

Novel Experiments With Electricity

by

John Potter Shields



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Preface

Electricity and magnetism help to form the "building blocks" of the modern world. While we often take these invisible servants for granted, they are both very fascinating. A good understanding of them can be intriguing and useful. You will learn how all matter is composed of basic building blocks called molecules. A simple discussion will show how these molecules are constructed, and how they are associated with electricity and magnetism.

The book is intended to introduce the myriad of the fascinating properties of electricity and magnetism. In the pages that follow, you will find first a brief introduction to the fundamentals of electricity and magnetism. Secondly, you will find a number of interesting and novel experiments that range from a ground telephone and electric arc to a miniature lightning generator and synchronous motor. To help in the construction of the experiments, the book has been profusely illustrated.

All efforts have been made to keep project costs down. In many cases, the projects can be assembled with parts from your junk box. The parts have been selected so that they are readily available from your local electronics distributors or one of the catalog supply houses.

It is the sincere hope of the author that you will find this book a source of many hours of enjoyment.

JOHN POTTER SHIELDS

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Miscellaneous Electrical Experiments

In this final chapter, we will present a number of miscellaneous experiments that are interesting and unusual.

THE MERCURY SWITCH

One of the most interesting switches available to the experimenter is the mercury switch. As shown in Fig. 4-1A, the basic mercury switch consists of a glass envelope that contains two metal contacts and a globule of mercury. In the upright position, the mercury is not in contact with the two electrodes, and so the switch is in its "open" or "off" position.

When the mercury switch is tilted as shown in Fig. 4-1B, the blob of mercury shifts so that it bridges the two contacts. Since mercury is an electrical conductor, current is conducted through the contacts. The switch is now in the "closed" or "on" position.

There are a number of interesting applications for the mercury switch. One of the most common applications is the "silent" light switch. In the "off" position, mercury is positioned so that it is not in contact with the contacts. When the switch lever is placed in the ON position, the internal switch is tilted so the mercury makes contact with the contacts.



Fig. 4-1. The basic mercury switch.

The experimenter can readily obtain inexpensive mercury switches from most electrical or electronic parts distributors. This switch is supplied with leads for easy interconnection into the external circuit.

Fig. 4-2 shows how the mercury switch can be used as a safety switch for an electric heater. In normal operations, with the heater in the upright position, the mercury switch is also in a horizontal position, and its contacts are closed. Thus, there is current through the heater. Now, should the heater be accidentally knocked over, the mercury switch will be tilted, the contacts will be opened, and current through it and the heater will be interrupted.

If you decide to add this safety feature, use electrical tape to insulate all exposed electrical connections. This safety feature can also be added to devices other than electrical heaters.

Fig. 4-3 shows another application for the mercury switch—a simple burglar alarm. The alarm will sound if the window is opened. As shown, the mercury switch is attached to a small piece of wood. The wood is held in place against the window sill by means of a small spring. The mercury switch

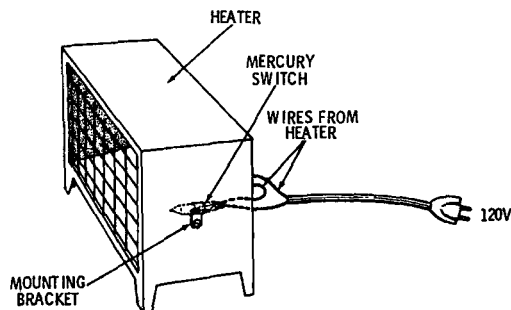


Fig. 4-2. Mercury switch used as heater safety switch.

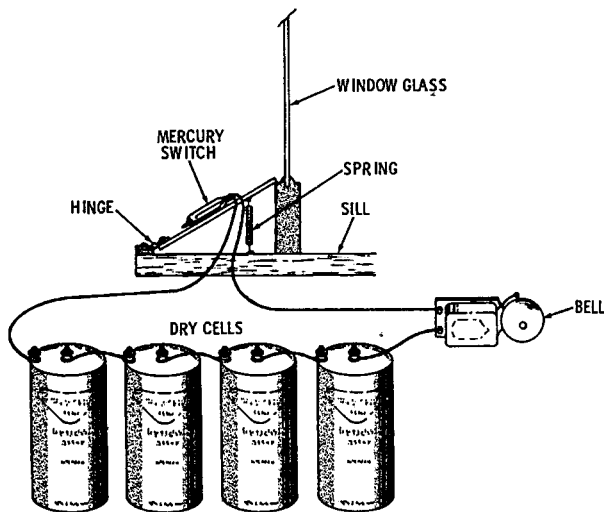


Fig. 4-3. Mercury switch burglar alarm.

is so oriented that with the window closed, the switch is in the "off" position. The contacts of the mercury switch are wired in series with a bell or buzzer and a six-volt battery as shown.

In operation, when the window is opened, the piece of wood drops down to a horizontal position, causing the mercury switch to tilt downward. In turn, this will close the contacts of the switch, and the alarm bell will ring.

THE MAGNETIC REED SWITCH

Another interesting type of switch for the experimenter is the magnetic reed switch. Fig. 4-4 shows the basic magnetic reed switch. Two long metal contacts are encased in a sealed glass tube, and leads to these contacts are brought out through the ends of the tube. Normally, the contacts are separated and the switch is in the OFF position.

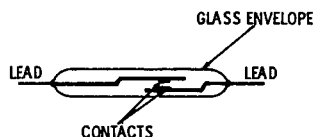


Fig. 4-4. Basic magnetic reed switch.

When an external magnet is brought near the glass tube of the reed switch, the magnetic field causes attraction between the two contacts, and they close, placing the switch in the ON position.

There are a number of interesting applications for the magnetic reed switch. Fig. 4-5 shows how the magnetic reed switch can be used as a simple intrusion alarm. The reed switch is mounted on the base of the window by means of either a nonmagnetic bracket, or by a bit of duco cement. A small permanent magnet is mounted on the window. The magnet is positioned directly over the switch so that the reed switch is actuated (contacts closed).

The reed switch is wired through a relay to a bell or buzzer. The relay is a 6-Vac type with spdt contacts. A suitable relay is the Potter and Brumfield KUP5A15. A 6-volt filament transformer powers the relay. A suitable transformer is the Allied 54A1419 or equivalent.

In operation, with the window in the normally closed position, the magnet actuates the reed switch. Thus, the current path is through the switch, relay coil, and the secondary of the filament transformer. The relay is energized, and no current is applied to the warning bell. Should the window be opened, the magnet will move away from the reed switch. This will open the circuit, causing the relay to drop out

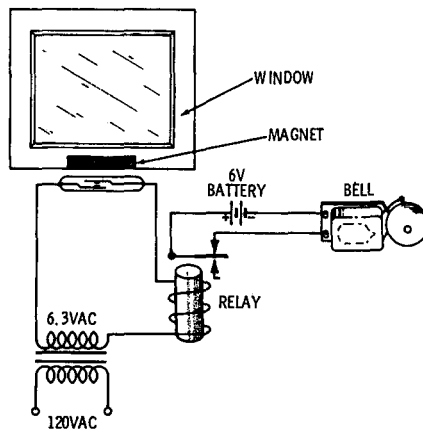


Fig. 4-5. Magnetic reed switch burglar alarm.

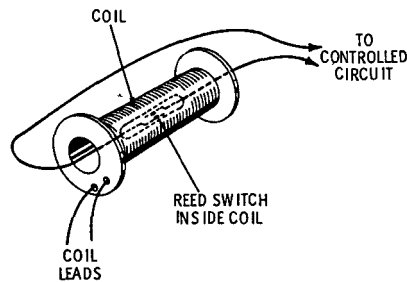
(open). The circuit to the alarm bell will be closed; this rings the bell.

This alarm circuit has a rather novel feature, in that it is "fail-safe." That is, should the 120-volt power line be opened, the alarm bell will ring as the relay drops out. Similarly, if the wires to the reed switch are cut, the relay will again drop out, ringing the alarm bell.

Fig. 4-6 shows how the magnetic reed switch can be converted to a sensitive electromagnetic relay. Make a cardboard tube with a diameter just large enough to slip the reed switch into. Make two cardboard washers and cement them to the ends of the cardboard tube. Apply several coats of duco or radio service cement to the cardboard tube and washers to stiffen them.

Wind the core full of No. 24 or No. 26 enamel magnet wire. Bring the ends of the winding out through the small holes punched in one of the cardboard washers.

Fig. 4-6. Coil-actuated reed switch.



To operate the relay, place the reed switch into the center of the coil. Connect the circuit to be controlled to the reed switch terminals. The coil can be energized by a 6-volt battery or other low-voltage dc source. Fig. 4-7 shows the setup.

The magnetic reed switch can also be used as a safety interlock switch, as shown in Fig. 4-8. Here, the reed switch is mounted on the inside of the equipment cabinet by means of a small bracket. A small magnet is mounted on the door of the equipment. The contacts of the reed switch are wired in series with the 120-volt power source feeding the equipment.

In operation, when the door of the equipment cabinet is closed, the permanent magnet is next to the reed switch, its

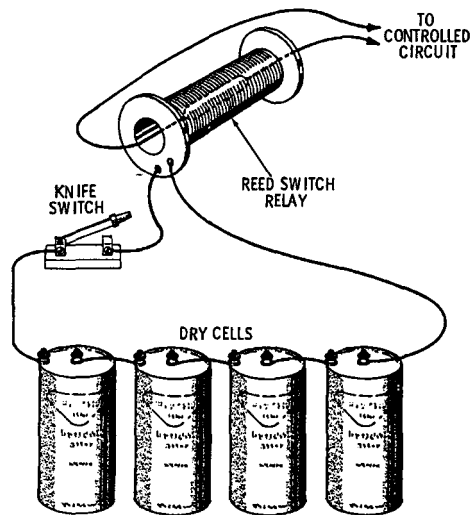


Fig. 4-7. Hookup of coil-actuated reed switch.

contacts close, and power is applied to the equipment. If the door is opened, the magnet is moved away from the reed switch. The reed switch contacts open, removing power from the equipment.

NOTE: If the equipment draws much more than a few hundred watts, a relay should be used in series with the reed switch, because the reed switch contacts will not handle

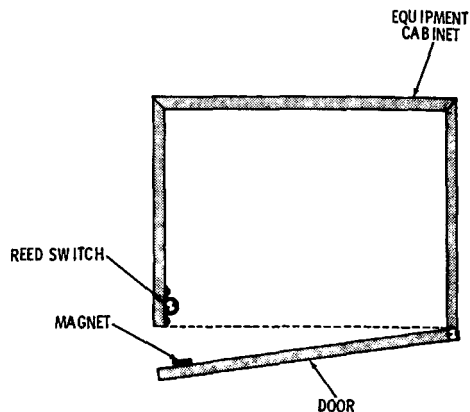


Fig. 4-8. Reed switch safety interlock.

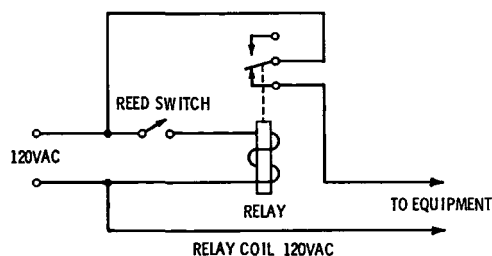


Fig. 4-9. Using a relay in series with the reed switch interlock.

more than a few amperes. Fig. 4-9 shows the setup for using a relay in series with the reed switch.

A SIMPLE WATTMETER

This simple wattmeter is a very handy device for checking the current consumption of various pieces of electrical equipment and appliances. To operate the wattmeter, simply plug the unit that is to be measured into the receptacle and note the meter reading.

Fig. 4-10 shows the schematic of the wattmeter. The device whose current consumption is to be checked is plugged into the receptacle, which is in series with half of the secondary of T1 and the 120-volt line. Thus, the amount of current through the secondary of T1 will be determined by the current drawn by the device plugged into the receptacle.

The amount of current drawn by the load connected in series with the secondary of T1 will be reflected as a voltage across the primary terminals of T1. Thus, the greater the current drawn by the load, the greater is the voltage de-

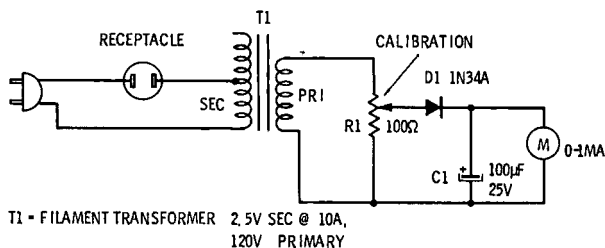


Fig. 4-10. Schematic diagram of a wattmeter.

veloped across the primary of T1 and vice versa. As a result, the voltage developed across the primary of T1 is an indication of the load current.

The voltage developed across the primary of T1 is applied to calibration potentiometer R1. The voltage appearing at the slider of R1 is rectified by the half-wave rectifier, consisting of D1 and C1. The resulting dc voltage developed by the half-wave rectifier is applied to indicating meter M.

To calibrate the wattmeter, plug a known load (light bulbs of various wattages will do nicely) into the socket, and plug the line cord into a source of 120 Vac. Assuming the meter scale of 0-1 mA to represent 0-1000 watts, adjust the calibration control for appropriate reading. For example, if a 100-watt light bulb is used as the load, adjust the calibration control for a reading of 0.1 mA, on the meter, and so on.

A DEMONSTRATION CARBON MICROPHONE

This demonstration carbon microphone is similar in design to the first telephone invented by Alexander Graham Bell.

Fig. 4-11 shows how the demonstration carbon microphone is constructed. First, obtain a discarded No. 6 dry cell and disassemble it so as to salvage the carbon rod. After the carbon rod is removed, saw off two sections as shown in Fig. 4-11A. Next, saw a "flat" on each of the two sections of carbon rod and cement these sections to a cigar box. The spacing between the carbon rod "blocks" should be about three inches.

Next, mount the cigar box with the attached carbon blocks to a second cigar box by means of small machine screws and nuts, as shown in Fig. 4-11B. Attach a wire to each carbon block by using tape. Tape a piece of mechanical pencil lead and position it between the two carbon blocks so that it makes a "loose fit."

Finally, connect the leads from the carbon blocks in series with an spst switch, a pair of 2000-ohm headphones, and two series-connected No. 6-dry cells.

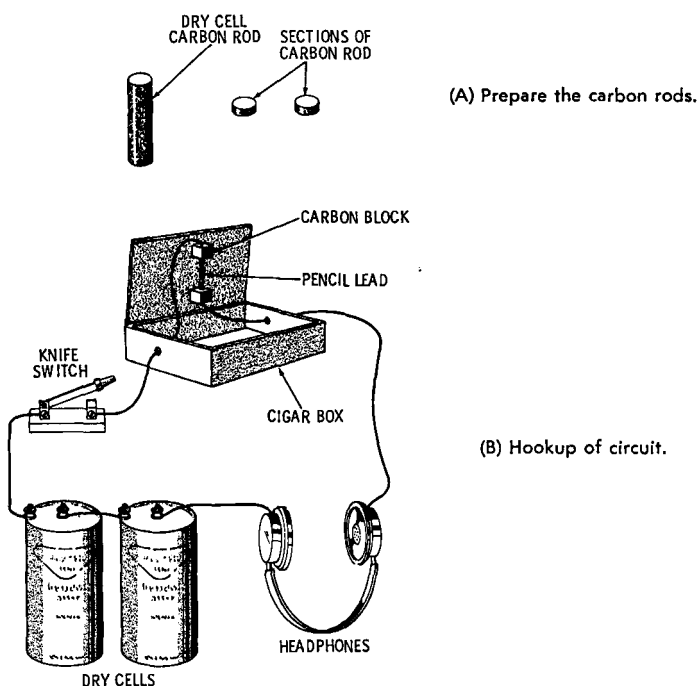


Fig. 4-11. Demonstration carbon microphone.

To operate the demonstration carbon microphone, place the switch in the ON position. Tap the cigar box lightly with a finger tip and notice how the greatly amplified sound is heard in the headphones. To further demonstrate the amplifying qualities of this microphone, place a watch on the cigar box. You will hear the greatly amplified sound of the watch ticking in the headphones.