THERMOPOWER OF METALS IN HIGH MAGNETIC FIELDS

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Chwan-Kang Chiang

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[signature]
Major professor

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ABSTRACT

THERMOPOWER OF METALS IN HIGH MAGNETIC FIELDS

By

Chwan-Kang Chiang

The thermopower of polycrystalline Copper, Silver, Gold, Aluminum, Indium and Lead was measured from liquid helium temperature to 100°K in magnetic fields up to 50 kG. Large enhancement of thermopower by the magnetic field was found and a peak in the temperature dependence of $\Delta S(H,T)$ was observed for the first time. The field results in a large enhancement of the phonon-drag thermopower in contrast to early expectation of MacDonald and Pearson.

We have developed two theoretical models to explain the observed effects. The electron-diffusion model relies on the well-known Mott formula for the diffusion-thermopower, and Wiedemann-Franz law. The phonon-drag model is based on the semiclassical electron dynamics in a magnetic field, and also a concept from Pippard. It is found that these two models together can give a good explanation of the experimental results.

In the course of these studies we have developed a new technique for measuring thermopower in high magnetic fields. The method measures directly the change of thermopower due to a magnetic field, thereby obviating the problem associated with measurements of temperature in a field, and also

the problem of a proper reference material in a field. By applying this new method to thermocouple wires we have calibrated Chromel-P versus Au-0.07 at.% Fe and Silver Normal versus Au-0.07 at.% Fe thermocouples in magnetic fields. This is of practical importance for studies of thermoelectricity in a magnetic field.

THERMOPOWER OF METALS IN HIGH MAGNETIC FIELDS

By

Chwan-Kang Chiang

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To My Parents

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CHAPTER I

INTRODUCTION

Our program was largely stimulated by interest in the electron-magnon interaction in ferromagnetic metals. Previous studies[1,2] indicated that the electron-magnon interaction played an important role in the transport processes of ferromagnetic metals. Since the study of thermopower is a useful method to understand a scattering process and a magnetic field is a powerful instrument for resolving the degeneracy of the electronic system, it is of interest to see how the electron-magnon interaction responds to the applied magnetic field. Therefore, we needed to measure thermopower in strong magnetic fields in a temperature range from liquid helium temperature to room temperature. This immediately presented us with the problem of temperature measurements in strong magnetic field, which is one of the most difficult techniques in low temperature solid state physics.

In addition to the problem of measuring temperature in a magnetic field, we also faced the difficulty that no thermoelectric standard in non-zero fields was in existence. Normally, the absolute thermopower of a material is established by measuring the thermopower of a couple in which one arm is a metal whose absolute thermopower has been previously determined. However, until now no absolute thermopower at non-zero fields has ever been determined except at temperature below about 18°K when the reference arm of the thermocouple may be superconducting.

Due to the experimental difficulties only few attempts have been made to measure the thermopower of pure metals in a magnetic field. MacDonald and Pearson[3] measured the thermopower of copper and copper alloys in 1957 and concluded that the influence of a magnetic field on a pure monovalent cubic metal is very small and the phonon-drag thermopower will be uneffected by the field.

Recently, Averback, Stephan and Bass[4,5] have produced some evidence that in aluminum and indium not only the electron diffusion thermopower but also the phonon drag thermopower has a field dependence.

By means of the development of a new method, which we call the "difference method" we are able to measure the thermopower of polycrystalline metals in strong magnetic fields at wide temperature range. This now opens the whole field of magnetothermoelectric effects to experimental and theoretical studies. We have made extensive studies on this subject, although only limited results will be reported in this thesis.

In the thesis the new experimental technique, the difference method for thermopower measurement will be described in detail in Chapter II. An important application of this method is to calibrate thermocouple wires in high fields. These calibration results are contained in a reference table entitled "Reference Tables for Low Temperature Thermocouples in Magnetic Fields"[6,7]. The calibration will be described in Chapter III and the reference tables are included in the Appendix.

Six metals which belong to three types of electronic structure were studied. The full experimental details and the results are included in Chapter IV. In Chapter V, we begin with a very brief review of current theories and then we will present two theoretical models to explain the observed results. Finally, in Chapter VI, the results of the calculation will be compared with the experiments.

CHAPTER II

DIFFERENCE METHOD FOR MEASURING THERMOPOWER IN A MAGNETIC FIELD

1. Introduction

There are two basic methods for measuring absolute thermopower: the integral method and the differential method. Many techniques related to these two methods have been developed. A quite complete description of these techniques is given by Barnard.[8]

In the integral thermopower measurement, a constant temperature bath is used which holds one junction of the thermocouple at a known temperature, the other junction is raised in temperature and the total emf measured over the temperature range of interest. To obtain thermopower from the data one differentiates the voltage versus temperature curve. In the differential measurement the thermopower is obtained directly by raising both junctions of thermocouple to the required temperature, and then further increasing one junction by a small temperature ΔT, and measuring the small emf ΔV created. The thermopower at $T+\Delta T/2$ is then simply $\Delta V/\Delta T$. In both methods the absolute thermopower of the sample is obtained in terms of a standard reference used as the other arm of the couple. The accuracy of the two methods is about the same, and depends on the accuracy of measuring emf, temperature and temperature difference.

When a strong magnetic field is present, these conventional methods become very difficult to use. The temperature measurements in a strong field are one major problem. We will discuss this subject in the next chapter. However, even with an adequate thermometer, the experiment is still rather difficult. The reason is that both branches of the thermocouple are in the field and contribute to the measured thermopower. The absolute thermopower of the sample can not be deduced without a known reference.

A common solution to the reference problem is using an alloy. In early work[9,10] it was assumed that the change of thermopower due to a field could be neglected because of the higher resistivity of the alloy. This reference branch introduces, to the result, an unknown uncertainty which increases with increasing applied field. A superconducting material can be used as the reference, if the temperature range of interest is below its transition temperature. This option works at very low temperatures when the field is not very high.

Alternatively, a measurement can be carried out as a function of field at a fixed temperature[11,12]. But, there is a technical difficulty related to the temperature control. A relatively large uncertainty on the thermopower results is, therefore, unavoidable.

A major problem in the measurement of thermopower in a magnetic field is that either the thermocouple or the lead wires must pass through a region of inhomogeneous magnetic field and temperature. This is an experimental necessity which one can not avoid if a conventional method is used. Therefore, a new method is desirable.

We have developed a third method, the difference method, which is a combination of two conventional methods. MacDonald and Pearson[3] had made a similar but complicated system which was not very successful. Our method is an improved version of their technique. We are able to circumvent both temperature and reference problems and obtain directly the thermopower difference due to the magnetic field. This method is relatively simple and powerful.

In this chapter we will describe the difference method in detail. The description is divided into five sections: design, cryostat, experimental procedure, data analysis, and application and improvement.

2. Principle and Design

If two different metals A and B are connected as shown in Fig. 2.1a, and if the two junctions are kept at different temperatures T_1 and T_2, a thermoelectric emf is developed in the circuit. The thermopower is defined as

$$S_{BA} \equiv S_B - S_A = dV/dT \quad . \qquad (2.1)$$

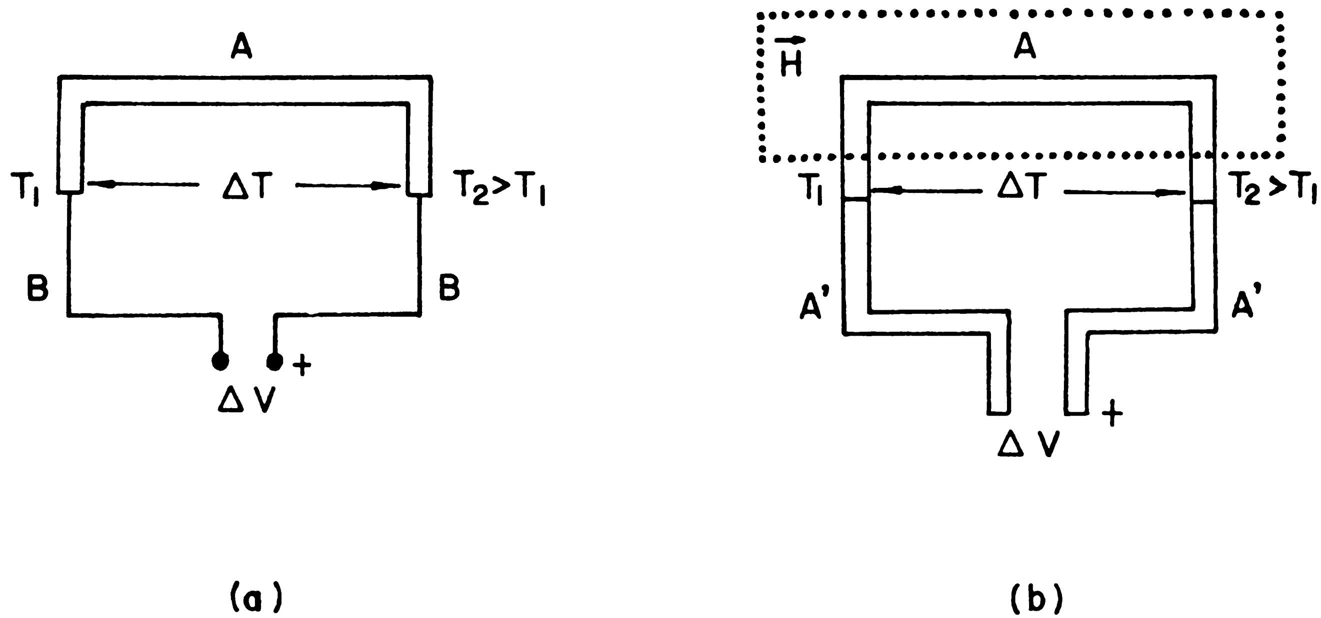

Fig. 2.1 The Principle of the Difference Method for Measuring Thermopower in a Magnetic Field

where S_{BA} is the thermopower of metal B relative to metal A, and S_A and S_B are the absolute thermopowers of metal A and B, respectively. The Seebeck effect still exists, if A and B are the same metal but in a different state. In this work, we let A be in a magnetic field H, and replace B by the same metal A, but in zero magnetic field (denoted by A' in Fig. 2.1b), then

$$S_{AA'} = \Delta S(H,T) = S(H,T) - S(0,T) \qquad (2.2)$$

where T is the temperature of the sample at the limit $\Delta T \to 0$. Equation 2.2 forms the basis of the difference method.

The magnetic field produced by a magnet has its own pattern and extends over a finite region. Since we are unable to restrict the field, our design must adapt to the field profile. A typical field profile of a superconducting magnet is shown in Fig. 2.2b. (An electromagnet can be used equally well with a different sample arrangement.) The arrangement in this type of field is shown graphically in Fig. 2.2b, where we have $T_1 = 4.2°K$ and $T_2 = T$. The temperatures T_1 and T_2 extend over the isothermal range AB and DC, respectively. In other words, the thermoelectric emf generated in the section BC is transmitted to A and D through two isothermal ranges. We recall that no thermoelectric emf can be generated without a temperature gradient.

Hence $V_{AB} = V_{CD} = V_{EF} = 0$ (2.3) and

$$V_{AF} = V_{AB} + V_{BC} + V_{CD} + V_{DE} + V_{EF}$$

$$= V_{BC} - V_{ED}$$

$$= \int_{4.2}^{T} S(H,T')\,dT' - \int_{4.2}^{T} S(0,T')\,dT' \quad (2.4)$$

Differentiating Eq. 2.4, one obtains Eq. 2.2.
There is a non-vanishing voltage V_{AF}, if and only if BC and DE are in a different state. In this design we use the sample itself as reference, which is a meaningful way to detect the change.

In designing a cryostat, we require a cryostat such that the measured voltages to satisfy Eqs. 2.3 and 2.4. Figure 2.2b shows a schematic of the arrangement for a superconducting magnet.

3. Cryostat

Based on the design of Fig. 2.2b, we have constructed the cryostat shown schematically in Fig. 2.3. A typical magnetic field profile in relation to the cryostat configuration and to the magnet is shown to scale in Fig. 2.2.

Our cryostat is suspended such that point C is in the central field region of the solenoid used to generate the magnetic field. The distance C-D is made sufficiently great (17 cm in our case) so that point D is located in the weak fringing field of the solenoid. Measurements for our magnets

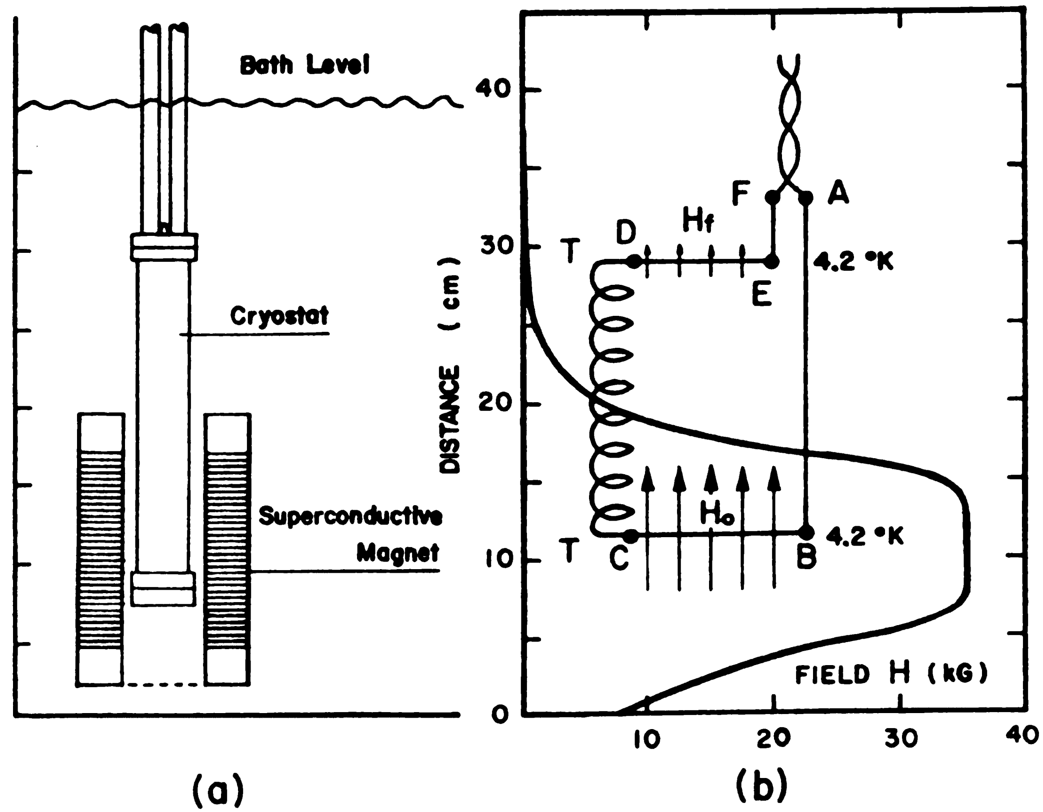

Fig. 2.2 The Relation between the Sample, the Cryostat, the Superconducting Magnet and a Typical Magnetic Field Profile

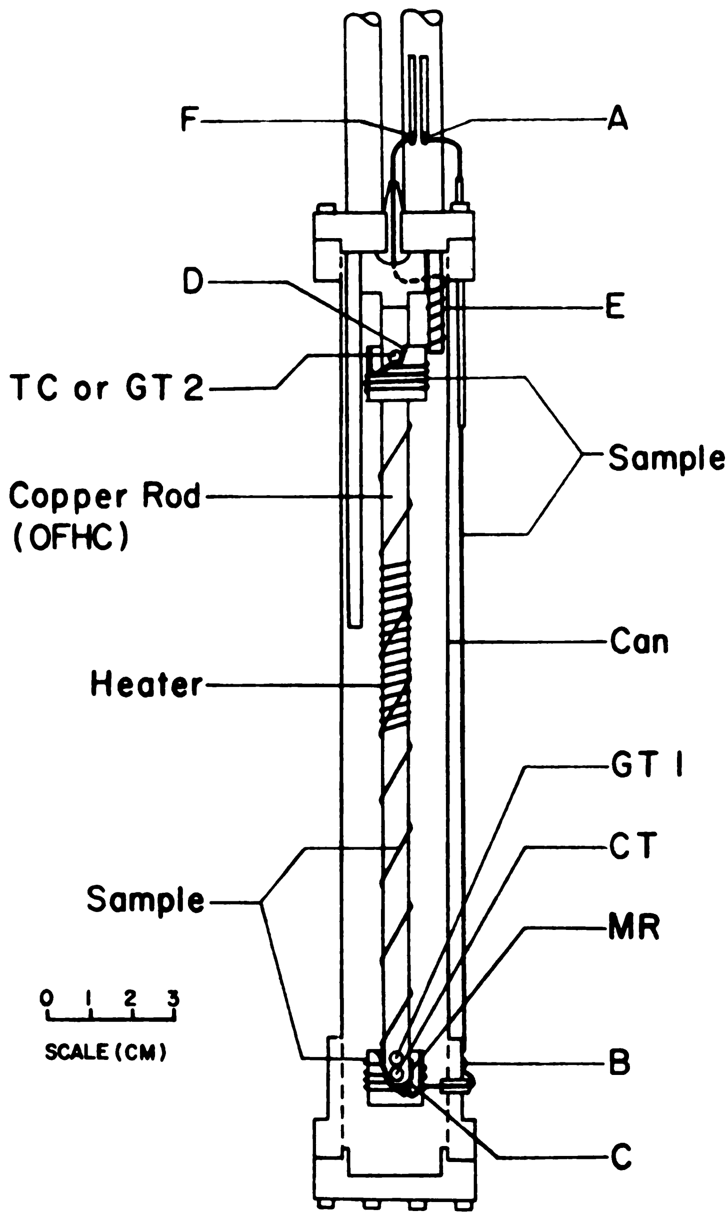

Fig. 2.3 The Schematic Representation of the $\Delta S(H,T)$ Cryostat

showed that the field at D was between 3 and 4% of the central field H_o . For H_o equal to 50 kG the fringing field is 1.7 kG.

The sample wire, approximately 2 meters in length, is attached to the measuring leads at points A and F. Both of these junctions are submerged in the liquid helium bath, and they are in close proximity to each other, and hence in the same fringing field. The sample is then brought into the high field region isothermally, in contact with the helium bath (section A-B). At point B the sample wire enters the vacuum can through an epoxy feed-through. At least three turns (longer than 20 cm) of the wire are wound on the can to insure the sample junction is truly at the bath temperature. Inside the can the sample wire is thermally anchored at C and D and along the entire length C-D, to a 0.635 cm diameter, 18 cm long OFHC copper rod attached to the top flange by a thermally insulating support. The temperature of this rod can be controlled by a heater wound near its center. Finally, the wire is brought back to the bath temperature along D-E, passes through another epoxy feed-through into the helium bath and is attached to the measuring lead at F. Point E is a copper binding post which is near the bath temperature.

The two sections of the continuous wire which have a temperature gradient are each coiled about the vertical axis on a paper form and are about 20 to 50 cm in length, thus reducing the heat loss by conduction to the helium bath. Though this is not such an important consideration in some measurements, it proved essential in measurements on pure metals. The use of these coils also assures that the magnetic field is normal to the sections of wire with the temperature gradient.

The temperature of the copper rod was measured by means of a Chromel P versus Gold-0.07 at.% Iron thermocouple, attached to the rod at point D, in the weak fringing field. At high fields when the effect of the fringing field on the thermocouple could not be ignored, the temperature was corrected by using our results. To determine if the copper rod was, indeed, at uniform temperature, we employed a differential thermocouple attached at points C and D.

The various thermocouple voltages were measured with a Keithley Model 180 digital nanovoltmeter and a Keithley Model 147 nanovoltmeter. The thermocouple for measuring the temperature T was read by a digital voltmeter with 1 micro-volt resolution. Magnetic fields were produced by an Oxford superconducting solenoid for fields below 50 kG and a RCA solenoid for fields up to 100 kG.

4. Experimental Procedure

4.1 Tests

Prior to the start of the experiments, we had made various tests to make sure the apparatus did work as we expected.

The major test was to determine the temperature difference along the copper rod. Two calibrated germanium resistance thermometers (GT 1 and GT 2 in Fig. 2.3) were mounted on the two ends of the copper rod. The tests were made under various conditions: with and without sample, good vacuum and bad vacuum in the can, heater on and heater off, temperature increasing and decreasing, etc. A small amount of exchange gas (< 10 micron) did help to keep the temperature difference small. Also the heat flow through the sample should be reduced as much as possible.

The germanium resistor thermometer, GT 1, does change calibration in a magnetic field. We, therefore, also used a capacitance thermometer, CT, located adjacent to GT 1 to determine the magnitude of the temperature difference along the copper rod in a magnetic field. The result of the above tests indicated that, although there were small temperature gradients along the copper rod, the temperature differences between C and D never exceeded 5% of the temperature of the rod, and was at all times less than 1°K.

After these tests, GT 2 was replaced by a Chromel-P vs Au-0.07 at.%Fe thermocouple. This is possible because the thermocouple has small field dependence in low fields. (see Chapter III). We used a differential thermocouple to measure the temperature difference along the rod and removed all germanium thermometers and capacitance thermometer. This arrangement made the measurements more efficient and reduced the thermal leakage.

Since the thermopower of this thermocouple is increasing in a magnetic field, the voltage reading of the differential thermocouple gives a upper limit on the temperature gradient. (If the calibration tables are used, we can obtain a correct result of the temperature gradient). A typical result of the temperature gradients along the copper rod as a function of temperature is shown in Fig. 2.4.

The next step was to determine the fringing fields. The fringing field H_f was measured as a function of the central field H_o . The result is shown in Fig. 2.5. The distance between the two points C and D of Fig. 2.3 was 16 cm. Since these fringing fields were small compared to the central field, (less than 4% of H_o), they can be considered as zero field to the first approximation, although we ultimately did correct for the effect of the fringing field on the measured voltage.

4.2 Runs

A typical $\Delta S(H,T)$ experiment started with a zero field run. We performed the measurement outside the magnet. The thermo-emf of the sample, ideally, should be zero. That is not true in the real case. Since the sample is not strictly homogeneous, small variations of thermopower along the sample will cause finite thermal voltages. Our acceptable criterion was that a sample had thermal voltages less than

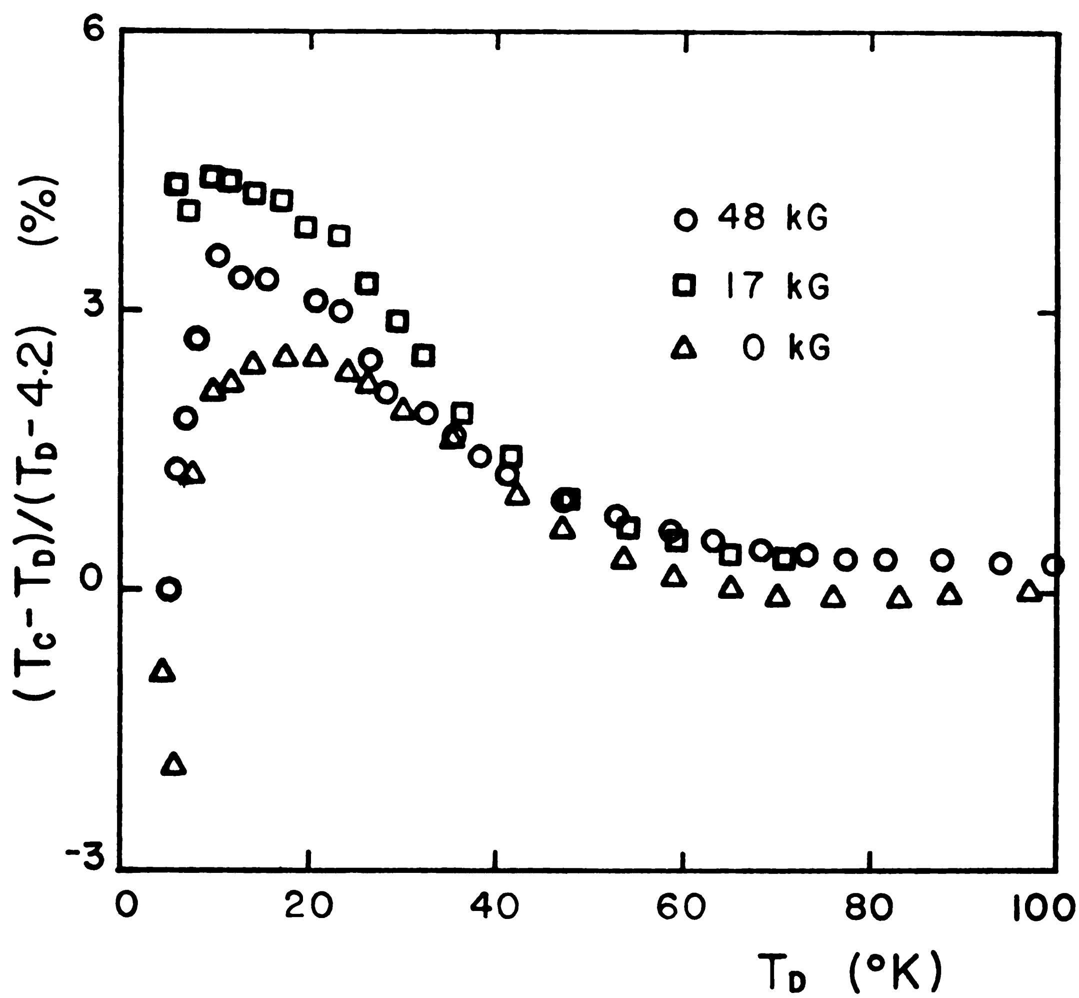

Fig. 2.4 A Typical Result of the Temperature Gradients along the Copper Rod

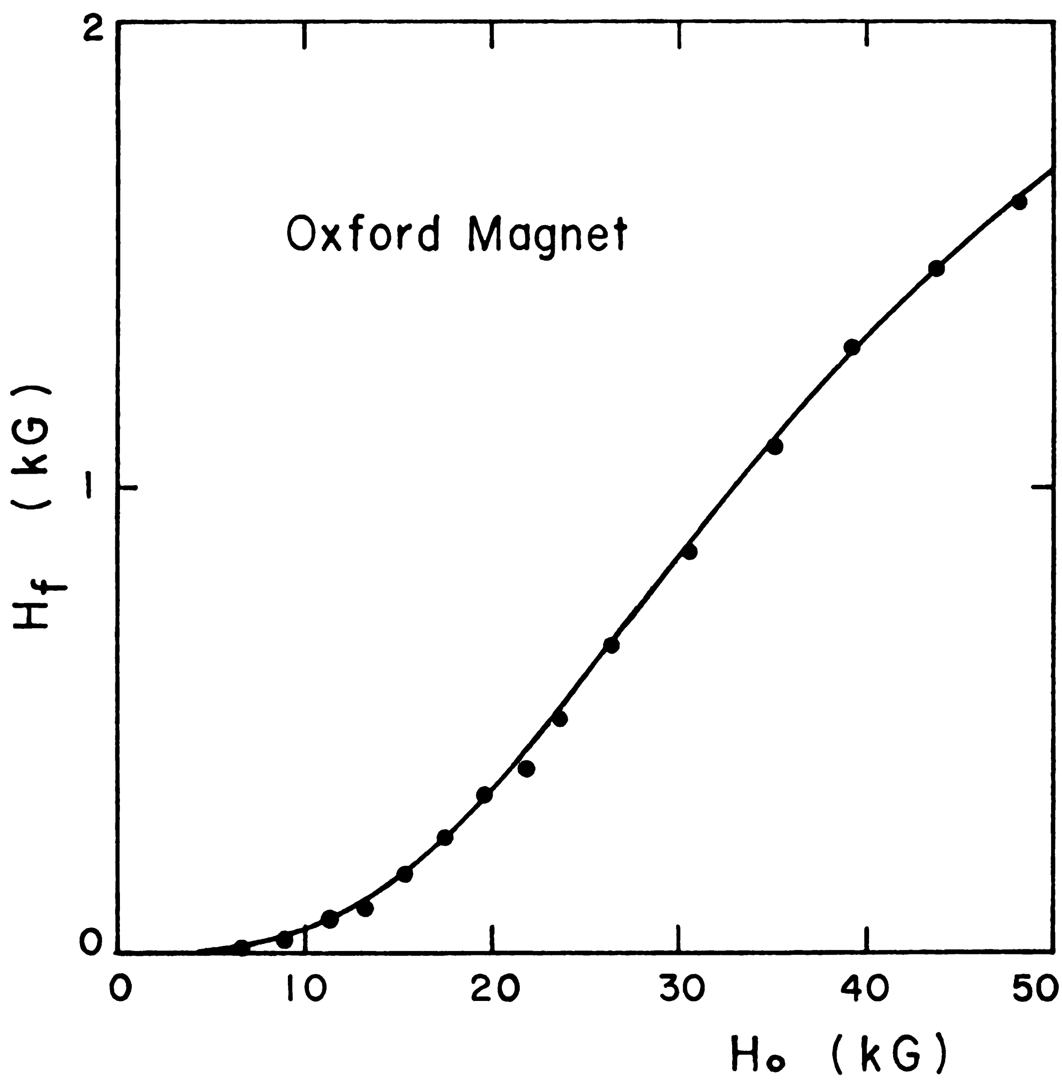

Fig. 2.5 The Fringing Field of the Oxford Superconducting Magnet as a Function of the Central Field

5 micro-volts at 100°K. During this run, the system is carefully checked for vacuum conditions and other troubles to avoid unnecessary waste of liquid helium in cooling the magnet.

In the magnet run the cryostat is arranged as shown in Fig. 2.1. A magnetic flux sensor (MistoR) was used to determine the relative position between the sample and the field. This position was pre-determined in the test period. For each field, we measured the thermo-emf of the sample as a function of temperature. The temperatures are obtained from the reading of Chromel versus Au-0.07 at.%Fe thermocouple. The temperatures were incremented in steps of 1°K to 5°K. At the same time, we recorded the temperature difference developed along the heating copper rod. We stopped at about 100°K or at a temperature where the thermo-emf from the sample saturated. The sample was cooled down by allowing small amounts of helium exchange gas into the vacuum can and the process repeated for the next magnetic field value. The following field sequence was normally used: 0.87 kG, 1.7 kG, 4.4 kG, 8.7 kG, 17 kG, 26 kG, 35 kG, 43 kG and 48 kG. Due to time limitation some fields were occasionally skipped.

At the end of a run, all connections were checked once more to verify the sign of the measured thermo-emf.

5. Data Analysis

5.1 The Change of Thermopower in a Magnetic Field

The raw data from a run was in the form of a thermoelectric emf as a function of temperature, arising from the difference in thermopower of sections DE and BC of the sample at a fixed magnetic field. This data was first displayed graphically to obtain a general idea of the behavior of $\Delta S(H_o T)$. Next we converted thermocouple voltages into temperatures. A computer generated calibration table with accuracy 10 mK was used for this conversion. The calibration data of Chromel-Au+0.07 at.%Fe thermocouples was taken from Sparks and Powell[13]. The change of thermopower was then computed by a computer program, which made a least squares fit of five neighboring data points to a quadratic function and then differentiated with respect to temperature. $\Delta S(H_o T)$ was evaluated at the central data point only. We shall refer to the output of the computer program as the direct result. No smoothing was included in the direct results.

In arriving at the final result three corrections must be made to the direct result. The first correction is the correction for inhomogeneity. Inhomogeneity of the sample, if any, was detected by the zero field measurement. We simply subtracted the zero field result from the direct result. The second correction is the correction due to the temperature difference along the copper rod. We shall discuss this correction in detail in the Section 5.2. The third correction is the correction due to the finite fringing field. This correction shall be considered in Section 5.3. The final result after these corrections, is

$$\Delta S(H,T) = S(H,T) - S(0,T)$$

5.2 Temperature Difference Along the Copper Rod

In our measurements, a small temperature difference ΔT does develop between C and D on the copper rod. (see Figs. 2.2 and 2.3.) How much does this contribute to the measured thermo-emf? A simple analysis is provided by the following.

As shown in Fig. 2.2b, the temperature at D is T, which was measured in the experiments. At C the temperature will be $T + \Delta T$ in the actual experiment. The measured thermo-emf is

$$E = \int_{4.2}^{T} S(H_f,T')\, dT' + \int_{T}^{T+\Delta T} S(\nabla H,T')\, dT' + \int_{T+\Delta T}^{4.2} S(H_o,T')\, dT' \qquad (2.4)$$

where we used $S(\nabla H,T')$ to represent the thermopower along CD, which can not be defined precisely, since we do not know the temperature versus field variation along this length of wire. The thermo-emf along AB is essentially zero, since the temperature difference is extremely small in the helium bath. We can rewrite Eq. 2.4 as

$$E = \int_{T}^{4.2} [S(H_o,T') - S(H_f,T')]\, dT' + E_1 \qquad (2.5)$$

The first term of the above equation is V_{AF}, the quantity we need. The second term E_1 is the correction due to the existence of ΔT, i.e.

$$E_1 = \int_{T}^{T+\Delta T} [S(\nabla H,T') - S(H_o,T')]\, dT' \qquad (2.6)$$

In an ideal condition $\Delta T = 0$ and $E_1 = 0$. For a small ΔT, we estimate the correction from the field dependence of $\Delta S(H,T)$ as follows:

(a) If $\Delta S(H,T)$ saturates at low fields we obtain an approximation by setting

$$S(\nabla H,T) \sim S(H_o,T) \qquad (2.7)$$

so $$E_1 \sim 0$$

(b) If $\Delta S(H,T)$ is significant only at very high fields then

$$S(\nabla H,T) \sim S(H_f,T)$$

and $$(2.8)$$

$$E_1 \sim [S(H_f,T) - S(H_o,T)] \cdot \Delta T$$

(c) In general, $\Delta S(H,T)$ is intermediate between cases (a) and (b). As an approximation, we assume

$$E_1 \sim \frac{1}{2}\Delta T \cdot [S(H_f,T) - S(H_o,T)] \qquad (2.9)$$

$$\sim \frac{1}{2}\Delta T \cdot \Delta S(H_o,T) \qquad (2.10)$$

We show this correction graphically in Fig. 2.6. The measured thermo-emf is the area ABC'CD. The result we need is the area ABC'D. The correction is the area C'CD. A triangle probably is a fair approximation to the area C'CD, which is given by Eq. 2.9. In Fig. 2.6 $\Delta T = T' - T$ has been greatly enlarged to clarify the picture.

In our experimental work, we found there was very little change in the pattern of ΔT during one series of runs. Thus we could use one set of ΔT to make this correction. Differentiating Eq. 2.10 we obtain

$$S_1 = d\,E_1/dT = \frac{1}{2}\frac{d}{dT}[\Delta S(H_o,T)\cdot\Delta T] \qquad (2.11)$$

where S_1 is the correction term for $\Delta S(H_o,T)$.

This correction was done by a computer program similar to the one used for calculating thermopower. The correction due to the temperature difference along the copper rod was less than 3% of $\Delta S(H,T)$.

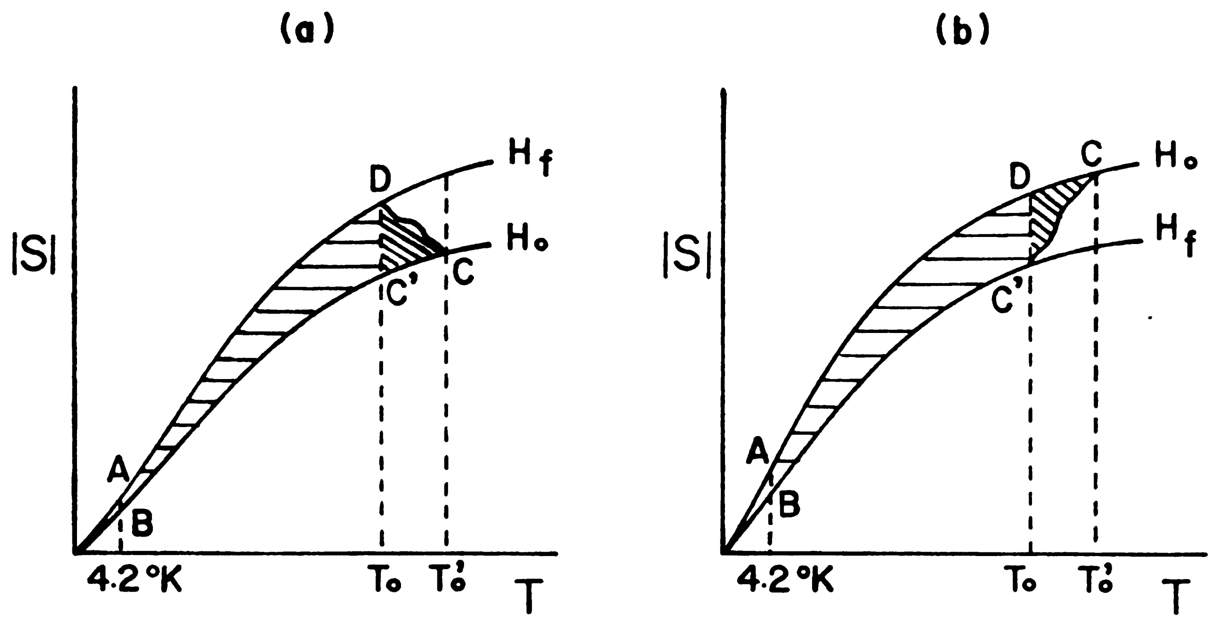

Fig. 2.6 The Correction of the Temperature Gradient along the Copper Rod

5.3 Fringing Field

The fringing field correction is done graphically. We plotted the change of thermopower as a function of field at a given temperature. When the central field was low the fringing field was negligible and no correction was needed. As the central field was increased there was a finite fringing field. To obtain $\Delta S(H,T) = S(H,T) - S(0,T)$, we added the change at the fringing field to that at the central field, using the measured fringing field as a function of central field and the measured change in S at low central fields. Mathematically we have

$$\Delta S(H_f,T) = S(H_f,T) - S(0,T) \qquad (2.12)$$

$$\Delta S(H_o,T) = S(H_o,T) - S(H_f,T) \qquad (2.13)$$

so

$$\begin{aligned} \Delta S(H,T) &= S(H_o,T) - S(0,T) \\ &= \Delta S(H_o,T) + \Delta S(H_f,T) \end{aligned} \qquad (2.14)$$

The size of this correction depended on the field dependence of the thermopower of the sample, and the temperature range. The largest correction was about 10% of the direct result. For the most cases it was less than 5% of the final result.

5.4 The Uncertainties

Errors entered into the final result of $\Delta S(H,T)$ from the non-exact corrections and the uncertainties in the measurements. The uncertainty in the temperature of the hot junction was less than 0.05°K. The uncertainty of individual voltage readings was 10^{-8} volt. The reading was good to three significant figures. The correction for the temperature difference, Eq. 2.10, contained an approximation. We estimate this uncertainty to be less than 3% of $\Delta S(H,T)$. The correction of the fringing field depended on the exact measurements related to the location of the sample and the field at that point, and also on the number of data points at low field values. In our case we estimated the uncertainty was less than 3% of $\Delta S(H,T)$. Therefore, we concluded the uncertainty of the final results, i.e. the curves of $\Delta S(H,T)$ is 5% or less, or $\pm\ 10^{-8}$ V/°K whichever is greater.

6. Application and Improvement

The difference method is the only method at present capable of measuring the absolute thermopower of a conductor in magnetic field above the transition temperature of a superconductor. However, the method is only good for a wire sample. For future work on various types of samples, particularly single crystals,two standardizations should be done by this method. First, we should establish a standard reference material, at high fields, comparable to lead which is employed for zero field measurements of thermopower. With the present techniques it is very difficult to perform a measurement of Thomson heat and to construct the absolute thermopower scale in magnetic fields. The difference method provides the solution to this problem. To this end we have measured S(H,T) for lead and for Ag-0.37 at.%Au (silver normal), an alloy frequently used as a secondary standard. The results of these measurements will be discussed in later sections. A very small field dependence alloy Ag+1.5 at.%Au has been studied[14].

Second, it is necessary to calibrate commercial thermocouple wires in magnetic fields. The thermo-emf in magnetic fields may be measured by many other methods[12], but the change in thermopower is best obtained using the difference method. Details of this work are described in the next chapter.

For more precise studies the system should be built by using two heaters to control the temperature of the copper rod so that the difference of temperature along its length can be eliminated. Careful study at low fields should also result in a better correction for the fringing field effect.

The difference method is applicable not only in a transverse magnetic field but also in a longitudinal magnetic field. All the experimental results reported in chapter III and IV are in transverse magnetic field unless otherwise stated.

CHAPTER III

TEMPERATURE MEASUREMENTS IN HIGH MAGNETIC FIELDS

1. Introduction

In the temperature range from 4.2°K to 100°K, germanium resistors are the most commonly used thermometers. Unfortunately, they have a very strong magnetic field dependence. Accurate measurement of the temperature in the presence of high magnetic fields is difficult, because there are no convenient cryogenic liquids available for vapor pressure thermometry in this temperature range. The properties of germanium resistors in high fields have been studied by Neuringer *et al.*,[15] and Neuringer and Rubin[16]. A change by as much as a factor 10 has been observed in a field of 130 kG at 4.22°K. Moreover, the magneto-resistance of a germanium resistor also has an orientation dependence. Nueringer and Rubin[16] suggest that germanium resistors not be used in a field above 25 kG.

Other types of thermometers have also been studied[16]. Most thermometers are found to have a magnetic field dependence, except gas and capacitance thermometers. Gas thermometers offer an absolute standard of temperature. However, employing gas thermometers in a magnetic field at low temperature is extremely tedious and inefficient.

Capacitance thermometers are found to be magnetic field independent. This was first reported by Brand et al.,[17] and Fiory,[18] who used Potassium Chloride (KCl) crystals. Further studies were done by Lawless[19,20] using $SrTiO_3$ glass ceramic capacitance thermometers. The reports indicate that this type of thermometer may be a secondary standard for the measurement of temperature in high fields. However, the $SrTiO_3$ capacitance thermometer has poor reproducibility, especially at a temperature higher than 30°K.

Thermocouples are probably the most convenient temperature sensing transducers. Although various types of thermocouples are widely used for the measurement of temperature in the helium range, i.e. from 4.2°K up, a Chromel-P versus Au-0.07 at.%Fe thermocouple appears particularly well suited by virtue of its large thermopower at low temperatures. The thermopower and thermoelectric emf of this couple in zero field have been measured carefully, and calibration tables published by the National Bureau of Standards[13]. As a result of this work this thermocouple has gained wide popularity among cryogenic workers. Unfortunately this thermocouple also suffers from the same disadvantage of field dependence. We thought it worthwhile to study this thermocouple using the newly developed difference method. The aim of this work was to obviate the restriction to zero magnetic field.

As a result of this study, we obtained a set of calibration tables[6,7]. These reference tables for low temperature thermocouples in magnetic fields are contained in the Appendix. In this chapter, we discuss the work related to the calibration of these thermocouple wires in fields up to 100 kG.

2. Experiments

We measured three thermocouple wires, Chromel-P (KP), Silver-0.37 at.% Gold (AgN), and Gold-0.07 at.% Iron (AuFe). These three wires are generally used to form two types of thermocouple: Chromel-P versus Gold-0.07 at.% Iron thermocouple (KP-AuFe TC), and Silver-0.37 at.% Gold versus Gold-0.07 at.% Iron thermocouple (AgN-AuFe TC). The characteristics of the wires are listed in Table 1. All samples were purchased from Sigmund Cohn Corporation.

The measurements were made on the individual wires by using the difference method. Two samples of AuFe from the same spool were measured to check the variation between the samples. We also extended the magnetic field from 50 kG to 100 kG by using our RCA superconducting magnet.

3. Results

3.1 Thermocouple Wires

Figures 3.1 to 3.5 show the thermopower and $\Delta S(H,T)$ of AuFe, KP and AgN wires in zero and two transverse magnetic fields of 48 and 80 kG between 5°K and 100°K. The zero field thermoelectric power of AgN was obtained from Foiles[21],

Table 3.1

The Characteristics of Thermocouple Samples

Items	Au-0.07 at.% Fe	Chromel-P	Silver Normal
Alloy	Gold+0.07at.%Iron	Nickel+10%Chromium	Silver+0.37at.%Gold
Type	wire	wire	wire
Size (mm)	0.13	0.13	0.25
Insulation	Teflon	Teflon	Cotton
Heat treatment	as received	as received	as received
Tested Homogeneity (μv/°K)	±0.02	±0.03	±0.005
RRR = R(300°K)/R(4.2°K)	4.5	1.1	11.5

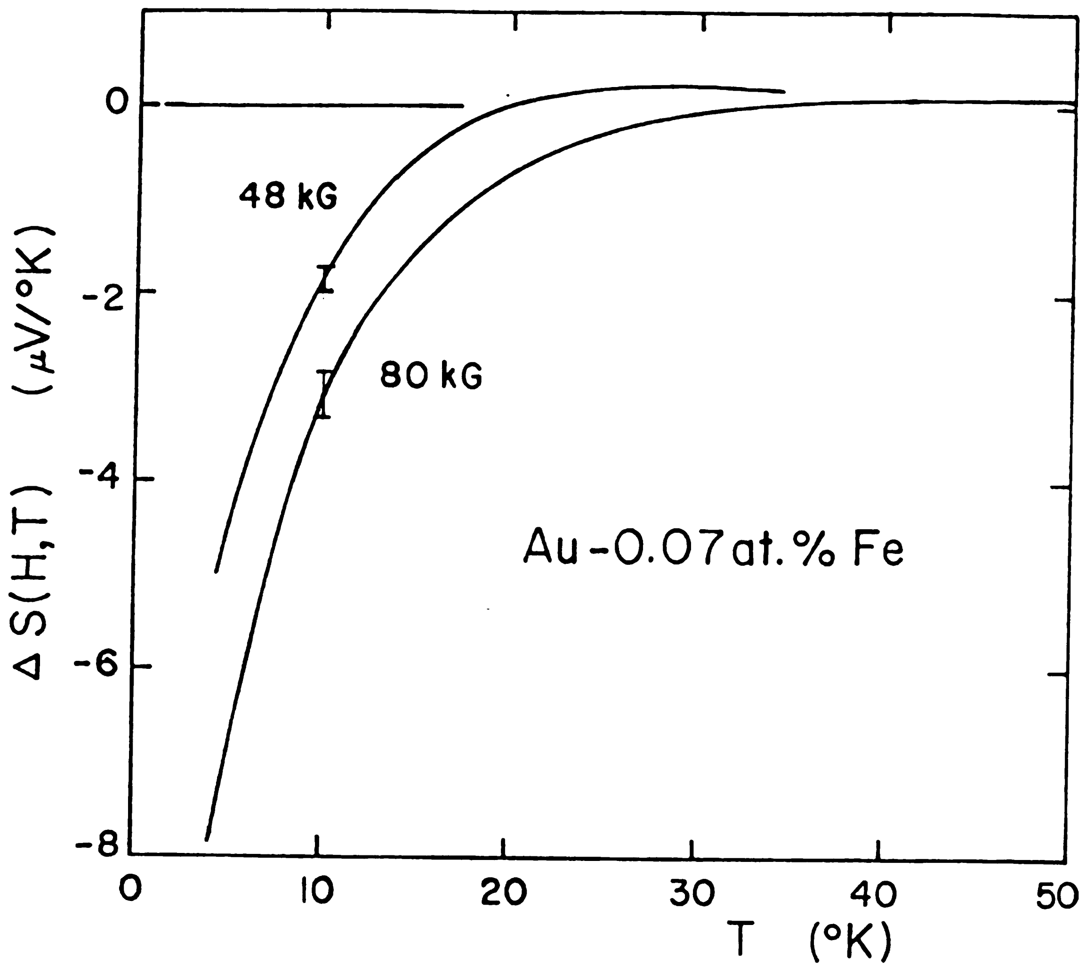

Fig. 3.1 The $\Delta S(H,T)$ of Au-0.07 at.% Fe

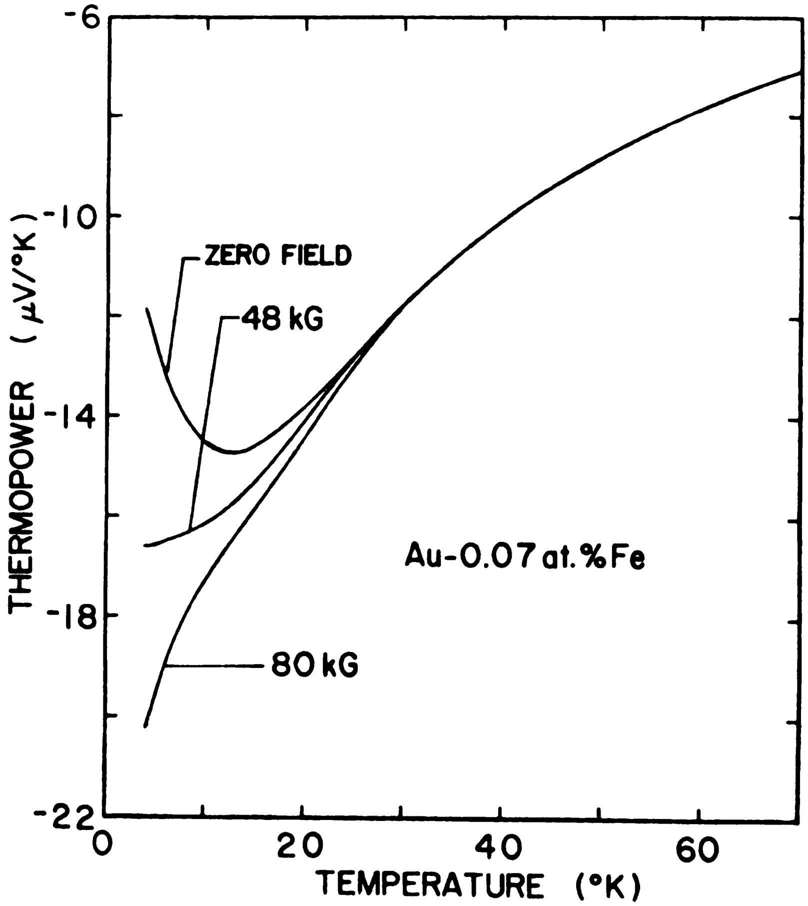

Fig. 3.2 The Thermopower of Au-0.07 at.% Fe in Magnetic Fields

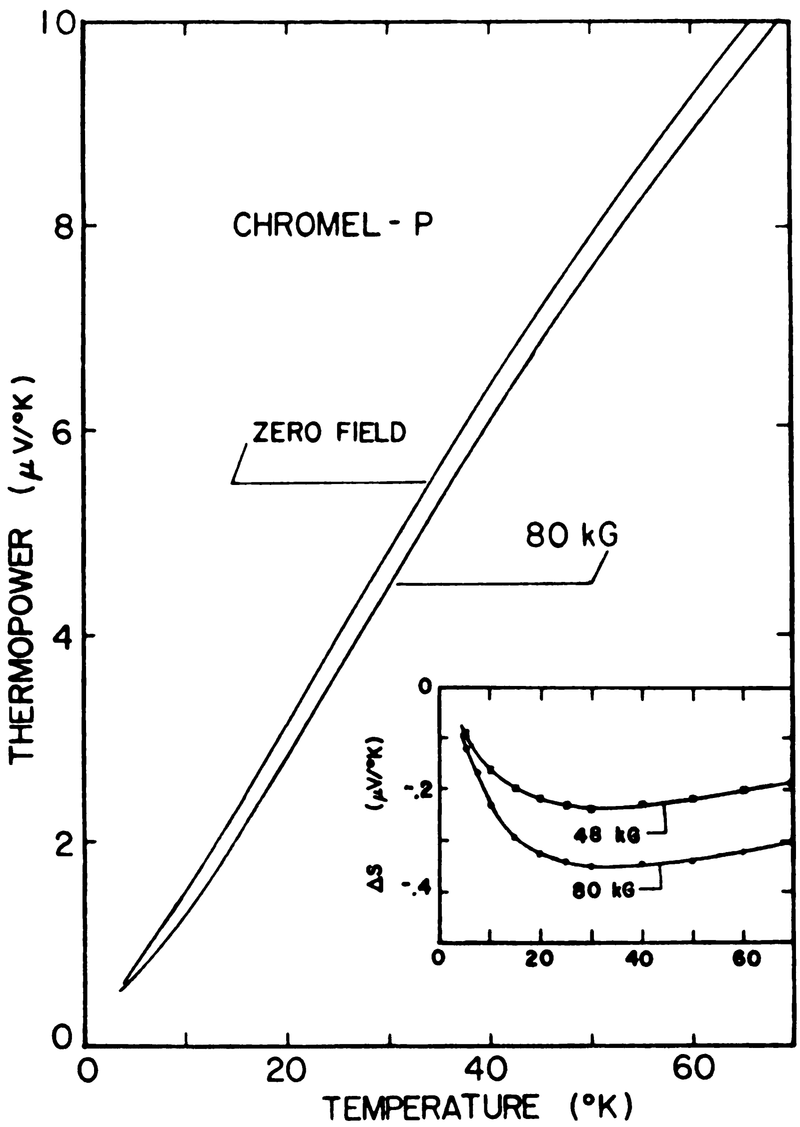

Fig. 3.3 The Thermopower of Chromel-P in Magnetic Fields. The Inset is the Δ S(H,T) of Chromel-P.

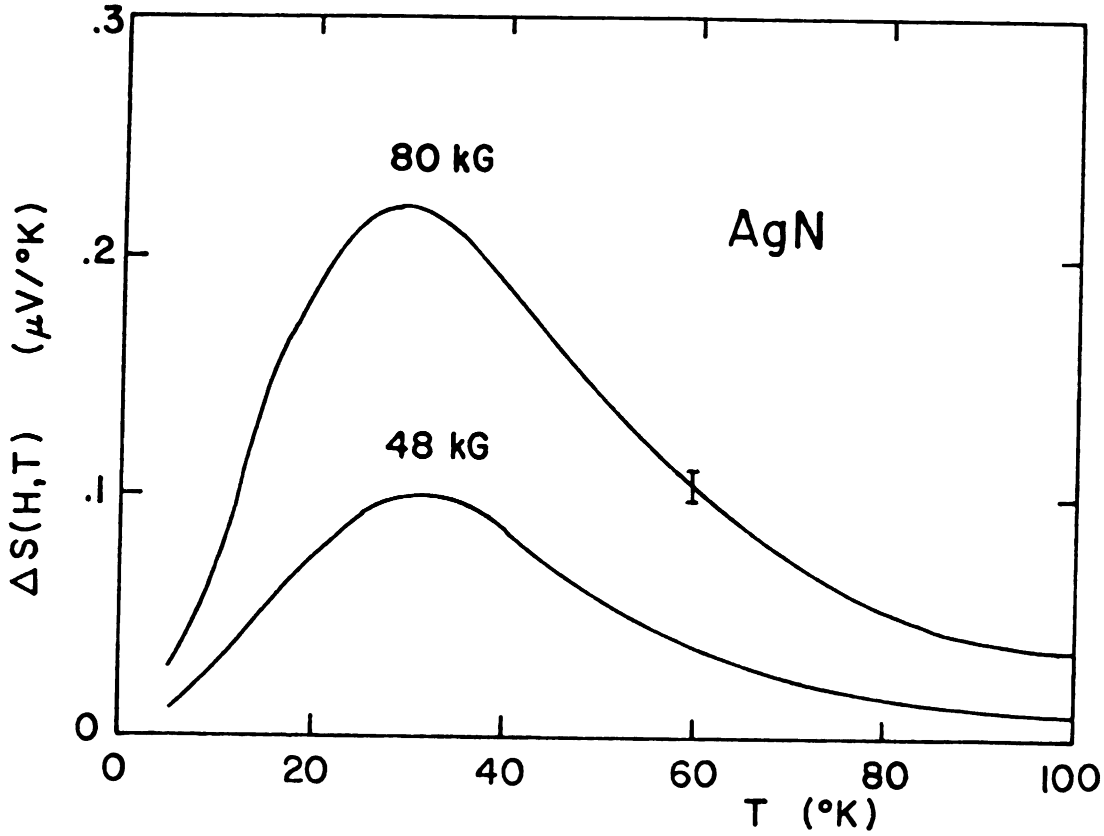

Fig. 3.4 The $\Delta S(H,T)$ of Silver Normal Alloy

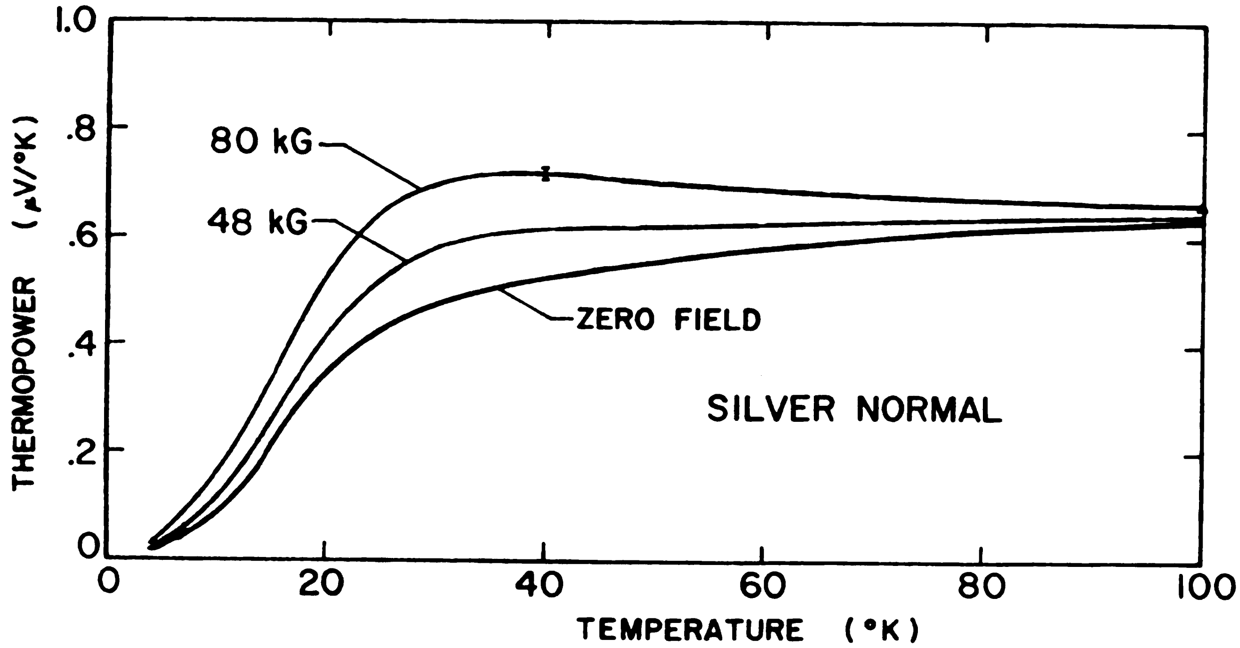

Fig. 3.5 The Thermopower of Silver Normal in Magnetic Fields

and of AuFe and Chromel-P was from Sparks and Powell[13]. Of the three materials, AuFe shows, at low temperature, the greatest sensitivity to magnetic field. As shown in Fig. 3.1, $\Delta S(H,T)$ is negative at low temperatures, its magnitude greatest at the lowest temperature, and decreases about exponentially with increasing temperature to about 14 degrees. Near 25°K, depending somewhat on the magnitude of the field, $\Delta S(H,T)$ vanishes, and is of opposite sign and very greatly reduced magnitude at higher temperatures. The pronounced field dependence at low temperature is a well-known phenomenon associated with Kondo systems, and has been discussed extensively by Berman et al.[22]. Our results are in reasonably good agreement with those of Berman et al.[22], von Middendorff[23] and of Sample et al.[12], as shown in Figs. 3.6 and 3.7.

In Chromel-P we find that $\Delta S(H,T)$ is negative at all temperatures, and shows a broad minimum around 30°K. The magnitude of $\Delta S(H,T)$ then decreases slowly with increasing temperature. (See inset of Fig. 3.3). The magnitude of this negative peak varies approximately linearly in field. Although relatively small, this change in thermopower of Chromel-P is by no means negligible in practical application, and we shall return to this point presently.

Finally, AgN (See figure 3.4 and 3.5) exhibits a pattern reminiscent of the pure noble metals[24]. $\Delta S(H,T)$ is positive over the entire temperature range with a well defined maximum near 30°K. The magnetic field dependence of silver normal wire is very small for fields up to about 15 kG. Thereafter, the magnitude of $\Delta S(H,T)$ at its peak value increases approximately linear with H . In pure silver the behavior is similar. However, the magnitude of $\Delta S(H,T)$ is greater in particular and a tendency toward saturation at high fields has been observed. It has been attributed by us to the influence of the magnetic field on the phonon-drag component of the thermoelectric power[24].

3.2 Thermocouples

From the results of the thermocouple wires it is clear that at low temperatures for thermocouples employing AuFe the dominant effect of a magnetic field is attributable to this arm of the couple. At higher temperatures, however, the change in thermopower of chromel is greater, in magnitude, than that of AuFe, and will play an increasingly important role as shown in Fig. 3.6. This is most effectively demonstrated in Fig. 3.7 which shows the change in the thermo-emf of a KP-AuFe TC, whose cold junction is maintained at 4.2°K, as a function of temperature for several values of magnetic field. We see that above 25°K, $\Delta V(H,T)$, which increases rapidly at the lower temperatures, now diminishes, and for small values of the magnetic field reverses sign. The decrease in $\Delta V(H,T)$ at the higher temperatures, is, of course, the result of the negative value of $\Delta S(H,T)$ of chromel-P

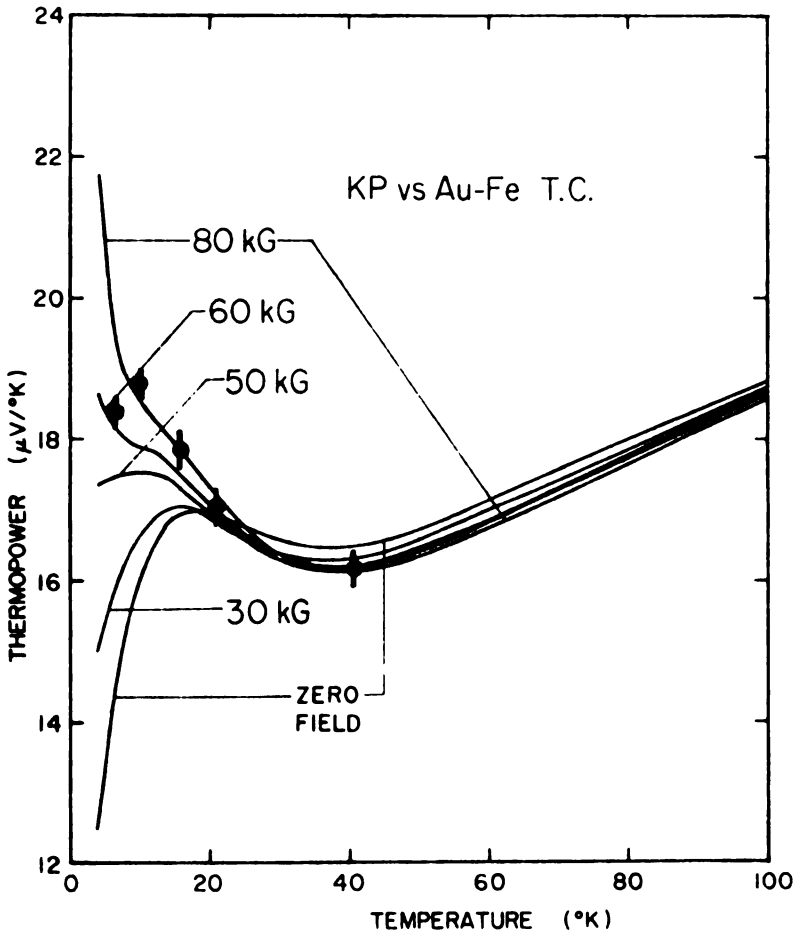

Fig. 3.6 The Thermopower of Type Chromel-P versus Au-0.07 at.% Fe Thermocouples in Magnetic Fields.
The Data Points (ɸ) are Taken from a Longitudinal Field 60 kG of von Middendorff.

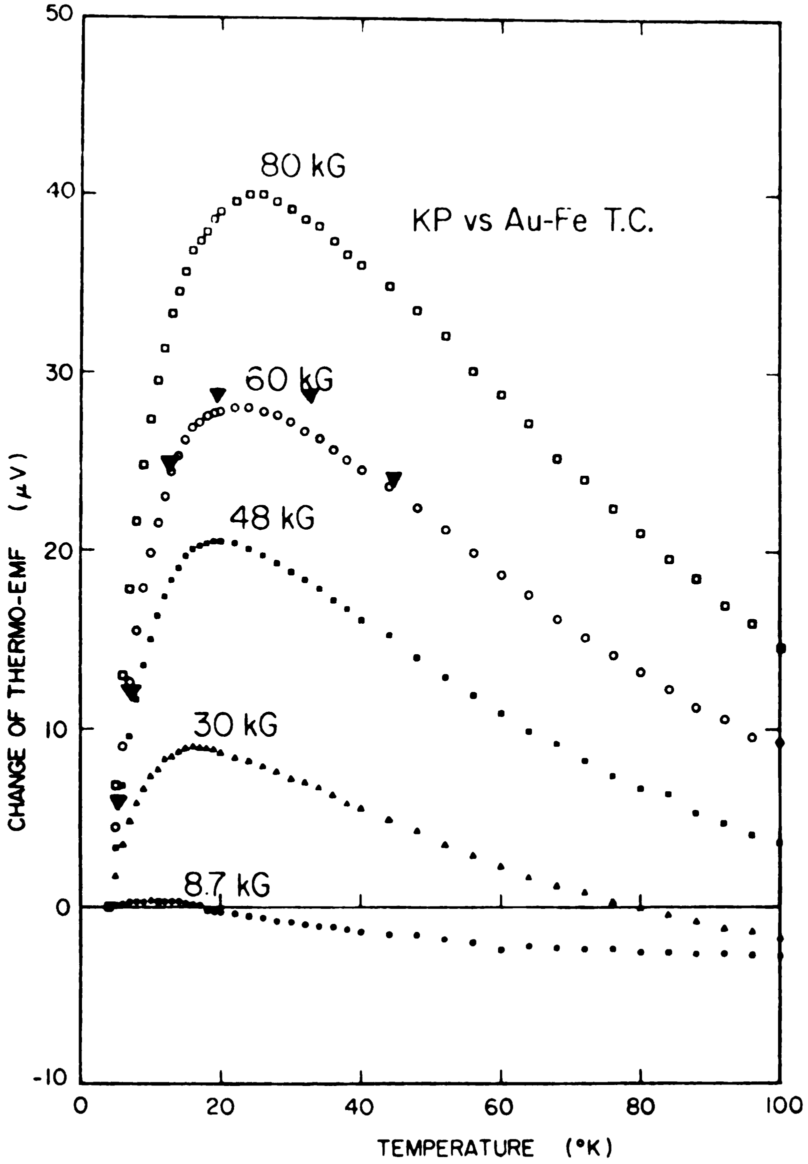

Fig. 3.7 The Change in the Thermo-emf of Type Chromel-P versus Au-0.07 at.% Fe Thermocouples in Magnetic Fields. The Data Points (▼) are Taken from a Longitudinal Field 60 kG of Sample et al.

(see Fig. 3.3). As shown in Figs. 3.8 and 3.9, we see that for a AgN - AuFe thermocouple, above a saturation temperature which increases with magnetic field, there is no further change in the thermoelectric voltage due to a magnetic field.

It is evident from these results that if temperatures are measured in a magnetic field by means of these thermocouples, the voltage reading must be interpreted by recourse to thermoelectric voltage tables appropriate to the specified magnetic field. The reference tables for KP-AuFe and AgN-AuFe thermocouples are given in the Appendix. In the construction of the tables, we have used the zero-field data of Sparks and Powell[13]. These reference tables apply only to a geometry where the magnetic field is perpendicular to the temperature gradient along the thermocouple. The dependence on field geometry has been reported[25] for temperatures between 4.2°K and 50°K. These tables assume that the reference junction is maintained at 4.2°K. The maximum uncertainty of the tabulations is 0.1°K for the fields up to 50 kG, and is 0.3° from 50 kG to 100 kG[7].

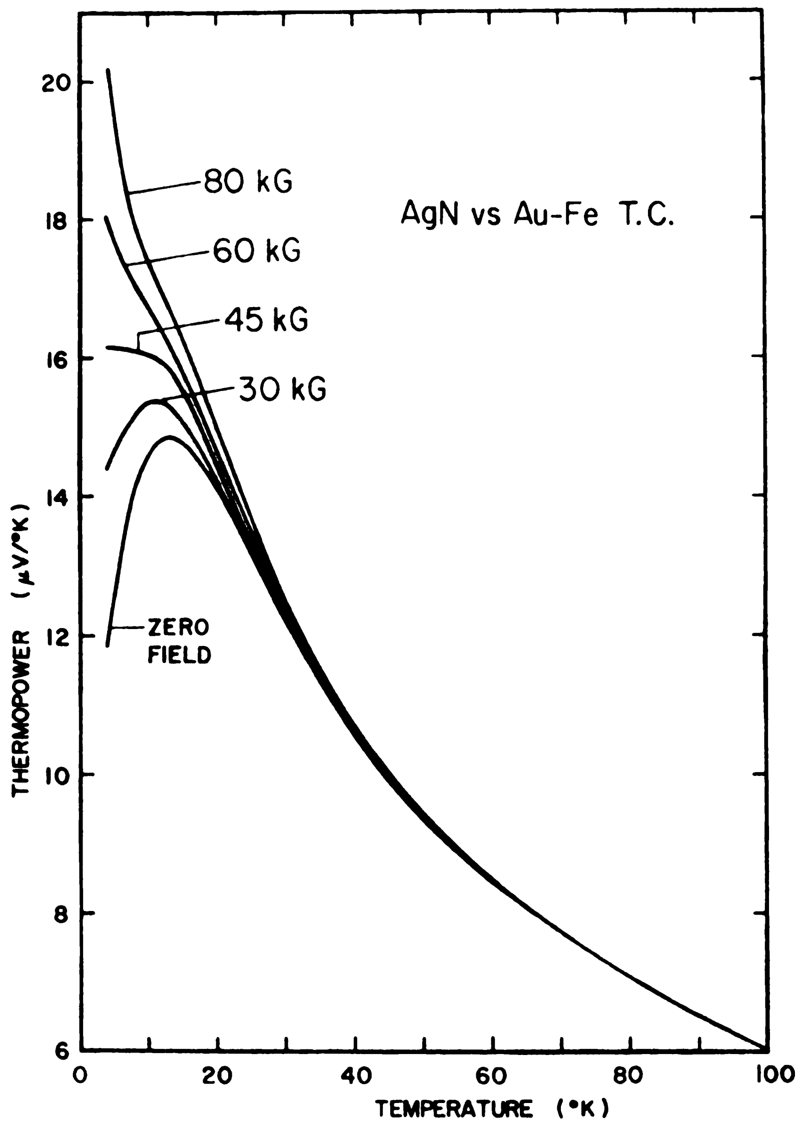

Fig. 3.8 The Thermopower of Silver Normal versus Au-0.07 at.% Fe Thermocouples in Magnetic Fields

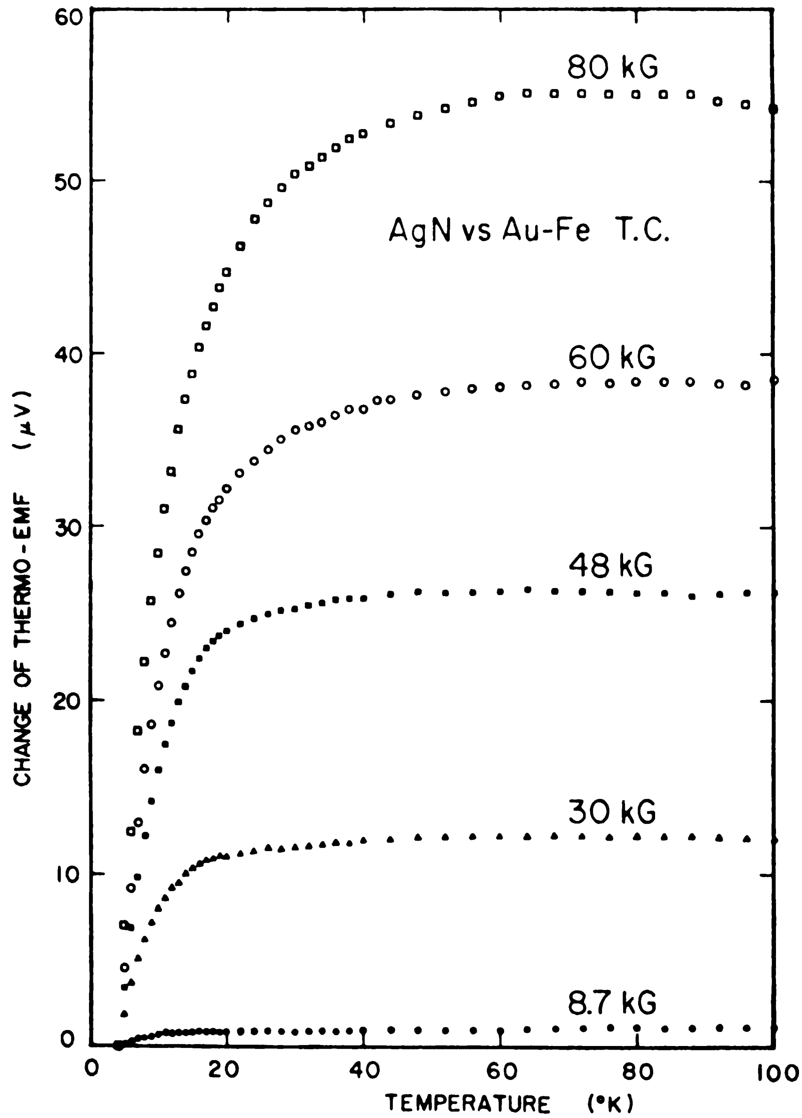

Fig. 3.9 The Change in Thermo-emf of Silver Normal versus Au-0.07 at.% Fe Thermocouples in Magnetic Fields

CHAPTER IV

THERMOPOWER OF THE NOBLE METALS AND OF ALUMINUM, INDIUM AND LEAD IN MAGNETIC FIELDS

1. Introduction

No measurements seem to have been made on simple metals previous to experiments by Taylor and Coles[10]. Extensive work on copper and copper alloys was one by MacDonald and Pearson[3]. More recently Averback, Stephan and Bass[4,5] have measured aluminum and aluminum alloys at very low temperatures. Sirota _et_ _al_.[11] measured the field dependence of single crystal aluminum. The result of Averback _et_ _al_. shows that not only the electron-diffusion thermopower, but also the phonon drag thermopower has a magnetic field dependence. As regards the latter their results were only an indication of the pattern that may exist.

With the difference method described in Chapter II we are able to measure the thermopower of noble metals in strong magnetic fields at higher temperatures. The measurements, performed in the temperature range where the phonon density is much greater than in previous studies, now clearly demonstrate that the magnetic field has a profound effect on the phonon drag thermopower.

Our measurements have been extended from noble metals to aluminum, indium and lead, so we could compare our results at low temperatures with the work of Averback _et_ _al_.[4,5].

2. Copper, Silver, and Gold

2.1 Sample Preparation

The copper sample was made from a piece of 14 AWG Belden copper wire. The heavy polythermaleze coating of the wire was removed by burning in a gas flame. The oxidized material on the surface of burnt wire was washed off in a nitric acid bath. The clean bare copper wire had a diameter 1.47 mm. This wire was then drawn through tungsten carbide dies and diamond dies to 0.18 mm. After each pass through a die the first section of wire (about 5 - 20 cm) was cutt off. Acetone was used if lubricant was needed during the drawing procedure.

The fine wire was wound onto a 9 mm Vycor glass tube. The ends were held in place with loops of spare copper wire. The copper wire with tube was washed in dilute NaOH solution to remove finger grease. After a rinse with distilled water the wire was etched in dilute HNO_3 solution for a few minutes. Then it was washed again with distilled water and rinsed with methyl alcohol. This cleaned copper wire was annealed in an oxidizing atmosphere to remove magnetic impurities from metallic solution.

The oxidizing annealing was done in a system shown in Figure 4.1. We inserted the wired tube into a 15 mm Vycor glass tube A. Tube A was approximately 60 cm long and was seated in a Lindberg Type 54082A furnace. One end of the tube was connected to a pumping system. The other end of

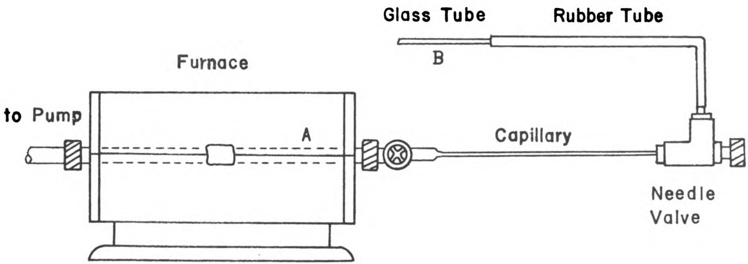

Fig. 4.1 The Oxidizing Annealing System

the tube was connected to a 70 cm long capillary. There was a needle valve at the end of the capillary. The valve was used to control the pressure inside tube A. Finally, the valve was connected to a rubber hose with a glass tube B at its end.

Prior to annealing the air flow rate was checked with an oil drop in the horizontal glass tube B. The oil drop should move at a speed of the order of 1 mm/min. A scale was set up for fine control of the pressure. When the annealing of the copper started, the system was pumped down to approximately 0.5 microns. The temperature of the furnace was then raised to about 500°K for three hours. The needle valve was carefully opened to admit air while the pump was still running. We set the pressure to approximately 1 micron 700°K. The annealing took about 70 hours. After the annealing the furnace was turned off and the copper allowed to cool inside the furnace.

The copper sample was the central section of the annealed copper wire. The residual resistance ratio - RRR = R(300°K)/R(4.2°K) - was 265.

The silver sample was made from Cominco 6N silver. The silver was cleaned carefully. They were etched in a mixed solution of NH_4OH and H_2O_2 (approximately 3:1) for 10 minutes, and soaked in HNO_3 solution for a half hour to remove any bare metal contaminant. The silver shots were melted in a graphite mold to form a silver rod. The silver rod was rolled down to 1 mm wire with a rolling mill. This wire was then drawn to 0.26 mm diameter through tungsten carbide dies and diamond dies.

For the oxidizing annealing we used the same procedure for the copper sample. The pressure was 10 microns and the temperature was 650°C. After 70 hours we found its RRR was 500.

Pure gold wire came from Wesgo Company. It was 0.20 mm in diameter and 5N in purity. We annealed the gold wire at atmospheric pressure at 600°K for 48 hours. The RRR was also 500 for the gold sample.

A summary of the characteristics of these samples is shown in Table 4.1.

2.2 Thermopowers in Transverse Magnetic Fields

A zero applied field measurement, $\Delta S(0,T)$, gives a check on the homogeneity of sample. We found that the thermopower due to inhomogeneity was less than 0.05 μV/°K for all three samples. Measurements of $\Delta S(H,T)$ were then performed in magnetic fields. The results of $\Delta S(H,T)$ are shown as a function of temperature for a sequence of fields in Fig. 4.2.

For a given field there is a peak in the $\Delta S(H,T)$ versus temperature curve. The peak temperature is found to be closely related to Debye temperature, θ_D , of the noble metals. For all three metals the peak occurs at $T/\theta_D \sim 0.07$.

Table 4.1

The Characteristics of Samples

Sample	Source	Size (in mm)	RRR	Anneal Temp.	Anneal Vacuum	Anneal Time
Cu	Belden	0.18	265	700 °C	1μ Air	70 hr.
Ag	Cominco	0.26	500	650 °C	10μ Air	70 hr.
Au	Wesgo	0.20	500	600 °C	Air	48 hr.
Al	Sigmund Cohn	0.26	1300	600 °C	5μ Air	3 hr.
In	Indium	0.51	5400	24 °C	Air	70 hr.
Pb	Cominco	0.25	8000	as received		

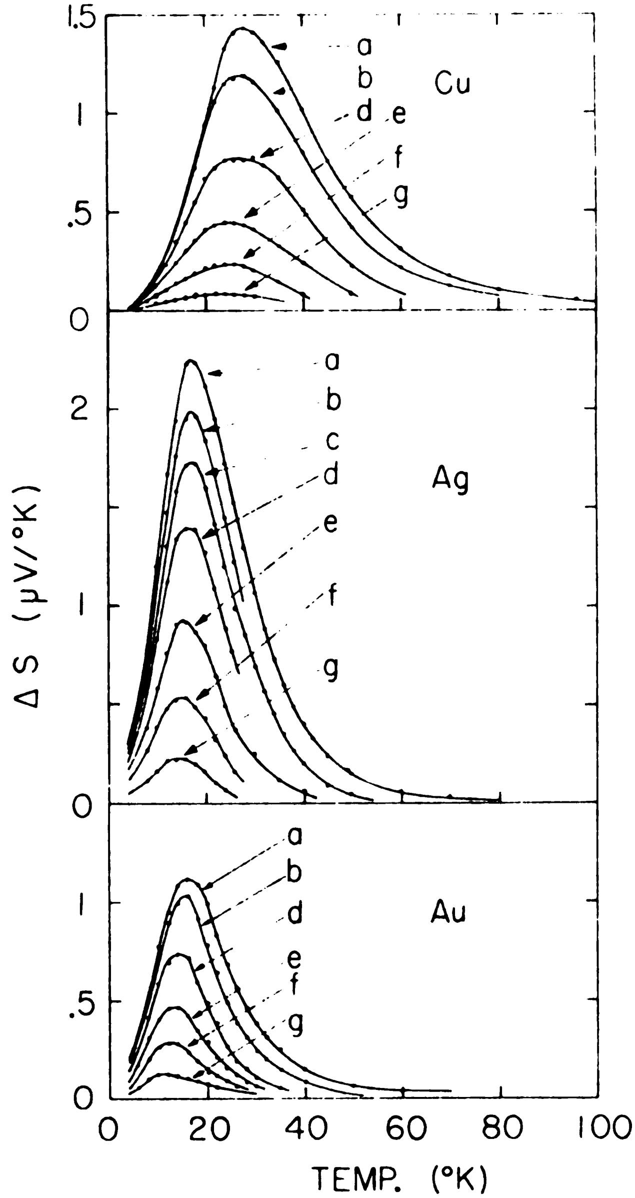

Fig. 4.2 The Δ S(H,T) of the Noble Metals. Fields: a=48kG; b=35kG; c=26kG; d=17.4kG; e=8.7kG; f=4.4kG; g=1.7kG

The peaks shift slowly to higher temperature with increasing field. The size of the peak increases monotonically with applied field H . In the high field range the peak size is comparable to the phonon drag contribution to the zero field thermopower.

To see the behavior of the thermopower in magnetic fields we add $\Delta S(H,T)$ to the zero field thermopower. The results of $S(H,T)$ as a function of temperature are shown in Fig. 4.3. The zero field thermopower of copper below 20°K is taken from sample #1 of Gold et al.[26]. Above 30°K, they are taken from the 'special' copper sample of Henry and Schroeder[27]. The zero field thermopowers of oxidized silver and gold are from Pearson[28]. Below 12°K, the thermopower is an extrapolation to the result of Anderson and Nielsen[29]. The low temperature thermopowers of the noble metals are extremely sensitive to iron contamination. The data we used are from experiments where such effects have been minimized. We have also oxidized our sample to remove the magnetic impurities.[28] Had iron contamination been important in the samples an additional characteristic field dependence, typical of a Kondo alloy, would have been present at the lowest temperature[22]. The absence of any such anomaly is good evidence for the efficacity of our oxidation procedures.

From Fig. 4.3, it is clear that the zero field thermopower has been enhanced. The new peak is at lower temperature, and moves toward the zero field peak temperature with

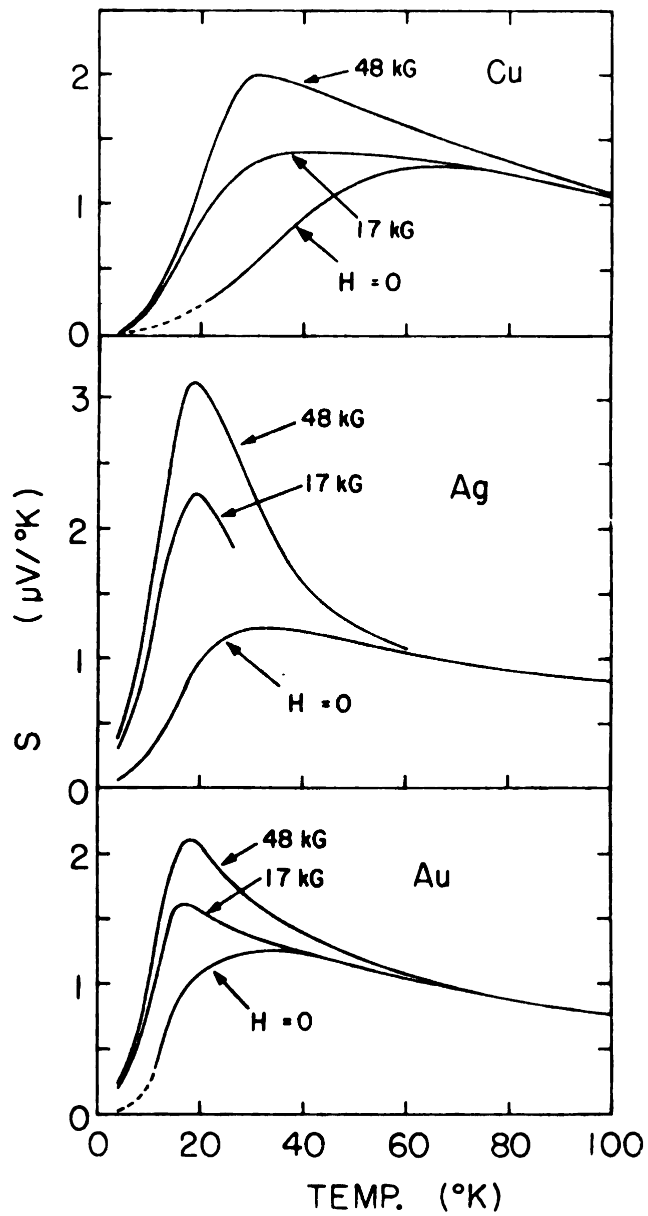

Fig. 4.3 The Thermopower of the Noble Metals in Magnetic Fields

increasing field for high fields.

The Magnetic Field dependence of $\Delta S(H,T)$ is shown in Fig. 4.4. Each curve represents a typical dependence. At low temperatures, below the peak temperature, the thermopower tends to saturate as the field is increased. A linear behavior is seen in the high field region above the peak temperature.

In the temperature range where saturation is approached the thermopowers are enhanced several times in magnitude. Table 4.2 gives the values of S(48 kG)/S(0), the ratio of the thermopowers at 48 kG and at the zero field.

3. Aluminum, Indium and Lead

3.1 Sample Preparation

The aluminum sample was obtained from Sigmund Cohn Corporation. It was 0.40 mm in diameter and 5N in purity. We drew it down to .26 mm in diamond dies. The sample was carefully cleaned before annealing. The oxidizing annealing was done on the sample in 5μ vacuum at 500°C for about 3 hours. The RRR was 1300.

The indium wire was purchased from the Indium Corporation of America. It was 0.51 mm in diameter and 5N in purity. The RRR of the indium sample was 5400. The total length of the sample was about 2.5 m. The extra length was used for increasing the length in the temperature

Table 4.2

The Values of S(H,T)/S(0,T) for the Noble Metals

at 48 kG

Temperature	Copper	Silver	Gold
6 ^{o}K	3.0	5.7	4.4
10 ^{o}K	4.8	5.3	4.0
15 ^{o}K	5.1	4.5	2.4
at peak (in 48 kG Graph)	3.5	3.3	2.1

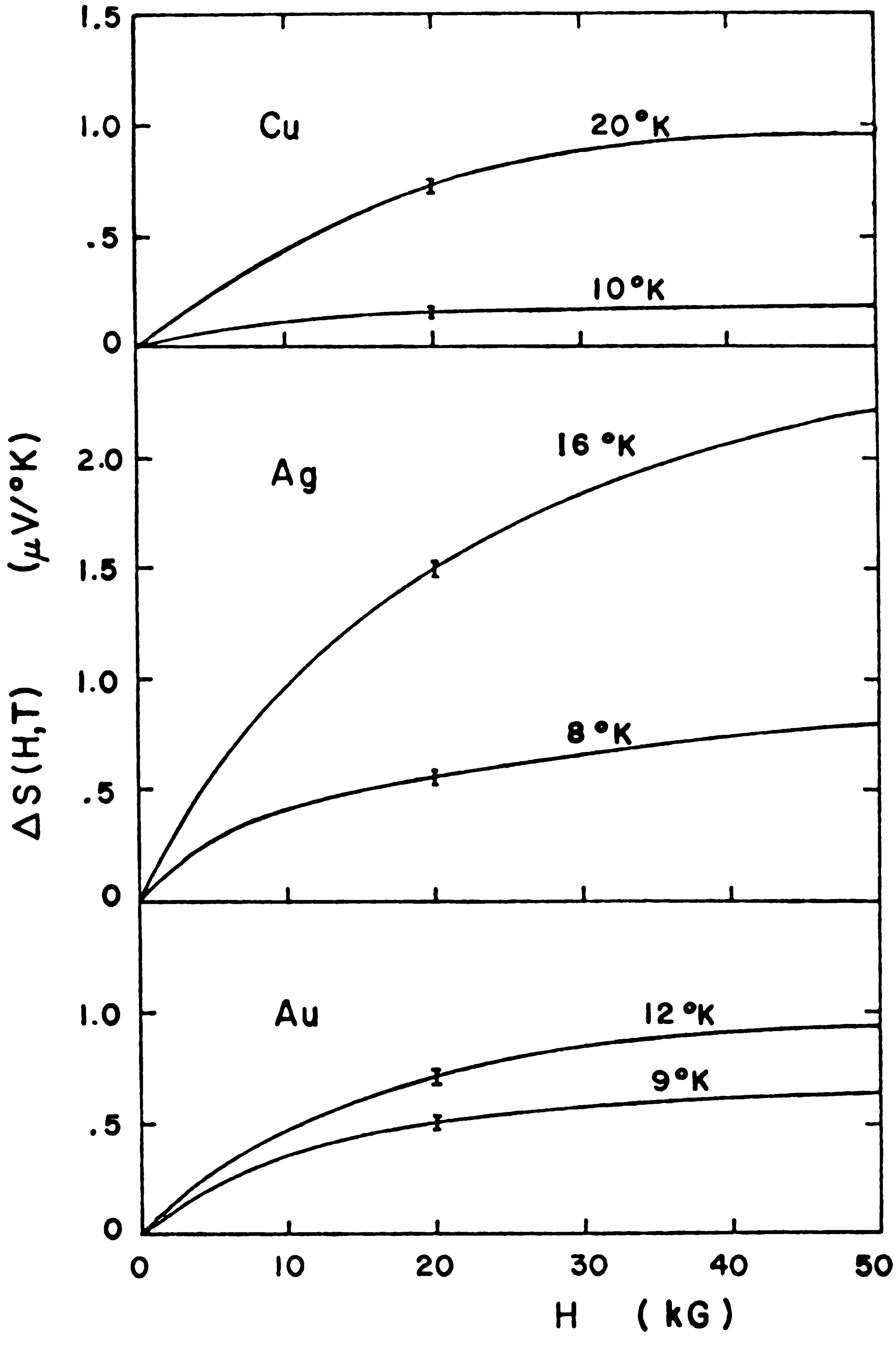

Fig. 4.4 The Magnetic Field Dependence of the $\Delta S(H,T)$ of the Noble Metals

gradient so as to reduce the heat leak through the sample. We let the sample set on the apparatus after mounting for three days. The indium sample was therefore annealed at room temperature for 3 days.

The 69 grade polycrystalline lead wire was obtained from Cominco Incorporated. It was 0.25 mm diameter. Its RRR was about 6000. The resistance at 4.2°K was obtained from the extrapolation of magnetoresistance measurements at 4.2°K. Since the lead sample had a high thermal conductivity, we increased the length of the sample to reduce the heat flow through the sample. The portion of the sample in the temperature gradient was about 80 cm long

3.2 Thermopowers in Transverse Magnetic Fields

The aluminum sample had very good homogeneity; its thermopower in zero field was less than 0.01 μV/°K. The results of $\Delta S(H,T)$ are very interesting. Figure 4.5 shows $\Delta S(H,T)$ as a function of temperature in three measured fields. Two points on this figure are particularly notable. First, the peak of $\Delta S(H,T)$ versus temperature curve is negative in contrast to the positive peak of the noble metals. As in the noble metals, the peak temperature is also approximately at $T/\theta_D = 0.07$, and moves to higher temperature with increasing magnetic field. Below the peak temperature the magnetic field dependence of $\Delta S(H,T)$ tends to saturate. Second, $\Delta S(H,T)$ changes sign at approximately 12°K for all

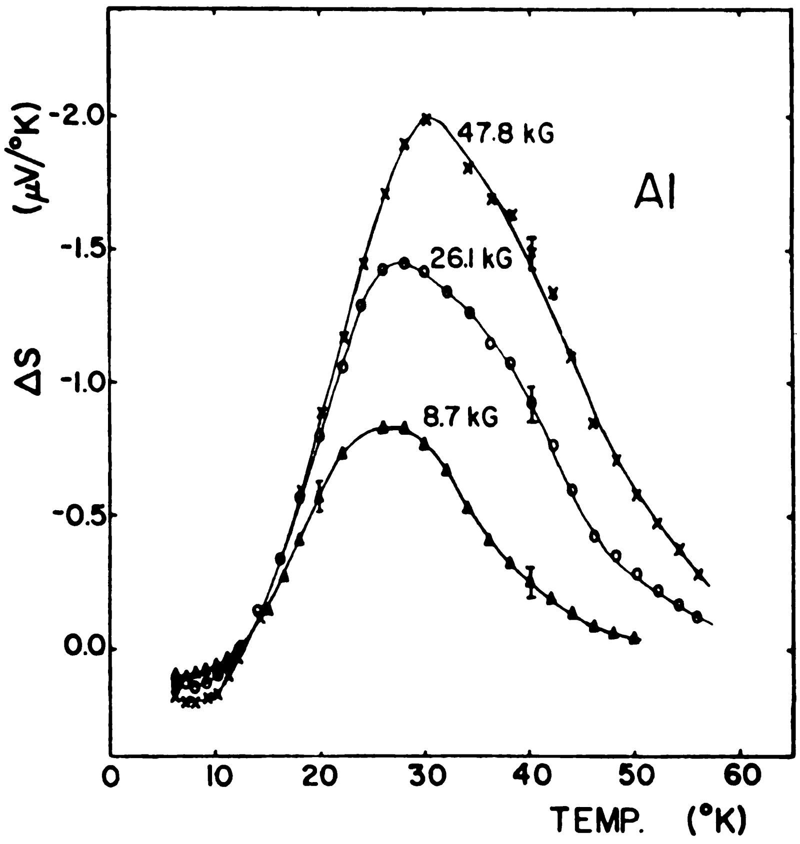

Fig. 4.5 The Δ S(H,T) of Aluminum

measured fields. This portion is enlarged in Fig. 4.6. The ΔS(H,T) as a function of field is shown in Fig. 4.7. Below 12°K, ΔS(H,T) has a strong tendency to saturation.

The zero field thermopower of aluminum is taken from Huebener[30] and added to the change due to the field. The results are shown in Fig. 4.8. A sign change, at low temperatures, due to the magnetic field is clearly demonstrated. This behavior is in good agreement with results of Averback et al.[4,5]. At higher temperature, it seems that the phonon drag thermopower is also enhanced in magnitude by applied magnetic fields. The enhancement seems to create a new peak in the ΔS(H,T) temperature curve.

Indium has an electronic structure similar to that of aluminum, but their zero field thermopowers are quite different. Our measurement shows that ΔS(H,T) of indium is negative and no sign change is seen down to 4.2°K. The result of ΔS(H,T) is shown in Fig. 4.9. Again, a peak is shown in this ΔS(H,T) versus temperature curve. Its behavior is also similar to that of aluminum and the noble metals. The peak temperature is again about at 0.07 θ .

The magnetic field dependence of ΔS(H,T) for indium is shown in Fig. 4.10. The zero field thermopower of indium is shown in Fig. 4.11. Our result has a slightly smaller peak than that reported by Bosacchi and Huebener[31]. Nevertheless, the strong negative ΔS(H,T) reduces the peak as much as 30% at 48 kG, and turns the thermopower below 19°K

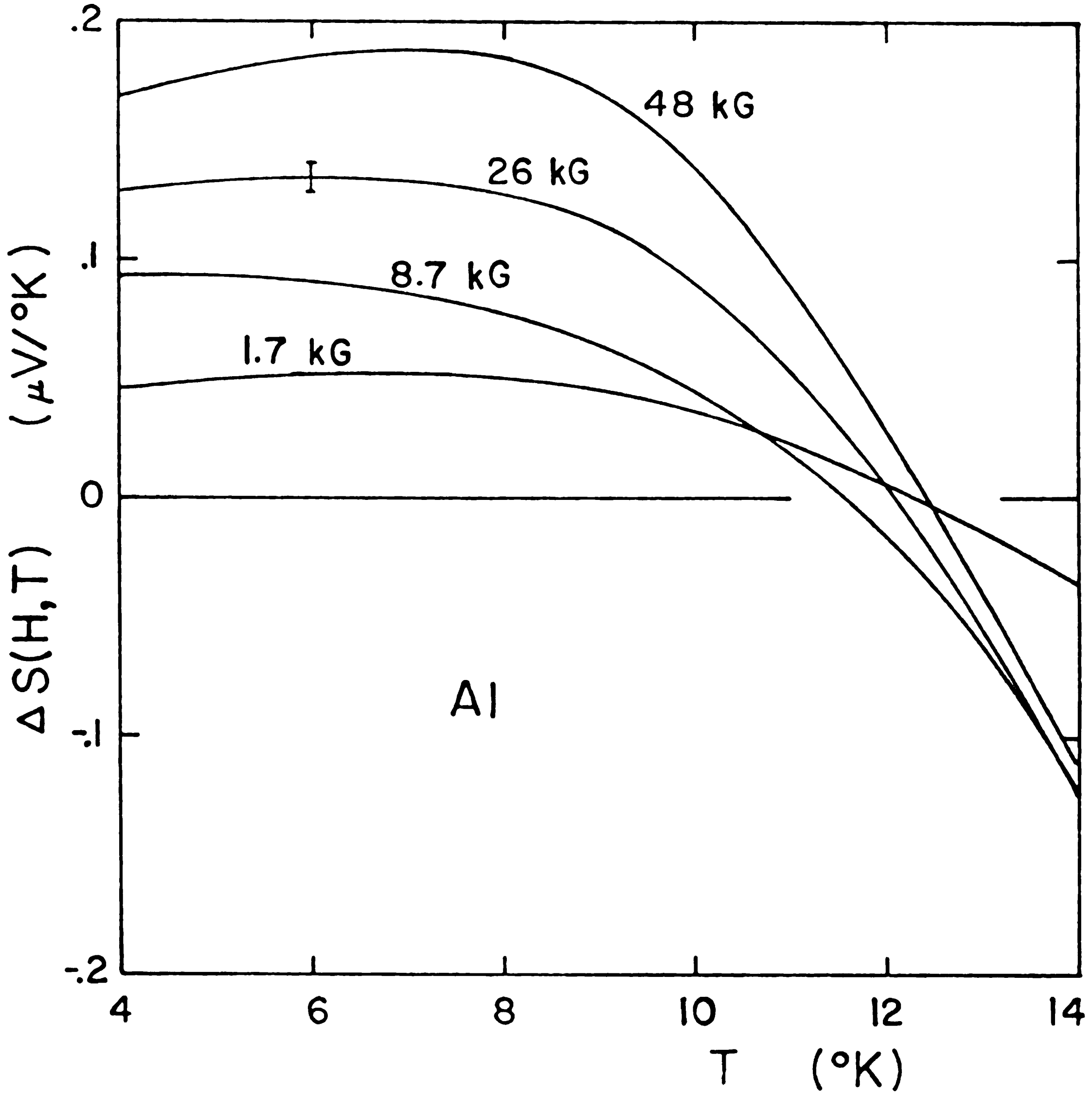

Fig. 4.6 The Sign Change in the Δ S(H,T) of Aluminum

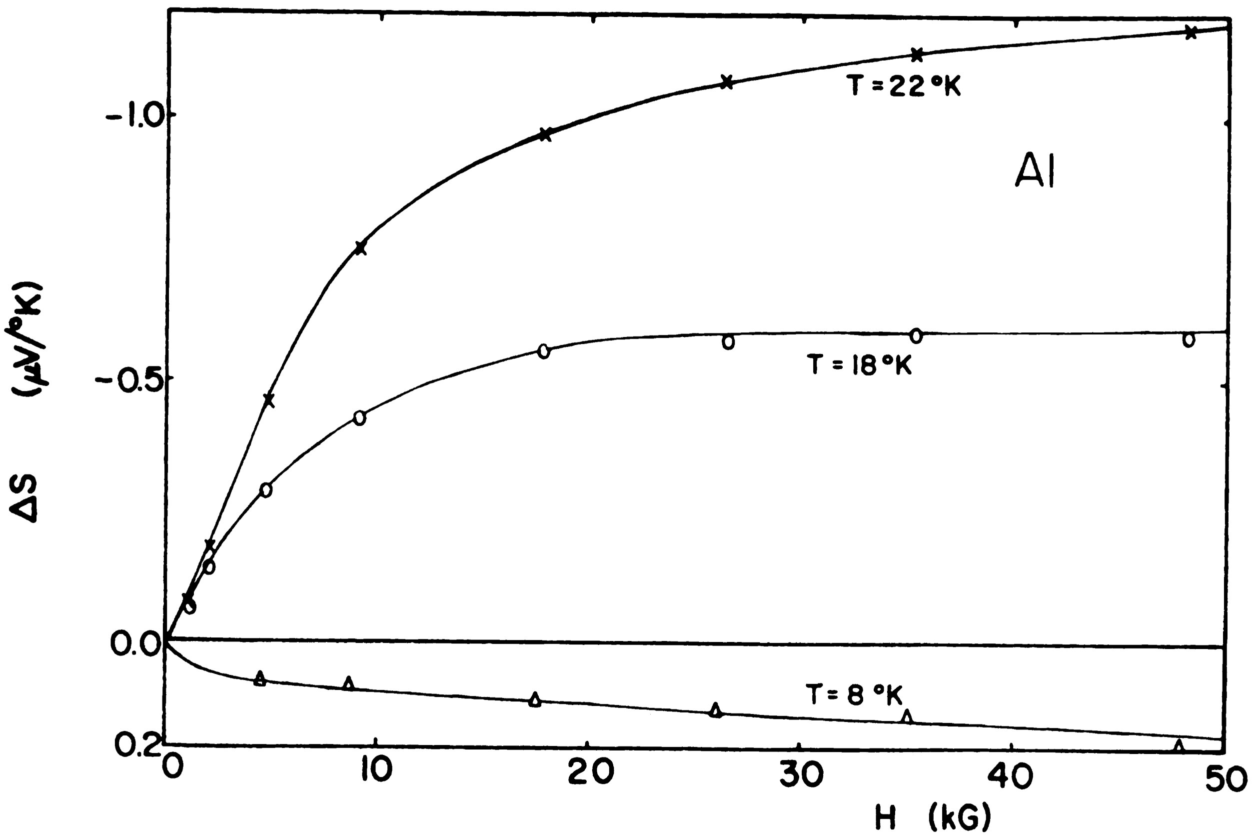

Fig. 4.7 The Magnetic Field Dependence of the Δ S(H,T) of Aluminum

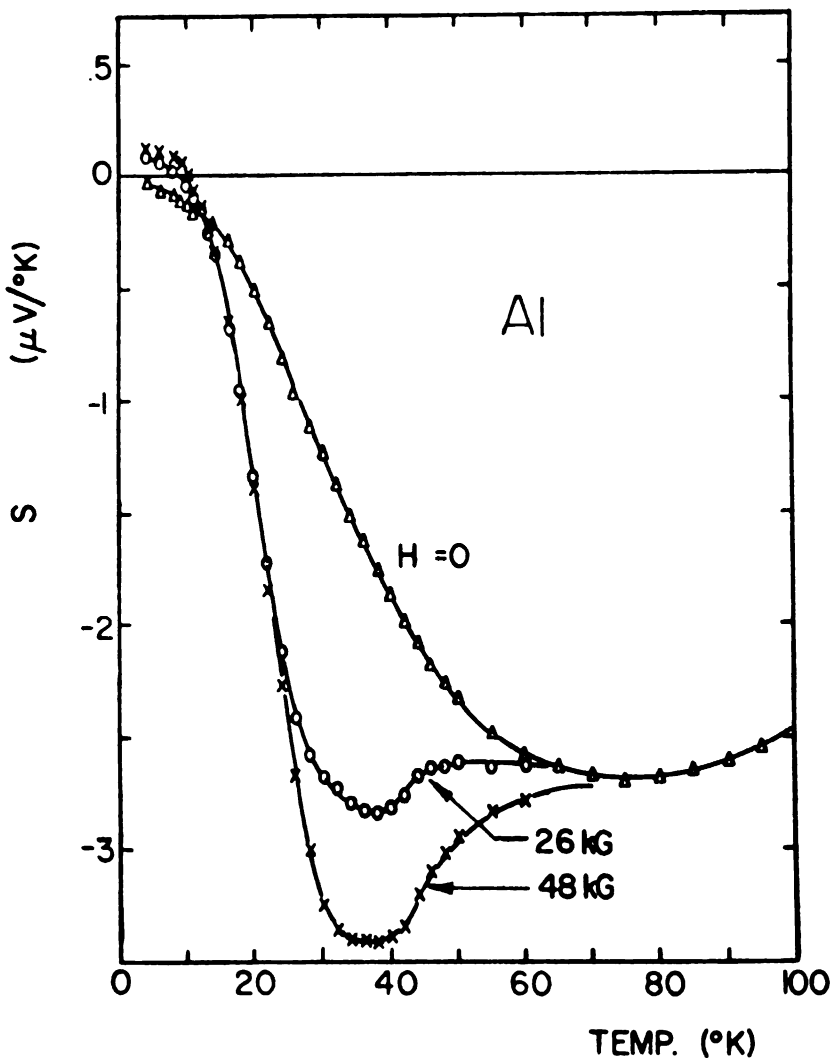

Fig. 4.8 The Thermopower of Aluminum in Magnetic Fields

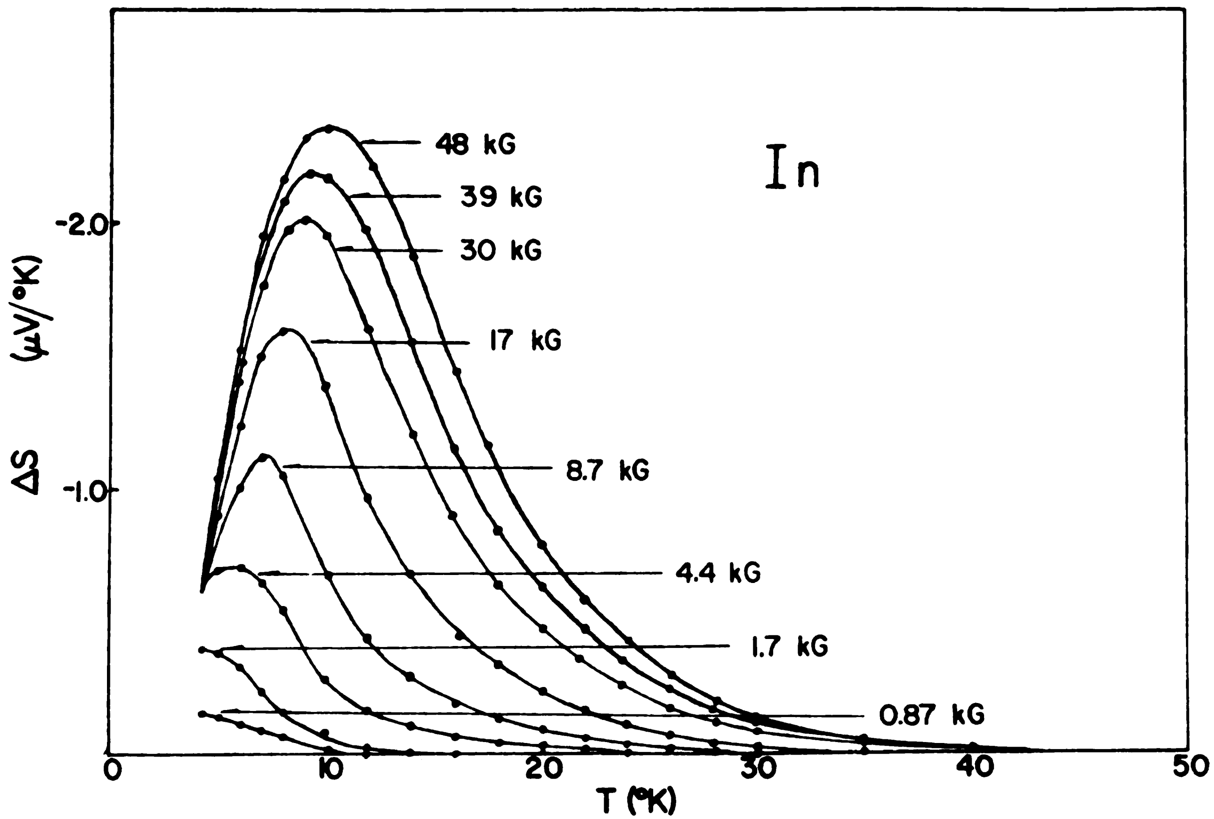

Fig. 4.9 The Δ S(H,T) of Indium

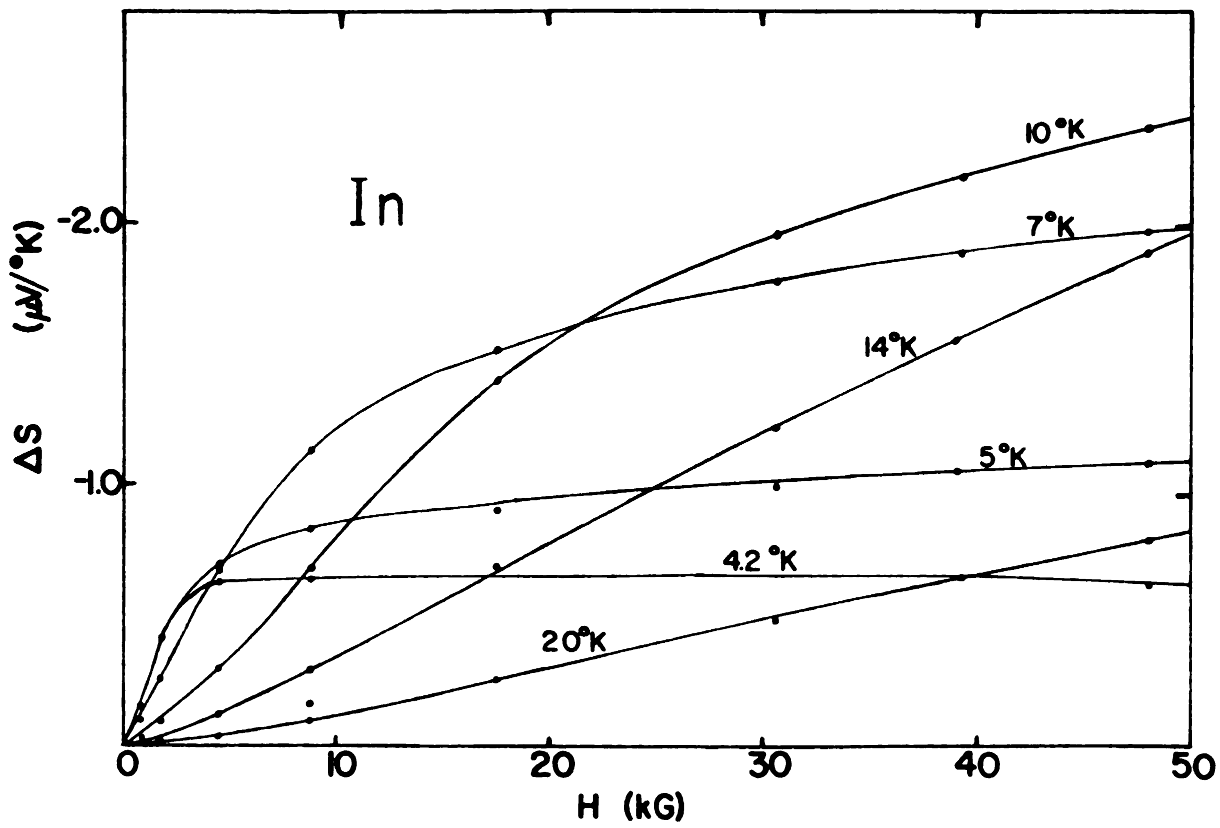

Fig. 4.10 The Magnetic Field Dependence of the Δ S(H,T) of Indium

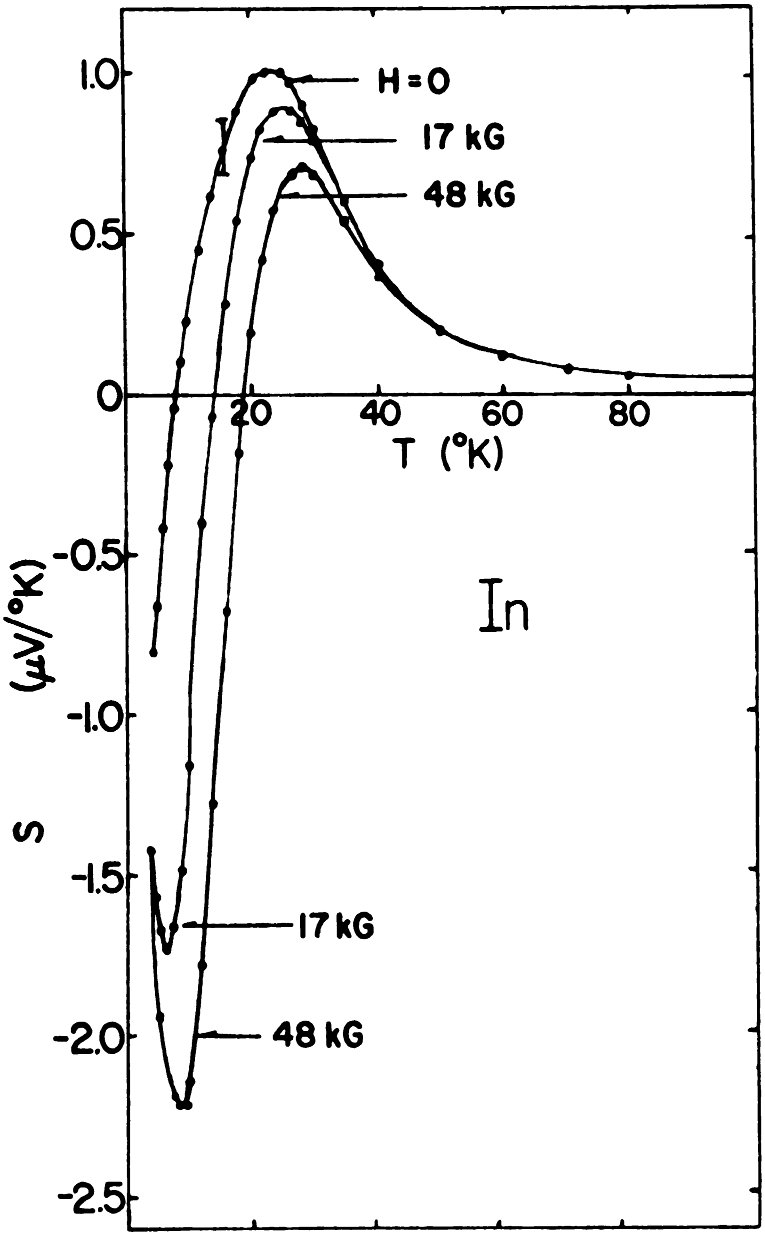

Fig. 4.11 The Thermopower of Indium in Magnetic Fields

negative. A negative peak is formed in the $\Delta S(H,T)$ versus temperature curve at approximately 8°K. This peak temperature moves toward lower temperature with decreasing field.

Pure lead goes superconducting at 7.2°K. The critical temperature moves to lower temperature when a magnetic field is present. In most of our $\Delta S(H,T)$ measurements there is a finite fringing field in the top section of the sample. At high fields, the fringing field is sufficiently large so that the entire sample is normal. However, as the field decreases the portion of the sample in the fringing field will become superconducting and its thermopower will drop to zero discontinuously. In the computer analysis of the data these two regions must be handled separately. The result of $\Delta S(H,T)$ versus temperature is shown in Fig. 4.12. The discontinuity of the curves is due to the superconducting transition at 7.2°K. If we plot $S(H,T)$, using the zero-field thermopower as determined by Christian <u>et</u> <u>al</u>.[32], we obtain a well-defined peak which again occurs at about $T \sim 0.07\ \theta_D$. This peak also has similar properties to those of aluminum and indium. The magnetic field dependence of $\Delta S(H,T)$ is shown in Fig. 4.14.

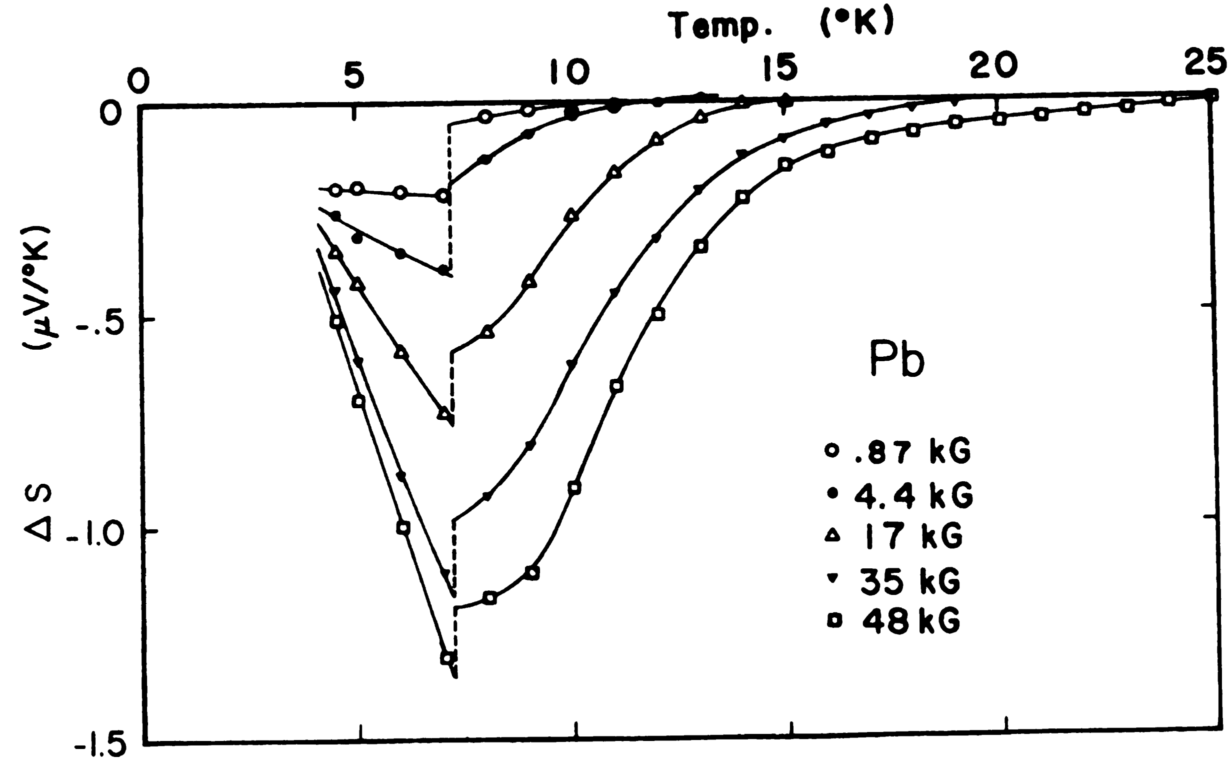

Fig. 4.12 The Δ S(H,T) of Lead

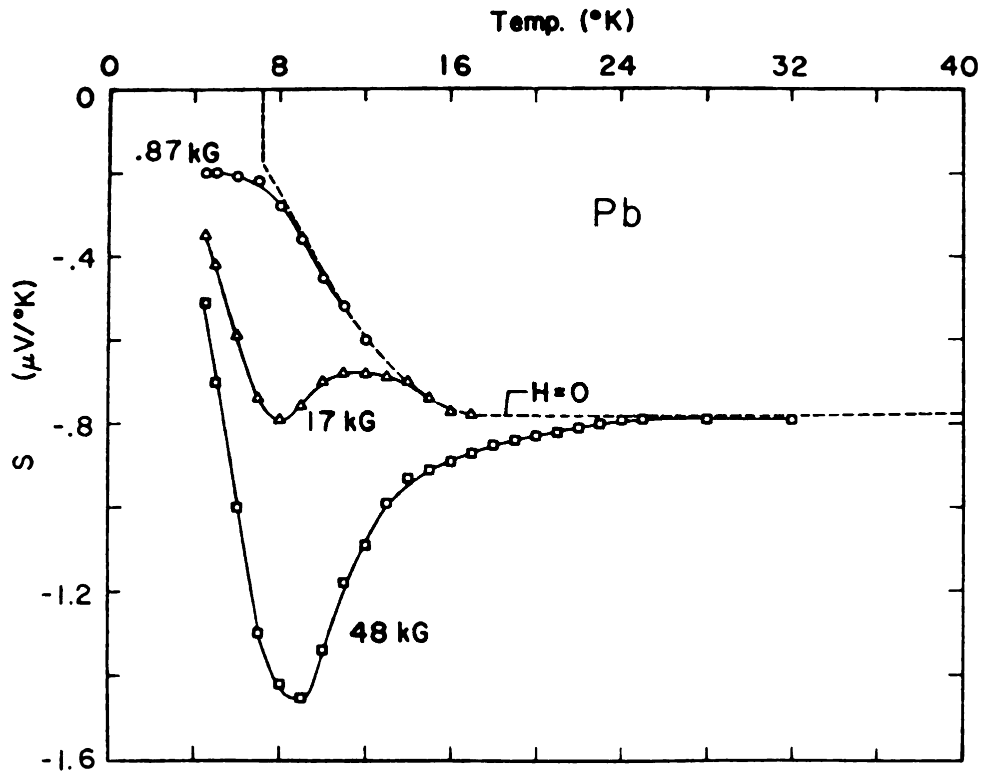

Fig. 4.13 The Thermopower of Lead in Magnetic Fields

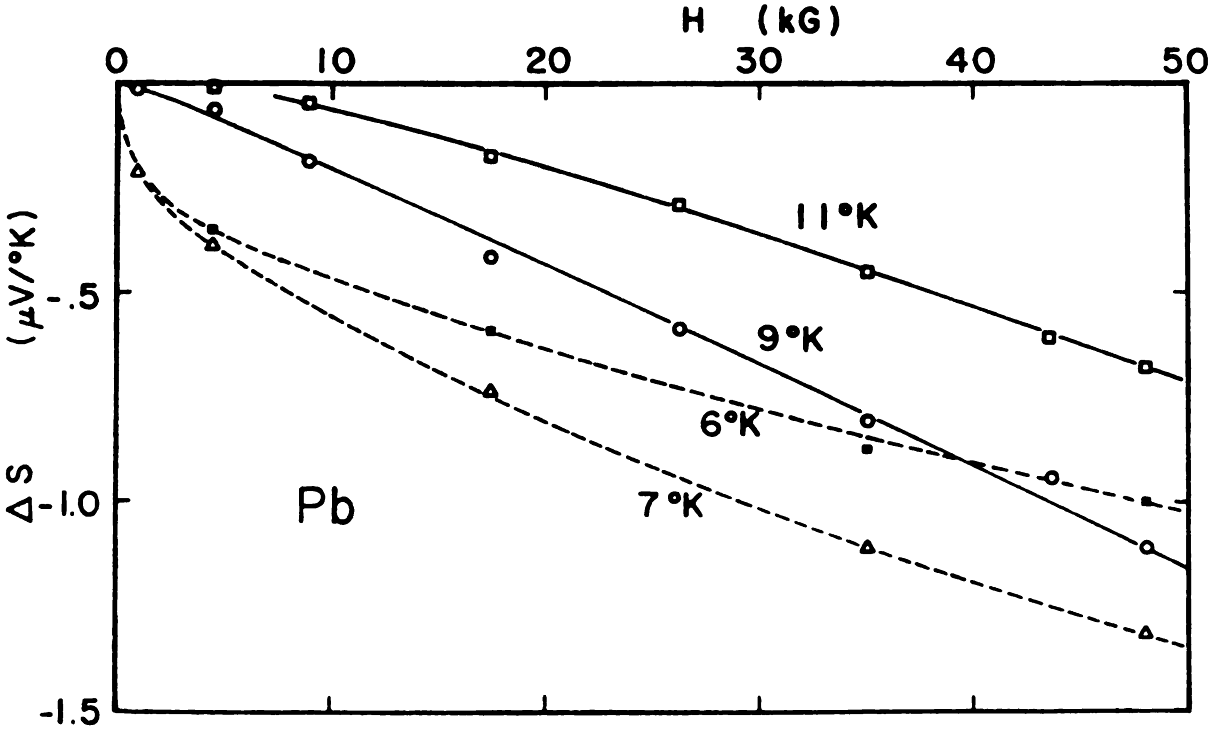

Fig. 4.14 The Magnetic Field Dependence of the Δ S(H,T) of Lead

4. Summary on Experimental Results

The thermopowers of polycrystalline copper, silver, gold, aluminum, indium and lead have been measured from 4.2°K to 100°K in transverse magnetic fields up to 48 kG. For a given field there is a peak in the change of thermopower versus temperature curve. The peak has the following characteristics:

(1) The peak occurs at a temperature between $\theta_D/15$ and $\theta_D/12$, where θ_D is the Debye temperature of the metal.

(2) The peak temperature shifts to higher temperature when the applied field is increased. The shift is about 2 to 5°K as the field increases from 0.87 kG to 48 kG.

(3) The peak appears approximately where $\omega\tau \sim 1$, where ω is the cyclotron frequency and τ is the relaxation time.

(4) The size of the peak increases monotonically with increasing field. The increment is greatest on the high temperature side of the peak, but the half widths of the peak has only a small variation.

(5) The peak can apparently be significantly depressed by alloying with a small amount of non-magnetic impurities, for example, Au in Ag. (See Fig. 3.4)

(6) The sign of the peak can be either positive or negative. For these six metals the peak has the same sign as the phonon-drag thermopower except in indium.

Table 4.3

Thermopower Peak Temperatures of Zero Field and of 48 kG

(in ^{o}K)

Metals	Debye Temp. θ_D	Peak $H=0$	Peak of $\Delta S(H,T)$ $H=48$ kG
Cu	343	72	28
Ag	225	32	17
Au	165	30	16
Al	428	75	30
In	108	23	11
Pb	105	20	9

The experimental $\Delta S(H,T)$ values have the following properties:

(1) At low temperatures, below the peak, $\Delta S(H,T)$ always tends to saturate at high fields.

(2) At low temperatures the temperature dependence of $\Delta S(H,T)$ is not linear but between quadratic and cubic.

(3) In the region where $\Delta S(H,T)$ saturates, the values of $\Delta S(H,T)$ are several times the zero field thermopower.

(4) In a given field $\Delta S(H,T)$ decreases approximately exponentially at high temperatures.

(5) The $\Delta S(H,T)$ of aluminum shows a sign change at 12°K. The cross-over points of $\Delta S(H,T)$ versus temperature curves appears independent of the magnetic field.

CHAPTER V

THERMOELECTRIC THEORY IN A MAGNETIC FIELD

1. Introduction

Early in the 1940's, thermoelectric effects in magnetic fields were studied by Sondheimer and Wilson[33,34]. They proposed a quasi-free electron model, and extended the model from one conduction band to two conduction bands. In experiments on sodium MacDonald and Pearson[3] found that the one band quasi-free electron model did not predict the correct change of thermopower in a magnetic field. The two-band model is more sophisticated and has more flexibility to account for the observed data, but one must realize that Sondheimer's expression was derived for two spherical energy bands, and was valid only if the field was transverse to the temperature gradient. In a longitudinal field this calculation yielded no field dependence of transport properties. Nevertheless, the two-band concept is very useful if the two-band parameters can be properly defined and if one avoids longitudinal effects.

Later in 1956 Lifshitz, Azbel and Kaganov[35,36] suggested a semiclassical theory to explain the magnetoresistance in metals. Bychkov, Gurevich and Nedlin[37] applied the theory to calculate the electron-diffusion thermopower. Gurevich and Nedlin[38] and Lang and Pavlov[39] calculated the phonon-drag thermopower. This semiclassical theory required the solution of the Boltzmann equations for electrons and for phonons, and is applicable only in the high field limit. Gurevich and Nedlin[38] predicted a linear magnetic field dependence of $\Delta S(H,T)$, which disagrees with our observation. Averback and Wagner[40] extending the work of Bychkov, Gurevich and Nedlin[37] obtained an analytic form of the electron-diffusion thermopower. A review of the electron-diffusion thermopower based on the semiclassical theory is given by Abrikosov[41].

Since the existing theories have limited ability to explain the experimental results, we shall try to develop a theory which is able to cover the observations. In this chapter we will present two theoretical models: (1) the electron-diffusion model and (2) the phonon-drag model. Both models are able to account for most experimental features and also are very simple. We shall discuss these models in detail.

We shall not discuss the zero field thermopower except where it is necessary for understanding our theory. There are excellent surveys on this subject given by MacDonald[42], Huebener[43], and Barnard[8]. The general transport theory can be found in many solid state theory books.

Quantum oscillation effects are ignored here, since we are dealing with polycrystalline samples at high temperatures. Those quantum theories[44,45] are able to give a successful prediction of the frequency of oscillation of thermopower in magnetic field, but not of the amplitude.

2. The Electron-Diffusion Model

We assume that the experimental conditions are such that the measurements yield the adiabatic thermoelectric power, i.e. we take field $\vec{H} = (0,0,H)$, heat current $\vec{Q} = (Q,0,0)$ and electrical current $\vec{J} = 0$. We also consider only isotropic conductors. The thermopower is then given by[33]

$$S_d = S_{xx} + S_{xy} \frac{(\nabla T)_y}{(\nabla T)_x} \tag{5.1}$$

where S_{ij} are the components of the isothermal thermoelectric power tensor, $(\nabla T)_i$ are the components of the temperature gradient. From the thermal conductivity tensor we also obtain

$$\frac{(\nabla T)_y}{(\nabla T)_x} = - \frac{K_{yx}}{K_{yy}} \tag{5.2}$$

where K_{ij} are the components of thermal conductivity.

We now assume that S is given by the Mott relation[46].

$$S_d = eL_o T \left(\frac{\partial \ell n \sigma}{\partial \varepsilon}\right)_{\varepsilon_F} \tag{5.3}$$

Here e is the electron charge, σ is the electrical conductivity, ε_F is Fermi energy and L_o is Lorentz number.

If we further assume the validity of the Wiedemann-Franz law, then with the aid of Eqs. 5.1 and 5.2 we arrive at the result of Averbach *et al.*[5]

$$S_d = eL_oT\,[(\underline{\underline{\rho\sigma'}})_{xx} - (\underline{\underline{\rho\sigma'}})_{xy}\,(\frac{\sigma_{yx}}{\sigma_{xx}})]_{\varepsilon_F} \tag{5.4}$$

where the primes denote differentiation with respect to energy ε.

We now rewrite Eq. 5.4 in terms of the resistivity tensor. We make use of the following relations

$$\underline{\underline{\rho\sigma}} = \underline{\underline{\sigma\rho}} = 1 \quad , \quad \underline{\underline{\rho\sigma'}} = -\underline{\underline{\rho}}'\underline{\underline{\sigma}} \tag{5.5}$$

In our case (isotropic conductors) we have

$$\underline{\underline{\sigma}} = \begin{vmatrix} \sigma_1 & \sigma_2 & 0 \\ -\sigma_2 & \sigma_1 & 0 \\ 0 & 0 & \sigma_3 \end{vmatrix} \quad , \qquad \underline{\underline{\rho}} = \begin{vmatrix} \rho_1 & \rho_2 & 0 \\ -\rho_2 & \rho_1 & 0 \\ 0 & 0 & \rho_3 \end{vmatrix} \tag{5.6}$$

where

$$\rho_1 = \frac{\sigma_1}{\sigma_1^2 + \sigma_2^2} \quad , \qquad \rho_2 = \frac{-\sigma_2}{\sigma_1^2 + \sigma_2^2}$$

$$\frac{\sigma_{yx}}{\sigma_{xx}} = -\frac{\sigma_2}{\sigma_1} = -\frac{\rho_{yx}}{\rho_{xx}} \tag{5.7}$$

Hence

$$S_d = eL_oT[(\underline{\underline{\rho}}\underline{\underline{\sigma}}')_{xx} - (\underline{\underline{\rho}}\underline{\underline{\sigma}}')_{xy}\,(\frac{\sigma_{yx}}{\sigma_{xx}})]_{\varepsilon_F}$$

$$= -eL_oT[(\underline{\underline{\rho}}'\underline{\underline{\sigma}})_{xx} + (\underline{\underline{\rho}}'\underline{\underline{\sigma}})_{xy}\,(\frac{\rho_{yx}}{\rho_{xx}})]_{\varepsilon_F}$$

$$= -eL_oT\{(\frac{1}{\rho_{xx}})[(\underline{\underline{\rho}}'\underline{\underline{\sigma}})_{xx}\rho_{xx} + (\underline{\underline{\rho}}'\underline{\underline{\sigma}})_{xy}\rho_{yx}]\}_{\varepsilon_F}$$

$$= -eL_oT\{(\frac{1}{\rho_{xx}})[(\underline{\underline{\rho}}'\underline{\underline{\sigma}}\underline{\underline{\rho}})_{xx}]\}_{\varepsilon_F}$$

$$= -eL_oT(\frac{\rho'_{xx}}{\rho_{xx}})_{\varepsilon_F}$$

$$= -eL_oT(\frac{\partial \ell n\rho_{xx}}{\partial\varepsilon})_{\varepsilon_F} \qquad (5.8)$$

Thus we regain an expression analogous to the Mott formula, where ρ_{xx} is the diagonal component of the resistivity tensor in the transverse magnetic field. The change in the thermopower due to the magnetic field, $\Delta S\ (H,T) = S_d(H,T) - S_d(0,T)$ can now be expressed in terms of the magnetoresistance ratio

$$\frac{\Delta\rho}{\rho} = \frac{\rho_{xx}(H) - \rho_{xx}(0)}{\rho_{xx}(0)}$$ as follows

$$\Delta S\ (H,T) = eL_oT\ [\frac{\rho'_{xx}(H)}{\rho_{xx}(H)} - \frac{\rho'_{xx}(0)}{\rho_{xx}(0)}]_{\varepsilon_F}$$

$$= eL_oT\ [\frac{\rho'_{xx}(H)}{\rho_{xx}(0)}]/[\frac{\rho_{xx}(H)}{\rho_{xx}(0)}]_{\varepsilon_F}$$

$$= eL_oT[\frac{(\Delta\rho/\rho + 1)'}{\Delta\rho/\rho + 1}]_{\varepsilon_F}$$

Finally, we have

$$\Delta S(H,T) = -eL_oT \left[\frac{(\Delta\rho/\rho)}{1+(\Delta\rho/\rho)} \quad \frac{\partial}{\partial\varepsilon} \quad (\ell n \frac{\Delta\rho}{\rho})_{\varepsilon_F} \right] \qquad (5.9)$$

The above equation is derived for the transverse field but it is also valid in longitudinal fields. Equation 5.9 is valid provided the Wiedemann-Franz law and the Mott relation hold.

To proceed further it is necessary to employ some model from which the logarithmic derivative of the magnetoresistance ratio can be derived. However, even without the use of such a specific model, some fairly interesting general conclusions can be obtained from Eq. 5.9 provided Kohler's rule[46], namely $\frac{\Delta\rho}{\rho} = f(H/\rho,\varepsilon)$ is applicable. We then have

$$\Delta S(H,T) = eL_oT \left\{\frac{1}{1+f} \left[- \frac{\partial f}{\partial(H/\rho)} \frac{H}{\rho} \frac{\partial}{\partial\varepsilon} \ell n\rho + \frac{\partial f}{\partial\varepsilon}\right]\right\}_{\varepsilon_F} \qquad (5.10)$$

Since $S(0,T) = -eL_oT \left(\frac{\partial \ell n\rho}{\partial\varepsilon}\right)_{\varepsilon_F}$, it follows that Eq. 519 and Kohler's rule lead to a Kohler-like relation for $\Delta S(H,T)$, namely

$$\Delta S(H,T) = g(S(0,T),\ H/\rho) \qquad (5.11)$$

Without invoking a specific model from which the Kohler function $f(H/\rho)$ could be evaluated, we can still make further progress in establishing certain general behavior patterns for $\Delta S(H,T)$. We consider three commonly encountered situations; an uncompensated metal without open orbits, for which the magnetoresistance saturates; a compensated metal, for which the magnetoresistance does not saturate; and an uncompensated metal with open orbits, for which the magnetoresistance also fails to saturate. Since, for our purposes the cause for non-saturation and the functional relationship between $\Delta\rho/\rho$ and H is not critical, we divide our discussion into consideration of two cases.

Case (a). Metals whose magnetoresistance saturates at high fields.

Case (b). Metals whose magnetoresistance fails to saturate at high fields; we assume that in the high field limit $\Delta\rho/\rho = A(H/\rho)^{\beta}$.

Let us, for convenience, assume that the magnetoresistance is given by an expression of the form[47],

$$\frac{\Delta\rho}{\rho} \equiv \alpha = \frac{A(H/\rho)^{\beta}}{1+B(H/\rho)^{\beta}} \tag{5.12}$$

where A and B are constants which are independent of temperature and magnetic field, but they are energy dependent. β is a numerical constant. Cases (a) and (b) are distinguished formally by the condition $B \neq 0$ for case (a) and $B = 0$ for case (b). In the high field limit, Eq. (5.12) shows the saturation

$$\alpha_{\infty} = A/B \tag{5.13}$$

In the low field limit, we have

$$\alpha_o = A(H/\rho)^{\beta} \tag{5.14}$$

It is easy to show the following relations

$$\frac{\partial \ln \alpha_o}{\partial \varepsilon} = \frac{\partial \ln A}{\partial \varepsilon} - \beta \frac{\partial \ln \rho}{\partial \varepsilon}$$

(5.15)

$$\frac{\partial \ln \alpha_\infty}{\partial \varepsilon} = \frac{\partial \ln (A/B)}{\partial \varepsilon}$$

Thus, at high fields, Eq. 5.9 becomes

$$\Delta S(H,T) = -eL_oT \left\{\frac{\alpha}{1+\alpha} \left[(1-\frac{\alpha}{\alpha_\infty})(\frac{\partial \ln A}{\partial \varepsilon} - \beta \frac{\partial \ln \rho}{\partial \varepsilon}) + \frac{\alpha}{\alpha_\infty}(\frac{\partial \ln \alpha_\infty}{\partial \varepsilon})\right]\right\}_{\varepsilon_F}$$

(5.16)

At very low temperatures where electron scattering is elastic this equation is equivalent to the formula derived by Averback and Wagner[40]. For a metal whose magnetoresistance fails to saturate the Eq. 5.16 should be written as

$$\Delta S(H,T) = -eL_oT \left\{\frac{\alpha}{1+\alpha} (\frac{\partial \ln A}{\partial \varepsilon} - \beta \frac{\partial \ln \rho}{\partial \varepsilon})\right\}_{\varepsilon_F} \tag{5.17}$$

For both cases (a) and (b) the temperature and magnetic field dependence of $\Delta S(H,T)$ will be determined in large measure by the "envelope function" F.

$$F = T \left(\frac{\alpha}{1+\alpha}\right) \tag{5.18}$$

A typical F is shown in Fig. 5.1. At a sufficiently high magnetic field and in a pure metal, $\alpha > 1$ at low temperature and decreases toward zero with increasing temperature. Consequently, the envelope function for a pure metal will increase approximately linearly with temperature at low temperatures and high fields, and it will diminish to zero as the resistivity increases with temperature. It forms a peak whose shape is determined by the form of the temperature dependence of the resistivity and the form of the Kohler function.

We note that regardless of the behavior of the magneto-resistance, saturation or failure to saturate, the thermopower always saturates at high magnetic fields. This general result from Eq. 5.16 of the model appears to be obeyed in those metals which have been investigated experimentally. The saturation value of $\Delta S(H,T)$ is, however, different for the cases (a) and (b), which we shall now examine separately.

The two terms inside the square bracket of Eq. 5.16 are dominant at opposite extremes. At a fixed high field $(1 - \alpha/\alpha_\infty)$ increases from zero to unity with increasing temperature while α/α_∞ decreases from unity to zero. Hence, if $\left(\frac{\partial \ell nA}{\partial \varepsilon} - \beta \frac{\partial \ell n\rho}{\partial \varepsilon}\right)_{\varepsilon_F}$ and $\left(\frac{\partial \ell n\alpha_\infty}{\partial \varepsilon}\right)_{\varepsilon_F}$ are of opposite sign, as may well be the case, Eq. 5.16 predicts a change in sign of the magnetothermopower as the temperature is changed. At an "infinite" field, i.e. in the high field limit and fixed

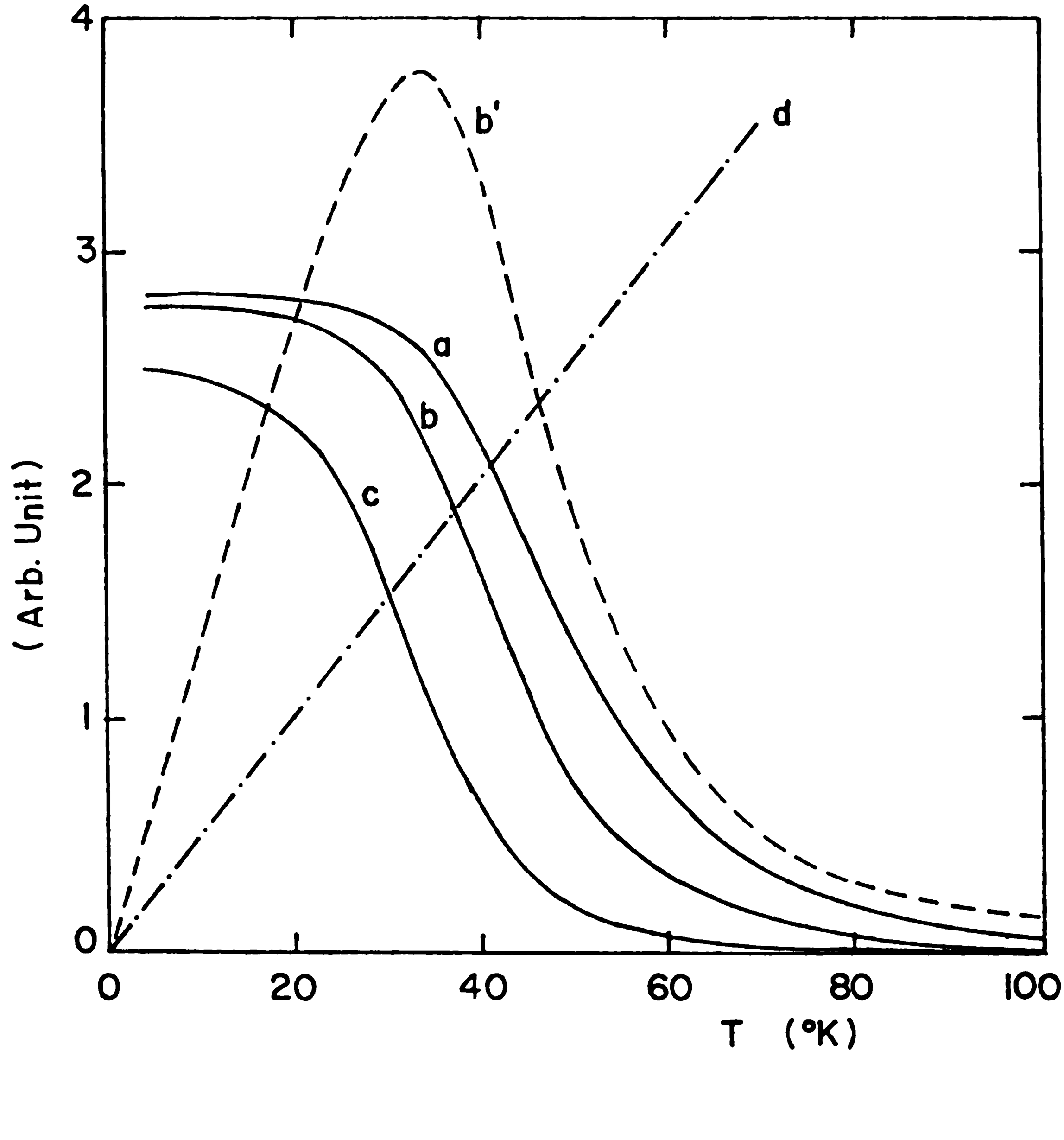

Fig. 5.1 A Typical Magnetoresistance Results (a, b, c) and the Envelope Function (b', which is Calculated from b) for the Electron-Diffusion Model

temperature, the saturation value is given by

$$\Delta S(\infty,T) = -eL_oT \left(\frac{\partial \ln\alpha_\infty}{\partial\varepsilon}\right)_{\varepsilon_F} \tag{5.19}$$

Since we assume that the constants A and B in Eq. 5.12 are independent of temperature, it follows from Eq. 5.19 that the saturation value of $\Delta S(H,T)/T$ is also temperature independent. Indeed this parameter $\left(\frac{\partial \ln\alpha_\infty}{\partial\varepsilon}\right)_{\varepsilon_F}$ can be determined experimentally from the high field limit of $\Delta S(H,T)$. Moreover, since Eq. 5.19 does not involve the derivative of the zero-field resistivity explicitly, the saturation value of $\Delta S(H,T)/T$ is not only independent of temperature but also independent of composition for alloys for which Kohler's rule remains valid.

Turning now to the low field and low temperature region we have remarked on the possibility that $\Delta S(H,T)$ may reverse sign with increasing temperature for a fixed value of field. In Eq. 5.16 the parameter $\left(\frac{\partial \ln A}{\partial\varepsilon} - \beta\frac{\partial \ln\rho}{\partial\varepsilon}\right)_{\varepsilon_F}$ can be determined experimentally, for example, the value of magnetoresistance at that temperature and field for which $\Delta S(H,T) = 0$, where

$$(1 - \alpha/\alpha_\infty)\left(\beta\frac{\partial \ln\rho}{\partial\varepsilon} - \frac{\partial \ln A}{\partial\varepsilon}\right)_{\varepsilon_F} = \left(\frac{\alpha}{\alpha_\infty}\right)\left(\frac{\partial \ln}{\partial\varepsilon}\right)_{\varepsilon_F} \tag{5.20}$$

Qualitatively, we would then expect that the temperatures at which $\Delta S(H,T) = 0$ will shift to higher values with increasing field. Of course, Eq. 5.20 is a consequence of assuming Eq. 5.12 for Kohler's rule.

In contrast with the situation that pertains when the magnetoresistance saturates, the behavior of $\Delta S(H,T)$ in case (b) is significantly different. In this case the saturation value is given by

$$\Delta S(\infty,T) = -eL_oT \left(\frac{\partial \ell n A}{\partial \varepsilon} - \beta \frac{\partial \ell n \rho}{\partial \varepsilon}\right)_{\varepsilon_F} \tag{5.21}$$

We find that the saturation value of magnetothermopower should depend on $\left(\frac{\partial \ell n \rho}{\partial \varepsilon}\right)_{\varepsilon_F}$, i.e. on the zero field diffusion thermopower. This means, first, that even in a pure metal $\Delta S(\infty,T)/T$ may now depend on temperature especially in the temperature range in which the electron relaxation time changes from being dominated by impurity-electron to phonon-electron scattering. The value of $\left(\frac{\partial \ell n \rho}{\partial \varepsilon}\right)_{\varepsilon_F}$ changes from $-1/2\varepsilon_F$ to $-3/2\varepsilon_F$ in the free electron model. Second, since the diffusion thermopower at zero field depends sensitively on alloying, $\Delta S(\infty,T)/T$ should also depend on alloying provided Kohler's rule remains valid. However, the temperature dependence of $\Delta S(H,T)$ becomes simpler. There is only one constant to be determined, and presumably no change of sign in $\Delta S(H,T)$ occurs.

3. Phonon-Drag Model

Consider a conductor with a temperature gradient along the x-direction. The non-equilibrium phonon system will create a phonon flux flowing from the high temperature and to the low temperature end of the conductor. These phonons will interact with all other particles, such as electrons, impurities, defects and also other phonons. At high temperatures the phonon-phonon interactions are strong so that the phonon system maintains itself near equilibrium. When the temperature is reduced the phonon-phonon interaction become less important. The phonons now start to transfer their momentum into the electron system via the electron-phonon interaction. In other words, the phonon flux drags the electrons to the cold end of the conductor. This extra force produces the phonon drag thermopower. The theory of phonon-drag thermopower in the absence of a magnetic field has been developed by Bailyn[48]. The phonon-drag thermopower $S_g(0,T)$ is given by

$$S_g(0,T) = - \frac{\kappa \frac{2}{3} e^2 \Sigma \ \tau v \cdot w[-\partial f_o/\partial \varepsilon]}{e \ \frac{2}{3} e^2 \Sigma \tau v^2 [-\partial f_o/\partial \varepsilon]} \qquad (5.22)$$

where κ is the thermal conductivity, e is the charge of electron, τ is the electron relaxation time. $v(k\ell)$ is the velocity of electron in wave vector k and band ℓ, f_o is the Fermi function of the electrons, and

$$w(k\ell) = (\partial f_o/\partial \varepsilon)^{-1} \sum_{k'\ell'} [p(jq;k\ell,k'\ell')+p(jq;k'\ell',k\ell)] \times [\partial N_o(jq)/\partial kT]v(jq) \tag{5.23}$$

in which $N_o(jq)$ is the equilibrium distribution of phonons of wave vector q and polarization j. $p(jq;k\ell,k'\ell')$ is the relative probability that the jq phonon will engage in the interaction that sends the electron state from $k\ell$ to $k'\ell'$. For low temperatures, using a free electron model the above equation gives a simple result for temperature dependence of $S_g(0,T)$, namely

$$S_g(0,T) \propto T^3 \tag{5.24}$$

The contribution of the phonon-drag thermopower, therefore, can be identified from the temperature dependence. In the real metals the phonon drag thermopower can be either positive or negative. This is due to the existence of Umklapp processes. In normal processes we have

$$k + q = k' \tag{5.25}$$

while in Umklapp processes we have

$$k + q = k' + g \tag{5.26}$$

where k and k' are the wave vector of the electron before and after scattering, and g is a reciprocal lattice vector.

Umklapp scattering generally reverses the velocity of the electron and therefore gives a positive contribution to the phonon drag thermopower[49]. Based on the above picture, the probability P(q) contains two parts, i.e.

$$P(q) = P_N(q) + P_U(q) \qquad (5.27)$$

where the subscripts N and U refer to the normal processes and the Umklapp processes, respectively. In the case of a nobel metal, we may assume a finite probability $P_U(q)$ which gives the positive component of the thermopower. This positive component is so large that it exceeds the negative component and gives a positive phonon-drag thermopower. The major part of the $P_U(q)$ comes from the neck region of the Fermi surface. If we assume that electron-phonon scattering processes are not affected by a magnetic field, the redistribution of electron states on the Fermi surface due to the field may play an important role in the observed effects. In the following we shall examine the distribution of electrons on the Fermi surface before and after the field is present.

Let us consider the Fermi sphere shown in Fig. 5.2[50,51]. In the absence of the field the electrons are distributed around the sphere, statically. An electron remains in its position until it is scattered by phonons or other quasi-particles. After the scattering the electron occupies

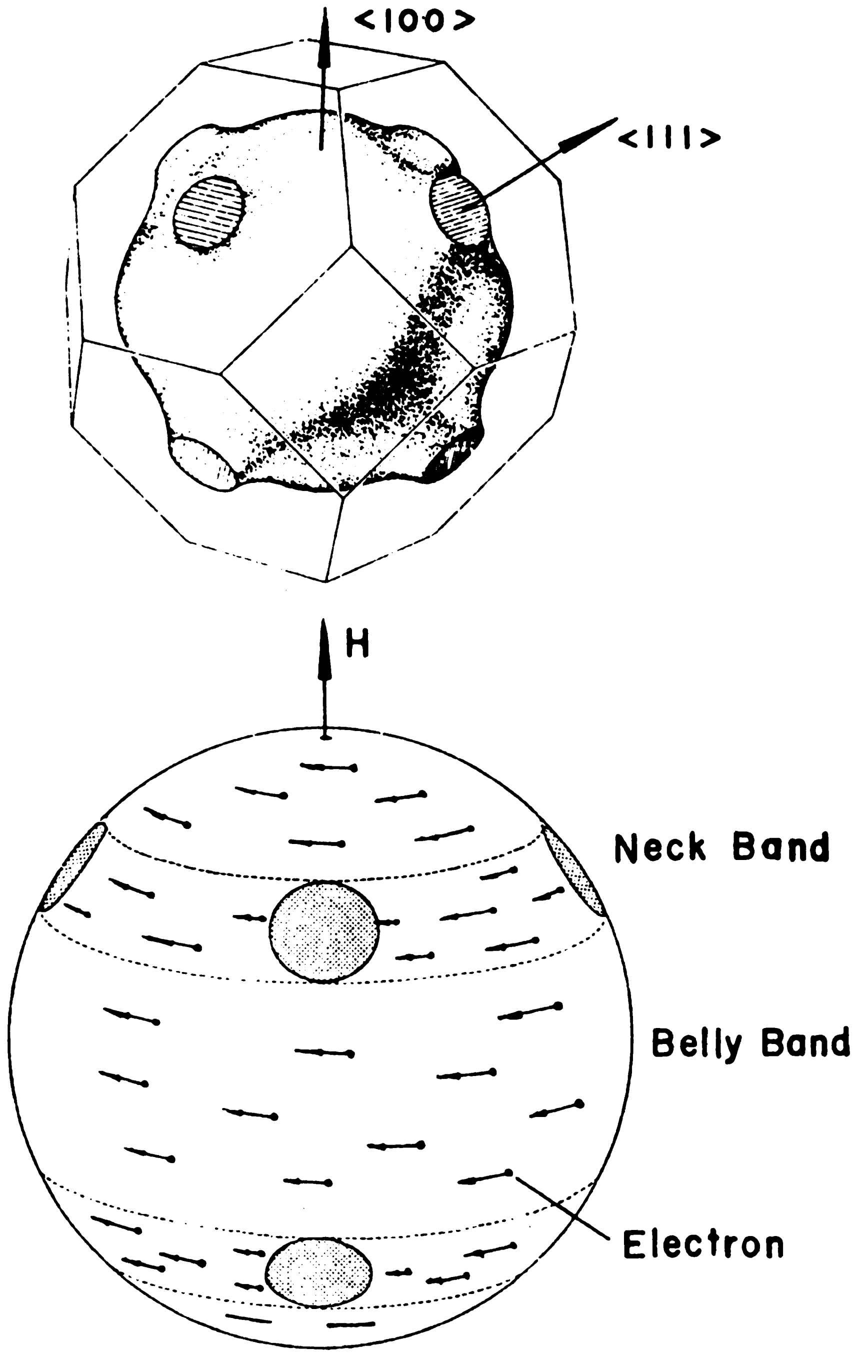

Fig. 5.2 The Fermi Surface of Copper and the Influence of a Magnetic Field

a new position on the Fermi sphere and stays there until the next scattering occurs. The scattering processes involve both normal processes and Umklapp processes whose ratio depends on q, k, and temperature.

Now we turn on the magnetic field. The field results in a Lorentz force acting on the electrons, and also on the ions. It is easy to show that the Lorentz force on the ions is small compared to the nearest neighbor interaction between ions. For the field we used, the ratio is of the order of 10^{-4}. Therefore, the phonon system is not affected by the magnetic field. However, the electron is affected by the field. Its wave vector k is changed according to

$$\hbar \dot{k} = (e/c) \cdot v \times H \tag{5.28}$$

Since the Lorentz force is always perpendicular to the velocity vector v, this motion is limited to the constant energy surface normal to H. The magnetic field sweeps an electron on the Fermi surface around the Fermi sphere about an axis parallel to the field. In other words, the picture of the model will be: the electron on the Fermi sphere will travel in an orbit around the Fermi sphere, driven by the Lorentz force, until it is scattered. After the scattering the electron changes to another point on the Fermi sphere, start its journey again until it is scattered again.

As we have seen in the Fig. 5.2 the Fermi surface of copper is not a perfect sphere. The electron will travel through the area where the scattering probability and the relaxation time is different. The fact that some electrons must pass through both the neck region where the Umklapp scattering dominates and the belly region where the normal scattering dominates must be taken into consideration.

To proceed further, we divide the orbits on the Fermi surface into two classes: (a) orbits that intersect a neck, and (b) orbits that do not intersect a neck. As shown in Fig. 5.2 the cases (a) and (b) are not a single orbit but a wide band. We shall call them the neck band and belly band, respectively. The properties of a neck region (for copper a neck region including a neck of about 20° angular radius and the shoulder area) are: the relaxation time for the electron-phonon scattering is short[52] with a large probability for Umklapp scattering, which is responsible for the positive component, S_g^U, of the phonon drag thermopower in zero field[49]. Contrariwise, the properties of the belly region are: the relaxation time for the electron-phonon scattering is longer with a large probability for normal scattering which is the source of negative component, S_g^N, of the phonon drag thermopower.

For electrons in the belly bands the magnetic field does not have significant influence in the electron-phonon scattering. The contrary is true in the neck bands. The magnetic field sweeps electrons from the belly region to the neck region and vice versa. This concept was first suggested by Pippard[51]. We now examine the motion of the electrons on the Fermi sphere. Halse[53] reviewed the Fermi velocity of copper. The contours of Fermi velocity for copper is shown in Fig. 5.3. We see that the Fermi velocity is smaller near the neak region than the bellies. For a given magnetic field, the sweeping rate is smaller in the neck region than in the belly region. In other words, the electrons will tend to stay in the neck region longer than in the belly region. Thus, the electrons will be easy to be scattered when they are traversing the neck region, due to a short relaxation time associated with the neck region. The contrary is true for the electrons traversing the belly region. We then expect that the chance of an electron to be scattered in the neck region is higher than in the belly region during its journey. As we remark before, there is a large probability for Umklapp scattering in the neck region.

Because of the large probability of scattering at the neck region the electron distribution will be comparatively close to the equilibrium distribution f_o even in the absence of a magnetic field. On the other hand the distribution of electrons on the bellies will be considerably different from f_o, since there few interactions tending to restore equilibrium on the belly. Now if we apply a magnetic filed, because of the above mechanisms, electrons entering the neck region from bellies will tend to rapidly come to

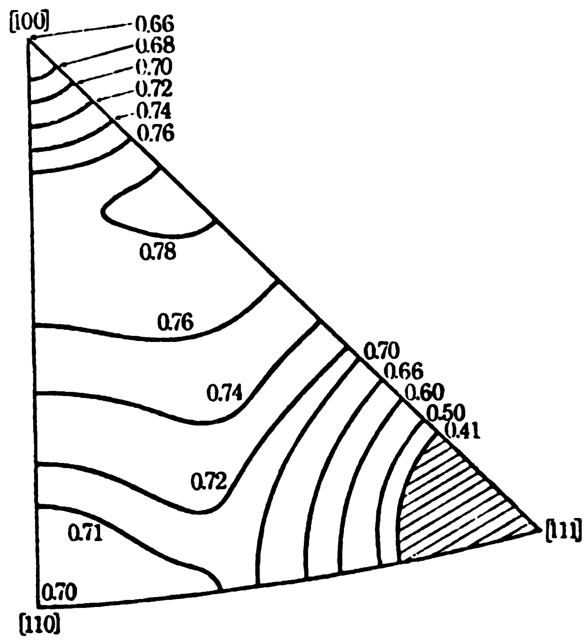

Fig. 5.3 Contours of Fermi Velocity (Expressed in the Unit of the Fermi Velocity of Free Electron) for Copper

the local neck equilibrium. Meanwhile, electrons moving from neck to belly will tend to carry with them the neck distribution, since the scattering necessary to restore local equilibrium is small on the bellies. Thus the simultaneous application of both temperature gradient and magnetic field produces a different distribution of electrons from that where the temperature gradient acts alone.

Returning now to our hypothesis on page 85 that electron-phonon scattering processes are not affect by the magnetic field, and that the redistribution of electron states in the Fermi surface may play an important role, we see now how such a redistribution can take place. The redistribution will affect both the electron diffusion thermopower and phonon drag thermopower, and it is not obvious how these would be separated.

Another picture is as follows. Again we assume that the phonon electron interaction is indepedent of magnetic field, but the phonon drag thermopower does depend on what happens to the electrons before and after the interaction. This is the idea behind the theory of Bailyn and Dugdale[48] whereby S_g can be split into i components S_i, corresponding with groups of similar carriers. If σ_i is the corresponding electrical conductivity, then

$$S_g = \sum_i \frac{\sigma_i}{\sigma_T} S_i \tag{5.29}$$

where σ_T is the total conductivity. Where S_i are considered independent of field, σ_i are field dependent. Hence the contribution to S_g from the ith region can be profoundly modified by the magnetic field. In the case of copper, the relevant regions would seem to be those belly regions containing no orbits intercepting the necks ($\sigma_B S_B$), the belly band, and those regions of the Fermi surface containing orbits which do intercept the necks ($\sigma_N S_N$), the neck band. It is reasonably certain that σ_B and σ_N will vary differently on applying a field and thus affecting the contributions from the two regions. In the case of aluminum, the relevant regions would be the second and the third band of the Fermi surface.

We meight expect the effect of the magnetic field should saturate when $\omega\tau \sim 1$ although as Pippard[51] has shown, true saturation does not set in until $\omega\tau >> 1$ (about $\omega\tau \sim 10$) When $\omega\tau \sim 1$, an electron is able to make a complete trip around the Fermi surface. For still higher fields, the effect of the sweeping the electrons reaches its limit. Therefore, we expect that the magnetothermopower will saturate in high fields. Since the orbit of the electrons is determined by the direction of the magnetic field we meight also expect the field effect on the thermopower to be anisotropic. Other factors such as alloying which change zero-field phonon-drag thermopower could also affect the magnetothermopower.

CHAPTER VI

DISCUSSION AND CONCLUSION

1. Comparison with Experiments

The two theoretical models presented in the last chapter will now be compared with the experimental results. We shall determine the parameters of the electron-diffusion model and make a quantitative comparison with the observed values. No quantitative comparison is made on the phonon-drag model. A qualitative comparison between the experimental results and the phonon-drag model is given in Table 6.1. The comparison shall center on the two representative metals: copper and aluminum. The results for the rest of metals follows a pattern similar to that which we will see in the copper and aluminum.

Since the transverse magnetoresistance of copper does not saturate, the electron-diffusion model gives the following formula for computing the $\Delta S(H,T)$.

$$\Delta S(H,T) = -eL_oT\left(\frac{\alpha}{1+\alpha}\right) D \qquad (6.1)$$

where

$$D = \left(\frac{\partial \ell nA}{\partial \varepsilon} - \beta\frac{\partial \ell n\rho}{\partial \varepsilon}\right)_{\varepsilon_F} \qquad (6.2)$$

We assume that the phonon-drag thermopower is uninfluenced by the magnetic field. This assumption was also adapted by

MacDonald[3]. In obtaining a "theoretical curve" the parameter D was normalized to the magnitude of the peak of the measured $\Delta S(H,T)$ for H = 48 kG. From $\Delta S(H,T)$ at H = 48 kG and T = 30°K we obtained $D = 21.4/\varepsilon_F$. Using this D value and the measured data of α we calculated $\Delta S(H,T)$ as a function of temperature at different fields. The results of the calculation (dashed curves) are shown in Fig. (6.1) together with experimental results (solid curves).

The agreement between the experimental and calculated curves is remarkably good in view of the crudeness of the model and the many assumptions we have made. In particular the following qualitative features of the experimental data are reproduced by the calculated curves.

(a) $\Delta S(H,T)$ for a given H increases with increasing temperature at low temperatures, reaches a peak and thereafter falls off. The temperature of the peak is in the neighborhood of 30°K.

(b) At any temperature $\Delta S(H,T)$ is a monotonically increasing function of magnetic field.

(c) At sufficiently low temperatures and high magnetic fields the thermopower exhibits a well defined saturation even though the magnetoresistance fails to saturation.

(d) The temperature at which the peak in $\Delta S(H,T)$ appears shifts toward high values with increasing field. The close agreement between the experimental and calculated curves suggests that, within the limits of our model, the

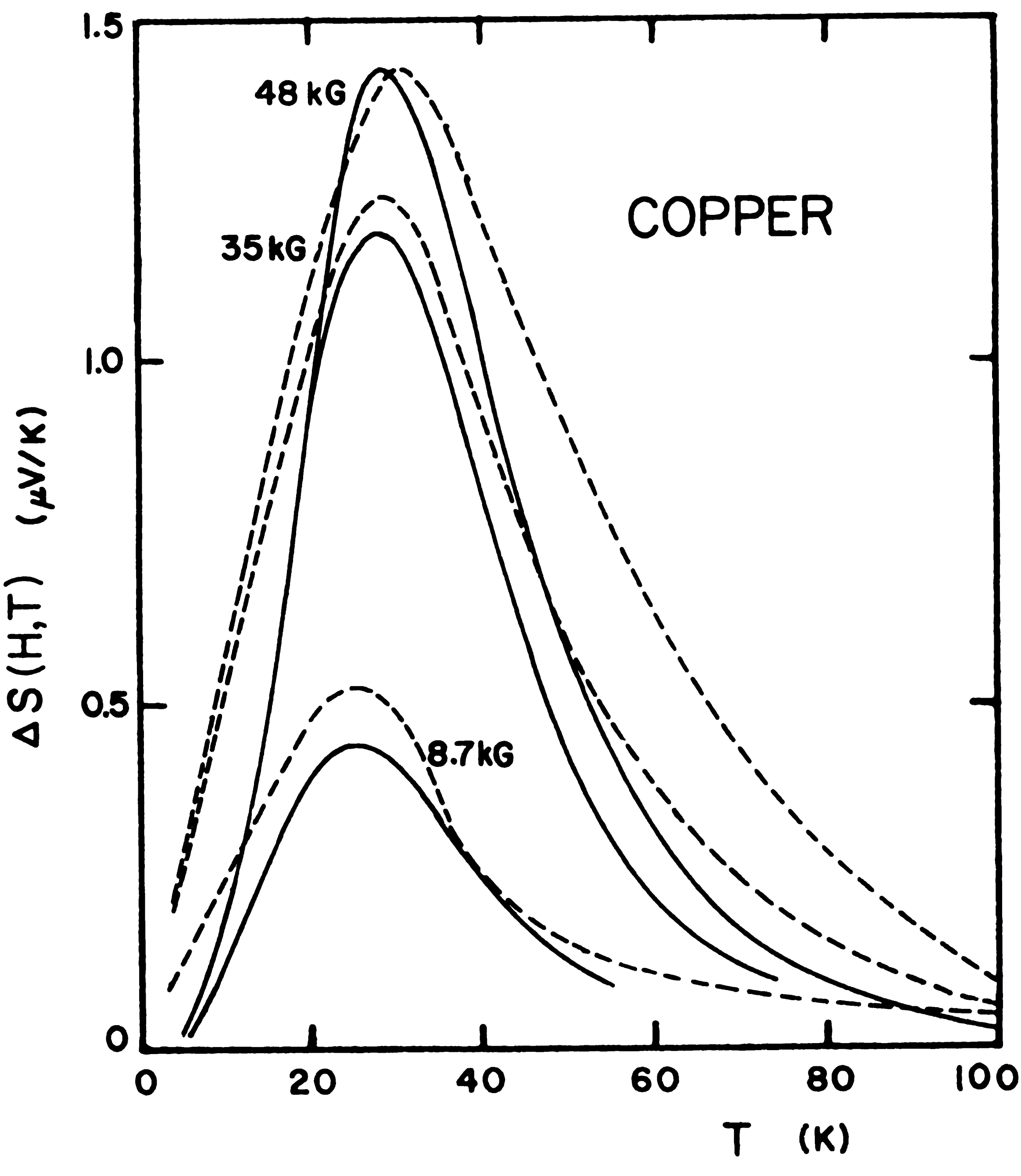

Fig. 6.1 Calculated (Dashed Curves) and Experimental (Solid Curves) Results of Δ S(H,T) of Copper as a Function of Temperature at Three Field Values

parameter D is not a sensitive function of magnetic field. However, the value of D is unphysically large, i.e. implies an energy dependence of α more than one order of magnitude greater than $\left(\frac{\partial \ell n\rho}{\partial \varepsilon}\right)_{\varepsilon_F}$. Also, the parameter D is temperature dependent.

Recently, Nielsen and Taylor[54,55] considered the $S_d(0,T)$ term by taking into account the second order effect of intrinsic two phonon processes in the electron-phonon interaction. They found that the $S_d(0,T)$ should contain a non-linear contribution. Rosler[56] performed a variational calculation and gave a similar prediction for alkali metals. In other words, a term which is similar to the phonon drag term may be included in the electron-diffusion thermopower. If we denote the linear term of $S_d(0,T)$ as $S_{dd}(0,T)$, then

$$S_d(0,T) = S_{dd}(0,T) + S_{dg}(0,T) \tag{6.3}$$

where $S_{dg}(0,T)$ is the contribution to the electron-diffusion thermopower from the Nielsen-Taylor calculation. Although Guenault[57] argued that the $S_{dg}(0,T)$ is negligible at very low temperatures we shall not ignore the possible contribution from this effect, especially when the temperature is higher. $S_{dg}(0,T)$ has a T^3-temperature dependence at low temperatures, which is similar to the zero-field phonon drag thermopower. If we include the Nielsen-Taylor term into our electron-diffusion model, the temperature dependence and the magnitude of the parameter D may be justified. Moreover, the non-linear temperature dependence of $\Delta S(H,T)$ at low temperatures can also be understood.

To calculate $\Delta S(H,T)$ for aluminum, an uncompensated metal, the electron-diffusion model provided the formula

$$\Delta S(H,T) = -eL_oT\ \left(\frac{\alpha}{1+\alpha}\right)\ \left(C_1+C_2\ \frac{\alpha}{\alpha_\infty}\right)_{\varepsilon_F} \tag{6.4}$$

where
$$C_1 = \left(\frac{\partial \ell nA}{\partial \varepsilon} - \beta\ \frac{\partial \ell n\rho}{\partial \varepsilon}\right)_{\varepsilon_F} \tag{6.5}$$

and
$$C_2 = \left(\frac{\partial \ell n\alpha_\infty}{\partial \varepsilon}\right)_{\varepsilon_F} - C_1 \tag{6.6}$$

The magnetoresistance of aluminum saturates at moderate high fields, but Kohler's rule fails to be obeyed at very high fields[58]. We find that α of aluminum exhibits a large anomaly near 20-30°K[59]. In order to proceed with the calculations we assumed Kohler's rule is obeyed by the magnetoresistance of aluminum. We made a crude extrapolation of the low field magnetoresistance to obtain the high field limit α_∞. There are two parameters to be determined. First, the ratio C_1/C_2 is obtained from the temperature where the $\Delta S(H,T)$ changes sign. The magnitude of parameters C_1 and C_2 are normalized to the peak value of $\Delta S(H,T)$ at 26 kG. We find $C_1 = +49.6/\varepsilon_F$ and $C_2 = -66.2/\varepsilon_F$. This set of parameters together with the α from Kohler's plot were used to calculate the $\Delta S(H,T)$. The results of the calculation (dashed curves) and observed data (solid surves) are shown in Fig. 6.2.

It is apparent that there are many differences between the calculated and the experimental curves, although some qualitative features are retained.

(a) The cross-over point of $\Delta S(H,T)$ is shifted to higher temperature with increasing field, while the experimental data shows that it is nearly constant.

(b) At the temperature below the peak of $\Delta S(H,T)$, the calculated values decrease rather than increase with increasing field.

(c) The calculated peaks of $\Delta S(H,T)$ appear at temperatures substantially above those observed.

Figure 6.2 also suggests that, the parameters C_1 and C_2 will depend strongly on the field and temperature. Also, we are aware that this set of parameters is unrealistically large.

These discrepancies may be related to the failure of Kohler's rule and the assumption we have made on the parameters. Despite the obvious inadequacy of the model in this case, some qualitative features are again reproduced.

2. Discussion and Conclusion

We have presented two different models to explain the experimental results. The predictions of the models and the experimental facts are summarized in Table 6.1. A glance at table 6.1 shows that both theories are able to explain the general picture of the experimental results. However, some weaknesses do exist in the models.

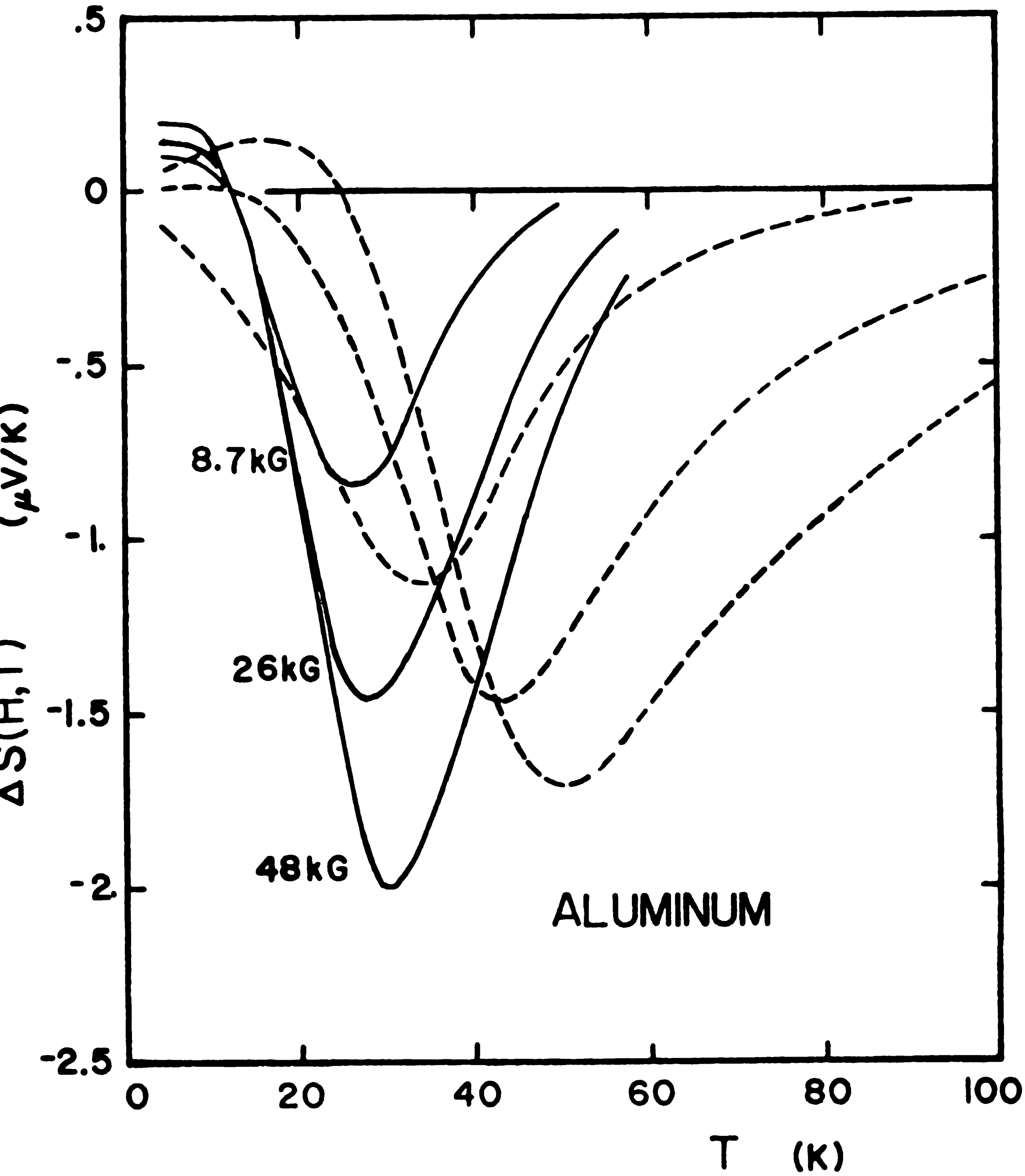

Fig. 6.2 Calculated (Dashed Curves) and Experimental (Solid Curves) Results of $\Delta S(H,T)$ of Aluminum as a Function of Temperature at Three Field Values

Table 6.1

The Comparison between the Electron-Diffusion Model, the Phonon-Drag Model and the Experimental Results

Experimental Results	Electron-Diffusion Model	Phonon-Drag Model
Peak	Yes	Yes
Peak Shifts to high Temp.	Yes	Yes
Peak at $\omega\tau \sim 1$	Possible	Yes
Size of Peak	Possible	Yes
Sign of Peak	+/-	+/-
$\Delta S(H,T)$ saturates at High Fields	Yes	Yes
Non-linear $\Delta S(H,T)$ at low Temp.	Possible	Yes
Sign Change in Al	Possible	No
Alloying	Affects	Affects

First, we shall point out that the parameter D which gives Fig. 6.1 is too large (~ 20 times) compared to the free electron expectation. We shall now try to determine the parameter D in the free electron theory region. Consider the zero field thermopower, which contains two components, i.e.

$$S(0,T) = S_d(0,T) + S_g(0,T) \tag{6.7}$$

At low temperatures we expect the following simple relation to hold

$$S(0,T) = A(0)T + B(0)T^3 \tag{6.8}$$

where A(0) and B(0) are constants. Equation (6.8) should be valid in the temperature range where impurity scattering dominates. If we assume it holds also for the change of thermopower in a magnetic field, then

$$S(H,T) = A(H)\ T + B(H)\ T^3 \tag{6.9}$$

and

$$\Delta S(H,T) = \Delta A(H)T + \Delta B(H)\ T^3 \tag{6.10}$$

Based on our resistivity data we assume Eq. (6.10) is good up to 11°K for both copper and aluminum. Therefore, we may separate low temperature ΔS(H,T) into the electron-diffusion component and phonon-drag component according to Eq. 6.10. The analysis and the results of $\Delta A(H)$ and $\Delta B(H)$ are shown in Figs. 6.3 to 6.5 for copper, and in Figs. 6.6 to 6.8 for aluminum. Now, if we require that the parameter D satisfies only the $\Delta A(H)$ term, the value of D will be $0.8/\varepsilon_F$ for copper. With the new value of D, the peak of $\Delta S(H,T)$ at 48 kG is only 0.05 μV/°K. This is too small to account for the experimental results, and favors the phonon-drag model. In the case of aluminum, the electron diffusion term is positive, the same sign as in copper, and there is no sign change. From Eq. 6.1, we can determine C_1 at the high field limit, and C_2 from one other point. At $H = 26$ kG, we obtained $C_1 = 15.4/\varepsilon_F$ and $C_2 = 4.8/\varepsilon_F$. The positive diffusion component implies that there is a negative phonon-drag component in $\Delta S(H,T)$ for aluminum, even larger than the total observed change.

Next, let us consider the phonon drag model based on the above discussion of the electron-diffusion model. The former model does not preclude the existence of the latter model. In fact, the co-existence of these two models explains the experimental result in aluminum much better than either one alone. For example, in the case of aluminum, the electron-diffusion thermopower gives a positive change and the phonon-drag thermopower gives a negative change in the field. At low temperature $\Delta S_d(H,T)$ has T-dependence and $\Delta S_g(H,T)$ has T^3-dependence, so that $\Delta S_d(H,T)$ is larger than

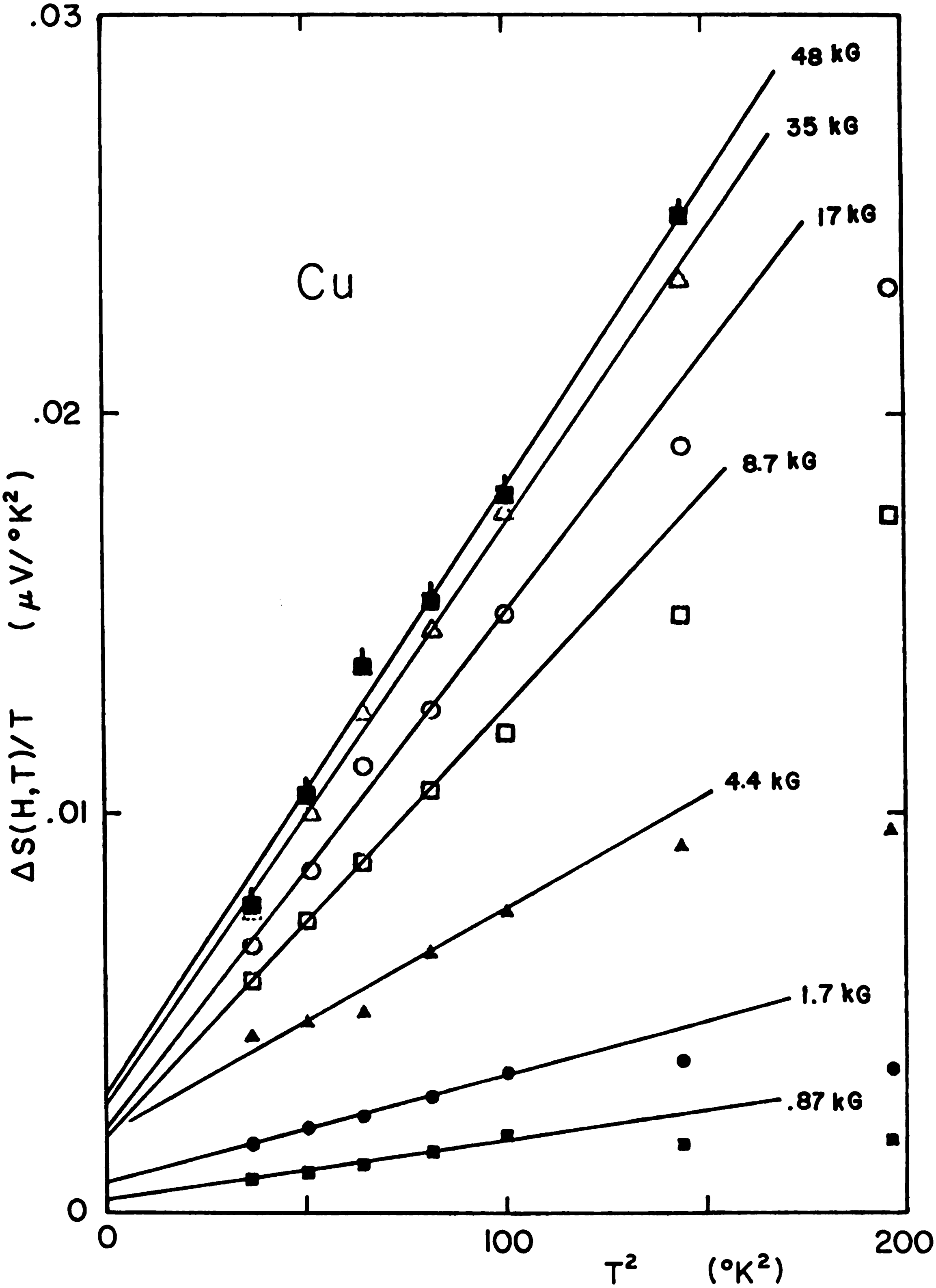

Fig. 6.3 The Separation of the T- and T^3-Dependence of $\Delta S(H,T)$ for Copper

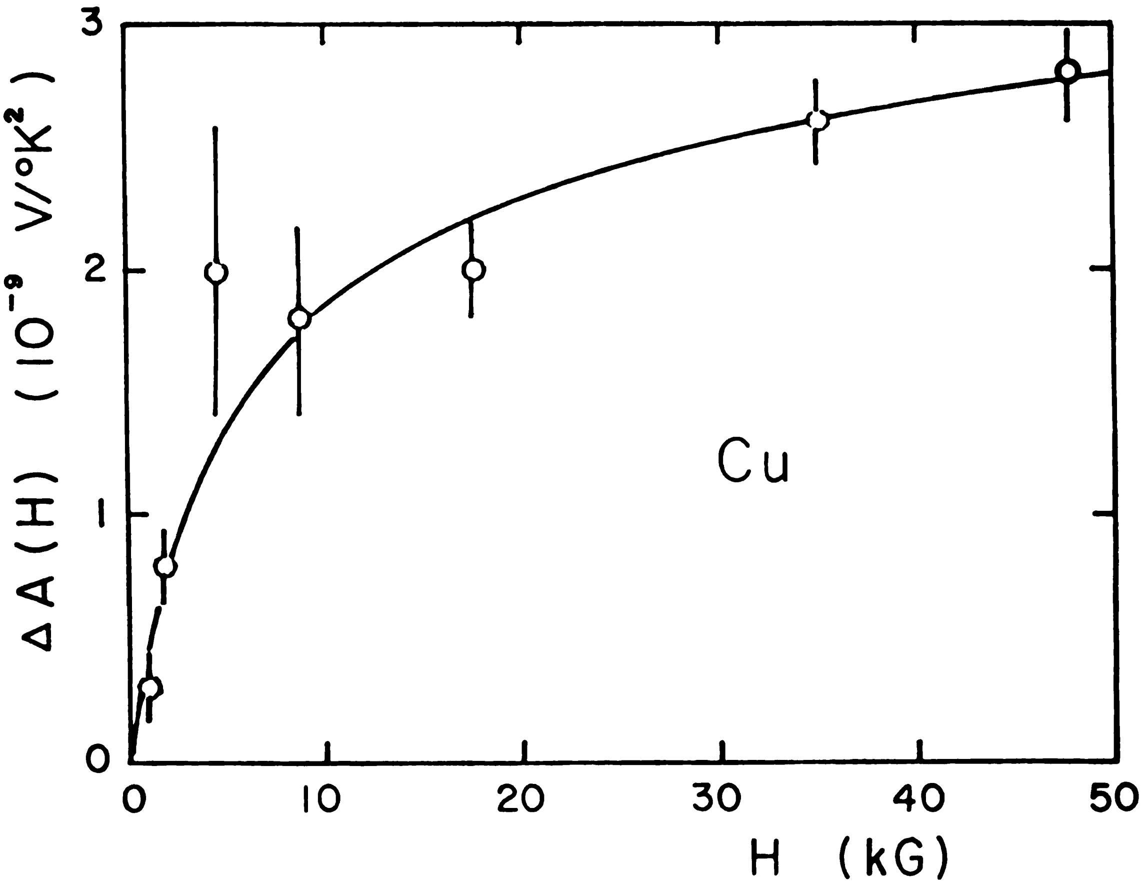

Fig. 6.4 The Δ A(H) of Copper as a Function of Magnetic Field

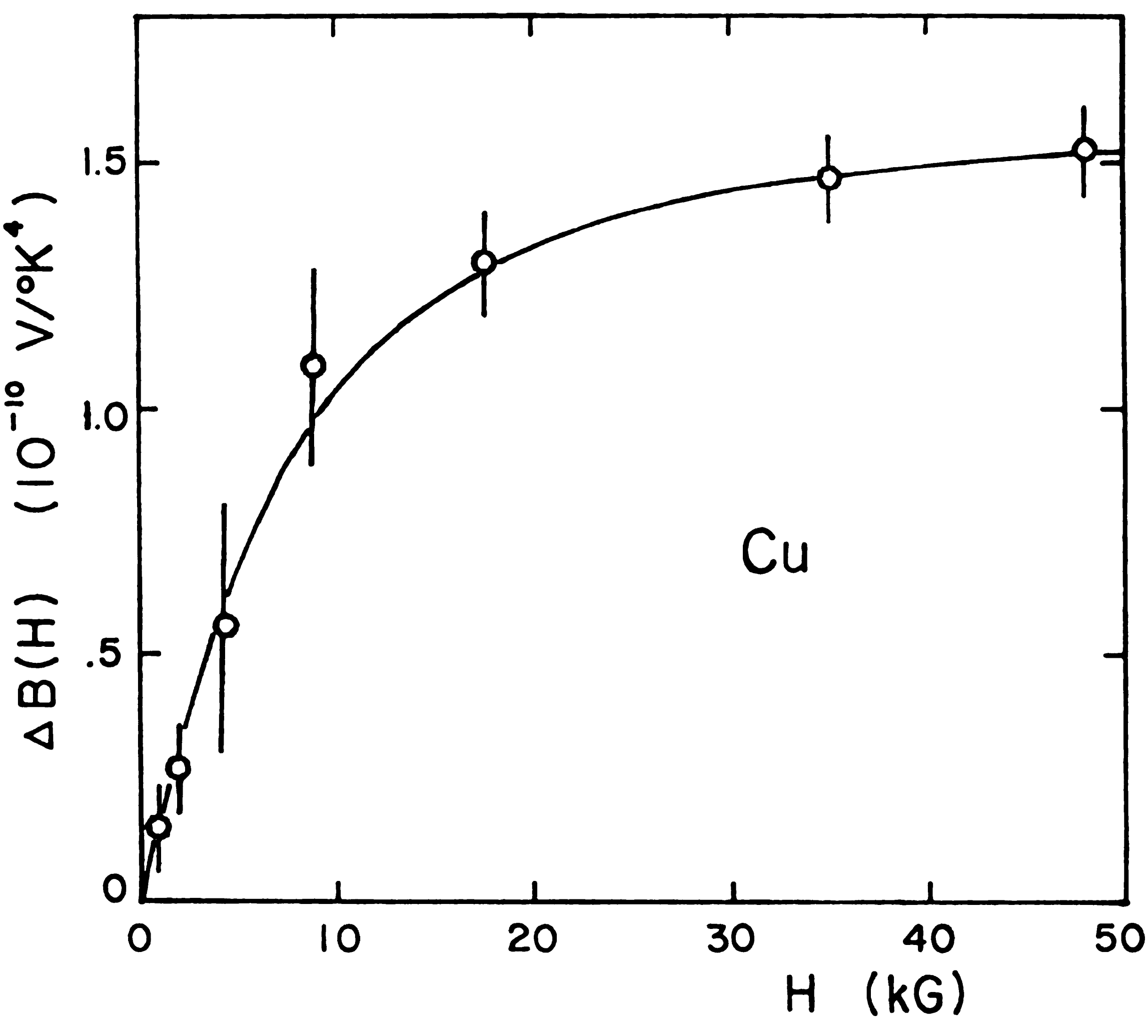

Fig. 6.5 The Δ B(H) of Copper as a Function of Magnetic Field

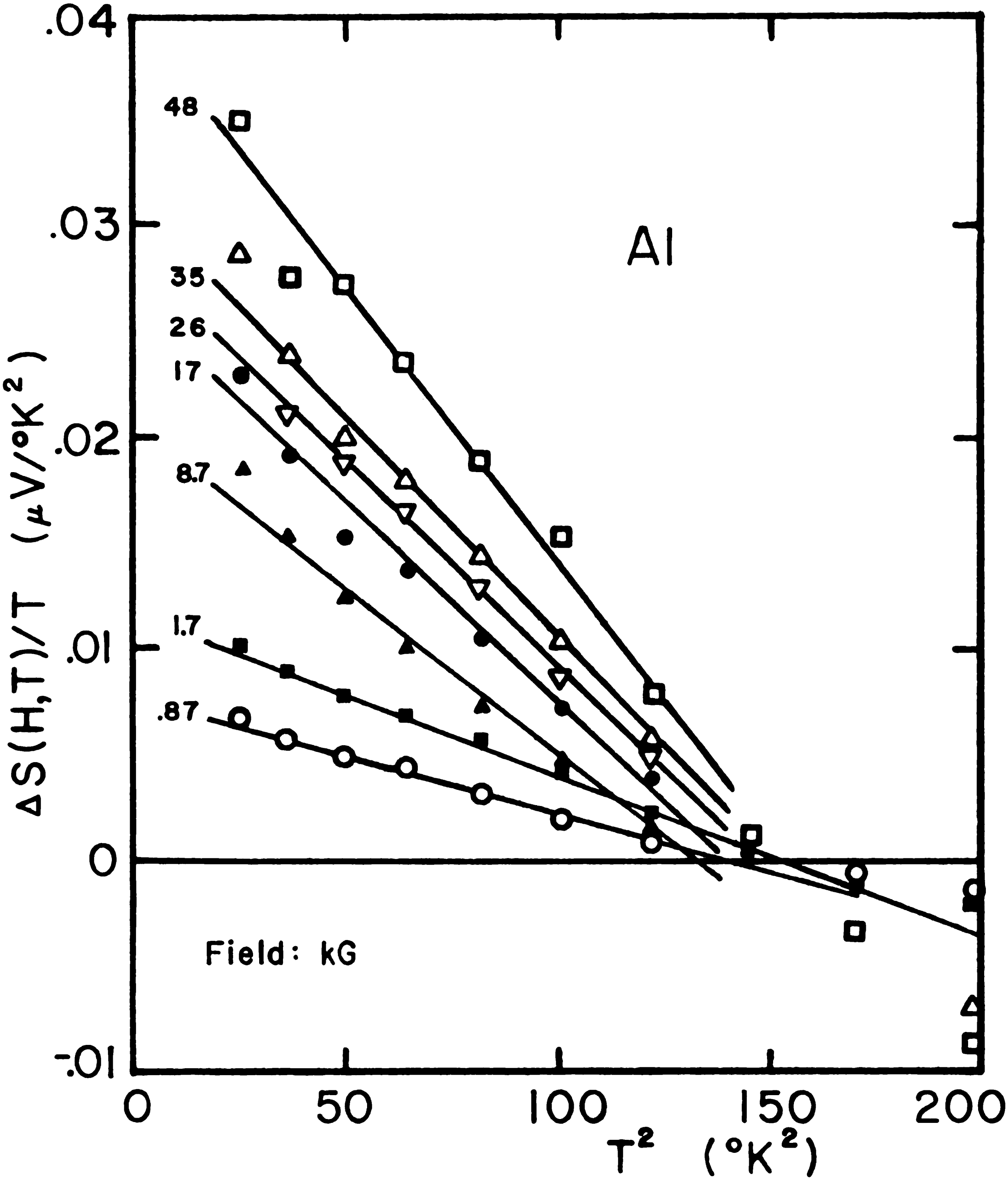

Fig. 6.6 The Separation of the T- and T^3-Dependence of $\Delta S(H,T)$ for Aluminum

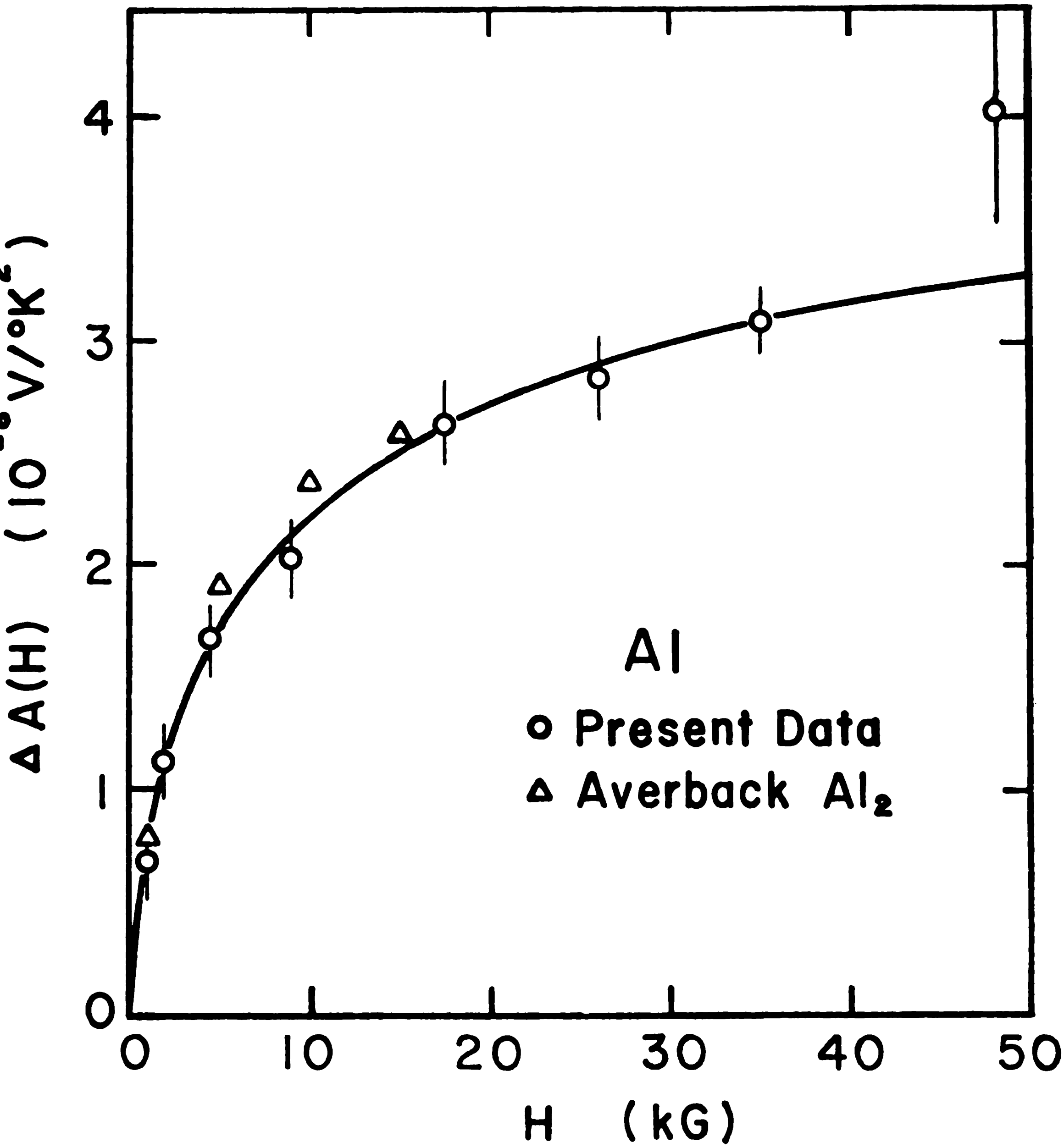

Fig. 6.7 The Δ A(H) of Aluminum as a Function of Magnetic Field

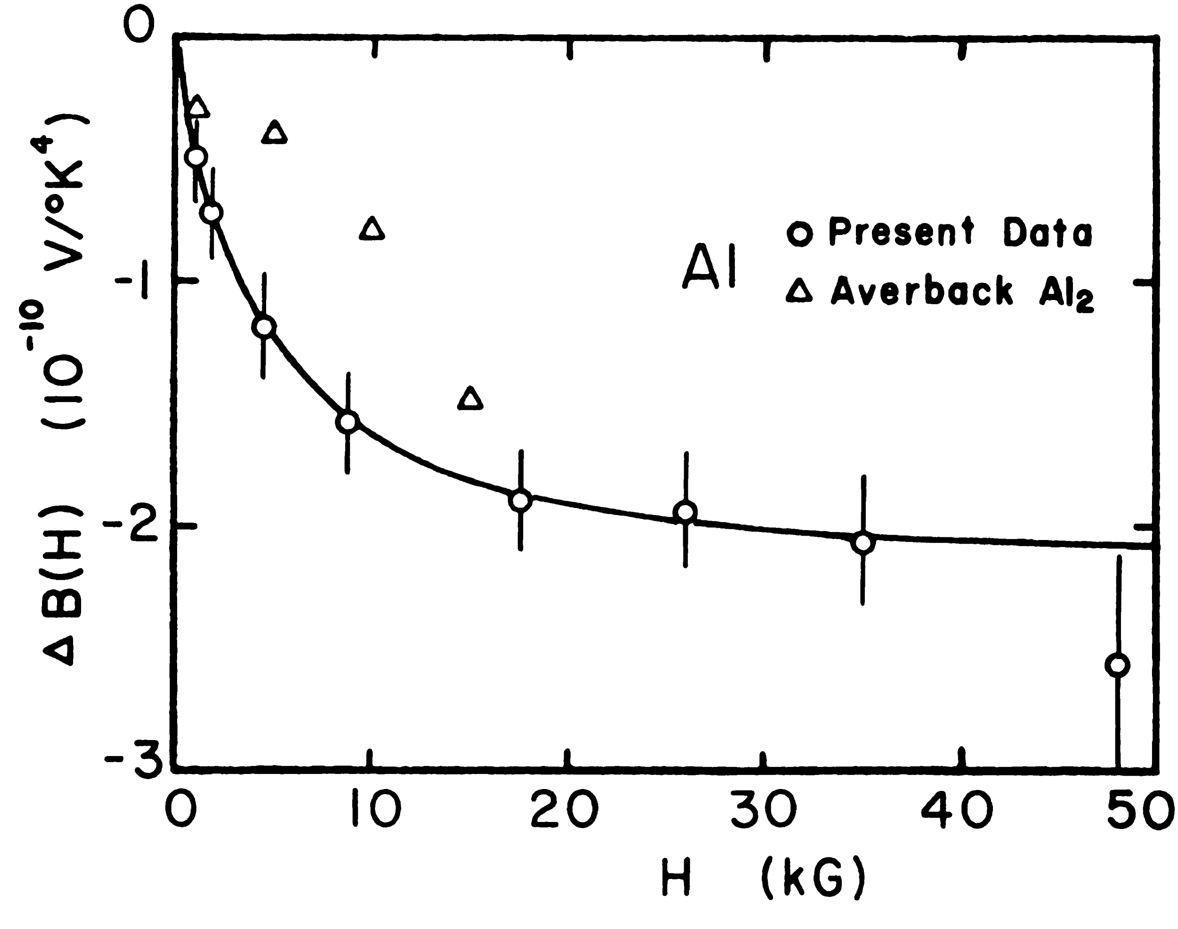

Fig. 6.8 The Δ B(H) of Aluminum as a Function of Magnetic Field

$\Delta S_g(H,T)$ and $\Delta S(H,T)$ is positive.

With increasing temperature, $S_g(H,T)$ increases faster than $S_d(H,T)$ thus causing the sign $S(H,T)$ to reverse at sufficiently high temperatures. Therefore, the sign change of the thermopower of aluminum in a magnetic field is a natural consequence of the competition between the positive change of electron-diffusion thermopower and the negative change of phonon-drag thermopower in the presence of a magnetic field. This argument holds also for copper, except that here the change of phonon-drag thermopower is now positive.

In conclusion, we believe that the observed effect of the magnetic field on the thermopower is due to the changes in electron-diffusion thermopower and in phonon-drag thermopower.

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APPENDIX

APPENDIX

REFERENCE TABLES
FOR LOW-TEMPERATURE THERMOCOUPLES
IN MAGNETIC FIELDS

I. Chromel-P versus Gold-0.07 at.% Iron Thermocouples

Magnetic Field	Page
Zero Magnetic Field	117
5 kG	119
10 kG	121
15 kG	123
20 kG	125
25 kG	127
30 kG	129
35 kG	131
40 kG	133
45 kG	135
50 kG	137
60 kG	139
70 kG	141
80 kG	143
90 kG	145
100 kG	147

II. Silver Normal versus Gold-0.07 at.% Iron Thermocouples

Magnetic Field	Page
Zero Magnetic Field	150
5 kG	152
10 kG	154
15 kG	156
20 kG	158
25 kG	160
30 kG	162
35 kG	164
40 kG	166
45 kG	168
50 kG	170
60 kG	172
70 kG	174
80 kG	176
90 kG	178
100 kG	180

I.

Chromel-P versus Gold-0.07 at.% Iron

Thermocouples

CHROMEL P VERSUS GOLD-0.07 AT. PERCENT IRON

AT 0. KG

TEMP. (DEG. K)	EMF (UV)	EMF (UV) CHANGE	S (UV/K)	S(UV/K) INCREMENT
4.22	0.00	0.00	12.638	---
5.00	10.21	0.00	13.342	.704
6.00	23.94	0.00	14.103	.761
7.00	38.37	0.00	14.739	.636
8.00	53.38	0.00	15.265	.526
9.00	68.87	0.00	15.697	.432
10.00	84.75	0.00	16.045	.348
11.00	100.94	0.00	16.323	.278
12.00	117.37	0.00	16.540	.217
13.00	134.00	0.00	16.704	.164
14.00	150.77	0.00	16.825	.121
15.00	167.64	0.00	16.909	.084
16.00	184.57	0.00	16.962	.053
17.00	201.55	0.00	16.989	.027
18.00	218.55	0.00	16.997	.008
19.00	235.54	0.00	16.988	-.009
20.00	252.52	0.00	16.966	-.022
21.00	269.47	0.00	16.935	-.031
22.00	286.39	0.00	16.898	-.037
23.00	303.26	0.00	16.856	-.042
24.00	320.10	0.00	16.811	-.045
25.00	336.89	0.00	16.766	-.045
26.00	353.63	0.00	16.721	-.045
27.00	370.33	0.00	16.678	-.043
28.00	386.99	0.00	16.637	-.041
29.00	403.60	0.00	16.600	-.037
30.00	420.19	0.00	16.566	-.034
31.00	436.74	0.00	16.536	-.030
32.00	453.26	0.00	16.511	-.025
33.00	469.76	0.00	16.490	-.021
34.00	486.25	0.00	16.474	-.016
35.00	502.71	0.00	16.463	-.011
36.00	519.17	0.00	16.456	-.007
37.00	535.63	0.00	16.453	-.003
38.00	552.08	0.00	16.455	.002
39.00	568.54	0.00	16.461	.006
40.00	585.00	0.00	16.471	.010
41.00	601.48	0.00	16.484	.013
42.00	617.97	0.00	16.501	.017
43.00	634.48	0.00	16.521	.020
44.00	651.01	0.00	16.544	.023
45.00	667.57	0.00	16.569	.025
46.00	684.15	0.00	16.597	.028
47.00	700.77	0.00	16.628	.031
48.00	717.41	0.00	16.660	.032
49.00	734.09	0.00	16.694	.034
50.00	750.80	0.00	16.730	.036

CHROMEL P VERSUS GOLD-0.07 AT. PERCENT IRON

AT 0. KG

TEMP. (DEG. K)	EMF (UV)	EMF (UV) CHANGE	S (UV/K)	S(UV/K) INCREMENT
51.00	767.55	0.00	16.767	.037
52.00	784.33	0.00	16.806	.039
53.00	801.16	0.00	16.845	.039
54.00	818.02	0.00	16.885	.040
55.00	834.93	0.00	16.926	.041
56.00	851.88	0.00	16.968	.042
57.00	868.87	0.00	17.010	.042
58.00	885.90	0.00	17.053	.043
59.00	902.97	0.00	17.096	.043
60.00	920.09	0.00	17.139	.043
61.00	937.25	0.00	17.183	.044
62.00	954.46	0.00	17.226	.043
63.00	971.70	0.00	17.270	.044
64.00	988.99	0.00	17.314	.044
65.00	1006.33	0.00	17.358	.044
66.00	1023.71	0.00	17.401	.043
67.00	1041.13	0.00	17.445	.044
68.00	1058.60	0.00	17.489	.044
69.00	1076.11	0.00	17.532	.043
70.00	1093.66	0.00	17.575	.043
71.00	1111.26	0.00	17.619	.044
72.00	1128.90	0.00	17.662	.043
73.00	1146.59	0.00	17.705	.043
74.00	1164.31	0.00	17.748	.043
75.00	1182.08	0.00	17.790	.042
76.00	1199.89	0.00	17.833	.043
77.00	1217.75	0.00	17.875	.042
78.00	1235.64	0.00	17.918	.043
79.00	1253.58	0.00	17.960	.042
80.00	1271.56	0.00	18.002	.042
81.00	1289.59	0.00	18.044	.042
82.00	1307.65	0.00	18.086	.042
83.00	1325.76	0.00	18.128	.042
84.00	1343.91	0.00	18.169	.041
85.00	1362.10	0.00	18.211	.042
86.00	1380.33	0.00	18.252	.041
87.00	1398.60	0.00	18.293	.041
88.00	1416.91	0.00	18.334	.041
89.00	1435.27	0.00	18.375	.041
90.00	1453.66	0.00	18.415	.040
91.00	1472.10	0.00	18.456	.041
92.00	1490.57	0.00	18.496	.040
93.00	1509.90	0.00	18.536	.040
94.00	1527.65	0.00	18.576	.040
95.00	1546.24	0.00	18.615	.039
96.00	1564.88	0.00	18.655	.040
97.00	1583.55	0.00	18.694	.039
98.00	1602.26	0.00	18.733	.039
99.00	1621.02	0.00	18.772	.039
100.00	1639.81	0.00	18.810	.038

CHROMEL P VERSUS GOLD-0.07 AT. PERCENT IRON
AT 5. KG

TEMP. (DEG. K)	EMF (UV)	EMF(UV) CHANGE	S (UV/K)	S(UV/K) INCREMENT
4.22	0.00	0.00	12.658	---
5.00	10.18	-.03	13.360	.702
6.00	23.94	-.00	14.114	.754
7.00	38.38	.01	14.745	.631
8.00	53.39	.00	15.265	.520
9.00	68.86	-.01	15.693	.428
10.00	84.70	-.04	16.037	.344
11.00	100.86	-.08	16.311	.274
12.00	117.25	-.13	16.524	.213
13.00	133.83	-.17	16.684	.160
14.00	150.54	-.23	16.802	.118
15.00	167.35	-.28	16.883	.081
16.00	184.23	-.34	16.934	.051
17.00	201.15	-.40	16.960	.026
18.00	218.09	-.45	16.966	.006
19.00	235.03	-.51	16.955	-.011
20.00	251.95	-.56	16.932	-.023
21.00	268.85	-.62	16.901	-.031
22.00	285.72	-.67	16.864	-.037
23.00	302.55	-.72	16.822	-.042
24.00	319.33	-.76	16.777	-.045
25.00	336.08	-.81	16.732	-.045
26.00	352.78	-.85	16.688	-.044
27.00	369.44	-.89	16.646	-.042
28.00	386.06	-.92	16.606	-.040
29.00	402.65	-.96	16.569	-.037
30.00	419.20	-.99	16.535	-.034
31.00	435.72	-1.02	16.506	-.02[illegible]
32.00	452.21	-1.05	16.481	-.025
33.00	468.69	-1.08	16.460	-.021
34.00	485.14	-1.10	16.444	-.016
35.00	501.59	-1.12	16.433	-.011
36.00	518.02	-1.15	16.426	-.007
37.00	534.46	-1.17	16.423	-.003
38.00	550.89	-1.19	16.425	.002
39.00	567.33	-1.21	16.431	.006
40.00	583.77	-1.23	16.441	.010
41.00	600.23	-1.25	16.455	.014
42.00	616.71	-1.27	16.472	.017
43.00	633.20	-1.28	16.492	.020
44.00	649.71	-1.30	16.516	.024
45.00	666.25	-1.32	16.541	.025
46.00	682.82	-1.33	16.570	.029
47.00	699.42	-1.35	16.601	.031
48.00	716.04	-1.37	16.634	.033
49.00	732.70	-1.38	16.668	.034
50.00	749.40	-1.40	16.705	.037

CHROMEL P VERSUS GOLD-0.07 AT. PERCENT IRON

AT 5. KG

TEMP. (DEG. K)	EMF (UV)	EMF(UV) CHANGE	S (UV/K)	S(UV/K) INCREMENT
51.00	766.13	-1.41	16.742	.037
52.00	782.91	-1.43	16.783	.041
53.00	799.72	-1.44	16.823	.040
54.00	816.57	-1.45	16.864	.041
55.00	833.46	-1.47	16.906	.042
56.00	850.40	-1.48	16.949	.043
57.00	867.38	-1.49	16.991	.042
58.00	884.40	-1.50	17.035	.044
59.00	901.46	-1.51	17.078	.043
60.00	918.57	-1.52	17.122	.044
61.00	935.72	-1.53	17.166	.044
62.00	952.92	-1.53	17.210	.044
63.00	970.17	-1.54	17.254	.044
64.00	987.45	-1.54	17.299	.045
65.00	1004.78	-1.55	17.343	.044
66.00	1022.16	-1.55	17.387	.044
67.00	1039.58	-1.55	17.432	.045
68.00	1057.05	-1.55	17.477	.045
69.00	1074.56	-1.55	17.521	.044
70.00	1092.11	-1.55	17.565	.044
71.00	1109.71	-1.55	17.610	.045
72.00	1127.35	-1.55	17.654	.044
73.00	1145.05	-1.54	17.698	.044
74.00	1162.77	-1.54	17.741	.043
75.00	1180.54	-1.54	17.784	.043
76.00	1198.36	-1.53	17.827	.043
77.00	1216.22	-1.53	17.870	.043
78.00	1234.11	-1.53	17.913	.043
79.00	1252.05	-1.53	17.956	.043
80.00	1270.03	-1.53	17.998	.042
81.00	1288.06	-1.53	18.040	.042
82.00	1306.12	-1.53	18.082	.042
83.00	1324.23	-1.53	18.124	.042
84.00	1342.38	-1.53	18.165	.041
85.00	1360.56	-1.54	18.208	.043
86.00	1378.79	-1.54	18.249	.041
87.00	1397.05	-1.55	18.290	.041
88.00	1415.35	-1.56	18.331	.041
89.00	1433.70	-1.57	18.372	.041
90.00	1452.08	-1.58	18.413	.041
91.00	1470.51	-1.59	18.455	.042
92.00	1488.97	-1.60	18.495	.040
93.00	1508.29	-1.61	18.535	.040
94.00	1526.03	-1.62	18.575	.040
95.00	1544.62	-1.62	18.615	.040
96.00	1563.25	-1.63	18.655	.040
97.00	1581.92	-1.63	18.694	.039
98.00	1600.64	-1.62	18.733	.039
99.00	1619.41	-1.61	18.772	.039
100.00	1638.22	-1.59	18.810	.038

CHROMEL P VERSUS GOLD-0.07 AT. PERCENT IRON

AT 10. KG

TEMP. (DEG. K)	EMF (UV)	EMF(UV) CHANGE	S (UV/K)	S(UV/K) INCREMENT
4.22	0.00	0.00	12.852	---
5.00	10.36	.15	13.523	.671
6.00	24.29	.35	14.242	.719
7.00	38.86	.48	14.854	.612
8.00	53.95	.57	15.345	.491
9.00	69.48	.61	15.742	.397
10.00	85.37	.62	16.070	.328
11.00	101.55	.61	16.318	.248
12.00	117.94	.57	16.520	.202
13.00	134.52	.52	16.668	.148
14.00	151.22	.46	16.778	.110
15.00	168.02	.38	16.856	.078
16.00	184.88	.31	16.903	.047
17.00	201.78	.23	16.926	.023
18.00	218.69	.14	16.932	.006
19.00	235.60	.06	16.923	-.009
20.00	252.50	-.02	16.898	-.025
21.00	269.37	-.10	16.865	-.033
22.00	286.21	-.17	16.828	-.037
23.00	303.02	-.25	16.786	-.042
24.00	319.78	-.32	16.741	-.045
25.00	336.50	-.39	16.698	-.043
26.00	353.18	-.45	16.655	-.043
27.00	369.82	-.51	16.614	-.041
28.00	386.41	-.58	16.575	-.039
29.00	402.97	-.64	16.539	-.036
30.00	419.49	-.69	16.506	-.033
31.00	435.99	-.75	16.476	-.030
32.00	452.46	-.80	16.451	-.025
33.00	468.90	-.86	16.430	-.021
34.00	485.33	-.91	16.414	-.016
35.00	501.75	-.97	16.405	-.009
36.00	518.15	-1.02	16.400	-.005
37.00	534.55	-1.08	16.399	-.001
38.00	550.95	-1.13	16.402	.003
39.00	567.35	-1.18	16.409	.007
40.00	583.76	-1.24	16.420	.011
41.00	600.19	-1.29	16.433	.013
42.00	616.62	-1.35	16.451	.018
43.00	633.08	-1.40	16.471	.020
44.00	649.56	-1.46	16.494	.023
45.00	666.06	-1.51	16.519	.025
46.00	682.59	-1.56	16.548	.029
47.00	699.15	-1.62	16.580	.032
48.00	715.74	-1.67	16.612	.032
49.00	732.37	-1.72	16.647	.035
50.00	749.03	-1.77	16.684	.037

CHROMEL P VERSUS GOLD-0.07 AT. PERCENT IRON

AT 10. KG

TEMP. (DEG. K)	EMF (UV)	EMF(UV) CHANGE	S (UV/K)	S(UV/K) INCREMENT
51.00	765.73	-1.82	16.723	.039
52.00	782.47	-1.87	16.764	.041
53.00	799.25	-1.91	16.804	.040
54.00	816.07	-1.95	16.844	.040
55.00	832.93	-2.00	16.886	.042
56.00	849.84	-2.04	16.928	.042
57.00	866.79	-2.07	16.971	.043
58.00	883.79	-2.11	17.014	.043
59.00	900.83	-2.14	17.058	.044
60.00	917.92	-2.17	17.102	.044
61.00	935.05	-2.20	17.147	.045
62.00	952.23	-2.23	17.192	.045
63.00	969.45	-2.25	17.238	.046
64.00	986.72	-2.28	17.283	.045
65.00	1004.03	-2.30	17.328	.045
66.00	1021.39	-2.32	17.371	.043
67.00	1038.79	-2.34	17.416	.045
68.00	1056.25	-2.35	17.461	.045
69.00	1073.74	-2.37	17.505	.044
70.00	1091.28	-2.38	17.549	.044
71.00	1108.86	-2.40	17.595	.046
72.00	1126.49	-2.41	17.640	.045
73.00	1144.17	-2.42	17.684	.044
74.00	1161.88	-2.43	17.728	.044
75.00	1179.63	-2.45	17.770	.042
76.00	1197.43	-2.46	17.814	.044
77.00	1215.28	-2.47	17.857	.043
78.00	1233.16	-2.48	17.901	.044
79.00	1251.09	-2.49	17.944	.043
80.00	1269.06	-2.50	17.988	.044
81.00	1287.08	-2.51	18.031	.043
82.00	1305.13	-2.52	18.074	.043
83.00	1323.23	-2.53	18.117	.043
84.00	1341.38	-2.53	18.159	.042
85.00	1359.56	-2.54	18.201	.042
86.00	1377.78	-2.55	18.242	.041
87.00	1396.05	-2.55	18.284	.042
88.00	1414.35	-2.56	18.326	.042
89.00	1432.71	-2.56	18.367	.041
90.00	1451.10	-2.56	18.408	.041
91.00	1469.54	-2.56	18.450	.042
92.00	1488.01	-2.56	18.491	.041
93.00	1507.34	-2.56	18.531	.040
94.00	1525.09	-2.56	18.572	.041
95.00	1543.68	-2.56	18.611	.039
96.00	1562.32	-2.56	18.652	.041
97.00	1580.98	-2.57	18.691	.039
98.00	1599.68	-2.58	18.730	.039
99.00	1618.43	-2.59	18.770	.040
100.00	1637.20	-2.61	18.808	.038

CHROMEL P VERSUS GOLD-0.07 AT. PERCENT IRON

AT 15. KG

TEMP. (DEG. K)	EMF (UV)	EMF(UV) CHANGE	S (UV/K)	S(UV/K) INCREMENT
4.22	0.00	0.00	13.278	---
5.00	10.67	.46	13.867	.589
6.00	24.87	.93	14.484	.617
7.00	39.65	1.28	15.049	.565
8.00	54.91	1.53	15.500	.451
9.00	70.57	1.70	15.847	.347
10.00	86.55	1.80	16.130	.283
11.00	102.80	1.86	16.348	.218
12.00	119.25	1.87	16.530	.182
13.00	135.86	1.86	16.674	.144
14.00	152.59	1.82	16.775	.101
15.00	169.40	1.76	16.844	.069
16.00	186.27	1.69	16.887	.043
17.00	203.16	1.61	16.909	.022
18.00	220.07	1.53	16.911	.002
19.00	236.98	1.44	16.898	-.013
20.00	253.86	1.35	16.876	-.022
21.00	270.72	1.25	16.845	-.031
22.00	287.55	1.16	16.808	-.037
23.00	304.33	1.07	16.766	-.042
24.00	321.07	.98	16.721	-.045
25.00	337.77	.89	16.676	-.045
26.00	354.43	.80	16.631	-.045
27.00	371.04	.71	16.589	-.042
28.00	387.60	.62	16.549	-.040
29.00	404.13	.53	16.512	-.037
30.00	420.63	.44	16.479	-.033
31.00	437.09	.35	16.449	-.030
32.00	453.52	.26	16.425	-.024
33.00	469.94	.17	16.405	-.020
34.00	486.33	.08	16.389	-.016
35.00	502.71	-.01	16.379	-.010
36.00	519.08	-.10	16.373	-.006
37.00	535.44	-.19	16.371	-.002
38.00	551.80	-.28	16.374	.003
39.00	568.17	-.37	16.381	.007
40.00	584.55	-.46	16.391	.010
41.00	600.93	-.55	16.405	.014
42.00	617.34	-.63	16.422	.017
43.00	633.76	-.72	16.443	.021
44.00	650.21	-.81	16.467	.024
45.00	666.68	-.89	16.493	.026
46.00	683.17	-.98	16.522	.029
47.00	699.70	-1.06	16.554	.032
48.00	716.27	-1.14	16.587	.033
49.00	732.87	-1.22	16.622	.035
50.00	749.50	-1.30	16.659	.037

CHROMEL P VERSUS GOLD-0.07 AT. PERCENT IRON

AT 15. KG

TEMP. (DEG. K)	EMF (UV)	EMF (UV) CHANGE	S (UV/K)	S (UV/K) INCREMENT
51.00	766.17	-1.37	16.697	.038
52.00	782.89	-1.45	16.746	.049
53.00	799.64	-1.52	16.777	.031
54.00	816.44	-1.59	16.818	.041
55.00	833.27	-1.65	16.860	.042
56.00	850.16	-1.72	16.903	.043
57.00	867.09	-1.78	16.947	.044
58.00	884.06	-1.84	16.992	.045
59.00	901.07	-1.90	17.036	.044
60.00	918.13	-1.96	17.080	.044
61.00	935.24	-2.01	17.125	.045
62.00	952.39	-2.06	17.170	.045
63.00	969.59	-2.11	17.216	.046
64.00	986.84	-2.16	17.262	.046
65.00	1004.12	-2.21	17.308	.046
66.00	1021.46	-2.25	17.351	.043
67.00	1038.84	-2.29	17.396	.045
68.00	1056.27	-2.33	17.441	.045
69.00	1073.74	-2.37	17.486	.045
70.00	1091.25	-2.41	17.531	.045
71.00	1108.81	-2.45	17.577	.046
72.00	1126.42	-2.48	17.622	.045
73.00	1144.08	-2.51	17.666	.044
74.00	1161.77	-2.54	17.710	.044
75.00	1179.51	-2.57	17.753	.043
76.00	1197.29	-2.60	17.797	.044
77.00	1215.13	-2.62	17.841	.044
78.00	1232.99	-2.65	17.886	.045
79.00	1250.91	-2.67	17.930	.044
80.00	1268.87	-2.69	17.972	.042
81.00	1286.88	-2.71	18.016	.044
82.00	1304.92	-2.73	18.059	.043
83.00	1323.02	-2.74	18.102	.043
84.00	1341.15	-2.76	18.145	.043
85.00	1359.33	-2.77	18.189	.044
86.00	1377.54	-2.79	18.231	.042
87.00	1395.80	-2.80	18.273	.042
88.00	1414.09	-2.82	18.314	.041
89.00	1432.44	-2.83	18.357	.043
90.00	1450.81	-2.85	18.398	.041
91.00	1469.23	-2.87	18.440	.042
92.00	1487.68	-2.89	18.481	.041
93.00	1506.99	-2.91	18.523	.042
94.00	1524.72	-2.93	18.565	.042
95.00	1543.29	-2.95	18.605	.040
96.00	1561.91	-2.97	18.645	.040
97.00	1580.57	-2.98	18.684	.039
98.00	1599.26	-3.00	18.724	.040
99.00	1618.02	-3.00	18.763	.039
100.00	1636.81	-3.00	18.801	.038

CHROMEL P VERSUS GOLD-0.07 AT. PERCENT IRON

AT 20. KG

TEMP. (DEG. K)	EMF (UV)	EMF(UV) CHANGE	S (UV/K)	S(UV/K) INCREMENT
4.22	0.00	0.00	13.784	---
5.00	11.04	.83	14.288	.504
6.00	25.58	1.64	14.799	.511
7.00	40.64	2.26	15.299	.500
8.00	56.13	2.75	15.700	.401
9.00	71.98	3.11	16.032	.332
10.00	88.12	3.38	16.300	.268
11.00	104.50	3.56	16.453	.153
12.00	121.05	3.68	16.640	.187
13.00	137.74	3.74	16.764	.124
14.00	154.53	3.76	16.845	.081
15.00	171.39	3.75	16.924	.079
16.00	188.29	3.71	16.917	-.007
17.00	205.21	3.66	16.914	-.003
18.00	222.13	3.59	16.902	-.012
19.00	239.05	3.51	16.886	-.016
20.00	255.93	3.42	16.863	-.023
21.00	272.79	3.32	16.827	-.036
22.00	289.61	3.22	16.788	-.039
23.00	306.38	3.12	16.744	-.044
24.00	323.11	3.01	16.695	-.049
25.00	339.80	2.91	16.647	-.048
26.00	356.43	2.80	16.601	-.046
27.00	373.02	2.69	16.558	-.043
28.00	389.57	2.59	16.517	-.041
29.00	406.08	2.48	16.480	-.037
30.00	422.56	2.37	16.446	-.034
31.00	439.00	2.26	16.416	-.030
32.00	455.41	2.15	16.391	-.025
33.00	471.80	2.04	16.370	-.021
34.00	488.17	1.92	16.354	-.016
35.00	504.52	1.81	16.343	-.011
36.00	520.86	1.69	16.337	-.006
37.00	537.20	1.58	16.334	-.003
38.00	553.54	1.46	16.337	.003
39.00	569.88	1.34	16.344	.007
40.00	586.23	1.22	16.355	.011
41.00	602.58	1.11	16.370	.015
42.00	618.96	.99	16.389	.019
43.00	635.35	.87	16.411	.022
44.00	651.77	.75	16.434	.023
45.00	668.21	.64	16.460	.026
46.00	684.68	.52	16.489	.029
47.00	701.18	.41	16.522	.033
48.00	717.71	.30	16.556	.034
49.00	734.28	.19	16.592	.036
50.00	750.88	.08	16.629	.037

CHROMEL P VERSUS GOLD-0.07 AT. PERCENT IRON

AT 20. KG

TEMP. (DEG. K)	EMF (UV)	EMF (UV) CHANGE	S (UV/K)	S (UV/K) INCREMENT
51.00	767.53	-.02	16.667	.038
52.00	784.21	-.12	16.707	.040
53.00	800.94	-.22	16.747	.040
54.00	817.71	-.31	16.789	.042
55.00	834.52	-.41	16.832	.043
56.00	851.38	-.50	16.876	.044
57.00	868.28	-.58	16.920	.044
58.00	885.23	-.67	16.964	.044
59.00	902.22	-.75	17.010	.046
60.00	919.26	-.83	17.055	.045
61.00	936.35	-.90	17.101	.046
62.00	953.48	-.97	17.146	.045
63.00	970.66	-1.05	17.191	.045
64.00	987.88	-1.11	17.238	.047
65.00	1005.15	-1.18	17.285	.047
66.00	1022.47	-1.24	17.330	.045
67.00	1039.82	-1.31	17.375	.045
68.00	1057.23	-1.37	17.420	.045
69.00	1074.68	-1.43	17.465	.045
70.00	1092.18	-1.48	17.511	.046
71.00	1109.72	-1.54	17.557	.046
72.00	1127.31	-1.59	17.602	.045
73.00	1144.94	-1.65	17.647	.045
74.00	1162.61	-1.70	17.692	.045
75.00	1180.33	-1.75	17.736	.044
76.00	1198.09	-1.80	17.781	.045
77.00	1215.90	-1.85	17.825	.044
78.00	1233.75	-1.89	17.870	.045
79.00	1251.64	-1.94	17.914	.044
80.00	1269.58	-1.98	17.958	.044
81.00	1287.56	-2.03	18.002	.044
82.00	1305.58	-2.07	18.046	.044
83.00	1323.65	-2.11	18.090	.044
84.00	1341.77	-2.14	18.132	.042
85.00	1359.92	-2.18	18.175	.043
86.00	1378.12	-2.21	18.218	.043
87.00	1396.35	-2.25	18.261	.043
88.00	1414.63	-2.28	18.304	.043
89.00	1432.96	-2.31	18.345	.041
90.00	1451.32	-2.34	18.387	.042
91.00	1469.73	-2.37	18.429	.042
92.00	1488.18	-2.39	18.471	.042
93.00	1507.48	-2.42	18.513	.042
94.00	1525.20	-2.45	18.555	.042
95.00	1543.76	-2.48	18.595	.040
96.00	1562.37	-2.51	18.636	.041
97.00	1581.01	-2.54	18.677	.041
98.00	1599.69	-2.57	18.717	.040
99.00	1618.41	-2.61	18.757	.040
100.00	1637.16	-2.65	18.796	.039

CHROMEL P VERSUS GOLD-0.07 AT. PERCENT IRON

AT 25. KG

TEMP. (DEG. K)	EMF (UV)	EMF(UV) CHANGE	S (UV/K)	S(UV/K) INCREMENT
4.22	0.00	0.00	14.334	---
5.00	11.47	1.26	14.784	.450
6.00	26.42	2.48	15.227	.443
7.00	41.82	3.45	15.619	.392
8.00	57.60	4.22	15.920	.301
9.00	73.69	4.82	16.212	.292
10.00	90.03	5.28	16.440	.228
11.00	106.55	5.62	16.623	.183
12.00	123.23	5.86	16.770	.147
13.00	140.02	6.02	16.869	.099
14.00	156.88	6.11	16.925	.056
15.00	173.78	6.15	16.959	.034
16.00	190.72	6.14	16.942	-.017
17.00	207.65	6.10	16.914	-.028
18.00	224.58	6.04	16.897	-.017
19.00	241.49	5.95	16.876	-.021
20.00	258.36	5.85	16.849	-.027
21.00	275.20	5.73	16.813	-.036
22.00	291.99	5.61	16.772	-.041
23.00	308.74	5.47	16.727	-.045
24.00	325.44	5.34	16.680	-.047
25.00	342.09	5.20	16.633	-.047
26.00	358.69	5.06	16.586	-.047
27.00	375.24	4.91	16.540	-.046
28.00	391.75	4.77	16.498	-.042
29.00	408.23	4.62	16.460	-.038
30.00	424.66	4.48	16.425	-.035
31.00	441.07	4.33	16.394	-.031
32.00	457.44	4.18	16.368	-.026
33.00	473.80	4.04	16.346	-.022
34.00	490.13	3.89	16.330	-.016
35.00	506.45	3.74	16.319	-.011
36.00	522.76	3.59	16.312	-.007
37.00	539.07	3.45	16.309	-.003
38.00	555.38	3.30	16.311	.002
39.00	571.69	3.15	16.318	.007
40.00	588.00	3.00	16.328	.010
41.00	604.33	2.85	16.341	.013
42.00	620.68	2.71	16.359	.018
43.00	637.04	2.56	16.380	.021
44.00	653.43	2.41	16.403	.023
45.00	669.84	2.27	16.429	.026
46.00	686.28	2.12	16.457	.028
47.00	702.75	1.98	16.488	.031
48.00	719.25	1.84	16.522	.034
49.00	735.79	1.70	16.557	.035
50.00	752.36	1.56	16.594	.037

CHROMEL P VERSUS GOLD-0.07 AT. PERCENT IRON

AT 25. KG

TEMP. (DEG. K)	EMF (UV)	EMF(UV) CHANGE	S (UV/K)	S(UV/K) INCREMENT
51.00	768.97	1.42	16.633	.039
52.00	785.62	1.29	16.675	.042
53.00	802.31	1.15	16.715	.040
54.00	819.04	1.02	16.756	.041
55.00	835.82	.89	16.798	.042
56.00	852.64	.76	16.842	.044
57.00	869.50	.64	16.886	.044
58.00	886.41	.51	16.931	.045
59.00	903.37	.39	16.975	.044
60.00	920.36	.28	17.019	.044
61.00	937.41	.16	17.065	.046
62.00	954.50	.05	17.110	.045
63.00	971.64	-.06	17.156	.046
64.00	988.82	-.17	17.202	.046
65.00	1006.05	-.28	17.248	.046
66.00	1023.33	-.38	17.293	.045
67.00	1040.65	-.48	17.339	.046
68.00	1058.02	-.58	17.386	.047
69.00	1075.44	-.67	17.431	.045
70.00	1092.90	-.76	17.475	.044
71.00	1110.41	-.85	17.521	.046
72.00	1127.96	-.94	17.566	.045
73.00	1145.57	-1.02	17.612	.046
74.00	1163.21	-1.10	17.658	.046
75.00	1180.91	-1.17	17.702	.044
76.00	1198.64	-1.25	17.747	.045
77.00	1216.43	-1.32	17.791	.044
78.00	1234.26	-1.38	17.836	.045
79.00	1252.13	-1.45	17.880	.044
80.00	1270.05	-1.51	17.924	.044
81.00	1288.02	-1.57	17.968	.044
82.00	1306.02	-1.63	18.014	.046
83.00	1324.07	-1.69	18.058	.044
84.00	1342.16	-1.75	18.100	.042
85.00	1360.30	-1.80	18.144	.044
86.00	1378.47	-1.86	18.188	.044
87.00	1396.69	-1.91	18.231	.043
88.00	1414.94	-1.97	18.274	.043
89.00	1433.24	-2.03	18.316	.042
90.00	1451.57	-2.09	18.358	.042
91.00	1469.95	-2.15	18.402	.044
92.00	1488.36	-2.21	18.445	.043
93.00	1507.63	-2.27	18.487	.042
94.00	1525.32	-2.33	18.529	.042
95.00	1543.85	-2.39	18.571	.042
96.00	1562.43	-2.45	18.614	.043
97.00	1581.05	-2.50	18.655	.041
98.00	1599.72	-2.54	18.696	.041
99.00	1618.45	-2.57	18.737	.041
100.00	1637.22	-2.59	18.778	.041

CHROMEL P VERSUS GOLD-0.07 AT. PERCENT IRON

AT 30. KG

TEMP. (DEG. K)	EMF (UV)	EMF(UV) CHANGE	S (UV/K)	S(UV/K) INCREMENT
4.22	0.00	0.00	14.964	---
5.00	11.94	1.73	15.318	.354
6.00	27.33	3.39	15.643	.325
7.00	43.11	4.73	15.926	.283
8.00	59.19	5.81	16.210	.284
9.00	75.53	6.66	16.422	.212
10.00	92.07	7.32	16.645	.223
11.00	108.77	7.83	16.768	.123
12.00	125.59	8.21	16.895	.127
13.00	142.49	8.49	16.999	.104
14.00	159.44	8.68	17.015	.016
15.00	176.43	8.79	17.034	.019
16.00	193.42	8.85	16.992	-.042
17.00	210.41	8.86	16.959	-.033
18.00	227.38	8.83	16.937	-.022
19.00	244.31	8.77	16.908	-.029
20.00	261.21	8.69	16.866	-.042
21.00	278.05	8.58	16.820	-.046
22.00	294.85	8.47	16.773	-.047
23.00	311.60	8.33	16.721	-.052
24.00	328.29	8.19	16.668	-.053
25.00	344.93	8.04	16.618	-.050
26.00	361.52	7.89	16.570	-.048
27.00	378.06	7.73	16.522	-.048
28.00	394.56	7.57	16.479	-.043
29.00	411.01	7.40	16.439	-.040
30.00	427.43	7.24	16.402	-.037
31.00	443.81	7.07	16.370	-.032
32.00	460.17	6.90	16.343	-.027
33.00	476.50	6.73	16.322	-.021
34.00	492.81	6.57	16.306	-.016
35.00	509.11	6.40	16.295	-.011
36.00	525.40	6.23	16.288	-.007
37.00	541.68	6.06	16.286	-.002
38.00	557.97	5.89	16.289	.003
39.00	574.26	5.72	16.296	.007
40.00	590.55	5.55	16.307	.011
41.00	606.86	5.38	16.321	.014
42.00	623.18	5.21	16.339	.018
43.00	639.52	5.04	16.360	.021
44.00	655.89	4.87	16.384	.024
45.00	672.28	4.71	16.410	.026
46.00	688.69	4.54	16.439	.029
47.00	705.13	4.37	16.471	.032
48.00	721.61	4.20	16.504	.033
49.00	738.12	4.03	16.540	.036
50.00	754.67	3.87	16.578	.038

CHROMEL P VERSUS GOLD-0.07 AT. PERCENT IRON

AT 30. KG

TEMP. (DEG. K)	EMF (UV)	EMF (UV) CHANGE	S (UV/K)	S (UV/K) INCREMENT
51.00	771.25	3.70	16.616	.038
52.00	787.87	3.54	16.656	.040
53.00	804.53	3.37	16.696	.040
54.00	821.24	3.21	16.737	.041
55.00	837.98	3.05	16.779	.042
56.00	854.77	2.89	16.822	.043
57.00	871.60	2.74	16.866	.044
58.00	888.48	2.58	16.911	.045
59.00	905.40	2.43	16.956	.045
60.00	922.37	2.28	17.000	.044
61.00	939.38	2.13	17.045	.045
62.00	956.45	1.99	17.090	.045
63.00	973.55	1.85	17.136	.046
64.00	990.71	1.72	17.182	.046
65.00	1007.91	1.58	17.228	.046
66.00	1025.16	1.45	17.275	.047
67.00	1042.46	1.33	17.318	.043
68.00	1059.81	1.21	17.364	.046
69.00	1077.20	1.09	17.410	.046
70.00	1094.64	.98	17.455	.045
71.00	1112.13	.87	17.501	.046
72.00	1129.66	.76	17.546	.045
73.00	1147.24	.65	17.591	.045
74.00	1164.86	.55	17.636	.045
75.00	1182.53	.45	17.680	.044
76.00	1200.24	.35	17.725	.045
77.00	1218.00	.25	17.769	.044
78.00	1235.79	.15	17.815	.046
79.00	1253.64	.06	17.859	.044
80.00	1271.52	-.04	17.902	.043
81.00	1289.46	-.13	17.946	.044
82.00	1307.42	-.23	17.990	.044
83.00	1325.44	-.32	18.036	.046
84.00	1343.49	-.42	18.079	.043
85.00	1361.59	-.51	18.123	.044
86.00	1379.73	-.60	18.166	.043
87.00	1397.91	-.69	18.209	.043
88.00	1416.13	-.78	18.252	.043
89.00	1434.40	-.87	18.295	.043
90.00	1452.71	-.95	18.337	.042
91.00	1471.07	-1.03	18.380	.043
92.00	1489.47	-1.10	18.422	.042
93.00	1508.72	-1.18	18.465	.043
94.00	1526.41	-1.24	18.507	.042
95.00	1544.93	-1.31	18.548	.041
96.00	1563.51	-1.37	18.590	.042
97.00	1582.11	-1.44	18.632	.042
98.00	1600.75	-1.51	18.673	.041
99.00	1619.43	-1.59	18.713	.040
100.00	1638.11	-1.70	18.753	.040

CHROMEL P VERSUS GOLD-0.07 AT. PERCENT IRON

AT 35. KG

TEMP. (DEG. K)	EMF (UV)	EMF(UV) CHANGE	S (UV/K)	S(UV/K) INCREMENT
4.22	0.00	0.00	15.583	---
5.00	12.36	2.15	15.853	.270
6.00	28.22	4.28	16.073	.220
7.00	44.39	6.02	16.304	.231
8.00	60.82	7.43	16.505	.201
9.00	77.45	8.58	16.707	.202
10.00	94.23	9.48	16.895	.188
11.00	111.14	10.20	16.963	.068
12.00	128.12	10.75	17.060	.097
13.00	145.17	11.17	17.084	.024
14.00	162.24	11.47	17.100	.016
15.00	179.32	11.68	17.109	.009
16.00	196.34	11.81	17.077	-.032
17.00	213.43	11.88	17.044	-.033
18.00	230.44	11.89	16.977	-.067
19.00	247.40	11.86	16.928	-.049
20.00	264.32	11.80	16.880	-.048
21.00	281.18	11.71	16.825	-.055
22.00	297.98	11.59	16.775	-.050
23.00	314.73	11.46	16.720	-.055
24.00	331.42	11.31	16.662	-.058
25.00	348.04	11.16	16.609	-.053
26.00	364.62	10.99	16.558	-.051
27.00	381.15	10.82	16.508	-.050
28.00	397.62	10.64	16.465	-.043
29.00	414.06	10.45	16.424	-.041
30.00	430.46	10.27	16.386	-.038
31.00	446.82	10.08	16.352	-.034
32.00	463.16	9.89	16.323	-.029
33.00	479.47	9.70	16.301	-.022
34.00	495.76	9.51	16.285	-.016
35.00	512.04	9.33	16.273	-.012
36.00	528.31	9.14	16.266	-.007
37.00	544.57	8.95	16.262	-.004
38.00	560.84	8.76	16.264	.002
39.00	577.10	8.57	16.269	.005
40.00	539.38	8.38	16.279	.010
41.00	609.67	8.19	16.291	.012
42.00	625.97	8.00	16.308	.017
43.00	642.29	7.81	16.328	.020
44.00	658.64	7.62	16.352	.024
45.00	675.00	7.43	16.378	.026
46.00	691.40	7.24	16.407	.029
47.00	707.82	7.05	16.438	.031
48.00	724.27	6.86	16.470	.032
49.00	740.76	6.67	16.505	.035
50.00	757.28	6.48	16.543	.038

CHROMEL P VERSUS GOLD-0.07 AT. PERCENT IRON

AT 35. KG

TEMP. (DEG. K)	EMF (UV)	EMF(UV) CHANGE	S (UV/K)	S(UV/K) INCREMENT
51.00	773.84	6.29	16.582	.039
52.00	790.44	6.10	16.624	.042
53.00	807.07	5.91	16.665	.041
54.00	823.75	5.73	16.707	.042
55.00	840.47	5.54	16.749	.042
56.00	857.23	5.35	16.791	.042
57.00	874.04	5.17	16.835	.044
58.00	890.89	4.99	16.882	.047
59.00	907.78	4.81	16.928	.046
60.00	924.72	4.63	16.974	.046
61.00	941.71	4.46	17.021	.047
62.00	958.75	4.29	17.066	.045
63.00	975.82	4.12	17.112	.046
64.00	992.95	3.96	17.158	.046
65.00	1010.13	3.80	17.205	.047
66.00	1027.35	3.64	17.250	.045
67.00	1044.62	3.49	17.296	.046
68.00	1061.95	3.35	17.341	.045
69.00	1079.32	3.21	17.388	.047
70.00	1096.73	3.07	17.433	.045
71.00	1114.20	2.94	17.479	.046
72.00	1131.71	2.81	17.524	.045
73.00	1149.27	2.68	17.569	.045
74.00	1166.87	2.56	17.615	.046
75.00	1184.52	2.44	17.660	.045
76.00	1202.21	2.32	17.705	.045
77.00	1219.96	2.21	17.749	.044
78.00	1237.73	2.09	17.794	.045
79.00	1255.56	1.98	17.839	.045
80.00	1273.42	1.86	17.883	.044
81.00	1291.34	1.75	17.927	.044
82.00	1309.29	1.64	17.972	.045
83.00	1327.28	1.52	18.016	.043
84.00	1345.32	1.41	18.059	.043
85.00	1363.40	1.30	18.102	.043
86.00	1381.51	1.18	18.146	.044
87.00	1399.61	1.07	18.190	.044
88.00	1417.87	.96	18.234	.044
89.00	1436.12	.85	18.276	.042
90.00	1454.41	.75	18.317	.041
91.00	1472.75	.65	18.362	.045
92.00	1491.12	.55	18.404	.042
93.00	1510.36	.46	18.447	.043
94.00	1528.03	.38	18.489	.042
95.00	1546.54	.30	18.530	.041
96.00	1565.11	.23	18.572	.042
97.00	1583.71	.16	18.613	.041
98.00	1602.35	.09	18.655	.042
99.00	1621.05	.03	18.697	.042
100.00	1639.74	-.05	18.738	.041

CHROMEL P VERSUS GOLD-0.07 AT. PERCENT IRON

AT 40. KG

TEMP. (DEG. K)	EMF (UV)	EMF(UV) CHANGE	S (UV/K)	S(UV/K) INCREMENT
4.22	0.00	0.00	16.199	---
5.00	12.89	2.69	16.400	.201
6.00	29.16	5.22	16.533	.133
7.00	45.71	7.34	16.659	.126
8.00	62.48	9.10	16.800	.141
9.00	79.42	10.55	16.947	.147
10.00	96.47	11.72	17.105	.158
11.00	113.61	12.67	17.193	.088
12.00	130.79	13.41	17.270	.077
13.00	147.99	13.99	17.294	.024
14.00	165.19	14.42	17.240	-.054
15.00	182.37	14.73	17.184	-.056
16.00	199.52	14.94	17.122	-.062
17.00	216.62	15.07	17.069	-.053
18.00	233.67	15.12	17.022	-.047
19.00	250.66	15.12	16.964	-.058
20.00	267.59	15.07	16.902	-.062
21.00	284.45	14.98	16.839	-.063
22.00	301.25	14.87	16.778	-.061
23.00	317.99	14.73	16.716	-.062
24.00	334.67	14.57	16.647	-.069
25.00	351.28	14.40	16.594	-.053
26.00	367.84	14.21	16.537	-.057
27.00	384.35	14.02	16.482	-.055
28.00	400.81	13.82	16.433	-.049
29.00	417.22	13.62	16.389	-.044
30.00	433.60	13.41	16.346	-.043
31.00	449.94	13.20	16.314	-.032
32.00	466.25	12.99	16.283	-.031
33.00	482.54	12.77	16.260	-.023
34.00	498.80	12.56	16.242	-.018
35.00	515.05	12.34	16.228	-.014
36.00	531.29	12.11	16.218	-.010
37.00	547.52	11.89	16.213	-.005
38.00	563.74	11.67	16.215	.002
39.00	579.97	11.44	16.221	.006
40.00	596.21	11.21	16.231	.010
41.00	612.45	10.98	16.244	.013
42.00	628.71	10.74	16.262	.018
43.00	644.99	10.51	16.282	.020
44.00	661.28	10.27	16.306	.024
45.00	677.60	10.03	16.333	.027
46.00	693.94	9.79	16.363	.030
47.00	710.31	9.55	16.396	.033
48.00	726.72	9.31	16.430	.034
49.00	743.15	9.07	16.465	.035
50.00	759.63	8.83	16.502	.037

CHROMEL P VERSUS GOLD-0.07 AT. PERCENT IRON

AT 40. KG

TEMP. (DEG. K)	EMF (UV)	EMF(UV) CHANGE	S (UV/K)	S(UV/K) INCREMENT
51.00	776.14	8.59	16.541	.039
52.00	792.69	8.35	16.584	.043
53.00	809.28	8.12	16.625	.041
54.00	825.91	7.89	16.667	.042
55.00	842.59	7.66	16.710	.043
56.00	859.31	7.44	16.755	.045
57.00	876.08	7.22	16.799	.044
58.00	892.90	7.00	16.844	.045
59.00	909.76	6.79	16.890	.046
60.00	926.67	6.59	16.936	.046
61.00	943.64	6.39	16.983	.047
62.00	960.65	6.19	17.028	.045
63.00	977.70	6.00	17.076	.048
64.00	994.81	5.82	17.123	.047
65.00	1011.97	5.64	17.169	.046
66.00	1029.17	5.46	17.214	.045
67.00	1046.42	5.29	17.263	.049
68.00	1063.73	5.13	17.309	.046
69.00	1081.08	4.97	17.354	.045
70.00	1098.47	4.81	17.401	.047
71.00	1115.92	4.66	17.448	.047
72.00	1133.41	4.51	17.492	.044
73.00	1150.96	4.37	17.538	.046
74.00	1168.53	4.22	17.586	.048
75.00	1186.16	4.08	17.630	.044
76.00	1203.83	3.94	17.675	.045
77.00	1221.56	3.81	17.721	.046
78.00	1239.31	3.67	17.767	.046
79.00	1257.11	3.53	17.811	.044
80.00	1274.96	3.40	17.856	.045
81.00	1292.85	3.26	17.902	.046
82.00	1310.78	3.13	17.947	.045
83.00	1328.75	2.99	17.992	.045
84.00	1346.77	2.86	18.037	.045
85.00	1364.82	2.72	18.081	.044
86.00	1382.92	2.59	18.124	.043
87.00	1401.06	2.46	18.170	.046
88.00	1419.24	2.33	18.214	.044
89.00	1437.47	2.20	18.258	.044
90.00	1455.74	2.08	18.302	.044
91.00	1474.06	1.96	18.346	.044
92.00	1492.41	1.84	18.389	.043
93.00	1511.62	1.72	18.433	.044
94.00	1529.26	1.61	18.475	.042
95.00	1547.75	1.51	18.517	.042
96.00	1566.28	1.40	18.562	.045
97.00	1584.85	1.30	18.604	.042
98.00	1603.46	1.20	18.646	.042
99.00	1622.12	1.10	18.689	.043
100.00	1640.81	1.00	18.730	.041

CHROMEL P VERSUS GOLD-0.07 AT. PERCENT IRON

AT 45. KG

TEMP. (DEG. K)	EMF (UV)	EMF(UV) CHANGE	S (UV/K)	S(UV/K) INCREMENT
4.22	0.00	0.00	16.661	---
5.00	13.35	3.15	16.849	.188
6.00	29.99	6.04	16.966	.117
7.00	46.87	8.50	17.034	.068
8.00	63.96	10.57	17.125	.091
9.00	81.18	12.31	17.247	.122
10.00	98.49	13.74	17.340	.093
11.00	115.86	14.92	17.393	.053
12.00	133.25	15.88	17.420	.027
13.00	150.64	16.64	17.419	-.001
14.00	168.00	17.23	17.375	-.044
15.00	185.32	17.68	17.319	-.056
16.00	202.59	18.01	17.242	-.077
17.00	219.79	18.24	17.129	-.113
18.00	236.92	18.38	17.047	-.082
19.00	253.98	18.44	16.964	-.083
20.00	270.96	18.45	16.926	-.038
21.00	287.87	18.40	16.867	-.059
22.00	304.70	18.31	16.798	-.069
23.00	321.45	18.19	16.735	-.063
24.00	338.14	18.04	16.666	-.069
25.00	354.75	17.87	16.601	-.065
26.00	371.31	17.68	16.541	-.060
27.00	387.80	17.47	16.481	-.060
28.00	404.25	17.26	16.427	-.054
29.00	420.64	17.04	16.380	-.047
30.00	436.99	16.81	16.336	-.044
31.00	453.31	16.57	16.297	-.039
32.00	469.59	16.33	16.266	-.031
33.00	485.85	16.09	16.240	-.026
34.00	502.09	15.84	16.220	-.020
35.00	518.31	15.60	16.205	-.015
36.00	534.52	15.35	16.196	-.009
37.00	550.72	15.10	16.193	-.003
38.00	566.92	14.84	16.195	.002
39.00	583.13	14.59	16.201	.006
40.00	599.33	14.33	16.211	.010
41.00	615.55	14.08	16.224	.013
42.00	631.79	13.82	16.241	.017
43.00	648.04	13.56	16.261	.020
44.00	664.31	13.30	16.285	.024
45.00	680.60	13.03	16.311	.026
46.00	696.93	12.77	16.340	.029
47.00	713.28	12.51	16.372	.032
48.00	729.66	12.25	16.405	.033
49.00	746.07	11.98	16.441	.036
50.00	762.52	11.72	16.479	.038

CHROMEL P VERSUS GOLD-0.07 AT. PERCENT IRON

AT 45. KG

TEMP. (DEG. K)	EMF (UV)	EMF(UV) CHANGE	S (UV/K)	S(UV/K) INCREMENT
51.00	779.01	11.46	16.517	.038
52.00	795.53	11.20	16.557	.040
53.00	812.10	10.94	16.598	.041
54.00	828.71	10.68	16.640	.042
55.00	845.36	10.43	16.684	.044
56.00	862.05	10.17	16.728	.044
57.00	878.79	9.92	16.772	.044
58.00	895.58	9.68	16.817	.045
59.00	912.41	9.44	16.864	.047
60.00	929.29	9.20	16.909	.045
61.00	946.21	8.96	16.956	.047
62.00	963.19	8.73	17.003	.047
63.00	980.21	8.51	17.050	.047
64.00	997.28	8.28	17.096	.046
65.00	1014.40	8.07	17.143	.047
66.00	1031.57	7.86	17.190	.047
67.00	1048.78	7.65	17.236	.046
68.00	1066.04	7.44	17.283	.047
69.00	1083.35	7.24	17.330	.047
70.00	1100.71	7.05	17.375	.045
71.00	1118.12	6.86	17.423	.048
72.00	1135.57	6.67	17.470	.047
73.00	1153.08	6.49	17.516	.046
74.00	1170.62	6.31	17.563	.047
75.00	1188.21	6.13	17.610	.047
76.00	1205.85	5.96	17.655	.045
77.00	1223.53	5.78	17.699	.044
78.00	1241.26	5.62	17.746	.047
79.00	1259.03	5.45	17.791	.045
80.00	1276.84	5.28	17.836	.045
81.00	1294.71	5.12	17.882	.046
82.00	1312.61	4.96	17.926	.044
83.00	1330.55	4.79	17.970	.044
84.00	1348.55	4.64	18.016	.046
85.00	1366.58	4.48	18.060	.044
86.00	1384.65	4.32	18.103	.043
87.00	1402.77	4.17	18.146	.043
88.00	1420.93	4.02	18.191	.045
89.00	1439.14	3.87	18.235	.044
90.00	1457.38	3.72	18.277	.042
91.00	1475.68	3.58	18.322	.045
92.00	1494.01	3.44	18.365	.043
93.00	1513.20	3.30	18.407	.042
94.00	1530.82	3.17	18.450	.043
95.00	1549.28	3.04	18.493	.043
96.00	1567.80	2.92	18.535	.042
97.00	1586.34	2.79	18.576	.041
98.00	1604.94	2.68	18.620	.044
99.00	1623.58	2.56	18.662	.042
100.00	1642.26	2.45	18.702	.040

CHROMEL P VERSUS GOLD-0.07 AT. PERCENT IRON

AT 50. KG

TEMP. (DEG. K)	EMF (UV)	EMF(UV) CHANGE	S (UV/K)	S(UV/K) INCREMENT
4.22	0.00	0.00	17.310	---
5.00	13.75	3.55	17.408	.098
6.00	30.92	6.98	17.413	.005
7.00	48.26	9.89	17.389	-.024
8.00	65.71	12.33	17.425	.036
9.00	83.24	14.37	17.482	.057
10.00	100.81	16.06	17.545	.063
11.00	118.38	17.44	17.588	.043
12.00	135.94	18.57	17.585	-.003
13.00	153.46	19.46	17.564	-.021
14.00	170.93	20.16	17.510	-.054
15.00	188.34	20.70	17.429	-.081
16.00	205.67	21.10	17.342	-.087
17.00	222.93	21.38	17.224	-.118
18.00	240.11	21.56	17.122	-.102
19.00	257.20	21.66	17.028	-.094
20.00	274.21	21.69	16.956	-.072
21.00	291.14	21.67	16.890	-.066
22.00	307.98	21.60	16.818	-.072
23.00	324.75	21.49	16.751	-.067
24.00	341.45	21.35	16.694	-.057
25.00	358.08	21.19	16.611	-.083
26.00	374.64	21.01	16.548	-.063
27.00	391.14	20.81	16.488	-.060
28.00	407.59	20.61	16.429	-.059
29.00	423.99	20.39	16.377	-.052
30.00	440.35	20.16	16.331	-.046
31.00	456.67	19.93	16.288	-.043
32.00	472.95	19.69	16.253	-.035
33.00	489.21	19.44	16.228	-.025
34.00	505.44	19.20	16.209	-.019
35.00	521.66	18.94	16.191	-.018
36.00	537.86	18.69	16.180	-.011
37.00	554.06	18.43	16.173	-.007
38.00	570.25	18.17	16.171	-.002
39.00	586.44	17.90	16.179	.008
40.00	602.63	17.63	16.191	.012
41.00	618.84	17.36	16.204	.013
42.00	635.06	17.09	16.221	.017
43.00	651.29	16.81	16.241	.020
44.00	667.54	16.53	16.264	.023
45.00	683.81	16.24	16.290	.026
46.00	700.11	15.96	16.319	.029
47.00	716.44	15.67	16.351	.032
48.00	732.80	15.39	16.384	.033
49.00	749.18	15.10	16.419	.035
50.00	765.61	14.81	16.456	.037

CHROMEL P VERSUS GOLD-0.07 AT. PERCENT IRON AT 50. KG

TEMP. (DEG. K)	EMF (UV)	EMF (UV) CHANGE	S (UV/K)	S (UV/K) INCREMENT
51.00	782.07	14.52	16.493	.037
52.00	798.57	14.23	16.532	.039
53.00	815.11	13.95	16.572	.040
54.00	831.69	13.66	16.615	.043
55.00	848.31	13.38	16.663	.048
56.00	864.98	13.10	16.703	.040
57.00	881.70	12.83	16.747	.044
58.00	898.46	12.56	16.792	.045
59.00	915.26	12.29	16.837	.045
60.00	932.12	12.03	16.881	.044
61.00	949.02	11.77	16.930	.049
62.00	965.97	11.52	16.976	.046
63.00	982.97	11.27	17.023	.047
64.00	1000.02	11.02	17.071	.048
65.00	1017.12	10.79	17.118	.047
66.00	1034.26	10.55	17.165	.047
67.00	1051.45	10.32	17.212	.047
68.00	1068.70	10.10	17.258	.046
69.00	1085.99	9.88	17.305	.047
70.00	1103.32	9.66	17.355	.050
71.00	1120.71	9.45	17.401	.046
72.00	1138.15	9.25	17.447	.046
73.00	1155.63	9.04	17.494	.047
74.00	1173.15	8.84	17.540	.046
75.00	1190.72	8.64	17.586	.046
76.00	1208.34	8.45	17.633	.047
77.00	1226.00	8.25	17.677	.044
78.00	1243.70	8.06	17.724	.047
79.00	1261.45	7.87	17.770	.046
80.00	1279.24	7.68	17.816	.046
81.00	1297.09	7.50	17.861	.045
82.00	1314.96	7.31	17.906	.045
83.00	1332.89	7.13	17.950	.044
84.00	1350.86	6.95	17.993	.043
85.00	1368.88	6.78	18.039	.046
86.00	1386.93	6.60	18.082	.043
87.00	1405.03	6.43	18.126	.044
88.00	1423.17	6.26	18.171	.045
89.00	1441.37	6.10	18.215	.044
90.00	1459.60	5.94	18.258	.043
91.00	1477.88	5.78	18.303	.045
92.00	1496.20	5.63	18.346	.043
93.00	1515.39	5.49	18.388	.042
94.00	1532.99	5.34	18.433	.045
95.00	1551.44	5.20	18.476	.043
96.00	1569.94	5.06	18.521	.045
97.00	1588.47	4.92	18.561	.040
98.00	1607.04	4.78	18.604	.043
99.00	1625.66	4.64	18.648	.044
100.00	1644.30	4.49	18.689	.041

CHROMEL P VERSUS GOLD-0.07 AT. PERCENT IRON

AT 60. KG

TEMP. (DEG. K)	EMF (UV)	EMF(UV) CHANGE	S (UV/K)	S(UV/K) INCREMENT
4.22	0.00	0.00	18.430	---
5.00	14.76	4.55	18.402	-.028
6.00	32.74	8.80	18.247	-.155
7.00	50.77	12.40	18.069	-.178
8.00	68.82	15.43	17.975	-.094
9.00	86.85	17.98	17.927	-.048
10.00	104.85	20.10	17.910	-.017
11.00	122.80	21.86	17.893	-.017
12.00	140.67	23.30	17.850	-.043
13.00	158.47	24.47	17.784	-.066
14.00	176.18	25.41	17.700	-.084
15.00	193.79	26.15	17.599	-.101
16.00	211.30	26.73	17.502	-.097
17.00	228.72	27.17	17.349	-.153
18.00	246.04	27.49	17.252	-.097
19.00	263.25	27.71	17.155	-.097
20.00	280.38	27.86	17.071	-.084
21.00	297.41	27.94	16.987	-.084
22.00	314.35	27.96	16.901	-.086
23.00	331.20	27.94	16.819	-.082
24.00	347.98	27.88	16.743	-.076
25.00	364.68	27.80	16.668	-.075
26.00	381.31	27.68	16.594	-.074
27.00	397.88	27.55	16.530	-.064
28.00	414.39	27.40	16.469	-.061
29.00	430.84	27.24	16.417	-.052
30.00	447.25	27.06	16.364	-.053
31.00	463.61	26.88	16.318	-.046
32.00	479.94	26.68	16.282	-.036
33.00	496.23	26.47	16.250	-.032
34.00	512.50	26.25	16.224	-.026
35.00	528.74	26.03	16.202	-.022
36.00	544.97	25.80	16.188	-.014
37.00	561.18	25.55	16.178	-.010
38.00	577.38	25.30	16.175	-.003
39.00	593.58	25.05	16.176	.001
40.00	609.78	24.78	16.181	.005
41.00	625.98	24.50	16.190	.009
42.00	642.19	24.22	16.203	.013
43.00	658.42	23.93	16.221	.018
44.00	674.65	23.64	16.241	.020
45.00	690.91	23.34	16.264	.023
46.00	707.18	23.03	16.289	.025
47.00	723.49	22.72	16.319	.030
48.00	739.81	22.40	16.351	.032
49.00	756.17	22.09	16.385	.034
50.00	772.56	21.76	16.421	.036

CHROMEL P VERSUS GOLD-0.07 AT. PERCENT IRON

AT 60. KG

TEMP. (DEG. K)	EMF (UV)	EMF(UV) CHANGE	S (UV/K)	S(UV/K) INCREMENT
51.00	788.99	21.44	16.458	.037
52.00	805.45	21.12	16.496	.038
53.00	821.95	20.79	16.535	.039
54.00	838.49	20.47	16.575	.040
55.00	855.08	20.15	16.616	.041
56.00	871.71	19.83	16.658	.042
57.00	888.38	19.51	16.701	.043
58.00	905.10	19.20	16.746	.045
59.00	921.86	18.89	16.792	.046
60.00	938.67	18.58	16.837	.045
61.00	955.53	18.28	16.883	.046
62.00	972.44	17.99	16.927	.044
63.00	989.40	17.70	16.973	.046
64.00	1006.40	17.41	17.021	.048
65.00	1023.46	17.13	17.067	.046
66.00	1040.56	16.85	17.112	.045
67.00	1057.71	16.58	17.159	.047
68.00	1074.91	16.31	17.209	.050
69.00	1092.15	16.04	17.253	.044
70.00	1109.44	15.78	17.299	.046
71.00	1126.78	15.52	17.347	.048
72.00	1144.16	15.26	17.393	.046
73.00	1161.60	15.01	17.439	.046
74.00	1179.07	14.76	17.486	.047
75.00	1196.58	14.50	17.530	.044
76.00	1214.14	14.25	17.577	.047
77.00	1231.75	14.00	17.622	.045
78.00	1249.39	13.75	17.668	.046
79.00	1267.09	13.51	17.712	.044
80.00	1284.82	13.26	17.757	.045
81.00	1302.60	13.01	17.803	.046
82.00	1320.41	12.76	17.847	.044
83.00	1338.28	12.52	17.892	.045
84.00	1356.18	12.27	17.937	.045
85.00	1374.13	12.03	17.981	.044
86.00	1392.13	11.80	18.025	.044
87.00	1410.17	11.57	18.070	.045
88.00	1428.25	11.34	18.114	.044
89.00	1446.39	11.12	18.157	.043
90.00	1464.57	10.91	18.201	.044
91.00	1482.80	10.70	18.244	.043
92.00	1501.08	10.51	18.286	.042
93.00	1520.22	10.32	18.329	.043
94.00	1537.80	10.15	18.373	.044
95.00	1556.22	9.98	18.415	.042
96.00	1574.71	9.83	18.457	.042
97.00	1593.23	9.68	18.499	.042
98.00	1611.80	9.54	18.542	.043
99.00	1630.43	9.41	18.583	.041
100.00	1649.09	9.28	18.623	.040

CHROMEL P VERSUS GOLD-0.07 AT. PERCENT IRON

AT 70. KG

TEMP. (DEG. K)	EMF (UV)	EMF(UV) CHANGE	S (UV/K)	S(UV/K) INCREMENT
4.22	0.00	0.00	19.823	---
5.00	15.98	5.78	19.530	-.293
6.00	34.66	10.72	19.043	-.487
7.00	53.29	14.92	18.649	-.394
8.00	71.85	18.47	18.435	-.214
9.00	90.32	21.45	18.317	-.118
10.00	108.70	23.95	18.225	-.092
11.00	126.97	26.03	18.153	-.072
12.00	145.12	27.75	18.060	-.093
13.00	163.16	29.16	17.974	-.086
14.00	181.08	30.31	17.875	-.099
15.00	198.87	31.23	17.759	-.116
16.00	216.55	31.97	17.662	-.097
17.00	234.10	32.55	17.544	-.118
18.00	251.54	32.99	17.392	-.152
19.00	268.87	33.33	17.282	-.110
20.00	286.08	33.57	17.177	-.105
21.00	303.20	33.73	17.077	-.100
22.00	320.21	33.82	16.982	-.095
23.00	337.13	33.86	16.888	-.094
24.00	353.96	33.86	16.799	-.089
25.00	370.70	33.82	16.713	-.086
26.00	387.37	33.74	16.624	-.089
27.00	403.97	33.64	16.541	-.083
28.00	420.49	33.51	16.465	-.076
29.00	436.96	33.36	16.400	-.065
30.00	453.37	33.19	16.341	-.059
31.00	469.74	33.00	16.294	-.047
32.00	486.05	32.79	16.250	-.044
33.00	502.33	32.57	16.204	-.046
34.00	518.58	32.34	16.184	-.020
35.00	534.80	32.09	16.164	-.020
36.00	551.00	31.83	16.150	-.014
37.00	567.18	31.55	16.138	-.012
38.00	583.35	31.27	16.134	-.004
39.00	599.51	30.97	16.133	-.001
40.00	615.66	30.66	16.140	.007
41.00	631.82	30.34	16.149	.009
42.00	647.99	30.02	16.162	.013
43.00	664.16	29.68	16.180	.018
44.00	680.35	29.34	16.201	.021
45.00	696.56	28.99	16.223	.022
46.00	712.79	28.64	16.250	.027
47.00	729.04	28.28	16.280	.030
48.00	745.33	27.92	16.311	.031
49.00	761.64	27.55	16.345	.034
50.00	777.99	27.19	16.380	.035

CHROMEL P VERSUS GOLD-0.07 AT. PERCENT IRON

AT 70. KG

TEMP. (DEG. K)	EMF (UV)	EMF(UV) CHANGE	S (UV/K)	S(UV/K) INCREMENT
51.00	794.37	26.82	16.417	.037
52.00	810.80	26.46	16.456	.039
53.00	827.26	26.10	16.495	.039
54.00	843.76	25.74	16.536	.041
55.00	860.31	25.38	16.577	.041
56.00	876.91	25.03	16.621	.044
57.00	893.55	24.68	16.666	.045
58.00	910.23	24.34	16.710	.044
59.00	926.97	24.00	16.755	.045
60.00	943.75	23.66	16.800	.045
61.00	960.58	23.33	16.846	.046
62.00	977.46	23.01	16.892	.046
63.00	994.39	22.68	16.939	.047
64.00	1011.36	22.37	16.985	.046
65.00	1028.38	22.05	17.032	.047
66.00	1045.45	21.74	17.079	.047
67.00	1062.56	21.43	17.125	.046
68.00	1079.72	21.12	17.171	.046
69.00	1096.93	20.82	17.219	.048
70.00	1114.17	20.51	17.265	.046
71.00	1131.47	20.21	17.311	.046
72.00	1148.81	19.91	17.358	.047
73.00	1166.19	19.60	17.404	.046
74.00	1183.61	19.30	17.449	.045
75.00	1201.07	18.99	17.494	.045
76.00	1218.58	18.69	17.541	.047
77.00	1236.14	18.39	17.585	.044
78.00	1253.72	18.08	17.631	.046
79.00	1271.36	17.78	17.677	.046
80.00	1289.04	17.48	17.722	.045
81.00	1306.78	17.19	17.766	.044
82.00	1324.54	16.89	17.811	.045
83.00	1342.36	16.60	17.856	.045
84.00	1360.23	16.32	17.899	.043
85.00	1378.15	16.05	17.943	.044
86.00	1396.11	15.78	17.989	.046
87.00	1414.12	15.52	18.032	.043
88.00	1432.19	15.28	18.075	.043
89.00	1450.31	15.04	18.118	.043
90.00	1468.48	14.82	18.162	.044
91.00	1486.70	14.60	18.205	.043
92.00	1504.97	14.40	18.247	.042
93.00	1524.10	14.20	18.289	.042
94.00	1541.65	14.00	18.333	.044
95.00	1560.04	13.80	18.375	.042
96.00	1578.48	13.60	18.417	.042
97.00	1596.92	13.37	18.459	.042
98.00	1615.38	13.12	18.501	.042
99.00	1633.85	12.83	18.542	.041
100.00	1652.28	12.47	18.581	.039

CHROMEL P VERSUS GOLD-0.07 AT. PERCENT IRON

AT 80. KG

TEMP. (DEG. K)	EMF (UV)	EMF (UV) CHANGE	S (UV/K)	S (UV/K) INCREMENT
4.22	0.00	0.00	21.165	---
5.00	17.08	6.87	20.641	-.524
6.00	36.65	12.71	19.867	-.774
7.00	55.92	17.55	19.199	-.668
8.00	74.95	21.56	18.825	-.374
9.00	93.75	24.88	18.617	-.208
10.00	112.38	27.63	18.495	-.122
11.00	130.84	29.90	18.383	-.112
12.00	149.15	31.78	18.280	-.103
13.00	167.33	33.33	18.164	-.116
14.00	185.39	34.62	18.045	-.119
15.00	203.32	35.69	17.954	-.091
16.00	221.14	36.57	17.812	-.142
17.00	238.85	37.30	17.709	-.103
18.00	256.45	37.90	17.582	-.127
19.00	273.93	38.39	17.473	-.109
20.00	291.31	38.79	17.351	-.122
21.00	308.57	39.10	17.231	-.120
22.00	325.73	39.34	17.113	-.118
23.00	342.78	39.51	16.996	-.117
24.00	359.73	39.63	16.880	-.116
25.00	376.57	39.69	16.768	-.112
26.00	393.32	39.69	16.663	-.105
27.00	409.98	39.65	16.570	-.093
28.00	426.55	39.57	16.484	-.086
29.00	443.05	39.44	16.410	-.074
30.00	459.46	39.28	16.346	-.064
31.00	475.82	39.08	16.287	-.059
32.00	492.11	38.84	16.241	-.046
33.00	508.35	38.58	16.200	-.041
34.00	524.54	38.30	16.169	-.031
35.00	540.70	37.99	16.143	-.026
36.00	556.83	37.66	16.126	-.017
37.00	572.95	37.32	16.112	-.014
38.00	589.04	36.96	16.105	-.007
39.00	605.13	36.60	16.105	-.000
40.00	621.22	36.22	16.106	.001
41.00	637.32	35.84	16.112	.006
42.00	653.43	35.46	16.124	.012
43.00	669.56	35.08	16.140	.016
44.00	685.71	34.70	16.157	.017
45.00	701.89	34.32	16.179	.022
46.00	718.10	33.94	16.205	.026
47.00	734.34	33.57	16.234	.029
48.00	750.61	33.20	16.262	.028
49.00	766.93	32.84	16.295	.033
50.00	783.28	32.48	16.330	.035

CHROMEL P VERSUS GOLD-0.07 AT. PERCENT IRON

AT 80. KG

TEMP. (DEG. K)	EMF (UV)	EMF(UV) CHANGE	S (UV/K)	S(UV/K) INCREMENT
51.00	799.67	32.12	16.367	.037
52.00	816.10	31.77	16.406	.039
53.00	832.57	31.42	16.445	.039
54.00	849.09	31.06	16.485	.040
55.00	865.64	30.71	16.526	.041
56.00	882.23	30.35	16.569	.043
57.00	898.86	29.99	16.612	.043
58.00	915.53	29.63	16.655	.043
59.00	932.23	29.26	16.699	.044
60.00	948.97	28.88	16.745	.046
61.00	965.75	28.50	16.791	.046
62.00	982.56	28.11	16.836	.045
63.00	999.41	27.71	16.880	.044
64.00	1016.30	27.30	16.926	.046
65.00	1033.22	26.89	16.972	.046
66.00	1050.18	26.47	17.017	.045
67.00	1067.17	26.04	17.063	.046
68.00	1084.22	25.62	17.109	.046
69.00	1101.29	25.18	17.154	.045
70.00	1118.41	24.75	17.199	.045
71.00	1135.58	24.32	17.246	.047
72.00	1152.79	23.89	17.291	.045
73.00	1170.06	23.47	17.336	.045
74.00	1187.36	23.05	17.382	.046
75.00	1204.73	22.65	17.428	.046
76.00	1222.14	22.25	17.474	.046
77.00	1239.62	21.87	17.519	.045
78.00	1257.14	21.50	17.568	.049
79.00	1274.73	21.15	17.612	.044
80.00	1292.37	20.81	17.656	.044
81.00	1310.08	20.49	17.702	.046
82.00	1327.82	20.17	17.746	.044
83.00	1345.64	19.88	17.789	.043
84.00	1363.50	19.59	17.832	.043
85.00	1381.40	19.30	17.878	.046
86.00	1399.36	19.03	17.922	.044
87.00	1417.35	18.75	17.965	.043
88.00	1435.37	18.46	18.009	.044
89.00	1453.44	18.17	18.054	.045
90.00	1471.52	17.86	18.096	.042
91.00	1489.65	17.55	18.140	.044
92.00	1507.78	17.21	18.183	.043
93.00	1526.75	16.85	18.227	.044
94.00	1544.13	16.48	18.270	.043
95.00	1562.34	16.10	18.313	.043
96.00	1580.60	15.72	18.356	.043
97.00	1598.90	15.35	18.399	.043
98.00	1617.28	15.02	18.443	.044
99.00	1635.77	14.75	18.484	.041
100.00	1654.40	14.59	18.527	.043

CHROMEL P VERSUS GOLD-0.07 AT. PERCENT IRON

AT 90. KG

TEMP. (DEG. K)	EMF (UV)	EMF(UV) CHANGE	S (UV/K)	S(UV/K) INCREMENT
4.22	0.00	0.00	22.671	---
5.00	18.42	8.21	21.820	-.851
6.00	38.63	14.69	20.637	-1.183
7.00	58.41	20.04	19.639	-.998
8.00	77.82	24.44	19.125	-.514
9.00	96.94	28.07	18.852	-.273
10.00	115.81	31.06	18.665	-.187
11.00	134.47	33.53	18.588	-.077
12.00	152.94	35.57	18.440	-.148
13.00	171.27	37.27	18.324	-.116
14.00	189.45	38.68	18.185	-.139
15.00	207.49	39.86	18.119	-.066
16.00	225.42	40.84	17.902	-.217
17.00	243.22	41.67	17.759	-.143
18.00	260.91	42.36	17.647	-.112
19.00	278.48	42.94	17.518	-.129
20.00	295.93	43.42	17.391	-.127
21.00	313.27	43.80	17.263	-.128
22.00	330.50	44.11	17.140	-.123
23.00	347.61	44.34	17.012	-.128
24.00	364.61	44.51	16.881	-.131
25.00	381.49	44.61	16.756	-.125
26.00	398.27	44.64	16.636	-.120
27.00	414.95	44.62	16.531	-.105
28.00	431.52	44.53	16.436	-.095
29.00	448.00	44.40	16.356	-.080
30.00	464.40	44.21	16.286	-.070
31.00	480.72	43.98	16.235	-.051
32.00	496.96	43.70	16.190	-.045
33.00	513.14	43.38	16.150	-.040
34.00	529.26	43.02	16.118	-.032
35.00	545.34	42.63	16.092	-.026
36.00	561.38	42.21	16.072	-.020
37.00	577.39	41.77	16.060	-.012
38.00	593.39	41.31	16.048	-.012
39.00	609.37	40.83	16.044	-.004
40.00	625.34	40.34	16.048	.004
41.00	641.32	39.84	16.053	.005
42.00	657.31	39.34	16.062	.009
43.00	673.32	38.84	16.075	.013
44.00	689.36	38.34	16.094	.019
45.00	705.42	37.85	16.113	.019
46.00	721.51	37.36	16.138	.025
47.00	737.65	36.88	16.166	.028
48.00	753.82	36.41	16.193	.027
49.00	770.03	35.94	16.225	.032
50.00	786.29	35.49	16.260	.035

CHROMEL P VERSUS GOLD-0.07 AT. PERCENT IRON

AT 90. KG

TEMP. (DEG. K)	EMF (UV)	EMF (UV) CHANGE	S (UV/K)	S (UV/K) INCREMENT
51.00	802.59	35.05	16.295	.035
52.00	818.94	34.61	16.332	.037
53.00	835.34	34.18	16.369	.037
54.00	851.78	33.75	16.409	.040
55.00	868.26	33.33	16.450	.041
56.00	884.79	32.91	16.492	.042
57.00	901.36	32.49	16.534	.042
58.00	917.97	32.07	16.579	.045
59.00	934.62	31.65	16.622	.043
60.00	951.31	31.22	16.667	.045
61.00	968.03	30.78	16.712	.045
62.00	984.79	30.34	16.755	.043
63.00	1001.59	29.88	16.800	.045
64.00	1018.42	29.42	16.845	.045
65.00	1035.28	28.95	16.890	.045
66.00	1052.18	28.47	16.935	.045
67.00	1069.11	27.98	16.982	.047
68.00	1086.08	27.48	17.029	.047
69.00	1103.09	26.98	17.074	.045
70.00	1120.13	26.47	17.119	.045
71.00	1137.22	25.96	17.165	.046
72.00	1154.35	25.45	17.210	.045
73.00	1171.52	24.93	17.255	.045
74.00	1188.74	24.43	17.302	.047
75.00	1206.01	23.93	17.348	.046
76.00	1223.33	23.44	17.393	.045
77.00	1240.71	22.96	17.438	.045
78.00	1258.13	22.49	17.485	.047
79.00	1275.62	22.04	17.530	.045
80.00	1293.17	21.61	17.575	.045
81.00	1310.79	21.20	17.621	.046
82.00	1328.45	20.80	17.666	.045
83.00	1346.18	20.42	17.711	.045
84.00	1363.96	20.05	17.756	.045
85.00	1381.80	19.70	17.801	.045
86.00	1399.69	19.36	17.845	.044
87.00	1417.62	19.02	17.890	.045
88.00	1435.60	18.69	17.934	.044
89.00	1453.62	18.35	17.977	.043
90.00	1471.67	18.01	18.021	.044
91.00	1489.75	17.65	18.066	.045
92.00	1507.85	17.28	18.108	.042
93.00	1526.79	16.89	18.152	.044
94.00	1544.13	16.48	18.194	.042
95.00	1562.28	16.04	18.236	.042
96.00	1580.47	15.59	18.278	.042
97.00	1598.69	15.14	18.321	.043
98.00	1616.96	14.70	18.363	.042
99.00	1635.30	14.28	18.405	.042
100.00	1653.74	13.93	18.446	.041

CHROMEL P VERSUS GOLD-0.07 AT. PERCENT IRON

AT 100. KG

TEMP. (DEG. K)	EMF (UV)	EMF(UV) CHANGE	S (UV/K)	S(UV/K) INCREMENT
4.22	0.00	0.00	24.335	---
5.00	19.88	9.67	23.081	-1.254
6.00	40.65	16.71	21.394	-1.687
7.00	60.86	22.49	20.019	-1.375
8.00	80.63	27.24	19.415	-.604
9.00	100.02	31.15	19.127	-.288
10.00	119.12	34.37	18.915	-.212
11.00	137.96	37.03	18.773	-.142
12.00	156.60	39.23	18.640	-.133
13.00	175.06	41.06	18.474	-.166
14.00	193.36	42.59	18.325	-.149
15.00	211.51	43.87	18.159	-.166
16.00	229.52	44.95	18.012	-.147
17.00	247.41	45.86	17.864	-.148
18.00	265.17	46.63	17.772	-.092
19.00	282.81	47.27	17.628	-.144
20.00	300.33	47.81	17.480	-.148
21.00	317.72	48.25	17.325	-.155
22.00	334.98	48.59	17.188	-.137
23.00	352.12	48.86	17.046	-.142
24.00	369.14	49.05	16.901	-.145
25.00	386.05	49.16	16.766	-.135
26.00	402.83	49.20	16.631	-.135
27.00	419.50	49.17	16.497	-.134
28.00	436.07	49.08	16.385	-.112
29.00	452.54	48.93	16.290	-.095
30.00	468.91	48.72	16.211	-.079
31.00	485.20	48.46	16.156	-.055
32.00	501.41	48.15	16.111	-.045
33.00	517.56	47.79	16.073	-.038
34.00	533.64	47.40	16.042	-.031
35.00	549.69	46.97	16.018	-.024
36.00	565.69	46.52	16.000	-.018
37.00	581.66	46.04	15.985	-.015
38.00	597.62	45.54	15.978	-.007
39.00	613.57	45.03	15.978	0.000
40.00	629.52	44.52	15.979	.001
41.00	645.47	43.99	15.986	.007
42.00	661.44	43.47	15.999	.013
43.00	677.44	42.95	16.013	.014
44.00	693.45	42.44	16.032	.019
45.00	709.50	41.93	16.053	.021
46.00	725.59	41.44	16.079	.026
47.00	741.72	40.95	16.108	.029
48.00	757.89	40.48	16.138	.030
49.00	774.10	40.01	16.170	.032
50.00	790.36	39.56	16.204	.034

CHROMEL P VERSUS GOLD-0.07 AT. PERCENT IRON

AT 100. KG

TEMP. (DEG. K)	EMF (UV)	EMF(UV) CHANGE	S (UV/K)	S(UV/K) INCREMENT
51.00	806.66	39.11	16.240	.036
52.00	823.00	38.67	16.279	.039
53.00	839.39	38.23	16.318	.039
54.00	855.82	37.80	16.358	.040
55.00	872.29	37.36	16.399	.041
56.00	888.80	36.93	16.442	.043
57.00	905.35	36.49	16.484	.042
58.00	921.93	36.04	16.530	.046
59.00	938.55	35.58	16.575	.045
60.00	955.20	35.11	16.619	.044
61.00	971.88	34.63	16.663	.044
62.00	988.59	34.13	16.708	.045
63.00	1005.33	33.62	16.753	.045
64.00	1022.09	33.10	16.801	.048
65.00	1038.89	32.56	16.847	.046
66.00	1055.72	32.01	16.891	.044
67.00	1072.58	31.45	16.937	.046
68.00	1089.47	30.87	16.983	.046
69.00	1106.41	30.30	17.030	.047
70.00	1123.37	29.71	17.075	.045
71.00	1140.39	29.13	17.120	.045
72.00	1157.45	28.55	17.166	.046
73.00	1174.57	27.98	17.213	.047
74.00	1191.72	27.41	17.259	.046
75.00	1208.94	26.86	17.304	.045
76.00	1226.22	26.33	17.350	.046
77.00	1243.57	25.82	17.395	.045
78.00	1260.97	25.33	17.441	.046
79.00	1278.44	24.86	17.486	.045
80.00	1295.98	24.42	17.532	.046
81.00	1313.60	24.01	17.576	.044
82.00	1331.26	23.61	17.620	.044
83.00	1349.00	23.24	17.666	.046
84.00	1366.80	22.89	17.711	.045
85.00	1384.64	22.54	17.757	.046
86.00	1402.54	22.21	17.801	.044
87.00	1420.48	21.88	17.844	.043
88.00	1438.45	21.54	17.890	.046
89.00	1456.46	21.19	17.934	.044
90.00	1474.48	20.82	17.976	.042
91.00	1492.52	20.42	18.022	.046
92.00	1510.55	19.98	18.066	.044
93.00	1529.42	19.52	18.108	.042
94.00	1546.66	19.01	18.153	.045
95.00	1564.72	18.48	18.195	.042
96.00	1582.81	17.93	18.238	.043
97.00	1600.92	17.37	18.281	.043
98.00	1619.11	16.85	18.324	.043
99.00	1637.40	16.38	18.368	.044
100.00	1655.85	16.04	18.410	.042

II.

Silver Normal versus Gold-0.07 at.% Iron

Thermocouples

SILVER NORMAL VERSUS GOLD-0.07 AT. PERCENT IRON

AT 0. KG

TEMP. (DEG. K)	EMF (UV)	EMF (UV) CHANGE	S (UV/K)	S (UV/K) INCREMENT
4.22	0.00	0.00	11.963	---
5.00	9.62	0.00	12.560	.597
6.00	22.51	0.00	13.187	.627
7.00	35.96	0.00	13.692	.505
8.00	49.85	0.00	14.089	.397
9.00	64.10	0.00	14.392	.303
10.00	78.61	0.00	14.612	.220
11.00	93.30	0.00	14.761	.149
12.00	108.11	0.00	14.847	.086
13.00	122.98	0.00	14.880	.033
14.00	137.86	0.00	14.868	-.012
15.00	152.70	0.00	14.816	-.052
16.00	167.48	0.00	14.732	-.084
17.00	182.16	0.00	14.620	-.112
18.00	196.71	0.00	14.486	-.134
19.00	211.12	0.00	14.333	-.153
20.00	225.37	0.00	14.166	-.167
21.00	239.45	0.00	13.988	-.178
22.00	253.35	0.00	13.801	-.187
23.00	267.05	0.00	13.608	-.193
24.00	280.56	0.00	13.412	-.196
25.00	293.87	0.00	13.213	-.199
26.00	306.99	0.00	13.013	-.200
27.00	319.90	0.00	12.814	-.199
28.00	332.62	0.00	12.617	-.197
29.00	345.13	0.00	12.422	-.195
30.00	357.46	0.00	12.231	-.191
31.00	369.60	0.00	12.043	-.188
32.00	381.55	0.00	11.860	-.183
33.00	393.32	0.00	11.681	-.179
34.00	404.91	0.00	11.507	-.174
35.00	416.33	0.00	11.338	-.169
36.00	427.59	0.00	11.174	-.164
37.00	438.68	0.00	11.016	-.158
38.00	449.62	0.00	10.862	-.154
39.00	460.41	0.00	10.713	-.149
40.00	471.05	0.00	10.569	-.144
41.00	481.55	0.00	10.430	-.139
42.00	491.91	0.00	10.295	-.135
43.00	502.14	0.00	10.165	-.130
44.00	512.24	0.00	10.039	-.126
45.00	522.22	0.00	9.917	-.122
46.00	532.08	0.00	9.798	-.119
47.00	541.82	0.00	9.684	-.114
48.00	551.45	0.00	9.573	-.111
49.00	560.96	0.00	9.465	-.108
50.00	570.38	0.00	9.360	-.105

SILVER NORMAL VERSUS GOLD-0.07 AT. PERCENT IRON

AT 0. KG

TEMP. (DEG. K)	EMF (UV)	EMF (UV) CHANGE	S (UV/K)	S(UV/K) INCREMENT
51.00	579.69	0.00	9.258	-.102
52.00	588.89	0.00	9.159	-.099
53.00	598.00	0.00	9.062	-.097
54.00	607.02	0.00	8.968	-.094
55.00	615.94	0.00	8.876	-.092
56.00	624.77	0.00	8.787	-.089
57.00	633.51	0.00	8.699	-.088
58.00	642.17	0.00	8.613	-.086
59.00	650.74	0.00	8.529	-.084
60.00	659.23	0.00	8.447	-.082
61.00	667.64	0.00	8.367	-.080
62.00	675.96	0.00	8.288	-.079
63.00	684.21	0.00	8.210	-.078
64.00	692.38	0.00	8.134	-.076
65.00	700.48	0.00	8.060	-.074
66.00	708.50	0.00	7.986	-.074
67.00	716.45	0.00	7.914	-.072
68.00	724.33	0.00	7.843	-.071
69.00	732.14	0.00	7.774	-.069
70.00	739.88	0.00	7.705	-.069
71.00	747.55	0.00	7.638	-.067
72.00	755.16	0.00	7.572	-.066
73.00	762.70	0.00	7.506	-.066
74.00	770.17	0.00	7.442	-.064
75.00	777.58	0.00	7.379	-.063
76.00	784.93	0.00	7.317	-.062
77.00	792.21	0.00	7.255	-.062
78.00	799.44	0.00	7.195	-.060
79.00	806.61	0.00	7.136	-.059
80.00	813.71	0.00	7.077	-.059
81.00	820.76	0.00	7.020	-.057
82.00	827.75	0.00	6.963	-.057
83.00	834.69	0.00	6.907	-.056
84.00	841.57	0.00	6.852	-.055
85.00	848.39	0.00	6.798	-.054
86.00	855.16	0.00	6.745	-.053
87.00	861.88	0.00	6.692	-.053
88.00	868.55	0.00	6.640	-.052
89.00	875.16	0.00	6.589	-.051
90.00	881.73	0.00	6.539	-.050
91.00	888.24	0.00	6.489	-.050
92.00	894.70	0.00	6.440	-.049
93.00	901.12	0.00	6.392	-.048
94.00	907.49	0.00	6.344	-.048
95.00	913.81	0.00	6.297	-.047
96.00	920.08	0.00	6.250	-.047
97.00	926.31	0.00	6.205	-.045
98.00	932.49	0.00	6.159	-.046
99.00	938.63	0.00	6.114	-.045
100.00	944.72	0.00	6.070	-.044

SILVER NORMAL VERSUS GOLD-0.07 AT. PERCENT IRON

AT 5. KG

TEMP. (DEG. K)	EMF (UV)	EMF(UV) CHANGE	S (UV/K)	S(UV/K) INCREMENT
4.22	0.00	0.00	12.053	---
5.00	9.65	.03	12.640	.587
6.00	22.53	.08	13.252	.612
7.00	36.07	.12	13.742	.490
8.00	50.01	.15	14.129	.387
9.00	64.28	.18	14.424	.295
10.00	78.81	.20	14.636	.212
11.00	93.52	.22	14.779	.143
12.00	108.34	.23	14.859	.080
13.00	123.22	.24	14.889	.030
14.00	138.11	.25	14.873	-.016
15.00	152.96	.26	14.818	-.055
16.00	167.74	.26	14.732	-.086
17.00	182.42	.26	14.620	-.112
18.00	196.98	.27	14.486	-.134
19.00	211.39	.27	14.333	-.153
20.00	225.64	.27	14.166	-.167
21.00	239.72	.27	13.988	-.178
22.00	253.62	.28	13.801	-.187
23.00	267.33	.28	13.608	-.193
24.00	280.84	.28	13.412	-.196
25.00	294.16	.28	13.213	-.199
26.00	307.27	.29	13.013	-.200
27.00	320.19	.29	12.814	-.199
28.00	332.91	.29	12.617	-.197
29.00	345.43	.30	12.422	-.195
30.00	357.76	.30	12.231	-.191
31.00	369.90	.31	12.043	-.188
32.00	381.86	.31	11.860	-.183
33.00	393.63	.32	11.681	-.179
34.00	405.23	.32	11.507	-.174
35.00	416.66	.33	11.338	-.169
46.00	532.44	.36	9.798	-.119
47.00	542.18	.36	9.684	-.114
48.00	551.81	.36	9.573	-.111
49.00	561.33	.36	9.465	-.108
50.00	570.74	.36	9.360	-.105
36.00	427.92	.33	11.174	-.164
37.00	439.02	.33	11.016	-.158
38.00	449.96	.34	10.862	-.154
39.00	460.75	.34	10.713	-.149
40.00	471.40	.35	10.569	-.144
41.00	481.90	.35	10.430	-.139
42.00	492.26	.35	10.295	-.135
43.00	502.50	.35	10.165	-.130
44.00	512.60	.36	10.039	-.126
45.00	522.58	.36	9.917	-.122

SILVER NORMAL VERSUS GOLD-0.07 AT. PERCENT IRON

AT 5. KG

TEMP. (DEG. K)	EMF (UV)	EMF(UV) CHANGE	S (UV/K)	S(UV/K) INCREMENT
51.00	580.05	.36	9.258	-.102
52.00	589.25	.36	9.159	-.099
53.00	598.36	.36	9.062	-.097
54.00	607.38	.36	8.968	-.094
55.00	616.30	.36	8.876	-.092
56.00	625.13	.35	8.787	-.089
57.00	633.87	.35	8.699	-.088
58.00	642.52	.35	8.613	-.086
59.00	651.09	.35	8.529	-.084
60.00	659.58	.35	8.447	-.082
61.00	667.98	.35	8.367	-.080
62.00	676.31	.35	8.288	-.079
63.00	684.56	.34	8.210	-.078
64.00	692.73	.34	8.134	-.076
65.00	700.82	.34	8.060	-.074
66.00	708.85	.34	7.986	-.074
67.00	716.80	.34	7.914	-.072
68.00	724.68	.34	7.843	-.071
69.00	732.48	.34	7.774	-.069
70.00	740.22	.34	7.705	-.069
71.00	747.90	.34	7.638	-.067
72.00	755.50	.34	7.572	-.066
73.00	763.04	.35	7.506	-.066
74.00	770.52	.35	7.442	-.064
75.00	777.93	.35	7.379	-.063
76.00	785.28	.35	7.317	-.062
77.00	792.57	.35	7.255	-.062
78.00	799.79	.35	7.195	-.060
79.00	806.96	.35	7.136	-.059
80.00	814.07	.36	7.077	-.059
81.00	821.12	.36	7.020	-.057
82.00	828.11	.36	6.963	-.057
83.00	835.04	.36	6.907	-.056
84.00	841.92	.36	6.852	-.055
85.00	848.75	.36	6.798	-.054
86.00	855.52	.36	6.745	-.053
87.00	862.24	.36	6.692	-.053
88.00	868.90	.35	6.640	-.052
89.00	875.51	.35	6.589	-.051
90.00	882.08	.35	6.539	-.050
91.00	888.59	.35	6.489	-.050
92.00	895.05	.35	6.440	-.049
93.00	901.46	.34	6.392	-.048
94.00	907.83	.34	6.344	-.048
95.00	914.15	.34	6.297	-.047
96.00	920.42	.34	6.250	-.047
97.00	926.65	.34	6.205	-.045
98.00	932.83	.34	6.159	-.046
99.00	938.98	.35	6.114	-.045
100.00	945.07	.36	6.070	-.044

SILVER NORMAL VERSUS GOLD-0.07 AT. PERCENT IRON

AT 10. KG

TEMP. (DEG. K)	EMF (UV)	EMF (UV) CHANGE	S (UV/K)	S (UV/K) INCREMENT
4.22	0.00	0.00	12.286	---
5.00	9.87	.25	12.830	.544
6.00	22.99	.48	13.400	.570
7.00	36.62	.67	13.862	.462
8.00	50.67	.81	14.219	.357
9.00	65.03	.93	14.492	.273
10.00	79.62	1.01	14.692	.200
11.00	94.38	1.08	14.826	.134
12.00	109.24	1.13	14.902	.076
13.00	124.14	1.16	14.925	.023
14.00	139.04	1.19	14.905	-.020
15.00	153.90	1.20	14.846	-.059
16.00	168.69	1.21	14.755	-.091
17.00	183.37	1.22	14.638	-.117
18.00	197.93	1.22	14.500	-.138
19.00	212.34	1.22	14.344	-.156
20.00	226.59	1.22	14.174	-.170
21.00	240.67	1.22	13.992	-.182
22.00	254.57	1.22	13.803	-.189
23.00	268.27	1.22	13.609	-.194
24.00	281.79	1.23	13.412	-.197
25.00	295.11	1.23	13.213	-.199
26.00	308.23	1.24	13.013	-.200
27.00	321.15	1.25	12.814	-.199
28.00	333.87	1.26	12.617	-.197
29.00	346.40	1.27	12.422	-.195
30.00	358.74	1.28	12.231	-.191
31.00	370.89	1.29	12.043	-.188
32.00	382.85	1.30	11.860	-.183
33.00	394.64	1.32	11.681	-.179
34.00	406.24	1.33	11.507	-.174
35.00	417.68	1.35	11.338	-.169
36.00	428.95	1.36	11.174	-.164
37.00	440.06	1.37	11.016	-.158
38.00	451.01	1.38	10.862	-.154
39.00	461.80	1.40	10.713	-.149
40.00	472.46	1.41	10.569	-.144
41.00	482.96	1.42	10.430	-.139
42.00	493.34	1.42	10.295	-.135
43.00	503.57	1.43	10.165	-.130
44.00	513.68	1.44	10.039	-.126
45.00	523.66	1.44	9.917	-.122
46.00	533.53	1.45	9.798	-.119
47.00	543.27	1.45	9.684	-.114
48.00	552.90	1.45	9.573	-.111
49.00	562.42	1.45	9.465	-.108
50.00	571.83	1.46	9.360	-.105

SILVER NORMAL VERSUS GOLD-0.07 AT. PERCENT IRON

AT 10. KG

TEMP. (DEG. K)	EMF (UV)	EMF (UV) CHANGE	S (UV/K)	S (UV/K) INCREMENT
51.00	581.14	1.46	9.258	-.102
52.00	590.35	1.46	9.159	-.099
53.00	599.46	1.45	9.062	-.097
54.00	608.47	1.45	8.968	-.094
55.00	617.39	1.45	8.876	-.092
56.00	626.22	1.45	8.787	-.089
57.00	634.96	1.45	8.699	-.088
58.00	643.62	1.45	8.613	-.086
59.00	652.19	1.45	8.529	-.084
60.00	660.67	1.44	8.447	-.082
61.00	669.08	1.44	8.367	-.080
62.00	677.41	1.44	8.288	-.079
63.00	685.65	1.44	8.210	-.078
64.00	693.83	1.44	8.134	-.076
65.00	701.92	1.44	8.060	-.074
66.00	709.95	1.44	7.986	-.074
67.00	717.90	1.45	7.914	-.072
68.00	725.78	1.45	7.843	-.071
69.00	733.59	1.45	7.774	-.069
70.00	741.33	1.45	7.705	-.069
71.00	749.01	1.45	7.638	-.067
72.00	756.62	1.46	7.572	-.066
73.00	764.16	1.46	7.506	-.066
74.00	771.63	1.46	7.442	-.064
75.00	779.05	1.47	7.379	-.063
76.00	786.40	1.47	7.317	-.062
77.00	793.69	1.47	7.255	-.062
78.00	800.92	1.48	7.195	-.060
79.00	808.09	1.48	7.136	-.059
80.00	815.20	1.48	7.077	-.059
81.00	822.25	1.49	7.020	-.057
82.00	829.24	1.49	6.963	-.057
83.00	836.18	1.49	6.907	-.056
84.00	843.06	1.49	6.852	-.055
85.00	849.89	1.50	6.798	-.054
86.00	856.66	1.50	6.745	-.053
87.00	863.38	1.50	6.692	-.053
88.00	870.05	1.50	6.640	-.052
89.00	876.66	1.50	6.589	-.051
90.00	883.23	1.50	6.539	-.050
91.00	889.74	1.50	6.489	-.050
92.00	896.21	1.50	6.440	-.049
93.00	902.62	1.50	6.392	-.048
94.00	908.99	1.50	6.344	-.048
95.00	915.31	1.50	6.297	-.047
96.00	921.58	1.50	6.250	-.047
97.00	927.81	1.50	6.205	-.045
98.00	933.99	1.50	6.159	-.046
99.00	940.13	1.50	6.114	-.045
100.00	946.22	1.50	6.070	-.044

SILVER NORMAL VERSUS GOLD-0.07 AT. PERCENT IRON

AT 15. KG

TEMP. (DEG. K)	EMF (UV)	EMF(UV) CHANGE	S (UV/K)	S(UV/K) INCREMENT
4.22	0.00	0.00	12.715	---
5.00	10.22	.60	13.187	.472
6.00	23.60	1.09	13.657	.470
7.00	37.45	1.49	14.077	.420
8.00	51.67	1.82	14.399	.322
9.00	66.18	2.08	14.627	.228
10.00	80.90	2.29	14.802	.175
11.00	95.76	2.45	14.906	.104
12.00	110.69	2.58	14.962	.056
13.00	125.65	2.67	14.975	.013
14.00	140.60	2.74	14.943	-.032
15.00	155.50	2.79	14.878	-.065
16.00	170.31	2.83	14.782	-.096
17.00	185.01	2.85	14.660	-.122
18.00	199.58	2.87	14.518	-.142
19.00	214.00	2.88	14.360	-.158
20.00	228.26	2.88	14.187	-.173
21.00	242.34	2.89	14.007	-.180
22.00	256.23	2.89	13.817	-.190
23.00	269.94	2.89	13.621	-.196
24.00	283.46	2.89	13.423	-.198
25.00	296.77	2.90	13.223	-.200
26.00	309.89	2.90	13.021	-.202
27.00	322.81	2.91	12.820	-.201
28.00	335.54	2.92	12.621	-.199
29.00	348.07	2.93	12.425	-.196
30.00	360.41	2.95	12.233	-.192
31.00	372.56	2.96	12.044	-.189
32.00	384.52	2.98	11.860	-.184
33.00	396.31	2.99	11.681	-.179
34.00	407.92	3.01	11.507	-.174
35.00	419.36	3.03	11.338	-.169
36.00	430.64	3.05	11.174	-.164
37.00	441.75	3.06	11.016	-.158
38.00	452.70	3.08	10.862	-.154
39.00	463.51	3.10	10.713	-.149
40.00	474.17	3.12	10.569	-.144
41.00	484.68	3.13	10.430	-.139
42.00	495.06	3.15	10.295	-.135
43.00	505.30	3.16	10.165	-.130
44.00	515.42	3.18	10.039	-.126
45.00	525.41	3.19	9.917	-.122
46.00	535.28	3.20	9.798	-.119
47.00	545.03	3.21	9.684	-.114
48.00	554.66	3.22	9.573	-.111
49.00	564.19	3.23	9.465	-.108
50.00	573.61	3.23	9.360	-.105

SILVER NORMAL VERSUS GOLD-0.07 AT. PERCENT IRON

AT 15. KG

TEMP. (DEG. K)	EMF (UV)	EMF (UV) CHANGE	S (UV/K)	S (UV/K) INCREMENT
51.00	582.93	3.24	9.258	-.102
52.00	592.14	3.25	9.159	-.099
53.00	601.26	3.25	9.062	-.097
54.00	610.28	3.26	8.968	-.094
55.00	619.20	3.26	8.876	-.092
56.00	628.04	3.27	8.787	-.089
57.00	636.79	3.27	8.699	-.088
58.00	645.44	3.27	8.613	-.086
59.00	654.02	3.28	8.529	-.084
60.00	662.51	3.28	8.447	-.082
61.00	670.92	3.28	8.367	-.080
62.00	679.25	3.29	8.288	-.079
63.00	687.50	3.29	8.210	-.078
64.00	695.68	3.29	8.134	-.076
65.00	703.78	3.30	8.060	-.074
66.00	711.81	3.30	7.986	-.074
67.00	719.76	3.30	7.914	-.072
68.00	727.64	3.31	7.843	-.071
69.00	735.45	3.31	7.774	-.069
70.00	743.20	3.31	7.705	-.069
71.00	750.87	3.32	7.638	-.067
72.00	758.48	3.32	7.572	-.066
73.00	766.02	3.32	7.506	-.066
74.00	773.50	3.33	7.442	-.064
75.00	780.91	3.33	7.379	-.063
76.00	788.26	3.33	7.317	-.062
77.00	795.54	3.33	7.255	-.062
78.00	802.77	3.33	7.195	-.060
79.00	809.94	3.33	7.136	-.059
80.00	817.04	3.33	7.077	-.059
81.00	824.09	3.33	7.020	-.057
82.00	831.09	3.33	6.963	-.057
83.00	838.02	3.33	6.907	-.056
84.00	844.90	3.33	6.852	-.055
85.00	851.73	3.34	6.798	-.054
86.00	858.50	3.34	6.745	-.053
87.00	865.22	3.34	6.692	-.053
88.00	871.89	3.34	6.640	-.052
89.00	878.50	3.34	6.589	-.051
90.00	885.07	3.35	6.539	-.050
91.00	891.59	3.35	6.489	-.050
92.00	898.06	3.35	6.440	-.049
93.00	904.48	3.36	6.392	-.048
94.00	910.85	3.36	6.344	-.048
95.00	917.17	3.36	6.297	-.047
96.00	923.45	3.37	6.250	-.047
97.00	929.68	3.37	6.205	-.045
98.00	935.85	3.36	6.159	-.046
99.00	941.98	3.36	6.114	-.045
100.00	948.06	3.34	6.070	-.044

SILVER NORMAL VERSUS GOLD-0.07 AT. PERCENT IRON

AT 20. KG

TEMP. (DEG. K)	EMF (UV)	EMF(UV) CHANGE	S (UV/K)	S(UV/K) INCREMENT
4.22	0.00	0.00	13.226	---
5.00	10.63	1.01	13.618	.392
6.00	24.35	1.84	13.987	.369
7.00	38.49	2.53	14.342	.355
8.00	52.95	3.10	14.619	.277
9.00	67.67	3.56	14.827	.208
10.00	82.55	3.94	14.962	.135
11.00	97.55	4.25	15.041	.079
12.00	112.60	4.49	15.072	.031
13.00	127.66	4.68	15.060	-.012
14.00	142.69	4.83	15.014	-.046
15.00	157.65	4.95	14.938	-.076
16.00	172.51	5.04	14.834	-.104
17.00	187.26	5.11	14.706	-.128
18.00	201.87	5.16	14.558	-.148
19.00	216.32	5.20	14.393	-.165
20.00	230.60	5.23	14.217	-.176
21.00	244.71	5.26	14.031	-.186
22.00	258.63	5.28	13.839	-.192
23.00	272.35	5.30	13.640	-.199
24.00	285.88	5.32	13.441	-.199
25.00	299.21	5.34	13.240	-.201
26.00	312.34	5.36	13.038	-.202
27.00	325.28	5.38	12.838	-.200
28.00	338.01	5.40	12.639	-.199
29.00	350.55	5.42	12.443	-.196
30.00	362.90	5.44	12.251	-.192
31.00	375.06	5.47	12.063	-.188
32.00	387.04	5.49	11.879	-.184
33.00	398.84	5.52	11.699	-.180
34.00	410.46	5.54	11.525	-.174
35.00	421.90	5.57	11.355	-.170
36.00	433.19	5.60	11.190	-.165
37.00	444.31	5.62	11.030	-.160
38.00	455.27	5.65	10.875	-.155
39.00	466.08	5.67	10.725	-.150
40.00	476.74	5.69	10.581	-.144
41.00	487.26	5.71	10.441	-.140
42.00	497.64	5.73	10.305	-.136
43.00	507.89	5.75	10.175	-.130
44.00	518.01	5.77	10.048	-.127
45.00	528.00	5.78	9.926	-.122
46.00	537.88	5.80	9.806	-.120
47.00	547.63	5.81	9.692	-.114
48.00	557.27	5.82	9.580	-.112
49.00	566.80	5.83	9.472	-.108
50.00	576.22	5.84	9.366	-.106

SILVER NORMAL VERSUS GOLD-0.07 AT. PERCENT IRON

AT 20. KG

TEMP. (DEG. K)	EMF (UV)	EMF(UV) CHANGE	S (UV/K)	S(UV/K) INCREMENT
51.00	585.54	5.85	9.263	-.103
52.00	594.75	5.86	9.164	-.099
53.00	603.87	5.87	9.066	-.098
54.00	612.89	5.87	8.972	-.094
55.00	621.82	5.88	8.879	-.093
56.00	630.66	5.89	8.790	-.089
57.00	639.41	5.90	8.701	-.089
58.00	648.07	5.90	8.615	-.086
59.00	656.65	5.91	8.530	-.085
60.00	665.15	5.92	8.447	-.083
61.00	673.56	5.92	8.367	-.080
62.00	681.89	5.93	8.288	-.079
63.00	690.15	5.94	8.210	-.078
64.00	698.33	5.95	8.134	-.076
65.00	706.44	5.95	8.060	-.074
66.00	714.47	5.96	7.986	-.074
67.00	722.43	5.97	7.914	-.072
68.00	730.31	5.98	7.843	-.071
69.00	738.13	5.99	7.774	-.069
70.00	745.88	6.00	7.705	-.069
71.00	753.56	6.00	7.638	-.067
72.00	761.17	6.01	7.572	-.066
73.00	768.72	6.02	7.506	-.066
74.00	776.20	6.03	7.442	-.064
75.00	783.61	6.03	7.379	-.063
76.00	790.97	6.04	7.317	-.062
77.00	798.26	6.04	7.255	-.062
78.00	805.49	6.05	7.195	-.060
79.00	812.66	6.06	7.136	-.059
80.00	819.77	6.06	7.077	-.059
81.00	826.83	6.07	7.020	-.057
82.00	833.82	6.07	6.963	-.057
83.00	840.76	6.08	6.907	-.056
84.00	847.65	6.08	6.852	-.055
85.00	854.48	6.09	6.798	-.054
86.00	861.26	6.09	6.745	-.053
87.00	867.98	6.10	6.692	-.053
88.00	874.66	6.11	6.640	-.052
89.00	881.28	6.12	6.589	-.051
90.00	887.86	6.13	6.539	-.050
91.00	894.38	6.14	6.489	-.050
92.00	900.86	6.15	6.440	-.049
93.00	907.28	6.16	6.392	-.048
94.00	913.66	6.17	6.344	-.048
95.00	919.99	6.18	6.297	-.047
96.00	926.27	6.19	6.250	-.047
97.00	932.50	6.19	6.205	-.045
98.00	938.67	6.18	6.159	-.046
99.00	944.79	6.16	6.114	-.045
100.00	950.85	6.13	6.070	-.044

SILVER NORMAL VERSUS GOLD-0.07 AT. PERCENT IRON

AT 25. KG

TEMP. (DEG. K)	EMF (UV)	EMF (UV) CHANGE	S (UV/K)	S (UV/K) INCREMENT
4.22	0.00	0.00	13.775	---
5.00	11.04	1.42	14.112	.337
6.00	25.20	2.69	14.415	.303
7.00	39.70	3.75	14.672	.257
8.00	54.48	4.62	14.854	.182
9.00	69.44	5.34	15.032	.178
10.00	84.54	5.93	15.137	.105
11.00	99.71	6.40	15.176	.039
12.00	114.90	6.79	15.202	.026
13.00	130.07	7.09	15.170	-.032
14.00	145.18	7.33	15.113	-.057
15.00	160.21	7.51	15.021	-.092
16.00	175.13	7.65	14.902	-.119
17.00	189.92	7.76	14.762	-.140
18.00	204.56	7.85	14.609	-.153
19.00	219.03	7.91	14.439	-.170
20.00	233.32	7.95	14.258	-.181
21.00	247.44	7.99	14.068	-.190
22.00	261.36	8.01	13.873	-.195
23.00	275.09	8.04	13.672	-.201
24.00	288.62	8.05	13.471	-.201
25.00	301.95	8.07	13.263	-.208
26.00	315.08	8.09	13.060	-.203
27.00	328.01	8.11	12.857	-.203
28.00	340.74	8.13	12.657	-.200
29.00	353.28	8.15	12.459	-.198
30.00	365.63	8.17	12.266	-.193
31.00	377.79	8.19	12.076	-.190
32.00	389.76	8.22	11.891	-.185
33.00	401.56	8.24	11.711	-.180
34.00	413.18	8.27	11.536	-.175
35.00	424.63	8.29	11.366	-.170
36.00	435.91	8.32	11.200	-.166
37.00	447.03	8.35	11.040	-.160
38.00	458.00	8.37	10.884	-.156
39.00	468.81	8.40	10.734	-.150
40.00	479.47	8.42	10.589	-.145
41.00	489.99	8.44	10.449	-.140
42.00	500.38	8.46	10.313	-.136
43.00	510.62	8.48	10.181	-.132
44.00	520.74	8.50	10.053	-.128
45.00	530.74	8.52	9.929	-.124
46.00	540.61	8.53	9.809	-.120
47.00	550.36	8.54	9.695	-.114
48.00	560.00	8.55	9.583	-.112
49.00	569.53	8.56	9.475	-.108
50.00	578.95	8.57	9.370	-.105

SILVER NORMAL VERSUS GOLD-0.07 AT. PERCENT IRON

AT 25. KG

TEMP. (DEG. K)	EMF (UV)	EMF(UV) CHANGE	S (UV/K)	S(UV/K) INCREMENT
51.00	588.26	8.58	9.267	-.103
52.00	597.48	8.58	9.167	-.100
53.00	606.59	8.59	9.069	-.098
54.00	615.61	8.59	8.974	-.095
55.00	624.54	8.60	8.881	-.093
56.00	633.37	8.60	8.791	-.090
57.00	642.12	8.60	8.702	-.089
58.00	650.78	8.61	8.615	-.087
59.00	659.35	8.61	8.530	-.085
60.00	667.84	8.61	8.447	-.083
61.00	676.25	8.62	8.367	-.080
62.00	684.59	8.62	8.288	-.079
63.00	692.84	8.62	8.210	-.078
64.00	701.01	8.63	8.134	-.076
65.00	709.11	8.63	8.060	-.074
66.00	717.14	8.63	7.986	-.074
67.00	725.09	8.64	7.914	-.072
68.00	732.97	8.64	7.843	-.071
69.00	740.78	8.64	7.774	-.069
70.00	748.52	8.64	7.705	-.069
71.00	756.19	8.64	7.638	-.067
72.00	763.80	8.64	7.572	-.066
73.00	771.33	8.64	7.506	-.066
74.00	778.81	8.63	7.442	-.064
75.00	786.21	8.63	7.379	-.063
76.00	793.55	8.63	7.317	-.062
77.00	800.84	8.62	7.255	-.062
78.00	808.05	8.61	7.195	-.060
79.00	815.21	8.61	7.136	-.059
80.00	822.31	8.60	7.077	-.059
81.00	829.35	8.59	7.020	-.057
82.00	836.33	8.58	6.963	-.057
83.00	843.26	8.57	6.907	-.056
84.00	850.13	8.57	6.852	-.055
85.00	856.95	8.56	6.798	-.054
86.00	863.72	8.55	6.745	-.053
87.00	870.43	8.55	6.692	-.053
88.00	877.09	8.55	6.640	-.052
89.00	883.71	8.55	6.589	-.051
90.00	890.27	8.55	6.539	-.050
91.00	896.79	8.55	6.489	-.050
92.00	903.26	8.56	6.440	-.049
93.00	909.68	8.56	6.392	-.048
94.00	916.06	8.57	6.344	-.048
95.00	922.39	8.58	6.297	-.047
96.00	928.67	8.59	6.250	-.047
97.00	934.91	8.60	6.205	-.045
98.00	941.09	8.60	6.159	-.046
99.00	947.22	8.60	6.114	-.045
100.00	953.30	8.58	6.070	-.044

SILVER NORMAL VERSUS GOLD-0.07 AT. PERCENT IRON

AT 30. KG

TEMP. (DEG. K)	EMF (UV)	EMF(UV) CHANGE	S (UV/K)	S(UV/K) INCREMENT
4.22	0.00	0.00	14.376	---
5.00	11.49	1.87	14.639	.263
6.00	26.10	3.60	14.850	.211
7.00	40.99	5.04	15.012	.162
8.00	56.09	6.24	15.159	.147
9.00	71.33	7.23	15.272	.113
10.00	86.66	8.05	15.362	.090
11.00	102.01	8.71	15.356	-.006
12.00	117.36	9.25	15.342	-.014
13.00	132.67	9.69	15.305	-.037
14.00	147.90	10.04	15.208	-.097
15.00	163.02	10.32	15.111	-.097
16.00	178.02	10.54	14.952	-.159
17.00	192.87	10.71	14.795	-.157
18.00	207.56	10.85	14.641	-.154
19.00	222.09	10.96	14.468	-.173
20.00	236.43	11.05	14.286	-.182
21.00	250.58	11.13	14.093	-.193
22.00	264.53	11.19	13.895	-.198
23.00	278.29	11.24	13.693	-.202
24.00	291.85	11.29	13.492	-.201
25.00	305.21	11.33	13.283	-.209
26.00	318.36	11.38	13.081	-.202
27.00	331.32	11.42	12.876	-.205
28.00	344.08	11.46	12.675	-.201
29.00	356.64	11.50	12.474	-.201
30.00	369.01	11.55	12.281	-.193
31.00	381.19	11.59	12.090	-.191
32.00	393.18	11.63	11.905	-.185
33.00	404.99	11.68	11.723	-.182
34.00	416.63	11.72	11.547	-.176
35.00	428.09	11.76	11.374	-.173
36.00	439.39	11.80	11.208	-.166
37.00	450.52	11.84	11.048	-.160
38.00	461.50	11.88	10.892	-.156
39.00	472.32	11.91	10.741	-.151
40.00	482.99	11.94	10.595	-.146
41.00	493.52	11.97	10.454	-.141
42.00	503.91	12.00	10.317	-.137
43.00	514.16	12.02	10.185	-.132
44.00	524.29	12.04	10.057	-.128
45.00	534.28	12.06	9.933	-.124
46.00	544.15	12.08	9.812	-.121
47.00	553.91	12.09	9.696	-.116
48.00	563.55	12.10	9.583	-.113
49.00	573.07	12.11	9.475	-.108
50.00	582.49	12.12	9.370	-.105

SILVER NORMAL VERSUS GOLD-0.07 AT. PERCENT IRON

AT 30. KG

TEMP. (DEG. K)	EMF (UV)	EMF(UV) CHANGE	S (UV/K)	S(UV/K) INCREMENT
51.00	591.81	12.12	9.267	-.103
52.00	601.02	12.13	9.167	-.100
53.00	610.13	12.13	9.069	-.098
54.00	619.15	12.13	8.975	-.094
55.00	628.08	12.14	8.882	-.093
56.00	636.91	12.14	8.792	-.090
57.00	645.66	12.14	8.703	-.089
58.00	654.31	12.14	8.616	-.087
59.00	662.89	12.15	8.531	-.085
60.00	671.38	12.15	8.448	-.083
61.00	679.79	12.15	8.367	-.081
62.00	688.12	12.16	8.288	-.079
63.00	696.37	12.16	8.210	-.078
64.00	704.55	12.16	8.134	-.076
65.00	712.65	12.17	8.060	-.074
66.00	720.68	12.17	7.986	-.074
67.00	728.63	12.18	7.914	-.072
68.00	736.51	12.18	7.843	-.071
69.00	744.33	12.18	7.774	-.069
70.00	752.07	12.19	7.705	-.069
71.00	759.74	12.19	7.638	-.067
72.00	767.35	12.19	7.572	-.066
73.00	774.89	12.19	7.506	-.066
74.00	782.36	12.19	7.442	-.064
75.00	789.77	12.19	7.379	-.063
76.00	797.11	12.18	7.317	-.062
77.00	804.39	12.18	7.255	-.062
78.00	811.61	12.17	7.195	-.060
79.00	818.77	12.16	7.136	-.059
80.00	825.86	12.15	7.077	-.059
81.00	832.90	12.14	7.020	-.057
82.00	839.88	12.13	6.963	-.057
83.00	846.81	12.12	6.907	-.056
84.00	853.68	12.11	6.852	-.055
85.00	860.50	12.10	6.798	-.054
86.00	867.26	12.10	6.745	-.053
87.00	873.97	12.09	6.692	-.053
88.00	880.63	12.09	6.640	-.052
89.00	887.25	12.08	6.589	-.051
90.00	893.81	12.08	6.539	-.050
91.00	900.32	12.08	6.489	-.050
92.00	906.79	12.09	6.440	-.049
93.00	913.21	12.09	6.392	-.048
94.00	919.58	12.09	6.344	-.048
95.00	925.90	12.10	6.297	-.047
96.00	932.17	12.09	6.250	-.047
97.00	938.39	12.08	6.205	-.045
98.00	944.56	12.06	6.159	-.046
99.00	950.66	12.03	6.114	-.045
100.00	956.70	11.98	6.070	-.044

SILVER NORMAL VERSUS GOLD-0.07 AT. PERCENT IRON
AT 35. KG

TEMP. (DEG. K)	EMF (UV)	EMF(UV) CHANGE	S (UV/K)	S(UV/K) INCREMENT
4.22	0.00	0.00	14.985	---
5.00	11.95	2.33	15.169	.184
6.00	27.01	4.51	15.280	.111
7.00	42.30	6.35	15.387	.107
8.00	57.75	7.90	15.469	.082
9.00	73.29	9.19	15.557	.088
10.00	88.87	10.26	15.607	.050
11.00	104.45	11.15	15.581	-.026
12.00	120.00	11.88	15.537	-.044
13.00	135.46	12.48	15.445	-.092
14.00	150.83	12.97	15.338	-.107
15.00	166.07	13.37	15.201	-.137
16.00	181.17	13.69	15.062	-.139
17.00	196.11	13.95	14.880	-.182
18.00	210.87	14.16	14.701	-.179
19.00	225.45	14.33	14.513	-.188
20.00	239.84	14.47	14.326	-.187
21.00	254.04	14.59	14.128	-.198
22.00	268.03	14.68	13.936	-.192
23.00	281.82	14.77	13.720	-.216
24.00	295.40	14.84	13.512	-.208
25.00	308.78	14.91	13.306	-.206
26.00	321.95	14.97	13.099	-.207
27.00	334.93	15.03	12.896	-.203
28.00	347.70	15.08	12.693	-.203
29.00	360.27	15.14	12.492	-.201
30.00	372.66	15.20	12.297	-.195
31.00	384.85	15.25	12.105	-.192
32.00	396.85	15.31	11.918	-.187
33.00	408.68	15.36	11.733	-.185
34.00	420.32	15.41	11.557	-.176
35.00	431.80	15.47	11.386	-.171
36.00	443.11	15.52	11.220	-.166
37.00	454.25	15.57	11.059	-.161
38.00	465.24	15.61	10.903	-.156
39.00	476.07	15.66	10.752	-.151
40.00	486.75	15.70	10.607	-.145
41.00	497.29	15.74	10.466	-.141
42.00	507.69	15.78	10.328	-.138
43.00	517.96	15.81	10.196	-.132
44.00	528.09	15.85	10.068	-.128
45.00	538.09	15.87	9.945	-.123
46.00	547.98	15.90	9.825	-.120
47.00	557.74	15.92	9.710	-.115
48.00	567.39	15.94	9.598	-.112
49.00	576.93	15.96	9.488	-.110
50.00	586.35	15.98	9.380	-.108

SILVER NORMAL VERSUS GOLD-0.07 AT. PERCENT IRON

AT 35. KG

TEMP. (DEG. K)	EMF (UV)	EMF(UV) CHANGE	S (UV/K)	S(UV/K) INCREMENT
51.00	595.68	15.99	9.276	-.104
52.00	604.90	16.00	9.175	-.101
53.00	614.02	16.01	9.076	-.099
54.00	623.04	16.02	8.980	-.096
55.00	631.98	16.03	8.886	-.094
56.00	640.82	16.04	8.795	-.091
57.00	649.57	16.05	8.705	-.090
58.00	658.23	16.06	8.617	-.088
59.00	666.81	16.07	8.531	-.086
60.00	675.31	16.08	8.447	-.084
61.00	683.72	16.08	8.367	-.080
62.00	692.06	16.09	8.288	-.079
63.00	700.31	16.10	8.210	-.078
64.00	708.49	16.11	8.134	-.076
65.00	716.60	16.12	8.060	-.074
66.00	724.63	16.13	7.986	-.074
67.00	732.59	16.13	7.914	-.072
68.00	740.48	16.14	7.843	-.071
69.00	748.29	16.15	7.774	-.069
70.00	756.04	16.15	7.705	-.069
71.00	763.71	16.16	7.638	-.067
72.00	771.32	16.16	7.572	-.066
73.00	778.86	16.17	7.506	-.066
74.00	786.34	16.17	7.442	-.064
75.00	793.75	16.17	7.379	-.063
76.00	801.10	16.17	7.317	-.062
77.00	808.38	16.17	7.255	-.062
78.00	815.60	16.16	7.195	-.060
79.00	822.76	16.16	7.136	-.059
80.00	829.86	16.15	7.077	-.059
81.00	836.91	16.15	7.020	-.057
82.00	843.89	16.14	6.963	-.057
83.00	850.82	16.13	6.907	-.056
84.00	857.69	16.13	6.852	-.055
85.00	864.51	16.12	6.798	-.054
86.00	871.28	16.12	6.745	-.053
87.00	877.99	16.11	6.692	-.053
88.00	884.66	16.11	6.640	-.052
89.00	891.28	16.11	6.589	-.051
90.00	897.84	16.12	6.539	-.050
91.00	904.36	16.13	6.489	-.050
92.00	910.84	16.13	6.440	-.049
93.00	917.26	16.14	6.392	-.048
94.00	923.64	16.16	6.344	-.048
95.00	929.97	16.17	6.297	-.047
96.00	936.26	16.18	6.250	-.047
97.00	942.49	16.18	6.205	-.045
98.00	948.66	16.17	6.159	-.046
99.00	954.78	16.16	6.114	-.045
100.00	960.84	16.12	6.070	-.044

SILVER NORMAL VERSUS GOLD-0.07 AT. PERCENT IRON

AT 40. KG

TEMP. (DEG. K)	EMF (UV)	EMF(UV) CHANGE	S (UV/K)	S(UV/K) INCREMENT
4.22	0.00	0.00	15.601	---
5.00	12.40	2.78	15.716	.115
6.00	27.94	5.44	15.740	.024
7.00	43.65	7.69	15.752	.012
8.00	59.45	9.59	15.789	.037
9.00	75.30	11.20	15.817	.028
10.00	91.15	12.54	15.837	.020
11.00	106.96	13.66	15.811	-.026
12.00	122.70	14.59	15.757	-.054
13.00	138.34	15.36	15.670	-.087
14.00	153.85	15.99	15.493	-.177
15.00	169.22	16.52	15.316	-.177
16.00	184.43	16.95	15.152	-.164
17.00	199.46	17.30	14.945	-.207
18.00	214.31	17.60	14.751	-.194
19.00	228.96	17.84	14.555	-.196
20.00	243.41	18.04	14.356	-.199
21.00	257.66	18.21	14.158	-.198
22.00	271.69	18.35	13.951	-.207
23.00	285.52	18.47	13.745	-.206
24.00	299.14	18.58	13.535	-.210
25.00	312.54	18.67	13.325	-.210
26.00	325.74	18.75	13.116	-.209
27.00	338.73	18.83	12.909	-.207
28.00	351.52	18.90	12.707	-.202
29.00	364.10	18.97	12.506	-.201
30.00	376.49	19.03	12.310	-.196
31.00	388.69	19.09	12.115	-.195
32.00	400.69	19.14	11.928	-.187
33.00	412.51	19.20	11.744	-.184
34.00	424.16	19.25	11.566	-.178
35.00	435.63	19.29	11.392	-.174
36.00	446.92	19.33	11.224	-.168
37.00	458.06	19.37	11.064	-.160
38.00	469.03	19.41	10.906	-.158
39.00	479.85	19.44	10.754	-.152
40.00	490.52	19.47	10.608	-.146
41.00	501.04	19.49	10.467	-.141
42.00	511.42	19.51	10.329	-.138
43.00	521.67	19.52	10.197	-.132
44.00	531.78	19.54	10.069	-.128
45.00	541.77	19.55	9.946	-.123
46.00	551.63	19.56	9.826	-.120
47.00	561.38	19.56	9.711	-.115
48.00	571.01	19.56	9.599	-.112
49.00	580.53	19.57	9.490	-.109
50.00	589.94	19.57	9.382	-.108

SILVER NORMAL VERSUS GOLD-0.07 AT. PERCENT IRON

AT 40. KG

TEMP. (DEG. K)	EMF (UV)	EMF(UV) CHANGE	S (UV/K)	S(UV/K) INCREMENT
51.00	599.25	19.57	9.278	-.104
52.00	608.46	19.57	9.176	-.102
53.00	617.57	19.57	9.077	-.099
54.00	626.59	19.57	8.980	-.097
55.00	635.51	19.57	8.886	-.094
56.00	644.34	19.57	8.795	-.091
57.00	653.09	19.57	8.705	-.090
58.00	661.75	19.58	8.616	-.089
59.00	670.33	19.59	8.530	-.086
60.00	678.82	19.59	8.447	-.083
61.00	687.24	19.60	8.367	-.080
62.00	695.58	19.62	8.288	-.079
63.00	703.84	19.63	8.210	-.078
64.00	712.03	19.64	8.134	-.076
65.00	720.14	19.66	8.060	-.074
66.00	728.18	19.67	7.986	-.074
67.00	736.15	19.69	7.914	-.072
68.00	744.04	19.71	7.843	-.071
69.00	751.87	19.72	7.774	-.069
70.00	759.62	19.74	7.705	-.069
71.00	767.31	19.75	7.638	-.067
72.00	774.92	19.77	7.572	-.066
73.00	782.47	19.78	7.506	-.066
74.00	789.96	19.79	7.442	-.064
75.00	797.38	19.80	7.379	-.063
76.00	804.73	19.80	7.317	-.062
77.00	812.02	19.80	7.255	-.062
78.00	819.24	19.81	7.195	-.060
79.00	826.41	19.80	7.136	-.059
80.00	833.51	19.80	7.077	-.059
81.00	840.56	19.80	7.020	-.057
82.00	847.54	19.79	6.963	-.057
83.00	854.47	19.78	6.907	-.056
84.00	861.34	19.77	6.852	-.055
85.00	868.16	19.77	6.798	-.054
86.00	874.92	19.76	6.745	-.053
87.00	881.63	19.75	6.692	-.053
88.00	888.30	19.75	6.640	-.052
89.00	894.91	19.75	6.589	-.051
90.00	901.47	19.75	6.539	-.050
91.00	907.99	19.75	6.489	-.050
92.00	914.46	19.76	6.440	-.049
93.00	920.89	19.77	6.392	-.048
94.00	927.27	19.78	6.344	-.048
95.00	933.60	19.79	6.297	-.047
96.00	939.88	19.80	6.250	-.047
97.00	946.12	19.81	6.205	-.045
98.00	952.30	19.81	6.159	-.046
99.00	958.42	19.79	6.114	-.045
100.00	964.48	19.76	6.070	-.044

SILVER NORMAL VERSUS GOLD-0.07 AT. PERCENT IRON

AT 45. KG

TEMP. (DEG. K)	EMF (UV)	EMF (UV) CHANGE	S (UV/K)	S (UV/K) INCREMENT
4.22	0.00	0.00	16.062	---
5.00	12.86	3.24	16.164	.102
6.00	28.77	6.26	16.173	.009
7.00	44.81	8.85	16.127	-.046
8.00	60.93	11.08	15.929	-.198
9.00	77.08	12.97	16.027	.098
10.00	93.20	14.59	16.087	.060
11.00	109.27	15.97	16.136	.049
12.00	125.24	17.13	16.137	.001
13.00	141.09	18.11	15.840	-.297
14.00	156.80	18.94	15.683	-.157
15.00	172.34	19.64	15.511	-.172
16.00	187.70	20.22	15.297	-.214
17.00	202.87	20.71	15.060	-.237
18.00	217.83	21.12	14.836	-.224
19.00	232.59	21.47	14.623	-.213
20.00	247.13	21.76	14.406	-.217
21.00	261.45	22.00	14.198	-.208
22.00	275.55	22.21	13.986	-.212
23.00	289.43	22.38	13.773	-.213
24.00	303.09	22.53	13.562	-.211
25.00	316.54	22.66	13.343	-.219
26.00	329.76	22.78	13.130	-.213
27.00	342.78	22.88	12.924	-.206
28.00	355.58	22.96	12.717	-.207
29.00	368.18	23.04	12.512	-.205
30.00	380.58	23.12	12.316	-.196
31.00	392.78	23.18	12.123	-.193
32.00	404.79	23.24	11.935	-.188
33.00	416.62	23.30	11.751	-.184
34.00	428.26	23.35	11.572	-.179
35.00	439.73	23.40	11.398	-.174
36.00	451.03	23.44	11.228	-.170
37.00	462.16	23.48	11.064	-.164
38.00	473.14	23.51	10.906	-.158
39.00	483.96	23.55	10.753	-.153
40.00	494.63	23.58	10.605	-.148
41.00	505.15	23.60	10.462	-.143
42.00	515.54	23.63	10.323	-.139
43.00	525.79	23.65	10.190	-.133
44.00	535.91	23.66	10.061	-.129
45.00	545.90	23.68	9.937	-.124
46.00	555.77	23.69	9.816	-.121
47.00	565.52	23.70	9.699	-.117
48.00	575.15	23.71	9.586	-.113
49.00	584.68	23.72	9.477	-.109
50.00	594.10	23.72	9.371	-.106

SILVER NORMAL VERSUS GOLD-0.07 AT. PERCENT IRON

AT 45. KG

TEMP. (DEG. K)	EMF (UV)	EMF(UV) CHANGE	S (UV/K)	S(UV/K) INCREMENT
51.00	603.41	23.73	9.268	-.103
52.00	612.62	23.73	9.169	-.099
53.00	621.74	23.73	9.070	-.099
54.00	630.76	23.74	8.974	-.096
55.00	639.68	23.74	8.880	-.094
56.00	648.52	23.74	8.789	-.091
57.00	657.26	23.75	8.701	-.088
58.00	665.92	23.75	8.614	-.087
59.00	674.50	23.76	8.530	-.084
60.00	682.99	23.76	8.447	-.083
61.00	691.41	23.77	8.367	-.080
62.00	699.74	23.77	8.288	-.079
63.00	707.99	23.78	8.210	-.078
64.00	716.17	23.79	8.134	-.076
65.00	724.28	23.80	8.060	-.074
66.00	732.31	23.80	7.986	-.074
67.00	740.26	23.81	7.914	-.072
68.00	748.15	23.82	7.843	-.071
69.00	755.96	23.82	7.774	-.069
70.00	763.71	23.83	7.705	-.069
71.00	771.38	23.83	7.638	-.067
72.00	778.99	23.83	7.572	-.066
73.00	786.53	23.83	7.506	-.066
74.00	794.00	23.83	7.442	-.064
75.00	801.41	23.83	7.379	-.063
76.00	808.75	23.82	7.317	-.062
77.00	816.03	23.82	7.255	-.062
78.00	823.25	23.81	7.195	-.060
79.00	830.41	23.80	7.136	-.059
80.00	837.50	23.79	7.077	-.059
81.00	844.54	23.78	7.020	-.057
82.00	851.52	23.77	6.963	-.057
83.00	858.44	23.75	6.907	-.056
84.00	865.31	23.74	6.852	-.055
85.00	872.12	23.73	6.798	-.054
86.00	878.89	23.72	6.745	-.053
87.00	885.60	23.72	6.692	-.053
88.00	892.26	23.71	6.640	-.052
89.00	898.87	23.71	6.589	-.051
90.00	905.44	23.71	6.539	-.050
91.00	911.96	23.72	6.489	-.050
92.00	918.43	23.73	6.440	-.049
93.00	924.86	23.74	6.392	-.048
94.00	931.24	23.75	6.344	-.048
95.00	937.57	23.77	6.297	-.047
96.00	943.86	23.78	6.250	-.047
97.00	950.10	23.79	6.205	-.045
98.00	956.28	23.79	6.159	-.046
99.00	962.41	23.79	6.114	-.045
100.00	968.48	23.76	6.070	-.044

SILVER NORMAL VERSUS GOLD-0.07 AT. PERCENT IRON

AT 50. KG

TEMP. (DEG. K)	EMF (UV)	EMF(UV) CHANGE	S (UV/K)	S(UV/K) INCREMENT
4.22	0.00	0.00	16.711	---
5.00	13.26	3.64	16.724	.013
6.00	29.71	7.21	16.620	-.104
7.00	46.21	10.26	16.502	-.118
8.00	62.72	12.86	16.434	-.068
9.00	79.18	15.08	16.377	-.057
10.00	95.57	16.96	16.312	-.065
11.00	111.85	18.55	16.241	-.071
12.00	128.01	19.89	16.127	-.114
13.00	144.01	21.03	15.980	-.147
14.00	159.84	21.99	15.793	-.187
15.00	175.49	22.79	15.586	-.207
16.00	190.95	23.47	15.372	-.214
17.00	206.20	24.05	15.140	-.232
18.00	221.24	24.53	14.911	-.229
19.00	236.07	24.94	14.693	-.218
20.00	250.67	25.30	14.478	-.215
21.00	265.05	25.60	14.258	-.220
22.00	279.21	25.86	14.041	-.217
23.00	293.14	26.09	13.820	-.221
24.00	306.86	26.29	13.605	-.215
25.00	320.35	26.48	13.386	-.219
26.00	333.62	26.64	13.167	-.219
27.00	346.68	26.78	12.956	-.211
28.00	359.53	26.92	12.747	-.209
29.00	372.17	27.04	12.540	-.207
30.00	384.61	27.15	12.336	-.204
31.00	396.85	27.26	12.143	-.193
32.00	408.90	27.35	11.952	-.191
33.00	420.76	27.44	11.766	-.186
34.00	432.43	27.52	11.585	-.181
35.00	443.93	27.60	11.411	-.174
36.00	455.25	27.66	11.242	-.169
37.00	466.41	27.72	11.078	-.164
38.00	477.40	27.78	10.910	-.168
39.00	488.24	27.83	10.767	-.143
40.00	498.92	27.87	10.619	-.148
41.00	509.46	27.91	10.476	-.143
42.00	519.85	27.94	10.337	-.139
43.00	530.11	27.97	10.205	-.132
44.00	540.24	27.99	10.076	-.129
45.00	550.23	28.01	9.951	-.125
46.00	560.11	28.03	9.830	-.121
47.00	569.86	28.04	9.712	-.118
48.00	579.50	28.06	9.598	-.114
49.00	589.03	28.06	9.487	-.111
50.00	598.45	28.07	9.380	-.107

SILVER NORMAL VERSUS GOLD-0.07 AT. PERCENT IRON

AT 50. KG

TEMP. (DEG. K)	EMF (UV)	EMF(UV) CHANGE	S (UV/K)	S(UV/K) INCREMENT
51.00	607.77	28.08	9.277	-.103
52.00	616.98	28.09	9.176	-.101
53.00	626.10	28.10	9.077	-.099
54.00	635.12	28.11	8.981	-.096
55.00	644.06	28.12	8.887	-.094
56.00	652.90	28.13	8.796	-.091
57.00	661.65	28.14	8.706	-.090
58.00	670.32	28.15	8.618	-.088
59.00	678.91	28.17	8.532	-.086
60.00	687.42	28.18	8.448	-.084
61.00	695.84	28.20	8.367	-.081
62.00	704.19	28.22	8.288	-.079
63.00	712.46	28.24	8.210	-.078
64.00	720.65	28.26	8.134	-.076
65.00	728.77	28.29	8.060	-.074
66.00	736.81	28.31	7.986	-.074
67.00	744.78	28.33	7.914	-.072
68.00	752.68	28.35	7.843	-.071
69.00	760.51	28.37	7.774	-.069
70.00	768.27	28.38	7.705	-.069
71.00	775.95	28.40	7.638	-.067
72.00	783.57	28.41	7.572	-.066
73.00	791.12	28.42	7.506	-.066
74.00	798.60	28.42	7.442	-.064
75.00	806.01	28.43	7.379	-.063
76.00	813.36	28.43	7.317	-.062
77.00	820.64	28.42	7.255	-.062
78.00	827.86	28.42	7.195	-.060
79.00	835.01	28.41	7.136	-.059
80.00	842.11	28.40	7.077	-.059
81.00	849.14	28.38	7.020	-.057
82.00	856.12	28.37	6.963	-.057
83.00	863.04	28.36	6.907	-.056
84.00	869.91	28.34	6.852	-.055
85.00	876.72	28.33	6.798	-.054
86.00	883.49	28.32	6.745	-.053
87.00	890.20	28.32	6.692	-.053
88.00	896.86	28.32	6.640	-.052
89.00	903.48	28.32	6.589	-.051
90.00	910.05	28.33	6.539	-.050
91.00	916.58	28.34	6.489	-.050
92.00	923.06	28.36	6.440	-.049
93.00	929.50	28.38	6.392	-.048
94.00	935.89	28.40	6.344	-.048
95.00	942.23	28.42	6.297	-.047
96.00	948.52	28.44	6.250	-.047
97.00	954.76	28.45	6.205	-.045
98.00	960.93	28.44	6.159	-.046
99.00	967.03	28.41	6.114	-.045
100.00	973.06	28.34	6.070	-.044

SILVER NORMAL VERSUS GOLD-0.07 AT. PERCENT IRON

AT 60. KG

TEMP. (DEG. K)	EMF (UV)	EMF(UV) CHANGE	S (UV/K)	S(UV/K) INCREMENT
4.22	0.00	0.00	17.835	---
5.00	14.26	4.64	17.727	-.108
6.00	31.53	9.03	17.469	-.258
7.00	48.74	12.79	17.187	-.282
8.00	65.86	16.00	16.999	-.188
9.00	82.85	18.75	16.837	-.162
10.00	99.70	21.09	16.712	-.125
11.00	116.39	23.09	16.621	-.091
12.00	132.90	24.79	16.467	-.154
13.00	149.23	26.25	16.280	-.187
14.00	165.35	27.49	16.088	-.192
15.00	181.26	28.56	15.866	-.222
16.00	196.96	29.48	15.632	-.234
17.00	212.44	30.28	15.365	-.267
18.00	227.69	30.98	15.126	-.239
19.00	242.71	31.59	14.888	-.238
20.00	257.50	32.13	14.666	-.222
21.00	272.06	32.61	14.438	-.228
22.00	286.39	33.05	14.214	-.224
23.00	300.49	33.44	13.998	-.216
24.00	314.36	33.80	13.769	-.229
25.00	328.01	34.13	13.543	-.226
26.00	341.43	34.44	13.315	-.228
27.00	354.63	34.73	13.094	-.221
28.00	367.61	35.00	12.877	-.217
29.00	380.38	35.25	12.662	-.215
30.00	392.94	35.48	12.451	-.211
31.00	405.30	35.70	12.245	-.206
32.00	417.45	35.90	12.050	-.195
33.00	429.41	36.09	11.854	-.196
34.00	441.18	36.27	11.669	-.185
35.00	452.77	36.43	11.488	-.181
36.00	464.17	36.58	11.314	-.174
37.00	475.41	36.72	11.146	-.168
38.00	486.47	36.85	10.982	-.164
39.00	497.37	36.96	10.825	-.157
40.00	508.11	37.06	10.674	-.151
41.00	518.70	37.15	10.529	-.145
42.00	529.14	37.23	10.387	-.142
43.00	539.45	37.31	10.253	-.134
44.00	549.61	37.37	10.121	-.132
45.00	559.65	37.43	9.995	-.126
46.00	569.55	37.48	9.872	-.123
47.00	579.34	37.52	9.754	-.118
48.00	589.01	37.56	9.638	-.116
49.00	598.57	37.60	9.526	-.112
50.00	608.01	37.64	9.417	-.109

SILVER NORMAL VERSUS GOLD-0.07 AT. PERCENT IRON

AT 60. KG

TEMP. (DEG. K)	EMF (UV)	EMF(UV) CHANGE	S (UV/K)	S(UV/K) INCREMENT
51.00	617.36	37.67	9.312	-.105
52.00	626.60	37.70	9.210	-.102
53.00	635.74	37.74	9.110	-.100
54.00	644.79	37.77	9.012	-.098
55.00	653.75	37.80	8.917	-.095
56.00	662.61	37.84	8.825	-.092
57.00	671.39	37.88	8.735	-.090
58.00	680.09	37.92	8.647	-.088
59.00	688.70	37.96	8.561	-.086
60.00	697.23	38.00	8.476	-.085
61.00	705.69	38.05	8.394	-.082
62.00	714.06	38.09	8.313	-.081
63.00	722.35	38.14	8.233	-.080
64.00	730.57	38.19	8.155	-.078
65.00	738.71	38.23	8.079	-.076
66.00	746.78	38.28	8.004	-.075
67.00	754.77	38.32	7.930	-.074
68.00	762.69	38.36	7.857	-.073
69.00	770.53	38.39	7.786	-.071
70.00	778.30	38.42	7.716	-.070
71.00	786.00	38.45	7.648	-.068
72.00	793.63	38.47	7.582	-.066
73.00	801.18	38.48	7.515	-.067
74.00	808.66	38.49	7.448	-.067
75.00	816.07	38.49	7.383	-.065
76.00	823.41	38.48	7.319	-.064
77.00	830.69	38.47	7.256	-.063
78.00	837.89	38.45	7.195	-.061
79.00	845.03	38.43	7.136	-.059
80.00	852.11	38.40	7.076	-.060
81.00	859.13	38.37	7.018	-.058
82.00	866.09	38.34	6.961	-.057
83.00	872.99	38.30	6.904	-.057
84.00	879.83	38.27	6.849	-.055
85.00	886.63	38.24	6.795	-.054
86.00	893.37	38.21	6.741	-.054
87.00	900.07	38.19	6.688	-.053
88.00	906.72	38.18	6.635	-.053
89.00	913.33	38.17	6.584	-.051
90.00	919.90	38.18	6.534	-.050
91.00	926.43	38.19	6.484	-.050
92.00	932.92	38.22	6.435	-.049
93.00	939.38	38.26	6.387	-.048
94.00	945.79	38.30	6.339	-.048
95.00	952.16	38.35	6.292	-.047
96.00	958.48	38.40	6.245	-.047
97.00	964.75	38.45	6.200	-.045
98.00	970.97	38.48	6.154	-.046
99.00	977.11	38.48	6.109	-.045
100.00	983.17	38.45	6.065	-.044

SILVER NORMAL VERSUS GOLD-0.07 AT. PERCENT IRON

AT 70. KG

TEMP. (DEG. K)	EMF (UV)	EMF(UV) CHANGE	S (UV/K)	S(UV/K) INCREMENT
4.22	0.00	0.00	19.239	---
5.00	15.49	5.86	18.864	-.375
6.00	33.48	10.98	18.275	-.589
7.00	51.31	15.35	17.787	-.488
8.00	68.96	19.10	17.479	-.308
9.00	86.41	22.31	17.262	-.217
10.00	103.66	25.05	17.112	-.150
11.00	120.71	27.41	16.901	-.211
12.00	137.54	29.43	16.747	-.154
13.00	154.15	31.17	16.550	-.197
14.00	170.53	32.67	16.348	-.202
15.00	186.68	33.98	16.116	-.232
16.00	202.60	35.12	15.922	-.194
17.00	218.28	36.13	15.625	-.297
18.00	233.72	37.01	15.356	-.269
19.00	248.93	37.81	15.089	-.267
20.00	263.89	38.52	14.815	-.274
21.00	278.61	39.16	14.588	-.227
22.00	293.09	39.75	14.358	-.230
23.00	307.33	40.28	14.113	-.245
24.00	321.34	40.78	13.887	-.226
25.00	335.11	41.24	13.643	-.244
26.00	348.65	41.66	13.408	-.235
27.00	361.95	42.05	13.179	-.229
28.00	375.03	42.42	12.955	-.224
29.00	387.89	42.76	12.732	-.223
30.00	400.53	43.07	12.514	-.218
31.00	412.96	43.36	12.307	-.207
32.00	425.18	43.63	12.105	-.202
33.00	437.19	43.87	11.908	-.197
34.00	449.01	44.10	11.717	-.191
35.00	460.63	44.30	11.533	-.184
36.00	472.07	44.48	11.355	-.178
37.00	483.33	44.65	11.186	-.169
38.00	494.42	44.79	11.017	-.169
39.00	505.33	44.92	10.860	-.157
40.00	516.09	45.04	10.704	-.156
41.00	526.69	45.14	10.557	-.147
42.00	537.14	45.23	10.415	-.142
43.00	547.45	45.31	10.277	-.138
44.00	557.62	45.38	10.143	-.134
45.00	567.66	45.44	10.017	-.126
46.00	577.57	45.50	9.892	-.125
47.00	587.37	45.55	9.774	-.118
48.00	597.04	45.60	9.658	-.116
49.00	606.61	45.65	9.545	-.113
50.00	616.07	45.70	9.436	-.109

SILVER NORMAL VERSUS GOLD-0.07 AT. PERCENT IRON

AT 70. KG

TEMP. (DEG. K)	EMF (UV)	EMF(UV) CHANGE	S (UV/K)	S(UV/K) INCREMENT
51.00	625.43	45.75	9.331	-.105
52.00	634.70	45.80	9.229	-.102
53.00	643.86	45.86	9.129	-.100
54.00	652.94	45.92	9.031	-.098
55.00	661.92	45.98	8.936	-.095
56.00	670.82	46.05	8.844	-.092
57.00	679.64	46.13	8.752	-.092
58.00	688.37	46.20	8.663	-.089
59.00	697.02	46.28	8.577	-.086
60.00	705.60	46.37	8.492	-.085
61.00	714.09	46.45	8.409	-.083
62.00	722.50	46.54	8.328	-.081
63.00	730.84	46.62	8.248	-.080
64.00	739.09	46.71	8.169	-.079
65.00	747.27	46.79	8.092	-.077
66.00	755.37	46.87	8.016	-.076
67.00	763.39	46.94	7.942	-.074
68.00	771.34	47.00	7.869	-.073
69.00	779.20	47.06	7.797	-.072
70.00	786.99	47.11	7.726	-.071
71.00	794.71	47.15	7.658	-.068
72.00	802.34	47.18	7.590	-.068
73.00	809.90	47.20	7.523	-.067
74.00	817.38	47.21	7.457	-.066
75.00	824.79	47.21	7.392	-.065
76.00	832.13	47.20	7.328	-.064
77.00	839.39	47.18	7.265	-.063
78.00	846.59	47.15	7.204	-.061
79.00	853.72	47.12	7.144	-.060
80.00	860.79	47.08	7.083	-.061
81.00	867.79	47.03	7.024	-.059
82.00	874.74	46.99	6.966	-.058
83.00	881.64	46.95	6.909	-.057
84.00	888.48	46.92	6.853	-.056
85.00	895.28	46.89	6.798	-.055
86.00	902.04	46.87	6.745	-.053
87.00	908.75	46.87	6.692	-.053
88.00	915.43	46.88	6.639	-.053
89.00	922.06	46.90	6.587	-.052
90.00	928.67	46.94	6.536	-.051
91.00	935.23	46.99	6.485	-.051
92.00	941.76	47.06	6.436	-.049
93.00	948.25	47.13	6.387	-.049
94.00	954.69	47.20	6.339	-.048
95.00	961.07	47.26	6.292	-.047
96.00	967.39	47.30	6.245	-.047
97.00	973.62	47.31	6.200	-.045
98.00	979.75	47.25	6.154	-.046
99.00	985.75	47.12	6.109	-.045
100.00	991.59	46.87	6.065	-.044

SILVER NORMAL VERSUS GOLD-0.07 AT. PERCENT IRON
AT 80. KG

TEMP. (DEG. K)	EMF (UV)	EMF(UV) CHANGE	S (UV/K)	S(UV/K) INCREMENT
4.22	0.00	0.00	20.026	---
5.00	16.56	6.93	19.660	-.366
6.00	35.18	12.68	19.084	-.576
7.00	53.57	17.62	18.432	-.652
8.00	71.71	21.86	17.889	-.543
9.00	89.61	25.50	17.572	-.317
10.00	107.25	28.64	17.332	-.240
11.00	124.65	31.35	17.161	-.171
12.00	141.80	33.68	16.962	-.199
13.00	158.69	35.71	16.770	-.192
14.00	175.33	37.48	16.568	-.202
15.00	191.72	39.02	16.331	-.237
16.00	207.86	40.38	16.092	-.239
17.00	223.75	41.59	15.855	-.237
18.00	239.38	42.67	15.576	-.279
19.00	254.76	43.63	15.319	-.257
20.00	269.88	44.51	15.059	-.260
21.00	284.76	45.31	14.798	-.261
22.00	299.39	46.04	14.531	-.267
23.00	313.77	46.72	14.263	-.268
24.00	327.91	47.35	14.007	-.256
25.00	341.80	47.93	13.743	-.264
26.00	355.46	48.47	13.488	-.255
27.00	368.88	48.98	13.244	-.244
28.00	382.07	49.45	13.007	-.237
29.00	395.03	49.89	12.782	-.225
30.00	407.76	50.30	12.561	-.221
31.00	420.28	50.68	12.351	-.210
32.00	432.58	51.03	12.150	-.201
33.00	444.67	51.35	11.951	-.199
34.00	456.56	51.65	11.771	-.180
35.00	468.26	51.92	11.578	-.193
36.00	479.76	52.17	11.399	-.179
37.00	491.08	52.39	11.228	-.171
38.00	502.21	52.59	11.082	-.146
39.00	513.18	52.77	10.903	-.179
40.00	523.98	52.93	10.750	-.153
41.00	534.62	53.07	10.602	-.148
42.00	545.11	53.20	10.457	-.145
43.00	555.46	53.31	10.318	-.139
44.00	565.66	53.42	10.186	-.132
45.00	575.73	53.51	10.057	-.129
46.00	585.67	53.59	9.930	-.127
47.00	595.48	53.67	9.808	-.122
48.00	605.18	53.74	9.690	-.118
49.00	614.77	53.81	9.577	-.113
50.00	624.25	53.87	9.465	-.112

SILVER NORMAL VERSUS GOLD-0.07 AT. PERCENT IRON

AT 80. KG

TEMP. (DEG. K)	EMF (UV)	EMF(UV) CHANGE	S (UV/K)	S(UV/K) INCREMENT
51.00	633.63	53.94	9.368	-.097
52.00	642.90	54.01	9.252	-.116
53.00	652.08	54.08	9.149	-.103
54.00	661.17	54.15	9.048	-.101
55.00	670.16	54.22	8.950	-.098
56.00	679.07	54.30	8.857	-.093
57.00	687.90	54.38	8.764	-.093
58.00	696.64	54.46	8.672	-.092
59.00	705.29	54.55	8.581	-.091
60.00	713.87	54.64	8.495	-.086
61.00	722.36	54.73	8.411	-.084
62.00	730.78	54.81	8.328	-.083
63.00	739.11	54.90	8.246	-.082
64.00	747.37	54.98	8.164	-.082
65.00	755.54	55.06	8.084	-.080
66.00	763.64	55.14	8.006	-.078
67.00	771.66	55.20	7.930	-.076
68.00	779.59	55.26	7.855	-.075
69.00	787.45	55.31	7.784	-.071
70.00	795.23	55.35	7.710	-.074
71.00	802.93	55.37	7.643	-.067
72.00	810.54	55.39	7.572	-.071
73.00	818.08	55.39	7.501	-.071
74.00	825.55	55.38	7.434	-.067
75.00	832.93	55.35	7.369	-.065
76.00	840.25	55.32	7.303	-.066
77.00	847.48	55.27	7.238	-.065
78.00	854.65	55.21	7.175	-.063
79.00	861.75	55.15	7.113	-.062
80.00	868.79	55.08	7.052	-.061
81.00	875.76	55.00	6.992	-.060
82.00	882.68	54.93	6.933	-.059
83.00	889.54	54.86	6.875	-.058
84.00	896.35	54.79	6.817	-.058
85.00	903.12	54.73	6.760	-.057
86.00	909.84	54.68	6.705	-.055
87.00	916.52	54.64	6.650	-.055
88.00	923.16	54.61	6.596	-.054
89.00	929.76	54.60	6.542	-.054
90.00	936.33	54.61	6.490	-.052
91.00	942.86	54.63	6.439	-.051
92.00	949.36	54.65	6.390	-.049
93.00	955.81	54.69	6.342	-.048
94.00	962.21	54.72	6.294	-.048
95.00	968.55	54.74	6.247	-.047
96.00	974.81	54.73	6.200	-.047
97.00	980.99	54.68	6.155	-.045
98.00	987.05	54.56	6.109	-.046
99.00	992.96	54.34	6.064	-.045
100.00	998.71	53.99	6.020	-.044

SILVER NORMAL VERSUS GOLD-0.07 AT. PERCENT IRON

AT 90. KG

TEMP. (DEG. K)	EMF (UV)	EMF(UV) CHANGE	S (UV/K)	S(UV/K) INCREMENT
4.22	0.00	0.00	22.131	---
5.00	17.95	8.33	21.191	-.940
6.00	37.57	15.06	19.896	-1.295
7.00	56.57	20.62	18.792	-1.104
8.00	75.08	25.23	18.199	-.593
9.00	93.18	29.08	17.847	-.352
10.00	110.94	32.33	17.582	-.265
11.00	128.40	35.10	17.416	-.166
12.00	145.61	37.50	17.157	-.259
13.00	162.58	39.60	16.930	-.227
14.00	179.33	41.47	16.718	-.212
15.00	195.86	43.16	16.476	-.242
16.00	212.17	44.69	16.232	-.244
17.00	228.26	46.11	15.980	-.252
18.00	244.13	47.42	15.726	-.254
19.00	259.76	48.64	15.473	-.253
20.00	275.15	49.78	15.216	-.257
21.00	290.29	50.83	14.958	-.258
22.00	305.17	51.82	14.731	-.227
23.00	319.78	52.73	14.478	-.253
24.00	334.13	53.57	14.172	-.306
25.00	348.21	54.33	13.825	-.347
26.00	362.01	55.02	13.563	-.262
27.00	375.54	55.64	13.310	-.253
28.00	388.81	56.19	13.069	-.241
29.00	401.81	56.68	12.837	-.232
30.00	414.55	57.09	12.621	-.216
31.00	427.05	57.45	12.403	-.218
32.00	439.30	57.75	12.195	-.208
33.00	451.32	58.00	11.993	-.202
34.00	463.11	58.20	11.799	-.194
35.00	474.70	58.36	11.613	-.186
36.00	486.08	58.49	11.432	-.181
37.00	497.28	58.59	11.256	-.176
38.00	508.29	58.67	11.088	-.168
39.00	519.14	58.73	10.925	-.163
40.00	529.84	58.79	10.769	-.156
41.00	540.38	58.83	10.619	-.150
42.00	550.79	58.88	10.470	-.149
43.00	561.07	58.93	10.330	-.140
44.00	571.23	58.99	10.194	-.136
45.00	581.28	59.06	10.062	-.132
46.00	591.21	59.13	9.930	-.132
47.00	601.04	59.22	9.812	-.118
48.00	610.77	59.32	9.692	-.120
49.00	620.40	59.44	9.575	-.117
50.00	629.94	59.56	9.464	-.111

SILVER NORMAL VERSUS GOLD-0.07 AT. PERCENT IRON

AT 90. KG

TEMP. (DEG. K)	EMF (UV)	EMF(UV) CHANGE	S (UV/K)	S(UV/K) INCREMENT
51.00	639.38	59.69	9.356	-.108
52.00	648.72	59.83	9.249	-.107
53.00	657.98	59.97	9.142	-.107
54.00	667.14	60.12	9.043	-.099
55.00	676.20	60.26	8.946	-.097
56.00	685.17	60.40	8.850	-.096
57.00	694.05	60.53	8.756	-.094
58.00	702.82	60.65	8.663	-.093
59.00	711.50	60.76	8.574	-.089
60.00	720.08	60.85	8.487	-.087
61.00	728.56	60.92	8.402	-.085
62.00	736.94	60.97	8.318	-.084
63.00	745.22	61.01	8.238	-.080
64.00	753.41	61.02	8.157	-.081
65.00	761.50	61.01	8.080	-.077
66.00	769.49	60.99	8.001	-.079
67.00	777.40	60.94	7.924	-.077
68.00	785.22	60.88	7.843	-.081
69.00	792.95	60.81	7.772	-.071
70.00	800.61	60.72	7.700	-.072
71.00	808.19	60.63	7.630	-.070
72.00	815.70	60.54	7.562	-.068
73.00	823.14	60.45	7.494	-.068
74.00	830.53	60.36	7.426	-.068
75.00	837.86	60.28	7.359	-.067
76.00	845.13	60.20	7.294	-.065
77.00	852.36	60.15	7.229	-.065
78.00	859.54	60.10	7.167	-.062
79.00	866.68	60.07	7.106	-.061
80.00	873.77	60.06	7.045	-.061
81.00	880.82	60.06	6.985	-.060
82.00	887.82	60.07	6.925	-.060
83.00	894.77	60.09	6.866	-.059
84.00	901.67	60.11	6.808	-.058
85.00	908.52	60.13	6.751	-.057
86.00	915.30	60.14	6.696	-.055
87.00	922.01	60.13	6.641	-.055
88.00	928.64	60.10	6.587	-.054
89.00	935.20	60.03	6.534	-.053
90.00	941.66	59.93	6.482	-.052
91.00	948.03	59.79	6.430	-.052
92.00	954.31	59.61	6.379	-.051
93.00	960.51	59.39	6.329	-.050
94.00	966.62	59.13	6.279	-.050
95.00	972.67	58.86	6.231	-.048
96.00	978.69	58.61	6.182	-.049
97.00	984.71	58.40	6.136	-.046
98.00	990.78	58.29	6.089	-.047
99.00	996.99	58.36	6.043	-.046
100.00	1003.41	58.69	5.997	-.046

SILVER NORMAL VERSUS GOLD-0.07 AT. PERCENT IRON

AT 100. KG

TEMP. (DEG. K)	EMF (UV)	EMF(UV) CHANGE	S (UV/K)	S(UV/K) INCREMENT
4.22	0.00	0.00	23.795	---
5.00	19.40	9.78	22.452	-1.343
6.00	39.61	17.10	20.653	-1.799
7.00	59.08	23.12	19.182	-1.471
8.00	77.95	28.10	19.454	.272
9.00	96.64	32.25	18.047	-1.407
10.00	114.37	35.76	17.812	-.235
11.00	132.06	38.76	17.611	-.201
12.00	149.47	41.36	17.402	-.209
13.00	166.63	43.65	17.185	-.217
14.00	183.56	45.70	16.948	-.237
15.00	200.26	47.56	16.711	-.237
16.00	216.75	49.27	16.432	-.279
17.00	233.01	50.85	16.155	-.277
18.00	249.03	52.32	15.881	-.274
19.00	264.81	53.69	15.600	-.281
20.00	280.35	54.98	15.311	-.289
21.00	295.63	56.18	15.013	-.298
22.00	310.64	57.29	14.721	-.292
23.00	325.37	58.32	14.431	-.290
24.00	339.82	59.26	14.145	-.286
25.00	353.99	60.12	13.871	-.274
26.00	367.88	60.89	13.600	-.271
27.00	381.48	61.58	13.342	-.258
28.00	391.81	62.19	13.095	-.247
29.00	407.85	62.72	12.861	-.234
30.00	420.64	63.18	12.634	-.227
31.00	433.16	63.56	12.415	-.219
32.00	445.43	63.88	12.210	-.205
33.00	457.47	64.15	12.006	-.204
34.00	469.28	64.37	11.812	-.194
35.00	480.87	64.54	11.626	-.186
36.00	492.27	64.68	11.444	-.182
37.00	503.48	64.80	11.272	-.172
38.00	514.51	64.89	11.104	-.168
39.00	525.39	64.98	10.943	-.161
40.00	536.10	65.05	10.786	-.157
41.00	546.68	65.13	10.636	-.150
42.00	557.13	65.22	10.491	-.145
43.00	567.45	65.31	10.349	-.142
44.00	577.66	65.42	10.213	-.136
45.00	587.76	65.54	10.082	-.131
46.00	597.75	65.67	9.953	-.129
47.00	607.65	65.83	9.830	-.123
48.00	617.45	66.00	9.710	-.120
49.00	627.14	66.18	9.595	-.115
50.00	636.76	66.38	9.480	-.115

SILVER NORMAL VERSUS GOLD-0.07 AT. PERCENT IRON

AT 100. KG

TEMP. (DEG. K)	EMF (UV)	EMF(UV) CHANGE	S (UV/K)	S(UV/K) INCREMENT
51.00	646.27	66.58	9.370	-.110
52.00	655.69	66.80	9.259	-.111
53.00	665.01	67.01	9.159	-.100
54.00	674.24	67.22	9.058	-.101
55.00	683.36	67.42	8.959	-.099
56.00	692.39	67.62	8.863	-.096
57.00	701.30	67.79	8.769	-.094
58.00	710.95	67.95	8.676	-.093
59.00	718.83	68.09	8.586	-.090
60.00	727.43	68.20	8.497	-.089
61.00	735.93	68.29	8.412	-.085
62.00	744.31	68.35	8.328	-.084
63.00	752.59	68.38	8.243	-.085
64.00	760.76	68.38	8.162	-.081
65.00	768.83	68.35	8.082	-.080
66.00	776.80	68.30	8.004	-.078
67.00	784.68	68.23	7.926	-.078
68.00	792.48	68.13	7.850	-.076
69.00	800.17	68.03	7.776	-.074
70.00	807.79	67.91	7.702	-.074
71.00	815.34	67.79	7.631	-.071
72.00	822.83	67.67	7.560	-.071
73.00	830.25	67.55	7.489	-.071
74.00	837.61	67.44	7.422	-.067
75.00	844.94	67.36	7.355	-.067
76.00	852.22	67.29	7.289	-.066
77.00	859.45	67.24	7.223	-.066
78.00	866.66	67.22	7.157	-.066
79.00	873.83	67.22	7.095	-.062
80.00	880.95	67.24	7.033	-.062
81.00	888.05	67.29	6.971	-.062
82.00	895.11	67.36	6.911	-.060
83.00	902.13	67.44	6.851	-.060
84.00	909.09	67.52	6.793	-.058
85.00	915.98	67.59	6.736	-.057
86.00	922.82	67.66	6.679	-.057
87.00	929.57	67.69	6.622	-.057
88.00	936.24	67.69	6.568	-.054
89.00	942.80	67.64	6.513	-.055
90.00	949.27	67.54	6.459	-.054
91.00	955.61	67.37	6.407	-.052
92.00	961.85	67.15	6.356	-.051
93.00	967.98	66.86	6.304	-.052
94.00	974.02	66.53	6.254	-.050
95.00	979.99	66.18	6.204	-.050
96.00	985.92	65.84	6.153	-.051
97.00	991.89	65.58	6.106	-.047
98.00	997.95	65.46	6.058	-.048
99.00	1004.23	65.60	6.011	-.047
100.00	1010.83	66.11	5.963	-.048