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REPORT NO. 710/63

CRITICAL POINTS OF NITRIDING STEELS

By

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Research Metallurgist

September 17, 1936
WATERTOWN ARSENAL
WATERTOWN, MASS.

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Report No. 710/63
Watertown Arsenal

September 17, 1936

Critical Points of Nitriding Steels

Purpose:

The purpose of this investigation was to determine the critical points of nitriding steels including an Armor Plate composition of the chrome-molybdenum-vanadium type.

Conclusions:

1. Aluminum contents of .50 and 1% raise the transformation point of chrome-molybdenum-vanadium Armor Plate 20 and 30 degrees centigrade respectively.

2. Nickel content of 3% counteracts the effect of aluminum and lowers the transformation point of the Armor Plate composition some 30-45 degrees centigrade.

3. An addition of 1% aluminum raises the critical point some 25 degrees centigrade, which is equivalent to the combined addition of 3% chromium and .40% aluminum.

Experimental Procedure:

Critical point specimens of the alloy steels investigated were machined as follows: 1-1/2" long, 1/2" diameter, with a 3/16" hole drilled into one end to a depth of 3/4".

Inverse rate curves were constructed as illustrated in Figures 1 to 8 inclusive.

Experimental Results:

Chemical compositions and the critical point determinations are given in Table I.

Discussion:

The effect of nickel, aluminum chromium, and the combined effect of nickel and aluminum on the transformation points on heating of the Cr-Mo-Va Armor Plate composition is shown in Table II.

TABLE I

Chemical Composition and Transformation Points

Spec. No.	Heat No.	Chemical Composition											Transformation Points			
		C	Mn	P	S	Si	Ni	Cr	Mo	Va	Al	Ti	Heating °C	Heating °F	Cooling °C	Cooling °F
1	1312	.445	.66	.005	.017	.280	3.31	1.20	.60	.27	.55	-	750±	1382±	395	743
2	1213	.525	.64	.005	.015	.265	3.09	1.24	.72	.24	-	-	750	1382	465	869
3	1313	.45	.64	.005	.018	.250	3.23	1.20	.61	.255	1.00	-	735±	1355±	375	707
4	1203	.555	.58	.005	.020	.275	--	1.26	.76	.255	.011	-	780	1436	460	860
5	1319	.39	.46	.005	.018	.335	--	3.50	.53	.225	.40	-	805	1481	485	905
6	1320	.49	.60	.008	.017	.275	--	1.28	.67	.21	1.19	-	805	1481	480	896
7	1321	.27	.60	.009	.015	.335	--	1.31	.64	.21	--	.18	780	1436	450	842
8	1272	.48	.65	.006	.019	.280	--	1.31	.60	.255	.50	-	800	1472	480	896

TABLE II

Effect of Various Elements on Transformation Points of Cr-Mo-Va Armor Plate

Alloy	Sample No.	Transformation Point Temperatures °C Heating	Increase	Decrease
Armor Plate composition	4	780	---	---
Addition of 3% nickel only	2	750	---	30
Addition of .5% aluminum only	8	800	20	---
Addition of 1.00% Al only	6	805	25	---
Addition of 3% Cr and .4% aluminum	5	805	25	---
Addition of 3% Ni and .5% aluminum	1	750±	---	30±
Addition of 3% Ni and 1% aluminum	3	735±	---	45±

The results of this investigation indicate that the addition of 1% aluminum is equivalent to the combined action of 3% chromium and .4% aluminum in raising the critical point of the Cr-Mo-Va composition.

Aluminum in the proportions of .5 and 1% raise the critical point of the composition in question 20 and 25 degrees centigrade respectively.

The well-known effect of nickel on lowering of the transformation point is clearly shown and it is interesting to note that a combined effect of 3% and 1% nickel lowers the transformation point on heating 45°C.

Furthermore, there is an apparent sluggishness of transformation on heating in the steels containing nickel and aluminum as noted in Figures 1 and 3. The transformation appears to occur within a short range of temperature rather than at a definite temperature.

Respectfully submitted,

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Research Metallurgist

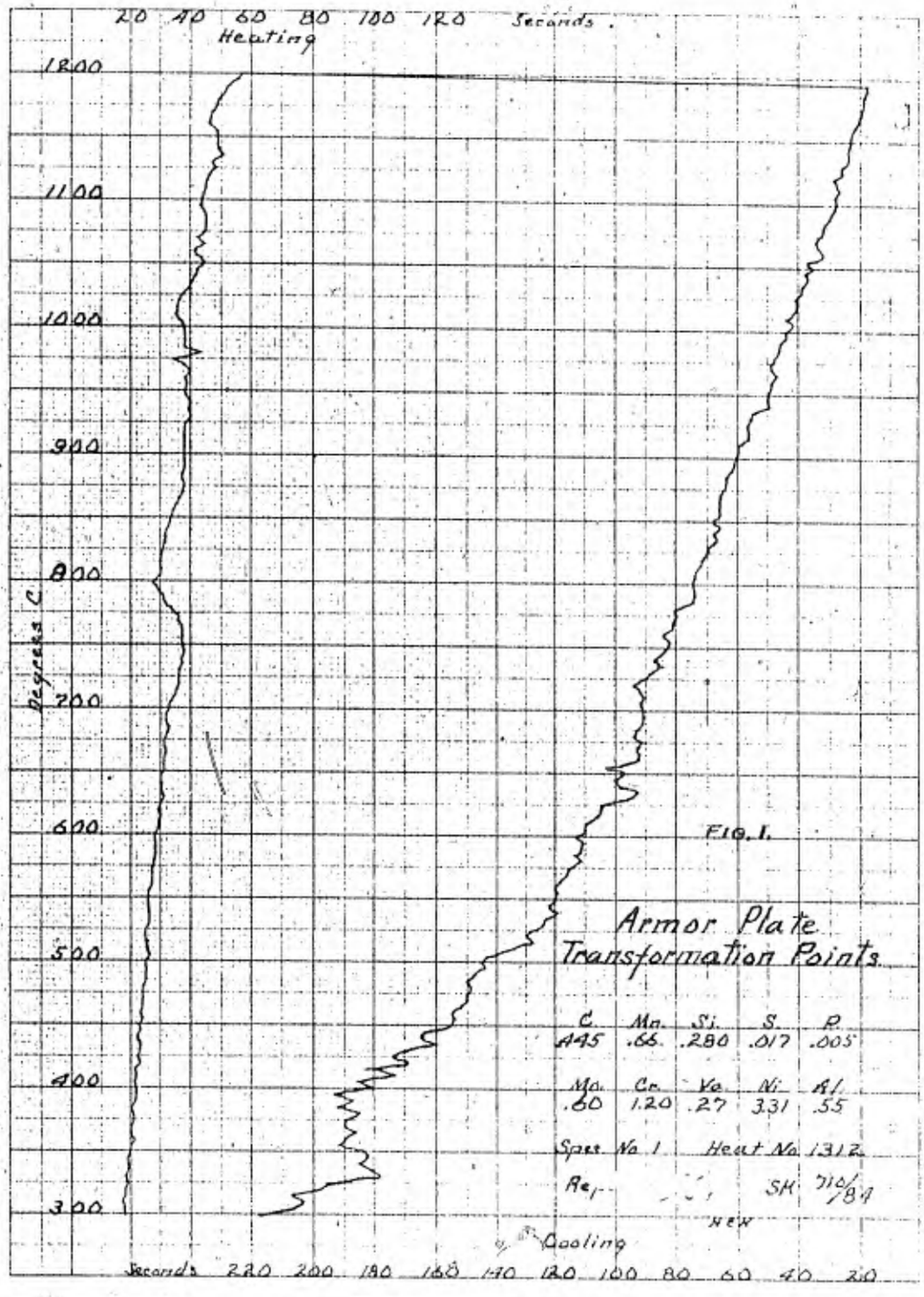

FIG. 1.

Armor Plate Transformation Points.

C.	Mn.	Si.	S.	P.
.445	.66	.280	.017	.005

Mo.	Cr.	Va.	Ni.	Al.
.60	1.20	.27	3.31	.55

Spec. No. 1 Heat No. 1312

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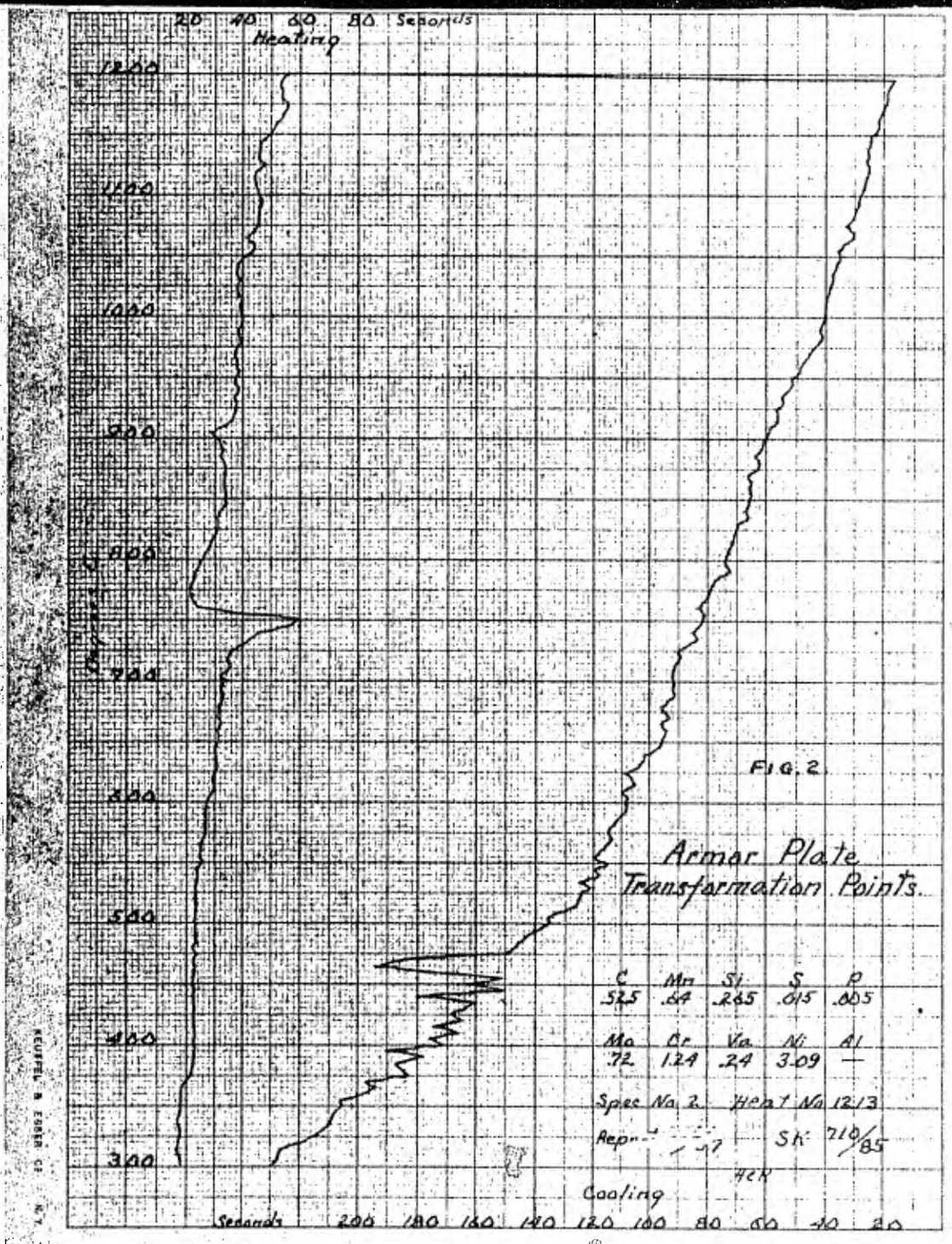

FIG. 2

Armor Plate
Transformation Points.

C	Mn	Si	S	P
.525	.64	.265	.015	.005

Mo	Cr	Va	Ni	Al
.72	1.24	.24	3.09	—

Spec No. 2 Heat No 1213

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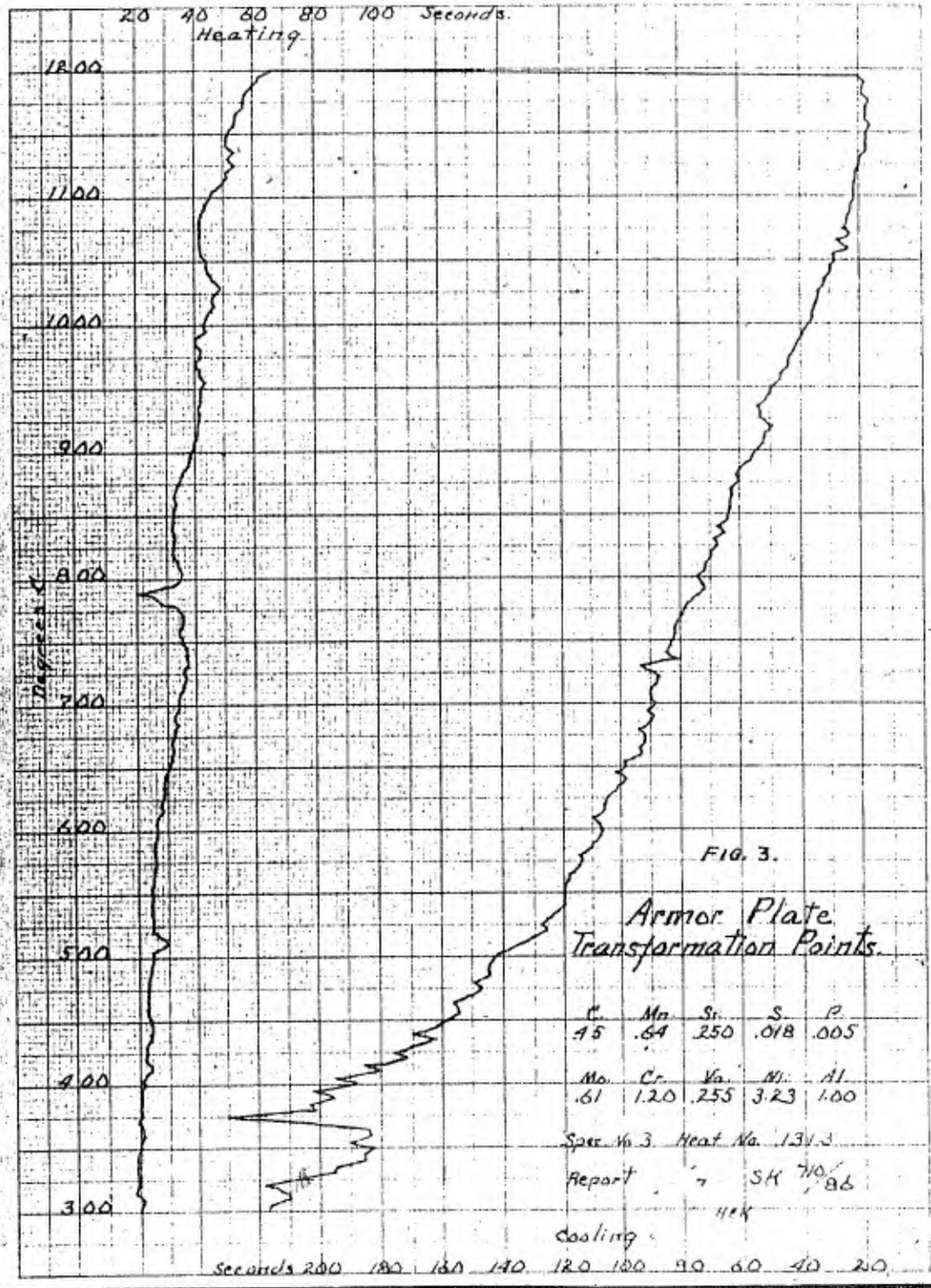

FIG. 3.

Armor Plate Transformation Points.

C.	Mn.	Si.	S.	P.
.45	.64	.250	.018	.005

Mo.	Cr.	Va.	Ni.	Al.
.61	1.20	.255	3.23	1.00

Spec. No. 3 Heat No. 13V3

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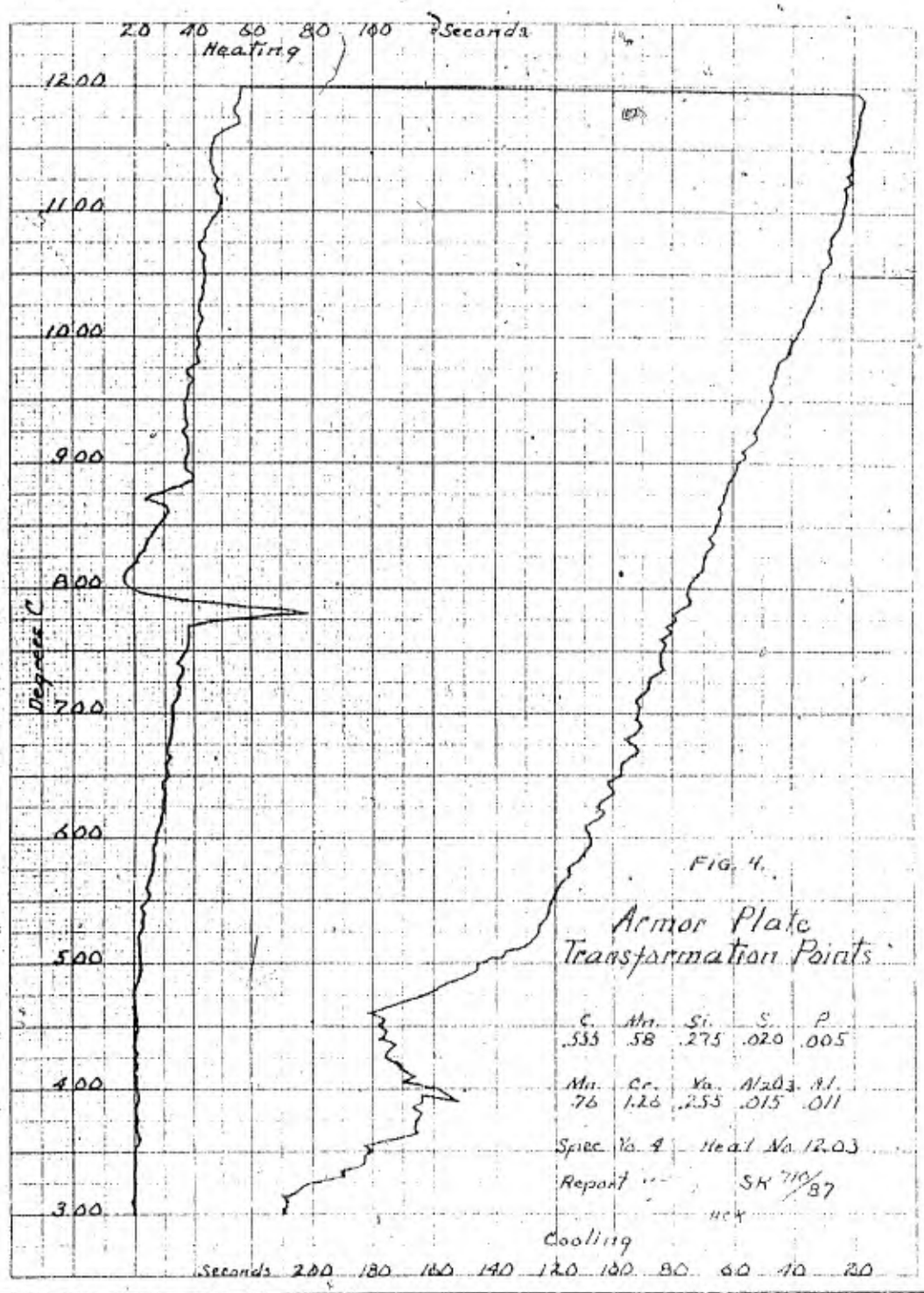

FIG. 4.

Armor Plate
Transformation Points

C.	Mn.	Si.	S.	P.
.333	.58	.275	.020	.005

Mn.	Cr.	Va.	Al_2O_3	Al.
.76	1.26	.255	.015	.011

Spec. No. 4 Heat No. 12.03

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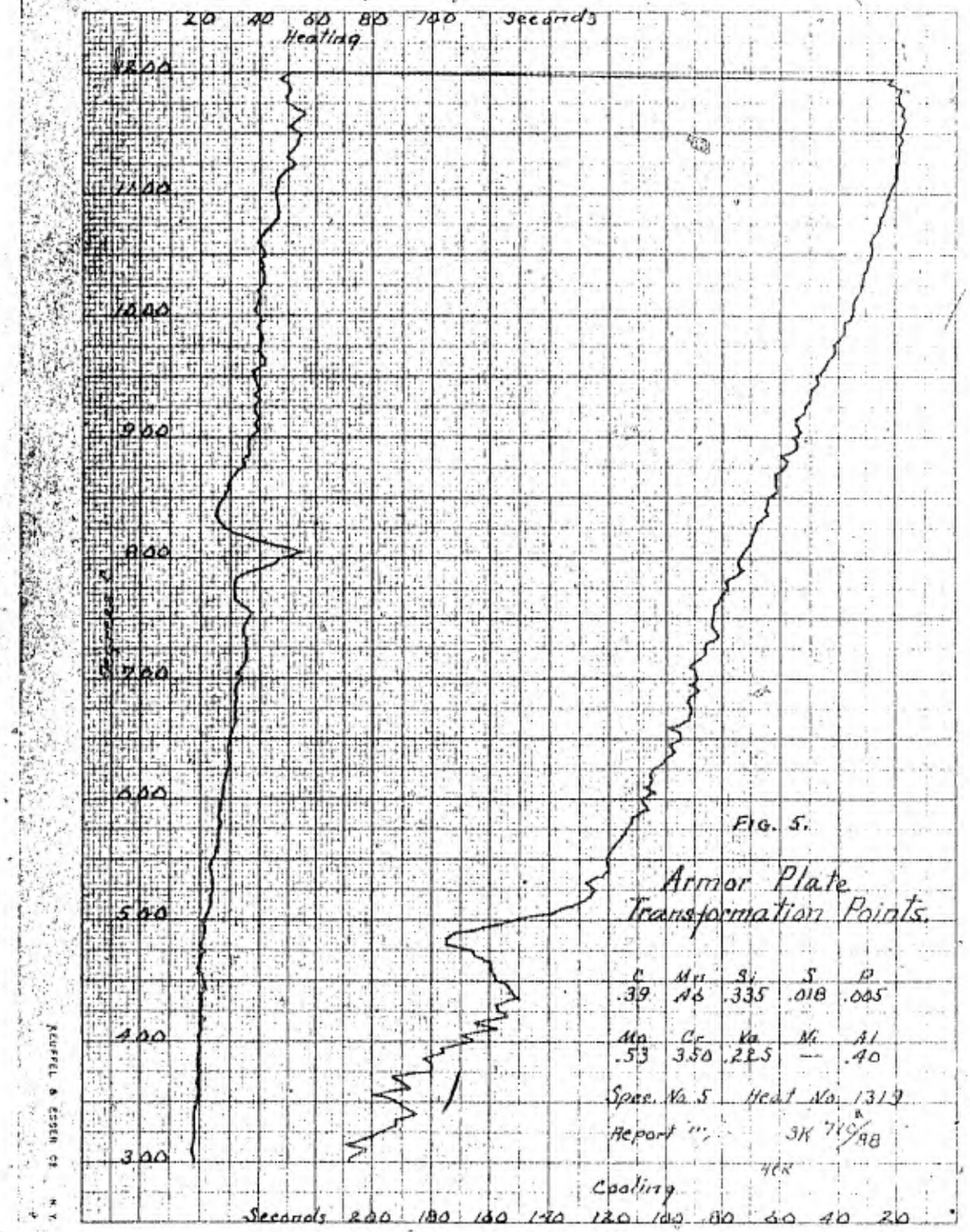

FIG. 5.

Armor Plate
Transformation Points.

C	Mn	Si	S	P
.39	N6	.335	.018	.005

Mo	Cr	Va	Ni	Al
.53	3.50	.225	—	.40

Spec. No. 5 Heat No. 1313

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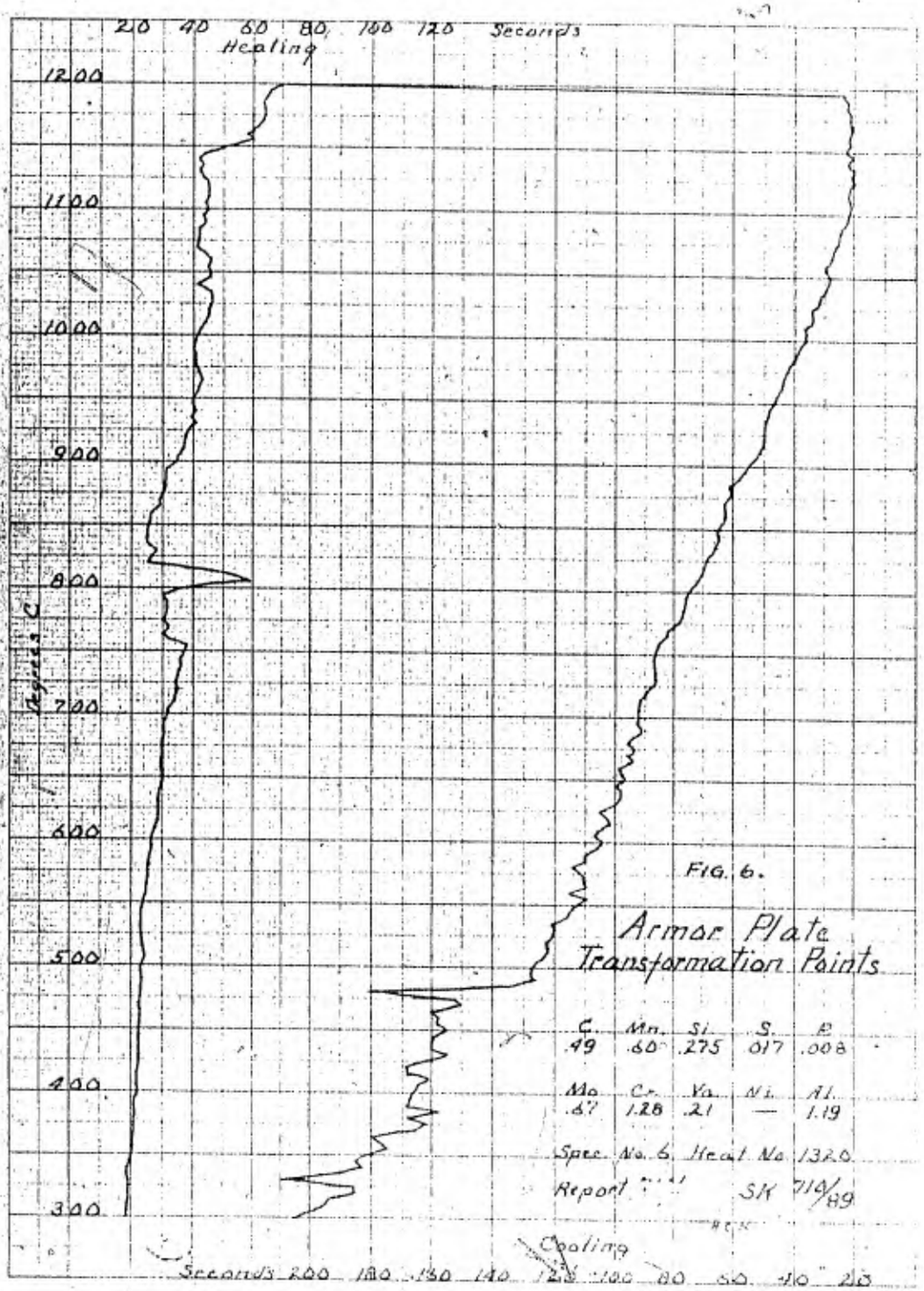

FIG. 6.

Armor Plate
Transformation Points

C	Mn.	Si	S.	P
.49	.60	.275	017	.008

Mo	Cr	Va	Ni	Al
.67	1.28	.21	—	1.19

Spec. No. 6 Heat No. 1320
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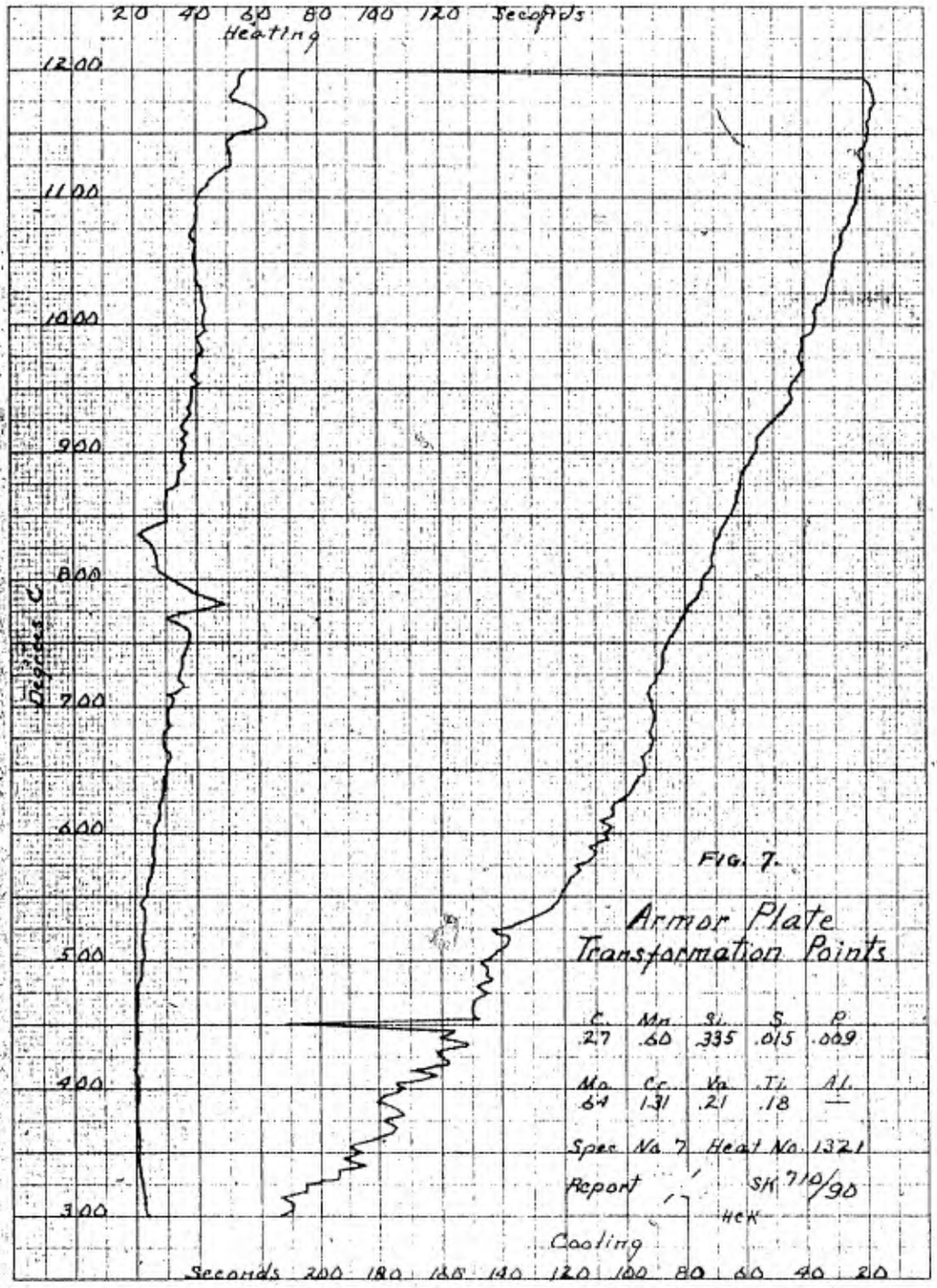

FIG. 7.

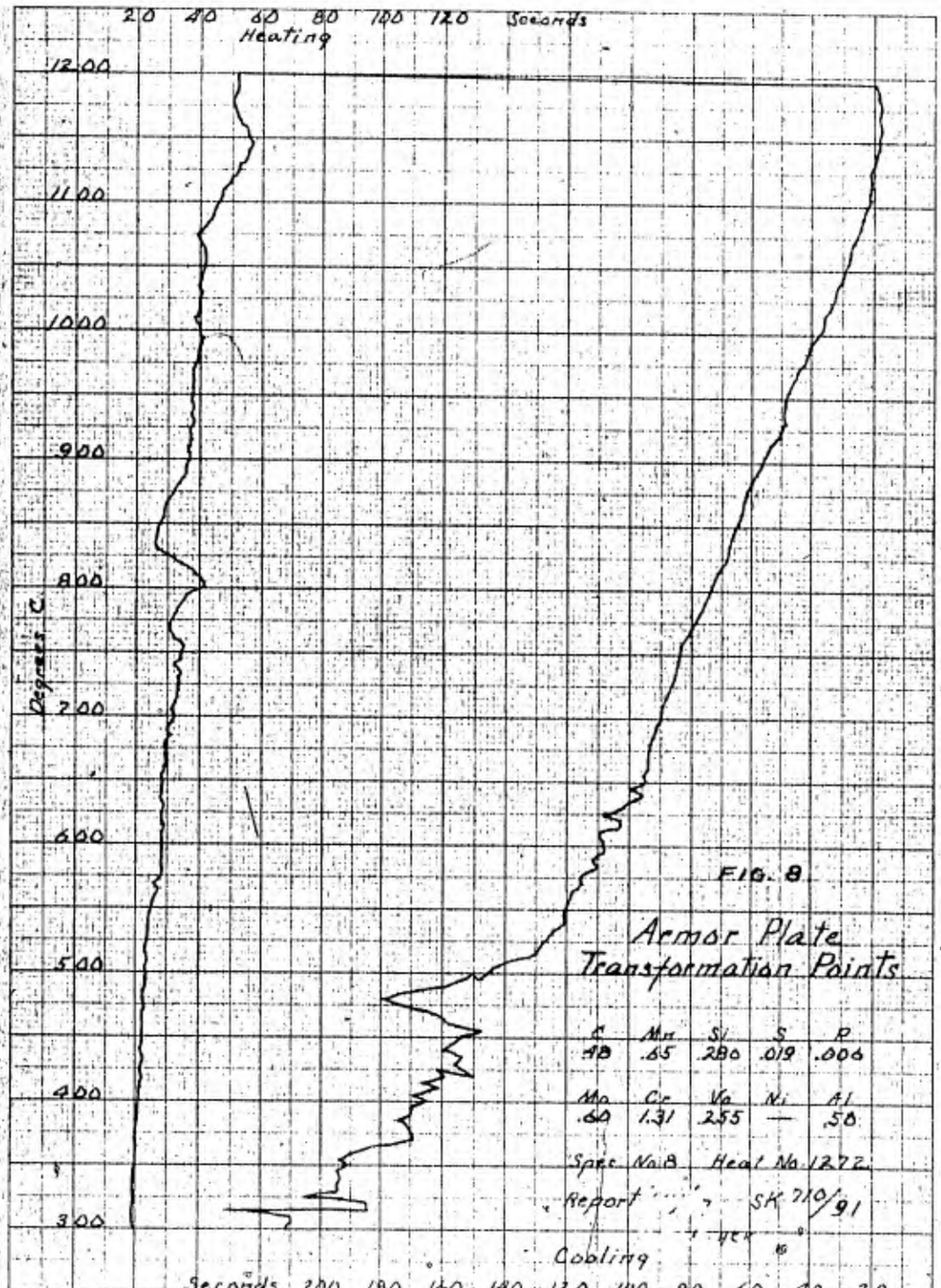

FIG. 8

Armor Plate
Transformation Points

C	Mn	Si	S	P
AB	.65	.280	.019	.006

Mo	Cr	Va	Ni	Al
.60	1.31	255	—	.58

Spec No. B Heat No. 1272

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