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PED: Pressurized electroosmotic dewatering

by

Leon William Heath

A Dissertation Submitted to the

Graduate Faculty in Partial Fulfillment of the

Requirements for the Degree of

DOCTOR OF PHILOSOPHY

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Iowa State University
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1985

DOE Report IS-T-1223. The research on ultra-fine coal suspension dewatering has been performed for the Ames Laboratory, operated under Contract Number W-7405-Eng-82, and is supported by the Assistant Secretary of Fossil Energy, Division of Coal Utilization, through the Pittsburgh Energy Technology Center, Coal Preparation Branch.

The opinions, findings and conclusions expressed in this publication are those of the author and not necessarily those of the Pittsburgh Energy Technology Center, Department of Energy.

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GENERAL INTRODUCTION

There have been numerous attempts made in modifying mechanical separation processes of liquids from fine-particulate suspensions. The resulting processes are usually expensive or impractical. Many of these suspensions are waste products that require enormous storage impoundments because of the incurred large volume resulting from poor or no solid/liquid separation. Moreover, some of these fine-grained suspensions are marketable products if the solids can be recovered. If the solids must be recovered to obtain the product, state-of-the-art processes are costly which, obviously, is passed on to the consumers.

In addition, these slurried materials present handling problems that are solved, again, with some more costly method than if the material were solidified. Impoundment of waste slurries also may pose a problem, depending on the material, in the leaching potential of heavy metals or toxic chemicals into the groundwater supply.

Originally, this project addressed the dewatering of sewage sludge. However, funding opportunities led to dewatering coal sludge and resulted in a patent application for the pressurized electroosmotic dewatering (PED) process. It was found that the combination of the two dewatering mechanisms was synergistic. The coal sludge dewatering project defined those slurry characterists which could be modified prior to dewatering such that the PED process could be optimized and developed into a cost effective, continuous dewatering process.

The current project concerns the dewatering of ultra-fine coal suspensions and is addressed herein. This project was funded by the U. S.

Department of Energy (DOE) and was once of major interest since presently, 10 to 15 percent of the coal mined in the United States is discarded because of its fineness and the associated dewatering difficulties. Although dewatering is still an important industrial problem, it is no longer of any major concern to the DOE since research interests are now directed towards direct combustion of coal-water-mixtures (CWM).

Explanation of Dissertation Format

The dissertation is composed of three separate papers and supplementary appendixes.

Part I, "Pressurized Electroosmotic Dewatering (PED)" was an invited presentation at the Engineering Foundation Conference on "Flocculation, Sedimentation and Consolidation", on January 31, 1985 at Sea Island, Georgia. The paper has been formally reviewed and accepted for publication.

Part II, "Augmenting Research with a Microcomputer" has been accepted for presentation at the American Society of Civil Engineers' Third National Conference on Microcomputers in Civil Engineering to be held November 4 to 6, 1985 at Orlando, Florida. The paper will be submitted for review and publication at the conference conclusion.

Part III, "Fine Coal Dewatering by Pressurized Electroosmosis" has been accepted for presentation at the Engineering Foundation Conference on "Science and Technology of Processing Fine Coal" on August 15, 1985 at New England College, Henniker, New Hampshire. The paper will be submitted for review and publication at the conference conclusion.

Appendix A presents the software developed to conduct the research. Also included is that software modified to improve the microcomputer-mainframe communications and to enable re-addressable files to be stored on a floppy disc.

Appendix B includes those items that page limitations of the publications required the omission of and are included in this publication for clarification purposes.

PART I. PRESSURIZED ELECTROOSMOTIC DEWATERING (PED)

ABSTRACT

Laboratory bench tests are being conducted to optimize pressurized electroosmotic dewatering (PED) of ultra-fine coal suspensions. The tests show that PED increases the dewatering rate and decreases the final moisture content as compared to conventional processes. Other slurries, slimes and sludges have also been dewatered using the PED process and the results have proven that the PED process is effective with a variety of materials and suspensions. Optimization of the PED process will be used to develop a cost effective, continuous dewatering process for fine-particle suspensions.

PRESSURIZED ELECTROOSMOTIC DEWATERING (PED)

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INTRODUCTION

Many industrial processes produce large quantities of suspended fine-grained material that is usually rejected as waste. Much of this waste is useful material that is only rejected because of the filtration difficulties and handling problems presented by its fineness. For example, over half of the coal produced in the United States is processed through preparation plants in which up to 25 percent is discarded. With the introduction of new deep cleaning methods, larger quantities of fine coal will be generated and thus, wasted. A majority of the material is recoverable, but because state-of-the-art dewatering techniques cannot sufficiently dewater the suspensions, subsequent expensive thermal drying is required for further utilization and handling.

Disposal of waste slurries requires enormous impoundments if the suspending liquid is not removed. This quickly becomes uneconomical because of the land that must be committed only to disposal purposes. Another problem that exists is the possibility of groundwater contamination by leachates from these disposal sites. Therefore, industry is presssed to find an economical method of dewatering recoverable fines and waste for utilization, economic land usage and environmental reasons.

Although many solid/liquid separation processes have been studied in an attempt to modify the processes to dewater suspensions of fine-grained material, electroosmosis and the belt filter press show the greatest promise (1-4). Previous research by the authors has shown that the combination of electroosmosis and pressure is very effective in dewatering coal sludge, a fine-grained waste material (5). The marriage of the two dewatering mechanisms enhance the dewatering rate and overall moisture reduction. The coal sludge was not physically or chemically altered prior to dewatering. However, the tests indicated that parameters such as particle size distribution and zeta potential could be modified to substantially improve the PED process.

Therefore, the ongoing research is investigating the parameters which affect the PED process and how effective the modifications of those parameters are. These results will then be used to optimize the process such that equipment and operational procedures can be developed to effectively and economically dewater slurries, slimes and sludges in a continuous process. Once the PED process is developed into a continuous process and employed on an industrial scale, utilization of recovered fine material, that is currently wasted, will be enhanced, environmental problems and disposal site sizes will be reduced and handling problems will be alleviated.

Many of the industries that are forced to deal with fine-particulate slurries, prepare or process raw material. Thus, elimination of the associated problems and utilization of recovered material will reduce the overall cost which, in turn, should reduce the consumer's cost.

THEORY

One of the most widely used theoretical expressions for electroosmosis was introduced by Helmholtz and later refined by Smoluchowski. The Helmholtz-Smoluchowski equation for electroosmotic flow rate of water through a porous medium is

$$Q_e = k_e i_e A, \ m^3/s \qquad (1)$$

where

$$k_e = n\varepsilon\zeta/\mu, \ m^2/V{\cdot}s \qquad (2)$$

$$i_e = E/L, \ V/m \qquad (3)$$

n = porosity, dimensionless

ε = static permittivity, $C^2/N{\cdot}m$

ζ = electrokinetic or zeta potential, V

μ = viscosity of water, $kg/s{\cdot}m$

E = electrical potential (voltage), V

L = distance between electrodes, m

A = cross-sectional area, m^2

Equation (1) is similar to Darcy's hydraulic flow equation which is

$$Q_h = k_h i_h A, \ m^3/s \qquad (4)$$

where

$$k_h = \rho g R^2 n/8\mu \ , \ m/s \qquad (5)$$

$$i_h = H/L, \ \text{dimensionless} \qquad (6)$$

ρ = mass density of liquid, kg/cm^3

g = gravitational acceleration, m/s^2

R = capillary radius, m

H = total headloss in distance L, m

The main difference is that in the Helmholtz-Smoluchowski equation, k_e is theoretically independent of pore sizes whereas in Darcy's equation, k_h is directly proportional to the square of the pore size. However, Winterkorn and Fang show that n = RS/2, where S is the specific surface area per unit volume (6). Substituting this expression into Equations (2) and (5) shows that the electroosmotic flow rate is dependent on the pore radius, but the hydraulic flow rate is more dependent on pore size since it becomes a function of the radius cubed. Hence, it can be seen that an electrical potential can more easily transport water through fine-grained material than can a hydraulic potential.

When a saturated, particulate matrix is electroosmotically dewatered, consolidation must occur with a decrease in volume equivalent to the quantity of water removed. This assumes saturation is maintained. However, for consolidation to occur, an increase in the effective stress should take place. Thus, if the total stress remains constant, negative pore pressures should develop in the compressed layer near the anode. However, at the open cathode, there is no change in either the pore pressure or total stress. With this difference in pore pressure a hydraulic gradient is induced which opposes the electroosmotic flow. Thus, water will continue to flow as long as the electroosmotic driving force remains greater than the induced hydraulic gradient, but will cease once an equilibrium is established.

The negative pore pressure that develops for a given potential depends on the k_e/k_h ratio (7). Since k_h decreases rapidly as the particle size, and pore size, decreases and since k_e is theoretically independent of pore size, the negative pore pressure that develops in a fine-grained material would be greater in magnitude than that developed in a coarser material. Therefore, the relative amount of consolidation, which depends on the magnitude of the negative pore pressure, is potentially greater for fine-grained material.

When combining gradients to induce the flow of water through a porous medium, the total flow rate can be theoretically represented by superposition of the flow rates due to the individual gradients. It has been demonstrated experimentally (8) that combined gradients produce a total flow rate that can be represented by superposition as

$$Q_{total} = (k_h i_h + k_e i_e)A \qquad (8)$$

Therefore, as a compressible material consolidates, k_h will decrease as will k_e. Since k_h is a function of $e^3/(1+e)$[1] and k_e is directly proportional to porosity, n, which is equivalent to e/(1+e), k_h will decrease more rapidly than k_e. The electrical potential gradient, i_e, will increase, assuming applied voltage is constant, as the distance decreases between the electrodes. The behavior of the hydraulic gradient in the consolidation process is complex since it is a function of two constantly changing variables; the rate of dissipation of the excess pore pressure and the rate of change in sample height. Nevertheless, it can be seen that as the material consolidates, the flow rate due to the hydraulic gradient will decrease with time whereas electroosmotic flow will increase. Thus, if the initial k_h value is great enough, hydraulic flow will account for a greater portion of the total flow rate initially and electro-osmotic flow will become more significant as the material consolidates.

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[1]According to Kozeny-Carmen equation where e is the void ratio (5,6).

EXPERIMENTAL APPARATUS AND TESTING PROCEDURE

The experimental apparatus[2] consisted of two Lexan cells having an inside cross-sectional area of 61.81 cm^2. One of the cells served as reference for the other cell. This enabled the variability of the slurries from test to test to be factored out.

The bottom of the cell (cathode) was made of stainless steel #200 mesh screen and supported by a stainless steel, perforated plate. This plate was supported by another stainless steel plate that was attached to the frame and was tapered down towards the center to funnel the removed water out. This exit was valved to prevent water from escaping prematurely and allowed the pressure and electrical potentials to be applied before the test was started. Pressure was applied using an air cylinder to press a graphite-faced, stainless steel plate down onto the slurry. The plate was sealed with o-rings. A perforation in the pressure plate was fitted with a zerk to remove the air when inserting the plate into the cell.

A computer data acquisition system was interfaced to the testing apparatus so that a number of different variables could be monitored frequently and rapidly. The monitored and recorded variables include voltage, current, slurry depth, the weight of water removed and elapsed time.

A slurry sample was collected randomly as the cell was filled. This sample was used to determine the initial solids content, zeta potential and particle size distribution. Zeta potentials were determined on a Komline-Sanderson Model ZR-12S Zeta Reader and particle size distributions were

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[2]See Figure 1 of Part II.

determined on a Leeds & Northrup Model 7991-0 Microtrac particle size analyzer.

After dewatering, the support plates were removed, the sample was extruded and the solids content was determined. The recorded raw data were then printed out as well as the computed incremental data including water removed, dewatering rate, current density, resistance, depth, accumulative electrical energy consumed and mechanical work done.

RESULTS AND DISCUSSION

Materials

Coal slurries of 40% solids by weight were prepared using Illinois #6 coal from Peabody Coal Company, River King Mine, St. Clair County, Freeburg, Illinois. The lignite slurries[3] were received from the University of North Dakota Energy Research Center where they were prepared in the hot-water-drying Process Development Unit (PDU) from Indian Head lignite. The red mud[3] (bauxite preparation waste) and phosphate slime[3] were received from the Tuscaloosa Research Center, Bureau of Mines, U. S. Department of Interior, University, Alabama. The kaolinite slurries[3] (Lustra Slurries) were received from the Freeport Kaolin Company, Gordon, Georgia.

Zeta Potential Modification

When the zeta potentials were determined, it was found, in many cases, that the specific conductivity was greater than 2 mmho/cm. Since the maximun allowable specific conductivity on the Zeta Reader is 2 mmho/cm, all samples were prepared by combining 2 g of solids/liter of deionized water. This reduced the electrolyte concentration and thus, the specific conductivity which allowed a zeta potential to be determined. However, dilution expands the electric double layer, so the zeta potentails obtained were not the 'true' zeta potentials and were used as a relative measure of potential. In order to find a compound that effectively increased the magnitude of the negative zeta potential while minimizing the specific con-

[3]See Appendix B for particle size distribution.

ductivity and the cost, a coal slurry zeta potential - chemical additive study was conducted using various selected compounds. Increasing the zeta potential increases the dewatering rate and by minimizing the specific conductivity, more of the electrical energy is used to transport water.

Figure 1 shows the five most effective compounds found in the zeta potential modification study. The results are plotted as change in zeta potential to remove the variability of the coal samples versus total cost. Total cost is defined as the cost of the compound addition times the specific conductivity since an increase in specific conductivity can also be taken as a cost to the process. As can be seen in Figure 1, the test results showed that Calgon, sodium hexametaphosphate buffered with sodium carbonate, was the most effective in increasing the magnitude of the zeta potential with a low total cost. Ammonium oxalate, sodium carbonate, sodium hydroxide and sodium oxalate were also effective but at a slightly higher cost and/or smaller increase in the magnitude of the zeta potential.

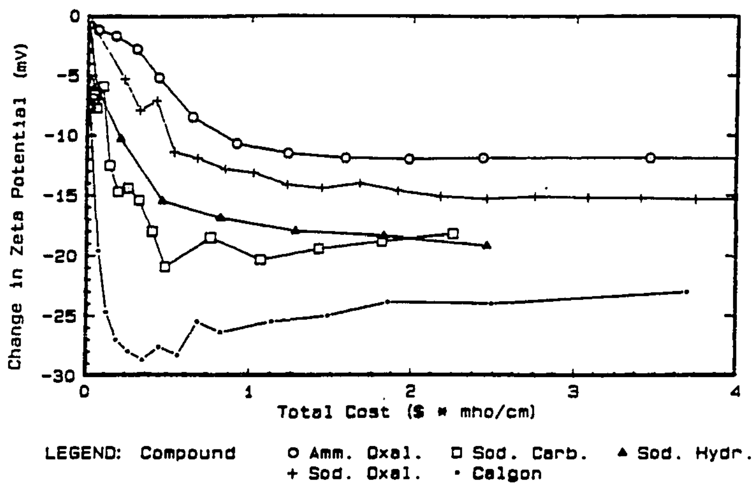

Figure 1. The five most effective compounds in increasing the magnitude of the zeta potential at a low total cost

Pressurized Electroosmotic Dewatering

The PED test results showed, as expected, that the dewatering rate was initially high due to the hydraulic potential. The flow rate then tapered off and electroosmotic dewatering became dominant. This effect was only observed when the initial hydraulic conductivity was high and the suspension particles were not small enough to plug the pores of the filter. As shown in Figure 2, the use of electroosmosis in conjunction with pressure increases the initial dewatering rate over that of pressure dewatering.

In several PED tests, it was found that the resistance initially decreased then increased, as typically shown in Figure 3. The resistance cannot be lowered since water is continuously being removed. However, the resistance is computed from the measured voltage and current and this drop in resistance occurs congruently with a high dewatering rate. This can be seen by comparing Figures 2 and 3. The initial resistance drop is explainable by the existence of a streaming potential which would have a polarity opposite to that of the applied potential. Thus, the measured voltage is less than the actual applied voltage. The resistance then increases with water removal and when most of the water is removed, heat generation increases the resistance further.

Figure 4 shows the cake depth versus the water removed for a lignite slurry that was heated to 60°C. The lignite slurry that was dewatered using PED had a higher initial solids content than did the slurry that was dewatered by pressure alone, 54.5% and 45.0% solids by weight, respectively. Thus, the maximum consolidation or minimum depth obtainable was different. The important observation that can be made is that after

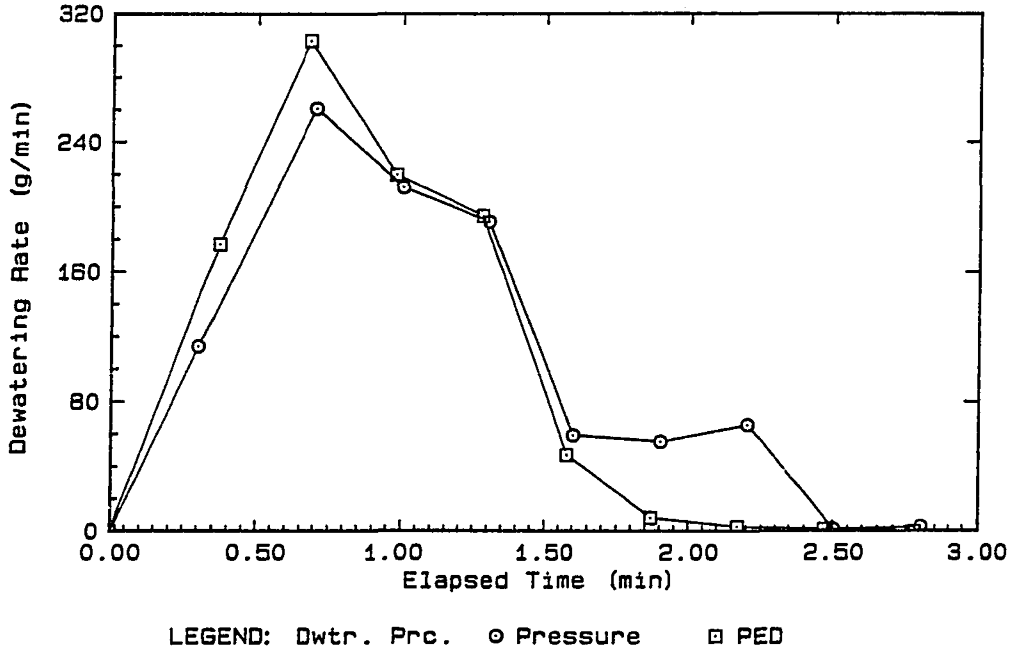

Figure 2. Dewatering rate versus time for a 10% solids coal slurry comparing pressure and PED (voltage=50 VDC) at a pressure of 759 kN/m^2

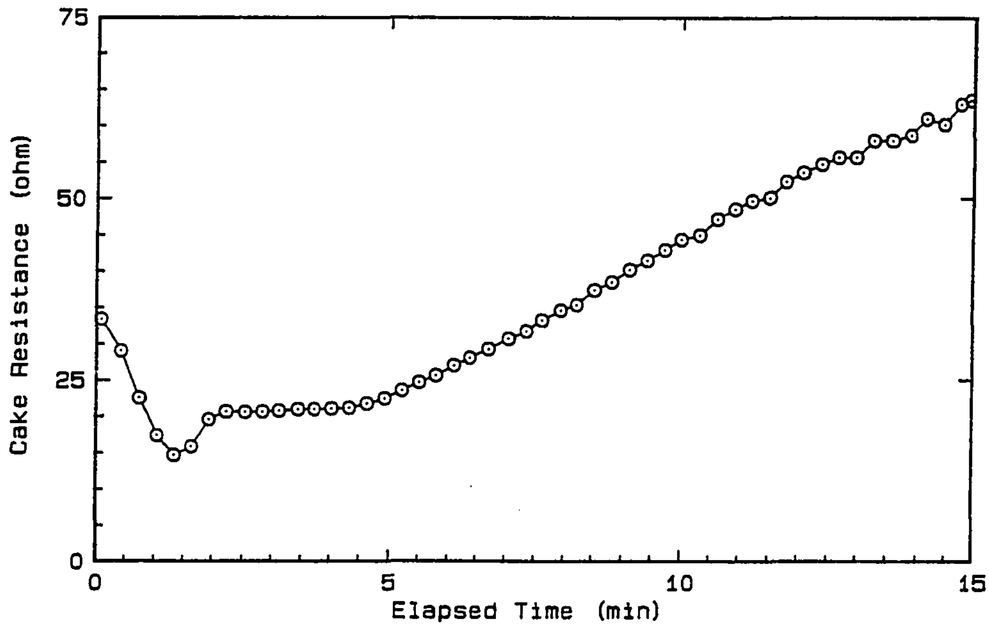

Figure 3. Computed resistance versus time for a 10% solids coal slurry using PED, voltage=50 VDC and pressure=759 kN/m^2

the slurry cake was completely consolidated, electroosmosis continued to remove water.

The lignite slurry was still fairly viscous at 60°C, had a high initial solids content, possessed a high zeta potential, (-71 mV), and exhibited a particle size distribution that enabled good consolidation. These factors were near optimum and magnified the effectiveness of PED which can be seen in Figure 5 showing the water removed versus elapsed time. These are the same lignite slurries as previously mentioned as having a difference in initial solids content, so one must remember that the pressure dewatered slurry had more water available for removal. One can see that the dewatering rate is greater with PED than with pressure alone. Also, it shows that with time, pressure dewatering may eventually remove an equivalent amount of water as PED.

In this case, Figure 5 indicates that the equilibrium between the electroosmotic driving force and the induced hydraulic gradient is established quickly as noted by the abrupt change in the slope or dewatering rate of PED.

With the application of an electrical field, the dissociated ions are attracted to the electrodes. Since the water is free to drain at the cathode, cations are washed out with the water. Carbonation then takes place in the collected water giving it a milky or turbid appearance. These carbonates then precipitate out.

Given in Table 1 are some typical results of various slurries that have been tested. These slurries were tested as received and were not modified in any way prior to testing.

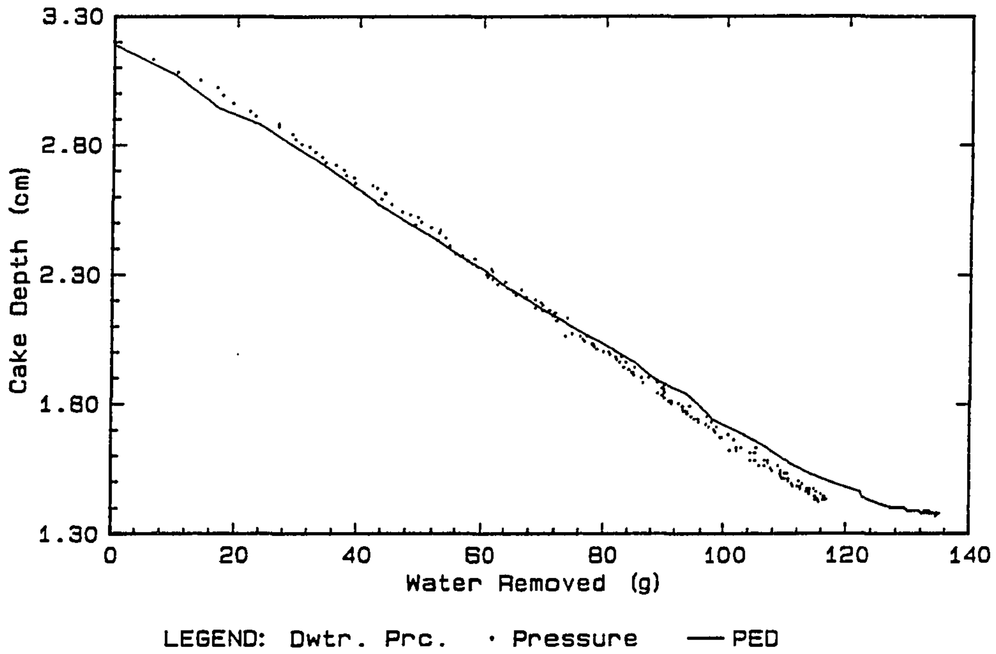

Figure 4. Cake depth for a 50% solids lignite slurry comparing pressure dewatering and PED (voltage=50 VDC) at a pressure of 759 kN/m^2

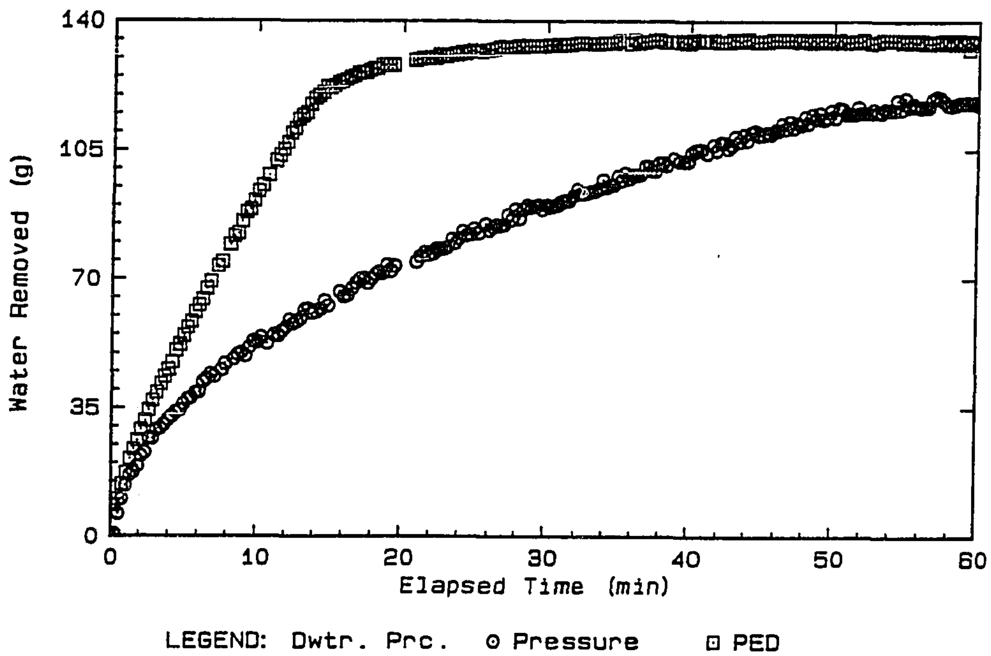

Figure 5. Water removed for a 50% solids lignite slurry comparing pressure dewatering and PED (voltage=50 VDC) at a pressure of 759 kN/m^2

Table 1. Typical test results for various slurries tested as received

Slurry	Zeta Pot. (mV)	PED Init. (% SS)	PED Final (% SS)	PED Time (min)	Pressure Init. (% SS)	Pressure Final (% SS)	Pressure Time (min)
Kaolinite	-19.1	58.7	87.1	80	58.7	58.7	90
Red Mud	-10.3	25.7	64.9	17	33.8	63.9	30
Phosphate Slime	-22.2	2.6	63.4	21	2.8	6.3	30
Lignite	-71.0	54.5	73.1	28	45.0	62.3	60

CONCLUSIONS

The research completed thus far has shown that the PED process is a very effective means of dewatering fine-grained material. Also, it has been proven to be applicable to all types of slurries, slimes and sludges. The results show that the final moisture content can be substantially reduced and/or obtained in a greatly reduced time. For example, final moisture contents of 15 to 20% by total weight have been accomplished in less than 10 minutes for 40% solids coal slurries having a top particle size of 40 micrometers.

The PED process can be economically improved by increasing the magnitude of the zeta potential such that the dewatering rate is increased and thereby, reduces the electrical energy consumption. Lower moisture contents are obtainable for material having a particle size distribution which augments packing density upon consolidation while pore saturation is maintained.

ACKNOWLEDGEMENT

The research on ultra-fine coal suspension dewatering is being performed for the Ames Laboratory, operated under Contract Number W-7405-Eng-82, and is supported by the Assistant Secretary of Fossil Energy, Division of Coal Utilization, through the Pittsburgh Energy Technology Center, Coal Preparation Branch.

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PART II. AUGMENTING RESEARCH WITH A MICROCOMPUTER

ABSTRACT

A microcomputer automated data acquisition system was built to conduct testing for a study in pressurized electroosmotic dewatering (PED) of ultra-fine particulate suspensions. The PED research project required numerous variables to be recorded in a short time. In previous research, manual data recording greatly increased the elapsed time between observation cycles. By using a microcomputer to collect and record data, a substantial increase in data accumulation was realized. The increase in the quantity of data and the reduction in cycle time not only enhanced the reliability of the PED data, but also provided evidence of a short-lived phenomena that would have otherwise gone unnoticed under manual data recording.

Additional software was developed to reduce the raw data, calculate incremental data, prepare data files to enable uploading to a mainframe computer for statistical analysis, plot the raw, incremental and computed data on an x-y plotter and, of course, printout the raw data.

Data collection automation has allowed more tests to be run, a greater number of testing situations to be addressed and testing of more material types. This enhancement of research increases the ability to address field situations.

AUGMENTING RESEARCH WITH A MICROCOMPUTER

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INTRODUCTION

Since the advent of the microcomputer in the late 1970s, numerous instrument interfaces and data acquisition systems have become available. However, these systems are sometimes expensive or specialized to an extent that any generic application is difficult. If one tries to build an interface, it can be quite complex because of the nonstandardized operating languages found especially in electronic instruments designed early in the microcomputer age.

In this project a PET/CBM[1] Series 2001/32K with a Basic 4.0 upgrade microcomputer was used to monitor pressurized electroosmotic dewatering (PED) research tests. The computer was interfaced with an Instruments Division, Measurements Group, Vishay/Ellis (V/E) 220 Strain Gage Instrumentation System to monitor pressure, displacement and weight of water removed using a pressure transducer, a linear variable differential transformer (LVDT) and a strain gage on a cantilever, respectively. The current and voltage were measured using an analog to digital (A/D) converter.

The collected data were sequentially stored on a CBM 8050 Dual Drive Floppy Disk and printed out at the conclusion of the test run on a CBM 8023P Tractor Printer. The raw and calculated data were plotted on a Hewlett-Packard 7220C Graphics Plotter.

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[1]CBM and PET are trademarks of Commodore Business Machines, Inc.

SCOPE OF STUDY

The objective of the research project was to investigate the influence of particle size distribution and zeta potential on PED of ultra-fine coal suspensions. Because of the variability of coal, it was necessary to run two tests simultaneously such that one test was a reference to the other to remove this variability when analyzing the results.

Originally, it was intended to monitor with respect to elapsed time the slurry temperature, pore water pressure at the top and bottom of the cake, the applied pressure, cake depth, voltage, current and the quantity of water removed. In addition, the electrochemical effects on the cake were to be quantitatively analyzed using X-ray diffraction (XRD). However, as with many research projects, limited funding prevented purchasing the devices required to collect data on the slurry temperature and pore water pressures as well as restricting the XRD usage.

Nonetheless, the number of variables that could be monitored for both cells were excessive if data acquisition was to be done manually and still preserve the integrity of the tests.

SYSTEM ORGANIZATION

Hardware

Figure 1 shows the computer and associated interfaced instrumentation and research equipment. To increase the speed of data collection and reduce the software requirements, the PET's IEEE 488 Bus (GPIB) port was used. This allowed the V/E system's interface to be daisy-chained, as shown in Figure 1, by assigning it a device number. This interface was assigned device number 5 since this number is normally used for modem communications and does not require software secondary addresses to define the information as an input or output. All of the devices, i.e. pressure transducers, LVDTs and strain gages that were monitored by the V/E, were wired in full-bridge circuitry.

Software

Since the V/E system's output was in binary coded decimel (BCD) language, the software was written to convert the eight-bit input. Simultaneously, the converted input was entered into the associated channel and device calibration curve to define a real number before the data was stored. Data could have been collected at a much faster rate except that before inputting data after a channel advance on the V/E, a time delay of one to two seconds was required because of the systems archaic slowness, i.e. in respect to today's computer systems. Thus, the elapsed time at which each observation was made, rather than for one complete cycle, was collected and recorded using the PET's internal clock.

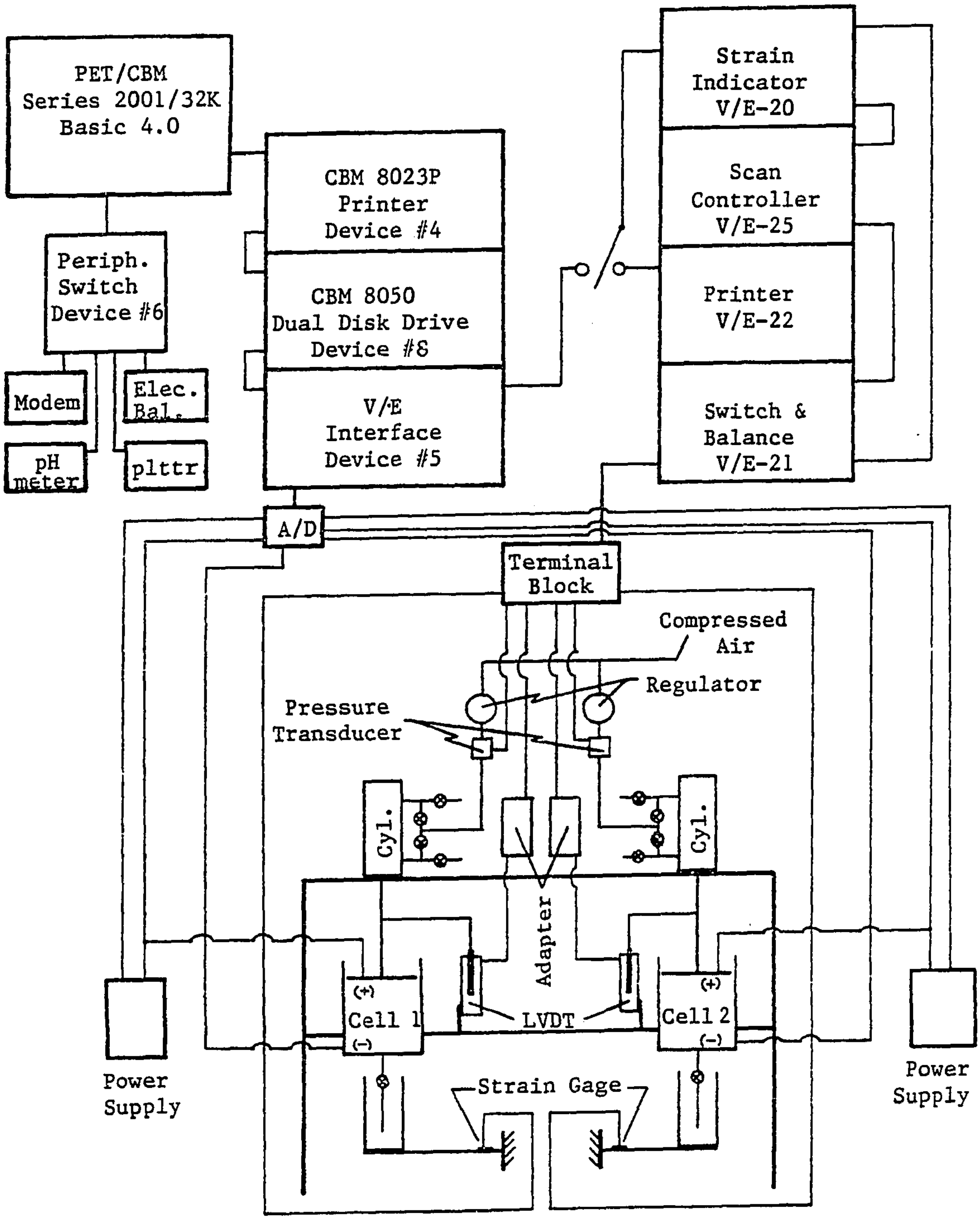

Figure 1. Computer, interface and research equipment organization.

Prior to each test run, variables such as voltage, pressure, test identification filenames, date, and zero depth reference were preset. In the same program, the V/E was initialized and the total elapsed time for the test was entered.

All of the preset data were stored in a sequential file. The memory was then cleared and upon chain-loading the data acquisition software, the preset data were read back into the memory. This minimized the memory usage of nonessential variables and thereby minimized the run time of the data acquisition software. The run time could have been further reduced had there been a compiler available. Nonetheless, a complete observation cycle in which, for both cells, 10 variables and the elapsed time for each were collected and recorded in 15 to 20 seconds.

Although both cells were normally used for a test run, software was also developed such that a test could be conducted in either cell independently. Additional software was developed to reduce the raw data, calculate incremental data, prepare data files to enable uploading to a mainframe computer for statistical analysis, plot the raw, incremental and computed data on an x-y plotter and, of course, printout the raw data. Other software was developed to reduce the zeta potential modification test data and prepare the reduced data for uploading. Existing communication programs were modified so that the PET and mainframe could communicate at a baudrate of 1200 bps. A program was written on the mainframe to massage the SAS/GRAPH™ files prior to downloading so the files could be stored on the disk drive and erased from the mainframe's storage bank. Programs were also written to continuously download a number of SAS/GRAPH files and erase them from the mainframe's storage bank and to continuously download all of the other files in the mainframe's storage banks for backup.

All of the developed software is presented in Appendix A. Figures 2 through 5 present examples of the printouts of the software.

PRESSURIZED ELECTROOSMOTIC DEWATERING

PED

Test Code : ABRV53Z1
Date Tested : 16-FEB-85

Cum. H2O (g)	ET (min)	Depth (cm)	ET (min)	Current (mA)	ET (min)	Voltage (V)	ET (min)	Press. (psi)	ET (min)
.0	.00	3.32	.05	2012	.08	49.7	.08	108.8	.13
37.3	.40	2.65	.43	2012	.47	50.3	.47	108.3	.53
70.1	.72	2.10	.75	2012	.78	49.3	.78	108.4	.85
95.9	1.00	1.70	1.03	2012	1.07	49.3	1.07	108.6	1.13
108.4	1.28	1.60	1.32	2012	1.33	50.1	1.35	108.8	1.42
113.3	1.57	1.58	1.60	1768	1.62	50.5	1.63	108.8	1.68
115.4	1.83	1.58	1.87	1537	1.90	50.5	1.90	108.8	1.97
117.6	2.12	1.58	2.15	1327	2.17	50.5	2.18	108.8	2.23
120.0	2.38	1.57	2.42	1186	2.43	50.5	2.45	108.7	2.50
121.7	2.65	1.57	2.68	1061	2.72	50.5	2.72	108.7	2.77
122.8	2.93	1.57	2.97	966	2.98	50.5	2.98	108.7	3.05
123.6	3.20	1.57	3.23	864	3.27	50.5	3.27	108.6	3.32
126.0	3.47	1.57	3.52	792	3.53	50.5	3.53	108.6	3.63
126.7	3.78	1.57	3.82	721	3.85	50.5	3.85	108.5	3.92
127.9	4.07	1.57	4.10	697	4.13	50.5	4.13	108.5	4.18
128.6	4.35	1.57	4.38	657	4.42	50.5	4.42	108.4	4.48
128.7	4.62	1.57	4.67	610	4.68	50.5	4.68	108.4	4.75
128.9	4.90	1.57	4.93	602	4.97	50.5	4.97	108.3	5.02
129.5	5.17	1.57	5.20	562	5.23	50.5	5.23	108.3	5.28
129.4	5.43	1.57	5.47	538	5.50	50.5	5.50	108.2	5.55
129.5	5.72	1.57	5.75	538	5.77	50.5	5.77	108.2	5.85
130.0	5.98	1.57	6.03	522	6.05	50.5	6.05	108.2	6.12
130.7	6.27	1.57	6.30	498	6.33	50.5	6.33	108.1	6.38
130.3	6.53	1.57	6.58	490	6.60	50.5	6.60	108.1	6.67
130.3	6.82	1.57	6.87	458	6.88	50.5	6.88	108.1	6.95
130.8	7.08	1.57	7.13	450	7.15	50.5	7.15	108.0	7.23
131.1	7.38	1.57	7.42	434	7.43	50.5	7.45	108.0	7.52
131.1	7.67	1.57	7.70	434	7.72	50.5	7.73	108.0	7.78
131.3	7.93	1.56	7.97	434	8.00	50.5	8.00	108.0	8.10
131.8	8.25	1.57	8.28	410	8.32	50.5	8.32	108.0	8.37
131.5	8.52	1.57	8.57	402	8.58	50.5	8.58	108.0	8.65
131.9	8.78	1.57	8.83	394	8.85	50.5	8.85	108.0	8.93
132.1	9.08	1.57	9.12	394	9.15	50.5	9.15	107.9	9.22
132.4	9.37	1.57	9.40	377	9.42	50.5	9.43	107.9	9.48
132.4	9.63	1.57	9.67	369	9.70	50.5	9.70	107.9	9.75
132.6	9.92	1.57	9.95	386	9.98	50.5	10.00	107.9	10.05
132.3	10.20	1.57	10.25	377	10.27	50.5	10.27	107.9	10.33
132.7	10.48	1.57	10.55	353	10.58	50.5	10.58	107.9	10.65
132.7	10.80	1.56	10.83	345	10.85	50.5	10.87	107.9	10.92
133.2	11.08	1.56	11.12	369	11.13	50.5	11.15	107.9	11.20

Page 1 of 2

Figure 2. Example of the PED test raw data printout

PRESSURIZED ELECTROOSMOTIC DEWATERING

PED

Test Code : ABRV53Z1
Date Tested : 16-FEB-85

ΔH_2O (g)	Dwtr. Rate (g/min)	Volt. Grad. (V/cm)	Current Density (mA/cm2)	R (ohm)	Δl (cm)	Cumulative Work Elec. (kW-hr)	Cumulative Work Mech. (J)
+ .0	+ .0	15.0	32.55	24.7	-3.32	.000	0
+ 37.3	+ 93.3	19.0	32.55	25.0	+ .67	.000	31
+ 32.8	+102.5	23.5	32.55	24.5	+ .55	.001	57
+ 25.8	+ 92.1	29.0	32.55	24.5	+ .40	.002	76
+ 12.5	+ 44.6	31.3	32.55	24.9	+ .10	.003	81
+ 4.9	+ 16.9	32.0	28.61	28.6	+ .02	.004	82
+ 2.1	+ 8.1	32.0	24.87	32.9	+ .00	.005	82
+ 2.2	+ 7.6	32.0	21.47	38.1	+ .00	.006	82
+ 2.4	+ 9.2	32.2	19.19	42.6	+ .01	.007	82
+ 1.7	+ 6.3	32.2	17.17	47.6	+ .00	.008	82
+ 1.1	+ 3.9	32.2	15.63	52.3	+ .00	.009	82
+ .8	+ 3.0	32.2	13.98	58.4	+ .00	.010	82
+ 2.4	+ 8.9	32.2	12.81	63.8	+ .00	.011	82
+ .7	+ 2.3	32.2	11.67	70.0	+ .00	.012	82
+ 1.2	+ 4.1	32.2	11.28	72.5	+ .00	.013	82
+ .7	+ 2.5	32.2	10.63	76.9	+ .00	.014	82
+ .1	+ .4	32.2	9.87	82.8	+ .00	.015	82
+ .2	+ .7	32.2	9.74	83.9	+ .00	.016	82
+ .6	+ 2.2	32.2	9.09	89.9	+ .00	.017	82
- .1	- .4	32.2	8.70	93.9	+ .00	.018	82
+ .1	+ .3	32.2	8.70	93.9	+ .00	.019	82
+ .5	+ 1.9	32.2	8.45	96.7	+ .00	.020	82
+ .7	+ 2.4	32.2	8.06	101.4	+ .00	.021	82
- .4	- 1.5	32.2	7.93	103.1	+ .00	.022	82
+ .0	+ .0	32.2	7.41	110.3	+ .00	.023	82
+ .5	+ 1.9	32.2	7.28	112.2	+ .00	.024	82
+ .3	+ 1.0	32.2	7.02	116.4	+ .00	.025	82
+ .0	+ .0	32.2	7.02	116.4	+ .00	.026	82
+ .2	+ .8	32.4	7.02	116.4	+ .01	.027	82
+ .5	+ 1.6	32.2	6.63	123.2	- .01	.028	82
- .3	- 1.1	32.2	6.50	125.6	+ .00	.029	82
+ .4	+ 1.5	32.2	6.37	128.2	+ .00	.030	82
+ .2	+ .7	32.2	6.37	128.2	+ .00	.032	82
+ .3	+ 1.0	32.2	6.10	134.0	+ .00	.034	82
+ .0	+ .0	32.2	5.97	136.9	+ .00	.036	82
+ .2	+ .7	32.2	6.25	130.8	+ .00	.038	82
- .3	- 1.1	32.2	6.10	134.0	+ .00	.040	82
+ .4	+ 1.4	32.2	5.71	143.1	+ .00	.042	82
+ .0	+ .0	32.4	5.58	146.4	+ .01	.044	82
+ .5	+ 1.8	32.4	5.97	136.9	+ .00	.046	82

Page 1 of 2

Figure 3. Example of the PED test calculated data printout.

PRESSURIZED ELECTROOSMOTIC DEWATERING

PED

Test Code : AXDV33Z10
Date Tested : 21-MAY-85

Initial voltage	30.1	V
Initial pressure	100.8	psi
Elapsed Time	15	min
Empty depth	5.08	cm
Initial water added	.00	g

V/E balance adjustment:

Channel 0 = - 290.00

Channel 1 = + 2.33

Channel 4 = - 236.33

Test conducted in cell no. 1

Figure 4. Example of the PED test initialization variables printout.

Zeta Potential Investigation

Test Code - CAL1G1

Final Concentration (M)	Zeta Potential (mV)	Specific Conductivity (μmhos/cm)	Temperature (C)
0.000000000	-25.5	112	27.2
0.000005632	-28.3	122	27.8
0.000011264	-28.4	129	28.1
0.000022525	-31.0	142	28.7
0.000045039	-32.9	167	29.6
0.000090028	-35.5	216	30.3
0.000168641	-45.1	305	30.9
0.000224700	-50.2	377	31.4
0.000280683	-52.5	452	32.0
0.000336588	-53.5	528	32.4
0.000392417	-54.2	607	33.2
0.000448169	-53.1	682	33.6
0.000503845	-53.8	765	34.5
0.000559444	-51.0	835	34.6
0.000614968	-51.9	908	34.8
0.000725787	-51.8	1059	35.8
0.000836304	-50.5	1199	35.9
0.000946520	-49.4	1329	36.1
0.001111282	-49.5	1524	36.4
0.001384397	-48.5	1818	36.7

Figure 5. Example of the zeta potential modification test calculated data printout.

DISCUSSION

The biggest advantage to computerized automated data acquisition is that the investigator is freed to more closely observe the test as it progresses. This allows one to draw conclusions from the results that may otherwise be unsubstantiated and require another test to be run.

Also, because of the number of observations taken in a short time, evidence of short-lived phenomena can be obtained. These occurrences may go completely unnoticed if manual data recording is used. A prime example of this was found in this project where the existence of a streaming potential was assumed not to occur when data were collected manually. With the present computerized data acquisition system, evidence that a streaming potential could have occurred was obtained. However, to fully substantiate this occurrence, non-polarizable electrodes must be used. Nonetheless, it is now realized that a streaming potential may exist.

Another advantage to computerization is that once the raw data have been collected and recorded, the computer can then be used to reduce the data and remove the tedium of doing so manually. Also, the data may be analyzed in many more approaches. This enables more tests to be run because of the shortened time in reducing the raw data. Because more tests can be run, the basic testing of a research project can be completed more quickly and allow specific testing, e.g., into various field situations. In this project, numerous types of slurried materials other than coal suspensions were tested using PED for various industries concerned with the dewatering of fine-grained materials.

One major disadvantage to any computer software that cannot be overlooked is the phenomena of 'GIGO' - garbage in, garbage out. Thus, one must thoroughly understand the computer system and the operation of each device the computer communicates with. If one does not completely understand the system or even if one does, for the sake of checking, a full array of tests covering the occurrence of any possible event must be performed with knowledge ot the outcome beforehand. The required extent of one's computer knowledge, obviously, depends on the involvement in software development or as in many cases, the amount of financial support available to contract software development.

CONCLUSION

Using a microcomputer for research data acquisition enhanced not only the volume of data collected but also the quality and the field applicability. Short-lived occurrences were detected and a better understanding of the testing was gained.

With time, it can be forseen that microcomputers will become a common part of experimental programs, especially as computer systems become more standardized, versatile and inexpensive.

ACKNOWLEDGEMENT

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PART III. FINE COAL DEWATERING BY PRESSURIZED ELECTROOSMOSIS

ABSTRACT

Increasing quantities of fine coal are being generated with the introduction of new deep cleaning methods. In response, improved fine coal recovery processes are being developed. Current dewatering techniques for fine coal suspensions are either expensive or not as effective as required.

Many solid/liquid separation processes have been studied and some investigators have shown that electroosmotic dewatering of fine-grained material is promising. However, combining electroosmosis with pressure increases the dewatering rate and substantially reduces the final moisture content.

The electroosmotic flow rate is theoretically independent of the pore size and electroosmosis does not affect the intergranular pressure (effective stress). Also, the efficiency of electroosmosis decreases rapidly if the pores do not remain saturated. Thus, when electroosmosis is used for dewatering, consolidation must occur simultaneously with water removal to maintain pore saturation. If consolidation does not occur, an equilibrium state will be reached in which the flow of water ceases. Therefore, in the pressurized electroosmotic dewatering (PED) process, electroosmosis is utilized as the driving force on the pore water and the applied pressure is used to consolidate the material by increasing the intergranular pressure.

Automated laboratory bench tests have been conducted to optimize the PED process by controlling the parameters which affect the dewatering rate and the particulate consolidation of coal suspensions. The variables include zeta potential, voltage, particle size distribution and pressure.

FINE COAL DEWATERING BY PRESSURIZED ELECTROOSMOSIS

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Contract No. W-7405-Eng-82

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INTRODUCTION

New coal cleaning processes are making use of pulverization to improve mineral liberation and often, the resulting clean coal is in an aqueous state. State-of-the-art dewatering techniques are inadequate for these fine coal suspensions. The reason being that the movement of water within the particulate matrix is governed by the hydraulic conductivity which, for fine-grained material, is relatively low. Thus, subsequent expensive thermal drying is necessary. An approach by others (1,2) is to use extremely high consolidating pressures, 10,000 to 30,000 psi, which is also expensive in equipment maintenance and somewhat impractical.

Electroosmosis, the electrokinetic movement of water through a porous medium by an electrical field, is theoretically independent of pore size. However, electroosmosis has no influence on the intergranular or effective stress. Very little consolidation takes place when dewatering is done solely by electroosmosis. If the material does not consolidate equivalently with water removal, the pores become unsaturated. Once this occurs, the electroosmotic flow of water is terminated because electrical conductivity is governed by the pore saturation.

Pore saturation can be maintained by applying a pressure to the slurry. Initially, the applied pressure increases the pore water pressure and causes water to flow out of the particulate matrix. As this excess pore pressure dissipates, the load is transferred to the particles and thereby, increases the effective stress and consolidation is initiated.

By combining pressure and electroosmosis into a pressurized electroosmotic dewatering (PED) process, a more effective solid/liquid separation method is realized because of the dewatering enhancement.

THEORETICAL ASPECTS OF PED

A discussion of the theory has been presented in another publication (3) and thus, the reader is referred to it for a background in the combination of the hydraulic and electroosmotic water transport mechanisms. The particle size distribution (size consist[1]) influence and the grounds for the synergistic aspects will be presented herein.

The principle of superposition is directly applicable to hydraulic and electroosmotic flow rate provided the material undergoes no consolidation. However, superposition cannot be applied for the PED flow rate of water. This is because of the nonlinearity presented by the consolidation and water removal for which depth is continually changing. This changes the hydraulic and voltage gradients as well as the hydraulic conductivity and porosity. Therefore, in this study an experimental approach has been used to assess the results of the PED process.

Particle size distribution controls the degree of consolidation obtainable and thus, controls pore saturation for a given quantity of water. Since pore saturation affects the electroosmotic efficiency, a particle size distribution which enhances packing density is beneficial to the PED process. The Talbot formula expresses the particle size distribution which produces a maximum density as

$$p = 100\ (d/D)^{x} \qquad (9)$$

where p = weight percent finer than D

d = particle size

[1]Terminology used in other disciplines for particle size distribution.

D = maximum particle (top) size

x = exponent value depends on particle shape, $0.25 \leq x \geq 0.40$

Dewatering is enhanced in the PED process because of the consolidation provided by the applied pressure and fluid flow by pore size independent electroosmosis. The theoretical electroosmotic flow rate expression does indicate, however, a dependence on porosity. Hence, the consolidation does decrease the electroosmotic flow rate. The excess pore pressure is dissipated by water flowing from the particulate matrix and eletroosmosis augments the flow rate. Also, the hydraulic potential rapidly removes the water from the larger pores. The maintenance of the pore saturation increases the time that electroosmosis is effective. Therefore, the reduced electroosmotic flow rate due to the decreasing porosity is offset by the enhanced pore pressure dissipation and the prolonged duration of the electroosmotic effect.

RESULTS AND DISCUSSION

The following treatise describes the results of using three samples with different particle size distributions, as shown in Figure 1. Also shown in Figure 1 are the Talbot maximum density distribution ranges for top sizes of 425 and 176 micrometers. The sample identified as 'PSD R' represents the fraction of coal passing a #40 mesh sieve received from the Ames Coal Preparation Test Facility. The lump coal was size reduced at the test facility using a hammer mill with a #8 mesh screen. The sample 'PSD 1' was prepared by further grinding the coal received from the test facility (-#8 mesh) using a Tekmar-Fritsch Pulversette 14 Rotor Speed Mill with a 0.08 mm screen. The sample identified as 'PSD R1' was a 50/50 mix of 'PSD 1' and that fraction passing a #80 mesh sieve of the coal prepared at the plant.

The PED test results showed, as expected, that the dewatering rate was initially high due to the hydraulic potential. The flow rate then tapered off and electroosmotic dewatering became dominant, as shown in Figure 2. The water removed has been normalized by reporting the water removed as a percent of the initial water available to remove the effect of inconsistent initial slurry volumes. Figure 2 also shows that the dewatering rate due to electroosmosis is higher, as theory predicted, with a higher applied voltage.

Theory also predicts that a higher zeta potential should also increase the dewatering rate. To verify this prediction, coal slurry samples were treated with solutions of potential-determining ions to increase the zeta potential (3). The effect of increasing the zeta potential by using a pH

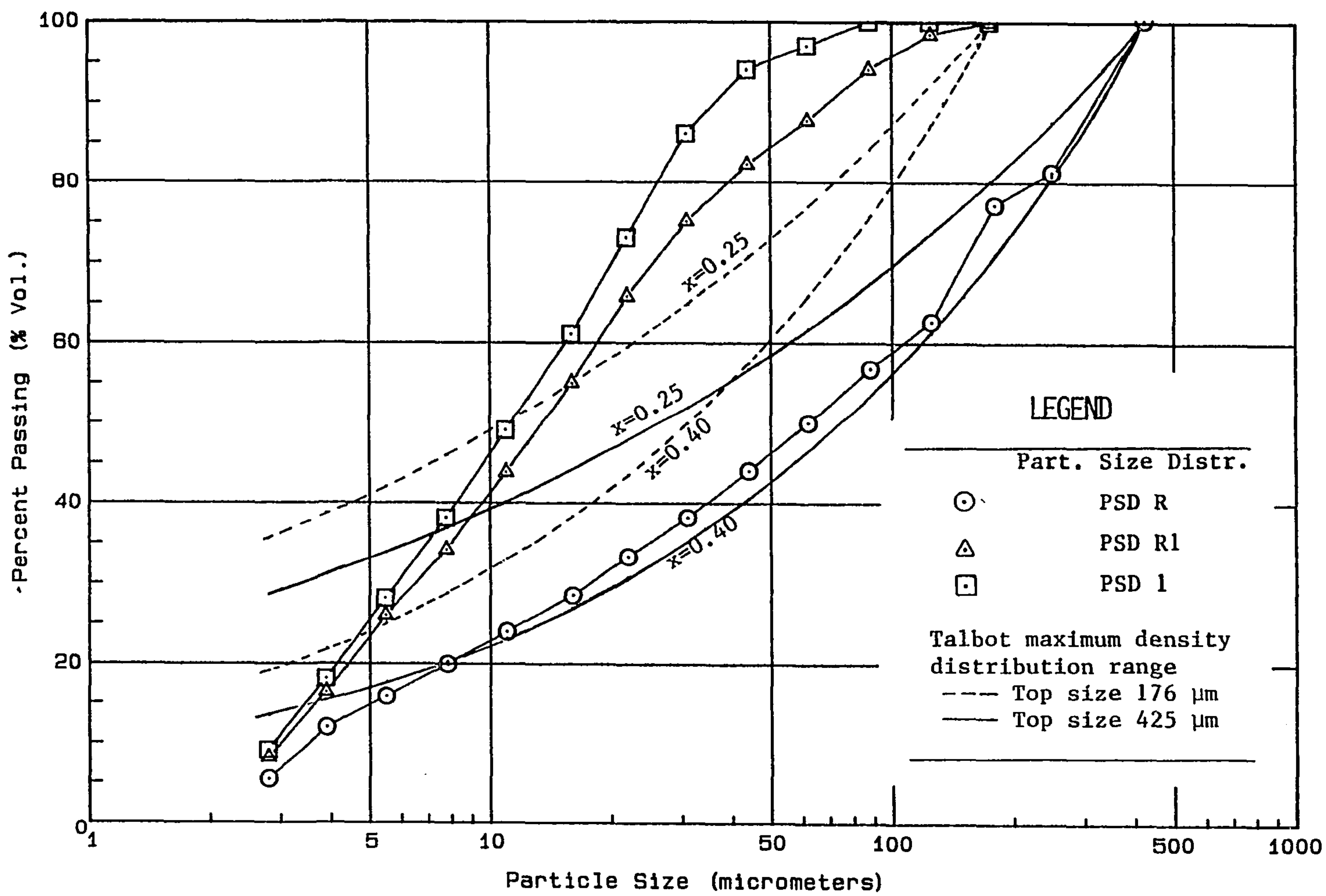

Figure 1. Particle size distributions of the three slurries

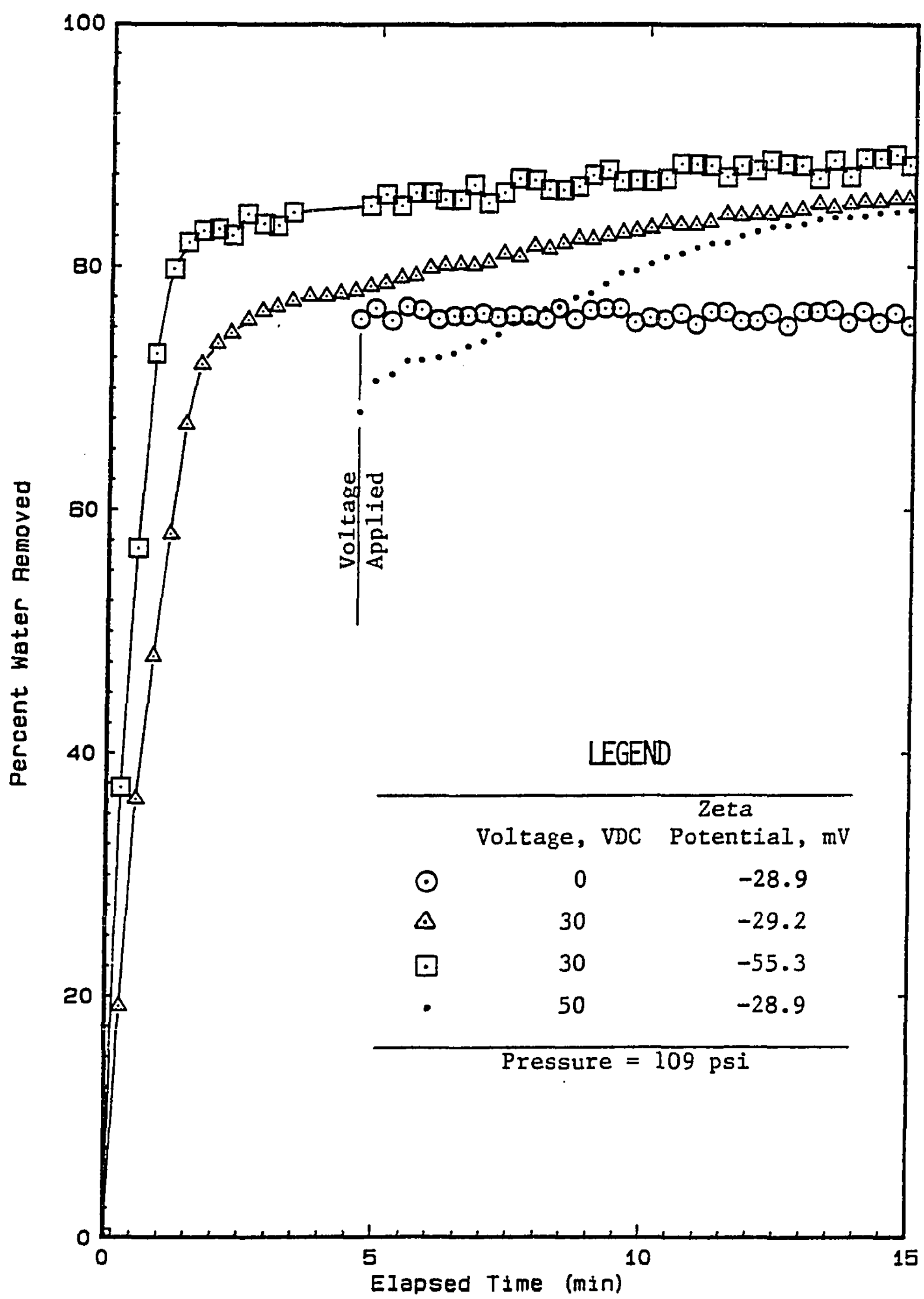

Figure 2. Water removed versus time for slurry PSD 1

10 buffer (potassium carbonate - potassium borate - potassium hydroxide) can be seen in the portion of the curves prior to the point of inflection in Figure 2. However, after a major portion of the water had been removed, the dewatering rate became equivalent to that of the unbuffered slurry. This may be due to the reduction in the buffer activity because of the reduced volume present and the inherent electrochemical reactions. However, it does show that the increase in zeta potential by the buffer did increase the potential to remove water.

Figure 3 shows that by increasing the zeta potential by buffering the slurry, more water was removed with an equivalent amount of electrical energy. It also shows that about the same amount of water was removed from the buffered slurry using a lower voltage than that used on the unbuffered slurry. Thus, by increasing the zeta potential, less electrical energy was used to remove the same amount of water.

Figure 4 shows the water removed versus time by using the same pressure and voltage for the three samples having different particle size distributions. One can see that the dewatering rate, or actually, the hydraulic conductivity, k_h, is greater for the as received, PSD R, coal. For the other two slurry particle size distributions, the initial dewatering rate is less but the dewatering rate due to electroosmosis is greater.

The reason that the electroosmotic portion of the dewatering rate is less for PSD R than the others, even though it had a particle size distribution more closely in the Talbot maximum density range, is that the larger particles settled out quickly. Thus, the particle size distribution was not homogeneous with depth. In addition, in each test that electroosmosis

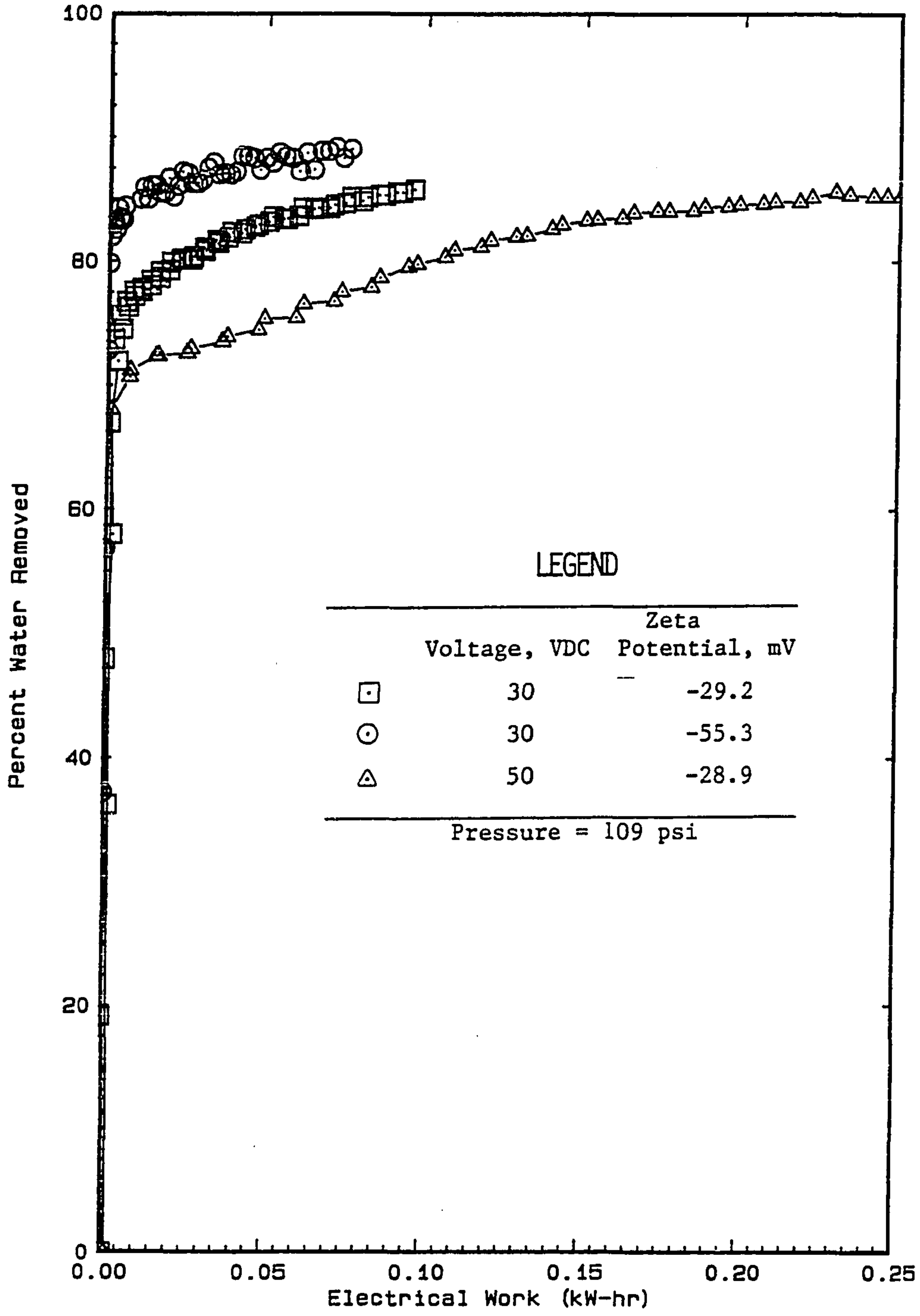

Figure 3. Water removed versus electrical work for slurry PSD 1

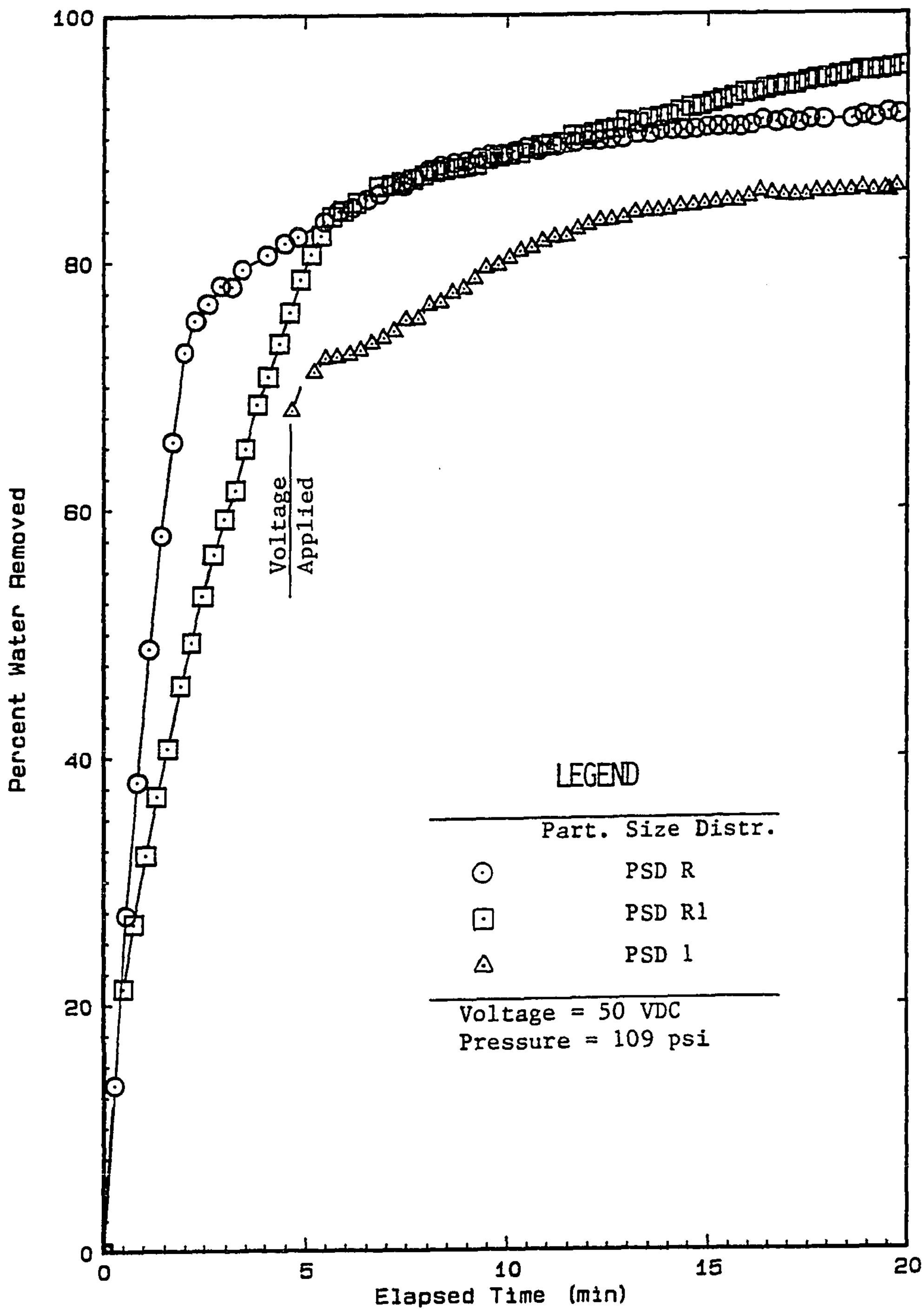

Figure 4. Water removed versus time for each of the slurries with different particle size distributions

was used, some of the small particles could have been attracted to the anode by electrophoresis which added to the nonhomogenity of the particle size distribution with depth. Because of this nonhomogenity, the degree of pore saturation may not have been uniform with depth. Electroosmosis was then less effective in removing water because pore saturation controls the electrical conductiviy. Also, because the degree of pore saturation was less, the resistance increased more rapidly with water removal for the PSD R coal slurry as can be seen in Figure 5.

The tests were run using a constant voltage, so as the resistance increased the current decreased. Power or electrical work is equal to voltage times current, P=VI, so in Figure 6 it appears that the electro-osmotic removal of water was more efficient because of the reduced power consumption. In reality, the efficiency in water removal was due to the higher hydraulic conductivity allowing pressure dewatering to be more effective.

The slope of a line tangent to a point is then the water removed per unit of consumed electrical energy. Thereby, Figure 5 shows that a good particle size distribution in which pore saturation is maintained, the electroosmotic removal of water is more efficient and more water can be removed because of the extended time that the pores are saturated. Thereby, making electroosmosis effective for a longer time.

In each test that electroosmosis was used, the water removed was turbid or milky in appearance. X-ray diffraction of the suspended and dissolved material showed that it was sodium sulfate and calcium carbonate. Whereas, the water removed by pressure was clear and on evaporation X-ray diffraction showed that the dissolved compound was calcium sulfate. This

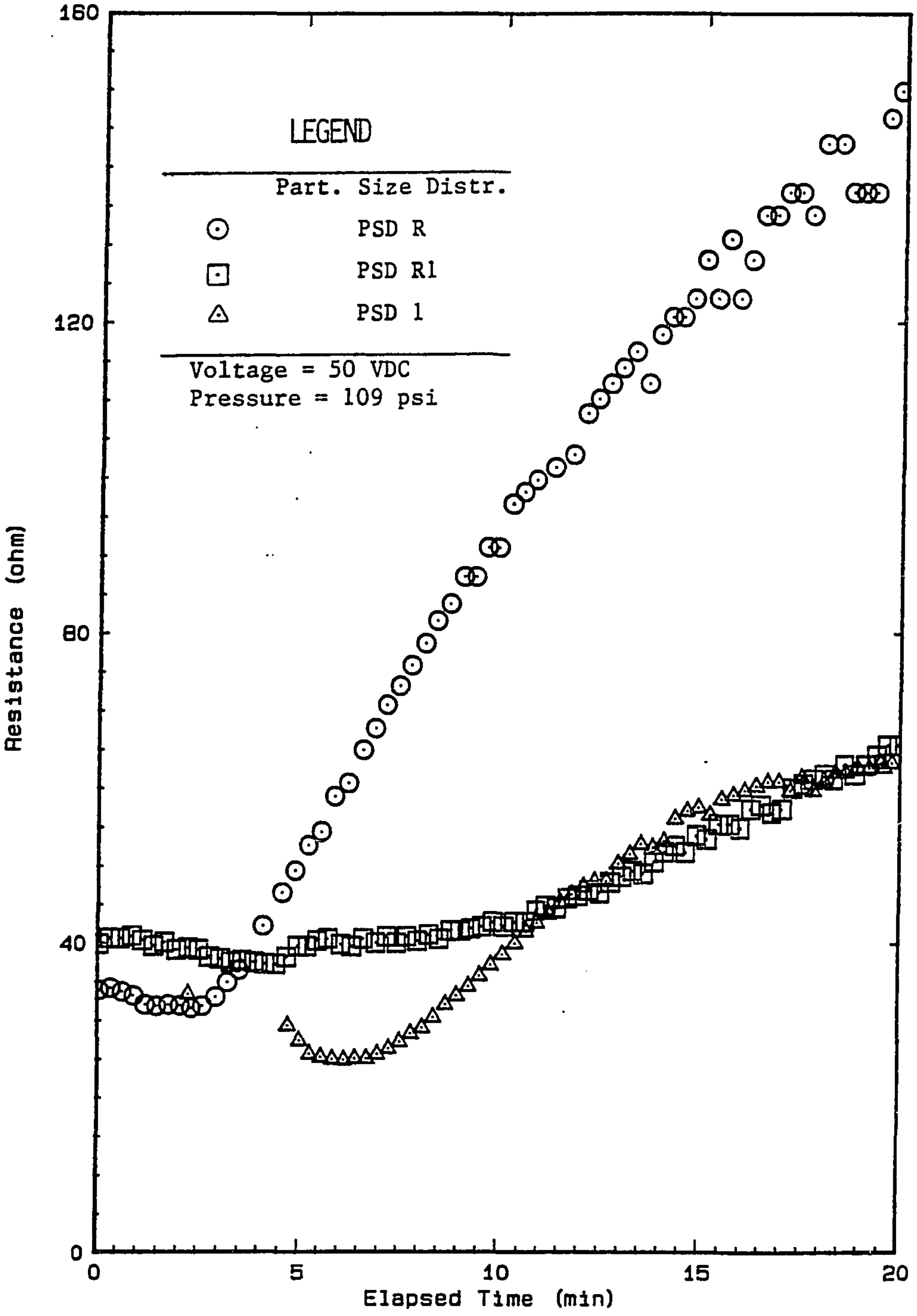

Figure 5. Resistance versus time for each of the slurries with different particle size distributions

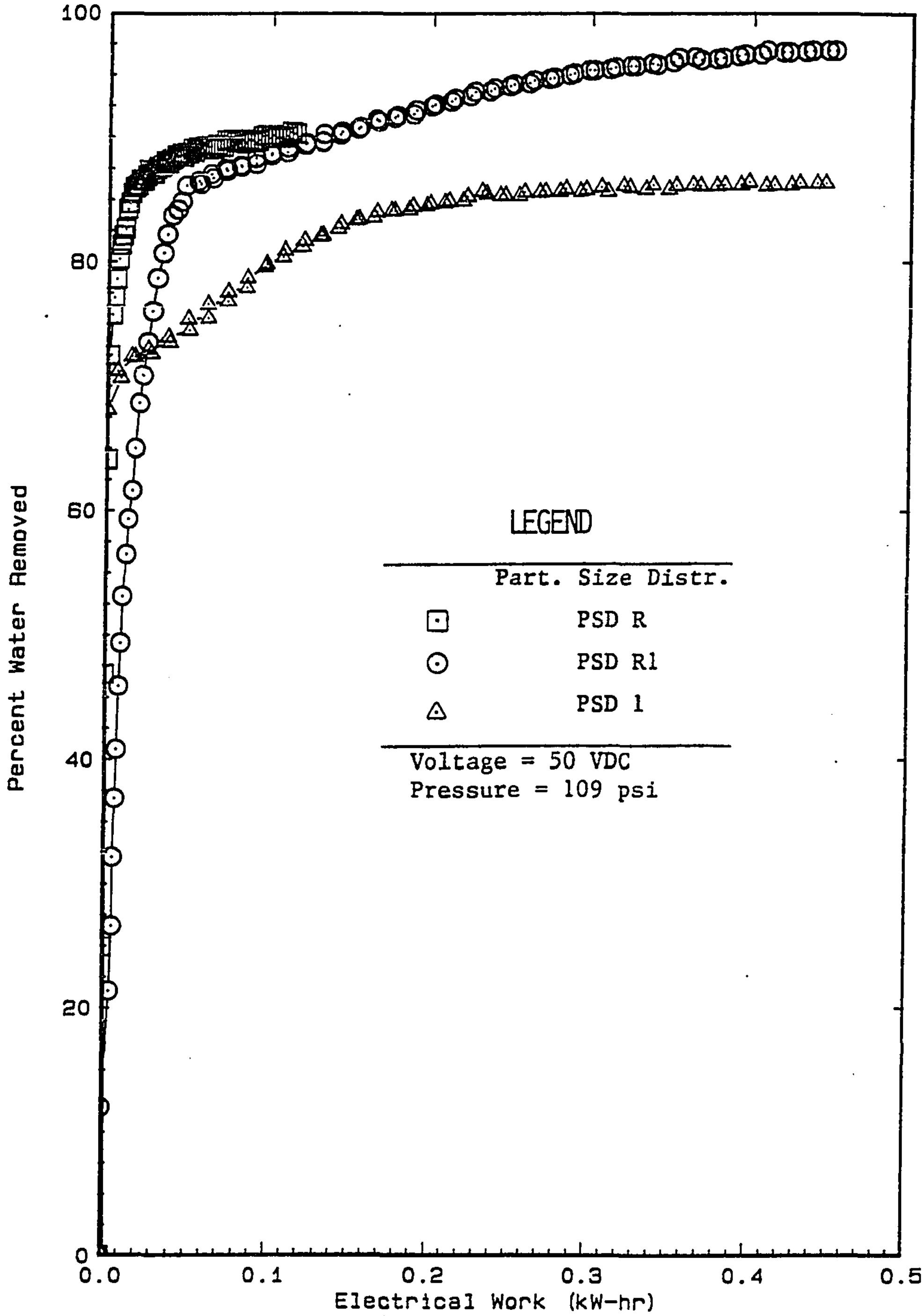

Figure 6. Water remove versus electrical work for each of the slurries with different particle size distributions

observation then also makes the application of a theoretical expression for electroosmotic flow rate questionable beca use of the usual theoretical assumption that no electrochemical reactions occur.

CONCLUSIONS

The results have shown that there are basically two characteristics of the coal slurries that can be economically and easily modified to improve the PED process. One is the particle size distribution which is very important in obtaining good consolidation so that pore saturation is maintained. Thereby, allowing the electroosmotic component of PED to be more effective such that more water is removed. Secondly, it has been found that modifying the zeta potential is also effective in increasing the initial dewatering rate and also increases the amount of water removed. Both of these observations are explainable by reasoning that the 'no flow' equilibrium between the electroosmotic driving force and the induced hydraulic gradient is not established as soon. The reduction in dewatering time reduces the consumed electrical energy. Thus, the degree of consolidation controls the achievable reduction in moisture content and the zeta potential controls the dewatering rate.

It has been found that in each test that the combination of electro-osmosis with pressure increased the dewatering rate as compared to dewatering by pressure alone.

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GENERAL SUMMARY AND RECOMMENDATIONS

The investigation has shown that the pressurized electroosmotic dewatering (PED) process is an effective method for solid/liquid separation of ultra-fine, i.e. smaller than 200 micrometers, coal suspensions. The PED process is also effective for many other slurries, sludges and slimes. Conceivably, the only suspension that PED could not be applied to is one that would be detrimently effected by the incurring electrochemical reactions. Also, the PED process would not be cost effective if the slurried material had previously undergone some type of flocculation or coagulation since, in general, the zeta potential is then reduced to the 0 to +/- 10 millivolt range.

In the PED process, electroosmosis provides the driving force on water in the relatively small pores and the pressure induces consolidation by increasing the effective stress. Pore saturation can be maintained for a longer period if the particulate material has a particle size distribution conducive to a maximum packing density. An increase in the magnitude of the zeta potential using chemical additives can cost effectively increase the flow rate.

It was found that a zeta potential modification not only increased the flow rate but also decreased the final moisture content. This is reasoned to be because of the increased electroosmotic potential delaying the establishment of the equilibrium between it and the opposing induced hydraulic gradient.

The effectiveness of the PED process is related to the depth of the slurry cake, in that the depth controls the hydraulic and voltage gradients. It is well known that the flow rate of water is greater for higher gradients in both cases. However, the amount of water remaining when the equilibrium is established is less when the gradients are higher. Greater depths could be used but the magnitude of the applied pressure and voltage required to obtained the same gradients may be limited by equipment restrictions.

For highly viscous materials such as the lignite slurry, the PED effectiveness is greater because the lesser dependence on viscosity.

Further study addressing the current density relationship of the PED process may be another step in improving the process. This would maximize the efficiency of the applied voltage and thereby, dewatering a greater volume for a given depth. Other investigators have shown that periodic current reversal can be used to offset the opposing induced hydraulic gradient caused by electroosmosis and any occurrence of desiccation. It follows that the elapsed time at which current reversal is initiated and the frequency of current reversal is dependent on the magnitude of the negative pore pressure that develops.

Further research and development of the PED process in either a batch or continuous process should entail a study into the shape of pressure application mechanism. It is known that a domed piston will provide a more uniform pressure gradient than a flat plate. The degree of curvature on the dome is dependent on the geometrics of the system.

The results of this study can be used to outline the development of PED into a continuous process. It is anticipated that the belt filter press is the dewatering device on the market today that will be the most effective and easily modified to make PED a continuous process.

Currently, a device marketed by Dorr-Oliver, Inc. (1,2), electrically augmented vacuum filtration (EAVF), and another under development at Battelle Columbus Laboratories (3), electroacoustic filtration, incorporate electroosmosis in a continuous manner. The dewatering enhancement in each process is not as substantial as in the PED process because of the separation mechanics involved. In the EAVF process, no effective stress is gained. Hence, consolidation does not take place, the pores become unsaturated and the electroosmotic driving force equilibrates with the induced hydraulic gradient too rapidly to be effective. Battelle's process provides some consolidation, but not a substantial amount. Also, there is an additional cost in generating the acoustics.

Dr. N. C. Lockhart, Commonwealth Scientific and Industrial Research Organization, Austrailia has done a substantial amount of field work using electroosmosis with a belt filter press and has reported some success (4). However, his success has been limited because he has overlooked the influence of the slurry's zeta potential, in that the developed process includes flocculation prior to subjecting the material to the process.

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APPENDIX A. COMPUTER SOFTWARE DEVELOPED TO CONDUCT RESEARCH

The software developed to acquire data from the research tests and reduce the collected data is presented herein. Also included are those programs modified to improve communications between the microcomputer and mainframe and to enable graphic file downloading and re-addressability.

MENU-SETUP is the setup and initialization program that also allows one to chain load the other PED test programs directly.

PED1 is the data acquisition program for conducting a test in Cell 1 only.

PED2 is the data acquisition program for conducting a test in Cell 2 only.

PED3 is the data acquisition program for conducting tests in Cell 1 and Cell 2 simultaneously.

PRINTOUT is the program that prints out the raw data, calculated data and the initialization test variables.

ZETA is the program that reduces the zeta potential modification test data, stores the raw data and prepares an upload file.

UPLOAD PREP is the program for preparing the PED test data files for uploading to the mainframe.

MENU/SAS is the modified program to enable downloading of the graphic files from the mainframe and to chain load the other mainframe communications programs.

MODWYL is the program modified only to increase the communication speed to 1200 bps.

NITEDWN is the modified program to enable continuous downloading of graphic job files run and held in the mainframe's storage bank.

DUMPFILE is the modified program that downloads continuously all files in the mainframe's storage bank.

PLOTSAS is the program written to read graphic files downloaded and stored on the dual disk drive and the output the information to the plotter.

WRITEFET is the program that creates the sequential file holding the information needed to run the NITEDWN program.

PSDPLOT is the program written to create a particle size distribution plot on the plotter.

MENU-SETUP

```
1 goto78
2 print"
3 print"Running - channel"c
4 print#1,chr$(11):gosub9:input#1,a$:print#1,chr$(7):ifa$=""then2
5 gosub10:ch=15-(8*a5+4*a6+2*a7+a8):ifch<ctheng=c-ch:gosub8:goto4
6 ifc<chtheng=12-ch+c:gosub8:goto4
7 goto13
8 fori=1tog:print#1,chr$(13)chr$(7):fork=1to120:nextk,i:return
9 forw=0to99:next:return
10 a=asc(a$):a1=int(a/128):a=a-a1*128:a2=int(a/64):a=a-a2*64:a3=int(a/32)
11 a=a-a3*32:a4=int(a/16):a=a-a4*16:a5=int(a/8):a=a-a5*8:a6=int(a/4):a=a-a6*4
12 a7=int(a/2):a=a-a7*2:a8=int(a/1):a=a-a8*1:return
13 fz=0:z=0:ar=0:fori=1to3:fx=0
14 print#1,chr$(9):gosub9:input#1,a$
15 ifa$=""andz<5thenz=z+1:print#1,chr$(7):goto14
16 ifa$=""andz=>5thenr1=0:fx=1:goto18
17 z=0:gosub10:r1=1000*(8*a1+4*a2+2*a3+a4)+100*(8*a5+4*a6+2*a7+a8)
18 print#1,chr$(10):gosub9:input#1,a$
19 ifa$=""andz<5thenz=z+1:goto18
20 ifa$=""andz=>5thenrd=0:fx=1:goto22
21 z=0:gosub10:r2=10*(8*a1+4*a2+2*a3+a4)+8*a5+4*a6+2*a7+a8:rd=r1+r2
22 print#1,chr$(11):gosub9:input#1,a$:ifa$=""then22
23 gosub10:print#1,chr$(7):rd=(rd+(a3*10000))*(2*a4-1)*(-9*a2+10)
24 iffx<>1thenar=ar+rd:fz=fz+1
25 next:iffz=0then13
26 rd=ar/fz:return
27 ifs=1thenrd=rd+i9:p1=rd*rd*-4.8536091e-9+rd*.00786563+.07813882
28 ifs=1thenp1=(int((p1*xl)*10+.5))/10:p=p1
29 ifs=2thenrd=rd+i0:p2=rd*rd*-1.3368269e-9+rd*.00997651-30.00349075
30 ifs=2thenp2=(int((p2*xr)*10+.5))/10:p=p2
31 print"The pressure in cell"s" =       "p" psi   ":goto68
32 ifs=1thenv1=(int((v*.21348935+.03912292)*10+.5))/10:v=v1
33 ifs=2thenv2=v*v*v*7.6230514e-8+v*v*-5.2882118e-5+v*.21025828+.02727155
34 ifs=2thenv2=(int(v2*10+.5))/10:v=v2
35 print"PS No."s" voltage is     "v"V":goto68
36 ifs=1thenr=-11578-rd+i6:l=r*r*r*-6.9302343e-14+r*r*-2.0853794e-9
37 ifs=1thenl=l+r*-.0002431+.40931775:i3=l:l=(int(l*100+.5))/100
38 ifs=2thenr=8743-rd+i8:l=r*r*r*2.8272226e-13+r*r*-7.0882956e-9
39 ifs=2thenl=l+r*.00033299+.35580661:i4=l:l=(int(l*100+.5))/100
40 print"LVDT No.   "s"depth is"l"cm":goto68
41 input"Which disk drive  0 or 1  ";dl:fu=1
42 ifdl=0thendopen#2,(l$),d0,w:goto49
43 ifdl=1thendopen#2,(l$),d1,w:goto49
44 goto41
45 input"Which disk drive  0 or 1  ";dr:fu=2
46 ifdr=0thendopen#3,(r$),d0,w:goto49
47 ifdr=1thendopen#3,(r$),d1,w:goto49
48 goto44
49 ifds=63thenprint""ds$:dclose:goto52
50 ifds<>0thenprint""ds$:dclose:goto59
51 return
52 input"Would you like a directory ";q$:ifleft$(q$,1)="y"then55
53 ifleft$(q$,1)="n"thenprint"":goto59
54 goto52
55 print"    Remember spacebar stops listing"
56 input"Which disk drive ";q:ifq=0thendirectoryd0:goto59
57 ifq=1thendirectoryd1:goto59
```

```
58 goto56
59 print"Enter Filename/Test Code for :"
60 iffu=1theninput"Cell 1 : ";l$:goto41
61 iffu=2theninput"Cell 2 : ";l$:goto45
62 print#4,l$;c$;dl;c$;i1;c$;i3;c$;i5;c$;i6;c$;i9;c$;s1;c$;v1;c$;p1;c$;l1;c$;t0
63 print#4,t1;c$;t2;c$;t3;c$;t4;c$;c;c$;ch;c$;v1$;c$;p1$;c$;a$;c$;a;c$;a1;c$;a2
64 print#4,a3;c$;a4;c$;a5;c$;a6;c$;a7;c$;a8;c$;e1;c$;w1;c$;x1;c$;d$:return
65 print#4,r$;c$;dr;c$;i2;c$;i4;c$;i7;c$;i8;c$;i0;c$;s2;c$;v2;c$;p2;c$;l2;c$;t5
66 print#4,t6;c$;t7;c$;t8;c$;t9;c$;c;c$;ch;c$;v2$;c$;p2$;c$;a$;c$;a;c$;a1;c$;a2
67 print#4,a3;c$;a4;c$;a5;c$;a6;c$;a7;c$;a8;c$;e2;c$;w2;c$;xr;c$;d$:return
68 print"          Press < RETURN > to re-run"
69 print"    Press < SPACEBAR > to continue"
70 geta$:ifa$=""then70
71 fori=33334to33360:pokei,32:next:fori=33412to33442:pokei,32:next:return
72 print"       Press <RETURN> when ready"
73 getz$:ifz$=""then73
74 return
75 print"":fori=1to40:print" ";:next
76 print"  Pressurized Electroosmotic Dewatering "
77 print"";:fori=1to40:print" ";:next:print:print:return
78 poke59468,14:gosub75:printtab(6)"*****  PROGRAM MENU  *****"
79 printtab(8)"1 - Setup":printtab(8)"2 - Printout Data"
80 printtab(8)"3 - Prepare Upload File"
81 printtab(5)" Enter Option No.  ? ";
82 getq$:ifq$=""then82
83 printq$:q=val(q$):ifq<1orq>3thenprinttab(8)"**** TRY AGAIN ****":goto81
84 ifq=1thenclr:goto87
85 ifq=2thenclr:dload"printout",d0:run
86 ifq=3thenclr:dload"upload prep",d0:run
87 open1,5:i1=0:i2=0:i3=0:i4=0:i5=0:i6=0:i7=0:i8=0:i9=0:i0=0:s1=0:s2=0:p1=0
88 p2=0:l1=0:l2=0:t0=0:t1=0:t2=0:t3=0:t4=0:t5=0:t6=0:t7=0:t8=0:t9=0:c=0:ch=0
89 v1$="n":v2$="n":p1$="n":p2$="n":a$="":a=0:a1=0:a2=0:a3=0:a4=0:a5=0:a6=0:a7=0
90 a8=0:e1=0:e2=0:w1=0:w2=0:x1=.736780645:xr=.738910189:c$=chr$(13):gosub75
91 f=0:input"Enter date DD-MMM-YR ";d$:input"What time is it ";ti$
92 input"Which cell - No. 1, 2 or both";r$:f=val(r$):ifr$="b"thenf=3
93 iff<1orf>3then92
94 iff<>2theninput"Elapsed time for cell 1 (min.) ";e1
95 iff<>1theninput"Elapsed time for cell 2 (min.) ";e2
96 gosub75:print"Enter Filename/Test Code for :"
97 iff<>2theninput"Cell 1 : ";l$:gosub41
98 iff<>1theninput"Cell 2 : ";r$:gosub45
99 gosub75:printtab(7)"VISHAY/ELLIS Initialization":
100 print"   Put V/E on a channel other than X":gosub72
101 gosub75:ifz$<>chr$(13)thenprinttab(15)"Try again":gosub72:goto101
102 iff<>2thenc=0:gosub2:i5=0-rd:c=1:gosub3:i6=-11578-rd:c=4:gosub3:i9=0-rd
103 iff<>1thenc=2:gosub2:i7=0-rd:c=3:gosub3:i8=8743-rd:c=5:gosub3:i0=3000-rd
104 d=0:gosub75:printtab(10)"LVDT Initialization":gosub72
105 ifz$<>chr$(13)thenprinttab(15)"Try again":gosub72:goto105
106 iff<>2thenc=1:s=1:goto108
107 iff<>1thenc=3:s=2
108 gosub2:gosub36
109 ifa$=chr$(13)then108
110 ifa$=chr$(32)thend=d+1:goto112
111 gosub68:goto109
112 ifd>1orf<3then114
113 goto107
114 gosub75:iff<>2theninput"Initial water in cell 1 (g) ";w1
115 iff<>1theninput"Initial water in cell 2 (g) ";w2
116 d=0:gosub75:printtab(13)"Pressure Setup":print
117 iff<>2theninput"Is the pressure in cell 1 zero ";p1$:goto119
```

```
118 goto122
119 ifp1$="n"thenc=4:s=1:goto127
120 ifp1$="y"thenp1=0:goto122
121 goto117
122 iff<>1theninput"Is the pressure in cell 2 zero ";p2$:gotc
123 goto131
124 ifp2$="n"thenc=5:s=2:goto127
125 ifp2$="y"thenp2=0:goto133
126 goto122
127 gosub2:gosub27
128 ifa$=chr$(13)then127
129 ifa$=chr$(32)thend=d+1:goto131
130 gosub68:goto128
131 ifd>1orf<3then133
132 goto122
133 d=0:gosub75:printtab(7)"Power Supply Voltage Setup":print
134 iff<>2theninput"Is the PS#1 voltage zero ";v1$:goto136
135 goto139
136 ifv1$="n"thens=1:ad$=chr$(124):goto144
137 ifv1$="y"thenv1=0:d=d+1:goto139
138 goto134
139 iff<>1theninput"Is the PS#2 voltage zero ";v2$:goto141
140 goto151
141 ifv2$="n"thens=2:ad$=chr$(108):goto144
142 ifv2$="y"thenv2=0:d=d+1:goto151
143 goto139
144 print"":fori=1to50:print" ";:next:print"":print"Running"
145 v=0:fori=1to3
146 print#1,ad$chr$(8):input#1,a$:print#1,chr$(7):ifa$=""then146
147 a=asc(a$):v=v+a:next:v=v/3:gosub32
148 ifa$=chr$(13)then144
149 ifa$=chr$(32)thend=d+1:goto151
150 gosub68:goto148
151 ifd>1orf<3then153
152 goto139
153 gosub75:print"    Please Wait ... I'm storing data"
154 dopen#4,"@dump",d0,w:iff<>2thengosub62
155 iff<>1thengosub65
156 dclose#4:g=4:gosub8:close1
157 gosub75:printtab(12)"Setup Completed"
158 f$=right$(str$(f),1):printtab(11)"I'm loading PED"f$
159 iff=1thendclose#2:clr:dload"ped1":run
160 iff=2thendclose#3:clr:dload"ped2":run
161 dclose#2:dclose#3:clr:dload"ped3":run
170 fillerfillerfillerfillerfillerfillerfillerfillerfillerfiller
180 fillerfillerfillerfillerfillerfillerfillerfillerfillerfiller
190 fillerfillerfillerfillerfillerfillerfillerfillerfillerfiller
200 fillerfillerfillerfillerfillerfillerfillerfillerfillerfiller
210 fillerfillerfillerfillerfillerfillerfillerfillerfillerfiller
220 fillerfillerfillerfillerfillerfillerfillerfillerfillerfiller
230 fillerfillerfillerfillerfillerfillerfillerfillerfillerfiller
```

PED1

```
1 goto57
2 print#1,chr$(13)chr$(7):fork=1to120:next:return
3 print#1,chr$(11):gosub7:input#1,a$:print#1,chr$(7):ifa$=""then3
4 a=asc(a$):gosub10:ch=15-(8*a5+4*a6+2*a7+a8):ifch<ctheng=c-ch:gosub9:goto3
5 ifc<chtheng=12-ch+c:gosub9:goto3
6 goto16
7 forw=0to199:next:return
8 printtab(22)"        [illegible]":return
9 fori=1tog:gosub2:next:return
10 a1=int(a/128):a=a-a1*128:a2=int(a/64):a=a-a2*64:a3=int(a/32):a=a-a3*32
11 a4=int(a/16):a=a-a4*16:a5=int(a/8):a=a-a5*8:a6=int(a/4):a=a-a6*4
12 a7=int(a/2):a=a-a7*2:a8=int(a):return
13 t$=ti$:tm=val(left$(t$,2))*60+val(mid$(t$,3,2))+val(right$(t$,2))/60
14 iftm<i3thentm=tm+1440
15 return
16 fx=0:z=0:gosub13:tr=tm
17 print#1,chr$(9):gosub7:input#1,a$
18 ifa$=""andz<5thenz=z+1:print#1,chr$(7):goto17
19 ifa$=""andz=>5thena=0:fx=1:goto21
20 a=asc(a$)
21 z=0:gosub10:r1=1000*(8*a1+4*a2+2*a3+a4)+100*(8*a5+4*a6+2*a7+a8)
22 print#1,chr$(10):gosub7:input#1,a$
23 ifa$=""andz<5thenz=z+1:goto22
24 ifa$=""andz=>5thena=0:fx=1:goto26
25 a=asc(a$)
26 z=0:gosub10:r2=10*(8*a1+4*a2+2*a3+a4)+8*a5+4*a6+2*a7+a8:rd=r1+r2
27 print#1,chr$(11):gosub7:input#1,a$:ifa$=""then27
28 a=asc(a$):gosub10:print#1,chr$(7)
29 rd=(rd+(a3*10000))*(2*a4-1)*(-9*a2+10):iffx=1then16
30 return
31 gosub13:t2=(int((tm-i1)*100+.5))/100
32 print#1,chr$(44)chr$(8):input#1,a$:print#1,chr$(7):ifa$=""then32
33 cc=asc(a$):c1=int(cc*cc*-.00115908+cc*8.10789809+10.05448516):z5$=str$(c1)
34 gosub13:t3=(int((tm-i1)*100+.5))/100
35 print#1,chr$(124)chr$(8):input#1,a$:print#1,chr$(7):ifa$=""then35
36 v=asc(a$):v1=(int((v*.21348935+.03912292)*10+.5))/10:z4$=str$(v1):return
37 print#2,s1;c$;t0;c$;l1;c$;t1;c$;c1;c$;t2;c$;v1;c$;t3;c$;p1;c$;t4:return
38 t0=(int((tr-i1)*100+.5))/100:z1$=str$(t0):rd=rd+i5
39 s1=rd*rd*rd*-2.574239e-9+rd*rd*2.3046103e-6+rd*.18747794+.857257
40 s1=(int((s1-w1)*10+.5))/10:z2$=str$(s1):return
41 t1=(int((tr-i1)*100+.5))/100:rd=-11578-rd+i6:l=rd*rd*rd*-6.9302343e-14
42 l=l+rd*rd*-2.0853794e-9+rd*-.0002431+.40931775
43 l1=(int((i3-l)*100+.5))/100:z6$=str$(l1):return
44 t4=(int((tr-i1)*100+.5))/100:rd=rd+i9:p1=rd*rd*-4.8536091e-9
45 p1=(int((p1+rd*.00786563+.07813882)*x1*10+.5))/10:z3$=str$(p1):return
46 nl=nl+1:c=0:gosub3:ifi1=0theni1=tr
47 gosub38:c=1:gosub3:gosub41:ifv1$="n"thengosub31
48 ifp1$="n"thenc=4:gosub3:gosub44
49 gosub37:print"[illegible]":gosub8:printtab(28-len(z1$))t0"[illegible]"
50 gosub8:printtab(28-len(z2$))s1"[illegible]":gosub8:printtab(28-len(z3$))p1"[illegible]"
51 gosub8:printtab(28-len(z4$))v1"[illegible]":gosub8:printtab(28-len(z5$))c1"[illegible]"
52 gosub8:printtab(28-len(z6$))l1"[illegible]":ift0<e1tthen46
53 print#5,l$;c$;d$;c$;nl:dclose#5:goto70
54 print"[illegible]":fori=1to40:print"[illegible] ";:next
55 print"[illegible]  Pressurized Electroosmotic Dewatering "
56 print"[illegible]";:fori=1to40:print"[illegible] ";:next:print:return
57 dopen#4,"dump",d0:input#4,l$,dl,i1,i3,i5,i6,i9,s1,v1,p1,l1,t0,t1,t2,t3,t4
```

```
58 input#4,c,ch,v1$,p1$,a$,a,a1,a2,a3,a4,a5,a6,a7,a8,e1,w1,x1,d$:dclose#4
59 c$=chr$(13):ls$="@"+l$:nl=0:open1,5:gosub54:printtab(13)"*** Cell 1 ***"
60 ifdl=0thendopen#2,(ls$),d0,w:append#5,"tests",d0
61 ifdl=1thendopen#2,(ls$),d1,w:append#5,"tests",d1
62 print"          Elapsed Time ="spc(8)"min."
63 printtab(9)"Accum. H20 ="spc(8)"g":printtab(11)"Pressure ="spc(8)"psi"
64 printtab(12)"Voltage ="spc(8)"V":printtab(12)"Current ="spc(8)"mA"
65 printtab(14)"Depth ="spc(8)"cm":printtab(18)"Press  S  to start"
66 geta$:ifa$=""then66
67 ifa$="S"then69
68 goto66
69 printtab(18)"                       ":goto46
70 dclose#2:close1:printtab(7)" The test is completed "
```

PED2

```
1 goto58
2 print#1,chr$(13)chr$(7):fork=1to120:next:return
3 print#1,chr$(11):gosub7:input#1,a$:print#1,chr$(7):ifa$=""then3
4 a=asc(a$):gosub10:ch=15-(8*a5+4*a6+2*a7+a8):ifch<ctheng=c-ch:gosub9:goto3
5 ifc<chtheng=12-ch+c:gosub9:goto3
6 goto16
7 forw=0to199:next:return
8 printtab(22)"        ■":return
9 fori=1tog:gosub2:next:return
10 a1=int(a/128):a=a-a1*128:a2=int(a/64):a=a-a2*64:a3=int(a/32):a=a-a3*32
11 a4=int(a/16):a=a-a4*16:a5=int(a/8):a=a-a5*8:a6=int(a/4):a=a-a6*4
12 a7=int(a/2):a=a-a7*2:a8=int(a):return
13 t$=ti$:tm=val(left$(t$,2))*60+val(mid$(t$,3,2))+val(right$(t$,2))/60
14 iftm<i2thentm=tm+1440
15 return
16 fx=0:z=0:gosub13:tr=tm
17 print#1,chr$(9):gosub7:input#1,a$
18 ifa$=""andz<5thenz=z+1:print#1,chr$(7):goto17
19 ifa$=""andz=>5thena=0:fx=1:goto21
20 a=asc(a$)
21 z=0:gosub10:r1=1000*(8*a1+4*a2+2*a3+a4)+100*(8*a5+4*a6+2*a7+a8)
22 print#1,chr$(10):gosub7:input#1,a$
23 ifa$=""andz<5thenz=z+1:goto22
24 ifa$=""andz=>5thena=0:fx=1:goto26
25 a=asc(a$)
26 z=0:gosub10:r2=10*(8*a1+4*a2+2*a3+a4)+8*a5+4*a6+2*a7+a8:rd=r1+r2
27 print#1,chr$(11):gosub7:input#1,a$:ifa$=""then27
28 a=asc(a$):gosub10:print#1,chr$(7)
29 rd=(rd+(a3*10000))*(2*a4-1)*(-9*a2+10):iffx=1then16
30 return
31 gosub13:t7=(int((tm-i2)*100+.5))/100
32 print#1,chr$(60)chr$(8):input#1,a$:print#1,chr$(7):ifa$=""then32
33 cc=asc(a$):c2=int(cc*cc*-.00100369+cc*8.1245116+6.378832):z5$=str$(c2)
34 gosub13:t8=(int((tm-i2)*100+.5))/100
35 print#1,chr$(108)chr$(8):input#1,a$:print#1,chr$(7):ifa$=""then35
36 v=asc(a$):v2=v*v*v*7.6230514e-8+v*v*-5.2882118e-5+v*.21025828+.02727155
37 v2=(int(v2*10+.5))/10:z4$=str$(v2):return
38 print#3,s2;c$;t5;c$;l2;c$;t6;c$;c2;c$;t7;c$;v2;c$;t8;c$;p2;c$;t9:return
39 t5=(int((tr-i2)*100+.5))/100:rd=rd+i7:z1$=str$(t5):s2=rd*rd*rd
40 s2=s2*-3.4728697e-9+rd*rd*1.8580123e-5+rd*.13595533-.73453202
41 s2=(int((s2-w2)*10+.5))/10:z2$=str$(s2):return
42 t6=(int((tr-i2)*100+.5))/100:rd=8743-rd+i8:l=rd*rd*rd*2.8272226e-13
43 l=l+rd*rd*-7.0882956e-9+rd*.00033299+.35580661
44 l2=(int((i4-l)*100+.5))/100:z6$=str$(l2):return
45 t9=(int((tr-i2)*100+.5))/100:rd=rd+i0:p2=rd*rd*-1.3368269e-9
46 p2=(int((p2+rd*.00997651-30.00349075)*xr*10+.5))/10:z3$=str$(p2):return
47 nr=nr+1:c=2:gosub3:ifi2=0theni2=tr
48 gosub39:c=3:gosub3:gosub42:ifv2$="n"thengosub31
49 ifp2$="n"thenc=5:gosub3:gosub45
50 gosub38:print"■■■■■■■■":gosub8:printtab(28-len(z1$))t5"■"
51 gosub8:printtab(28-len(z2$))s2"■":gosub8:printtab(28-len(z3$))p2"■"
52 gosub8:printtab(28-len(z4$))v2"■":gosub8:printtab(28-len(z5$))c2"■"
53 gosub8:printtab(28-len(z6$))l2"■":ift5<e2tthen47
54 print#5,r$;c$;d$;c$;nr:dclose#5:goto71
55 print"■":fori=1to40:print"■ ";:next
56 print"■  Pressurized Electroosmotic Dewatering "
```

```
57 print"█";:fori=1to40:print"█ ";:next:print:return
58 dopen#4,"dump",d0:input#4,r$,dr,i2,i4,i7,i8,i0,s2,v2,p2,l5,t5,t6,t7,t8,t9
59 input#4,c,ch,v2$,p2$,a$,a,a1,a2,a3,a4,a5,a6,a7,a8,e2,w2,xr,d$:dclose#4
60 c$=chr$(13):rs$="@"+r$:nr=0:open1,5:gosub55:printtab(13)"*** Cell 2 ***"
61 ifdr=0thendopen#3,(rs$),d0,w:append#5,"tests",d0
62 ifdr=1thendopen#3,(rs$),d1,w:append#5,"tests",d1
63 print"█████████       Elapsed Time ="spc(8)"min."
64 printtab(9)"█Accum. H2O ="spc(8)"g":printtab(11)"█Pressure ="spc(8)"psi"
65 printtab(12)"█Voltage ="spc(8)"V":printtab(12)"█Current ="spc(8)"mA"
66 printtab(14)"█Depth ="spc(8)"cm":printtab(10)"█Press █ S █ to start"
67 geta$:ifa$=""then67
68 ifa$="S"then70
69 goto67
70 printtab(10)"█                        ":goto47
71 dclose#2:close1:printtab(7)"██ The test is completed █"
```

PED3

```
1 goto79
2 print#1,chr$(13)chr$(7):fork=1to150:next:return
3 print#1,chr$(11):gosub7:input#1,a$:print#1,chr$(7):ifa$=""then3
4 a=asc(a$):gosub11:ch=15-(8*a5+4*a6+2*a7+a8):ifch<ctheng=c-ch:gosub18:goto3
5 ifc<chtheng=12-ch+c:gosub10:goto3
6 goto17
7 forw=0to129:next:return
8 print"■";:forw=1to9:print"■";:next
9 print tab(14)"            "tab(27)"           ■":return
10 fori=1tog:gosub2:next:return
11 a1=int(a/128):a=a-a1*128:a2=int(a/64):a=a-a2*64:a3=int(a/32):a=a-a3*32
12 a4=int(a/16):a=a-a4*16:a5=int(a/8):a=a-a5*8:a6=int(a/4):a=a-a6*4
13 a7=int(a/2):a=a-a7*2:a8=int(a):return
14 t$=ti$:tm=val(left$(t$,2))*60+val(mid$(t$,3,2))+val(right$(t$,2))/60
15 iftm<i1thentm=tm+1440
16 return
17 fx=0:z=0:gosub14:tr=tm
18 print#1,chr$(9):gosub7:input#1,a$
19 ifa$=""andz<5thenz=z+1:print#1,chr$(7):goto18
20 ifa$=""andz=>5thena=0:fx=1:goto22
21 a=asc(a$)
22 z=0:gosub11:r1=1000*(8*a1+4*a2+2*a3+a4)+100*(8*a5+4*a6+2*a7+a8)
23 print#1,chr$(10):gosub7:input#1,a$
24 ifa$=""andz<5thenz=z+1:goto23
25 ifa$=""andz=>5thena=0:fx=1:goto27
26 a=asc(a$)
27 z=0:gosub11:r2=10*(8*a1+4*a2+2*a3+a4)+8*a5+4*a6+2*a7+a8:rd=r1+r2
28 print#1,chr$(11):gosub7:input#1,a$:ifa$=""then28
29 a=asc(a$):gosub11:print#1,chr$(7)
30 rd=(rd+(a3*10000))*(2*a4-1)*(-9*a2+10):iffx=1then17
31 return
32 gosub14:t2=(int((tm-i1)*100+.5))/100
33 print#1,chr$(44)chr$(8):input#1,a$:print#1,chr$(7):ifa$=""then33
34 cc=asc(a$):c1=int(cc*cc*-.00115908+cc*8.10789809+10.05448516):z$(5)=str$(c1)
35 gosub14:t3=(int((tm-i1)*100+.5))/100
36 print#1,chr$(124)chr$(8):input#1,a$:print#1,chr$(7):ifa$=""then36
37 v=asc(a$):v1=(int((v*.21348935+.03912292)*10+.5))/10:z$(4)=str$(v1):return
38 gosub14:t7=(int((tm-i2)*100+.5))/100
39 print#1,chr$(60)chr$(8):input#1,a$:print#1,chr$(7):ifa$=""then39
40 cc=asc(a$):c2=int(cc*cc*-.00100369+cc*8.1245116+6.378832):z$(11)=str$(c2)
41 gosub14:t8=(int((tm-i2)*100+.5))/100
42 print#1,chr$(108)chr$(8):input#1,a$:print#1,chr$(7):ifa$=""then42
43 v=asc(a$):v2=v*v*v*7.6230514e-8+v*v*-5.288118e-5+v*.21025828+.02727155
44 v2=(int(v2*10+.5))/10:z$(10)=str$(v2):return
45 print#2,s1;c$;t0;c$;l1;c$;t1;c$;c1;c$;t2;c$;v1;c$;t3;c$;p1;c$;t4
46 print#3,s2;c$;t5;c$;l2;c$;t6;c$;c2;c$;t7;c$;v2;c$;t8;c$;p2;c$;t9:return
47 t0=(int((tr-i1)*100+.5))/100:z$(1)=str$(t0):rd=rd+i5
48 s1=rd*rd*rd*-2.574239e-9+rd*rd*2.3046103e-6+rd*.18747794+.857257
49 s1=(int((s1-w1+a1)*10+.5))/10:z$(2)=str$(s1):return
50 t1=(int((tr-i1)*100+.5))/100:r=-11578-rd+i6:l=r*r*r*-6.9302343e-14
51 l=l+r*r*-2.0853794e-9+r*-.0002431+.40931775
52 l1=(int((i3-l)*100+.5))/100:z$(6)=str$(l1):return
53 t5=(int((tr-i2)*100+.5))/100:z$(7)=str$(t5):rd=rd+i7
54 s2=rd*rd*rd*-3.4728697e-9+rd*rd*1.8580123e-5+rd*.13595533-.734532
55 s2=(int((s2-w2+ar)*10+.5))/10:z$(8)=str$(s2):return
56 t6=(int((tr-i2)*100+.5))/100:r=8743-rd+i8:l=r*r*r*2.8272226e-13
```

```
57 l=l+r*r*-7.0882956e-9+r*.00033299+.35580661
58 l2=(int((i4-l)*100+.5))/100:z$(12)=str$(l2):return
59 t4=(int((tr-i1)*100+.5))/100:rd=rd+i9:p1=rd*rd*-4.8536091e-9
60 p1=(int((p1+rd*.00786563+.07813882)*xl*10+.5))/10:z$(3)=str$(p1):return
61 t9=(int((tr-i2)*100+.5))/100:rd=rd+i0:p2=rd*rd*-1.3368269e-9
62 p2=(int((p2+rd*.00997651-30.00349075)*xr*10+.5))/10:z$(9)=str$(p2):return
63 nl=nl+1:nr=nr+1:c=0:gosub3:ifi1=0theni1=tr
64 gosub47:ifad<>1thenal=0-s1:s1=s1+al:z$(2)=str$(s1)
65 c=1:gosub3:gosub50:ifv1$="n"thengosub32
66 c=2:gosub3:ifi2=0theni2=tr
67 gosub53:ifad<>1thenar=0-s2:s2=s2+ar:z$(8)=str$(s2):ad=1
68 c=3:gosub3:gosub56:ifv2$="n"thengosub38
69 ifp1$="n"thenc=4:gosub3:gosub59
70 ifp2$="n"thenc=5:gosub3:gosub61
71 gosub45:gosub8:printtab(21-len(z$(1)))t0tab(34-len(z$(7)))t5"■"
72 gosub9:printtab(21-len(z$(2)))s1tab(34-len(z$(8)))s2"■"
73 gosub9:printtab(21-len(z$(3)))p1tab(34-len(z$(9)))p2"■"
74 gosub9:printtab(21-len(z$(4)))v1tab(34-len(z$(10)))v2"■"
75 gosub9:printtab(21-len(z$(5)))c1tab(34-len(z$(11)))c2"■"
76 gosub9:printtab(21-len(z$(6)))l1tab(34-len(z$(12)))l2"■"
77 ift0<e1ort5<e2then63
78 print#5,l$;c$;d$;c$;nl;c$;r$;c$;d$;c$;nr:dclose#5:goto105
79 dopen#4,"dump",d0:input#4,l$,dl,i1,i3,i5,i6,i9,s1,v1,p1,l1,t0,t1,t2,t3,t4,c
80 input#4,ch,v1$,p1$,a$,a,a1,a2,a3,a4,a5,a6,a7,a8,e1,w1,xl,d$,r$,dr,i2,i4,i7
81 input#4,i8,i0,s2,v2,p2,l2,t5,t6,t7,t8,t9,c,ch,v2$,p2$,a$,a,a1,a2,a3,a4,a5
82 input#4,a6,a7,a8,e2,w2,xr,d$:dclose#4:nl=0:nr=0:ls$="@"+l$:rs$="@"+r$
83 dimz$(12):ifdl=0thendopen#2,(ls$),d0,w:append#5,"tests",d0
84 ifdl=1thendopen#2,(ls$),d1,w:append#5,"tests",d1
85 ifdr=0thendopen#3,(rs$),d0,w
86 ifdr=1thendopen#3,(rs$),d1,w
87 open1,5:c$=chr$(13):fori=1to12:z$(i)=" 0":next
88 print"■":fori=1to40:print"■ ";:next
89 print"■  Pressurized Electroosmotic Dewatering "
90 print"■";:fori=1to40:print"■ ";:next:print"■■"
91 print"──────────────── Cell 1 ───┬─── Cell 2 ───┐"
92 print"Elapsed Time ="spc(8)"min"spc(10)"min"
93 print"■  Accum. H2O ="spc(8)"g"spc(12)"g"
94 print"■     Pressure ="spc(8)"psi"spc(10)"psi"
95 print"■      Voltage ="spc(8)"V"spc(12)"V"
96 print"■      Current ="spc(8)"mA"spc(11)"mA"
97 print"■        Depth ="spc(8)"cm"spc(11)"cm"
98 fori=33114to33594step40:pokei,93:pokei+13,93:next:fori=1to26
99 print"─";:next:print"┴";:fori=1to12:print"─";:next:print"┘"
100 printtab(10)"Press ■ S ■ to start ";
101 geta$:ifa$=""then101
102 printa$:ifa$="S"thenfori=33648to33720:pokei,32:next:goto104
103 printtab(15)"Try again■■":goto100
104 c=1:gosub3:gosub50:z1=l1:z3=tr:c=3:gosub3:gosub56:z2=l2:z4=tr:goto63
105 z3=(int((z3-i1)*100-.5))/100:z4=(int((z4-i2)*100-.5))/100
106 print#2,z1;c$;z3:print#3,z2;c$;z4:close1:dclose#2:dclose#3:print"■";
107 printtab(7)"■■■■■■ The tests are completed ":print"■■■■■■■■■■■■■■"
```

PRINTOUT

```
1 goto99
2 print#1,lf$lf$lf$lf$
3 print#1,e$"    PRESSURIZED ELECTROOSMOTIC DEWATERING"lf$lf$
4 print#1,e$tab(26)"PED"lf$lf$:print#1,tab(31)"Test Code : "f$(k)
5 print#1,tab(29)"Date Tested : "d$(k)lf$:return
6 print#1,ff$:fori=1to10:print#1,lf$;:next
7 print#1,tab(z)f$(k)" con't."lf$:return
8 print#2,"         aaaa  aaaaa aaaaa  aaaaa aaaaaaa aaaaa aaaaaaa";
9 print#2,"  aaaaa  aaaaaa  aaaaa"
10 print#3,"Cum."s$:print#3,"H2O"s$" ET"s$"Depth"s$" ET"s$"Current"s$;
11 print#3," ET"s$"Voltage"s$" ET"s$"Press."s$" ET"
12 print#3,"(g)"s$"(min)"s$" (cm)"s$"(min)"s$"  (mA)"s$;
13 print#3,"(min)"s$"  (V)"s$"(min)"s$" (psi)"s$"(min)"
14 print#1,tab(5);:fori=1to35:print#1,"¯¯";:next:print#1,"¯"
15 print#2,"       999.9 999.99  9.99 999.99   9999 999.99   99.9";
16 print#2,"  999.99   999.9 999.99":return
17 print#2,"       aaaa    aaaaaaa    aaaaaa    aaaaaaaa   aaaaa      aaaa";
18 print#2,"     aaaaaaaaaaaaaa"
19 print#3,s$" Dwtr."s$" Volt."s$"Current"s$s$s$"Cumulative Work";
20 print#1,chr$(141)tab(63)"__________________"
21 print#3,chr$(254)"H2O"s$" Rate"s$" Grad."s$"Density"s$"  R"s$" ";
22 print#3,chr$(254)"l"s$"  Elec.  Mech."
23 print#3," (g)"s$"(g/min)"s$"(V/cm)"s$"(mA/cm2)"s$"(ohm)"s$"(cm)"s$;
24 print#3," (kW-hr)  (J)"
25 print#1,tab(4);:fori=1to38:print#1,"¯¯";:next:print#1
26 print#2,"     s999.9    s999.9     999.9     99.99    9999.9    s9.99";
27 print#2,"      9.999    999":return
28 j=0:print"■":input"Which drive is data disk in ";d$:dz=val(d$)
29 ifdz<0ordz>1thenprinttab(15)"TRY AGAIN":goto28
30 ifdz=0thendopen#4,"tests",d0
31 ifdz=1thendopen#4,"tests",d1
32 j=j+1:input#4,f$(j),d$(j),n(j)
33 ifst=64thendclose#4:goto35
34 goto32
35 gosub96:mx=j:f=1:l=10
36 print"■■■■■":printtab(3)"No."spc(6)"Test Code"spc(7)"Date":print
37 ifmx<10thenl=mx:f=1
38 i=1:form=ftol:i=i+1:print"■■■■■":fork=1toi:print"■";:next
39 print"                                      ":print"■■"
40 printtab(2)mtab(12)f$(m)tab(26)d$(m):next:print
41 print"■      To scroll press u,d,/,*,f,l      "
42 print"■   Press r to enable file no. input    "
43 getq$:ifq$=""then43
44 ifq$="u"thenf=f-10:l=l-10:goto52
45 ifq$="d"thenf=f+10:l=l+10:goto54
46 ifq$="/"thenf=f-1:l=l-1:goto52
47 ifq$="*"thenf=f+1:l=l+1:goto54
48 ifq$="f"thenf=1:l=10:goto52
49 ifq$="l"thenl=mx:f=mx-9:goto54
50 ifq$="r"then56
51 goto41
52 iff<0thenf=1:l=10
53 print"■":print"■":goto37
54 ifl>mxthenl=mx:f=mx-9
55 print"■":print"■":goto37
56 input"■Enter file no. ";k:ifk<1ork>jthenprinttab(15)"TRY AGAIN":goto56
```

```
57 zr=1:ifk=pthenreturn
58 p=k:ifdz=0thendopen#4,(f$(k)),d0
59 ifdz=1thendopen#4,(f$(k)),d1
60 print"":print"   Please Wait ... I'm reading data":n=n(k)+1
61 fori=1ton(k):input#4,s(i),t0(i),l(i),t1(i),c(i),t2(i),v(i),t3(i),p(i),t4(i)
62 next:dclose#4
63 w$="":z=len(f$(k)):fori=1toz:q$=mid$(f$(k),i,1)
64 ifasc(q$)>64andasc(q$)<91thenq$=chr$(asc(q$)+128)
65 w$=w$+q$:next:f$(k)=w$:pg=int(n(k)/40+.999):z=(78-len(f$(k)))/2
66 return
67 open1,4:open2,4,2:open3,4,1:c=0:a=1:b=40:ifb>n(k)thenb=n(k)
68 print"";:printtab(14)"Here goes !":gosub2
69 c=c+1:gosub8:fori=atob
70 print#3,s(i),t0(i),l(i),t1(i),c(i),t2(i),v(i),t3(i),p(i),t4(i):next
71 print#1,lf$lf$:print#1,tab(64)"Page"c" of"pg
72 ifb=n(k)then75
73 a=a+40:b=b+40:ifb>n(k)thenb=n(k)
74 gosub6:goto69
75 print#1,ff$:close1:close2:close3:ifq=4then77
76 return
77 print"":print"Please Wait ... I'm working on it":we=0:wm=0
78 open1,4:open2,4,2:open3,4,1:gosub2:cp=0:a=1:b=40:ifb>n(k)thenb=n(k)
79 cp=cp+1:gosub17:fori=atob
80 t2=(t2(i)+t2(i-1))/2:t3=(t3(i)+t3(i-1))/2:t=(t2+t3)/2-t
81 c=(c(i)+c(i-1))/2:v=(v(i)+v(i-1))/2:w=((c/1000)*v*t)/60000:we=we+w
82 vg=0:r=0:dr=0:cd=(int((c(i)/.618059)+.5))/100
83 ifl(i)<>0thenvg=v(i)/l(i)
84 ifc(i)<>0thenr=1000*v(i)/c(i)
85 wr=s(i)-s(i-1):dt=t0(i)-t0(i-1):ld=l(i-1)-l(i):lw=ld:ifld<0thenlw=0
86 wp=lw*p(i)*.428:wm=wm+wp:ifdt<>0thendr=wr/dt
87 wr=(int(wr*10+.5))/10:dr=(int(dr*10+.5))/10:vg=(int(vg*10+.5))/10
88 r=(int(r*10+.5))/10:ld=(int(ld*100+.5))/100:we=(int(we*1000+.5))/1000
89 wm=int(wm+.5):print#3,wr,dr,vg,cd,r,ld,we,wm:next
90 print#1,lf$lf$tab(64)"Page"cp" of"pg
91 ifb=n(k)then94
92 a=a+40:b=b+40:ifb>n(k)thenb=n(k)
93 gosub6:goto79
94 print#1,ff$:close1:close2:close3:ifq=4then123
95 return
96 print"":fori=1to20:print"  ";:next
97 print"  Pressurized Electroosmotic Dewatering "
98 print"";:fori=1to20:print"  ";:next:print:return
99 poke59468,14:open7,4,7:print#7:close7:c$=chr$(13):e$=chr$(1):s$=chr$(29)
100 n=300:lf$=chr$(10):ff$=chr$(12):dimf$(50),d$(50),n(50),s(300)
101 dimt0(300),l(300),t1(300),c(300),t2(300),v(300),t3(300),p(300),t4(300)
102 open5,4,5:fori=1to6:reada:a$=a$+chr$(a):next:print#5,a$
103 gosub96:print"************* Printout Menu *************"
104 printtab(10)"1 - Raw Data":printtab(10)"2 - Computed Data"
105 printtab(10)"3 - Summary":printtab(10)"4 - Dump file"
106 printtab(10)"5 - All":print"*****************************************"
107 printtab(7)" Enter choice :  ";
108 getq$:ifq$=""then108
109 printq$:q=val(q$):ifq<1orq>5thenprinttab(15)"TRY AGAIN":goto107
110 ifq=4thenprint"Dump file printout":gosub124:goto114
111 ifzz<>1thengosub28
112 ifzz=1thengosub35
113 onqgosub67,77,123,124,67
114 input"Continue (y/n) ";z$
115 ifz$="n"thenprint"":printtab(15)"All done !"
116 ifz$="n"thenopen1,4:print#1,ff$:close1:end
```

```
117 ifz$<>"y"then114
118 ifzr=1theninput"%Same data disk (y/n) ";z$:goto120
119 ifzr=0thenzz=0:goto103
120 ifz$="y"thenzz=1:goto103
121 ifz$="n"thenzz=0:goto103
122 goto118
123 clr:dload"summary",d0:run
124 dopen#4,"dump",d0:open1,4:open2,4,2:open3,4,1:k=1:l$="":r$="":zd=0
125 input#4,l$,dl,i1,i3,i5,i6,i9,s1,v(k),p(k),l,t0,t1,t2,t3,t4,c,ch,v1$
126 input#4,p1$,a$,a,a1,a2,a3,a4,a5,a6,a7,a8,e(k),w(k),xl,d$(k):ifst=64then129
127 k=2:input#4,r$,dr,i2,i4,i7,i8,i0,s2,v(k),p(k),l,t5,t6,t7,t8,t9,c,ch,v2$
128 input#4,p2$,a$,a,a1,a2,a3,a4,a5,a6,a7,a8,e(k),w(k),xr,d$(k)
129 dclose#4:k=1:l(k)=(int(i3*100+.5))/100:a(k)=(int(i5*100+.5))/100
130 b(k)=(int(i6*100+.5))/100:c(k)=(int(i9*100+.5))/100
131 k=2:l(k)=(int(i4*100+.5))/100:a(k)=(int(i7*100+.5))/100
132 b(k)=(int(i8*100+.5))/100:c(k)=(int(i0*100+.5))/100:k=1:f$(k)=l$:gosub63
133 gosub2:ifxl<.738thence=1:cw=0:cl=1:cp=4
134 ifxl>.737thence=2:cw=2:cl=3:cp=5
135 print#2,tab(24)"aaaaaaaaaaaaaaaaaaaaaa     99.9   a"
136 print#3,lf$lf$"Initial voltage"s$v(k)"V"lf$lf$
137 print#2,tab(24)"aaaaaaaaaaaaaaaaaaaaaa    999.9 aaa"
138 print#3,"Initial pressure"s$p(k)"psi"lf$lf$
139 print#2,tab(24)"aaaaaaaaaaaaaaaaaaaaaa       99 aaa"
140 print#3,"Elapsed Time"s$e(k)"min"lf$lf$
141 print#2,tab(24)"aaaaaaaaaaaaaaaaaaaaaa     9.99  aa"
142 print#3,"Empty depth"s$l(k)"cm"lf$lf$
143 print#3,"Initial water added "s$w(k)" g"lf$lf$
144 print#3,"V/E balance adjustment:"lf$lf$
145 print#2,tab(31)"aaaaaaa 9 a s9999.99"
146 print#3,"Channel"s$cw"="s$a(k)lf$lf$
147 print#3,"Channel"s$cl"="s$b(k)lf$lf$
148 print#3,"Channel"s$cp"="s$c(k)lf$lf$
149 print#1,tab(24)"Test conducted in cell no."ce:print#1,ff$
150 ifr$=""orzd=1then152
151 ce=2:cw=2:cl=3:cp=5:k=2:f$(k)=r$:gosub63:gosub2:zd=1:goto135
152 close1:close2:close3:return
153 data6,10,18,10,6,0
```

ZETA

```
1 dim a(100),b(100),c(100),d(100),e(100),w(100),f(100),x(100),g$(100)
2 lf$=chr$(10):r$=chr$(13):en$=chr$(1):ff$=chr$(12)
3 poke59468,14:open7,4,7:print#7:close7
4 open13,4,13:print#13:close13:open15,4,15:print#15:close15
5 open5,4,5:fork=1to6:readb:b$=b$+chr$(b):next:print#5,b$;:close5:goto31
6 print"":printtab(8)"data may not be correct yet"
7 fori=1to200:poke59468,12:poke59468,14:next:goto50
8 for k=1to10:getq$:next
9 getq$:if q$=""goto9
10 return
11 id=1:j=0:print:print"Enter raw data for slurry concentration.":print
12 input"Test Code";tc$:print:input"Tare";t:print
13 input"Tare + Slurry";ts:print:input"Tare + Coal";tc:print
14 input"Weight of coal added";ca:print
15 print:print"Concentration of chemical solution":input"Molecular Wt. ";mw
16 input"Weight of chemical";w1:input"Volume of water";w2
17 input"Are data correct (y/n) ";q$:ifq$="y"then20
18 if q$="n"then11
19 goto17
20 cs=w1/w2:wc=tc-t:ww=ts-tc:tw=ca*(ww/wc):tw=tw-ww:ca=ca-wc
21 print"   Enter  q  for Amount when through"
22 printtab(13)"entering data.":print
23 j=j+1:a(j)=j:input"Amount of chemical added ";b$:b(j)=val(b$)
24 ifb$="q"thenj=j-1:goto50
25 input"Zeta potential              ";c(j)
26 input"Specific conductivity       ";d(j)
27 input"Temperature                 ";e(j):print
28 w(j)=cs*b(j):f(j)=((w(j)/(tw+b(j)))*1000)/mw
29 x(j)=(int(f(j)*10↑9+0.5))/10↑4
30 goto21
31 print"Main Menu:":print
32 print"   1- Input data":print
33 print"   2- Review data":print
34 print"   3- Edit data":print
35 print"   4- Print hard copy of data":print
36 print"   5- Save data on a disk":print
37 print"   6- Read data from a disk":print
38 print"   7- Exit program":print:print
39 print"     Enter Option No.":gosub8
40 ifval(q$)=5andid=1thengoto6
41 onval(q$)goto11,43,97,182,206,230,253
42 goto32
43 print" Review Menu:":print
44 print"      1- Raw data":print
45 print"      2- Calculated data":print
46 print"      3- Return to main menu":print:print
47 print"        Enter Option No.":gosub8
48 onval(q$)goto50,75,31
49 goto43
50 mx=j:f=1:l=15
51 print""tab(3)"Point"spc(3)"Chem."spc(3)"Zeta"spc(3)"Spec."spc(3)"Temp."
52 printtab(4)"No."spc(5)"Add."spc(3)"Pot."spc(3)"Cond."spc(4)"(C)"
53 if mx<15 then l=mx:f=1
54 i=1:for m=ftol:i=i+1
55 print"":for k=1toi:print"";:next
56 print"                                        ":print""
```

```
57 printtab(4)a(m)tab(11)b(m)tab(19)c(m)tab(26)d(m)tab(34)e(m):next
58 print:printtab(6)"█ To scroll press u,d,/,*,f,l ":printtab(11)"█ Press R to retu
59 gosub8:ifq$="u"thenf=f-15:l=l-15:goto67
60 ifq$="d"thenf=f+15:l=l+15:goto69
61 ifq$="/"thenf=f-1:l=l-1:goto67
62 ifq$="*"thenf=f+1:l=l+1:goto69
63 ifq$="f"thenf=1:l=15:goto53
64 ifq$="l"thenl=mx:f=mx-14:goto69
65 ifq$="r"then71
66 goto59
67 iff<0thenf=1:l=15
68 print"█":print"█":goto53
69 ifl>mxthenl=mx:f=mx-14
70 print"█":print"█":goto53
71 ifid=0then31
72 input"█Are data correct (y/n) ";q$:ifq$="y"thenid=0:goto31
73 if q$="n"then97
74 goto72
75 ma=j:g=1:v=15
76 print"█"tab(3)"Point"spc(3)"Final"spc(3)"Zeta"spc(3)"Spec."spc(3)"Temp."
77 printtab(4)"No."spc(4)"Conc."spc(3)"Pot."spc(3)"Cond."spc(4)"(C)"
78 printtab(10)"(10E-5)"
79 if ma<15 then v=ma:g=1
80 z=2:for y=gtov:z=z+1
81 print"█":for i=1toz:print"█";:next
82 print"                                          ":print"██"
83 printtab(4)a(y)tab(10)x(y)tab(19)c(y)tab(26)d(y)tab(34)e(y):next
84 print:printtab(6)"█ To scroll press u,d,/,*,f,l ":printtab(11)"█ Press R to retu
85 gosub8:if q$="u"theng=g-15:v=v-15:goto93
86 ifq$="d"theng=g+15:v=v+15:goto95
87 ifq$="/"theng=g-1:v=v-1:goto93
88 ifq$="*"theng=g+1:v=v+1:goto95
89 ifq$="f"theng=1:v=15:goto79
90 ifq$="l"thenv=ma:g=ma-14:goto95
91 ifq$="r"then31
92 goto85
93 ifg<0theng=1:v=15
94 print"█":print"█":goto79
95 ifv>mathenv=ma:g=ma-14
96 print"█":print"█":goto79
97 print"███ Edit Menu:":print
98 print"      1- Correct data":print
99 print"      2- Delete data":print
100 print"      3- Insert data":print
101 print"      4- Renumber points":print
102 print"      5- Return to main menu":print:print
103 print"        Enter Option No.":gosub8
104 onval(q$)goto106,129,150,177,31
105 goto97
106 print"█     To exit correction mode "
107 print"      type █ 0 █ for Point No."
108 print"████"
109 input"Point No. ";n:print
110 ifid=1andn=0then50
111 ifn=0then97
112 print"Data values originally entered:":print
113 print"   Amount of chemical added";b(n):print
114 print"   Zeta Potential           ";c(n):print
115 print"   Specific Conductivity    ";d(n):print
116 print"   Temperature              ";e(n):print:print
```

```
117 print"Enter correct values:":print
118 input"   Amount of chemical added ";rc:print
119 input"   Zeta Potential           ";rz:print
120 input"   Specific Conductivity    ";rs:print
121 input"   Temperature              ";rt:print:print
122 input"Are data correct (y/n) ";q$:ifq$="y"then125
123 ifq$="n"then106
124 goto122
125 a(n)=n:b(n)=rc:c(n)=rz:d(n)=rs:e(n)=rt
126 w(n)=cs*b(n):f(n)=w(n)/(tw+b(n))
127 x(n)=(int(f(n)*10↑9+0.5))/10↑4
128 goto106
129 print"■     To exit deletion mode"
130 print"      type ■ 0 ■ for Point No."
131 print"■■■■"
132 input"Point No. ";n:print
133 ifid=1andn=0then50
134 ifn=0then97
135 print"Data values originally entered:":print
136 print"   Amount of chemical added";b(n):print
137 print"   Zeta Potential          ";c(n):print
138 print"   Specific Conductivity   ";d(n):print
139 print"   Temperature             ";e(n):print:print
140 print"Is this the point you"
141 print"want to delete (y/n) ?":gosub8:ifq$="y"then143
142 ifq$="n"then129
143 print:input"Are you sure (y/n) ";a$:print:ifa$="y"then145
144 ifa$="n"then140
145 x=j-1:fork=ntox
146 b(k)=b(k+1):c(k)=c(k+1):d(k)=d(k+1):e(k)=e(k+1)
147 f(k)=f(k+1):w(k)=w(k+1):x(k)=x(k+1):next
148 j=j-1
149 goto129
150 print"■     To exit insertion mode"
151 print"      type ■ 0 ■ for Point No."
152 print"■■■■"
153 print"There are";j;"Point Nos.":print
154 input"New Point No. ";n:print
155 ifid=1andn=0then50
156 ifn=0then97
157 input"   Amount of chemical added ";nc:print
158 input"   Zeta Potential           ";nz:print
159 input"   Specific Conductivity    ";ns:print
160 input"   Temperature              ";nt:print:print
161 input"Are data correct (y/n) ";q$:ifq$="y"then163
162 goto150
163 if n>a(j)thenj=j+1:a(j)=n:b(j)=nc:c(j)=nz:d(j)=ns:e(j)=nt
164 w(j)=cs*b(j):f(j)=w(j)/(tw+b(j))
165 x(j)=(int(f(j)*10↑9+0.5))/10↑4:goto150
166 for l=1toj
167 ifv=1then169
168 ifn<a(l)thenf=l:v=1
169 next
170 form=jtofstep-1:z=m+1:a(z)=a(m):b(z)=b(m):c(z)=c(m):d(z)=d(m)
171 e(z)=e(m):w(z)=w(m):f(z)=f(m):x(z)=x(m)
172 next
173 a(f)=n:b(f)=nc:c(f)=nz:d(f)=ns:e(f)=nt
174 w(f)=cs*b(f):f(f)=w(f)/(tw+b(f))
175 x(f)=(int(f(f)*10↑9+0.5))/10↑4:j=j+1
176 goto150
```

```
177 forf=1toj:a(f)=f:next
178 print"":print"The last Point No. is ";j
179 print:print"To return to Edit Menu press  r  ":gosub8
180 ifq$="r"then97
181 goto178
182 open1,4,1:open2,4,2:open3,4:print#3,lf$lf$lf$lf$
183 print"";:printtab(12)"Please Wait ..."
184 print#3,en$tab(13)"Zeta Potential Investigation"lf$lf$lf$
185 zz=int((72-len(tc$))/2):gosub256:print#3,tab(zz)"Test Code - "tp$lf$lf$
186 open4,4:print#3,tab(14)"Final"spc(12)"Zeta"spc(11)"Specific"
187 print#3,tab(10)"Concentration"spc(6)"Potential"spc(6)"Conductivity";
188 print#3,spc(7)"Temperature"
189 print#4,tab(15)"(M)"spc(12)"(mV)"spc(10)"("chr$(254)"mhos/cm)";
190 print#3,tab(12)"(C)"
191 print#3,tab(10);:forl=1to64:print#3,"¯";:next:print#3,r$;lf$
192 print#2,tab(11)"z.999999999        s99.9              9999";
193 print#2,spc(15)"99.9"
194 fork=1toj:print#1,f(k);c(k);d(k);e(k);lf$:ifk>20thenpr=1
195 ifpr<>1orpp=1then205
196 pp=1:print#3,ff$lf$lf$lf$lf$
197 print#3,tab(25)"Zeta Potential Investigation Cont."lf$lf$lf$
198 print#3,tab(zz)"Test Code - "tp$lf$lf$
199 print#3,tab(14)"Final"spc(12)"Zeta"spc(11)"Specific"
200 print#3,tab(10)"Concentration"spc(6)"Potential"spc(6)"Conductivity";
201 print#3,spc(7)"Temperature"
202 print#4,tab(13)"(g/ml)"spc(12)"(mV)"spc(10)"("chr$(254)"mhos/cm)";
203 print#3,tab(12)"(C)"
204 print#3,tab(10);:forl=1to64:print#3,"¯";:next:print#3,r$;lf$
205 next:print#3,ff$:close1:close2:close3:close4:pr=0:pp=0:goto31
206 print"":goto208
207 input"Enter filename";tc$:print
208 input"Which disk drive  0 or 1  ";q:print
209 ifq=0thendopen#4,(tc$),d0,w:go212
210 ifq=1thendopen#4,(tc$),d1,w:goto212
211 goto208
212 ifds=62thenprint""ds$:dclose#4:goto217
213 ifds<>0thenprint""ds$:dclose#4:goto207
214 tw$="wyl"+tc$:ifq=0thendopen#5,(tw$),d0,w
215 ifq=1thendopen#5,(tw$),d1,w
216 goto224
217 input"Would you like a disk directory ";z$:ifleft$(z$,1)="y"then220
218 ifleft$(z$,1)="n"then207
219 goto217
220 input"Which disk drive  0 or 1  ";q
221 print"Remember <SPACEBAR> stops the listing":ifq=0thendirectoryd0:goto207
222 ifq=1thendirectoryd1:goto207
223 goto221
224 print"";:print"  I'm saving data. It has"j" points"
225 print#4,j:forp=1toj:printa(p);b(p);c(p);d(p);e(p)
226 print#4,a(p);r$;b(p);r$;c(p);r$;d(p);r$;e(p):next
227 print#4,t;r$;ts;r$;tc;r$;ca;r$;w1;r$;w2;r$;mw
228 fori=1toj:g$(i)=str$(x(i))+" "+str$(c(i))+" "+str$(d(i)):next
229 print#5,tc$:forp=1toj:print#5,g$(p):next
230 dclose#4:dclose#5:goto31
231 print"";:printtab(15)"Data Read"
232 input"Enter filename";rd$:tc$=rd$
233 input"Which disk drive  0 or 1  ";q:ifq=0thendopen#4,(rd$),d0:goto236
```

```
234 ifq=1thendopen#4,(rd$),d1:goto236
235 goto233
236 ifds=62thenprint"■■"ds$:dclose#4:goto239
237 ifds<>0thenprint"■■"ds$:dclose#4:goto232
238 goto246
239 input"■Would you like a disk directory ";z$:ifleft$(z$,1)="y"then242
240 ifleft$(z$,1)="n"then232
241 goto239
242 input"■Which disk drive ■ 0 or 1 ■ ";q
243 print"■Remember <■SPACEBAR■> stops the listing■":ifq=0thendirectoryd0:goto232
244 ifq=1thendirectoryd1:goto232
245 goto243
246 input#4,j:print"■"j" data points"
247 forp=1toj:input#4,a(p),b(p),c(p),d(p),e(p):next
248 input#4,t,ts,tc,ca,w1,w2,mw
249 cs=w1/w2:wc=tc-t:ww=ts-tc:tw=ca*(ww/wc):fork=1toj
250 f(k)=((cs*b(k)/(tw+b(k)))*1000)/mw
251 x(k)=(int(f(k)*10↑9+0.5))/10↑4
252 printa(k);b(k);c(k);d(k);e(k):next
253 dclose#4:goto31
254 end
255 data 1,62,4,4,60,2
256 tp$="":ln=len(tc$):forh=1toln:y$=mid$(tc$,h,1):x=asc(y$)
257 ifx<91andx>64thenx=x+128:y$=chr$(x)
258 tp$=tp$+y$:next:return
```

UPLOAD PREP

```
1 goto61
2 printtab(15)"TRY AGAIN":return
3 input#4,s,t0,l,t1,c,t2,v,t3,p,t4:return
4 j=0:gosub58:input"Which drive is raw data disk in ";d$:dk=val(d$)
5 ifdk<0ordk>1thengosub2:goto4
6 ifdk=0thendopen#4,"tests",d0:dw=1
7 ifdk=1thendopen#4,"tests",d1:dw=0
8 j=j+1:input#4,f$(j),d$(j),n(j)
9 ifst=64thenclose#4:goto11
10 goto8
11 print"       Place PED/WYL disk in drive"dw
12 printtab(8)"Press <RETURN> when ready"
13 getq$:ifq$=""then13
14 ifq$=chr$(13)then16
15 gosub2:goto13
16 gosub58:mx=j:f=1:l=10
17 print"":printtab(3)"No."spc(6)"Test Code"spc(7)"Date":print
18 ifmx<10thenl=mx:f=1
19 i=1:form=ftol:i=i+1:print"":fork=1toi:print"";:next
20 print"                                                    ":print""
21 printtab(2)mtab(12)f$(m)tab(26)d$(m):next:print
22 print"       To scroll press u,d,/,*,f,l       "
23 print"   Press r to enable file no. input      "
24 getq$:ifq$=""then24
25 ifq$="u"thenf=f-10:l=l-10:goto33
26 ifq$="d"thenf=f+10:l=l+10:goto35
27 ifq$="/"thenf=f-1:l=l-1:goto33
28 ifq$="*"thenf=f+1:l=l+1:goto35
29 ifq$="f"thenf=1:l=10:goto33
30 ifq$="l"thenl=mx:f=mx-9:goto35
31 ifq$="r"then37
32 goto22
33 iff<0thenf=1:l=10
34 print"":print"":goto18
35 ifl>mxthenl=mx:f=mx-9
36 print"":print"":goto18
37 input"Enter file no. ";k:ifk<1ork>jthengosub2:goto37
38 w$="wyl"+f$(k):ifdk=0thendopen#4,(f$(k)),d0:dopen#5,(w$),d1,w
39 n=n(k)+1:ifdk=1thendopen#4,(f$(k)),d1:dopen#5,(w$),d0,w
40 :w$="":z=len(f$(k)):fori=1toz:q$=mid$(f$(k),i,1)
41 ifasc(q$)>64andasc(q$)<91thenq$=chr$(asc(q$)+128)
42 w$=w$+q$:next:f$(k)=w$:pg=int(n(k)/40+.999):z=(78-len(f$(k)))/2:return
43 print"":printtab(15)"Here goes !"
44 w$=f$(k)+" "+d$(k):print#5,w$
45 t=0:we=0:wm=0:i0=0:i1=0:i2=0:i3=0:i4=0:i5=0:i6=0
46 fori=1ton(k):gosub3:a$=str$(s)+" "+str$(t0)+" "+str$(l)+" "+str$(t1)+" "
47 a$=a$+str$(c)+" "+str$(t2)+" "+str$(v)+" "+str$(t3)+" "+str$(p)+" "+str$(t4)
48 z1=(t2+i2)/2:z2=(t3+i3)/2:t=(z1+z2)/2-t:ifi6=0theni6=1
49 ca=(c+i4)/2:va=(v+i5)/2:w=((ca/1000)*va*t)/60000:we=we+w:vg=0
50 r=0:dr=0:ifl<>0thenvg=(int((v/l)*10+.5))/10
51 wr=(int((s-i1)*10+.5))/10:dt=t0-i0:ld=i6-l:ifc<>0thenr=1000*v/c
52 lw=ld:ifld<0thenlw=0
53 wp=lw*p*.428:wm=wm+wp:ifdt<>0thendr=(int((wr/dt)*10+.5))/10
54 r=(int(r*10+.5))/10:ld=(int(ld*100+.5))/100:we=(int(we*1000+.5))/1000
55 wm=int(wm+.5):i0=t0:i1=s:i2=t2:i3=t3:i4=c:i5=v:i6=l
56 b$=str$(wr)+" "+str$(dr)+" "+str$(vg)+" "+str$(r)+" "+str$(ld)+" "
```

```
57 b$=b$+str$(we)+" "+str$(wm):print#5,a$;c$;b$:next:dclose#4:dclose#5:return
58 print"▓":fori=1to20:print"▓  ";:next
59 print"▓  Pressurized Electroosmotic Dewatering "
60 print"▓";:fori=1to20:print"▓  ";:next:print:return
61 poke59468,14:c$=chr$(13):dimf$(100),d$(100),n(100)
62 ifzz<>1thengosub4:gosub43
63 ifzz=1thengosub16:gosub43
64 input"▓▓Continue (y/n) ";z$
65 ifz$="n"thenprint"▓":printtab(15)"▓▓▓▓▓▓▓▓▓▓▓▓All done !▓▓▓▓▓▓":end
66 ifz$="y"then68
67 gosub2:goto64
68 input"▓Same data disks (y/n) ";z$:ifz$="y"thenzz=1:goto62
69 ifz$="n"thenzz=0:goto62
70 gosub2:goto68
```

MENU/SAS

```
1 poke59468,14:print"Please Wait ...":goto156
2 j=len(p$):fori=1toj:a=peek(pa+asc(mid$(p$,i,1))):print#1,chr$(a);:next
3 print#1,chr$(141);:syswt:return
4 r$="":sk=1
5 poke15,0:sysdn:j=peek(15)-1:fori=0toj:a$=chr$(peek(db+i)):ifsk=1then13
6 ifa$=chr$(13)theni=j:goto12
7 ifa$="!"theni=j:pr=1:goto11
8 ifa$="&"thenlb=0:pr=1:goto11
9 ifa$="#"andlb=1then12
10 ifa$="#"thenlb=1:a$="":pr=1
11 r$=r$+a$:iflen(r$)>76orpr=1thenprint#2,chr$(34)r$chr$(34):printr$:r$="":pr=0
12 nexti:return
13 r$=r$+a$:ifa$=chr$(13)theni=j
14 nexti:sk=0:return
15 gosub116:open1,6:mh=peek(53):poke53,60:printfre(0)
16 print"":print"***** WYLBUR COMMUNICATIONS PROGRAM ****"
17 printtab(8)"Revised by Leon W. Heath"
18 rd=15361:pa=15760:dn=15480:db=15984:co=15561:wt=15595:wc=15616:goto20
19 print""
20 print"Do you wish to:":print"      1 - Logon to WYLBUR"
21 print"      2 - Reestablish terminal mode":print"      3 - Upload a text file"
22 print"      4 - Download a text file":print"      5 - Execute a downloaded file"
23 print"      6 - Print out a file":print"      7 - Exit this program":print
24 print"     FOR OPTIONS 3 & 4, YOU MUST BE":printtab(10)"CONNECTED TO WYLBUR
25 print"Enter choice - ";:gosub108
26 onval(a$)goto68,76,28,54,81,95,27:goto19
27 poke53,mh:end
28 print"":printtab(14)"Text Upload":print"YOU SHOULD BE LOGGED INTO WYLBUR"
29 printtab(8)"AND IN THE COLLECT MODE.":print:print:gosub103:ife$=""then19
30 print"      Press <HOME> to EXIT option":print""
31 print"Upload File From Disk Drive 0 or 1 ?";:gosub108:print""
32 ifa$="0"thendopen#2,(f$),d0:goto35
33 ifa$="1"thendopen#2,(f$),d1:goto35
34 goto31
35 ifds=62thenprint""ds$:dclose:goto38
36 ifds<>0thenprint""ds$:dclose:goto28
37 goto45
38 input"Would you like a directory ";q$:ifleft$(q$,1)="y"then41
39 ifleft$(q$,1)="n"then28
40 goto38
41 print"    Remember spacebar stops listing"
42 input"Which disk drive ";q:ifq=0thendirectoryd0:gosub40:goto31
43 ifq=1thendirectoryd1:gosub40:goto31
44 goto42
45 ifds<>0thenprint""ds$:dclose:goto20
46 print"Data upload will now begin.":pokewc,17:gete$:ife$=""then52
47 get#2,a$:printa$;:ifst<>0then51
48 iflen(a$)<1then47
49 a=peek(pa+asc(a$)):ifa<>141thenprint#1,chr$(a);:goto47
50 print#1,chr$(a);:syswt:goto47
51 ifa$<>chr$(13)thenprint#1,a$;
52 print#1,chr$(141);:syswt:print#1,chr$(17):syswt
53 print"":printtab(10)"UPLOADING COMPLETED":dclose:goto20
54 print"":printtab(13)"Text Download":gosub103:ife$=""then19
55 print"      Press <HOME> to EXIT option":print""
56 print"Download File To Disk Drive 0 or 1 ? ";:gosub108:print""
57 ife$=""then19
```

```
58 ifa$="0"thendopen#2,(f$),d0,w:goto61
59 ifa$="1"thendopen#2,(f$),d1,w:goto61
60 goto56
61 ifds<>0thenprint"██"ds$:dclose:goto20
62 p$="set # first":pokewc,17:gosub2:p$="count":pokewc,10:gosub2:gosub4
63 l=val(r$):print:printl;" lines to transfer":print:r$=""
64 p$="point # unnum":pokewc,10:gosub2:gosub5
65 gete$:ife$="█"thendclose:goto19
66 l=l-1:ifl>0thenp$="set # next":pokewc,17:gosub2:goto64
67 print"█":printtab(9)"██DOWNLOADING COMPLETED":dclose:goto20
68 print"█":printtab(14)"█WYLBUR LOGON":print"█Please follow these steps:"
69 print"█1. Type █at█,██atf0█ and then █atn1█."
70 print"██ NOTE█: You must get an";
71 print" █OK█ response for":print"        each command. If you don't,"
72 print"        repeat the command."
73 print"█2. When you get the █CONNECT█ response,"
74 print"    type █ooo█<CR> twice."
75 goto77
76 print"█":printtab(8)"██Terminal Reestablishment"
77 print"██Remember cursor left = backspace"
78 print"            cursor down = control Q"
79 print"█    Press <█HOME█> to return to menu":ifh<>0thenprint#1,chr$(141)
80 print:h=1:sysrd:goto19
81 print"█"tab(16)"██EXECUTE":print"██This option will load a sequential file"
82 print"from the disk as a program.":print"██This option will also erase the WYLBU
83 print"COMMUNICATION PROGRAM.If you have":print"second thoughts, press <█HOME█> t
84 print"return to the menu.":print"█press <█RETURN█> to continue"
85 geta$:ifa$=""then85
86 ifa$="█"then19
87 ifa$<>chr$(13)then81
88 print"███████      Press <█HOME█> to EXIT option":gosub103:ife$="█"then19
89 print"█Is the file disk in drive █0 or 1█ ?";:gosub108
90 ife$="█"thendclose:goto19
91 ifa$<>"0"ora$<>"1"then89
92 print"███To begin loading the file as a program,":print"type this line:"
93 ifa$="0"thenprint"██dopen#10,(f$),d0:sys826":poke53,mh:new
94 ifa$="1"thenprint"██dopen#10,(f$),d1:sys826":poke53,mh:new
95 open3,4:p$="set # first":pokewc,17:gosub2:p$="count":pokewc,10:gosub2
96 gosub4:l=val(r$):print:printl;" lines to print"
97 p$="point # unnum":pokewc,10:gosub2:gosub4:printr$;
98 iflen(r$)<62thenprint#3,"      "r$;:goto100
99 fi=len(r$):print#3,"      "left$(r$,60):r$=mid$(r$,61,fi):goto98
100 gete$:ife$="█"thenclose3:goto19
101 l=l-1:ifl>0thenp$="set # next":pokewc,17:gosub2:goto97
102 close3:print"█":printtab(10)"██PRINTING COMPLETED":goto20
103 print"█Enter PET Filename:  ";:gosub108:ife$="█"thenreturn
104 f$=a$:ifl=0thenprint:goto103
105 print"██Filename is '"f$"'":return
106 j=len(p$):fori=1toj:a=peek(pa+asc(mid$(p$,i,1))):print#1,chr$(a);:next
107 print#1,chr$(141);:syswt:return
108 a$="":l=0:poke167,0
109 gete$:ife$=""then109
110 ife$="█"ore$=chr$(13)thenprint:return
111 ife$<>chr$(20)ande$<>"█"thengoto114
112 l=l-1:ifl<0thenl=0:goto109
113 a$=left$(a$,l):printchr$(20);:goto109
114 ifasc(e$)<32thengoto109
115 printe$;:l=l+1:a$=a$+e$:goto109
116 fori=15360to15984:reada:pokei,a:next:fori=826to919:reada:pokei,a:next:return
117 data0,32,204,255,32,174,241,32,219,60,160,0,132,150,32,192,241,164,150
```

```
118 data208,28,32,173,60,240,23,234,201,17,240,18,72,173,19,232,41,254,141
119 data19,232,32,201,60,104,32,2,226,208,211,169,0,133,167,173,19,232,9,1
120 data141,19,232,32,13,242,240,194,72,32,204,255,104,201,19,240,44
121 data201,3,240,40,201,18,240,31
122 data201,146,240,27,174,0,60,240,8,162,0,142,0,60,32,185,60
123 data32,180,60,162,1,32,201,255,32,210,255,76,1,60,141,0,60,240,138,96
124 data32,204,255,32,174,241,32,219,60,160,0,132,150,32,192,241,164,150,208
125 data16,32,173,60,240,11,164,15,153,112,62,230,15,201,17,240,13,32,13
126 data242,240,218,201,3,240,4,201,19,208,210,32,204,255,96,41,127,170,189
127 data16,61,96,170,189,144,61,96,41,127,201,64,144,7,201,95,176,3,41,31
128 data96,169,0,96,169,1,133,167,165,170,240,9,169,0,133,170,165,169,32
129 data6,230,96,72,138,72,152,72,169,6,133,212,169,255,133,211,76,198,247
130 data32,204,255,32,174,241,32,219,60,160,0,132,150
131 data32,192,241,164,150,208,4,201,17,240,9,32,13,242
132 data240,230,201,3,208,226,32,204,255,96
133 data0,0,0,0,0,0,0,0,157,0,0,0,0,13,0,0,0,17,0,0
134 data0,0,0,0,0,0,0,0,0,0,0,0,32,33,34,35,36,37,38,39
135 data40,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59
136 data60,61,62,63,64,193,194,195,196,197,198,199,200,201,202,203,204,205
137 data206,207,208,209,210,211,212,213,214,215,216,217,218
138 data91,92,93,94,95,96,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80
139 data81,82,83,84,85,86,87,88,89,90,181,221,182,171,20
140 data0,129,130,3,132,5,6,135,136,9,10,139,12,141,142,15,144
141 data17,18,147,255,149,150,23,24,153,154,27,156,29,30,159,160
142 data33,34,163,36,165,166,39,40,169,170,43,172,45,46,175,48
143 data177,178,51,180,53,54,183,184,57,58,187,60,189,190,63,192
144 data225,226,99,228,101,102,231,232,105,106,235,108,237,238
145 data111,240,113,114,243,116,245,246,119,120,249,250,219,92,221,222,95
146 data0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
147 data0,0,0,0,0,0,0,0,0,0,0,141,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,136,0,0,160
148 data0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
149 data65,66,195,68,197,198,71,72,201,202,75,204,77,78,207,80
150 data209,210,83,212,85,86,215,216,89,90,123,252,125,126,0,0
151 data120,166,144,142,128,3,166,145,142,129,3,88,120,162,94,134,144,162,3
152 data134,145,88,96,120,172,128,3,132,144,172,129,3,132,145,88,96,166,158
153 data224,10,240,27,32,81,3,32,130,3,32,228,255,166,158,157,111,2,232,134
154 data158,166,150,208,3,32,70,3,32,204,255,76,0,0,72,72,72,169,8,133,212
155 data169,99,133,211,169,10,133,210,169,0,133,150,76,198,247
156 print"■":printtab(14)"■■■*** MENU ***":printtab(10)"■1 - Wylbur Comm. Prg."
157 printtab(10)"■2 - Wylbur/SAS dwnld.":printtab(10)"■3 - Auto download"
158 printtab(10)"■4 - Plot SAS/GRAPH file":printtab(10)"■5 - Write fetch file"
159 printtab(10)"■6 - Dump Wylbur files"
160 printtab(8)"■■ Enter option no. ■ ";
161 getq$:ifq$=""then161
162 q=val(q$):printq:ifq<1orq>6thenprinttab(15)"■TRY AGAIN":goto160
163 ifq=1thendload"modwyl,d0:run
164 ifq=2then15
165 ifq=3thendload"nitedwn",d0:run
166 ifq=4thendload"plotsas",d0:run
167 ifq=5thendload"writefet",d0:run
168 ifq=6thendload"dumpfile",d0:run
```

MODWYL

```
1 poke59468,14:print"Please Wait ...":open7,4,7:print#7:close7
2 gosub96:open1,6:mh=peek(53):poke53,60:printfre(0)
3 print"":print"**** WYLBUR COMMUNICATIONS PROGRAM ****"
4 printtab(8)"Revised by Leon W. Heath":printtab(10)"& Matthew J. Kramer"
5 rd=15361:pa=15760:dn=15480:db=15984:co=15561:wt=15595:wc=15616:goto7
6 print""
7 print"Do you wish to:":print"     1 - Logon to WYLBUR"
8 print"      2 - Reestablish terminal mode":print"     3 - Upload a text file"
9 print"      4 - Download a text file":print"     5 - Execute a downloaded file"
10 print"     6 - Print out a file":print"     7 - Exit program"
11 print"     FOR OPTIONS 3 & 4, YOU MUST BE":printtab(10)"CONNECTED TO WYLBUR
12 print"Enter choice - ";:gosub88
13 onval(a$)goto46,52,15,32,56,72,14:goto6
14 poke53,mh:end
15 print"":printtab(14)"Text Upload":print"YOU SHOULD BE LOGGED INTO WYLBUR"
16 printtab(8)"AND IN THE COLLECT MODE.":print:print:gosub80:ife$=""then6
17 print"      Press <HOME> to EXIT option":print""
18 print"Upload File From Disk Drive 0 or 1 ?";:gosub88:print""
19 ife$=""then6
20 ifa$="0"thendopen#2,(f$),d0:goto23
21 ifa$="1"thendopen#2,(f$),d1:goto23
22 goto 18
23 ifds<>0thenprint""ds$:dclose:goto7
24 print"Data upload will now begin.":pokewc,17:gete$:ife$=""then30
25 get#2,a$:printa$;:ifst<>0then29
26 iflen(a$)<1then25
27 a=peek(pa+asc(a$)):ifa<>141thenprint#1,chr$(a);:goto25
28 print#1,chr$(a);:syswt:goto25
29 ifa$<>chr$(13)thenprint#1,a$;
30 print#1,chr$(141);:syswt:print#1,chr$(17):syswt
31 print"":printtab(10)"UPLOADING COMPLETED":dclose:goto7
32 print"":printtab(13)"Text Download":gosub80:ife$=""then6
33 print"      Press <HOME> to EXIT option":print""
34 print"Download File To Disk Drive 0 or 1 ? ";:gosub88:print"":ife$=""the
35 ifa$="0"thendopen#2,(f$),d0,w:goto38
36 ifa$="1"thendopen#2,(f$),d1,w:goto38
37 goto34
38 ifds<>0thenprint""ds$:dclose:goto7
39 p$="set * first":pokewc,17:gosub83:p$="count":pokewc,10:gosub83:gosub85
40 l=val(r$):print:printl;" lines to transfer":print
41 p$="point * unnum":pokewc,10:gosub83:gosub85
42 print#2,r$;:printr$;
43 gete$:ife$=""thendclose:goto6
44 l=l-1:ifl>0thenp$="set * next":pokewc,17:gosub83:goto41
45 print"":printtab(9)"DOWNLOADING COMPLETED":dclose:goto7
46 print"":printtab(14)"WYLBUR LOGON":print"Please follow these steps:"
47 print"1. Type at,atf0 and then atn1.":print"NOTE: You must get an";
48 print" OK response for":print"        each command. If you don't,"
49 print"        repeat the command."
50 print"2. When you get the CONNECT response,":print"type boo<CR> twice."
51 goto53
52 print"":printtab(8)"Terminal Reestablishment"
53 print"Remember cursor left = backspace":printtab(9)"cursor down = control Q"
54 print"    Press <HOME> to return to menu":ifh<>0thenprint#1,chr$(141)
55 print:h=1:sysrd:goto6
56 print""tab(16)"EXECUTE":print"This option will load a sequential file"
```

```
57 print"from the disk as a program."
58 print"This option will also erase the WYLBUR"
59 print"COMMUNICATION PROGRAM.If you have"
60 print"second thoughts, press <HOME> to"
61 print"return to the menu.":print"Press <RETURN> to continue"
62 geta$:ifa$=""then62
63 ifa$=""then6
64 ifa$<>chr$(13)then56
65 print"       Press <HOME> to EXIT option":gosub80:ife$=""then6
66 print"Is the file disk in drive 0 or 1 ?";:gosub88
67 ife$=""thendclose:goto6
68 ifa$<>"0"ora$<>"1"then66
69 print"To begin loading the file as a program,":print"type this line:"
70 ifa$="0"thenprint"dopen#10,(f$),d0:sys826:poke53,mh:new
71 ifa$="1"thenprint"dopen#10,(f$),d1:sys826:poke53,mh:new
72 open3,4:p$="set * first":pokewc,17:gosub83:p$="count":pokewc,10:gosub83
73 gosub85:l=val(r$):print:printl;" lines to print"
74 p$="point * unnum":pokewc,10:gosub83:gosub85:printr$;
75 iflen(r$)<79thenprint#3,"      "r$;:goto77
76 fi=len(r$):print#3,"      "left$(r$,78):r$=mid$(r$,79,fi):goto75
77 gete$:ife$=""thenclose3:goto6
78 l=l-1:ifl>0thenp$="set * next":pokewc,17:gosub83:goto74
79 close3:print"":printtab(10)"PRINTING COMPLETED":goto7
80 print"Enter PET Filename:  ";:gosub88:ife$=""thenreturn
81 f$=a$:ifl=0thenprint:goto80
82 print"Filename is '"f$"'":return
83 j=len(p$):fori=1toj:a=peek(pa+asc(mid$(p$,i,1))):print#1,chr$(a);:next
84 print#1,chr$(141);:syswt:return
85 poke15,0:sysdn:r$="":j=peek(15)-1:fori=0toj:a$=chr$(peek(db+i))
86 r$=r$+a$:ifa$=chr$(13)theni=j
87 nexti:return
88 a$="":l=0:poke167,0
89 gete$:ife$=""then89
90 ife$=""ore$=chr$(13)thenprint:return
91 ife$<>chr$(20)ande$<>""thengoto94
92 l=l-1:ifl<0thenl=0:goto89
93 a$=left$(a$,l):printchr$(20);:goto89
94 ifasc(e$)<32thengoto89
95 printe$;:l=l+1:a$=a$+e$:goto89
96 fori=15360to15984:reada:pokei,a:next:fori=826to919:reada:pokei,a:next
97 data0,32,204,255,32,174,241,32,219,60,160,0,132,150,32,192,241,164,150
98 data208,28,32,173,60,240,23,234,201,17,240,18,72,173,19,232,41,254,141
99 data19,232,32,201,60,104,32,2,226,208,211,169,0,133,167,173,19,232,9,1
100 data141,19,232,32,13,242,240,194,72,32,204,255,104,201,19,240,44
101 data201,3,240,40,201,18,240,31
102 data201,146,240,27,174,0,60,240,8,162,0,142,0,60,32,185,60
103 data32,180,60,162,1,32,201,255,32,210,255,76,1,60,141,0,60,240,138,96
104 data32,204,255,32,174,241,32,219,60,160,0,132,150,32,192,241,164,150,208
105 data16,32,173,60,240,11,164,15,153,112,62,230,15,201,17,240,13,32,13
106 data242,240,218,201,3,240,4,201,19,208,210,32,204,255,96,41,127,170,189
107 data16,61,96,170,189,144,61,96,41,127,201,64,144,7,201,95,176,3,41,31
108 data96,169,0,96,169,1,133,167,165,170,240,9,169,0,133,170,165,169,32
109 data6,230,96,72,138,72,152,72,169,6,133,212,169,255,133,211,76,198,247
110 data32,204,255,32,174,241,32,219,60,160,0,132,150
111 data32,192,241,164,150,208,4,201,17,240,9,32,13,242
112 data240,230,201,3,208,226,32,204,255,96
113 data0,0,0,0,0,0,0,0,157,0,0,0,0,13,0,0,0,17,0,0
114 data0,0,0,0,0,0,0,0,0,0,0,0,32,33,34,35,36,37,38,39
115 data40,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59
116 data60,61,62,63,64,193,194,195,196,197,198,199,200,201,202,203,204,205
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117 data206,207,208,209,210,211,212,213,214,215,216,217,218
118 data91,92,93,94,95,96,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80
119 data81,82,83,84,85,86,87,88,89,90,181,221,182,171,20
120 data0,129,130,3,132,5,6,135,136,9,10,139,12,141,142,15,144
121 data17,18,147,255,149,150,23,24,153,154,27,156,29,30,159,160
122 data33,34,163,36,165,166,39,40,169,170,43,172,45,46,175,48
123 data177,178,51,180,53,54,183,184,57,58,187,60,189,190,63,192
124 data225,226,99,228,101,102,231,232,105,106,235,108,237,238
125 data111,240,113,114,243,116,245,246,119,120,249,250,219,92,221,222,95
126 data0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
127 data0,0,0,0,0,0,0,0,0,0,141,0,0,0,0,0,0,0,0,0,0,0,0,0,0,136,0,0,160
128 data0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
129 data65,66,195,68,197,198,71,72,201,202,75,204,77,78,207,80
130 data209,210,83,212,85,86,215,216,89,90,123,252,125,126,0,0
131 data120,166,144,142,128,3,166,145,142,129,3,88,120,162,94,134,144,162,3
132 data134,145,88,96,120,172,128,3,132,144,172,129,3,132,145,88,96,166,158
133 data224,10,240,27,32,81,3,32,130,3,32,228,255,166,158,157,111,2,232,134
134 data158,166,150,208,3,32,70,3,32,204,255,76,0,0,72,72,72,169,8,133,212
135 data169,99,133,211,169,10,133,210,169,0,133,150,76,198,247:return
```

NITEDWN

```
1 poke59468,14:print"▒▒▒▒▒▒▒▒▒▒Please Wait ...":gosub25:goto15
2 j=len(p$):fori=1toj:a=peek(pa+asc(mid$(p$,i,1))):print#1,chr$(a);:next
3 print#1,chr$(141);:syswt:return
4 r$="":sk=1
5 poke15,0:sysdn:j=peek(15)-1:fori=0toj:a$=chr$(peek(db+i)):ifsk=1then13
6 ifa$=chr$(13)theni=j:goto12
7 ifa$="!"theni=j:pr=1
8 ifa$="&"then lb=0:pr=1
9 ifa$="#"and lb=1then12
10 ifa$="#"then lb=1:a$="":pr=1
11 r$=r$+a$:iflen(r$)>76orpr=1thenprint#2,chr$(34)r$chr$(34):r$="":pr=0
12 nexti:return
13 r$=r$+a$:ifa$=chr$(13)theni=j
14 nexti:sk=0:return
15 print"▒LOGON":open1,6:poke53,60:rd=15361:pa=15760:dn=15480
16 db=15984:wt=15595:wc=15616:sysrd
17 forq=1tocq:p$="fet"+str$(n(q))+" cle":pokewc,17:gosub2
18 p$="exec from #nitepet cle":pokewc,10:gosub2:gosub4:printr$
19 p$="count":pokewc,10:gosub2:gosub4:printr$:l=val(r$):printl:r$="":sk=0:gosub62
20 p$="set # first":pokewc,17:gosub2
21 p$="point # unnum":pokewc,10:gosub2:gosub5
22 l=l-1:ifl>0thenp$="set # next":pokewc,17:gosub2:goto21
23 dclose#2:p$="pur "+str$(n(q)):pokewc,10:gosub2:gosub4:printr$:nextq
24 p$="logoff cle":pokewc,10:gosub2:end
25 fori=15360to15984:reada:pokei,a:next
26 dopen#7,"fetsas",d0:input#7,cq:dimn(200),f$(200),z$(200)
27 fori=1tocq:input#7,n(i),f$(i):next:dclose#7:printfre(0):return
28 data0,32,204,255,32,174,241,32,219,60,160,0,132,150,32,192,241,164,150
29 data208,28,32,173,60,240,23,234,201,17,240,18,72,173,19,232,41,254,141
30 data19,232,32,201,60,104,32,2,226,208,211,169,0,133,167,173,19,232,9,1
31 data141,19,232,32,13,242,240,194,72,32,204,255,104,201,19,240,44
32 data201,3,240,40,201,18,240,31
33 data201,146,240,27,174,0,60,240,8,162,0,142,0,60,32,185,60
34 data32,180,60,162,1,32,201,255,32,210,255,76,1,60,141,0,60,240,138,96
35 data32,204,255,32,174,241,32,219,60,160,0,132,150,32,192,241,164,150,208
36 data16,32,173,60,240,11,164,15,153,112,62,230,15,201,17,240,13,32,13
37 data242,240,218,201,3,240,4,201,19,208,210,32,204,255,96,41,127,170,189
38 data16,61,96,170,189,144,61,96,41,127,201,64,144,7,201,95,176,3,41,31
39 data96,169,0,96,169,1,133,167,165,170,240,9,169,0,133,170,165,169,32
40 data6,230,96,72,138,72,152,72,169,6,133,212,169,255,133,211,76,198,247
41 data32,204,255,32,174,241,32,219,60,160,0,132,150
42 data32,192,241,164,150,208,4,201,17,240,9,32,13,242
43 data240,230,201,3,208,226,32,204,255,96
44 data0,0,0,0,0,0,0,157,0,0,0,0,13,0,0,0,17,0,0
45 data0,0,0,0,0,0,0,0,0,0,0,0,32,33,34,35,36,37,38,39
46 data40,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59
47 data60,61,62,63,64,193,194,195,196,197,198,199,200,201,202,203,204,205
48 data206,207,208,209,210,211,212,213,214,215,216,217,218
49 data91,92,93,94,95,96,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80
50 data81,82,83,84,85,86,87,88,89,90,181,221,182,171,20
51 data0,129,130,3,132,5,6,135,136,9,10,139,12,141,142,15,144
52 data17,18,147,255,149,150,23,24,153,154,27,156,29,30,159,160
53 data33,34,163,36,165,166,39,40,169,170,43,172,45,46,175,48
54 data177,178,51,180,53,54,183,184,57,58,187,60,189,190,63,192
55 data225,226,99,228,101,102,231,232,105,106,235,108,237,238
56 data111,240,113,114,243,116,245,246,119,120,249,250,219,92,221,222,95
57 data0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
```

```
58 data0,0,0,0,0,0,0,0,0,0,0,141,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,136,0,0,160
59 data0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,9,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
60 data65,66,195,68,197,198,71,72,201,202,75,204,77,78,207,80
61 data209,210,83,212,85,86,215,216,89,90,123,252,125,126,0,0
62 dopen#6,"@catalog",d1,w:cmd6:catalogd1:dclose#6:dopen#7,"catalog",d1:k=0
63 k=k+1:input#7,z$(k):ifst64then65
64 goto63
65 dclose#7:eb=val(z$(k))
66 bn=.54*l:ifbn<ebthendopen#2,(f$(q)),d1,w:goto68
67 dopen#2,(f$(q)),d0,w
68 print"█":print"██████████I'm downloading "f$(q):return
```

DUMPFILE

```
1 poke59468,14:print"▓▓▓▓▓▓▓▓▓▓▓Please Wait ...":gosub33:goto15
2 j=len(p$):fori=1toj:a=peek(pa+asc(mid$(p$,i,1))):print#1,chr$(a);:next
3 print#1,chr$(141);:syswt:return
4 r$="":sk=1
5 poke15,0:sysdn:j=peek(15)-1:fori=0toj:a$=chr$(peek(db+i)):ifsk=1then13
6 ifa$=chr$(13)theni=j:goto12
7 ifa$="!"theni=j:pr=1
8 ifa$="&"then lb=0:pr=1
9 ifa$="#"and lb=1then11
10 ifa$="#"then lb=1:a$="":pr=1
11 r$=r$+a$:iflen(r$)>76orpr=1thenprint#2,chr$(34)r$chr$(34):r$="":pr=0
12 nexti:return
13 r$=r$+a$:ifa$=chr$(13)theni=j
14 nexti:sk=0:return
15 print"▓LOGON":open1,6:poke53,60:rd=15361:pa=15760:dn=15480:dc=0
16 db=15984:wt=15595:wc=15616:sysrd
17 dc=1:gosub26:goto28
18 p$="exec from #nitepet cle":pokewc,10:gosub2:gosub4:printr$
19 p$="count":pokewc,10:gosub2:gosub4:printr$:l=val(r$):r$="":sk=0:gosub70
20 p$="set * first":pokewc,17:gosub2
21 p$="point * unnum":pokewc,10:gosub2:ifdc<>1thengosub5:goto23
22 gosub4:print#2,r$;
23 l=l-1:ifl>0thenp$="set * next":pokewc,17:gosub2:goto21
24 dclose#2:ifdc=1thenreturn
25 p$="pur "+str$(n(q)):pokewc,10:gosub2:gosub4:printr$:nextq:dc=1
26 dopen#5,"files",d0:input#5,a$:cq=val(a$)
27 forq=1tocq:input#5,f$(q):printf$(q),:next:dclose#5:return
28 forq=1tocq:iff$(q)="LIB"thennextq
29 p$="use "+f$(q)+" cle":pokewc,10:gosub2:gosub4:printr$
30 ifleft$(r$,5)="ARKIV"thennextq
31 gosub19:nextq
32 p$="logoff cle":pokewc,10:gosub2:end
33 fori=15360to15984:reada:pokei,a:next
34 dimn(100),f$(1000),z$(100)
35 return
36 data0,32,204,255,32,174,241,32,219,60,160,0,132,150,32,192,241,164,150
37 data208,28,32,173,60,240,23,234,201,17,240,18,72,173,19,232,41,254,141
38 data19,232,32,201,60,104,32,2,226,208,211,169,0,133,167,173,19,232,9,1
39 data141,19,232,32,13,242,240,194,72,32,204,255,104,201,19,240,44
40 data201,3,240,40,201,18,240,31
41 data201,146,240,27,174,0,60,240,8,162,0,142,0,60,32,185,60
42 data32,180,60,162,1,32,201,255,32,210,255,76,1,60,141,0,60,240,138,96
43 data32,204,255,32,174,241,32,219,60,160,0,132,150,32,192,241,164,150,208
44 data16,32,173,60,240,11,164,15,153,112,62,230,15,201,17,240,13,32,13
45 data242,240,218,201,3,240,4,201,19,208,210,32,204,255,96,41,127,170,189
46 data16,61,96,170,189,144,61,96,41,127,201,64,144,7,201,95,176,3,41,31
47 data96,169,0,96,169,1,133,167,165,170,240,9,169,0,133,170,165,169,32
48 data6,230,96,72,138,72,152,72,169,6,133,212,169,255,133,211,76,198,247
49 data32,204,255,32,174,241,32,219,60,160,0,132,150
50 data32,192,241,164,150,208,4,201,17,240,9,32,13,242
51 data240,230,201,3,208,226,32,204,255,96
52 data0,0,0,0,0,0,0,0,157,0,0,0,0,13,0,0,0,17,0,0
53 data0,0,0,0,0,0,0,0,0,0,0,0,32,33,34,35,36,37,38,39
54 data40,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59
55 data60,61,62,63,64,193,194,195,196,197,198,199,200,201,202,203,204,205
56 data206,207,208,209,210,211,212,213,214,215,216,217,218
```

```
57 data91,92,93,94,95,96,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80
58 data81,82,83,84,85,86,87,88,89,90,181,221,182,171,20
59 data0,129,130,3,132,5,6,135,136,9,10,139,12,141,142,15,144
60 data17,18,147,255,149,150,23,24,153,154,27,156,29,30,159,160
61 data33,34,163,36,165,166,39,40,169,170,43,172,45,46,175,48
62 data177,178,51,180,53,54,183,184,57,58,187,60,189,190,63,192
63 data225,226,99,228,101,102,231,232,105,106,235,108,237,238
64 data111,240,113,114,243,116,245,246,119,120,249,250,219,92,221,222,95
65 data0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
66 data0,0,0,0,0,0,0,0,0,0,0,141,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,136,0,0,160
67 data0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
68 data65,66,195,68,197,198,71,72,201,202,75,204,77,78,207,80
69 data209,210,83,212,85,86,215,216,89,90,123,252,125,126,0,0
70 dopen#6,"@catalog",d1,w:cmd6:catalogd1:dclose#6:dopen#7,"catalog",d1:k=0
71 k=k+1:input#7,z$(k):ifst64then73
72 goto71
73 dclose#7:eb=val(z$(k))
74 bn=.54*l:ifbn<ebthendopen#2,(f$(q)),d1,w:goto76
75 dopen#2,(f$(q)),d0,w
76 print"[illegible]":print"[illegible]I'm downloading "f$(q):return
```

PSDPLOT

```
1 poke59468,14:c$=chr$(3):open 1,6:dim ps(13),pp(13),ls(14),p(14):q$=""
2 input"▒▒Sample ID ";a$:gosub47:si$=b$
3 ifq$<>""then9
4 e$=chr$(27):print#1,e$".(":print#1,"in;"e$".i400;0;17:"e$".n;19:"
5 a$="Particle Size (micrometers)":gosub47:p$=b$:a$="Sample ID = ":gosub47
6 s$=b$:a$="Percent Passing (% Vol.)":gosub47:y$=b$
7 ps(1)=176:ps(2)=125:ps(3)=88:ps(4)=62:ps(5)=44:ps(6)=31:ps(7)=22:ps(8)=16
8 ps(9)=11:ps(10)=7.8:ps(11)=5.5:ps(12)=3.9:ps(13)=2.8
9 print"▒Type in Cum. % Finer":fori=1to13:print"▒% finer"ps(i);:inputpp(i)
10 ls(i)=2500*((log(ps(i)))/(log(10)))+1625:p(i)=50*pp(i)+1675:next
11 print"▒▒▒▒▒▒▒▒▒▒":printtab(12)"Please Wait ..."
12 print#1,"ip1625,1675,9125,6675;di;"
13 print#1,"sp1;pa1625,1675;pd;pa9125,1675,9125,6675,1625,6675,1625,1675;"
14 print#1,"pa1630,1670,9130,1670,9130,6680,1630,6680,1630,1670;pu;"
15 print#1,"si0.15,0.20;tl1;sp1;cp-.25,-1;lb1▒"
16 print#1,"pa1630,1670;cp-1,-.5;lb0▒"
17 for x=2to10step1:c=(2500*(log(x)/log(10)))+1625
18 ifx=5thenprint#1,"tl100;pa"c",1670;pd;xt;pu;cp-.25,-1;lb5▒":goto21
19 ifx=10thenprint#1,"tl100;pa"c",1670;pd;xt;pu;cp-.85,-1;lb10▒":goto21
20 print#1,"pa"c",1670;pd;xt;pu;"
21 print#1,"tl1;":next
22 forx=20to100step10:c=(2500*(log(x)/log(10)))+1625
23 ifx=50thenprint#1,"tl100;pa"c",1670;pd;xt;pu;cp-.85,-1;lb50▒":goto26
24 ifx=100thenprint#1,"tl100;pa"c",1670;pd;xt;pu;cp-1.5,-1;lb100▒":goto26
25 print#1,"pa"c",1670;pd;xt;pu;"
26 print#1,"tl1;":next
27 forx=200to1000step100:c=(2500*(log(x)/log(10)))+1625
28 ifx=500thenprint#1,"tl100;pa"c",1670;pd;xt;pu;cp-1.5,-1;lb500▒":goto31
29 ifx=1000thenprint#1,"tl100;pa"c",1670;cp-2,-1;lb1000▒":goto31
30 print#1,"pa"c",1670;pd;xt;pu;"
31 print#1,"tl1;":next
32 fory=0to80step20:d=(y*50)+1675:ify=0then34
33 print#1,"tl100;pa1630,"d";pd;yt;pu;cp-3.4,-.25;lb"y"▒"
34 fork=1to3:d=(y+k*5)*50+1675:print#1,"tl1;pa1630,"d";pd;yt;pu;":nextk,y
35 print#1,"pa1630,6680;cp-3.4,-0.25;lb100▒"
36 print#1,"pa5375,1675;cp-13,-2.5;lb"p$"▒"
37 print#1,"pa1625,4125;cp-4.5,-6;di0,1;lb"y$"▒":print#1,"sp3;"
38 print#1,"iw1630,1670,9130,6675;"
39 forj=1to13:a=ls(j)-ls(j+1):b=p(j)-p(j+1):c=atn(b/a):d=ls(j)-50*cos(c)
40 e=p(j)-50*sin(c):f=ls(j+1)+50*cos(c):g=p(j+1)+50*sin(c)
41 print#1,"pu;pa"ls(j)","p(j)";pd;ci50,5;pu;"
42 ifj=13goto44
43 print#1,"pa"d","e";pd;pa"f","g";pu;":next
44 print#1,"iw;di1,0;sp1;pa9150,6675;":z=-(13+len(si$))
45 print#1,"cp"z",0.5;lb"s$"▒;sp2;lb"si$"▒"
46 print#1,"sp0;pa16000,11400;":print"▒▒▒▒▒▒▒▒▒▒▒▒▒":goto50
47 b$="":z=len(a$):fori=1toz:c$=mid$(a$,i,1)
48 ifc$>chr$(64)andc$<chr$(91)thenb=asc(c$)+32:c$=chr$(b)
49 b$=b$+c$:next:return
50 input"Continue (y/n) ";q$:ifq$="y"then2
51 ifq$<>"n"thenprint"▒              Try again":goto50
52 print"▒▒▒▒▒▒▒▒▒▒▒▒             Bye":close1
```

WRITEFET

```
1 poke59468,14:input"▒▒How many files are to be fetched ";q:dimn(q),f$(q)
2 fori=1toq:print"▒▒▒File no."i:input"▒Enter job no. ";n(i)
3 input"▒▒Download filename ";f$(i):next
4 print"▒":fori=1toq:printi,n(i),f$(i):next
5 input"Are data correct ";q$:ifq$="y"then10
6 ifq$="n"then8
7 goto5
8 input"Which no. is wrong ";a
9 input"Job no. ";n(a):input"Filename ";f$(a):goto4
10 dopen#1,"@fetsas",d0,w:print#1,q
11 forj=1toq:print#1,n(j);chr$(13);f$(j):next:dclose#1
```

PLOTSAS

```
1 poke59468,14:print"▒▒▒          SAS/GRAPH PLOT PROGRAM          "
2 open1,6:e$=chr$(27):goto7
3 input#2,a$:ifright$(a$,1)="!"then21
4 ifleft$(a$,2)="LB"thengoto22
5 z=len(a$):ifright$(a$,1)="&"thena$=left$(a$,z-1)+"▒"
6 print#1,a$;:goto3
7 input"▒▒Enter SAS/GRAPH Filename ";m$:print
8 input"▒Which disk drive ▒ 0 or 1 ▒ ";q:print:ifq=0thendopen#2,(m$),d0:goto11
9 ifq=1thendopen#2,(m$),d1:goto11
10 goto7
11 ifds=62thenprint"▒▒▒"ds$:dclose#2:goto15
12 ifds<>0thenprint"▒▒▒"ds$:dclose#2:goto20
13 print"▒";:printtab(12)"▒▒▒▒▒▒▒▒▒▒▒Please Wait...":print#1,"in;"e$".("
14 print#1,e$".i400;0;17:"e$".n;19:":goto3
15 input"▒Would you like a disk directory ";z$:ifleft$(z$,1)="y"then18
16 ifleft$(z$,1)="n"then7
17 goto15
18 input"▒Which disk drive ▒ 0 or 1 ▒ ";q
19 print"▒Remember <▒SPACEBAR▒> stops the listing▒":ifq=0thendirectoryd0:goto7
20 ifq=1thendirectoryd1:goto7
21 z=len(a$):print#1,left$(a$,z-1);dclose#2:close1:goto28
22 b$="":z=len(a$):fori=3toz:c$=mid$(a$,i,1)
23 ifc$="&"thenc$=""
24 ifc$>chr$(64)andc$<chr$(91)thenb=asc(c$)+32:c$=chr$(b)
25 b$=b$+c$:next
26 a$="LB"+b$+"▒"
27 print#1,a$;:goto3
28 input"▒▒Continue (y/n) ";q$:ifq$="y"thenrun
29 ifq$="n"thenend
30 goto28
```

APPENDIX B. CLARIFICATION ADDITIONS

The items within this appendix are added to this publication for clarification purposes since it was necessary to omit the information from the referent publication because of page limitations.

Figures 1, 2, 3 and 4 show the particle size distributions for the lignite slurry, red mud, phosphate slime and kaolinite slurry, respectively.

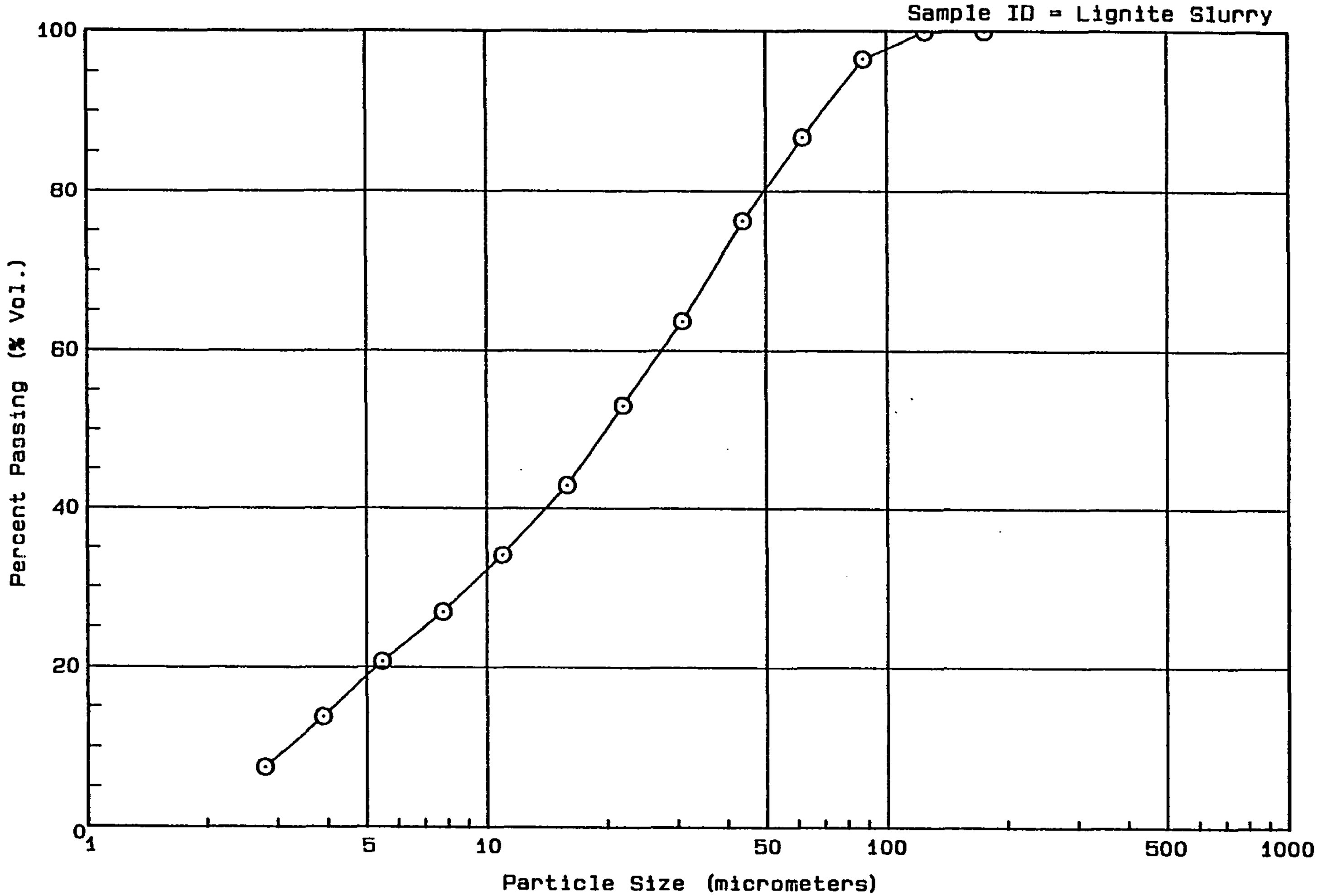

Figure 1. Lignite slurry particle size distribution

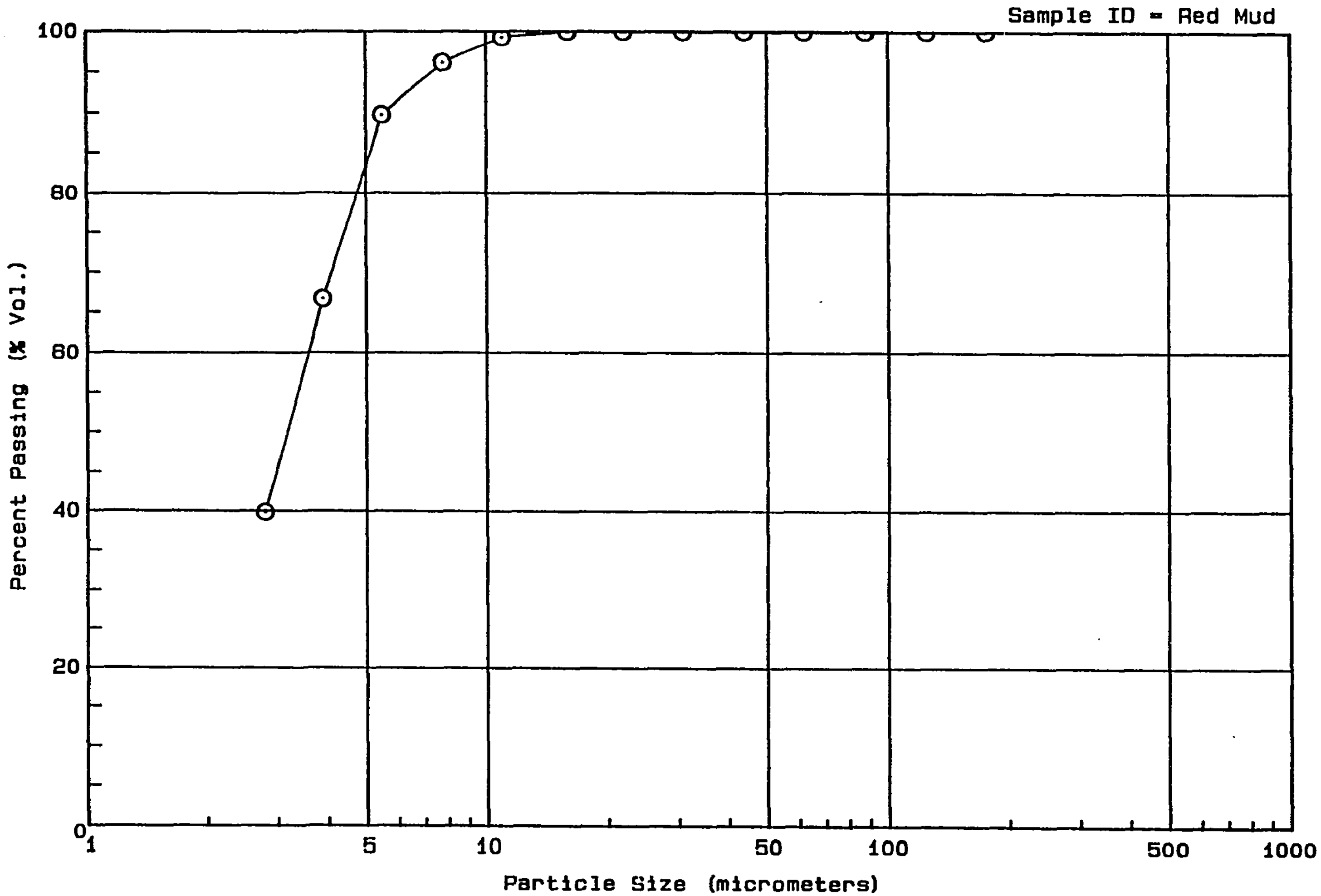

Figure 2. Red mud particle size distribution

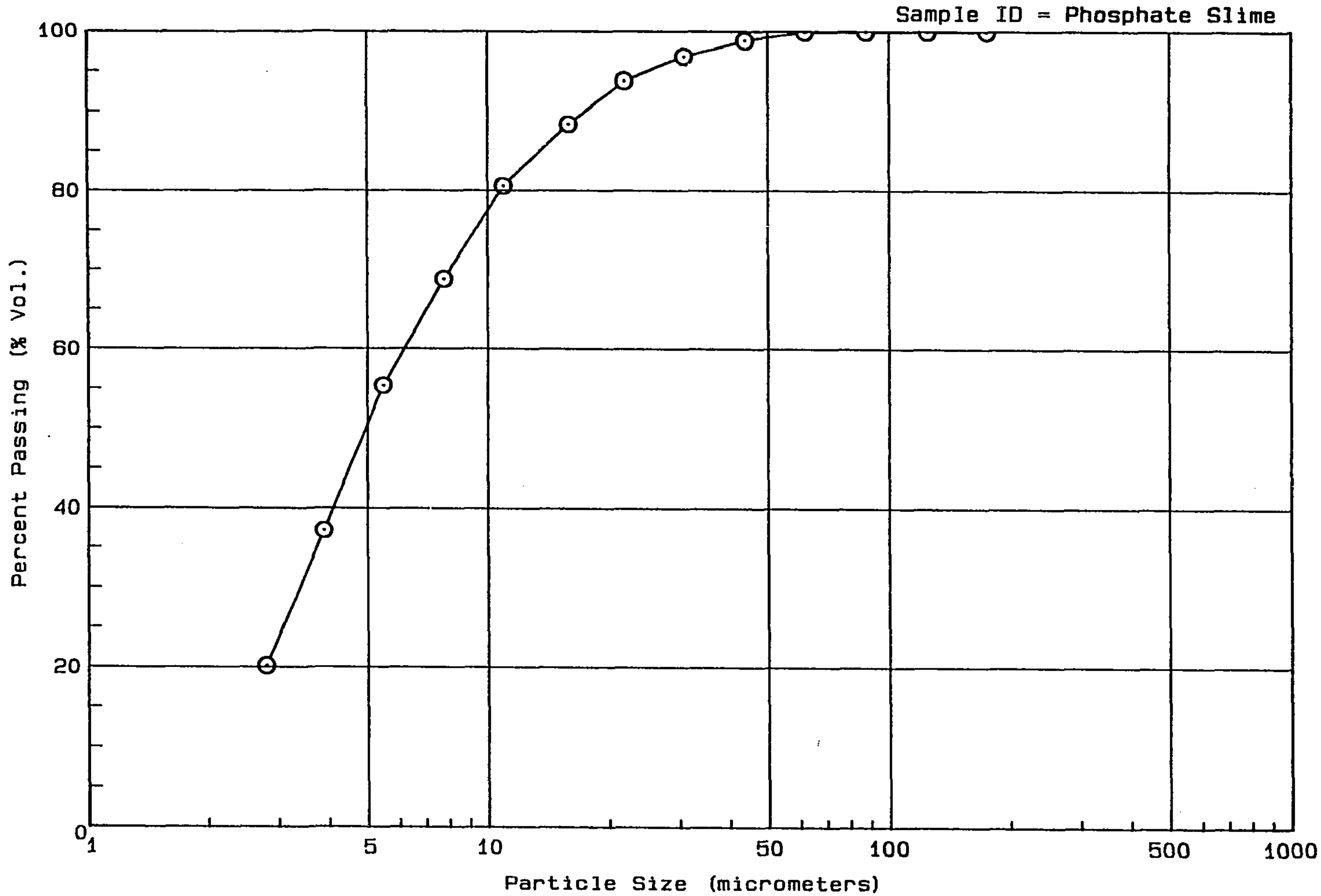

Figure 3. Phosphate slime particle size distribution

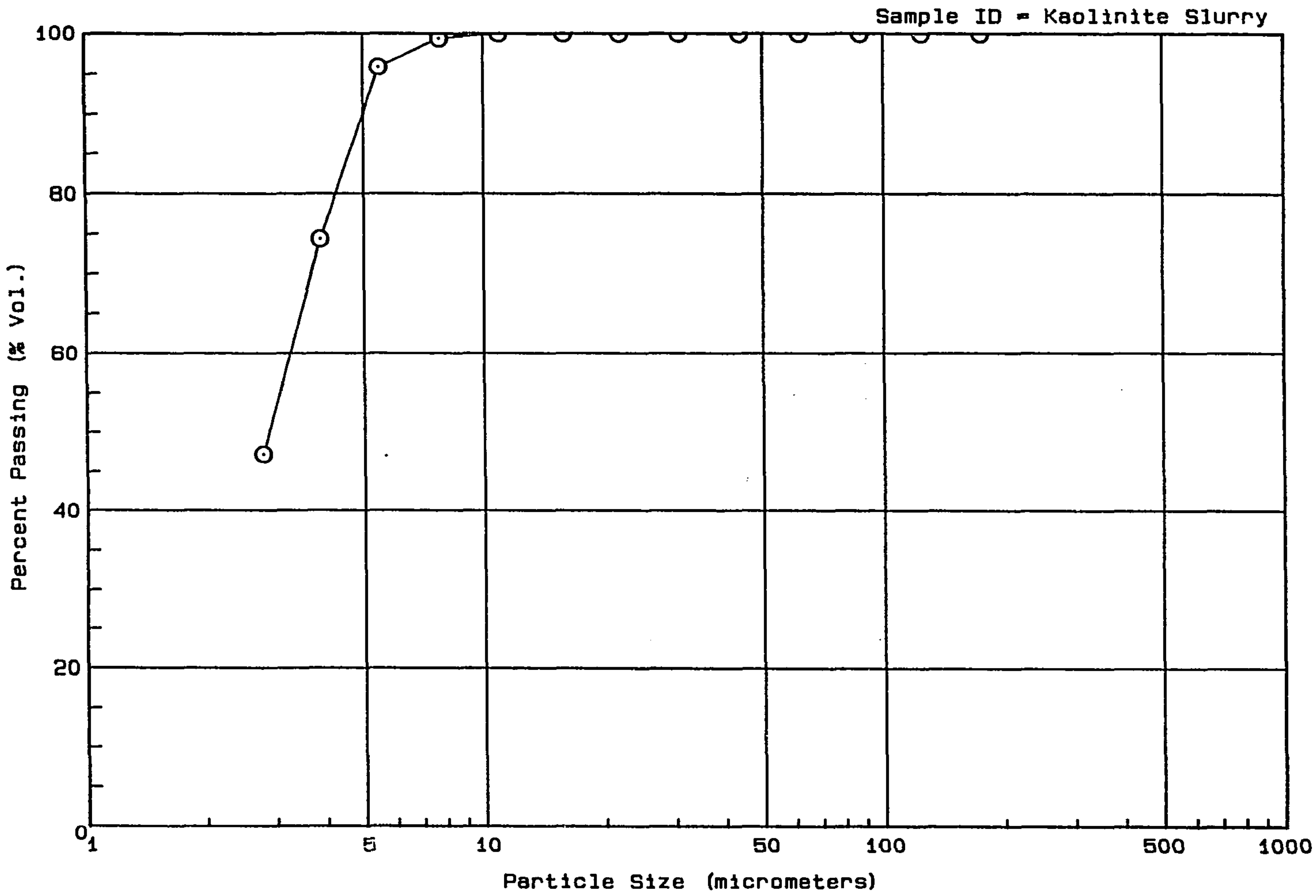

Figure 4. Kaolinite slurry particle size distribution