMER on top of the cover. Be sure the cable is secure and out of the path of the probe.
- (7) Turn the SAMPLER POWER and TIMER POWER "ON." Set desired times and check for proper toperation. NOTE: The first cycle whether SAMPLE or WASH is not accurate - do not have a sample in the first cup.

### OPERATION

1. Setting SAMPLE and WASH cycles - select a desired sampling rate and ratio from Table 6-1 or 6-2. Set the INTERVAL switch to either x10 or x20 seconds and the SAMPLE and WASH switches to any desired digit.

Example: should a 40/hr sampling rate and a 2:7  
sample wash be desired, use the settings shown  
in Table 6-1 as follows:

INTERVAL SWITCH to x10 seconds  
SAMPLE INCREMENT = 2 (x10 = 20 secs)  
WASH INCREMENT = 7 (x10 = 70 secs)

2. START-UP - turn the SAMPLER POWER "ON" then the TIMER "ON."

NOTE: When first starting the TIMER after a period of inactivity, it may require a short period (1-60 seconds) to reset its logic circuits. It may remain in its INITIAL CYCLE (whichever it goes into) for this period before it begins to cycle normally. It is a good idea therefore not to turn the SAMPLER POWER "ON" until the TIMER has gone into its SECOND WASH CYCLE.

TABLE 6-1  
 SAMPLING RATES AND RATIOS  
 for 10 second intervals

Sample increment settings	Wash Increment Settings								
	[1] 10"	[2] 20"	[3] 30"	[4] 40"	[5] 50"	[6] 60"	[7] 70"	[8] 80"	[9] 90"
[1] 10"	<b>180</b> (1:1)	<b>120</b> (1:2)	<b>90</b> (1:3)	<b>72</b> (1:4)	<b>60</b> (1:5)	<b>51</b> (1:6)	<b>45</b> (1:7)	<b>40</b> (1:8)	<b>36</b> (1:9)
[2] 20"	<b>120</b> (2:1)	<b>90</b> (1:1)	<b>72</b> (2:3)	<b>60</b> (1:2)	<b>51</b> (2:5)	<b>45</b> (1:3)	<b>40</b> (2:7)	<b>36</b> (1:4)	<b>33</b> (2:9)
[3] 30"	<b>90</b> (3:1)	<b>72</b> (3:2)	<b>60</b> (1:1)	<b>51</b> (3:4)	<b>45</b> (3:5)	<b>40</b> (1:2)	<b>36</b> (3:7)	<b>33</b> (3:8)	<b>30</b> (1:3)
[4] 40"	<b>72</b> (4:1)	<b>60</b> (2:1)	<b>51</b> (4:3)	<b>45</b> (1:1)	<b>40</b> (4:5)	<b>36</b> (2:3)	<b>33</b> (4:7)	<b>30</b> (1:2)	<b>28</b> (4:9)
[5] 50"	<b>60</b> (5:1)	<b>51</b> (5:2)	<b>45</b> (5:3)	<b>40</b> (5:4)	<b>36</b> (1:1)	<b>33</b> (5:6)	<b>30</b> (5:7)	<b>28</b> (5:8)	<b>26</b> (5:9)
[6] 60"	<b>51</b> (6:1)	<b>45</b> (3:2)	<b>40</b> (2:1)	<b>36</b> (3:2)	<b>33</b> (6:5)	<b>30</b> (1:1)	<b>28</b> (6:7)	<b>26</b> (3:4)	<b>24</b> (2:3)
[7] 70"	<b>45</b> (7:1)	<b>40</b> (7:2)	<b>36</b> (7:3)	<b>33</b> (7:4)	<b>30</b> (7:5)	<b>28</b> (7:6)	<b>26</b> (1:1)	<b>24</b> (7:8)	<b>22</b> (7:9)
[8] 80"	<b>40</b> (8:1)	<b>36</b> (4:1)	<b>33</b> (8:3)	<b>30</b> (2:1)	<b>28</b> (8:5)	<b>26</b> (4:3)	<b>24</b> (8:7)	<b>22</b> (1:1)	<b>21</b> (8:9)
[9] 90"	<b>36</b> (9:1)	<b>33</b> (9:2)	<b>30</b> (3:1)	<b>28</b> (9:4)	<b>26</b> (9:5)	<b>24</b> (3:2)	<b>22</b> (9:7)	<b>21</b> (9:8)	<b>20</b> (1:1)

The bold numbers represent sampling rates per hour and the numbers in parentheses represent the SAMPLE:WASH ratios.

TABLE 6-2  
 SAMPLING RATES AND RATIOS  
 for 20 second intervals

Sample increment settings	Wash Increment Settings								
	[1] 20"	[2] 40"	[3] 60"	[4] 80"	[5] 100"	[6] 120"	[7] 140"	[8] 160"	[9] 180"
[1] 20"	90 (1:1)	60 (1:2)	45 (1:3)	36 (1:4)	30 (1:5)	26 (1:6)	22 (1:7)	20 (1:8)	18 (1:9)
[2] 40"	60 (2:1)	45 (1:1)	36 (2:3)	30 (1:2)	26 (2:5)	22 (1:3)	20 (2:7)	18 (1:4)	16 (2:9)
[3] 60"	45 (3:1)	36 (3:2)	30 (1:1)	26 (3:4)	22 (3:5)	20 (1:2)	18 (3:7)	16 (3:8)	15 (1:3)
[4] 80"	36 (4:1)	30 (2:1)	26 (4:3)	22 (1:1)	20 (4:5)	18 (2:3)	16 (4:7)	15 (1:2)	14 (4:9)
[5] 100"	30 (5:1)	26 (5:2)	22 (5:3)	20 (5:4)	18 (1:1)	16 (5:6)	15 (5:7)	14 (5:8)	13 (5:9)
[6] 120"	26 (6:1)	22 (3:2)	20 (2:1)	18 (3:2)	16 (6:5)	15 (1:1)	14 (6:7)	13 (3:4)	12 (1:3)
[7] 140"	22 (7:1)	20 (7:2)	18 (7:3)	16 (7:4)	15 (7:5)	14 (7:6)	13 (1:1)	12 (7:8)	11 (7:9)
[8] 160"	20 (8:1)	18 (4:1)	16 (8:3)	15 (2:1)	14 (8:5)1	13 (4:3)	12 (8:7)	11 (1:1)	11 (8:9)
[9] 180"	18 (9:1)	16 (9:2)	15 (3:1)	14 (9:4)	13 (9:5)	12 (3:2)	11 (9:7)	11 (9:8)	10 (1:1)

The numbers above the parentheses represent sampling rates per hour and those in the parentheses represent the SAMPLE:WASH ratios.

## CONTROLS

ON/OFF (POWER) This (red-capped) toggle switch controls the TIMER power. When in the "OFF" position, the TIMER is deactivated and the SAMPLER PROBE will be allowed to be in the wash reservoir.

x10s/x20s (INTERVALS) This (white-capped) toggle switch allows the selection of either 10 or 20 second intervals for the WASH and SAMPLE cycles simultaneously.

SAMPLE/WASH (INCREMENTS) The two independent thumbwheel switches allow the independent selection of the duration of the SAMPLE and WASH cycles.

[Example: with the INTERVAL switch at x10 and the SAMPLE and WASH switches at 3 and 5 respectively, the SAMPLING TIME would be (3x10) or 30 seconds and the WASH TIME (5x10) or 50 seconds respectively.]

RED/GREEN (LEDs) Either one or the other must be lit when the TIMER is in operation "ON." The RED LED, when lit indicates that the TIMER is in its SAMPLE cycle, whereas the GREEN LED indicates the WASH period.

ELECTRICAL REQUIREMENTS: 0.5A at 115 V, 60 Hz

FEATURES: TIMING ACCURACY better than 99.99%  
TIMING PRECISION better than 99.99%

SERIAL No. 97 (Model IV-10/20)

### Conversion of AutoAnalyzer Sampler IV for 2 oz. Poly Bottles

Another significant change in the sampler is ability to analyze samples directly from sample collection bottles rather than the small sample cups. The volume difference between sample bottles and cups is not a big argument for switching, but if ammonium is determined many contamination problems are reduced. The changes that we made to the sampler will allow the small sample cups to still be used, if so desired, while 2 oz. nalgene sample bottles are normally used to collect, analyze, and freeze the samples. The sample bottles can be clearly numbered so fewer mixups concerning sample numbers occur. The two items changed in the sampler is the cam which rotates the sample tray (Figure 6-2). The original plastic cam was replaced by a brass cam which was constructed to rotate the sample tray exactly twice as far as the original. The new sample tray constructed from plexiglass (Figure 6-3) holds 20 of the nalgene sample bottles (Fischer no. 2-923B, Nalgene no. 2002). If the original tray and small cups are used, the cups are placed in every other hole.

### Scale Expander

Another possible modification involves the addition of scale expanders which will catch peaks that would otherwise go offscale. The description and diagram to produce scale expanders, sent to me by colleagues at the Sandy Hook Laboratory of NMFS, are included as I received them. The scale expander circuit effectively doubles the range of the chart, allowing concentrations up to

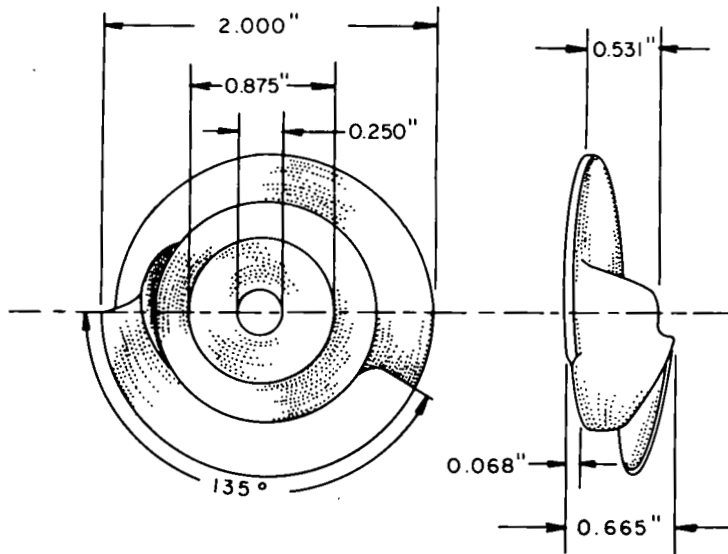


Figure 6-2. Brass Cam for AutoAnalyzer Sampler Modification for 2 oz. Polyethylene Sample Bottles

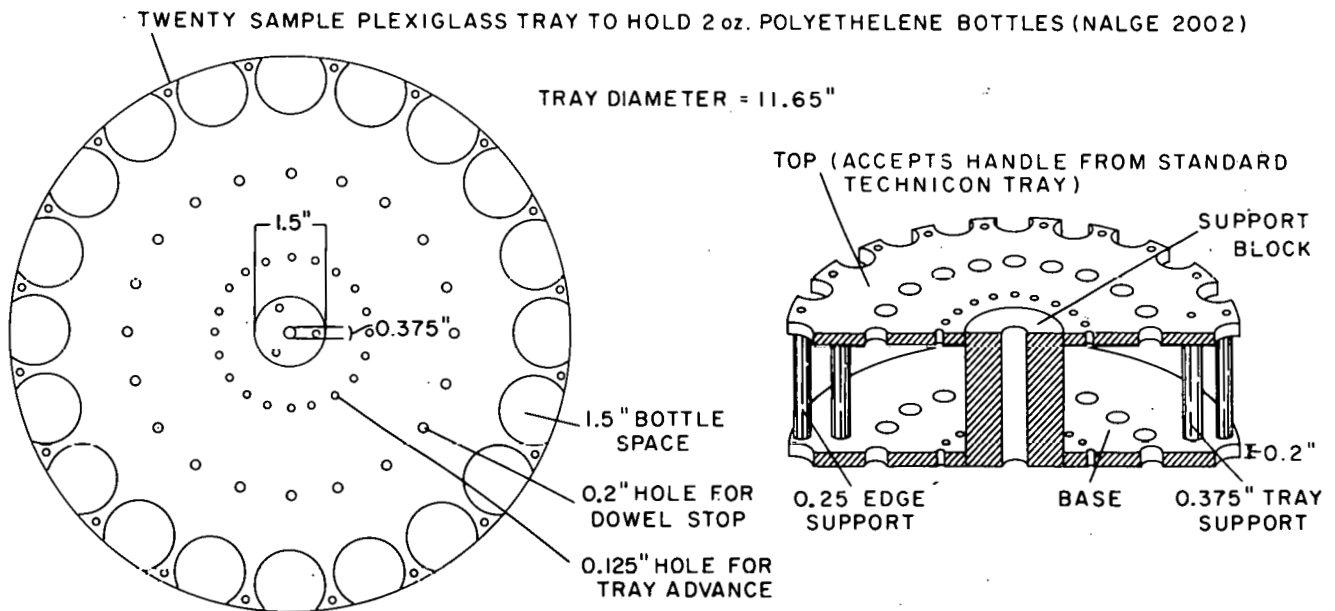


Figure 6-3. Plexiglass Sample Tray for AutoAnalyzer Sampler Modification for 2 oz. Polyethylene Sample Bottles

two times the standard to be accommodated. If a peak appears to be going off chart, this circuit will decrease the peak size in order to get the total peak height. The circuit is activated through a manual switch (Figure 6-4). The switches (one for each channel) are set up as follows:

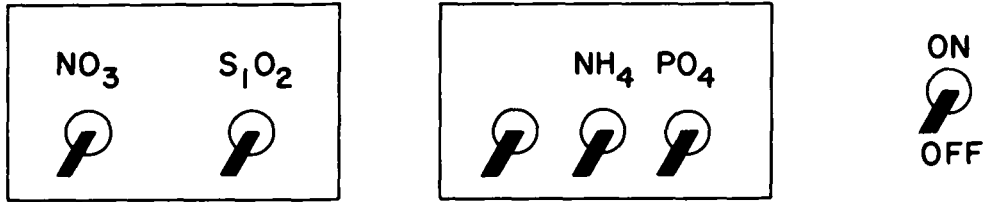


Figure 6-4. Control Boxes for Scale Expanders

The unmarked switch can be flipped up at the beginning of the run and will "bleep" when a pen reaches contact installed near the top of the chart. The "bleeper" is for operator notification, and need not be used to operate the scale expander control.

Operation is straightforward:

- (1) When the "bleep" sounds, flip the appropriate channel switch up. This will cause the pen to drop down to approximately 10% of the peak height and allows continuation of the peak (calibration is described below).
- (2) When the peak has been recorded, the pen will move back down the chart. At this point the switch may be flipped back down.
- (3) The actual number of chart divisions "cancelled" in this operation is obtained through calibration (see below). This number is added to the observed peak height to get the total peak height. The scale expander is effective, of course, only if the peak does not go off the chart.

A wiring diagram for the scale expander circuit is given in Figure 6-5.

#### Scale Expander Calibration

- (1) Set colorimeter on 'zero,' adjust pen to zero with helipot zero control.
- (2) Set the recorder setting knob on the colorimeter to full scale (adjust pen to 100 with helipot).
- (3) Turn the chart drive on to establish a small reference line.
- (4) Turn on the scale expander switch, the pen will deflect down the chart paper to around 10; if you wish the calibration to be exactly 90, you may adjust with the helipot located on the scale expander control box.
- (5) Establish another small reference line, and note the exact deflection for use in calculations.
- (6) Turn gain control switch off, turn chart drive off and reset recorder to its operational setting.
- (7) The distance in chart units from the full scale point to where the pen drops is the calibration number. Add this to the observed sample peak height.

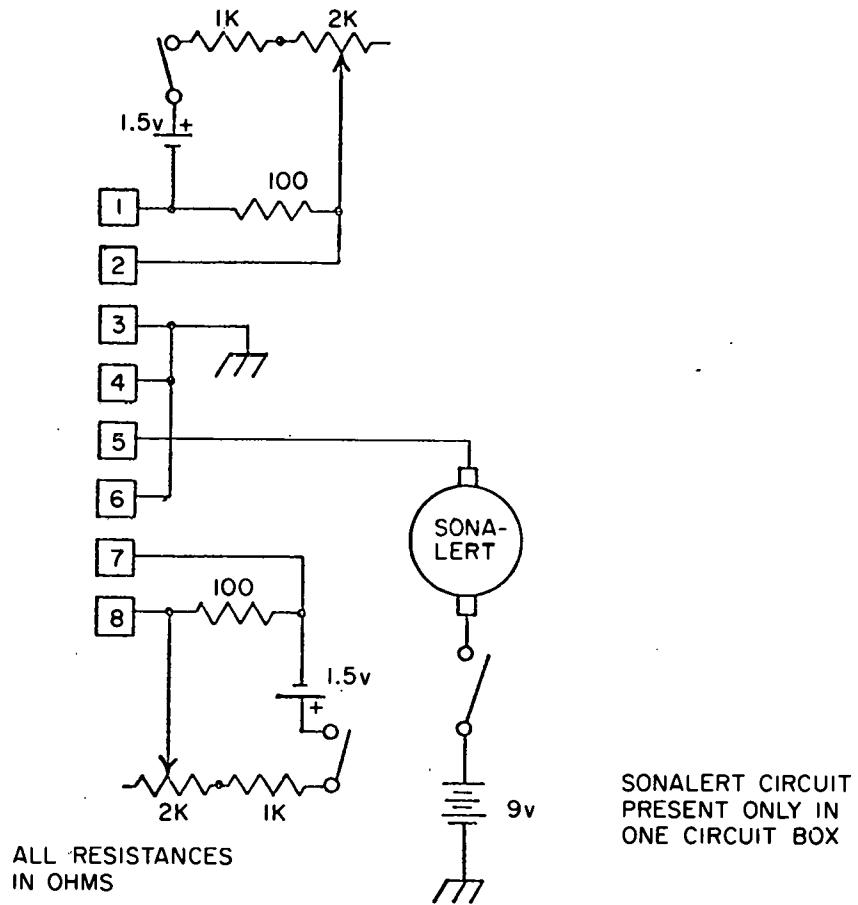


Figure 6-5. Scale Expander Wiring Diagram



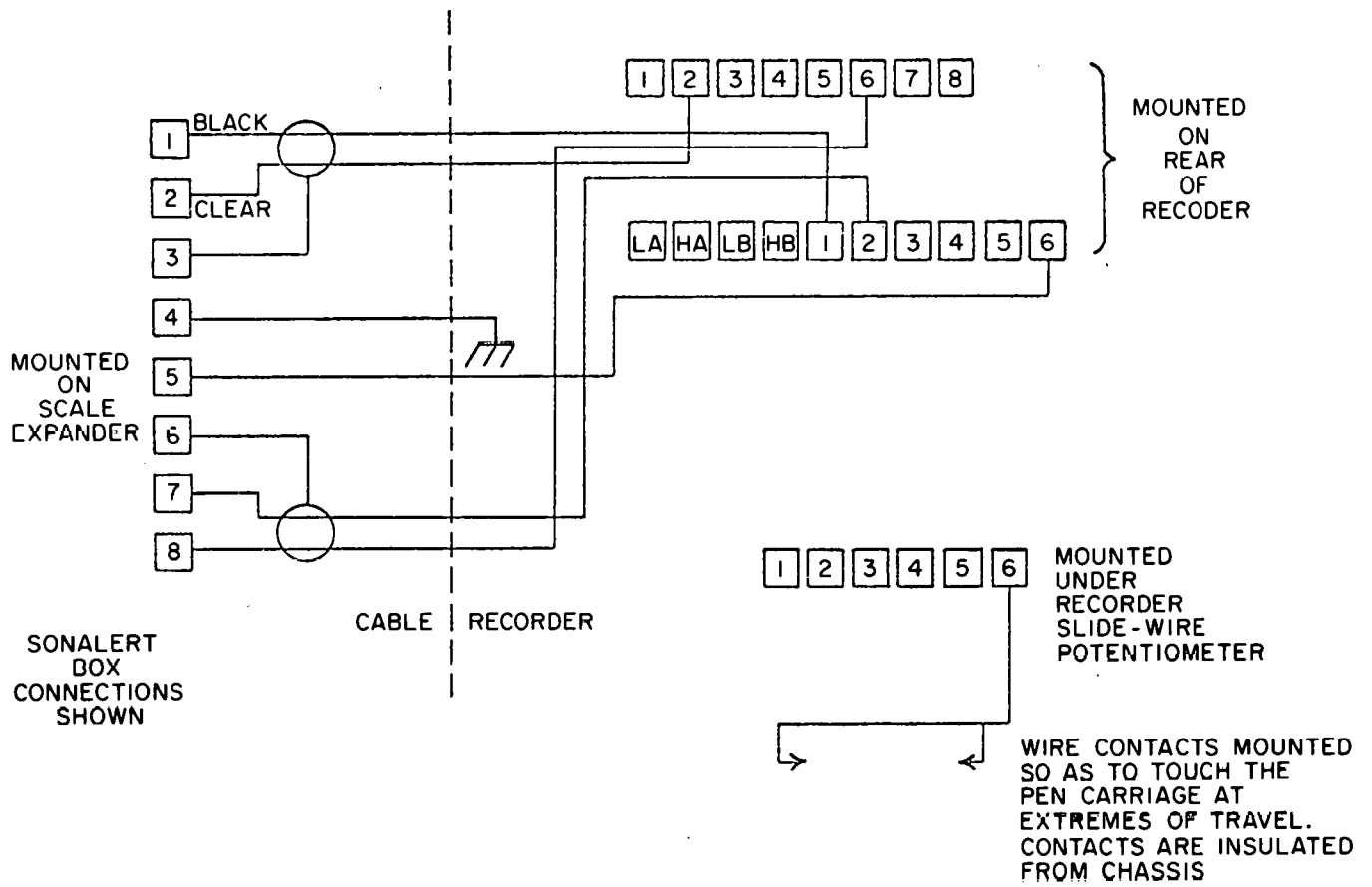
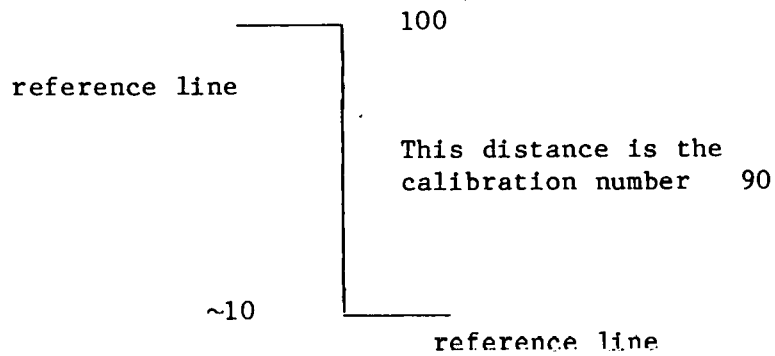


Figure 6-5 (continued). Scale Expander Wiring Diagram



## 7. TROUBLE SHOOTING

Each continuous flow system has its own unique set of problems which are the result of the manifold configuration; flow rate, flow cell size, glass and pump tube diameter, reaction chemicals, and other variables. After several years of development and operation, we have narrowed down the number of persistent problems to a few. With the present system, only routine maintenance and adherence to the steps below will ensure optimum machine performance.

### Ammonium

In our experience, the ammonium channel is subject to periodic fluctuations. A good portion of this instability is the result of flow problems in the heating bath assembly. In the most troublesome cases, a persistent irregular bubble pattern is observed as the flow stream emerges from the bath. We are successful in stabilizing and smoothing the flow by one or a combination of the following steps.

1. Add more Brij-35 to the dilution complex. Up to 2-3 ml/l have been used without adversely affecting the sensitivity or color development.

2. Make new reagents especially the dilution complex, reagent A and reagent B.

3. Change the pump tube for the dilution complex and reagents A and B. The pH and the ratio of the reagents must be very precise or the method will not work properly. The reagents used for the ammonium determination cause a rapid decline in the pumping rate of the pump tubes, so change them often to stay out of trouble.

4. Increase the reaction temperature to 75-80°C. No loss of sensitivity has been observed at this temperature range.

5. Flush the coil. Regular and direct flushing of the heating bath coil with a 5 ml syringe filled with 70% HCl is recommended for every 4-6 hours of operation. This treatment not only improves the flow but cleans the flow cell and makes for cleaner peaks.

6. Replace the old heating bath coil. The ammonium reagents are apparently very hard on the bath coil either by chemical action or direct deposition of stubborn precipitates. The old coil should be replaced if the ammonium channel has been used heavily during its last year of operation and if none of the previous steps provides remedy.

Poor flow is also experienced in the flow cell. Typically, air bubbles are sucked into the flow cell because of retarded movement of the stream across the tygon bridge joining the flow cell proper and the flow cell extension (199-0084-01). This piece of tygon should be replaced as the ammonium reaction products coat the tubing and make it "sticky." Clean the inside diameter of the new bridge with a "Q-tip" dipped in Brij-35. In addition, if the waste line is old and coated, the waste air sample stream will back up and force air into the flow cell. Clean and replace this line as described. Should the flow cell continue to suck air bubbles after all of the above conditions have been satisfied, it will be necessary to try different tube combinations on the waste and pull through lines.

## Phosphate and Silicate

Problems associated with the phosphate heating bath or flow cell should be tackled using the procedures outlined for the ammonium channel. However, sodium lauryl sulfate should be used for lubricating new tubing. After continuous operation, a positive baseline drift and noisy peaks are indicative of flow cell and/or reagent line coating with ammonium molybdate. Flush the channel with 0.1 N KOH or NaOH. Similarly, the silicate molybdate line should be washed if the baseline is drifting upward or when a white precipitate is observed in the injector fitting (116-0489-01).

## Nitrate plus Nitrite, Nitrite

As the first step in the operation of the nitrate plus nitrite channel put the ammonium chloride reagent on line first. After ammonium chloride has flowed through the manifold for a few minutes, open the 4-way Hamilton valve to allow its passage through the Cu-Cd column. Failure to run  $\text{NH}_4\text{Cl}$  through the system first may result in the accidental destruction of the column with wash  $\text{HCl}$ .

The apparent loss of sensitivity of the nitrate plus nitrite may be caused by several factors.

1. Deterioration of the standards. Nitrate standards are subject to rapid biological breakdown if not preserved with chloroform and refrigerated. If the primary stock is suspect, discard it. Secondary standards should be prepared fresh daily.
2. Drop in cadmium column efficiency. Continuous analyses on the channel will gradually diminish the level of cadmium in the column. Replenish the column as explained in Repacking the Column. If the cadmium itself is suspect, treat it again with 2% copper sulfate.
3. Pump tube plugging. Both nitrate plus nitrite and nitrite channels are subject to line constriction by reagent blockage. The NNED reagent will coat the pump tube turning it orange-brown and restrict the flow. Change this tubing periodically. In addition, the acidic sulfanilamide will corrode the metal nipple of the stream divider sending particles in the flow stream. Eventually this fitting will be eaten through. Check the sulfanilamide stream divider for leaks and weaknesses and replace if necessary.

## Appendix A - References of Additional Reading

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## Appendix B - Manifold Components and Chemicals

All of the individual components of mixing coils, injection fittings, nipples, and heating baths are listed for each of the six analyses. Also included are colorimeter flow cell sizes, phototubes, and interference filters used in the AutoAnalyzer single channel industrial colorimeters. The brand and grade of chemicals used in preparing reagent solution is included for most analyses.



### Phosphate Channel

Description	Technicon Part Number
1. Injector fitting with N-6 nipple	116-0489-01, 116-0004-01
2. 5-Turn coil, right hand	170-0103-01
3. Fitting connector, A6	116-B008-01
4. 20-Turn coil	157-B089-01
5. "G" coil 7.7 ml 35.5 turns	157-0225-01
6. Heating bath assembly for "G" coil	157-B273-32
7. Connector, water jacket straight	Made at BNL
8. Flow cell assembly 50 mm x 1.5 mm I.D.	199-B007-01
9. Filter assembly, 880 M $\mu$	170-B070-48
10. Adjustable temperature controller for heating bath	170-B070-28

Reagents	Manufacturer
Ascorbic acid	Fisher
Ammonium molybdate	Mallinckrodt
Sulfuric acid	Mallinckrodt
Sodium lauryl sulfate	Sigma Chemical
Potassium phosphate (standard)	J.T. Baker Chemical

### Silicate Channel

Description	Technicon Part Number
1. Injector fitting with N-6 nipple	116-0489-01, 116-0004-01
2. 20-Turn coil	157-0248-01
3. Fitting connector, A6	116-B008-01
4. 20-Turn coil	157-B089-01
5. Flow cell assembly 15 mm x 1.5 mm	199-B018-01
6. Filter assembly 820 M $\mu$	170-B070-57

Reagents	Manufacturer
Ammonium molybdate	Mallinckrodt, Inc.
Antimony potassium tartrate 1/2 hydrate	J.T. Baker Chemical Company
Stannous chloride	Mallinckrodt, Inc.
Tartaric acid	Matheson, Coleman, and Bell
Acetone	J.T. Baker Chemical Company
Sulfuric acid	Mallinckrodt, Inc.
Sodium lauryl sulfate	Sigma Chemical Co.
Sodium hexafluorosilicate (standard)	Alfa/Ventron Corporation

Nitrate + Nitrite Channel

Description	Technicon Part Number
1. Injector fitting with N-6 nipple	116-0489-01, 116-0004-01
2. 5-Turn coil, right hand	170-0103-01
3. Fitting connector, A2	116-0200-02
4. Injector fitting with N-6 nipple	116-0489-01, 116-0004-01
5. 20-Turn coil	157-B089-01
6. 10-Turn coil, right hand	157-0251-01
7. 4-Way valve, no. 1	4MMM4 (Hamilton)
8. Flow cell assembly 50 mm x 1.5 mm	199-B007-01
9. Filter assembly, 540 M $\mu$	177-B070-40
10. Flow cell assembly, 15 mm x 1.5 mm I.D.	199-B018-01

Chemicals	Manufacturer
N-1-Naphthylethylene-diamine dihydrochloride	Eastman Kodak
Sulfanilamide	Sigma Chemical Co.
Ammonium Chloride	J.T. Baker Chemical Company
Hydrochloric acid	J.T. Baker Chemical Company
Brij-35	Technicon Instruments Co.
Potassium nitrate (standard)	J.T. Baker Chemical Company

Nitrite Channel

Description	Technicon Part Number
1. Injector fitting with N-6 nipple	116-0489-01, 116-0004-01
2. 5-Turn coil, right hand	170-0103-01
3. Fitting connector, A6	116-B008-01
4. 20-Turn coil	157-B089-01
5. 10 Turn coil, left hand	157-0226-01
6. Flow cell assembly 15 mm x 1.5 mm	199-B018-01
7. Filter assembly 540 M $\mu$	177-B070-40

Reagents	Manufacturer
N-1-Naphthylethylene-diamine dihydrochloride	Eastman Kodak
Sulfanilamide	Sigma Chemical Co.
Hydrochloric acid	J.T. Baker Chemical Company
Brij-35	Technicon Instruments Co.
Sodium nitrite	J.T. Baker Chemical Company

Ammonium Channel

Description	Technicon Part Number
1. Injector fitting with N-6 nipple	116-0489-01, 116-0004-01
2. 5-Turn coil, right hand	170-0103-01
3. Fitting connector, A6	116-B008-01
4. 20-Turn coil	157-B089-01
5. "G" coil 7.7 ml 35.5 turns	157-0225-01
6. Heating bath assembly for "G" coil	157-B273-32
7. Adjustable temperature controller for heating bath	170-B070-28
8. Connector water jacketed, straight	Made at BNL
9. Filter assembly, 640 M $\mu$	170-B173-02
10. Flow cell assembly 50 mm x 1.5 mm I.D.	199-B007-01

Reagents	Manufacturer
Phenol	J.T. Baker Chemical Company
Sodium nitroprusside	J.T. Baker Chemical Company
Sodium citrate, dihydrate	J.T. Baker Chemical Company
Sodium hydroxide	J.T. Baker Chemical Company
Sodium hypochlorite	Chlorox Company
Brij-35	Technicon Instruments Co.
Ammonium chloride (standard)	J.T. Baker Chemical Company

Urea Channel

Description	Technicon Part Number
1. Injector fitting with N-6 nipple	116-0489-01, 116-0004-01
2. 10-Turn coil, right hand	157-0251-01
3. Fitting connector, A6	116-B008-01
4. 20-Turn coil	157-B089-01
5. 2-"SS" coil, 10.4 ml	170-G060
6. Adjustable temperature controller for heating bath	170-B173-02
7. 2-Heating bath assembly for "SS" coil	157-B273-41
8. Connector, water jacketed	Made at BNL
9. Flow cell assembly 50 mm x 1.5 mm I.D.	199-B007-01
10. Filter assembly, 520 M $\mu$	177-B070-28

Reagents	Manufacturer
Diacetyl monoxime	J.T. Baker Chemical Company
Semicarbazide hydrochloride	Sigma Chemical Co.
Potassium phosphate	J.T. Baker Chemical Company
Potassium nitrate	J.T. Baker Chemical Company
Sulfuric acid	Mallinckrodt, Inc.
Sodium chloride	J.T. Baker Chemical Company
Brij-35	Technicon Instruments Co.
Urea (standard)	Sigma Chemical Co.

Miscellaneous Parts

Plastic Connectors and Stream Dividers	Technicon Part Number
N-8 Nipple (placed on both ends of of the silicone air-bar tubing)	116-0003-01
N-6 Nipple (mounts on injector fitting carrying air to manifold; also connects to colorimeter "to pump" outlet)	116-0004-01
Stream Divider, PT02	116-B000-01
Stream Divider, PT10	116-B042
Stream Divider, PT11	116-B043

## Appendix C - Software Listings

This section contains the listings of the BASIC programs used for nutrient analyses on the Hewlett Packard 9845 S. The only additional routines not listed here that are required, I/O binary routines, can be obtained from Hewlett-Packard at no cost. Most of the listings contain REM statements at the beginning and at critical points in the program that describe the task being done.

```

10  REM :  STAND
20  REM :  VERSION CREATED BY C.D. WIRICK 04 APRIL 1978, WHILE AT SEA
30  REM :  MODIFIED      11 FEB 1980
40  REM :  ALL USER CHANGES ARE DONE IN SUBPROGRAM DATA
50  REM *****
60  REM              MACHINE STATUS
70  OPTION BASE 1
80  EXIT GRAPHICS
90  FIXED 3
100 SHORT Rf(6),F(6),B1(6),B2(6),P(40,6)
110 DIM A$(6)[4],Id$(40)[1],L$(6),Da$(7),Hr$(4),Op$(6),D(6),Cs(12,6),Ls$(6)[4],
D$[4],Xmax(6),Idt$(40),X(50),Y(50),Mess#[50],Lat#[12],Lon#[12]
120 INTEGER Nsamp,C(6),Icode(40),Nc,Ic(12),Is(12,6),Ict(40)
130 PRINTER IS 16
140 REM *****
150 REM :              VARIABLES
160 REM :      IS(I,J) = INTEGER ARRAY FOR NUTS IN STANDARD SIJ
170 REM :              I= 1 TO 2,  J=1 TO 6 FOR THE SIX CHANNELS
180 REM :      CS(I,J) = NUT CONCENTRATION IN STANDARD SIJ
190 REM :              I= 1 TO 2,  J=1 TO 6 FOR THE SIX CHANNELS
200 REM : *****
210 PRINT PAGE,SPA(15)," HELLO FROM REGRESSION OF STANDARDS  "
220 PRINT "VARIABLE NAMES ARE P04,SIO4,N+N,NO2,NH4,URE"
230 I1=3
240 REM LOOP FOR GETTING DATA FILES
250 INPUT "FILE WANTED",L$
260 File$=L$
270 GOSUB Read
280 GOSUB List
290 INPUT "DO WANT A COPY OF THE LIST?,Y,N",Kw$
300 IF Kw$="N" THEN 330
310 PRINTER IS 0
320 GOSUB List
330 PRINTER IS 16
340 GOSUB Stand
350 GOSUB Reg
360 GOTO 350
370 List: PRINT USING 390;L$,Da$,Hr$,Lat$,Lon$,Depth,Mess$
380 PRINT USING 400;Nsamp,Op$,A$(*),C(*),F(*) !SUBPROG LIST
390 IMAGE "LABEL=",10A,/, "DATE=",10A,/, "HR=",10A,/, "LAT= ",12A,/, "LON= ",12A,/,
"DEPTH= ",DDDDDDDD,/, "COMMENT= ",50A
400 IMAGE "NO. SAMPLES=",3D,/, "OPERATOR=",10A,/, "CHANNEL=",6(6X,4A),/, "STATUS=",
1X,6(10D),/, "FACTORS=",6(6D.3D)
410 PRINT USING 420;Rf(*),B1(*),B2(*)
420 IMAGE "RF'S=",3X,6(6D.3D),/, "BASE1=",2X,6(6D.3D),/, "BASE2=",2X,6(6D.3D)
430 IF I1=1 THEN 520
440 PRINT USING 450
450 IMAGE /,"NO. ID"
460 FOR I=1 TO Nsamp
470 IF I1=3 THEN 500
480 PRINT USING " 2D,1X,1A, 4D";I,Id$(I),Icode(I)
490 GOTO 510
500 PRINT USING "2D,1X,1A,4D,4X,6(2D.3D,4X)";I,Id$(I),Icode(I),P(I,1),P(I,2),P(
I,3),P(I,4),P(I,5),P(I,6)
510 NEXT I
520 RETURN
530 Read:REM THIS SECTION READS THE FILE L$ !SUBPROG READ
540 Ifile=0
550 GOSUB Drive
560 ASSIGN #2 TO File$
570 BUFFER #2
580 Lat$=Lon$=Mess$="N.A."
590 Depth=-99
600 READ #2;L$,Da$,Hr$,Op$,A$(*)
610 Ktyp=TYP(2)
620 IF (Ktyp=2) OR (Ktyp>7) THEN READ #2;Mess$,Lat$,Lon$,Depth

```

```

630 READ #2;Nsamp,Nc
640 READ #2;C(*),F(*),Rf(*),B1(*),B2(*)
650 FOR I=1 TO Nsamp
660 READ #2;I,Id$(I),Icode(I),P(I,1),P(I,2),P(I,3),P(I,4),P(I,5),P(I,6)
670 NEXT I
680 PRINT "FINISHED READING FILE "
690 RETURN
700 Stand: REM THIS ROUTINE SETS STANDARD VALUES      !SUBPROG STAND
710 DATA "P04","SI04","N+N","NO2","NH4","URE"
720 READ Ls$(*)
730 DATA 5,50,50,5,10,50
740 READ Xmax(*)
750 DATA 10,11,12,13,14,15,20,21,22,23,24,25
760 READ Ic(*)
770 DATA 0,1,1,0,0,1
780 DATA 0,1,1,0,0,1
790 DATA 0,1,1,0,0,1
800 DATA 0,1,1,0,0,1
810 DATA 0,1,1,0,0,1
820 DATA 0,1,1,0,0,1
830 DATA 1,0,1,1,1,1
840 DATA 1,0,1,1,1,1
850 DATA 1,0,1,1,1,1
860 DATA 1,0,1,1,1,1
870 DATA 1,0,1,1,1,1
880 DATA 1,0,1,1,1,1
890 FOR I=1 TO 12
900 READ D(*)
910 FOR J=1 TO 6
920 Is(I,J)=D(J)
930 NEXT J
940 NEXT I
950 DATA 0,0,0,0,0,0
960 DATA 0,5,5,0,0,5
970 DATA 0,15,15,0,0,15
980 DATA 0,25,25,0,0,25
990 DATA 0,35,35,0,0,35
1000 DATA 0,45,45,0,0,45
1010 DATA 0,0,0,0,0,0
1020 DATA .5,0,.5,.5,.5,.5
1030 DATA 1.5,0,1.5,1.5,1.5,1.5
1040 DATA 2.5,0,2.5,2.5,2.5,2.5
1050 DATA 3.5,0,3.5,3.5,3.5,3.5
1060 DATA 4.5,0,4.5,4.5,4.5,4.5
1070 FOR I=1 TO 12
1080 READ D(*)
1090 FOR J=1 TO 6
1100 Cs(I,J)=D(J)
1110 NEXT J
1120 NEXT I
1130 RETURN
1140 Reg: REM THIS IS REGRESSION SECTION      !SUBPROG REG
1150 PRINT PAGE," REGRESSION SECTION "
1160 IF Ifile>0 THEN 1260
1170 FOR I=1 TO Nsamp
1180 FOR J=1 TO 6
1190 P(I,J)=P(I,J)-(B1(J)+(B2(J)-B1(J))*I/(Nsamp+1))
1200 IF P(I,J)<-5 THEN 1220
1210 GOTO 1230
1220 P(I,J)=-9.99
1230 NEXT J
1240 NEXT I
1250 Ifile=1
1260 INPUT "VARIABLE NAME",D$
1270 REM SEARCH STANDARD TABLE FOR NUT
1280 FOR I=1 TO 6

```

```

1290 IF POS(D#,Ls#(I))<>0 THEN 1330
1300 NEXT I
1310 PRINT D#;"BAD CHOICE TRY AGAIN"
1320 GOTO 1260
1330 Js=I
1340 REM SEARCH FILE FOR NUT REQUESTED
1350 FOR I=1 TO 6
1360 J=POS(A#(I),D#)
1370 IF J>0 THEN 1410
1380 NEXT I
1390 PRINT "CANNOT FIND LABEL IN FILE";D
1400 GOTO 1130
1410 Jf=I
1420 REM JS= STAND COLUMN, JF=FILE COLUMN
1430 REM FIND S10,S20
1440 S10=S20=0
1450 FOR I=1 TO Nsamp
1460 IF Id#(I)<>"S" THEN 1530
1470 IF Icode(I)=10 THEN 1500
1480 IF Icode(I)=20 THEN 1520
1490 GOTO 1530
1500 S10=P(I,Jf)
1510 GOTO 1530
1520 S20=P(I,Jf)
1530 NEXT I
1540 N=0
1550 FOR I=1 TO Nsamp
1560 IF Id#(I)<>"S" THEN 1750
1570 IF (Icode(I)=10) OR (Icode(I)=20) THEN 1750
1580 REM CHECK FOR NUT IN STANDARD
1590 FOR Ii=1 TO 12
1600 IF Icode(I)=Ic(Ii) THEN 1640
1610 NEXT Ii
1620 PRINT "NO MATCH FOR";Id#(I);Icode(I)
1630 GOTO 1160
1640 IF Is(Ii,Js)=0 THEN 1750
1650 N=N+1
1660 IF Icode(I)<20 THEN 1690
1670 IF Icode(I)>20 THEN 1710
1680 PRINT "ERROR ON S10 OR S20"
1690 Y(N)=P(I,Jf)-S10
1700 GOTO 1720
1710 Y(N)=P(I,Jf)-S20
1720 X(N)=Cs(Ii,Js)
1730 Idt#(N)=Id#(I)
1740 Ict(N)=Icode(I)
1750 NEXT I
1760 PRINT PAGE
1770 Itab=0
1780 GOSUB Table
1790 GOSUB Edit
1800 PRINT PAGE
1810 CALL Linear(X(*),Y(*),N,Arege,Brege,Regss,Resss,Totals,Regms,Resms,F,Dfreg,Dfres,Dftot,Abort)
1820 IF Abort<.1 THEN 1870
1830 BEEP
1840 PRINT "ERROR IN REGRESSION N=";N
1850 WAIT 500
1860 PAUSE
1870 Itab=1
1880 GOSUB Table
1890 PRINTER IS 16
1900 INPUT " DO YOU WANT A LIST OF TABLE?,Y/N",Kw#
1910 IF Kw#="N" THEN 1960
1920 PRINTER IS 0
1930 PRINT LIN(2)

```



```

1940 GOSUB Table
1950 PRINTER IS 16
1960 INPUT "DO YOU WANT A PLOT?,Y/N",Kw#
1970 IF Kw#="N" THEN 1160
1980 PLOTTER IS "GRAPHICS"
1990 GRAPHICS
2000 Xm=Xmax(Js)
2010 CALL Pltax(0,0,Xm,10,0,0,5,5,2,2,0,0,"CONC","ABS",3)
2020 CALL Pltsym(X(*),Y(*),N)
2030 X(1)=0
2040 X(2)=Xm
2050 Y(1)=Areg+Breg*X(1)
2060 Y(2)=Areg+Breg*X(2)
2070 CALL Pltlin(X(*),Y(*),2,1,1)
2080 SETGU
2090 LORG 1
2100 MOVE 90,80
2110 LABEL L#
2120 MOVE 90,75
2130 LABEL Ls$(Js)
2140 PAUSE
2150 INPUT "DO YOU WANT A HARD COPY OF THE PLOT? Y/N",D#
2160 IF D#="N" THEN 2180
2170 DUMP GRAPHICS
2180 GCLEAR
2190 PLOTTER 13 IS OFF
2200 RETURN
2210 Table:PRINT "TABLE OF DATA FOR REGRESSION"      !SUBPROG TABLE
2220 PRINT "LABEL=";L#,LIN(1),"NUTRIENT=";Ls$(Js)
2230 PRINT USING "1X,1A,3X,2A,2X,5A,2X,5A";"N","ID","CONC.", "ABS"
2240 FOR I=1 TO N
2250 PRINT USING "2D,2X,1A,2D,2(3D.3D)";I,Idt$(I),Ict(I),X(I),Y(I)
2260 NEXT I
2270 IF Itab=0 THEN 2290
2280 PRINT "INTERCEPT=";Areg,LIN(1),"SLOPE=";SPA(4);Breg,LIN(1),"R*R=";SPA(6);Re
gss/Totals, LIN(1),"FACTOR=";SPA(3),1/Breg
2290 RETURN
2300 Edit: REM THIS IS EDIT SECTION
2310 INPUT "DO YOU WANT TO DELETE?, Y/N",Kw#
2320 IF Kw#="N" THEN 2440
2330 INPUT "WHICH SAMPLE IS TO BE DELETED? NO.",J
2340 N=N-1
2350 FOR I=J TO N
2360 X(I)=X(I+1)
2370 Y(I)=Y(I+1)
2380 Ict(I)=Ict(I+1)
2390 Idt$(I)=Idt$(I+1)
2400 NEXT I
2410 PRINT PAGE
2420 GOSUB Table
2430 GOTO 2310
2440 RETURN
2450 END
2460 Drive:REM THIS MAKES LABEL SPECIFY A TAPE DRIVE.
2470 REM THIS ROUTINE ADDS :T15, :T14 OR :F8 TO FILE NAME FILE#
2480 INPUT "TAPE DRIVE WANTED? 14 OR 15 OR F8",T#
2490 Nchar=LEN(File#)
2500 IF T#="14" THEN File#[Nchar+1]=":T14"
2510 IF T#="15" THEN File#[Nchar+1]=":T15"
2520 IF T#="F8" THEN File#[Nchar+1]=":F8"
2530 RETURN
2540 END
2550 SUB Linear(X(*),Y(*),N,A,B,Regss,Resss,Totals,Regms,Resms,F,Dfreg,Dfres,Df
tot,Abort)
2560 ! *** MODEL: Y=A+B*X ***
2570 ON ERROR GOTO Bomb

```

```

2580 Abort=0
2590 Y1=X1=Z=X2=Y2=0
2600 FOR I=1 TO N
2610     X1=X1+X(I)           ! Sum of X's
2620     Y1=Y1+Y(I)         ! Sum of Y's
2630     X2=X2+X(I)*X(I)    ! Sum of X squares
2640     Y2=Y2+Y(I)*Y(I)    ! Sum of Y squares
2650     Z=Z+X(I)*Y(I)      ! Sum of XY's
2660 NEXT I
2670 X1=X1/N                 ! Mean X
2680 Y1=Y1/N                 ! Mean Y
2690 B=(Z-N*X1*Y1)/(X2-N*X1*X1)
2700 A=Y1-B*X1
2710 Totalss=Y2-N*Y1*Y1     ! Total Sum of Squares
2720 Regss=(Z-N*X1*Y1)^2/(X2-N*X1*X1)! Regression Sum of Squares
2730 Resss=Totalss-Regss    ! Residual Sum of Squares
2740 Regms=Regss            ! Regression Mean Squares
2750 Resms=Resss/(N-2)     ! Residual Mean Squares
2760 OFF ERROR
2770 DEFAULT ON
2780 F=Regms/Resms         ! F Ratio
2790 DEFAULT OFF
2800 Dfreg=1                ! Degrees of Freedom
2810 Dfres=N-2
2820 Dftot=Dfreg+Dfres
2830 SUBEXIT
2840 Bomb: Abort=1
2850 SUBEND
2860 SUB Pltax(Xmin,Ymin,Xmax,Ymax,Xorig,Yorig,Ndivx,Ndivy,Nticx,Nticy,Ndigx,Ndigy,Xlab$,Ylab$,Ch)
2870 DEG
2880 FIXED 5
2890 Ch=3
2900 Cw=3*Ch/5
2910 CSIZE Ch,3/5
2920 L1x=25
2930 L2x=Xum=110
2940 L1y=15
2950 L2y=90
2960 I=J=1
2970 I=MAX(I,Nticx)
2980 J=MAX(J,Nticy)
2990 LOCATE L1x,L2x,L1y,L2y
3000 AXES (L2x-L1x)/(Ndivx*I),(L2y-L1y)/(Ndivy*J),L1x+(L2x-L1x)*(Xorig-Xmin)/(Xmax-Xmin),L1y+(L2y-L1y)*(Yorig-Ymin)/(Ymax-Ymin),Nticx,Nticy,4
3010 UNCLIP
3020 LORG 4
3030 FOR J=0 TO Ndivx
3040 P#=VAL$(Xmin+(Xmax-Xmin)*J/Ndivx)
3050 I=POS(P#,".")-1
3060 IF Ndigx=0 THEN 3080
3070 I=I+1+Ndigx
3080 V#=P#[1,I]
3090 MOVE L1x+J*(L2x-L1x)/Ndivx,L1y-1.2*Ch
3100 LABEL USING "K";V#
3110 NEXT J
3120 MOVE (L1x+L2x)/2,L1y-2.4*Ch
3130 LABEL USING "K";Xlab$
3140 LORG 7
3150 FOR J=0 TO Ndivy
3160 P#=VAL$(Ymin+J*(Ymax-Ymin)/Ndivy)
3170 I=POS(P#,".")-1
3180 IF Ndigy=0 THEN 3200
3190 I=I+1+Ndigy
3200 Xum=MIN(L1x-(I+1)*Cw,Xum)
3210 V#=P#[1,I]

```

```

3220 MOVE L1x-Cw,L1y+J*(L2y-L1y)/Ndiy-.3*Ch
3230 LABEL USING "K";V#
3240 NEXT J
3250 LDIR 90
3260 LORG 4
3270 MOVE Xwm-Ch,(L1y+L2y)/2
3280 LABEL USING "K";Ylab#
3290 LDIR 0
3300 SCALE Xmin,Xmax,Ymin,Ymax
3310 LORG 1
3320 SUBEXIT
3330 SUBEND
3340 SUB Pltlin(X(*),Y(*),N,Itype,Lp)
3350 LINE TYPE Itype
3360 PLOT X(1),Y(1),-2
3370 FOR I=2 TO N
3380 PLOT X(I),Y(I),-1
3390 NEXT I
3400 PEN Up
3410 SUBEXIT
3420 SUBEND
3430 SUB Pltsym(X(*),Y(*),N)
3440 D=.5
3450 FOR I=1 TO N
3460 PLOT X(I),Y(I),-2
3470 SETGU
3480 WHERE Xc,Yc,Ps#
3490 PLOT Xc-D,Yc,-2
3500 PLOT Xc+D,Yc,-1
3510 PLOT Xc,Yc-D,-2
3520 PLOT Xc,Yc+D,-1
3530 SETUU
3540 NEXT I
3550 PENUP
3560 SUBEXIT
3570 SUBEND

```

```

10  REM *****
20  REM :APILOT
30  REM *****
40  REM :   VERSION 05 FEB 1981
50  REM :
60  REM : CREATED CDW
70  REM : PURPOSE: CONTROL THE AUTOANALYZER AND SAMPLER
80  REM *****
90  REM "THIS IS THE PEAK FINDING PROGRAM
100 REM "IT DRIVES THE SAMPLER
110 REM SYSTEM NOW SYNC'S OFF TIME OF FIRST RISE AND TIME OF FIRST FALL
120 REM THIS VERSION OF "APILOT" PROVIDES GRAPHIC DISPLAY OF REGENERATED
    ABSORBANCE VALUES
130 REM 1:DISPLAY SECTION AVAILABLE ONLY IN PEAK FINDER MODE
140 REM 2:SELECT CHANNEL DISPLAYED BY TYPING IN Cplot=(channel#[1 TO 6])
    THEN PRESS EXECUTE
150 REM 3:PRESS KEY 15 TO OBTAIN DISPLAY OF REGENERATED ABSORBANCE FOR
    SELECTED CHANNEL
160 REM 4:THE DISPLAY FILLS UP FROM LEFT TO RIGHT.WHEN FILLED THE DISPLAY WILL
    AUTOMATICALLY CLEAR AND THEN CONTINUE FROM THE FAR LEFT.
170 REM 5: THE DISPLAY CAN BE CLEARED AND REINITIATED AT THE FAR LEFT MANUALLY
    AT ANY TIME BY PRESSING KEY 15
180 REM 6:PRESS SHIFT KEY 15 TO RETURN TO NORMAL NONGRAPHIC PEAK FINDER
    DISPLAY
190 REM : ***** MACHINE STATUS *****
200 OVERLAP
210 FIXED 3
220 OPTION BASE 1
230 SHORT Ds(3),P(40,6),Rf(6),F(6),B1(6),B2(6),Tout,Dout(6)
240 INTEGER I,J,K,L,M,N,N0,N1,N2,N3,N4,N5,Nsmax,Ncmax,L0,L1,L2,L3,Iexit,Ib2,Ib1
    ,Nlag,Cdec(6),Bstat(6),Cdec(6),Cdecw(6)
250 DIM T(0:40,1:6),Ti(-1:14),V(0:14,1:6),E(-1:14,1:6),A(-1:14,1:6),Cn(40,6)
260 DIM B(6),Tf(6),Tr(6),Se(6),D(6),See(6),Tfr(6),Rwc(6),Frc(6),Tff(6),Ffc(6)
270 INTEGER Icode(40),Istat(6),C(6),Nplat(6),Np(6)
280 DIM A$(6)[4],Id$(40)[1],L#[6],Da#[7],Hr#[4],Op#[6],Kw#[1],Ro1#[1],H$(5)[5]
    ,Clock#[14],Mess#[50],Lat#[12],Lon#[12]
290 INTEGER B1n(6),B2n(6)
300 OUTPUT 9;"A"           ! REM HALT THE CLOCK UNITS
310 DATA 0,0,3
320 READ Iread,Iwrite,Nsamp !DEFAULT
321 OUTPUT 2 WHS USING "#,W";0 ! WASH
330 ENABLE
340 REM : *****
350 PRINT "           HELLO FROM APILOT   ",LIN(2),SPA(10),"I HAV
E RUN OFF TO GET THE TIME BACK IN 20 SEC"
360 CALL Error           ! CHECKS FOR CLOCK ERRORS
370 CALL Unserv         !CHECKS FOR UNSERVICED INTER
380 OUTPUT 9;"R"         !REQUEST TIME
390 ENTER 9;Clock$      !GET TIME
400 PRINT LIN(2),SPA(5)," CLOCK TIME IS= ",Clock$
410 INPUT "IS DATA FROM TAPE? Y/N",Kw$
420 IF (Kw#[1,1]="N") OR (Kw#[1,1]="n") THEN 510
430 INPUT "INPUT FILE NAME? ",Infile$
440 File#=Infile$
450 GOSUB Drive
460 ASSIGN File$ TO #3
470 BUFFER #3
480 ON END #3 GOTO 4730
490 Iread=1
500 GOTO 590
510 INPUT "DO YOU WANT TO SAVE DATA FILE ON TAPE? Y/N",Kw$
520 IF (Kw#[1,1]="N") OR (Kw#[1,1]="n") THEN 590
530 INPUT "OUTPUT FILE NAME?",Outfile$
540 Iwrite=1
550 File#=Outfile$

```

```

560 GOSUB Drive
570 ASSIGN File# TO #4
580 BUFFER #4
590 GOSUB Const
600 PRINTER IS 16
610 DISP " WAITING FOR A COMMAND "
620 ON KEY #0,1 GOSUB Init
630 ON KEY #1,1 GOSUB List
640 ON KEY #2,2 GOSUB Peak
650 ON KEY #3 GOSUB Edit
660 ON KEY #4 GOSUB Save
670 ON KEY #5,1 GOSUB Fini           !THIS IS THE FINISHED COMMAND
680 ON KEY #6,1 GOSUB Fetch
690 ON KEY #7,1 GOSUB Disp
700 ON KEY #23,1 GOSUB Wash
710 ON KEY #22,1 GOSUB Samp
720 ON KEY #15,1 GOSUB Disp
730 GOTO 610
740 Samp: REM TAKES A SAMP
750 PRINT " HELLO FROM SAMP SAMPLER IS IN "
760 OUTPUT 2 WHS USING "#,W";Cdecs(1)
770 WAIT 1000
780 RETURN
790 Wash: REM DOES A WASH
800 PRINT " HELLO FROM WASH SAMPLER IS IN WASH "
810 OUTPUT 2 WHS USING "#,W";Cdecw(1)
820 WAIT 1000
830 RETURN
840 Init: PRINT LIN(5)," HELLO FROM INITIALIZE "
850 BEEP
860 Lat#=Lon#=Mess#="N.A."
870 Depth=-99
880 INPUT "LABEL [6]?",L#
890 INPUT "DATE [7]?",Da#
900 INPUT "TIME [4]?",Hr#
910 INPUT "LAT? 12A OR [CONT]",Lat#
920 INPUT "LON? 12A OR [CONT]",Lon#
930 INPUT "STATION DEPTH ? FLOAT OR [CONT]",Depth
940 INPUT "COMMENT ? 50A OR [CONT]",Mess#
950 INPUT "OPPRATOR [6]?",Op#
960 INPUT "NO. SAMPLES?",Nsamp
970 I1=1
980 GOSUB List
990 I1=2
1000 INPUT "DO YOU WANT TO CHANGE THE TABLE? Y/N",D#
1010 IF (D#[1,1]="Y") OR (D#[1,1]="y") THEN 850
1020 PRINT USING 1030
1030 IMAGE /,/, 5X," ENTER SAMP#, ID (OPTIONS=Exit and List)"
1040 BEEP
1050 LINPUT "NO., ID.?",D#
1060 I=POS(D#,"")
1070 IF I=0 THEN 1140
1080 N=VAL(D#[1,I-1])
1090 Id#(N)=D#[I+1,I+1]
1100 Icode(N)=VAL(D#[I+2,10])
1110 PRINT USING 1120;N,Id#(N),Icode(N)
1120 IMAGE 25X,3D,2X,"ID=",1A,K
1130 GOTO 1040
1140 IF D#[1,1]="L" THEN GOSUB List
1150 IF D#[1,1]="E" THEN 1170
1160 GOTO 1040
1170 PRINT " INITIALIZE FINISHED "
1180 I1=3
1190 GOSUB List
1200 RETURN
1210 List: PRINT PAGE," HELLO FROM LIST " !SUBPROGRAM LIST

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1220 Nprint=16
1230 L=1
1240 IF (I1=1) OR (I1=2) THEN 1270
1250 INPUT "OUTPUT TYPE: 1=ABS,2=TIME,3=DELTA TIME,4=UG-AT,5=CONFID",L
1260 IF (L<1) OR (L>5) THEN 1250
1270 PRINTER IS Nprint
1280 PRINT USING 1300;L#,Da#,Hr#,Lat#,Lon#,Mess#,Depth
1290 PRINT USING 1310;Nsamp,Op#,A#(*),C#(*),F#(*)
1300 IMAGE "LABEL=",10A,/, "DATE=",10A,/, "HR=",10A,/, "LATITUDE= ",12A,/, "LONGITUD
E= "12A,/, "COMMENT=",50A,/"DEPTH= ",DDDDDDDD
1310 IMAGE "NO. SAMPLES=",3D,/, "OPERATOR=",10A,/, "CHANNEL=",6(6X,4A),/, "STATUS=",
1X,6(10D),/, "FACTORS=",6(6D.3D)
1320 PRINT USING 1330;Rf(*),B1(*),B2(*)
1330 IMAGE "RF'S=",3X,6(6D.3D),/, "BASE1=",2X,6(6D.3D),/, "BASE2=",2X,6(6D.3D)
1340 IF I1=1 THEN 1660
1350 PRINT USING 1360;H#(L),H#(L),H#(L),H#(L),H#(L),H#(L)
1360 IMAGE /, "NO. ID",6(5X,5A)
1370 FOR I=1 TO MAX(Mp, Nsamp)
1380 FOR J=1 TO Ncmax
1390 D(J)=-9.99
1400 ON L GOTO 1410,1430,1450,1470,1500
1410 D(J)=P(I,J)
1420 GOTO 1510
1430 D(J)=T(I,J)
1440 GOTO 1510
1450 D(J)=T(I,J)-T(I-1,J)
1460 GOTO 1510
1470 IF P(I,J)<1.0E-12 THEN 1510
1480 D(J)=F(J)*(P(I,J)-(B1(J)+(B2(J)-B1(J))*I/(Nsamp+1)+Rf(J)))
1490 GOTO 1510
1500 D(J)=Ch(I,J)
1510 NEXT J
1520 IF I1=2 THEN 1550
1530 PRINT USING "2D,1X,1A,4D, 6(6D.3D )";I,Id#(I),Icode(I),D(*)
1540 GOTO 1560
1550 PRINT USING "2D,1X,1A,4D";I,Id#(I),Icode(I)
1560 NEXT I
1570 IF Nprint=0 THEN 1640
1580 INPUT "DO YOU WANT HARD COPY, Y/N?",Kw#
1590 IF (Kw#="Y") OR (Kw#="y") THEN 1610
1600 GOTO 1640
1610 Nprint=0
1620 GOTO 1270
1630 NEXT I
1640 Nprint=16
1650 PRINTER IS Nprint
1660 PRINT " LIST FINISHED "
1670 RETURN
1680 Peak:REM THIS IS THE BEGIN OF PEAK !SUBPROGRAM PEAK
1690 PRINT " HELLO FROM PEAK "
1700 ON KEY #8,5 GOSUB Show1
1710 ON KEY #9,5 GOSUB Show2
1720 ON KEY #10,5 GOSUB Show3
1730 ON KEY #11,5 GOSUB Show4
1740 ON KEY #14,5 GOSUB Setexit
1750 ON KEY #15,5 GOSUB Graphon
1760 ON KEY #31,5 GOSUB Graphoff
1770 REM SET SOME INITIAL CONSTANTS
1780 PLOTTER IS 13,"GRAPHICS"
1790 CALL Unserv
1800 OUTPUT 9 USING "3A,5A,3A,DDDDDD";"U1H","U1=01","U1P",Dtm
1810 OUTPUT 9;"U2H","U2C"
1820 ON INT #9,15 GOTO 2140
1830 CONTROL MASK 9;128
1840 CARD ENABLE 9
1850 I1=3

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1860 Ic=Cplot=1
1870 Nlag=10
1880 Noff=Seqn*(Nsamp+2)+MAX(Bin(1),Bin(2),Bin(3),Bin(4),Bin(5),Bin(6))
1890 N=Ntab=Ndata=Iexit=Idraw=Sb1=Sb2=0
1900 MAT Tf=ZER           !PREDICTED FALL TIME VECTOR
1910 MAT Tr=ZER           !PREDICTED RISE TIME VECTOR
1920 MAT See=ZER          !SUM OF E^2 VECTOR
1930 MAT Se=ZER           !SUM OF E VECTOR
1940 MAT Istat=ZER        !PEAK STATUS VECTOR
1950 MAT Nplat=ZER        !NO. IN PLAT VECTOR
1960 MAT Np=ZER           !NO. PEAKS FOUND NOW VECTOR
1970 MAT T=ZER            !TIME FOR PEAKS ARRAY
1980 MAT P=ZER            !VALUE FOR PEAKS ARRAY
1990 MAT Cn=(-.99)        !CONF. INT. FOR PEAKS ARRAY
2000 MAT E=ZER            !REGEN VALUES ARRAY (BOX CAR)
2010 MAT V=ZER            !VALUE ARRAY (BOX CAR)
2020 MAT Ti=ZER           !TIME VECTOR (BOX CAR)
2030 MAT Bstat=ZER        !BASE LINE STATUS VECTOR
2040 MAT B1=(-9.99)       !BASE LINE 1
2050 MAT B2=(-9.99)       !BASE LINE 2
2060 IF Iread=0 THEN OUTPUT 9;"U1G","U2G" !START THE CLOCKS
2070 REM GET NEW DATA
2080 IF Iread=1 THEN 2140
2090 Isw=1
2100 IF N MOD Seqn>Wn THEN Isw=2
2110 IF N>Nsamp*Seqn THEN Isw=1
2120 REM WAITING
2130 GOTO 2120
2140 IF Iexit<>1 THEN GOSUB Data
2150 IF N>Noff THEN Iexit=1
2160 IF Iexit=1 THEN 3240
2170 REM UPDATE COUNTERS FOR LOCATION
2180 N=N+1
2190 L0=(N-1) MOD 15 !BOX CAR COUNTERS
2200 L1=(N-2) MOD 15
2210 L2=(N-3) MOD 15
2220 L3=(N-4) MOD 15
2230 N0=(N-10) MOD 15
2240 N1=(N-9) MOD 15
2250 N2=(N-8) MOD 15
2260 N3=(N-7) MOD 15
2270 N4=(N-6) MOD 15
2280 N5=(N-5) MOD 15
2290 IF Sb1<>Ncmax THEN GOSUB Cbase1 !FALSE ALL B1'S ARE SET
2300 IF Mp>=Nsamp THEN GOSUB Cbase2 !TRUE NOT TIME TO SET B2'S
2310 Ti(L0)=Time
2320 FOR J=1 TO Ncmax
2330 V(L0,J)=D(J)
2340 NEXT J
2350 IF N<3 THEN 2440
2360 FOR J=1 TO Ncmax
2370 A(L1,J)=.25*(V(L2,J)+2*V(L1,J)+V(L0,J))
2380 NEXT J
2390 IF N<5 THEN 2440
2400 Tbr=Ti(L1)-Ti(L3)
2410 FOR J=1 TO Ncmax
2420 E(L2,J)=A(L2,J)+B(J)*(A(L1,J)-A(L3,J))/Tbr
2430 NEXT J
2440 REM BEGIN DISPLAY SECTION
2450 REM :CHECK FOR GRAPHICS
2460 IF Idraw=0 THEN 2490
2470 GOSUB Draw
2480 GOTO 2630
2490 ON Ic GOTO 2500,2520,2540,2560
2500 DISP "TIME=";Time;"|INPUT ABS";D(1);D(2);D(3);D(4);D(5);D(6)
2510 GOTO 2630

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2520 DISP "TIME=";Tzero;"|REGEN ABS";E(N0,1);E(N0,2);E(N0,3);E(N0,4);E(N0,5);E(N
0,6)
2530 GOTO 2630
2540 DISP "TIME=";Tzero;"|AVER ABS";A(N0,1);A(N0,2);A(N0,3);A(N0,4);A(N0,5);A(N
0,6)
2550 GOTO 2630
2560 PRINT USING 2570;Ntab,P(Ntab,1),P(Ntab,2),P(Ntab,3),P(Ntab,4),P(Ntab,5),P(N
tab,6)
2570 IMAGE 2X,4D,6(4X,2D.3D)
2580 Ntab=Ntab+1
2590 IF Ntab<=Mp THEN 2630
2600 PRINT "FINISHED TIME=";Tzero
2610 Ntab=0
2620 Ic=1
2630 REM SPACE HOLDER END OF DISPLAY SECTION
2640 Tzero=Ti(N0)
2650 REM BEGIN OF PEAK FINDING SECTION
2660 FOR J=1 TO Ncmax
2670 REM CHECK AND SEE IF ALL EXPECTED PEAKS ARE IN
2680 IF Bstat(J)<>1 THEN 3210
2690 Istatj=Istat(J)
2700 Npj=Np(J)
2710 IF Istatj=1 THEN 2810
2720 REM LOOKING FOR A RISE
2730 IF (Npj>0) AND (Tzero-Rvc(J)<Washt) THEN 3180 !***NEXT RISE DUE?***
2740 IF (E(N2,J)-E(N1,J)>Y1) AND (E(N3,J)-E(N2,J)>Y1) AND (E(N4,J)-E(N3,J)>Y1) T
HEN Istatj=1 !***RISE TESTER***
2750 IF (Npj>0) AND (Tzero-Frc(J)>5) THEN Istatj=1 !***FORCED RISE CONDITION***
2760 IF (A(N2,J)<B1(J)+1) AND (Npj=0) THEN Istatj=0 !***FALSE RISE SQUELCH
ER***
2770 IF (Istatj=1) AND (Npj=0) THEN Tfr(J)=Tzero !***INITIAL RISE TIME***
2780 IF Istatj=1 THEN Tr(J)=Tzero !***SEQUENTIAL RISE TIME***
2790 IF Istatj=1 THEN Frc(J)=Tfr(J)+(Npj+1)*Pw !***RISE SCHEDULER***
2800 GOTO 3180
2810 REM LOOKING FOR A PLATEAU AND THEN A FALL
2820 IF Tzero-Tr(J)<Dtp1t THEN 3180 !***PLATEAU ALLOWED?***
2830 IF (ABS(E(N0,J)-E(N1,J))<Y1) AND (ABS(E(N1,J)-E(N2,J))<Y1) THEN 2870 !
***PLATEAU TESTER***
2840 IF (Tzero-Tr(J)>Pumin) AND (Tzero-Tr(J)<Pwmax) AND (Nplat(J)<4) THEN 2870!
***FORCED PLATEAU CONDITION***
2850 REM PLAUERU POINT IS BAD
2860 GOTO 2940
2870 REM PLATEAU IS A GOOD ONE
2880 Nplat(J)=Nplat(J)+1
2890 IF Nplat(J)=1 THEN Tp1(J)=Ti(N1)
2900 Ee=(E(N0,J)+E(N1,J)+E(N2,J))/3
2910 Se(J)=Se(J)+Ee
2920 See(J)=See(J)+Ee*Ee
2930 Tp2(J)=Ti(N1)
2940 REM CHECK TO SEE IF FALL ALLOWED AT THIS TIME
2950 IF Tzero-Tr(J)<Pwmax THEN 2980
2960 IF (E(N0,J)-E(N1,J)>Y1d2) AND (E(N1,J)-E(N2,J)>Y1) AND (E(N2,J)-E(N3,J)>Y1t
2) THEN 3000
2970 IF (Npj>0) AND (Tzero-Ffc(J)>5) THEN 3000 !***FORCED FALL CONDITION***
2980 REM NO FALL FOUND
2990 GOTO 3180
3000 REM FALL FOUND
3010 IF Npj=0 THEN Tff(J)=Izero
3020 Ffc(J)=Tff(J)+(Npj+1)*Pw
3030 Npj=K=MIN(Npj+1,40)
3040 Mp=MAX(K,Mp)
3050 T(K,J)=.5*(Tp2(J)+Tp1(J))
3060 Ne=Nplat(J)
3070 IF Ne>0 THEN P(K,J)=Se(J)/Ne
3080 IF Ne>1 THEN Cn(K,J)=1.96*SQR(ABS((See(J)-Ne*P(K,J)^2)/(Ne-1)/Ne))
3090 Istatj=0

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3100 Tf(J)=Tzero
3110 Rwc(J)=Tf(J)-5
3120 IF Npj<>Nsamp THEN 3150 !TRUE DO NOT CALCULATE BASE2
3130 B2n(J)=INT(Seqn+T(K,J)/Dt)
3140 Bstat(J)=2
3150 PRINT USING " 28A,3(4D),3(6D.3D) ";"[CHAN,#P,#VAL,ABS,CONF,TIME]",J,Npj,Np1
at(J),P(K,J),Cn(K,J),T(K,J)
3160 Nplat(J)=0
3170 See(J)=Se(J)=0
3180 REM GO DO ANOTHER CHANNEL
3190 Istat(J)=Istat.j
3200 Np(J)=Npj
3210 NEXT J
3220 REM THIS IS A SPACE HOLDER
3230 GOTO 2070
3240 REM CLOSING SHOP
3250 OUTPUT 9;"A"
3260 IF Iread=0 THEN OUTPUT 2 WHS USING "#,W";Cdecw(1)
3270 IF Iread=0 THEN Vn=READBIN(2)
3280 WAIT 1000
3290 PRINT " PEAK FINISHED "
3300 RETURN
3310 Setexit:REM MAKES IEXIT=1
3320 OUTPUT 9;"A"
3330 Iexit=1
3340 PRINT "SETTING EXIT"
3350 RETURN
3360 Cbase1:REM
3370 FOR I=1 TO Ncmax
3380 IF N<>B1n(I) THEN 3430
3390 B1(I)=A(L2,I)
3400 PRINT "INIT BASE CHAN VAL=";I,B1(I)
3410 Bstat(I)=1
3420 Sb1=Sb1+1
3430 NEXT I
3440 RETURN
3450 Cbase2:REM
3460 FOR I=1 TO Ncmax
3470 IF N<>B2n(I) THEN 3520
3480 B2(I)=A(L3,I)
3490 PRINT "FINAL BASE CHAN VAL=";I,B2(I)
3500 Sb2=Sb2+1
3510 Bstat(I)=3
3520 NEXT I
3530 IF Sb2=Ncmax THEN Iexit=1 !TRUE ALL BASELINES SET EXIT FROM PEAK
3540 RETURN
3550 Edit: REM EDITS P MATRIX !SUBPROGRAM EDIT
3560 PRINT " HELLO FROM EDIT "
3570 INPUT "ENTER EDIT OPERATION LETTER,Add,Replace,Delete,Exit,List",Kw#
3580 V=0
3590 Roll#=""
3600 IF Kw#="E" THEN 4060
3610 IF Kw#="L" THEN 4040
3620 INPUT "ROW,COLUMN?",Nr,J
3630 IF Kw#="R" THEN 3660
3640 INPUT "ROLL REQUIRED. U/D?",Roll#
3650 IF Kw#="D" THEN 3670
3660 INPUT "VALUE REQUIRED. VALUE?",V
3670 PRINT USING 3680;Kw#,Nr,J,Roll#,V
3680 IMAGE "COMMAND IS=",1A,1X,2(3D),1X,1A,4D.3D
3690 INPUT "DO YOU WANT TO EXECUTE, Y/N",D#
3700 IF (D#[1,1]="N") OR (D#[1,1]="n") THEN 3570
3710 IF Kw#="R" THEN 4020
3720 IF Kw#="D" THEN 3860
3730 IF Roll#="D" THEN 3810
3740 REM ADD-UP

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3750 FOR I=1 TO Nr-1
3760 P(I,J)=P(I+1,J)
3770 NEXT I
3780 P(Nr,J)=V
3790 GOTO 3570
3800 REM ADD-DOWN
3810 FOR I=Nsmax TO Nr+1 STEP -1
3820 P(I,J)=P(I-1,J)
3830 NEXT I
3840 P(Nr,J)=V
3850 GOTO 3570
3860 IF Roll#="D" THEN 3940
3870 REM DELETE-UP
3880 FOR I=Nr TO Nsmax-1
3890 P(I,J)=P(I+1,J)
3900 T(I,J)=T(I+1,J)
3910 NEXT I
3920 GOTO 3570
3930 REM DEL-DOWN
3940 FOR I=Nr TO 2 STEP -1
3950 P(I,J)=P(I-1,J)
3960 T(I,J)=T(I-1,J)
3970 NEXT I
3980 P(1,J)=0
3990 T(1,J)=0
4000 GOTO 3570
4010 REM REPLACE
4020 P(Nr,J)=V
4030 GOTO 3570
4040 GOSUB List
4050 GOTO 3570
4060 PRINT " EDIT FINISHED "
4070 RETURN
4080 Show1: Ic=1 !SUBPROGRAM SHOW1
4090 RETURN
4100 Show2: Ic=2 !SUBPROGRAM SHOW2
4110 RETURN
4120 Show3: Ic=3 !SUBPROGRAM SHOW3
4130 RETURN
4140 Show4: Ic=4 !SUBPROGRAM SHOW4
4150 PRINT USING 4160;A#(*)
4160 IMAGE @,"PEAK LISTING",/,2X,"PEAK",6(6X,4A)
4170 Ntab=Ntab+1
4180 RETURN
4190 Save:REM THIS SECTION SAVES RESULTS ON TAPE !SUBPROGRAM SAVE
4200 ON ERROR GOTO 4300
4210 PRINT " HELLO FROM SAVE "
4220 INPUT "DO YOU WANT TO SAVE THE FILE, Y/N?",Kw#
4230 IF (Kw#="Y") OR (Kw#="y") THEN 4250
4240 GOTO 4460
4250 N=4+Nsamp/8 !CALCULATE NO. REC FOR CREATE
4260 File#=L#
4270 GOSUB Drive !PICK DEVICE FOR INPUT
4280 ASSIGN File# TO #3 !CHECK TO SEE IF FILE ALREADY USED
4290 GOTO 4450
4300 CREATE File#,N !CREATE THE OUTPUT FILE
4310 ASSIGN File# TO #2
4320 BUFFER #2
4330 PRINT #2;L#,Da#,Hr#,Op#,A#(*)
4340 PRINT #2;Mess#,Lat#,Lon#,Depth !NEW PRINT ADDED 11FEB
4350 PRINT #2;Nsamp,Nc
4360 PRINT #2;C(*),F(*),Rf(*),B1(*),B2(*)
4370 FOR I=1 TO Nsamp
4380 PRINT #2;I,Id#(I),Icode(I),P(I,1),P(I,2),P(I,3),P(I,4),P(I,5),P(I,6)
4390 NEXT I
4400 PRINT #2;END

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4410 ASSIGN File$ TO #2
4420 PRINT " FILE HAS BEEN SAVED ON T:15 "
4430 Isave=1
4440 GOTO 4460
4450 PRINT " WARNING YOU HAVE TRIED TO SAVE AN EXISTING FILE ,I REFUSE TO DO I
T!-TURKEY "
4460 PRINT " BYE-FROM SAVE "
4470 RETURN
4480 Fetch:REM THIS SECTION READS THE FILE L$ !SUBPROGRAM FETCH
4490 PRINT " HELLO FROM FETCH "
4500 INPUT "FILE WANTED? [6]",L$
4510 File$=L$
4520 GOSUB Drive
4530 ASSIGN File$ TO #2
4540 BUFFER #2
4550 Lat$=Lon$=Mess$="N.A."
4560 Depth=-99
4570 READ #2;L$,Da$,Hr$,Op$,R$(*)
4580 Ktyp=TYP(2)
4590 IF (Ktyp=2) OR (Ktyp>7) THEN READ #2;Mess$,Lat$,Lon$,Depth
4600 READ #2;Nsamp,Nc
4610 READ #2;C(*),F(*),Rf(*),B1(*),B2(*)
4620 FOR I=1 TO Nsamp
4630 READ #2;I,Ic(I),Icode(I),P(I,1),P(I,2),P(I,3),P(I,4),P(I,5),P(I,6)
4640 NEXT I
4650 PRINT " FINISHED READING FILE "
4660 RETURN
4670 Data: REM THIS IS THE DATA GETTING SECTION !SUBPROGRAM DATA
4680 IF Iread=0 THEN 4770
4690 READ #3;Tout,Dout(*)
4700 MAT D=Dout
4710 Time=Tout
4720 GOTO 4930
4730 PRINT "EOF ENCOUNTER ON #3 IN DATA"
4740 Iexit=1
4750 REM
4760 GOTO 4980
4770 REM SPACE HOLDER FOR BOX READING
4780 OUTPUT 9;"U2V"
4790 ENTER 9;Time
4800 CARD ENABLE 9
4810 Time=Time/1000
4820 FOR I=1 TO Ncmax
4830 ON Icw GOTO 4840,4860
4840 OUTPUT 2 WHS USING "#,W";Cdecw(I)
4850 GOTO 4870
4860 OUTPUT 2 WHS USING "#,W";Cdecs(I)
4870 Vn=C(I)/409.5*READBIN(2)
4880 REM CHECK FOR TOO LARGE A CHANGE IN VALUE
4890 IF N<2 THEN 4910
4900 IF ABS((D(I)-Vn)/Dt)>1 THEN 4920
4910 D(I)=Vn
4920 NEXT I
4930 IF Iwrite=0 THEN 4980
4940 IF Sb1=0 THEN 4980
4950 MAT Dout=D
4960 Tout=Time
4970 IF N<4000 THEN PRINT #4;Tout,Dout(*)
4980 RETURN
4990 Disp:REM THIS SECTION MAKES WORKING DISPLAY
5000 K=0
5010 PRINT " HELLO FROM CHECK EXIT USING K-7"
5020 ON KEY #7,9 GOTO 5110
5030 IF Iread=1 THEN 5130
5040 FOR I=1 TO Ncmax
5050 OUTPUT 2 WHS USING "#,W";Cdecw(I)

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5060 D(I)=C(I)/409.5*READBIN(2)
5070 NEXT I
5080 DISP "CHECK";K;"|INPUT ABS";D(1);D(2);D(3);D(4);D(5);D(6)
5090 K=K+1
5100 GOTO 5040
5110 PRINT " BYE-FROM CHECK "
5120 GOTO 5140
5130 PRINT " BYE-FROM CHECK YOU ARE READING FROM TAPE "
5140 RETURN
5150 Fini:REM THIS IS THE END
5160 IF Isave=1 THEN 5190
5170 PRINT " WARNING YOU HAVE NOT SAVED THE FILE YOU HAVE BEEN RETURNED
"
5180 GOTO 5210
5190 PRINT " BYE FROM PROGRAM TO START AGAIN DO CONTROL RESET AND RUN"
5200 GOTO 5650
5210 RETURN
5220 Const: REM SETS CONSTANTS !SUBPROGRAM CONSTANT
5230 REM ***** USER CAN CHANGE THESE VALUES*****
5240 DATA " P04", "S104", " N+N", " N02", " NH4", "URE ."
5250 READ A#(*) !READ CHANNEL LABELS
5260 DATA 1,1,1,1,1,0
5270 READ C(*) !READ CHANNEL STATUS
5280 DATA 40,6,6
5290 READ Nsmax,Ncmax,Nc !READ MAX SAMP,MAX CHAN, ACTIVE CHAN
5300 DATA 1.039,4.911,5.996,1.023,3.498,1.000
5310 READ F(*) !READ FACTORS
5320 DATA .14,.09,.03,.04,.15,0
5330 READ Rf(*) !READ REFRACTIVE INDEX CORRECTION
5340 DATA 9.0,8.0,13.5,9.5,11.5,7.5
5350 READ B(*) !READ B VALUES
5360 DATA 550,450,400,400,575,300
5370 READ B1n(*) !READ TIME (SEC) TO WAIT FOR INIT BASE
5380 DATA .01,120,60,1.00
5390 READ Yl,Sampt,Washt,Dt !READ YLIM,SAMP,WASH,DELTA SAMP BOX
5400 REM ***** END OF USER CHANGES *****
5410 DATA " ABS", " TIME", " DT", "UG-AT", " CONF"
5420 READ H#(*) !UNITS FOR LIST SUBPROGRAM
5430 Yld2=Yl/2 !LIMITS FOR GETTING PLATEAU
5440 Ylt2=Yl*2
5450 Pw=Sampt+Washt !TOTAL TIME (SEC) FOR 1 SEQ
5460 Dtplt=.6*Sampt
5470 Pwmin=.8*Sampt !PEAK WIDTH MIN
5480 Pwmax=.95*Sampt !PEAK WIDTH MAX
5490 Ffc=Sampt+5
5500 Dtm=Dt*1000 !BOX SAMPLE TIME (MILLISEC)
5510 Seqn=Pw/Dt !WASH+SAMP IN N UNITS
5520 Wn=Washt/Dt !WASH IN N UNITS
5530 Sn=Sampt/Dt !SAMP IN N UNITS
5540 MAT B1n=(1/Dt)*B1n !BASE 1 SET IN N UNITS
5550 FOR I=1 TO Nsmax
5560 Id#(I)="?"
5570 NEXT I
5580 DATA 0,256,512,768,1024,1280 !A TO D CONVERTER
5590 READ Cdec(*) !DEC CODES FOR CHANNELS 1-6
5600 MAT Cdec=(128)+Cdec !SETS UP SAMP VOLTS=5
5610 MAT Cdecw=(0)+Cdec !SETS UP WASH VOLTS=0
5620 PRINTER IS 0
5630 PRINT USING 5640;Sampt,Washt,Dt,Yl,B(*)
5640 IMAGE /,"SAMPLE TIME (SEC)=",5D.2D,/,"WASH TIME (SEC)=",5D.2D,/,"SAMPLING R
ATE (SEC)=",5D.2D,/,"Y LIMIT=",4D.5D,/,"B(*)="6(3D.2D,2X)
5650 RETURN
5660 Drive:REM THIS MAKES LABEL SPECIFY A TAPE DRIVE
5670 REM THIS ROUTINE ADDS :T15 OR :T14 TO FILE NAME FILE#
5680 INPUT "TAPE DRIVE WANTED? 14 OR 15 OR F8",T#
5690 Nchar=LEN(File#)

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5700 IF T$="14" THEN File#[Nchar+1]=":T14"
5710 IF T$="15" THEN File#[Nchar+1]=":T15"
5720 IF T$="F8" THEN File#[Nchar+1]=":F8"
5730 RETURN
5740 END
5750 Draw: REM THIS A PLOTTER
5760 IF Cplot<>Old THEN Nplot=1
5770 IF Nplot=Npmax THEN Nplot=1
5780 IF Nplot>1 THEN 5810
5790 GCLEAR
5800 MOVE Nplot,E(N0,Cplot)
5810 DRAW Nplot,E(N0,Cplot)
5820 Old=Cplot
5830 Nplot=Nplot+1
5840 RETURN
5850 Graphon:REM
5860 Npmax=500
5870 Nplot=1
5880 Old=Cplot
5890 GRAPHICS
5900 GCLEAR
5910 SCALE 1,Npmax,-1,11
5920 Idraw=1
5930 RETURN
5940 Graphoff: REM
5950 Idraw=0
5960 EXIT GRAPHICS
5970 RETURN
5980 SUB Unserv
5990 REM THIS ROUTINE CHECKS FOR UNSERVICED INTER
6000 OUTPUT 9;"W"
6010 ENTER 9 USING "#,B";Z
6020 FOR Itr=0 TO 3
6030 IF BIT(2,Itr) THEN PRINT USING 6040;Itr+1
6040 IMAGE "CHECK ON W, UNSERVICED INTERRUPT ON UNIT=",ZZZ
6050 NEXT Itr
6060 SUBEXIT
6070 SUBEND
6080 SUB Error
6090 REM THIS ROUTINE GIVES THE ERROR CODES FOR THE CLOCK
6100 OUTPUT 9;"E"
6110 ENTER 9 USING 6120;E
6120 IMAGE #,B
6130 IF E<>0 THEN PRINT " CLOCK ERROR SUMMARY"
6140 IF BIT(E,7) THEN PRINT "BAD R/W MEMORY"
6150 IF BIT(E,6) THEN PRINT "BAD R/W MEMORY"
6160 IF BIT(E,5) THEN PRINT "BAD CLOCK CHIP"
6170 IF BIT(E,4) THEN PRINT "LOST REAL TIME"
6180 IF BIT(E,3) THEN PRINT "INVALID COMMAND"
6190 IF BIT(E,2) THEN PRINT "UNIT MISMATCH"
6200 IF BIT(E,1) THEN PRINT "DATA RANGE ERROR"
6210 IF BIT(E,0) THEN PRINT "INTERRUPT MISSED"
6220 SUBEXIT
6230 SUBEND
6240 SUB Read
6250 OPTION BASE 1
6260 SHORT Tout,Dout(6)
6270 ASSIGN #1 TO "DATA:T15"
6280 BUFFER #1
6290 ON END #1 GOTO 6360
6300 I=0
6310 I=I+1
6320 READ #1;Tout,Dout(*)
6330 PRINT USING 6340;I;Tout;Dout(*)
6340 IMAGE DDD,DDDDDD.DD,6(2X,DDD.DD)
6350 GOTO 6310

```

6360 PRINT "EOF READ"  
6370 SUBEXIT  
6380 SUBEND

```

10  REM : MANDAT
20  REM : VERSION          09 APRIL 1978, CREATED BY C.D.WIRICK WHILE AT SEA
30  REM : MODIFIED        11FEB1980 TO ALLOW LAT LON FILE READS
40  REM : PURPOSE=       ENTER NUTRIENT DATA MANUALLY
50  REM : *****
60  REM :                 MACHINE STATUS
70  FIXED 2
80  OPTION BASE 1
90  INTEGER I, J, K, L, M, N, Nsamp, C(6), Nc, Ncmax, Icode(40), Istat(6)
100 SHORT Rf(6), F(6), B1(6), B2(6), P(40, 6)
110 DIM A$(6)[4], Id$(40)[1], L$(6), Da$(7), Hr$(4), Op$(6), Kw$(1), Roll$(1), H$(4)[5]
, Clock$(14), T(0:40, 1:6), D(6), Mess$(50), Lat$(12), Lon$(12)
120 REM *****
130 GOSUB Const
140 PRINTER IS 16
150 ENABLE
160 PRINT PAGE, "          HELLO FROM MANDAT          "
170 PRINTER IS 0
180 PRINT "          HELLO FROM MANDAT          "
190 PRINT "KEY 0- INITIALIZE", LIN(1), "KEY 1- LIST", LIN(1), "KEY 2- INPUT DATA", L
IN(1), "KEY 3- EDIT", LIN(1), "KEY 4- SAVE DATA", LIN(1), "KEY 5- FINISHED"
200 PRINT "KEY 6- FETCH"
210 PRINT LIN(2), "WHEN IN DOUBT PUSH CONTINUE, SOMETHING WILL HAPPEN"
220 PRINTER IS 16
230 DISP " WAITING FOR A COMMAND "
240 ON KEY #0,1 GOSUB Init
250 ON KEY #1,1 GOSUB List
260 ON KEY #2 GOSUB Make
270 ON KEY #3 GOSUB Edit
280 ON KEY #4 GOSUB Save
290 ON KEY #5,1 GOSUB Fini          !THIS IS THE FINISHED COMMAND
300 ON KEY #6 GOSUB Read
310 GOTO 230
320 Init: PRINT LIN(5), " HELLO FROM INITIALIZE "
330 BEEP
340 Depth=-99
350 Lat#=Lon#=Mess#="N.A."
360 INPUT "LABEL [6]?", L$
370 INPUT "DATE [7]?", Da$
380 INPUT "TIME [4]?", Hr$
390 INPUT "LAT? 12A OR [CONT]", Lat$
400 INPUT "LON? 12A OR [CONT]", Lon$
410 INPUT "STATION DEPTH? FLOAT OR [CONT]", Depth
420 INPUT "COMMENT? 50A OR [CONT]", Mess$
430 INPUT "OPERATOR [6]?", Op$
440 INPUT "NO. SAMPLES?", Nsamp
450 I1=1
460 INPUT "BEGIN BASE LINE? [6NO.S]", B1(*)
470 INPUT "FINAL BASE LINE? [6NO.S]", B2(*)
480 GOSUB List
490 INPUT "DO YOU WANT TO CHANGE FACTORS? Y/N", Kw$
500 IF Kw$="Y" THEN 520
510 GOTO 540
520 INPUT " FACTORS? [6 NO.S]", F(x)
530 GOSUB List
540 I1=2
550 INPUT "IS THE TABLE CORRECT? Y/N", D$
560 IF (D$(1,1)="N") OR (D$(1,1)="n") THEN 330
570 PRINT " INITIALIZE FINISHED "
580 RETURN
590 List: PRINT PAGE, " HELLO FROM LIST "          !SUBPROGRAM LIST
600 Nprint=16
610 L=1
620 IF (I1=1) OR (I1=2) THEN 650
630 INPUT "OUTPUT TYPE: 1=ABS, 2=UG-AT/L", L
640 IF (L<1) OR (L>2) THEN 630

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```

650 PRINTER IS Nprint
660 PRINT USING 680;L$,Da$,Hr$,Lat$,Lon$,Depth,Mess$
670 PRINT USING 690;Nsamp,Op$,R$(*),C$(*),F$(*)
680 IMAGE "LABEL=",10A,/, "DATE=",10A,/, "HR=",10A,/, "LAT=" 12A,/, "LON=",12A,/, "D
EPH=",10A,/, "COMMENT=" 50A
690 IMAGE "NO.SAMPLES=",3D,/, "OPERATOR=",10A,/, "CHANNEL=",6(6X,4A),/, "STATUS=",
1X,6(10D),/, "FACTORS=",6(6D.3D)
700 PRINT USING 710;Rf$(*),B1$(*),B2$(*)
710 IMAGE "RF'S=",3X,6(6D.3D),/, "BASE1=",2X,6(6D.3D),/, "BASE2=",2X,6(6D.3D)
720 IF I1=1 THEN 990
730 PRINT USING 740;H$(L),H$(L),H$(L),H$(L),H$(L),H$(L)
740 IMAGE /,"NO. ID",6(5X,5A)
750 FOR I=1 TO MAX(Mp,Nsamp)
760 FOR J=1 TO Ncmax
770 ON L GOTO 780,800
780 D(J)=P(I,J)
790 GOTO 850
800 D(J)=F(J)*(P(I,J)-(B1(J)+(B2(J)-B1(J))*I/(Nsamp+1)+Rf(J)))
810 IF P(I,J)>.0001 THEN 850
820 D(J)=0
830 IF P(I,J)>-1 THEN 850
840 D(J)=-99
850 NEXT J
860 IF I1=2 THEN 890
870 PRINT USING "2D,1X,1A,4D, 6(7D.2D )";I,Id$(I),Icode(I),D(*)
880 GOTO 900
890 PRINT USING "2D,1X,1A,4D";I,Id$(I),Icode(I)
900 NEXT I
910 IF Nprint=0 THEN 970
920 INPUT "DO YOU WANT HARD COPY, Y/N?",Kw$
930 IF Kw$="N" THEN 970
940 Nprint=0
950 GOTO 650
960 NEXT I
970 Nprint=16
980 PRINTER IS Nprint
990 PRINT " LIST FINISHED "
1000 RETURN
1010 Make: REM THIS ROUTINE ALLOWS ONE TO ENTER DATA FROM KEY BOARD
1020 I1=3
1030 PRINT LIN(2),SPA(25)," HELLO FROM MAKE "
1040 INPUT "SAMPLE NO. ,List OR Exit ?",D$
1050 IF D#[1,1]="E" THEN 1170
1060 IF D#[1,1]="L" THEN 1140
1070 I=VAL(D$)
1080 PRINT SPA(10),"SAMPLE NO=";I
1090 INPUT "ID, NUT1,NUT2,NUT3,NUT4,NUT5,NUT6?",D$,P(I,1),P(I,2),P(I,3),P(I,4),P
(I,5),P(I,6)
1100 L=LEN(D$)
1110 Id$(I)=D#[1,1]
1120 Icode(I)=VAL(D#[2,L])
1130 GOTO 1040
1140 GOSUB List
1150 PRINT " YOU ARE STILL IN MAKE "
1160 GOTO 1040
1170 PRINT " BYE FROM MAKE "
1180 RETURN
1190 Save:REM THIS SECTION SAVES RESULTS ON TAPE !SUBPROGRAM SAVE
1200 ON ERROR GOTO 1300
1210 PRINT " HELLO FROM SAVE "
1220 INPUT "DO YOU WANT TO SAVE THE FILE, Y/N?",Kw$
1230 IF (Kw$="Y") OR (Kw$="y") THEN 1250
1240 GOTO 1460
1250 N=4+Nsamp/8
1260 File$=L$
1270 GOSUB Drive

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1280 ASSIGN File# TO #3
1290 GOTO 1450
1300 CREATE File#,N
1310 ASSIGN File# TO #2
1320 BUFFER #2
1330 PRINT #2;L$,Da$,Hr$,Op$,R$(*)
1340 PRINT #2;Mess$,Lat$,Lon$,Depth
1350 PRINT #2;Nsamp,Nc
1360 PRINT #2;C(*),F(*),Rf(*),B1(*),B2(*)
1370 FOR I=1 TO Nsamp
1380 PRINT #2;I,Id$(I),Icode(I),P(I,1),P(I,2),P(I,3),P(I,4),P(I,5),P(I,6)
1390 NEXT I
1400 PRINT #2;END
1410 ASSIGN File# TO #2
1420 PRINT " FILE HAS BEEN SAVED ON :T";T#
1430 Isave=1
1440 GOTO 1460
1450 PRINT " WARNING YOU HAVE TRIED TO SAVE AN EXISTING FILE ,I REFUSE TO DO I
TI-TURKEY "
1460 PRINT " BYE-FROM SAVE "
1470 RETURN
1480 Edit: REM EDITS P MATRIX          !SUBPROGRAM EDIT
1490 PRINT " HELLO FROM EDIT "
1500 INPUT "ENTER EDIT OPERATION LETTER,Add,Replace,Delete,Exit,List",Kw#
1510 V=0
1520 Roll$=""
1530 IF Kw#="E" THEN 1990
1540 IF Kw#="L" THEN 1970
1550 INPUT "ROW,COLUMN?",Nr,J
1560 IF Kw#="R" THEN 1590
1570 INPUT "ROLL REQUIRED. U/D?",Roll$
1580 IF Kw#="D" THEN 1600
1590 INPUT "VALUE REQUIRED. VALUE?",V
1600 PRINT USING 1610;Kw#,Nr,J,Roll$,V
1610 IMAGE "COMMAND IS=",1R,1X,2(3D),1X,1R,4D.3D
1620 INPUT "DO YOU WANT TO EXECUTE, Y/N",D#
1630 IF (D#[1,1]="N") OR (D#[1,1]="n") THEN 1500
1640 IF Kw#="R" THEN 1950
1650 IF Kw#="D" THEN 1790
1660 IF Roll$="D" THEN 1740
1670 REM ADD-UP
1680 FOR I=1 TO Nr-1
1690 P(I,J)=P(I+1,J)
1700 NEXT I
1710 P(Nr,J)=V
1720 GOTO 1500
1730 REM ADD-DOWN
1740 FOR I=Nsmax TO Nr+1 STEP -1
1750 P(I,J)=P(I-1,J)
1760 NEXT I
1770 P(Nr,J)=V
1780 GOTO 1500
1790 IF Roll$="D" THEN 1870
1800 REM DELETE-UP
1810 FOR I=Nr TO Nsmax-1
1820 P(I,J)=P(I+1,J)
1830 T(I,J)=T(I+1,J)
1840 NEXT I
1850 GOTO 1500
1860 REM DEL-DOWN
1870 FOR I=Nr TO 2 STEP -1
1880 P(I,J)=P(I-1,J)
1890 T(I,J)=T(I-1,J)
1900 NEXT I
1910 P(1,J)=0
1920 T(1,J)=0

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1930 GOTO 1500
1940 REM REPLACE
1950 P(Nr,J)=V
1960 GOTO 1500
1970 GOSUB List
1980 GOTO 1500
1990 PRINT "  EDIT FINISHED  "
2000 RETURN
2010 Const: REM SETS CONSTANTS          !SUBPROGRAM CONST
2020 Dnull=-9.99
2030 DATA " P04","SI04"," N+N"," NO2"," NH4","URE"
2040 READ A#(*)                          !READ CHANNEL LABELS
2050 DATA 1,1,1,1,0,1
2060 READ C#(*)                          !READ CHANNEL STATUS
2070 DATA 40,6,6
2080 READ Nsmax,Ncmax,Nc                !READ MAX SAMP,MAX CHAN, ACTIVE CHAN
2090 DATA 1.020,5.086,4.959,1.03,0.000,0.00
2100 READ F#(*)                        !READ FACTORS
2110 DATA .171,.094,.06,.09,.12,0
2120 READ Rf#(*)                       !READ REFRACTIVE INDEX CORRECTION
2130 DATA 200,.1,50,5,1
2140 READ Peakw,Peakh,N1,Ns,Dt        !READ PEAK FINDER CONSTANTS
2150 DATA " ABS","UG-AT","*****","*****"
2160 READ H#(*)                        !UNITS FOR LIST SUBPROGRAM
2170 FOR I=1 TO Nsmax
2180 Id$(I)="?"
2190 NEXT I
2200 RETURN
2210 Fini: PRINT PAGE;" HELLO FROM FINI  "
2220 IF Isave=0 THEN 2250
2230 PRINT "  FINI FINISHED AND PROGRAM IS ENDED-BYE  "
2240 GOTO 2230
2250 FOR I=1 TO 5
2260 BEEP:
2270 PRINT "  WARNING FILE HAS NOT BEEN STORED-YOU HAVE BEEN RETURNED TO MAI
N PROGRAM"
2280 WAIT 2000
2290 NEXT I
2300 RETURN
2310 Read:REM THIS SECTION READS THE FILE L#
2320 INPUT "FILE WANTED? [6]",L#
2330 File#=L#
2340 GOSUB Drive
2350 ASSIGN File# TO #2
2360 BUFFER #2
2370 Lat#=Lon#=Mess#="N.A."
2380 Depth=-99
2390 READ #2;L#,Da#,Hr#,Op#,A#(*)
2400 Ktyp=TYP(2)
2410 IF (Ktyp=2) OR (Ktyp>7) THEN READ #2;Mess#,Lat#,Lon#,Depth
2420 READ #2;Nsamp,Nc
2430 READ #2;C#(*),F#(*),Rf#(*),B1#(*),B2#(*)
2440 FOR I=1 TO Nsamp
2450 READ #2;I,Id$(I),Icode(I),P(I,1),P(I,2),P(I,3),P(I,4),P(I,5),P(I,6)
2460 NEXT I
2470 PRINT "  FINISHED READING FILE  "
2480 RETURN
2490 Drive:REM THIS MAKES LABEL SPECIFY A TAPE DRIVE
2500 REM THIS ROUTINE ADDS :T15 OR :T14 TO FILE NAME FILE#
2510 T#="15"
2520 INPUT "TAPE DRIVE WANTED? 14,15 OR F8?",T#
2530 Nchar=LEN(File#)
2540 File#[Nchar+1]=":T"&T#
2550 IF T#="F8" THEN File#[Nchar+1]=":F8"
2560 RETURN
2570 END

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```

10  REM :  BFIND
20  REM :  VERSION      14 FEB 1980
30  REM :  PURPOSE=    FIND THE B VALUES FOR PEAK REGENERATION
40  REM :
50  REM :      ORIGINAL-    CDW-06 OCT 1978
60  REM :      MODIFIED-   CJP AND CDW-14 FEB 1980
70  REM : *****
80  REM :  USER NOTES-
90  REM :  STEPS OF THE PROGRAM
100 REM :      1-GIVE CHANNEL NO.
110 REM :      2-GIVE NO. POINTS TO PLOT
120 REM :      3-COLLAPSE DATA USING CURSOR, TWO PUSH [CONT]
130 REM :      4-PICK SEGMENTS USING CURSOR, N TRYS YOU EXIT WITH KEY#0
140 REM :      5-PICK E VALUES USING CURSOR, AUTO POSITIONING
150 REM :      6-CHANGE E VALUES
160 REM :      7-B VALUES ARE CALCULATED
170 REM :      8-PLOT REGENERATED VALUES- AS MANY TIMES AS YOU WISH
180 REM :  DATA TAPE-
190 REM :      1. THE DATA TAPE IS MADE IN PROGRAM PEAK- SAMPLING TIMES
200 REM :          SHOULD BE LARGE ENOUGH TO ALLOW STEADY STATE ,(180 SEC)
210 REM : *****
220 REM
230 REM :          MACHINE STATUS
240 OPTION BASE 1
250 DIM Ascii$(32:96)[12]
260 DIM Hp(50),Tp(50),Nb(20),Nf(20),Ein(20),File#[9]
270 DIM Title#[80],Aseg(10),Bseg(10),Npseg(10)
280 SHORT D(6),Ts,H(2500),T(2500)
290 REM *****
300 REM :      SPECIAL VALUES
310 REM :      WIDTH = 15 AUTO SELECT OF SEGMENT LENGTH- USER SHOULD NOT ALTER
320 REM *****
330 PRINT "HELLO FROM BFINDER"
340 PRINT "YOU HAVE BEEN NEGLECTING ME, YOU SHOULD ABUSE ME MORE OFTEN"
350 GOSUB Setgraph          !SET UP GPRINT
360 ON END #1 GOTO 560      !BRANCH FOR EOF ON TAPE
370 INPUT "CHANNEL WANTED?",Nchan          !INPUT CHANNEL NUMBER
380 INPUT "MAX NO. DATA POINTS?",Nmax     !NO. DATA POINTS
390 IF Nmax<2500 THEN 420
400 PRINT " ERROR ONLY 2500 ALLOWED TRY AGAIN"
410 GOTO 380
420 INPUT "FILE FOR DATA?",File$          !FILE
430 INPUT "FILE DEVICE? 1=T14,2=T15,3=F8",Dev
440 IF Dev=1 THEN File$=File$&":T14"
450 IF Dev=2 THEN File$=File$&":T15"
460 IF Dev=3 THEN File$=File$&":F8"
470 ASSIGN #1 TO File$                    !GET DEVICE READY FOR READ
480 BUFFER #1                             !BUFFER TAPE 1
490 N=J=0                                  !ZERO
500 INPUT "SAMPLE TIME (SEC)?",Sampt
510 PRINT "SAMPLE TIME",Sampt
520 INPUT "WASH TIME (SEC)?",Washt
530 PRINT "WASH TIME=",Washt
540 Width=15                              !CURSOR AUTO JUMP UNITS[8]SAMPLE NO.]
550 REM SET UP FOR PLOT OF COMPLETE DATA
560     FIXED 0
570     CALL Pltin(Xmin,Ymin,Xmax,Ymax,Xorig,Yorig,Ndiux,Ndiuy,Nticx,Ndigx,Nd
igy,Nticy,Xlab$,Ylab$,Dev,Title$)
580     IF Dev=0 THEN PLOTTER IS 13,"GRAPHICS"
590     IF Dev=1 THEN PLOTTER IS "9872A"
600     GCLEAR
610     GRAPHICS
620     Title$="INPUT DATA CHANNEL "&VAL$(Nchan)
630     CALL Pltax(Xmin,Ymin,Nmax,Ymax,Xorig,Yorig,Ndiux,Ndiuy,Nticx,Ndigx,Nd
igy,Nticy,Xlab$,Ylab$,Title$,Dev,Isym)
640 REM LOOP FOR READING DATA

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650 READ #1;Ts,D(*)          !READ DATA
660 N=N+1                    !COUNT DATA
670 H(N)=D(Nchan)           !HEIGHT
680 T(N)=Ts                  !TIME
690 IF N=1 THEN PLOT N,H(N),-2 !TRUE-MOVE WITH PEN UP FOR FIRST POINT
700 PLOT N,H(N),-1          !PLOT THE REST
710 IF N>Nmax THEN 730      !TRUE-REQUEST NUMBER VALUES ARE IN EXIT
720 GOTO 650                !GO READ ANOTHER VALUE
730 PENUP
740     REM : PLOTTING OF ORIGINAL DATA IS FINISHED
750     REM :NOW CALL CURSOR TO COLLAPSE DATA
760 GPRINT 0,0,"COMMAND- MOVE CURSOR TO FIRST VALUE- PUSH CONT"
770 POINTER 0,0             !PLACE POINTER FOR FIRST VALUE OF COLLAP
780 DIGITIZE Xd,Yd         !ON [CONT] GET X,Y LOCATIONS
790 Ib=INT(Xd)              !INTEGER VALUE OF NO. SAMPLE
800 GPRINT 0,0,"COMMAND- MOVE CURSOR TO LAST VALUE - PUSH CONT"
810 POINTER N,0            !PLACE POINTER FOR LAST VALUE OF COLLAP
820 DIGITIZE Xd,Yd         !ON [CONT] GET X,Y LOCATIONS
830 Ie=INT(Xd)             !INTEGER VALUE OF NO. SAMPLE
840 Xmax=Ncol=Ie-Ib+1      !NO. COLLAPSED VALUES
850 PLOTTER IS 13,"GRAPHICS"
860 GPRINT 0,0,"
870 GRAPHICS
880 FIXED 0
890 Title$="COLLAPSED CHANNEL= "&VAL$(Nchan)
900 CALL Pltax(Xmin,Ymin,Ncol,Ymax,Xorig,Yorig,Ndivx,Ndivy,Nticx,Ndigx,Ndigy,Nt
icy,Xlab$,Ylab$,Title$,Dev,Dsym)
910 N=0                     !SET COUNTER FOR NUMBER OF COLLAP
920     FOR I=Ib TO Ie      !COLLAPSE DATA INTO ORIGINAL VECTO
RS
930     N=N+1
940     H(N)=H(I)
950     T(N)=T(I)
960     IF N=1 THEN PLOT N,H(N),-2          !TRUE- MOVE ONLY FOR POINT 1
970     PLOT N,H(N),-1                    !PLOT POINT
980     NEXT I
990 PENUP
1000 FIXED 0
1010 PRINT "READY TO MARK THE DATA SEGMENTS, USE CONT ,EXIT IS KEY 0"
1020 GPRINT 0,20,"EXIT AFTER ENTERING REQUESTED SEGMENTS WITH KEY-0"
1030 GPRINT 0,0,"COMMAND- MOVE CURSOR TO BEGIN OF FIRST RISE +5, PUSH CONT"
1040 POINTER 10,0          !MOVE CURSOR
1050 Nseg=0                ! COUNTER
1060 DIGITIZE Xd,Yd       !ON [CONT] GET X Y LOC OF FIRST RISE
1070 IF Nseg=0 THEN Xbeg=Xd !SET LOCATION
1080 PLOT Xd,5,-2         !MARK THE SEGMENT
1090 PLOT Xd,5.2,-1      !MARK THE SEGMENT
1100 Nseg=Nseg+1         !INC SEGMENT COUNTER
1110 Nb(Nseg)=INT(Xd)    !STORE LOCATION
1120 POINTER Xd+Width,Yd !MOVE CURSOR TO END OF SEGMENT AUTO
1130 GPRINT 0,0,"COMMAND- MARK END OF SEGMENT "&VAL$(Nseg)&" PUSH CONT
"
1140 DIGITIZE Xd,Yd
1150 PLOT Xd,5,-2
1160 PLOT Xd,5.2,-1
1170 Nf(Nseg)=INT(Xd)
1180 ON KEY #0 GOTO 1220
1190 GPRINT 0,0,"COMMAND MARK DEG OF SEGMENT "&VAL$(Nseg+1)&" PUSH CONT
"
1200 POINTER Xbeg+Nseg*(Washt+Sampt),Yd
1210 GOTO 1060
1220     REM ALL OF THE POINTS ARE IN NOW GO BACK AND GET EYS
1230     GPRINT 0,20,"ENTER THE STEADY STATE VALUES WITH THE CURSOR
1240     FOR I=1 TO Nseg
1250     J=Nf(I)
1260     GPRINT 0,0,"COMMAND- ADJUST CURSOR TO TOP OF PEAK "&VAL$(I)&" PUSH CON

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T
1270     POINTER Nf(I),H(J),1           !MOVE TO EXPECTED TOP OF PEAK
1280     DIGITIZE Xd,Ein(I)             !ON [CONT] GET X,Y LOCATION
1290     NEXT I
1300     GPRINT 0,20,"
"
1310     GPRINT 0,0,"
"
1320     K$="N"
1330     INPUT " DO YOU WANT A HARD COPY OF THE GRAPH ? Y/N",K$
1340     IF K$="Y" THEN DUMP GRAPHICS
1350     Nprint=16
1360     PRINTER IS Nprint
1370     IF Nprint=16 THEN PRINT PAGE
1380     PRINT LIN(1),"SEGMENT TABLE",LIN(1)
1390     PRINT USING 1400
1400     IMAGE 6X,"PEAK",8X,"TB", 8X,"TF",9X,"E"
1410     FOR I=1 TO Nseg
1420     PRINT USING "3(10D),4D.5D";I,Nb(I),Nf(I),Ein(I)
1430     NEXT I
1440     IF Nprint=0 THEN 1580           !TRUE TABLE IS PRINTED EXIT
1450     K$="N"
1460     INPUT " DO YOU WANT TO CHANGE E'S?",K$
1470     IF K$(1,1)="Y" THEN 1550
1480     K$="N"
1490     INPUT "DO YOU WANT A HARDCOPY? Y/N",K$
1500     IF K$="N" THEN 1530           !TRUE - SKIP PRINT
1510     Nprint=0
1520     GOTO 1360
1530     Nprint=16
1540     GOTO 1580
1550     INPUT "PEAK NO.,E?",I,Xd
1560     Ein(I)=Xd
1570     GOTO 1390
1580     PRINTER IS 16
1590     REM BEGIN PLOT SET UP
1600     Tmax=Nmax=0
1610     FOR I=1 TO Nseg
1620     J=Nb(I)
1630     K=Nf(I)
1640     Nmax=MAX(K-J,Nmax)
1650     Tmax=MAX(Tmax,T(K)-T(J))
1660     NEXT I
1670     Bs=0
1680     PLOTTER IS 13,"GRAPHICS"
1690     GCLEAR
1700     GRAPHICS
1710     Title$="REGRESSION"
1720     CALL Pltax(0,-3,Tmax,3,0,-3,Tmax,6,0,0,1,5,"TIME (SEC)","LN(E-H)",Tit
le$,Dev,Dsym)
1730     FOR Iseg=1 TO Nseg             !LOOP FOR SEGMENTS
1740     N=0
1750     E=Ein(Iseg)                   !E FOR SEGMENT ISEG
1760     J=Nb(Iseg)                   !BEG. OF SEGMENT [N]
1770     Tb=T(J)
1780     FOR I=Nb(Iseg) TO Nf(Iseg)    !LOOP FOR PACKING DATA
1790     IF H(I)>=E THEN 1830         !TRUE-SKIP POINT H(I)>E
1800     N=N+1
1810     Hp(N)=LOG(E-H(I))
1820     Tp(N)=T(I)-Tb
1830     NEXT I
1840     CALL Pltsym(Tp(*),Hp(*),N)     !PLOT SYMBOLS FOR DATA POINTS
1850     A=B=0
1860     IF N>3 THEN CALL Linear(Tp(*),Hp(*),N,A,B,Regss,Resss,Totals,Regms,Reams,F
,Dfreg,Dfres,Dftot,Abort)
1870     Aseg(Iseg)=A                 !STORE INTERCEPT

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```

1880 Bseg(Iseg)=B                               !STORE SLOPE
1890 Npseg(Iseg)=N
1900 MOVE Tp(1),A+B*Tp(1)
1910 DRAW Tp(N),A+B*Tp(N)
1920 Bs=-1/B+Bs
1930 NEXT Iseg
1940 Bs=Bs/Nseg
1950 K#="N"
1960 INPUT " DO YOU WANT A COPY OF REGRESSION PLOT? Y/N",K#
1970 IF K#="Y" THEN DUMP GRAPHICS
1980 Nprint=16
1990 PRINTER IS Nprint
2000 IF Nprint=16 THEN PRINT PAGE
2010 PRINT LIN(1),"REGRESSION TABLE",LIN(1)
2020 PRINT USING 2030
2030 IMAGE 7X,"SEG",6X,"INTC",5X,"SLOPE",9X,"B",7X,"NO."
2040 FOR I=1 TO Nseg
2050 PRINT USING 2060;I,Aseg(I),Bseg(I),-1/Bseg(I),Npseg(I)
2060 IMAGE 10D,3(4D.5D),10D
2070 NEXT I
2080 PRINT USING 2090;Bs                               !AVERAGE B VALUE
2090 IMAGE 30X," $\frac{\quad}{\quad}$ ",/,30X,4D.5D
2100 IF Nprint=0 THEN 2160
2110 K#="N"
2120 INPUT "DO YOU WANT A HARDCOPY ? Y/N ",K#
2130 IF K#="N" THEN 2160                               !TRUE- DO NOT HARD COPY
2140 Nprint=0
2150 GOTO 1990
2160 PRINTER IS 16
2170 REM THE B VALUE HAS BEEN FOUND NOW PLOT REGEN DATA
2180 PRINT PAGE,"REGENERATE DATA"
2190 PRINT "NOTE- 1. THE B VALUE FROM THE REGRESSION IS MOST LIKELY TOO LARGE"
2200 PRINT "          A GOOD GUESS IS B-1."
2210 PRINT "          2. HIGH LEADING EDGE INDICATES OVER REGENERATION- DECREASE
B"
2220 PRINT "          3. ROUNDED LEADING EDGES IMPLIES UNDER REGENERATION-INCREASE
B"
2230 INPUT "B VALUE FOR REGENERATION?",B
2240 CALL Pltin(Xmin,Ymin,Xmax,Ymax,Xorig,Yorig,Ndivx,Ndivy,Nticx,Ndigx,Nd
igy,Nticy,Xlab#,Ylab#,Dev,Title#)
2250 IF Dev=0 THEN PLOTTER IS 13,"GRAPHICS"
2260 IF Dev=1 THEN PLOTTER IS "9872A"
2270 GOCLEAR
2280 GRAPHICS
2290 FIXED 0
2300 Title#="REGEN CHANNEL"&VAL$(Nchan)
2310 FIXED 2
2320 Title#=Title#&" B= "&VAL$(B)
2330 CALL Pltax(Xmin,Ymin,Ncol,Ymax,Xorig,Yorig,Ndivx,Ndivy,Nticx,Ndigx,Nd
igy,Nticy,Xlab#,Ylab#,Title#,Dev,Isym)
2340 UNCLIP !ALLOW LOW VALUES
2350 FOR I=2 TO Ncol-2
2360 A1=A2 !DELAY START FOR DATA
2370 A2=A3 !BOX CAR AVERAGES
2380 A3=.25*(H(I-1)+2*H(I)+H(I+1)) !BOX CAR AVERAGES
2390 IF I<5 THEN 2430 !NEW AVERAGE
2400 Reg=A2+B*(A3-A1)/(T(I-1)-T(I-3)) !TRUE- NOT ENOUGH DATA
2410 IF I=5 THEN MOVE I,Reg !REGENERATED VALUE
2420 DRAW I,Reg !PLOT THE VALUE
2430 NEXT I
2440 K#="N"
2450 INPUT "DO YOU WANT TO DUMP PLOT? Y/N ",K#
2460 IF K#="Y" THEN DUMP GRAPHICS
2470 K#="N"
2480 INPUT "DO YOU WANT TO TRY REGEN AGAIN? Y/N",K# !DO YOU WANT TO TRY AGAI
N

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2490 IF K#="Y" THEN 2180                                !GO BACK FOR ANOTHER PLOT
2500 PRINT PAGE,"BYE- FROM BFIND"
2510 EXIT GRAPHICS
2520 END
2530 Setgraph: ! SETS UP GPRINT
2540 RESTORE 2650
2550 FOR I=32 TO 96
2560   READ N
2570   FOR J=1 TO N
2580     READ M
2590     Ascii$(I)[J]=CHR$(M)
2600   NEXT J
2610 NEXT I
2620 GCHARSET Ascii$(*),5,7,6,0
2630 PLOTTER IS 13,"GRAPHICS"
2640 GRAPHICS
2650 DATA 6,0,0,0,0,0,0,1,0,1,0,1,0,1,0,1,0,1,0,1,0,1,0,1,0,1,0,1,0,6,0,1,9,242
2660 DATA 16,0,6,0,65,24,192,0,0,6,0,0,1,240,0,0,6,0,99,0,0,0,0,1,0,6,0,116
2670 DATA 103,92,197,192,6,0,113,8,66,48,128,6,0,252,24,32,197,192,6,0,116,66
2680 DATA 96,197,192,6,0,16,191,37,24,64,6,0,116,66,31,67,224,6,0,116,99,232
2690 DATA 69,192,6,0,66,16,65,7,224,6,0,116,98,232,197,192,6,0,116,66,248,197
2700 DATA 192,6,0,99,0,6,48,0,1,0,1,0,6,0,0,62,15,128,0,1,0,1,0,1,0,6,0,140
2710 DATA 99,248,197,192,6,0,244,99,232,199,192,6,0,116,97,8,69,192,6,0,242
2720 DATA 82,148,167,192,6,0,252,33,232,67,224,6,0,132,33,232,67,224,6,0,124
2730 DATA 103,8,69,192,6,0,140,99,248,198,32,6,0,113,8,66,17,192,6,0,100,132
2740 DATA 33,8,224,6,0,140,169,138,74,32,6,0,252,33,8,66,0,6,0,140,99,90,238
2750 DATA 32,6,0,140,103,92,198,32,6,0,116,99,24,197,192,6,0,132,33,232,199
2760 DATA 192,6,0,108,171,24,197,192,6,0,140,169,232,199,192,6,0,116,66,232
2770 DATA 69,192,6,0,33,8,66,19,224,6,0,116,99,24,198,32,6,0,33,20,168,198,32,6
2780 DATA 0,142,235,88,198,32,6,0,140,84,69,70,32,6,0,33,8,69,70,32,6,0,252
2790 DATA 16,65,7,224,1,0,1,0,1,0,1,0,1,0,1,0,1,0
2800 RETURN
2810 REM :*****
2820 REM :      SUBROUTINES
2830 SUB Pltlin(X(*),Y(*),N,Itype,Lp)
2840 LINE TYPE Itype
2850 PLOT X(1),Y(1),-2
2860 FOR I=2 TO N
2870 PLOT X(I),Y(I),-1
2880 NEXT I
2890 PEN 0
2900 LINE TYPE 1
2910 SUBEXIT
2920 SUBEND
2930 SUB Pltsym(X(*),Y(*),N)
2940 D=.5
2950 FOR I=1 TO N
2960 PLOT X(I),Y(I),-2
2970 SETGU
2980 WHERE Xc,Yc,Ps#
2990 PLOT Xc-D,Yc,-2
3000 PLOT Xc+D,Yc,-1
3010 PLOT Xc,Yc-D,-2
3020 PLOT Xc,Yc+D,-1
3030 SETUU
3040 PLOT X(I),Y(I),-2
3050 NEXT I
3060 PENUP
3070 SUBEXIT
3080 SUBEND
3090 SUB Linear(X(*),Y(*),N,A,B,Regss,Resss,Totals,Regms,Resms,F,Dfreg,Dfres,Df
tot,Abort)
3100 ! *** MODEL: Y=A+B*X ***
3110 ON ERROR GOTO Bomb
3120 Abort=0
3130 Y1=X1=Z=X2=Y2=0

```

```

3140 FOR I=1 TO N
3150     X1=X1+X(I)           ! Sum of X's
3160     Y1=Y1+Y(I)         ! Sum of Y's
3170     X2=X2+X(I)*X(I)   ! Sum of X squares
3180     Y2=Y2+Y(I)*Y(I)   ! Sum of Y squares
3190     Z=Z+X(I)*Y(I)     ! Sum of XY's
3200 NEXT I
3210 X1=X1/N               ! Mean X
3220 Y1=Y1/N               ! Mean Y
3230 B=(Z-N*X1*Y1)/(X2-N*X1*X1)
3240 A=Y1-B*X1
3250 Totalss=Y2-N*Y1*Y1   ! Total Sum of Squares
3260 Regss=(Z-N*X1*Y1)^2/(X2-N*X1*X1)! Regression Sum of Squares
3270 Resss=Totalss-Regss  ! Residual Sum of Squares
3280 Regms=Regss          ! Regression Mean Squares
3290 Resms=Resss/(N-2)   ! Residual Mean Squares
3300 OFF ERROR
3310 DEFAULT ON
3320 F=Regms/Resms        ! F Ratio
3330 DEFAULT OFF
3340 Dfreg=1              ! Degrees of Freedom
3350 Dfres=N-2
3360 Dftot=Dfreg+Dfres
3370 SUBEXIT
3380 Bomb: Abort=1
3390 SUBEND
3400 EXIT GRAPHICS
3410 SUB Pltax(Xmin,Ymin,Xmax,Ymax,Xorig,Yorig,Ndivx,Ndivy,Nticx,Ndigx,Ndigy,Nticy,Xlab$,Ylab$,Title$,Dev,Dsym)
3420 H=4 !HEIGHT OF CHARACTERS MM
3430 Dsym=1 !HEIGHT OF SYMBOLS IN MM
3440 Th=3 !TIC HEIGHT IN MM
3450 Tx=90 !LOCATION OF TITLE CENTER IN MM FROM (0,0) PHYSICAL
3460 Ty=140 !LOCATION OF TITLE BOTTOM IN MM FROM (0,0) PHYSICAL
3470 X1=30 !DISTANCE FROM LEFT MARGIN IN MM TO Y AXIS MM
3480 X2=120 !LENGTH OF X AXIS IN MM
3490 Y1=20 !DISTANCE IN MM FROM BOTTOM TO X AXIS
3500 Y2=90 !LENGTH OF Y AXIS IN MM
3510 REM *****
3520 DEG
3530 FIXED 5
3540 Xm=184 !SIZE IN MM
3550 Ym=149 !SIZE IN MM
3560 IF Dev=1 THEN Ym=285 !SIZE IN MM OF 9872A
3570 IF Dev=1 THEN Xm=400 !SIZE IN MM OF 9872A
3580 LIMIT 0,Xm,0,Ym
3590 One=NIN(Xm,Ym)/100 !CONVERSION FOR MM TO GU
3600 X1=X1/One !CONVERT TO GU
3610 X2=Xm=X1+X2/One !CONVERT TO GU
3620 Y1=Y1/One !CONVERT TO GU
3630 Y2=Y1+Y2/One !CONVERT TO GU
3640 Xo=X1+(X2-X1)*(Xorig-Xmin)/(Xmax-Xmin)
3650 Yo=Y1+(Y2-Y1)*(Yorig-Ymin)/(Ymax-Ymin)
3660 Tx=Tx/One !TITLE LOCATION IN GU
3670 Ty=Ty/One !TITLE LOCATION IN GU
3680 Th=Th/One !TIC IN GU
3690 Thm=Th/2 !MINOR TIC IN GU
3700 H=H/One !CHARACTER HEIGHT IN GU
3710 W=3*H/5 !CHARACTER WIDTH GU
3720 Dsym=Dsym/One
3730 CSIZE H,3/5 !SET CHARACTER
3740 LOCATE X1,X2,Y1,Y2
3750 PLOT X1,Yo,-2 !MAKE THE AXIS LINES
3760 PLOT X2,Yo,-1
3770 PLOT Xo,Y1,-2
3780 PLOT Xo,Y2,-1

```



```

3790 LORG 4
3800 FIXED Ndigx
3810 D=(X2-X1)/Ndiux
3820 Dx=(Xmax-Xmin)/Ndiux
3830 FOR J=0 TO Ndiux
3840 X=X1+J*D
3850 V#=VAL$(Xmin+J*Dx)
3860 IF X=Xo THEN 3890
3870 PLOT X,Yo,-2
3880 PLOT X,Yo+Th,-1
3890 PLOT X,Yo-1.2*H,-2
3900 LABEL USING "K";V#
3910 IF Nticx=0 THEN 3960
3920 FOR I=1 TO Nticx
3930 PLOT X+D*I/(Nticx+1),Yo,-2
3940 PLOT X+D*I/(Nticx+1),Yo+Thm,-1
3950 NEXT I
3960 NEXT J
3970 PLOT (X1+X2)/2,Yo-2.4*H,-2
3980 LABEL USING "K";Xlab#
3990 LORG 7          !BEGIN LABEL OF Y AXIS
4000 FIXED Ndigy
4010 D=(Y2-Y1)/Ndivy
4020 Dy=(Ymax-Ymin)/Ndivy
4030 FOR J=0 TO Ndivy
4040 V#=VAL$(Ymin+J*Dy)
4050 Xwm=MIN(Xo-(1+LEN(V#))*W,Xwm)
4060 Y=Y1+J*D
4070 IF Y=Yo THEN 4100
4080 PLOT Xo,Y,-2
4090 PLOT Xo+Th,Y,-1
4100 PLOT Xo-W,Y-.3*H,-2
4110 LABEL USING "K";V#
4120 IF Nticy=0 THEN 4170
4130 FOR I=1 TO Nticy
4140 PLOT Xo,Y+D*I/(Nticy+1),-2
4150 PLOT Xo+Thm,Y+D*I/(Nticy+1),-1
4160 NEXT I
4170 NEXT J
4180 LDIR 90
4190 LORG 4
4200 PLOT Xwm-H,(Y1+Y2)/2,-2
4210 LABEL USING "K";Ylab#
4220 LDIR 0
4230 PLOT Tx,Ty,-2
4240 LORG 4
4250 LABEL USING "K";Title#
4260 PLOT 0,0,-2
4270 SCALE Xmin,Xmax,Ymin,Ymax !SET TO USER UNITS
4280 PENUP
4290 FIXED 5
4300 SUBEXIT
4310 SUBEND
4320 SUB Ptitn(Xmin,Ymin,Xmax,Ymax,Xorig,Yorig,Ndiux,Ndivy,Nticx,Ndigx,Ndigy,Nticy,Xlab#,Ylab#,Dev,Title#)
4330 Ndiux=10
4340 Dev=0
4350 Ndivy=5
4360 Nticx=2
4370 Nticy=2
4380 Ndigx=0
4390 Ymax=10
4400 Ndigy=1
4410 Xmax=50
4420 Ymin=0
4430 Xmin=0

```

```
4440 Xlab$="SAMPLE NO."  
4450 Ylab$="PEAK (ABS)"  
4460 Title$="INPUT DATA"  
4470 Xorig=0  
4480 Yorig=Ymin  
4490 REM : ***** END OF USER PARAMTERS *****  
4500 SUBEXIT  
4510 SUBEND
```

```

10  REM : CLOCK
11  REM : VERISON 11FEB 1980
12  REM : PURPOSE= CHANGE THE CLOCK TIME
13  REM :*****
90  DIM A#[14]
100 PRINT PAGE,SPA(10)," HELLO FROM PROGRAM CLOCK ",LIN(2),SPA(10)," I AM
    LOOKING FOR THE TIME BACK IN 20 SEC  "
101 OUTPUT 9;"B"
110 OUTPUT 9;"R"
120 ENTER 9;A#
130 BEEP
140 PRINT LIN(2),SPA(10)," AT THE TIME OF THE TONE IT WAS ",A#
141 CALL Error
150 INPUT "DO YOU WANT TO CHANGE IT ?Y/N",B#
160 IF (B#="Y") OR (B#="y") THEN 180
170 GOTO 330
180 A#=" "
190 INPUT "MONTH (MM)?",A#[1,2]
200 INPUT "DAY (DD)?",A#[4,5]
210 INPUT "HOUR (HH)?",A#[7,8]
220 INPUT "MINUTE(MM)?",A#[10,11]
230 INPUT "SECOND (SS)?",A#[13,14]
240 PRINT ,LIN(2),SPA(10),"THE TIME YOU SET IS=",A#
250 INPUT "DO YOU WANT TO SET IT? Y/N",B#
260 IF (B#="Y") OR (B#="y") THEN 280
270 GOTO 330
280 DISP " WORKING AT SETTING CLOCK "
290 OUTPUT 9;"S",A#
300 OUTPUT 9;"R"
310 ENTER 9;A#
320 PRINT SPA(10);"THE TIME HAS BEEN SET IT IS=",A#
330 PRINT SPA(10)," CLOCK IS FINISHED  "
340 END
350 SUB Error
360 REM THIS ROUTINE GIVES THE ERROR CODES FOR THE CLOCK
370 OUTPUT 9;"E"
380 ENTER 9 USING 390;E
390 IMAGE #,B
400 PRINT "ERROR SUMMARY"
410 IF BIT(E,7) THEN PRINT "BAD R/W MEMORY"
420 IF BIT(E,6) THEN PRINT "BAD R/W MEMORY"
430 IF BIT(E,5) THEN PRINT "BAD CLOCK CHIP"
440 IF BIT(E,4) THEN PRINT "LOST REAL TIME"
450 IF BIT(E,3) THEN PRINT "INVALID COMMAND"
460 IF BIT(E,2) THEN PRINT "UNIT MISMATCH"
470 IF BIT(E,1) THEN PRINT "DATA RANGE ERROR"
480 IF BIT(E,0) THEN PRINT "INTERRUPT MISSED"
481 IF BIT(E,"0000000") THEN PRINT "NO CLOCK ERRORS"
490 SUBEXIT
500 SUBEND

```

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10  REM "THIS IS PROGRAM"AvsM" FOR COMPARING PEAKS READ MANUALLY WITH THOSE
    FOUND BY PROGRAM "APILOT"
20  PRINT "HELLO FROM AUTOMATIC & MANUAL PEAK COMPARATOR "
30  REM THIS IS VERSION 27 SEPT 1978, BY CDW(cjp)
40  FIXED 2
50  OPTION BASE 1
60  SHORT Ds(3),P1(40,6),P2(40,6),P(40,6)
70  INTEGER I,J,K,L,M,N,L1s,R,Rs,Nsamp,C(6),Nc,N1,N2,N3,Ncmax
80  DIM T(0:40,1:6),A1(6),As(6)
90  DIM Ti(0:100),A(0:100,1:6)
100 DIM S1(6),Ss(6),Hm(6),Tm(6),Dlim(6),Vmax(6)
110 DIM D(6),Mess#[50],Lat#[12],Lon#[12]
120 SHORT Rf(6),F(6),B1(6),B2(6)
130 INTEGER Icode(40),Istat(6)
140 DIM A$(6)[4],Id$(40)[1],L#[6],Da#[7],Hr#[4],Op#[6],Kw#[1],Roll#[1],H$(4)[5]
    ,Clock#[14],Chmax(6),X(50),Y(50),L1#[6],L2#[6]
150 DATA 10,50,50,10,10,50,6
160 READ Chmax(*),Ncmax
170 Is=1
180 GOSUB Read
190 L1#=L$
200 Is=2
210 GOSUB Read
220 L2#=L$
230 INPUT "CHANNEL WANTED IN PLOT?",Icw
240 EXIT GRAPHICS
250 Xlab#[1]="1 "
260 Ylab#[1]="2 "
270 Xlab#[3]=A$(Icw)
280 Ylab#[3]=A$(Icw)
290 PRINT "THIS IS A TABLE OF MANUAL AND COMPUTER READ ABSORBRANCE FOR",A$(Icw)
300 PRINT "1=";L1#
310 PRINT "2=";L2#
320 PRINT USING 330;Xlab#,Ylab#
330 IMAGE 3X,"PEAK NO.",4X,6A,4X,6A,6X,"1-2"
340 FOR I=1 TO Nsamp
350 X(I)=I
360 Y(I)=P1(I,Icw)-P2(I,Icw)
370 PRINT USING "10D,3(7D.2D)";I,P1(I,Icw),P2(I,Icw),Y(I)
380 NEXT I
390 PRINTER IS 16
400 INPUT "DO YOU WANT A HARD COPY OF THE TABLE? Y/N",Kw#
410 IF Kw#="N" THEN 450
420 IF Kw#="Y" THEN PRINTER IS 0
430 GOTO 290
440 PRINTER IS 16
450 GOSUB Plot
460 WAIT 5000
470 PRINT PAGE
480 INPUT "DO YOU WANT A HARD COPY OF THE GRAPH? Y/N",Kw#
490 IF Kw#="N" THEN 520
500 IF Kw#="Y" THEN 510
510 DUMP GRAPHICS
520 GOTO 230
530 List: PRINT PAGE,"HELLO FROM LIST " !SUBPROGRAM LIST
540 Nprint=16
550 L=1
560 PRINTER IS Nprint
570 PRINT "THIS IS A LIST FOR DATA SET=",Is
580 PRINT USING 600;L#,Da#,Hr#,Lat#,Lon#,Depth,Mess#
590 PRINT USING 610;Nsamp,Op#,A$(*),C(*),F(*)
600 IMAGE "LABEL=",10A,/, "DATE=",10A,/, "HR=",10A,/, "LAT=",12A,/, "LON=",12A,/, "D
    EPTH=",10A,/, "COMMENT=",50A
610 IMAGE "NO. SAMPLES=",3D,/, "OPERATOR=",10A,/, "CHANNEL=",6(6X,4A),/, "STATUS=",
    1X,6(10D),/, "FACTORS=",6(6D.3D)
620 PRINT USING 630;Rf(*),B1(*),B2(*)

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630 IMAGE "RF'S=",3X,6(6D.3D),/, "BASE1=",2X,6(6D.3D),/, "BASE2=",2X,6(6D.3D)
640 PRINT USING 650;H$(L),H$(L),H$(L),H$(L),H$(L),H$(L)
650 IMAGE /,"NO. ID",6(5X,5A)
660 FOR I=1 TO MAX(Mp,Nsamp)
670 FOR J=1 TO Ncmax
680 D(J)=P(I,J)
690 NEXT J
700 PRINT USING "2D,1X,1A,4D,6(7D.2D)";I,Id$(I),Icode(I),D(*)
710 NEXT I
720 IF Nprint=0 THEN 780
730 INPUT "DO YOU WANT HARD COPY, Y/N?",Kw$
740 IF Kw$="N" THEN 780
750 Nprint=0
760 GOTO 560
770 NEXT I
780 Nprint=16
790 PRINTER IS Nprint
900 PRINT " LIST FINISHED "
810 RETURN
820 Read: REM THIS SECTION READS THE FILE L$
830 INPUT "FILE WANTED? [6]",L$
840 File$=L$
850 GOSUB Drive
860 ASSIGN #2 TO File$
870 BUFFER #2
880 Lat$=Lon$=Mess$="N.A."
890 Depth=-99
900 READ #2;L$,Da$,Hr$,Op$,A$(*)
910 Ktyp=TYP(2)
920 IF (Ktyp=2) OR (Ktyp>7) THEN READ #2;Mess$,Lat$,Lon$,Depth
930 READ #2;Nsamp,Nc
940 READ #2;C(*),F(*),Rf(*),B1(*),B2(*)
950 FOR I=1 TO Nsamp
960 READ #2;I,Id$(I),Icode(I),P(I,1),P(I,2),P(I,3),P(I,4),P(I,5),P(I,6)
970 NEXT I
980 REM MAKE A TABLE
990 GOSUB List
1000 FOR I=1 TO Nsamp
1010 FOR J=1 TO Nc
1020 IF Is=1 THEN P1(I,J)=P(I,J)
1030 IF Is=2 THEN P2(I,J)=P(I,J)
1040 NEXT J
1050 NEXT I
1060 PRINT " FINISHED READING FILE ."
1070 RETURN
1080 Plot:REM THIS IS A PLOTTING SECTION TO BE LINKED TO PROGRAMS
1090 REM : CDWPLT CREATED 16JULY78
1100 REM : USER MUST DELETE THE TEST SECTION AFTER SUPPLYING DIM FOR X AND Y
1110 REM : ***** BEGIN OF TEST SECTION *****
1120 REM : ***** START OF USER PARAMETERS *****
1130 Ndivx=8
1140 Ch=3
1150 Ndivy=10
1160 Nticx=5
1170 Nticy=2
1180 Ndigx=0
1190 Ndigy=2
1200 Xmax=40
1210 Ymax=.05
1220 Ymin=-.05
1230 Xmin=0
1240 Xlab#[1,9]=" "
1250 Ylab#[1,5]=L1$
1260 Xlab#[10,13]=A$(Icw)
1270 Ylab#[6]="-"
1280 Ylab#[7,12]=L2$

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```

1290 Xorig=0
1300 Yorig=0
1310 Npoints=Nsamp
1320 REM : ***** END OF USER PARAMTERS *****
1330 DEG
1340 PLOTTER IS 13,"GRAPHICS"
1350 GRAPHICS
1360 FIXED 5
1370 REM : ***** PLOTS WANTED *****
1380 REM : 1) A CALL TO PLTAX DRAWS THE AXES
1390 REM : 2) A CALL TO PLTSYM PLOTS X AND Y AS SYMBOL
1400 REM : 3) A CALL TO PLTLIN PLOTS X AND Y AS LINE
1410 REM : USER CAN USE THESE CALLS ANYWAY HE WANTS
1420 REM : *****
1430 CALL Pltax(Xmin,Ymin,Xmax,Ymax,Xorig,Yorig,Ndiux,Ndiuy,Nticx,Ndigx,Ndigy,Nticy,Xlab$,Ylab$,Ch)
1440 CALL Pltsym(X(*),Y(*),Npoints)
1450 RETURN
1460 Drive:REM THIS MAKES LABEL SPECIFY A TAPE DRIVE
1470 REM THIS ROUTINE ADDS :T15, :T14 OR :F8 TO FILE NAME FILE#
1480 INPUT "TAPE DRIVE WANTED? 14 OR 15 OR F8",T#
1490 Nchar=LEN(FILE#)
1500 IF T#="14" THEN FILE#[Nchar+1]=":T14"
1510 IF T#="15" THEN FILE#[Nchar+1]=":T15"
1520 IF T#="F8" THEN FILE#[Nchar+1]=":F8"
1530 RETURN
1540 END
1550 REM :*****
1560 REM :*****
1570 REM :*****
1580 REM : SUBROUTINES
1590 SUB Pltax(Xmin,Ymin,Xmax,Ymax,Xorig,Yorig,Ndiux,Ndiuy,Nticx,Ndigx,Ndigy,Nticy,Xlab$,Ylab$,Ch)
1600 DEG
1610 FIXED 5
1620 Ch=3
1630 Cw=3*Ch/5
1640 Csize Ch,3/5
1650 L1x=25
1660 L2x=Xwm=110
1670 L1y=15
1680 L2y=90
1690 I=J=1
1700 I=MAX(I,Nticx)
1710 J=MAX(J,Nticy)
1720 LOCATE L1x,L2x,L1y,L2y
1730 AXES (L2x-L1x)/(Ndiux*I),(L2y-L1y)/(Ndiuy*J),L1x+(L2x-L1x)*(Xorig-Xmin)/(Xmax-Xmin),L1y+(L2y-L1y)*(Yorig-Ymin)/(Ymax-Ymin),Nticx,Nticy,4
1740 UNCLIP
1750 LOG 4
1760 FOR J=0 TO Ndiux
1770 P#=VAL$(Xmin+(Xmax-Xmin)*J/Ndiux)
1780 I=POS(P#,".")-1
1790 IF Ndigx=0 THEN 1810
1800 I=I+1+Ndigx
1810 V#=P#[1,I]
1820 MOVE L1x+J*(L2x-L1x)/Ndiux,L1y-1.2*Ch
1830 LABEL USING "K";V#
1840 NEXT J
1850 MOVE (L1x+L2x)/2,L1y-2.4*Ch
1860 LABEL USING "K";Xlab$
1870 LOG 7
1880 FOR J=0 TO Ndiuy
1890 P#=VAL$(Ymin+J*(Ymax-Ymin)/Ndiuy)
1900 I=POS(P#,".")-1
1910 IF Ndigy=0 THEN 1930

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```

1920 I=I+1+Ndigy
1930 Xwm=MIN(L1x-(1+I)*Cw,Xwm)
1940 V$=P$(1,I)
1950 MOVE L1x-Cw,L1y+J*(L2y-L1y)/Ndiyy-.3*Ch
1960 LABEL USING "K";V$
1970 NEXT J
1980 LDIR 90
1990 LORG 4
2000 MOVE Xwm-Ch,(L1y+L2y)/2
2010 LABEL USING "K";Ylab$
2020 LDIR 0
2030 SCALE Xmin,Xmax,Ymin,Ymax
2040 SUBEXIT
2050 SUBEND
2060 SUB Pltlin(X(*),Y(*),N,Itype,Lp)
2070 LINE TYPE Itype
2080 PLOT X(1),Y(1),-2
2090 FOR I=2 TO N
2100 PLOT X(I),Y(I),-1
2110 NEXT I
2120 PEN Up
2130 SUBEXIT
2140 SUBEND
2150 SUB Pltsym(X(*),Y(*),N)
2160 D=.5
2170 FOR I=1 TO N
2180 PLOT X(I),Y(I),-2
2190 SETGU
2200 WHERE Xc,Yc,P$#
2210 PLOT Xc-D,Yc,-2
2220 PLOT Xc+D,Yc,-1
2230 PLOT Xc,Yc-D,-2
2240 PLOT Xc,Yc+D,-1
2250 SETUU
2260 NEXT I
2270 PENUP
2280 SUBEXIT
2290 SUBEND
2300 END

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```

10  REM : PLOT
20  REM : VERSION   C.D. WIRICK 05 MAY 1978 IN THE BERING
30  REM : MODIFIED   11FEB1980
40  REM *****
50  REM                MACHINE STATUS
60  OPTION BASE 1
70  EXIT GRAPHICS
80  FIXED 3
90  SHORT Rf(6),F(6),B1(6),B2(6),P(40,6)
100 DIM A$(6)[4],Id$(40)[1],L#[6],Da#[7],Hr#[4],Op#[6],D(6),Cs(12,6),Ls(6)[4],
D#[4],Xmax(6),Idt$(40),X1#[20],Mess#[50],Lat#[12],Lon#[12],Title#[50]
110 INTEGER Nsamp,C(6),Icode(40),Nc,Ic(12),Is(12,6),Ict(40)
120 DIM X(50),Y(50)
130 REM : *****8
140 Ncmax=6
150 PRINTER IS 16
160 PRINT PAGE,SPA(15)," HELLO FROM PLOT USING STANDARD FILE "
170 PRINT "VARIABLE NAMES ARE PO4,SIO4,N+N,NO2,NH4,URE"
180 I1=3
190 REM LOOP FOR GETTING DATA FILES
200 INPUT "FILE WANTED",L$
210 GOSUB Read
220 GOSUB List
230 GOSUB Mplot
240 INPUT "DO YOU WANT A NEW STATION? Y/N",Kw$
250 IF Kw$="Y" THEN 200
260 GOTO 230
270 Read:REM THIS SECTION READS THE FILE L$          !SUBPROG READ
280 File$=L$
290 GOSUB Drive
300 ASSIGN #2 TO File$
310 BUFFER #2
320 Lat$=Lon$=Mess$="N.A."
330 Depth=-99
340 READ #2;L$,Da$,Hr$,Op$,A$(*)
350 Ktyp=TYP(2)
360 IF (Ktyp=2) OR (Ktyp>7) THEN READ #2;Mess$,Lat$,Lon$,Depth
370 READ #2;Nsamp,Nc
380 READ #2;C(*),F(*),Rf(*),B1(*),B2(*)
390 FOR I=1 TO Nsamp
400 READ #2;I,Id$(I),Icode(I),P(I,1),P(I,2),P(I,3),P(I,4),P(I,5),P(I,6)
410 NEXT I
420 PRINT "FINISHED READING FILE "
430 RETURN
440 Mplot: PRINTER IS 16
450 INPUT "DO YOU WANT A PLOT?,Y/N",Kw$
460 IF Kw$="N" THEN 850
470 INPUT "VARIABLE NAME? [6A]",D$
480 REM CHECK INPUT LABELS FOR VARIABLE
490 FOR I=1 TO 6
500 IF POS(A$(I),D$)<>0 THEN 540
510 NEXT I
520 PRINT D$;" IS A BAD CHOICE TRY AGAIN"
530 GOTO 470
540 INPUT " XMIN,XMAX?",Xmin,Xmax
550 INPUT "DEPTH MIN,DEPTH MAX",Ymax,Ymin
560 X1#[1,4]=D#[1,4]
570 X1#[5,14]=" <UG-AT/L>"
580 PLOTTER IS "GRAPHICS"
590 Nv=I
600 GRAPHICS
610 N=0
620 Dev=0          !CRT
630 Title$=L$
640 CALL Pltaxz(Xmin,Ymin,Xmax,Ymax,Xmin,Ymax,5,5,1,2,0,0,X1$,"DEPTH (M)",Title
$,Dev,Dsym)

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650 REM : CALL Pltaxz(Xmin,Ymin,Xmax,Ymax,Xorig,Yorig,Ndix,Ndiy,Nticx,Ndigx,N
digy,Nticy,Xlab$,Ylab$,Title$,Dev,Dsym)
660 REM SEARCH FOR HYDRO AND DEPTH
670 N=0
680 FOR I=1 TO Nsamp
690 IF Id$(I)<>"H" THEN 760
700 N=N+1
710 J=Nv
720 X(N)=0
730 IF (P(I,J)=0) OR (P(I,J)=9.99) THEN 750
740 X(N)=F(J)*(P(I,J)-(B1(J)+(B2(J)-B1(J))*I/(Nsamp+1)+Rf(J)))
750 Y(N)=Icode(I)
760 NEXT I
770 CALL Pltsym(X(*),Y(*),N,1,Dsym)
780 WAIT 2000
790 INPUT "DO YOU WANT A HARD COPY OF THE PLOT? Y/N",D$
800 IF D$="Y" THEN 820
810 GOTO 830
820 DUMP GRAPHICS
830 GCLEAR
840 PLOTTER IS OFF
850 RETURN
860 List: PRINT PAGE," HELLO FROM LIST " !SUBPROGRAM LIST
870 Nprint=16
880 H$(1)=" ABS"
890 H$(2)="UG-AT"
900 L=1
910 IF (I1=1) OR (I1=2) THEN 940
920 INPUT "OUTPUT TYPE: 1=ABS,2=UG-AT/L",L
930 IF (L<1) OR (L>2) THEN 920
940 PRINTER IS Nprint
950 PRINT USING 970;L$,Da$,Hr$,Lat$,Lon$,Depth,Mess$
960 PRINT USING 980;Nsamp,Op$,A$(*),C$(*),F$(*
970 IMAGE "LABEL=",10A,/, "DATE=",10A,/, "HR=",10A,/, "LAT=",12A,/, "LON=",12A,/, "D
EPTH=",10A,/, "COMMENT=",50A
980 IMAGE "NO. SAMPLES=",3D,/, "OPERATOR=",10A,/, "CHANNEL=",6(6X,4A),/, "STATUS=",
1X,6(10D),/, "FACTORS=",6(6D.3D)
990 PRINT USING 1000;Rf(*),B1(*),B2(*)
1000 IMAGE "RF/S=",3X,6(6D.3D),/, "BASE1=",2X,6(6D.3D),/, "BASE2=",2X,6(6D.3D)
1010 IF I1=1 THEN 1300
1020 PRINT USING 1030;H$(L),H$(L),H$(L),H$(L),H$(L),H$(L)
1030 IMAGE /,"NO. ID",G(5X,50)
1040 FOR I=1 TO MAX(Mp,Nsamp)
1050 FOR J=1 TO Ncmax
1060 ON L GOTO 1070,1090
1070 D(J)=P(I,J)
1080 GOTO 1140
1090 D(J)=F(J)*(P(I,J)-(B1(J)+(B2(J)-B1(J))*I/(Nsamp+1)+Rf(J)))
1100 IF P(I,J)>.0001 THEN 1140
1110 D(J)=0
1120 IF P(I,J)>-1 THEN 1140
1130 D(J)=-99
1140 NEXT J
1150 IF I1=2 THEN 1180
1160 PRINT USING "2D,1X,1A,4D, 6(7D.2D )";I,Id$(I),Icode(I),D(*)
1170 GOTO 1190
1180 PRINT USING "2D,1X,1A,4D";I,Id$(I),Icode(I)
1190 NEXT I
1200 IF Nprint=0 THEN 1280
1210 Kw$="N"
1220 INPUT "DO YOU WANT HARD COPY, Y/N?",Kw$
1230 IF Kw$="Y" THEN 1250
1240 GOTO 1280
1250 Nprint=0
1260 GOTO 940
1270 NEXT I

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1280 Nprint=16
1290 PRINTER IS Nprint
1300 PRINT " LIST FINISHED "
1310 RETURN
1320 Drive:REM THIS MAKES LABEL SPECIFY A TAPE DRIVE
1330 REM THIS ROUTINE ADDS :T15, :T14 OR :F8 TO FILE NAME FILE#
1340 INPUT "TAPE DRIVE WANTED? 14 OR 15 OR F8",T#
1350 Nchar=LEN(File#)
1360 IF T#="14" THEN File#[Nchar+1]=":T14"
1370 IF T#="15" THEN File#[Nchar+1]=":T15"
1380 IF T#="F8" THEN File#[Nchar+1]=":F8"
1390 RETURN
1400 END
1410 SUB Pltaxz(Xmin,Ymin,Xmax,Ymax,Xorig,Yorig,Ndivx,Ndivy,Nticx,Ndigx,Ndigy,Nticy,Xlab$,Ylab$,Title$,Dev,Dsym)
1420 REM *****
1430 REM : VERSION 07 DEC 79
1440 REM : REQUIRES STATEMENT= PLOTTER IS 13,"GRAPHICS" OR PLOTTER IS "9872A"
1450 REM : PURPOSE = TO MAKE A X Y AXIS
1460 REM : ROUTINE EXITS IN USER UNITS
1470 REM : ARGUMENTS
1480 REM : XMIN = MIN X VALUE TO BE PLOTTED USER UNITS
1490 REM : XMAX = MAX X VALUE TO BE PLOTTED USER UNITS
1500 REM : XORIG = ORIGIN FOR X AXIS IN USER UNITS
1510 REM : NDIVX = NO. DIVISIONS ALONG X AXIS
1520 REM : NTICX = NO. TICS OR DIVISIONS PER MAJOR DIVISION
1530 REM : NDIGX = NO. DIGITS TO RIGHT OF DECIMAL IN X VALUES
1540 REM : XLAB$ = LABEL FOR X AXIS
1550 REM : TITLE$ = TITLE
1560 REM : DEV = DEVICE 0=CRT,1=PLOTTER
1570 REM : DSYM = HEIGHT OF SYMBOLS IN GU FOR FUTURE PLOTS
1580 REM :
1590 REM : SIMILAR VALUES FOR Y AXIS
1600 REM : CALL Pltaxz(Xmin,Ymin,Xmax,Ymax,Xorig,Yorig,Ndivx,Ndivy,Nticx,Ndigx,Ndigy,Nticy,Xlab$,Ylab$,Title$,Dev,Dsym)
1610 REM *****
1620 REM : PARAMETERS TO CHANGE PLOT SIZE
1630 H=5 !HEIGHT OF CHARACTERS MM
1640 Dsym=1 !HEIGHT OF SYMBOLS IN MM
1650 Th=3 !TIC HEIGHT IN MM
1660 Tx=100 !LOCATION OF TITLE CENTER IN MM FROM (0,0) PHYSICAL
1670 Ty=15 !LOCATION OF TITLE BOTTOM IN MM FROM (0,0) PHYSICAL
1680 X1=30 !DISTANCE FROM LEFT MARGIN IN MM TO Y AXIS MM
1690 X2=120 !LENGTH OF X AXIS IN MM
1700 Y1=20 !DISTANCE IN MM FROM BOTTOM TO Y AXIS
1710 Y2=90 !LENGTH OF Y AXIS IN MM
1720 REM *****
1730 DEG
1740 FIXED 5
1750 Xm=184 !SIZE IN MM
1760 Ym=149 !SIZE IN MM
1770 IF Dev=1 THEN Ym=285 !SIZE IN MM OF 9872A
1780 IF Dev=1 THEN Xm=400 !SIZE IN MM OF 9872A
1790 LIMIT 0,Xm,0,Ym
1800 ! FRAME
1810 One=MIN(Xm,Ym)/100 !CONVERSION FOR MM TO GU
1820 X1=X1/One !CONVERT TO GU
1830 X2=Xum=X1+X2/One !CONVERT TO GU
1840 Y1=Y1/One !CONVERT TO GU
1850 Y2=Y1+Y2/One !CONVERT TO GU
1860 Xo=X1+(X2-X1)*(Xorig-Xmin)/(Xmax-Xmin)
1870 Yo=Y1+(Y2-Y1)*(Yorig-Ymin)/(Ymax-Ymin)
1880 Tx=Tx/One !TITLE LOCATION IN GU
1890 Ty=Ty/One !TITLE LOCATION IN GU
1900 Th=Th/One !TIC IN GU
1910 Thm=Th/2 !MINOR TIC IN GU

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1920 H=H/One      !CHARACTER HEIGHT IN GU
1930 W=3*H/5     !CHARACTER WIDTH GU
1940 Dsym=Dsym/One
1950 CSIZE H,3/5 !SET CHARACTER
1960 LOCATE X1,X2,Y1,Y2
1970 PLOT X1,Yo,-2 !MAKE THE AXIS LINES
1980 PLOT X2,Yo,-1
1990 PLOT Xo,Y1,-2
2000 PLOT Xo,Y2,-1
2010 LORG 6
2020 FIXED Ndigx
2030 D=(X2-X1)/Ndigx
2040 Dx=(Xmax-Xmin)/Ndigx
2050 FOR J=0 TO Ndigx
2060 X=X1+J*D
2070 V#=VAL$(Xmin+J*Dx)
2080 IF X=Xo THEN 2110
2090 PLOT X,Yo,-2
2100 PLOT X,Yo-Th,-1
2110 PLOT X,Yo+1.2*H,-2
2120 LABEL USING "K";V#
2130 IF Nticx=0 THEN 2100
2140 FOR I=1 TO Nticx
2150 PLOT X+D*I/(Nticx+1),Yo,-2
2160 PLOT X+D*I/(Nticx+1),Yo-Thm,-1
2170 NEXT I
2180 NEXT J
2190 PLOT (X1+X2)/2,Yo+2.4*H,-2
2200 LABEL USING "K";Xlab#
2210 LORG 7      !BEGIN LABEL OF Y AXIS
2220 FIXED Ndigy
2230 D=(Y2-Y1)/Ndigy
2240 Dy=(Ymax-Ymin)/Ndigy
2250 FOR J=0 TO Ndigy
2260 V#=VAL$(Ymin+J*Dy)
2270 Xwm=MIN(Xo-(1+LEN(V#))*W,Xum)
2280 Y=Y1+J*D
2290 IF Y=Yo THEN 2320
2300 PLOT Xo,Y,-2
2310 PLOT Xw+Th,Y,-1
2320 PLOT Xo-W,Y-.3*H,-2
2330 LABEL USING "K";V#
2340 IF Nticy=0 THEN 2390
2350 FOR I=1 TO Nticy
2360 PLOT Xo,Y+D*I/(Nticy+1),-2
2370 PLOT Xo+Thm,Y+D*I/(Nticy+1),-1
2380 NEXT I
2390 NEXT J
2400 LDIR 90
2410 LORG 4
2420 PLOT Xwm-H,(Y1+Y2)/2,-2
2430 LABEL USING "K";Ylab#
2440 LDIR 0
2450 PLOT Tx,Ty,-2
2460 LORG 4
2470 LABEL USING "K";Title#
2480 PLOT 0,0,-2
2490 SCALE Xmin,Xmax,Ymin,Ymax !SET TO USER UNITS
2500 PENUP
2510 FIXED 5
2520 SUBEXIT
2530 SUB Pltsym(X(*),Y(*),N,Isym,Dsy)
2540 REM VERSION 14 NOV 79
2550 REM SUB PLACES SYMBOLS
2560 REM X= VECTOR OF X VALUES IN USER UNITS
2570 REM Y= VECTOR OF Y VALUES IN USER UNITS

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2580 REM      N=   NO. VALUES
2590 REM      ISYM=SYMBOL
2600 REM      DSY= SYMBOL HEIGHT CALCULATED IN PLTAX OR PLTAXZ
2610 REM              1=TRIANGLE
2620 REM              2=CROSS
2630 REM              3=SQUARE
2640 REM              4=DIAMOND
2650 REM              5=X
2660 D=Dsy
2670 FOR I=1 TO N
2680 PLOT X(I),Y(I),-2
2690 SETGU
2700 WHERE Xc,Yc,Ps$
2710 IF Isym=1 THEN 2790
2720 IF Isym=2 THEN 2840
2730 IF Isym=3 THEN 2900
2740 IF Isym=4 THEN 2970
2750 IF Isym=5 THEN 3040
2760 PRINT "ERROR IN SYMBOL ISYM= ";Isym
2770 SUBEXIT
2780 REM THIS IS SYMBOL 1= TRIANGLE
2790 PLOT Xc-D,Yc-D,-2
2800 PLOT Xc+D,Yc-D,-1
2810 PLOT Xc,Yc+D,-1
2820 PLOT Xc-D,Yc-D,-1
2830 GOTO 3100
2840 REM THIS IS SYMBOL 2=CROSS
2850 PLOT Xc-D,Yc,-2
2860 PLOT Xc+D,Yc,-1
2870 PLOT Xc,Yc+D,-2
2880 PLOT Xc,Yc-D,-1
2890 GOTO 3100
2900 REM THIS IS SYMBOL 3=SQUARE
2910 PLOT Xc-D,Yc-D,-2
2920 PLOT Xc+D,Yc-D,-1
2930 PLOT Xc+D,Yc+D,-1
2940 PLOT Xc-D,Yc+D,-1
2950 PLOT Xc-D,Yc-D,-1
2960 GOTO 3100
2970 REM THIS IS SYMBOL 4= DIAMOND
2980 PLOT Xc-D,Yc,-2
2990 PLOT Xc,Yc+D,-1
3000 PLOT Xc+D,Yc,-1
3010 PLOT Xc,Yc-D,-1
3020 PLOT Xc-D,Yc,-1
3030 GOTO 3100
3040 REM THIS IS SYMBOL 5= X
3050 PLOT Xc-D,Yc-D,-2
3060 PLOT Xc+D,Yc+D,-1
3070 PLOT Xc-D,Yc+D,-2
3080 PLOT Xc+D,Yc-D,-1
3090 GOTO 3100
3100 SETUU
3110 NEXT I
3120 PENUP
3130 SUBEXIT
3140 SUBEND
3150 SUB Pltlin(X(*),Y(*),N,Itype,Lp)
3160 REM *****
3170 REM : VERSION 11 SEPT 79
3180 REM :      X      = VECTOR OF X VALUES TO BE PLOTTED
3190 REM :      Y      = VECTOR OF Y VALUES TO BE PLOTTED
3200 REM :      N      = NO. VALUES TO BE PLOTTED
3210 REM :      ITYPE  = LINE TYPE (1=SOLID, 3=DASHED, ETC.)
3220 REM :      LP     = LENGTH OF DASH IN GU
3230 REM *****

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3240 LINE TYPE Itype,Lp
3250 PLOT X(1),Y(1),-2
3260 FOR I=2 TO N
3270 PLOT X(I),Y(I),-1
3280 NEXT I
3290 PENUP
3300 SUBEXIT
3310 SUBEND
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10  REM  PROGRAM NAME= SECS
20  REM  CREATED BY T.E. WHITLEDGE 3 MARCH 80
30  REM  MODIFIED FOR RATIOS AND INTEGRATION 3 OCTOBER 1980
40  REM  MODIFIED FOR DEPTH-ORDERED VALUES 5 NOVEMBER 1980
50  REM  MODIFIED FOR CONTOURING BY CDW 19 NOVEMBER 1980
60  REM  VARIABLES USED IN THE INITIAL READ
70  REM  B1=    INITIAL BASE LINES
80  REM  B2=    FINAL BASE LINES
90  REM  RF=    REFRACTIVE INDEXS
100 REM  P=     PEAK VALUES P(SEQ,CHANNEL)
110 REM  ID#=   SAMPLE ALPHA IDENT  H,S,I....ECT.
120 REM  ICODE#= SAMPLE INTEGER IDENT  DEPTH
130 REM  DA#=   DATE AS 03MAY79
140 REM  NSAMP= NO. SAMPLES
150 REM  NC=    NO. CHANNNELS
160 REM
170 REM  VARIABLES USED FOR OUTPUTTING TO TAPE
180 REM
190 OPTION BASE 1
200 EXIT GRAPHICS
210 FIXED 3
220 SHORT Rf(6),F(6),B1(6),B2(6),P(30,6),Bon(30,25,6),Dp(30,25),Intex(30,6)
230 DIM A$(6)[4],Id$(40)[1],L$(6),Da$(7),Hr$(4),Op$(6),D(6),Cs(12,6),Ls$(6)[4],
D$(4),Xmax(6),Idt$(40),X1$(20),Nz(6),Stn$(20)
240 INTEGER Nsamp,C(6),Icode(40),Nc,Istat,Ns(30)
250 DIM Rf$(6)[7],F$(6)[7],B1$(6)[7],B2$(6)[7],P$(40,6)[7]
260 DIM C#[80],Mon$(12),Card$(50)[80],W#[80]
270 DIM Code$(6)[3],Title$(45)
280 DIM F15$(30)[10],Sta(30),Lat(30),Lon(30),Dis(30),Sde(30)
290 DIM Mess#[50],Lat#[12],Lon#[12],Q#[20],Ylab#[35],X(30),Y(30),X1(30),Y1(30),
Con(20)
300 DATA "JAN","FEB","MAR","APR","MAY","JUN","JUL","AUG","SEP","OCT","NOV","DEC
"
310 DATA " 09"," 10"," 11"," 12"," 13"," 27",0,0,6
320 READ Mon#(*)
330 READ Code#(*),N15,N14,Ncmax
340 Dnull=-9900
350 GOSUB Init15
360 INPUT "DO YOU WANT TO RUN? Y/N",K$
370 IF K#[1,1]="N" THEN 1290
380 I=0
390 FOR Ifile=1 TO N15
400 L1#=F15$(Ifile)
410 IF L1#[1;4]<>"NEXT" THEN 460
420 BEEP
430 PRINT "I NEED A NEW TAPE, PUSH CONT"
440 PAUSE
450 GOTO 490
460 I=I+1
470 GOSUB Read
480 GOSUB Matmak
490 NEXT Ifile
500 N15=I
510 GOSUB Distance
520 PRINT "SECTION LENGTH IS",Dis(N15)
530 INPUT "VARIABLE NAME? [6A]",D$
540 IF D#[1,1]="I" THEN 620
550 IF D#[1,1]="R" THEN 630
560 FOR L=1 TO 6
570 Nv=L
580 IF POS(A$(L),D#)<>0 THEN 630 !IF TRUE -MATCH FOUND,CHAN =Nv
590 NEXT L
600 PRINT D#;"THAT IS A BAD CHOICE, TRY AGAIN"
610 GOTO 530
620 IF D#[1,1]="I" THEN GOSUB Inte
630 INPUT "SECTION LENGTH?",Xmax

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640 IF D#[1,1]="I" THEN 670
650 INPUT "MAXIMUM PLOT DEPTH?",Ymax
660 GOTO 680
670 INPUT "MAXIMUM INTEGRATED CONC?",Ymax
680 IF D#[1,1]="I" THEN 740
690 Lnut#=D#[1,4]
700 IF D#[1,1]="R" THEN 720
710 GOTO 740
720 INPUT "WHAT IS THE LABEL FOR THE PLOT? [18] ",Q#
730 Lnut#=Q#
740 Dev=1
750 Ncon=0
760 EXIT GRAPHICS
770 IF D#[1,1]="I" THEN 880
780 INPUT "TYPE OF PLOT 1=NUMBERS, 2=NUMBERS+CONTOURS,3=CONTOURS",Idplt
790 IF Idplt=1 THEN 880 !SKIP CONTOURS
800 LINPUT "CONTOUR LEVEL VALUE OR E TO EXIT",Con#
810 IF Con#[1,1]="E" THEN 880
820 FIXED 5
830 Ncon=Ncon+1
840 Con(Ncon)=VAL(Con#)
850 PRINT USING 860;"CONTOUR(";Ncon;")= ";Con(Ncon)
860 IMAGE 8A,DDD,3A,DDD.DD
870 GOTO 900
880 FIXED 2
890 IF Dev=0 THEN PLOTTER IS 13,"GRAPHICS"
900 IF Dev=1 THEN PLOTTER IS "9872A"
910 IF Dev=2 THEN PLOTTER IS "9872A"
920 Clr=1
930 GRAPHICS
940 Ndivx=5
950 Ch=2
960 Ndivy=4
970 Nticx=1
980 Nticy=1
990 Ndigx=0
1000 Ndigy=0
1010 Ymin=0
1020 Xmin=0
1030 IF D#[1,1]="I" THEN GOTO 1090
1040 Xlab#="DISTANCE (Km)"
1050 Ylab#="DEPTH (m)"
1060 Xlab2#="STATIONS"
1070 Title#="PROBES LEG IV"
1080 GOTO 1130
1090 Xlab#="DISTANCE (Km)"
1100 Ylab#="INT CONC (MG-RT/M**2)"
1110 Xlab2#="STATIONS"
1120 Title#="PROBES LEG IV"
1130 Xorig=Yorig=0
1140 Sym=1
1150 CALL Pltax(Xmin,Ymin,Xmax,Ymax,Xorig,Yorig,Ndivx,Ndivy,Nticx,Ndigx,Ndigy,Nticy,Xlab#,Ylab#,Title#,Dev,Dsym,Lnut#,Xlab2#,D#,Zmin,Zmax)
1160 IF D#[1,1]="R" THEN 1210
1170 IF D#[1,1]="I" THEN GOSUB Intplt
1180 IF D#[1,1]="I" THEN 1270
1190 GOSUB Dtplt
1200 GOTO 1220
1210 GOSUB Rat
1220 GOSUB Bplt
1230 IF Dev>0 THEN 1270
1240 INPUT "DO YOU WANT A HARDCOPY OF THE PLOT? Y/N",K#
1250 IF K#[1,1]="N" THEN 1270
1260 DUMP GRAPHICS
1270 INPUT "DO YOU WANT ANOTHER VARIABLE ON THIS SECTION? Y/N",K#
1280 IF K#[1,1]="Y" THEN 530

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1290 END
1300 Read: ! READ
1310 ASSIGN #2 TO L1$
1320 BUFFER #2
1330 READ #2;L$,Da$,Hr$,Op$,A$(*)
1340 Ktyp=TYP(2)
1350 IF (Ktyp=2) OR (Ktyp>7) THEN READ #2;Mess$,Lat$,Lon$,Depth
1360 READ #2;Nsamp,Nc
1370 READ #2;C(*),F(*),Rf(*),B1(*),B2(*)
1380 Ns(I)=Nsamp
1390 K=POS(Lat$," ")
1400 Dlat=VAL(Lat$[1;K-1])
1410 T$=TRIM$(Lat$[K+1,12])
1420 Elat=VAL(T$)
1430 Kk=POS(Lon$," ")
1440 Dlon=VAL(Lon$[1;Kk-1])
1450 Tt$=TRIM$(Lon$[Kk+1,12])
1460 Elon=VAL(Tt$)
1470 Lat(I)=Elat/60+Dlat
1480 Lon(I)=Elon/60+Dlon
1490 Sde(I)=Depth
1500 FOR J=1 TO Nsamp
1510 READ #2;J,Id$(J),Icode(J),P(J,1),P(J,2),P(J,3),P(J,4),P(J,5),P(J,6)
1520 NEXT J
1530 PRINT "FINISHED READING FILE ";L$
1540 RETURN
1550 Matmak:J=0 ! MAKES MATRIX AND PRINTS IT
1560 FOR Jj=1 TO Nsamp
1570 IF Id$(Jj)="H" THEN 1590
1580 GOTO 1660
1590 IF Jj=1 THEN 1610
1600 IF Icode(Jj)=Icode(Jj-1) THEN 1660 !REMOVE DUPS
1610 J=J+1
1620 Dp(I,J)=Icode(Jj)
1630 FOR K=1 TO Ncmax
1640 Bon(I,J,K)=F(K)*(P(Jj,K)-(B1(K)+(B2(K)-B1(K))*Jj/(Nsamp+1)+Rf(K)))
1650 NEXT K
1660 NEXT Jj
1670 REM ORDER THE ALL VALUES BY DEPTH
1680 Ns(I)=J
1690 FOR J=1 TO Ns(I)-1
1700 K=J
1710 Dmin=Dp(I,J)
1720 FOR Jj=J+1 TO Ns(I)
1730 IF Dp(I,Jj)>=Dmin THEN 1760
1740 Dmin=Dp(I,Jj)
1750 K=Jj
1760 NEXT Jj
1770 REM NOW EXCHANGE J WITH K ALL VARIABLES
1780 D=Dp(I,J)
1790 Dp(I,J)=Dp(I,K)
1800 Dp(I,K)=D
1810 FOR Kk=1 TO Ncmax
1820 D=Bon(I,J,Kk)
1830 Bon(I,J,Kk)=Bon(I,K,Kk)
1840 Bon(I,K,Kk)=D
1850 NEXT Kk
1860 NEXT J
1870 RETURN
1880 Init15:Ncmax=6
1890 N15=0
1900 PRINT "RUNNING LIST OF FILE INFO"
1910 LINPUT "ENTER FILE NAMES, STA NO.? TYPE EXIT TO QUIT",C$
1920 L1$="NEXT"
1930 IF C$[1;4]="NEXT" THEN 2090
1940 IF C$[1;4]="EXIT" THEN 2150

```



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1950 I1=POS(C#,"")
1960 IF I1=0 THEN 2060
1970 L1#=C#[I1;I1-1]
1980 St#=TRIM$(C#[I1+1,80])
1990 I1=LEN(St#)
2000 IF I1=0 THEN 2060
2010 St=VAL(St#)
2020 ON ERROR GOTO 2060
2030 ASSIGN #2 TO L1#
2040 OFF ERROR
2050 GOTO 2090
2060 BEEP
2070 PRINT SPA(20);"INPUT ERROR IN ";C#[I1;40];" TRY AGAIN"
2080 GOTO 1910
2090 N15=N15+1
2100 F15$(N15)=L1#
2110 Sta(N15)=St
2120 PRINT USING 2130;N15;F15$(N15),Sta(N15)
2130 IMAGE DDD,2X,6A,2X,5D
2140 GOTO 1910
2150 GOSUB List15
2160 INPUT "DO YOU WANT A HARDCOPY? Y/N",K#
2170 IF K#[1,1]="Y" THEN PRINTER IS 0
2180 GOSUB List15
2190 PRINTER IS 16
2200 ! INPUT "HARD COPY? Y/N",K#
2210 ! IF K#="Y" THEN PRINTER IS 0
2220 ! GOSUB List15
2230 ! PRINTER IS 16
2240 RETURN
2250 List15:PRINT "HERE IS A LIST OF FILES YOU HAVE ASKED FOR"
2260 PRINT " NO. NAME STATION"
2270 FOR I=1 TO N15
2280 PRINT USING 2310;I,F15$(I),Sta(I)
2290 NEXT I
2300 PRINT LIN(3)
2310 IMAGE 4D,5X,6A,3X,4D
2320 RETURN
2330 Distance:Dis(I)=0
2340 DEG
2350 FOR I3=1 TO N15
2360 Dis(I3+1)=ACS(SIN(Lat(I3))*SIN(Lat(I3+1))+COS(Lat(I3))*COS(Lat(I3+1))*COS(Lon(I3+1)-Lon(I3)))*111.12
2370 IF I3=1 THEN 2390
2380 Dis(I3)=Dis(I3)+Dis(I3-1)
2390 NEXT I3
2400 RETURN
2410 Dtplt:K=Nv ! DATA PLOT SUBPROGRAM
2420 Dsym=.5
2430 LORG 4
2440 FOR I4=1 TO N15
2450 CSIZE 3.3,.5
2460 IF Dev=0 THEN 2480
2470 CSIZE 1.9,.45
2480 FIXED 0
2490 PLOT Dis(I4),Ymax,-2
2500 SETGU
2510 WHERE Xc,Yc,Ps#
2520 PLOT Xc,Yc+9*Dsym,-2
2530 SETUU
2540 LDIR 90
2550 LORG 5
2560 LABEL USING "K";VAL$(Sta(I4))
2570 LDIR 0
2580 FIXED 1
2590 CSIZE 2.3,.45

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```

2600 IF Dev=1 THEN CSIZE 1.2,.45
2610 IF Idplt>2 THEN 2690 !SKIPS NUM
2620 FOR J2=1 TO Ns(I4)
2630 IF Bon(I4,J2,K)<=0 THEN 2680
2640 IF Dp(I4,J2)>Ymax THEN 2680
2650 V#=VAL$(Bon(I4,J2,K))
2660 PLOT Dis(I4),Ymax-Dp(I4,J2),-2
2670 LABEL USING "K";V#
2680 NEXT J2
2690 Nx=Nx1=0
2700 IF Idplt=1 THEN 2870 !SKIPS CONTOURS
2710 FOR J2=1 TO Ns(I4)
2720 IF Dp(I4,J2)>Ymax THEN 2770
2730 IF Bon(I4,J2,K)<=0 THEN 2770
2740 Nx=Nx+1
2750 Y(Nx)=Bon(I4,J2,K)
2760 X(Nx)=Ymax-Dp(I4,J2)
2770 NEXT J2
2780 IF I4=N15 THEN 2870
2790 FOR J2=1 TO Ns(I4+1)
2800 IF Bon(I4+1,J2,K)<=0 THEN 2850
2810 IF Dp(I4+1,J2)>Ymax THEN 2850
2820 Nx1=Nx+1
2830 Y1(Nx1)=Bon(I4+1,J2,K)
2840 X1(Nx1)=Ymax-Dp(I4+1,J2)
2850 NEXT J2
2860 CALL Column(Dis(I4),Dis(I4+1),X(*),X1(*),Y(*),Y1(*),Nx,Nx1,Con(*),Ncon,2)
2870 NEXT I4
2880 RETURN
2890 Bplt:I5=1
2900 PLOT Dis(I5),Sde(I5),-2
2910 FOR I5=1 TO N15
2920 PLOT Dis(I5),Ymax-Sde(I5),-1
2930 NEXT I5
2940 PENUP
2950 PEN 0
2960 RETURN
2970 Rat:K=Nv
2980 Dsym=.5
2990 LORG 4
3000 FOR I4=1 TO N15
3010 CSIZE 3.3,.5
3020 IF Dev=0 THEN 3040
3030 CSIZE 1.9,.45
3040 FIXED 0
3050 PLOT Dis(I4),Ymax,-2
3060 SETGU
3070 WHERE Xc,Yc,Ps#
3080 PLOT Xc,Yc+9*Dsym,-2
3090 SETUU
3100 LDIR 90
3110 LORG 5
3120 LABEL USING "K";VAL$(Sta(I4))
3130 LDIR 0
3140 FIXED 1
3150 CSIZE 2.3,.45
3160 IF Dev=0 THEN 3180
3170 CSIZE 1.2,.45
3180 FOR J2=1 TO Ns(I4)
3190 IF Bon(I4,J2,K)<=0 THEN 3260
3200 IF Dp(I4,J2)>Ymax THEN 3260
3210 Totn=Bon(I4,J2,3)
3220 Ntop=Totn/Bon(I4,J2,2)
3230 V#=VAL$(Ntop)
3240 PLOT Dis(I4),Ymax-Dp(I4,J2),-2
3250 LABEL USING "K";V#

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3260 NEXT J2
3270 NEXT I4
3280 RETURN
3290 Inte:Dsym=.5
3300 INPUT "WHAT IS THE INTEGRATION MIN?",Zmin
3310 INPUT "WHAT IS THE INTEGRATION MAX?",Zmax
3320 LORG 4
3330 FOR I5=1 TO N15 !STA
3340 FOR K=1 TO Ncmax !CHAN
3350 Nn=0
3360 FOR J2=1 TO Ns(I5)!DEPTH
3370 IF Bon(I5,J2,K)<=0 THEN 3410
3380 Nn=Nn+1
3390 Y(Nn)=Bon(I5,J2,K)
3400 X(Nn)=Dp(I5,J2)
3410 NEXT J2
3420 Nc=0
3430 FOR I=1 TO Nn
3440 IF X(I)<0 THEN 3490
3450 IF Y(I)<=0 THEN 3490
3460 Nc=Nc+1
3470 X(Nc)=X(I)
3480 Y(Nc)=Y(I)
3490 NEXT I
3500 Nn=Nc
3510 REM GO TO THE SHALLOWER OF (ZMAX,SONIC DEPTH)
3520 Zz=Sde(I5)
3530 Zp=MIN(Zmax,Zz)
3540 Int=0
3550 IF Nn>0 THEN CALL Zint(X(*),Y(*),Nn,Zmin,Zp,Int)
3560 Intex(I5,K)=Int
3570 NEXT K
3580 NEXT I5
3590 INPUT "DO YOU WANT A HARDCOPY OF THE INTEGRATED VALUES? Y/N",K#
3600 IF K#[1,1]="N" THEN 3710
3610 PRINTER IS 0
3620 PRINT "          INTEGRATED CONCENTRATIONS (MG-AT/M**2)"
3630 PRINT USING 3640;"INTEGRATED FROM",Zmin,"TO",Zmax,"m"
3640 IMAGE 21X,15A,5D,1X,2A,5D,1X,1A
3650 PRINT "   STA NO.   P04       SI04       N+N       NO2       NH4
   CHL "
3660 FOR I5=1 TO N15
3670 PRINT USING 3680;Sta(I5),Intex(I5,1),Intex(I5,2),Intex(I5,3),Intex(I5,4),In
tex(I5,5),Intex(I5,6)
3680 IMAGE 2X,5D,6(3X,5D,2D)
3690 NEXT I5
3700 PRINTER IS 16
3710 RETURN
3720 Intplt:PRINT "VARIABLE #       VARIABLE NAME"
3730 FOR I=1 TO 6
3740 PRINT I,A#(I)
3750 NEXT I
3760 INPUT "VARIABLE MASK? [6#'S]",C(*)
3770 K=Nu
3780 Dsym=.5
3790 LORG 4
3800 FOR I4=1 TO N15
3810 CSIZE 3.3,.5
3820 IF Dev=0 THEN 3840
3830 CSIZE 1.9,.45
3840 FIXED 0
3850 PLOT Dis(I4),Ymax,-2
3860 SETGU
3870 WHERE Xc,Yc,P=#
3880 PLOT Xc,Yc+9*Dsym,-2
3890 SETUU

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3900 LDIR 90
3910 LORG 5
3920 LABEL USING "K";VAL$(Sta(I4))
3930 NEXT I4
3940 LDIR 0
3950 GRAPHICS
3960 FOR K=1 TO Ncmax
3970 IF C(K)=0 THEN 4060
3980 FOR I=1 TO N15
3990 Y(I)=Intex(I,K)
4000 X(I)=Dis(I)
4010 NEXT I
4020 CALL Pltlin(X(*),Y(*),N15,1,1,Clr) !PLOT THE LINE
4030 CALL Pltsym(X(*),Y(*),N15,K,Dsym,Clr,A$(*)) !PLOT THE SYMBOLS AND TITLE
4040 Clr=Clr+1
4050 IF Clr>4 THEN Clr=1
4060 NEXT K
4070 RETURN
4080 SUB Pltax(Xmin,Ymin,Xmax,Ymax,Xorig,Yorig,Ndivx,Ndivy,Nticx,Ndigx,Ndigy,Nti
cy,Xlab$,Ylab$,Title$,Dev,Dsym,Lnut$,Xlab2$,D$,Zmin,Zmax)
4090 H=5
4100 Dsym=1
4110 Th=3
4120 IF Dev=0 THEN 4160
4130 Tx=85
4140 Ty=195
4150 GOTO 4180
4160 Tx=60
4170 Ty=145
4180 X1=25
4190 X2=153
4200 Y1=20
4210 Y2=105
4220 IF Dev=2 THEN 4270
4230 IF Dev=0 THEN 4290
4240 X2=210
4250 Y2=155
4260 GOTO 4290
4270 X2=300
4280 Y2=155
4290 Tnx=30
4300 Tny=7
4310 DEG
4320 FIXED 5
4330 Xm=184
4340 Ym=149
4350 IF Dev=1 THEN Ym=285 !SIZE IN MM OF 9872A
4360 IF Dev=2 THEN Ym=285 !SIZE IN MM OF 9872A
4370 IF Dev=1 THEN Xm=400 !SIZE IN MM OF 9872A
4380 IF Dev=2 THEN Xm=400 !SIZE IN MM OF 9872A
4390 LIMIT 0,Xm,0,Ym
4400 One=MIN(Xm,Ym)/100
4410 X1=X1/One
4420 X2=Xm=X1+X2/One
4430 Y1=Y1/One
4440 Y2=Y1+Y2/One
4450 Xo=X1+(X2-X1)*(Xorig-Xmin)/(Xmax-Xmin)
4460 Yo=Y1+(Y2-Y1)*(Yorig-Ymin)/(Ymax-Ymin)
4470 Tx=Tx/One
4480 Ty=Ty/One
4490 Tnx=Tnx/One
4500 Tny=Tny/One
4510 Th=Th/One
4520 Thm=Th/2
4530 H=H/One
4540 W=3*H/5

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4550 Dsym=Dsym/One
4560 CSIZE H,3/5
4570 LOCATE X1,X2,Y1,Y2
4580 FRAME
4590 FOR I=1 TO 3
4600 PLOT X1,Yo,-2
4610 PLOT X2,Yo,-1
4620 PLOT Xo,Y1,-2
4630 PLOT Xo,Y2,-1
4640 NEXT I
4650 LORG 4
4660 FIXED Ndigx
4670 D=(X2-X1)/Ndivx
4680 Dx=(Xmax-Xmin)/Ndivx
4690 FOR J=0 TO Ndivx
4700 X=X1+J*D
4710 V#=VAL$(Xmin+J*Dx)
4720 IF X=Xo THEN 4750
4730 PLOT X,Yo,-2
4740 PLOT X,Yo+Th,-1
4750 PLOT X,Yo-1.2*H,-2
4760 LABEL USING "K";V#
4770 IF Nticx=0 THEN 4820
4780 FOR I=1 TO Nticx
4790 PLOT X+D*I/(Nticx+1),Yo,-2
4800 PLOT X+D*I/(Nticx+1),Yo+Thm,-1
4810 NEXT I
4820 NEXT J
4830 PLOT (X1+X2)/2,Yo-2.4*H,-2
4840 LABEL USING "K";Xlab#
4850 LORG 7
4860 FIXED Ndigy
4870 D=(Y2-Y1)/Ndivy
4880 IF D#[1,1]="I" THEN 4910
4890 Dy=(Ymin-Ymax)/Ndivy
4900 GOTO 4920
4910 Dy=(Ymax-Ymin)/Ndivy
4920 FOR J=0 TO Ndivy
4930 IF D#[1,1]="I" THEN 4960
4940 V#=VAL$(Ymax+J*Dy)
4950 GOTO 4970
4960 V#=VAL$(Ymin+J*Dy)
4970 Xwm=MIN(Xo-(1+LEN(V#))*W,Xwm)
4980 Y=Y1+J*D
4990 IF Y=Yo THEN 5020
5000 PLOT Xo,Y,-2
5010 PLOT Xo+Th,Y,-1
5020 PLOT Xo-2*W,Y-.3*H,-2
5030 LABEL USING "K";V#
5040 IF Nticy=0 THEN 5090
5050 FOR I=1 TO Nticy
5060 PLOT Xo,Y+D*I/(Nticy+1),-2
5070 PLOT Xo+Thm,Y+D*I/(Nticy+1),-1
5080 NEXT I
5090 NLXI J
5100 LDIR 90
5110 LORG 4
5120 PLOT Xwm-H,(Y1+Y2)/2,-2
5130 LABEL USING "K";Ylab#
5140 LDIR 0
5150 PLOT X1+X2/2,Yo+Y2,-2
5160 LABEL USING "K";Xlab2#
5170 LABEL USING "K";Stn#
5180 PLOT Tnx,Tny,-2
5190 IF D#[1,1]="I" THEN 5220
5200 LABEL USING "K";Lnut#

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5210 GOTO 5240
5220 LABEL USING 5230;"INT. LIMITS=",Zmin,"TO",Zmax
5230 IMAGE 2X,12A,1X,DD,1X,2A,DDDD
5240 PLOT Tx,Ty,-2
5250 LORG 4
5260 LABEL USING "K";Title#
5270 PLOT 0,0,-2
5280 SCALE Xmin,Xmax,Ymin,Ymax
5290 PENUP
5300 FIXED 5
5310 SUBEXIT
5320 SUBEND
5330 RETURN
5340 SUB Pltlin(X(*),Y(*),N,Itype,Lp,Clr)
5350 LINE TYPE Itype
5360 GRAPHICS
5370 PEN Clr
5380 PLOT X(1),Y(1),-2
5390 FOR I=1 TO N
5400 PLOT X(I),Y(I),-1
5410 NEXT I
5420 PENUP
5430 SUBEXIT
5440 SUBEND
5450 SUB Pltsym(X(*),Y(*),N,Sym,Dsym,Clr,A#(*))
5460 FOR I=1 TO N
5470 D=Dsym
5480 PEN Clr
5490 PLOT X(I),Y(I),-2
5500 SETGU
5510 WHERE Xc,Yc,Ps#
5520 IF Sym=1 THEN 5640
5530 IF Sym=2 THEN 5750
5540 IF Sym=3 THEN 5800
5550 IF Sym=4 THEN 5850
5560 IF Sym=5 THEN 5900
5570 IF Sym=6 THEN 5990
5580 PLOT Xc-D,Yc-D,-2
5590 PLOT Xc+D,Yc-D,-1
5600 PLOT Xc+D,Yc+D,-1
5610 PLOT Xc-D,Yc+D,-1
5620 PLOT Xc-D,Yc-D,-1
5630 GOTO 6140
5640 PLOT Xc,Yc+D,-2
5650 PLOT Xc-D/2,Yc+D,-1
5660 PLOT Xc-D,Yc+D/2,-1
5670 PLOT Xc-D,Yc-D/2,-1
5680 PLOT Xc-D/2,Yc-D,-1
5690 PLOT Xc+D/2,Yc-D,-1
5700 PLOT Xc+D,Yc-D/2,-1
5710 PLOT Xc+D,Yc+D/2,-1
5720 PLOT Xc+D/2,Yc+D,-1
5730 PLOT Xc,Yc+D,-1
5740 GOTO 6140
5750 PLOT Xc,Yc+D,-2
5760 PLOT Xc-D,Yc-D,-1
5770 PLOT Xc+D,Yc-D,-1
5780 PLOT Xc,Yc+D,-1
5790 GOTO 6140
5800 PLOT Xc-D,Yc,-2
5810 PLOT Xc+D,Yc,-1
5820 PLOT Xc,Yc-D,-2
5830 PLOT Xc,Yc+D,-1
5840 GOTO 6140
5850 PLOT Xc-D,Yc+D,-2
5860 PLOT Xc+D,Yc-D,-1

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5870 PLOT Xc+D,Yc+D,-2
5880 PLOT Xc-D,Yc-D,-1
5890 GOTO 6140
5900 FOR L=1 TO 5
5910 PLOT Xc-D,Yc-D,-2
5920 PLOT Xc+D,Yc-D,-1
5930 PLOT Xc+D,Yc+D,-1
5940 PLOT Xc-D,Yc+D,-1
5950 PLOT Xc-D,Yc-D,-1
5960 D=D-.09
5970 NEXT L
5980 GOTO 6140
5990 FOR L=1 TO 9
6000 PLOT Xc,Yc+D,-2
6010 PLOT Xc-D/2,Yc+D,-1
6020 PLOT Xc-D,Yc+D/2,-1
6030 PLOT Xc-D,Yc-D/2,-1
6040 PLOT Xc-D/2,Yc-D,-1
6050 PLOT Xc+D/2,Yc-D,-1
6060 PLOT Xc+D,Yc-D/2,-1
6070 PLOT Xc+D,Yc+D/2,-1
6080 PLOT Xc+D/2,Yc+D,-1
6090 PLOT Xc,Yc+D,-1
6100 D=D-.05
6110 NEXT L
6120 GOTO 6140
6130 NEXT L
6140 SETUU
6150 NEXT I
6160 LORG 2
6170 PLOT X(N),Y(N),-2
6180 SETGU
6190 WHERE Xc,Yc,Ps#
6200 PLOT Xc+9*Daym,Yc,-2
6210 LABEL USING "K";TRIM#(A#(Sym))
6220 SETUU
6230 PENUP
6240 SUBEXIT
6250 SUBEND
6260 SUB Zint(Z(*),A(*),N,Zmin,Zmax,Int)
6270 REM *****
6280 REM : SUB ZINT
6290 REM : VERSION 9 DEC 79
6300 REM : PURPOSE= INTEGRATION OF VERTICAL PROFILES
6310 REM : Z - DEPTH VECTOR
6320 REM : A = ATTRIBUTE VECTOR
6330 REM : N = NO. VALUES IN VECTOR
6340 REM : ZMIN = DEPTH TO BEGIN INTEGRATION
6350 REM : ZMAX = DEPTH TO END INTEGRATION
6360 REM : INT = INTEGRATED VALUE
6370 REM *****
6380 OPTION BASE 1
6390 Int=0
6400 IF Zmin<Zmax THEN 6440 !CHECK INTEGRATION LIMITS
6410 BEEP
6420 PRINT "ERROR IN SUB ZINT BAD LIMITS"
6430 SUBEXIT
6440 B=Zmin
6450 FOR I=1 TO N-1
6460 IF Z(I)<=Z(I+1) THEN 6510 !CHECK DEPTHS FOR ORDER
6470 BEEP
6480 PRINT "ZINT ERROR DEPTHS OUT OF ORDER"
6490 Int=0
6500 SUBEXIT
6510 T=MAX(B,Zmin)
6520 B=MIN(.5*(Z(I+1)+Z(I)),Zmax)

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6530     IF T>B THEN 6550
6540     Int=Int+(B-T)*A(I)
6550     NEXT I
6560     Int=Int+(Zmax-B)*A(N)
6570     SUBEXIT
6580     SUBEND
6590 SUB Column(Xa,Xb,A(*),B(*),Fa(*),Fb(*),Na,Nb,C(*),Nc,K)
6600 REM *****
6610 OPTION BASE 1
6620 IF Na*Nb=0 THEN SUBEXIT
6630 IF Na+Nb<3 THEN SUBEXIT
6640 Ma=Mb=1
6650 X1=Xa
6660 X2=Xb
6670 Y1=A(Ma)
6680 Y2=B(Mb)
6690 Z1=Fa(Ma)
6700 Z2=Fb(Mb)
6710 IF Ma=Na THEN 6810
6720 Da=ABS(A(Ma+1)-Y2)
6730 IF Mb=Nb THEN 6760
6740 Db=ABS(B(Mb+1)-Y1)
6750 IF (Ma=Na) OR (Db<=Da) THEN 6810
6760 Ma=Ma+1
6770 Y3=A(Ma)
6780 X3=Xa
6790 Z3=Fa(Ma)
6800 GOTO 6850
6810 Mb=Mb+1
6820 Y3=B(Mb)
6830 X3=Xb
6840 Z3=Fb(Mb)
6850 IF K=2 THEN 6900
6860 PLOT X1,Y1,-2
6870 PLOT X2,Y2,-1
6880 PLOT X3,Y3,-1
6890 PLOT X1,Y1,-1
6900 IF K>0 THEN GOTO 6930
6910 IF (Ma<>Na) OR (Mb<>Nb) THEN 6670
6920 GOTO 7320
6930 L=MIN(Z1,Z2,Z3)
6940 U=MAX(Z1,Z2,Z3)
6950 FOR I=1 TO Nc
6960 Fc=C(I)
6970     IF Fc<L THEN 7290
6980     IF Fc>U THEN 7300
6990 Ip1=T=0
7000     IF Fc<MIN(Z1,Z2) THEN 7060
7010     IF Fc>MAX(Z1,Z2) THEN 7060
7020 Ip1=1
7030 IF Z1<>Z2 THEN T=(Fc-Z1)/(Z2-Z1)
7040 Xp1=X1+T*(X2-X1)
7050 Yp1=Y1+T*(Y2-Y1)
7060 Ip2=T=0
7070     IF Fc<MIN(Z2,Z3) THEN 7130
7080     IF Fc>MAX(Z2,Z3) THEN 7130
7090 Ip2=1
7100 IF Z2<>Z3 THEN T=(Fc-Z2)/(Z3-Z2)
7110 Xp2=X2+T*(X3-X2)
7120 Yp2=Y2+T*(Y3-Y2)
7130 Ip3=T=0
7140     IF Fc<MIN(Z3,Z1) THEN 7200
7150     IF Fc>MAX(Z3,Z1) THEN 7200
7160 Ip3=1
7170 IF Z3<>Z1 THEN T=(Fc-Z3)/(Z1-Z3)
7180 Xp3=X3+T*(X1-X3)

```



```
7190 Yp3-Y3+T*(Y1-Y3)
7200 IF Ip1+Ip2<2 THEN 7230
7210 PLOT Xp1,Yp1,-2
7220 PLOT Xp2,Yp2,-1
7230 IF Ip2+Ip3<2 THEN 7260
7240 PLOT Xp2,Yp2,-2
7250 PLOT Xp3,Yp3,-1
7260 IF Ip1+Ip3<2 THEN 7290
7270 PLOT Xp1,Yp1,-2
7280 PLOT Xp3,Yp3,-1
7290 NEXT I
7300 PENUM
7310 GOTO 6910
7320 PENUM
7330 SUBEXIT
7340 SUBEND
```

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