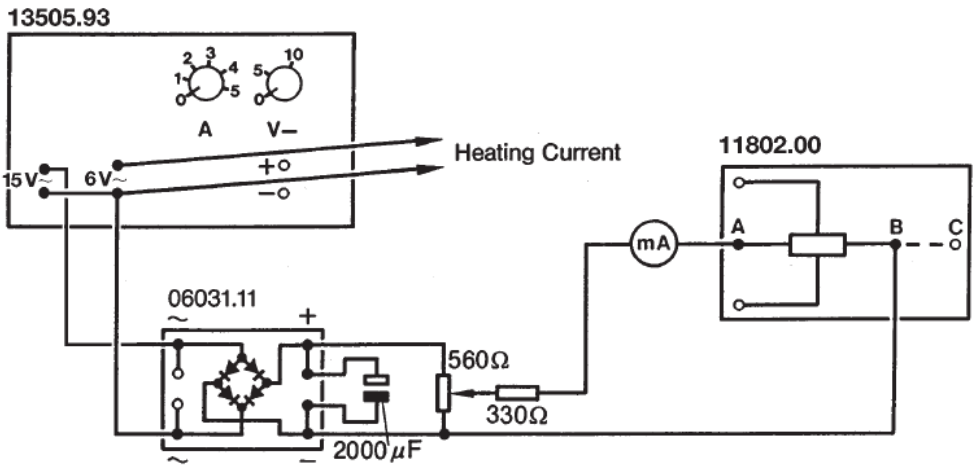
HALL EFFECT IN GERMANIUM

AIM OF THE PRACTICE: To determine several physical magnitudes of a doped semiconductor: Hall constant, concentration of carriers, mobility, energy gap. In order to get them the electrical resistance of a sample and the hall potential are measured as a function of the temperature and the applied magnetic field.

EXPERIMENTAL PROCEDURE: Place the plate with the semiconductor within the pole pieces of the magnet taking great care in it in order to not damage the sample. You should be extremely careful at not bending the sample under any circumstance. This would easily brake the sample.

a) The control current is generated in the AC output of the power supply after intersecting a rectifying step. Connect the rectifying step to the lower socket of the power supply unit and to the socket marked "15V" on the selector ring above it. (see fig. 1).
b) The control current is set with the aid of a potentiometer. A 330Ω resistor is connected in series to limit the current and so prevent accidental overstepping of the maximum permissible current (50 mA).
c) The magnetic field is produced by the electromagnet connected to the DC outlet of the power supply. It is advisable for this purpose to set the voltage to the maximum value and adjust the magnetic field to the desired value by means of the current control knob. The power supply then acts as a constant current source, so ensuring that temperature induced resistance changes have no effect on the field strength. The magnetic field is measured by the teslameter, the Hall probe of it being placed at the centre of the field (after the apparatus has been adjusted).
d) The Hall voltage is measured with the digital multimeter between the side electrodes. As it may happen that a voltage may appear even at zero field, this can be compensated by means of an auxiliary circuit in the plate. The potentiometer allows to adjust the reading of the transverse potential to zero at B=0. If we want this circuit to operate, the control current has to be established between terminal A and C. If we do not want to make use of the compensating circuit apply the control current between the A and B terminals.



EXPERIMENTS

1) Set the control current between contacts A and B and apply a magnetic field of 0.2 T. Starting from below change the control current and measure the Hall potential (U_H) we as a function of the control current wit the value of B fixed. A plot of U_H as a function of the current control should give rise to a linear plot. Try to understand this result.
2) Measurement of the energy gap. Remove the Hall probe and the pole pieces. Set the current control at 30 mA and measure with another multimeter the voltage drop along the sample (U) between terminals A and B. At constant current the inverse of the voltage is proportional to the conductivity of the sample. Now change the temperature of the sample by means of the heating resistance built in the plate. The current to the heating resistance will be provided by a variable transformer (variac). The current must be increment very slowly allowing the system to reach a stable condition before taking the measure of the voltage drop. Never surpass 160ºC! The temperature reading will be done with a thermocouple at the sample. Keep always the control current at 30mA by making the necessary adjustments.
3) Represent ln (U^{-1}) as a function of 1/T. Discuss the result and obtain a value for E_g (energy gap) of Ge.
4) Hall constant. Get back to room temperature by removing the heating current. Establish the control current between terminals A an C, so the compensating circuit may act. Remove the pole pieces and adjust U_H to zero when the control current is 30mA by means of the potentiometer in the auxiliary circuit. Replace the pole caps and insert the mica plate that electrically isolates one them from the sample. Now measure the Hall voltage as a function of the intensity of the magnetic field for both orientations of the magnetic field. Obtain the value of R_H and its sign.
5) Obtain the carrier concentration and its mobility.
6) Temperature dependence of the Hall voltage. Keep constant all the time the control current at 30 mA and the magnetic field at 200mTand remove the Hall probe of the magnetometer (to prevent being damaged by the temperature). Now keeping constant the control current increase the sample temperature and register the change in the Hall voltage. Represent this dependence and discuss the results.