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CATALYST RESEARCH CORPORATION

February 16, 1968

VIA: AIR MAIL

[redacted]

Sandia Corporation
P.O. Box 5800
Albuquerque, New Mexico 87115

Attention: Mr. F. Duggin, Jr., Buyer
Mr. R. Rosenberg, Requester

[redacted]

Reference: Purchase Order Number 58-2486

Subject: Progress Report Number 5
January 1, 1968 to February 1, 1968

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Gentlemen:

The following work was accomplished during the reporting period:

1.0 Abstract

1.1 A conference was held at Sandia and the direction of work, parameters, specifications and future work were outlined in detail.

1.2 Blue asbestos (A-80, S-80, 713, and H), asbestos 5R fibers improved electrical resistance. PKT and Kaowool fibers were found unacceptable.

1.3 The addition of Al_2O_3 to heat paper had an adverse effect on the burning rate, but improved electrical resistance up to 8% Al_2O_3 was recorded.

1.4 Due to the reduction in burning rate the addition of fibers was found to be an unacceptable method of improving electrical resistance.

1.5 The addition of Silicon to $Ti:CaCrO_4$ heat paper produced the greatest improvement in electrical resistance. But the burning was reduced.

1.6 Silicon blends with $KSiO_4$ and $K_2Cr_2O_7$ were found insensitive.

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SANDIA SYSTEMATIC DECLASSIFICATION REVIEW
Determination (Circle Numbers):
1. Classification Retained
2. Classification Changed to: U
3. Contains No DOE Classified Information
4. Coordinate With: Information
5. Contains UCNI?
6. Comments: Release to Approved
1st Review Date: 12-14-95
Authority: DADC ADD W. Lange
Name:
2nd Review Date: 1/3/96
Authority: ADD
Name:

SANDIA SYSTEMATIC DECLASSIFICATION REVIEW
DECLASSIFICATION REVIEW
CLASSIFICATION CHANGED TO: U
AUTHORITY: R.B. Crowe
RECORD ID: 95SN026
DATED: 01-03-96
PERSON CHANGING MARKING & DATE: 6-26-96
PERSON VERIFYING MARKING & DATE:

CATALYST RESEARCH CORP.
Approved for release by
[illegible]

6101 FALLS ROAD, BALTIMORE, MARYLAND 21209 • TELEPHONE [illegible]

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1.7 V_2O_5 and MnO_2 oxidizers were found inferior to $CaCrO_4$.

2.0 Summary of Accomplishments

2.1 Conference at Sandia

A conference was held at Sandia on February 8, 1966 between Catalyst Research and Sandia technical personnel.

The burning rate, 6 inches per second, minimum, and the resistance, 2000 ohms, minimum, 10 milli second after burning, are to be considered the most important parameters. The 200 to 400 cal./gm. heat value does not apply any more. Paper quality is critical only before burning. Other parameters have not yet been established.

2.1.1 Future Work

Improving Electrical Resistance of the Fuse Strip

A fuse strip electrical resistance measuring apparatus similar to cell stack conditions will be fabricated. The fiber study resistance test will be made using the above apparatus. An all vitron paper will also be studied. The fuse strip, after burning, will be inspected under the microscope for conductive particles.

Improving Burning Rate

Finer Ti and $CaCrO_4$ particle sizes will be purchased to improve burning rate. The effects of atomizing and calcining $CaCrO_4$ on burning rate will also be studied.

Oxidizer Study

Twenty-five oxidizers have been selected, by mutual agreement, for comparative studies. The number of oxidizers studied will be reduced by a preliminary literature study. Each feasible oxidizer will be combined with Ti in paper form and studied.

2.2 Fiber Study

Blue asbestos (A-80, S-80, 713, and H), asbestos 5R, and fiberfrax fibers were found to have improved electrical resistance when compared to standard vitron-fiberfrax heat paper. PKT and Kaowool fibers were found to be unacceptable. These fibers had reduced burning rate and resistance, and poor paper strength. Fiberfrax paper had reduced burning rate and fair paper strength, but does not warrant rejection. The blue asbestos papers had the same or improved burning rate and good paper strength. The 5R asbestos slightly reduced burning rate, but had good paper strength. See Figure 1.

The type of fiber was varied to improve electrical resistance. The vitron used in the standard paper was replaced with the fibers to be studied. This was done because of the poor electrical resistance properties of vitron in heat paper. A ratio of 26.5:73.5, Ti:$CaCrO_4$, was used. The per cent fibers were held constant.

2.3 Al_2O_3 Diluent Study

The addition of Al_2O_3 to heat paper improved the electrical resistance, but had an adverse effect on burning rate. The addition of 4% Al_2O_3 reduced the burning rate 41.2%. The resistance improved as the Al_2O_3 was increased up to 8%. Above 8%, Al_2O_3 the resistance decreased. As the Al_2O_3 was increased, the heat value was reduced as a linear function (-7.5 cal/1% Al_2O_3). See Figure 2.

Al_2O_3 was added to heat paper in 4% increments to 12% as a diluent. A ratio of 26.5:73.5, Ti:$CaCrO_4$, was used. The fibers were held constant.

2.4 The Effect of Increasing the Per Cent of Fibers

Increasing the fibers from 12% to 24% in heat papers was found to be an unacceptable method of improving electrical resistance, due to the reduction in burning rate. Increasing the fibers by 4%, to 16%, reduced the burning rate 43.4%. The resistance was improved when the fibers were increased (34.2 ohm, 12% fibers; 189 ohm, 24% fibers). The heat value was reduced as the fibers were increased (599.66 cal/gm. 12%; fibers 521.26 cal/gm. 24% fibers). See Figure 3.

The fibers were increased from 12 to 24% in 4% increments.

2.4 The Effect of Increasing the Per Cent of Fibers (Continued ---)

The ratio of 26.5:73.5, Ti:$CaCrO_4$, was used. This ratio was selected because it was near the maximum burning rate. A 50:50 ratio of vitron to fiberfrax was used.

2.5 Addition of Silicon to Heat Paper

The addition of Silicon to Ti:$CaCrO_4$ heat paper was not successful because of reduced burning rate. The heat paper produced a magnitude of improvement when electrical resistance was read. The heat value was similar. See Figure 4.

The metal to oxidizer ratio was varied. Equivalent weights of Silicon to Titanium were used. The per cent fibers were held constant.

2.6 Silicon - Oxidizer Study

Silicon blends with $KMnO_4$ and $K_2Cr_2O_7$ were found insensitive. The $KMnO_4$ and $K_2Cr_2O_7$ had to be ignited with heat paper. After ignition the $KMnO_4$ burned fast. Ti was found to burn violently when added to Si:$KClO_4$ mixture. Chart 1 is a synopsis of powder mixtures, blending methods, and oxidizers. Any oxidizers found too active for Ti will be tried with Silicon.

2.7 Ti Oxidizer Study

V_2O_5 and MnO_2 oxidizers were found inferior to $CaCrO_4$. Ti-V_2O_5 heat paper had about one half the burning rate of Ti:$CaCrO_4$ paper. Also the V_2O_5 heat values were similar to Ti:$CaCrO_4$. The Ti:MnO_2 paper would not burn under pressure. Also, incomplete burning was noted in the calorimeter ash. See Chart II.

The following stochiometric heat calculations were made.

1. $Ti + V_2O_5 \rightarrow TiO_2 + V_2O_3$

$\Delta H = 636.68$ cal/gm.

2. $3Ti + 2V_2O_5 \rightarrow 3\ TiO_2 + 4\ VO$

   $\Delta H = 641.42$ cal/gm

3. $5Ti + 2V_2O_5 \rightarrow 5\ TiO_2 + 4V$

   $\Delta H = 626.36$ cal/gm.

4. $Ti + MnO_2 \rightarrow TiO_2 + Mn$

   $\Delta H = 756.16$ cal/gm.

5. $Ti + 2MnO_2 \rightarrow TiO_2 + 2\ MnO$

   $\Delta H = 724.86$

6. $Ti + 3\ MnO_2 \rightarrow TiO_2 + Mn_3O_4$

   $\Delta H = 588.11$ cal/gm.

7. $Ti + 4\ MnO_2 \rightarrow TiO_2 + 2Mn_2O_3$

   $\Delta H = 465$ cal/gm.

From the above calculations, heat paper, was made. The fibers were kept constant.

3.0 Future Work

The electrical resistance, burning rate and oxidizer studies will be continued.

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Approved By:

CATALYST RESEARCH CORPORATION

H. J. Goldsmith, Manager
Research & Development Div.

Submitted By:

CATALYST RESEARCH CORPORATION

C. C. Bowser
Project Engineer

Distribution:

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Figure I

Fiber Study

Ti:$CaCrO_4$ Ratio

26.5:73.5

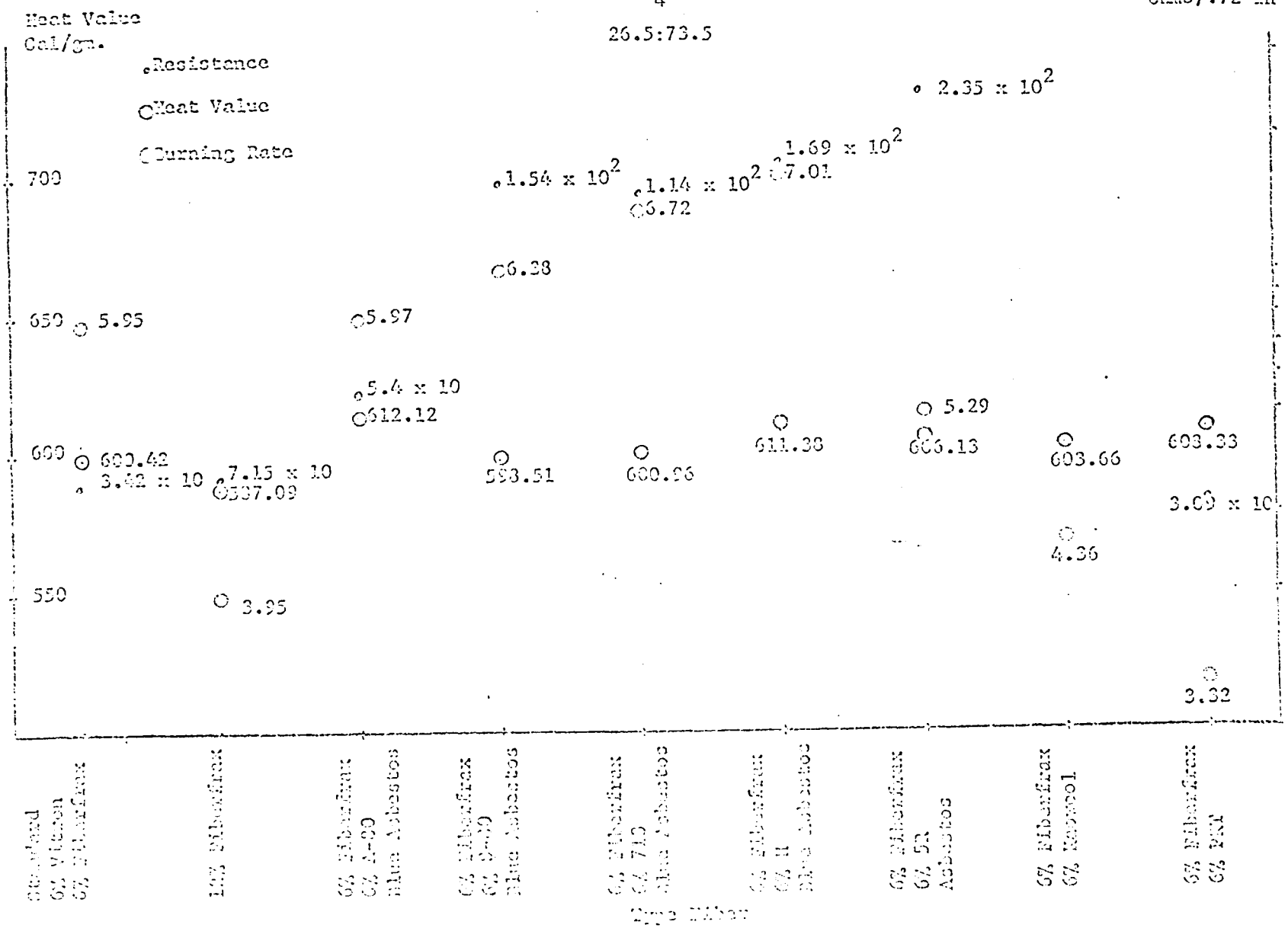

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Figure 2

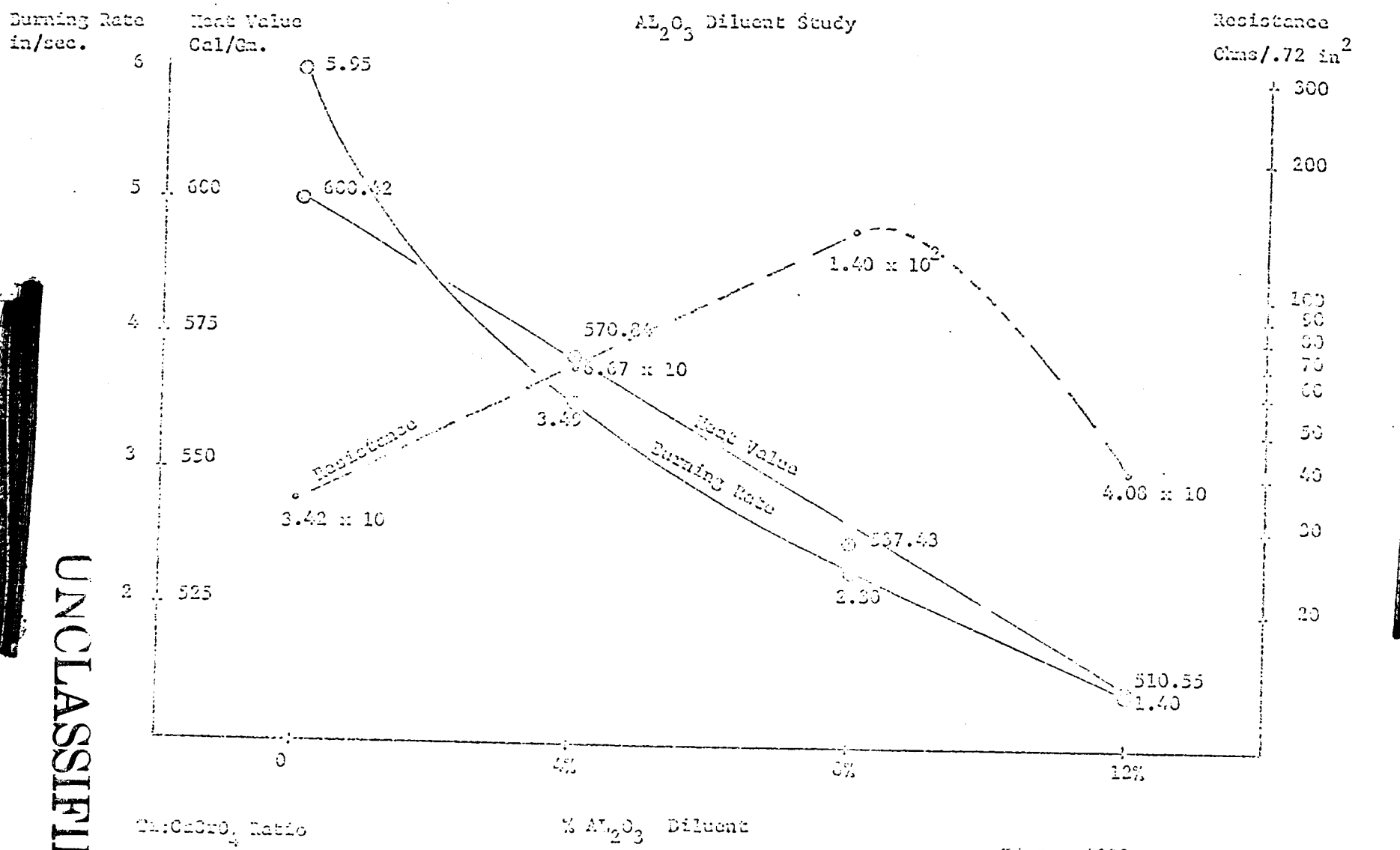

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Figure 3

Effect of Increasing

Fiber Per Cent

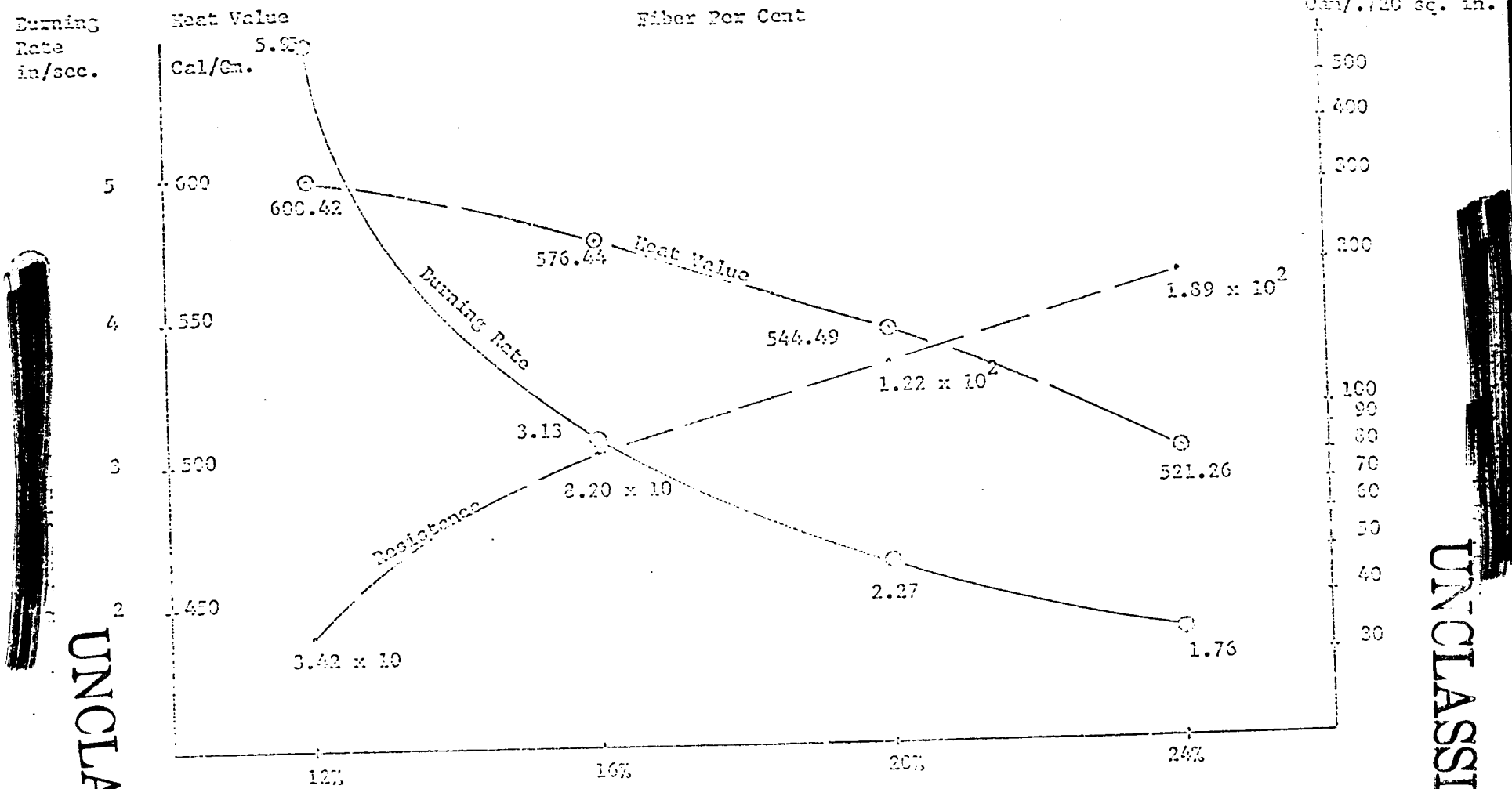

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Figure 4

Addition of Silicon to

Heat Paper

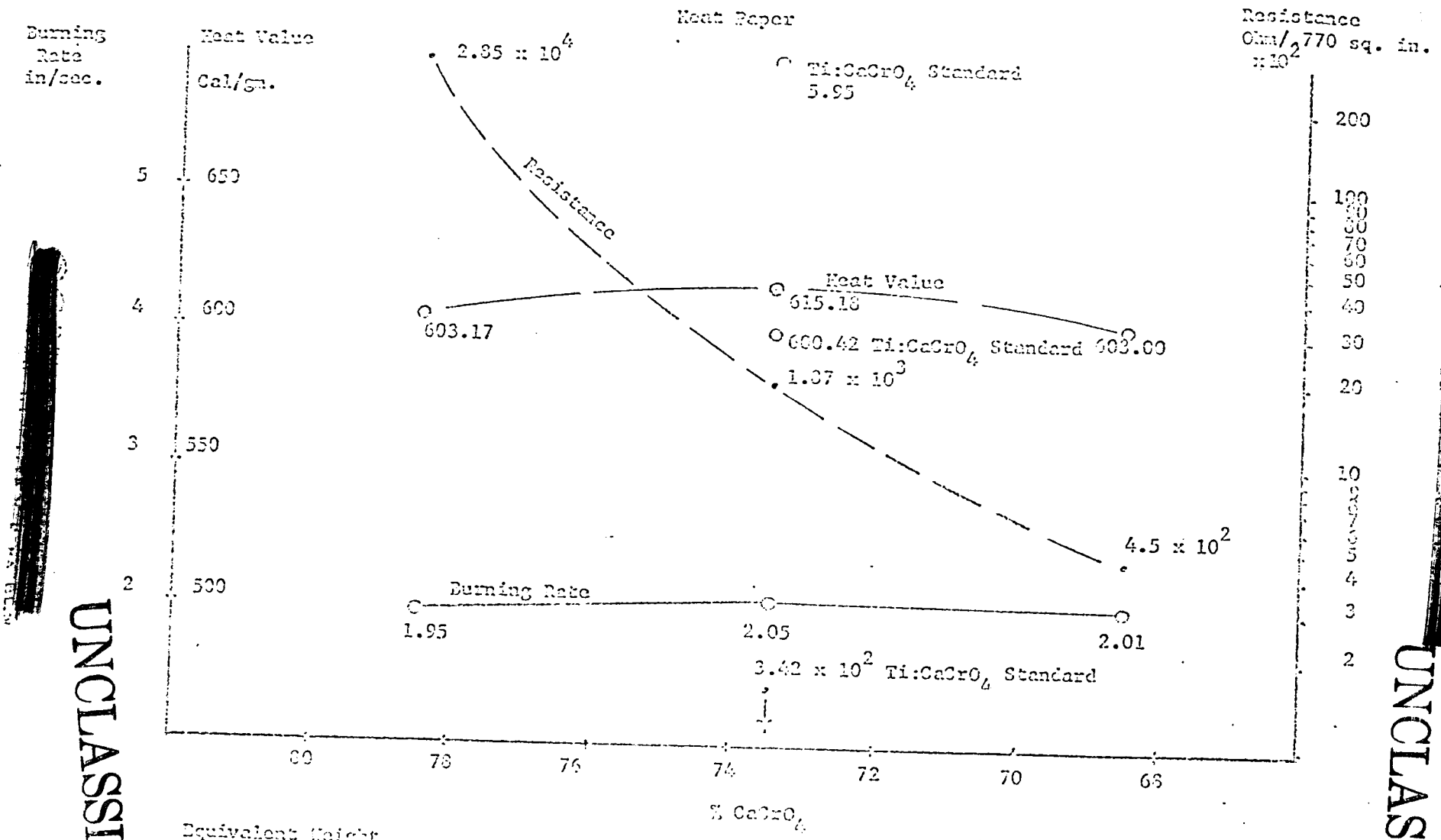

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CHART #1

SUPPLIER	WT.% Ti	WT.% Si	OXIDIZER	WT.%	(BLENDING METHOD)	RESULTS
Ti (Metal Hydrids)	-----	23.71	$KMnO_4$	76.29	Slurry	Burned well but had to be ignited with heat paper.
Si (Hummel) 4 μ	-----	12.52	$K_2Cr_2O_7$	87.48	Slurry	Did not burn.
	22.00	13.14	$KCLO_4$	64.86	Slurry	(Burned Violently) Ignited with electrical match.
	-----	10.00	$KMnO_4$	90.00	Dry Blend B	Did not burn.
	-----	20.00	$KMnO_4$	80.00	Dry Blend B	Burned well (fast) but had to be ignited with heat paper.
	-----	25.00	$KMnO_4$	75.00	Dry Blend B	Burned well (fast) but had to be ignited with heat paper.
	-----	50.00	$KMnO_4$	50.00	Dry Blend B	Burned fair but had to be ignited with heat paper.
	-----	75.00	$KMnO_4$	25.00	Dry Blend B	Burned slow; had to be ignited with heat paper.
	-----	10.00	$K_2Cr_2O_7$	90.00	Dry Blend B	Did not burn.
	-----	25.00	$K_2Cr_2O_7$	75.00	Dry Blend B	Burned fair; had to be ignited with heat paper.
	-----	50.00	$K_2Cr_2O_7$	50.00	Dry Blend B	Burned slow; had to be ignited with heat paper.

Slurries were made by mixing the prescribed weight ratios of Si, Ti to oxidizer and several ml. of water in a mortar and pestle.

Dry blends method B were made by mixing the prescribed weight ratios of Si to oxidizer in a mortar and pestle.

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CHART #2

OXIDIZER	Ti-OXIDIZER RATIO	PER CENT FIBERS	FREE Ti	IMPURITIES	TRUE OXIDIZER	IMPURITIES	SOLUBILITY ADJUSTMENT	HEAT VALUE CAL/GM.	BURNING RATE IN/SEC.	TUBE TEST	RESISTANCE OHMS/.720 AFTER BURNING
MnO_2	35.52 / 54.48	12%	31.258	1.925	56.742	.17%	None	406.97	----	Passed	Did not burn under pressure
V_2O_5	20.84 / 79.16	12%	18.339	1.129	69.661	----	None	507.57	2.37	Passed	1.83
V_2O_5	28.32 / 71.68	12%	24.922	1.535	63.078	----	None	551.90	2.91	Passed	.118
V_2O_5	39.7 / 60.3	12%	34.936	2.144	53.064	----	None	566.92	2.97	Passed	.047