

HALL EFFECT APPARATUS IMPROVEMENT

- o THERMAL EMF'S NOT PREVIOUSLY ACCOUNTED FOR
- o SOME DATA SETS INDICATE LARGE ERRORS IN BOTH ρ AND R_H
- o PREVIOUS ρ DATA CAN BE CORRECTED
- o PREVIOUS R_H DATA CANNOT BE CORRECTED
- o IMPROVED PROCEDURES ARE EXPECTED TO PROVIDE 1% ACCURACY IN ρ , R_H , n_H AND

COMPARISON OF SiGe-BASED MATERIALS

- o ANNEALED SiGe/GaP
 - LARGE GRAIN SIZE
 - NUCLEATION SITES ANNEALED OUT
 - SLOW PRECIPITATION / RESOLUTION KINETICS
 - LARGE SOURCE OF PHOSPHORUS (i.e. GaP)

- o ZONE LEVELED SiGe
 - LARGE GRAIN SIZE
 - FEW NUCLEATION SITES
 - SLOW PRECIPITATION / RESOLUTION KINETICS
 - LESS STABLE SOURCE OF PHOSPHORUS (SiP)

10/2/81
CBV

Thermal Emf Elimination By Current Reversal



I^+ , V^+ from one measurement

I^- , V^- from second measurement performed quickly after the first

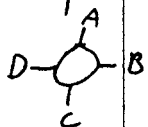
$$\begin{aligned} V^+ &= I^+ R + S \Delta T \\ V^- &= I^- R + S \Delta T \end{aligned}$$

$$\left(\frac{V^+ - V^-}{I^+ - I^-} \right) = R$$

$$S \Delta T = \frac{1}{2} (V^+ + V^-) - \frac{1}{2} R (I^+ + I^-)$$

Note V^+ & V^- normally have opposite signs
if I^+ & I^- have opposite signs

VPD Resistivity using thermal Emf Elimination



Voltage / Current

Average

VPD Resistivity

- AB/CD >
- AB/DC >
- BC/DA >
- BC/AD >
- CD/AB >
- CD/BA >
- DA/BC >
- DA/CD >
- AB/CD >
- AB/DC >

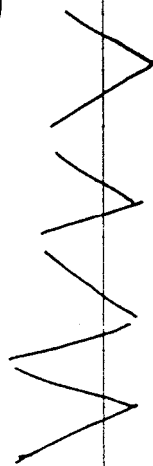
$$\left(\frac{V^+ - V^-}{I^+ - I^-} \right)$$

"

"

"

"



$$f \Rightarrow \rho^{(1)}$$

$$" \rho^{(2)}$$

$$" \rho^{(3)}$$

$$" \rho^{(4)}$$

Average $\bar{\rho} \pm \delta\rho$

Hall Determination Procedure

101-

		Average Current Reversals	Hall Coefficients	
Field off	B = 0			
AC/BD	$\left(\frac{V_+ - V_-}{I_+ - I_-} \right)$		$R_H^{(1)}$	
AC/DB				
BD/AC				
BD/CA				
Field Normal	B = +10			
AC/BD	"		$R_H^{(2)}$	
AC/DB				
BD/AC				
BD/CA				
Field Reverse	B = -10			
AC/BD	"		$R_H^{(3)}$	
AC/DB				
BD/AC				
BD/CA				
Field off	B = 0			
AC/BD	"		$R_H^{(4)}$	
AC/DB				
BD/AC				
BD/CA				
		Average Hall	$\overline{R_H} \pm \delta R_H$	

MOBILITYMAXIMUM***MINIMUM MAG TIME= 375 SECK1= 4
 1.39570E+001 1.793E+001 1.04950E+001

MAXIMUM MINIMUM
 +2.44990E-002 CM^3/C +1.2329E-002CM^3/C

TEST COMPLETED

 SIGe E40RN THICKNESS= .1 DATE IS 42087
 N-typeVACUUM= .00001 TIME IS 1510
 TEMPERATURE= 791.8E+000 1000/T(K)= .939 T/C=5.85E-002
 TIME TO TEMP= 150.0E-002 HRS
 STAB CRITERION=450.0E-007 STD DEV = .000
 HEATER POWER= 172.69 W V= 35 I= 4.934

J L	nV READING	AMPS	
1 1	-2.16023E-004	.2037	3.188 x 10 ⁻³
2 1	+1.08283E-003	.2037	
1 2	-1.01303E-003	.2033	3.174 x 10 ⁻³
2 2	+2.77978E-004	.2034	
3 1	-7.95227E-004	.2035	3.218 x 10 ⁻³
4 1	+5.14330E-004	.2035	
3 2	-5.82113E-004	.2038	3.174 x 10 ⁻³
4 2	+7.11498E-004	.2038	

Handwritten notes: 1.442 x 10⁻³, 1.449 x 10⁻³, 1.449 x 10⁻³, 1.442 x 10⁻³

J L	VOLTS APPL.	OHMS	POWER
1 1	+.8957	.001	.182
1 2	+.8957	.005	.182
2 1	-.8842	.005	-.180
2 2	-.8842	.001	-.180
3 1	+.7759	.004	.158
3 2	+.7759	.003	.158
4 1	-.7771	.003	-.158
4 2	-.7771	.003	-.158

$\rho = 1.446 \times 10^{-3} \pm 0.004 \times 10^{-3} \Omega\text{-cm}$

RESISTIVITY	RATIO	F	SIGMA
1.1022E-003	4.7	80E-002	9.0728E+002 (OHM-CM)^-1
1.2668E-003	3.9	84E-002	7.8939E+002 (OHM-CM)^-1
1.4775E-003	1.4	96E-002	6.7682E+002 (OHM-CM)^-1
1.3140E-003	1.4	96E-002	7.6104E+002 (OHM-CM)^-1

AUG RHO	STD DEV	AUG SIGMA	MEAN + STD DEV	MEAN - STD DEV
1.29013E-003	6.687E-005	7.75119E+002	8.17489E+002	7.36924E+002

***** HALL MEASUREMENT AC/BD *****

POWER= .1866495188

nV READING	CURRENT	DELTA V
+5.08604E-005	+2.032E-001	
+4.53817E-005	+2.032E-001	-5.30010E-006
+5.06632E-005	+2.032E-001	
+5.45292E-005	+2.032E-001	+3.70580E-006
+5.09837E-005	+2.032E-001	

HALL CONSTANTS MAG FIELD

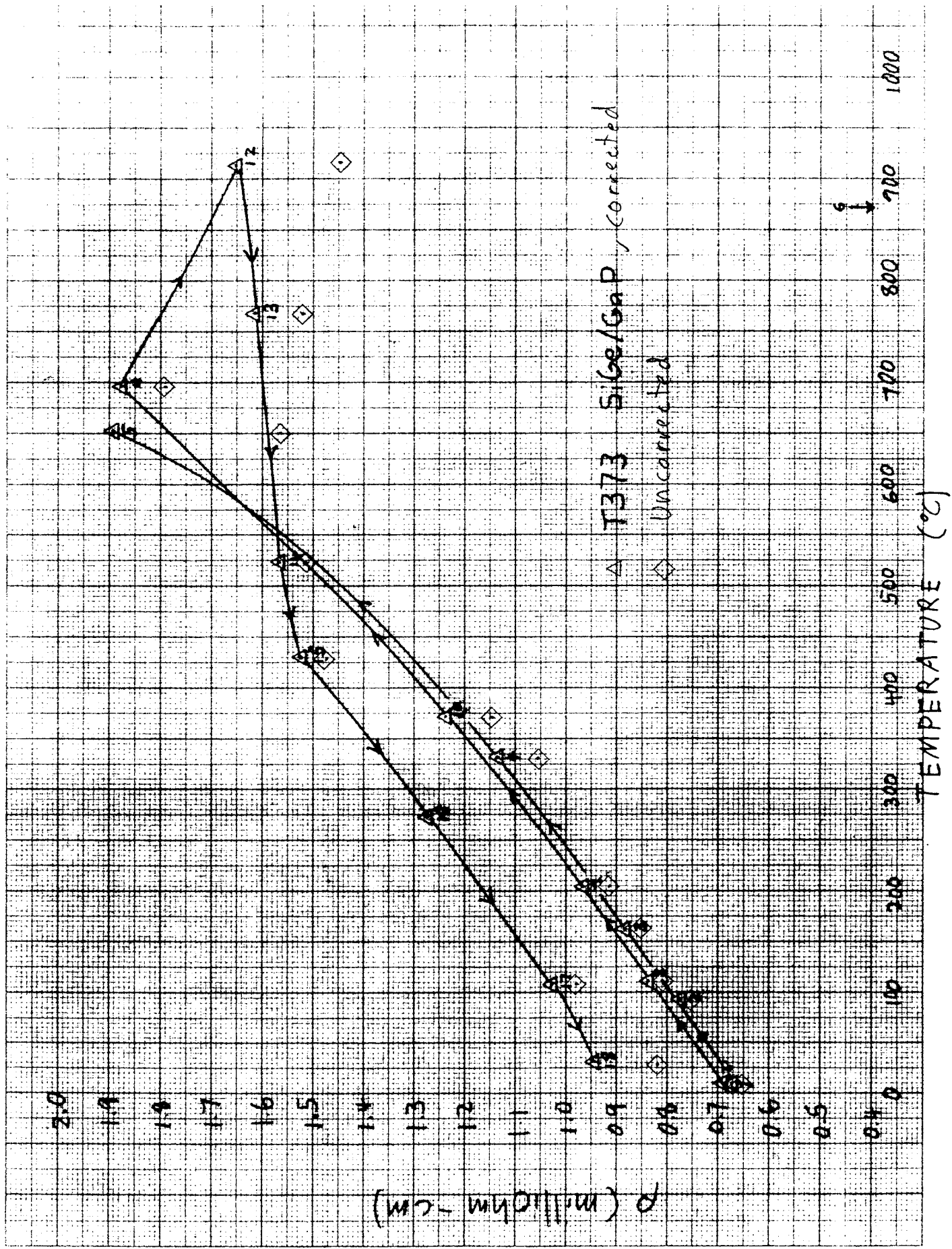
-2.84990E-002 CM^3/C	+9.8410E+002GAUSS
-1.85690E-002 CM^3/C	-9.8200E+002GAUSS

POWER= -.1881460427

nV READING	CURRENT	DELTA V
+6.42415E-005	-2.032E-001	
+6.71057E-005	-2.032E-001	+3.53420E-006
+6.29015E-005	-2.032E-001	
+5.74093E-005	-2.032E-001	-5.37480E-006
+6.26667E-005	-2.032E-001	

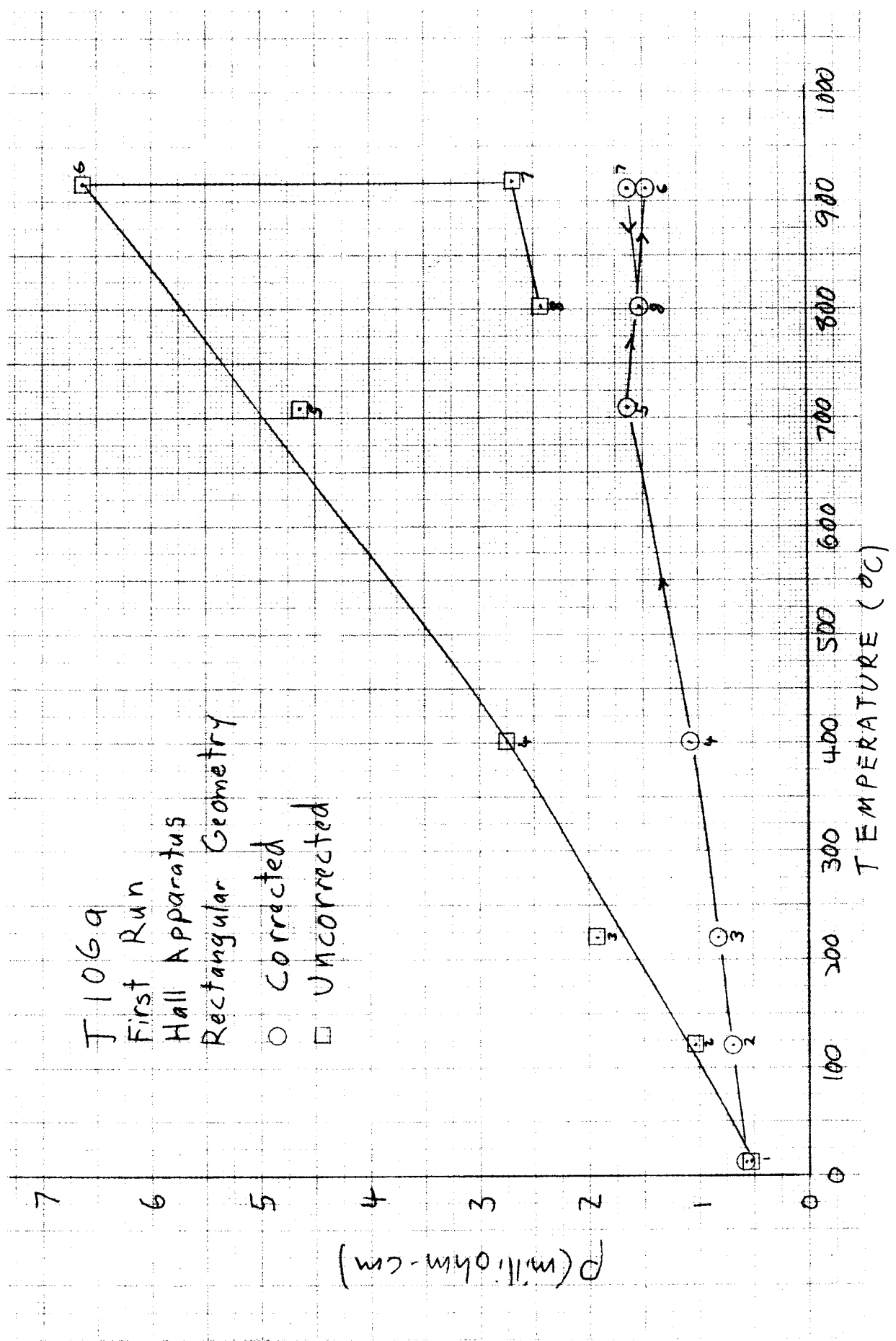
HALL CONSTANTS MAG FIELD

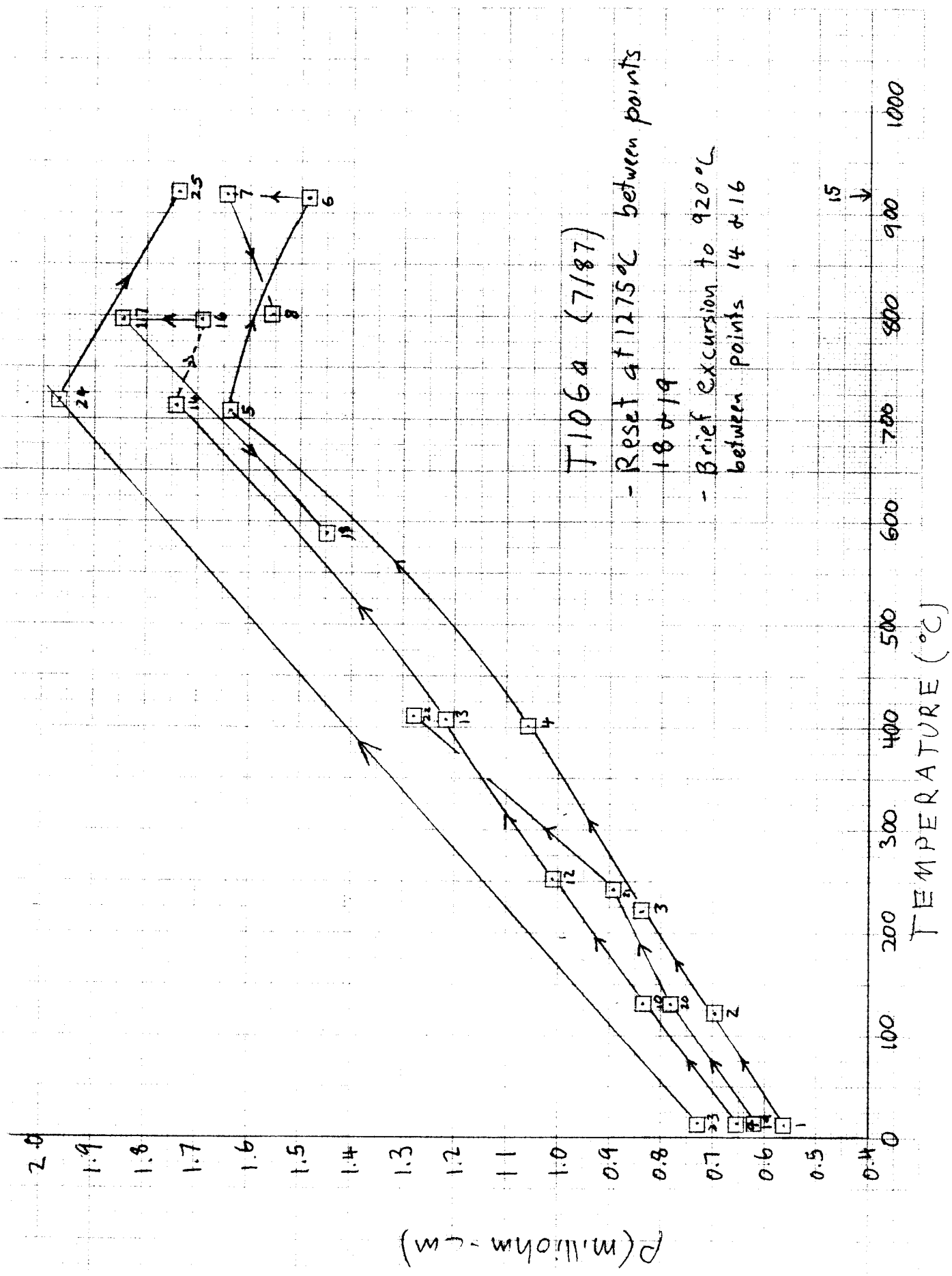
-1.74440E-002 CM^3/C	+9.9710E+002GAUSS
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J106a
 First Run
 Hall Apparatus
 Rectangular Geometry

○ Corrected
 □ Uncorrected





T.106a (7/87)

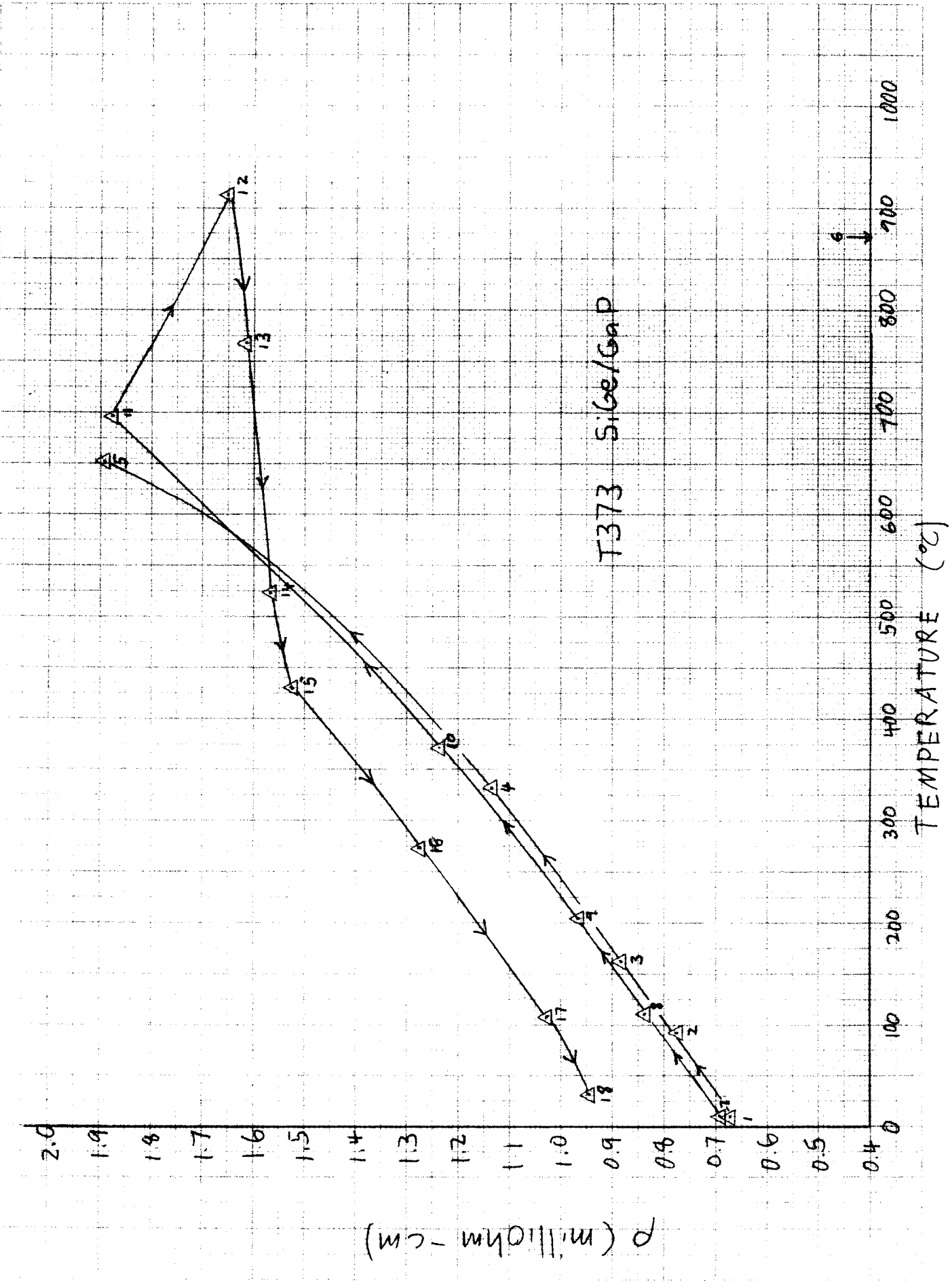
- Reset at 1275°C between points 18 & 19

- Brief excursion to 920°C between points 14 & 16

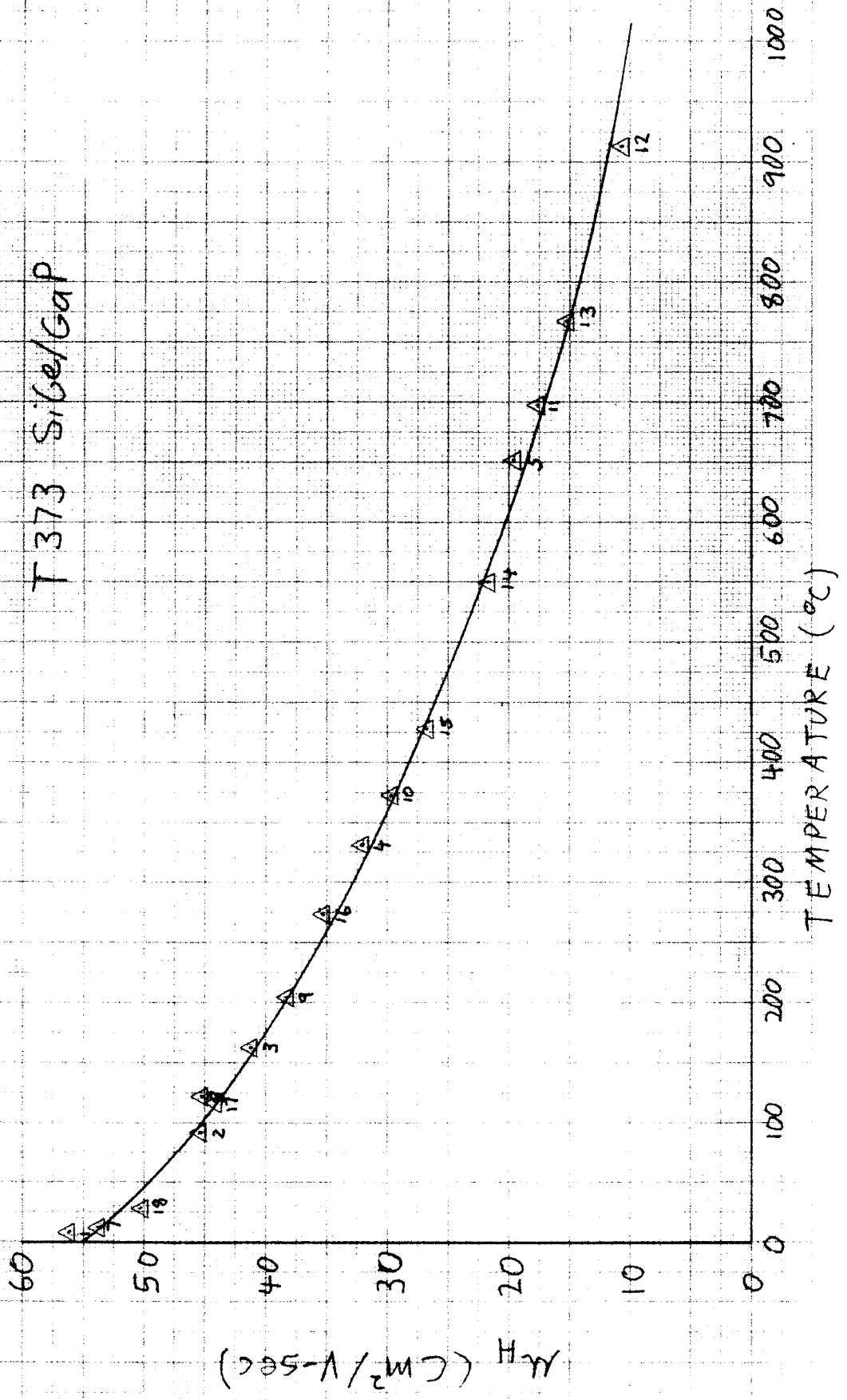
15

TEMPERATURE ($^{\circ}\text{C}$)

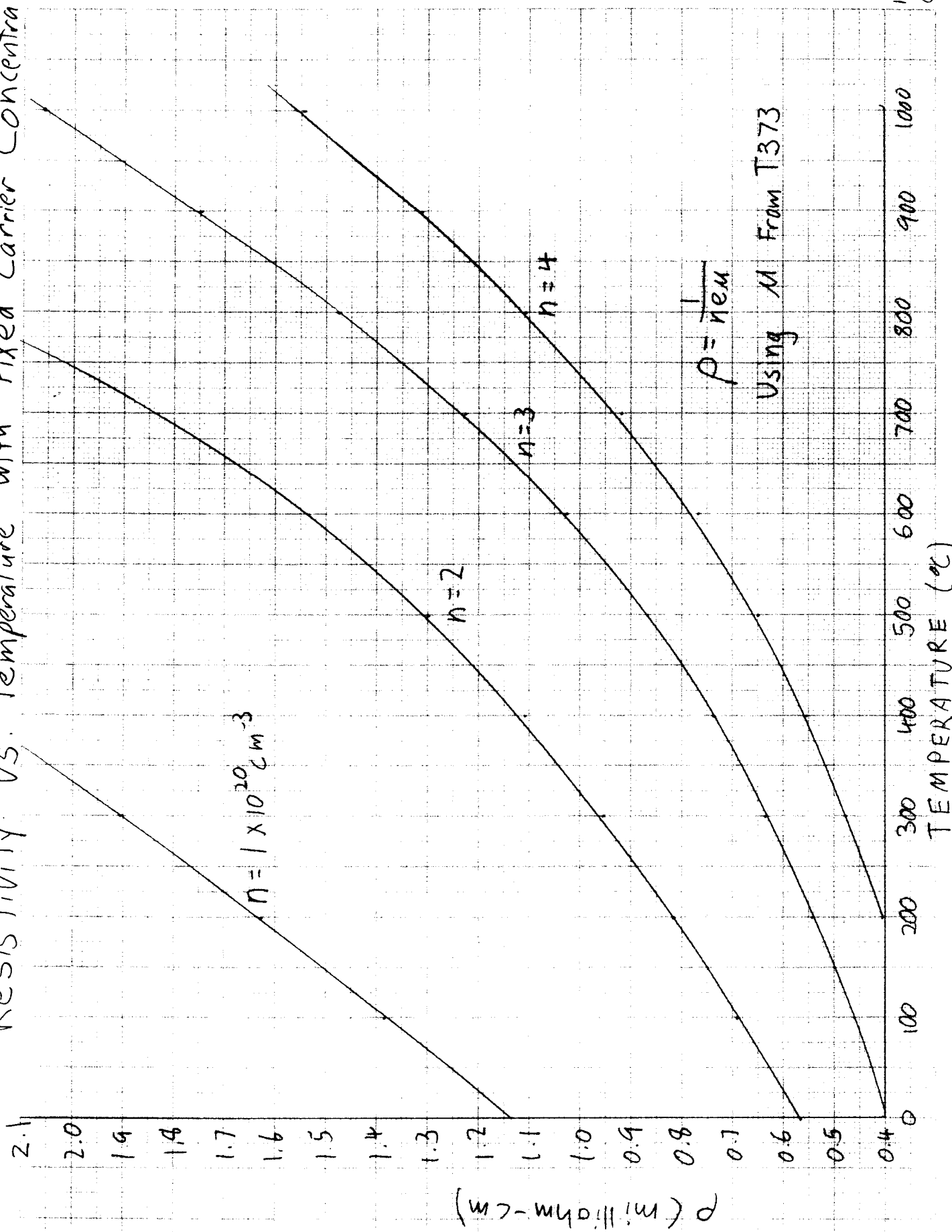
P (millihm-cm)



T 373 SiGe/GaP



Resistivity vs. Temperature With Fixed Carrier Concentration



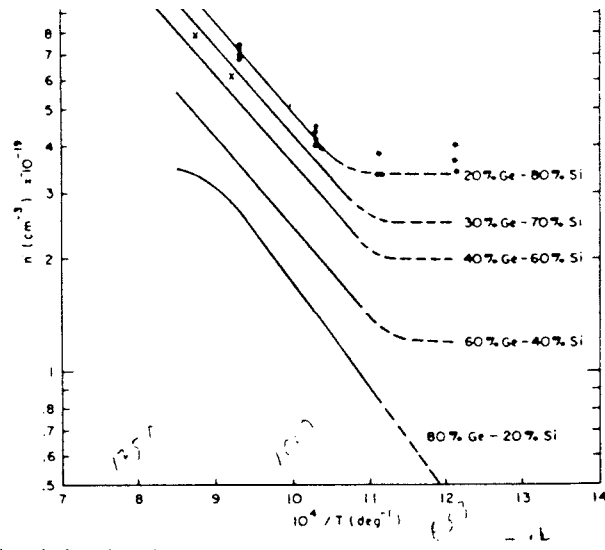
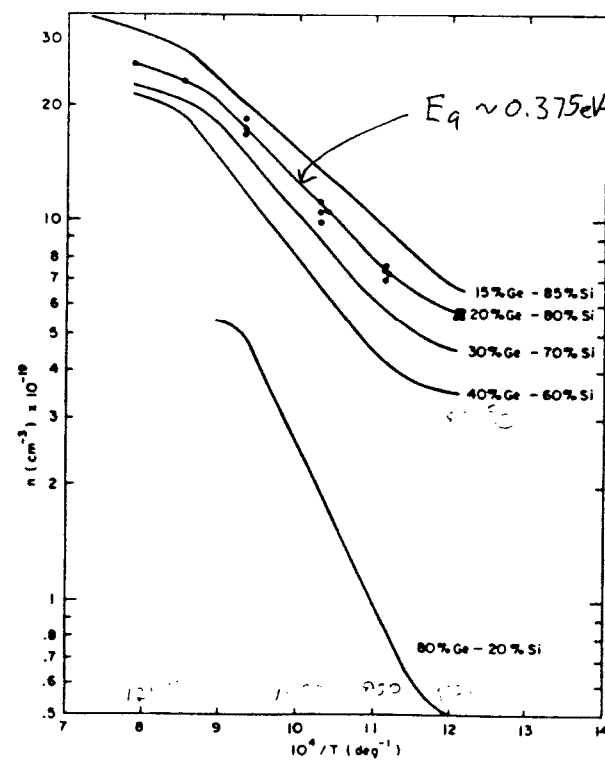
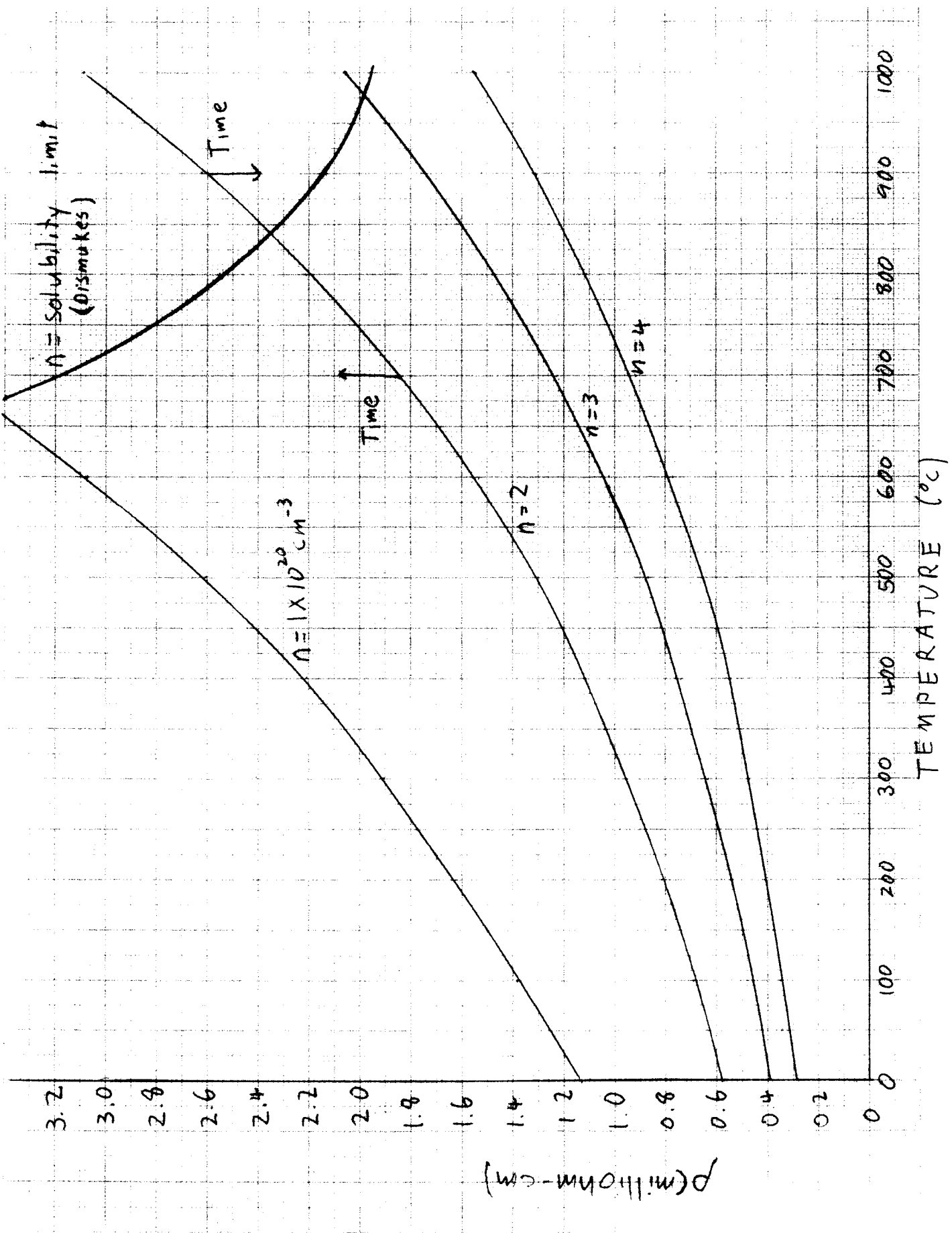


Fig. 24. Variation of solid solubility of arsenic with temperature in Si-Ge alloy compositions

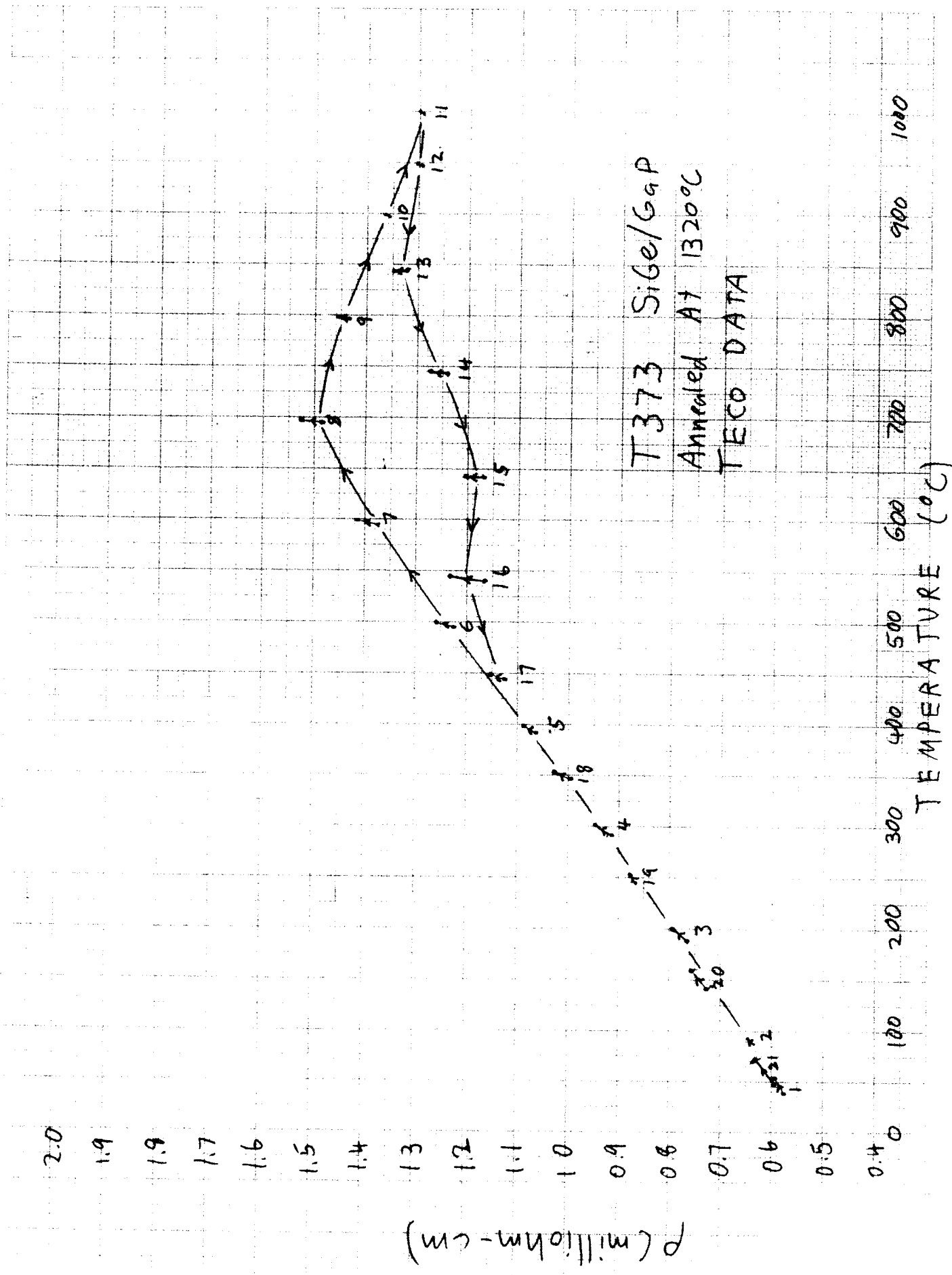


Dismukes 196
 $n = Ae^{-E_a/kT}$

Fig. 25. Variation of the solid solubility of phosphorus with temperature in Si-Ge alloy compositions

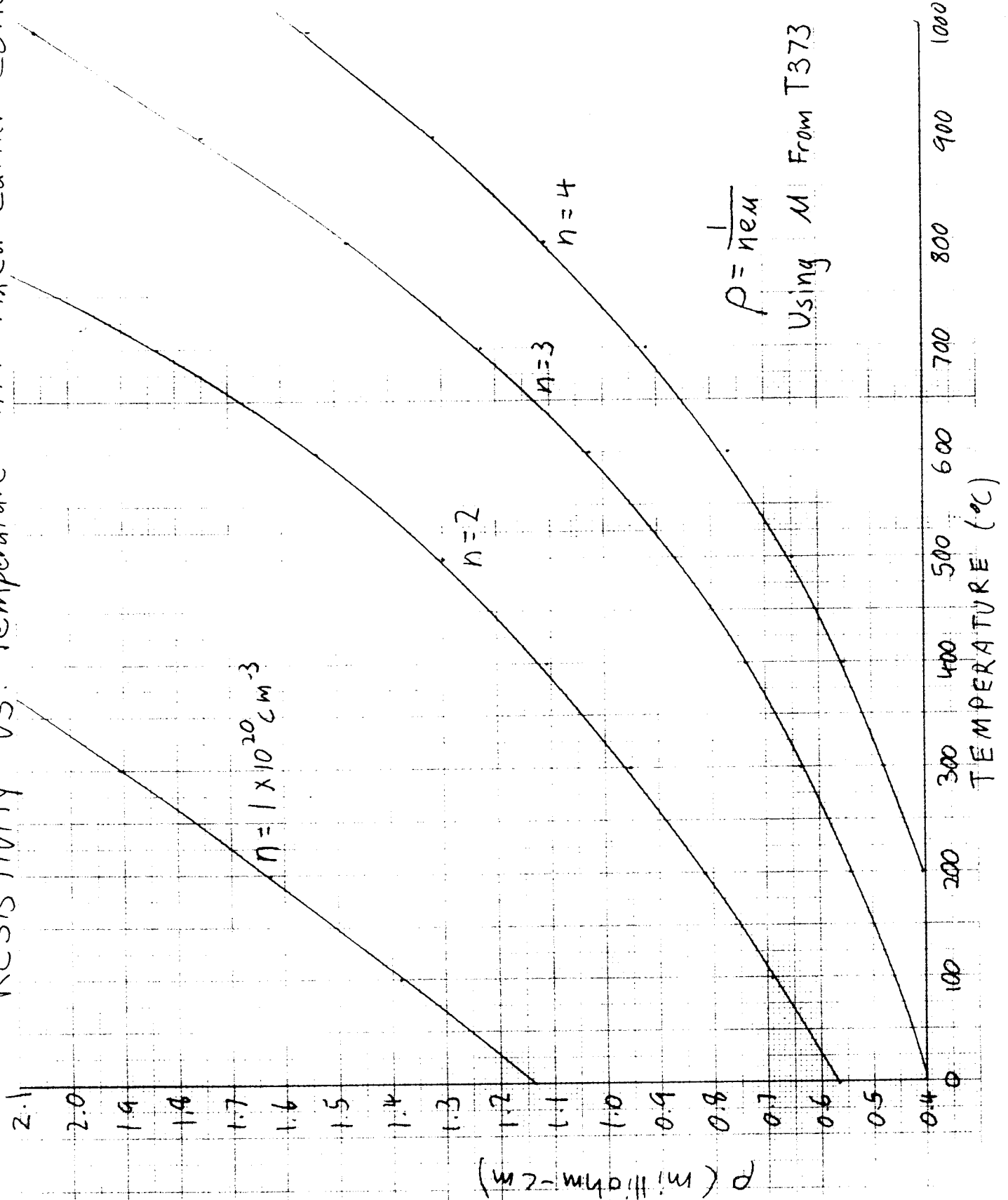


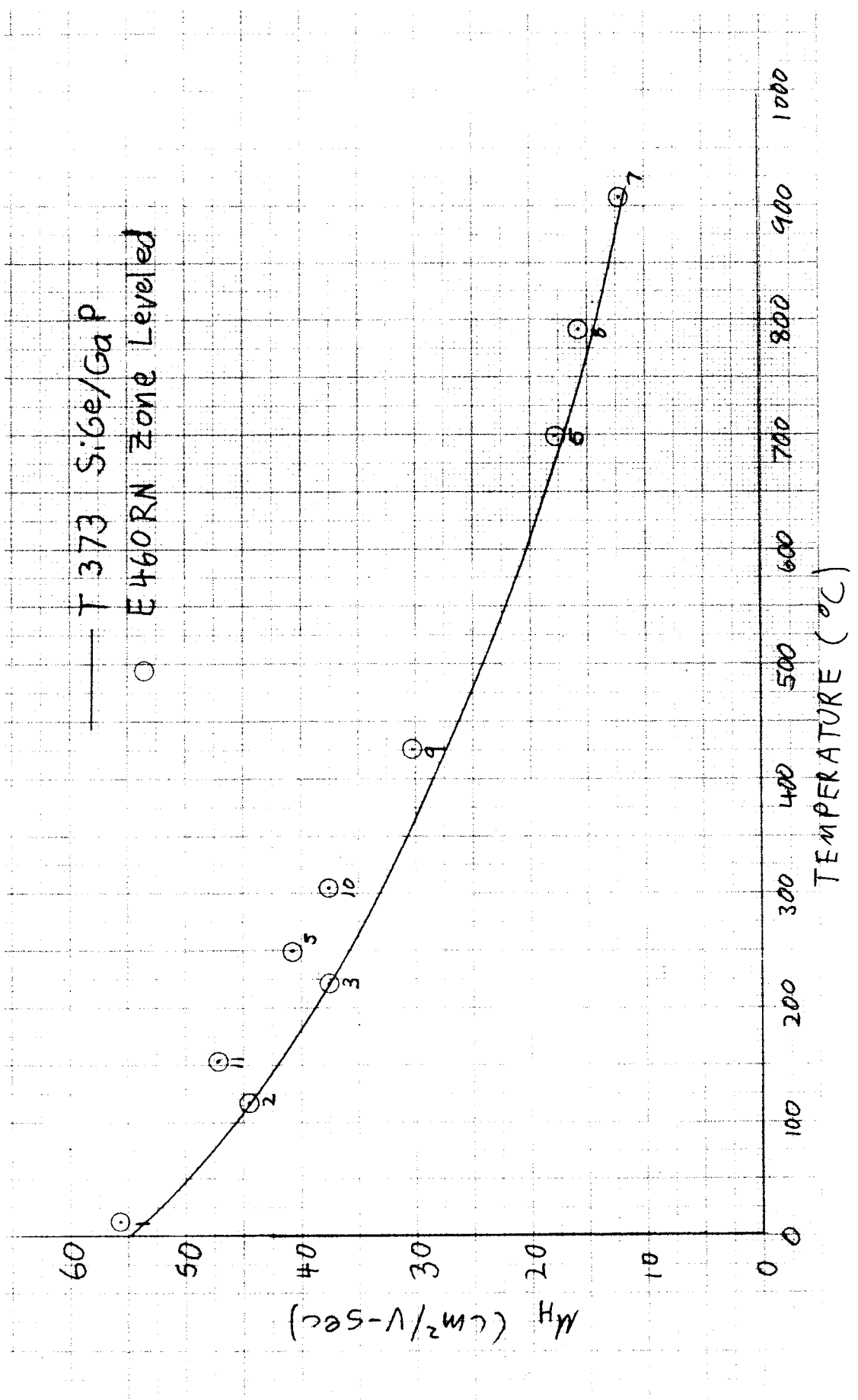
500693

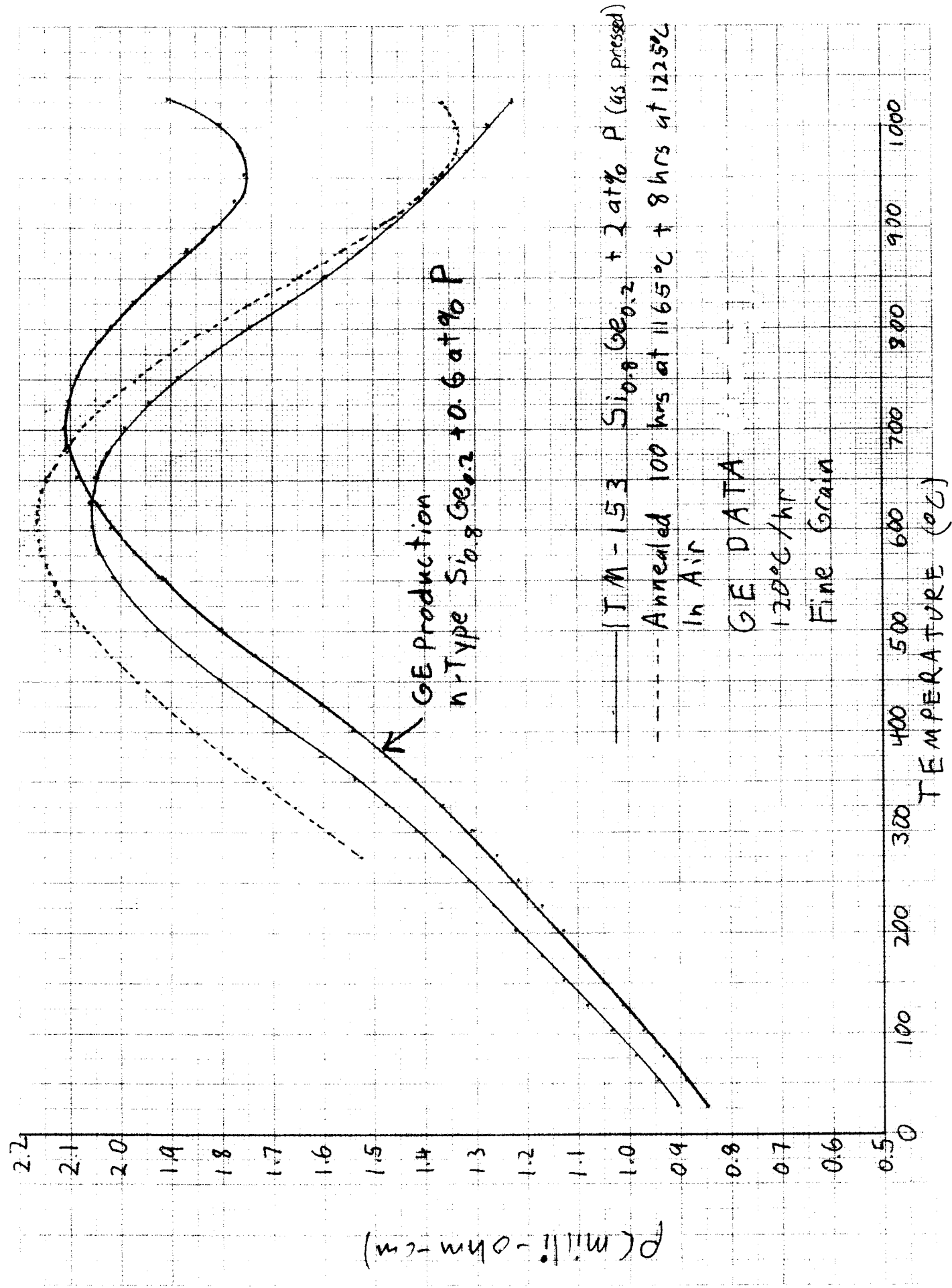


T373 SiGe/GaP
Annealed At 1320 $^{\circ}\text{C}$
TECO DATA

Resistivity vs. Temperature with Fixed Carrier Concentration







ALO (2510)-T1
AEC RESEARCH AND
DEVELOPMENT REPORT
CATEGORY UC33
TID 4500

TOPICAL REPORT

**SILICON GERMANIUM THERMOELECTRIC MATERIALS
AND MODULE DEVELOPMENT PROGRAM (U)**

BY

THERMOELECTRIC PRODUCTS ENGINEERING
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ELECTRONIC COMPONENTS
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HARRISON, NEW JERSEY 07029

PREPARED UNDER
CONTRACT AT(29-2)-2510

FOR THE
ALBUQUERQUE OPERATIONS OFFICE
U.S. ATOMIC ENERGY COMMISSION

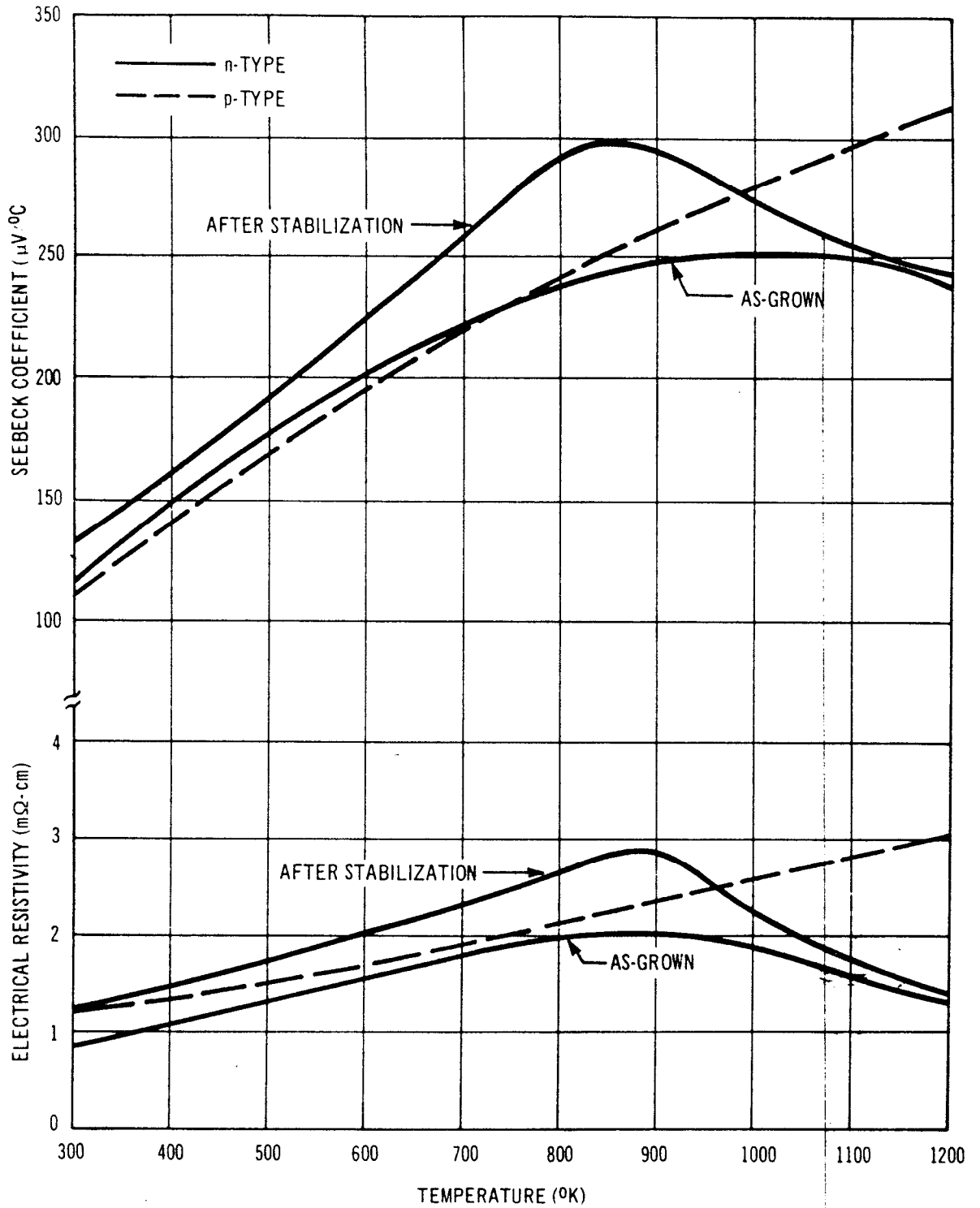
FOR THE PERIOD: 1 JANUARY 1968 TO 1 NOVEMBER 1969

Printed in the United States of America

Available from

Clearinghouse for Federal Scientific and Technical Information
National Bureau of Standards, U.S. Department of Commerce
Springfield, Virginia 22151

Price: Printed Copy \$3.00; Microfiche \$0.65



A. SEEBECK COEFFICIENT AND ELECTRICAL RESISTIVITY VS. TEMPERATURE

03681L

Figure 6. 80.0 At. % SiGe, Thermoelectric Properties (Sheet 1 of 2)

10/87
CAV

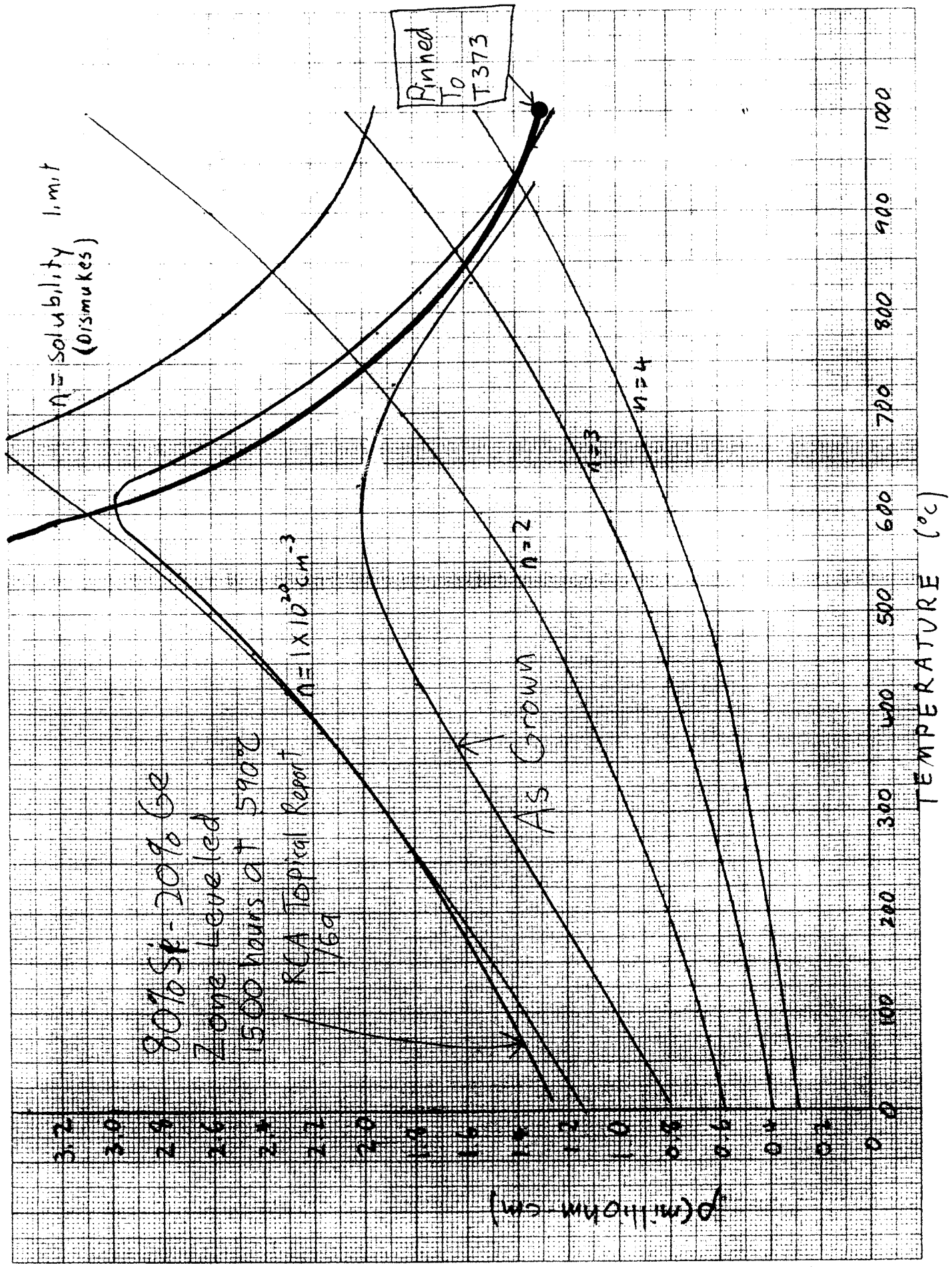


TABLE II. 80.0 at.% SiGe, STABILIZED THERMOELECTRIC PROPERTIES

Temp. (°C)	n-Type			p-Type		
	Seebeck ($\mu\text{V}/^\circ\text{C}$)	Electrical Resistivity ($\Omega\text{-cm} \times 10^{-3}$)	Thermal Conductivity ($\text{W}/^\circ\text{C-cm}$)	Seebeck ($\mu\text{V}/^\circ\text{C}$)	Electrical Resistivity ($\Omega\text{-cm} \times 10^{-3}$)	Thermal Conductivity ($\text{W}/^\circ\text{C-cm}$)
20	128	1.29	0.0510	106	1.26	0.0547
60	142	1.36	0.0501	125	1.30	0.0525
100	156	1.43	0.0493	142	1.35 ¹⁵⁶	0.0517 ^{1.32}
140	169	1.52	0.0485	156	1.40	0.0508
180	182	1.61	0.0478	168	1.46	0.0500
220	195	1.71	0.0470	179	1.52	0.0492
260	207	1.82	0.0464	188	1.59	0.0485
300	219	1.93	0.0456	198	1.67 ²⁰⁰	0.0478 ^{1.66}
340 ^(613K)	231	2.05	0.0449	206	1.75	0.0471
380 ^(623K)	243	2.17	0.0443	214	1.83	0.0465
420 ^(623K)	255	2.30	0.0437	222	1.91	0.0459
460	266	2.43	0.0431	230	1.99	0.0454
500	276	2.56	0.0426	237	2.08 ²⁰⁸	0.0449 ^{2.06}
540 ⁴¹³	285	2.72	0.0421	244	2.16	0.0444
580	291	2.92	0.0417	251	2.25	0.0440
620	294	2.98	0.0413	258	2.34	0.0437
660	289 ²⁸⁶	2.71	0.0408	265	2.42	0.0432
700	276	2.42	0.0411	272	2.51	0.0432
740	266	2.16	0.0415 ^{0.412}	279	2.60	0.0431
780	257	1.94 ^{1.96}	0.0423 ^{0.416}	286	2.69	0.0431
820	251 ²⁵¹	1.77 ^{1.80}	0.0437 ^{0.418}	293	2.78 ^{2.99}	0.0431
860 ²²³	246 ²⁴⁶	1.63 ^{1.65}	0.0446 ^{0.414}	300 ²⁹⁸	2.87 ^{2.88}	0.0434 ⁴³⁴
900 ²²³	243 ²³⁹	1.50 ^{1.52}	0.0467 ^{0.419}	307	2.95 ^{2.87}	0.0438 ^{0.44}
940	239 ²³⁴	1.39 ^{1.49}	0.0490 ^{0.435}	314 ³¹¹	3.04 ^{3.07}	0.0434 ^{0.445}
980	236 ²²⁹	1.29 ^{1.42}	0.0520 ^{0.439}	320 ³¹⁸	3.14 ^{3.15}	0.0450 ^{0.455}
1000	234 ²²⁸	1.24 ^{1.38}	0.0530 ^{0.444}	324 ³²¹	3.19 ^{3.19}	0.0454 ⁴⁶³