Relays and Telegraphs

Overview In this lab, we're going to build our own relay that will attract a strip of metal to make our telegraph 'click' each time we energize the coil.

What to Learn Relays *are* telegraphs, and they both are basically "electrical switches." This means you can turn something on and off without touching it – you can use electricity to switch something else on or off, as we did in the last experiment.

Materials

- Block of foam about 6" square
- Sandpaper
- Alligator wires
- Battery case
- AA batteries
- Film canister or similar
- 2-4" nail
- Magnet wire
- Brass fasteners
- 1/2" strip from a steel soup can for the clicker
- Paper clip
- Hot glue gun
- Scissors
- Tape

Lab Time

IMPORTANT! This experiment is very tricky to get working right. You'll want to pair up with someone who's handy in the workshop and has a keen eye and a feather touch for adjusting the clicker in the final step. Someone who is a patient, fix-it type of person will be able to help you get this project working well.

1. Review the instructions on their worksheets and then break the students into their lab groups. Hand each group their materials.
2. Watch the video as you walk through these steps:
3. Make the electromagnet first. Wrap the magnet wire around the nail. (More wraps mean more power for your magnet, so use a lot!) You can insert a nail into a drill and wind it on slow speed.
4. Sand the insulation off the end leads.
5. Insert the AA batteries into their case.
6. Stick the electromagnet, pointy-end down, into the foam. If it wiggles around, you will need to hot glue it into place later (not now).
7. Hot glue one end of the clicker (the steel soup can piece) to the top of a film canister.

8. Attach the bottom of the film canister to the foam with hot glue, making sure the tip of the clicker is over the nail head. Do not glue the lid to the canister! It's a big plus to have it rotate and be adjustable.
9. Adjust and bend the clicker so that the electromagnet and nail have a *tiny* clearance between the nail head and the metal strip. You'll be adjusting this constantly as you play with your relay.
10. Hot glue the battery case to the foam off to one side.
11. Remove some of the insulation from the wires from the battery case. You need more wire exposed to wrap it around a brass fastener.
12. Wind the free end of the exposed wire from the negative black wire of the battery case around a brass fastener and insert it into the foam. Make sure you're only wrapping the part you've stripped or it won't make a good connection.
13. Bend a paperclip into a "V" shape.
14. Insert the brass fastener through the tip of the "V" shape and then into the foam. Do not use glue.
15. Wrap one of the electromagnet wires around a second brass fastener, making sure to only wrap the part of the wire that you sanded, and insert the fastener into the foam within reach of the paperclip. Be sure the smaller side of the "V" rests on the foam such that it does not reach the brass fastener; but the larger side of the "V", when pressed down, does. This is your switch.
16. Clip an alligator clip wire onto the positive battery wire, the other end connected to the last electromagnet wire. Again, make sure you're connecting to the part of the electromagnet wire that is sanded or it won't make a good connection.
17. Push your switch to the "ON" position (make it touch the second brass fastener), and the electromagnet should *click*.
18. ***Troubleshooting:*** If it doesn't click, move your electromagnet up or down, changing the nail-head-to-clicker distance until it clicks. If it sticks, it's too close. If it doesn't move at all, it's too far away. Hot glue the nail into the right position. Note that the clicker is bendable. Take your time – this is a project that requires patience and observation to figure out what's going on. If you're frustrated, STOP, take a breath, help someone else, and return later.

Reading

Why does this work? Anytime you run electricity through a wire, a magnetic field shows up. We're multiplying this effect when we coil the wire around a nail. A nail with wire wrapped around it is called an electromagnet. Think of it like a magnet you can turn on and off.

Using a paper-clip switch, we can turn the electricity on and send it through the electromagnet, turning the ordinary nail and wire into a magnet. When we release the paper-clip switch, the current (electricity) stops flowing and our electromagnet turns back into ordinary nail and wire.

When the electromagnet is energized (magnetized), it attracts the metal strip, which causes it to click downwards. Release the paper-clip switch, and the strip is no longer attracted to the nail (because it's no longer a magnet).

When the switch is on, it's a magnet. When it's off, it's not a magnet. Magnets attract steel, and that's why the strip bends and clicks. It's amazing we could communicate over thousands of miles this way, but we did, using telegraphs and repeaters!

Exercises

1. Why does the soup can clicker move?
2. Does this circuit use a permanent or electromagnet?
3. Why do we need multiple turns around a nail? Why not just a couple wraps?
4. What is the paper-clip switch used for?
5. How can a relay be used in real life? Give three examples.

Answers to Exercises: Relays and Telegraphs

1. Why does the soup can clicker move? (When the switch is on, the nail becomes a magnet. When it's off, it's not a magnet. Magnets attract steel, and that's why the strip bends and clicks.)
2. Does this circuit use a permanent or electromagnet? (Electromagnet)
3. Why do we need multiple turns around a nail? Why not just a couple wraps? (Anytime you run electricity through a wire, a magnetic field shows up. We're multiplying this effect when we coil the wire around a nail. A nail with wire wrapped around it is called an electromagnet.)
4. What is the paper-clip switch used for? (Using a paper-clip switch, we can turn the electricity on and send it through the electromagnet, turning the ordinary nail and wire into a magnet. When we release the paperclip switch, the current stops flowing and our electromagnet turns back into ordinary nail and wire.)
5. How can a relay be used in real life? Give three examples. (As part of the circuitry to keep the fridge cold, to repeat signals over long distances, and as a position indicator using a mercury switch.)