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[Monobath]

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ABSTRACT

A monobath designed for Kodak panatomic-X 35 mm film was obtained, which produced similar contrast and 2/3 of a stop increase in speed as compared to Haist's monobath MM-1 formula. Formulation of monobath was based on his formula by ~~varying~~ increasing the phenidone from 4 to 7 grams, sodium thiosulfate from 110 to 125 grams; pH and temperature were set at 11.0 and 85° F respectively.

INTRODUCTION:

*Most photographers feel that using the conventional baths to process their film is a tiresome and time-consuming procedure. For these reasons, an improved processing method combining the developer and fixer into a single solution called monobath is formed. The stop bath would then be unnecessary. A combined developer-fixer solution would not only simplify the processing cycle, but might offer other advantages over the conventional baths. Overdevelopment would be impossible, because the fixing action would automatically stop development. Agitation and temperature effects should be lessened during single solution treatment, and better image uniformity and possibly finer grained images might be expected from the simpler more solvent processing solution.

In forming a monobath solution, generally one of two possibilities must be considered. i.e. (1) either the developing activity is too vigorous, resulting in high contrast and grain or (2) the fixing action is too fast producing low contrast and an emulsion speed loss. A practical monobath requires that a competitive balance be achieved so that adequate image development occurs before the fixing action removes the developable silver salts.

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*G. Haist, Monobath Manual (Morgan & Morgan, Inc., Publishers, Hastings-on-Hudson, N.Y. 1966).

Haist* had formed a monobath for panatomic-X 35 mm film has the following composition:

Monobath MM-1

Purpose	Ingredient	Quantity
Solvent	water	750.00 c.c.
Preservative	sodium sulfite, desicated	50.0 grams
Developing agent	phenidone	4.0 grams
Developing agent	hydroquinone	12.0 grams
Alkali	sodium hydroxide	6.5 grams
Fixing agent	sodium thiosulfate, pentahydrate	110.0 grams
Hardener	glutaraldehyde (25 % in water)	8.0 c.c.
Solvent	water to make	1,000.00 c.c.

When treated for 7 minutes at 75° F with 30 second initial agitation, followed by 30 second agitation at 1-min. intervals, this bath produced the same contrast as D-76 developer, but the emulsion speed was reduced by 2/3 of a stop. This indicates that this formula requires some adjustment, possibly in the rate of developing ~~ratio~~. relation to fixation

The phenidone and hydroquinone were used as developing agents where development is the process of converting the exposed silver salts to metallic silver. The developing agents will engage in chemical action with oxidizing agents

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G. Haist, Monobath Manual (Morgan & Morgan, Inc., Publishers, Hastings-on-Hudson, N.Y. 1966), pp. 51.

other than silver salts. Sodium sulfite is used to protect against the absorption of atmospheric oxygen, as this will destroy the reducing activity, thus, shortening the useful life of the bath. The sodium hydroxide is used to increase the akalinity as it will activate the developing agents. After the developed image is formed, the remaining silver salts must be removed from the emulsion layer. These silver salts are almost insoluble in water and so cannot be removed by washing. These salts can be made water-soluble by combination with sodium thiosulfate. Water is ideal for making photographic solution as it is substantially free from harmful impurities.

Sodium thiosulfate reduces the rate of develoment, and contrast can be controlled by varying the thiosulfate content between 70 and 125 grams per liter. More speed may be obtained by increasing the concentration of phenidone. ~~It is also cheaper and harmless~~.

It was decided to use Haist's formula as basis. An increase in phenidone above 4 grams, and adjustment of the thiosulfate content between 80 to 125 grams were first tested.

OBJECTIVE:

To design a monobath by modification of Haist' MM-1 formula, that would increase the speed of panatomic-X 35mm film and maintain the same contrast.

EXPERIMENTAL DESIGN:

The experiment can be classified into 3 phases;

1) A 2 factors 4 levels experiment was made with phenidone and thiosulfate as the factors, at the levels of 5,6,7,8 grams phenidone and 80,95, 110,125 grams thiosulfate, with 5 randomized replicates of the baths. Densitometric procedure was used for evaluation of the data. The speed and contrast of the Haist's formula were equalled by some of the baths, but there was no improvement. And yet, ~~they~~ Phenidone and Thiosulfate have significant effect ~~over~~ on contrast. However, study of the data indicated that further changes of variables were necessary in order to increase the speed.

2) Combination of temperature and pH at levels 80°F, 85°F and 11.5, 12.0 respectively were used. Speed and gamma (or contrast) increased with temperature and pH. Furthermore, speed at a given contrast increased.

3) Finally, based on the information obtained, it was decided again to run a 2^2 experiment at 85, with pH and thiosulfate combination at levels 10.5, 11.0 and 125, 140 grams respectively. This time the desired results were obtained. The film had similar contrast and 2/3 of a stop increased speed as compared to Haist, on treatment with a bath containing 125 grams thiosulfate and

7 grams phenidone, at pH-11.0 and 85°F in temperature.

PROCEDURE:

1) Mix out 22 monobaths at various components according to its treatment combination.

2) Test the pH of each monobath.

3) Determine the exposure level, by using no filter, .8 and 1.0 N.D. filters to expose three 7-inch strips accordingly in the sensitometer. Process them with Haist's formula. Read, plot and evaluate the curves, choose the optimum curve as standard exposure.

4) Cut the panatomic-X 35mm film into 7-inch long, identify the emulsion side.

5) Expose all strips, using exposure level obtained in step 3.

6) Tape 2 strips (emulsion side up) in a 8x10 tray, process it in monobath at 75°F, 7 minutes with 30 sec initial agitation follow by 30 sec agitation at 1-min intervals.

7) Repeat step 6 until all monobaths have processed.

8) After all processed strips were dried, read the densities, then plot, draw and evaluate the characteristic curves.

9) Determine the gamma, contrast and speed from each curve.

10) Analyze the data by means of the ANOVA Table.

CONCLUSION:

Data analysis had shown that in phase I phenidone, thiosulfate and their interaction were all significant for contrast. In phase III only pH has significant effect on contrast, while in speed all variables and interaction were significant.

An additional single variable test has indicated the linear relationship between gamma and speed. But, by comparing the rate of changes in speed over gamma in previous experiments, shown that the rate of changes of temperature at given gamma over other composition is still favorable in speed increases with the gamma and speed relation. In the best modification of Haist's formula, the phenidone, thiosulfate, pH and temperature had been varied. The formula obtained as follow:

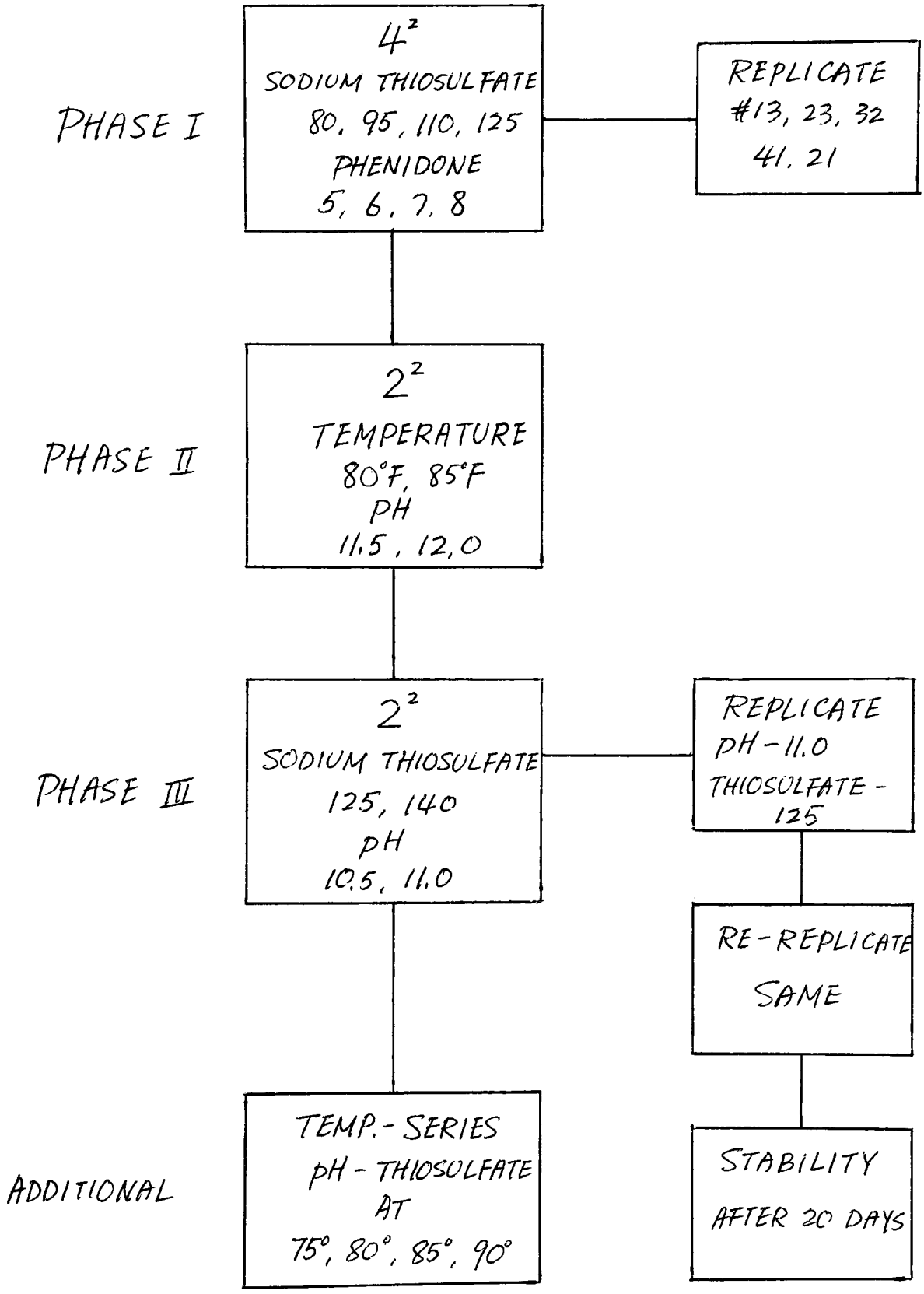
Ingredient	Quantity
water	750.00 c.c.
sodium sulfite	50.0 grams
phenidone	7.0 grams
hydroquinone	12.0 grams
sodium thiosulfate	125.0 grams
glutaraldehyde	8.0 c.c.
water to make	1 liter

adjusted to pH-11 and processed at 85°F in temperature.

This monobath appeared to be quite stable after 20 days; only slight changes had found in both contrast and speed.

Image qualities as processed by monobath had no obvious change as far as could be determined by visual examination made under the microscope in comparison with development in D-76 to the same contrast.

FLOW DIAGRAM



Data on phase I

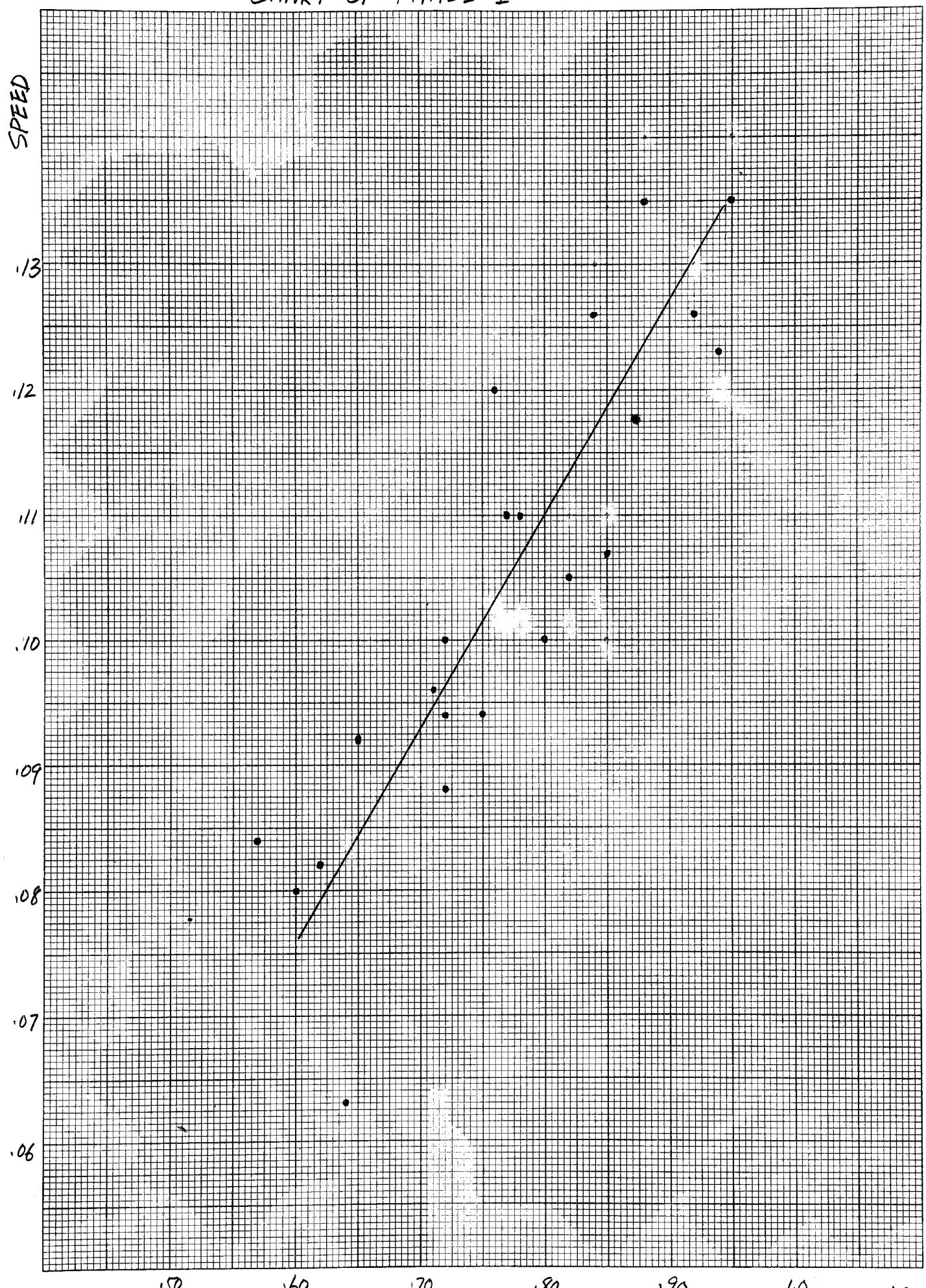
	gamma	speed	contrast	phenidone	thiosulfate
# 44	.57	.0837	.54	8	125
14	.60	.0800	.60	5	125
34	.62	.0818	.56	7	125
24	.64	.0634	.58	6	125
43	.65	.0918	.62	8	110
13-R	.71	.0961	.65	5	110
23-R	.72	.1006	.67	6	110
23	.72	.0877	.67	6	110
Haist	.72	.0877	.65	4	110
33	.72	.0940	.66	7	110
13	.75	.0940	.70	5	110
42	.76	.1156	.70	8	95
32-R	.77	.1103	.74	7	95
32	.78	.1103	.73	7	95
41-R	.80	.1006	.72	8	80
22	.82	.1054	.75	6	95
41	.84	.1267	.76	8	80
12	.85	.1079	.80	5	95
31	.88	.1358	.82	7	80
21	.92	.1267	.86	6	80
21-R	.94	.1238	.88	6	80
11	.95	.1358	.86	5	80

Temp. - 75° F

pH - 11.05

Time - 7 min.

CHART OF PHASE I



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Data analysis on phase *I*

Contrast

		SODIUM-THIOSULFATE - B				
		80	95	110	125	
PHENIDONE - A	5	.86	.80	.70 .65	.60	3.61
	6	.88 .86	.75	.67 .67	.58	4.41
	7	.82	.73 .74	.66	.56	3.51
	8	.76 .72	.70	.62	.54	3.34
		4.90	3.72	3.97	2.28	14.87

ANOVA-Contrast

Source	SS	D.F.	M.S.	F
A	.0135	3	.0045	9.7*
B	.1663	3	.0554	120.4*
AB	.0155	9	.0017	3.7*
Error	.0023	5	.00046	
Total	.1976	20	.00988	

Due to large diff. in gamma no speed had been analyzed.

*They were all significant on contrast

Data on phase II

pH \ TEMP		80	85
	11.5	11	12
	12.0	21	22

phenidone-7grams

thiosulfate-110 grams

		Gamma	Speed	Contrast
80	# 11	.85	.1210	.80
85	12	.92	.1596	.86
80	21	1.01	.1356	.93
85	22	1.07	.1752	1.0
115°	33	.72	.0940	.66

No data analysis had been made, because by inspection there are great diff. as compared to Haist. And yet, it does indicate the speed increases as both pH and temp. increase, the speed increase due to temp. is greater than that due to the pH, but the gamma and contrast also increase. In the next experiments, to maintain the speed increase and to lower the gamma and contrast, the temp. was held constant at 85F and the thiosulfate concentration and pH were varied.

Data on phase III

pH \ THIOSULFATE		125	140
	10.5	11	12
	11.0	21	22

temp. - 85° F

phenidone - 7 grams

	gamma	speed	contrast
# 11	.61	.1006	.55
12	.53	.0877	.50
21	.72	.1280	.69
22	.67	.1006	.67

#21 gave a similar contrast and approximate 2/3 of a stop increased in speed as compared to Haist. Accordingly replicates of this number had been made in order to estimate error.

Data on replicates # 21

	gamma	speed	contrast
R1	.73	.1006	.68
R2	.69	.0877	.65
R3	.73	.1129	.70
R4	.71	.1326	.67

pH measurements were believed to be unreliable, because of performance of meter and apparent changes in buffer solutions.

THIOSULFATE - B (speed)

pH - A	125	140	
10.5	.1006	.0877	.1883
11.0	.1280 .1006 .0877 .1129 .1326	.1006	.6624
	.6624	.1883	.8507

Due to great diff. in speeds and the ANOVA shown ns at all believed certain unknown errors had been introduced, it is decided to re-run these replicates.

ANOVA - speed

Source	SS	DF	MS	F
A	.0003	1	.0003	1 NS
B	.0003	1	.0003	1 NS
AB	.00008	1	.00008	.28 NS
Error	.00112	4	.00028	
Total	.0018	3		

They were all no significant on contrast.

Data on re-replicates # 21

	gamma	speed	contrast
# RR1	.72	.1238	.69
RR2	.71	.1358	.65
RR3	.71	.1267	.66

error:

gamma = .0001

speed = .0002

contrast = .001

THIOSULFATE - B (speed)

pH-A	125	140	
10.5	.1006	.0877	.1883
11.0	.1280 .1238 .1358 .1267	.1006	.6149
	.6149	.1883	.8032

The speeds diff. on the re-replicates seemed to be reasonable and all data analysis will be based on these results.

ANOVA - speed

Source	SS	DF	MS	F
A	.001	1	.001	14.3 *
B	.001	1	.001	14.3 *
AB	.0023	1	.0023	32.9 *
Error	.0002	3	.000066	
Total	.0045	3		

* They were all significant on speed.

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THIOSULFATE - B

pH - A	125	140	
10.5	.55	.50	1.05
11.0	.69 .69 .65 .66	.67	3.36
	3.24	1.17	4.41

B

A	125	140	
10.5	.55	.50	1.05
11.0	.67	.67	1.34
	1.22	1.17	2.39

The SSAB turned out to be negative and is not valid, an alternate arrangement is used on the upper right corner.

ANOVA - contrast

Source	SS	DF	MS	F
A	.02105	1	.02105	4[illegible].95 *
B	.00065	1	.00065	1.5 NS
AB	.0006	1	.0006	1.4 NS
Error	.0013	3	.00043	
Total	.0223	3		

* Only pH has significant effect on contrast.

Stability results of re-replicate of pH - thiosulfate # 21 (after 20 days).

	gamma	speed	contrast
RR1	.72	.1210	.68
RR2	.68	.1238	.65
RR3	.72	.1267	.68

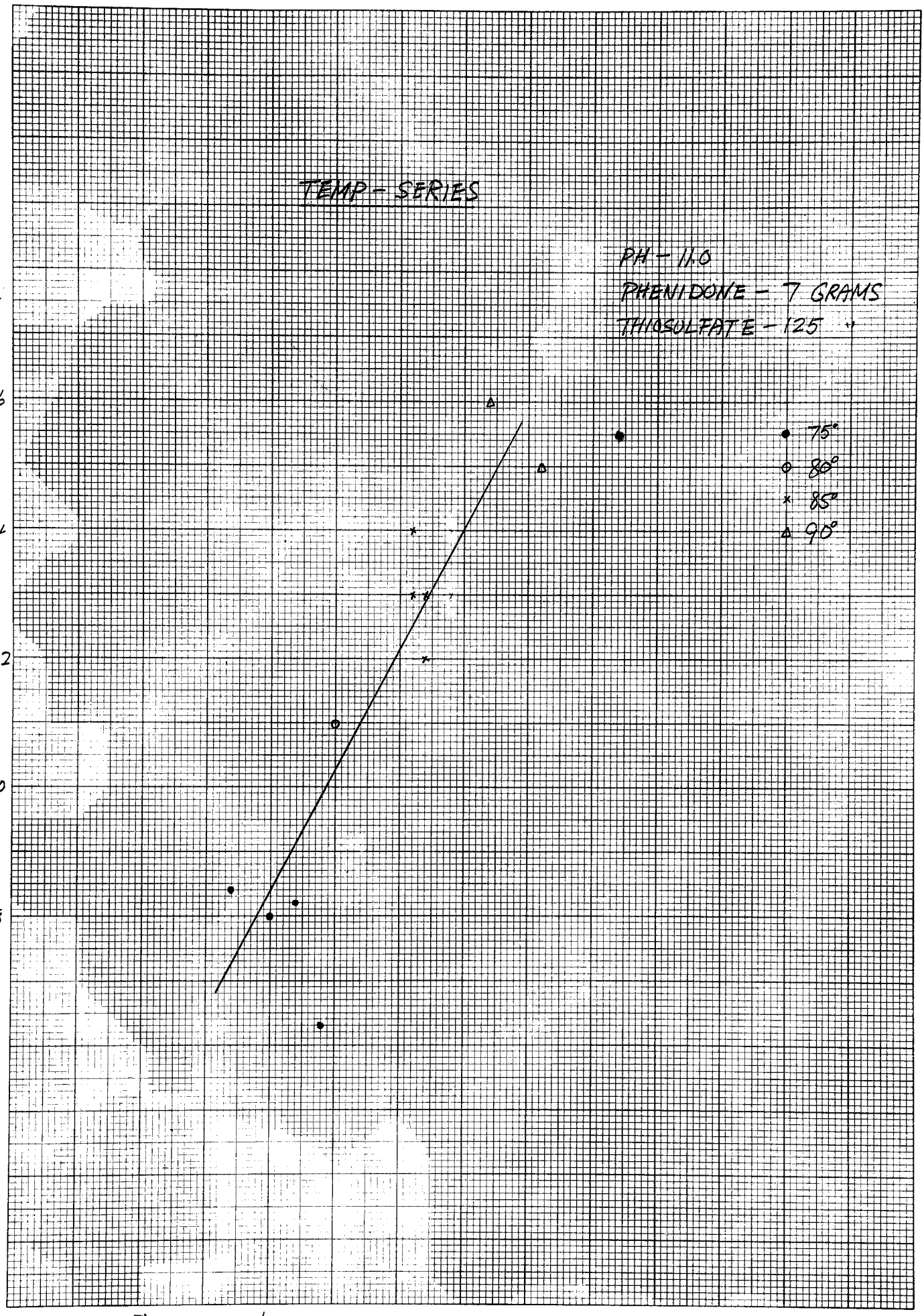
Temp. - 85°F

Results of temp. - series.

	gamma	speed	contrast
80°F	.65	.1054	.60
90°F	.81	.1523	.73
90°FR	.77	.1596	.70

Results on previous experiments.

	gamma	speed	contrast
75°F-44	.57	.0837	.54
14	.60	.0800	.60
34	.62	.0818	.56
24	.64	.0634	.58
85°F	.72	.1280	.69
RR1	.72	.1238	.69
RR2	.71	.1358	.65
RR3	.71	.1267	.66


TEMP - SERIES
PH - 11.0
PHENIDONE - 7 GRAMS
THIOSULFATE - 125
75°
80°
85°
90°
SPEED
.16
.14
.12
.10
.08
.06
150
160
170
180
190

REFERENCES:

1) G. Haist, Monobath Manual (Morgan & Morgan, Inc., Publishers, Hastings-on-Hudson, N.Y. 1966).

2) J. C. Barnes, Mechanism of Development in Monobaths Containing Thiosulfate Ion, Photographic science and Engineering, Volume 5, Number 4, July-August 1961.

3) C. E. K. Mees, The Theory of the Photographic Process, rev. ed., Macmillan, New York, 1966.