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HYDROCYCLONE EFFICIENCY

by

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ABSTRACT

The efficiency of a 4 inch hydrocyclone was studied using a suspension of fine silica at pulp densities of up to 50% solids by weight. The variables manipulated were diameter of the vortex finder, flowrate, percent solids in the feed and cyclone length. Slurry temperature was also measured. All measurements were made with the spigot adjusted to give the same degree of roping at the underflow.

The product size distributions were analysed using an electronic particle sizing instrument similar to the "Coulter Counter" but interfaced with a digital computer. An advantage of this method is the continuous curves produced (154 data points per run).

Equations were developed by means of stepwise regression analyses to predict (1) separating size, (2) inlet pressure, (3) bypass ratio, (4) sharpness of classification, alpha, (5) zero classification size and (6) water recovery in the underflow, as a function of hydrocyclone variables including temperature of the feed slurry. Two forms of a roping constraint equation were obtained. One predicts the underflow percent solids at which roping occurs, whilst the other gives the spigot size required to avoid roping.

The separating size was found to depend on several factors including the temperature of the feed slurry. Moreover, the sharpness of classification, alpha, was identified to be a variable parameter. This parameter was found to be dependent on variables such as vortex finder diameter and the volume recovery of slurry to the overflow. The variability of alpha has not been widely recognized. Acceptance of this variability concept offers hope that classification efficiencies may be improved by choosing the proper combination of variables in an operating environment. Interestingly, the zero classification size was judged to be a constant at the 0.05 level of significance. The bypass ratio depended primarily on the water split, as expected, but was also influenced by the cyclone feed percent solids.

It is suggested that this particular study advances the understanding of sub-sieve sized particle behaviour in hydrocyclones fed with slurries containing a high proportion of solids.

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NOMENCLATURE

a = a constant in Mular and Runnels' equation

alpha, α = parameter in the Lynch equation related to the sharpness of separation

B, bypass = fraction of feed solids bypassing classification

b = a constant in Mular and Runnels' equation

d = diameter of particles (microns)

d_0 = diameter below which particles are not classified (microns)

d_{50} = diameter of particle for which the classification efficiency is 50% (microns)

Di = diameter of inlet or of circle with the same area as the inlet (inches)

Do = vortex finder inside diameter (inches)

Du = spigot (apex) orifice diameter (inches)

F = tons per hour of feed solids

Fe_{50} = 50% passing size of the calculated feed

f_x = fraction of feed in narrow size fraction of mean size x

h = length of cyclone expressed as the "free vortex height", i.e. distance from bottom of vortex finder to top of spigot constriction (inches)

H = inlet head in feet of slurry

n = a constant in Mular and Runnels' equation

P = inlet pressure to hydrocyclone (P.S.I.G.)

Q = hydrocyclone feed flowrate (U.S.G.P.M.)

R_f = fractional recovery of water to the underflow

R_v = fractional recovery of feed volume in the underflow

T = temperature (^oC)

U = tons per hour of solids in underflow stream

U_g = gm per sec. of solids in underflow stream

u_x = fraction of underflow in narrow size fraction of mean size x

x = particle size

Y_x = raw efficiency at size x

Y_{cx} = corrected efficiency at size x

ϕ = feed percent solids by weight

ϕ_u = underflow percent solids by weight

ϕ_v = volume fraction of solids in the feed

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INTRODUCTION

In recent years there has been a renewed interest in the hydrocyclone and a realization that this piece of equipment holds the key to further improvements in the efficiency of closed circuit grinding for flotation. Although the cyclone literature is voluminous there is rather a wide gap between the fundamental studies using dilute slurries in small cyclones and the results obtained in industrial equipment on thick non-Newtonian slurries. This gap has been bridged to a certain extent by the use of semi-empirical methods of cyclone modelling. As shown in subsequent sections, additional work is necessary to reconcile several conflicting pieces of evidence. This study contributes towards such a goal.

Objectives

The objectives of this study were:-

a) to establish a procedure for the measurement of cyclone efficiency in a size range in which sizing could not be performed using conventional sieving techniques.

b) to measure the spigot capacity at an incipient roping condition in order to establish a typical relationship which could be used as a constraint equation in cyclone modelling, optimization or control under conditions similar to those tested.

c) to fit a suitable equation to the efficiency curves and then to determine how the parameters in this equation vary with operating and design parameters.

d) from these results to draw conclusions which would be of practical importance in mineral processing and which would help to resolve some of the grey areas in our understanding of the cyclone.

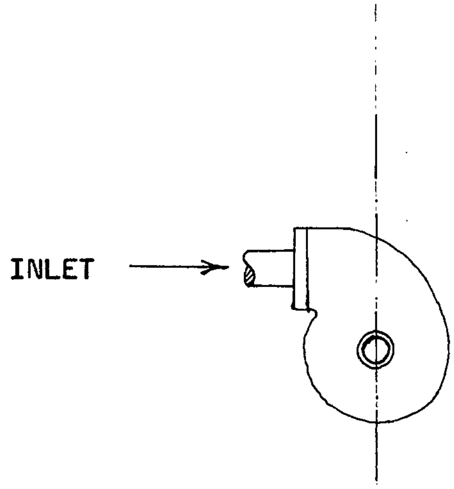
Definition of Cyclone Efficiency

A major stumbling block to progress has been the difficulty and cost of obtaining accurate data for the efficiency of the cyclone.

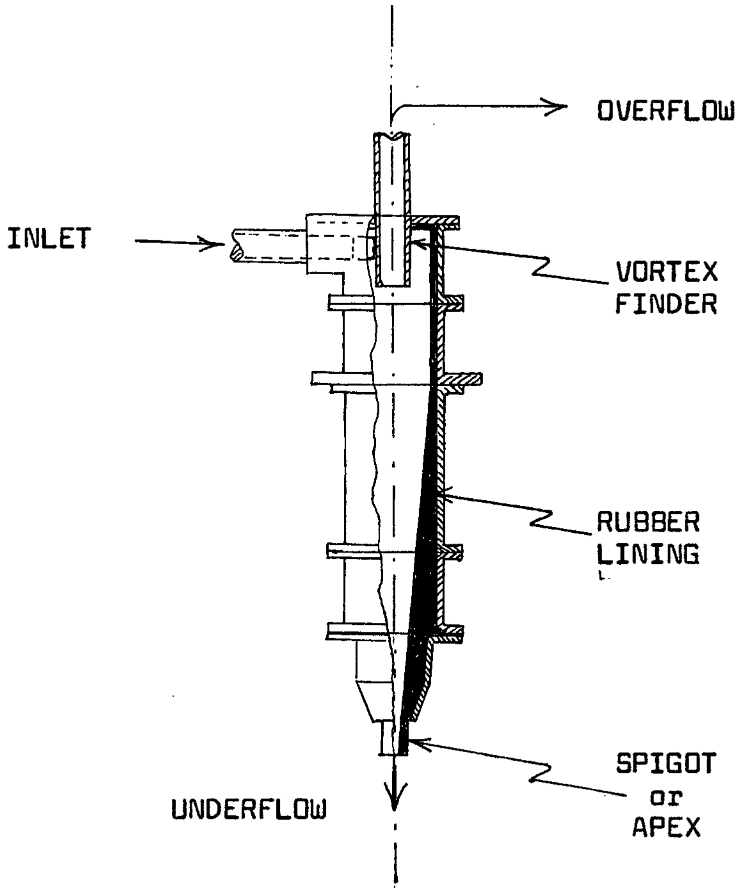
The hydrocyclone is usually a cylindrical vessel with a conical bottom into which a slurry is injected tangentially in order to throw the larger, denser particles towards the outside wall for discharge through the 'spigot' (or apex). The lighter, smaller particles stay closer to the axis of the cyclone and overflow through the vortex finder. Fig. 1 shows a sketch of a typical hydrocyclone.

Please note that where the more general term, "cyclone", is used in this work, it generally refers to the hydrocyclone.

Whilst the cyclone has a variety of industrial applications, its use as a size classifier will be studied.



PLAN SHOWING CURVED INLET



PARTIALLY SECTIONED ELEVATION

Fig. 1 Sketch of a Typical Hydrocyclone

The efficiency of the cyclone is generally defined as the fraction (or percentage) of the feed material of a given size which is recovered in the underflow stream. Because this efficiency is a function of particle size it is normal to draw a "raw" efficiency curve showing the variation of efficiency with particle size as in fig. 2(a).

The raw efficiency curve is displaced from the size axis by a distance which varies with the fraction of the feed water which is recovered in the underflow. This dispacement is explained by considering that solids arrive in the underflow a) as a result of a size separation due to the separating process and b) as a result of short circuit flow directly into the underflow. For this reason it is common to construct a "corrected efficiency curve" in which only particles arriving in the underflow as a result of the classification process are considered.

Let B be the fraction of the feed which bypasses classification. Consider F tons/hour of feed with size distribution such that a fraction f_x of the feed is in a narrow size interval of mean size x. U and u_x are similarly defined for the underflow. Y_{cx} is the corrected efficiency at size x and Y_x is the raw efficiency at size x. Ff_x tons per hour of size x enter the cyclone and Ff_xB tons/hour bypass the classification process.

$$Y_{cx} = \frac{\text{TPH of narrow size fraction arriving in the U/F by classification}}{\text{TPH of the same size fraction of the feed capable of being class.}}$$

$$= \frac{Uu_x - Ff_xB}{(1-B)Ff_x}$$

$$= \frac{\frac{Uu_x}{Ff_x} - B}{1-B}$$

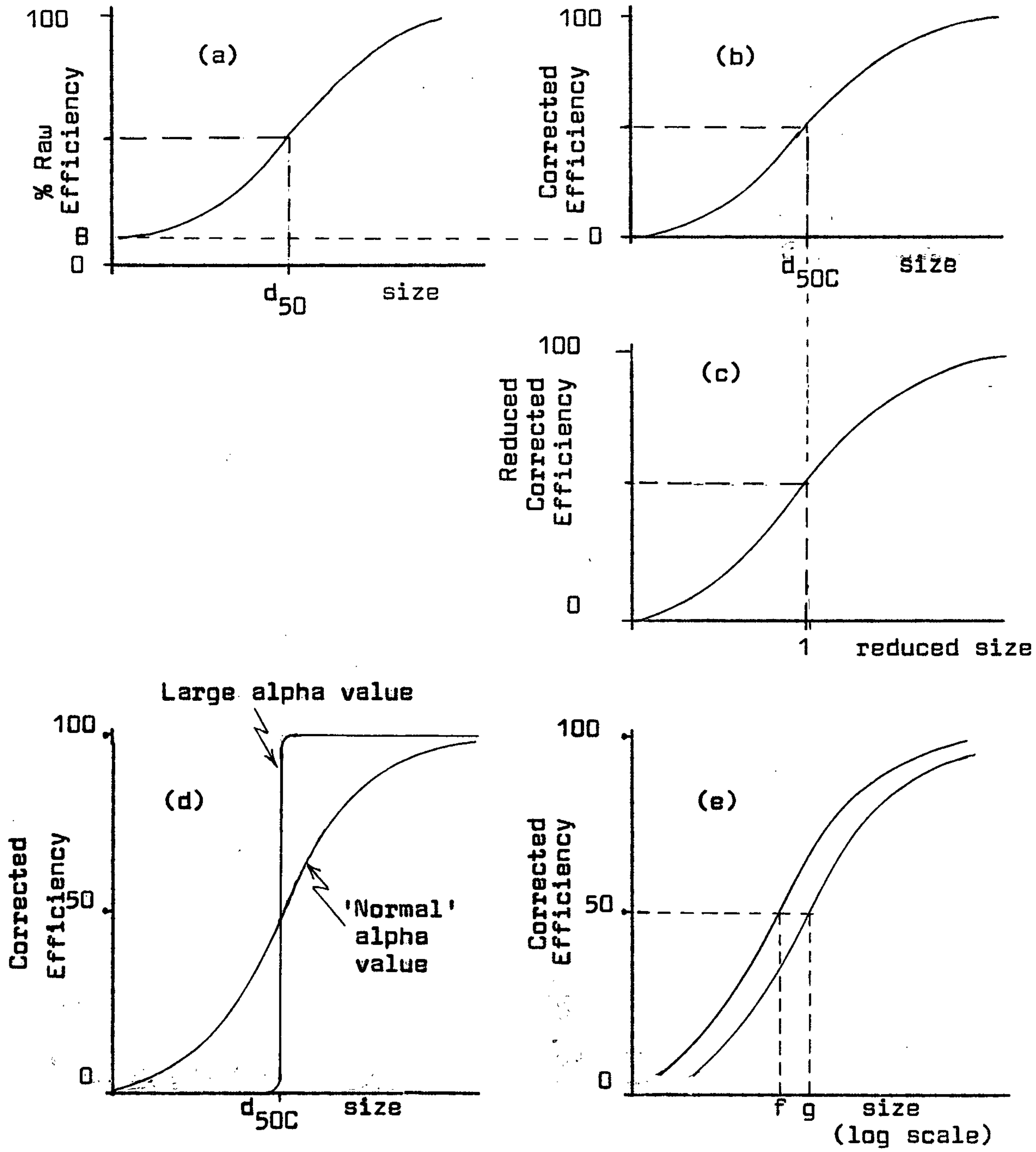


Fig. 2 Hydrocyclone Efficiency Curves

$$\text{so } Y_{cx} = \frac{Y_x - B}{1 - B}$$

What one does in effect is to subtract the bypass from the bottom of the raw efficiency curve y-axis and re-scale this axis as in fig. 2(b) to give corrected efficiency values which represent the behaviour of that portion of the feed which entered the underflow by this classification process.

The reduced, corrected efficiency curve (fig. 2(c)) is a corrected efficiency curve with the size axis plotted as a reduced size equal to the size in microns divided by the d_{50C} size in microns.

Fig. 2(d) shows how the shape of the corrected efficiency curve varies with the value of the parameter, alpha, which defines the sharpness of classification in the equations which will be fitted to the efficiency curve. The most efficient separation occurs when alpha is high (steep curve) and the bypass ratio small.

The d_{50} size is that size at which the efficiency is 50%. There is, strictly speaking, a distinction between the d_{50} size on the raw efficiency curve and the d_{50C} size on the corrected efficiency curve and they have different numeric values. It is common, however, to call the d_{50C} size the "dee fifty size" and so this rule is not always strictly adhered to. In this study the term d_{50} is used as an abbreviated reference to d_{50C}, except in this discusion of fig. 2.

Fig. 2(e) shows how the corrected efficiency curve is shifted along the size axis as the d_{50C} size varies with alpha remaining constant.

Literature Survey

For the reader who is interested in the general development of hydrocyclone theory the book by Bradley[1] gives a good summary of the history of the early development of the cyclone in several industries. The bibliography herewith is essentially concerned with recent studies of the efficiency of hydrocyclones as classifiers in mineral processing. Mention is also made of several papers which were not considered to be directly relevant to this study but may be of use to the reader interested in a more complete bibliography for detailed study of recent developments in, say the use of the hydrocyclone in coal processing.

a. Developments in the use of the Hydrocyclone

Most of the early research and development of the hydrocyclone was related to its use in coal beneficiation in the Netherlands in the 1940's. Since then it has found increasing use in coal preparation and mineral processing. As a classifier the cyclone has almost completely replaced the spiral classifier in wet milling circuits. The advantages claimed for the hydrocyclone include low capital cost, more compact design and ease with which it may be incorporated into the flowsheet. Hydrocyclone classification is also generally more efficient and circulating loads often lower. The chief disadvantage of the cyclone is that it requires a slurry pump to feed it. With a coarse cyclone feed the cost and inconvenience of pump maintenance could be a disadvantage.

Dahlstrom[2] and Kelsall and Holmes[3] studied the use of water injection as a means of reducing the bypass of fine material to the cyclone underflow. This development has been useful for the production of sandfill but is not extensively used for closed circuit grinding.

Kelsall et al[4,5] developed the cyclosizer which has since found wide application for sizing submesh particles down to about 10 microns (for quartz). More recently Kelsall et al[6] has extended the range of the cyclosizer down to about 5 microns (for quartz) by the addition of a decantation step.

b. Theoretical Studies of the Hydrocyclone

Much of the early work on cyclones centred around the measurements of flow patterns by Yoshioka and Hotta (see ref.1) and by Kelsall (see ref.1). Rietema (see ref.1) pointed out that the residence times of particles in hydrocyclones is so short that acceleration effects are more important than terminal velocities. He used a cyclone number which should be minimised to give a small d_{50C} size with a low pressure drop through the cyclone. Bradley[1] gives details of these early studies together with some of his own results. He tabulates the various relationships for d_{50C} and capacity. Lilge[7] studied flow patterns to give his "cone force equation".

The semi-empirical studies of Dahlstrom[2,8], Fontein et al[9], de Kok[10], Chaston[11], Peachy[12], Marais and Hoffman[13] and Wagner and Murphy[14], are amongst the more significant early studies of cyclone behaviour.

Fahlstrom[15] developed his "crowding theory" based on experimental and plant studies.

Mizrahi[16] has tried to unify the various theories and with Cohen et al[17] has tried using residence time distribution to predict cyclone performance. The superiority of Rietema's and Mizrahi's non-equilibruim orbit theories has been supported by measurements of the effect of solid particle injection position on cyclone performance by Mackenzie and Wood[18].

Recently Bloor and Ingham[19-23] have studied flow patterns in hydrocyclones. Gupta and Grover[24] and Gerrard and Liddle[25,26] have used Rietema's concept of the cyclone number to optimise the design of cyclone circuits.

Unfortunately most of these studies were on small cyclones operating with dilute feed pulps. They are therefore of limited industrial utility.

Luckie and Austin[27] give details of no less than nine different equations used to describe classification efficiency curves. The most popular basic equations are those of Lynch and Rao[28] and the Rosin Rammler equation derived by Plitt[29] and Reid[30].

Mular and Runnels showed that these equations are related through a common equation. They introduced the concept that there was a finite size at which the reduced efficiency of a cyclone was zero. Their equation is:-

$$\frac{Y_{cx}}{1 - Y_{cx}} = Q = -a \pm b \exp(kd^{n+1})$$

where a, b, k and n are constants and d is the particle diameter.

The recent program of semi-empirical modelling studies by Lynch, Rao et al are summarised in Lynch's paper[32]. This work has formed the basis of most subsequent studies into the optimization and/or control of grinding circuits.

Their conclusion was that the shape of the reduced efficiency curve was constant irrespective of changes in the hydrocyclone diameter, vortex and spigot diameters, throughput, solids content and fineness of the feed. The shape was considered to be dependent on the nature of the particles such as their specific gravity and shape.

When they studied natural ores in producing plants they found that the reduced efficiency curve was of a shape which could be described by considering it to be the sum of the efficiency curves of each of the component minerals. Each component has a different specific gravity and will, therefore, have a different d_{50C} value. They found that the d_{50C} size varied inversely with the density difference between solids and water according to the turbulent rather than the Stoke's law relationship most commonly found to be applicable in small cyclones.

Plitt[33] carried out a series of experiments with fine silica in small cyclones and combined his data with that of Lynch et al in an attempt to derive a universally applicable mathematical model of the hydrocyclone.

His conclusion was that the slope of the reduced efficiency curve is not in fact constant and he claims to be the first person to quantitatively express the sharpness of classification in terms of the operating and design variables. This expression is:-

$$m = \exp(0.58 - 1.58R_v) \left(\frac{Dc^2\ h}{Q}\right)^{0.15}$$

where Dc is the cyclone diameter in inches and m is the parameter in Plitt's equation for the corrected efficiency curve which is related to alpha by the approximate relation:-

$$\alpha = 1.34m - 0.47$$

This relationship is partially mechanistic in that it considers the sharpness of separation to be a function of retention time in the cyclone. Because the R_v term is mainly controlled by the ratio of the spigot and vortex finder diameters it represents the fact that the sharpness of classification is reduced as the spigot size is increased relative to the vortex finder diameter.

The multiple correlation coefficient for this equation of only 0.75 indicated that more work was required in this area.

Plitt gives a good review of the numerous equations obtained by various researchers for the d_{50C} size, the flow split and pressure drop.

Schubert and Nesse[34] studied turbulence in wet classification and propose a pulp partition model for the cyclone efficiency. The usefulness of his approach has yet to be established.

A number of workers have used dimensional analysis for the study of the hydrocyclone capacity equation[35-37].

c. Uses of the Hydrocyclone

The cyclone is a useful piece of equipment in many industries where it has supplemented screens, thickeners and centrifuges for the processing of starches, mineral particles, mixtures of liquids and so forth.

Cyclones have been used in the thickening and washing of coal[38-46] with the latest development being in the extensive use of the water-only cyclone for cleaning fine coal. Outside of the coal industry the major use of the cyclone would be as a classifier in closed circuit grinding and the desliming of pulps for flotation, tailings dam construction or underground sandfill. In these operations it is being used as a classifier.

Cyclones have also been used for the recovery of tin[47,48], diamonds[49] and clay [50]. Papacharalambous and Sun[51] showed the usefulness of cyclones for the sizing of abrasive powders.

The potential of small cyclones used for the desanding of industrial water was studied by Visman and Rozenhart[52]. Whitcomb[53] showed how calcium carbonate sludge from water treatment could be purified in a cyclone prior to re-calcination.

Plitt and Lilge[54] and Visman et al[55] succeeded in classifying material which was flocculated. This was previously considered to be impossible.

The use of a hydrocyclone for liquid/liquid extraction was studied by Molyneux[56] and Shastry et al[57], Heavy liquid concentration using a cyclone has been considered[58].

d. <u>Hydrocyclone Design</u>

Bradley[59] found that the shape of the vortex finder outside wall made little difference to short circuit flow from the inlet to the vortex. The length of the vortex finder is however important.

Beverloo et al[60] studied flow in a flat vortex hydrosifter (a flat cylindrical cyclone). Pownall[61] describes cyclones made from 40 gallon oil drums whilst Burt[62] gives details of small low-cost cyclones without a conical section which were used for cassiterite beneficiation.

Hukki[63] describes a new classifier for coarse grinding in closed circuit with a rod mill. The possibility of producing a dry cyclone underflow was demonstrated by Visman[64] in his study of the "slugging" cyclone.

e. Simulation, Optimization, On-stream Size Analysis and Control

The cyclone modelling methodology proposed by Lynch and Rao is also described by Mular and Bull[65]. This work has formed the basis of much of the work which has been done in recent years on the simulation of cyclones in grinding circuits with a view to optimization, control or prediction of product size analysis.

The papers by Draper and Lynch[66], Lynch and Whiten et al[67], and Draper, Dredge and Lynch[68] show how they used this methodology to optimise the grinding circuits at Mount Isa Mine in Australia.

Pitts, et al[69] describe how they used a similar approach at the Silver Bell.

Lynch et al[70] have recently used this methodology for cyclone modelling in an autogenous milling circuit treating nickel ores.

Mular and Bates[71] describe how they used this methodology in the modelling of cyclones in parallel at Strathcona. In the study of the Gibraltar circuit by Allan, Mular et al[72] the modified equation of Mular and Runnels was used.

Plitt's equation has been used to describe the efficiency curve of a complex ore in the analysis of a closed grinding circuit[73].

Mular et al[74] give details of a method for the adjustment of data for a modelling program which would use the equation of Mular and Runnels to describe the reduced efficiency curve.

Some workers have used a simple multiple linear regression equation to relate cyclone efficiency to water and solids flows to the cyclone. Brookes, et al[75] and Watson, Crompton and Brookes[76] have used this approach.

Presgrave[77] discusses the hardware used in the control of cyclones. Bradburn et al[78] concern themselves with some of the more practical aspects of mill and cyclone control. Hamilton[79] proposes the use of a grinding circuit with dual cyclone classification.

The use of a particle size monitor (PSM) in operating plants is described by Webber and Diaz[80] and Mokken et al[81].

f. <u>Summary of the Literature Survey</u>

The important points which emerged from the literature survey were:-

i) The theoretical studies of hydrocyclone efficiency are not yet comprehensive enough to be applicable to all the practical applications of the cyclone.

ii) Semi-empirical cyclone models and practical experience are presently the basis of most cyclone specifications, modelling, optimization and control.

iii) Pressure drop and d_{50C} size prediction equations are numerous and relatively accurate but there is still very little known about the maximum capacity of the spigot or the factors determining the sharpness of separation.

EXPERIMENTAL APPARATUS AND PROCEDURE

Experimental Apparatus

The cyclone test rig is illustrated in fig. 3. It is also shown schematically in fig. 4. Referring to fig. 4 solids and water are kept suspended in the rubberlined 50 gallon pumpbox (1) by means of a propeller type Chemineer mixer (2). The model D4B - 12° - 827 Krebs cyclone (3) is fed by a 1½ x 2 inch Galigher Vacseal pump (4) driven by a 3HP motor through a Woods MS - 77 variable speed pulley drive.

The pulp flowrate is measured by a 2 inch Foxboro magnetic flowmeter (F). An Ohmart nuclear density gauge (D) and a pressure gauge (P) are also installed in the cyclone feed line.

The two valves (6 and 7) and bypass line (8) allow the pulp to be recirculated without flowing through the cyclone. The whole test rig was supported on two frames which were bolted together and fitted with castors.

The sampling device (5) takes simultaneous cuts of the overflow and underflow streams. A sectional sketch of this device is shown in fig. 5. Referring to fig. 5 the underflow sample container (6) fits into a frame (7) which slides on guide rails (8) which are fixed to the pumpbox (1). When the underflow sample container is slid under the spigot a pushrod (9) simultaneously moves the flexible overflow pipe into such a position that the overflow stream is diverted to the overflow bucket (10) by the splitter (11). A splash guard (12) keeps the guide rails clean.

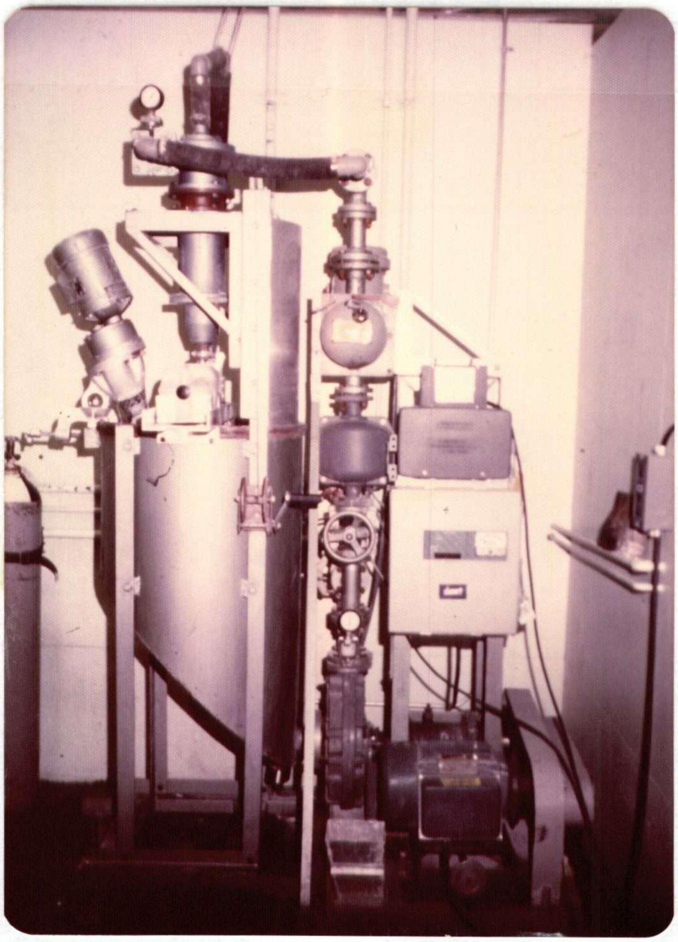


Fig. 3 Photograph of Test Rig

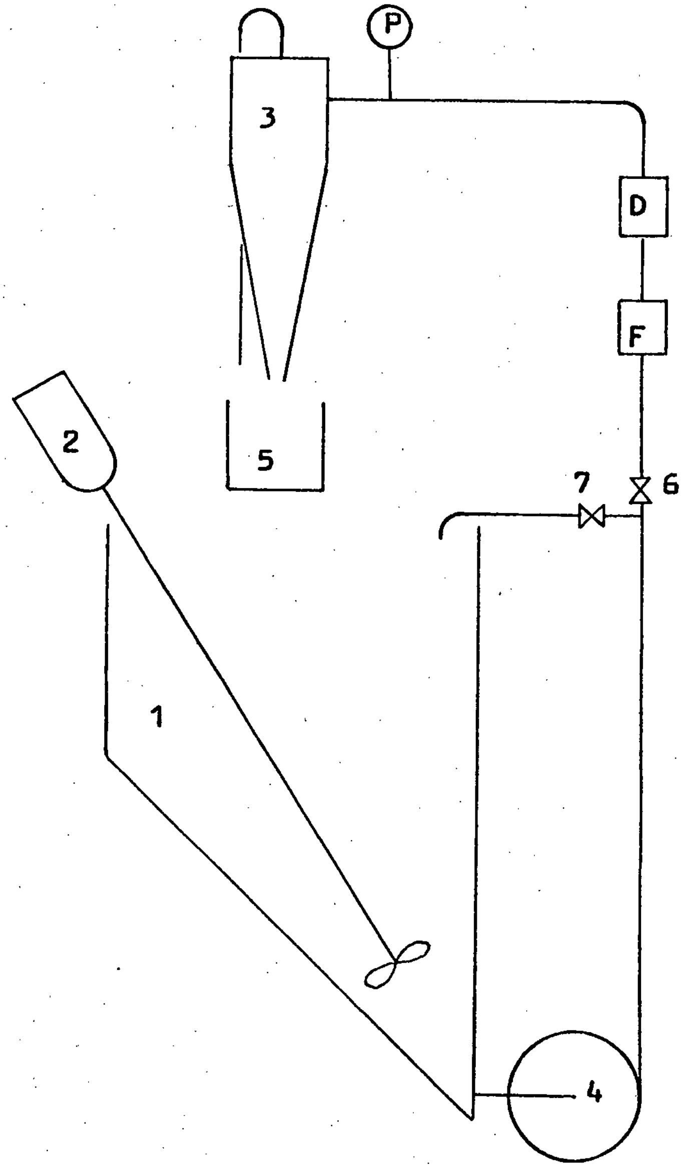


Fig. 4 Schematic of Test Rig

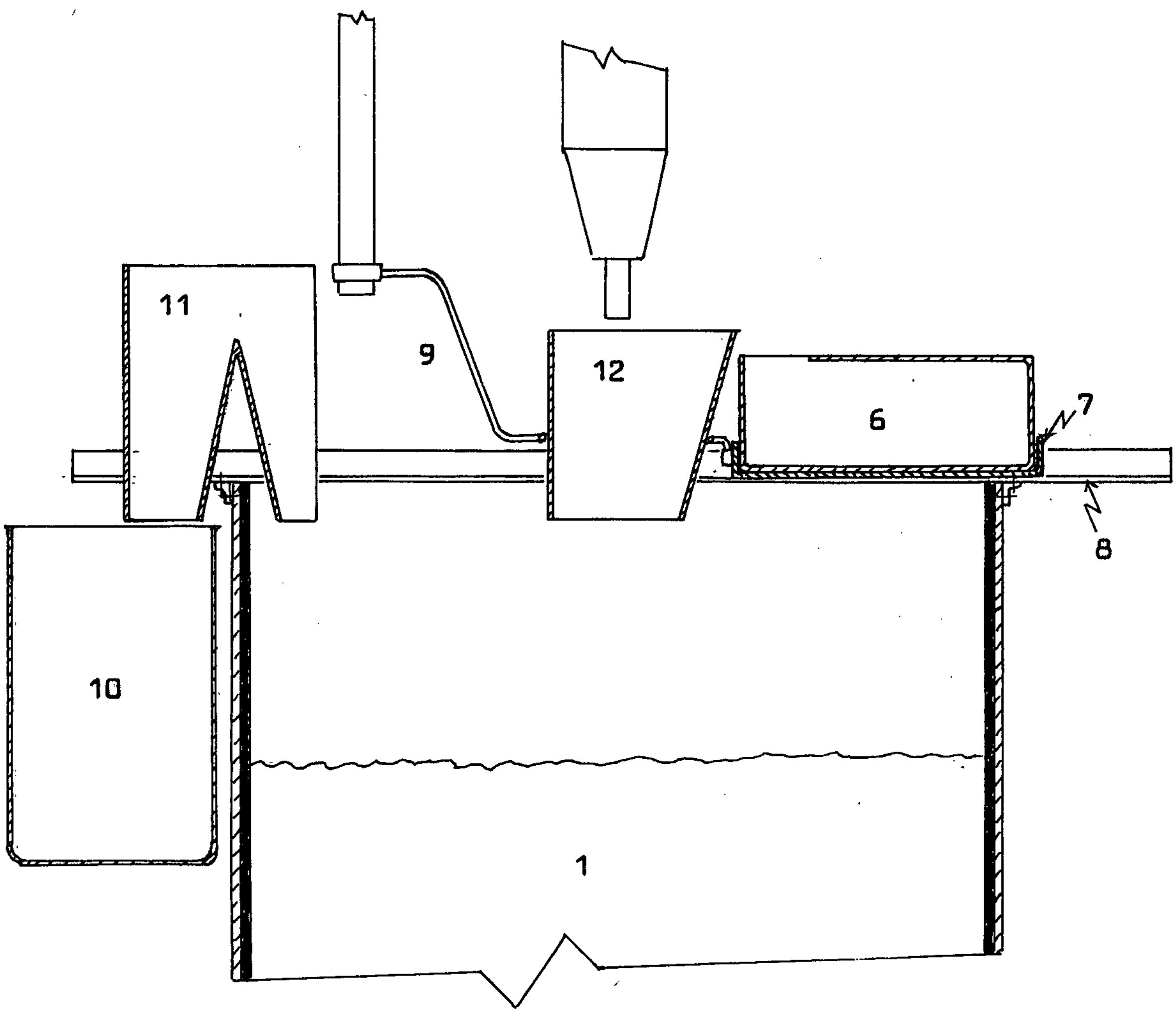


Fig. 5 Sketch of Sampling Device

Procedure for Acquisition of Data

a. Selection of the Test Material

Silica was chosen for this study because it is closest in density to the gangue treated in most milling and tailings classification operations. The size range used was finer than that used by Lynch and Rao in most of their work and close to that used by Plitt. Some of the reasons for choosing a fine size of silica were :-

a) Problems with segregation in the cyclone feed pumpbox would be minimised.

b) Viscosity effects should be more significant with a finer material.

c) Coarser feed would probably require the use of a combination of two different methods of size analysis. This is a serious problem for many investigators, especially when a complex ore is being treated.

d) In order to maintain geometric similarity it is generally necessary to scale down all dimensions proportionately.

b. Construction of the Experimental Design

Preliminary tests were performed on the cyclone test rig to check the sampling and sizing techniques and to get a feel for the best operating range for each of the variables tested.

Because of the difficulty in obtaining results with sufficient accuracy to detect changes in the sharpness of classification it was decided to include a large number of repeat runs into an experimental design.

A full two level factorial design, as described by Mular and Bull[65], was chosen with four centre point runs and repeats of all eight runs for the long cyclone plus one repeat on the short cyclone. The order in which the runs were performed was randomized, as much as possible consistent with the efficient use of the time available.

The independent variables and their ranges were:-

a) Vortex finder diameter varied linearly from 0.75 inch to 1.25 inch diameter.
b) Flow rate varied from 7.2 U.S.G.P.M. to 20 U.S.G.P.M. with the centre point being the log mean value of 12 U.S.G.P.M.
c) Feed percent solids varied linearly from 10% to 50% by weight.
d) Length of the cylindrical section was varied linearly over a limited range by removing one of the standard sections to give a shorter cyclone or replacing it with a section of half the standard length.

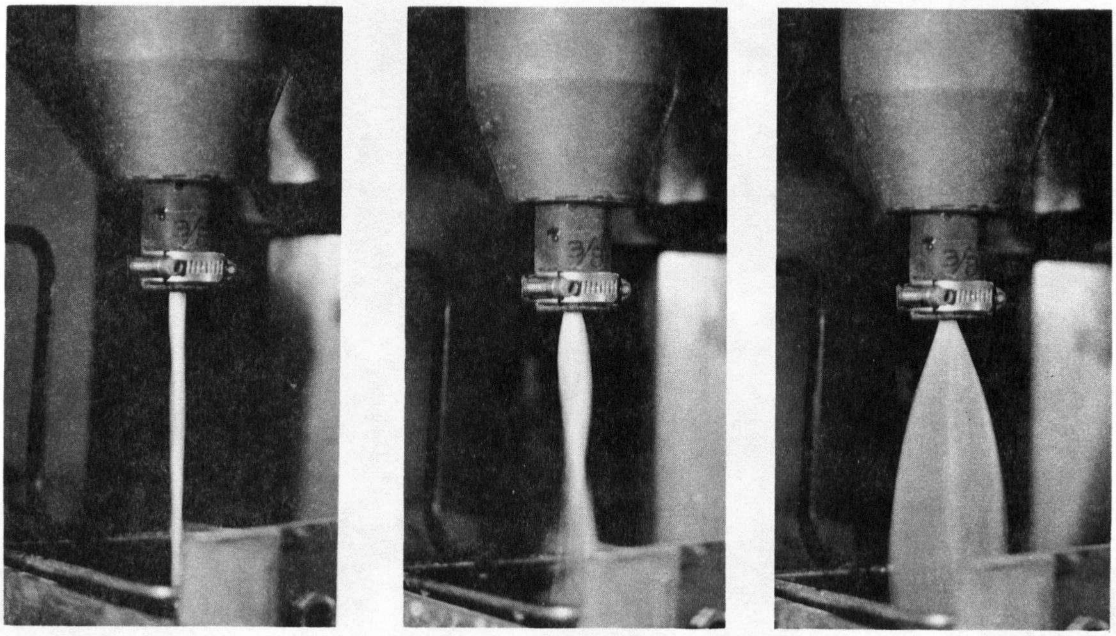
The factorial design is shown in fig. 6. "+" indicates the higher value and "-" the lower value of each variable whilst "CP" represents the centre point.

Run Numbers	Vortex Finder	Flow	Feed % Solids	Cyclone Length
21	-	-	-	-
22	+	-	-	-
23	-	+	-	-
24	+	+	-	-
25	-	-	+	-
26	+	-	+	-
27, 47	-	+	+	-
28	+	+	+	-
11, 31	-	-	-	+
12, 32	+	-	-	+
13, 33	-	+	-	+
14, 34	+	+	-	+
15, 35	-	-	+	+
16, 36	+	-	+	+
17, 37	-	+	+	+
18, 38	+	+	+	+
19, 29	CP	CP	CP	CP
39, 49	CP	CP	CP	CP

fig. 6 Design matrix for the experimental runs.

Most researchers have considered the spigot diameter to be an independent variable. Whilst this approach is not wrong it often leads to analysis of cyclone performance under conditions which would not be considered for normal operation. In practice spigot diameters are usually adjusted, either automatically or by selection of a fixed spigot, to give a discharge which is not overloaded but neither is it flaring excessively.

Fig. 7a shows a spigot which is overloaded and roping badly. Fig. 7c shows a larger spigot with a "vortex" or flaring discharge. The type of discharge shown in fig. 7b is what was used to adjust the spigot diameter for each run. Although this type of discharge may be a little too close to the roping codition for, say, a closed circuit grinding operation, it was a convenient point to adjust to as it could easily be checked by observing the spigot discharge when the flowrate was increased or decreased slightly.



(a) (b) (c)

Fig. 7 Types of Spigot Discharge

The only reference to this type of approach in the recent literature appears to be in the work of Drëissen and Fontein[82] who adjusted the spigot to give a constant percent solids in the underflow.

No literature references were found on the effect of temperature on cyclone efficiency with high feed pulp densities. Although temperature was not considered as a manipulable independent variable, it did vary and so it was necessary to record it.

c. Sampling

The pumpbox was filled with water and the pump used to circulate water through the system.

The cyclone spigot was plugged with a small cork so that water only flowed out of the overflow pipe. The valve on the pump discharge was closed with the pump still running to check the zero adjustment of the flowmeter.

The valve was then opened and the pump speed adjusted to give a flowmeter reading of 20 U.S.G.P.M. The sampling device was used to collect the cyclone overflow (which will be the same as the cyclone feed) over a period of one minute. The water was collected in a drum and its volume measured with a calibrated 'dipstick'. If the measured volume differed from the instrument reading then the SPAN setting inside the flowrate control panel was adjusted. This procedure was then repeated for a flowrate of 7 U.S.G.P.M.

The zero reading on the gamma ray density gauge was checked with clear water in the pipe.

The cork was then removed from the cyclone spigot and sufficient water and 'Supersil' silica added to give the required percent solids in the feed. To adjust the percent solids in the feed the flow through the cyclone was reduced to the point where discharge through the overflow just ceased. The underflow was carefully collected in a density can to measure the percent solids using a 'Marcy' pulp density scale. The reading on the gamma ray density gauge was noted.

The slurry was recirculated for a sufficient length of time to give complete dispersion.

Following the installation of a vortex finder of the desired size, the flowrate, as measured by the magnetic flowmeter, was adjusted to a predetermined value.

The slurry temperature was measured and recorded together with the sump level. The apex size was adjusted to the incipient rope condition. The overflow sample bucket was lined with a plastic bag to assist in the disposal of the overflow solids. The tare weights of the overflow bucket and underflow container were measured on a suitable balance.

The sampling device was then used to collect overflow and underflow samples over a carefully timed period. Re-weighing gave the overflow and underflow pulp sample weights by difference.

Samples for size analysis and for percent solids determination were collected from the overflow and underflow, in that order. Splashed material was wiped off the outside of the container and the samples for percent solids determination were weighed and dried in the oven to constant weight.

Samples for size analysis were then collected from the overflow then underflow steams.

Analysis of Samples

a) Pulp Density and Flows

Samples for pulp density determination were dried to constant weight in the oven. The percent solids by weight in the overflow and underflow streams could thus be calculated with a high degree of accuracy.

The overflow and underflow flowrate sample weights were used, together with the percent solids in each stream, to calculate the flowrates of solids and pulp in the various streams.

b) Size Analyses

The samples for size analysis were reduced in bulk using a wet splitter which was carefully washed down with distilled water after each pass. This ensured that coarse solids did not remain in the splitter.

The ElectroZone Celloscope (fig.8) was chosen for size analysis because:-

a) The size distribution produced is almost continuous on a log size scale, thus avoiding problems with interpolation.
b) The data output is on paper tape and was therefore suitable for input back into the main UBC computer system for data analysis.
c) One method could be used for the complete size analysis.
d) Size analyses could be performed on wet samples.

The disadvantages of this method included:-

a) The possibility of electronic noise influencing results and the necessity to reduce the sample down to a sufficiently small bulk for analysis.
b) The time taken for each analysis.

The principle on which the Celloscope operates is that the sample to be tested is dispersed in an electrolyte and sucked through a small orifice. The change in electrical conductivity as each particle passes the orifice is measured to give the effective volume of the particle. The instrument was calibrated using ragweed pollen and latex spheres. Pulses from the passage of particles are analysed by a minicomputer to give a size distribution for the particles which is essentially continuous. Further details on the use of the Celloscope may be found in appendix I.

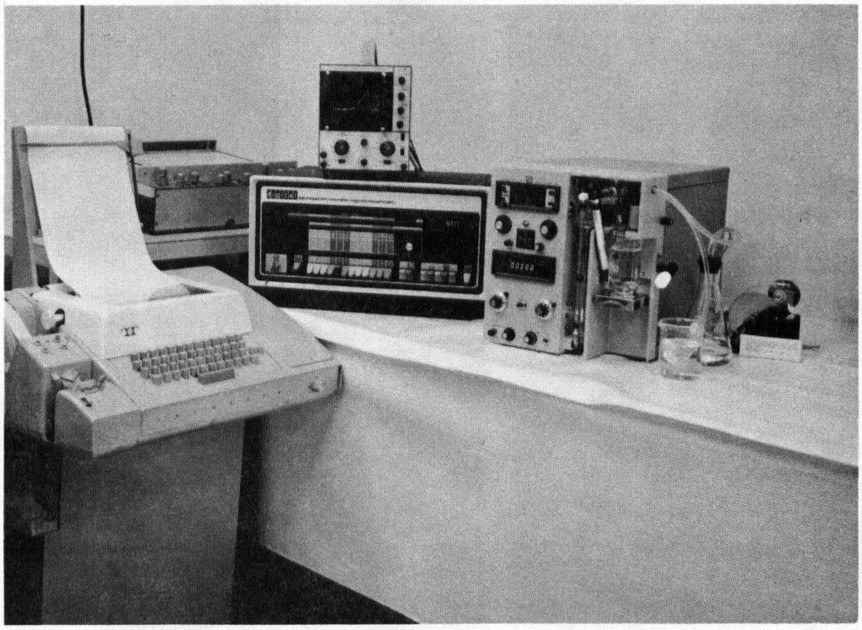


fig. 8 ElectroZone^{R} Celloscope - Computerized Particle Size Analyzer

Computational Procedure

a. Size Analysis Data Files

The paper tapes for the size analysis of the cyclone overflow and underflow streams were mounted on the high speed paper tape reader and read into an MTS file. The program "CONVERT" was used to write these numbers on a "Basic" language data file. The name of the data file for the overflow size analysis from run #19 would be "E19OF" and the underflow size analysis called "E19U". For further details please see appendices III and IV.

b. Program "CLTR2" to Calculate Efficiencies

These data files were then used together with the appropriate data from the experimental run as input to the program "CLTR2" which was used to produce a data file called say "RUN19@D" of the raw and reduced efficiencies at each size in the selected range. "CLTR2" also prints the total number of counts for each of the data files. These numbers were used to check for errors in the reading of the papertape. More information of this program may be found in appendix V.

c. Simplex Search Programs

The program "LYN" uses a simplex search method to give constants for Lynch and Rao's equation for the efficiency curve. The simplex search method is described by Mular and Bull[65], Mular[83] and Nelder and Mead[84]. An advantage of the simplex search method is that it is a non-derivitive method (i.e. it is not necessary to calculate partial derivities).

The simplex search method was used to minimise an objective function which was equal to the sum of squares of the difference between the calculated and predicted cyclone efficiencies at each data point.

Fig. 9 gives the flow diagram of a simplex search. Initial estimates of the variables searched for and starting step sizes are used to set up a starting simplex. This simplex would be triangular in a two-dimensional search. The simplex is reflected towards the minimum of the objective function and is capable of contraction and expansion.

The values of the d_{50C} size and alpha from "LYN" were added to the end of the data file for the run as the best estimates to

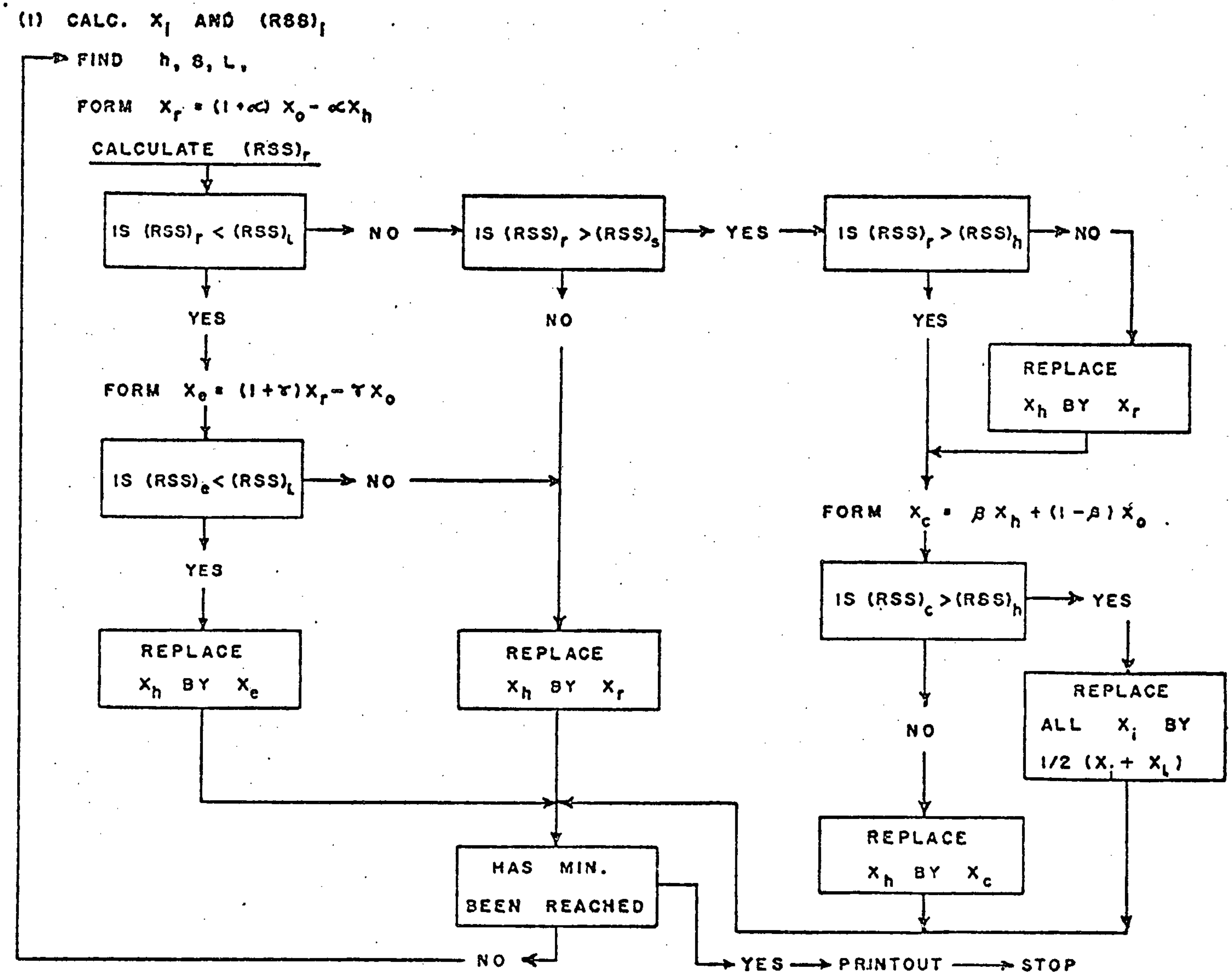


Fig. 9 Flow Diagram of a Simplex Search

be used as starting values for the other simplex search programs. Appendix VI gives more details of the program "LYN".

"GENWT" (see appendix VII) and "WTFILL" (see appendix VIII) were used to calculate weighting factors from repeat runs. "LYNWT" may be used with these weighting factors to give estimates of d_{50C} and alpha obtained from statistically weighted data and Lynch and Rao's equation. Appendix IX gives more information on "LYNWT".

"MURU" calculates the constants of the cyclone efficiency curve based on Mular and Runnels equation with allowance for the bypass ratio to be different from the water recovery in the underflow. In order to ensure that negative d_0 values were not allowed it was necessary to include a penalty function in the objective function for "MURU". Please see appendix X for details of "MURU".

d. Plotting Programs

For Calcomp plots of the efficiency curves a WATFIV program was used to format data for the FORTRAN plotting program. These programs are listed in appendix XI.

e. Multiple Linear Regression of Parameters.

The data from the simplex search programs was analysed using the new "UBC TRP" program which is a triangular regression package for stepwise multiple linear regression. Various transformation of the variables were used to study alternate relationships. Further details on the use of this computer program package may be found in appendix XII.

RESULTS AND DISCUSSION

Table I gives a summary of the data from the experimental runs. The actual sample weights and sampling time are not listed here. A sample of the output from the program "CLTR2" which gives this information may be found in the appendix. It will be noted that the experimental design could not be followed exactly, especially in the case of some of the flowrate settings where a fault developed in the flowmeter during a series of tests. The wide variation in temperatures should be noted.

Table II gives the best fit values of alpha and d_{50C} obtained by the program "LYN". This may be compared with the values of alpha, d_{50C}, d_0 and the new bypass ratio obtained from the program "MURU". These results may be found in Table III.

The mean value of alpha is higher with "LYN" than with "MURU". This is explained by the fact that the curve calculated from the results of "LYN" tends to be forced closer to the steeper part of the curve near the d_{50C} size. A study of the curves in appendix XIII will show how this results in a higher value for alpha.

On average the values of alpha obtained tended to be marginally higher than those reported by Plitt[29] from Lynch's testwork using silica. This sharper classification may be due to the fact that the testwork reported here was all done at the near-rope condition, but it could also be due to other factors.

TABLE I

Summary of Experimental Results

RUN NO.	VORTEX inches	SPIGOT inches	CALC. FLOW USGPM	FEED %SOLIDS by wt.	LENGTH inches	TEMP ^{o}C	INLET PRESS psig	O/F %SOLIDS by wt.	U/F %SOLIDS by wt.
11	0.75	0.23	10.45	11.0	22	19	1.5	6.7	62.3
12	1.25	0.16	18.0	10.3	22	21	2.3	8.6	55.0
13	0.75	0.38	31.65	10.0	22	25	16.0	4.6	66.6
14	1.25	0.39	40.9	11.1	22	29	14.0	5.4	67.3
15	0.75	0.16	8.06	49.3	22	33	1.0	48.1	68.3
16	1.25	0.18	8.23	49.3	22	31	0.6	48.1	65.4
17	0.75	0.28	18.5	49.6	22	26	6.0	47.2	71.3
18	1.25	0.26	21.9	49.8	22	28	5.0	48.6	71.8
19	1.00	0.35	13.3	30.3	19.5	22	1.9	26.8	59.9
21	0.75	0.16	9.9	10.0	17	23	1.6	6.0	62.8
22	1.25	0.16	10.2	10.5	17	21	1.0	7.1	55.1
23	0.75	0.25	22.1	9.4	17	25	11.4	4.1	64.9
24	1.25	0.39	21.9	10.8	17	19	4.7	6.2	64.4
25	0.75	0.12	7.8	50.6	17	32	1.1	49.2	65.1
26	1.25	0.15	7.6	50.7	17	35	0.9	49.6	63.8
27	0.75	0.31	20.6	50.7	17	24	9.0	48.3	72.4
28	1.25	0.30	20.7	50.7	17	35	5.3	49.2	69.3
29	1.00	0.35	12.9	30.9	19.5	23	1.9	26.7	68.5
31	0.75	0.23	10.9	10.9	22	20	1.5	6.7	62.6
32	1.25	0.19	17.5	11.5	22	24	2.3	7.8	66.1
33	0.75	0.38	28.2	9.8	22	27	16.0	4.4	66.1
34	1.25	0.39	41.4	11.1	22	31	13.9	5.3	67.5
35	0.75	0.16	8.0	49.2	22	34	1.0	48.0	67.6
36	1.25	0.18	8.0	49.3	22	32	0.6	48.1	65.6
37	0.75	0.28	18.2	49.4	22	27	6.0	47.1	71.3
38	1.25	0.26	21.7	49.5	22	30	5.0	48.4	71.7
39	1.00	0.35	12.9	30.7	19.5	25	1.9	26.8	63.6
47	0.75	0.31	21.0	50.7	17	26	9.1	48.3	72.4
49	1.00	0.35	13.1	30.1	19.5	26	1.9	26.1	63.4

TABLE II

Results of Regression Using "LYN"

RUN NO.	ALPHA	d_{50C} microns
11	6.25	28.9
12	7.25	43.6
13	6.25	20.0
14	6.8	21.1
15	6.5	83.0
16	4.6	88.65
17	4.5	77.9
18	6.6	84.1
19	6.1	58.5
21	7.3	28.3
22	7.0	36.0
23	6.7	16.5
24	9.2	28.9
25	5.3	89.2
26	5.8	95.0
27	5.0	74.4
28	6.7	82.0
29	6.4	54.7
31	6.7	29.1
32	9.2	35.6
33	6.4	17.1
34	6.5	20.5
35	6.6	97.1
36	5.2	87.0
37	6.2	73.1
38	8.0	87.0
39	6.2	53.4
47	6.1	76.8
49	6.6	54.6

TABLE III

Results Using "MURU" With Weighting Factors

RUN	ALPHA	d_{50C} microns	d_0 microns	BYPASS
11	4.1	27.2	5.1	0.039
12	7.4	43.4	2.1	0.017
13	5.25	20.5	0.0	0.021
14	5.95	21.3	0.4	0.035
15	5.3	84.7	13.5	0.038
16	3.2	94.4	9.1	0.036
17	4.55	79.15	0.9	0.066
18	5.2	86.6	3.9	0.026
19	6.0	58.9	1.1	0.070
21	5.3	27.1	2.3	0.031
22	7.4	35.8	2.3	0.035
23	4.7	19.8	1.9	0.034
24	7.2	28.25	9.7	0.033
25	4.8	93.0	0.0	0.066
26	5.0	98.5	2.55	0.055
27	4.3	75.5	3.9	0.056
28	5.9	83.6	4.0	0.057
29	6.4	55.7	0.1	0.068
31	4.6	27.8	5.7	0.036
32	9.4	35.5	7.3	0.020
33	5.1	19.7	0.8	0.022
34	5.8	20.6	0.15	0.037
35	9.0	95.1	31.9	0.061
36	4.1	91.6	14.4	0.051
37	5.7	74.6	6.5	0.069
38	6.8	88.55	1.9	0.034
39	6.0	54.0	3.2	0.064
47	4.3	79.6	0.0	0.061
49	6.3	55.0	0.02	0.063

The predicting equations for the parameters obtained from "MURU" were determined by the linear regression program to be:-

a) $\log d_{50C} = 1.358 + 0.191\ D_o - 0.0064\ Q + 0.0128\ \phi - 0.00505\ T$

b) $\log P = 2.168 \log Q - 0.95 \log h + 0.39\ \phi_v - 0.624 \log (D_u^2 + D_o^2) - 0.913$

c) $B = 0.973\ R_f + 0.00028\ \phi + 0.00166\ Fe_{50} - 0.0405$

d) $\log \alpha = 5.18\ (1 - R_v) + 0.0302\ Fe_{50} + 0.1372 \log \phi + 6.38 \log D_o - 2.668\ D_o - 2.242$

e) $\log d_o = 0.35$

f) $\log R_f = -0.933 + 0.688 \log \phi - 0.703 \log d_{50C} + \dfrac{8.09 D_u}{(1-\phi_v)\ Q} - 0.02\ h$

g) $\phi_u = 75.58 + 64.9\ \phi_v + 6.47 \log U_g - 18.6 \log d_{50C}$

h) $D_u = 0.0935 + 0.355 \log U_g - 0.007\ \phi_u$

where logarithms are to the base 10.

Appendix XII gives full details of the various measures of "goodness of fit" together with a set of printer plots for each equation.

Equation (a):-

The d_{50C} equation selected from those tested has the same functional form as the equations used by Lynch[32] except that an increase in the temperature of the slurry was found to have a significant effect in decreasing the d_{50C} size and the spigot size was not found to be significant at the 0.05 significance level. The standard error of the equation for log d_{50C} was $\pm$ 0.04 and the value of R^2 was 0.98.

The effect of temperature on the viscosity of non-Newtonian slurries is not fully understood[85] but for relatively low solids concentrations viscosity will decrease with an increase in temperature.

For Newtonian systems of low percent solids in sucrose solutions it has been found[86] that:-

$$d_{50C} = K_1 \mu^{0.58}$$

$$\text{so } \log d_{50C} = \log K_1 + 0.58 \log \mu$$

where K_1 is a constant representing the variables which are not of interest in this context and μ is the viscosity of the aqueous phase.

If for such a system the temperature is increased from 20°C to 30°C then the viscosity is reduced from 1.0 centipose to 0.8 centipoise. This corresponds to a reduction in log d_{50C} of 0.056.

Most of the theories of cyclone operation for dilute, Newtonian pulps predict that the d_{50C} size is proportional to the square root of the viscosity. They would predict a reduction of 0.048 in the value of log d_{50C} as the temperature was increased from 20°C to 30°C.

Thus the result of 0.051 predicted by the regression equation obtained in this study is in good agreement with the theory and practice applicable to Newtonian slurries.

In order to appreciate the magnitude of the temperature effect it may be noted that conditions which give a d_{50C} size of 50 microns at $20^{o}C$ will give a d_{50C} size of only 44.5 microns at $30^{o}C$. Such a difference is significant in cyclone testing and could be of industrial importance when water temperatures fluctuate significantly. An example of this might be when the source of cyclone feed water is switched from a warm recycle supply to water from an almost frozen lake.

The fact that the d_{50C} size was not significantly influenced by the spigot size would seem to support the experience of Jull[87] who considers that the d_{50C} size is only decreased by a spigot size in excess of the minimum size required to prevent roping.

Fig. 10 shows a plot of the predicted values of log d_{50C} versus the measured values.

Equation (b):-

The pressure relationship of the form used by Plitt was found to give accurate predictions of the cyclone inlet pressure, the value of R^2 for this regression being 0.987.

Equation (c):-

The accepted relationship for the bypass ratio is simply to assume that it is constant and equal to the recovery of water in the underflow. This assumption has, however, not always been found to be accurate[73]. The predicting equation chosen for the fraction of the feed solids bypassing classification indicated that as the cyclone becomes loaded with a less dilute feed an increasing portion of the feed bypasses classification.

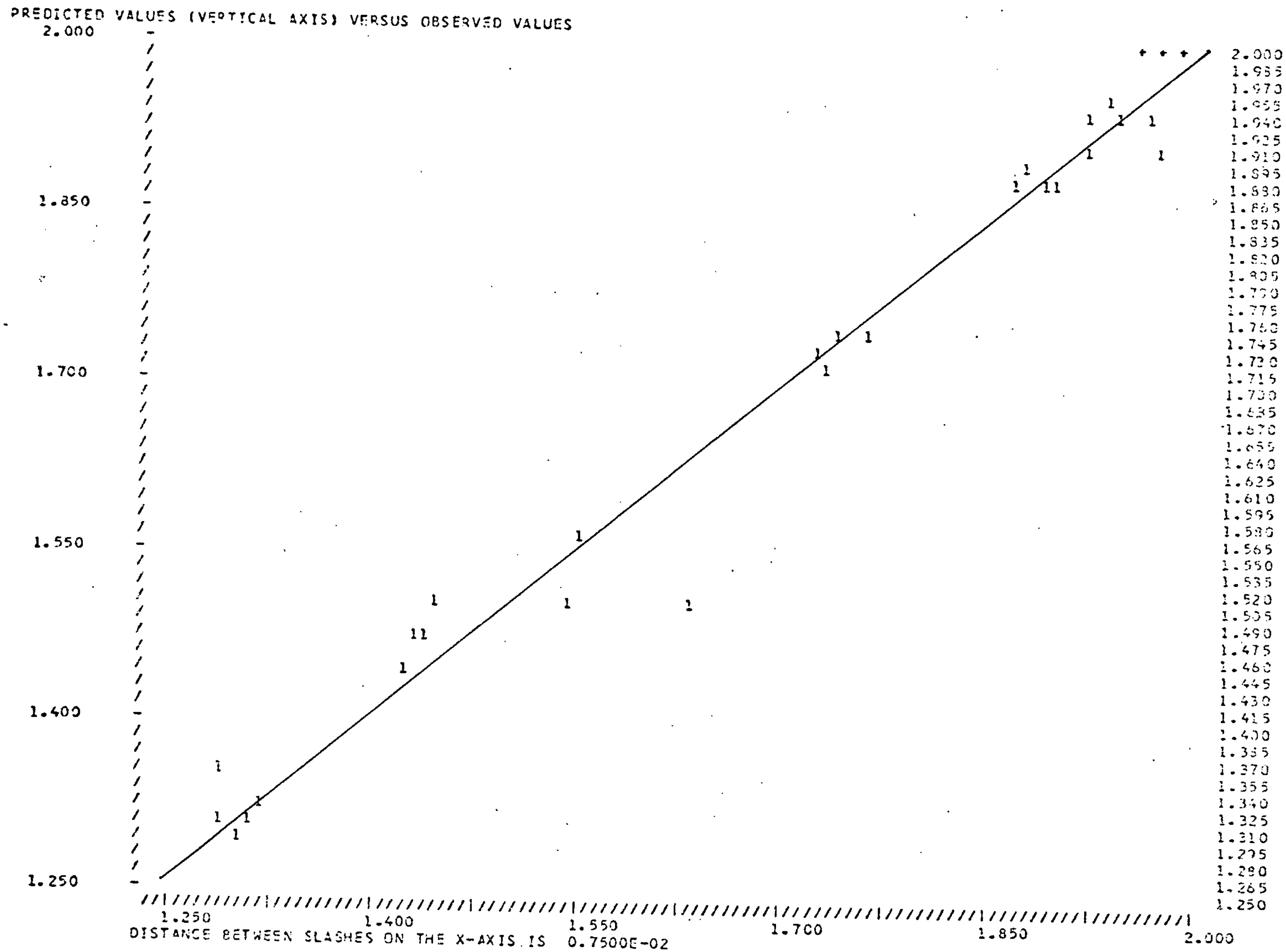


Fig. 10 Comparison of Predicted and Observed Values of log d_{50C}

The calculated 50% passing size of the feed was not deliberately manipulated but it varied because of bag to bag variations in the silica, attrition, some unavoidable segregation in the pumpbox and experimental error. The equations indicated that this variation in feed size did affect the bypass ratio. The value of R^2 was 0.89 for this equation.

Equation (d):-

The empirical relation presented for alpha indicates that it depends on the volume recovery factor $(1-R_v)$ (which is itself a function of cyclone geometry), vortex finder size and the coarseness of the feed. The feed percent solids term indicates an increase in alpha with increase in feed percent solids - an unexpected conclusion. Fahlstrom[15] concluded the opposite effect whilst Lynch[32] and Plitt[33] could detect no effect of feed percent solids on the steepness of the efficiency curve. It has previously been speculated that alpha may depend on feed size[71]. Plitt's relationship was rejected at the 0.05 significance level. The value of R^2 was 0.80 for this expression. Fig. 11 shows the predicted values of log alpha plotted against the measured values.

Equation (e):-

The value of d_0 represents the point at which two almost parallel lines intersect. It is therefore very sensitive to the slightest change in data around this point. The log mean value of d_0 was 2.2 microns with a standard deviation on log d_0 of 0.72. This small value of d_0 may be an indication that d_0 is a function of cyclone diameter.

Equation (f):-

The equation for the water recovery in the underflow contains a term with the spigot diameter in it. Because the

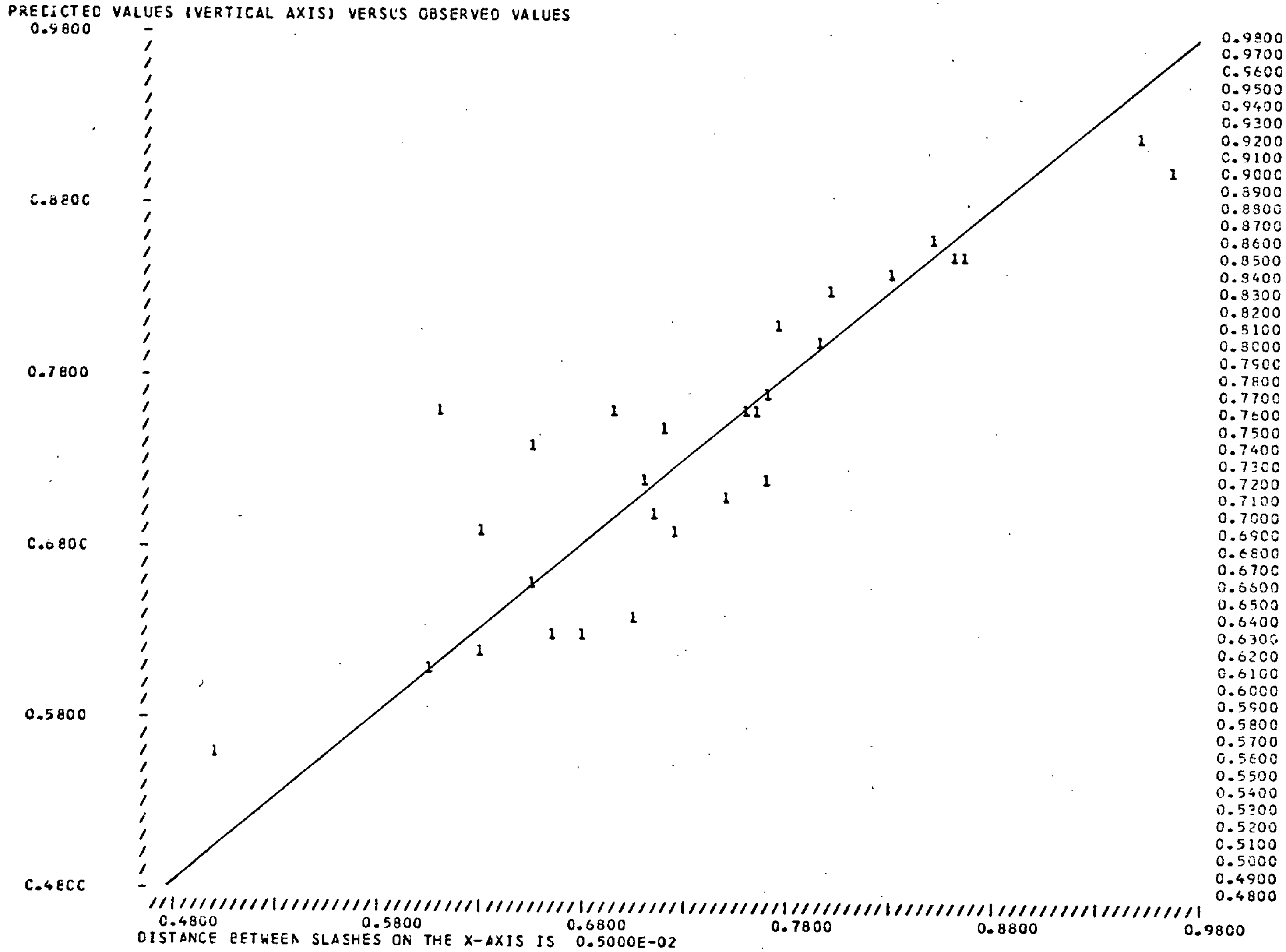


Fig. 11 Comparison of Predicted and Observed Values of log alpha

spigot was small, made of rubber and not perfectly round, it was difficult to measure accurately. This explains the R^2 value of 0.8 and standard error of 66 thousandths of an inch.

Equations (g) and (h):-

Two roping constraint equations were obtained. The first gives the spigot size at which roping would occur. It is of the same form as the graph given by Tarr[88] for larger spigots. Tarr's graph indicates that finite flowrates are possible through spigots of zero diameter. Obviously this results from unintentional extrapolation of straight lines into an area where there is significant curvature. The results obtained in this work fall into this area near the origin and cannot, therefore, be meaningfully compared with his graphical estimates.

The second roping constraint studied was the underflow percent solids. This would be expected to be a function of the variables influencing the solids to slurry ratio of an underflow which has rheological properties resulting in free discharge from the spigot orifice.

The value of R^2 for these two equations were 0.73 and 0.78 respectively.

The equations obtained in this study apply only within the limits over which the variables were tested. Outside this range the user should proceed with caution and may find Lynch's thoughts on scale up[32] of the hydrocyclone useful.

CONCLUSIONS AND RECOMMENDATIONS

1. The d_{50C} size was found to decrease with an increase in temperature according to the relationship predicted for Newtonian flow with dilute slurries. The modern semi-empirical equations for separation at high feed percent solids ignore this temperature effect. Further work should be carried out to check the effect of temperature on the d_{50C} size under an even wider range of conditions.

2. When tests were performed with the spigot adjusted so that roping is just avoided the d_{50C} size was found to be independent of the spigot size.

3. The best fit value of the bypass ratio was found to increase slightly with an increase in the percent solids in the cyclone feed and with the calculated value of the 50 percent passing size of the feed.

4. The roping constraint equations obtained show how the point at which a cyclone starts to rope may be defined mathematically. This type of relationship would be useful in the optimization or direct digital control of, say, a closed circuit grinding operation.

5. Contrary to evidence by other investigators, the parameter alpha, which describes the steepness of the efficiency curve, was found to be variable rather than constant. An equation which predicts alpha as a function of operating variables was developed. By making alpha as large as possible, classification efficiency increases. Consequently a grinding circuit which incorporates hydrocyclones would operate more efficiently to provide an economic benefit.

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APPENDIX I

DETAILS OF SIZE ANALYSIS PROCEDURE

Introduction

The size analyses represented a considerable portion of the experimental effort as it was necessary to learn to operate a rather sophisticated piece of equipment and because size analyses were rather time-consuming. During the course of this work there were a number of advances made which were useful both for this research and for future work. Most of these advances centered around the new '8K' program recently supplied for the mini-computer system.

There are a number of limitations on the size range that the Celloscope can span in any one "range". For this reason it was necessary to analyse over three ranges each of which, in this case, was associated with a different orifice size.

The computer reads the first range (range 3) into the raw data area until the maximum number of counts in any channel reaches a present value (in our case 2000 for range 3, 4000 for ranges 4 and 5). The operator then instructs the computer to save these values in the normal data area and then clears the raw data area.

Raw data is then obtained for the second range (range 4) and this is added to the data already in the normal data area by scaling the data set to give a good match at the common point. This is illustrated in fig. 12.

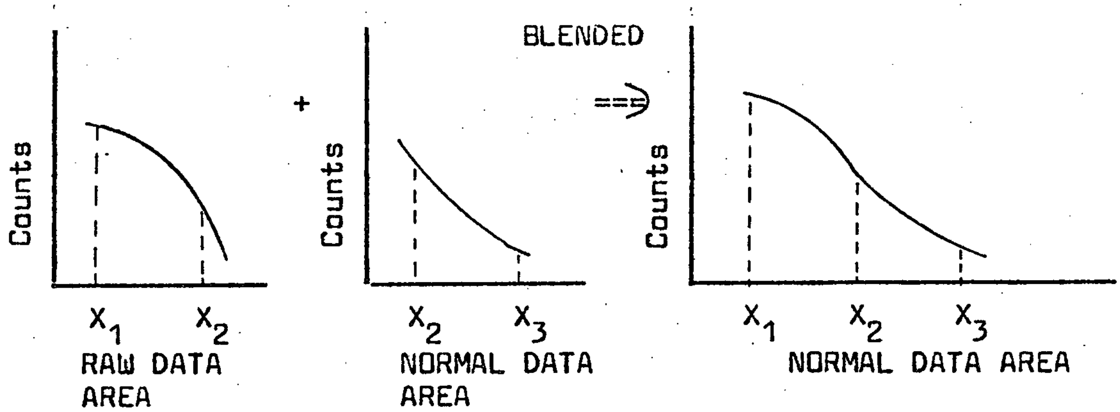

fig. 12 Blending of Data.

Once all three ranges have been analysed the data in the normal area is converted to a volume basis by multiplying each number of counts by a factor which is proportional to the volume of a sphere of the size concerned. The fraction of the total volume in any size "channel" equals the counts in that "channel" divided by the total"counts" for all sizes. In the case of the overflow size analysis it was necessary to use the Gaussian extrapolation feature to estimate counts for sizes below the smallest size measured.

<u>The Control Tape</u>

A control tape was punched on papertape. The final version is the most general - it is designed to be of use to future users of the system who may not require all the instrument ranges.

Whilst there are advantages to learning how to use the Celloscope without the use of a control tape, the use of this control tape had a number of advantages:-

a) The operator is given explicit instructions as to dial settings, orifice sizes and dilutions to be used.

b) The operator is prompted to remember to empty the liquid trap on the vacuum line and to adjust the "normalize" potentiometer regularly.

c) All output has provision for typing the sample number and date and time in a regular format.

d) All samples are analysed in the same way and the operator does not have to remember the order of computer instructions.

e) The operator has more time to concentrate on sample splitting, electrolyte filtration and other duties.

Blockage Detection

Because a blockage of the orifice would result in disruption of the analysis or distortion of the size distribution, it is necessary to keep a constant watch out for blockages. The latest program had a blockage detection routine which detected changes in the particle count rate due to blockages. This feature did not work successfully in the two coarse size ranges but it was very useful for the small size range.

Procedure

The sample was dispersed in a solution of 10% Calgon diluted to 4% with distilled water. Dispersion was assisted by mixing in a blender. Experience has shown that the mixing time in the blender should be as short as possible to minimize sample attrition.

A scoop was used to remove samples from the blender for dilution with sodium chloride - sodium pyrophosphate electrolyte. All solutions were previously filtered twice through a 0.45 micron filter.

For each range the correct orifice was fitted to the apparatus and the current, gain, log and timer controls were set to the values given by the control tape via the teletype. The stirrer was adjusted to its maximum speed then slowed down, if necessary, to prevent air bubble formation. The solution was emptied from the flask in the vacuum line. The function knob was set to 3, and the normalizing control adjusted. The coincidence count was then checked and the dilution adjusted if necessary. The dilution used was low enough to ensure that the probability of two particles going through the orifice together was only about 1%. After rechecking the normalizing setting the analysis was started.

With the smaller orifice sizes it was necessary to carefully sieve out the very coarse material so as to reduce the possibility of blockages occurring.

Care should be taken not to touch the sample container during the size analysis as ths could result in one's body acting as an antena for electronic noise.

```
CONTROL TAPE DATED FRID. 26TH NOVEMBER,1976



SAMPLE NUMBER:--

DATE AND TIME:--

PR 2000

NR

ER

MO NA

MO NB


NR

BA 0

CHANGE TO 300 MICRON ORIFICE
          LOG 6
          1/16
          G2 1/8
          6.5 SEC.
EMPTY FLASK, FLUSH, NORMALISE,CHANGE TO FUNCTION 3 & DIL. TO 560 COUNTS
--

CHANGE TO FUNCTION 1
--

CHECK CALIBRATION 3L 23 5610
                  3H  97 12550

CA 3L
CA 3H
--

RA

AN

**SWITCH ON PUNCH***
--
OU
MS 8

--

NR ER
```

```
RA

FU 3

--

RA



PR 4ØØØ

CHANGE TO 15Ø MICRON ORIFICE
         LOG 8
         1/16
         G4 1/4
         11.Ø SEC.
EMPTY FLASK,FLUSH,NORMALISE,CHANGE TO FUNCTION 3 & DIL. TO 22ØØ COUN
--

CHECK CALIBRATION 4L 17   127Ø
                  4H 118 561Ø

CA 4L
CA 4H

CHANGE TO FUNCTION 1
--

AN

**SWITCH ON PUNCH***
--
OU

MS 8

--

RA

IF THIS IS THE FIRST RANGE ANALYSED, TYPE IN FU@4 AND USE 'FREE' ON
READER SWITCH TO SKIP TO NEXT LEADER ON PAPERTAPE--

BL 4

--

RA
```

```
CHANGE TO 60 MICRON ORIFICE
          LOG 8
          1/4
          G 6
          14.5 SEC.
EMPTY FLASK, FLUSH, NORMALISE, CHANGE TO FUNCTION 3 & DIL. TO 7000 COU
--

CHANGE BACK TO FUNCTION 1
--

CHECK CALIBRATION 5L 20  323
                  5H 117 1270

CA 5L
CA 5H

BA 4095

IF BLOCKAGE DETECTION IS NOT WANTED TYPE '@' AFTER SWITCHING OFF READE
THEN TYPE 'BA@ 0@' AND RESTART READER

--

SWITCH OFF TAPE READER DURING ANALYSIS***
--

AN

**START PUNCH**

--

OU

MS 8

IF THIS IS YOUR FIRST RANGE ,STOP READER AND MOVE ON TO NEXT LEADER
ON CONTROL TAPE BEFORE RESTARTING. TYPE '@' TO FREE COMPUTER THEN
TYPE'FU@5'

TO CONTINUE NORMALLY SIMPLE PRESS'@' TO CONTINUE
N.B. '@' REFERS TO THE 'ALT. MODE' KEY
BL 5

IF YOU WANT RANGE 6 THEN PUT IT IN HERE BEFORE PROCEEDING
--
```

MS 1Ø

CO V

MAKE LEADER ON NEW PAPERTAPE, SWITCH OFF AGAIN THEN ON AGAIN AS SOON AS COMPUTER HAS TYPED 'OUTPUT'
STOP PUNCH WHILST COMPUTER IS STILL PRODUCING TRAILER ON TAPE.
INCREASE TRAILER LENGTH MANUALLY.
--

OU

GAUSIAN EXTRAPOLATION TO BE DONE HERE BEFORE RESTARTING TAPE READER
--

MAKE LEADER ON NEW PAPERTAPE, SWITCH PUNCH OFF AGAIN THEN ON AGAIN AS SOON AS COMPUTER HAS TYPED 'OUTPUT'.
STOP PUNCH WHILST COMPUTER IS STILL PRODUCING TRAILER ON TAPE.
INCREASE TRAILER LENGTH MANUALLY.
--
OU

CHARACTERISTICS OF CURVE FOLLOW IN THE ORDER- LOG MEAN, MODE, MEDIAN

CH

CUMULATIVE PERMIL. (I.E. % X 1Ø) OVERSIZE FOLLOWS FOR VARIOUS MICRON SIZES
CU 1Ø5D
CU 75D
CU 42.7D
CU 31.2D
CU 22.2D
CU 16.2D
CU 11.6D

```
CU 3.27D
CU 4.62D
CU 6.54D
CU 9.25D
CU 13.Ø8D
CU 18.6D
CU 26.16D
CU 37.ØD
CU 52.3D
CU 74D
CU 1Ø4.6D


NR

PG

NR


STOP READER, PRESS'ALT MODE' THEN RESTART READER FOR LONG ENOUGH
FOR IT TO PROMPT THE COMPUTER  TO COMPLETE THE WORD 'GRAPH'
FINALLY RESTART THE READER.
--
GR A


STOP READER, PRESS 'ALT MODE' THEN RESTART FOR JUST LONG ENOUGH TO
PROMPT COMPUEER TO COMPLETE THE WORD 'GRAPH', WAIT A FEW SECONDS
THEN RESTART READER

--
GR C


TIME:--
```

APPENDIX II

DATA FILES & DATA FOR THE PROGRAM "CLTR2"

What follows on the next 29 pages is a listing of the data used as input to the program "CLTR2" with one page devoted to the data associated with each experimental run.

LISTING OF FILE R1 04:07 P.M. FEB. 24, 1977 ID=RALU

```
GET E110F@D
 1 30,0,0,0,0,0,1,1,1,1,1,37,1,1,2,2,2,2,2,3,3,3,47,3,4,4,5,5,6,6,7,7,8,60,8
 2 9,10,11,12,13,14,15,16,17,75,19,20,22,23,25,27,29,31,33,36,95,39,41,44,47
 3 51,54,58,62,66,70,119,75,80,85,90,96,102,109,116,123,130,151,138,146,155
 4 164,174,184,194,205,217,229,190,241,255,268,283,298,313,330,346,364,382
 5 239,401,421,441,463,485,507,531,555,581,607,301,634,661,690,643,690,739
 6 787,834,882,928,379,973,1015,1056,1095,1133,1171,1210,1250,1289,1323,477
 7 1353,1379,1405,1431,1460,1490,1520,1546,1570,1597,601,1634,1677,1718,1748
 8 1768,1785,1803,1821,1841,1869,756,1906,1944,1977,2003,2036,2087,2149,2202
 9 2227,2227,952,2224,2245,2298,2371,2437,2475,2482,2467,2450,2457,1199,2509
 10 2608,2734,2858,2964,3047,3114,3174,3235,3299,1509,3370,3444,3521,3594
 11 3657,3706,3742,3770,3793,3814,1900,3839,3871,3911,3949,3967,3958,3920
 12 3866,3810,3752,2392,3677,3566,3419,3261,3121,3002,2879,2722,2528,2311
 13 3012,2094,1885,1686,1492,1311,1155,1035,951,889,834,3791,777,718,665,627
 14 599,575,549,528,525,491,4773,463,470,452,422,401,399,406,365,348,318
 15 6009,284,252,226,206,186,167,148,130,113,99,7565,90,85,80,73,63,62,56,50
 16 47,40,9523,37,37,40,43,43,37,28,30,42,45,11989,37,28,24,19,28,45,44,43
 17 36,40,15093,43,46,49,26,0,0,0,0,0,0,270033,28
GET E11U@D
 1 239,0,0,0,0,0,1,3,7,9,11,301,12,12,12,13,14,16,21,28,36,42,379,45,47,48
 2 50,52,54,56,58,59,60,477,61,62,63,65,67,69,71,72,73,74,601,75,76,78,80,81
 3 82,83,85,88,90,756,92,94,96,98,100,102,104,108,112,116,952,120,124,127
 4 130,134,140,145,151,156,160,1199,163,166,171,176,183,189,197,205,215,224
 5 1509,232,240,250,261,274,290,308,328,351,376,1900,403,431,463,500,544,599
 6 664,738,821,913,2392,1017,1137,1275,1427,1591,1764,1947,2142,2348,2558
 7 3012,2763,2953,3127,3284,3425,3546,3645,3723,3786,3845,3791,3901,3946
 8 3967,3959,3926,3883,3841,3801,3764,3727,4773,3680,3611,3516,3402,3282
 9 3162,3037,2907,2779,2668,6009,2573,2489,2408,2327,2231,2112,1973,1824
 10 1684,1569,7565,1479,1407,1329,1233,1127,1014,911,842,802,765,9523,726
 11 671,586,487,398,345,315,280,250,241,11989,244,230,164,88,56,81,86,93,99
 12 80,15093,57,61,32,35,37,0,0,0,0,0
GET CLTR2
160 DATA 11, 0.75, 0.23, 1.5, 22.6
170 DATA 280, 14747, 1237.7, 984, 771
180 FILE E110F
190 FILE E11U
195 FILE RUN11
197 B7=CMD("%EMPTYäNC RUN11@D")
```

LISTING OF FILE R2 C4:07 P.M. FEB. 24, 1977 ID=RALU

```
GET E120F@C
 1 23,0,0,1,1,1,1,1,1,1,1,30,1,2,2,2,2,2,3,3,3,3,37,4,4,4,5,5,5,6,6,7,7,47,8
 2 9,9,10,11,12,13,13,14,15,60,17,18,19,20,22,23,25,27,28,30,75,32,34,37,39
 3 41,44,47,50,53,56,95,59,63,67,71,75,79,84,89,94,99,119,105,111,117,124
 4 130,137,145,153,161,169,151,178,187,197,207,217,228,239,251,263,276,190
 5 289,303,317,332,347,363,379,396,413,432,239,450,470,490,510,531,553,576
 6 599,623,648,301,673,699,726,667,714,761,806,851,898,944,379,988,1029,1073
 7 1119,1167,1212,1248,1274,1294,1312,477,1335,1365,1401,1436,1466,1489,1508
 8 1531,1562,1596,601,1627,1650,1667,1684,1707,1737,1770,1802,1826,1842,756
 9 1857,1878,1910,1949,1988,2025,2060,2090,2114,2134,952,2156,2189,2230,2268
 10 2291,2297,2294,2292,2307,2346,1199,2412,2492,2566,2624,2671,2723,2788
 11 2858,2921,2975,1509,3026,3082,3142,3197,3241,3275,3305,3337,3374,3418
 12 1900,3474,3547,3628,3703,3760,3798,3822,3836,3845,3853,2392,3872,3905
 13 3944,3967,3960,3927,3881,3869,3894,3923,3012,3909,3835,3738,3668,3626
 14 3563,3429,3223,2991,2777,3791,2583,2384,2163,1938,1742,1585,1441,1279
 15 1102,936,4773,802,697,608,532,471,419,363,299,235,185,6009,153,131,113
 16 98,83,70,62,55,49,43,7565,37,33,29,25,21,18,16,12,9,8,9523,8,6,2,2,2,3,6
 17 6,7,3,11989,0,4,9,10,5,0,0,0,0,0,15093,8,9,9,0,0,0,0,0,0,0,301904,29
GET E12U@D
 1 239,0,0,0,0,0,1,4,10,16,21,301,24,25,26,27,29,31,33,35,37,39,379,41,42,44
 2 46,48,49,51,52,53,54,477,55,55,56,57,58,59,61,62,63,64,601,65,66,67,67,69
 3 70,71,72,73,75,756,76,78,79,81,82,84,86,88,90,91,952,93,95,97,100,102,104
 4 106,108,112,116,1199,120,124,126,128,131,135,140,145,151,157,1509,162,169
 5 175,182,189,197,205,213,222,231,1900,242,256,271,286,301,316,331,348,367
 6 389,2392,414,442,473,507,544,587,634,686,744,812,3012,891,981,1080,1185
 7 1298,1420,1556,1707,1874,2052,3791,2239,2432,2630,2830,3027,3216,3392
 8 3553,3691,3798,4773,3875,3927,3958,3967,3947,3899,3835,3771,3713,3661
 9 6009,3601,3518,3409,3290,3174,3066,2957,2834,2696,2547,7565,2408,2285
 10 2160,2036,1915,1808,1707,1609,1509,1395,9523,1265,1135,1018,929,833,707
 11 559,452,413,397,11989,376,333,282,221,172,138,124,106,113,122,15093,98
 12 105,75,40,0,0,0,0,0,0,159585,19
GET CLTR2
160 DATA 12, 1.25, 0.16, 2.3, 20.1
170 DATA 290, 23516, 912.6, 2023, 502.2
180 FILE E120F
190 FILE E12U
195 FILE RUN12
197 B7=CMD("%EMPTY@NC RUN12@D")
```

LISTING OF FILE R3 04:07 P.M. FEB. 24, 1977 ID=RALU

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GET E130F@D
 1 30,1,1,1,1,1,1,1,2,2,2,37,2,2,3,3,3,4,4,5,5,6,47,6,7,7,8,9,10,10,11,12,13
 2 60,15,16,17,19,20,22,24,26,28,30,75,32,35,37,40,43,46,50,54,58,62,95,66
 3 71,76,81,87,93,99,106,113,120,119,128,136,145,154,164,174,185,196,208,221
 4 151,234,247,262,277,292,309,326,344,362,382,190,402,423,445,467,491,516
 5 541,567,595,623,239,652,682,714,746,779,813,848,885,922,960,301,999,1040
 6 1081,1017,1111,1201,1277,1337,1385,1426,379,1463,1501,1545,1597,1654,1711
 7 1765,1816,1866,1918,477,1973,2029,2080,2120,2154,2187,2227,2276,2327,2377
 8 601,2422,2464,2502,2534,2562,2588,2619,2658,2704,2753,756,2800,2844,2882
 9 2914,2939,2958,2984,3029,3097,3172,952,3227,3243,3229,3214,3230,3289,3374
 10 3448,3482,3479,1199,3475,3510,3593,3701,3804,3887,3943,3968,3963,3941
 11 1509,3911,3876,3829,3767,3694,3616,3532,3439,3329,3199,1900,3045,2867
 12 2673,2471,2267,2061,1866,1696,1564,1458,2392,1355,1238,1110,989,887,803
 13 729,659,591,526,3012,463,408,364,336,319,306,290,265,232,203,3791,189
 14 189,187,170,142,118,112,124,143,153,4773,143,118,91,69,51,33,16,4,0,0
 15 6009,0,0,0,0,0,0,0,0,0,0,7565,0,0,0,0,0,0,0,0,0,0,9523,0,0,0,0,0,0,0,0,0
 16 0,11989,0,0,0,0,0,0,0,0,0,0,15093,0,0,0,0,0,0,0,0,0,0,268716,28
GET E13U@D
 1 239,0,0,0,0,0,1,4,9,13,16,301,17,17,17,17,18,20,21,22,24,25,379,27,29,31
 2 32,34,35,36,38,39,41,477,43,46,48,50,52,54,56,57,59,62,601,64,67,69,71,72
 3 73,76,79,83,87,756,90,93,96,100,104,107,110,112,116,121,952,128,133,138
 4 142,148,156,166,176,186,197,1199,209,224,241,260,284,311,343,378,420,468
 5 1509,524,585,651,724,805,897,998,1107,1221,1336,1900,1449,1564,1685,1816
 6 1952,2089,2225,2363,2502,2637,2392,2761,2874,2981,3083,3179,3266,3346
 7 3424,3501,3575,3012,3637,3686,3722,3752,3786,3829,3875,3915,3942,3959
 8 3791,3968,3961,3926,3861,3780,3707,3654,3614,3576,3529,4773,3472,3402
 9 3311,3195,3066,2941,2836,2756,2685,2607,6009,2508,2392,2268,2151,2045
 10 1940,1830,1718,1612,1510,7565,1404,1301,1194,1086,982,899,844,793,730
 11 647,9523,563,505,473,451,414,360,317,265,193,134,11989,104,111,120,112
 12 86,55,39,42,90,97,15093,52,27,29,64,34,0,0,0,0,0
GET CLTR2
160 DATA 13, 0.75, 0.38, 16, 10.0
170 DATA 280, 19450, 1835, 900.7, 1222
180 FILE E130F
190 FILE E13U
195 FILE RUN13
197 B7=CMD("%EMPTY@NC RUN13@D")
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LISTING OF FILE R4                    04:07 P.M.  FEB. 24, 1977    ID=RALU

GET E140F@D
 1 19,0,0,1,1,1,1,1,1,1,1,23,2,2,2,2,2,3,3,3,3,4,30,4,4,5,5,6,6,7,7,8,9,37,9
 2 10,11,12,13,14,15,16,17,18,47,19,21,22,24,26,28,29,31,34,36,60,38,41,44
 3 47,50,53,56,60,64,68,75,72,77,81,86,92,97,103,109,115,122,95,129,136,144
 4 152,161,170,179,189,199,209,119,220,232,244,257,270,283,297,312,327,343
 5 151,360,377,394,413,432,451,472,493,515,537,190,560,584,609,635,661,688
 6 716,744,774,804,239,835,866,899,932,966,1001,1037,1074,1111,1149,301,1188
 7 1227,1268,1110,1188,1271,1353,1430,1502,1569,379,1633,1699,1766,1829,1886
 8 1935,1981,2025,2066,2100,477,2132,2169,2212,2260,2306,2346,2384,2419,2452
 9 2481,601,2507,2529,2548,2568,2599,2648,2709,2766,2804,2822,756,2829,2844
 10 2877,2929,2982,3018,3030,3036,3061,3110,952,3165,3208,3236,3263,3299
 11 3340,3382,3421,3456,3486,1199,3510,3532,3558,3593,3633,3676,3721,3772
 12 3825,3875,1509,3916,3948,3967,3965,3934,3881,3814,3737,3644,3523,1900
 13 3368,3189,3002,2824,2658,2495,2328,2154,1975,1785,2392,1582,1378,1197
 14 1059,962,883,801,704,600,504,3012,434,397,378,348,292,219,159,133,137
 15 149,3791,147,127,101,82,74,71,65,52,36,25,4773,23,32,46,55,51,36,17,5,0
 16 0,6009,0,0,0,0,0,0,0,0,0,0,7565,0,0,0,0,0,0,0,0,0,9523,0,0,0,0,0,0,0,0
 17 0,0,11989,0,0,0,0,0,0,0,0,0,0,15093,0,0,0,0,0,0,0,0,0,286339,30
GET E14U@D
 1 239,0,0,0,0,0,2,6,13,20,24,301,26,27,27,28,30,32,35,37,39,41,379,43,45,47
 2 48,50,51,52,54,55,57,477,58,60,62,63,64,65,67,69,71,73,601,75,77,78,80,82
 3 85,87,89,91,93,756,96,99,103,106,110,114,117,121,124,127,952,130,135,140
 4 146,152,158,163,168,176,186,1199,196,206,215,223,233,247,263,283,306,334
 5 1509,369,411,459,512,572,641,722,813,915,1023,1900,1137,1258,1385,1518
 6 1653,1792,1937,2090,2250,2408,2392,2555,2689,2813,2934,3055,3177,3297
 7 3410,3512,3599,3012,3668,3723,3771,3817,3861,3899,3931,3954,3966,3967
 8 3791,3958,3941,3918,3886,3851,3816,3785,3750,3692,3605,4773,3497,3398
 9 3327,3283,3240,3181,3101,3013,2928,2855,6009,2791,2724,2638,2528,2396
 10 2255,2121,2012,1928,1861,7565,1794,1719,1632,1533,1419,1296,1188,1103
 11 1035,977,9523,925,861,791,731,694,648,572,471,387,327,11989,296,288,247
 12 182,159,171,183,174,163,150,15093,134,115,92,66,0,0,0,0,0,0,216820,19
GET CLTR2
160 DATA 14, 1.25, 0.39, 14, 5.7
170 DATA 300, 14334, 1454, 776.7, 977.9
180 FILE E140F
190 FILE E14U
195 FILE RUN14
197 B7=CMD("%EMPTY@NC RUN14@D")
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LISTING OF FILE R5                    04:07 P.M.  FEB. 24, 1977    ID=RALU

GET E150F@D
 1 14,0,0,6,3,3,3,3,3,4,4,18,4,4,5,5,5,6,6,7,7,8,24,8,9,9,10,10,11,11,12,13
 2 14,30,14,15,16,17,18,19,20,21,23,24,37,25,27,28,29,31,33,34,36,38,40,48
 3 42,44,47,49,52,54,57,60,63,66,59,69,72,76,79,83,87,91,95,100,104,75,109
 4 114,119,124,130,136,142,148,154,161,95,168,175,182,190,198,206,214,223
 5 232,241,119,251,261,271,282,293,304,315,327,340,352,151,365,379,393,407
 6 421,436,452,467,484,500,190,517,535,553,571,590,609,629,649,670,691,239
 7 712,734,757,780,804,828,852,877,902,928,301,955,982,1009,995,995,1006
 8 1054,1082,1120,1173,379,1233,1289,1340,1385,1429,1474,1519,1563,1606,1648
 9 477,1688,1720,1741,1750,1754,1761,1778,1806,1839,1873,601,1900,1921,1940
 10 1959,1980,2004,2031,2059,2080,2092,756,2100,2117,2150,2188,2218,2237
 11 2255,2284,2324,2360,952,2378,2370,2349,2339,2362,2416,2479,2528,2556
 12 2570,1199,2580,2588,2605,2651,2741,2864,2984,3065,3102,3115,1509,3136
 13 3179,3236,3290,3333,3374,3423,3474,3512,3529,1900,3535,3550,3578,3607
 14 3631,3658,3702,3761,3813,3839,2392,3839,3830,3824,3818,3811,3805,3802
 15 3803,3808,3825,3012,3863,3916,3961,3968,3923,3829,3701,3559,3435,3353
 16 3791,3314,3287,3239,3162,3085,3041,3027,3001,2916,2771,4773,2609,2483
 17 2422,2418,2189,2178,2114,1999,1870,1761,6009,1683,1614,1534,1437,1339
 18 1247,1157,1060,961,866,7564,785,717,649,576,498,423,352,285,225,178,9523
 19 150,135,116,86,52,29,22,14,9,10,11989,11,12,13,14,16,8,9,9,20,10,15093,0
 20 14,15,C,C,C,0,C,0,0,381432,31.3
GET E15U@D
 1 239,0,0,0,0,10,34,73,116,151,173,301,185,195,206,221,237,254,271,288,303
 2 317,379,332,349,366,382,397,408,417,424,431,442,477,456,474,492,507,517
 3 521,520,516,514,517,601,527,544,560,572,579,585,595,607,617,621,756,618
 4 614,616,632,662,698,724,733,729,728,952,740,761,774,769,750,736,746,785
 5 836,880,1199,905,916,927,945,970,996,1020,1041,1063,1089,1509,1116,1141
 6 1161,1181,1209,1246,1288,1323,1348,1366,1900,1388,1418,1455,1491,1521
 7 1544,1566,1597,1643,1700,2392,1754,1791,1812,1832,1866,1918,1973,2021
 8 2058,2094,3012,2137,2187,2238,2278,2301,2311,2319,2340,2374,2413,3791
 9 2447,2481,2529,2600,2678,2727,2718,2658,2591,2567,4773,2600,2653,2672
 10 2645,2607,2603,2909,2978,3039,3081,6009,3114,3153,3209,3284,3358,3408
 11 3439,3471,3526,3604,7565,3692,3787,3899,4031,4167,4275,4337,4363,4359
 12 4322,9523,4231,4089,3910,3698,3456,3183,2899,2626,2372,2107,11989,1801
 13 1509,1248,1070,955,862,752,621,503,404,15093,329,287,213,151,53,0,0,0,0
 14 0,283855,19
GET CLTR2
160 DATA 15, 0.75, C.16, 1.0, 21.3
170 DATA 310, 14710; 920.6, 7077, 628.3
180 FILE E150F
190 FILE E15U
195 FILE RLN15
197 B7=CMD("%EMPTY@NC RUN15@D")
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LISTING OF FILE R6                      04:07 P.M.  FEB. 24, 1977     ID=RALU

GET E16CFãD
 1 37,0,1,1,1,1,1,1,1,2,2,47,2,2,3,3,3,4,4,5,5,6,60,7,7,8,9,10,11,12,13,14
 2 16,75,17,19,20,22,24,27,29,32,34,37,95,41,44,48,52,56,60,65,71,76,82,119
 3 88,95,102,110,118,127,136,146,156,167,151,179,191,204,218,232,247,263,280
 4 298,317,190,336,357,378,401,424,449,474,501,529,558,239,588,620,652,686
 5 721,757,795,833,874,915,301,957,1001,1046,1093,1140,1189,1239,1290,1343
 6 1396,379,1451,1506,1719,1715,1718,1738,1773,1814,1846,1861,477,1866,1876
 7 1900,1940,1987,2029,2063,2093,2129,2178,601,2233,2286,2327,2358,2385,2415
 8 2455,2507,2570,2635,756,2689,2727,2759,2802,2864,2931,2985,3022,3057,3103
 9 952,3160,3212,3247,3266,3285,3323,3381,3444,3504,3579,1199,3690,3825,3934
 10 3967,3916,3814,3709,3626,3559,3472,1509,3323,3100,2832,2571,2360,2207
 11 2091,1991,1912,1877,1900,1903,1978,2058,2097,2072,1995,1898,1818,1776
 12 1772,2392,1788,1802,1814,1840,1885,1934,1966,1978,1992,2019,3012,2048
 13 2063,2056,2030,1989,1941,1909,1910,1928,1927,3791,1889,1831,1791,1783
 14 1793,1796,1776,1735,1682,1631,4773,1600,1598,1613,1616,1586,1521,1439
 15 1360,1298,1249,6009,1203,1152,1092,1034,984,947,910,870,826,779,7565,731
 16 682,621,553,492,436,380,333,298,255,9523,212,179,143,121,100,85,80,61,26
 17 0,11989,0,0,0,0,0,0,0,0,0,0,15093,0,0,0,0,0,0,0,0,0,0,320079,27
GET E16UãD
 1 151,0,0,0,0,0,0,0,0,0,1,190,1,1,1,1,1,1,1,2,2,2,239,2,3,3,3,4,4,4,5,5,501
 2 301,499,524,456,524,520,515,511,507,505,508,379,512,518,526,535,544,555
 3 564,574,584,592,477,597,600,606,619,641,665,686,699,707,711,601,713,714
 4 724,743,768,793,812,827,841,857,756,874,885,898,912,931,948,959,970,988
 5 1017,952,1047,1064,1067,1068,1076,1090,1096,1083,1054,1139,1199,1134,1164
 6 1222,1159,1208,1241,1261,1275,1285,1297,1509,1311,1331,1354,1380,1401
 7 1422,1446,1476,1511,1544,1900,1575,1600,1625,1649,1679,1714,1748,1779
 8 1806,1832,2392,1860,1885,1903,1916,1932,1961,2013,2080,2150,2203,3012
 9 2225,2220,2210,2215,2243,2284,2332,2385,2445,2504,3791,2555,2590,2607
 10 2613,2623,2653,2708,2776,2838,2883,4773,2904,2891,3119,3023,3114,3171
 11 3163,3159,3181,3232,6009,3300,3369,3416,3440,3448,3453,3461,3461,3459
 12 3469,7565,3503,3569,3669,3785,3883,3946,3967,3965,3949,3919,9523,3839
 13 3710,3552,3403,3269,3144,3010,2854,2645,2347,11989,1992,1679,1462,1346
 14 1291,1176,963,715,567,547,15093,521,418,299,280,300,276,147,52,0,0
 15 308043,21
GET CLTR2
160 DATA 16, 1.25, 0.18, 0.6, 28.5,
170 DATA 270, 19942, 1396.2, 9605, 913
180 FILE E16CF
190 FILE E16U
195 FILE RLN16
197 B7=CMD("%EMPTYãNC RUN16@D")
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LISTING OF FILE R7 04:07 P.M. FEB. 24, 1977 ID=RALU

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GET E17U@D
 1 37,0,0,0,0,0,1,1,1,1,1,47,1,1,1,1,1,2,2,2,2,2,60,3,3,3,3,3,4,4,4,5,5,75,5
 2 6,6,7,7,8,8,9,9,10,95,11,11,12,13,14,15,15,16,17,19,119,20,21,22,24,25,27
 3 28,30,32,33,151,35,37,39,42,44,47,49,52,55,58,190,61,64,68,71,75,79,83,87
 4 92,96,239,101,106,111,117,123,129,135,141,148,155,301,162,170,178,213,229
 5 246,263,280,296,313,379,329,342,354,365,377,390,403,415,425,437,477,451
 6 467,482,492,498,504,514,526,539,551,601,563,575,588,601,615,628,640,648
 7 656,667,756,682,700,718,734,750,767,783,797,808,821,952,840,867,895,915
 8 927,937,955,984,1017,1043,1199,1057,1063,1071,1089,1116,1148,1181,1215
 9 1249,1282,1509,1312,1339,1369,1405,1446,1486,1523,1558,1593,1629,1900
 10 1668,1707,1746,1785,1824,1861,1898,1938,1991,2055,2392,2120,2167,2192
 11 2204,2222,2255,2300,2353,2414,2484,3012,2559,2630,2682,2713,2731,2749
 12 2784,2837,2895,2941,3791,2967,2980,2993,3007,3022,3042,3081,3147,3240
 13 3350,4773,3465,3558,3591,3545,3441,3339,3299,3340,3438,3541,6009,3602
 14 3614,3617,3659,3753,3867,3949,3968,3933,3872,7565,3824,3791,3757,3685
 15 3563,3393,3193,2981,2774,2582,9523,2402,2214,2001,1774,1560,1372,1229
 16 1088,951,844,11989,740,616,485,375,309,265,231,209,183,174,15093,140,100
 17 80,57,30,0,0,0,0,0
GET E17OF@D
 1 30,0,0,0,0,0,1,1,1,1,1,37,1,1,1,2,2,2,2,2,3,3,47,3,3,4,4,4,5,5,6,6,7,60,7
 2 8,9,9,10,11,12,13,14,15,75,16,17,18,19,21,22,24,26,27,29,95,31,34,36,38
 3 41,44,46,49,53,56,119,60,63,67,72,76,81,85,91,96,102,151,108,114,121,127
 4 135,142,150,159,167,176,190,186,196,206,217,228,240,252,265,278,292,239
 5 307,322,337,353,370,387,405,512,535,433,301,477,504,535,576,624,674,721
 6 766,807,849,379,889,932,976,1024,1072,1121,1171,1218,1260,1300,477,1344
 7 1392,1444,1493,1534,1565,1587,1603,1616,1629,601,1641,1655,1671,1676,1666
 8 1646,1627,1625,1640,1659,756,1670,1675,1679,1696,1721,1750,1774,1788,1794
 9 1795,952,1805,1833,1882,1937,1979,2009,2031,2058,2082,2091,1199,2091,2128
 10 2263,2286,2337,2560,2690,2734,2742,2761,1509,2808,2876,2953,3027,3086
 11 3123,3141,3153,3172,3203,1900,3248,3307,3378,3454,3518,3558,3573,3585
 12 3615,3666,2392,3720,3753,3758,3755,3771,3818,3884,3941,3968,3958,3012
 13 3923,3876,3830,3796,3788,3813,3862,3903,3899,3838,3791,3733,3613,3500
 14 3413,3369,3371,3389,3369,3279,3142,4773,3001,2874,2747,2613,2492,2408
 15 2348,2274,2160,2016,6009,1864,1717,1581,1454,1328,1205,1072,943,825,737
 16 7565,672,611,542,468,393,338,297,265,233,195,9523,163,154,157,161,146
 17 138,148,148,125,109,11989,104,111,134,144,120,92,59,42,68,72,15093,78
 18 111,89,32,0,0,0,0,0,0,341043,28
GET CLTR2
160 DATA 17, 0.75, 0.28, 6, 11.5
170 DATA 280, 17543, 1894, 8283, 1350
180 FILE E17OF
190 FILE E17U
195 FILE RUN17
197 B7=CMD("%EMPTY@NC RUN17@D")
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LISTING OF FILE R8 04:07 P.M. FEB. 24, 1977 ID=RALU

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GET  RUN18@D
GET E18OF@D
 1 15,30,31,32,34,35,36,38,40,41,43,19,45,47,49,51,53,55,57,59,62,64,23,67
 2 69,72,75,78,80,84,87,90,93,30,97,101,104,108,112,116,120,125,129,134,37
 3 139,143,149,154,159,165,170,176,182,188,47,195,201,208,215,222,229,236
 4 244,252,260,60,268,277,285,294,303,313,322,332,342,352,75,363,374,385,396
 5 407,419,431,444,456,469,95,482,496,509,523,538,552,567,582,598,613,119
 6 629,646,662,679,697,714,732,750,769,788,151,807,826,846,866,887,907,928
 7 950,972,994,190,1016,1038,1061,1085,1108,1132,1156,1181,1206,1231,239
 8 1256,1282,1308,1334,1361,1387,1414,1442,1469,1497,301,1525,1554,1582,1611
 9 1640,1670,1699,1729,1759,1789,379,1772,1935,1906,1900,1917,1953,1998,2040
 10 2070,2087,477,2096,2106,2127,2161,2204,2240,2248,2217,2154,2089,601,2059
 11 2084,2142,2170,2243,2235,2229,2275,2376,2501,756,2598,2641,2636,2597
 12 2543,2495,2479,2517,2609,2734,952,2850,2922,2942,2921,2886,2865,2877
 13 2929,3014,3097,1199,3137,3316,3324,3245,3144,3064,2985,3199,3119,3057
 14 1509,3046,3069,3093,3096,3082,3073,3095,3156,3249,3349,1900,3430,3471
 15 3473,3461,3464,3498,3560,3636,3716,3791,2392,3848,3870,3849,3807,3780
 16 3793,3840,3887,3908,3906,3012,3904,3920,3946,3961,3950,3920,3887,3862
 17 3832,3766,3791,3644,3480,3327,3236,3224,3258,3281,3249,3152,3009,4773
 18 2863,2743,2642,2515,2318,2056,1795,1763,1656,1619,6009,1596,1554,1490
 19 1418,1351,1286,1215,1127,1022,919,7565,834,776,724,663,589,515,450,391
 20 327,258,9523,193,137,91,54,35,27,20,9,2,0,11989,0,0,0,0,0,0,0,0,0
 21 15093,0,0,0,0,0,0,0,0,0,445416,31
GET E18U@D
 1 47,0,0,0,0,0,0,0,0,0,0,60,0,1,1,1,1,1,1,1,1,1,75,1,2,2,2,2,2,3,3,3,3,95,4
 2 4,4,4,5,5,6,6,6,7,119,7,8,9,9,10,10,11,12,13,14,151,14,15,16,18,19,20,21
 3 22,24,25,190,27,29,30,32,34,36,38,40,43,45,239,48,51,53,56,60,63,66,70
 4 130,136,301,143,149,177,250,247,245,245,246,249,252,379,255,260,263,267
 5 270,273,277,281,285,287,477,289,294,301,307,315,320,326,334,342,349,601
 6 355,360,366,375,388,399,410,418,424,426,756,425,425,431,443,460,477,492
 7 504,512,518,952,526,540,556,571,580,586,597,615,632,637,1199,631,666,640
 8 665,691,706,716,728,745,763,1509,778,794,812,835,860,884,902,916,929,944
 9 1900,964,988,1016,1042,1063,1079,1096,1120,1152,1185,2392,1211,1225,1231
 10 1241,1265,1307,1358,1406,1438,1452,3012,1455,1462,1475,1496,1522,1550
 11 1577,1603,1633,1669,3791,1708,1740,1754,1749,1738,1739,1764,1805,1837
 12 1843,4773,1823,1994,1978,1986,2007,2032,2059,2089,2119,2147,6009,2170
 13 2189,2201,2207,2220,2245,2285,2332,2381,2437,7564,2519,2634,2782,2947
 14 3115,3287,3467,3648,3809,3926,9523,3968,3925,3807,3639,3442,3224,2966
 15 2674,2367,2102,11989,1895,1699,1478,1232,990,825,739,696,642,577,15093
 16 523,484,436,351,219,134,107,38,0,0,216790,25.8
GET CLTR2
160 DATA 18, 1.25, 0.26, 5.0, 11.8
170 DATA 310, 22445, 1176.5, 10914, 844.8
180 FILE E18OF
190 FILE E18U
195 FILE RUN18
197 B7=CMD("%EMPTY@NC RUN18@D")
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LISTING OF FILE R9                    04:07 P.M.  FEB. 24, 1977    ID=RALU

GET  E190F@D
 1 19,0,0,0,0,0,0,1,1,1,1,23,1,1,1,1,1,2,2,2,2,2,30,2,3,3,3,3,4,4,4,4,5,37,5
 2 5,6,6,7,7,8,8,9,10,47,10,11,12,12,13,14,15,16,17,18,60,19,20,22,23,24,26
 3 27,29,31,33,75,35,37,39,41,43,46,48,51,54,57,95,60,63,67,70,74,78,82,86
 4 91,95,119,100,105,110,116,122,128,134,140,147,154,151,162,169,177,185,194
 5 203,212,222,231,242,190,252,263,275,286,299,311,324,338,351,366,239,381
 6 396,412,428,444,462,479,497,516,535,301,555,575,596,618,640,662,685,709
 7 733,758,379,783,809,986,1000,1013,1025,1039,1054,1070,1084,477,1097,1111
 8 1126,1142,1159,1178,1201,1225,1248,1269,601,1290,1317,1353,1392,1426,1451
 9 1466,1478,1492,1512,756,1539,1574,1613,1653,1690,1724,1754,1781,1800,1813
 10 952,1829,1857,1902,1959,2020,2083,2138,2171,2170,2153,1199,2154,2195
 11 2259,2308,2324,2323,2331,2360,2399,2432,1509,2459,2490,2535,2592,2644
 12 2677,2693,2714,2762,2843,1900,2935,3015,3075,3122,3165,3209,3255,3309
 13 3380,3467,2392,3561,3637,3678,3685,3692,3742,3841,3940,3967,3893,3012
 14 3755,3638,3603,3654,3742,3818,3865,3890,3893,3864,3791,3807,3752,3732
 15 3742,3734,3648,3455,3189,2923,2714,4773,2570,2458,2362,2296,2271,2171
 16 2119,1866,1679,1462,6009,1249,1056,888,745,621,515,433,370,316,264,7565
 17 217,175,145,120,105,102,99,99,94,94,9523,79,54,41,35,37,40,54,58,37,40
 18 11989,57,62,33,35,75,81,65,46,50,54,15093,57,61,65,71,75,40,43,0,0,0
 19 314038,30
GET  E19U@D
 1 75,0,0,0,0,0,0,1,1,1,1,95,1,1,1,1,2,2,2,2,2,3,119,3,3,3,4,4,5,5,5,6,6,151
 2 7,8,8,9,10,10,11,12,13,14,190,15,17,18,19,21,22,24,25,27,29,239,31,34,36
 3 38,41,44,47,50,53,57,301,61,64,69,73,78,83,88,93,99,105,379,111,116,170
 4 173,177,180,181,182,185,189,477,192,196,201,203,207,210,216,220,224,225
 5 601,227,231,237,244,251,255,258,259,260,261,756,264,270,278,283,283,282
 6 284,295,311,328,952,339,343,341,340,341,348,357,367,379,388,1199,395,392
 7 379,392,449,419,445,435,433,436,1509,442,452,467,484,501,516,529,543,560
 8 581,1900,603,619,629,637,651,676,706,734,755,770,2392,786,804,825,847,871
 9 901,936,974,1014,1055,3012,1099,1148,1201,1256,1307,1349,1383,1415,1449
 10 1490,3791,1541,1608,1693,1783,1864,1936,2005,2074,2141,2210,4773,2299
 11 2421,2567,2712,2849,2992,3154,3330,3496,3634,6009,3747,3843,3920,3967
 12 3965,3908,3807,3685,3560,3434,7565,3304,3170,3034,2898,2765,2623,2478
 13 2317,2136,1948,9523,1768,1600,1453,1332,1240,1155,1044,905,770,663,11989
 14 592,527,470,426,372,296,193,133,126,118,15093,109,77,62,89,95,77,27,0,0
 15 0,180965,24
GET CLTR2
160 DATA 19, 1, 0.35, 1.9, 17.5
170 DATA  300, 16168, 1871.7, 4341.2, 1121.7
180 FILE E190F
190 FILE E19U
195 FILE RUN19
197 B7=CMD("%EMPTY@NC RUN19@C")
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LISTING OF FILE R10 04:07 P.M. FEB. 24, 1977 ID=RALU

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GET E210F@D
 1 19,0,0,0,0,0,0,0,1,1,1,23,1,1,1,1,1,2,2,2,2,2,30,3,3,3,3,4,4,4,5,5,5,37,6
 2 6,7,7,8,9,9,10,11,12,47,12,13,14,15,16,18,19,20,21,23,60,25,26,28,30,32
 3 34,36,38,41,43,75,46,49,52,55,59,62,66,70,74,79,95,83,88,93,99,104,110
 4 116,123,129,136,119,144,151,159,168,177,186,195,205,216,226,151,238,249
 5 261,274,287,301,315,329,345,360,190,377,394,411,429,448,467,487,508,529
 6 551,239,573,596,620,645,670,696,723,750,778,807,301,837,867,898,881,923
 7 966,1011,1053,1092,1130,379,1171,1219,1274,1330,1378,1417,1449,1478,1506
 8 1531,477,1552,1565,1572,1581,1599,1630,1673,1718,1751,1768,601,1774,1783
 9 1803,1826,1838,1837,1840,1868,1921,1982,756,2027,2052,2064,2074,2084,2098
 10 2118,2145,2169,2184,952,2192,2201,2213,2217,2209,2203,2227,2302,2413
 11 2520,1199,2589,2622,2650,2704,2783,2865,2931,2981,3031,3088,1509,3149
 12 3204,3247,3279,3312,3361,3436,3533,3632,3709,1900,3747,3750,3746,3765
 13 3820,3896,3957,3967,3913,3804,2392,3673,3551,3457,3369,3239,3023,2724
 14 2390,2080,1830,3012,1636,1476,1324,1168,1010,864,749,669,612,558,3791
 15 500,439,385,338,300,276,266,259,238,199,4773,152,118,107,110,113,99,99
 16 74,81,81,6009,75,68,61,55,50,43,36,32,29,28,7565,28,25,20,18,18,18,17,12
 17 9,9,9523,9,10,9,9,14,14,13,8,6,6,11989,6,7,2,3,3,4,4,5,6,6,15093,0,0,0,0
 18 0,0,0,0,0,0,265490,30
GET E21U@D
 1 239,0,0,0,0,0,3,7,12,18,21,301,23,24,26,28,30,32,34,36,38,40,379,42,44,46
 2 48,49,51,52,53,55,56,477,58,59,61,62,63,64,66,68,70,71,601,72,73,74,75,76
 3 78,80,82,85,87,756,89,91,93,95,97,100,102,105,108,110,952,112,114,117,121
 4 125,129,133,137,141,145,1199,148,152,157,163,170,177,185,192,200,209,1509
 5 219,229,240,250,261,274,291,310,332,356,1900,382,411,445,485,534,593,665
 6 753,858,981,2392,1119,1273,1441,1621,1813,2012,2214,2413,2606,2793,3012
 7 2974,3148,3313,3459,3580,3673,3744,3798,3838,3867,3791,3892,3919,3947
 8 3967,3967,3944,3906,3855,3795,3731,4773,3680,3654,3640,3609,3542,3445
 9 3338,3237,3157,3097,6009,3046,2980,2880,2749,2622,2518,2436,2346,2226
 10 2085,7565,1961,1879,1839,1814,1771,1683,1568,1433,1314,1215,9523,1143
 11 1077,996,907,817,720,615,502,383,282,11989,233,250,284,304,271,213,145
 12 89,71,76,15093,82,88,62,33,0,0,0,0,0,0
GET CLTR2
160 DATA 21, 0.75, 0.16, 1.6, 24.8
170 DATA 300, 15337, 1157.4, 918.3, 727.4
180 FILE E210F
190 FILE E21U
195 FILE RUN21
197 B7=CMD("%EMPTY@NC RUN21@D")
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LISTING OF FILE R11 04:07 P.M. FEB. 24, 1977 ID=RALU

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GET E22OF@D
 1 19,0,0,0,0,0,0,0,1,1,1,23,1,1,1,1,1,2,2,2,2,2,30,2,3,3,3,4,4,4,4,5,5,37,6
 2 6,7,7,8,8,9,10,10,11,47,12,13,14,15,16,17,18,19,20,22,60,23,25,27,28,30
 3 32,34,36,39,41,75,44,46,49,52,55,59,62,66,70,74,95,78,82,87,92,97,103,108
 4 114,120,127,119,134,141,148,156,164,172,181,190,200,210,151,220,231,242
 5 253,265,278,291,304,318,333,190,348,363,379,396,413,431,449,468,488,508
 6 239,529,550,572,595,618,642,667,692,718,745,301,772,800,829,744,802,857
 7 911,966,1023,1077,379,1124,1168,1213,1261,1305,1341,1369,1396,1429,1465
 8 477,1497,1518,1533,1554,1589,1637,1687,1732,1771,1802,601,1823,1832,1835
 9 1838,1845,1855,1865,1882,1910,1945,756,1979,2010,2044,2086,2131,2170,2202
 10 2232,2267,2304,952,2332,2339,2327,2306,2299,2318,2359,2402,2432,2446
 11 1199,2460,2489,2535,2593,2655,2717,2776,2832,2888,2951,1509,3025,3108
 12 3193,3270,3338,3400,3459,3518,3579,3639,1900,3691,3724,3732,3723,3722
 13 3747,3801,3868,3926,3960,2392,3967,3955,3933,3914,3904,3901,3896,3885
 14 3861,3806,3012,3696,3531,3345,3181,3052,2926,2758,2533,2284,2056,3791
 15 1873,1717,1546,1336,1109,914,781,700,640,575,4773,503,433,377,339,319
 16 310,304,226,201,178,6009,162,150,151,147,142,135,128,122,117,113,7565
 17 108,103,99,99,95,90,83,80,78,78,9523,72,64,56,45,38,38,36,33,27,19,11989
 18 18,19,18,10,5,0,1,1,2,2,15093,0,0,0,0,0,0,0,0,0,302860,30
GET E22U@D
 1 239,0,0,0,0,0,2,7,12,17,20,301,22,24,25,27,29,31,33,35,37,39,379,41,43,45
 2 46,48,49,51,52,53,54,477,56,57,58,60,61,62,64,65,65,66,601,67,68,70,72,74
 3 75,77,78,80,81,756,83,84,86,88,91,93,95,97,99,101,952,104,107,110,111,113
 4 114,116,119,124,129,1199,134,138,141,145,150,155,162,168,174,179,1509,185
 5 192,200,208,216,224,233,244,258,273,1900,288,303,318,333,349,365,384,406
 6 432,461,2392,492,524,560,604,657,718,785,857,938,1034,3012,1145,1271,1415
 7 1576,1756,1952,2158,2372,2595,2831,3791,3074,3307,3513,3676,3795,3874
 8 3921,3943,3952,3959,4773,3967,3966,3941,3885,3806,3710,3604,3492,3385
 9 3301,6009,3251,3213,3159,3056,2901,2726,2570,2458,2388,2330,7565,2262
 10 2172,2066,1954,1829,1691,1549,1428,1335,1279,9523,1214,1119,1005,893,796
 11 728,657,572,495,442,11989,406,362,295,216,160,152,163,131,70,25,15093,27
 12 28,31,0,0,0,0,0,0,0
GET CLTR2
160 DATA 22, 1.25, 0.16, 1, 23.4
170 DATA 300, 15044, 1126.7, 1072.5, 621
180 FILE E22OF
190 FILE E22U
195 FILE RUN22
197 B7=CMD("%EMPTY@NC RUN22@D")
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LISTING OF FILE R12 04:07 P.M. FEB. 24, 1977 ID=RALU

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GET E230F@D
 1 30,0,0,0,0,1,1,1,1,1,1,37,1,2,2,2,3,3,3,4,4,4,47,5,6,6,7,7,8,9,10,11,12
 2 60,13,15,16,18,19,21,23,25,27,30,75,32,35,38,41,45,49,53,57,62,67,95,72
 3 78,84,90,97,104,112,120,129,138,119,148,159,170,182,194,207,221,236,251
 4 267,151,284,302,321,341,361,383,405,429,454,480,190,506,534,564,594,625
 5 658,692,727,764,801,239,840,880,922,964,1008,1054,1100,1148,1197,1247,301
 6 1298,1350,1404,1395,1495,1582,1652,1712,1770,1834,379,1902,1974,2047,2116
 7 2181,2242,2303,2366,2426,2477,477,2510,2530,2550,2588,2653,2738,2822,2886
 8 2921,2936,601,2950,2980,3027,3082,3137,3189,3236,3279,3317,3353,756,3389
 9 3426,3464,3500,3537,3582,3645,3730,3820,3895,952,3939,3953,3941,3913,3912
 10 3935,3968,3963,3903,3827,1199,3791,3810,3850,3869,3859,3833,3801,3756
 11 3684,3574,1509,3423,3234,3017,2790,2567,2353,2146,1943,1747,1568,1900
 12 1413,1287,1185,1101,1024,949,872,797,732,687,2392,661,645,627,602,572
 13 546,527,512,495,472,3012,446,425,415,415,418,416,401,371,331,292,3791
 14 260,239,226,220,217,211,198,179,161,146,4773,127,104,87,83,92,102,102,90
 15 72,56,6009,49,48,46,42,41,39,35,34,33,31,7565,29,28,25,24,23,22,16,14,11
 16 12,9523,17,14,10,5,5,6,6,7,0,0,11989,0,0,0,0,0,0,0,0,0,15093,0,0,0,0
 17 0,0,0,0,0,0
GET E23U@D
 1 239,0,0,0,0,1,6,13,22,28,30,301,30,30,31,33,36,39,41,44,47,49,379,52,55
 2 57,60,62,65,67,69,71,74,477,76,80,83,85,88,90,92,95,99,102,601,105,107
 3 110,113,117,121,126,131,136,141,756,145,150,155,160,166,172,179,186,194
 4 204,952,214,224,235,246,260,277,296,316,336,358,1199,383,414,451,496,550
 5 615,693,784,890,1010,1509,1145,1296,1457,1622,1787,1952,2120,2286,2447
 6 2598,1900,2737,2865,2985,3099,3209,3320,3429,3531,3618,3681,2392,3718
 7 3733,3747,3774,3816,3853,3867,3861,3859,3887,3012,3935,3967,3950,3882
 8 3800,3744,3728,3733,3725,3689,3791,3645,3616,3601,3569,3498,3403,3316
 9 3259,3216,3164,4773,3097,3023,2949,2870,2784,2695,2616,2551,2489,2415
 10 6009,2330,2249,2188,2146,2109,2052,1957,1838,1722,1625,7565,1549,1482
 11 1419,1359,1291,1206,1111,1032,973,934,9523,885,818,743,691,660,612,545
 12 465,413,386,11989,353,300,237,209,208,189,129,98,127,136,15093,97,52,27
 13 29,0,0,0,0,0,0
GET CLTR2
160 DATA 23, 0.75, 0.25, 11.4,11.6
170 DATA 280, 15648, 1489, 637.9, 966.8
180 FILE E230F
190 FILE E23U
195 FILE RUN23
197 B7=CMD("%EMPTY@NC RUN23@D")
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LISTING OF FILE R13   04:07 P.M. FEB. 24, 1977   ID=RALU

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GET E24CF@C
 1 30,0,0,1,1,1,1,1,1,1,1,37,2,2,2,2,2,3,3,3,3,4,47,4,5,5,5,6,6,7,8,8,9,60
 2 10,10,11,12,13,14,15,17,18,19,75,21,22,24,26,28,30,32,34,36,39,95,42,45
 3 48,51,54,58,62,66,70,75,119,79,84,90,95,101,107,114,121,128,136,151,144
 4 152,161,170,180,190,200,211,223,235,190,247,260,274,288,303,319,335,351
 5 369,387,239,406,425,445,466,488,510,533,557,582,607,301,633,660,688,672
 6 715,762,812,863,912,960,379,1006,1051,1094,1133,1170,1205,1240,1272,1300
 7 1326,477,1357,1394,1432,1467,1495,1519,1543,1572,1605,1640,601,1670,1696
 8 1724,1758,1792,1819,1838,1856,1879,1911,756,1952,2001,2051,2098,2135,2160
 9 2175,2186,2207,2251,952,2317,2392,2450,2476,2475,2476,2506,2565,2617,2626
 10 1199,2594,2565,2582,2654,2755,2859,2960,3060,3157,3242,1509,3309,3363
 11 3415,3474,3541,3612,3675,3717,3734,3744,1900,3771,3827,3897,3949,3968
 12 3961,3953,3958,3963,3941,2392,3869,3742,3565,3344,3091,2825,2566,2316
 13 2068,1817,3012,1577,1368,1196,1048,908,775,656,556,472,406,3791,359,328
 14 304,276,240,199,156,115,84,68,4773,69,77,79,67,44,20,5,0,0,0,6009,0,0
 15 0,0,0,0,0,0,0,0,7565,0,0,0,0,0,0,0,0,0,9523,0,0,0,0,0,0,0,0,0
 16 11989,0,0,0,0,0,0,0,0,0,0,15093,0,0,0,0,0,0,0,0,0
GET E24U@D
 1 239,0,0,0,0,0,1,4,7,10,12,301,13,14,15,16,17,18,19,20,22,23,379,24,25,26
 2 27,28,29,30,30,31,32,477,33,34,35,36,36,37,38,38,39,41,601,42,43,44,45,45
 3 46,47,48,49,50,756,51,52,52,54,55,57,59,61,62,64,952,65,67,70,73,75,77,78
 4 80,82,84,1199,87,91,96,101,106,112,118,124,129,135,1509,140,146,154,163
 5 174,185,195,206,219,233,1900,250,267,286,309,336,369,411,462,523,596,2392
 6 681,782,899,1032,1181,1348,1528,1714,1902,2088,3012,2270,2444,2604,2753
 7 2894,3033,3168,3294,3402,3488,3791,3554,3602,3642,3684,3736,3799,3865
 8 3921,3956,3968,4773,3959,3940,3910,3873,3829,3783,3733,3672,3596,3510
 9 6009,3426,3347,3263,3159,3038,2914,2803,2704,2605,2493,7565,2363,2224
 10 2081,1956,1862,1789,1721,1647,1554,1447,9523,1324,1194,1103,1063,1064
 11 1049,965,811,631,496,11989,435,414,406,396,382,341,243,156,83,59,15093
 12 64,34,36,0,0,0,0,0,0,0
GET CLTR2
160 DATA 24, 1.25, 0.39, 4.7, 10.5
170 DATA 280,  14333, 1231.2, 890.3, 792.6
180 FILE E240F
190 FILE E24U
195 FILE RUN24
197 B7=CMD("%EMPTY@NC RUN24@D")
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LISTING OF FILE R14 04:07 P.M. FEB. 24, 1977 ID=RALU

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GET E250F@C
 1 19,0,0,0,0,1,1,1,1,1,1,23,1,1,1,1,2,2,2,2,2,3,30,3,3,3,4,4,4,4,5,5,6,37,6
 2 6,7,7,8,8,9,10,10,11,47,12,13,14,14,15,16,17,19,20,21,60,22,24,25,27,29
 3 30,32,34,36,38,75,41,43,45,48,51,54,57,60,63,67,95,70,74,78,82,87,91,96
 4 101,107,112,119,118,124,130,137,143,150,158,165,173,182,151,190,199,208
 5 218,228,238,249,260,272,284,190,296,309,322,336,350,365,380,396,412,429
 6 239,446,463,482,500,520,539,560,581,602,625,301,647,671,694,599,645,693
 7 741,787,829,868,379,909,954,1003,1051,1094,1131,1165,1197,1230,1261,477
 8 1289,1313,1336,1359,1386,1419,1455,1491,1521,1546,601,1568,1592,1619,1644
 9 1666,1689,1719,1758,1799,1832,756,1854,1872,1900,1947,2008,2066,2104,2120
 10 2125,2137,952,2169,2223,2287,2345,2388,2416,2430,2438,2451,2483,1199
 11 2537,2605,2670,2727,2783,2848,2926,3011,3094,3165,1509,3213,3235,3241
 12 3251,3278,3320,3366,3408,3446,3483,1900,3518,3549,3571,3586,3599,3617
 13 3647,3685,3721,3747,2392,3765,3783,3801,3813,3821,3829,3839,3852,3868
 14 3891,3012,3921,3950,3968,3964,3925,3845,3739,3648,3609,3623,3791,3649
 15 3645,3600,3541,3497,3463,3413,3328,3223,3128,4773,3052,2984,2916,2843
 16 2751,2609,2403,2168,1964,1833,6009,1764,1710,1636,1532,1419,1310,1220
 17 1142,1064,976,7565,873,763,669,594,536,485,431,375,314,241,9523,177,130
 18 110,106,100,78,61,57,44,28,11989,30,21,23,24,13,14,0,0,0,0
 19 15093,0,0,0,0,0,0,0,0,0,0
GET E25U@D
 1 23,0,0,1,1,1,1,1,1,1,1,30,1,1,2,2,2,2,2,2,3,3,37,3,3,4,4,4,4,5,5,6,6,47,6
 2 7,7,8,8,9,9,10,11,11,60,12,13,14,15,15,16,17,19,20,21,75,22,23,25,26,28
 3 29,31,33,35,37,95,39,41,43,45,48,50,53,56,59,62,119,65,68,72,76,80,84,88
 4 92,97,101,151,106,112,117,122,128,134,141,147,154,161,190,168,176,184,192
 5 200,209,218,228,237,248,239,258,269,280,291,303,316,328,341,355,369,301
 6 383,398,413,397,428,459,490,519,547,572,379,595,616,639,662,686,709,730
 7 750,767,783,477,801,821,842,861,879,899,919,938,954,971,601,990,1008,1020
 8 1028,1036,1049,1067,1084,1099,1115,756,1134,1157,1179,1194,1201,1202,1204
 9 1209,1223,1247,952,1282,1319,1348,1360,1358,1352,1355,1374,1408,1448,1199
 10 1483,1507,1530,1561,1600,1641,1678,1714,1756,1804,1509,1854,1905,1956
 11 2007,2052,2087,2113,2136,2166,2210,1900,2267,2333,2398,2455,2500,2536
 12 2573,2619,2681,2757,2392,2834,2901,2952,2995,3039,3088,3133,3165,3178
 13 3184,3012,3205,3255,3333,3416,3487,3544,3590,3630,3665,3698,3791,3720
 14 3749,3739,3706,3688,3716,3780,3834,3836,3801,4773,3785,3828,3909,3967
 15 3954,3863,3738,3637,3601,3616,6009,3642,3643,3626,3606,3604,3608,3599
 16 3571,3524,3467,7565,3410,3350,3270,3180,3124,3095,3085,3059,2995,2876
 17 9523,2704,2482,2275,2102,1948,1791,1602,1428,1293,1210,11989,1108,941
 18 744,566,441,413,443,440,363,272,15093,208,178,143,51,0,0,0,0,0,0
GET CLTR2
160 DATA 25, 0.75, 0.12, 1.1, 26
170 DATA 300, 17093, 1607, 8411, 1046
180 FILE E250F
190 FILE E25U
195 FILE RUN25
197 87=CMD("%EMPTY@NC RUN25@D")
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LISTING OF FILE R15   04:07 P.M. FEB. 24, 1977   ID=RALU

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GET E260F@D
 1 19,0,1,1,1,1,1,1,1,1,1,23,2,2,2,2,2,2,3,3,3,3,30,4,4,4,5,5,5,6,6,7,7,37,8
 2 8,9,9,10,11,11,12,13,14,47,15,16,17,18,19,20,21,23,24,26,60,27,29,31,33
 3 34,36,39,41,43,46,75,48,51,54,57,60,63,67,70,74,78,95,82,87,91,96,101,106
 4 112,117,123,129,119,136,142,149,156,164,172,180,188,197,206,151,215,225
 5 235,246,257,268,280,292,304,317,190,330,344,359,373,388,404,420,437,454
 6 472,239,490,509,528,548,568,589,611,633,655,679,301,702,727,752,661,713
 7 765,814,860,903,945,379,985,1026,1067,1108,1147,1181,1210,1239,1271,1305
 8 477,1341,1373,1404,1434,1464,1494,1519,1538,1553,1568,601,1588,1617,1653
 9 1691,1727,1763,1801,1837,1864,1880,756,1888,1900,1923,1955,1988,2011,2026
 10 2046,2091,2151,952,2208,2244,2261,2277,2305,2344,2386,2422,2446,2454
 11 1199,2453,2457,2477,2517,2572,2634,2692,2741,2785,2836,1509,2900,2974
 12 3043,3095,3130,3155,3182,3219,3266,3314,1900,3357,3395,3433,3476,3526
 13 3584,3646,3700,3738,3757,2392,3768,3784,3814,3853,3885,3896,3891,3888
 14 3904,3937,3012,3964,3968,3944,3906,3867,3839,3831,3847,3876,3906,3791
 15 3929,3946,3948,3915,3839,3734,3616,3478,3296,3070,4773,2840,2670,2592
 16 2582,2579,2533,2437,2320,2208,2102,6009,1994,1886,1792,1715,1641,1557
 17 1449,1327,1203,1087,7565,983,882,784,696,627,577,521,449,370,302,9523
 18 251,209,173,144,125,102,76,54,48,41,11989,44,35,38,27,29,15,16,36,38,20
 19 15093,22,0,0,0,0,0,0,0,0,0
GET E26U@D
 1 30,0,0,0,0,0,0,0,0,1,1,37,1,1,1,1,1,1,1,2,2,2,47,2,2,2,3,3,3,4,4,4,4,60,5
 2 5,6,6,7,7,8,8,9,10,75,10,11,12,13,14,15,16,17,18,19,95,20,22,23,25,26,28
 3 30,32,34,36,119,38,41,43,46,49,51,55,58,61,65,151,69,73,77,81,86,91,96
 4 101,107,112,190,118,125,131,138,146,153,161,169,178,187,239,196,206,216
 5 226,237,249,260,273,285,299,301,312,326,341,395,422,448,473,497,520,545
 6 379,570,597,623,647,669,687,701,714,728,749,477,773,797,815,828,837,850
 7 868,888,908,921,601,930,939,952,973,1001,1029,1054,1071,1081,1087,756
 8 1096,1111,1134,1161,1187,1212,1238,1263,1287,1303,952,1314,1331,1362,1405
 9 1445,1471,1483,1490,1500,1510,1199,1521,1539,1570,1614,1662,1705,1746
 10 1790,1840,1892,1509,1940,1985,2027,2067,2102,2135,2170,2212,2263,2319
 11 1900,2375,2425,2471,2517,2571,2635,2706,2775,2835,2888,2392,2938,2985
 12 3026,3057,3085,3123,3177,3240,3297,3340,3012,3371,3391,3400,3408,3432
 13 3481,3543,3597,3635,3675,3791,3734,3809,3880,3927,3939,3915,3867,3831
 14 3841,3896,4773,3955,3967,3918,3825,3719,3618,3531,3469,3441,3448,6009
 15 3473,3493,3491,3467,3432,3406,3393,3402,3419,3433,7565,3438,3430,3402
 16 3361,3300,3232,3174,3143,3129,3108,9523,3074,3034,2971,2862,2696,2510
 17 2341,2194,2070,1927,11989,1729,1493,1257,1086,984,931,885,786,648,556
 18 15093,496,452,370,244,98,0,0,0,0,0
GET CLTR2
160 DATA 26, 1.25, 0.15, 0.9, 24.5
170 DATA 300, 15813, 1269, 7844, 810.2
180 FILE E260F
190 FILE E26U
195 FILE RUN26
197 B7=CMD("%EMPTY@NC RUN26@D")
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LISTING OF FILE R16   04:07 P.M. FEB. 24, 1977   ID=RALU

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GET E270F@D
 1 23,0,0,0,0,0,0,0,0,1,1,30,1,1,1,1,1,1,2,2,2,2,37,2,3,3,3,3,4,4,4,5,5,47,6
 2 6,7,7,8,8,9,10,11,11,60,12,13,14,15,17,18,19,20,22,23,75,25,27,29,31,33
 3 35,37,40,43,45,95,48,52,55,58,62,66,70,74,79,84,119,89,94,100,105,112,118
 4 125,132,139,147,151,155,164,173,182,192,202,213,224,235,247,190,260,273
 5 286,300,315,330,346,362,379,397,239,415,434,454,474,495,516,539,562,429
 6 527,301,584,618,651,692,737,781,821,859,900,944,379,987,1027,1062,1093
 7 1122,1150,1180,1213,1247,1278,477,1302,1321,1339,1363,1391,1420,1447,1471
 8 1493,1513,601,1534,1557,1581,1602,1617,1625,1628,1632,1645,1670,756,1705
 9 1741,1769,1789,1803,1820,1851,1899,1958,2012,952,2044,2053,2047,2046,2062
 10 2094,2128,2147,2143,2126,1199,2116,2133,2178,2244,2315,2384,2449,2512
 11 2575,2638,1509,2701,2763,2826,2891,2956,3019,3076,3132,3191,3256,1900
 12 3329,3407,3489,3568,3638,3698,3754,3811,3869,3921,2392,3959,3967,3926
 13 3824,3680,3545,3470,3467,3498,3503,3012,3455,3378,3308,3260,3218,3176
 14 3149,3157,3187,3192,3791,3124,2986,2840,2758,2761,2805,2826,2798,2736
 15 2671,4773,2622,2598,2598,2594,2543,2422,2248,2067,1916,1799,6009,1697
 16 1592,1481,1369,1258,1148,1040,935,837,744,7565,651,568,498,427,355,297
 17 258,226,194,155,9523,136,139,135,114,81,61,46,40,43,46,11989,49,39,56,75
 18 65,52,37,40,42,45,15093,49,79,84,60,0,0,0,0,0,0
GET E27U@D
 1 75,0,0,0,0,0,0,0,1,1,1,95,1,1,1,1,2,2,2,2,2,3,119,3,3,3,4,4,5,5,6,6,7,151
 2 7,8,8,9,10,15,17,18,19,20,190,21,25,29,31,34,37,40,43,47,51,239,54,58,63
 3 69,73,76,83,90,97,102,301,109,117,125,135,142,151,162,170,182,195,379,204
 4 219,232,246,259,274,328,337,346,355,477,364,373,383,393,403,413,422,430
 5 439,450,601,461,471,478,485,494,505,517,529,541,555,756,568,579,586,592
 6 600,613,632,651,667,679,952,693,709,726,742,757,773,790,807,824,840,1199
 7 854,864,869,873,881,895,913,931,948,964,1509,983,1008,1037,1066,1093,1118
 8 1143,1171,1201,1232,1900,1263,1294,1330,1371,1415,1458,1497,1534,1572
 9 1612,2392,1655,1701,1746,1789,1825,1856,1885,1917,1959,2014,3012,2088
 10 2171,2249,2306,2344,2386,2454,2548,2642,2705,3791,2725,2720,2722,2753
 11 2809,2871,2921,2955,2974,2978,4773,2980,3000,3058,3149,3249,3332,3388
 12 3429,3467,3506,6009,3540,3568,3586,3597,3607,3623,3654,3692,3730,3768
 13 7565,3827,3903,3964,3968,3916,3837,3758,3681,3558,3383,9523,3153,2897
 14 2643,2387,2136,1893,1684,1521,1377,1258,11989,1174,1071,947,815,705,624
 15 563,509,444,411,15093,440,472,399,228,61,0,0,0,0,0
GET CLTR2
160 DATA 27,0.75,0.31,9,12
170 DATA 290, 20475, 2297.3, 9888, 1663.5
180 FILE E270F
190 FILE E27U
195 FILE RUN27
197 B7=CMD("%EMPTY@NC RUN27@D")
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LISTING OF FILE R17 04:07 P.M. FEB. 24, 1977 ID=RALU

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GET E280F@D
 1 15,0,0,0,0,0,0,0,0,1,1,19,1,1,1,1,1,1,1,1,2,2,23,2,2,2,3,3,3,3,3,4,4,30,4
 2 5,5,5,6,6,7,7,8,8,37,9,9,10,11,11,12,13,14,15,16,47,17,18,19,20,21,23,24
 3 25,27,29,60,30,32,34,36,38,40,42,45,47,50,75,53,56,59,62,65,69,72,76,80
 4 84,95,89,93,98,103,108,114,119,125,131,138,119,144,151,158,166,173,181
 5 190,198,207,217,151,226,236,247,257,268,280,292,304,316,330,190,343,357
 6 371,386,401,417,433,450,467,485,239,503,521,541,560,580,601,622,644,666
 7 689,301,713,736,761,659,707,756,805,855,904,953,379,999,1042,1081,1117
 8 1151,1185,1220,1256,1292,1324,477,1350,1371,1393,1418,1446,1472,1496,1518
 9 1543,1572,601,1604,1635,1663,1682,1693,1703,1725,1768,1826,1879,756,1909
 10 1912,1902,1901,1920,1953,1986,2007,2019,2042,952,2089,2155,2219,2260,2274
 11 2274,2278,2297,2326,2351,1199,2360,2360,2371,2412,2478,2554,2624,2689
 12 2752,2813,1509,2868,2912,2947,2978,3015,3060,3107,3147,3178,3210,1900
 13 3252,3301,3346,3376,3396,3415,3441,3480,3530,3584,2392,3631,3661,3672
 14 3671,3670,3680,3700,3718,3714,3682,3012,3640,3621,3647,3723,3826,3922
 15 3968,3936,3826,3664,3791,3495,3363,3296,3297,3336,3365,3338,3249,3122
 16 2996,4773,2874,2737,2570,2395,2270,2237,2270,2076,2057,1981,6009,1878
 17 1776,1682,1585,1480,1370,1263,1164,1071,974,7565,863,749,644,548,460,374
 18 285,214,166,141,9523,123,96,63,41,21,23,25,18,9,9,11989,21,23,25,27,14,0
 19 16,18,18,20,15093,21,23,25,0,0,0,0,0,0,0,350778,31
GET E28U@D
 1 15,0,0,0,0,0,0,0,0,0,1,19,1,1,1,1,1,1,1,1,1,1,23,2,2,2,2,2,2,2,3,3,3,30,3
 2 3,4,4,4,4,5,5,5,5,37,6,6,7,7,7,8,8,9,9,10,47,10,11,11,12,13,13,14,15,16
 3 17,60,17,18,19,20,21,22,24,25,26,27,75,29,30,32,33,35,36,38,40,42,44,95
 4 46,48,50,53,55,58,60,63,66,69,119,72,75,78,82,85,89,93,97,101,105,151,109
 5 114,118,123,128,134,139,145,150,156,190,162,169,175,182,189,196,204,211
 6 219,228,239,236,245,254,263,272,282,292,302,313,324,301,335,346,305,321
 7 339,357,381,402,421,438,379,457,478,498,512,529,545,560,577,598,618,477
 8 632,646,661,679,702,727,746,764,772,782,601,794,808,820,829,833,843,854
 9 863,866,867,756,873,886,903,917,928,934,945,965,995,1024,952,1041,1047
 10 1048,1060,1082,1107,1129,1146,1170,1201,1199,1228,1244,1253,1264,1284
 11 1310,1336,1363,1392,1421,1509,1453,1450,1506,1526,1542,1555,1574,1603
 12 1647,1698,1900,1746,1786,1818,1846,1872,1901,1939,1987,2022,2073,2392
 13 2132,2170,2205,2249,2296,2333,2353,2362,2375,2413,3012,2481,2566,2643
 14 2699,2741,2775,2811,2847,2866,2872,3791,2873,2885,2918,2968,3027,3090
 15 3155,3209,3235,3231,4773,3216,3221,3257,3299,3324,3325,3325,3348,3494
 16 3534,6009,3549,3543,3527,3521,3528,3546,3572,3612,3661,3707,7565,3745
 17 3782,3816,3839,3858,3892,3939,3968,3931,3806,9523,3586,3315,3023,2757
 18 2536,2374,2205,1999,1741,1472,11989,1242,1078,955,855,753,684,601,503
 19 388,277,15093,223,212,199,152,65,0,0,0,0,0,322547,31
GET CLTR2
160 DATA 28, 1.25, 0.3 , 5.3, 10.6
170 DATA 310, 18641, 1547, 9168.5, 1072.4
180 FILE E280F
190 FILE E28U
195 FILE RUN28
197 B7=CMD("%EMPTY@NC RUN28@D")
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LISTING OF FILE R18 04:07 P.M. FEB. 24, 1977 ID=RALU

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GET  E29OF@D
 1 19,0,0,0,0,1,1,1,1,1,1,23,1,1,1,2,2,2,2,2,2,3,30,3,3,3,4,4,4,4,5,5,6,37,6
 2 6,7,7,8,8,9,10,10,11,47,12,12,13,14,15,16,17,18,19,20,60,22,23,25,26,28
 3 29,31,33,35,37,75,39,41,43,46,48,51,54,57,60,63,95,67,70,74,78,82,86,91
 4 95,100,105,119,111,116,122,128,134,140,147,154,162,169,151,177,185,194
 5 203,212,221,231,241,252,263,190,274,286,298,311,324,337,351,365,380,395
 6 239,411,427,443,461,478,496,515,534,554,574,301,595,616,638,661,684,707
 7 731,756,781,807,379,987,1001,1015,1031,1047,1060,1073,1088,1110,1138,477
 8 1168,1196,1222,1245,1264,1282,1300,1321,1343,1363,601,1387,1413,1446,1486
 9 1527,1561,1578,1587,1605,1646,756,1704,1756,1784,1796,1818,1872,1952,2035
 10 2095,2125,952,2128,2117,2113,2136,2191,2266,2340,2401,2458,2519,1199
 11 2574,2592,2555,2602,2672,2627,2626,2650,2670,2674,1509,2667,2661,2667
 12 2687,2722,2769,2825,2881,2927,2961,1900,2990,3023,3066,3120,3183,3248
 13 3312,3368,3413,3443,2392,3460,3475,3503,3544,3585,3620,3656,3699,3738
 14 3760,3012,3773,3801,3858,3921,3961,3967,3959,3952,3939,3899,3791,3835
 15 3788,3785,3795,3739,3569,3338,3156,3080,3053,4773,2969,2779,2522,2267
 16 2046,1845,1645,1448,1261,1086,6009,919,760,621,509,416,339,269,213,172
 17 144,7565,117,92,71,53,40,39,37,30,21,17,9523,18,19,14,15,16,8,0,0,10,22
 18 11989,24,13,14,0,0,0,0,0,0,0,15093,0,0,0,0,0,0,0,0,0,322093,30
GET  E29U@D
 1 239,0,0,5,23,50,87,106,135,139,135,301,133,132,134,135,137,137,136,135
 2 135,136,379,138,142,144,147,149,150,152,153,156,158,477,161,164,168,171
 3 175,179,183,189,195,200,601,202,203,204,207,212,219,226,232,236,239,756
 4 241,243,244,247,252,260,270,279,288,293,952,295,296,298,306,320,337,349
 5 354,353,356,1199,366,383,401,414,419,445,473,480,490,498,1509,503,507,512
 6 519,527,535,542,553,569,589,1900,608,622,634,647,666,689,714,739,759,779
 7 2392,800,827,858,890,916,932,941,952,974,1008,3012,1047,1082,1109,1128
 8 1146,1170,1207,1264,1343,1441,3791,1541,1623,1681,1723,1765,1812,1855
 9 1899,1967,2085,4773,2260,2466,2673,2865,3043,3219,3404,3590,3752,3863
 10 6009,3919,3942,3956,3968,3962,3919,3838,3726,3598,3470,7565,3354,3245
 11 3130,2987,2809,2610,2424,2266,2142,2029,9523,1899,1725,1510,1286,1100
 12 963,891,828,750,658,11989,587,535,483,409,335,276,222,174,153,145,15093
 13 156,146,157,168,154,110,59,0,0,0,181241,19
GET CLTR2
160 DATA 29, 1, 0.35, 1.9, 18.2
170 DATA 300, 16509, 1867, 4401, 1279.8
180 FILE E29OF
190 FILE E29U
195 FILE RUN29
197 B7=CMD("%EMPTY@NC RUN29@D")
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LISTING OF FILE R19                          04:07 P.M.  FEB. 24, 1977    ID=RALU
GET E310F@D
 1 30,0,0,1,1,1,1,1,1,1,1,37,2,2,2,2,3,3,3,3,4,4,47,4,5,5,6,6,7,7,8,9,10,60
 2 10,11,12,13,14,15,16,18,19,21,75,22,24,26,28,30,32,34,36,39,42,95,45,48
 3 51,54,58,62,66,70,75,80,119,85,90,96,102,108,115,122,129,137,145,151,153
 4 162,172,182,192,202,214,225,238,250,190,264,278,292,307,323,339,356,374
 5 393,412,239,431,452,473,495,518,542,566,591,617,644,301,671,700,729,680
 6 731,783,833,880,928,978,379,1027,1072,1113,1152,1191,1231,1272,1312,1350
 7 1384,477,1416,1447,1480,1512,1539,1561,1582,1606,1635,1663,601,1687,1710
 8 1739,1777,1823,1868,1903,1930,1955,1985,756,2020,2055,2082,2097,2107,2127
 9 2166,2224,2286,2334,952,2357,2365,2379,2418,2487,2577,2668,2735,2756,2727
 10 1199,2678,2660,2717,2844,2993,3114,3192,3246,3303,3376,1509,3458,3535
 11 3603,3669,3733,3790,3829,3843,3842,3840,1900,3855,3889,3930,3959,3967
 12 3962,3954,3940,3901,3812,2392,3667,3487,3309,3155,3019,2875,2702,2501
 13 2288,2081,3012,1889,1707,1532,1371,1239,1140,1057,968,863,754,3791,665
 14 611,586,571,542,493,438,398,379,370,4773,361,354,360,374,371,328,250,169
 15 113,89,6009,83,81,75,66,57,50,44,39,34,28,7565,24,21,17,14,12,12,9,8,7,4
 16 9523,2,2,5,5,5,3,0,0,0,0,11989,0,0,0,0,0,0,0,0,0,15093,0,0,0,0,0,0,0,0
 17 0,0,270329,28
GET E31U@D
 1 239,0,0,0,0,0,0,2,6,10,14,301,17,19,21,22,23,24,26,28,29,31,379,32,34,35
 2 37,38,40,41,42,43,45,477,46,47,48,49,50,52,53,54,55,57,601,59,60,62,64,65
 3 66,68,69,70,71,756,73,75,78,81,83,84,86,89,92,94,952,97,99,101,104,107
 4 110,113,115,118,122,1199,127,132,138,143,150,158,166,174,182,190,1509,200
 5 211,224,238,252,267,282,301,323,351,1900,382,415,452,493,543,602,672,750
 6 836,934,2392,1046,1173,1316,1473,1643,1821,2003,2184,2363,2539,3012,2714
 7 2881,3037,3178,3307,3430,3543,3639,3710,3760,3791,3798,3836,3876,3908
 8 3927,3940,3955,3967,3954,3900,4773,3813,3733,3688,3673,3639,3541,3372
 9 3170,3000,2896,6009,2845,2802,2732,2631,2516,2403,2311,2237,2174,2101
 10 7565,1998,1874,1743,1617,1511,1421,1337,1268,1212,1149,9523,1063,944,811
 11 705,636,612,603,578,522,429,11989,321,254,256,291,275,197,126,113,97,77
 12 15093,55,89,95,68,0,0,0,0,0,0,187462,19
GET CLTR2
160 DATA 31, 0.75, 0.23, 1.5, 20
170 DATA 280, 13644, 1113, 910, 696.5
180 FILE E310F
190 FILE E31U
195 FILE RUN31
197 B7=CMD("%EMPTY@NC RUN31@C")
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LISTING OF FILE R20   04:07 P.M. FEB. 24, 1977   ID=RALU

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GET E320F@D
 1 19,0,0,0,0,0,0,0,1,1,1,23,1,1,1,1,1,1,2,2,2,2,30,2,3,3,3,3,4,4,4,5,5,37,5
 2 6,6,7,7,8,8,9,10,10,47,11,12,13,14,15,16,17,18,19,20,60,22,23,25,26,28,30
 3 32,34,36,38,75,40,43,45,48,51,54,57,61,64,68,95,72,76,80,85,89,94,99,105
 4 111,116,119,123,129,136,143,150,158,166,174,183,192,151,202,211,222,232
 5 243,255,267,279,292,305,190,319,333,348,363,379,395,412,429,447,466,239
 6 485,505,525,546,568,590,613,636,660,685,301,710,736,763,746,792,837,878
 7 913,948,983,379,1020,1056,1090,1124,1161,1200,1238,1270,1293,1309,477
 8 1325,1350,1385,1427,1467,1497,1514,1523,1535,1559,601,1593,1627,1649,1663
 9 1680,1711,1755,1799,1831,1852,756,1870,1890,1912,1932,1948,1962,1978,2003
 10 2037,2072,952,2091,2081,2050,2026,2034,2079,2136,2182,2213,2243,1199
 11 2288,2350,2423,2497,2565,2628,2690,2752,2814,2872,1509,2926,2974,3018
 12 3056,3089,3121,3153,3190,3235,3286,1900,3341,3391,3435,3476,3524,3565
 13 3651,3703,3724,3715,2392,3697,3696,3735,3813,3905,3967,3966,3900,3797
 14 3680,3012,3549,3386,3190,2986,2805,2642,2460,2224,1938,1641,3791,1374
 15 1153,972,816,678,555,450,367,313,283,4773,265,247,220,189,159,137,126
 16 123,120,111,6009,96,82,70,59,50,43,37,30,23,20,7565,18,17,14,10,8,6,7,5
 17 2,2,9523,4,2,0,0,3,6,7,3,4,4,11989,0,0,0,6,6,6,7,0,0,0,15093,0,0,0,0,0,0
 18 0,0,0,0,275114,30
GET E32U@D
 1 239,0,0,0,0,0,1,2,4,5,6,301,6,6,8,10,14,17,20,21,21,22,379,23,24,25,25,26
 2 27,27,28,29,30,477,30,31,32,32,33,34,35,35,36,36,601,37,38,39,39,40,41,42
 3 43,43,44,756,45,46,47,48,49,50,51,52,53,54,952,55,57,59,61,63,64,65,67,69
 4 71,1199,73,76,78,81,85,88,91,94,97,101,1509,105,109,114,119,124,129,135
 5 141,148,156,1900,163,171,179,189,199,211,225,240,256,273,2392,292,315,343
 6 377,419,470,533,608,694,792,3012,906,1037,1186,1352,1532,1722,1922,2128
 7 2334,2536,3791,2731,2918,3096,3262,3413,3547,3665,3767,3850,3911,4773
 8 3949,3966,3967,3953,3927,3889,3838,3762,3659,3532,6009,3400,3288,3200
 9 3112,2991,2831,2657,2502,2374,2265,7565,2171,2091,2020,1937,1814,1663
 10 1503,1366,1261,1173,9523,1086,988,886,781,684,598,527,487,474,470,11989
 11 449,394,328,268,233,192,144,110,94,76,15093,54,58,31,0,0,0,0,0,0,0
 12 155674,19
GET CLTR2
160 DATA 32,  1.25, 0.19, 2.3, 11.5
170 DATA 300, 12798, 862.7, 997.1, 570
180 FILE E320F
190 FILE E32U
195 FILE RUN32
197 B7=CMD("%EMPTY@NC RUN32@D")
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LISTING OF FILE R21 04:07 P.M. FEB. 24, 1977 ID=RALU

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SAVE RUN32@D
LIST RUN32@D
GET E330F@D
 1 37,0,0,0,0,0,1,1,1,1,1,47,1,2,2,2,3,3,3,4,4,5,60,5,6,7,7,8,9,10,11,12,14
 2 75,15,17,18,20,22,25,27,30,32,35,95,39,42,46,50,55,59,65,70,76,82,119,89
 3 97,104,113,122,131,142,152,164,176,151,189,203,218,233,250,267,285,304
 4 325,346,190,369,392,417,443,470,499,529,560,592,626,239,661,698,736,776
 5 816,859,903,948,995,1043,301,1092,1143,1196,1127,1206,1290,1373,1455,1537
 6 1618,379,1698,1776,1850,1920,1987,2057,2134,2212,2285,2344,477,2394,2440
 7 2491,2548,2611,2674,2731,2778,2814,2844,601,2872,2901,2934,2972,3021,3079
 8 3141,3197,3243,3283,756,3321,3358,3399,3454,3530,3618,3695,3739,3749,3746
 9 952,3753,3782,3830,3885,3934,3963,3967,3952,3926,3883,1199,3810,3698,3566
 10 3444,3353,3296,3260,3229,3185,3109,1509,2997,2857,2708,2565,2428,2292
 11 2152,2011,1868,1720,1900,1562,1397,1242,1117,1030,975,932,885,828,766
 12 2392,711,666,630,595,555,513,475,448,433,418,3012,393,357,317,285,264
 13 247,232,221,217,220,3791,226,229,226,215,194,166,139,119,109,106,4773
 14 105,104,101,93,80,64,50,43,41,41,6009,38,34,31,27,25,23,20,19,17,15,7565
 15 16,17,16,15,14,12,8,8,12,10,9523,7,7,8,13,14,10,10,11,6,6,11989,7,7,8,0
 16 0,0,0,0,0,0,15093,0,0,0,0,0,0,0,0,0,262363,27
GET E33U@D
 1 239,0,0,0,0,0,1,5,10,16,20,301,21,21,21,22,23,25,26,28,30,32,379,34,36,38
 2 40,42,44,46,49,51,53,477,54,56,58,60,63,66,68,70,73,75,601,78,81,84,86,88
 3 91,95,100,104,107,756,111,115,120,126,133,140,147,153,160,166,952,174,183
 4 194,207,220,236,255,277,303,332,1199,363,395,430,470,517,573,638,713,797
 5 890,1509,989,1093,1202,1316,1434,1556,1684,1816,1953,2093,1900,2233,2370
 6 2503,2633,2763,2893,3018,3134,3237,3327,2392,3409,3489,3573,3653,3732
 7 3785,3818,3850,3891,3932,3012,3953,3948,3933,3932,3946,3964,3967,3957
 8 3941,3926,3791,3912,3890,3857,3815,3763,3702,3643,3594,3555,3511,4773
 9 3442,3348,3249,3161,3084,2991,2866,2721,2585,2476,6009,2381,2277,2160
 10 2041,1931,1827,1720,1605,1489,1378,7565,1276,1183,1098,1025,957,886,810
 11 743,684,624,9523,552,473,408,362,323,268,213,169,160,182,11989,183,144
 12 112,105,80,34,18,39,42,22,15093,24,26,28,30,32,0,0,0,0,0
GET CLTR2
160 DATA 33, 0.75, 0.38, 16, 6.6
170 DATA 270, 11394, 1094.4, 505, 723.2
180 FILE E330F
190 FILE E33U
195 FILE RUN33
197 B7=CMD("%EMPTY@NC RUN33@D")
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LISTING OF FILE R22   04:07 P.M. FEB. 24, 1977   ID=RALU

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GET E340F@D
 1 23,0,0,0,1,1,1,1,1,1,1,30,1,2,2,2,2,2,3,3,3,4,37,4,4,5,5,6,6,7,7,8,9,47
 2 10,10,11,12,13,14,16,17,18,20,60,21,23,24,26,28,30,33,35,38,40,75,43,46
 3 50,53,57,61,65,69,74,79,95,84,89,95,101,107,114,121,129,137,145,119,154
 4 163,172,182,193,204,216,228,240,254,151,267,282,297,312,329,346,363,382
 5 401,421,190,441,463,485,508,532,556,582,608,635,663,239,692,721,752,784
 6 816,849,884,919,955,992,301,1029,1068,1108,982,1050,1123,1196,1269,1341
 7 1414,379,1487,1559,1628,1690,1744,1789,1827,1860,1895,1937,477,1988,2042
 8 2087,2123,2154,2189,2229,2271,2308,2339,601,2372,2414,2467,2521,2561,2589
 9 2613,2644,2679,2709,756,2737,2772,2824,2883,2931,2950,2948,2954,3004,3115
 10 952,3258,3378,3431,3425,3402,3399,3417,3443,3475,3524,1199,3593,3657
 11 3689,3684,3673,3689,3745,3824,3900,3951,1509,3967,3954,3924,3890,3857
 12 3818,3758,3658,3517,3351,1900,3186,3027,2854,2646,2412,2190,2017,1893
 13 1782,1644,2392,1472,1288,1118,973,850,743,650,569,498,438,3012,387,343
 14 302,260,221,188,161,141,127,117,3791,108,97,85,76,69,61,51,39,29,23,4773
 15 18,15,13,12,10,7,3,0,0,0,6009,0,0,0,0,0,0,0,0,0,7565,0,0,0,0,0,0,0,0
 16 0,9523,0,0,0,0,0,0,0,0,0,0,11989,0,0,0,0,0,0,0,0,0,15093,0,0,0,0,0,0,0
 17 0,0,0,271370,29
GET E34U@D
 1 239,0,0,0,0,0,1,5,11,17,22,301,24,24,25,26,28,30,32,34,37,39,379,41,43,45
 2 47,49,51,53,55,57,59,477,61,63,65,67,69,71,73,75,77,80,601,82,83,85,86,88
 3 91,94,97,100,103,756,107,110,113,116,119,122,127,133,140,146,952,151,156
 4 160,166,174,182,190,197,202,208,1199,217,229,245,262,280,300,323,349,377
 5 409,1509,446,494,553,622,700,785,877,974,1075,1181,1900,1295,1422,1560
 6 1704,1846,1988,2132,2280,2427,2566,2392,2695,2815,2934,3049,3154,3246
 7 3327,3407,3492,3579,3012,3660,3727,3780,3822,3859,3897,3935,3962,3967
 8 3953,3791,3931,3912,3896,3871,3826,3762,3692,3632,3586,3538,4773,3467
 9 3367,3258,3167,3101,3044,2978,2896,2797,2681,6009,2553,2423,2309,2215
 10 2137,2057,1967,1860,1745,1637,7565,1536,1441,1341,1224,1097,989,913,860
 11 807,736,9523,657,578,508,459,410,381,356,347,312,244,11989,165,118,126
 12 152,145,116,104,111,95,51,15093,27,59,63,33,36,0,0,0,0,0,211564,19
GET CLTR2
160 DATA 34, 1.25, 0.39, 13.9, 6.5
170 DATA 290, 16545, 1706, 873.0, 1151.4
180 FILE E340F
190 FILE E34U
195 FILE RUN34
197 B7=CMD("%EMPTY@NC RUN34@D")
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LISTING OF FILE R23 04:07 P.M. FEB. 24, 1977 ID=RALU

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GET E350F@D
 1 23,0,1,1,1,1,1,1,1,1,1,30,1,2,2,2,2,2,2,3,3,3,37,3,4,4,4,5,5,5,6,6,6,47,7
 2 7,8,8,9,10,10,11,12,13,60,13,14,15,16,17,18,19,21,22,23,75,25,26,28,29,31
 3 33,35,37,39,41,95,43,46,48,51,54,57,60,63,66,70,119,74,77,82,86,90,95,100
 4 105,110,115,151,121,127,133,139,146,153,160,168,176,184,190,192,201,210
 5 219,229,239,250,260,272,283,239,295,308,320,334,347,361,376,391,406,422
 6 301,439,456,473,434,462,495,528,558,587,617,379,647,679,712,744,772,796
 7 817,837,858,876,477,891,906,923,943,967,993,1018,1041,1060,1076,601,1092
 8 1110,1131,1153,1176,1199,1220,1236,1247,1259,756,1281,1317,1362,1403,1431
 9 1443,1441,1429,1418,1422,952,1451,1500,1551,1593,1624,1654,1683,1705,1718
 10 1725,1199,1738,1763,1799,1840,1881,1920,1958,1999,2043,2088,1509,2131
 11 2171,2211,2254,2303,2361,2426,2492,2551,2600,1900,2642,2682,2724,2760
 12 2783,2799,2823,2870,2936,3004,2392,3058,3089,3108,3133,3180,3251,3331
 13 3405,3474,3547,3012,3626,3693,3725,3716,3691,3683,3709,3757,3806,3837
 14 3791,3846,3840,3836,3852,3895,3947,3968,3922,3819,3705,4773,3619,3566
 15 3527,3487,3441,3376,3268,3118,2959,2833,6009,2742,2645,2514,2358,2209
 16 2088,1970,1840,1684,1524,7565,1376,1244,1122,1002,898,817,739,639,521
 17 399,9523,307,265,245,210,157,120,77,55,29,0,11989,0,18,39,41,22,24,25,27
 18 0,0,15093,0,0,0,0,0,0,0,0,0,0,318356,29
GET E35U@D
 1 239,0,0,24,94,213,353,378,474,483,471,301,461,460,465,469,474,480,487,496
 2 505,516,379,526,535,543,550,560,571,582,589,595,601,477,613,630,648,662
 3 669,673,677,683,689,695,601,704,717,735,757,777,796,811,820,825,829,756
 4 834,843,850,851,846,844,854,879,915,954,952,987,1012,1030,1047,1065,1082
 5 1089,1084,1074,1071,1199,1088,1126,1177,1227,1260,1273,1274,1273,1279
 6 1289,1509,1303,1320,1337,1354,1368,1374,1374,1375,1386,1413,1900,1453
 7 1492,1520,1532,1536,1543,1558,1580,1604,1632,2392,1662,1693,1721,1746
 8 1775,1811,1851,1688,1923,1960,3012,2005,2061,2122,2186,2246,2288,2299
 9 2278,2250,2253,3791,2312,2416,2519,2574,2850,2794,2749,2762,2841,2935
 10 4773,2967,2899,2775,2703,2764,2945,3153,3302,3373,3400,6009,3427,3467
 11 3513,3555,3589,3619,3652,3690,3731,3774,7565,3817,3853,3886,3924,3960
 12 3968,3936,3855,3736,3598,9523,3440,3262,3092,2921,2734,2515,2251,1977
 13 1741,1545,11989,1388,1228,1067,924,789,647,501,413,376,308,15093,228,217
 14 233,250,234,179,115,41,0,0,294113,19
GET CLTR2
160 DATA 35, 0.75, 0.16, 1.0, 17.4
170 DATA 290, 11850, 759.4, 5691, 513.1
180 FILE E350F
190 FILE E35U
195 FILE RUN35
197 B7=CMD("%EMPTY@NC RUN35@D")
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LISTING OF FILE R24 04:07 P.M. FEB. 24, 1977 ID=RALU

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GET E360F@D
 1 15,3,3,3,3,4,4,4,5,5,5,19,6,6,7,7,8,8,9,10,10,11,23,12,13,14,15,16,17,18
 2 19,20,22,30,23,25,26,28,30,32,34,36,38,40,37,43,45,48,51,54,57,60,64,67
 3 71,47,75,79,84,88,93,98,104,109,115,121,60,128,134,141,148,156,164,172
 4 180,189,199,75,208,218,228,239,250,262,274,286,299,313,95,327,341,356,371
 5 387,403,420,437,455,474,119,493,513,533,554,575,597,620,643,667,691,151
 6 716,742,768,795,823,851,880,910,940,971,190,1002,1034,1067,1100,1134,1168
 7 1203,1239,1275,1312,239,1349,1387,1425,1464,1503,1543,1583,1624,1665,1706
 8 301,1748,1790,1832,1875,1918,1935,1992,2047,2104,2166,379,2236,2315,2400
 9 2479,2534,2550,2526,2475,2422,2383,477,2364,2359,2358,2361,2374,2409,2470
 10 2546,2612,2648,601,2648,2623,2592,2574,2574,2590,2620,2667,2736,2824,756
 11 2912,2976,3001,2995,2990,3028,3128,3275,3418,3507,952,3524,3499,3481
 12 3500,3549,3601,3636,3657,3676,3703,1199,3735,3760,3762,3724,3641,3522
 13 3395,3296,3247,3245,1509,3266,3287,3293,3289,3287,3297,3318,3341,3364
 14 3390,1900,3428,3479,3532,3582,3629,3675,3716,3737,3727,3700,2392,3683
 15 3704,3760,3828,3873,3875,3834,3763,3688,3631,3012,3605,3611,3649,3722
 16 3821,3908,3930,3855,3706,3559,3791,3479,3472,3486,3464,3406,3354,3336
 17 3313,3211,3008,4773,2773,2619,2601,2667,2701,2617,2415,2166,1949,1803
 18 6009,1716,1656,1594,1518,1430,1338,1248,1163,1081,998,7565,911,822,742
 19 683,641,599,538,454,362,286,9523,241,220,201,167,121,74,40,26,30,41
 20 11989,45,39,30,21,14,7,2,0,0,0,15093,0,0,0,0,0,0,0,0,0,471689,31
GET E36U@D
 1 19,1,1,1,1,1,1,1,1,1,1,23,1,2,2,2,2,2,2,2,3,3,30,3,3,3,4,4,4,4,5,5,5,37,5
 2 6,6,6,7,7,8,8,9,9,47,10,10,11,11,12,13,13,14,15,16,60,16,17,18,19,20,21
 3 22,23,24,26,75,27,28,30,31,33,34,36,37,39,41,95,43,45,47,49,52,54,56,59
 4 62,64,119,67,70,73,76,80,83,87,90,94,98,151,102,106,111,115,120,125,130
 5 135,141,146,190,152,158,164,170,177,184,191,198,205,213,239,221,229,237
 6 246,255,264,273,283,293,303,301,314,324,335,645,645,639,631,623,619,618
 7 379,617,615,613,613,619,628,639,649,658,667,477,678,689,701,713,725,737
 8 749,763,779,798,601,816,832,847,863,880,897,909,914,915,918,756,927,948
 9 976,1004,1025,1044,1071,1107,1144,1167,952,1176,1181,1191,1208,1229,1250
 10 1274,1299,1328,1358,1199,1391,1419,1437,1443,1443,1449,1464,1484,1500
 11 1511,1509,1519,1530,1548,1574,1602,1633,1666,1703,1741,1770,1900,1788
 12 1805,1834,1878,1928,1972,2009,2049,2100,2155,2392,2199,2230,2260,2303
 13 2361,2425,2486,2537,2578,2610,3012,2643,2683,2722,2741,2732,2709,2702
 14 2734,2806,2900,3791,2991,3057,3084,3078,3064,3074,3122,3194,3253,3271
 15 4773,3243,3192,3152,3144,3167,3202,3238,3262,3282,3298,6009,3321,3351
 16 3379,3403,3428,3459,3493,3533,3561,3568,7565,3554,3556,3610,3705,3820
 17 3906,3955,3967,3955,3913,9523,3852,3770,3666,3547,3402,3228,3023,2822
 18 2656,2494,11989,2295,2054,1785,1523,1234,981,776,636,577,562,15093,572
 19 581,518,407,357,340,227,97,0,0,344039,30
GET CLTR2
160 DATA 36, 1.25, 0.18, 0.6, 21.0
170 DATA 310, 14254, 1031.3, 6855, 676.6
180 FILE E360F
190 FILE E36U
195 FILE RUN36
197 B7=CMD("%EMPTY@NC RUN36@D")
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LISTING OF FILE R25   04:07 P.M. FEB. 24, 1977   ID=RALU

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GET E370F@D
 1 30,1,1,1,1,1,1,1,1,2,2,37,2,2,2,2,3,3,3,4,4,4,47,5,5,5,6,6,7,7,8,8,9,60
 2 10,10,11,12,13,14,15,16,17,18,75,20,21,22,24,25,27,29,31,33,35,95,37,40
 3 42,45,48,51,54,57,60,64,119,68,72,76,80,85,90,95,100,106,112,151,118,124
 4 131,138,145,153,161,169,178,187,190,197,207,217,227,239,250,262,275,288
 5 301,239,315,329,344,360,376,392,410,427,319,390,301,433,463,494,532,572
 6 610,644,674,704,734,379,763,793,821,850,879,909,941,970,995,1014,477,1027
 7 1041,1059,1083,1108,1129,1142,1153,1170,1196,601,1227,1254,1270,1278,1286
 8 1302,1329,1366,1404,1435,756,1457,1478,1504,1535,1562,1578,1585,1592,1607
 9 1633,952,1668,1707,1744,1782,1827,1878,1920,1940,1944,1955,1199,1986,2032
 10 2072,2102,2135,2185,2253,2327,2397,2456,1509,2504,2548,2599,2666,2752
 11 2847,2937,3010,3065,3111,1900,3160,3219,3290,3368,3444,3508,3552,3579
 12 3597,3609,2392,3619,3635,3662,3699,3734,3754,3756,3743,3729,3731,3012
 13 3762,3822,3890,3943,3967,3967,3939,3879,3794,3716,3791,3682,3711,3782
 14 3856,3897,3888,3826,3724,3599,3469,4773,3337,3204,3080,2984,2908,2815
 15 2664,2457,2236,2043,6009,1879,1720,1553,1394,1252,1122,997,856,711,581
 16 7565,483,421,375,325,265,201,147,112,96,90,9523,83,66,55,59,54,49,42,45
 17 36,12,11989,0,14,31,17,18,19,20,22,24,25,15093,0,0,0,0,0,0,0,0,0
GET E37U@D
 1 47,0,1,1,1,1,1,1,1,1,1,60,2,2,2,2,2,2,3,3,3,3,75,4,4,4,5,5,5,6,6,7,7,95,8
 2 8,9,10,10,11,12,12,13,14,119,15,16,17,18,19,21,22,23,25,26,151,28,30,31
 3 33,35,37,40,42,44,47,190,49,52,55,58,62,65,68,72,76,80,239,84,89,94,98
 4 104,109,114,120,126,132,301,139,146,153,160,168,176,184,193,202,211,379
 5 221,258,268,278,288,297,308,319,330,338,477,346,354,363,372,381,390,400
 6 409,418,427,601,438,450,462,473,484,495,509,522,534,546,756,560,578,595
 7 608,614,618,625,635,648,659,952,673,689,710,731,748,757,763,774,793,817
 8 1199,841,862,878,893,908,926,949,975,1000,1025,1509,1047,1065,1083,1108
 9 1140,1181,1224,1262,1294,1324,1900,1356,1398,1445,1495,1541,1579,1613
 10 1652,1703,1763,2392,1824,1873,1901,1916,1933,1967,2015,2064,2097,2116
 11 3012,2133,2167,2225,2302,2382,2454,2506,2544,2573,2603,3791,2633,2665
 12 2705,2757,2818,2864,2885,2892,2907,2938,4773,2977,3022,3080,3154,3214
 13 3180,3330,3303,3342,3358,6009,3331,3395,3517,3642,3733,3771,3777,3777
 14 3799,3831,7565,3839,3794,3697,3574,3454,3330,3192,3021,2824,2604,9523
 15 2371,2163,1994,1852,1708,1542,1368,1198,1025,883,11989,781,719,656,582
 16 493,435,433,463,497,471,15093,395,282,176,108,28,0,0,0,0,0,262148,26
GET CLTR2
160 DATA 37, 0.75, 0.28, 6, 9.9
170 DATA 280, 14862, 1575, 7002, 1123.6
180 FILE E370F
190 FILE E37U
195 FILE RUN37
197 B7=CMD("%EMPTY@NC RUN37@D")
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LISTING OF FILE R26 04:07 P.M. FEB. 24, 1977 ID=RALU

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GET E38OF@D
 1 15,2,2,3,3,3,3,4,4,4,4,19,5,5,5,6,6,6,7,7,8,8,23,9,9,10,10,11,12,12,13,14
 2 15,30,16,17,18,19,20,21,22,23,24,26,37,27,29,30,32,33,35,37,39,41,43,47
 3 45,48,50,52,55,58,61,64,67,70,60,73,77,80,84,88,92,97,101,106,110,75,115
 4 121,126,132,137,143,150,156,163,170,95,177,184,192,200,208,216,225,234
 5 243,253,119,263,273,284,295,306,318,330,342,355,368,151,381,395,409,423
 6 438,454,470,486,502,519,190,537,555,573,592,611,631,651,672,693,714,239
 7 736,759,782,805,829,853,878,903,929,955,301,982,1009,1037,1065,1094,1123
 8 1153,1183,1213,1244,379,1275,1307,1339,1466,1498,1516,1540,1565,1582,1595
 9 477,1611,1632,1656,1676,1693,1711,1736,1770,1801,1818,601,1818,1817,1839
 10 1894,1968,2025,2044,2033,2026,2046,756,2088,2129,2152,2165,2187,2232
 11 2285,2326,2348,2368,952,2401,2447,2494,2523,2525,2505,2479,2471,2504
 12 2583,1199,2681,2756,2772,2728,2641,2820,2709,2904,2810,3036,1509,2970
 13 2926,2901,2895,2906,2933,2975,3029,3086,3139,1900,3177,3202,3225,3257
 14 3303,3354,3399,3432,3461,3493,2392,3526,3548,3555,3558,3577,3630,3720
 15 3825,3914,3962,3012,3965,3933,3884,3829,3778,3740,3734,3770,3838,3902
 16 3791,3913,3836,3673,3466,3286,3200,3231,3340,3437,3449,4773,3377,3289
 17 3240,3193,3043,2731,2318,2355,2082,1975,6009,1939,1890,1649,1732,1652
 18 1566,1462,1354,1253,1167,7565,1075,969,768,724,622,537,467,409,353,289
 19 9523,221,150,94,58,37,25,14,5,1,0,11989,0,0,0,0,0,0,0,0,0,15093,0,0,0
 20 0,0,0,0,0,0,0,388690,31
GET E38U@D
 1 30,0,0,0,0,1,1,1,1,1,1,37,1,1,1,1,1,2,2,2,2,2,47,2,3,3,3,3,3,4,4,4,5,60,5
 2 5,6,6,6,7,7,8,8,9,75,9,10,10,11,12,12,13,14,15,15,95,16,17,18,19,20,22,23
 3 24,25,27,119,28,30,31,33,35,36,38,40,42,45,151,47,49,52,54,57,60,63,66,69
 4 73,190,76,80,83,87,91,96,100,105,110,114,239,120,125,131,136,142,148,155
 5 162,168,176,301,183,191,199,322,320,318,317,319,323,327,379,332,338,344
 6 352,359,367,373,378,385,392,477,400,408,414,419,424,430,436,445,455,466
 7 601,477,485,493,501,507,510,511,514,524,543,756,567,590,608,621,627,628
 8 627,629,638,657,952,682,705,720,726,726,725,725,725,722,722,1199,733,759
 9 734,740,754,756,755,757,763,769,1509,774,776,783,794,808,824,844,866,894
 10 926,1900,958,988,1009,1020,1029,1043,1069,1102,1135,1161,2392,1179,1191
 11 1204,1219,1243,1278,1323,1368,1405,1434,3012,1464,1505,1548,1581,1594
 12 1589,1581,1588,1623,1692,3791,1783,1869,1921,1932,1919,1911,1922,1939
 13 1941,1915,4773,1869,1817,1785,1782,1808,1847,1879,1876,1903,2020,6009
 14 2072,2145,2146,2153,2184,2242,2326,2413,2492,2559,7565,2628,2724,2867
 15 3051,3249,3445,3616,3763,3879,3947,9523,3968,3929,3815,3622,3371,3090
 16 2817,2565,2353,2145,11989,1912,1663,1427,1245,1107,981,830,681,566,479
 17 15093,427,421,432,378,270,193,129,55,0,0,226320,28
GET CLTR2
160 DATA 38, 1.25, 0.26, 5.0, 10.6
170 DATA 310, 19955, 1042, 9650, 747.5
180 FILE E38OF
190 FILE E38U
195 FILE RUN38
197 B7=CMD("%EMPTY@NC RUN38@D")
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LISTING OF FILE R27 04:07 P.M. FEB. 24, 1977 ID=RALU

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GET  E390F@D
 1 15,1,1,2,2,2,2,2,2,3,3,19,3,3,3,4,4,4,5,5,5,6,23,6,6,7,7,8,8,9,9,10,11,30
 2 11,12,13,13,14,15,16,17,18,19,37,20,21,22,24,25,26,28,29,31,32,47,34,36
 3 38,40,42,44,47,49,52,54,60,57,60,63,66,69,73,76,80,84,88,75,92,96,101,106
 4 111,116,121,126,132,138,95,144,151,157,164,171,178,186,194,202,211,119
 5 219,228,238,247,257,268,278,289,301,312,151,324,337,350,363,376,390,405
 6 419,435,450,190,466,483,500,517,535,553,572,591,611,631,239,651,672,694
 7 716,738,761,785,809,834,859,301,884,910,937,964,991,1019,1048,1077,1106
 8 1136,379,1167,1198,1323,1353,1387,1418,1436,1443,1445,1450,477,1462,1480
 9 1500,1527,1560,1596,1627,1648,1663,1683,601,1715,1759,1807,1854,1897,1937
 10 1973,2006,2034,2057,756,2076,2099,2134,2183,2231,2270,2315,2388,2486
 11 2566,952,2586,2547,2496,2480,2512,2568,2617,2647,2669,2702,1199,2753
 12 2810,2851,2865,2863,2864,2880,2910,2943,2972,1509,3001,3036,3077,3114
 13 3145,3180,3226,3278,3315,3325,1900,3320,3331,3380,3466,3568,3657,3715
 14 3738,3743,3750,2392,3773,3812,3858,3899,3925,3929,3908,3871,3840,3837
 15 3012,3869,3921,3962,3968,3930,3867,3804,3758,3737,3739,3791,3749,3738
 16 3674,3545,3375,3204,3057,2939,2837,2741,4773,2633,2491,2298,2063,1822
 17 1615,1458,1336,1214,1074,6009,919,767,637,530,441,361,291,231,185,150
 18 7565,117,86,63,49,40,34,28,20,10,11,9523,12,13,14,15,16,17,18,20,10,11
 19 11989,0,0,0,0,0,0,0,0,0,15093,0,0,0,0,0,0,0,0,0,0,360373,31
GET  E39U@D
 1 239,0,0,3,14,36,69,104,133,149,154,301,151,148,146,146,147,149,150,150
 2 151,153,379,155,157,158,160,162,164,166,168,170,172,477,174,176,179,182
 3 186,190,194,195,196,198,601,202,207,214,219,224,228,231,233,234,235,756
 4 240,248,257,265,273,280,287,291,292,292,952,293,299,310,324,339,353,361
 5 366,370,375,1199,382,391,398,401,402,402,406,413,423,434,1509,441,446,449
 6 456,469,487,506,521,531,538,1900,546,558,577,602,630,656,677,694,710,725
 7 2392,740,755,772,795,825,860,899,939,979,1019,3012,1054,1085,1113,1142
 8 1179,1226,1284,1345,1406,1463,3791,1523,1586,1652,1715,1780,1858,1963
 9 2092,2231,2365,4773,2495,2629,2785,2967,3173,3378,3556,3689,3782,3849
 10 6009,3905,3948,3968,3957,3908,3829,3718,3578,3425,3271,7565,3126,2985
 11 2849,2719,2599,2481,2353,2203,2033,1858,9523,1694,1548,1404,1250,1095
 12 949,801,661,552,492,11989,485,475,424,350,278,223,191,154,146,157,15093
 13 168,158,120,103,111,89,63,0,0,0,178070,19
GET CLTR2
160 DATA 39, 1, 0.35, 1.9, 17.85
170 DATA 310, 16018, 1892.7, 4299, 1204.2
180 FILE E390F
190 FILE E39U
195 FILE RUN39
197 B7=CMD("%EMPTY@NC RUN39@D")
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LISTING OF FILE R28 04:07 P.M. FEB. 24, 1977 ID=RALU

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GET E470F@D
 1 19,0,0,0,0,0,0,0,1,1,1,23,1,1,1,1,1,1,2,2,2,2,30,2,2,3,3,3,3,4,4,4,4,37,5
 2 5,6,6,6,7,7,8,8,9,47,10,10,11,12,13,13,14,15,16,17,60,18,19,21,22,23,25
 3 26,28,30,31,75,33,35,37,39,42,44,47,49,52,55,95,58,61,64,68,71,75,79,84
 4 88,92,119,97,102,107,113,118,124,131,137,144,151,151,158,165,173,181,190
 5 198,207,217,227,237,190,247,258,270,281,293,306,319,332,346,360,239,375
 6 390,406,422,438,455,473,491,510,477,301,486,521,554,595,582,626,668,709
 7 747,784,379,821,859,897,934,966,993,1018,1042,1068,1094,477,1121,1150
 8 1179,1208,1233,1253,1272,1295,1323,1350,601,1368,1378,1386,1403,1429,1457
 9 1484,1507,1526,1543,756,1558,1576,1601,1633,1673,1716,1754,1781,1794,1803
 10 952,1820,1848,1880,1908,1930,1945,1955,1967,1994,2047,1199,2116,2181
 11 2223,2249,2278,2323,2377,2427,2463,2491,1509,2523,2567,2620,2673,2720
 12 2763,2808,2853,2891,2917,1900,2939,2976,3039,3124,3213,3290,3347,3389
 13 3425,3463,2392,3506,3554,3602,3640,3672,3704,3741,3777,3795,3789,3012
 14 3774,3769,3789,3834,3892,3942,3967,3961,3927,3884,3791,3845,3810,3770
 15 3729,3707,3715,3725,3686,3564,3378,4773,3174,2998,2875,2814,2804,2817
 16 2703,2493,2412,2308,6009,2191,2061,1923,1788,1665,1556,1439,1312,1174
 17 1040,7565,911,790,665,541,429,348,297,245,186,117,9523,69,54,57,62,57,44
 18 37,40,43,46,11989,37,27,28,30,49,71,56,40,43,46,15093,49,53,57,30,32,0,0
 19 0,0,0,335650,30
GET E47U@D
 1 37,0,0,0,1,1,1,1,1,1,1,47,1,1,1,2,2,2,2,2,2,3,60,3,3,3,3,4,4,4,5,5,5,75,6
 2 6,6,7,7,8,8,9,10,10,95,11,12,12,13,14,15,16,17,18,19,119,20,21,22,24,25
 3 27,30,32,34,36,151,38,37,42,45,48,54,57,61,59,68,190,71,75,86,5,12,15,5
 4 81,85,90,239,94,99,104,109,113,120,126,131,137,158,301,166,173,145,189
 5 198,207,194,226,234,258,379,269,281,294,306,317,326,334,342,350,357,477
 6 363,368,373,380,389,361,413,422,430,437,601,444,453,463,473,482,489,499
 7 512,527,541,756,551,560,568,577,584,590,597,607,620,634,952,650,668,690
 8 717,745,764,775,783,799,825,1199,853,876,892,905,922,946,975,1007,1041
 9 1076,1509,1113,1150,1186,1218,1250,1282,1318,1359,1405,1452,1900,1496
 10 1534,1564,1586,1605,1627,1660,1702,1753,1807,2392,1863,1919,1975,2024
 11 2064,2095,2128,2172,2226,2273,3012,2306,2333,2375,2436,2492,2523,2531
 12 2544,2584,2650,3791,2711,2741,2740,2730,2737,2766,2804,2831,2835,2819
 13 4773,2790,2755,2859,2861,2856,2916,2976,2930,3166,3244,6009,3254,3260
 14 3261,3272,3308,3368,3438,3500,3554,3603,7565,3655,3717,3793,3870,3940
 15 3968,3914,3758,3510,3224,9523,2942,2688,2461,2230,1999,1771,1561,1359
 16 1169,1008,11989,853,731,613,489,404,353,309,239,177,169,15093,158,145
 17 130,83,29,0,0,0,0,0,266450,27
GET CLTR2
160 DATA 47, 0.75, 0.31, 9.1, 12.7
170 DATA 300, 22030, 2513, 10635, 1819.4
180 FILE E470F
190 FILE E47U
195 FILE RUN47
197 B7=CMD("%EMPTY@NC RUN47@D")
```

LISTING OF FILE R29 04:07 P.M. FEB. 24, 1977 ID=RALU

```
GET  E490F@D
 1 19,0,0,0,0,0,0,0,0,0,1,23,1,1,1,1,1,1,1,1,2,2,30,2,2,2,3,3,3,3,4,4,4,37,5
 2 5,5,6,6,7,7,8,8,9,47,10,10,11,12,13,13,14,15,16,17,60,19,20,21,23,24,26
 3 27,29,31,33,75,35,37,39,41,44,47,49,52,55,58,95,62,65,69,73,77,81,86,90
 4 95,100,119,106,111,117,123,130,136,143,150,158,166,151,174,183,191,201
 5 210,220,231,241,253,264,190,276,289,301,315,329,343,358,373,389,405,239
 6 422,439,457,476,495,514,535,555,577,599,301,621,645,668,693,718,744,770
 7 797,825,853,379,882,911,1014,1030,1045,1060,1076,1092,1113,1138,477,1168
 8 1198,1227,1252,1272,1286,1296,1303,1313,1333,601,1364,1404,1444,1481,1514
 9 1547,1581,1616,1650,1682,756,1713,1751,1797,1843,1872,1874,1861,1868,1917
 10 1999,952,2081,2140,2184,2227,2270,2295,2298,2301,2337,2408,1199,2484
 11 2530,2539,2533,2533,2544,2562,2581,2606,2644,1509,2695,2752,2804,2844
 12 2873,2902,2945,3008,3084,3159,1900,3223,3275,3321,3371,3428,3487,3540
 13 3583,3618,3653,2392,3695,3745,3794,3834,3863,3888,3919,3951,3967,3956
 14 3012,3921,3886,3866,3864,3873,3894,3922,3944,3932,3869,3791,3769,3667
 15 3593,3556,3543,3529,3490,3413,3296,3148,4773,2971,2769,2557,2353,2163
 16 1971,1757,1528,1310,1119,6009,955,805,670,554,455,374,306,250,208,172
 17 7565,139,108,83,65,55,48,43,37,29,21,9523,18,20,21,18,20,16,17,18,19,14
 18 11989,7,8,8,18,29,32,22,24,13,0,15093,15,32,34,37,39,21,22,0,0,0,328490
 19 30
GET  E49U@D
 1 239,0,0,3,18,48,87,123,117,122,121,301,119,120,122,126,127,127,127,127
 2 126,127,379,127,129,130,134,135,136,135,136,138,142,477,145,148,149,149
 3 152,154,160,163,167,168,601,169,170,172,178,185,190,195,198,198,196,756
 4 194,195,199,205,211,218,226,234,240,243,952,245,251,260,270,275,273,268
 5 267,276,291,1199,303,305,295,311,331,325,328,334,340,347,1509,356,366,375
 6 383,391,399,411,425,442,459,1900,474,486,494,502,513,530,552,577,603,628
 7 2392,652,676,701,726,750,774,799,828,859,886,3012,910,935,970,1020,1080
 8 1142,1204,1265,1327,1386,3791,1444,1506,1581,1667,1754,1826,1881,1934
 9 2014,2147,4773,2335,2556,2778,2977,3153,3315,3479,3640,3782,3884,6009
 10 3943,3967,3968,3941,3877,3770,3638,3508,3399,3296,7565,3168,3013,2857
 11 2715,2586,2455,2307,2152,1999,1858,9523,1718,1570,1435,1312,1191,1061
 12 914,766,657,587,11989,524,471,409,335,276,236,190,153,127,97,15093,104
 13 89,72,51,55,29,0,0,0,0,169450,19
GET CLTR2
160 DATA 49, 1, 0.35, 1.9, 17.4
170 DATA 300, 15737, 1893.3, 4111, 1201
180 FILE E49OF
190 FILE E49U
195 FILE RUN49
197 B7=CMD("%EMPTY@NC RUN49@D")
EXECUTION TERMINATED
```

$SIG

APPENDIX III

TAPE MOUNTING AND EDITING

To mount the papertapes on a reader it was necessary to take them to the reception area of the Computer Centre where they were assigned a rack number. In the example herewith this number was PT0151. The instruction for mounting the papertape also states that there is no parity check on the papertape and that the hexadecimal code for the "end of record" is 28D8A. This means that each line of input is terminated by two characters, a "carriage return" character (8D) followed by a "line feed" character (8A). The last piece of information required for the mount command is the name of the papertape. This enables the operator to check that the correct tape is mounted. It also guards against the unauthorized reading of tapes.

The output from the Celloscope is thus read from the reader which has the pseudo device name *R* to an MTS file for editing and then as input to the program "CONVERT" which converts it into a Basic language data file. Use of the MTS line file editor is necessary both to remove the "*" from line 4 and to erase the headings in line 3.

```
$SIG RALU C=100 FORM=BLANK

RRRRRRRRRRR      AAAAAAAAAA     LL               UU            UU
RRRRRRRRRRRRR   AAAAAAAAAAAA    LL               UU            UU
RR          RR  AA          AA  LL               UU            UU
RR          RR  AA          AA  LL               UU            UU
RR          RR  AA          AA  LL               UU            UU
RRRRRRRRRRRRR   AAAAAAAAAAAA    LL               UU            UU
RRRRRRRRRRRR    AAAAAAAAAAAA    LL               UU            UU
RR     RR       AA          AA  LL               UU            UU
RR      RR      AA          AA  LL               UU            UU
RR       RR     AA          AA  LL               UU            UU
RR        RR    AA          AA  LLLLLLLLLLLL     UUUUUUUUUUUU
RR         RR   AA          AA  LLLLLLLLLLLL      UUUUUUUUUU

**LAST SIGNON WAS: 00:54:18
 USER "RALU" SIGNED ON AT  16:19:07 ON TUE FEB 08/77
$CREATE JKL
 FILE "JKL" HAS BEEN CREATED.
$EMPTY JKL
DONE.
$MOUNT PT0151 PTPR *R* PARITY=NONE EOR=28D8A ' NEW380F PLEASE'
PT0151 PTPR *R* PARITY=NONE EOR=28D8A ' NEW380F PLEASE'

*R*: MOUNTED ON HSR1
$COP *R* JKL
$LIST JKL
     3      EZ NR       0     1     2     3     4     5     6     7     8     9
     4     388690*   1024
     5          15      2     2     3     3     3     3     4     4     4     4
     6          19      5     5     5     6     6     6     7     7     8     8
     7          23      9     9    10    10    11    12    12    13    14    15
     8          30     16    17    18    19    20    21    22    23    24    26
     9          37     27    29    30    32    33    35    37    39    41    43
    10          47     45    48    50    52    55    58    61    64    67    70
    11          60     73    77    80    84    88    92    97   101   106   110
    12          75    115   121   126   132   137   143   150   156   163   170
    13          95    177   184   192   200   208   216   225   234   243   253
```

14	119	263	273	284	295	306	318	330	342	355	368
15	151	381	395	409	423	438	454	470	486	502	519
16	190	537	555	573	592	611	631	651	672	693	714
17	239	736	759	782	805	829	853	878	903	929	955
18	301	982	1009	1037	1065	1094	1123	1153	1183	1213	1244
19	379	1275	1307	1339	1466	1498	1516	1540	1565	1582	1595
20	477	1611	1632	1656	1676	1693	1711	1736	1770	1801	1818
21	601	1818	1817	1839	1894	1968	2025	2044	2033	2026	2046
22	756	2088	2129	2152	2165	2187	2232	2285	2326	2348	2368
23	952	2401	2447	2494	2523	2525	2505	2479	2471	2504	2583
24	1199	2681	2756	2772	2728	2641	2820	2709	2904	2810	3036
25	1509	2970	2926	2901	2895	2906	2933	2975	3029	3086	3139
26	1900	3177	3202	3225	3257	3303	3354	3399	3432	3461	3493
27	2392	3526	3548	3555	3558	3577	3630	3720	3825	3914	3962
28	3012	3965	3933	3884	3829	3778	3740	3734	3770	3838	3902
29	3791	3913	3836	3673	3466	3286	3200	3231	3340	3437	3449
30	4773	3377	3289	3240	3193	3043	2731	2318	2355	2082	1975
31	6009	1939	1890	1649	1732	1652	1566	1462	1354	1253	1167
32	7565	1075	969	768	724	622	537	467	409	353	289
33	9523	221	150	94	58	37	25	14	5	1	0

END OF FILE

```
$EDIT JKL
03
1 LINE
ALTER 4 '*' '
   4        388690     1024
STOP
```

$LIST JKL

4	338690	1024									
5	15	2	2	3	3	3	3	4	4	4	4
6	19	5	5	5	6	6	6	7	7	8	8
7	23	9	9	10	10	11	12	12	13	14	15
8	30	16	17	18	19	20	21	22	23	24	26
9	37	27	29	30	32	33	35	37	39	41	43
10	47	45	48	50	52	55	58	61	64	67	70
11	60	73	77	80	84	88	92	97	101	106	110
12	75	115	121	126	132	137	143	150	156	163	170
13	95	177	184	192	200	208	216	225	234	243	253
14	119	263	273	284	295	306	318	330	342	355	368
15	151	381	395	409	423	438	454	470	486	502	519
16	190	537	555	573	592	611	631	651	672	693	714
17	239	736	759	782	805	829	853	878	903	929	955
18	301	982	1009	1037	1065	1094	1123	1153	1183	1213	1244
19	379	1275	1307	1339	1466	1498	1516	1540	1565	1582	1595
20	477	1611	1632	1656	1676	1693	1711	1736	1770	1801	1818
21	601	1818	1817	1839	1894	1968	2025	2044	2033	2026	2046
22	756	2088	2129	2152	2165	2187	2232	2285	2326	2348	2368
23	952	2401	2447	2494	2523	2525	2505	2479	2471	2504	2583
24	1199	2681	2756	2772	2728	2641	2820	2709	2904	2810	3036
25	1509	2970	2926	2901	2895	2906	2933	2975	3029	3086	3139
26	1900	3177	3202	3225	3257	3303	3354	3399	3432	3461	3493
27	2392	3526	3548	3555	3558	3577	3630	3720	3825	3914	3962
28	3012	3965	3933	3884	3829	3778	3740	3734	3770	3838	3902
29	3791	3913	3836	3673	3466	3286	3200	3231	3340	3437	3449

```
 30      4773    3377  3289  3240  3193  3043  2731  2318  2355  2082  1975
 31      6009    1939  1890  1649  1732  1652  1566  1462  1354  1253  1167
 32      7565    1075   969   768   724   622   537   467   409   353   289
 33      9523     221   150    94    58    37    25    14     5     1     0
END OF FILE


$RUN *BASIC
EXECUTION BEGINS
UBC BASIC SYSTEM
GET CONVERT
15 FILE E380F
GET E380F@D
 "E380F(D)" HAS BEEN CREATED.
RUN CONVERT

LOCATION ON PDP8 (CELLOSCOPE) 1024

31              LINES

 PROGRAM ENDS


$COPY -FILE *PUNCH*
$SIG
HSR1 RELEASED.
```

APPENDIX IV
THE PROGRAM "CONVERT"

The Basic language program "CONVERT" reads the total counts (T) and the address in the PDP8 minicomputer of the beginning of the data file (F). It then reads one line at a time of the sizing data and writes this on a Basic data file. If the size analysis does not go up to 15093 centimicrons then lines are added with zero counts in each size channel.

Finally the total counts and the number of lines of data in the original file, extended down to 15093 centimicrons if necessary, are written on the Basic data file. Because "CONVERT" has been revised a number of times not all the Basic data files have these last two numbers printed at the end of the file.

Data is read in via the "INPUT" statements so it is necessary to use the statement:-

$ CONTINUE WITH filename RETURN

when input to the program is stored on an MTS file. The term "filename" above represents the name of the MTS file concerned. Termination may be achieved by reading in a row of eleven zeros stored in the MTS file "TERMINATION".

```
LISTING OF FILE B.CONVERT                          08:37 P.M.   MAR. 14, 1977

 2 DIM A(11),S(1,12),C(10),B(11)
 3 DIM L(11)
 4 DATA 1199,1509,1900,2392,3012,3791,4773,6009,7565,95
23,11989,15093
 6 MAT S=ZER(1,12)
 10 MAT READ S
 12 FOR J=1 TO 10
 13 LET C(J)=0
 14 NEXT J
 15 FILE TEST
 18 INPUT T,F
 19 IF ( F-10*INT(F/10)-4)=4 THEN 300
 20 INPUT A(1),A(2),A(3),A(4),A(5),A(6),A(7),A(8),A(9),
A(10),A(11)
 25 IF A(1)=0 THEN50
 30 MAT WRITE FILE1,A
 32 LET L(1)=A(1)
 40 GOTO 20
 50 LET A(1)=L(1)
 60 IF A(1)<S(1,1) THEN 200
 80 FOR J=1 TO 12
 90 IF A(1)>=S(1,J) THEN 130
 100 WRITE #1,S(1,J)
 110 MAT WRITE #1,C
 130 NEXT J
 150 WRITE #1,T
 160 PRINT
 170 PRINT "LOCATION ON PDP8 (CELLOSCOPE)";F
 175 PRINT
 180 PRINT 82-((F-4)/20),"LINES"
 185 WRITE #1, 82-((F-4)/20)
 198 GO TO 210
 200 PRINT"**************SIZE RANGE TOO SMALL OR OFFSET
 FROM USUAL"
 210 PRINT
 290 GO TO 500
 300 B(10)=0
 301 B(11)=0
 303 INPUT A(1),A(2),A(3),A(4),A(5),A(6),A(7),A(8),A(9)
,A(10),A(11)
 320 IF A(1)=0 THEN 50
 330 WRITE#1,INT(A(1)/(((10)**0.01)**2)+0.5)
 340 WRITE#1,B(10),B(11)
 350 FOR I=2 TO 9
 360 WRITE#1,A(I)
 370 NEXT I
 380 LET B(10)=A(10)
 390 LET B(11)=A(11)
 410 LET L(1)=A(1)
 430 GO TO 303
 500 END
 END-OF-FILE
```

APPENDIX V

THE PROGRAM "CLTR2"

The program "CLTR2" uses the size analysis data files together with measured data to calculate the efficiency of the cyclone for each size together with the flow rate and other mass balances. Originally a simple method for estimating alpha and d_{50C} was incorporated but this was bypassed as it converged to a false optimum.

The data required is as follows:-

160 DATA run number, vortex in inches, spigot, pressure, sampling time.

170 DATA length of overflow size analysis vector (= 10 times the number of lines given by "CONVERT"), gm O/F pulp, gm U/F pulp, calc. gm O/F solids, calc. gm U/F solids.

180 FILE EnnOP

190 FILE EnnU

195 FILE RUNnn

197 B7=CMD ("%EMPTY@NC RUNnn@D")

where nn is the last 4 lines represents the run number.

Appendix II lists this information for all runs.

LISTING OF FILE B.CLTR2 08:37 P.M. MAR. 14, 1977

```
100 DIM B(390),M(390),W(390),U(390),F(390),E(390),V(390),S(390)
101 DIM P(390)
102 DIM A(390)
110 PRINT
120 PRINT
130 PRINT
140 PRINT "PROG. TO CALC. EFF. & CORR. EFF. OF CYC. FROM PRODS."
150 DATA 2.65
160 DATA 19, 1, 0.35, 1.9, 17.5
170 DATA  300, 16168, 1871.7, 4341.2, 1121.7
180 FILE E19OF
190 FILE E19U
195 FILE RUN19
197 B7=CMD("%EMPTY@NC RUN19@D")
200 READ D1,N2,V1,S1,P2,T5
210 READN,V4,S4,V3,S3
220 LET F3=S3+V3
230 LET F4=S4+V4
240 LET F2=F4-F3
250 LET S2=S4-S3
260 LET V2=V4-V3
270 FOR I=1 TO N-9 STEP 10
280 READ#1,M(I),V(I),V(I+1),V(I+2),V(I+3),V(I+4),V(I+5)
290 READ#1,V(I+6),V(I+7),V(I+8),V(I+9)
310 FOR J=1 TO 9
320 LET M(I+J)=INT(M(I+J-1)*((10)**0.01)+0.5)
330 NEXT J
340 NEXT I
342 FOR I=1 TO N
344 LET S(I)=0
346 NEXT I
348 READ#2, C9
354 FOR K1=0 TO 20
355 IF C9=M(1+K1*10) THEN 358
356 NEXT K1
357 GO TO 2000
358 FOR J=1+K1*10  TO 10+K1*10
359 READ#2, S(J)
360 NEXT J
362 FOR I=11 + K1*10 TO N-9 STEP 10
365 READ#2,C9
370 IF ABS(C9- M(I))>2 THEN 414
380 FOR K=1 TO 10
390 READ#2,S(I+K-1)
410 NEXT K
412 GO TO 420
414 IF (N-9-I)>10 THEN 2000
416 FOR K=1 TO 10
417 LET S(I+K-1)=0
418 NEXT K
418 NEXT K
419 PRINT "*****ZEROS ADDED TO TOP OF OVERFLOW SIZE ANALYSIS*****"
420 NEXTI
421 LET C7=0
422 LET C8=0
```

```
424 FOR J=1 TO N
425 LET C7=C7 + V(J)
426 LET C8=C8 + S(J)
428 NEXT J
429 PRINT "COUNTS ON OVERFLOW AND UNDERFLOW SIZING ARE
: ";C7,C8
430 PRINT
432 FOR J=1 TO N
434 LET V(J)=V(J)*V3/100/C7
436 LET S(J)=S(J)*S3/100/C8
438 NEXT J
440 PRINT
450 PRINT
460 LET B6=S2/F2
470 PRINT "TEST NUMBER:";N2
480 PRINT "**************  "
490 PRINT
500 PRINT
510 PRINT"SIZE","EFFICIENCY","CORRECTED EFF.","CALC. F
EED"
520 PRINT
529 LET C5=0
530 FOR J=1 TO N
540 LET F(J)=V(J)+S(J)
550 LET B(J)=B6*F(J)
560 LET W(J)=F(J)-B(J)
570 LET U(J)=S(J)-B(J)
580 IF W(J)>0 THEN 620
590 LET E(J)=1.5
600 PRINT M(J), "                 "," ",F(J)/F3*100
610 GO TO 640
620 LET E(J)=U(J)/W(J)
622 LET E8=INT(10000*E(J)  +0.5)/10000
628 LET C5=C5 +  (F(J)/F3*100)
630 LET F8=INT(1000000* F(J)/F3 +0.5)/10000
631 LET F9= INT(10000*C5 +0.5)/100
635 PRINT M(J),S(J)/F(J),E8,F8,F9
640 NEXT J
642 PRINT
644 PRINT "TEST NUMBER:";N2
646 PRINT "***************"
650 PRINT
660 PRINT" ","INCHES","MM"
670 PRINT "VORTEX" ,V1,INT((V1*25.4)+0.5)
680 PRINT "SPIGOT",S1,INT (S1*25.4+0.5)
690 PRINT
700 PRINT "PRESSURE=";P2;" PSIG (";INT(P2*6.89 +0.5);"
KILOPASCALS)"
710 PRINT
720 PRINT "SAMPLING TIME (SECONDS)=";T5
730 LET L1=60*(F2+F3/D1)/(1000*T5)
731 LET L1=0.01*INT(L1*100 +0.5)
740 LET G1=L1/3.785
741 LET G1=0.01*INT(G1*100 +0.5)
750 PRINT
760 PRINT"FLOWRATE=";L1;" LITRES/MIN. (";G1;" USGPM )"

770 PRINT
```

```
780 PRINT "  ","OVERFLOW","UNDERFLOW","CALC. FEED"
788 PRINT "PULP (C.C.)", V2+V3/D1, S2+S3/D1, F2+F3/D1
790 PRINT "PULP(GM.)",V4,S4,F4
800 PRINT "SOLIDS(GM.)",V3,S3,F3
805 PRINT "WATER(GM.)",V2,S2,F2
810 PRINT "% SOLIDS",V3/V4*100,S3/S4*100,F3/F4*100
820 PRINT
824 PRINT
825 PRINT "BYPASS RATIO = ";B6
826 PRINT
830 PRINT
832 FOR J=1 TO N
833 IF M(J)>300 THEN 836
834 LET N3=J
835 GO TO 839
836 IF M(J)>10000 THEN 839
838 LET N4=J
839 NEXT J
840 PRINT
842 PRINT "LIMITS OF 'GOOD DATA'",N3,N4
844 PRINT
846 PRINT
847 PRINT " ";TAB(7);"CORRECTED EFFICIENCY"
850 PRINT
860 PRINT TAB(5);"0";TAB(30);"50";TAB(54);"100"
870 PRINT TAB(5) ;"|....|....|....|....|....|....|....|....|....|....|    "
880 PRINT TAB(5);">"
890 PRINT TAB(5);">"
900 FOR I=N3 TO N4 STEP3
910 LET J=I
920 LET P8=INT(E(J)*50+.5)+5
922 IF E(J)>0 THEN 926
924 PRINT"EFFICIENCY=";INT(1000*E(J) +0.5)/1000
925 GO TO 940
926 IF E(J)<1.01 THEN 930
928 PRINT M(J); TAB(5);">"
929 GO TO 940
930 PRINT M(J);TAB(5);">";TAB(P8);"+"
940 NEXT I
950 PRINT TAB(5) ;"|....|....|....|....|....|....|....|....|....|....|    "
955 PRINT TAB(5);"0";TAB(30);"50";TAB(54);"100"
960 FOR J=1 TO 5
961 PRINT
964 NEXT J
965 REM WRITE ON FILE
966 WRITE#3,N2,N3,N4,B6,D1,V1,S1,P2
976 FOR I=N3 TO N4
978 WRITE# 3, M(I),E(I)*100, 100*S(I)/F(I)
980 NEXT I
985 GO TO 1990
990 FOR J=N3 TO N4
1000 LET P(J)=(E(J)*100)/(1-E(J)*100)
1010 NEXT J
1015 LET N6=0
1020 LET A1=0.001
1025 LET A2= 0.003
```

```
1030 LET A4=A1
1040 GOSUB 1200
1050 LET C1=C4
1070 LET A4=A2
1080 GOSUB 1200
1090 LET C2=C4
1100 LET A3=A1 -C1*((A2-A1)/(C2-C1))
1105 LET N6=N6 +1
1110 LET A4=A3
1120 GOSUB 1200
1130 LET C3=C4
1140 IF ABS(C3/B1)<0.001 THEN 1190
1150 IF N6>40 THEN 1180
1160 IF ABS(A2-A3)> ABS(A1-A3) THEN 1170
1165 LET A1=A3
1167 LET C1=C3
1169 GO TO 1100
1170 LET A2=A3
1175 LET C2=C3
1179 GO TO 1100
1180 PRINT
1185 PRINT "FAILED TO CONVERGE";A3,B1,B2
1186 GO TO 1990
1190 PRINT
1199 GO TO 1350
1200 LET W1=0
1205 LET W2=0
1210 LET W3=0
1215 LET W4=0
1220 LET W5=0
1225 LET W6=0
1230 LET W7=0
1240 FOR J=N3 TO N4
1245 LET W1=W1 + P(J)*M(J)*EXP(A4*M(J))
1250 LET W2=W2 +M(J)*EXP(2*A4*M(J))
1255 LET W3=W3 +M(J)*EXP(A4*M(J))
1260 LET W4=W4 +P(J)*EXP(A4*M(J))
1265 LET W5=W5 +P(J)
1270 LET W6=W6 +2*EXP(A4*M(J))
1275 LET W7=W7 +EXP(2*A4*M(J))
1290 NEXT J
1294 IF ABS(W2-W1)>0 THEN 1300
1295 PRINT "DIV. BY ZERO ";J,W1,W2,W3
1300 LET B1=W1/(W2-W3)
1310 LET B2=(W4-W5)/(N4-N3-W6+W7)
1320 LET C4=B1-B2
1322 PRINT A4,B1,B2
1340 RETURN
1350 PRINT "ESTIMATES BY REGRESSION"
1355 PRINT
1360 PRINT "A VALUES", A1,A2,A3
1370 PRINT "B VALUES AT LAST POINT", " ",B1,B2
1380 PRINT
1382 PRINT N6;"   CYCLES"
1384 PRINT
1385 LET  X5=LOG((1+B2)/B2) /A3
1390 LET A9=A3*X5
1395 PRINT
```

```
1400 PRINT "D50C:";X5;" CENTIMICRONS"
1405 PRINT
1410 PRINT "ALPHA= "; A9
1420 PRINT
1430 PRINT "CALCULATED CORRECTED EFFICIENCIES"
1435 PRINT
1440 PRINT "SIZE","CALC. EFF.","MEASURED","D/D50"
1450 FOR J=N3 TO N4 STEP 3
1460 LET A(J)=(EXP(A9*M(J)/X5)-1)/(EXP(A9*M(J)/X5)+EXP(A9)-2)
1470 PRINT M(J),A(J),E(J),M(J)/X5
1480 NEXT J
1990 GO TO 2010
2000 PRINT "**ERROR IN SIZING TERMINATED PROGRAM******"
2001 PRINT "SIZING ON O/F & U/F "; M(1+K1*10), C9 ; "CENTIMICRONS"
2002 PRINT "K1= ";K1
2010 END
END-OF-FILE
```

```
$SIG RALU FORM=BLANK

RRRRRRRRRRR     AAAAAAAAAA    LL                UU          UU
RRRRRRRRRRRR   AAAAAAAAAAAA   LL                UU          UU
RR         RR  AA        AA   LL                UU          UU
RR         RR  AA        AA   LL                UU          UU
RR         RR  AA        AA   LL                UU          UU
RRRRRRRRRRRR   AAAAAAAAAAAA   LL                UU          UU
RRRRRRRRRRR    AAAAAAAAAAAA   LL                UU          UU
RR     RR      AA        AA   LL                UU          UU
RR      RR     AA        AA   LL                UU          UU
RR       RR    AA        AA   LL                UU          UU
RR        RR   AA        AA   LLLLLLLLLLLL      UUUUUUUUUUUU
RR         RR  AA        AA   LLLLLLLLLLLL       UUUUUUUUUU
```

```
**LAST SIGNON WAS: 16:19:07
 USER "RALU" SIGNED ON AT  16:22:22 ON TUE FEB 08/77
$RUN *BASIC
EXECUTION BEGINS
UBC BASIC SYSTEM
GET  RUN19@D
 "RUN19(D)" HAS BEEN CREATED.
GET  E19DF@D
 "E19DF(D)" HAS BEEN CREATED.
 1 19,0,0,0,0,0,0,1,1,1,1,23,1,1,1,1,1,2,2,2,2,2,30,2,3,3,3,3,4,4,4,4,5,37,5
 2 5,6,6,7,7,8,8,9,10,47,10,11,12,12,13,14,15,16,17,18,60,19,20,22,23,24,26
 3 27,29,31,33,75,35,37,39,41,43,46,48,51,54,57,95,60,63,67,70,74,78,82,86
 4 91,95,119,100,105,110,116,122,128,134,140,147,154,151,162,169,177,185,194
 5 203,212,222,231,242,190,252,263,275,286,299,311,324,338,351,366,239,381
 6 396,412,428,444,462,479,497,516,535,301,555,575,596,618,640,662,685,709
 7 733,758,379,783,809,986,1000,1013,1025,1039,1054,1070,1084,477,1097,1111
 8 1126,1142,1159,1178,1201,1225,1248,1269,601,1290,1317,1353,1392,1426,1451
 9 1466,1478,1492,1512,756,1539,1574,1613,1653,1690,1724,1754,1781,1800,1813
 10 952,1829,1857,1902,1959,2020,2083,2138,2171,2170,2153,1199,2154,2195
 11 2259,2308,2324,2323,2331,2360,2399,2432,1509,2459,2490,2535,2592,2644
 12 2677,2693,2714,2762,2843,1900,2935,3015,3075,3122,3165,3209,3255,3309
 13 3380,3467,2392,3561,3637,3678,3685,3692,3742,3841,3940,3967,3893,3012
 14 3755,3638,3603,3654,3742,3818,3865,3890,3893,3864,3791,3807,3752,3732
```

```
 15 3742,3734,3648,3455,3189,2923,2714,4773,2570,2458,2362,2296,2271,2171
 16 2119,1866,1679,1462,6009,1249,1056,888,745,621,515,433,370,316,264,7565
 17 217,175,145,120,105,102,99,99,94,94,9523,79,54,41,35,37,40,54,58,37,40
 18 11989,57,62,33,35,75,81,65,46,50,54,15093,57,61,65,71,75,40,43,0,0,0
 19 314038,30
GET  E19U@D
 "E19U(D)" HAS BEEN CREATED.
 1 75,0,C,0,C,0,0,1,1,1,1,95,1,1,1,1,2,2,2,2,2,3,119,3,3,3,4,4,5,5,5,6,6,151
 2 7,8,8,9,10,10,11,12,13,14,190,15,17,18,19,21,22,24,25,27,29,239,31,34,36
 3 38,41,44,47,50,53,57,301,61,64,69,73,78,83,88,93,99,105,379,111,116,170
 4 173,177,180,181,182,185,189,477,192,196,201,203,207,210,216,220,224,225
 5 601,227,231,237,244,251,255,258,259,260,261,756,264,270,278,283,283,282
 6 284,295,311,328,952,339,343,341,340,341,348,357,367,379,388,1199,395,392
 7 379,392,449,419,445,435,433,436,1509,442,452,467,484,501,516,529,543,560
 8 581,1900,603,619,629,637,651,676,706,734,755,770,2392,786,804,825,847,871
 9 901,936,974,1014,1055,3012,1099,1148,1201,1256,1307,1349,1383,1415,1449
 10 1490,3791,1541,1608,1693,1783,1864,1936,2005,2074,2141,2210,4773,2299
 11 2421,2567,2712,2849,2992,3154,3330,3496,3634,6009,3747,3843,3920,3967
 12 3965,3908,3807,3685,3560,3434,7565,3304,3170,3034,2898,2765,2623,2478
 13 2317,2136,1948,9523,1768,1600,1453,1332,1240,1155,1044,903,770,663,11989
 14 592,527,470,426,372,296,193,133,126,118,15093,109,77,62,89,95,77,27,0,0
 15 0,180965,24
GET CLTR2
160 DATA 19, 1, 0.35, 1.9, 17.5
170 DATA  300, 16168, 1871.7, 4341.2, 1121.7
180 FILE F19OF
190 FILE E19U
195 FILE RUN19
197 B7=CMD("%EMPTY@NC RUN19@D")
SAVE CLTR2
DØNE
RUN  CLTR2


PROG. TO CALC. EFF. & CORR. EFF. OF CYC. FROM PRODS.
%EMPTY@NC RUN19@D
DØNE
COUNTS ON OVERFLOW AND UNDERFLOW SIZING ARE:  314038          180965


TEST NUMBER: 19
*************


SIZE              EFFICIENCY       CORRECTED EFF. CALC. FEED

19                                                0
19                                                0
19                                                0
19                                                0
19                                                0
19                                                0
19                0                -0.0633        0                0
19                0                -0.0633        0                0
19                0                -0.0633        0                0
19                0                -0.0633        0                0
23                0                -0.0633        0                0
24                0                -0.0633        0                0
```

25	0	-0.0633	0	0
26	0	-0.0633	0	0
27	0	-0.0633	0	0
28	0	-0.0633	0	0
29	0	-0.0633	0	0
30	0	-0.0633	0	0
31	0	-0.0633	0	0
32	0	-0.0633	0	0
30	0	-0.0633	0	0.01
31	0	-0.0633	0	0.01
32	0	-0.0633	0	0.01
33	0	-0.0633	0	0.01
34	0	-0.0633	0	0.01
35	0	-0.0633	0	0.01
36	0	-0.0633	0	0.01
37	0	-0.0633	0	0.01
38	0	-0.0633	0	0.01
39	0	-0.0633	0	0.01
37	0	-0.0633	0	0.01
38	0	-0.0633	0	0.02
39	0	-0.0633	0	0.02
40	0	-0.0633	0	0.02
41	0	-0.0633	0	0.02
42	0	-0.0633	0	0.02
43	0	-0.0633	0	0.02
44	0	-0.0633	0	0.03
45	0	-0.0633	0	0.03
46	0	-0.0633	0	0.03
47	0	-0.0633	0	0.03
48	0	-0.0633	0	0.04
49	0	-0.0633	0	0.04
50	0	-0.0633	0	0.04
51	0	-0.0633	0	0.05
52	0	-0.0633	0	0.05
53	0	-0.0633	0	0.05
54	0	-0.0633	0	0.06
55	0	-0.0633	0	0.06
56	0	-0.0633	0	0.07
60	0	-0.0633	0	0.07
61	0	-0.0633	0.0001	0.08
62	0	-0.0633	0.0001	0.08
63	0	-0.0633	0.0001	0.09
64	0	-0.0633	0.0001	0.09
65	0	-0.0633	0.0001	0.1
67	0	-0.0633	0.0001	0.11
69	0	-0.0633	0.0001	0.11
71	0	-0.0633	0.0001	0.12
73	0	-0.0633	0.0001	0.13
75	0	-0.0633	0.0001	0.14
77	0	-0.0633	0.0001	0.15
79	0	-0.0633	0.0001	0.16
81	0	-0.0633	0.0001	0.17
83	0	-0.0633	0.0001	0.18
85	0	-0.0633	0.0001	0.19
87	9.254974E-3	-0.0535	0.0001	0.2
89	8.715308E-3	-0.054	0.0001	0.22
91	8.235112E-3	-0.0546	0.0001	0.23
93	7.805068E-3	-0.055	0.0001	0.25
95	7.417709E-3	-0.0554	0.0002	0.26
97	7.066981E-3	-0.0558	0.0002	0.28

99	6.647877E-3	-0.0562	0.0002	0.29
101	6.364781E-3	-0.0565	0.0002	0.31
103	1.197351E-2	-0.0506	0.0002	0.33
105	1.136646E-2	-0.0512	0.0002	0.35
107	0.010818	-0.0518	0.0002	0.37
109	1.032003E-2	-0.0523	0.0002	0.39
112	9.758527E-3	-0.0529	0.0002	0.42
115	1.396194E-2	-0.0485	0.0002	0.44
119	1.327311E-2	-0.0492	0.0003	0.47
122	1.264905E-2	-0.0499	0.0003	0.49
125	1.208104E-2	-0.0505	0.0003	0.52
128	1.522625E-2	-0.0471	0.0003	0.55
131	1.448827E-2	-0.0479	0.0003	0.58
134	1.721368E-2	-0.045	0.0003	0.62
137	0.0164556	-0.0458	0.0003	0.65
140	1.576148E-2	-0.0466	0.0004	0.69
143	1.797265E-2	-0.0442	0.0004	0.72
146	1.716974E-2	-0.0451	0.0004	0.76
151	1.900657E-2	-0.0431	0.0004	0.81
155	2.078434E-2	-0.0412	0.0004	0.85
159	1.986359E-2	-0.0422	0.0005	0.9
163	2.134783E-2	-0.0406	0.0005	0.94
167	2.259068E-2	-0.0393	0.0005	0.99
171	2.161077E-2	-0.0403	0.0005	1.05
175	2.273647E-2	-0.0391	0.0005	1.1
179	2.366368E-2	-0.0382	0.0006	1.16
183	2.461291E-2	-0.0371	0.0006	1.22
187	2.528397E-2	-0.0364	0.0006	1.28
190	2.599597E-2	-0.0357	0.0007	1.35
194	2.816692E-2	-0.0334	0.0007	1.41
199	2.851226E-2	-0.033	0.0007	1.49
204	2.892639E-2	-0.0326	0.0007	1.56
209	0.0305307	-0.0308	0.0008	1.64
214	3.074365E-2	-0.0306	0.0008	1.72
219	3.214626E-2	-0.0291	0.0008	1.8
224	3.210024E-2	-0.0292	0.0009	1.89
229	3.334144E-2	-0.0279	0.0009	1.99
234	3.430912E-2	-0.0268	0.001	2.08
239	0.0351989	-0.0259	0.001	2.18
245	3.707086E-2	-0.0239	0.001	2.29
251	3.770242E-2	-0.0232	0.0011	2.39
257	3.828603E-2	-0.0226	0.0011	2.51
263	3.975902E-2	-0.021	0.0012	2.62
269	4.095476E-2	-0.0198	0.0012	2.74
275	4.214227E-2	-0.0185	0.0013	2.87
281	4.316248E-2	-0.0174	0.0013	3
288	0.0440277	-0.0165	0.0014	3.14
295	4.559411E-2	-0.0148	0.0014	3.28
301	4.696767E-2	-0.0134	0.0015	3.43
308	4.753523E-2	-0.0128	0.0015	3.58
315	4.934901E-2	-0.0108	0.0016	3.74
322	5.030081E-2	-0.0098	0.0016	3.9
330	5.181576E-2	-0.0082	0.0017	4.08
338	5.322567E-2	-0.0067	0.0018	4.25
346	0.0544658	-0.0054	0.0018	4.44
354	5.554833E-2	-0.0042	0.0019	4.63
362	0.0571019	-0.0026	0.002	4.82
370	0.0584796	-0.0011	0.002	5.03
379	5.976568E-2	0.0001	0.0021	5.24
388	6.040916E-2	0.0008	0.0022	5.45

397	7.176067E-2	0.0129	0.0027	5.72
406	0.0719971	0.0131	0.0027	6
415	0.0726541	0.0138	0.0028	6.27
425	7.299378E-2	0.0142	0.0028	6.55
435	7.245255E-2	0.0136	0.0028	6.84
445	7.186178E-2	0.013	0.0029	7.12
455	0.0719474	0.0131	0.0029	7.42
466	7.250975E-2	0.0137	0.003	7.71
477	7.276755E-2	0.014	0.003	8.01
488	7.330496E-2	0.0145	0.003	8.31
499	7.410918E-2	0.0154	0.0031	8.62
511	7.382092E-2	0.0151	0.0031	8.93
523	0.0741454	0.0154	0.0032	9.25
535	7.401701E-2	0.0153	0.0032	9.57
547	7.462479E-2	0.0159	0.0033	9.9
560	7.452561E-2	0.0158	0.0033	10.24
573	7.448541E-2	0.0158	0.0034	10.58
586	7.364651E-2	0.0149	0.0035	10.92
601	7.313218E-2	0.0144	0.0035	11.28
615	7.291242E-2	0.0141	0.0036	11.64
629	7.282287E-2	0.014	0.0037	12
644	7.286953E-2	0.0141	0.0038	12.38
659	0.0731506	0.0144	0.0039	12.77
674	7.304429E-2	0.0143	0.004	13.17
690	7.313992E-2	0.0144	0.004	13.57
706	7.285005E-2	0.0141	0.004	13.97
722	7.247445E-2	0.0137	0.0041	14.38
739	7.183997E-2	0.013	0.0041	14.79
756	7.142295E-2	0.0125	0.0042	15.21
774	7.142199E-2	0.0125	0.0043	15.64
792	0.0717359	0.0129	0.0044	16.08
810	7.129299E-2	0.0124	0.0045	16.53
829	6.984115E-2	0.0109	0.0046	16.99
848	0.0683325	0.0093	0.0047	17.46
868	6.768697E-2	0.0086	0.0048	17.94
888	0.0691352	0.0101	0.0048	18.42
909	7.190128E-2	0.013	0.0049	18.91
930	7.503372E-2	0.0164	0.005	19.41
952	7.673066E-2	0.0182	0.005	19.91
974	7.648572E-2	0.0179	0.0051	20.42
997	7.440774E-2	0.0157	0.0052	20.94
1020	0.0722025	0.0134	0.0053	21.47
1044	7.036701E-2	0.0114	0.0055	22.02
1068	6.969026E-2	0.0107	0.0057	22.59
1093	6.965601E-2	0.0107	0.0058	23.17
1118	7.045792E-2	0.0115	0.0059	23.76
1144	0.0726255	0.0138	0.0059	24.35
1171	7.476436E-2	0.0161	0.0059	24.94
1199	7.597806E-2	0.0174	0.0059	25.53
1227	7.413981E-2	0.0154	0.006	26.13
1256	0.0699644	0.011	0.0061	26.74
1285	7.076679E-2	0.0118	0.0063	27.37
1315	7.972295E-2	0.0214	0.0064	28.01
1346	7.482444E-2	0.0162	0.0064	28.65
1377	7.885016E-2	0.0204	0.0064	29.29
1409	7.633866E-2	0.0178	0.0065	29.93
1442	7.487114E-2	0.0162	0.0066	30.59
1476	7.440442E-2	0.0157	0.0066	31.26
1509	7.458553E-2	0.0159	0.0067	31.93
1544	7.526786E-2	0.0166	0.0068	32.61

1580	7.629958E-2	0.0177	0.0069	33.3
1617	7.725828E-2	0.0187	0.0071	34.01
1655	7.830975E-2	0.0199	0.0073	34.74
1694	7.955268E-2	0.0212	0.0074	35.48
1733	8.094934E-2	0.0227	0.0074	36.22
1773	8.232529E-2	0.0241	0.0075	36.97
1814	8.333537E-2	0.0252	0.0076	37.73
1856	8.394155E-2	0.0258	0.0079	38.51
1900	8.435145E-2	0.0263	0.0081	39.33
1944	8.429707E-2	0.0262	0.0083	40.16
1989	8.401351E-2	0.0259	0.0085	41.01
2035	8.381898E-2	0.0257	0.0086	41.87
2082	8.444007E-2	0.0264	0.0087	42.75
2130	8.630442E-2	0.0284	0.0089	43.63
2180	8.863413E-2	0.0308	0.009	44.54
2231	9.046361E-2	0.0328	0.0092	45.46
2283	9.103949E-2	0.0334	0.0094	46.4
2336	9.056551E-2	0.0329	0.0096	47.36
2392	9.005734E-2	0.0324	0.0099	48.35
2448	9.018237E-2	0.0325	0.0101	49.37
2505	9.138533E-2	0.0338	0.0102	50.39
2563	9.343301E-2	0.0359	0.0103	51.42
2623	9.566246E-2	0.0383	0.0103	52.45
2684	9.744291E-2	0.0402	0.0105	53.5
2747	9.850319E-2	0.0413	0.0108	54.58
2811	9.978464E-2	0.0427	0.0111	55.69
2876	0.1028269	0.0459	0.0112	56.81
2943	0.1033474	0.0518	0.011	57.91
3012	0.1160086	0.06	0.0107	58.99
3082	0.123954	0.0684	0.0105	60.04
3154	0.1300284	0.0749	0.0105	61.08
3227	0.1335434	0.0786	0.0107	62.15
3302	0.1354062	0.0806	0.011	63.25
3379	0.1367608	0.082	0.0112	64.37
3458	0.1382619	0.0836	0.0113	65.5
3539	0.1402308	0.0857	0.0114	66.65
3621	0.1430235	0.0887	0.0115	67.8
3705	0.1474149	0.0933	0.0115	68.94
3791	0.1536176	0.0999	0.0114	70.08
3879	0.161191	0.108	0.0113	71.21
3969	0.1690272	0.1163	0.0114	72.35
4061	0.176039	0.1238	0.0115	73.5
4156	0.1828957	0.1311	0.0116	74.65
4253	0.1922199	0.141	0.0114	75.8
4352	0.2064803	0.1562	0.011	76.9
4453	0.225775	0.1767	0.0104	77.94
4557	0.2472215	0.1995	0.0098	78.92
4663	0.2674643	0.221	0.0094	79.86
4773	0.2862787	0.241	0.0091	80.77
4884	0.3063451	0.2624	0.009	81.67
4998	0.3276428	0.285	0.0089	82.56
5114	0.346247	0.3048	0.0089	83.45
5233	0.3600039	0.3194	0.009	84.34
5355	0.3819355	0.3427	0.0089	85.23
5480	0.4002634	0.3622	0.0089	86.13
5608	0.4444997	0.4093	0.0085	86.98
5739	0.4828382	0.45	0.0082	87.8
5873	0.5270819	0.4971	0.0078	88.58
6009	0.5735909	0.5466	0.0074	89.32
6149	0.6200287	0.5959	0.007	90.03

6292	0.6643589	0.6431	0.0067	90.7
6439	0.7048052	0.6861	0.0064	91.33
6589	0.7411271	0.7247	0.0061	91.94
6742	0.7728578	0.7585	0.0057	92.51
6899	0.797665	0.7848	0.0054	93.06
7060	0.8170411	0.8054	0.0051	93.57
7224	0.8347508	0.8243	0.0048	94.05
7392	0.8536396	0.8444	0.0046	94.51
7565	0.8722334	0.8641	0.0043	94.94
7741	0.8903778	0.8834	0.004	95.34
7921	0.9036808	0.8976	0.0038	95.72
8106	0.915459	0.9101	0.0036	96.08
8295	0.9219212	0.917	0.0034	96.42
8488	0.9201955	0.9151	0.0032	96.75
8686	0.918189	0.913	0.0031	97.05
8888	0.9129989	0.9075	0.0029	97.34
9095	0.9106258	0.905	0.0027	97.61
9307	0.9028385	0.8967	0.0024	97.85
9523	0.9093778	0.9036	0.0022	98.07
9745	0.9299994	0.9256	0.002	98.27
9972	0.940795	0.937	0.0018	98.44
10204	0.9446425	0.9411	0.0016	98.6
10442	0.9376056	0.9336	0.0015	98.75
10685	0.9283011	0.9238	0.0014	98.89
10934	0.896575	0.89	0.0013	99.03
11189	0.8747016	0.8668	0.0012	99.14
11450	0.903207	0.8971	0.001	99.24
11717	0.8814047	0.8739	0.0009	99.32
11989	0.8232262	0.812	0.0008	99.41
12268	0.7921561	0.779	0.0008	99.48
12554	0.8646113	0.856	0.0006	99.54
12846	0.845142	0.8353	0.0006	99.6
13145	0.689827	0.6702	0.0006	99.66
13451	0.6210048	0.597	0.0005	99.72
13764	0.5710675	0.5439	0.0004	99.75
14085	0.5645411	0.5369	0.0003	99.78
14413	0.530503	0.5007	0.0003	99.81
14749	0.4949016	0.4629	0.0003	99.83
15093	0.461626	0.4275	0.0003	99.86
15445	0.3614299	0.3209	0.0002	99.89
15805	0.2995697	0.2552	0.0002	99.91
16173	0.3598216	0.3192	0.0003	99.94
16550	0.3622282	0.3218	0.0003	99.97
16935	0.463274	0.4292	0.0002	99.99
17329	0.2196927	0.1702	0.0001	100
17733			0	
18146			0	
18569			0	

TEST NUMBER: 19
****

	INCHES	MM
VORTEX	1	25
SPIGOT	0.35	9

PRESSURE= 1.9 PSIG (13 KILOPASCALS)

SAMPLING TIME (SECONDS)= 17.5

```
FLOWRATE= 50.19 LITRES/MIN. ( 13.26 USGPM )

                 OVERFLOW        UNDERFLOW        CALC. FEED
PULP (C.C.)        13464.99        1173.283         14638.27
PULP(GM.)          16168           1871.7           18039.7
SOLIDS(GM.)        4341.2          1121.7           5462.9
WATER(GM.)         11826.8         750              12576.8
% SOLIDS           26.85057        59.92948         30.28265

BYPASS RATIO =   5.963361E-2


LIMITS OF 'GOOD DATA'             120              273

      CORRECTED EFFICIENCY

    0                        50                        100
    |....|....|....|....|....|....|....|....|....|....|
    >
    >
EFFICIENCY= -0.014
EFFICIENCY= -0.01
EFFICIENCY= -0.006
EFFICIENCY= -0.002
388 +
415 >+
445 >+
477 >+
511 >+
547 >+
586 >+
629 >+
674 >+
722 >+
774 >+
829 >+
888 >+
952 >+
1020>+
1093>+
1171>+
1256>+
1346>+
1442>+
1544>+
1655>+
1773>+
1900>+
2035>+
2180> +
2336> +
2505> +
2684> +
2876> +
3082>  +
3302>   +
3539>   +
```

```
3791>    +
4061>     +
4352>       +
4663>          +
4998>             +
5355>                +
5739>                      +
6149>                             +
6589>                                   +
7060>                                       +
7565>                                          +
8106>                                             +
8686>                                             +
9307>                                            +
9972>                                              +
    |....|....|....|....|....|....|....|....|....|....|
    0                        50                      100
```

```
 PRØGRAM ENDS
SAVE RUN19@D
DØNE
LIST RUN19@D
1 19,120,273,5.963361E-2,2.65,1,0.35,1.9,295,-1.492982,4.559411,301
2 -1.346915,4.696767,308,-1.28656,4.753523,315,-1.09368,4.934901,322
3 -0.9924642,5.030081,330,-0.8313619,5.181576,338,-0.6814305,5.322567,346
4 -0.549553,5.44658,354,-0.4344352,5.554833,362,-0.2692265,5.71019,370
5 -0.1227196,5.84796,379,0.0140443,5.976568,388,8.247287E-2,6.040916,397
6 1.28961,7.176067,406,1.313689,7.19871,415,1.384619,7.26541,425,1.42074
7 7.299378,435,1.363186,7.245255,445,1.300362,7.186178,455,1.309467,7.19474
8 466,1.369268,7.250975,477,1.396683,7.276755,488,1.453833,7.330496,499
9 1.539354,7.410918,511,1.5087,7.382092,523,1.543206,7.41454,535,1.529553
10 7.401701,547,1.594185,7.462479,560,1.583638,7.452561,573,1.579364
11 7.448541,586,1.490153,7.364651,601,1.435458,7.313218,615,1.412089
12 7.291242,629,1.402566,7.282287,644,1.407528,7.286953,659,1.437418
13 7.31506,674,1.426112,7.304429,690,1.436281,7.313992,706,1.405456
14 7.285005,722,1.365515,7.247445,739,1.298043,7.183997,756,1.253696
15 7.142295,774,1.253595,7.142199,792,1.286975,7.17359,810,1.239876
16 7.129299,829,1.085486,6.984115,848,0.9250535,6.83325,868,0.8564061
17 6.768697,888,1.010414,6.91352,909,1.304562,7.190128,930,1.637671
18 7.503372,952,1.818127,7.673066,974,1.792079,7.648572,997,1.571104
19 7.440774,1020,1.336595,7.22025,1044,1.141406,7.036701,1068,1.069439
20 6.969026,1093,1.065798,6.965601,1118,1.151074,7.045792,1144,1.381578
21 7.26255,1171,1.609026,7.476436,1199,1.738094,7.597806,1227,1.542612
22 7.413981,1256,1.098592,6.99644,1285,1.18392,7.076679,1315,2.136331
23 7.972295,1346,1.615417,7.482444,1377,2.043517,7.885016,1409,1.776441
24 7.633866,1442,1.620382,7.497114,1476,1.57075,7.440442,1509,1.59001
25 7.458553,1544,1.66257,7.526786,1580,1.772327,7.629998,1617,1.874235
26 7.725828,1655,1.986049,7.830975,1694,2.118224,7.955268,1733,2.266747
27 8.094934,1773,2.413068,8.232529,1814,2.520481,8.333537,1856,2.584944
28 8.394155,1900,2.628533,8.435145,1944,2.62275,8.429707,1989,2.592596
29 8.401351,2035,2.571909,8.381898,2082,2.637957,8.444007,2130,2.836215
30 8.630442,2180,3.08396,8.863413,2231,3.278509,9.046361,2283,3.339749
31 9.103949,2336,3.289246,9.056551,2392,3.235306,9.005734,2448,3.248602
32 9.018237,2505,3.376527,9.138533,2563,3.59428,9.343301,2623,3.831363
33 9.566246,2684,4.020698,9.744291,2747,4.13345,9.850319,2811,4.269722
34 9.978464,2876,4.593236,10.28269,2943,5.180294,10.83474,3012,5.995006
```

```
35 11.60086,3082,6.839931,12.3954,3154,7.485893,13.00284,3227,7.859681
36 13.35434,3302,8.05777,13.54062,3379,8.201826,13.67608,3458,8.361452
37 13.82619,3539,8.570824,14.02308,3621,8.867809,14.30235,3705,9.334798
38 14.74149,3791,9.9944,15.36176,3879,10.79977,16.1191,3969,11.63308
39 16.90272,4061,12.37872,17.6039,4156,13.10788,18.28957,4253,14.09942
40 19.22199,4352,15.6159,20.64803,4453,17.66773,22.5775,4557,19.94945
41 24.72315,4663,22.10103,26.74643,4773,24.10179,28.62787,4884,26.23568
42 30.63451,4998,28.5005,32.76428,5114,30.47891,34.6247,5233,31.94183
43 36.00039,5355,34.27408,38.19355,5480,36.22309,40.02634,5608,40.92725
44 44.44997,5739,45.00423,48.28382,5873,49.70916,52.70819,6009,54.655
45 57.35909,6149,59.59327,62.00287,6292,64.30741,66.43589,6439,68.60854
46 70.48052,6589,72.47106,74.11271,6742,75.84536,77.28578,6899,78.48339
47 79.7665,7060,80.54387,81.70411,7224,82.42715,83.47508,7392,84.43581
48 85.36396,7565,86.41364,87.22384,7741,88.34261,89.03778,7921,89.75727
49 90.36808,8106,91.00978,91.5459,8295,91.69698,92.19212,8488,91.51347
50 92.01955,8686,91.3001,91.8189,8888,90.74817,91.29989,9095,90.49581
51 91.06258,9307,89.66769,90.28385,9523,90.3631,90.93778,9745,92.55603
52 92.99994,9972,93.70405,94.0795
END-ØF-FILE
LOGOFF
 ØFF AT 16:22:31 ØN 02-08-77
EXECUTION TERMINATED
```

CNT3 XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

APPENDIX VI

THE PROGRAM "LYN"

The program "LYN" uses the simplex search method described by Mular and Bull[65] to search for the best values for the d_{50C} and alpha in the Lynch equation:-

$$\text{Corrected efficiency, } Y_{cx} = \frac{e^{\alpha d/d_{50C}} - 1}{e^{\alpha d/d_{50}} + e^{\alpha} - 2}$$

The starting value for d_{50C} is found by the program simply by scanning the data for the size at which the corrected efficiency is closest to 50%. The starting value for alpha is estimated from an approximate relationship between alpha and the efficiency at a size of 1.5 (d_{50C}).

The choice of step sizes has also been programmed into this program based on various step sizes during de-bugging of the program.

To run this program it is only necessary to alter line 17 to read:-

17 FILE RUNnn
where "nn" is the run number.

The values of alpha and d_{50C} calculated from this program were added to the file RUNnn@D to serve as starting values for the later search programs.

LISTING OF FILE B.LYN 08:37 P.M. MAR. 14, 1977

```
1 *THIS IS A SIMPLEX PROGRAM METHOD WRITTEN IN BASIC.
IT MAY BE USED
2 *TO ESTIMATE CONSTANTS FOR THE CYCLONE EFF. CURVES
3 *BASIS IS LYNCH EQUATION
4 *X50, ALPHA SEARCHED FOR
11 DIM A(190)
12 DIM D(1,4),C(1,4),Q(5,4),X(5,4)
13 DIM M(190),E(190),G(190)
15 DATA 2
16 DATA 1, 2, 0.5
17 FILE RUN5P2
20 READ N,A,V,B
25 READ#1,N6,N3,N4,B6,D1,V1,S1,P2
28 LET N2=N4-N3+1
30 FOR J=1 TO N2
32 READ#1,M(J),E(J),G(J)
34 NEXT J
36 MAT Q=ZER(N+1,N)
37 MAT X=ZER(N+1,N)
38 MAT Y=ZER(N+1,1)
39 MAT Z=ZER(1,N)
40 FOR J= N2 TO 1 STEP-1
41 IF E(J)<0.001 THEN 43
42 NEXT J
43 LET N1=J-INT(N2/29)-((J-INT(N2/29))-1-ABS(J-INT(N2/
29)-1))/2
46 LET B7=1
47 LET B5=1
48 FOR J=1 TO N2
49 IF ABS(50-E(J))>(45-35*INT(N2/100)) THEN 52
50 IF ABS(50-E(J))>ABS(50-E(B5))  THEN 54
52 LET B5=J
53 NEXT J
54 PRINT"ROUGH ESTIMATE OF D50 IS ";M(B5)
55 LET C(1,1)=M(B5)
56 LET D(1,1)=C(1,1)*0.002
57 FOR J=1 TO N2
58 IF ABS(M(J)-M(B5)*1.5)>ABS(M(B7)-M(B5)*1.5)  THEN 6
0
59 LET B7=J
60 NEXT J
61 LET C(1,2)=2*LOG(E(B7)/(100-E(B7)))
62 LET D(1,2)=C(1,2)*0.01
63 PRINT"ROUGH EST. OF ALPHA IS";C(1,2)
64 PRINT
67 * SET UP STARTING SIMPLEX
68 FOR J=1 TO N
69 FOR I=1 TO N+1
70 LET X(I,J)=C(1,J)-(2/(J+1))*D(1,J)
75 IF I=J+1 THEN 85
80 GO TO 88
85 LET X(I,J)=C(1,J)+((2/(J+1))*D(1,J))*J
88 NEXT I
90 FOR I=J+2 TO N+1
95 LET X(I,J)=C(1,J)
100 NEXT I
105 NEXT J
106 PRINT
```

```
107 PRINT "MATRIX X FOLLOWS. STARTING SIMPLEX: "
108 MAT PRINT X
109 PRINT"CYCLE","O.F.STD.ERROR","O.F.LOW VALUE","O.F.
HIGH"
110 * CALC STND ERROR OF OBJECTIVE FUNCTION
114 LET Z7=0
115 LET Z8=0
116 LET Z9=0
120 LET T3=1.E70
125 FOR I=1 TO N+1
130 LET H=I
135 GOSUB 560
140 LET Y(I,1)=Y1
145 NEXT I
150 GOSUB 600
155 T1=0
156 T2=0
160 FOR I=1 TO N+1
165 LET T1=T1+Y(I,1)
170 NEXT I
172 LET T1=T1/(N+1)
175 FOR I=1 TO N+1
176 LET T2=T2+(Y(I,1)-T1)**2
178 NEXT I
180 LET T= SQR(T2/N)
185 IF T> 1E-7 THEN 270
190 GO TO 205
195 PRINT
200 PRINT "CYCLE LIMIT. STOP CRITERION =";T3,T
201 PRINT "FAILED TO CONVERGE AFTER ";Z9;" ITERATIONS.
X MATRIX FOLLOWS "
202 PRINT
203 MAT PRINT X
204 GO TO 265
205 PRINT
210 PRINT "CONVERGENCE AFTER "; Z9 ;" CYCLES. T3, T =
";T3,T
212 PRINT
214 PRINT "RUN NUMBER: ";N6
216 PRINT "****************    "
218 PRINT
222 PRINT
224 LET X5=X(L,1)
226 PRINT "D50C= ";X5;" CENTIMICRONS "
227 PRINT
228 LET A9=X(L,2)
230 PRINT "ALPHA= ";A9
231 PRINT
232 PRINT "SIZE","CALC. EFF. ","MEASURED" , "D/D50C","
CALC. - MEAS."
234 FOR J=N1 TO N2
235 LET A(J)=100*(EXP(A9*M(J)/X5)-1)
236 LET A(J)=A(J)/(EXP(A9*M(J)/X5) + EXP(A9) -2)
240 PRINT M(J),A(J),E(J),M(J)/X5,A(J)-E(J)
245 NEXT J
246 *CALC. SUM OF SQUARES DUE TO ERROR
247 LET Z7=0
248 FOR J=N1 TO N2
```

```
249 LET Z7=Z7+ (E(J)-A(J))**2
250 NEXT J
252 PRINT "SUM OF SQUARES=";Z7
254 PRINT "VARIANCE=";Z7/(N2-N1+1-N)
263 PRINT
264 PRINT
265 STOP
270 IF Z9=300 THEN 273
271 IF Z9>700 THEN 195
272 GO TO 275
273 MAT PRINT X
274 GO TO 271
275 IF T>T3 THEN 295
280 LET T3=T
285 PRINT Z9,T  ,Y(L,1)  ,Y(H,1)
290 * REFLECTION
295 MAT Q=(1)*X
300 FOR J=1 TO N
305 LET P=0
310 FOR I=1 TO N+1
315  IF I=H THEN 325
320 LET P=P+X(I,J)/N
325 NEXT I
330 LET Z(1,J)=(1+A)*P-A*X(H,J)
335 LET X(H,J)=Z(1,J)
340 LET D(1,J)=P
345 NEXT J
350 GOSUB 560
355 MAT X=(1)*Q
360 LET Y=Y1
365 IF Y>=Y(L,1) THEN 410
370  * EXPANSION
375 FOR J=1 TO N
380 LET X(H,J)=(1+V)*Z(1,J)-V*D(1,J)
385 NEXT J
390 GOSUB 560
395 IF Y1>Y(L,1) THEN 415
400 LET Y(H,1)=Y1
405 GO TO 150
410 IF Y>Y(S,1) THEN 440
415 LET Y(H,1)=Y
420 FOR J=1 TO N
425 LET X(H,J)=Z(1,J)
430 NEXTJ
435 GO TO 150
440 IF Y>Y(H,1) THEN 465
445 FOR J=1 TO N
450 LET X(H,J)=Z(1,J)
455 NEXT J
457 LET Y(H,1)=Y
460 * CONTRACTION
465 FOR J=1 TO N
470 LET X(H,J)=B*X(H,J)+(1-B)*D(1,J)
475 NEXT J
480GOSUB 560
485 IF Y1>Y(H,1) THEN505
490 LET Y(H,1)=Y1
495 GO TO 150
```

```
500 * REDUCE SIZE OF SIMPLEX
505 FOR J=1 TO N
510 FOR I=1 TO N+1
515 LET X(I,J)=(Q(I,J)+Q(L,J))/2
520 NEXT I
525 NEXT J
530 LET Z8=Z8+1
535 PRINT
540 PRINT "STEP CHANGE";Z8
545 PRINT
550 GO TO 125
555 *OBJECTIVE FUNCTION CALCULATION
560 LET S8=0
561 FOR K=N1 TO N2
562 LET Y7=100*(EXP(X(H,2)*M(K)/X(H,1))-1)
563 LET Y7=Y7/(EXP(X(H,2)*M(K)/X(H,1))+EXP(X(H,2))-2)
565 LET S8=S8 + (E(K)-Y7)**2
566 NEXT K
567 LET Z9=Z9+1
568 LET Y1=S8
570 RETURN
598 * CALC HIGH, 2ND HIGH, LOW, (SERCH2)
600 IF Y(1,1)>Y(2,1) THEN 615
605 S=1
606 L=1
607 H=2
610 GO TO 620
615 S=2
616 L=2
617 H=1
620 FOR I=3 TO N+1
625 IF Y(I,1)>Y(L,1) THEN 635
630 L=I
635 IF Y(I,1)<Y(S,1) THEN 665
640 IF Y(I,1)<Y(H,1) THEN 660
645 S=H
650 H=I
655 GO TO 665
660 S=I
665 NEXT I
670 RETURN
675 END
END-OF-FILE
```

```
$SIG RALU FORM=BLANK

RRRRRRRRRRR      AAAAAAAAAA    LL               UU          UU
RRRRRRRRRRRR    AAAAAAAAAAAA   LL               UU          UU
RR         RR   AA         AA  LL               UU          UU
RR         RR   AA         AA  LL               UU          UU
RR         RR   AA         AA  LL               UU          UU
RRRRRRRRRRRR    AAAAAAAAAAAA   LL               UU          UU
RRRRRRRRRRR     AAAAAAAAAAAA   LL               UU          UU
RR     RR       AA         AA  LL               UU          UU
RR      RR      AA         AA  LL               UU          UU
RR       RR     AA         AA  LL               UU          UU
RR        RR    AA         AA  LLLLLLLLLLLL     UUUUUUUUUUUU
RR         RR   AA         AA  LLLLLLLLLLLL      UUUUUUUUUU
```

```
**LAST SIGNON WAS: 16:25:42   TUE FEB 08/77
 USER "RALU" SIGNED CN AT  17:29:10 ON WED FEB 09/77
$RUN *BASIC
EXECUTION BEGINS
UBC BASIC SYSTEM
GET LYN
17 FILE RUN19
RUN LYN
ROUGH ESTIMATE OF D50 IS  5873
ROUGH EST. OF ALPHA IS 4.566534

MATRIX X FOLLOWS. STARTING SIMPLEX:
5861.254        4.53609
5884.746        4.53609
5873            4.627421
CYCLE           O.F.STD.ERROR   O.F.LOW VALUE   O.F.HIGH
3               106.5053        1687.737        1875.971
10              96.68654        908.1919        1090.906
17              23.90324        561.4425        605.2579
19              15.66976        537.3732        566.7896
23              6.066354        525.3348        537.3732
25              2.71675         525.3348        530.0463
```

27	C.9880751	523.6294	525.3467
31	0.4334573	522.765	523.6294
33	0.2226784	522.7447	523.1401
35	0.1338521	522.5237	522.765
39	3.787257E-2	522.448	522.5237
41	2.589348E-2	522.4343	522.4844
42	7.013479E-3	522.4343	522.448
48	3.024609E-3	522.4112	522.4169
50	1.C26801E-3	522.4102	522.4123
54	6.633896E-4	522.4089	522.4102
55	3.094728E-4	522.4089	522.4095
57	1.210537E-4	522.4088	522.409
59	8.7532E-5	522.4087	522.4089
61	2.512079E-5	522.4087	522.4088
63	2.322396E-5	522.4087	522.4087
65	1.467035E-5	522.4087	522.4087
67	3.353963E-6	522.4087	522.4087
69	2.485058E-6	522.4087	522.4087
71	1.926631E-6	522.4087	522.4087
73	1.156964E-6	522.4087	522.4087
75	5.239531E-7	522.4087	522.4087
77	1.574889E-7	522.4087	522.4087

CONVERGENCE AFTER 79 CYCLES. T3, T = 1.574889E-7 7.603665E-8

RUN NUMBER: 19
****

D50C= 5849.765 CENTIMICRONS

ALPHA= 6.080744

SIZE	CALC. EFF.	MEASURED	D/D50C	CALC. - MEAS.
330	9.369163E-2	-0.8313619	5.641252E-2	0.9250535
338	9.638333E-2	-0.6814305	0.0577801	0.7778138
346	9.909735E-2	-0.549553	5.914767E-2	0.6486504
354	0.1018339	-0.4344352	6.051525E-2	0.5362691
362	0.1045931	-0.2692265	6.188282E-2	0.3738196
370	0.1073753	-0.1227196	0.0632504	0.2300949
379	0.1105327	0.0140443	6.478892E-2	9.648844E-2
388	0.1137197	8.247287E-2	6.632745E-2	3.124683E-2
397	0.1169364	1.28961	6.786597E-2	-1.172674
406	0.1201831	1.313689	6.940449E-2	-1.193506
415	0.1234602	1.384619	7.094302E-2	-1.261159
425	0.1271372	1.42074	7.265249E-2	-1.293603
435	0.1308524	1.363186	7.436196E-2	-1.232334
445	C.1346C61	1.300362	7.607143E-2	-1.165756
455	0.1383988	1.309467	0.0777809	-1.171068
466	0.1426161	1.369268	7.966132E-2	-1.226652
477	0.1468816	1.396683	8.154173E-2	-1.249801
488	0.1511958	1.453833	8.342215E-2	-1.302637
499	0.1555593	1.539354	8.530257E-2	-1.383795
511	0.1603762	1.5087	8.735393E-2	-1.348324
523	0.1652531	1.543206	0.0894053	-1.377953
535	0.1701907	1.529553	9.145666E-2	-1.359362
547	0.1751898	1.594185	9.350803E-2	-1.418995
560	C.1806757	1.583638	9.573034E-2	-1.402962
573	0.1862357	1.579364	9.795265E-2	-1.393128
586	0.1918707	1.490153	0.100175	-1.298282

601	0.1984671	1.435458	0.1027392	-1.236991
615	0.2047165	1.412089	0.1051324	-1.207373
629	0.2110566	1.402566	0.1075257	-1.191509
644	0.2179519	1.407528	0.1100899	-1.189576
659	0.2249546	1.437418	0.1126541	-1.212463
674	0.2320663	1.426112	0.1152183	-1.194046
690	0.2397742	1.436281	0.1179535	-1.196507
706	0.2476101	1.405456	0.1206886	-1.157846
722	0.2555762	1.365515	0.1234238	-1.109939
739	0.2641852	1.298043	0.1263299	-1.033858
756	0.2729462	1.253696	0.129236	-0.9807498
774	0.282391	1.253595	0.132313	-0.971204
792	0.2920125	1.286975	0.13539	-0.9949625
810	0.3018137	1.239876	0.1384671	-0.9380623
829	0.3123582	1.085486	0.1417151	-0.7731278
848	0.3231107	0.9250535	0.1449631	-0.6019428
868	0.3346583	0.8564061	0.148382	-0.5217478
888	0.3464458	1.010414	0.151801	-0.6639682
909	0.3590861	1.304562	0.1553908	-0.9454759
930	0.3720021	1.637671	0.1589807	-1.265669
952	0.3858352	1.818127	0.1627416	-1.432292
974	0.3999844	1.792079	0.1665024	-1.392095
997	0.4151223	1.571104	0.1704342	-1.155982
1020	0.4306217	1.336595	0.174366	-0.9059733
1044	0.4471897	1.141406	0.1784687	-0.6942163
1068	0.4641705	1.069439	0.1825714	-0.6052685
1093	0.4823087	1.065798	0.1868451	-0.5834893
1118	0.5009176	1.151074	0.1911188	-0.6501564
1144	0.520783	1.381578	0.1955634	-0.860795
1171	0.54198	1.609026	0.200179	-1.067046
1199	0.5645896	1.738094	0.2049655	-1.173504
1227	0.5878562	1.542612	0.209752	-0.9547558
1256	0.6126663	1.098592	0.2147095	-0.4859257
1285	0.6382228	1.18392	0.2196669	-0.5456972
1315	0.6654695	2.136331	0.2247953	-1.470862
1346	0.6945148	1.615417	0.2300947	-0.9209022
1377	0.7244936	2.043517	0.2353941	-1.319023
1409	0.7564496	1.776441	0.2408644	-1.019991
1442	0.7905141	1.620382	0.2465056	-0.8298679
1476	0.8268288	1.57075	0.2523178	-0.7439212
1509	0.8632975	1.59001	0.2579591	-0.7267125
1544	0.9033373	1.66257	0.2639422	-0.7592327
1580	0.9460336	1.772327	0.2700963	-0.8262934
1617	0.9915725	1.874235	0.2764213	-0.8826625
1655	1.040155	1.986049	0.2829173	-0.9458938
1694	1.092	2.118224	0.2895843	-1.026224
1733	1.145932	2.266747	0.2962512	-1.120815
1773	1.2035	2.413068	0.3030891	-1.209568
1814	1.264971	2.520481	0.3100979	-1.25551
1856	1.330633	2.584944	0.3172777	-1.254311
1900	1.402467	2.628533	0.3247994	-1.226066
1944	1.47755	2.62275	0.332321	-1.1452
1989	1.557849	2.592596	0.3400136	-1.034747
2035	1.643763	2.571909	0.3478772	-0.9281461
2082	1.735726	2.637957	0.3559117	-0.9022314
2130	1.834208	2.836215	0.3641172	-1.002007
2180	1.941929	3.08396	0.3726645	-1.142031
2231	2.057463	3.278509	0.3813828	-1.221046
2283	2.181438	3.339749	0.3902721	-1.158311
2336	2.314535	3.289346	0.3993323	-0.9748109

2392	2.462937	3.235306	0.4089053	-0.7723694
2448	2.619742	3.248602	0.4184783	-0.6288604
2505	2.783437	3.376527	0.4282223	-0.5880898
2563	2.970011	3.59428	0.4381372	-0.6242694
2623	3.168946	3.831363	0.4483941	-0.6624171
2684	3.383408	4.020698	0.4588218	-0.6372899
2747	3.618552	4.13345	0.4695915	-0.5148975
2811	3.872439	4.269722	0.4805321	-0.3972832
2876	4.146664	4.593236	0.4916437	-0.4465721
2943	4.447592	5.180294	0.5030971	-0.7327021
3012	4.778015	5.995006	0.5148925	-1.216991
3082	5.135747	6.839931	0.5268587	-1.704184
3154	5.528766	7.485893	0.5391669	-1.957127
3227	5.954727	7.859681	0.5516461	-1.904954
3302	6.422884	8.05777	0.5644671	-1.634886
3379	6.937607	8.201826	0.57763	-1.264219
3458	7.503694	8.361452	0.5911348	-0.8577582
3539	8.126395	8.570824	0.6049815	-0.4444294
3621	8.802883	8.867809	0.6189992	-6.492552E-2
3705	9.546649	9.334798	0.6333587	0.2118514
3791	10.36424	9.9944	0.6480602	0.3698381
3879	11.26267	10.79977	0.6631035	0.4628959
3969	12.24939	11.63308	0.6784888	0.6163133
4061	13.33228	12.37872	0.6942159	0.9535572
4156	14.53258	13.10788	0.7104559	1.424695
4253	15.84748	14.09942	0.7270377	1.748056
4352	17.28557	15.6159	0.7439615	1.669666
4453	18.85527	17.66773	0.7612271	1.187539
4557	20.58172	19.94945	0.7790056	0.6322675
4663	22.45722	22.10103	0.797126	0.3561867
4773	24.52664	24.10179	0.8159302	0.4248513
4884	26.73971	26.23568	0.8349053	0.5040348
4998	29.13852	28.5005	0.8543933	0.6380189
5114	31.70304	30.47891	0.8742231	1.224126
5233	34.45281	31.94183	0.8945658	2.510978
5355	37.38247	34.27408	0.9154213	3.108388
5480	40.48155	36.22309	0.9367897	4.258456
5608	43.73396	40.92725	0.9586709	2.806705
5739	47.11773	45.00423	0.981065	2.113505
5873	50.60514	49.70916	1.003972	0.895981
6009	54.13731	54.655	1.027221	-0.5176901
6149	57.7291	59.59327	1.051153	-1.86417
6292	61.31424	64.30741	1.075599	-2.993168
6439	64.87501	68.60854	1.100728	-3.733526
6589	68.34456	72.47106	1.12637	-4.126505
6742	71.68417	75.84536	1.152525	-4.161188
6899	74.87929	78.48339	1.179364	-3.604104
7060	77.89676	80.54387	1.206886	-2.647111
7224	80.69383	82.42715	1.234921	-1.733317
7392	83.27103	84.43581	1.26364	-1.164777
7565	85.62966	86.41364	1.293214	-0.7839762
7741	87.73832	88.34261	1.323301	-0.6042947
7921	89.61389	89.75727	1.354071	-0.1433767
8106	91.27268	91.00978	1.385697	0.2628952
8295	92.71623	91.69698	1.418006	1.019246
8488	93.96047	91.51347	1.450998	2.446999
8686	95.02821	91.3001	1.484846	3.728107
8888	95.93162	90.74817	1.519377	5.183455
9095	96.69327	90.49581	1.554763	6.19746
9307	97.32985	89.66769	1.591004	7.662159

```
9523          97.85535      90.3631       1.627929      7.492246
9745          98.28976      92.55603      1.665879      5.733733
9972          98.64438      93.70405      1.704684      4.940326
SUM OF SQUARES= 522.4087
VARIANCE= 3.553801

STOP!
 AT LINE "265" IN PRØGRAM "LYN"
 PRØGRAM ENDS
MTS

$SIG
```

APPENDIX VII
THE PROGRAM "GENWT"

The accuracy of the cyclone efficiency curve is influenced by the accuracy of measurement of all of the data from which the curve is calculated. A study of repeat runs will show:-

a) The difference in efficiency for repeat runs is highest near the d_{50C} size where the curve is steepest.
b) The accuracy of the efficiency curve is less at the top end of the size range probably due to the difficulty of ensuring that the Celloscope sample container is stirred efficiently.
c) In the case of the centre point runs there is an upward kink in the efficiency curve at the bottom end of the size range due to increased electronic noise in this size range when the Celloscope amplifier was modified near the end of the experimental phase. Normally the limits of the size range should be changed when the instrument is re-calibrated but this was not done then just to be consistent with the size ranges for the other runs.

It is standard statistical procedure to weight data in regression by a weighting factor which inversely proportional to the error variance when this is known. This results in a fit where the most accurate values are more heavily weighted.

Graphs of the standard deviations for repeated runs showed that the square root of the error variance was probably best represented by a function which was fairly constant except for an increase at the top (and sometimes the bottom) of the size scale. On this was superimposed a bell-shaped curve which peaked around the d_{50C} size. The height of this bell-shaped peak was well correlated with the difference between the d_{50C} values for the two repeats.

Because sufficient time was not available to obtain a general weighting factor function it was decided to use the following approach:-

The d_{50C} size is related primarily to the precent solids in the cyclone feed slurry so it was decided to calculate a set of weighting factors for each of the three values of the feed percent solids. Figs. 13 to 15 shows graphs of the square root of the error variance versus size for each class. The reciprocal of this number squared is the weighting factor.

'GENWT' is the program used to calculate the values of the error variance for all repeats and the weighting factors for all repeats. The weighting factors for all repeats was calculated in case it would be useful but in fact it was not used for the reasons mentioned.

The output from this program is not listed because of its length.

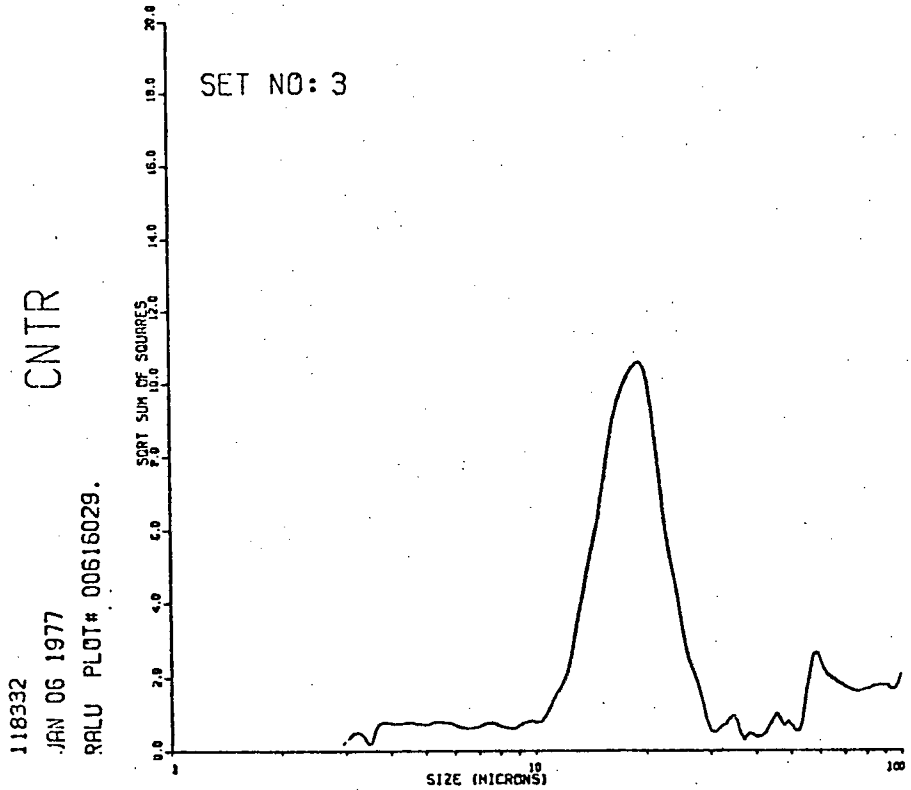

Fig.13 Pooled Standard Deviation versus Size for Low Percent Solids

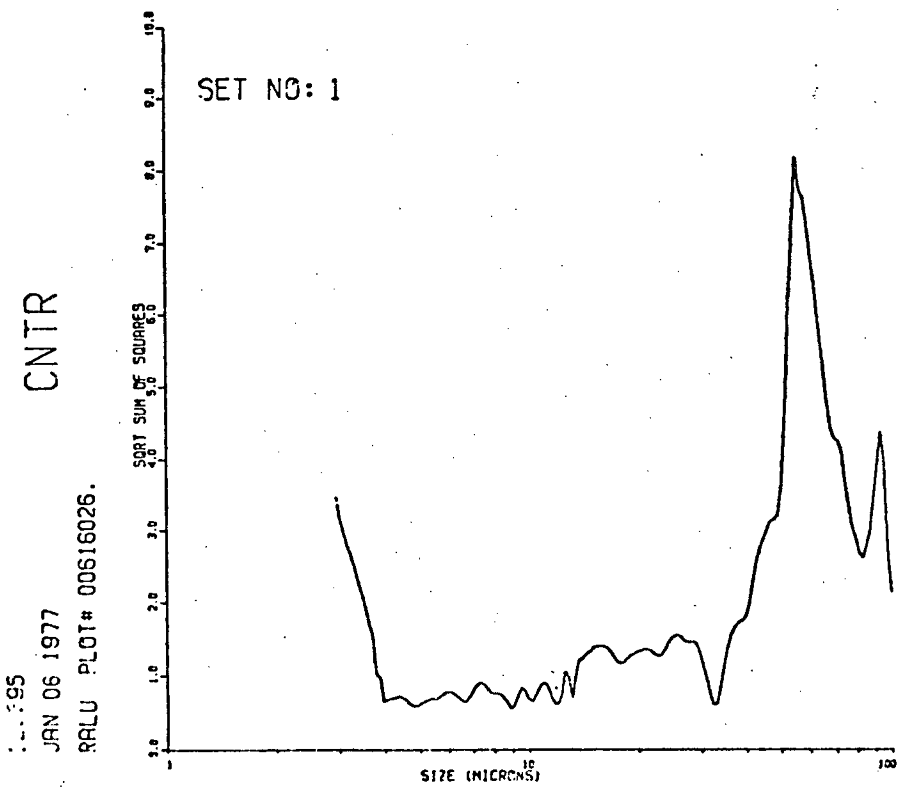

Fig.14 Pooled Standard Deviation versus Size for Centre Point Runs

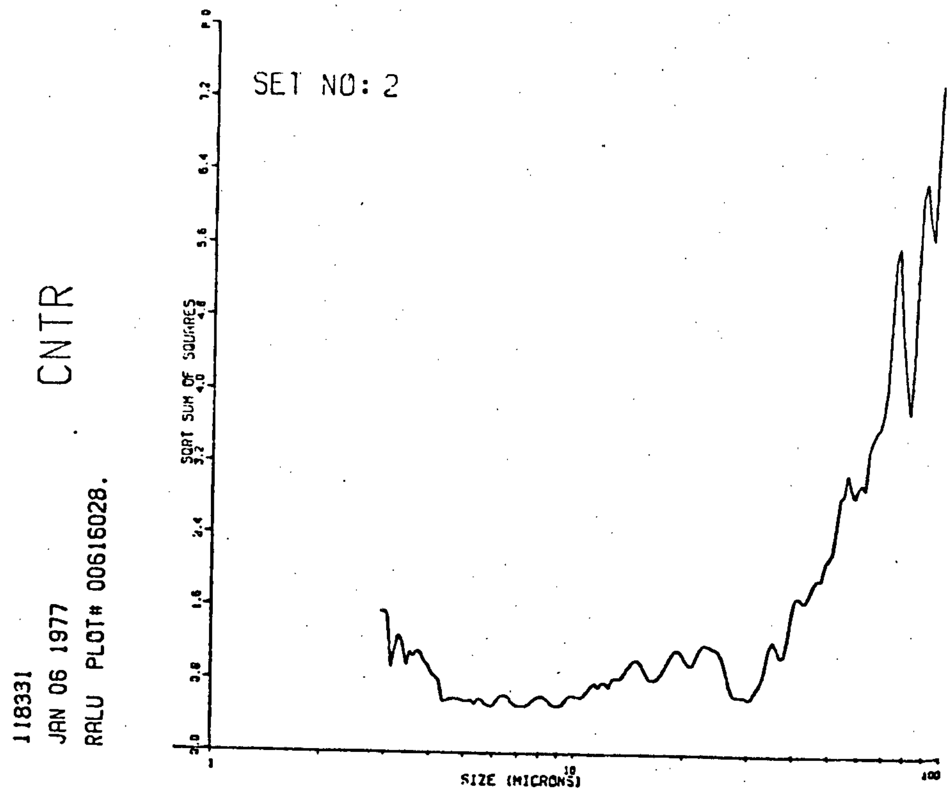

Fig.15 Pooled Standard Deviation versus Size for High Percent Solids

LISTING OF FILE B.GENWT   08:37 P.M. MAR. 14, 1977

```
10* GENERAL WEIGHTING FACTOR CALC. FOR ALL REPEAT RUNS
20 *
30 DIM E(29,154),M(154),S(12,154), T(154),W(154)
50 FILE RUN19
52 FILE RUN29
53 FILE RUN39
54 FILE RUN49
70 FILE RUN11
75 FILE RUN31
80 FILE RUN12
85 FILE RUN32
90 FILE RUN13
95 FILE RUN33
100 FILE RUN14
110 FILE RUN34
120 FILE RUN15
130 FILE RUN35
140 FILE RUN16
150 FILE RUN36
160 FILE RUN17
170 FILE RUN37
180 FILE RUN18
190 FILE RUN38
200 FILE RUN27
210 FILE RUN47
300 FOR L=1 TO 22
310 READ #L,N6,N3,N4,B6,D1,V1,S1,P2
330 LET N2=N4-N3+1
350 FOR J=1 TO N2
360 READ#L,M(J),E(L,J),G
370 NEXT J
380 NEXT L
400 FOR J=1 TO N2
410 LET T(J)=0
420 NEXT J
430 FOR J=1 TO N2
435 FOR I=1 TO 4
440 LET T(J)=T(J)+E(I,J)
450 NEXT I
452 NEXT J
453 FOR J=1 TO N2
455 LET T(J)=T(J)/4
460 NEXT J
475 FOR I=1 TO 3
480 FOR J=1 TO N2
482 LET S(I,J)=0
484 NEXT J
486 NEXT I
500 FOR J=1 TO N2
510 FOR I=1 TO 4
520 LET S(1,J)=(T(J)-E(I,J))**2 +S(1,J)
522 NEXT I
524 LET S(1,J)=S(1,J)/3
526 LET S(2,J)=S(1,J)
528 LET S(3,J)=S(1,J)
530 NEXT J
600 FOR L=5 TO 21 STEP 2
```

```
610 FOR J=1 TO N2
612 LET M1=(L/2)+1.5
614 LET M2=L+1
620 LET S(M1,J)= 2*(((E(L,J)-E(M2,J))/2)**2)
630 NEXT J
640 NEXT L
642 FOR L=3 TO 12 STEP 3
643 PRINT " ",L-2,L-1,L
644 PRINT "154"
645 FOR J=1 TO N2
647 PRINT M(J),S(L-2,J),S(L-1,J),S(L,J)
648 NEXT J
649 NEXT L
650 FOR J=1 TO N2
660 LET W(J)=0
670 NEXT J
672 PRINT "1234"
674 PRINT "154"
680 FOR J=1 TO N2
690 FOR I=1 TO 12
700 LET W(J)=W(J)+S(I ,J)
710 NEXT I
720 LET W(J)=W(J)/12
730 LET W(J)=1/(W(J))
740 PRINT M(J),1/W(J),W(J)
750 NEXT J
1000 END
END-OF-FILE
```

APPENDIX VIII

THE PROGRAM "WTFILL"

The program "WTFILL" was used to calculate the weighting factors for each class of d_{50} values and punch this information on cards as a Basic language data file for use in the simplex searches which included weighting factors, namely "LYNWT" and "MURU".

LISTING OF FILE B.WTFILL 08:37 P.M. MAR. 14, 1977

```
10 * PROGRAM TO CREATE FILE OF WEIGHT FACTORS WEIGHT@D

20 DIM  M(300),W(300)
50 FILE WEIGHT
80 INPUT R
90 INPUT N
100 FOR J=1 TO N
120 INPUT M(J),S2,W(J)
150 WRITE#1,M(J),W(J)
210 NEXT J
500 END
END-OF-FILE
```

APPENDIX IX

THE PROGRAM "LYNWT"

"LYNWT" is identical to "LYN" except that weighting factors are read in from the data file WEIGHT@D.

In the latest version the starting values for alpha and d_{50C} are read from the end of the data file for the run being studied.

Care should be taken to ensure that the data file containing the weighting factors is the correct one.

LISTING OF FILE B.LYNWT 08:37 P.M. MAR. 14, 1977

```
1 *THIS IS A SIMPLEX PROGRAM METHOD WRITTEN IN BASIC. IT MAY BE USED
2 *TO ESTIMATE CONSTANTS FOR THE CYCLONE EFF. CURVES
3 *BASIS IS LYNCH EQUATION
4 *X50, ALPHA SEARCHED FOR
5 *A WEIGHTING FACTOR IS USED AND ESTIMATES OF D50C AND ALPHA
6 *ARE READ FROM THE FILE GIVING THE EFFICIENCIES FOR THE RUN.
7 PRINT "THIS IS LYNWT"
10 DIM W(190),S(190)
11 DIM A(190)
12 DIM D(1,4),C(1,4),Q(5,4),X(5,4)
13 DIM M(190),E(190),G(190)
15 DATA 2
16 DATA 1, 2, 0.5
17 FILE STD3
18 FILE WEIGHT
19 FILE WTRES
20 READ N,A,V,B
25 READ#1,N6,N3,N4,B6,D1,V1,S1,P2
28 LET N2=N4-N3+1
30 FOR J=1 TO N2
32 READ#1,M(J),E(J),G(J)
34 NEXT J
36 MAT Q=ZER(N+1,N)
37 MAT X=ZER(N+1,N)
38 MAT Y=ZER(N+1,1)
39 MAT Z=ZER(1,N)
40 FOR J= N2 TO 1 STEP-1
41 IF E(J)<0.001 THEN 43
42 NEXT J
43 LET N1=J-INT(N2/29)-((J-INT(N2/29))-1-ABS(J-INT(N2/29)-1))/2
46 LET B7=1
47 LET B5=1
48 FOR J=1 TO N2
49 IF ABS(50-E(J))>(45-35*INT(N2/100)) THEN 52
50 IF ABS(50-E(J))>ABS(50-E(B5))  THEN 54
52 LET B5=J
53 NEXT J
54 READ#1,C(1,1)
55 LET C(1,1)=C(1,1)*100
56 LET D(1,1)=C(1,1)*0.002
57 FOR J=1 TO N2
58 IF ABS(M(J)-M(B5)*1.5)>ABS(M(B7)-M(B5)*1.5)  THEN 60
59 LET B7=J
60 NEXT J
61 LET C(1,2)=2*LOG(E(B7)/(100-E(B7)))
62 LET D(1,2)=C(1,2)*0.01
63 READ#1,C(1,2)
64 FOR J=1 TO N2
65 READ#2,S(J),W(J)
66 IF S(J)<>M(J) THEN 674
67 NEXT J
68 FOR J=1 TO N
69 FOR I=1 TO N+1
```

```
70 LET X(I,J)=C(1,J)-(2/(J+1))*D(1,J)
75 IF I=J+1 THEN 85
80 GO TO 88
85 LET X(I,J)=C(1,J)+((2/(J+1))*D(1,J))*J
88 NEXT I
90 FOR I=J+2 TO N+1
95 LET X(I,J)=C(1,J)
100 NEXT I
105 NEXT J
106 PRINT
107 PRINT "MATRIX X FOLLOWS. STARTING SIMPLEX: "
108 MAT PRINT X
109 PRINT"CYCLE","O.F.STD.ERROR","O.F.LOW VALUE","O.F
.HIGH"
110 * CALC STND ERROR OF OBJECTIVE FUNCTION
114 LET Z7=0
115 LET Z8=0
116 LET Z9=0
120 LET T3=1.E70
125 FOR I=1 TO N+1
130 LET H=I
135 GOSUB 560
140 LET Y(I,1)=Y1
145 NEXT I
150 GOSUB 600
155 T1=0
156 T2=0
160 FOR I=1 TO N+1
165 LET T1=T1+Y(I,1)
170 NEXT I
172 LET T1=T1/(N+1)
175 FOR I=1 TO N+1
176 LET T2=T2+(Y(I,1)-T1)**2
178 NEXT I
180 LET T= SQR(T2/N)
185 IF T> 1E-7 THEN 270
190 GO TO 205
195 PRINT
200 PRINT "CYCLE LIMIT. STOP CRITERION =";T3,T
201 PRINT "FAILED TO CONVERGE AFTER ";Z9;" ITERATIONS
. X MATRIX FOLLOWS "
202 PRINT
203 MAT PRINT X
204 GO TO 265
205 PRINT
210 PRINT "CONVERGENCE AFTER "; Z9 ;" CYCLES. T3, T =
";T3,T
212 PRINT
214 PRINT "RUN NUMBER: ";N6
216 PRINT "***************      "
218 PRINT
222 PRINT
224 LET X5=X(L,1)
226 PRINT "D50C= ";0.01*ABS(X5*1 +0.5);" MICRONS"
227 PRINT
228 LET A9=X(L,2)
230 PRINT "ALPHA= ";A9
231 PRINT
```

```
232 PRINT "SIZE","CALC. EFF. ","MEASURED" , "D/D50C",
" CALC. - MEAS."
234 FOR J=N1 TO N2
235 LET A(J)=100*(EXP(A9*M(J)/X5)-1)
236 LET A(J)=A(J)/(EXP(A9*M(J)/X5) + EXP(A9) -2)
240 PRINT M(J),A(J),E(J),M(J)/X5,A(J)-E(J)
245 NEXT J
246 *CALC. SUM OF SQUARES DUE TO ERROR
247 LET Z7=0
248 FOR J=N1 TO N2
249 LET Z7=Z7+ (E(J)-A(J))**2
250 NEXT J
252 PRINT "SUM OF SQUARES=";Z7
254 PRINT "VARIANCE=";Z7/(N2-N1+1-N)
260 WRITE#3,N6,X5/100,A9,Z7/(N2-N1+1-N)
263 PRINT
264 PRINT
265 STOP
270 IF Z9=300 THEN 273
271 IF Z9>700 THEN 195
272 GO TO 275
273 MAT PRINT X
274 GO TO 271
275 IF T>T3 THEN 295
280 LET T3=T
285 PRINT Z9,T ,Y(L,1) ,Y(H,1)
290 * REFLECTION
295 MAT Q=(1)*X
300 FOR J=1 TO N
305 LET P=0
310 FOR I=1 TO N+1
315 IF I=H THEN 325
320 LET P=P+X(I,J)/N
325 NEXT I
330 LET Z(1,J)=(1+A)*P-A*X(H,J)
335 LET X(H,J)=Z(1,J)
340 LET D(1,J)=P
345 NEXT J
350 GOSUB 560
355 MAT X=(1)*Q
360 LET Y=Y1
365 IF Y>=Y(L,1) THEN 410
370 * EXPANSION
375 FOR J=1 TO N
380 LET X(H,J)=(1+V)*Z(1,J)-V*D(1,J)
385 NEXT J
390 GOSUB 560
395 IF Y1>Y(L,1) THEN 415
400 LET Y(H,1)=Y1
405 GO TO 150
410 IF Y>Y(S,1) THEN 440
415 LET Y(H,1)=Y
420 FOR J=1 TO N
425 LET X(H,J)=Z(1,J)
430 NEXTJ
435 GO TO 150
440 IF Y>Y(H,1) THEN 465
445 FOR J=1 TO N
```

```
450 LET X(H,J)=Z(1,J)
455 NEXT J
457 LET Y(H,1)=Y
460 * CONTRACTION
465 FOR J=1 TO N
470 LET X(H,J)=B*X(H,J)+(1-B)*D(1,J)
475 NEXT J
480 GOSUB 560
485 IF Y1>Y(H,1) THEN505
490 LET Y(H,1)=Y1
495 GO TO 150
500 * REDUCE SIZE OF SIMPLEX
505 FOR J=1 TO N
510 FOR I=1 TO N+1
515 LET X(I,J)=(Q(I,J)+Q(L,J))/2
520 NEXT I
525 NEXT J
530 LET Z8=Z8+1
535 PRINT
540 PRINT "STEP CHANGE";Z8
545 PRINT
550 GO TO 125
555 *OBJECTIVE FUNCTION CALCULATION
560 LET S8=0
561 FOR K=N1 TO N2
562 LET Y7=100*(EXP(X(H,2)*M(K)/X(H,1))-1)
563 LET Y7=Y7/(EXP(X(H,2)*M(K)/X(H,1))+EXP(X(H,2))-2)
565 LET S8=S8 +W(K)*((E(K)-Y7)**2)
566 NEXT K
567 LET Z9=Z9+1
568 LET Y1=S8
570 RETURN
598 * CALC HIGH, 2ND HIGH, LOW, (SERCH2)
600 IF Y(1,1)>Y(2,1) THEN 615
605 S=1
606 L=1
607 H=2
610 GO TO 620
615 S=2
616 L=2
617 H=1
620 FOR I=3 TO N+1
625 IF Y(I,1)>Y(L,1) THEN 635
630 L=I
635 IF Y(I,1)<Y(S,1) THEN 665
640 IF Y(I,1)<Y(H,1) THEN 660
645 S=H
650 H=I
655 GO TO 665
660 S=I
665 NEXT I
670 RETURN
673 GO TO 675
674 PRINT "ERROR IN SIZE RUNN@D, WEIGHT@D GIVE ",M(J)
,S(J)
675 END
END-OF-FILE
```

```
$SIG RALU FORM=BLANK

RRRRRRRRRRR     AAAAAAAAAA    LL             UU          UU
RRRRRRRRRRRR   AAAAAAAAAAAA   LL             UU          UU
RR         RR  AA        AA   LL             UU          UU
RR         RR  AA        AA   LL             UU          UU
RR         RR  AA        AA   LL             UU          UU
RRRRRRRRRRRR   AAAAAAAAAAAA   LL             UU          UU
RRRRRRRRRRR    AAAAAAAAAAAA   LL             UU          UU
RR     RR      AA        AA   LL             UU          UU
RR      RR     AA        AA   LL             UU          UU
RR       RR    AA        AA   LL             UU          UU
RR        RR   AA        AA   LLLLLLLLLLLL   UUUUUUUUUUUU
RR         RR  AA        AA   LLLLLLLLLLLL    UUUUUUUUUU

**LAST SIGNON WAS: 10:37:15
 USER "RALU" SIGNED ON AT  11:45:37 ON FRI FEB 11/77
$RUN *BASIC
EXECUTION BEGINS
UBC BASIC SYSTEM
GET WEIGHT@D
 "WEIGHT(D)" HAS BEEN CREATED.
 1 295,8.292042E-2,301,9.965954E-2,308,0.1135801,315,0.1282506,322,0.1411801
 2 330,0.1602988,338,0.1903628,346,0.2310482,354,0.2823259,362,0.3535313,370
 3 0.4275185,379,1.000825,388,1.061777,397,2.514567,406,2.321932,415
 4 2.178723,425,2.124101,435,2.009806,445,2.192197,455,2.307377,466,2.787332
 5 477,2.994877,488,3.040036,499,2.703238,511,2.447293,523,2.316219,535
 6 2.175769,547,2.325353,560,2.045002,573,1.862149,586,1.65995,601,1.691893
 7 615,1.744487,629,1.949884,644,2.239412,659,2.469707,674,2.258023,690
 8 1.861831,706,1.491887,722,1.293745,739,1.264201,756,1.432423,774,1.649657
 9 792,1.806199,810,1.817447,829,1.869327,848,2.12663,868,2.643669,888
 10 3.448093,909,2.925587,930,1.929222,952,1.483023,974,1.643419,997
 11 2.262834,1020,2.456184,1044,1.888975,1068,1.411482,1093,1.250321,1118
 12 1.350085,1144,1.915953,1171,2.691489,1199,2.804723,1227,1.849388,1256
 13 0.8930986,1285,1.043757,1315,2.103111,1346,0.9078154,1377,0.6612419,1409
 14 0.6343517,1442,0.5807025,1476,0.5364002,1509,0.510053,1544,0.4982161
 15 1580,0.4945632,1617,0.4983092,1655,0.5255731,1694,0.5755588,1733
 16 0.6626093,1773,0.7194616,1814,0.7156418,1856,0.6545476,1900,0.5984084
```

```
18 0.5323924,2180,0.5599474,2231,0.5877674,2283,0.6117259,2336,0.5822392
17 1944,0.5719266,1989,0.5530041,2035,0.538395,2082,0.5234234,2130
19 2392,0.5240803,2448,0.4595101,2505,0.4229871,2563,0.4125256,2623
20 0.4243971,2684,0.4508761,2747,0.4669141,2811,0.4627042,2876,0.4634131
21 2943,0.5065903,3012,0.6580658,3082,0.9839923,3154,1.655335,3227,2.872056
22 3302,2.671873,3379,1.404164,3458,0.767372,3539,0.5103546,3621,0.3986988
23 3705,0.3569294,3791,0.3328987,3879,0.3221394,3969,0.3049064,4061
24 0.2439381,4156,0.1858632,4253,0.1496482,4352,0.1303634,4453,0.1186885
25 4557,0.1078405,4663,0.1007779,4773,9.963893E-2,4884,9.532144E-2,4998
26 0.0736723,5114,0.0454934,5233,2.630974E-2,5355,1.929748E-2,5480
27 1.487174E-2,5608,1.663638E-2,5739,1.715659E-2,5873,1.896732E-2,6009
28 2.171406E-2,6149,2.501844E-2,6292,2.927407E-2,6439,3.495914E-2,6589
29 4.233826E-2,6742,0.0508044,6899,5.468946E-2,7060,5.534098E-2,7224
30 5.956929E-2,7392,7.272368E-2,7565,8.854578E-2,7741,0.1070485,7921
31 0.1185186,8106,0.1379645,8295,0.1453829,8488,0.129486,8686,0.1136825
32 8888,0.0843052,9095,6.575692E-2,9307,5.217504E-2,9523,6.328038E-2,9745
33 0.1339139,9972,0.2211506
GET  RUN198D
1 19,120,273,5.963361E-2,2.65,1,0.35,1.9,295,-1.492982,4.559411,301
2 -1.346915,4.696767,308,-1.28656,4.753523,315,-1.09368,4.934901,322
3 -0.9924642,5.030081,330,-0.8313619,5.181576,338,-0.6814305,5.322567,346
4 -0.549553,5.44658,354,-0.4344352,5.554833,362,-0.2692265,5.71019,370
5 -0.1227196,5.84796,379,0.0140443,5.976568,388,8.247287E-2,6.040916,397
6 1.28961,7.176067,406,1.213689,7.19371,415,1.384619,7.26541,425,1.42074
7 7.299378,435,1.363186,7.245255,445,1.300362,7.186178,455,1.309467,7.19474
8 466,1.369268,7.250975,477,1.396683,7.276755,488,1.453833,7.330496,499
9 1.539354,7.410918,511,1.5087,7.382092,523,1.543206,7.41454,535,1.529553
10 7.401701,547,1.594185,7.462479,560,1.583638,7.452561,573,1.579364
11 7.448541,586,1.490153,7.364651,601,1.435458,7.313218,615,1.412089
12 7.291242,629,1.402566,7.282287,644,1.407528,7.286953,659,1.437418
13 7.31506,674,1.426112,7.304429,690,1.436281,7.313992,706,1.405456
14 7.285005,722,1.365515,7.247445,739,1.298043,7.183997,756,1.253696
15 7.142295,774,1.253595,7.142199,792,1.286975,7.17359,810,1.239876
16 7.129299,829,1.085486,6.984115,848,0.9250535,6.83325,868,0.8564061
17 6.768697,888,1.010414,6.91352,909,1.304562,7.190128,930,1.637671
18 7.503372,952,1.818127,7.673066,974,1.792079,7.648572,997,1.571104
19 7.440774,1020,1.336595,7.22025,1044,1.141406,7.036701,1068,1.069439
20 6.969026,1093,1.065798,6.965601,1118,1.151074,7.045792,1144,1.381578
21 7.26255,1171,1.609026,7.476436,1199,1.738094,7.597806,1227,1.542612
22 7.413981,1256,1.093592,6.99644,1285,1.18392,7.076679,1315,2.136331
23 7.972295,1346,1.615417,7.482444,1377,2.043517,7.885016,1409,1.776441
24 7.633866,1442,1.620382,7.487114,1476,1.57075,7.440442,1509,1.59001
25 7.458553,1544,1.66257,7.526786,1580,1.772327,7.629998,1617,1.874235
26 7.725828,1655,1.986049,7.830975,1694,2.118224,7.955268,1733,2.266747
27 8.094934,1773,2.413068,8.232529,1814,2.520481,8.333537,1856,2.584944
28 8.394155,1900,2.628533,8.435145,1944,2.62275,8.429707,1989,2.592596
29 8.401351,2035,2.571909,8.381898,2082,2.637957,8.444007,2130,2.836215
30 8.630442,2180,3.08396,8.863413,2231,3.278509,9.046361,2283,3.339749
31 9.103949,2336,3.289346,9.056551,2392,3.235306,9.005734,2448,3.248602
32 9.018237,2505,3.376527,9.138533,2563,3.59428,9.343301,2623,3.831363
33 9.566246,2684,4.020698,9.744291,2747,4.13345,9.850319,2811,4.269722
34 9.978464,2876,4.593236,10.28269,2943,5.180294,10.83474,3012,5.995006
35 11.60086,3082,6.839931,12.3954,3154,7.485893,13.00284,3227,7.859681
36 13.35434,3302,8.05777,13.54062,3379,8.201826,13.67608,3458,8.361452
37 13.82619,3539,8.570824,14.02308,3621,8.867809.14.30235,3705,9.334798
38 14.74149,3791,9.9944,15.36176,3879,10.79977,16.1191,3969,11.63308
39 16.90272,4061,12.37872,17.6039,4156,13.10788,18.28957,4253,14.09942
40 19.22199,4352,15.6159,20.64803,4453,17.66773,22.5775,4557,19.94945
41 24.72315,4663,22.10103,26.74643,4773,24.10179,28.62787,4884,26.23568
42 30.63451,4998,28.5005,32.76428,5114,30.47891,34.6247,5233,31.94183
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 43 36.00039,5355,34.27408,38.19355,5480,36.22309,40.02634,5608,40.92725
 44 44.44997,5739,45.00423,48.28382,5873,49.70916,52.70819,6009,54.655
 45 57.35909,6149,59.59327,62.00287,6292,64.30741,66.43589,6439,68.60854
 46 70.48052,6589,72.47106,74.11271,6742,75.84536,77.28578,6899,78.48339
 47 79.7665,7060,80.54387,81.70411,7224,82.42715,83.47508,7392,84.43581
 48 85.36396,7565,86.41364,87.22384,7741,88.34261,89.03778,7921,89.75727
 49 90.36808,8106,91.00978,91.5459,8295,91.69698,92.19212,8488,91.51347
 50 92.01955,8686,91.3001,91.8189,8888,90.74817,91.29989,9095,90.49581
 51 91.06258,9307,89.66769,90.28385,9523,90.3631,90.93778,9745,92.55603
 52 92.99994,9972,93.70405,94.0795
80              58.5
81              6.08
GET WTRES@D
 "WTRES(D)" HAS BEEN CREATED.
GET LYNWT
17 FILE RUN19
RUN
THIS IS LYNWT

MATRIX X FOLLOWS. STARTING SIMPLEX:
5838.3          6.049556
5861.7          6.049556
5850            6.140887
CYCLE           O.F.STD.ERROR   O.F.LOW VALUE   O.F.HIGH
3               8.797616        214.1055        230.5791
9               3.10409         175.5683        181.344
11              2.162836        172.3653        176.4846
13              2.002965        171.8832        175.5683
15              1.213292        170.0647        172.3653
19              0.7231571       168.7351        170.0647
21              0.2848779       168.3505        168.9069
25              0.1932525       167.9662        168.3505
27              8.264563E-2     167.9662        168.123
29              1.873843E-2     167.9662        167.9993
31              1.695531E-2     167.9375        167.9675
33              1.601797E-2     167.9375        167.9662
35              1.905401E-3     167.9357        167.9395
41              1.844827E-5     167.93          167.93
54              8.909434E-6     167.929         167.929
58              2.02855E-6      167.9289        167.929
60              1.997035E-6     167.9289        167.929
62              1.467361E-6     167.9289        167.9289
64              3.795479E-7     167.9289        167.9289
65              1.344831E-7     167.9289        167.9289

CONVERGENCE AFTER  71 CYCLES. T3, T =  1.344831E-7            8.002416E-8

RUN NUMBER:  19
***************

D50C=  58.91951 MICRONS

ALPHA=  5.470541

SIZE            CALC. EFF.      MEASURED        D/D50C          CALC. - MEAS.
330             0.1513238       -0.8313619      5.601337E-2     0.9826857
338             0.1555921       -0.6814305      5.737127E-2     0.8370226
346             0.159892        -0.549553       5.872917E-2     0.709445
354             0.1642235       -0.4344352      6.008707E-2     0.5986587
```

362	0.1685869	-0.2692265	6.144497E-2	0.4378134
370	0.1729825	-0.1227196	6.280287E-2	0.2957021
379	0.1779662	0.0140443	0.0643305	0.1639219
389	0.1829913	8.247287E-2	6.585814E-2	0.1005184
397	0.188058	1.28961	6.738578E-2	-1.101552
406	0.1931667	1.313689	6.891342E-2	-1.120522
415	0.1983178	1.384619	7.044105E-2	-1.136301
425	0.2040913	1.42074	7.213843E-2	-1.216649
435	0.209918	1.363186	0.0738358	-1.153268
445	0.2157983	1.300362	7.553318E-2	-1.084564
455	0.2217328	1.309467	7.723055E-2	-1.087734
466	0.2283239	1.369268	7.909766E-2	-1.140944
477	0.2349817	1.396683	8.096478E-2	-1.161701
488	0.241707	1.453833	8.283189E-2	-1.212126
499	0.2485005	1.539354	0.084699	-1.290854
511	0.25599	1.5087	8.673585E-2	-1.25271
523	0.2635623	1.543206	0.0887727	-1.279644
535	0.2712182	1.529553	9.080955E-2	-1.258335
547	0.2789588	1.594185	0.0928464	-1.315226
560	0.2874409	1.583638	9.505299E-2	-1.296197
573	0.2960246	1.579364	9.725957E-2	-1.283339
586	0.304711	1.490153	9.946616E-2	-1.185442
601	0.314863	1.435458	0.1020122	-1.120595
615	0.3244648	1.412089	0.1043885	-1.087624
629	0.3341903	1.402566	0.1067649	-1.068376
644	0.3447496	1.407528	0.1093109	-1.062778
659	0.3554547	1.437418	0.111857	-1.081963
674	0.3663076	1.426112	0.1144031	-1.059804
690	0.3780492	1.436281	0.1171189	-1.058232
706	0.3899637	1.405456	0.1198347	-1.015492
722	0.4020536	1.365515	0.1225505	-0.9634614
739	0.4150942	1.298043	0.125436	-0.8829488
756	0.4283388	1.253696	0.1282215	-0.8253572
774	0.4425883	1.253595	0.1313768	-0.8110067
792	0.4570738	1.286975	0.1344321	-0.8299012
810	0.4717992	1.239876	0.1374874	-0.7680768
829	0.487607	1.085486	0.1407124	-0.597879
848	0.5036911	0.9250535	0.1439374	-0.4213624
868	0.5209254	0.8564061	0.1473321	-0.3354807
888	0.5384765	1.010414	0.1507269	-0.4719375
909	0.5572525	1.304562	0.1542914	-0.7473095
930	0.576391	1.637671	0.1578559	-1.06128
952	0.596837	1.818127	0.1615901	-1.22129
974	0.6176962	1.792079	0.1653243	-1.174383
997	0.6399545	1.571104	0.1692283	-0.9311495
1020	0.6626829	1.336595	0.1731322	-0.6739121
1044	0.6869112	1.141406	0.1772059	-0.4544948
1068	0.7116734	1.069439	0.1812796	-0.3577656
1093	0.7380473	1.065798	0.1855231	-0.3277507
1118	0.7650261	1.151074	0.1897665	-0.3860479
1144	0.7937403	1.381578	0.1941797	-0.5878377
1171	0.8242835	1.609026	0.1987626	-0.7847425
1199	0.8567566	1.738094	0.2035152	-0.8813374
1227	0.890063	1.542612	0.2082679	-0.652549
1256	0.9254595	1.098592	0.2131903	-0.1731325
1285	0.9617958	1.18392	0.2181127	-0.2221242
1315	1.0004	2.136331	0.2232048	-1.135931
1346	1.041404	1.615417	0.2284666	-0.5740134
1377	1.083569	2.043517	0.2337285	-0.9599476
1409	1.128348	1.776441	0.2391601	-0.648093

1442	1.175896	1.620382	0.2447614	-0.4444856
1476	1.226384	1.57075	0.2505325	-0.3443664
1509	1.276882	1.59001	0.2561339	-0.3131277
1544	1.322101	1.66257	0.2620747	-0.3304694
1580	1.390732	1.772327	0.2681852	-0.3815947
1617	1.452994	1.874235	0.2744655	-0.4212411
1655	1.519118	1.986049	0.2809155	-0.466931
1694	1.589355	2.118224	0.2875353	-0.5288689
1732	1.662077	2.266747	0.294155	-0.6046704
1773	1.739332	2.413068	0.3009445	-0.6737364
1814	1.82142	2.520481	0.3079038	-0.6990615
1856	1.908663	2.584944	0.3150328	-0.6762811
1900	2.003608	2.628533	0.3225012	-0.624925
1944	2.102317	2.62275	0.3299697	-0.5204327
1989	2.20731	2.592596	0.3376078	-0.3852855
2035	2.319021	2.571909	0.3454158	-0.2528881
2082	2.437915	2.637957	0.3533934	-0.2000415
2130	2.564497	2.836215	0.3615408	-0.2717183
2180	2.702117	3.08396	0.3700277	-0.3818427
2231	2.848801	3.278509	0.3786843	-0.4297083
2283	3.005198	3.339749	0.3875107	-0.3345511
2336	3.17201	3.289346	0.3965067	-0.117336
2392	3.356744	3.235306	0.406012	0.1214376
2448	3.550577	3.248602	0.4155173	0.3019746
2505	3.757636	3.376527	0.4251924	0.3811092
2563	3.978897	3.59428	0.4350372	0.3846174
2623	4.21952	3.931363	0.4452214	0.3881566
2684	4.476947	4.020698	0.4555754	0.4562493
2747	4.756993	4.13345	0.4662688	0.6235428
2811	5.056931	4.269722	0.477132	0.7872094
2876	5.37825	4.593236	0.488165	0.7850144
2943	5.727903	5.180294	0.4995374	0.5476095
3012	6.108508	5.995006	0.5112493	0.1135015
3082	6.516922	6.839931	0.5231309	-0.3230088
3154	6.961562	7.485893	0.535352	-0.524331
3227	7.439017	7.859681	0.5477428	-0.4206637
3302	7.958819	8.05777	0.5604731	-9.895148E-2
3379	8.524791	8.201826	0.5735429	0.3229649
3458	9.141069	8.361452	0.5869522	0.7796169
3539	9.812105	8.570824	0.6007009	1.241281
3621	10.5336	8.867809	0.6146194	1.665795
3705	11.31859	9.334798	0.6288773	1.983791
3791	12.17235	9.9944	0.6434748	2.177948
3879	13.10045	10.79977	0.6584117	2.300677
3969	14.1087	11.63308	0.673688	2.475616
4061	15.2031	12.37872	0.6893039	2.824383
4156	16.4028	13.10788	0.7054289	3.294919
4253	17.70251	14.09942	0.7218935	3.603087
4352	19.10838	15.6159	0.7386975	3.492483
4453	20.62633	17.66773	0.755841	2.958598
4557	22.27811	19.94945	0.7734937	2.328659
4663	24.05395	22.10103	0.7914859	1.952916
4773	25.99385	24.10179	0.810157	1.892061
4884	28.04883	26.23568	0.8289978	1.813153
4998	30.25685	28.5005	0.8483479	1.756346
5114	32.59874	30.47891	0.8680375	2.119834
5233	35.09245	31.94183	0.8882362	3.150619
5355	37.73392	34.27408	0.9089442	3.459844
5480	40.51568	36.22309	0.9301614	4.29259
5608	43.42644	40.92725	0.9518878	2.499188

5739	46.45093	45.00423	0.9741234	1.446696
5873	49.56987	49.70916	0.9968682	-0.139292
6009	52.73696	54.655	1.019952	-1.918041
6149	55.97253	59.59327	1.043716	-3.620739
6292	59.22427	64.30741	1.067988	-5.083145
6439	62.4833	68.60854	1.09294	-6.125241
6589	65.69488	72.47106	1.1184	-6.77618
6742	68.82794	75.84536	1.14437	-7.017418
6899	71.87219	78.48339	1.171019	-6.611201
7060	74.79781	80.54387	1.198347	-5.74606
7224	77.56235	82.42715	1.226184	-4.864796
7392	80.16304	84.43581	1.254699	-4.272765
7565	82.59672	86.41364	1.284064	-3.816919
7741	84.8241	88.34261	1.313938	-3.518505
7921	86.85419	89.75727	1.344491	-2.903078
8106	88.69553	91.00978	1.375892	-2.314246
8295	90.34008	91.69698	1.407972	-1.356904
8488	91.7955	91.51347	1.440732	0.2820323
8686	93.07842	91.3001	1.47434	1.77832
8888	94.19376	90.74817	1.508627	3.445588
9095	95.16015	90.49581	1.543762	4.664337
9307	95.99045	89.66769	1.579747	6.322758
9523	96.69514	90.3631	1.61641	6.332041
9745	97.29418	92.55603	1.654092	4.738154
9972	97.79714	93.70405	1.692622	4.093093

```
SUM OF SQUARES= 705.6993
VARIANCE= 4.800675

STOP!
 AT LINE "265" IN PRØGRAM "LYNWT"
 PRØGRAM ENDS
LIST WTRESØD
1 19,58.91451,5.470541,4.800675
END-ØF-FILE
MTS


$SIG
```

APPENDIX X

THE PROGRAM "MURU"

The program "MURU" uses the simplex search method to find the values of alpha, d_{50C}, d_0 and bypass which give the best fit to the efficiency curve proposed by Mular and Runnels:-

$$\text{Raw efficiency, } Y_x = \frac{(e^{\alpha} - e^{\alpha\, d_0/d_{50}})\, B + e^{\alpha\, d/d_{50}} - e^{\alpha\, d_0/d_{50}}}{e^{\alpha} + e^{\alpha\, d/d_{50}} - 2e^{\alpha\, d_0/d_{50}}}$$

Only line 17 needs to be altered to give the file of run number under consideration. Again care should be taken to ensure that the data file WEIGHT@D contains the correct set of weighting factors.

LISTING OF FILE B.MURU   08:37 P.M.   MAR. 14, 1977

```
1 *THIS IS A SIMPLEX PROGRAM METHOD WRITTEN IN BASIC.
 IT MAY BE USED
2 *TO ESTIMATE CONSTANTS FOR THE CYCLONE EFF. CURVES
3 *BASIS IS GENERAL EQUATION OF MULAR AND RUNNELS
4 *D50,ALPHA,D ZERO,& NEW BYPASS SEARCHED FOR
5 *WEIGHTING FACTORS ARE USED & ESTIMATES OF D50C & A
LPHA
6 *ARE READ FROM THE MAIN FILE
7 PRINT "THIS IS MURU"
8 PRINT "************"
11 DIM A(190)
12 DIM D(1,4),C(1,4),Q(5,4),X(5,4)
13 DIM M(190),E(190),G(190)
14 DIM W(190),S(190)
15 DATA 4
16 DATA 1, 2, 0.5
17 FILE STD3
18 FILE WEIGHT
19 FILE WTRES
25 READ N,A,V,B
30 READ#1 ,N6,N3,N4,B6,D1,V1,S1,P2
32 LET N2=N4-N3+1
34 FOR J=1 TO N2
36 READ #1,M(J),E(J),G(J)
38 NEXT J
40 MAT X= ZER(N+1,N)
41 MAT Z= ZER(1,N)
42 MAT Y= ZER(N+1,1)
43 MAT Q=ZER(N+1,N)
44 LET C(1,3)=B6
45 LET D(1,3)=C(1,3)*0.002 +0.0002
46 LET N1=1
54 READ#1,C(1,1)
55 LET C(1,1)=C(1,1)*100
56 LET D(1,1)=C(1,1)*0.002
57 LET C(1,4)=10
58 LET D(1,4)=50
61 READ#1,C(1,2)
62 LET D(1,2)=C(1,2)*0.01
63 PRINT
64 FOR J=1 TO N2
65 READ#2,S(J),W(J)
66 IF S(J)<>M(J) THEN 674
67 NEXT J
68 FOR J=1 TO N
69 FOR I=1 TO N+1
70 LET X(I,J)=C(1,J)-(2/(J+1))*D(1,J)
75 IF I=J+1 THEN 85
80 GO TO 88
85 LET X(I,J)=C(1,J)+((2/(J+1))*D(1,J))*J
88 NEXT I
90 FOR I=J+2 TO N+1
95 LET X(I,J)=C(1,J)
100 NEXT I
105 NEXT J
106 PRINT
107 PRINT "MATRIX X FOLLOWS. STARTING SIMPLEX: "
108 MAT PRINT X
```

```
109 PRINT"CYCLE","O.F.STD.ERROR","O.F.LOW VALUE","O.F.HIGH"
110 *CALC STND ERROR OF OBJECTIVE FUNCTION
114 LET Z7=0
115 LET Z8=0
116 LET Z9=0
120 LET T3=1.E70
125 FOR I=1 TO N+1
130 LET H=I
135 GOSUB 560
140 LET Y(I,1)=Y1
145 NEXT I
150 GOSUB 600
155 T1=0
156 T2=0
160 FOR I=1 TO N+1
165 LET T1=T1+Y(I,1)
170 NEXT I
172 LET T1=T1/(N+1)
175 FOR I=1 TO N+1
176 LET T2=T2+(Y(I,1)-T1)**2
178 NEXT I
180 LET T= SQR(T2/N)
185 IF T> 1E-3 THEN 270
190 GO TO 205
195 PRINT
200 PRINT "CYCLE LIMIT. STOP CRITERION =";T3,T
201 PRINT "FAILED TO CONVERGE AFTER ";Z9;" ITERATIONS. X MATRIX FOLLOWS "
202 PRINT
203 MAT PRINT X
204 GO TO 265
205 PRINT
210 PRINT "CONVERGENCE AFTER "; Z9 ;" CYCLES. T3, T = ";T3,T
212 PRINT
214 PRINT "RUN NUMBER: ";N6
216 PRINT "***************     "
218 PRINT
220 PRINT"X ZERO= ";INT(X(L,4)+.5)/100;" MICRONS.  NEW BYPASS=";X(L,3)
222 PRINT
224 LET X5=X(L,1)
226 PRINT "X50C= ";INT(X5+.5)/100;" MICRONS "
227 PRINT
228 LET A9=X(L,2)
230 PRINT "ALPHA= ";A9
231 PRINT
232 PRINT "SIZE","CALC. EFF. ","MEASURED" , "D/D50C"," CALC. - MEAS."
234 FOR J=1 TO N2
235 LETA(J)=(EXP(X(L,2))-EXP(X(L,2)*X(L,4)/X(L,1)))*X(L,3)
236 LET A(J)=A(J)+EXP(X(L,2)*M(J)/X(L,1))-EXP(X(L,2)*X(L,4)/X(L,1))
237 LET A(J)=100*A(J)/(EXP(X(L,2))+EXP(X(L,2)*M(J)/X(L,1))-2*EXP(X(L,2)*X(L,4)/X(L,1)))
240 PRINT M(J),A(J),G(J),M(J)/X5,A(J)-G(J)
```

```
245 NEXT J
246 *CALC. SUM OF SQUARES DUE TO ERROR
247 LET Z7=0
248 FOR J=1 TO N2
249 LET Z7=Z7+(G(J)-A(J))**2
250 NEXT J
252 PRINT "SUM OF SQUARES=";Z7
254 PRINT "VARIANCE=";Z7/(N2-N1+1-N)
255 PRINT"N1=";N1
256 PRINT
260 WRITE#3,N6,INT(X5+.5)/100,A9,INT(X(L,4)+.5)/100,I
NT(X(L,3)*10000+.5)/10000
261 PRINT
263 PRINT "FILE HAS: RUN#,D50C,ALPHA,D ZERO,NEW BYPAS
S,OLD,VARIANCE"
264 PRINT
265 STOP
270 IF Z9=300 THEN 273
271 IF Z9>700 THEN 195
272 GO TO 275
273 MAT PRINT X
274 GO TO 271
275 IF T>T3 THEN 295
280 LET T3=T
285 PRINT Z9,T  ,Y(L,1)  ,Y(H,1)
290 * REFLECTION
295 MAT Q=(1)*X
300 FOR J=1 TO N
305 LET P=0
310 FOR I=1 TO N+1
315 IF I=H THEN 325
320 LET P=P+X(I,J)/N
325 NEXT I
330 LET Z(1,J)=(1+A)*P-A*X(H,J)
335 LET X(H,J)=Z(1,J)
340 LET D(1,J)=P
345 NEXT J
350 GOSUB 560
355 MAT X=(1)*Q
360 LET Y=Y1
365 IF Y>=Y(L,1) THEN 410
370 * EXPANSION
375 FOR J=1 TO N
380 LET X(H,J)=(1+V)*Z(1,J)-V*D(1,J)
385 NEXT J
390 GOSUB 560
395 IF Y1>Y(L,1) THEN 415
400 LET Y(H,1)=Y1
405 GO TO 150
410 IF Y>Y(S,1) THEN 440
415 LET Y(H,1)=Y
420 FOR J=1 TO N
425 LET X(H,J)=Z(1,J)
430 NEXTJ
435 GO TO 150
440 IF Y>Y(H,1) THEN 465
445 FOR J=1 TO N
450 LET X(H,J)=Z(1,J)
```

```
455 NEXT J
457 LET Y(H,1)=Y
460 *CONTRACTION
465 FOR J=1 TO N
470 LET X(H,J)=B*X(H,J)+(1-B)*D(1,J)
475 NEXT J
480 GOSUB 560
485 IF Y1>Y(H,1) THEN505
490 LET Y(H,1)=Y1
495 GO TO 150
500 * REDUCE SIZE OF SIMPLEX
505 FOR J=1 TO N
510 FOR I=1 TO N+1
515 LET X(I,J)=(Q(I,J)+Q(L,J))/2
520 NEXT I
525 NEXT J
530 LET Z8=Z8+1
535 PRINT
540 PRINT "STEP CHANGE";Z8
545 PRINT
550 GO TO 125
555 *OBJECTIVE FUNCTION CALCULATION
560 LET S8=0
561 FOR K=1 TO N2
562 LET Y7=(EXP(X(H,2))-EXP(X(H,2)*X(H,4)/X(H,1)))*X(
H,3)
563 LET Y7=Y7 + EXP(X(H,2)*M(K)/X(H,1))-EXP(X(H,2)*X(
H,4)/X(H,1))
564 LET Y7=100*Y7/(EXP(X(H,2))+EXP(X(H,2)*M(K)/X(H,1)
)-2*EXP(X(H,2)*X(H,4)/X(H,1)))
565 LET S8=S8+W(K)*((G(K)-Y7)**2)*EXP(SQR(ABS(X(H,4))
-X(H,4)))
566 NEXT K
567 LET Z9=Z9+1
568 LET Y1=S8
570 RETURN
598 * CALC HIGH, 2ND HIGH, LOW, (SERCH2)
600 IF Y(1,1)>Y(2,1) THEN 615
605 S=1
606 L=1
607 H=2
610 GO TO 620
615 S=2
616 L=2
617 H=1
620 FOR I=3 TO N+1
625 IF Y(I,1)>Y(L,1) THEN 635
630 L=I
635 IF Y(I,1)<Y(S,1) THEN 665
640 IF Y(I,1)<Y(H,1) THEN 660
645 S=H
650 H=I
655 GO TO 665
660 S=I
665 NEXT I
670 RETURN
674 PRINT "ERROR IN SIZING BETWEEN FILES"
675 END
```

RFS NO. 129678 UNIVERSITY OF B C COMPUTING CENTRE MTS(EP256)

$SIG RALU FORM=BLANK C=400 T=60SEC

```
RRRRRRRRRRR    AAAAAAAAAA    LL            UU         UU
RRRRRRRRRRRR  AAAAAAAAAAAA   LL            UU         UU
RR        RR  AA        AA   LL            UU         UU
RR        RR  AA        AA   LL            UU         UU
RR        RR  AA        AA   LL            UU         UU
RRRRRRRRRRRR  AAAAAAAAAAAA   LL            UU         UU
RRRRRRRRRRR   AAAAAAAAAAAA   LL            UU         UU
RR     RR     AA        AA   LL            UU         UU
RR      RR    AA        AA   LL            UU         UU
RR       RR   AA        AA   LL            UU         UU
RR        RR  AA        AA   LLLLLLLLLLLL  UUUUUUUUUUUUU
RR        RR  AA        AA   LLLLLLLLLLLL    UUUUUUUUUU
```

```
**LAST SIGNON WAS: 12:21:29
 USER "RALU" SIGNED ON AT  12:23:07 ON WED MAR 09/77
$RUN *BASIC
EXECUTION BEGINS
UBC BASIC SYSTEM
GET WEIGHT@D
 1 295,8.292042E-2,301,9.965954E-2,308,0.1135801,315,0.1282506,322,0.1411801
 2 330,0.1602988,338,0.1903628,346,0.2310482,354,0.2823259,362,0.3535313,370
 3 0.4275185,379,1.000825,388,1.061777,397,2.514567,406,2.321932,415
 4 2.178723,425,2.124101,435,2.009806,445,2.192197,455,2.307377,466,2.787332
 5 477,2.994877,488,3.040036,499,2.703238,511,2.447293,523,2.316219,535
 6 2.175769,547,2.325353,560,2.045002,573,1.862149,586,1.65995,601,1.691893
 7 615,1.744487,629,1.949884,644,2.239412,659,2.469707,674,2.258023,690
 8 1.861831,706,1.491887,722,1.293745,739,1.264201,756,1.432423,774,1.649657
 9 792,1.806199,810,1.817447,829,1.869327,848,2.12663,868,2.643669,888
 10 3.448093,909,2.925587,930,1.929222,952,1.483023,974,1.643419,997
 11 2.262834,1020,2.456184,1044,1.888975,1068,1.411482,1093,1.250321,1118
 12 1.350085,1144,1.915953,1171,2.691489,1199,2.804723,1227,1.849388,1256
 13 0.8930986,1285,1.043757,1315,2.103111,1346,0.9078154,1377,0.6612419,1409
 14 0.6343517,1442,0.5807025,1476,0.5364002,1509,0.510053,1544,0.4982161
 15 1580,0.4945632,1617,0.4983092,1655,0.5255731,1694,0.5755588,1733
 16 0.6626093,1773,0.7194616,1814,0.7156418,1856,0.6545476,1900,0.5984084
 18 0.5323924,2180,0.5599474,2231,0.5877674,2283,0.6117259,2336,0.5822392
```

```
17 1944,0.5719266,1989,0.5530041,2035,0.538395,2082,0.5234234,2130
19 2392,0.5240803,2448,0.4595101,2505,0.4229871,2563,0.4125256,2623
20 0.4243971,2684,0.4508761,2747,0.4669141,2811,0.4627042,2876,0.4634131
21 2943,0.5065903,3012,0.6580658,3082,0.9839923,3154,1.655335,3227,2.872056
22 3302,2.671873,3379,1.404164,3458,0.767372,3539,0.5103546,3621,0.3986988
23 3705,0.3569294,3791,0.3328987,3879,0.3221394,3969,0.3049064,4061
24 0.2489381,4156,0.1858632,4253,0.1496482,4352,0.1303634,4453,0.1186885
25 4557,0.1078405,4663,0.1007779,4773,9.963893E-2,4884,9.532144E-2,4998
26 0.0736723,5114,0.0454934,5233,2.630974E-2,5355,1.929748E-2,5480
27 1.487174E-2,5608,1.663638E-2,5739,1.715659E-2,5873,1.896732E-2,6009
28 2.171406E-2,6149,2.501844E-2,6292,2.927407E-2,6439,3.495914E-2,6589
29 4.233826E-2,6742,0.0508044,6899,5.468946E-2,7060,5.534098E-2,7224
30 5.956929E-2,7392,7.272368E-2,7565,8.354578E-2,7741,0.1070485,7921
31 0.1185186,8106,0.1379645,8295,0.1453829,8488,0.129486,8686,0.1136825
32 8888,0.0843052,9095,6.575692E-2,9307,5.217504E-2,9523,6.328038E-2,9745
33 0.1339139,9972,0.2211506
GET  RUN19ØD
1 19,120,273,5.963361E-2,2.65,1,0.35,1.9,295,-1.492982,4.559411,301
2 -1.346915,4.696767,308,-1.28656,4.753523,315,-1.09368,4.934901,322
3 -0.9924642,5.030081,330,-0.8313619,5.181576,338,-0.6814305,5.322567,346
4 -0.549553,5.44658,354,-0.4344352,5.554833,362,-0.2692265,5.71019,370
5 -0.1227196,5.84796,379,0.0140443,5.976568,388,8.247287E-2,6.040916,397
6 1.28961,7.176067,406,1.313689,7.19871,415,1.384619,7.26541,425,1.42074
7 7.299373,435,1.363186,7.245255,445,1.300362,7.186178,455,1.309467,7.19474
8 466,1.369268,7.250975,477,1.396683,7.276755,488,1.453833,7.330496,499
9 1.539354,7.410918,511,1.5087,7.382092,523,1.543206,7.41454,535,1.529553
10 7.401701,547,1.594185,7.462479,560,1.583638,7.452561,573,1.579364
11 7.448541,586,1.490153,7.364651,601,1.435458,7.313218,615,1.412089
12 7.291242,629,1.402566,7.282287,644,1.407528,7.286953,659,1.437418
13 7.31506,674,1.426112,7.304429,690,1.436281,7.313992,706,1.405456
14 7.285005,722,1.365515,7.247445,739,1.298043,7.183997,756,1.253696
15 7.142295,774,1.253595,7.142199,792,1.286975,7.17359,810,1.239876
16 7.129299,829,1.085486,6.984115,848,0.9250535,6.83325,868,0.8564061
17 6.768697,888,1.010414,6.91352,909,1.304562,7.190128,930,1.637671
18 7.503372,952,1.818127,7.673066,974,1.792079,7.648572,997,1.571104
19 7.440774,1020,1.336595,7.22025,1044,1.141406,7.036701,1068,1.069439
20 6.969026,1093,1.065798,6.965601,1118,1.151074,7.045792,1144,1.381578
21 7.26255,1171,1.609026,7.476436,1199,1.738094,7.597306,1227,1.542612
22 7.413981,1256,1.098592,6.99644,1285,1.18392,7.076679,1315,2.136331
23 7.972295,1346,1.615417,7.482444,1377,2.043517,7.885016,1409,1.776441
24 7.633866,1442,1.620382,7.487114,1476,1.57075,7.440442,1509,1.59001
25 7.458553,1544,1.66257,7.526786,1580,1.772327,7.629998,1617,1.874235
26 7.725828,1655,1.986049,7.830975,1694,2.118224,7.955268,1733,2.266747
27 8.094934,1773,2.413068,8.232529,1814,2.520481,8.333537,1856,2.584944
28 8.394155,1900,2.628533,8.435145,1944,2.62275,8.429707,1989,2.592596
29 8.401351,2035,2.571909,8.381898,2082,2.637957,8.444007,2130,2.836215
30 8.630442,2180,3.08396,8.863413,2231,3.278509,9.046361,2283,3.339749
31 9.103949,2336,3.289346,9.056551,2392,3.235306,9.005734,2448,3.248602
32 9.018237,2505,3.376527,9.138533,2563,3.59428,9.343301,2623,3.831363
33 9.566246,2684,4.020698,9.744291,2747,4.13345,9.850319,2811,4.269722
34 9.978464,2876,4.593236,10.28269,2943,5.180294,10.83474,3012,5.995006
35 11.60086,3082,6.839931,12.3954,3154,7.485893,13.00284,3227,7.859681
36 13.35434,3302,8.05777,13.54062,3379,8.201826,13.67608,3458,8.361452
37 13.82619,3539,8.570824,14.02308,3621,8.867809,14.30235,3705,9.334798
38 14.74149,3791,9.9944,15.36176,3879,10.79977,16.1191,3969,11.63308
39 16.90272,4061,12.37872,17.6039,4156,13.10788,18.28957,4253,14.09942
40 19.22199,4352,15.6159,20.64803,4453,17.66773,22.5775,4557,19.94945
41 24.72315,4663,22.10103,26.74643,4773,24.10179,28.62787,4884,26.23568
42 30.63451,4998,28.5005,32.76428,5114,30.47891,34.6247,5233,31.94183
43 36.00039,5355,34.27408,38.19355,5480,36.22309,40.02634,5608,40.92725
```

```
 44 44.44997,5739,45.00423,48.28382,5873,49.70916,52.70819,6009,54.655
 45 57.35909,6149,59.59327,62.00287,6292,64.30741,66.43589,6439,68.60854
 46 70.48052,6589,72.47106,74.11271,6742,75.84536,77.28578,6899,78.48339
 47 79.7665,7060,80.54387,81.70411,7224,82.42715,83.47508,7392,84.43581
 48 85.36396,7565,86.41364,87.22384,7741,88.34261,89.03778,7921,89.75727
 49 90.36808,8106,91.00978,91.5459,8295,91.69698,92.19212,8488,91.51347
 50 92.01955,8686,91.3001,91.8189,8888,90.74817,91.29989,9095,90.49581
 51 91.06258,9307,89.66769,90.28385,9523,90.3631,90.93778,9745,92.55603
 52 92.99994,9972,93.70405,94.0795
80              58.5
81              6.08
GET WTRES@D
 "WTRES(D)" HAS BEEN CREATED.
GET MURU
17 FILE RUN19
RUN
THIS IS MURU
************


MATRIX X FOLLOWS. STARTING SIMPLEX:
5838.3          6.039467        5.947398E-2     -10
5861.7          6.039467        5.947398E-2     -10
5850            6.161067        5.947398E-2     -10
5850            6.08            6.011251E-2     -10
5850            6.08            5.963361E-2     90
CYCLE           O.F.STD.ERROR   O.F.LOW VALUE   O.F.HIGH
5               7620.065        201.6545        18565.04
9               7039.068        151.4008        15908.39
10              20.15549        151.4008        201.6545
12              11.25957        135.9007        165.69
13              9.824518        135.9007        159.7962
16              8.300127        129.0285        151.4008
17              5.714441        129.0285        142.1449
38              5.615161        55.58821        69.36869
40              2.862014        55.58821        63.14399
42              1.071445        55.58821        58.4512
44              0.8166528       55.58821        57.81402
46              0.6107038       55.58821        57.13022
48              0.522921        55.58821        56.98332
49              0.4243126       55.58821        56.62084
57              0.2658212       53.81211        54.44059
66              0.2275553       52.92332        53.4977
68              0.2112718       52.92332        53.44283
70              0.170338        52.92332        53.32758
72              0.1122291       52.92332        53.21872
73              4.356468E-2     52.92332        53.03589
77              4.162653E-2     52.90949        53.00431
78              2.765721E-2     52.90949        52.97793
80              1.548664E-2     52.88455        52.92332
81              0.0138243       52.88455        52.92012
87              1.171087E-2     52.87508        52.90481
89              4.069025E-3     52.87456        52.88455
91              2.880425E-3     52.87371        52.87989
93              2.601567E-3     52.87249        52.87935
95              1.496411E-3     52.87143        52.87508
97              1.465473E-3     52.87113        52.87456
99              1.123561E-3     52.8711         52.87371

CONVERGENCE AFTER  101 CYCLES. T3, T =  1.123561E-3          6.047651E-4
```

RUN NUMBER: 19
****

X ZERO= 1.09 MICRONS. NEW BYPASS= 6.985402E-2

X50C= 58.92 MICRONS

ALPHA= 6.039038

SIZE	CALC. EFF.	MEASURED	D/D50C	CALC. - MEAS.
295	7.037687	4.559411	5.007164E-2	2.478276
301	7.039541	4.696767	5.109005E-2	2.342774
308	7.041718	4.753523	5.227819E-2	2.288195
315	7.043911	4.934901	5.346633E-2	2.10901
322	7.046119	5.030081	5.465447E-2	2.016038
330	7.048662	5.181576	5.601234E-2	1.867086
338	7.051226	5.322567	5.737022E-2	1.728659
346	7.053811	5.44658	5.872809E-2	1.607231
354	7.056417	5.554833	6.008597E-2	1.501584
362	7.059044	5.71019	6.144384E-2	1.348854
370	7.061693	5.84796	6.280172E-2	1.213733
379	7.064699	5.976568	6.432933E-2	1.088131
388	7.067732	6.040916	6.585694E-2	1.026816
397	7.070794	7.176067	6.738455E-2	-0.1052734
406	7.073883	7.19871	6.891216E-2	-0.1248268
415	7.077001	7.26541	7.043976E-2	-0.1884089
425	7.080499	7.299378	7.213711E-2	-0.2188788
435	7.084033	7.245255	7.383445E-2	-0.161222
445	7.087603	7.186178	0.0755318	-9.857504E-2
455	7.091209	7.19474	7.722914E-2	-0.1035306
466	7.095219	7.250975	7.909622E-2	-0.1557559
477	7.099274	7.276755	0.0809633	-0.177481
488	7.103374	7.330496	8.283037E-2	-0.2271216
499	7.107521	7.410918	8.469745E-2	-0.303397
511	7.112098	7.382092	8.673426E-2	-0.2699943
523	7.116731	7.41454	8.877108E-2	-0.2978093
535	7.12142	7.401701	9.080789E-2	-0.2802805
547	7.126168	7.462479	0.0928447	-0.3363112
560	7.131377	7.452561	9.505125E-2	-0.3211844
573	7.136655	7.448541	0.0972578	-0.3118864
586	7.142003	7.364651	9.946434E-2	-0.2226482
601	7.148262	7.313218	0.1020104	-0.1649558
615	7.154191	7.291242	0.1043866	-0.1370509
629	7.160205	7.282287	0.1067629	-0.1220822
644	7.166744	7.286953	0.1093089	-0.1202093
659	7.173383	7.31506	0.111855	-0.141677
674	7.180124	7.304429	0.114401	-0.1243048
690	7.187429	7.313992	0.1171167	-0.1265631
706	7.194853	7.285005	0.1198325	-9.015185E-2
722	7.202399	7.247445	0.1225482	-4.504603E-2
739	7.210552	7.183997	0.1254337	0.0265548
756	7.218846	7.142295	0.1283192	7.655146E-2
774	7.227786	7.142199	0.1313744	8.558736E-2
792	7.236891	7.17359	0.1344296	6.330097E-2
810	7.246163	7.129299	0.1374848	0.1168643
829	7.256136	6.984115	0.1407098	0.272021
848	7.266303	6.83325	0.1439347	0.4330527
868	7.277218	6.768697	0.1473294	0.5085211
888	7.288357	6.91352	0.1507241	0.3748369

909	7.300298	7.190128	0.1542885	0.1101701
930	7.312496	7.503372	0.157853	-0.1908761
952	7.325556	7.673066	0.1615871	-0.3475103
974	7.33891	7.648572	0.1653213	-0.3096624
997	7.353192	7.440774	0.1692252	-8.758197E-2
1020	7.367811	7.22025	0.1731291	0.1475606
1044	7.383432	7.036701	0.1772027	0.3467306
1068	7.399436	6.969026	0.1812763	0.4304101
1093	7.416525	6.965601	0.1855197	0.4509245
1118	7.434052	7.045792	0.189763	0.3882599
1144	7.452755	7.26255	0.1941761	0.1902047
1171	7.472703	7.476436	0.198759	-3.732568E-3
1199	7.493973	7.597806	0.2035115	-0.103833
1227	7.515852	7.413981	0.2082641	0.1018707
1256	7.539172	6.99644	0.2131864	0.5427321
1285	7.563184	7.076679	0.2181087	0.4865049
1315	7.588773	7.972295	0.2232007	-0.3835224
1346	7.616038	7.482444	0.2284625	0.1335945
1377	7.644168	7.885016	0.2337242	-0.2408483
1409	7.674138	7.633866	0.2391557	0.0402725
1442	7.706071	7.487114	0.244757	0.2189575
1476	7.740097	7.440442	0.2505279	0.2996553
1509	7.774251	7.458553	0.2561292	0.3156977
1544	7.81173	7.526786	0.2620699	0.2849438
1580	7.851675	7.629998	0.2681803	0.221677
1617	7.894257	7.725828	0.2744605	0.1684288
1655	7.93966	7.830975	0.2809104	0.1086849
1694	7.988084	7.955268	0.28753	3.281641E-2
1733	8.03843	8.094934	0.2941497	-5.650415E-2
1773	8.092139	8.232529	0.300939	-0.1403898
1814	8.149456	8.333537	0.3078982	-0.1840813
1856	8.210643	8.394155	0.315027	-0.1835121
1900	8.277539	8.435145	0.3224953	-0.1576056
1944	8.347418	8.429707	0.3299636	-8.228916E-2
1989	8.422102	8.401351	0.3376017	2.075118E-2
2035	8.501957	8.381898	0.3454094	0.1200586
2082	8.587376	8.444007	0.353387	0.1433689
2130	8.678789	8.630442	0.3615342	4.834663E-2
2180	8.778706	8.863413	0.3700209	-0.0847067
2231	8.885794	9.046361	0.3786774	-0.160567
2283	9.000621	9.103949	0.3875036	-0.1033282
2336	9.123804	9.056551	0.3964995	6.725339E-2
2392	9.261047	9.005734	0.4060046	0.2553127
2448	9.405946	9.018237	0.4155097	0.3877093
2505	9.56171	9.138533	0.4251846	0.423177
2563	9.72923	9.343301	0.4350292	0.3859288
2623	9.912618	9.566246	0.4452133	0.3463716
2684	10.11015	9.744291	0.4555671	0.3658631
2747	10.32656	9.850319	0.4662603	0.4762378
2811	10.56001	9.978464	0.4771233	0.5815428
2876	10.81194	10.28269	0.4881561	0.5292502
2943	11.08816	10.83474	0.4995283	0.253424
3012	11.39119	11.60086	0.5112399	-0.2096686
3082	11.71897	12.3954	0.5231213	-0.6764302
3154	12.07876	13.00284	0.5353422	-0.9240845
3227	12.46835	13.35434	0.5477328	-0.8859932
3302	12.89615	13.54062	0.5604629	-0.6444748
3379	13.36607	13.67608	0.5735324	-0.3100084
3458	13.88243	13.82619	0.5869415	5.623791E-2
3539	14.44992	14.02308	0.6006899	0.4268392

3621	15.06589	14.30235	0.6146082	0.7635433
3705	15.74255	14.74149	0.6288659	1.001064
3791	16.48577	15.36176	0.643463	1.124008
3879	17.30183	16.1191	0.6583996	1.182728
3969	18.19743	16.90272	0.6736757	1.294709
4061	19.17963	17.6039	0.6892913	1.575733
4156	20.26766	18.28957	0.7054161	1.978088
4253	21.45892	19.22199	0.7218803	2.236928
4352	22.7612	20.64803	0.738684	2.113168
4453	24.18218	22.5775	0.7558272	1.604682
4557	25.74473	24.72315	0.7734795	1.021583
4663	27.44208	26.74643	0.7914714	0.6956504
4773	29.31514	28.62787	0.8101422	0.6872672
4884	31.31882	30.63451	0.8289827	0.684311
4998	33.49179	32.76428	0.8483324	0.7275118
5114	35.81664	34.6247	0.8680216	1.19194
5233	38.31198	36.00039	0.88822	2.311588
5355	40.97405	38.19355	0.9089276	2.780496
5480	43.79463	40.02634	0.9301444	3.768286
5608	46.76053	44.44997	0.9518704	2.31056
5739	49.85329	48.28382	0.9741056	1.569473
5873	53.04916	52.70819	0.99685	0.3409744
6009	56.29565	57.35909	1.019934	-1.063441
6149	59.6078	62.00287	1.043697	-2.395067
6292	62.92578	66.43589	1.067969	-3.510113
6439	66.23409	70.48052	1.09292	-4.246432
6589	69.47109	74.11271	1.11838	-4.641615
6742	72.60054	77.28578	1.144349	-4.685241
6899	75.60822	79.7665	1.170997	-4.158279
7060	78.46204	81.70411	1.198325	-3.242072
7224	81.12006	83.47508	1.226161	-2.355016
7392	83.58095	85.36396	1.254676	-1.783013
7565	85.84403	87.22384	1.284041	-1.379812
7741	87.87699	89.03778	1.313914	-1.160785
7921	89.69383	90.36808	1.344466	-0.6742546
8106	91.30816	91.5459	1.375867	-0.2377432
8295	92.71947	92.19212	1.407947	0.5273481
8488	93.94137	92.01955	1.440705	1.921821
8686	94.99453	91.8189	1.474313	3.175628
8888	95.88942	91.29939	1.508599	4.589532
9095	96.64704	91.06258	1.543734	5.584459
9307	97.28285	90.28385	1.579718	6.998999
9523	97.80983	90.93778	1.61638	6.872048
9745	98.2472	92.99994	1.654061	5.247262
9972	98.60563	94.0795	1.692591	4.526133

```
SUM OF SQUARES= 446.4563
VARIANCE= 2.976375
N1= 1

FILE HAS: RUN#,D50C,ALPHA,D ZERO,NEW BYPASS,OLD,VARIANCE

STOP!
 AT LINE "265" IN PRØGRAM "MURU"
 PRØGRAM ENDS
LIST WTRES@D
1 19,58.92,6.039038,1.09,0.0699
END-ØF-FILE
MTS
```

APPENDIX XI

THE PLOTTING PROGRAMS

In order to format the data for the plotting it was decided to use a WATFIV language program to read in the unformatted data to produce formatted data in an MTS file or on punched cards. The program used for the punching of formatted data onto cards is listed.

This formatted data was then used as the data for the FORTRAN language plotting programs. This program plots a solid line through every second measured efficiency value and then draws a dashed curve representing the fit equation. The run number and values of the alpha, d_{50C}, d_0 and bypass are also recorded by the plotter.

The plotting program is a considerably modified version of an example given in the manual for the UBC plot routines. Because the size axis is on a log scale it was decided to modify the program to give uneven tics on the X-axis.

The plot file produced by the plotting routines was directed to the permanent disc file RUNPLOT. This was useful for previewing the plots using the Tektronix storage scope plot previewing facility.

```
$SIG RALU FORM=BLANK CARDS=200

RRRRRRRRRRR      AAAAAAAAAA     LL                UU          UU
RRRRRRRRRRRR   AAAAAAAAAAAA   LL                UU          UU
RR          RR   AA          AA   LL                UU          UU
RR          RR   AA          AA   LL                UU          UU
RR          RR   AA          AA   LL                UU          UU
RRRRRRRRRRRR   AAAAAAAAAAAA   LL                UU          UU
RRRRRRRRRRR    AAAAAAAAAAAA   LL                UU          UU
RR     RR        AA          AA   LL                UU          UU
RR      RR       AA          AA   LL                UU          UU
RR       RR      AA          AA   LL                UU          UU
RR        RR     AA          AA   LLLLLLLLLLLL   UUUUUUUUUUUU
RR          RR   AA          AA   LLLLLLLLLLLL     UUUUUUUUUU
```

```
**LAST SIGNON WAS: 17:43:47
 USER "RALU" SIGNED ON AT  17:50:54 ON WED FEB 09/77
$RUN *BASIC
EXECUTION BEGINS
UBC BASIC SYSTEM
GET  RUN29@D
 "RUN29(D)" HAS BEEN CREATED.
 1 29,120,273,0.0462537,2.65,1,0.35,1.9,295,6.513179,10.83729,301,6.008086
 2 10.35556,308,5.603847,9.970018,315,5.416627,9.791458,322,5.160395
 3 9.547078,330,4.98524,9.380025,338,4.694416,9.102652,346,4.347084,8.771385
 4 354,4.00879,8.448739,362,3.748481,8.20047,370,3.550358,8.011511,379
 5 2.215863,6.738741,388,2.311935,6.83037,397,2.312583,6.830988,406,2.345878
 6 6.862742,415,2.333248,6.850697,425,2.29553,6.814724,435,2.302563,6.821431
 7 445,2.253898,6.775017,455,2.249921,6.771224,466,2.16977,6.69478,477
 8 2.122687,6.649875,488,2.088739,6.617497,499,2.105548,6.633528,511,2.0994
 9 6.627665,523,2.151336,6.677199,535,2.206811,6.730108,547,2.26069,6.781495
 10 560,2.369064,6.884856,573,2.468745,6.979927,586,2.540793,7.048642,601
 11 2.489405,6.999631,615,2.396894,6.911399,629,2.275266,6.795397,644
 12 2.191468,6.715475,659,2.169499,6.694522,674,2.238341,6.760179,690
 13 2.375915,6.89139,706,2.515161,7.024195,722,2.555086,7.062274,739
 14 2.468893,6.980068,756,2.291883,6.811245,774,2.148189,6.674198,792
 15 2.072082,6.601611,810,2.107829,6.635704,829,2.159098,6.684602,848
 16 2.172073,6.696977,868,2.145215,6.671361,888,2.087651,6.61646,909
```

```
17 2.105105,6.633106,930,2.124571,6.651672,952,2.159757,6.68523,974
18 2.215998,6.73887,997,2.273047,6.793281,1020,2.377755,6.893145,1044
19 2.508802,7.018131,1068,2.633637,7.137192,1093,2.653496,7.156132,1118
20 2.573713,7.08004,1144,2.394393,6.909013,1171,2.286895,6.806488,1199
21 2.327596,6.845306,1227,2.588859,7.094485,1256,3.016545,7.502389,1285
22 3.116635,7.59785,1315,3.010249,7.496384,1346,3.590202,8.049512,1377
23 4.079153,8.515847,1409,4.124944,8.55952,1442,4.233038,8.662614,1476
24 4.355712,8.779614,1509,4.462163,8.881142,1544,4.548842,8.963812,1580
25 4.613739,9.025707,1617,4.666458,9.075987,1655,4.686855,9.09544,1694
26 4.669071,9.078479,1733,4.608465,9.020677,1773,4.612449,9.024476,1814
27 4.722186,9.129138,1856,4.924102,9.321714,1900,5.120855,9.509367,1944
28 5.227728,9.611296,1989,5.273225,9.654689,2035,5.299211,9.679473,2082
29 5.381569,9.758022,2130,5.509098,9.879652,2180,5.660644,10.02419,2231
30 5.828719,10.18449,2283,5.958228,10.30801,2336,6.126671,10.46866,2392
31 6.341512,10.67356,2448,6.633381,10.95193,2505,6.930932,11.23572,2563
32 7.194699,11.48729,2623,7.380282,11.66429,2684,7.462638,11.74283,2747
33 7.459538,11.73988,2811,7.458767,11.73914,2876,7.593655,11.86779,2943
34 7.908987,12.16854,3012,8.300779,12.54221,3082,8.596734,12.82447,3154
35 8.711589,12.93402,3227,8.720916,12.94291,3302,8.788181,13.00707,3379
36 9.017743,13.22601,3458,9.421568,13.61116,3539,10.02264,14.18443,3621
37 10.85725,14.98044,3705,11.96477,16.03673,3791,13.17947,17.19524,3879
38 14.15781,18.12833,3969,14.72296,18.66734,4061,15.07623,19.00427,4156
39 15.71245,19.61106,4253,16.94271,20.78442,4352,18.5439,22.31154,4453
40 20.02064,23.71998,4557,21.16814,24.8144,4663,22.50206,26.08662,4773
41 24.75162,28.23214,4884,28.11549,31.44042,4998,32.25599,35.3894,5114
42 36.57442,39.50809,5233,40.71668,43.45875,5355,44.86397,47.41421,5480
43 49.33323,51.67676,5608,54.03894,56.16481,5739,58.6827,60.59378,5873
44 63.05866,64.76733,6009,67.2735,68.78722,6149,71.51224,72.82991,6292
45 75.57178,76.70168,6439,79.14992,80.11431,6589,82.29472,83.11365,6742
46 84.9664,85.66176,6899,87.47825,88.05743,7060,89.55703,90.04006,7224
47 91.12238,91.533,7392,92.20637,92.56685,7565,93.37011,93.67677,7741
48 94.54707,94.79929,7921,95.59131,95.79523,8106,96.51958,96.68056,8295
49 97.18839,97.31844,8488,97.05357,97.18985,8686,96.99199,97.13112,8888
50 97.28105,97.50219,9095,98.04796,98.13824,9307,98.32724,98.40461,9523
51 98.11155,98.1989,9745,97.81195,97.91316,9972,98.15209,98.23757
90              54.7
81              6.43
GET OUTPUT
5 DIM A(11)
10 FILE RUN29
20 FILE RUN35
30 FILE RUN37
40 FILE RUN38
50 FILE RUN47
200 FOR L=1 TO 9
210 FOR J=1 TO 8
220 READ#L,A(J)
230 NEXT J
231 LET N3=A(2)
232 LET N4=A(3)
240 LET N2=N4-N3+1
250 PRINT N2
260 FOR J=1 TO N2
270 READ#L,B,C,D
280 PRINT B,C,D
300 NEXT J
320 READ#L,D5
330 READ#L,A9
340 PRINT D5,A9,A(4)
360 PRINT A(1)
```

```
500 NEXT L
900 END
SAVE
DØNE
EXECUTION TERMINATED
NEXT CARD IS
MTS


$EDIT -FILE
01
1 LINE
STOP


$RUN *WATFIV
EXECUTION BEGINS
                INTEGER B,E
                DO 300 KK=1,9
                READ,NUMB
                PUNCH 19,NUMB
        19      FORMAT (I6)
        29      FORMAT(I6,2F8.4,I6,2F8.4)
        59      FORMAT (3F8.4)
                NUMB=NUMB/2
                DO 200 I=1,NUMB
                READ,B,C,D
                READ,E,F,G
                PUNCH 29,B,C,D,E,F,G
        200     CONTINUE
                READ,D5C,ALPHA,BYPASS
                PUNCH 59,D5C,ALPHA,BYPASS
                READ, NRUN
                PUNCH 19,NRUN
        300     CONTINUE
                STOP
                END

        $DATA
```

```
$SIG RALU FORM=BLANK

RRRRRRRRRRR      AAAAAAAAAA     LL             UU          UU
RRRRRRRRRRRRR  AAAAAAAAAAAA   LL             UU          UU
RR          RR  AA          AA  LL             UU          UU
RR          RR  AA          AA  LL             UU          UU
RR          RR  AA          AA  LL             UU          UU
RRRRRRRRRRRRR  AAAAAAAAAAAA   LL             UU          UU
RRRRRRRRRRRR   AAAAAAAAAAAA   LL             UU          UU
RR      RR      AA          AA  LL             UU          UU
RR       RR     AA          AA  LL             UU          UU
RR        RR    AA          AA  LL             UU          UU
RR         RR   AA          AA  LLLLLLLLLLLL  UUUUUUUUUUUU
RR          RR  AA          AA  LLLLLLLLLLLL    UUUUUUUUUU

**LAST SIGNON WAS: 10:33:58
 USER "RALU" SIGNED ON AT  10:37:15 ON FRI FEB 11/77
$CREATE RUNPLOT
FILE ALREADY EXISTS
$EMPTY RUNPLOT
DONE.
$RUN *FTN
EXECUTION BEGINS
```

```
MICHIGAN TERMINAL SYSTEM FORTRAN G(41336)          MAIN          02-11-77          10:37:18          PAGE P001
               C
               C  SAMPLE PLOT PROGRAM
               C
               C*** DECLARE ARRAY TO HOLD THE DATA
  0001               DIMENSION X(300),Y(300)
  0002               COMMON ALPHA,D5C
  0003               COMMON NRUN
               C*** READ IN THE DATA
  0004         1     N=0
  0005               READ 19,NUM
  0006         19    FORMAT(I6)
  0007         29    FORMAT (F6.0,2F8.4)
  0008               IF (NUM.EQ.0) GO TO 300
  0009               NUM=NUM/2
  0010               DO 100 I=1,NUM
  0011               READ 29,X(I),Z,Y(I)
  0012               X(I)=ALOG10(X(I)/100.)
  0013         100   N=I
               C*** IF EQUAL TO ZERO TERMINATE PROGRAM
  0014         200   IF(N.EQ.0) GO TO 300
               C*** CALL SUBROUTINE TO DO THE PLOTTING
  0015               CALL SUMFUN(X,Y,N)
               C*** AND RETURN FOR MORE DATA
  0016               GO TO 1
               C*** PROGRAM COMES HERE WHEN FINISHED
  0017         300   CONTINUE
               C*** TERMINATE PLOTTING THEN STOP
  0018               CALL PLCTND
  0019               STOP
  0020               END
   *OPTIONS IN EFFECT*  ID,EBCDIC,SOURCE,NOLIST,NODECK,LOAD,NOMAP
   *OPTIONS IN EFFECT*  NAME = MAIN     , LINECNT =      60
   *STATISTICS*    SOURCE STATEMENTS =        20,PROGRAM SIZE =      3000
   *STATISTICS*  NO DIAGNOSTICS GENERATED
NO ERRORS IN MAIN
```

```
      SUBROUTINE SUMFUN(X,Y,N)
C***  MODIFIED SUBROUTINE DRAWS LINE THROUGH N POINTS-LOG SIZE X AXIS
      DIMENSION Z(300)
      DIMENSION XX(2),YY(2)
      DIMENSION X(N),Y(N)
C***  CALCULATE EFFICIENCY FROM LYNCH'S MODEL
      READ 69,D5C,ALPHA,DZERO,BYPS
69    FORMAT(4F8.4)
      READ 19,NRUN
19    FORMAT (I6)
49    FORMAT (2F8.4)
      DO 1000 J=1,N
      XR=((10.)**(X(J)))/D5C
      XZ=DZERO/D5C
      Z(J)=BYPS*(EXP(ALPHA)-EXP(ALPHA*XZ))+EXP(ALPHA*XR)-EXP(ALPHA*XZ)
      Z(J)=Z(J)/(EXP(ALPHA)+EXP(ALPHA*XR)-2*EXP(ALPHA*XZ))
      Z(J)=100*Z(J)
1000    CONTINUE
C***  FIRST SCALE THE POINTS.
      YMIN=0.
      ZMIN=0.
      DY=10.
      DZ=10.
      DO 700 I=1,N
      X(I)=5*X(I)
700   CONTINUE
      DO 1200 J=1,N
      Y(J)=(Y(J)-YMIN)/DY
      Z(J)=(Z(J)-ZMIN)/DZ
1200  CONTINUE
C***  NOW PLOT THE AXES
      XX(1)=0.
      YY(1)=0.
      XX(2)=10.
      YY(2)=0.
      CALL LINE(XX,YY,2,1)
      CALL SYMBOL(3.5,-0.45,0.140,'SIZE (MICRONS)',0.0,14)
      CALL SYMBOL(0.,-0.27,0.10,'1',0.,1)
      DO 800 I=1,9
      AI=I
      XTIC=(ALOG10(AI))*5
      CALL SYMBOL(XTIC,0.,0.100,14,0.,-1)
800   CONTINUE
      CALL SYMBOL (4.9,-0.27,0.10,'10',0.,2)
      DO 900 I=10,100,10
      AI=I
      XTIC=(ALOG10(AI))*5
      CALL SYMBOL (XTIC,0.,0.100,14,0.,-1)
900   CONTINUE
      CALL SYMBOL (9.8,-0.27,0.10,'100',0.,3)
      CALL AXIS(0.,0.,'PERCENT EFFICIENCY',18,10.,90.,YMIN,DY)
C***  PLOT THE RUN NUMBER
      CALL SYMBOL(0.5,9.,0.28,'RUN NO:',0.,7)
      ARUN=NRUN
      CALL NUMBER (2.3,9.0,0.28,ARUN,0.,-1)
      CALL SYMBOL (0.5,8.5,0.14,'D50C(MICRONS):',0.,14)
      CALL NUMBER(2.40,8.50,0.14,D5C,0.,2)
      CALL SYMBOL (0.5,8.0,0.14,'ALPHA:',0.,6)
```

```
MICHIGAN TERMINAL SYSTEM FORTRAN G(41336)          SUMFUN          02-11-77          10:37:18          PAGE P002
   0054              CALL NUMBER (1.40,8.0,0.14,ALPHA,0.,2)                                             89.000
   0055              CALL SYMBOL(0.5,7.5,0.14,'BYPASS:',0.,7)                                           90.000
   0056              CALL NUMBER(1.5,7.5,0.14,BYPS,0.,3)                                                91.000
   0057              CALL SYMBOL(0.5,7.0,0.14,'DO(MICRONS):',0.,12)                                     92.000
   0058              CALL NUMBER(2.0,7.0,0.14,DZERO,0.,2)                                               93.000
               C*** FINALLY PLOT THE LINES                                                              94.000
   0059              CALL LINE(X,Y,N,1)                                                                 95.000
   0060              CALL DASHLN(0.2,0.1,0.2,0.1)                                                       96.000
   0061              CALL PLOT (X(1),Z(1),3)                                                            97.000
   0062              DO 1100 J=2,N                                                                      98.000
   0063              CALL PLOT (X(J),Z(J),4)                                                            99.000
   0064        1100  CONTINUE                                                                          100.000
               C*** MOVE THE ORIGIN AND RETURN                                                         101.000
   0065              CALL PLOT(12.0,0.,-3)                                                             102.000
   0066              RETURN                                                                            103.000
   0067              END                                                                               104.000
  *OPTIONS IN EFFECT*  ID,EBCDIC,SOURCE,NOLIST,NODECK,LOAD,NOMAP
  *OPTIONS IN EFFECT*  NAME = SUMFUN   , LINECNT =       60
  *STATISTICS*    SOURCE STATEMENTS =        67,PROGRAM SIZE =      3788
  *STATISTICS*  NO DIAGNOSTICS GENERATED
NO ERRORS IN SUMFUN

NO STATEMENTS FLAGGED IN THE ABOVE COMPILATIONS.


NAME       NUMBER OF ERRORS/WARNINGS  SEVERITY

MAIN                     0                   0
SUMFUN                   0                   0
EXECUTION TERMINATED



$RUN -LOAD 9=RUNPLOT
EXECUTION BEGINS
PLOTTING WILL TAKE APPROX.    2 MIN.   1 SEC. AND   15 INCHES OF PAPER.
MAXIMUM Y VALUE IS APPROX.   10 INCHES.
  0 MIN   46 SEC, OR  38% OF TOTAL PLOT TIME IS WITH PEN UP.
SUCCESSFUL PLOT.
EXECUTION TERMINATED



$RUN PLOT:Q PAR=RUNPLOT
EXECUTION BEGINS
00652023  QUEUED FOR SMALL  BLANK   PAPER
TOTAL PLOT TIME    1 MIN.   56 SEC.
EXECUTION TERMINATED



$SIG
```

APPENDIX XII

MULTIPLE LINEAR REGRESSION

The relevant experimental data and values of d_{50C}, alpha, etc. were punched onto cards and manipulated into a formatted data matrix suitable for a wide range of combinations of $\log_{10}$ or linear forms of the independent and dependent variables. A few special functional forms of the variables were also included because of their potential usefulness based on the literature survey or intuition.

The relationship between these variables was studied using UBC TRP. This is a new version of the triangular regression program of UBC TRIP which is still being developed by the computer centre. It may be of interest to note that UBC TRIP is currently used 23 times a day at UBC, on average.

The STPREG control card is the key to using this program for various combinations of dependent and independent variables. Columns 31 to 80 on this card will be punched with:-

a) blank or "0" (zero) if a variable is to be ignored.
b) "1" if a variable is to be included as an independent variable if it is significant at the significances level specified in columns 19-21 (default value 0.05).
c) "2" if the variable is to be a dependent variable.
d) "3" if the variable is to be included in the regression equation regardless of its significance.

Full details of the TRP program package are available from the UBC computing centre.

The names of the variables used in the program TRP are:-

RUN = run number
ALPHA = alpha
LOGD50 = $\log_{10}$ (d_{50C})
LOGDZ = LOG_{10} (d_0)
BYPASS = fraction of feed solids which bypasses classification
WATUF = fraction of feedwater recovered in the underflow
VORTEX = vortex finder diameter in inches
SPIGOT = spigot diameter in inches
USGPM = feed slurry flowrate in US gallons per minute
FE%SOL = percent by weight of solids in the feed slurry
HEIGHT = free vortex height in the cyclone
FE50 = size in microns through which 50% of the calculated cyclone feed passes.
VSPLIT = ratio of slurry volume in the underflow to that in the overflow
TEMP = slurry temperature in ^{o}C
LGALPH = $\log_{10}$ (ALPHA)
LGBPS = $\log_{10}$ (BYPASS)
LOGWUF = $\log_{10}$ (WATUF)
LOGVTX = $\log_{10}$ (VORTEX)
LGSPIG = $\log_{10}$ (SPIGOT)
LUSGPM = $\log_{10}$ (USGPM)
LGFEPS = $\log_{10}$ (FE%SOL)
LGHT = $\log_{10}$ (HEIGHT)
LGFE50 = $\log_{10}$ (FE50)
LGS = $\log_{10}$ (VSPLIT)
LGTEMP = $\log_{10}$ (TEMP)
FEFVOL = volume fraction of solids in the feed
LGS/V = $\log_{10}$ (SPIGOT/VORTEX)
LGVSAR = $\log_{10}$ (SPIGOT^2 + VORTEX^2)
1-RV = one minus volume recovery to the underflow
LOGHFT = $\log_{10}$ (inlet pressure head in feet of slurry)
LGPSIG = $\log_{10}$ (cyclone inlet pressure in p.s.i.g.)

LGHT/Q = $\log_{10}$ (HEIGHT/USGPM)

SUFG/S = underflow solids flow in grams per second

UF%S = underflow percent solids by weight

OF%S = overflow percent solids by weight

LUSGPS = $\log_{10}$ (SUFG/S)

CONRFN = 1/((1-FEFVOL) USGPM)

CONRFS = CONRFN * SPIGOT

```
$SIG RALU PAGES=300 TIME=60 FORM=BLANK

RRRRRRRRRRR     AAAAAAAAAA    LL              UU          UU
RRRRRRRRRRRRR  AAAAAAAAAAAA   LL              UU          UU
RR          RR  AA          AA  LL              UU          UU
RR          RR  AA          AA  LL              UU          UU
RR          RR  AA          AA  LL              UU          UU
RRRRRRRRRRRR  AAAAAAAAAAAA   LL              UU          UU
RRRRRRRRRRR   AAAAAAAAAAAA   LL              UU          UU
RR     RR       AA          AA  LL              UU          UU
RR      RR      AA          AA  LL              UU          UU
RR       RR     AA          AA  LL              UU          UU
RR        RR    AA          AA  LLLLLLLLLLLL  UUUUUUUUUUUU
RR          RR  AA          AA  LLLLLLLLLLLL    UUUUUUUUUU

**LAST SIGNON WAS: 10:07:00
 USER "RALU" SIGNED ON AT  10:07:19 ON FRI FEB 25/77
$RUN *TRP 4=DAT3
A FILE EXISTS CONTAINING THE *FMT SOURCE OF THE DOCUMENTATION
FOR UBC TRP. IT IS NOT A FINAL TEXT - INDEED, IT IS IN THE
PROCESS OF BEING EDITED FOR FUTURE PUBLICATION. HOWEVER, IF YOU
ARE INTERESTED IN OBTAINING INFORMATION ON THIS FILE, PLEASE
CALL THE PROGRAM LIBRARIAN AT 4966. *** N.B. *** IT WILL BE
NECESSARY TO RUN THIS FILE WITH *FMT UNDER YOUR ID. SOURCE=83 PAGES.
EXECUTION BEGINS
***** ATTENTION TRP USER
      THERE ARE INCONSISTENCIES REGARDING PLOT OPTIONS IN
      SIMREG AND STPREG ROUTINES BETWEEN TECHNICAL NOTE TN6
      AND THE TRP MANUAL WHICH IS THE MOST UP-TO-DATE DOCU-
      MENTATION FOR THE TRP PROGRAM. THIS MANUAL IS A FIRST
      DRAFT AND DOES NOT CONTAIN FORMULAE AND GRAPHS BUT
      IS USEFUL NEVERTHELESS FOR SETTING UP TRP CONTROL CARDS.
      FOR A COPY OF THIS MANUAL, PLEASE SUBMIT THE FOLLOWING
      JOB:
         $SIGNON YOURID P=200 FORM=8X11 PRINT=TN T=1M PRIO=L
         YOURPW
         $RUN *FMT SCARDS=VOLC:TRP
         $SIGNOFF
```

```
TRP IMPLEMENTATION 28/10/75

CONTROL CARDS
        5   10   15   20   25   30   35   40   45   50   55   60   65   70   75   80
    ....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|
 1. INMSDC 38 1      3     1 1         2
 2. TITLE RESULTS WITH MURU + WEIGHTING FACTOR
 3. STPREG  5  1      .05      3    2 111111111
 4. STPREG  5  1      .05      3  0                  1 1   1 1  2
 5. STPREG  5  1      .05      3      21   1 1
 6. STPREG  5  1      .05      3  0    11  1 11 2 11  1 1  1 11    11
 7. STPREG  5  1      .05      3   11       1     2   1   1           11
 8. STPREG  5  1      .05      3    1                     11       2 1
 9. STPREG  5  1      .05      3         2                         1 1
10. END
    ....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|
```

CONTROL CARD NO. 1 ** INMSDC **** INMSDC **** INMSDC **** INMSDC **** INMSDC **** INMSDC **** INMSDC ** CONTROL CARD NO. 1
FORMAT CARDS
(7F8.4/7F8.4/7F8.4/7F8.4/7F8.4/3F8.4)

INPUT DATA

	RUN HEIGHT LGFEPS LGPSIG	ALPHA FE50 LGHT LGHT/Q	LGD50 VSPLIT LGFE50 UFSG/S	LOGDZ TEMP LGS UF%SOL	BYPASS LGALPH LGTEMP OF%SOL	WATUF LOGBPS FEFVOL LUSG/S	VORTEX LOGWUF LGS/V CONRFN	SPIGOT LOGVTX LGVSAR CONRFS	USGPM LGSPIG 1-RV	FE%SOL LUSGPM LOGHFT
1	11.00	4.110	1.435	0.7084	0.3920E-01	0.3280E-01	0.7500	0.2300	10.45	10.98
1	22.00	24.40	0.5360E-01	19.00	0.6138	-1.407	-1.484	-0.1249	-0.6383	1.019
1	1.041	1.342	1.387	-1.271	1.279	0.4450E-01	-0.5133	-0.2108	0.9491	0.5089
1	0.1761	0.3233	34.12	62.29	6.670	1.533	0.1001	0.2300E-01		
2	12.00	7.440	1.637	0.3201	0.1680E-01	0.1870E-01	1.250	0.1600	18.03	10.34
2	22.00	20.70	0.2700E-01	21.00	0.8716	-1.775	-1.728	0.9690E-01	-0.7959	1.256
2	1.014	1.342	1.316	-1.569	1.322	0.4170E-01	-0.8928	0.2009	0.9737	0.6964
2	0.3617	0.8640E-01	24.99	55.03	8.600	1.398	0.5790E-01	0.9300E-02		
3	13.00	5.250	1.312		0.2140E-01	0.3200E-01	0.7500	0.3800	31.65	9.970
3	22.00	23.20	0.5690E-01	25.00	0.7202	-1.670	-1.495	-0.1249	-0.4202	1.500
3	0.9987	1.342	1.365	-1.245	1.398	0.4010E-01	-0.2953	-0.1506	0.9462	1.540
3	1.204	-0.1580	122.2	66.59	4.630	2.087	0.3290E-01	0.1250E-01		
4	14.00	5.950	1.328	-0.4318	0.3500E-01	0.3390E-01	1.250	0.3900	40.87	11.11
4	22.00	23.20	0.6100E-01	29.00	0.7745	-1.456	-1.470	0.9690E-01	-0.4089	1.611
4	1.046	1.342	1.365	-1.215	1.462	0.4500E-01	-0.5058	0.2342	0.9425	1.479
4	1.146	-0.2690	171.6	67.26	5.420	2.234	0.2560E-01	0.1000E-01		
5	15.00	5.346	1.928	1.132	0.3830E-01	0.3690E-01	0.7500	0.1600	8.060	49.30
5	22.00	19.00	0.5140E-01	33.00	0.7280	-1.417	-1.433	-0.1249	-0.7959	0.9063
5	1.693	1.342	1.279	-1.289	1.518	0.2684	-0.6709	-0.2305	0.9511	0.2044
5	0.0	0.4361	29.50	68.25	48.11	1.470	0.1696	0.2710E-01		
6	16.00	3.210	1.975	0.9576	0.3610E-01	0.4470E-01	1.250	0.1800	8.230	49.29
6	22.00	13.10	0.5930E-01	31.00	0.5065	-1.442	-1.350	0.9690E-01	-0.7447	0.9154
6	1.693	1.342	1.117	-1.227	1.491	0.2684	-0.8416	0.2027	0.9440	-0.1740E-01
6	-0.2218	0.4270	32.04	65.39	48.16	1.506	0.1661	0.2990E-01		
7	17.00	4.550	1.899	-0.3150E-01	0.6630E-01	0.5550E-01	0.7500	0.2800	18.53	49.56
7	22.00	22.90	0.8500E-01	26.00	0.6580	-1.179	-1.256	-0.1249	-0.5528	1.268
7	1.695	1.342	1.360	-1.071	1.415	0.2705	-0.4279	-0.1932	0.9217	0.9815
7	0.7782	0.7450E-01	117.4	71.28	47.22	2.070	0.7400E-01	0.2070E-01		
8	18.00	5.160	1.937	0.5911	0.2610E-01	0.2800E-01	1.250	0.2600	21.90	49.78
8	22.00	15.60	0.4160E-01	28.00	0.7126	-1.583	-1.553	0.9690E-01	-0.5850	1.340
8	1.697	1.342	1.193	-1.381	1.447	0.2722	-0.6819	0.2122	0.9601	0.9015
8	0.6990	0.2000E-02	71.59	71.81	48.63	1.855	0.6270E-01	0.1630E-01		
9	19.00	6.040	1.770	0.3740E-01	0.6980E-01	0.5960E-01	1.000	0.3500	13.26	30.28
9	19.50	24.90	0.8710E-01	22.00	0.7810	-1.156	-1.225	0.0	-0.4559	1.123
9	1.481	1.290	1.396	-1.060	1.342	0.1408	-0.4559	0.5020E-01	0.9199	0.5516
9	0.2788	0.1675	64.10	59.93	26.85	1.807	0.8780E-01	0.3070E-01		
10	21.00	5.310	1.433	0.3560	0.3110E-01	0.2900E-01	0.7500	0.1600	9.890	9.980
10	17.00	23.40	0.4770E-01	23.00	0.7251	-1.507	-1.538	-0.1249	-0.7959	0.9952
10	0.9991	1.230	1.369	-1.321	1.362	0.4020E-01	-0.6709	-0.2305	0.9545	0.5399

10	0.2041	0.2353	29.33	62.85	5.990	1.467	0.1053	0.1690E-01		
11	22.00	7.370	1.554	0.3636	0.3500E-01	0.3490E-01	1.250	0.1600	10.24	10.47
11	17.00	24.50	0.5150E-01	21.00	0.8675	-1.456	-1.457	0.9690E-01	-0.7959	1.010
11	1.020	1.230	1.389	-1.288	1.322	0.4230E-01	-0.8928	0.2009	0.9510	0.3343
11	0.0	0.2201	26.54	55.12	7.130	1.424	0.1020	0.1630E-01		
12	23.00	4.660	1.296	0.2833	0.3410E-01	0.3360E-01	0.7500	0.2500	22.05	9.360
12	17.00	21.30	0.5820E-01	25.00	0.6684	-1.467	-1.474	-0.1249	-0.6021	1.343
12	0.9713	1.230	1.328	-1.235	1.398	0.3750E-01	-0.4771	-0.2041	0.9450	1.394
12	1.057	-0.1130	83.34	64.93	4.080	1.921	0.4710E-01	0.1180E-01		
13	24.00	7.190	1.451	0.9854	0.3320E-01	0.3160E-01	1.250	0.3900	21.92	10.81
13	17.00	25.20	0.5350E-01	19.00	0.8567	-1.479	-1.500	0.9690E-01	-0.4089	1.341
13	1.034	1.230	1.401	-1.272	1.279	0.4370E-01	-0.5058	0.2342	0.9492	1.005
13	0.6721	-0.1104	75.49	64.38	6.210	1.878	0.4770E-01	0.1860E-01		
14	25.00	4.840	1.969		0.6600E-01	0.6070E-01	0.7500	0.1200	7.810	50.57
14	17.00	21.10	0.8060E-01	32.00	0.6848	-1.181	-1.217	-0.1249	-0.9208	0.8927
14	1.704	1.230	1.324	-1.094	1.505	0.2785	-0.7959	-0.2389	0.9254	0.2408
14	0.4140E-01	0.3378	40.23	65.09	49.21	1.604	0.1775	0.2130E-01		
15	26.00	4.990	1.994	0.4065	0.5520E-01	0.5430E-01	1.250	0.1500	7.570	50.66
15	17.00	21.40	0.7000E-01	35.00	0.6981	-1.258	-1.265	0.9690E-01	-0.8239	0.8791
15	1.705	1.230	1.330	-1.155	1.544	0.2793	-0.9208	0.2000	0.9346	0.1533
15	-0.4580E-01	0.3514	33.07	63.85	49.60	1.519	0.1833	0.2750E-01		
16	27.00	4.320	1.878	0.5888	0.5620E-01	0.5650E-01	0.7500	0.3100	20.58	50.73
16	17.00	22.00	0.8810E-01	24.00	0.6355	-1.250	-1.248	-0.1249	-0.5086	1.313
16	1.705	1.230	1.342	-1.055	1.380	0.2798	-0.3837	-0.1814	0.9190	1.153
16	0.9542	-0.8300E-01	138.6	72.41	48.29	2.142	0.6750E-01	0.2090E-01		
17	28.00	5.900	1.922	0.6010	0.5750E-01	0.4770E-01	1.250	0.3000	20.66	50.73
17	17.00	21.00	0.6800E-01	35.00	0.7709	-1.240	-1.321	0.9690E-01	-0.5229	1.315
17	1.705	1.230	1.322	-1.167	1.544	0.2798	-0.6198	0.2181	0.9363	0.9230
17	0.7243	-0.8470E-01	101.2	69.32	49.18	2.005	0.6720E-01	0.2020E-01		
18	29.00	6.400	1.746	-1.097	0.6850E-01	0.4630E-01	1.000	0.3500	12.92	30.91
18	19.50	24.10	0.7770E-01	23.00	0.8062	-1.164	-1.334	0.0	-0.4559	1.111
18	1.490	1.290	1.382	-1.110	1.362	0.1444	-0.4559	0.5020E-01	0.9279	0.5495
18	0.2788	0.1788	70.32	68.55	26.66	1.847	0.9050E-01	0.3170E-01		
19	31.00	4.590	1.444	0.7574	0.3600E-01	0.3170E-01	0.7500	0.2300	10.90	10.89
19	22.00	23.70	0.5190E-01	20.00	0.6618	-1.444	-1.499	-0.1249	-0.6383	1.037
19	1.037	1.342	1.375	-1.285	1.301	0.4410E-01	-0.5133	-0.2108	0.9507	0.5092
19	0.1761	0.3050	34.83	62.58	6.670	1.542	0.9600E-01	0.2210E-01		
20	32.00	9.370	1.550	0.8615	0.1960E-01	0.2420E-01	1.250	0.1900	17.48	11.47
20	22.00	24.60	0.4170E-01	24.00	0.9717	-1.708	-1.616	0.9690E-01	-0.7212	1.242
20	1.060	1.342	1.391	-1.380	1.380	0.4660E-01	-0.8182	0.2037	0.9600	0.6932
20	0.3617	0.9990E-01	49.57	66.07	7.790	1.695	0.6000E-01	0.1140E-01		
21	33.00	5.100	1.294	-0.1135	0.2180E-01	0.3300E-01	0.7500	0.3800	28.16	9.830
21	22.00	21.50	0.5810E-01	27.00	0.7076	-1.661	-1.482	-0.1249	-0.4202	1.450
21	0.9926	1.342	1.332	-1.236	1.431	0.3950E-01	-0.2953	-0.1506	0.9451	1.540
21	1.204	-0.1072	109.6	66.08	4.430	2.040	0.3700E-01	0.1400E-01		
22	34.00	5.810	1.315	-0.8239	0.3740E-01	0.3420E-01	1.250	0.3900	41.44	11.09
22	22.00	22.90	0.6180E-01	31.00	0.7642	-1.427	-1.466	0.9690E-01	-0.4089	1.617
22	1.045	1.342	1.360	-1.209	1.491	0.4500E-01	-0.5058	0.2342	0.9418	1.476

22	1.143	-0.2750	85.32	67.49	5.280	1.931	0.2530E-01	0.9900E-02		
23	35.00	8.970	1.978	1.504	0.6150E-01	0.3840E-01	0.7500	0.1600	7.970	49.20
23	22.00	26.90	0.5300E-01	34.00	0.9528	-1.211	-1.416	-0.1249	-0.7959	0.9015
23	1.692	1.342	1.430	-1.276	1.532	0.2677	-0.6709	-0.2305	0.9497	0.2048
23	0.0	0.4410	29.49	67.57	48.03	1.470	0.1713	0.2740E-01		
24	36.00	4.060	1.962	1.159	0.5140E-01	0.4570E-01	1.250	0.1800	8.000	49.27
24	22.00	14.90	0.6110E-01	32.00	0.6085	-1.289	-1.340	0.9690E-01	-0.7447	0.9031
24	1.653	1.342	1.173	-1.214	1.505	0.2682	-0.8416	0.2027	0.9424	-0.1740E-01
24	-0.2218	0.4393	32.22	65.61	48.09	1.508	0.1708	0.3070E-01		
25	37.00	5.690	1.873	0.8102	0.6900E-01	0.5430E-01	0.7500	0.2800	18.22	49.43
25	22.00	24.40	0.8340E-01	27.00	0.7551	-1.161	-1.265	-0.1249	-0.5528	1.260
25	1.694	1.342	1.387	-1.079	1.431	0.2695	-0.4279	-0.1932	0.9230	0.9820
25	0.7782	0.8190E-01	113.5	71.49	47.11	2.055	0.7510E-01	0.2100E-01		
26	38.00	6.810	1.947	0.2718	0.3410E-01	0.2780E-01	1.250	0.2600	21.72	49.52
26	22.00	19.60	0.4130E-01	30.00	0.8331	-1.467	-1.556	0.9690E-01	-0.5850	1.337
26	1.695	1.342	1.292	-1.384	1.477	0.2702	-0.6819	0.2122	0.9603	0.9025
26	0.6990	0.5600E-02	70.52	71.74	48.36	1.848	0.6310E-01	0.1640E-01		
27	39.00	5.960	1.732	0.5092	0.6380E-01	0.5550E-01	1.000	0.3500	12.86	30.73
27	19.50	21.70	0.8570E-01	25.00	0.7752	-1.195	-1.256	0.0	-0.4559	1.109
27	1.488	1.290	1.337	-1.067	1.398	0.1434	-0.4559	0.5020E-01	0.9211	0.5501
27	0.2788	0.1808	67.46	63.62	26.94	1.829	0.9080E-01	0.3180E-01		
28	47.00	4.310	1.901		0.6130E-01	0.5740E-01	0.7500	0.3100	20.96	50.75
28	17.00	24.40	0.8960E-01	26.00	0.6345	-1.212	-1.241	-0.1249	-0.5086	1.321
28	1.705	1.230	1.387	-1.048	1.415	0.2800	-0.3837	-0.1814	0.9178	1.158
28	0.9590	-0.9090E-01	143.3	72.40	48.28	2.156	0.6630E-01	0.2050E-01		
29	49.00	6.330	1.740	-1.695	0.6310E-01	0.5620E-01	1.000	0.3500	13.05	30.13
29	19.50	24.60	0.8690E-01	26.00	0.8014	-1.200	-1.250	0.0	-0.4559	1.116
29	1.479	1.290	1.391	-1.061	1.415	0.1400	-0.4559	0.5020E-01	0.9200	0.5521
29	0.2788	0.1744	69.02	63.43	26.12	1.839	0.8910E-01	0.3120E-01		

NUMBER OF PAIRED OBSERVATIONS

	RUN	ALPHA	LGD50	LOGDZ	BYPASS	WATUF	VORTEX	SPIGOT	USGPM	FE%SOL	HEIGHT
RUN	29.										
ALPHA	29.	29.									
LGD50	29.	29.	29.								
LOGDZ	26.	26.	26.	26.							
BYPASS	29.	29.	29.	26.	29.						
WATUF	29.	29.	29.	26.	29.	29.					
VORTEX	29.	29.	29.	26.	29.	29.	29.				
SPIGOT	29.	29.	29.	26.	29.	29.	29.	29.			
USGPM	29.	29.	29.	26.	29.	29.	29.	29.	29.		
FE%SOL	29.	29.	29.	26.	29.	29.	29.	29.	29.	29.	
HEIGHT	29.	29.	29.	26.	29.	29.	29.	29.	29.	29.	29.
FE5C	29.	29.	29.	26.	29.	29.	29.	29.	29.	29.	29.
VSPLIT	29.	29.	29.	26.	29.	29.	29.	29.	29.	29.	29.
TEMP	29.	29.	29.	26.	29.	29.	29.	29.	29.	29.	29.
LCALPH	29.	29.	29.	26.	29.	29.	29.	29.	29.	29.	29.
LOGBPS	29.	29.	29.	26.	29.	29.	29.	29.	29.	29.	29.
LOGWUF	29.	29.	29.	26.	29.	29.	29.	29.	29.	29.	29.
LOGVTX	29.	29.	29.	26.	29.	29.	29.	29.	29.	29.	29.
LGSPIG	29.	29.	29.	26.	29.	29.	29.	29.	29.	29.	29.
LUSGPM	29.	29.	29.	26.	29.	29.	29.	29.	29.	29.	29.

LGFEPS	29.	29.	29.	26.	29.	29.	29.	29.	29.	29.	29.
LGHT	29.	29.	29.	26.	29.	29.	29.	29.	29.	29.	29.
LGFE50	29.	29.	29.	26.	29.	29.	29.	29.	29.	29.	29.
LGS	29.	29.	29.	26.	29.	29.	29.	29.	29.	29.	29.
LGTEMP	29.	29.	29.	26.	29.	29.	29.	29.	29.	29.	29.
FEFVOL	29.	29.	29.	26.	29.	29.	29.	29.	29.	29.	29.
LGS/V	29.	29.	29.	26.	29.	29.	29.	29.	29.	29.	29.
LGVSAR	29.	29.	29.	26.	29.	29.	29.	29.	29.	29.	29.
1-RV	29.	29.	29.	26.	29.	29.	29.	29.	29.	29.	29.
LOGHFT	29.	29.	29.	26.	29.	29.	29.	29.	29.	29.	29.
LGPSIG	29.	29.	29.	26.	29.	29.	29.	29.	29.	29.	29.
LGHT/Q	29.	29.	29.	26.	29.	29.	29.	29.	29.	29.	29.
UFSG/S	29.	29.	29.	26.	29.	29.	29.	29.	29.	29.	29.
UF%SOL	29.	29.	29.	26.	29.	29.	29.	29.	29.	29.	29.
OF%SOL	29.	29.	29.	26.	29.	29.	29.	29.	29.	29.	29.
LUSG/S	29.	29.	29.	26.	29.	29.	29.	29.	29.	29.	29.
CONRFN	29.	29.	29.	26.	29.	29.	29.	29.	29.	29.	29.
CONRFS	29.	29.	29.	26.	29.	29.	29.	29.	29.	29.	29.

NUMBER OF PAIRED OBSERVATIONS

	FE50	VSPLIT	TEMP	LGALPH	LOGBPS	LOGWUF	LOGVTX	LGSPIG	LUSGPM	LGFEPS	LGHT
FE50	29.										
VSPLIT	29.	29.									
TEMP	29.	29.	29.								
LGALPH	29.	29.	29.	29.							
LOGBPS	29.	29.	29.	29.	29.						
LOGWUF	29.	29.	29.	29.	29.	29.					
LOGVTX	29.	29.	29.	29.	29.	29.	29.				
LGSPIG	29.	29.	29.	29.	29.	29.	29.	29.			
LUSGPM	29.	29.	29.	29.	29.	29.	29.	29.	29.		
LGFEPS	29.	29.	29.	29.	29.	29.	29.	29.	29.	29.	
LGHT	29.	29.	29.	29.	29.	29.	29.	29.	29.	29.	29.
LGFE50	29.	29.	29.	29.	29.	29.	29.	29.	29.	29.	29.
LGS	29.	29.	29.	29.	29.	29.	29.	29.	29.	29.	29.
LGTEMP	29.	29.	29.	29.	29.	29.	29.	29.	29.	29.	29.
FEFVOL	29.	29.	29.	29.	29.	29.	29.	29.	29.	29.	29.
LGS/V	29.	29.	29.	29.	29.	29.	29.	29.	29.	29.	29.
LGVSAR	29.	29.	29.	29.	29.	29.	29.	29.	29.	29.	29.
1-RV	29.	29.	29.	29.	29.	29.	29.	29.	29.	29.	29.
LOGHFT	29.	29.	29.	29.	29.	29.	29.	29.	29.	29.	29.
LGPSIG	29.	29.	29.	29.	29.	29.	29.	29.	29.	29.	29.
LGHT/Q	29.	29.	29.	29.	29.	29.	29.	29.	29.	29.	29.
UFSG/S	29.	29.	29.	29.	29.	29.	29.	29.	29.	29.	29.
UF%SOL	29.	29.	29.	29.	29.	29.	29.	29.	29.	29.	29.
OF%SOL	29.	29.	29.	29.	29.	29.	29.	29.	29.	29.	29.
LUSG/S	29.	29.	29.	29.	29.	29.	29.	29.	29.	29.	29.
CONRFN	29.	29.	29.	29.	29.	29.	29.	29.	29.	29.	29.
CONRFS	29.	29.	29.	29.	29.	29.	29.	29.	29.	29.	29.

NUMBER OF PAIRED OBSERVATIONS

	LGFE50	LGS	LGTEMP	FEFVOL	LGS/V	LGVSAR	1-RV	LOGHFT	LGPSIG	LGHT/Q	UFSG/S
LGFE50	29.										
LGS	29.	29.									
LGTEMP	29.	29.	29.								
FEFVOL	29.	29.	29.	29.							
LGS/V	29.	29.	29.	29.	29.						
LGVSAR	29.	29.	29.	29.	29.	29.					
1-RV	29.	29.	29.	29.	29.	29.	29.				
LOGHFT	29.	29.	29.	29.	29.	29.	29.	29.			
LGPSIG	29.	29.	29.	29.	29.	29.	29.	29.	29.		

LGHT/Q	29.	29.	29.	29.	29.	29.	29.	29.	29.	29.	
UFSG/S	29.	29.	29.	29.	29.	29.	29.	29.	29.	29.	29.
UF%SOL	29.	29.	29.	29.	29.	29.	29.	29.	29.	29.	29.
OF%SOL	29.	29.	29.	29.	29.	29.	29.	29.	29.	29.	29.
LUSG/S	29.	29.	29.	29.	29.	29.	29.	29.	29.	29.	29.
CONRFN	29.	29.	29.	29.	29.	29.	29.	29.	29.	29.	29.
CONRFS	29.	29.	29.	29.	29.	29.	29.	29.	29.	29.	29.

NUMBER OF PAIRED OBSERVATIONS

	UF%SOL	OF%SOL	LUSG/S	CONRFN	CONRFS
UF%SOL	29.				
OF%SOL	29.	29.			
LUSG/S	29.	29.	29.		
CONRFN	29.	29.	29.	29.	
CONRFS	29.	29.	29.	29.	29.

CORRELATION MATRIX

	RUN	ALPHA	LGD50	LOGDZ	BYPASS	WATUF	VORTEX	SPIGOT	USGPM	FE%SOL	HEIGHT
RUN	1.0000										
ALPHA	0.1696	1.0000									
LGD50	0.2245	-0.0949	1.0000								
LOGDZ	-0.2346	-0.0004	0.3071	1.0000							
BYPASS	0.4119	-0.1441	0.5816	-0.1791	1.0000						
WATUF	0.3554	-0.3640	0.5537	-0.1923	0.9041	1.0000					
VORTEX	-0.0309	0.3187	0.0931	-0.0843	-0.2641	-0.2615	1.0000				
SPIGOT	0.1988	-0.0270	-0.4082	-0.5814	0.0871	0.1227	0.0103	1.0000			
USGPM	-0.0423	0.0495	-0.5441	-0.4131	-0.3506	-0.2879	0.1653	0.7098	1.0000		
FE%SOL	0.2566	-0.2557	0.9505	0.2725	0.6107	0.6157	-0.0307	-0.2598	-0.3670	1.0000	
HEIGHT	-0.1411	0.0745	-0.0702	0.0823	-0.3069	-0.3901	0.0515	0.0490	0.2037	-0.0622	1.0000
FE50	0.2011	0.5022	-0.3772	-0.2457	0.2318	0.0652	-0.3499	0.2901	0.1199	-0.3988	-0.2243
VSPLIT	0.3981	-0.3494	0.3159	-0.3671	0.8571	0.9450	-0.3461	0.3799	-0.0644	0.4221	-0.3695
TEMP	0.1894	-0.1026	0.5396	0.1343	0.2365	0.2630	0.1707	-0.2316	-0.0093	0.6460	0.0850
LGALPH	0.1746	0.9870	-0.1275	-0.0812	-0.1186	-0.3434	0.3026	0.0448	0.1028	-0.2748	0.0368
LOGBPS	0.4048	-0.2122	0.5670	-0.1465	0.9830	0.8875	-0.2468	0.0737	-0.3528	0.6159	-0.3365
LOGWUF	0.3607	-0.3968	0.5237	-0.1733	0.9010	0.9888	-0.2746	0.1500	-0.2740	0.6095	-0.3804
LOGVTX	-0.0171	0.3248	0.0967	-0.1115	-0.2400	-0.2405	0.9989	0.0287	0.1559	-0.0310	0.0463
LGSPIG	0.2136	-0.0503	-0.3814	-0.5614	0.0890	0.1118	0.0001	0.9904	0.6896	-0.2312	0.0768
LUSGPM	0.0040	0.0871	-0.5129	-0.4102	-0.3306	-0.2766	0.1295	0.7488	0.9648	-0.3529	0.1511
LGFEPS	0.2936	-0.2245	0.9564	0.1979	0.6714	0.6631	-0.0157	-0.2069	-0.3891	0.9910	-0.0589
LGHT	-0.1341	0.0782	-0.0683	0.0679	-0.2951	-0.3801	0.0519	0.0589	0.1993	-0.0626	0.9997
LGFE50	0.1944	0.4907	-0.3905	-0.2683	0.2200	0.0599	-0.3602	0.2979	0.1476	-0.4047	-0.2435
LGS	0.3865	-0.3846	0.2693	-0.3298	0.8361	0.9250	-0.3532	0.3900	-0.0527	0.4014	-0.3684
LGTEMP	0.2116	-0.1122	0.5330	0.0963	0.2385	0.2758	0.1532	-0.2012	0.0237	0.6486	0.0997
FEFVOL	0.2402	-0.2661	0.9432	0.3027	0.5821	0.5927	-0.0340	-0.2804	-0.3546	0.9984	-0.0636
LGS/V	0.1886	-0.2243	-0.3740	-0.3974	0.2091	0.2285	-0.5601	0.8140	0.4906	-0.1765	0.0384
LGVSAR	0.0018	0.3127	0.0515	-0.1654	-0.2422	-0.2280	0.9912	0.1306	0.2306	-0.0599	0.0555
1-RV	-0.3969	0.3536	-0.3120	0.3648	-0.8565	-0.9447	0.3461	-0.3812	0.0631	-0.4206	0.3701
LOGHFT	0.0080	-0.0180	-0.5745	-0.3859	-0.2839	-0.2113	-0.1352	0.7250	0.9076	-0.3765	0.0372
LGPSIG	0.0428	-0.0549	-0.4678	-0.3609	-0.2133	-0.1365	-0.1455	0.7187	0.8965	-0.2541	0.0301
LGHT/Q	-0.0355	-0.0693	0.5006	0.4229	0.2636	0.1891	-0.1183	-0.7405	-0.9250	0.3409	0.0830
UFSG/S	0.1258	-0.1835	-0.1837	-0.3612	0.1361	0.2395	-0.1658	0.7346	0.7467	0.0381	-0.0404
UF%SOL	0.2957	-0.2295	0.3645	0.0411	0.2696	0.2557	-0.2081	0.2897	0.3092	0.5862	0.1265
OF%SOL	0.2416	-0.2425	0.9599	0.2965	0.5917	0.5945	-0.0159	-0.2946	-0.3886	0.9990	-0.0582
LUSG/S	0.2079	-0.1537	-0.1751	-0.4114	0.1770	0.2667	-0.1427	0.8091	0.7390	0.0470	-0.0532
CONRFN	-0.0003	-0.1684	0.6280	0.4480	0.3646	0.3491	-0.0766	-0.7331	-0.8319	0.5330	-0.0859
CONRFS	0.2722	-0.2145	0.6003	0.0563	0.6996	0.6498	-0.1138	-0.1174	-0.7027	0.5359	-0.0932

CORRELATION MATRIX

	FE50	VSPLIT	TEMP	LGALPH	LOGBPS	LOGWUF	LOGVTX	LGSPIG	LUSGPM	LGFEPS	LGHT
FE50	1.0000										
VSPLIT	0.2290	1.0000									
TEMP	-0.4339	0.0936	1.0000								
LGALPH	0.5356	-0.3122	-0.1126	1.0000							
LOGBPS	0.1911	0.8371	0.2708	-0.1874	1.0000						
LOGWUF	0.0571	0.9430	0.2986	-0.3769	0.9040	1.0000					
LOGVTX	-0.3387	-0.3219	0.1599	0.3108	-0.2252	-0.2546	1.0000				
LGSPIG	0.2686	0.3714	-0.2570	0.0164	0.0786	0.1401	0.0181	1.0000			
LUSGPM	0.1611	-0.0376	-0.1431	0.1426	-0.3535	-0.2790	0.1229	0.7501	1.0000		
LGFEPS	-0.3636	0.4791	0.6112	-0.2392	0.6699	0.6545	-0.0100	-0.1796	-0.3698	1.0000	
LGHT	-0.2193	-0.3579	0.0796	0.0415	-0.3261	-0.3709	0.0480	0.0866	0.1481	-0.0560	1.0000
LGFE50	0.9948	0.2277	-0.4251	0.5351	0.1777	0.0478	-0.3495	0.2749	0.1917	-0.3719	-0.2387
LGS	0.2186	0.9842	0.1440	-0.3499	0.8386	0.9476	-0.3311	0.3788	-0.0499	0.4531	-0.3579
LGTEMP	-0.4429	0.1196	0.9960	-0.1207	0.2674	0.3093	0.1434	-0.2252	-0.1054	0.6157	0.0949
FEFVOL	-0.4095	0.3961	0.6570	-0.2871	0.5902	0.5874	-0.0370	-0.2516	-0.3432	0.9818	-0.0653
LGS/V	0.4151	0.4917	-0.3051	-0.1606	0.1922	0.2601	-0.5456	0.8280	0.5598	-0.1450	0.0457
LGVSAR	-0.3147	-0.2827	0.1321	0.3049	-0.2321	-0.2402	0.9938	0.1193	0.2039	-0.0352	0.0579
1-RV	-0.2275	-0.9999	-0.0993	0.3165	-0.8386	-0.9449	0.3220	-0.3723	0.0388	-0.4772	0.3586
LOGHFT	0.2603	0.0471	-0.1887	0.0455	-0.3039	-0.2054	-0.1429	0.7265	0.9531	-0.4042	0.0331
LGPSIG	0.2154	0.1058	-0.1064	0.0085	-0.2333	-0.1312	-0.1538	0.7243	0.9458	-0.2847	0.0256
LGHT/Q	-0.2138	-0.0464	0.1630	-0.1339	0.2794	0.1937	-0.1126	-0.7353	-0.9725	0.3594	0.0861
UFSG/S	0.1964	0.4501	0.0073	-0.1323	0.1200	0.2503	-0.1672	0.7412	0.7840	0.0279	-0.0414
UF%SOL	-0.1510	0.3173	0.4351	-0.2261	0.2907	0.2938	-0.2164	0.3310	0.3358	0.5582	0.1222
OF%SOL	-0.4111	0.3908	0.6440	-0.2641	0.5957	0.5856	-0.0171	-0.2656	-0.3737	0.9880	-0.0590
LUSG/S	0.1956	0.4872	-0.0072	-0.0954	0.1552	0.2783	-0.1389	0.8207	0.8023	0.0510	-0.0514
CONRFN	-0.3043	0.0802	0.4522	-0.2253	0.4004	0.3642	-0.0766	-0.7534	-0.9292	0.5308	-0.0862
CONRFS	-0.1167	0.5202	0.1808	-0.2333	0.7143	0.6729	-0.0858	-0.1065	-0.7036	0.6119	-0.0787

CORRELATION MATRIX

	LGFE50	LGS	LGTEMP	FEFVOL	LGS/V	LGVSAR	1-RV	LOGHFT	LGPSIG	LGHT/Q	UFSG/S
LGFE50	1.0000										
LGS	0.2132	1.0000									
LGTEMP	-0.4331	0.1661	1.0000								
FEFVOL	-0.4144	0.3776	0.6585	1.0000							
LGS/V	0.4264	0.5031	-0.2692	-0.1902	1.0000						
LGVSAR	-0.3243	-0.2919	0.1199	-0.0673	-0.4574	1.0000					
1-RV	-0.2259	-0.9869	-0.1249	-0.3948	-0.4926	0.2829	1.0000				
LOGHFT	0.2977	0.0458	-0.1491	-0.3631	0.6891	-0.0603	-0.0467	1.0000			
LGPSIG	0.2536	0.1018	-0.0649	-0.2401	0.6933	-0.0717	-0.1053	0.9917	1.0000		
LGHT/Q	-0.2493	-0.0340	0.1285	0.3304	-0.5532	-0.1918	0.0453	-0.9524	-0.9468	1.0000	
UFSG/S	0.2182	0.4451	0.0531	0.0428	0.7150	-0.0844	-0.4500	0.8161	0.8568	-0.7995	1.0000
UF%SOL	-0.1435	0.3447	0.4677	0.5952	0.3987	-0.1891	-0.3193	0.3546	0.4518	-0.3095	0.5907
OF%SOL	-0.4172	0.3676	0.6448	0.9982	-0.2131	-0.0494	-0.3891	-0.4009	-0.2796	0.3626	0.0057
LUSG/S	0.2188	0.4847	0.0406	0.0454	0.7657	-0.0507	-0.4872	0.8294	0.8715	-0.8203	0.9694
CONRFN	-0.3321	0.1105	0.4163	0.5305	-0.5885	-0.1557	-0.0835	-0.9010	-0.8659	0.9158	-0.6656
CONRFS	-0.1536	0.5304	0.1645	0.5000	-0.0411	-0.1049	-0.5219	-0.6956	-0.6536	0.6903	-0.3328

CORRELATION MATRIX

	UF%SOL	OF%SOL	LUSG/S	CONRFN	CONRFS
UF%SOL	1.0000				
OF%SOL	0.5623	1.0000			
LUSG/S	0.6258	0.0119	1.0000		
CONRFN	-0.1432	0.5498	-0.7039	1.0000	
CONRFS	0.0140	0.5305	-0.2823	0.6788	1.0000

NAME	MEAN	STANDARD DEVIATION
RUN	26.5861	10.2940

ALPHA	5.69089	1.41268
LGD50	1.69651	0.255776
LOGDZ	0.346454	0.723740
BYPASS	0.449931E-01	0.171579E-01
WATUF	0.412103E-01	0.122796E-01
VORTEX	0.991379	0.236064
SPIGOT	0.264138	0.886613E-01
USGPM	17.4268	9.21271
FE%SOL	30.9358	18.6018
HEIGHT	20.1033	2.28105
FE50	22.0758	3.18105
VSPLIT	0.631965E-01	0.171047E-01
TEMP	26.6551	4.79789
LGALPH	0.742941	0.104151
LOGBPS	-1.38148	0.183236
LOGWUF	-1.40462	0.135204
LOGVTX	-0.158931E-01	0.104906
LGSPIG	-0.604134	0.156840
LUSGPM	1.18744	0.218157
LGFEPS	1.38866	0.322267
LGHT	1.30041	0.509753E-01
LGFE50	1.33977	0.711281E-01
LGS	-1.21590	0.125579
LGTEMP	1.41891	0.789071E-01
FEFVOL	0.159700	0.109237
LGS/V	-0.588224	0.187110
LGVSAR	0.513275E-02	0.197184
1-RV	0.940796	0.151255E-01
LOGHET	0.747899	0.469966
LGPSIG	0.481555	0.450599
LGHT/Q	0.112996	0.216567
UF SG/S	71.3934	41.0320
UF%SOL	65.9451	4.50738
OF%SOL	27.8495	19.9778
LUSG/S	1.73208	0.257761
CONREN	0.899857E-01	0.484204E-01
CONRES	0.207276E-01	0.730503E-02

29 OBSERVATIONS TOTAL
26 OBSERVATIONS ARE COMPLETE
28 DEGREES OF FREEDOM

RESULTS WITH MURU + WEIGHTING FACTOR

CONTROL CARD NO. 3 ** STPREG **** STPREG **** STPREG **** STPREG **** STPREG **** STPREG **** STPREG ** CONTROL CARD NO. 3

POTENTIAL INDEPENDENT AND OTHER VARIABLES IN THE REGRESSION ANALYSIS FOR LGD50

	PARTIAL CORR.	TOLERANCE	F-RATIO	F-PROB
WATUF	0.5537	1.0000	11.94	0.0019
VORTEX	0.0931	1.0000	0.2362	0.6357
SPIGOT	0.4082	1.0000	5.400	0.0266
USGPM	0.5441	1.0000	11.35	0.0024
FE%SOL	0.9505	1.0000	252.7	0.0000
HEIGHT	0.0702	1.0000	0.1337	0.7162
FE50	0.3772	1.0000	4.478	0.0416
VSPLIT	0.3159	1.0000	2.993	0.0915
TEMP	0.5396	1.0000	11.09	0.0026

\>>>>>>STEP NUMBER 1 REGRESSION EQUATION FOR LGD50

R-SQUARED = 0.9034753 F-PROBABILITY LEVEL = 0.0500

STANDARD ERROR LGD50 = 0.8092E-01

F-PROBABILITY = .00000000

VARIABLE	COEFFICIENT	STD. ERR.	F-RATIO	F-PROB	NORM COEFF
FE%SOL	0.13069626E-01	0.8221E-03	252.7	0.0000	0.9505
CONSTANT	1.2921944	0.2954E-01	1913.	0.0	5.052

POTENTIAL INDEPENDENT AND OTHER VARIABLES IN THE REGRESSION ANALYSIS FOR LGD50

	PARTIAL CORR.	TOLERANCE	F-RATIO	F-PROB
WATUF	0.1285	0.6209	0.4365	0.5215
VORTEX	0.3937	0.9991	4.769	0.0363
SPIGOT	0.5377	0.9325	10.57	0.0032
USGPM	0.6754	0.8653	21.81	0.0001
HEIGHT	0.0356	0.9961	0.3291E-01	0.8350
FE50	0.0067	0.8409	0.1151E-02	0.9235
VSPLIT	0.3028	0.8219	2.624	0.1136
TEMP	0.3140	0.5826	2.845	0.1000

\>>>>>>STEP NUMBER 2 REGRESSION EQUATION FOR LGD50

R-SQUARED = 0.9475116 F-PROBABILITY LEVEL = 0.0500

STANDARD ERROR LGD50 = 0.6081E-01

F-PROBABILITY = .00000000

VARIABLE	COEFFICIENT	STD. ERR.	F-RATIO	F-PROB	NORM COEFF
USGPM	-0.62632181E-02	0.1341E-02	21.81	0.0001	-0.2256
FE%SOL	0.11931121E-01	0.6642E-03	322.7	0.0000	0.8677
CONSTANT	1.4365627	0.3806E-01	1425.	0.0	5.616

POTENTIAL INDEPENDENT AND OTHER VARIABLES IN THE REGRESSION ANALYSIS FOR LGD50

	PARTIAL CORR.	TOLERANCE	F-RATIO	F-PROB
WATUF	0.2526	0.6165	1.703	0.2012
VORTEX	0.6952	0.9716	23.38	0.0001
SPIGOT	0.1406	0.4961	0.5042	0.4907
HEIGHT	0.1327	0.9583	0.4485	0.5160
FE50	0.0195	0.8401	0.9476E-02	0.8857
VSPLIT	0.3140	0.8124	2.735	0.1070
TEMP	0.1393	0.5226	0.4948	0.4949

\>>>>>>STEP NUMBER 3 REGRESSION EQUATION FOR LGD50

R-SQUARED = 0.9728797 F-PROBABILITY LEVEL = 0.0500

STANDARD ERROR LGD50 = 0.4458E-01

F-PROBABILITY = .00000000

VARIABLE	COEFFICIENT	STD. ERR.	F-RATIO	F-PROB	NORM COEFF
VORTEX	0.17507323	0.3620E-01	23.38	0.0001	0.1616
USGPM	-0.70617476E-02	0.9968E-03	50.19	0.0000	-0.2544
FE%SOL	0.11854064E-01	0.4871E-03	592.2	0.0000	0.8621
CONSTANT	1.2792984	0.4285E-01	891.5	0.0	5.002

POTENTIAL INDEPENDENT AND OTHER VARIABLES IN THE REGRESSION ANALYSIS FOR LGD50

	PARTIAL CORR.	TOLERANCE	F-RATIO	F-PROB
WATUF	0.0650	0.5613	0.1017	0.7472
SPIGOT	0.0471	0.4844	0.5328E-01	0.8042
HEIGHT	0.1673	0.9580	0.6911	0.4188
FE50	0.3870	0.7087	4.228	0.0484

VSPLIT	0.0617	0.6869	0.9163E-01	0.7579
TEMP	0.4064	0.4995	4.749	0.0375

```
>>>>>>STEP NUMBER    4      REGRESSION EQUATION FOR LGD50
        R-SQUARED = 0.9773594          F-PROBABILITY LEVEL = 0.0500
        STANDARD ERROR LGD50    =  0.4157E-01
        F-PROBABILITY = .00000000
```

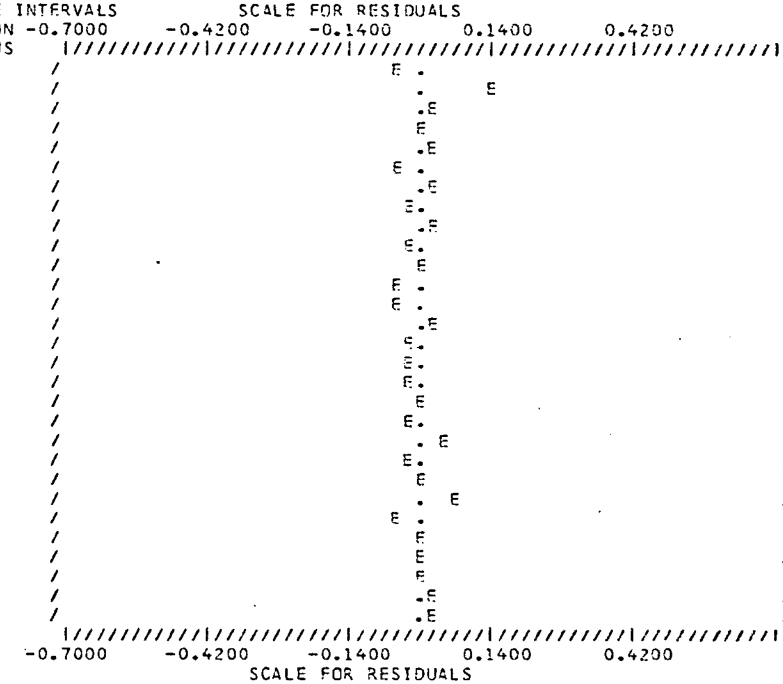
VARIABLE	COEFFICIENT	STD. ERR.	F-RATIO	F-PROB	NORM COEFF
VORTEX	0.19090917	0.3453E-01	30.56	0.0000	0.1762
USGPM	-0.64416249E-02	0.9721E-03	43.91	0.0000	-0.2320
FE3SOL	0.12814194E-01	0.6328E-03	410.0	0.0000	0.9319
TEMP	-0.50486107E-02	0.2317E-02	4.749	0.0375	-0.9470E-01
CONSTANT	1.3576610	0.5375E-01	637.9	0.0000	5.308

POTENTIAL INDEPENDENT AND OTHER VARIABLES IN THE REGRESSION ANALYSIS FOR LGD50

	PARTIAL CORR.	TOLERANCE	F-RATIO	F-PROB
WATUF	0.1424	0.5476	0.4757	0.5039
SPIGOT	0.2658	0.3968	1.748	0.1965
HEIGHT	0.2326	0.9468	1.316	0.2625
FE50	0.3446	0.6826	3.100	0.0882
VSPLIT	0.1868	0.6424	0.8317	0.3746

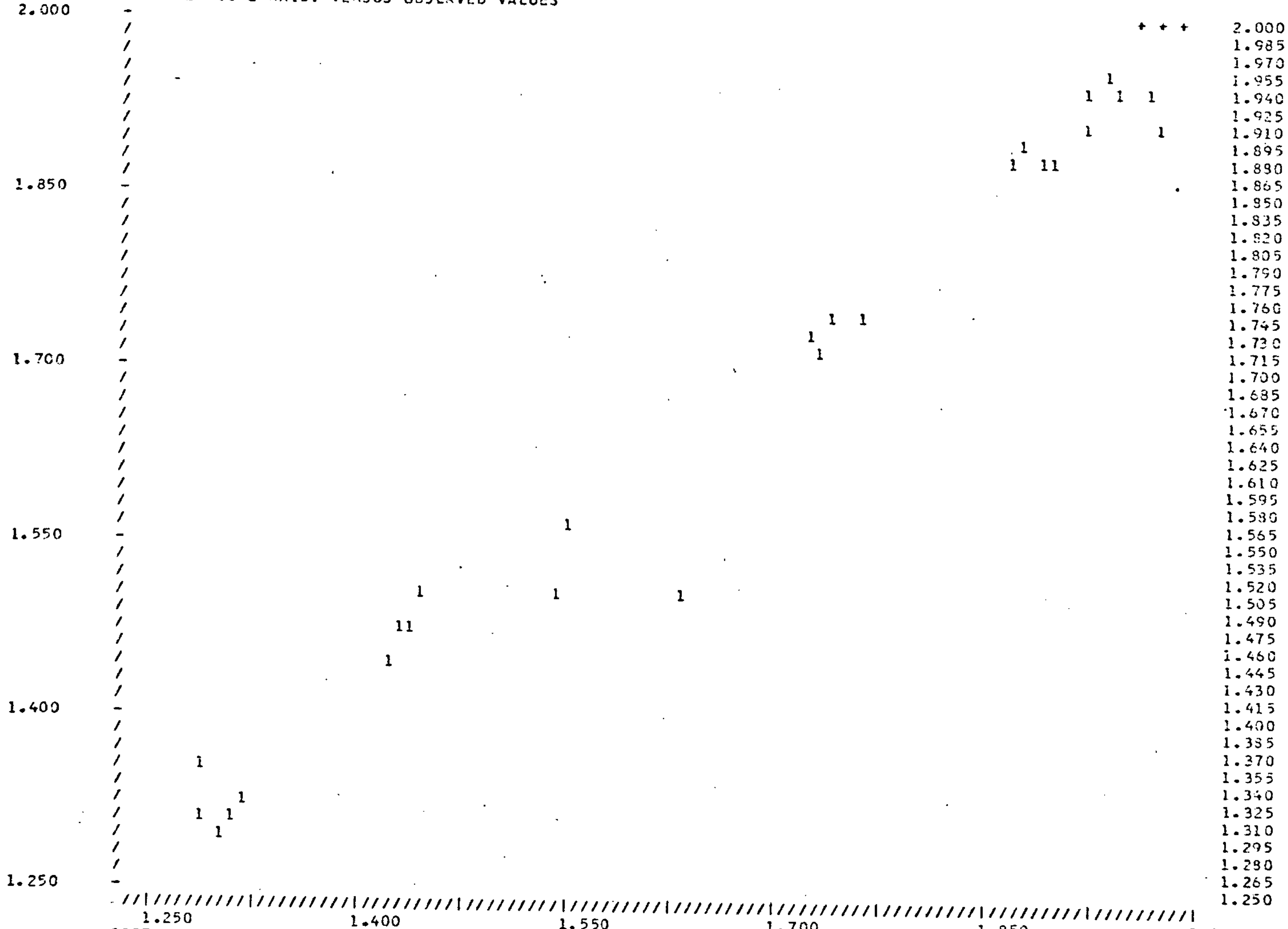
.0 (100%) CONFIDENCE INTERVALS — SCALE FOR RESIDUALS

	OBSERVED	RESIDUAL	PREDICTED	MEAN PLUS-MINUS	OBSERVATION PLUS-MINUS
1	1.4347	-0.4360E-01	1.4783		
2	1.6374	0.1308	1.5066		
3	1.3122	0.1369E-01	1.2985		
4	1.3276	-0.1382E-02	1.3290		
5	1.9280	0.1394E-01	1.9141		
6	1.9751	-0.4329E-01	2.0184		
7	1.8985	0.1322E-01	1.8853		
8	1.9374	-0.1435E-01	1.9518		
9	1.7702	0.3010E-01	1.7401		
10	1.4330	-0.1590E-01	1.4489		
11	1.5539	-0.4577E-02	1.5585		
12	1.2960	-0.5653E-01	1.3525		
13	1.4510	-0.4669E-01	1.4977		
14	1.9686	0.3161E-01	1.9370		
15	1.9936	-0.2640E-01	2.0200		
16	1.8780	-0.1917E-01	1.8972		
17	1.9220	-0.1457E-01	1.9366		
18	1.7458	0.4883E-03	1.7453		
19	1.4437	-0.2550E-01	1.4692		
20	1.5502	0.4069E-01	1.5095		
21	1.2942	-0.1490E-01	1.3091		
22	1.3147	-0.2565E-03	1.3150		
23	1.9783	0.6999E-01	1.9083		
24	1.9618	-0.5276E-01	2.0146		
25	1.8728	-0.7767E-02	1.8806		
26	1.9472	0.7716E-02	1.9395		
27	1.7325	-0.7935E-03	1.7333		
28	1.9007	0.1582E-01	1.8849		
29	1.7400	0.2067E-01	1.7193		



29 COMPLETE OBSERVATIONS   AUTO CORR COEFF= -0.2312   DURBIN WATSON D-STATISTIC = 2.401

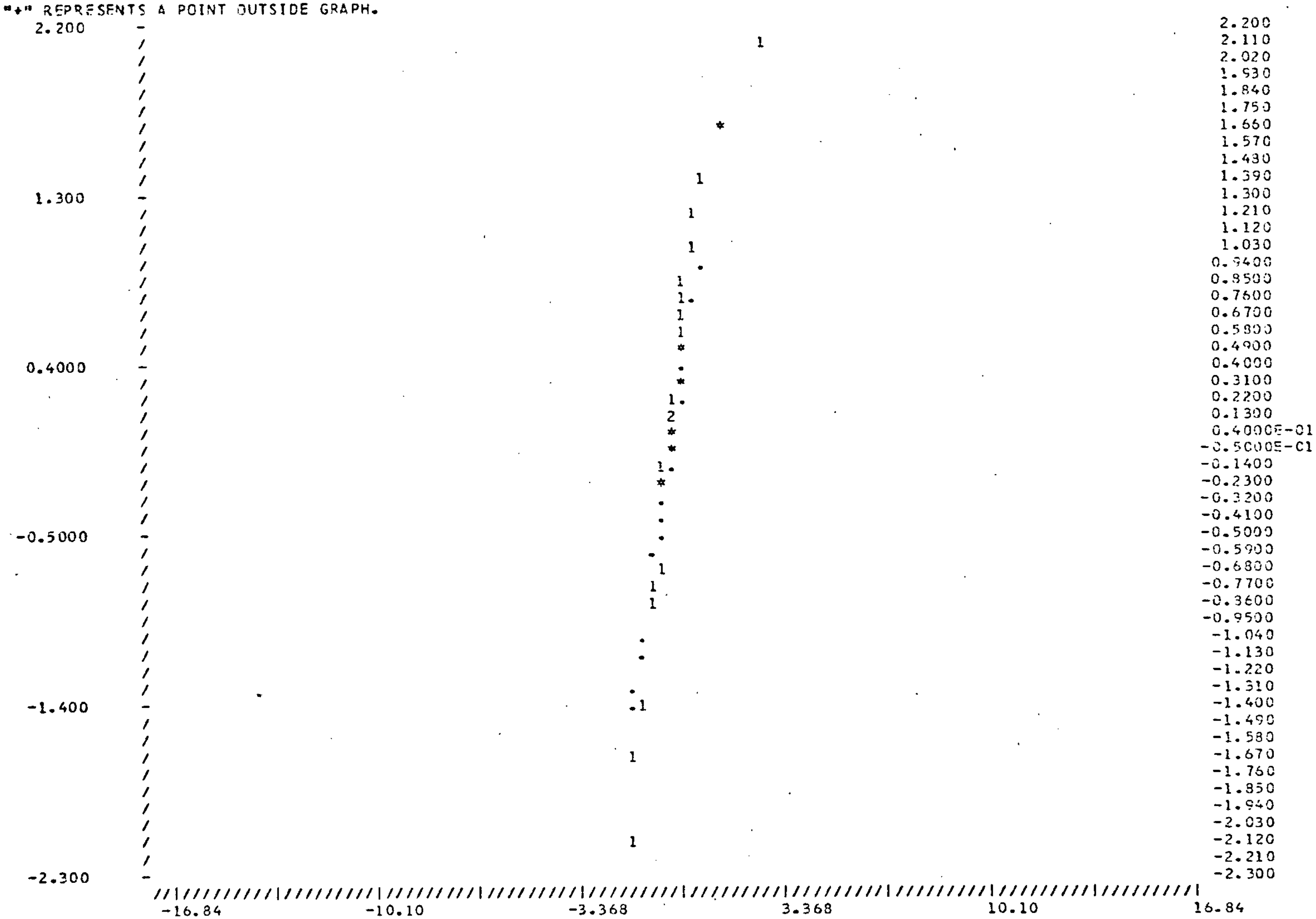
PREDICTED VALUES (VERTICAL AXIS) VERSUS OBSERVED VALUES



DISTANCE BETWEEN SLASHES ON THE X-AXIS IS 0.7500E-02

PROBABILITY OF RESIDUALS VS RESIDUALS
(PLOT TO VERIFY THE NORMALITY OF THE DIST OF RESIDUALS)

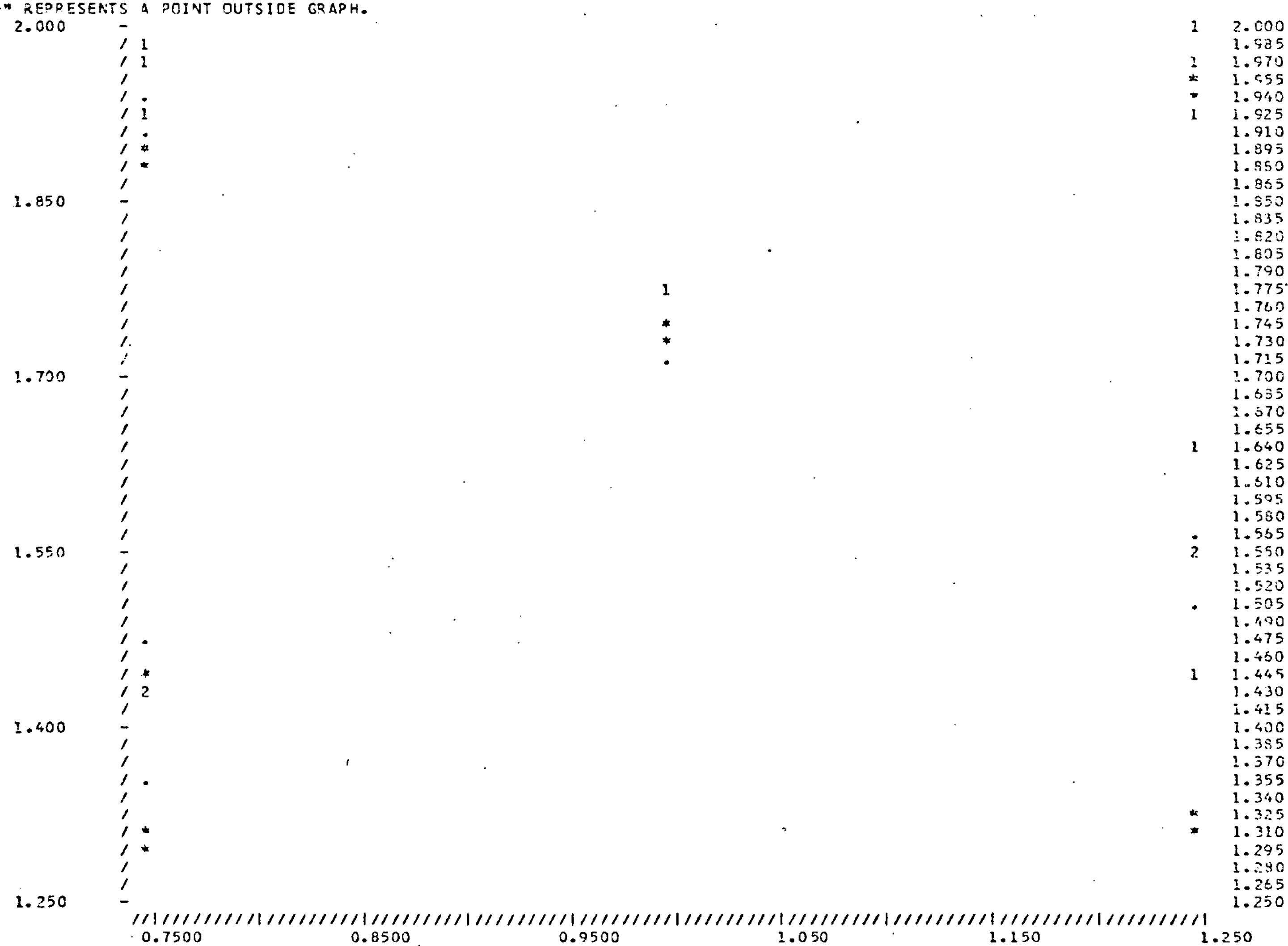
THE ".","+" AND "*" ARE USED TO PLOT PREDICTED VALUES; "*" IS USED WHERE PREDICTED VALUES COVER DATA POINTS
"+" REPRESENTS A POINT OUTSIDE GRAPH.



DISTANCE BETWEEN SLASHES ON THE X-AXIS IS 0.3368

PLOT OF Y & YHAT VS VORTEX .VERTICAL AXIS IS Y-AXIS.

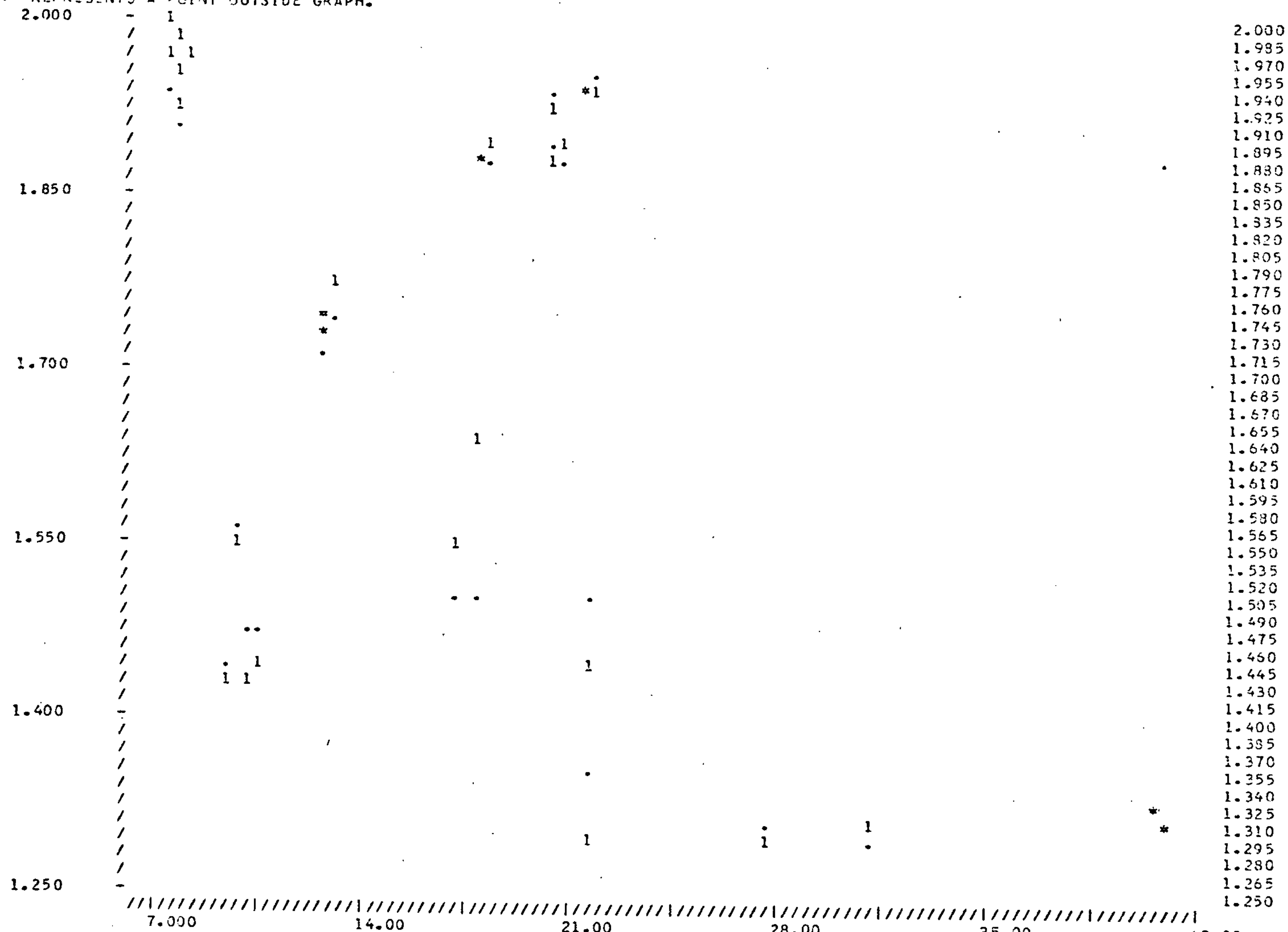
THE ".","+" AND "*" ARE USED TO PLOT PREDICTED VALUES; "*" IS USED WHERE PREDICTED VALUES COVER DATA POINTS
"+" REPRESENTS A POINT OUTSIDE GRAPH.



DISTANCE BETWEEN SLASHES ON THE X-AXIS IS 0.5000E-02

PLOT OF Y & YHAT VS USGPM .VERTICAL AXIS IS Y-AXIS.

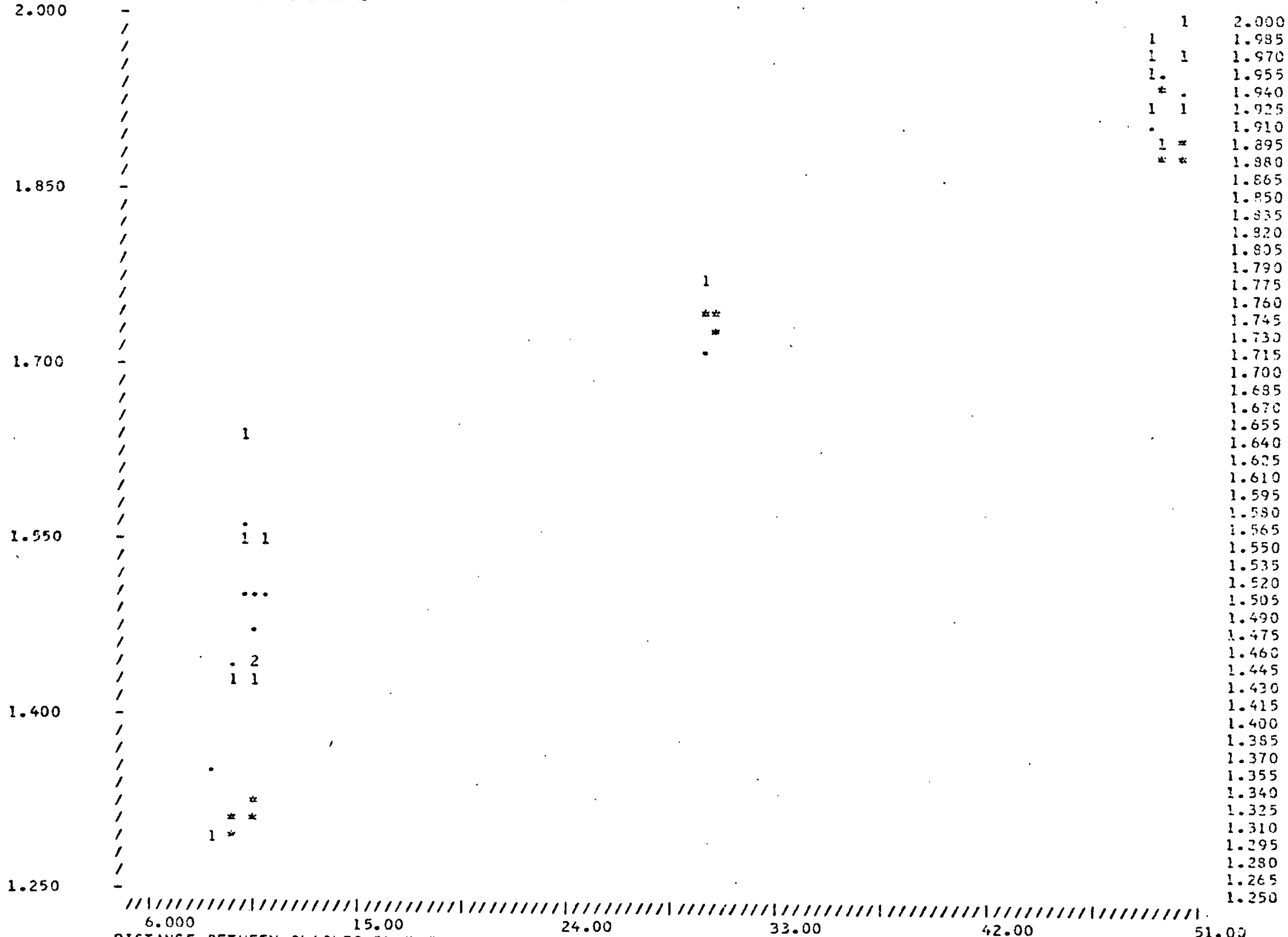
THE ".","+" AND "*" ARE USED TO PLOT PREDICTED VALUES; "*" IS USED WHERE PREDICTED VALUES COVER DATA POINTS
"+" REPRESENTS A POINT OUTSIDE GRAPH.



DISTANCE BETWEEN SLASHES ON THE X-AXIS IS 0.3500

PLOT OF Y & YHAT VS FE%SOL .VERTICAL AXIS IS Y-AXIS.

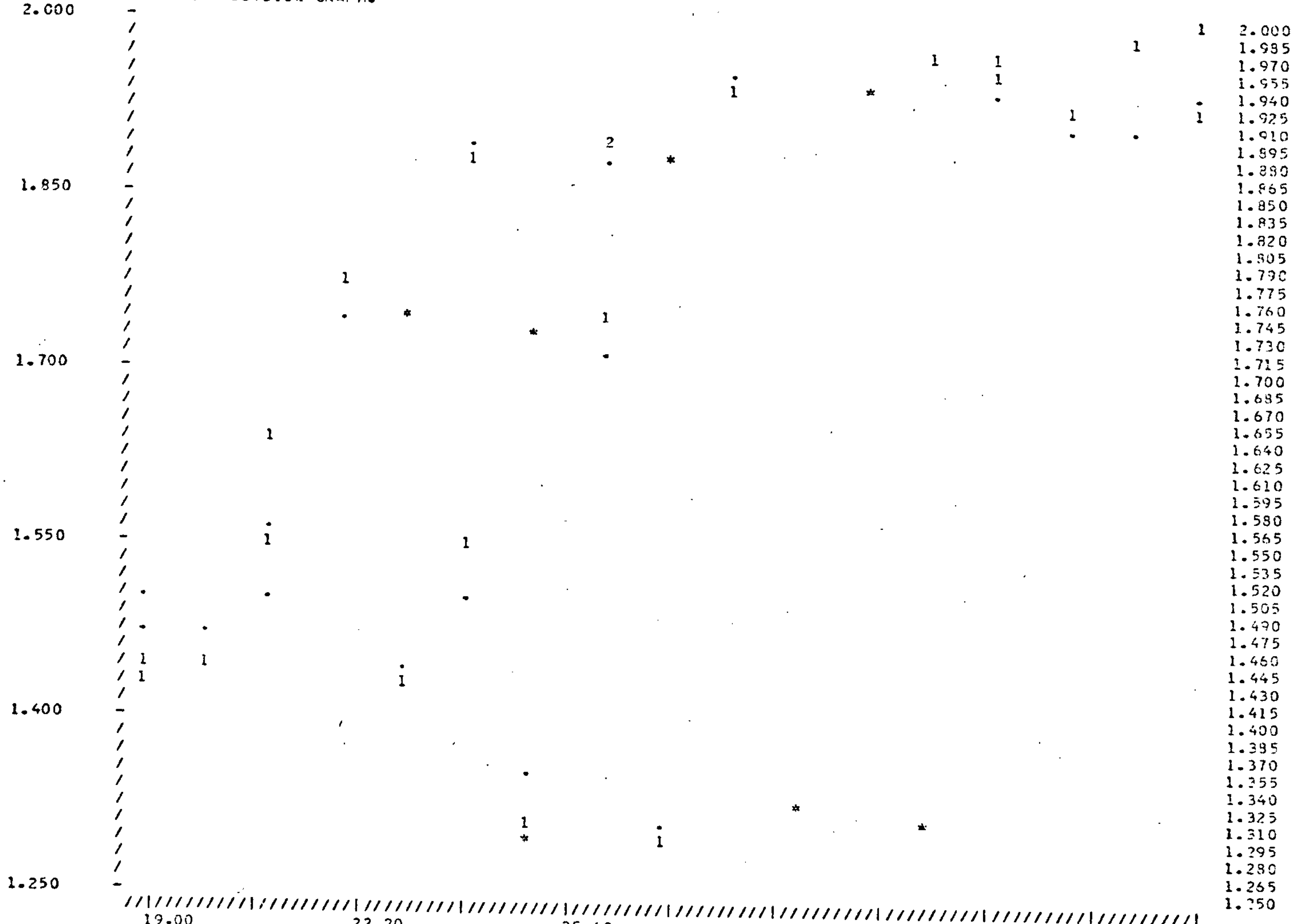
THE ".","+" AND "*" ARE USED TO PLOT PREDICTED VALUES; "*" IS USED WHERE PREDICTED VALUES COVER DATA POINTS
"+" REPRESENTS A POINT OUTSIDE GRAPH.



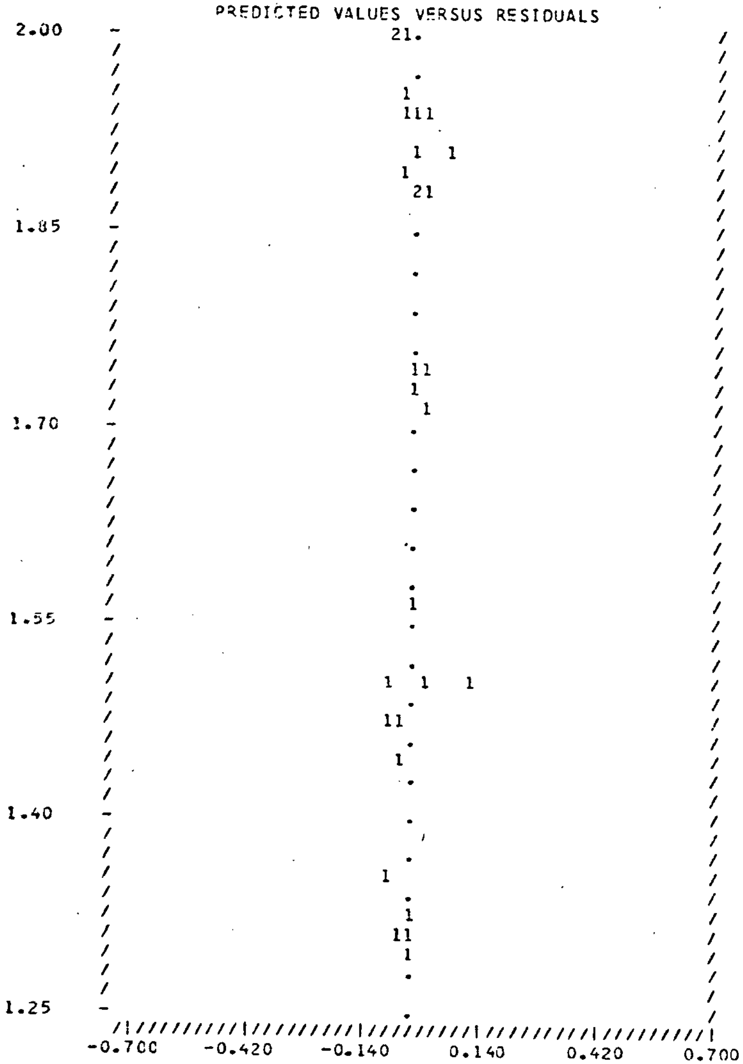
DISTANCE BETWEEN SLASHES ON THE X-AXIS IS 0.4500

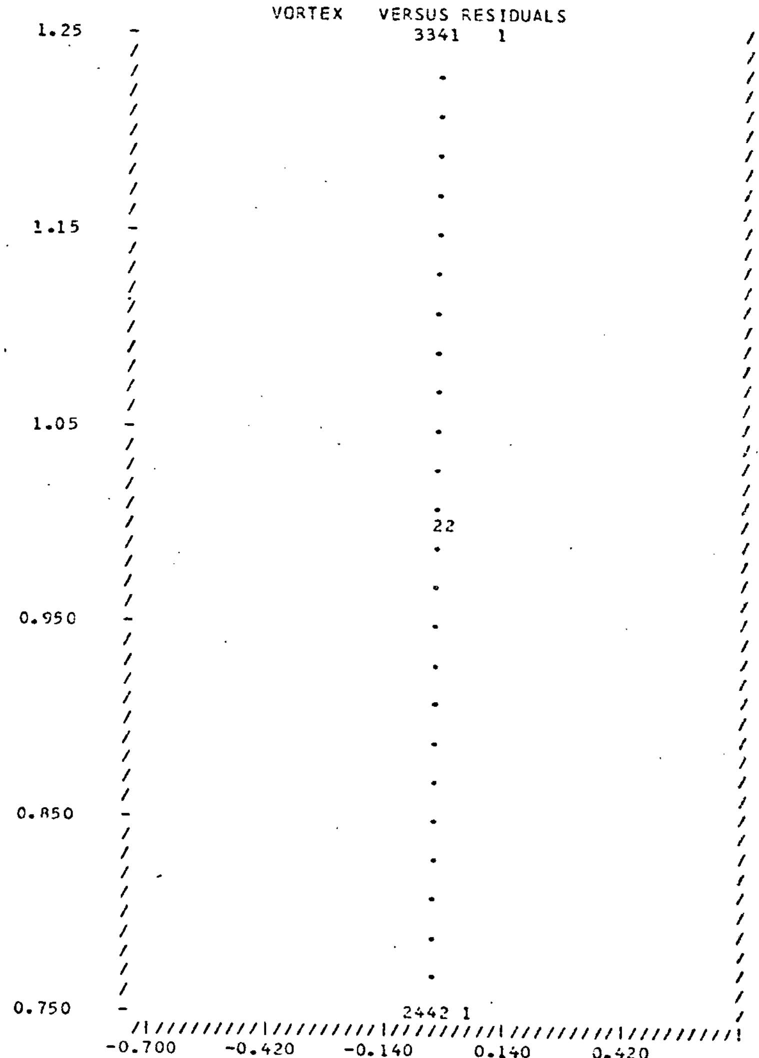
PLOT OF Y & YHAT VS TEMP .VERTICAL AXIS IS Y-AXIS.

THE ".","+" AND "*" ARE USED TO PLOT PREDICTED VALUES; "*" IS USED WHERE PREDICTED VALUES COVER DATA POINTS
"+" REPRESENTS A POINT OUTSIDE GRAPH.

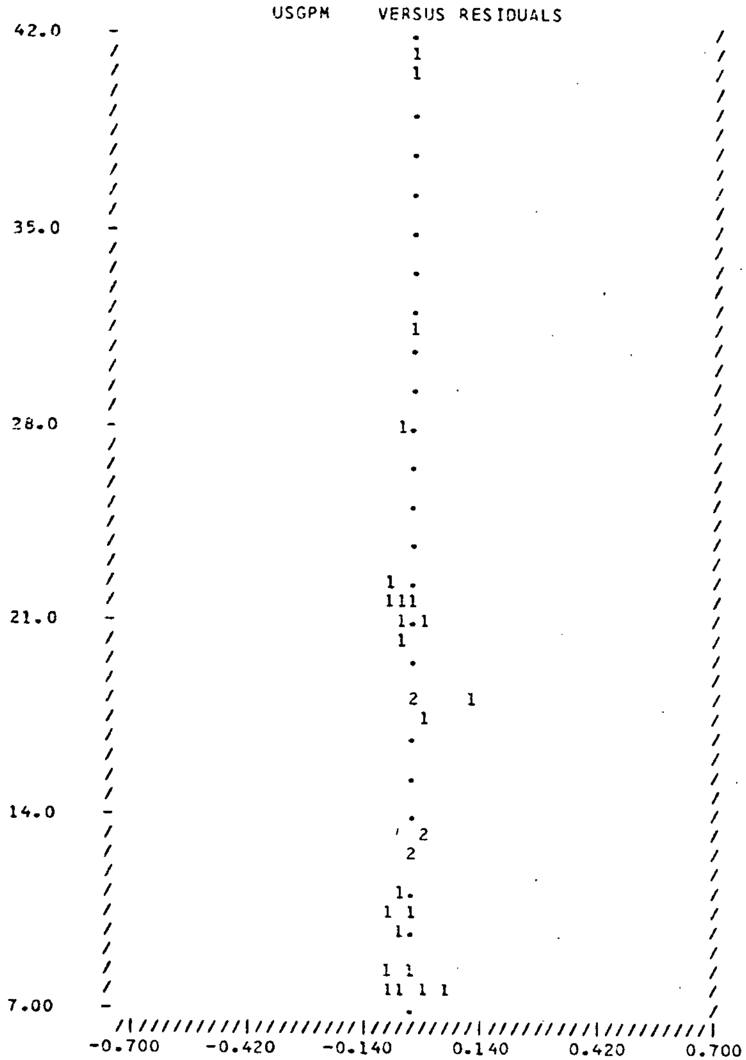


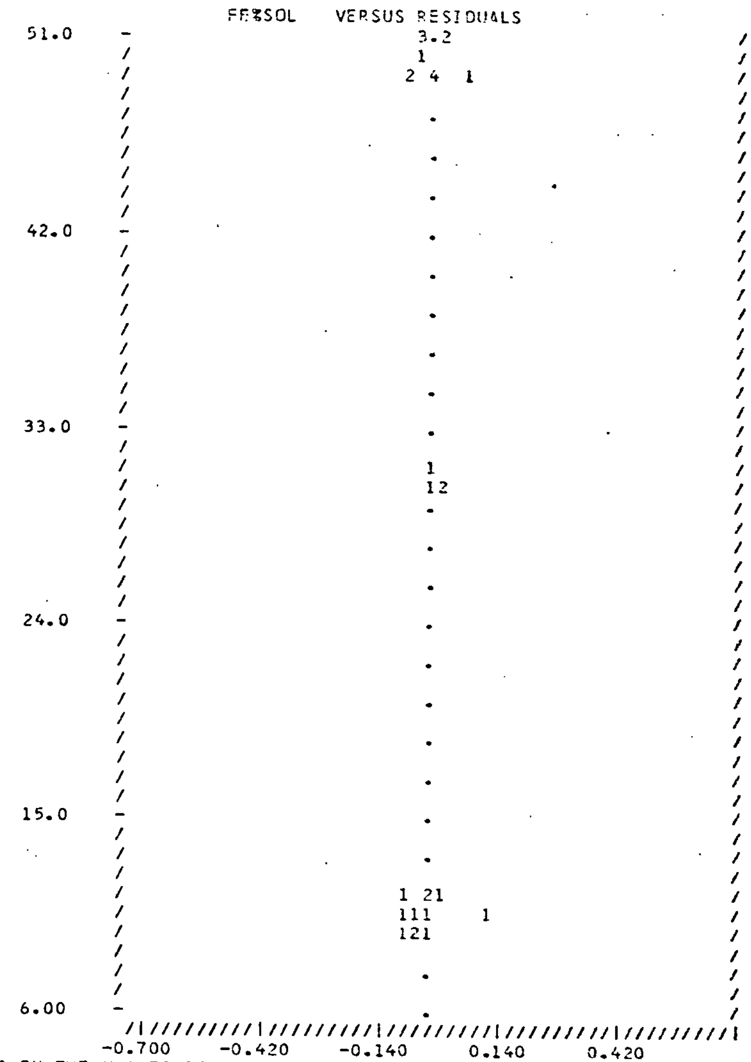
DISTANCE BETWEEN SLASHES ON THE X-AXIS IS 0.1600



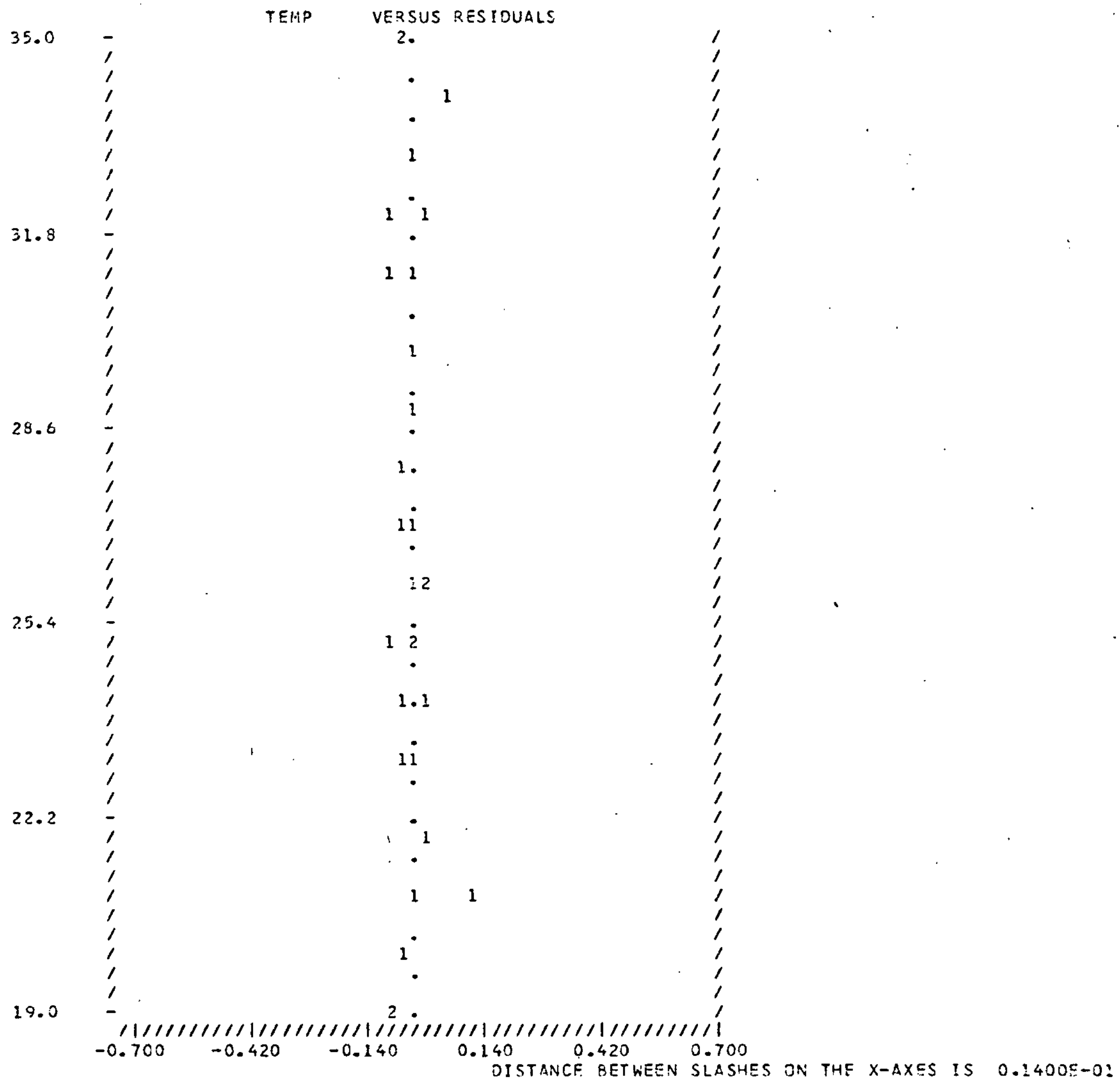


DISTANCE BETWEEN SLASHES ON THE X-AXES IS 0.1400E-01





DISTANCE BETWEEN SLASHES ON THE X-AXES IS 0.1400E-01


TEMP VERSUS RESIDUALS
35.0
31.8
28.6
25.4
22.2
19.0
-0.700 -0.420 -0.140 0.140 0.420 0.700
DISTANCE BETWEEN SLASHES ON THE X-AXES IS 0.1400E-01

CONTROL CARD NO. 4 ** STPREG **** STPREG **** STPREG **** STPREG **** STPREG **** STPREG **** STPREG ** CONTROL CARD NO. 4

POTENTIAL INDEPENDENT AND OTHER VARIABLES IN THE REGRESSION ANALYSIS FOR LGPSIG

	PARTIAL CORR.	TOLERANCE	F-RATIO	F-PROB
LUSGPM	0.9458	1.0000	229.0	0.0000
LGHT	0.0256	1.0000	0.1777E-01	0.8642
FEFVOL	0.2401	1.0000	1.651	0.2073
LGVSAR	0.0717	1.0000	0.1394	0.7110

>>>>>>STEP NUMBER 1 REGRESSION EQUATION FOR LGPSIG
R-SQUARED = 0.8945452 F-PROBABILITY LEVEL = 0.0500
STANDARD ERROR LGPSIG = 0.1490
F-PROBABILITY = .00000000

VARIABLE	COEFFICIENT	STD. ERR.	F-RATIO	F-PROB	NORM COEFF
LUSGPM	1.9535434	0.1291	229.0	0.0000	0.9458
CONSTANT	-1.9381517	0.1558	139.3	0.0000	-4.079

POTENTIAL INDEPENDENT AND OTHER VARIABLES IN THE REGRESSION ANALYSIS FOR LGPSIG

	PARTIAL CORR.	TOLERANCE	F-RATIO	F-PROB
LGHT	0.3564	0.9781	3.782	0.0599
FEFVOL	0.2771	0.8822	2.162	0.1499
LGVSAR	0.8320	0.9584	58.46	0.0000

>>>>>>STEP NUMBER 2 REGRESSION EQUATION FOR LGPSIG
R-SQUARED = 0.9675361 F-PROBABILITY LEVEL = 0.0500
STANDARD ERROR LGPSIG = 0.8425E-01
F-PROBABILITY = .00000000

VARIABLE	COEFFICIENT	STD. ERR.	F-RATIO	F-PROB	NORM COEFF
LUSGPM	2.0697497	0.7455E-01	770.8	0.0	1.002
LGVSAR	-0.63062633	0.8248E-01	58.46	0.0000	-0.2760
CONSTANT	-1.9728707	0.8981E-01	482.5	0.0000	-4.378

POTENTIAL INDEPENDENT AND OTHER VARIABLES IN THE REGRESSION ANALYSIS FOR LGPSIG

	PARTIAL CORR.	TOLERANCE	F-RATIO	F-PROB
LGHT	0.5996	0.9773	14.04	0.0010
FEFVOL	0.5037	0.8822	8.499	0.0072

>>>>>>STEP NUMBER 3 REGRESSION EQUATION FOR LGPSIG
R-SQUARED = 0.9792085 F-PROBABILITY LEVEL = 0.0500
STANDARD ERROR LGPSIG = 0.6876E-01
F-PROBABILITY = .00000000

VARIABLE	COEFFICIENT	STD. ERR.	F-RATIO	F-PROB	NORM COEFF
LUSGPM	2.1018552	0.6144E-01	1170.	0.0	1.018
LGHT	-0.96606620	0.2579	14.04	0.0010	-0.1093
LGVSAR	-0.62340723	0.6734E-01	85.70	0.0000	-0.2728
CONSTANT	-0.75475168	0.3333	5.128	0.0309	-1.675

POTENTIAL INDEPENDENT AND OTHER VARIABLES IN THE REGRESSION ANALYSIS FOR LGPSIG

	PARTIAL CORR.	TOLERANCE	F-RATIO	F-PROB
FEFVOL	0.6177	0.8820	14.81	0.0008

>>>>>>>STEP NUMBER 4 REGRESSION EQUATION FOR LGPSIG

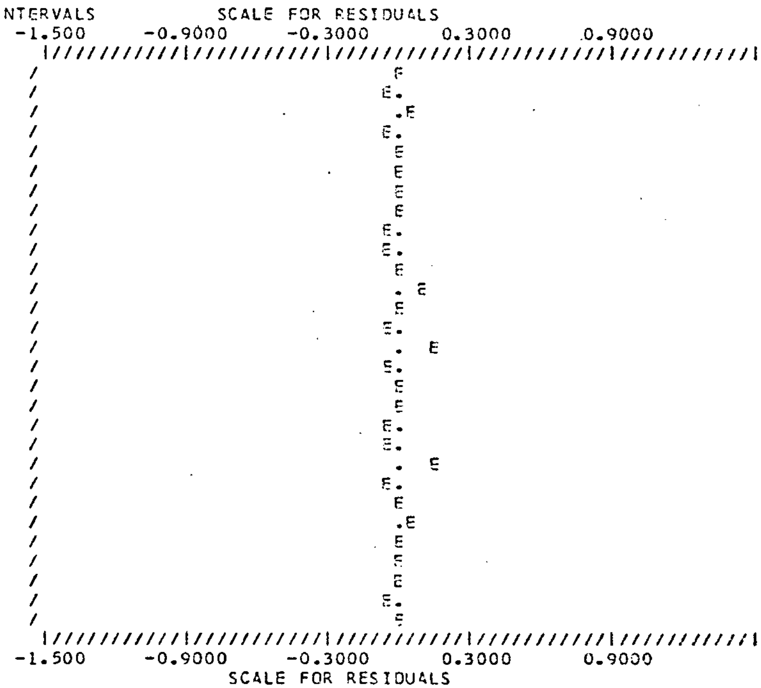
R-SQUARED = 0.9871423 F-PROBABILITY LEVEL = 0.0500

STANDARD ERROR LGPSIG = 0.5519E-01

F-PROBABILITY = .0

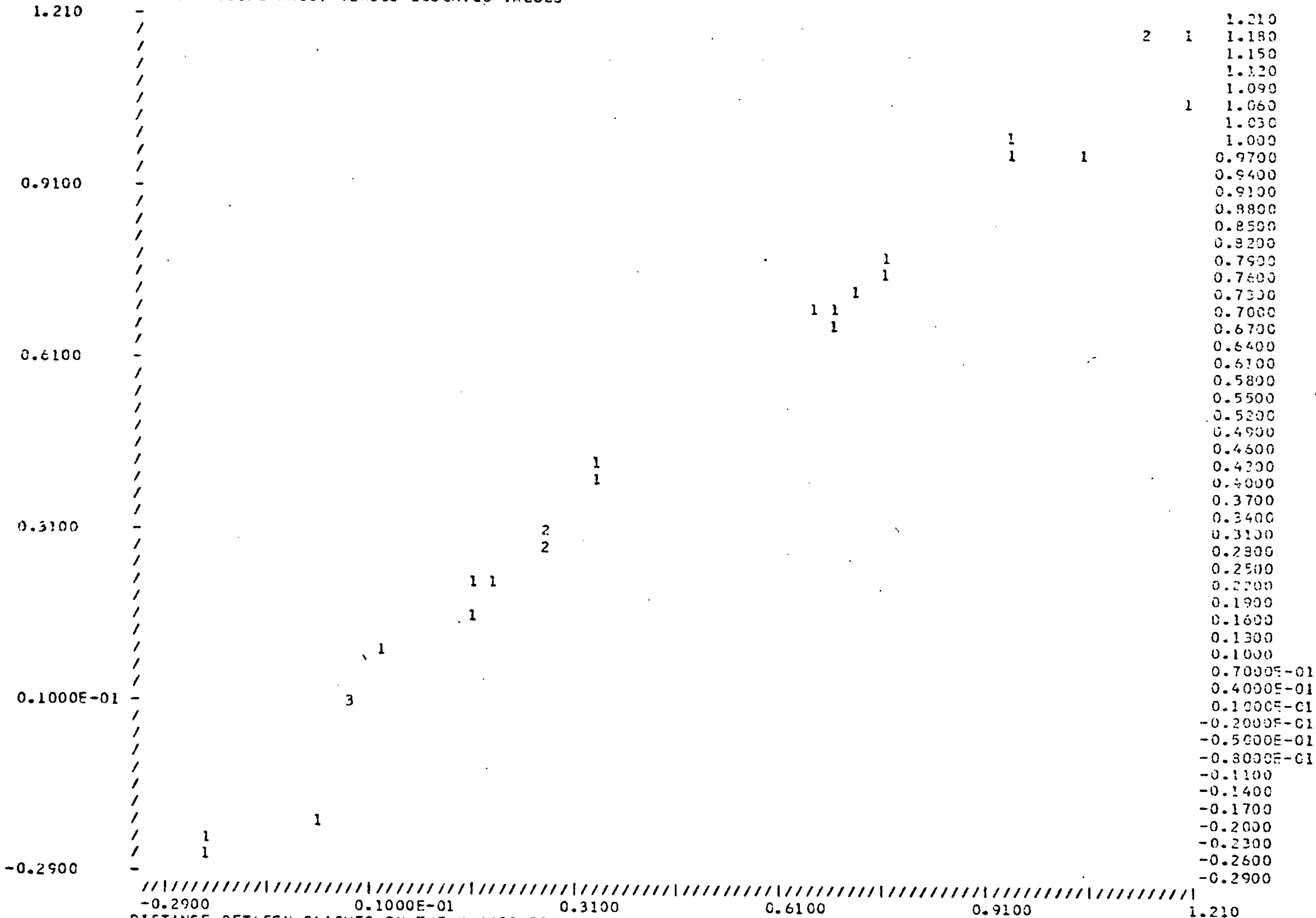
VARIABLE	COEFFICIENT	STD. ERR.	F-RATIO	F-PROB	NORM COEFF
LUSGPM	2.1687742	0.5229E-01	1720.	0.0	1.050
LGHT	-0.95356612	0.2070	21.22	0.0001	-0.1079
FEFVOL	0.39122172	0.1017	14.81	0.0008	0.9484E-01
LGVSAR	-0.62410101	0.5405E-01	133.3	0.0000	-0.2731
CONSTANT	-0.91294309	0.2707	11.38	0.0026	-2.026

	OBSERVED	RESIDUAL	PREDICTED	.0 (100%)CONFIDENCE INTERVALS MEAN PLUS-MINUS	OBSERVATION PLUS-MINUS
1	0.17610	0.9943E-02	0.16616		
2	0.36170	-0.6020E-01	0.42190		
3	1.2041	0.3340E-01	1.1707		
4	1.1461	-0.2709E-01	1.1732		
5	0.0	-0.2141E-01	0.21408E-01		
6	-0.22180	0.7416E-02	-0.22922		
7	0.77820	-0.4980E-02	0.78318		
8	0.69900	0.1093E-01	0.68807		
9	0.27880	-0.3636E-01	0.31516		
10	0.20410	-0.2764E-01	0.23174		
11	0.0	0.3932E-02	-0.39324E-02		
12	1.0569	0.8753E-01	0.96937		
13	0.67210	-0.2051E-01	0.69261		
14	0.41400E-01	-0.6651E-01	0.10791		
15	-0.45800E-01	0.1494	-0.19519		
16	0.95420	-0.3073E-01	0.98493		
17	0.72430	-0.1499E-01	0.73929		
18	0.27880	-0.1348E-01	0.29228		
19	0.17610	-0.2959E-01	0.20569		
20	0.36170	-0.3109E-01	0.39279		
21	1.2041	0.1438	1.0603		
22	1.1430	-0.4320E-01	1.1862		
23	0.0	-0.1072E-01	0.10725E-01		
24	-0.22180	0.3417E-01	-0.25597		
25	0.77820	0.1146E-01	0.76674		
26	0.69900	0.1930E-01	0.67970		
27	0.27880	-0.8531E-02	0.28733		
28	0.95900	-0.4336E-01	1.0024		
29	0.27880	-0.2108E-01	0.29988		



29 COMPLETE OBSERVATIONS   AUTO CORR COEFF= -0.3328   DURBIN WATSON D-STATISTIC = 2.654

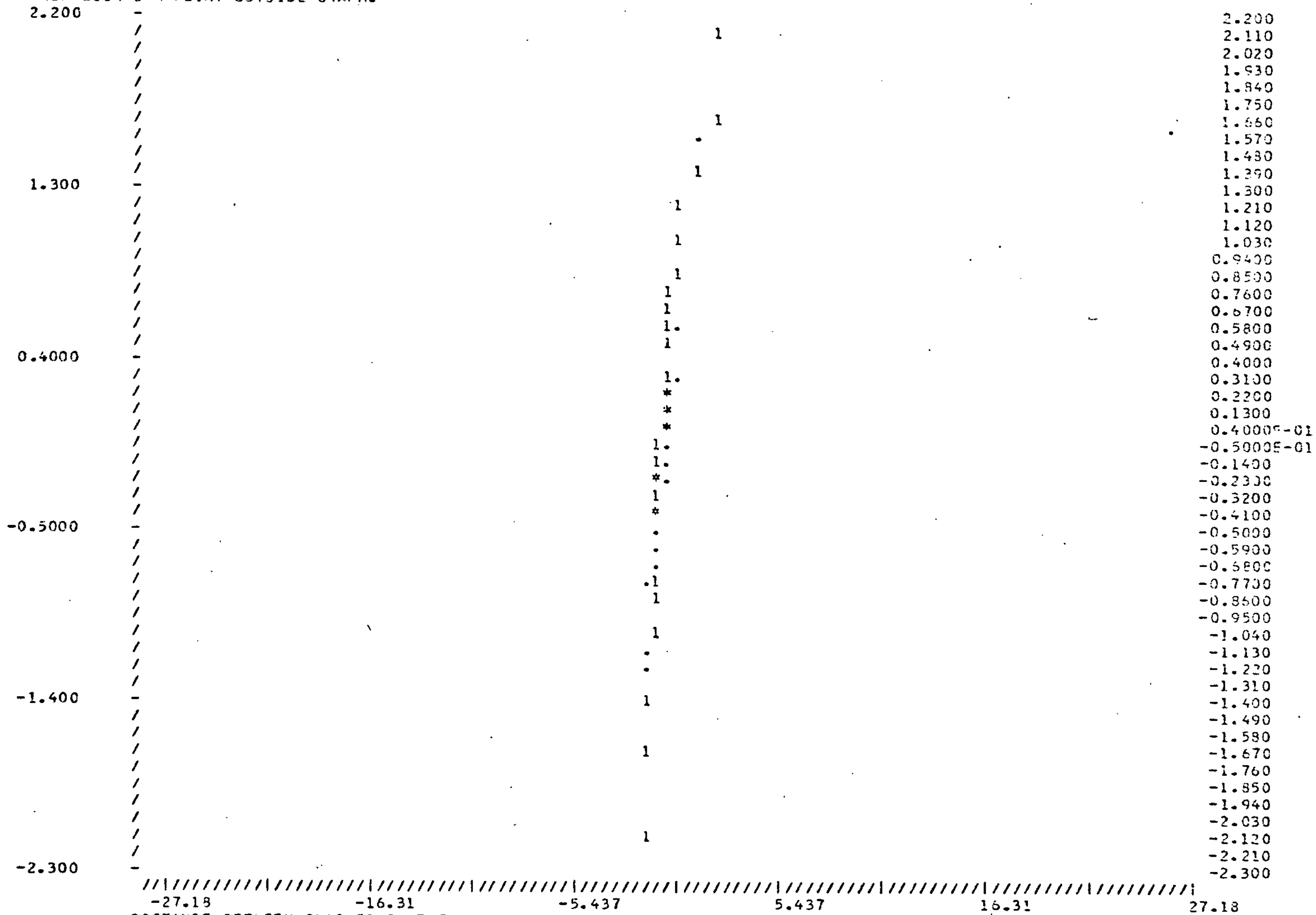
PREDICTED VALUES (VERTICAL AXIS) VERSUS OBSERVED VALUES



DISTANCE BETWEEN SLASHES ON THE X-AXIS IS 0.1500E-01

PROBABILITY OF RESIDUALS VS RESIDUALS
(PLOT TO VERIFY THE NORMALITY OF THE DIST OF RESIDUALS)

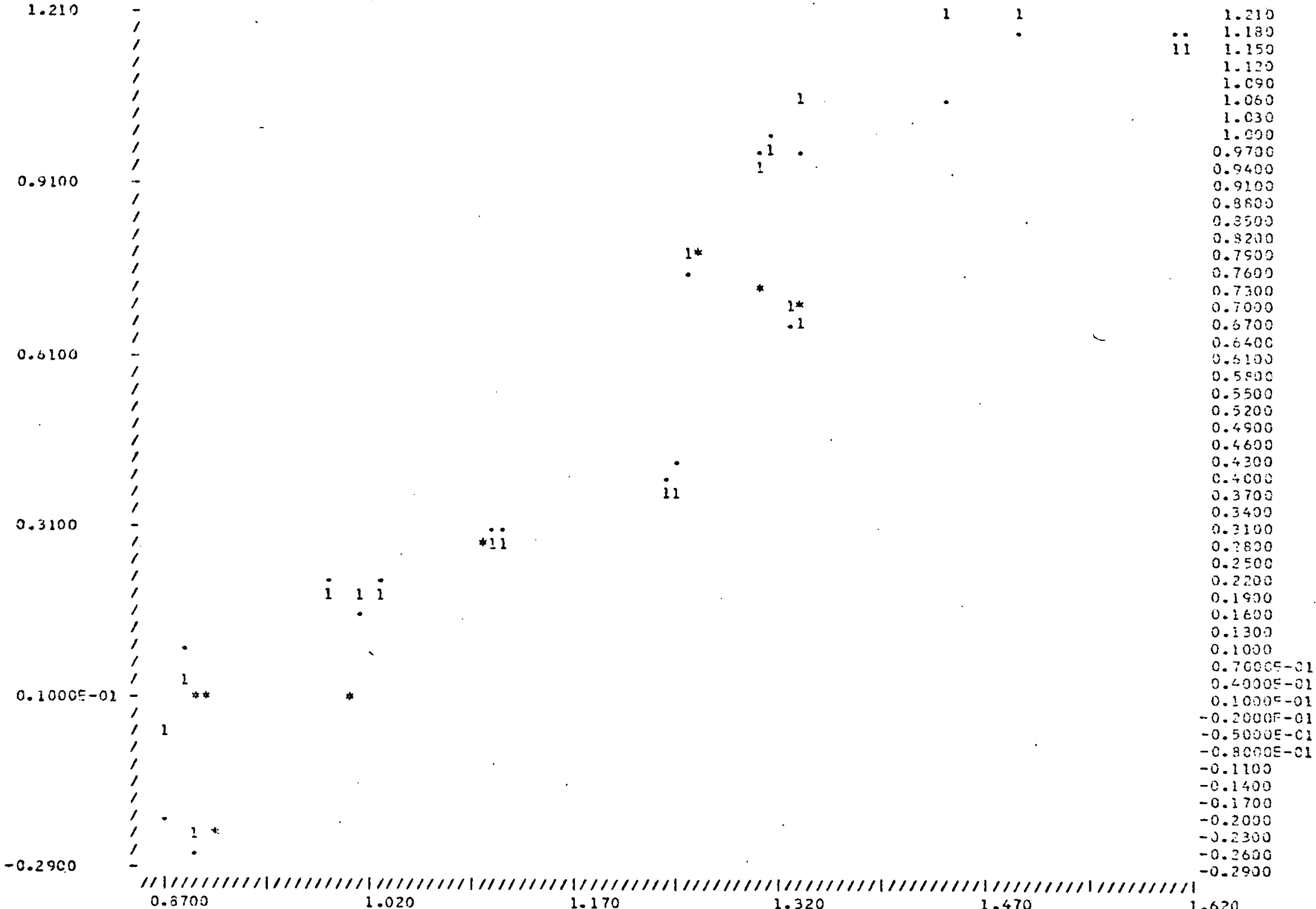
THE ".","+" AND "*" ARE USED TO PLOT PREDICTED VALUES: "*" IS USED WHERE PREDICTED VALUES COVER DATA POINTS
"+" REPRESENTS A POINT OUTSIDE GRAPH.



DISTANCE BETWEEN SLASHES ON THE X-AXIS IS 0.5437

PLOT OF Y & YHAT VS LUSGPM .VERTICAL AXIS IS Y-AXIS.

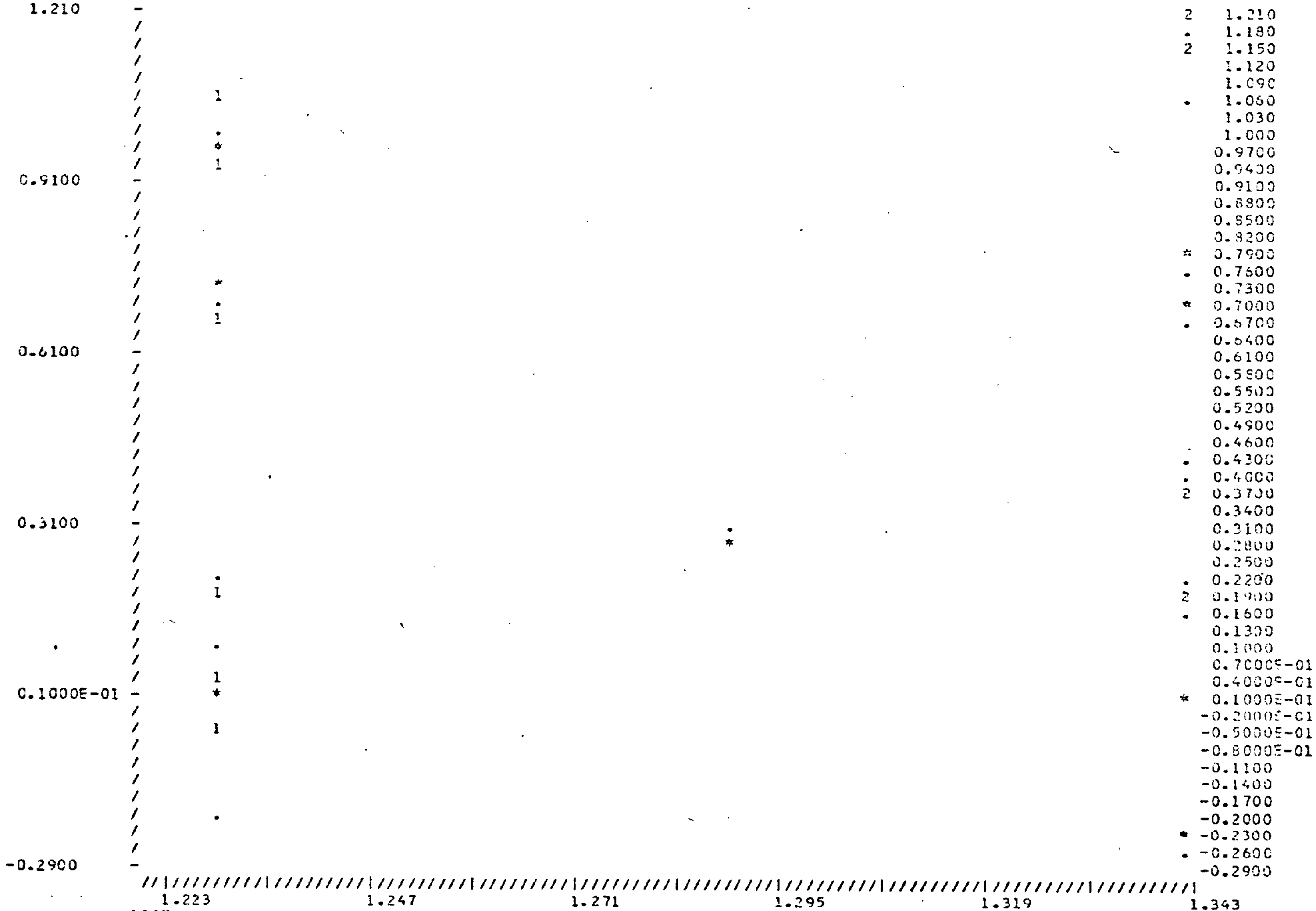
THE ".","+" AND "*" ARE USED TO PLOT PREDICTED VALUES; "*" IS USED WHERE PREDICTED VALUES COVER DATA POINTS
"+" REPRESENTS A POINT OUTSIDE GRAPH.



DISTANCE BETWEEN SLASHES ON THE X-AXIS IS 0.7500E-02

PLOT OF Y & YHAT VS LGHT .VERTICAL AXIS IS Y-AXIS.

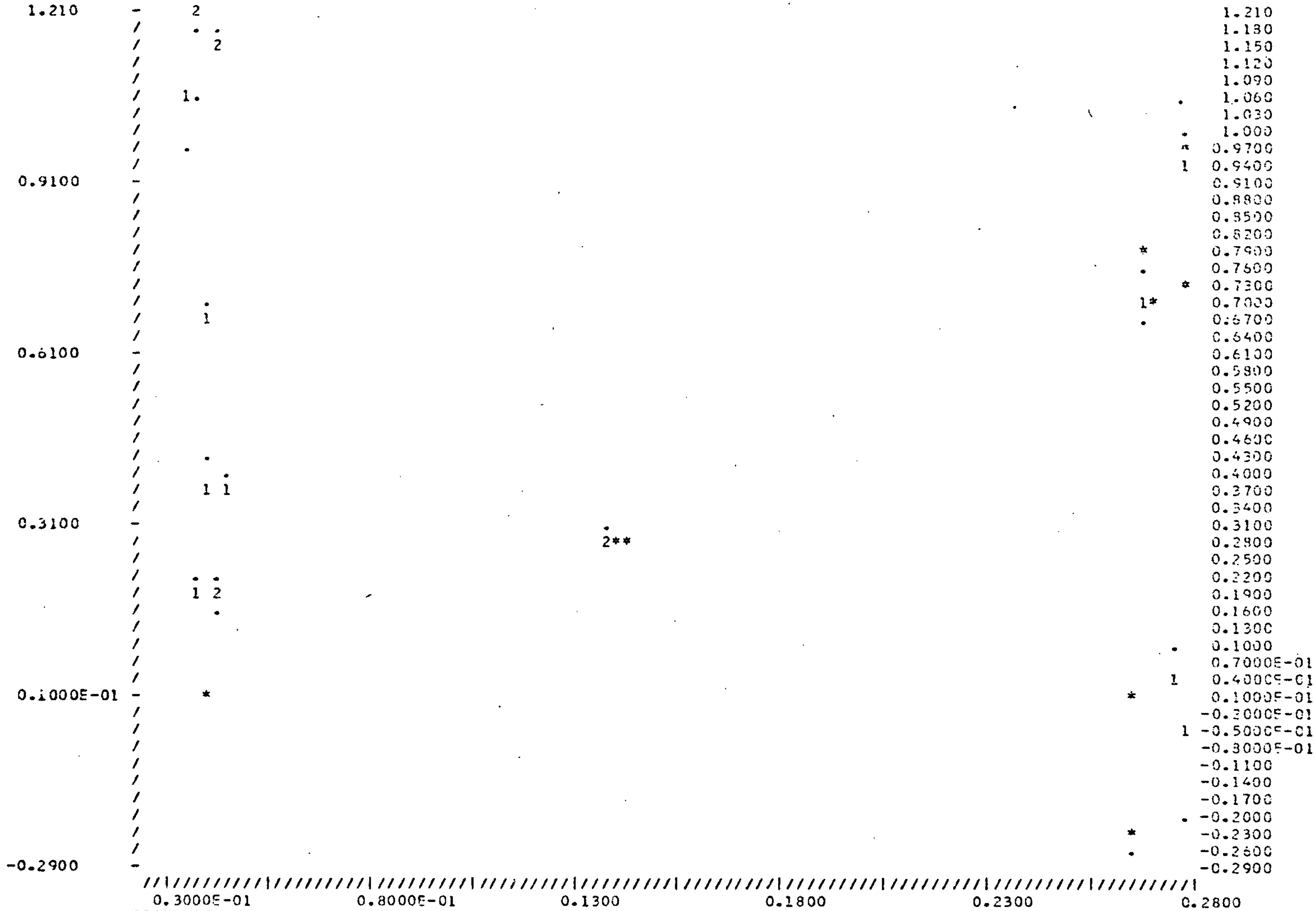
THE ".","+" AND "*" ARE USED TO PLOT PREDICTED VALUES; "*" IS USED WHERE PREDICTED VALUES COVER DATA POINTS
"+" REPRESENTS A POINT OUTSIDE GRAPH.



DISTANCE BETWEEN SLASHES ON THE X-AXIS IS 0.1200E-02

PLOT OF Y & YHAT VS FEFVOL .VERTICAL AXIS IS Y-AXIS.

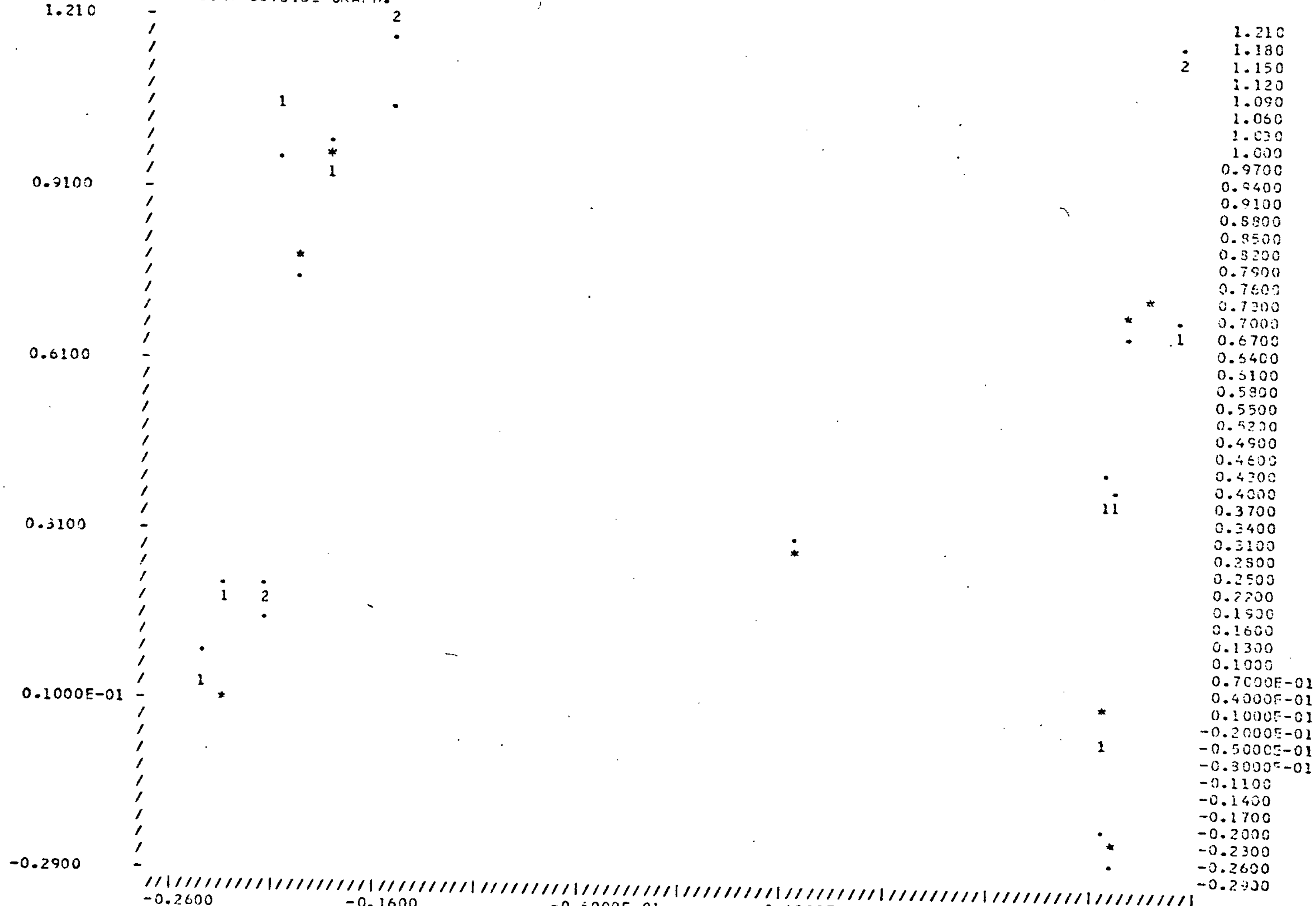
THE ".","+" AND "*" ARE USED TO PLOT PREDICTED VALUES; "*" IS USED WHERE PREDICTED VALUES COVER DATA POINTS
"+" REPRESENTS A POINT OUTSIDE GRAPH.



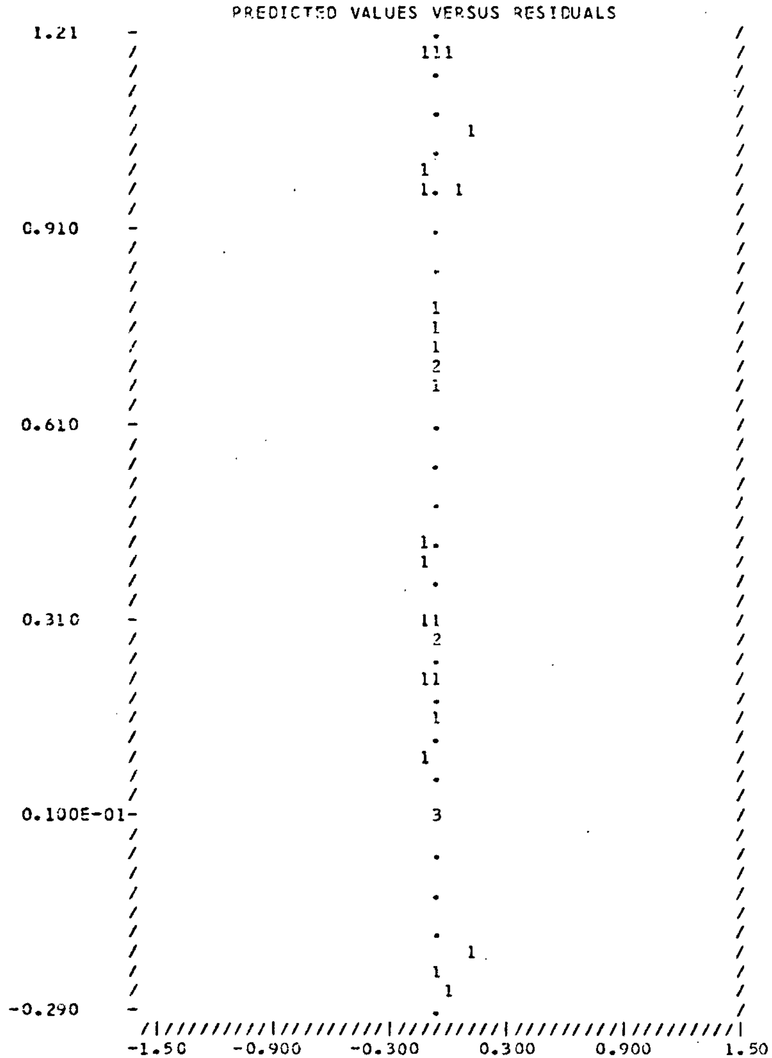
DISTANCE BETWEEN SLASHES ON THE X-AXIS IS 0.2500E-02

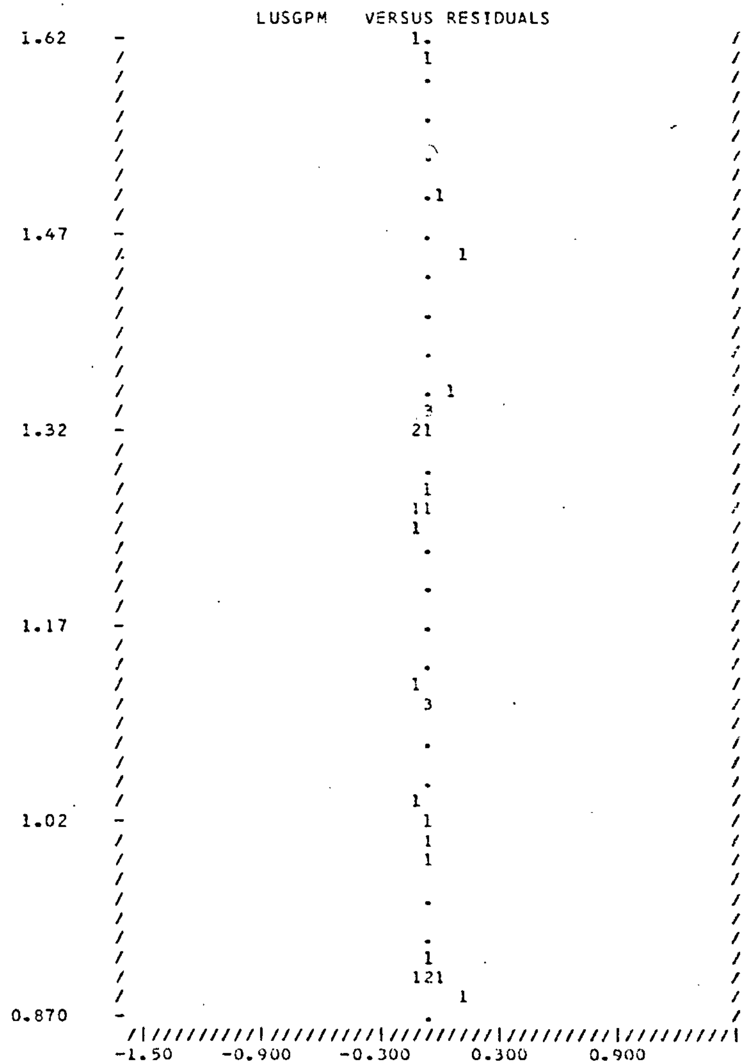
PLOT OF Y & YHAT VS LGVSAR .VERTICAL AXIS IS Y-AXIS.

THE ".","+" AND "*" ARE USED TO PLOT PREDICTED VALUES; "*" IS USED WHERE PREDICTED VALUES COVER DATA POINTS
"+" REPRESENTS A POINT OUTSIDE GRAPH.

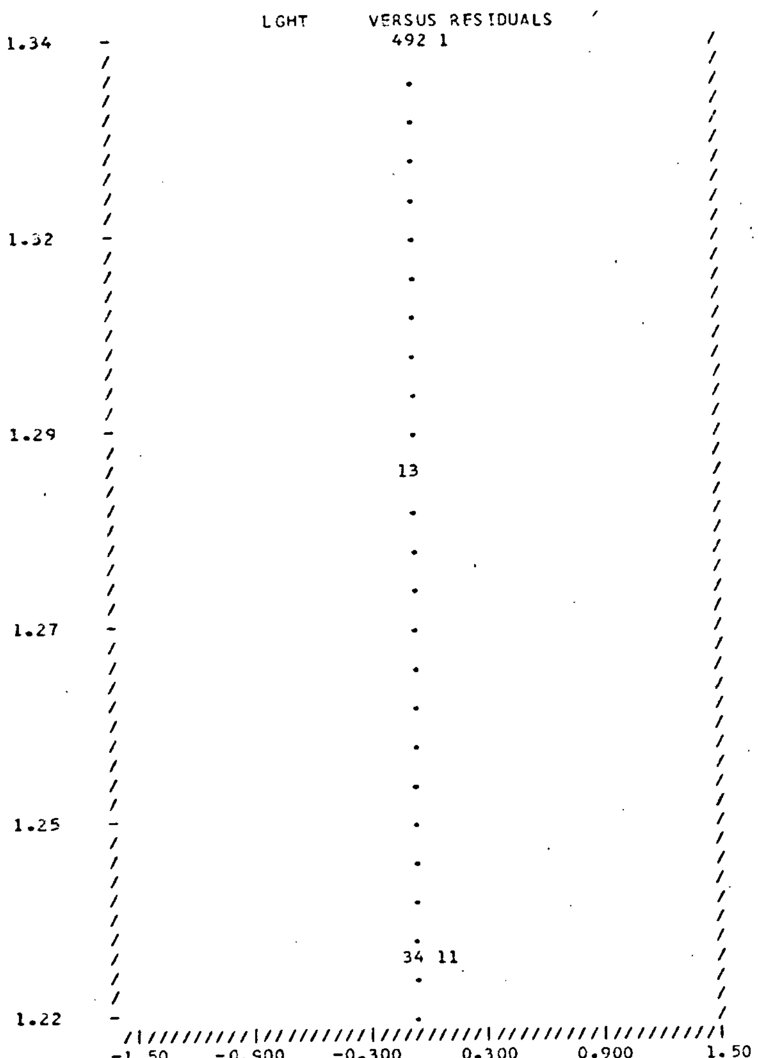


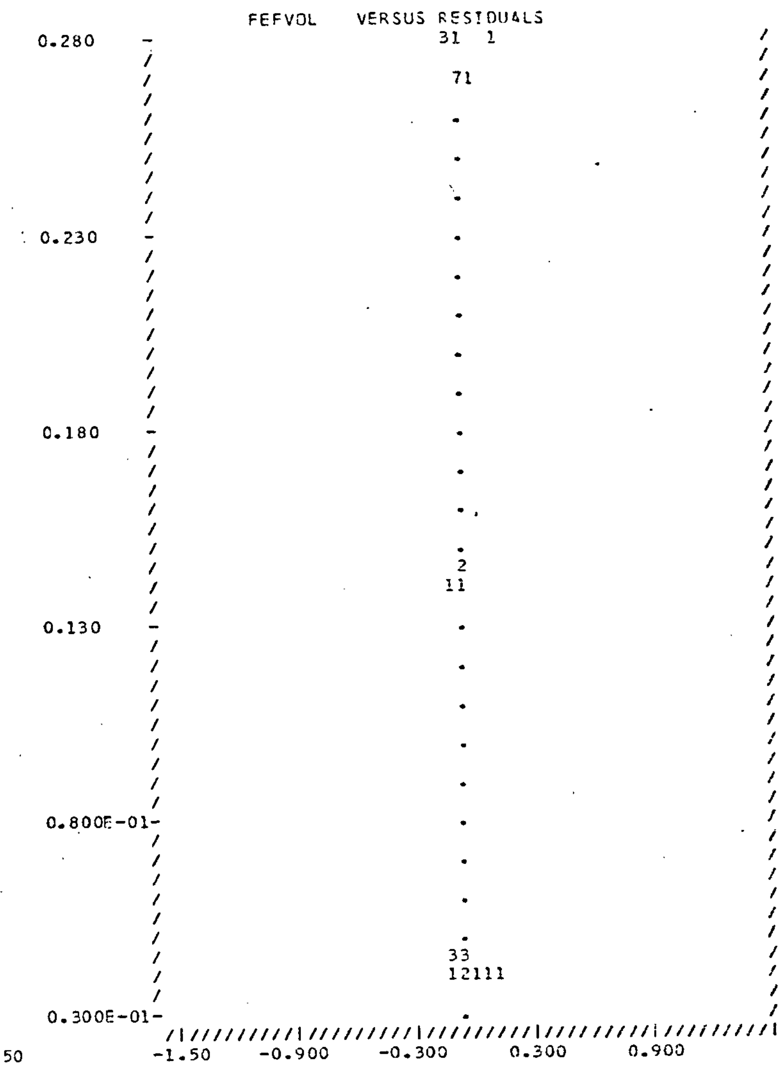
DISTANCE BETWEEN SLASHES ON THE X-AXIS IS 0.5000E-02



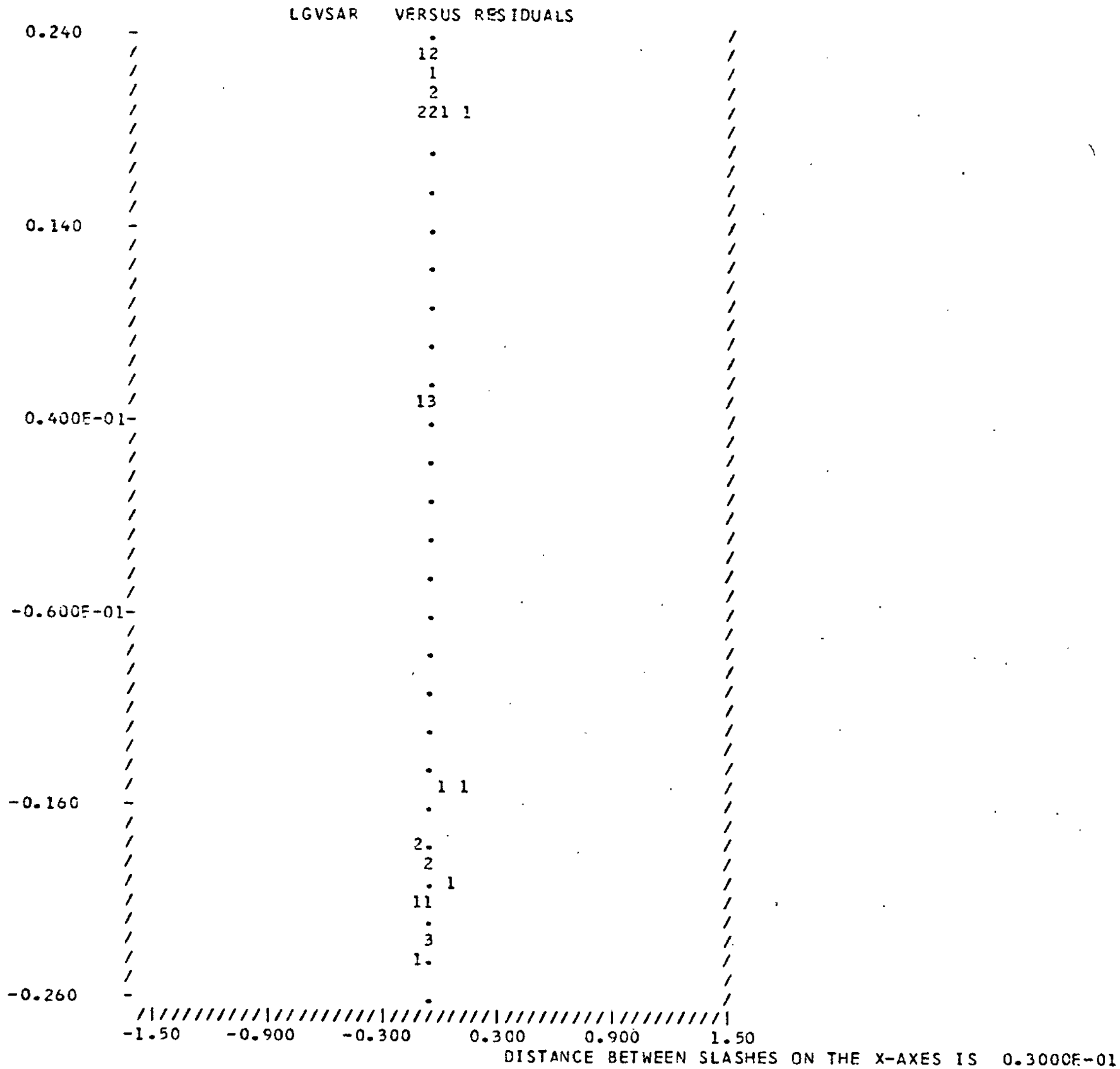


DISTANCE BETWEEN SLASHES ON THE X-AXES IS 0.3000E-01





DISTANCE BETWEEN SLASHES ON THE X-AXES IS 0.3000E-01


LGVSAR VERSUS RESIDUALS
0.240
0.140
0.400E-01
-0.600E-01
-0.160
-0.260
-1.50
-0.900
-0.300
0.300
0.900
1.50
DISTANCE BETWEEN SLASHES ON THE X-AXES IS 0.3000E-01

CONTROL CARD NO. 5 ** STPREG **** STPREG **** STPREG **** STPREG **** STPREG **** STPREG ** CONTROL CARD NO. 5

POTENTIAL INDEPENDENT AND OTHER VARIABLES IN THE REGRESSION ANALYSIS FOR BYPASS

	PARTIAL CORR.	TOLERANCE	F-RATIO	F-PROB
WATUF	0.9041	1.0000	120.9	0.0000
FE%SOL	0.6107	1.0000	16.06	0.0005
FF50	0.2318	1.0000	1.532	0.2245

>>>>>>STEP NUMBER 1 REGRESSION EQUATION FOR BYPASS

R-SQUARED = 0.8174639 F-PROBABILITY LEVEL = 0.0500

STANDARD ERROR BYPASS = 0.7465E-02

F-PROBABILITY = .00000000

VARIABLE	COEFFICIENT	STD. ERR.	F-RATIO	F-PROB	NORM COEFF
WATUF	1.2633181	0.1149	120.9	0.0000	0.9041
CONSTANT	-0.70686661E-02	0.4923E-02	2.053	0.1599	-0.4120

POTENTIAL INDEPENDENT AND OTHER VARIABLES IN THE REGRESSION ANALYSIS FOR BYPASS

	PARTIAL CORR.	TOLERANCE	F-RATIO	F-PROB
FE%SOL	0.1606	0.6209	0.6886	0.4191
FF50	0.4054	0.9958	5.113	0.0308

>>>>>>STEP NUMBER 2 REGRESSION EQUATION FOR BYPASS

R-SQUARED = 0.8474632 F-PROBABILITY LEVEL = 0.0500

STANDARD ERROR BYPASS = 0.6954E-02

F-PROBABILITY = .00000000

VARIABLE	COEFFICIENT	STD. ERR.	F-RATIO	F-PROB	NORM COEFF
WATUF	1.2475139	0.1073	135.3	0.0000	0.8928
FF50	0.93621037E-03	0.4140E-03	5.113	0.0308	0.1736
CONSTANT	-0.27084937E-01	0.9974E-02	7.375	0.0112	-1.579

POTENTIAL INDEPENDENT AND OTHER VARIABLES IN THE REGRESSION ANALYSIS FOR BYPASS

	PARTIAL CORR.	TOLERANCE	F-RATIO	F-PROB
FE%SOL	0.5101	0.4275	8.795	0.0065

>>>>>>STEP NUMBER 3 REGRESSION EQUATION FOR BYPASS

R-SQUARED = 0.8871607 F-PROBABILITY LEVEL = 0.0500

STANDARD ERROR BYPASS = 0.6100E-02

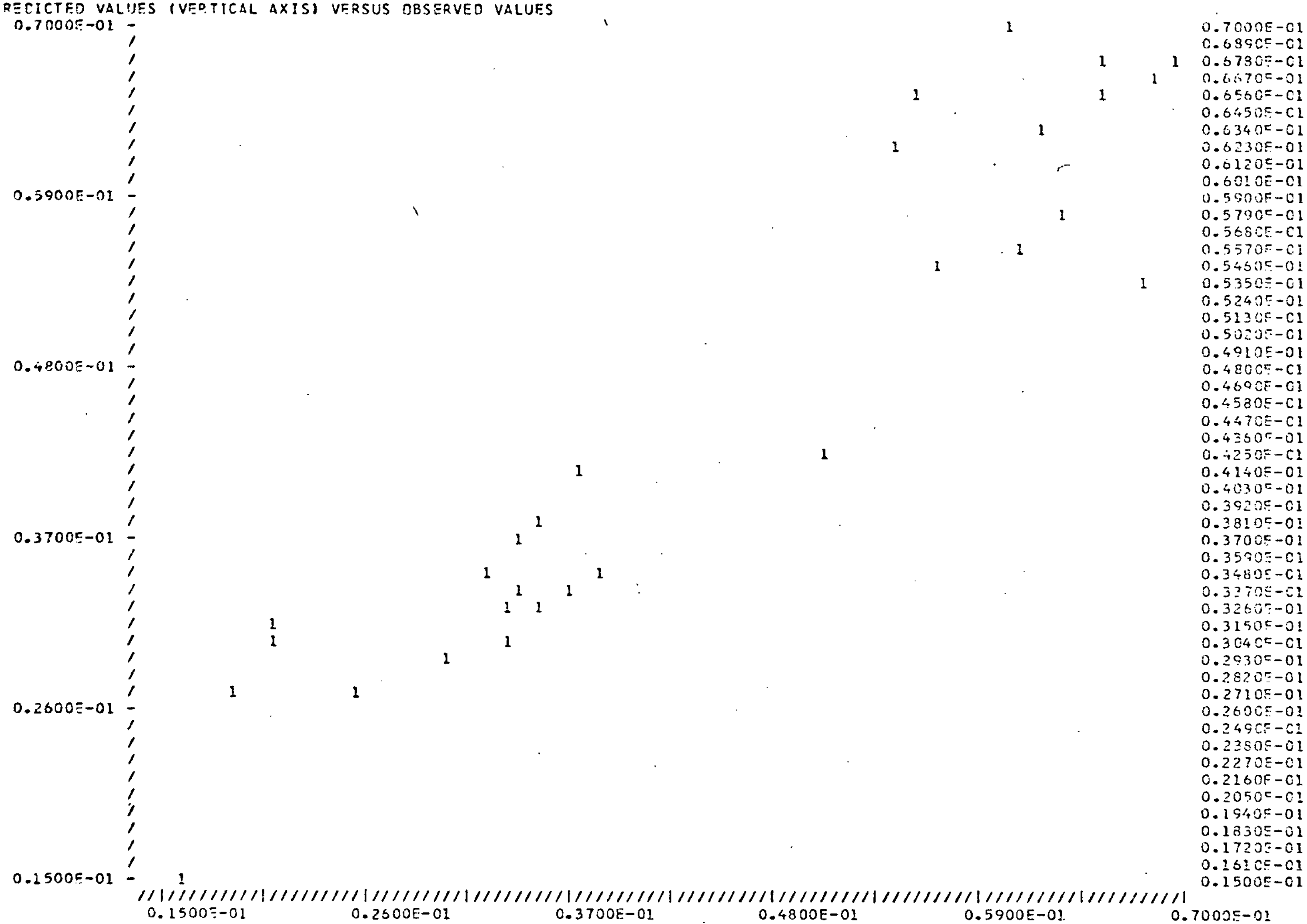
F-PROBABILITY = .00000000

VARIABLE	COEFFICIENT	STD. ERR.	F-RATIO	F-PROB	NORM COEFF
WATUF	0.97312452	0.1319	54.39	0.0000	0.6965
FE%SOL	0.28108818E-03	0.9478E-04	8.795	0.0065	0.3047
FF50	0.16607694E-02	0.4377E-03	14.40	0.0009	0.3079
CONSTANT	-0.40468139E-01	0.9843E-02	16.90	0.0004	-2.359

```
                                         .0 (100%)CONFIDENCE INTERVALS          SCALE FOR RESIDUALS
   OBSERVED    RESIDUAL    PREDICTED     MEAN    OBSERVATION -0.5500E-01 -0.3300E-01 -0.1100E-01  0.1100E-01  0.3300E-01
                                       PLUS-MINUS  PLUS-MINUS    |///////////|///////////|///////////|///////////|///////////|
  1  0.39200E-01  0.4141E-02  0.35059E-01                        /                               . E                             /
  2  0.16800E-01  0.1786E-02  0.15014E-01                        /                               .E                              /
  3  0.21400E-01 -0.1060E-01  0.32004E-01                        /                         E     .                               /
  4  0.35000E-01  0.8265E-03  0.34174E-01                        /                               E                               /
  5  0.38300E-01 -0.2552E-02  0.40852E-01                        /                              E.                               /
  6  0.36100E-01 -0.2541E-02  0.38641E-01                        /                              E.                               /
  7  0.66300E-01  0.7974E-03  0.65503E-01                        /                               E                               /
  8  0.26100E-01 -0.5799E-03  0.26680E-01                        /                               E                               /
  9  0.69800E-01  0.2405E-02  0.67395E-01                        /                               .E                              /
 10  0.31100E-01  0.1680E-02  0.29420E-01                        /                               .E                              /
 11  0.35000E-01 -0.2126E-02  0.37126E-01                        /                              E.                               /
 12  0.34100E-01  0.3866E-02  0.30234E-01                        /                               . E                             /
 13  0.23200E-01 -0.1973E-02  0.35173E-01                        /                              E.                               /
 14  0.66000E-01 -0.1857E-02  0.67857E-01                        /                              E.                               /
 15  0.55200E-01 -0.6953E-02  0.62153E-01                        /                           E   .                               /
 16  0.56200E-01 -0.9110E-02  0.65310E-01                        /                          E    .                               /
 17  0.57500E-01  0.2414E-02  0.55086E-01                        /                               .E                              /
 18  0.68500E-01  0.1520E-01  0.53301E-01                        /                               .        E                      /
 19  0.36000E-01  0.3199E-02  0.32801E-01                        /                               . E                             /
 20  0.19600E-01 -0.7560E-02  0.27160E-01                        /                           E   .                               /
 21  0.21800E-01 -0.8315E-02  0.30115E-01                        /                          E    .                               /
 22  0.37400E-01  0.3438E-02  0.33962E-01                        /                               . E                             /
 23  0.61500E-01  0.6096E-02  0.55404E-01                        /                               .  E                            /
 24  0.51400E-01  0.8802E-02  0.42598E-01                        /                               .    E                          /
 25  0.69000E-01  0.2210E-02  0.66789E-01                        /                               .E                              /
 26  0.34100E-01  0.1045E-02  0.33055E-01                        /                               .E                              /
 27  0.63800E-01  0.5583E-02  0.58217E-01                        /                               .  E                            /
 28  0.61300E-01 -0.8877E-02  0.70177E-01                        /                          E    .                               /
 29  0.63100E-01 -0.4455E-03  0.63546E-01                        /                               E                               /
                                                                 |///////////|///////////|///////////|///////////|///////////|
                                                              -0.5500E-01 -0.3300E-01 -0.1100E-01  0.1100E-01  0.3300E-01
                                                                                  SCALE FOR RESIDUALS

 29 COMPLETE OBSERVATIONS    AUTO CORR COEFF=  0.1879       DURBIN WATSON D-STATISTIC =   1.606
```

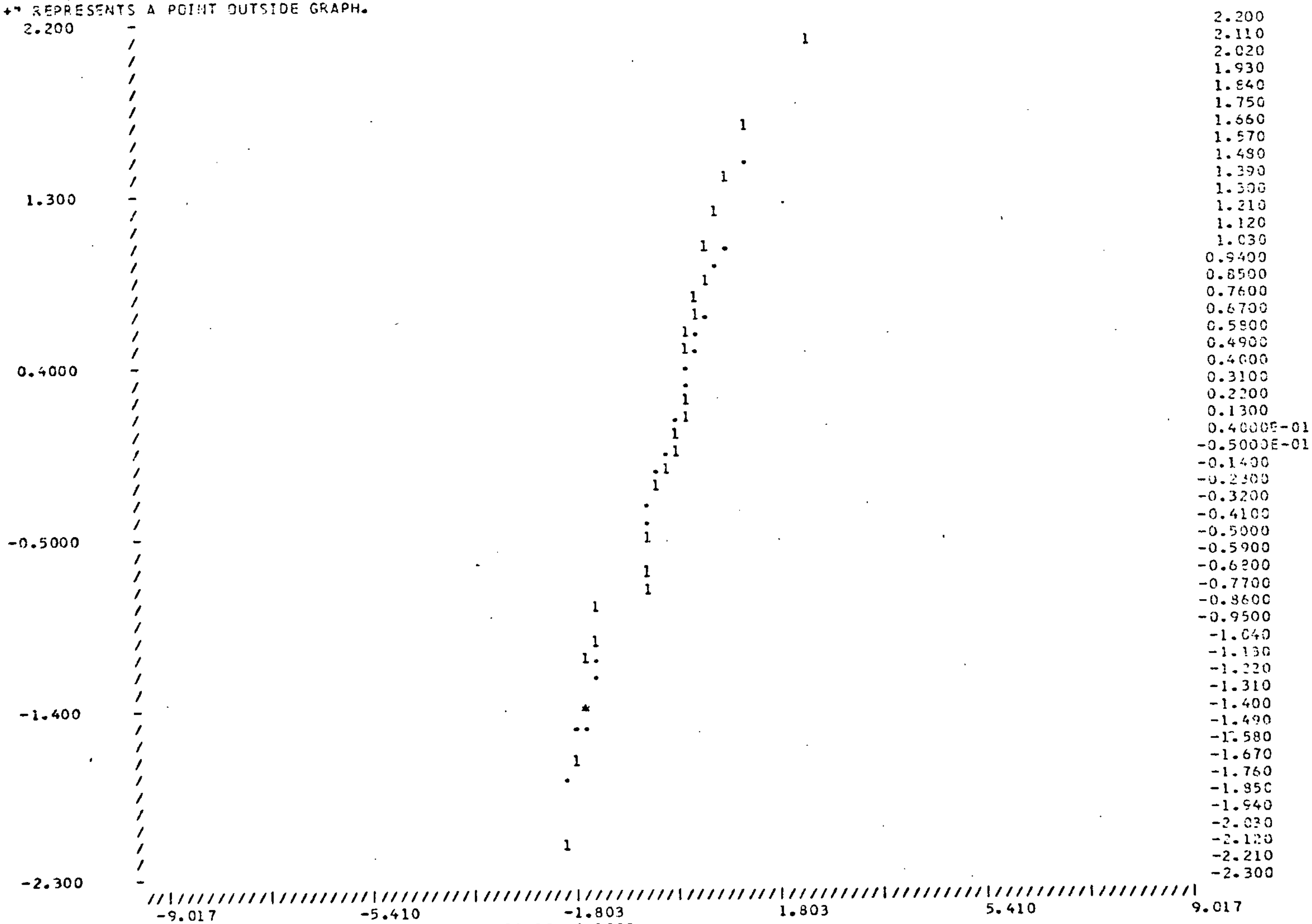
PREDICTED VALUES (VERTICAL AXIS) VERSUS OBSERVED VALUES



DISTANCE BETWEEN SLASHES ON THE X-AXIS IS 0.5500E-03

PROBABILITY OF RESIDUALS VS RESIDUALS
(PLOT TO VERIFY THE NORMALITY OF THE DIST OF RESIDUALS)

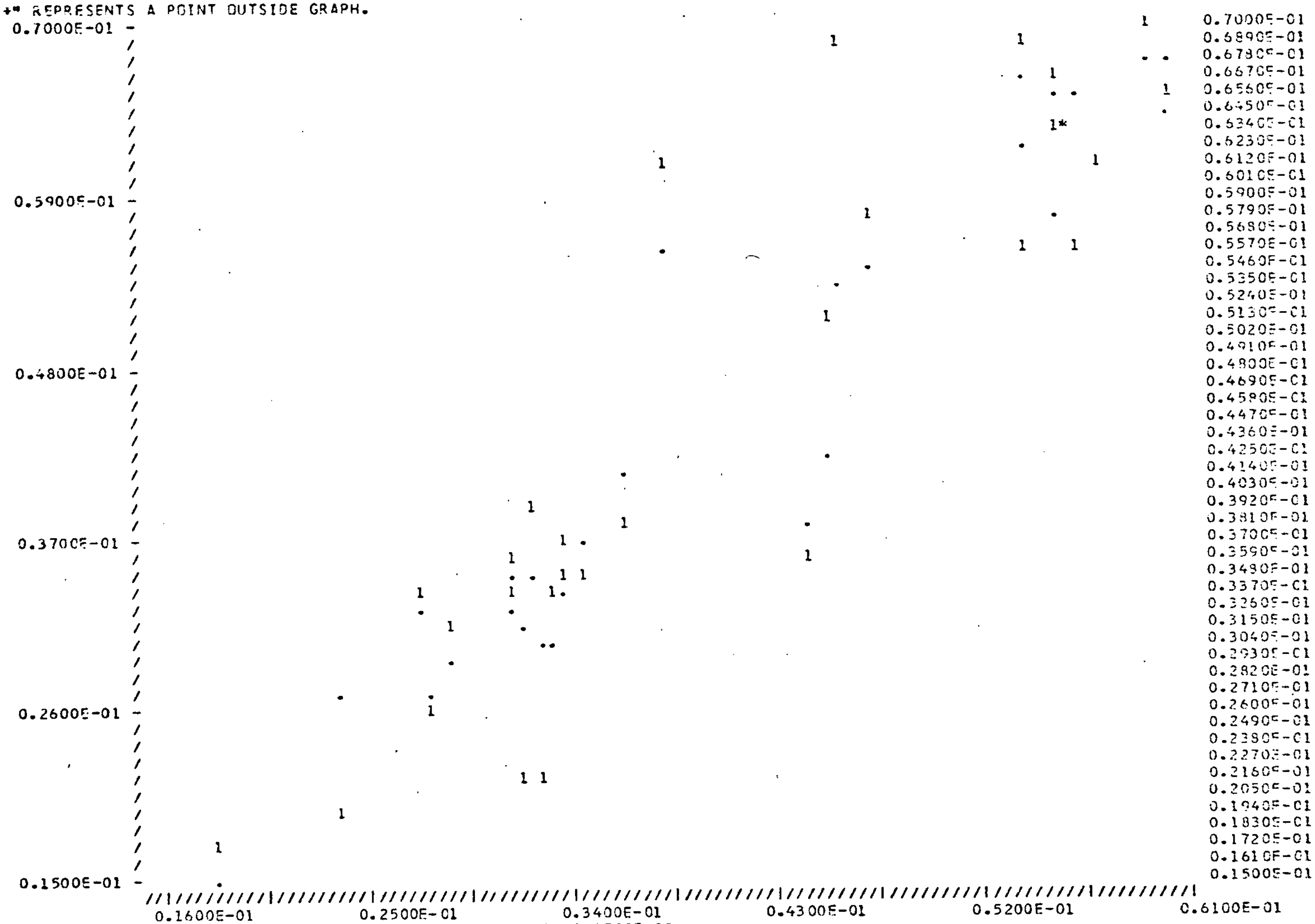
THE ".","+" AND "*" ARE USED TO PLOT PREDICTED VALUES; "*" IS USED WHERE PREDICTED VALUES COVER DATA POINTS
"+" REPRESENTS A POINT OUTSIDE GRAPH.



DISTANCE BETWEEN SLASHES ON THE X-AXIS IS 0.1803

PLOT OF Y & YHAT VS WATUF .VERTICAL AXIS IS Y-AXIS.

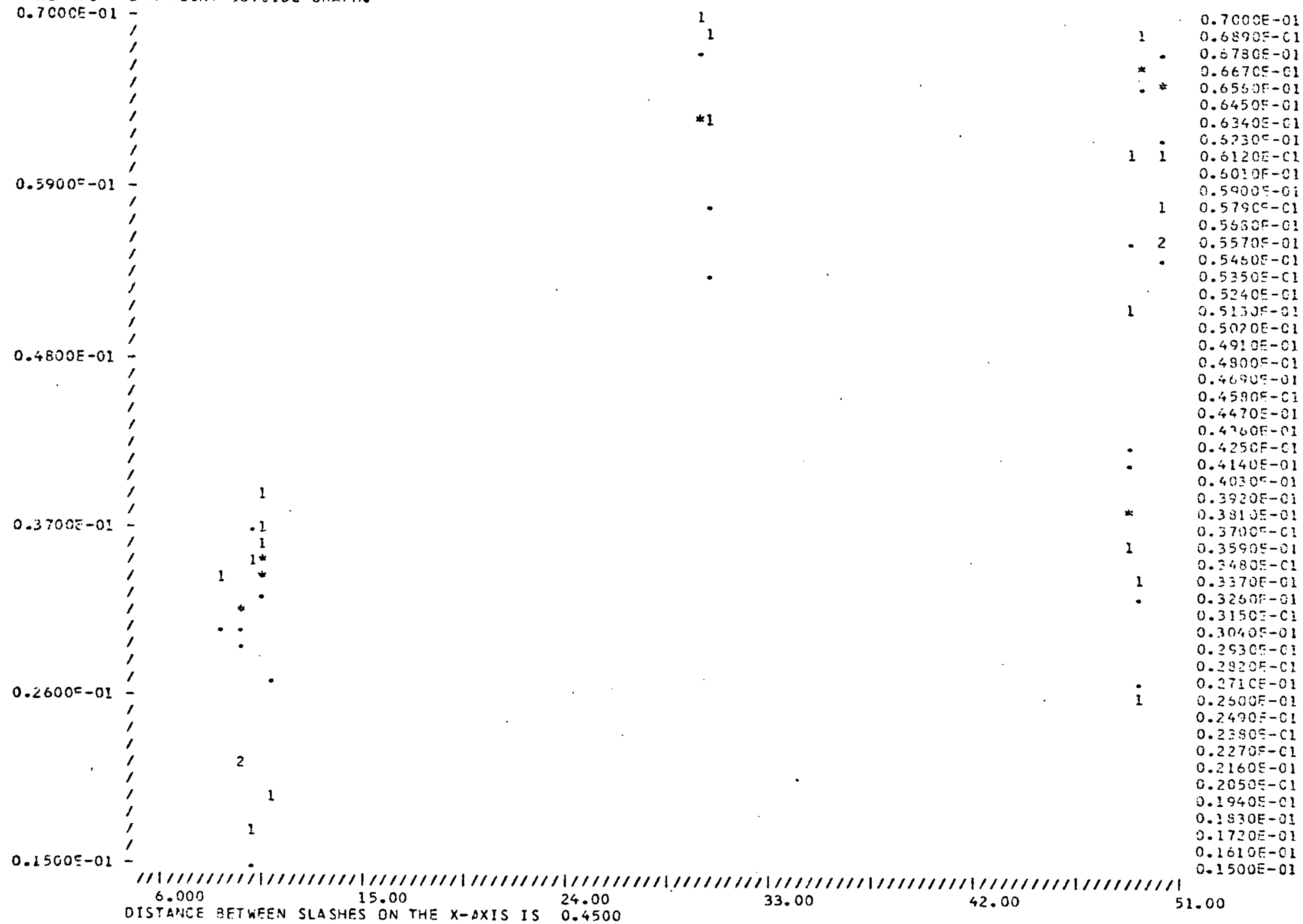
THE ".","+" AND "*" ARE USED TO PLOT PREDICTED VALUES; "*" IS USED WHERE PREDICTED VALUES COVER DATA POINTS
"+" REPRESENTS A POINT OUTSIDE GRAPH.



DISTANCE BETWEEN SLASHES ON THE X-AXIS IS 0.4500E-03

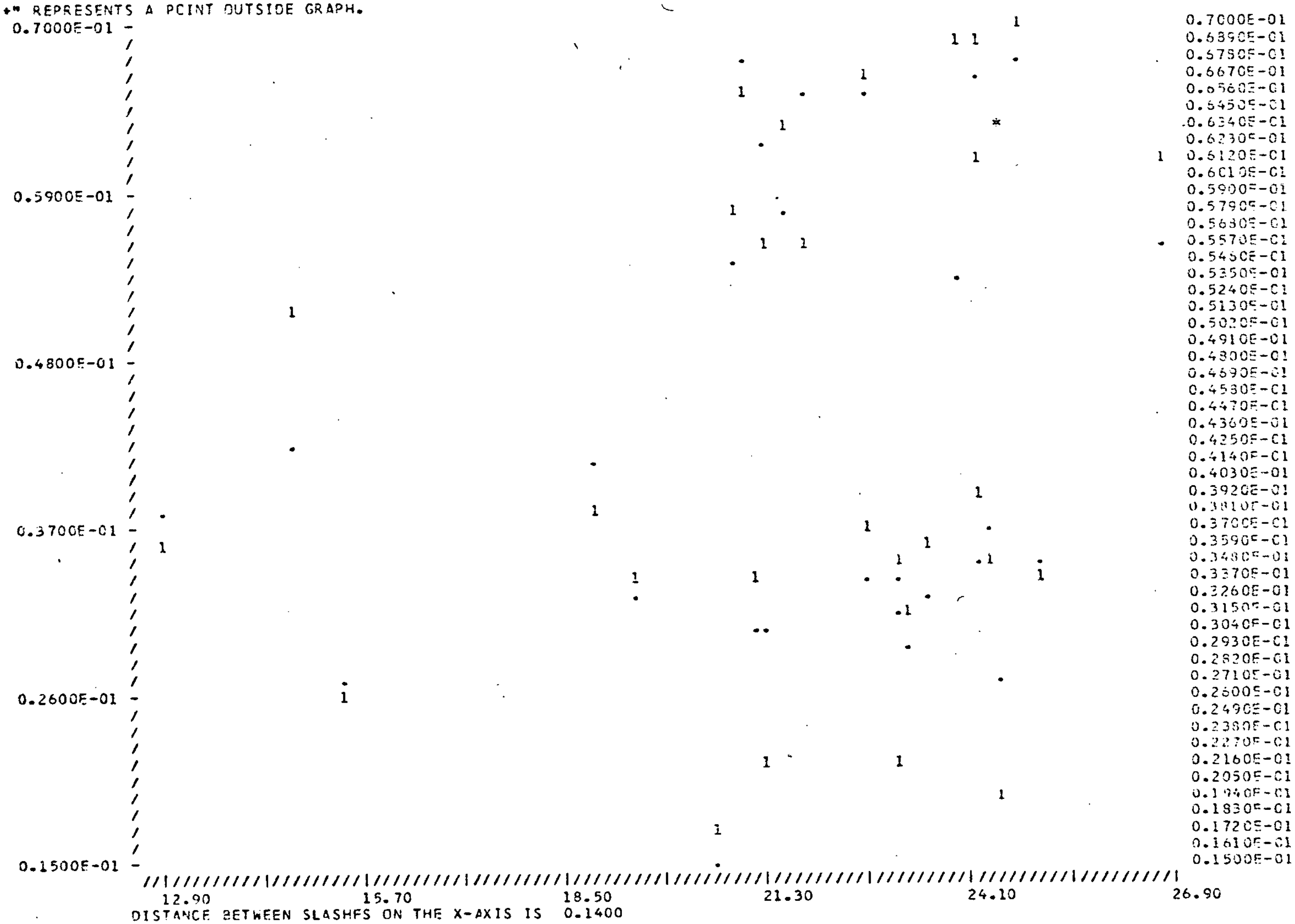
PLOT OF Y & YHAT VS FE%SOL .VERTICAL AXIS IS Y-AXIS.

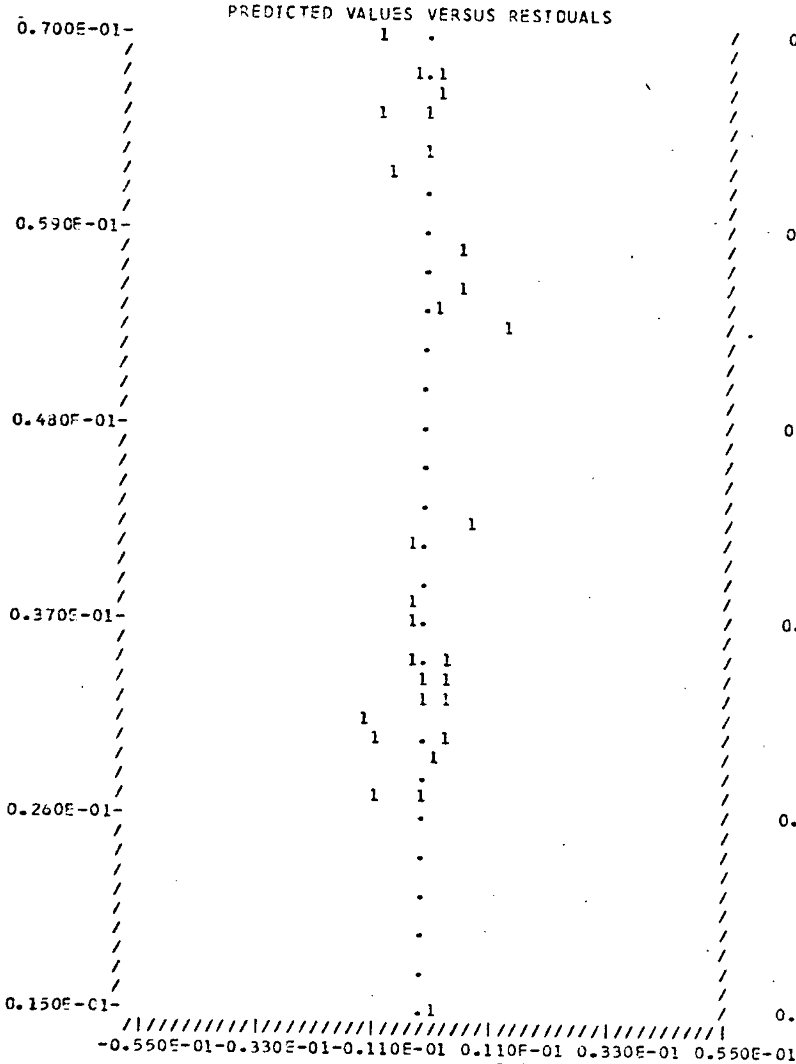
THE ".","+" AND "*" ARE USED TO PLOT PREDICTED VALUES; "*" IS USED WHERE PREDICTED VALUES COVER DATA POINTS.
"+" REPRESENTS A POINT OUTSIDE GRAPH.

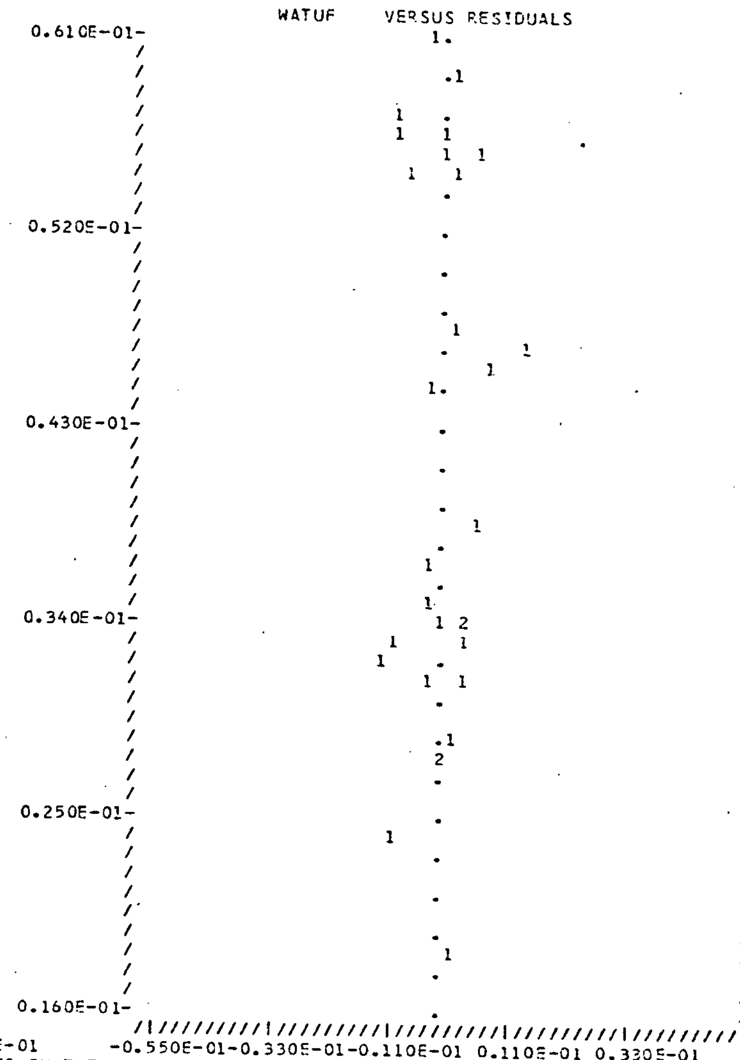


PLOT OF Y & YHAT VS FE50 .VERTICAL AXIS IS Y-AXIS.

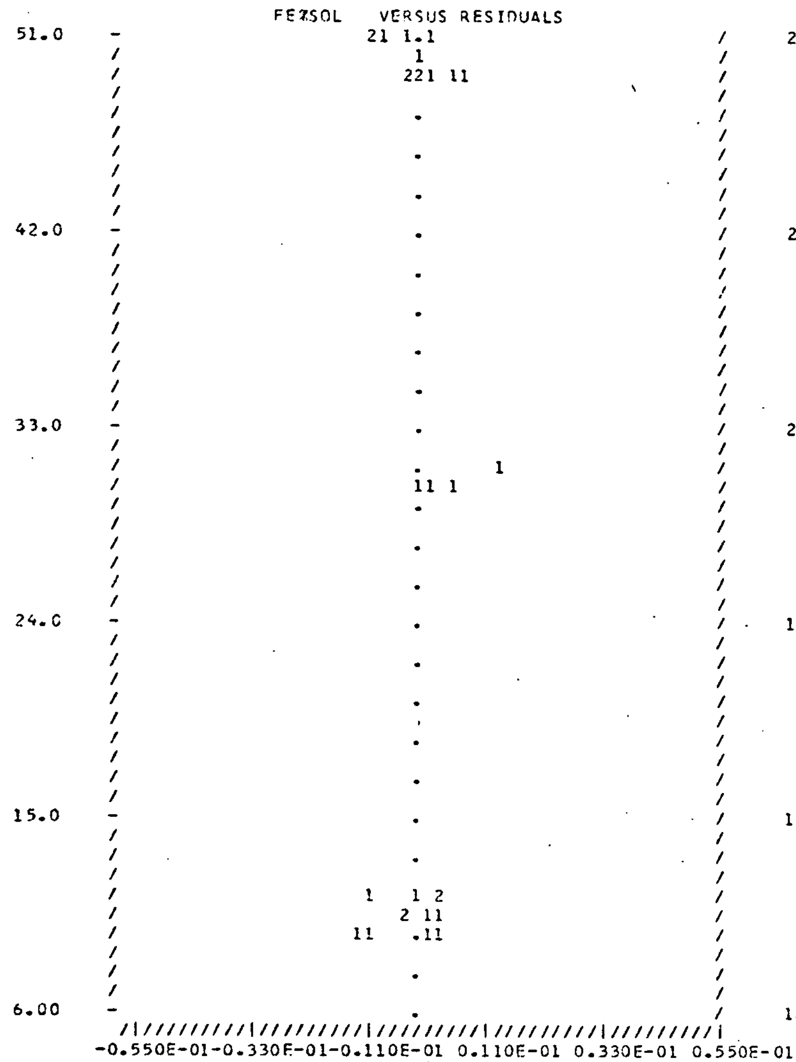
THE ".","+" AND "*" ARE USED TO PLOT PREDICTED VALUES; "*" IS USED WHERE PREDICTED VALUES COVER DATA POINTS
"+" REPRESENTS A POINT OUTSIDE GRAPH.

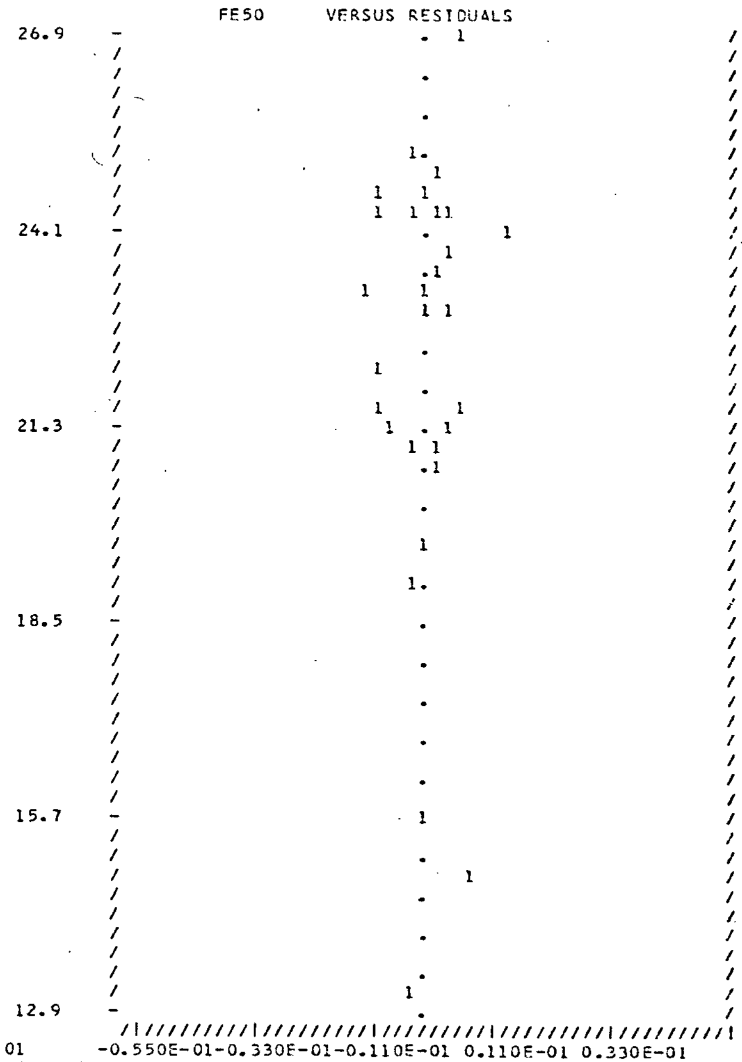






DISTANCE BETWEEN SLASHES ON THE X-AXES IS 0.1100E-02





DISTANCE BETWEEN SLASHES ON THE X-AXES IS 0.1100E-02

CONTROL CARD NO. 6 ** STPREG **** STPREG **** STPREG **** STPREG **** STPREG **** STPREG **** STPREG ** CONTROL CARD NO. 6

POTENTIAL INDEPENDENT AND OTHER VARIABLES IN THE REGRESSION ANALYSIS FOR LGALPH

	PARTIAL CORR.	TOLERANCE	F-RATIO	F-PROB
WATUF	0.3434	1.0000	3.611	0.0651
VORTEX	0.3026	1.0000	2.721	0.1069
FE%SOL	0.2748	1.0000	2.206	0.1455
FE50	0.5356	1.0000	10.86	0.0028
VSPLIT	0.3122	1.0000	2.916	0.0956
LOGWUF	0.3769	1.0000	4.469	0.0418
LOGVTX	0.3108	1.0000	2.888	0.0971
LGFEPS	0.2392	1.0000	1.638	0.2091
LGFE50	0.5351	1.0000	10.83	0.0028
FEFVOL	0.2971	1.0000	2.426	0.1273
LGVSAR	0.3049	1.0000	2.768	0.1040
1-RV	0.3165	1.0000	3.006	0.0908
UF%SOL	0.2261	1.0000	1.455	0.2366
OF%SOL	0.2641	1.0000	2.025	0.1626

>>>>>>STEP NUMBER 1 REGRESSION EQUATION FOR LGALPH
R-SQUARED = 0.2868856 F-PROBABILITY LEVEL = 0.0500
STANDARD ERROR LGALPH = 0.8957E-01
F-PROBABILITY = .00281635

VARIABLE	COEFFICIENT	STD. ERR.	F-RATIO	F-PROB	NORM COEFF
FE50	0.17536697E-01	0.5321E-02	10.86	0.0028	0.5356
CONSTANT	0.35580465	0.1186	8.995	0.0057	3.416

POTENTIAL INDEPENDENT AND OTHER VARIABLES IN THE REGRESSION ANALYSIS FOR LGALPH

	PARTIAL CORR.	TOLERANCE	F-RATIO	F-PROB
WATUF	0.4490	0.9958	6.565	0.0159
VORTEX	0.6194	0.8776	16.18	0.0005
FE%SOL	0.0790	0.8409	0.1634	0.6905
VSPLIT	0.5290	0.9475	10.11	0.0038
LOGWUF	0.4833	0.9967	7.922	0.0089
LOGVTX	0.6196	0.8853	16.20	0.0005
LGFEPS	0.0564	0.8678	0.8308E-01	0.7672
LGFE50	0.0260	0.0103	0.1765E-01	0.8645
FEFVOL	0.0880	0.8323	0.2029	0.6596
LGVSAR	0.5907	0.9010	13.94	0.0010
1-RV	0.5331	0.9482	10.32	0.0035
UF%SOL	0.1740	0.9772	0.8115	0.3795
OF%SOL	0.0571	0.8310	0.8500E-01	0.7650

>>>>>>STEP NUMBER 2 REGRESSION EQUATION FOR LGALPH
R-SQUARED = 0.5606276 F-PROBABILITY LEVEL = 0.0500
STANDARD ERROR LGALPH = 0.7164E-01
F-PROBABILITY = .00002962

VARIABLE	COEFFICIENT	STD. ERR.	F-RATIO	F-PROB	NORM COEFF
FE50	0.23704022E-01	0.4524E-02	27.46	0.0000	0.7240
LOGVTX	0.55207555	0.1372	16.20	0.0005	0.5561
CONSTANT	0.22843035	0.1000	5.214	0.0293	2.193

POTENTIAL INDEPENDENT AND OTHER VARIABLES IN THE REGRESSION ANALYSIS FOR LGALPH

	PARTIAL CORR.	TOLERANCE	F-RATIO	F-PROB
WATUF	0.3993	0.9418	4.742	0.0372

VORTEX	0.0137	0.0020	0.4661E-02	0.9029
FE%SOL	0.0523	0.8098	0.6845E-01	0.7844
VSPLIT	0.4809	0.8801	7.520	0.0108
LOGWUF	0.4317	0.9342	5.728	0.0234
LGFEPS	0.0486	0.8477	0.5911E-01	0.7963
LGFE50	0.1376	0.0102	0.4824	0.5004
FEFVOL	0.0506	0.7974	0.6407E-01	0.7899
LGVSAR	0.2758	0.0118	2.058	0.1604
1-RV	0.4858	0.8804	7.723	0.0099
UF%SOL	0.0057	0.8963	0.8035E-03	0.9271
OF%SOL	0.0724	0.8034	0.1316	0.7182

VARIABLE VSPLIT IS A LINEAR COMBINATION OF VARIABLES INCLUDED IN THIS REGRESSION

>>>>>>STEP NUMBER 3 REGRESSION EQUATION FOR LGALPH
R-SQUARED = 0.6643214 F-PROBABILITY LEVEL = 0.0500
STANDARD ERROR LGALPH = 0.6386E-01
F-PROBABILITY = .00000539

VARIABLE	COEFFICIENT	STD. ERR.	F-RATIO	F-PROB	NORM COEFF
FE50	0.25207971E-01	0.4068E-02	38.39	0.0000	0.7699
LOGVTX	0.45779479	0.1269	13.02	0.0014	0.4611
1-RV	2.3630959	0.8503	7.723	0.0099	0.3432
CONSTANT	-2.0294515	0.8174	6.165	0.0192	-19.49

POTENTIAL INDEPENDENT AND OTHER VARIABLES IN THE REGRESSION ANALYSIS FOR LGALPH

	PARTIAL CORR.	TOLERANCE	F-RATIO	F-PROB
WATUF	0.2481	0.0834	1.574	0.2197
VORTEX	0.3372	0.0014	3.078	0.0887
FE%SOL	0.4388	0.5638	5.723	0.0238
LOGWUF	0.1267	0.0808	0.3915	0.5443
LGFEPS	0.4927	0.5369	7.695	0.0102
LGFE50	0.1342	0.0101	0.4405	0.5200
FEFVOL	0.4102	0.5782	4.855	0.0356
LGVSAR	0.1367	0.0105	0.4571	0.5122
UF%SOL	0.1911	0.8075	0.9099	0.3522
OF%SOL	0.4376	0.5841	5.685	0.0242

>>>>>>STEP NUMBER 4 REGRESSION EQUATION FOR LGALPH
R-SQUARED = 0.7458188 F-PROBABILITY LEVEL = 0.0500
STANDARD ERROR LGALPH = 0.5672E-01
F-PROBABILITY = .00000102

VARIABLE	COEFFICIENT	STD. ERR.	F-RATIO	F-PROB	NORM COEFF
FE50	0.31510326E-01	0.4268E-02	54.50	0.0000	0.9624
LOGVTX	0.45237132	0.1127	16.11	0.0006	0.4557
LGFEPS	0.12591420	0.4539E-01	7.695	0.0102	0.3896
1-RV	3.9571662	0.9490	17.39	0.0004	0.5747
CONSTANT	-3.8432233	0.9770	15.47	0.0007	-36.90

POTENTIAL INDEPENDENT AND OTHER VARIABLES IN THE REGRESSION ANALYSIS FOR LGALPH

	PARTIAL CORR.	TOLERANCE	F-RATIO	F-PROB
WATUF	0.1085	0.0482	0.2738	0.6115
VORTEX	0.4534	0.0014	5.951	0.0218
FE%SOL	0.3887	0.0117	4.094	0.0523
LOGWUF	0.2417	0.0518	1.427	0.2431
LGFE50	0.2308	0.0100	1.294	0.2665
FEFVOL	0.4050	0.0242	4.513	0.0425
LGVSAR	0.1361	0.0080	0.4342	0.5233

UF%SOL	0.0399	0.6434	0.3675E-01	0.8287
OF%SOL	0.3903	0.0125	4.133	0.0513

VARIABLE FE%SOL IS A LINEAR COMBINATION OF VARIABLES INCLUDED IN THIS REGRESSION

>>>>>>STEP NUMBER 5 REGRESSION EQUATION FOR LGALPH

R-SQUARED = 0.7980694 F-PROBABILITY LEVEL = 0.0500

STANDARD ERROR LGALPH = 0.5164E-01

F-PROBABILITY = .00000039

VARIABLE	COEFFICIENT	STD. ERR.	F-RATIO	F-PROB	NORM COEFF
VORTEX	-2.6675551	1.093	5.951	0.0218	-6.046
FE50	0.30195990E-01	0.3923E-02	59.24	0.0000	0.9223
LOGVTX	6.3784758	2.431	6.882	0.0146	6.425
LGFEPS	0.13722239	0.4159E-01	10.89	0.0032	0.4246
1-RV	5.1806013	0.9990	26.89	0.0000	0.7524
CONSTANT	-2.2421715	1.105	4.114	0.0518	-21.53

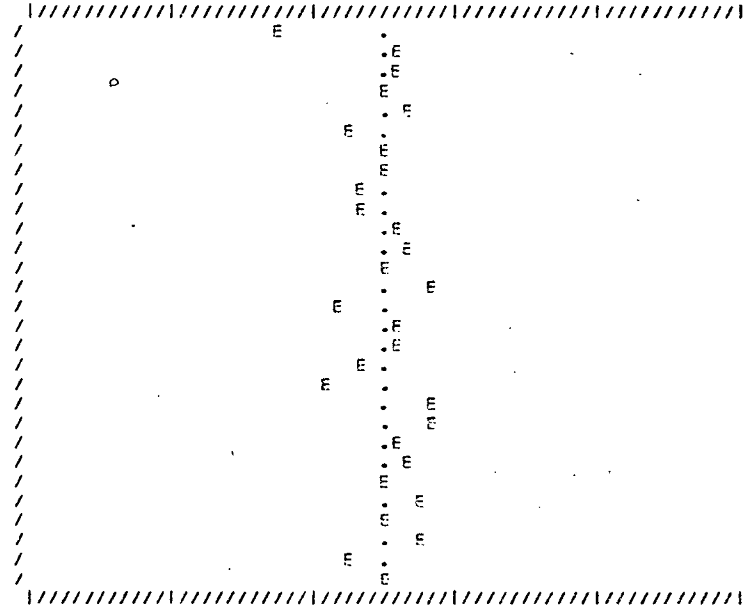
POTENTIAL INDEPENDENT AND OTHER VARIABLES IN THE REGRESSION ANALYSIS FOR LGALPH

	PARTIAL CORR.	TOLERANCE	F-RATIO	F-PROB
WATUF	0.1008	0.0482	0.2258	0.6436
LOGWUF	0.2070	0.0510	0.9853	0.3336
LGFE50	0.2873	0.0099	1.979	0.1703
FEFVOL	0.1827	0.0012	0.7600	0.3969
LGVSAR	0.1374	0.0080	0.4235	0.5287
UF%SOL	0.1447	0.5627	0.4707	0.5065
OF%SOL	0.0859	0.0018	0.1637	0.6907

.0 (100%)CONFIDENCE INTERVALS — SCALE FOR RESIDUALS

	OBSERVED	RESIDUAL	PREDICTED	MEAN PLUS-MINUS	OBSERVATION PLUS-MINUS
1	0.61380	-0.1432	0.75698		
2	0.87160	0.2152E-01	0.85008		
3	0.72020	0.2023E-01	0.69997		
4	0.77450	0.6282E-02	0.76822		
5	0.72800	0.3422E-01	0.69378		
6	0.50650	-0.5331E-01	0.55981		
7	0.65800	-0.1547E-02	0.65955		
8	0.71260	-0.6694E-02	0.71929		
9	0.78100	-0.3004E-01	0.81104		
10	0.72510	-0.2396E-01	0.74906		
11	0.86750	0.1953E-01	0.84797		
12	0.66840	0.3578E-01	0.63262		
13	0.85670	-0.4987E-02	0.86169		
14	0.68480	0.5923E-01	0.62557		
15	0.69810	-0.6527E-01	0.76337		
16	0.63550	0.1572E-01	0.61978		
17	0.77090	0.1072E-01	0.76018		
18	0.80620	-0.2335E-01	0.82955		
19	0.66180	-0.8184E-01	0.74364		
20	0.97170	0.6864E-01	0.90306		
21	0.70760	0.6550E-01	0.64210		
22	0.76420	0.8777E-02	0.75542		
23	0.95280	0.2784E-01	0.92496		
24	0.60850	0.2657E-02	0.60584		
25	0.75510	0.4367E-01	0.71143		
26	0.83310	-0.7698E-02	0.84080		
27	0.77520	0.5369E-01	0.72151		
28	0.63450	-0.5155E-01	0.68605		
29	0.80140	-0.8012E-03	0.80220		

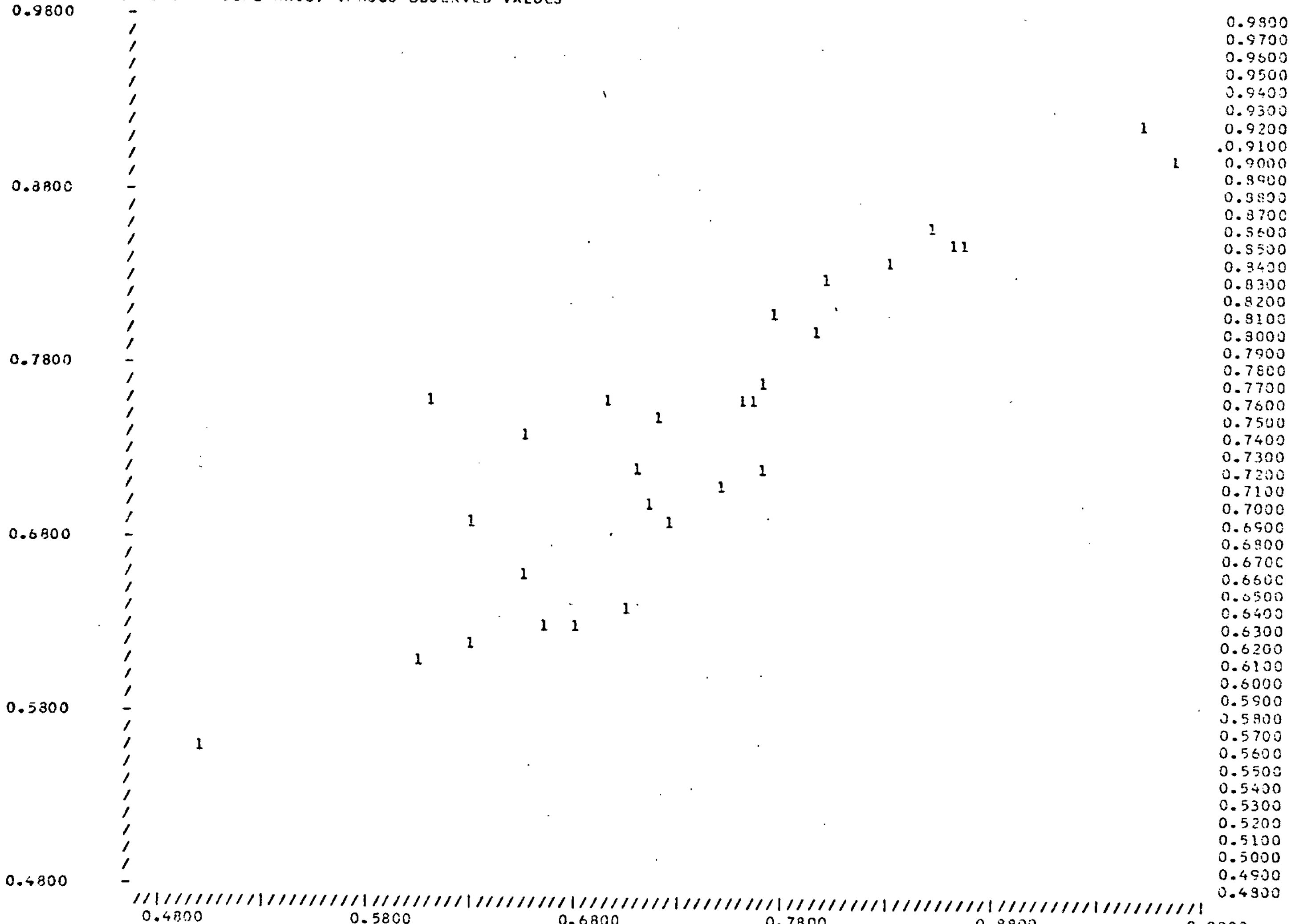
-0.5000 -0.3000 -0.1000 0.1000 0.3000



-0.5000 -0.3000 -0.1000 0.1000 0.3000
SCALE FOR RESIDUALS

29 COMPLETE OBSERVATIONS AUTO CORR COEFF= -0.1631 DURBIN WATSON D-STATISTIC = 1.992

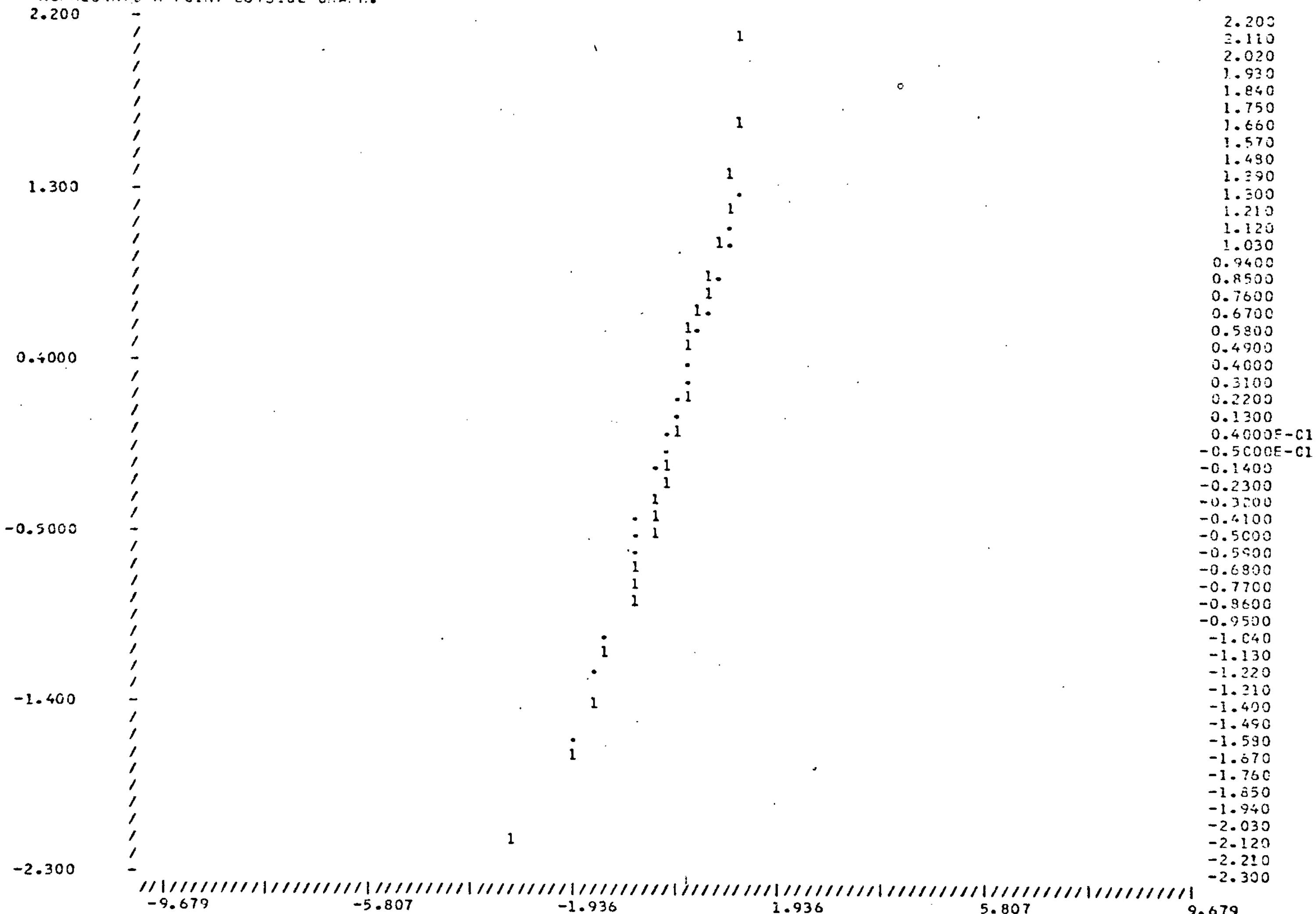
PREDICTED VALUES (VERTICAL AXIS) VERSUS OBSERVED VALUES



DISTANCE BETWEEN SLASHES ON THE X-AXIS IS 0.5000E-02

PROBABILITY OF RESIDUALS VS RESIDUALS
(PLOT TO VERIFY THE NORMALITY OF THE DIST OF RESIDUALS)

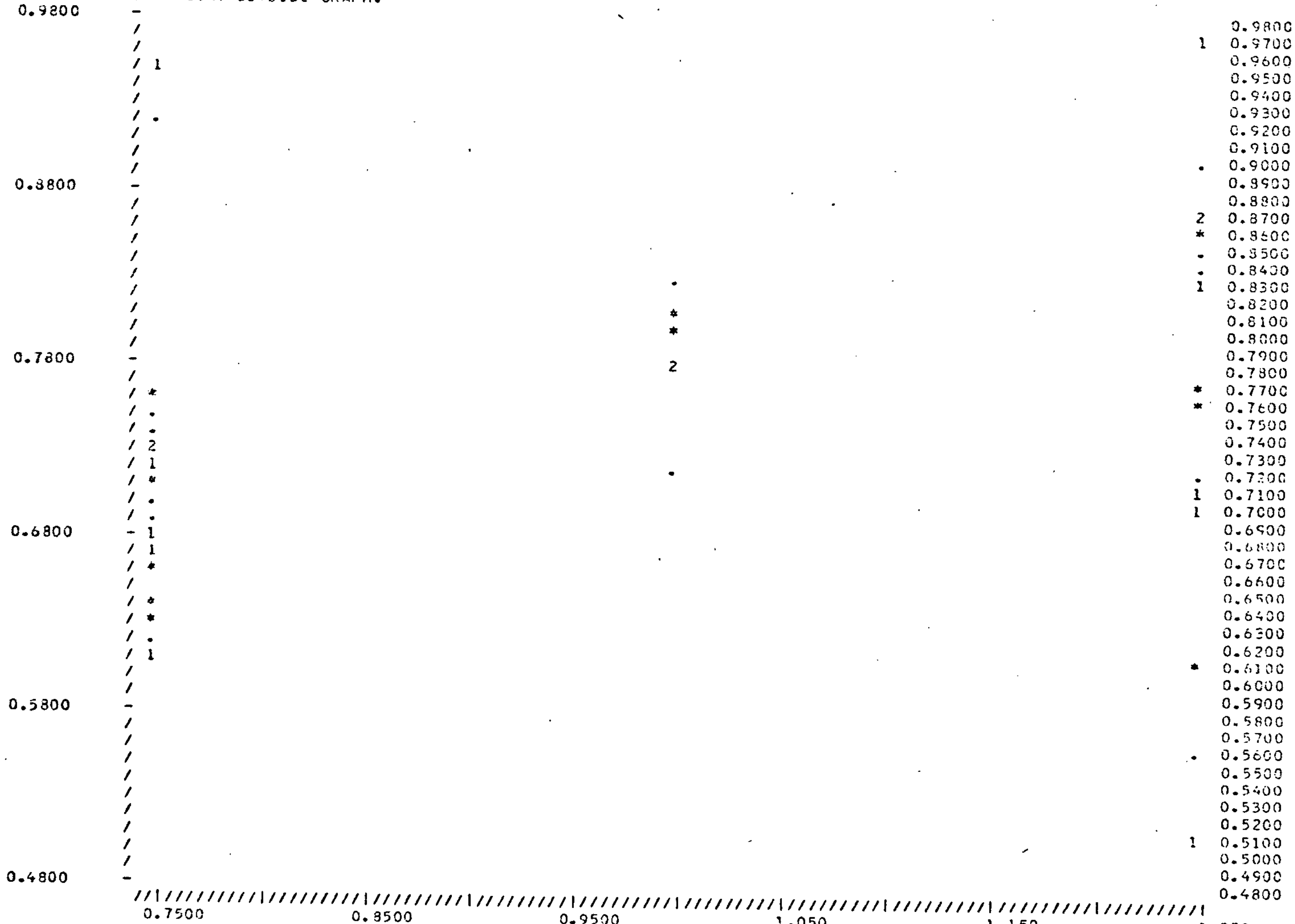
THE ".","+" AND "*" ARE USED TO PLOT PREDICTED VALUES; "*" IS USED WHERE PREDICTED VALUES COVER DATA POINTS
"+" REPRESENTS A POINT OUTSIDE GRAPH.



DISTANCE BETWEEN SLASHES ON THE X-AXIS IS 0.1936

PLOT OF Y & YHAT VS VORTEX .VERTICAL AXIS IS Y-AXIS.

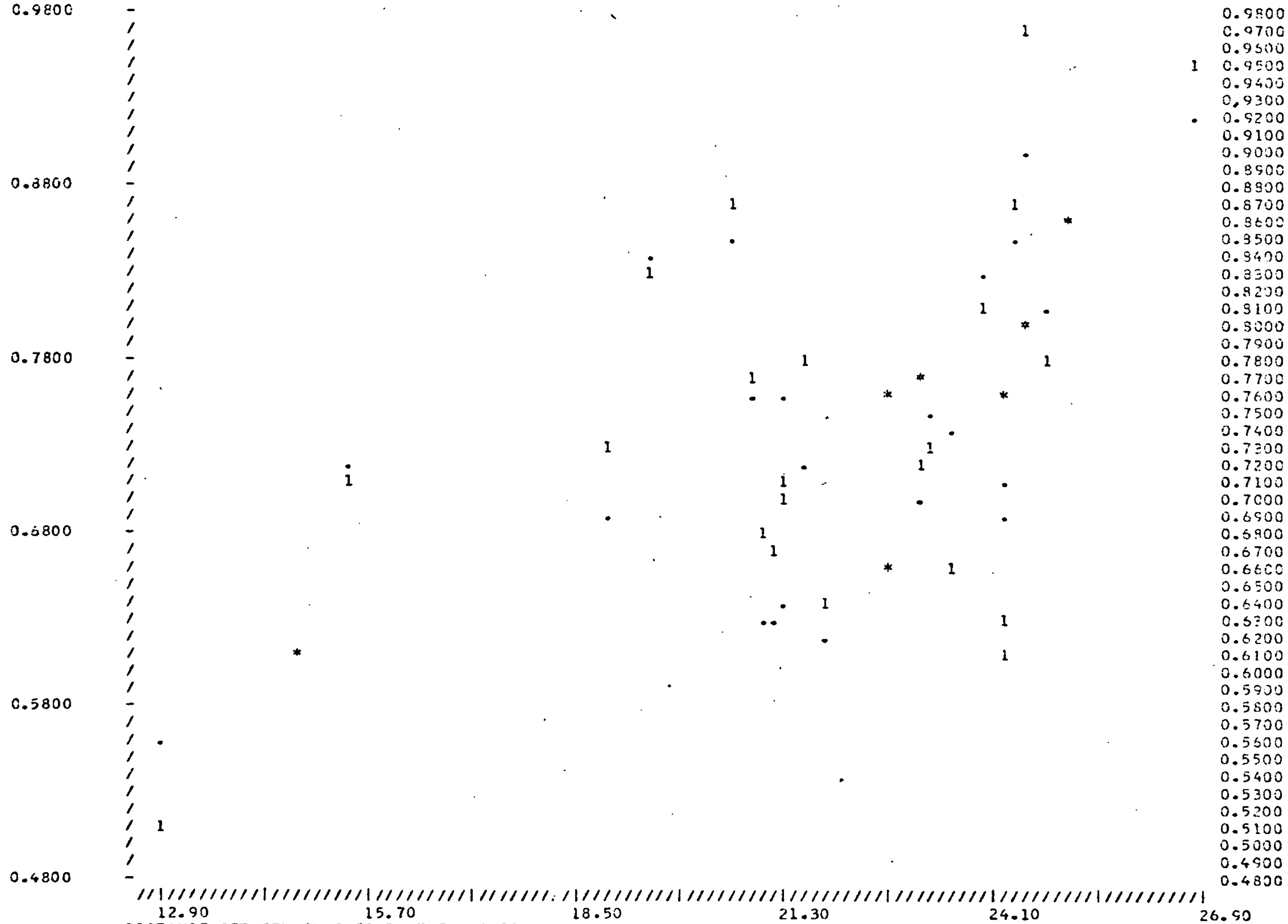
THE ".","+" AND "*" ARE USED TO PLOT PREDICTED VALUES; "*" IS USED WHERE PREDICTED VALUES COVER DATA POINTS
"+" REPRESENTS A POINT OUTSIDE GRAPH.



DISTANCE BETWEEN SLASHES ON THE X-AXIS IS 0.5000E-02

PLOT OF Y & YHAT VS FE50 .VERTICAL AXIS IS Y-AXIS.

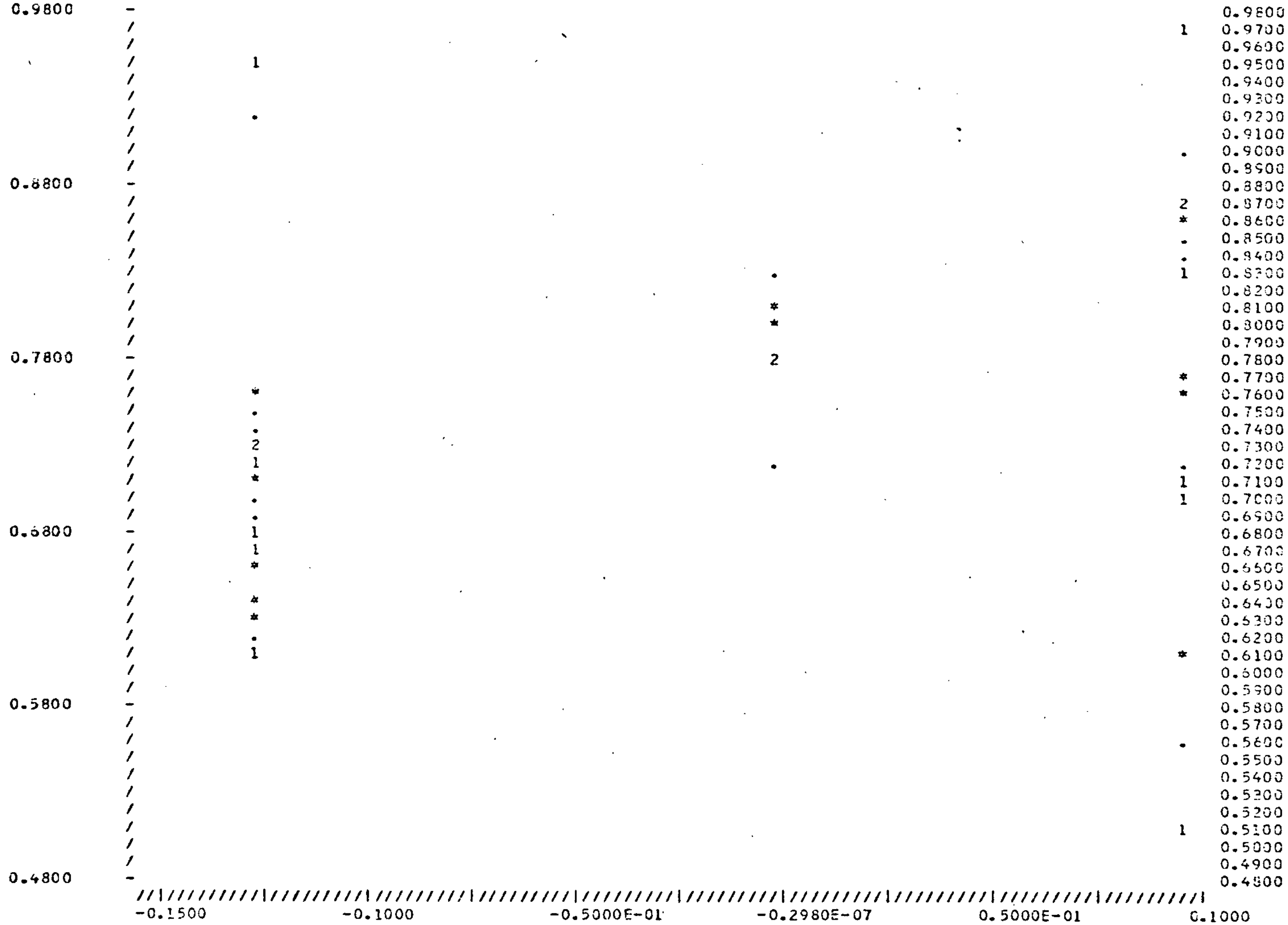
THE ".","+" AND "*" ARE USED TO PLOT PREDICTED VALUES: "*" IS USED WHERE PREDICTED VALUES COVER DATA POINTS
"+" REPRESENTS A POINT OUTSIDE GRAPH.



DISTANCE BETWEEN SLASHES ON THE X-AXIS IS 0.1400

PLOT OF Y & YHAT VS LOGVTX .VERTICAL AXIS IS Y-AXIS.

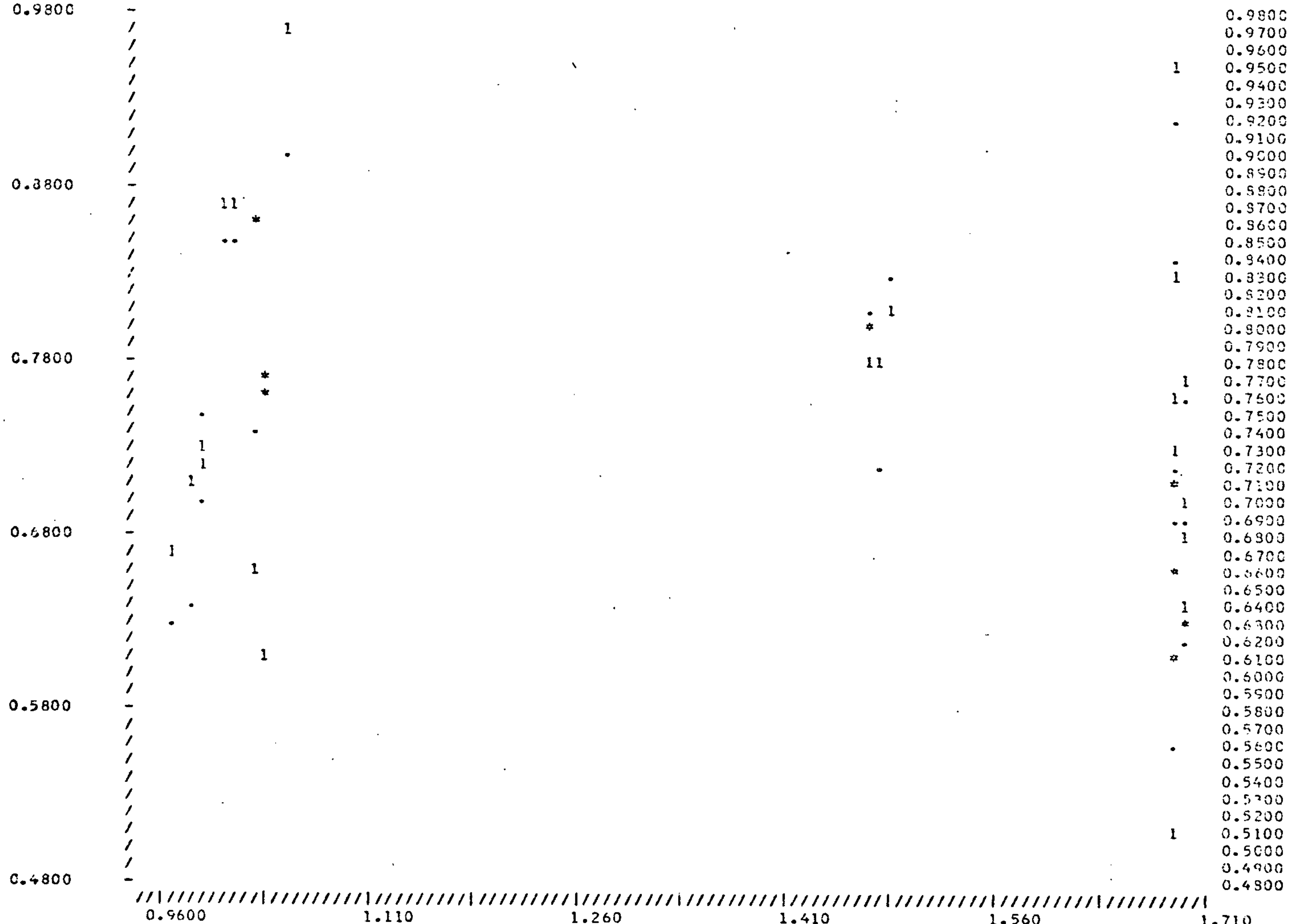
THE ".","+" AND "*" ARE USED TO PLOT PREDICTED VALUES; "*" IS USED WHERE PREDICTED VALUES COVER DATA POINTS
"+" REPRESENTS A POINT OUTSIDE GRAPH.



DISTANCE BETWEEN SLASHES ON THE X-AXIS IS 0.2500E-02

PLOT OF Y & YHAT VS LGFEPS .VERTICAL AXIS IS Y-AXIS.

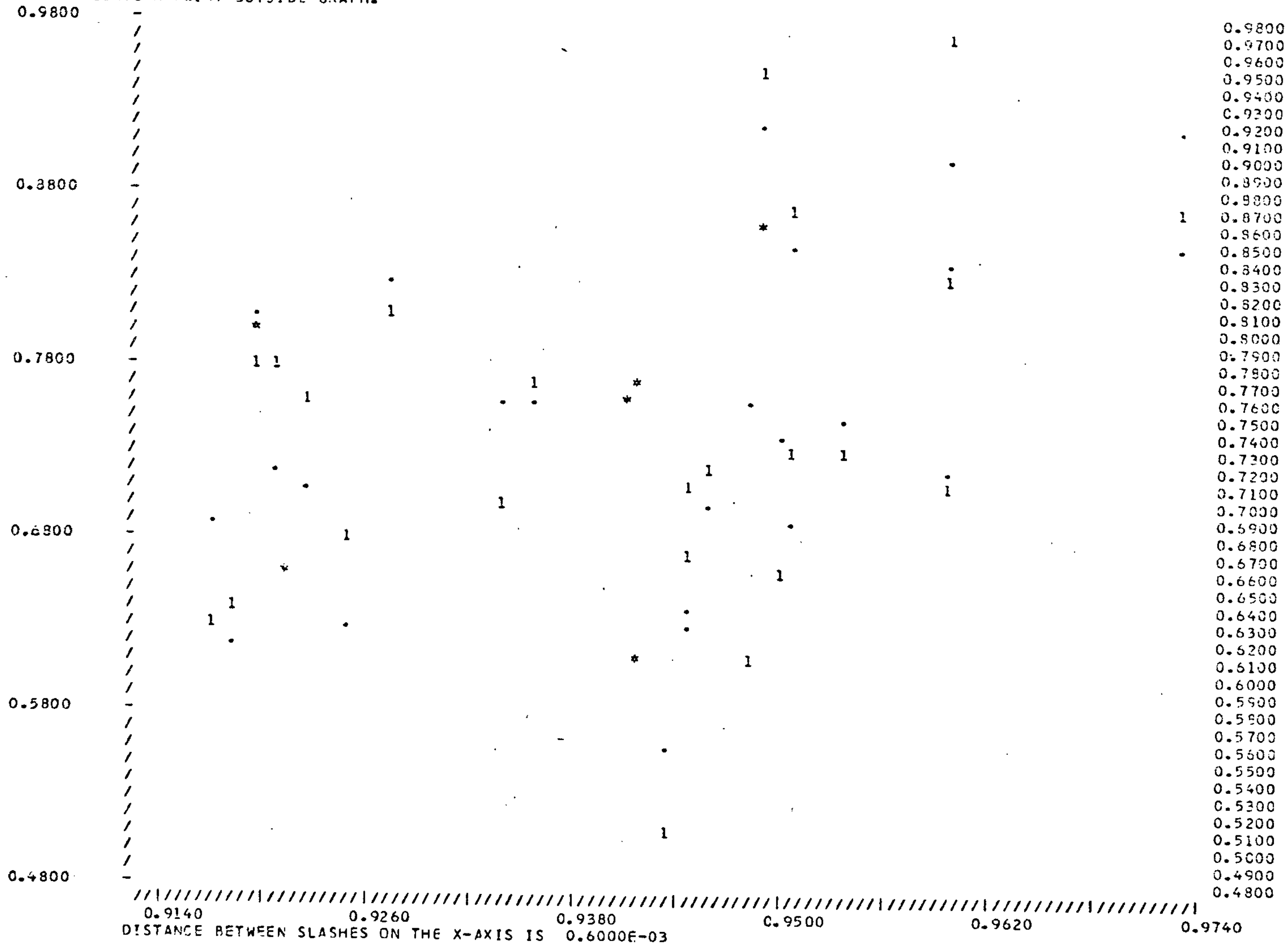
THE ".","+" AND "*" ARE USED TO PLOT PREDICTED VALUES; "*" IS USED WHERE PREDICTED VALUES COVER DATA POINTS
"+" REPRESENTS A POINT OUTSIDE GRAPH.



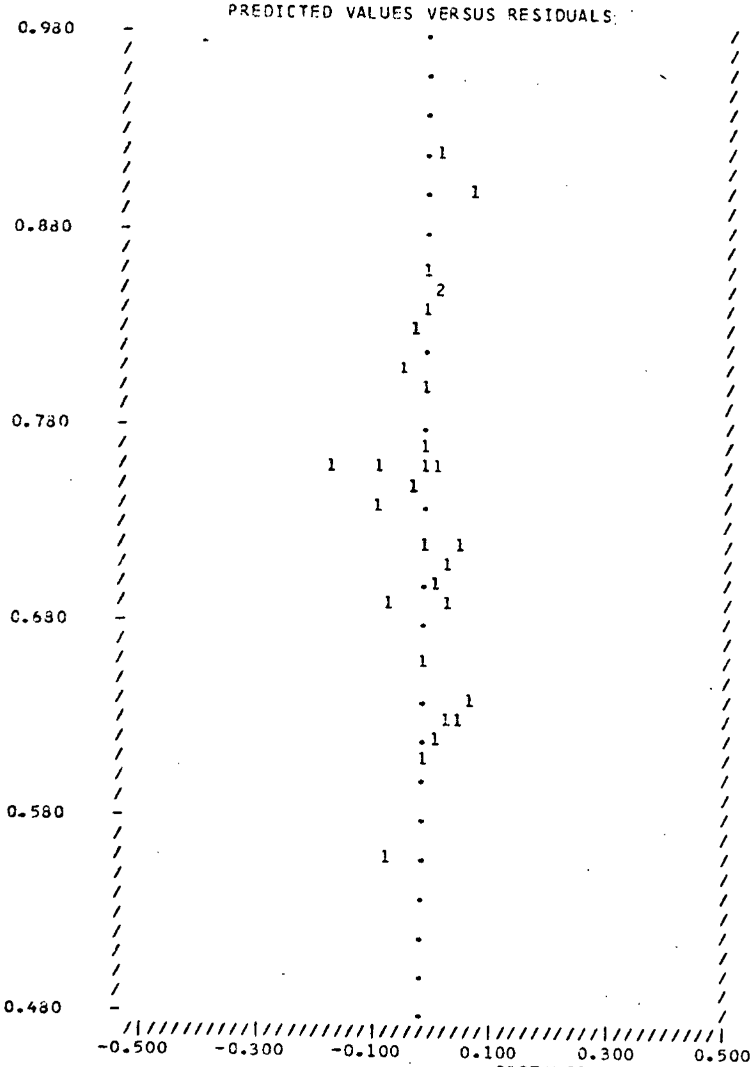
DISTANCE BETWEEN SLASHES ON THE X-AXIS IS 0.7500E-02

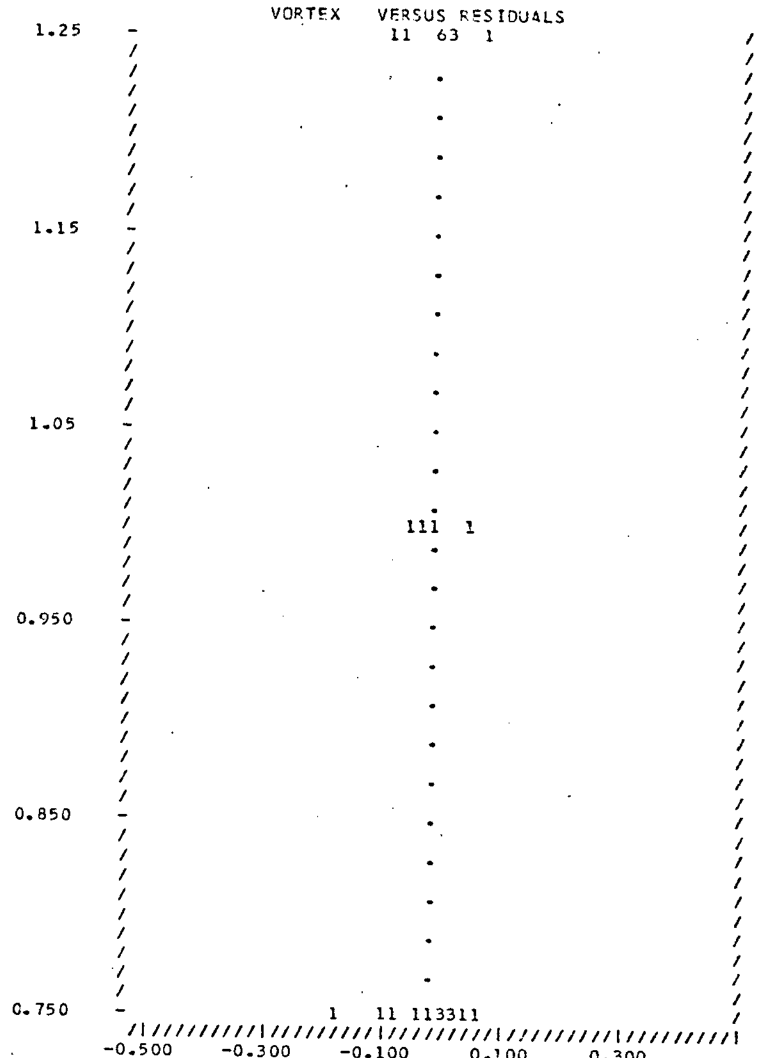
PLOT OF Y & YHAT VS 1-PV .VERTICAL AXIS IS Y-AXIS.

THE ".","+" AND "*" ARE USED TO PLOT PREDICTED VALUES: "*" IS USED WHERE PREDICTED VALUES COVER DATA POINTS
"+" REPRESENTS A POINT OUTSIDE GRAPH.

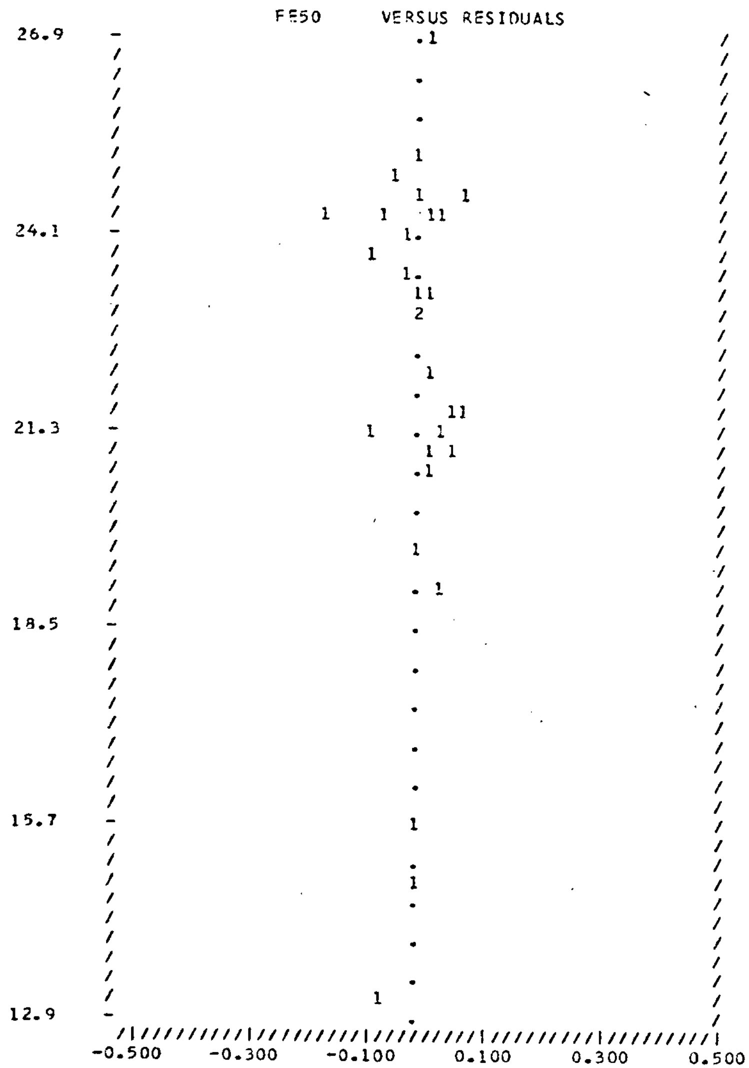


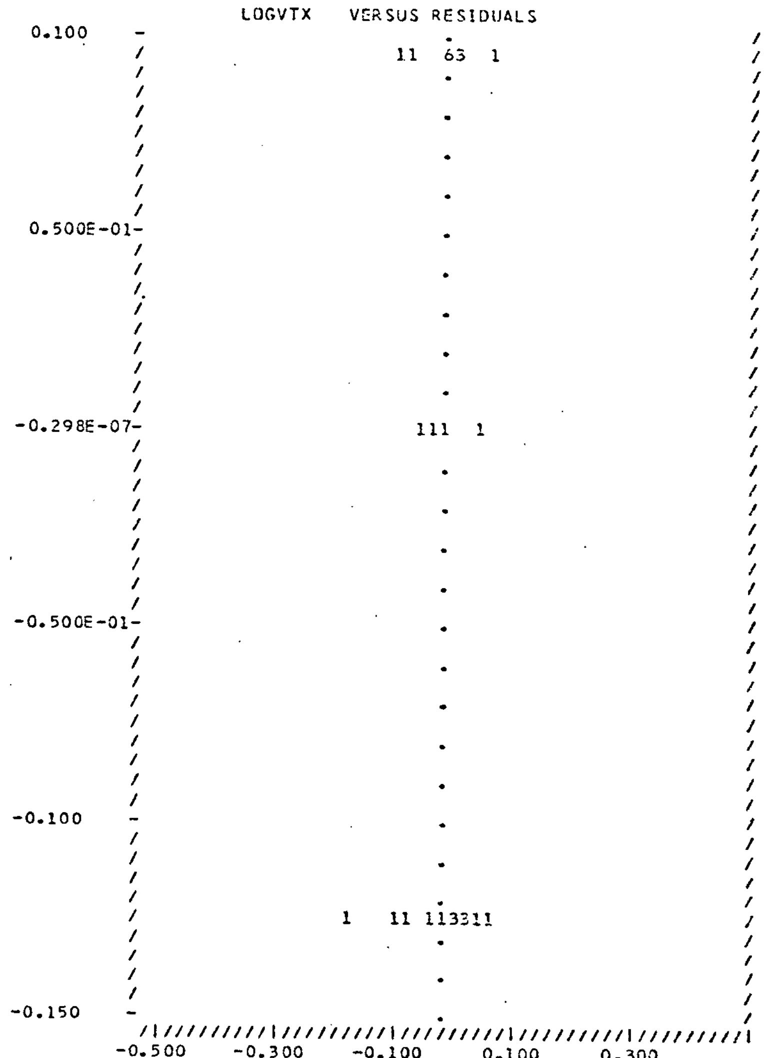
DISTANCE BETWEEN SLASHES ON THE X-AXIS IS 0.6000E-03



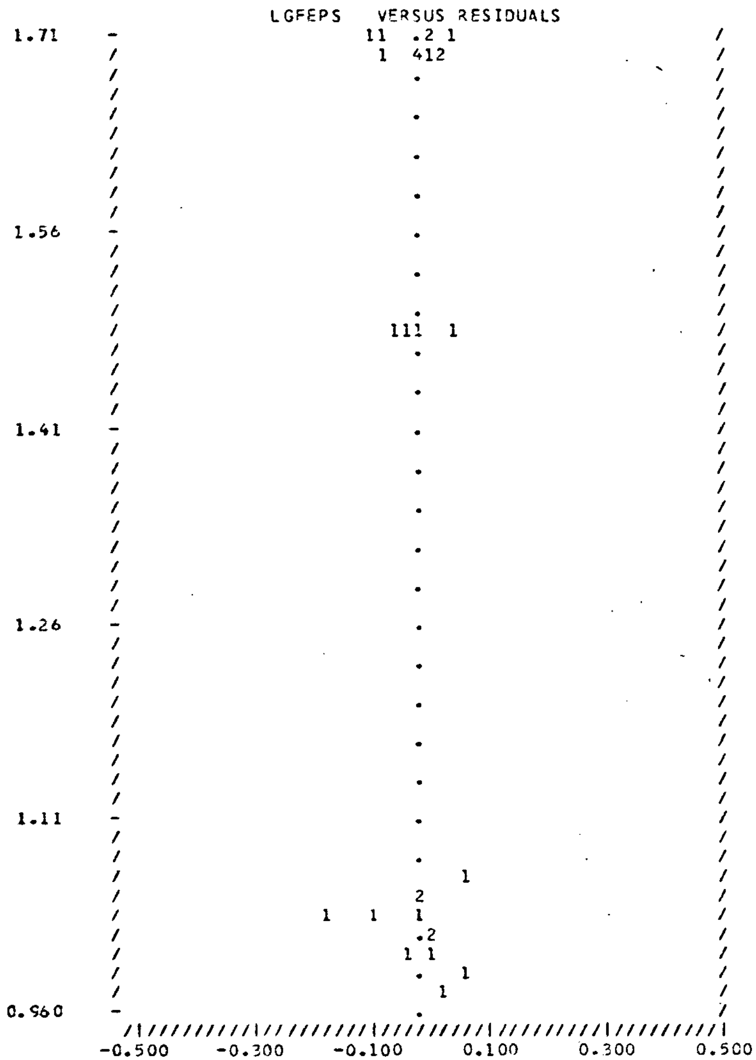


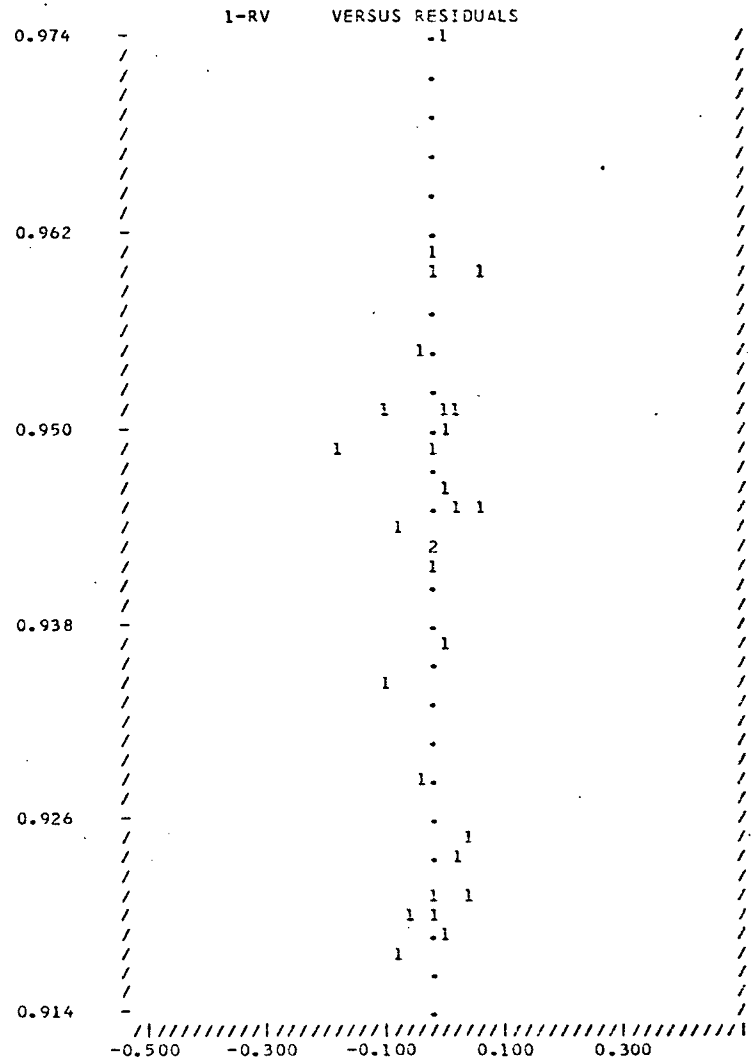
DISTANCE BETWEEN SLASHES ON THE X-AXES IS 0.1000E-01





DISTANCE BETWEEN SLASHES ON THE X-AXES IS 0.1000E-01





DISTANCE BETWEEN SLASHES ON THE X-AXES IS 0.1000E-01

CONTROL CARD NO. 7 ** STPREG **** STPREG **** STPREG **** STPREG **** STPREG **** STPREG **** STPREG ** CONTROL CARD NO. 7

POTENTIAL INDEPENDENT AND OTHER VARIABLES IN THE REGRESSION ANALYSIS FOR LOGWUF .

	PARTIAL CORR.	TOLERANCE	F-RATIO	F-PROB
ALPHA	0.3968	1.0000	5.045	0.0315
LGD50	0.5237	1.0000	10.20	0.0036
HEIGHT	0.3804	1.0000	4.567	0.0398
LGFEPS	0.6545	1.0000	20.23	0.0001
LGTEMP	0.3093	1.0000	2.857	0.0988
CONREN	0.3642	1.0000	4.129	0.0496
CONRES	0.6729	1.0000	22.35	0.0001

>>>>>>STEP NUMBER 1 REGRESSION EQUATION FOR LOGWUF
R-SQUARED = 0.4528455 F-PROBABILITY LEVEL = 0.0500
STANDARD ERROR LOGWUF = 0.1018
F-PROBABILITY = .00008524

VARIABLE	COEFFICIENT	STD. ERR.	F-RATIO	F-PROB	NORM COEFF
CONRES	12.454997	2.635	22.35	0.0001	0.6729
CONSTANT	-1.6627866	0.5779E-01	827.8	0.0	-12.30

POTENTIAL INDEPENDENT AND OTHER VARIABLES IN THE REGRESSION ANALYSIS FOR LOGWUF

	PARTIAL CORR.	TOLERANCE	F-RATIO	F-PROB
ALPHA	0.3494	0.9540	3.617	0.0653
LGD50	0.2024	0.6396	1.110	0.3025
HEIGHT	0.4313	0.9913	5.942	0.0209
LGFEPS	0.4148	0.6256	5.405	0.0268
LGTEMP	0.2723	0.9730	2.082	0.1575
CONREN	0.1704	0.5393	0.7776	0.3899

>>>>>>STEP NUMBER 2 REGRESSION EQUATION FOR LOGWUF
R-SQUARED = 0.5546336 F-PROBABILITY LEVEL = 0.0500
STANDARD ERROR LOGWUF = 0.9364E-01
F-PROBABILITY = .00003496

VARIABLE	COEFFICIENT	STD. ERR.	F-RATIO	F-PROB	NORM COEFF
HEIGHT	-0.18993184E-01	0.7792E-02	5.942	0.0209	-0.3204
CONRES	11.902303	2.433	23.93	0.0001	0.6431
CONSTANT	-1.2695040	0.1699	55.86	0.0000	-9.390

POTENTIAL INDEPENDENT AND OTHER VARIABLES IN THE REGRESSION ANALYSIS FOR LOGWUF

	PARTIAL CORR.	TOLERANCE	F-RATIO	F-PROB
ALPHA	0.3611	0.9510	3.748	0.0614
LGD50	0.2158	0.6394	1.221	0.2796
LGFEPS	0.4587	0.6256	6.662	0.0155
LGTEMP	0.3603	0.9596	3.729	0.0620
CONREN	0.2038	0.5387	1.083	0.3089

>>>>>>STEP NUMBER 3 REGRESSION EQUATION FOR LOGWUF
R-SQUARED = 0.6483412 F-PROBABILITY LEVEL = 0.0500
STANDARD ERROR LOGWUF = 0.8485E-01
F-PROBABILITY = .00000926

VARIABLE	COEFFICIENT	STD. ERR.	F-RATIO	F-PROB	NORM COEFF
HEIGHT	-0.18950809E-01	0.7061E-02	7.204	0.0123	-0.3197
LGFEPS	0.16236869	0.6291E-01	6.662	0.0155	0.3870

```
     CONRES        7.5208109           2.783           7.305          0.0118      0.4063
     CONSTANT     -1.4050136           0.1626          74.64          0.0000     -10.39

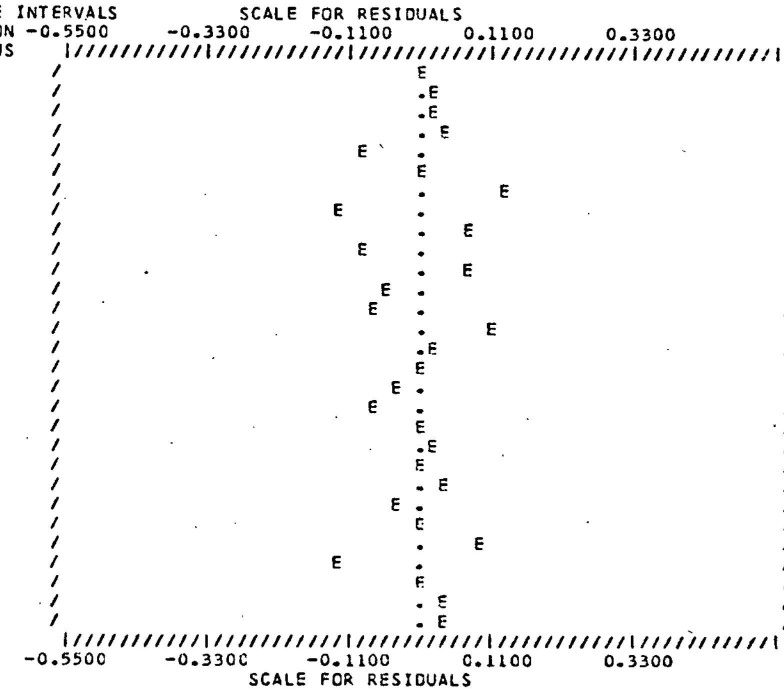
POTENTIAL INDEPENDENT AND OTHER VARIABLES IN THE REGRESSION ANALYSIS FOR LOGWUF
               PARTIAL CORR.      TOLERANCE      F-RATIO        F-PROB
      ALPHA         0.3465          0.9371      3.275         0.0796
      LGD50         0.6533          0.0848      17.87         0.0003
      LGTEMP        0.0832          0.5351     0.1672         0.6876
      CONREN        0.3387          0.5175      3.111         0.0871


>>>>>>STEP NUMBER    4       REGRESSION EQUATION FOR LOGWUF
          R-SQUARED = 0.7984419              F-PROBABILITY LEVEL = 0.0500
          STANDARD ERROR LOGWUF  =  0.6556E-01
          F-PROBABILITY = .00000008
     VARIABLE       COEFFICIENT       STD. ERR.          F-RATIO       F-PROB       NORM COEFF
     LGD50        -0.70327569         0.1664            17.87          0.0003       -1.330
     HEIGHT       -0.19946308E-01     0.5461E-02        13.34          0.0013      -0.3365
     LGFEPS        0.68790267         0.1335            26.56          0.0000        1.640
     CONRES        8.0890347           2.154            14.10          0.0011       0.4370
     CONSTANT     -0.93345138         0.1680            30.86          0.0000       -6.904

POTENTIAL INDEPENDENT AND OTHER VARIABLES IN THE REGRESSION ANALYSIS FOR LOGWUF
               PARTIAL CORR.      TOLERANCE      F-RATIO        F-PROB
      ALPHA         0.0923          0.7606     0.1977         0.6638
      LGTEMP        0.0922          0.5065     0.1973         0.6641
      CONREN        0.0143          0.3707     0.4716E-02     0.9027
```

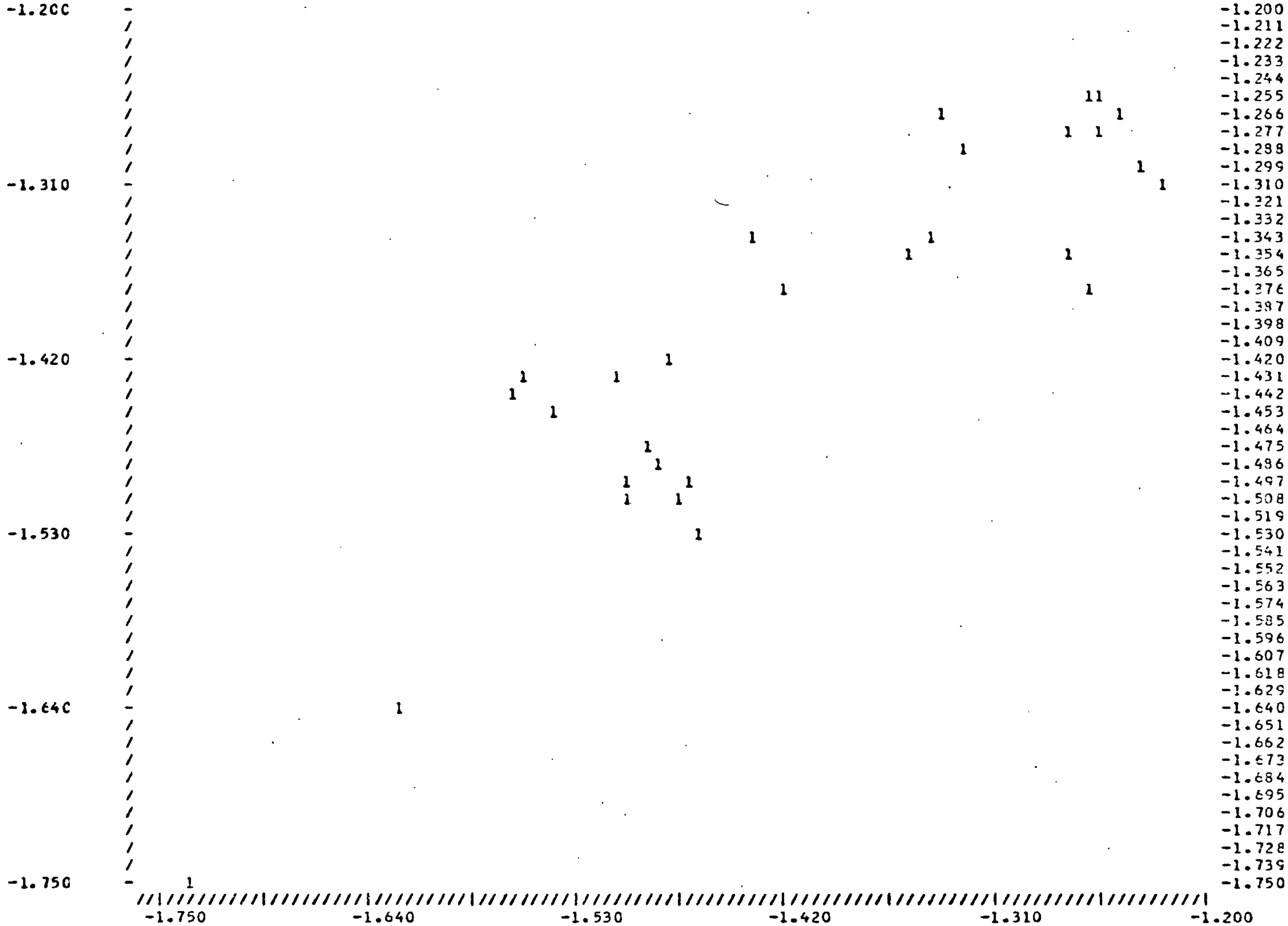
	OBSERVED	RESIDUAL	PREDICTED
1	-1.4841	-0.4722E-02	-1.4794
2	-1.7282	0.2251E-01	-1.7507
3	-1.4948	0.1219E-01	-1.5070
4	-1.4698	0.3591E-01	-1.5057
5	-1.4330	-0.8851E-01	-1.3445
6	-1.3497	0.5264E-02	-1.3550
7	-1.2557	0.1182	-1.3739
8	-1.5528	-0.1173	-1.4355
9	-1.2248	0.7529E-01	-1.3001
10	-1.5376	-0.8126E-01	-1.4563
11	-1.4572	0.7471E-01	-1.5319
12	-1.4737	-0.5333E-01	-1.4204
13	-1.5003	-0.6892E-01	-1.4314
14	-1.2168	0.9579E-01	-1.3126
15	-1.2652	0.1427E-01	-1.2795
16	-1.2430	0.3148E-02	-1.2511
17	-1.3215	-0.3375E-01	-1.2878
18	-1.3344	-0.6569E-01	-1.2687
19	-1.4989	-0.3436E-02	-1.4955
20	-1.6162	0.2517E-01	-1.6414
21	-1.4815	0.4889E-02	-1.4864
22	-1.4660	0.3199E-01	-1.4980
23	-1.4157	-0.3771E-01	-1.3780
24	-1.3401	-0.8230E-03	-1.3393
25	-1.2652	0.8899E-01	-1.3542
26	-1.5560	-0.1128	-1.4432
27	-1.2557	0.4573E-02	-1.2603
28	-1.2411	0.2918E-01	-1.2703
29	-1.2503	0.2602E-01	-1.2763

.0 (100%)CONFIDENCE INTERVALS
MEAN PLUS-MINUS | OBSERVATION PLUS-MINUS



29 COMPLETE OBSERVATIONS AUTO CORR COEFF= -0.4994 DURBIN WATSON D-STATISTIC = 2.985

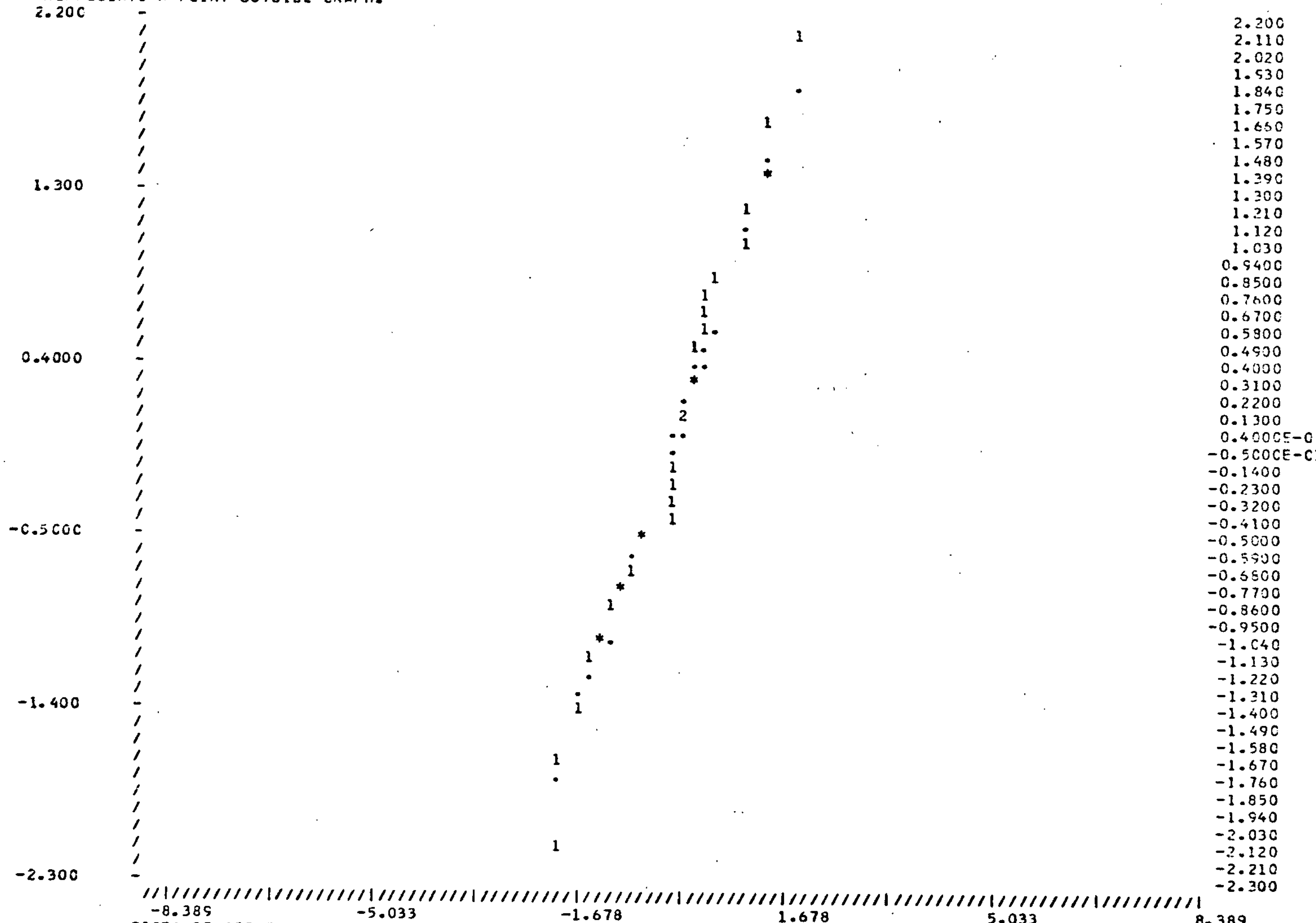
PRECICTED VALUES (VERTICAL AXIS) VERSUS OBSERVED VALUES



CISTANCE BETWEEN SLASHES ON THE X-AXIS IS 0.5500E-02

PROBABILITY OF RESIDUALS VS RESIDUALS
(PLOT TO VERIFY THE NORMALITY OF THE DIST OF RESIDUALS)

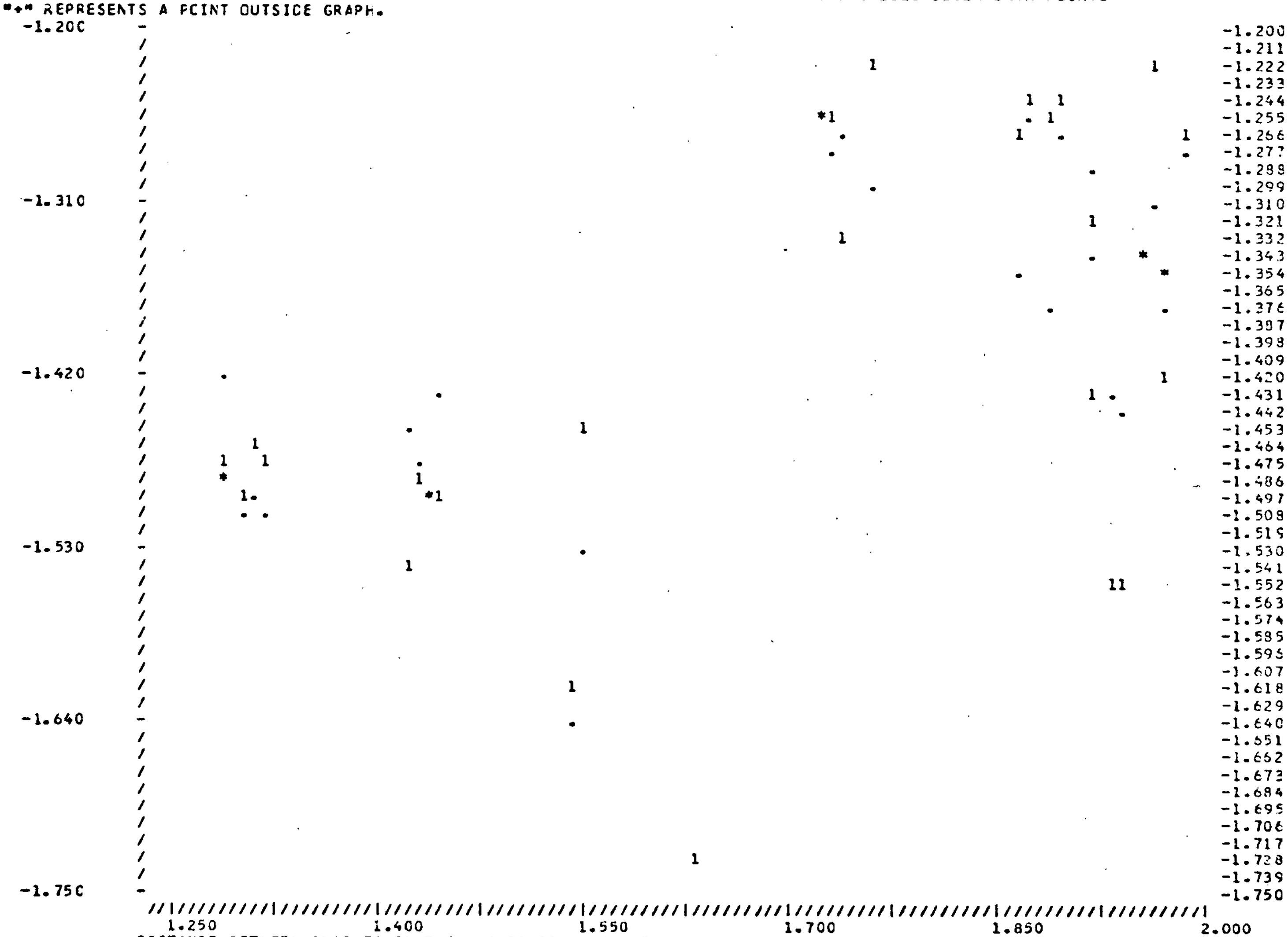
THE ".","+" AND "*" ARE USED TO PLOT PREDICTED VALUES; "*" IS USED WHERE PREDICTED VALUES COVER DATA POINTS
"+" REPRESENTS A POINT OUTSIDE GRAPH.



DISTANCE BETWEEN SLASHES ON THE X-AXIS IS 0.1678

PLOT OF Y & YHAT VS LGD50 .VERTICAL AXIS IS Y-AXIS.

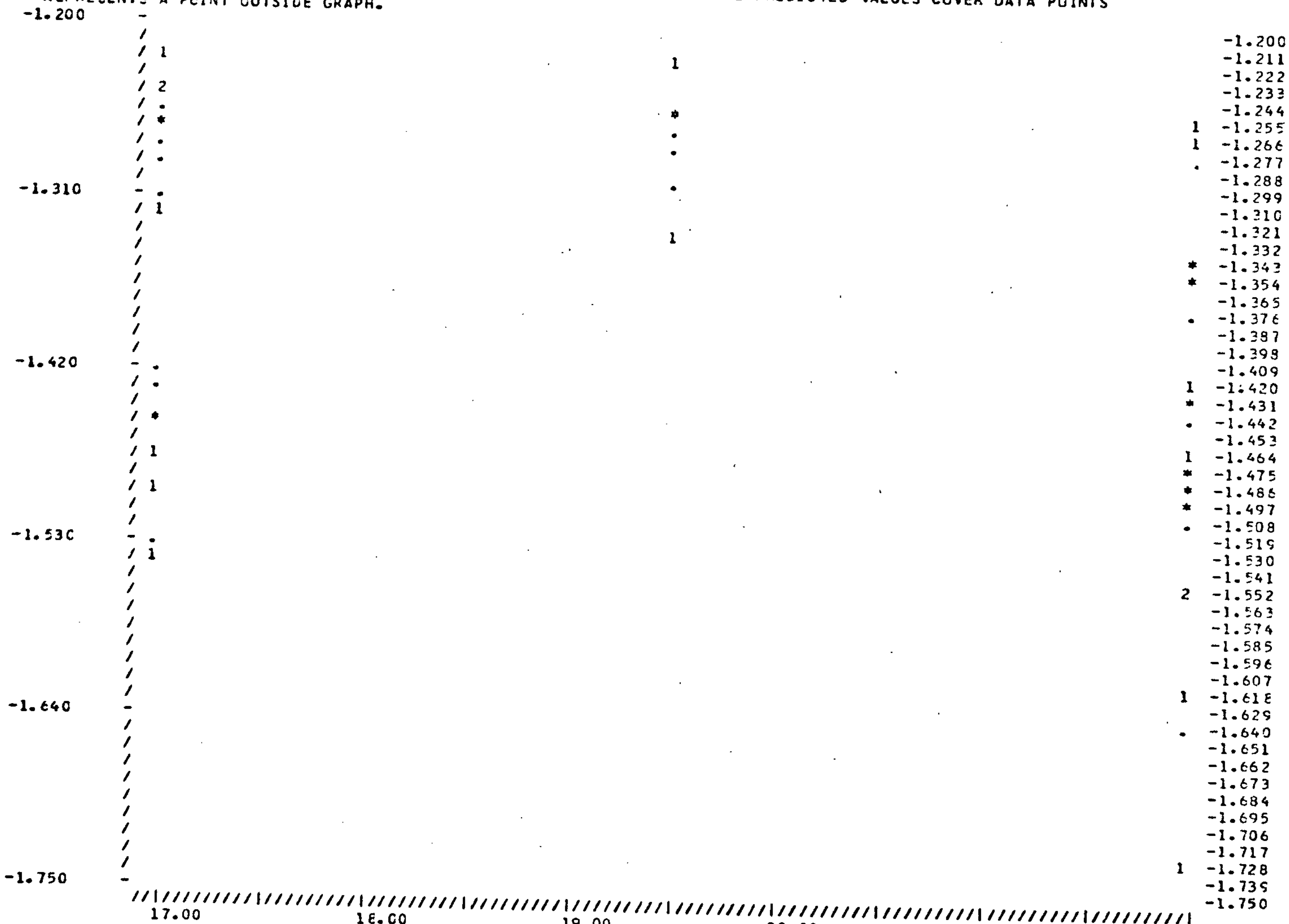
THE ".","+" AND "*" ARE USED TO PLOT PREDICTED VALUES; "*" IS USED WHERE PREDICTED VALUES COVER DATA POINTS
"+" REPRESENTS A POINT OUTSIDE GRAPH.



DISTANCE BETWEEN SLASHES ON THE X-AXIS IS 0.7500E-02

PLOT OF Y & YHAT VS HEIGHT .VERTICAL AXIS IS Y-AXIS.

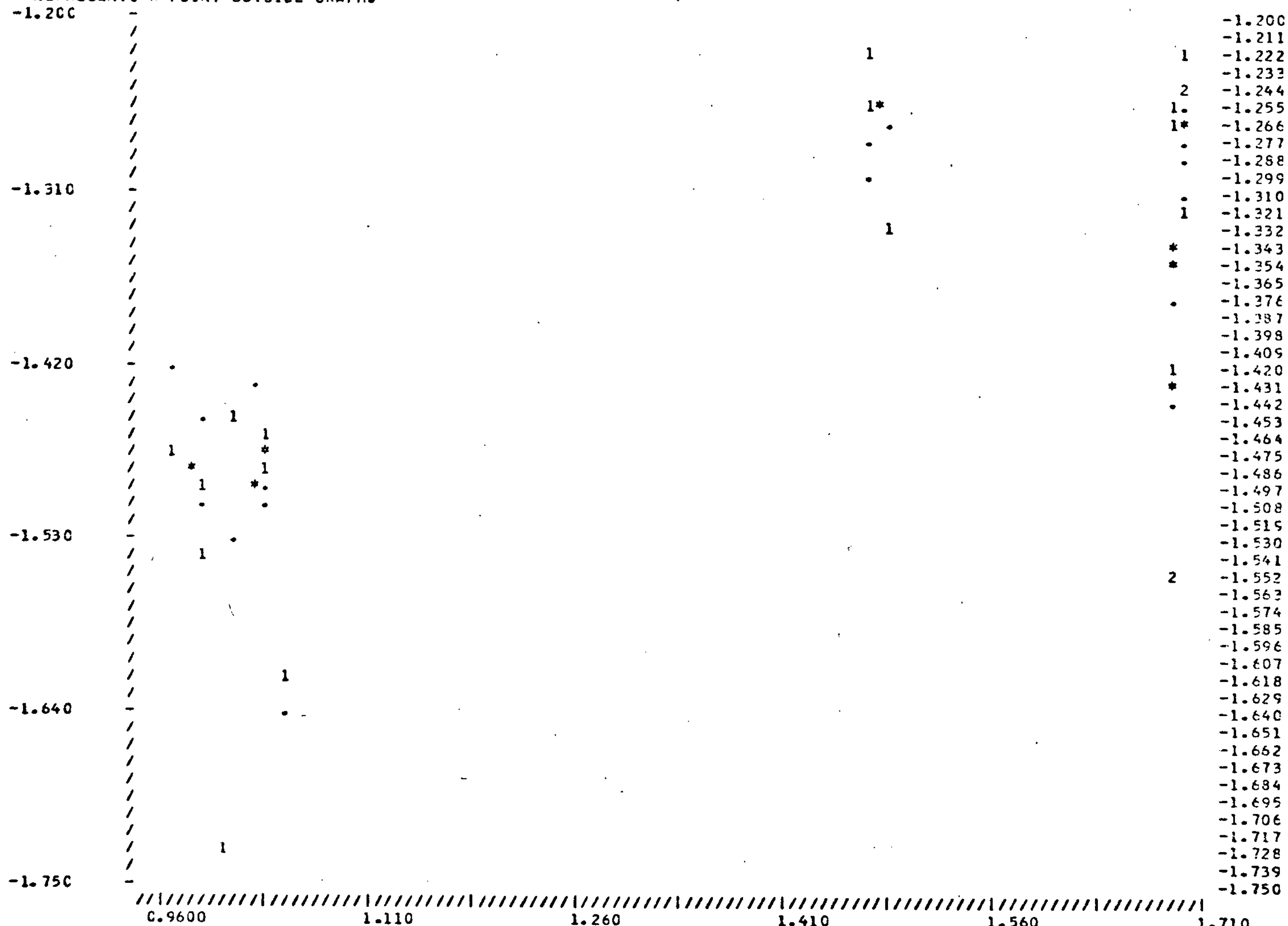
THE ".","+" AND "*" ARE USED TO PLOT PREDICTED VALUES; "*" IS USED WHERE PREDICTED VALUES COVER DATA POINTS
"+" REPRESENTS A POINT OUTSIDE GRAPH.



DISTANCE BETWEEN SLASHES ON THE X-AXIS IS 0.5000E-01

PLOT OF Y & YHAT VS LGFEPS .VERTICAL AXIS IS Y-AXIS.

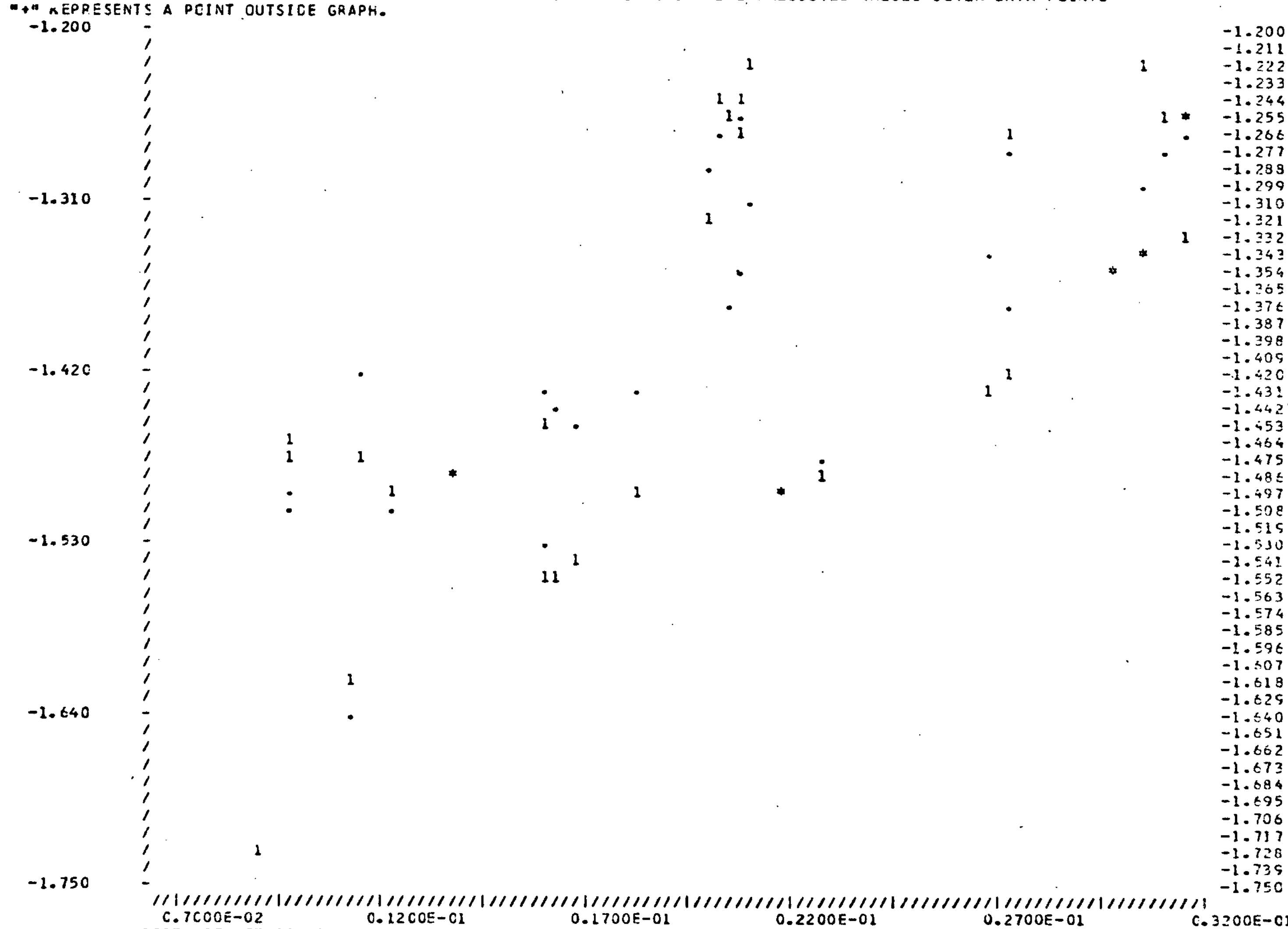
THE ".","+" AND "*" ARE USED TO PLOT PREDICTED VALUES; "*" IS USED WHERE PREDICTED VALUES COVER DATA POINTS
"+" REPRESENTS A POINT OUTSIDE GRAPH.



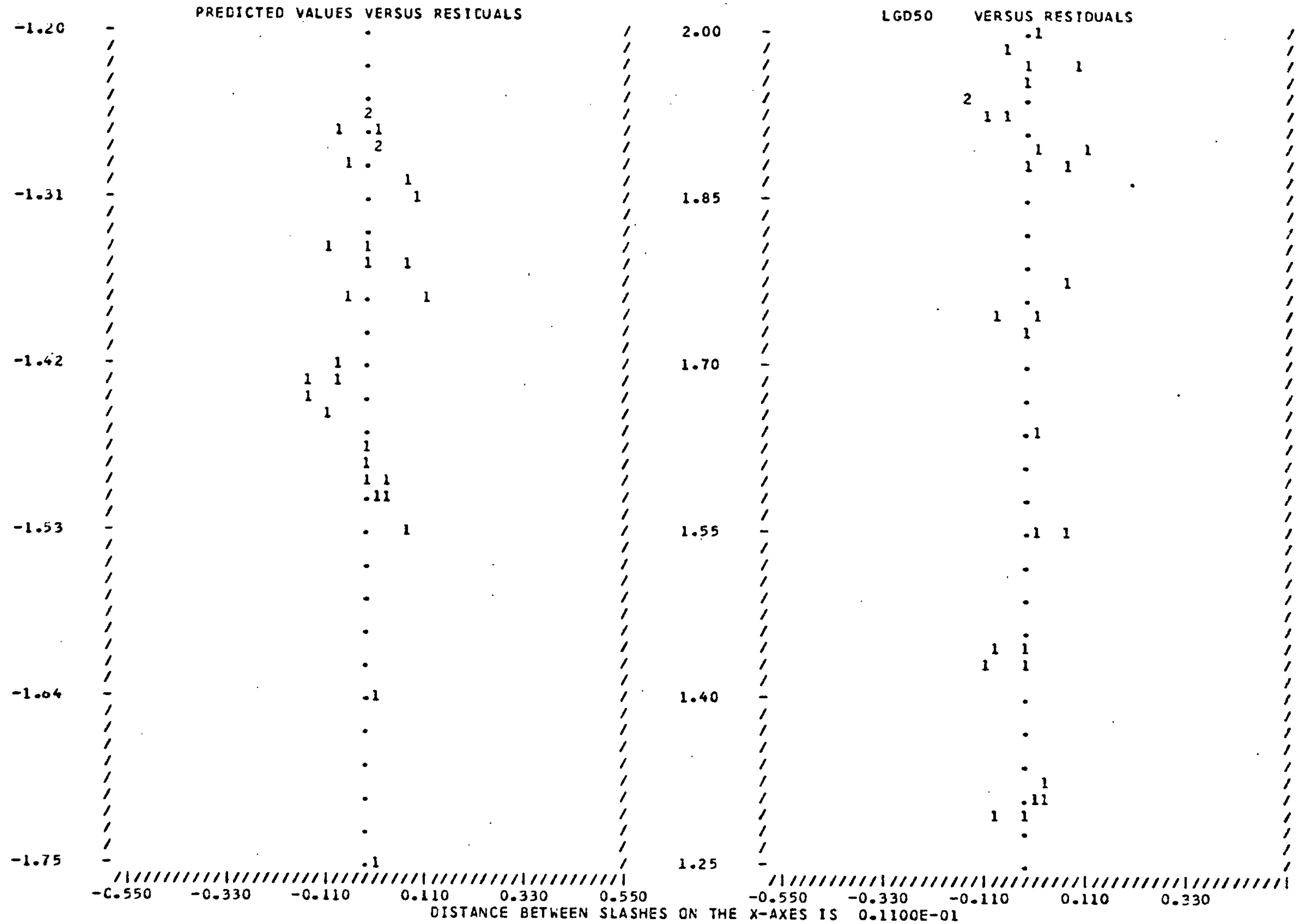
DISTANCE BETWEEN SLASHES ON THE X-AXIS IS 0.7500E-02

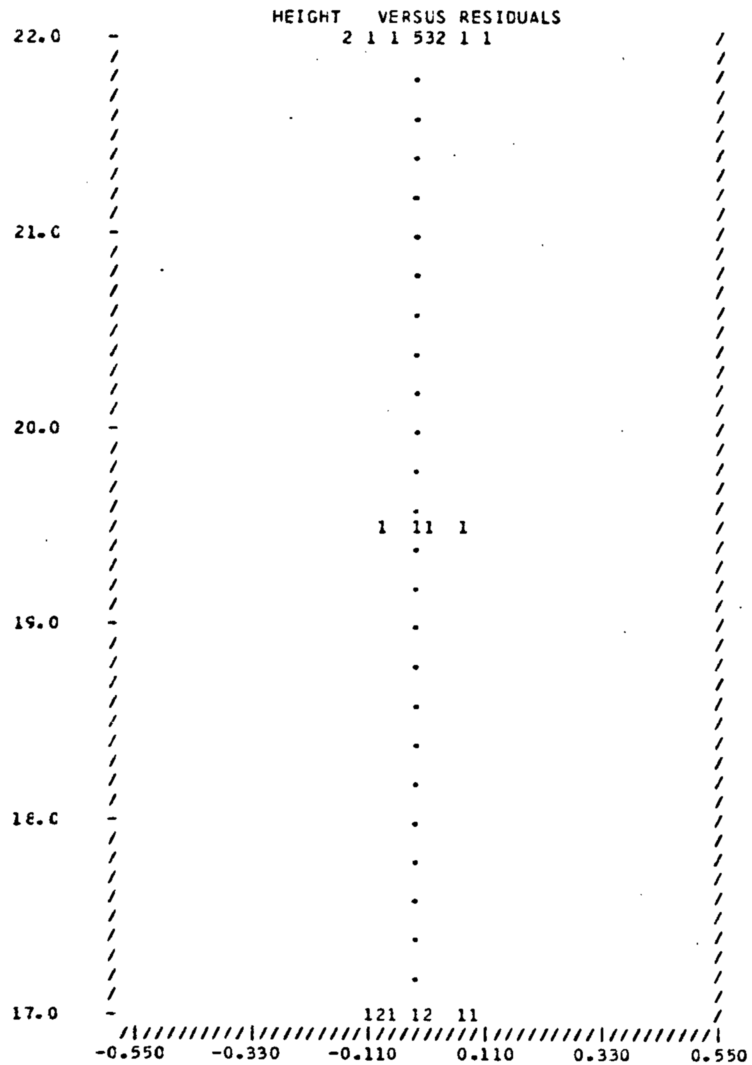
PLOT OF Y & YHAT VS CCNRFS .VERTICAL AXIS IS Y-AXIS.

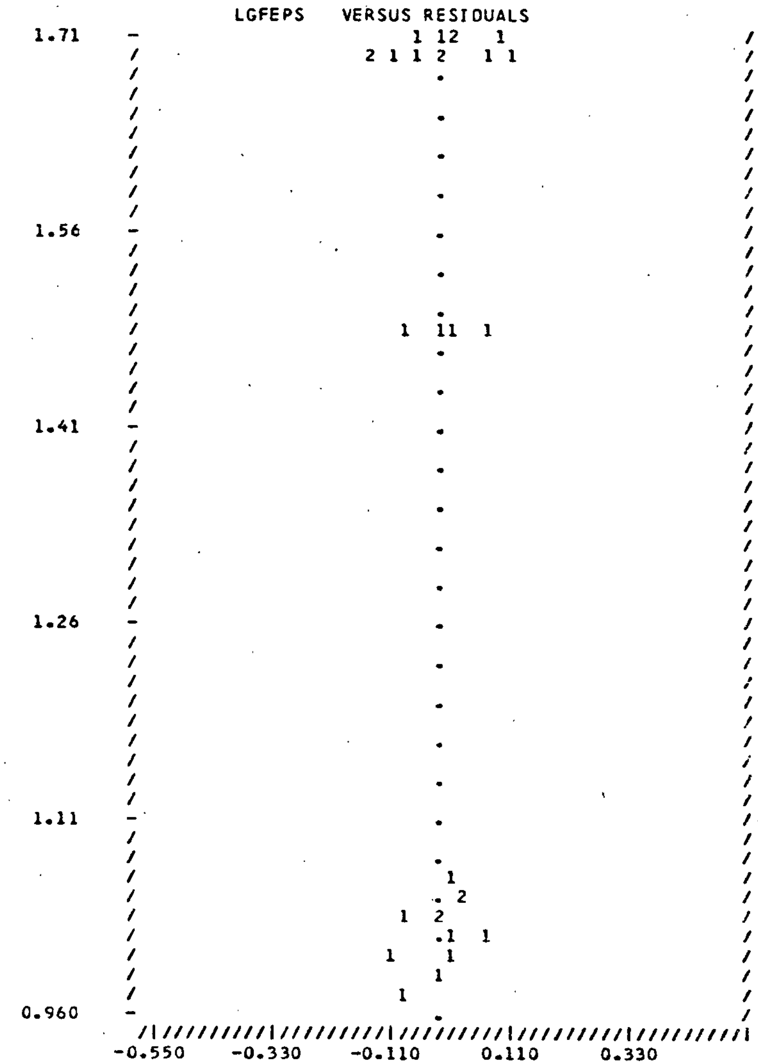
THE ".","+" AND "*" ARE USED TO PLOT PREDICTED VALUES; "*" IS USED WHERE PREDICTED VALUES COVER DATA POINTS
"+" REPRESENTS A POINT OUTSIDE GRAPH.



DISTANCE BETWEEN SLASHES ON THE X-AXIS IS 0.2500E-03

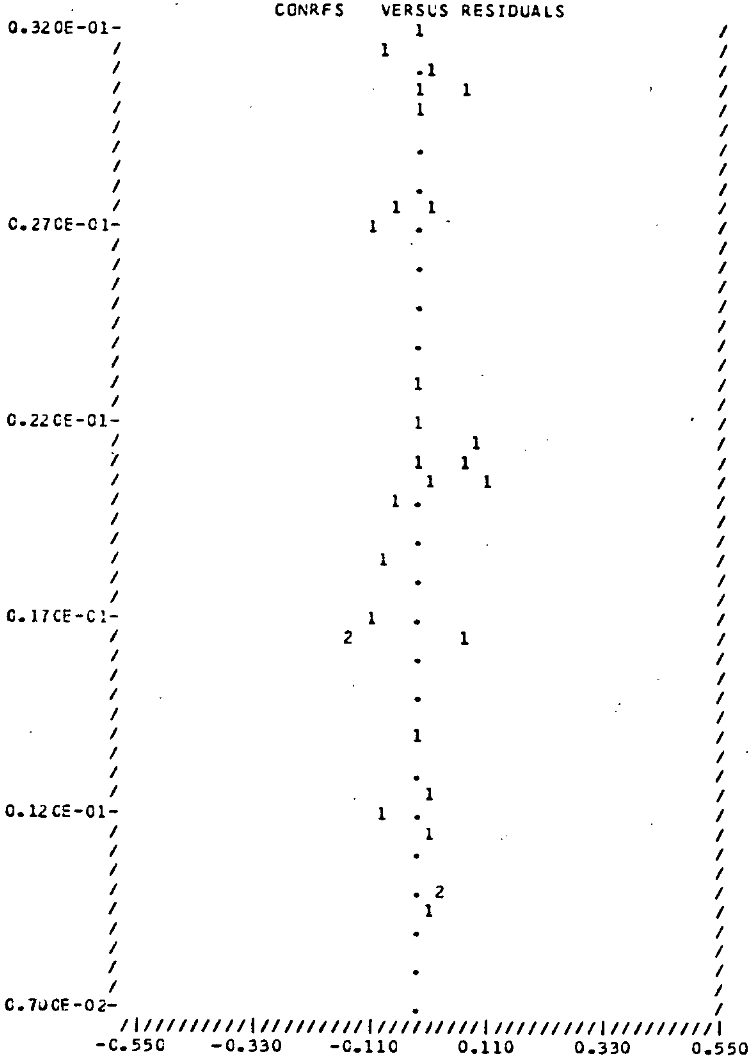

PREDICTED VALUES VERSUS RESIDUALS
-1.20
-1.31
-1.42
-1.53
-1.64
-1.75
-0.550 -0.330 -0.110 0.110 0.330 0.550
LGD50 VERSUS RESIDUALS
2.00
1.85
1.70
1.55
1.40
1.25
-0.550 -0.330 -0.110 0.110 0.330
DISTANCE BETWEEN SLASHES ON THE X-AXES IS 0.1100E-01





DISTANCE BETWEEN SLASHES ON THE X-AXES IS 0.1100E-01

CONRFS VERSUS RESIDUALS



DISTANCE BETWEEN SLASHES ON THE X-AXES IS 0.1100E-01

CONTROL CARD NO. 8 ** STPREG **** STPREG **** STPREG **** STPREG **** STPREG **** STPREG **** STPREG ** CONTROL CARD NO. 8

POTENTIAL INDEPENDENT AND OTHER VARIABLES IN THE REGRESSION ANALYSIS FOR UF%SOL

	PARTIAL CORR.	TOLERANCE	F-RATIO	F-PROB
LGD50	0.3645	1.0000	4.136	0.0494
LGTEMP	0.4677	1.0000	7.559	0.0102
FEFVOL	0.5952	1.0000	14.81	0.0007
LUSG/S	0.6258	1.0000	17.38	0.0003

>>>>>>STEP NUMBER 1 REGRESSION EQUATION FOR UF%SOL

R-SQUARED = 0.3916415 F-PROBABILITY LEVEL = 0.0500

STANDARD ERROR UF%SOL = 3.580

F-PROBABILITY = .00033602

VARIABLE	COEFFICIENT	STD. ERR.	F-RATIO	F-PROB	NORM COEFF
LUSG/S	10.943383	2.625	17.38	0.0003	0.6258
CONSTANT	46.443072	4.725	96.63	0.0000	10.30

POTENTIAL INDEPENDENT AND OTHER VARIABLES IN THE REGRESSION ANALYSIS FOR UF%SOL

	PARTIAL CORR.	TOLERANCE	F-RATIO	F-PROB
LGD50	0.6174	0.9693	16.01	0.0005
LGTEMP	0.5675	0.9984	12.35	0.0017
FEFVOL	0.7274	0.9979	29.22	0.0000

>>>>>>STEP NUMBER 2 REGRESSION EQUATION FOR UF%SOL

R-SQUARED = 0.7135632 F-PROBABILITY LEVEL = 0.0500

STANDARD ERROR UF%SOL = 2.503

F-PROBABILITY = .00000017

VARIABLE	COEFFICIENT	STD. ERR.	F-RATIO	F-PROB	NORM COEFF
FEFVOL	23.435717	4.335	29.22	0.0000	0.5680
LUSG/S	10.492520	1.837	32.61	0.0000	0.6000
CONSTANT	43.503871	3.348	168.8	0.0000	9.652

POTENTIAL INDEPENDENT AND OTHER VARIABLES IN THE REGRESSION ANALYSIS FOR UF%SOL

	PARTIAL CORR.	TOLERANCE	F-RATIO	F-PROB
LGD50	0.4934	0.0627	8.047	0.0087
LGTEMP	0.1722	0.5663	0.7636	0.3946

>>>>>>STEP NUMBER 3 REGRESSION EQUATION FOR UF%SOL

R-SQUARED = 0.7833084 F-PROBABILITY LEVEL = 0.0500

STANDARD ERROR UF%SOL = 2.221

F-PROBABILITY = .00000003

VARIABLE	COEFFICIENT	STD. ERR.	F-RATIO	F-PROB	NORM COEFF
LGD50	-18.579495	6.550	8.047	0.0087	-1.054
FEFVOL	64.900317	15.11	18.44	0.0003	1.573
LUSG/S	6.4661834	2.161	8.952	0.0061	0.3698
CONSTANT	75.577606	11.69	41.80	0.0000	16.77

POTENTIAL INDEPENDENT AND OTHER VARIABLES IN THE REGRESSION ANALYSIS FOR UF%SOL

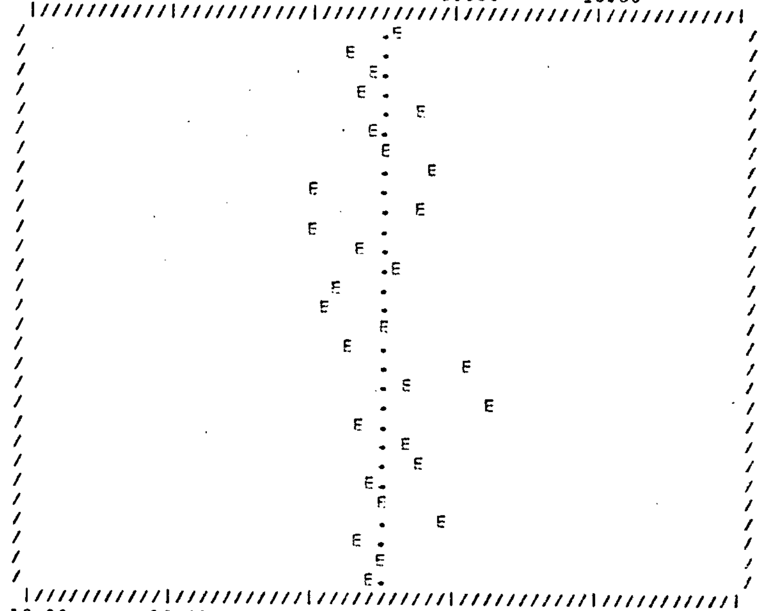
	PARTIAL CORR.	TOLERANCE	F-RATIO	F-PROB
LGTEMP	0.0675	0.4492	0.1097	0.7392

.0 (100%) CONFIDENCE INTERVALS

	OBSERVED	RESIDUAL	PREDICTED	MEAN PLUS-MINUS	OBSERVATION PLUS-MINUS
1	62.290	0.5677	61.722		
2	55.030	-1.870	56.900		
3	66.590	-0.7056	67.296		
4	67.260	-1.021	68.281		
5	68.250	1.570	66.680		
6	65.390	-0.6456	66.037		
7	71.280	0.3766E-01	71.242		
8	71.810	2.568	69.242		
9	59.930	-3.580	63.510		
10	62.850	1.800	61.050		
11	55.120	-3.539	58.659		
12	64.930	-1.423	66.353		
13	64.380	0.7323	63.598		
14	65.090	-2.362	67.452		
15	63.850	-2.639	66.489		
16	72.410	-0.2843	72.694		
17	69.320	-1.672	70.992		
18	68.550	4.093	64.457		
19	62.580	0.9927	61.587		
20	66.070	5.309	60.761		
21	66.080	-1.205	67.285		
22	67.490	0.9315	66.558		
23	67.570	1.871	65.699		
24	65.610	-0.6762	66.286		
25	71.490	-0.7054E-01	71.561		
26	71.740	2.853	68.887		
27	63.620	-0.9020	64.522		
28	72.400	0.2264E-01	72.377		
29	63.430	-0.7966	64.227		

SCALE FOR RESIDUALS

-18.00 -10.80 -3.600 3.600 10.80

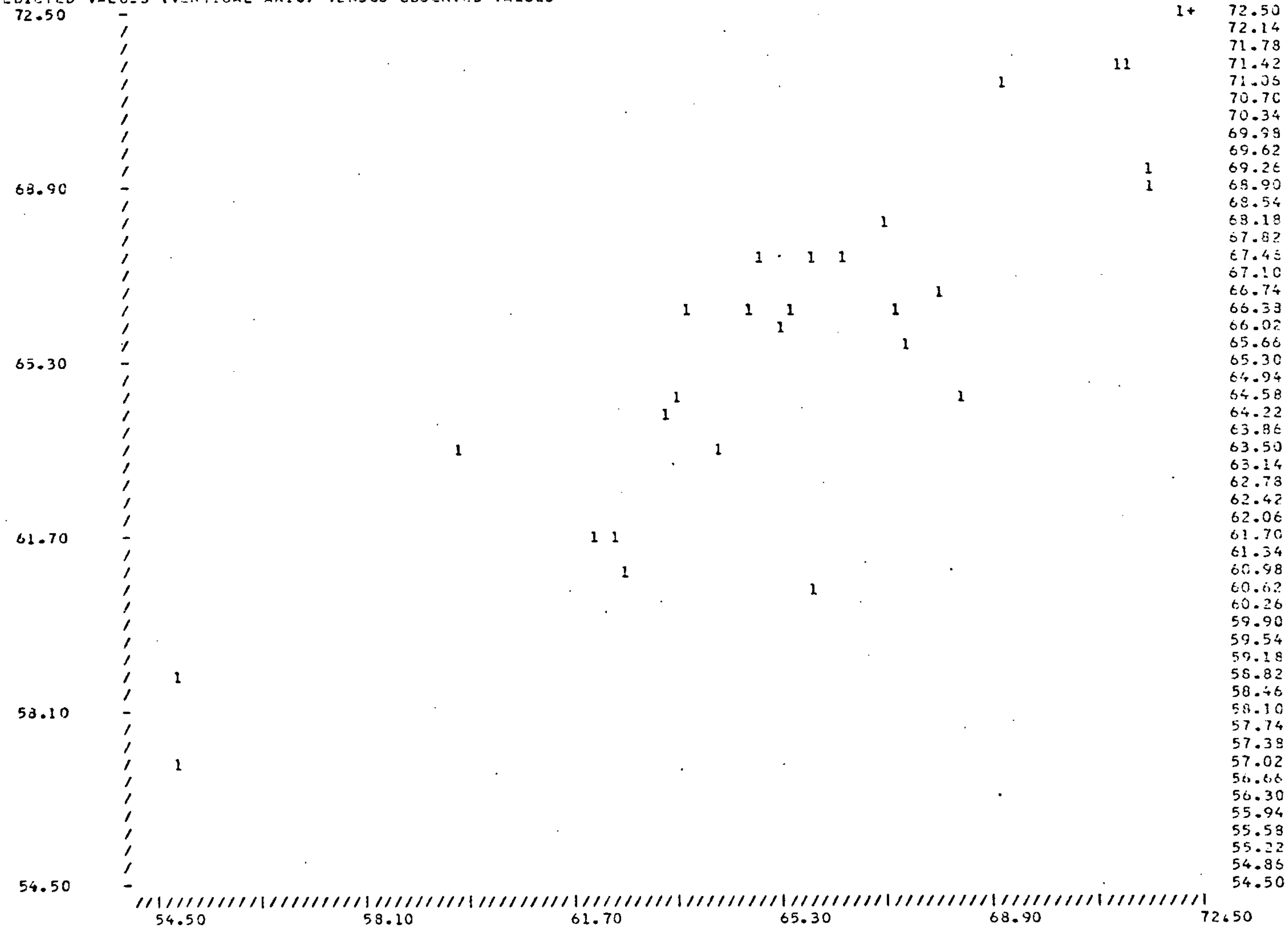


-18.00 -10.80 -3.600 3.600 10.80

SCALE FOR RESIDUALS

29 COMPLETE OBSERVATIONS AUTO CORR COEFF= -0.1742 DURBIN WATSON D-STATISTIC = 2.339

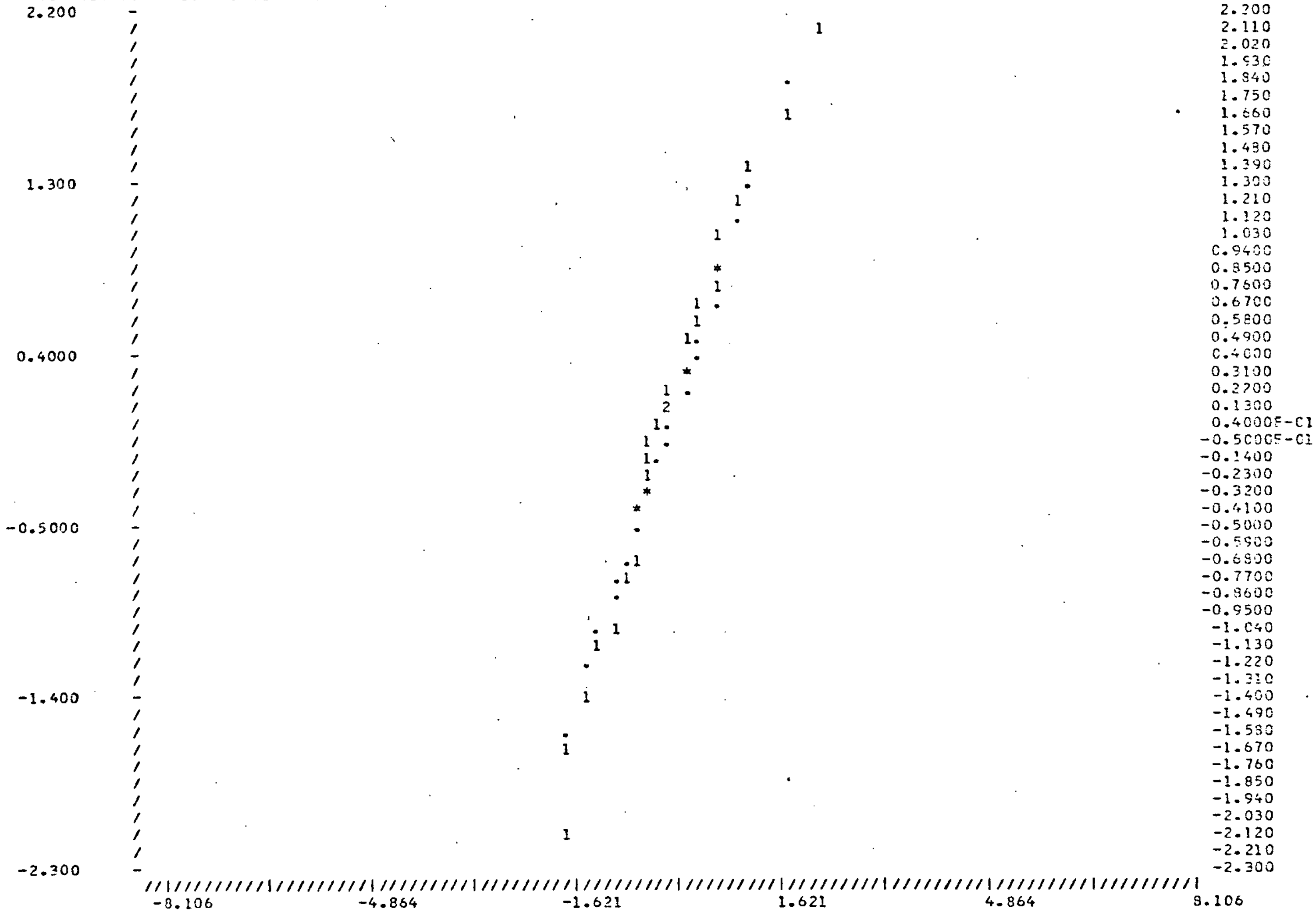
PREDICTED VALUES (VERTICAL AXIS) VERSUS OBSERVED VALUES



DISTANCE BETWEEN SLASHES ON THE X-AXIS IS 0.1800

PROBABILITY OF RESIDUALS VS RESIDUALS
(PLOT TO VERIFY THE NORMALITY OF THE DIST OF RESIDUALS)

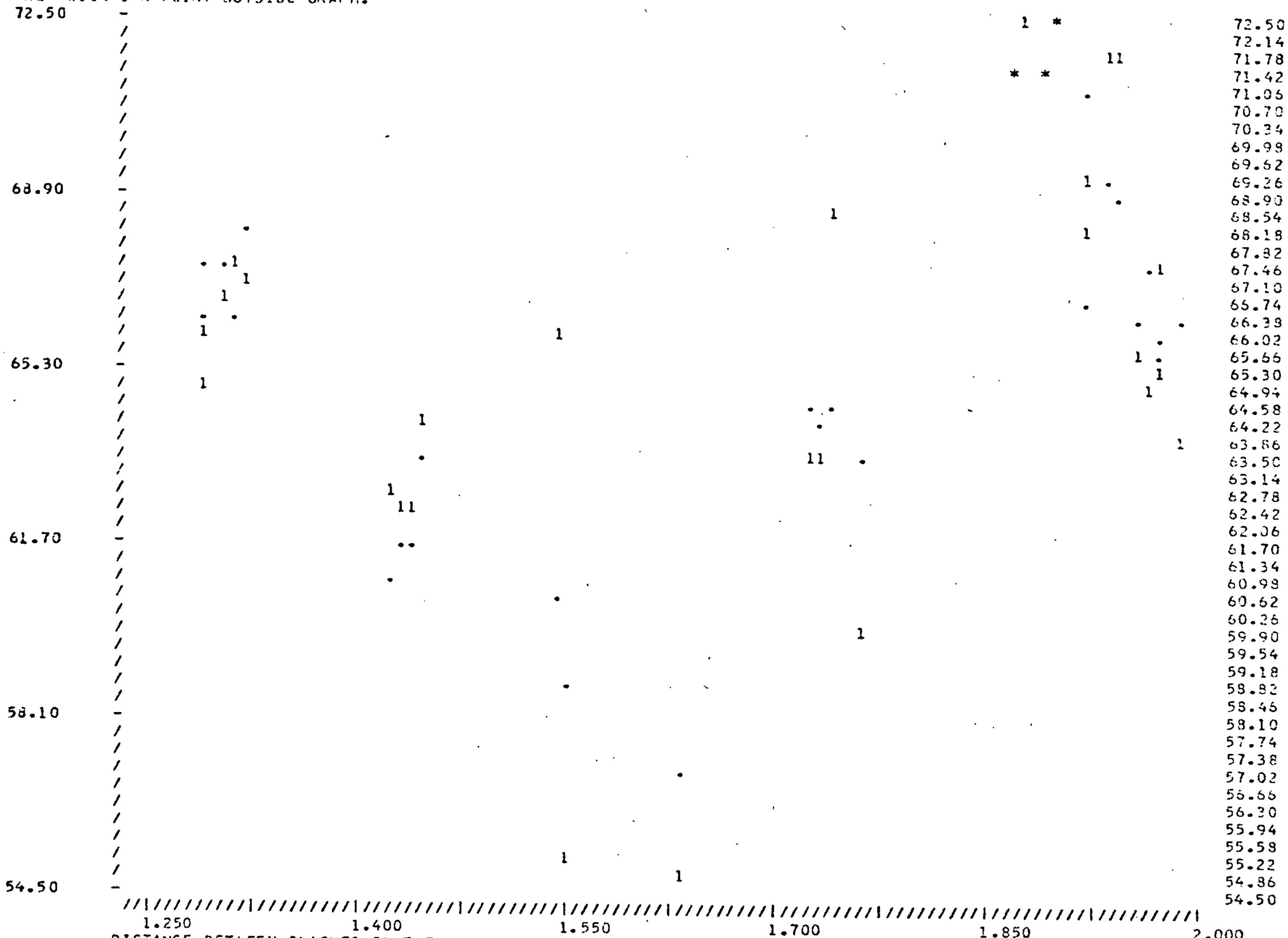
THE ".","+" AND "*" ARE USED TO PLOT PREDICTED VALUES; "*" IS USED WHERE PREDICTED VALUES COVER DATA POINTS
"+" REPRESENTS A POINT OUTSIDE GRAPH.



DISTANCE BETWEEN SLASHES ON THE X-AXIS IS 0.1621

PLOT OF Y & YHAT VS LGD50 .VERTICAL AXIS IS Y-AXIS.

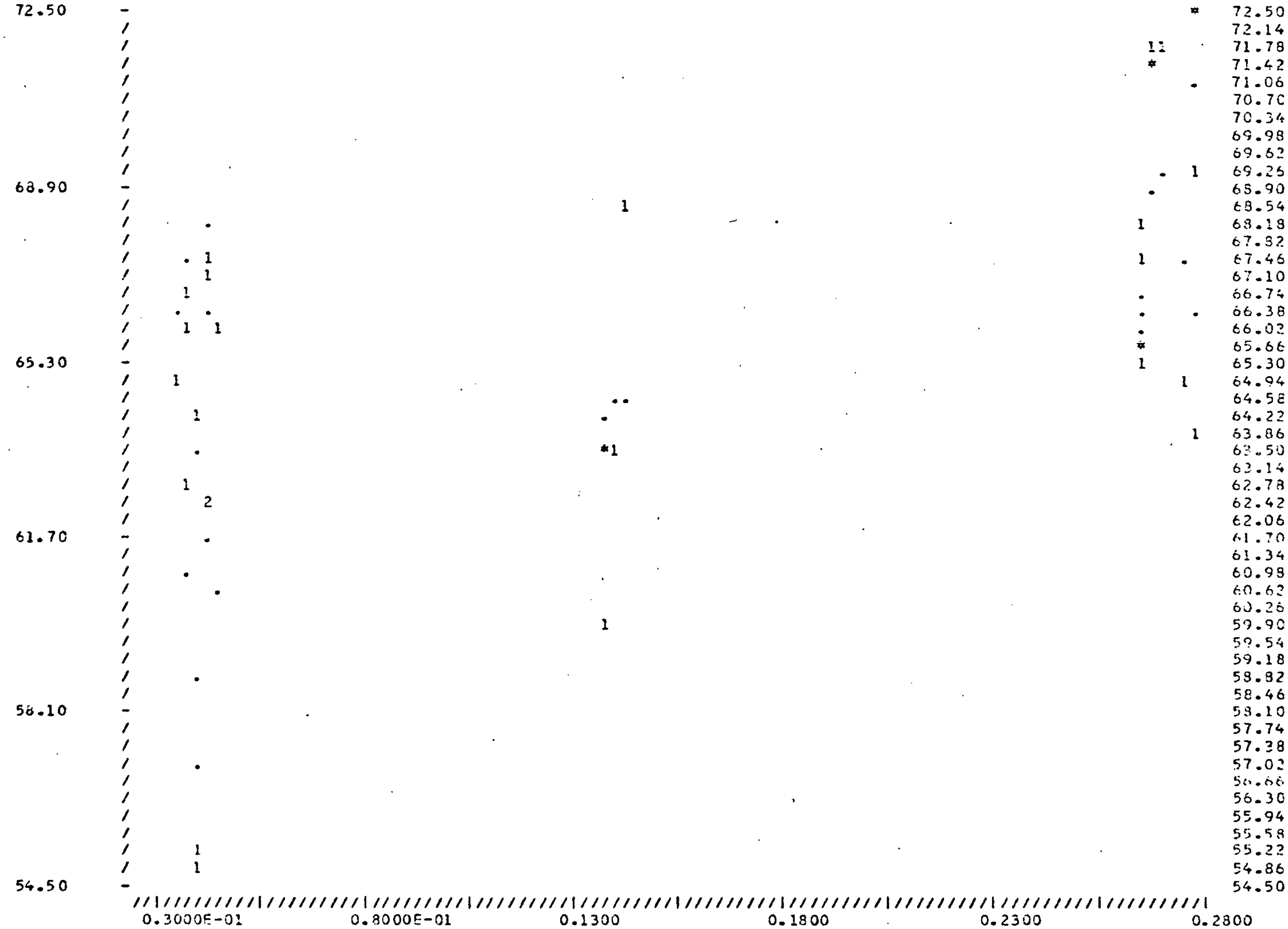
THE ".","+" AND "*" ARE USED TO PLOT PREDICTED VALUES; "*" IS USED WHERE PREDICTED VALUES COVER DATA POINTS
"+" REPRESENTS A POINT OUTSIDE GRAPH.



DISTANCE BETWEEN SLASHES ON THE X-AXIS IS 0.7500E-02

PLOT OF Y & YHAT VS FEFVOL .VERTICAL AXIS IS Y-AXIS.

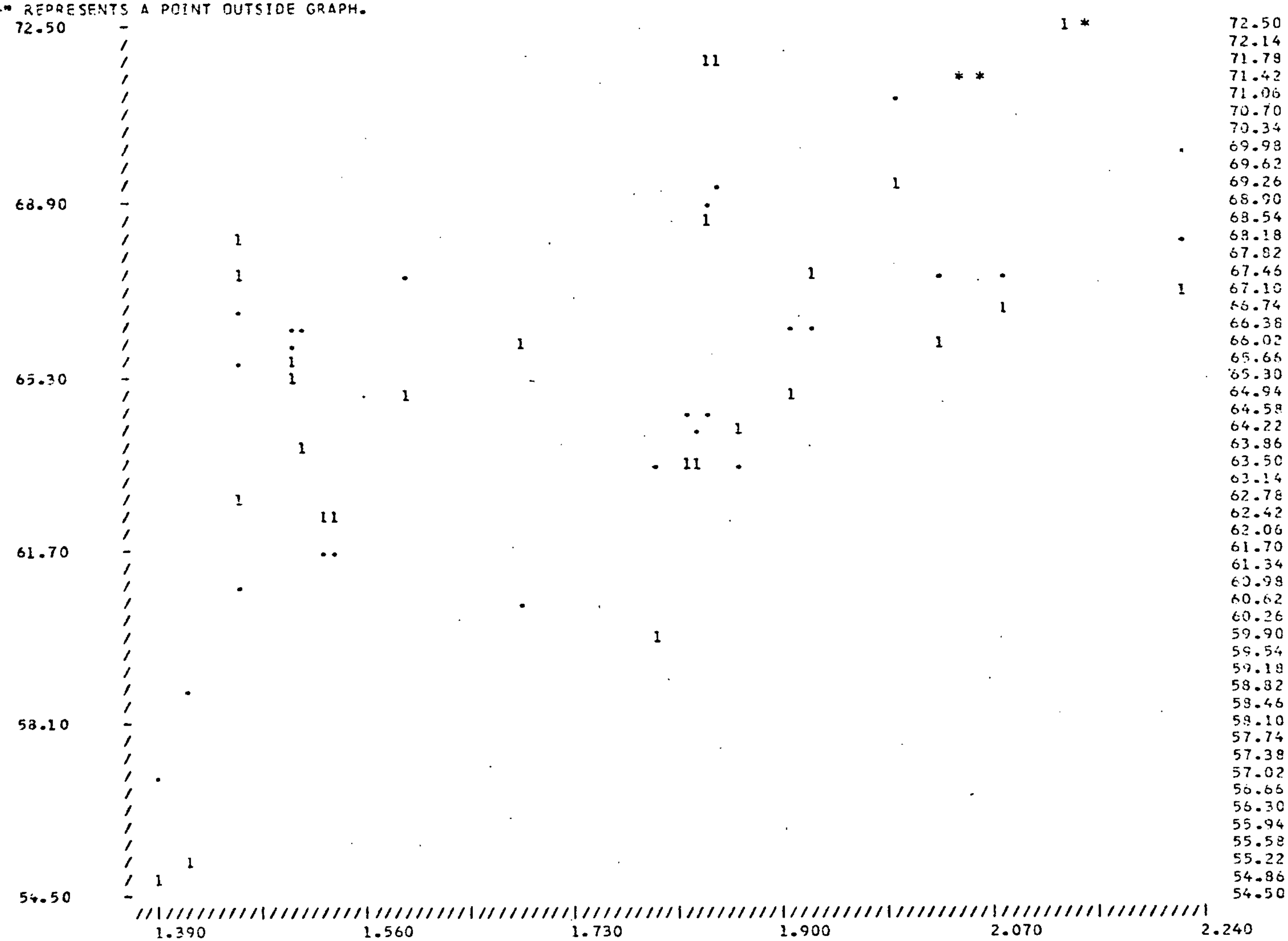
THE ".","+" AND "*" ARE USED TO PLOT PREDICTED VALUES; "*" IS USED WHERE PREDICTED VALUES COVER DATA POINTS
"+" REPRESENTS A POINT OUTSIDE GRAPH.



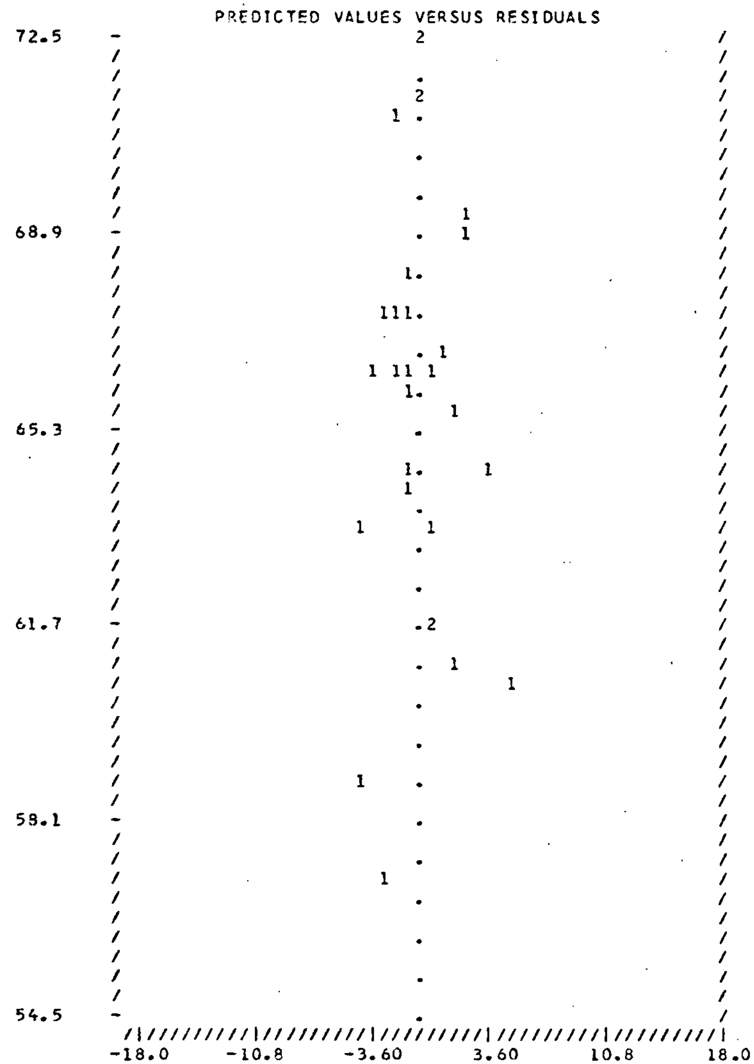
DISTANCE BETWEEN SLASHES ON THE X-AXIS IS 0.2500E-02

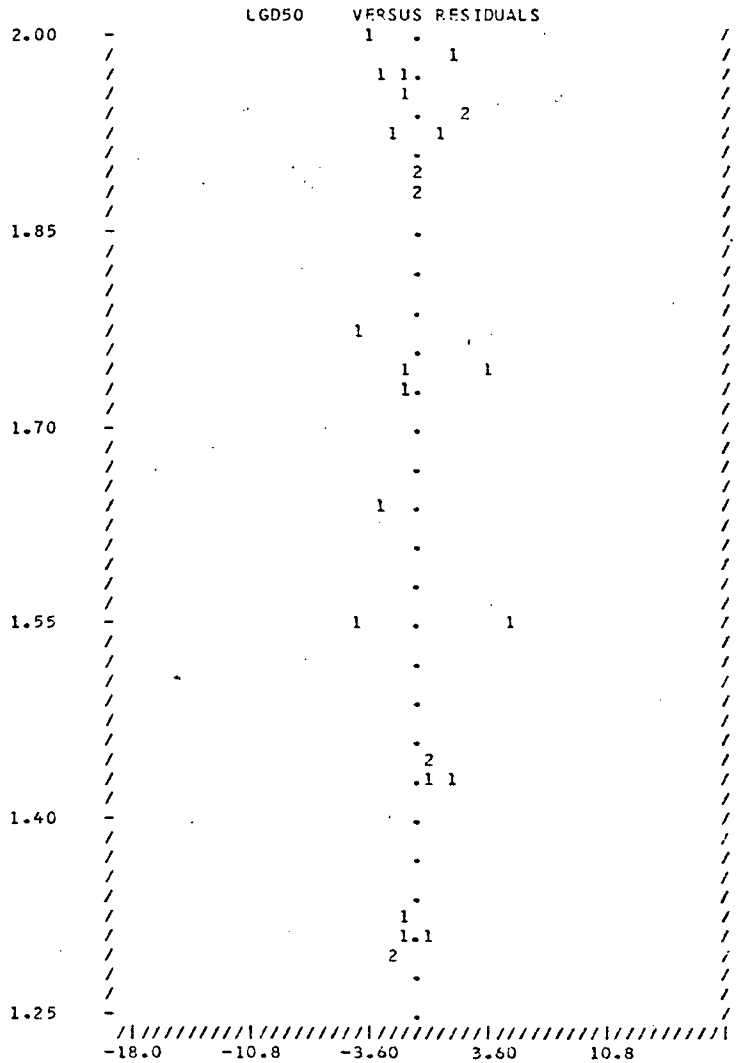
PLOT OF Y & YHAT VS LUSG/S .VERTICAL AXIS IS Y-AXIS.

THE ".","+" AND "*" ARE USED TO PLOT PREDICTED VALUES: "*" IS USED WHERE PREDICTED VALUES COVER DATA POINTS
"+" REPRESENTS A POINT OUTSIDE GRAPH.

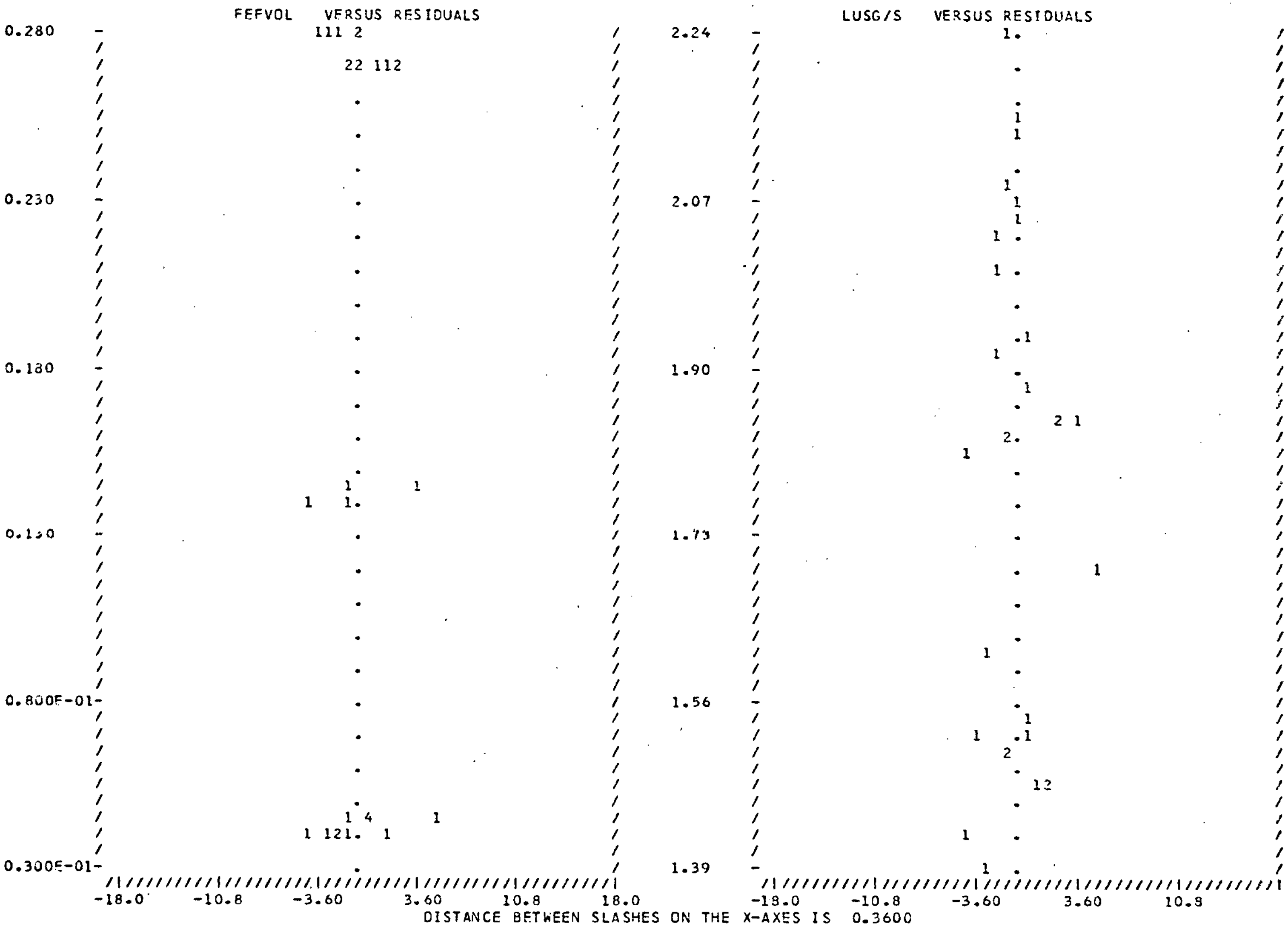


DISTANCE BETWEEN SLASHES ON THE X-AXIS IS 0.8500E-02





DISTANCE BETWEEN SLASHES ON THE X-AXES IS 0.3600


FEFVOL VERSUS RESIDUALS
0.280
0.230
0.180
0.130
0.800E-01
0.300E-01
-18.0
-10.8
-3.60
3.60
10.8
18.0
LUSG/S VERSUS RESIDUALS
2.24
2.07
1.90
1.73
1.56
1.39
-18.0
-10.8
-3.60
3.60
10.8
DISTANCE BETWEEN SLASHES ON THE X-AXES IS 0.3600

CONTROL CARD NO. 9 ** STPREG **** STPREG **** STPREG **** STPREG **** STPREG **** STPREG **** STPREG ** CONTROL CARD NO. 9

POTENTIAL INDEPENDENT AND OTHER VARIABLES IN THE REGRESSION ANALYSIS FOR SPIGOT

	PARTIAL CORR.	TOLERANCE	F-RATIO	F-PROB
UF%SOL	0.2897	1.0000	2.474	0.1236
LUSG/S	0.8091	1.0000	51.19	0.0000

>>>>>>STEP NUMBER 1 REGRESSION EQUATION FOR SPIGOT

R-SQUARED = 0.6546862 F-PROBABILITY LEVEL = 0.0500

STANDARD ERROR SPIGOT = 0.5306E-01

F-PROBABILITY = .00000027

VARIABLE	COEFFICIENT	STD. ERR.	F-RATIO	F-PROB	NORM COEFF
LUSG/S	0.27831302	0.3890E-01	51.19	0.0000	0.8091
CONSTANT	-0.23183841	0.7002E-01	10.96	0.0027	-2.615

POTENTIAL INDEPENDENT AND OTHER VARIABLES IN THE REGRESSION ANALYSIS FOR SPIGOT

	PARTIAL CORR.	TOLERANCE	F-RATIO	F-PROB
UF%SOL	0.4727	0.6084	7.480	0.0107

>>>>>>STEP NUMBER 2 REGRESSION EQUATION FOR SPIGOT

R-SQUARED = 0.7318318 F-PROBABILITY LEVEL = 0.0500

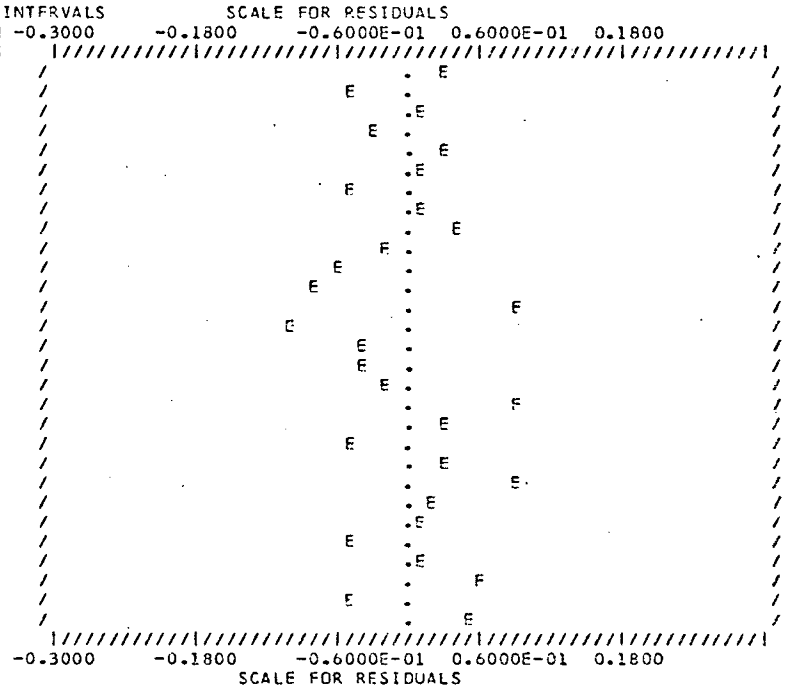
STANDARD ERROR SPIGOT = 0.4765E-01

F-PROBABILITY = .00000007

VARIABLE	COEFFICIENT	STD. ERR.	F-RATIO	F-PROB	NORM COEFF
UF%SOL	-0.70046345E-02	0.2561E-02	7.480	0.0107	-0.3561
LUSG/S	0.35496742	0.4479E-01	62.82	0.0000	1.032
CONSTANT	0.93478333E-01	0.1345	0.4827	0.5000	1.054

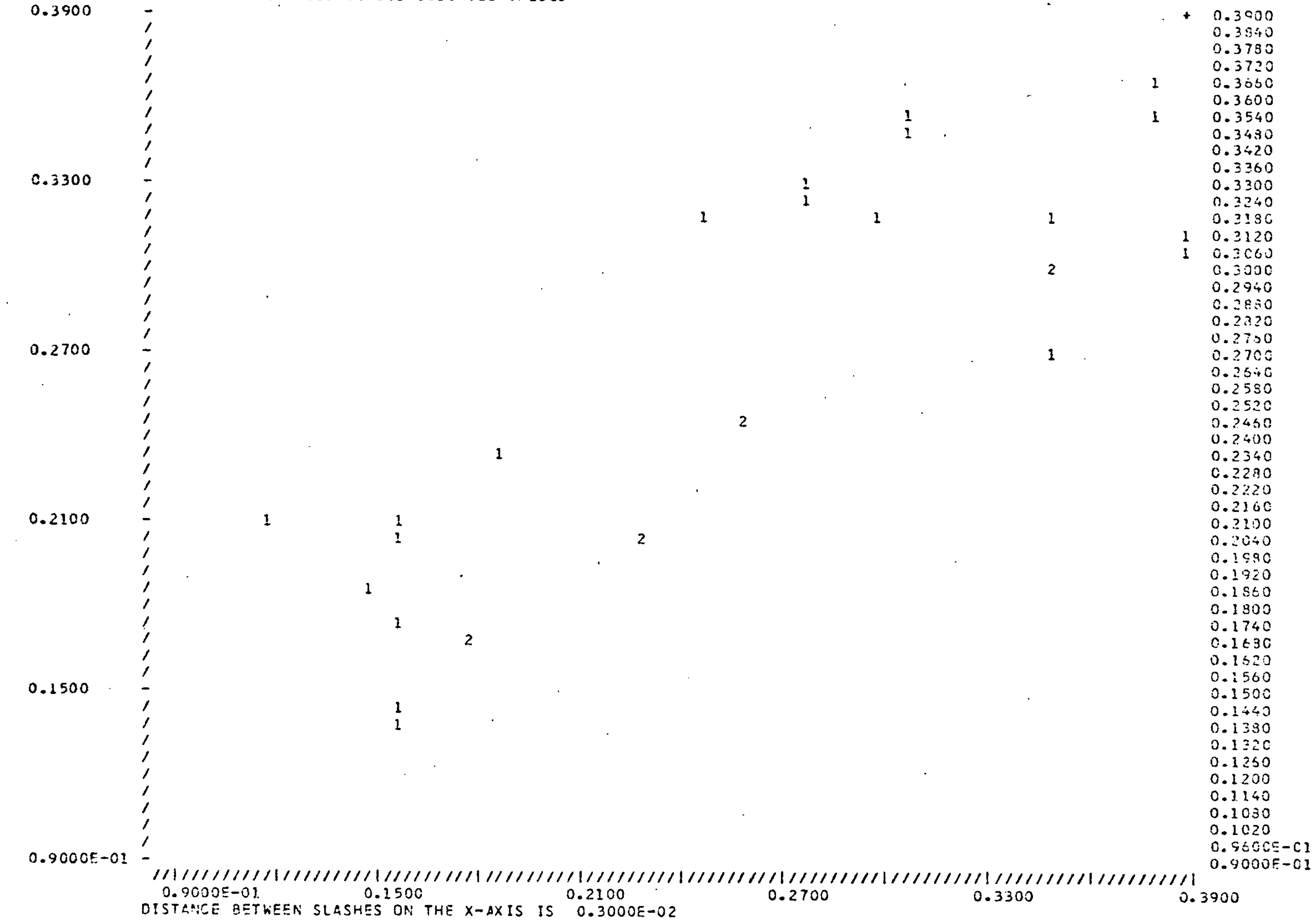
.0 (100%)CONFIDENCE INTERVALS

	OBSERVED	RESIDUAL	PREDICTED	MEAN PLUS-MINUS	OBSERVATION PLUS-MINUS
1	0.23000	0.2868E-01	0.20132		
2	0.16000	-0.4419E-01	0.20419		
3	0.38000	0.1211E-01	0.36789		
4	0.39000	-0.2552E-01	0.41552		
5	0.16000	0.2286E-01	0.13714		
6	0.18000	0.1008E-01	0.16992		
7	0.28000	-0.4883E-01	0.32883		
8	0.26000	0.1110E-01	0.24890		
9	0.35000	0.3492E-01	0.31508		
10	0.16000	-0.1408E-01	0.17408		
11	0.16000	-0.5282E-01	0.21282		
12	0.25000	-0.7052E-01	0.32052		
13	0.39000	0.8089E-01	0.30911		
14	0.12000	-0.8709E-01	0.20709		
15	0.15000	-0.3557E-01	0.18557		
16	0.21000	-0.3658E-01	0.24658		
17	0.30000	-0.1966E-01	0.31966		
18	0.35000	0.8103E-01	0.26897		
19	0.23000	0.2751E-01	0.20249		
20	0.19000	-0.4242E-01	0.23242		
21	0.38000	0.2536E-01	0.35464		
22	0.39000	0.8379E-01	0.30621		
23	0.16000	0.1813E-01	0.14187		
24	0.18000	0.1077E-01	0.16923		
25	0.28000	-0.4218E-01	0.32218		
26	0.26000	0.1295E-01	0.24705		
27	0.35000	0.5292E-01	0.29708		
28	0.31000	-0.4169E-01	0.35169		
29	0.35000	0.4804E-01	0.30196		



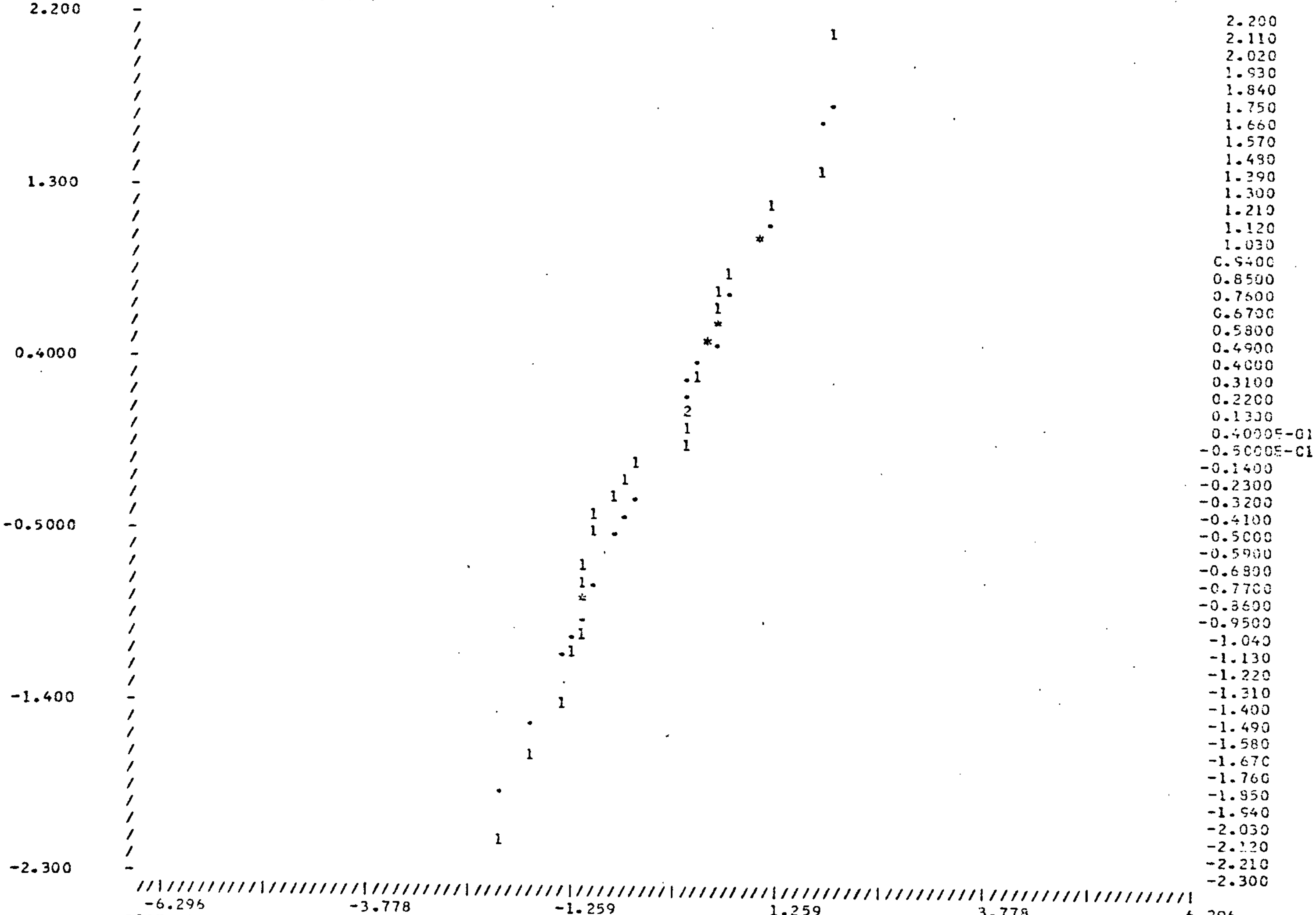
29 COMPLETE OBSERVATIONS AUTO CORR COEFF= -0.1597 DURBIN WATSON D-STATISTIC = 2.254

PREDICTED VALUES (VERTICAL AXIS) VERSUS OBSERVED VALUES



PROBABILITY OF RESIDUALS VS RESIDUALS
(PLOT TO VERIFY THE NORMALITY OF THE DIST OF RESIDUALS)

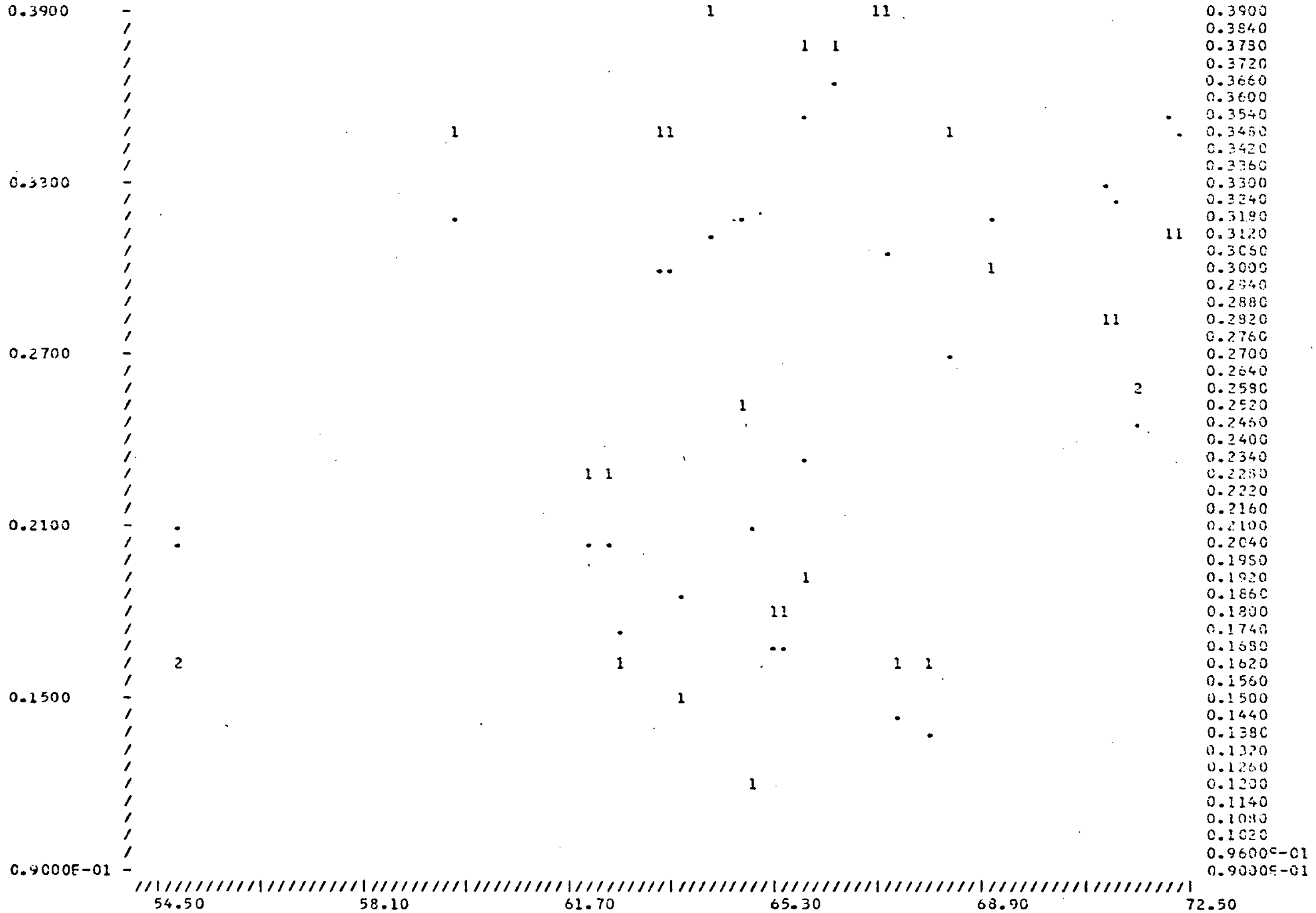
THE ".","+" AND "*" ARE USED TO PLOT PREDICTED VALUES; "*" IS USED WHERE PREDICTED VALUES COVER DATA POINTS
"+" REPRESENTS A POINT OUTSIDE GRAPH.



DISTANCE BETWEEN SLASHES ON THE X-AXIS IS 0.1259

PLOT OF Y & YHAT VS UF%SOL .VERTICAL AXIS IS Y-AXIS.

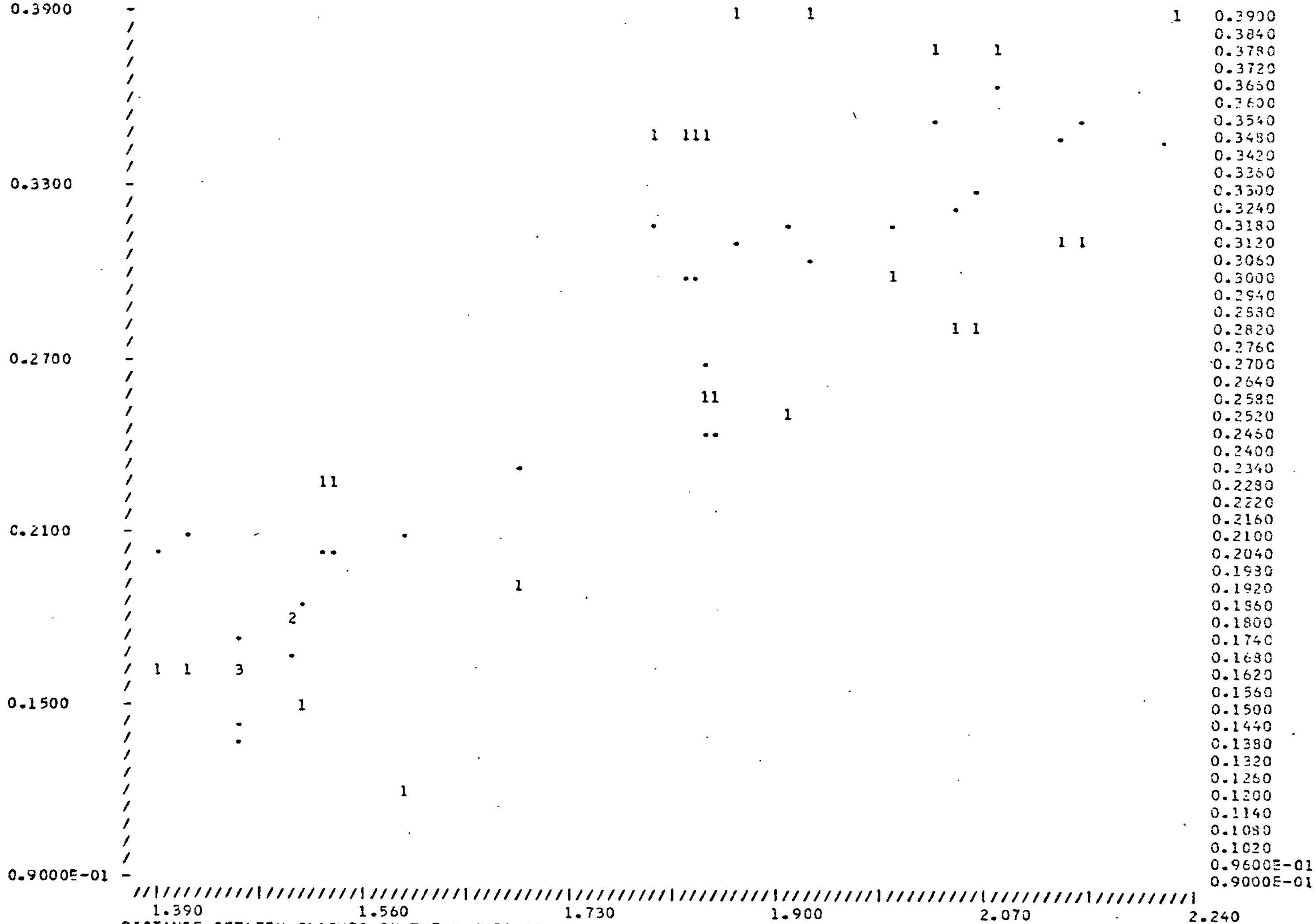
THE ".","+" AND "*" ARE USED TO PLOT PREDICTED VALUES: "*" IS USED WHERE PREDICTED VALUES COVER DATA POINTS
"+" REPRESENTS A POINT OUTSIDE GRAPH.



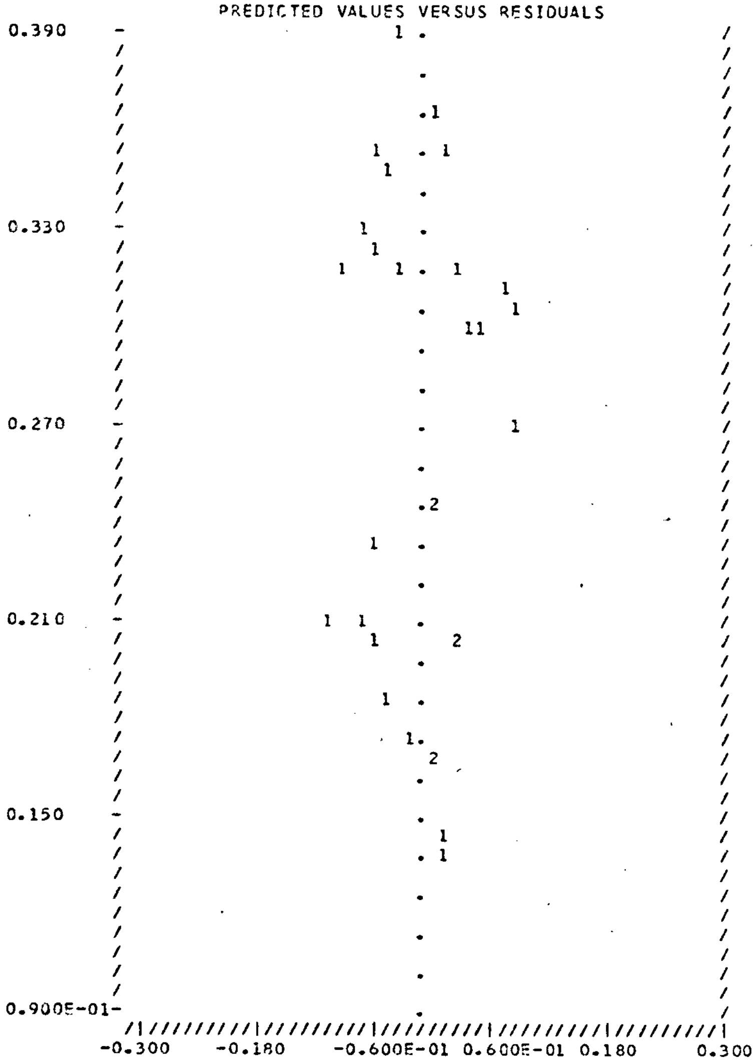
DISTANCE BETWEEN SLASHES ON THE X-AXIS IS 0.1800

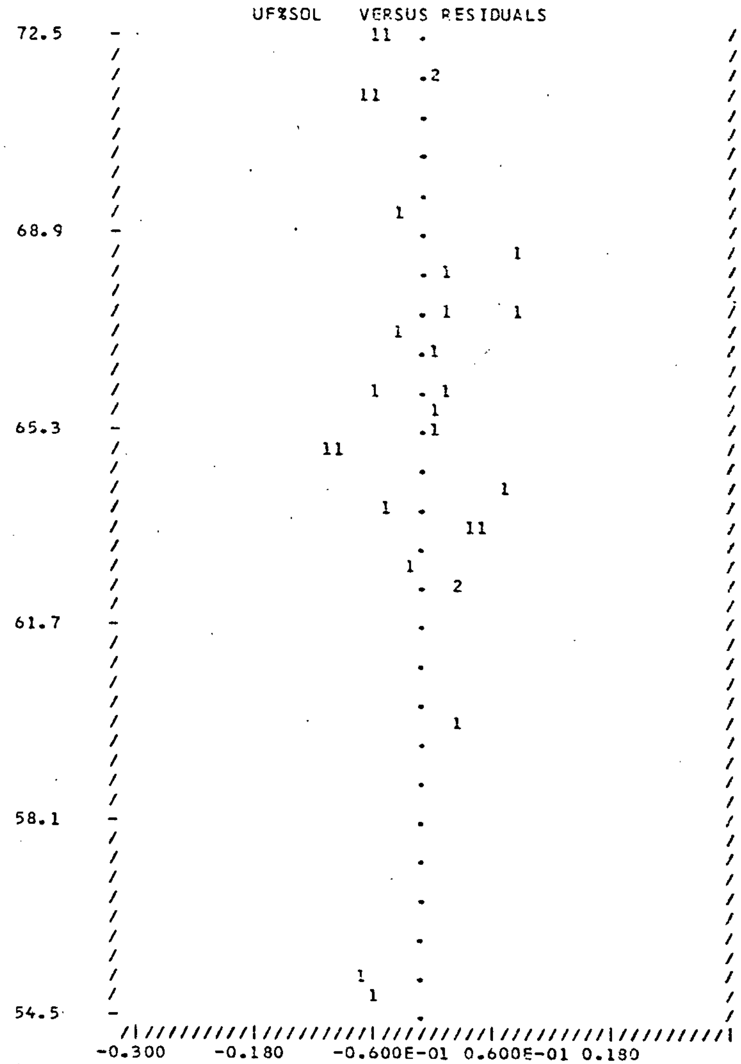
PLOT OF Y & YHAT VS LUSG/S .VERTICAL AXIS IS Y-AXIS.

THE ".","+" AND "*" ARE USED TO PLOT PREDICTED VALUES; "*" IS USED WHERE PREDICTED VALUES COVER DATA POINTS
"+" REPRESENTS A POINT OUTSIDE GRAPH.

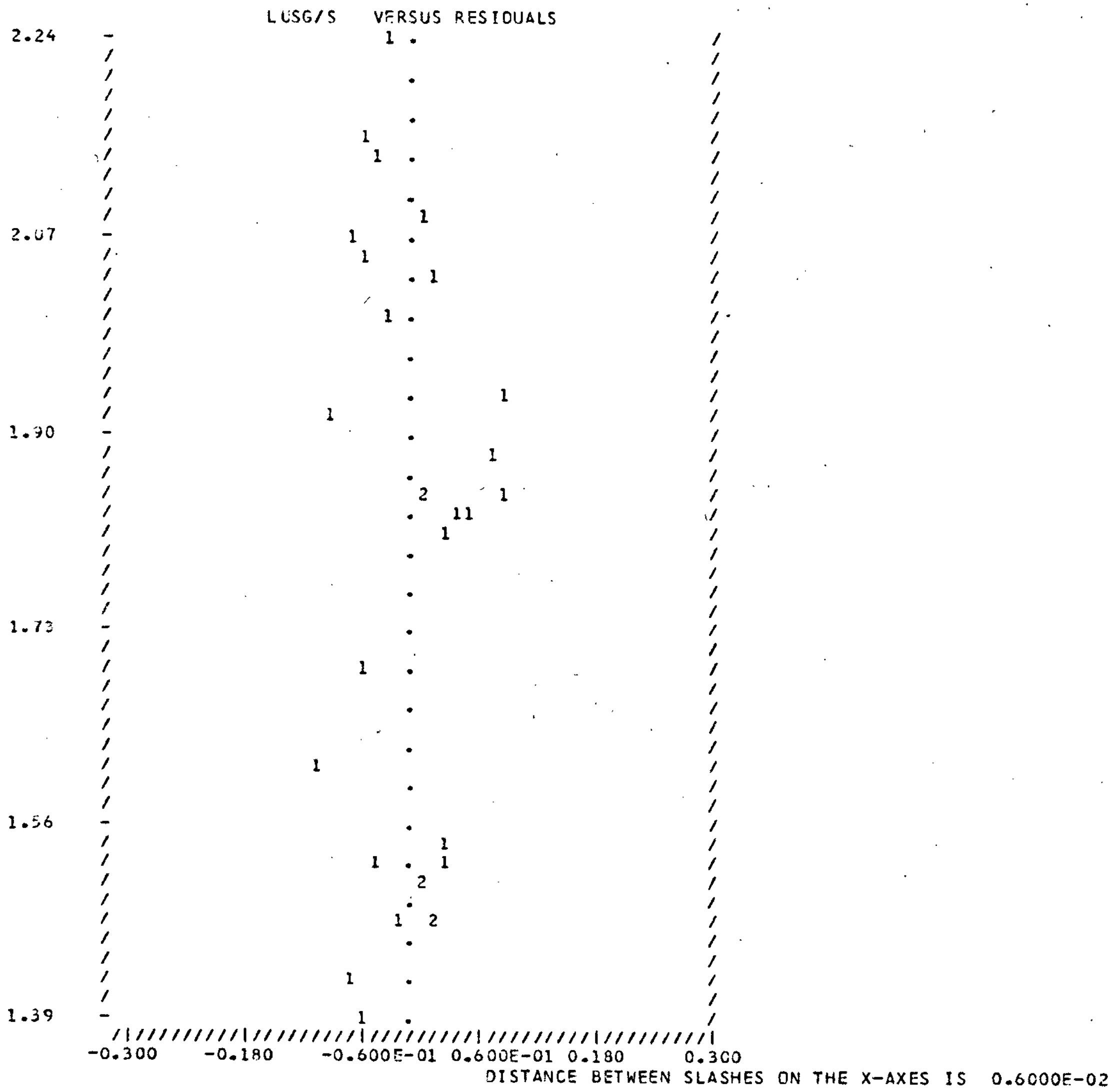


DISTANCE BETWEEN SLASHES ON THE X-AXIS IS 0.8500E-02





DISTANCE BETWEEN SLASHES ON THE X-AXES IS 0.6000E-02


LUSG/S VERSUS RESIDUALS
2.24
2.07
1.90
1.73
1.56
1.39
-0.300
-0.180
-0.600E-01
0.600E-01
0.180
0.300
DISTANCE BETWEEN SLASHES ON THE X-AXES IS 0.6000E-02

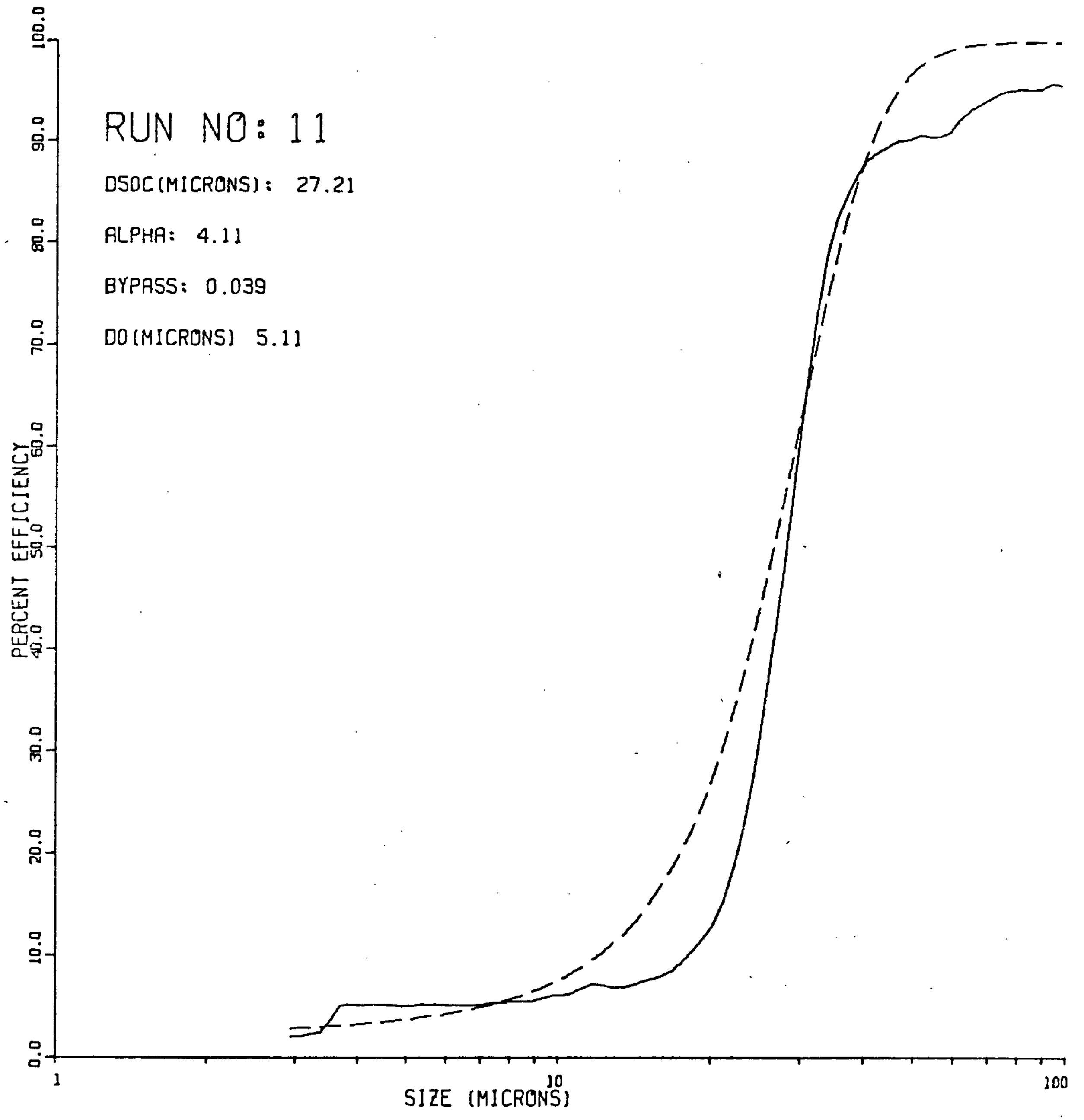
```
CONTROL CARD NO. 10  ** END    **** END    **** END    **** END    **** END    **** END    **** END    ** CONTROL CARD NO. 10
EXECUTION TERMINATED

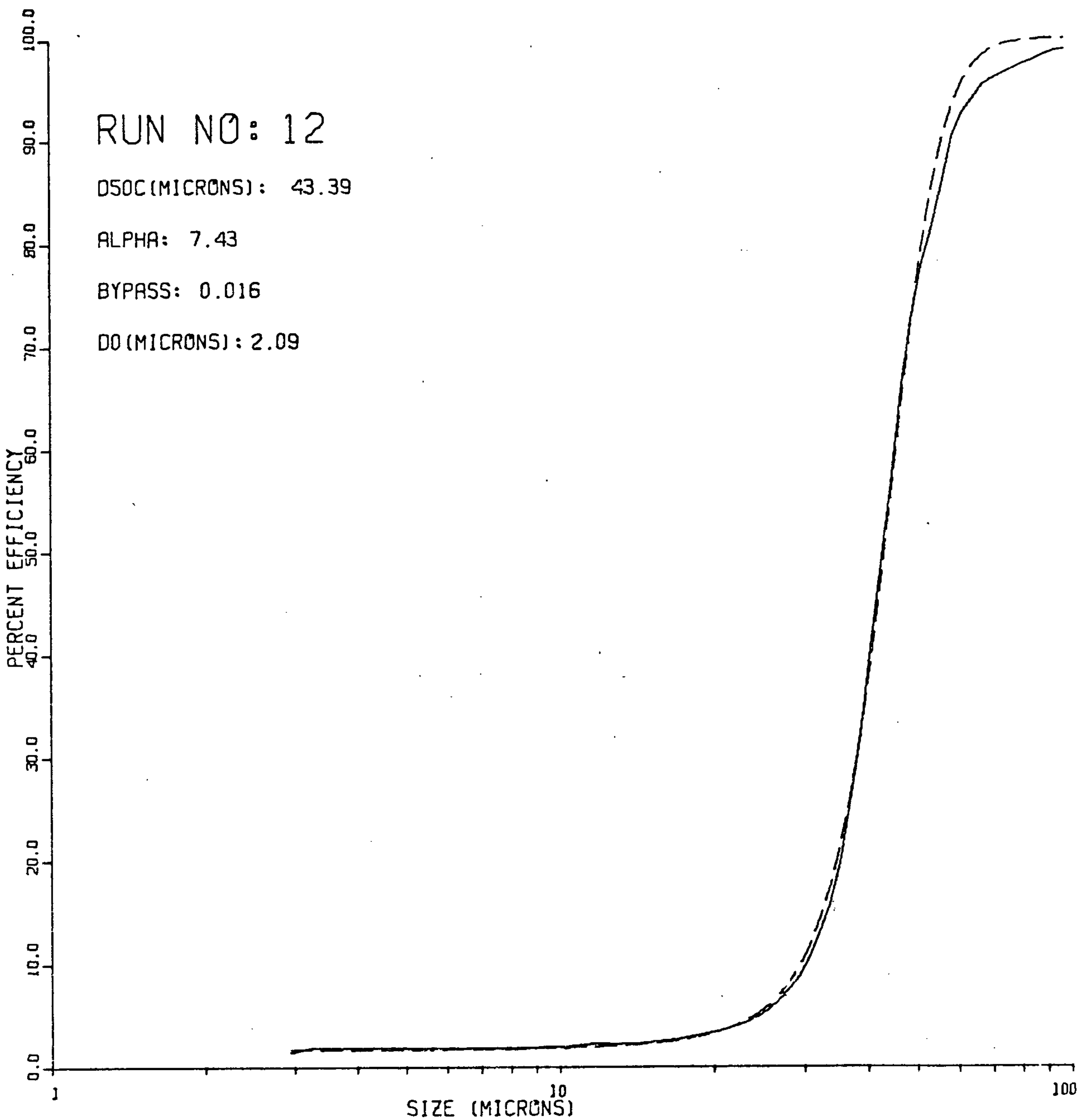

$SIG
```

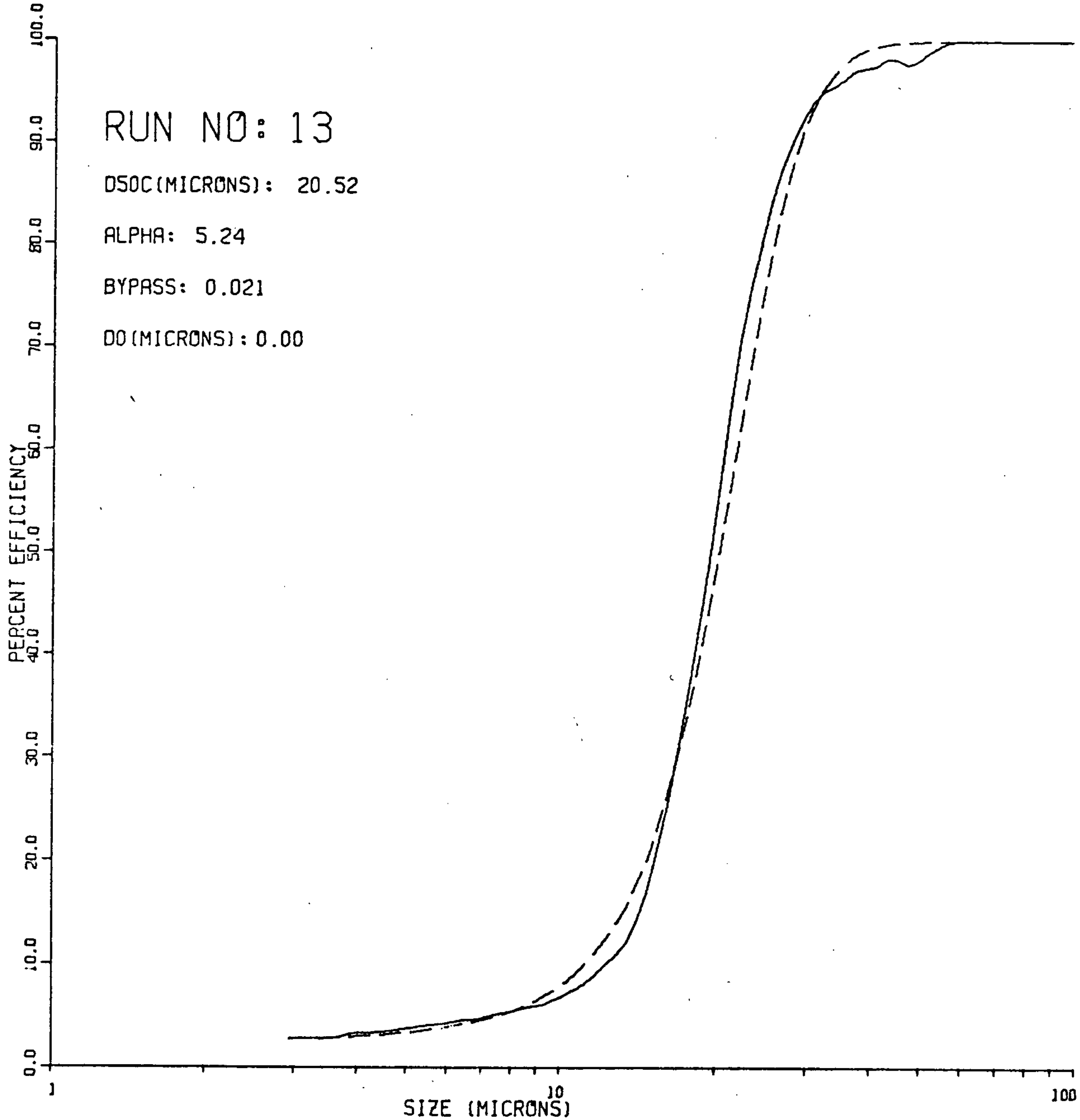
APPENDIX XIII

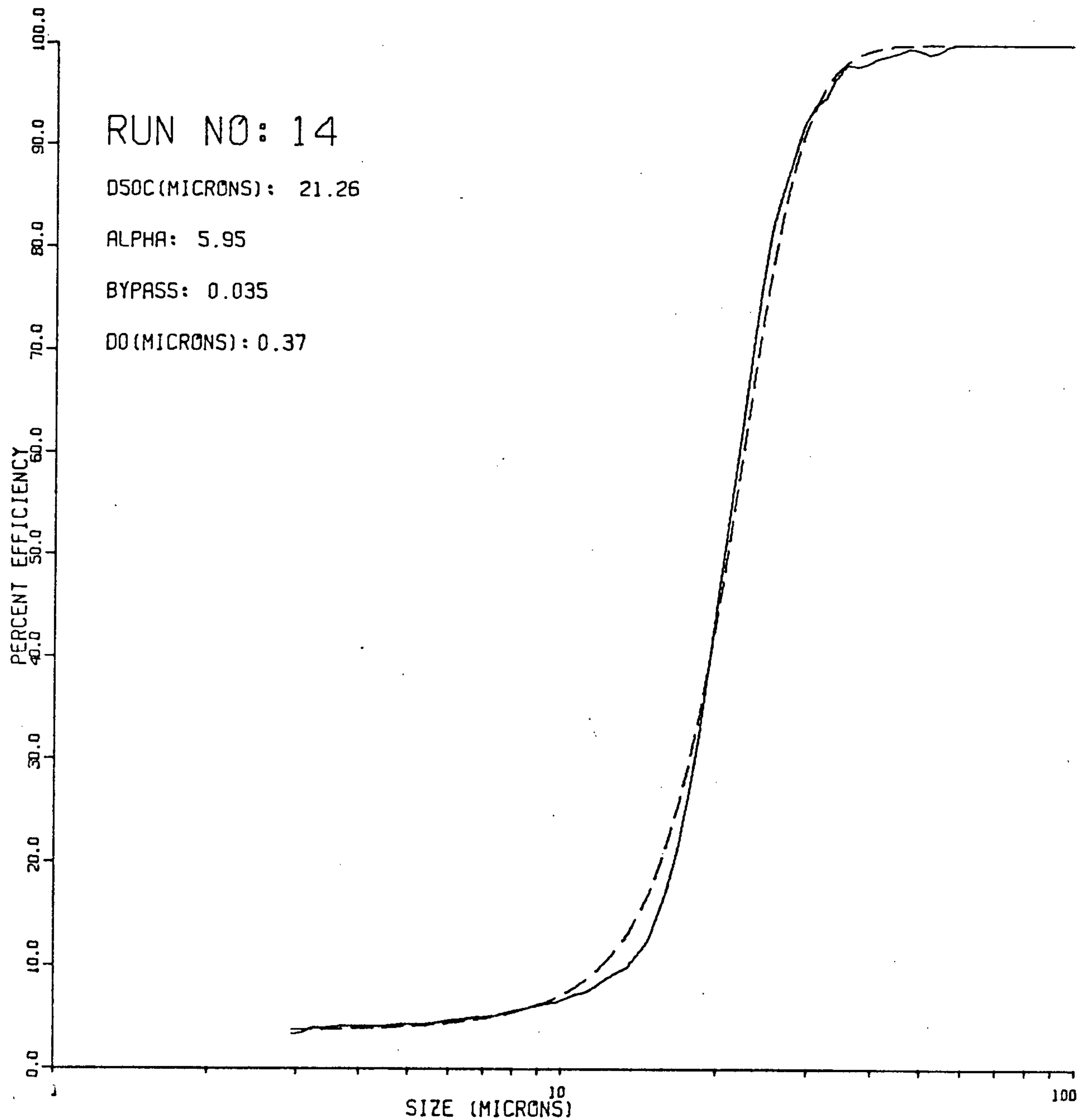
GRAPHS OF RAW EFFICIENCY CURVES

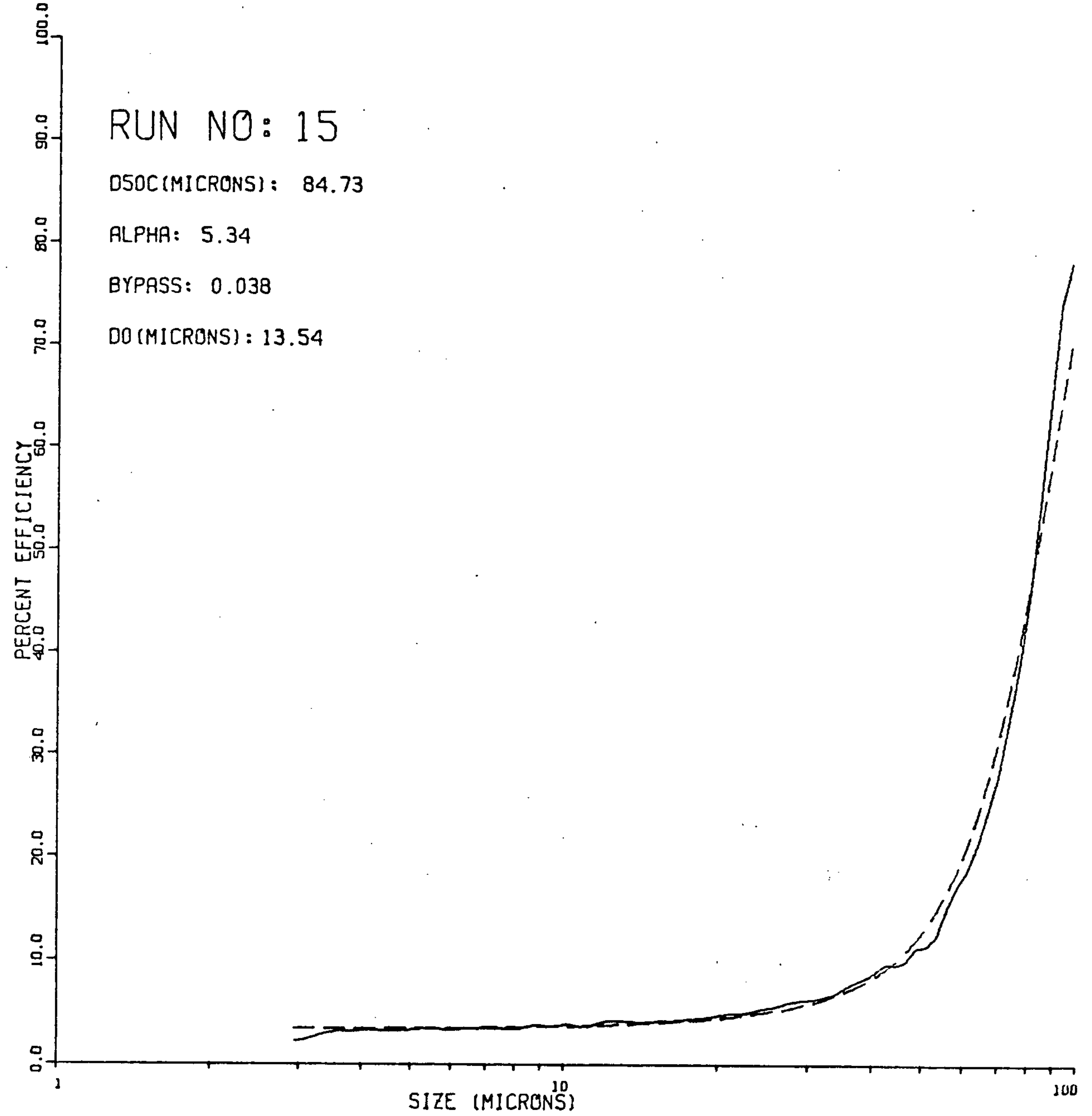
The next 29 pages show the calculated raw efficiency curves for each of the runs as an unbroken line. The dashed line is the curve calculated from the parameters given by the program "MURU". These parameters are listed on each graph.

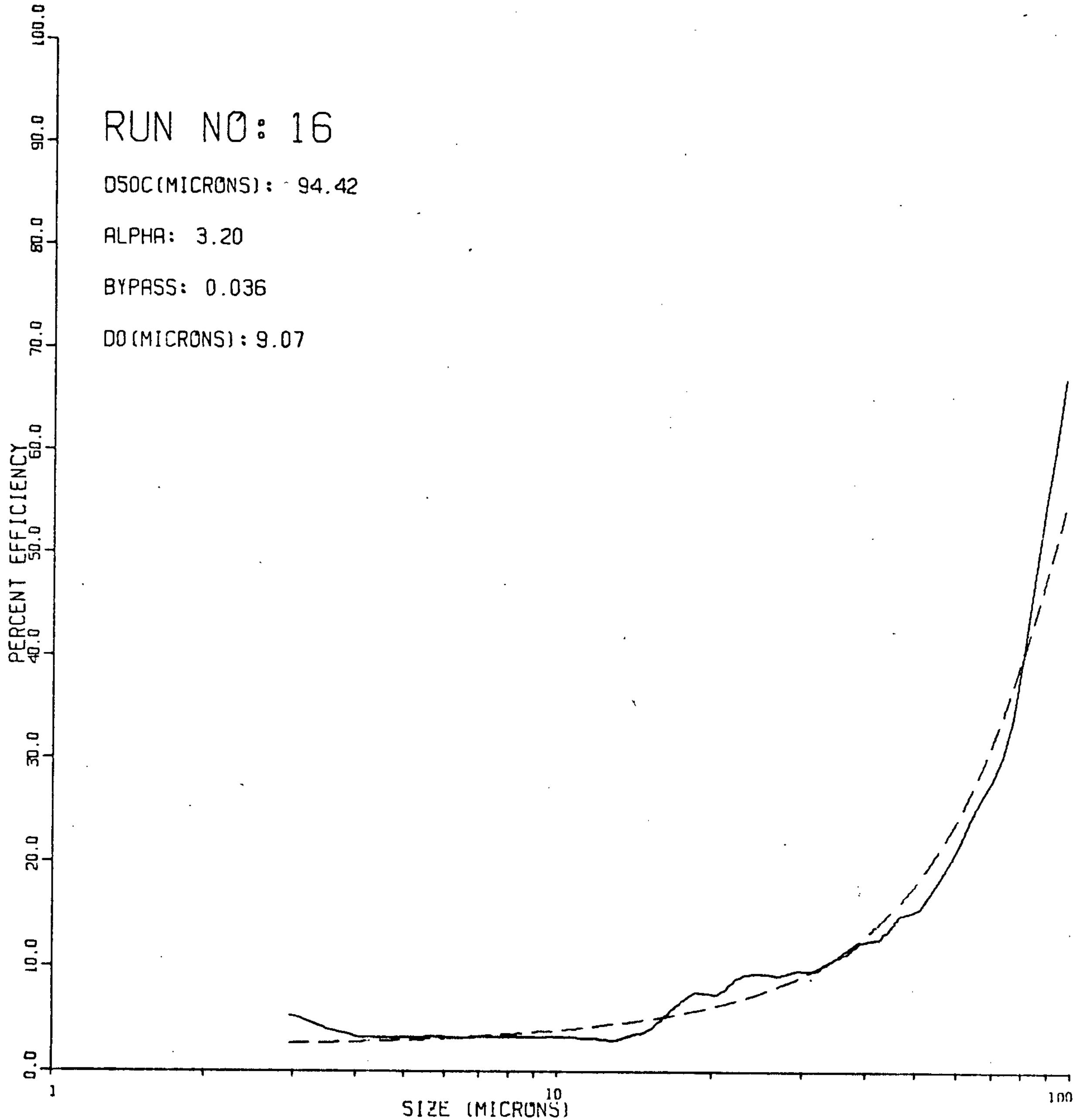

RUN NO: 11
D50C(MICRONS): 27.21
ALPHA: 4.11
BYPASS: 0.039
DO(MICRONS) 5.11
PERCENT EFFICIENCY
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
SIZE (MICRONS)
1
10
100

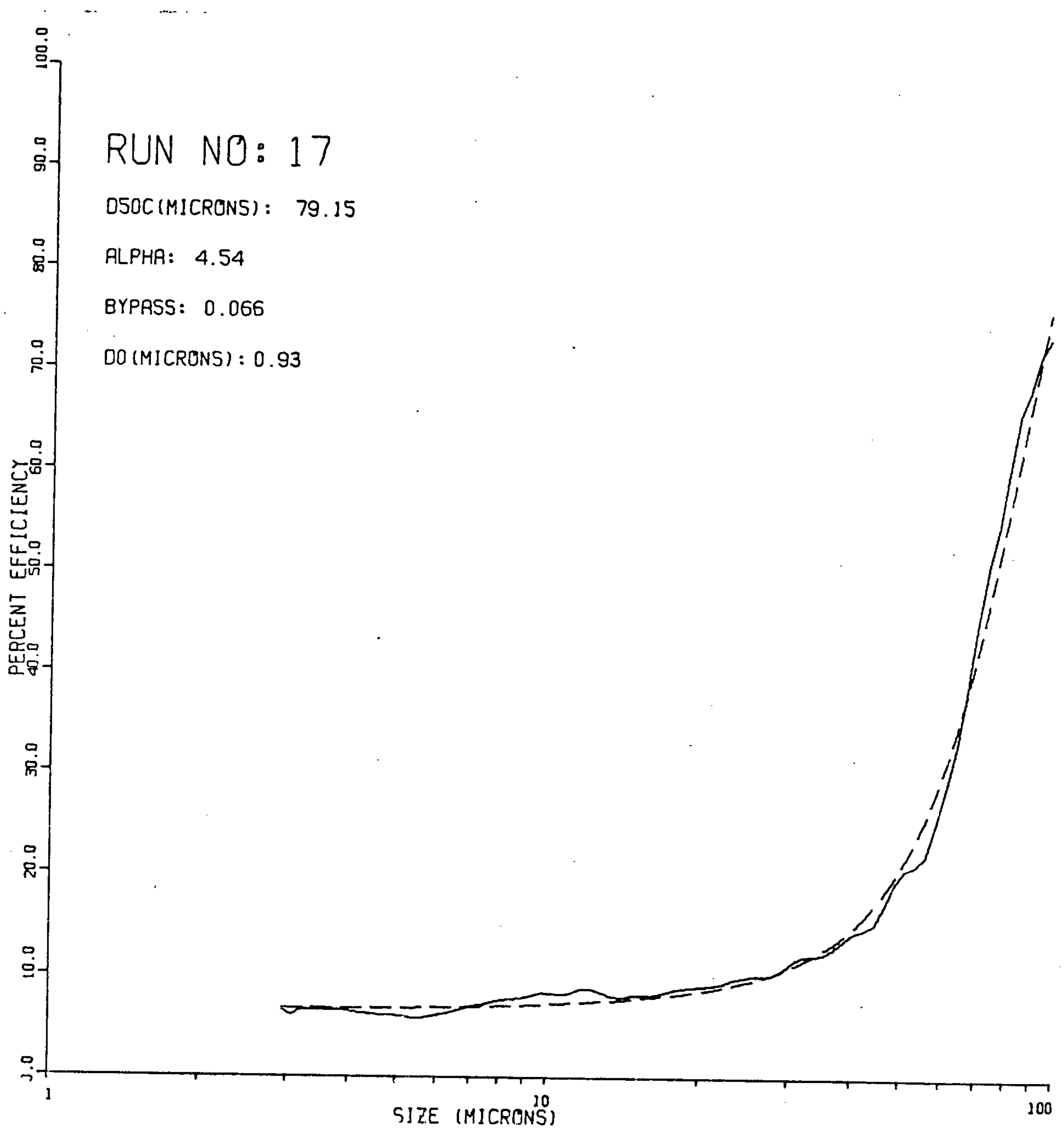

RUN NO: 12
D50C(MICRONS): 43.39
ALPHA: 7.43
BYPASS: 0.016
D0(MICRONS): 2.09
PERCENT EFFICIENCY
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
SIZE (MICRONS)
1
10
100


RUN NO: 13
D50C(MICRONS): 20.52
ALPHA: 5.24
BYPASS: 0.021
DO(MICRONS): 0.00
PERCENT EFFICIENCY
SIZE (MICRONS)
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
1
10
100

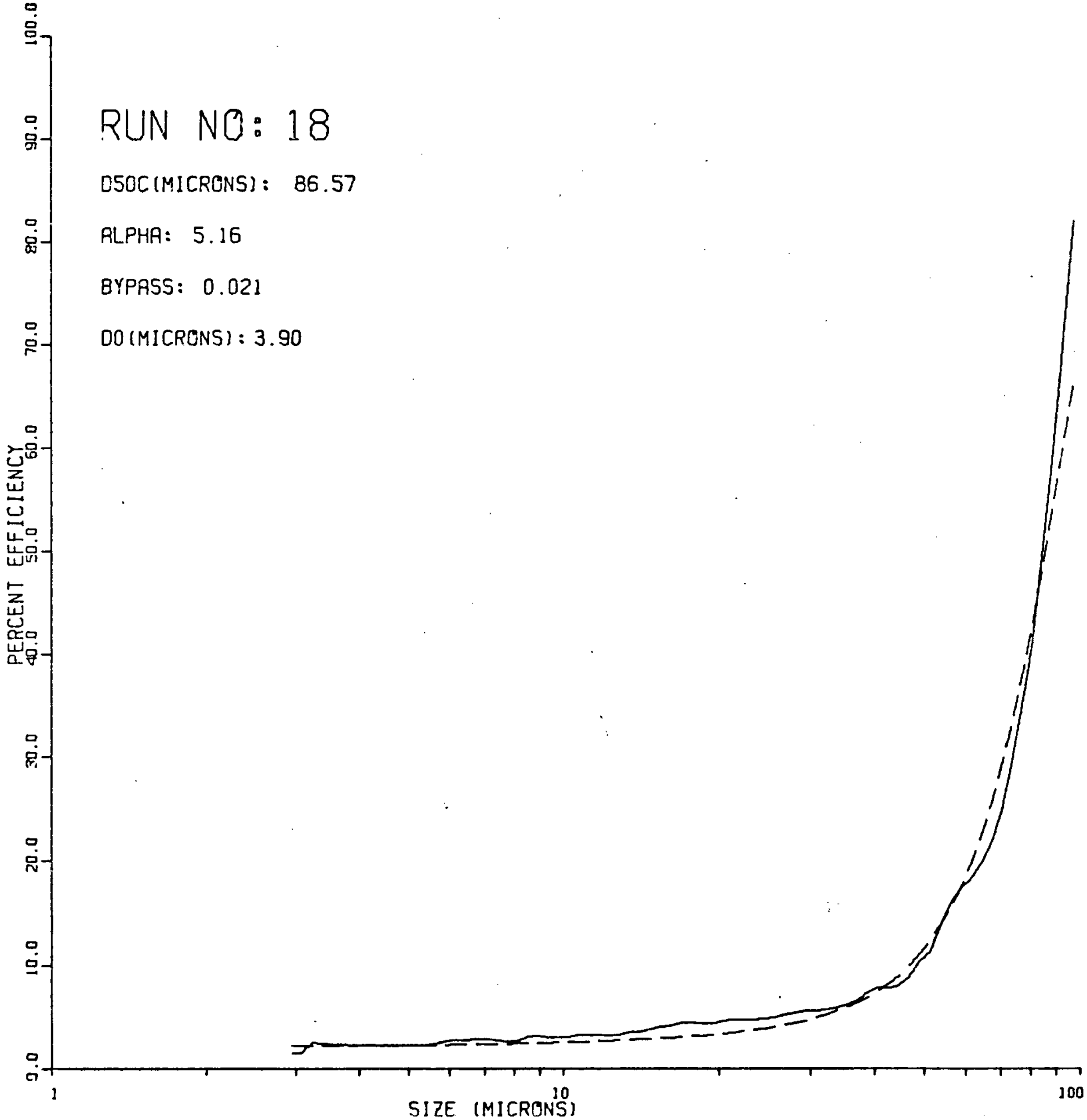

RUN NO: 14
D50C(MICRONS): 21.26
ALPHA: 5.95
BYPASS: 0.035
DO(MICRONS): 0.37
PERCENT EFFICIENCY
SIZE (MICRONS)
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
1
10
100

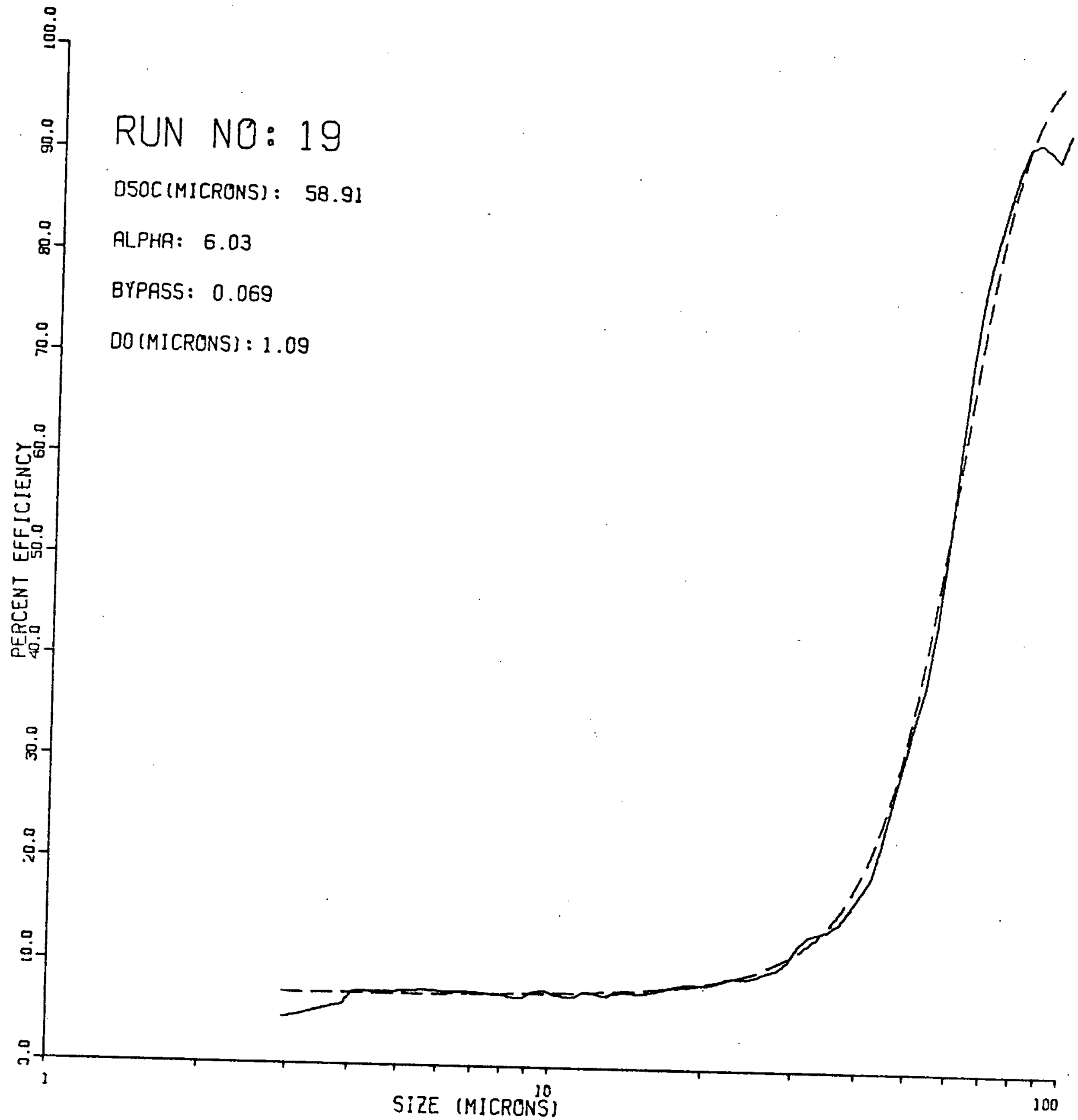

RUN NO: 15
D50C(MICRONS): 84.73
ALPHA: 5.34
BYPASS: 0.038
D0(MICRONS): 13.54
PERCENT EFFICIENCY
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
SIZE (MICRONS)
1
10
100

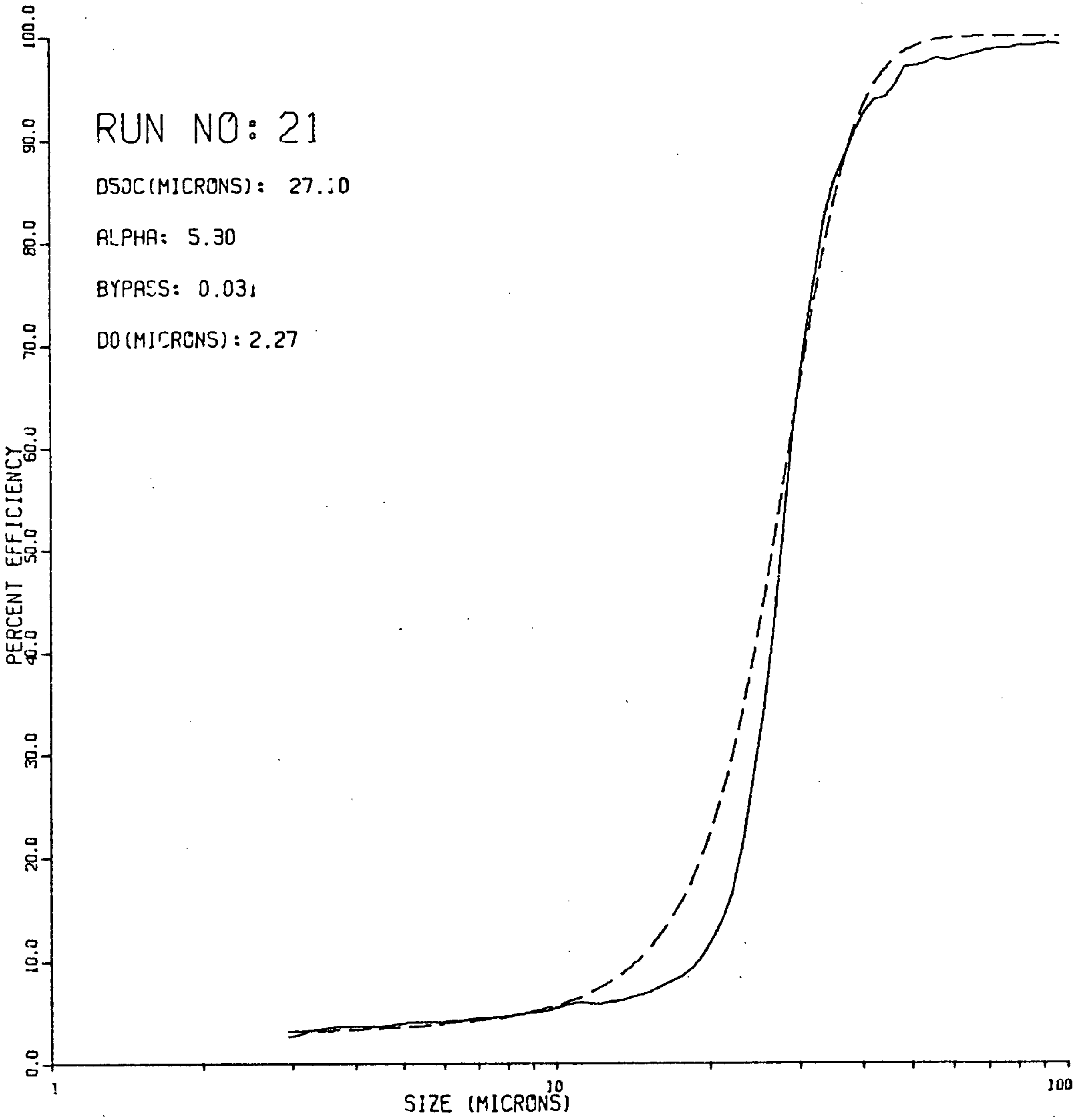

RUN NO: 16
D50C(MICRONS): 94.42
ALPHA: 3.20
BYPASS: 0.036
DO(MICRONS): 9.07
PERCENT EFFICIENCY
SIZE (MICRONS)
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
1
10
100

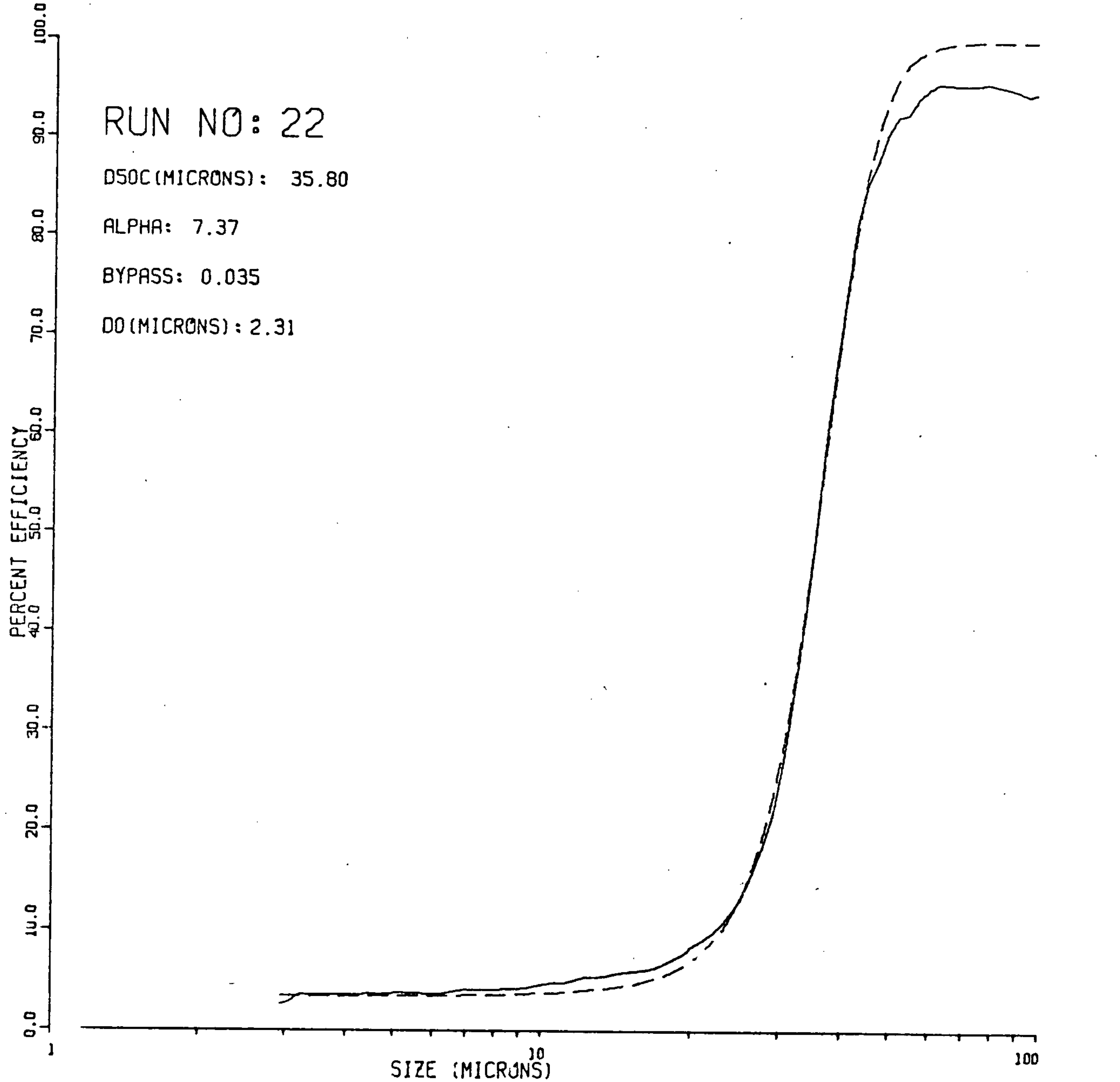


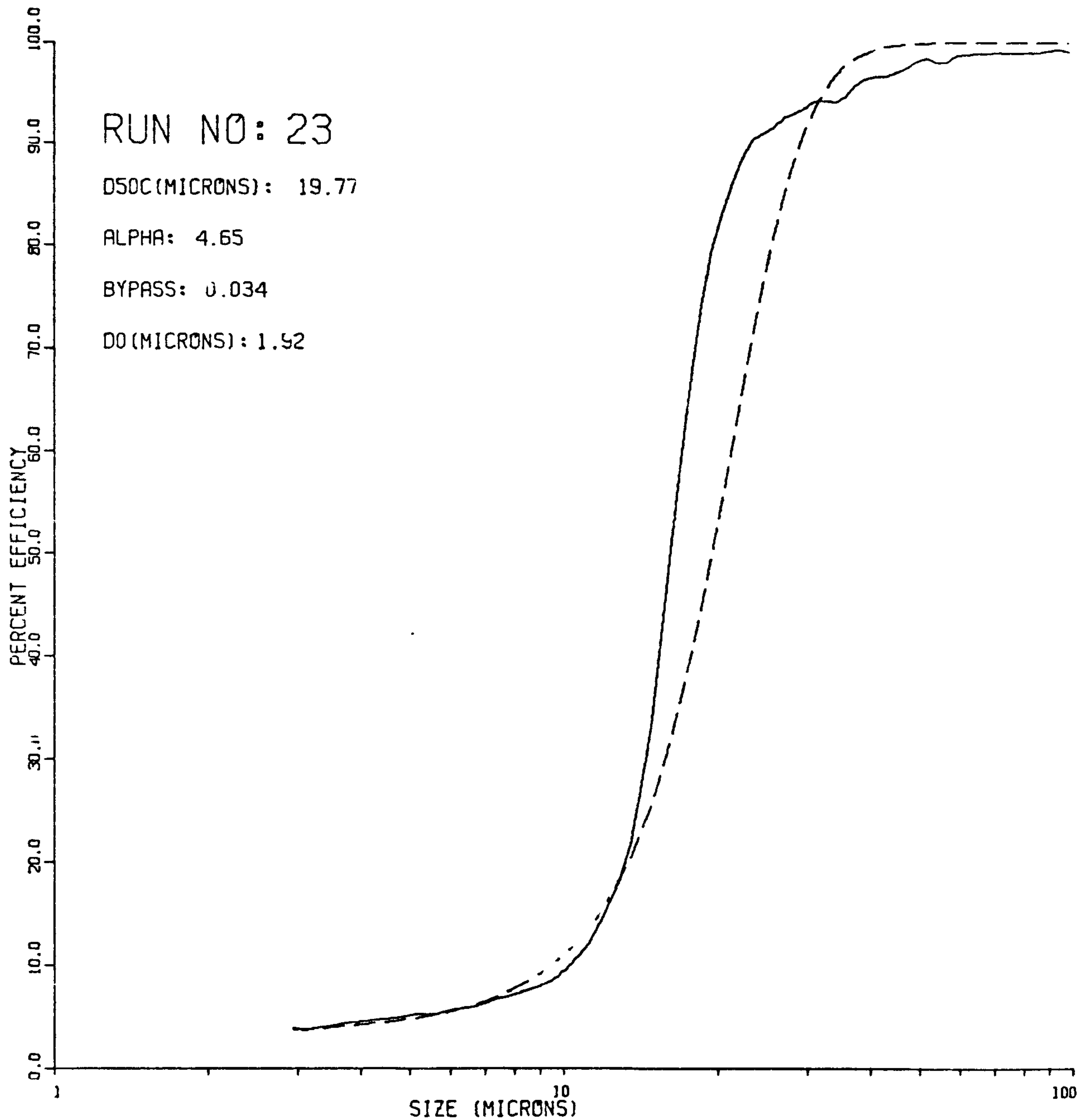
RUN NO: 17
D50C(MICRONS): 79.15
ALPHA: 4.54
BYPASS: 0.066
DO(MICRONS): 0.93
PERCENT EFFICIENCY
SIZE (MICRONS)
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
1
10
100

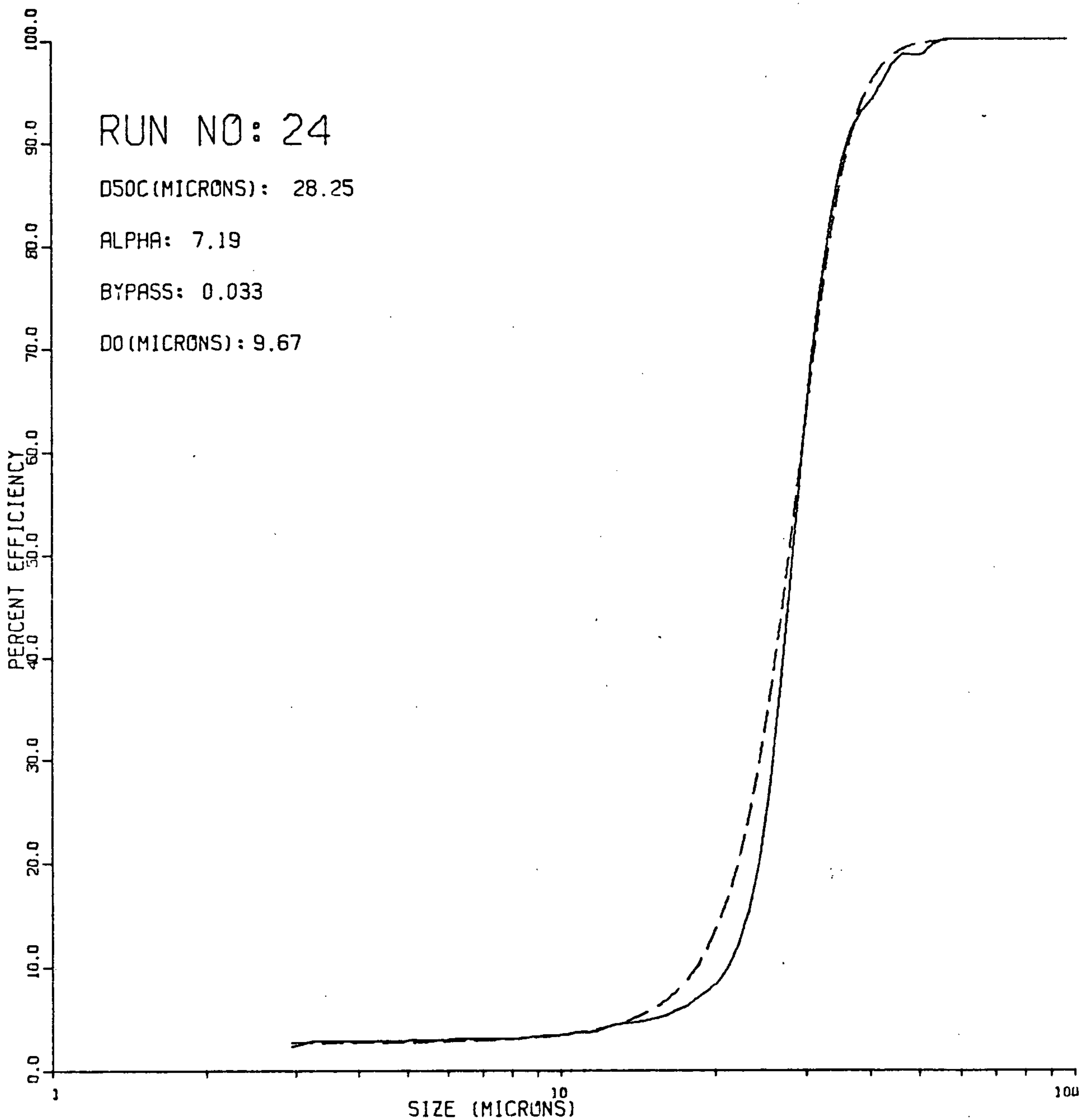

RUN NO: 18
D50C(MICRONS): 86.57
ALPHA: 5.16
BYPASS: 0.021
DO(MICRONS): 3.90
PERCENT EFFICIENCY
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
1
10
100
SIZE (MICRONS)

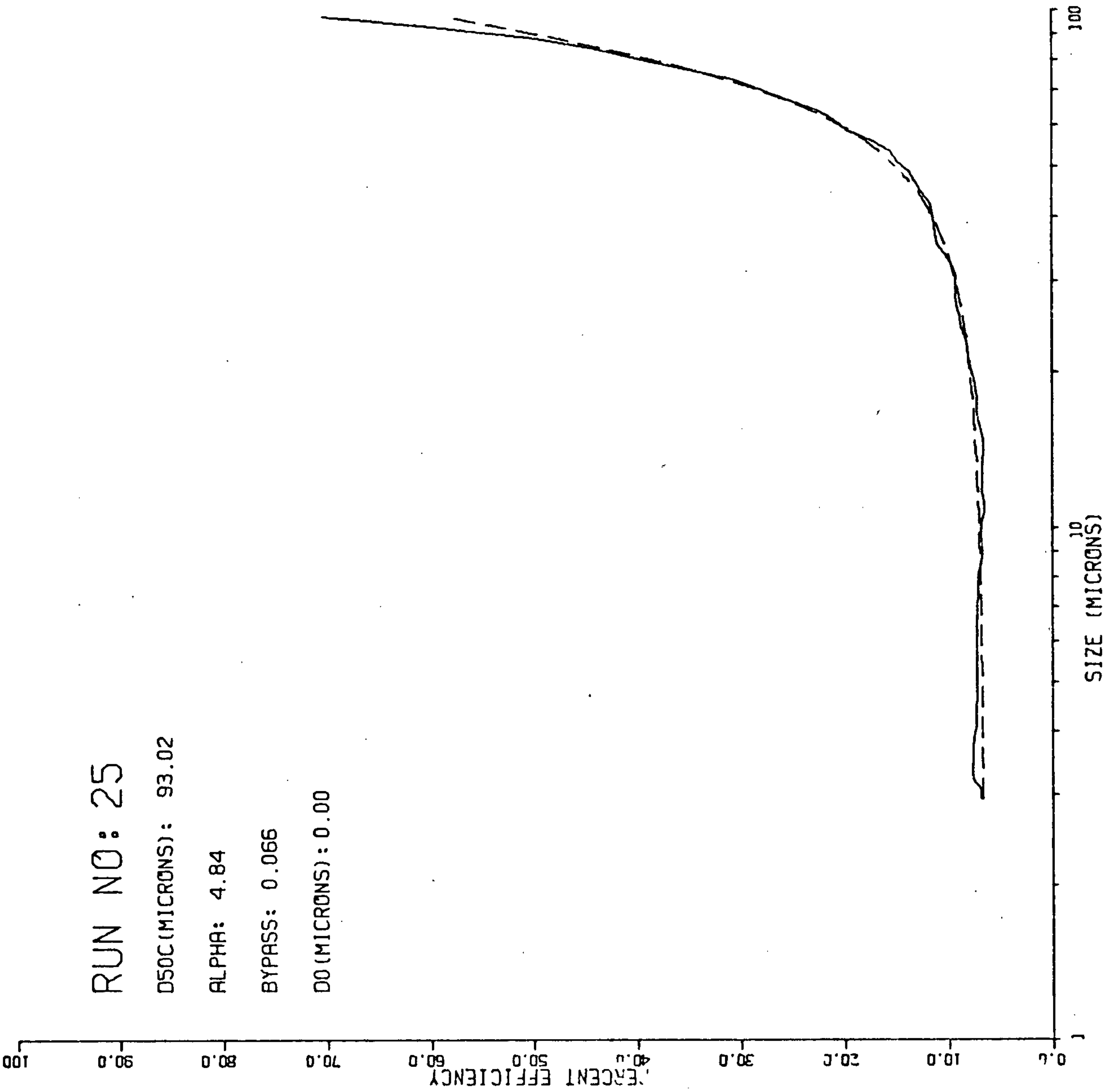

RUN NO: 19
D50C(MICRONS): 58.91
ALPHA: 6.03
BYPASS: 0.069
DO(MICRONS): 1.09
PERCENT EFFICIENCY
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
SIZE (MICRONS)
1
10
100

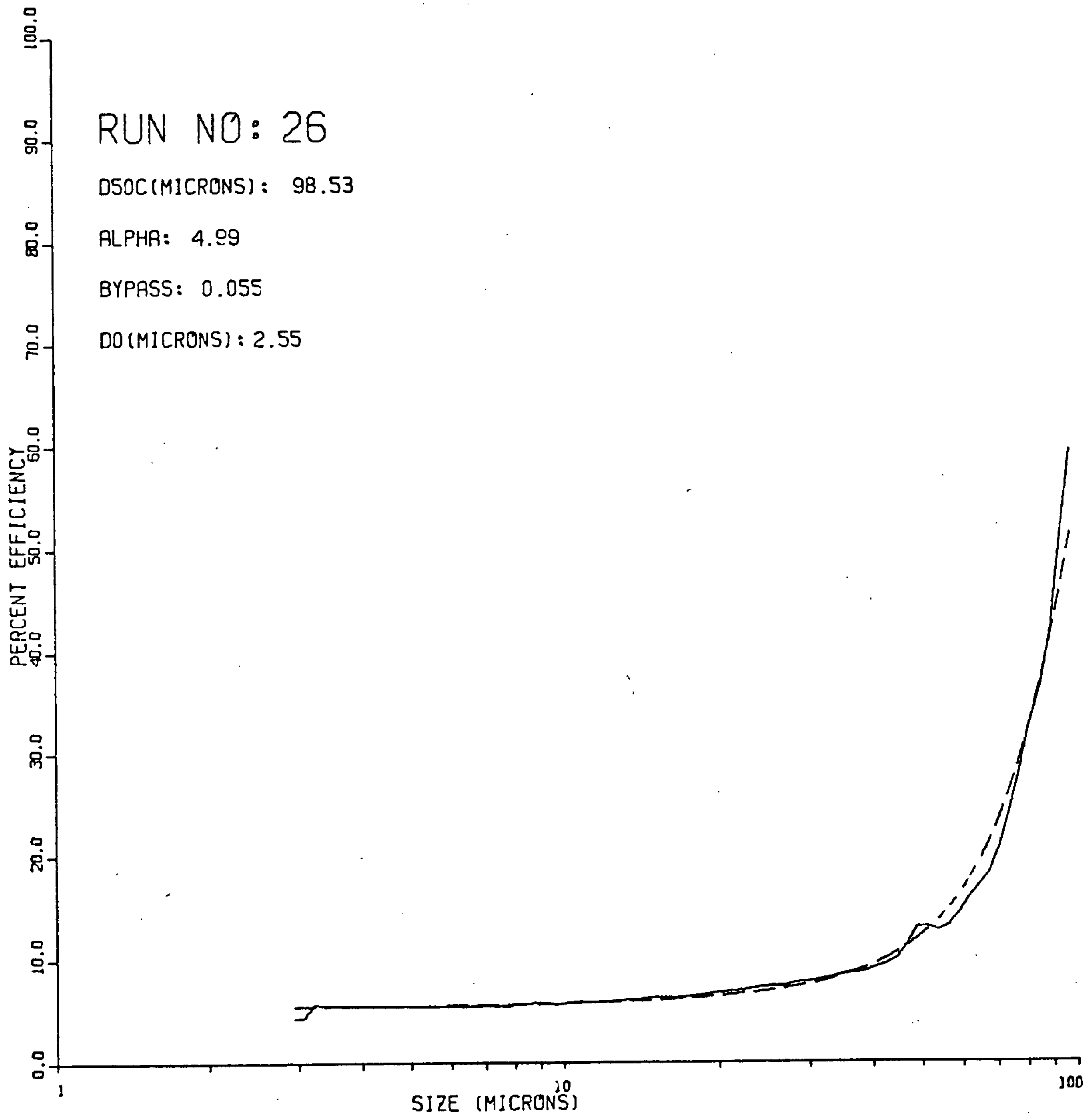

RUN NO: 21
D50C(MICRONS): 27.10
ALPHA: 5.30
BYPASS: 0.031
DO(MICRONS): 2.27
PERCENT EFFICIENCY
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
SIZE (MICRONS)
1
10
100


RUN NO: 22
D50C(MICRONS): 35.80
ALPHA: 7.37
BYPASS: 0.035
D0(MICRONS): 2.31
PERCENT EFFICIENCY
SIZE (MICRONS)
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
1
10
100

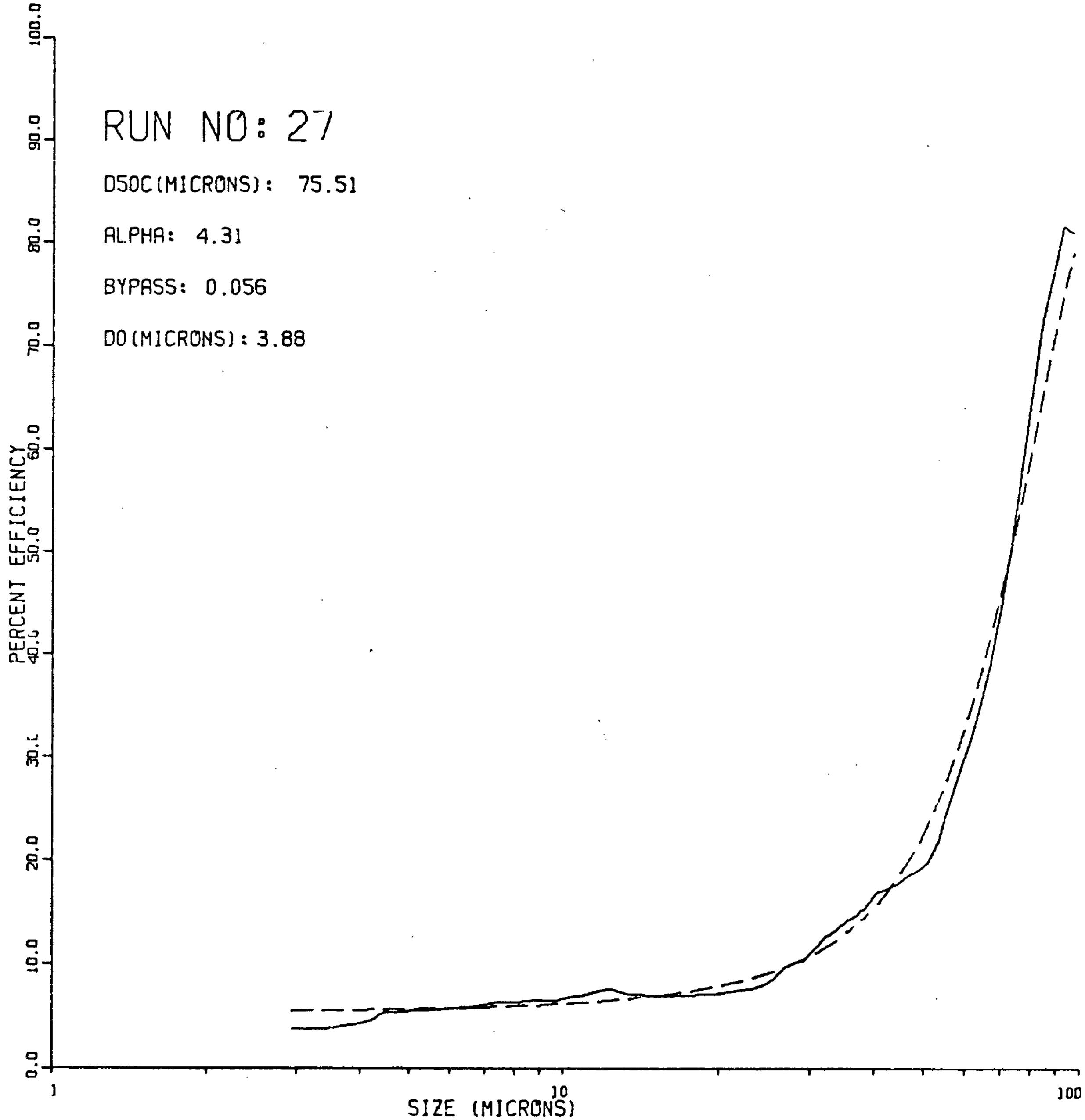

RUN NO: 23
D50C(MICRONS): 19.77
ALPHA: 4.65
BYPASS: 0.034
DO(MICRONS): 1.92
PERCENT EFFICIENCY
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
1
10
100
SIZE (MICRONS)

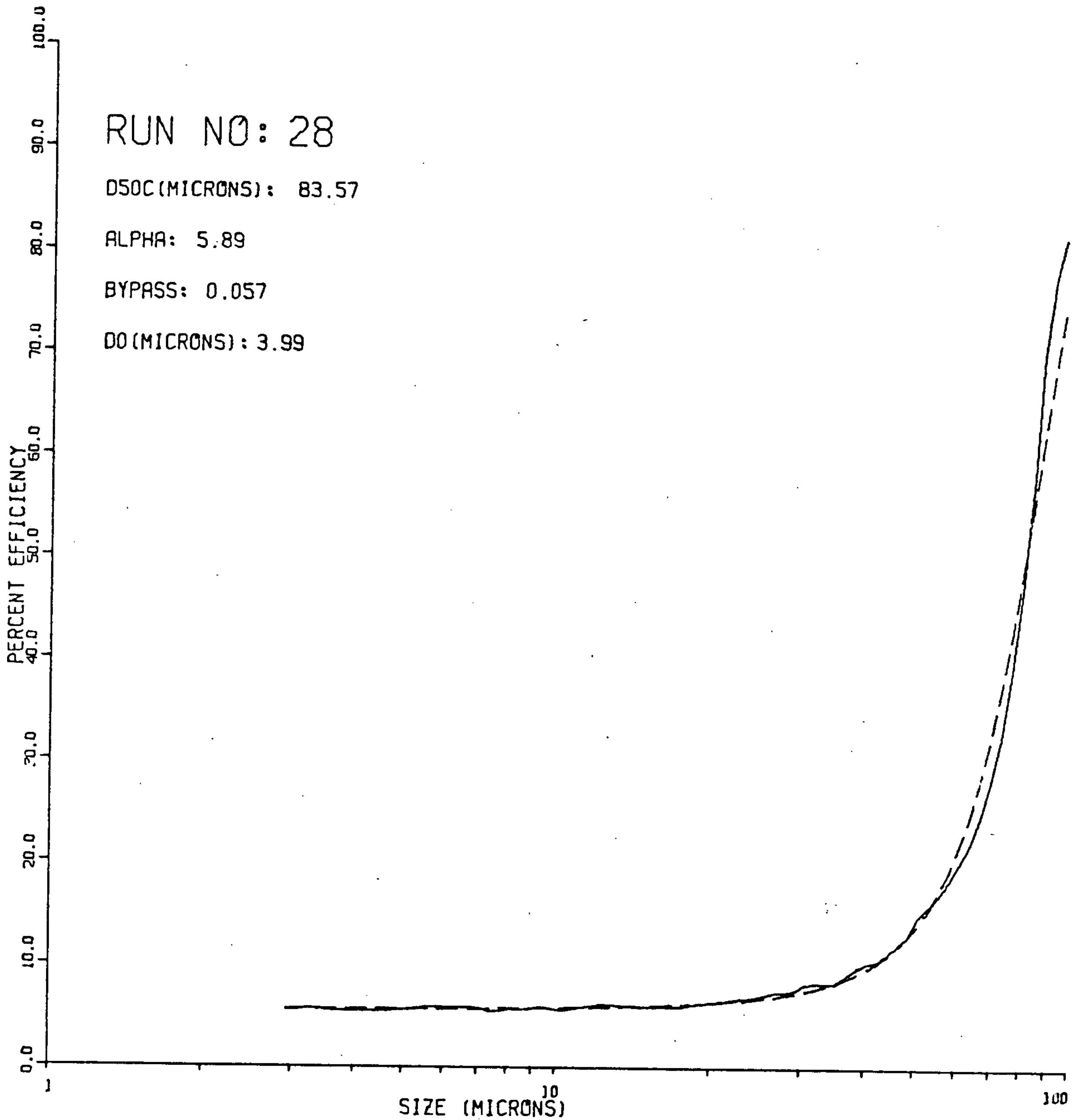

RUN NO: 24
D50C(MICRONS): 28.25
ALPHA: 7.19
BYPASS: 0.033
DO(MICRONS): 9.67
PERCENT EFFICIENCY
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
1
10
100
SIZE (MICRONS)

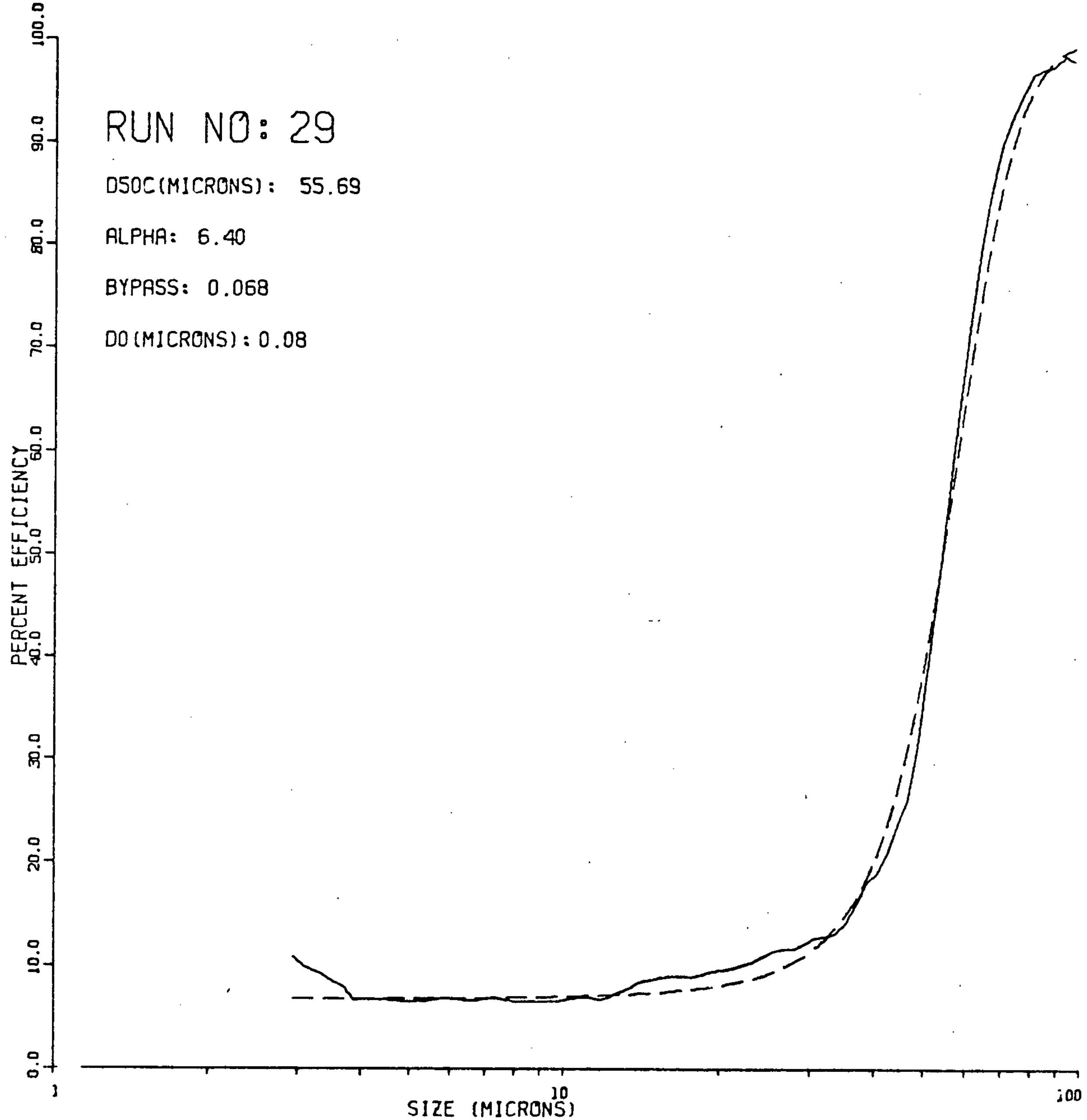

RUN NO: 25
D50C(MICRONS): 93.02
ALPHA: 4.84
BYPASS: 0.066
D0(MICRONS): 0.00
PERCENT EFFICIENCY
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
SIZE (MICRONS)
1
10
100

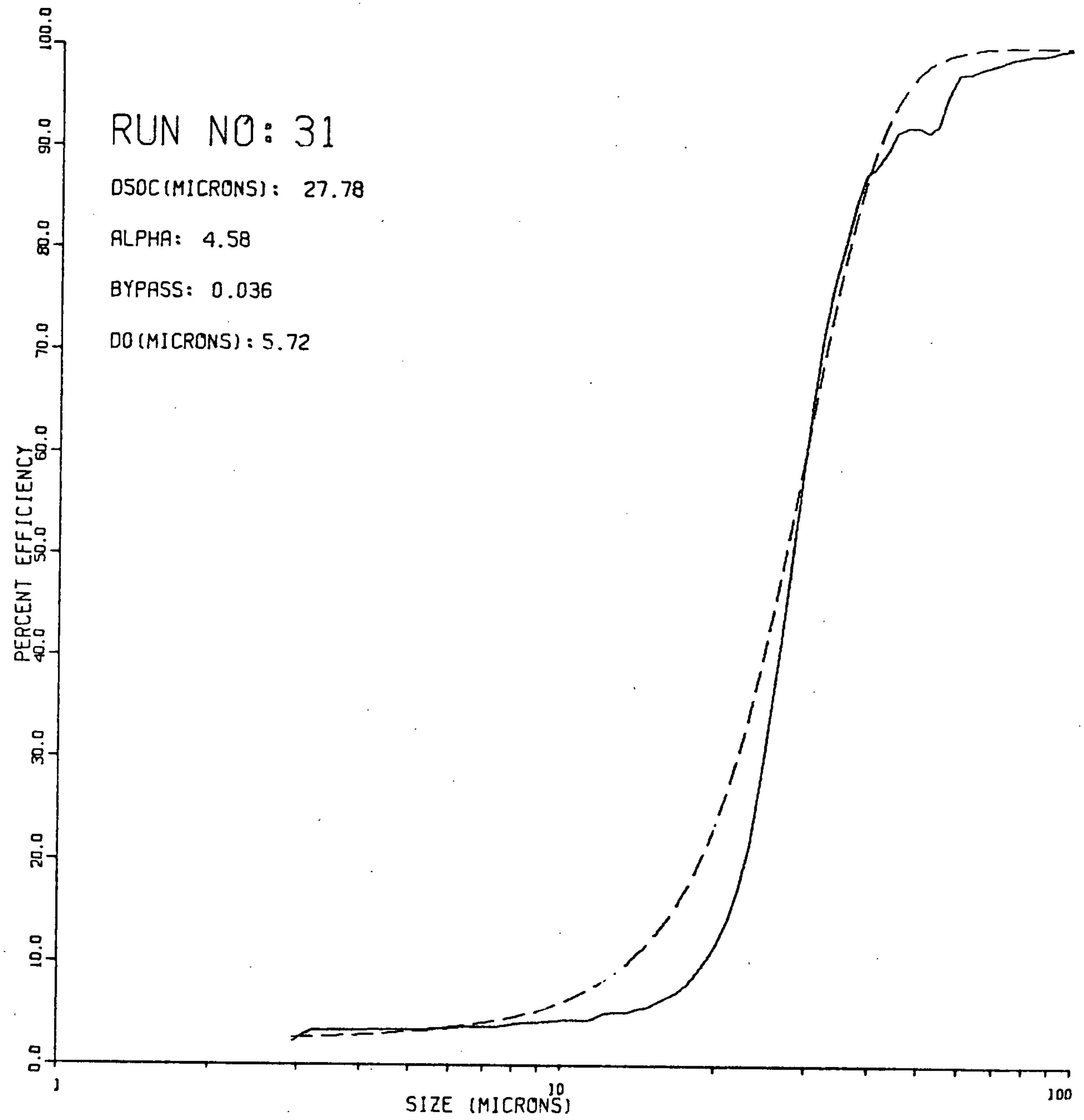


RUN NO: 26
D50C(MICRONS): 98.53
ALPHA: 4.99
BYPASS: 0.055
DO(MICRONS): 2.55
PERCENT EFFICIENCY
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
SIZE (MICRONS)
1
10
100

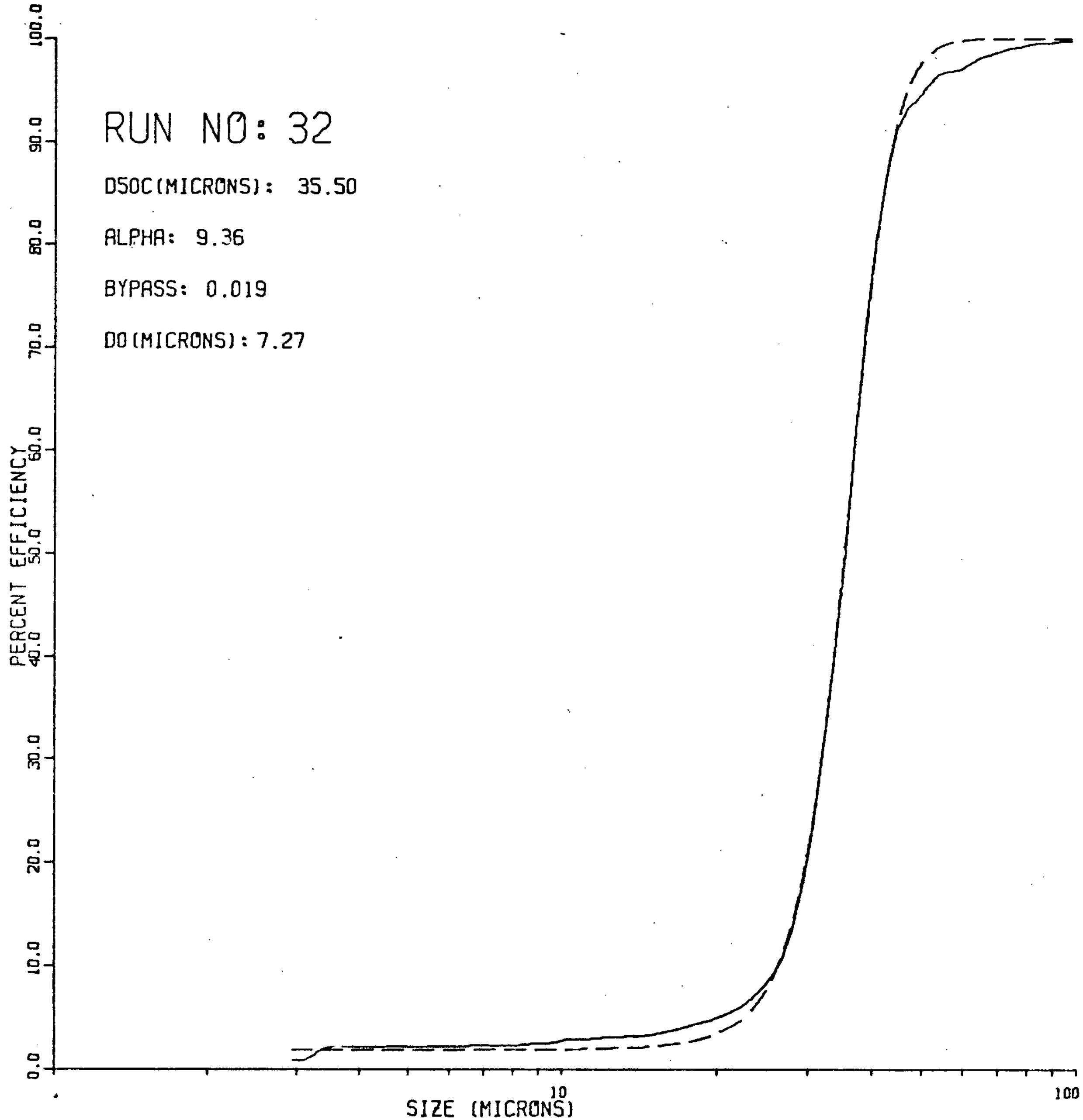

RUN NO: 27
D50C(MICRONS): 75.51
ALPHA: 4.31
BYPASS: 0.056
D0(MICRONS): 3.88
PERCENT EFFICIENCY
SIZE (MICRONS)
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
1
10
100

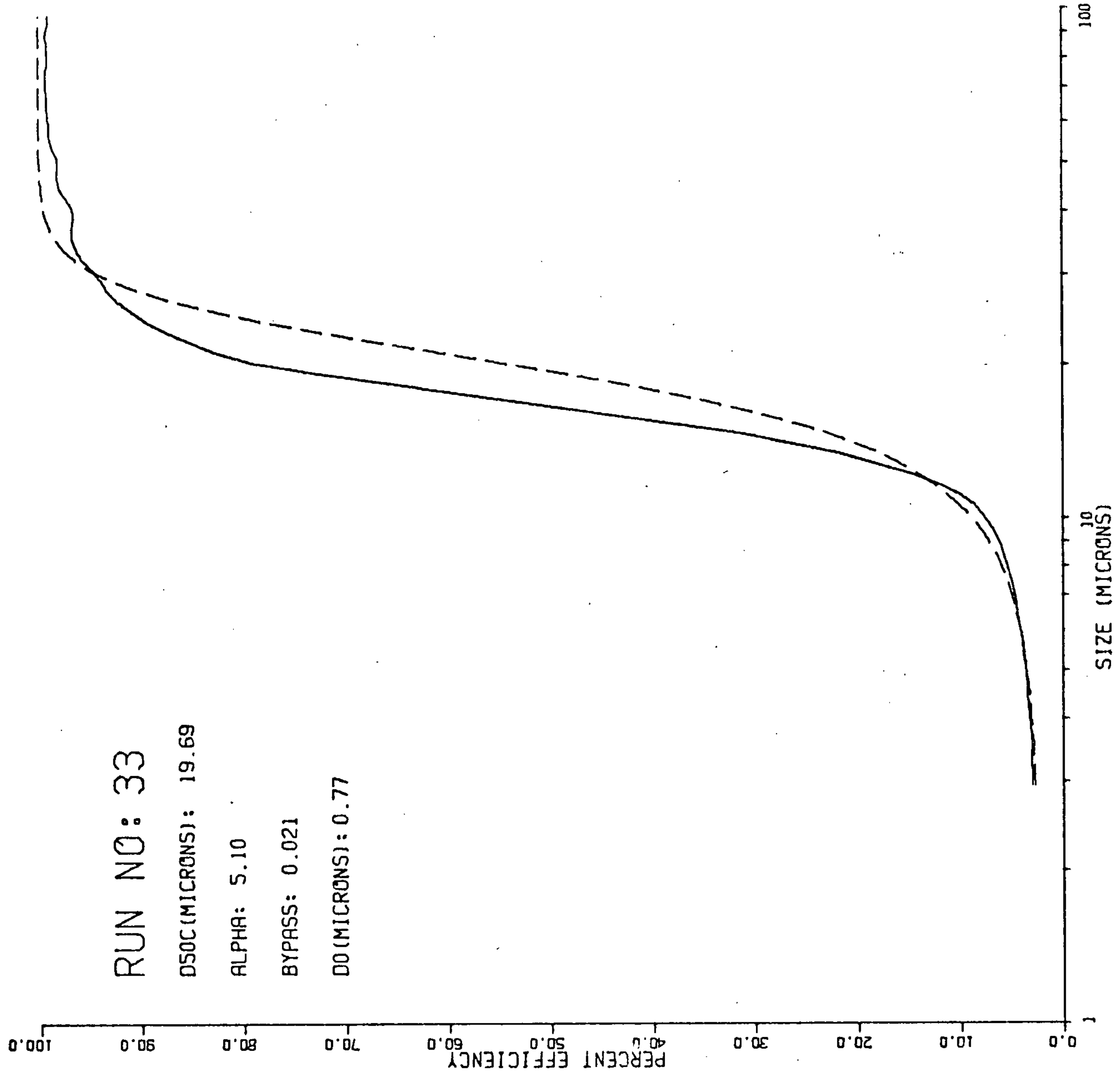

RUN NO: 28
D50C(MICRONS): 83.57
ALPHA: 5.89
BYPASS: 0.057
DO(MICRONS): 3.99
PERCENT EFFICIENCY
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
1
10
100
SIZE (MICRONS)

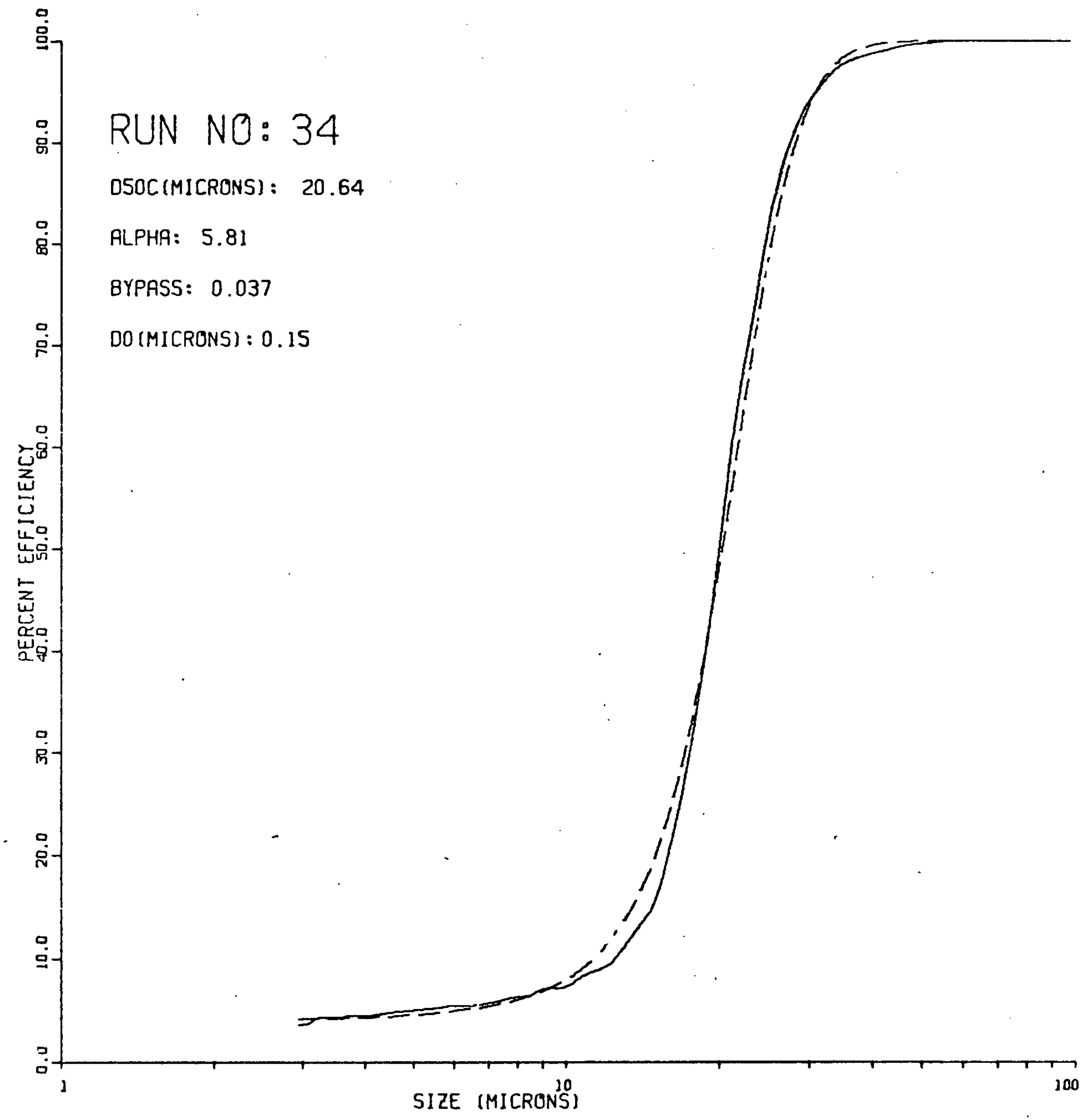

RUN NO: 29
D50C(MICRONS): 55.69
ALPHA: 6.40
BYPASS: 0.068
D0(MICRONS): 0.08
PERCENT EFFICIENCY
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
SIZE (MICRONS)
1
10
100

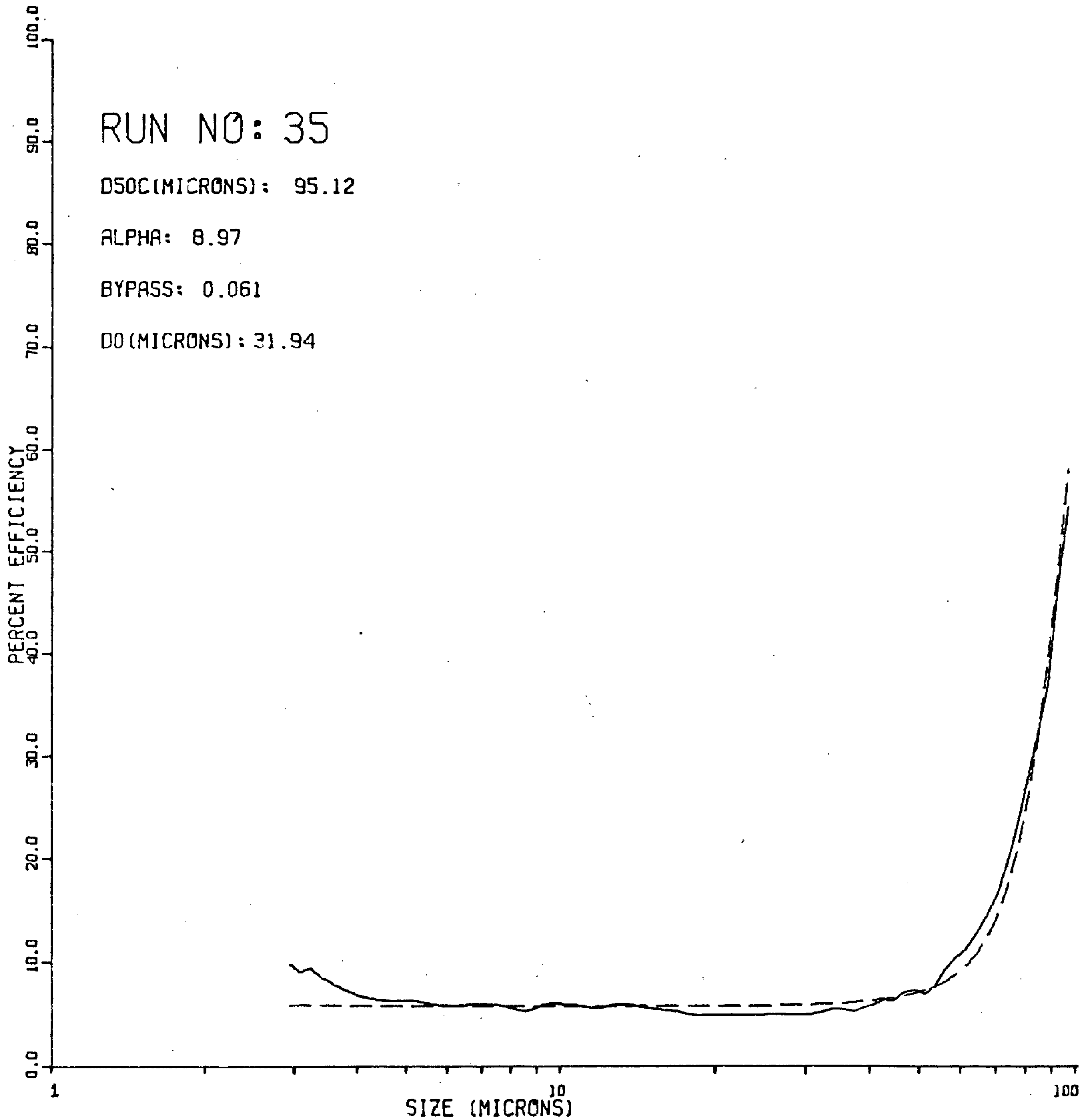


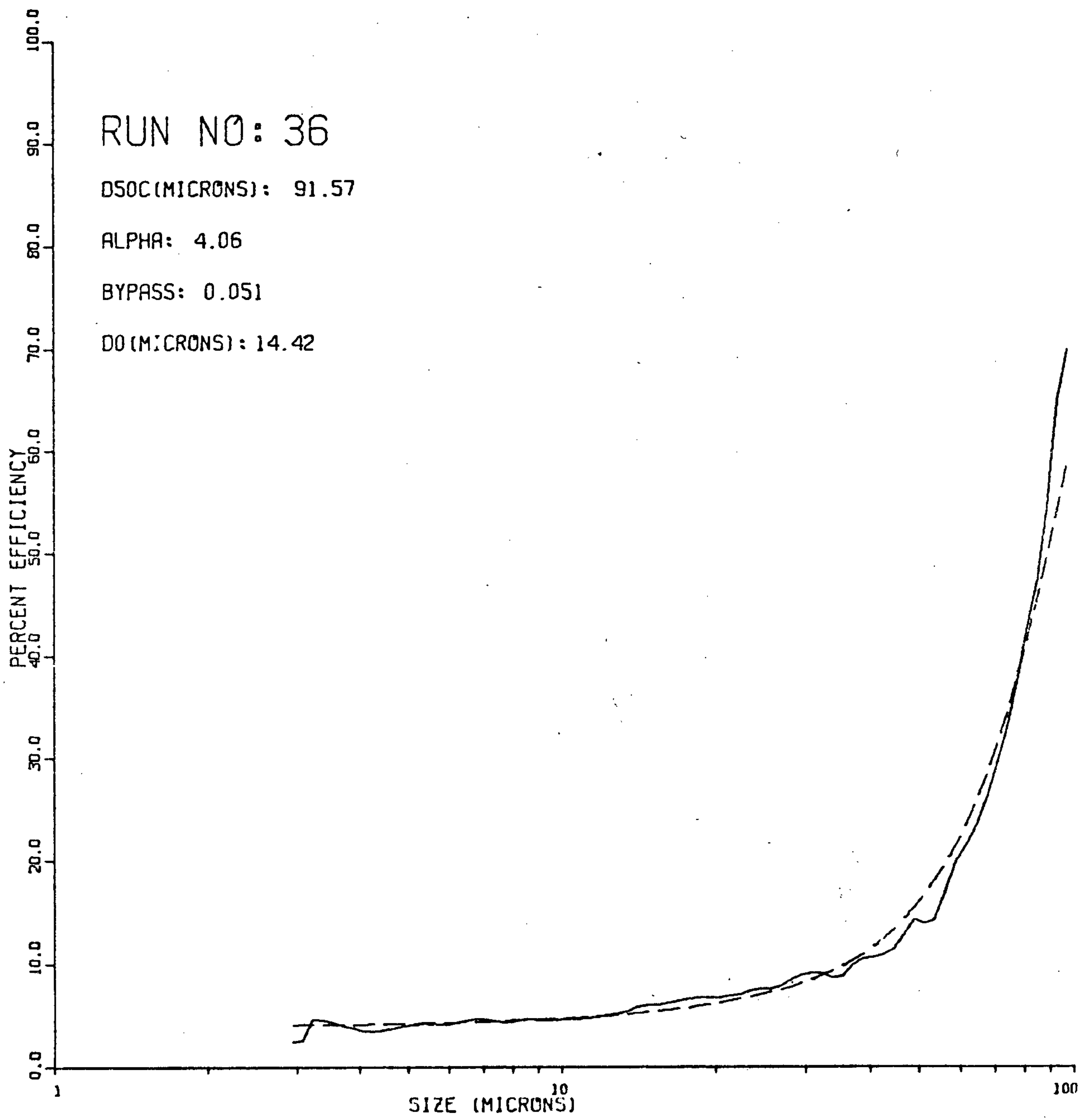
RUN NO: 31
D50C(MICRONS): 27.78
ALPHA: 4.58
BYPASS: 0.036
DO(MICRONS): 5.72
PERCENT EFFICIENCY
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
SIZE (MICRONS)
1
10
100

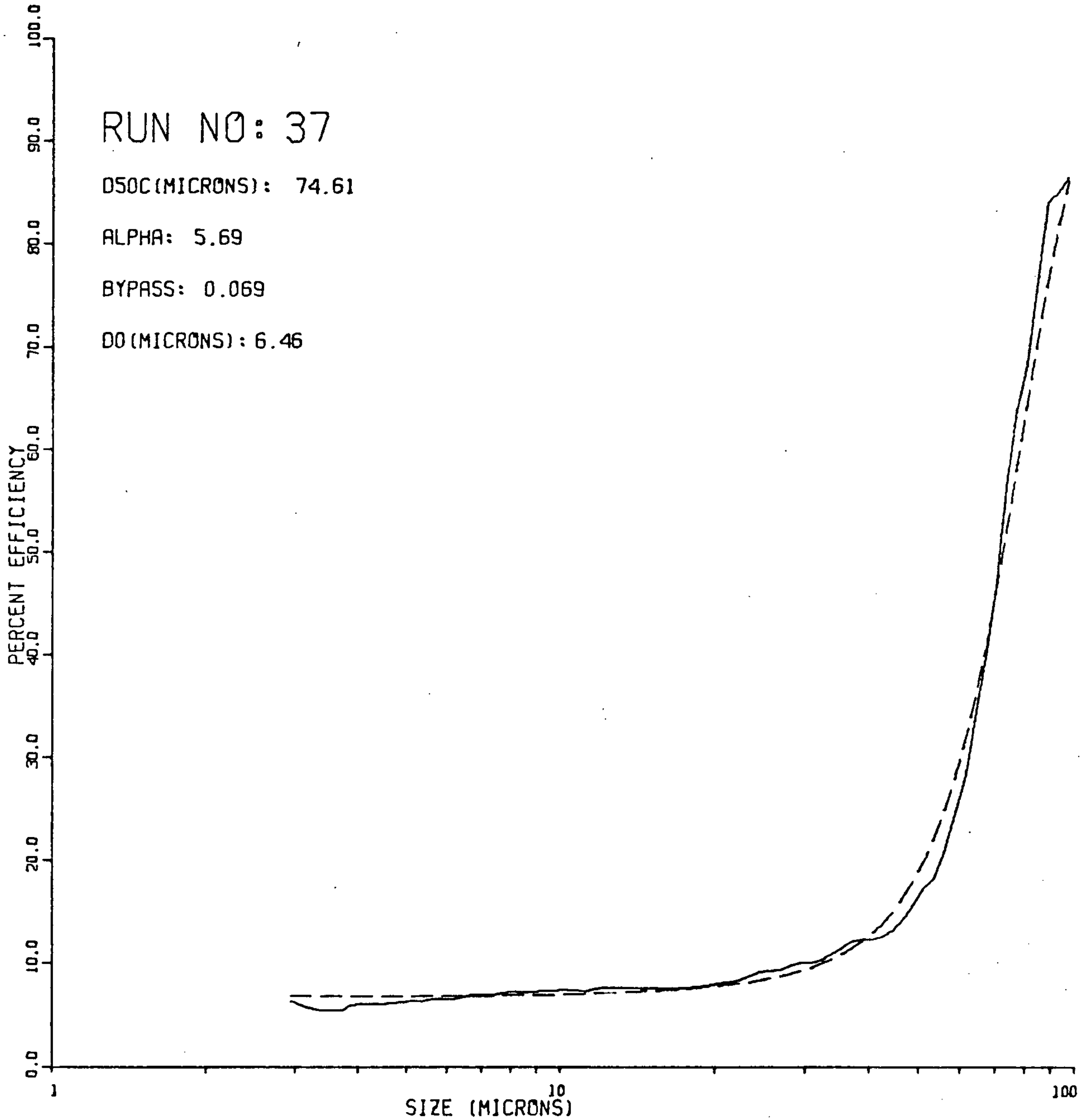

RUN NO: 32
D50C(MICRONS): 35.50
ALPHA: 9.36
BYPASS: 0.019
D0(MICRONS): 7.27
PERCENT EFFICIENCY
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
SIZE (MICRONS)
10
100

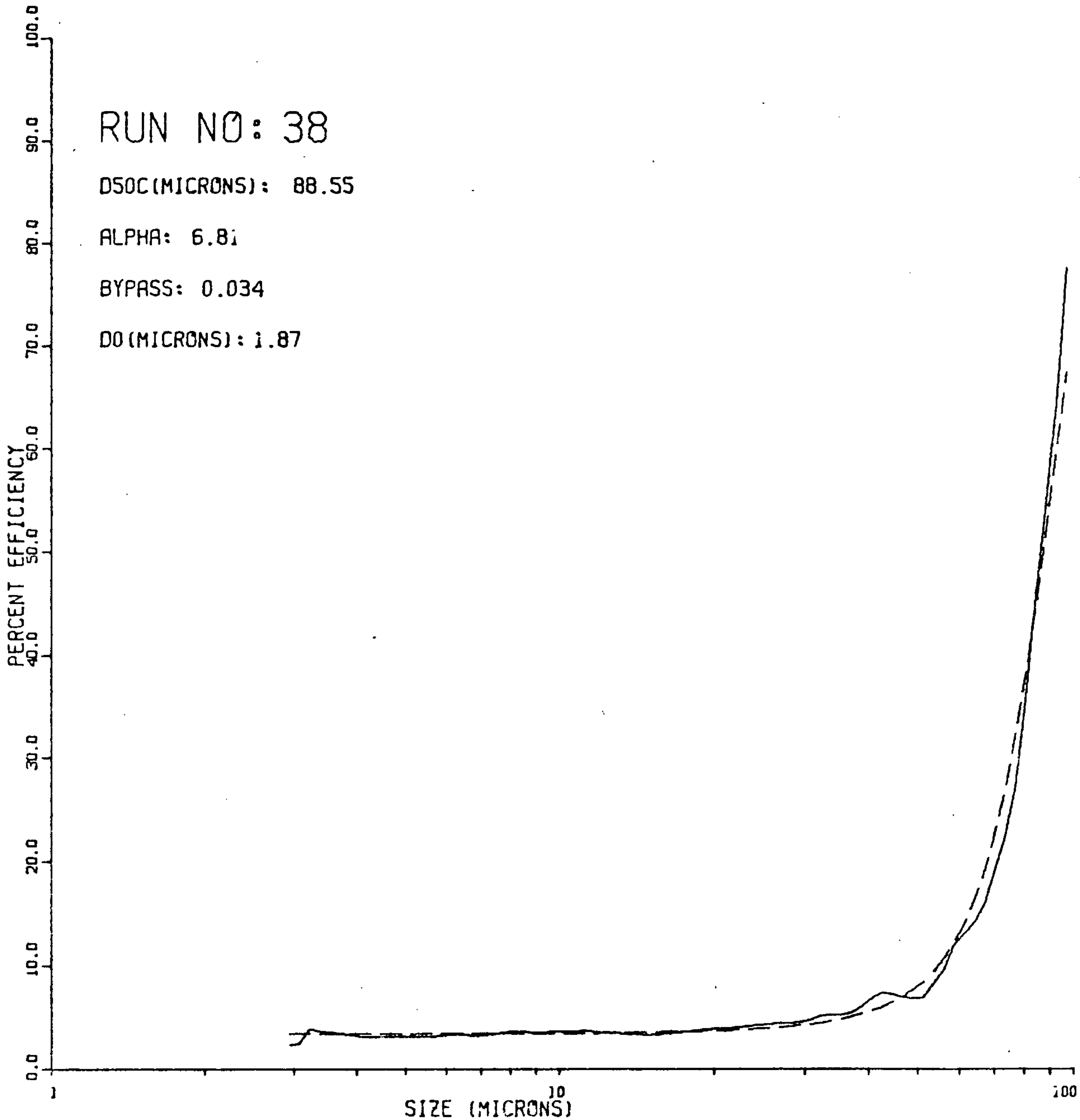

RUN NO: 33
D50C(MICRONS): 19.69
ALPHA: 5.10
BYPASS: 0.021
DO(MICRONS):0.77
SIZE (MICRONS)
1
10
100
PERCENT EFFICIENCY
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0

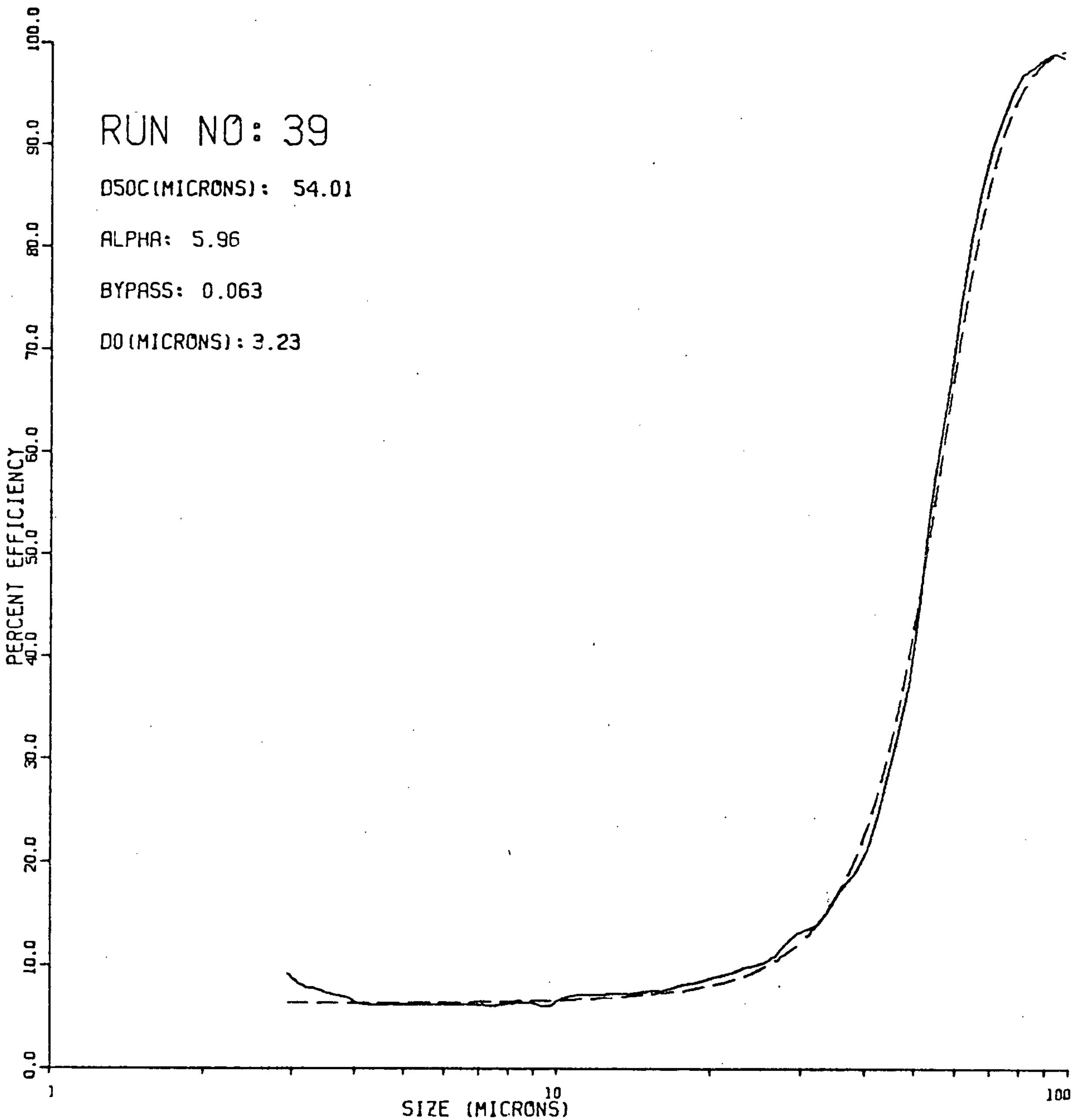

RUN NO: 34
D50C(MICRONS): 20.64
ALPHA: 5.81
BYPASS: 0.037
D0(MICRONS): 0.15
PERCENT EFFICIENCY
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
1
10
100
SIZE (MICRONS)

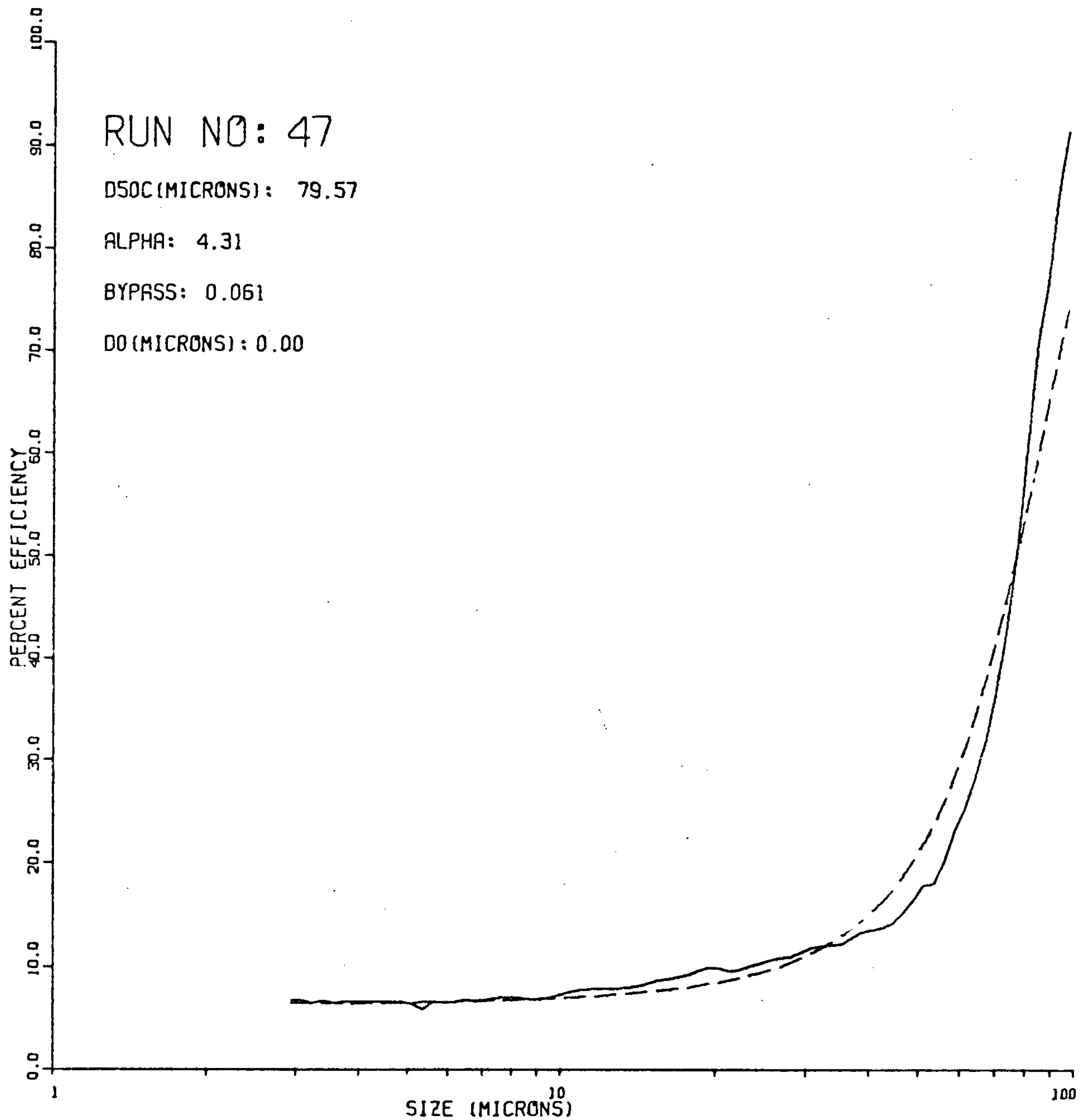

RUN NO: 35
D50C(MICRONS): 95.12
ALPHA: 8.97
BYPASS: 0.061
D0(MICRONS): 31.94
PERCENT EFFICIENCY
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
1
10
100
SIZE (MICRONS)


RUN NO: 36
D50C(MICRONS): 91.57
ALPHA: 4.06
BYPASS: 0.051
D0(MICRONS): 14.42
PERCENT EFFICIENCY
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
SIZE (MICRONS)
1
10
100

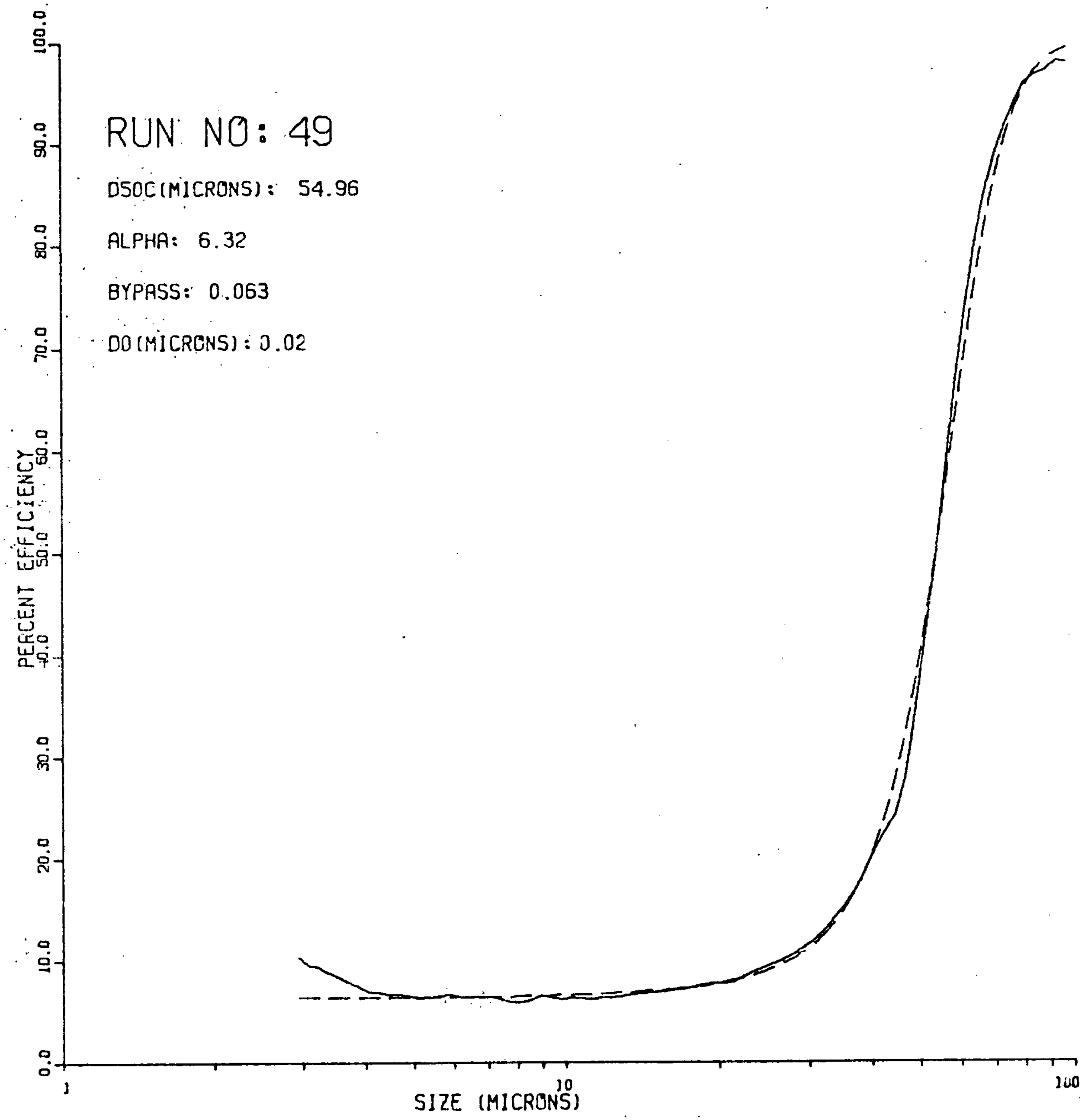

RUN NO: 37
D50C(MICRONS): 74.61
ALPHA: 5.69
BYPASS: 0.069
DO(MICRONS): 6.46
PERCENT EFFICIENCY
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
1
10
100
SIZE (MICRONS)


RUN NO: 38
D50C(MICRONS): 88.55
ALPHA: 6.81
BYPASS: 0.034
D0(MICRONS): 1.87
PERCENT EFFICIENCY
SIZE (MICRONS)
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
1
10
100


RUN NO: 39
D50C(MICRONS): 54.01
ALPHA: 5.96
BYPASS: 0.063
D0(MICRONS): 3.23
PERCENT EFFICIENCY
SIZE (MICRONS)
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
1
10
100



RUN NO: 47
D50C(MICRONS): 79.57
ALPHA: 4.31
BYPASS: 0.061
D0(MICRONS): 0.00
PERCENT EFFICIENCY
SIZE (MICRONS)
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
1
10
100


RUN NO: 49
D50C(MICRONS): 54.96
ALPHA: 6.32
BYPASS: 0.063
D0(MICRONS): 0.02
PERCENT EFFICIENCY
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
1
10
100
SIZE (MICRONS)