1/1/172 January 1976

THE SOUTH AUSTRALIAN DEPARTMENT OF MINES

Amdel Report.

No. 1093

IN SITU URANIUM LEACHING — LABORATORY TESTING

STAGE 1

by

J.A. Lackey and P.G. Moeskops

Literature Survey Amdel Rept - No. 988
ENV. 2403

Investigated by: Chemical Metallurgy and Mineralogy/Petrology Sections

Officers in Charge: CM J.E.A. Gooden
MP K.J. Henley

F.R. Hartley. Director

THE AUSTRALIAN MINERAL DEVELOPMENT LABORATORIES
Adelaide South Australia

CONTENTS

CONTENTS

SUMMARY

Background

Discussions were held at Amdel on 8 May 1975 between Messrs D. Brunt (Minad) and B. Robinson (SADM), and Messrs B. Timms, K. Henley, J. Gooden and P. Moeskops (Amdel) concerning proposed analytical, mineralogical and metallurgical work to be undertaken by Amdel on samples from diamond drillholes from the 'Honeymoon' uranium propsect held by Minad on Yeramba Station, 80 km north of Mingarie in the Frome Embayment.

Mr Brunt showed the group several plans and sections of the deposit which is of the 'roll-front' sedimentary type. The uraniferous horizon is about 4 to 5 m thick and lies 105 to 120 m beneath the surface; it was stated to consist largely of fluviatile sands, silts and gravels which are bonded by clay, humic material and fine-grained pyritic material and contained the uranium mineral (?)coffinite. Grades (based on gamma log data) range from 0.06% U_3O_8 to 1+% U_3O_8, averaging about 0.26% U_3O_8.

Objective

The object of this preliminary investigation was to determine the suitability of treating Minad's 'Honeymoon' deposit by *in situ* leaching.

Summary of Work Done

The following analytical and mineralogical work was carried out on core material from four drillholes (Nos 11AC, 45C, 50C and 190C):

(1) All samples were analysed for U, Th and radioactive equilibrium (about 25 to 35 samples from each drillhole).

(2) A moderate proportion of the U-bearing samples were analysed for Mo, Cu, Pb, V, Au, Zn and S.

(3) Five samples were analysed for a wide range of elements, using a semi-quantitative spectrographic technique.

(4) The petrographic and mineragraphic features of a range of rock types were determined and the uraniferous minerals were characterised using conventional autoradiograph, X-ray diffraction and electron-probe techniques.

(5) The sands were sized and the porosity measured on a selected number of samples.

In addition, a metallurgical investigation was carried out. This consisted of a number of agitation and percolation leaching experiments using both acid and alkaline reagents to dissolve the uranium.

Conclusions

Analytical and Mineralogical Study

1. The uranium analysis of the ore was consistently higher than the level predicted from laboratory gamma counting. As a first approximation, the predicted average ore grade of about 0.26% U_3O_8 may in fact be as high as 0.38% U_3O_8 (i.e., uranium in the deposit is enriched with respect to its daughter-products).

2. Petrographic data indicate that the uraniferous unit is composed largely of light to dark grey clay-rich sands which are locally pebbly and/or gravelly. The sands consist mainly of poorly-sorted angular to sub-rounded quartz clasts and elongate to sheaf-like muscovite flakes in a clay-rich opaque-bearing matrix.

3. Present in accessory to trace amounts are clasts of staurolite, andalusite, sillimanite and tourmaline and in minor traces are sphene, monazite and apatite. The opaques consist largely of pyrite, marcasite, goethite and humic material.

4. The matrix 'clay' is kaolinite, while uranium is present as the mineral coffinite which typically occurs as 3 to 8 μm sized grains in the clayey matrix.

5. Spectrographic scans do not indicate the presence of any unexpected or deleterious elements in the uraniferous unit.

6. Within the uraniferous unit, U_3O_8 values range up to 1.8%, Th values are low (mainly <20 ppm), S values (mainly due to pyrite) are generally high (1 to 5%), Zn values are generally high (up to 1%), Cu values are locally high, especially in Hole 190C, Mo, Pb and V values are very low (<20 ppm) and Au is effectively absent (<0.1 ppm).

7. On the basis of sizing data, sands of the uraniferous zone are extremely poorly sorted and clay-rich.

Metallurgical Study

1. Preliminary agitation leaching experiments with low- and high-grade

composites from Hole 45C showed that:

(a) Acid leaching of the low-grade composite gave erratic results, probably due to adsorption of uranium on clay or carbonaceous material. However, a substantial proportion of the uranium appears to be leached from the ore.

(b) Acid leaching at low pH (<1.0) resulted in substantial gangue attack.

(c) Acid leaching of high-grade composite at pH 1.75 to 2.0 gave satisfactory extraction rates without excessive acid consumption.

(d) Alkaline leaching of the composites was much slower than acid leaching. However, after 7 days, extraction efficiencies approached those of 12-hour acid leaching.

2. Agitation leaching of composite samples from Holes 11AC, 50C and 190C at pH 1.75 showed a range of extraction efficiencies (some better than composites from Hole 45C and some not as good). Both acid and oxidant consumptions were acceptably low.

3. Acid percolation leaching experiments on high- and low-grade composites from Hole 45C showed considerable promise, with 60 to 80% of the uranium being extracted in 14 days. Acid consumptions were extremely low. There was no evidence of reprecipitation.

4. Alkaline percolation leaching experiments gave results very similar to the acid percolation leaching tests. Uranium appeared to be extracted at approximately the same rates as in acid leaching, and after 27 days 69 to 77% of the uranium was extracted.

5. At this stage, acid and alkaline leaching look equally attractive and it has not been possible to choose between them.

6. Comparison of Minad's Honeymoon deposit with commercial solution mining operations has indicated that orebody grades, operating depths and formation types appear to be similar. Also, both acid and alkaline leaching reagents have been used commercially. There is no factor to indicate that solution mining would not be an applicable treatment method for the Honeymoon deposit.

Recommendations

Further Laboratory Development. The leaching investigation on Minad's Honeymoon deposit has been particularly encouraging and further examination of the following unresolved aspects is recommended:

(1) Comparative economics of *in situ* leaching operations.

(2) Best reagent (acid or alkali). In Section 5.3, some of the disadvantages of each leaching reagent are discussed and some of these aspects need investigation to determine which reagent is to be recommended.

(3) Optimum alkali strength. Because of the possible loss of alkaline reagent from the solution on passing through the ore, it may be economically important to have low alkali strength. Hence it will be necessary to investigate the effect of alkali strength on the leaching efficiency of uranium.

(4) Applicability of alternative alkaline reagents; e.g., ammonium carbonate/bicarbonate. As mentioned in Section 5.1, a number of proposed solution mining operations in the United States intend to use ammonium carbonate instead of sodium carbonate as the leaching reagent. It is generally considered that ammonium carbonate is an equally suitable reagent for uranium. However, this aspect needs checking.

(5) Applicability of percolation results to other samples (e.g., Hole Nos 11AC, 50C and 190C). All percolation tests have been carried out on composites from Hole 45C. It will be of value to carry out a modest number of experiments on ore from the other holes.

Examination of the economics of solution mining is the next logical step in this work programme. This would be aimed at indicating the type and size of operation required to be economically feasible.

Field Studies. In addition, knowledge of ground-water flow through the ore-body would help in assessing the pattern of inflow and outflow wells required for a solution mining operation, and a study of this aspect is recommended.

1. INTRODUCTION

Discussions were held at Amdel on 8 May 1975 between Messrs D. Brunt (Minad) and B. Robinson (SADM), and Messrs B. Timms, K. Henley, J. Gooden and P. Moeskops (Amdel) concerning proposed analytical, mineralogical and metallurgical work to be undertaken by Amdel on samples from diamond drill-holes from the 'Honeymoon' uranium prospect held by Minad on Yeramba Station, 80 km north of Mingarie in the Frome Embayment.

Mr Brunt showed the group several plans and sections of the deposit which is of the 'roll-front' sedimentary type. The uraniferous horizon is about 4 to 5 m thick and lies 105 to 120 m beneath the surface; it was stated to consist largely of fluviatile sands silts and gravels which are bonded by clay, humic material and fine-grained pyritic material and contained the uranium mineral (?)coffinite. Grades (based on gamma log data) range from 0.06% U_3O_8 to 1+% U_3O_8, averaging about 0.26% U_3O_8.

It had been decided that, to enhance recovery, 7.6-cm dia. cores would be collected; furthermore, because of the probable friable nature of the material and its susceptibility to surface oxidation (due to contained pyrite), cores were to be sealed in split polythene pipes covered by polythene sheaths. Drilling was to commence on 19 May 1975; four to six holes were proposed, depending upon core recoveries, each taking about 3 to 5 days to complete. Amdel were to be provided with (1) the cores of the mineralised horizon and its immediate environs, (2) the geological drill logs, and (3) the standard down-hole gamma, resistivity and S.P. charts.

It was decided that Amdel would undertake the following work using quartered core samples (depending upon recoveries) covering 0.3 to 0.5 m intervals:

(i) Analyse all samples for U, Th and radioactive equilibrium (about 25 to 35 samples from each drillhole).

(ii) Analyse a moderate proportion of the U-bearing samples for Mo, Cu, Pb, V, Au, Zn and S.

(iii) Analyse five samples, covering a range of U_3O_8 grades for a wide range of elements, using a semi-quantitative spectrographic technique.

(iv) Determine the petrographic and mineragraphic features of a range of rock types and characterise the uraniferous mineral(s) using conventional autoradiograph X-ray diffraction and electron-probe techniques; identify the components of certain very-fine-grained silty-argillaceous rocks by X-ray diffraction.

(v) Carry out sieve analysis down to a particle size of 300 mesh BSS (0.053 mm) and determine the porosities and if possible the permeabilities of a range of samples from the mineralised zone and its environs.

On the basis of this work, samples were to be selected for leaching tests which were to consist of (a) preliminary agitation leaching on ground ore (to provide a quick determination of ultimate uranium extractions and optimum conditions) followed by (b) percolation leaching on coarser samples. Both sulphuric acid and sodium carbonate were to be used as leachants for the uranium.

During the latter part of May and early June 1975 four holes were drilled by the SADM and the cores, with relevant data, were delivered to Amdel upon completion of each hole. Two additional holes originally proposed were not drilled, as core recovery within the uraniferous unit turned out to be very poor.

2. MATERIALS EXAMINED

Drill-core from the four holes (11AC, 45C, 50C and 190C) was used in this study and cores were recovered over the following depths:

Hole No.	Drill Run m
11AC	101 – 123
45C	110 – 122
50C	88 – 107
190C	97 – 118

Drillcore from each hole was subdivided into 25 to 35 samples, on which analytical, mineralogical and metallurgical work was carried out.

3. ANALYTICAL AND MINERALOGICAL STUDIES

The analytical and mineralogical programmes described in the Introduction were carried out on the core material from each of the four holes. Appendix A details:

(1) Sampling numbers and positions.

(2) Porosity and analytical data.

(3) Additional work on chosen samples.

Petrographic-mineragraphic, X-ray diffraction and electron-probe data are listed in Appendix B. Spectrographic scan and sieve analysis data are listed in Appendixes C and D respectively. Permeability measurements were not made, as the material was too friable to be cored.

3.1 Discussion and Conclusions Concerning Radioactive Equilibrium

Examination of laboratory data indicated that true U_3O_8 values (determined by XRF) appeared to be consistently higher than those predicted by laboratory gamma counting. Data from samples containing 200+ ppm U (57 in all) were used to calculate the linear regression equation:

$$A = \frac{B-393}{0.582},$$

where A = Actual ppm U present, determined by X-ray fluorescence, and

B = Total gamma radioactivity expressed as ppm U, assuming no Th or K present and radiochemical equilibrium of the uranium.

The correlation coefficient for the above-determined linear regression equation is very high (0.954) and is significant at the 1% confidence level. The equation refers, of course, to laboratory data, and in order to improve the actual ore reserves a more precise equation would need to be determined which would relate down-hole radiometric data to XRF-determined U_3O_8 values (corrected for the presence of Th). As a first approximation, however, the predicted average ore-grade of about 0.26% U_3O_8 may, in fact, be as high as 0.38% U_3O_8 (i.e., overall, uranium in the deposit is enriched with respect to its daughter products).

3.2 Conclusions Concerning Other Data

(1) Petrographic data (Appendix B) indicate that the uraniferous unit is composed largely of light- to dark-grey clay-rich

sands which are locally pebbly and/or gravelly. The sands consist mainly of poorly sorted angular to sub-rounded quartz clasts and elongate to sheaf-like muscovite flakes in a clay-rich, opaque-bearing matrix. Clasts of staurolite, andalusite, sillimanite and tourmaline are present in accessory to trace amounts, and minor traces of sphene, monazite, apatite and other heavy mineral grains are also present. The opaques consist largely of pyrite, marcasite, goethite and humic material; however, chalcopyrite is present locally. The sands appear to be fluviatile in origin and were probably derived by brief transport from metamorphic rocks of the nearby Flinders Ranges.

(2) X-ray diffraction and electron-probe data indicate:

(a) The matrix 'clay' is kaolinite.

(b) Uranium is present in the mineral coffinite $U(SiO_4)_{1-x}(OH)_{4x}$, which typically occurs as 3 to 8 μm sized grains in the clayey matrix.

(3) Spectrographic scan data do not indicate the presence of any unexpected elements in the uraniferous unit.

(4) Analytical data indicate that within the uraniferous unit:

(a) U values range up to 1.5%; however, Th values are low (mainly <20 ppm),

(b) S values (mainly due to pyrite) are generally high (1 to 5%) and locally very high (>10%),

(c) Zn values are generally high (up to 1%) but are very low in samples from Hole SE 50C,

(d) Cu values are locally high, especially in Hole 190C,

(e) Mo, Pb and V values are very low (≤20 ppm), and

(f) Au is effectively absent (<0.1 ppm).

(5) Sizing data indicate that the sands of the uraniferous zone are (a) extremely poorly sorted and (b) clay-rich.

4. METALLURGICAL STUDY

4.1 Preliminary Agitation Leaching Experiments

4.1.1 Material Preparation

In the preliminary leaching experiments, drill-core material from only Hole 45 was used. A quarter of the core was removed and crushed to minus 1.7 mm for analytical purposes. A considerable amount of these samples remained following analysis and this material was used in the leaching experiments. Only samples analysing greater than 500 ppm U were used for the making up of two composites — Composite A of low grade (samples >500 ppm and <2000 ppm), and Composite B of high grade (samples >2000 ppm).

From Hole 45, Samples 2 to 13 were used in these two composites. Table 1 describes the samples — their location in the hole, weight and uranium analysis. Tables 2 and 3 describe the composites.

4.1.2 Leaching Tests

Two series of agitation leaching experiments were carried out on the low- and high-grade ore composites. These were to establish a suitable leaching reagent (i.e., sulphuric acid or sodium carbonate), acid leaching characteristics (leachant strength, leaching efficiency and rate) and leachant consumption. Because of the limited amount of material available, it was considered important to conduct experiments with a minimum quantity of ore.

First Series. Six sulphuric acid leaching experiments were carried out (three on each composite) with different levels of controlled free acidity (pH 1 to 2). Because the main uranium ore mineral was coffinite $\{U(SiO_4)_{1-x}(OH)_{4x}\}$, with the uranium mainly in the quadrivalent state, it was necessary to add an oxidant. Head samples were taken of the two composites, which analysed 650 and 6625 ppm U_3O_8 for Composites A and B respectively. From Tables 2 and 3 it can be seen that the calculated analyses from the individual samples were higher.

In each experiment, about 75 g of minus 1.7 mm ore was slurried with an equal amount by weight of distilled water in a beaker with an anchor-type laboratory stirrer. Sulphuric acid was added to keep the pH at the controlled level (either pH 1.0, 1.5 or 2.0) over the duration of the run (12 hours). Oxidant (sodium chlorate) was added to maintain the redox at greater than minus 400 mV (measured by a platinum-calomel electrode). Samples of the slurry were taken at 3 and 6 hours after the commencement of the run (for analysis of residual uranium in the solids) and, on completion of the run, final leached residue was recovered. The solid samples were washed thoroughly first with acidified water before washing with distilled water, to ensure that soluble uranium in liquor adhering to the solids was not precipitated during washing.

The operating conditions and results of these experiments are detailed in Table 4. The uranium in the ore appears to be readily leached over the controlled pH range studied (i.e., pH 1.0 to 2.0). The uranium residue analyses and extraction efficiencies of the controlled acid leaching experiments for Composite A (Tests 1 to 3) show considerable uranium extraction but an unusual decrease in uranium extraction with time. This appears to indicate rapid leaching and slower loss from solution by some means (e.g., reprecipitation or adsorption of the uranium by clay minerals present in the ore) but may be due to non-representative samples taken during leaching or low analytical sensitivity at the concentration levels encountered. Some of these experiments are duplicated in the next series to check on the reproducibility of unusual results.

The results of leaching the high-grade Composite B (Tests 4 to 6) were in accordance with the normal trend expected in leaching experiments. The extraction efficiency as a function of time is plotted in Fig. 1 for the three levels of acidity (pH 1, 1.5 and 2.0). This shows that good extraction of uranium is achieved over the pH range studied (82 to 96% after 12 hours). While the rate of extraction is faster at pH 1 than 1.5 or 2.0, the overall extraction efficiency after 12 hours was the same at both pH 1.0 and pH 1.5 (96%) and it would appear that extraction at pH 2.0 would eventually approach the 96% figure achieved at stronger acid levels.

Acid-consumption rates during leaching are detailed in Table 4; these indicate that significant gangue attack occurs at the lowest pH levels (1.0) for both low- and high-grade composites (500 to 600 kg H_2SO_4/tonne ore). However, acid consumption is lower at pH 2.0 (50 to 100 times less than at pH 1.0) with intermediate consumption at pH 1.5. It can be stated that acid consumption is quite unacceptable at pH 1, very acceptable at pH 2 (for acid at $60 per tonne, this consumption amounts to $0.07 per kg of U_3O_8 extracted), and intermediate at pH 1.5. Since the extraction rate at pH 2 on the high-grade composite is relatively slow, it is of interest to obtain extraction and acid consumption rates at pH 1.75.

The major gangue minerals present in the ore are quartz and kaolinite. Quartz is not readily attacked by acid but kaolinite may be attacked under relatively strong acid conditions. This would explain the high acid consumption at pH 1.0.

Second Series. Seven leaching experiments were carried out to:

(a) Check erratic extraction efficiencies on the low-grade composite (A) at the higher pHs of 1.5 and 2.0 (Tests 7 to 10).

(b) Measure extraction and acid consumption rates at pH 1.75 on the high-grade composite (B).

(c) Examine alkaline leaching on both low- and high-grade composites.

Since non-representative sampling was one possible explanation of the erratic extraction data, the ore samples for this series of experiments were ground to 100% minus 63 μm to ensure better dispersion of the slurry during agitation leaching.

In Runs 7 and 8 the pH was controlled at 1.5 while Experiments 9 and 10 were controlled at pH 2.0. Runs 7 and 9 were continued for six hours, whereas Runs 8 and 10 lasted 12 hours. No samples were taken during the experiments, only the final leach residues being collected; in this way representative residue samples were ensured. The basic procedure used in these experiments was similar to that described for the first series of leaching runs.

Experiment 11 was carried out on Composite B at pH 1.75. For this run, the same procedure was followed as for the first series of leaching experiments.

An alkaline leachant was used in Runs 12 and 13 (Composites A and B respectively). The solution used in these experiments contained 80 g/l Na_2CO_3 and 20 g/l $NaHCO_3$ and was added to the solids to make a slurry of 20% solids by weight. Sodium chlorate was added as an oxidant at the rate of 6.25 kg/tonne ore. These agitation leaching experiments were continued for seven days with a slurry sample being removed after three days.

The results of Leaching Runs 7 to 11 are reported in Table 5, while Experiments 12 and 13 are reported in Table 6. The measured uranium concentrations in the head samples for this series of experiments were about 20% higher than the previous series (see Table 4) but closer to the calculated heads (see Tables 2 and 3). This suggests some sampling inaccuracy.

From Table 5, the uranium extraction efficiency of the low-grade composite (A) still showed uranium extraction decreasing with time at pH 1.5 (86% after 6 h and 46% after 12 h: Tests 7 and 8) but normal behaviour at pH 2.0 (83% after 6 h and 92% after 12 h: Tests 8 and 10). It is considered that this unusual behaviour is probably significant and would result from reprecipitation or adsorption of the uranium by clay or carbonaceous minerals. If adsorption of uranium is occurring to significant levels for the low-grade composite, it would not necessarily be significant for the high-grade composite (containing ten times the uranium). This would account for the difference in leaching characteristics between the composites.

Leaching of the high-grade composite (B) at pH 1.75 initially showed rapid extraction (78% after 3 h: see Table 5) and this was probably related to the finer particle size (100% -63 μm *v.* 100% -1.7 mm in the first series tests). However, very little further extraction was achieved (82% after 6 and 12 h). From the experiments of the first series 82% was also extracted after 12 h at pH 2.0. Thus it would appear that acceptable extraction is achieved at pH 1.75 to 2.0 with quite acceptable acid consumption.

Table 6 details the results of the alkaline leaching runs. As was expected, extraction rates of the uranium at ambient temperature were very much slower than acid leaching, but high uranium recoveries were achieved after seven days (87% and 88% for composites (A) and (B) respectively). Hence this reagent is also effective in solubilising the uranium from the ore.

The adsorption phenomenon noted in the acid-leaching experiments on the low-grade composite was considered to require further consideration of:

(a) Whether it would be significant for *in situ* leaching of economic material, and whether barren or low-grade material would strip uranium from pregnant acidic liquor emerging from economic material.

(b) Whether it is related to the sand or clay content of the material.

(c) Whether it also occurs with alkaline solutions (apparently not, on the single experiment carried out on low-grade ore).

4.2 Agitation Leaching of Samples from Holes 11AC, 50C and 190C

In the previous sections, preliminary agitation leaching experiments were carried out on composite samples from Hole 45C. This showed that 80 to 90% of the uranium was leached from the ore with sulphuric acid. Also, provided that the controlled pH level of leaching was 1.75 or 2.0, acid consumption was very low.

Leaching experiments were then carried out on material from Holes 11AC, 50C and 190C to see whether the results on Hole 45C ore were representative.

Samples from the other three drillholes were used to make composites for each hole and a leaching experiment was carried out on each composite. Samples used to make up the composites are detailed in Table 7. The samples were ground to about 70% minus 63 μm to ensure good dispersion of the slurry during leaching.

In each experiment, 250 g of ore was slurried with an equal weight of distilled water in a beaker with an anchor-type laboratory stirrer. Sulphuric acid was added to keep the pH at the controlled level of 1.75 over the duration of the run (12 hours). Oxidant (sodium chlorate) was added to maintain the redox at greater than minus 400 mV (measured by a platinum-calomel combined electrode). Solid samples were collected for analysis for uranium 6 to 12 h after the commencement of the run. The extraction efficiencies and acid and oxidant consumptions are given in Table 8.

These results show a range of extraction efficiencies (some better than composites from Hole 45C and some not as good). Both acid and oxidant consumptions are acceptably low.

4.3 Percolation Leaching Tests

In Section 4.1 agitation leaching experiments showed that both acid and alkaline leaching reagents were satisfactory for dissolving the uranium minerals in the ore. Percolation leaching experiments, which resemble *in situ* leaching more closely than agitation leaching, were carried out on the ore from Hole 45C to test the feasibility of extracting the uranium by this method. Again, both sulphuric acid and sodium carbonate/bicarbonate were used as the leaching reagents. Two composites (one low-, one high-grade) were made up from the same samples as described in Section 4.1.1 for this series. Pieces of ore from the core were lightly crushed to minus 9 mm and the minus 300 μm fraction separated. The minus 9 mm plus 300 μm material was used for this investigation.

A sample of 250 g of ore was placed in each percolation column with 500 ml of liquor (distilled water in the case of the acid experiments and 80 g/l Na_2CO_3/20 g/l $NaHCO_3$ for the alkaline experiments). Liquor circulation in these columns was by air lifts. Sulphuric acid was added daily (if necessary) to keep the pH of the acid leaching experiments at the required level (pH 1.75 or 2.0) and sodium chlorate was added at the commencement of the experiment (10 kg/tonne ore). Four acid leaching experiments and two alkaline-leaching experiments were conducted.

4.3.1 Acid Leaching

The results of the four acid leaching experiments are reported in Table 9. From Table 9 it can be seen that about 60 to 80% of the uranium is extracted in these acid-leaching experiments after 14 days of percolation. These leaching rates are very encouraging. Percolation rates of the liquor through the ore were acceptable and there was no evidence of blocking or plugging. A comparison of acid consumption from Tables 4 and 5 for the agitation leaching tests shows that the percolation-leaching acid consumptions are only about one tenth of the agitation leaching consumptions. For the high grade samples (Tests P4 and P5) the acid consumption is lower than that required to leach out the uranium by the following reaction:

$$\underset{\text{coffinite}}{U(SiO_4)_{1-x}\,OH_{4x}} + \tfrac{1}{2}O_2 + 2H^+ \longrightarrow UO_2^{++} + (1-x)SiO_2 + (1+2x)\,H_2O$$

This suggests that acid is being generated by other gangue reactions in the ore (e.g., the oxidation of pyrite, marcasite):

$$\begin{aligned} 2FeS_2 + O_2 + 4H^+ &\longrightarrow 2Fe^{++} + 4S + 2H_2O \\ 4Fe^{++} + O_2 + 4H^+ &\longrightarrow 4Fe^{+++} + 2H_2O \\ 2S + 3O_2 + 2H_2O &\longrightarrow 2SO_4^{=} + 4H^+ \end{aligned}$$

With liquor circulation by air lift, one would expect some oxidation of sulphide minerals in the ore. It should be noted that solution mining on a commercial scale will not have such a highly oxygenated recirculation liquor. It is considered that this will result in a slightly higher acid consumption but there will not be a significantly reduced uranium extraction efficiency. (Uranium is generally preferentially oxidised to sulphide minerals.)

In conclusion, the acid percolation leaching investigation shows considerable promise. No 'reprecipitation' of uranium was found (as indicated in some of the agitation leaching experiments described in the previous section).

4.3.2 Alkaline Leaching

The results of the two alkaline leaching experiments are reported in Table 10. These experiments were continued for 27 days, after which 69 to 77% of the uranium had been dissolved. Comparison with acid leaching (Table 9) showed that a similar extraction efficiency was achieved (extraction efficiencies for alkaline leaching were about the same as pH 2 acid leaching and slightly below pH 1.75 experiments). It is of interest to note that the extraction rate of uranium does not appear to be very different for acid or alkaline leaching (although extraction information is not available in the most sensitive range of initial leaching). This is in contrast to some ores from which uranium dissolution by carbonate can be an order of magnitude slower than acid leaching at ambient conditions.

While no quantitative measurements were recorded, percolation liquor rates for alkaline leaching were noted to be greater than the acid leaching tests, with both being acceptable. This could indicate that less sulphide oxidation and iron precipitation occurred during the alkaline leaching experiments. (It is important that sulphide oxidation be kept low in alkaline leaching to avoid consumption of the carbonate reagent by the reaction:

$$2FeS_2 + 7O_2 + 8Na_2CO_3 + 6H_2O \rightarrow 2Fe(OH)_2 + 4Na_2SO_4 + 8NaHCO_3)$$

In conclusion, alkaline leaching reagents appear to be as suitable as sulphuric acid for dissolving uranium.

5. SOLUTION MINING OF THE HONEYMOON DEPOSIT

Solution mining for the recovery of valuable metals is becoming a recognised extraction method particularly in the United States of America. However, this technique has yet to be applied in Australia. It is therefore of interest to survey the available information in the literature and compare similar orebody types to the Honeymoon deposit already being treated by this technique.

5.1 Description of Solution Mining Operations

The following description is restricted to solution mining of unbroken orebodies. This is particularly relevant to roll-type formations (e.g., Minad's Honeymoon deposit).

The best documented solution-mining operation is that of Utah Mining and Construction Co. (now Utah International Mining Co.) at Shirley Basin, Wyoming. This operated from the early 1960s until 1968 and is described by Anderson and Ritchie (1968). Many of the operating details were included in Amdel Report No. 988 'Solution Mining (*in situ* leaching) — A literature survey'.

A pattern of inflow and outflow wells was chosen as the method for solution dispersal and recovery. The design was based on the assumption that natural ground-water could be made to act as a containment shell for the leaching solutions. An experimental programme of various test drillhole patterns showed that, provided the optimum pattern geometry was used, solution recovery was very high.

The optimal design is based on the fact that inflow between wells in an aquifer having regional flow can be controlled by varying inflow-effluent rates, by distances between wells, and by aligning wells at specific angles to the direction of ground-water flow. The present pattern used at Shirley Basin Mines consists of three inflow wells upstream from a production well, with the centre inflow well directly upstream of the regional ground-water flow direction. The remaining two inflow wells are located on radii diverging at an angle of 75° from one another, equally spaced from the centre inflow well. Distances from inflow wells to the production wells are about 7 to 8 metres (see Fig. 2).

Well drilling and development was found to be important for satisfactory operation of the solution mining pattern. Except for the finished diameter, the procedure for drilling and completion of inflow and production wells is the same. Wells are first pilot-drilled and probed, after which they are reamed to take the required casing. Inflow well casing is 75-mm dia. stainless steel and production well casing is 0.2-m dia. with stainless steel on the

see Table II   7.5mm & 20 mm respect.

bottom 12 m. Screens are placed in the ore zone in all wells. The wells are developed by means of a high-pressure jet, this treatment being continued until the wells are capable of a satisfactory rate of inflow by water test.

Pattern operation starts with the introduction of leaching solution to the three inflow wells and simultaneous pumping in the production well at a rate which barely exceeds total input to the inflow wells. Patterns start with an acid inflow of 1 to 1.5 g/l until titratable acid is measured in the effluent, at which time the concentration of sulphuric acid is increased in increments to a maximum of 5 g/l. After an acid condition has been established in the pattern network, uranium leaching is enhanced by the addition of small quantities of sodium chlorate. Flocculant addition (5 to 10 ppm) has been infrequently used to promote solution flow in less permeable formations.

Uranium values generally have been found to appear in the effluent in less than 48 h and the uranium concentration continues to build up for about a week before remaining constant at about 0.2 to 0.3 g/l. Towards the end of the life of the well (greater than one month), the uranium concentration drops off. A number of patterns are operated simultaneously. After a pattern has been finished, pumps, screens and casings are salvaged.

Uranium is recovered from pregnant solution by means of ion exchange columns. Stripping of uranium from the ion exchange resin is by a mixture of nitric acid, sodium nitrate and sulphuric acid. The strip solution is precipitated with dolomitic lime or magnesia slurry. The barren solution emanating from the top of the column is discarded as waste, since while it contains some acid it cannot be recycled underground because of its dissolved calcium content.

This project never produced more than 3000 to 3500 kg U_3O_8 per month, even with as many as 5 well systems operating simultaneously. Leaching was discontinued in 1968 when the operation was converted to an open pit. It is believed that the increase in yellow cake price had a great deal to do with this decision (Fluor, 1975).

In April 1975, Atlantic Richfield started up the largest *in situ* leaching operation at Clay West near George West, Texas (see White 1975). It was built at a cost of US$7 million and has a design capacity of about 120 tonnes U_3O_8 per annum.

The mine extracts uranium from a maximum depth of 170 m in the Miocene Oakville sandstones - about 100 m of unbedded sands, silts and bentomitic clays. The ore occurs in zones 3 to 20 m thick and grades from a low of 0.05% U_3O_8 to as high as 0.5% — the latter being uncommon. The deposit is underlain by low permeability clays. Uranium in the deposit is thought to derive from deposited volcanic ash, with percolating ground waters having dissolved the uranium and transported it to neighbouring rocks where, in the presence of H_2S derived from oil-bearing formations, the uranium has precipitated.

The Clay West mine taps the Oakville deposits through a pattern of 66 production wells spaced at 18 m intervals (see Fig. 3). The 46 extraction wells are interspersed at regular intervals with a grid of injection wells, and are surrounded by monitor wells. These occupy an area of a little more than 1 hectare. The Oakville sandstone is a regional aquifer having a slow rate of flow — about 4 m per annum. Should the monitor wells detect leaching solution escaping from the production zone, the rate of production can be increased or the rate of injection decreased to pull the solution back.

Table 2 10mm — 15 mm

The injection holes are 100-mm dia. and the extraction wells 150-mm dia. (see Fig. 4), the latter being larger to accommodate a submersible pump at the bottom of the well. Open screened sections of pipe in the ore zones permit production of leach solution with minimal extraction of entrained particulates.

The operation uses a proprietary alkaline leach solution (probably sodium or ammonium carbonate/bicarbonate). The pregnant solution is collected in a 100-m^3 field gathering tank and then pumped to the plant area. There the solution passes through one of six parallel trains, each consisting of a carbon column and an ion exchange column in series. Solution circulates through the leach pattern at about 450 m^3/h. A sodium chloride solution is used to strip uranium from the ion exchange resin and the uranium-rich solution (about 1% U_3O_8) passes through a charcoal column for removal of impurities and then reports to precipitation tanks where yellow cake is precipitated with ammonia. Fig. 5 shows the flow sheet.

The mining lease has access to 35 to 40 sections, and patterns of injection and production wells will eventually be operated up to 3 km from the central processing plant.

Many environmental controls have been placed on this leaching operation as it is located in a good farming district. The following methods will be used to reduce the impact to the environment of this mining operation:

(1) Construction of shallow and deep monitor wells in close proximity to the leaching pattern.

(2) Extensive well-water sampling within an 8-km radius of the

pattern. In addition, surface drainage monitoring.

(3) All injection and producing wells in the leach area are cased and cemented to the surface, preventing upward migration of injected solutions behind the casing.

(4) Restoration of the water in the orebody after the conclusion of leaching.

(5) Waste solution disposal by evaporation in a pond, or deep-well injection into a low-quality saline aquifer.

Other solution mining operations are either in the development stage or have been carried out on a small scale. Anon. (1975) states that Exxon is experimenting with the technique used at Shirley Basin except that the carbonate system is used permitting recirculation of leach solution. Fluor (1975) mentions that Exxon recovered uranium from ore deposits too small or too low in grade to mine and process by conventional methods. On their Wyoming property they achieved recoveries of 80% at a cost of US$13 per kg U_3O_8.

The most advanced project in the planning, design or construction stage belongs to Westinghouse's wholly owned subsidiary, Wyoming Minerals, which is building a 120-tonne U_3O_8 plant near Bruni, Texas (Crawford, 1975). It appears that the operation will use a weak ammoniacal leach and a proprietary ion exchange extraction system. Wyoming Minerals also plan a second commercial uranium *in situ* leach plant near Kay Point, north of George West in Five Oak County.

In Duval County, Union Carbide is considering a pilot-scale *in situ* leach operation.

Southwest of Bruni, in Webb County, Texas, Mobil Oil Corp. has built a pilot plant to test the feasibility of a proprietary *in situ* uranium leaching method. The plant was expected to start up around October 1 to leach uranium at depths of 125 to 130 m. The Mobil pilot operation planned to inject a leach solution into the uranium-bearing formation through 15 injection wells and extract it through seven production wells. The solution is identified as a dilute ammonium carbonate with an unidentified oxidant. Processing of the pregnant solution will be conventional (sand filter to remove the suspended solids and an ion exchange column to extract U_3O_8). The barren effluent will be recycled after the addition of further chemicals. A system of eight monitoring wells will determine if there is leakage of chemicals outside the planned injection production pattern.

5.2 Interpretation of Solution Mining Operations With Respect to the 'Honeymoon' Deposit

In Amdel Final Report No. 988 'Solution Mining (*in situ* leaching) — A literature survey' the prerequisites for consideration of solution mining were stated as:

(1) *The mineral values should occur in a generally horizontal bed underlain by a relatively impermeable stratum.*

(2) *The ore must occur below the static water table.*

(3) *Direction and velocity of regional water flow must be known.*

(4) *Mineralogy of the ore should be determined so that its amenability to the proposed leaching process may be assessed.*

Items (1) and (2) are true of the 'Honeymoon' deposit and the results of preliminary leaching experiments detailed in this Report (Section 4) are encouraging. At present, hydrological information is not available and will have to be collected before any pilot-scale *in situ* leaching study is commenced.

Thus, there is nothing at this stage to indicate that solution mining is not an applicable treatment method for Minad's 'Honeymoon' deposit. The present and proposed operations give some details that are of interest to the operation under study. These have been detailed in Table 11. This information is far from complete but the following comments can be made:

(i) Capital costs are relatively low for this size of operation.

(ii) Orebody grades, operating depths and formations appear to be similar to the 'Honeymoon' deposit.

(iii) Both acid and alkaline leaching reagents have been used commercially.

5.3 Acid *v.* Alkaline Leaching

The problem of which leaching reagent should be used to extract the uranium from the 'Honeymoon' deposit has yet to be resolved. From the testwork described in Section 4, both reagents appear to be equally suitable, but both reagents have potential disadvantages — for example:

(1) Acid leaching:

(a) Barren acidic leach liquors probably cannot be recycled as this may result in precipitation and blockage in the orebody.

(b) This will result in acidic wastes for disposal (treatment) and a higher water consumption.

(c) Acidic water containing toxic pollutants could enter local ground-water from the orebody.

(d) Excessive oxidation of pyrite may result in precipitation and blockage of the ore.

(2) Alkaline leaching:

(a) Alkaline reagents are more expensive than acid, and high recycle rates must be achieved for these reagents to be economic.

(b) Excessive inflow of ground-water will dilute the reagent which will have to be concentrated for reuse.

(c) Excessive outflow of leach reagent will be an expensive loss.

(d) The present ore-ground-water environment is acidic and reducing. The alkaline reagent will have to neutralise this (resulting in some reagent loss).

It is difficult to assess some of the above factors for solution-mining operations because there is only a very limited amount of data available from the literature.

In conventional processing, it is generally assumed that acid leaching of uranium ores is the cheapest way of extracting the valuable constituent, provided that acid consumption is not excessive. Merritt (1971) gives the cut-off from acid to alkaline leaching at about 10 to 15% $CaCO_3$-$MgCO_3$ (equivalent to an acid consumption of about 100 to 150 kg H_2SO_4/tonne ore). With ores containing above this amount of acid-consuming gangue, alkaline leaching may be practised. The presence of carbonates in the ore represents a greater difficulty for solution-mining operations than conventional processing where acid leaching is envisaged. Firstly, carbonate minerals on dissolving form carbon dioxide at low pH, and this CO_2 may exsolve and form bubbles of gas if its concentration exceeds the solubility at the hydrostatic pressure in the orebody. These bubbles of gas are very difficult to move and their presence reduces the contact of leach solution with the orebody. Secondly, if calcite is the carbonate mineral, only very weak acid can be used so that the solubility product of calcium sulphate is not exceeded. This ensures that precipitation of gypsum does not occur; this precipitate would block the pores in the orebody, restricting solution circulation. In conclusion, if the ore contains more than a low percentage of carbonate minerals, acid leaching is probably not suitable.

The carbonate content of the Honeymoon deposit is acceptably low, as is the acid consumption at a leaching pH of 1.75 to 2.0. However, it is not so easy to estimate reagent consumption for alkaline leaching, due to the complexity of the reaction occurring. With conventional processing, soluble losses in the tailings represents the major loss and it is expected that this will also be true with *in situ* leaching.

The major uranium mineral in the ore is coffinite containing uranium in the quadrivalent state, requiring an oxidising reagent for dissolution. For alkaline leaching, air is commonly used in conventional processing but there will be a very limited contact of air with the leach solution in solution mining. Sodium hypochlorite (NaOCl) or hydrogen peroxide could appear to be suitable chemical oxidants. For acid leaching, sodium chlorate was successfully used at Shirley Basin, Wyoming (Anderson and Ritchie, 1968).

6. CONCLUSIONS

6.1 Analytical and Mineralogical Study

1. The uranium analysis of the ore was consistently higher than the level predicted from laboratory gamma counting. As a first approximation, the predicted average ore grade of about 0.26% U_3O_8 may in fact be as high as 0.38% U_3O_8 (i.e., uranium in the deposit is enriched with respect to its daughter-products).
2. Petrographic data indicate that the uraniferous unit is composed largely of light to dark grey clay-rich sands which are locally pebbly and/or gravelly. The sands consist mainly of poorly-sorted angular to sub-rounded quartz clasts and elongate to sheaf-like muscovite flakes in a clay-rich opaque-bearing matrix.
3. Present in accessory to trace amounts are clasts of staurolite, andalurite, sillimanite and tourmaline and in minor traces are sphene, monazite and apatite. The opaques consist largely of pyrite, marcasite, goethite and humic material.
4. The matrix 'clay' is kaolinite, while uranium is present as the mineral coffinite which typically occurs as 3 to 8 μm sized grains in the clayey matrix.
5. Spectrographic scans do not indicate the presence of any unexpected or deleterious elements in the uraniferous unit.
6. Within the uraniferous unit, U_3O_8 values range up to 1.8%, Th values are low (mainly <20 ppm), S values (mainly due to pyrite) are generally high (1 to 5%), Zn values are generally high (up to 1%), Cu values are locally high, especially in Hole 190C, Mo, Pb and V values are very low (<20 ppm) and Au is effectively absent (<0.1 ppm).
7. On the basis of sizing data, sands of the uraniferous zone are extremely poorly sorted and clay-rich.

6.2 Metallurgical Study

1. Preliminary agitation leaching experiments with low- and high-grade composites from Hole 45C showed that:
   (a) Acid leaching of the low-grade composite gave erratic results, probably due to adsorption of uranium on clay or carbonaceous material. However, a substantial proportion of the uranium appears to be leached from the ore.

(b) Acid leaching at low pH (<1.0) resulted in substantial gangue attack.

(c) Acid leaching of high-grade composite at pH 1.75 to 2.0 gave satisfactory extraction rates without excessive acid consumption.

(d) Alkaline leaching of the composites was much slower than acid leaching. However, after 7 days, extraction efficiencies approached those of 12-hour acid leaching.

2. Agitation leaching of composite samples from Holes 11AC, 50C and 190C at pH 1.75 showed a range of extraction efficiencies (some better than composites from Hole 45C and some not as good). Both acid and oxidant consumptions were acceptably low.

3. Acid percolation leaching experiments on high- and low-grade composites from Hole 45C showed considerable promise, with 60 to 80% of the uranium being extracted in 14 days. Acid consumptions were extremely low. There was no evidence of reprecipitation.

4. Alkaline percolation leaching experiments gave results very similar to the acid percolation leaching tests. Uranium appeared to be extracted at approximately the same rates as in acid leaching, and after 27 days 69 to 77% of the uranium was extracted.

5. At this stage, acid and alkaline leaching look equally attractive and it has not been possible to choose between them.

6. Comparison of Minad's Honeymoon deposit with commercial solution mining operations has indicated that orebody grades, operating depths and formation types appear to be similar. Also, both acid and alkaline leaching reagents have been used commercially. There is no factor to indicate that solution mining would not be an applicable treatment method for the Honeymoon deposit.

7. RECOMMENDATIONS

7.1 Further Laboratory Development

The leaching investigation on Minad's Honeymoon deposit has been particularly encouraging and further examination of the following unresolved aspects is recommended:

(1) Comparative economics of *in situ* leaching operations.

(2) Best reagent (acid or alkali). In Section 5.3, some of the disadvantages of the leaching reagent are discussed and some of these aspects need investigation to determine which reagent is to be recommended.

(3) Optimum alkali strength. Because of the possible loss of alkaline reagent from the solution on passing through the ore, it may be economically important to have low alkali strength. Hence it will be necessary to investigate the effect of alkali strength on the leaching efficiency of uranium.

(4) Applicability of alternative alkaline reagents; e.g., ammonium carbonate/bicarbonate. As mentioned in Section 5.1, a number of proposed solution mining operations in the United States intend to use ammonium carbonate instead of sodium carbonate as the leaching reagent. It is generally considered that ammonium carbonate is an equally suitable reagent for uranium. However, this aspect needs checking.

(5) Applicability of percolation results to other samples (e.g., Hole Nos 11AC, 50C and 190C). All percolation tests have been carried out on composites from Hole 45C. It will be of value to carry out a modest number of experiments on ore from the other holes.

Examination of the economics of solution mining is the next logical step in this work programme. This would be aimed at indicating the type and size of operation required to be economically feasible.

7.2 Field Studies

In addition, knowledge of ground-water flow through the orebody would help in assessing the pattern of inflow and outflow wells required for a solution mining operation, and a study of this aspect is recommended.

8. REFERENCES

ANDERSON, J.S., and RITCHIE, M.I. (1968). Solution mining of uranium. *Mining Congress J.*, 54, Jan. 20.

ANON. (1975). Note on other mines that have recovered U_3O_8 by *in situ* leaching. *Engng Min. J.*, 176, July, 80.

CRAWFORD, E. (1975). Developers eye Texas potential for *in situ* uranium leaching. *Engng Min. J.*, 176, July, 81.

FLUOR, (1975). Solution mining of uranium (Communication to Mr B. Webb on 30 May 1975 from Fluor Australia Pty Ltd).

MERRITT, R.C. (1971). The extractive metallurgy of uranium. *Colorado School of Mines Research Institute*. (Chap. 3).

WHITE, L. (1975). *In situ* leaching opens new uranium reserves in Texas. *Engng Min. J.*, 176, July, 73.

APPENDIX A

ANALYTICAL, EQUILIBRIUM AND POROSITY DATA

Tables A-1 to A-4 list for each of the four holes (1) Sample Nos, (2) Sample Locations, (3) Analytical Data, (4) Equilibrium Data, and (5) Porosity Data. In addition, the tables also indicate which samples were used to prepare thin sections, polished slabs and/or polished sections, autoradiographs and which samples were selected for plus 300 mesh size analyses. A few samples were also chosen for whole rock X-ray diffraction analysis, semi-quantitative spectrographic scan analysis and uranium mineral identification work.

Note on Equilibrium:

$$\text{Equilibrium} = {}^{A}/_{B}$$

A = actual ppm U_3O_8, by X-ray fluorescence.

B = calculated ppm U_3O_8 from gamma radioactivity assuming radiochemical equilibrium of uranium and daughters (after deduction of activity attributed to Th).

The ratio indicates the state of radiochemical equilibrium, viz.,

0 = radioactivity due entirely to daughter products with no uranium present.

1 = radiochemical equilibrium.

9 = radioactivity due entirely to uranium with no daughter products present.

TABLE A-1: MINAD HOLE No. SE 11AC

Sample No.	Down Hole Depth m	Analytical Results (ppm unless indicated)										Porosity (%)	Thin Section	Polished Section or Slab	Auto-radio-graph	Sieve Analysis	Other Work (as indicated)
		U	Th	Equil-ibrium	Mo	Cu	Pb	V	Au	Zn	S(%)						
1	103.00-103.50	225	28	1.67	-	-	-	-	-	-	-	-	-	-	-	-	-
2	103.50-103.85	36	55	1.28	-	-	-	-	-	-	-	-	-	-	-	-	-
3	104.14-104.50	46	55	1.21	-	-	-	-	-	-	-	-	-	-	-	-	-
4	104.50-105.00	70	55	1.02	-	-	-	-	-	-	-	-	-	-	-	-	-
5	105.10-105.50	75	50	1.00	-	-	-	-	-	-	-	-	-	-	-	-	-
6	105.50-106.00	80	36	1.02	-	-	-	-	-	-	-	-	-	-	-	-	-
7	106.50-107.00	245	18	1.16	-	-	-	-	-	-	-	-	-	-	-	-	-
8	107.00-107.43	48	4	0.87	-	-	-	-	-	-	-	-	-	-	-	-	-
9	107.57-107.90	380	14	0.87	-	-	-	-	-	-	-	-	-	-	-	-	-
10	108.00-108.20	150	12	0.46	-	-	-	-	-	-	-	-	-	-	-	-	-
11	108.20-108.50	205	16	0.46	-	-	-	-	-	-	-	-	-	-	-	-	-
12	108.50-108.70	1170	14	1.14	-	30	20	30	<0.1	800	0.46	-	x	x	x	-	Uranium min. ident.
13	108.70-109.00	100	16	0.20	-	-	-	-	-	-	-	-	-	-	-	-	-
14	109.20-109.69	55	12	0.36	-	-	-	-	-	-	-	-	-	-	-	-	-
15	109.78-110.31	65	14	0.34	-	-	-	-	-	-	-	-	-	-	-	-	-
16	110.45-110.60	185	20	0.56	-	-	-	-	-	-	-	-	-	-	-	-	-
17	110.74-110.90	100	14	0.39	-	-	-	-	-	-	-	-	-	-	-	-	-

1093

(Continued)

TABLE A-1: CONTINUED

Sample No.	Down Hole Depth m	Analytical Results (ppm unless indicated) U	Th	Equilibrium	Mo	Cu	Pb	V	Au	Zn	S(%)	Porosity (%)	Thin Section	Polished Section or Slab	Autoradiograph	Sieve Analysis	Other Work (as indicated)
18	111.52–111.60	46	32	0.18	–	–	–	–	–	–	–	–	–	–	–	–	–
19	113.13–113.29	36	26	0.40	–	–	–	–	–	–	–	–	–	–	–	–	–
20	113.79–113.89	18	30	1.12	–	–	–	–	–	–	–	–	–	–	–	–	–
21	114.79–114.90	250	<4	0.83	10	100	10	10	0.1	600	0.11	25.9	–	–	–	x	–
22	114.90–115.00	920	6	0.60	–	50	20	20	<0.1	100	1.21	29.5	x	x	x	x	–
23	115.60–116.00	1370	12	0.78	3	20	100	20	<0.1	1%	2.22	30.8	x	x	x	x	Uranium min. ident.
24 A, B	116.78–117.00	1.21%	14	1.45	–	10	30	30	<0.1	1000	5.02	33.8	x	x	x	x	Uranium min. ident.
25	117.41–117.54	530	14	1.60	–	20	200	50	<0.1	1500	2.65	29.4	–	–	–	x	–
26	117.71–117.77	1020	8	1.54	–	10	20	20	<0.1	800	1.44	60.3	x	x	x	x	–
27	118.00–118.12	180	4	1.28	3	10	50	50	<0.1	5000	1.52	47.1	x	x	x	x	–
28	118.30–118.39	410	12	1.49	–	–	–	–	–	–	–	33.0	–	–	–	x	–
29	118.60–118.88	115	12	1.15	–	–	–	–	–	–	–	–	–	–	–	–	–
30	119.10–119.65	130	22	1.30	–	--	–	–	–	–	–	–	–	–	–	–	–

TABLE A-2: MINAD HOLE No. SE 45C — PRELIMINARY AGITATION LEACHING TESTS UNDERTAKEN ON SAMPLES 2 TO 13 INCLUSIVE

Sample No.	Down Hole Depth m	Analytical Results (ppm unless indicated)										Porosity (%)	Thin Section	Polished Section or Slab	Auto-radio-graph	Sieve Analysis	Other Work (as indicated)
		U	Th	Equil-ibrium	Mo	Cu	Pb	V	Au	Zn	S(%)						
1	110.70–110.95	285	18	0.27	3	100	20	20	0.1	600	0.07	29.0	–	–	–	x	–
2	111.60–111.95	1.11%	4	1.47	3	20	20	10	0.1	400	1.31	15.1	x	x	x	x	–
3	111.95–112.28	7170	12	1.05	–	20	20	100	<0.1	800	1.02	32.8	–	–	–	x	–
4	112.28–112.36	1.14%	6	1.71	3	5	20	20	<0.1	2000	0.56	32.0	x	x	x	x	Uranium min. ident.
5	112.63–112.83	1.23%	4	1.75	3	10	20	20	0.1	2500	7.56	30.4	x	x	x	x	–
6	112.93–113.09	1000	10	0.90	–	20	10	20	0.1	200	6.32	24.1	–	–	–	x	A10 spectroscopic scan
7	113.30–113.60	5290	6	1.37	–	20	30	10	<0.1	1500	6.00	33.8	x	x	x	x	–
8	113.60–113.79	5400	12	1.16	–	10	30	10	0.1	800	1.20	22.6	–	–	–	x	–
9	113.90–114.20	8310	14	1.49	–	20	30	10	0.1	1000	3.17	28.3	–	–	–	x	–
10	114.20–114.40	4450	16	0.90	–	10	30	20	<0.1	>1%	5.02	16.2	x	x	x	x	–
11	114.54–114.89	1300	18	1.02	–	10	50	10	<0.1	500	0.93	31.1	–	–	–	x	A10 spectroscopic scan
12	114.89–115.27	565	14	0.59	–	10	30	10	<0.1	800	4.79	33.3	x	x	x	x	Uranium min. ident.
13	115.27–115.62	835	16	0.75	–	10	20	20	<0.1	300	3.84	–	–	–	–	–	–
14	115.62–115.96	315	6	0.70	–	–	–	–	–	–	–	–	–	–	–	–	–
15	115.96–116.31	470	20	0.94	–	–	–	–	–	–	–	–	–	–	–	–	–
16	116.41–116.69	225	22	0.77	–	–	–	–	–	–	–	–	–	–	–	–	–
17	116.78–117.20	310	28	1.03	–	–	–	–	–	–	–	–	–	–	–	–	–

(Continued)

TABLE A-2: CONTINUED

Sample No.	Down Hole Depth m	Analytical Results (ppm unless indicated) U	Th	Equil-ibrium	Mo	Cu	Pb	V	Au	Zn	S(%)	Porosity (%)	Thin Section	Polished Section or Slab	Auto-radio-graph	Sieve Analysis	Other Work (as indicated)
18	117.20–117.70	185	32	1.03	–	–	–	–	–	–	–	–	x	x	x	–	–
19	117.70–118.20	90	32	1.38	–	–	–	–	–	–	–	–	–	–	–	–	–
20	118.20–118.70	90	34	1.06	–	–	–	–	–	–	–	–	–	–	–	–	–
21	118.70–119.20	80	34	1.23	–	–	–	–	–	–	–	–	–	–	–	–	–
22	119.20–119.70	60	32	1.20	–	–	–	–	–	–	–	–	–	–	–	–	–
23	119.70–120.20	40	32	1.33	–	–	–	–	–	–	–	–	–	–	–	–	Whole rock XRD analysis
24	120.20–120.70	26	30	1.30	–	–	–	–	–	–	–	–	–	–	–	–	–
25	120.70–121.20	22	34	1.10	–	–	–	–	–	–	–	–	–	–	–	–	–
26	121.20–121.47	14	32	0.93	–	–	–	–	–	–	–	–	–	–	–	–	–

TABLE A-3: MINAD HOLE No. SE 50C

Sample No.	Down Hole Depth m	Analytical Results (ppm unless indicated)										Porosity (%)	Thin Section	Polished Section	Auto-radio-graph	Sieve Analysis	Other Work (as indicated)
		U	Th	Equil-ibrium	Mo	Cu	Pb	V	Au	Zn	S(%)						
1	88.28-88.50	22	14	0.55	-	-	-	-	-	-	-	-	-	-	-	-	-
2	88.50-88.90	18	18	1.00	-	-	-	-	-	-	-	-	-	-	-	-	-
3	88.90-89.30	26	16	0.86	-	-	-	-	-	-	-	-	-	-	-	-	-
4	89.30-89.60	215	16	1.38	-	-	-	-	-	-	-	-	-	-	-	-	-
5	89.60-89.90	255	16	1.50	-	-	-	-	-	-	-	-	x	x	x	-	-
6	89.90-90.20	640	12	1.64	-	10	20	10	<0.1	-	0.11	19.7	-	-	-	x	-
7	90.20-90.34	160	10	1.07	-	-	-	-	-	-	-	-	-	-	-	-	-
8	91.40-91.60	350	10	2.33	-	-	-	-	-	-	-	-	-	-	-	-	-
9	92.00-92.19	280	16	1.19	-	-	-	-	-	-	-	-	-	-	-	-	-
10	92.90-93.08	305	16	1.30	-	-	-	-	-	-	-	-	-	-	-	-	-
11	93.20-93.26	210	12	1.05	-	-	-	-	-	-	-	-	-	-	-	-	-
12	94.38-94.49	135	22	0.73	-	-	-	-	-	-	-	-	-	-	-	-	-
13	94.78-95.10	630	28	1.30	-	30	30	30	<0.1	-	0.13	26.3	-	-	-	x	-
14	95.23-95.70	1240	36	1.27	-	30	20	30	<0.1	-	0.17	-	-	-	-	-	-
15	95.70-96.00	405	32	0.92	-	-	-	-	-	-	-	-	x	x	x	-	-
16	96.00-96.50	55	18	0.92	-	-	-	-	-	-	-	-	-	-	-	-	-
17	96.50-97.00	55	16	1.00	-	-	-	-	-	-	-	-	-	-	-	-	-

(Continued)

TABLE A-3: CONTINUED

Sample No.	Down Hole Depth m	Analytical Results (ppm unless indicated)										Porosity (%)	Thin Section	Polished Section	Auto-radio-graph	Sieve Analysis	Other Work (as indicated)
		U	Th	Equil-ibrium	Mo	Cu	Pb	V	Au	Zn	S(%)						
18	97.00-97.14	32	12	0.80	-	-	-	-	-	-	-	-	-	-	-	-	-
19	97.50-97.72	80	16	1.23	-	-	-	-	-	-	-	-	-	-	-	-	-
20	98.00-98.20	110	20	0.88	-	-	-	-	-	-	-	-	-	-	-	-	-
21	98.30-98.40	90	14	0.67	-	-	-	-	-	-	-	-	-	-	-	-	-
22	98.60-98.90	155	16	1.07	-	-	-	-	-	-	-	-	-	-	-	-	-
23	98.90-99.20	75	12	0.94	-	-	-	-	-	-	-	-	-	-	-	-	-
24	99.20-99.50	85	14	0.77	-	-	-	-	-	-	-	-	-	-	-	-	Whole rock XRD analysis
25	99.50-99.67	300	20	1.09	-	-	-	-	-	-	-	-	-	-	-	-	-
26	100.00-100.25	115	14	0.68	-	-	-	-	-	-	-	-	-	-	-	-	-
27	101.00-101.20	1170	24	1.14	-	10	20	30	<0.1	-	0.80	27.2	x	x	x	x	-
28	101.20-101.70	930	36	0.90	30	5000	20	100	0.1	-	2.69	32.4	-	-	-	x	-
29	101.70-101.97	165	22	0.57	-	-	-	-	-	-	-	-	-	-	-	-	-
30	102.20-102.35	42	10	0.27	-	-	-	-	-	-	-	-	-	-	-	-	-
31	102.70-103.00	795	12	0.88	3	20	10	30	<0.1	50	9.04	32.0	-	-	-	x	-
32	103.20-103.46	1990	8	1.34	3	10	10	20	<0.1	-	3.80	29.9	x	x	x	x	-
33	104.20-104.50	620	10	0.40	3	100	10	20	<0.1	-	0.29	36.0	x	x	x	x	-
34	105.20-105.38	2150	12	1.20	-	10	20	150	<0.1	-	1.04	40.9	-	-	-	x	A10 spectroscopic scan
35	106.00-106.33	665	14	0.77	3	80	10	80	<0.1	-	0.44	40.1	-	-	-	x	-

TABLE A-4: MINAD HOLE No. SE 190C

Sample No.	Down Hole Depth m	Analytical Results (ppm unless indicated) U	Th	Equilibrium	Mo	Cu	Pb	V	Au	Zn	S(%)	Perosity (%)	Thin Section	Polished Section	Auto-radiograph	Sieve Analysis	Other Work (as indicated)
1	98.20-98.45	32	18	1.77	-	-	-	-	-	-	-	-	x	x	x	-	-
2	98.90-99.10	24	32	1.20	-	-	-	-	-	-	-	-	-	-	-	-	-
3	99.10-99.40	26	30	0.93	-	-	-	-	-	-	-	-	-	-	-	-	-
4	99.40-99.90	28	26	0.61	-	-	-	-	-	-	-	-	-	-	-	-	-
5	99.90-100.40	390	32	1.18	-	-	-	-	-	-	-	-	-	-	-	-	-
6	100.40-100.90	200	46	1.00	-	-	-	-	-	-	-	-	-	-	-	-	Whole rock XRD analysis
7	100.90-101.44	920	44	1.21	-	-	-	-	-	-	-	-	-	-	-	-	-
8	101.44-101.80	75	14	0.33	-	-	-	-	-	-	-	-	-	-	-	-	-
9	101.80-102.30	155	26	0.76	-	-	-	-	-	-	-	-	-	-	-	-	-
10	102.30-102.80	160	24	1.03	-	-	-	-	-	-	-	-	-	-	-	-	-
11	102.80-103.60	80	18	1.00	-	-	-	-	-	-	-	-	-	-	-	-	Whole rock XRD analysis
12	103.90-104.27	14	10	0.47	-	-	-	-	-	-	-	-	-	-	-	-	-
13	104.27-104.63	12	10	0.46	-	-	-	-	-	-	-	-	-	-	-	-	-
14	104.63-105.06	6	7	0.23	-	-	-	-	-	-	-	-	-	-	-	-	-
15	105.06-105.31	10	8	0.20	-	-	-	-	-	-	-	-	-	-	-	-	-
16	105.85-105.92	310	18	1.48	-	-	-	-	-	-	-	46.2	-	-	-	x	-
17	106.29-106.52	530	10	2.41	-	50	10	20	<0.1	-	0.15	40.7	-	-	-	x	-

(Continued)

TABLE A-4: CONTINUED

Sample No.	Down Hole Depth m	Analytical Results (ppm unless indicated) U	Th	Equil-ibrium	Mo	Cu	Pb	V	Au	Zn	S(%)	Porosity (%)	Thin Section	Polished Section	Auto-radio-graph	Sieve Analysis	Other Work (as indicated)
18	106.52-106.62	1.50%	8	2.42	3	100	30	200	<0.1	200	0.21	43.1	x	x	x	x	A10 spectroscopic scan
19	107.50-107.90	130	6	0.41	3	80	10	100	<0.1	-	0.03	30.3	x	x	x	x	-
20	108.23-108.64	1760	60	0.98	10	>1%	30	100	0.1	200	2.85	31.8	x	x	x	x	-
21	108.73-108.98	6020	48	1.54	20	>1%	30	150	0.1	600	2.75	34.6	x	x	x	x	A10 spectroscopic scan. Whole rock XRD analysis. Uranium min. ident.
22	109.23-109.41	205	26	0.29	-	50	30	80	0.1	-	2.75	31.6	x	x	x	x	-
23	109.73-109.78	95	20	0.22	10	30	30	50	0.1	50	13.7	34.7	-	-	-	x	-
24	111.50-111.74	3730	10	1.55	-	>1%	10	80	<0.1	30	0.71	40.4	x	x	x	x	-
25	115.00-116.50	180	28	1.00	-	50	50	80	<0.1	-	0.12	33.5	-	-	-	x	Whole rock XRD analysis.

APPENDIX B

PETROGRAPHIC-MINERAGRAPHIC; X-RAY DIFFRACTION AND ELECTRON-MICROPROBE DATA

(1) Hole SE11 AC

(a) Sample No. 12 (108.67-108.70 m) TS34274

Hand Specimen:

Fine to very fine-grained light olive grey sand containing mica and clay plus minor opaques.

Thin Section:

An optical estimate of the constituents gives the following:

	%
Quartz	60-65
Clay	∿20
Muscovite	∿10
Opaques	3- 5
Tourmaline	2
Andalusite	1

This is a fine-grained sand composed largely of quartz plus lesser clay and muscovite. Quartz is well sorted; grains are angular to sub-rounded and range in size from 0.01 to 0.2 mm, averaging about 0.1 mm. Muscovite occurs as evenly distributed flakes which are markedly elongate and range in length from 0.1 to 0.6 mm, averaging about 0.2 mm. Quartz and muscovite are embedded in a web-like matrix of clay which appears light brown in plane-polarised light. The matrix contains evenly disseminated 0.1 to 0.5-mm sized patches composed of very fine-grained opaques (probably largely pyrite, humic material and uraniferous minerals), plus occasional grains of pleochroic blue-green tourmaline. The accessory phases are sphene, monazite, andalusite, chlorite and apatite. The last occurs as minute needles in quartz clasts.

Examination of the autoradiograph indicates that the uraniferous phase in the rock is extremely fine-grained and evenly disseminated in the matrix. X-ray diffraction analysis of one autoradiograph exposure spot indicated that it consisted of the minerals pyrite and kaolinite in association with the uraniferous mineral coffinite $\{U(SiO_4)_{1-x}(OH)_{4x}$; UO_2 typically 50 to 70%$\}$.

(b) <u>Sample No. 22</u> (114.90-114.93 m) TS34275; PS23771

Hand Specimen:

Dark grey, poorly sorted gravelly sand containing much clayey, humic and pyritic material.

Thin Section:

An optical estimate of the constituents gives the following:

	%
Quartz	∿45
Clay	30-40
Opaques	10-15
Muscovite	2- 3
Tourmaline, andalusite	∿1

This is a poorly sorted clay-bearing gravel, or coarse sand, composed largely of poorly sorted coarse to fine quartz fragments in a matrix of clay and opaques. Quartz clasts range in size from 0.01 to 8 mm, averaging about 1.0 mm; larger grains are sub-rounded, whereas the smaller grains are sub-angular to angular. Clasts are embedded in a matrix of light brown humic-bearing clay containing unevenly disseminated 0.5 to 2.0-mm sized opaque particles, some of which enclose from several to over a dozen 0.05 to 0.2-mm sized quartz grains. Muscovite occurs as disorientated, elongate 0.01 to 0.2-mm long flakes. The section contains accessory tourmaline, sphene, andalusite, monazite and chlorite. Examination of the autoradiograph indicates that the uraniferous phases are concentrated in unevenly disseminated 0.1 to 0.5-mm sized patches. X-ray diffraction analysis of the patches was not attempted.
Goethite and pyrite (plus marcasite) are the main opaque phases evident in polished section. Goethite occurs as 0.5 to 1.0 mm long, silicate inclusion rich plates along fractures in quartz and as similar-sized patches in the matrix. Goethite is partially rimmed and (?) replaced by pyrite-marcasite; pyrite-marcasite also occurs as massive 0.2 to 2-mm sized patches and as framboidal aggregates. Framboids range in size from 0.01 to 0.05 mm.

(c) <u>Sample No. 23</u> (115.63-116.00 m) TS34436

Hand Specimen:

Medium grey, poorly sorted gravelly sand containing clay, pyrite mica and humic material.

Thin Section:

An optical estimate of the constituents gives the following:

	%
Quartz	∿50
Clay	40
Opaques	5
Muscovite	2-3
Andalusite, tourmaline	1-2

This closely resembles the previously described section; however, quartz grains are more rounded and better sorted and the proportion of opaques is smaller.
Exposure spots on the autoradiograph coincided with opaque patches; however, X-ray diffraction analysis only indicated the presence of pyrite. Electron-probe microanalysis, however, indicated the presence of 2 to 4-μm sized coffinite grains.

(d) Sample No. 24A (116.81-116.83 m) TS34276

Hand Specimen:

3-cm dia. pyrite nodule in dark grey to black clay and mica-bearing sand.

Thin Section:

An optical estimate of the constituents gives the following:

	%
Quartz	40
Clay	30
Opaques (largely pyrite)	25
Muscovite	5
Andalusite, tourmaline	trace

The core zone of the nodule, an area of about 2 cm^2 consists almost entirely of pyrite; whereas its margins consist of fine evenly disseminated angular quartz (grains) in pyrite. The remainder of the section consists largely of angular to sub-angular 0.01 to 2.0-mm sized quartz grains in clay and opaque-bearing matrix. Although the quartz clasts show a wide grain size variation, most clasts lie within the range

0.3 to 0.5 mm. Muscovite occurs as equant flakes which range in size from 0.1 to 1.0 mm. Unlike the above-described sections, opaques (pyrite, humic material) occur not only as patches but also as very fine disseminations (≤0.002 mm sized) within the clay matrix. The section contains traces of andalusite, tourmaline, monazite, etc.
Examination of the autoradiograph indicates that the uraniferous phase is very fine-grained (≤0.05 mm), evenly disseminated and associated with the matrix. X-ray diffraction analysis was not attempted.

(e) <u>Sample No. 24B</u> (116.95-117.00 m) TS34277; PS23772

Hand Specimen:

Dark grey to black medium-grained clay-bearing sand containing accessory amounts of mica.

Thin Section:

An optical estimate of the constituents gives the following:

	%
Quartz	60
Clay	∿35
Muscovite	2-3
Opaques	2-3
Andalusite, tourmaline	∿1

This is a coarse to very-coarse sand composed of quartz clasts, plus minor muscovite and andalusite clasts in a clay-rich matrix containing opaque patches.
Quartz clasts are angular to sub-angular and range in size from 0.2 to 4.0 mm, although most are about 1.0 mm in size. The boundaries of some grains are highly sutured and hence appear to have been partially dissolved by the matrix. Muscovite grains mainly occur as curved disorientated sheaf-like aggregates which typically range in size from 0.5 to 2.0 mm. Andalusite and tourmaline clasts tend to be smaller (≤0.5 mm) and are mainly sub-angular.
Clasts reside in a web-like matrix of clayey material which ranges in colour from light to dark brown and locally appears semi-opaque to opaque due to the presence of pyritic, humic and (?)uraniferous material. Under high-power magnification the darker parts of the matrix are seen to contain evenly disseminated rounded, dark-brown semi-translucent grains

of a mineral which physically resembles coffinite. The grains range in size from 2 to 10 μm, averaging about 5 μm. The section also contains 0.1 to 0.3-mm sized patches of pyritic material, plus minor traces of sphene, monazite and chlorite.

Examination of the autoradiograph of the polished section indicated the presence of a high proportion of fine-grained radioactive material associated with the matrix. X-ray diffraction analysis of four autoradiograph 'hot spots' indicated that they consist of the uraniferous mineral coffinite in association with kaolinite and lesser pyrite.

The dominant opaque phases in polished section are pyrite and marcasite, which occur as evenly disseminated 0.01 to 0.05-mm sized framboids; the section also contains several larger (<0.5 mm) pyrite-marcasite patches. Goethite (plates in quartz) and traces of galena (minute groundmass flecks) are also present in the section.

Electron-probe microanalysis of several of the coffinite grains indicated that (1) they mainly range in size from 3 to 8 μm, (2) they are devoid of As, V and other minor elements which are sometimes present in coffinite and (3) they contain about 54 to 65% UO_2.

(f) Sample No. 26 (117.71-117.77 m) TS34278

Hand Specimen:

Medium to coarse-grained, moderately compact, grey-black sand.

Thin Section:

An optical estimate of the constituents gives the following:

	%
Quartz	50
Clay	∿45
Muscovite	2-3
Opaques, semi-opaques	3-5
Andalusite, tourmaline	∿1

This section very closely resembles the above-described sections; however, quartz grains mainly lie within two size ranges. Most grains are sub-rounded to sub-angular and are 1.5 to 2 mm in size, whereas the remainder are angular and less than or equal to 0.3 mm in size.

Examination of the autoradiograph indicated that the uraniferous mineral is very fine-grained and occurs within the clay-rich matrix.

(g) Sample No. 27 (118.08-118.12) TS34279

Hand Specimen:

Medium to coarse-grained light grey sand containing clay, plus traces of opaques and mica.

Thin Section:

An optical estimate of the constituents gives the following:

	%
Quartz	∿55
Clay	40
Opaques	∿5
Muscovite	2-3
Andalusite, tourmaline	∿1

This section closely resembles those described above. Quartz clasts range in size from 0.1 to 5 mm, averaging about 2 mm; larger clasts are sub-rounded whereas smaller ones are generally more angular, and the clasts are packed more closely together than in the above-described sections.

Opaque patches range in size from 0.2 to 2.0 mm; and most appear rounded and globular (?due to sample preparation).

Autoradiograph examination failed to indicate the presence of radioactivity in the section.

(2) Hole SE 45C

(a) Sample No. 2 (111.92-111.95 m) TS34336

Hand Specimen:

Clay and pyrite-bearing gravel.

Thin Section:

An optical estimate of the constituents gives the following:

	%
Quartz	∿55
Clay	40
Opaques	2-3
Muscovite	2-3
Staurolite	∿1

This is a poorly sorted pebbly gravel composed of clasts, ranging in size from 0.1 to 10 mm, embedded in a matrix composed largely of clay, muscovite and opaques. Larger clasts are well rounded, whereas smaller ones are angular to sub-angular. The web-like clayey matrix containing opaque patches is similar to matrixes seen in the above-mentioned sections and muscovite occurs as 0.1 to 1.0 mm long disoriented elongate flakes in the matrix. Staurolite, similar to that described above, is the dominant accessory mineral.

(b) Sample No. 4 (112.28-111.30 m) TS34430; PS23932

Hand Specimen:

Coarse clay and opaque-bearing gravel.

Thin Section:

An optical estimate of the constituents gives the following:

	%
Quartz	∿35
Andalusite, sillimanite	30
Clay	30
Opaques	∿5
Muscovite	2-3
Staurolite	∿1

This is a clay-bearing gravel composed mainly of quartz and altered andalusite clasts in a web-like matrix of clay and lesser opaques. Quartz and andalusite clasts are poorly sorted, angular to sub-angular, and range in size from 0.1 to 10 mm, averaging about 1.5 mm. Andalusite clasts are partially altered in patches to very fine-grained sillimanite and are also rich in fractures which have been filled with clayey matrix material. Muscovite occurs in the matrix as very fine disoriented sheave-like patches and flakes which appear to be preferentially associated with opaques. Other features are similar to those recorded in above-described sections.

In polished section the main opaque phases are goethite, pyrite and marcasite.

Goethite largely occurs as 0.1 to 0.5-mm long plates in quartz fractures. Plates are locally rimmed and (?) replaced by pyrite and marcasite which

also form minute framboids in the matrix. The section contains traces of galena (minute flecks in matrix) and (?) detrital iron-titanium oxides. The hand specimen was observed to be secreting a yellow salt-like mineral which was identified by X-ray diffraction analysis to be zippeite $\{(UO_2)_3(SO_4)_2(OH)_2.8H_2O;\ UO_2 = 72 \text{ to } 75\%\}$.
Electron-probe microanalysis of several autoradiograph exposure spots indicated that they consist of 2 to 8-μm sized grains of coffinite in association with clay and pyrite.

(c) Sample No. 5 (112.63-112.66 m) TS34337

Hand Specimen:

Brownish-black clayey sand containing traces of mica.

Thin Section:

An optical estimate of the constituents gives the following:

	%
Quartz	∿55
Clay	35
Opaques	∿5
Muscovite	2-3
Andalusite, staurolite	2

Quartz clasts are well-sorted angular to sub-angular and range in size from 0.1 to 8 mm, averaging about 2 mm. Most clasts are sub-angular; however, the larger ones are sub-rounded. Andalusite clasts average about 0.5 mm, are angular, and in part altered to fibrous sillimanite. Muscovite is flaky and very fine-grained (⩽0.2 mm) and opaques occur largely in 0.5 to 1.0-mm sized patches.

(d) Sample No. 7 (113.35-113.38) TS34431

Hand Specimen:

Brownish-black clayey sand.

Thin Section:

An optical estimate of the constituents gives the following:

	%
Quartz	∿60
Clay	30
Opaques	10
Muscovite	∿1
Tourmaline, staurolite	traces

Quartz clasts are poorly sorted and range in size from 0.1 to 4.0 mm, averaging about 1.5 mm; larger clasts are sub-rounded whereas the smaller ones are angular to sub-angular. Compared with most of the above-described sections, this section contains a high proportion of opaques and minor and accessory minerals are largely absent. In places clasts are cemented entirely by opaques.

(e) Sample No. 10 (114.20-114.22 m) TS34338

Hand Specimen:

Coarse, dark grey to black, clay-bearing sand.

Thin Section:

An optical estimate of the constituents gives the following:

	%
Quartz	∿50
Clay	∿40
Opaques	5-10
Muscovite	1- 2
Staurolite	∿1

Quartz clasts are angular to sub-angular, moderately sorted and range in size from 0.1 to 4.0 mm, averaging about 1 mm. In other respects this section closely resembles the previously-described section.

(f) Sample No. 12 (114.89-114.91) TS34432; PS23930

Hand Specimen:

Medium-grained, olive-green clay-bearing sand.

Thin Section:

An optical estimate of the constituents gives the following:

	%
Quartz	50-55
Clay	∿40
Muscovite	2-3
Opaques	∿5
Tourmaline, staurolite	∿1

This is a moderately well-sorted, fine to medium-grained clay and mica-bearing sand containing traces of opaques and accessory minerals. Quartz clasts are angular to sub-angular and range in size from 0.1 to 1.5 mm, averaging about 0.5 mm. Clasts are embedded in a light brown clay-rich matrix which is speckled by very fine-grained (0.001-0.005 mm) opaques and semi-opaques (?humic material, sulphides and uraniferous phases) which are locally aggregated together to form massive to semi-massive 0.2 to 0.5-mm sized patches. The matrix also contains highly elongate muscovite flakes, which range up to 2.5 mm in length, plus accessory-to-trace amounts of tourmaline and staurolite. Monazite and sphene are notable trace minerals. Quartz clasts locally appear sutured in a manner suggestive of resorption.

In polished section the only opaques evident are (?)detrital iron-titanium oxides plus traces of very fine-grained pyrite, marcasite and goethite. Electron-probe microanalysis of several autoradiograph exposure points indicated that they are due to 2 to 5-μm sized grains of the mineral coffinite in close association with clays and sulphides (mainly pyrite).

(g) Sample No. 18 (117.25-117.27 m) TS34339

Hand Specimen:

Grey-black, clay-bearing gravelly material.

Thin Section:

An optical estimate of the constituents gives the following:

	%
Andalusite and sillimanite	30-35
Muscovite and clay	∿30
Quartz	30
Opaques	∿5-10
Staurolite	trace

This is a gravelly aggregate composed largely of altered andalusite clasts in a matrix of fine-grained quartz, clay and muscovite. Opaques make up 5 to 10% of the rock.

Andalusite clasts are angular to sub-angular and range in size from 0.2 to 15 mm; most are partially altered to fine-grained (?)sillimanite which is itself partly altered back to smaller crystals of secondary (?)sillimanite. Some of the clasts contain fine-grained opaque inclusions. The remainder of the section consists of an opaque spotted matrix composed of silt-sized quartz grains, brown clay and fine muscovite flakes. In addition to forming specks in the matrix, opaques also occur as 0.5 to 2.0-mm sized patches and wisps in the matrix.

In polished section the main opaque minerals are (?)detrital iron-titanium oxides; however, the section also contains 0.01 to 0.05-mm sized pyrite-marcasite framboids.

(h) Sample No. 23 (120.19-120.22 m)

Hand Specimen:

Grey, greasy silty clay.

As this specimen is very fine-grained, its constituents were identified by X-ray diffraction analysis, yielding the following results:

Constituent	Proportion (see footnotes, P. B-18).
Quartz	Dominant
Muscovite	Sub-dominant
Kaolinite	Sub-dominant
Andalusite, sillimanite	Accessory

(3) Hole SE 50C

(a) Sample No. 5 (89.87-89.90 m) TS34341

Hand Specimen:

Light grey, clay-bearing sand.

Thin Section:

An optical estimate of the constituents gives the following:

	%
Quartz	∿70
Clay	20
Opaques	5
Muscovite	∿5
Staurolite, chlorite, tourmaline, sillimanite	traces

Quartz clasts are poorly sorted, angular to sub-angular and range in size from 0.1 to 3.0 mm, averaging about 1.5 mm. In other respects this section clearly resembles the above-described sections; however, muscovite is extremely fine-grained.

(b) Sample No. 15 (95.96-96.00 m) TS34340

Hand Specimen:

Light grey, clay-bearing sand.

Thin Section:

An optical estimate of the constituents gives the following:

	%
Quartz	∿40
Clay	∿60
Opaques	1-2
Muscovite	∿1

Quartz is moderately poorly sorted; clasts angular to sub-angular and range in size from about 0.4 to 3.5 mm averaging about 1.5 mm. Textural features are similar to those recorded in the above-described sections; however, muscovite is very fine-grained (⩽0.2 mm) and opaques are present only in trace amounts.

(c) Sample No. 25 (99.25-99.27 m)

Hand Specimen:

Fawn coloured, greasy, clay-rich aggregate.

As this specimen is very fine-grained, its constituents and their approximate proportions were identified by X-ray diffraction analysis, yielding the following results:

Constituent	Proportion
Quartz	Dominant
Muscovite	Sub-dominant
Kaolinite	Sub-dominant
Tourmaline	Trace

(d) Sample No. 27 (101.00-101.20 m) TS34435

Head Specimen:

Light green-grey, clay and mica-bearing sand.

Thin Section:

An optical estimate of the constituents gives the following:

	%
Quartz	∿80
Clay	∿20
Muscovite	∿2
Opaques	∿1
Andalusite, tourmaline	trace

Quartz clasts are angular to sub-angular and range from 0.2 to 4.0 mm in size, averaging about 1.5 mm; sorting is poor. Other features are similar to those recorded in the above-described sections.

(e) Sample No. 32 (103.20-103.46 m) TS34434

Hand Specimen:

Fawn-grey, clay and mica-bearing gravelly sand.

Thin Section:

An optical estimate of the constituents gives the following:

	%
Quartz	∿35
Clay	∿60
Opaques	∿5
Muscovite	2-3
Tourmaline, andalusite	trace

Quartz is angular to sub-angular, poorly sorted and clasts range in size from 0.2 to 8.0 mm, averaging about 1.0 mm. Muscovite mainly occurs as ragged elongate 0.5 to 1.5-mm long flakes. Other features are similar to those recorded in the above-described sections.

(f) Sample No. 33 (104.20-104.50 m) TS34433

Hand Specimen:

Fawn coloured, micaceous clay-bearing sand.

Thin Section:

An optical estimate of the constituents gives the following:

	%
Quartz	∿40
Clay	∿50
Muscovite	∿10
Opaques	2-3
Tourmaline, andalusite	trace

This section very closely resembles the previously-described section.

(4) Hole SE 190

(a) Sample No. 1 (98.20-98.25 m) TS34342

Hand Specimen:

Coarse, clay-bearing fawn coloured sand.

Thin Section:

An optical estimate of the constituents gives the following:

	%
Quartz	∿80
Clay	∿20
Muscovite	∿1
Opaques, staurolite, andalusite	trace

Quartz is angular to sub-rounded and clasts range in size from 0.2 to 6.0 mm, averaging about 1.5 mm. Muscovite is very fine-grained (⩽0.2 mm) and opaques plus other minerals are only present in trace amounts.

(b) Sample No. 6 (100.40-100.46 m)

Hand Specimen:

Fawn coloured, greasy clay-rich rock.

X-ray diffraction analysis was used to characterise the contained minerals and to determine their proportions, indicating the following:

Constituent	Proportion
Kaolinite	Dominant
Muscovite	Sub-dominant
Quartz	Sub-dominant to accessory
Andalusite	Trace

(c) Sample No. 11 (102.80-103.60 m)

Hand Specimen:

Grey silty clay.

X-ray diffraction analysis indicated the following:

Constituent	Proportion
Quartz, muscovite and kaolinite	Co-dominant
Tourmaline	Trace

(d) Sample No. 18 (106.52-106.54) TS34343

Hand Specimen:

Grey clay and mica-bearing sand.

Thin Section:

An optical estimate of the constituents gives the following:

	%
Quartz	~65
Clay	15
Mica	~15
Opaques	~5
Staurolite, tourmaline	trace

Quartz is poorly sorted; clasts are angular to sub-rounded and range in size from 0.2 to 4.0 mm, averaging about 1.0 mm. Muscovite occurs as ragged elongate flakes which range up to 2.5 mm in length. Quartz, mica and trace minerals reside in a light brown, clay-rich matrix which contains disseminated specks (2 to 10 μm) and patches up to 2 mm of opaques.

(e) Sample No. 19 (107.50-107.90 m) TS34344

Hand Specimen:

Light fawn, clay-bearing coarse sand.

Thin Section:

An optical estimate of the constituents gives the following:

	%
Quartz	~90
Muscovite	~5
Clay	~5
Opaques	~1
Tourmaline, monazite	trace

This is a clean, poorly-sorted, sand composed of angular to sub-angular quartz clasts which range in size from 0.2 to 3.0 mm, averaging about 1.5 mm. Quartz grains are coated by, and embedded in, a clayey and micaceous matrix.

(f) Sample No. 20 (108.23-108.64 m) TS34437

Hand Specimen:

Black silty clay.

Thin Section:

An optical estimate of the constituents gives the following:

	%
Clay	~55
Muscovite	~20
Quartz	~15
Opaques	~10
Sillimanite, staurolite	trace

Quartz clasts are largely angular and range up to about 0.5 mm in size. Muscovite occurs as elongate flakes, which range up to 0.5 mm in length and average about 0.2 mm, and opaques occur as 0.01 to 0.5-mm sized granules and patches. Quartz, muscovite, opaques and accessories reside in a matrix of dark brown clay containing traces of lighter brown clay which form rounded 0.1 to 0.2-mm sized, areas after an unknown (?)detrital mineral.

(g) Sample No. 21 (108.73-108.75 m) TS34438

Hand Specimen:

Grey silty clay.

Thin Section:

An optical estimate of the constituents gives the following:

	%
Clay	∿55
Muscovite	30
Quartz	∿10
Opaques	2-3
Andalusite, sillimanite	trace

Quartz clasts are angular and range up to 1.0 mm in size, averaging about 0.1 mm; muscovite forms straight highly elongate flakes which range up to 1.0 mm in length. Quartz, muscovite, opaques and the trace minerals are embedded in a light brown clay matrix. Opaques are extremely fine-grained (⩽0.03 mm).

Whole rock X-ray diffraction analysis indicated that the clay is kaolinite; however, several attempts to probe and to X-ray autoradiograph exposure spots to identify the uraniferous phases were unsuccessful.

(h) Sample No. 22 (109.23-109.41 m)

Hand Specimen:

As for Sample 21.

Thin Section:

As for Sample 21.

(i) Sample No. 24 (111.50-111.53 m) TS34438

Hand Specimen:

Light grey-green sand.

Thin Section:

An optical estimate of the constituents gives the following:

	%
Quartz	∿70
Clay	∿20
Muscovite	∿5
Opaques	3-5
Andalusite, tourmaline	∿1

This is a well-sorted clay and mica-bearing sand. Quartz clasts are sub-angular to sub-rounded and range in size from 0.2 to 0.8 mm, averaging about 0.5 mm. Muscovite occurs as straight, highly elongate flakes which range up to about 1.0 mm in length. Tourmaline and andalusite occur as sub-rounded to sub-angular clasts which average about 0.3 mm in length. Clasts are embedded in a light brown matrix of clay which contains fine dusty opaques and 0.2 to 0.3-mm sized patches of opaques.

(j) Sample No. 25 (115.00-116.50 m)

Hand Specimen:

Grey, clay-bearing silt.

Whole rock XRD analysis indicated the following:

Constituent	Proportion
Quartz	Dominant
Muscovite	Sub-dominant
Kaolinite	Sub-dominant
Tourmaline	Trace

Footnotes:

(1) X-ray Diffraction Abbreviations

Dominant: Used for the component apparently most abundant, regardless of its probable percentage level.

Co-dominant: Used for two (or more) predominating components, both or all of which are judged to be present in roughly equal amounts.

Sub-dominant: The next most abundant component(s) providing its percentage level is judged above about 20.

Accessory: Components judged to be present between the levels of roughly 5 and 20%.

Trace: Components judged to be below about 5%.

(2) Most sections contain minor traces of sphene, monazite, apatite and related heavy mineral grains.

APPENDIX C

QUALITATIVE SPECTROGRAPHIC ANALYSIS OF SELECTED SAMPLES*

Sample No.		Major	Minor	Heavy Trace (0.1—1%)	Trace (0.01—0.1%)	Faint Trace (0.001—0.01%)	Very Faint Trace (0.0001—0.001%)
45	6	Si	Al, Fe	Co, Ti, Na, K	Ni, Cr, Mg, Zn, P	B, As, V, Ca, Y, Cu, Li, Pb	Mn, Ga, Be, Tl, Ge, Ag, Sn
45	11	Si	Al, Fe	Na, Ti, K	P, Co, Mg, Zn, Cr	Ca, Ni, Li, Cu, Pb, Y, B	Mn, Ga, Ge, Be, V, Rb, Ag, Zr, Sn
50	34	Al, Si	Fe	Na, K, Mg, Ti	P, V, Ba	Rb, Cr, Li, Cu, Ca, B, Ga, Pb	Co, Ni, Ge, Be, Mn, Ag, Zr, Y, Sn
190	18	Si, Al	Fe	K, Ti, Mg	P, Na, Cr, Cu, V, Ba, Zn, As, Ca	Co, Ag, B, Rb, Ga, Pb, Li	Mn, Ge, Be, Ni, Sn, Mo, Zr, Bi
190	21	Si, Al	Fe, Cu	Co, Na, K, Mg, Ti	Zn, Ni, V, P, Ca	Cr, B, As, Mo, Rb, Ga, Y, Ge, Li, Pb	Mn, Sn, Be, Zr, Ag, Bi

*Elements not sought: Hg
Other elements not detected at limits quoted below: Mo, Nb, Re, Ta, Th, W, Zr, As, Bi, Cd, In, Sb, Zn, Au, Te, Cs, Rb, Ba, Ce, Er, Eu, La, Nd, Pr, Sc, Sr, Y

SPECTROGRAPHIC ANALYSIS — DETECTION—LIMIT CONCENTRATIONS OF ELEMENTS, DC Arc EXCITATION

Element	%	ppm	Element	%	ppm	Element	%	ppm	Element	%	ppm
Ag	0.00001	0.1	Eu	0.005	50	Na	0.005	50	Sm	0.03	300
Al	0.02	200	Fe	0.005	50	Nb	0.02	20	Sn	0.0001	1
As	0.005	50	Ga	0.0001	1	Nd	0.03	300	Sr	0.001	10
Au	0.0003	3	Gd	0.03	300	Ni	0.0005	5	Ta	0.01	100
B	0.001	10	Ge	0.0001	1	Os	0.001	10	Tb	0.01	100
Ba	0.005	50	Hf	0.02	200	P	0.01	100	Te	0.002	20
Be	0.0001	1	Hg	0.01	100	Pb	0.0001	1	Th	0.01	100
Bi	0.0001	1	Ho	0.01	100	Pd	0.001	10	Ti	0.01	100
Ca	0.002	20	In	0.001	10	Pr	0.01	100	Tl	0.0001	1
Cd	0.003	3	Ir	0.0002	2	Pt	0.001	10	Tm	0.01	100
Ce	0.03	300	K	0.0005	5	Rb	0.001	10	U	0.1	1000
Co	0.0005	5	La	0.01	100	Re	0.001	10	V	0.001	10
Cr	0.002	20	Li	0.0001	1	Rh	0.0002	2	W	0.005	50
Cs	0.003	30	Lu	0.03	300	Ru	0.0002	2	Y	0.001	10
Cu	0.00005	0.5	Mg	0.01	100	Sb	0.003	30	Yb	0.005	50
Dy	0.01	100	Mn	0.001	10	Sc	0.005	50	Zn	0.002	20
Er	0.01	100	Mo	0.0003	3	Si	0.02	200	Zr	0.02	200

TABLES 1 to 11

FIGS 1 to 5

TABLE 1: SAMPLES USED IN LEACHING PROGRAMME FROM HOLE 45C

Sample No.	Weight g	Analysis U_3O_8, ppm	Meterage m	
			From	To
2	212.2	13 100	111.6	111.95
3	321.0	8 450	111.95	112.28
4	22.8	13 400	112.28	112.36
5	91.1	14 500	112.63	112.83
6	37.8	1 180	112.93	113.09
7	164.7	6 240	113.30	113.60
8	137.1	6 370	113.60	113.79
9	214.3	9 800	113.90	114.20
10	107.3	5 250	114.20	114.40
11	279.8	1 530	114.54	114.89
12	497.5	665	114.89	115.27
13	247.7	985	115.27	115.62

TABLE 2: SAMPLES BULKED TOGETHER TO MAKE THE LOW-GRADE COMPOSITE A

Sample No.	Weight g	Analysis U_3O_8, ppm
6	37.8	1180
11	279.8	1530
12	497.5	665
13	247.7	985
Calculated Average	1062.8	990

TABLE 3: SAMPLES BULKED TOGETHER TO MAKE THE HIGH-GRADE COMPOSITE B

Sample No.	Weight g	Analysis U_3O_8, ppm
2	212.2	13 100
3	321.0	8 450
4	22.8	13 400
5	91.1	14 500
7	164.7	6 240
8	137.1	6 370
9	214.3	9 800
10	107.3	5 250
Calculated Average	1270.5	9 200

TABLE 4: FIRST SERIES — ACID LEACHING CONDITIONS AND RESULTS

	Experiment No.					
	1	2	3	4	5	6
Composite	A	A	A	B	B	B
Controlled pH level	1.0	1.5	2.0	1.0	1.5	2.0
Extraction efficiency (%)						
at: 3 h	93	90	70	83	51	30
6 h	a	88	a	91	76	56
12 h	85	62	83	96	96	82
Acid consumption kg H_2SO_4/tonne ore						
at: 3 h	243	104	7.4	222	72	6.6
6 h	505	104	13.6	496	84.5	6.6
12 h	603	104	13.6	522	84.5	6.6
kg H_2SO_4/kg U_3O_8 leached, 12 h	1091	258	25	82	13.3	1.2
Oxidant added kg $NaClO_3$/tonne ore	3	3	3	4	4	4
Head sample, ppm U_3O_8	650	650	650	6625	6625	6625
Residue sample, ppm U_3O_8						
at: 3 h	45	65	195	1150	3360	4650
6 h	a	80	a	615	1590	2900
12 h	95	245	105	235	290	1180

a = apparently anomalous result.

TABLE 5: SECOND SERIES — ACID LEACHING EXPERIMENTS

	Experiment No.				
	7	8	9	10	11
Composite	A	A	A	A	B
Controlled pH level	1.5	1.5	2.0	2.0	1.75
Extraction efficiency (%)					
at: 3 h	–	–	–	–	78
6 h	86	–	83	–	82
12 h	–	46	–	92	82
Acid consumption kg H_2SO_4/tonne ore					
at: 3 h	31.5	31.5	11.3	11.3	16.9
6 h	31.5	31.5	11.3	11.3	16.9
12 h	–	36	11.3	11.3	34.9
kg H_2SO_4/kg U_3O_8					
at: 6 or 12 h	43.6	93	16.2	14.6	4.5
Oxidant added kg $NaClO_3$/tonne ore	5	5	5	5	3
Head sample, ppm U_3O_8	840	840	840	840	9450
Residue sample, ppm U_3O_8					
at: 3 h	–	–	–	–	2050
6 h	120	–	140	–	1750
12 h	–	450	–	70	1750

TABLE 6: SECOND SERIES — ALKALINE LEACHING EXPERIMENTS AT AMBIENT TEMPERATURE

	Experiment No. 12	Experiment No. 13
Composite	A	B
Extraction efficiency (%)		
3 days	71	76
7 days	87	88
Head sample, ppm U_3O_8	840	9450
Residue sample, ppm U_3O_8 at: 3 days	240	2250
7 days	110	1150

TABLE 7: COMPOSITE OF ORE SAMPLES FOR HOLES 11AC, 50C AND 190C

11AC			50C			190C		
Sample No.*	U_3O_8 ppm	Weight g	Sample No.*	U_3O_8 ppm	Weight g	Sample No.*	U_3O_8 ppm	Weight g
12	1 380	113	14	1460	329	7	1 100	484
23	1 620	179	32	2350	290	18	17 700	37
24 A,B	14 300	115	34	2540	106	20	2 080	184
						24	4 400	29
Estimated head	5 130	407		1970	725		2 310	734
Measured head	3 850			1650			1 850	

*For sample locations see Appendix A.

TABLE 8: AGITATION LEACHING RESULTS FOR COMPOSITED SAMPLES FROM HOLES 11AC, 50C AND 190C

	Hole No.		
	11AC	50C	190C
Measured head	3850	1650	1850
Leaching residue U_3O_8, ppm			
6 h	1500	130	400
12 h	1100	60	380
Extraction efficiency (%)			
6 h	61	92	78
12 h	71	96	79
Acid consumption, kg/tonne ore	15.1	13.7	24.5
Oxidant: $NaClO_3$, kg/tonne ore	0.4	1.2	1.6

TABLE 9: ACID PERCOLATION LEACHING

	Sample			
	Low Grade Composite		High Grade Composite	
	P1*	P2	P4	P5
Calculated head, U_3O_8 ppm	578	696	10 020	9740
Controlled pH	1.75	2.0	1.75	2.0
Acid consumption, kg/tonne ore	2.2	0.7	1.8	0.7
Extraction efficiency, %				
days: 2	67	60	45	37
5	72	53	49	44
6	82	63	52	50
8	82	65	58	53
14	84	66	65	59

* Experiment number.

TABLE 10: ALKALINE PERCOLATION LEACHING TESTS

	Sample	
	Low Grade Composite P3*	High Grade Composite P6
Calculated head, U_3O_8 ppm	636	8950
Extraction efficiency, %		
days: 6	63	51
9	64	56
13	47(?)	59
15	66	64
27	77	69

* Experiment number.

TABLE 11: DETAILS OF SOLUTION-MINING OPERATIONS

	Location			
	Shirley Basin Wyoming	Clay West Texas	Webb County Texas	Bruni Texas
	Utah International Mining Co.*	Atlantic Richfield Petroleum Co.*	Mobil Oil*	Wyoming Minerals Corp. (Westinghouse)*
Orebody Details:				
Formation	Roll front	Roll front	Roll front	Roll front
Uranium minerals	?	?	?	?
Gangue minerals	Sandstone	Imbedded sands, silts and bentonitic clays	Sandstone(?)	Sandstone(?)
Ore grade, % U_3O_8	-	0.05 to 0.5%	-	-
Capital cost	-	\$US 7 × 10^6	-	-
Timing of operations	1962-68	Commenced April 1975	Was due to start Oct. 1975	-
Operating depth	-	to 170 m	125 to 130 m	-
Production rate (actual or planned) t U_3O_8/a	40	120	-	120
Drill pattern per system Inflow/production wells	3/1	66/46	15/7	-
Well diameter:	Text pg 12	Text pg 14		
Inflow, mm	7.5 75mm	10 100mm	-	-
Production, mm	20 0.2m	15 150mm	-	-
Ground-water flow	relatively fast	4m/a (slow)	Presumed to be slow	Presumed to be slow
Leachant	H_2SO_4	Alkaline (Na_2 or $(NH_4)_2CO_3^=$)	$(NH_4)_2CO_3$	NH_3 ($CO_3^=$?)
Oxidant	$NaClO_3$	-	Unidentified	-
Solution recycle	No	Yes	Yes	Yes
Pregnant liq., g/l U_3O_8	0.3	-	-	-
Solution flow per system	20 m^3/h	450 m^3/h	-	-
Uranium recovery method	Ion exchange	Ion exchange	Ion exchange	Ion exchange

*Operating company.

RB 76/7

Amdel Report

No. 1093

APPENDIX D

computer services

amdel

the australian mineral
development laboratories

Conyngham St., Frewville, S.A. 5063.
Tel. 79 1662.
Perth Office: 182 Wittenoom St., Perth,
W.A. 6000. Tel. 25 7311.

1/1/172 H50 NO. 6

WET SCREENED ON 300# SCREENING TIME 15 MINS.

80 0/0 PASSING SIZE = 1018. MICRONS

AVERAGE SLOPE = .4 INTERCEPT = 2.7 INCHES

SCREEN SIZE OR CONE NO.	SIZE IN MICRONS	WEIGHT 0/0 RETAINED	CUMULATIVE WEIGHT 0/0	CUMULATIVE WT 0/0 PASSING
7	2400.00	.66	.66	99.34
14	1200.00	13.47	14.13	85.87
25	600.00	23.49	37.62	62.38
52	300.00	13.21	50.83	49.17
100	150.00	4.30	55.13	44.87
200	75.00	4.03	59.15	40.85
300	53.00	1.64	60.80	39.20
-300	-53.00	39.20	100.00	.00

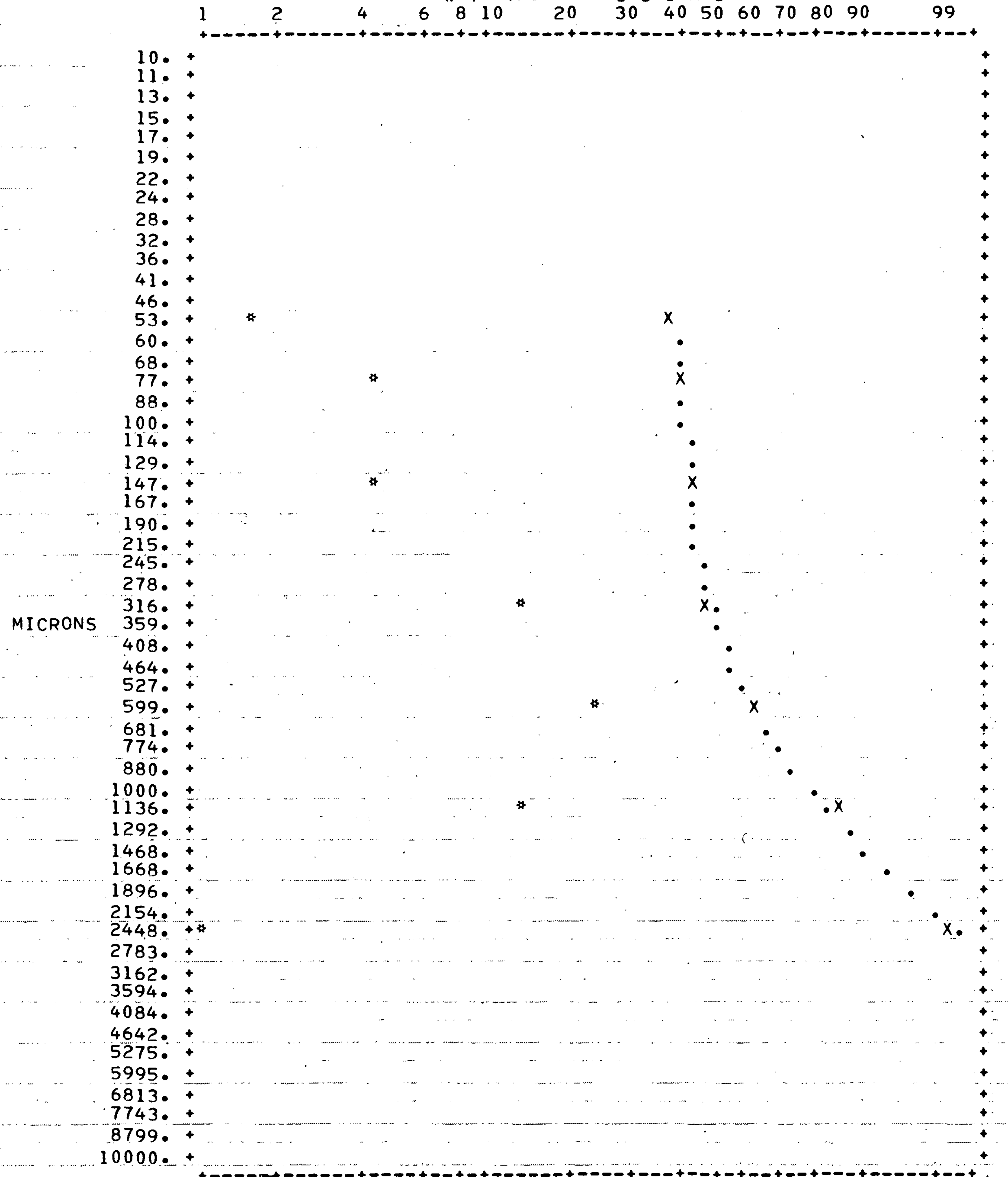
ROSIN RAMMLER PLOT

* = INDIVIDUAL WT. 0/0 RETAINED
* AT 1 0/0 MEANS 1 0/0 OR LESS

X = ACTUAL VALUE

. = BEST FIT LINE USED

THE MICRON VALUES REFER TO THE LINE PRINTER PLOT
POSITIONS AND NOT TO SCREEN APERTURES
USE OF THE LINE PRINTER PLOT IS NOT
RECOMMENDED FOR ACCURATE INTERPOLATION



1 2 4 6 8 10 20 30 40 50 60 70 80 90 99
MICRONS
10. 11. 13. 15. 17. 19. 22. 24. 28. 32. 36. 41. 46. 53. 60. 68. 77. 88. 100. 114. 129. 147. 167. 190. 215. 245. 278. 316. 359. 408. 464. 527. 599. 681. 774. 880. 1000. 1136. 1292. 1468. 1668. 1896. 2154. 2448. 2783. 3162. 3594. 4084. 4642. 5275. 5995. 6813. 7743. 8799. 10000.

1/1/172 H45 NO. 12

WET SCREENED ON 300# SCREENING TIME 15 MINS.

80 0/0 PASSING SIZE = 374. MICRONS

AVERAGE SLOPE = .7 INTERCEPT = 1.6 INCHES

SCREEN SIZE OR CONE NO.	SIZE IN MICRONS	WEIGHT 0/0 RETAINED	CUMULATIVE WEIGHT 0/0	CUMULATIVE WT 0/0 PASSING
188	4763.00	.02	.02	99.98
7	2400.00	.07	.09	99.91
14	1200.00	1.67	1.76	98.24
25	600.00	5.41	7.17	92.83
52	300.00	20.54	27.71	72.29
100	150.00	35.21	62.91	37.09
200	75.00	14.06	76.98	23.02
300	53.00	2.59	79.56	20.44
-300	-53.00	20.44	100.00	.00

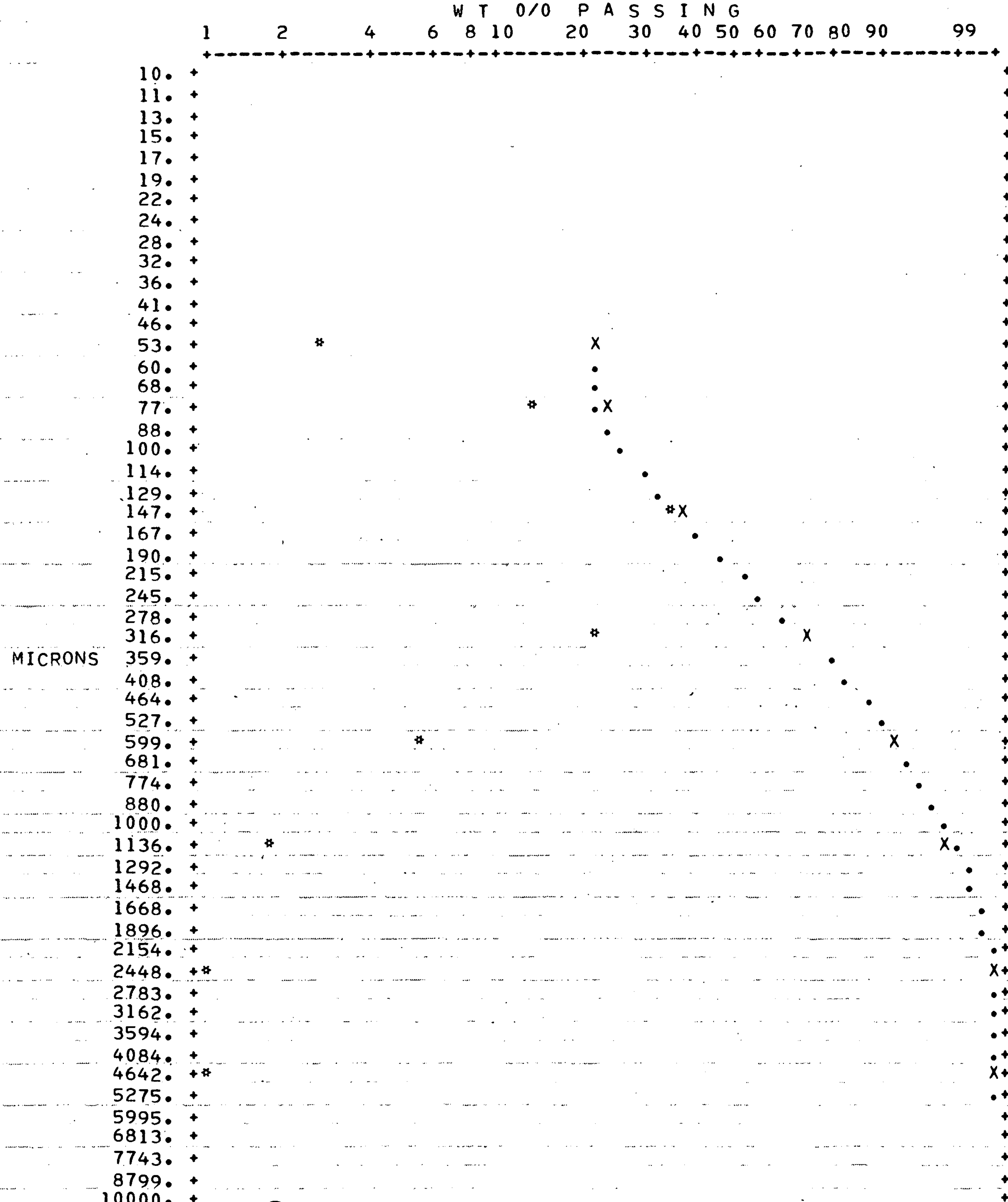
ROSIN RAMMLER PLOT

* = INDIVIDUAL WT. 0/0 RETAINED
* AT 1 0/0 MEANS 1 0/0 OR LESS

X = ACTUAL VALUE

. = BEST FIT LINE USED

THE MICRON VALUES REFER TO THE LINE PRINTER PLOT
POSITIONS AND NOT TO SCREEN APERTURES
USE OF THE LINE PRINTER PLOT IS NOT
RECOMMENDED FOR ACCURATE INTERPOLATION


W T 0/0 P A S S I N G
1 2 4 6 8 10 20 30 40 50 60 70 80 90 99
MICRONS
10. 11. 13. 15. 17. 19. 22. 24. 28. 32. 36. 41. 46. 53. 60. 68. 77. 88. 100. 114. 129. 147. 167. 190. 215. 245. 278. 316. 359. 408. 464. 527. 599. 681. 774. 880. 1000. 1136. 1292. 1468. 1668. 1896. 2154. 2448. 2783. 3162. 3594. 4084. 4642. 5275. 5995. 6813. 7743. 8799. 10000.

1/1/172 H50 NO. 13

WET SCREENED ON 300# SCREENING TIME 15 MINS.

80 0/0 PASSING SIZE = 908. MICRONS

AVERAGE SLOPE = .5 INTERCEPT = 2.3 INCHES

SCREEN SIZE OR CONE NO.	SIZE IN MICRONS	WEIGHT 0/0 RETAINED	CUMULATIVE WEIGHT 0/0	CUMULATIVE WT 0/0 PASSING
7	2400.00	.79	.79	99.21
14	1200.00	11.22	12.01	87.99
25	600.00	20.50	32.51	67.49
52	300.00	18.98	51.49	48.51
100	150.00	8.68	60.17	39.83
200	75.00	5.23	65.40	34.60
300	53.00	1.88	67.27	32.73
-300	-53.00	32.73	100.00	.00

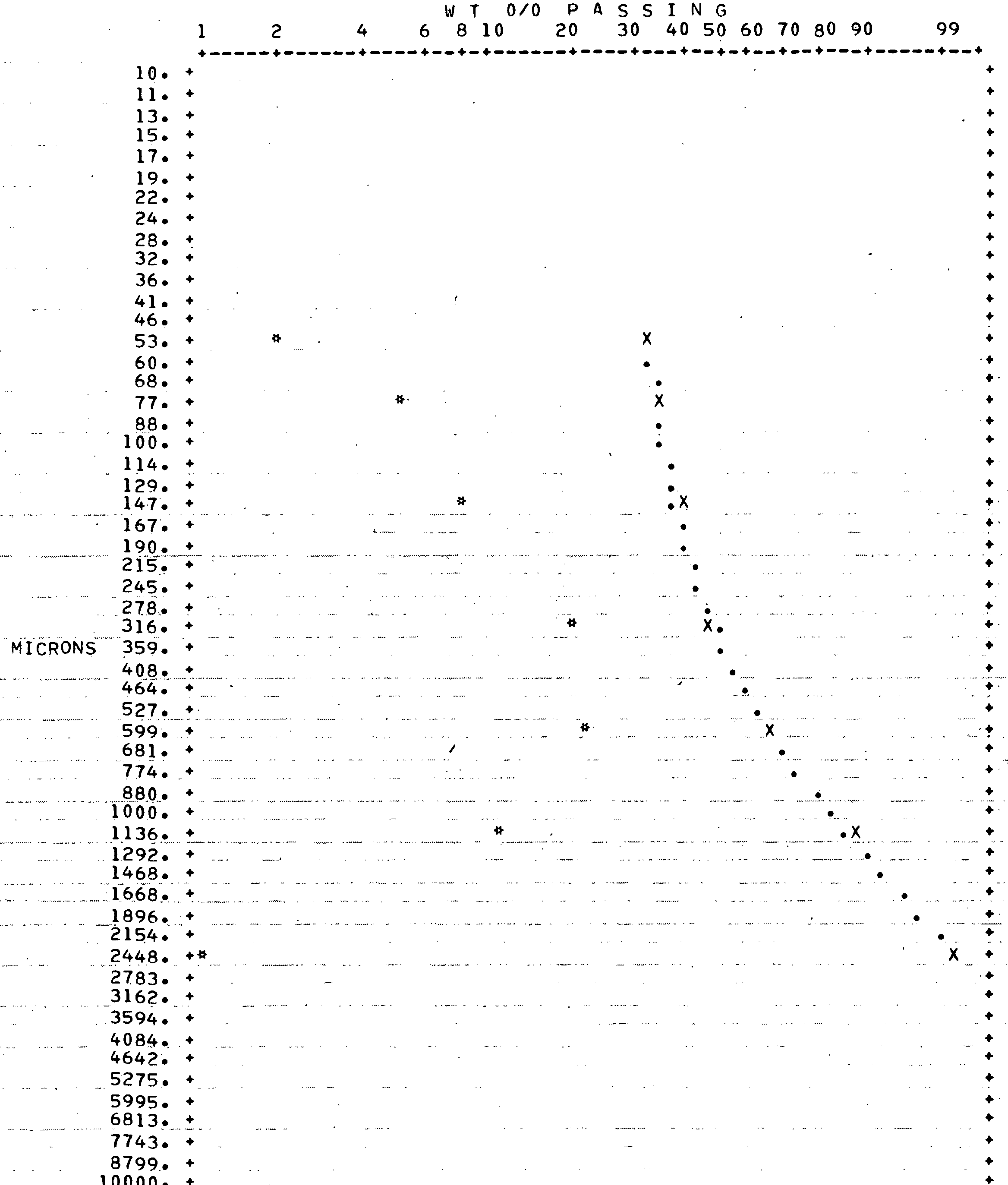
ROSIN RAMMLER PLOT

* = INDIVIDUAL WT. 0/0 RETAINED
* AT 1 0/0 MEANS 1 0/0 OR LESS

X = ACTUAL VALUE

. = BEST FIT LINE USED

THE MICRON VALUES REFER TO THE LINE PRINTER PLOT
POSITIONS AND NOT TO SCREEN APERTURES
USE OF THE LINE PRINTER PLOT IS NOT
RECOMMENDED FOR ACCURATE INTERPOLATION



W T 0/0 P A S S I N G
1 2 4 6 8 10 20 30 40 50 60 70 80 90 99
MICRONS
10. 11. 13. 15. 17. 19. 22. 24. 28. 32. 36. 41. 46. 53. 60. 68. 77. 88. 100. 114. 129. 147. 167. 190. 215. 245. 278. 316. 359. 408. 464. 527. 599. 681. 774. 880. 1000. 1136. 1292. 1468. 1668. 1896. 2154. 2448. 2783. 3162. 3594. 4084. 4642. 5275. 5995. 6813. 7743. 8799. 10000.

1/1/172 H50 NO 28

WET SCREENED ON 300# SCREENING TIME 15 MINS.

80 0/0 PASSING SIZE = 45. MICRONS

AVERAGE SLOPE = .2 INTERCEPT = 4.5 INCHES

SCREEN SIZE OR CONE NO.	SIZE IN MICRONS	WEIGHT 0/0 RETAINED	CUMULATIVE WEIGHT 0/0	CUMULATIVE WT 0/0 PASSING
7	2400.00	.37	.37	99.63
14	1200.00	1.42	1.79	98.21
25	600.00	1.87	3.65	96.35
52	300.00	3.39	7.05	92.95
100	150.00	5.27	12.32	87.68
200	75.00	4.15	16.47	83.53
300	53.00	1.46	17.93	82.07
-300	-53.00	82.07	100.00	.00

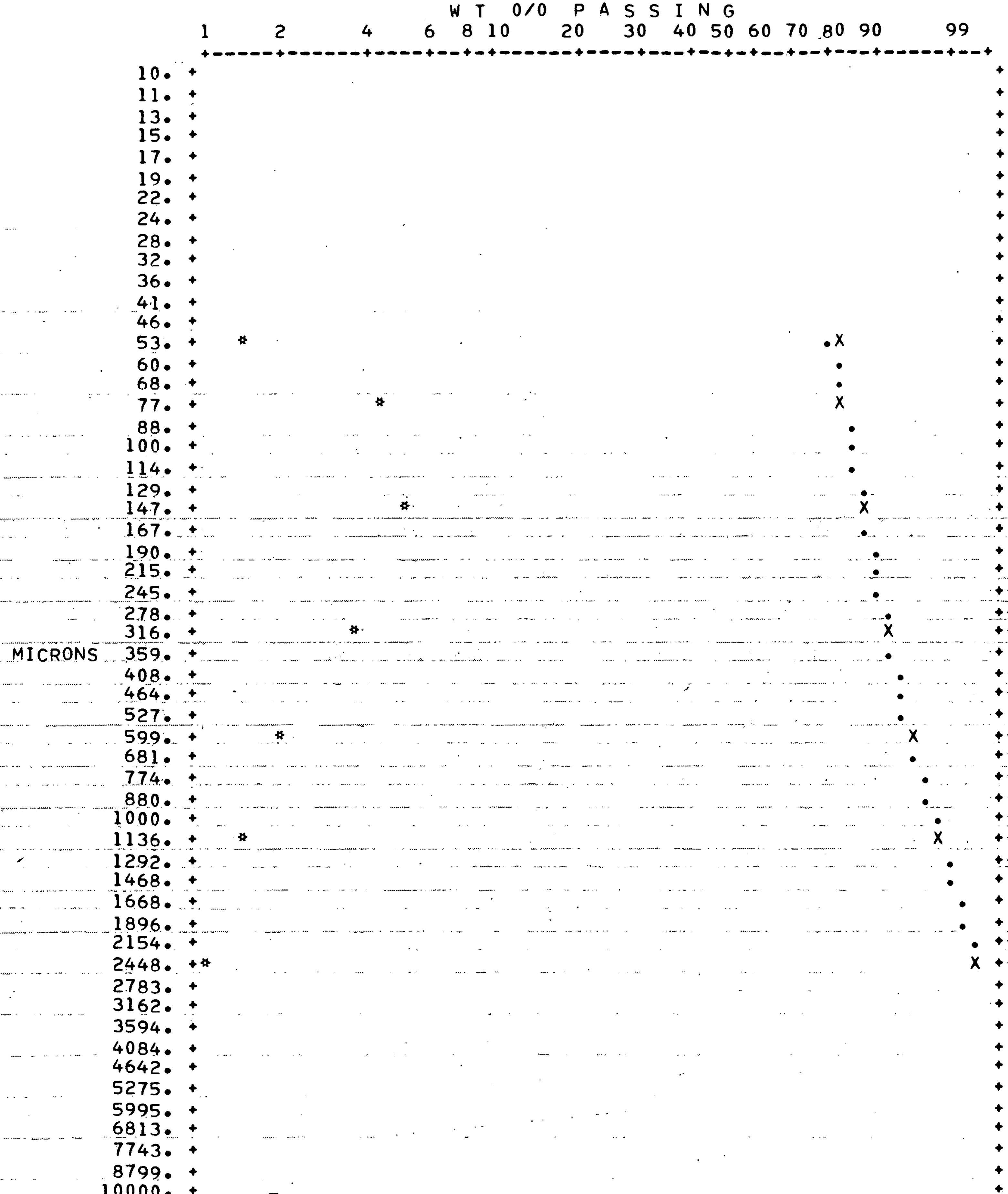
ROSIN RAMMLER PLOT

* = INDIVIDUAL WT. 0/0 RETAINED
* AT 1 0/0 MEANS 1 0/0 OR LESS

X = ACTUAL VALUE

. = BEST FIT LINE USED

THE MICRON VALUES REFER TO THE LINE PRINTER PLOT
POSITIONS AND NOT TO SCREEN APERTURES
USE OF THE LINE PRINTER PLOT IS NOT
RECOMMENDED FOR ACCURATE INTERPOLATION


W T 0/0 P A S S I N G
1 2 4 6 8 10 20 30 40 50 60 70 80 90 99
MICRONS
10. 11. 13. 15. 17. 19. 22. 24. 28. 32. 36. 41. 46. 53. 60. 68. 77. 88. 100. 114. 129. 147. 167. 190. 215. 245. 278. 316. 359. 408. 464. 527. 599. 681. 774. 880. 1000. 1136. 1292. 1468. 1668. 1896. 2154. 2448. 2783. 3162. 3594. 4084. 4642. 5275. 5995. 6813. 7743. 8799. 10000.

1/1/172 H50 NO 27

WET SCREENED ON 300# SCREENING TIME 15 MINS.

80 0/0 PASSING SIZE = 1163. MICRONS

AVERAGE SLOPE = .5 INTERCEPT = 2.3 INCHES

SCREEN SIZE OR CONE NO.	SIZE IN MICRONS	WEIGHT 0/0 RETAINED	CUMULATIVE WEIGHT 0/0	CUMULATIVE WT 0/0 PASSING
188	4763.00	.79	.79	99.21
7	2400.00	3.92	4.71	95.29
14	1200.00	15.54	20.24	79.76
25	600.00	17.90	38.15	61.85
52	300.00	16.80	54.95	45.05
100	150.00	8.75	63.70	36.30
200	75.00	4.62	68.32	31.68
300	53.00	1.42	69.74	30.26
-300	-53.00	30.26	100.00	-.00

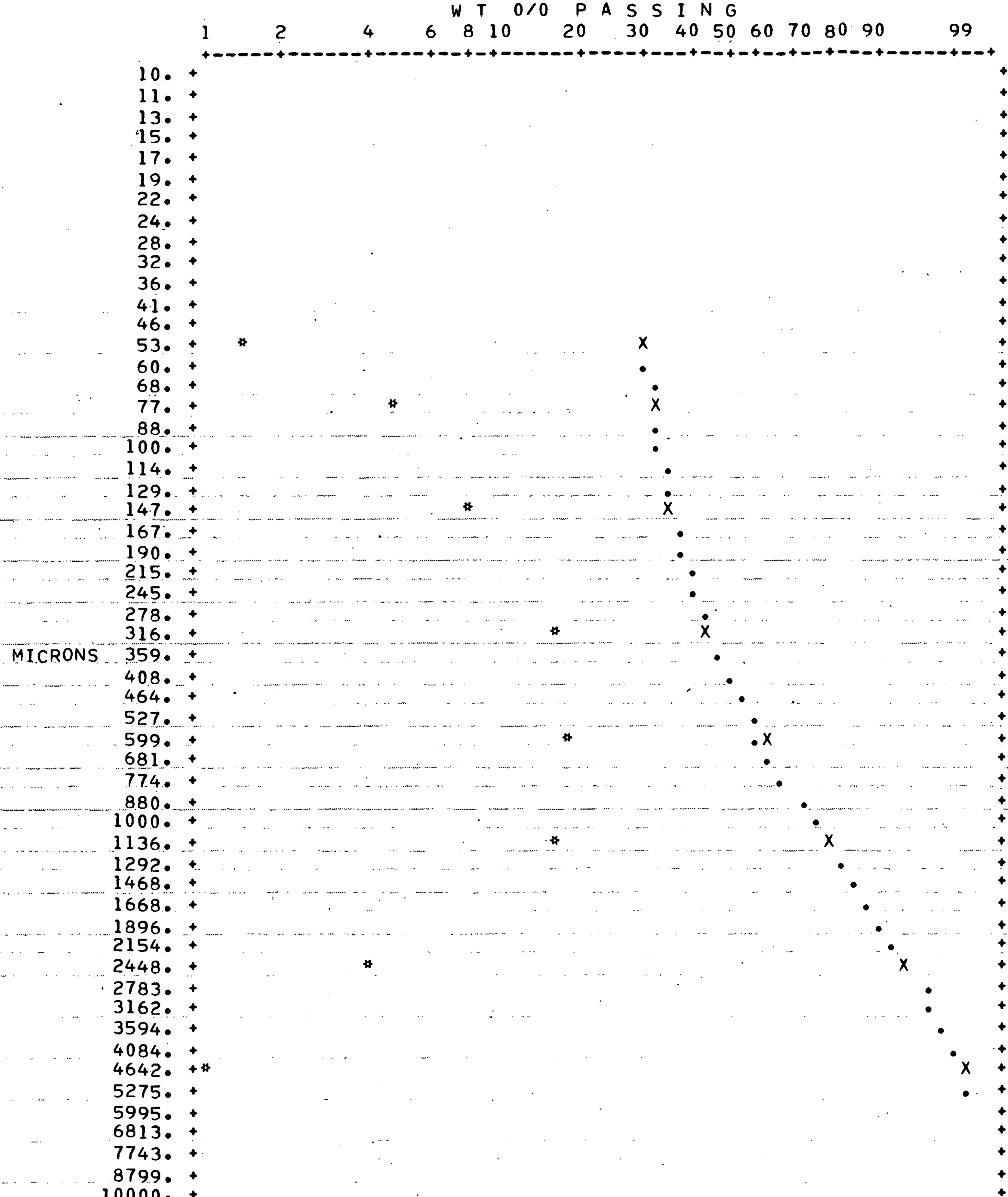
ROSIN RAMMLER PLOT

* = INDIVIDUAL WT. 0/0 RETAINED
* AT 1 0/0 MEANS 1 0/0 OR LESS

X = ACTUAL VALUE

. = BEST FIT LINE USED

THE MICRON VALUES REFER TO THE LINE PRINTER PLOT
POSITIONS AND NOT TO SCREEN APERTURES
USE OF THE LINE PRINTER PLOT IS NOT
RECOMMENDED FOR ACCURATE INTERPOLATION


W T 0/0 P A S S I N G
1 2 4 6 8 10 20 30 40 50 60 70 80 90 99
MICRONS
10. 11. 13. 15. 17. 19. 22. 24. 28. 32. 36. 41. 46. 53. 60. 68. 77. 88. 100. 114. 129. 147. 167. 190. 215. 245. 278. 316. 359. 408. 464. 527. 599. 681. 774. 880. 1000. 1136. 1292. 1468. 1668. 1896. 2154. 2448. 2783. 3162. 3594. 4084. 4642. 5275. 5995. 6813. 7743. 8799. 10000.

1/1/172 H50 NO 31

WET SCREENED ON 300# SCREENING TIME 15 MINS.

80 0/0 PASSING SIZE = 836. MICRONS

AVERAGE SLOPE = .5 INTERCEPT = 2.4 INCHES

SCREEN SIZE OR CONE NO.	SIZE IN MICRONS	WEIGHT 0/0 RETAINED	CUMULATIVE WEIGHT 0/0	CUMULATIVE WT 0/0 PASSING
7	2400.00	2.50	2.50	97.50
14	1200.00	8.68	11.19	88.81
25	600.00	17.51	28.70	71.30
52	300.00	21.01	49.72	50.28
100	150.00	11.88	61.60	38.40
200	75.00	5.20	66.80	33.20
300	53.00	1.56	68.36	31.64
-300	-53.00	31.64	100.00	.00

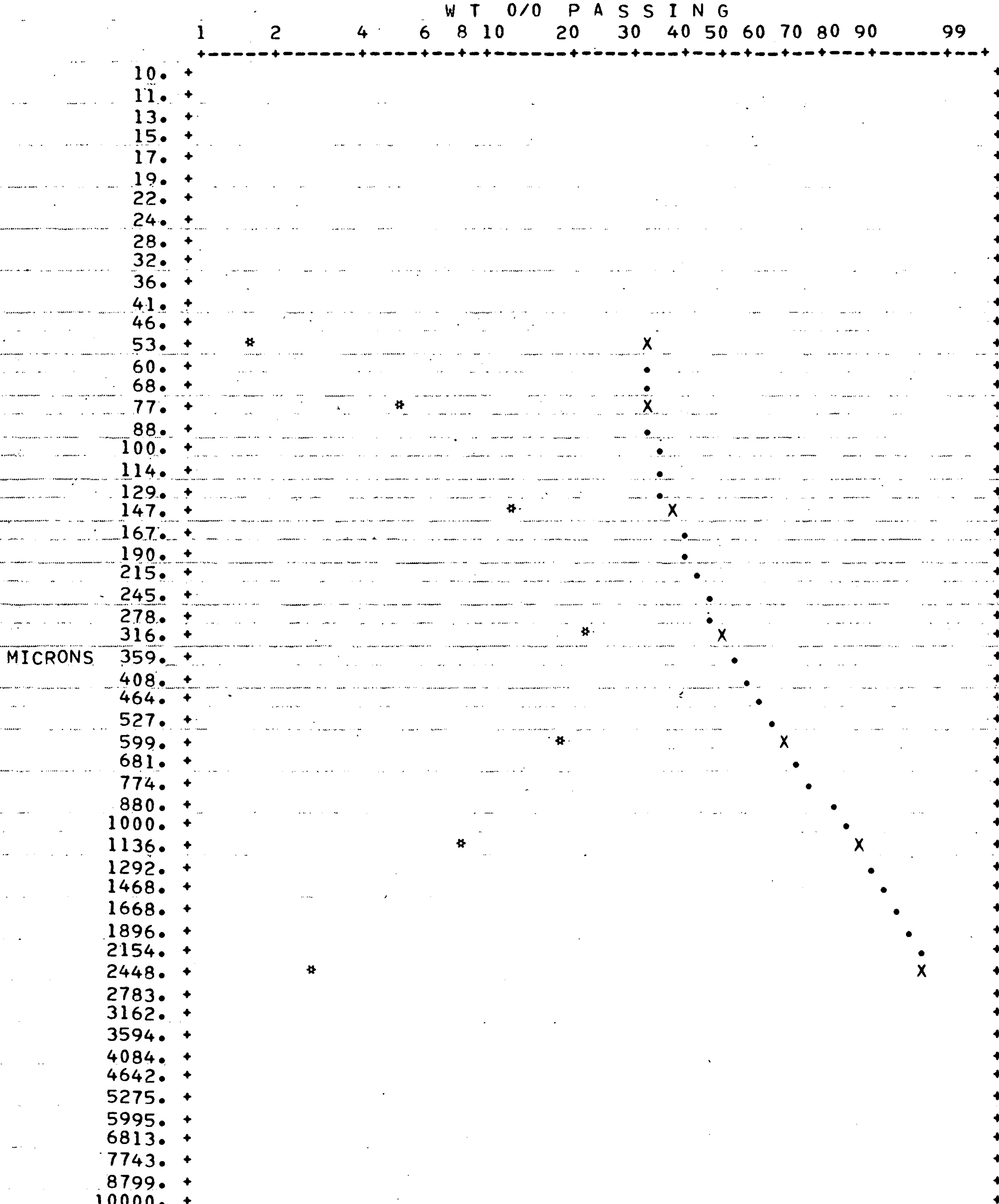
ROSIN RAMMLER PLOT

* = INDIVIDUAL WT. 0/0 RETAINED
* AT 1 0/0 MEANS 1 0/0 OR LESS

X = ACTUAL VALUE

. = BEST FIT LINE USED

THE MICRON VALUES REFER TO THE LINE PRINTER PLOT POSITIONS AND NOT TO SCREEN APERTURES
USE OF THE LINE PRINTER PLOT IS NOT RECOMMENDED FOR ACCURATE INTERPOLATION


W T 0/0 P A S S I N G
1 2 4 6 8 10 20 30 40 50 60 70 80 90 99
MICRONS
10. 11. 13. 15. 17. 19. 22. 24. 28. 32. 36. 41. 46. 53. 60. 68. 77. 88. 100. 114. 129. 147. 167. 190. 215. 245. 278. 316. 359. 408. 464. 527. 599. 681. 774. 880. 1000. 1136. 1292. 1468. 1668. 1896. 2154. 2448. 2783. 3162. 3594. 4084. 4642. 5275. 5995. 6813. 7743. 8799. 10000.

1/1/172 H50 NO 32

WET SCREENED ON 300# SCREENING TIME 15 MINS.

80 0/0 PASSING SIZE = 1519. MICRONS

AVERAGE SLOPE = .4 INTERCEPT = 2.6 INCHES

SCREEN SIZE OR CONE NO.	SIZE IN MICRONS	WEIGHT 0/0 RETAINED	CUMULATIVE WEIGHT 0/0	CUMULATIVE WT 0/0 PASSING
188	4763.00	7.00	7.00	93.00
7	2400.00	5.58	12.58	87.42
14	1200.00	12.59	25.17	74.83
25	600.00	16.70	41.87	58.13
52	300.00	15.74	57.61	42.39
100	150.00	7.60	65.21	34.79
200	75.00	3.83	69.04	30.96
300	53.00	1.31	70.35	29.65
-300	-53.00	29.65	100.00	.00

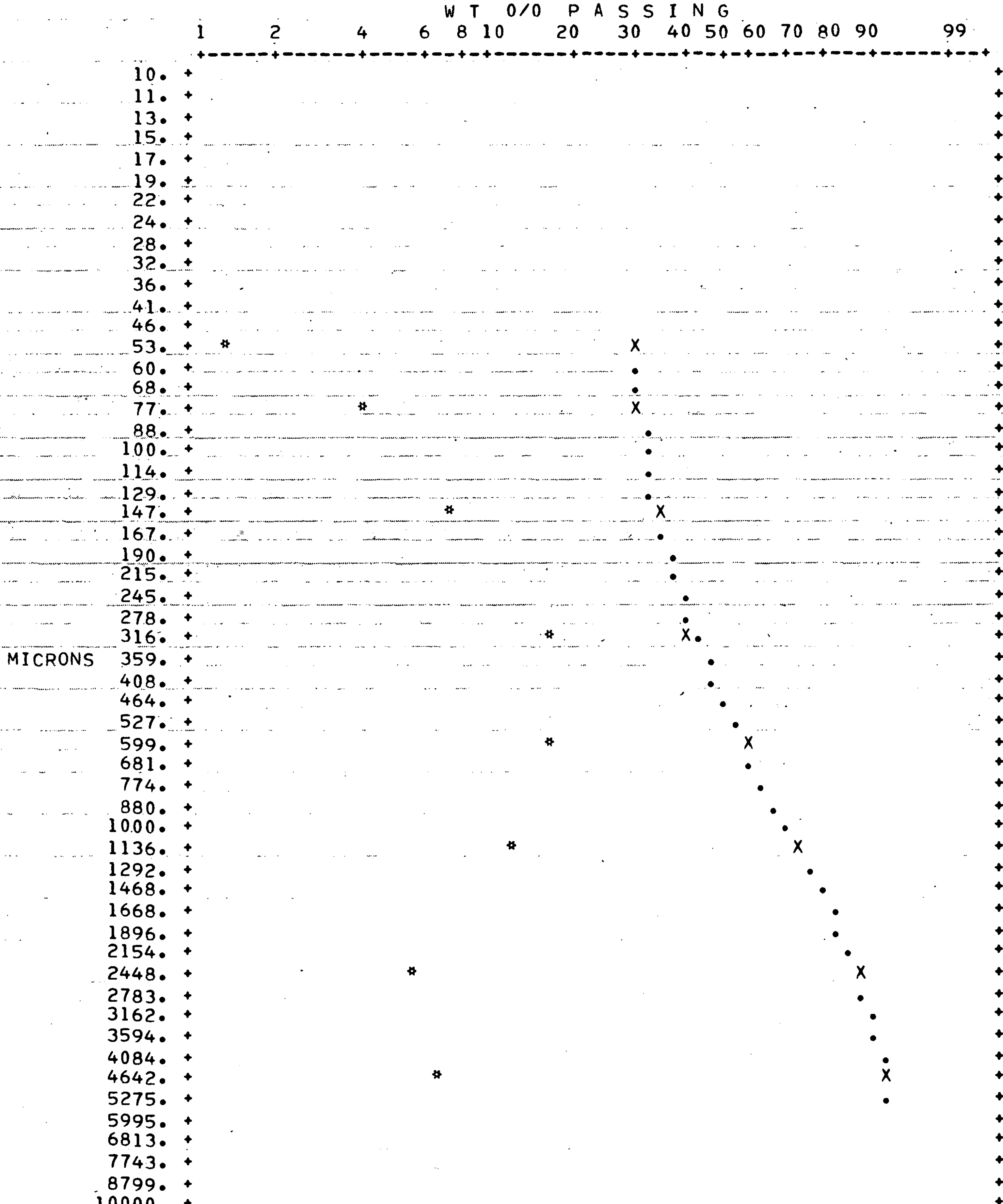
ROSIN RAMMLER PLOT

* = INDIVIDUAL WT. 0/0 RETAINED
* AT 1 0/0 MEANS 1 0/0 OR LESS

X = ACTUAL VALUE

. = BEST FIT LINE USED

THE MICRON VALUES REFER TO THE LINE PRINTER PLOT
POSITIONS AND NOT TO SCREEN APERTURES
USE OF THE LINE PRINTER PLOT IS NOT
RECOMMENDED FOR ACCURATE INTERPOLATION



W T 0/0 P A S S I N G
1 2 4 6 8 10 20 30 40 50 60 70 80 90 99
MICRONS
10.
11.
13.
15.
17.
19.
22.
24.
28.
32.
36.
41.
46.
53.
60.
68.
77.
88.
100.
114.
129.
147.
167.
190.
215.
245.
278.
316.
359.
408.
464.
527.
599.
681.
774.
880.
1000.
1136.
1292.
1468.
1668.
1896.
2154.
2448.
2783.
3162.
3594.
4084.
4642.
5275.
5995.
6813.
7743.
8799.
10000.

1/1/172 H50 NO 33

WET SCREENED ON 300# SCREENING TIME 15 MINS.

80 0/0 PASSING SIZE = 632. MICRONS

AVERAGE SLOPE = .3 INTERCEPT = 3.4 INCHES

SCREEN SIZE OR CONE NO.	SIZE IN MICRONS	WEIGHT 0/0 RETAINED	CUMULATIVE WEIGHT 0/0	CUMULATIVE WT 0/0 PASSING
188	4763.00	.27	.27	99.73
7	2400.00	2.88	3.15	96.85
14	1200.00	6.48	9.62	90.38
25	600.00	10.50	20.12	79.88
52	300.00	13.89	34.01	65.99
100	150.00	6.45	40.46	59.54
200	75.00	2.76	43.22	56.78
300	53.00	.89	44.12	55.88
-300	-53.00	55.88	100.00	.00

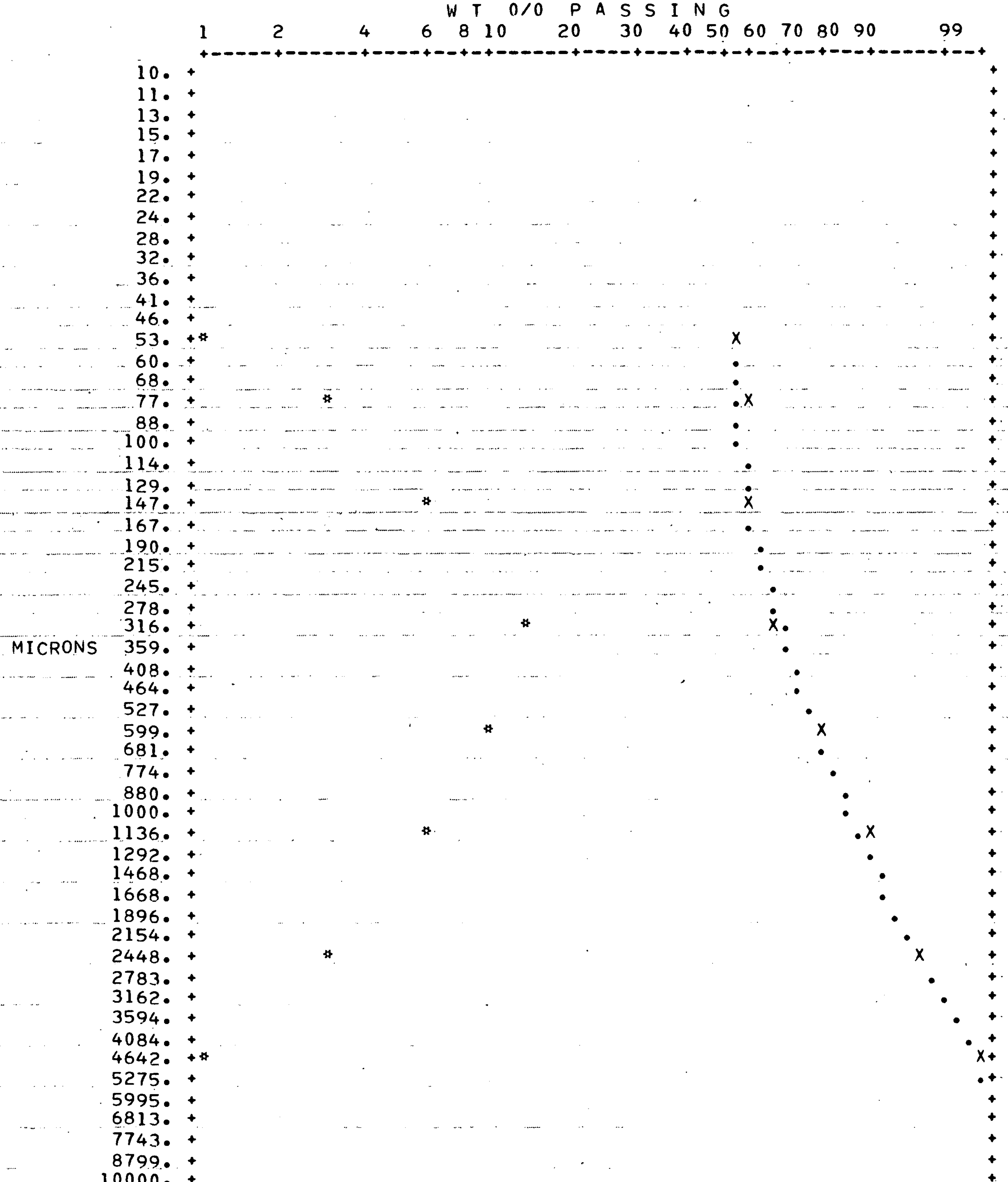
ROSIN RAMMLER PLOT

* = INDIVIDUAL WT. 0/0 RETAINED
* AT 1 0/0 MEANS 1 0/0 OR LESS

X = ACTUAL VALUE

. = BEST FIT LINE USED

THE MICRON VALUES REFER TO THE LINE PRINTER PLOT
POSITIONS AND NOT TO SCREEN APERTURES
USE OF THE LINE PRINTER PLOT IS NOT
RECOMMENDED FOR ACCURATE INTERPOLATION


W T 0/0 P A S S I N G
1 2 4 6 8 10 20 30 40 50 60 70 80 90 99
MICRONS
10.
11.
13.
15.
17.
19.
22.
24.
28.
32.
36.
41.
46.
53.
60.
68.
77.
88.
100.
114.
129.
147.
167.
190.
215.
245.
278.
316.
359.
408.
464.
527.
599.
681.
774.
880.
1000.
1136.
1292.
1468.
1668.
1896.
2154.
2448.
2783.
3162.
3594.
4084.
4642.
5275.
5995.
6813.
7743.
8799.
10000.

1/1/172 H50 NO 34

WET SCREENED ON 300# SCREENING TIME 15 MINS.

80 0/0 PASSING SIZE = . MICRONS

AVERAGE SLOPE = .2 INTERCEPT = 5.1 INCHES

SCREEN SIZE OR CONE NO.	SIZE IN MICRONS	WEIGHT 0/0 RETAINED	CUMULATIVE WEIGHT 0/0	CUMULATIVE WT 0/0 PASSING
7	2400.00	.72	.72	99.28
14	1200.00	.26	.98	99.02
25	600.00	1.13	2.11	97.89
52	300.00	2.14	4.26	95.74
100	150.00	2.05	6.31	93.69
200	75.00	1.90	8.21	91.79
300	53.00	.68	8.89	91.11
-300	-53.00	91.11	100.00	-.00

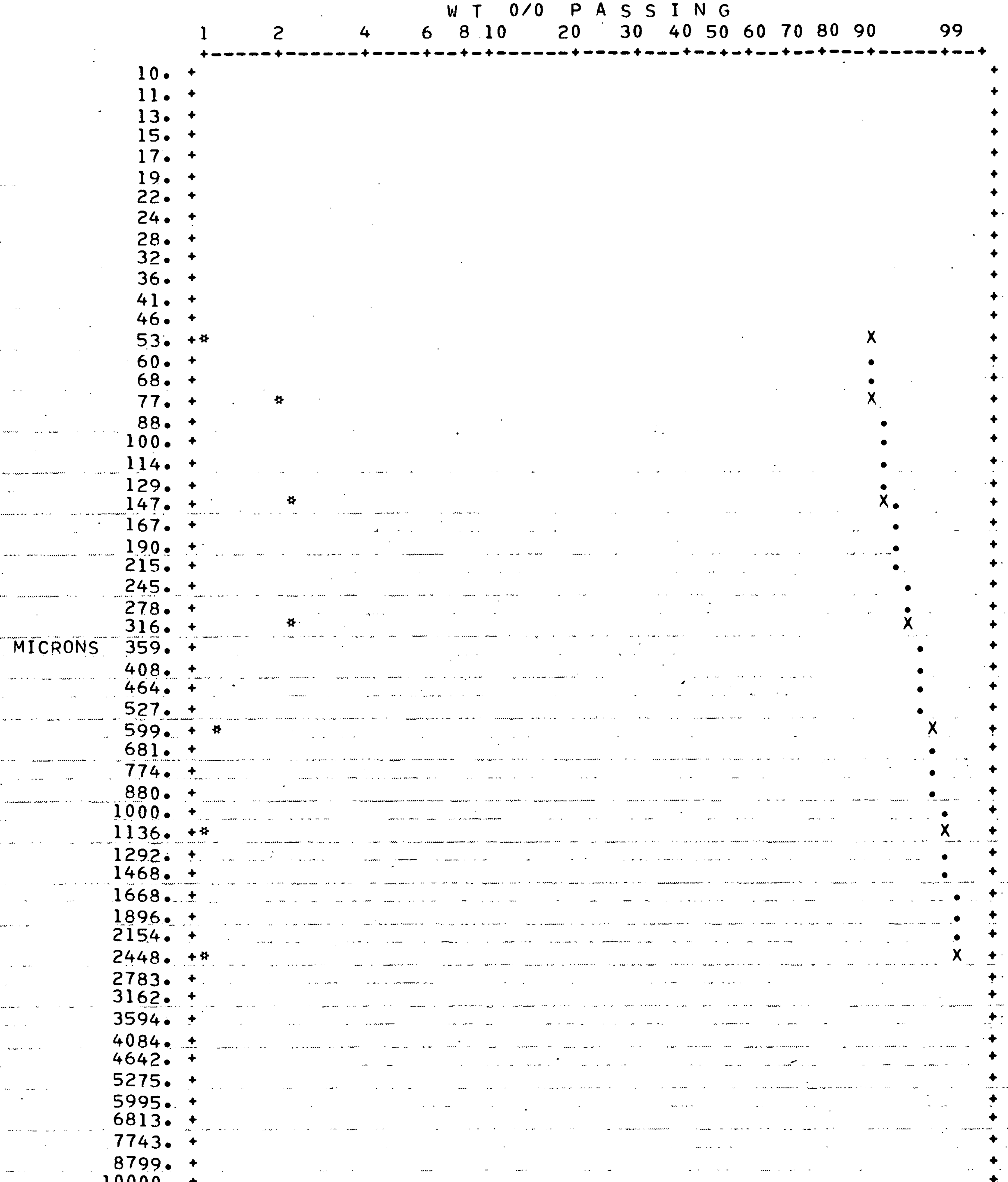
ROSIN RAMMLER PLOT

* = INDIVIDUAL WT. 0/0 RETAINED
* AT 1 0/0 MEANS 1 0/0 OR LESS

X = ACTUAL VALUE

. = BEST FIT LINE USED

THE MICRON VALUES REFER TO THE LINE PRINTER PLOT
POSITIONS AND NOT TO SCREEN APERTURES
USE OF THE LINE PRINTER PLOT IS NOT
RECOMMENDED FOR ACCURATE INTERPOLATION


W T 0/0 P A S S I N G
1 2 4 6 8 10 20 30 40 50 60 70 80 90 99
MICRONS
10.
11.
13.
15.
17.
19.
22.
24.
28.
32.
36.
41.
46.
53.
60.
68.
77.
88.
100.
114.
129.
147.
167.
190.
215.
245.
278.
316.
359.
408.
464.
527.
599.
681.
774.
880.
1000.
1136.
1292.
1468.
1668.
1896.
2154.
2448.
2783.
3162.
3594.
4084.
4642.
5275.
5995.
6813.
7743.
8799.
10000.

1/1/172 H50 NO 35

WET SCREENED ON 300# SCREENING TIME 15 MINS.

80 0/0 PASSING SIZE = . MICRONS

AVERAGE SLOPE = .2 INTERCEPT = 5.3 INCHES

SCREEN SIZE OR CONE NO.	SIZE IN MICRONS	WEIGHT 0/0 RETAINED	CUMULATIVE WEIGHT 0/0	CUMULATIVE WT 0/0 PASSING
25	600.00	.25	.25	99.75
52	300.00	1.16	1.41	98.59
100	150.00	1.07	2.48	97.52
200	75.00	.78	3.26	96.74
300	53.00	.29	3.55	96.45
-300	-53.00	96.45	100.00	.00

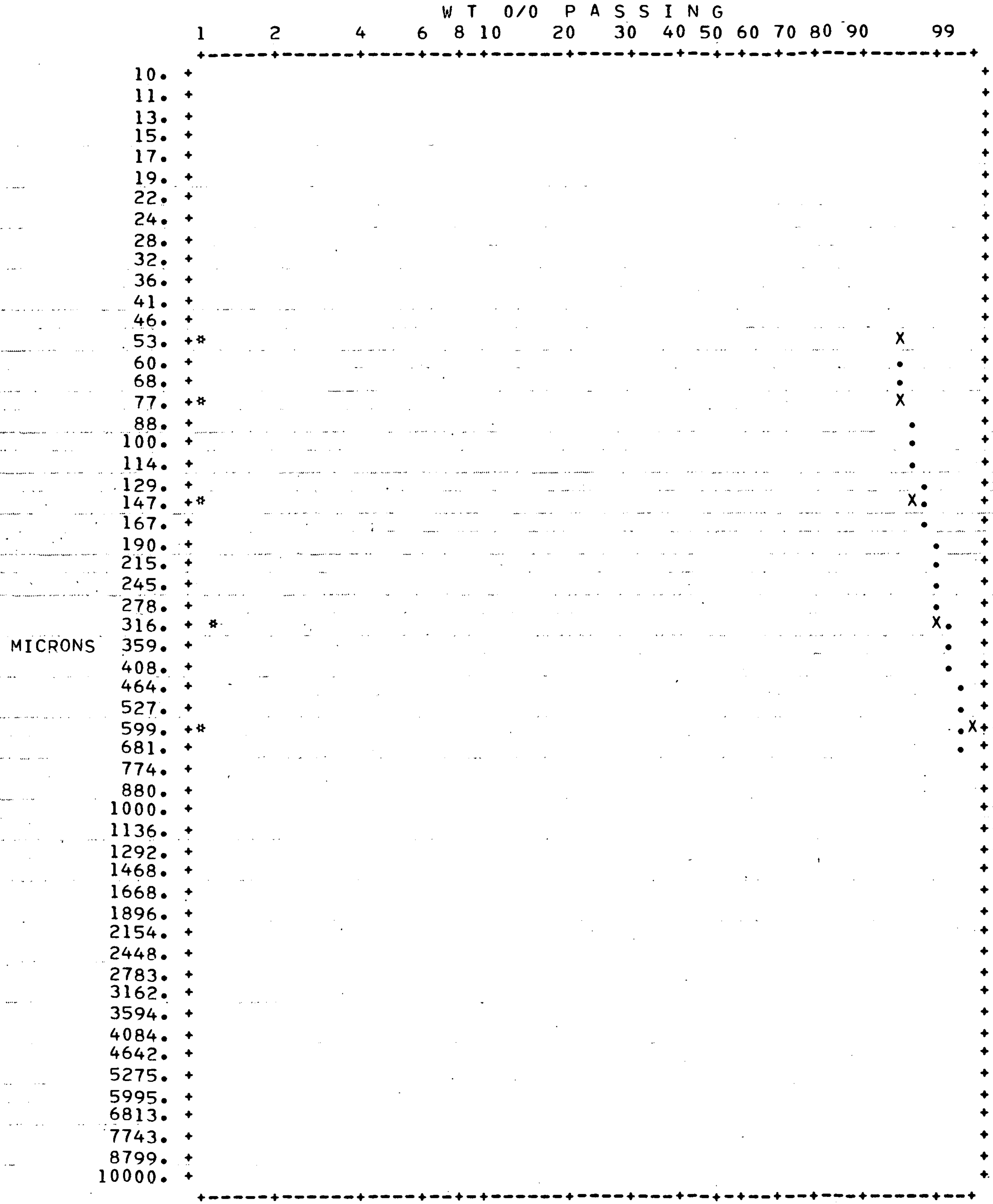
ROSIN RAMMLER PLOT

* = INDIVIDUAL WT. 0/0 RETAINED
* AT 1 0/0 MEANS 1 0/0 OR LESS

X = ACTUAL VALUE

. = BEST FIT LINE USED

THE MICRON VALUES REFER TO THE LINE PRINTER PLOT
POSITIONS AND NOT TO SCREEN APERTURES
USE OF THE LINE PRINTER PLOT IS NOT
RECOMMENDED FOR ACCURATE INTERPOLATION


W T 0/0 P A S S I N G
1 2 4 6 8 10 20 30 40 50 60 70 80 90 99
MICRONS
10. 11. 13. 15. 17. 19. 22. 24. 28. 32. 36. 41. 46. 53. 60. 68. 77. 88. 100. 114. 129. 147. 167. 190. 215. 245. 278. 316. 359. 408. 464. 527. 599. 681. 774. 880. 1000. 1136. 1292. 1468. 1668. 1896. 2154. 2448. 2783. 3162. 3594. 4084. 4642. 5275. 5995. 6813. 7743. 8799. 10000.

1/1/172   H190 NO 16

WET SCREENED ON 300# SCREENING TIME 15 MINS.

80 0/0 PASSING SIZE =   1665. MICRONS

AVERAGE SLOPE =   .4   INTERCEPT =   2.1 INCHES

SCREEN SIZE OR CONE NO.	SIZE IN MICRONS	WEIGHT 0/0 RETAINED	CUMULATIVE WEIGHT 0/0	CUMULATIVE WT 0/0 PASSING
7	2400.00	8.55	8.55	91.45
14	1200.00	20.64	29.19	70.81
25	600.00	12.95	42.14	57.86
52	300.00	11.94	54.08	45.92
100	150.00	11.30	65.38	34.62
200	75.00	10.40	75.78	24.22
300	53.00	3.70	79.48	20.52
-300	-53.00	20.52	100.00	-.00

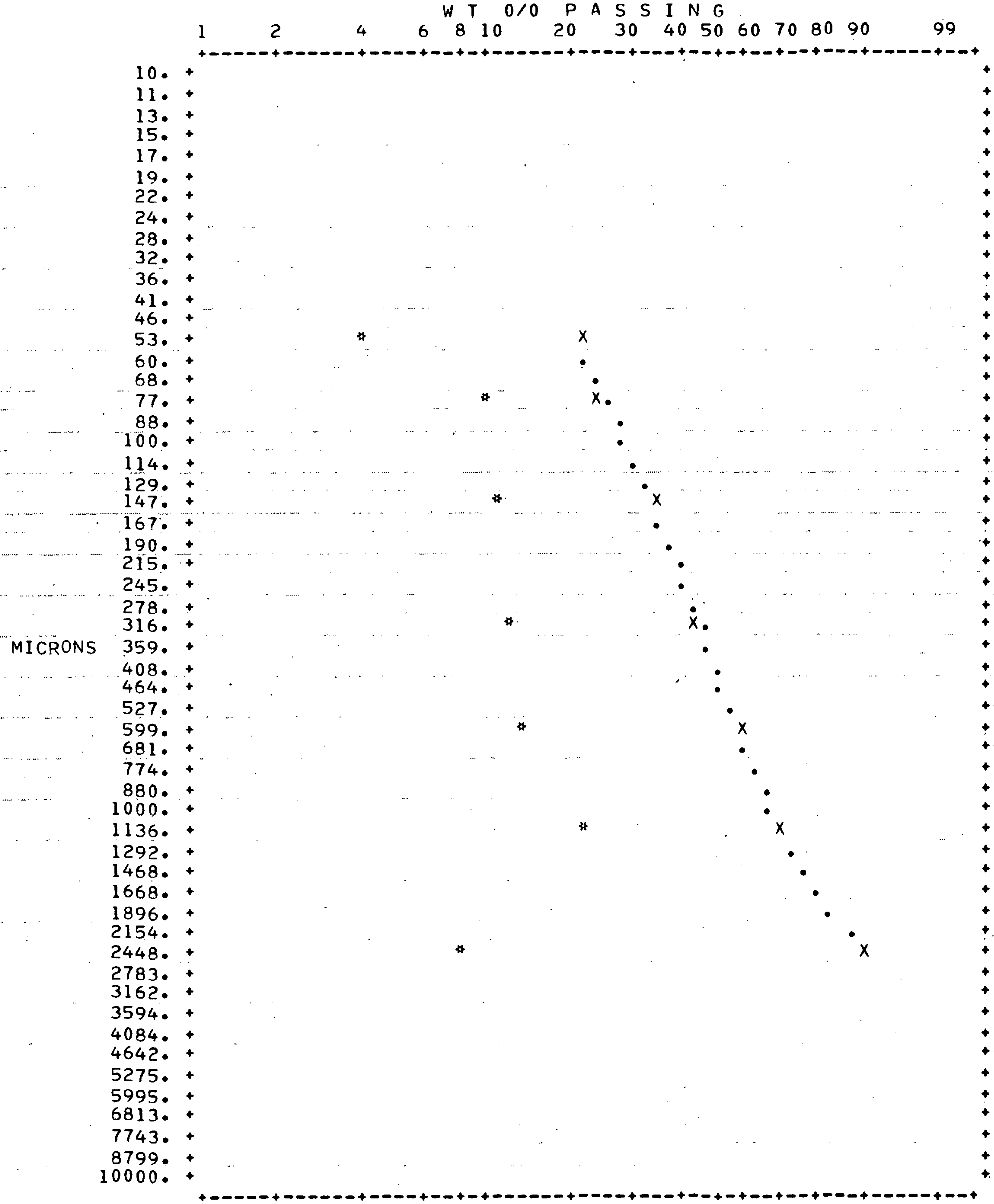
ROSIN RAMMLER PLOT

* = INDIVIDUAL WT. 0/0 RETAINED
* AT 1 0/0 MEANS 1 0/0 OR LESS

X = ACTUAL VALUE

. = BEST FIT LINE USED

THE MICRON VALUES REFER TO THE LINE PRINTER PLOT
POSITIONS AND NOT TO SCREEN APERTURES
USE OF THE LINE PRINTER PLOT IS NOT
RECOMMENDED FOR ACCURATE INTERPOLATION



W T 0/0 P A S S I N G
1 2 4 6 8 10 20 30 40 50 60 70 80 90 99
MICRONS
10.
11.
13.
15.
17.
19.
22.
24.
28.
32.
36.
41.
46.
53.
60.
68.
77.
88.
100.
114.
129.
147.
167.
190.
215.
245.
278.
316.
359.
408.
464.
527.
599.
681.
774.
880.
1000.
1136.
1292.
1468.
1668.
1896.
2154.
2448.
2783.
3162.
3594.
4084.
4642.
5275.
5995.
6813.
7743.
8799.
10000.

1/1/172 H190 NO 17

WET SCREENED ON 300# SCREENING TIME 15 MINS.

80 0/0 PASSING SIZE = 923. MICRONS

AVERAGE SLOPE = .6 INTERCEPT = 1.2 INCHES

SCREEN SIZE OR CONE NO.	SIZE IN MICRONS	WEIGHT 0/0 RETAINED	CUMULATIVE WEIGHT 0/0	CUMULATIVE WT 0/0 PASSING
7	2400.00	4.71	4.71	95.29
14	1200.00	9.61	14.32	85.68
25	600.00	18.04	32.36	67.64
52	300.00	24.14	56.50	43.50
100	150.00	16.77	73.27	26.73
200	75.00	11.33	84.60	15.40
300	53.00	2.77	87.37	12.63
-300	-53.00	12.63	100.00	.00

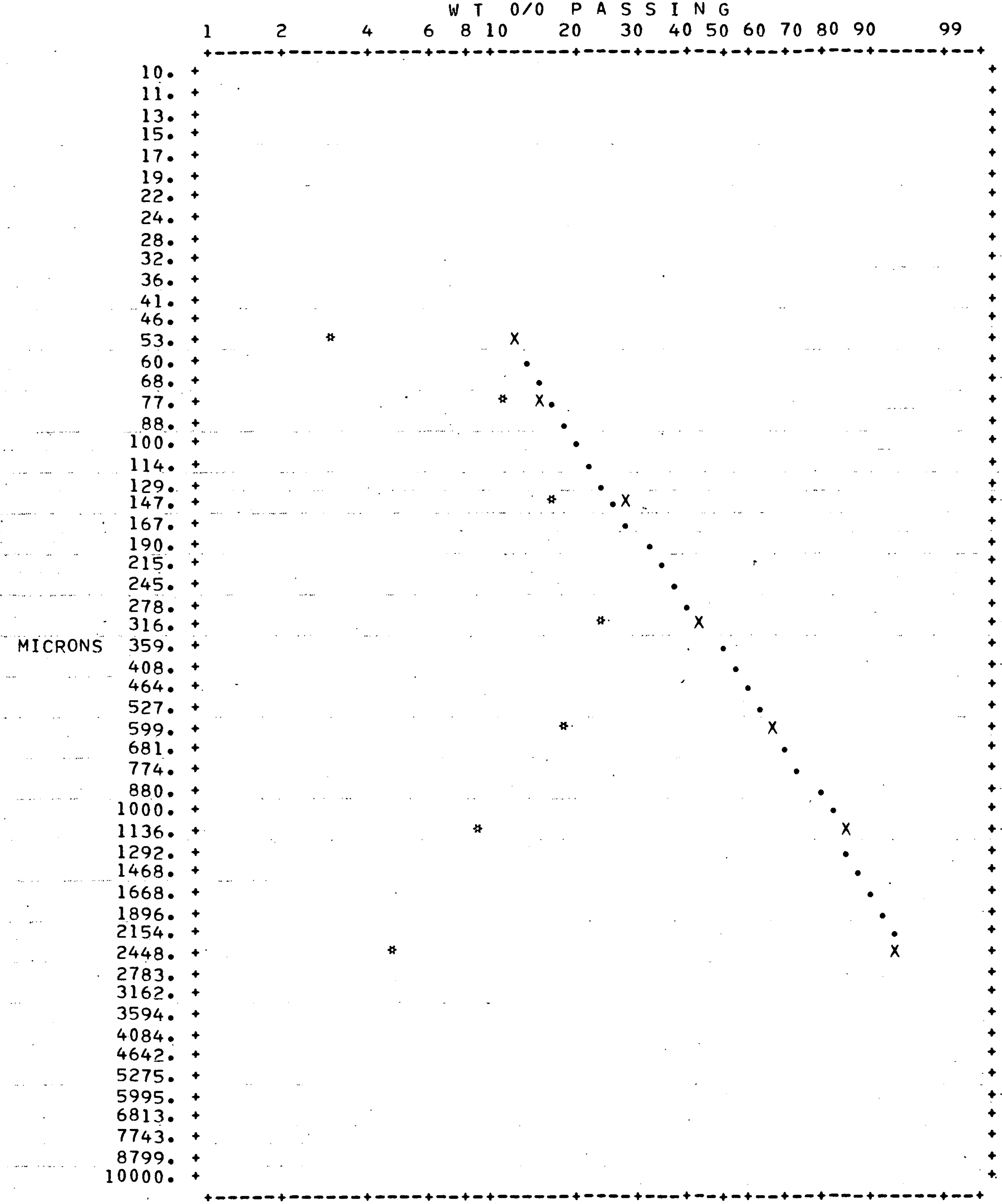
ROSIN RAMMLER PLOT

* = INDIVIDUAL WT. 0/0 RETAINED
* AT 1 0/0 MEANS 1 0/0 OR LESS

X = ACTUAL VALUE

. = BEST FIT LINE USED

THE MICRON VALUES REFER TO THE LINE PRINTER PLOT
POSITIONS AND NOT TO SCREEN APERTURES
USE OF THE LINE PRINTER PLOT IS NOT
RECOMMENDED FOR ACCURATE INTERPOLATION


W T 0/0 P A S S I N G
1 2 4 6 8 10 20 30 40 50 60 70 80 90 99
MICRONS
10. 11. 13. 15. 17. 19. 22. 24. 28. 32. 36. 41. 46. 53. 60. 68. 77. 88. 100. 114. 129. 147. 167. 190. 215. 245. 278. 316. 359. 408. 464. 527. 599. 681. 774. 880. 1000. 1136. 1292. 1468. 1668. 1896. 2154. 2448. 2783. 3162. 3594. 4084. 4642. 5275. 5995. 6813. 7743. 8799. 10000.

1/1/172 H190 NO 18

WET SCREENED ON 300# SCREENING TIME 15 MINS.

80 0/0 PASSING SIZE = 736. MICRONS

AVERAGE SLOPE = .5 INTERCEPT = 2.2 INCHES

SCREEN SIZE OR CONE NO.	SIZE IN MICRONS	WEIGHT 0/0 RETAINED	CUMULATIVE WEIGHT 0/0	CUMULATIVE WT 0/0 PASSING
188	4763.00	.92	.92	99.08
7	2400.00	1.75	2.68	97.32
14	1200.00	9.70	12.37	87.63
25	600.00	12.36	24.73	75.27
52	300.00	12.12	36.85	63.15
100	150.00	17.68	54.52	45.48
200	75.00	19.16	73.68	26.32
300	53.00	5.10	78.77	21.23
-300	-53.00	21.23	100.00	-.00

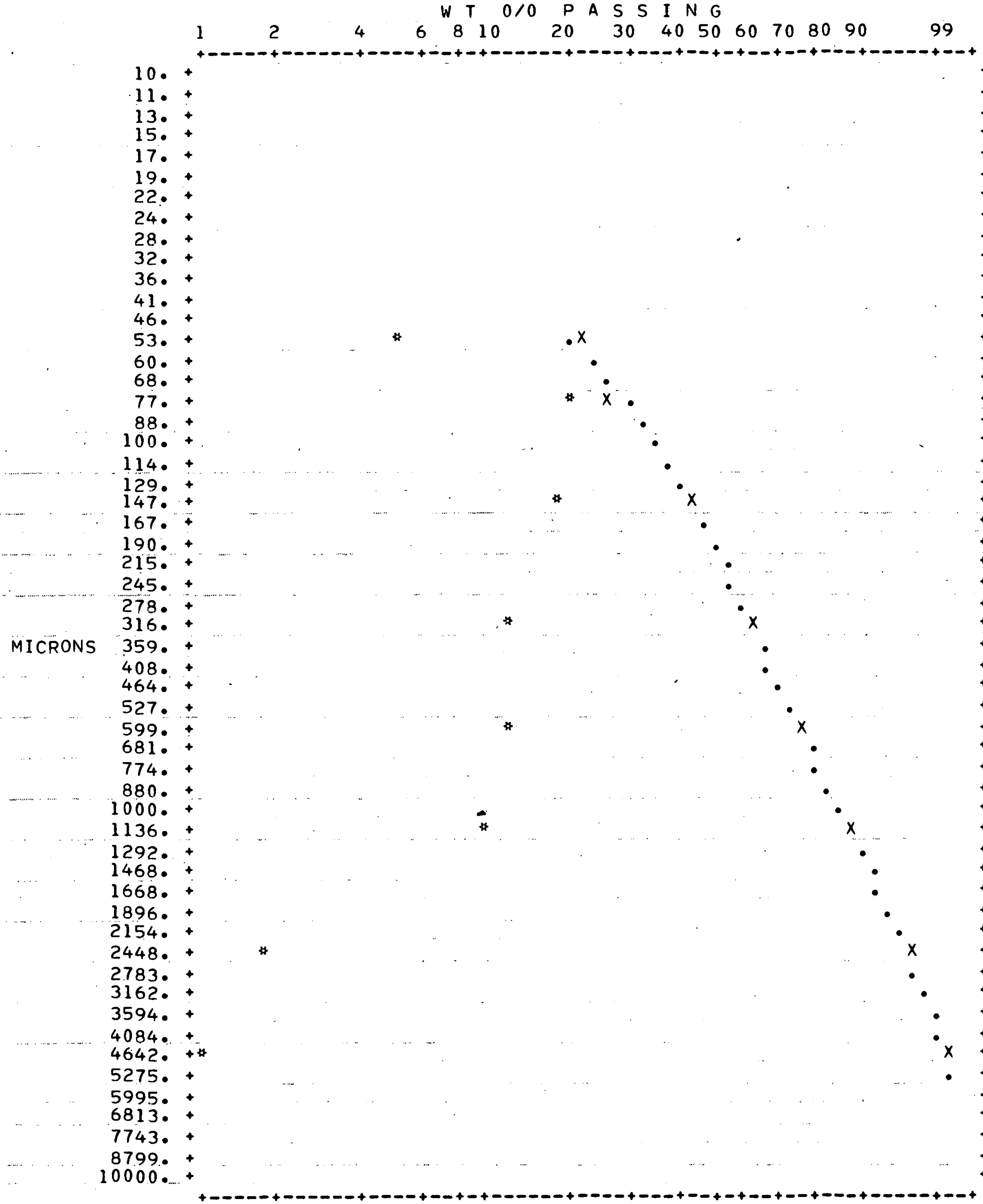
ROSIN RAMMLER PLOT

* = INDIVIDUAL WT. 0/0 RETAINED
* AT 1 0/0 MEANS 1 0/0 OR LESS

X = ACTUAL VALUE

. = BEST FIT LINE USED

THE MICRON VALUES REFER TO THE LINE PRINTER PLOT
POSITIONS AND NOT TO SCREEN APERTURES
USE OF THE LINE PRINTER PLOT IS NOT
RECOMMENDED FOR ACCURATE INTERPOLATION


WT 0/0 PASSING
1 2 4 6 8 10 20 30 40 50 60 70 80 90 99
MICRONS
10. 11. 13. 15. 17. 19. 22. 24. 28. 32. 36. 41. 46. 53. 60. 68. 77. 88. 100. 114. 129. 147. 167. 190. 215. 245. 278. 316. 359. 408. 464. 527. 599. 681. 774. 880. 1000. 1136. 1292. 1468. 1668. 1896. 2154. 2448. 2783. 3162. 3594. 4084. 4642. 5275. 5995. 6813. 7743. 8799. 10000.

1/1/172   H190 NO 19

WET SCREENED ON 300#   SCREENING TIME 15 MINS.

80 0/0 PASSING SIZE =   979. MICRONS

AVERAGE SLOPE =   .7   INTERCEPT =   1.1 INCHES

SCREEN SIZE OR CONE NO.	SIZE IN MICRONS	WEIGHT 0/0 RETAINED	CUMULATIVE WEIGHT 0/0	CUMULATIVE WT 0/0 PASSING
188	4763.00	.23	.23	99.77
7	2400.00	2.80	3.03	96.97
14	1200.00	9.93	12.96	87.04
25	600.00	21.83	34.79	65.21
52	300.00	28.36	63.15	36.85
100	150.00	12.08	75.23	24.77
200	75.00	7.84	83.07	16.93
300	53.00	3.18	86.25	13.75
-300	-53.00	13.75	100.00	-.00

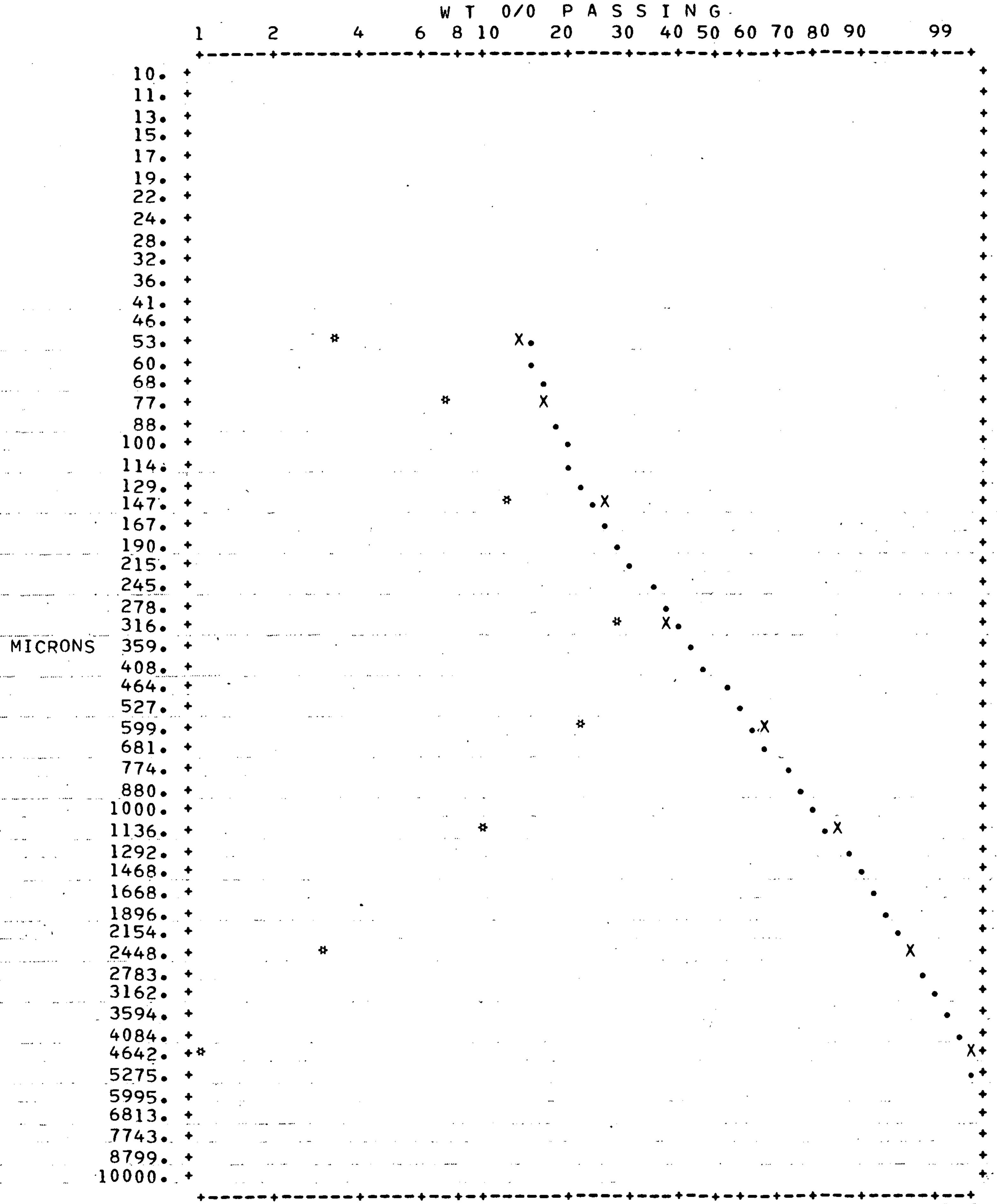
ROSIN RAMMLER PLOT

* = INDIVIDUAL WT. 0/0 RETAINED
* AT 1 0/0 MEANS 1 0/0 OR LESS

X = ACTUAL VALUE

. = BEST FIT LINE USED

THE MICRON VALUES REFER TO THE LINE PRINTER PLOT
POSITIONS AND NOT TO SCREEN APERTURES
USE OF THE LINE PRINTER PLOT IS NOT
RECOMMENDED FOR ACCURATE INTERPOLATION


W T 0/0 P A S S I N G
1 2 4 6 8 10 20 30 40 50 60 70 80 90 99
MICRONS
10. 11. 13. 15. 17. 19. 22. 24. 28. 32. 36. 41. 46. 53. 60. 68. 77. 88. 100. 114. 129. 147. 167. 190. 215. 245. 278. 316. 359. 408. 464. 527. 599. 681. 774. 880. 1000. 1136. 1292. 1468. 1668. 1896. 2154. 2448. 2783. 3162. 3594. 4084. 4642. 5275. 5995. 6813. 7743. 8799. 10000.

1/1/172   H190 NO 20

WET SCREENED ON 300# SCREENING TIME 15 MINS.

80 0/0 PASSING SIZE =   24. MICRONS

AVERAGE SLOPE =   .2   INTERCEPT =   4.8 INCHES

SCREEN SIZE OR CONE NO.	SIZE IN MICRONS	WEIGHT 0/0 RETAINED	CUMULATIVE WEIGHT 0/0	CUMULATIVE WT 0/0 PASSING
7	2400.00	.05	.05	99.95
14	1200.00	.62	.67	99.33
25	600.00	1.56	2.23	97.77
52	300.00	1.28	3.50	96.50
100	150.00	1.89	5.39	94.61
200	75.00	3.91	9.31	90.69
300	53.00	2.32	11.63	88.37
-300	-53.00	88.37	100.00	.00

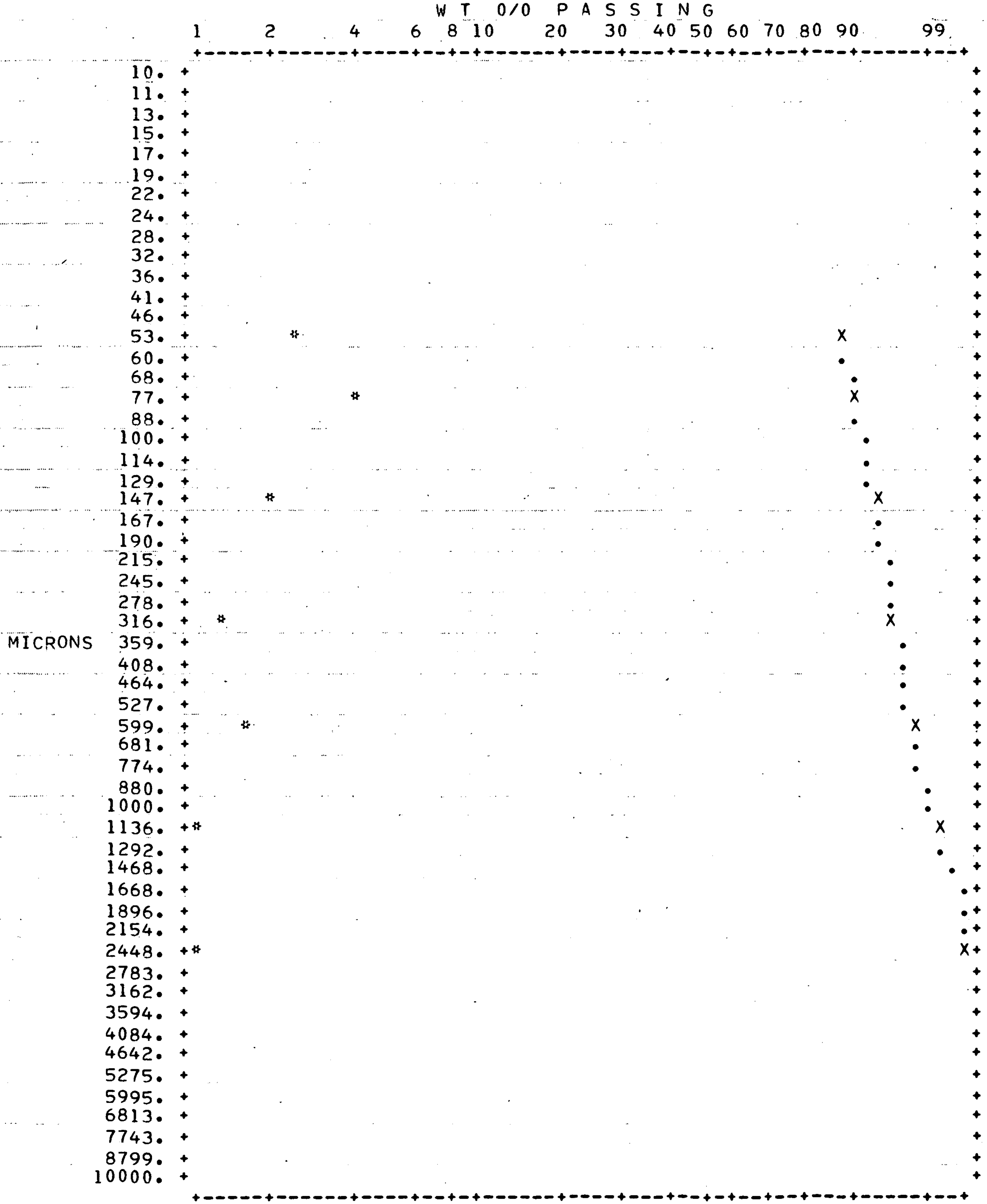
ROSIN RAMMLER PLOT

* = INDIVIDUAL WT. 0/0 RETAINED
* AT 1 0/0 MEANS 1 0/0 OR LESS

X = ACTUAL VALUE

. = BEST FIT LINE USED

THE MICRON VALUES REFER TO THE LINE PRINTER PLOT
POSITIONS AND NOT TO SCREEN APERTURES
USE OF THE LINE PRINTER PLOT IS NOT
RECOMMENDED FOR ACCURATE INTERPOLATION



W T 0/0 P A S S I N G
1 2 4 6 8 10 20 30 40 50 60 70 80 90 99
MICRONS
10.
11.
13.
15.
17.
19.
22.
24.
28.
32.
36.
41.
46.
53.
60.
68.
77.
88.
100.
114.
129.
147.
167.
190.
215.
245.
278.
316.
359.
408.
464.
527.
599.
681.
774.
880.
1000.
1136.
1292.
1468.
1668.
1896.
2154.
2448.
2783.
3162.
3594.
4084.
4642.
5275.
5995.
6813.
7743.
8799.
10000.

1/1/172 H190 NO 21

WET SCREENED ON 300# SCREENING TIME 15 MINS.

80 0/0 PASSING SIZE = 142. MICRONS

AVERAGE SLOPE = .4 INTERCEPT = 3.9 INCHES

SCREEN SIZE OR CONE NO.	SIZE IN MICRONS	WEIGHT 0/0 RETAINED	CUMULATIVE WEIGHT 0/0	CUMULATIVE WT 0/0 PASSING
7	2400.00	.04	.04	99.96
14	1200.00	.84	.87	99.13
25	600.00	4.34	5.22	94.78
52	300.00	7.03	12.24	87.76
100	150.00	7.12	19.36	80.64
200	75.00	5.71	25.07	74.93
300	53.00	2.56	27.63	72.37
-300	-53.00	72.37	100.00	.00

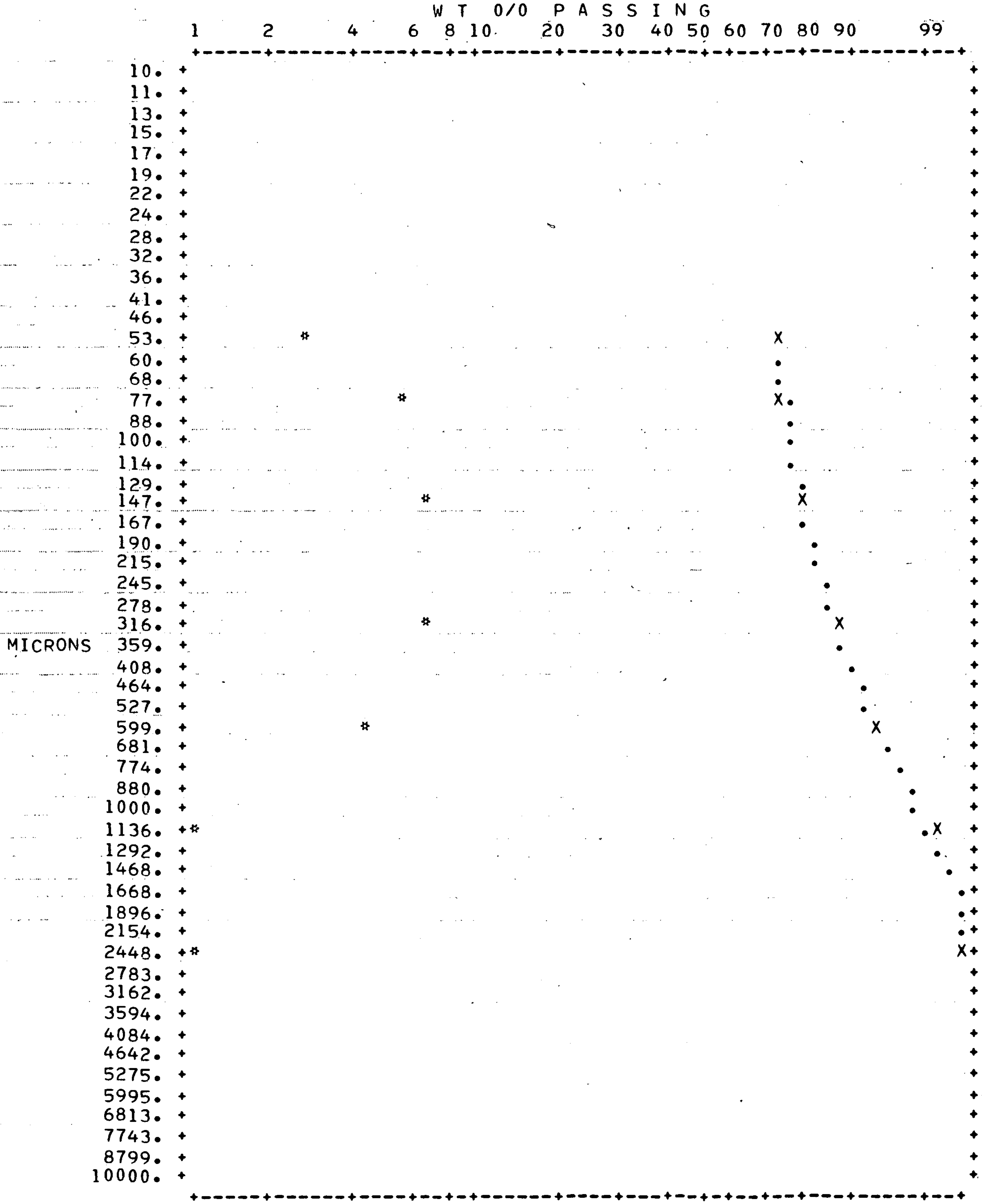
ROSIN RAMMLER PLOT

* = INDIVIDUAL WT. 0/0 RETAINED
* AT 1 0/0 MEANS 1 0/0 OR LESS

X = ACTUAL VALUE

. = BEST FIT LINE USED

THE MICRON VALUES REFER TO THE LINE PRINTER PLOT
POSITIONS AND NOT TO SCREEN APERTURES
USE OF THE LINE PRINTER PLOT IS NOT
RECOMMENDED FOR ACCURATE INTERPOLATION


W T 0/0 P A S S I N G
1 2 4 6 8 10 20 30 40 50 60 70 80 90 99
MICRONS
10. 11. 13. 15. 17. 19. 22. 24. 28. 32. 36. 41. 46. 53. 60. 68. 77. 88. 100. 114. 129. 147. 167. 190. 215. 245. 278. 316. 359. 408. 464. 527. 599. 681. 774. 880. 1000. 1136. 1292. 1468. 1668. 1896. 2154. 2448. 2783. 3162. 3594. 4084. 4642. 5275. 5995. 6813. 7743. 8799. 10000.

1/1/172 H190 NO 22

WET SCREENED ON 300# SCREENING TIME 15 MINS.

80 0/0 PASSING SIZE = 343. MICRONS

AVERAGE SLOPE = .2 INTERCEPT = 4.2 INCHES

SCREEN SIZE OR CONE NO.	SIZE IN MICRONS	WEIGHT 0/0 RETAINED	CUMULATIVE WEIGHT 0/0	CUMULATIVE WT 0/0 PASSING
188	4763.00	9.35	9.35	90.65
7	2400.00	1.86	11.21	88.79
14	1200.00	1.64	12.84	87.16
25	600.00	3.26	16.10	83.90
52	300.00	5.84	21.94	78.06
100	150.00	6.84	28.79	71.21
200	75.00	7.47	36.26	63.74
300	53.00	3.27	39.53	60.47
-300	-53.00	60.47	100.00	.00

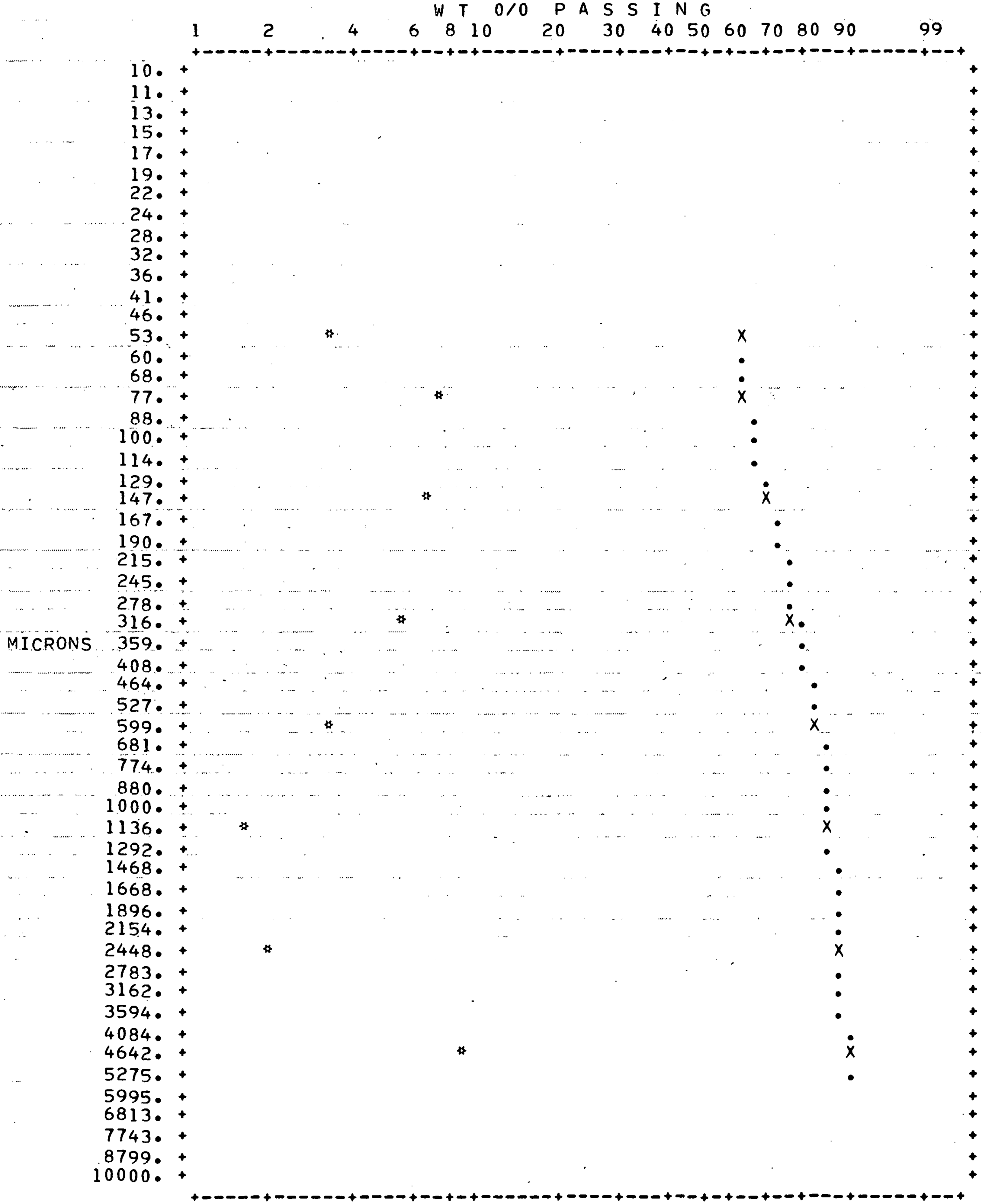
ROSIN RAMMLER PLOT

* = INDIVIDUAL WT. 0/0 RETAINED
* AT 1 0/0 MEANS 1 0/0 OR LESS

X = ACTUAL VALUE

. = BEST FIT LINE USED

THE MICRON VALUES REFER TO THE LINE PRINTER PLOT POSITIONS AND NOT TO SCREEN APERTURES
USE OF THE LINE PRINTER PLOT IS NOT RECOMMENDED FOR ACCURATE INTERPOLATION


W T 0/0 P A S S I N G
1 2 4 6 8 10 20 30 40 50 60 70 80 90 99
MICRONS
10. 11. 13. 15. 17. 19. 22. 24. 28. 32. 36. 41. 46. 53. 60. 68. 77. 88. 100. 114. 129. 147. 167. 190. 215. 245. 278. 316. 359. 408. 464. 527. 599. 681. 774. 880. 1000. 1136. 1292. 1468. 1668. 1896. 2154. 2448. 2783. 3162. 3594. 4084. 4642. 5275. 5995. 6813. 7743. 8799. 10000.

1/1/172   H190 NO 23

WET SCREENED ON 300#   SCREENING TIME 15 MINS.

80 0/0 PASSING SIZE =   2590. MICRONS

AVERAGE SLOPE =   .2   INTERCEPT =   3.3 INCHES

SCREEN SIZE OR CONE NO.	SIZE IN MICRONS	WEIGHT 0/0 RETAINED	CUMULATIVE WEIGHT 0/0	CUMULATIVE WT 0/0 PASSING
188	4763.00	17.05	17.05	82.95
7	2400.00	4.96	22.02	77.98
14	1200.00	10.08	32.09	67.91
25	600.00	11.40	43.49	56.51
52	300.00	4.81	48.29	51.71
100	150.00	3.84	52.13	47.87
200	75.00	8.37	60.50	39.50
300	53.00	3.84	64.34	35.66
-300	-53.00	35.66	100.00	-.00

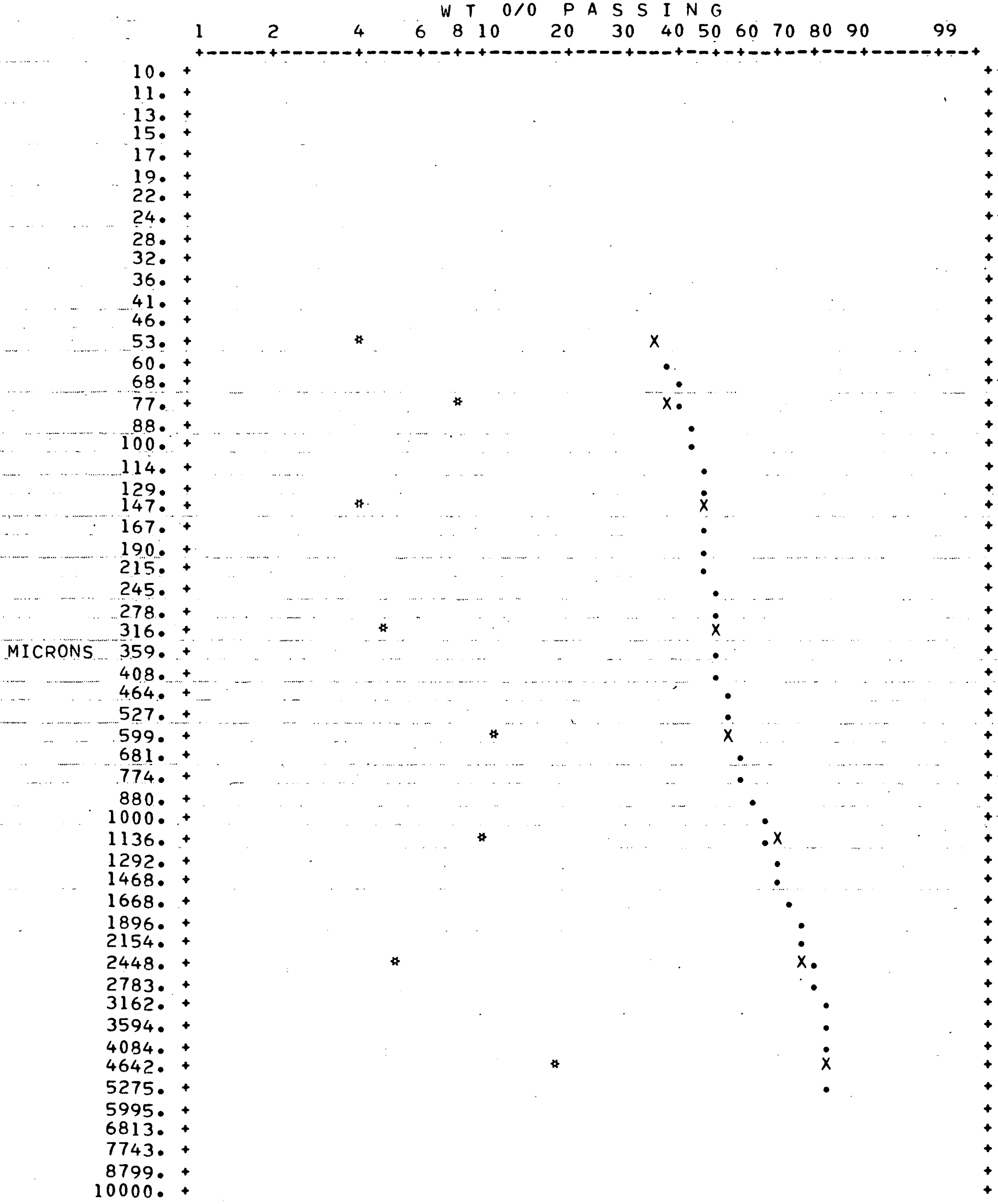
ROSIN RAMMLER PLOT

* = INDIVIDUAL WT. 0/0 RETAINED
* AT 1 0/0 MEANS 1 0/0 OR LESS

X = ACTUAL VALUE

. = BEST FIT LINE USED

THE MICRON VALUES REFER TO THE LINE PRINTER PLOT
POSITIONS AND NOT TO SCREEN APERTURES
USE OF THE LINE PRINTER PLOT IS NOT
RECOMMENDED FOR ACCURATE INTERPOLATION



W T 0/0 P A S S I N G
1 2 4 6 8 10 20 30 40 50 60 70 80 90 99
MICRONS
10. 11. 13. 15. 17. 19. 22. 24. 28. 32. 36. 41. 46. 53. 60. 68. 77. 88. 100. 114. 129. 147. 167. 190. 215. 245. 278. 316. 359. 408. 464. 527. 599. 681. 774. 880. 1000. 1136. 1292. 1468. 1668. 1896. 2154. 2448. 2783. 3162. 3594. 4084. 4642. 5275. 5995. 6813. 7743. 8799. 10000.

1/1/172 H190 NO 24

WET SCREENED ON 300# SCREENING TIME 15 MINS.

80 0/0 PASSING SIZE = 370. MICRONS

AVERAGE SLOPE = .6 INTERCEPT = 1.4 INCHES

SCREEN SIZE OR CONE NO.	SIZE IN MICRONS	WEIGHT 0/0 RETAINED	CUMULATIVE WEIGHT 0/0	CUMULATIVE WT 0/0 PASSING
188	4763.00	5.23	5.23	94.77
7	2400.00	.00	5.23	94.77
14	1200.00	.10	5.33	94.67
25	600.00	.33	5.66	94.34
52	300.00	9.65	15.31	84.69
100	150.00	54.64	69.95	30.05
200	75.00	18.64	88.58	11.42
300	53.00	2.24	90.83	9.17
-300	-53.00	9.17	100.00	.00

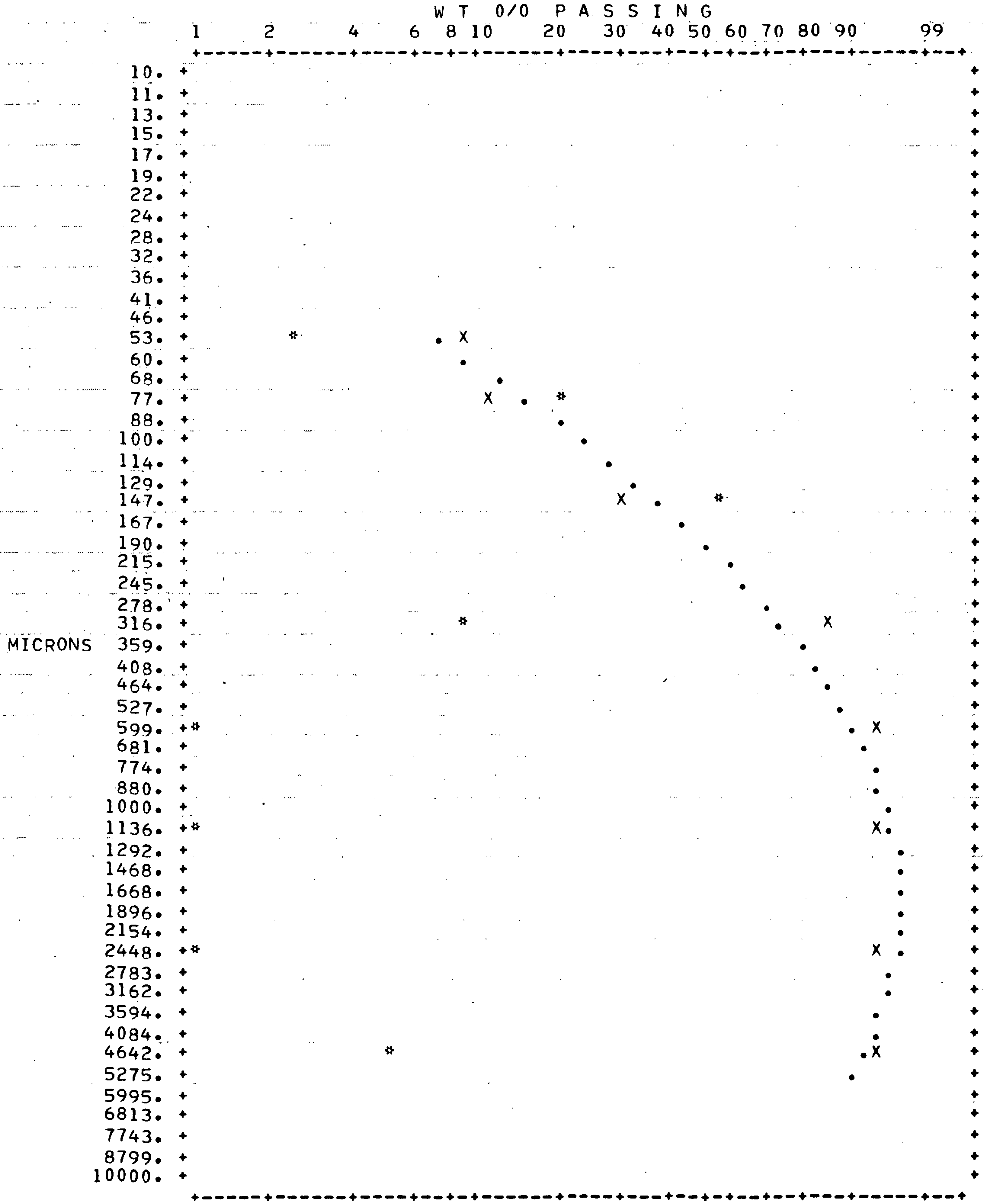
ROSIN RAMMLER PLOT

* = INDIVIDUAL WT. 0/0 RETAINED
* AT 1 0/0 MEANS 1 0/0 OR LESS

X = ACTUAL VALUE

. = BEST FIT LINE USED

THE MICRON VALUES REFER TO THE LINE PRINTER PLOT
POSITIONS AND NOT TO SCREEN APERTURES
USE OF THE LINE PRINTER PLOT IS NOT
RECOMMENDED FOR ACCURATE INTERPOLATION


W T 0/0 P A S S I N G
1 2 4 6 8 10 20 30 40 50 60 70 80 90 99
MICRONS
10. 11. 13. 15. 17. 19. 22. 24. 28. 32. 36. 41. 46. 53. 60. 68. 77. 88. 100. 114. 129. 147. 167. 190. 215. 245. 278. 316. 359. 408. 464. 527. 599. 681. 774. 880. 1000. 1136. 1292. 1468. 1668. 1896. 2154. 2448. 2783. 3162. 3594. 4084. 4642. 5275. 5995. 6813. 7743. 8799. 10000.

1/1/172 H190 NO 25

WET SCREENED ON 300# SCREENING TIME 15 MINS.

80 0/0 PASSING SIZE = 59. MICRONS

AVERAGE SLOPE = .1 INTERCEPT = 4.8 INCHES

SCREEN SIZE OR CONE NO.	SIZE IN MICRONS	WEIGHT 0/0 RETAINED	CUMULATIVE WEIGHT 0/0	CUMULATIVE WT 0/0 PASSING
188	4763.00	4.12	4.12	95.88
7	2400.00	.36	4.49	95.51
14	1200.00	.92	5.41	94.59
25	600.00	1.47	6.87	93.13
52	300.00	2.96	9.83	90.17
100	150.00	3.98	13.81	86.19
200	75.00	4.18	17.99	82.01
300	53.00	2.55	20.54	79.46
-300	-53.00	79.46	100.00	-.00

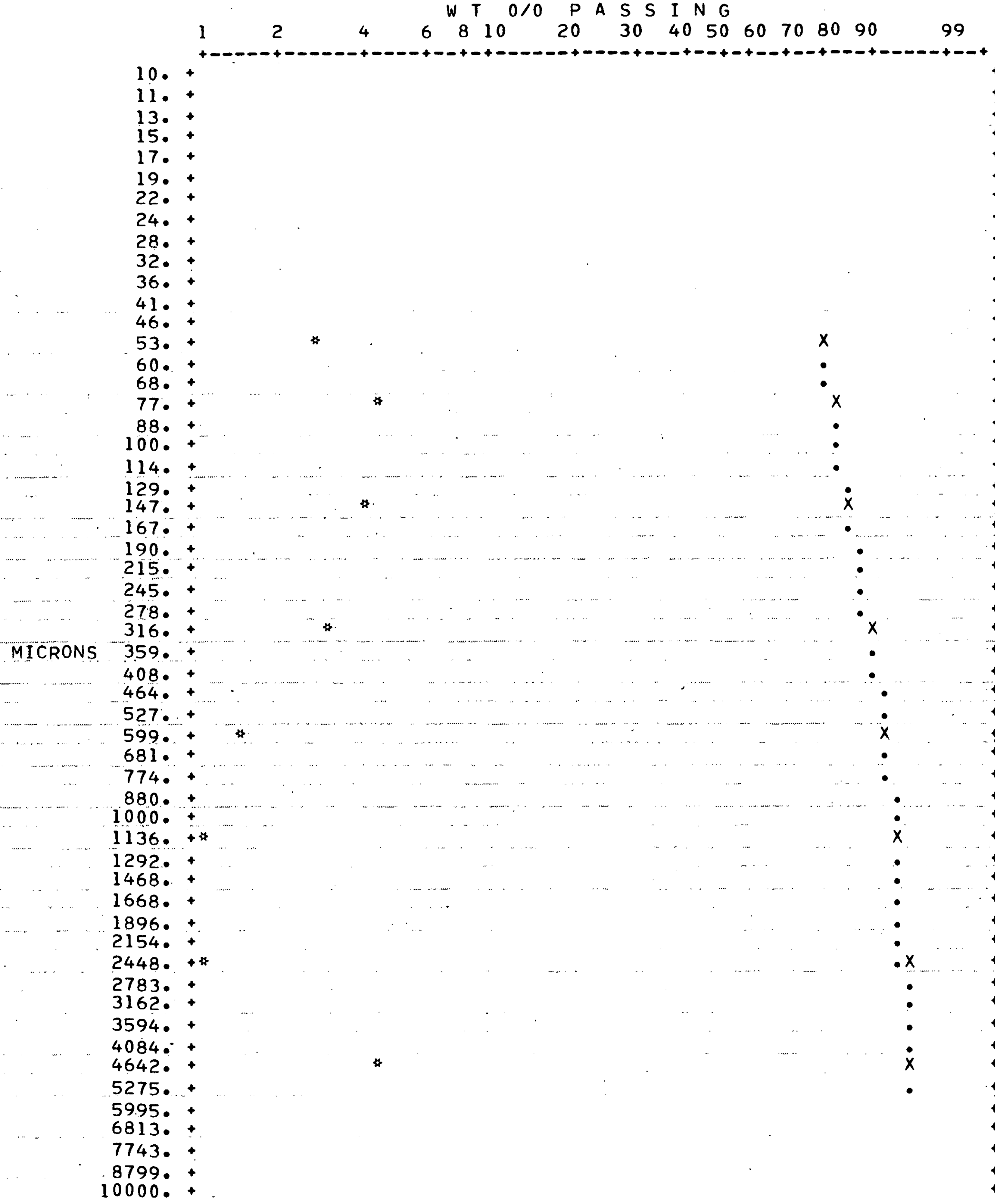
ROSIN RAMMLER PLOT

* = INDIVIDUAL WT. 0/0 RETAINED
* AT 1 0/0 MEANS 1 0/0 OR LESS

X = ACTUAL VALUE

. = BEST FIT LINE USED

THE MICRON VALUES REFER TO THE LINE PRINTER PLOT
POSITIONS AND NOT TO SCREEN APERTURES
USE OF THE LINE PRINTER PLOT IS NOT
RECOMMENDED FOR ACCURATE INTERPOLATION


W T 0/0 P A S S I N G
1 2 4 6 8 10 20 30 40 50 60 70 80 90 99
MICRONS
10. 11. 13. 15. 17. 19. 22. 24. 28. 32. 36. 41. 46. 53. 60. 68. 77. 88. 100. 114. 129. 147. 167. 190. 215. 245. 278. 316. 359. 408. 464. 527. 599. 681. 774. 880. 1000. 1136. 1292. 1468. 1668. 1896. 2154. 2448. 2783. 3162. 3594. 4084. 4642. 5275. 5995. 6813. 7743. 8799. 10000.

1/1/172 H11 114.79-114.90

WET SCREENED ON 300# SCREENING TIME 15 MINS.

80 0/0 PASSING SIZE =   2904. MICRONS

AVERAGE SLOPE =   .5   INTERCEPT =   1.4 INCHES

SCREEN SIZE OR CONE NO.	SIZE IN MICRONS	WEIGHT 0/0 RETAINED	CUMULATIVE WEIGHT 0/0	CUMULATIVE WT 0/0 PASSING
188	4763.00	8.85	8.85	91.15
7	2400.00	18.14	26.99	73.01
14	1200.00	25.10	52.08	47.92
25	600.00	17.27	69.36	30.64
52	300.00	9.10	78.46	21.54
100	150.00	3.22	81.68	18.32
200	75.00	3.18	84.86	15.14
300	53.00	.92	85.78	14.22
-300	-53.00	14.22	100.00	-.00

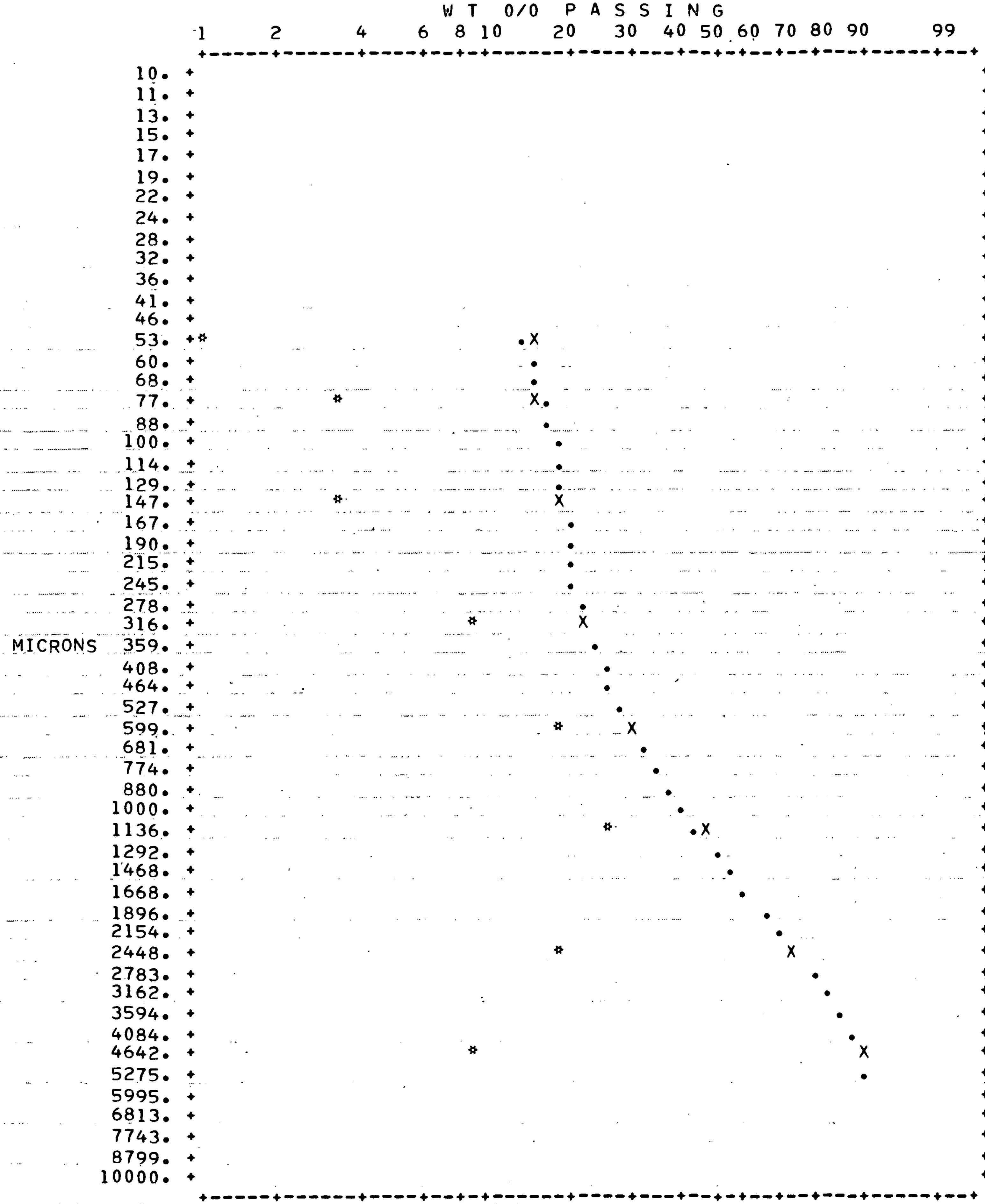
ROSIN RAMMLER PLOT

* = INDIVIDUAL WT. 0/0 RETAINED
* AT 1 0/0 MEANS 1 0/0 OR LESS

X = ACTUAL VALUE

. = BEST FIT LINE USED

THE MICRON VALUES REFER TO THE LINE PRINTER PLOT
POSITIONS AND NOT TO SCREEN APERTURES
USE OF THE LINE PRINTER PLOT IS NOT
RECOMMENDED FOR ACCURATE INTERPOLATION


W T 0/0 P A S S I N G
1 2 4 6 8 10 20 30 40 50 60 70 80 90 99
MICRONS
10.
11.
13.
15.
17.
19.
22.
24.
28.
32.
36.
41.
46.
53.
60.
68.
77.
88.
100.
114.
129.
147.
167.
190.
215.
245.
278.
316.
359.
408.
464.
527.
599.
681.
774.
880.
1000.
1136.
1292.
1468.
1668.
1896.
2154.
2448.
2783.
3162.
3594.
4084.
4642.
5275.
5995.
6813.
7743.
8799.
10000.

1/1/172 H11 114.90-115.00

WET SCREENED ON 300# SCREENING TIME 15 MINS.

80 0/0 PASSING SIZE =   2743. MICRONS

AVERAGE SLOPE =   .4   INTERCEPT =   2.2 INCHES

SCREEN SIZE OR CONE NO.	SIZE IN MICRONS	WEIGHT 0/0 RETAINED	CUMULATIVE WEIGHT 0/0	CUMULATIVE WT 0/0 PASSING
188	4763.00	2.79	2.79	97.21
7	2400.00	20.72	23.51	76.49
14	1200.00	19.49	43.00	57.00
25	600.00	9.22	52.22	47.78
52	300.00	9.58	61.80	38.20
100	150.00	5.92	67.72	32.28
200	75.00	7.33	75.05	24.95
300	53.00	2.34	77.39	22.61
-300	-53.00	22.61	100.00	-.00

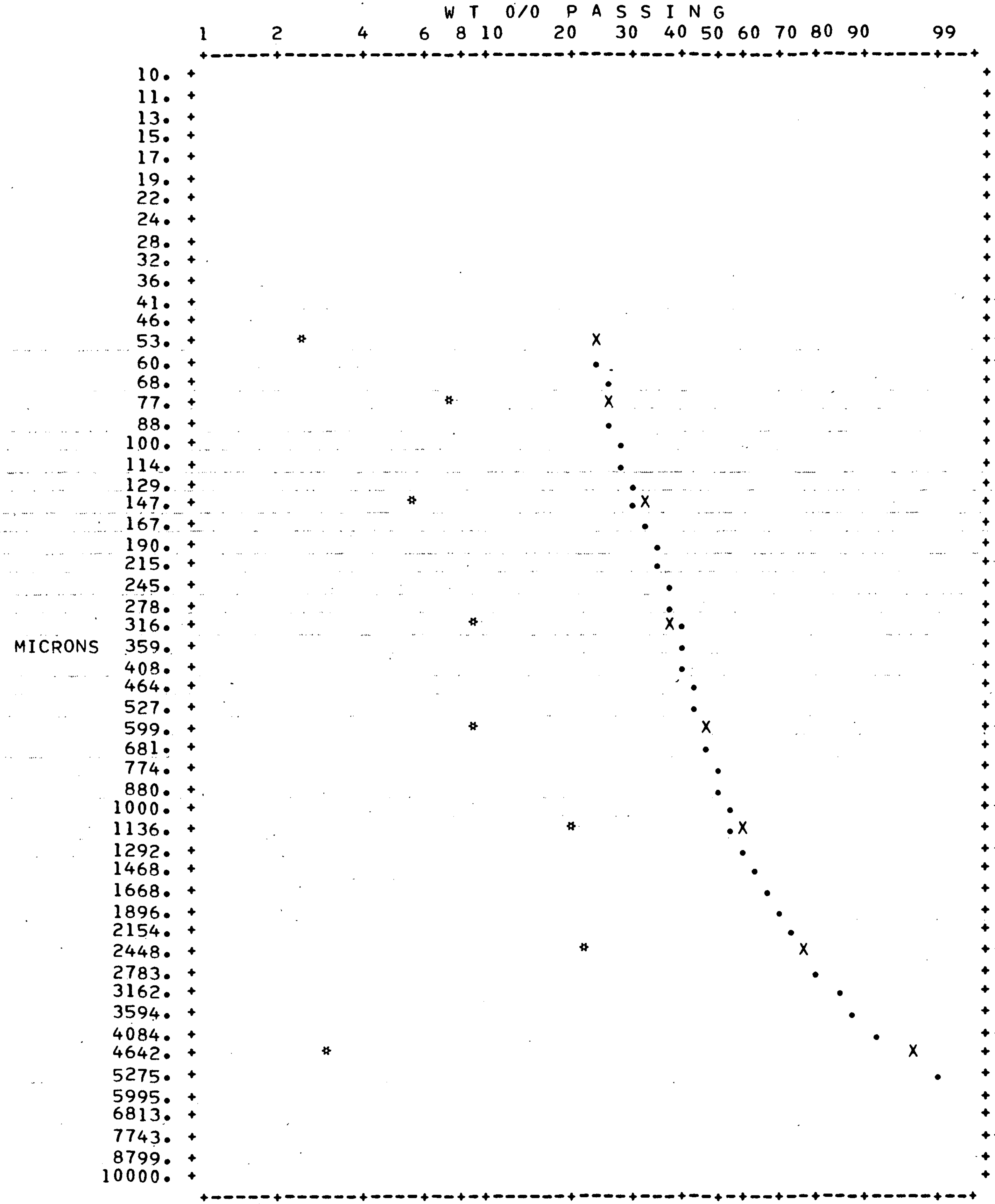
ROSIN RAMMLER PLOT

* = INDIVIDUAL WT. 0/0 RETAINED
* AT 1 0/0 MEANS 1 0/0 OR LESS

X = ACTUAL VALUE

. = BEST FIT LINE USED

THE MICRON VALUES REFER TO THE LINE PRINTER PLOT
POSITIONS AND NOT TO SCREEN APERTURES
USE OF THE LINE PRINTER PLOT IS NOT
RECOMMENDED FOR ACCURATE INTERPOLATION


W T 0/0 P A S S I N G
1 2 4 6 8 10 20 30 40 50 60 70 80 90 99
MICRONS
10. 11. 13. 15. 17. 19. 22. 24. 28. 32. 36. 41. 46. 53. 60. 68. 77. 88. 100. 114. 129. 147. 167. 190. 215. 245. 278. 316. 359. 408. 464. 527. 599. 681. 774. 880. 1000. 1136. 1292. 1468. 1668. 1896. 2154. 2448. 2783. 3162. 3594. 4084. 4642. 5275. 5995. 6813. 7743. 8799. 10000.

1/1/172 H11 115.60-116.00

WET SCREENED ON 300# SCREENING TIME 15 MINS.

80 0/0 PASSING SIZE = 632. MICRONS

AVERAGE SLOPE = .3 INTERCEPT = 3.1 INCHES

SCREEN SIZE OR CONE NO.	SIZE IN MICRONS	WEIGHT 0/0 RETAINED	CUMULATIVE WEIGHT 0/0	CUMULATIVE WT 0/0 PASSING
188	4763.00	3.10	3.10	96.90
7	2400.00	5.66	8.77	91.23
14	1200.00	5.35	14.12	85.88
25	600.00	6.86	20.98	79.02
52	300.00	9.67	30.65	69.35
100	150.00	10.45	41.11	58.89
200	75.00	19.22	60.33	39.67
300	53.00	5.22	65.55	34.45
-300	-53.00	34.45	100.00	.00

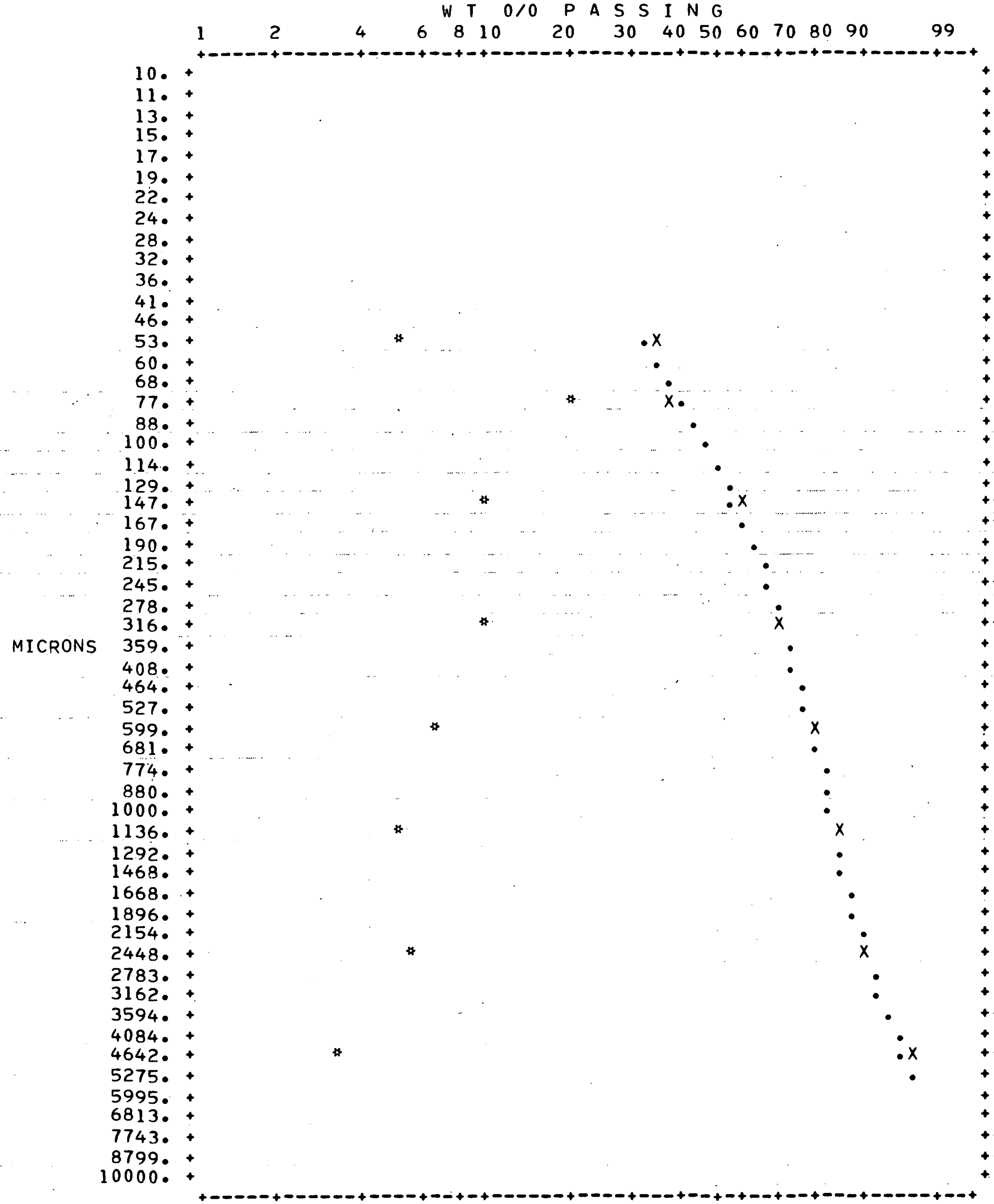
ROSIN RAMMLER PLOT

* = INDIVIDUAL WT. 0/0 RETAINED
* AT 1 0/0 MEANS 1 0/0 OR LESS

X = ACTUAL VALUE

. = BEST FIT LINE USED

THE MICRON VALUES REFER TO THE LINE PRINTER PLOT
POSITIONS AND NOT TO SCREEN APERTURES
USE OF THE LINE PRINTER PLOT IS NOT
RECOMMENDED FOR ACCURATE INTERPOLATION


W T 0/0 P A S S I N G
1 2 4 6 8 10 20 30 40 50 60 70 80 90 99
MICRONS
10.
11.
13.
15.
17.
19.
22.
24.
28.
32.
36.
41.
46.
53.
60.
68.
77.
88.
100.
114.
129.
147.
167.
190.
215.
245.
278.
316.
359.
408.
464.
527.
599.
681.
774.
880.
1000.
1136.
1292.
1468.
1668.
1896.
2154.
2448.
2783.
3162.
3594.
4084.
4642.
5275.
5995.
6813.
7743.
8799.
10000.

1/1/172 H11 116.78-117.00

WET SCREENED ON 300# SCREENING TIME 15 MINS.

80 0/0 PASSING SIZE = 2691. MICRONS

AVERAGE SLOPE = .4 INTERCEPT = 2.5 INCHES

SCREEN SIZE OR CONE NO.	SIZE IN MICRONS	WEIGHT 0/0 RETAINED	CUMULATIVE WEIGHT 0/0	CUMULATIVE WT 0/0 PASSING
188	4763.00	13.01	13.01	86.99
7	2400.00	5.95	18.96	81.04
14	1200.00	12.35	31.31	68.69
25	600.00	9.57	40.88	59.12
52	300.00	10.61	51.49	48.51
100	150.00	14.68	66.17	33.83
200	75.00	7.60	73.77	26.23
300	53.00	1.97	75.73	24.27
-300	-53.00	24.27	100.00	.00

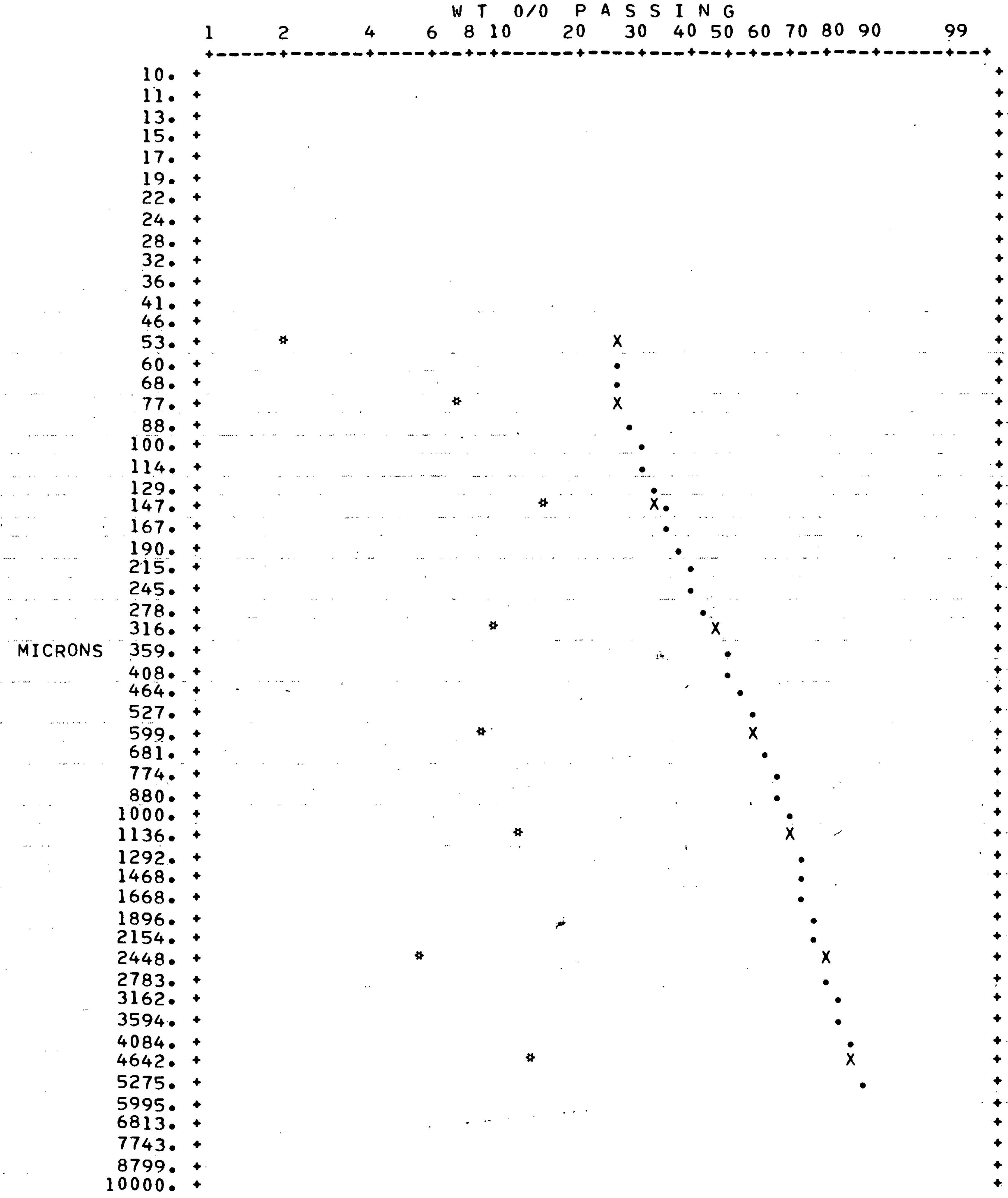
ROSIN RAMMLER PLOT

* = INDIVIDUAL WT. 0/0 RETAINED
* AT 1 0/0 MEANS 1 0/0 OR LESS

X = ACTUAL VALUE

. = BEST FIT LINE USED

THE MICRON VALUES REFER TO THE LINE PRINTER PLOT
POSITIONS AND NOT TO SCREEN APERTURES
USE OF THE LINE PRINTER PLOT IS NOT
RECOMMENDED FOR ACCURATE INTERPOLATION


W T 0/0 P A S S I N G
1 2 4 6 8 10 20 30 40 50 60 70 80 90 99
MICRONS
10.
11.
13.
15.
17.
19.
22.
24.
28.
32.
36.
41.
46.
53.
60.
68.
77.
88.
100.
114.
129.
147.
167.
190.
215.
245.
278.
316.
359.
408.
464.
527.
599.
681.
774.
880.
1000.
1136.
1292.
1468.
1668.
1896.
2154.
2448.
2783.
3162.
3594.
4084.
4642.
5275.
5995.
6813.
7743.
8799.
10000.

1/1/172 H11 117.41-117.54

WET SCREENED ON 300# SCREENING TIME 15 MINS.

80 0/0 PASSING SIZE = 1736. MICRONS

AVERAGE SLOPE = .5 INTERCEPT = 1.8 INCHES

SCREEN SIZE OR CONE NO.	SIZE IN MICRONS	WEIGHT 0/0 RETAINED	CUMULATIVE WEIGHT 0/0	CUMULATIVE WT 0/0 PASSING
188	4763.00	1.87	1.87	98.13
7	2400.00	6.16	8.03	91.97
14	1200.00	32.51	40.54	59.46
25	600.00	16.49	57.03	42.97
52	300.00	9.34	66.37	33.63
100	150.00	6.50	72.87	27.13
200	75.00	4.44	77.32	22.68
300	53.00	1.45	78.77	21.23
-300	-53.00	21.23	100.00	-.00

ROSIN RAMMLER PLOT

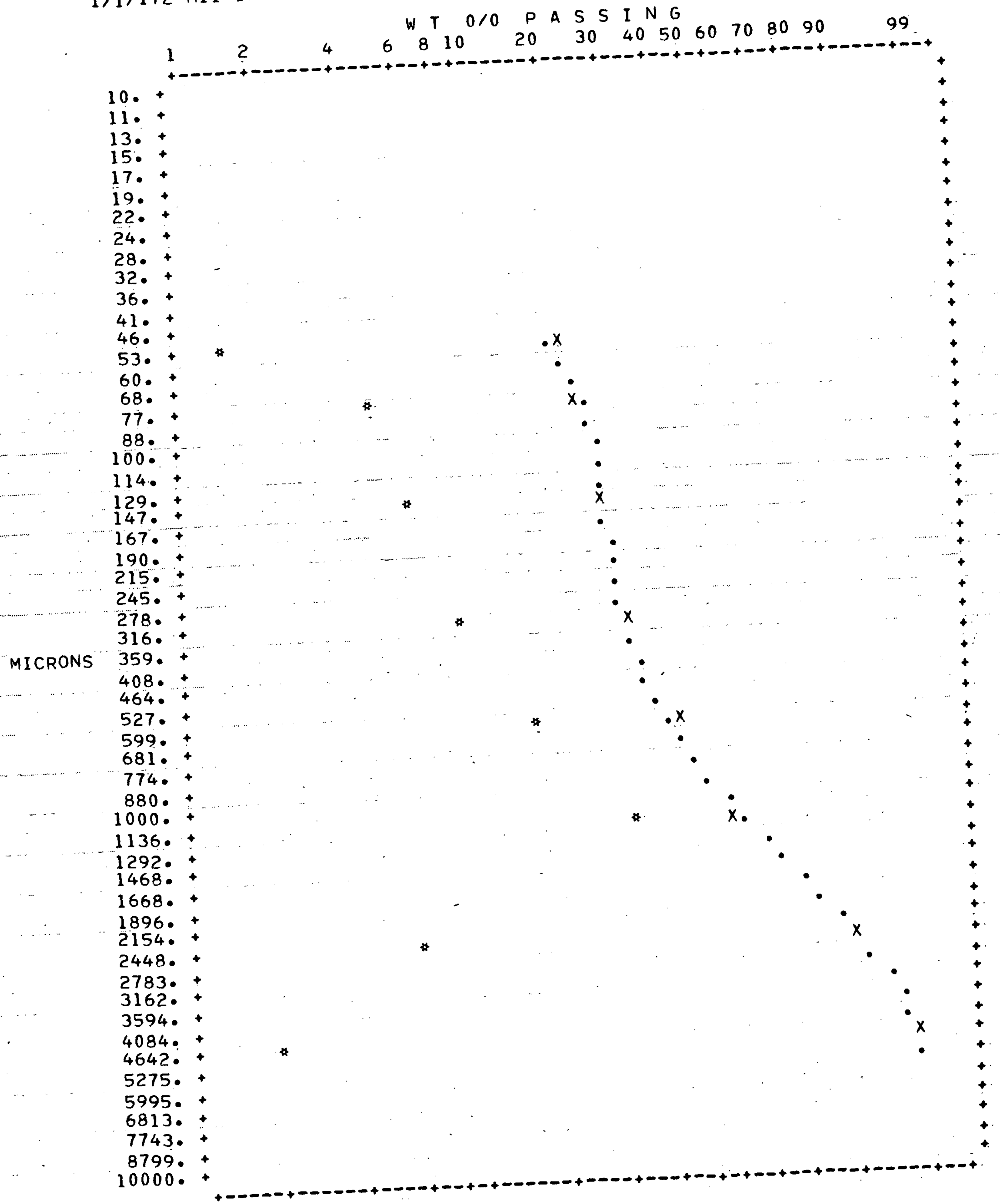
* = INDIVIDUAL WT. 0/0 RETAINED
* AT 1 0/0 MEANS 1 0/0 OR LESS

X = ACTUAL VALUE

. = BEST FIT LINE USED

THE MICRON VALUES REFER TO THE LINE PRINTER PLOT
POSITIONS AND NOT TO SCREEN APERTURES
USE OF THE LINE PRINTER PLOT IS NOT
RECOMMENDED FOR ACCURATE INTERPOLATION

1/1/172 H11 117.41-117.54



1/1/172 H11 117.71-117.77

WET SCREENED ON 300# SCREENING TIME 15 MINS.

80 0/0 PASSING SIZE =   1437. MICRONS

AVERAGE SLOPE =   .6   INTERCEPT =   1.2 INCHES

SCREEN SIZE OR CONE NO.	SIZE IN MICRONS	WEIGHT 0/0 RETAINED	CUMULATIVE WEIGHT 0/0	CUMULATIVE WT 0/0 PASSING
7	2400.00	1.67	1.67	98.33
14	1200.00	27.08	28.75	71.25
25	600.00	33.33	62.08	37.92
52	300.00	11.81	73.89	26.11
100	150.00	5.56	79.44	20.56
200	75.00	2.92	82.36	17.64
300	53.00	.97	83.33	16.67
-300	-53.00	16.67	100.00	-.00

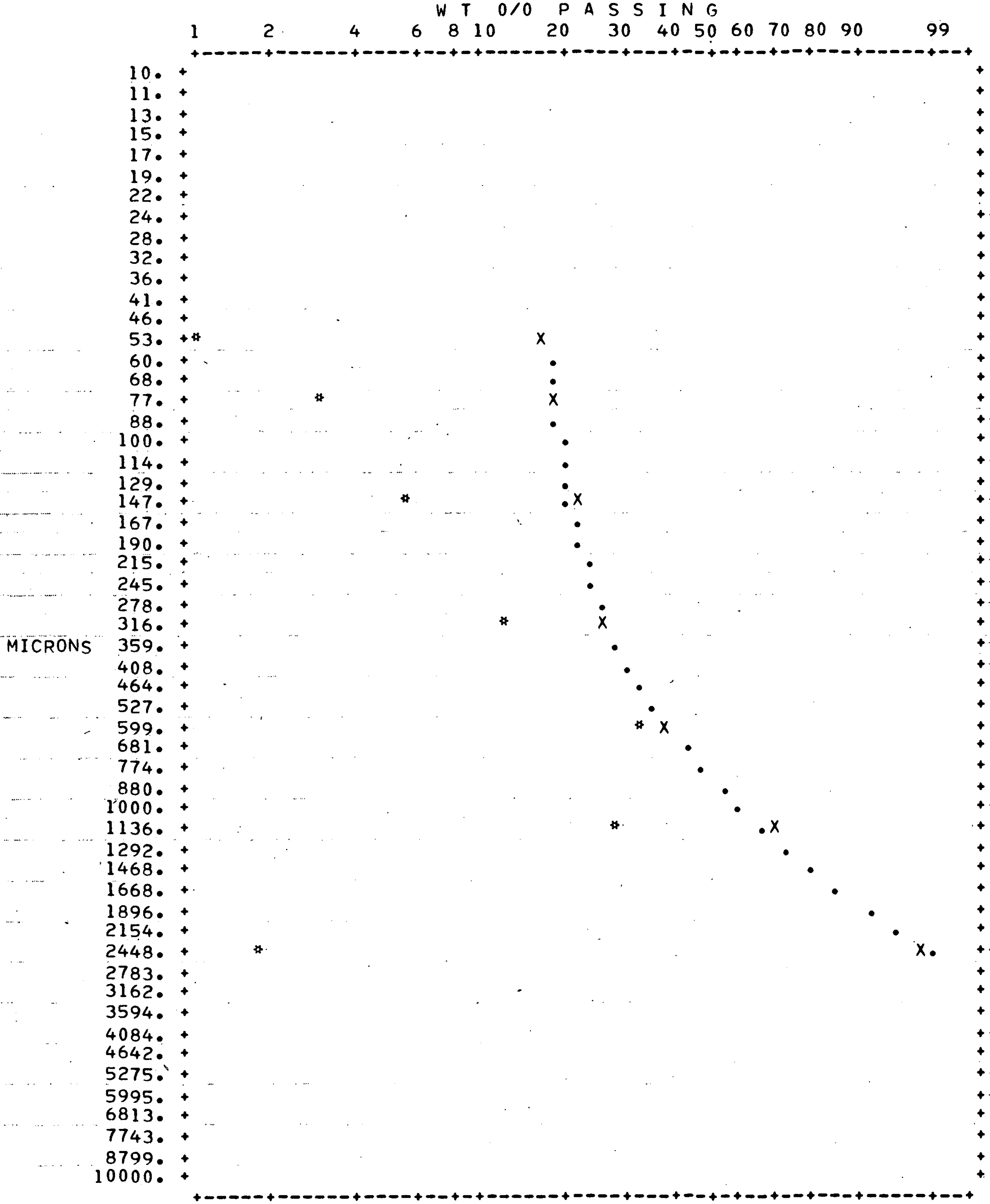
ROSIN RAMMLER PLOT

* = INDIVIDUAL WT. 0/0 RETAINED
* AT 1 0/0 MEANS 1 0/0 OR LESS

X = ACTUAL VALUE

. = BEST FIT LINE USED

THE MICRON VALUES REFER TO THE LINE PRINTER PLOT
POSITIONS AND NOT TO SCREEN APERTURES.
USE OF THE LINE PRINTER PLOT IS NOT
RECOMMENDED FOR ACCURATE INTERPOLATION



W T 0/0 P A S S I N G
1 2 4 6 8 10 20 30 40 50 60 70 80 90 99
MICRONS
10.
11.
13.
15.
17.
19.
22.
24.
28.
32.
36.
41.
46.
53.
60.
68.
77.
88.
100.
114.
129.
147.
167.
190.
215.
245.
278.
316.
359.
408.
464.
527.
599.
681.
774.
880.
1000.
1136.
1292.
1468.
1668.
1896.
2154.
2448.
2783.
3162.
3594.
4084.
4642.
5275.
5995.
6813.
7743.
8799.
10000.

1/1/172 H11 118.00-118.12

WET SCREENED ON 300# SCREENING TIME 15 MINS.

80 0/0 PASSING SIZE = 4986. MICRONS

AVERAGE SLOPE = .4 INTERCEPT = 1.9 INCHES

SCREEN SIZE OR CONE NO.	SIZE IN MICRONS	WEIGHT 0/0 RETAINED	CUMULATIVE WEIGHT 0/0	CUMULATIVE WT 0/0 PASSING
188	4763.00	21.38	21.38	78.62
7	2400.00	14.20	35.58	64.42
14	1200.00	21.00	56.58	43.42
25	600.00	12.36	68.94	31.06
52	300.00	7.04	75.98	24.02
100	150.00	3.68	79.66	20.34
200	75.00	2.00	81.66	18.34
300	53.00	.68	82.34	17.66
-300	-53.00	17.66	100.00	.00

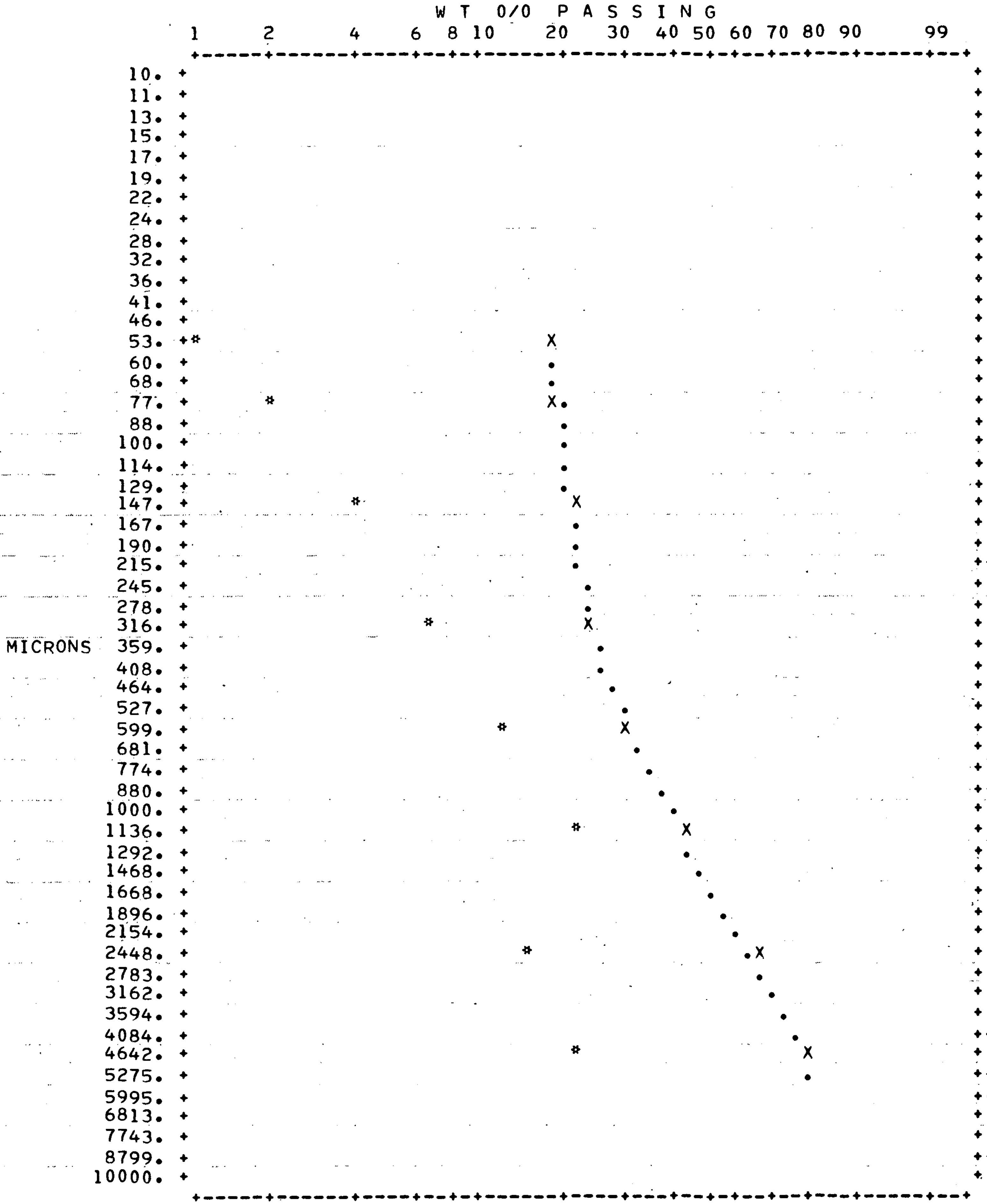
ROSIN RAMMLER PLOT

* = INDIVIDUAL WT. 0/0 RETAINED
* AT 1 0/0 MEANS 1 0/0 OR LESS

X = ACTUAL VALUE

. = BEST FIT LINE USED

THE MICRON VALUES REFER TO THE LINE PRINTER PLOT
POSITIONS AND NOT TO SCREEN APERTURES
USE OF THE LINE PRINTER PLOT IS NOT
RECOMMENDED FOR ACCURATE INTERPOLATION


W T 0/0 P A S S I N G
1 2 4 6 8 10 20 30 40 50 60 70 80 90 99
MICRONS
10.
11.
13.
15.
17.
19.
22.
24.
28.
32.
36.
41.
46.
53.
60.
68.
77.
88.
100.
114.
129.
147.
167.
190.
215.
245.
278.
316.
359.
408.
464.
527.
599.
681.
774.
880.
1000.
1136.
1292.
1468.
1668.
1896.
2154.
2448.
2783.
3162.
3594.
4084.
4642.
5275.
5995.
6813.
7743.
8799.
10000.

1/1/172 H11 118.30-118.39

WET SCREENED ON 300# SCREENING TIME 15 MINS.

80 0/0 PASSING SIZE = 4590. MICRONS

AVERAGE SLOPE = .4 INTERCEPT = 2.1 INCHES

SCREEN SIZE OR CONE NO.	SIZE IN MICRONS	WEIGHT 0/0 RETAINED	CUMULATIVE WEIGHT 0/0	CUMULATIVE WT 0/0 PASSING
188	4763.00	19.79	19.79	80.21
7	2400.00	7.79	27.58	72.42
14	1200.00	9.92	37.50	62.50
25	600.00	11.44	48.94	51.06
52	300.00	14.07	63.01	36.99
100	150.00	12.45	75.46	24.54
200	75.00	5.23	80.69	19.31
300	53.00	1.57	82.25	17.75
-300	-53.00	17.75	100.00	-.00

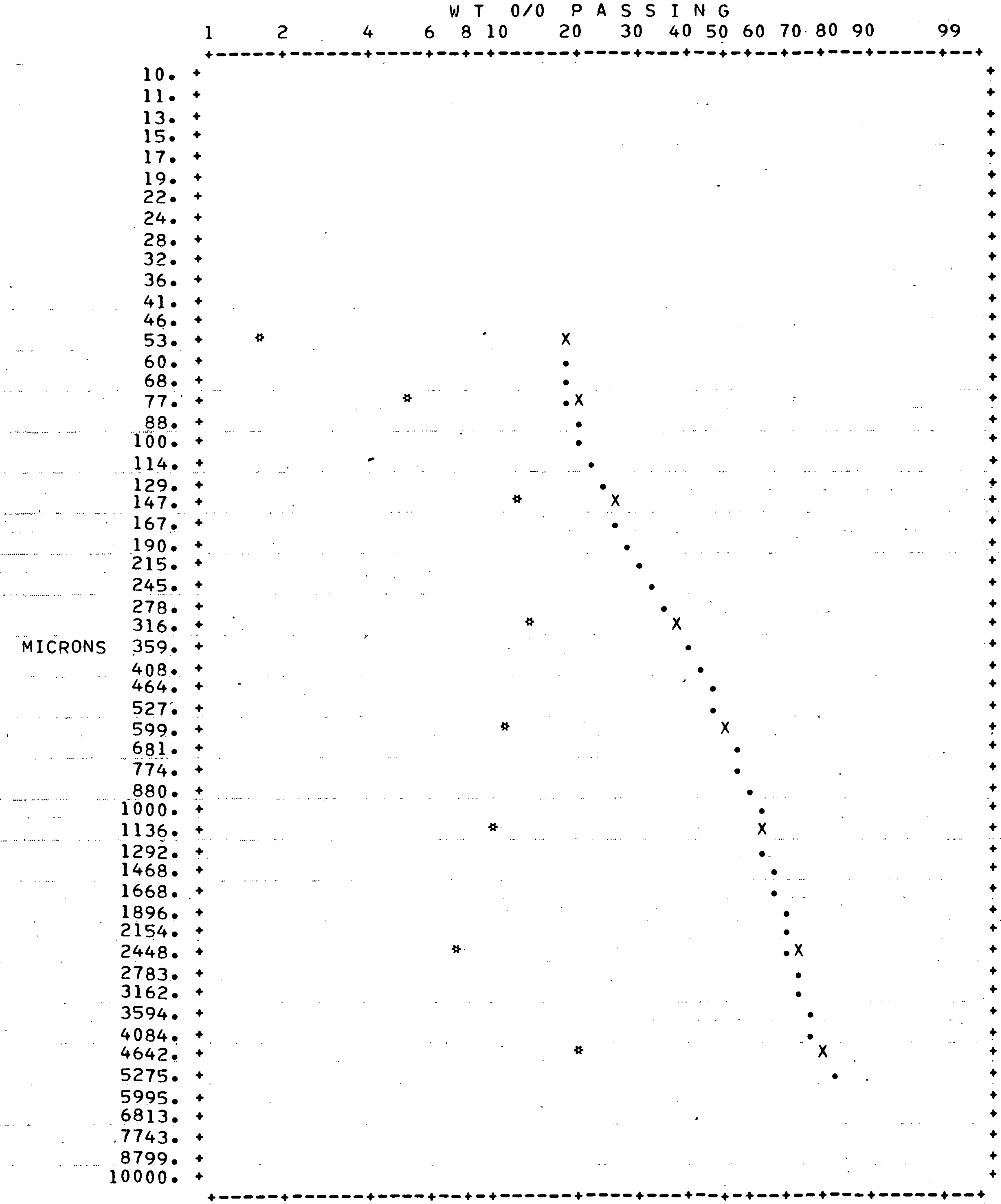
ROSIN RAMMLER PLOT

* = INDIVIDUAL WT. 0/0 RETAINED
* AT 1 0/0 MEANS 1 0/0 OR LESS

X = ACTUAL VALUE

. = BEST FIT LINE USED

THE MICRON VALUES REFER TO THE LINE PRINTER PLOT
POSITIONS AND NOT TO SCREEN APERTURES
USE OF THE LINE PRINTER PLOT IS NOT
RECOMMENDED FOR ACCURATE INTERPOLATION


W T 0/0 P A S S I N G
1 2 4 6 8 10 20 30 40 50 60 70 80 90 99
MICRONS
10.
11.
13.
15.
17.
19.
22.
24.
28.
32.
36.
41.
46.
53.
60.
68.
77.
88.
100.
114.
129.
147.
167.
190.
215.
245.
278.
316.
359.
408.
464.
527.
599.
681.
774.
880.
1000.
1136.
1292.
1468.
1668.
1896.
2154.
2448.
2783.
3162.
3594.
4084.
4642.
5275.
5995.
6813.
7743.
8799.
10000.

1/1/172 H45 NO. 1

WET SCREENED ON 300# SCREENING TIME 15 MINS.

80 0/0 PASSING SIZE = 2310. MICRONS

AVERAGE SLOPE = .4 INTERCEPT = 2.2 INCHES

SCREEN SIZE OR CONE NO.	SIZE IN MICRONS	WEIGHT 0/0 RETAINED	CUMULATIVE WEIGHT 0/0	CUMULATIVE WT 0/0 PASSING
188	4763.00	11.28	11.28	88.72
7	2400.00	7.63	18.92	81.08
14	1200.00	15.27	34.19	65.81
25	600.00	14.92	49.11	50.89
52	300.00	11.49	60.61	39.39
100	150.00	10.11	70.72	29.28
200	75.00	6.47	77.19	22.81
300	53.00	1.92	79.11	20.89
-300	-53.00	20.89	100.00	-.00

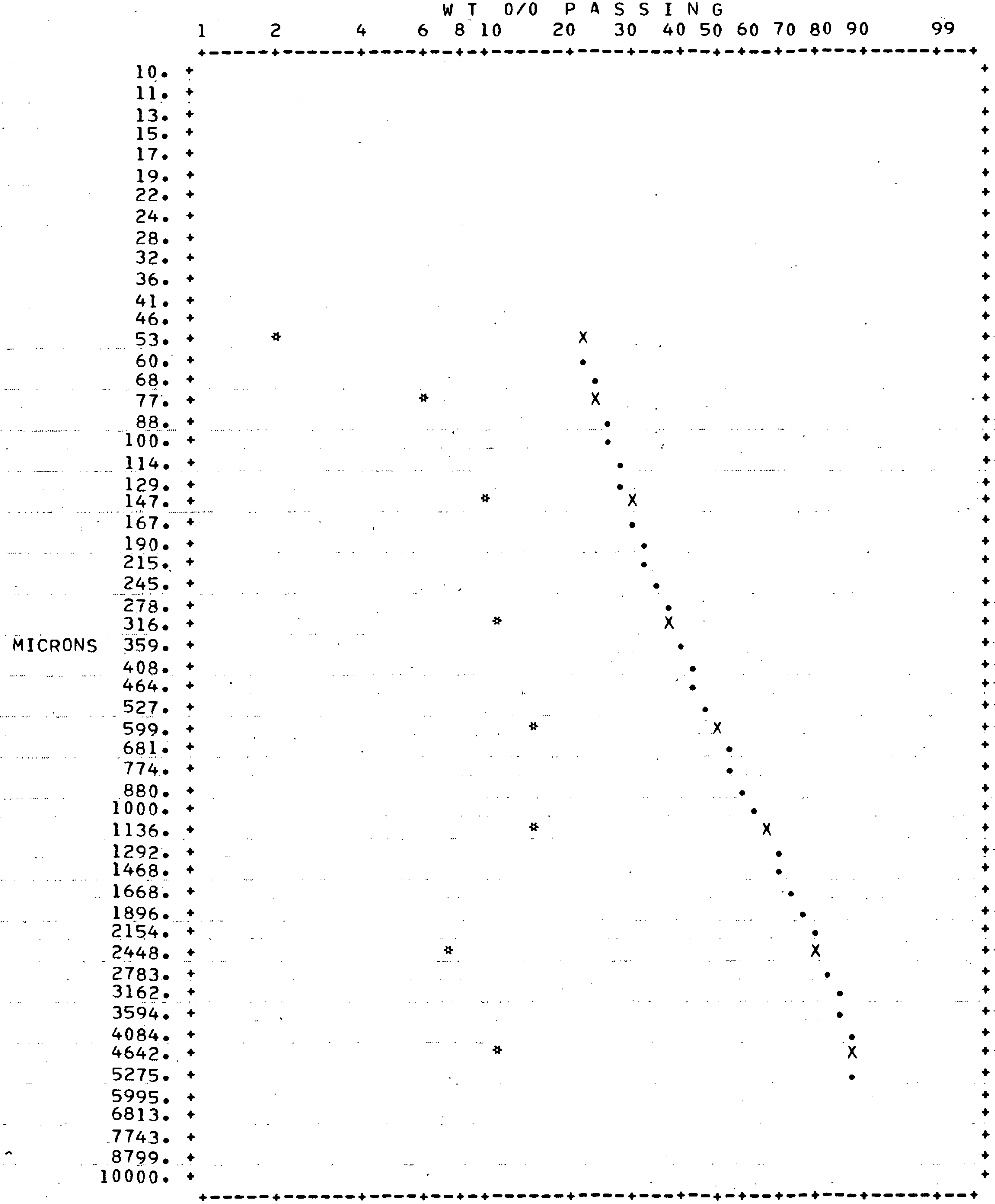
ROSIN RAMMLER PLOT

* = INDIVIDUAL WT. 0/0 RETAINED
* AT 1 0/0 MEANS 1 0/0 OR LESS

X = ACTUAL VALUE

. = BEST FIT LINE USED

THE MICRON VALUES REFER TO THE LINE PRINTER PLOT POSITIONS AND NOT TO SCREEN APERTURES
USE OF THE LINE PRINTER PLOT IS NOT RECOMMENDED FOR ACCURATE INTERPOLATION


W T 0/0 P A S S I N G
1 2 4 6 8 10 20 30 40 50 60 70 80 90 99
MICRONS
10. 11. 13. 15. 17. 19. 22. 24. 28. 32. 36. 41. 46. 53. 60. 68. 77. 88. 100. 114. 129. 147. 167. 190. 215. 245. 278. 316. 359. 408. 464. 527. 599. 681. 774. 880. 1000. 1136. 1292. 1468. 1668. 1896. 2154. 2448. 2783. 3162. 3594. 4084. 4642. 5275. 5995. 6813. 7743. 8799. 10000.

1/1/172 H45 NO. 2

WET SCREENED ON 300# SCREENING TIME 15 MINS.

80 0/0 PASSING SIZE = 14273. MICRONS

AVERAGE SLOPE = .3 INTERCEPT = 1.8 INCHES

SCREEN SIZE OR CONE NO.	SIZE IN MICRONS	WEIGHT 0/0 RETAINED	CUMULATIVE WEIGHT 0/0	CUMULATIVE WT 0/0 PASSING
1000	25400.00	8.89	8.89	91.11
500	12700.00	15.51	24.40	75.60
188	4763.00	12.24	36.64	63.36
7	2400.00	9.85	46.49	53.51
14	1200.00	14.41	60.90	39.10
25	600.00	12.38	73.29	26.71
52	300.00	4.66	77.94	22.06
100	150.00	4.22	82.16	17.84
200	75.00	2.72	84.88	15.12
300	53.00	.84	85.73	14.27
-300	-53.00	14.27	100.00	.00

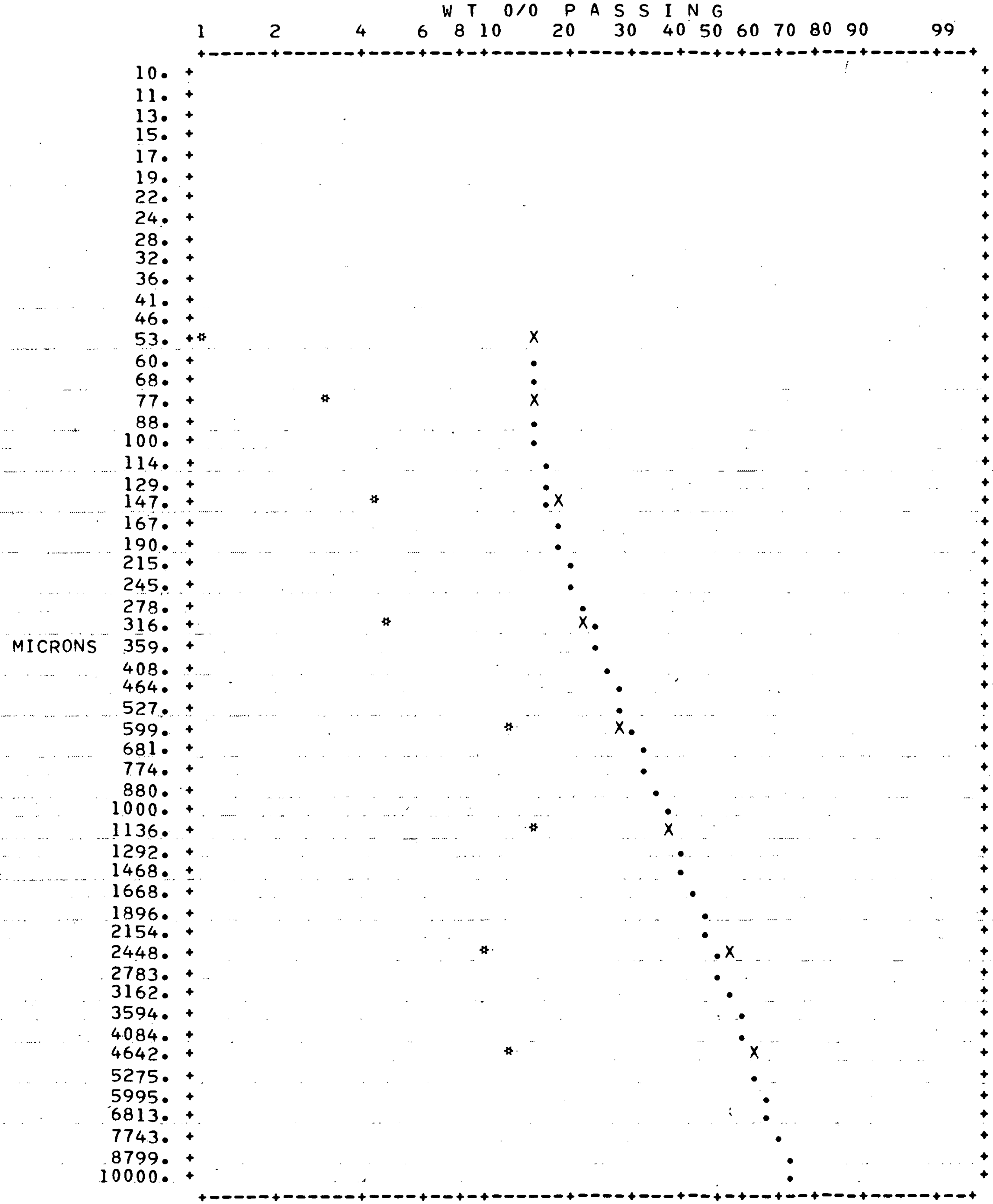
ROSIN RAMMLER PLOT

* = INDIVIDUAL WT. 0/0 RETAINED
* AT 1 0/0 MEANS 1 0/0 OR LESS

X = ACTUAL VALUE

. = BEST FIT LINE USED

THE MICRON VALUES REFER TO THE LINE PRINTER PLOT
POSITIONS AND NOT TO SCREEN APERTURES
USE OF THE LINE PRINTER PLOT IS NOT
RECOMMENDED FOR ACCURATE INTERPOLATION



W T 0/0 P A S S I N G
1 2 4 6 8 10 20 30 40 50 60 70 80 90 99
MICRONS
10.
11.
13.
15.
17.
19.
22.
24.
28.
32.
36.
41.
46.
53.
60.
68.
77.
88.
100.
114.
129.
147.
167.
190.
215.
245.
278.
316.
359.
408.
464.
527.
599.
681.
774.
880.
1000.
1136.
1292.
1468.
1668.
1896.
2154.
2448.
2783.
3162.
3594.
4084.
4642.
5275.
5995.
6813.
7743.
8799.
10000.

1/1/172 H45 NO. 3

WET SCREENED ON 300# SCREENING TIME 15 MINS.

80 0/0 PASSING SIZE = 585. MICRONS

AVERAGE SLOPE = .2 INTERCEPT = 3.9 INCHES

SCREEN SIZE OR CONE NO.	SIZE IN MICRONS	WEIGHT 0/0 RETAINED	CUMULATIVE WEIGHT 0/0	CUMULATIVE WT 0/0 PASSING
188	4763.00	2.38	2.38	97.63
7	2400.00	4.42	6.80	93.20
14	1200.00	6.55	13.35	86.65
25	600.00	6.40	19.75	80.25
52	300.00	6.95	26.70	73.30
100	150.00	5.55	32.25	67.75
200	75.00	4.50	36.75	63.25
300	53.00	2.50	39.25	60.75
-300	-53.00	60.75	100.00	-.00

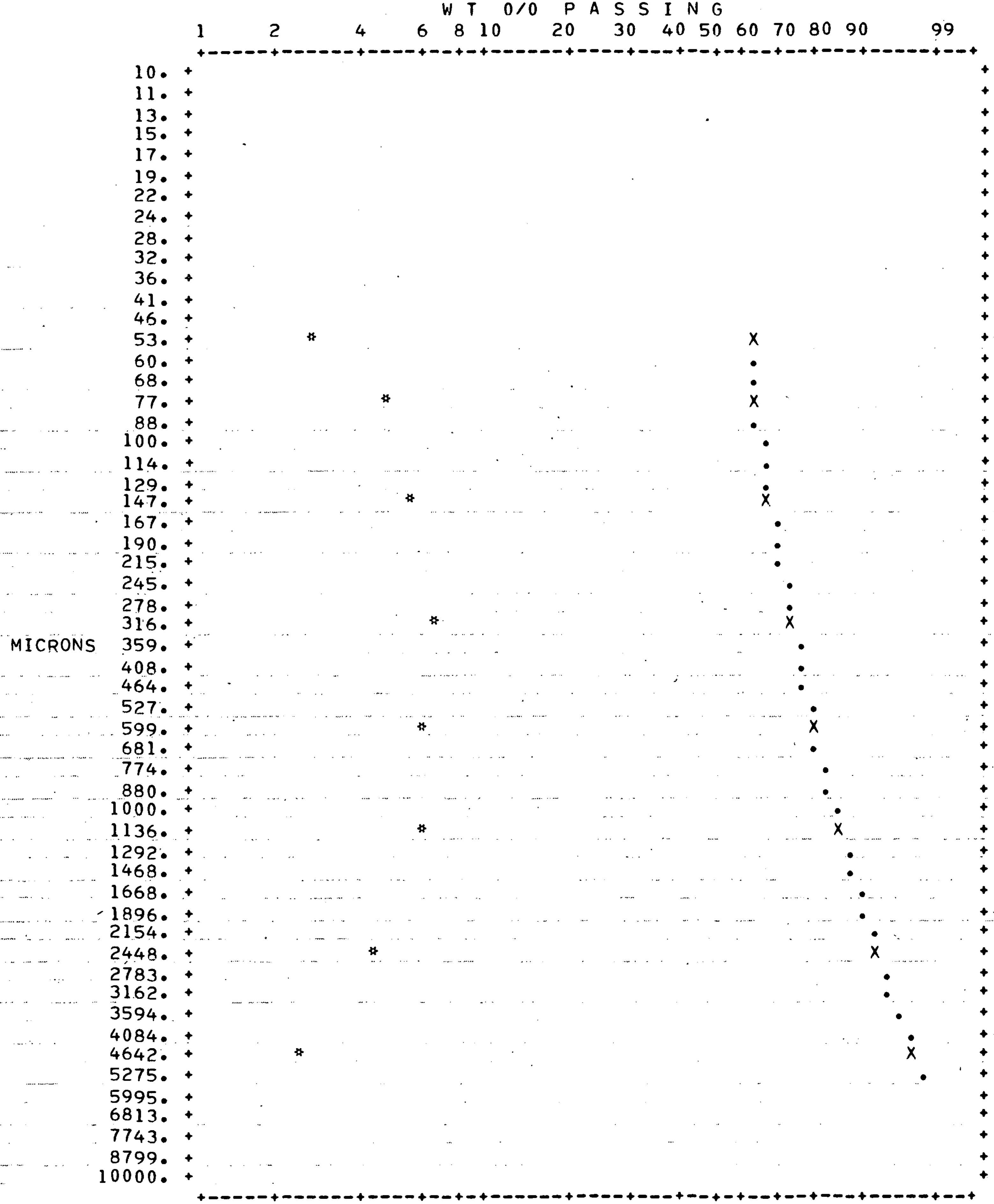
ROSIN RAMMLER PLOT

* = INDIVIDUAL WT. 0/0 RETAINED
* AT 1 0/0 MEANS 1 0/0 OR LESS

X = ACTUAL VALUE

. = BEST FIT LINE USED

THE MICRON VALUES REFER TO THE LINE PRINTER PLOT
POSITIONS AND NOT TO SCREEN APERTURES
USE OF THE LINE PRINTER PLOT IS NOT
RECOMMENDED FOR ACCURATE INTERPOLATION


W T 0/0 P A S S I N G
1 2 4 6 8 10 20 30 40 50 60 70 80 90 99
MICRONS
10.
11.
13.
15.
17.
19.
22.
24.
28.
32.
36.
41.
46.
53.
60.
68.
77.
88.
100.
114.
129.
147.
167.
190.
215.
245.
278.
316.
359.
408.
464.
527.
599.
681.
774.
880.
1000.
1136.
1292.
1468.
1668.
1896.
2154.
2448.
2783.
3162.
3594.
4084.
4642.
5275.
5995.
6813.
7743.
8799.
10000.

1/1/172 H45 NO. 4

WET SCREENED ON 300# SCREENING TIME 15 MINS.

80 0/0 PASSING SIZE = 1255. MICRONS

AVERAGE SLOPE = .3 INTERCEPT = 3.3 INCHES

SCREEN SIZE OR CONE NO.	SIZE IN MICRONS	WEIGHT 0/0 RETAINED	CUMULATIVE WEIGHT 0/0	CUMULATIVE WT 0/0 PASSING
188	4763.00	.83	.83	99.17
7	2400.00	8.22	9.05	90.95
14	1200.00	11.00	20.04	79.96
25	600.00	9.70	29.75	70.25
52	300.00	8.98	38.73	61.27
100	150.00	5.68	44.41	55.59
200	75.00	4.17	48.58	51.42
300	53.00	2.01	50.59	49.41
-300	-53.00	49.41	100.00	.00

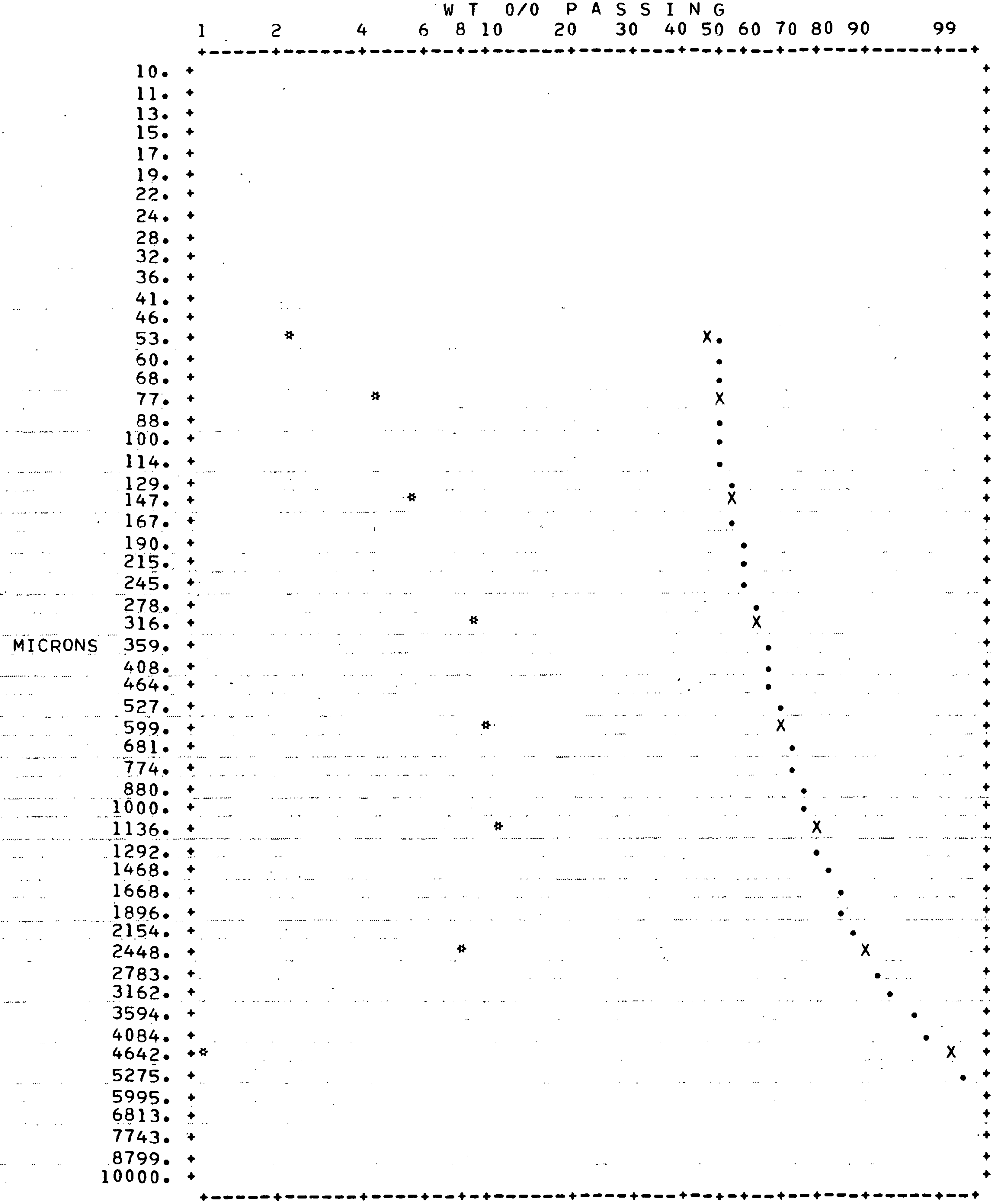
ROSIN RAMMLER PLOT

* = INDIVIDUAL WT. 0/0 RETAINED
* AT 1 0/0 MEANS 1 0/0 OR LESS

X = ACTUAL VALUE

. = BEST FIT LINE USED

THE MICRON VALUES REFER TO THE LINE PRINTER PLOT
POSITIONS AND NOT TO SCREEN APERTURES
USE OF THE LINE PRINTER PLOT IS NOT
RECOMMENDED FOR ACCURATE INTERPOLATION


WT 0/0 PASSING
1 2 4 6 8 10 20 30 40 50 60 70 80 90 99
MICRONS
10. 11. 13. 15. 17. 19. 22. 24. 28. 32. 36. 41. 46. 53. 60. 68. 77. 88. 100. 114. 129. 147. 167. 190. 215. 245. 278. 316. 359. 408. 464. 527. 599. 681. 774. 880. 1000. 1136. 1292. 1468. 1668. 1896. 2154. 2448. 2783. 3162. 3594. 4084. 4642. 5275. 5995. 6813. 7743. 8799. 10000.

1/1/172 H45 NO. 5

WET SCREENED ON 300# SCREENING TIME 15 MINS.

80 0/0 PASSING SIZE = 2022. MICRONS

AVERAGE SLOPE = .4 INTERCEPT = 1.7 INCHES

SCREEN SIZE OR CONE NO.	SIZE IN MICRONS	WEIGHT 0/0 RETAINED	CUMULATIVE WEIGHT 0/0	CUMULATIVE WT 0/0 PASSING
188	4763.00	14.16	14.16	85.84
7	2400.00	5.04	19.21	80.79
14	1200.00	12.38	31.58	68.42
25	600.00	23.82	55.40	44.60
52	300.00	17.27	72.67	27.33
100	150.00	6.23	78.90	21.10
200	75.00	3.34	82.23	17.77
300	53.00	1.02	83.26	16.74
-300	-53.00	16.74	100.00	.00

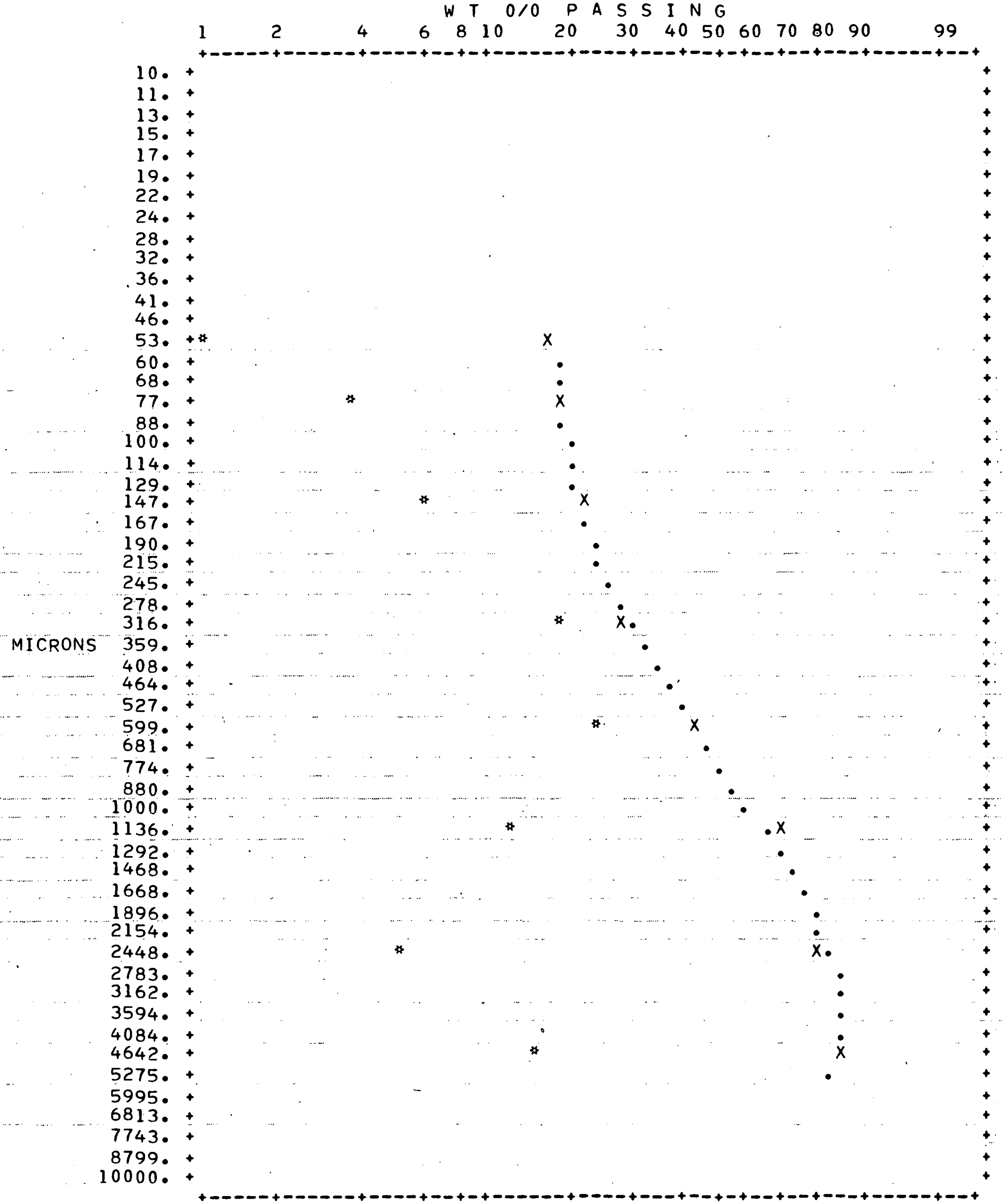
ROSIN RAMMLER PLOT

* = INDIVIDUAL WT. 0/0 RETAINED
* AT 1 0/0 MEANS 1 0/0 OR LESS

X = ACTUAL VALUE

. = BEST FIT LINE USED

THE MICRON VALUES REFER TO THE LINE PRINTER PLOT
POSITIONS AND NOT TO SCREEN APERTURES
USE OF THE LINE PRINTER PLOT IS NOT
RECOMMENDED FOR ACCURATE INTERPOLATION



W T 0/0 P A S S I N G
1 2 4 6 8 10 20 30 40 50 60 70 80 90 99
MICRONS
10. 11. 13. 15. 17. 19. 22. 24. 28. 32. 36. 41. 46. 53. 60. 68. 77. 88. 100. 114. 129. 147. 167. 190. 215. 245. 278. 316. 359. 408. 464. 527. 599. 681. 774. 880. 1000. 1136. 1292. 1468. 1668. 1896. 2154. 2448. 2783. 3162. 3594. 4084. 4642. 5275. 5995. 6813. 7743. 8799. 10000.

```
*************************************************************
*                                                           *
* 1/1/172 H45 NO. 6                                         *
*                                                           *
* WET SCREENED ON 300#  SCREENING TIME 15 MINS.             *
*                                                           *
*                                                           *
* 80 0/0 PASSING SIZE =    1255. MICRONS                    *
*                                                           *
*  AVERAGE SLOPE =    .4        INTERCEPT =   2.7 INCHES    *
*                                                           *
*-----------------------------------------------------------*
*                                                           *
*  SCREEN SIZE  SIZE IN  WEIGHT 0/0  CUMULATIVE  CUMULATIVE *
*  OR CONE NO.  MICRONS  RETAINED    WEIGHT 0/0  WT 0/0 PASSING *
*                                                           *
*-----------------------------------------------------------*
*                                                           *
*         188   4763.00    4.20        4.20       95.80     *
*           7   2400.00    6.94       11.14       88.86     *
*          14   1200.00    8.69       19.82       80.18     *
*          25    600.00   13.89       33.71       66.29     *
*          52    300.00   20.82       54.53       45.47     *
*         100    150.00    7.91       62.44       37.56     *
*         200     75.00    3.36       65.80       34.20     *
*         300     53.00    1.19       66.99       33.01     *
*        -300    -53.00   33.01      100.00        -.00     *
*                                                           *
*************************************************************
```

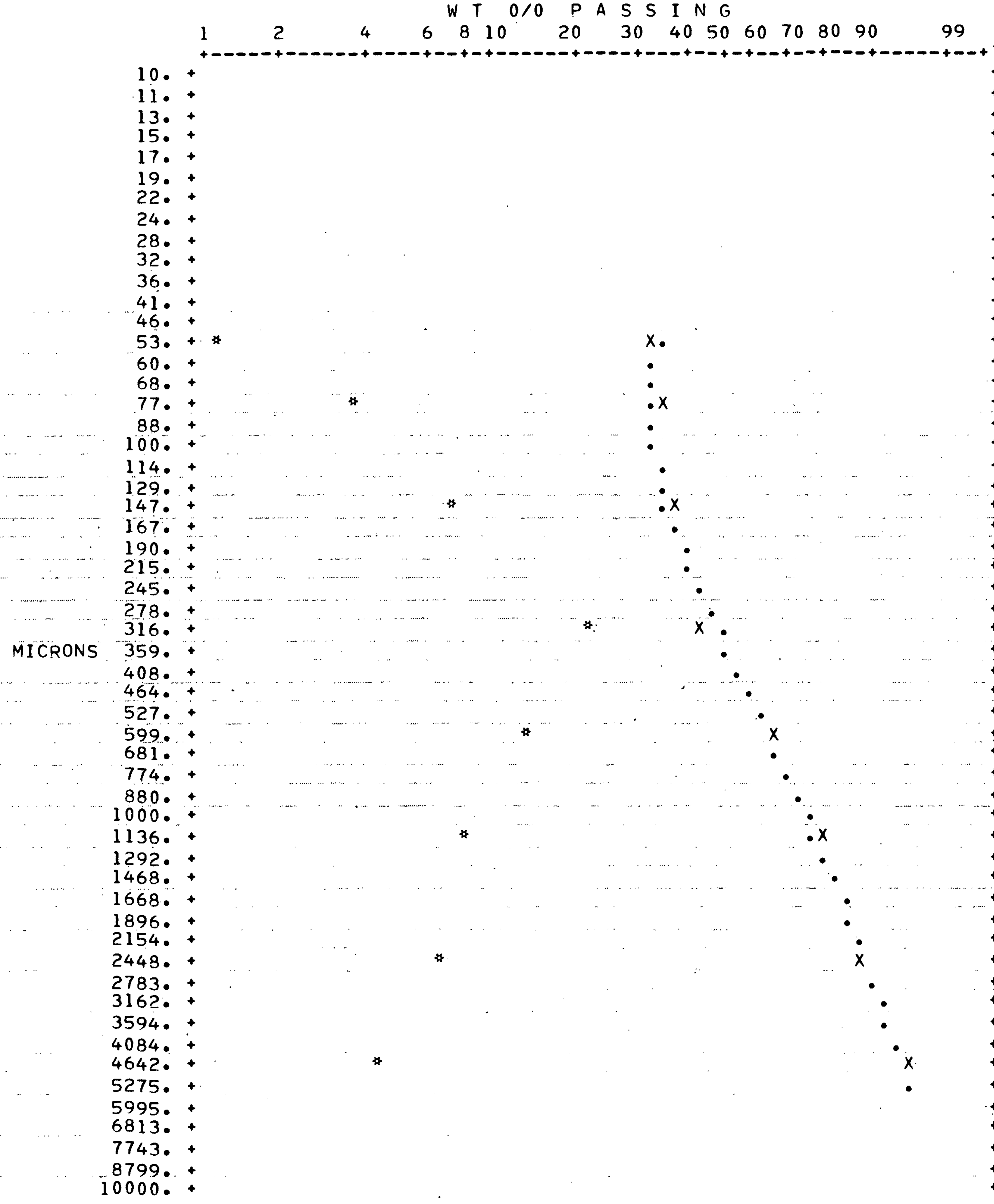
ROSIN RAMMLER PLOT

* = INDIVIDUAL WT. 0/0 RETAINED
* AT 1 0/0 MEANS 1 0/0 OR LESS

X = ACTUAL VALUE

. = BEST FIT LINE USED

THE MICRON VALUES REFER TO THE LINE PRINTER PLOT
POSITIONS AND NOT TO SCREEN APERTURES
USE OF THE LINE PRINTER PLOT IS NOT
RECOMMENDED FOR ACCURATE INTERPOLATION



W T 0/0 P A S S I N G
1 2 4 6 8 10 20 30 40 50 60 70 80 90 99
MICRONS
10. 11. 13. 15. 17. 19. 22. 24. 28. 32. 36. 41. 46. 53. 60. 68. 77. 88. 100. 114. 129. 147. 167. 190. 215. 245. 278. 316. 359. 408. 464. 527. 599. 681. 774. 880. 1000. 1136. 1292. 1468. 1668. 1896. 2154. 2448. 2783. 3162. 3594. 4084. 4642. 5275. 5995. 6813. 7743. 8799. 10000.

1/1/172 H45 NO. 7

WET SCREENED ON 300# SCREENING TIME 15 MINS.

80 0/0 PASSING SIZE = 1037. MICRONS

AVERAGE SLOPE = .5 INTERCEPT = 2.2 INCHES

SCREEN SIZE OR CONE NO.	SIZE IN MICRONS	WEIGHT 0/0 RETAINED	CUMULATIVE WEIGHT 0/0	CUMULATIVE WT 0/0 PASSING
188	4763.00	.70	.70	99.30
7	2400.00	1.61	2.31	97.69
14	1200.00	12.28	14.59	85.41
25	600.00	24.89	39.48	60.52
52	300.00	16.66	56.14	43.86
100	150.00	8.60	64.74	35.26
200	75.00	4.57	69.30	30.70
300	53.00	1.34	70.64	29.36
-300	-53.00	29.36	100.00	.00

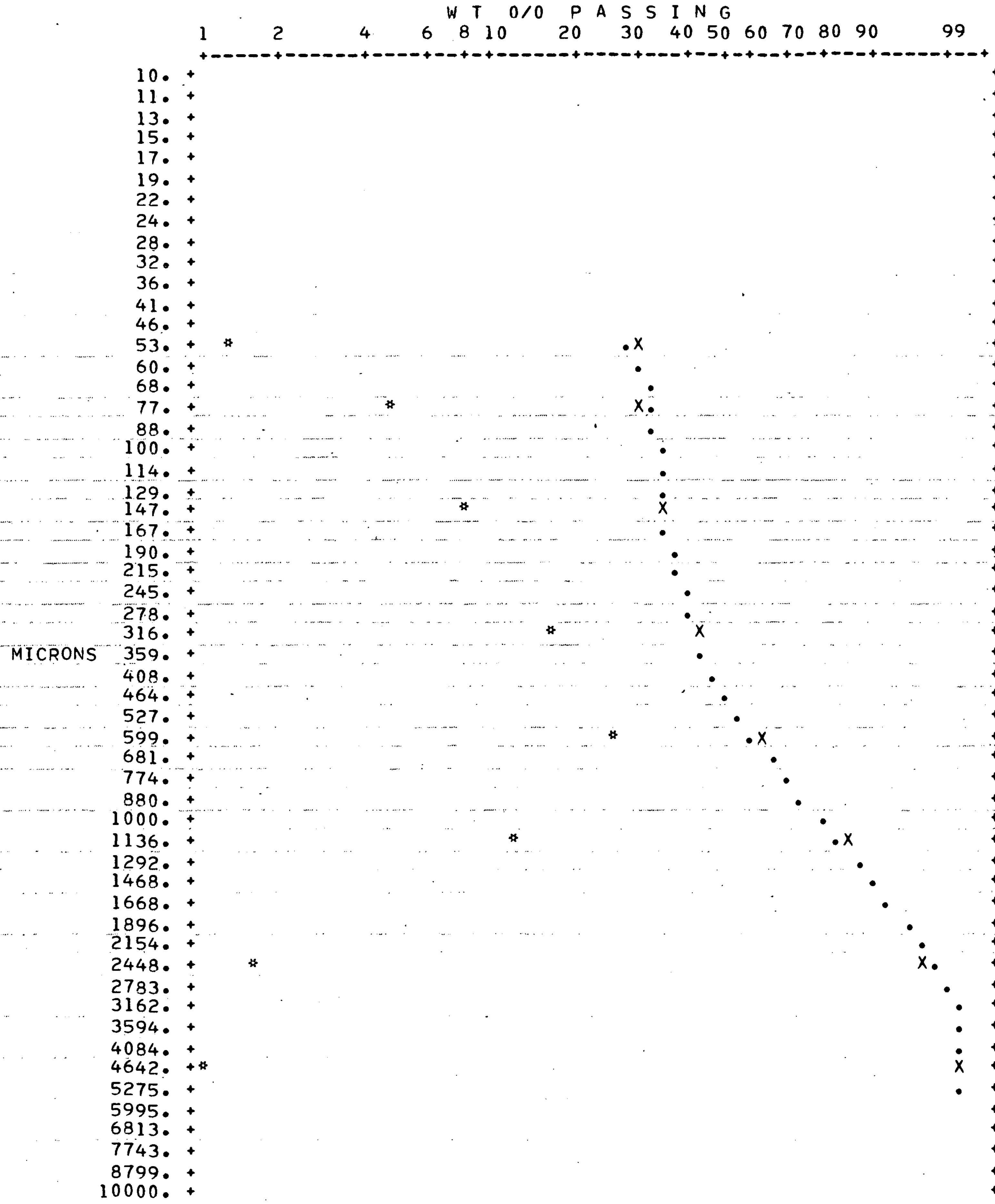
ROSIN RAMMLER PLOT

* = INDIVIDUAL WT. 0/0 RETAINED
* AT 1 0/0 MEANS 1 0/0 OR LESS

X = ACTUAL VALUE

. = BEST FIT LINE USED

THE MICRON VALUES REFER TO THE LINE PRINTER PLOT
POSITIONS AND NOT TO SCREEN APERTURES
USE OF THE LINE PRINTER PLOT IS NOT
RECOMMENDED FOR ACCURATE INTERPOLATION


W T 0/0 P A S S I N G
1 2 4 6 8 10 20 30 40 50 60 70 80 90 99
MICRONS
10. 11. 13. 15. 17. 19. 22. 24. 28. 32. 36. 41. 46. 53. 60. 68. 77. 88. 100. 114. 129. 147. 167. 190. 215. 245. 278. 316. 359. 408. 464. 527. 599. 681. 774. 880. 1000. 1136. 1292. 1468. 1668. 1896. 2154. 2448. 2783. 3162. 3594. 4084. 4642. 5275. 5995. 6813. 7743. 8799. 10000.

1/1/172 H45 NO. 8

WET SCREENED ON 300# SCREENING TIME 15 MINS.

80 0/0 PASSING SIZE = 825. MICRONS

AVERAGE SLOPE = .6 INTERCEPT = 1.5 INCHES

SCREEN SIZE OR CONE NO.	SIZE IN MICRONS	WEIGHT 0/0 RETAINED	CUMULATIVE WEIGHT 0/0	CUMULATIVE WT 0/0 PASSING
188	4763.00	.39	.39	99.61
7	2400.00	2.30	2.70	97.30
14	1200.00	7.00	9.70	90.30
25	600.00	20.74	30.43	69.57
52	300.00	27.26	57.70	42.30
100	150.00	15.64	73.34	26.66
200	75.00	7.27	80.61	19.39
300	53.00	1.24	81.84	18.16
-300	-53.00	18.16	100.00	.00

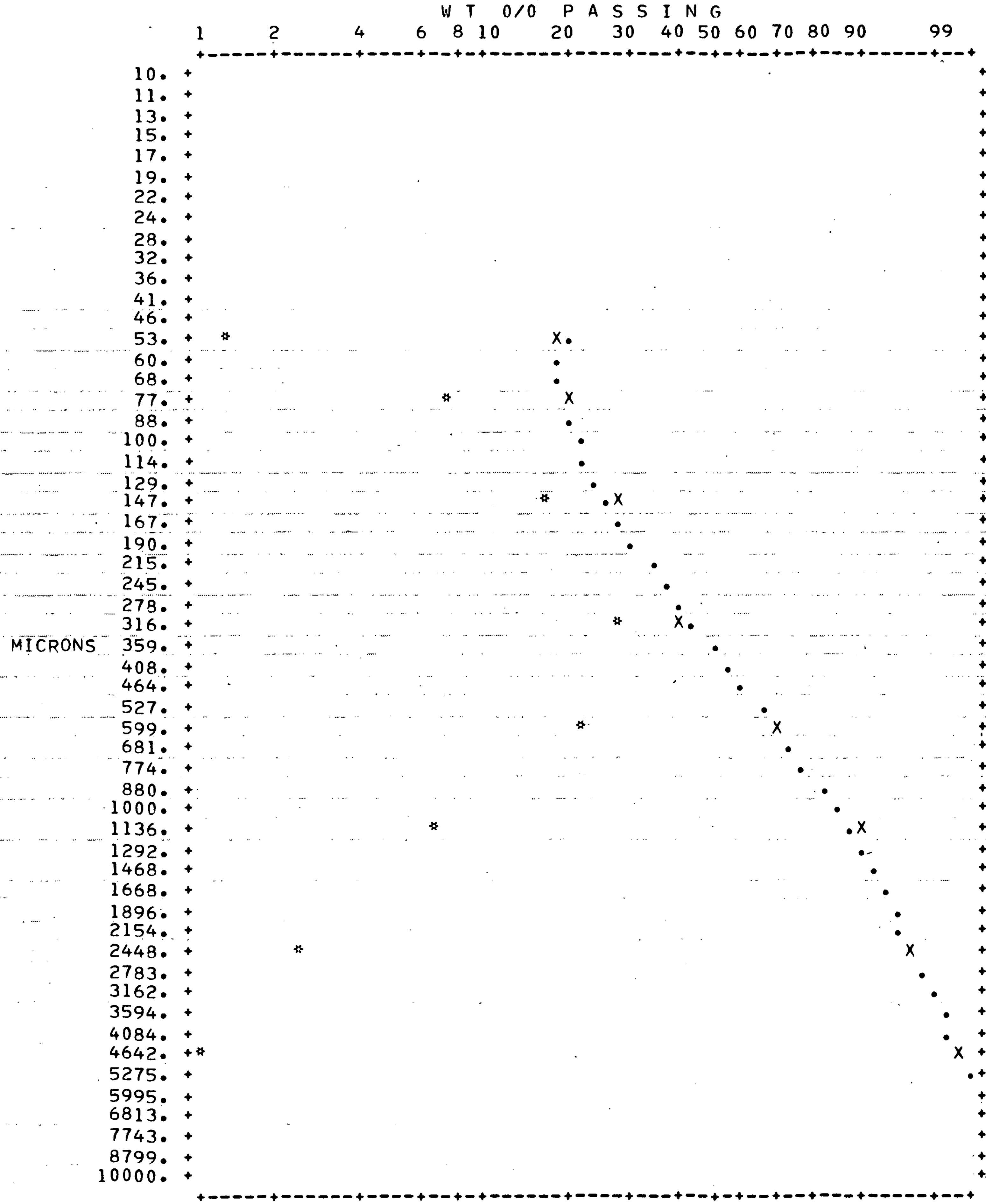
ROSIN RAMMLER PLOT

* = INDIVIDUAL WT. 0/0 RETAINED
* AT 1 0/0 MEANS 1 0/0 OR LESS

X = ACTUAL VALUE

. = BEST FIT LINE USED

THE MICRON VALUES REFER TO THE LINE PRINTER PLOT
POSITIONS AND NOT TO SCREEN APERTURES
USE OF THE LINE PRINTER PLOT IS NOT
RECOMMENDED FOR ACCURATE INTERPOLATION


W T 0/0 P A S S I N G
1 2 4 6 8 10 20 30 40 50 60 70 80 90 99
MICRONS
10.
11.
13.
15.
17.
19.
22.
24.
28.
32.
36.
41.
46.
53.
60.
68.
77.
88.
100.
114.
129.
147.
167.
190.
215.
245.
278.
316.
359.
408.
464.
527.
599.
681.
774.
880.
1000.
1136.
1292.
1468.
1668.
1896.
2154.
2448.
2783.
3162.
3594.
4084.
4642.
5275.
5995.
6813.
7743.
8799.
10000.

1/1/172 H45 NO.9

WET SCREENED ON 300# SCREENING TIME 15 MINS.

80 0/0 PASSING SIZE = 874. MICRONS

AVERAGE SLOPE = .5 INTERCEPT = 1.7 INCHES

SCREEN SIZE OR CONE NO.	SIZE IN MICRONS	WEIGHT 0/0 RETAINED	CUMULATIVE WEIGHT 0/0	CUMULATIVE WT 0/0 PASSING
188	4763.00	2.63	2.63	97.37
7	2400.00	.45	3.08	96.92
14	1200.00	4.82	7.90	92.10
25	600.00	27.26	35.16	64.84
52	300.00	26.55	61.70	38.30
100	150.00	12.20	73.91	26.09
200	75.00	4.58	78.49	21.51
300	53.00	1.16	79.65	20.35
-300	-53.00	20.35	100.00	.00

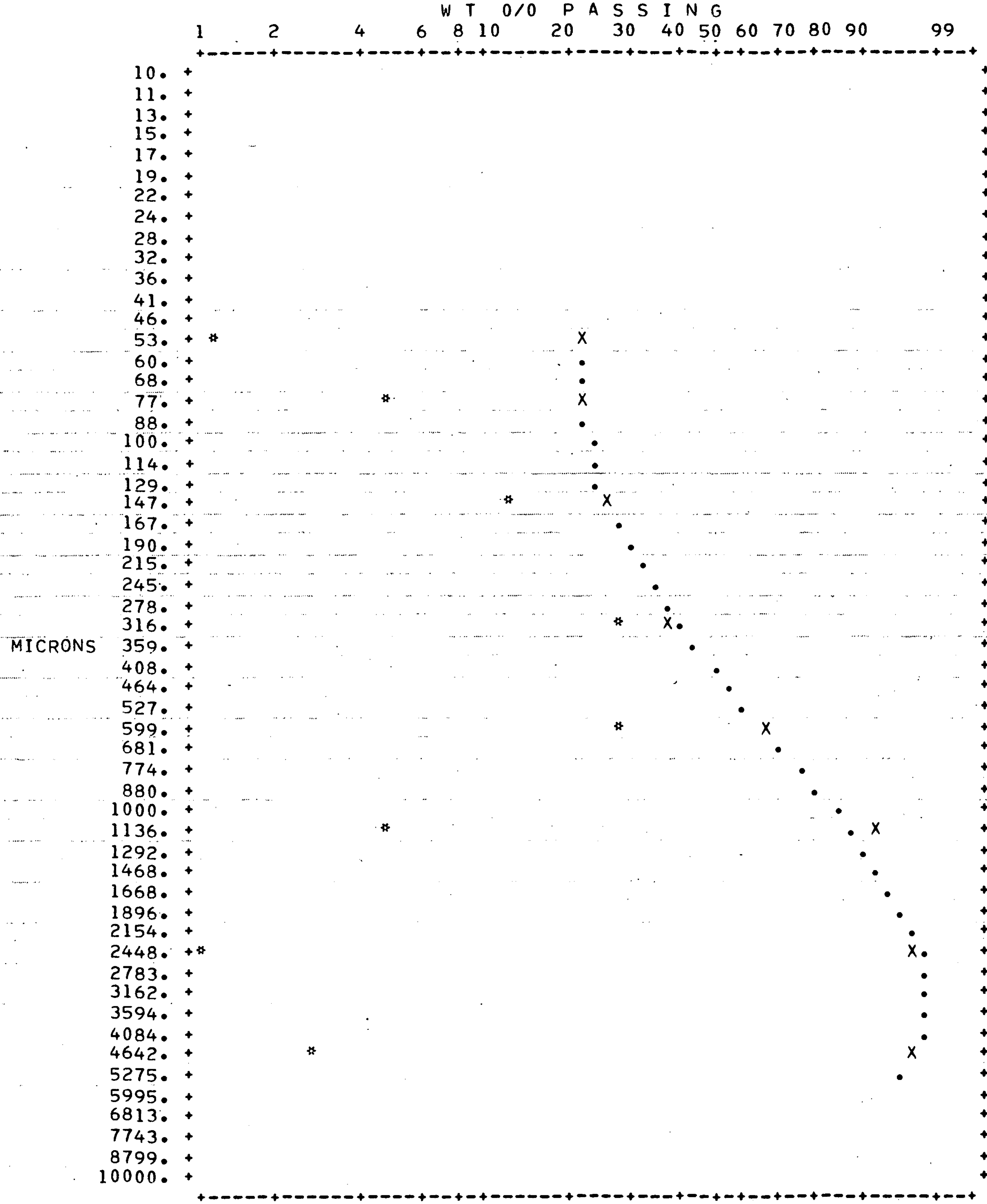
ROSIN RAMMLER PLOT

* = INDIVIDUAL WT. 0/0 RETAINED
* AT 1 0/0 MEANS 1 0/0 OR LESS

X = ACTUAL VALUE

. = BEST FIT LINE USED

THE MICRON VALUES REFER TO THE LINE PRINTER PLOT
POSITIONS AND NOT TO SCREEN APERTURES
USE OF THE LINE PRINTER PLOT IS NOT
RECOMMENDED FOR ACCURATE INTERPOLATION


W T 0/0 P A S S I N G
1 2 4 6 8 10 20 30 40 50 60 70 80 90 99
MICRONS
10.
11.
13.
15.
17.
19.
22.
24.
28.
32.
36.
41.
46.
53.
60.
68.
77.
88.
100.
114.
129.
147.
167.
190.
215.
245.
278.
316.
359.
408.
464.
527.
599.
681.
774.
880.
1000.
1136.
1292.
1468.
1668.
1896.
2154.
2448.
2783.
3162.
3594.
4084.
4642.
5275.
5995.
6813.
7743.
8799.
10000.

1/1/172 H45 NO. 10

WET SCREENED ON 300# SCREENING TIME 15 MINS.

80 0/0 PASSING SIZE = 1462. MICRONS

AVERAGE SLOPE = .5 INTERCEPT = 1.7 INCHES

SCREEN SIZE OR CONE NO.	SIZE IN MICRONS	WEIGHT 0/0 RETAINED	CUMULATIVE WEIGHT 0/0	CUMULATIVE WT 0/0 PASSING
188	4763.00	16.27	16.27	83.73
7	2400.00	.10	16.37	83.63
14	1200.00	5.32	21.69	78.31
25	600.00	18.14	39.83	60.17
52	300.00	24.80	64.63	35.37
100	150.00	15.15	79.77	20.23
200	75.00	4.11	83.89	16.11
300	53.00	.92	84.81	15.19
-300	-53.00	15.19	100.00	.00

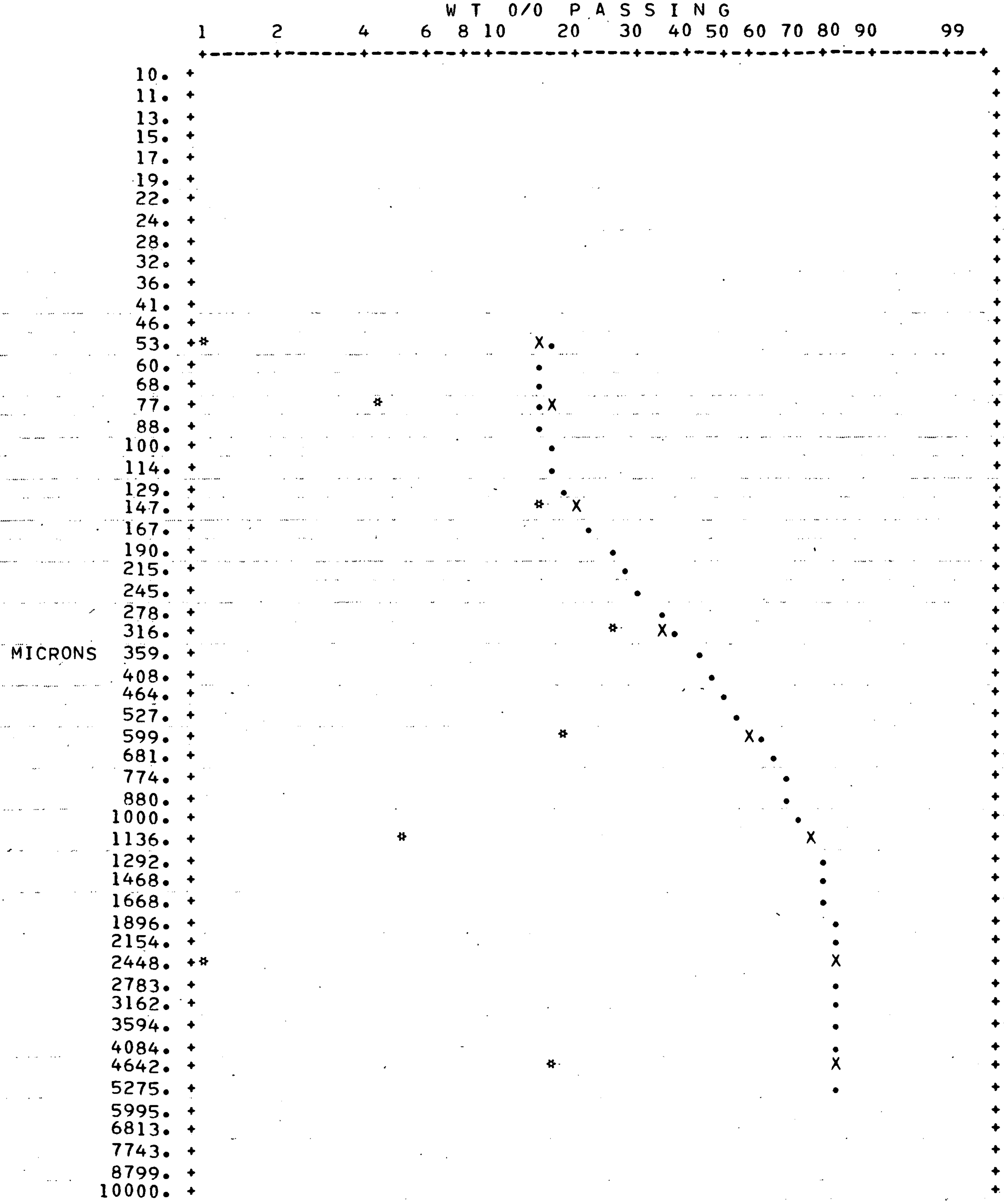
ROSIN RAMMLER PLOT

* = INDIVIDUAL WT. 0/0 RETAINED
* AT 1 0/0 MEANS 1 0/0 OR LESS

X = ACTUAL VALUE

. = BEST FIT LINE USED

THE MICRON VALUES REFER TO THE LINE PRINTER PLOT
POSITIONS AND NOT TO SCREEN APERTURES
USE OF THE LINE PRINTER PLOT IS NOT
RECOMMENDED FOR ACCURATE INTERPOLATION


W T 0/0 P A S S I N G
1 2 4 6 8 10 20 30 40 50 60 70 80 90 99
MICRONS
10.
11.
13.
15.
17.
19.
22.
24.
28.
32.
36.
41.
46.
53.
60.
68.
77.
88.
100.
114.
129.
147.
167.
190.
215.
245.
278.
316.
359.
408.
464.
527.
599.
681.
774.
880.
1000.
1136.
1292.
1468.
1668.
1896.
2154.
2448.
2783.
3162.
3594.
4084.
4642.
5275.
5995.
6813.
7743.
8799.
10000.

1/1/172 H45 NO. 11

WET SCREENED ON 300# SCREENING TIME 15 MINS.

80 0/0 PASSING SIZE = 682. MICRONS

AVERAGE SLOPE = .6 INTERCEPT = 1.4 INCHES

SCREEN SIZE OR CONE NO.	SIZE IN MICRONS	WEIGHT 0/0 RETAINED	CUMULATIVE WEIGHT 0/0	CUMULATIVE WT 0/0 PASSING
188	4763.00	.07	.07	99.93
7	2400.00	1.05	1.13	98.87
14	1200.00	3.91	5.03	94.97
25	600.00	18.80	23.84	76.16
52	300.00	34.19	58.02	41.98
100	150.00	15.90	73.92	26.08
200	75.00	5.04	78.96	21.04
300	53.00	1.13	80.09	19.91
-300	-53.00	19.91	100.00	.00

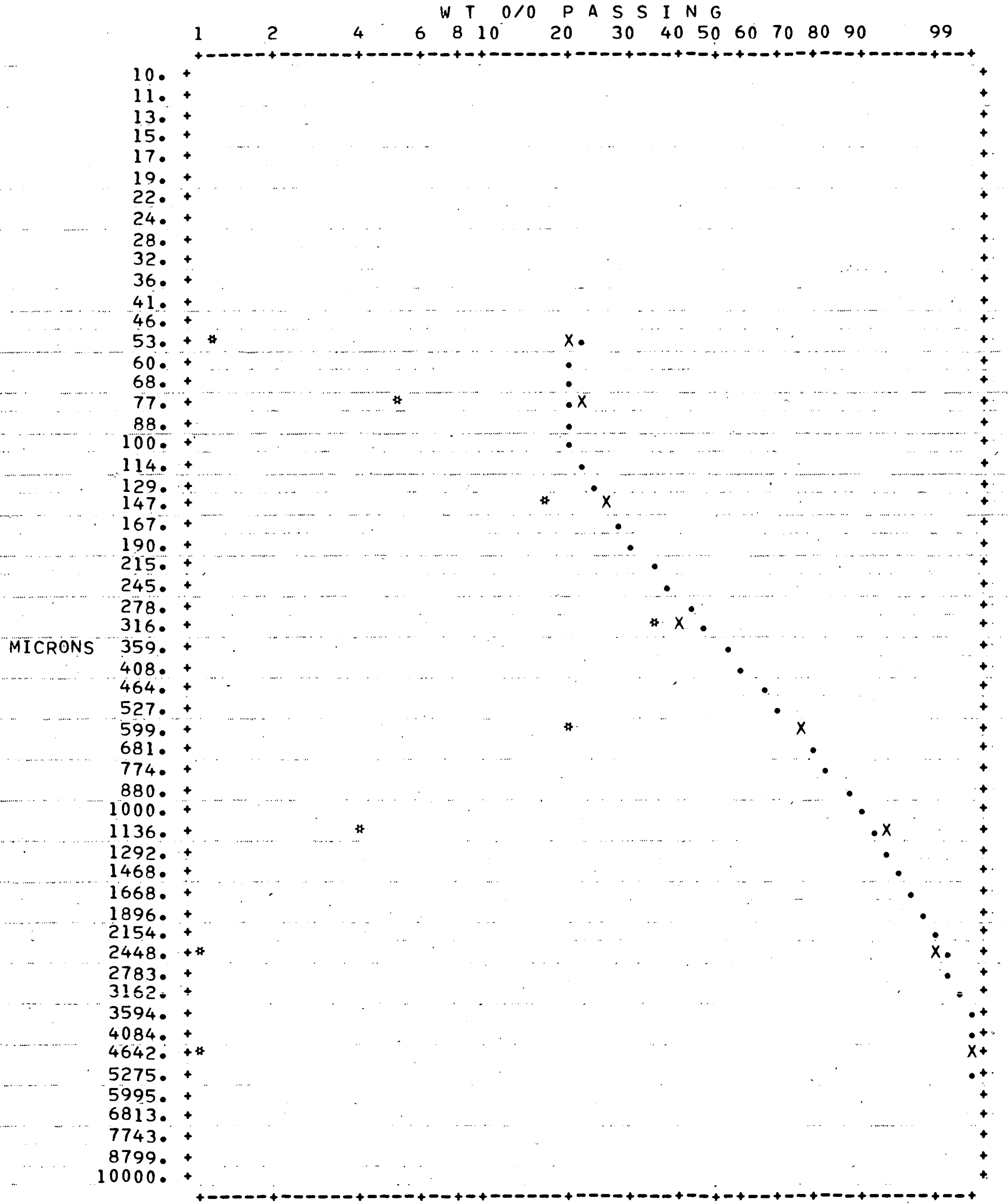
ROSIN RAMMLER PLOT

* = INDIVIDUAL WT. 0/0 RETAINED
* AT 1 0/0 MEANS 1 0/0 OR LESS

X = ACTUAL VALUE

. = BEST FIT LINE USED

THE MICRON VALUES REFER TO THE LINE PRINTER PLOT
POSITIONS AND NOT TO SCREEN APERTURES
USE OF THE LINE PRINTER PLOT IS NOT
RECOMMENDED FOR ACCURATE INTERPOLATION



W T 0/0 P A S S I N G
1 2 4 6 8 10 20 30 40 50 60 70 80 90 99
MICRONS
10. 11. 13. 15. 17. 19. 22. 24. 28. 32. 36. 41. 46. 53. 60. 68. 77. 88. 100. 114. 129. 147. 167. 190. 215. 245. 278. 316. 359. 408. 464. 527. 599. 681. 774. 880. 1000. 1136. 1292. 1468. 1668. 1896. 2154. 2448. 2783. 3162. 3594. 4084. 4642. 5275. 5995. 6813. 7743. 8799. 10000.

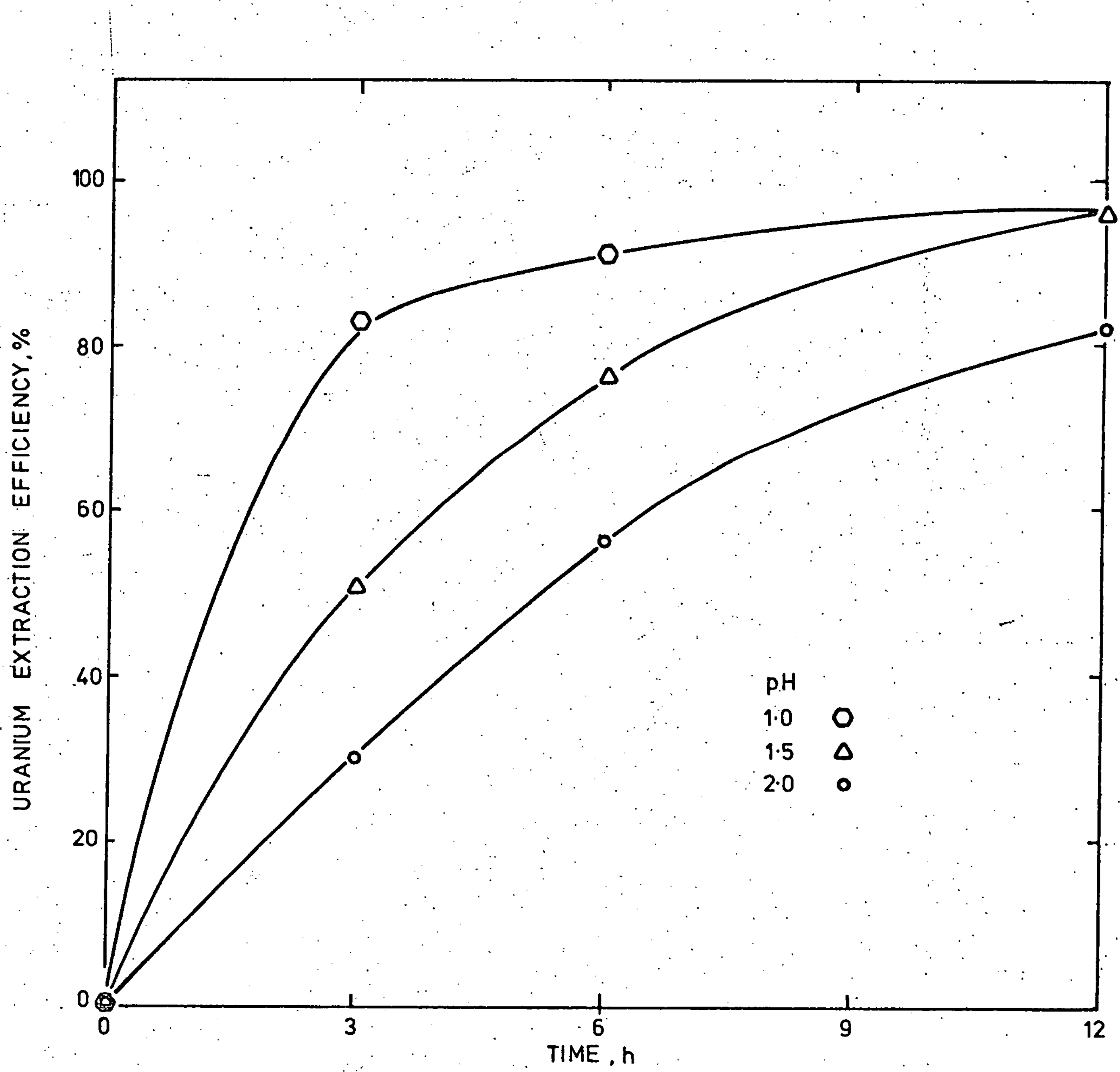


FIG.1: URANIUM EXTRACTION EFFICIENCY AS A FUNCTION OF TIME AND pH FOR COMPOSITE B

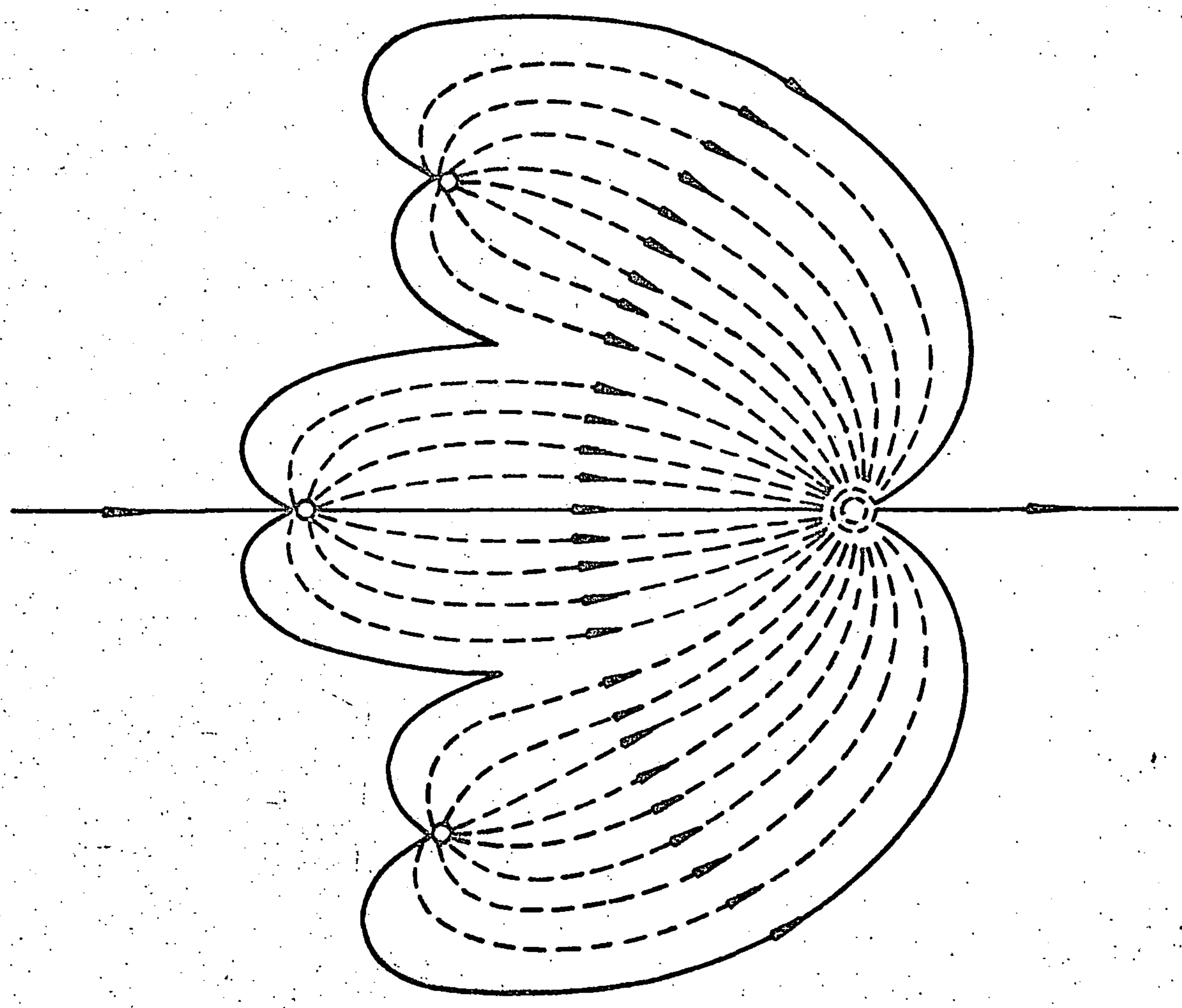


FIG. 2: THE WELL PATTERN CURRENTLY USED AT SHIRLEY BASIN MINES CONSISTS OF THREE INFLOW WELLS LOCATED UPSTREAM IN THE REGIONAL GROUND-WATER FLOW FROM A PRODUCTION WELL. THE CENTRE WELL IS DIRECTLY UPSTREAM AND THE OTHER TWO WELLS ARE ON RADII DIVERGING AT AN ANGLE OF 75° FROM ONE ANOTHER. INFLOW WELLS ARE 6 m FROM THE PRODUCTION WELL.

Reproduced from Anderson & Ritchie (1968)

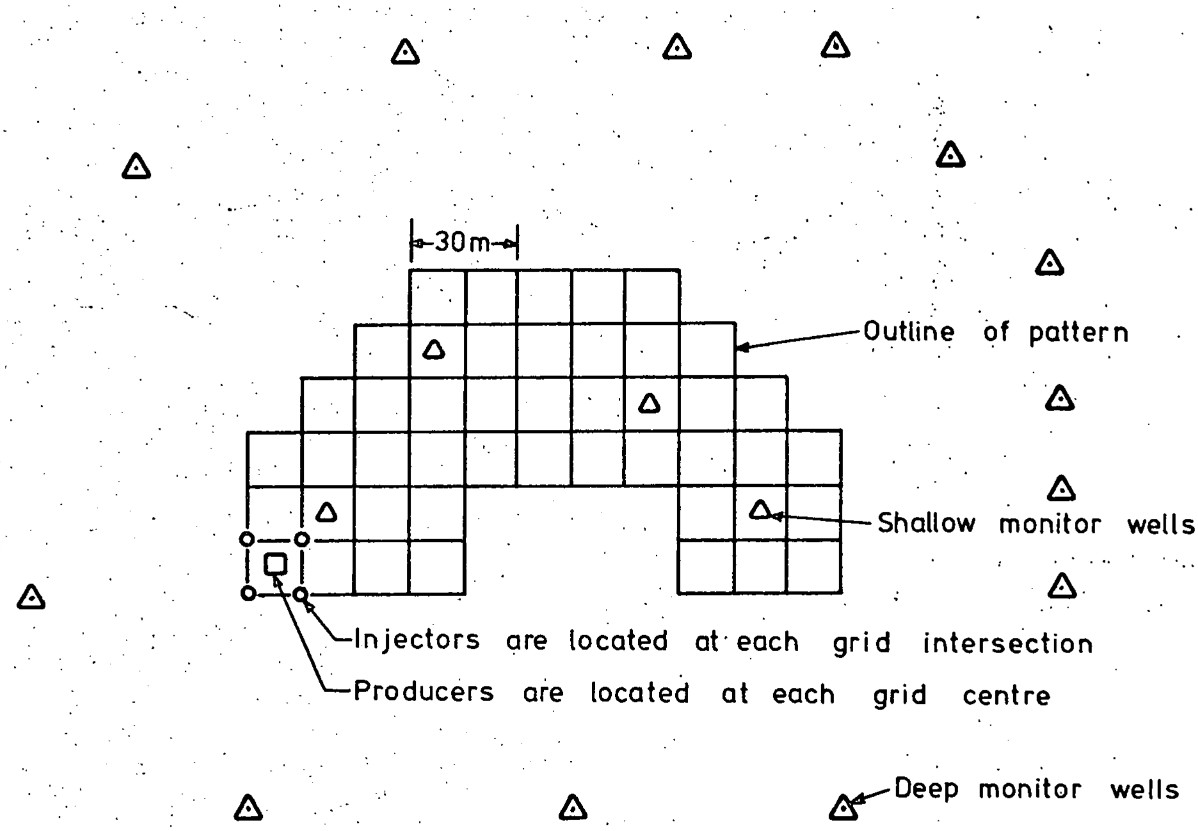


FIG. 3: CLAY WEST URANIUM LEACHING PATTERN

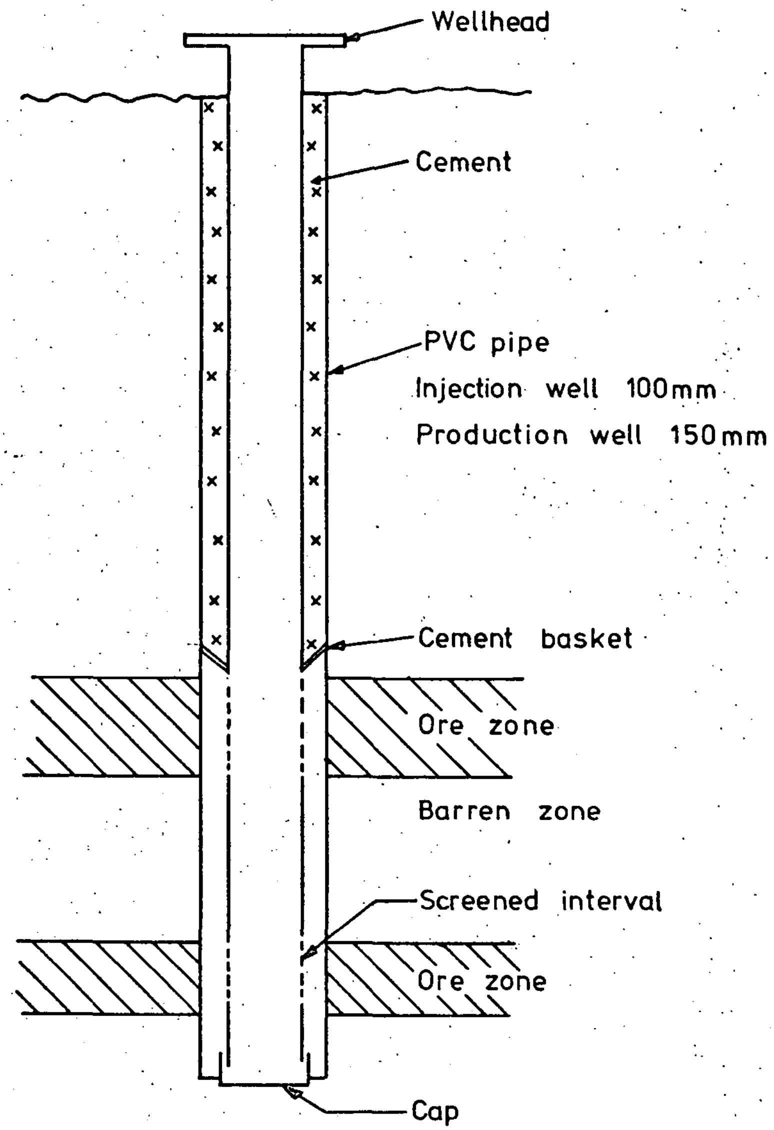


FIG.4: GENERALISED SECTION OF CLAY WEST INJECTION AND PRODUCTION WELLS

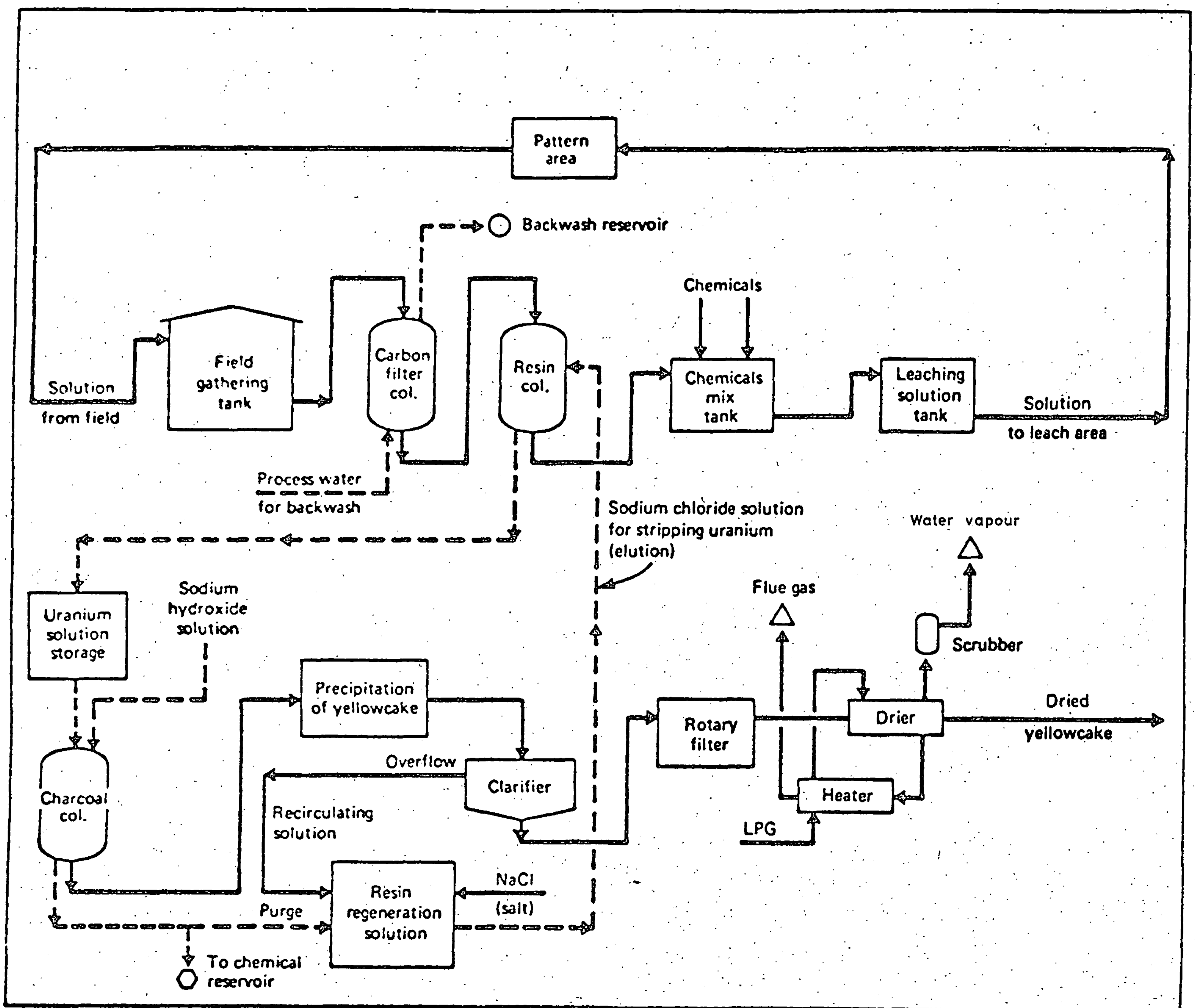


FIG.5: URANIUM EXTRACTION FLOW SHEET, CLAY WEST, TEXAS