Electric Circuit

~ Parallel Circuits~

NaRiKa Corporation

1. Learning Outcomes

Learners will learn about the relationship between current, voltage, and resistance through electricity experiments. Learning outcomes of this experiments for learners are to assemble a parallel circuit and to acquire the skill to correctly measure current and voltage of electricity flowing in the circuits with meters.

2. Introduction of Equipment for Experiments

DC ammeter and DC voltmeter are required for this experiment. Caution is needed when connecting conventional DC ammeter or DC voltmeter to the electric circuit because these types of meters will be damaged unless connected to a terminal with proper measurement range. Multimeter can be misleading equipment for learners, too, because they tend to waste much time in unrelated measurement due to the multi-functions.

A05-7060 Miniature DC Ammeter

- Measurement range: ±3A
- Automatically switchable display: 1mA (0~±500mA)
  0.01A (~±3.0A)
- Size: 53 × 21 × 15mm、Whole length: ca 280mm
- Battery: CR1220 x 1pc

A05-7065 Miniature DC Voltmeter

- Measurement range: ±25V
- Automatically switchable display: 0.01V (0~±5.00V)
  0.1V (±5.1V~±25.0V)
- Size (body): 53 × 21 × 15mm, Whole length: ca 280mm
- Battery: CR1220 x 1p

With these miniature meters, learners are no longer required to spend their time for the troublesome measurement range selection as happens with multimeters. These meters are suitable for learners' experiments due to the following functions such as automatic measurement range change and built-in protection circuit for overload prevention. Furthermore, learners can view the meters as a part of an electric circuit because they are small enough when compared with conventional ones.

3. Experiment of Parallel Circuit

1. Purpose of this experiment:

Learners will learn to assemble a parallel electric circuit by combining a dry cell battery (power source), a miniature incandescent bulb (resistance), and a switch. They will also acquire the skill of measuring current and voltage using the digital miniature meters properly.

2. What to prepare:

- A05-7060 Miniature DC Ammeter CT-A x 1 to 6 pieces
- A05-7065 Miniature DC Voltmeter CT-V x 1 to 3 pieces
- B10-6254-01 Knife switch (hereinafter "Switch") x 1
- B10-6413 Base for miniature bulb x 2
- P70-0366-11 Miniature bulb (3.8V0.3A) x 2
- P70-0720-03 Dry cell battery (AA type) x 2
- P70-0342 Dry cell battery holder x 2
- B10-6503 Lead wire with clips (red & black) x 2 pairs

3. Experiment Procedure:

1. Let us assemble a parallel electric circuit with two miniature bulbs.

1) Assemble a parallel circuit using two miniature bulbs, two dry cells batteries, and a switch as shown in Fig. 1 below.

2) Test the parallel circuit whether the bulbs will light up or not when closing the switch.

> **Caution:** If the bulbs will not light up, check each of the connections to the base for miniature bulb. In case one or both of the bulbs are securely screwed in but will not light up, change the bulb(s) to a new one(s) and/or change the dry cell battery to a new one.

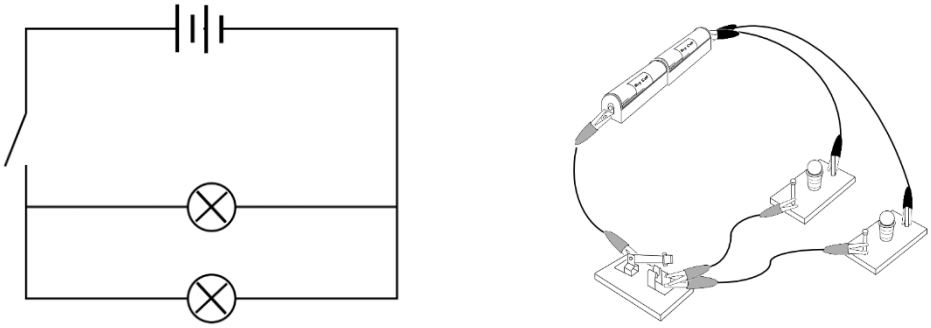

Fig. 1. Parallel Circuit (with two miniature bulbs)

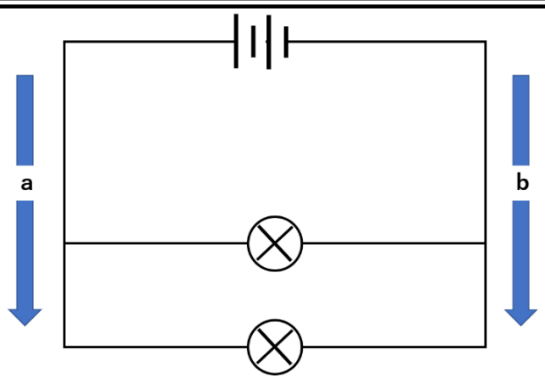

Fig. 2. Direction of electric current in parallel circuit

2. Let us measure the electric current flowing in the parallel circuit.

1) Predict direction of electric current that flows in the circuit shown in Fig. 1. Which direction, (a) or (b) as shown in Fig. 2, does the electric current flow in that circuit?

2) Connect an ammeter with each of the positions A1 - A6 in the parallel circuit shown in Fig. 3 and fill the measurement values in Table 1 below.

> **Caution:** When connecting a meter, confirm the polarity of the circuit. The red clip of lead from the meter should be connected to the positive (+) side and the black clip should be connected to the negative (-) side of the circuit.

3) According to the Table 1, which direction (a or b shown in Fig. 2) do you think the current flows in the circuit?

4) Remove one miniature bulb from the parallel circuit and assemble a simple circuit again (see Fig. 4).

5) Connect the ammeter to each of the positions A7 and A8 in the circuit shown in Fig. 4 and fill those measurement values in Table 1 below.

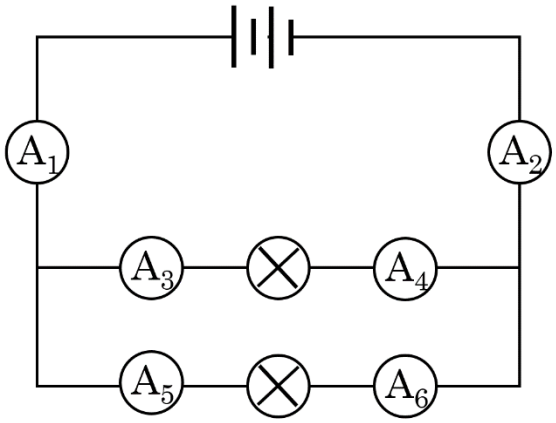

Fig. 3. Measurement current in the parallel circuit

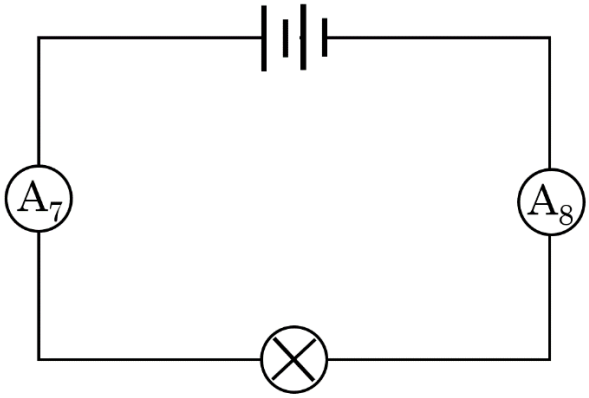

Fig. 4. Measurement current in the simple circuit

Table1. Result of Experiment 2

Parallel Circuit (Fig.3)		Simple Circuit (Fig.4)	
Ammeter	Amperage	Ammeter	Amperage
A_1	0.5 A	A_7	0.27 A
A_2	0.5 A	A_8	0.27 A
A_3	0.24 A		
A_4	0.24 A		
A_5	0.25 A		
A_6	0.25 A		

6) Describe the relationship between electric current value and type of the circuit based on the result shown in Table 1.

According to the result of Experiment 2, each amperage in Table 1 (A3 - A6 and A7 - A8) is almost equal to 0.3A. On the other hand, the amperage A1 (or A2) in the parallel circuit is equal to 0.5A and it is almost the doubled amount of A7 (or A8). According to the result, the current from the dry cell batteries is assumed to be the sum of the current flowing through each branch of the circuit.

3. Let us measure the voltage of the parallel circuit.

1) Predict voltage values to be measured at each of V1 - V3 in the circuit shown in Fig. 5 and Fig. 6, given voltage of one dry cell is 1.5V, and fill your prediction in Table 2 below.

2) Measure voltage value at each of V1 - V4 shown in Fig. 5 and fill it in Table 2.

3) Remove one of the miniature bulbs from the series circuit and assemble a simple circuit again (see Fig. 6).

4) Measure voltage value at V5 and V6 shown in Fig. 6 and fill it in Table 2.

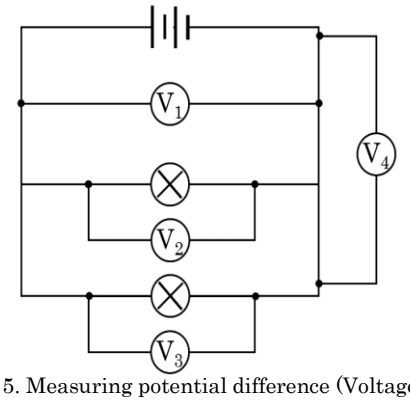

Fig. 5. Measuring potential difference (Voltage) in parallel circuit

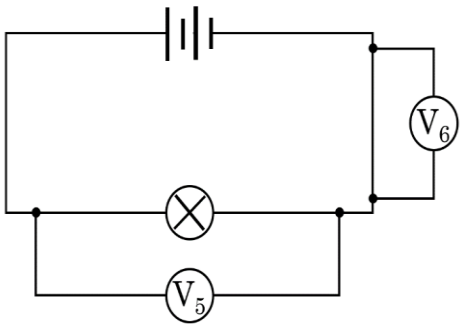

Fig. 6. Measuring potential difference (Voltage) in simple circuit

Table2. Result of Experiment 3

Parallel Circuit (Fig.5)			Simple Circuit (Fig.6)		
Voltmeter	Prediction	Voltage	Voltmeter	Prediction	Voltage
V_1	V	2.8 V	V_5	V	2.6 V
V_2	V	2.6 V	V_6	V	0 V
V_3	V	2.5 V			
V_4	V	0 V			

5) Describe the relationship between the voltage and the circuit based on the result shown in Table 2.

According to the result of Experiment 3, each voltage value measured, except for V4 and V6, are almost the same in both circuits, if the same number of dry cells batteries (power supply) are used. On the other hand, each voltage value measured (V4, V6) in between the dry cell and miniature bulb is equal to zero voltage (0V) in both types of circuits. This means there is no potential difference (voltage) between them.

4. Description

Learners acquire their skill to assemble parallel circuit with two miniature bulbs, two dry cells, and a switch through Experiment 1. Through Experiment 2, they realize the amperage (current value) measured at any point (A3 - A6) in the parallel circuit is consistent, as well as, it is almost the same as the amperage measured in the simple circuit (A7 - A8). They also realize original current value from the source (dry cell battery) (A1 or A2) of the parallel circuit is almost twice as much as amount of A7 or A8. Through Experiment 3, they recognize the parallel circuit is identical to two simple circuits combined in parallel because each of the measured voltages (V2 - V3) in the two circuits is almost the same. Furthermore, they find brightness of the bulb in each circuit almost the same.

An Electronic-hydraulic analogy familiar to teachers for enhancing learners' understanding on the electricity better illustrates aforementioned experiments to learners. Fig. 7 and Fig. 8 below illustrate parallel and simple circuit respectively as an Electronic-hydraulic analogy. According to the analogy, a pump that brings water up to the upper waterway plays the role of a dry cell battery. The height between the upper waterway and the lower one means the potential difference. The amount of water flowing in the waterway and the waterwheel play the role of electric current and a miniature bulb, respectively. Waterwheels shown in Fig. 7 and Fig. 8 are identical to each other. As such, amount of water flowing to turn the waterwheel shown in Fig. 7 and Fig. 8 are identical to each other. Analogies of Fig. 7 and Fig. 8 better illustrate the electric current that flows in each bulb (A3 - A8) as shown in Table 1 is mostly the same. Furthermore, the pump shown in Fig. 7 must be capable of bringing up amount of water sufficient for turning the two waterwheels, which is double amount of water for turning one waterwheel shown in Fig. 8. This better illustrates that the original current from/to the source of the parallel circuit (A1 or A2) is almost doubled in comparison to the current in the simple circuit (A7 or A8).

Pumps shown in Fig. 7 and Fig. 8 are identical to each other. Heights to the upper waterway shown in Fig. 7 and Fig. 8 are the same, as well. Fig. 7 and Fig. 8 illustrate voltage values measured across the two points before and after the bulb are mostly the same, regardless of the type of circuit, and the voltage value is zero (0) across the two points between the dry cell and the bulb as shown in Table 3.

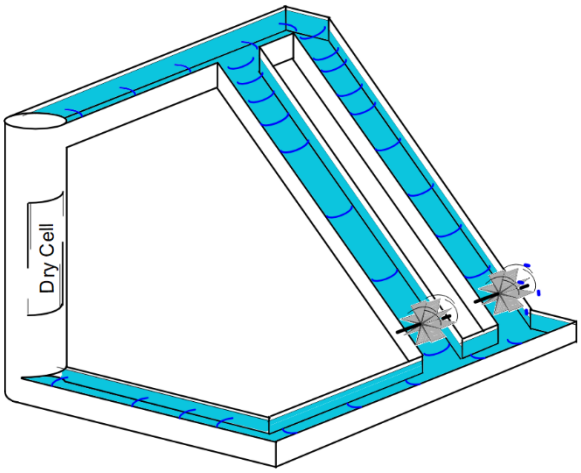

Fig. 7. Electric-hydraulic analogy of the parallel circuit

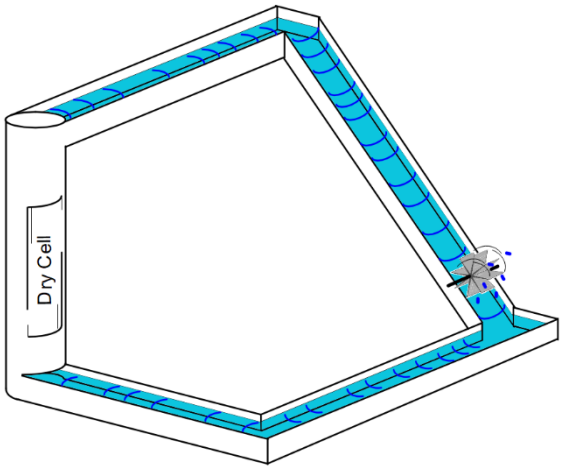

Fig. 8. Electric-hydraulic analogy of the simple circuit