HALL EFFECT APPARATUS - with 'Hall' probe

Cat: EM1900-001 with axial 'Hall' probe

DESCRIPTION:

The 'Hall Effect kit' consists of 3 parts:

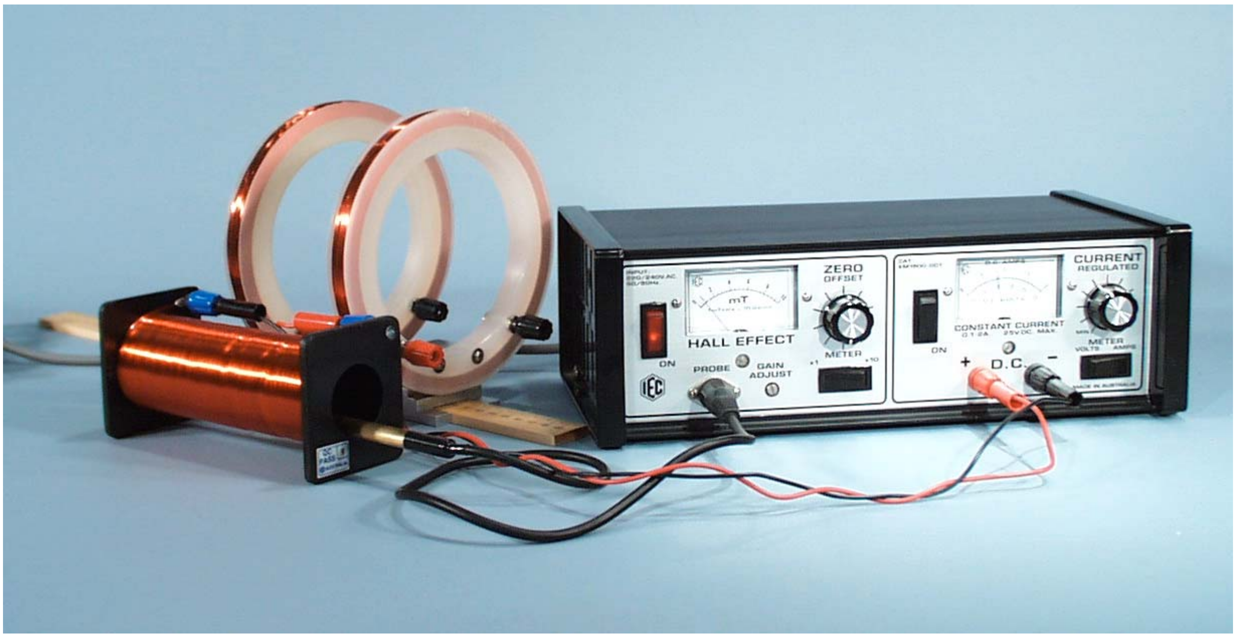
- Electronic power supply and detector instrument with two sections:

1) Constant Current (0-2A) power source for calibration of the instrument and for energising solenoids. The constant current power supply ensures the current through the coils or solenoid is constant although the coils become warm and the DC resistance rises.

2) Magnetic field measurement in mT (milliTesla) by the 'Hall' principle. The reading of this instrument is calibrated by the student from first principles using the current through an Air Cored solenoid. Switch selectable ranges of 0-10mT and 0-100mT.

- Hall Effect device on a 'wand', fitted with a multi pin plug. For axial field.
- Set of 2x cables, red and black, with banana plugs for connecting coils

EM1900-001 Power unit & axial 'Hall' probe



Physical size: 325x175x110mm LxWxH **Weight: 2.95 kg**

Power supply: 0-2A (const.current) using up to 25V.DC.

Field strength: Hall probe provides from 0-100mT over 2 ranges (0-10mT, 0-100mT)

The 'Hall Effect' instrument above is shown with a pair of Helmholtz Coils (EM1915-001) and an Air Cored Solenoid (EM0090-001). **These devices are not part of the standard Hall Effect kit.**

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OPERATION:

The instrument measures magnetic field strength in milli-tesla (mT) over two working ranges of 0-10 mT and 0-100 mT. At the tip of the wand, a small black device produces a small voltage as a magnetic field passes through its body. This device is called a 'Hall Effect' sensor and these are used in many applications in industry where switching must occur or signals must be obtained due to the presence of a small magnetic field.

The instrument must first be calibrated by measuring the magnetic field at the mid point of a Solenoid of known dimensions and turns and with a known current flowing through the coil.

The special Constant Current power source is different from the normal power sources used in the laboratory. Instead of presetting a particular voltage required, this power source permits the setting of a certain current through a load.

As the load changes its resistance with temperature, the output voltage changes automatically to maintain the preset current through the load. Using such a power source ensures a steady magnetic field in any solenoid since the strength of a magnetic field depends on the exact current flowing and the number of turns in the solenoid.

ADDITIONAL APPARATUS REQUIRED FOR EXPERIMENTS:

- 1 Air Cored Solenoid of 700 turns (IEC EM0090-001)
- 1pr. Helmholtz coils. (IEC EM1915-001) 148mm. mean diam. 1 amp.max. with 3 stands to carry the coils and the wand axially at the centre of the coils together with metric rule, 500mm long, to align coils and wand.
- 1set. Various types of magnets: Bar, circular & horse-shoe shaped.

EXPERIMENTAL SET UP:

Notice that one meter reads field strength in ranges of either 0-10 mT or 0-100 mT and the other meter reads either Amps or Volts of the output of the constant current power supply.

The panel controls are:

ZERO ADJUST: To set the zero reading on the meter to compensate for temperature drift in the Hall device during experiments.

GAIN ADJUST: This is a screwdriver setting to adjust the calibration of the instrument against a known field strength (see below).

METER x1/x10: Range setting for 0-10 mT or 0-100 mT.

CURRENT regulated: Adjusts current through a solenoid winding.

METER volts/amps: Select to monitor either volts or amps output.

CALIBRATION OF THE INSTRUMENT:

The Instrument must be calibrated by a known magnetic field before useful measurements can be made. Firstly, the zero fieldstrength is checked and then an Air Cored Solenoid with a known number of turns and known length is connected to the instrument. A certain current is passed through the coil and the fieldstrength is calculated. The instrument's Gain is adjusted so that the calculated fieldstrength in milliTesla is showing on the meter.

THEORY OF A 'UNIFORM MAGNETIC FIELD':

Magnetic field inside a coil is: $B = 2\pi KnI$ newtons/amp-metre. See your Physics text books or ask your instructor for proof of the value of constant K.

Constant $K = 2.00 \times 10^{-7}$ newtons/amp^2

A long thin solenoid produces an axial magnetic field given by:

$B = \mu_o nI$ newtons / amp-metre where μ_o is $2\pi K = 4\pi \times 10^{-7}$

n is number of turns **per metre length of solenoid. Number of turns / Length in metres**

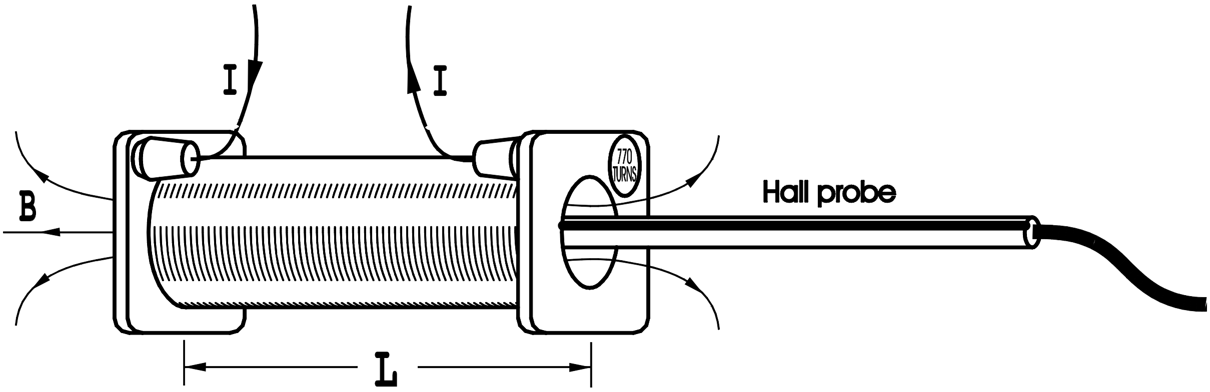
I is current through the coil **in amps.**

Connect the Hall probe to the socket on the front panel. Connect a calibration coil (an Air Cored Solenoid) to the terminals provided on the Constant Current Power Supply.

Important note: The magnetic field in the solenoid must be in the correct N-S direction or the Hall device cannot provide an output to the instrument. The magnetic field being measured must always pass through the Hall Effect device directly through its flat surface. To ensure this, be sure that the handle of the Hall probe is mounted so that it lies along the centre line and is parallel to the axis of the solenoid coil.

CHECKING INSTRUMENT CALIBRATION AND ZERO:

Mount the Hall probe such that the Hall device is at the centre of the Air Cored Solenoid. **With no current flowing** through the solenoid, switch the meter to read field strength in milliTesla. Using the 'Zero Adjust' knob, set the meter to read exactly zero.



Select meter to read amps and adjust the current through the solenoid to 1.7 amp. Use the equation " $B = \mu_o nI$ newtons / amp-metre " to calculate the expected field strength. The number of turns in the solenoid is marked on the coil. To find **'n'** number of turns per metre length of solenoid winding**, divide number of turns in the coil by length of coil in metres.**

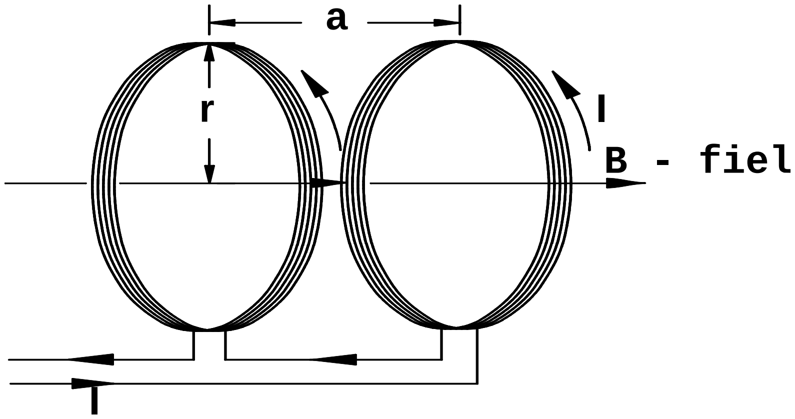
Measure the magnetic field with the Hall Effect probe and if the meter gives a different value in mT, using a small screwdriver, rotate the **'GAIN ADJUST'** control on the instrument until the meter reads the calculated field strength in mT.

IMPORTANT NOTES:

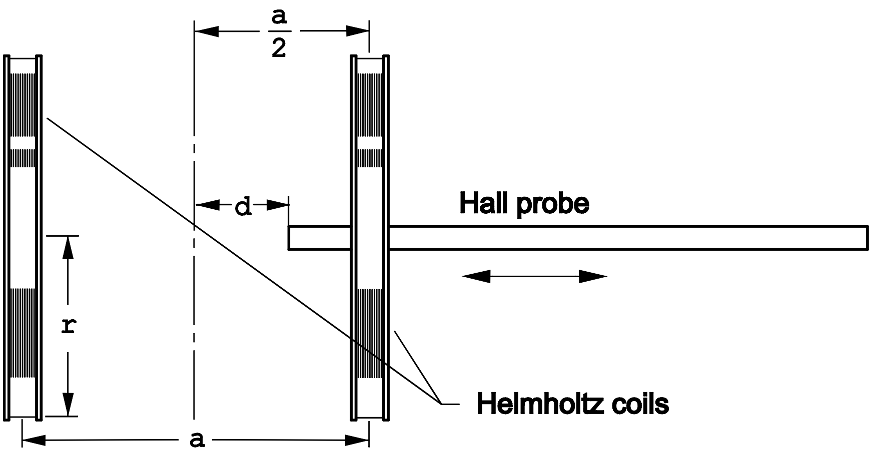
- As a check, if the Air Cored Solenoid has 700 turns (IEC standard) and the coil length is 149mm (IEC standard), then the coil current of 1.7 amp should give a field strength of very close to 10 mT.
- The Hall Effect device is temperature sensitive and will alter its calibration if it becomes warm. Take care not to allow the solenoid to heat too much during the calibration period otherwise the Hall probe may gain heat from the coil and calibration will drift.

HELMHOLTZ COILS: IEC cat: EM1915-001 (pair with mounts etc.)

Helmholtz coils are two identical coils connected in series so that thew currents in each coil flow in the same direction. The coils are physically arranged to be parallel and coaxial with one another. When the magnetic fields of each coil add together and it is possible to create a uniform magnetic field in the region between the coils. CONNECT IN SERIES:



THE MAGNETIC FIELD CREATED BY HELMHOLTZ COILS:



a = separation of coils r = mean radius of coils d = distance of the Hall device from the mid point between the two coils.

The coils must be connected in series so that they both carry the same current in the same direction. Using the Constant Current power supply, adjust the coil current to about 1.0 amp.

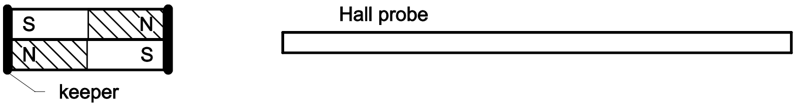
Slide the coil mounts on the 1/2m rule to separate the coils so that a = 2r. After checking the zero on the Hall probe, slide the Hall Probe mount over the rule to measure the field strength every centimetre along the axis of the coils. Take measurements on the rule up to 12cm either side of the centre line. Plot a graph of B (field strength in mT) against d in cm. Note that at the mid point, distance **d = 0.**

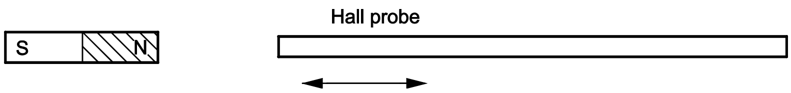
Repeat the experiment for a = r and a = r/2 and compare the three graphs.

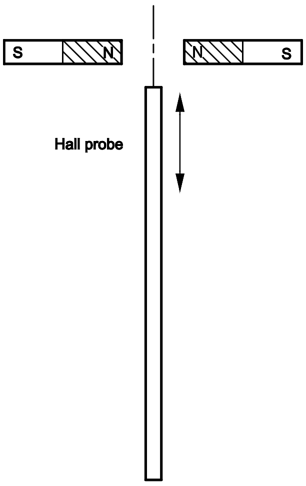
In which case is the magnetic field strength constant between the coils ?

EXPERIMENT WITH SIMPLE PERMANENT MAGNETS:

- Measure leakage magnetic fields around keepers at the ends of bar magnets.
- Measure various magnetic fields of bar magnets and plot the field strengths.
- Take measurements at different distances d from poles.







Designed and manufactured in Australia