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The AS-76 Interlaboratory Experiment on the Alpha Spectrometric Determination of Pu-238

**Part II:
Collection and Evaluation of
Representative Spectra**

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Projekt Spaltstoffflußkontrolle

Kernforschungszentrum Karlsruhe

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Part II: Collection and Evaluation of
Representative Spectra

G. Spannagel, W. Beyrich and G. Bortels⁺⁾

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Abstract

The AS-76 interlaboratory program furnished 828 alpha spectra. A selection of these spectra was evaluated in more detail by use of information supplied by the laboratories and by application of a common procedure of evaluation.

The selected spectra are presented as graphs.

Zusammenfassung

Das Interlaborexperiment AS-76 zur alphaspektrometrischen Bestimmung von Pu-238

Teil II: Zusammenstellung und Auswertung repräsentativer Spektren

Für das Interlaborprogramm AS-76 wurden 828 Alphaspektren gemessen. Eine Auswahl dieser Spektren wurde detaillierter untersucht, indem einerseits die von den Laboratorien übermittelte Information ausgewertet wurde, und andererseits die Spektren einer einheitlichen Auswertemethode unterzogen wurden.

Abbildungen aller ausgewählten Spektren sind beigelegt.

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W. Beyrich and G. Spannagel

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1. Introduction

The AS-76 interlaboratory program focused on the alpha-spectrometric determination of the ratio Pu-238/(Pu-239 + Pu-240). Each of the participating 23 laboratories handled 4 samples, 3 targets per sample, and 3 spectra per target; therefore, AS-76 provided a total of 828 alpha spectra.

For this study a total of 92 so-called 'representative' spectra were selected: for each sample as well as for each laboratory that spectrum was chosen which represented best the so-called 'laboratory mean' ¹⁾. Two of the participating laboratories were not in a position to furnish the necessary data; therefore, only 86 representative spectra are presented in this report. One laboratory submitted data from a repetition measurement because the data generated originally were no longer available. The representative spectra are compiled in Tab. 1.1.

In order to apply to these spectra one common evaluation procedure, plotting of the data submitted became necessary. It seemed meaningful to present in this report also the graphs so obtained.

¹⁾ 'laboratory mean': $y_{i..} = \frac{1}{9} \sum_{j=1}^3 \sum_{k=1}^3 y_{ijk}$, with y_{ijk} standing for the alpha-activity ratio Pu-238/(Pu-239 + Pu-240) reported by laboratory i on target j for spectrum k (see also Part I of this report).

Lab. Code	Sample	Target No.	Spectrum No.	Lab. Code	Sample	Target No.	Spectrum No.	Lab. Code	Sample	Target No.	Spectrum No.
1	A	1	1	9	A	3	1	17	A	1	1
	B	1	3		B	2	3		B	1	2
	C	3	2		C	3	2		C	1	3
	D	1	1		D	1	3		D	2	1
2	A	1	1	10	A	2	3	18	A	2	3
	B	2	2		B	1	1		B	2	1
	C	2	3		C	2	3		C	2	1
	D	2	3		D	2	3		D	2	2
3	A	2	3	11	A	1	2	19	A	1	1
	B	3	3		B	2	1		B	1	1
	C	2	3		C	2	1		C	3	2
	D	3	2		D	1	2		D	1	2
4	A	2	1	12	A	3	1	20	A	1	3
	B	1	1		B	1	2		B	1	2
	C	2	2		C	2	3		C	1	3
	D	1	1		D	3	1		D	3	3
5	A	1	1	13	A	2	2	21	A	3	1
	B	1	1		B	2	3		B	2	2
	C	3	3		C	3	3		C	3	3
	D	1	1		D	3	1		D	1	2
6	A	3	3	14	A	3	2	22	A	2	1
	B	1	3		B	3	3		B	1	3
	C	2	3		C	3	3		C	1	3
	D	3	3		D	2	2		D	1	1
7	A	2	2	15	A	2	1	23	A	1	3
	B	3	1		B	1	3		B	2	3
	C	3	3		C	3	3		C	1	1
	D	2	3		D	3	2		D	2	2
8	A	3	2	16	A	2	1				
	B	3	1		B	1	2				
	C	2	1		C	3	3				
	D	2	2		D	3	3				

Tab. 1.1: Representative spectra selected.

2. Remarks on the Plotting of Spectrum Data

The data registered by the laboratory's own analyzers had been recovered through printout (12 laboratories) and through punched paper tape (9 laboratories). This so-called 'basic' data material was transferred to disc storage and finally plotted by means of adapted plotting routines.

The graphs shown in the Appendix display on the abscissa arbitrarily chosen channel numbers, starting with channel number '1' and extending to channel numbers sufficiently high to cover the spectra data communicated by the laboratories ¹). On the ordinate the counts per channel are given in a logarithmic and in a normalized manner (the counts belonging to the highest peak were normalized to 10^5). Counts displayed for an ordinate value '1' represent basic data with the value '0'. Each graph is labeled according to 'sample', 'laboratory code', 'target'- and 'spectrum'-number, the latter 3 labels appearing below the sample indicator.

¹) Laboratory 3 reported only data covering the peak regions; the background data between the peak regions were not specified sufficiently.

3. Information Derived from the Spectra Reported

To correlate information contained in the representative spectra with data already reported by the laboratories, Tab. 3.1 was compiled ¹⁾. The following explanations are related to the information given:

Column 2: IE and SE stand for ion exchange and solvent extraction, respectively.

Column 3: ED and DE stand for electro-deposition and direct evaporation, respectively.

Column 4: Approximate figures are given for the solid angle in percent of 4π , calculated using the detector area and the target detector distance, and assuming a point source.

A dash is entered in case the information necessary for this estimation was not available or could not be evaluated for any other reason.

Column 5: The figures given were obtained through averaging the reported values related to a laboratory (total number of counts and counting times for all four samples). In connection with the information in columns 3 and 4, this conveys an idea of the source strength.

Columns

6 to 9 : 'Delta' stands for the absolute value of the relative deviation of the alpha-activity ratio related to a 'representative' spectrum (as determined by the participating laboratory) from the characterization value; for sample A, due to the missing characterization value, the deviation from the grand mean \bar{y}^* after elimination of outliers is presented.

¹⁾ This table presents also some data already mentioned in Tab. 3.1 of Part I of this report.

1	2	3	4	5	6	7	8	9	10	11	12	13
Lab. Code	Separation Procedure	Target Preparation	Counting Geometry (%)	Counting Rate ¹⁾ (cpm)	D e l t a (%)				R a t i o			
					A	B	C	D	A	B	C	D
1	IE	ED	-	2 905	0.04	0.07	0.27	0	3010	1050	2040	1350
2	IE	DE	8.0	976	1.15	0.41	0.49	0.23	670	150	90	310
3	SE	DE	2.8	1 251	0.24	2.00	1.44	6.84	60	160	60	20
4	IE	DE	8.3	1 267	0.19	0.07	0.87	0.31	330	330	210	200
5	IE	ED	1.3	8 031	2.07	0.16	0.16	0.01	1610	910	530	1060
6	IE	DE	-	1 315	0.93	1.43	4.81	0.62	110	250	60	170
7	SE	ED	0.5-2.0	1 743	0.19	0.53	2.57	1.33	1720	820	420	360
8	IE	DE	3.1	24 426	1.25	4.15	6.12	3.79	290	100	490	90
9	SE	ED	1.6	31	1.69	0.003	0.62	0.98	100	150	4	120
10	IE	ED	-	13 428	0.39	0.19	0.16	0.01	680	870	740	660
11	SE	DE	24	285	0.77	3.25	7.63	4.09	60	40	20	50
12	SE	DE	3.0	68	1.03	0.97	1.34	0.37	180	90	60	90
13	SE	DE	11	25 600	0.19	0.12	0.21	0.15	550	250	200	240
14	IE	DE	1.6	3 141	6.51	3.36	1.47	0.60	70	50	20	40
15	IE	ED	-	38 910	1.51	2.68	2.29	1.25	260	90	70	370
16	SE	DE	0.3	660	0.29	0.76	2.95	1.13	530	110	90	180
17	IE	ED	-	838	5.42	6.53	2.35	5.51	90	90	60	70
18	SE	ED	16	26 545	1.77	0.97	0.27	0.43	2940	1560	300	1110
19	SE	ED	0.2	²⁾	0.06	0.90	0.94	0.18	1830	1240	800	1320
21	IE	DE	-	10 920	10.90	0.48	5.25	1.89	30	80	20	20
23	IE	DE	0.9	10 315	1.13	0.007	9.35	0.92	60	10	10	140

¹⁾ The given counting rate represents an average of the counting rates reported for the samples A, B, C and D.

²⁾ Data were not reported.

Tab. 3.1: Survey on information gathered from the 'representative' spectra.

Columns

10 to 13: 'Ratio' indicates a rough quantity for the ratio of the counts per channel related to the maximum of one peak ¹⁾ versus the counts per one channel attributable to the 'valley' between the two peaks (see Fig. 3.1).

Looking at the data presented in Tab. 3.1, no clear-cut relationships seem to be indicated. To demonstrate one possible correlation, the dependence of 'Ratio' on 'Delta' ²⁾ is presented in Figs. 3.2 to 3.5: the expected trend might be derived, i.e. low values of the quantity 'Ratio' belong to high values of the quantity 'Delta'. This confirms that the better the resolution the smaller the tail correction is, which induces in this way an alpha-activity ratio somewhat closer to the 'true' value.

¹⁾ For sample A the Pu-238-peak and for samples B, C, and D the (Pu-239 + Pu-240)-peaks were chosen.

²⁾ Of course, 'Delta' is affected by several error sources which are not covered by the quantity 'Ratio'.

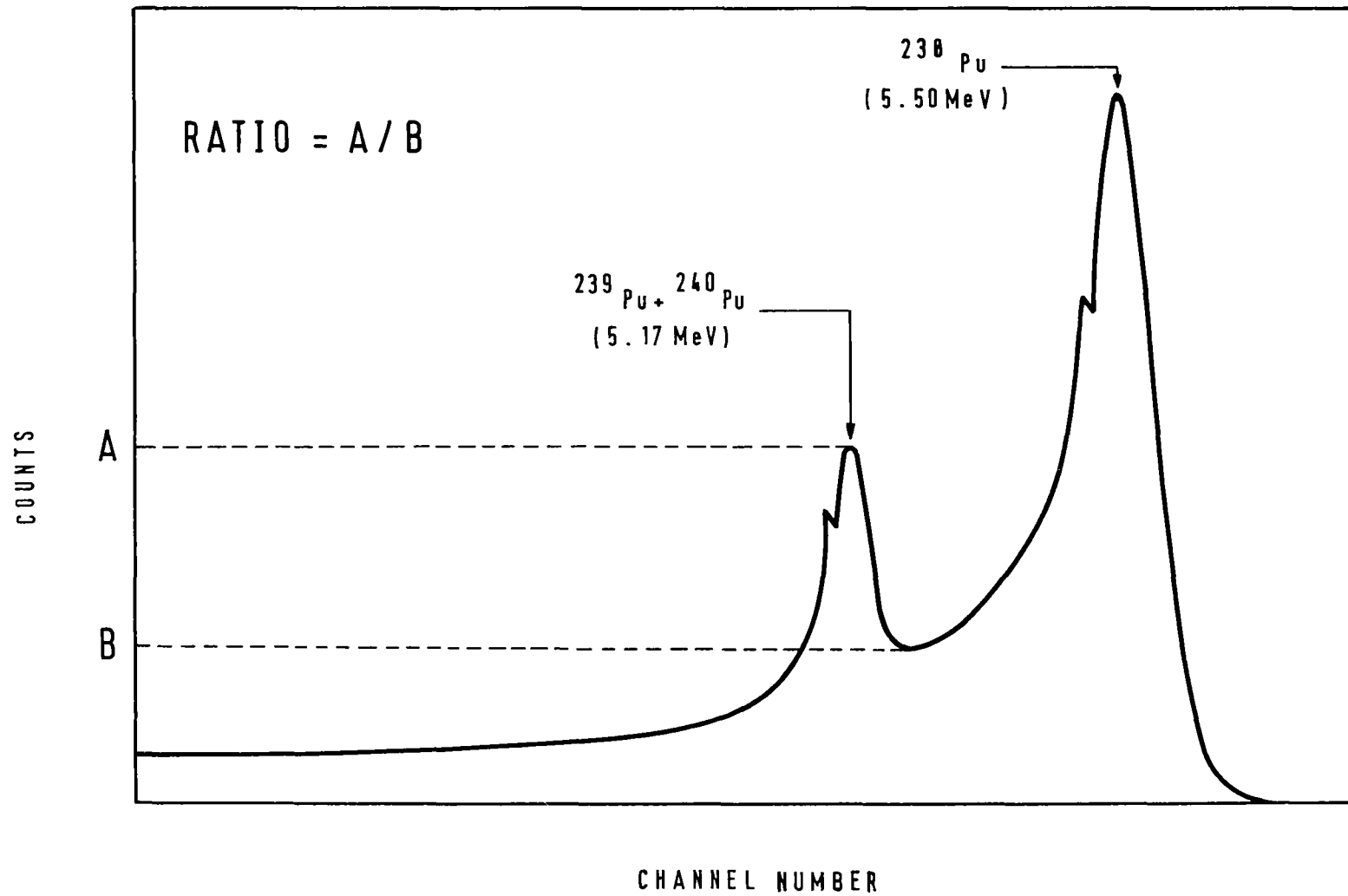


Fig. 3.1: Illustration of the peak-to-valley ratio.

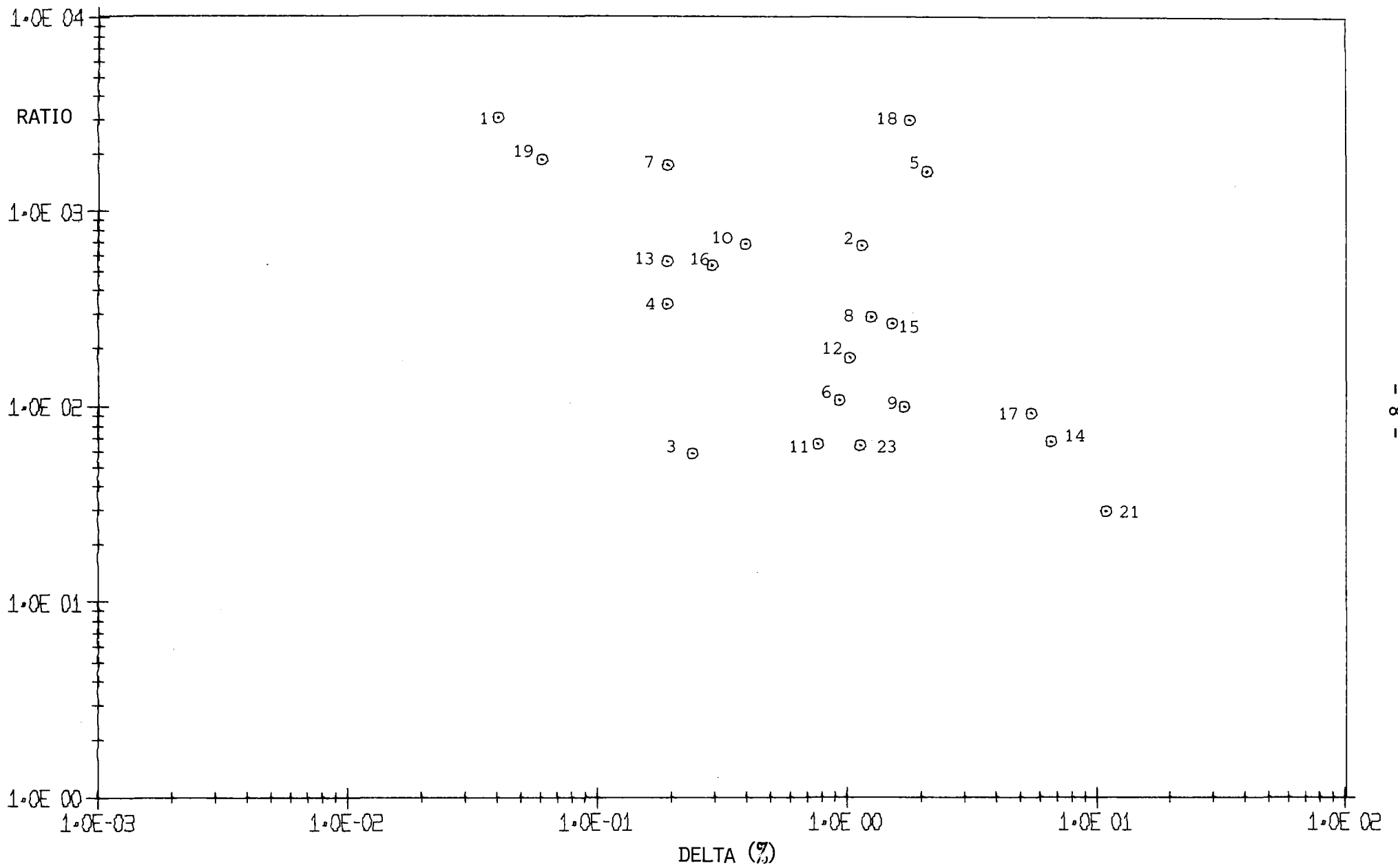


Fig. 3.2: Dependence of 'Ratio' on 'Delta' for sample A.

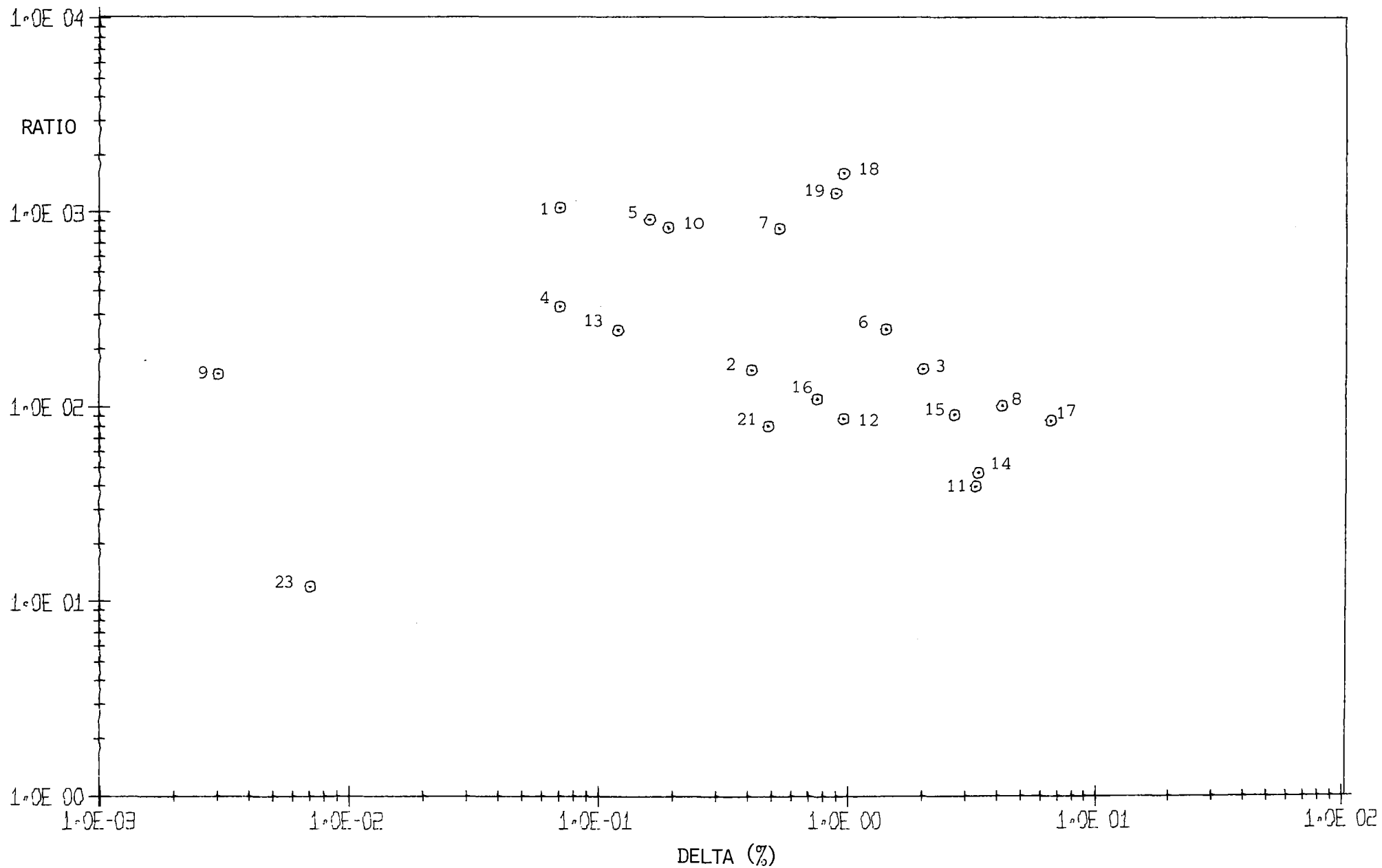


Fig. 3.3: Dependence of 'Ratio' on 'Delta' for sample B.

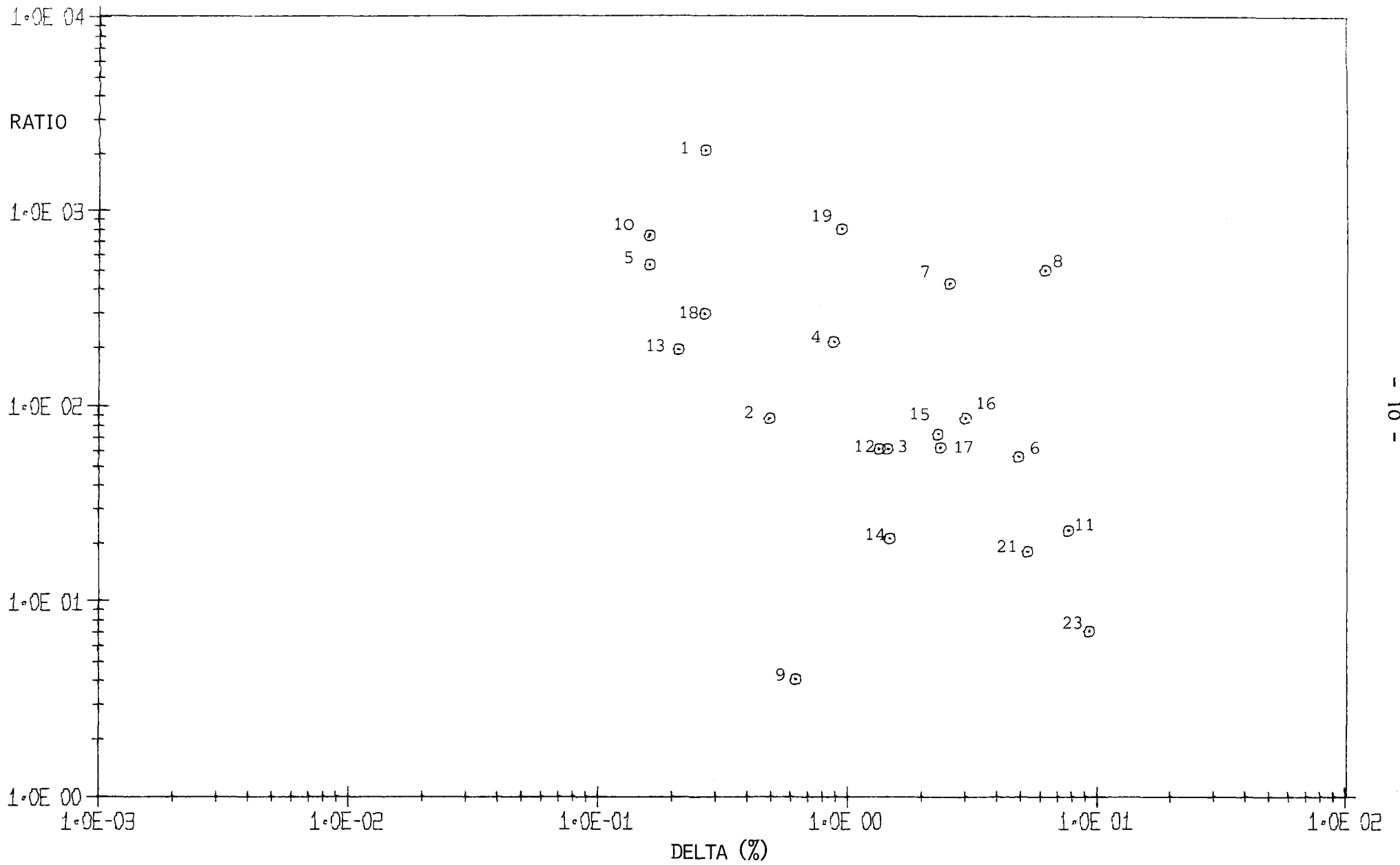


Fig. 3.4: Dependence of 'Ratio' on 'Delta' for sample C.

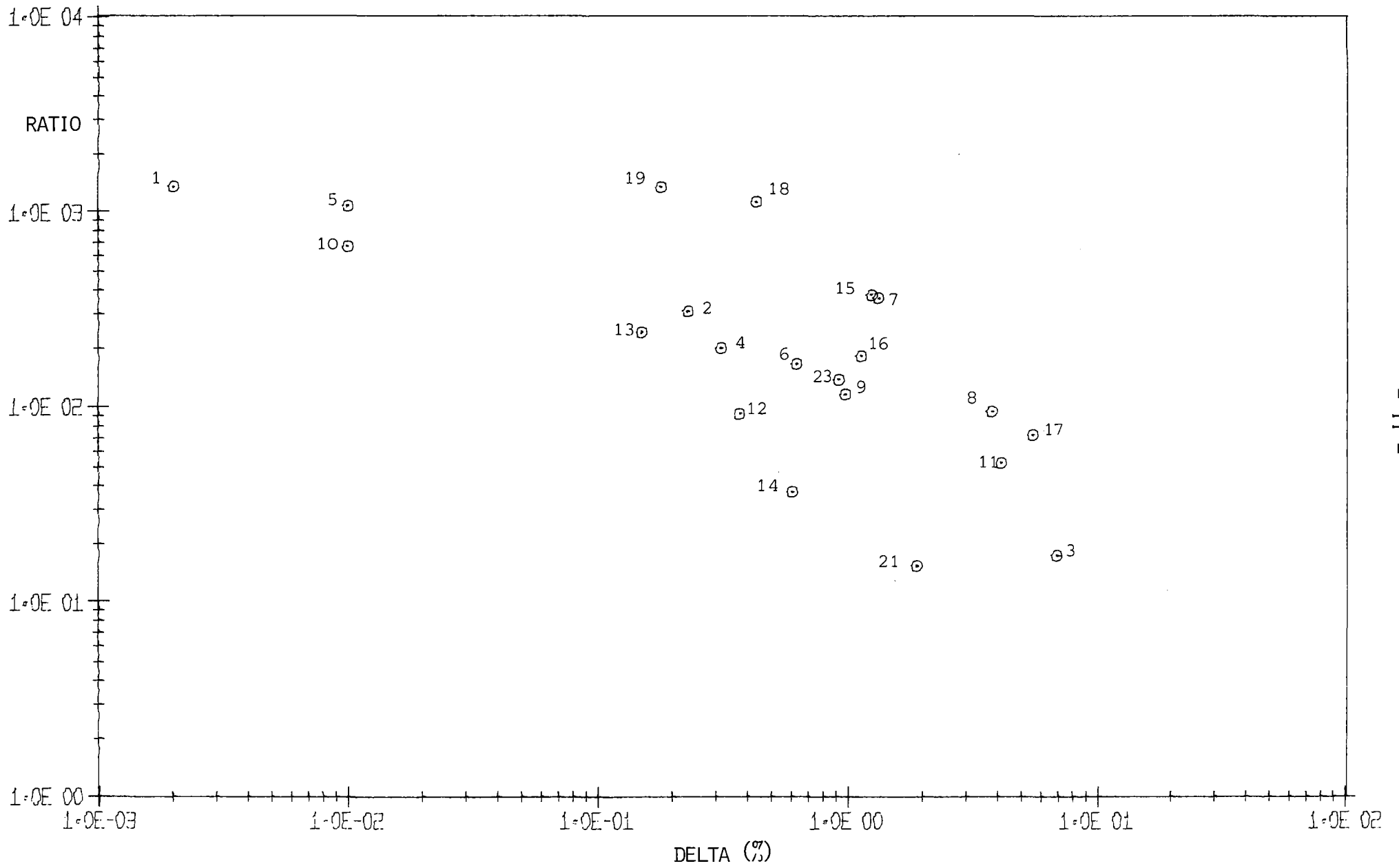


Fig. 3.5: Dependence of 'Ratio' on 'Delta' for sample D.

4. Application of one Common Method of an Evaluation of Representative Spectra

To demonstrate the influence of the individual evaluation procedures used by the participants it seemed interesting to evaluate the representative spectra applying one common uniform procedure.

Two of the participating laboratories (JRC-CBNM, Geel, Belgium /1/, and JAERI, Tokai-mura, Japan /2/) had offered their computer programs for use as an evaluation procedure. For the time being, the evaluation by means of the JRC-CBNM program has been finished; the results will be presented below.

Tab. 4.1 shows the Pu-238/(Pu-239 + Pu-240) alpha-activity ratios as derived by the participating laboratories. The Pu-238/(Pu-239 + Pu-240) alpha-activity ratios that were found by evaluation of the representative spectra with the JRC-CBNM program have been compiled in Tab. 4.2. For the spectra obtained by the laboratories 3, 9 and 13 and for the spectrum obtained on sample D by laboratory 21 the computer program was not able to furnish a result.

Figs. 4.1 to 4.4 display the alpha-activity ratios from Tabs. 4.1 and 4.2 for the four samples, together with the grand mean $y_{...}^*$ (sample A) and the characterization values CV (samples B, C, and D). In a first test the deviations were considered of the two sets of alpha-activity ratios given in Tabs. 4.1 and 4.2 from the characterization values: the common uniform evaluation procedure reduced this deviation in 7, 12, and 7 cases for the samples B, C, and D, respectively; the deviation was not reduced or was even increased in 11, 6, and 10 cases for the samples B, C, and D, respectively. Those results obtained for sample A were not evaluated because no characterization value was available for that sample (see Part III of this report).

A more detailed comparison of the two sets of alpha-activity ratios presented in Tabs. 4.1 and 4.2 makes use of the equation

$$RSM = \frac{100}{y_{...}} \sqrt{\frac{1}{\ell(\ell-1)} \sum_{i=1}^{\ell} (y_{i..} - y_{...})^2} .$$

The results are presented in Fig. 4.5.

Lab. Code	A	B	C	D
1	.3939	1.4480	2.9960	1.6370
2	.3895	1.4530	3.0027	1.6332
4	.3933	1.4460	2.9620	1.6320
5	.4022	1.4493	2.9927	1.6372
6	.3977	1.4677	3.1316	1.6472
7	.3948	1.4394	2.9113	1.6152
8	.3891	1.3870	2.8050	1.5750
10	.3925	1.4498	2.9832	1.6368
11	.3910	1.4000	2.7600	1.5700
12	.3900	1.4330	3.0280	1.6430
14	.4197	1.4956	2.9442	1.6469
15	.4000	1.4858	3.0565	1.6575
16	.3952	1.4360	2.9000	1.6185
17	.3727	1.3525	2.9178	1.5468
18	.4010	1.4330	2.9798	1.6299
19	.3949 ¹⁾	1.4448 ¹⁾	2.9617 ¹⁾	1.6312 ¹⁾
21	.4370	1.4400	2.8310	1.6060
23	.3985	1.4471	3.2674	1.6521

1) remeasured values

Tab. 4.1: Alpha-activity ratios Pu-238/(Pu-239 + Pu-240) derived by the participating laboratories for the representative spectra.

Lab. Code	A	B	C	D
1	.3933	1.4480	2.9965	1.6307
2	.3925	1.4550	3.0213	1.6436
4	.4049	1.4765	3.0018	1.6676
5	.4022	1.4509	3.0052	1.5909
6	.3902	1.4743	3.0654	1.7340
7	.3967	1.4637	2.9842	1.6420
8	.3969	1.4516	3.0308	1.6447
10	.3920	1.4546	3.0109	1.6403
11	.3962	1.4209	3.0464	1.6165
12	.4047	1.5140	3.0052	1.5991
14	.4093	1.4907	2.7801	1.6647
15	.3965	1.4641	2.9427	1.6391
16	.3984	1.4583	3.0139	1.6324
17	.3976	1.4085	3.0696	1.6051
18	.4050	1.4615	2.9810	1.6498
19	.3947	1.4457	2.9604	1.6291
21	.4573	1.4995	3.0792	¹⁾
23	.3990	1.5201	3.0496	1.6408

¹⁾ Computer program failed evaluating this spectrum

Tab. 4.2: Alpha-activity ratios Pu-238/(Pu-239 + Pu-240) obtained by one common evaluation procedure applied to the representative spectra.

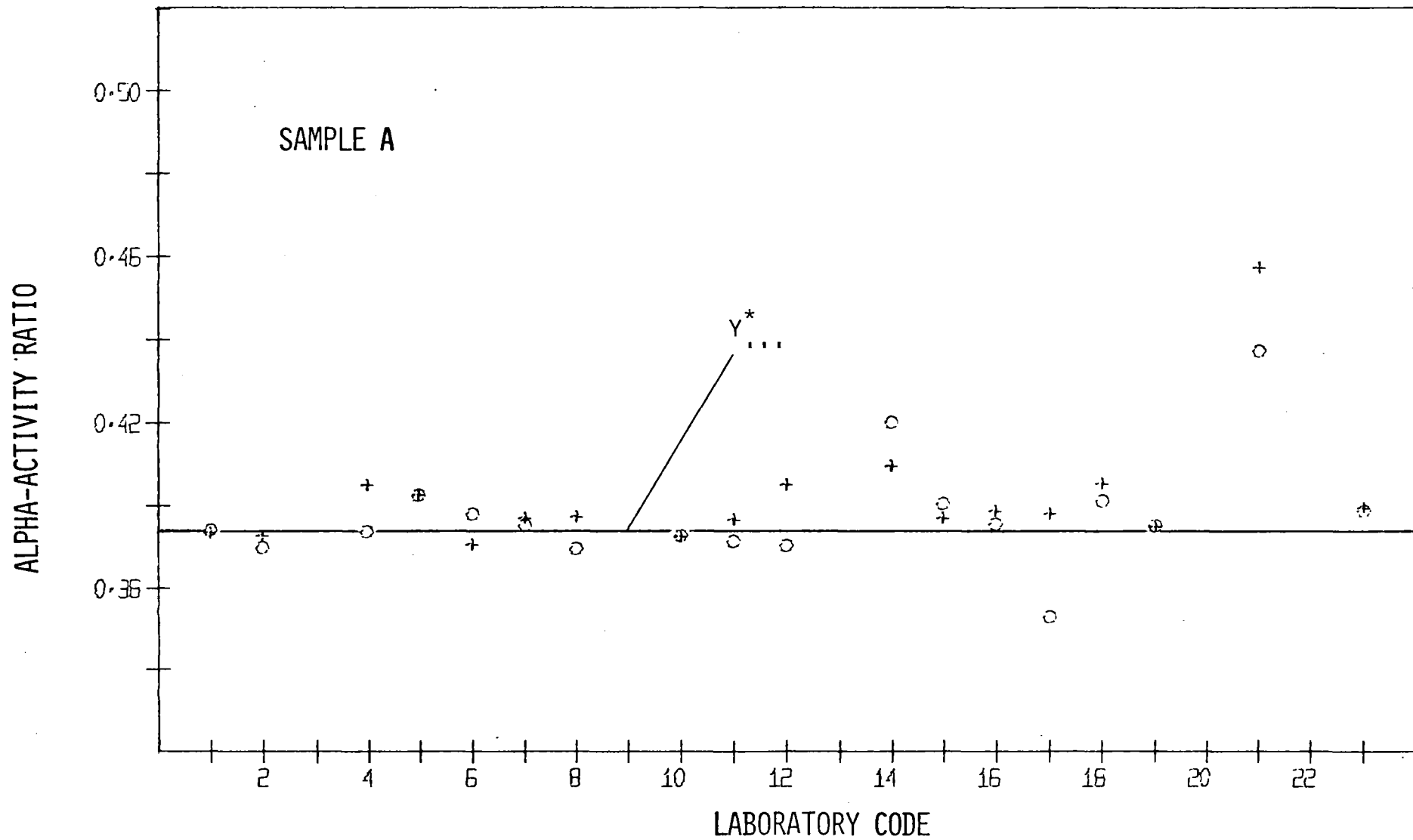


Fig. 4.1: Alpha-activity ratios reported by the laboratories (O) and arrived at by common evaluation procedure (+) for sample A together with the grand mean y^* calculated without the laboratories 14, 17 and 21.

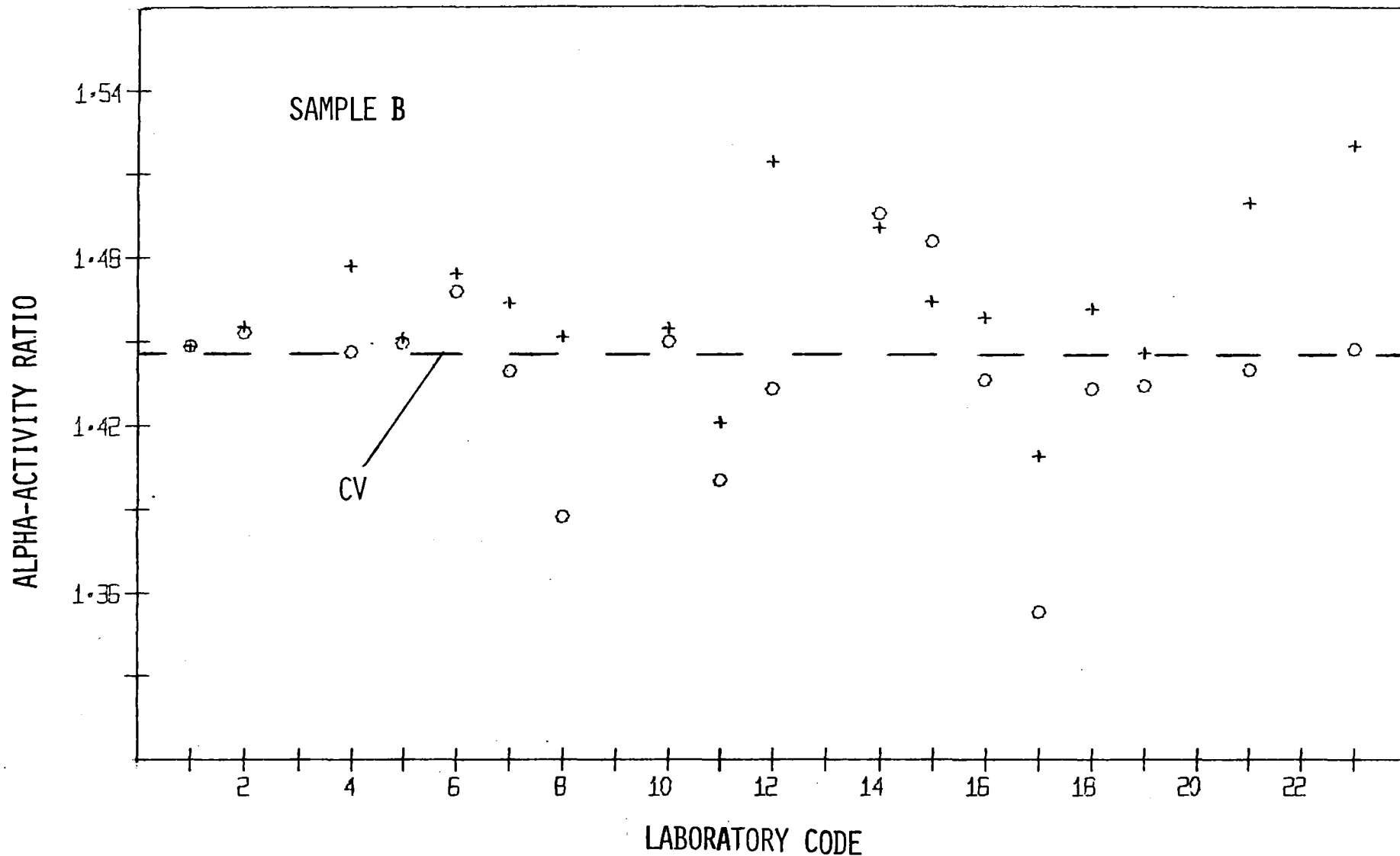


Fig. 4.2: Alpha-activity ratios reported by the laboratories (O) and arrived at by common evaluation procedure (+) together with the characterization value CV for sample B.

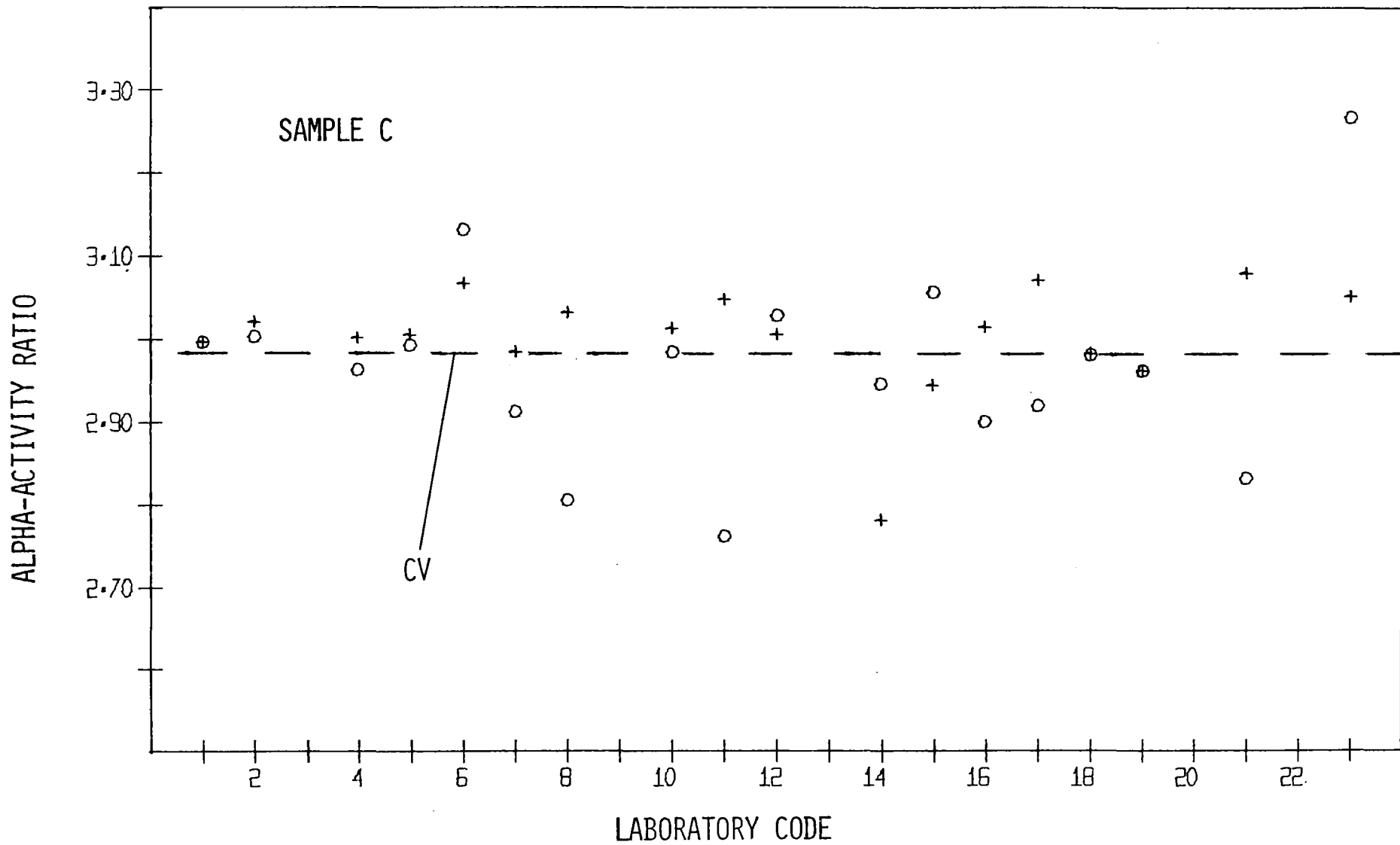


Fig. 4.3: Alpha-activity ratios reported by the laboratories (O) and arrived at by common evaluation procedure (+) together with the characterization value CV for sample C.

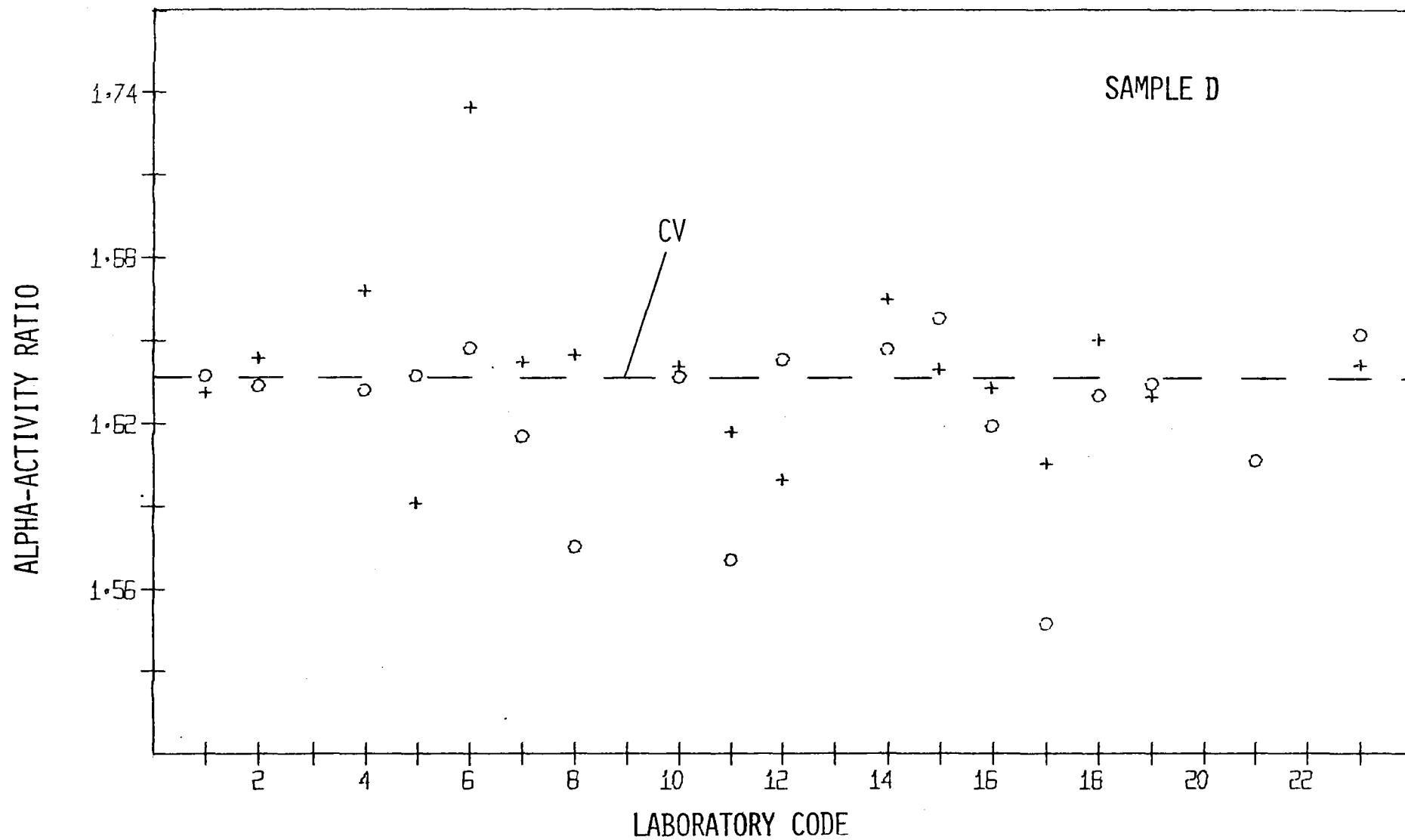


Fig. 4.4: Alpha-activity ratios reported by the laboratories (O) and arrived at by common evaluation procedure (+) together with the characterization value CV for sample D.

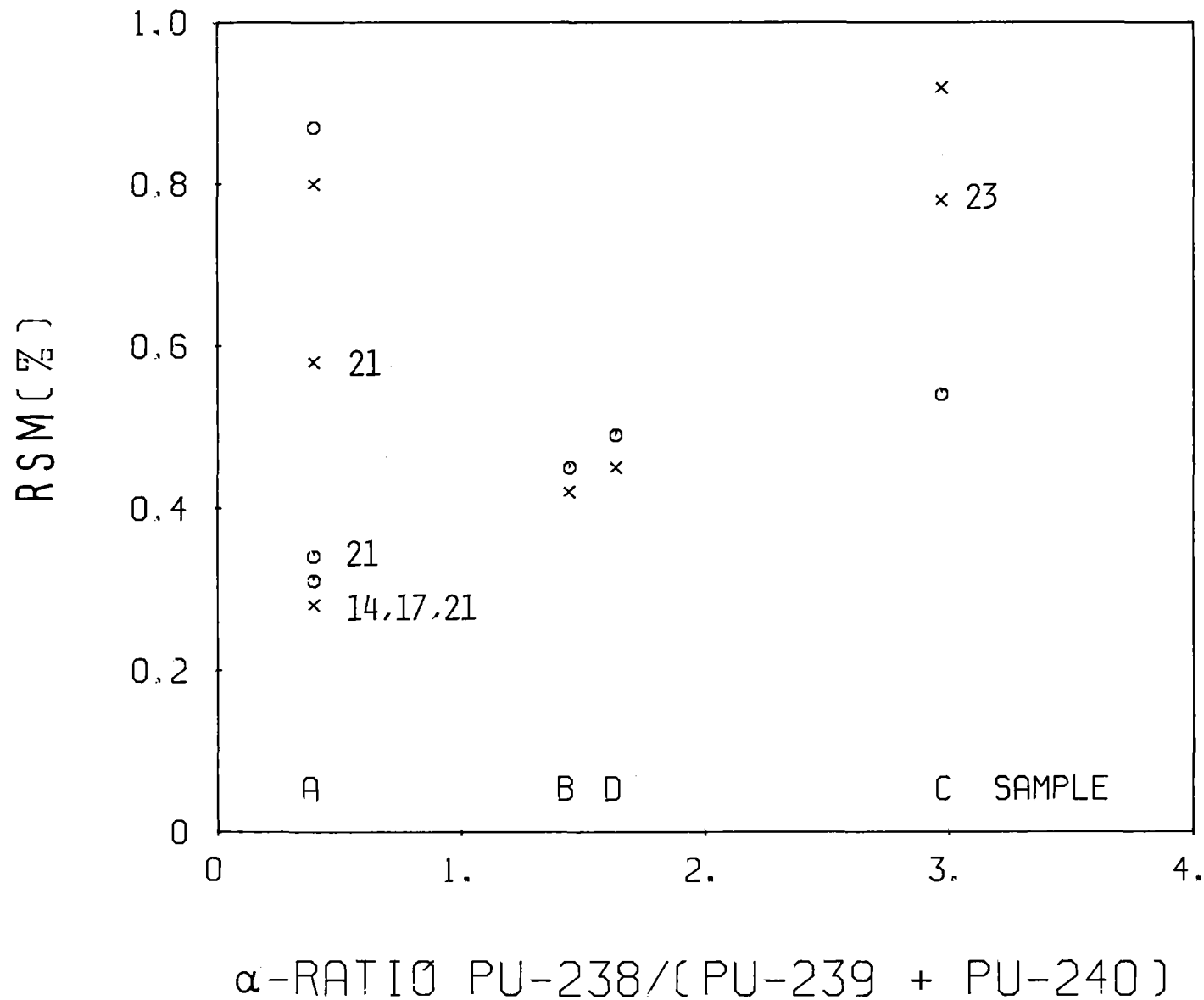


Fig. 4.5: RSM values calculated by Eq. (4-1) with alpha-activity ratios reported (x) as well as derived, applying one common evaluation procedure (o) for the representative spectra; the figures indicate the laboratories; the respective data were omitted in the calculation.

As to the alpha-activity ratios reported by the laboratories for sample A, the RSM drops from 0.80 % to 0.58 % and 0.28 % after elimination of laboratory 21 and laboratories 14, 17, and 21, respectively.

For the alpha-activity ratios obtained by the common evaluation procedure the RSM drops from 0.87 % to 0.34 % if laboratory 21 is considered as an outlier; the RSM then drops by only 0.03 % if laboratories 14 and 17 are considered as outliers in addition to laboratory 21.

From these observations follows that the representative spectra measured by laboratories 14 and 17 came into line after having been evaluated by the common procedure. The representative spectrum from laboratory 21 remained an outlier even after evaluation with the common procedure; this has to be explained by other reasons than those related to the procedure of evaluation.

Fig. 4.5 shows that the application of a common evaluation procedure to the representative spectra of the samples B and D does not induce any significant change in RSM if compared to the RSM related to the alpha-activity ratios reported. However, for sample C the application of a common evaluation procedure reduces the RSM from 0.92 % (from 0.78 % if laboratory 23 is considered as an outlier) to 0.54 %. This reduction in RSM is accompanied by the reduction already mentioned of the deviation of the alpha-activity ratio from the characterization value (in 12 out of 18 cases). Among the four samples, sample C has had the highest Pu-238 abundance. Therefore, one possible explanation for this RSM reduction might be the more effective evaluation of the low-energy tail of the Pu-238 line.

5. References

/1/ G. Bortels, JRC-CBNM, Geel, Belgium; the computer code is available on request

/2/ H. Umezawa, 'Alpha-ray spectrum analysis code 'ALPS'', private communication (1978)

Appendix: Graphs of the Spectra

N.B.: The following presentation of the
graphs is ordered by increasing
laboratory codes.

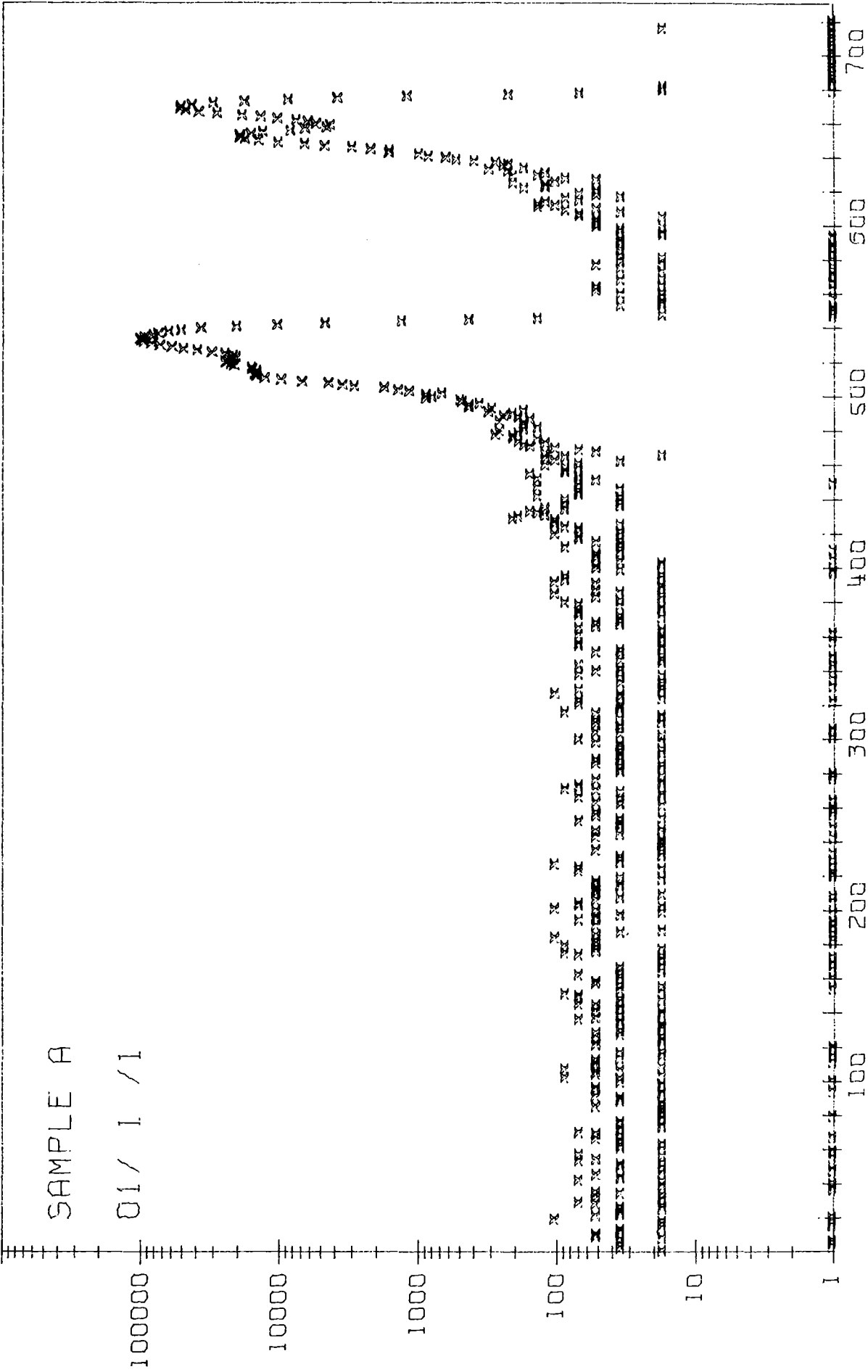
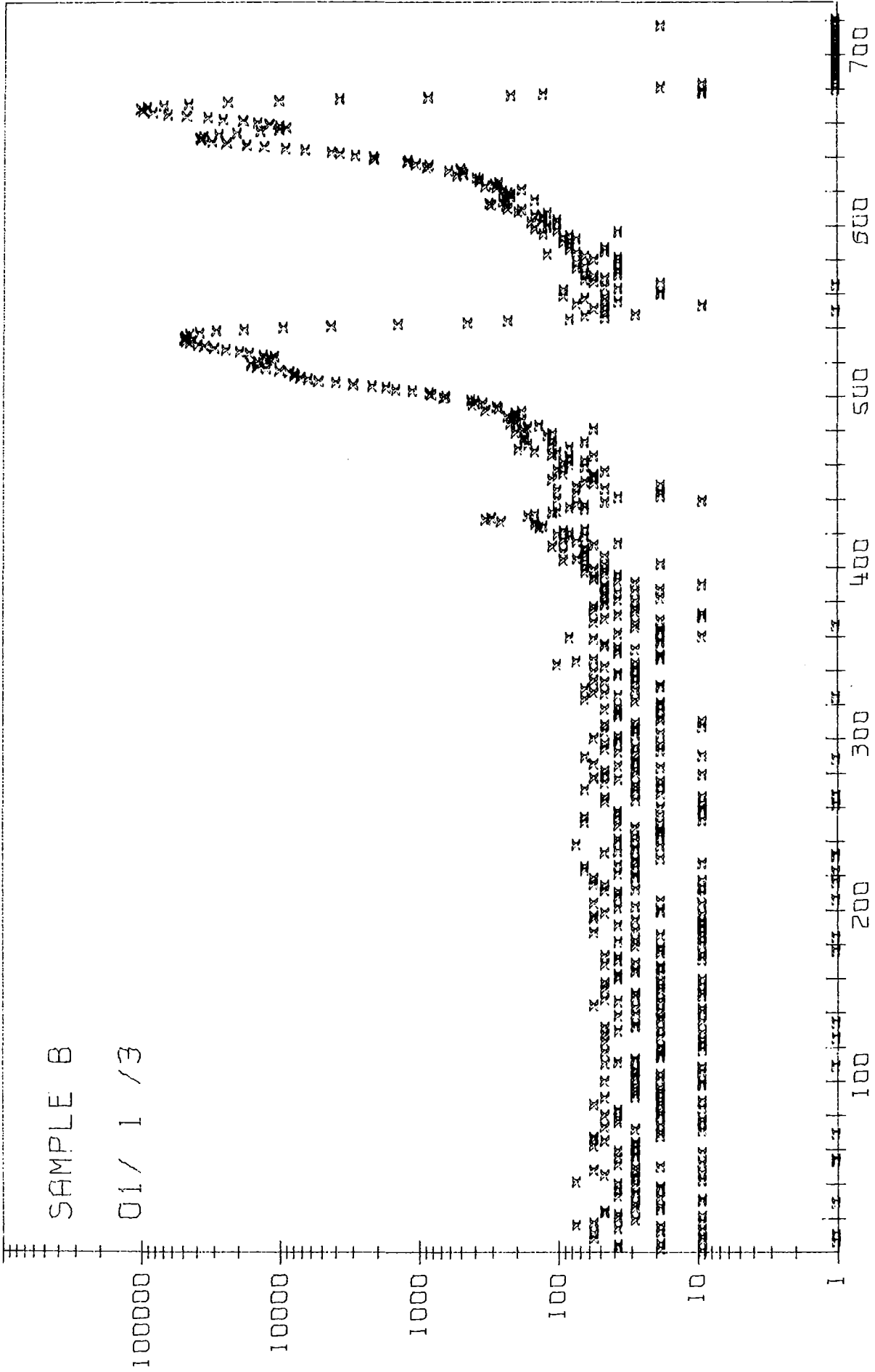


ABB.00111 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER



Q88.00113 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER

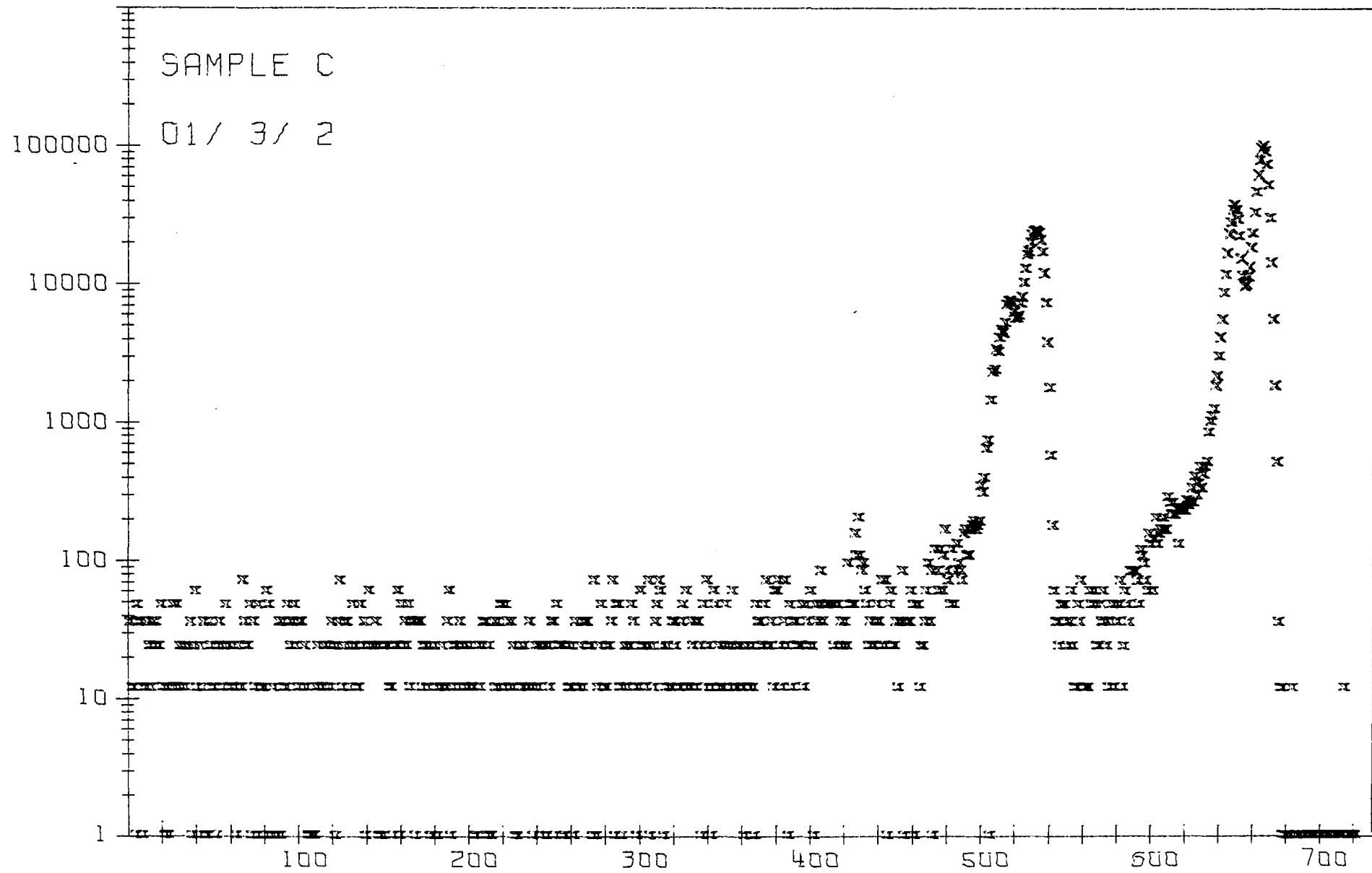


ABB.00132 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER

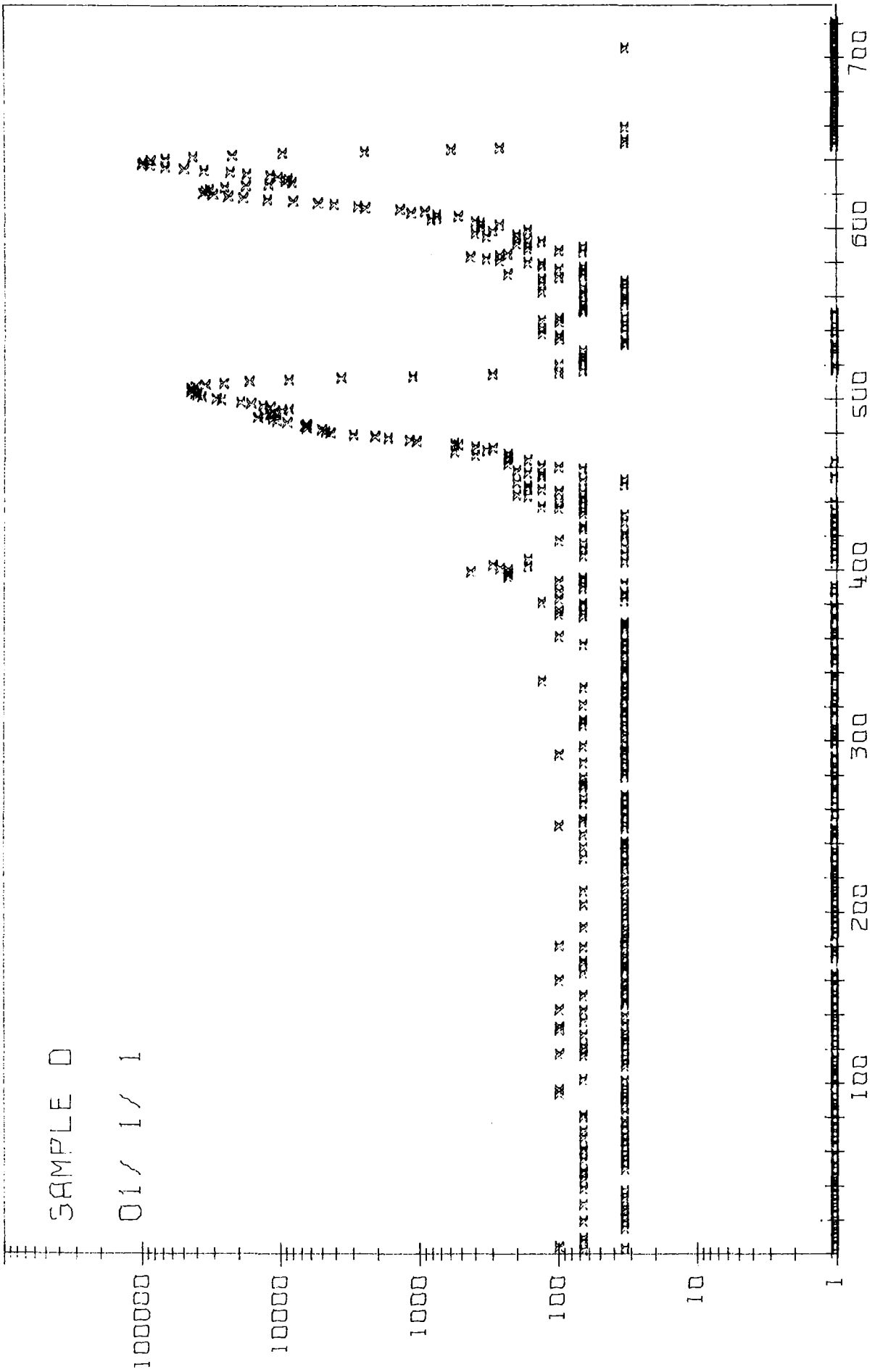
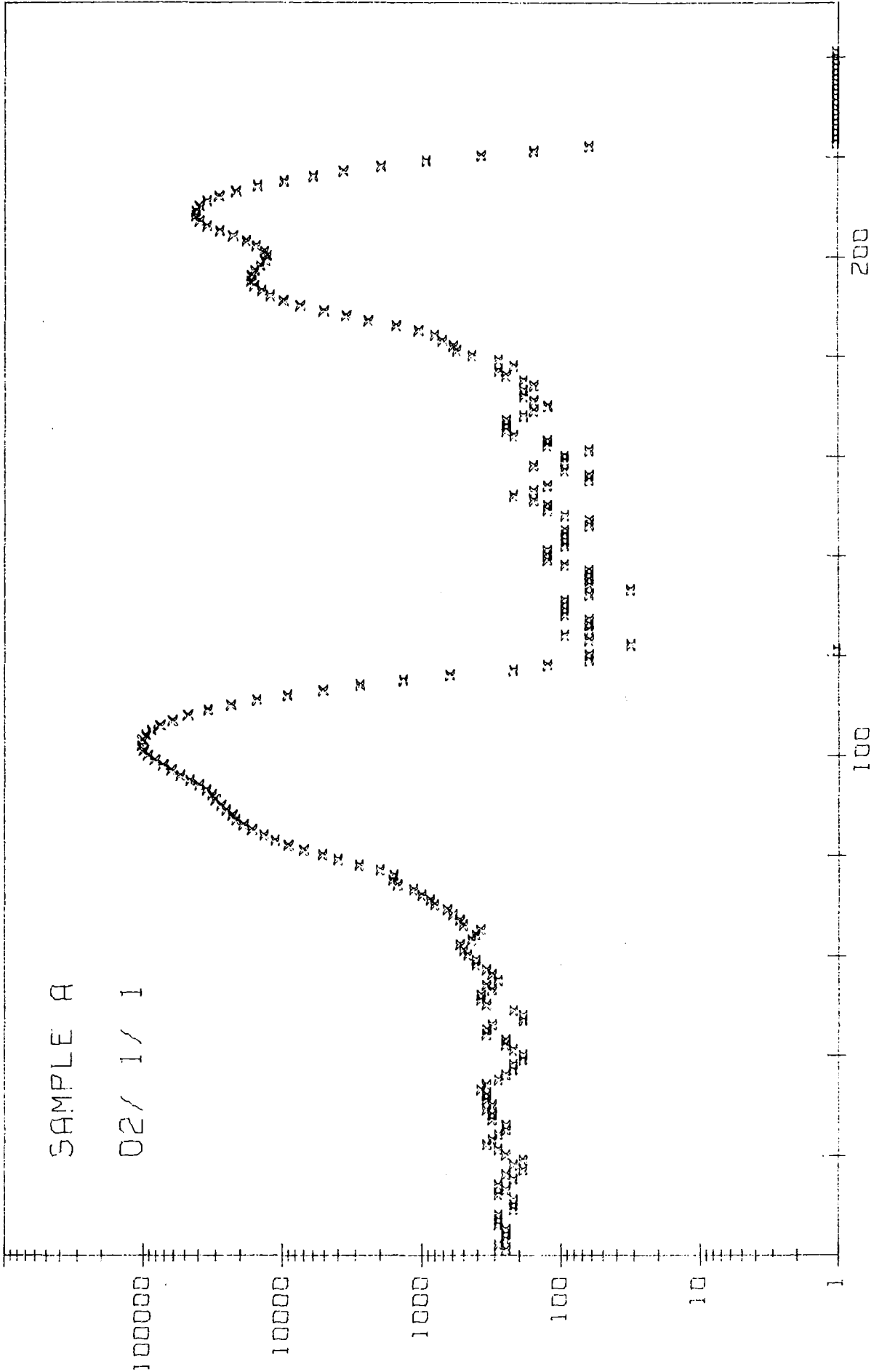


ABB.00111 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER



ASB.00211 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER

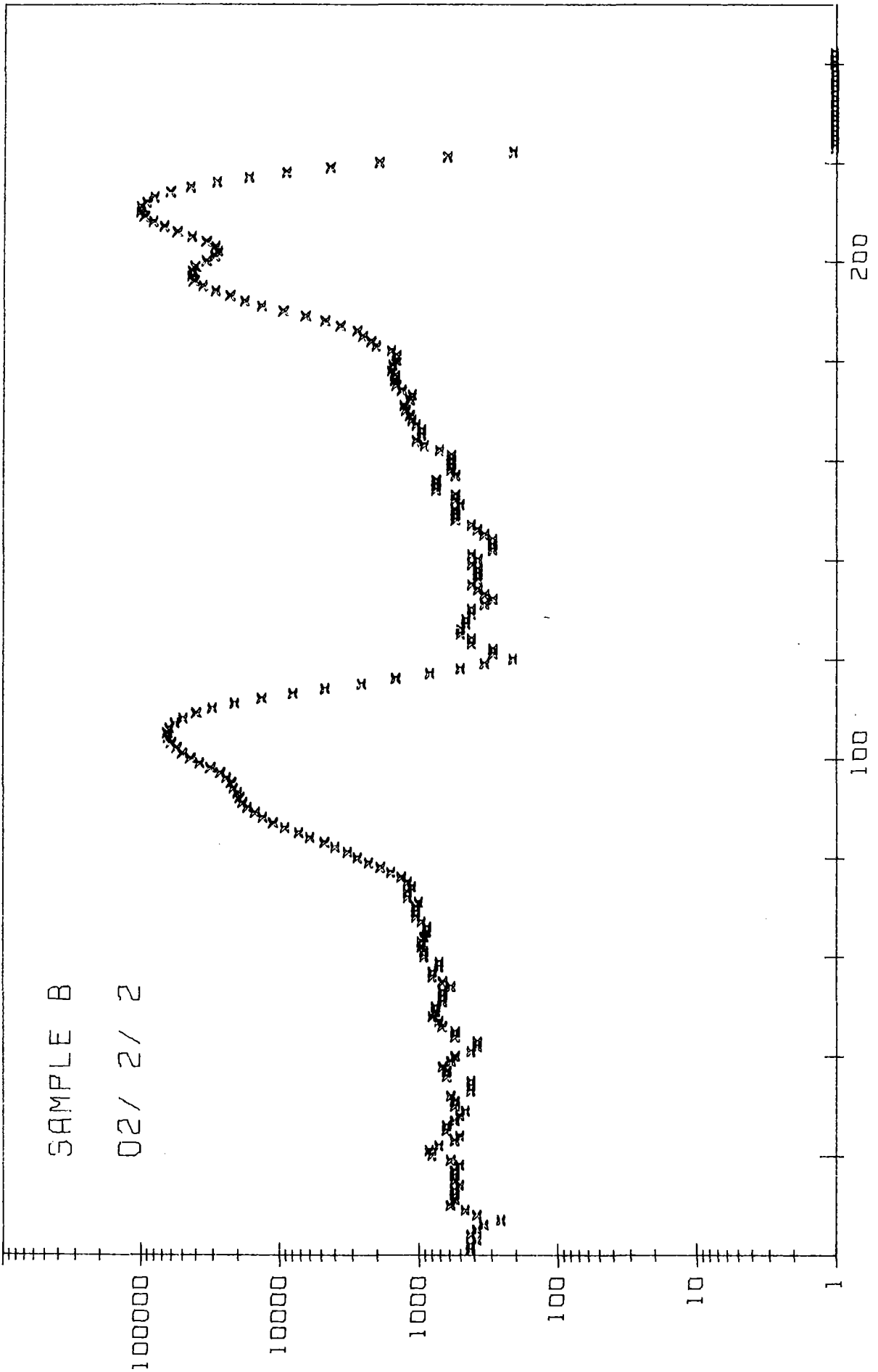
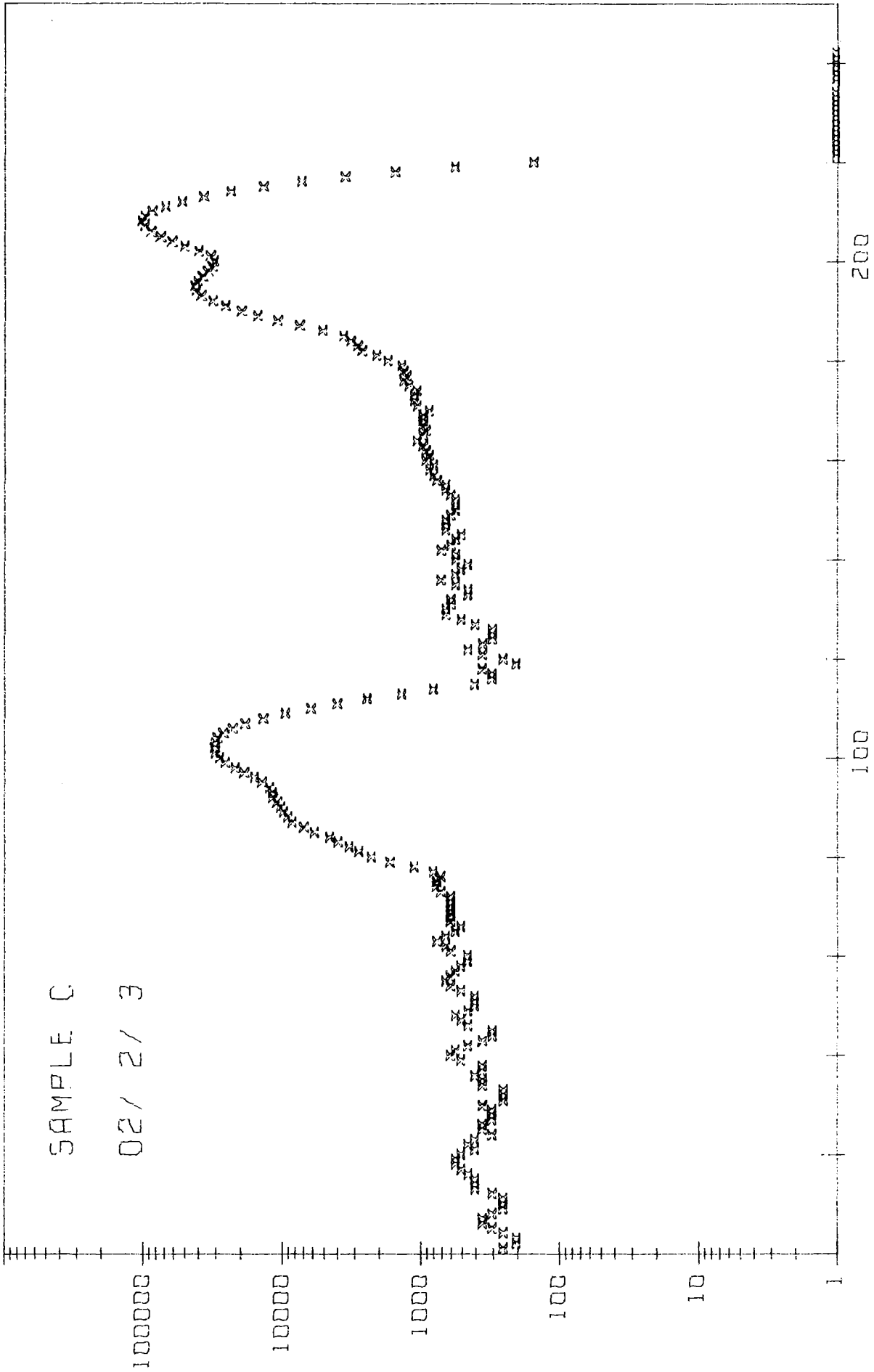


ABB.00222 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER



428.00223 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER

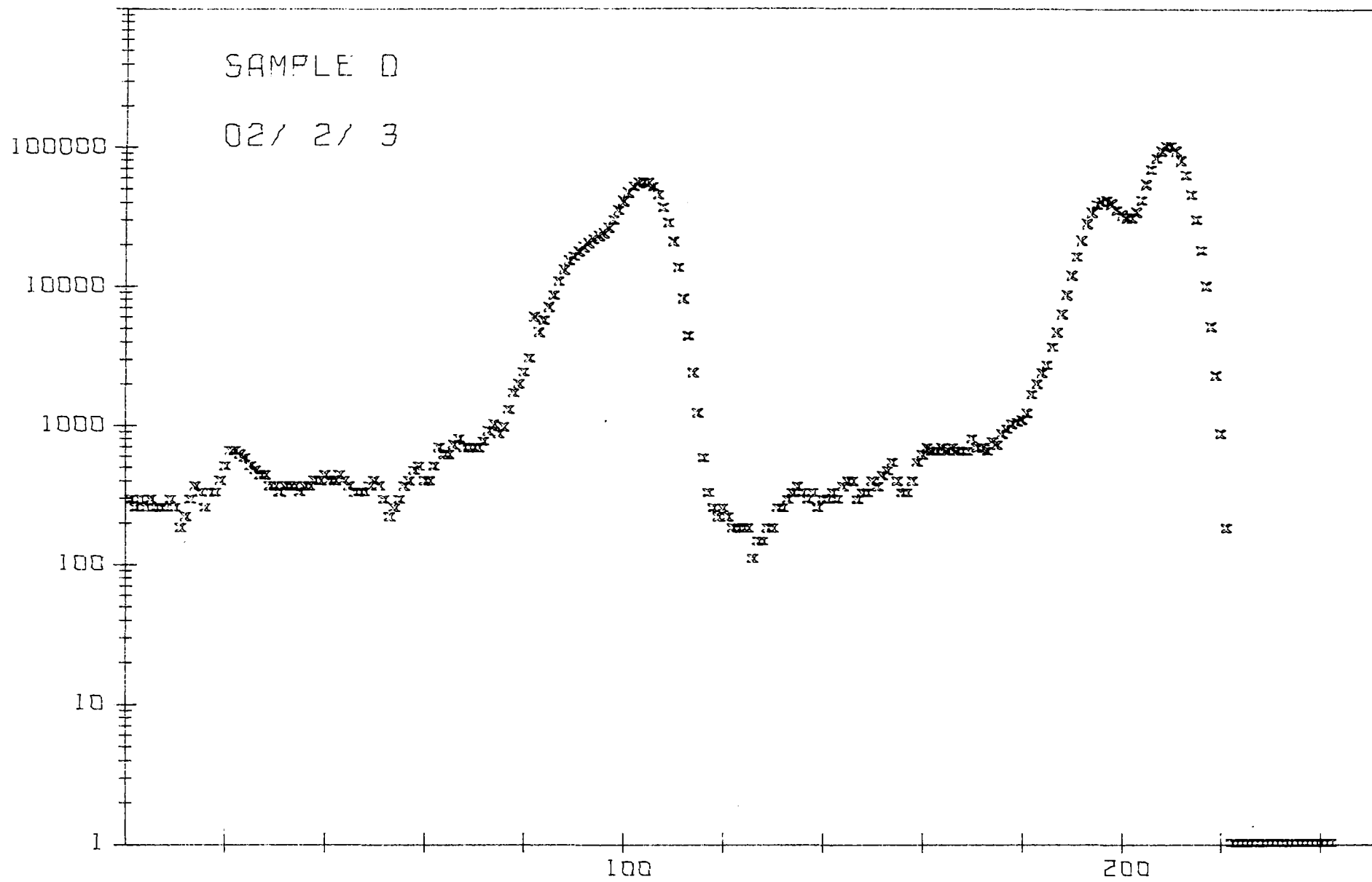


ABB.00223 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER

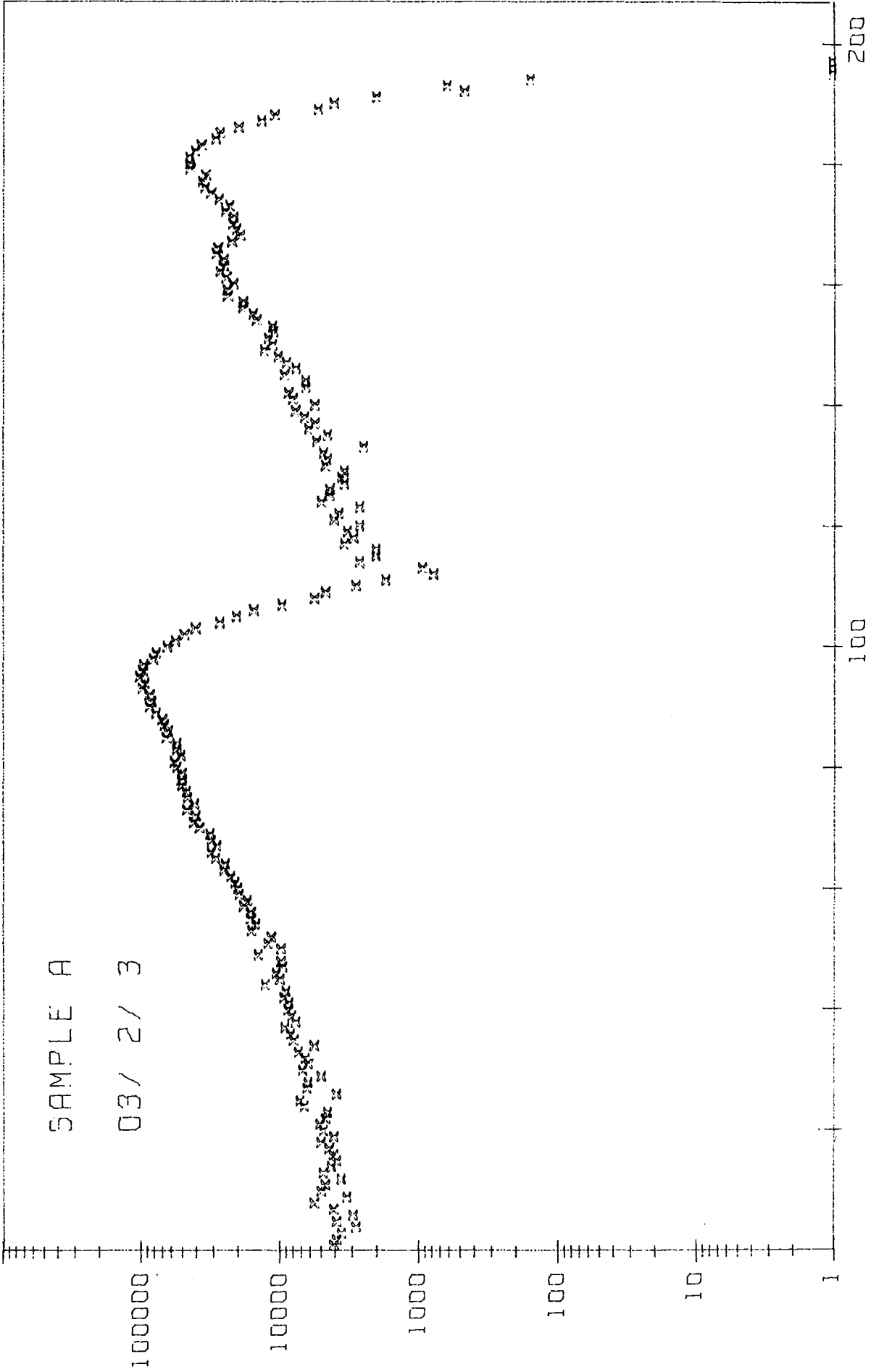


ABB 00323 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER

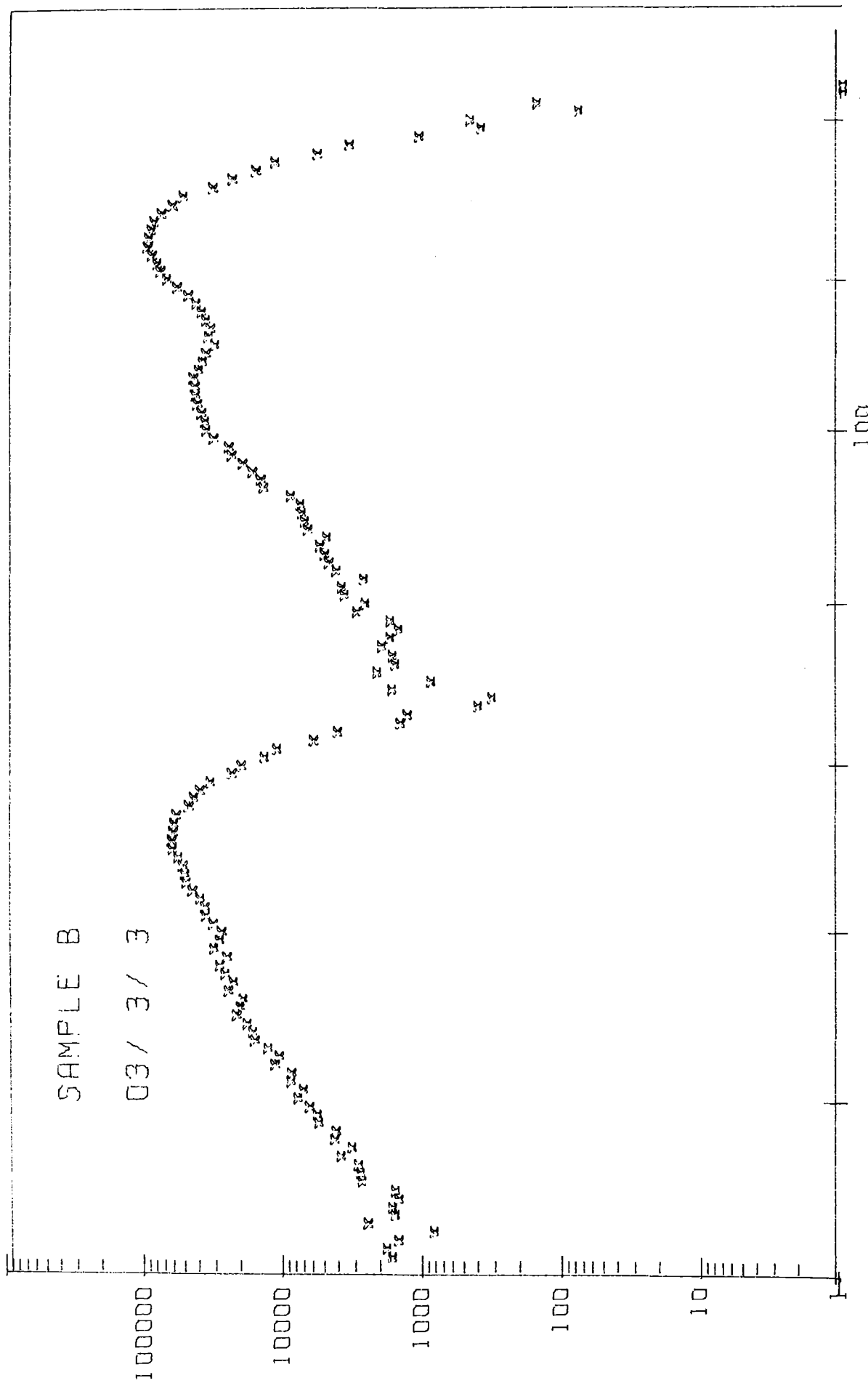
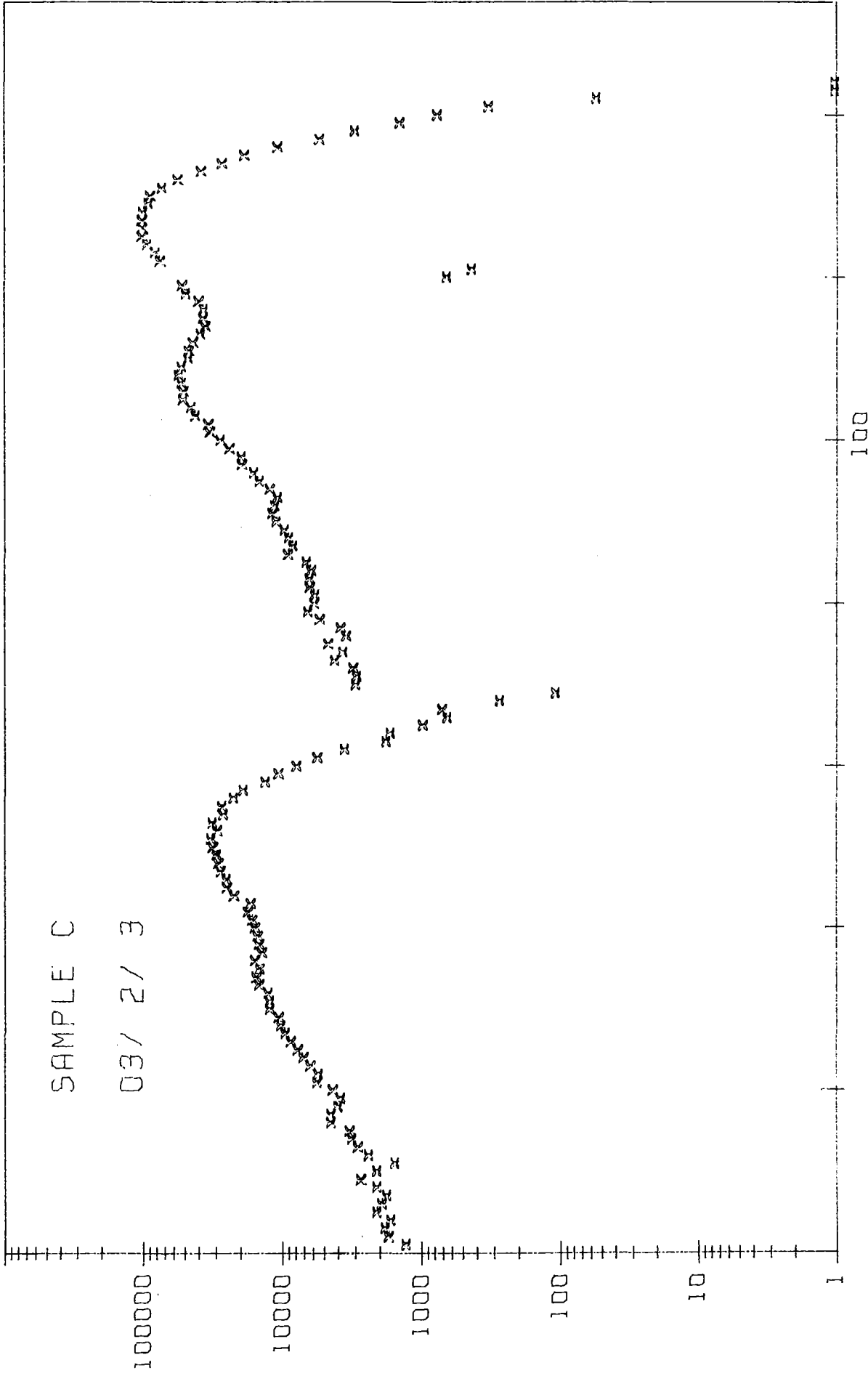


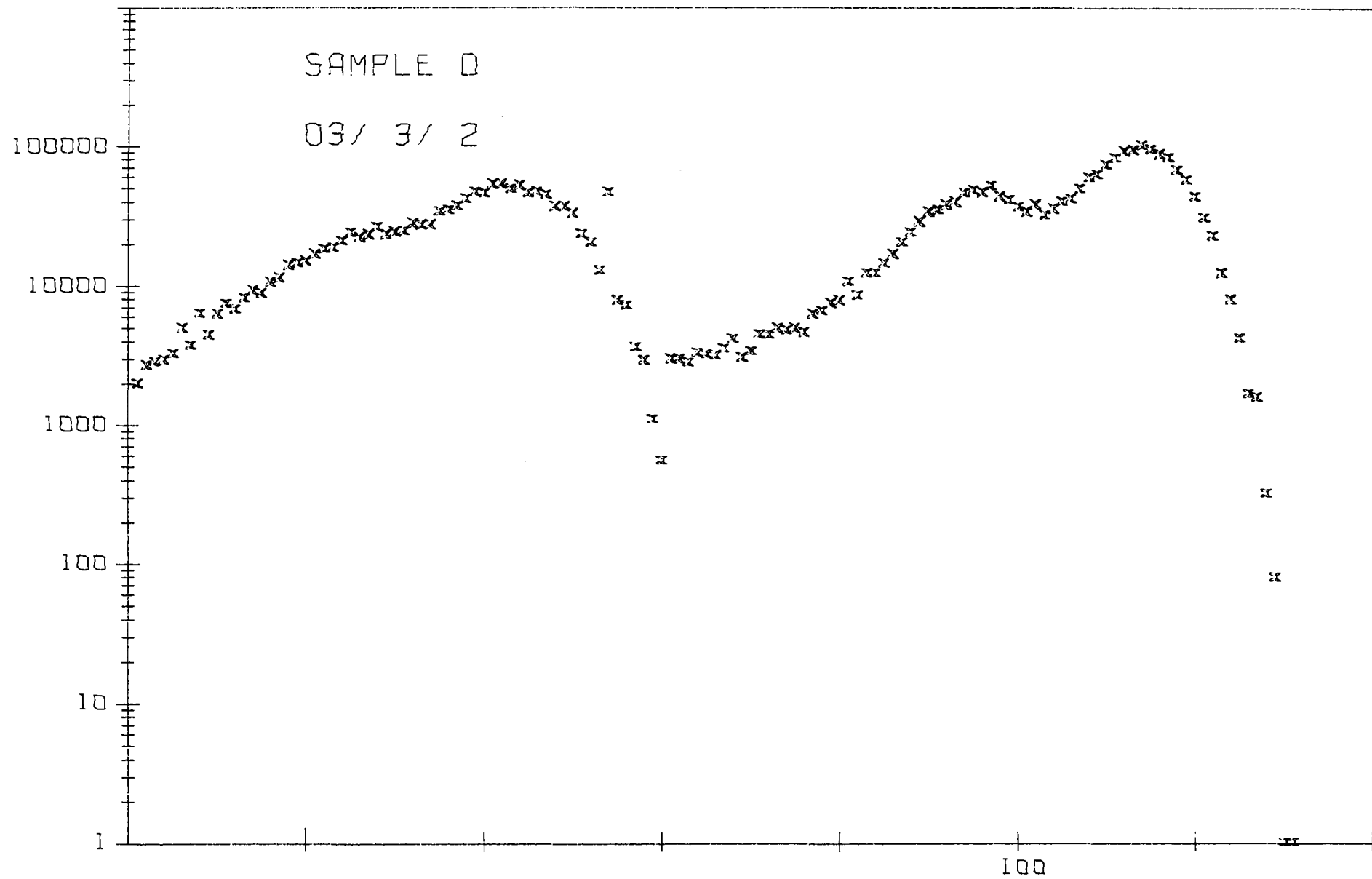
ABB. 00333 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER



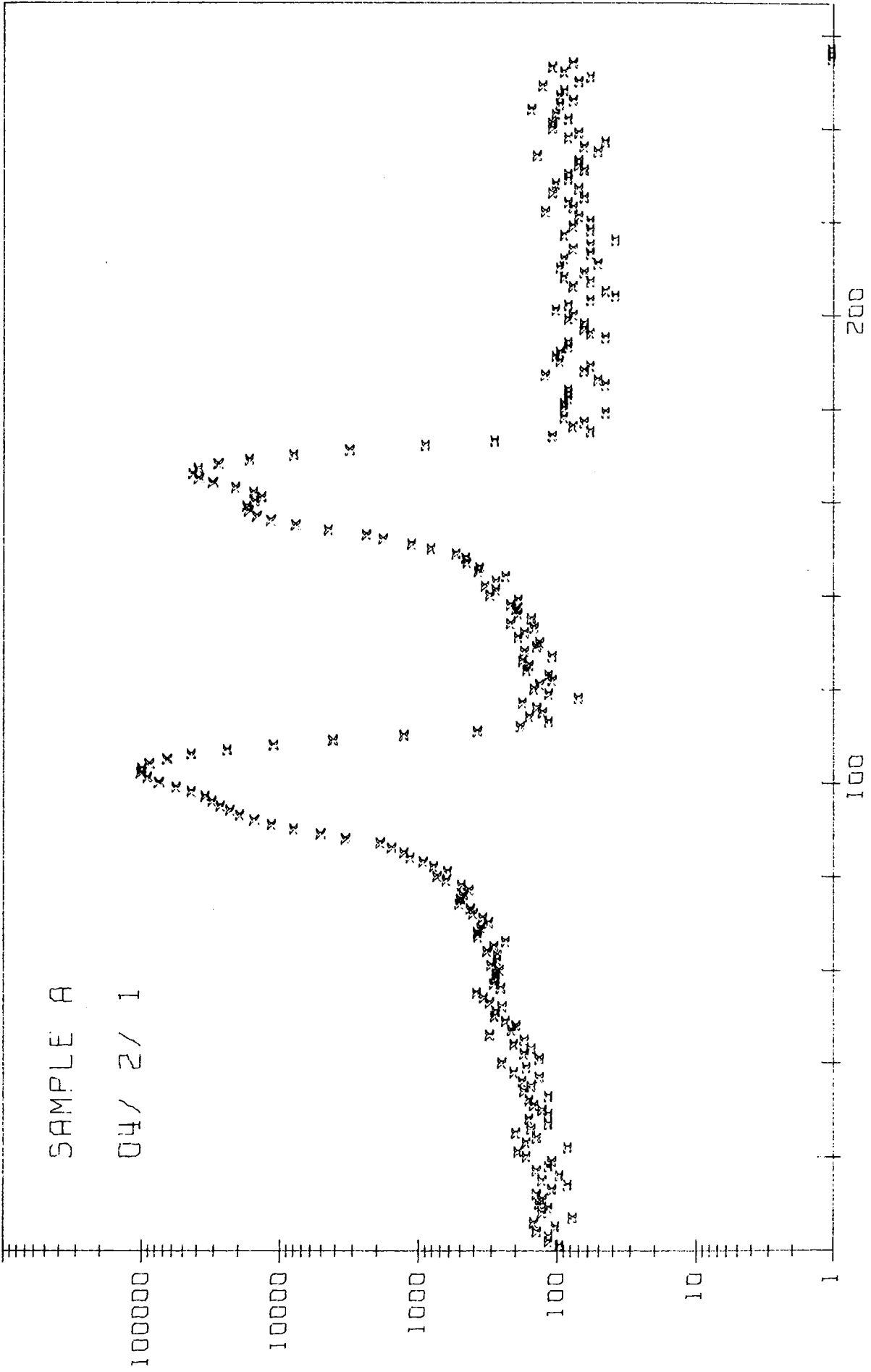
SAMPLE C

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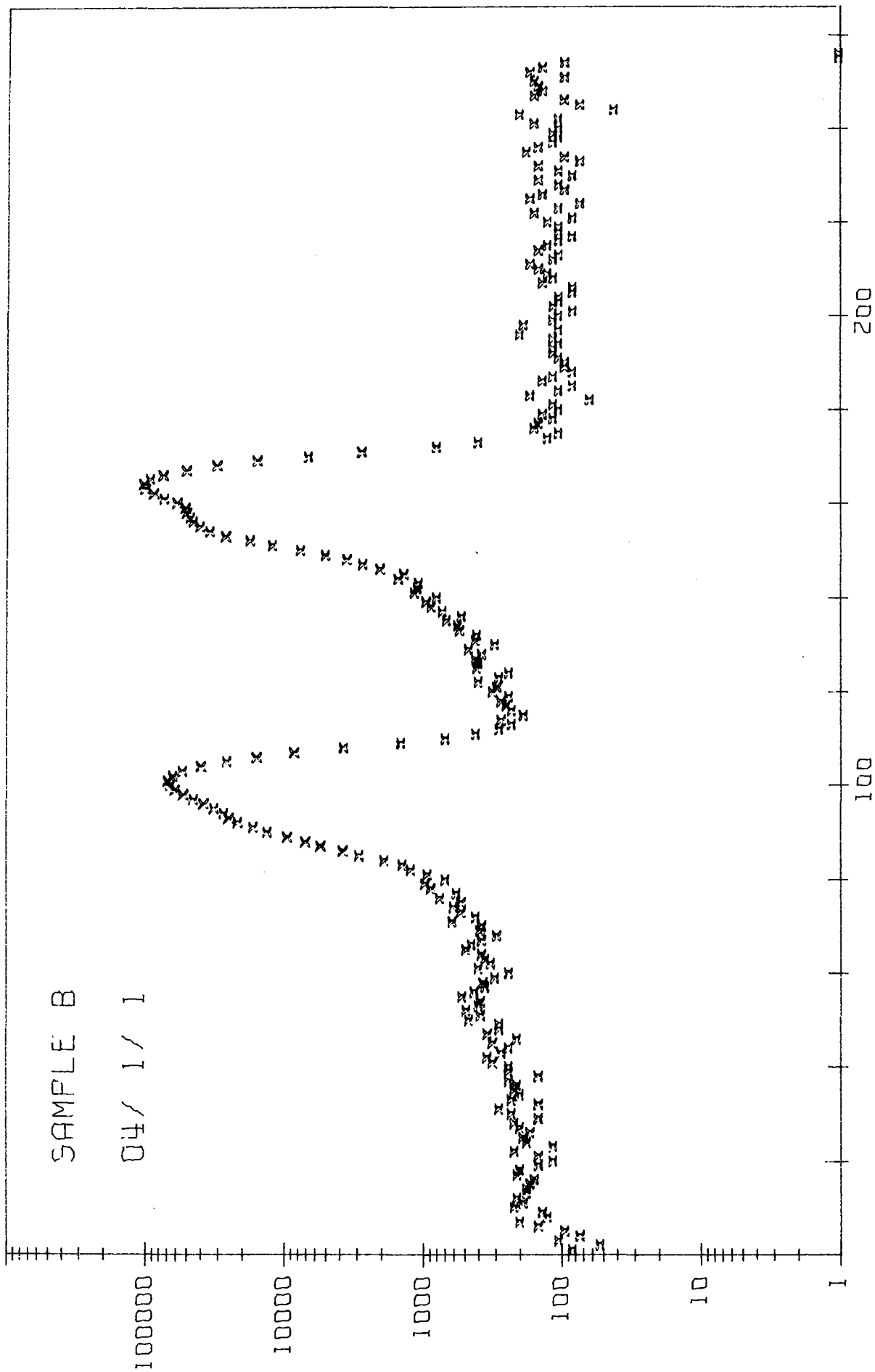
ABB.00323 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER



ARR.00332 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER



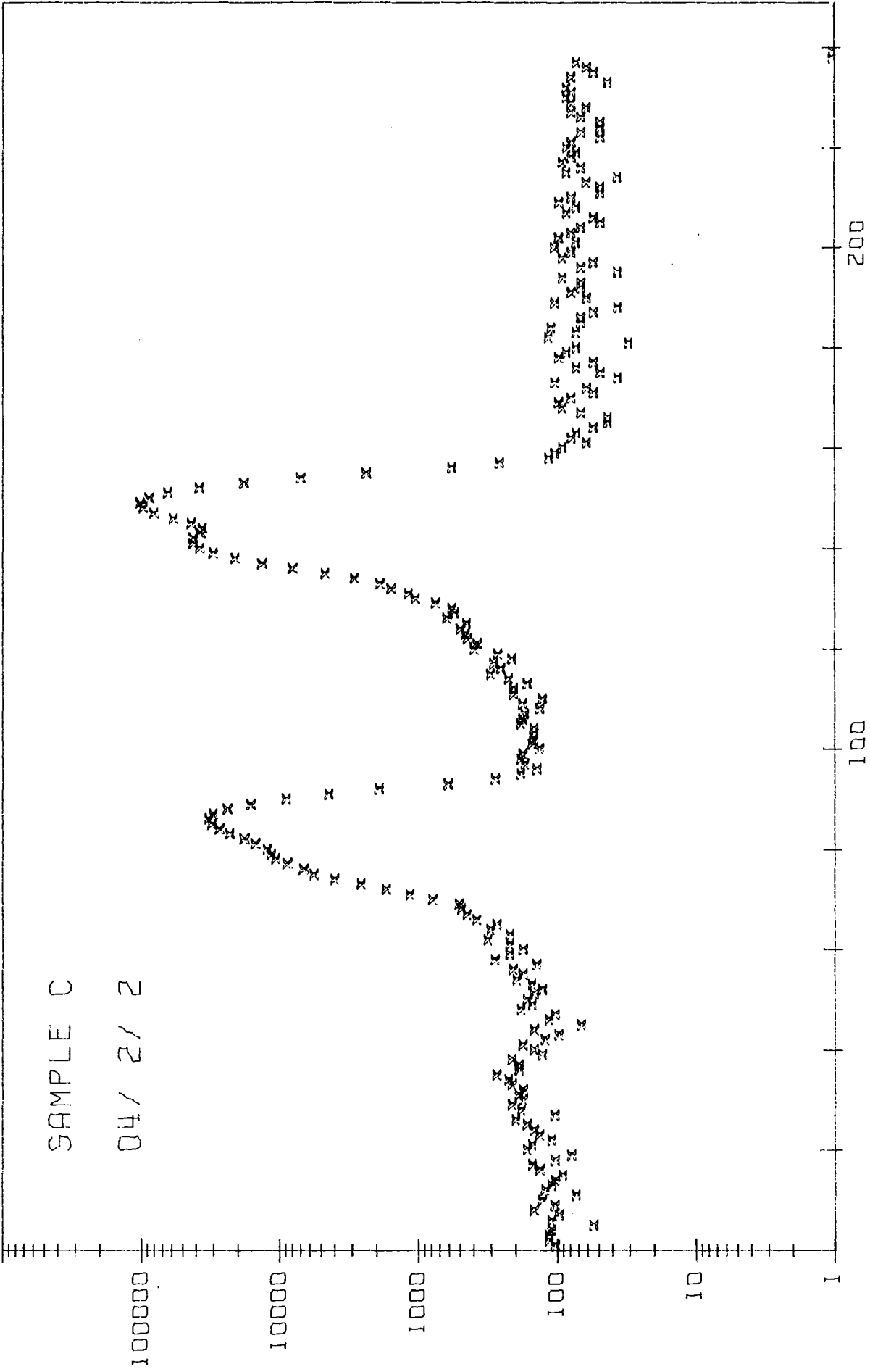
04/ 2/ 1 SAMPLE A
100000
10000
1000
100
10
1
100
200
COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER
048.00±21



SAMPLE B

04 / 1 / 1

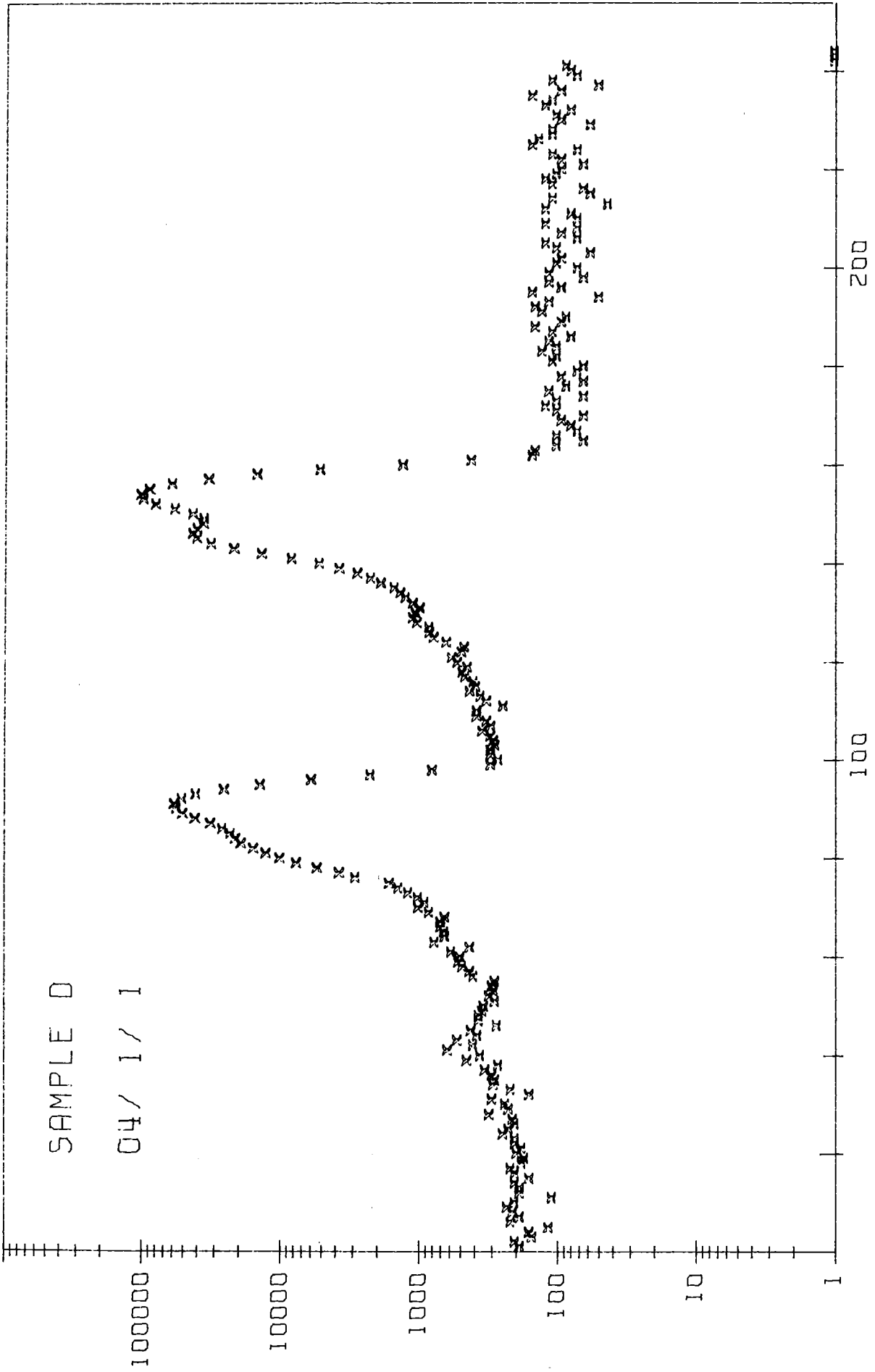
ABB.00411 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER



SAMPLE C

04 / 2 / 2

ABB.00422 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER



SAMPLE D
04 / 1 / 1

ABB.00411 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER

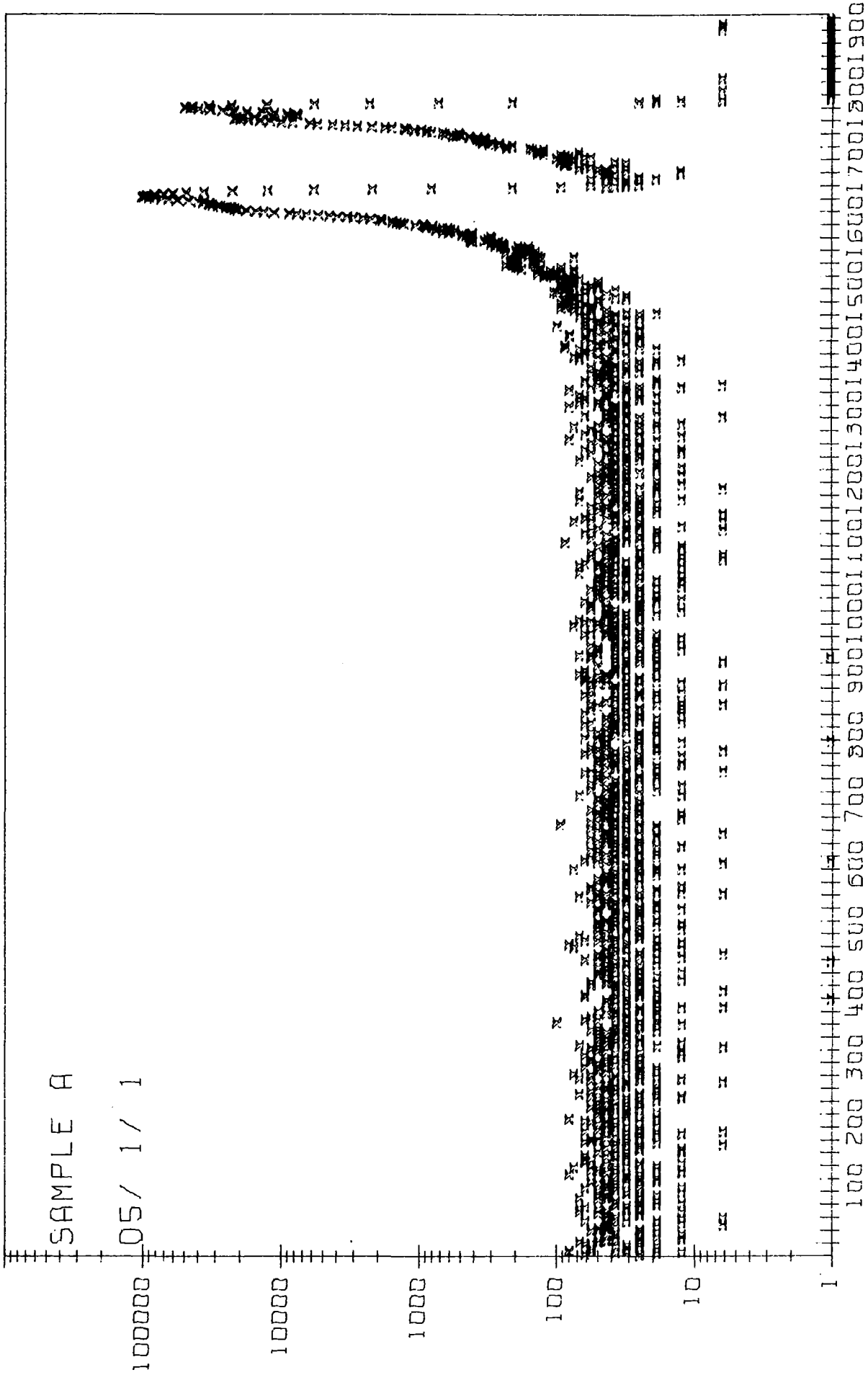


ABB 00511 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER

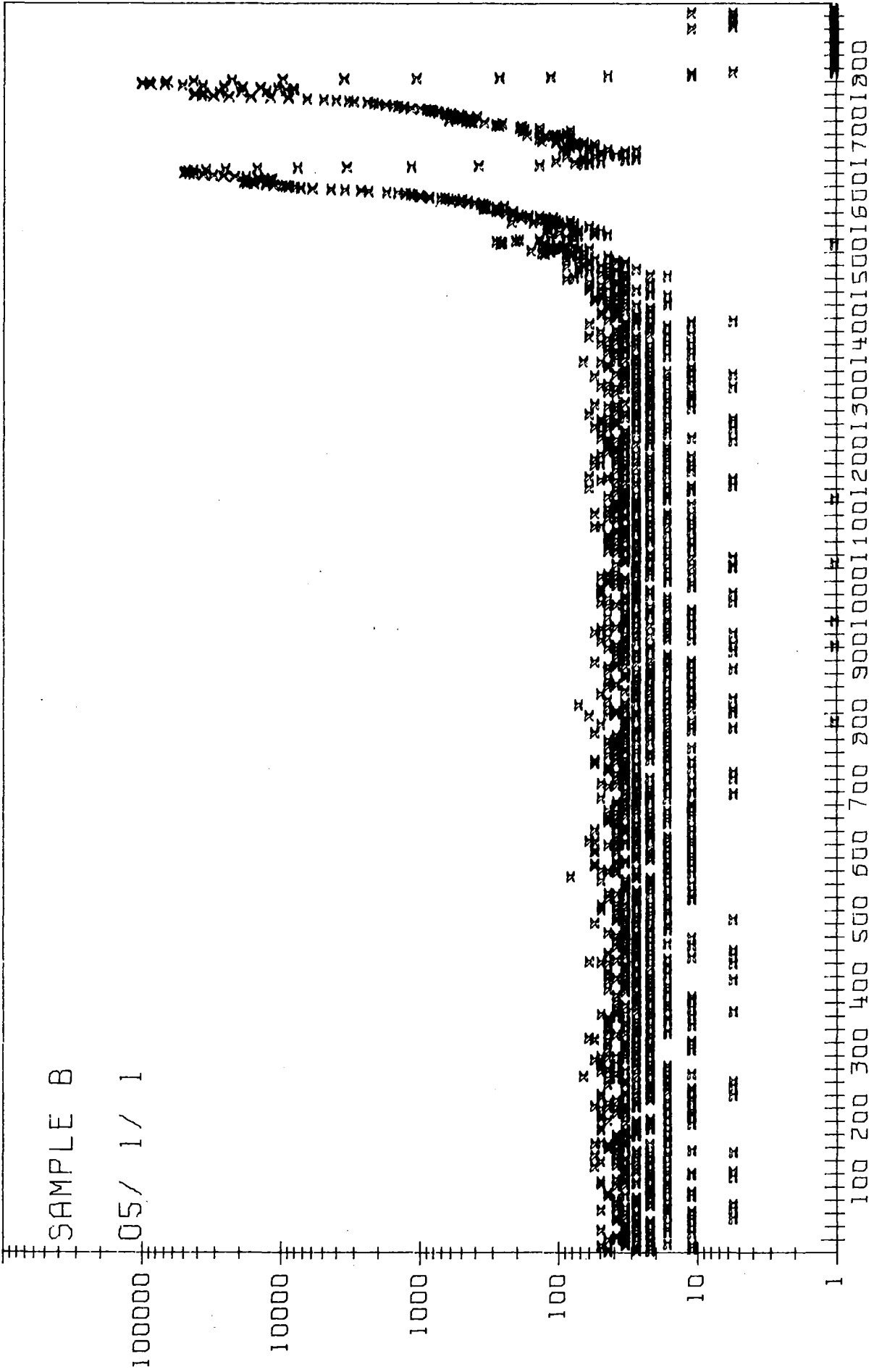
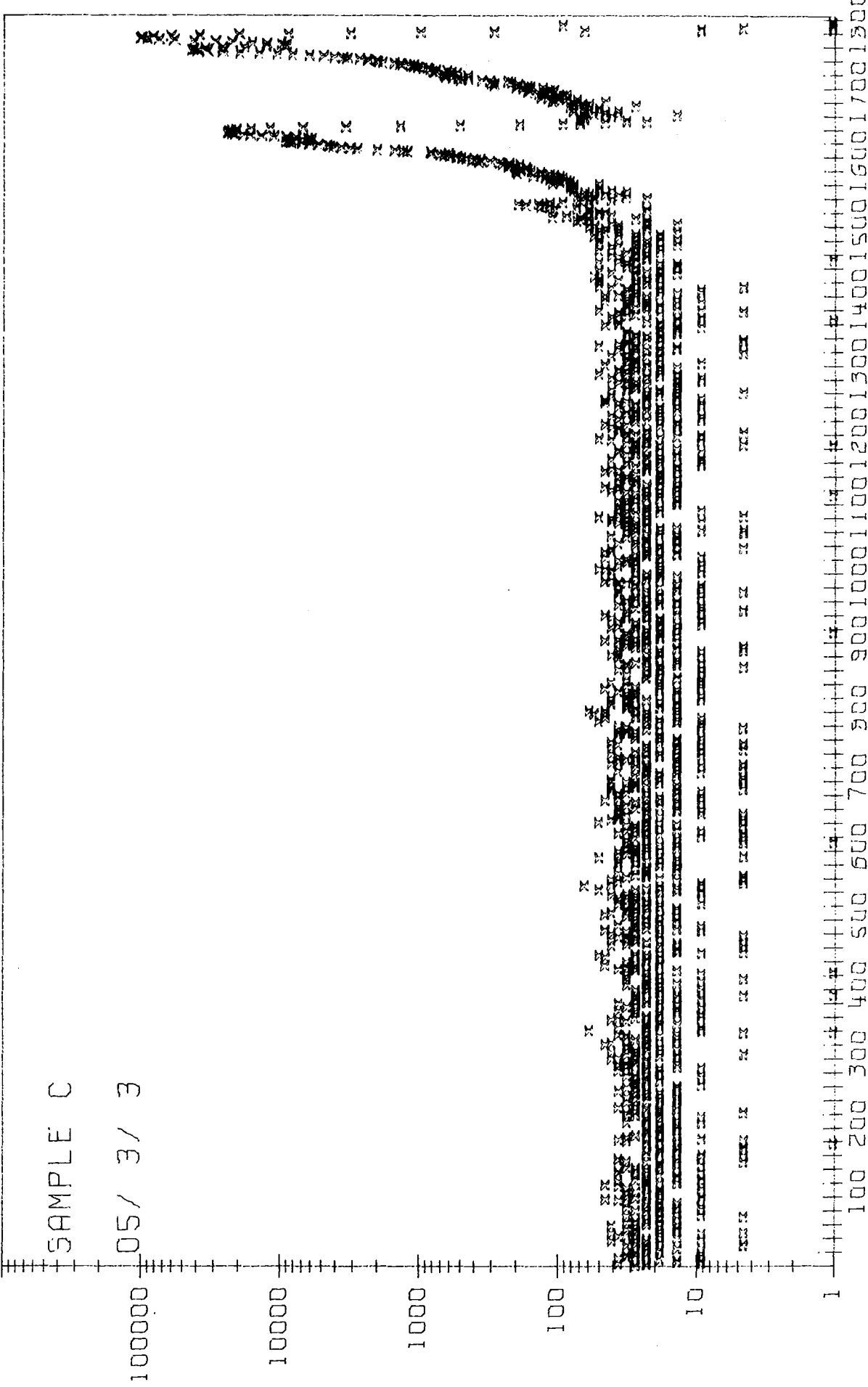


ABB.00511 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER

SAMPLE C

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ARB.00533 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER

SAMPLE 0

05/ 1/ 1

100000

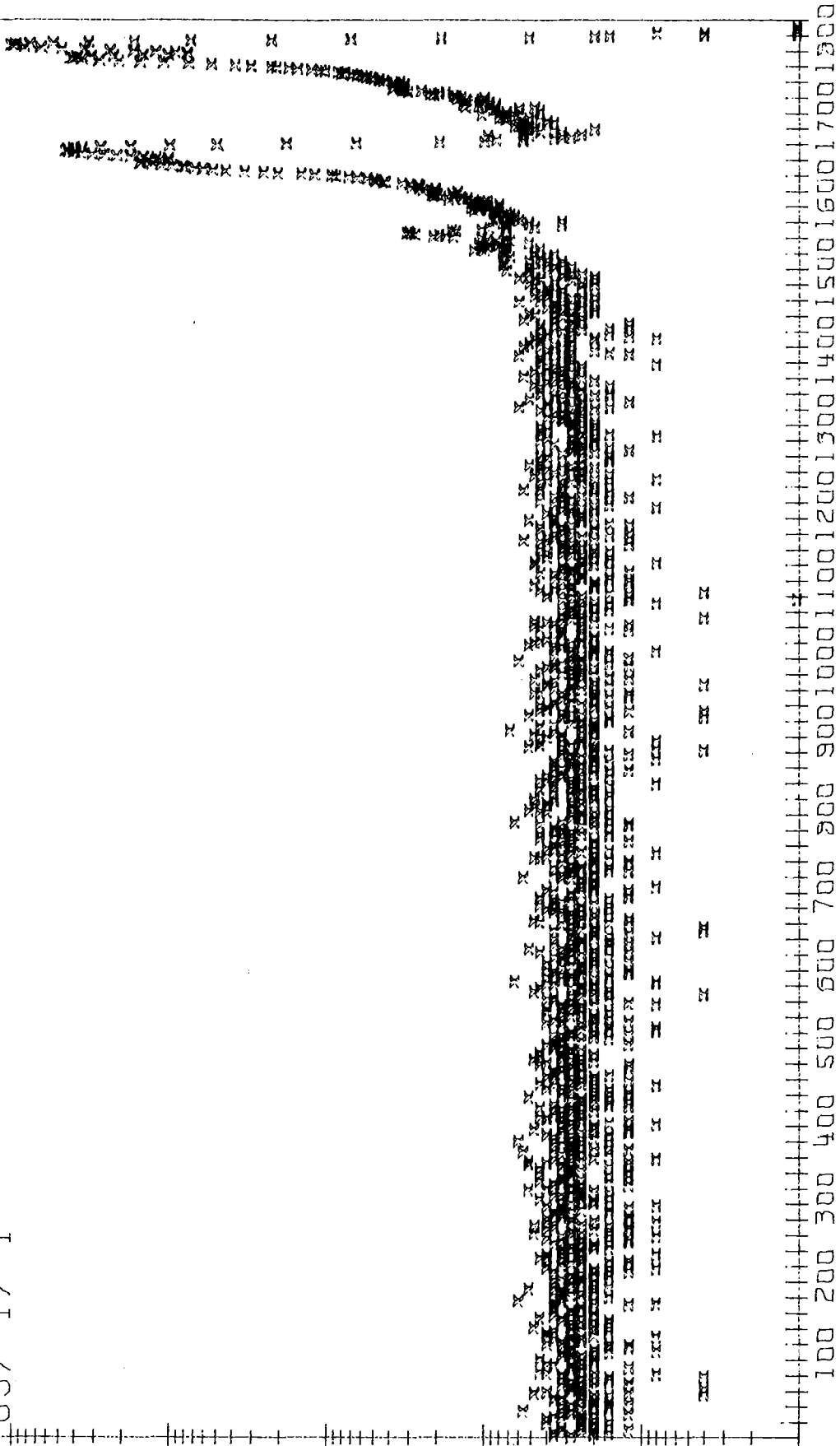
10000

1000

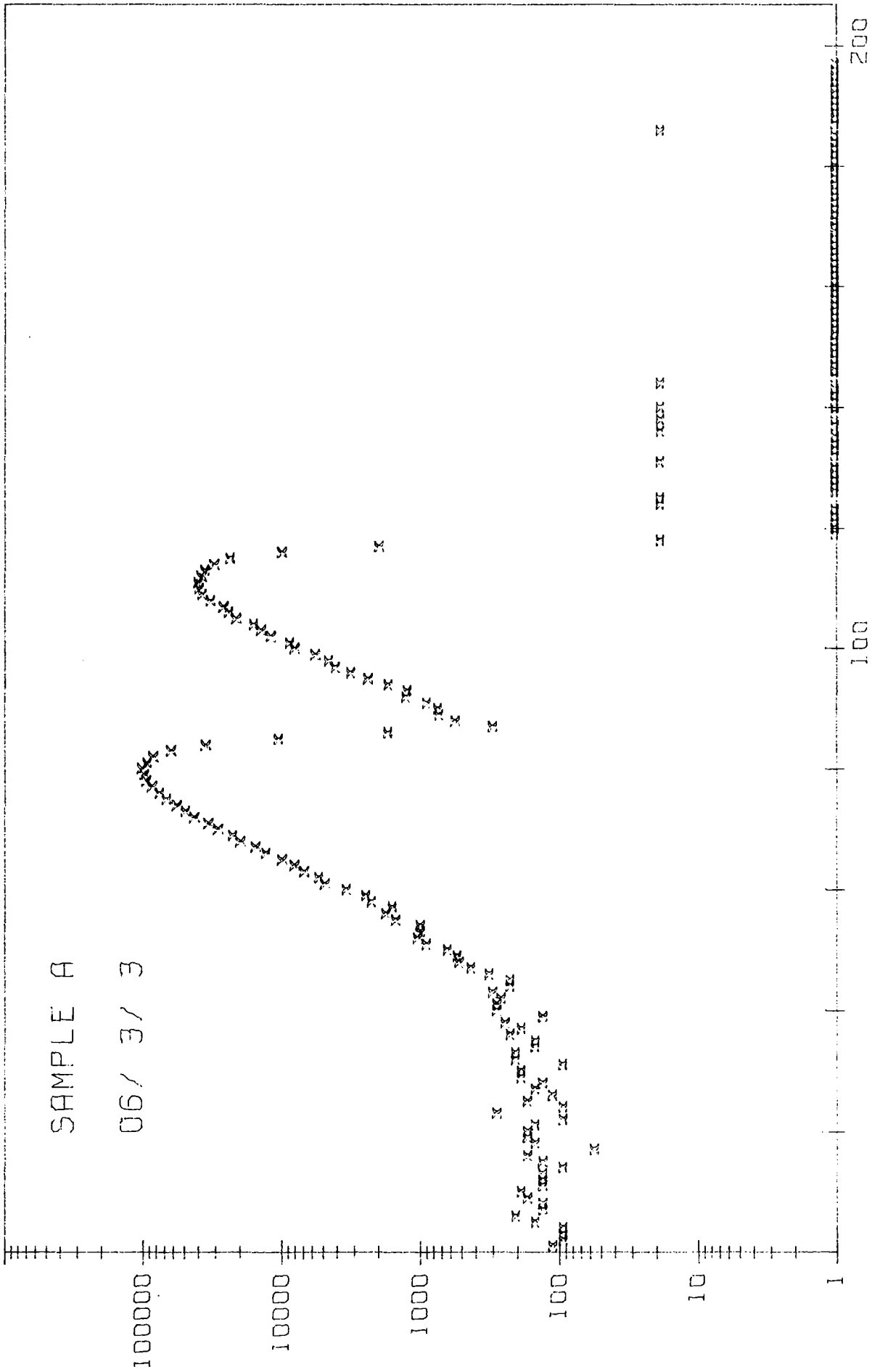
100

10

1



AB8.00511 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER



428.00533 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER

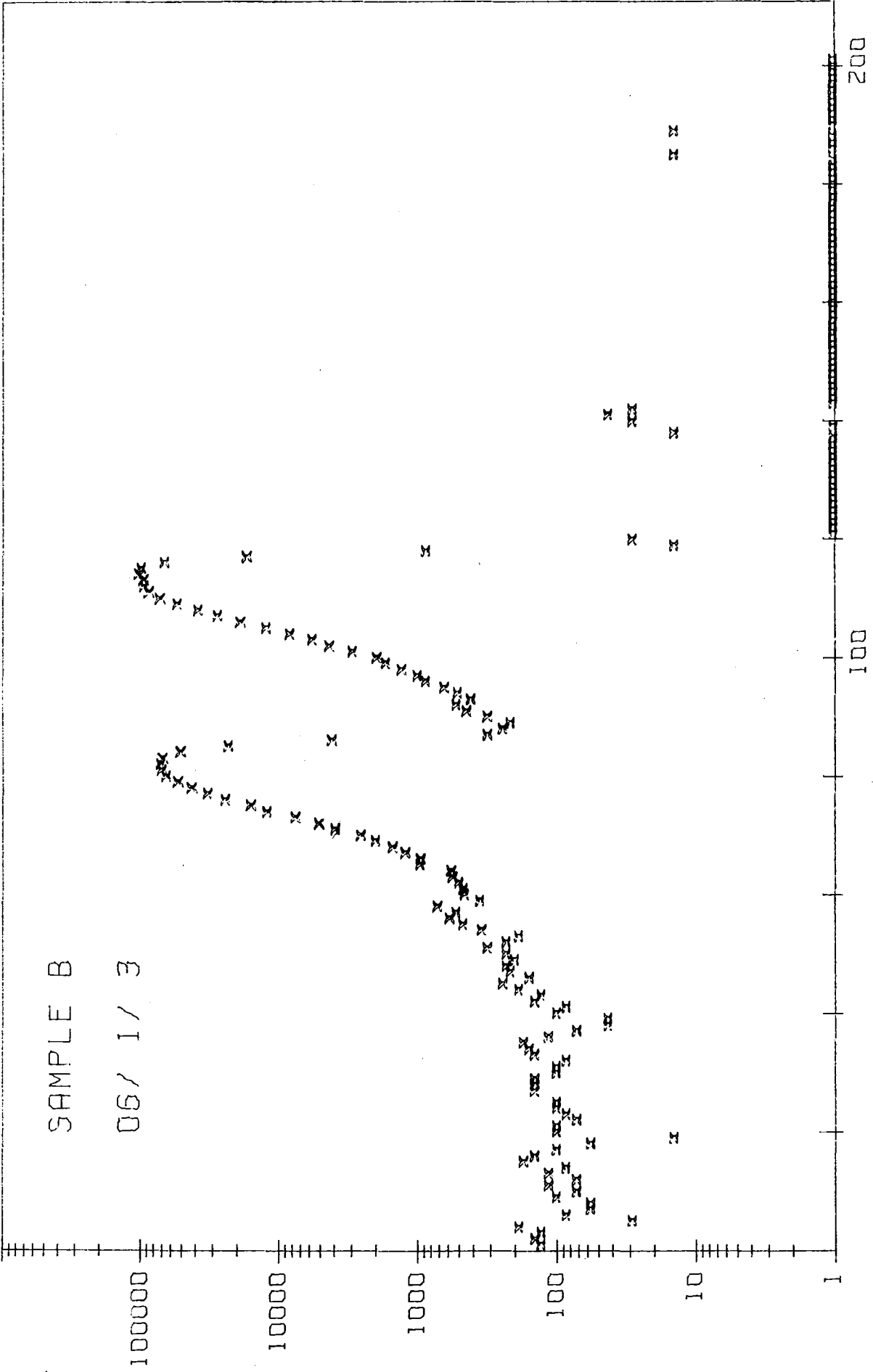
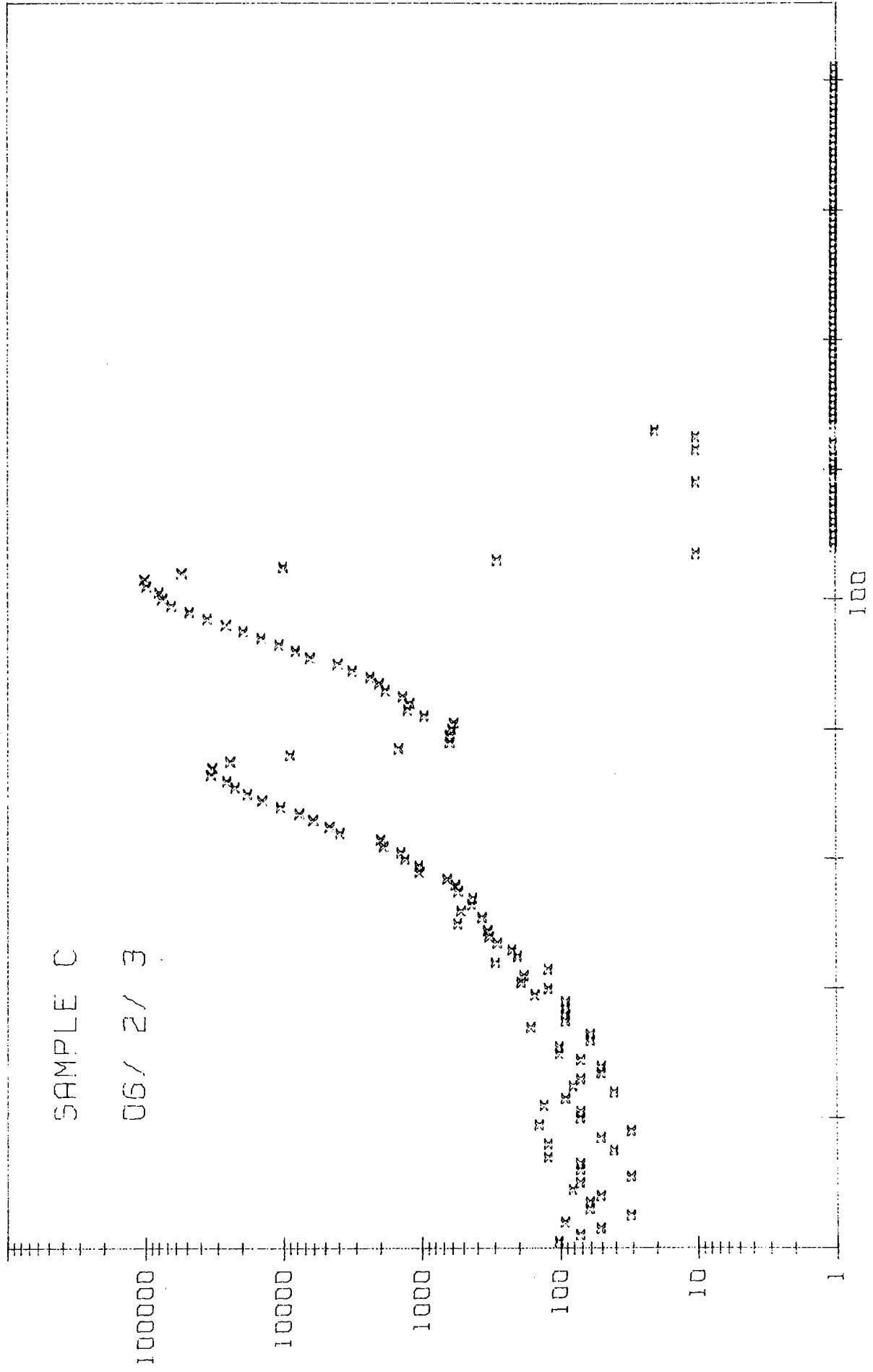


ABB.00513 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER



ASB.00523 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER

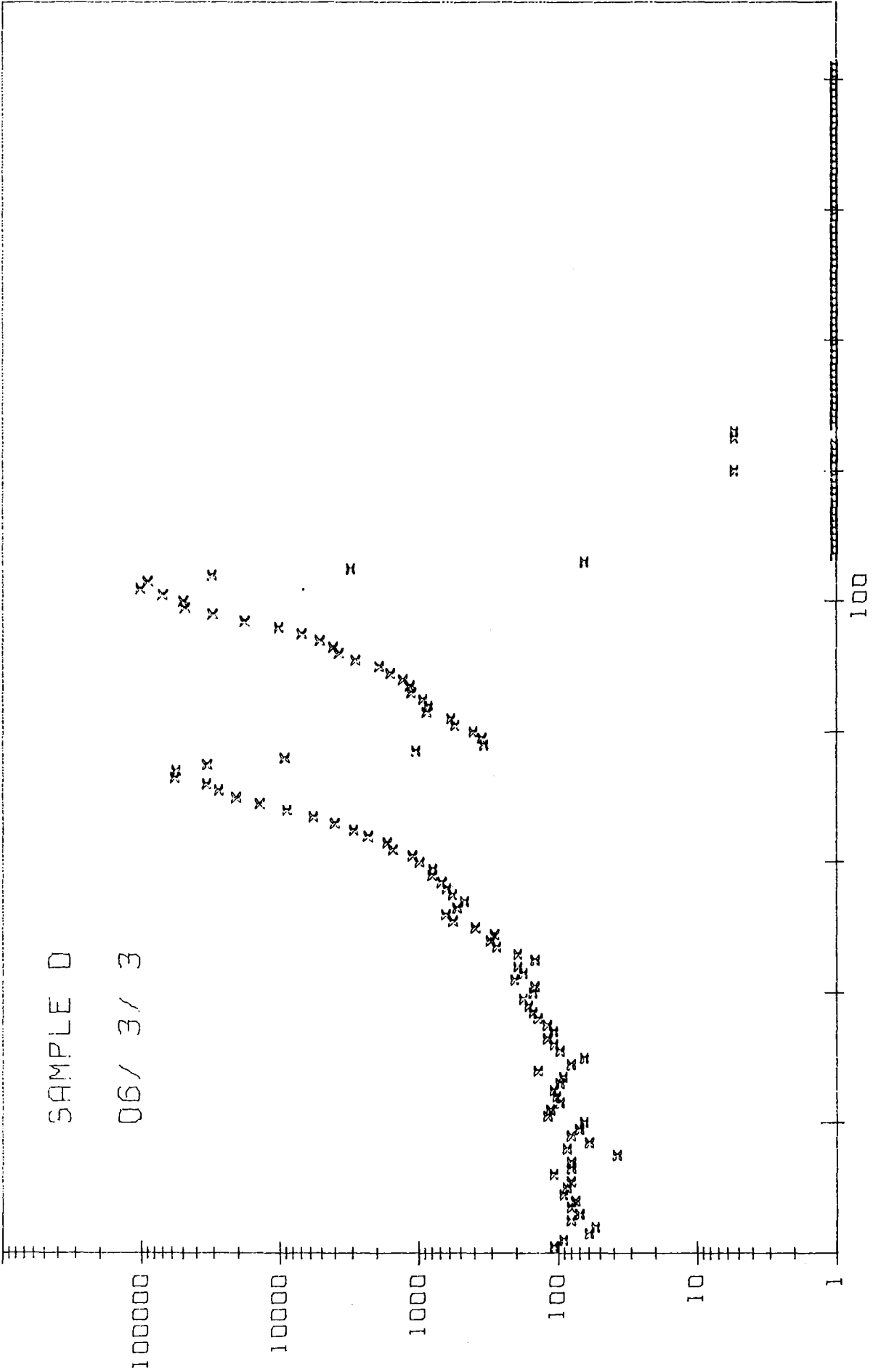


ABB.00633 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER

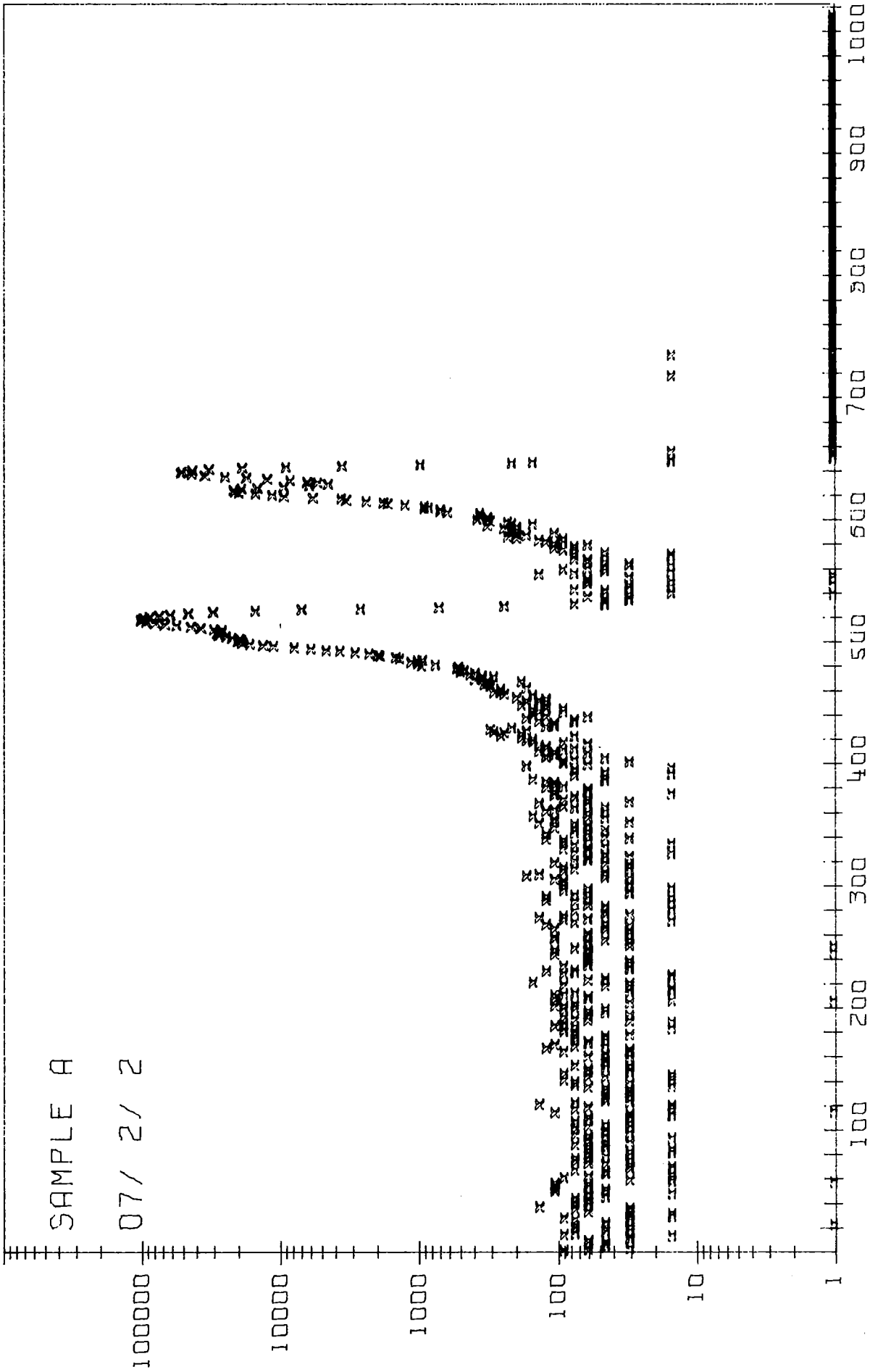


ABB.00722 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER

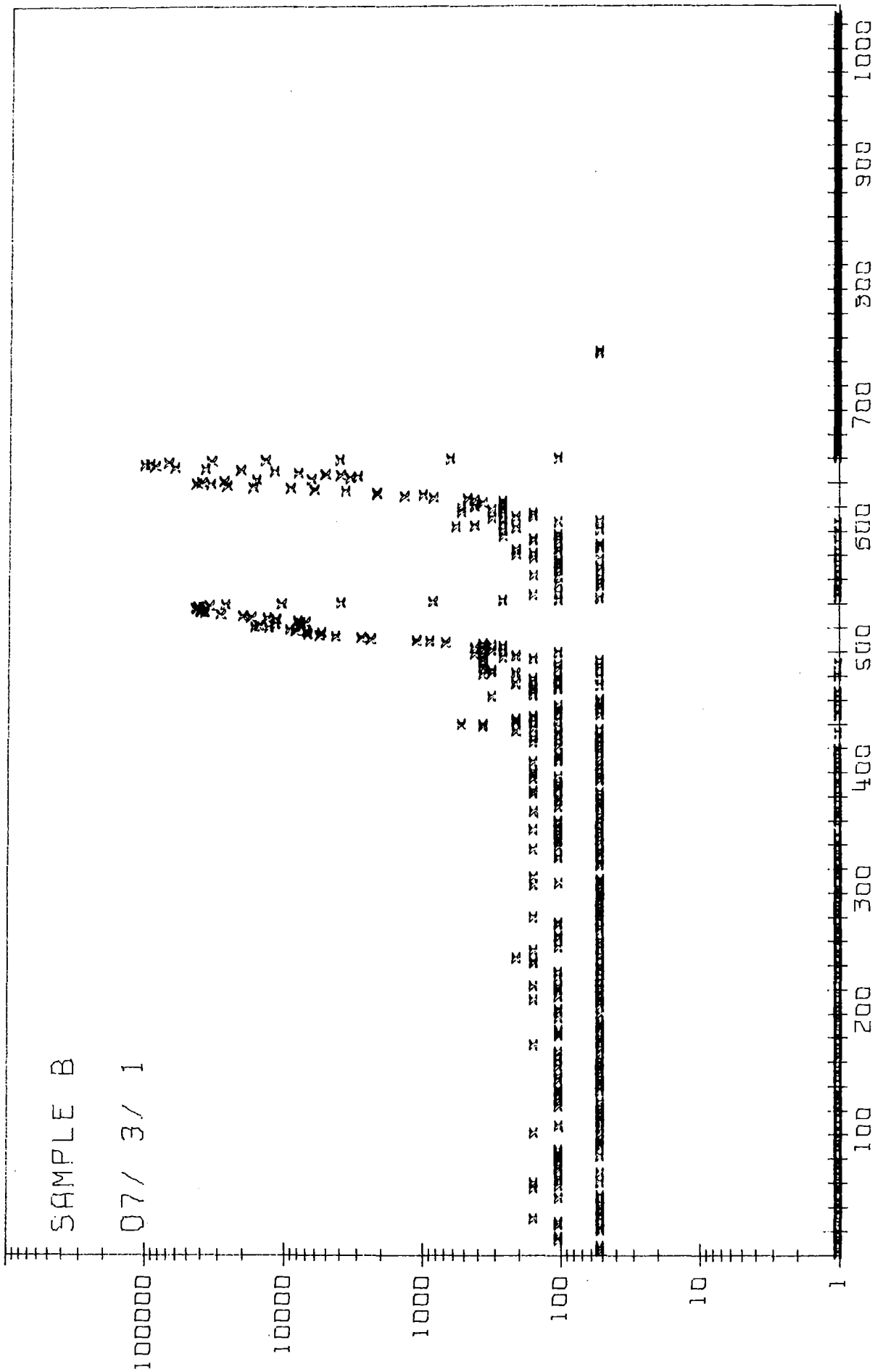
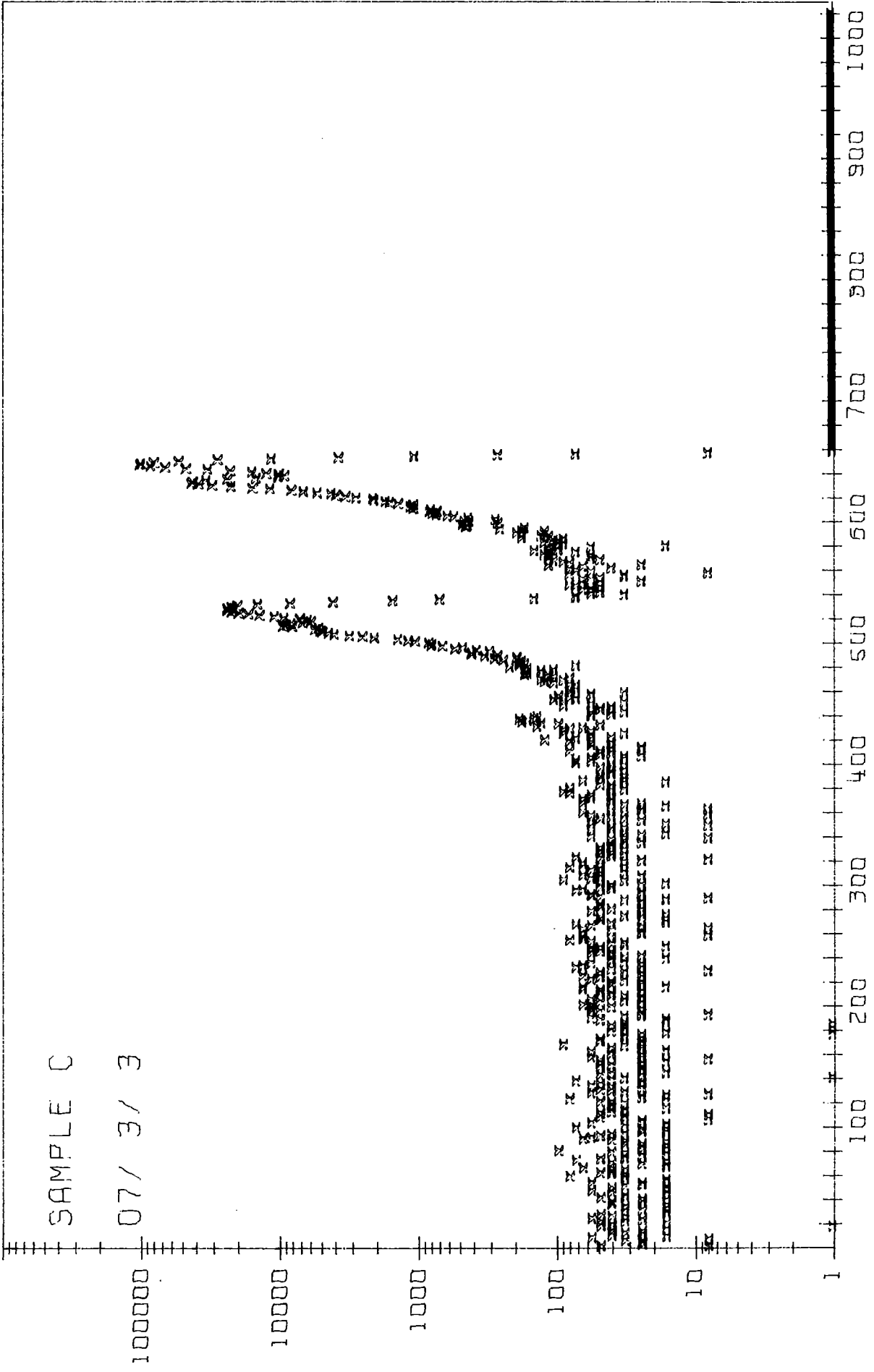


ABB.00731 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER



ARB. 00733 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER

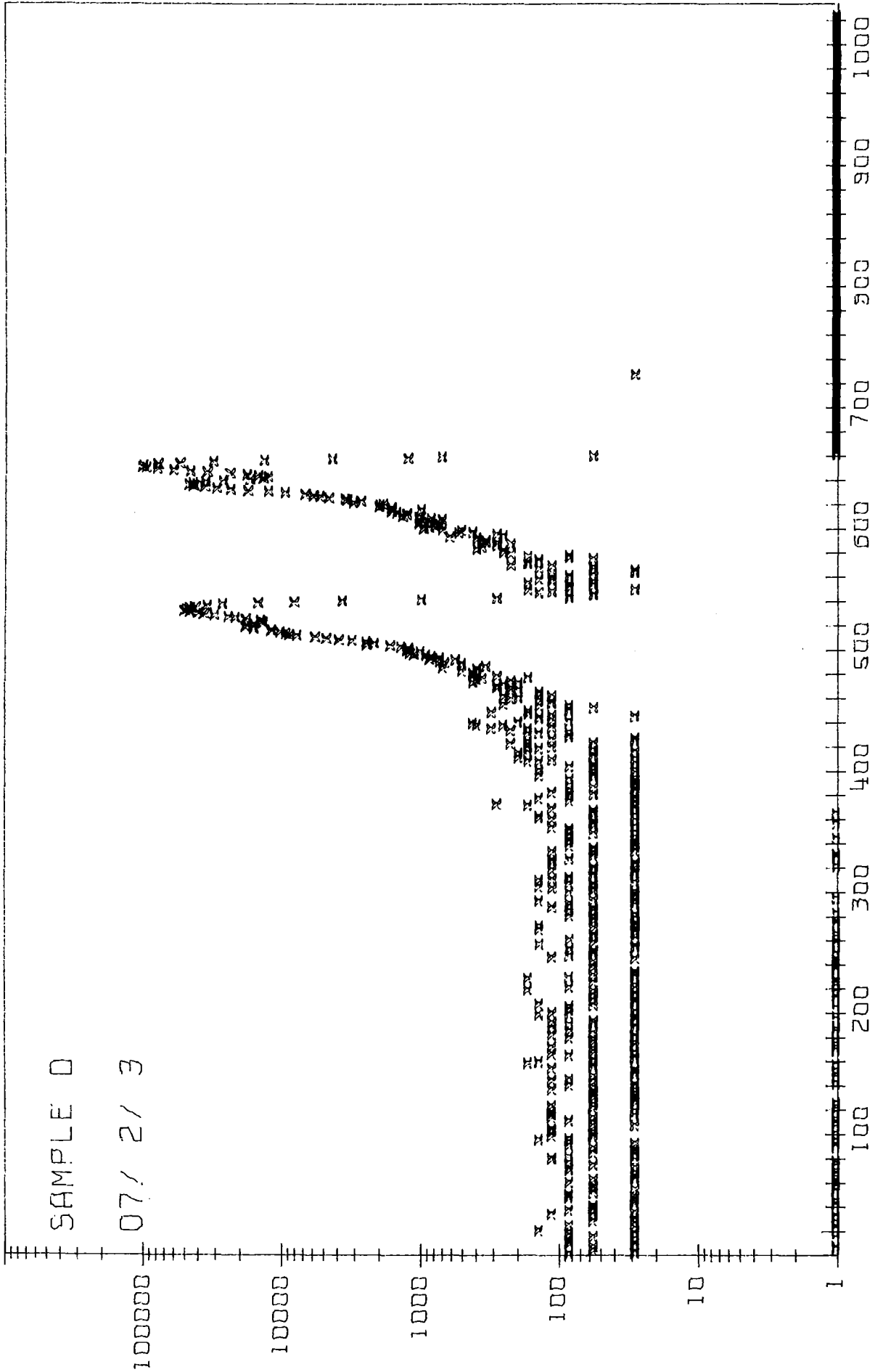


ABB.00725 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER

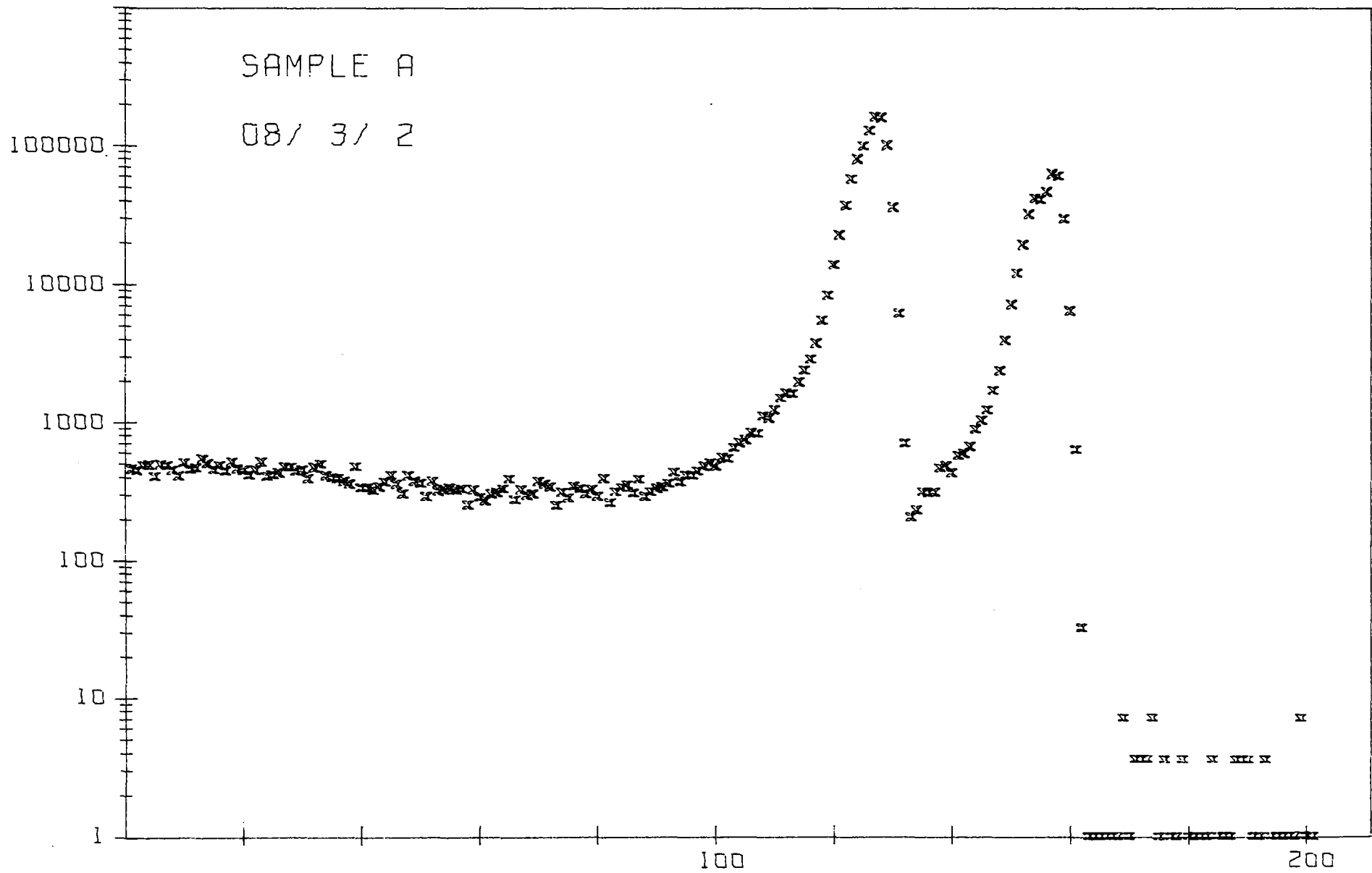


ABB.00832 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER

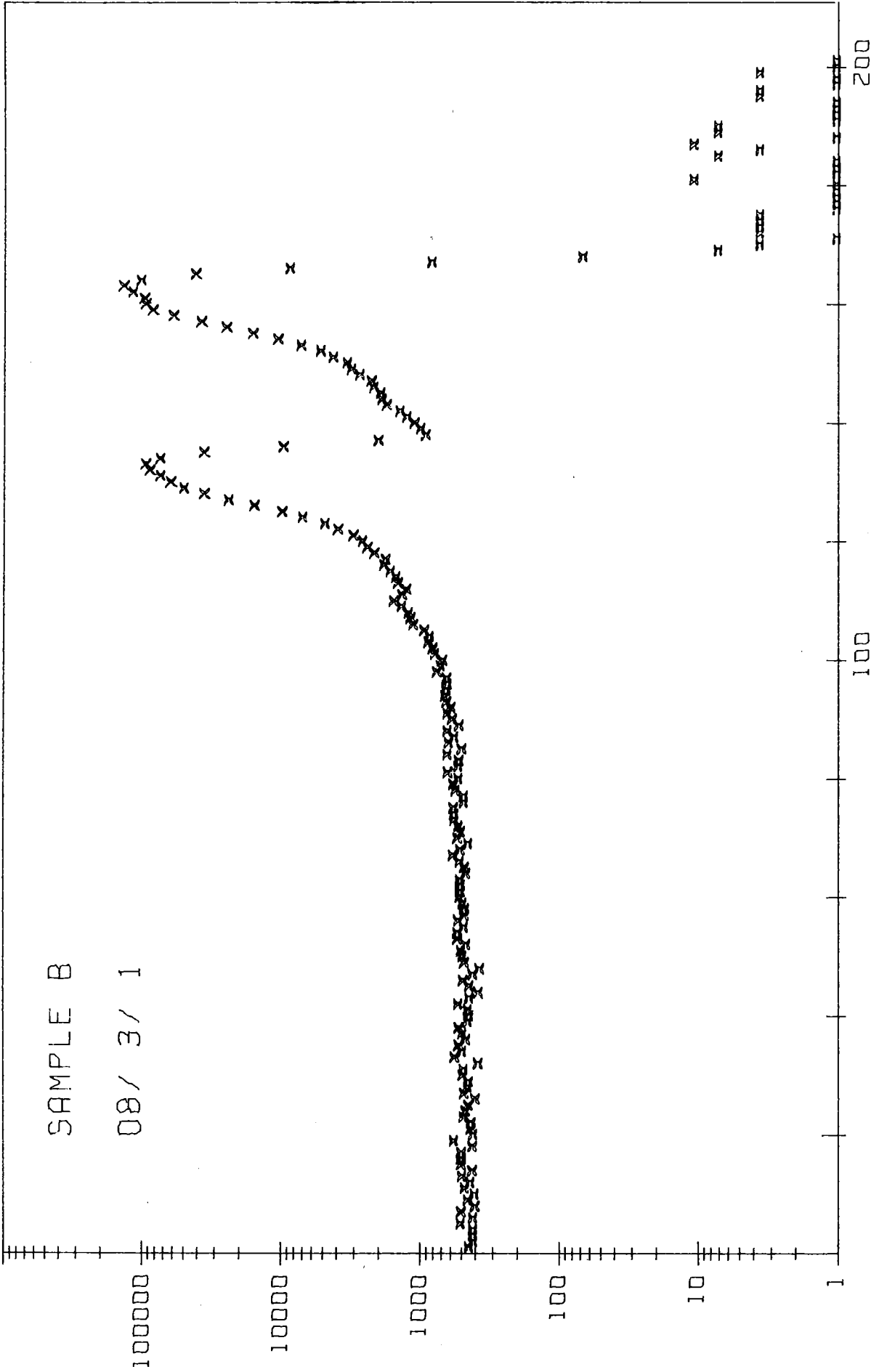
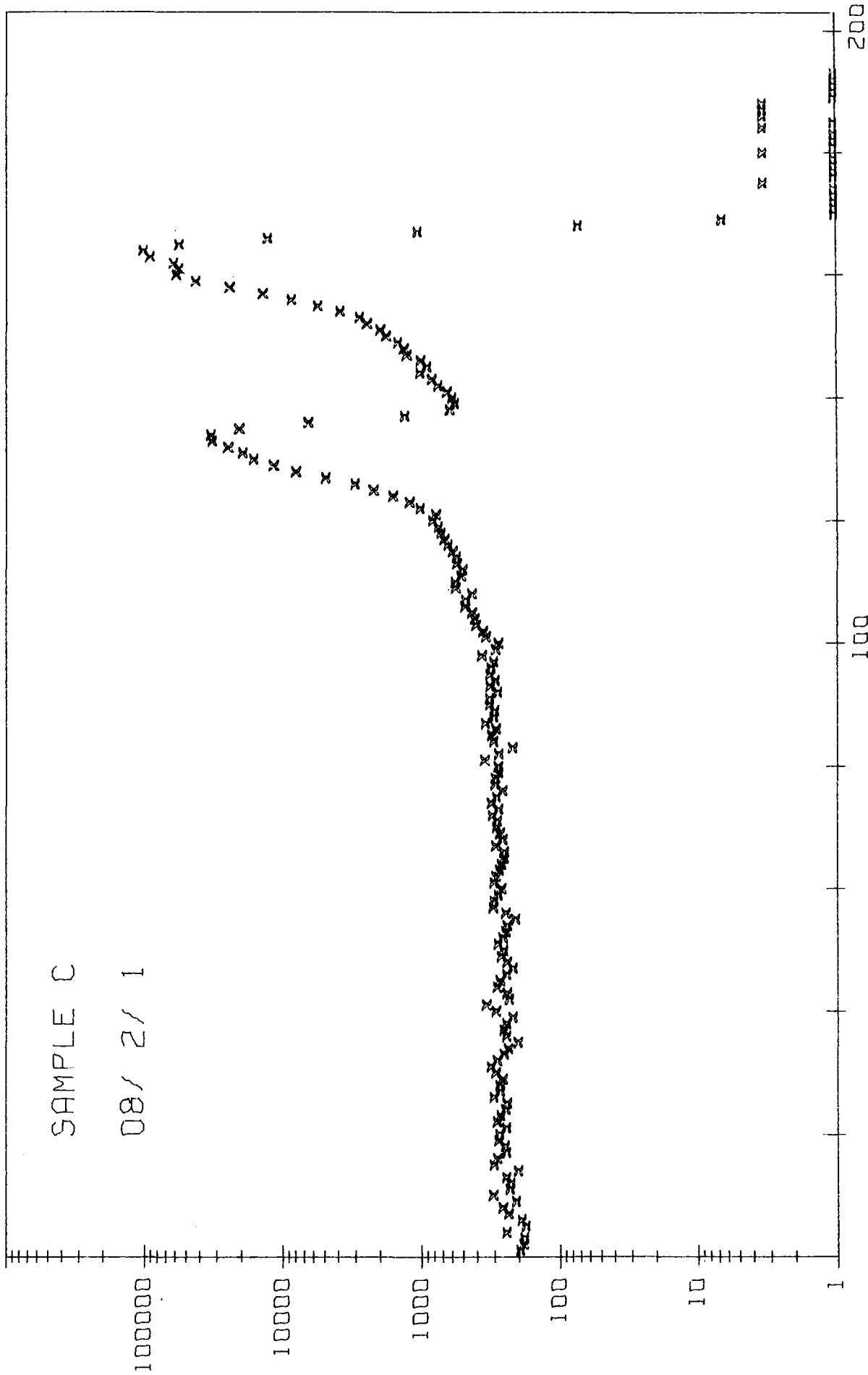


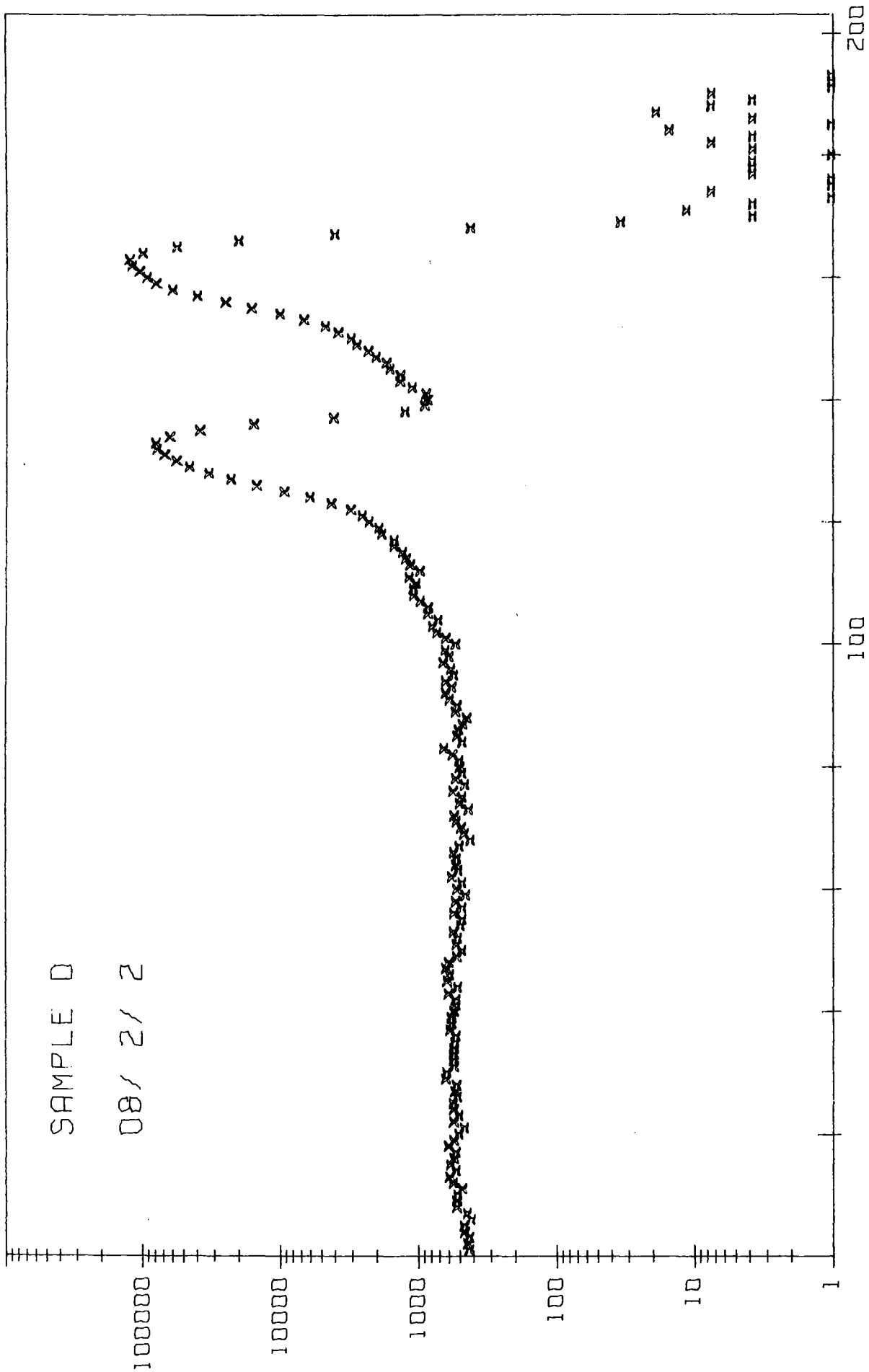
ABB.0031 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER



SAMPLE C

08/ 2/ 1

888.00821 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER



SAMPLE D
08/ 2/ 2

ABB.00822 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER

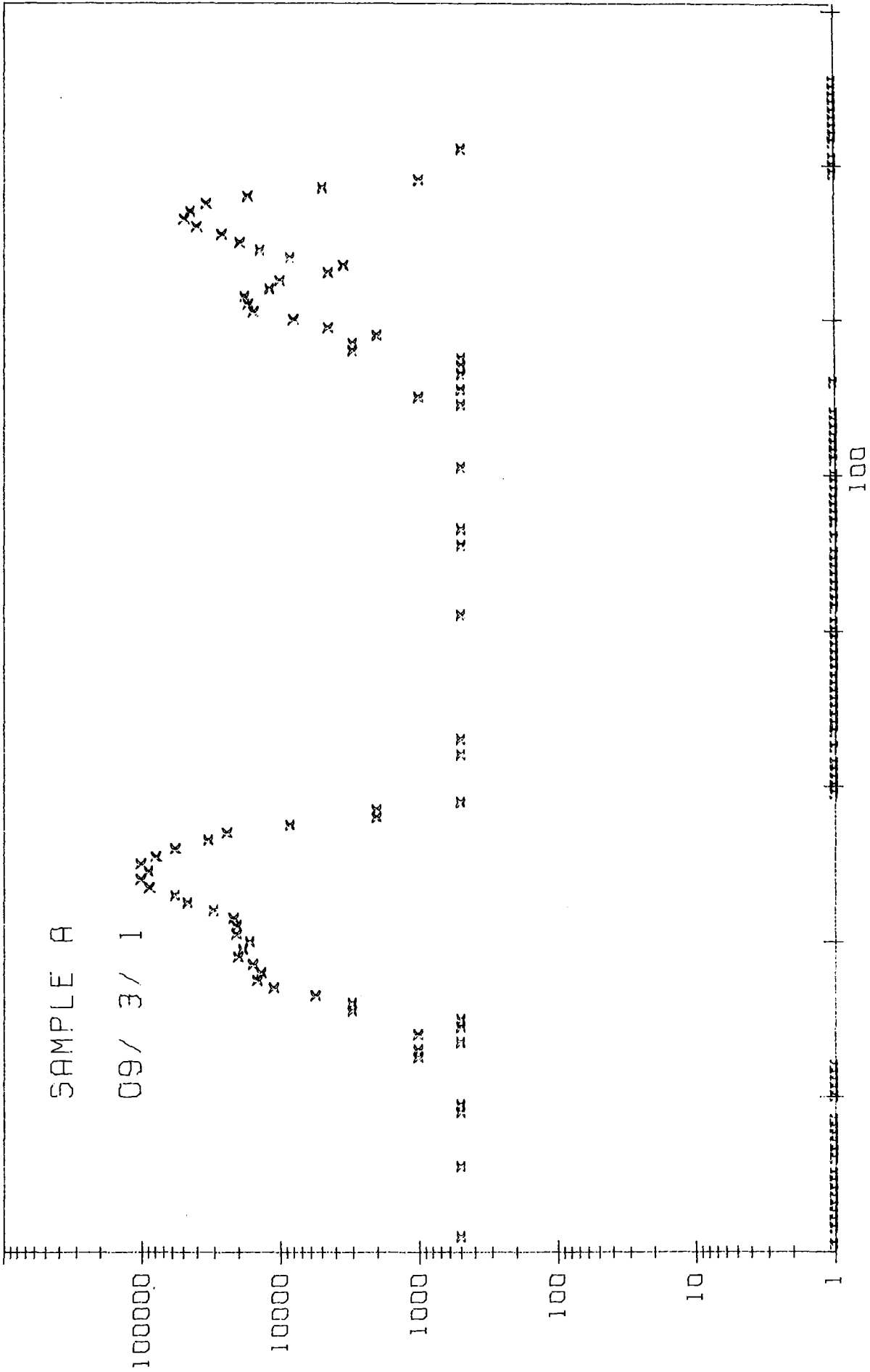


ABB. 00931 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER

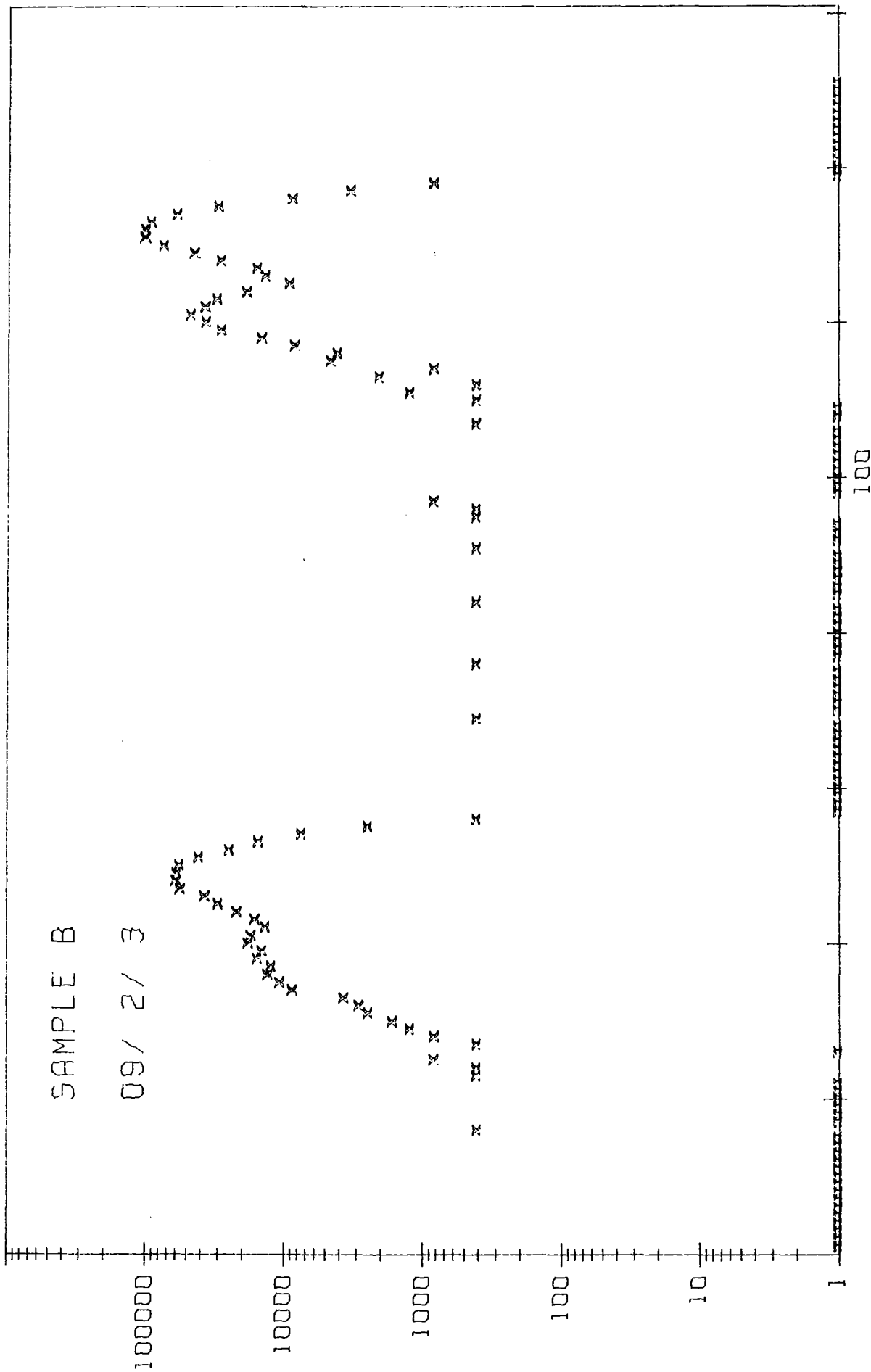


ABB. 00923 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER

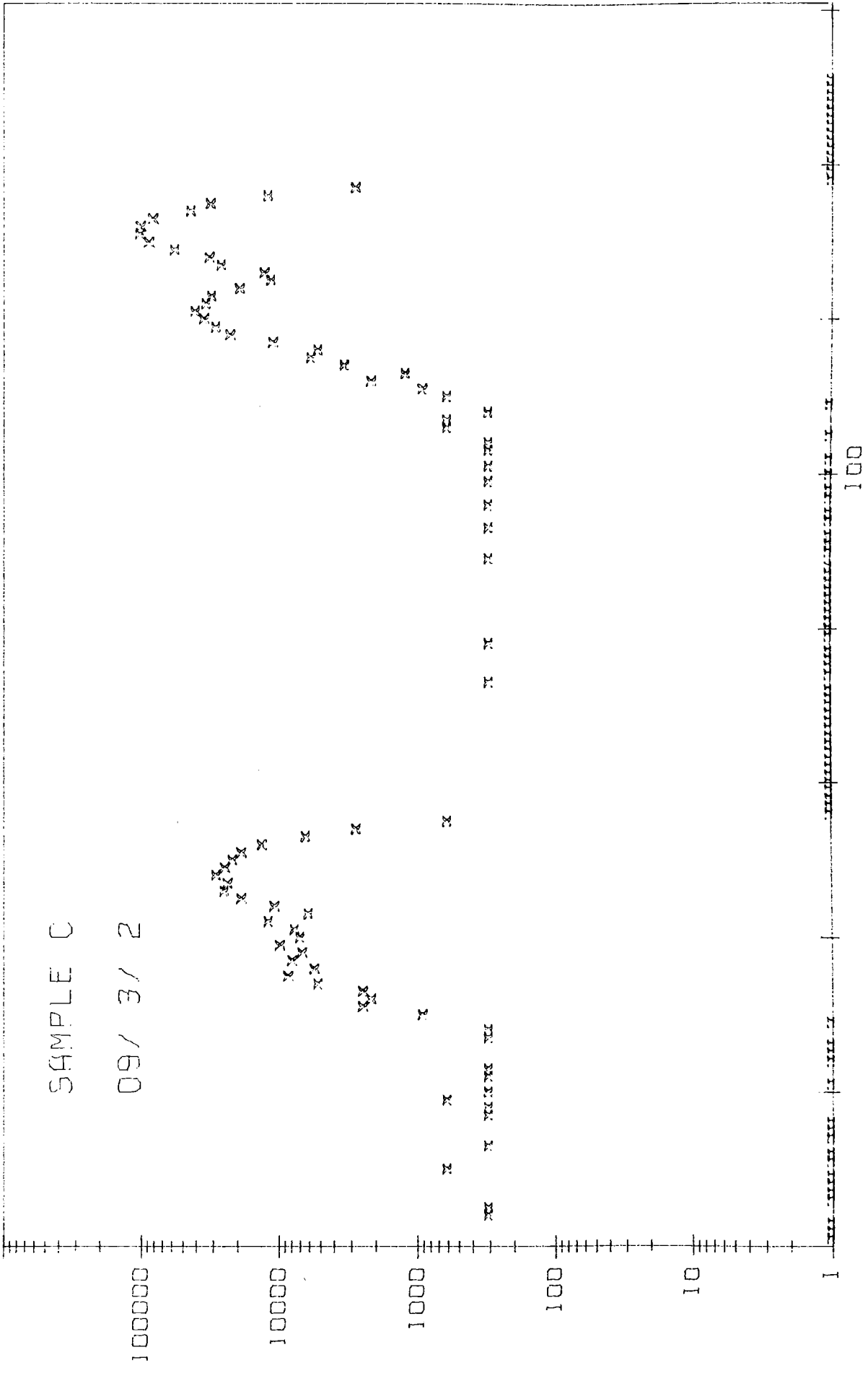


ABB. 00932 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER

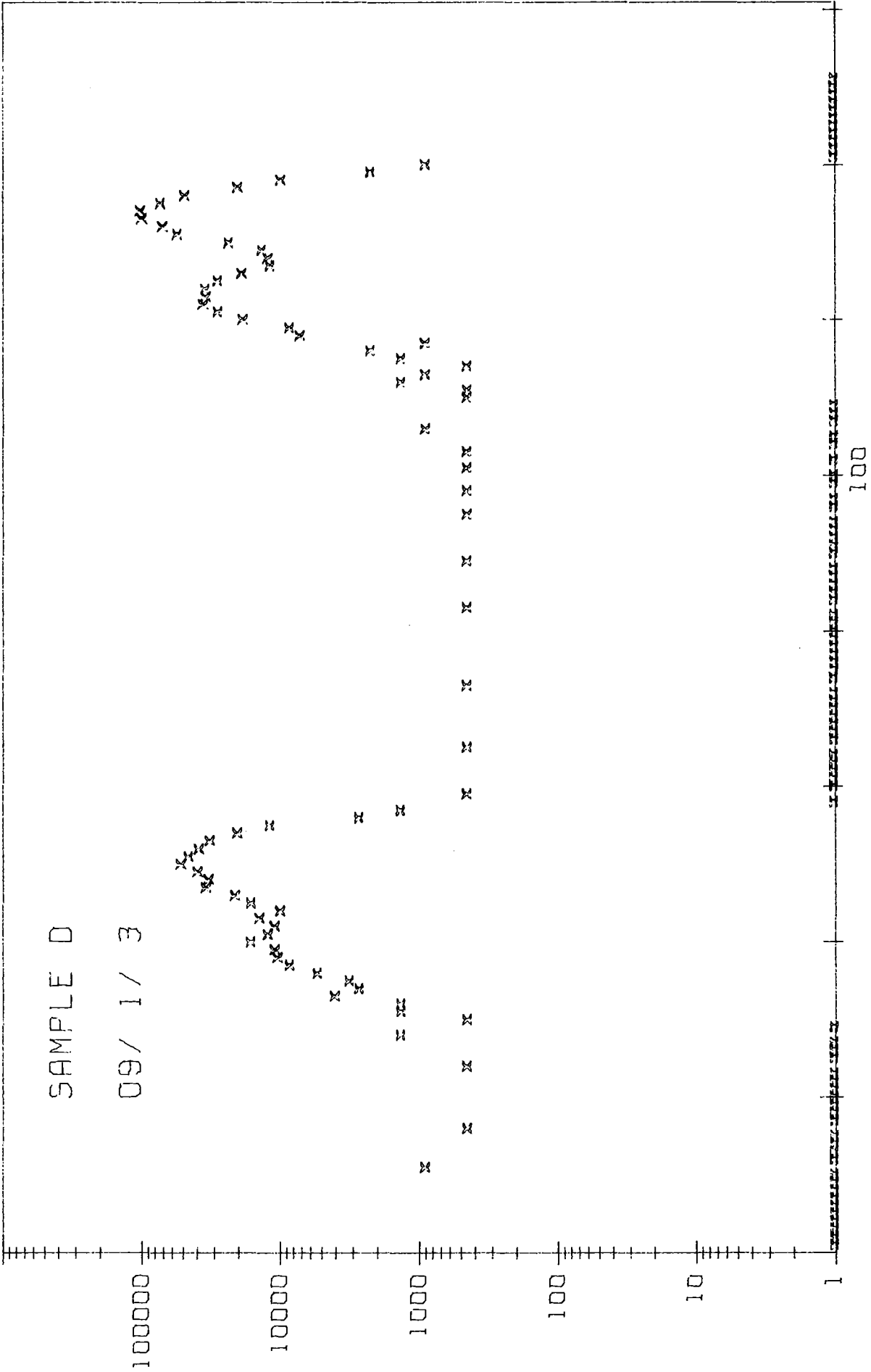


ABB. 00913 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER

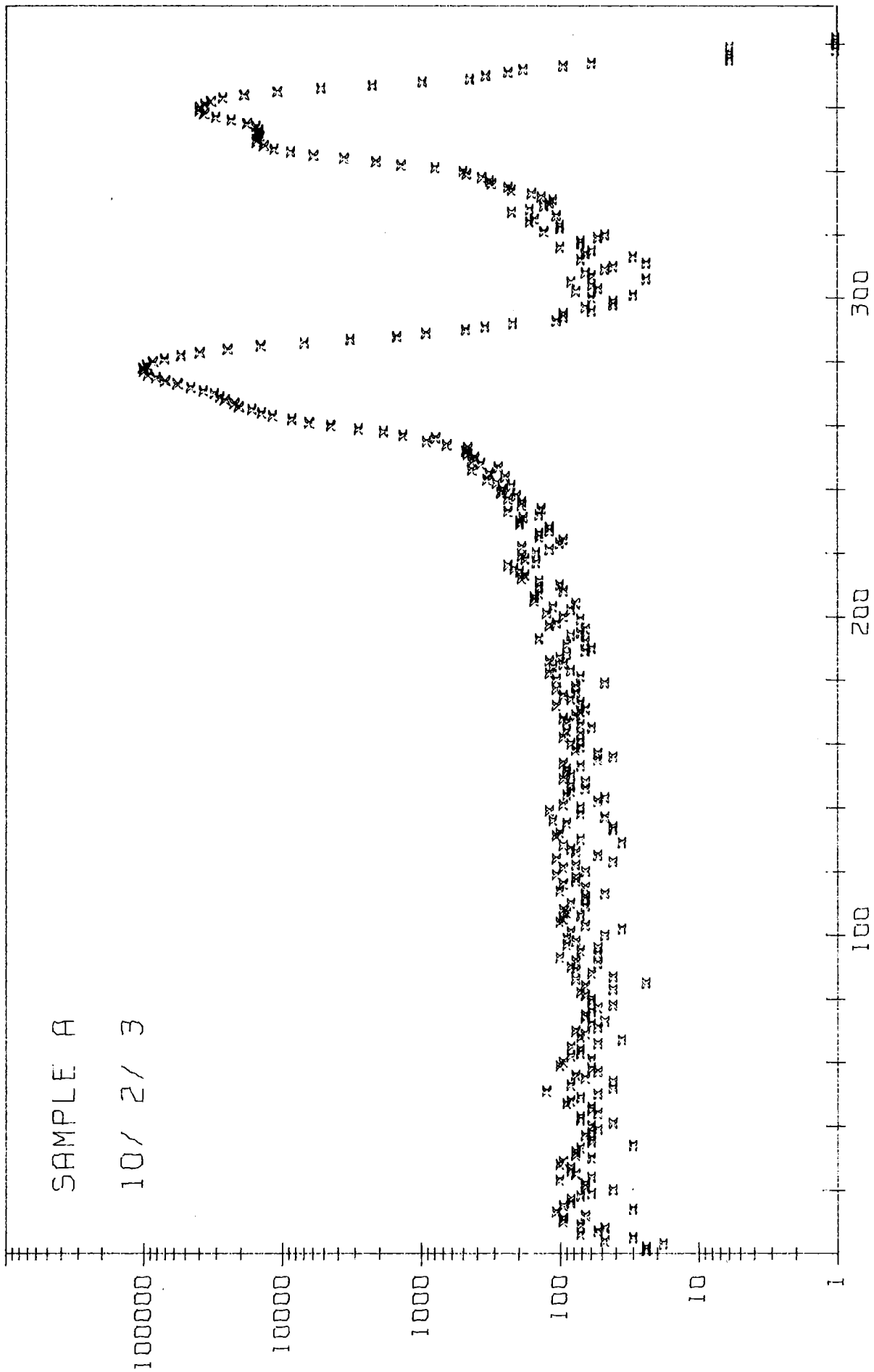
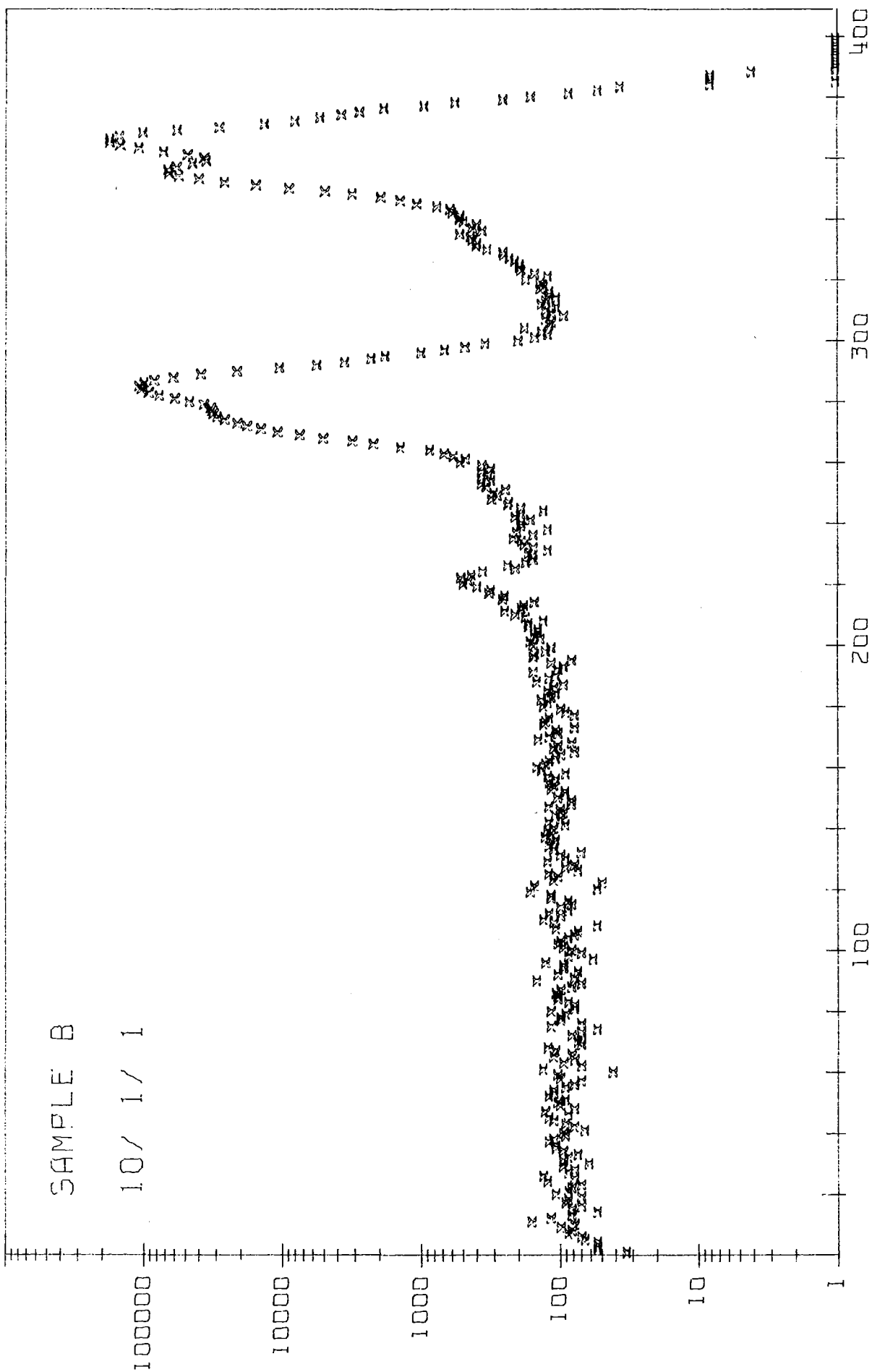


ABB.01023 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER



SAMPLE B

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ABB.01011 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER

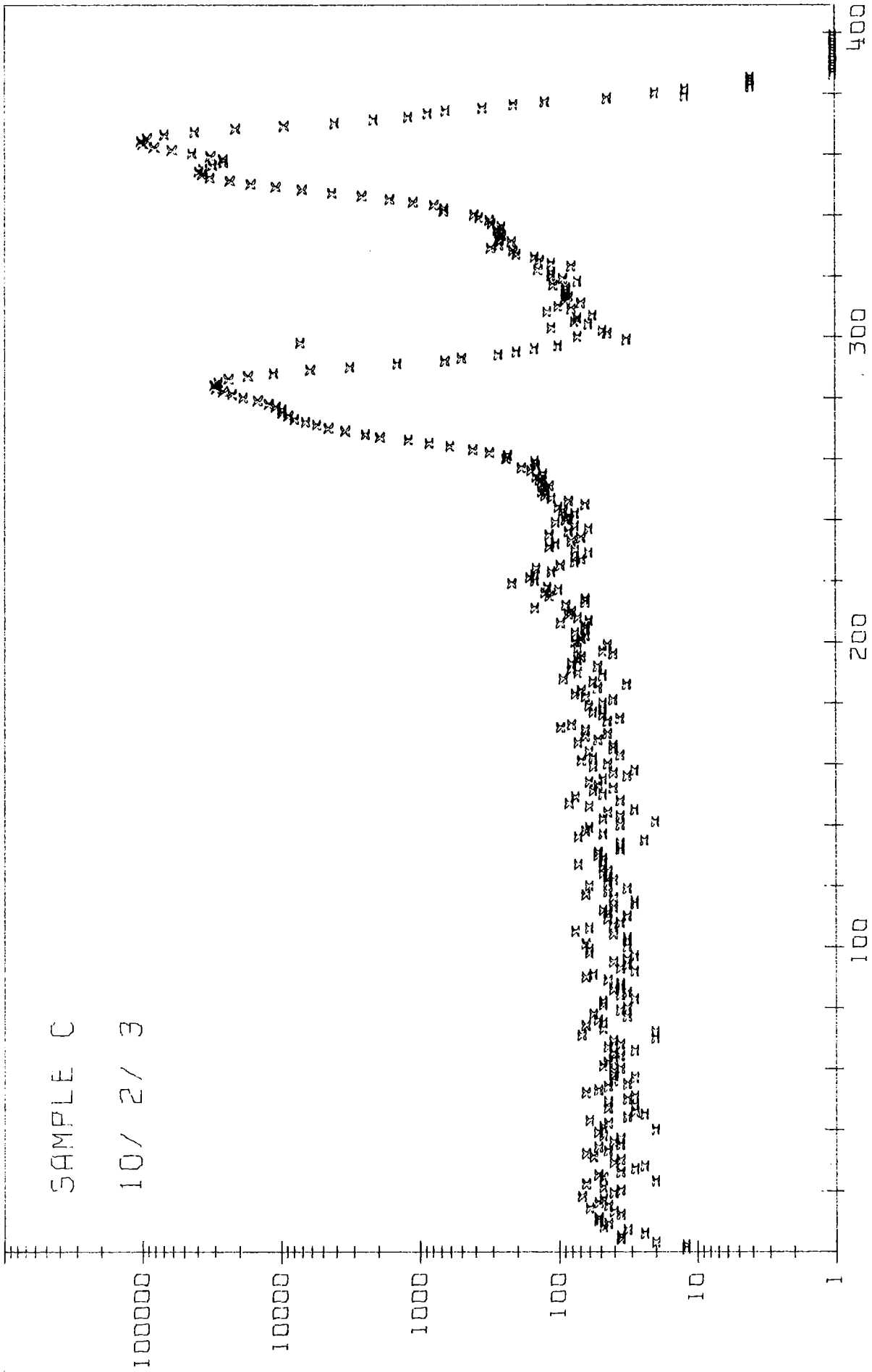
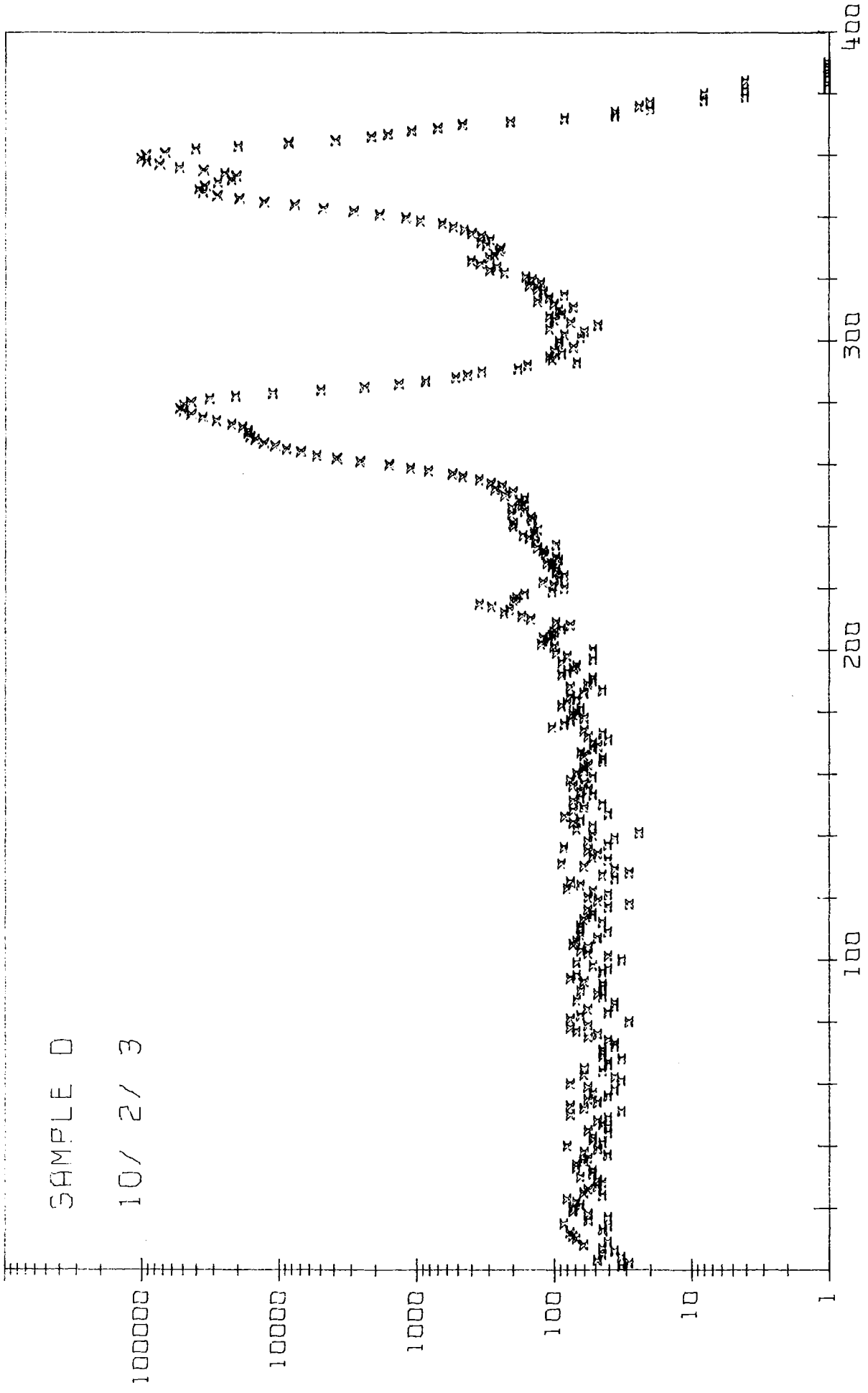


ABB.01023 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER



SAMPLE D
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ABB. 01025 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER

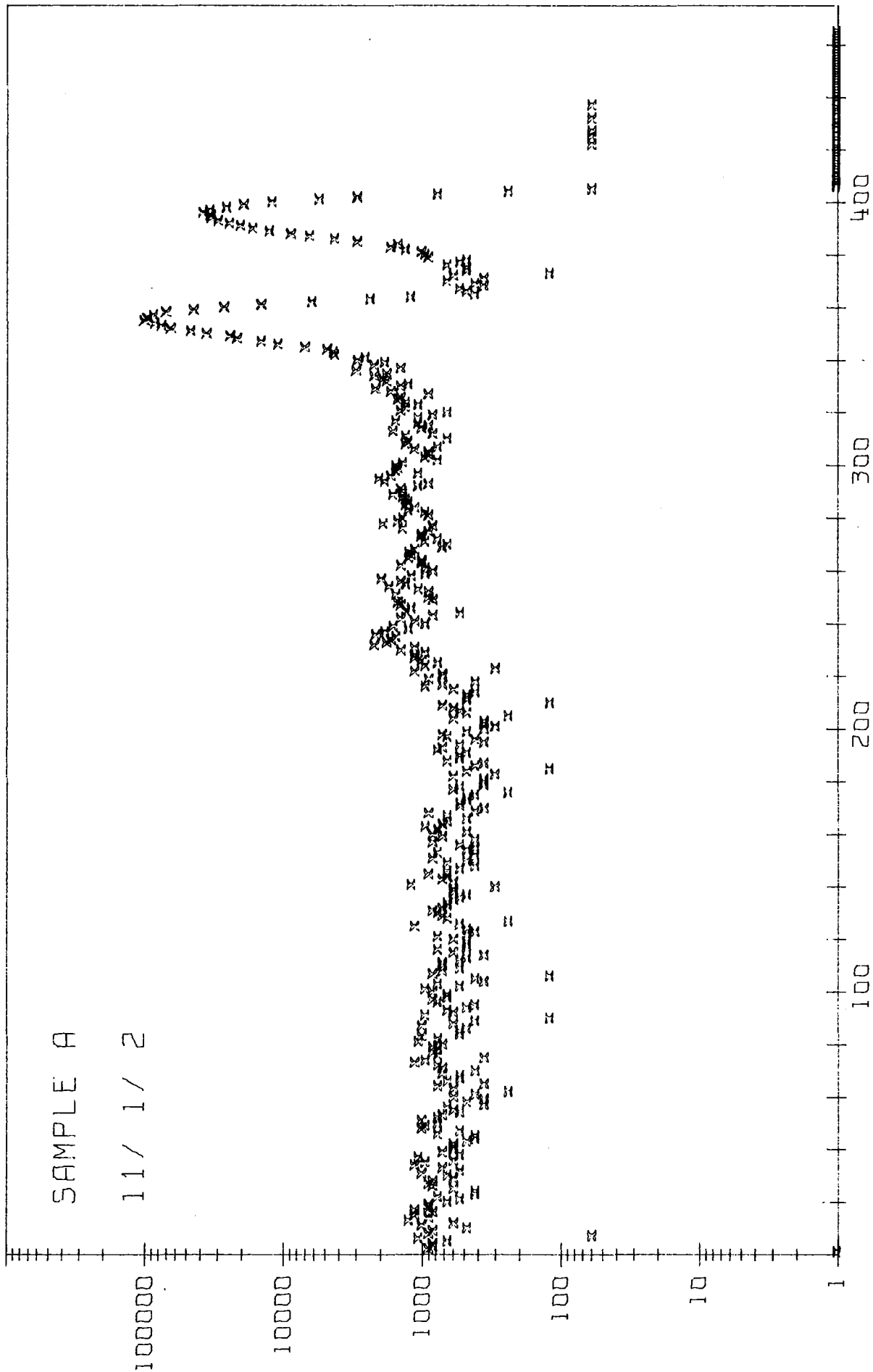


ABB 01112 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER

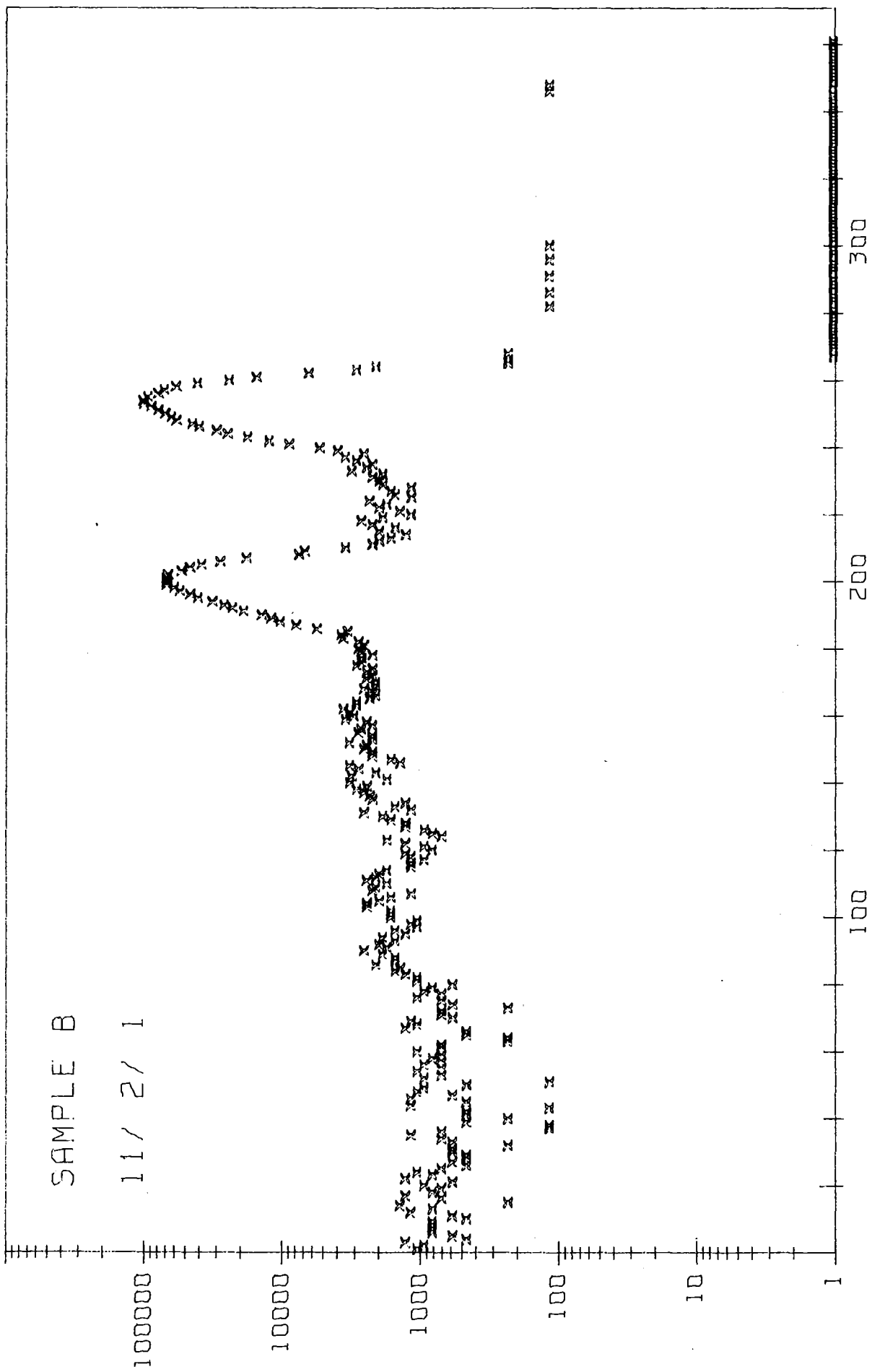


ABB.01121 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER

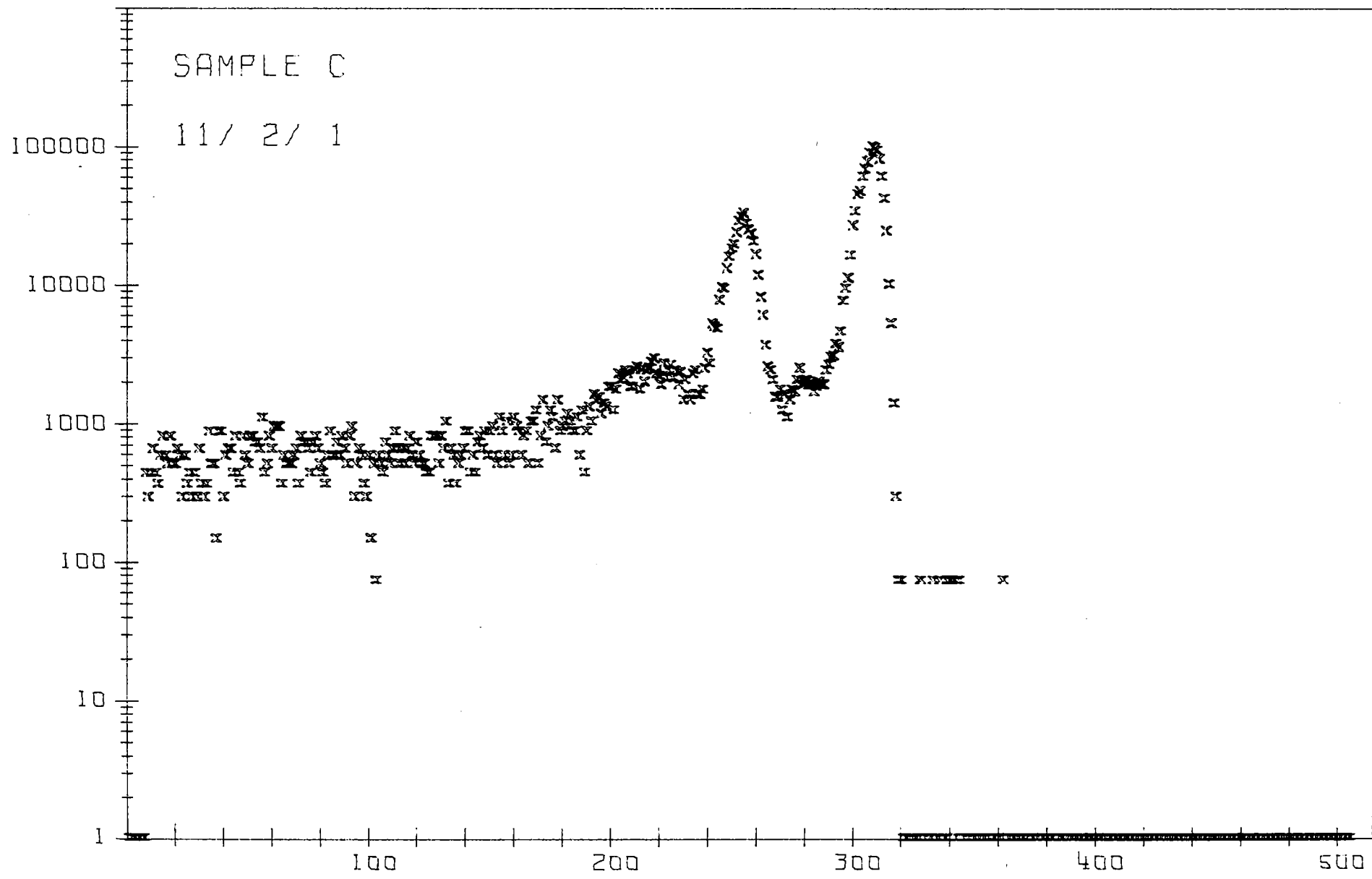


ABB.01121 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER

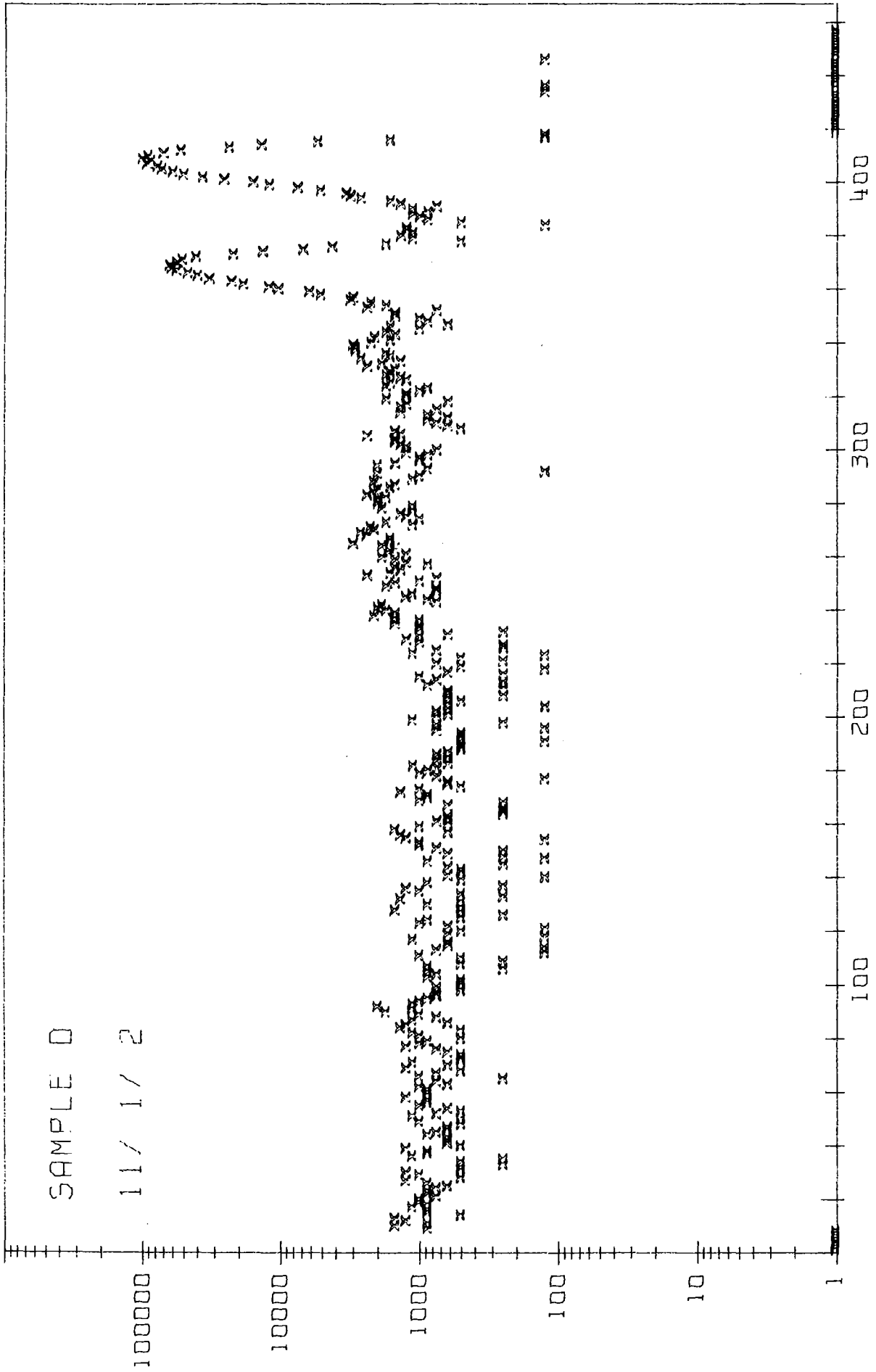
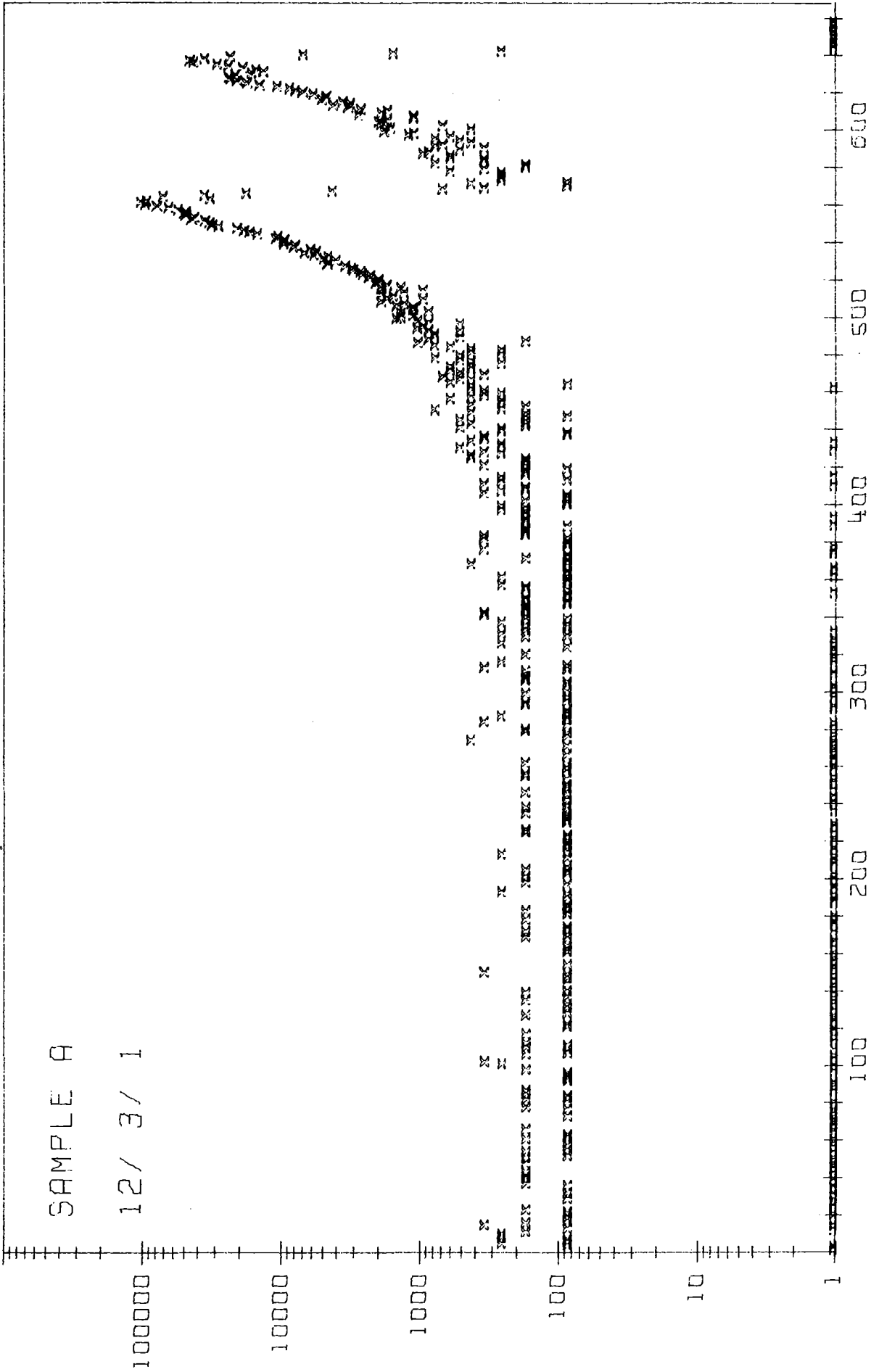


ABB. 01112 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER



428.01231 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER

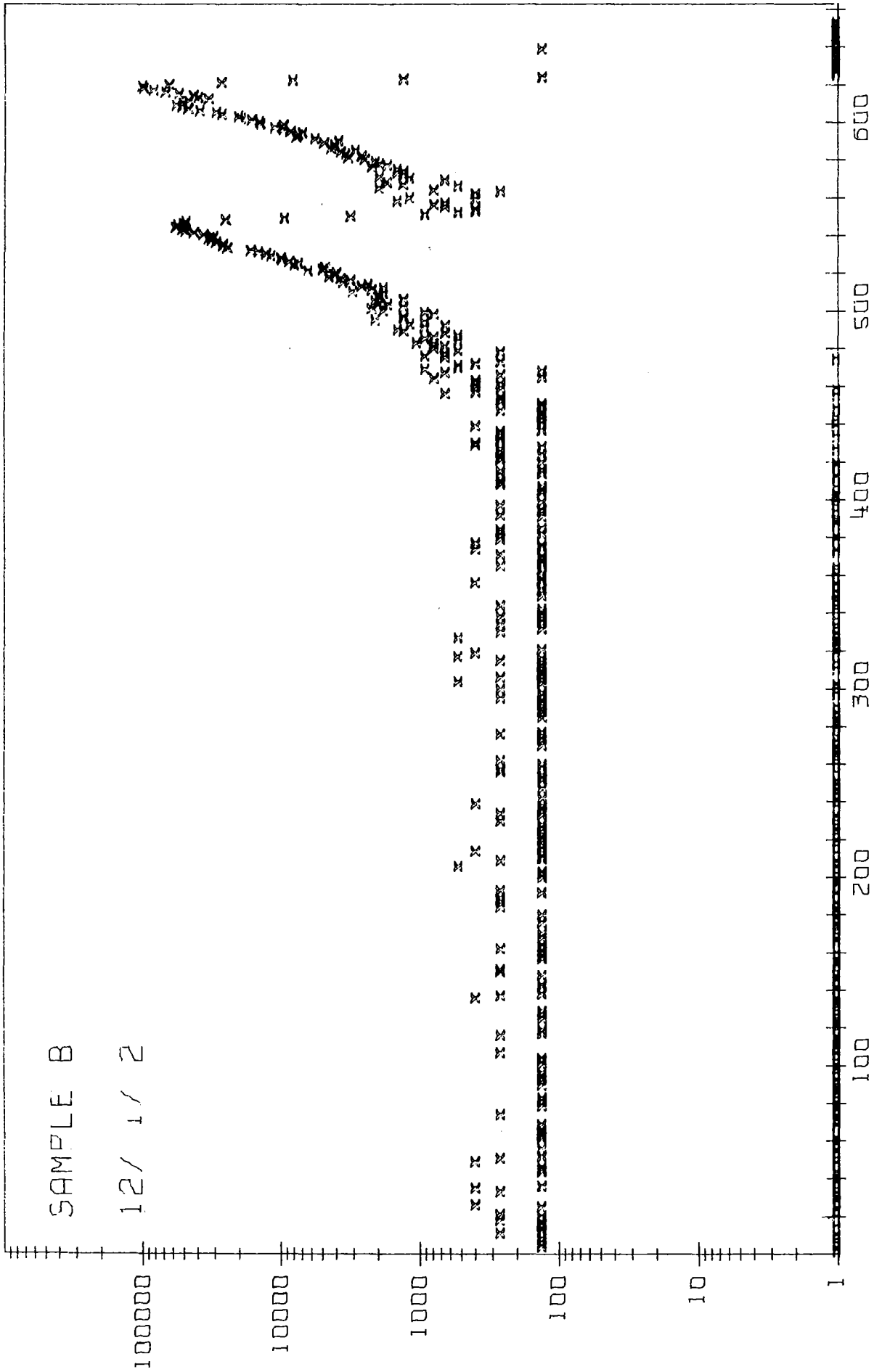


ABB.01212 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER

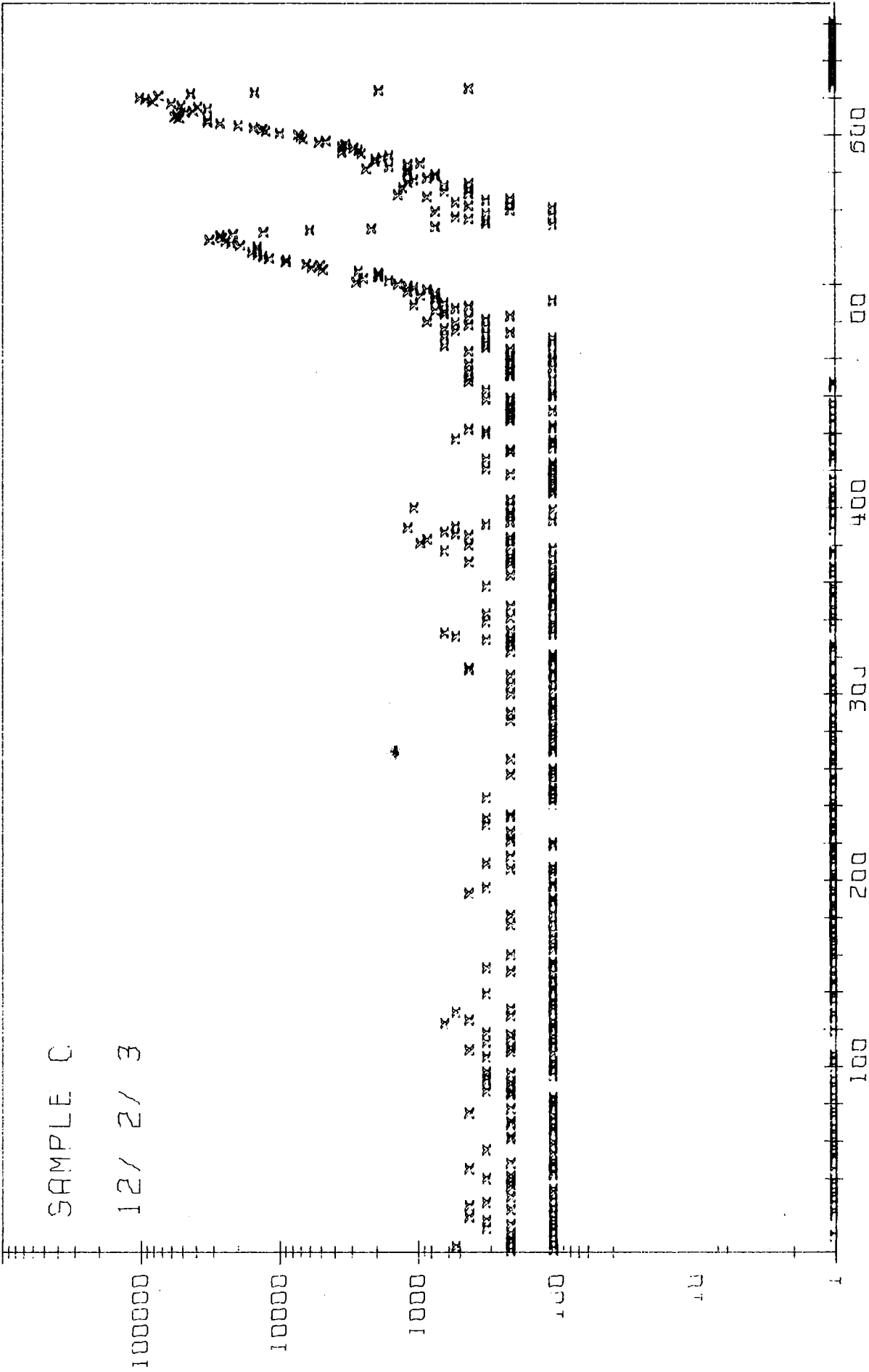


ABB. 01223 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER

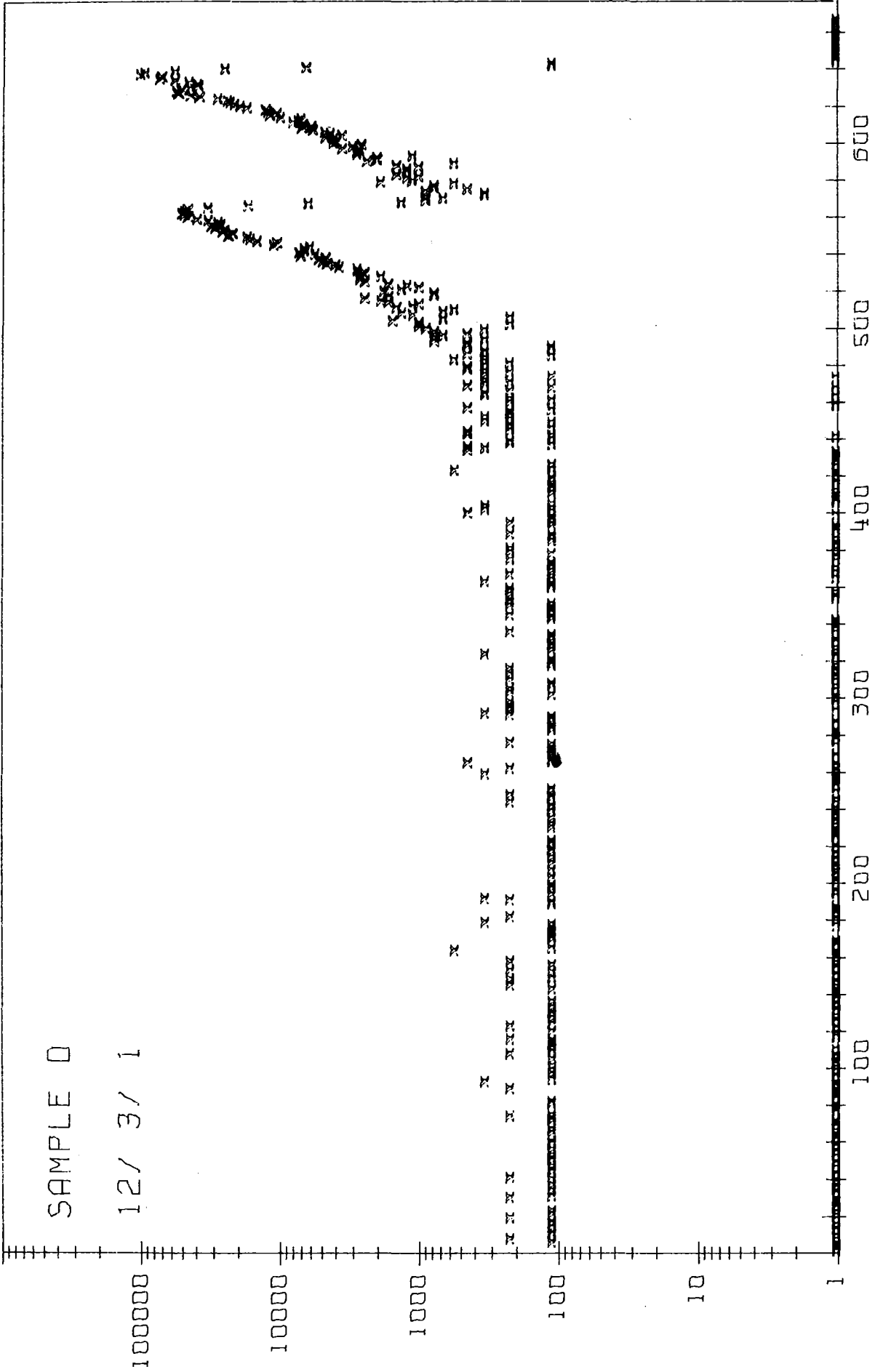
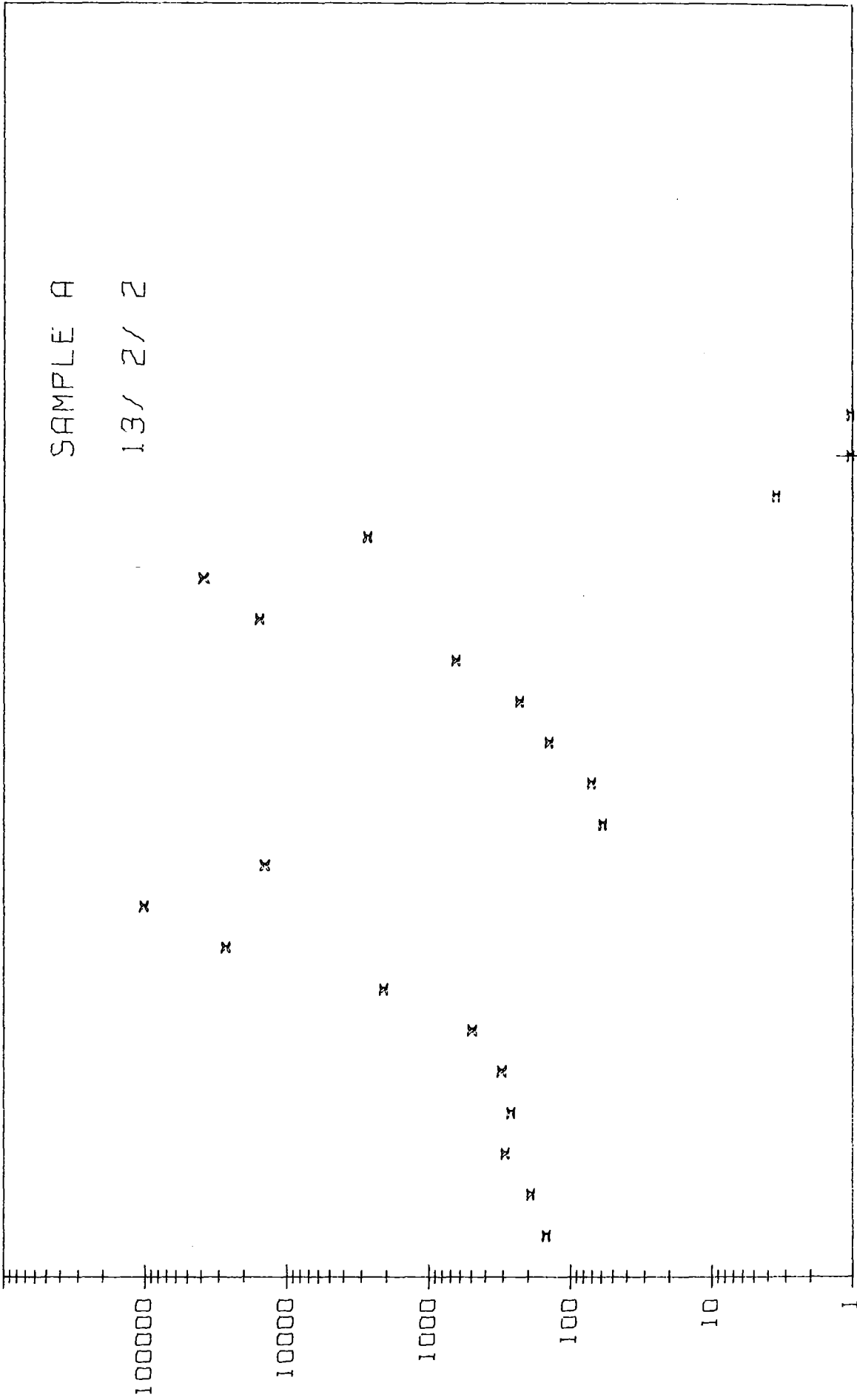


ABB. 01231 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER



ARB. 01322 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER

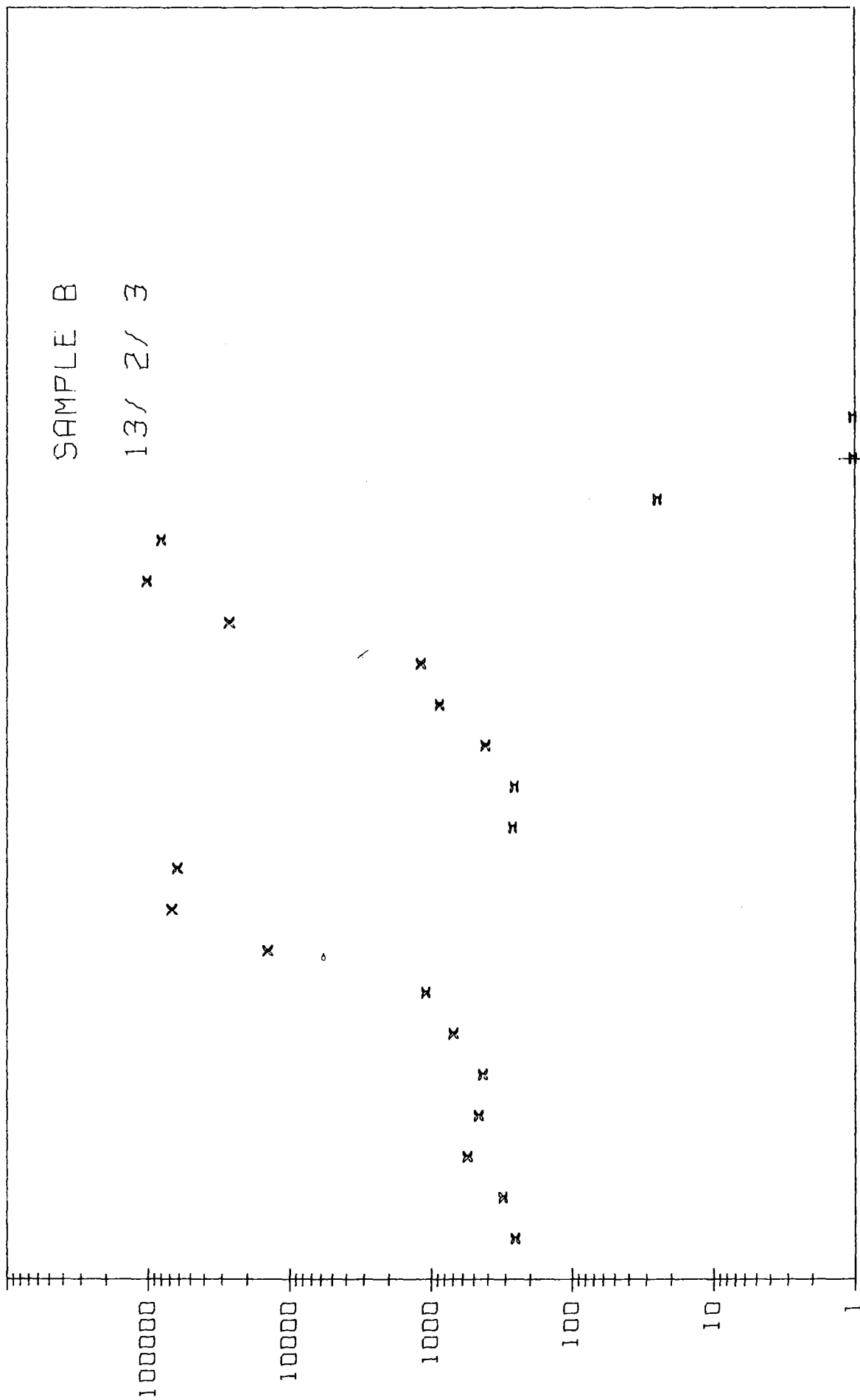


ABB. 01323 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER

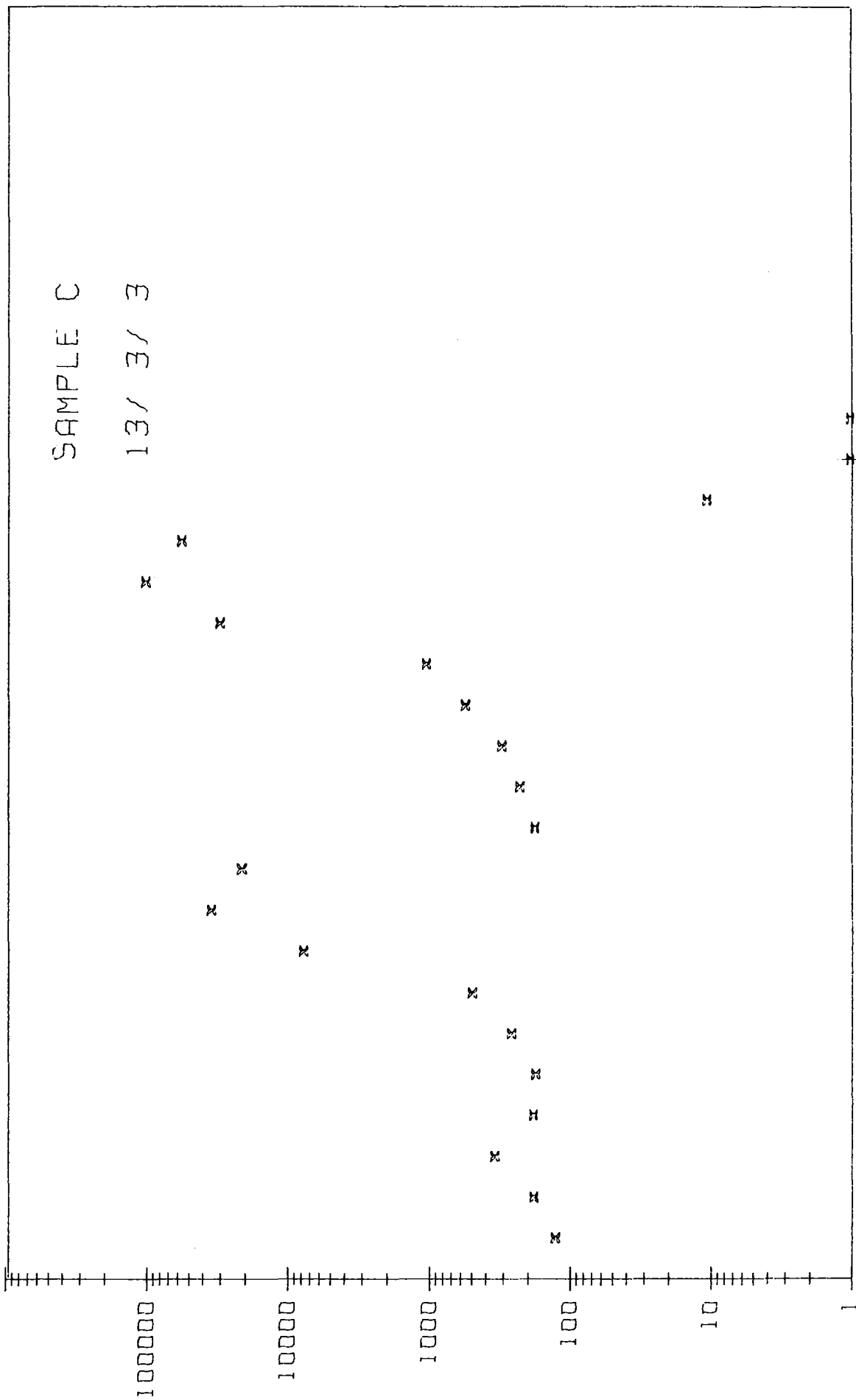


ABB 01333 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER

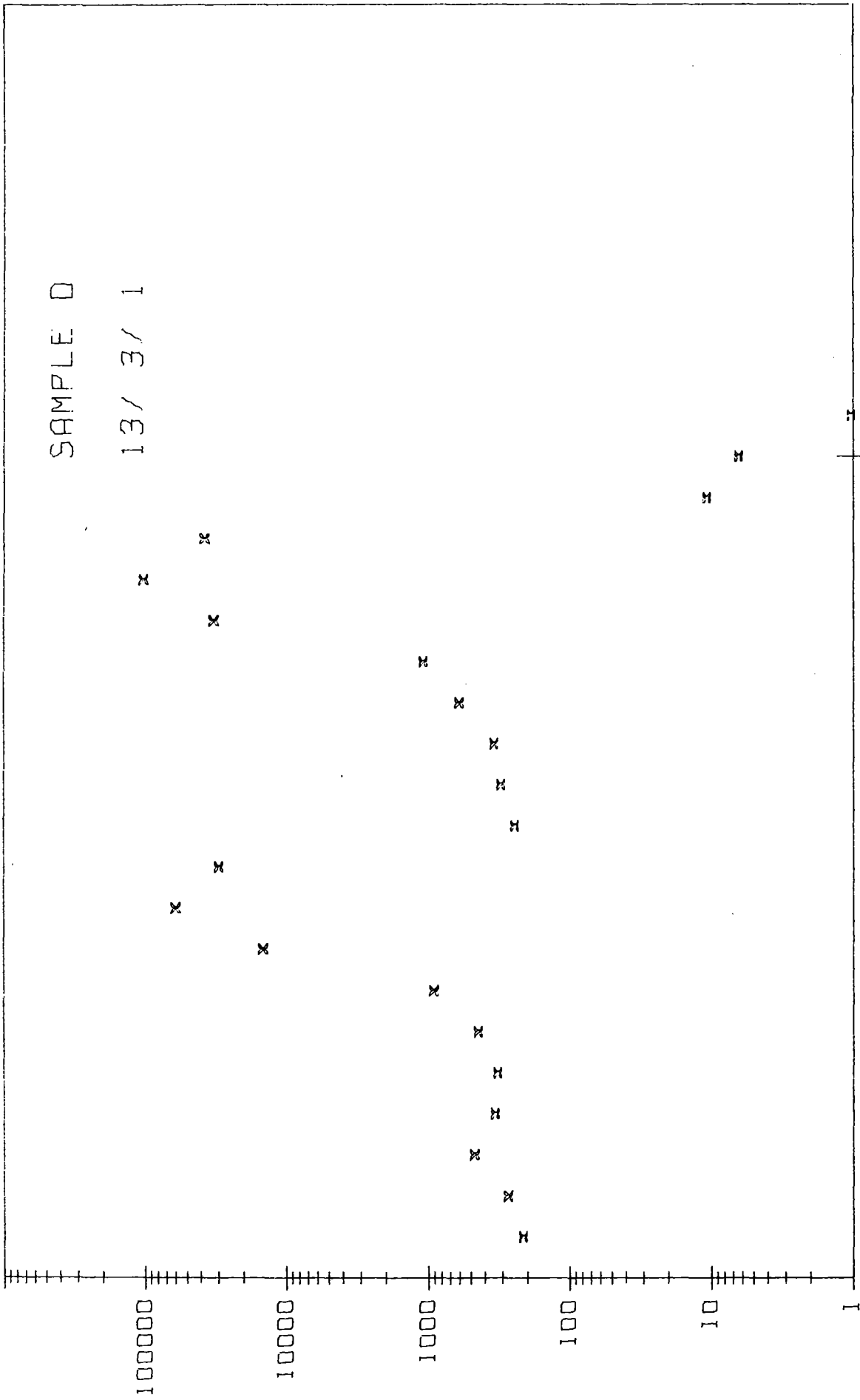


ABB.01531 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER

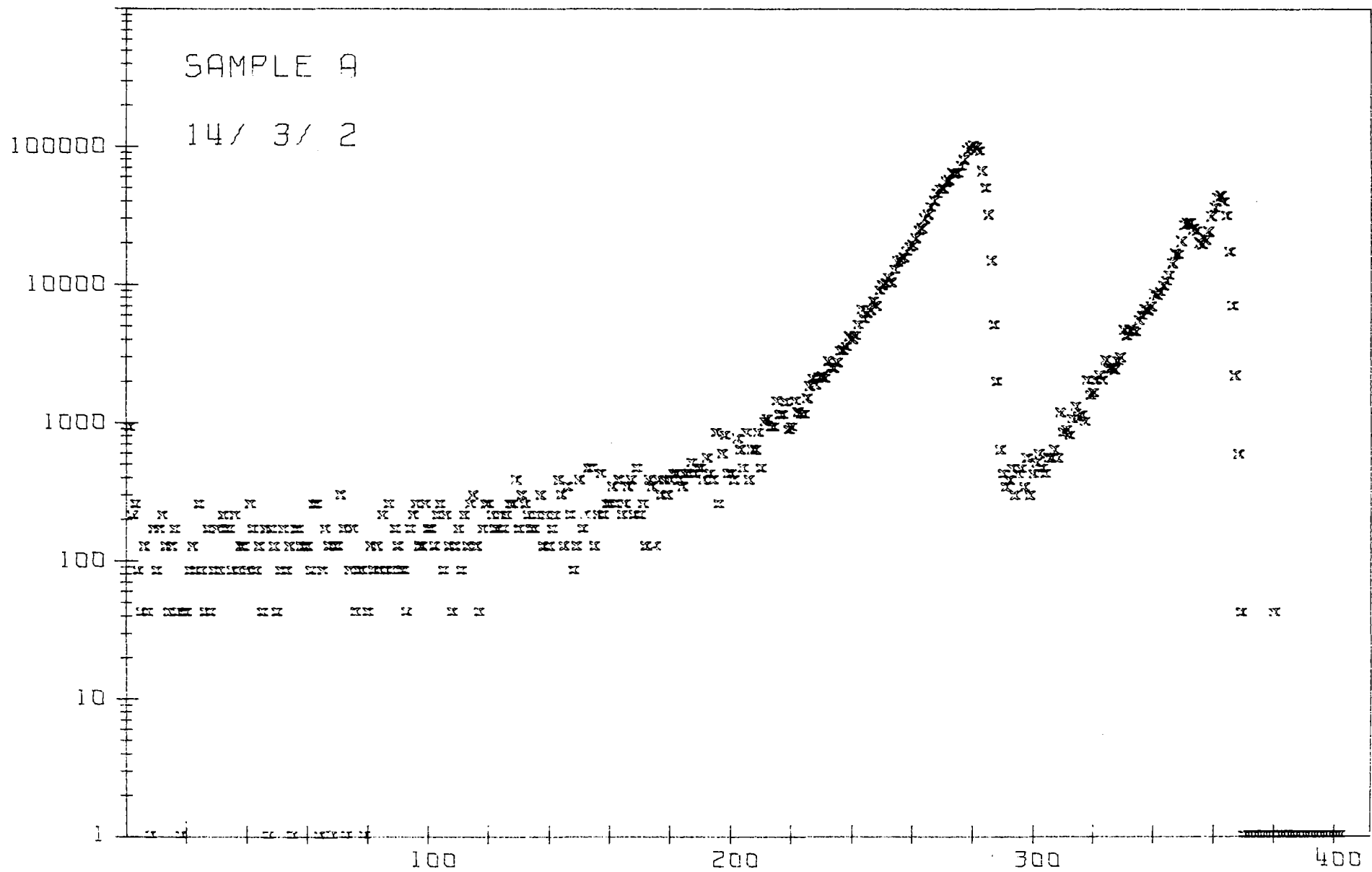


ABB.01432 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER

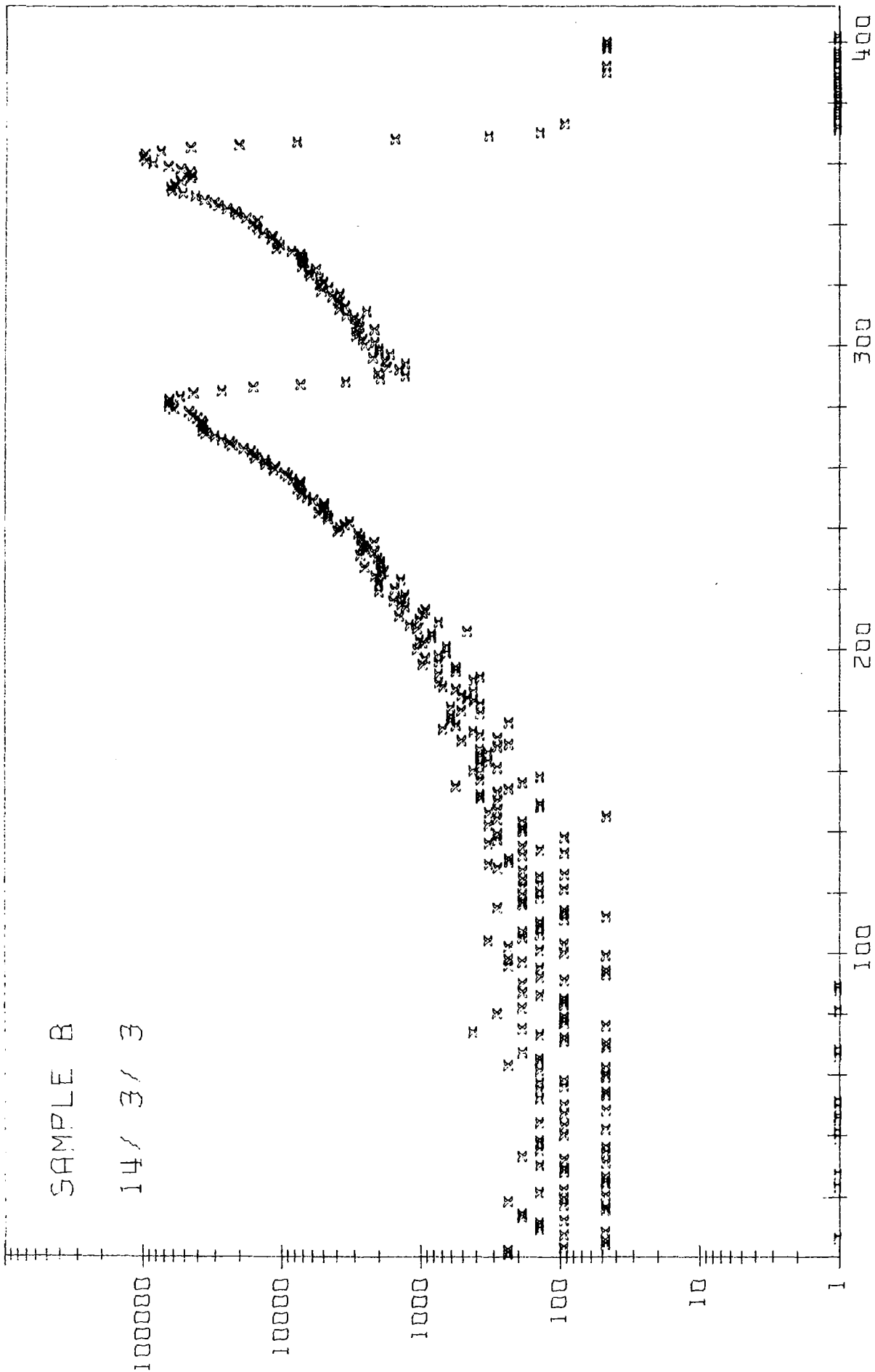


ABB. 01433 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER

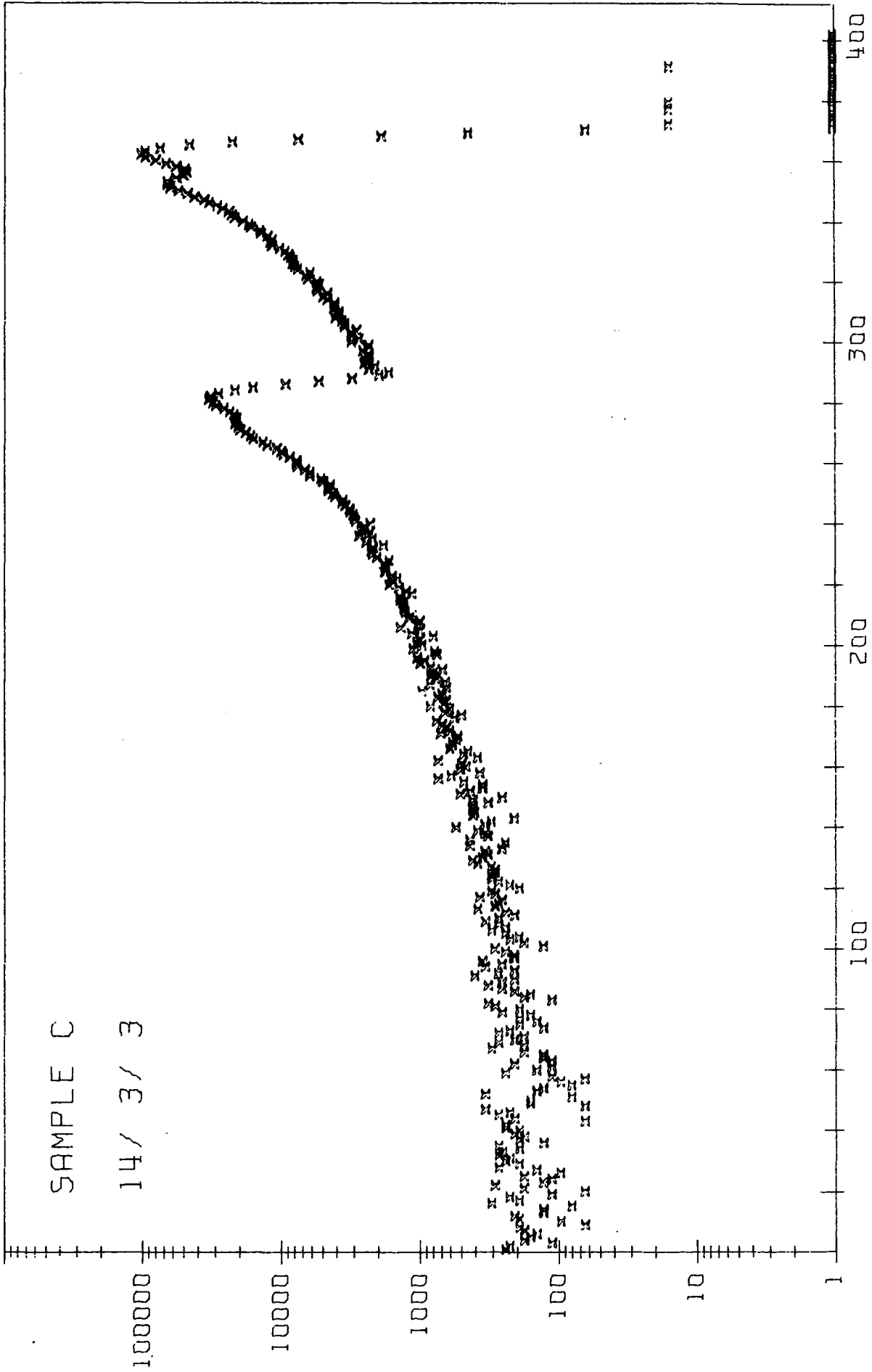
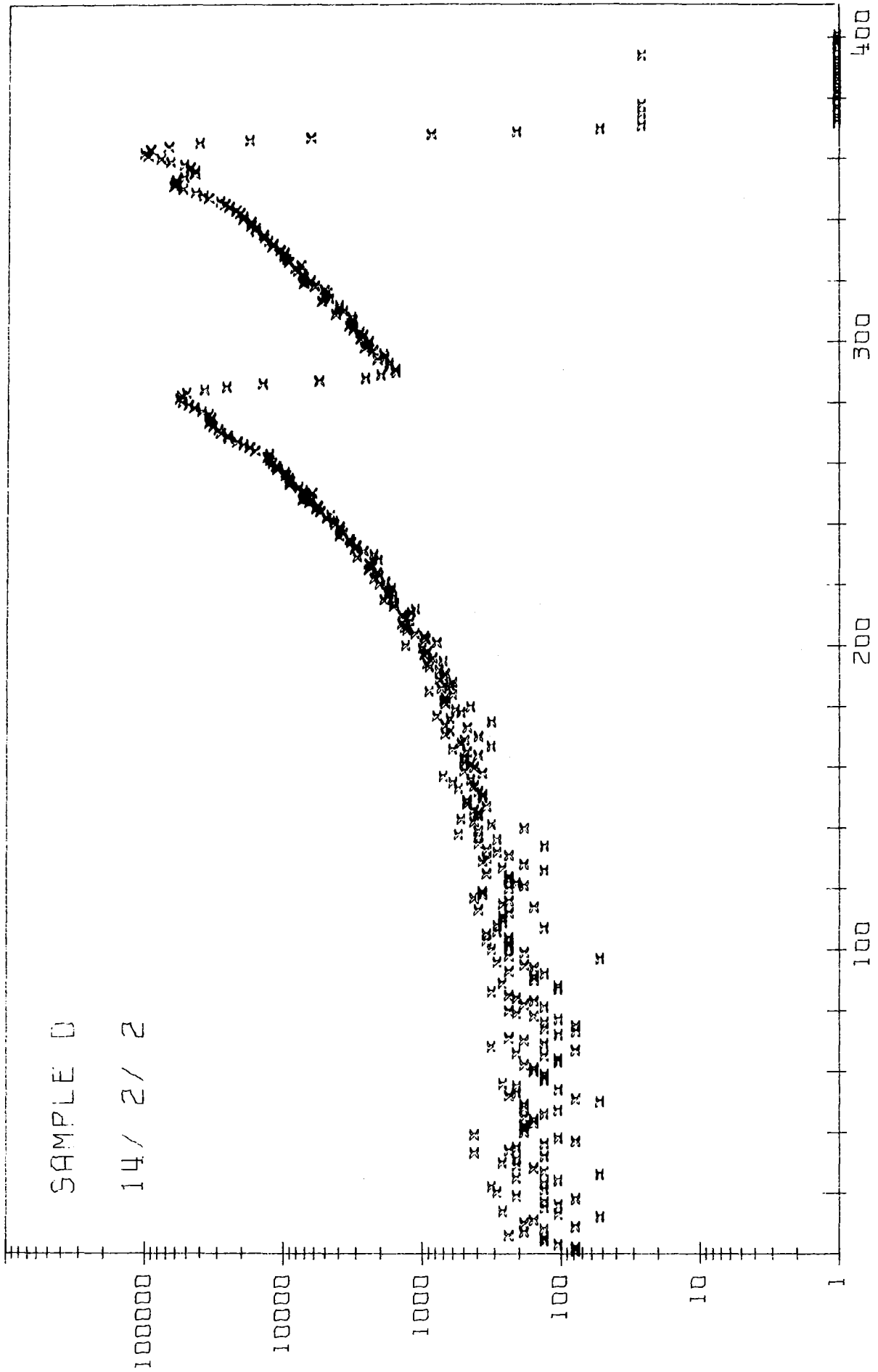


ABB.01433 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER



P 88.01422 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER

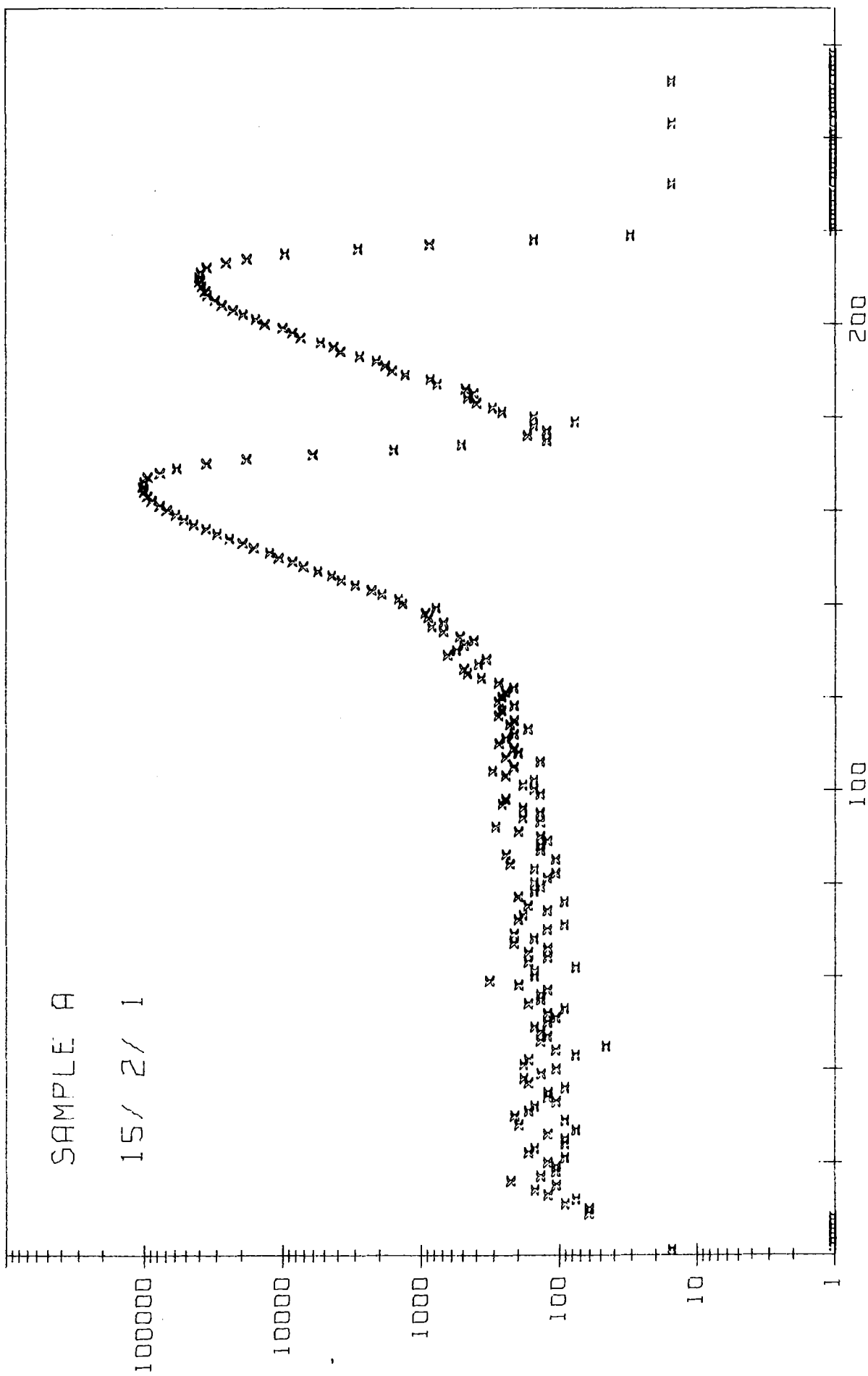


ABB.01521 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER

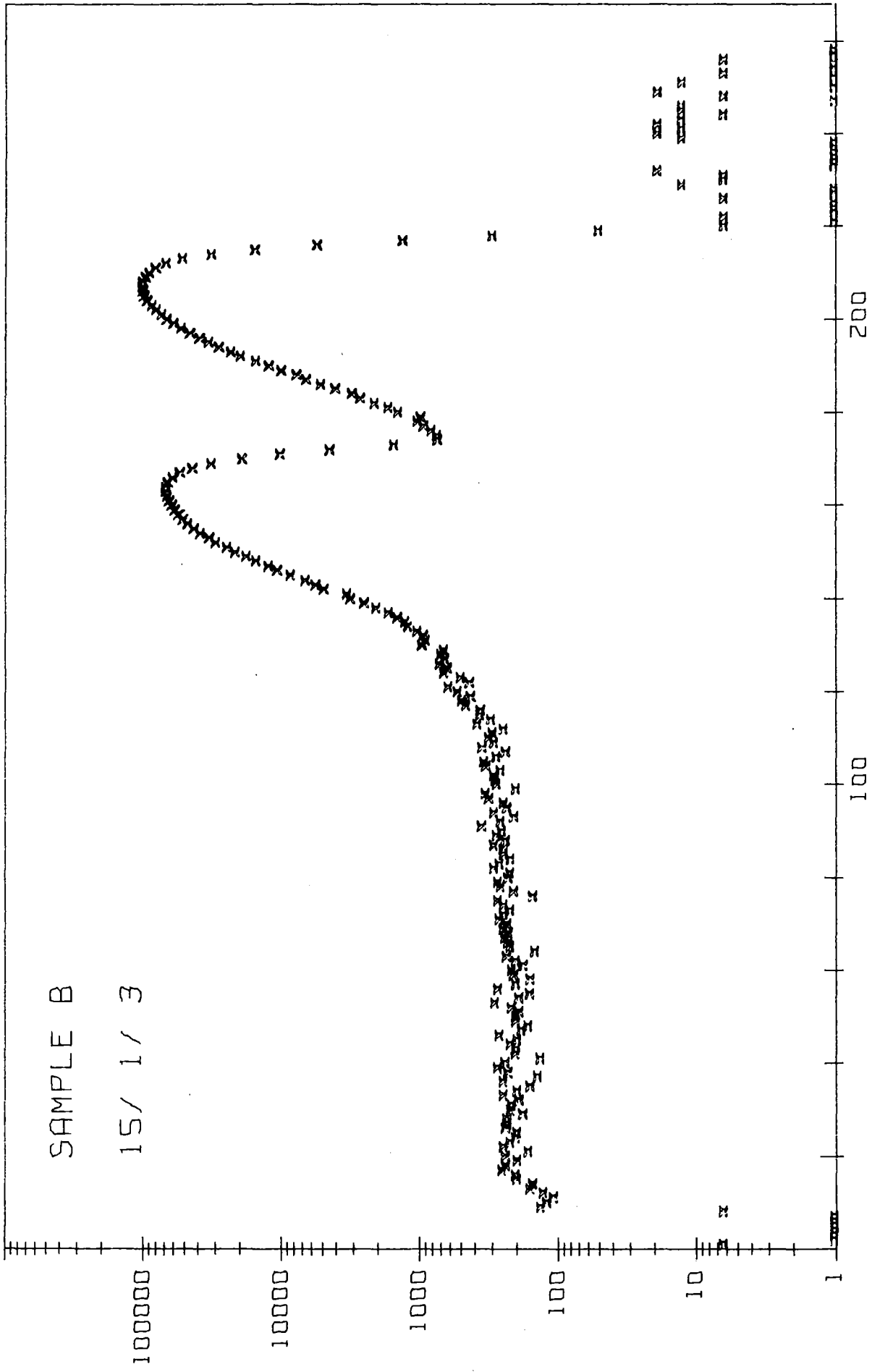
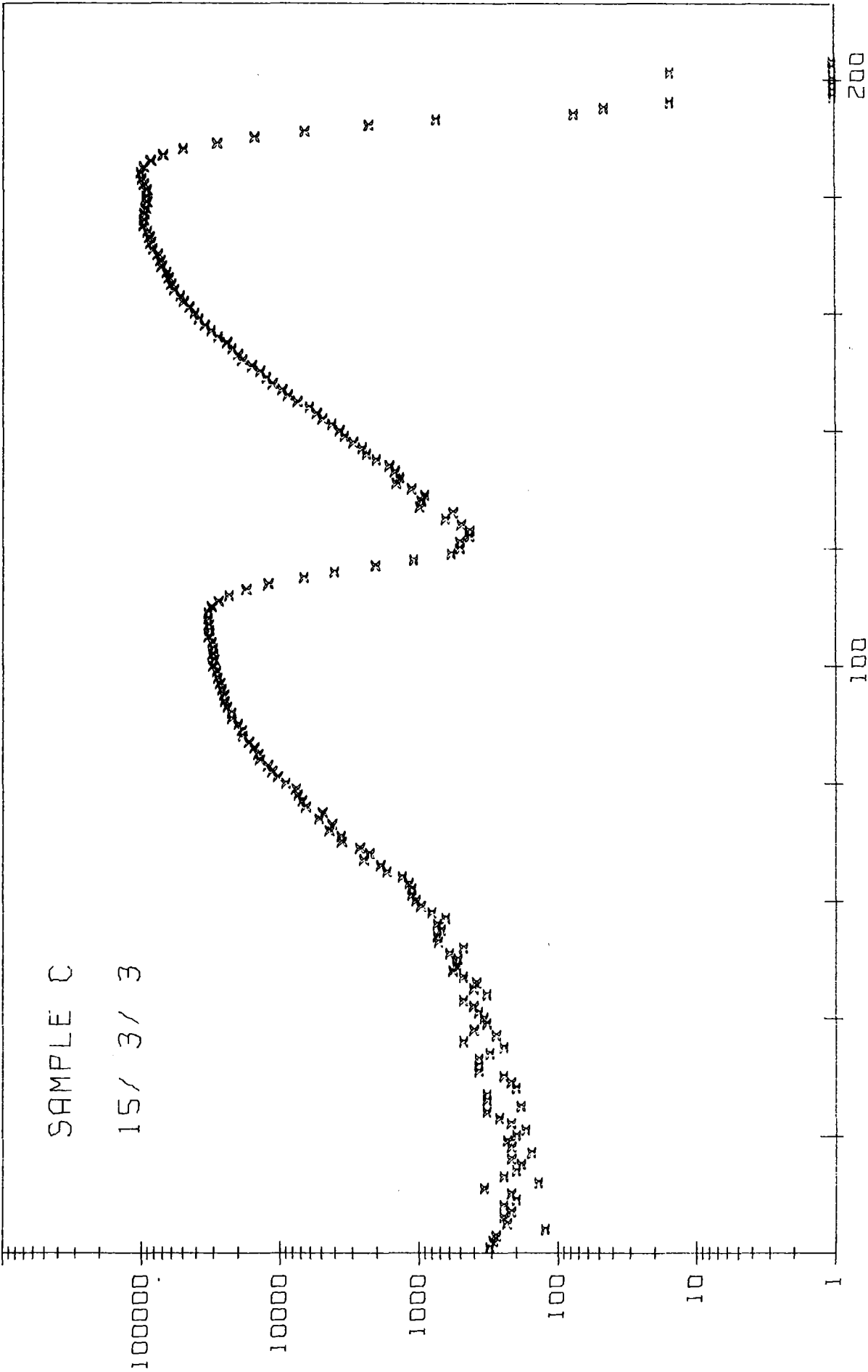


ABB. DISIS COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER



SAMPLE C
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ABB.01533 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER

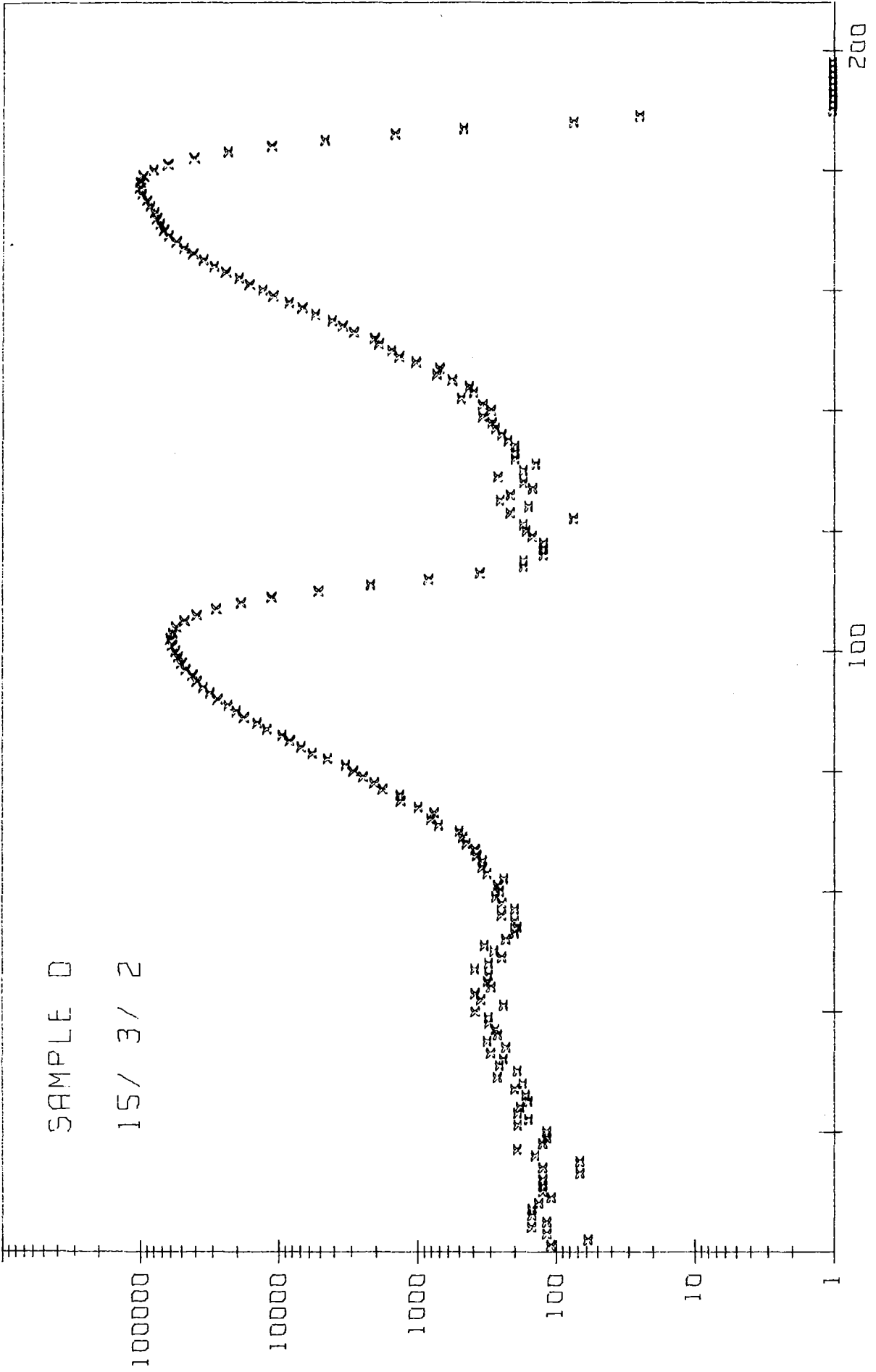
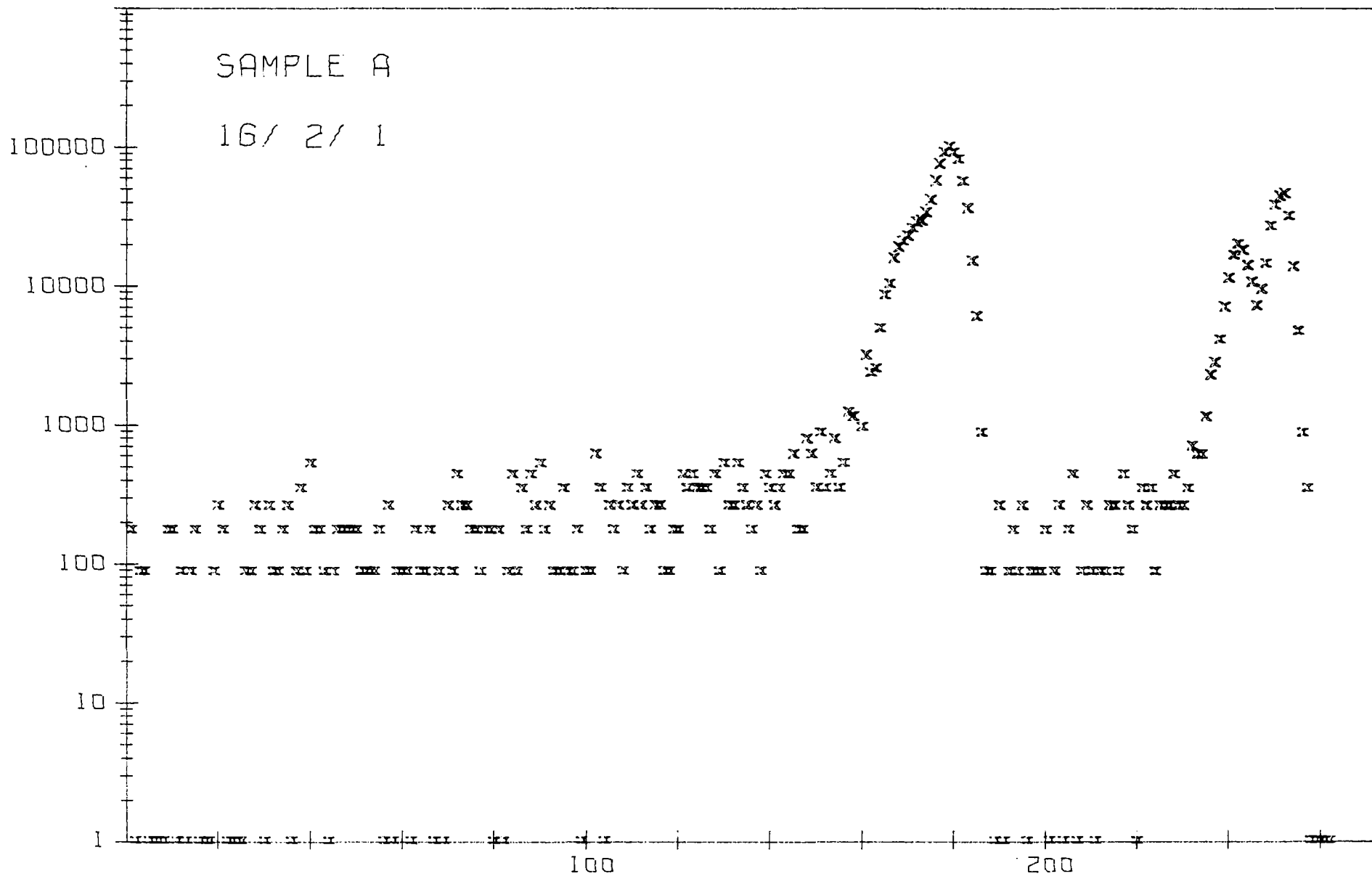


ABB.01532 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER



488.01621 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER

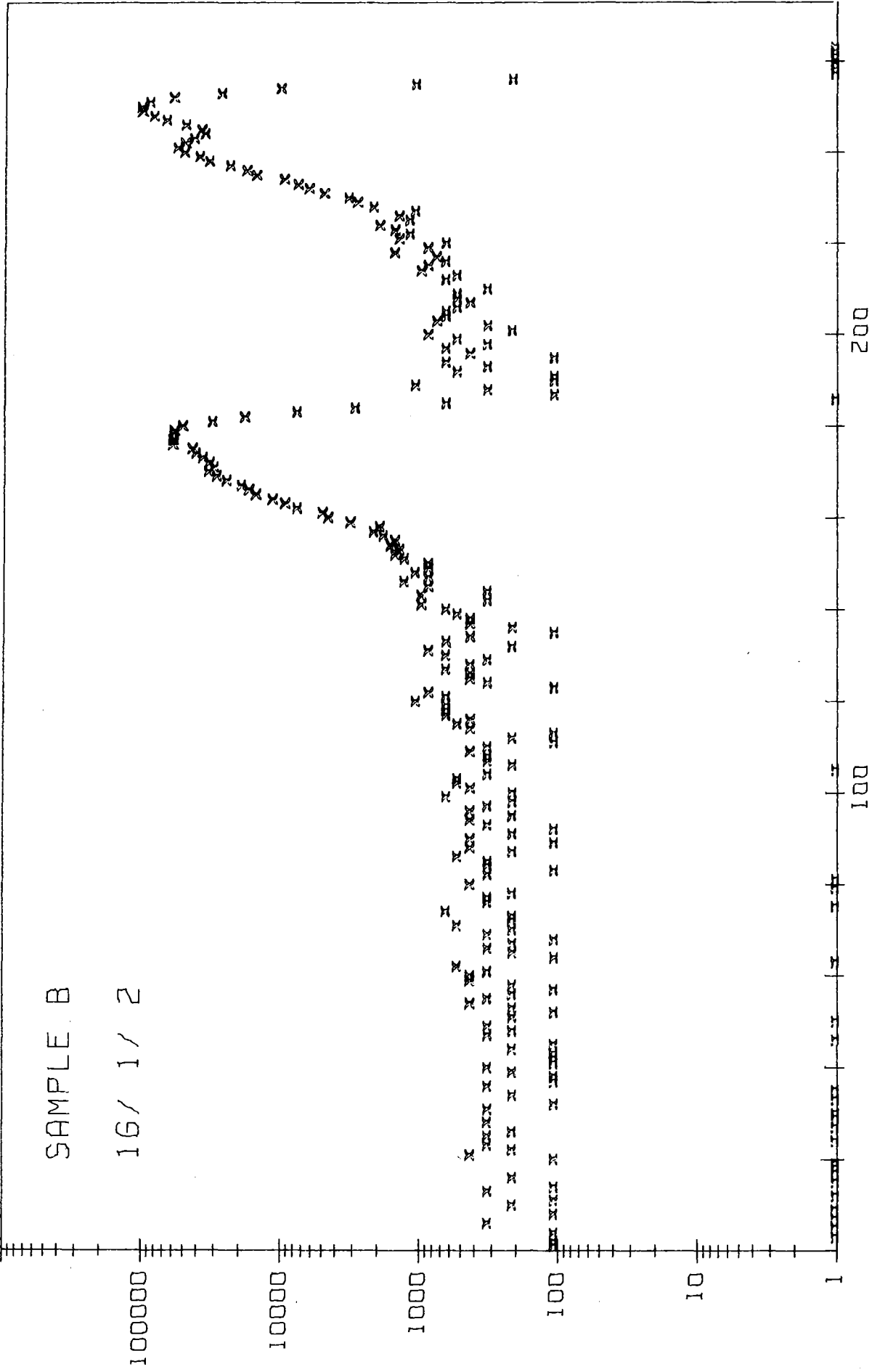


ABB.01612 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER

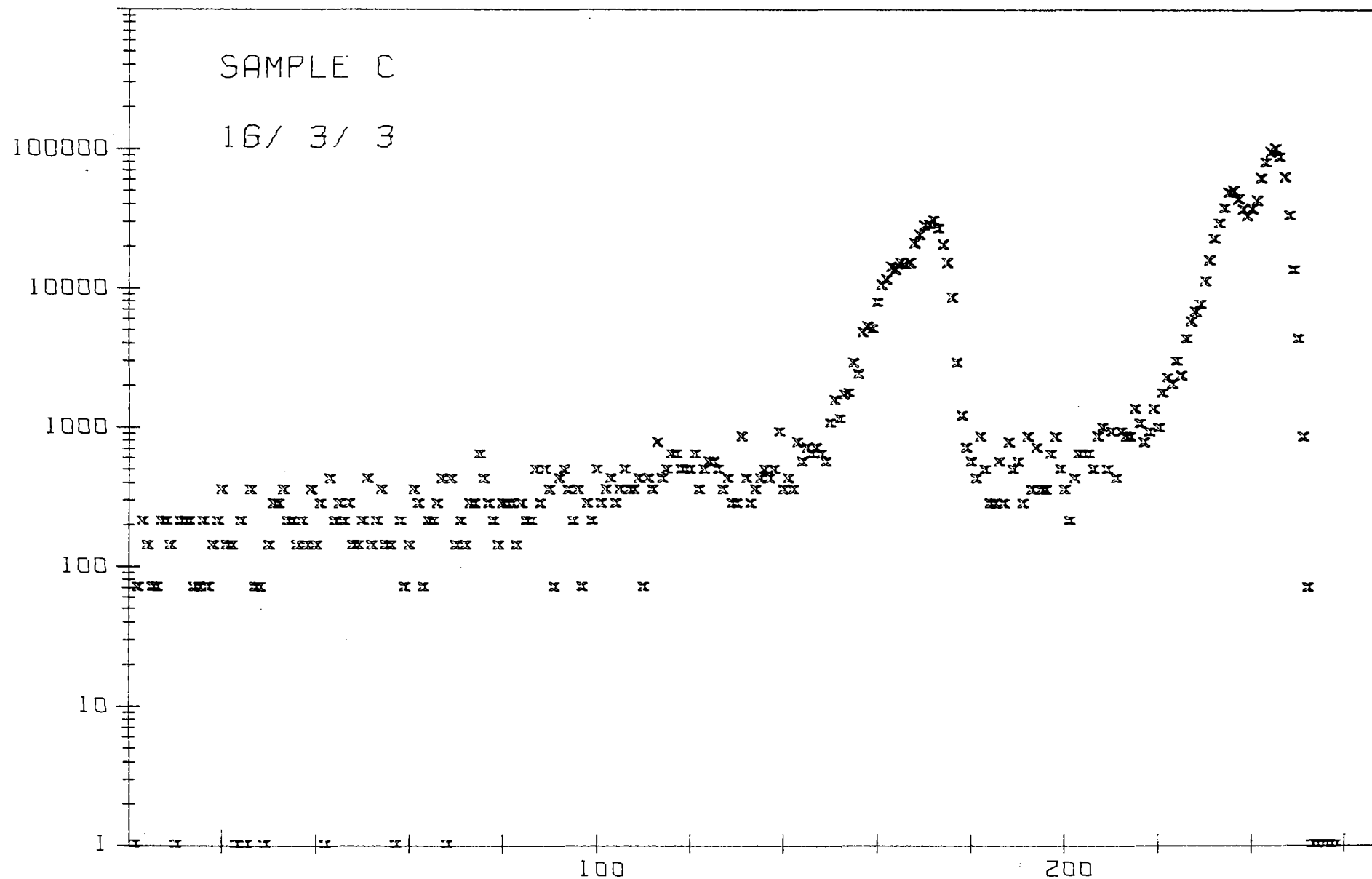


ABB. 01633 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER.

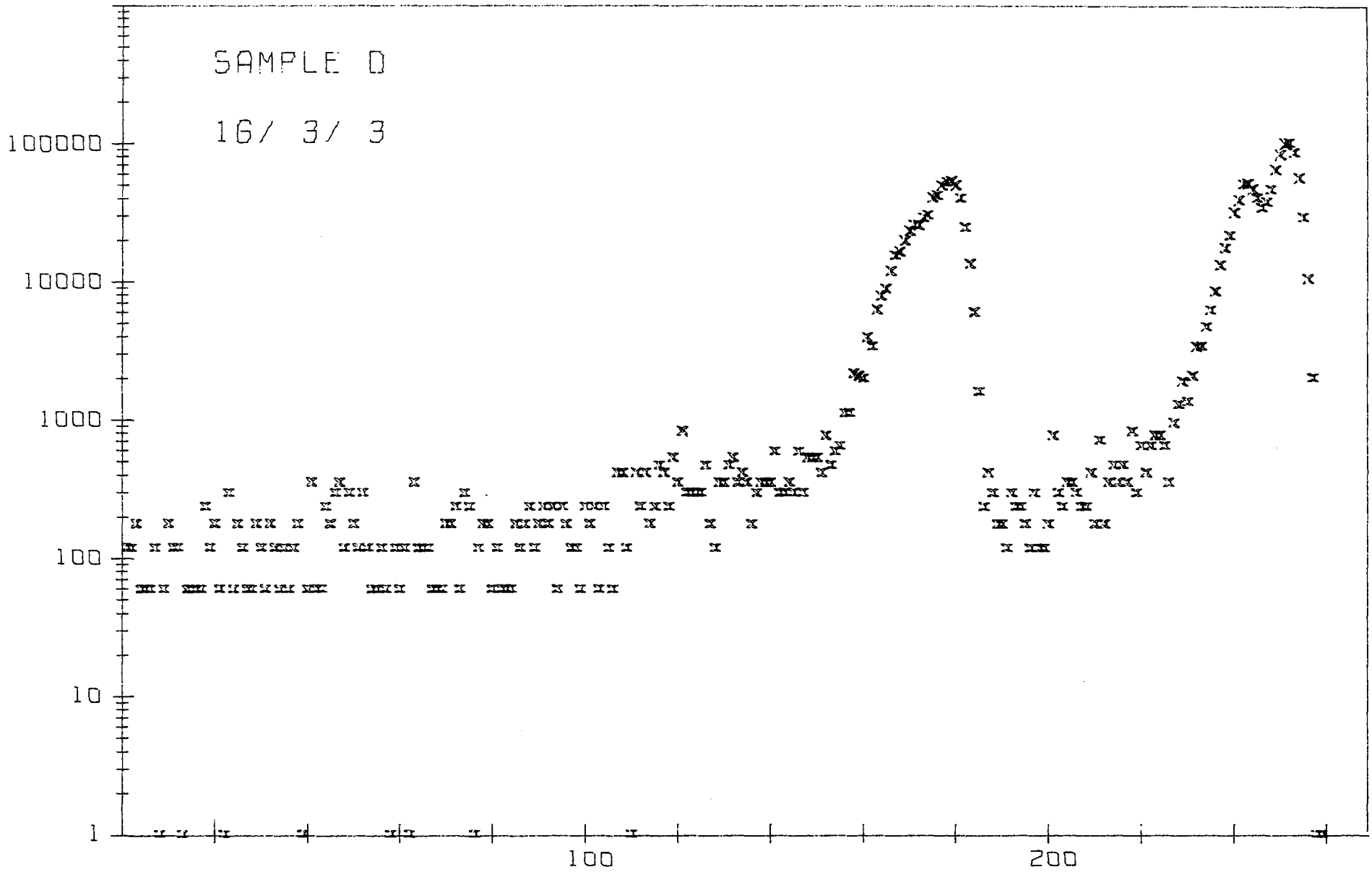
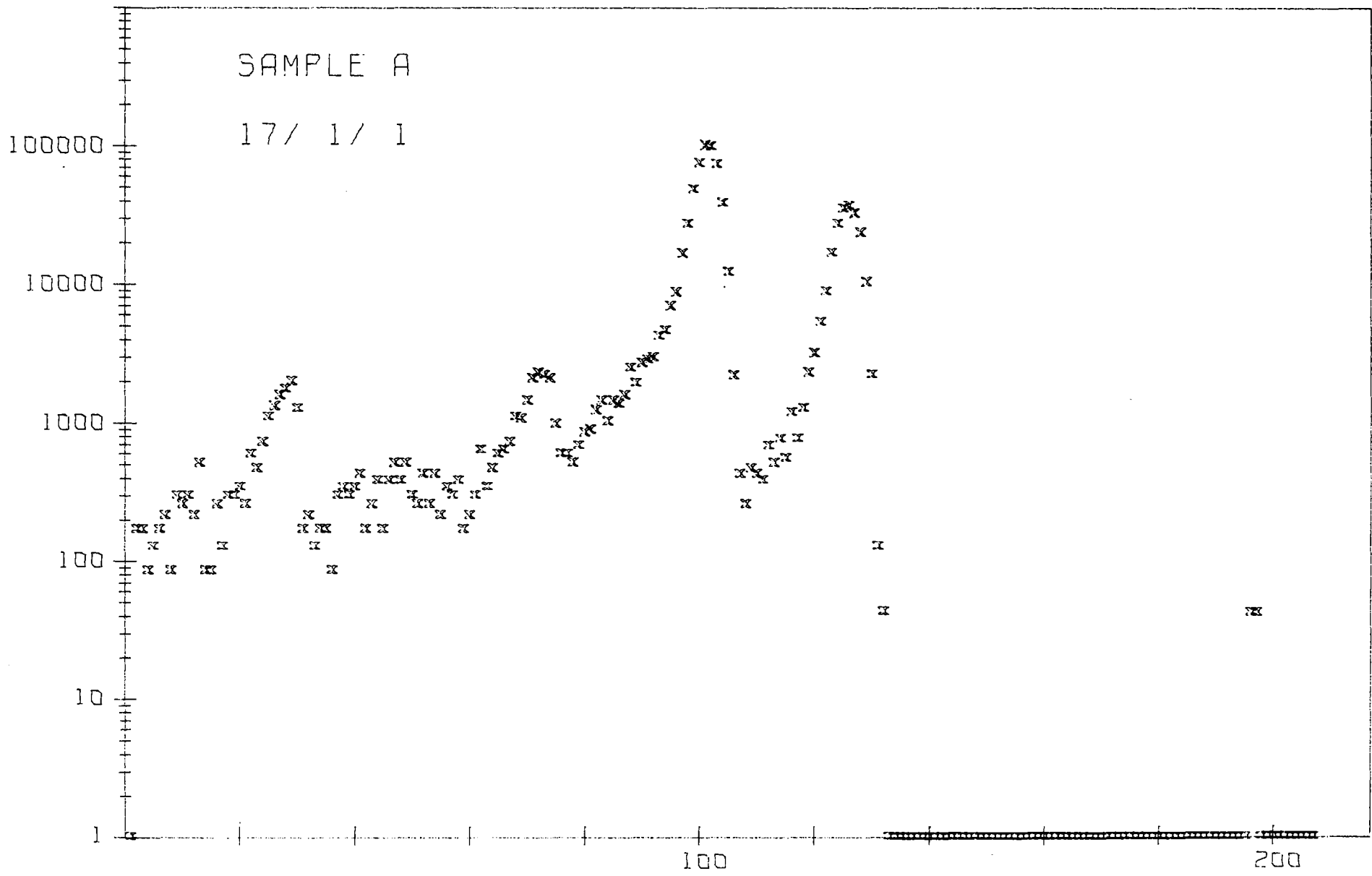


ABB.01633 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER



488 01711 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER

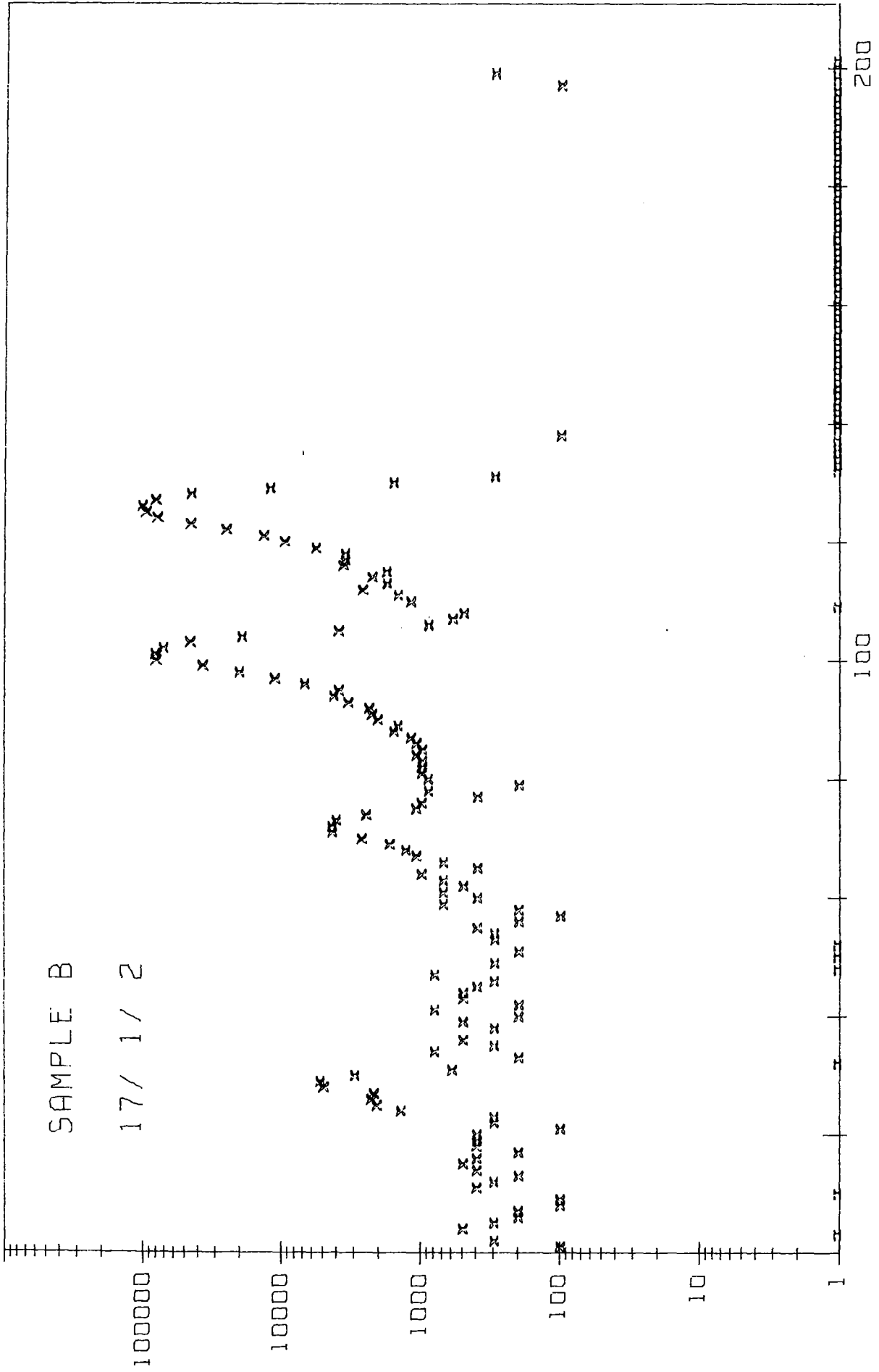
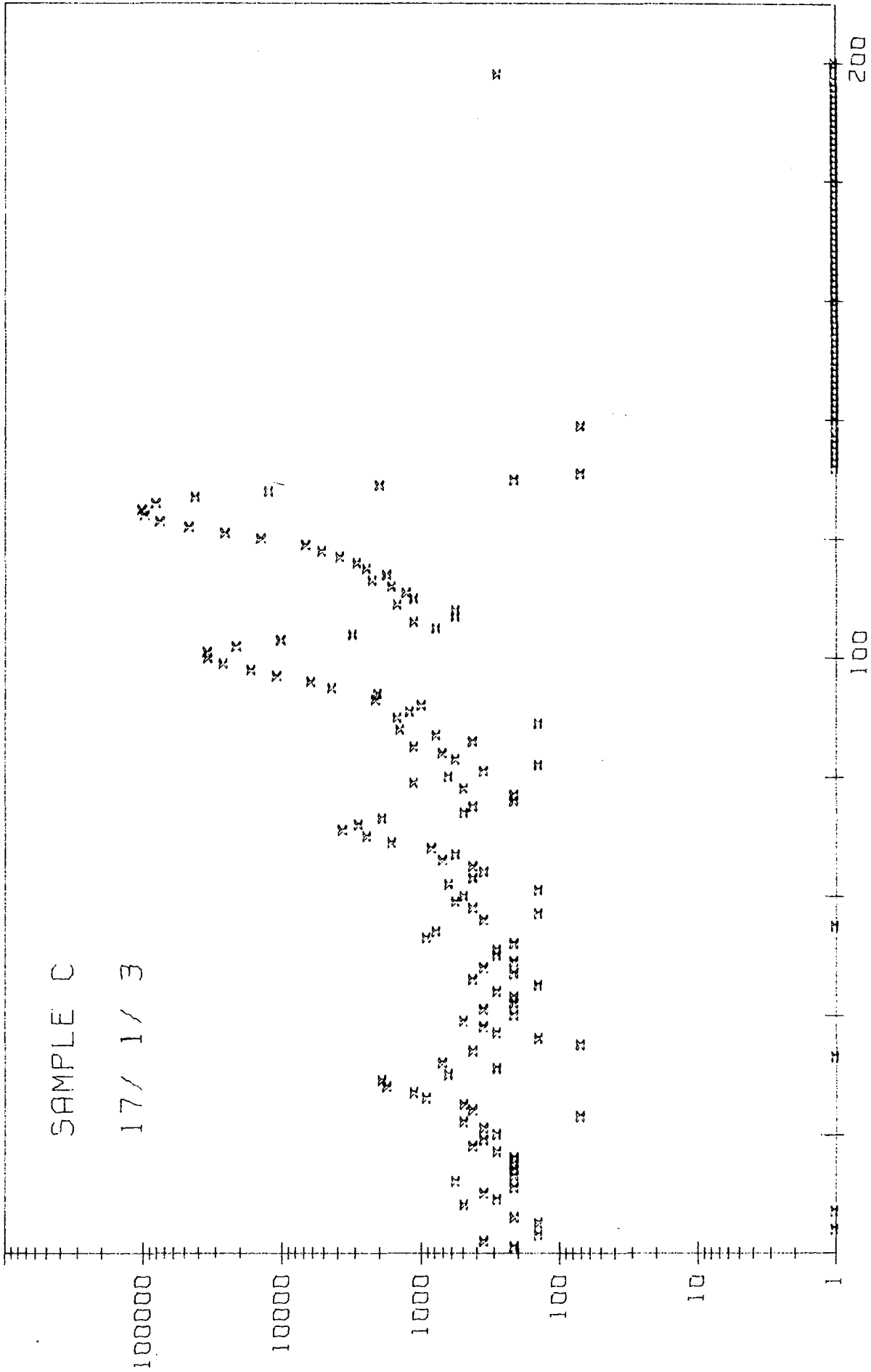


ABB. 01712 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER



SAMPLE C

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ARR 01713 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER

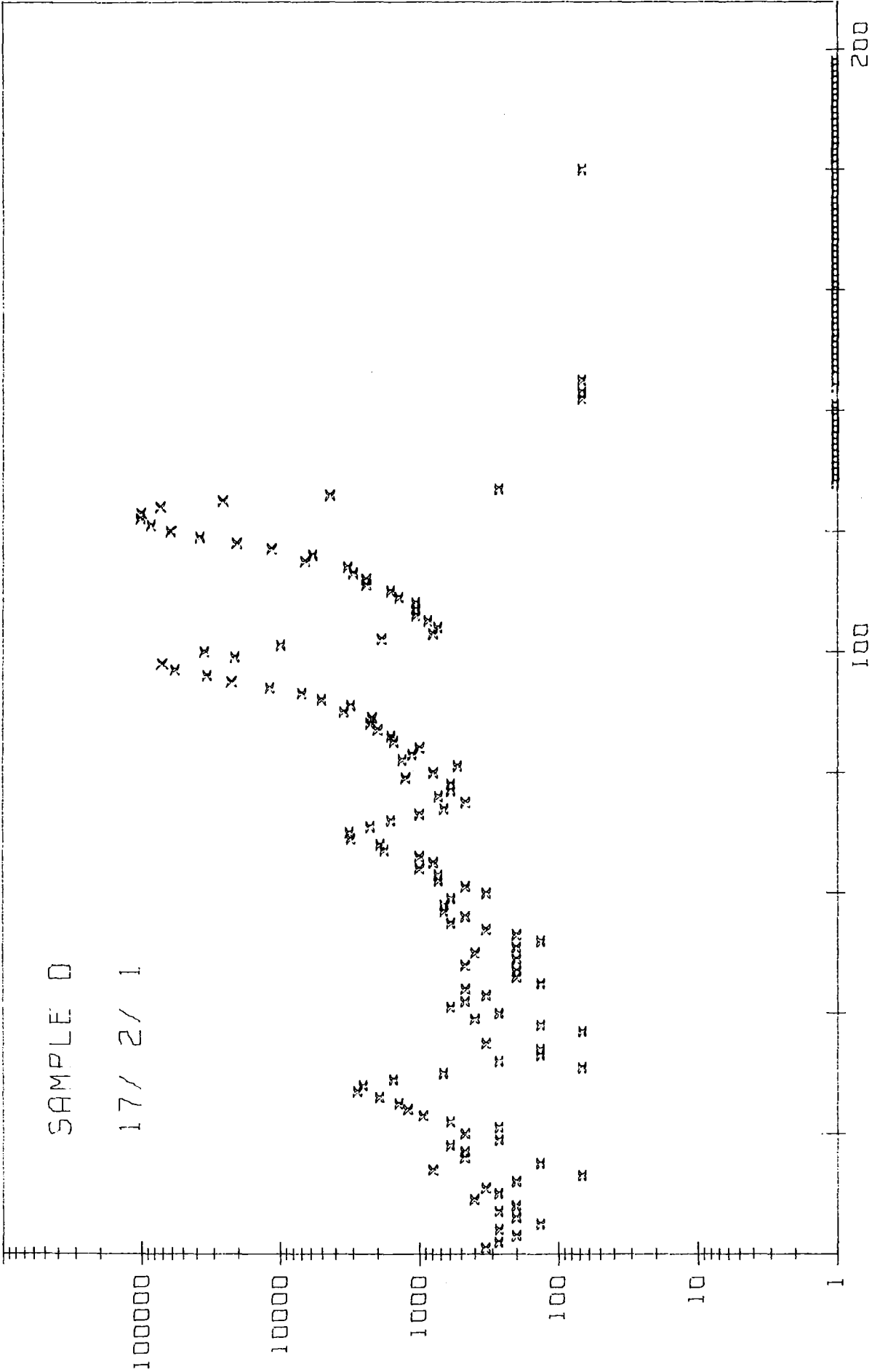


ABB. 01721 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER

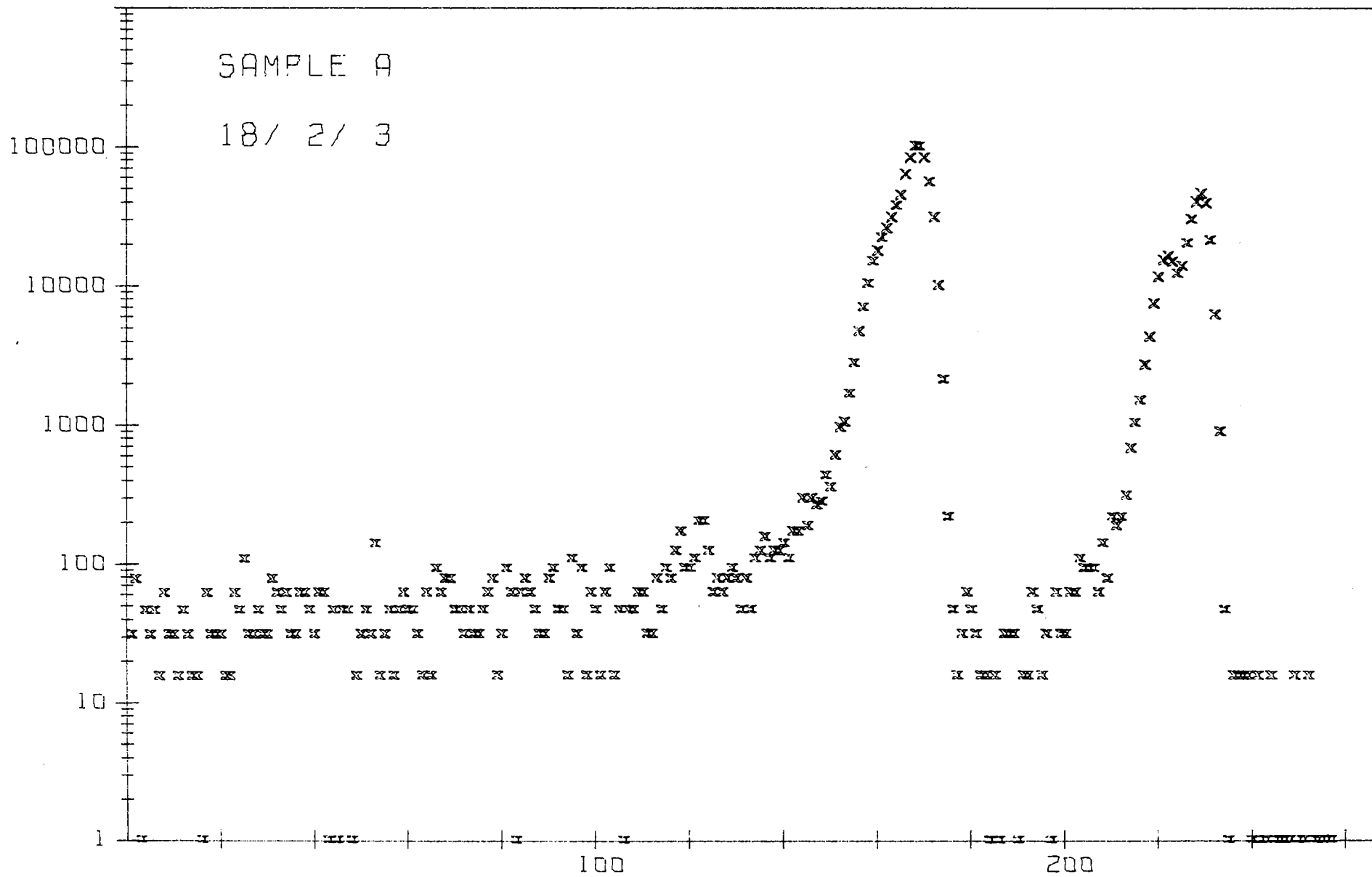


ABB 01823 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER

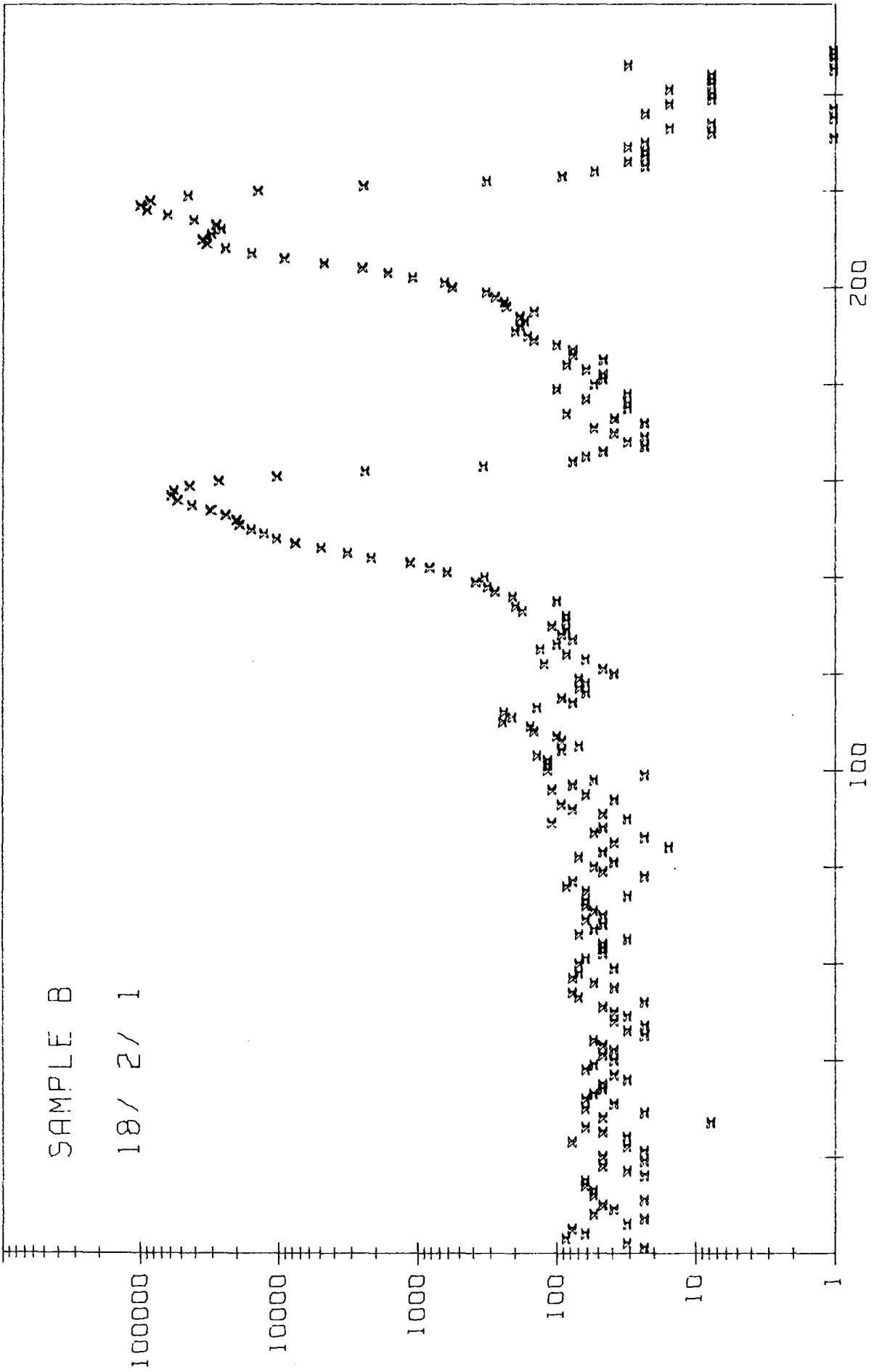
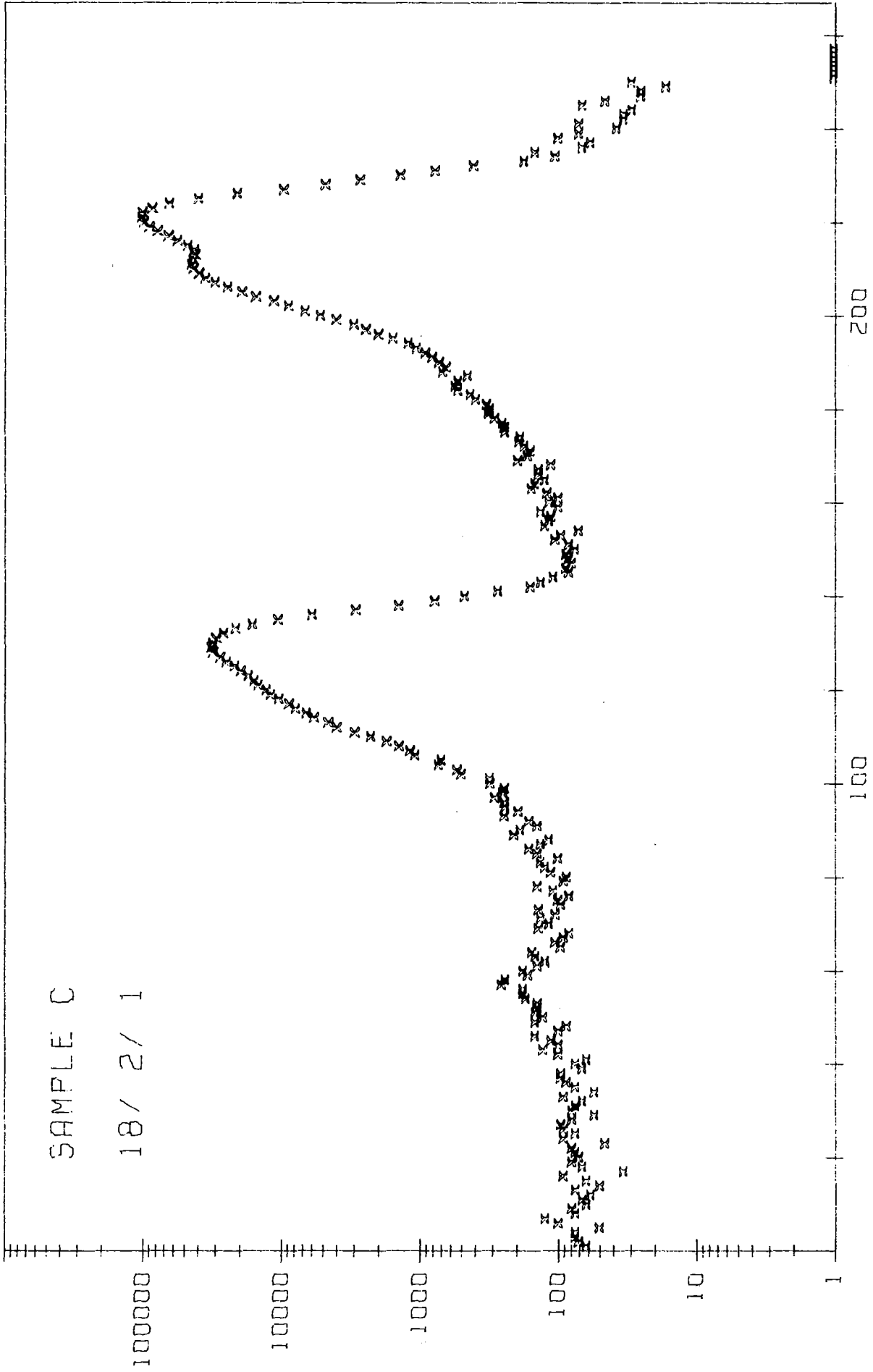


ABB.01821 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER



ARB. 01521 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER

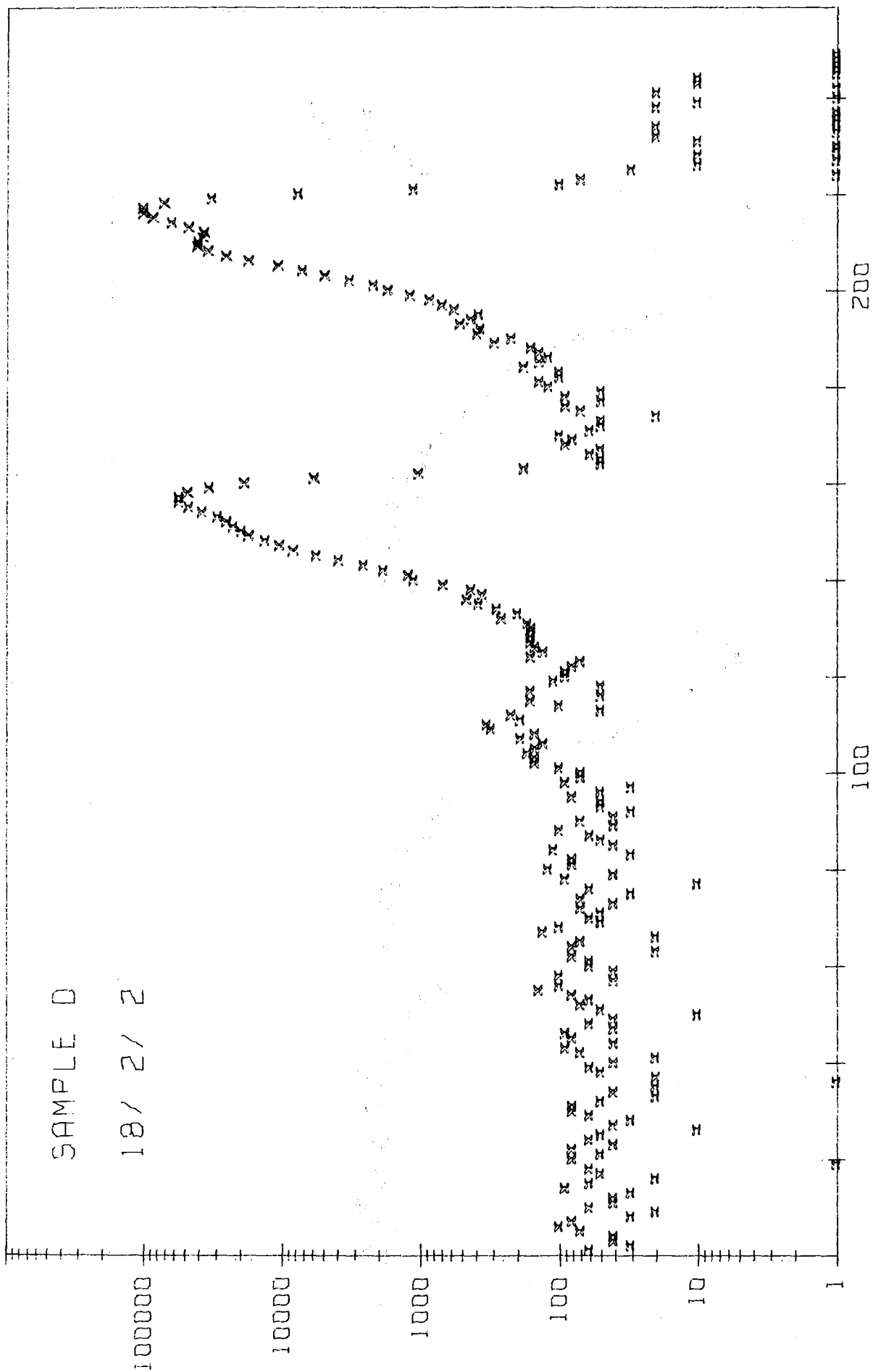
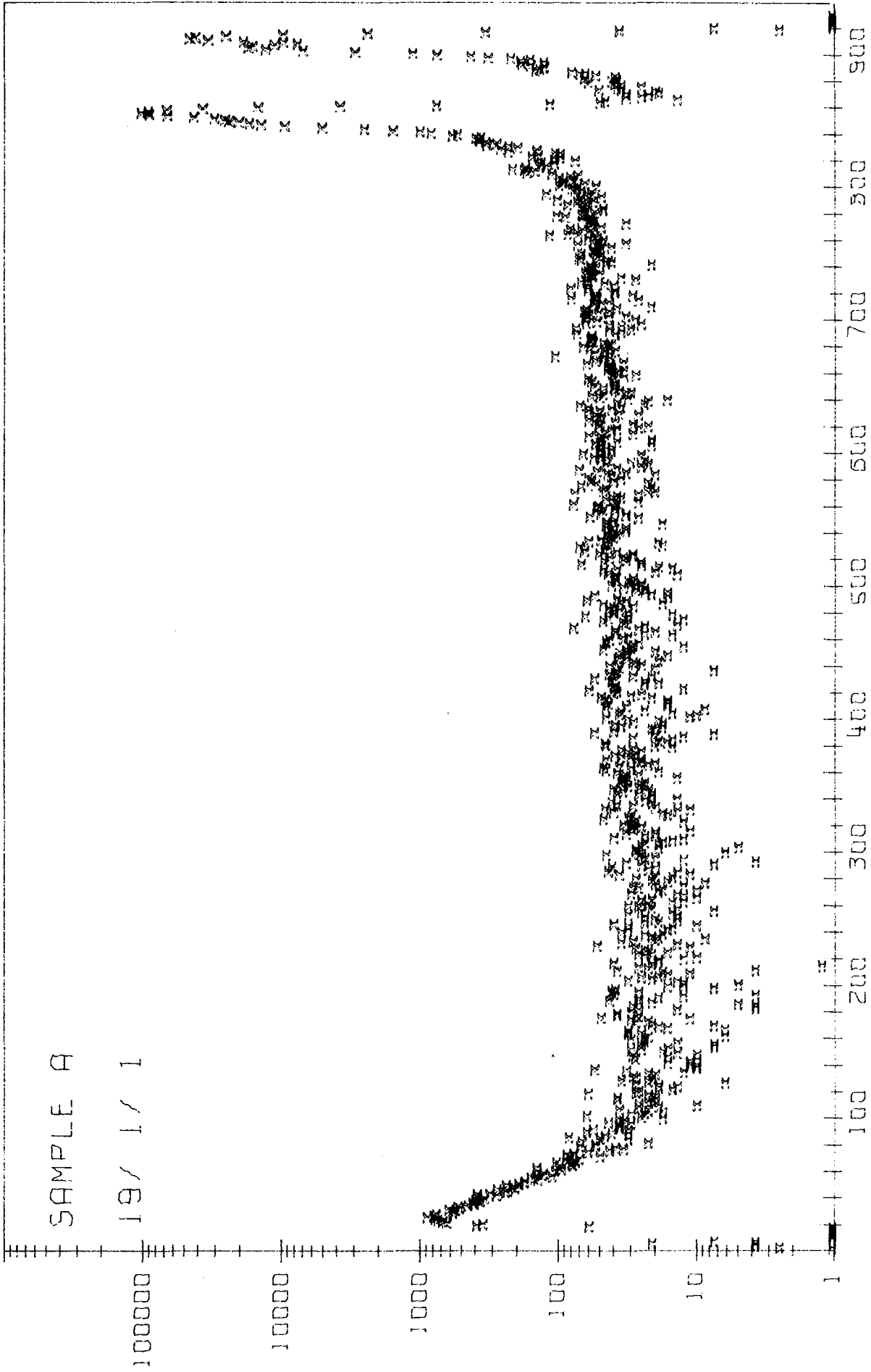


ABB. 01022 COUNTS PER CHANNEL INORMALIZED VERSUS CHANNEL NUMBER



ASB 01911 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER

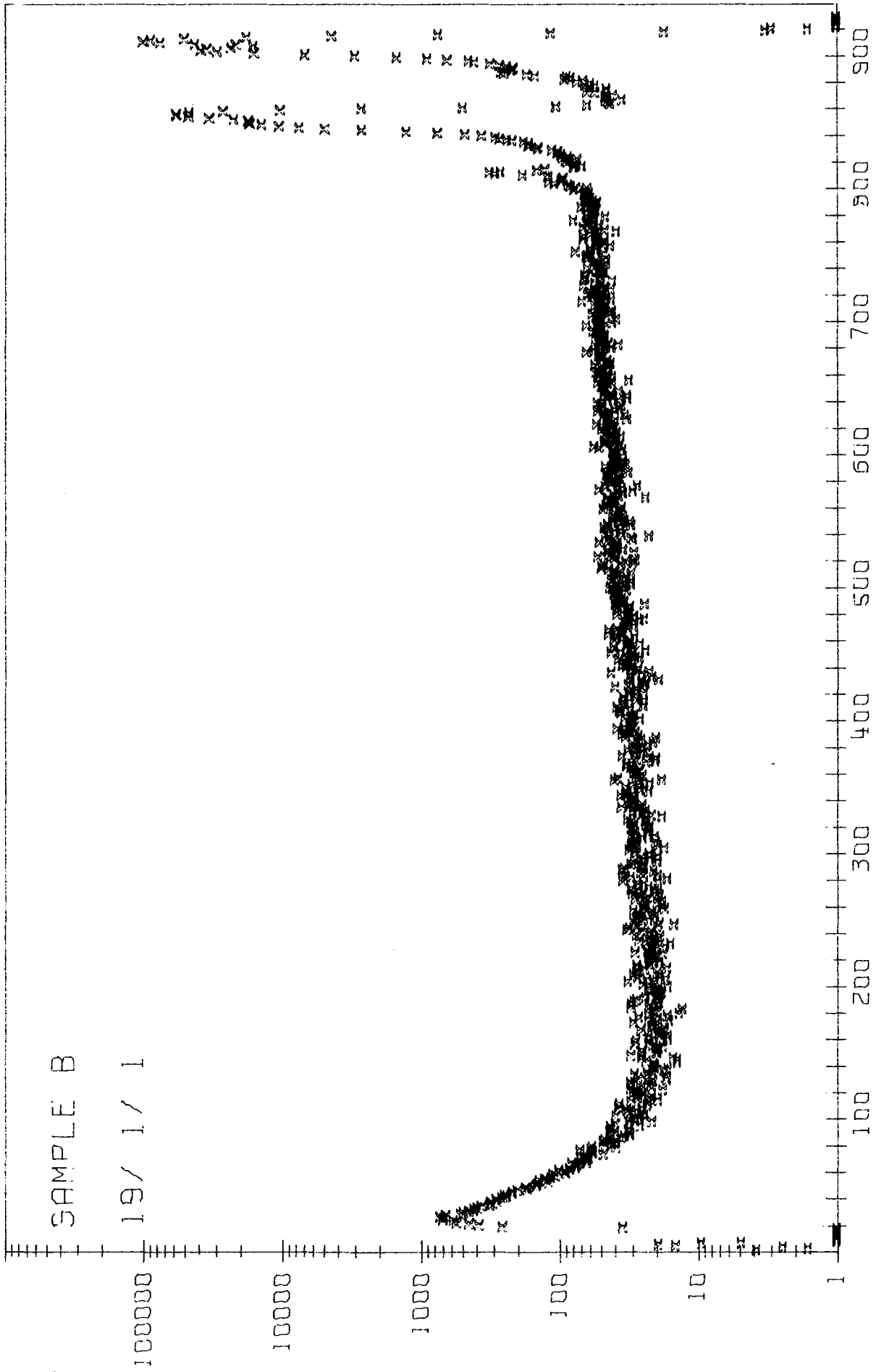
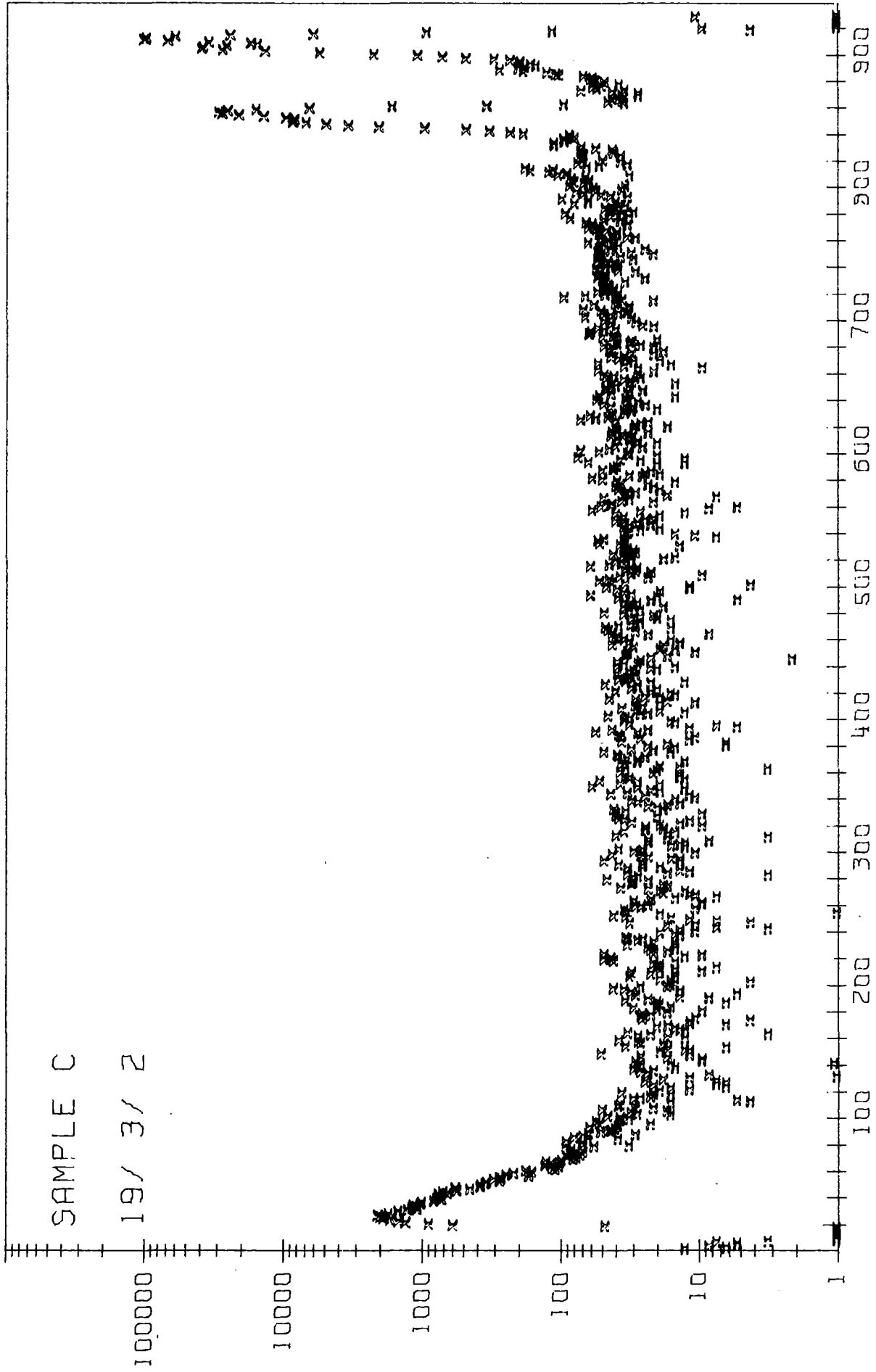


ABB. 01911 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER



SAMPLE C

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688.01932 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER

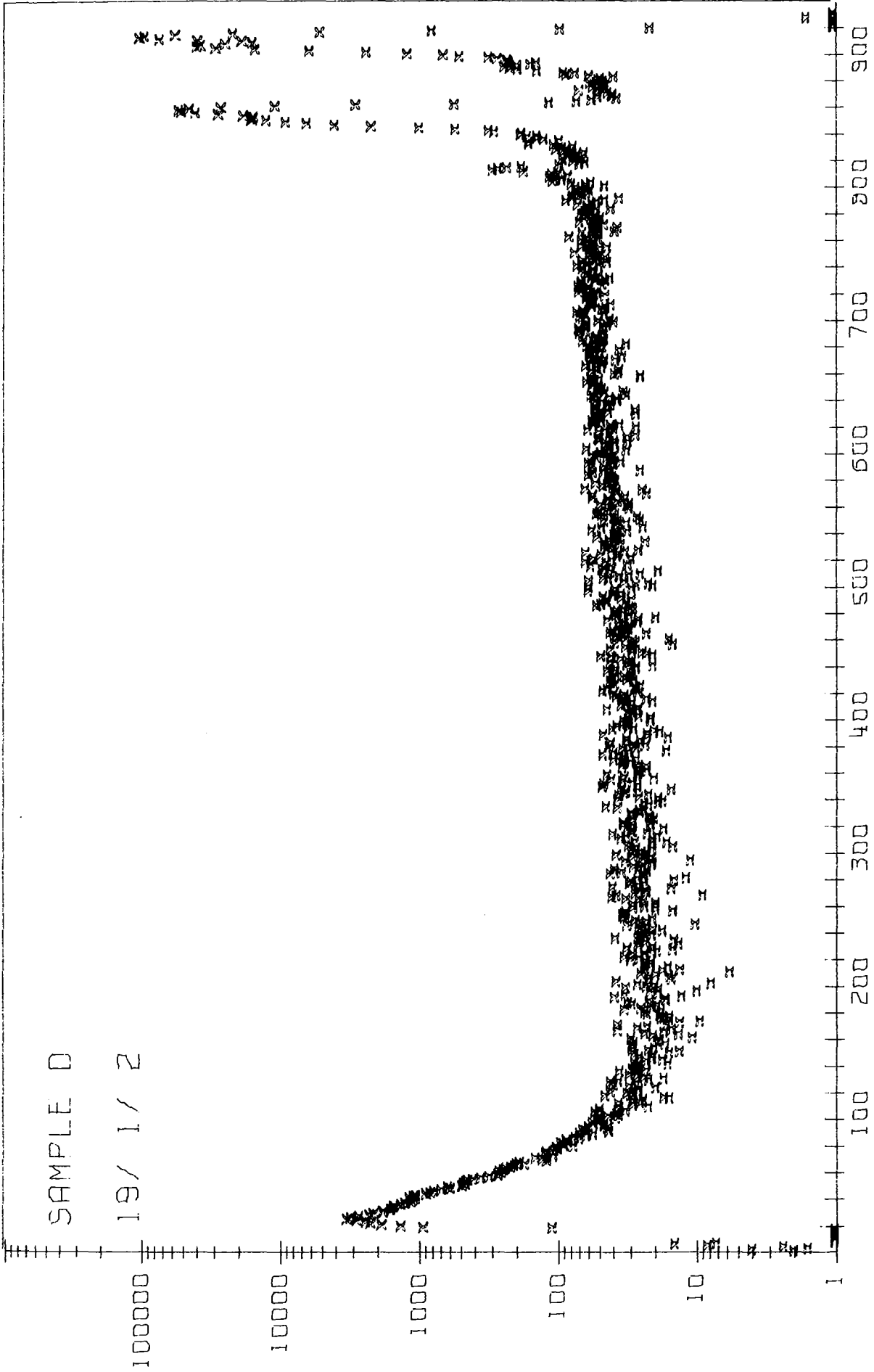


ABB. 01912 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER

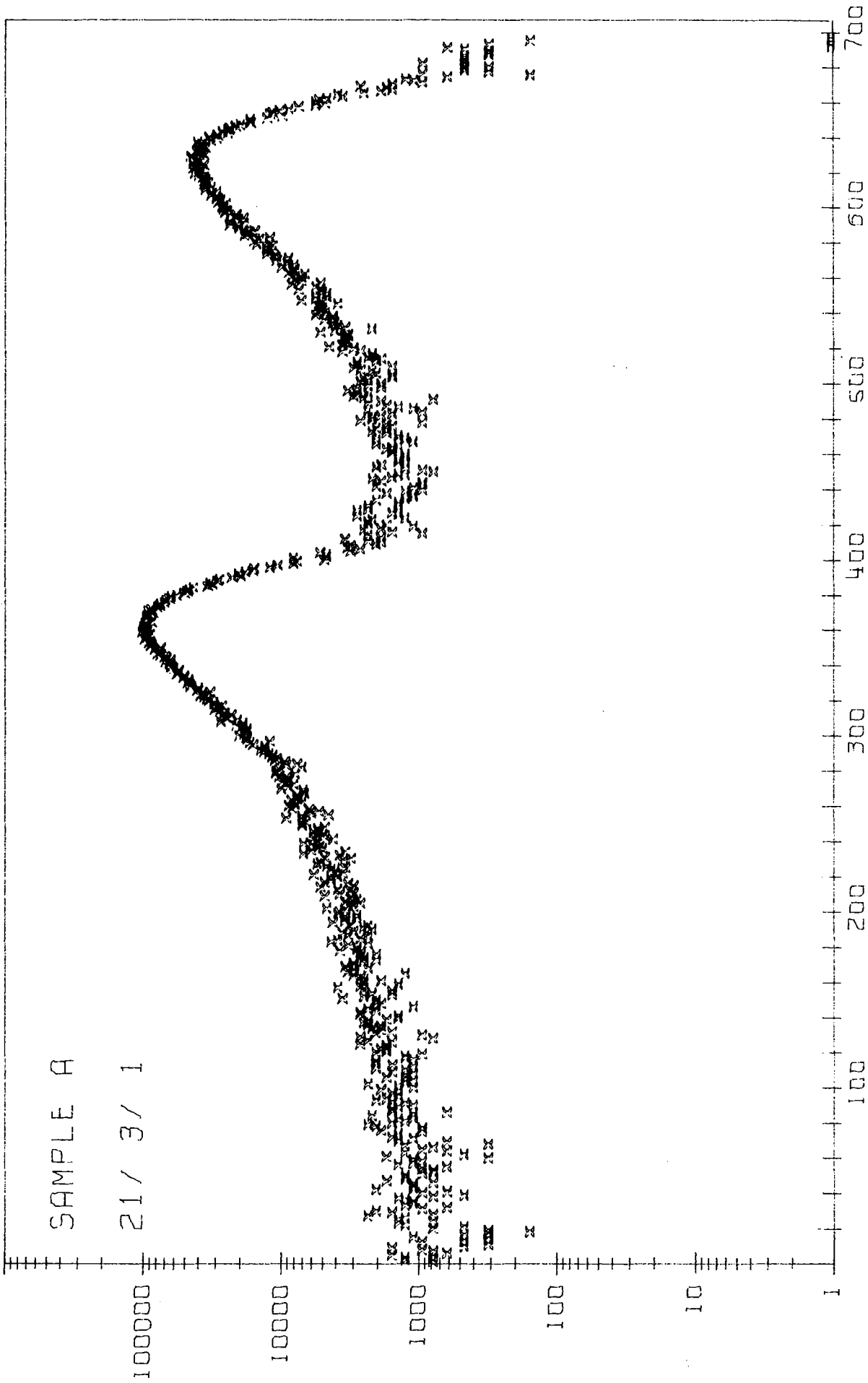


ABB. 02131 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER

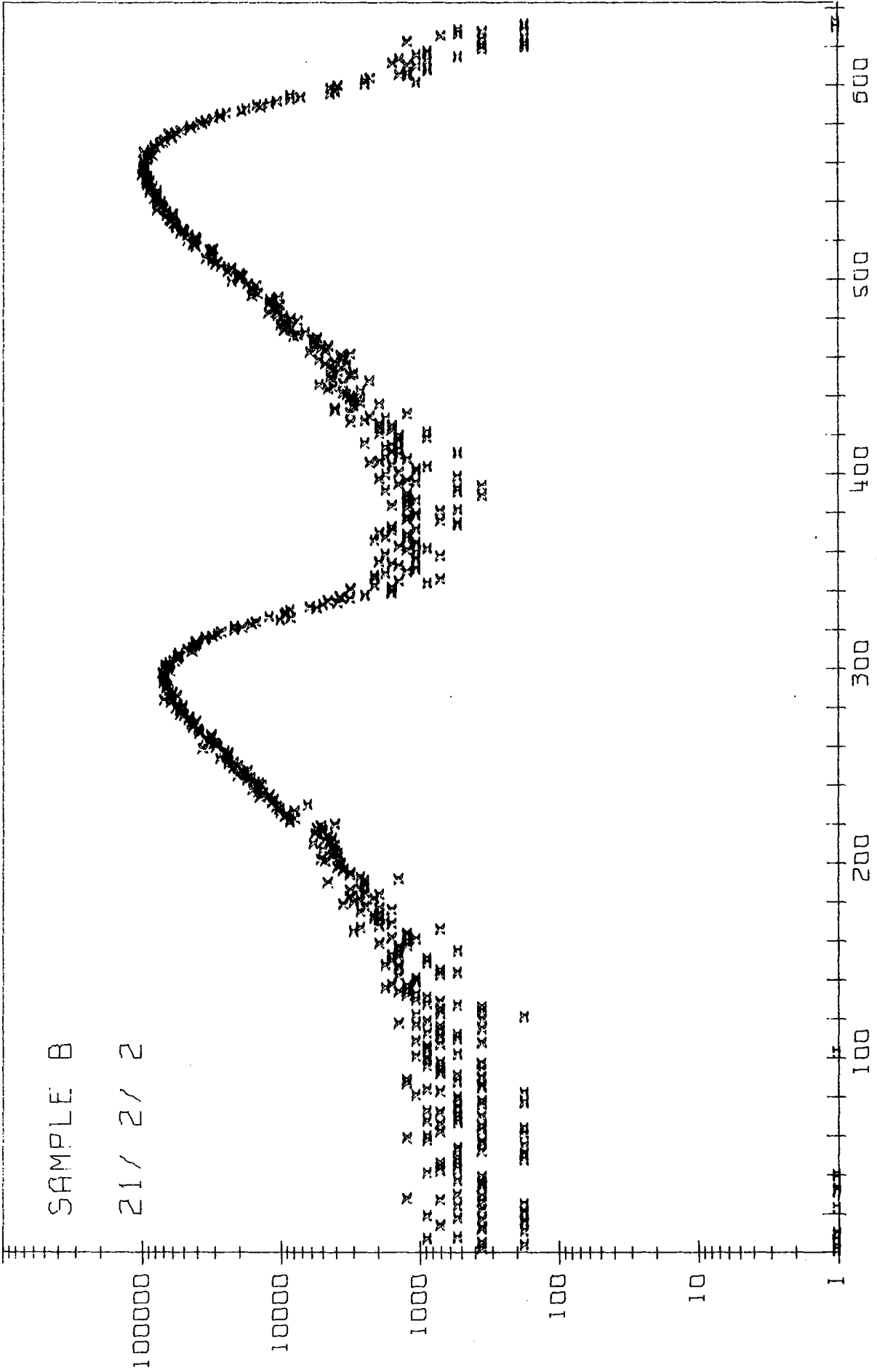
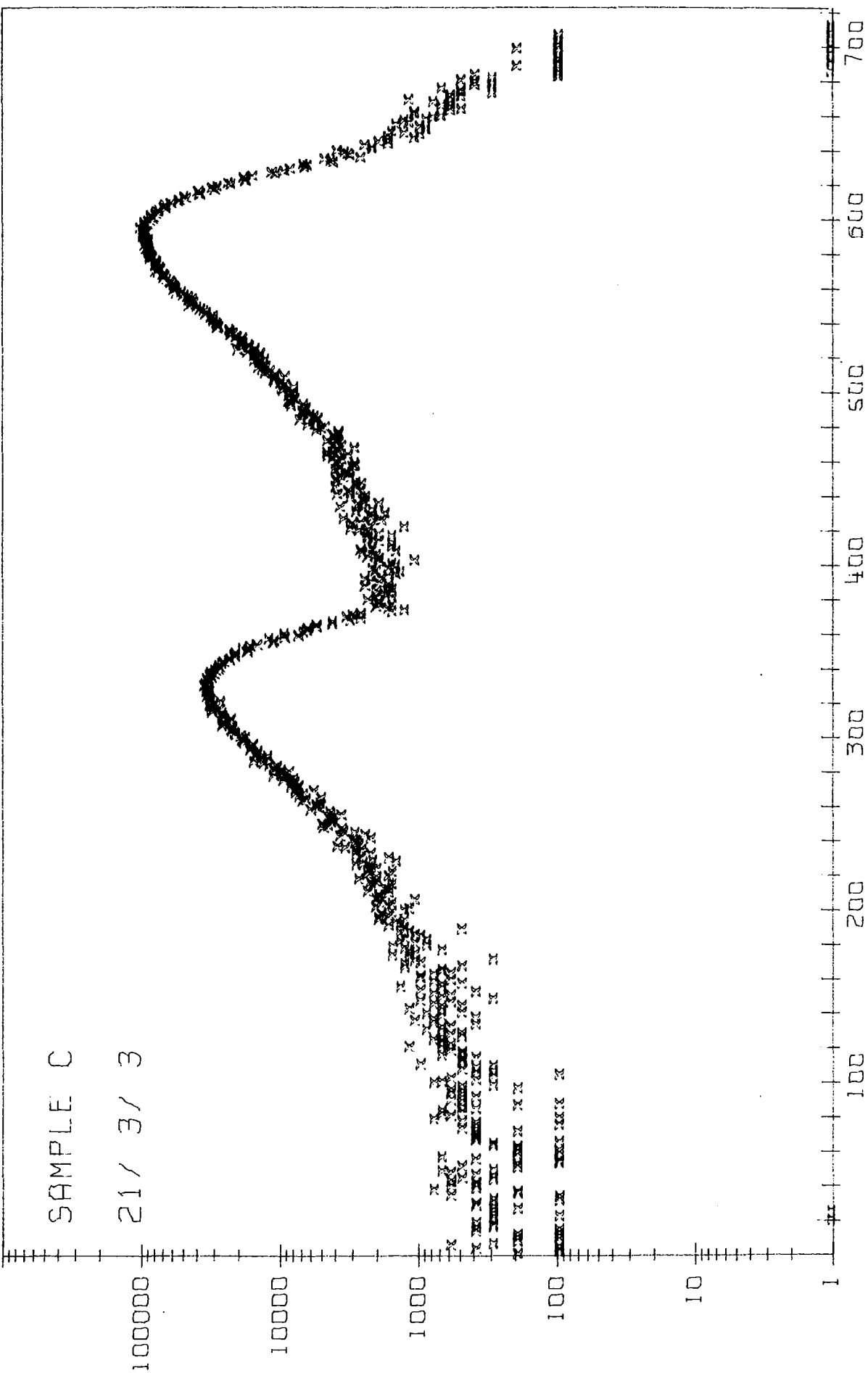


ABB.02122 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER



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RR2.02133 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER

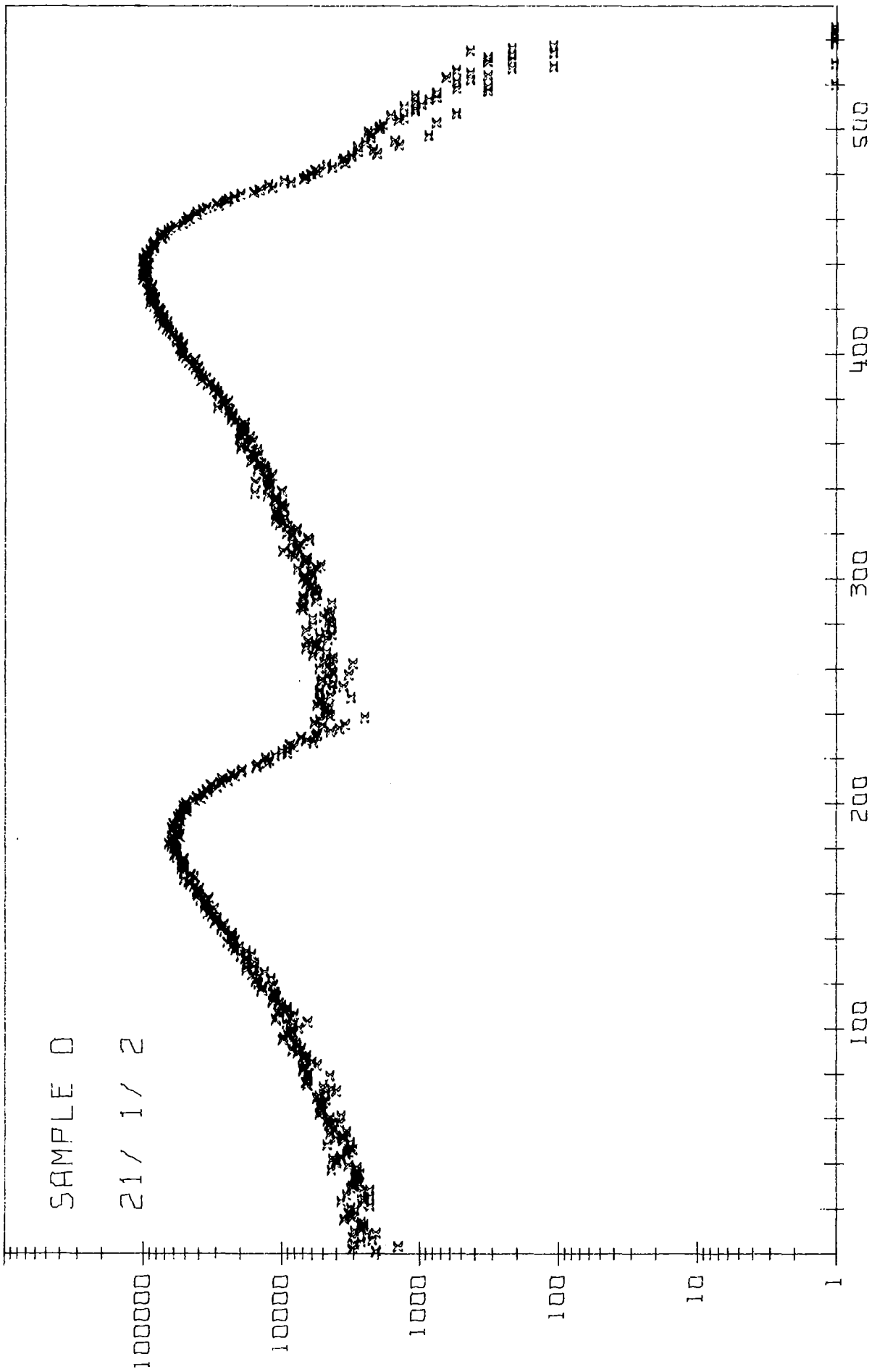
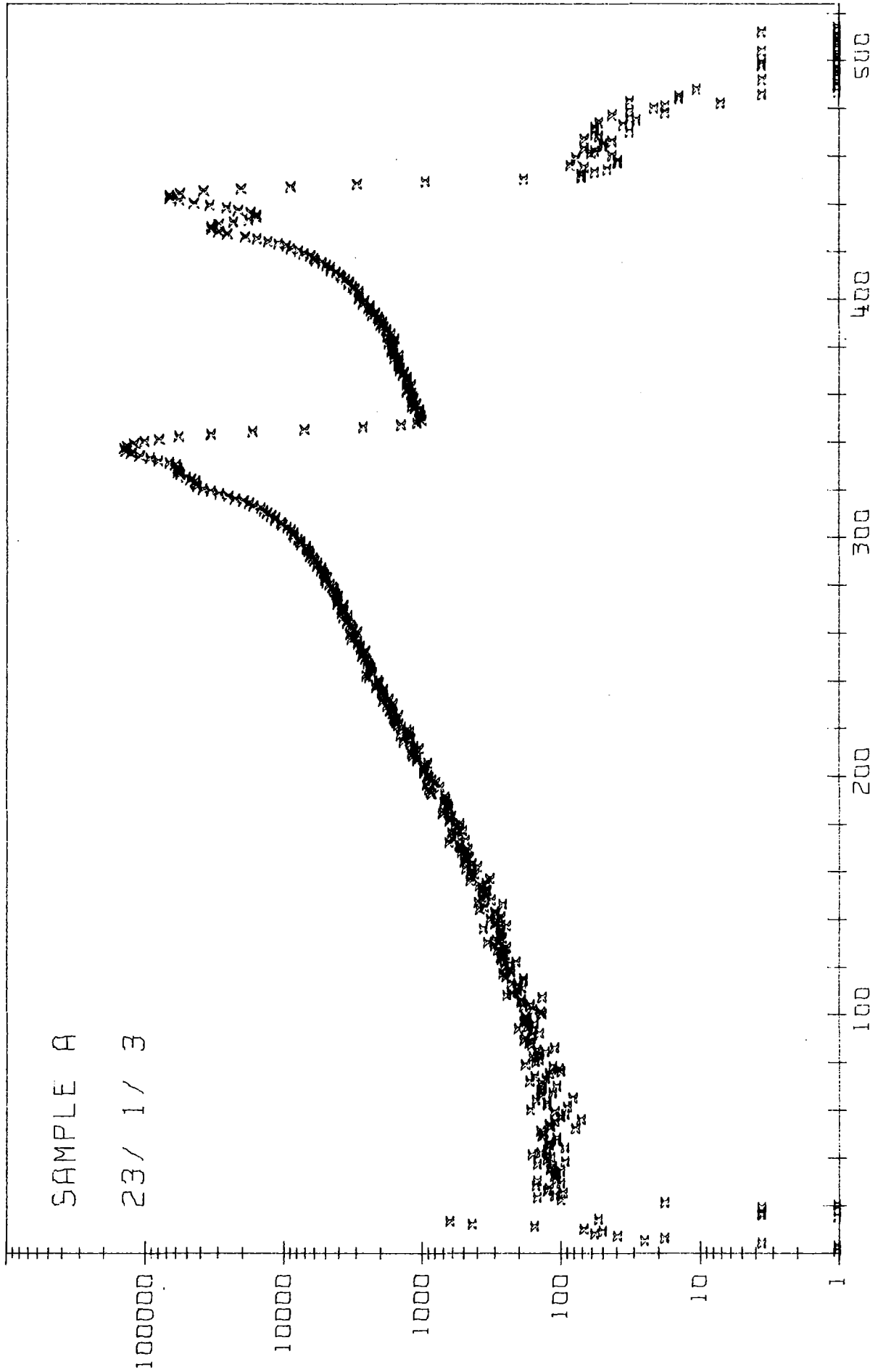


ABB. 02112 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER



SAMPLE A

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ABB.02313 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER

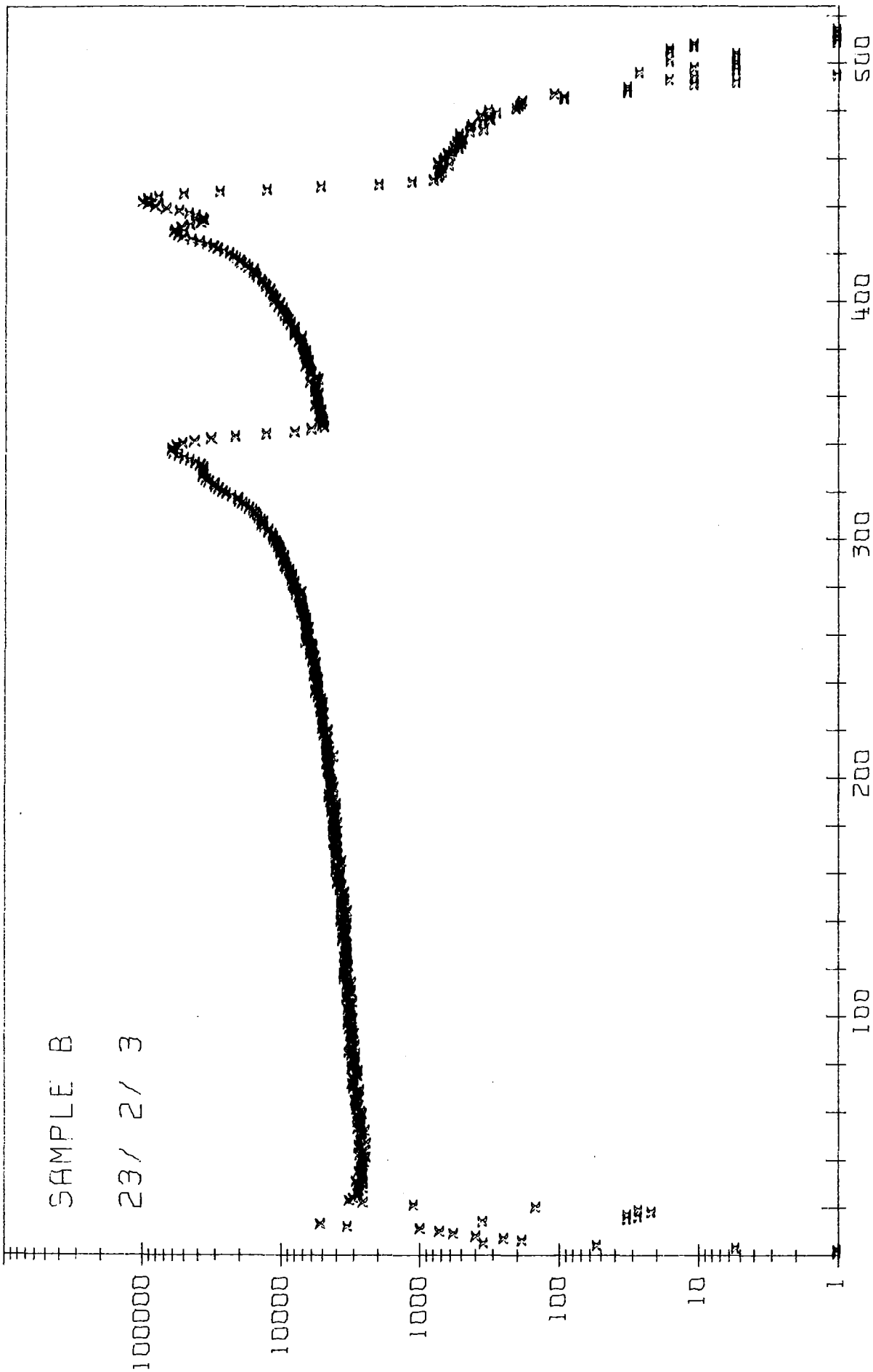
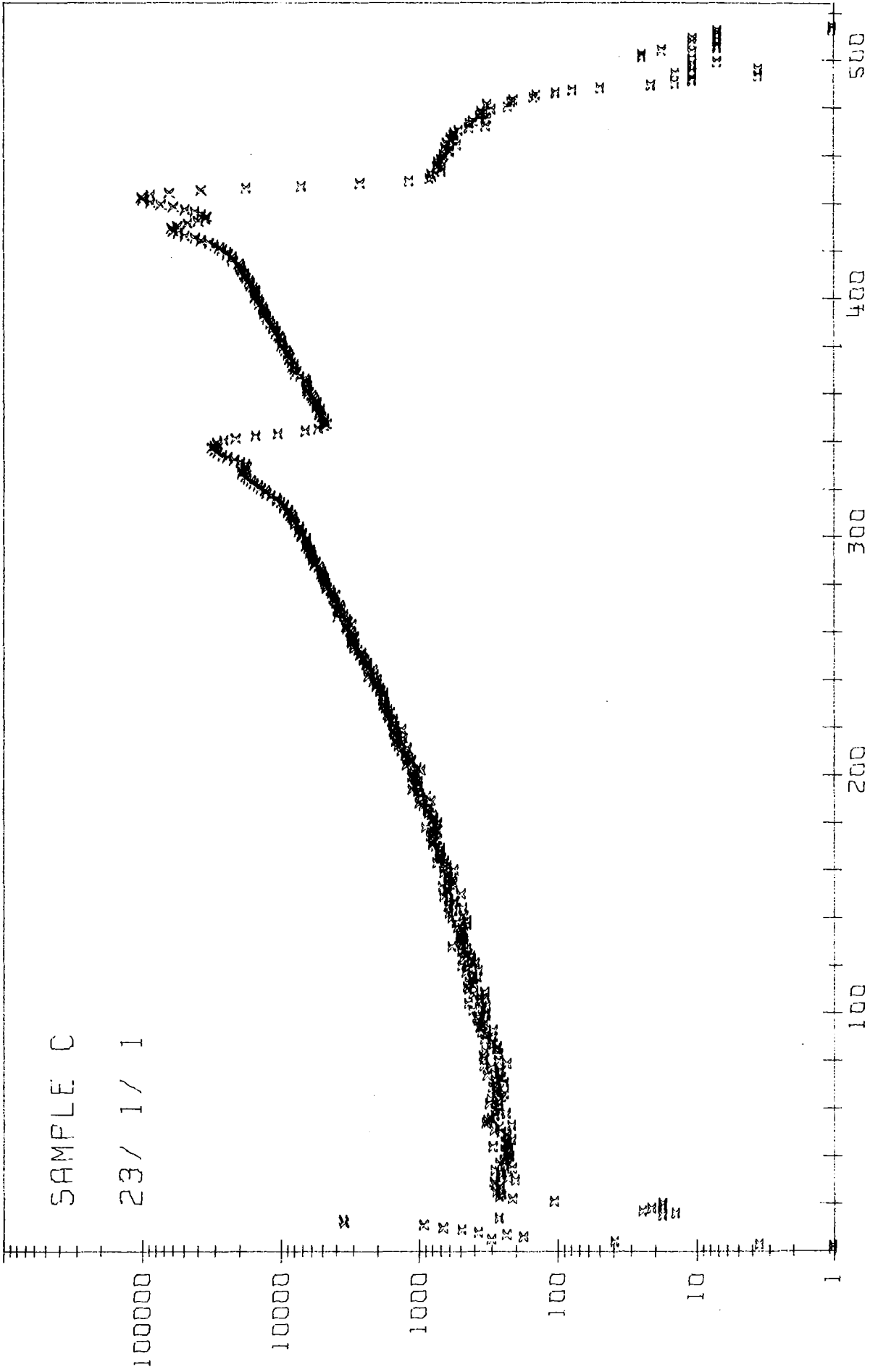
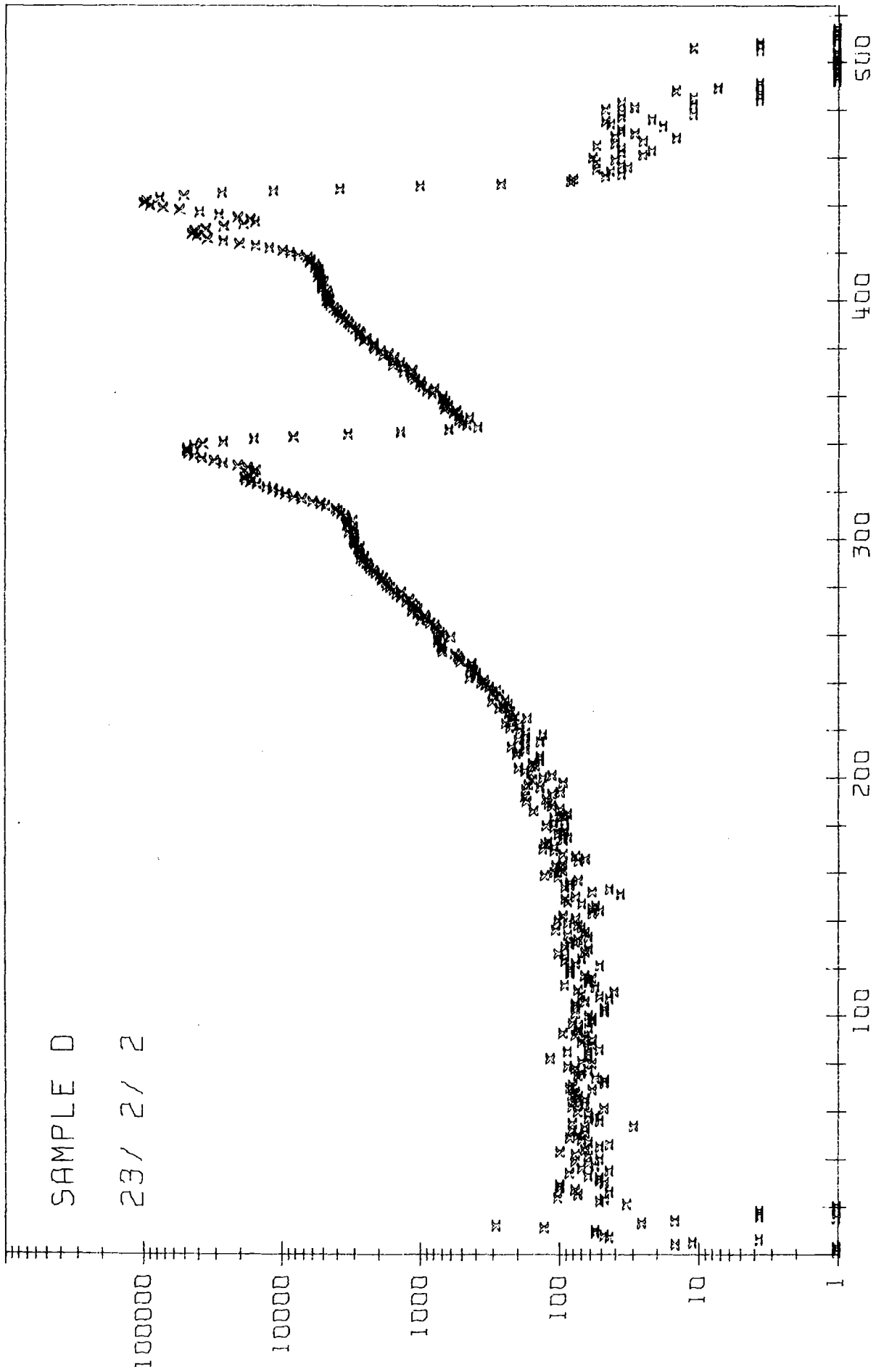


ABB 02323 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER



ARR 02311 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER



SAMPLE D
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488 02322 COUNTS PER CHANNEL (NORMALIZED) VERSUS CHANNEL NUMBER