

(MP3-8) Thermopile

Aim of experiment

Determination of the sensitivity of a thermopile.

Apparatus

Thermostatic Electric Oven – Thermometer – Thermopile – Voltmeter.

Theory of experiment

Radiometry is the science of measuring thermal radiation. The atoms and molecules that compose real materials are in motion, and the interactions among them (collisions and bonding forces) produce displacements in the elementary charges within them. The resulting accelerating charges and changing electrical dipole moments produce thermal radiation. The thermal radiation range in the electromagnetic spectrum is 0.1 to 100 μm , which include ultraviolet, U.V., visible and infrared I.R radiation.

Based on the thermoelectric effect, the thermopile can be used as a heat sensor to measure thermal radiation. A thermopile is made of thermocouple junction pairs connected electrically in series. The absorption of thermal radiation by one of the thermocouple junctions, called the active junction, increases its temperature. The differential temperature between the active junction and a reference junction kept at a fixed temperature produces an electromotive force directly proportional to the differential temperature created. This effect is called a thermoelectric effect, *figure 1*.

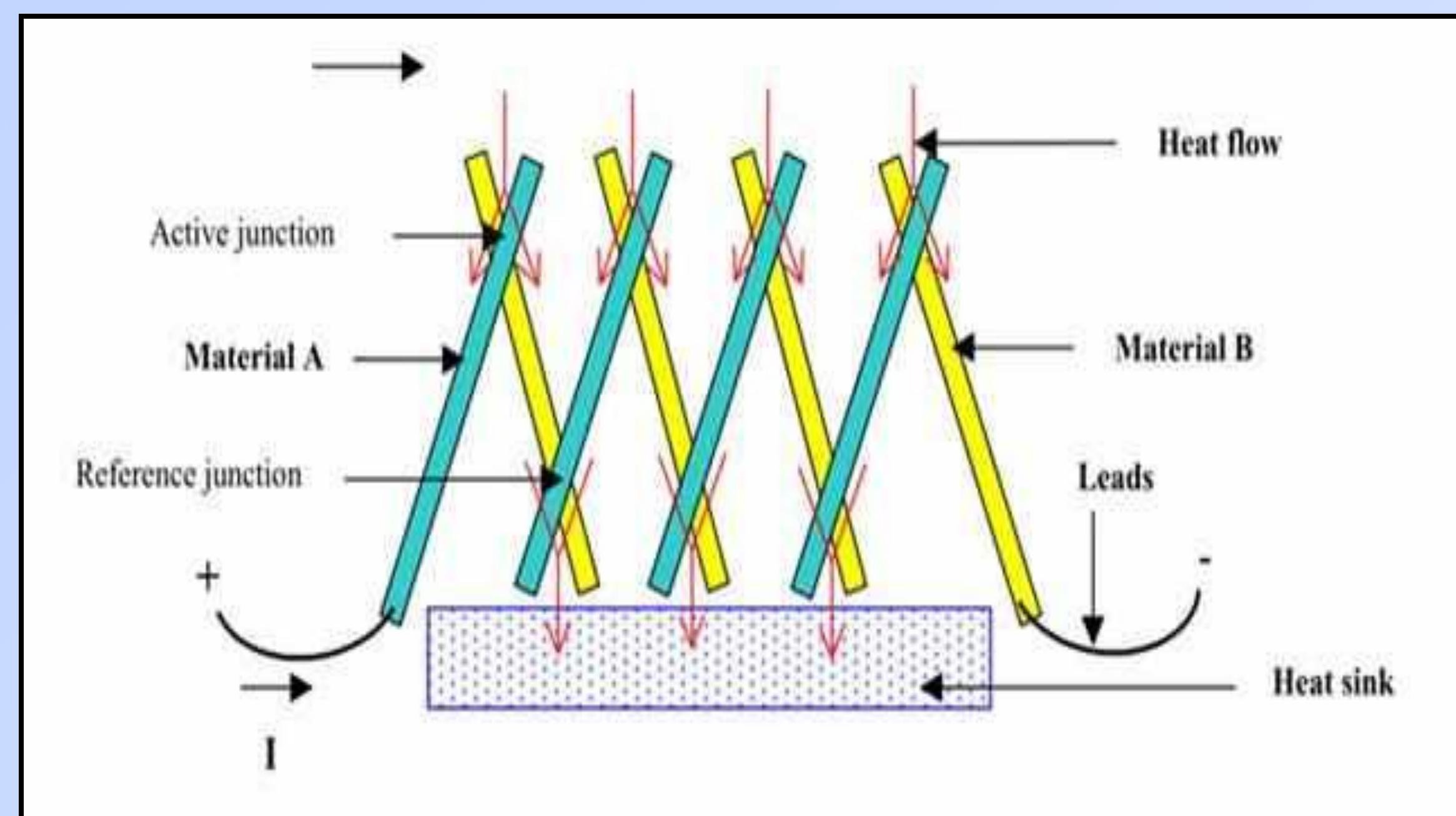


Figure 1. A sketch diagram of the structure of a thermopile

For an ideal thermocouple, the open-circuit voltage obtained is proportional to the temperature difference between the junctions constructed of conductors A and B,

$$\Delta V = S_{AB}(T) \Delta T$$

Where S_{AB} is the relative Seebeck's coefficient, expressed in $\mu\text{V/K}$.

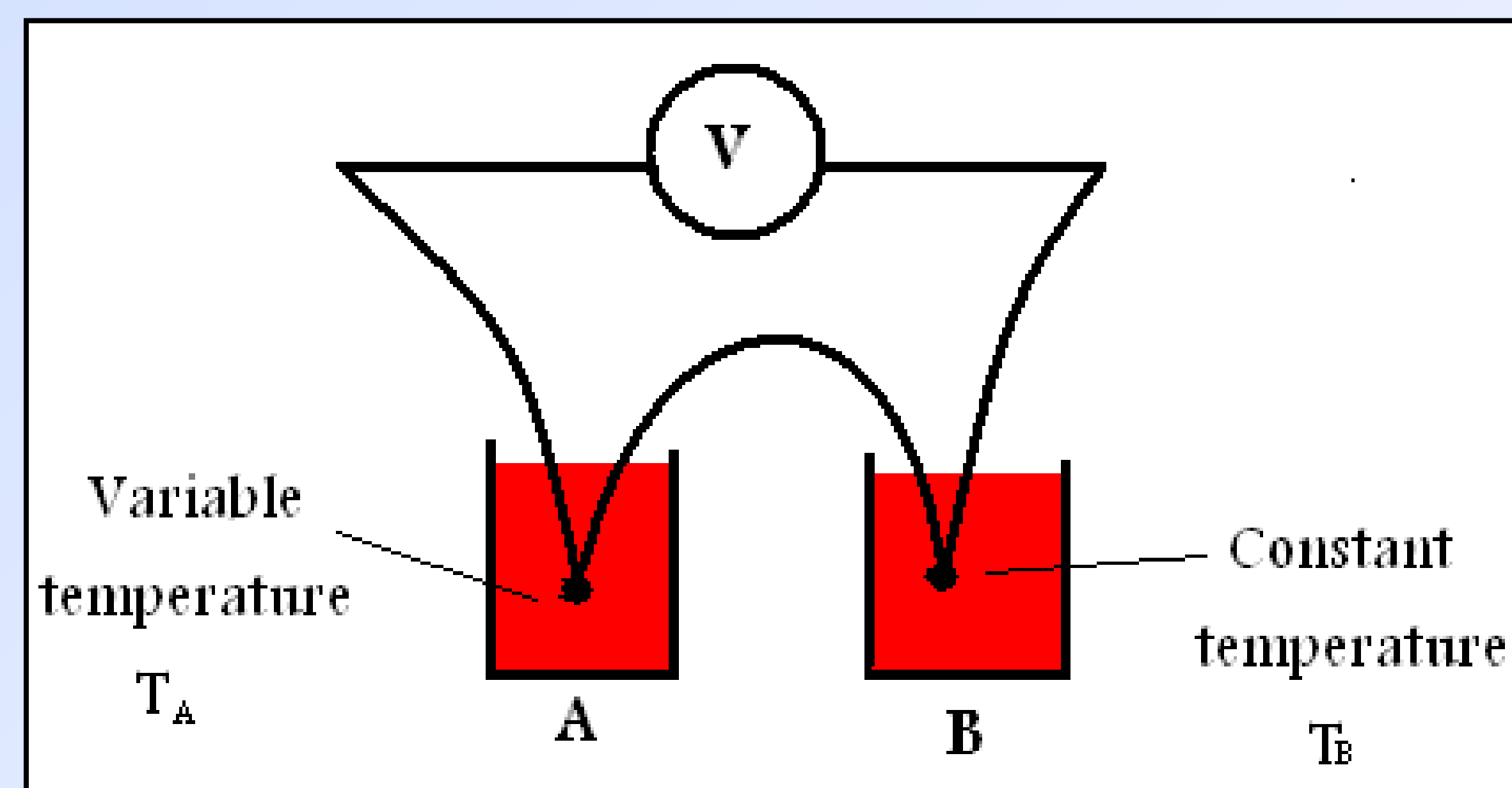


Figure 2 An ideal circuit diagram of a thermocouple

For a thermopile consists of n thermocouple junction pairs are placed in series, the thermoelectric voltage produced, ΔV is given by:

$$\Delta V = nS(T) \Delta T$$

where $nS(T)$ is the sensitivity of the thermopile

The measuring junctions of the thermocouples are blackened to absorb the incident radiation falling on them nearly completely. The reference junctions are maintained at the ambient temperature. A state of equilibrium is set up in few seconds between the radiant energy absorbed and thermal energy given off to the surroundings, so that the temperature difference between the measuring points and the reference points, and thus the thermoelectric voltage produced by the thermopile, is a measure for the irradiance at the measuring point, or for the radiant flux at this point

Procedure

1. Turn on the electric power of the oven
2. Set the applied voltage on the electric oven using thermostat to produce heat at temperature e.g. 40 $^{\circ}\text{C}$
3. Put the thermopile in front of the oven at distance = 5cm.
4. Insert the thermometer, or a thermocouple, inside the oven.
5. Record the equilibrium temperature of the thermometer T_{th} and the corresponding thermoelectric voltage.
6. Repeat at different oven temperatures and tabulate the results.
7. Repeat steps step 6 two more times.
8. Draw a relation between the temperature measured by thermometer and thermopile recorded voltage.

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Results

	ΔV (Volt)			ΔV_{avg} (Volt)
T_{th} (K)	1	2	3	