Humphry Davy and the Arc Light

» Thomas Edison did not invent the first electric light.* More than 70 years before Edison's 1879 incandescent lamp patent, the English scientist Humphry Davy developed a technique for producing controlled light from electricity.

Sir Humphry Davy (1778–1829) was one of the giants of 19th-century science. A fellow of the prestigious Royal Society, Davy is credited with discovering, and first isolating, elemental sodium, potassium, calcium, magnesium, boron, barium, and strontium. A pioneer in electrochemistry, he also developed the first medical use of nitrous oxide and invented the miner's safety lamp. The safety lamp alone is directly responsible for saving hundreds, if not thousands, of miners' lives.

But it is his invention of the arc lamp for which we remember him here. Davy's artificial electric light consisted of two carbon rods, made from wood charcoal, connected to the terminals of an enormous collection of voltaic cells. (In Davy's day, thousands of cells, similar to modern chemical batteries, had to be wired together in series to produce the voltage required to strike an arc between the carbon electrodes.) When Davy closed the switch connecting the battery to the electrodes, electricity jumped between the carbon tips. The result — a continuous, glaring, lucent dot of white heat — was so bright that it was dangerous to look at for more than a split second.

While making an arc light isn't terribly complicated, the arc's underlying physical processes are indeed complex. Although normally a nonconductor, carbon will conduct electricity in certain circumstances. The graphite rods used in arc lights conduct electricity, albeit grudgingly, if enough electrical potential is applied. At high voltage levels, the rod tips become white-hot, and carbon particles break away from the main body of the rod. Within the resulting particulate mist, small bits glow white with heat and jump across the spark gap between electrodes. This produces the incandescent arch of light known as an *electric arc*.

"The Dazzling Splendor," as Davy called it, was a tricky beast to control. After the initial sparks appeared between the electrode tips, Davy had to separate the carbon electrodes slightly and carefully in order to sustain the continuous, bright arc of electricity. Once that was accomplished, he found the device could sustain the arc for long periods, even as the carbon rods were consumed in the heat of the process.

BRILLIANT MISTAKES: Humphry Davy, chemist, inventor, and philosopher: "I have learned more from my failures than from my successes."

Image from National Portrait Gallery, London

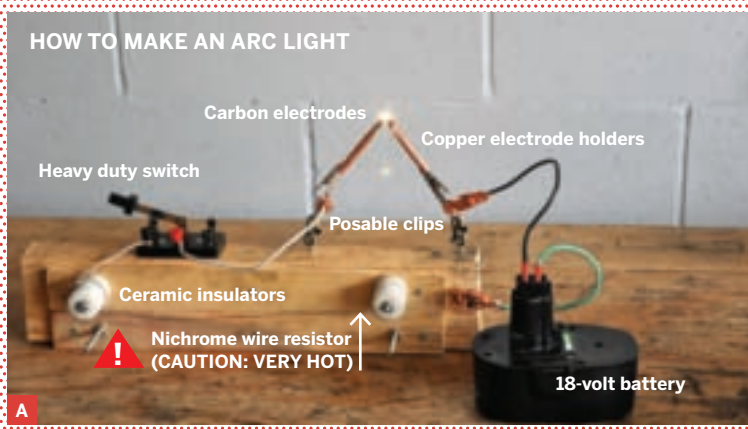
Davy's arc lamp of 1807 was not economically practical until the cost of producing a 50V-or-so power supply became reasonable. This didn't occur until the mid-1870s, with the introduction and commercialization of the electrical dynamo. But as soon as that happened, arc lights were everywhere, archetypically in searchlights, as well as in lighthouses, streetlights, movie sets, and movie projectors.

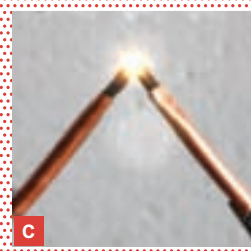
It took a lot of juice to run a searchlight. To maintain its arc, a 60-inch-diameter World War II vintage carbon arc searchlight drew about 150 amps at 78 volts, which is roughly equivalent to a 12,000-watt light bulb. A lot of power, yes, but it could light up an airplane 5 miles away.

Perhaps the largest carbon arc lamp ever made was the 80-inch-diameter monster searchlight built at the turn of the 20th century by General Electric. It lit the grounds of the 1904 St. Louis World's Fair with its billion-candlepower arc light.

This month's Remaking History project shows how to make a smaller version of the dazzling splendor in your workshop without too much trouble.

**It seems that Edison may deserve credit for the first electric light bulb, but even that is controversial.*





THE DAZZLING SPLENDOR: You can build Sir Davy's world-changing 1807 invention out of simple materials such as copper and carbon (Figure A), powered by a 12V or 18V battery instead of Davy's primitive voltaic cells. He used charcoal, but nowadays it's easiest to get your carbon rods straight out of non-alkaline batteries (Figure B). When electricity is applied, small bits of hot carbon jump across the gap, producing a dazzling incandescent arc (Figure C).

SAFETY CAUTIONS

Please read before beginning the project.

» The arc light produces *strong ultraviolet light* that can damage skin and eyes. For safety, use arc welding style eye and skin protection including gloves, long sleeves, and a helmet with #7 shade or darker when using the arc light.

» The Nichrome wire and copper electrode holders get *extremely hot*. Be very careful around them! There is little to no shock hazard associated with 12- and 18-volt batteries.

» This is a demonstration device only and should only be operated intermittently and for brief intervals. *Running the arc lamp for too long can damage your battery or battery charger.* If using a battery charger, check the ammeter on your charger to make sure the circuit is not shorted. If it is, or nearly is, use a longer Nichrome wire.

MATERIALS AND TOOLS

12-volt battery charger with ammeter, or an 18-volt battery from, say, a portable power drill
Carbon rod, about ¼" diameter, ½" lengths (2)
The easiest way to obtain a pure carbon rod is to cut open a regular non-alkaline AA, C, or D cell battery with a Dremel tool or hacksaw. Such batteries are usually labeled "heavy duty" or "non-alkaline." Cut off the top and carefully remove the carbon rod from the black, greasy packing that surrounds it. The packing material will stain hands, clothes, and work surfaces, so wear rubber gloves and cover surfaces with newspaper.
Miscellaneous wood pieces
20- to 24-gauge Nichrome wire, 2'
Porcelain insulators (2) Electric fence insulators work well.
Nuts and bolts to mount insulators to wood base
Heavy-duty flexible stranded lamp cord
Small copper spring clamps (2)
¼"-diameter copper tubing, 1½" lengths (2)
Heavy-duty on/off switch aka knife switch
Posable alligator clips I used clips from a discarded "third hand" tool, but you could easily make them by soldering an alligator clip to a stout copper wire.
Miscellaneous wood screws
Wire stripper/crimper
Needlenose pliers
Screwdriver
Sandpaper
Gloves
Eye protection such as an arc welding helmet

Photography by William Gurstelle

Making a Davy Carbon Arc Light

1. Carefully clean the 2 carbon electrodes. Sand them until they fit snugly into the ¼"-diameter copper tubes. Crimp each carbon rod into place in a copper tube. Sand the protruding end into a point.

2. Mount the posable clips to a wood frame as shown. Position the electrodes so the carbon points are just barely touching.

3. Mount the on/off switch as shown.

4. Mount the ceramic insulators as shown in the photo, approximately 10" apart.

5. Wire the circuit. The circuit is very simple. Electricity from the battery goes to the first electrode holder, through the carbon electrode, across a very small spark gap to the second electrode. From there, the electricity goes through the main on/off switch and then across a length of Nichrome wire before entering the opposite pole of the battery or battery charger.

6. Close the switch and carefully adjust the spark gap until a bright white light is obtained.

7. Once a bright arc is struck and maintained, you can optimize the light output of the system by making the Nichrome resistor wire longer or shorter.

Operation

Every homemade arc light is a bit different. Make adjustments as necessary. The spacing of the electrode gap is critical, so take your time adjusting it in order to obtain the best arc light. Too much or too little contact will result in no arc light.

Your battery will be damaged if the circuit is run without adequate load. The Nichrome wire provides just enough resistance to prevent the battery from shorting.

You'll have to adjust the length of the Nichrome wire for best performance; if it's too short, it will quickly burn up, but if it's too long, the arc light will be dim. Find the correct length through trial and error.

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Photography by Ed Troxell