

EQUIPMENT BUILD PLAN

ELECTRICITY & MAGNETISM

Tangent Galvanometer

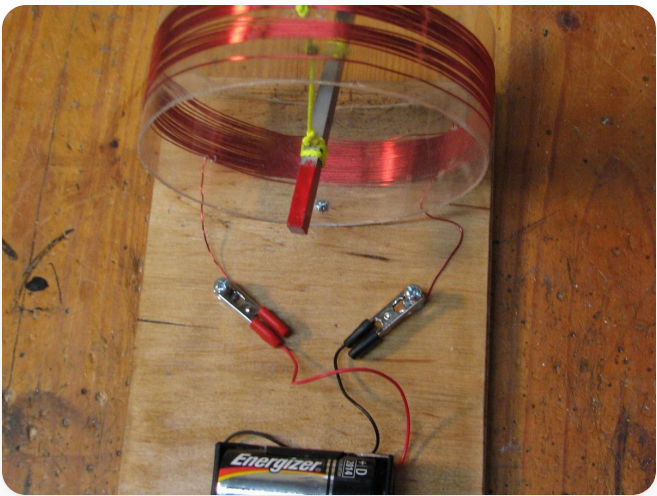
A classic 1800s instrument made from a ring cut from a plastic jar or soda bottle, about 20 turns of magnet wire and a bar magnet hanging on a string. Connecting a battery makes the coil an electromagnet, and the magnet turns to line up with its field. Reversing the current flips the field, and the magnet turns 180 degrees.

Written from Bruce's original workshop handout. Bruce's final review of this plan is in progress.

What it shows

Clip on one wire and a hanging bar magnet swings to face across a ring of copper wire; reverse the battery and it spins all the way around.

Key ideas: magnetic field of a current, electromagnets, magnetic poles, direction of current, galvanometer



DIFFICULTY	BUILD TIME
Beginner	1-2 hours
COST	SAFETY
About \$10	Everyday care
GOOD FOR	
Teachers, Makers, Families	

Safety (Everyday care). An adult should cut the jar and do any drilling and soldering. The coil has low resistance, so connect the battery only while demonstrating; left connected, the wire and battery get warm and the battery drains quickly.

Build it

Materials

- ☐ **Large clear plastic jar, or a 2- or 3-liter soda bottle** · 1
Its diameter should be a little larger than the bar magnet's length
- ☐ **Bar magnet** · 1
Paint or mark the ends to show the poles
- ☐ **Copper magnet wire, 22-26 gauge** · enough for about 20 turns plus two 8 in leads
- ☐ **Battery holder (1 D cell) and battery** · 1
- ☐ **Bolts with nuts** · 2
Connection terminals
- ☐ **Small screws** · 4
- ☐ **Alligator clips** · 2
- ☐ **String** · about 12 in
- ☐ **Plywood base** · large enough to hold everything

Tools

Scissors, utility knife or hacksaw

Drill with small bits

Screwdriver

Sandpaper

Soldering iron and solder

1

Cut the ring

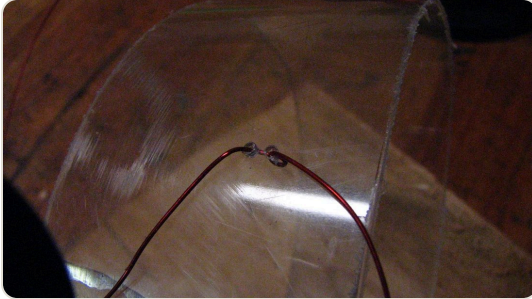
Cut a 3 in wide band from the jar or bottle. A soda bottle can be cut with scissors; a heavier jar may need a saw.



2

Drill the wire holes

Drill two small holes near the top of the ring and thread the start of the wire through them to anchor it, leaving about 8 in free for connecting to a terminal bolt.



3

Wind the coil

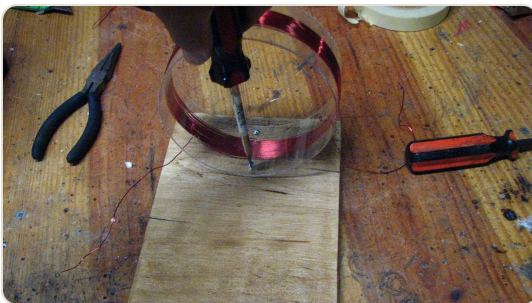
Wrap the wire around the ring about 20 times, keeping the turns together in a neat band. Drill two more holes about 3 in from the first pair and thread the end of the wire through them to lock the last turn, again leaving a lead.



4

Mount the ring

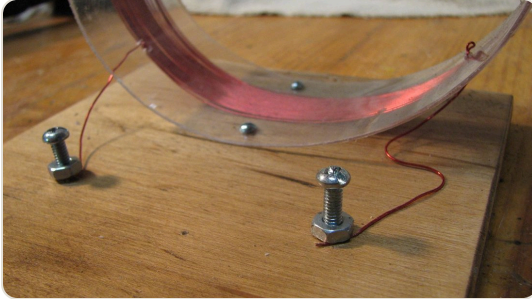
Screw the ring to the wood base with its wire ends near where the terminal bolts will go.



5

Add terminals

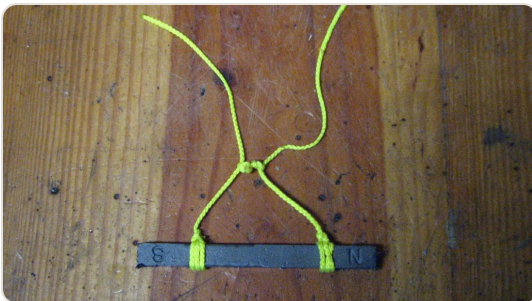
Drill holes for two bolts and screw them into the base. Sand the enamel off the ends of the coil wires, since the coating is an insulator, and wrap each end around a bolt.



6

Hang the magnet

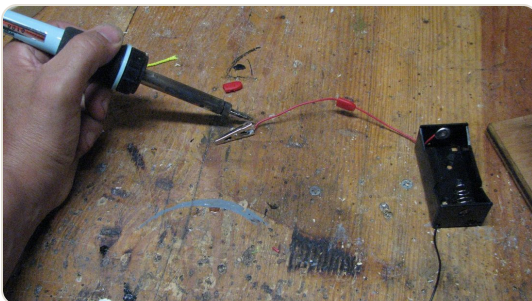
Tie the string around the bar magnet in a cradle so it hangs level. Push the coil wires aside at the top center of the ring and thread the string through the hole there so the magnet hangs in the middle of the coil.



7

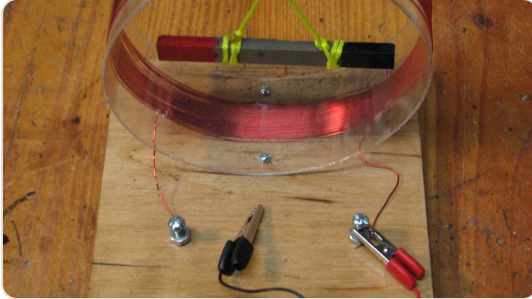
Wire the battery

Solder alligator clips to the battery holder's leads and screw the holder to the base. Clip one lead to a terminal bolt and leave the other free until you are ready to demonstrate.



Test it

With no current, the magnet can be turned freely. Clip on the second lead and the magnet swings to sit across the ring. Lift and turn the string to adjust its resting position.



THE PHYSICS

How it works

A current flowing around a loop of wire produces a magnetic field that runs straight through the center of the loop, at right angles to the plane of the coil. Twenty turns multiply that field twenty times. The coil behaves like a short, fat bar magnet with a north face on one side and a south face on the other.

The hanging magnet lines up with the field, so it turns until it points through the coil, perpendicular to the ring. Its south pole points toward the coil's north face and its north pole toward the south face.

Reverse the battery and the current runs the other way around the loop, so the coil's north and south faces swap. The bar magnet turns 180 degrees to match.

In a true tangent galvanometer, the coil is aligned north-south and the magnet is a small compass needle. The needle's deflection angle then depends on the balance between the coil's field and Earth's field: the tangent of the angle is proportional to the current, which gives the instrument its name. Bruce's

Using it

- Show the magnet turning freely with no current, then connect the battery. Ask: what made the magnet move?
- Before reversing the battery, ask students to predict what the magnet will do.
- Use a compass held near each face of the coil to find its north and south faces, and compare them with the bar magnet's marked poles.
- Turn the whole base so the coil faces north-south, swap the bar magnet for a compass, and use a weaker current (more resistance or fewer turns) to see the deflection angle change with current.
- Connect two batteries in series and compare how firmly the magnet snaps into position.

demonstration uses a strong current so the coil's field dominates.

GO FURTHER

Variations

- Replace the bar magnet with a compass sitting at the center of the coil for a version closer to the historical instrument.
- Try different numbers of turns and compare how strongly the magnet responds.

IF IT DOESN'T WORK

Troubleshooting

IF THIS HAPPENS

Magnet does not move when the battery is connected

TRY THIS

Sand the enamel completely off the wire ends at the bolts and check the battery.

IF THIS HAPPENS

Magnet rubs the ring

TRY THIS

Use a wider ring or a shorter magnet, and center the string at the top of the coil.

IF THIS HAPPENS

Magnet swings around and never settles

TRY THIS

Hold the string still for a moment, or tie the magnet closer to its center so it hangs level.