The transformation of electrical energy into thermal energy (Item No.: P1374700)

Curricular Relevance

Area of Expertise: Physik
Education Level: Klasse 7-10
Topic: Elektrizitätslehre
Subtopic: Elektrische Energie und Leistung
Experiment: Umwandlung von elektrischer Energie in thermische Energie

Difficulty	Preparation Time	Execution Time	Recommended Group Size
Intermediate	10 Minutes	10 Minutes	2 Students

Additional Requirements:

Experiment Variations:

Keywords:

Task and equipment

Information for teachers

Additional information

The heating and lighting effects of electric current are well known to the students from everyday life, and they have already experimented with filament lamps and utilised their illuminating, or lighting, effect as a measure of the strength of electric current.
In this experiment, it is important that they realise that in all these processes, electrical energy is converted into thermal energy in the form of heat.
In the evaluation, one of the following themes can be handled according to the state of knowledge of the students: in the simplest case, the phenomenon and for a higher theoretical demand, the energy ballance.

$E_{el} = Q$ with $E_{el} = U \times I \times t$

The heat capacity of the glass vessel must be taken into consideration in the evaluation.

$Q = [(c_{Glass} + c_{Water}) \times m_{Water}] \times \Delta T$.

Notes on setup and procedure

A current strength of 2 A is sufficient to bring the wire coil to a (weak) red glow when taking it out of the water.
Even if the coil does not come to a glow, however, it has such a high temperature that it is imperative to warn the students of the danger of being burnt on touching the coil.

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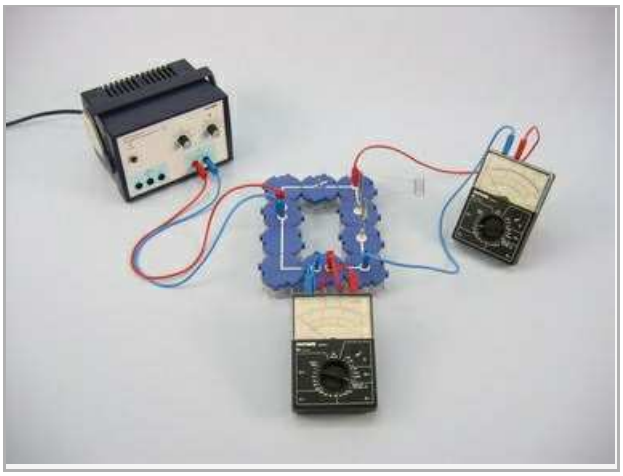
Task and equipment

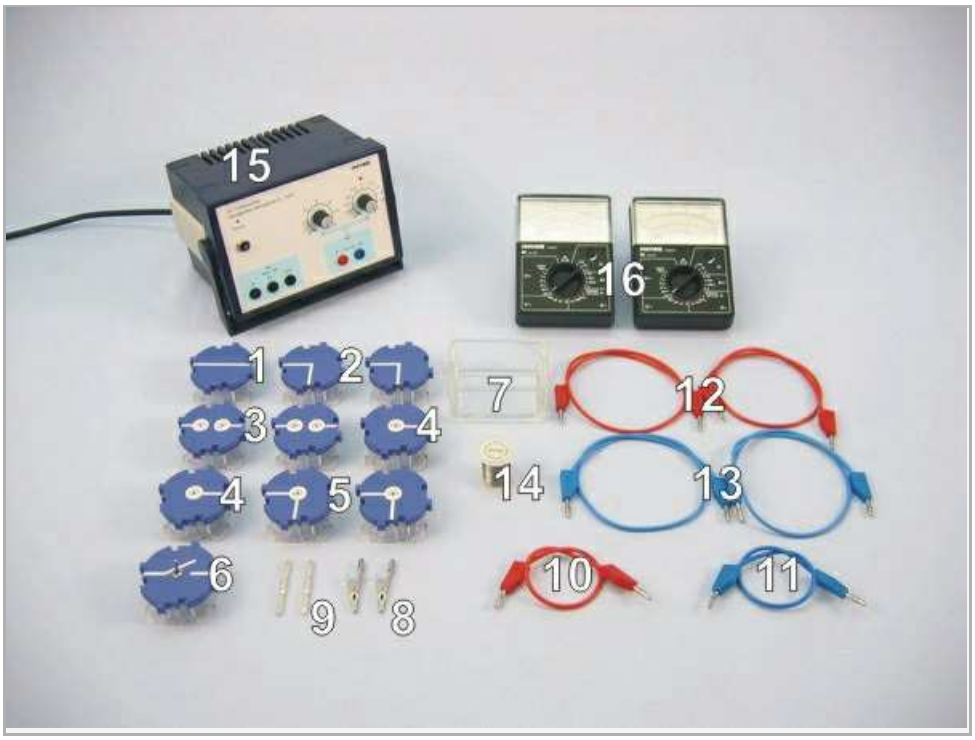
Task

How does an immersion heater work?

Set up a circuit with a model of an immersion heater and use it to convert electrical energy into thermal energy.



Equipment



Position No.	Material	Order No.	Quantity
1	Straight connector module, SB	05601-01	1
2	Angled connector module, SB	05601-02	2
3	Interrupted connector module, SB	05601-04	2
4	Junction module, SB	05601-10	2
5	Angled connector module with socket, SB	05601-12	2
6	On-off switch module, SB	05602-01	1
7	Trough, grooved, w/o lid	34568-01	1
8	Alligator clips, bare, 10 pcs	07274-03	(2)
9	Connecting plug, 2 pcs.	07278-05	1
10	Connecting cord, 32 A, 250 mm, red	07360-01	1
11	Connecting cord, 32 A, 250 mm, blue	07360-04	1
12	Connecting cord, 32 A, 500 mm, red	07361-01	2
13	Connecting cord, 32 A, 500 mm, blue	07361-04	2
14	Constantan wire, 6.9 Ohm/m, d = 0.3 mm, l = 100 m	06101-00	1
15	PHYWE power supply DC: 0...12 V, 2 A / AC: 6 V, 12 V, 5 A	13506-93	1
16	Multi-range meter, analogue	07028-01	2
	Stopwatch, digital, 1/100 s	03071-01	1
	Students thermometer,-10...+110°C, l = 180 mm	38005-02	

Set-up and procedure

Set-up

Set up the experiment as shown in Fig. 1, Fig. 2 and Fig. 3; form an approximately 70 cm long piece of constantan wire to a coil with the help of a round pencil, then fix this heating coil in position (on connecting plugs) with crocodile clips.

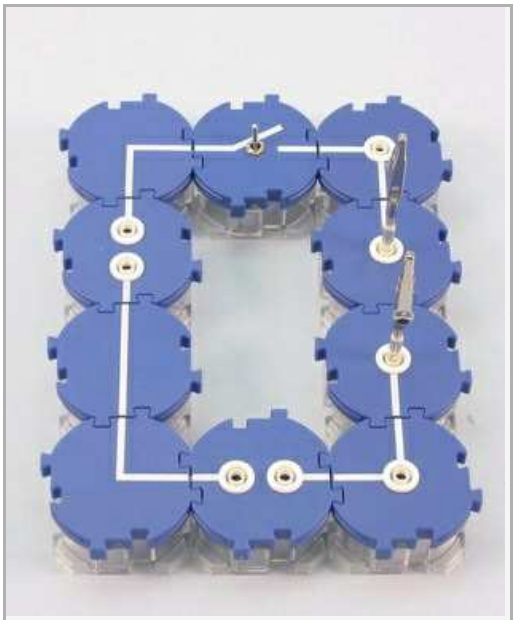


Fig. 1

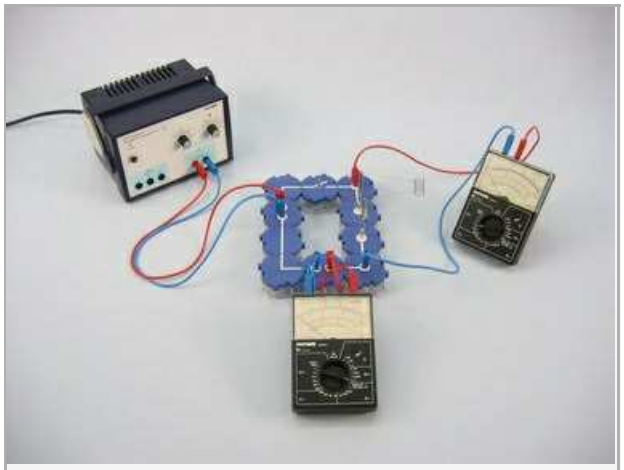


Fig. 2

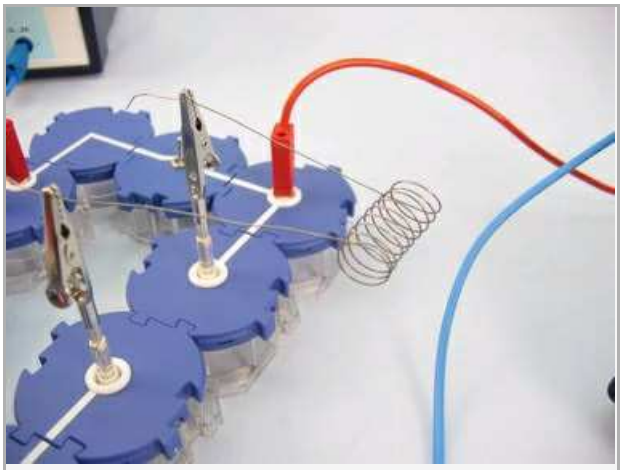


Fig. 3

Procedure

First experiment

- Fill the grooved trough about 2 cm high with cold water (approx. 100 ml), position it alongside the module and immerse the heating coil completely in the water
- Measure the temperature of the water and enter it in Table 1 in the report at t = 0 min
- Switch on the power supply
- Close the switch and start the stopwatch
- Adjust the voltage in such a way that the current intensity is 2 A and record the measured values for voltage and current intensity in Table 1
- Repeatedly stir the water; after 5 min open the switch, measure the water temperature and enter it in Table 1
- Pour the water out, rinse the grooved trough with cold water and refill it 2 cm high with cold water
- Repeat the upper procedure, but this time with a current intensity of 1.4 A
- Enter the measured values in Table 2 in the report

Second experiment

- Take the heating coil out of the water, close the switch
- Set the current intensity back to I = 2 A
- Observe the heating coil. **CAUTION!** Do not touch the hot coil!
- Open the switch and switch off the power supply
- Note your observations in the Report

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Report: The transformation of electrical energy into thermal energy

Result – Part 1

I = 2 A, U = ... V

Result – Table 1

Enter the measured values in the table.

t in min	Θ in °C
0	1
5	1 ±0

Result – Part 2

I = 1.4 A, U = ... V

Result – Table 2

Enter the measured values in the table.

t in min	Θ in °C
0	1
5	1

Result – Observations

Write down the observations about second experiment.

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Evaluation – Question 1

How can you explain the increase in temperature caused by the heating coil (immersion heater)?

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Evaluation – Table 1

Calculate the heating coil power at I = 2 A, the energie E and the temperature difference.

$P = U \times I$	1
$E = P \times t$	1
$\Delta\Theta$	1

Evaluation – Table 2

Calculate the heating coil power at I = 1.4 A, the energy E and the temperature difference.

$P = U \times I$	1
$E = P \times t$	1
$\Delta\Theta$	1

Evaluation – Question 2

Formulate the connections found in evaluation table 1 and 2.

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Evaluation – Question 3

A rule which must be followed when handling an immersion heater can be derived from the observation. What is this rule?

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Evaluation – Question 4

Name examples of electrical appliances in which the heating effect of electric current is utilised.

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Evaluation – Question 5

Use the model for the conduction of electric current in metallic conductors to explain why the immersion heater gets hot on being switched on.

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