When liquids or gases are heated, convection occurs. The heated medium flows upwards because of its decreased density.

A convection of liquids tube which allows fluids to circulate is filled with water and one side of it is heated. A drop of food colour makes the resulting circulation visible. The even, single colour background of the demo board makes observation easier. Thermal convection in air is demonstrated by the turning of a spiral above a flame.

Materials

Demo-Board Physics	02150.00	1
Shaft with magnetic base	02151.02	1
Clip, d = 26 ... 36 mm, with magnetic base	02151.06	2
Holder for burner, with magnetic base	02162.00	1
Convection of liquids tube	04510.00	1
Beaker, 100 ml, low form, plastic	36011.01	1
Glass beaker, short, 400 ml	36014.00	1
Funnel, plastic, dia. 50 mm	36890.00	1
Butane burner, Labogaz 206	32178.00	1
Butane cartridge C 206	47535.00	1
Fish line, l = 100 m	02090.00	1
Microspoon, special steel	33393.00	1
Food colour, patent blue V (E131)	48376.04	1
Pins		
Scissors		
Matches		

1st Experiment: HEAT CONVECTION IN LIQUIDS

Set-up and procedure

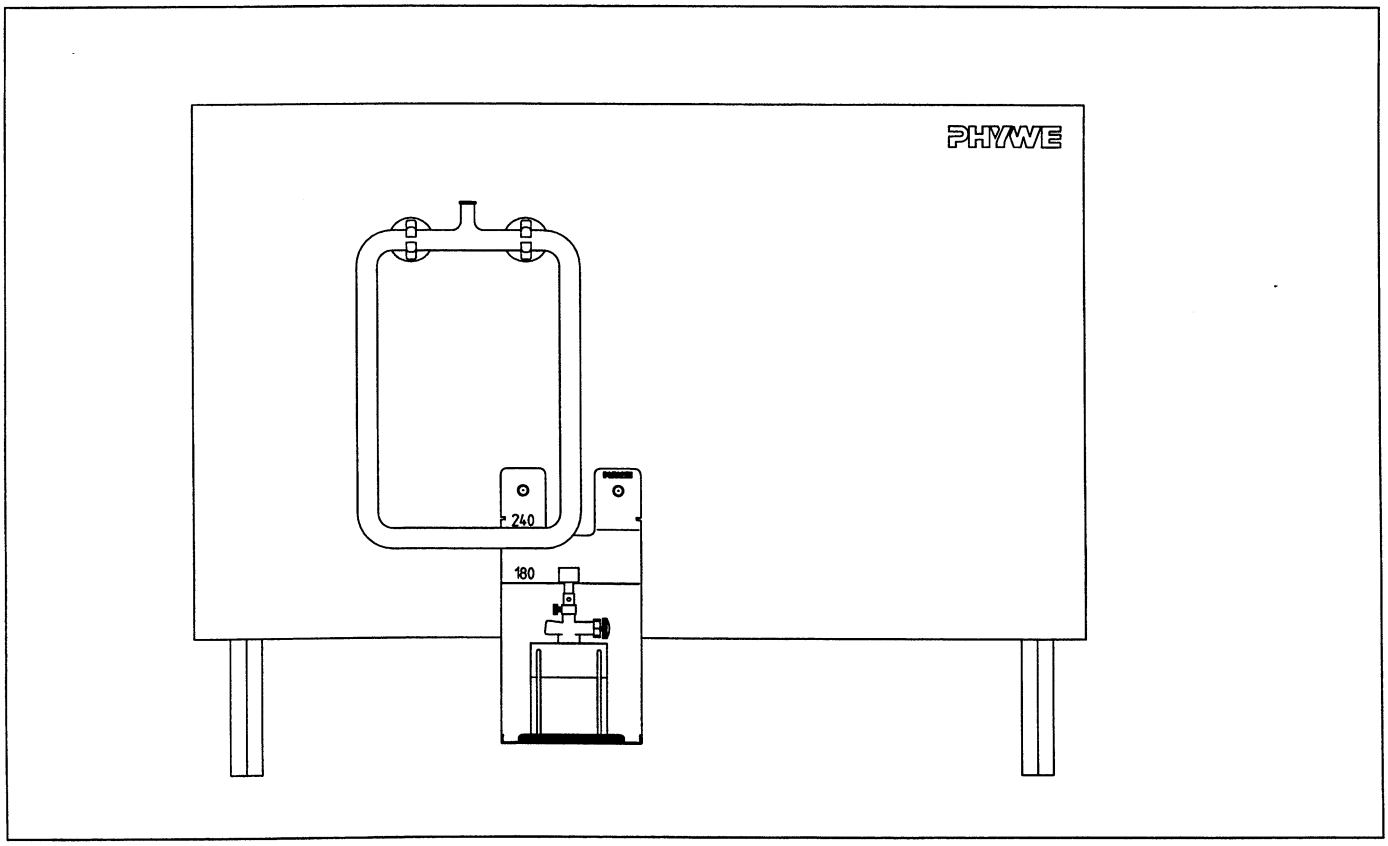
— Position the convection tube on the upper part of the board with two clips.
— Fix the holder for the burner and the burner so on the board, that the burner is situated under one corner of the circulation tube.
— Fill the circulation tube with water.
— Prepare about 5 ml of a highly concentrated food colour solution.
— Ignite the burner and adjust it to a small flame.
— Pour a little of the coloured solution in the circulation tube and watch the distribution of the coloured drops.

Observations and evaluation

The coloured drops first move towards the cold side and from there slowly fall downwards in streaks to the bottom. From there the coloured streaks move along towards the heated side and rise up it.

Hot water rises upwards because of its lower density, cold water flows in to replace it. In a closed system, a circulatory flow results.

Fig. 1



2nd Experiment: HEAT CONVECTION IN AIR

— Copy the spiral shown in Fig. 3 and cut it out.
— Pierce a small hole at the centre of the spiral.
— Make a small knot in a piece of fish line (appro. 10 cm) and thread it through the hole in the spiral.
— Position the holder for the burner and the burner at the bottom of the board.
— Fix the shaft with magnetic base near to the upper edge of the board, directly over the burner.
— Hang the spiral from the shaft, so that it is at least 20 cm above the burner.
— Ignite the burner and adjust it to a small flame.
— Watch the movement of the spiral.

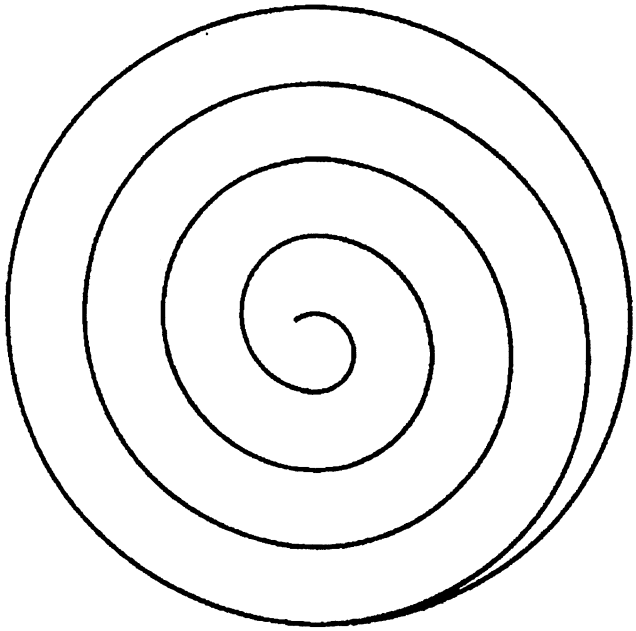


Fig. 3

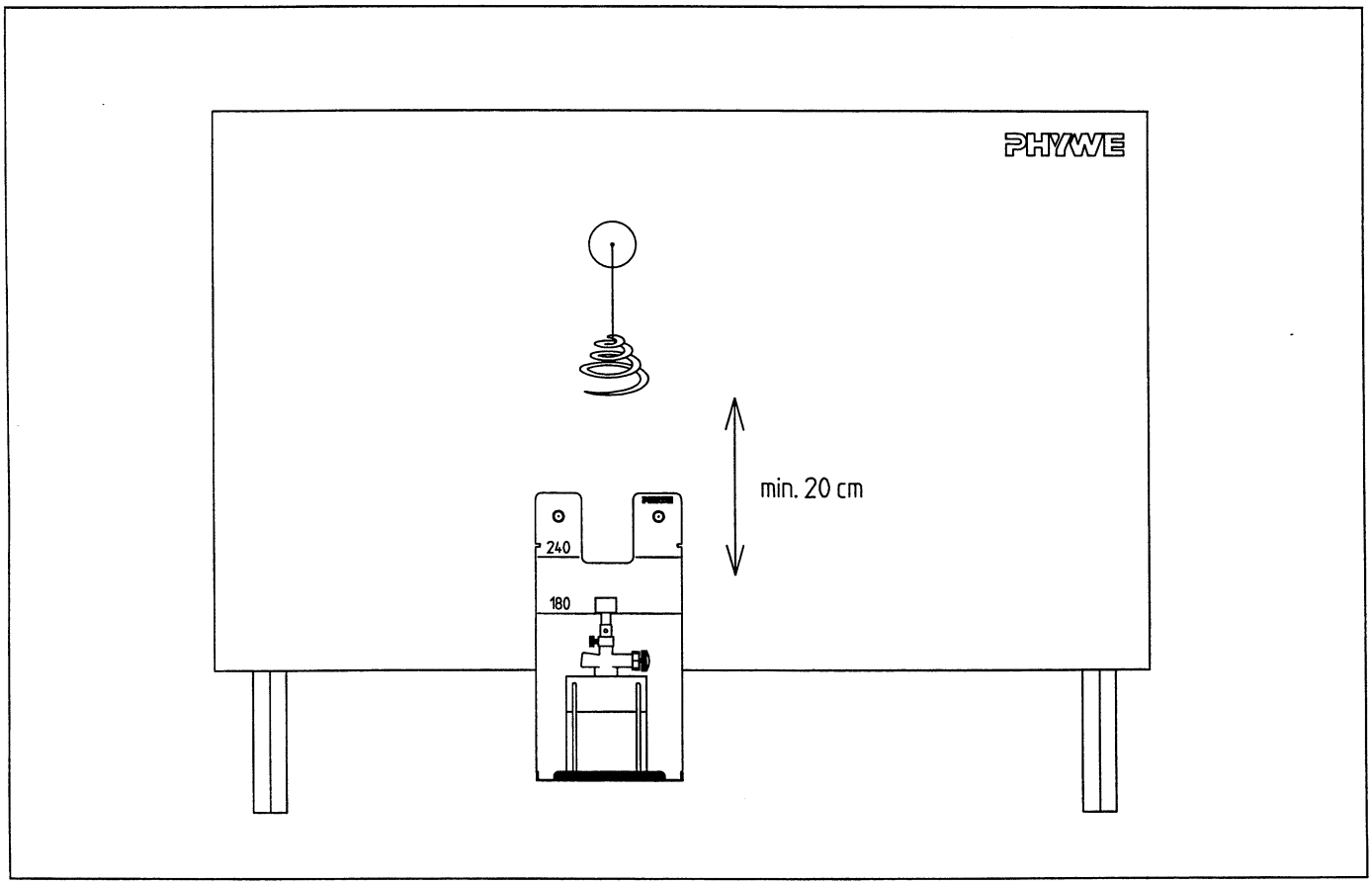
Observations and evaluation

The paper spiral turns clockwise (as seen from above) when it is hung as shown in Fig. 2. Hot air flows up and causes movement of the spiral. If you blow down on the spiral from above, however, the spiral turns anti-clockwise.

Note

The two experiments can be carried out simultaneously, when the spiral is hung far up, next to the circulation tube.

Fig. 2



The thermal conductivity of various metals and of glass are compared with each other. One side of rods bent into a U-shape are immersed in hot water. In the first part of the experiment, pieces of heat sensitive paper which turns red at approx. 40°C are stuck onto each rod, to demonstrate the conduction of heat. In the second part of the experiment, the warming up of a vessel on the other side of the rod shows that heat is transferred through a rod.

Materials

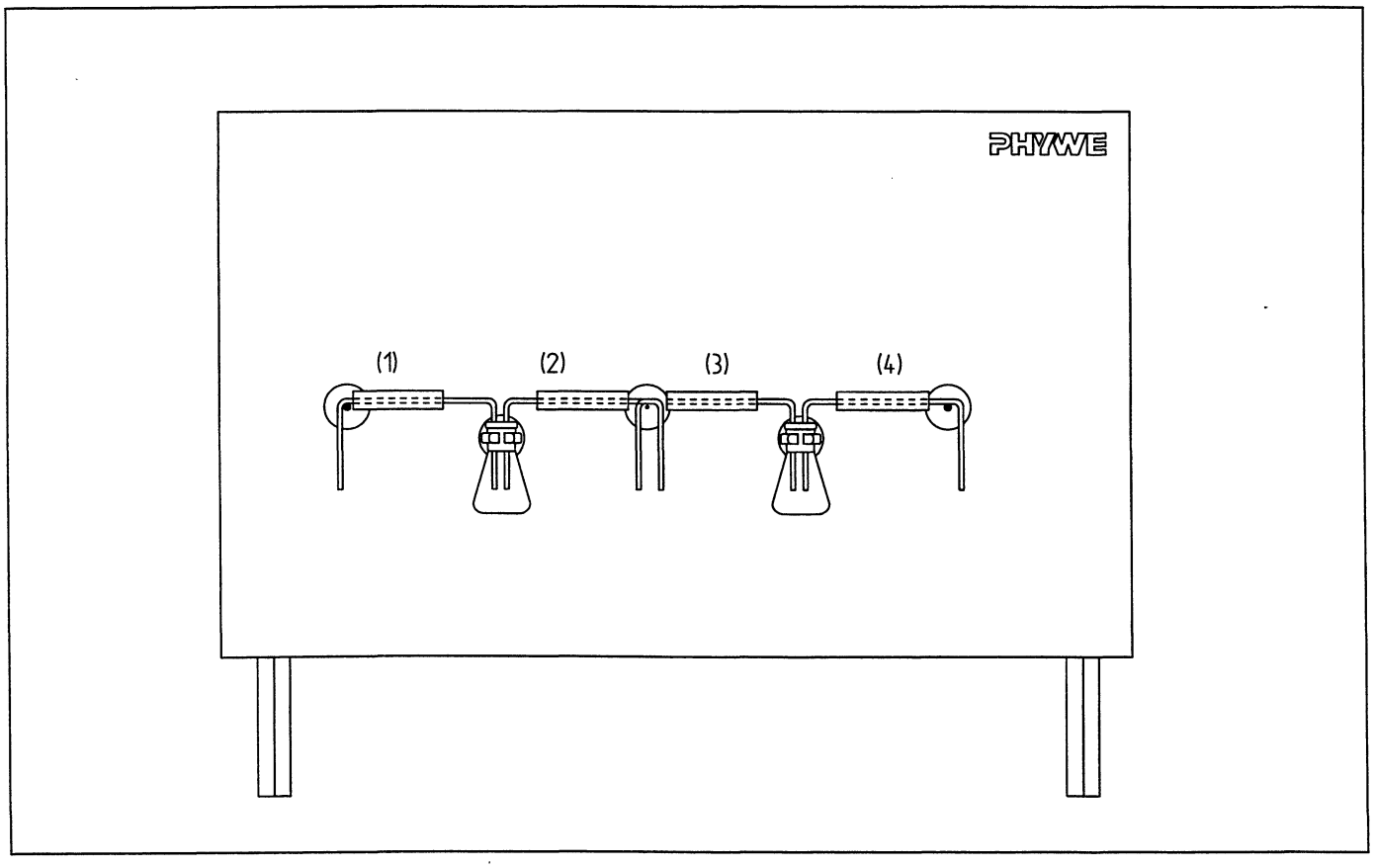
Demo-Board Physics	02150.00	1
Shaft with magnetic base	02151.02	1
Clip, d = 26 ... 36 mm, with magnetic base	02151.06	2
Clip, d = 0 ... 13 mm, with magnetic base	02151.07	2
Holder for hand-held measuring instruments, magnetic	02161.00	1
Holder for wire gauze, with magnetic base	02163.00	1
Wire gauze square, ceramic centre	33287.01	1
Beaker, polished	05903.00	2
Aluminium rod, U-shaped	05910.00	1
Copper rod, U-shaped	05910.01	1
Brass rod, U-shaped	05910.02	1
Glass rod, U-shaped	05911.00	1
Erlenmeyer flask, wide neck, 100 ml	36428.00	2
Silicone hose, i.d. 7 mm	39296.00	1
Funnel, plastic, dia. 50 mm	36890.00	1
Stop clock	03077.00	1
Heat sensitive paper, 5 sheets	04260.00	2
Immersion probe NiCr-Ni, 50/1000 C	13615.03	2
Hand-held measuring instrument 2xNiCr-Ni	07140.00	1
Digital large-scale display	07157.93	1
Data cable RS 232, SUB-D/USB	07157.01	1
Immersion heater, 300 W	05947.93	1
Aluminium pot, 500 ml	05933.00	1
Oven cloth		

1st Experiment: QUALITATIVE COMPARISON OF VARIOUS MATERIALS

Experimental set-up

— Two Erlenmeyer flasks serve as containers for hot water.
— Fix them to the board with 28...36 mm clips.
— Ease a piece of tubing over the shaft to insulate it.
— Position the two 0...13 mm clips and the shaft on the board as shown in Fig. 1, so that the cold ends of the U-shaped rods can lie on them.

Fig. 1: (1) copper, (2) aluminium, (3) brass, (4) glass



— Rest one side of the U-shaped rods on the rim of an Erlenmeyer flask and the other side on a clip or on the insulated shaft.
— Cut pieces from the heat sensitive paper and stick a piece on each of the rods (see Fig. 1), so that the students can observe the colour change.
— Remove the rods from the set-up and lay them on the bench, ready for use.

Procedure

— Fill the aluminium pot with water and heat it to boiling with the immersion heater.
— Carefully pour the boiling water through a funnel into the two Erlenmeyer flasks, filling them up to the brim.
— Simultaneously, or at least as quickly as possible, place the four rods next to each other on an Erlenmeyer flask and a second support in the succession: Glass, brass, aluminium, copper, i.e. starting with the material with the lowest thermal conductivity.
— Observe the colour change of the heat sensitive strips (these heat sensitive strips can be repeatedly used, as their colour change reverses on cooling).

Results

Table 1: Start of the red colouration

Material	Time taken
Copper	approx. 20 s
Aluminium	approx. 30 s
Brass	approx. 45 s
Glass	no red colouration

Table 2: Red colouration of the strips

Material	after approx 1.5 min	after approx. 3 min
Copper	three quarters	the whole length
Aluminium	more than half	three quarters, running thinly to the end
Brass	a quarter	a third
Glass	none at all	none at all

Evaluation

The colour of the heat sensitive paper changes from orange to red when the temperature increases above 40°C.

The heat spreads out at different speeds in the various rods. The heating up is made visible by the red colouration of the strips and is a measure of the thermal conductivity of the materials. When the materials are arranged from good to bad thermal conductivity, we obtain the following succession:

Copper – aluminium – brass – glass

The heat sensitive strips show also, in particular with aluminium and brass, that even after observing them for some time, there is a temperature gradient across the rods:

One side dips into hot water (temperature approx. 80°C) and in the region of the strips, the temperature changes from above 40°C to below 40°C.