

OPTIMIZING MICROPARTICULATE PROCESS EFFICIENCY

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ABSTRACT

The microparticulate process is discussed, together with the performance of an on-line zeta potential and drainage instrument. It is shown how the on-line instrument can be used to optimize the microparticulate process. The on-line instrument can also play a key role in the control of anionic trash, and to assess the thoroughness of mixing of headbox furnish, important pre-conditions to process optimization.

INTRODUCTION

The microparticulate process creates a microfloculation structure which can cost effectively improve three key process parameters in virtually any paper and boardmaking process: retention, drainage, and formation. Of the three key process parameters, drainage can conveniently be measured automatically in the laboratory and on the paper machine by a new instrument as an index of microparticulate process efficiency. The microparticulate process consists of the sequential addition of two components. The first is typically a cationic organic polymer and the second an anionic microparticle. Maximum effectiveness is usually achieved when the zeta potential polarity is changed by each additive. The new instrument, which also automatically measures zeta potential, can optimize microparticulate process paper machine runnability by enabling zeta potential control at the proper value and maximizing drainage at the headbox, thereby also maximizing retention, formation, and runnability.

It is important to obtain simultaneously a high level of retention, drainage, and formation in order to achieve a stable, efficient papermaking process with good runnability that yields a consistently high quality product. With conventional technology, a high level of retention is mutually opposed to both drainage and formation. The microparticulate process is an exception to conventional technology in the sense that it is unique in simultaneously enabling a high level of retention, formation, and drainage. The drainage improvement is caused by increased porosity which translates to an additional benefit, increased dewatering in the press section.

In principle, the efficiency of the microparticulate process can be optimized by adjusting chemical additions to obtain a high level of drainage, thereby also ensuring a high level of retention and formation.

Using a new automatic zeta potential and drainage instrument, drainage can be measured on-line one to two orders of magnitude more sensitively than the off-line freeness measurement. In monitoring on a paper machine the drainage measurement changes before paper machine performance because of its sensitivity. It serves therefore as a leading indicator or predictor of machine performance. This enables changes in wet end chemistry to be tracked very closely and appropriate adjustments made without upsetting the machine.

It has been shown that the drainage parameter correlates with Specific Filtration Resistance (1).

The chemical type, concentration, and point of addition can be varied to ensure the most cost-effective drainage and process chemistry performance. The zeta potential is simultaneously measured and is appropriately adjusted to ensure that the process is repeatable and can be continuously optimized.

PRINCIPLES

The microparticulate process is characterized by the following principles:

Principle No. 1

The microparticulate process creates a microfloculation structure which can cost effectively improve three key process parameters in virtually any paper and boardmaking process: retention, drainage, and formation.

Principle No. 2

Of the three key process parameters, drainage can be measured automatically in the laboratory and on the paper machine by an on-line instrument, as an index of microparticulate process efficiency.

Principle No. 3

The microparticulate process consists of the sequential addition of two components. The first is typically a cationic organic polymer (e.g., cationic starch, cationic PAM, wet strength resin); the higher the molecular weight, the greater is the effect. The second is an anionic microparticle (e.g., colloidal silica or bentonite) with a surface area greater than 300 m²/g; the larger the surface area, the greater is the effect.

Principle No. 4

For maximum efficiency, especially in a clean system, the cationic component of the microparticulate process must be thoroughly mixed in, prior to addition of the anionic microparticle.

Principle No. 5

An insufficient or excess amount of either chemical results in a negligible drainage effect. Maximum effectiveness is achieved when the equilibrium zeta potential is in the proper range after addition of the cationic and anionic components.

Principle No. 6

When the order of addition is reversed, so that the anionic microparticle is added first, the microfloculations effect, as measured by drainage, is greatly reduced but is much more persistent in terms of resistance to shear.

Principle No. 7

Microfloculation is a brief, transient phenomenon and the structure breaks down rapidly under shear. Monitoring with an on-line drainage instrument is of critical importance to ensure that microfloculation occurs where it is needed. The upstream point of microparticle addition and its concentration must be carefully selected to ensure that effectiveness peaks at the headbox.

LABORATORY DATA

We have carried out and logged on our computer more than 400 experiments, many of which are outside the patent literature. From this experience we have developed a fundamental understanding of the microparticulate process and have defined the mechanism through seven key principles, as previously described.

Experimental Method

Dry pulp is repulped in a Waring type blender in the laboratory, and adjusted to an appropriate consistency with tap water. Thirty liters of the furnish is transferred to a stainless steel vessel, equipped with an agitator. The contents of the vessel are circulated through the Manifold which supplies the Sensor Module with furnish.

Typically, a cationic organic chemical is added, followed after a specified delay, by an anionic inorganic microparticle. Using the system software, the zeta potential in millivolts is plotted, as is the drainage.

Example

30 liters of furnish were prepared of bleached HWD:SWD at 0.5% consistency (150 g) to which 0.125% PCC was added (37.5 g). Next, 0.25% quaternary amine (1% concentration) was added (46.9 ml). Following a ten minute delay, 1% bentonite (5% dispersion) was added (37.5 ml). (For maximum effectiveness, the bentonite dispersion should be freshly prepared).

Figures 1, 2, and 3 represent the respective printouts of the 060392B.LOG drainage and zeta potential graphs, and the logfile.

The last ten drainage data points in the logfile, Figure 3, prior to the addition of the quaternary amine are averaged, to obtain a value of 28.1 ml. The drainage peak after the addition of bentonite is noted as 40.5 ml. This is recorded as a "maximum" increase in drainage of 44.1%. The ten data points beginning with the drainage peak are averaged to obtain a value of 27.6 ml, and this is recorded as an "average" increase in drainage of 11.7%.

We consider that the "maximum" increase in drainage represents an assessment of the relative efficiency of that particular chemistry under ideal conditions. The "average" increase in drainage is always lower because it is degraded by shear. It may, however, represent a more reliable indication of what to expect on a paper machine. We have identified at least one means of substantially increasing the "average" drainage under certain conditions.

Logging, Review and Analysis of Data

A data base system is used to log the experimental data described above, and to selectively call it up for review and analysis. To obtain more data on a specific experiment of interest, system software may be used to print out the kind of data shown in Figures 1, 2, and 3.

INFLUENCE OF ZETA POTENTIAL

Figure 4, "The Influence of Zeta Potential on the Microparticulate Process" describes the incremental addition of a polyquaternary amine to an alkaline papermaking furnish, followed by the addition of an amount of colloidal silica proportional to the amount of polyquat. You will note that in this particular case one needs to operate in the range of +2 to +4 mV zeta potential to maximize drainage. Maximizing drainage is key to the success of the microparticulate process because it ensures that retention and formation are also maximized.

ANIONIC TRASH

A low molecular weight polyquaternary amine was added to never-dried sulfite pulp which had been reduced from 3.6% consistency to 0.2% with well water. Figure 5 shows that the zeta potential remained unchanged as 0.15% of the polyquat was added, because it was presumably reacting with the anionic trash, which is in the form of soluble and colloidal particles, and is more reactive than the fines and fibers. Beginning with the .02% addition level, and continuing thereafter, the addition of the polyquat produces the characteristic cationic spike, followed by a decay in zeta potential with time, which is a characteristic artifact of the charge neutralization of fines and fibers. Dashed lines have been drawn to show the negligible effect of the first three increments of polyquat, to a total of 0.15% and then the linear progressive charge neutralization of the next ten increments.

In monitoring the addition of polyquat on a paper machine the rate of addition would be incrementally increased until the zeta potential begins to move towards zero. At that point the anionic trash would be neutralized and the polyquat would start to react with the fines and fibers. This would, therefore, be the appropriate time to discontinue adding the polyquat as a cationic scavenger and to begin adding a (functional chemical

or) process chemical additive such as the cationic polymer used in the microparticulate process.

IS THE FURNISH THOROUGHLY MIXED?

The effect of various chemical additive addition modes and changes in plumbing, such as the effect of a right angle bend, has been the subject of a computer study by Jaroslav Meltzer (2). **Figure 6**, Meltzer's **Figure 5**, for example, shows the mixing effectiveness of introducing a chemical additive at four equidistant points well within a pipe circumference. The mixing effectiveness is distinctly unimpressive.

We have found through experience in many paper mill environments that the standard deviation of zeta potential data is a fair measure of how thoroughly the stock or furnish is mixed together at that point in the process. For example, in the laboratory we typically obtain a standard deviation of about 0.2 mV zeta potential, as shown in **Figure 7**. A non-integrated mill which uses beaters to thoroughly mix big batches of once-washed merchant pulp, with simple process chemistry and an old, slow paper machine can show a zeta potential standard deviation in the range 0.2–0.5 mV.

A high speed tissue machine can show a standard deviation of 1.6 mV, as shown in **Figure 8**. A high speed alkaline fine paper machine with a complex process which includes a reactive internal size and a microparticle can have a standard deviation of 2.9 mV, as shown in **Figure 9**. This does not represent an acceptable degree of mixing, and it is accompanied by poor runnability, in the form of 6–10 wet end breaks/day.

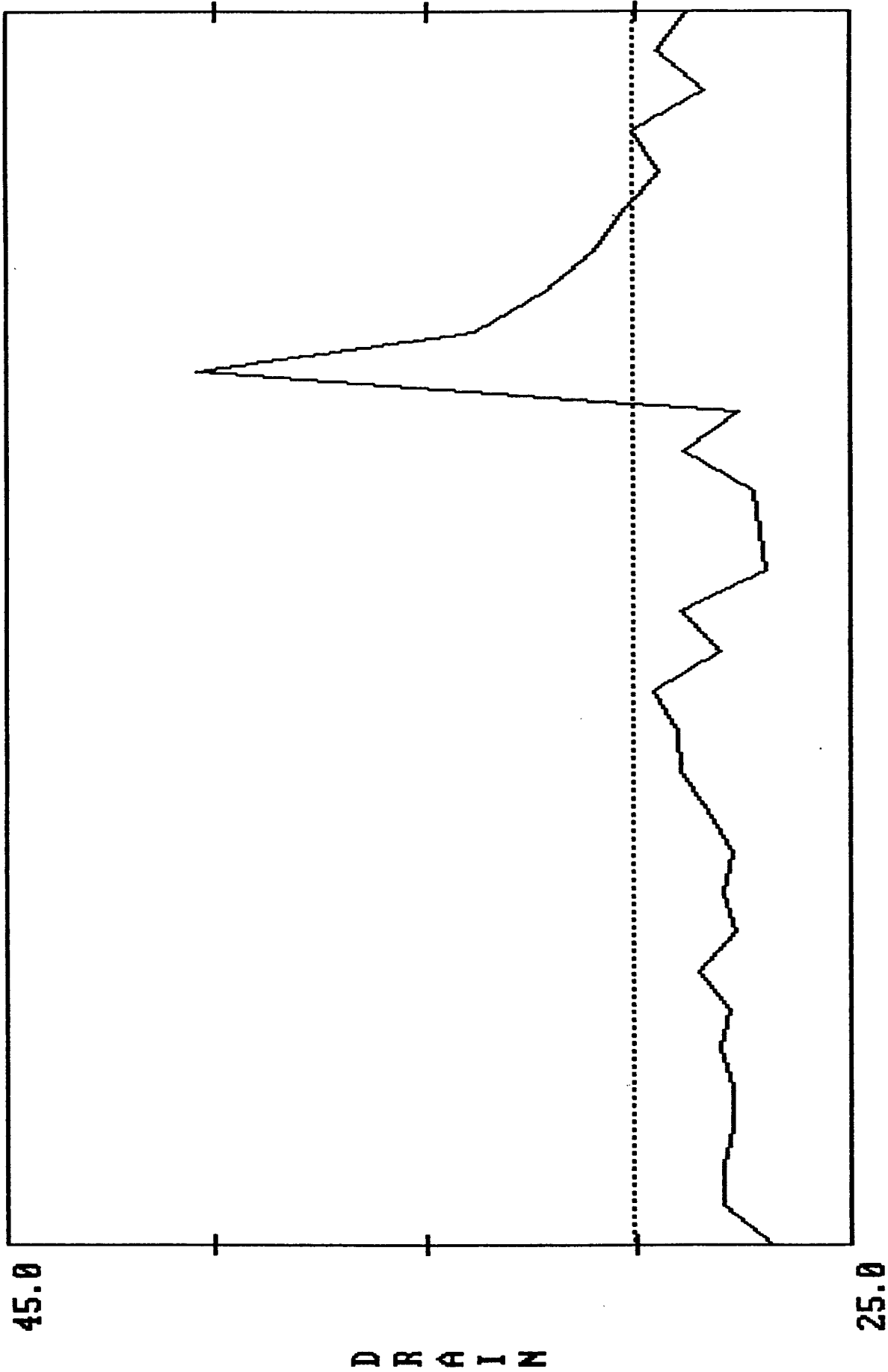
CONCLUSION

Proper use of the on-line zeta potential and drainage instrument can optimize microparticulate process paper machine runnability by enabling zeta potential control at the proper value, and maximizing drainage at the headbox, thereby also maximizing retention, formation, and runnability. Anionic trash can be effectively controlled, and thoroughness of mixing at the headbox can be easily assessed.

REFERENCES

- (1) Springer, Allan, University of Miami, Oxford, Ohio, personal communication.
- (2) Melzer, Jaroslav D.I., "Computersimulation der Hilfsmittelverteilung in Stoffleitungen", PTS Symposium, Munich, Germany, 15–18 September 1992.

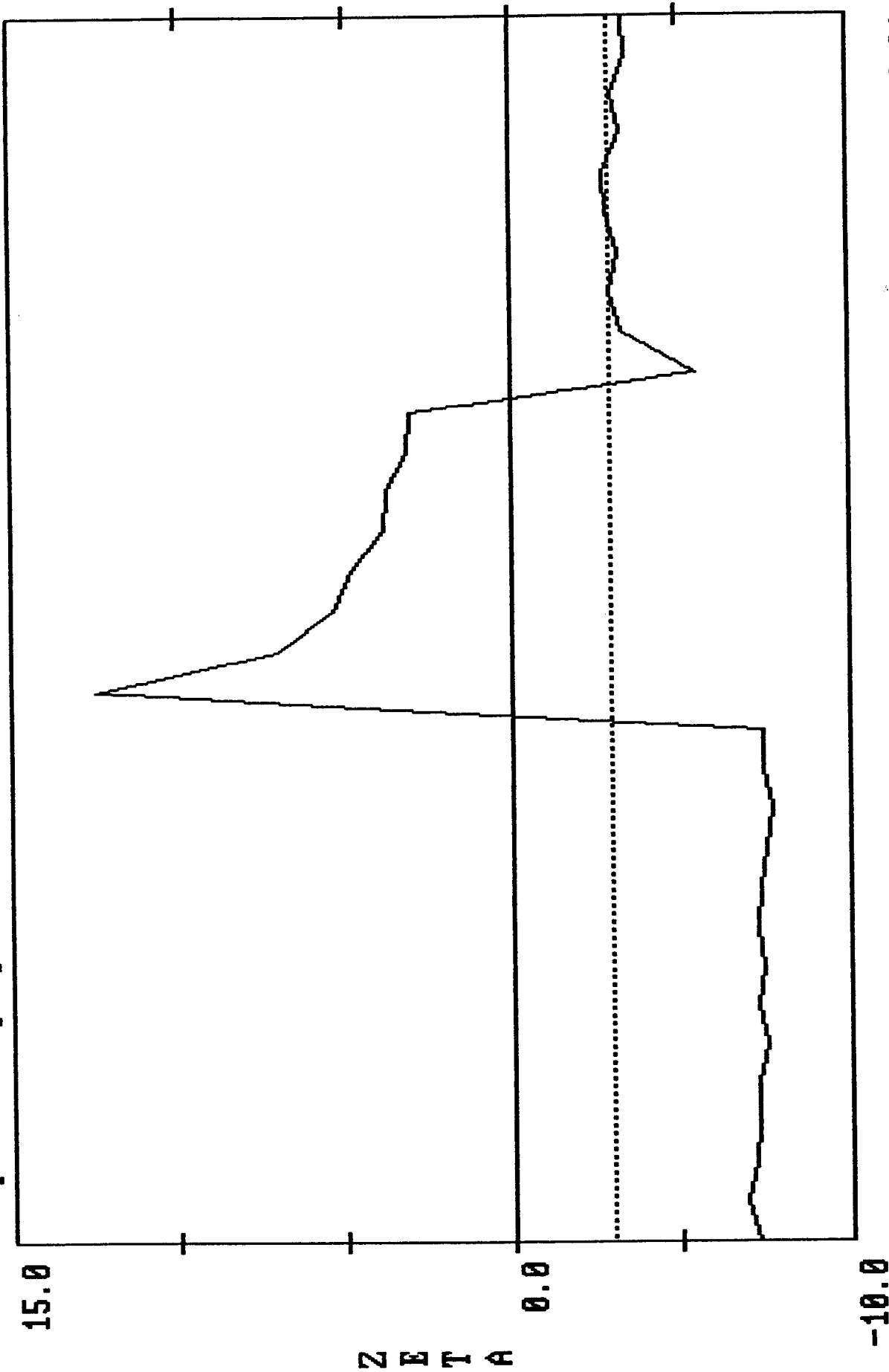
Zetaplot Display of 32 samples from 060392B.LOG Press ESC To EXIT



6/03/92 12:34:14 Average of samples = 30.1 6/03/92 13:14:21

Figure 1. 060392B.LOG Drainage, ml

Zetaplot Display of 32 samples from 060392B.LOG Press ESC To EXIT



6/03/92 12:34:14 Average of samples = -3.0 6/03/92 13:14:21

Figure 2. 060392B.LOG Zeta potential, mV

Figure 3. 060392B.LOG logfile

ZETADUMP printout of ZETADATA log file 060392B.LOG.

#	Fill Time	Chamber	Rinse Time	Rinse Interval	Log File	Type 4
1	12.0	0.686	2	0	12:34:13	6/03/92

#	ZETA	RANGE	COND	TEMP	DRAIN	CONF	Log File	Type 5
1	-7.25	0.00	320	17.9	26.8	0.998	12:34:14	6/03/92
1	-6.91	0.00	326	16.9	28.0	0.975	12:35:31	6/03/92
1	-7.17	0.00	329	16.9	28.0	0.985	12:36:47	6/03/92
1	-7.21	0.00	329	16.9	27.8	0.980	12:38:03	6/03/92
1	-7.22	0.00	331	17.1	27.8	0.981	12:39:19	6/03/92
1	-7.49	0.00	334	17.1	28.1	0.987	12:40:35	6/03/92
1	-7.21	0.00	332	17.3	27.9	0.979	12:41:51	6/03/92
1	-7.37	0.00	332	17.3	28.6	0.979	12:43:07	6/03/92
1	-7.21	0.00	332	17.3	27.7	0.980	12:44:23	6/03/92
1	-7.26	0.00	327	17.3	28.0	0.984	12:45:39	6/03/92
1	-7.47	0.00	327	17.5	27.8	0.984	12:46:55	6/03/92
1	-7.67	0.00	336	17.5	28.4	0.991	12:48:11	6/03/92
1	-7.39	0.00	334	17.5	29.0	0.982	12:49:27	6/03/92

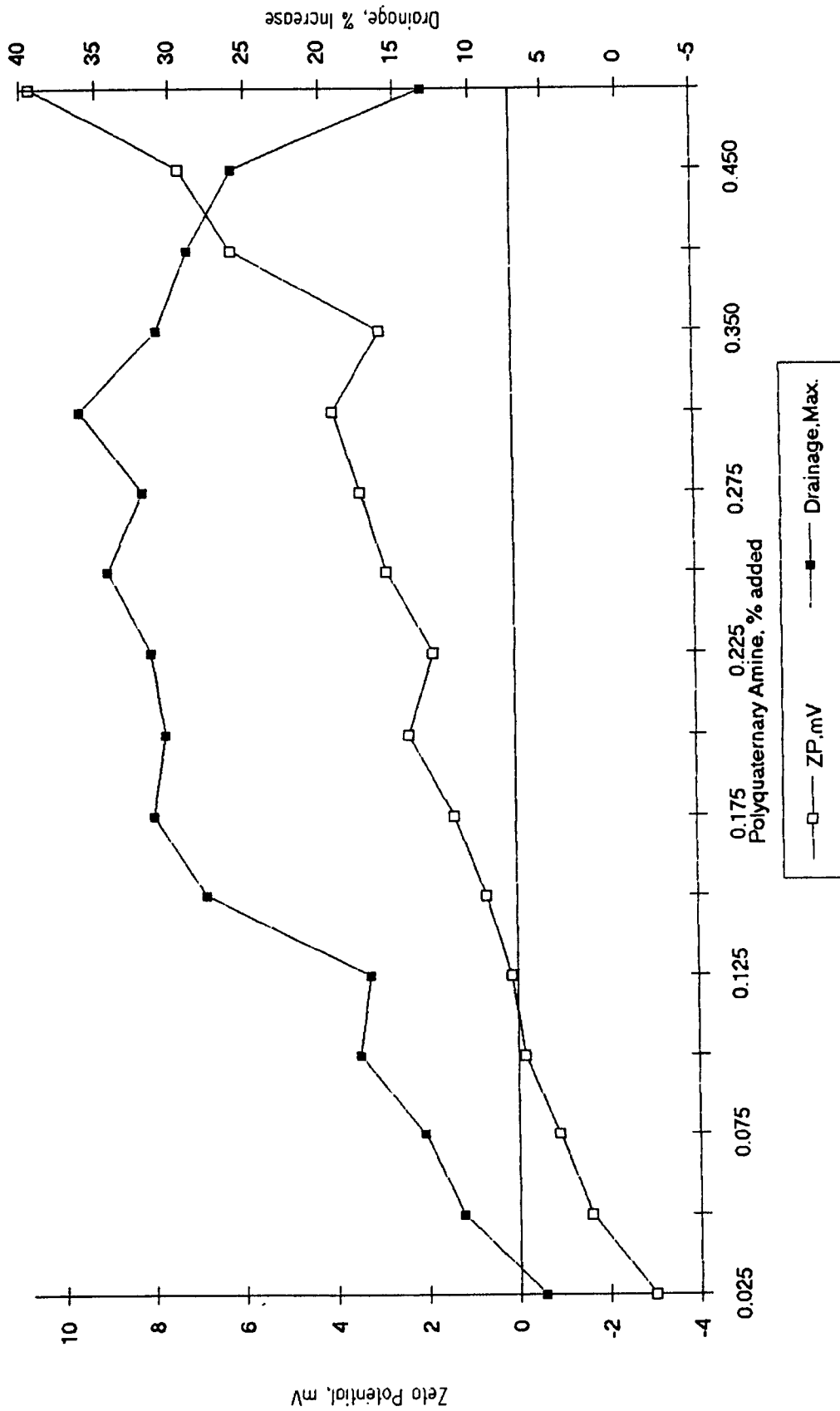
OPERATOR COMMENT Log File Type 3
 ADD 0.25% NALCO 7607 12:52:14 6/03/92

#	ZETA	RANGE	COND	TEMP	DRAIN	CONF	Log File	Type 5
1	-7.42	0.00	335	17.7	29.0	0.981	12:50:43	6/03/92
1	12.54	0.00	334	17.5	29.6	0.987	12:52:22	6/03/92
1	7.11	0.00	332	17.7	28.1	0.984	12:53:38	6/03/92
1	5.40	0.00	336	17.7	29.0	0.991	12:54:54	6/03/92
1	4.87	0.00	327	17.7	27.0	0.982	12:56:12	6/03/92
1	3.94	0.00	331	17.7	27.1	0.992	12:57:28	6/03/92
1	3.80	0.00	322	18.1	27.3	0.984	12:58:45	6/03/92
1	3.21	0.00	301	17.9	29.0	0.982	13:00:00	6/03/92

OPERATOR COMMENT Log File Type 3
 ADD 1% BENTONITE 13:02:31 6/03/92

#	ZETA	RANGE	COND	TEMP	DRAIN	CONF	Log File	Type 5
1	3.12	0.00	310	17.9	27.7	0.984	13:01:18	6/03/92
1	-5.44	0.00	340	17.9	40.5	0.985	13:02:50	6/03/92
1	-3.25	0.00	339	17.9	33.9	0.987	13:04:07	6/03/92
1	-2.85	0.00	322	18.1	32.2	0.989	13:05:23	6/03/92
1	-3.19	0.00	339	18.3	31.1	0.991	13:06:40	6/03/92
1	-2.80	0.00	340	18.3	30.4	0.981	13:07:57	6/03/92
1	-2.74	0.00	333	18.3	29.5	0.982	13:09:14	6/03/92
1	-3.22	0.00	338	18.3	30.1	0.985	13:10:31	6/03/92
1	-3.01	0.00	316	18.3	28.4	0.987	13:11:48	6/03/92
1	-3.38	0.00	336	18.5	29.6	0.987	13:13:05	6/03/92
1	-3.35	0.00	333	18.5	28.8	0.990	13:14:21	6/03/92

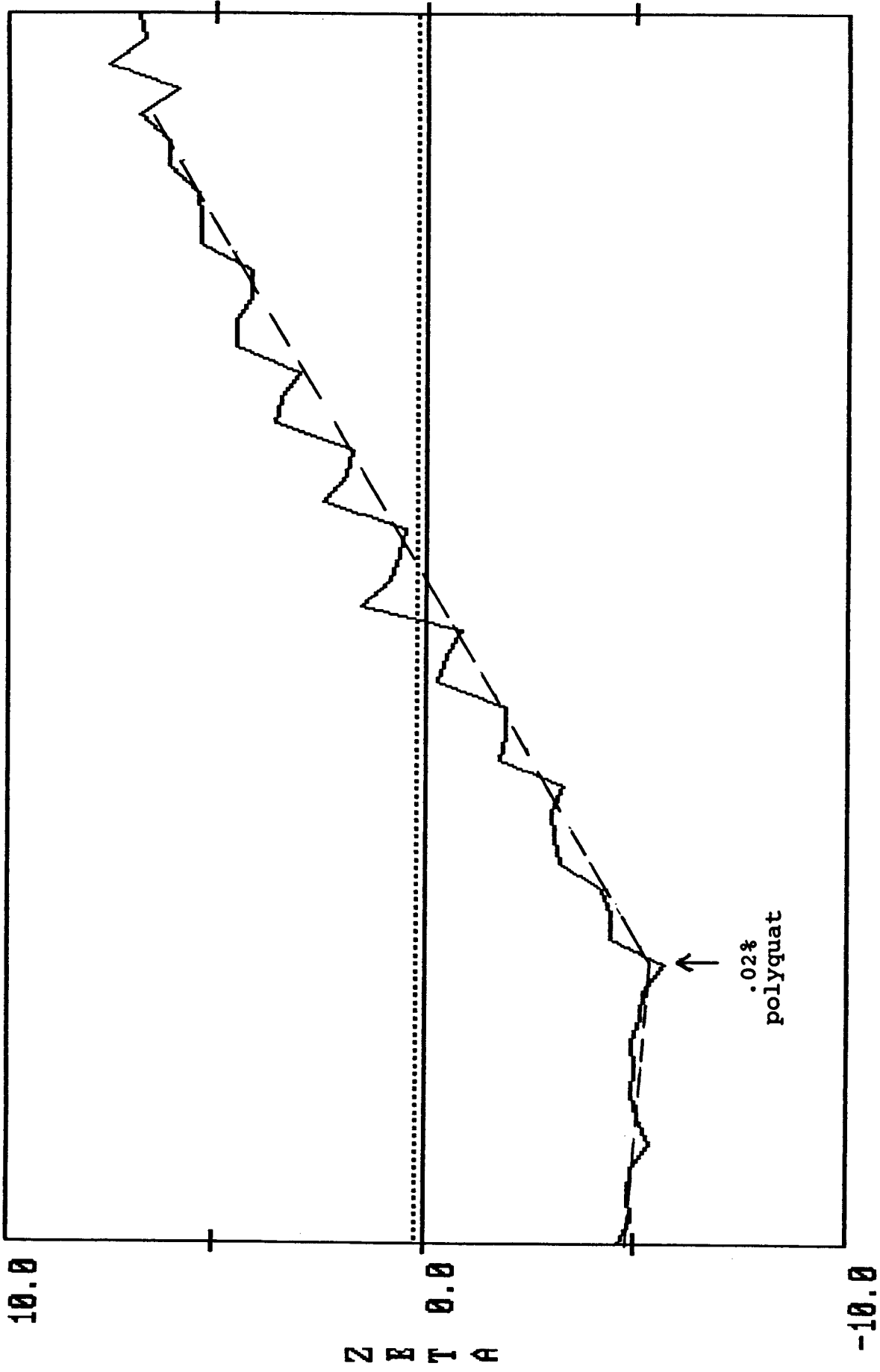
The Influence of Zeta Potential on the Microparticulate Process



The figure represents sixteen different experiments. In each experiment a polyquaternary amine was added in the amount shown, active basis, to 0.5% consistency bleached HWD:SWD 50:50 plus 0.125% PCC. Following a twenty minute delay, colloidal silica was added, in a weight amount 1.5 times that of the amine.

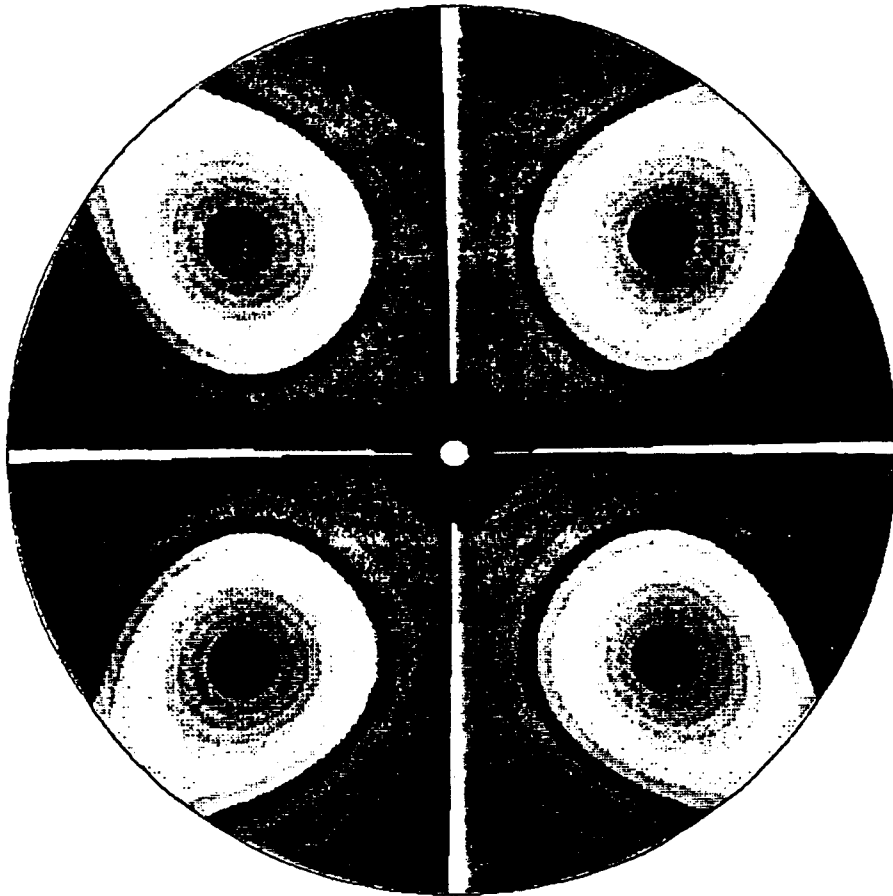
Figure 4

Zetaplot Display of 49 samples from 120792.log Press ESC To EXIT



12/07/92 13:06:08 Average of samples = 0.2 12/07/92 14:19:58

Figure 5



Papierherstellung 4 Duesen Kreuzanordnung
 $d = 1000 \text{ mm}$; $Tu = 0.04$

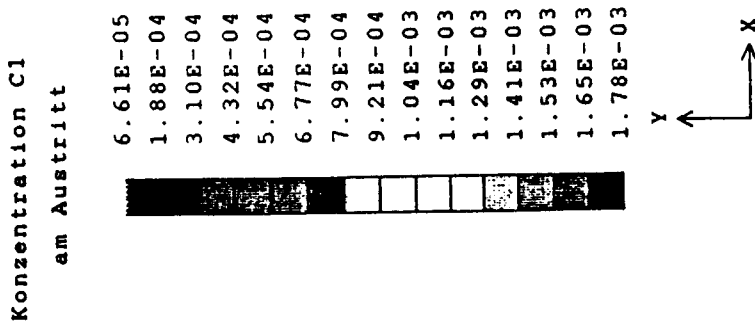
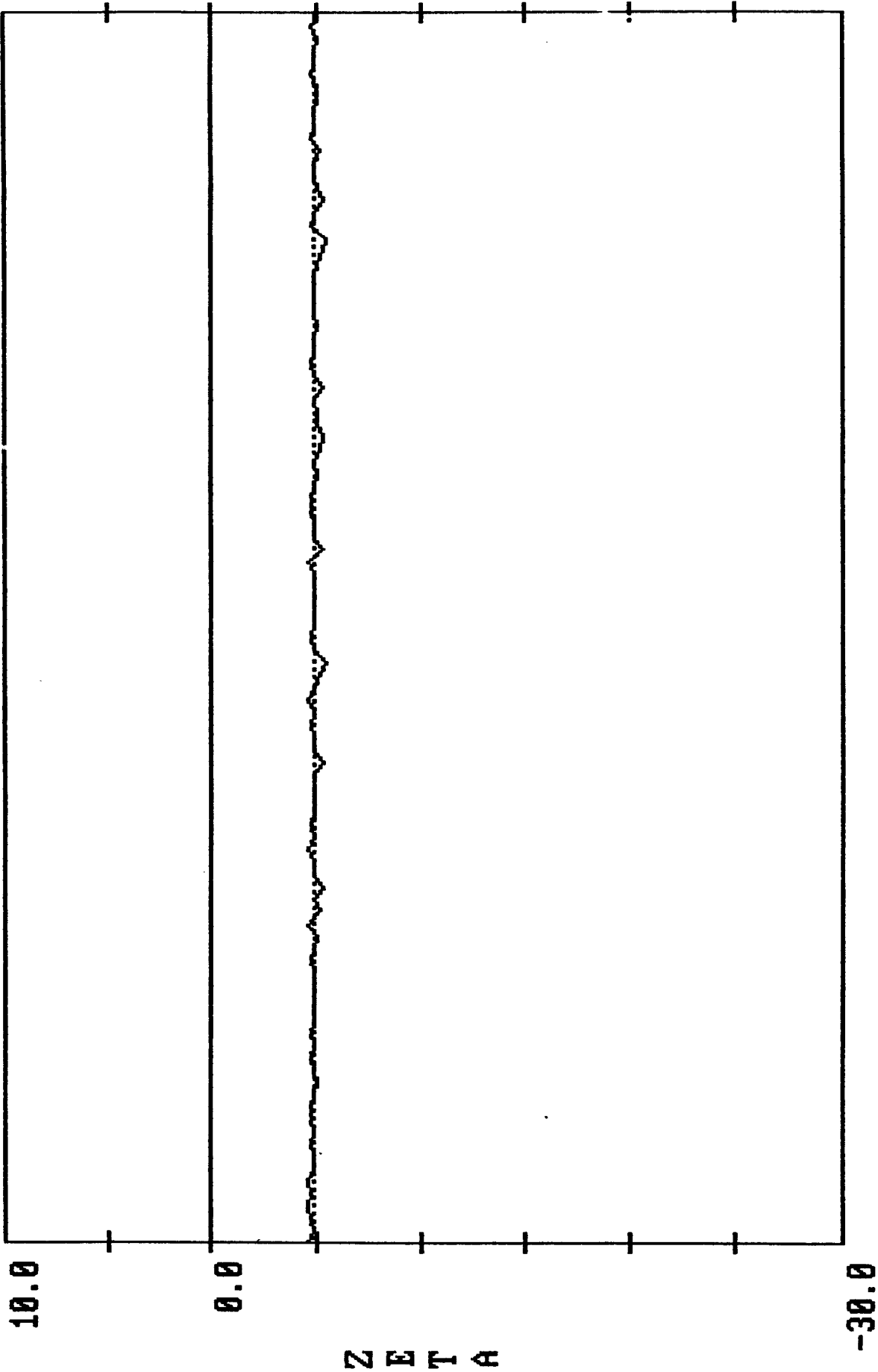


Figure 6

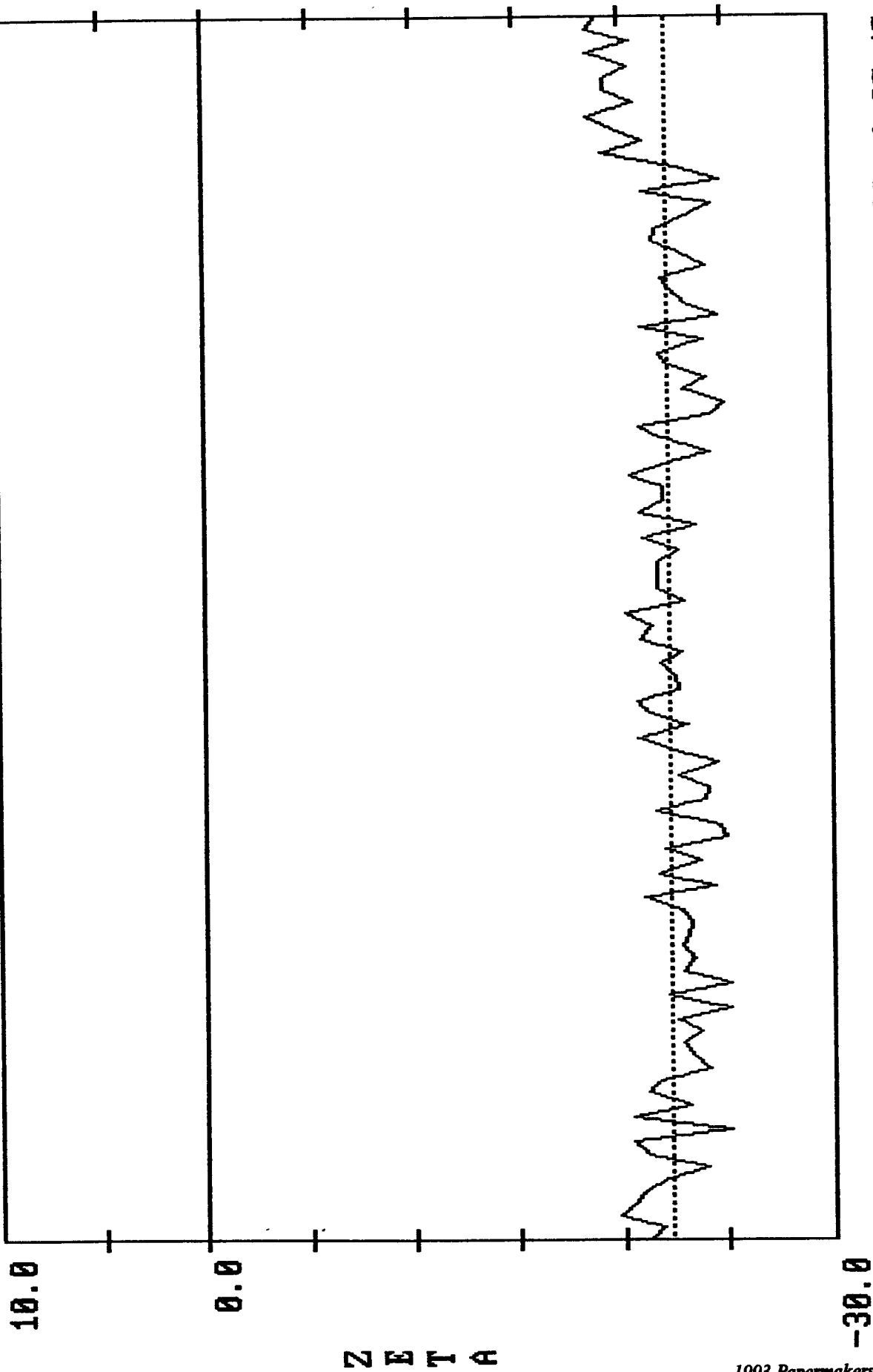
Zetaplot Display of 100 samples from 120792.log Press ESC To EXIT



12/07/92 9:35:50 Average of samples = -4.8 12/07/92 11:59:26

Figure 7

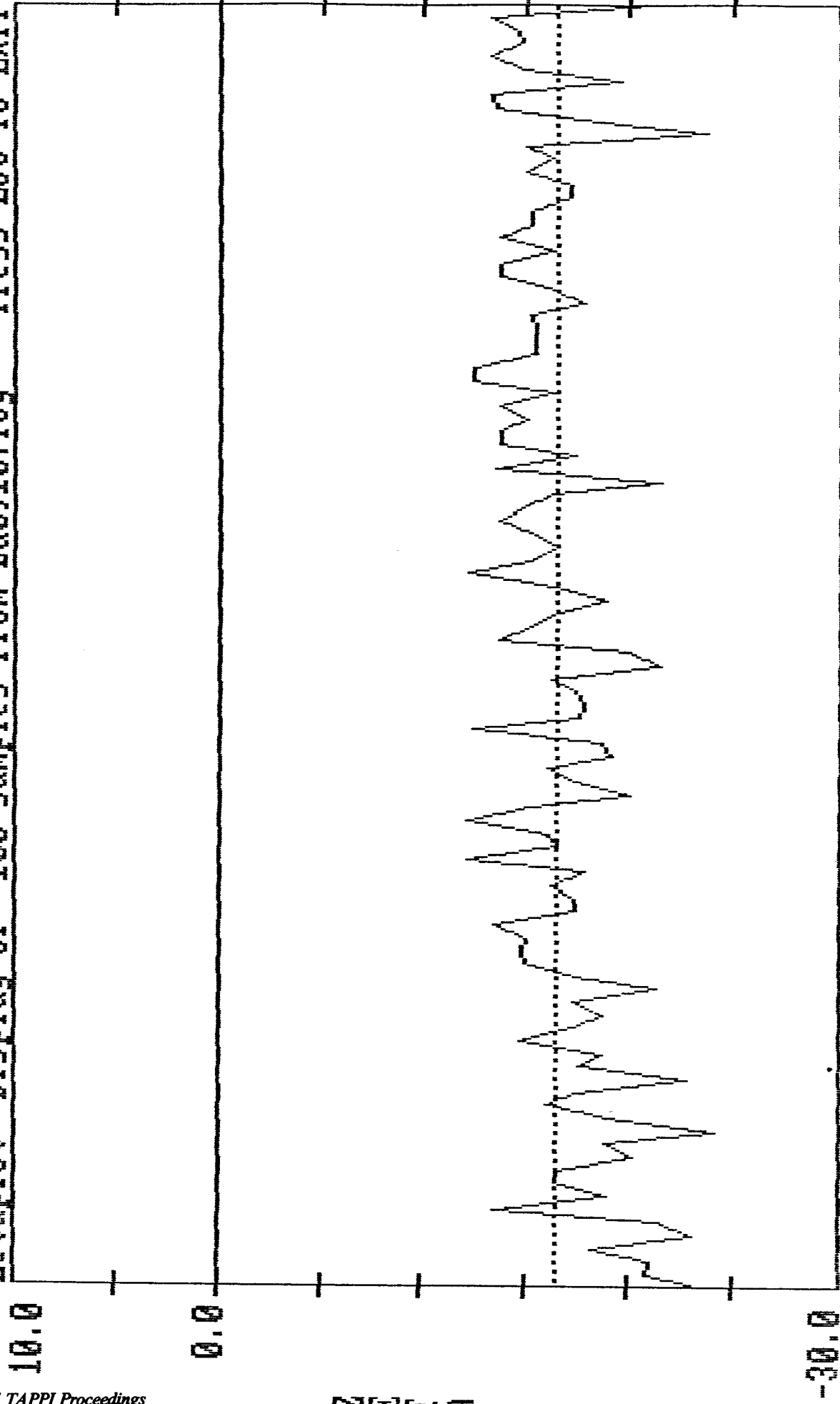
Zetaplot Display of 100 samples from a:111192.log Press ESC To EXIT



11/11/92 3:15:49 Average of samples = -22.3 11/11/92 6:07:47

Figure 8

Zetaplot Display of 100 samples from zd0910.1og Press ESC To EXIT



9/09/90 8:31:12 Average of samples = -16.6 9/09/90 10:09:16

Figure 9