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CRYOGENIC THERMOCOUPLE TABLES—PART III

MISCELLANEOUS AND COMPARISON MATERIAL COMBINATIONS

Larry L. Sparks and William J. Hall

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CRYOGENIC THERMOCOUPLE TABLES -- PART III
MISCELLANEOUS AND COMPARISON MATERIAL COMBINATIONS*

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The thermovoltage, thermopower, and thermopower derivative are presented in graphical and tabular form for a) Chromel, copper, platinum and "normal" silver vs gold-0.02 at.% iron, and b) copper vs gold-0.07 at.% iron. The experimental temperature range is from 4 to 280 K for each combination. The experimental data have been extrapolated from 4 to 0 K. The thermopower of Chromel vs gold-0.02 at.% iron is higher than that of Chromel vs gold-0.07 at.% iron below ~ 12 K. Copper, platinum, and "normal" silver vs gold-0.02 at.% iron are reasonably sensitive below ~ 15 K. In this temperature range the pure materials, copper and platinum, have high thermal conductivities and their thermopowers are very dependent upon trace impurities of iron. Thermoelectric comparisons are made graphically for Chromel, Alumel, constantan, "normal" silver and platinum. The results of these comparisons indicate the degree of noninterchangeability that exists between wires from different manufacturers.

Key Words: Cryogenics, thermocouples, interchangeability.

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This, the third and final report of the "Cryogenic Thermocouple Table" series, contains the remainder of the data acquired from the first set of test materials. The first report of the series[1] contained reference data for thermocouple types T, E, K, and Chromel† vs gold-0.07 at.% iron. These four thermocouple types are the most commonly used low temperature combinations. The second report[2] contains thermoelectric comparisons between reference materials and practical thermocouple alloys. Thermoelectric properties of any combination of the thermocouple alloys may be arrived at from the data in the second report. The combinations now being reported are the miscellaneous and comparison types. The miscellaneous combinations are usable, practical combinations of materials which have not received wide general usage. In some cases, however, the miscellaneous combinations may have important advantages over the more widely used combinations. Also included in this report are graphical comparisons of wires with the same nominal composition. These comparison data are intended to present a qualitative picture of how similar materials deviate thermoelectrically.

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† Authors' Note: The words Chromel and Alumel are registered trade names of Hoskins Mfg. Co. The ASA, ASTM, ISA, designations for the relevant thermocouple combinations and materials are as follows:

Type	Elements	Materials, Trade Names
E	EP (+)	Chromel, Tophel, T-1
	EN (-)	constantan, Advance, Cupron
K	KP (+)	Chromel, Tophel, T-1
	KN (-)	Alumel, Nial, T-2
T	TP (+)	copper
	TN (-)	constantan, Advance, Cupron

Names are usually given in this article because relatively few people are familiar with the designations KP, KN, etc. However, the use of the trade names does not constitute an endorsement of one manufacturer's products. All materials manufactured in compliance with the established standards are equally suitable.

The miscellaneous thermocouple combinations being reported are (a) Chromel, copper, "normal" silver, and platinum vs gold-0.02 at.% iron and (b) copper vs gold-0.07 at.% iron. Calibration data for these pairs are given in tables 1 thru 5 and figures 1 thru 20. A discussion of experimental errors is given in a previous report.[1] The temperature scales being used are IPTS-68[3] for temperatures above 20 K and the NBS acoustical scale for temperatures below 20 K. The data have been extrapolated to 0 K. These data may be more meaningful after a more thorough study of the properties of dilute gold-iron alloys. The Chromel vs gold-0.02 at.% iron thermocouple exhibits the same general characteristics as the Chromel vs gold-0.07 at.% iron thermocouple which was reported earlier. The sensitivity of the Chromel vs gold-0.02 at.% iron thermocouple is slightly higher than that of the Chromel vs gold-0.07 at.% iron thermocouple below ~ 12 K and slightly lower from ~ 12 K to room temperature. This agrees with the general rule for gold-iron alloys that decreasing the solute concentration increases the low temperature sensitivity and decreases the high temperature sensitivity.[4, 5] The principal advantage of gold-0.02 at.% iron over gold-0.07 at.% iron lies below the range of our present calibration system (4 to 280 K). Chromel vs gold-0.02 at.% iron has been tested below 4 K by Rosenbaum.[6] The remaining thermocouple combinations which utilize the gold-iron alloys have received much less general use. The pure materials, platinum and copper, are not suitable for very low temperature use because of their thermoelectric dependence upon trace impurities of iron and their high thermal conductivities at very low temperatures. Since the thermopower of the gold-iron alloys drops rapidly above 20 K, the platinum or copper vs gold-iron combinations are only sensitive in the range where platinum and copper should not be used. "Normal" silver does not suffer the thermal conductivity and trace impurity problems of copper and platinum. The thermopower of "normal" silver is small; however, when used with gold-iron alloys below ~ 15 K the high thermopower of the gold-iron makes the combinations usable.

The degree of noninterchangeability that exists between thermocouple materials from different manufacturers is illustrated in figures 21 thru 33. The data presented in these figures are for Chromel vs Chromel, Alumel vs Alumel, copper vs copper, constantan vs constantan, gold-0.07 at.% iron vs gold-0.02 at.% iron, annealed platinum vs unannealed platinum, and annealed "normal" silver vs unannealed "normal" silver. For Chromel and constantan, three wires were intercompared; figures 24 and 30 show the deviation of the individual thermovoltage from the group average for these materials.

Noninterchangeability of thermoelements represents a serious problem to thermocouple users. This is particularly true in the cryogenic temperature range where a small discrepancy in the output voltage can cause a relatively large error in the temperature determination. This problem was discussed briefly in connection with the reference materials presented in the second report of this series.[2] The control of thermoelectric variations found between wires of the same nominal composition can be increased by comparing the thermocouple materials to the proper reference materials, i.e., thermovoltage with respect to silver-28 at.% gold below 50 K and platinum above 50 K. Specifications for replacement wires may be given so that the new thermocouple system is within certain tolerances of the original system.

The comparison data presented in this report are for similar materials from different manufacturers. In an earlier article[7] comparisons were made between different spools of similar material from the same manufacturer. The results from these in-house comparisons show about $\frac{1}{2}$ of the variation observed when comparing wires from different manufacturers.

The method used to analyze and represent the experimental data for the miscellaneous materials is quite different from the usual least squares power series method. The experimental values for the voltages of each thermocouple combination are approximated by a series of orthonormal polynomials in the L_2 norm (least squares), that is,

$$E(T) = \sum_{n=1}^{L} A_n F_n(T)$$

where

$E(T)$	=	thermocouple potential in microvolts;
T	=	temperature in degrees Kelvin;
L	=	the highest order for a best fit, different for different combinations;
A_n	=	constants to be determined by the fitting approximation; and
$F_n(T)$	=	orthonormal polynomials, orthonormal <u>on</u> the data points <u>over</u> the range of variation of the independent variable, T.

The orthonormal polynomials are taken to be the truncated power series

$$F_n(T) = \sum_{j=1}^{n} C_{jn} T^j$$

where the C_{jn} are determined from the orthonormality conditions at the measured temperatures. It should be stressed that the F_n are determined by the values of the independent variable T only. The $F_n(T)$ are therefore the same for all thermocouple combinations. The coefficients A_n are determined by values of the dependent variable E and are different for each thermocouple combination. The highest order, L, necessary for a best fit is also different for each combination.

The general polynomials $F_n(T)$ are given in table 6. For computer economy the factored format used in table 6 is preferable to an unfactored form. The values of A_n and L for each thermocouple combination are given in table 7 with sufficient digits so that no significant precision is lost in the calculation of E(T).

An advantage of the orthonormal representation is that the function may be simplified by lowering the order of the fit without having to determine new A_n for the lower order. The lower order function uses the same A_n and represents the best fit for that order. The standard deviation of the fit increases as the order is reduced as is shown in table 8. Another method of simplifying the computation is to reduce the number of digits carried in the calculations. Table 9 shows the limits of error to be expected when using various numbers of digits in the calculation of E(T). When reducing either the number of coefficients used or the number of digits carried one must consider both the errors found in table 8 and table 9. For example, if one wishes to generate the data for platinum vs gold-0.02 at.% iron with a precision better than 1μ V, table 8 shows that n = 11. Table 9 shows that to achieve this precision 11 decimal digits (34 binary bits) should be carried. The thermocouple calibration data given in tables 1 thru 5 was computed using 26 digits (84 binary bits) and the highest order fit given for each thermocouple combination as given in table 7.

The following example is included to illustrate the use of the data in tables 6 and 7. Tables 8 and 9 cannot be applied to the results of this example since table 8 requires at least four polynomial coefficients and table 9 requires at least eight decimal digits.

EXAMPLE - For purposes of illustration consider the calculation of E with L = 2. $E(T) = \sum_{n=1}^{L} A_n F_n(T) = A_1 F_1(T) + A_2 F_2(T)$. From table 6, $F_1 = 2.627 \times 10^{-3}\,T$ and $F_2 = (3.216 \times 10^{-5}\,T - 1.117 \times 10^{-2})T$. Now, $E(T) = A_1 (2.627 \times 10^{-3}\,T) + A_2 (3.216 \times 10^{-5}\,T - 1.117 \times 10^{-2})T$. At this point the calculation may be used for any of the material combinations since the same $F_n(T)$ applies to all pairs. Assume that the particular combination of interest is Chromel vs gold-0.02 at.% iron at 100 K. From table 7, $A_1 = 6903.629$ and $A_2 = 561.689$. The solution using only two terms at 100 K is then E(T) = E(100 K) = 1813.6 - 446.8 = 1366.8 μV. The tabular value for Chromel vs gold-0.02 at.% iron is 1377.33 μV. The 0.8% difference is due to the low order (L = 2) used in this calculation.

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Temp. K	Voltage≡E μV	$\frac{dE}{dT}$≡S μV/K	$\frac{dS}{dT}$ μV/K^2	Temp. K	Voltage≡E μV	$\frac{dE}{dT}$≡S μV/K	$\frac{dS}{dT}$ μV/K^2
1	8.39	9.323	1.7626	51	693.41	12.600	0.0416
2	18.54	10.930	1.4584	52	706.03	12.642	0.0441
3	30.15	12.252	1.1919	53	718.70	12.688	0.0464
4	42.96	13.325	0.9593	54	731.41	12.735	0.0484
5	56.73	14.181	0.7573	55	744.17	12.784	0.0501
6	71.26	14.849	0.5826	56	756.98	12.835	0.0516
7	86.37	15.354	0.4324	57	769.84	12.888	0.0529
8	101.92	15.721	0.3041	58	782.75	12.941	0.0540
9	117.77	15.969	0.1952	59	795.72	12.996	0.0550
10	133.82	16.117	0.1037	60	808.74	13.051	0.0558
11	149.98	16.181	0.0274	61	821.82	13.107	0.0564
12	166.16	16.176	-0.0353	62	834.96	13.164	0.0570
13	182.31	16.114	-0.0862	63	848.15	13.221	0.0575
14	198.38	16.007	-0.1267	64	861.40	13.279	0.0579
15	214.31	15.864	-0.1581	65	874.71	13.337	0.0582
16	230.10	15.694	-0.1817	66	888.07	13.395	0.0584
17	245.70	15.503	-0.1984	67	901.50	13.454	0.0586
18	261.10	15.299	-0.2094	68	914.98	13.512	0.0588
19	276.29	15.086	-0.2155	69	928.52	13.571	0.0589
20	291.27	14.869	-0.2174	70	942.12	13.630	0.0590
21	306.03	14.652	-0.2158	71	955.78	13.689	0.0590
22	320.57	14.439	-0.2113	72	969.50	13.748	0.0591
23	334.91	14.230	-0.2045	73	983.28	13.807	0.0591
24	349.04	14.030	-0.1959	74	997.11	13.866	0.0591
25	362.97	13.839	-0.1857	75	1011.01	13.925	0.0591
26	376.72	13.659	-0.1745	76	1024.97	13.984	0.0591
27	390.29	13.490	-0.1626	77	1038.98	14.044	0.0590
28	403.70	13.334	-0.1501	78	1053.05	14.103	0.0590
29	416.97	13.190	-0.1373	79	1067.18	14.161	0.0589
30	430.09	13.059	-0.1245	80	1081.38	14.220	0.0588
31	443.09	12.941	-0.1117	81	1095.63	14.279	0.0587
32	455.98	12.836	-0.0991	82	1109.93	14.338	0.0586
33	468.76	12.743	-0.0869	83	1124.30	14.396	0.0585
34	481.47	12.662	-0.0751	84	1138.73	14.455	0.0584
35	494.09	12.593	-0.0637	85	1153.21	14.513	0.0582
36	506.66	12.534	-0.0529	86	1167.75	14.571	0.0581
37	519.17	12.487	-0.0426	87	1182.35	14.629	0.0579
38	531.63	12.449	-0.0330	88	1197.01	14.687	0.0577
39	544.07	12.421	-0.0239	89	1211.73	14.745	0.0575
40	556.48	12.401	-0.0154	90	1226.50	14.802	0.0573
41	568.87	12.390	-0.0076	91	1241.33	14.859	0.0570
42	581.26	12.386	-0.0004	92	1256.22	14.916	0.0568
43	593.64	12.389	0.0063	93	1271.16	14.973	0.0565
44	606.04	12.398	0.0124	94	1286.16	15.029	0.0562
45	618.44	12.413	0.0180	95	1301.2[illegible]	15.085	0.0559
46	630.87	12.434	0.0230	96	1316.33	15.141	0.0555
47	643.31	12.459	0.0276	97	1331.50	15.196	0.0552
48	655.79	12.489	0.0317	98	1346.72	15.251	0.0548
49	668.29	12.522	0.0354	99	1362.00	15.306	0.0545
50	680.83	12.559	0.0386	100	1377.33	15.360	0.0541

Table 1 Thermal voltage, thermopower, and thermopower derivative for Chromel vs gold-0.02 at.% iron.

Temp. K	Voltage≡E μV	$\frac{dE}{dT}$≡S μV/K	$\frac{dS}{dT}$ $\mu V/K^2$
101	1392.72	15.414	0.0537
102	1408.16	15.467	0.0533
103	1423.66	15.520	0.0529
104	1439.20	15.573	0.0525
105	1454.80	15.625	0.0521
106	1470.45	15.677	0.0516
107	1486.16	15.729	0.0512
108	1501.91	15.780	0.0508
109	1517.72	15.830	0.0503
110	1533.57	15.880	0.0499
111	1549.48	15.930	0.0495
112	1565.43	15.979	0.0491
113	1581.44	16.028	0.0486
114	1597.49	16.077	0.0482
115	1613.59	16.125	0.0478
116	1629.74	16.172	0.0474
117	1645.93	16.219	0.0470
118	1662.18	16.266	0.0466
119	1678.47	16.313	0.0463
120	1694.80	16.359	0.0459
121	1711.18	16.405	0.0456
122	1727.61	16.450	0.0452
123	1744.08	16.495	0.0449
124	1760.60	16.540	0.0446
125	1777.16	16.584	0.0443
126	1793.77	16.628	0.0440
127	1810.42	16.672	0.0437
128	1827.11	16.716	0.0435
129	1843.85	16.759	0.0432
130	1860.63	16.802	0.0430
131	1877.46	16.845	0.0427
132	1894.32	16.888	0.0425
133	1911.23	16.930	0.0423
134	1928.18	16.972	0.0421
135	1945.18	17.014	0.0419
136	1962.21	17.056	0.0417
137	1979.29	17.098	0.0415
138	1996.41	17.139	0.0413
139	2013.57	17.180	0.0411
140	2030.77	17.221	0.0409
141	2048.01	17.262	0.0407
142	2065.29	17.303	0.0405
143	2082.61	17.343	0.0403
144	2099.98	17.383	0.0401
145	2117.38	17.423	0.0399
146	2134.82	17.463	0.0397
147	2152.31	17.503	0.0395
148	2169.83	17.542	0.0393
149	2187.39	17.581	0.0391
150	2204.99	17.620	0.0389

Temp. K	Voltage≡E μV	$\frac{dE}{dT}$≡S μV/K	$\frac{dS}{dT}$ $\mu V/K^2$
151	2222.63	17.659	0.0387
152	2240.31	17.698	0.0385
153	2258.03	17.736	0.0382
154	2275.78	17.774	0.0380
155	2293.57	17.812	0.0377
156	2311.41	17.850	0.0375
157	2329.27	17.887	0.0372
158	2347.18	17.924	0.0369
159	2365.12	17.961	0.0366
160	2383.10	17.997	0.0364
161	2401.12	18.034	0.0361
162	2419.17	18.069	0.0358
163	2437.26	18.105	0.0355
164	2455.38	18.140	0.0352
165	2473.54	18.175	0.0349
166	2491.73	18.210	0.0346
167	2509.96	18.245	0.0343
168	2528.22	18.279	0.0339
169	2546.51	18.312	0.0336
170	2564.84	18.346	0.0333
171	2583.21	18.379	0.0330
172	2601.60	18.412	0.0327
173	2620.03	18.445	0.0324
174	2638.49	18.477	0.0322
175	2656.98	18.509	0.0319
176	2675.51	18.541	0.0316
177	2694.06	18.572	0.0313
178	2712.65	18.603	0.0311
179	2731.27	18.634	0.0308
180	2749.92	18.665	0.0306
181	2768.60	18.695	0.0303
182	2787.31	18.726	0.0301
183	2806.05	18.755	0.0299
184	2824.82	18.785	0.0297
185	2843.62	18.815	0.0295
186	2862.45	18.844	0.0293
187	2881.31	18.873	0.0291
188	2900.20	18.902	0.0289
189	2919.11	18.931	0.0288
190	2938.06	18.960	0.0286
191	2957.03	18.988	0.0285
192	2976.04	19.017	0.0283
193	2995.07	19.045	0.0282
194	3014.13	19.073	0.0280
195	3033.21	19.101	0.0279
196	3052.33	19.129	0.0278
197	3071.47	19.157	0.0277
198	3090.64	19.184	0.0276
199	3109.84	19.212	0.0274
200	3129.07	19.239	0.0273

Table 1 (cont,) Thermal voltage, thermopower, and thermopower derivative for Chromel vs gold-0.02 at. % iron

Temp. K	Voltage≡E μV	$\frac{dE}{dT} \equiv S$ μV/K	$\frac{dS}{dT}$ μV/K^2
201	3148.32	19.266	0.0272
202	3167.60	19.294	0.0271
203	3186.91	19.321	0.0269
204	3206.24	19.347	0.0268
205	3225.60	19.374	0.0266
206	3244.99	19.401	0.0265
207	3264.40	19.427	0.0263
208	3283.84	19.453	0.0262
209	3303.31	19.479	0.0260
210	3322.80	19.505	0.0258
211	3342.32	19.531	0.0256
212	3361.86	19.556	0.0254
213	3381.43	19.582	0.0251
214	3401.03	19.607	0.0249
215	3420.65	19.632	0.0247
216	3440.29	19.656	0.0244
217	3459.96	19.680	0.0241
218	3479.65	19.704	0.0239
219	3499.37	19.728	0.0236
220	3519.11	19.751	0.0233
221	3538.87	19.775	0.0230
222	3558.66	19.797	0.0227
223	3578.46	19.820	0.0224
224	3598.30	19.842	0.0221
225	3618.15	19.864	0.0218
226	3638.02	19.886	0.0215
227	3657.92	19.907	0.0212
228	3677.84	19.928	0.0210
229	3697.78	19.949	0.0207
230	3717.74	19.970	0.0205
231	3737.72	19.990	0.0202
232	3757.72	20.010	0.0200
233	3777.74	20.030	0.0198
234	3797.78	20.050	0.0196
235	3817.84	20.069	0.0195
236	3837.91	20.089	0.0193
237	3858.01	20.108	0.0192
238	3878.13	20.127	0.0191
239	3898.27	20.146	0.0191
240	3918.42	20.165	0.0190
241	3938.60	20.184	0.0190
242	3958.79	20.203	0.0190
243	3979.00	20.222	0.0190
244	3999.24	20.241	0.0190
245	4019.49	20.260	0.0190
246	4039.76	20.279	0.0191
247	4060.05	20.299	0.0191
248	4080.35	20.318	0.0191
249	4100.68	20.337	0.0191
250	4121.03	20.356	0.0191
251	4141.40	20.375	0.0190
252	4161.78	20.394	0.0190
253	4182.18	20.413	0.0188
254	4202.61	20.432	0.0187
255	4223.05	20.450	0.0184
256	4243.50	20.468	0.0181
257	4263.98	20.486	0.0178
258	4284.47	20.504	0.0173
259	4304.99	20.521	0.0168
260	4325.53	20.537	0.0162
261	4346.07	20.554	0.0156
262	4366.64	20.569	0.0149
263	4387.20	20.583	0.0142
264	4407.79	20.597	0.0134
265	4428.40	20.611	0.0126
266	4449.00	20.622	0.0119
267	4469.64	20.634	0.0112
268	4490.28	20.645	0.0107
269	4510.93	20.655	0.0103
270	4531.59	20.666	0.0103
271	4552.26	20.676	0.0106
272	4572.93	20.687	0.0113
273	4593.63	20.699	0.0127
274	4614.34	20.713	0.0149
275	4635.06	20.729	0.0179
276	4655.80	20.749	0.0222
277	4676.56	20.774	0.0278
278	4697.34	20.805	0.0351
279	4718.16	20.844	0.0443
280	4739.04	20.895	0.0559

Table 1 (cont.) Thermal voltage, thermopower, and thermopower derivative for Chromel vs gold-0.02 at. % iron

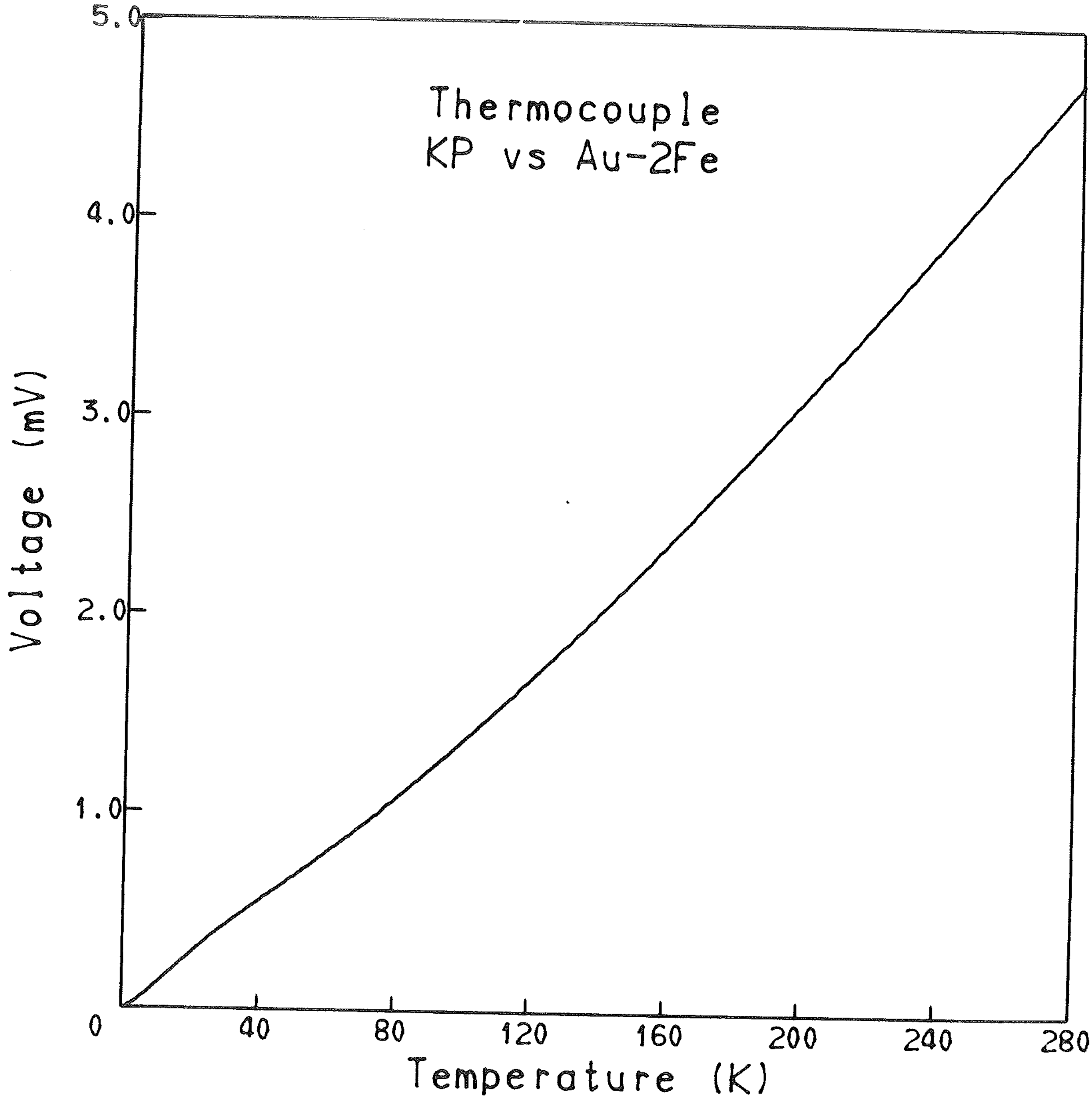

Figure 1 Thermoelectric voltage for Chromel vs gold-0.02 at.% iron

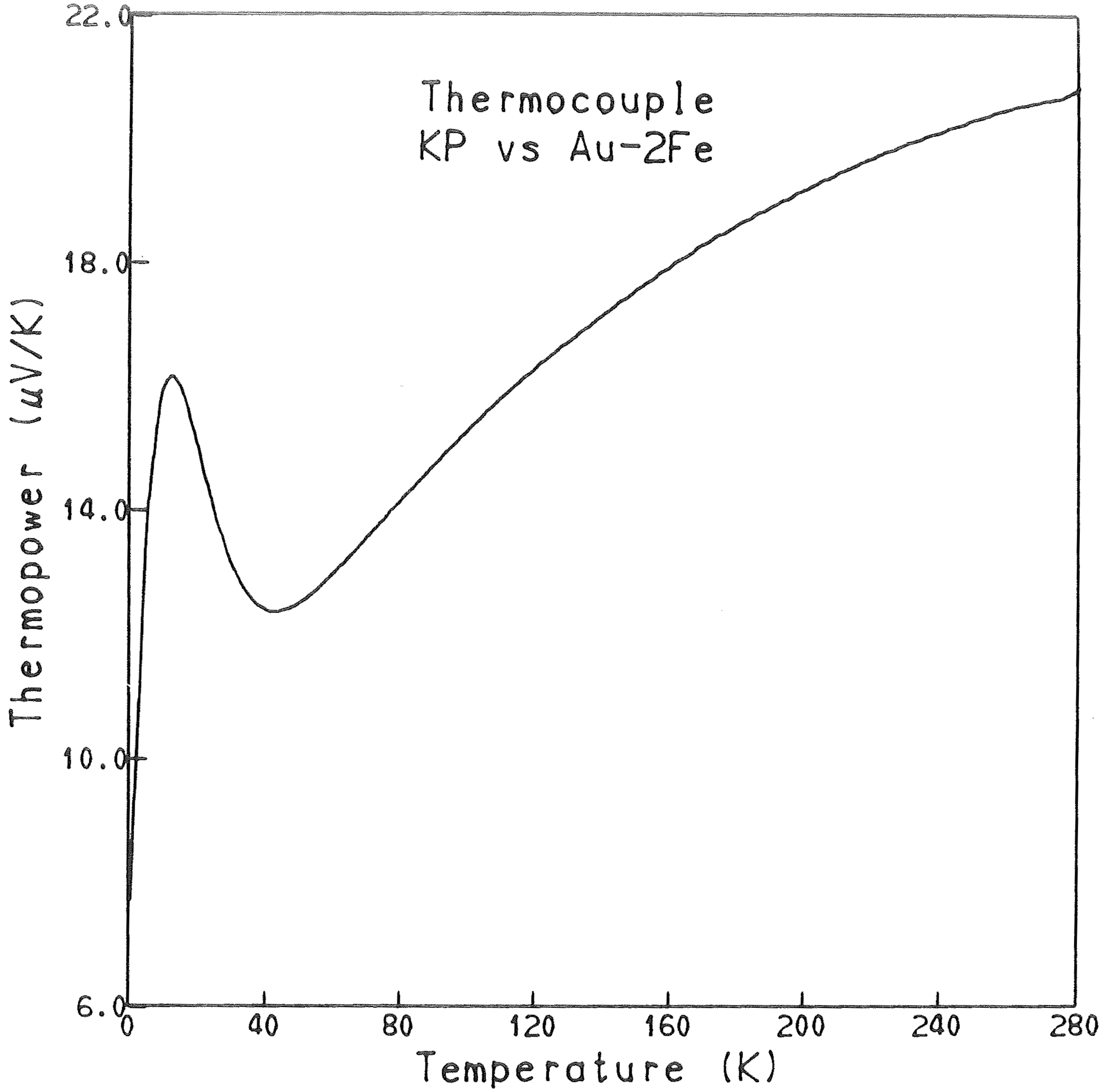

Figure 2 Thermopower for Chromel vs gold-0.02 at.% iron

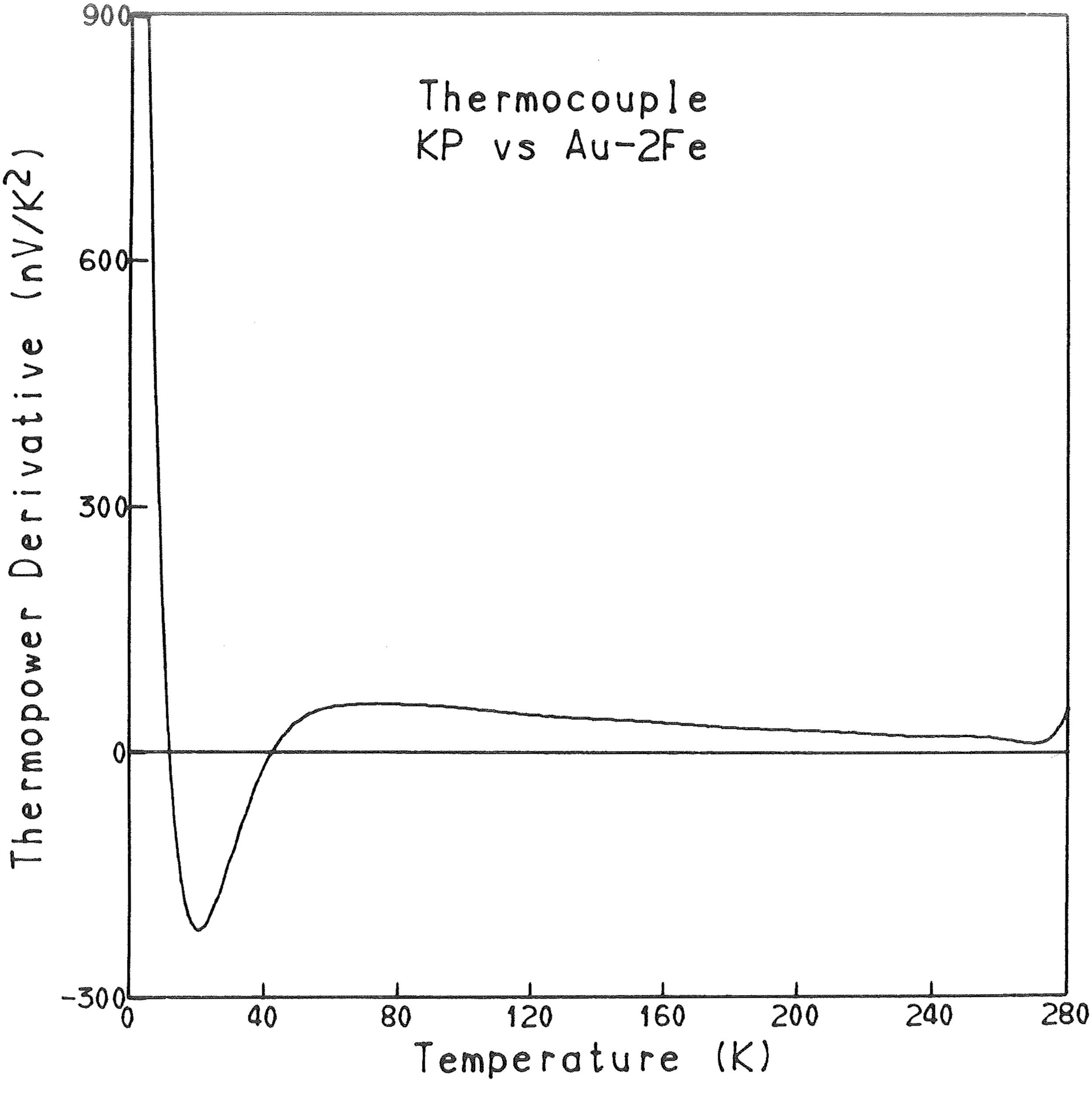

Figure 3 Thermopower derivative for Chromel vs gold -0.02 at.% iron

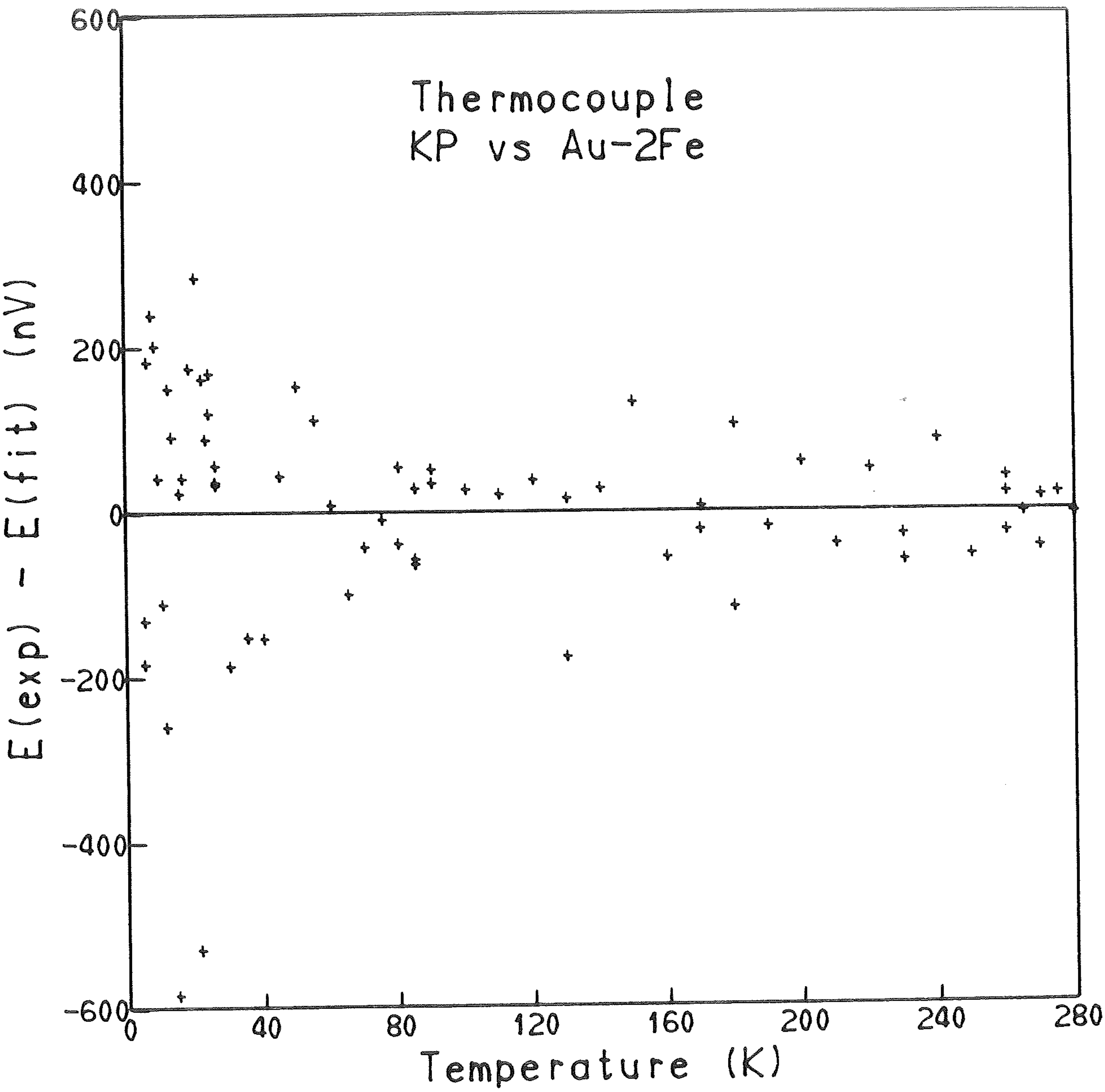

Figure 4 Deviations between calculated and experimental values of thermoelectric voltage for Chromel vs gold-0.02 at.% iron

Temp. K	Voltage≡E μV	$\frac{dE}{dT}$≡S μV/K	$\frac{dS}{dT}$ μV/K²	Temp. K	Voltage≡E μV	$\frac{dE}{dT}$≡S μV/K	$\frac{dS}{dT}$ μV/K²
1	7.75	8.476	1.3647	51	606.87	9.737	-0.0798
2	16.87	9.725	1.1394	52	616.56	9.657	-0.0790
3	27.13	10.764	0.9418	53	626.18	9.579	-0.0783
4	38.34	11.617	0.7690	54	635.72	9.501	-0.0776
5	50.31	12.309	0.6185	55	645.18	9.423	-0.0770
6	62.91	12.861	0.4879	56	654.57	9.346	-0.0765
7	75.99	13.291	0.3751	57	663.87	9.270	-0.0759
8	89.45	13.616	0.2782	58	673.11	9.195	-0.0754
9	103.20	13.852	0.1953	59	682.26	9.120	-0.0748
10	117.13	14.011	0.1249	60	691.35	9.045	-0.0743
11	131.20	14.105	0.0655	61	700.35	8.971	-0.0738
12	145.32	14.145	0.0158	62	709.29	8.897	-0.0732
13	159.47	14.140	-0.0254	63	718.15	8.825	-0.0726
14	173.59	14.097	-0.0592	64	726.94	8.752	-0.0721
15	187.65	14.023	-0.0866	65	735.65	8.680	-0.0714
16	201.63	13.925	-0.1084	66	744.30	8.609	-0.0708
17	215.50	13.808	-0.1254	67	752.87	8.539	-0.0702
18	229.24	13.676	-0.1383	68	761.38	8.469	-0.0695
19	242.85	13.533	-0.1476	69	769.81	8.400	-0.0688
20	256.30	13.382	-0.1540	70	778.18	8.331	-0.0681
21	269.61	13.226	-0.1580	71	786.47	8.264	-0.0673
22	282.75	13.066	-0.1599	72	794.70	8.197	-0.0666
23	295.74	12.906	-0.1601	73	802.87	8.131	-0.0658
24	308.57	12.747	-0.1589	74	810.97	8.065	-0.0650
25	321.24	12.589	-0.1567	75	819.00	8.001	-0.0642
26	333.75	12.434	-0.1537	76	826.97	7.937	-0.0634
27	346.10	12.282	-0.1500	77	834.87	7.874	-0.0626
28	358.31	12.134	-0.1459	78	842.72	7.812	-0.0618
29	370.37	11.990	-0.1416	79	850.50	7.750	-0.0610
30	382.29	11.851	-0.1370	80	858.22	7.690	-0.0602
31	394.07	11.716	-0.1324	81	865.88	7.630	-0.0594
32	405.73	11.586	-0.1278	82	873.48	7.571	-0.0586
33	417.25	11.460	-0.1233	83	881.02	7.513	-0.0579
34	428.65	11.339	-0.1190	84	888.50	7.455	-0.0571
35	439.93	11.222	-0.1149	85	895.93	7.398	-0.0564
36	451.09	11.109	-0.1109	86	903.30	7.342	-0.0556
37	462.15	11.000	-0.1073	87	910.61	7.287	-0.0549
38	473.09	10.895	-0.1038	88	917.87	7.232	-0.0543
39	483.94	10.792	-0.1007	89	925.08	7.179	-0.0536
40	494.68	10.693	-0.0978	90	932.23	7.125	-0.0530
41	505.32	10.597	-0.0951	91	939.33	7.073	-0.0524
42	515.87	10.503	-0.0927	92	946.38	7.021	-0.0518
43	526.33	10.411	-0.0906	93	953.37	6.969	-0.0512
44	536.70	10.322	-0.0886	94	960.31	6.918	-0.0506
45	546.97	10.234	-0.0869	95	967.21	6.868	-0.0501
46	557.17	10.148	-0.0853	96	974.05	6.818	-0.0496
47	567.27	10.063	-0.0839	97	980.84	6.769	-0.0491
48	577.29	9.980	-0.0827	98	987.59	6.720	-0.0487
49	587.23	9.898	-0.0816	99	994.28	6.671	-0.0482
50	597.09	9.817	-0.0806	100	1000.93	6.623	-0.0478

Table 2 Thermal voltage, thermopower, and thermopower derivative for copper vs gold-0.07 at.% iron.

Temp. K	Voltage ≡ E μV	$\frac{dE}{dT} \equiv S$ μV/K	$\frac{dS}{dT}$ μV/K^2
101	1007.53	6.575	-0.0474
102	1014.08	6.528	-0.0470
103	1020.59	6.481	-0.0466
104	1027.04	6.435	-0.0463
105	1033.46	6.389	-0.0459
106	1039.82	6.343	-0.0456
107	1046.14	6.298	-0.0452
108	1052.42	6.253	-0.0449
109	1058.65	6.208	-0.0446
110	1064.83	6.164	-0.0442
111	1070.97	6.119	-0.0439
112	1077.07	6.076	-0.0436
113	1083.13	6.032	-0.0433
114	1089.14	5.989	-0.0429
115	1095.10	5.946	-0.0426
116	1101.03	5.904	-0.0423
117	1106.91	5.862	-0.0419
118	1112.75	5.820	-0.0416
119	1118.55	5.779	-0.0412
120	1124.31	5.738	-0.0409
121	1130.03	5.697	-0.0405
122	1135.70	5.657	-0.0401
123	1141.34	5.617	-0.0398
124	1146.94	5.577	-0.0394
125	1152.50	5.538	-0.0390
126	1158.01	5.499	-0.0386
127	1163.49	5.461	-0.0382
128	1168.94	5.423	-0.0378
129	1174.34	5.385	-0.0373
130	1179.71	5.348	-0.0369
131	1185.04	5.311	-0.0365
132	1190.33	5.275	-0.0361
133	1195.59	5.239	-0.0357
134	1200.81	5.204	-0.0352
135	1205.99	5.169	-0.0348
136	1211.15	5.134	-0.0344
137	1216.26	5.100	-0.0340
138	1221.35	5.066	-0.0335
139	1226.40	5.033	-0.0331
140	1231.41	5.000	-0.0327
141	1236.40	4.967	-0.0323
142	1241.35	4.935	-0.0319
143	1246.27	4.904	-0.0316
144	1251.15	4.872	-0.0312
145	1256.01	4.841	-0.0308
146	1260.84	4.810	-0.0305
147	1265.63	4.780	-0.0302
148	1270.40	4.750	-0.0298
149	1275.13	4.720	-0.0295
150	1279.84	4.691	-0.0292
151	1284.51	4.662	-0.0289
152	1289.16	4.633	-0.0287
153	1293.78	4.605	-0.0284
154	1298.37	4.576	-0.0282
155	1302.93	4.548	-0.0279
156	1307.47	4.521	-0.0277
157	1311.98	4.493	-0.0275
158	1316.45	4.465	-0.0273
159	1320.91	4.438	-0.0272
160	1325.33	4.411	-0.0270
161	1329.73	4.384	-0.0268
162	1334.10	4.357	-0.0267
163	1338.44	4.331	-0.0266
164	1342.76	4.304	-0.0264
165	1347.05	4.278	-0.0263
166	1351.32	4.252	-0.0262
167	1355.56	4.226	-0.0261
168	1359.77	4.200	-0.0260
169	1363.96	4.174	-0.0259
170	1368.12	4.148	-0.0258
171	1372.25	4.122	-0.0257
172	1376.36	4.097	-0.0255
173	1380.44	4.071	-0.0254
174	1384.50	4.046	-0.0253
175	1388.54	4.020	-0.0252
176	1392.54	3.995	-0.0251
177	1396.53	3.970	-0.0250
178	1400.48	3.945	-0.0249
179	1404.42	3.921	-0.0247
180	1408.33	3.896	-0.0246
181	1412.21	3.871	-0.0244
182	1416.07	3.847	-0.0243
183	1419.90	3.823	-0.0241
184	1423.71	3.799	-0.0239
185	1427.50	3.775	-0.0237
186	1431.26	3.751	-0.0235
187	1435.00	3.728	-0.0233
188	1438.72	3.705	-0.0231
189	1442.41	3.682	-0.0229
190	1446.08	3.659	-0.0227
191	1449.73	3.636	-0.0224
192	1453.36	3.614	-0.0222
193	1456.96	3.592	-0.0219
194	1460.54	3.570	-0.0217
195	1464.10	3.549	-0.0214
196	1467.64	3.527	-0.0212
197	1471.16	3.506	-0.0209
198	1474.65	3.486	-0.0207
199	1478.13	3.465	-0.0204
200	1481.58	3.445	-0.0201

Table 2 (cont.) Thermal voltage, thermopower, and thermopower derivative for copper vs gold-0.07 at. % iron

Temp. K	Voltage≡E μV	$\frac{dE}{dT}$≡S μV/K	$\frac{dS}{dT}$ μV/K^2
201	1485.02	3.425	-0.0199
202	1488.43	3.405	-0.0196
203	1491.83	3.385	-0.0194
204	1495.20	3.366	-0.0192
205	1498.56	3.347	-0.0190
206	1501.90	3.328	-0.0187
207	1505.22	3.310	-0.0185
208	1508.52	3.291	-0.0183
209	1511.80	3.273	-0.0182
210	1515.06	3.255	-0.0180
211	1518.31	3.237	-0.0179
212	1521.54	3.219	-0.0177
213	1524.75	3.201	-0.0176
214	1527.94	3.184	-0.0175
215	1531.11	3.167	-0.0174
216	1534.27	3.149	-0.0173
217	1537.41	3.132	-0.0172
218	1540.54	3.115	-0.0172
219	1543.64	3.098	-0.0171
220	1546.73	3.080	-0.0171
221	1549.80	3.063	-0.0171
222	1552.86	3.046	-0.0171
223	1555.89	3.029	-0.0170
224	1558.92	3.012	-0.0170
225	1561.92	2.995	-0.0170
226	1564.91	2.978	-0.0170
227	1567.88	2.961	-0.0170
228	1570.83	2.944	-0.0170
229	1573.76	2.927	-0.0170
230	1576.68	2.910	-0.0169
231	1579.58	2.893	-0.0169
232	1582.47	2.876	-0.0168
233	1585.34	2.860	-0.0168
234	1588.19	2.843	-0.0167
235	1591.02	2.826	-0.0166
236	1593.84	2.810	-0.0165
237	1596.64	2.793	-0.0163
238	1599.43	2.777	-0.0162
239	1602.20	2.761	-0.0160
240	1604.95	2.745	-0.0158
241	1607.69	2.730	-0.0156
242	1610.41	2.714	-0.0153
243	1613.12	2.699	-0.0151
244	1615.81	2.684	-0.0148
245	1618.48	2.669	-0.0146
246	1621.14	2.655	-0.0143
247	1623.79	2.641	-0.0140
248	1626.43	2.627	-0.0138
249	1629.05	2.613	-0.0136
250	1631.65	2.600	-0.0133
251	1634.25	2.586	-0.0131
252	1636.83	2.573	-0.0130
253	1639.39	2.560	-0.0128
254	1641.95	2.548	-0.0128
255	1644.49	2.535	-0.0127
256	1647.01	2.522	-0.0128
257	1649.53	2.509	-0.0128
258	1652.03	2.496	-0.0130
259	1654.52	2.483	-0.0132
260	1657.01	2.470	-0.0135
261	1659.46	2.456	-0.0138
262	1661.92	2.442	-0.0142
263	1664.35	2.428	-0.0147
264	1666.77	2.413	-0.0151
265	1669.17	2.398	-0.0155
266	1671.55	2.381	-0.0159
267	1673.94	2.366	-0.0163
268	1676.29	2.349	-0.0164
269	1678.64	2.333	-0.0164
270	1680.96	2.316	-0.0162
271	1683.27	2.301	-0.0155
272	1685.55	2.285	-0.0145
273	1687.84	2.272	-0.0128
274	1690.10	2.260	-0.0103
275	1692.36	2.252	-0.0070
276	1694.61	2.247	-0.0025
277	1696.86	2.247	0.0033
278	1699.10	2.254	0.0107
279	1701.36	2.269	0.0200
280	1703.64	2.295	0.0315

Table 2 (cont.) Thermal voltage, thermopower, and thermopower derivative for copper vs gold-0.07 at. % iron

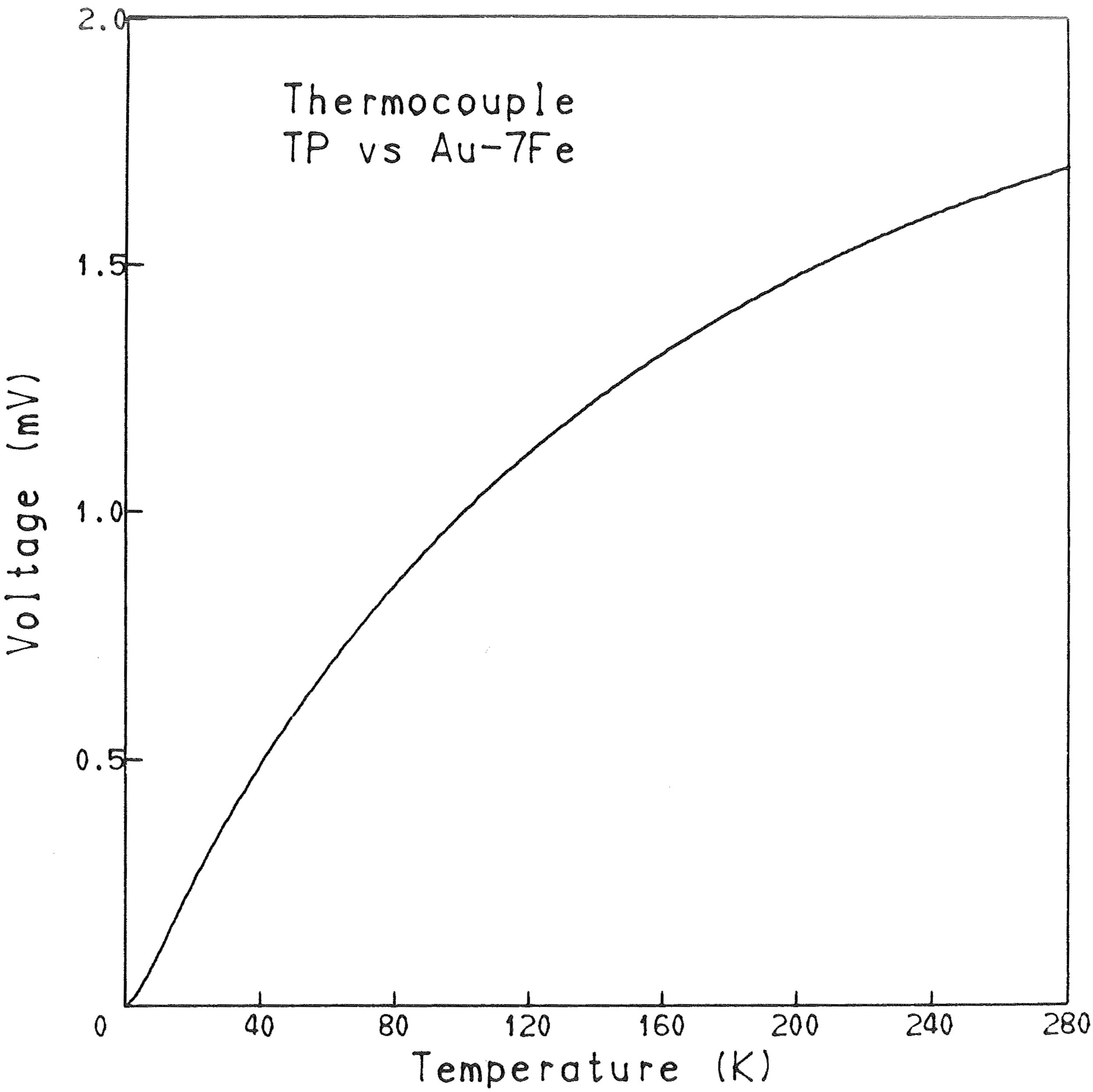

Figure 5 Thermoelectric voltage for copper vs gold-0.07 at.% iron

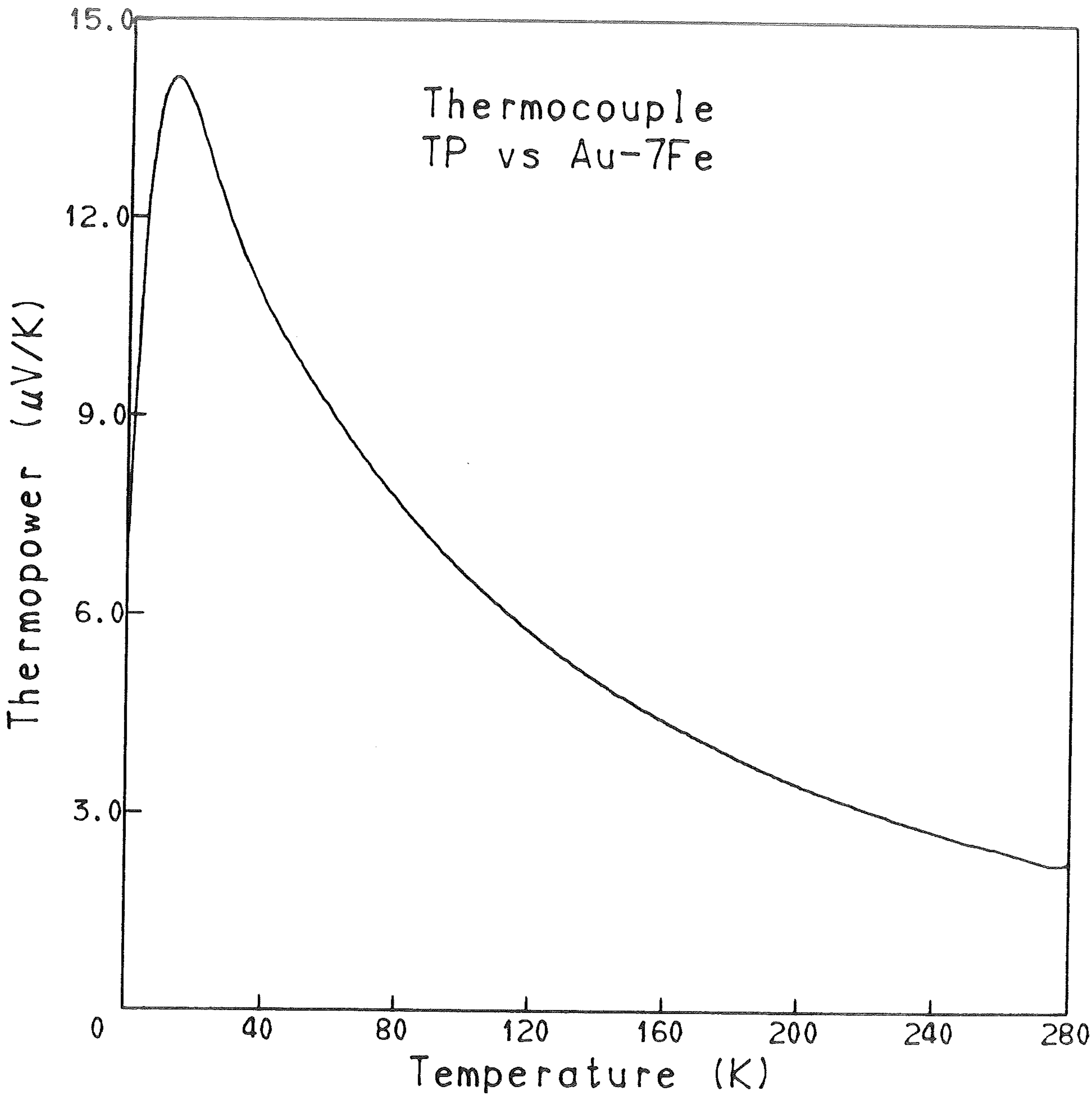

Figure 6 Thermopower for copper vs gold-0.07 at.% iron

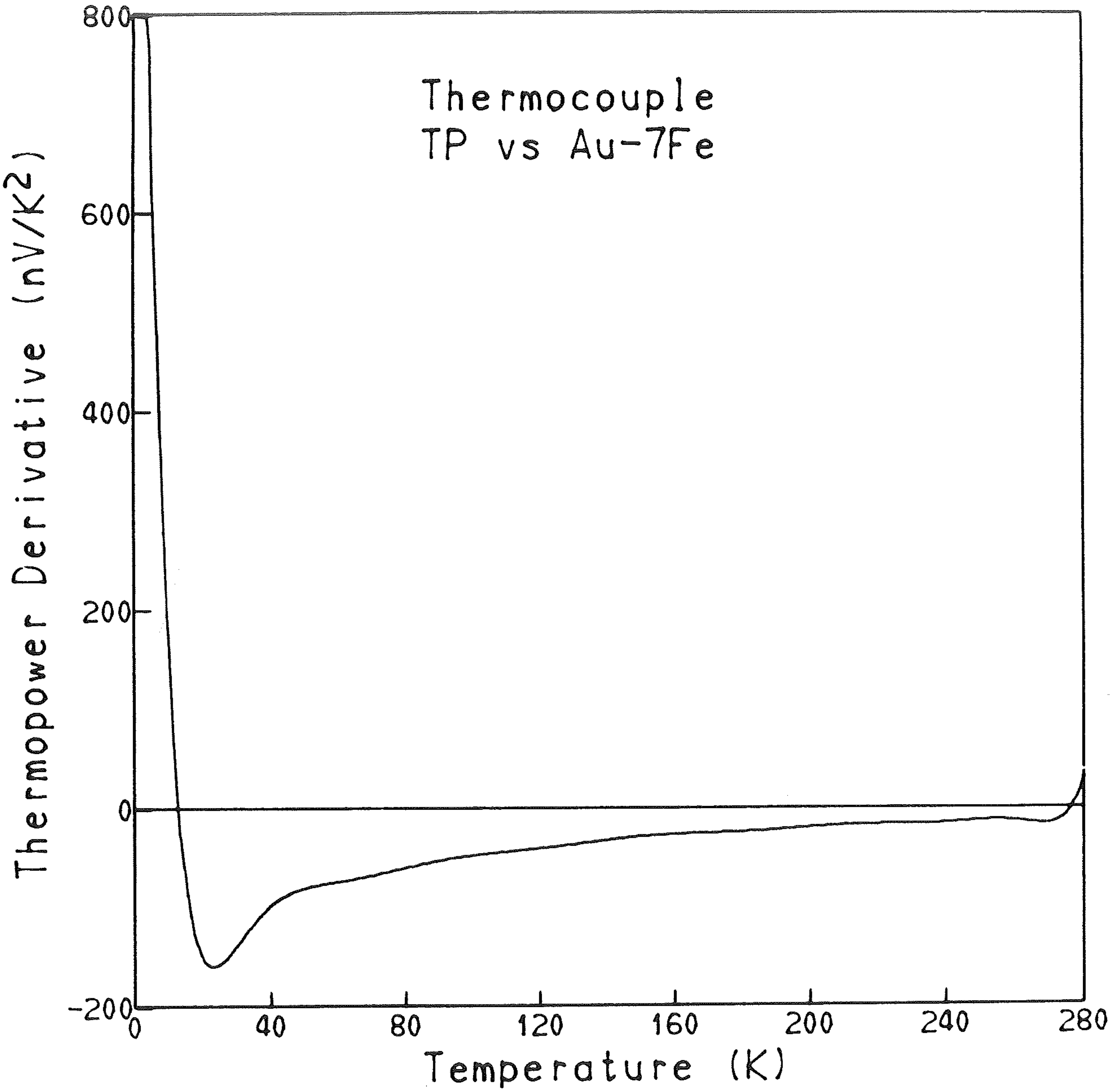

Figure 7 Thermopower derivative for copper vs gold-0.07 at.% iron

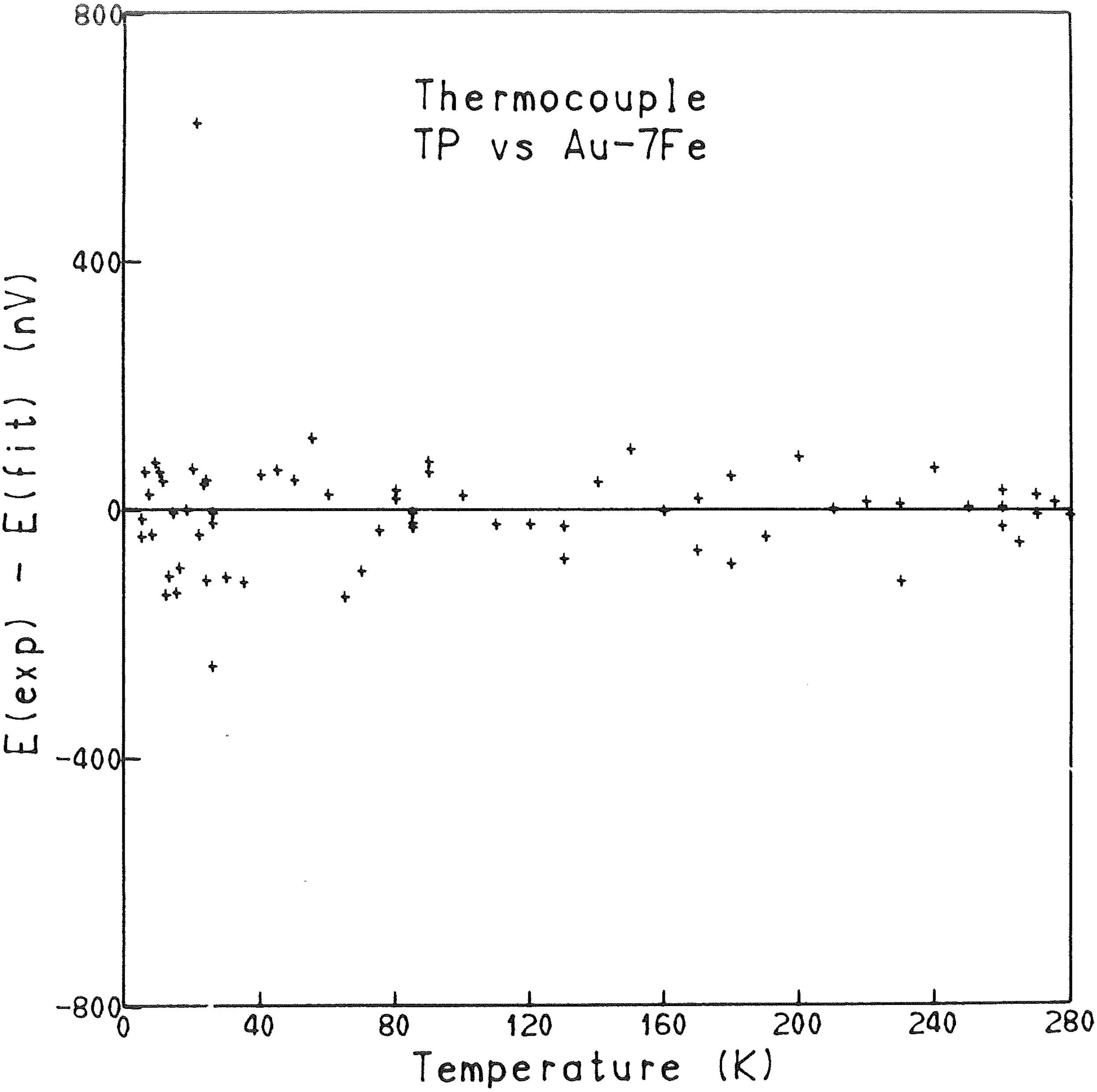

Figure 8 Deviations between calculated and experimental values of thermoelectric voltage for copper vs gold-0.07 at.% iron

Temp. K	Voltage≡E μV	$\frac{dE}{dT}$≡S μV/K	$\frac{dS}{dT}$ μV/K^2	Temp. K	Voltage≡E μV	$\frac{dE}{dT}$≡S μV/K	$\frac{dS}{dT}$ μV/K^2
1	8.28	9.153	1.6273	51	515.28	5.934	-0.0858
2	18.19	10.621	1.3146	52	521.17	5.850	-0.0833
3	29.43	11.796	1.0419	53	526.98	5.768	-0.0810
4	41.70	12.716	0.8052	54	532.71	5.688	-0.0790
5	54.78	13.417	0.6008	55	538.36	5.610	-0.0771
6	68.47	13.927	0.4251	56	543.93	5.534	-0.0754
7	82.59	14.276	0.2750	57	549.43	5.459	-0.0738
8	96.98	14.485	0.1478	58	554.85	5.386	-0.0723
9	111.52	14.578	0.0407	59	560.20	5.314	-0.0709
10	126.10	14.572	-0.0486	60	565.48	5.244	-0.0695
11	140.63	14.486	-0.1222	61	570.69	5.175	-0.0682
12	155.05	14.333	-0.1820	62	575.83	5.108	-0.0670
13	169.28	14.126	-0.2299	63	580.90	5.041	-0.0658
14	183.29	13.876	-0.2673	64	585.91	4.976	-0.0647
15	197.02	13.594	-0.2956	65	590.86	4.912	-0.0636
16	210.47	13.288	-0.3163	66	595.74	4.849	-0.0624
17	223.59	12.964	-0.3302	67	600.55	4.787	-0.0613
18	236.39	12.629	-0.3386	68	605.31	4.726	-0.0602
19	248.85	12.288	-0.3422	69	610.01	4.667	-0.0592
20	260.97	11.946	-0.3419	70	614.64	4.608	-0.0581
21	272.74	11.606	-0.3384	71	619.22	4.550	-0.0570
22	284.18	11.270	-0.3323	72	623.74	4.494	-0.0559
23	295.29	10.942	-0.3240	73	628.21	4.439	-0.0548
24	306.07	10.623	-0.3142	74	632.62	4.384	-0.0537
25	316.53	10.314	-0.3031	75	636.98	4.331	-0.0527
26	326.70	10.017	-0.2912	76	641.28	4.279	-0.0516
27	336.57	9.732	-0.2787	77	645.54	4.228	-0.0506
28	346.17	9.459	-0.2659	78	649.74	4.178	-0.0495
29	355.49	9.200	-0.2531	79	653.89	4.129	-0.0485
30	364.57	8.953	-0.2403	80	658.00	4.081	-0.0475
31	373.40	8.719	-0.2277	81	662.06	4.034	-0.0465
32	382.01	8.498	-0.2155	82	666.07	3.988	-0.0456
33	390.40	8.288	-0.2037	83	670.03	3.943	-0.0446
34	398.59	8.090	-0.1924	84	673.95	3.899	-0.0437
35	406.59	7.903	-0.1817	85	677.83	3.855	-0.0428
36	414.40	7.727	-0.1715	86	681.66	3.813	-0.0420
37	422.04	7.560	-0.1620	87	685.46	3.771	-0.0412
38	429.52	7.402	-0.1531	88	689.21	3.731	-0.0404
39	436.85	7.253	-0.1448	89	692.92	3.691	-0.0396
40	444.03	7.112	-0.1372	90	696.59	3.651	-0.0389
41	451.08	6.979	-0.1301	91	700.22	3.613	-0.0382
42	457.99	6.852	-0.1236	92	703.81	3.575	-0.0376
43	464.78	6.732	-0.1176	93	707.37	3.538	-0.0370
44	471.46	6.617	-0.1122	94	710.89	3.501	-0.0364
45	478.02	6.507	-0.1072	95	714.37	3.465	-0.0358
46	484.47	6.402	-0.1027	96	717.82	3.429	-0.0353
47	490.83	6.302	-0.0986	97	721.23	3.394	-0.0348
48	497.08	6.205	-0.0949	98	724.61	3.360	-0.0344
49	503.24	6.112	-0.0916	99	727.95	3.325	-0.0339
50	509.30	6.022	-0.0885	100	731.26	3.292	-0.0335

Table 3 Thermal voltage, thermopower, and thermopower derivative for copper vs gold-0.02 at. % iron

Temp. K	Voltage≡E μV	$\frac{dE}{dT}$≡S $\mu V/K$	$\frac{dS}{dT}$ $\mu V/K^2$
101	734.53	3.258	-0.0332
102	737.77	3.225	-0.0328
103	740.98	3.193	-0.0325
104	744.16	3.160	-0.0321
105	747.30	3.128	-0.0318
106	750.42	3.097	-0.0315
107	753.50	3.065	-0.0312
108	756.55	3.034	-0.0310
109	759.57	3.003	-0.0307
110	762.55	2.973	-0.0304
111	765.51	2.943	-0.0302
112	768.44	2.912	-0.0299
113	771.34	2.883	-0.0297
114	774.21	2.853	-0.0294
115	777.04	2.824	-0.0291
116	779.85	2.795	-0.0289
117	782.63	2.766	-0.0286
118	785.39	2.738	-0.0283
119	788.11	2.710	-0.0280
120	790.80	2.682	-0.0277
121	793.47	2.654	-0.0274
122	796.11	2.627	-0.0270
123	798.73	2.600	-0.0267
124	801.31	2.574	-0.0264
125	803.87	2.547	-0.0260
126	806.41	2.522	-0.0256
127	808.92	2.496	-0.0253
128	811.40	2.471	-0.0249
129	813.86	2.446	-0.0245
130	816.29	2.422	-0.0241
131	818.70	2.398	-0.0237
132	821.09	2.375	-0.0233
133	823.45	2.352	-0.0229
134	825.79	2.329	-0.0225
135	828.11	2.307	-0.0221
136	830.41	2.285	-0.0217
137	832.68	2.263	-0.0213
138	834.93	2.242	-0.0209
139	837.17	2.222	-0.0205
140	839.38	2.201	-0.0201
141	841.57	2.181	-0.0197
142	843.74	2.162	-0.0193
143	845.89	2.143	-0.0190
144	848.03	2.124	-0.0186
145	850.14	2.106	-0.0183
146	852.24	2.088	-0.0179
147	854.32	2.070	-0.0176
148	856.38	2.052	-0.0173
149	858.42	2.035	-0.0171
150	860.45	2.018	-0.0168
151	862.46	2.001	-0.0165
152	864.45	1.985	-0.0163
153	866.43	1.969	-0.0161
154	868.39	1.953	-0.0159
155	870.33	1.937	-0.0157
156	872.26	1.921	-0.0156
157	874.18	1.906	-0.0154
158	876.07	1.891	-0.0153
159	877.96	1.875	-0.0152
160	879.83	1.860	-0.0151
161	881.68	1.845	-0.0150
162	883.52	1.830	-0.0149
163	885.34	1.815	-0.0148
164	887.15	1.801	-0.0148
165	888.94	1.786	-0.0147
166	890.72	1.771	-0.0147
167	892.48	1.757	-0.0146
168	894.23	1.742	-0.0146
169	895.97	1.727	-0.0145
170	897.69	1.713	-0.0145
171	899.39	1.698	-0.0145
172	901.08	1.684	-0.0144
173	902.76	1.670	-0.0144
174	904.42	1.655	-0.0143
175	906.07	1.641	-0.0143
176	907.70	1.627	-0.0142
177	909.32	1.612	-0.0142
178	910.93	1.598	-0.0141
179	912.52	1.584	-0.0140
180	914.10	1.570	-0.0139
181	915.66	1.556	-0.0138
182	917.21	1.543	-0.0137
183	918.75	1.529	-0.0135
184	920.27	1.516	-0.0134
185	921.78	1.502	-0.0132
186	923.27	1.489	-0.0131
187	924.76	1.476	-0.0129
188	926.23	1.463	-0.0127
189	927.68	1.451	-0.0125
190	929.13	1.438	-0.0123
191	930.56	1.426	-0.0121
192	931.98	1.414	-0.0118
193	933.39	1.403	-0.0116
194	934.79	1.391	-0.0114
195	936.17	1.380	-0.0111
196	937.55	1.369	-0.0109
197	938.91	1.358	-0.0106
198	940.26	1.348	-0.0104
199	941.60	1.337	-0.0101
200	942.93	1.327	-0.0099

Table 3 (cont.) Thermal voltage, thermopower, and thermopower derivative for copper vs gold-0.02 at. % iron

Temp. K	Voltage≡E μV	$\frac{dE}{dT}$≡S μV/K	$\frac{dS}{dT}$ μV/K^2
201	944.26	1.317	-0.0097
202	945.57	1.308	-0.0095
203	946.87	1.299	-0.0092
204	948.17	1.289	-0.0090
205	949.45	1.280	-0.0089
206	950.73	1.272	-0.0087
207	952.00	1.263	-0.0085
208	953.25	1.255	-0.0084
209	954.50	1.246	-0.0083
210	955.75	1.238	-0.0082
211	956.98	1.230	-0.0081
212	958.21	1.222	-0.0080
213	959.42	1.214	-0.0080
214	960.63	1.206	-0.0079
215	961.84	1.198	-0.0079
216	963.03	1.190	-0.0079
217	964.22	1.182	-0.0080
218	965.39	1.174	-0.0080
219	966.56	1.166	-0.0080
220	967.73	1.158	-0.0081
221	968.88	1.150	-0.0082
222	970.03	1.142	-0.0083
223	971.16	1.133	-0.0083
224	972.29	1.125	-0.0084
225	973.41	1.117	-0.0085
226	974.53	1.108	-0.0086
227	975.63	1.099	-0.0087
228	976.73	1.091	-0.0087
229	977.81	1.082	-0.0088
230	978.89	1.073	-0.0088
231	979.96	1.064	-0.0088
232	981.02	1.055	-0.0088
233	982.07	1.047	-0.0088
234	983.11	1.038	-0.0087
235	984.14	1.029	-0.0086
236	985.17	1.021	-0.0085
237	986.19	1.012	-0.0084
238	987.19	1.004	-0.0082
239	988.19	0.996	-0.0080
240	989.19	0.988	-0.0077
241	990.17	0.980	-0.0075
242	991.15	0.973	-0.0072
243	992.12	0.966	-0.0069
244	993.08	0.959	-0.0066
245	994.04	0.953	-0.0062
246	994.98	0.947	-0.0059
247	995.93	0.941	-0.0056
248	996.87	0.936	-0.0053
249	997.80	0.931	-0.0050
250	998.73	0.926	-0.0047

Temp. K	Voltage≡E μV	$\frac{dE}{dT}$≡S μV/K	$\frac{dS}{dT}$ μV/K^2
251	999.66	0.921	-0.0045
252	1000.58	0.917	-0.0043
253	1001.48	0.912	-0.0042
254	1002.40	0.909	-0.0042
255	1003.31	0.904	-0.0042
256	1004.20	0.900	-0.0043
257	1005.10	0.896	-0.0045
258	1005.99	0.891	-0.0048
259	1006.89	0.886	-0.0052
260	1007.78	0.880	-0.0057
261	1008.65	0.875	-0.0063
262	1009.53	0.868	-0.0070
263	1010.38	0.860	-0.0077
264	1011.24	0.852	-0.0084
265	1012.09	0.844	-0.0091
266	1012.91	0.834	-0.0098
267	1013.75	0.824	-0.0103
268	1014.57	0.813	-0.0106
269	1015.39	0.803	-0.0107
270	1016.18	0.793	-0.0103
271	1016.96	0.783	-0.0093
272	1017.74	0.774	-0.0077
273	1018.51	0.768	-0.0052
274	1019.28	0.764	-0.0015
275	1020.04	0.765	0.0035
276	1020.81	0.772	0.0102
277	1021.60	0.786	0.0189
278	1022.38	0.810	0.0300
279	1023.20	0.846	0.0440
280	1024.08	0.900	0.0613

Table 3 (cont.) Thermal voltage, thermopower, and thermopower derivative for copper vs gold-0.02 at. % iron

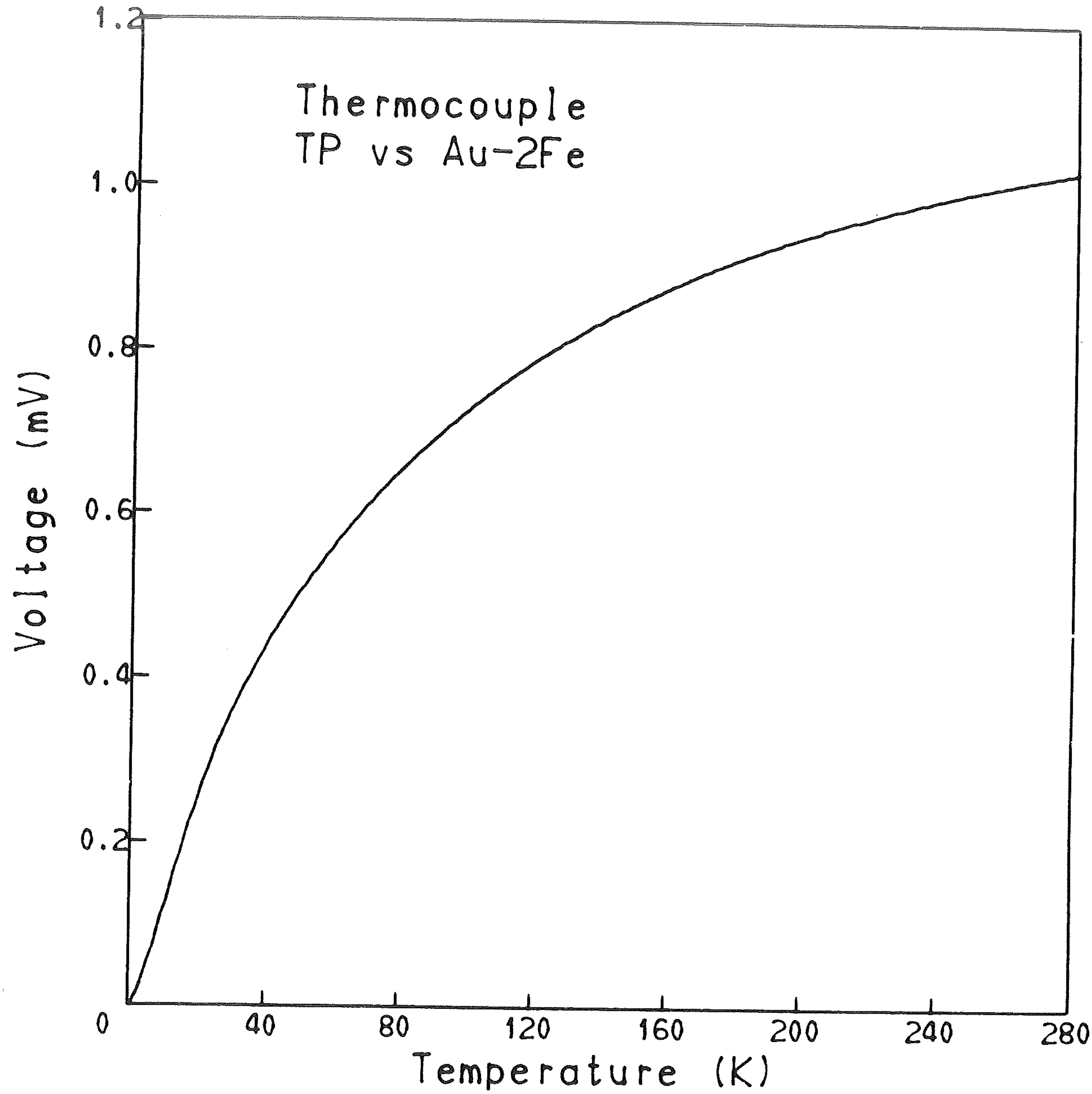

Figure 9 Thermoelectric voltage for copper vs gold-0.02 at. % iron

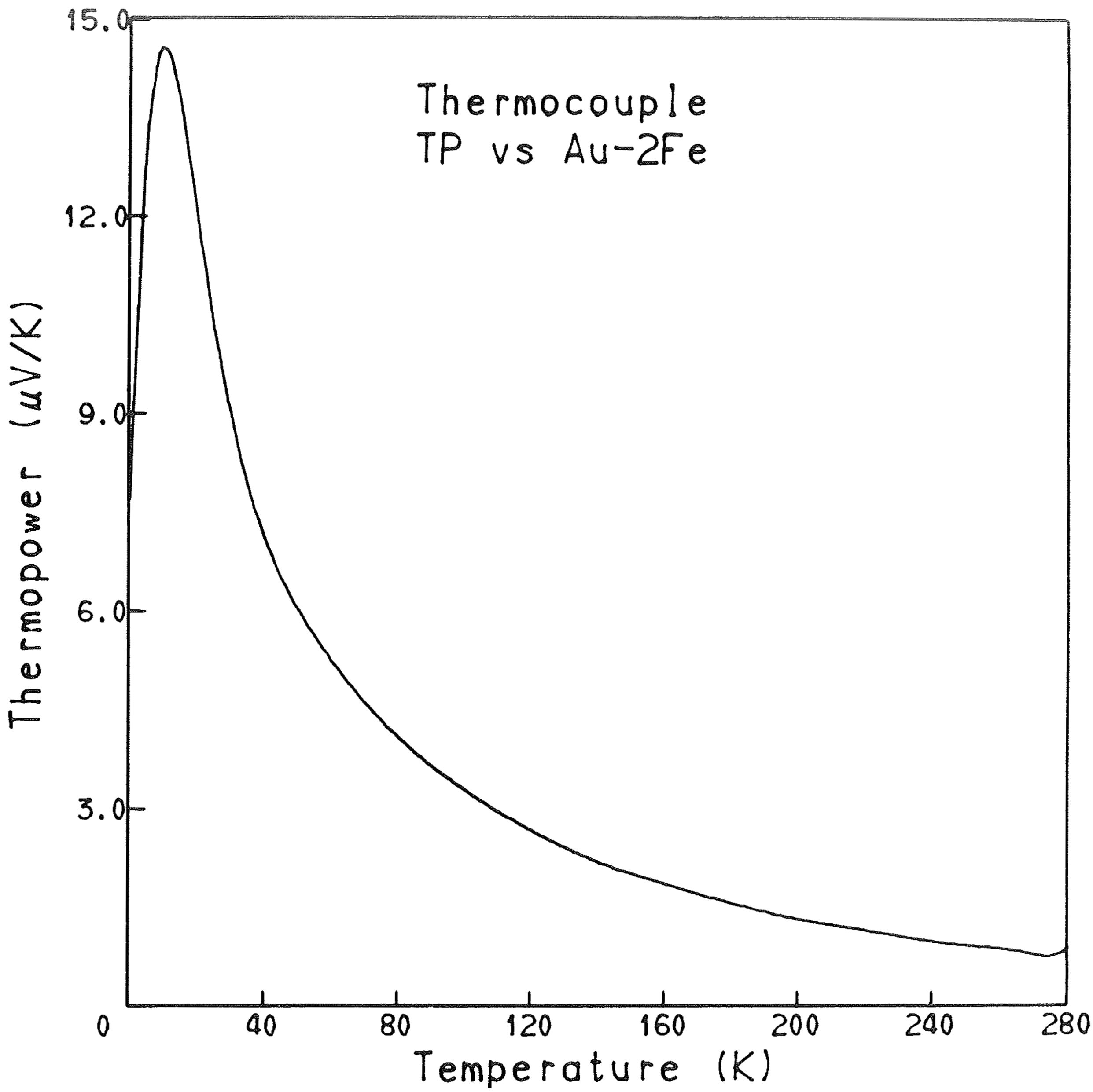

Figure 10 Thermopower for copper vs
gold-0.02 at.% iron

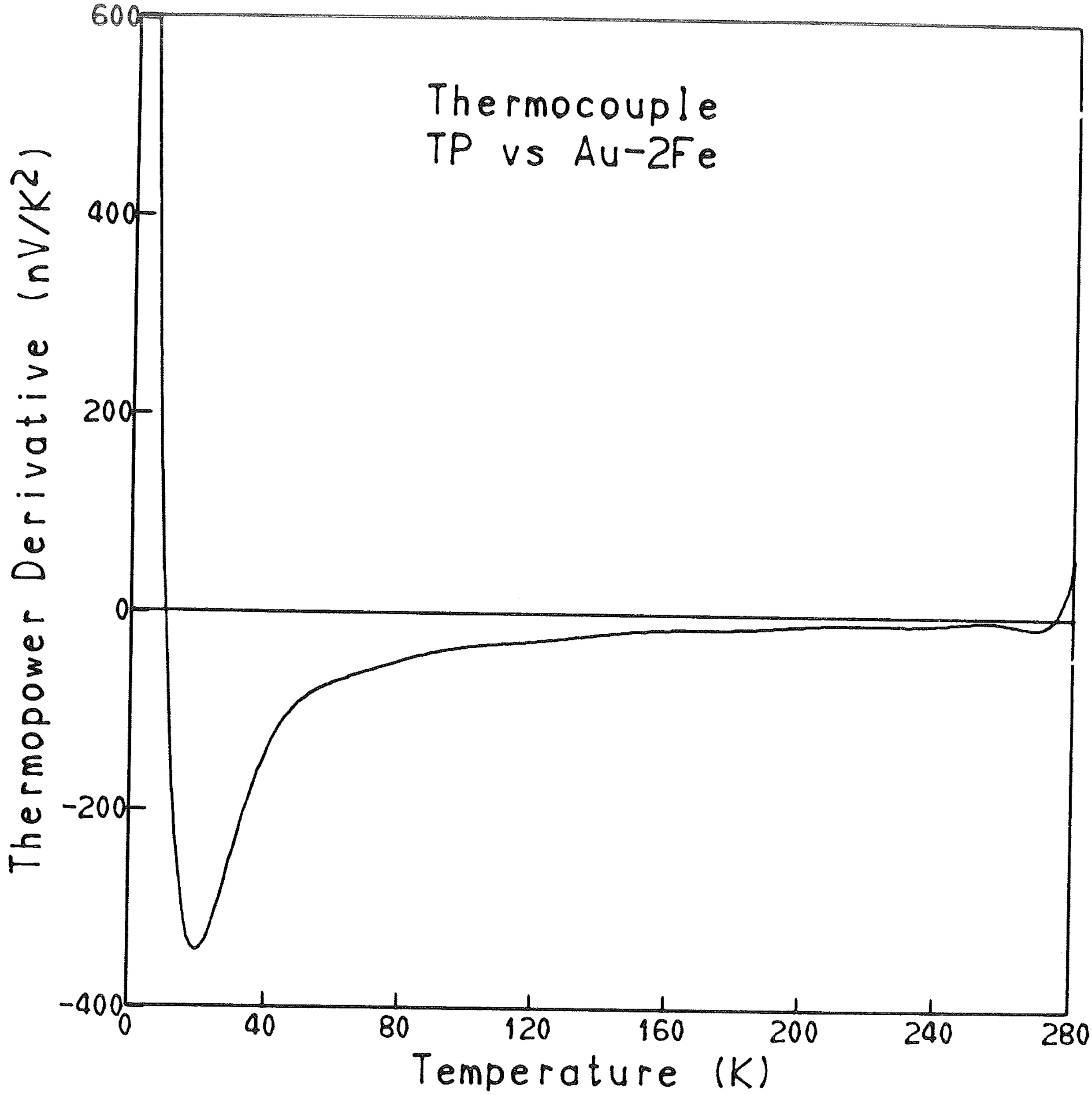

Figure 11 Thermopower derivative for copper vs gold -0.02 at.% iron

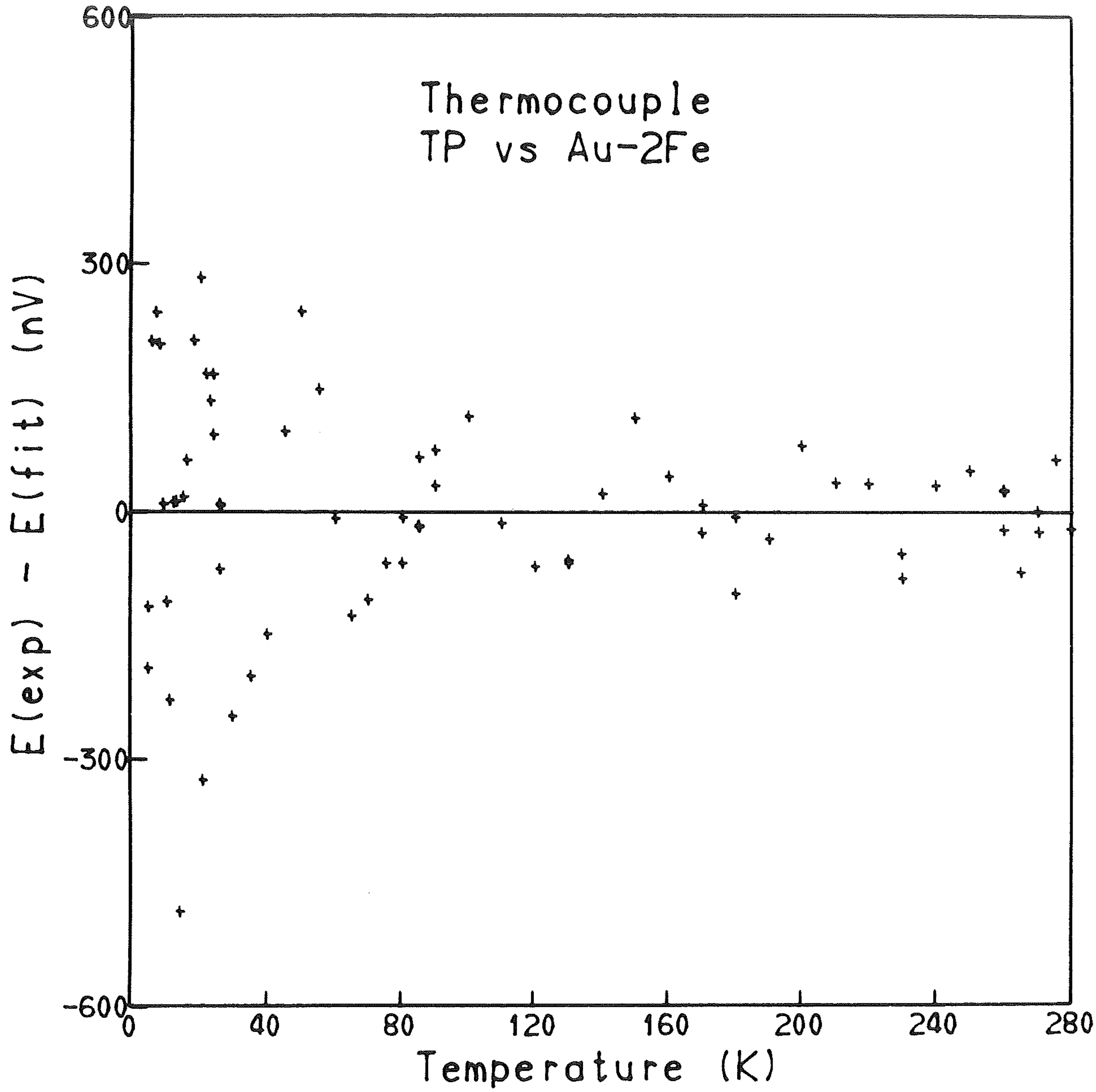

Figure 12 Deviations between calculated and experimental values of thermoelectric voltage for copper vs gold-0.02 at. % iron

Temp. K	Voltage≡E μV	$\frac{dE}{dT}$≡S μV/K	$\frac{dS}{dT}$ μV/K^2	Temp. K	Voltage≡E μV	$\frac{dE}{dT}$≡S μV/K	$\frac{dS}{dT}$ μV/K^2
1	7.28	8.256	1.8299	51	628.60	10.206	-0.0486
2	16.40	9.922	1.5110	52	638.78	10.157	-0.0492
3	27.03	11.291	1.2319	53	648.91	10.108	-0.0500
4	38.89	12.398	0.9888	54	658.99	10.057	-0.0510
5	51.75	13.279	0.7779	55	669.02	10.006	-0.0521
6	65.38	13.964	0.5959	56	679.00	9.953	-0.0535
7	79.62	14.480	0.4397	57	688.93	9.899	-0.0549
8	94.30	14.851	0.3064	58	698.80	9.843	-0.0565
9	109.28	15.099	0.1936	59	708.62	9.786	-0.0581
10	124.46	15.244	0.0989	60	718.37	9.727	-0.0598
11	139.74	15.302	0.0202	61	728.07	9.666	-0.0615
12	155.04	15.289	-0.0445	62	737.70	9.604	-0.0632
13	170.30	15.217	-0.0969	63	747.27	9.540	-0.0649
14	185.46	15.099	-0.1386	64	756.78	9.474	-0.0666
15	200.48	14.943	-0.1709	65	766.22	9.407	-0.0682
16	215.34	14.760	-0.1952	66	775.59	9.338	-0.0698
17	230.00	14.555	-0.2126	67	784.90	9.267	-0.0714
18	244.44	14.337	-0.2241	68	794.13	9.195	-0.0729
19	258.67	14.109	-0.2307	69	803.29	9.121	-0.0743
20	272.66	13.877	-0.2331	70	812.37	9.046	-0.0757
21	286.42	13.644	-0.2321	71	821.38	8.970	-0.0770
22	299.95	13.413	-0.2284	72	830.31	8.892	-0.0782
23	313.25	13.188	-0.2224	73	839.16	8.813	-0.0793
24	326.32	12.969	-0.2147	74	847.94	8.734	-0.0804
25	339.19	12.759	-0.2056	75	856.63	8.653	-0.0814
26	351.85	12.558	-0.1957	76	865.24	8.571	-0.0823
27	364.31	12.368	-0.1851	77	873.77	8.488	-0.0831
28	376.58	12.188	-0.1742	78	882.22	8.405	-0.0839
29	388.69	12.019	-0.1632	79	890.58	8.320	-0.0846
30	400.63	11.862	-0.1522	80	898.86	8.235	-0.0852
31	412.41	11.715	-0.1415	81	907.05	8.150	-0.0858
32	424.06	11.578	-0.1312	82	915.16	8.064	-0.0863
33	435.57	11.452	-0.1213	83	923.18	7.977	-0.0868
34	446.97	11.336	-0.1120	84	931.11	7.890	-0.0872
35	458.25	11.228	-0.1033	85	938.96	7.803	-0.0876
36	469.43	11.129	-0.0952	86	946.72	7.715	-0.0879
37	480.51	11.037	-0.0878	87	954.39	7.627	-0.0882
38	491.50	10.953	-0.0811	88	961.97	7.539	-0.0885
39	502.42	10.875	-0.0751	89	969.46	7.450	-0.0887
40	513.25	10.803	-0.0698	90	976.87	7.361	-0.0889
41	524.02	10.735	-0.0651	91	984.19	7.272	-0.0891
42	534.73	10.672	-0.0611	92	991.41	7.183	-0.0893
43	545.37	10.613	-0.0577	93	998.55	7.094	-0.0894
44	555.95	10.556	-0.0549	94	1005.60	7.004	-0.0895
45	566.48	10.503	-0.0527	95	1012.56	6.915	-0.0896
46	576.96	10.451	-0.0509	96	1019.43	6.825	-0.0897
47	587.38	10.401	-0.0497	97	1026.21	6.735	-0.0898
48	597.76	10.351	-0.0488	98	1032.90	6.645	-0.0899
49	608.09	10.303	-0.0484	99	1039.50	6.556	-0.0899
50	618.37	10.254	-0.0484	100	1046.01	6.466	-0.0900

Table 4 Thermal voltage, thermopower, and thermopower derivative for platinum vs gold-0.02 at.% iron.

Temp. K	Voltage=E μV	$\frac{dE}{dT}$=S μV/K	$\frac{dS}{dT}$ μV/K^2
101	1052.43	6.376	-0.0900
102	1058.76	6.286	-0.0900
103	1065.00	6.196	-0.0901
104	1071.16	6.105	-0.0901
105	1077.22	6.015	-0.0901
106	1083.19	5.925	-0.0901
107	1089.07	5.835	-0.0901
108	1094.86	5.745	-0.0901
109	1100.56	5.655	-0.0900
110	1106.17	5.565	-0.0900
111	1111.69	5.475	-0.0900
112	1117.12	5.385	-0.0899
113	1122.46	5.295	-0.0898
114	1127.71	5.205	-0.0898
115	1132.87	5.116	-0.0897
116	1137.94	5.026	-0.0896
117	1142.92	4.937	-0.0894
118	1147.81	4.847	-0.0893
119	1152.61	4.758	-0.0891
120	1157.33	4.669	-0.0889
121	1161.95	4.580	-0.0888
122	1166.49	4.492	-0.0885
123	1170.94	4.403	-0.0883
124	1175.29	4.315	-0.0881
125	1179.57	4.227	-0.0878
126	1183.75	4.139	-0.0875
127	1187.84	4.052	-0.0872
128	1191.85	3.965	-0.0869
129	1195.77	3.878	-0.0866
130	1199.61	3.792	-0.0862
131	1203.36	3.706	-0.0859
132	1207.02	3.620	-0.0855
133	1210.60	3.535	-0.0851
134	1214.09	3.450	-0.0847
135	1217.50	3.365	-0.0843
136	1220.82	3.281	-0.0838
137	1224.06	3.198	-0.0834
138	1227.22	3.115	-0.0829
139	1230.29	3.032	-0.0825
140	1233.28	2.950	-0.0820
141	1236.19	2.868	-0.0816
142	1239.02	2.787	-0.0811
143	1241.76	2.706	-0.0806
144	1244.43	2.625	-0.0802
145	1247.01	2.545	-0.0797
146	1249.52	2.466	-0.0792
147	1251.95	2.387	-0.0787
148	1254.29	2.308	-0.0783
149	1256.56	2.230	-0.0778
150	1258.75	2.153	-0.0774
151	1260.87	2.076	-0.0769
152	1262.91	1.999	-0.0765
153	1264.87	1.923	-0.0761
154	1266.75	1.847	-0.0756
155	1268.56	1.771	-0.0752
156	1270.29	1.696	-0.0748
157	1271.95	1.622	-0.0744
158	1273.54	1.547	-0.0741
159	1275.05	1.474	-0.0737
160	1276.48	1.400	-0.0733
161	1277.85	1.327	-0.0730
162	1279.14	1.254	-0.0727
163	1280.36	1.181	-0.0723
164	1281.50	1.109	-0.0720
165	1282.57	1.037	-0.0717
166	1283.58	0.966	-0.0714
167	1284.51	0.895	-0.0711
168	1285.37	0.824	-0.0709
169	1286.15	0.753	-0.0706
170	1286.87	0.682	-0.0703
171	1287.52	0.612	-0.0700
172	1288.10	0.542	-0.0698
173	1288.60	0.473	-0.0695
174	1289.04	0.403	-0.0693
175	1289.41	0.334	-0.0690
176	1289.71	0.265	-0.0688
177	1289.94	0.197	-0.0685
178	1290.10	0.128	-0.0683
179	1290.20	0.060	-0.0680
180	1290.22	-0.008	-0.0678
181	1290.18	-0.076	-0.0675
182	1290.07	-0.143	-0.0672
183	1289.90	-0.210	-0.0670
184	1289.65	-0.277	-0.0667
185	1289.34	-0.343	-0.0664
186	1288.96	-0.410	-0.0661
187	1288.52	-0.476	-0.0658
188	1288.01	-0.541	-0.0655
189	1287.44	-0.607	-0.0652
190	1286.80	-0.672	-0.0649
191	1286.10	-0.737	-0.0646
192	1285.33	-0.801	-0.0643
193	1284.49	-0.865	-0.0639
194	1283.60	-0.929	-0.0636
195	1282.64	-0.992	-0.0632
196	1281.61	-1.055	-0.0629
197	1280.53	-1.118	-0.0625
198	1279.38	-1.180	-0.0621
199	1278.17	-1.242	-0.0618
200	1276.89	-1.304	-0.0614

Table 4 (cont.) Thermal voltage, thermopower, and thermo-power derivative for platinum vs gold-0.02 at. % iron

Temp. K	Voltage≡E μV	$\frac{dE}{dT}$≡S $\mu V/K$	$\frac{dS}{dT}$ $\mu V/K^2$
201	1275.56	-1.365	-0.0610
202	1274.16	-1.426	-0.0607
203	1272.71	-1.486	-0.0603
204	1271.19	-1.547	-0.0599
205	1269.61	-1.606	-0.0596
206	1267.98	-1.666	-0.0592
207	1266.28	-1.725	-0.0588
208	1264.53	-1.783	-0.0585
209	1262.72	-1.842	-0.0581
210	1260.84	-1.900	-0.0578
211	1258.92	-1.957	-0.0575
212	1256.93	-2.015	-0.0572
213	1254.89	-2.072	-0.0568
214	1252.79	-2.128	-0.0565
215	1250.63	-2.185	-0.0563
216	1248.42	-2.241	-0.0560
217	1246.15	-2.297	-0.0557
218	1243.82	-2.352	-0.0555
219	1241.44	-2.408	-0.0552
220	1239.01	-2.463	-0.0550
221	1236.52	-2.518	-0.0548
222	1233.97	-2.572	-0.0545
223	1231.38	-2.627	-0.0543
224	1228.72	-2.681	-0.0542
225	1226.01	-2.735	-0.0540
226	1223.25	-2.789	-0.0538
227	1220.44	-2.842	-0.0536
228	1217.57	-2.896	-0.0534
229	1214.64	-2.949	-0.0533
230	1211.67	-3.003	-0.0531
231	1208.64	-3.056	-0.0529
232	1205.56	-3.108	-0.0527
233	1202.42	-3.161	-0.0526
234	1199.24	-3.214	-0.0524
235	1196.00	-3.266	-0.0522
236	1192.70	-3.318	-0.0520
237	1189.36	-3.370	-0.0518
238	1185.96	-3.421	-0.0516
239	1182.52	-3.473	-0.0513
240	1179.02	-3.524	-0.0511
241	1175.47	-3.575	-0.0508
242	1171.87	-3.626	-0.0506
243	1168.22	-3.676	-0.0503
244	1164.52	-3.726	-0.0500
245	1160.76	-3.776	-0.0497
246	1156.96	-3.826	-0.0495
247	1153.11	-3.875	-0.0492
248	1149.21	-3.924	-0.0489
249	1145.26	-3.973	-0.0486
250	1141.27	-4.021	-0.0483
251	1137.23	-4.070	-0.0480
252	1133.13	-4.118	-0.0478
253	1128.98	-4.165	-0.0475
254	1124.80	-4.213	-0.0473
255	1120.57	-4.260	-0.0471
256	1116.28	-4.307	-0.0470
257	1111.94	-4.354	-0.0469
258	1107.56	-4.401	-0.0468
259	1103.15	-4.448	-0.0468
260	1098.68	-4.494	-0.0468
261	1094.16	-4.541	-0.0468
262	1089.61	-4.588	-0.0469
263	1084.98	-4.635	-0.0470
264	1080.32	-4.682	-0.0471
265	1075.62	-4.728	-0.0472
266	1070.86	-4.776	-0.0472
267	1066.07	-4.823	-0.0473
268	1061.22	-4.871	-0.0472
269	1056.33	-4.918	-0.0470
270	1051.39	-4.965	-0.0467
271	1046.40	-5.011	-0.0460
272	1041.36	-5.057	-0.0451
273	1036.28	-5.101	-0.0438
274	1031.16	-5.144	-0.0419
275	1025.99	-5.185	-0.0395
276	1020.79	-5.222	-0.0362
277	1015.56	-5.257	-0.0320
278	1010.27	-5.286	-0.0267
279	1004.97	-5.310	-0.0200
280	999.66	-5.325	-0.0117

Table 4 (cont.) Thermal voltage, thermopower, and thermopower derivative for platinum vs gold-0.02 at. % iron

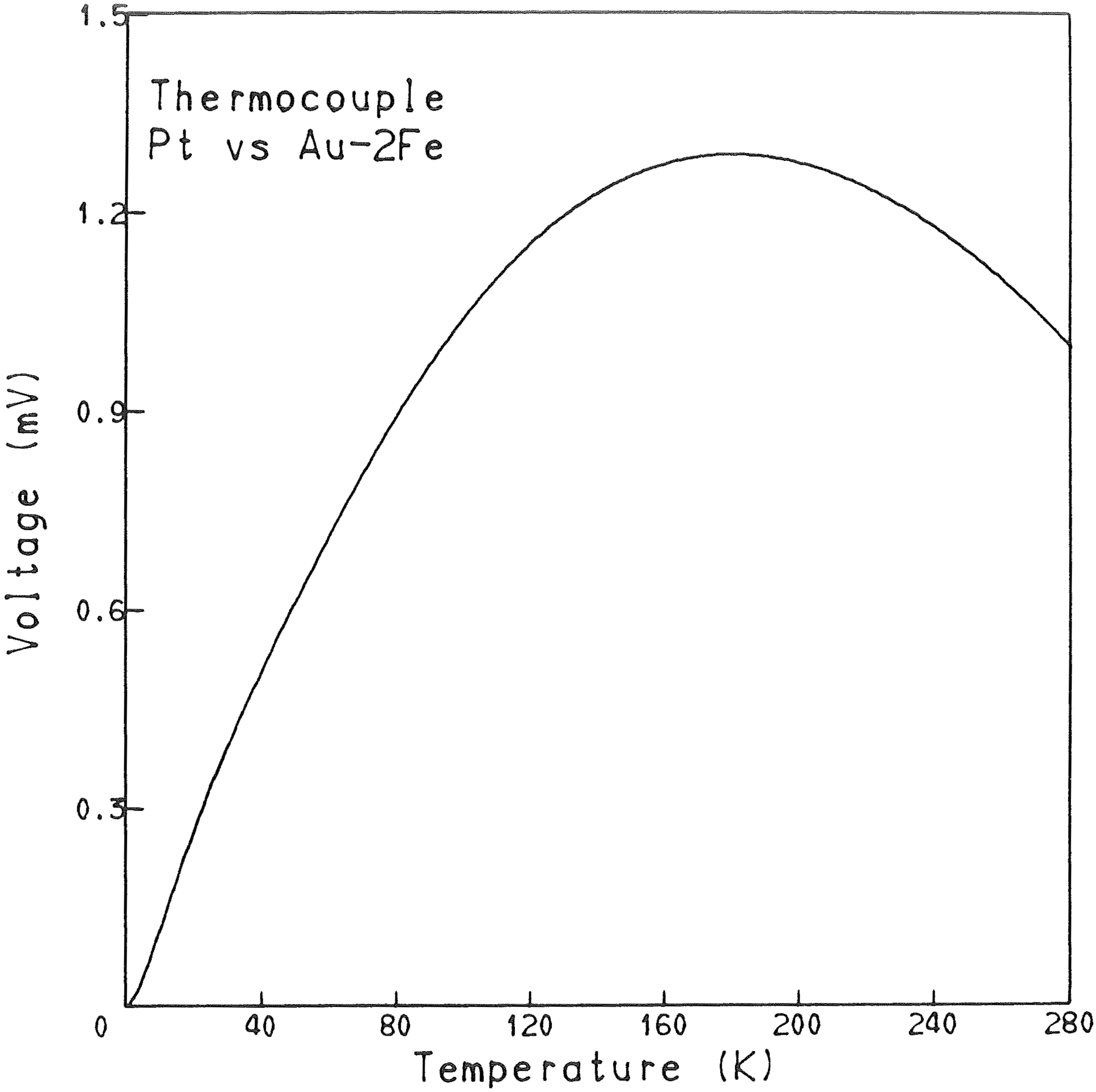

Figure 13 Thermoelectric voltage for platinum vs gold-0.02 at.% iron

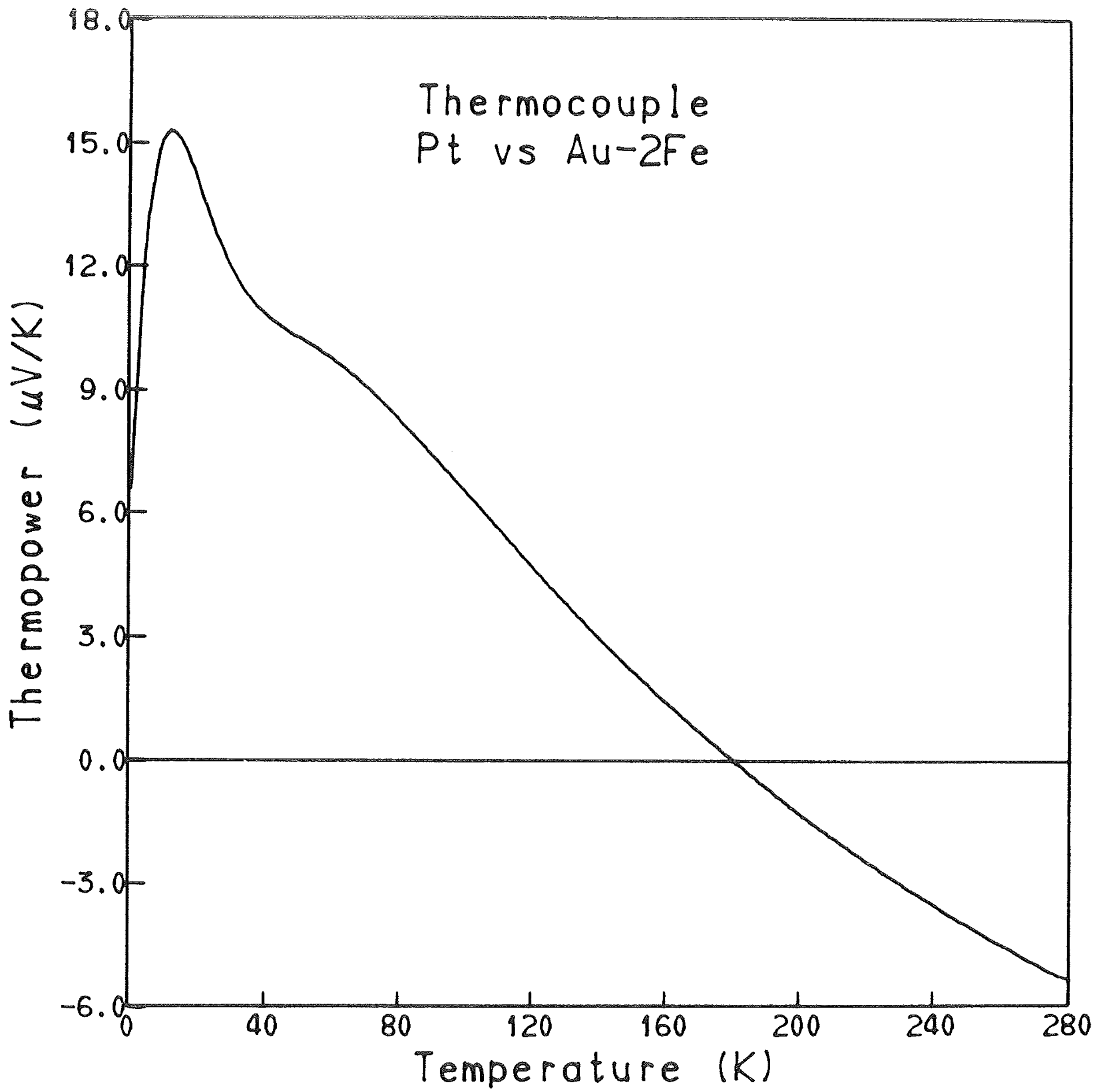

Figure 14 Thermopower for platinum vs gold-0.02 at.% iron

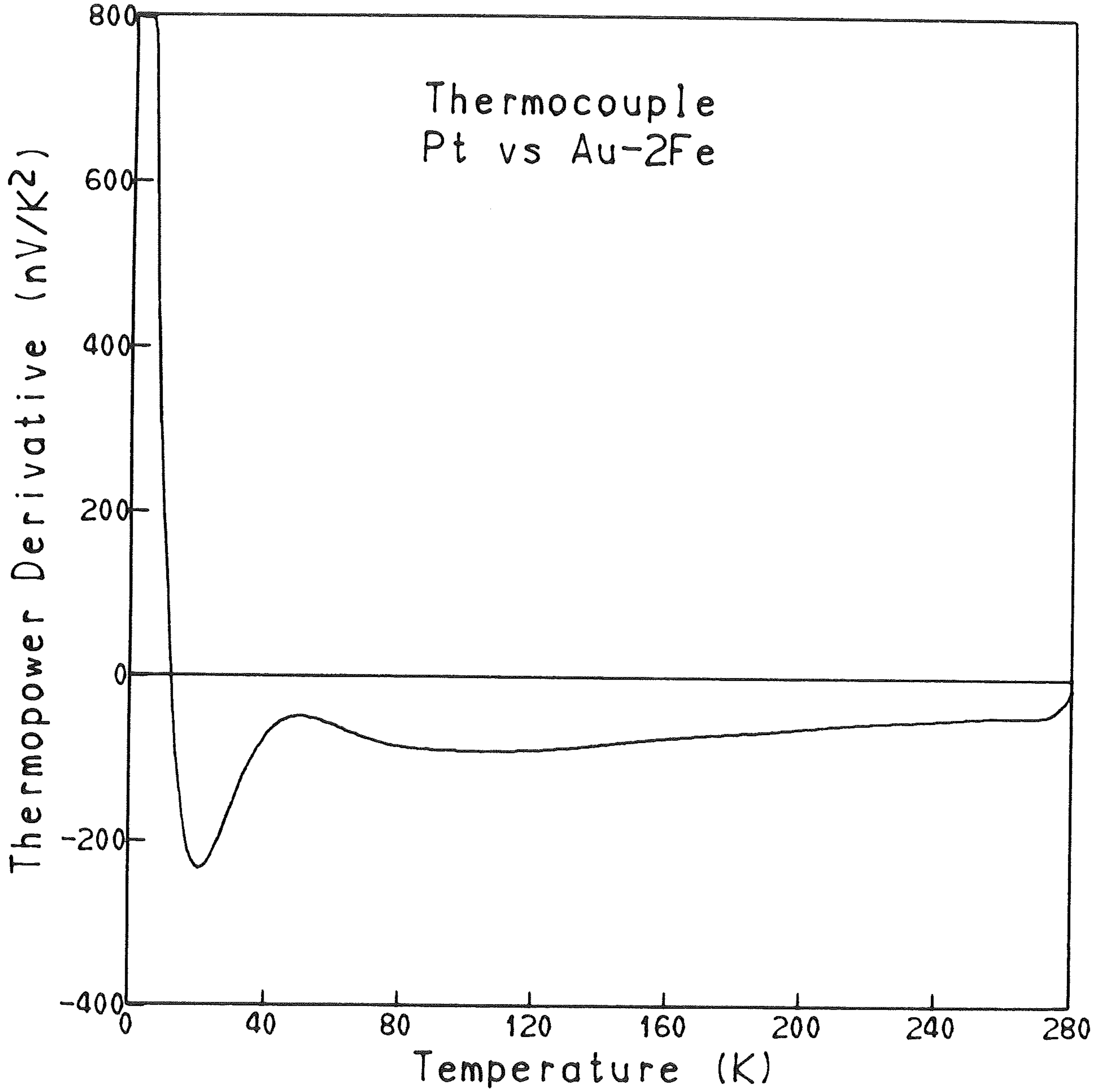

Figure 15 Thermopower derivative for platinum vs gold-0.02 at. % iron

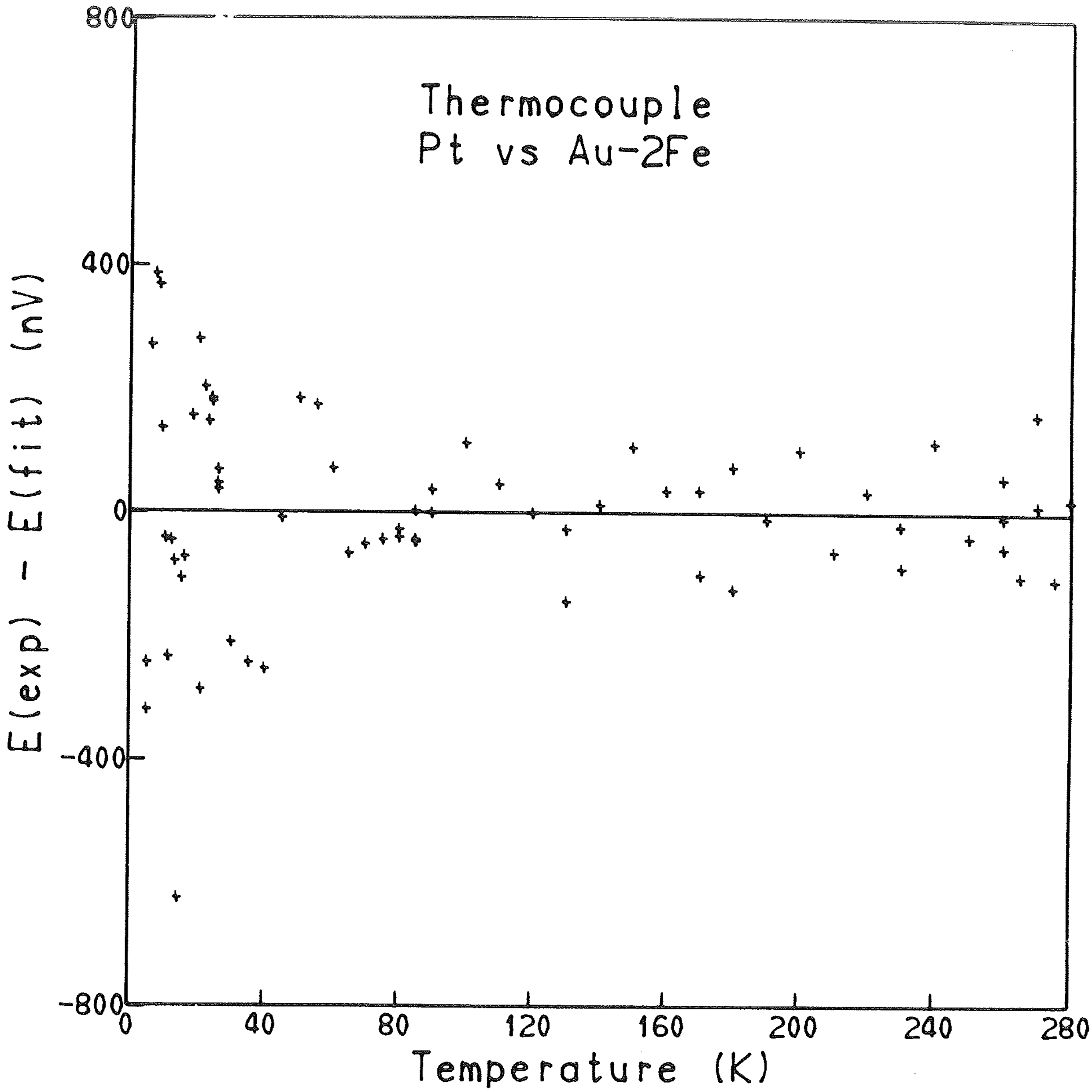

Figure 16 Deviations between calculated and experimental values of thermoelectric voltage for platinum vs gold-0.02 at.% iron.

Temp. K	Voltage=E μV	$\frac{dE}{dT}=S$ $\mu V/K$	$\frac{dS}{dT}$ $\mu V/K^2$
1	8.24	9.099	1.6061
2	18.09	10.555	1.3108
3	29.26	11.733	1.0512
4	41.48	12.668	0.8238
5	54.52	13.390	0.6255
6	68.20	13.928	0.4533
7	82.33	14.305	0.3046
8	96.76	14.544	0.1769
9	111.37	14.665	0.0680
10	126.06	14.685	-0.0243
11	140.72	14.621	-0.1017
12	155.27	14.486	-0.1659
13	169.67	14.293	-0.2186
14	183.85	14.052	-0.2610
15	197.76	13.774	-0.2945
16	211.38	13.466	-0.3203
17	224.69	13.136	-0.3392
18	237.65	12.789	-0.3523
19	250.26	12.433	-0.3604
20	262.51	12.070	-0.3642
21	274.40	11.705	-0.3645
22	285.92	11.342	-0.3617
23	297.09	10.983	-0.3564
24	307.89	10.630	-0.3491
25	318.35	10.285	-0.3402
26	328.47	9.950	-0.3300
27	338.25	9.625	-0.3189
28	347.72	9.312	-0.3070
29	356.88	9.012	-0.2947
30	365.75	8.723	-0.2822
31	374.33	8.447	-0.2696
32	382.65	8.184	-0.2570
33	390.70	7.933	-0.2446
34	398.52	7.695	-0.2324
35	406.10	7.468	-0.2206
36	413.46	7.253	-0.2092
37	420.61	7.050	-0.1982
38	427.56	6.857	-0.1878
39	434.32	6.674	-0.1778
40	440.91	6.501	-0.1684
41	447.33	6.337	-0.1594
42	453.59	6.182	-0.1511
43	459.70	6.035	-0.1432
44	465.66	5.895	-0.1358
45	471.49	5.763	-0.1289
46	477.19	5.637	-0.1225
47	482.77	5.518	-0.1165
48	488.23	5.404	-0.1110
49	493.58	5.296	-0.1059
50	498.82	5.192	-0.1011
51	503.96	5.093	-0.0967
52	509.01	4.999	-0.0926
53	513.96	4.908	-0.0889
54	518.82	4.821	-0.0854
55	523.60	4.737	-0.0822
56	528.30	4.656	-0.0792
57	532.92	4.579	-0.0764
58	537.46	4.504	-0.0738
59	541.92	4.431	-0.0714
60	546.32	4.361	-0.0692
61	550.65	4.293	-0.0671
62	554.91	4.226	-0.0651
63	559.10	4.162	-0.0632
64	563.23	4.100	-0.0615
65	567.30	4.039	-0.0598
66	571.31	3.980	-0.0582
67	575.26	3.923	-0.0567
68	579.16	3.867	-0.0553
69	583.00	3.812	-0.0539
70	586.78	3.759	-0.0526
71	590.51	3.707	-0.0513
72	594.20	3.656	-0.0500
73	597.83	3.607	-0.0488
74	601.41	3.559	-0.0477
75	604.94	3.512	-0.0465
76	608.43	3.466	-0.0454
77	611.88	3.421	-0.0444
78	615.28	3.377	-0.0433
79	618.63	3.334	-0.0423
80	621.94	3.292	-0.0413
81	625.22	3.251	-0.0404
82	628.45	3.211	-0.0395
83	631.64	3.172	-0.0386
84	634.79	3.134	-0.0377
85	637.91	3.097	-0.0369
86	640.99	3.060	-0.0361
87	644.03	3.025	-0.0353
88	647.04	2.990	-0.0346
89	650.01	2.956	-0.0339
90	652.95	2.922	-0.0332
91	655.85	2.889	-0.0326
92	658.73	2.857	-0.0320
93	661.57	2.825	-0.0314
94	664.38	2.794	-0.0308
95	667.15	2.764	-0.0303
96	669.90	2.733	-0.0298
97	672.62	2.704	-0.0293
98	675.31	2.675	-0.0289
99	677.97	2.646	-0.0284
100	680.60	2.618	-0.0280

Table 5 Thermal voltage, thermopower, and thermopower derivative for "normal" silver vs gold-0.02 at.% iron.

Temp. K	Voltage=E µV	$\frac{dE}{dT}$=S µV/K	$\frac{dS}{dT}$ µV/K^2	Temp. K	Voltage=E µV	$\frac{dE}{dT}$=S µV/K	$\frac{dS}{dT}$ µV/K^2
101	683.21	2.590	-0.0277	151	783.50	1.522	-0.0154
102	685.78	2.563	-0.0273	152	785.01	1.507	-0.0152
103	688.33	2.536	-0.0270	153	786.51	1.492	-0.0150
104	690.86	2.509	-0.0266	154	788.00	1.477	-0.0149
105	693.35	2.482	-0.0263	155	789.47	1.462	-0.0147
106	695.82	2.456	-0.0261	156	790.92	1.447	-0.0146
107	698.26	2.430	-0.0258	157	792.36	1.433	-0.0144
108	700.68	2.404	-0.0255	158	793.79	1.418	-0.0143
109	703.07	2.379	-0.0253	159	795.20	1.404	-0.0142
110	705.44	2.354	-0.0250	160	796.60	1.390	-0.0141
111	707.78	2.329	-0.0248	161	797.98	1.376	-0.0140
112	710.10	2.304	-0.0246	162	799.35	1.362	-0.0139
113	712.39	2.280	-0.0244	163	800.70	1.348	-0.0139
114	714.66	2.256	-0.0242	164	802.04	1.334	-0.0138
115	716.90	2.231	-0.0240	165	803.37	1.320	-0.0137
116	719.12	2.208	-0.0237	166	804.68	1.307	-0.0137
117	721.32	2.184	-0.0235	167	805.98	1.293	-0.0136
118	723.49	2.161	-0.0233	168	807.27	1.279	-0.0136
119	725.64	2.137	-0.0231	169	808.54	1.266	-0.0135
120	727.76	2.114	-0.0229	170	809.80	1.252	-0.0135
121	729.86	2.092	-0.0227	171	811.05	1.239	-0.0135
122	731.95	2.069	-0.0225	172	812.28	1.225	-0.0134
123	734.00	2.047	-0.0222	173	813.50	1.212	-0.0134
124	736.04	2.024	-0.0220	174	814.70	1.199	-0.0133
125	738.05	2.003	-0.0218	175	815.90	1.185	-0.0133
126	740.04	1.981	-0.0215	176	817.08	1.172	-0.0133
127	742.01	1.959	-0.0213	177	818.24	1.159	-0.0132
128	743.96	1.938	-0.0211	178	819.39	1.146	-0.0132
129	745.89	1.917	-0.0208	179	820.53	1.132	-0.0131
130	747.80	1.897	-0.0206	180	821.66	1.119	-0.0130
131	749.68	1.876	-0.0203	181	822.77	1.106	-0.0130
132	751.55	1.856	-0.0200	182	823.87	1.093	-0.0129
133	753.40	1.836	-0.0198	183	824.96	1.081	-0.0128
134	755.22	1.817	-0.0195	184	826.03	1.068	-0.0127
135	757.03	1.797	-0.0192	185	827.09	1.055	-0.0126
136	758.82	1.778	-0.0190	186	828.14	1.043	-0.0125
137	760.59	1.759	-0.0187	187	829.18	1.030	-0.0124
138	762.34	1.741	-0.0184	188	830.20	1.018	-0.0123
139	764.07	1.722	-0.0182	189	831.21	1.005	-0.0122
140	765.78	1.704	-0.0179	190	832.21	0.993	-0.0120
141	767.48	1.687	-0.0176	191	833.20	0.981	-0.0119
142	769.15	1.669	-0.0174	192	834.18	0.970	-0.0117
143	770.81	1.652	-0.0171	193	835.14	0.958	-0.0116
144	772.46	1.635	-0.0169	194	836.09	0.946	-0.0114
145	774.08	1.618	-0.0167	195	837.03	0.935	-0.0113
146	775.69	1.601	-0.0164	196	837.96	0.924	-0.0111
147	777.29	1.585	-0.0162	197	838.88	0.913	-0.0109
148	778.86	1.569	-0.0160	198	839.79	0.902	-0.0108
149	780.42	1.553	-0.0158	199	840.68	0.891	-0.0106
150	781.97	1.538	-0.0156	200	841.57	0.881	-0.0104

Table 5 (cont.) Thermal voltage, thermopower, and thermopower derivative for "normal" silver vs gold-0.02 at. % iron

Temp. K	Voltage≡E μV	$\frac{dE}{dT}$≡S μV/K	$\frac{dS}{dT}$ μV/K^2
201	842.45	0.870	-0.0102
202	843.31	0.860	-0.0101
203	844.17	0.850	-0.0099
204	845.01	0.840	-0.0098
205	845.85	0.831	-0.0096
206	846.67	0.821	-0.0095
207	847.49	0.812	-0.0093
208	848.30	0.803	-0.0092
209	849.10	0.794	-0.0091
210	849.89	0.785	-0.0089
211	850.67	0.776	-0.0088
212	851.44	0.767	-0.0088
213	852.20	0.758	-0.0087
214	852.95	0.749	-0.0086
215	853.70	0.741	-0.0086
216	854.43	0.732	-0.0085
217	855.16	0.724	-0.0085
218	855.88	0.715	-0.0085
219	856.59	0.707	-0.0085
220	857.30	0.698	-0.0085
221	857.99	0.690	-0.0085
222	858.68	0.682	-0.0085
223	859.35	0.673	-0.0085
224	860.02	0.664	-0.0086
225	860.68	0.656	-0.0086
226	861.33	0.647	-0.0087
227	861.98	0.639	-0.0087
228	862.61	0.630	-0.0087
229	863.24	0.621	-0.0088
230	863.85	0.612	-0.0088
231	864.46	0.603	-0.0089
232	865.06	0.595	-0.0089
233	865.65	0.586	-0.0089
234	866.23	0.577	-0.0089
235	866.80	0.568	-0.0089
236	867.37	0.559	-0.0089
237	867.92	0.550	-0.0088
238	868.47	0.541	-0.0088
239	869.00	0.533	-0.0087
240	869.53	0.524	-0.0086
241	870.05	0.515	-0.0085
242	870.56	0.507	-0.0083
243	871.07	0.499	-0.0082
244	871.56	0.491	-0.0080
245	872.05	0.483	-0.0078
246	872.53	0.475	-0.0076
247	873.00	0.467	-0.0074
248	873.46	0.460	-0.0072
249	873.92	0.453	-0.0070
250	874.37	0.446	-0.0068
251	874.82	0.439	-0.0066
252	875.25	0.433	-0.0064
253	875.67	0.426	-0.0063
254	876.10	0.420	-0.0061
255	876.52	0.414	-0.0060
256	876.93	0.408	-0.0059
257	877.33	0.402	-0.0058
258	877.73	0.397	-0.0058
259	878.13	0.391	-0.0059
260	878.52	0.385	-0.0060
261	878.90	0.379	-0.0061
262	879.28	0.373	-0.0063
263	879.64	0.366	-0.0065
264	880.00	0.359	-0.0068
265	880.36	0.353	-0.0071
266	880.70	0.345	-0.0074
267	881.05	0.338	-0.0077
268	881.38	0.329	-0.0080
269	881.71	0.322	-0.0082
270	882.03	0.313	-0.0083
271	882.34	0.305	-0.0082
272	882.63	0.297	-0.0079
273	882.93	0.289	-0.0072
274	883.21	0.283	-0.0062
275	883.49	0.277	-0.0047
276	883.77	0.274	-0.0025
277	884.05	0.272	0.0005
278	884.31	0.275	0.0044
279	884.59	0.281	0.0094
280	884.88	0.294	0.0159

Table 5 (cont.) Thermal voltage, thermopower, and thermopower derivative for "normal" silver vs gold-0.02 at. % iron

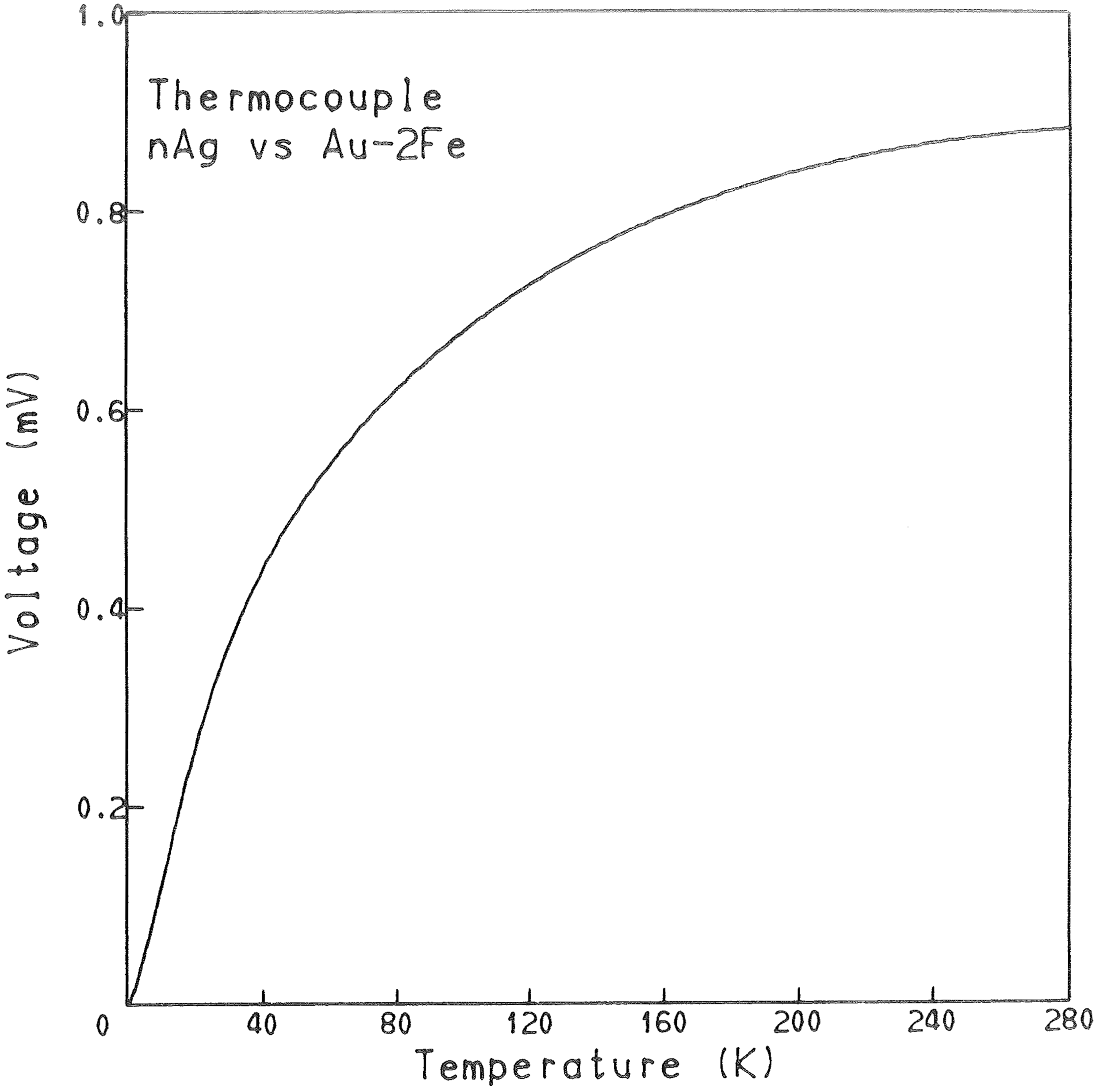

Figure 17 Thermoelectric voltage for "normal" silver vs gold-0.02 at.% iron

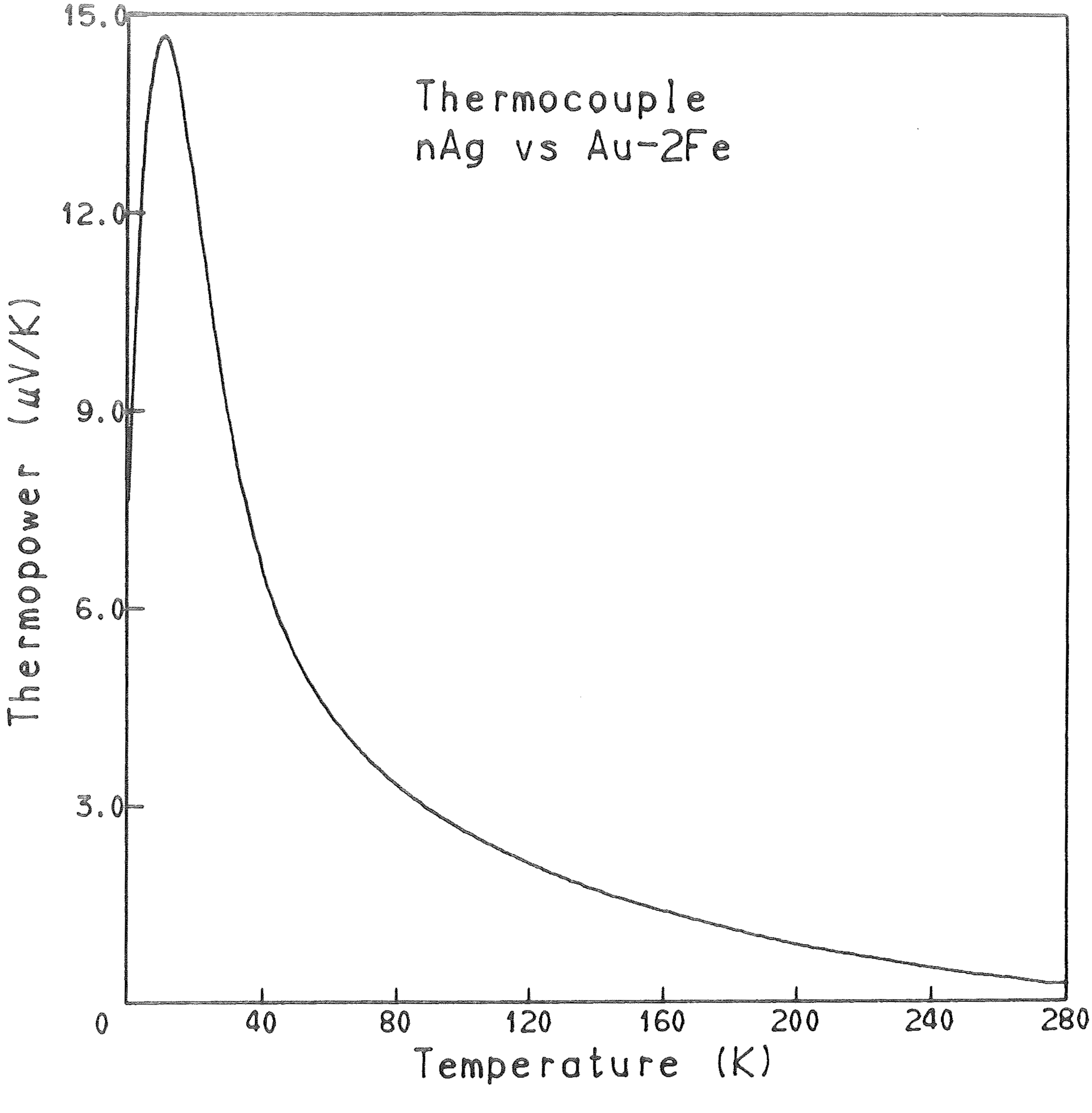

Figure 18 Thermopower for "normal" silver vs gold-0.02 at.% iron

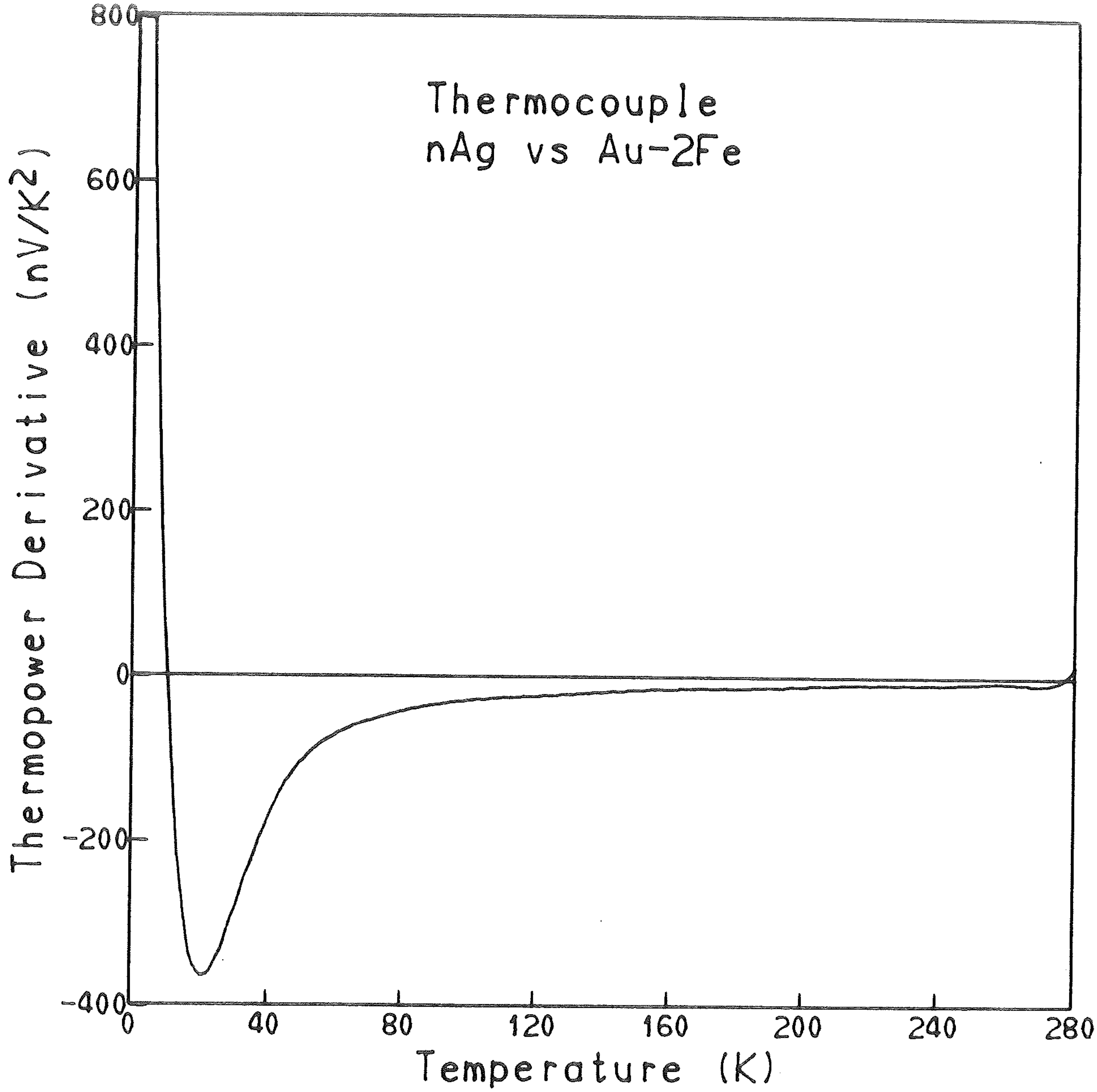

Figure 19 Thermopower derivative for "normal" silver vs gold-0.02 at.% iron

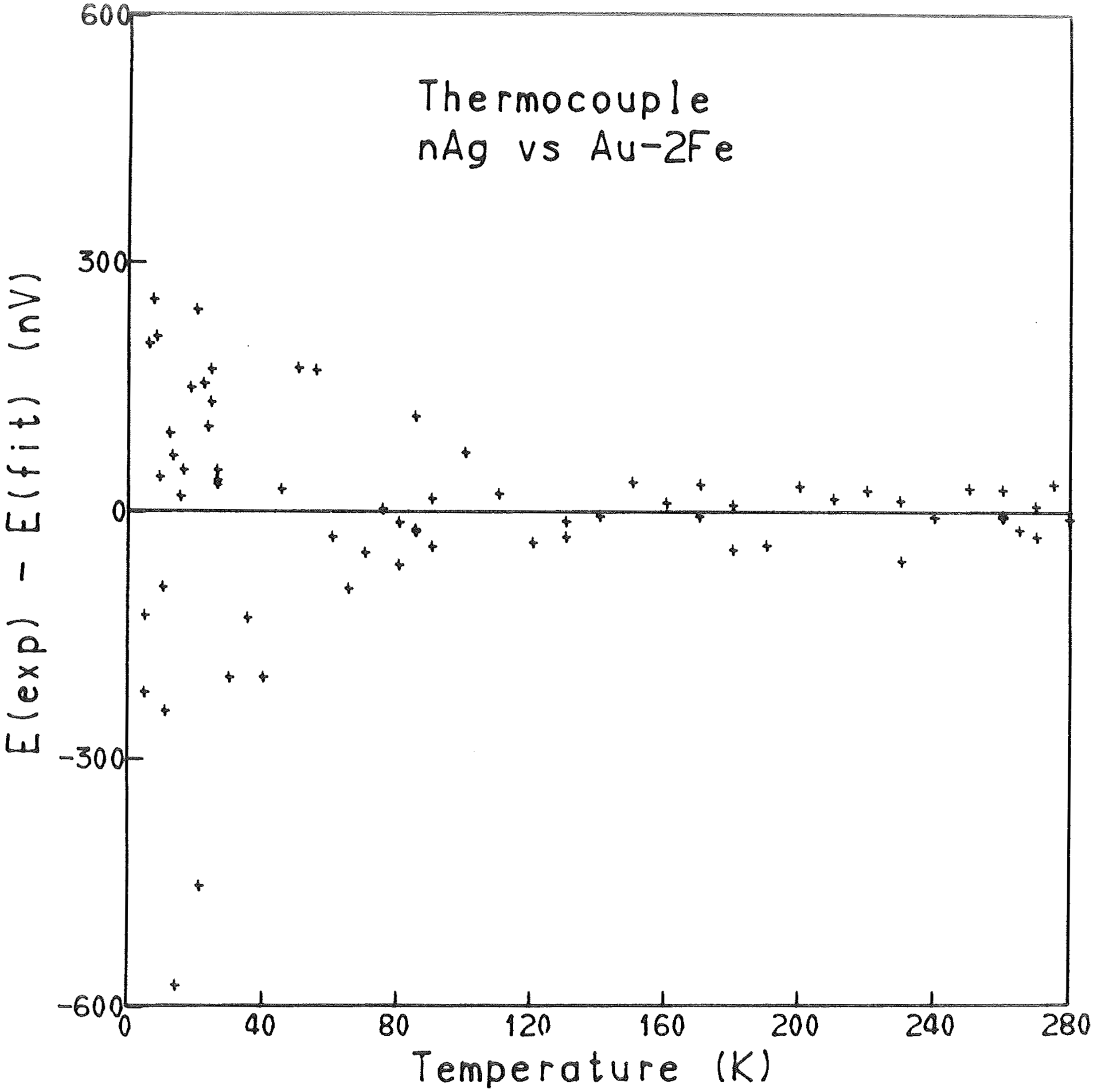

Figure 20 Deviations between calculated and experimental values of thermoelectric voltage for "normal" silver vs gold-0.02 at.% iron.

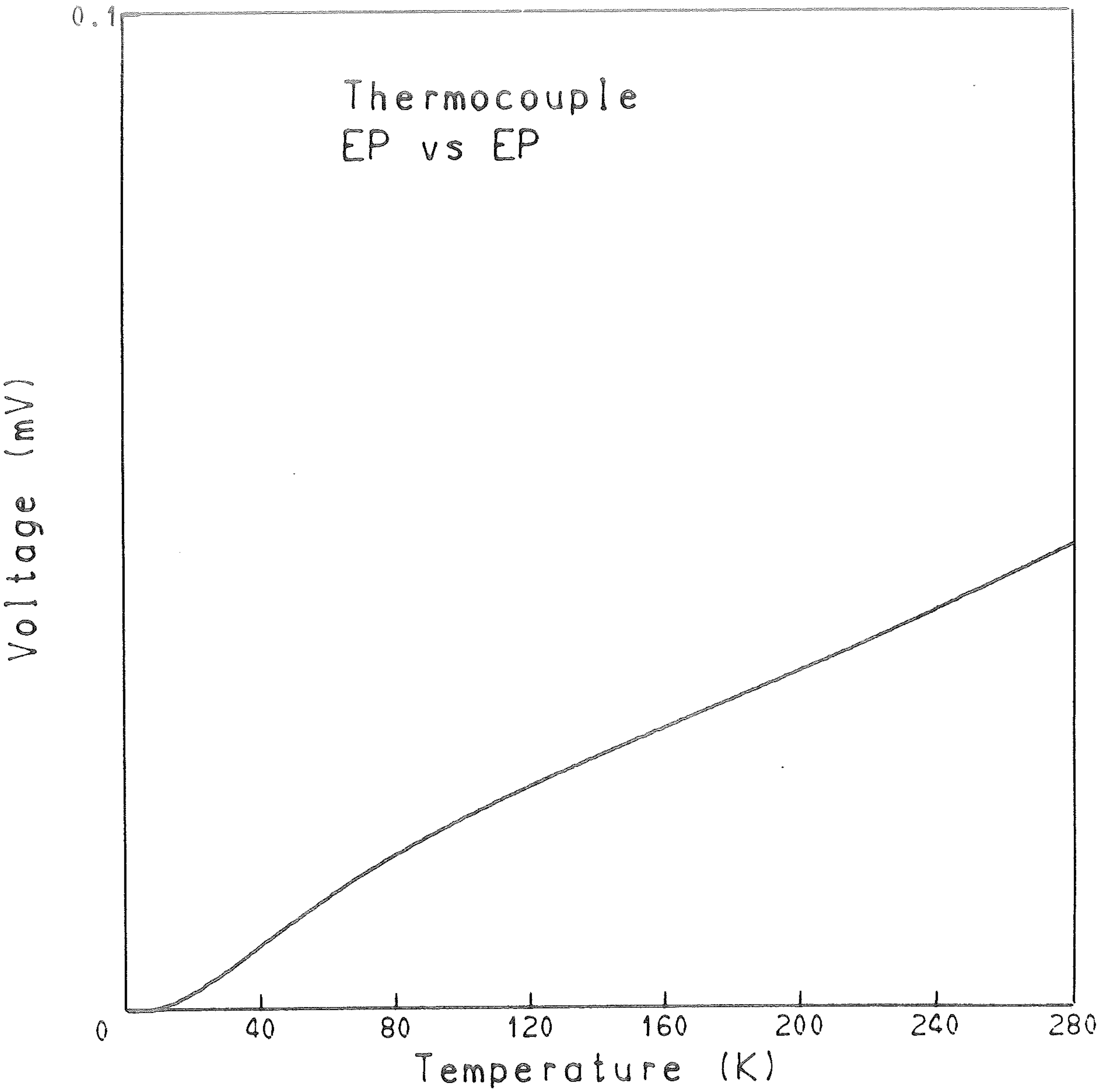

Figure 21 Thermoelectric voltage for Chromel (1) vs Chromel (2)

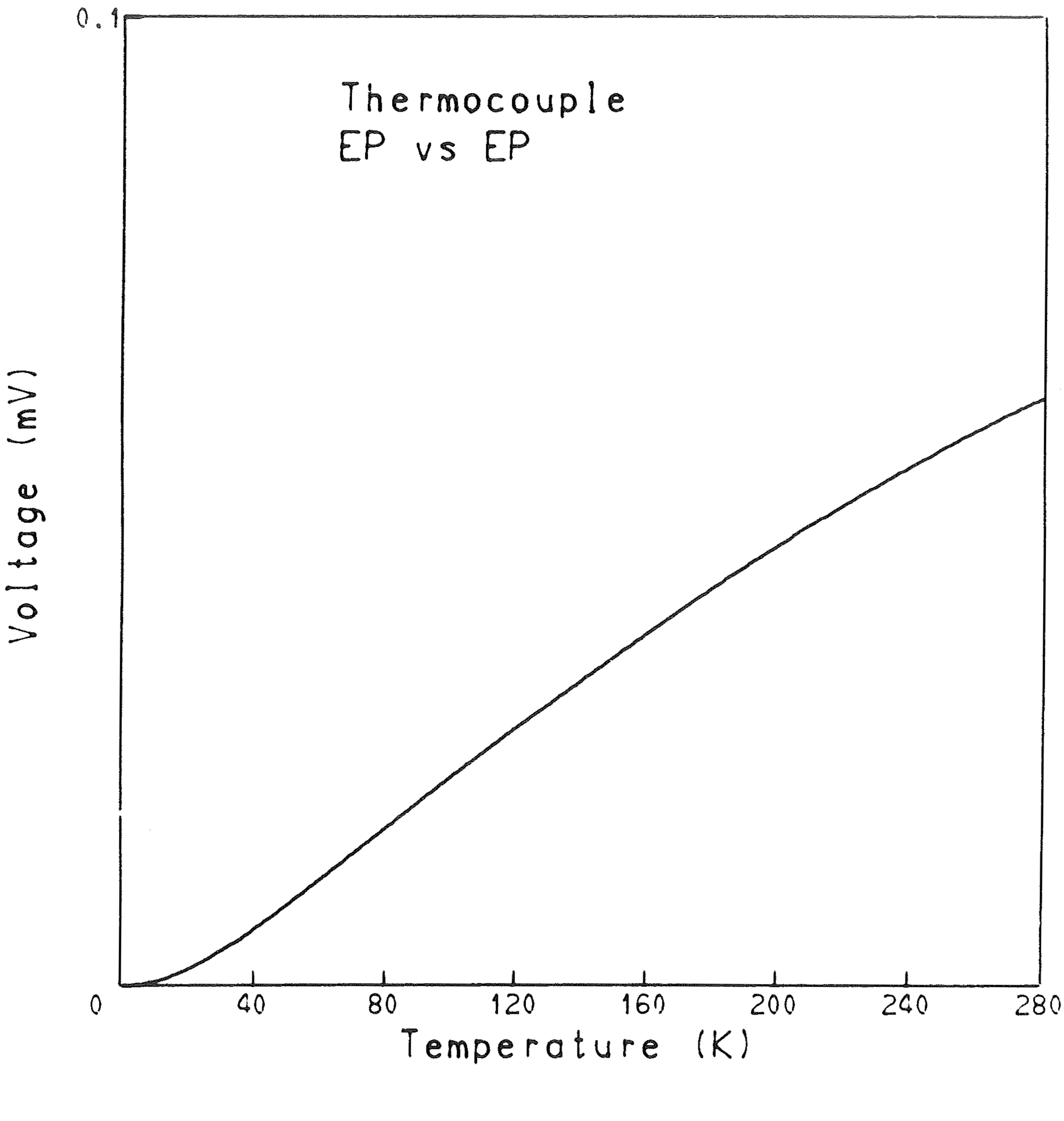

Figure 22 Thermoelectric voltage for Chromel (2) vs Chromel (3)

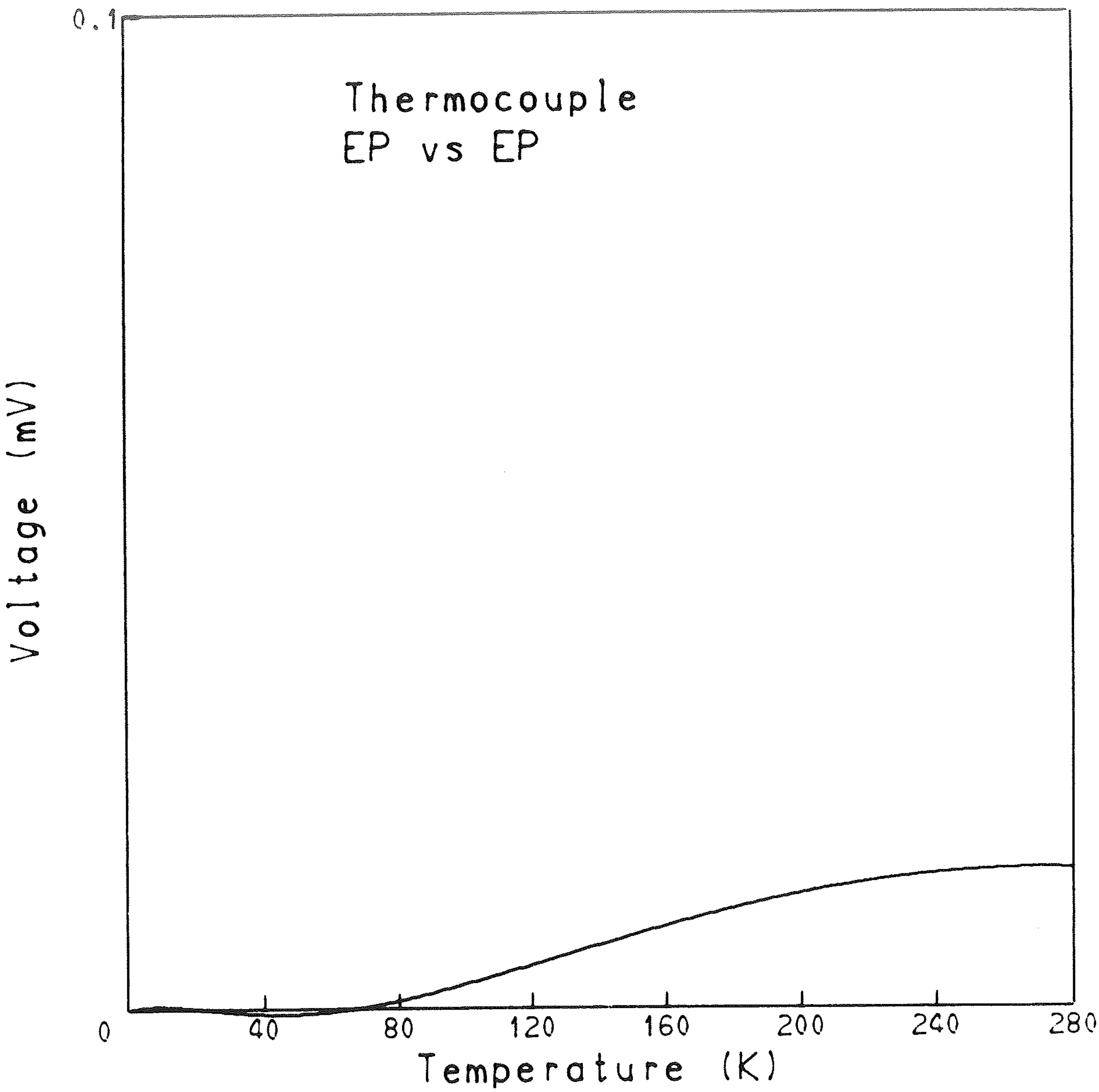

Figure 23 Thermoelectric voltage for Chromel (1) vs Chromel (3)

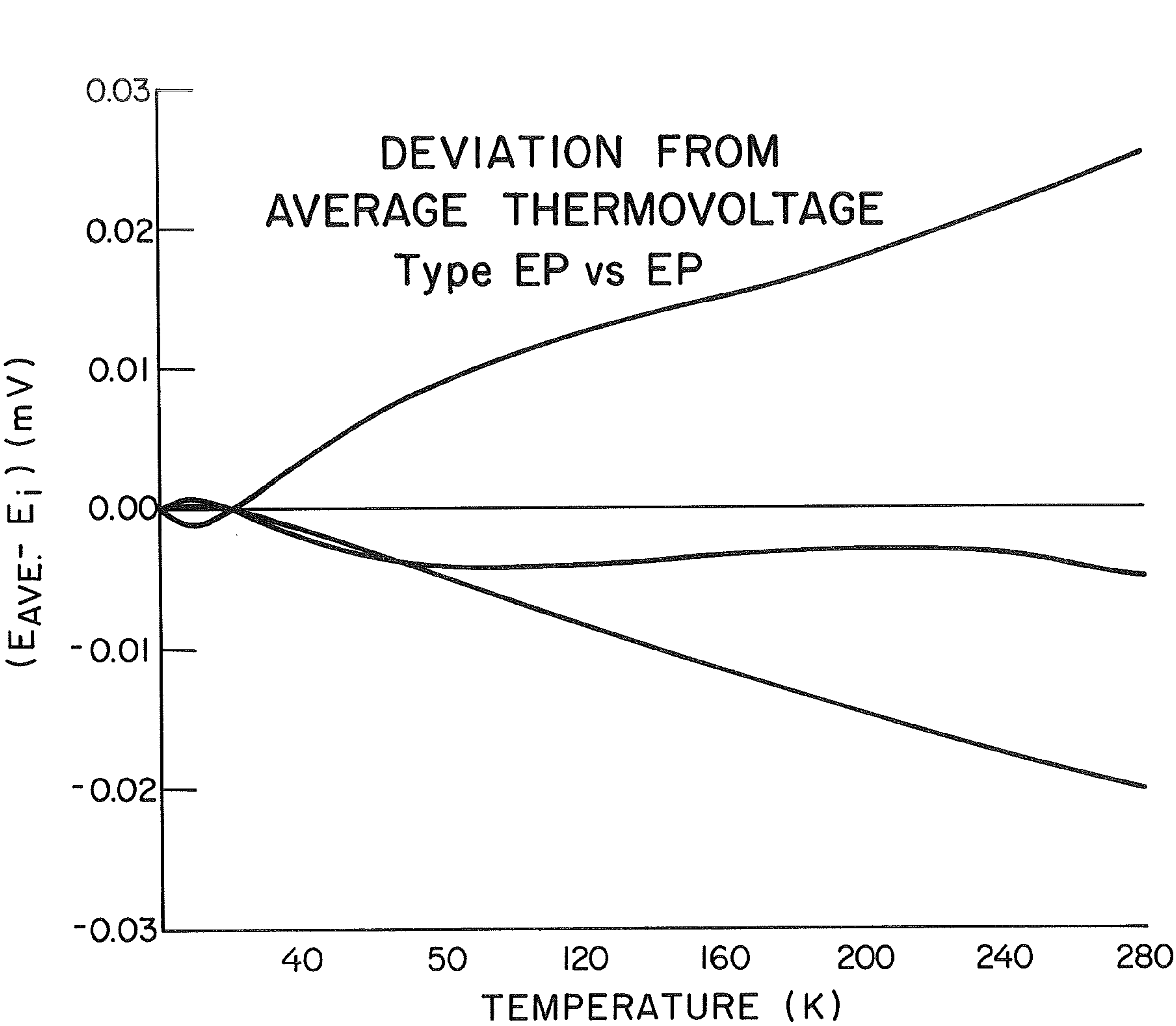

Figure 24 Deviations of individual thermovoltages from group average for Chromel.

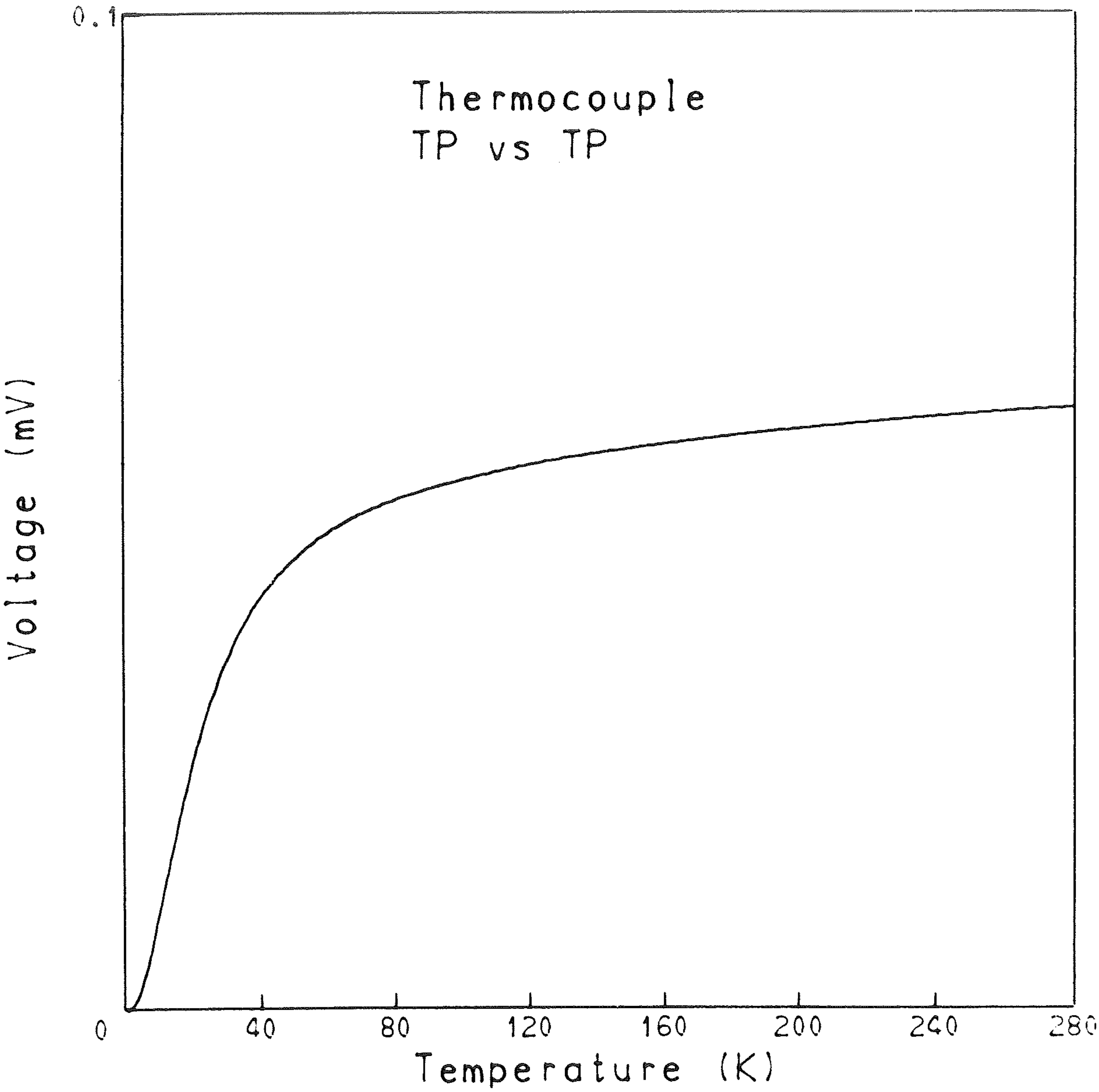

Figure 25 Thermoelectric voltage for copper (1) vs copper (2)

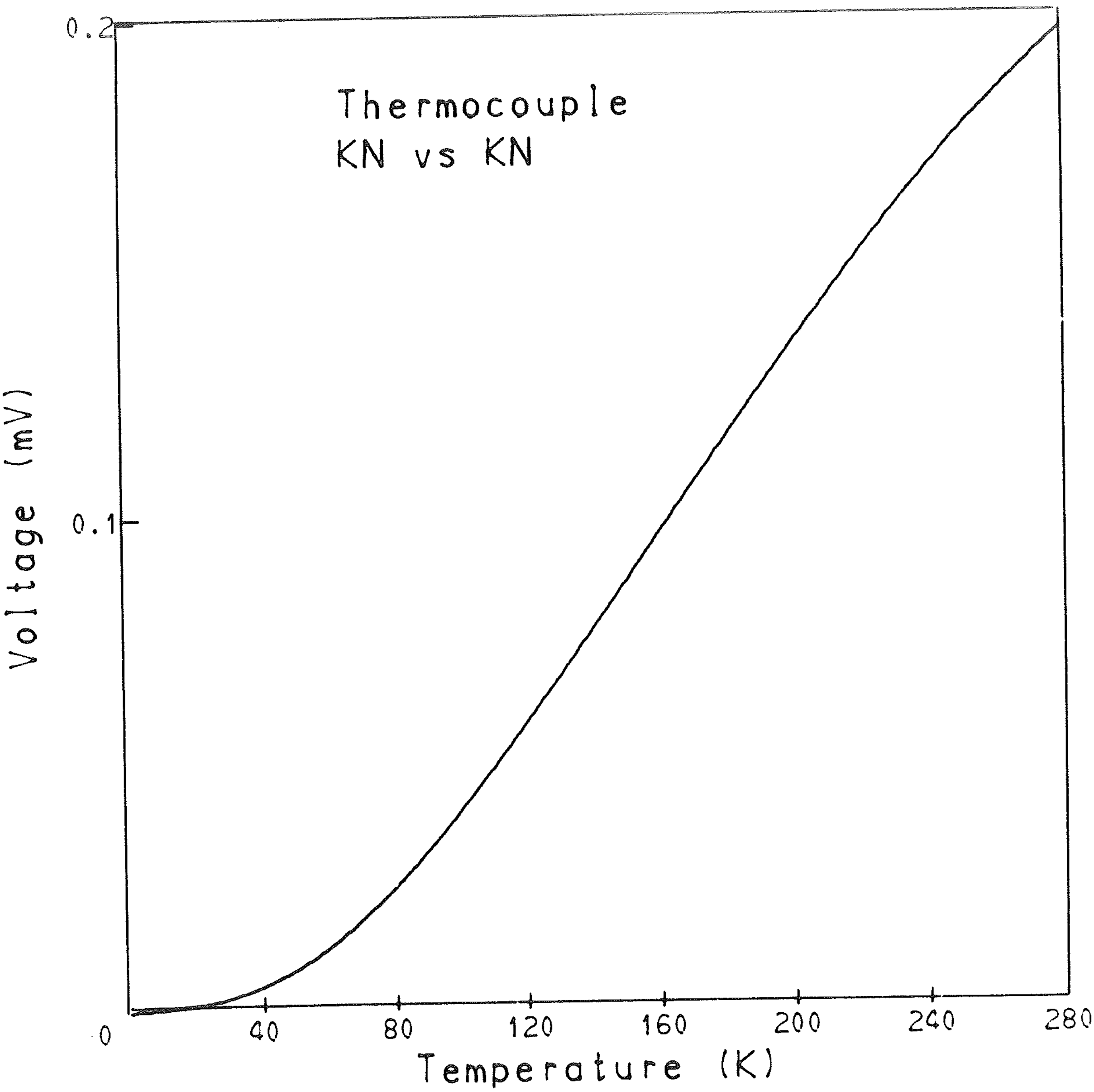

Figure 26 Thermoelectric voltage for Alumel (1) vs Alumel (2).

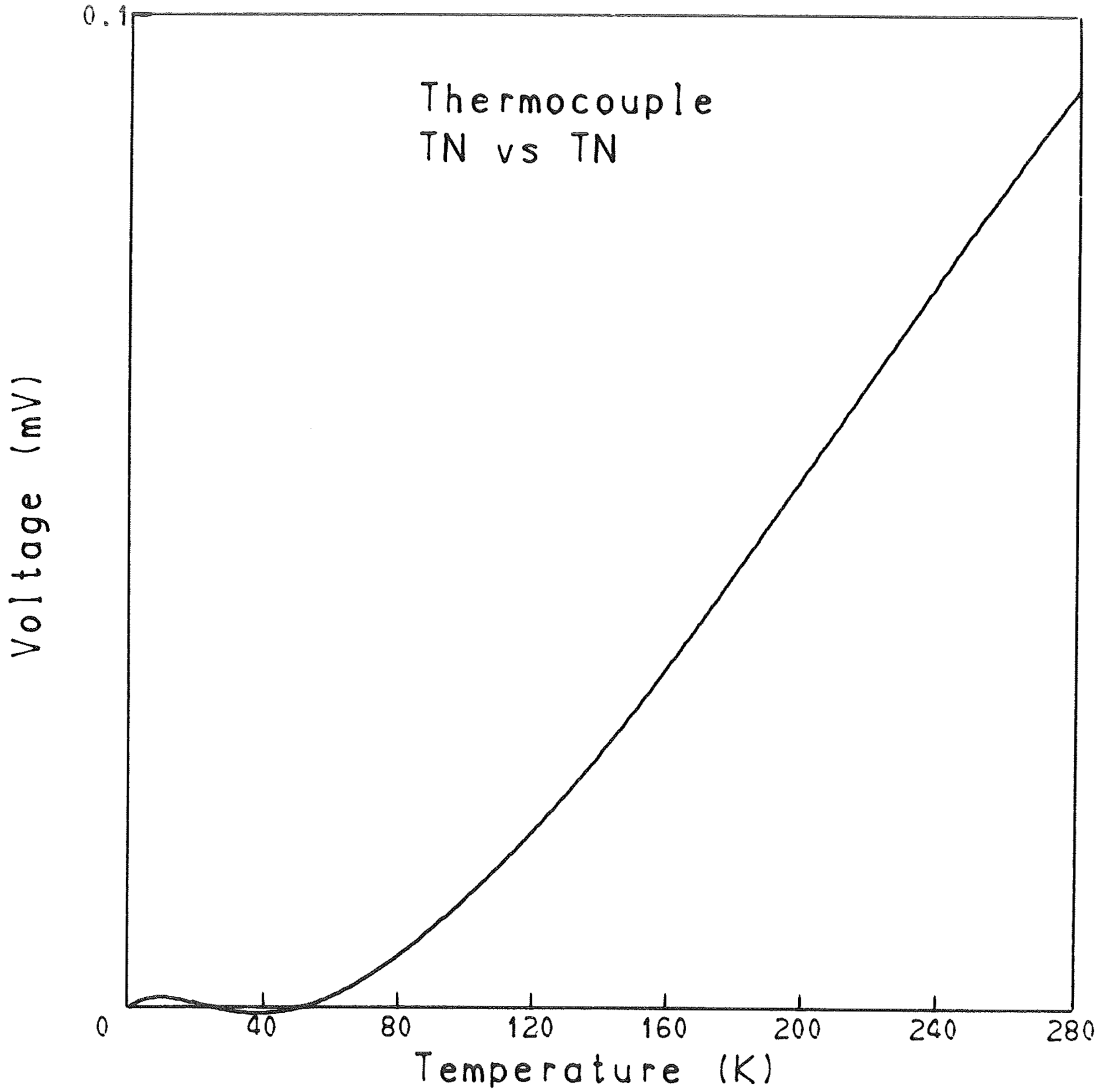

Figure 27 Thermoelectric voltage for constantan (1) vs constantan (2)

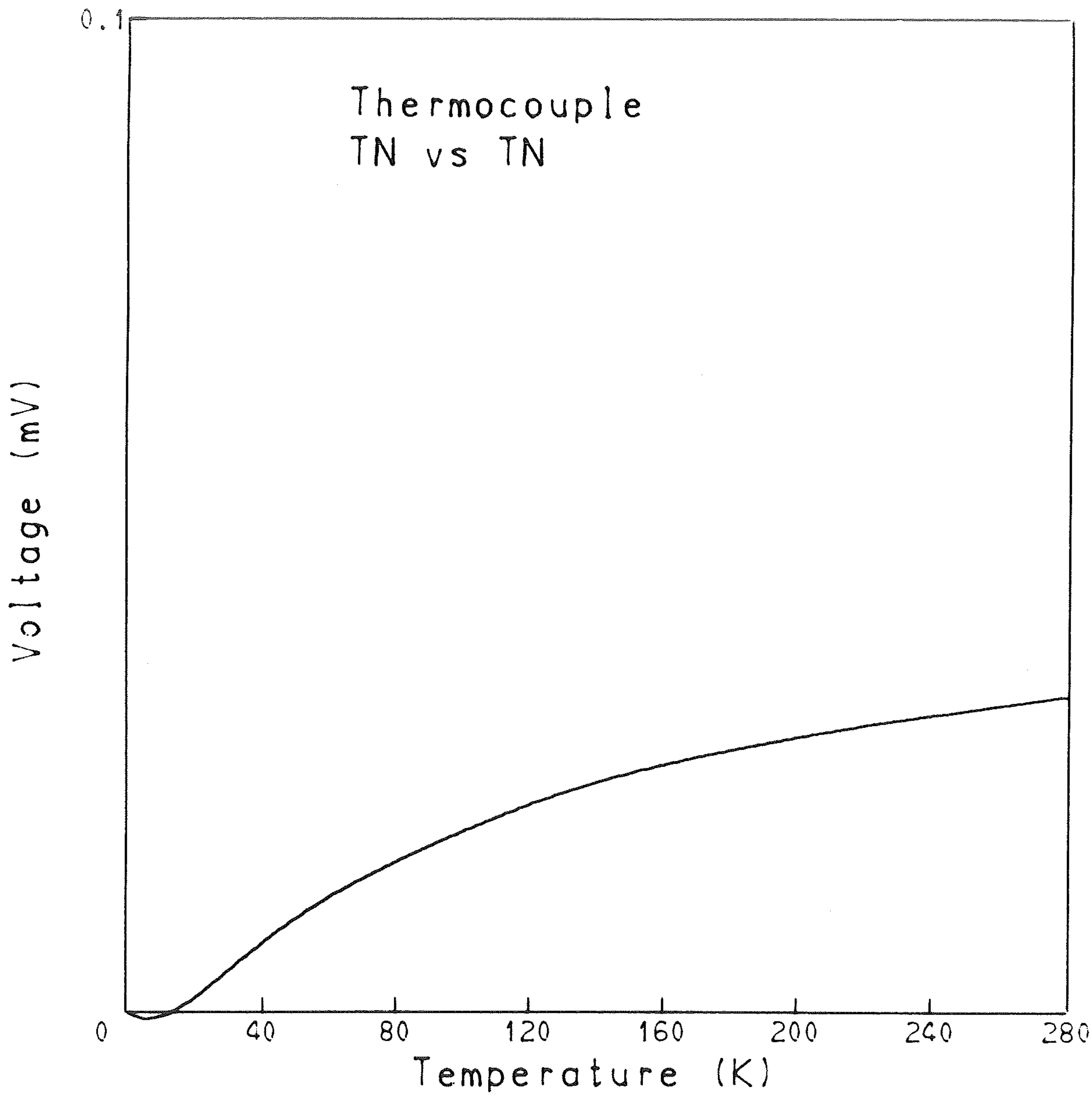

Figure 28 Thermoelectric voltage for constantan (2) vs constantan (3)

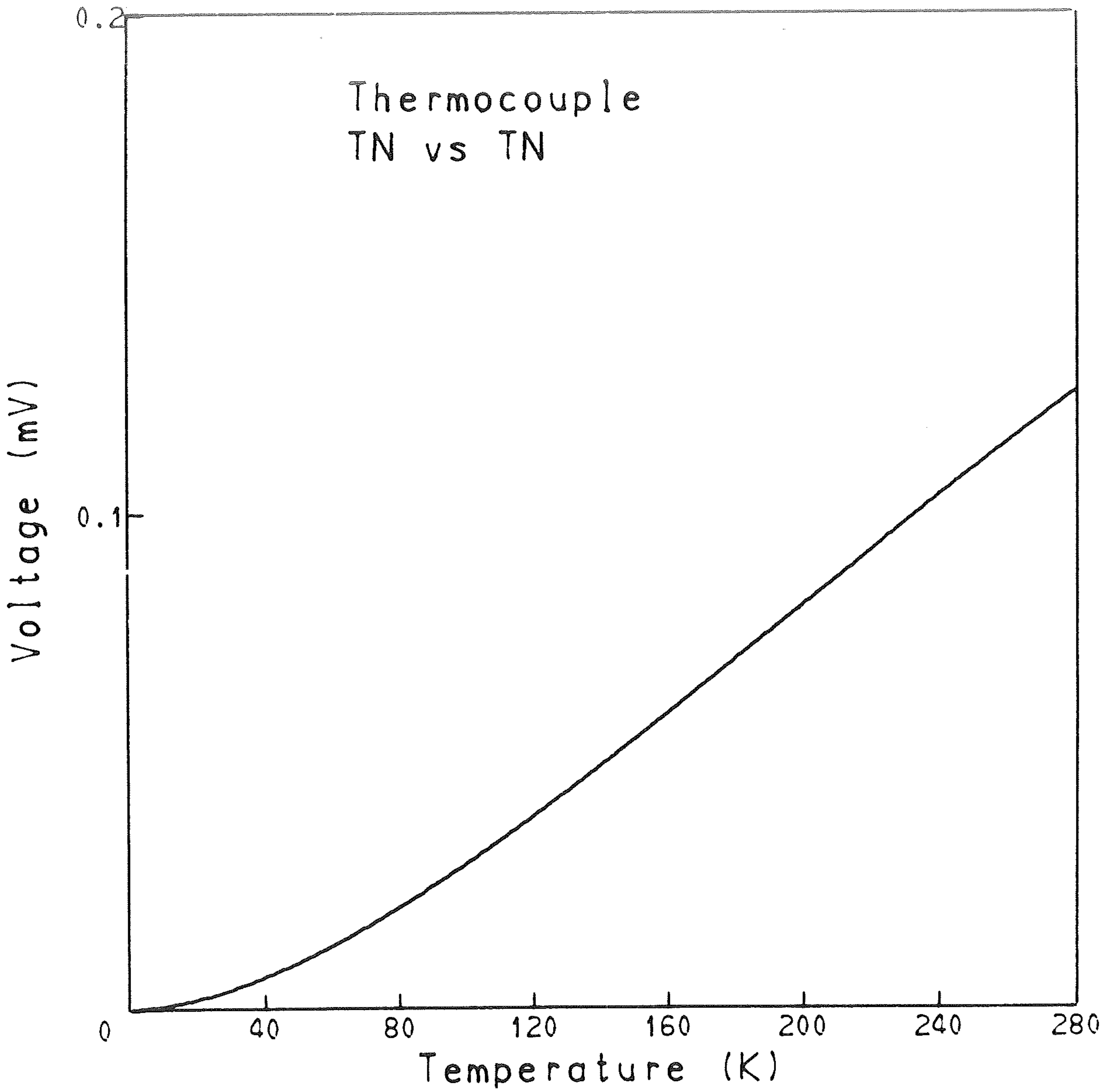

Figure 29 Thermoelectric voltage for constantan (1) vs constantan (3)

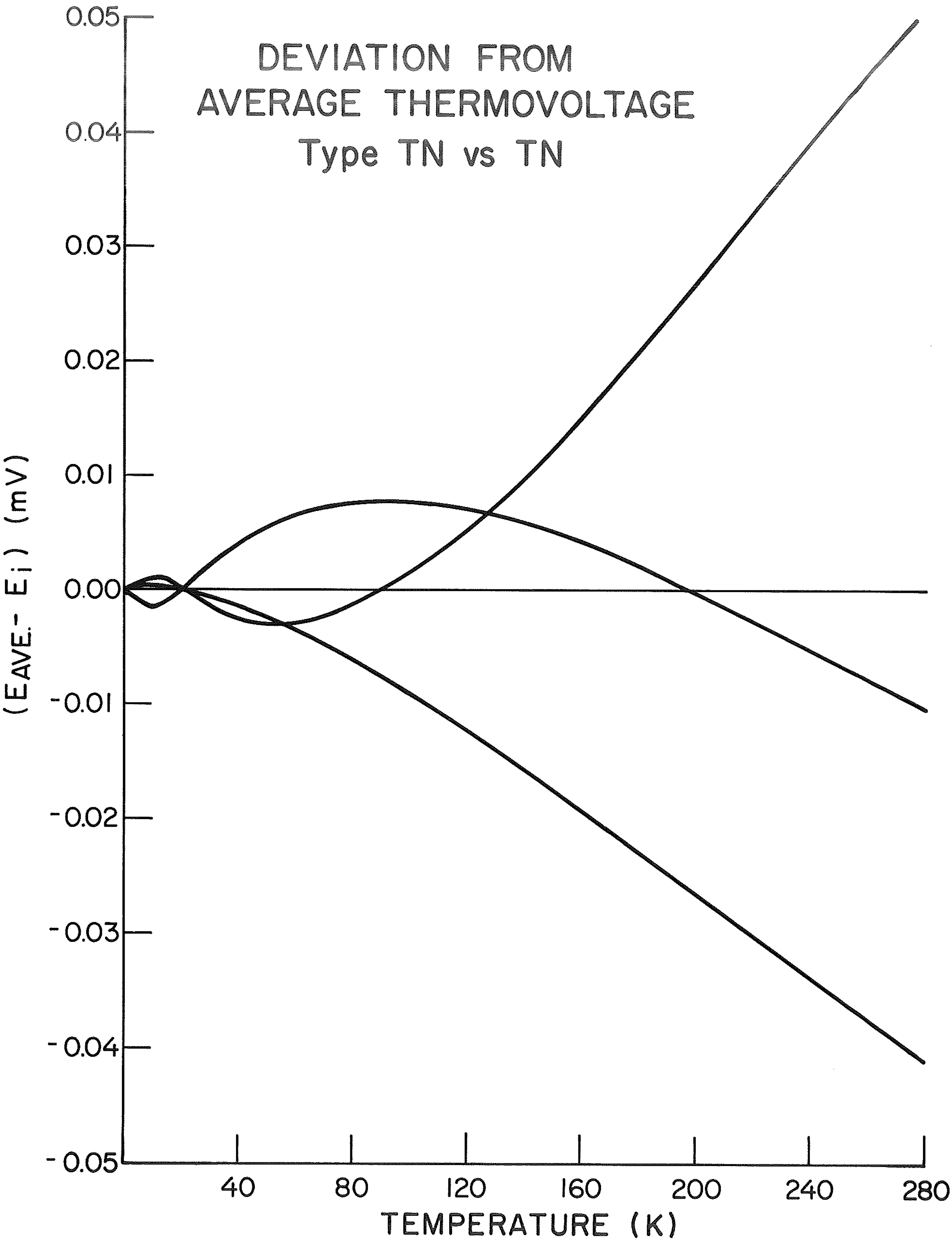

Figure 30 Deviation of individual thermovolatges from group average for constantan

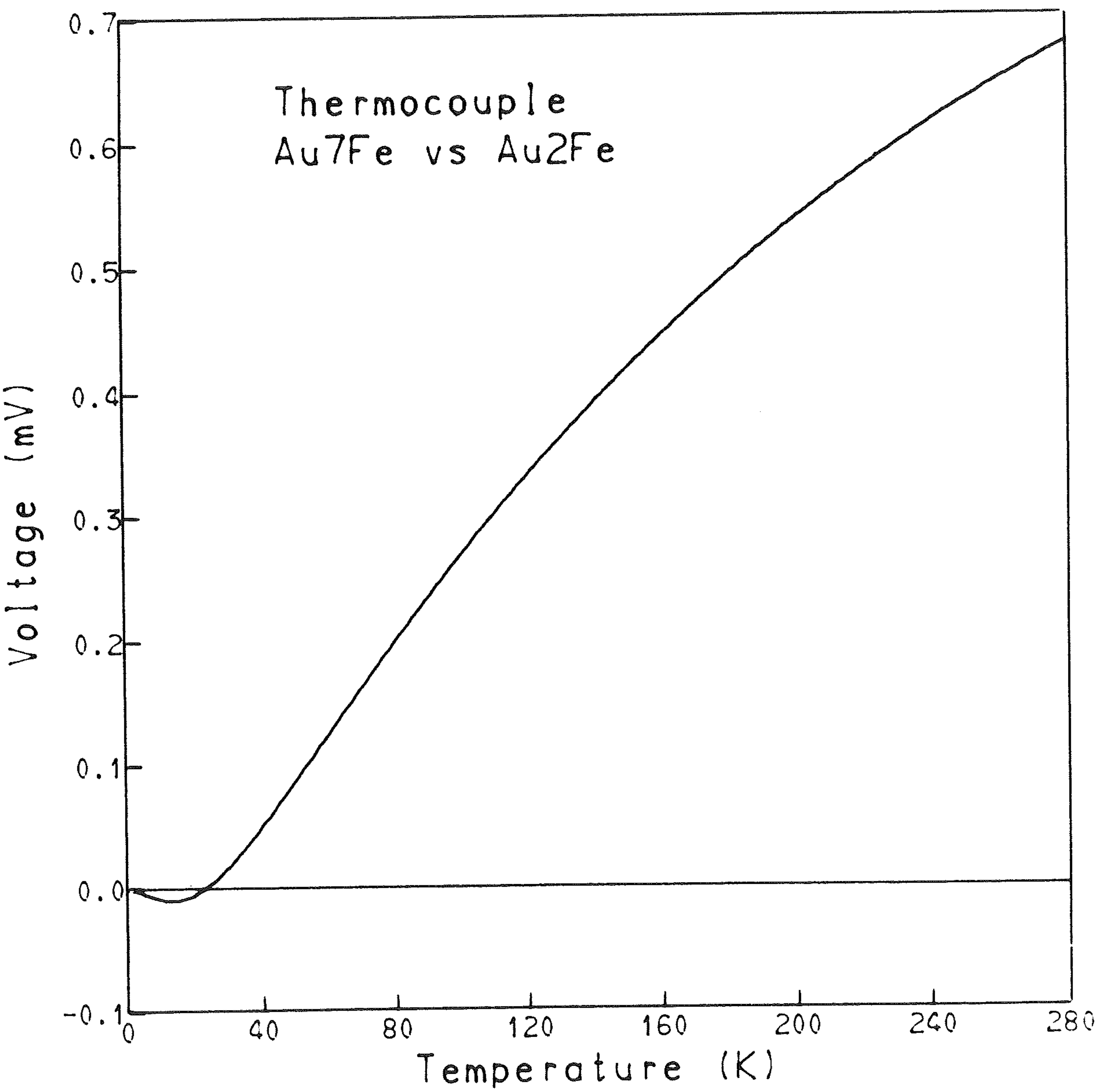

Figure 31 Thermoelectric voltage for gold-0.07 at.% iron vs gold-0.02 at. % iron

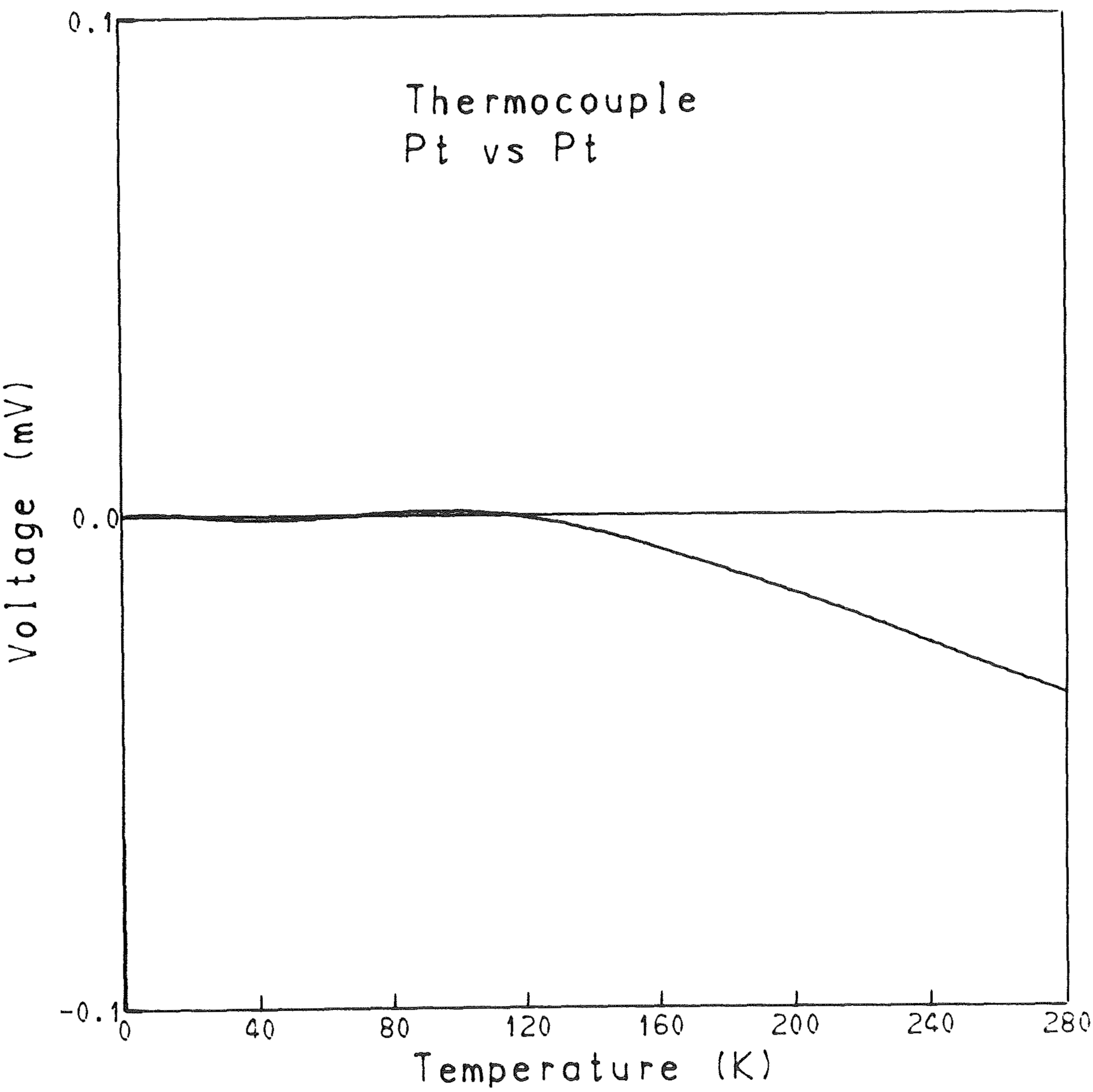

Figure 32 Thermoelectric voltage for annealed platinum vs unannealed platinum

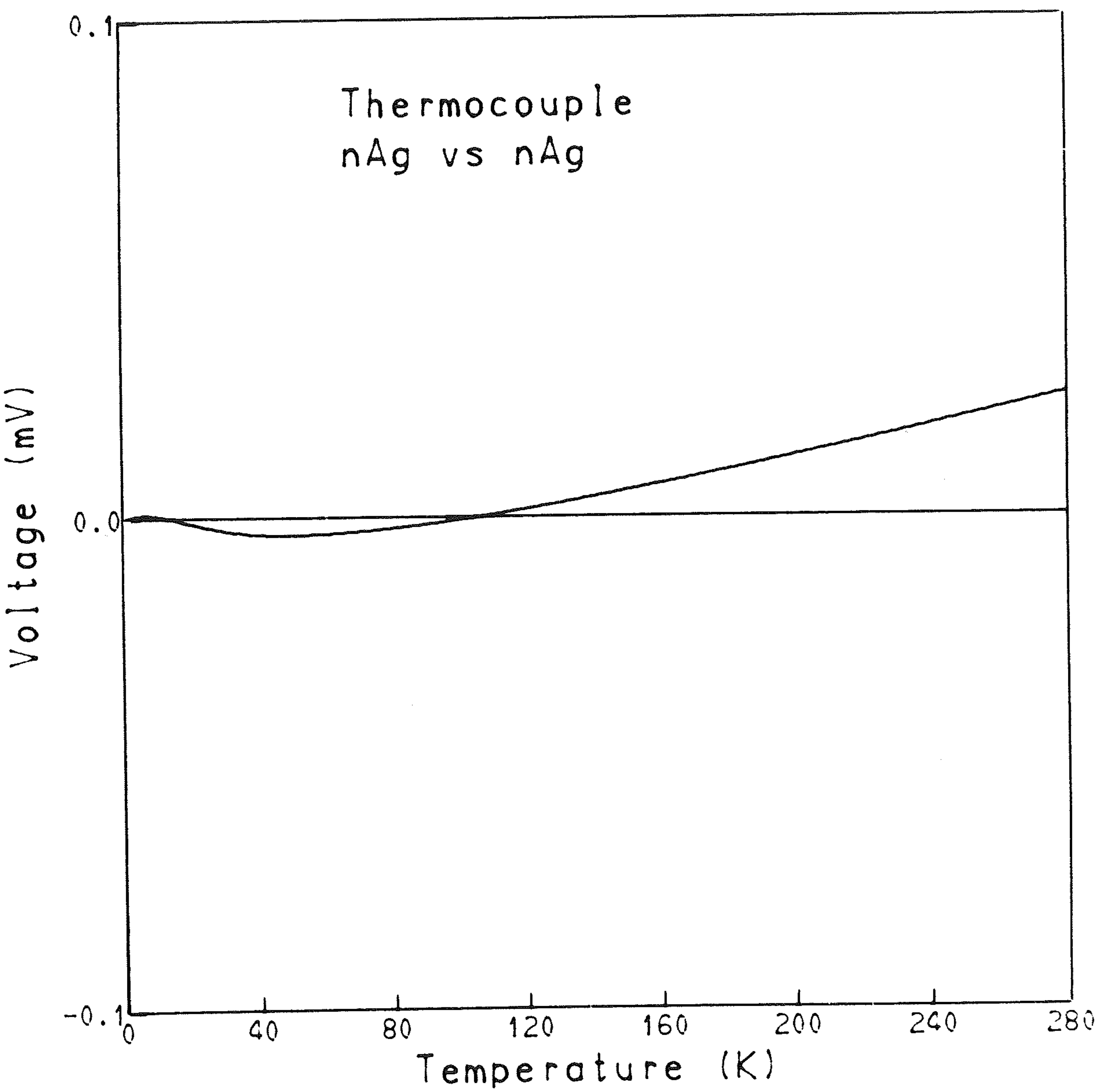

Figure 33 Thermoelectric voltage for annealed "normal" silver vs unannealed "normal" silver

$$F(1) = 2.62699813461*10^{-3}\ T$$

$$F(2) = [3.21644939212*10^{-5}\ T - 1.11693281748*10^{-2}\ ]T$$

$$\begin{aligned} F(3) = {} & [(3.58986173360*10^{-7}\ T - 1.55665286232*10^{-4}\ )T \\ & + 1.81137186628*10^{-2}\ ]T \end{aligned}$$

$$\begin{aligned} F(4) = {} & [([5.34727798756*10^{-9}\ T - 3.04978248031*10^{-6}\ ]T \\ & + 5.54625790795*10^{-4}\ )T - 3.34631223797*10^{-2}\ ]T \end{aligned}$$

$$\begin{aligned} F(5) = {} & [([(6.07093013715*10^{-11}\ T - 4.27373422008*10^{-8}\ )T \\ & + 1.07117698644*10^{-5}\ ]T - 1.13757942812*10^{-3}\ )T + 4.64537228886*10^{-2}\ ]T \end{aligned}$$

$$\begin{aligned} F(6) = {} & [([([8.82359212161*10^{-13}T - 7.28186199261*10^{-10}]T \\ & + 2.24765904282*10^{-7}\ )T - 3.18943408270*10^{-5}\ ]T + 2.05429286434*10^{-3}\ )T \\ & - 5.17871198112*10^{-2}\ ]T \end{aligned}$$

$$\begin{aligned} F(7) = {} & [([([(1.33824082457*10^{-14}T - 1.32030883347*10^{-11}\ )T \\ & + 5.13280189141*10^{-9}\ ]T - 9.93378385912*10^{-7}\ )T + 9.92080547172*10^{-5}\ ]T \\ & - 4.75674883206*10^{-3}\ )T + 8.88149787156*10^{-2}\ ]T \end{aligned}$$

$$\begin{aligned} F(8) = {} & [([([([1.91122488586*10^{-16}T - 2.16756712456*10^{-13}]T \\ & + 1.00341211234*10^{-10})T - 2.43627392132*10^{-8}\ ]T + 3.31519537388*10^{-6}\ )T \\ & - 2.49826333327*10^{-4}\ ]T + 9.57847982898*10^{-3}\ )T - 1.50658460622*10^{-1}\ ]T \end{aligned}$$

$$\begin{aligned} F(9) = {} & [([([([(2.92664884243*10^{-18}T - 3.70219405097*10^{-15})T \\ & + 1.95708484602*10^{-12}]T - 5.60572545443*10^{-10})T + 9.43371886071*10^{-8}\ ]T \\ & - 9.45983561819*10^{-6}\ )T + 5.47473023495*10^{-4}\ ]T - 1.67836957950*10^{-2}\ )T \\ & + 2.24869753823*10^{-1}\ ]T \end{aligned}$$

Table 6 The orthonormal polynomials $F_n(T)$

$$F(10) = [([([([([3.95801534382*10^{-20}T - 5.60568859106*10^{-17}]T$$
$$+ 3.38786223933*10^{-14})T - 1.13998063262*10^{-11}]T + 2.33700771017*10^{-9})T$$
$$- 3.00187384267*10^{-7}]T + 2.39434643671*10^{-5})T - 1.13590924597*10^{-3}]T$$
$$+ 2.93458112010*10^{-2})T - 3.46535708754*10^{-1}]T$$

$$F(11) = [([([([([(5.38516736601*10^{-22}T - 8.32331470995*10^{-19})T$$
$$+ 5.56674670636*10^{-16}]T - 2.11051706773*10^{-13})T + 4.99234280040*10^{-11}]T$$
$$- 7.64420856213*10^{-9})T + 7.61267444043*10^{-7}]T - 4.83150710271*10^{-5})T$$
$$+ 1.86327527031*10^{-3}]T - 4.00410161322*10^{-2})T + 4.09499105085*10^{-1}]T$$

$$F(12) = [([([([([([8.26232811079*10^{-24}T - 1.39942629861*10^{-20}]T$$
$$+ 1.03886749337*10^{-17})T - 4.44101985907*10^{-15}]T + 1.20800316490*10^{-12})T$$
$$- 2.18094014408*10^{-10}]T + 2.64618560604*10^{-8})T - 2.13895663004*10^{-6}]T$$
$$+ 1.11909300262*10^{-4})T - 3.59443137275*10^{-3}]T + 6.49353202556*10^{-2})T$$
$$- 5.70479386855*10^{-1}]T$$

$$F(13) = [([([([([([(1.25461027145*10^{-25}T - 2.30105779284*10^{-22})T$$
$$+ 1.87043885148*10^{-19}]T - 8.87601372259*10^{-17})T + 2.72632243976*10^{-14}]T$$
$$- 5.67999046167*10^{-12})T + 8.17908913314*10^{-10}]T - 8.14274313875*10^{-8})T$$
$$+ 5.51731174858*10^{-6}]T - 2.46158777788*10^{-4})T + 6.84002302040*10^{-3}]T$$
$$- 1.08288591279*10^{-1})T + 8.46075126398*10^{-1}]T$$

$$F(14) = [([([([([([([1.85341453474*10^{-27}T - 3.66081814236*10^{-24}]T$$
$$+ 3.23482126555*10^{-21})T - 1.68761557726*10^{-18}]T + 5.77754988256*10^{-16})T$$
$$- 1.36460361321*10^{-13}]T + 2.27598282316*10^{-11})T - 2.69808964571*10^{-9}]T$$
$$+ 2.25818509834*10^{-7})T - 1.30847059620*10^{-5}]T + 5.06916388647*10^{-4})T$$
$$- 1.24180968293*10^{-2}]T + 1.76154785795*10^{-1})T - 1.25353229615]T$$

Table 6 (cont.) The orthonormal polynomials $F_n(T)$

COEFFICIENT	KP VS AU-2FE	TP VS AU-7FE	TP VS AU-2FE	PT VS AU-2FE	NAG VS AU-2FE
A(1)	6903.629	1693.498	773.859	331.450	582.298
A(2)	561.689	-588.436	-460.685	-1156.211	-446.509
A(3)	-34.229	164.429	212.321	88.726	216.461
A(4)	-80.516	-36.578	-101.039	6.735	-120.439
A(5)	76.223	10.194	64.488	18.983	79.945
A(6)	-32.830	-1.033	-24.888	-21.385	-28.320
A(7)	9.423	-1.980	7.435	12.849	5.231
A(8)	2.385	3.617	1.298	-2.735	4.976
A(9)	-7.269	-4.440	-5.612	-5.021	-8.127
A(10)	8.928	5.135	7.622	8.666	9.073
A(11)	-6.388	-3.719	-5.779	-6.822	-6.215
A(12)	3.827	2.521	3.854	4.468	3.578
A(13)	-2.000	-1.598	-2.316	-2.349	-1.900
A(14)	0.833	0.760	1.098	0.797	0.693

Table 7 Coefficients for a polynomial expansion representation of the thermocouple data for Chromel vs gold-0.02 at.% iron, copper vs gold-0.07 at.% iron, copper vs gold-0.02 at.% iron, platinum vs gold-0.02 at.% iron, and "normal" silver vs gold-0.02 at.% iron.

NUMBER OF COEFFICIENTS	KP VS AU2FE	TP VS AU7FE	TP VS AU2FE	PT VS AU2FE	NAG VS AU2FE
4	10.8	1.8	9.0	4.4	11.1
5	4.8	1.2	3.7	3.7	4.2
6	2.2	1.2	1.9	2.4	2.1
7	1.9	1.2	1.6	1.8	2.0
8	1.8	1.1	1.6	1.8	1.9
9	1.6	0.95	1.4	1.6	1.6
10	1.1	0.66	1.0	1.2	1.0
11	0.62	0.44	0.65	0.72	0.58
12	0.34	0.27	0.38	0.39	0.32
13	0.20	0.16	0.21	0.22	0.18
14	0.16	0.12	0.15	0.19	0.16

Table 8 Standard deviation (in microvolts) for various orders of polynomial expansions for Chromel vs gold-0.02 at.% iron, copper vs gold-0.07 at.% iron, copper vs gold-0.02 at.% iron, platinum vs gold-0.02 at.% iron, and "normal" silver vs gold-0.02 at.% iron.

ERROR CRITERIA (MICROVOLTS)	EP VS AU-2FE	TP VS AU-7FE	TP VS AU-2FE	PT VS AU-2FE	NAG VS AU-2FE
0.005	13(40)	13(40)	13(40)	13(40)	13(40)
0.05	11(36)	11(36)	12(37)	11(36)	11(36)
0.5	11(34)	11(34)	11(34)	11(34)	10(33)
5.0	10(30)	10(30)	10(30)	10(30)	10(30)
50.0	8(25)	8(25)	9(27)	8(25)	8(25)

Table 9 Number of digits necessary in computations to reduce round-off errors below certain limits for Chromel vs gold-0.02 at.% iron, copper vs gold-0.07 at.% iron, copper vs gold-0.02 at.% iron, platinum vs gold-0.02 at.% iron and "normal" silver vs gold-0.02 at.% iron. Decimal digits not in parentheses, binary digits in parentheses.

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