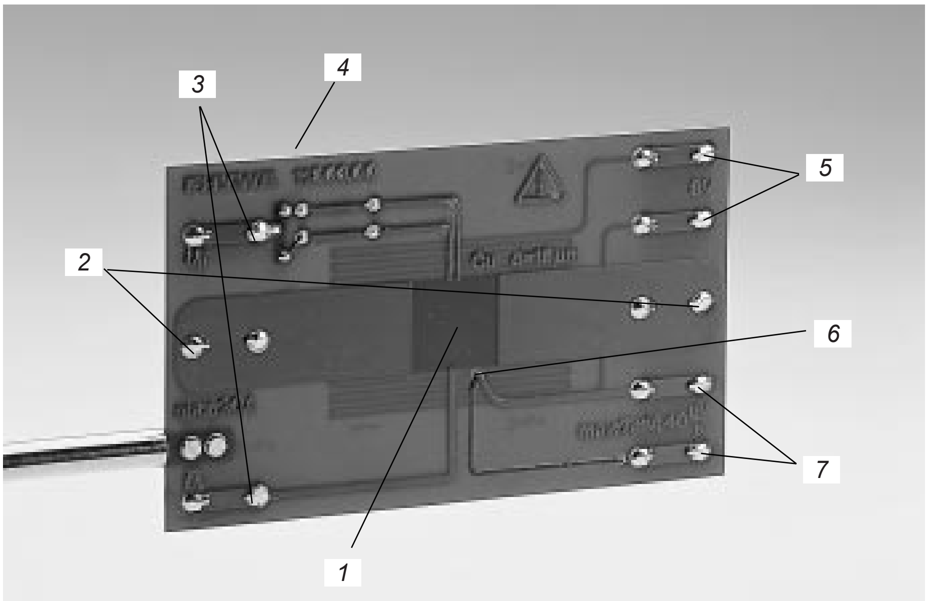
Hall Effect, copper, support plate

11803.00

Operating instructions



1 PURPOSE AND CHARACTERISTICS

The support plate allows to determine the Hall effect on a metal. The polarity of the generated Hall voltage allows to reach conclusions as to the transport of charges through mobile negative charge carriers. To demonstrate that in the case of metals, the Hall voltage is not temperature dependent, as opposed to semiconductors, the carrier board has a heating system which allows to change the temperature of the metallic sample.

2 DESCRIPTION AND HANDLING

2.1 Functional and control elements

The carrier board with the mounting rod consists of a conducting board with 4 mm sockets fixed at the back side, which can be tapped laterally.

A control current of 20 A at the utmost is fed over a pair of sockets ***2*** to the actual conductor, which consists of thin copper strip ***1***. The Hall voltage is tapped over socket ***3***. The control knob ***4*** of a potentiometer mounted at the back allows to compensate fault voltages superimposed over the Hall voltage (fig. 2) (voltage drop across the Hall voltage tapping sockets due to the control current, or thermoelectric voltages). Because if the Hall voltage contacts on the crystal are only slightly shifted laterally in the direction of the control current, the latter will cause a drop of voltage even in the absence of an exterior magnetic field, which will distort the Hall voltage to be determined. If one tap for the Hall voltage is replaced by two taps, between which the ideal tap is situated, a compensating potentiometer may be inserted, as was done in the case of the carrier board.

The copper-constantan thermocouple ***6*** provides a thermoelectric voltage which can be tapped at the pair of sockets ***7***. The pair of sockets ***5*** is used to feed heating current.

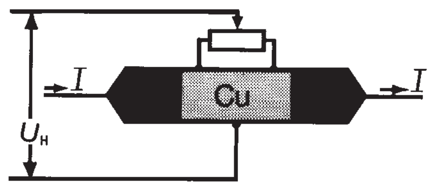


Abb. 2

2.2 General set-up

The carrier board is fixed in such a way between the pole pieces of an electromagnet that the marked measuring field is completely interspersed by the homogeneous magnetic field.

A direct voltage source is connected to the sockets ***2***, which provides a current of up to 20 A.

To start with, the Hall voltage tap is compensated without applied magnetic field, using control knob ***4***.

If the compensation is performed correctly and in presence of the control current, no voltage is present at the sockets ***3***. The magnetic field is then turned on. To generate a 10 µV Hall voltage, a magnetic flux density of about 250 mT and a control current of about 12 A are required. The electromagnet must imperatively be operated with smoothed direct current, as disturbing inductive voltages may occur otherwise.

To heat the copper sample, a maximum heating voltage of 8 V is applied to the two sockets ***5*** (required current: 5 A). Temperature control is carried out by means of the integrated thermocouple and through connection of a sensitive voltmeter (measuring range not greater than 30 mV).

Attention! As soon as the thermal voltage has reached 5 V (heating time about 2 minutes), the heating current must be interrupted, to avoid overheating of the carrier board. A possible brown discoloration of the board, which may occur after heating to the maximum admissible temperature limit, has no effect on the function of the unit.

Heating also generates a thermoelectric voltage in the measuring circuit, which superimposes itself onto the Hall voltage. This interfering voltage is of the order of magnitude of the Hall voltage, due to the very low value of the Hall constant for copper. In order to assess the correct Hall voltage in spite of this, voltage is measured at the sockets ***3*** with and without magnetic field. The Hall voltage is obtained from the potential difference.

2.3 Hints for the performance of the experiment

The use of an adjustable high current power supply is recommended as a supply for the control current (cf. list of accessories). Alternatively, a six cell Ni-Cd accumulator may be used, the cells of which are connected in parallel in pairs. Manganin strips (0.220 Ω/m) are used as protective resistors.

To generate the magnetic field, an assembling magnet consisting of a U-shaped iron core with two coils with 300 windings each and with two plane pole pieces is used. A 4 A direct current is required to operate the coils. Alternatively, the PHYWE electromagnet with the corresponding plane pole pieces may be used; this allows to reach very high field intensities.

To determine the Hall voltage, a sensitive voltmeter is connected to sockets ***3*** (measuring range 30 μV till 100 μV).

The precision of the determination of the Hall voltage can be strongly increased if alternating current is sent through the probe instead of direct current. In this case, an alternating Hall voltage is obtained, which can be assessed after being amplified by a low frequency test amplifier. A further advantage is that superimposed thermoelectrtic voltages have no influence on the measurement results. However, the alternating current method gives no indication as to the sign of the effective electric charge carriers.

The PHYWE teslameter used with a tangential Hall probe is suitable for the determination of the magnetic flux density.

3 TECHNICAL SPECIFICATIONS

Thickness of the copper sample	18 mm
Surface of the copper sample	(35 x 25 mm)
Maximum control current	20 A
Maximum sample temperature	175 °C
Thermocouple	Cu-CuNi
Thermal voltage coefficient	approx. 40 μV/K
Heating voltage	8 V≅ / approx. 5 A

4 LITERATURE REFERENCE

University Laboratory Courses in Physics 1 - 3   16502.01

5 LIST OF ACCESSORIES

For magnetic field generation		
Power supply, universal		13500.93
Coil with 300 windings	(2x)	06513.01
Pole pieces, plane	(2x)	06489.00
Iron core, U-shaped, laminated		06501.00
alternatively:		
Electromagnet		06480.01
Pole pieces, plane	(2x)	06480.02
For control current supply		
Power supply 0 - 30 V / 20 A, stabilised		13536.93
alternatively		
Ni-Cd accumulator, 6 cells		07490.26
For the alternating current method		
Adjustable transformer 25 V~ / 20 V- 12 A		13531.93
Sliding rheostat 10 Ω		06110.02
Test amplifier, universal		13626.93
To determine magnetic flux density		
Teslameter, digital		13610.93
Hall probe, tangential		13610.02

A voltmeter and an ammeter are also required.