Electric Circuit

~ Simple Circuit~

NaRiKa Corporation

1. Learning outcomes

Learners will learn about the relation between current, voltage and resistance through electricity experiments. Learning outcomes of this experiments for learners are to assemble simple 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 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 actually tend to waste much time in unrelated measurement due to the multi functions. In the following experiment, user friendly miniature digital DC ammeter and digital DC voltmeter with a single function will be used so that learners can do various experiment in a short time.

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 1pc

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, it is possible for learners to view this meter as a part of electric circuit because they are small enough when compared with conventional ones.

3. Experiment of Simple circuit

1. Purpose of this experiment:

Learners will learn to assemble a simple electric circuit by combining a dry cell battery (power source), a miniature bulb (resistance) and a switch. Also, they will 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
- A05-7065 Miniature DC Voltmeter x 1
- B10-6254-1 Knife switch x 1
- B10-6413 Base for miniature bulb x 1
- P70-0366-11 Miniature bulb (3.8V0.3A) x 1
- 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. Procedure for Experiment

1. Let us assemble a simple electricity circuit.

1) Assemble a simple circuit using a miniature bulb, dry cell batteries and a switch as shown in Fig. 1 below.

2) Test the simple circuit whether the bulb will lit when closing the switch or not.

Caution: If the bulb will not lit, check its connection to the base for miniature bulb. In case the bulb is securely screwed in but will not lit, change the bulb to a new one and/or change the dry cell battery to a new one.

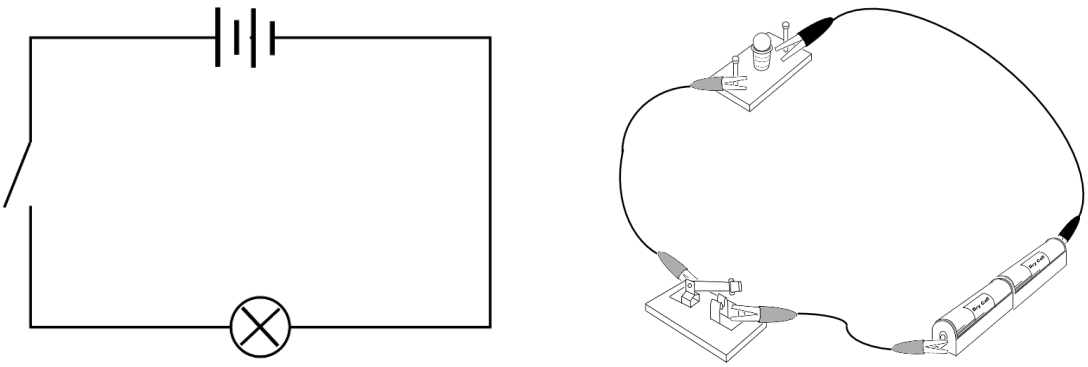

Fig. 1. Simple electricity circuit

2. Let us measure electric current flowing in the simple 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) Which diagrams shown in Fig. 3 and Fig. 4 is correct when connecting an DC ammeter with the circuit?

3) Measure and record electric current value for each of Fig. 3 and Fig. 4 by connecting the miniature DC ammeter with the circuit as shown in Fig. 3 and Fig. 4.

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

4) Consider why the difference in each value occurred in previous step 3) and describe the reason.

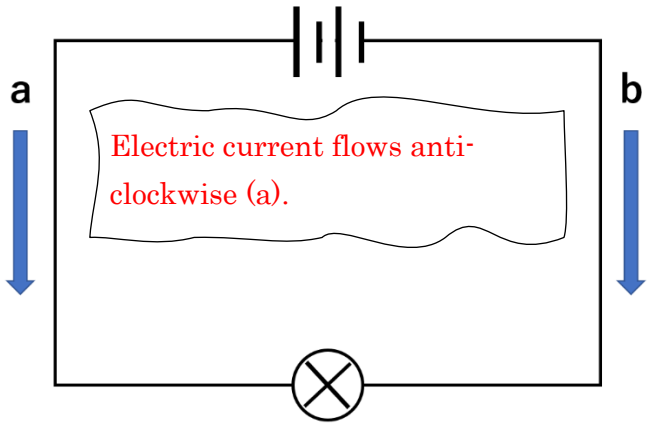

Fig. 2. Prediction of the direction of electric current flowing in the circuit.

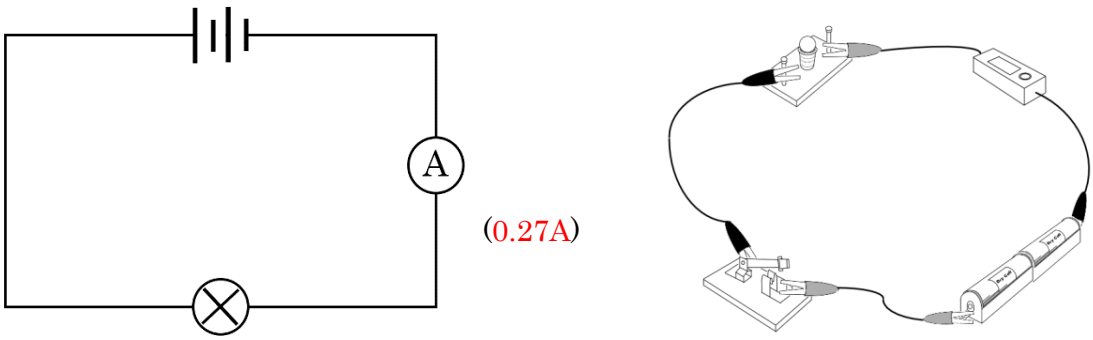

Fig. 3. How to connect an ammeter - 1

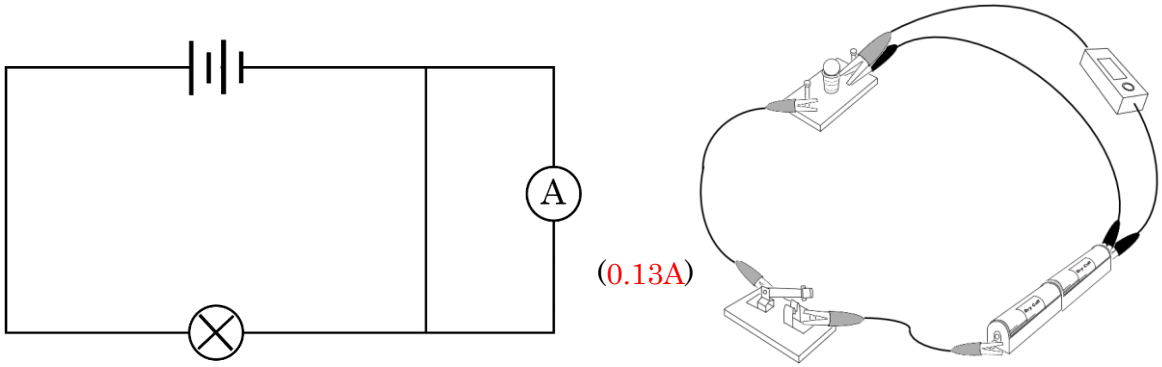

Fig. 4. How to connect an ammeter – 2

Description of the reason for the difference in measurement values.

It was caused because there is a difference in number of the paths for electric current between Fig. 3 and Fig. 4. As the paths shown in Fig.4 are twice the number of Fig. 3, the electric current that flows in Fig. 4 is split into two branches and the measurement electric current value for Fig. 4 is actually a half of value for Fig. 3.

3. Let us measure voltage in the simple circuit.

1) Predict the voltage value of electricity that flows in the electric circuit previously assembled in the section 1 and fill in the value in Fig. 5.

2) Which of the diagrams shown Fig. 6 and Fig. 7 is correct when connecting an DC voltmeter with the circuit?

3) Measure and record electric voltage value for each of Fig. 6 and Fig. 7 by connecting the miniature DC voltmeter with the circuit as shown in Fig. 6 and Fig. 7.

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

4) Consider why difference in brightness of miniature bulbs occurred in previous step 3) and describe the reason.

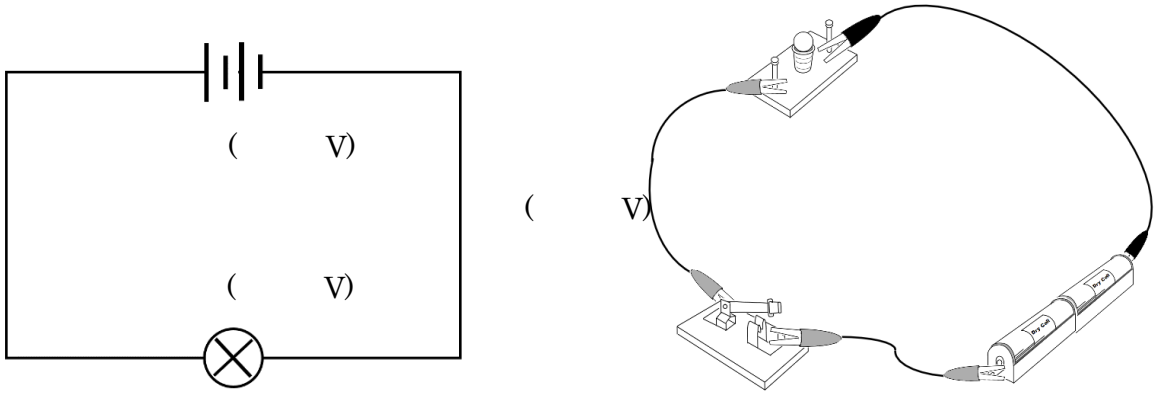

Fig. 5. Prediction of voltage value in the simple electric circuit

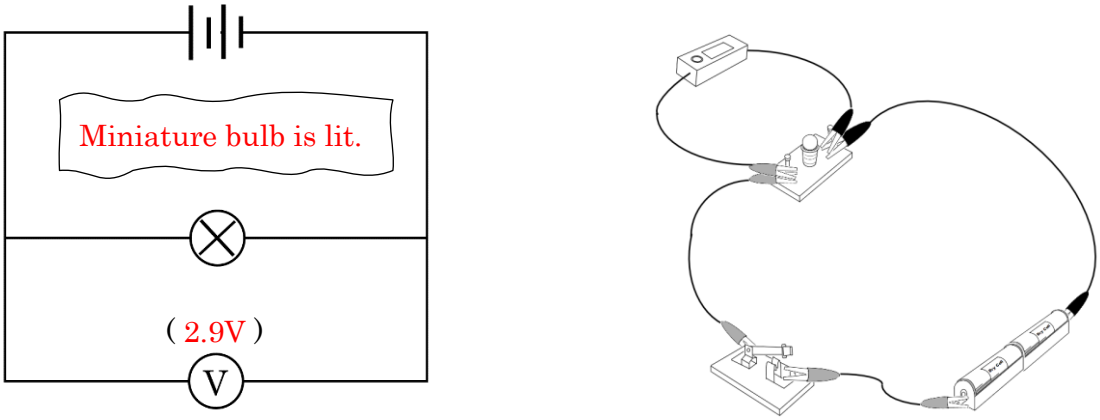

Fig. 6. How to connect a voltmeter - 1

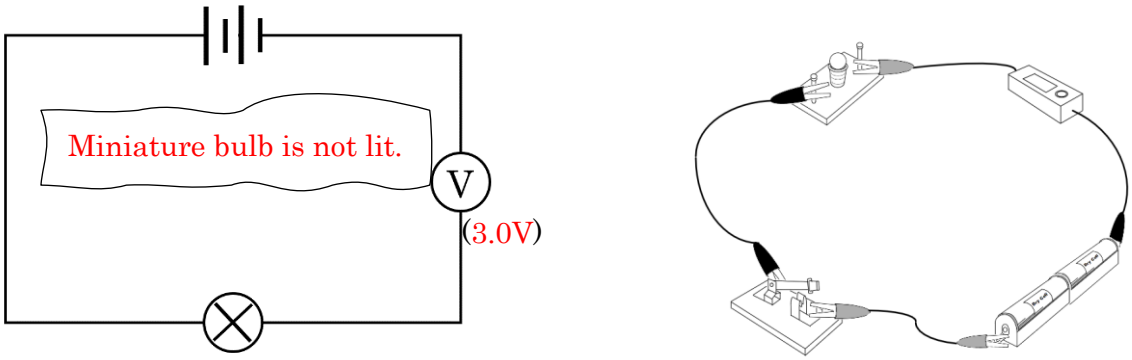

Fig. 7. How to connect a voltmeter – 2

5) Description of the reasons of difference in brightness of miniature bulbs of the circuits.

There is no significant difference in the voltage value between Fig. 6 and Fig. 7. While the miniature bulb is lit in case of Fig. 6, but not in case of Fig. 7. The voltmeter seems to block the electric current flow in the circuit shown in Fig. 7.

6) Choose proper connection of an ammeter and a voltmeter from Fig. 3 to Fig. 7 based on your results and describe the reason below.

a) Proper connection of an ammeter and the reason.

Fig. 3 is correct because the ammeter is supposed to be connected in series with (in the same single loop as the rest of) the circuit in order to measure the amount of electric current that flows in the circuit. On the other hand, according to the result of Fig. 4, the amount of electric current that flows in the circuit shown in Fig. 4 is half because the number of paths for electric current is twice the number of Fig. 3 due to the parallel connection of the ammeter.

b) The proper connection of voltmeter and the reason.

Fig. 6 is correct because the voltmeter is supposed to be connected in parallel with (outside the single loop of the rest of) the circuit in order to measure the potential difference in any given two points in the circuit. According to the result of Fig. 7, electric current does not flow in the circuit as shown by the miniature bulb that is not lit. Voltmeter connected in series acts as a resistant.

4. Advanced Experiment

Although the voltmeter is connected in parallel with the circuit correctly and the miniature bulb is lit, the voltmeter shows zero (0) voltage (see Fig. 8) Can you explain why?

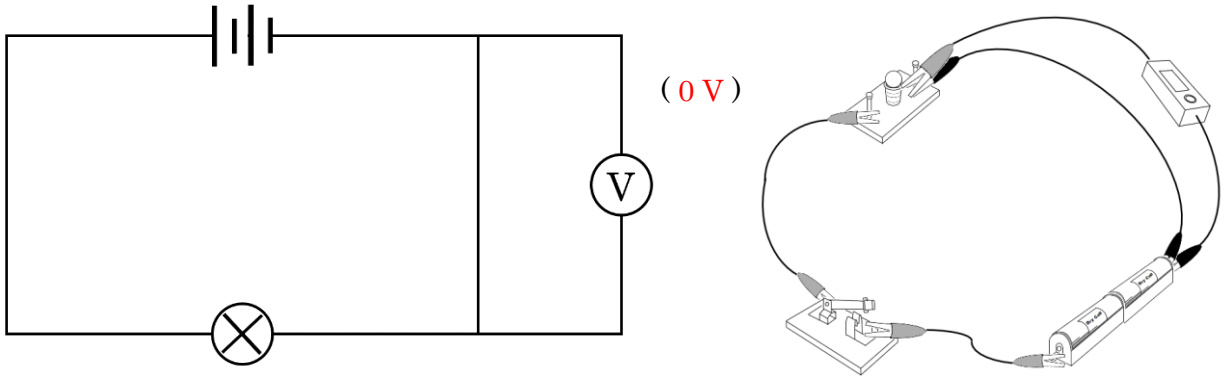

Fig. 8. How to connect a voltmeter - 3

When connecting a voltmeter with a circuit, point-to-point connection has to be correctly made by selecting correct section in a circuit. Result of Fig. 8 shows zero (0) voltage, which means there is no potential difference in the selected section. A voltmeter must be connected in parallel with a circuit by selecting proper section between two points (for example: before and after the miniature bulb).

5. Description

In the experiment 1, learners learn that electrical components that constitute a simple circuit are, among others, a miniature bulb, a dry cell battery and a switch. These components are connected with one another by lead wires. They also learn that the electric circuit works to light a miniature bulb on when its path of the circuit is closed by the switch making the circuit complete and the current flows through the whole path.

Instructor must explain to the learners, prior to the experiment, that direction of electric current flows from a positive terminal (+) to a negative terminal (-) of a dry cell battery. Therefore, the purpose of learners' experiment (for instructors) is to confirm the depth of learner's understanding of the topic.

Through the experiment 2, learners should notice that an ammeter displays results with plus (+) and minus (-) signs, from which they reaffirm the direction of electric current that flows in the circuit. When an ammeter displays result with plus sign, the current flows from its plus terminal to minus terminal, which means the ammeter is correctly connected with the circuit. On the other hand, when the ammeter displays result with minus sign, it is not correctly connected with the circuit (connected in reverse).

Instructors must explain to learners sufficiently how to properly connect conventional analog meter with circuit because it can be damaged easily from improper connection. Consequently, learners tend to be afraid of damaging meters and thus hesitate to use them, in which case they spend extra time for their experiment. On the contrary, the digital miniature meters introduced in this chapter are unlikely to be damaged from wrong connection. Instead the minus sign will be displayed, thanks to the built-in self-protection circuit (even if they are improperly connected with electric circuit). It goes without saying that the meters will be damaged if used over the limitation of the self-protection range. Check the specification carefully before use.

1. An ammeter is intended to be connected in series with (in the same single loop as the rest of) the circuit.

This experiment is intended for learners to find out how to properly connect the ammeter with the circuit, in a trial-and-error manner, from difference in measured electric current values.

It is recommended to use widely used electronic-hydraulic analogy when explaining the difference between current and voltage to learners.

Electric circuit shown in Fig. 3 can be illustrated as an analogy shown in Fig. 9. "Water" (for electric current) is brought up to the upper stream by a "pump" (for dry cell battery), and then, flows down toward a "waterwheel" (for a miniature bulb). Water at lower stream flows toward the pump to be brought up to the upper stream again.

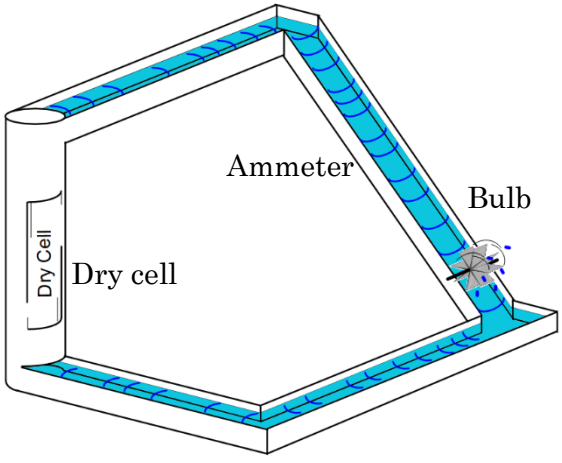

Fig. 9 Electronic-hydraulic analogy 1

Amount of flowing water shown in Fig. 9 is the analogy for electric current flowing in the circuit. As the ammeter measures the electric current in the circuit, it should be connected in series with (in the same single loop as the rest of) the electric circuit that stands for water stream shown in Fig. 9.

Electric circuit shown in Fig. 4 can be illustrated as the analogy shown in Fig. 10. "Water" is pumped up to the upper water stream by a "pump" (for dry cell battery), and then, flows down. When the water stream flows down toward the lower water stream, it is split into two streams at the beginning and is merged again at the lower stream. One of the two streams flow down toward the miniature bulb, while the other one flows down toward the ammeter.

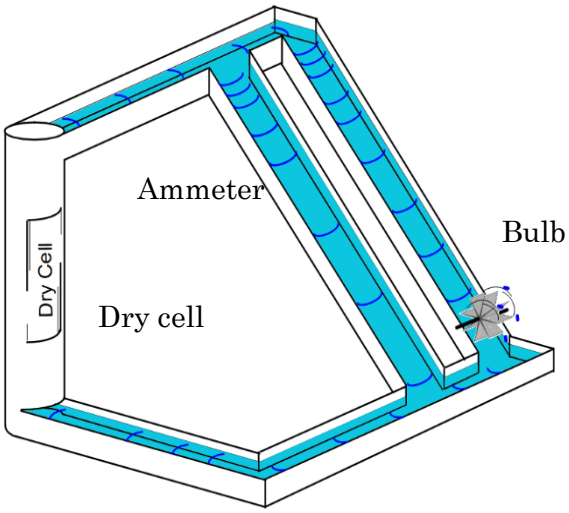

Fig. 10 Electronic-hydraulic analogy 2

As the capacity of the pump shown in Fig. 10 is same as the one shown in Fig. 9, the amount of water in the stream is also the same if using the same dry cell type battery. The amount of water in each of the inclined streams shown in Fig. 10 is split into half the amount of the water flowing in the upper stream. If an ammeter is not connected in series with the circuit (but in parallel with the circuit), two electric paths appear as shown in Fig. 10 and the electric current is split into half. Consequently, the measurement electric current value for Fig. 4 has displayed half the amount of Fig. 3.

2. Voltmeter is intended to be connected in parallel with the circuit.

This experiment is intended for learners to find out how to properly connect the voltmeter with the circuit, in a trial-and-error manner, from difference in measured electric voltage values. It is recommended to use electronic-hydraulic analogy when explaining the difference between current and voltage to learners.

Electric circuit shown in Fig. 6 can be illustrated as an analogy shown in Fig. 11 as the voltmeter is conned in parallel with the circuit. As shown in Fig. 11, like a water gauge, the voltmeter measures the potential difference in any given two points in the circuit.

The electric circuit shown in Fig. 7 can be illustrated as electronic-hydraulic analogy shown in Fig. 12 as the voltmeter is connected in series with the circuit (like an ammeter). As the diameter of the pipe for water stream (voltmeter) shown in Fig. 12 is very narrow, the water (electric current) can hardly flow in the pipe. Consequently, the waterwheel does not work (turn) (the bulb is not lit). Nevertheless, the potential difference can be measured by the voltmeter. The voltmeter resists or hinders the electric current flow with its high resistance, hence it is also kind of resistant.

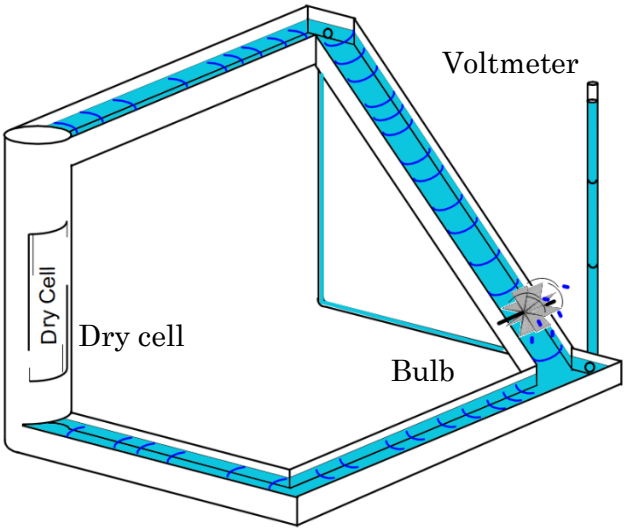

Fig.11 Electronic-hydraulic analogy 3

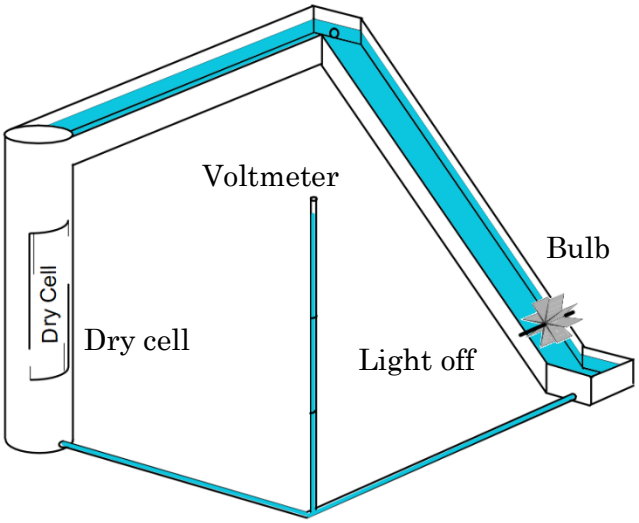

Fig.12 Electronic-hydraulic analogy 4

3. Voltmeter does not work in the connection between the dry cell and miniature bulb.

Although the miniature bulb is lit, the result of the experiment shown in Fig. 8 shows zero (0) voltage on the voltmeter due to no difference in height (at voltmeter) in the section shown in Fig. 13. As this section is the lowest point of the water stream, there is no height gap between both ends of the stream (after the bulb and before the dry cell battery).

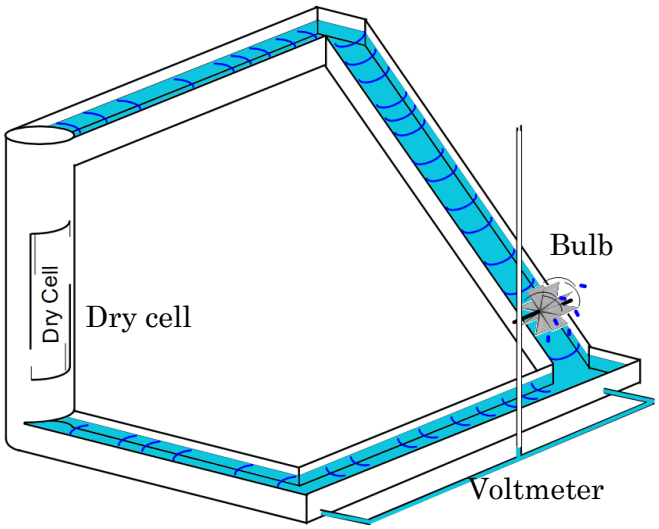

Fig.13 Electricity-hydraulic analogy 5

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