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Date 11/8/55 Init. J.F.E.

This Document Consists of 14 Pages and
Pages 6, 7, 8, 9 and 10 of MLM-55-10-26
This is Copy 13 of 13A Series.

Central File No. 55-11-14

November 7, 1955

Mr. Warren R. Grimes
Oak Ridge National Laboratory
P. O. Box P
Oak Ridge, Tennessee

Dear Warren:

Enclosed are pages 6, 7, 8, 9 and 10 from the Monthly Technical Activities Report through October 15, 1955, Mound Laboratory Central Files Number 55-10-26.

In addition to the material from the Technical Activities Report we are including summaries of the work to date on differential thermal analysis, petrographic filtration, viscosity and density measurements.

As you will recall we are expecting to visit you November 15 and 16 to discuss the present status of the work and a discussion of the future work. At this stage it seems possible that the density and viscosity equipment could be used on a new ternary system such as the $NaF-LiF-BeF_2$ or the $LiF-BeF_2-UF_4$. The men working on the $NaF-BeF_2-UF_4$ phase diagram feel that there is still much to be done to finish their work. We have given some consideration to the idea of setting up more DTA and petrographic equipment so that runs could be started on the same ternary system which is to be investigated with the viscosity and density apparatus. Results from additional filtration equipment would be slow unless the analytical work could be speeded up.

We are looking forward to seeing you next week.

Very truly yours,

John

John F. Eichelberger

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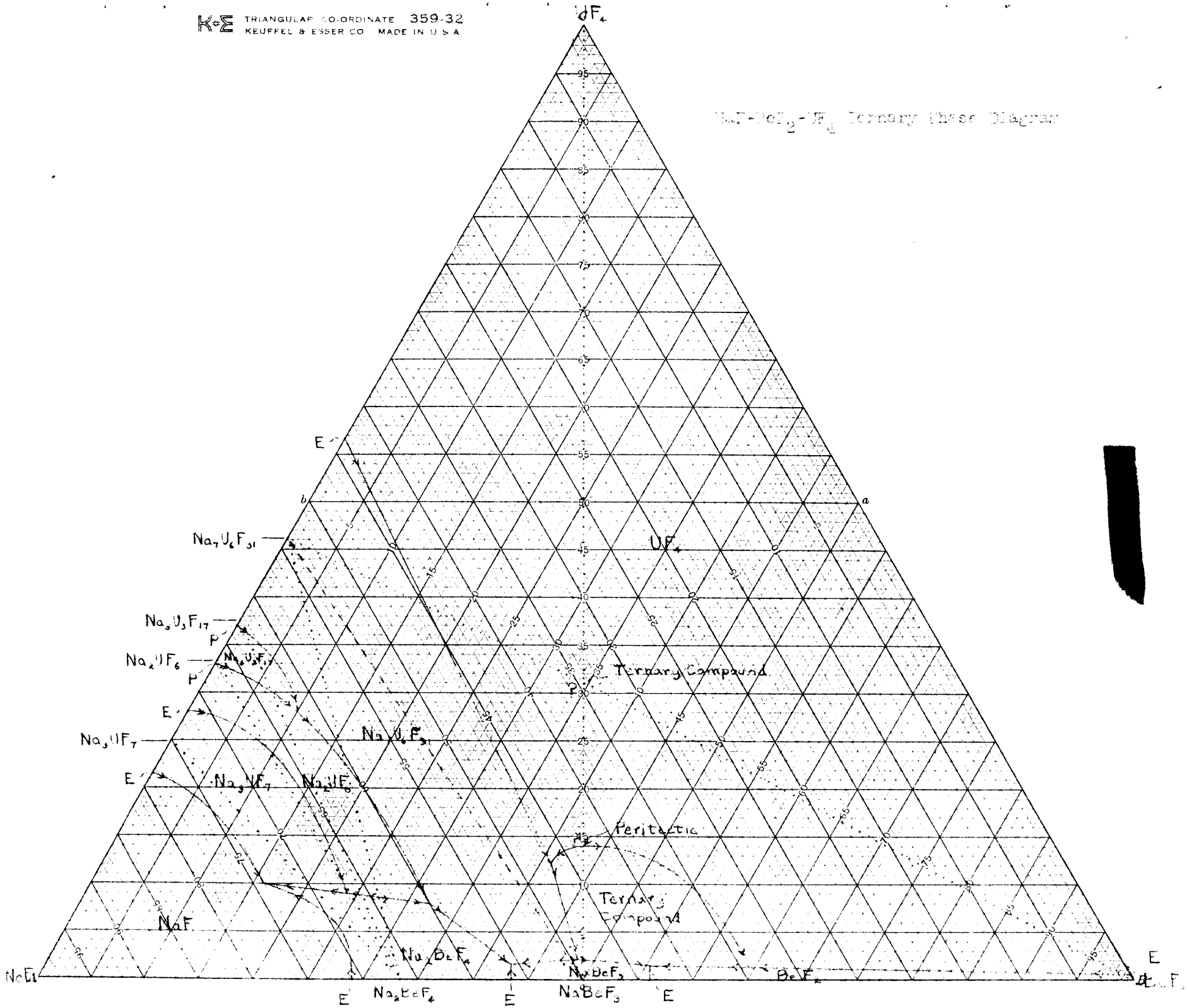
K&E TRIANGULAR CO-ORDINATE 359-32
KEUFFEL & ESSER CO MADE IN U.S.A.
NaF-BeF2-UF4 Ternary Phase Diagram
UF4
NaF
BeF2
Na7U6F31
Na3U3F17
Na2UF6
Na3UF7
Na2BeF4
NaBeF3
Ternary Compound
Peritectic
E
P

Central File No. 55-11-14 [redacted]

Progress Report on the $NaF-BeF_2-UF_4$ Ternary Phase Diagram

by

P. Tucker and B. Rhinehammer

In the preliminary investigation of the $NaF-BeF_2-UF_4$ ternary system all possibilities of quasi-binaries were investigated. Only one quasi-binary was established which is represented by the join between $NaBeF_3$ and $Na_7U_6F_{31}$. The location of the quasi eutectic has not been established definitely but is believed to exist very close to the compound, $NaBeF_3$.

The primary phase areas NaF, Na_3UF_7 and Na_2BeF_4 were found to form a ternary eutectic at the approximate composition as shown on the phase diagram. The eutectic temperature is 483°C ± 5°.

The primary phase areas Na_2BeF_4, $Na_7U_6F_{31}$ and $NaBeF_3$ were found to form a ternary eutectic at the approximate composition as shown on the phase diagram. The eutectic temperature, which is approximately 336°C, represents the lowest melting composition in the ternary diagram.

The primary phase areas $NaBeF_3$, ternary compound and BeF_2 are believed to form a ternary eutectic at the approximate composition as shown on the phase diagram. Difficulties in attaining equilibrium conditions with compositions in this area have made results inconclusive. However, the eutectic temperature at this point is known to be approximately 356°C.

The primary phase areas Na_2BeF_4, Na_3UF_7 and Na_2UF_6 were found to form a ternary peritectic at the approximate composition shown on the phase diagram. The peritectic temperature is approximately 527°C. The downward slope of the valley from the peritectic point to the $NaF-Na_3UF_7-Na_2BeF_4$ ternary eutectic has been established.

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The primary phase areas Na_2BeF_4, Na_2UF_6 and $Na_7U_6F_{31}$ are believed to form a ternary peritectic at a temperature of 500°C as shown on the phase diagram. The composition and peritectic temperature at this point are in doubt; however, petrographic results indicate the peritectic to be located to the right of the Na_2BeF_4 - $Na_7U_6F_{31}$ composition line.

In order to have two adjacent peritectics sloping in opposite directions as indicated on the phase diagram it is necessary that they be separated by a high point. This proposed point is indicated by the intersection of the peritectic valley with the Na_2BeF_4 - $Na_7U_6F_{31}$ composition line. The existence and location of this point are based on supposition and have not been proved.

The primary phase areas Na_2UF_6, $Na_5U_3F_{17}$ and $Na_7U_6F_{31}$ are believed to form a ternary peritectic as shown on the phase diagram. The existence and composition of this peritectic are based upon supposition as no examinations have been made in this area.

Three probable ternary peritectics are believed to exist as shown on the phase diagram. These are shown by the intersection of the following phase areas: $NaBeF_3$, $Na_7U_6F_{31}$ and ternary compound; $Na_7U_6F_{31}$, UF_4 and ternary compound; and BeF_2, ternary compound and UF_4. The existence of these peritectics is uncertain, and there is no conclusive evidence concerning their compositions or temperatures which is due largely to difficulties in obtaining equilibrium conditions for compositions in this area.

Investigations along the $NaBeF_3$ - UF_4 join have indicated the existence of an incongruent melting ternary compound, the composition of which is believed to lie on the join. Several unassigned thermal breaks have been found for compositions along this join. A strong break at 558°C is believed to be the peritectic temperature but has not been confirmed due to difficulties in attaining equilibrium conditions. If this peritectic temperature is correct the peritectic would occur

at approximately 14 mole percent UF_4.

In plotting this ternary diagram the course of each primary phase boundary line was based upon limited information and may vary significantly from that shown on the phase diagram.

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TABLE I

	Original Composition in Mole %			Temperature of Filtration (°C)	Analysis of Filtrate Mole %		
	UF_4	BeF_2	NaF		UF_4	BeF_2	NaF
1	12	15	73	492	11.9	15.8	72.3
2				520	7.8	20.3	71.9
3	5	20	75	527	7.4	22.6	70.0
4				539	6.4	24.7	68.9
5				540	4.8	26.2	69.0
6	[illegible]	27	[illegible]	552	3.2	26.5	70.3
7	2	30	68	550	4.1	26.7	69.2
8	5	28	67	534	8.1	25.7	66.2
9	7	27.5	65.5	528	8.7	24.6	66.7
10	12	20	68	530	9.4	25.1	65.5
11				520	9.4	22.2	68.4
12	20	40	40	574	16.3	44.0	39.7
13	30	35	35	606	20.2	42.4	37.4
14				700	28.7	35.5	35.8

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Filtration Experiments (L. J. Wittenberg)

Referring to the table, run #1 locates the ternary eutectic between NaF, Na_2BeF_4, and Na_3UF_7 which may be as low as 483°C as reported by DTA, although 492° is the lowest temperature tried in this work. Runs #2, thru #7 define the valley from this low eutectic point to the NaF-BeF_2 side of the phase diagram. Since all of these runs lie on a smooth curve although they are from three different starting compositions, the location of this valley appears to be reliable.

Runs #8, 9, and 10, which lie practically on top of each other although they are from three different starting compoistions, could possibly locate the peritectic point where the phases Na_3UF_7, Na_2BeF_4, and Na_2UF_6 come together. Run #11, which has the same starting composition as #10 although its temperature of filtration is 10° below #10, has a liquidus to the left of #10. This fact appears to agree with the DTA work in this region which indicates the peritectic point just described flows back into the eutectic formed by NaF-Na_3UF_7-Na_2BeF_4.

Runs #12,13 and 14, which are made from starting compositions which lie on the line between UF_4 and $NaBeF_3$, give liquidus compositions which are also close to this line. The fact that they are not exactly on this line is probably due to the fact that the error in the analysis of BeF_2 is large in this area. These runs agree closely with temperature breaks found in DTA work which can now be identified as liquidus temperatures. The filtrations do not help to solve the problem of whether there is a ternary compound in this area, but it does show that if there is a ternary compound its composition must lie on the line between $NaBeF_3$ and UF_4 since all of the filtrations were close to this line.

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Central File No. 55-11-14 [redacted]

Comments on Viscosity and Density Measurements

B. C. Blanke

The following data and graphs are summaries of measurements made during the past four months on viscosity and density of the ternary mixture; sodium fluoride, beryllium fluoride, uranium fluoride. The density values have been evaluated, weighted, and are essentially in their final form. The viscosity values have not been evaluated and should be considered as raw data until necessary reruns and correlations have been made. Any corrections found will be noted in the next report.

The area of the ternary studies was determined by engineering considerations. The liquidus temperature had to be lower than 650°C, and the viscosity less than 6 centipoise at 800°C.

The experimental data are reported completely for any one run, but for some mixtures when more than one run was made on identical samples, the reported runs were selected by consideration of slope, interpolations of values, and for reasons of experimental error. The values of density and viscosity were then interpolated at 600°C and 800°C for each mixture, and these values were used in the plotting of viscosity and density vs. functions of composition.

The density and viscosity of seven mixtures from ORNL are also reported.

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DENSITY OF NaF, BeF_2, UF_4 TERNARY MIXTURES

composition given in mole %

2 mole % UF_4 Series

76 22 2 NaF BeF_2 UF_4		70 28 2 NaF BeF_2 UF_4		64 34 2 NaF BeF_2 UF_4		58 40 2 NaF BeF_2 UF_4		52 46 2 NaF BeF_2 UF_4		46 52 2 NaF BeF_2 UF_4		Comments
density (gms/cm^3)	Temp °C	density (gm/cm^3)	Temp °C	density (gms/cm^3)	Temp °C	density (gms/cm^3)	Temp °C	density (gms/cm^3)	Temp °C	density (gms/cm^3)	Temp °C	
2.0946	909.8	2.0971	896.5	2.0973	893.3	2.0619	909.0	2.0507	908.0	2.0366	907.8	
2.1202	860.8	2.1185	849.3	2.1219	846.3	2.0889	858.0	2.0743	858.8	2.0628	858.5	
2.1459	809.8	2.1441	799.3	2.1375	793.5	2.1135	810.0	2.0998	809.8	2.0838	808.8	
2.1719	761.5	2.1692	749.3	2.1649	735.8	2.1360	758.8	2.1254	761.3	2.1060	759.5	
Slushy	712.2	2.1976	695.0	2.1911	684.2	2.1618	710.3	2.1504	712.7	2.1319	710.0	
2.1735	760.0	2.2244	645.3	2.2218	630.0	2.1924	660.8	2.1769	664.0	2.1567	660.3	
2.1798	749.3	2.2535	593.1	2.2517	576.3	2.2191	613.1	2.2147	588.9	2.1813	610.3	
2.1782	738.2	2.2828	542.5	2.2796	530.8	2.2492	561.0	2.2613	506.0	2.2043	558.7	
2.1808	731.2	Frozen	509.3	Mushy	501.3	2.2796	508.0	2.3080	423.8	2.2293	506.0	
Slushy	726.5	2.1588	767.1			2.3096	459.8	2.3429	360.5	2.2584	453.5	
		2.2149	667.6			2.3264	431.0			2.2860	401.3	
						Mushy	358.7			2.3094	358.4	
										2.3302	322.8	
										Frozen	304.5	

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DENSITY OF NaF, BeF_2, UF_4 TERNARY MIXTURES

Composition given in Mole %

4 mole % UF_4 series

76 NaF	20 BeF_2	4 UF_4	70 NaF	26 BeF_2	4 UF_4	64 NaF	32 BeF_2	4 UF_4	58 NaF	38 BeF_2	4 UF_4	52 NaF	44 BeF_2	4 UF_4	46 NaF	50 BeF_2	4 UF_4	Comments
density (gm/cm^3)		Temp °C	density (gm/cm^3)		Temp °C	density (gm/cm^3)		Temp °C	density (gm/cm^3)		Temp °C	density (gm/cm^3)		Temp °C	density (gm/cm^3)		Temp °C	
2.2712		902.5	2.2915		907.3	2.2956		904.8	2.2513		907.8	2.2150		912.3	2.2599		908.0	
2.2829		879.5	2.3211		858.3	2.3186		858.8	2.2767		857.8	2.2459		858.3	2.2570		857.8	
2.2974		854.5	2.3448		809.3	2.3420		807.3	2.3012		807.2	2.2742		809.3	2.2705		809.3	
2.3102		829.1	2.3749		758.5	2.3695		759.0	2.3286		759.0	2.3031		760.5	2.2950		757.8	
2.3244		804.0	2.4108		708.0	2.3981		708.5	2.3557		707.3	2.3332		709.2	2.3213		707.8	
2.3378		778.7	2.4365		660.3	2.4275		659.3	2.3868		656.9	2.3635		658.0	2.3465		658.2	
2.3533		752.5	2.4689		609.9	2.4618		606.3	2.4171		604.7	2.3920		608.9	2.3748		607.0	
2.3678		726.9	2.5025		559.3	2.4948		556.0	2.4490		554.0	2.4223		558.4	2.4033		556.8	
Slushy		702.9	Frozen		503.0	Frozen		504.9	2.4843		500.5	2.4529		507.8	2.4343		506.2	
2.3207		828.7				2.3136		858.2	2.5208		451.5	2.4559		456.4	2.4672		453.8	
2.2938		878.0																

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DENSITY OF NaF, BeF_2, UF_4 TERNARY MIXTURE

Compositions given in mole %

6 Mole % UF_4 Series

76 18 6 NaF BeF_2 UF_4		70 24 6 NaF BeF_2 UF_4		64 30 6 NaF BeF_2 UF_4		58 36 6 NaF BeF_2 UF_4		52 42 6 NaF BeF_2 UF_4		46 48 6 NaF BeF_2 UF_4		Comments
density (gm/cm^3)	Temp °C	density (gm/cm^3)	Temp °C	density (gm/cm^3)	Temp °C	density (gm/cm^3)	Temp °C	density (gm/cm^3)	Temp °C	density (gm/cm^3)	Temp °C	
2.4800	907.5	2.4469	904.5	2.4349	904.8	2.3847	914.3	2.4125	905.5	2.3970	908.8	solid line indicates data below line obtained from new mixture.
2.5082	862.3	2.4771	858.5	2.4548	855.5	2.4133	860.5	2.4167	857.5	2.4252	860.8	
2.5325	809.5	2.5015	808.0	2.4749	807.0	2.4371	813.2	2.4452	807.8	2.4423	809.8	
2.5666	758.3	2.5306	757.8	2.5070	755.2	2.4622	763.5	2.4683	756.6	2.4600	760.0	
2.5994	711.0	2.5620	708.5	2.5369	704.5	2.4924	713.1	2.4987	708.5	2.4828	712.2	
Mushy	660.5	2.5934	657.1	2.5633	654.8	2.5210	661.8	2.5367	657.8	2.5165	658.8	
2.5330	817.0	2.6280	607.0	2.6003	600.9	2.5508	609.3	2.5691	608.0	2.5445	611.8	
		2.6636	559.1	2.6350	551.1	2.5825	562.5	2.6025	556.5	2.5748	558.7	
		2.7399	506.5	2.6722	500.9	2.6185	508.4	2.6398	506.0	2.6072	504.7	
		Frozen	482.5	2.4239	899.3			2.4131	552.5	2.6210	485.0	
				2.4661	846.3			2.4123	908.0	2.4106	908.8	
				2.4988	790.8			2.4267	857.5	2.4255	860.8	
				2.5257	735.5			2.4447	809.2	2.4425	809.8	
				2.5503	695.8			2.4684	758.0	2.4600	760.0	
				2.5808	646.8			2.4978	710.8	2.4828	712.2	
				2.6135	594.3			2.5341	659.5	2.5164	658.8	
				2.6463	546.3			2.5693	608.7	2.5448	611.8	
								2.6006	559.6	2.5750	558.7	
								2.6235	523.8	2.6074	504.7	
								2.6335	508.7	2.6209	485.0	
								2.6348	499.1			

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Central File No. 55-11-14 [redacted]

DENSITY OF NaF, BeF_2, UF_4 TERNARY MIXTURES

8 mole % UF_4 Series.

Compositions given in mole %

76 16 8 NaF BeF_2 UF_4 density (gm/cm³)	Temp °C	70 22 8 NaF BeF_2 UF_4 density (gm/cm³)	Temp °C	64 28 8 NaF BeF_2 UF_4 density (gm/cm³)	Temp °C	58 34 8 NaF BeF_2 UF_4 density (gm/cm³)	Temp °C	52 40 8 NaF BeF_2 UF_4 density (gm/cm³)	Temp °C	46 46 8 NaF BeF_2 UF_4 density (gm/cm³)	Temp °C	Comments
2.6369	907.5	2.6439	899.3	2.6282	902.8	2.5996	903.8	2.5948	908.5	2.5783	900.8	dashed line indicates data below line obtained from same mixture remelted on following day.
2.6545	849.8	2.6799	850.5	2.6545	850.8	2.6262	848.4	2.6361	860.5	2.6320	850.8	
2.6867	798.2	2.6834	825.5	2.6874	800.5	2.6495	802.8	2.6499	808.3	2.6315	800.8	
2.7189	744.8	2.7111	774.8	2.7170	750.8	2.6784	747.0	2.6646	757.2	2.6622	752.8	
2.7409	711.5	2.7452	721.8	2.7452	705.0	2.7037	704.0	2.7006	702.5	2.6896	699.3	
2.7565	687.8	2.7782	676.3	2.7812	653.5	2.7376	649.3	2.7295	653.5	2.7218	648.4	
		2.8154	626.3	2.8024	624.0	2.7832	598.3	2.7675	601.2	2.7533	598.8	
		2.8494	599.0	2.8206	602.3	2.8201	543.8	2.8040	550.4	2.7803	547.5	
		2.8902	524.7	2.8335	580.7			2.6510	829.1	2.8127	495.3	
		2.9107	504.7	2.8466	558.4			2.5782	913.8			
		Frozen	472.7	2.8625	537.1			2.5966	892.8			
		2.7241	769.0	2.8814	512.7			2.6148	871.8			
				2.7105	789.8			2.6175	852.0			
				2.7713	686.3			2.6149	830.8			
				2.8450	582.5			2.6150	809.0			
								2.6229	784.3			
								2.6565	715.5			
								2.7241	620.2			

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Central File No. 55-11-14 [redacted] DENSITY OF NaF, BeF_2, UF_4 TERNARY MIXTURES 10 mole % UF_4 Series

Compositions given in mole %

76 NaF	14 BeF_2	10 UF_4	70 NaF	20 BeF_2	10 UF_4	64 NaF	26 BeF_2	10 UF_4	58 NaF	32 BeF_2	10 UF_4	52 NaF	38 BeF_2	10 UF_4	46 NaF	44 BeF_2	10 UF_4	Comments
density (gm/cm^3)		Temp C	density (gm/cm^3)		Temp C	density (gm/cm^3)		Temp C	density (gm/cm^3)		Temp C	density (gm/cm^3)		Temp C	density (gm/cm^3)		Temp C	
2.8628		905.0	2.8227		910.8	2.8533		845.5	2.7804		900.3	2.7325		900.8	2.8016		898.5	dashed line
2.8976		864.8	2.8278		870.5	2.9136		753.1	2.8114		849.1	2.7765		849.1	2.8355		851.0	indicates data below line obtained from same mixture remelted on following day.
2.9109		823.5	2.8478		841.5	2.7711		902.5	2.8235		802.3	2.8052		797.0	2.8578		801.0	
2.9376		773.0	2.8770		796.5	2.8115		861.8	2.8448		748.3	2.8278		750.0	2.8379		751.8	
2.9514		728.3	2.9123		741.8	2.8428		814.0	2.8740		703.1	2.8567		699.4	2.8593		697.6	
2.9788		683.5	2.9300		716.2	2.8788		766.0	2.9136		650.7	2.8903		646.0	2.9019		645.6	
2.9241		798.4	2.9531		688.7	2.9112		719.8	2.9561		598.8	2.9231		600.9	2.9352		593.1	
2.9600		746.5	2.9737		662.4	2.9508		666.2	2.9963		547.8	2.9789		550.4	2.9633		545.5	
2.9777		681.1	2.9899		647.3	2.9832		625.0	1.8695		493.0	1.8838		507.0	2.5928		487.2	
2.9901		663.4	3.0109		610.7	3.0071		592.7	1.6259		484.9	1.4482		494.4	2.3220		476.9	
3.0038		644.9	3.0316		586.0	3.0278		568.5	2.8467		796.3	2.7212		898.0	2.7233		892.5	
3.0226		632.7	3.0562		563.8	3.0433		546.5				2.7626		850.8	2.7646		845.3	
2.8570		854.0	3.0682		545.5	3.0616		525.8				2.8134		775.6	2.8293		796.8	
2.8686		814.3	3.0916		516.7	2.7234		502.8				2.9558		572.5	2.7595		808.5	
2.8854		787.8	3.1107		493.5													
2.9184		736.4	3.1170		486.3													
2.9552		684.9																
2.9758		658.3																
2.9962		645.1																
3.0103		633.4																
2.9073		765.5																
2.9272		735.8																
2.9638		685.3																
3.0074		645.3																

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Central File No. 55-11-14 [redacted]

DENSITY OF NaF, BeF_2, UF_4 TERNARY MIXTURES
Compositions given in mole %

12 mole % UF_4 Series

76 NaF 12 BeF_2 12 UF_4		70 NaF 18 BeF_2 12 UF_4		64 NaF 24 BeF_2 12 UF_4		58 NaF 30 BeF_2 12 UF_4		52 NaF 36 BeF_2 12 UF_4		46 NaF 42 BeF_2 12 UF_4		Comments
density (gm/cm^3)	Temp °C	density (gm/cm^3)	Temp °C	density (gm/cm^3)	Temp °C	density (gm/cm^3)	Temp °C	density (gm/cm^3)	Temp °C	density (gm/cm^3)	Temp °C	
2.9361	896.5	2.9496	903.5	2.9410	903.5	2.9177	902.5	2.9228	903.0	2.9538	902.5	dashed line indicates data below line obtained from same mixture remelted on following day.
2.9731	848.2	2.9772	850.0	2.9515	852.8	2.9515	851.5	2.9740	847.2	2.9596	855.5	
3.0134	796.0	3.0130	798.7	2.9749	798.8	2.9797	802.0	2.9950	798.7	2.9910	803.7	
3.0571	747.0	3.0532	745.3	3.0061	748.5	3.0187	748.1	3.0108	743.8	3.0099	754.5	
3.1038	693.3	3.0898	696.2	3.0463	699.5	3.0596	689.1	3.0318	692.0	3.0254	705.3	
3.1259	666.6	3.1298	644.2	3.0849	649.1	3.0836	640.2	3.0634	646.5	3.0596	654.8	Solid line indicates data below line obtained from new mixture
3.1462	639.5	3.1717	593.6	3.1302	598.3	3.1180	592.2	3.1132	589.5	3.0909	603.5	
3.1615	614.7	3.1967	563.1	3.1587	562.0	3.1547	544.3	2.9261	903.2	3.1327	548.9	
3.1812	589.8	3.2155	540.7	3.1739	544.0			2.9414	851.2	2.9536	905.5	
3.2064	559.3	3.2340	518.3	2.8920	907.5			2.9548	802.0	2.9990	849.3	
Freezing	529.1	3.2538	494.2	2.9320	858.5			2.9925	751.2	2.9876	800.8	
2.9497	902.3	3.2750	467.5	2.9643	807.5			3.0286	702.2	3.0074	748.1	
2.9666	872.8	Freezing	457.0	3.0015	760.0			3.0690	648.2	3.0234	693.8	
3.0021	818.0	3.0773	719.3	3.0408	703.3			3.1076	602.5	3.0553	642.5	
3.0339	766.4	2.9600	909.0	3.0775	652.0			2.9061	893.0	3.1154	588.8	
3.0806	711.5	2.9867	853.8	3.1203	603.0			2.9532	846.8	3.1540	551.3	
3.0994	684.2	3.0043	817.3	3.1611	553.0					3.1730	515.3	
3.1221	651.6	3.0477	749.8							2.9232	903.3	
3.1420	623.8	3.0809	702.8							2.9601	866.0	
3.1654	599.0	3.1192	657.1							2.9931	824.3	
3.1877	573.5	3.1586	601.6							3.0249	771.0	
3.1990	561.3	3.1977	556.5							3.0392	715.0	
3.2082	547.8	3.2282	520.9							3.0266	673.8	
		3.2510	494.5							3.1073	570.0	
		2.9867	468.8							3.1381	543.1	
										3.0811	598.8	

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VISCOSITY OF NaF, BeF_2, UF_4 TERNARY MIXTURES

Compositions given in mole %

Composition			600°C			800°C		
NaF	BeF_2	UF_4	η(poise)	ρ(g/cm³)	η/ρ	η(poise)	ρ(g/cm³)	η/ρ
76	12	12	--	3.171	--	.0452	3.017	.0150
70	18	12	.1002	3.162	.0317	.0353	3.013	.0117
64	24	12	.0821	3.122	.0263	.0289	2.983	.0097
58	30	12	.1280	3.117	.0411	.0331	2.986	.0111
52	36	12	.1290	3.104	.0416	.0289	2.973	.0097
46	42	12	.1780	3.094	.0575	.0369	2.978	.0124
76	14	10	--	3.031	--	.0313	2.879	.0109
70	20	10	.1200	3.024	.0397	.0510	2.874	.0177
64	26	10	.1001	3.002	.0333	.0316	2.852	.0111
58	32	10	.1180	2.954	.0399	.0297	2.804	.0106
52	38	10	.1004	2.926	.0343	.0271	2.794	.0097
46	44	10	.2790	2.927	.0953	.0657	2.797	.0235
76	16	8	--	Solid	--	.0450	2.687	.0167
70	22	8	.0946	2.834	.0334	.0271	2.695	.0101
64	28	8	.0882	2.819	.0313	.0293	2.683	.0109
58	34	8	.1002	2.779	.0360	.0302	2.650	.0114
52	40	8	.1190	2.767	.0430	.0331	2.639	.0125
46	46	8	.1470	2.749	.0535	.0403	2.632	.0153
76	18	6	--	Solid	--	.0361	2.543	.0142
70	24	6	.0603	2.633	.0229	.0409	2.505	.0163
64	30	6	.0912	2.604	.0350	.0358	2.481	.0144
58	36	6	.0834	2.601	.0321	.0311	2.477	.0126
52	42	6	.1270	2.573	.0494	.0349	2.440	.0143
46	48	6	.2230	2.579	.0865	.0468	2.441	.0192
76	20	4	--	Solid	--	.0261	2.328	.0112
70	26	4	.0629	2.476	.0254	.0226	2.350	.0096
64	32	4	.0740	2.467	.0300	.0310	2.345	.0132
58	38	4	.0972	2.443	.0398	.0342	2.313	.0148
52	44	4	.1284	2.397	.0536	.0431	2.279	.0189
46	50	4	.1647	2.381	.0692	.0440	2.275	.0193
76	22	2	--	Solid	--	.0261	2.152	.0121
70	28	2	.0629	2.249	.0280	.0226	2.144	.0105
64	34	2	.0740	2.254	.0328	.0310	2.144	0145
58	40	2	.0972	2.227	.0436	.0342	2.118	.0161
52	46	2	.1284	2.211	.0580	.0431	2.104	.0201
46	54	2	.1647	2.181	.0755	.0440	2.082	.0211
*76	24	0	--	2.126	--	.0299	2.018	.0148
70	30	0	.0498	2.113	.0236	.0281	2.012	.0140
64	36	0	.0591	2.108	.0280	.0309	2.008	.0154
58	42	0	.0883	2.103	.0420	.0352	2.005	.0176
52	48	0	.1282	2.098	.0611	.0415	1.992	.0208
46	54	0	.2090	2.058	.1016	.0536	1.985	.0270

* interpolated values from binary error.

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VISCOSITY AND DYNAMIC VISCOSITY OF NaF, BeF_2, UF_4 TERNARY MIXTURES

2 UF_4 Mole %
Series

Composition given in mole %

76 NaF	22 BeF_2	2 UF_4	70 NaF	28 BeF_2	2 UF_4	64 NaF	34 BeF_2	2 UF_4	58 NaF	40 BeF_2	2 UF_4	52 NaF	46 BeF_2	2 UF_4	46 NaB	52 BeF_2	2 UF_4
η Poise	η/ρ Stokes	temp °C	η Poise	η/ρ Stokes	temp °C	η Poise	η/ρ Stokes	temp °C	η Poise	η/ρ Stokes	temp °C	η Poise	η/ρ Stokes	temp °C	η Poise	η/ρ Stokes	temp °C
.0197	.0093	880	.0183	.0087	878	.0252	.0119	870	.0265	.0127	874	.0324	.0157	874	.0330	.0160	854
.0246	.0115	824	.0209	.0098	823	.0304	.0143	815	.0362	.0171	800	.0560	.0266	795	.0499	.0238	782
.0296	.0137	773	..0250	.0116	770	.0357	.0165	766	.0498	.0231	722	.0639	.0298	720	.0776	.0364	708
.0698	.0319	721	.0309	.0141	720	.0433	.0198	716	.0733	.0333	649	.0962	.0440	647	.1331	.0614	633
			.0393	.0178	668	.0536	.0242	663	.1167	.0521	573	.1561	.0703	571	.2197	.0999	562
			.0571	.0255	617	.0687	.0306	612	.2132	.0931	492	.2617	.1154	497	.4507	.2012	487
			.0781	.0344	567	.0945	.0415	557	.3876	.1661	416	.6229	.2695	417	1.192	.5219	408
															3.348	1.446	351

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VISCOSITY AND DYNAMIC VISCOSITY OF NaF, BeF_2, UF_4, TERNARY MIXTURES

$4UF_4$ Mole % Series

Composition given in Mole %

76 NaF	20 BeF_2	4 UF_4	70 NaF	26 BeF_2	4 UF_4	64 NaF	32 BeF_2	4 UF_4	58 NaF	38 BeF_2	4 UF_4	52 NaF	44 BeF_2	4 UF_4	46 NaF	50 BeF_2	4 UF_4
η Poise	η/ρ Stokes	temp °C	η Poise	η/ρ Stokes	temp °C	η Poise	η/ρ Stokes	temp °C	η Poise	η/ρ Stokes	temp °C	η Poise	η/ρ Stokes	temp °C	η Poise	η/ρ Stokes	temp °C
.0274	.0120	883	.0317	.0138	884	.0267	.0116	890	.0229	.0101	880	.0235	.0105	885	.0304	.0135	880
.0338	.0146	818	.0356	.0152	825	.0330	.0141	823	.0271	.0118	822	.0334	.0147	806	.0464	.0204	802
.0767	.0175	767	.0443	.0187	773	.0405	.0171	770	.0338	.0145	771	.0505	.0217	728	.0762	.0330	725
.0710	.0270	710	.0477	.0199	731	.0555	.0231	693	.0449	.0190	721	.0818	.0346	652	.1444	.0614	648
			.0650	.0267	670	.0706	.0290	643	.0662	.0275	650	.1468	.0609	578	.2437	.1018	573
			.0957	.0388	609	.0938	.0379	592	.1107	.0449	570	.2690	.1096	503	.5170	.2119	497
			.1360	.0542	548	.1318	.0526	540	.2080	.0828	493	.3461	.1401	476	.9968	.4039	450
									.3357	.1316	438						

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VISCOSITY AND DYNAMIC VISCOSITY OF NaF, BeF_2, UF_4 TERNARY MIXTURES

6 UF_4 Mole % series

Composition given in mole %

76 NaF	18 BeF_2	6 UF_4	70 NaF	24 BeF_2	6 UF_4	64 NaF	30 BeF_2	6 UF_4	58 NaF	36 BeF_2	6 UF_4	52 NaF	42 BeF_2	6 UF_4	46 NaF	48 BeF_2	6 UF_4
η Poise	η/ρ Stokes	temp °C	η Poise	η/ρ Stokes	temp °C	η Poise	η/ρ Stokes	temp °C	η Poise	η/ρ Stokes	temp °C	η Poise	η/ρ Stokes	temp °C	η Poise	η/ρ Stokes	temp °C
.0227	.0091	878	.0150	.0061	884	.0240	.0098	880	.0201	.0084	884	.0243	.0101	880	.0391	.0162	891
															.0663	.0273	820
.0319	.0126	822	.0167	.0067	831	.0302	.0122	828	.0243	.0100	830	.0306	.0126	824	.0908	.0370	766
															.1042	.0420	715
.0385	.0150	767	.0206	.0082	778	.0358	.0144	778	.0297	.0121	780	.0389	.0158	776	.1583	.0629	653
															.2009	.0793	621
.0509	.0197	722	.0307	.0120	722	.0437	.0173	727	.0385	.0155	724	.0530	.0212	717	.2929	.1137	556
			.0365	.0141	672	.0557	.0218	676	.0506	.0201	673	.0724	.0287	670	.4932	.1892	508
															.0294	.0122	876
			.0475	.0182	625	.0790	.0305	625	.0705	.0277	624	.1046	.0409	620	.0382	.0157	823
															.0546	.0226	772
			.0696	.0263	572	.1030	.0395	566	.0995	.0386	570	.1648	.0635	566	.0743	.0300	721
															.1057	.0422	670
									.1642	.0629	517	.2847	.1083	513	.204	.0800	597
															.300	.116	548
												.4573	.1715	461	.462	.177	496
															.968	.366	444

VISCOSITIES AND DYNAMIC VISCOSITIES OF NaF, BeF_2, UF_4 TERNARY MIXTURES

Composition given in mole %

8 Mole % UF_4 Series

76 NaF	16 BeF_2	8 UF_4	70 NaF	22 BeF_2	8 UF_4	64 NaF	28 BeF_2	8 UF_4	58 NaF	34 BeF_2	8 UF_4	52 NaF	40 BeF_2	8 UF_4	46 NaF	46 BeF_2	8 UF_4
η Poise	η/ρ Stokes	temp °C	η Poise	η/ρ Stokes	temp °C	η Poise	η/ρ Stokes	temp °C	η Poise	η/ρ Stokes	temp °C	η Poise	η/ρ Stokes	temp °C	η Poise	η/ρ Stokes	temp °C
.0284	.0107	864	.0203	.0076	860	.0246	.0093	870	.0292	.0112	876	.0262	.0101	882	.0294	.0113	865
.0415	.0155	821	.0277	.0103	808	.0277	.0103	821	.0233	.0089	827	.0295	.0112	821	.0394	.0150	816
.0501	.0185	770	.0305	.0112	757	.0332	.0123	774	.0346	.0130	776	.0385	.0145	772	.0510	.0193	771
.0587	.0214	720	.0462	.0168	710	.0416	.0152	720	.0435	.0162	732	.0518	.0193	723	.0507	.0189	712
			.0554	.0199	665	.0544	.0196	669	.0599	.0219	673	.0666	.0245	675	.0857	.0316	664
			.0941	.0333	613	.0730	.0260	624	.0802	.0290	672	.1326	.0478	586	.1252	.0457	617
			.1290	.0450	561	.1016	.0360	595	.1233	.0441	574						
						.1592	.0554	524	.0237	.0090	856						
									.0305	.0115	800						
									.0379	.0141	751						
									.0496	.0183	702						
									.0649	.0237	654						
									.0898	.0323	605						
									.1590	.0566	554						
									.2188	.0770	508						

VISCOSITIES AND DYNAMIC VISCOSITIES OF NaF, BeF_2, UF_4 TERNARY MIXTURES

10 Mole % UF_4 Series

Composition given in mole %

76 NaF	14 BeF_2	10 UF_4	70 NaF	20 BeF_2	10 UF_4	64 NaF	26 BeF_2	10 UF_4	58 NaF	32 BeF_2	10 UF_4	52 NaF	38 BeF_2	10 UF_4	46 NaF	44 BeF_2	10 UF_4
η Poise	η/ρ Stokes	temp °C	η Poise	η/ρ Stokes	temp °C	η Poise	η/ρ Stokes	temp °C	η Poise	η/ρ Stokes	temp °C	η Poise	η/ρ Stokes	temp °C	η Poise	η/ρ Stokes	temp °C
.0195	.0069	861	.0362	.0128	876	.0240	.0085	862	.0213	.0077	868	.0203	.0074	863	.0271	.0099	876
.0299	.0104	808	.0476	.0166	820	.0300	.0106	814	.0287	.0103	821	.0254	.0091	815	.0584	.0209	820
.0393	.0135	766	.0577	.0199	771	.0382	.0133	766	.0386	.0137	775	.0320	.0114	764	.0780	.0277	771
.1149	.0390	713	.0673	.0229	719	.0482	.0165	712	.0485	.0169	722	.0435	.0153	716	.1097	.0385	722
			.0895	.0301	666	.0651	.0221	663	.0747	.0257	672	.0634	.0220	665	.1669	.0579	669
			.1113	.0369	620	.0844	.0283	620	.0994	.0339	625	.0899	.0309	618	.2423	.0831	620
			.1426	.0468	570	.1220	.0403	572	.1484	.0499	572	.1459	.0495	566	.3094	.1050	573
			.1898	.0613	520				.2664	.0884	524	.2793	.0937	516	.5094	.1709	521

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VISCOSITIES AND DYNAMIC VISCOSITIES OF NaF BeF_2 UF_4 TERNARY MIXTURES

12 Mole % UF_4 Series

Composition given in mole %

76 NaF	12 BeF_2	12 UF_4	70 NaF	18 BeF_2	12 UF_4	64 NaF	24 BeF_2	12 UF_4	58 NaF	30 BeF_2	12 UF_4	52 NaF	36 BeF_2	12 UF_4	46 NaF	42 BeF_2	12 UF_4
η Poise	η/ρ Stokes	temp °C	η Poise	η/ρ Stokes	temp °C	η Poise	η/ρ Stokes	temp °C	η Poise	η/ρ Stokes	temp °C	η Poise	η/ρ Stokes	temp °C	η Poise	η/ρ Stokes	temp °C
.0328	.0109	872	.0342	.0115	872	.0327	.0080	860	.0248	.0085	881	.0286	.0097	858	.0190	.0064	880
.0427	.0142	813	.0286	.0096	812	.0274	.0092	814	.0286	.0097	828	.0282	.0095	812	.0305	.0103	828
.0554	.0182	766	.0416	.0137	765	.0342	.0114	762	.0403	.0134	778	.0322	.0108	762	.0410	.0137	783
.0665	.0215	715	.0671	.0216	670	.0399	.0131	718	.0567	.0187	727	.0514	.0170	714	.0589	.0196	727
.0812	.0261	668	.1176	.0369	575	.0488	.0159	668	.0697	.0227	678	.0694	.0227	664	.0842	.0277	679
.1076	.0341	615	.0339	.0114	867	.0673	.0216	618	.0993	.0320	624	.0979	.0317	621	.1255	.0409	636
			.0384	.0128	814	.0969	.0308	574	.1782	.0569	574	.1772	.0566	567	.2153	.0692	581
			.0434	.0143	757				.2506	.0791	522	.2617	.0827	518			
			.0509	.0166	714												
			.0684	.0219	665												
			.0881	.0279	616												
			.1188	.0372													

DENSITY OF OAK RIDGE SPECIAL SAMPLES

Compositions given in mole %

50% LiF 50% BeF_2		69 % LiF 31 % BeF_2		64% NaF 5% LiF 31% BeF_2 #381		#388		63.5% NaF 7.5% LiF #389 29.0% BeF_2		56% NaF 16% LiF C-78 28% BeF_2		Comments
density (gms/cm^3)	temp °C	density (gms/cm^3)	temp °C	density (gms/cm^3)	Temp °C	density (gms/cm^3)	temp °C	density (gms/cm^3)	temp °C	density (gms/cm^3)	temp °C	
1.8482	907.3	1.8240	911.0	1.9359	912.0	1.9045	910.8	1.9327	912.0	1.8550	911.0	Solid line indicates data below line obtained from new mixture.
1.8571	855.5	1.8545	859.0	1.9663	852.0	1.9340	861.8	1.9483	860.0	1.8747	860.8	
1.8856	799.6	1.8369	798.8	1.9923	793.8	1.9382	810.0	1.9660	812.8	1.8935	809.2	
1.9105	744.0	1.8543	749.0	2.0196	736.0	1.9579	761.0	1.9885	763.1	1.9028	762.0	
1.9340	685.6	1.8752	697.1	2.0589	660.0	1.9819	711.5	2.0144	712.3	1.9240	709.6	
1.9602	635.5	1.8989	645.1	2.0997	582.8	2.0067	662.0	2.0396	663.3	1.9452	661.3	
1.9771	583.3	1.9094	619.2	2.1119	560.0	2.0444	586.8	2.0670	611.4	1.9701	611.8	
1.9988	518.1	1.9180	597.6	2.1161	550.7	2.0826	512.0	2.0932	563.1	1.9927	562.0	
2.0223	433.8	1.9256	578.0	2.1206	541.3	2.1092	459.3	2.0772	512.7	2.0204	508.5	
2.0081	348.9	1.9481	530.0			2.1393	408.1	1.9295	902.0			
		1.9579	507.2			2.1794	356.7	1.9530	850.5			
		1.9589	501.1					1.9769	800.5			
		1.8299	864.5					2.0000	745.3			
								2.0248	700.0			
								2.0495	650.2			
								2.0752	598.8			
								2.1023	550.7			
								2.0025	722.5			

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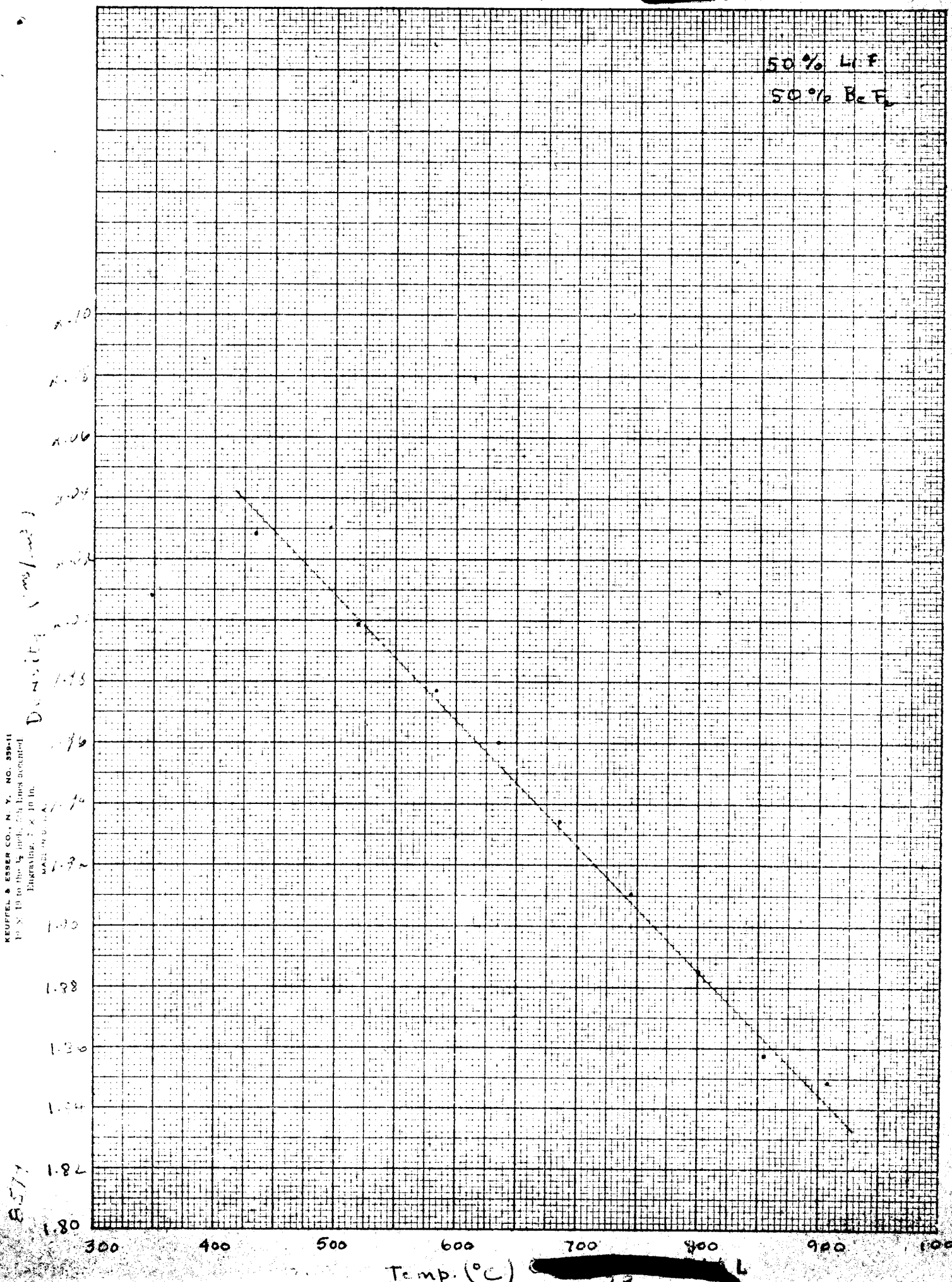
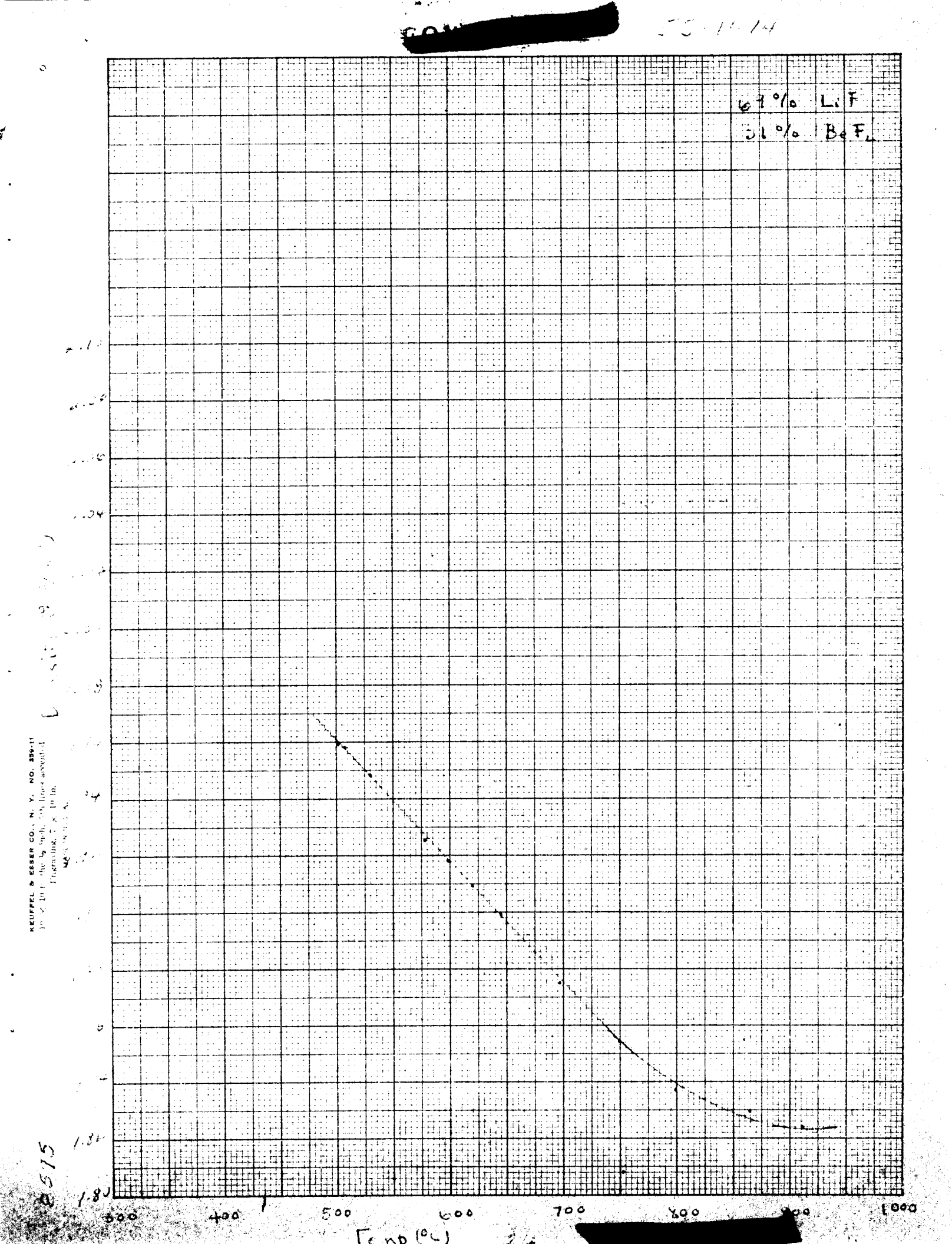


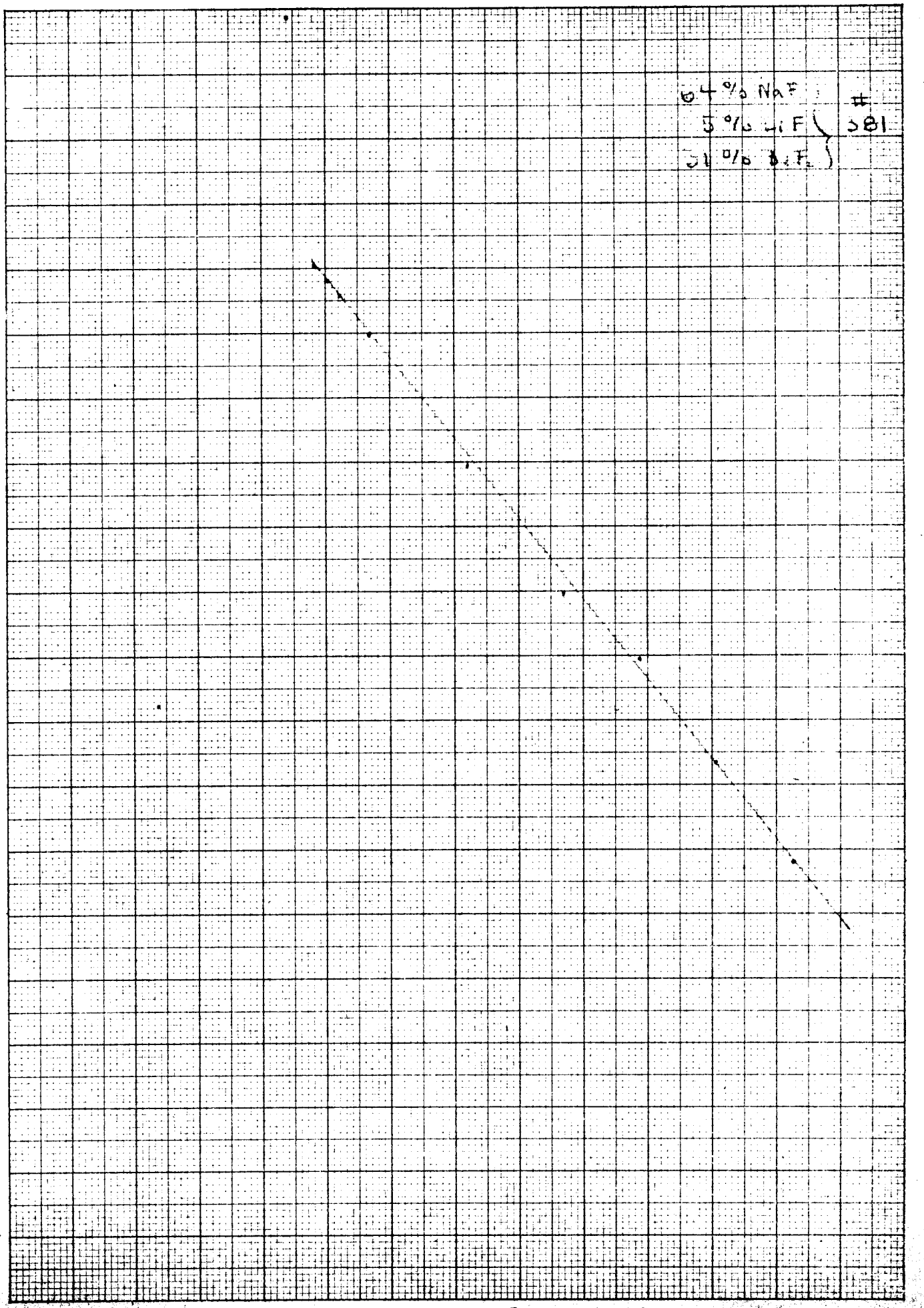
KEUFFEL & ESSER CO., N. Y. NO. 359-11
10 × 10 to the ½ inch, 5 lines accented
Engraving, 7 × 10 in.
MADE IN U.S.A.

[redacted]


67 % LiF
33 % BeF2
1.8
400
500
600
700
800
1000

[redacted]

64% NaF
5% LiF } #381
31% ZrF_4 }



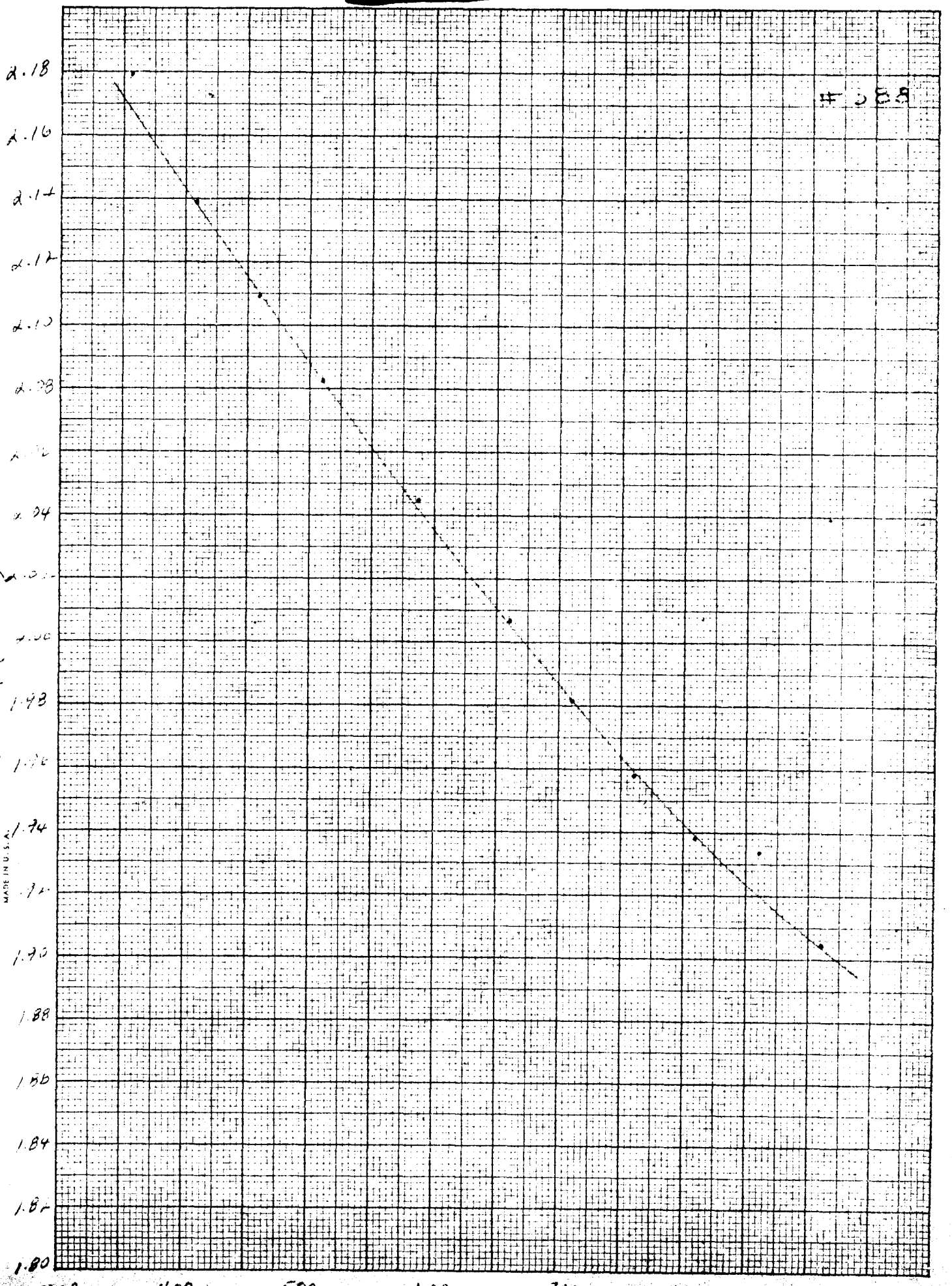
T_{emp} (°C)

[redacted]

KEUFFEL & ESSER CO., N. Y. NO. 358-11
MADE IN U.S.A.

9576

[redacted] 11-14

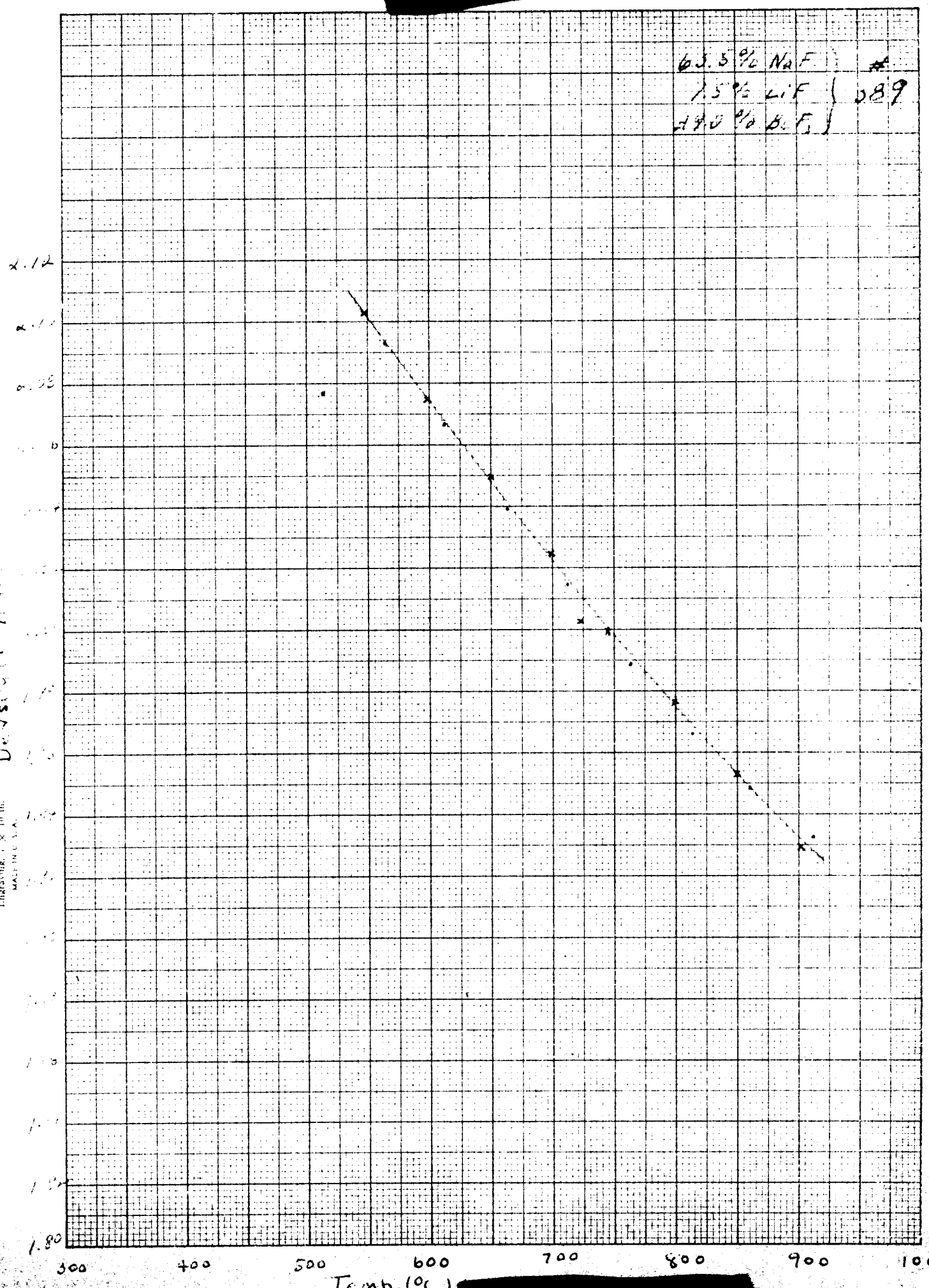


KEUFFEL & ESSER CO., N. Y. NO. 359-11
10 × 10 to the ½ inch, 5th lines accented
Engraving, 7 × 10 in.
MADE IN U.S.A.

8577

[redacted]

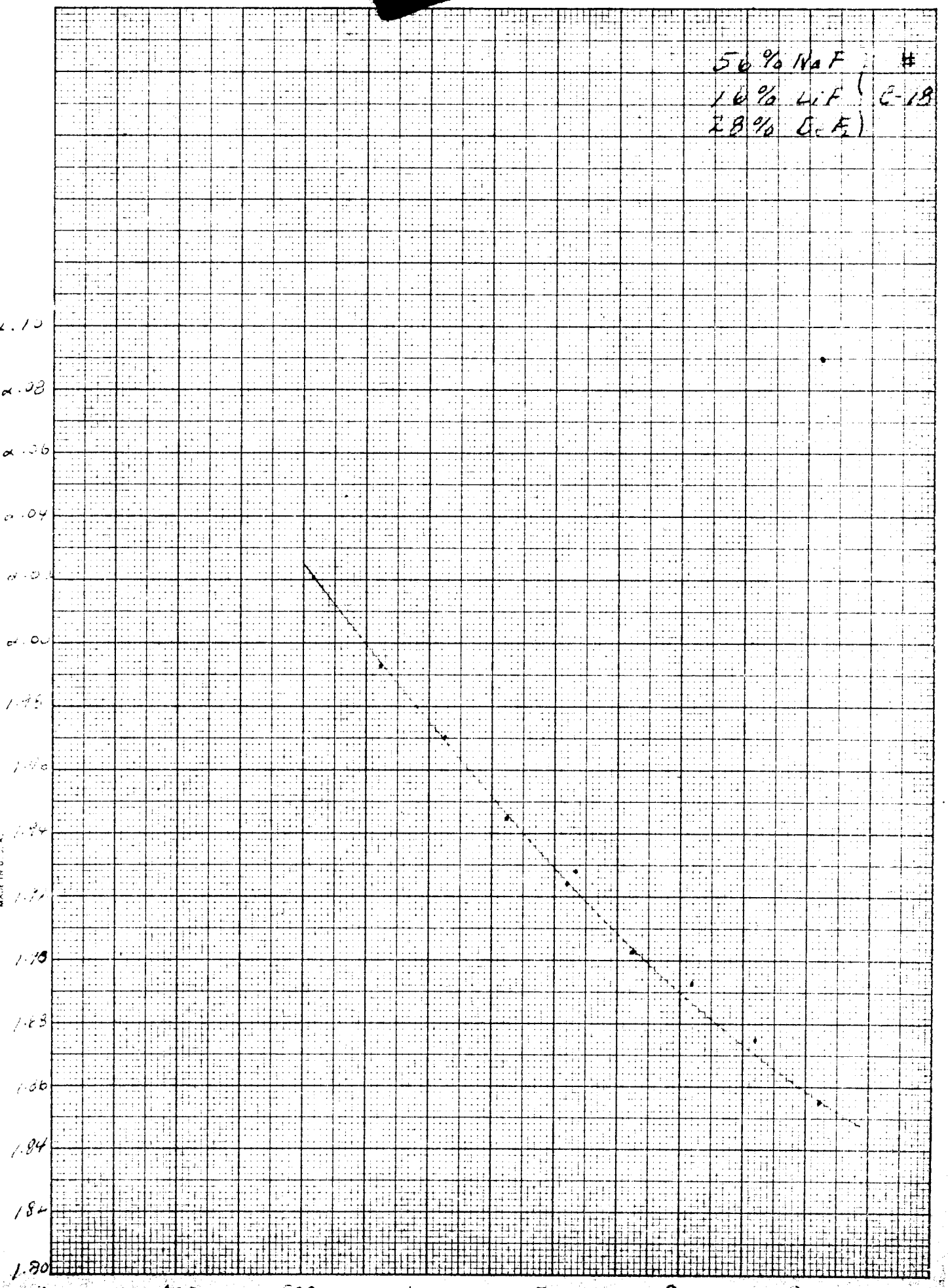
[redacted]



KEUFFEL & ESSER CO., N. Y. NO. 359 11
Engraving, 7 × 10 in.
MADE IN U.S.A.

8578

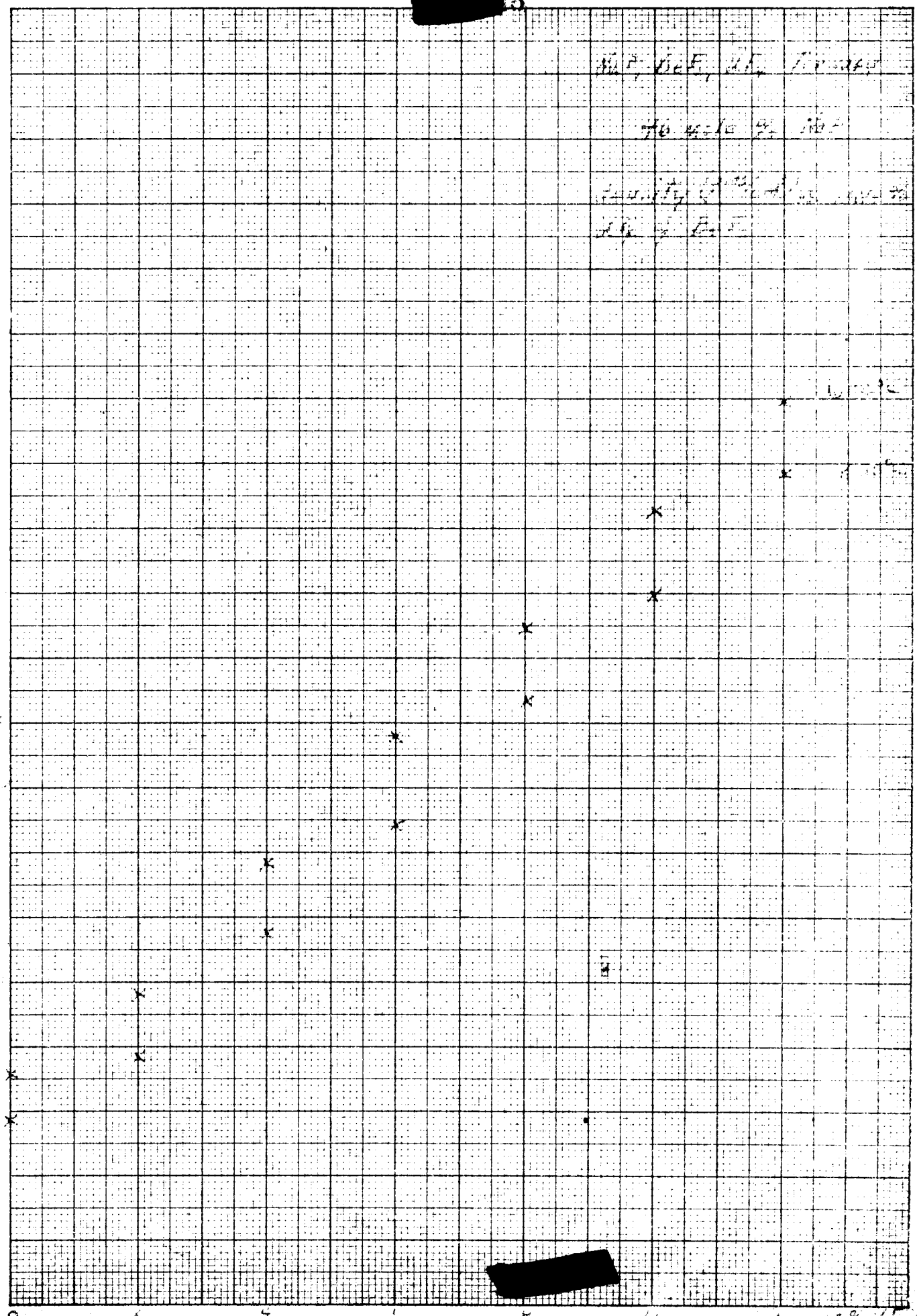
[redacted] 55-11-14

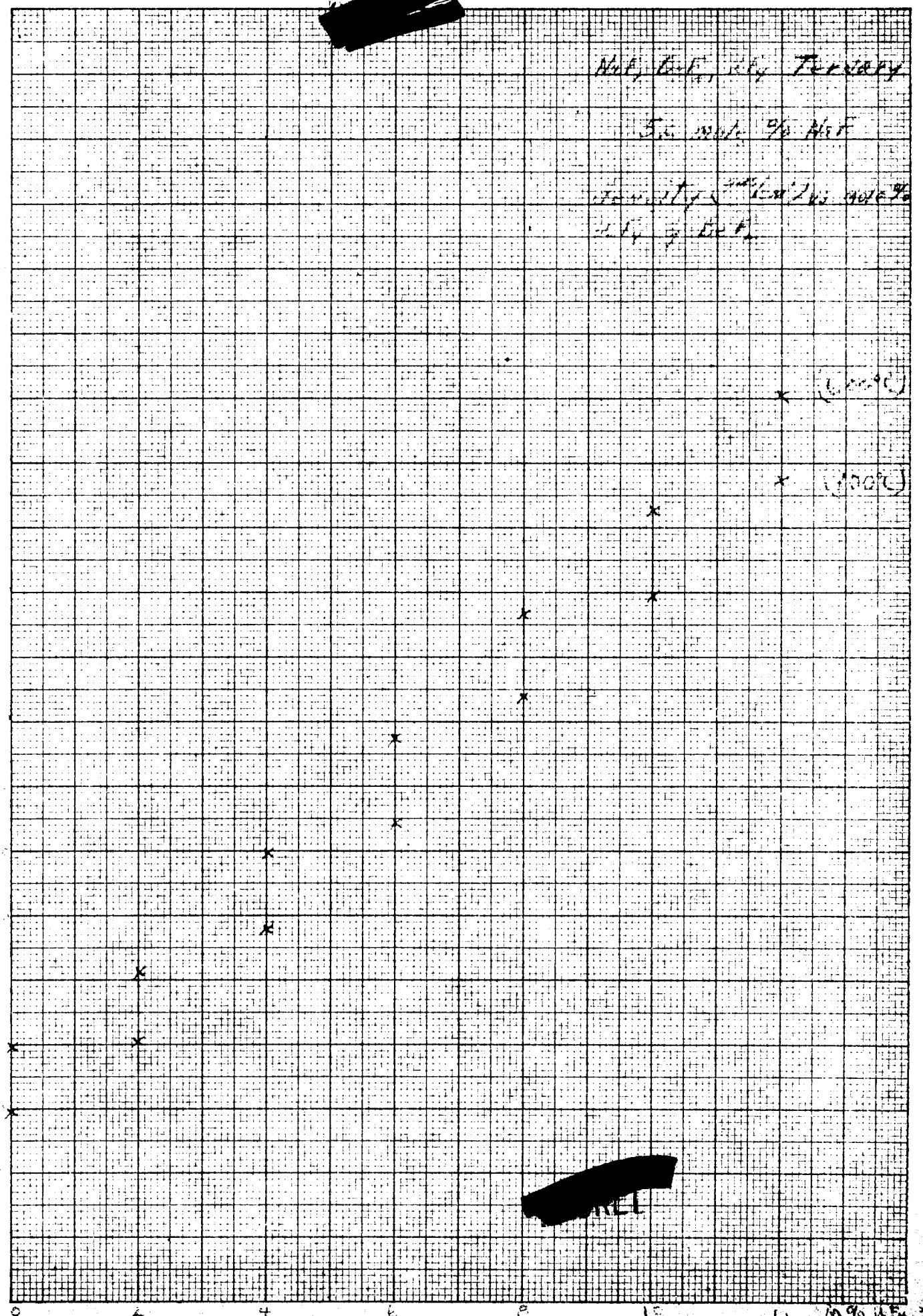


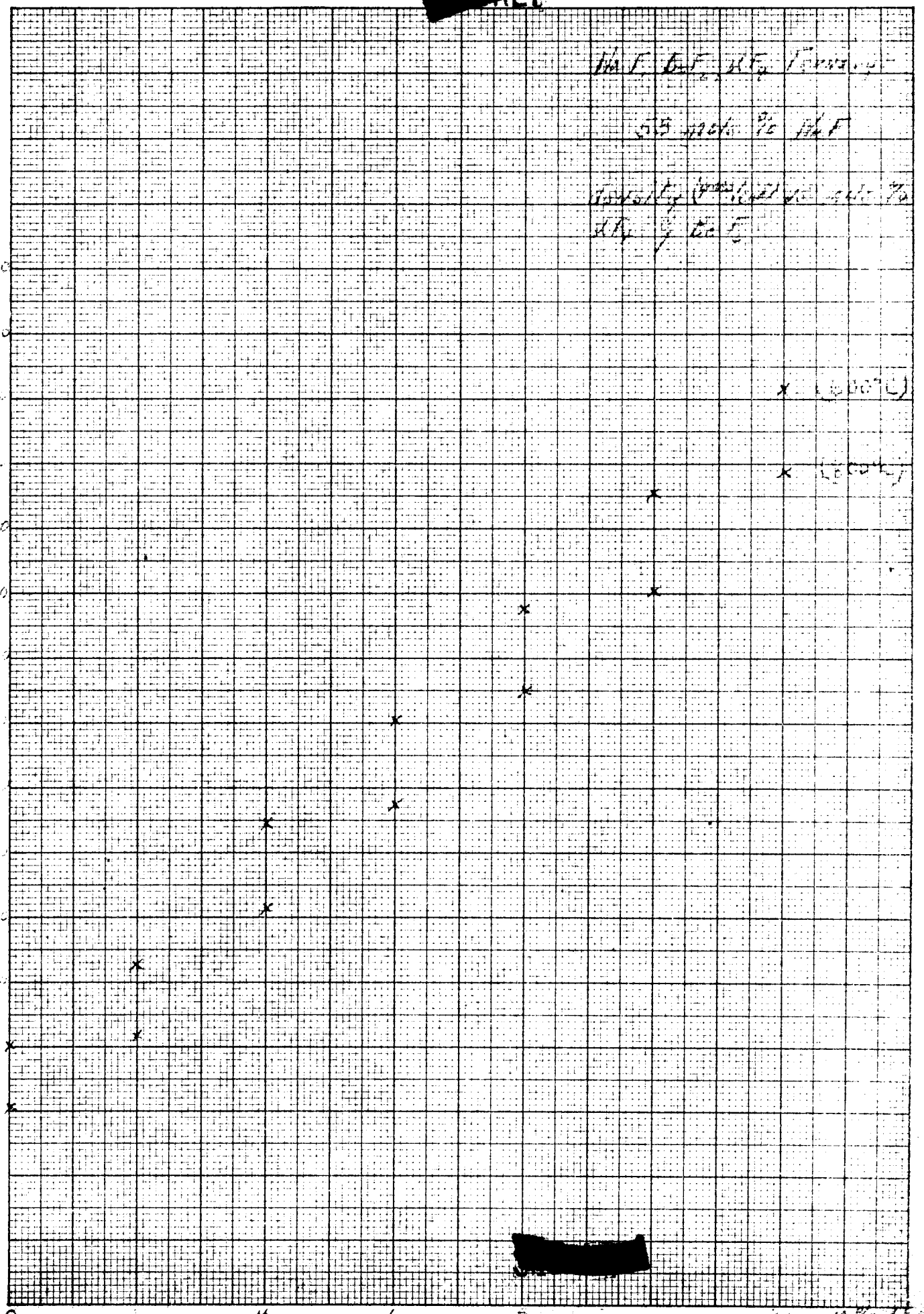
KEUFFEL & ESSER CO., N. Y. NO. 350-11
10 × 10 to the ½ inch, 5×5 lines accented
Eterprise, 7 × 10 in.
MADE IN U.S.A.

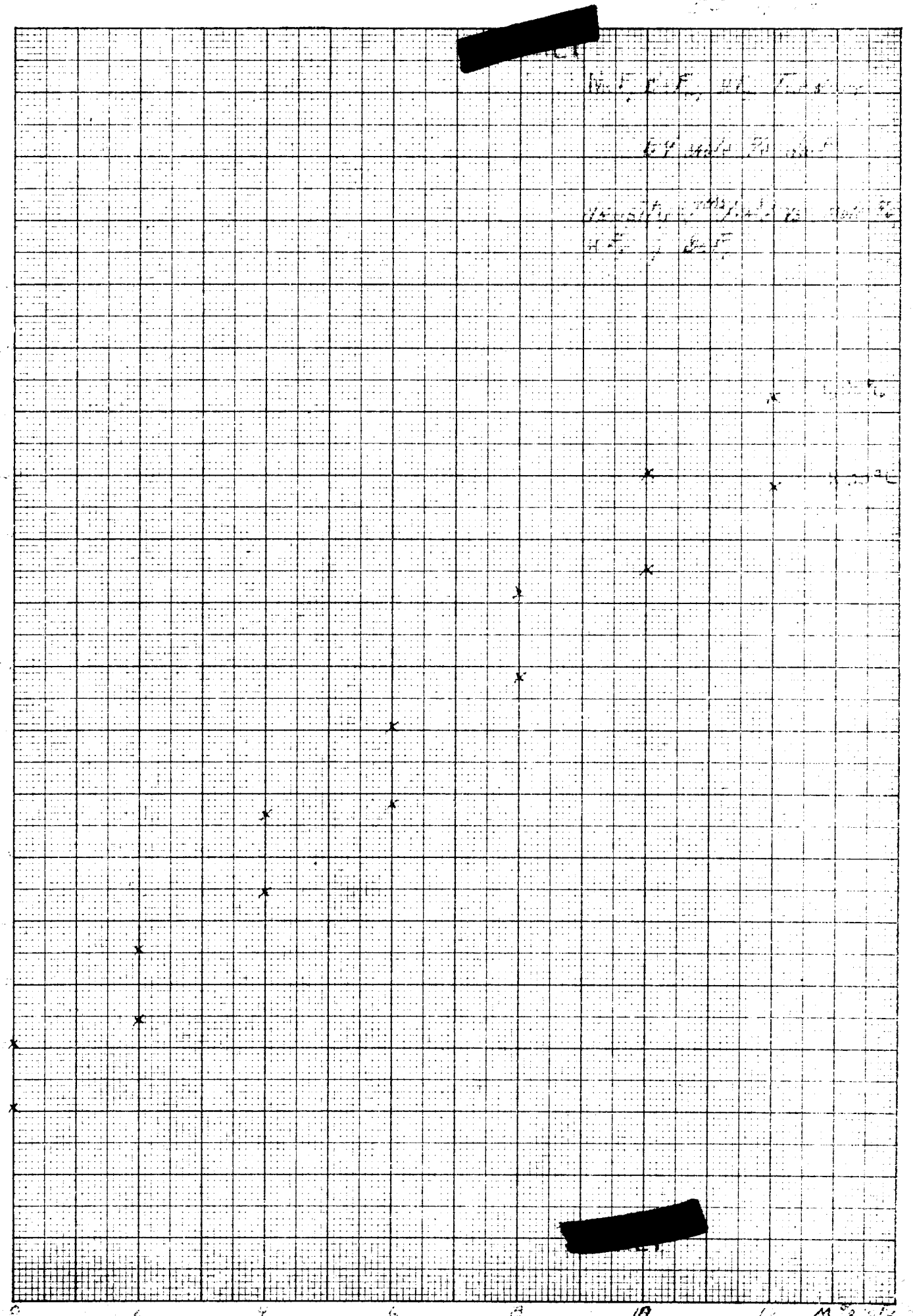
8574

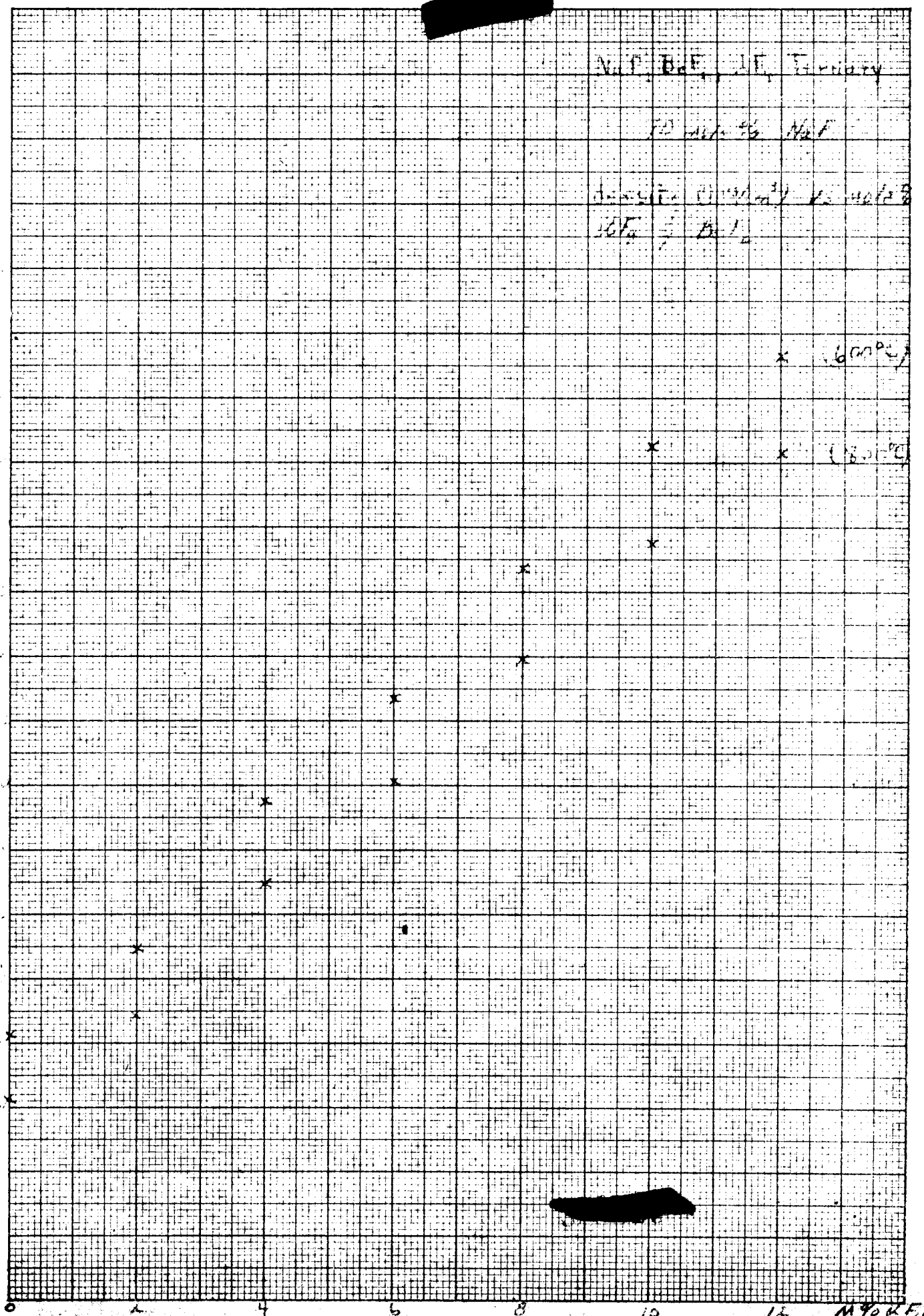
[redacted]

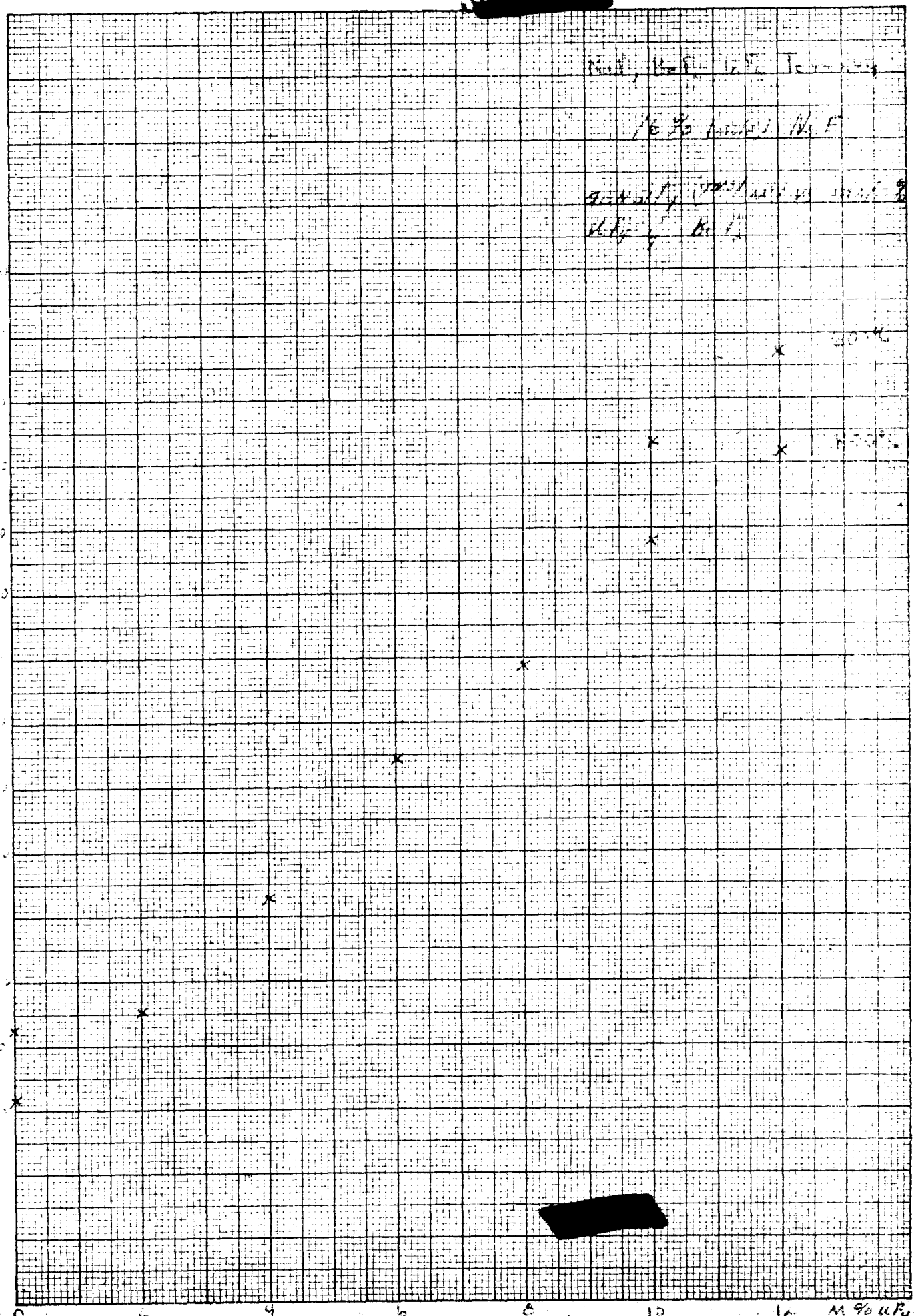


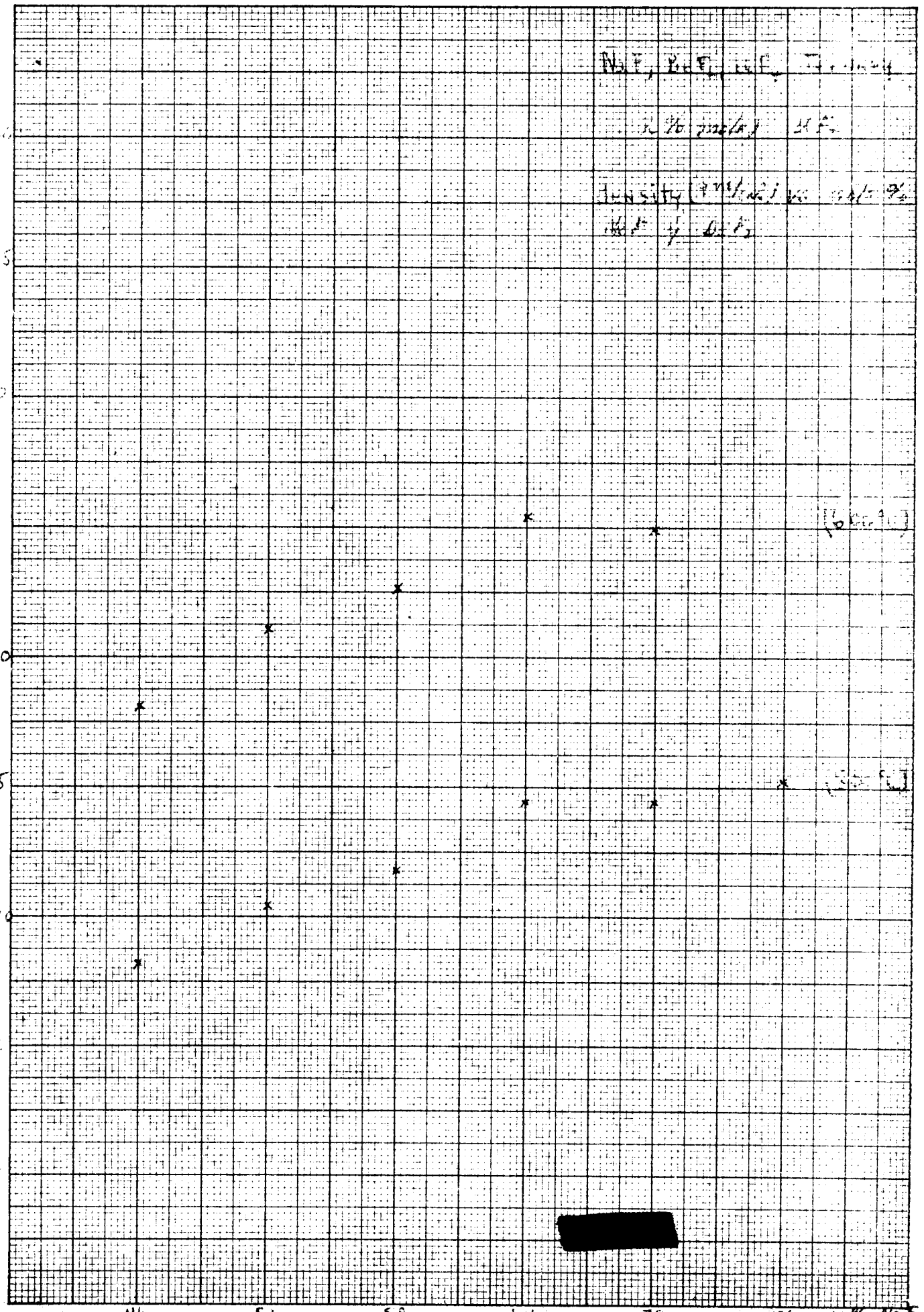




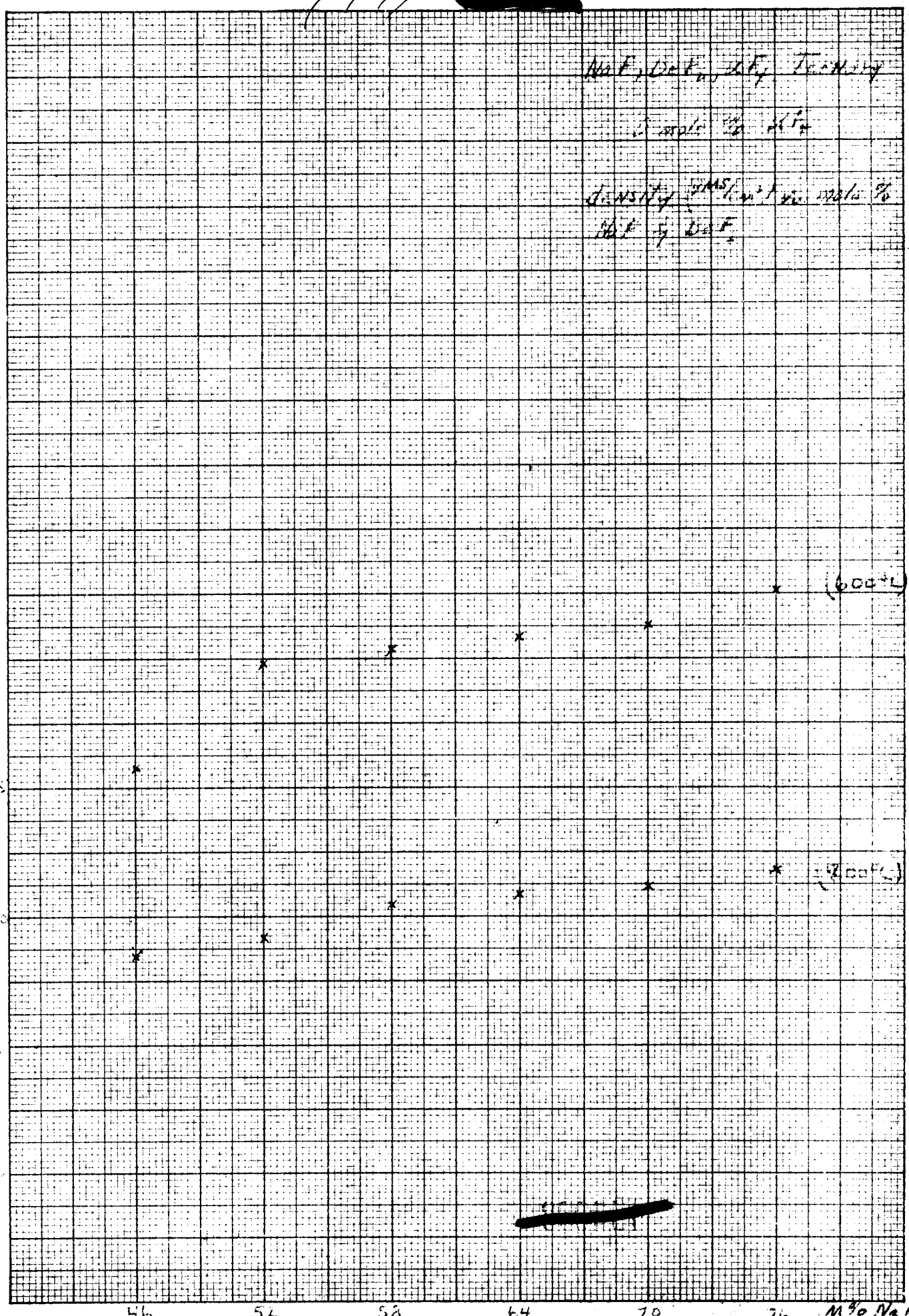




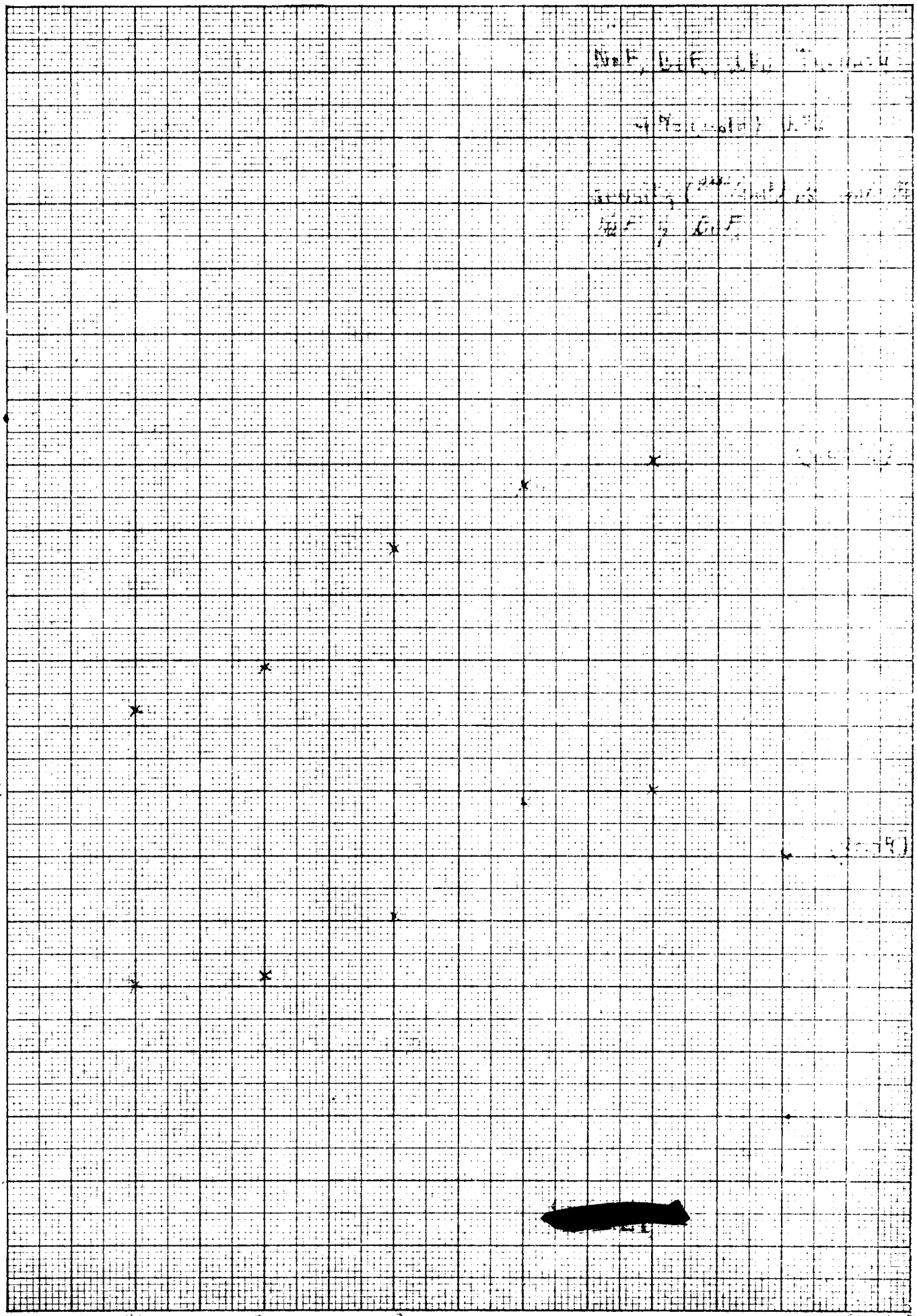


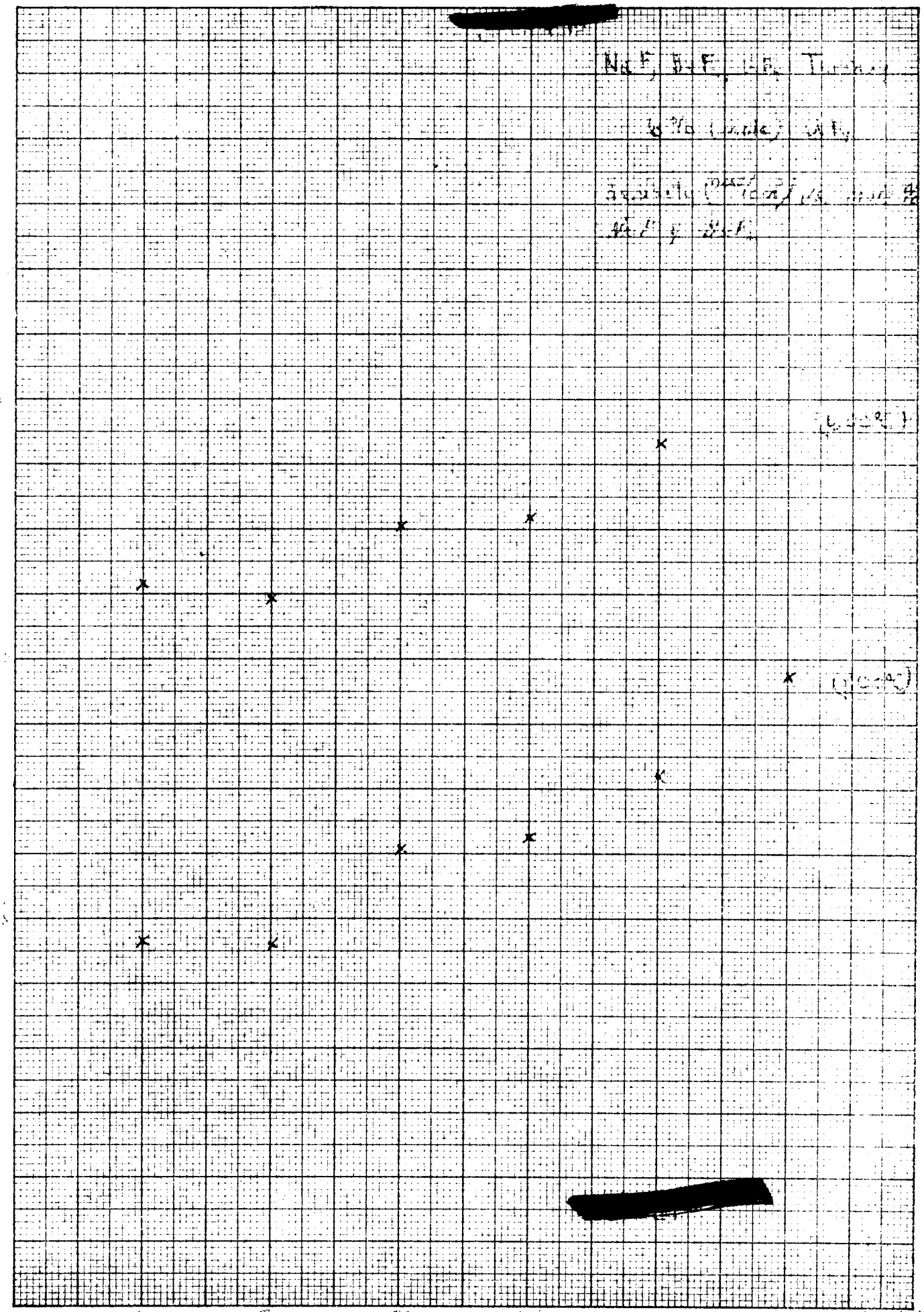


KEUFFEL & ESSER CO., N. Y. NO. 359-11
10 × 10 to the ½ inch, 5th lines accented.
Engraving, 7 × 10 in.
MADE IN U. S. A.

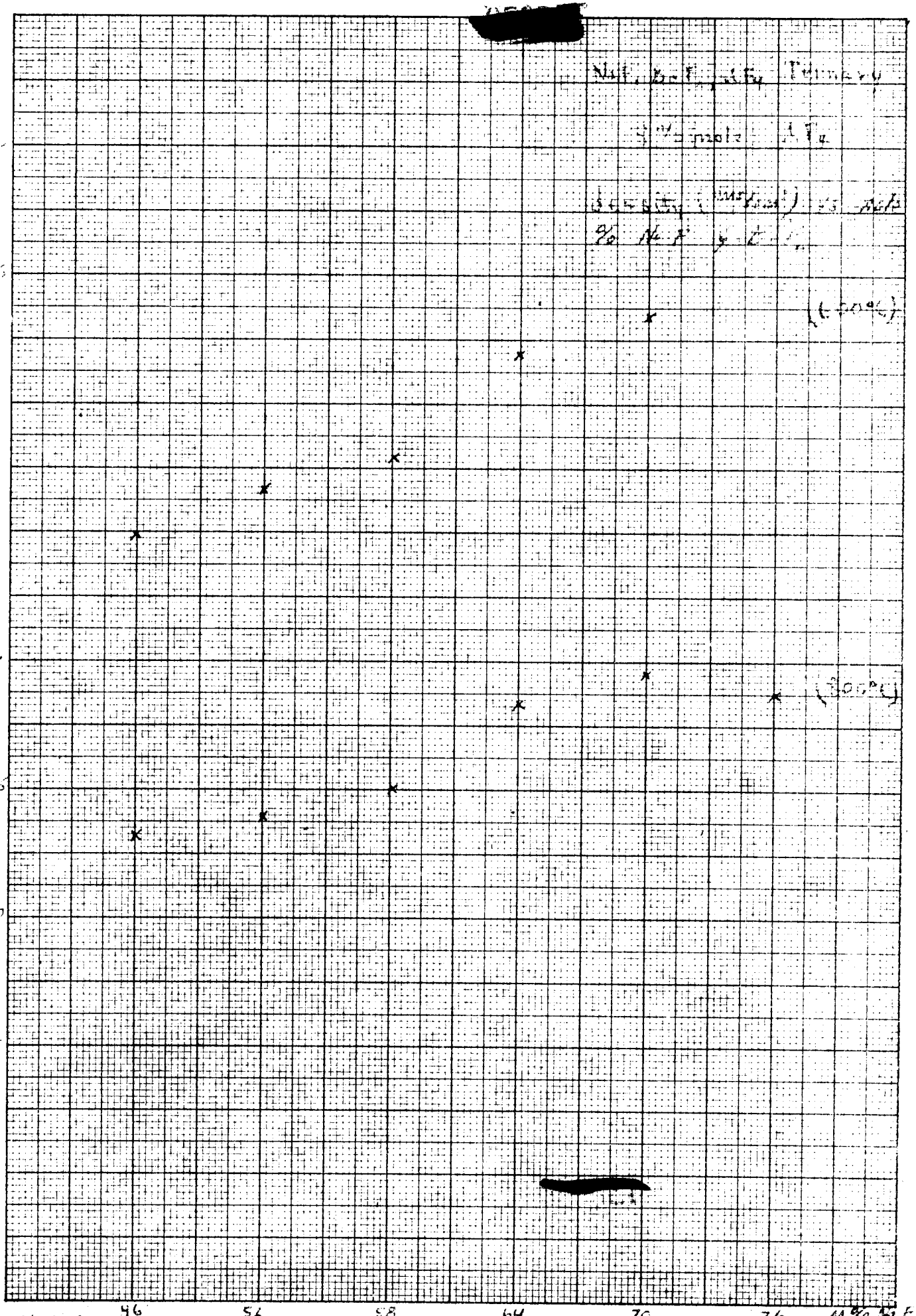


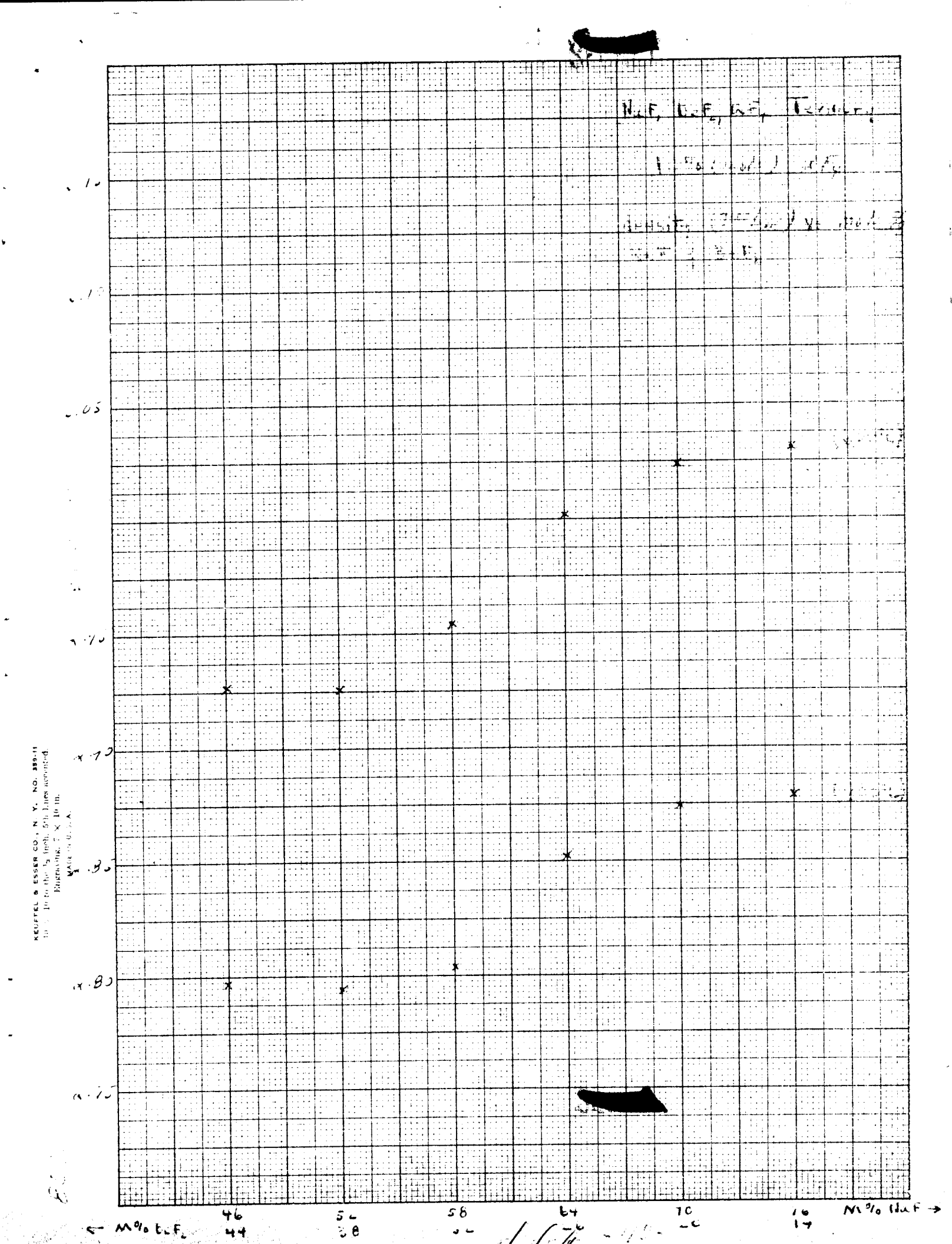
KEUFFEL & ESSER CO., N. Y. NO. 359-11
10 × 10 to the ½ inch, 5th lines accented.
Engraving, 7 × 10 in.
MADE IN U.S.A.

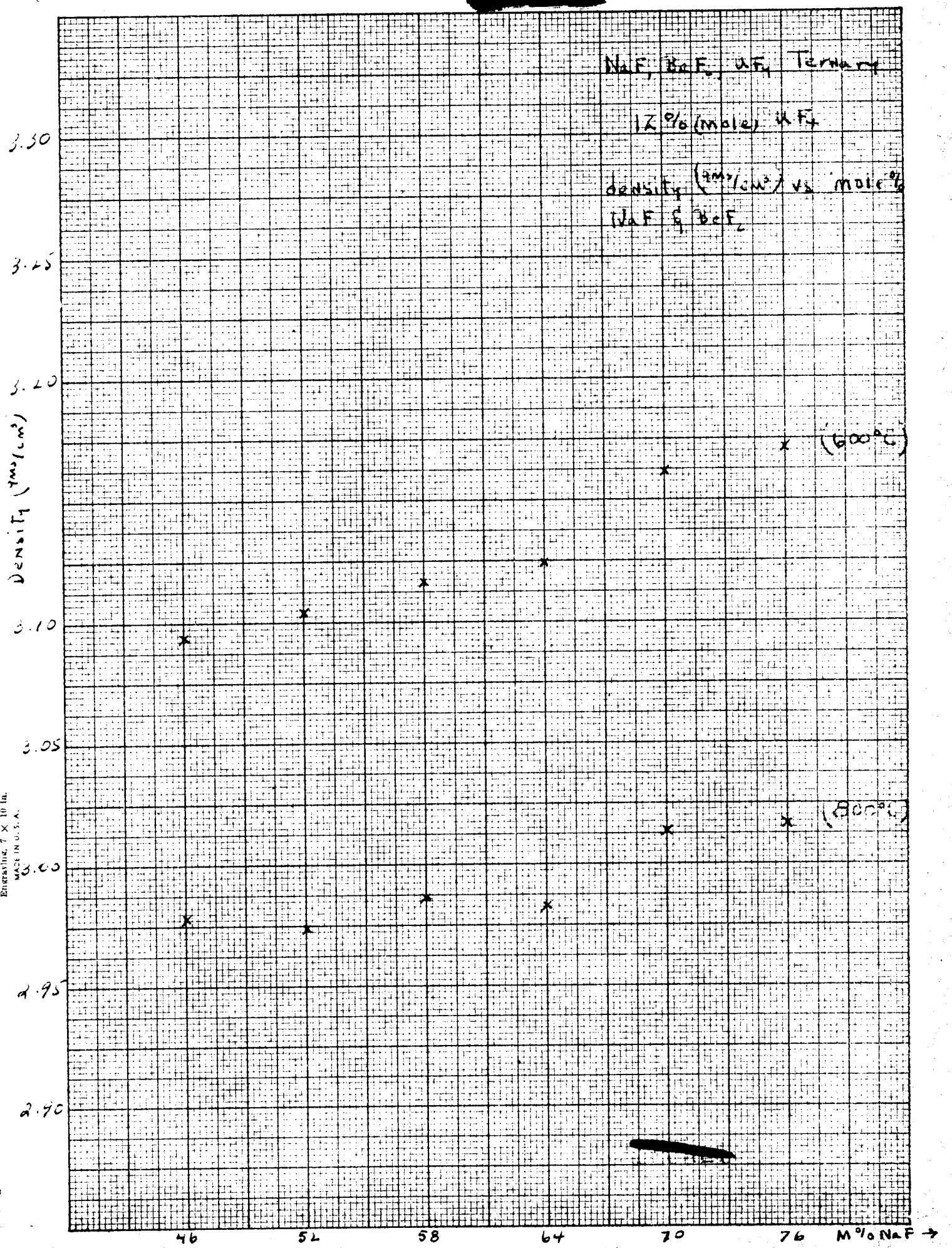




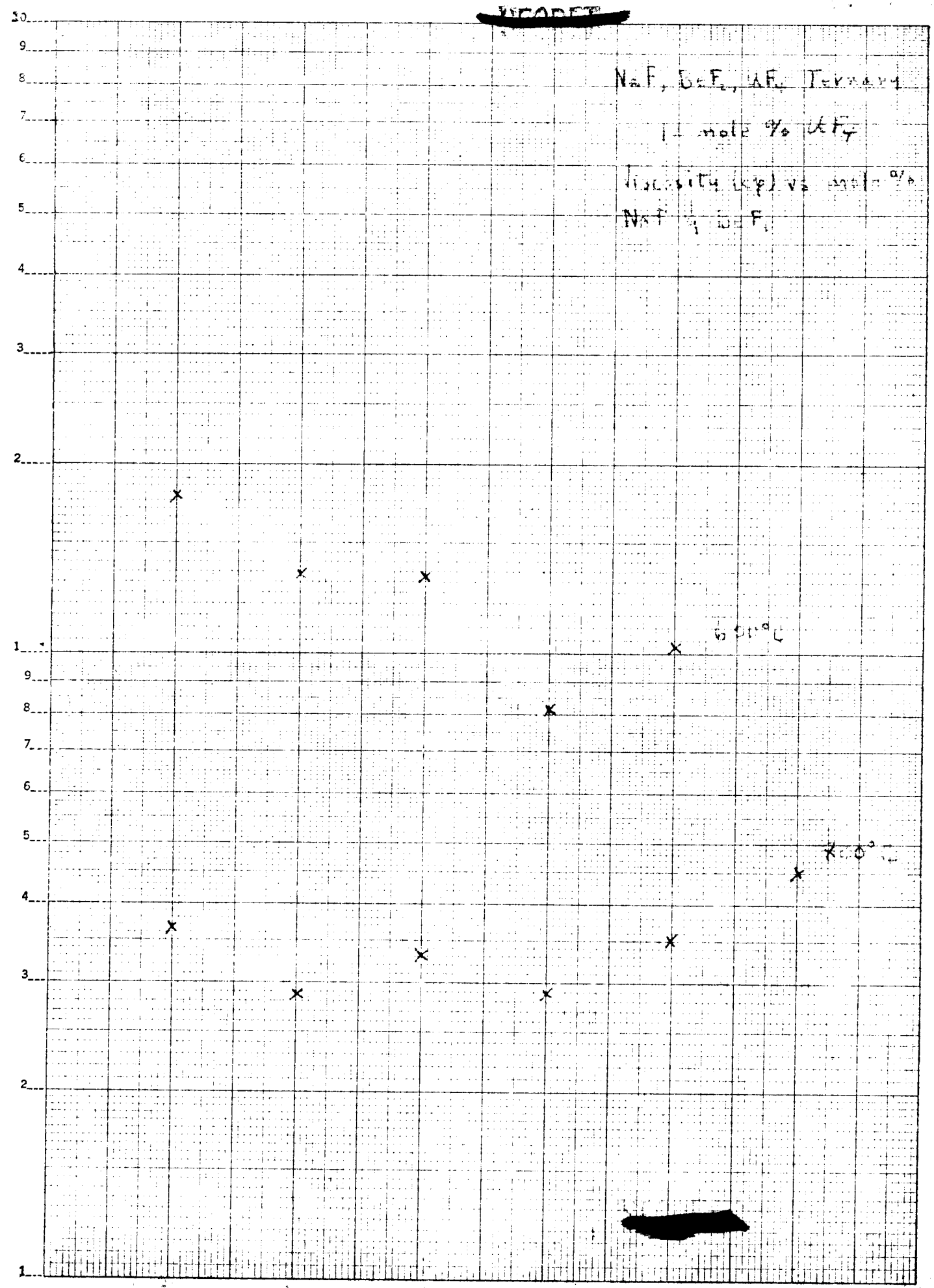
KEUFFEL & ESSER CO., N. Y. NO. 359-11
10 × 10 to the ½ inch, 6th lines accented.
Engraving, 7 × 10 in.
MADE IN U.S.A.

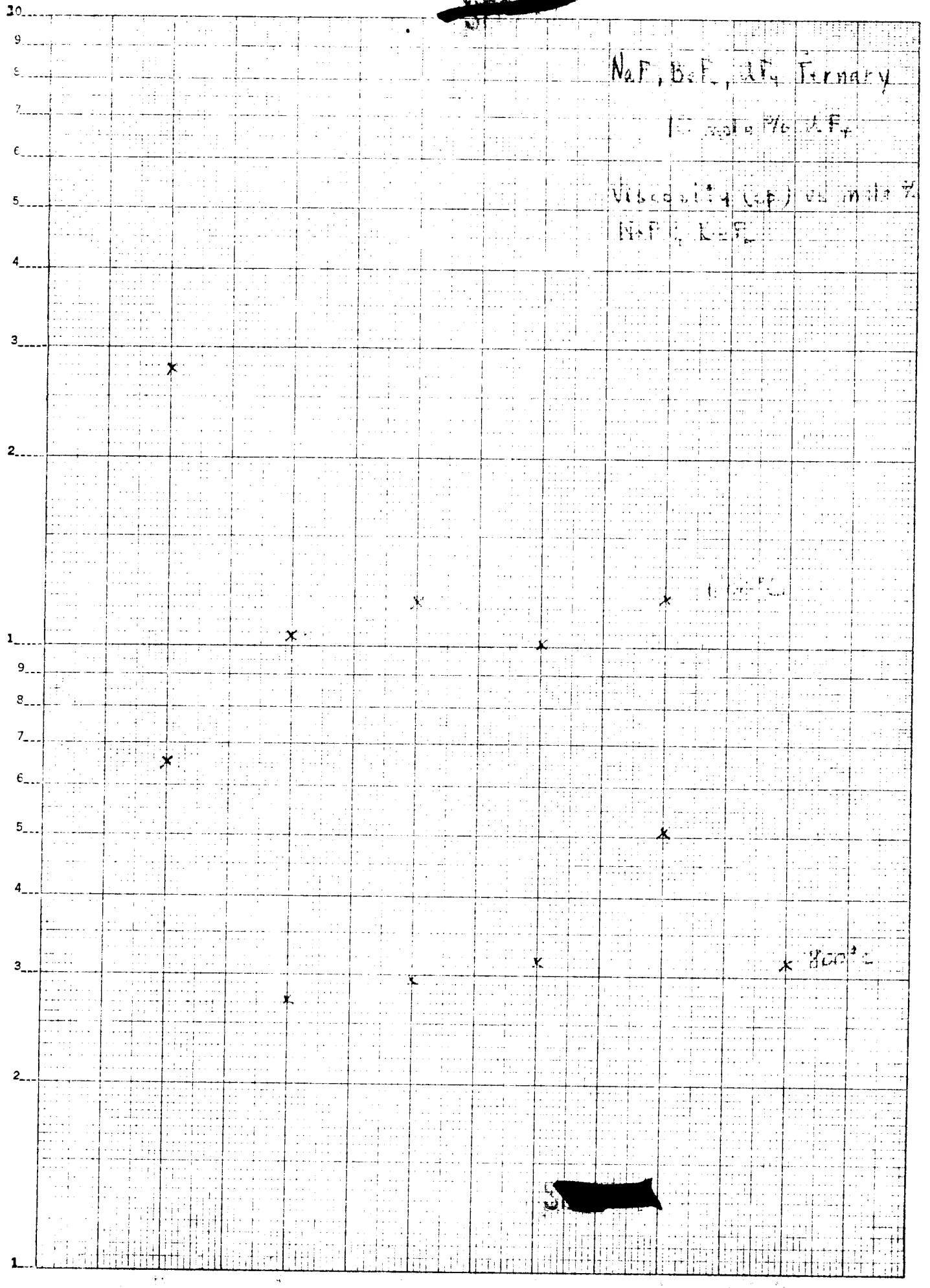


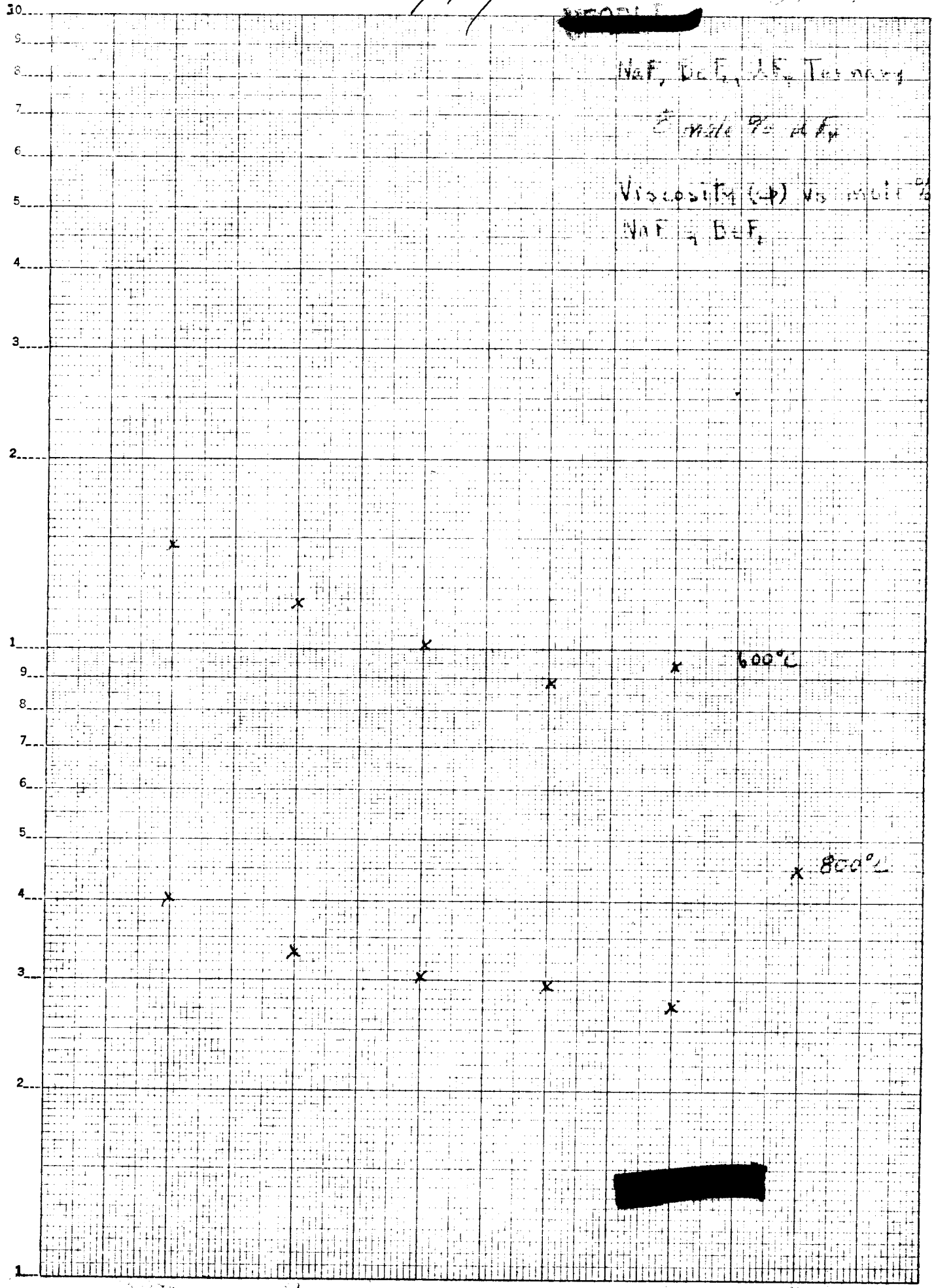

.10
.05
.70
.72
.80
.82
46
44
56
58
64
70
76
74
← M% LiF₂
M% NaF →

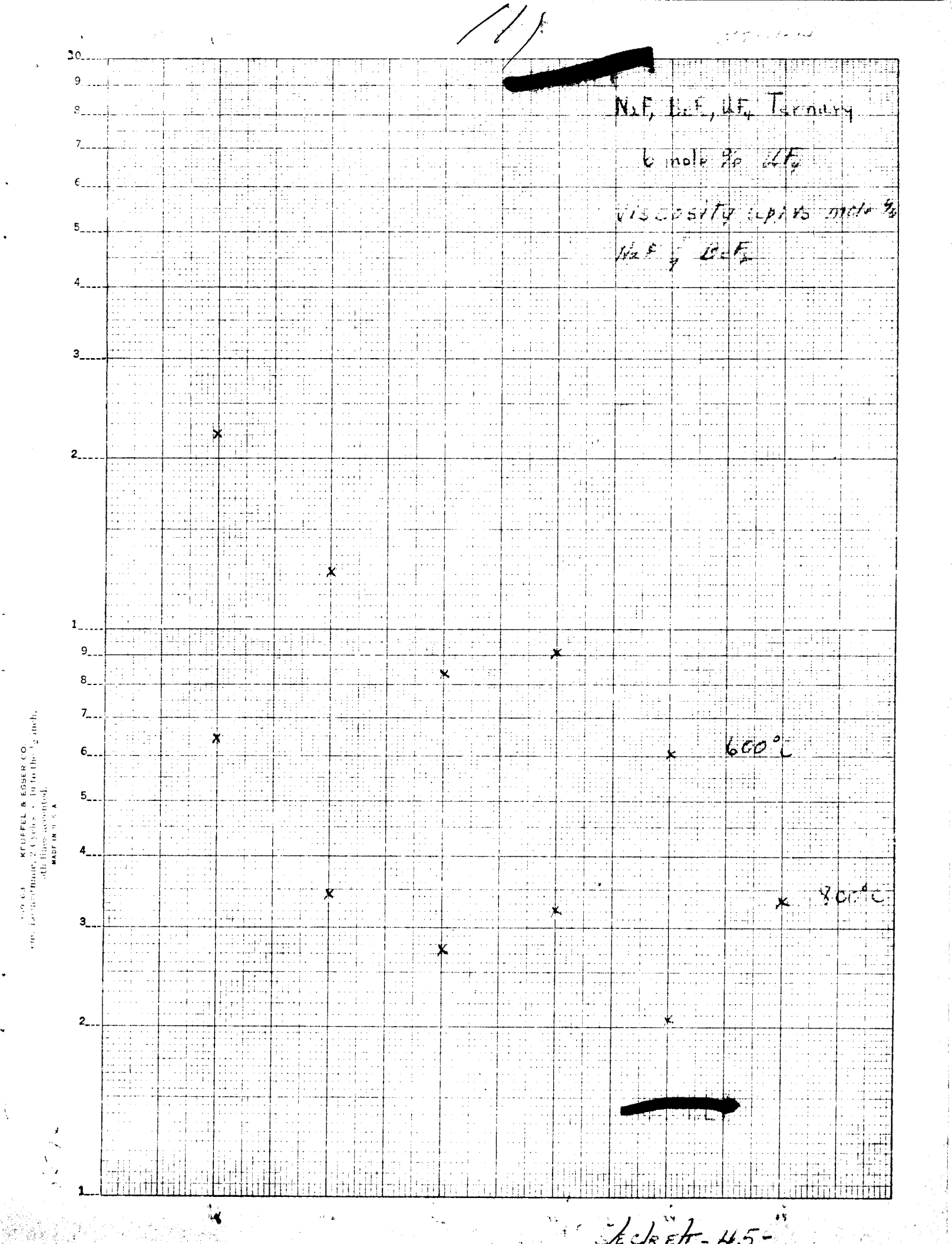


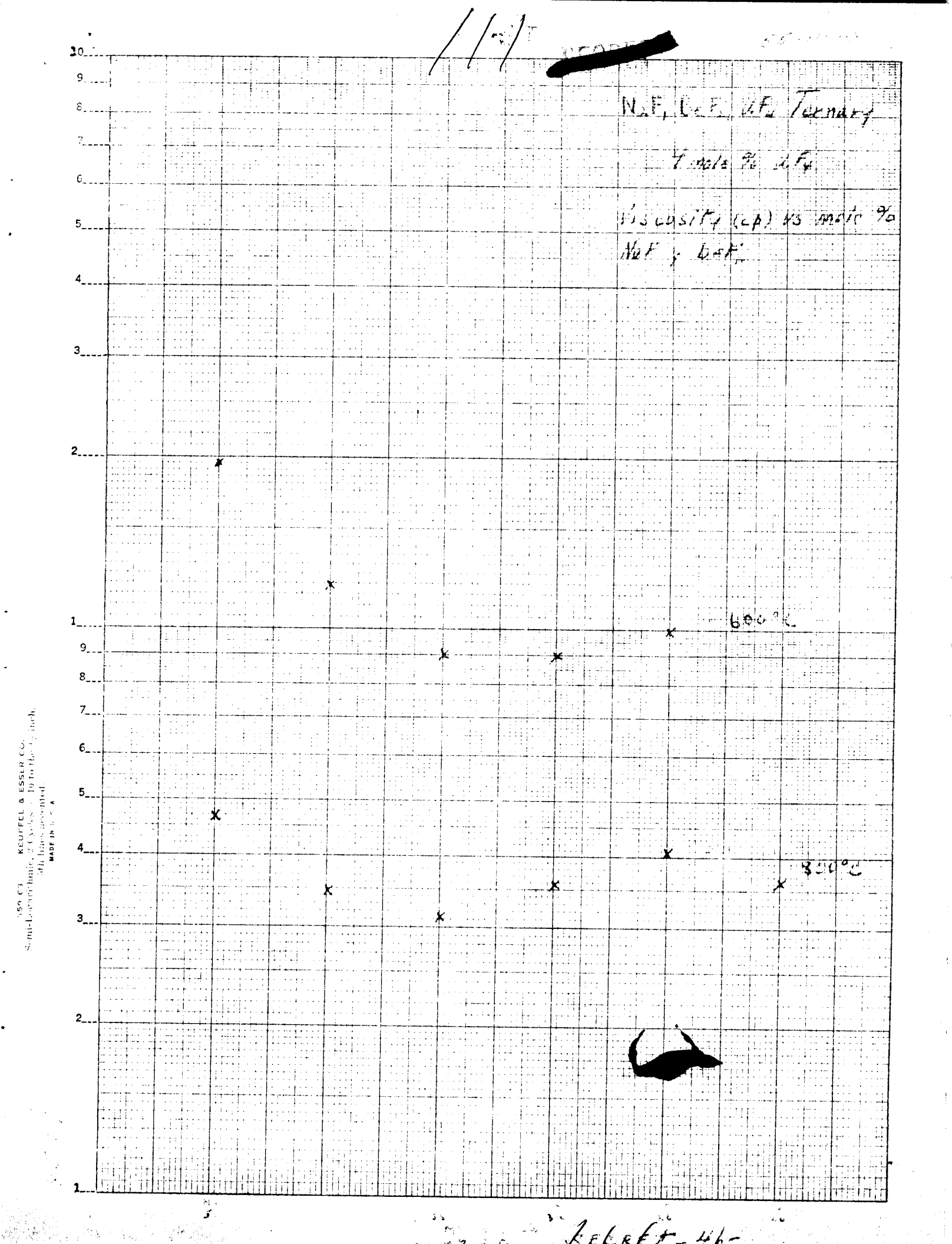
KEUFFEL & ESSER CO., N. Y. NO. 359-11
10 × 10 to the ½ inch, 5th lines accented.
Engraving, 7 × 10 in.
MADE IN U.S.A.


NaF, BeF2, AlF3 Ternary
11 mole % AlF3
Viscosity (cp) vs mole %
NaF : BeF2


NaF, BeF2, ZrF4 Ternary
Viscosity (cp) vs mole %
NaF, KaF2


NaF, BeF2, AlF3 Temary
Viscosity (cp) vs mole %
NaF + BeF2
600°C
800°C


NaF, LiF, UF4 Ternary
6 mole % UF4
viscosity (cps) mole %
NaF & LiF
600°C
700°C


NaF, LiF, UF4 Ternary
Viscosity (cp) vs mole %
NaF + UF4
600°C
500°C

[redacted]

11

NaF, LaF_3, UF_4 Ternary

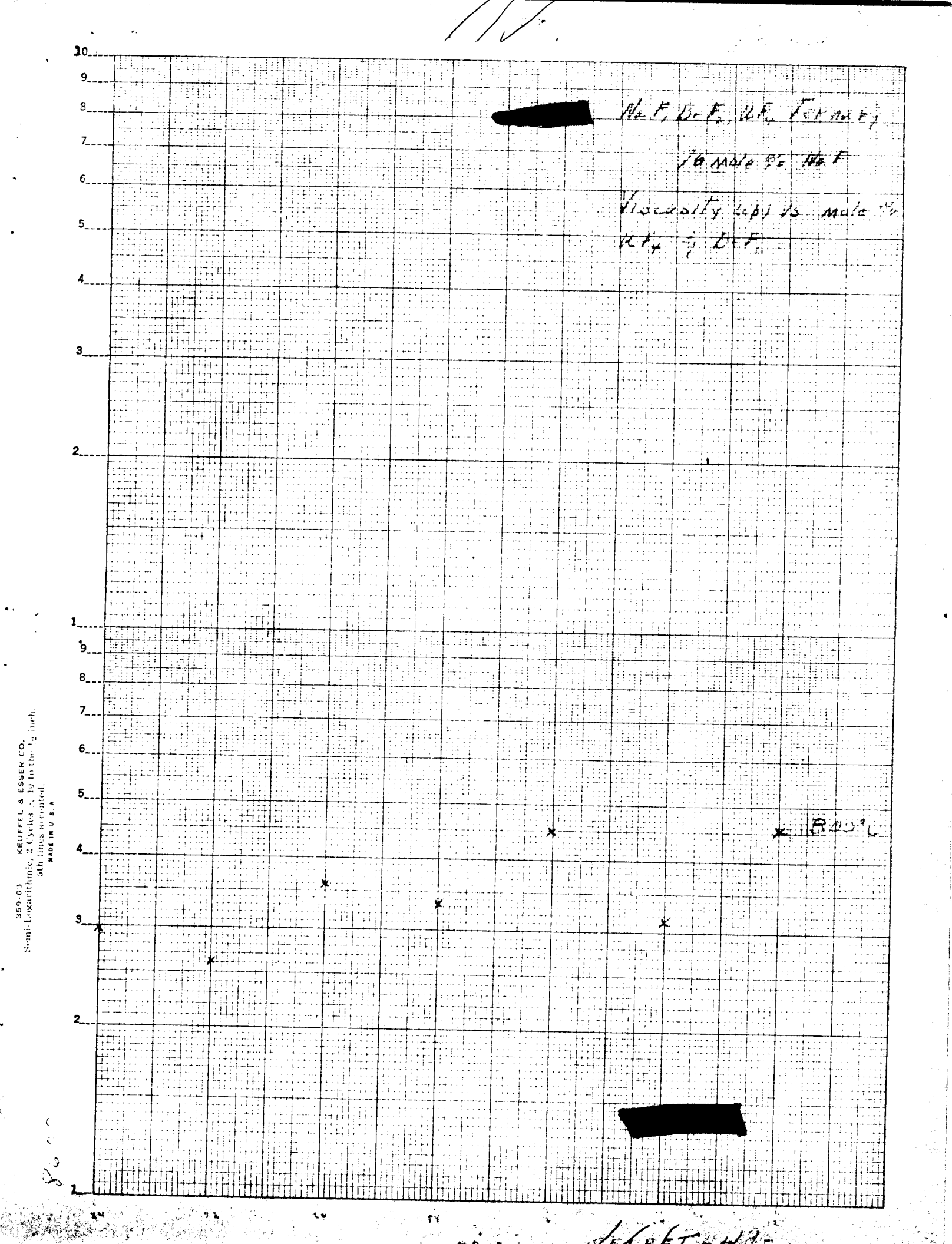
$\frac{1}{2}$ mole % UF_4

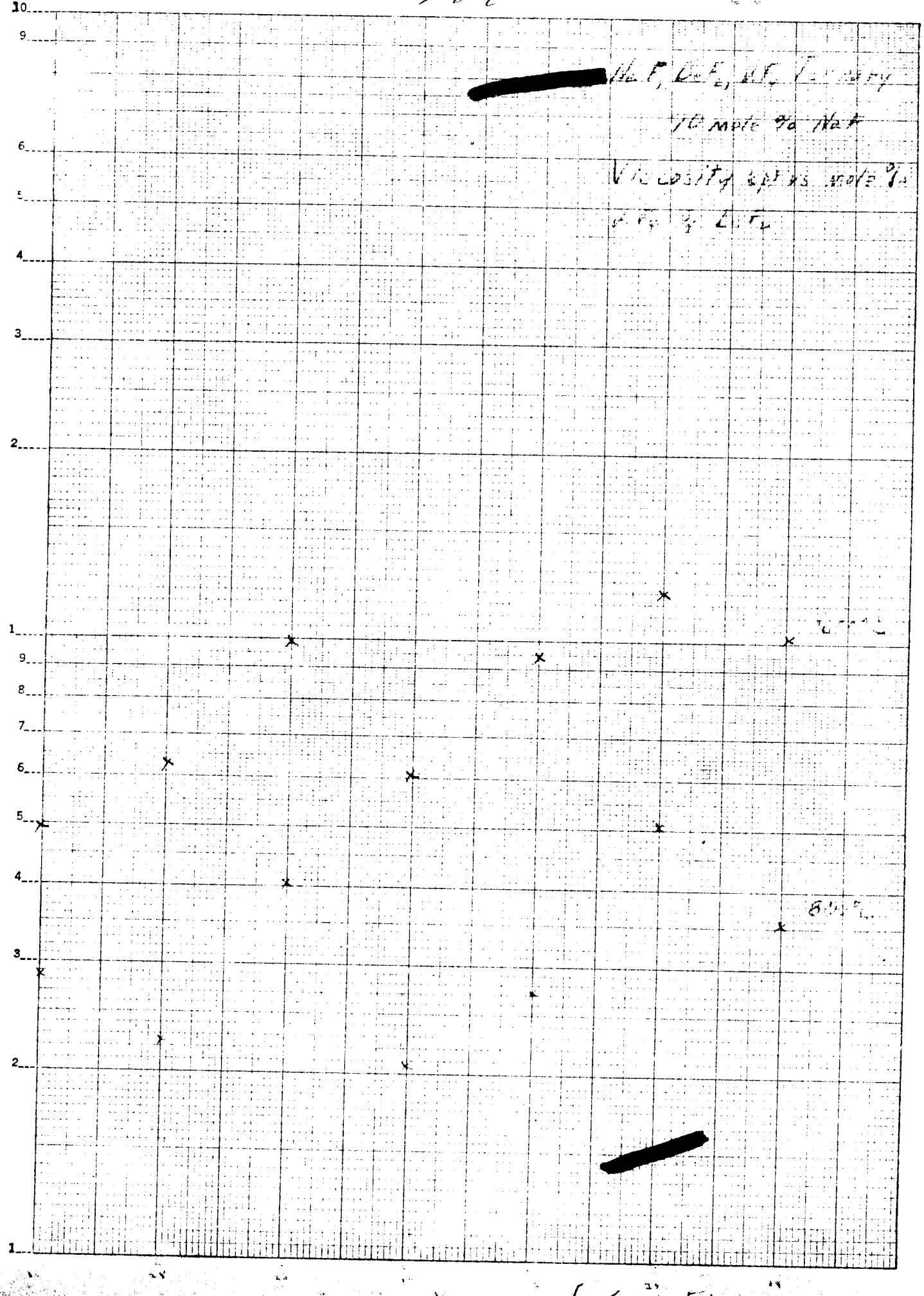
Viscosity (cp) vs mole % NaF / LaF_3

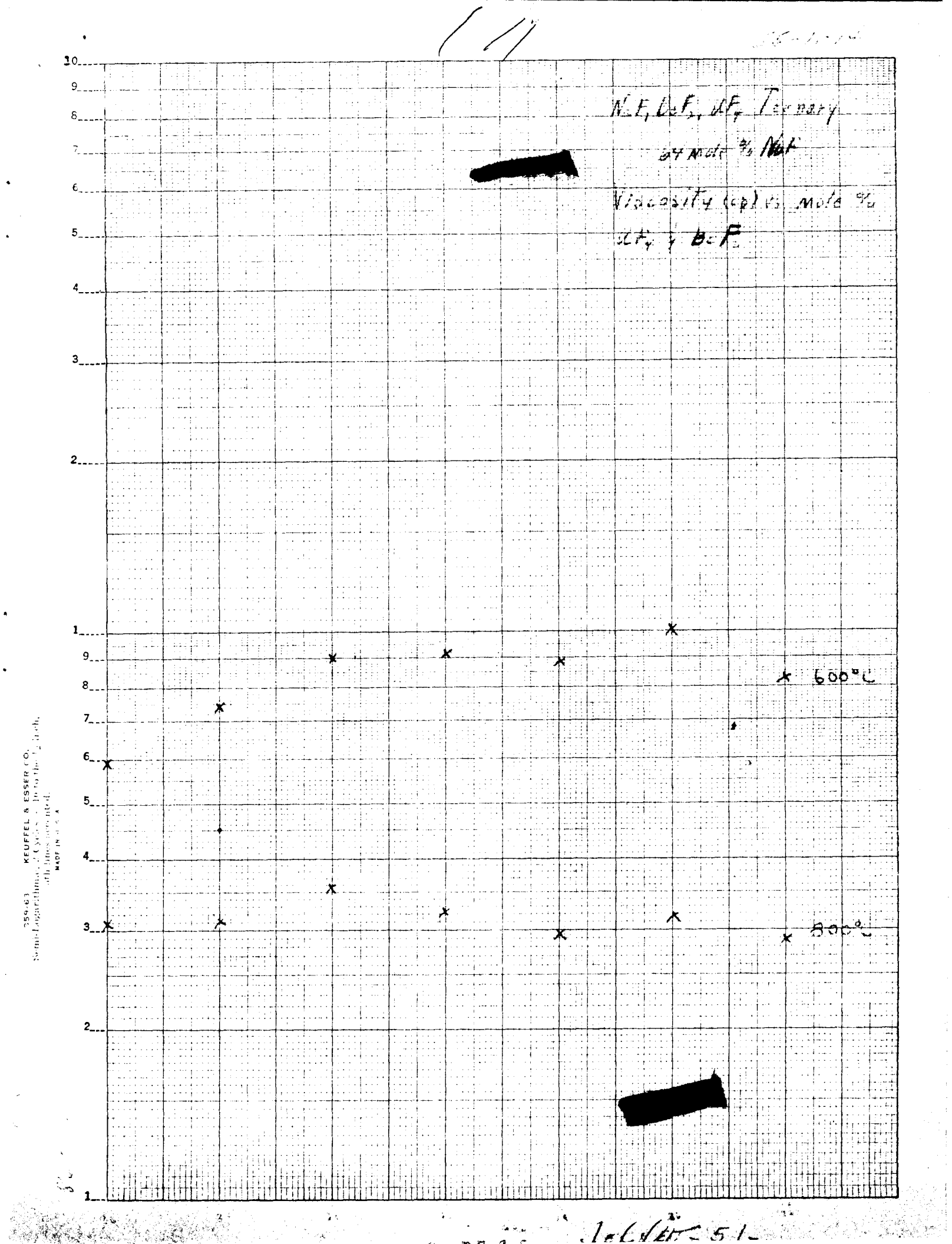
600°C

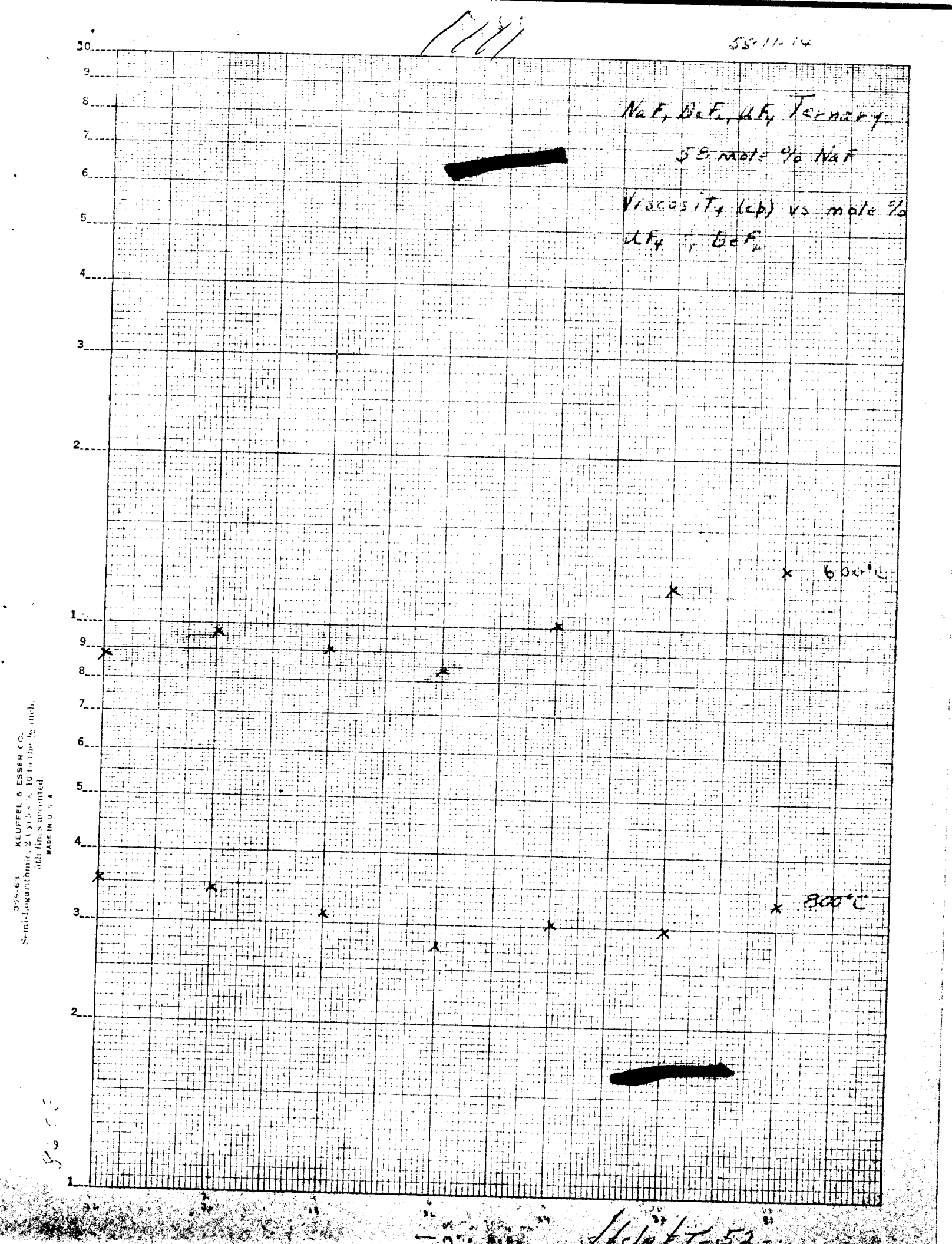
400°C

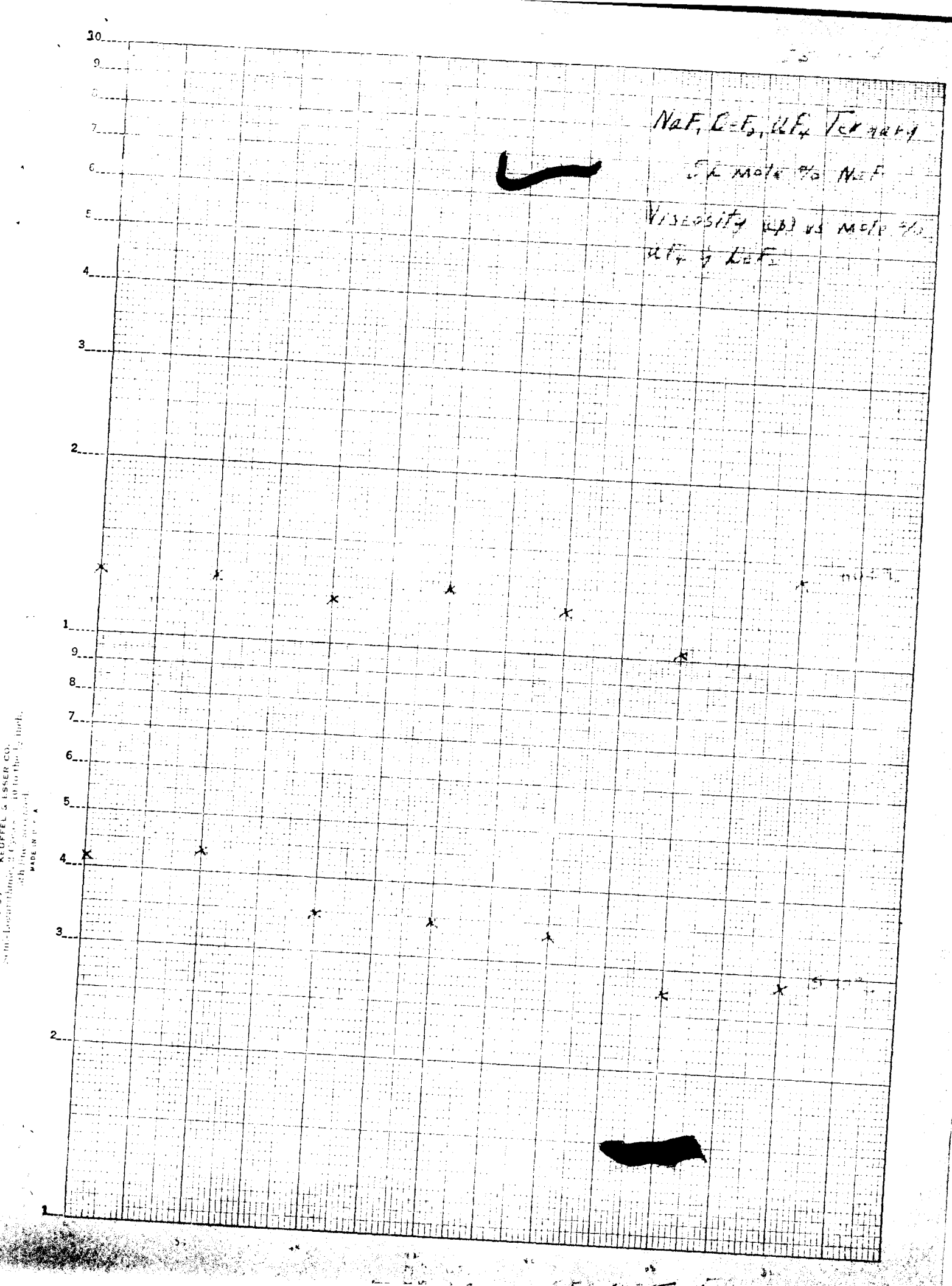
[redacted]


10
9
8
7
6
5
4
3
2
1
9
8
7
6
5
4
3
2
1
[redacted]
Re F, De F, Le F, Pr no F
Re no F
Viscosity Lap vs Mole %
Re F, Le F
Re no
359-63
KEUFFEL & ESSER CO.
Semi-Logarithmic, 2 Cycles, 10 to the 1/2 inch.
5th lines accented.
MADE IN U.S.A.
[redacted]




NaF, BeF2, UF4 Ternary
at mole % NaF
Viscosity (cp) vs. Mole %
UF4 + BeF2
600°C
500°C


NaF, BeF2, UF4 Ternary
55 mole % NaF
Viscosity (cp) vs mole % UF4 + BeF2
600°C
500°C
10
9
8
7
6
5
4
3
2
1


NaF, ZrF4, UF4 Ternary
Mole % NaF
Viscosity (cp) vs Mole % UF4 & ZrF4

[redacted]

58-11-104

NaF, BeF$_2$, ZrF$_4$ Ternary

46 mole % NaF

Viscosity (cp) vs mole % ZrF$_4$ & BeF$_2$

500°C

[redacted]

359-63 KEUFFEL & ESSER CO.
Semi-Logarithmic 2 Cycles X 10 to the 1/2 inch
with lines accented.
MADE IN U.S.A.

[redacted]

[redacted]

58-11-104

NaF, BeF$_2$, ZrF$_4$ Ternary

46 mole % NaF

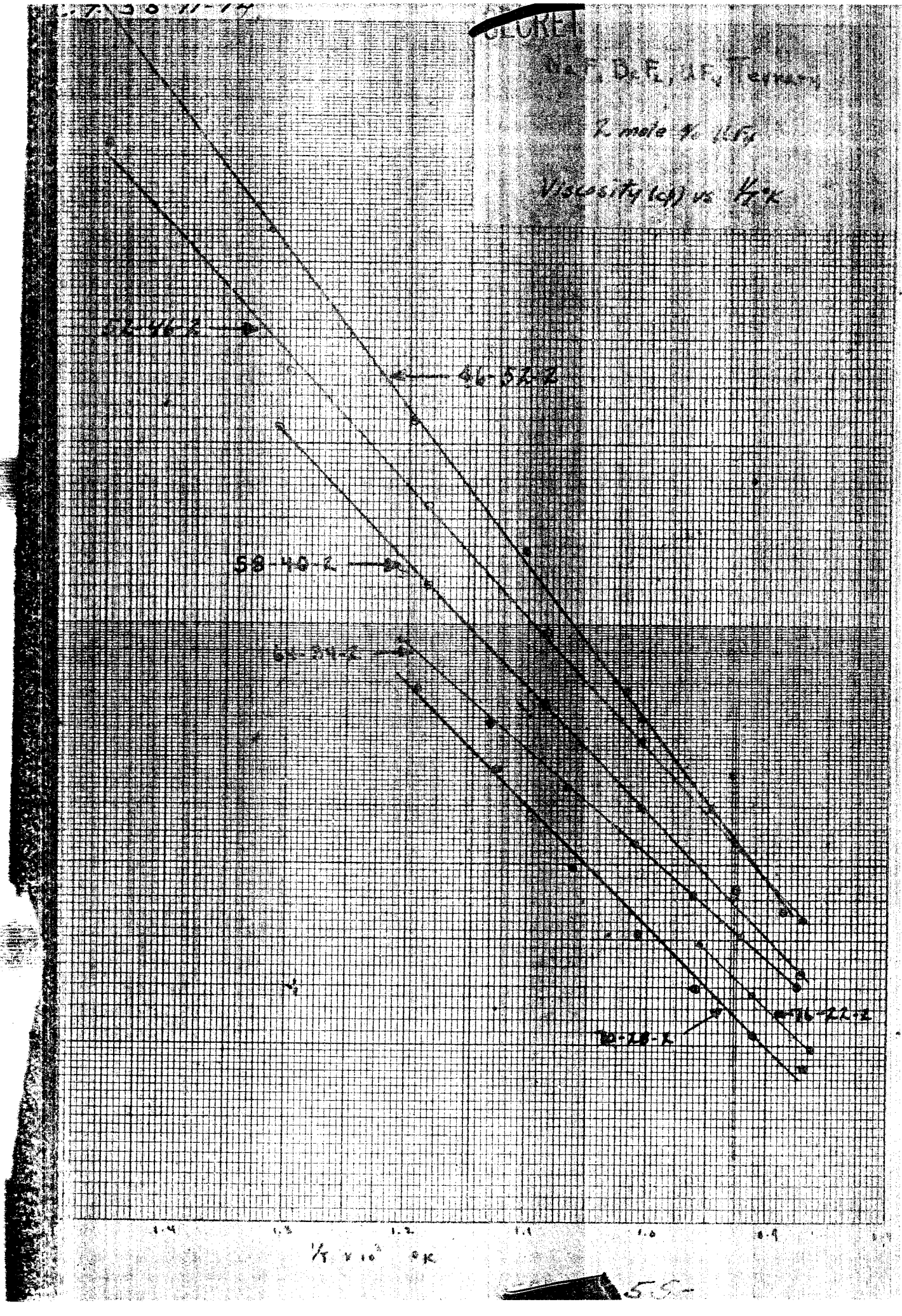
Viscosity (cp) vs mole % ZrF$_4$ & BeF$_2$

500°C

[redacted]

359-63 KEUFFEL & ESSER CO.
Semi-Logarithmic 2 Cycles X 10 to the 1/2 inch
with lines accented.
MADE IN U.S.A.

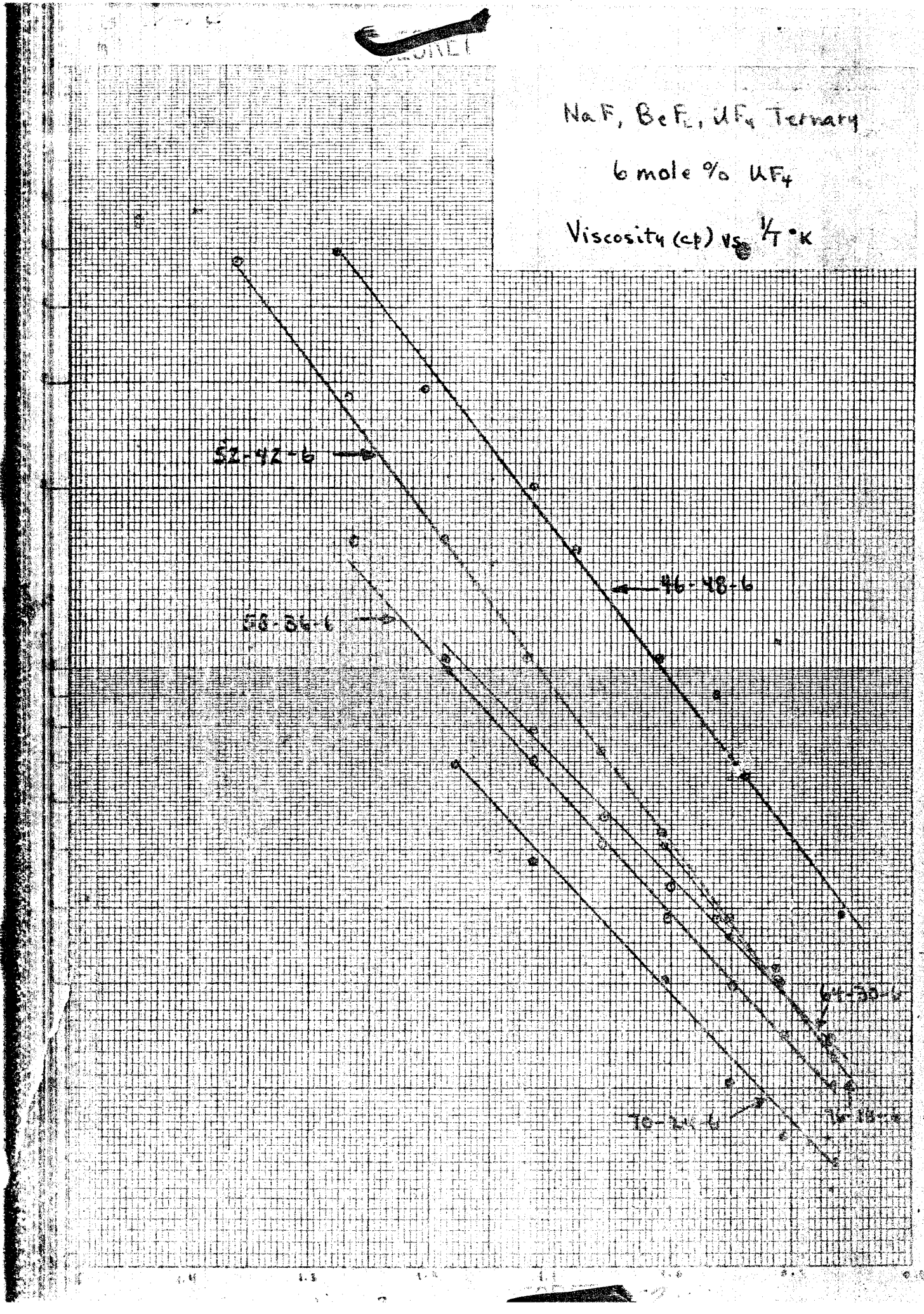
[redacted]

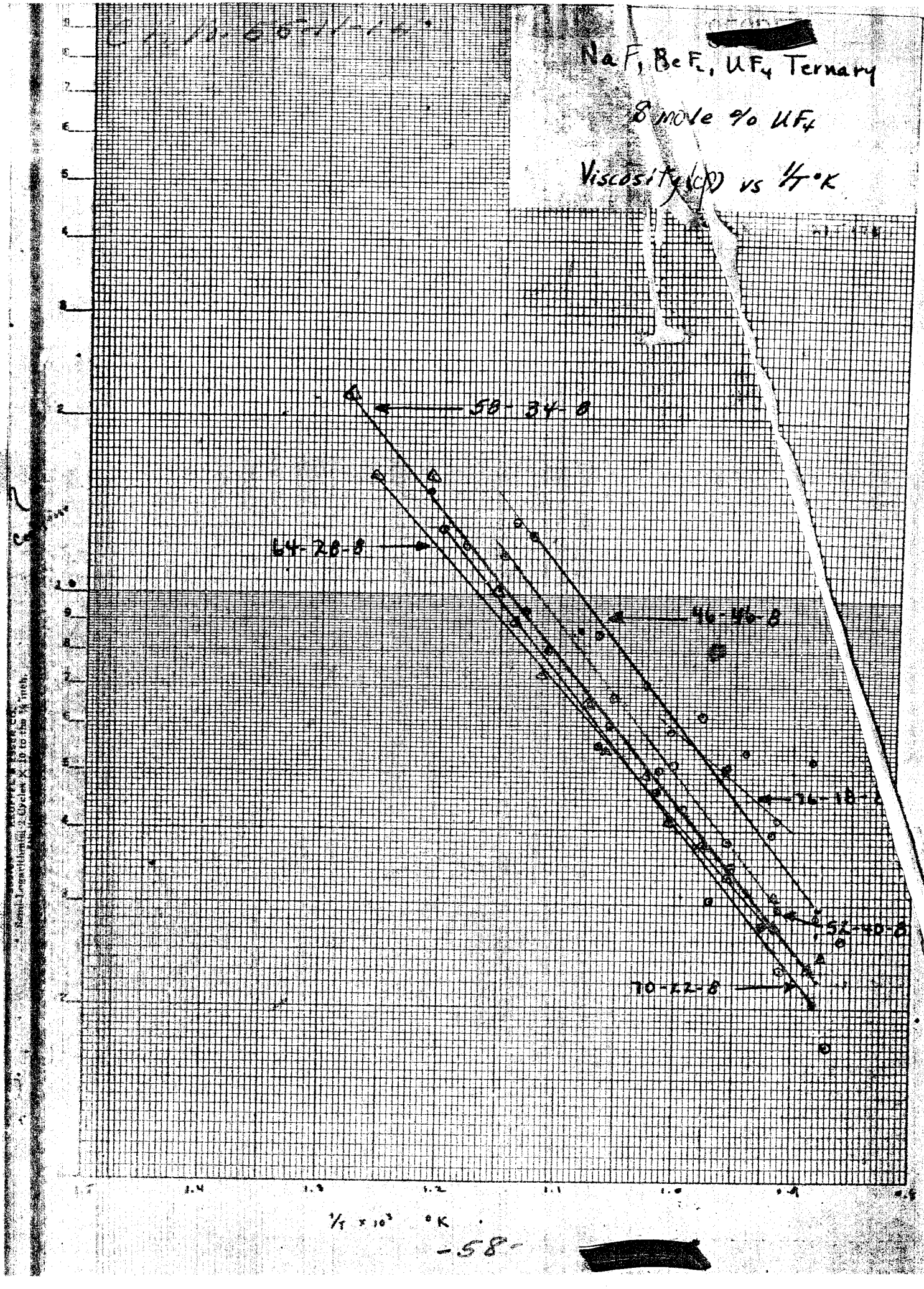

NaF - BeF2 - ZrF4 Ternary
Mole % ZrF4
Viscosity (cp) vs 1/T °K
72-16-12
46-54-0
58-40-2
64-34-2
76-22-2
70-28-2
1.4
1.3
1.2
1.1
1.0
0.9
1/T x 10³ °K

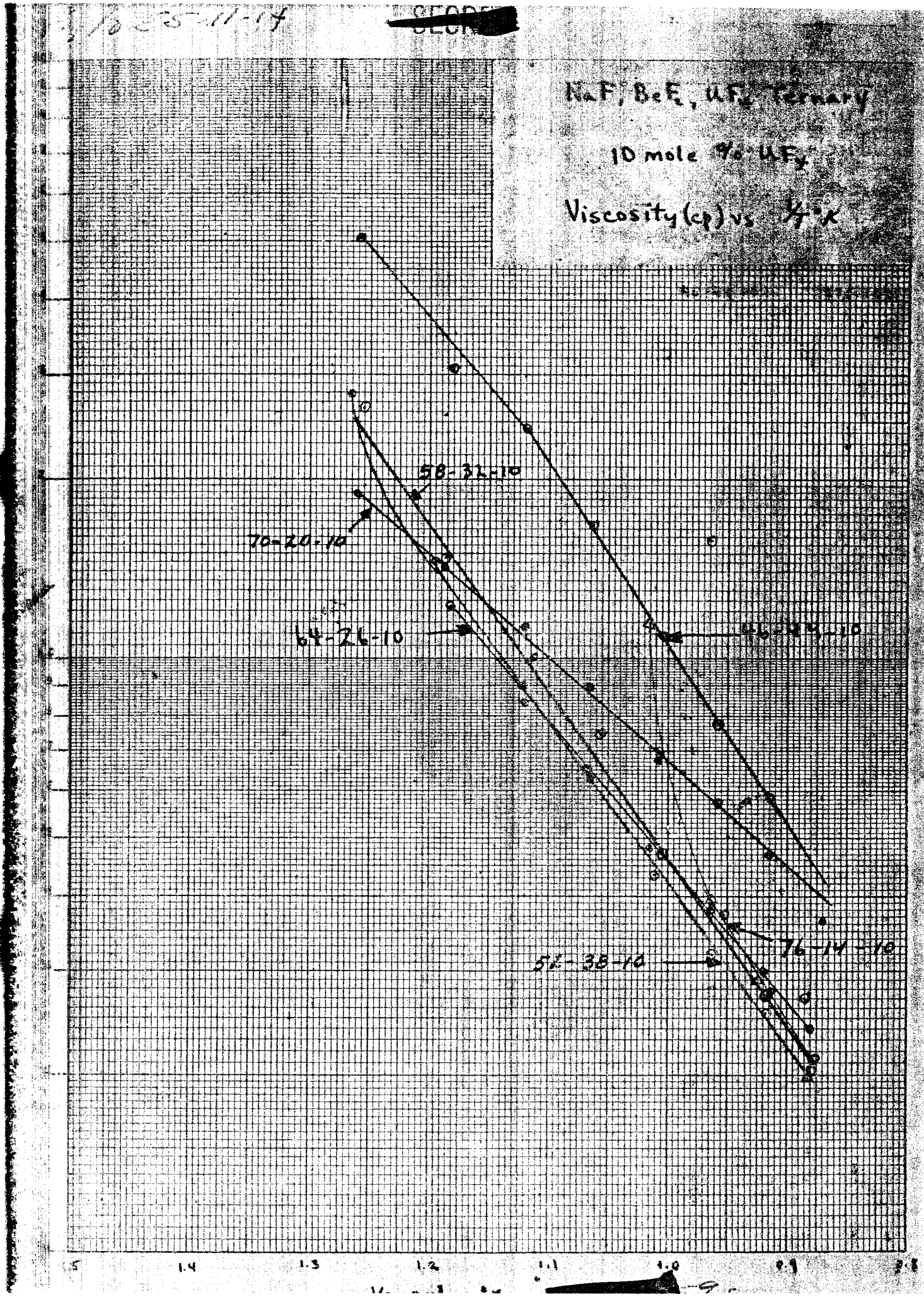
NaF, BeF_2, UF_4 Ternary

6 mole % UF_4

Viscosity (cp) vs $1/T \cdot K$



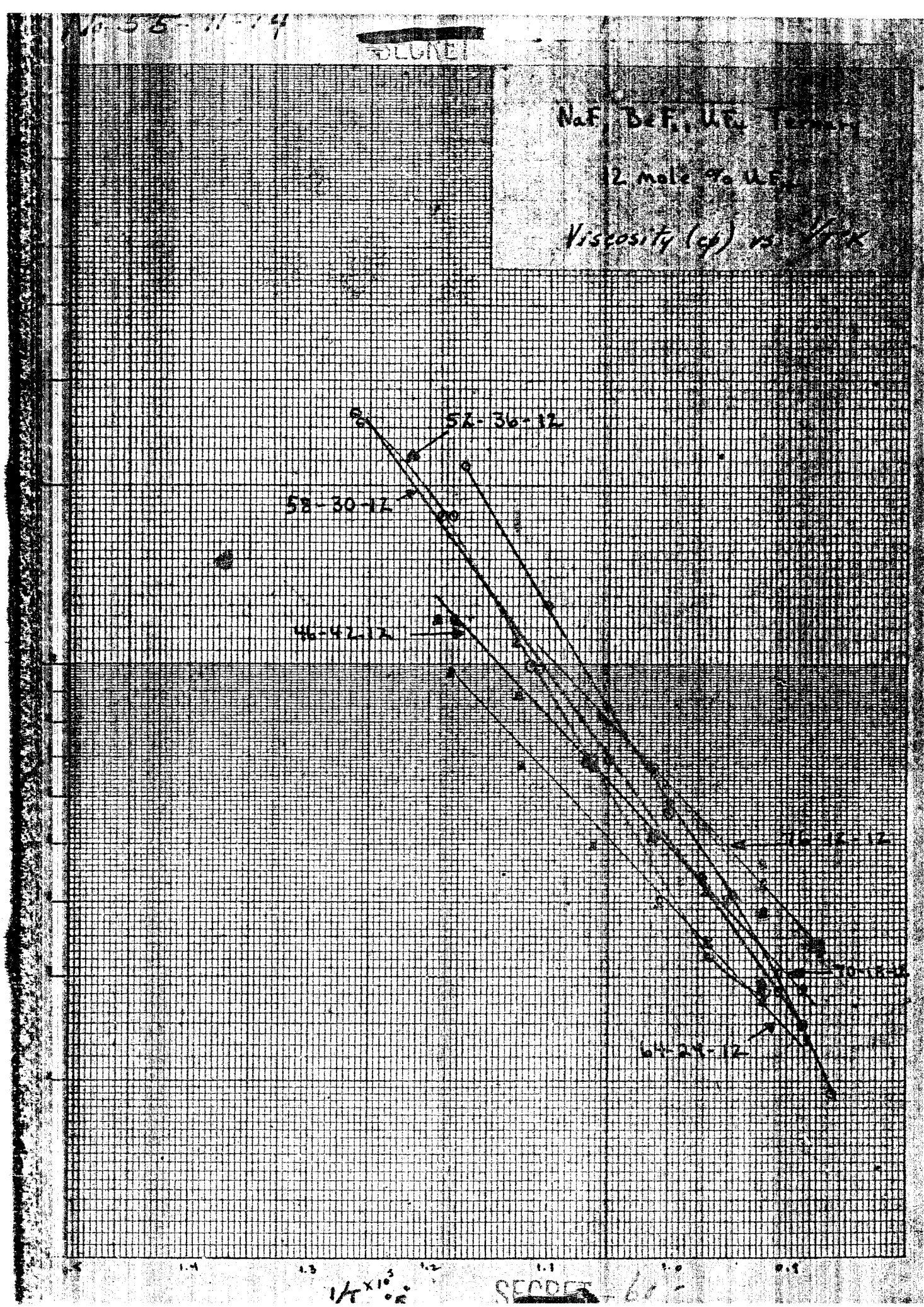

NaF, BeF2, UF4 Ternary
8 mole % UF4
Viscosity (cp) vs 1/T °K
58-34-8
64-28-8
46-46-8
34-18-8
52-40-8
70-22-8
1.4
1.3
1.2
1.1
1.0
.9
1/T x 10³ °K


NaF, BeF2, UF4 ternary
10 mole % UF4
Viscosity (cp) vs 1/T °K
58-32-10
70-20-10
64-26-10
46-42-10
76-14-10
52-38-10
1.4
1.3
1.2
1.1
1.0
.9

NaF, BeF₂, UF₄ Ternary

12 mole % UF_4

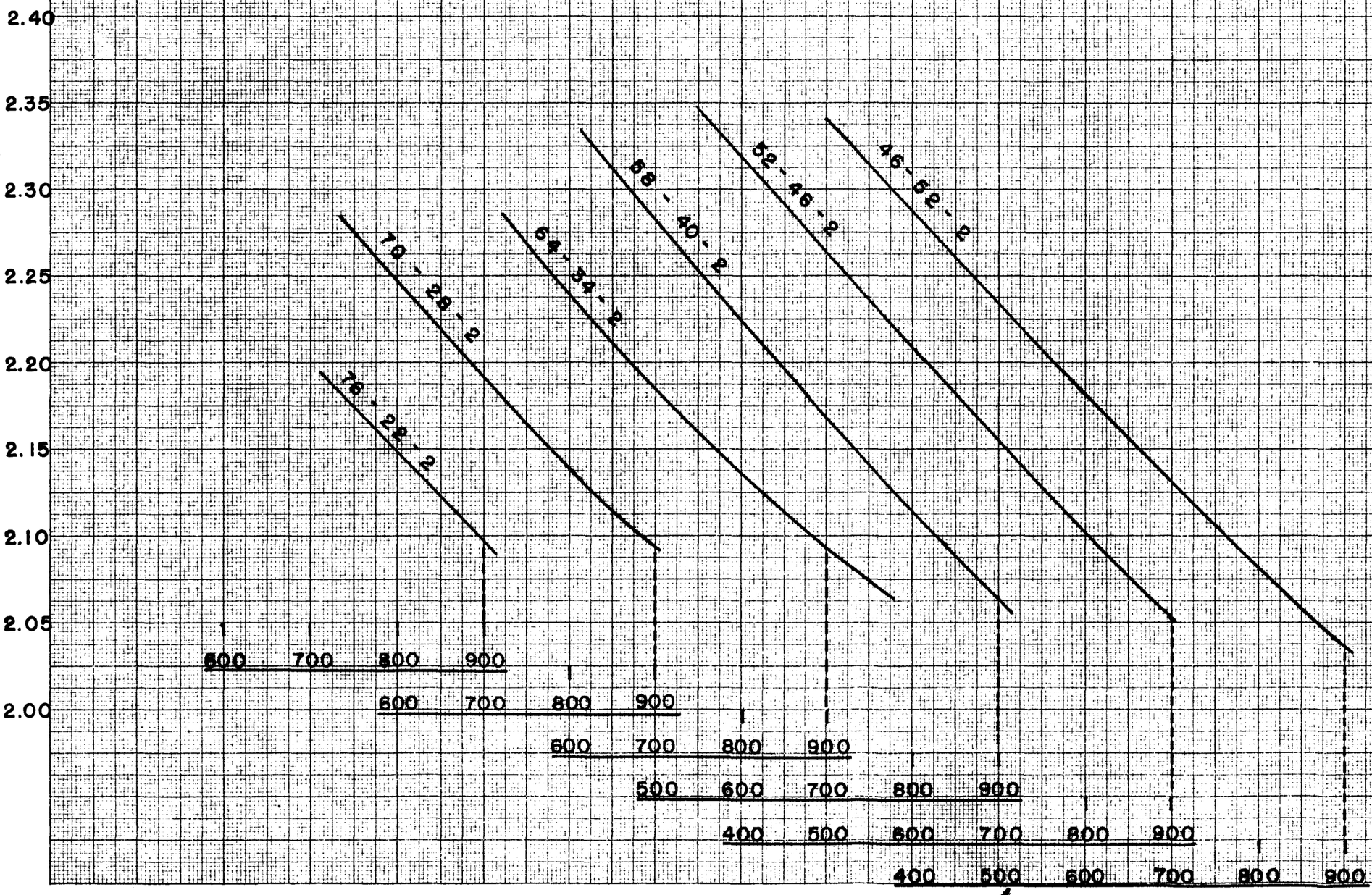
Viscosity (cp) vs. 1/T °K



C.F. No 55-11-14

[redacted]

DENSITIES OF 2 MOLE % UF_4 TERNARY MIXTURES

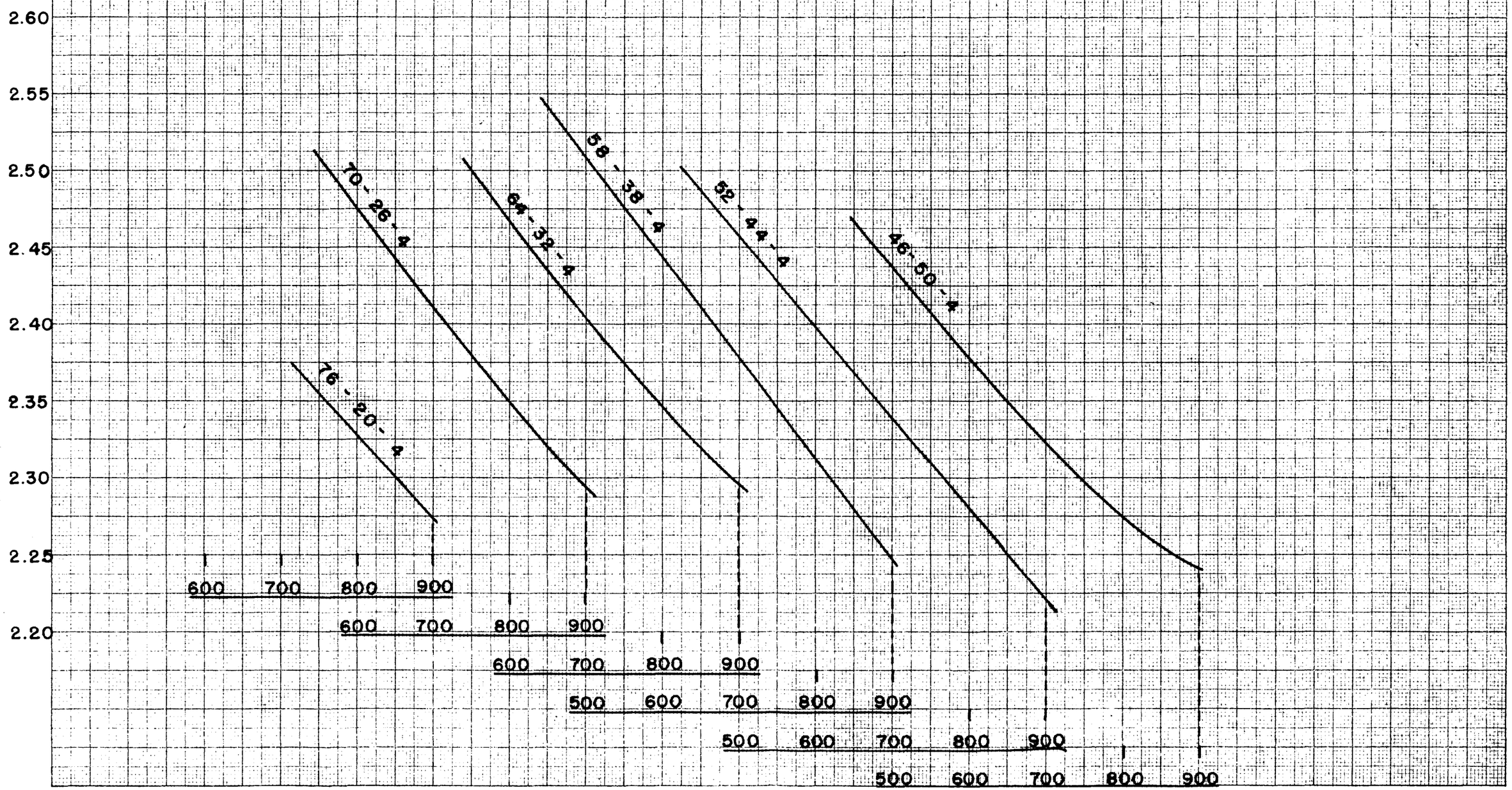


[redacted]

C.F. No. 55-11-14

[redacted]

DENSITIES OF 4 MOLE % UF_4 TERNARY MIXTURES

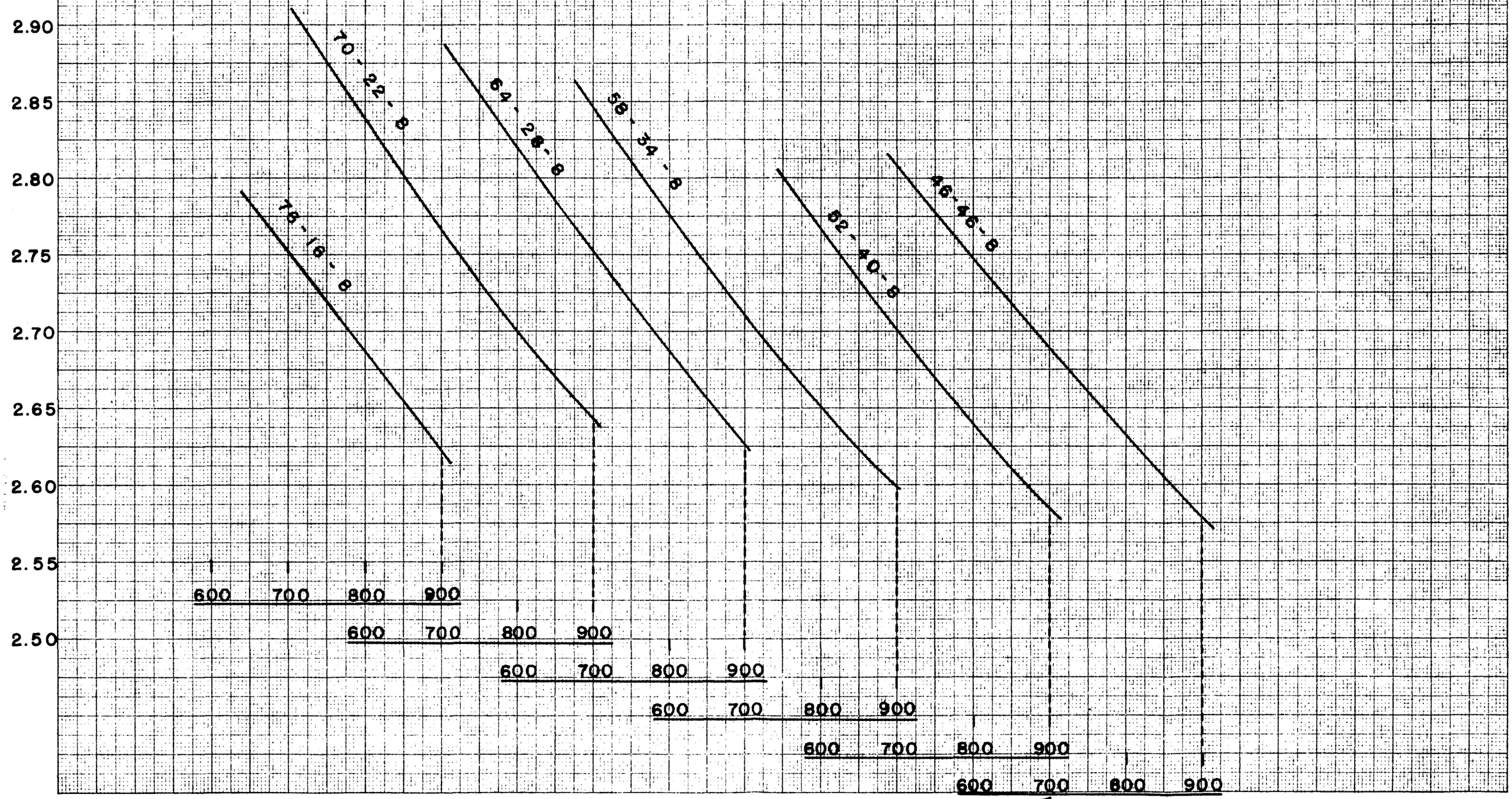


TEMPERATURE - °[redacted]

C.F. No 55-11-14

[redacted]

DENSITIES OF 8 MOLE % UF_4 TERNARY MIXTURES

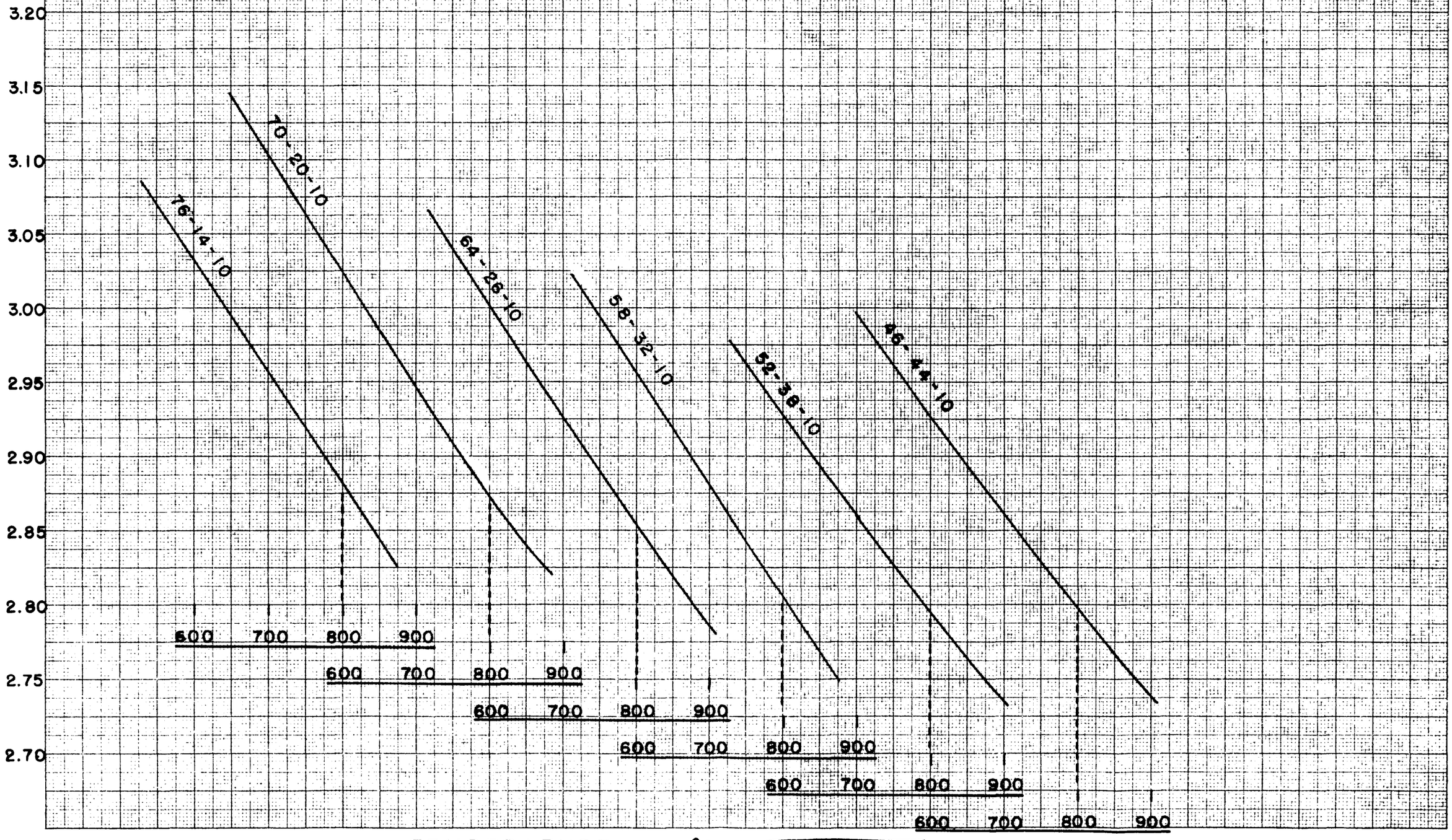


TEMPERATURE — °C [redacted]

CF No 55-11-14

[redacted]

DENSITIES OF 10 MOLE % UF_4 TERNARY MIXTURES



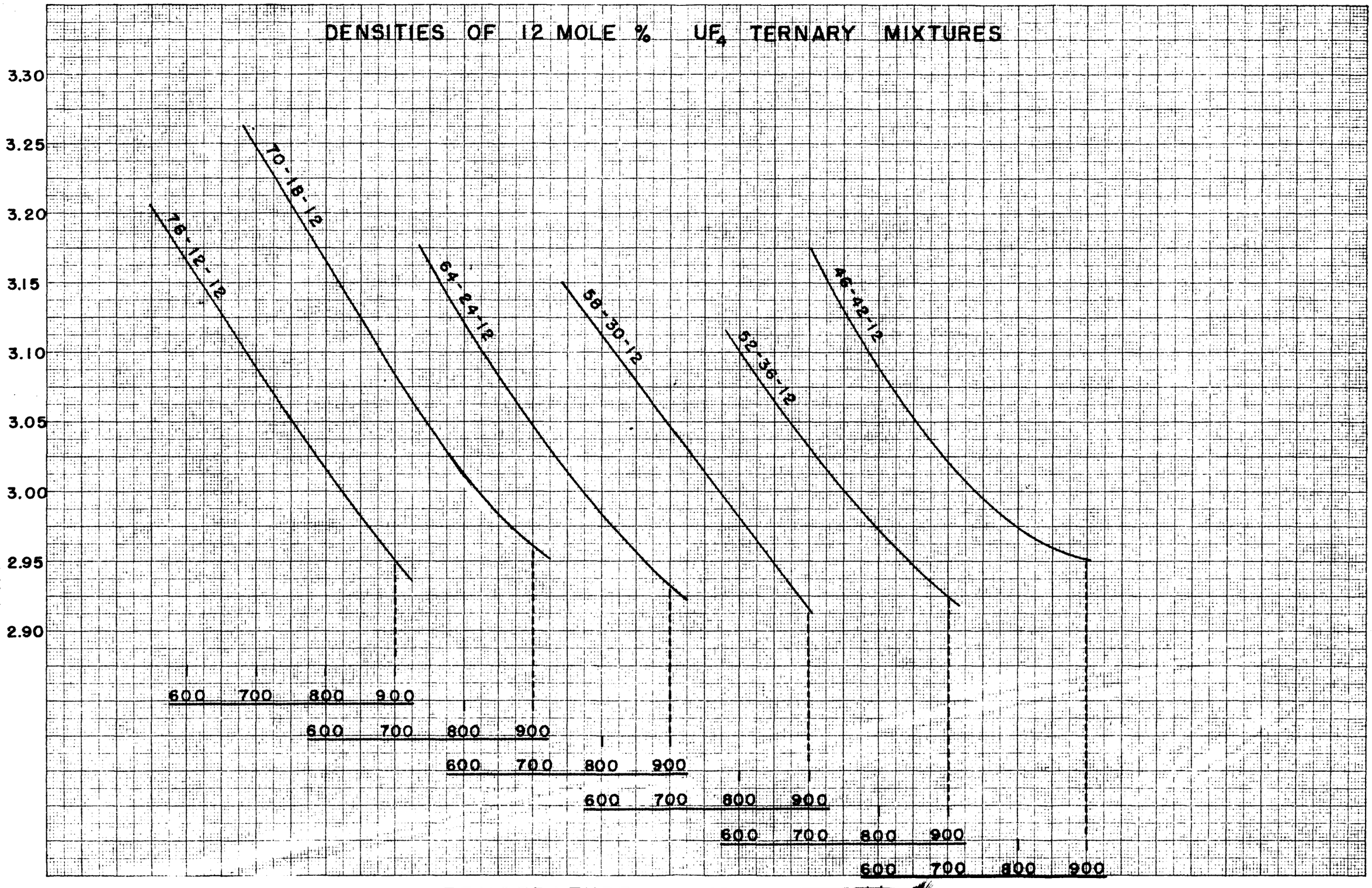
TEMPERATURE – °C

[redacted]

C.F. No 55-11-14

[redacted]

DENSITIES OF 12 MOLE % UF_4 TERNARY MIXTURES



TEMPERATURE — °C [redacted]