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Peltier Effect

Introduction

This experiment focuses on thermoelectric effects which describe the direct conversion of temperature differences to electric voltage and vice versa. A thermoelectric device creates a voltage when there is a different temperature on each side. On the other hand, when a voltage is applied to the thermoelectric device, it creates a temperature difference. There are three main such effects:

1) Thomson effect (W. Thomson & L. Kelvin, 1851): In a current-carrying conductor, an additional amount of heat is generated if there is a temperature gradient along the conductor.
2) Seebeck effect (T. J. Seebeck, 1821): In a closed circuit formed by two metals joined in two places, the current flows when there is a temperature difference between the junctions.
3) Peltier effect (J. C. A. Peltier, 1834): The production of heat at one junction and the absorption of heat at the other junction of a thermocouple when a current is passed around the thermocouple circuit.

Goal of the experiment

In this experiment, we will determine the Peltier coefficient of a copper-constantan thermocouple for temperatures T = 20, 50, 80, 110 °C.

Experimental Setup

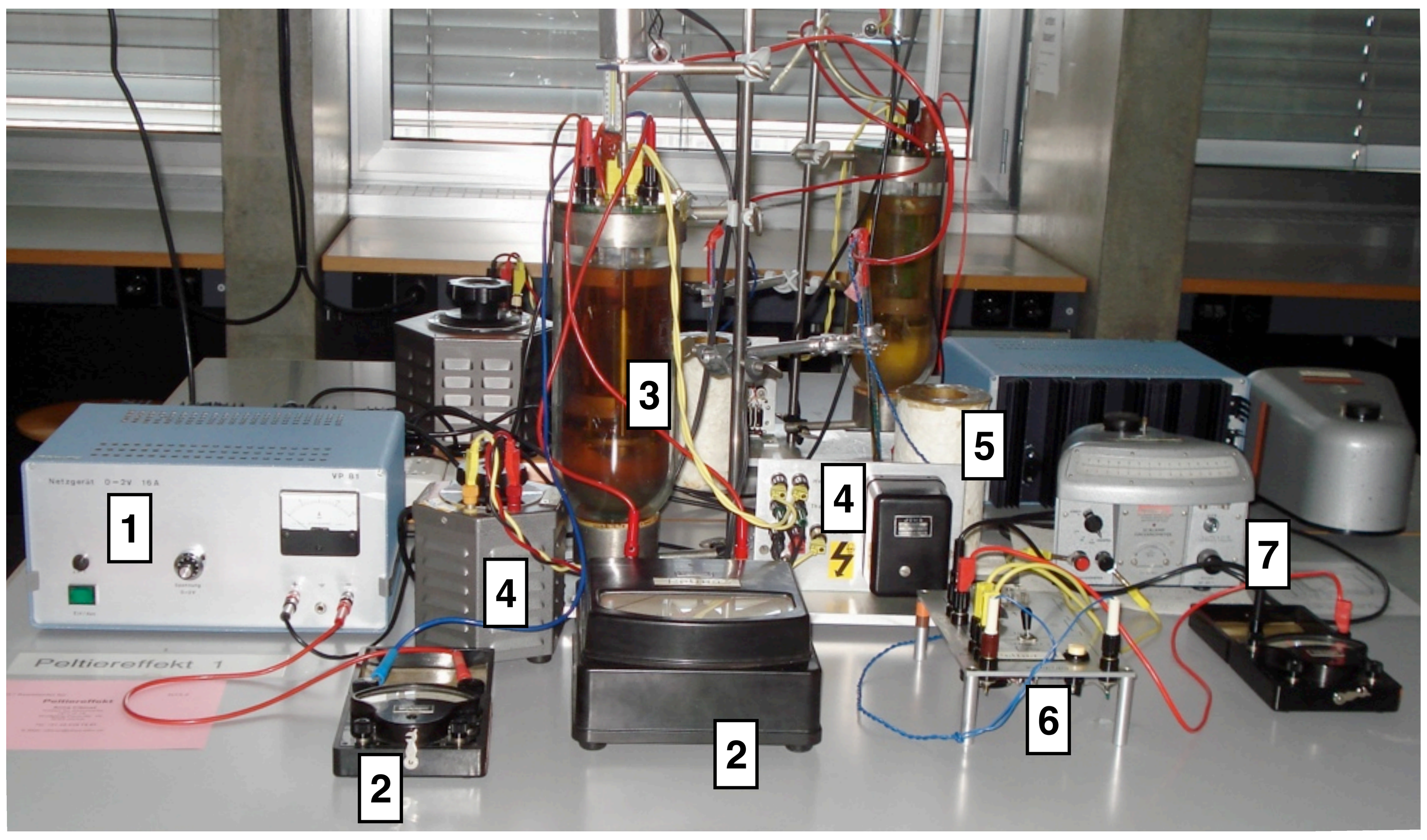


Figure 1: Experimental apparatus. The numbers in the picture indicate: (1) current supply, (2) voltage and current probes from copper constantan rods, (3) oil bath with the copper constantan rods in the diving bell, (4) heater, (5) external ice plus water bath for temperature reference, (6) compensation circuit, and (7) galvanometer and compensation current probe.

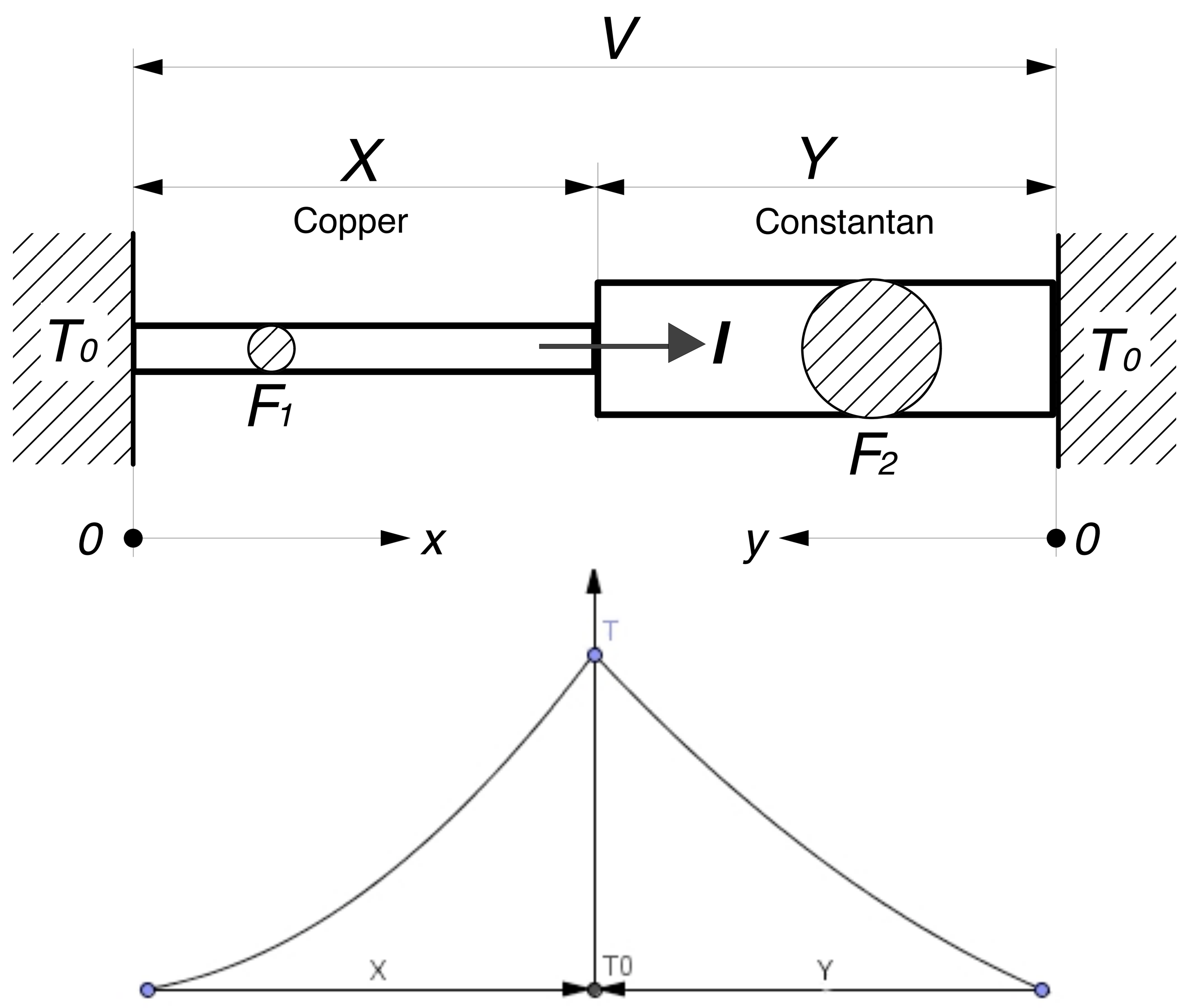


Figure 2: *Top:* illustration of the copper-constantan thermocouple used in the experiment. T_0 is the temperature of the oil bath, X and Y are the lengths of the rods, and F_1, F_2 indicate the rods section. *Bottom:* schematic plot of the temperature gradient which is generated by Peltier and Joule heating for a positive input current.

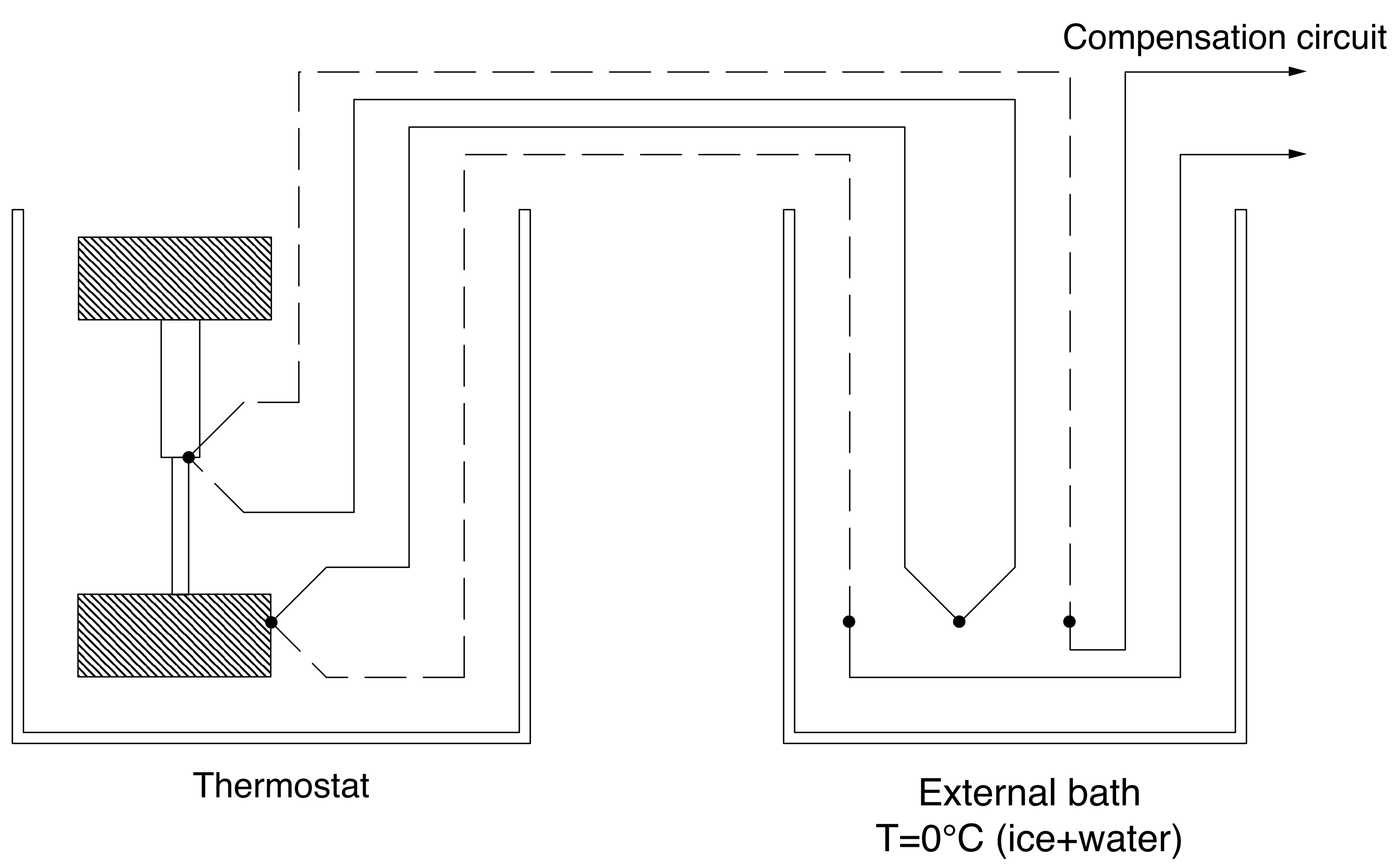


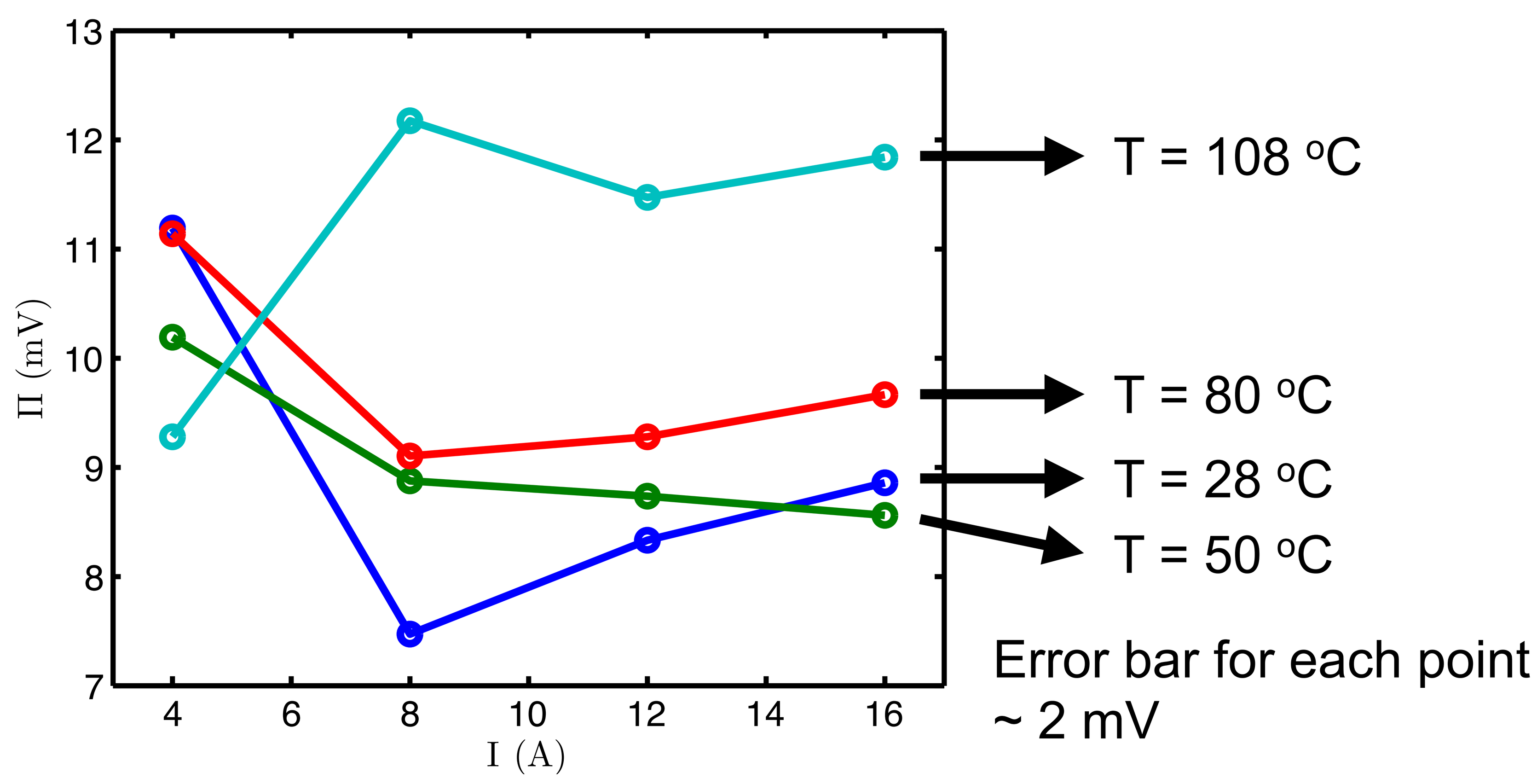
Figure 3: Setup for the temperature measurement. Two sets of copper-constantan thermocouples, connecting to a compensation circuit, are used to determined the temperature difference between the rods' end and the interface. In the sketch, the copper and constantan wires are represented by different lines.

Results

The Peltier coefficient Π can be calculated from

$$\Pi = \frac{1}{2I}(\Delta T^+ - \Delta T^-)\left(\frac{\kappa_1 F_1}{X} + \frac{\kappa_2 F_2}{Y}\right)$$

ΔT is the temperature difference between the rods' end and the interface, where the plus and minus signs depends on the direction of the applied current. κ_1 and κ_2 are thermal conductivities for copper and constantan, respectively.



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