Electra precision products MANUFACTURING COMPANY INDEPENDENCE KANSAS

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National Aeronautics and
Space Administration
Engineering Services and
Studies Branch
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George C. Marshall Space Flight Center
Huntsville, Alabama

Attention: M-P&C-MEA/Kittle

Gentlemen:

Transmitted herewith are ten copies, plus one reproducible copy, of the second Quarterly Progress Report in accordance with requirements of Contract NAS8-11076, Modification 2.

Submitted: G. A. Swartz
G. A. Swartz
Project Engineer

Approved: W. E. McLean
W. E. McLean
Project Manager

GAS/pd

Quarterly Progress Report No. 2

ACCELERATION FACTOR DETERMINATION

FOR METAL FILM RESISTORS

Prepared under Contract No. NAS8-11076
Modification No. 2

by

ELECTRA MANUFACTURING COMPANY
Independence, Kansas

for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Huntsville, Alabama

ABSTRACT

This Report covers results of screen test vs life test data obtained in the initial contract and the infra-red measurements made under the contract modification.

Correlation coefficients for Temperature Cycle, Burn-In, and Initial Noise vs Load Life are given. Regression lines are shown for Brun-In vs Load Life. While this data indicates that Burn-In is an effective screen test, it also indicates the need for further study on larger samples.

Infra-red profiles were taken on all resistors to be life-tested resulting in 9900 profiles on 1800 pages. Examples of the profiles are shown, however, no conclusions or correlation can be made until completion of the 2000 hour Load Life test.

1.0 INTRODUCTION

1.1 Correlation coefficients for Screen Tests vs Life Tests are shown for Temperature Cycle, Burn-In, and Initial Noise. Short Time Overload was not included due to the small resistance changes involved.

Correlation coefficients from the sample are shown along with the correlation coefficient expected for the population at 95% confidence level. A wide range is seen in the possible correlation coefficients for the population, even when the sample correlation is high. This is due to the small sample sizes involved.

Regression lines are also included for Burn-In, vs Life Test. Regression lines for Temperature cycle vs Life Test are to be included in the next quarterly report.

Test data for the three manufacturing types (A, B, C) were compared to determine if each type has the same or a different reaction.to the various tests performed. This was done by comparing F-ratios. From the Analysis of Variance table (Table 6) it is seen that the three types cannot be considered the same.

1.2 Infra-red profiles were made for the nine-hundred resistors to be Life Tested. Scans were made at power loading from .5 to 5 times rated power resulting in 9900 scans and 1800 pages of data. Examples of the I-R scans are included in this report, however, no analysis or conclusions are anticipated prior to the completion of the 2000 hour Life Test.

[redacted]

This analysis is an attempt to determine if one or more of the proposed screen tests gives us a significant means by which we can predict potential failures in load life. Sample correlation coefficients have been calculated and tabulated in tables 1, 2, 3, 4, and 5.

The sample correlation coefficient,

$$r = \sum_{i=1}^{n} (x_i - \bar{x})(y_i - \bar{y}) \Big/ \sqrt{\sum_{i=1}^{n} (x_i - \bar{x})^2 \sum_{i=1}^{n} (y_i - \bar{y})^2}$$

gives us the degree of relationship or association between screen test and the respective load life. Ninety-five percent (95%) confidence limits on each coefficient are also shown in the tables. The region between the two limits is where we would expect the population correlation to fall. The correlation coefficient here, though it may be close to ± 1, cannot be used as a decision tool alone, but does show areas in which larger investigations would be practical.

The "burn in vs. load life" data have also been plotted for each process and each ohmic value (Figures 1 through 6). In five of these cases a line of the form $L = a + bB$ has been fitted by least squares methods. These lines showing regression of L on B relate ΔR in load life (L) to ΔR in burn in (B), and the 90% confidence lines also shown give us a measure of the effectiveness of this screening technique. In Figure 1, for example, we may determine whether or not screening at a burn in maximum ΔR of 0.25% will give us 95% confidence that the load life ΔR will be less than 0.5%. To do this, we locate the abscissa at 0.25% for burn in ΔR and follow it up above the confidence lines. Since we are well below the 0.5% load life ΔR, we have greater than 95% confidence that the screening technique will remove any unit with over 0.5% ΔR in load life.

In spite of the small sample sizes (with consequent large uncertainty on correlation coefficient and parameters of the regression line), the general similarity in these regression curves is noticeable, and lead to the belief that further exploration of this screening technique using larger samples would be profitable.

2.1 It was agreed in a meeting at Electra with Messrs. John Wright and Mike Nowakowski that additional information could be obtained form the Med #2 Life Test data. This is to be accomplished by using the first 100 hour resistance change as Burn In data and the resistance change from 100 hours to 1100 hours as the 1000 hour data.

To verify the assumption that differences exist in the data for the manufacturing types (A, B, C), analysis of variance tests were run to compare both the means and variances of the various combinations of Types. This was done by calculating the F-ratio (ratio of variance between samples to variance within samples) and comparing these balues with table values.

It can be seen from Table 6 that significant differences exist between Manufacturing Types in most cases. Therefore, each Type must be studied separately.

2.2 Infra-red profiles were made on the 900 resistors which are being life tested. All resistors in each of the nine groups were scanned at one-half and one times rated power. One half of each group was scanned also at two and one-half times rated power and one-fourth of each group was scanned at five times rated power. The scans were made longitudinally and four scans per resistor per condition were made at 90° intervals around the circumference of the resistors. The scanning rate used was 16 milli-inches per second and the scan was initiated as soon as the ppwer was applied to the resistor. This was done to observe the effects of loading while th the resistor was heating rather than in an equilibrium condition.

Figures 7 thoough 24, are examples of the data recorded and are identified as follows:

Figure 7, 8	Type A	100 Ω
9, 10	A	39.2K Ω
11, 12	A	100K Ω
13, 14	Type B	100 Ω
15, 16	B	39.2K
17, 18	B	100K Ω
19, 20	Type C	100 Ω
21, 22	C	39.2K Ω
23, 24	C	100K Ω

Conclusions and analysis of this data is not anticipated until completion of the 2000 hour life test.

3.0 Analysis

3.1 Based on correlation coefficients the regression lines were plotted for Burn-in vs Life Test. From this information additional studies are recommended. This is to be performed as described in paragraph

2.1.

Certain anomolies exist in the infra-red data such as skewed traces, unexplained dips, etc. No attempt is anticipated to explain these anamolies until the 2000 hour life test is completed, at which time the resistors in question may be dismantled.

3.2 Regression lines for Temperature-Cycle vs Life Test will be plotted and analysed during the next quarter.

The 2000 hour Life Test will continue.

Determination of Acceleration Factor studies will continue.

TABLE 1

Sample Correlation Coefficients and Population Correlation coefficient limits at 95% confidence level for Screen Test data vs Life Test data:

$\rho(1-\alpha)$ = Upper population correlation coefficient

$\rho(\alpha)$ = Lower population correlation coefficient

r = Sample correlation coefficient

n = Sample size

α = Confidence Level (.025)

Table 2

100 At 1X Rated Power

		n	Temp. Cycle vs Load Life ρ(α)	r	ρ(1-α)	Burn In vs Load Life ρ(α)	r	ρ(1-α)	Initial Noise vs Load Life ρ(α)	r	ρ(1-α)
25°C	Process A	10	.72	.21	-.46	.03	-.62	-.87	.68	.16	-.50
	B	10	.64	.064	-.57	.82	.44	-.25	.88	.48	-.20
	C	10	.71	.20	-.47	.68	.15	-.50	.85	.54	-.12
70°C	Process A	15	.65	.23	-.30	.80	.50	-.02	.79	.49	-.03
	B	15	.15	-.38	-.74	.75	.42	-.12	.55	.076	-.45
	C	15	.25	-.30	-.68	.52	.002	-.47	.78	.48	-.03
125°C	Process A	15	.64	.21	[illegible]	.77	.47	-.07	.57	.11	-.42
	B	15	.79	.49	[illegible]	.57	.11	-.42	.56	.09	-.43
	C	15	.50	-.02	[illegible]	.43	-.09	-.56	.86	.64	.18
150°C	Process A	15	.54	.06	-.45	.54	.06	-.45	.54	.063	-.45
	B	15	.52	.029	-.47	.69	.30	-.25	.63	.21	-.34
	C	15	.51	.008	-.50	.57	.097	-.42	.73	.38	-.15

100 At 2 1/2 X Rated Power

		n	Temp. Cycle vs Load Life ρ(α)	r	ρ(1-α)	Burn In vs Load Life ρ(α)	r	ρ(1-α)	Initial Noise vs Load Life ρ(α)	r	ρ(1-α)
25°C	Process A	10	.65	.09	-.55	.30	-.38	-.77	.92	.74	.20
	B	10	.51	-.14	-.68	.27	-.42	-.81	.53	-.11	-.66
	C	10	.70	.18	-.47	.82	.46	-.23	.35	-.34	-.78
70°C	Process A	15	.35	-.18	-.62	.75	.40	-.15	.77	.46	-.07
	B	15	.51	.09	-.43	.72	.35	-.20	.74	.39	-.15
	C	15	.44	-.08	-.50	.68	.30	-.25	.59	.14	-.38
125°C	Process A	10	.84	.50	-.18	.77	.34	-.35	.68	.15	-.50
	B	10	.78	.36	-.33	.68	.16	-.50	.82	.43	-.34
	C	10	.66	.10	-.55	.67	.12	-.52	.75	.30	-.39
150°C	Process A	5	.92	.48	-.60	.86	.20	-.75	.99	.90	.10
	B	5	.84	.08	[illegible]	.88	.32	-.70	.94	.58	-.52
	C	5	.97	.75	[illegible]	.82	0	-.82	.85	.15	-.77

Table 3

			Temp. Cycle vs Load Life			Burn In vs Load Life			Initial Noise vs Load Life		
		n	$\rho(\alpha)$	r	$\rho(1-\alpha)$	$\rho(\alpha)$	r	$\rho(1-\alpha)$	$\rho(\alpha)$	r	$\rho(1-\alpha)$
100 At 5X Rated Power											
25°C	Process A	15	.88	.68	.27	.87	.66	.22	.60	.14	-.38
	B	15	.60	.14	-.38	.79	.49	-.03	.50	.005	-.50
	C	15	.78	.47	-.05	.66	.25	-.30	.51	.014	-.49
70°C	Process A	10	.61	.011	-.60	.74	.25	-.43	.95	.81	.33
	B	10	.62	.019	-.59	.62	.024	-.58	.72	.23	-.43
	C	10	.91	.71	.15	.92	.78	.20	.98	.93	.75
125°C	Process A	5	.83	.075	-.79	.88	.29	-.71	.95	.67	-.44
	B	55	.95	.62	-.48	.88	.28	-.72	.92	.51	-.57
	C	5	.98	.89	.05	.97	.79	-.25	.84	.098	-.73
150°C	Process A	5	.96	.71	-.38	.97	.80	-.23	.85	.12	-.77
	B	5	.98	.88	.05	.87	.24	-.73	.94	.60	-.50
	C	5	.86	.19	-.75	.83	.065	-.80	.95	.67	-.43
100 At 10 X Rated Power											
25°C	Process A	10	.86	.55	-.12	.67	.12	-.53	.80	.38	-.32
	B	10	.75	.28	-.40	.71	.20	-.47	.66	.10	-.64
	C	10	.92	.72	.16	.74	.26	-.42	.68	.14	-.50
70°C	Process A	5	.85	.16	-.76	.96	.72	-.35	.90	.37	-.67
	B	4	.89	.06	[illegible]	.89	.068	-.87	.9[illegible]	.49	-.75
	C	5	.99	.97	[illegible]	.86	.18	-.75	[illegible]	.16	-.76
125°C	Process A	5	.94	.39	-.78	.82	0	-.82	.93	.56	-.54
	B	3	.97	.32	-.94	1.00	.98	-.40	1.00	.98	-.40
	C	5	.88	.052	-.87	.87	.21	-.74	.87	.22	-.74
150°C	Process A	4	.90	.14	-.65	.98	.82	-.47	.94	.42	-.77
	B	4	.97	.66	-.65	.96	.55	-.72	.99	.94	-.05
	C	4	.99	.94	-.65	.96	.55	-.72	[illegible]	.58	-.70

Table 4

			Temp. Cycle vs Load Life				Burn In vs Load Life			Initial Noise vs Load Life		
		n	ρ(1-α)	r	ρ(α)		ρ(1-α)	r	ρ(α)	ρ(1-α)	r	ρ(α)
39.2K Value at 1X rated power												
25°C	Process A	10	.75	.27	-.40		.81	.42	-.27	.61	.017	-.54
	B	10	.57	.014	-.50		.80	.39	-.30	.60	0	-.55
	C	10	.78	.34	-.35		.87	.60	-.05	.77	.33	-.35
70°C	Process A	15	.56	.073	-.43		.87	.68	.25	.60	.15	-.37
	B	15	.52	.02	-.47		.55	.068	-.45	.54	.056	-.45
	C	15	.62	.19	[illegible]		.69	.30	-.25	.67	.26	-.30
125°C	Process A	15	.82	.57	[illegible]		.86	.67	.23	.88	.70	.27
	B	15	.71	.34	[illegible]		.83	.58	.10	.92	.78	.42
	C	15	.69	.30	[illegible]		.83	.58	.10	.91	.77	.40
150°C	* 14 units											
	Process A	15	.92	.79	.47		.51	* .019	-.49	.52	.02	-.47
	B	15	.58	.12	-.42		.53	.027	-.48	.65	.22	-.32
	C	15	.57	.11	-.42		.60	.14	-.38	.58	.12	-.40
39.2K Value a [illegible] Rated Power												
25°C	Process A	10	.63	.040	[illegible]		.91	.70	.10	[illegible]	.29	-.39
	B	10	.89	.65	.02		.84	.49	-.18	.70	.17	-.48
	C	10	.72	.21	-.47		.73	.24	-.43	.60	.00	-.55
70°C	* 14 units											
	Process A	15	.99	.96	.87		.62	* .18	-.35	.98	.95	.85
	* 13 units											
	B	13	.85	.62	.15		.70	.32	-.25	.68	* .22	-.40
	C	15	.78	.48	-.03		.77	.45	-.08	.58	.13	-.40
125°C	Process A	10	.75	.28	-.40		.65	.08	-.55	.73	.25	-.42
	B	10	.73	.23	-.43		.62	.003	-.60	.60	0	-.60
	C	10	.63	.05	-.57		.67	.11	-.52	.70	.17	-.48
150°C	Process A	5	.92	.49	-.58		.96	.72	-.36	.89	.34	-.68
	B	5	.91	.43	-.62		.85	.12	-.77	.91	.42	-.64
	C	5	.93	.56	-.55		.88	.31	-.70	.98	.86	-.20

Table 5

			Temp. Cycle vs Load Life			[illegible]	Burn In vs Load Life			Initial Noise vs Load Life		

39.2K Value [illegible] Rated Power

		n	ρ(α)	r	ρ(1-α)		ρ(α)	r	ρ(1-α)	ρ([illegible])	r	ρ(1-α)
25°C	Process A	15	1.00	.99	.98		1.00	.99	.98	.99	.97	.93
	B	14	.80	.52	.00		.50	.001	-.50	.65	.09	-.42
	C	15	.52	.015	-.48		.65	.24	-.30	.73	.39	-.15
70°C	Process A	10	.93	.76	.23		.97	.93	.70	.65	.085	-.55
	B	10	.70	.18	-.47		.77	.32	-.37	.63	.054	-.57
	C	10	.80	.39	-.30		.60[illegible]	.013	-.55	.62	.044	-.58
125°C	Process A	5* 4	.99	.98	.95		.98	.91*	-.25	.82	.18	-.74
	B	5	.82	.029	-.72		.85	.17	-.75	.96	.75	-.32
	C	5	.98	.78	-.25		.84	.13	-.76	.82	.18	-.74
[illegible]0°C	Process [illegible]	5	.93	.53	-.55		.97	.77	-.30	.99	.90	.10
	[illegible]	5	.89	.32	-.70		.92	.44	-.62	.81	0	-.75
	[illegible]	4	.98	.85	-.[illegible]		.87	.25	-.73	.93	.49	-.58

39.2K Value at 10X Rated Power

		n	ρ(α)	r	ρ(1-α)		ρ(α)	r	ρ(1-α)	ρ([illegible])	r	ρ(1-α)
25°C	Process A	10	.69	.16	-.50		.88	.63	0	.75	.30	-.38
	B	6	.77	.024	-.15		.87	.35	-.35	.78	.20	-.67
	C	9	.76	.24	-.47		.86	.086	-.58	.78	.32	-.42
70°C	Process A	5	.82	--0	-.80		.97	.87	-.05	.82	0	-.82
	B	1	---	----	----		----	----	----	----	----	----
	C	0	---	----	----		----	----	----	----	----	----
125°C	Process A	5	.90	.39	-.65		.82	.016	-.80	.97	.80	-.23
	B	3	.96	.15	-.95		.97	.35	-.93	.95	0	-.96
	C	0	---	---	----		----	----	----	---	---	----
150°C	Process A	5	.95	.64	-.46		.88	.10	-.77	.88	.098	-.78
	B	1	----	----	----		----	---	----	---	----	----
	C	0	----	----	----		----	---	----	---	----	----

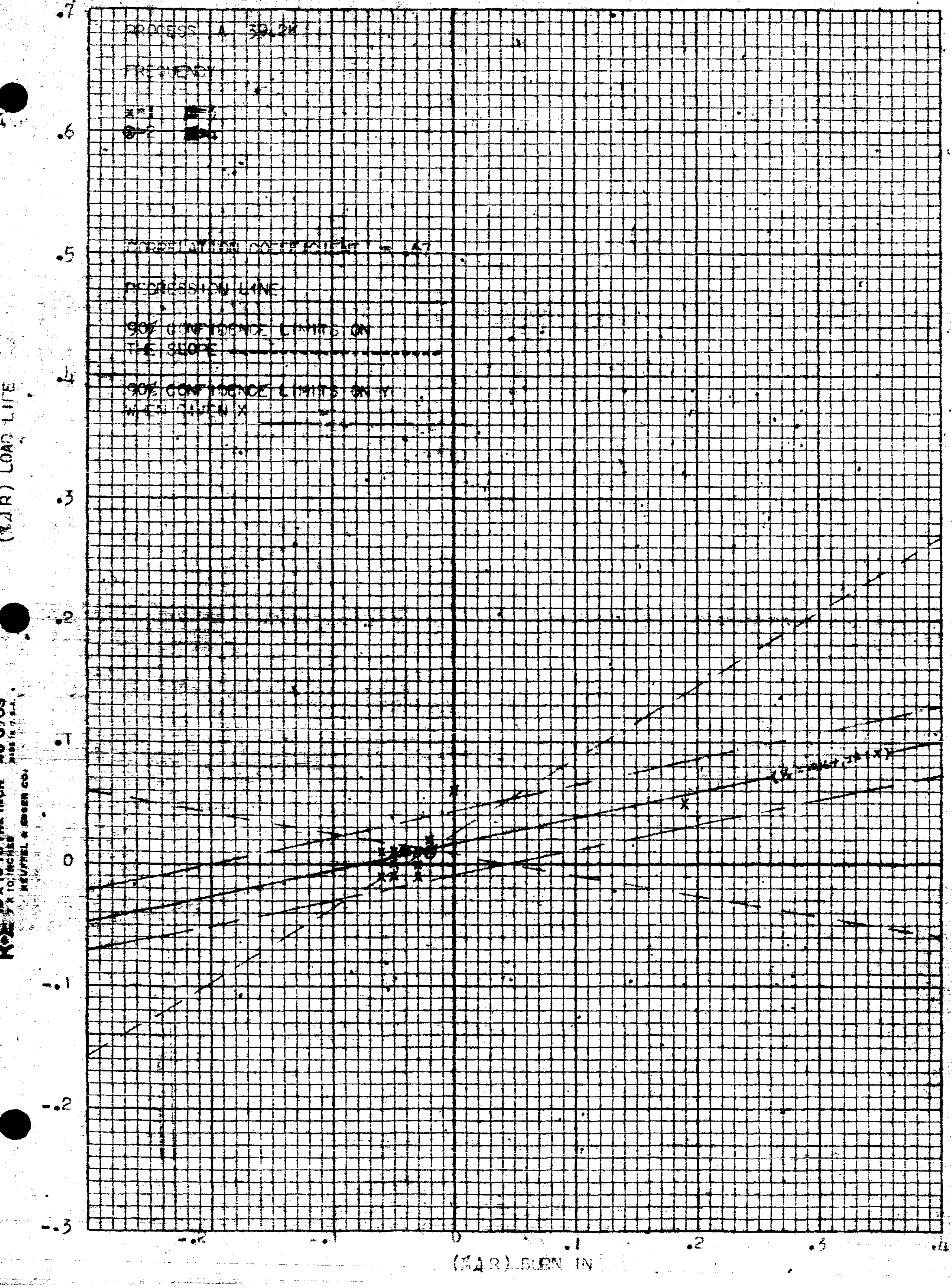
ANALYSIS OF VARIANCE

Table 6

	Variance 100 Ω					Mean 39.2 K			
	Method I		Method II			Method I		Method II	
	Same Var.	Diff't Var.	Same Mean.	Diff't Mean		Same Var.	Diff't Var.	Same Mean	Diff't Mean
A-				*** ΔR Temp. Cycle ***					
A-B		x		x			x	x	
A-C		x		x		x		x	
B-C		x	x				x		x
				*** ΔR STOL ***					
A-B	x		x			x		x	
A-C		x	x	x		x		x	
B-C		x		x		x		x	
				*** ΔR Burn In ***					
A-B		x		x			x	x	
A-C		x		x		x		x	
B-C	x			x			x	x	
				****Initial Noise ***					
A-B		x		x			x	x	
A-C	x		x				x		x
B-C		x		x			x		x
				***Δ Noise-Temp Cycle ***					
A-B	x		x			x		x	
A-C	x		x			x		x	
B-C	x		x			x		x	
				*** Δ Noise STOL***					
A-B	x		x			x		x	
A-C	x		x			x		x	
B-C	x		x			x		x	
				Δ Noise-Burn In					
A-B	x		x			x		x	
A-C			x			x			
B-C	x		x				x		x

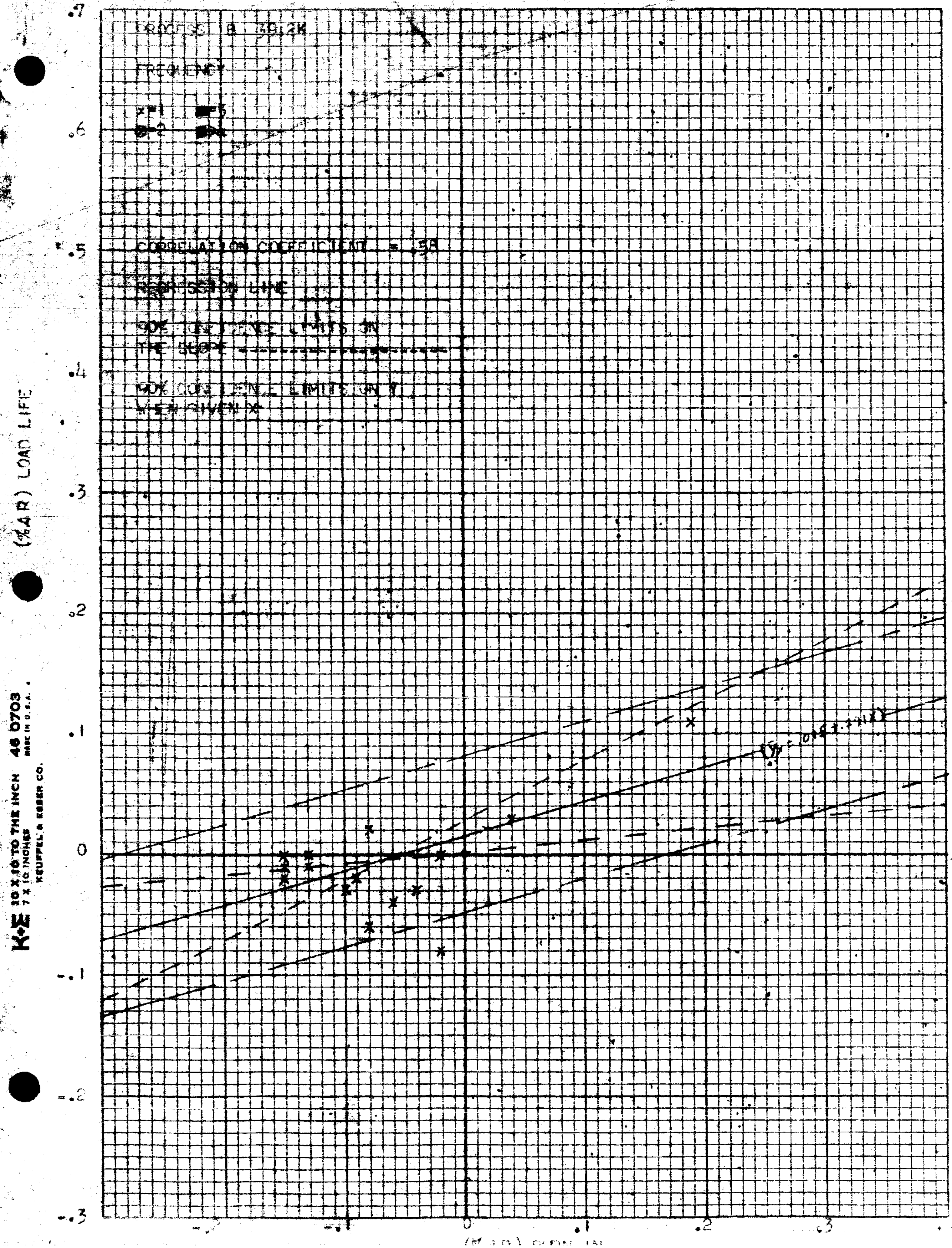
BURN IN Vs. LOAD LIFE

FIGURE 1



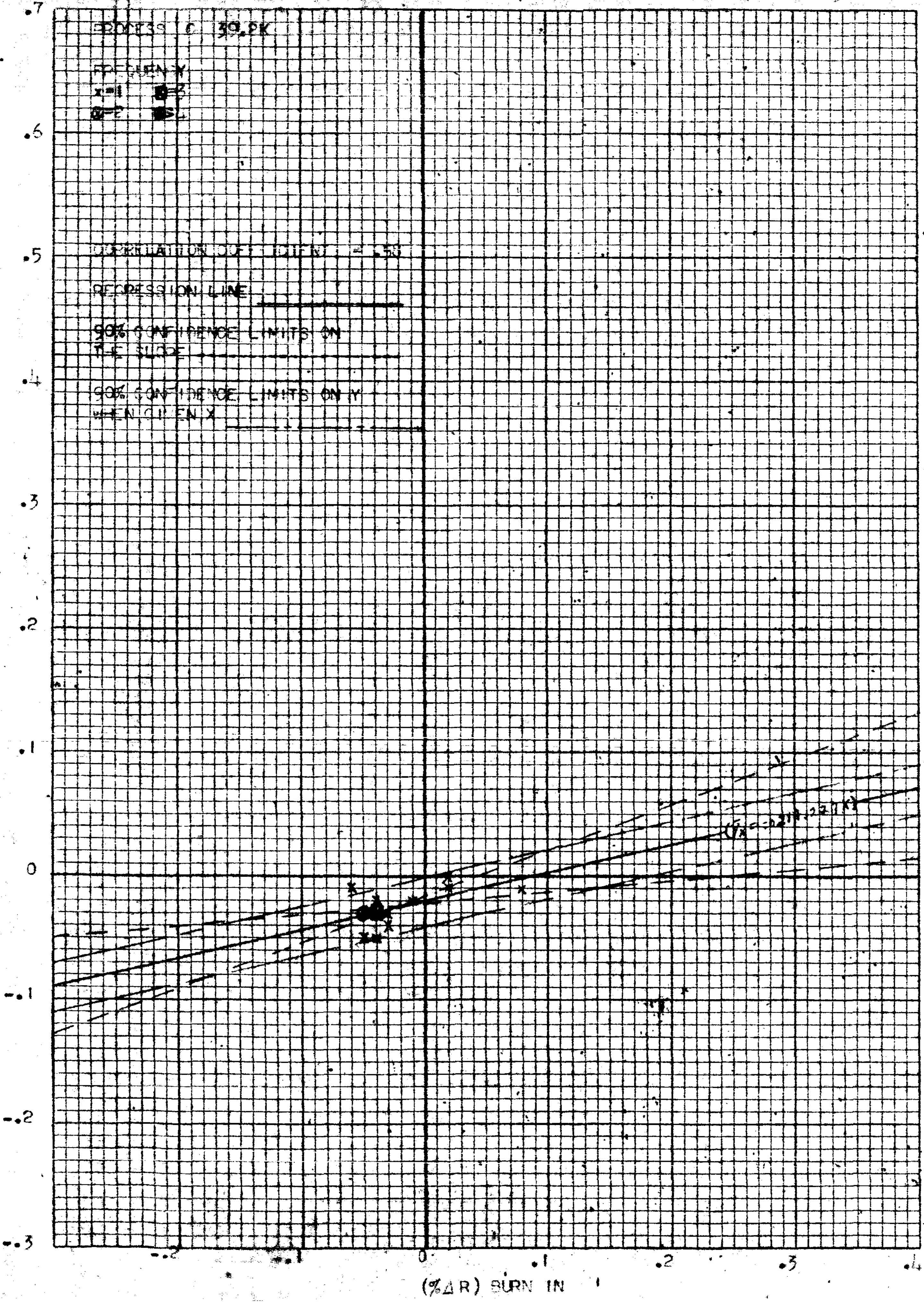
BURN IN Vs. LOAD LIFE

FIGURE 2



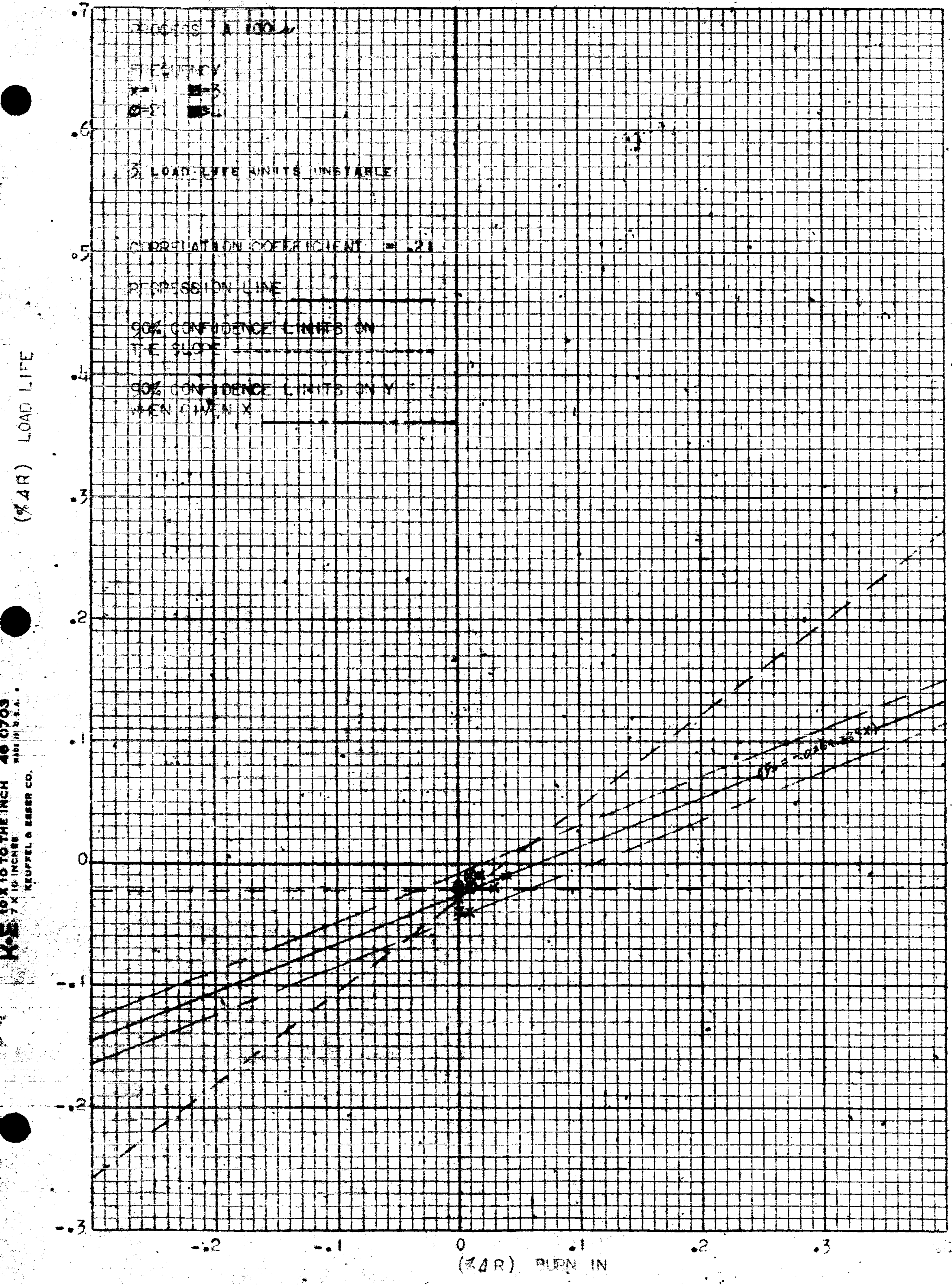
BURN IN Vs. LOAD LIFE

FIGURE 3

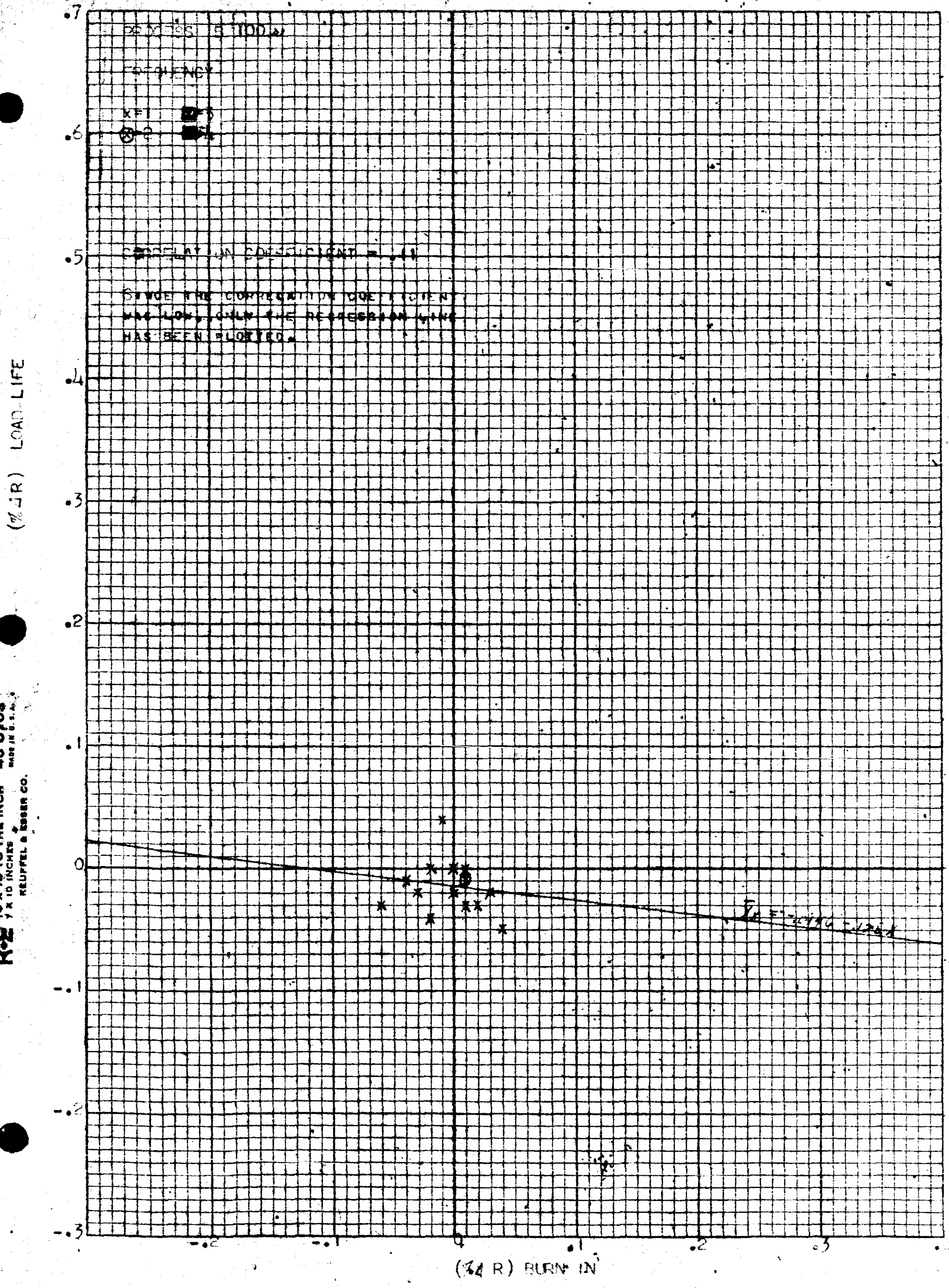


BURN IN VS. LOAD LIFE

FIGURE 4



BURN IN Vs. LOAD LIFE FIGURE 5



BURN IN Vs. LOAD LIFE

FIGURE 6

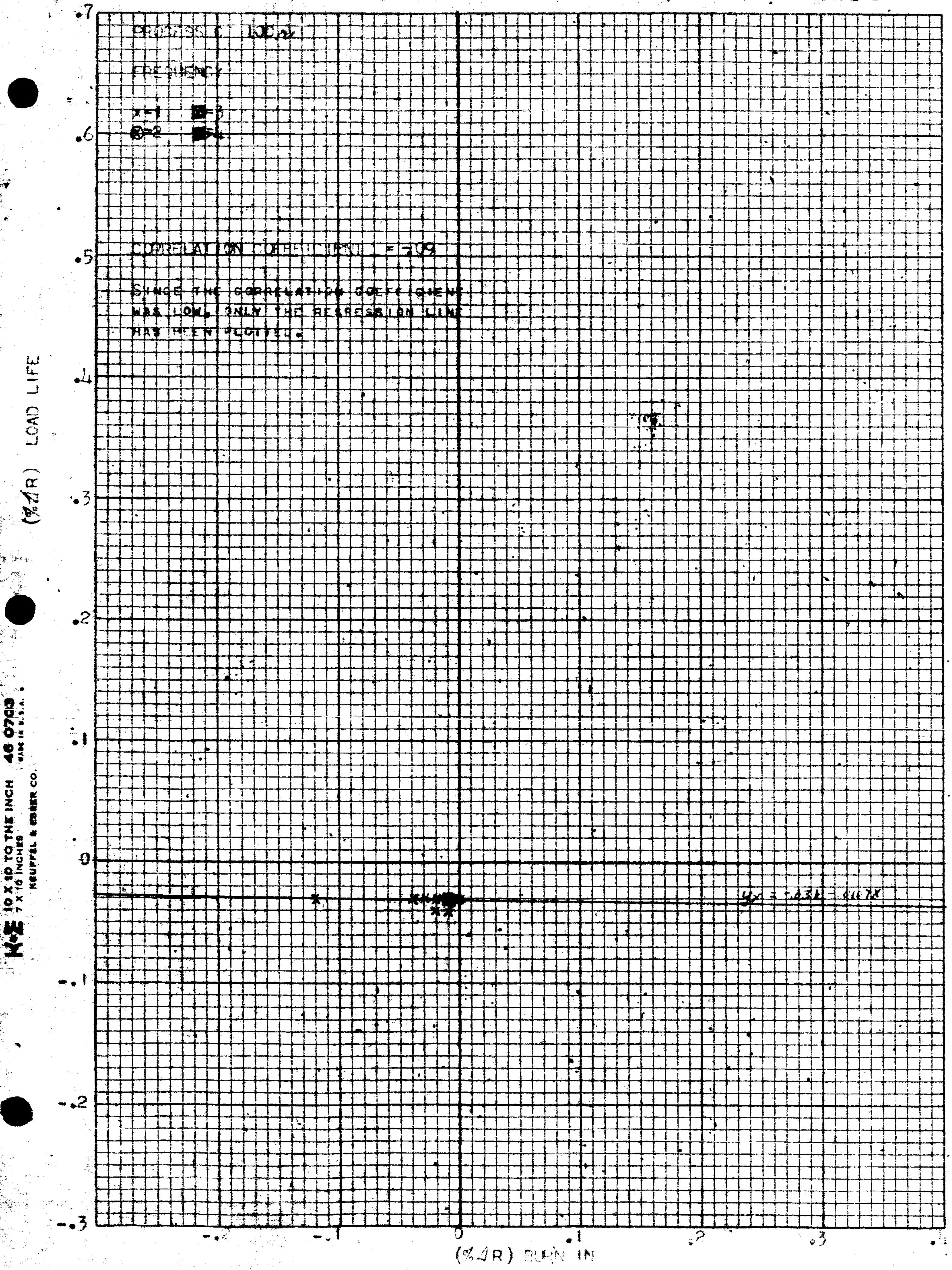


Figure 7

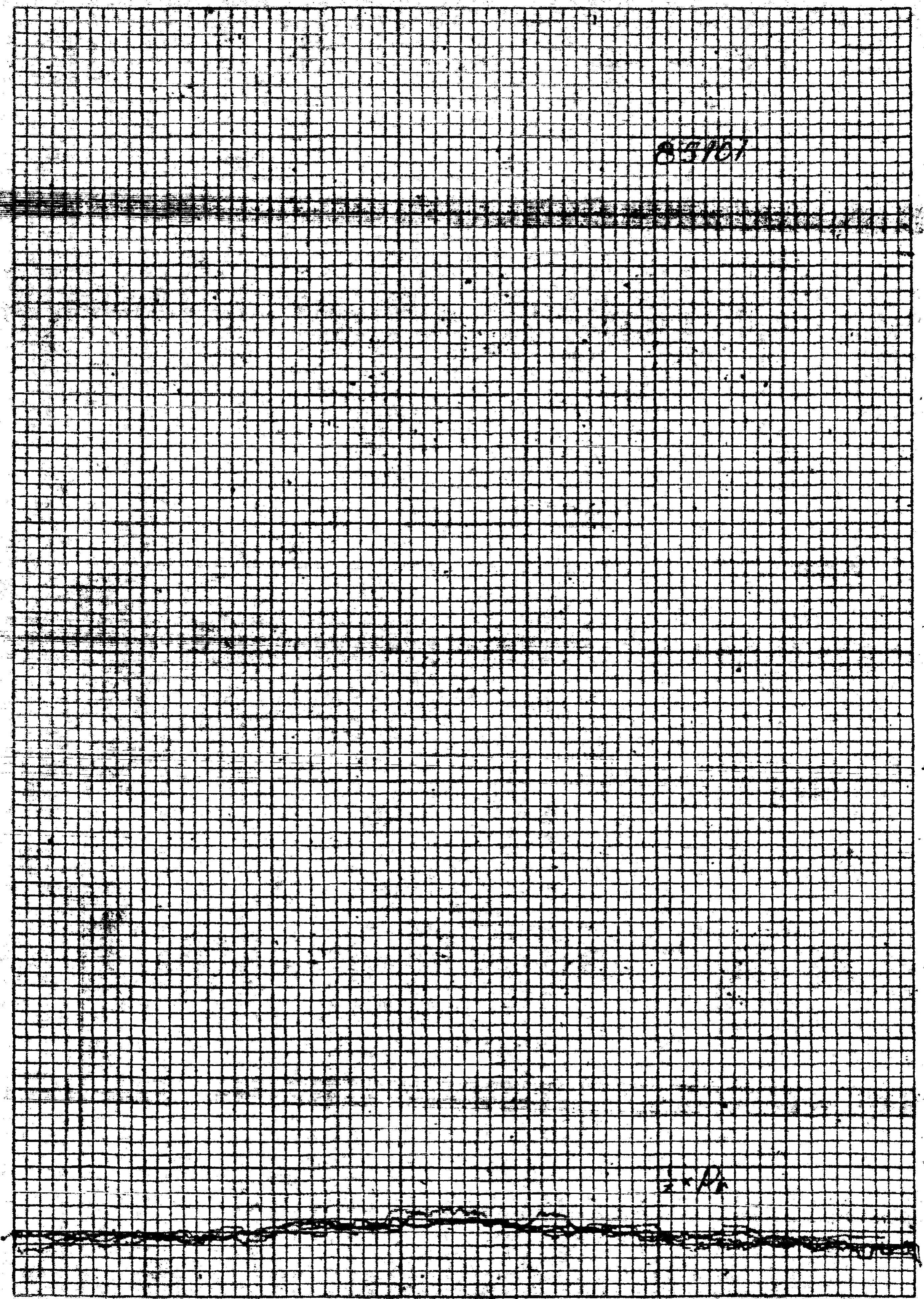


Figure 8

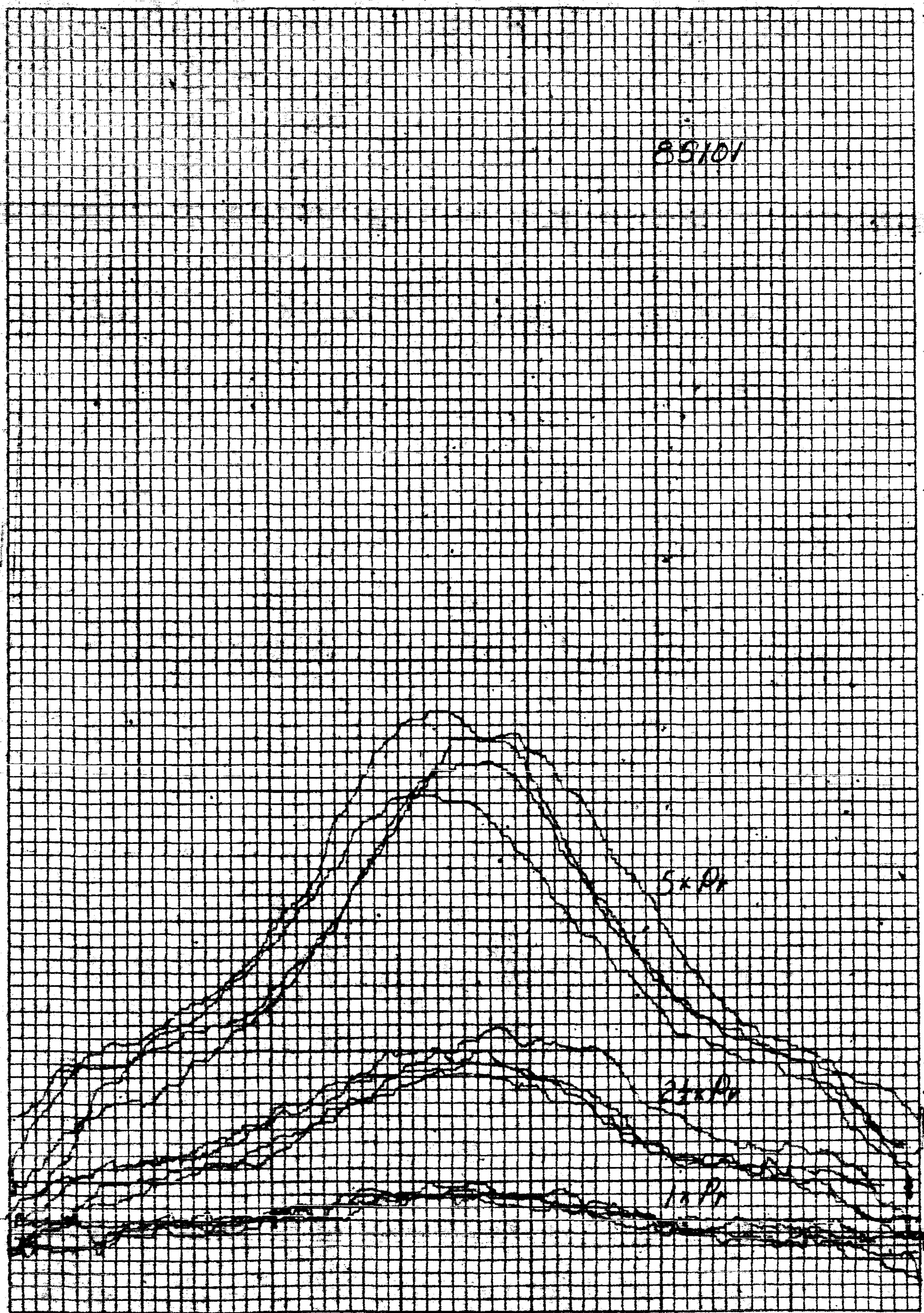


Figure 9

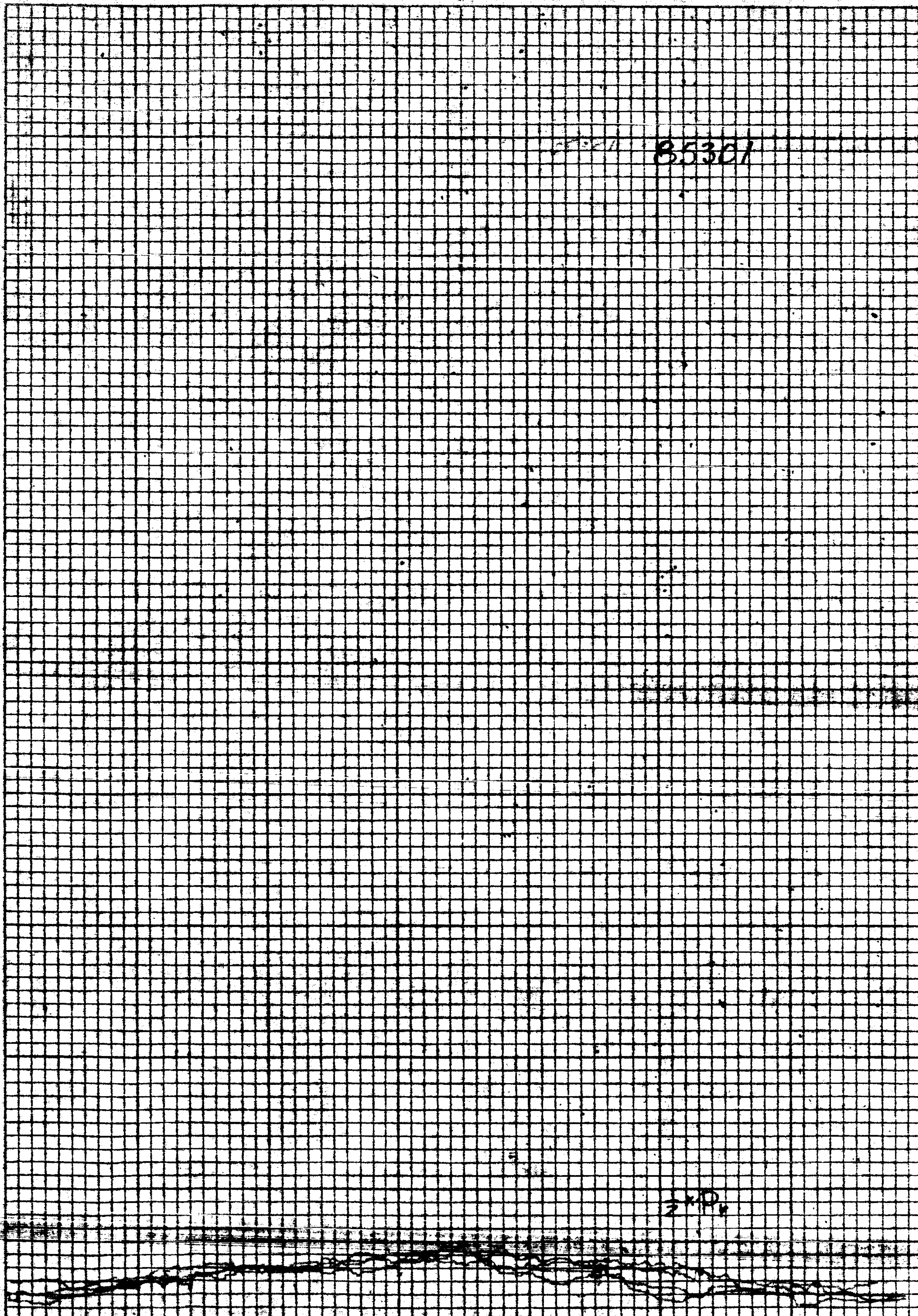


Figure 11

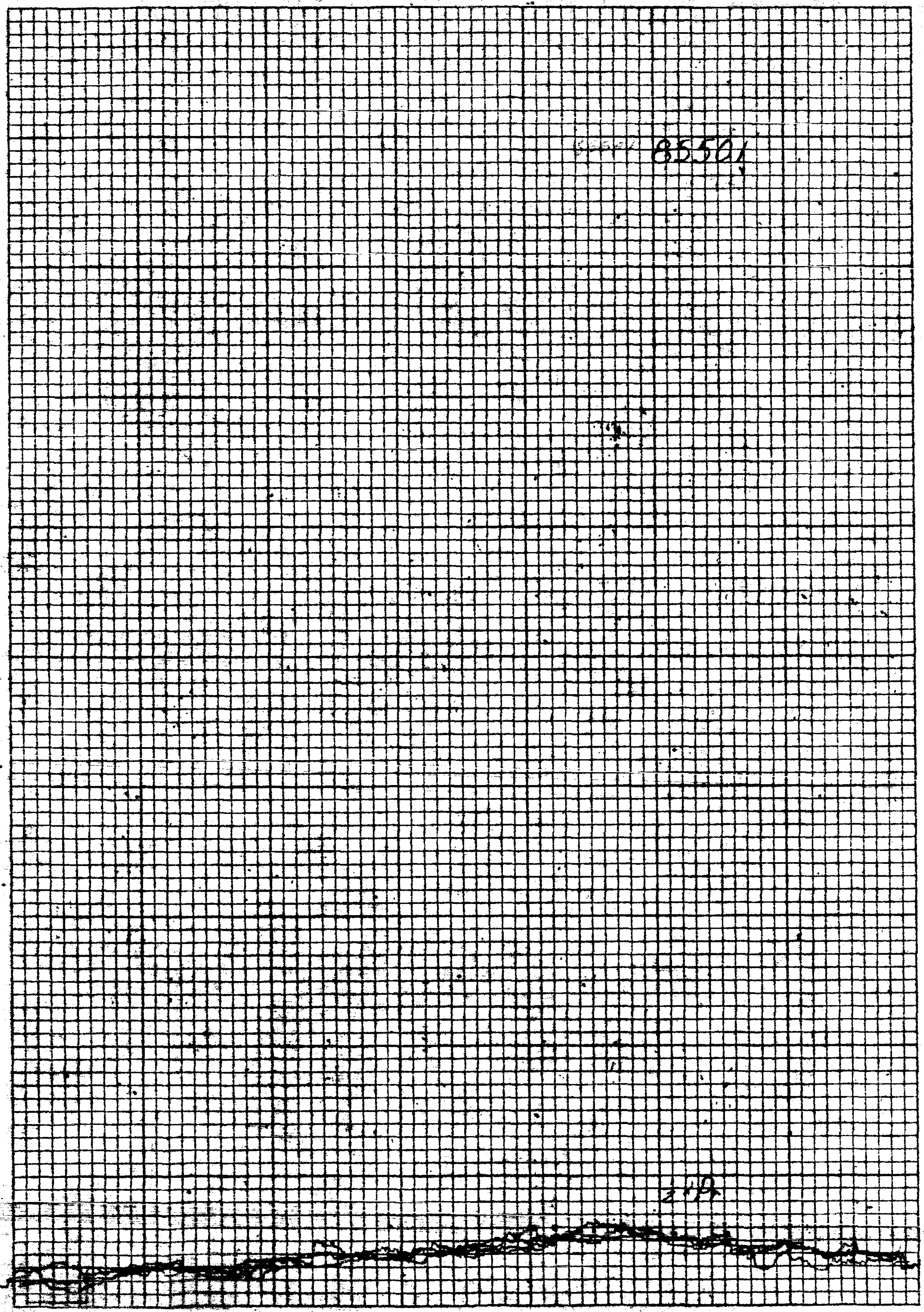
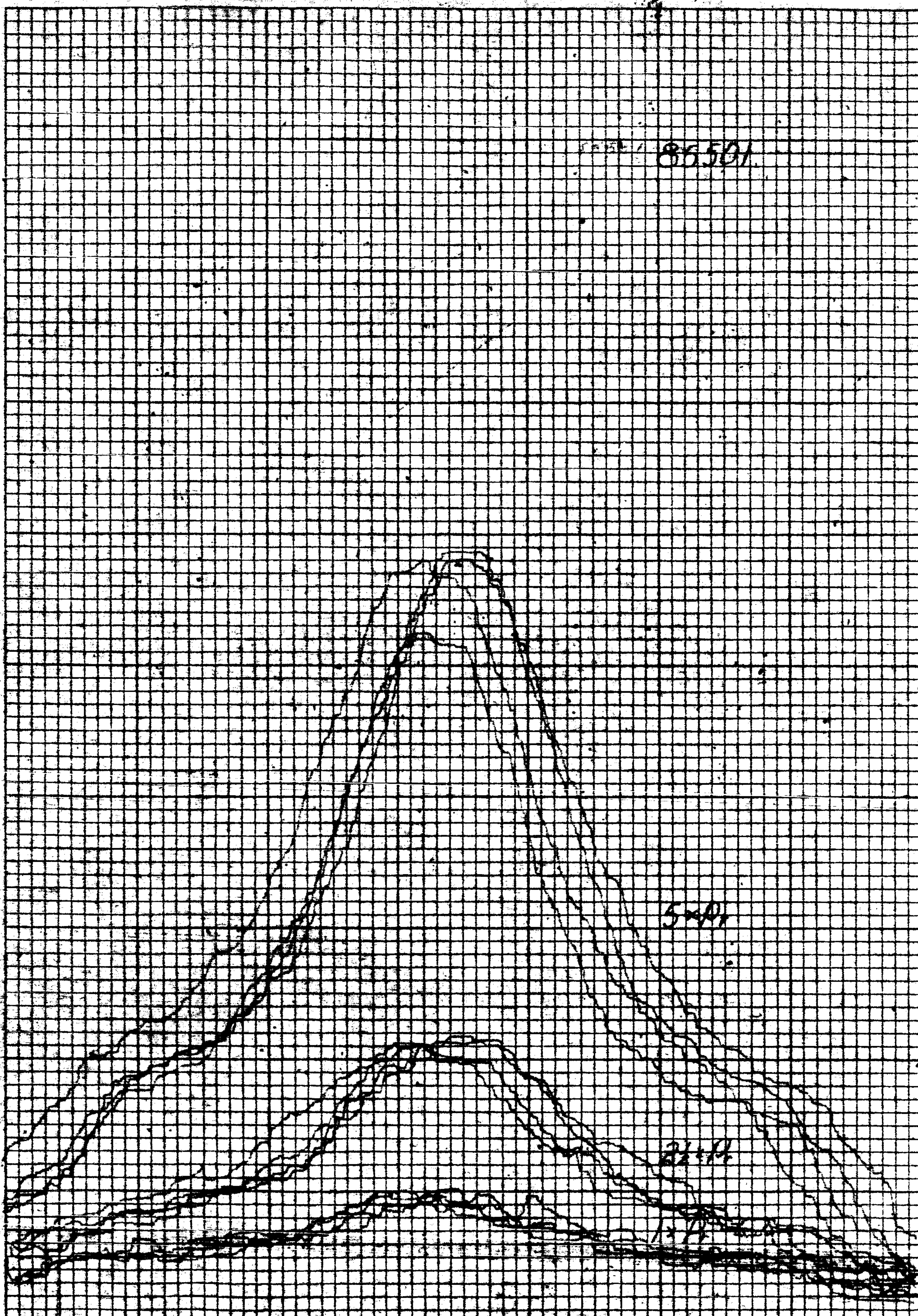


Figure 12



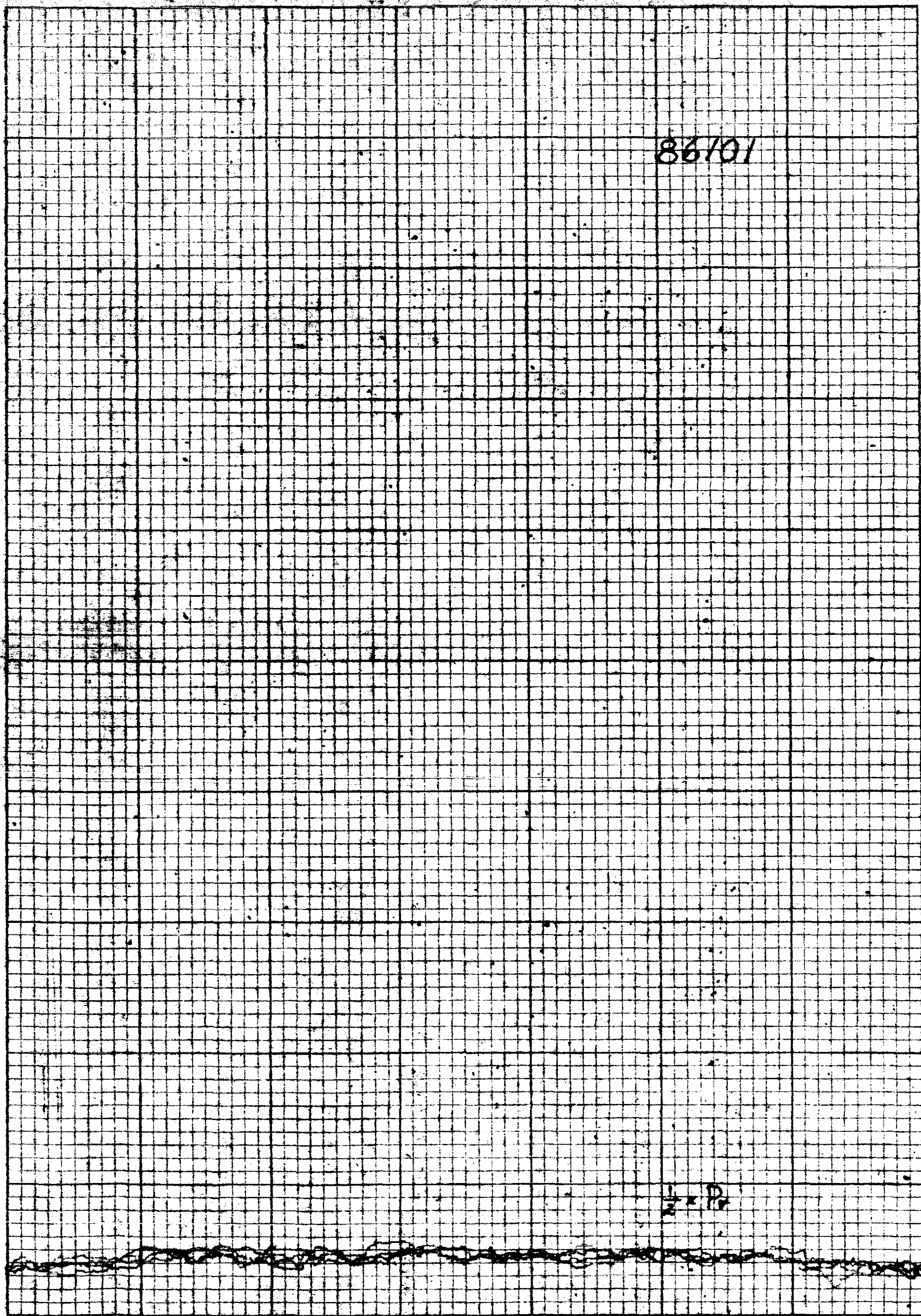

86101
½ x Pr

Figure 14

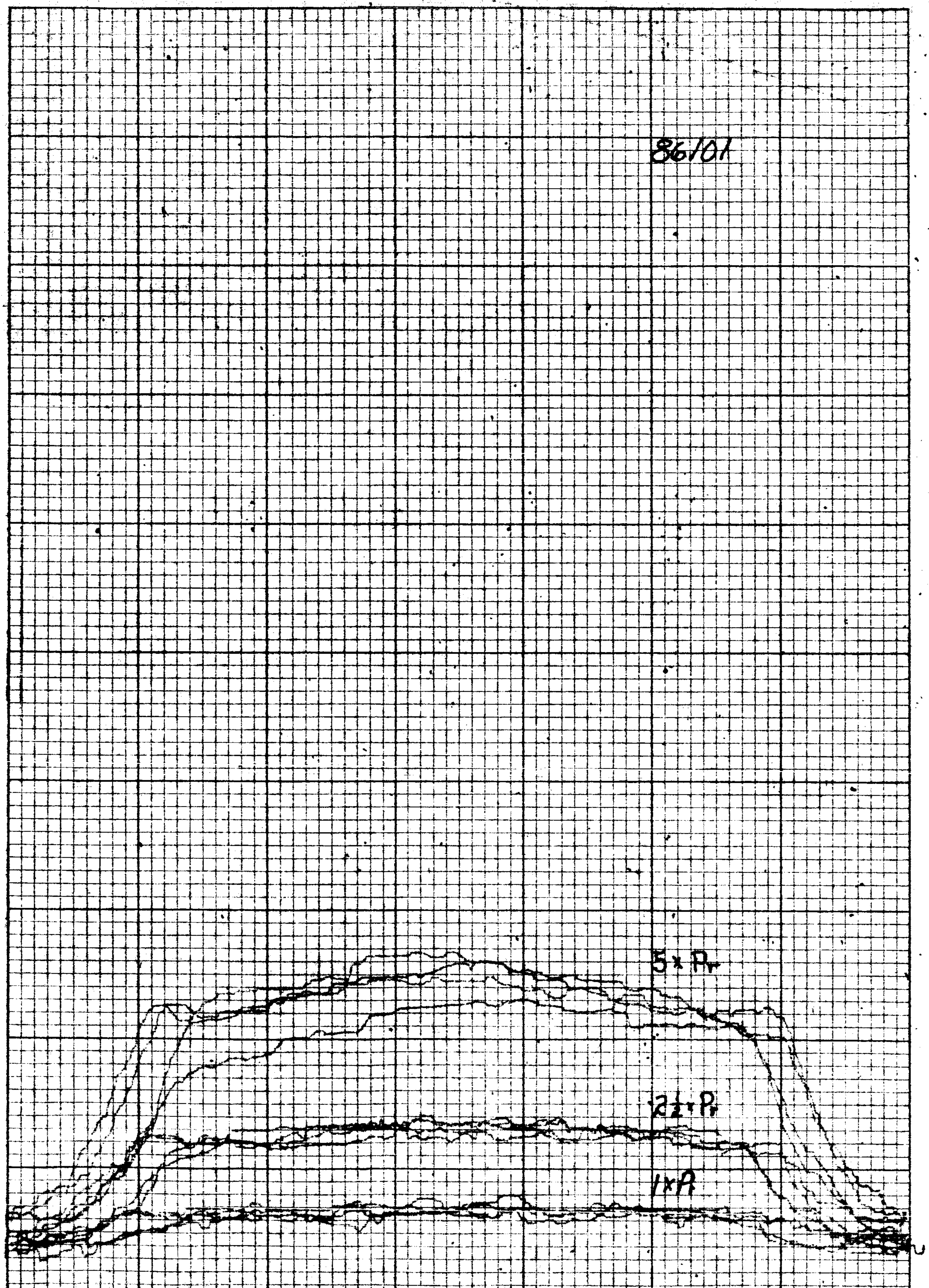


Figure 15

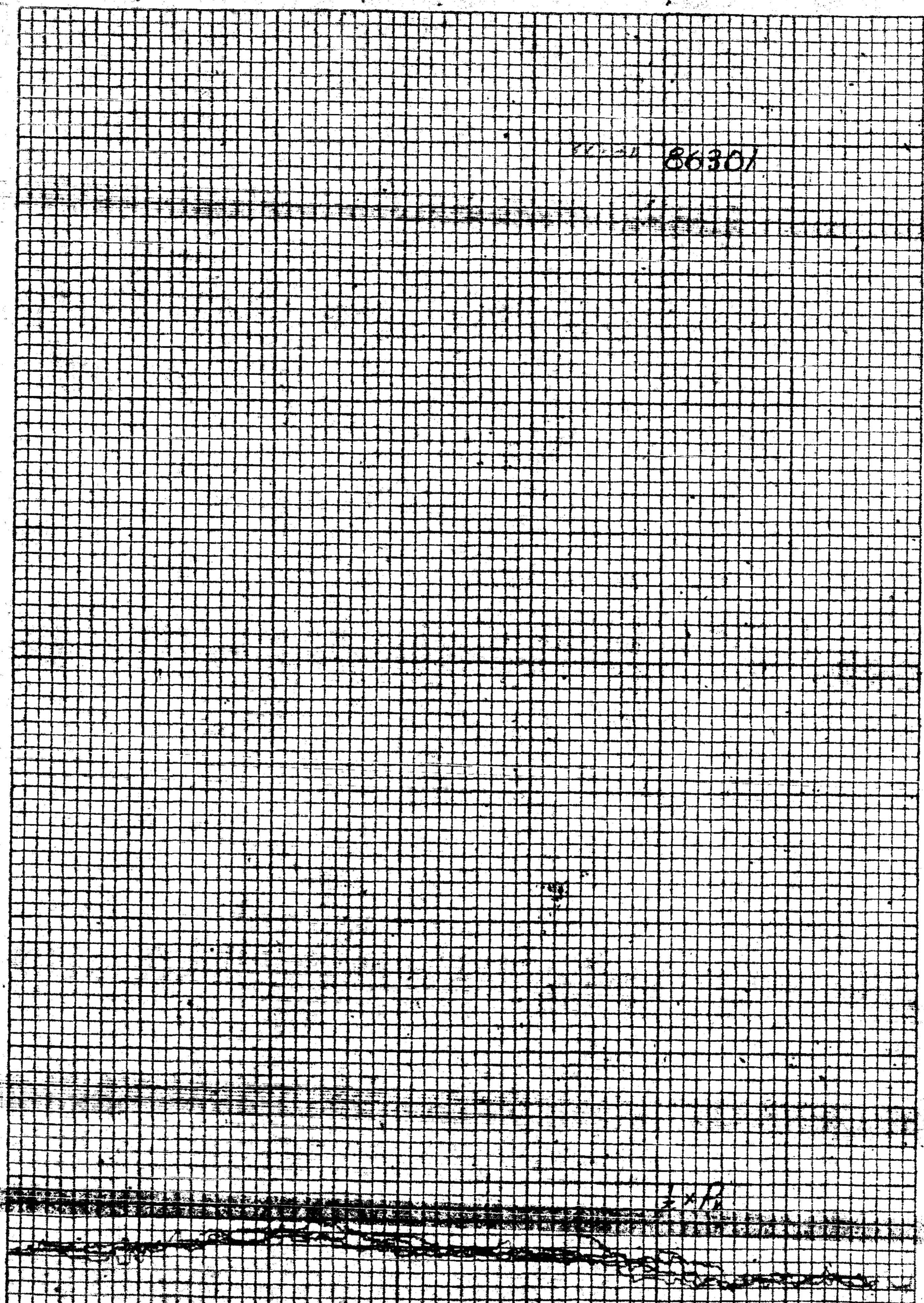


Figure 16

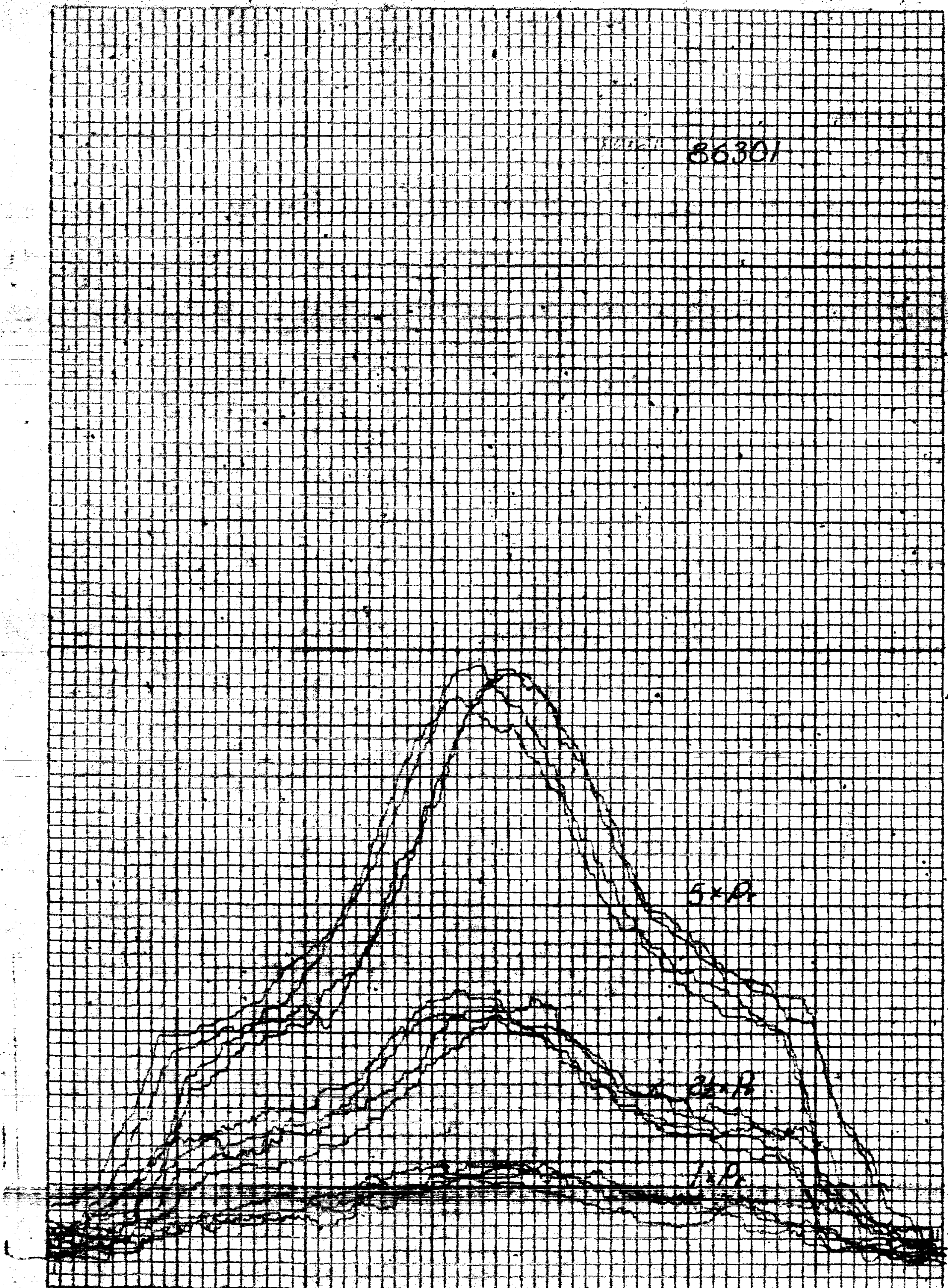
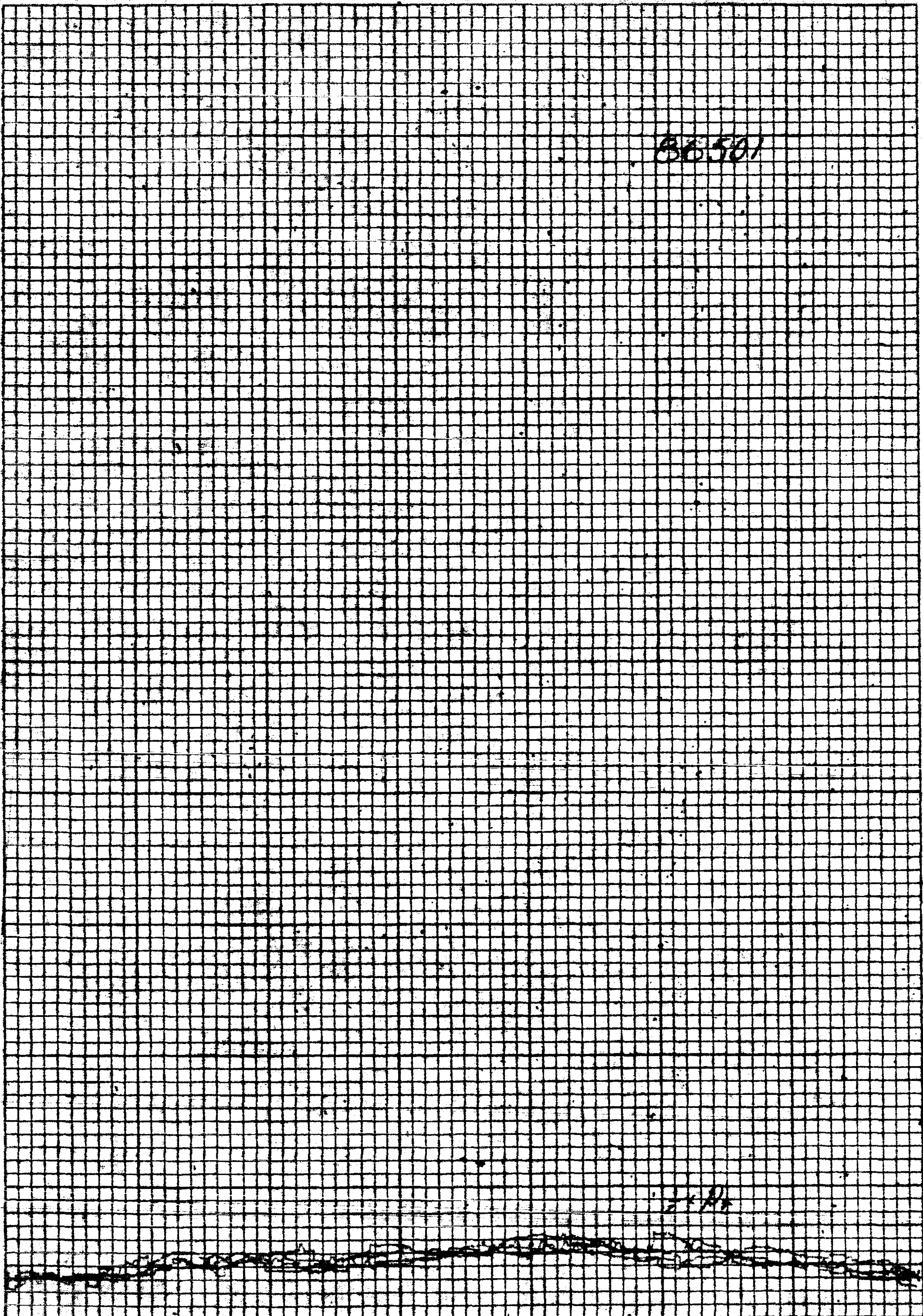


Figure 17



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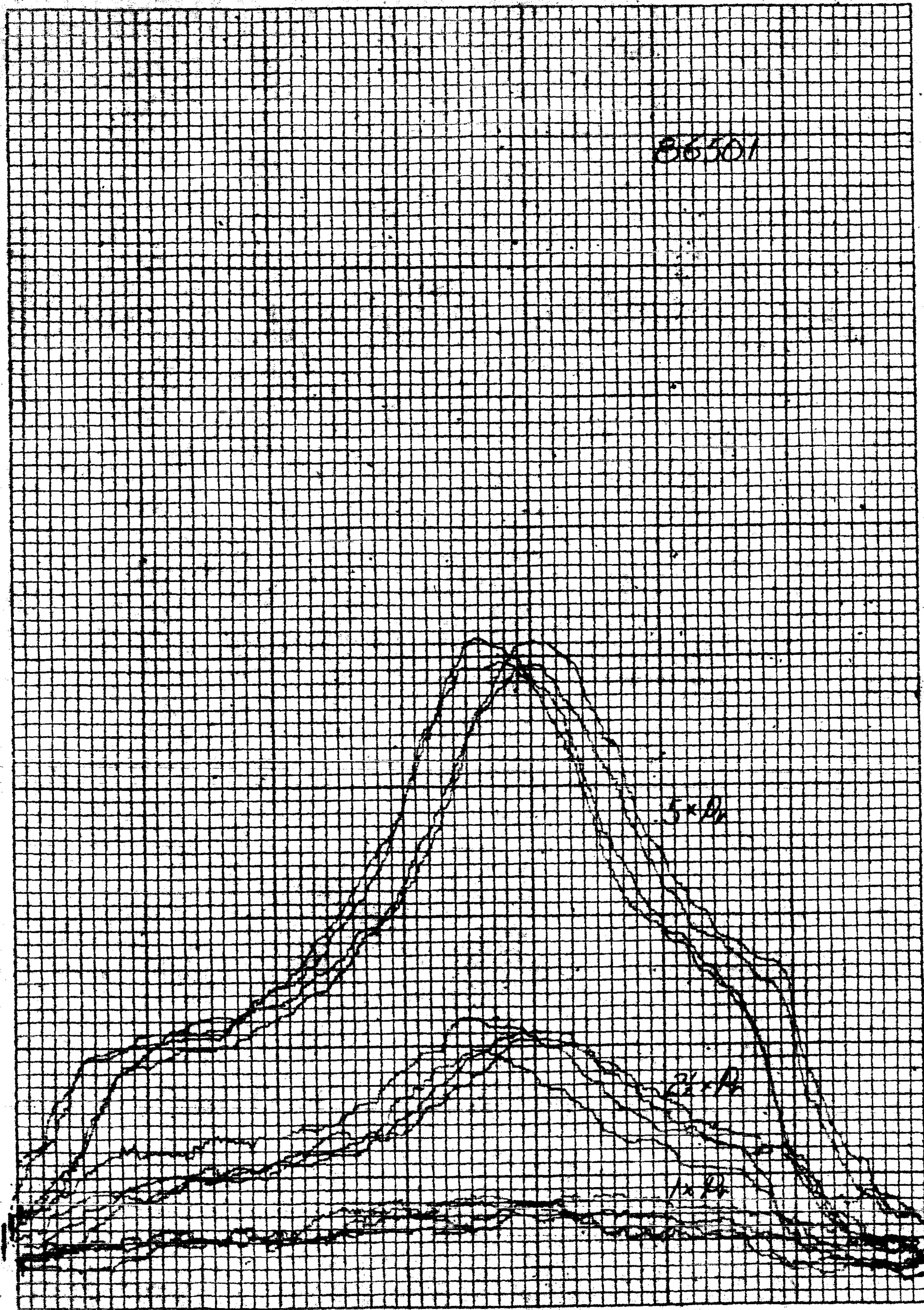
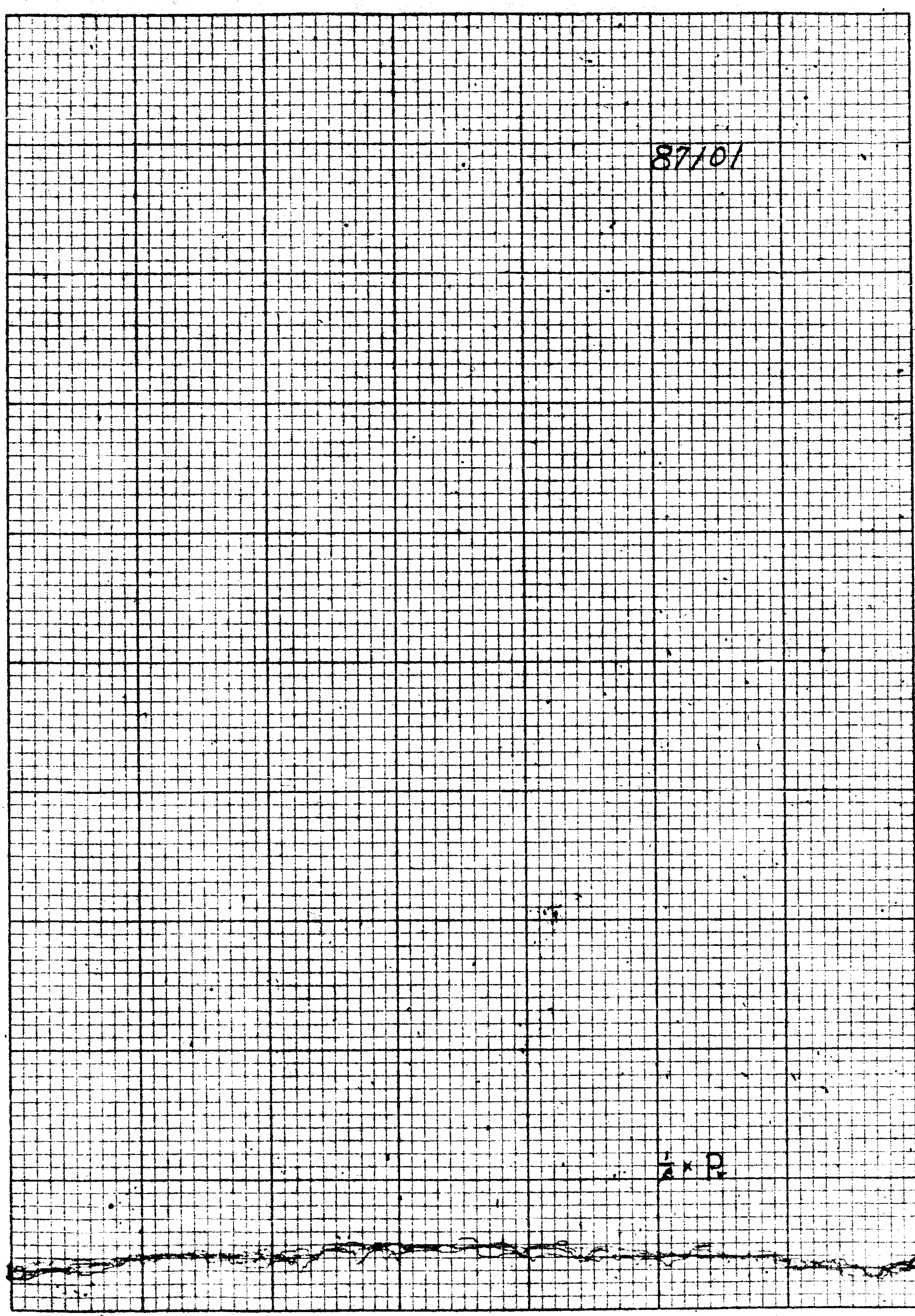


Figure 19



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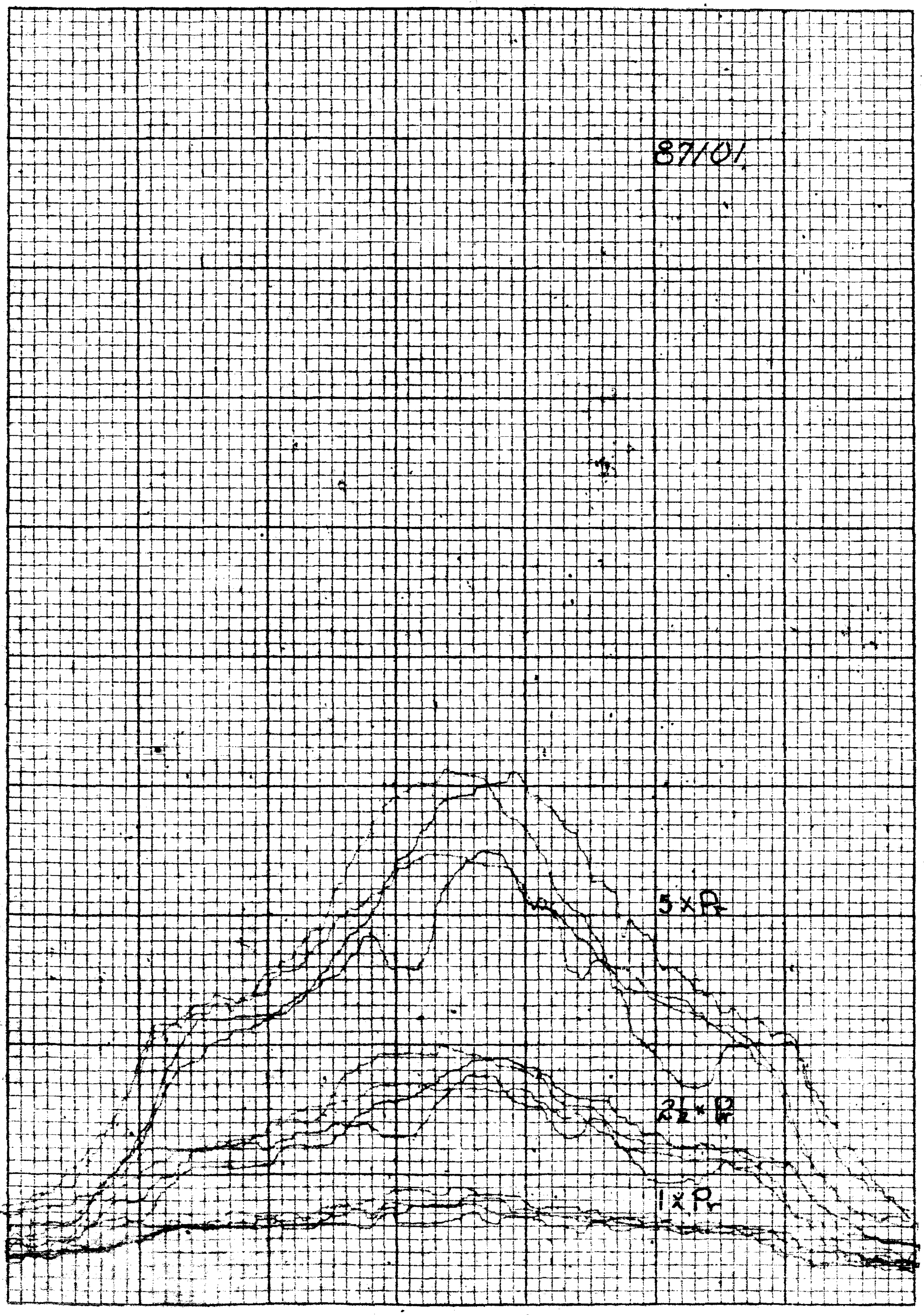

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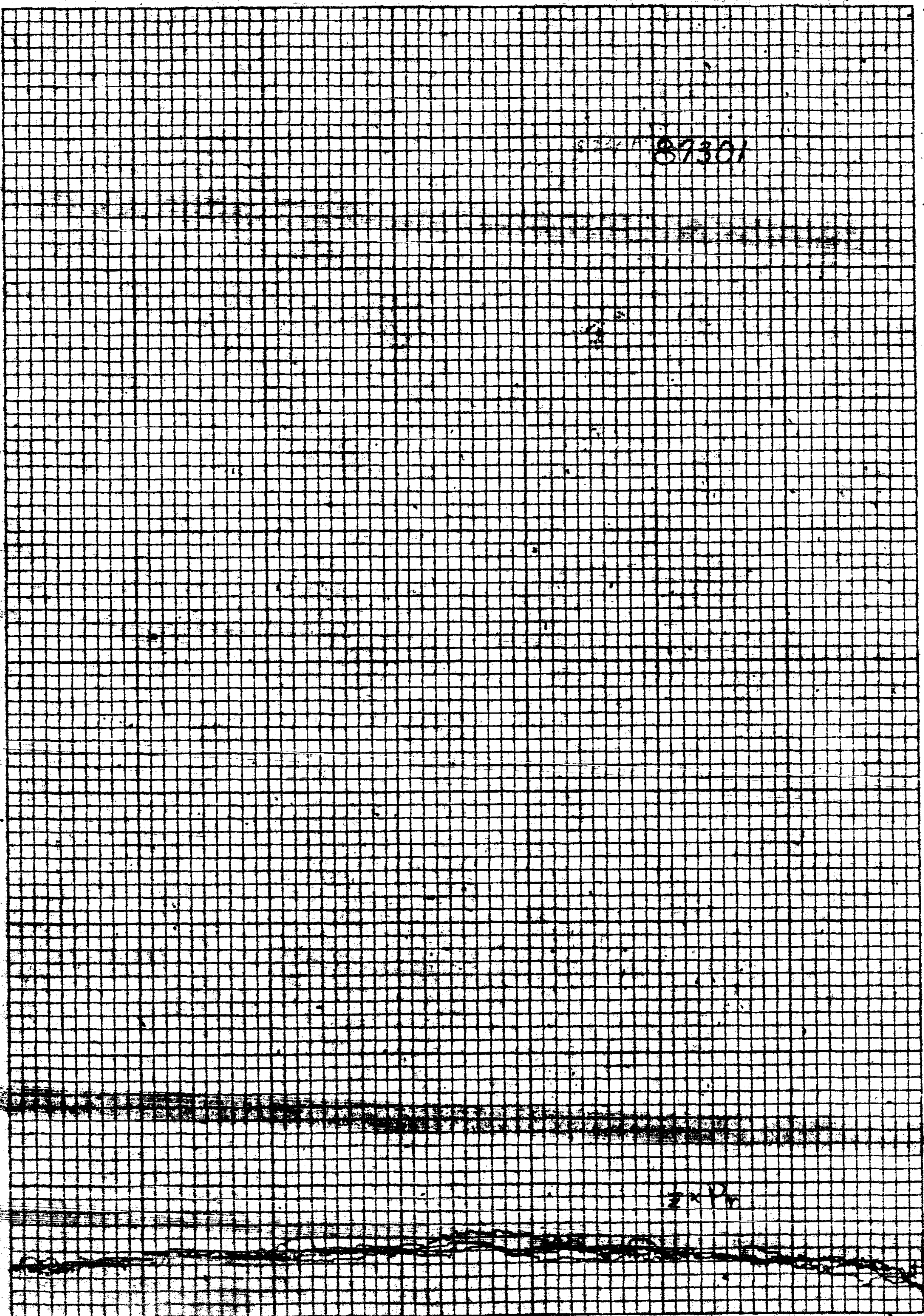

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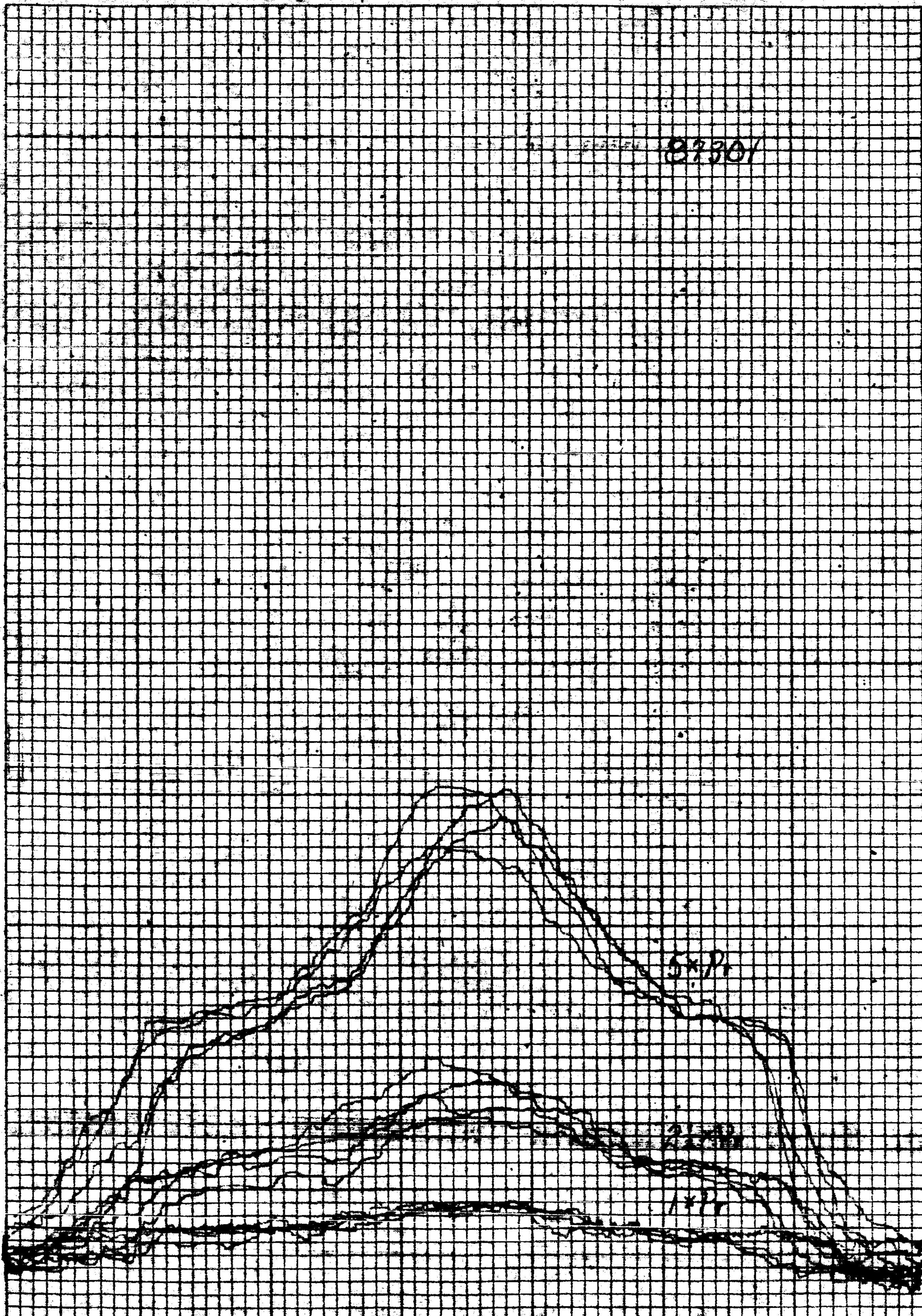
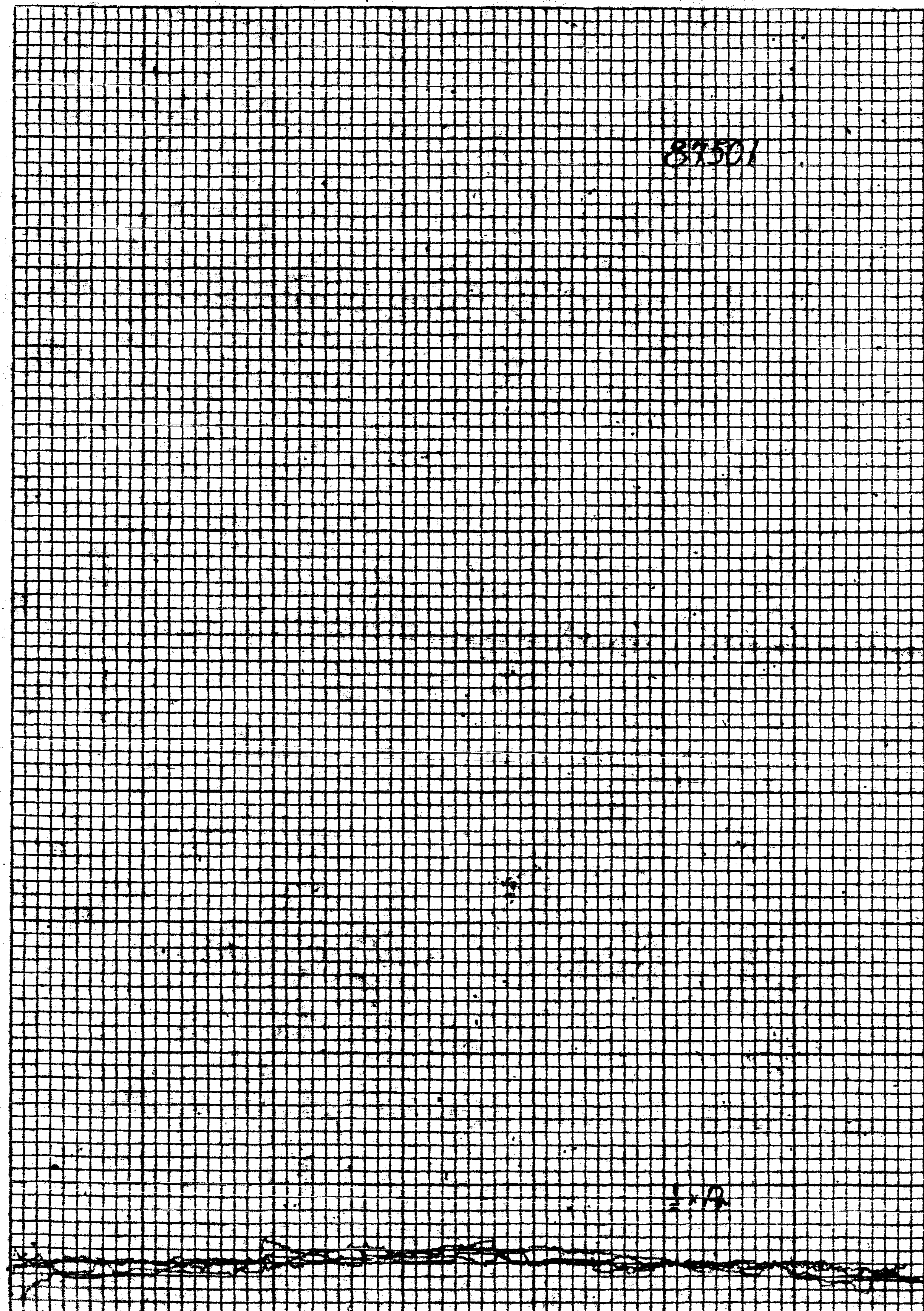


Figure 23



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10X10 TO THE INCH 40-460

Figure 24