Generating Magnetic Field by Electric Current 3

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NaRiKa Corporation

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1. Learning Outcome

While experiments on Electric Current and Magnetic Field are normally done by using dry cell batteries or electric power-supply units, we are going to use the hand-held generator "(Narika) Genecon V3" in this Unit. In case of using dry cell batteries or electric power-supply units, students can merely turn on a circuit and observe the electrical phenomena. However, they cannot only observe the experiment in operation, but also control it as they wish by using the hand-held generator Genecon V3, which helps students' better understanding of experiments objectives through hands-on experience involving them.

Students should have better understanding of the nature of and interaction between "Magnetic and Electric Current" through the experiment of Oersted and Ampere's law introduced in the previous two Units, "Generating Magnetic Field by Electric Current 1 & 2". In this Unit, we are going to learn through experiments about electromagnet.

2. Historical Background

Up until W. Gilbert (1544 - 1603, UK) reported his study in 1600, no major study report had been made public for 2200 years ever since Thales of Miletus of ancient Greece recognized the electrostatic phenomenon of attracting dust or feather when rubbing amber with fur in 600 B.C. In 1800, which is 200 years after the Gilbert's report, A.Volta (1745 - 1827, Italy) invented battery (known as the "Voltaic Cell"), which means it took 200 years for the transition from the study on static electricity to dynamic electricity.

A. M. Ampere

http://en.wikipedia.org/wiki/File:Ampere_Andre_1825.j

Using Voltaic Cell as a power source, notable study was made by H. C. Oersted (Denmark) when he discovered that compass needle should deflect near a cable carrying current, which was made public in publication named "Interaction of Current and Magnetism", on September 1st, 1820, at the conference of Paris Academy of Sciences. Soon after being deeply impressed with Oersted's report, A. M. Ampere (France) started his study and soon made public his theory of Electricity and Magnetism including previously discovered electromagnetic phenomena, which is called the dawn of Electromagnetics.

In 1826, Ohm made his research publication of "Ohm's law", followed by the discovery of electromagnet by William Sturgeon (1783 - 1850, UK) in 1828. Conceived from the Solenoid Wire experiment done by Ampere, Sturgeon found that iron block with coiled wire became magnetized when electric current is carried through the wire. In 1829, Joseph Henry (1797 - 1878,

USA) succeeded in creating high-powered magnet, as well as, in discovering self-induction and electromagnetic induction during his research on electromagnetism, whose achievement on electromagnetic induction was conceded to Michael Faraday (UK) merely because Faraday's presentation preceded before Henry's.

In this Unit, we will learn about the basic properties of electromagnet by using Genecon V3. We learned about Ampere's Right-handed Screw Rule showing that magnetic field is generated around the coiled wire(s) when electric current is carried though. Hereinafter, we will learn through experiments that: 1) the coiled wire becomes magnetized when metallic bar (core) is inserted, and 2) the power of the electromagnet changes depending on the coil turns.

Joseph Henry

http://www.photolib.noaa.gov/bigs/pers0124.jpg

3. Introduction of Equipment for Experiments

[1] Genecon V3:

Genecon V3 is a product name of the hand-held power generator manufactured by Narika Corporation. Up to 3V DC electricity can be generated just by turning the handle, hence the user realizes how he/she is generating electric power in person. Since Genecon V3 generates only up to 3V, it highly unlikely damage accessories used for experiment at schools like miniature bulbs, LED lamps, electric musical (melody) boxes, and others. Also, it replaces dry cell batteries used for experiment like lighting miniature bulbs/LEDs, electrically heated wire, or others.

Genecon V3

(Narika B10-2634)

Mechanism of Genecon V3 is quite simple, consisting of the motor inside for generating power, which should leave almost no room for students to misunderstand the relationship/function of internal motor, gears, shafts and handle due to its perfect visibility through the transplant body. For teachers, Genecon V3 significantly helps their explanation to students regarding the fact that motor and generator are identical.

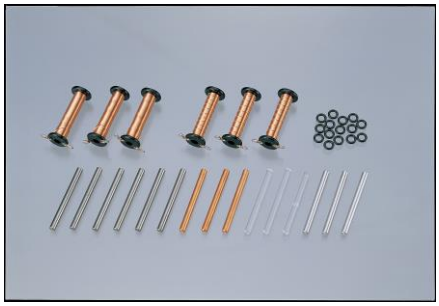
[2] Replacement Gear Set for Genecon V3:

Genecon V3 consists of plastic gears, motors and others. In particular, the gears are subject to wear, and eventually break causing strange noise and free spin. Thai is why Narika provides "Replacement Gear Set for Genecons". Also, Genecon V3 was designed taking into account user-friendliness for teachers who would like to change the gears by themselves.

[3] Coil Set for Electromagnet:

Sold in three (x3) sets with (2 types of) solenoidal coils and (4 types of) bar-cores. This set is suitable for confirming how electromagnet changes depending on the coil turns and/or the type of bar-core material by using in combination with Genecon V3, dry cell batteries or power supply unit.

Solenoid coil 100 turns: 3 pcs
Solenoid coil 200 turns: 3 pcs
Core metal (Copper, Aluminum, Glass): x 3 each
Core metal (Iron): x 6 each
O-ring (rubber): 15 pcs



Coil Set for Electromagnet (3

4. Formation of Magnetic Field by Electric Current ~William Sturgeon & Joseph Henry~

The year 1820 is called the dawn of Electromagnetics, when H. C. Oersted (Denmark) discovered electric current form magnetic field, followed by A. M. Ampere (France) who made public on his theory of Electricity and Magnetism.

In 1826, Ohm (1789 - 1854, Germany) made his research publication of "Ohm's law", followed by the discovery of electromagnet by William Sturgeon (UK) in 1828. From the idea of Solenoid Wire experiment by Ampere, Sturgeon found that iron block with coiled wire became magnetized only when electric current is carried through the wire.

In 1829, by improving William Sturgeon's electromagnet, Joseph Henry (USA) succeeded in creating high-powered magnet strong enough to lift up a mass of 1 ton. He discovered self-induction and electromagnetic induction during his research on electromagnetism. His achievement on electromagnetic induction was conceded to Michael Faraday (UK) merely because Faraday's presentation preceded before Henry's.

In this Unit, we are going to learn about the basic properties of electromagnet through the experiments discovered by the pioneer researchers.

Joseph Henry

http://www.photolib.noaa.gov/bigs/pers0124.jpg

5. Experiment with Electromagnet

1. Purpose of this experiment:

Under what conditions is electromagnet made, and what are the factors that determine strength of electromagnet.

2. What to prepare:

*Genecon V3:	1 pc	(Narika B10-2634)
*Solenoid coil (100 windings):	1 pc	(Narika S75-5606-01)
*Solenoid coil (200 windings):	1 pc	(Narika S75-5606-02)
*Core (copper):	1 pc	(Narika S75-5606-03)
*Core (aluminum):	1 pc	(Narika S75-5606-04)
*Core (glass):	1 pc	(Narika S75-5606-05)
*Core (iron):	1 pc	(Narika S75-5606-06)
*Paper clips (steel):	around 20 pcs	

Genecon V3 (Narika B10-2634)

Coil set (Narika S75-5606)

3. Experiment 1: with Solenoid coil (100 turnings) only

1) Connect Genecon V3 to Solenoid coil (100 turnings).
2) Put paper clips (approx. 20 pcs) on the table.
3) One person will start rotating the handle of Genecon V3.
4) The other person will take the coil and put it close to the paper clips on the table.
5) Write down the amount of paper clips attached to the coil.

4. Experiment 2: Check the difference in the number of solenoid coil turns

1) Connect Genecon V3 to Solenoid coil (100 turns).
2) Put paper clips (approx. 20 pcs) on table.
3) Insert into Solenoid coil iron core and ensure it will not move by enclosed rubber band.
4) One person will start rotating the handle of Genecon V3.
5) The other person will take the coil and put it close to the paper clips on the table.
6) Write down the amount of paper clips attached to the coil.
7) Change the coil to Solenoid coil (200 turnings) and connect it with Genecon V3.
8) Repeat steps 2-6.

5. Experiment 3 difference in type of cores inserted in Solenoid coil

1) Connect Genecon V3 to Solenoid coil (100 turnings).
2) Put paper clips (approx. 20 pcs) on table.
3) Insert into Solenoid coil enclosed iron core and ensure it will not move by enclosed rubber band.
4) One person will start rotating the handle of Genecon V3.
5) The other person will take the coil and put it close to the paper clips on the table.
6) Write down the amount of paper clips attached to the coil.
7) Exchange iron core for copper core, aluminum core and glass core and repeat steps 2-6.
8) Write down as well how many paper clips were attached to the coil when one person was rotating the handle of Genecon V3 slowly and when rotating the handle of Genecon V3 fast.

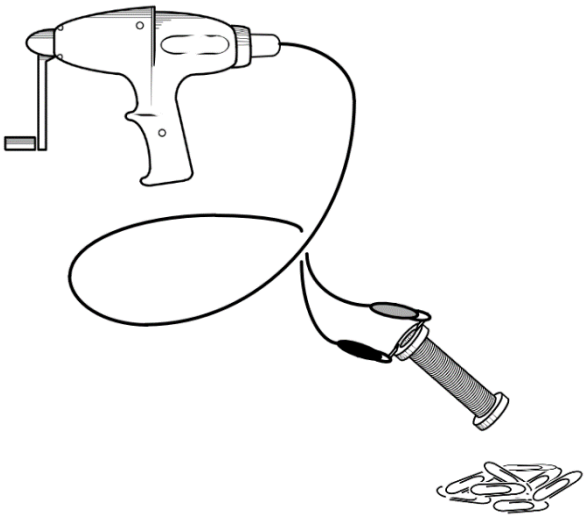


Fig.1. Without core inside the coil

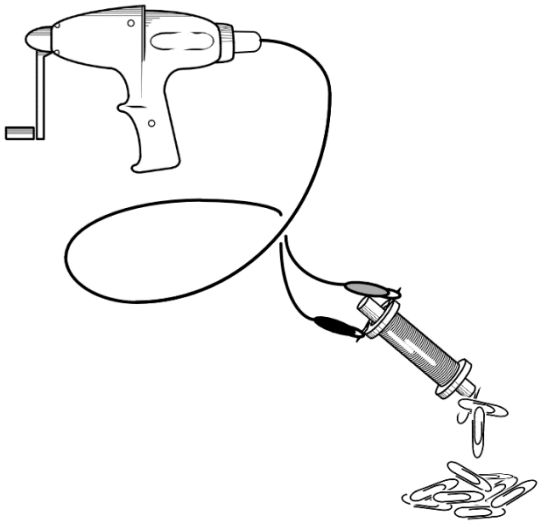


Fig.2. With core inside the coil

6. Summary of Experiments

In the table below, fill in the amount of paper clips that were attached to the electromagnet.

1. Experiment results: Amount of paper clips attached to the electromagnet

Rotation speed of Genecon V3 handle	Coil turnings	Without core	With core			
			Steel	Copper	Aluminum	Glass
When you turn the handle quickly	100	0 pc	23 pc	0 pc	0 pc	0 pc
	200	0 pc	39 pc	0 ps	0 pcs	0 pc
When you turn the handle slowly	100	0 pc	9 pc	0 pc	0 pc	0 pc
	200	0 pc	10 pc	0 pc	0 pc	0 pc

***This is just example. Actual amount of paper clips might be different.**

2. From the experiment result table above, which combination is most suitable as an electromagnet?

The most suitable is: "coil turnings: 200", with steel core and turning the handle quickly. In case of using core of copper, aluminum, or glass, no clips are attached, which means those materials are not magnetized even with inserted coil. Iron is ferromagnet, which is magnetized in magnetic field. Beside iron, cobalt, nickel and its composition are ferromagnet. Magnetic substances are categorized into: ferromagnet, diamagnet and paramagnet. Copper, aluminum and glass are also Magnetic substances.

3. What is the cause of different results if you are turning the handle of Genecon V3 quickly and if you are turning the handle of Genecon V3 slowly?

The different results are caused by the generated electric quantity. If you turn the handle more quickly, generated electric quantity (voltage and current) increases. If you turn the handle more slowly, generated electric quantity (voltage and current) decreases. Therefore, large amount of electric quantity is carried through (solenoid) coil when turning the handle quickly, while relatively small amount of electric quantity is carried through (solenoid) coil when turning the handle slowly. Magnetic force is strengthened when larger amount of electric quantity flows inside electric magnet.

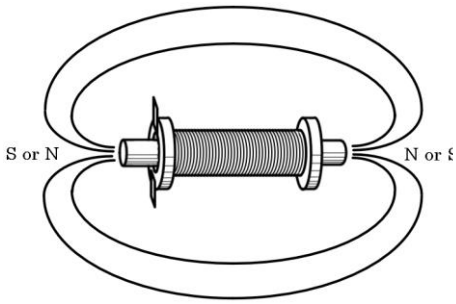
4. Based on the results of experiments, in order to create stronger electromagnet, what should we do?

We should: 1) increase the number of solenoid coil turnings, 2) provide larger amount of electricity, and/or 3) use iron core. If we increase the number of solenoid coil turnings, we will have more electric resistance in the coil. In case of connecting DC power supply to electromagnet, if the voltage is constant, amount of current to be carried through will differ depending on the resistance value determined by the number of coil turnings.

5. Draw magnetic field of electromagnet in the drawing below.

We can draw the magnetic field as shown on the right. Note that polarity changes depending on the direction of current. Give your students below questions:

1. How they can identify the magnetic field?
2. How they can determine the polarity?

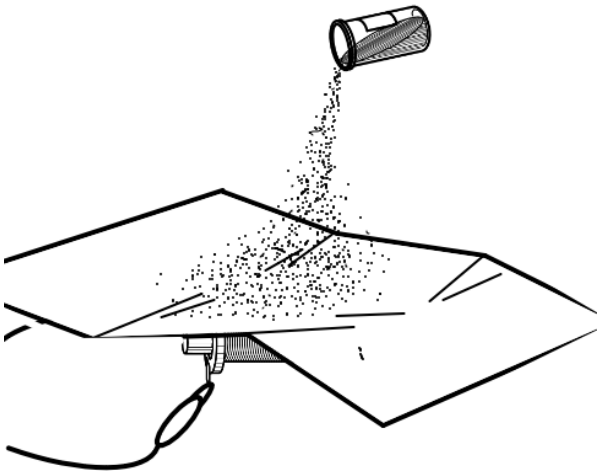


1. How to identify the magnetic field:

Cover a electromagnet with a white paper and pour iron sand (powder) on the paper. Then, turn the handle of Genecon V3 to observe the magnetic force lines generated by the electromagnet. It may be the good idea to use the "Mag Chip" provided by Narika.

Iron powder or iron sand is normally used in schools for observing magnetic field despite its user-unfriendliness in that experimental equipment and lab bench get easily dirty, which requires quite

time-consuming cleanup afterwards. Mag Chips are tiny fragments of galvanized iron wire divided into approx. 2 mm long chips, of which feature is resistance to corrosion and easy collection after use.



2. How to determine the polarity:

Use a magnetic compass. Around the electromagnet, place some compasses to indicate the polarity when turning the handle of Genecon V3.