Does electric current also exert magnetic effects?

Task

To use a compass needle to examine if a straight conductor which is carrying current exerts a magnetic effect.

Equipment

Plug-in board	06033.00	1
On/off switch	39139.00	1
Drawing compass, 1 from 2	06350.02	(1)
Connecting cable, 25 cm, red	07313.01	1
Connecting cable, 25 cm, blue	07313.04	2
Connecting cable, 50 cm, blue	07314.04	1
Connecting cable, 50 cm, red	07314.01	1
Multi-range meter	07028.01	1
Power supply, 0...12 V-,6 V~, 12 V~	13505.93	1

Set-Up and Procedure

— Connect up the circuit as shown in Fig.1, select the 3 A- measurement range. Plug a short connecting cable in the plug-in board so that it is runs roughly horizontally across the board, then re-position the board so that this “straight conductor” lies along the North-South direction.
— Set the limiting current of the power supply to 2 A.
— Set the power supply to 0 V and switch it on.
— Close the switch and adjust the power supply voltage so that a current of about 1.8 A flows.
— Open the switch and hold the compass directly under the straight conductor set to lie North-South.
— Close the switch and observe the compass needle.
— Open and close the switch several times while observing the compass needle, and note what you observe under (1); in addition, make a sketch of the position of the compass needle (N S) relative to the straight conductor (+ — -).
— With the switch closed, hold the compass directly over the straight conductor and observe the compass needle. Note your observation under (2), and sketch the present position of the compass needle to the straight conductor.
— Lift the compass up higher and higher and observe the deflection of the compass needle; hold the compass directly under the straight conductor and move it downwards while observing the compass needle; note your observations under (3).
— Hold the compass directly alongside the straight conductor, then slowly move it horizontally away from the straight conductor, while observing the compass needle. Note your observation under (4).
— Finally, again hold the compass under the straight conductor, open the switch, reverse the polarities of the power supply and ammeter connections, close the switch, observe the compass needle and note what you observe under (5).
— Set the power supply to 0 V and switch it off.

Observations

(1)

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....

....

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....

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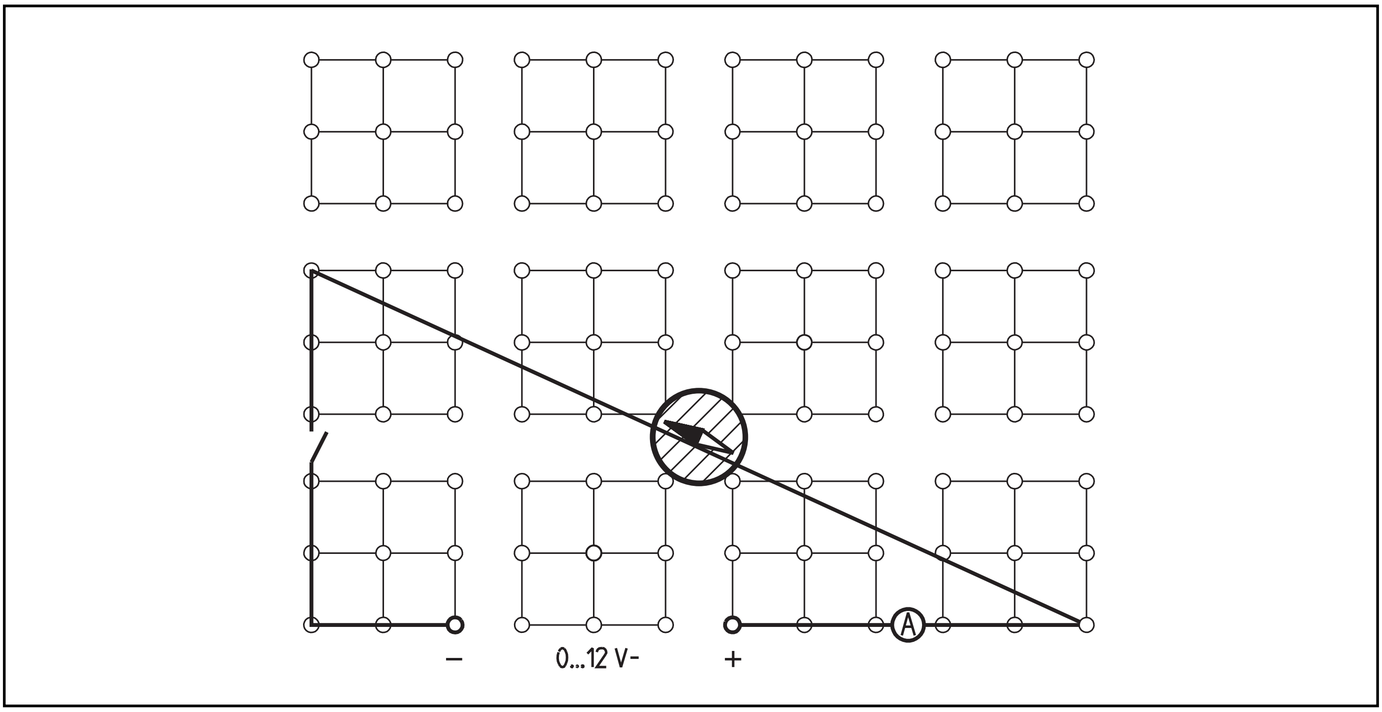
Fig. 1



(2)

(3)

(4)

(5)

Sketch to (1)

Sketch to (2)

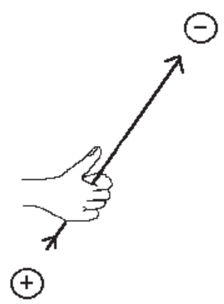
Evaluation

1. Which conclusion must be drawn from the observations which you have noted under (1), (2), (3) and (5)?

2. The form of the magnetic field which apparently surrounds the straight conductor when this carries current can be determined from the observations noted under (1), (2) and (4) and the sketches. Try to describe this magnetic field (the course of the field lines).

3. Fig. 2 shows how the course of the field lines of a current carrying conductor can be determined by the "right hand rule". Try to formulate this rule.

Fig. 2

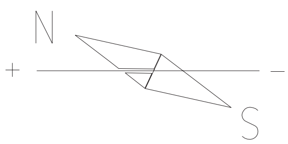


(Does electric current also exert magnetic effects?)

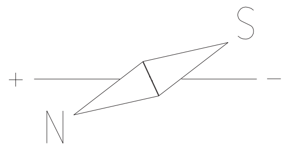
Whereas the heating and lighting effects of electric current are directly perceivable with human senses, this is not the case with the chemical and magnetic effects.
In this experiment, the students should recognize that a current-carrying conductor is surrounded by a magnetic field. They will then be in a position to understand the functioning of common electrical appliances and equipment, such as electric bells and electric motors.
For the explanation of the phenomena which occur during the experiment, it is helpful when the knowledge of the students on permanent magnetism (forces between magnets; magnetic poles; magnetic fields) is refreshed prior to this experiment.

Notes on Set-Up and Procedure
In this experiment, we are using de facto a short-circuit. This is permissible, because the power supply is equipped with an electronic current limitation. This should be pointed out to the students, because they could otherwise underestimate the dangers connected with short-cicuits.

Observations
(1) The compass needle is deflected, as long as current flows.
Sketch:



(2) The compass needle is deflected to the other side.
Sketch:



(3) The further the compass needle is from the straight conductor, the less is the deflection.
(4) The compass needle is not deflected.
(5) On reversing the direction of the current, the compass needle is deflected in the opposite direction.

Evaluation
1. Each conductor through which current flows is surrounded by a magnetic field; the direction of the field lines is dependent on the direction of the current.
2. The form of the field lines of the magnetic field which surrounds the straight conductor is concentric circles.
3. When the straight conductor is held with the right hand so that the thumb points to the negative pole, then the fingers show the direction of the field lines.

Remarks
As the connecting cables are made of copper, they cannot be related to the magnetic effect.
The fact that we are dealing here with field lines which do not run in the direction of one pole to the other, and also not pass into a body or emanate from it, is frequently surprising for the students and difficult for them to understand.

The magnetic effect of a current-carrying conductor

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Room for notes