

# Visual Electricity Demonstrator

P6-2600



## BACKGROUND:

Electricity; like many theories in science, requires students to imagine the invisible. The flow of tiny *charged particles* through a conductor is what constitutes *electric current*. The inability of many students to picture this process has contributed to the lack of conceptual understanding.

The Visual Electricity Demonstrator can be placed into many circuits to simulate the flow and direction of electric current. This is accomplished using LED's in the unit to represent charged particles in the circuit. Connecting the unit in series with electrical components such as batteries, generators, capacitors, switches and light bulbs will make it possible for your students to understand how these components interact and change the flow of charged particles.

## IMPORTANT CONCEPTS:

The Visual Electricity Demonstrator can clarify several important concepts:

1. Charged particles exist in the wires before current starts to flow.
2. Charged particles in complete circuits move at a finite, observable speed – not the speed of light.
3. When voltage is applied to a complete circuit, particles at all points in the circuit begin moving instantaneously and simultaneously.
4. Charged particles in complete circuits can flow in a single direction (direct current) or back and forth (alternating current).

## OPERATION:

At each end of Visual Electricity Demonstrator you will find a post to which the wires of a circuit are attached using alligator clips. The unit is powered by one 9V cell, which is activated when the switch at one end is flipped. (This battery powers the LED's, and does not provide any voltage to the circuit beyond the Visual Electricity Demonstrator tube.) The LED's represent individual charged particles. When a voltage, or "push", is added to the circuit, charged particles all along the circuit begin to move. Increasing the voltage or "push" makes the charges move more, increasing the current. Current is measured in Amperes or Amps (A), which is a measure of the amount of charge that flows past a point of the circuit in a second. Switch the unit off when it is not in use, to prolong battery life.

## POSITIVE, NEGATIVE, AND DIRECTION OF FLOW:

The Visual Electricity Demonstrator shows the flow of positively charged particles. However, the charge of the particle that moves when voltage is applied varies, depending on the type of conductor. In metals (such as ordinary wires), it is actually electrons (which carry a negative charge) that are moving. Electrons in metallic conductors actually move in the opposite direction from the positive particles depicted in the Visual Electricity Demonstrator.

Type of conductor	Moving particle
Solid metals	Free electrons
Liquid metals	Free electrons and metal ions
Semiconductors	Electrons/Holes
Ionized gases	Electrons/Gas Ions
Electrolytes (including human flesh)	Opposite dissolved ions
Proton conductors (including ice, a poor conductor)	Protons

To simplify things, scientists and engineers agree on the standard of describing Conventional **Current** as a flow of **positive charge** through a conductor. Conventional ammeters and other electrical devices do not show a difference between positive charge flow in one direction and negative charge flow in the other.

## ACTIVITIES:

- A. Add the unit to a simple circuit which uses a battery, a switch and a light bulb. Closing the switch and completing the circuit shows the direction of flow while lighting the bulb. Switching the leads to the battery shows the reversal of the current. What happens to the charged particles in a circuit that is not closed, or complete? (they are still there, but they can't move through the circuit.)
- B. Use a Genecon to demonstrate direct and alternating current, and show that both types will light a bulb.
- C. The effect of adding more batteries or light bulbs can be investigated. Ask the students to predict the effects of adding more light bulbs in series with the first. Does the Visual Electricity Demonstrator show the current increasing or decreasing? [decreasing]
- D. Next, add the unit to the end of a circuit which has several light bulbs connected in parallel along with a power source (the Genecon and the parallel bulb base work well). Have the students predict if the current will increase or decrease as each light bulb is connected to the circuit. Explain the different results obtained with the two circuits. [more paths allow more current to flow]
- E. Create a circuit using a 1-Farad capacitor and a Genecon. Adding the unit to the circuit helps demonstrate the recharging and discharging of a capacitor. Ask the students to predict the direction of the charge flow when the handle of the Genecon is released, allowing the capacitor to discharge. [opposite direction] As an advanced question, ask the students which direction the handle of the Genecon will turn when the capacitor discharges through it. [the same direction because of Lenz's Law]
- F. Investigate electromagnetic induction using a Neodymium magnet and a large coil of wire. Connect the coil in series with the Visual Electricity Demonstrator as the magnet is pushed into the coil and then pulled out.

## BATTERY AND FUSE REPLACEMENT:

With use, the display will become noticeably less bright, due to a depleted battery (10 hrs or greater).

### To replace the battery:

1. Gently slide the end cap with the switch off the body while turning back and forth slightly.
2. Slide the circuit board and battery out of the body slowly.
3. **Warning! Wrap electrical tape** around the body of the replacement 9V heavy duty or alkaline battery as the original and connect the battery. (Putting in an unwrapped battery may result in an electrical short circuit and damage to the device and battery.)
4. With the battery on the underside of the circuit board and the LED's opposite the feet of the body, slide the circuit board and battery back in the body slowly, being careful not to snag the red color filter. Align the post on the end so that it will come through the hole in the end cap.
5. Twist the end cap with the switch slightly as you push it back on the body. Make sure the post on the circuit board comes through the hole in the end cap.

### To replace the fuse:

A fuse within the unit will protect it if the current exceeds the recommended values of 1.5A. Any power source greater than 3 volts connected directly across the unit will blow the fuse. If the fuse is blown, the display will still light, however it will no longer act like a "piece of wire". You will feel very little resistance when you attach the Genecon and turn the handle, as if the Genecon was attached to nothing at all. Remove the circuit board as described above and insert a new 1.5A, 5mm fuse into the holder.

### ACKNOWLEDGEMENTS:

Thank you to William Beaty, Research Engineer and Science Hobbyist, for his development of this product and his assistance in writing these instructions.

### RELATED PRODUCTS:

The **Genecon** (P6-2631) is a low voltage, hand-operated generator. It lets students feel the power in an electrical circuit. There are many interesting activities possible with the Genecon.

The **1 Farad Capacitor Demonstration** (P6-8012) works well with the Genecon to show the operation of a capacitor.

The **Series/Parallel Bulb Board** (P6-1120) demonstrates different types of circuits. When connected to the Visual Electricity Demonstrator, students see the effect of adding more devices to a circuit.

