Let it Glow: Understanding Fluorescent Lamps

An ongoing dispute exists over who to credit with the invention of the fluorescent light bulb, an ingenious and innovative electrical breakthrough. Some say it was the electric eccentric, Nikola Tesla. Some say it was Peter Cooper Hewitt, who patented the necessary mercury vapor lamp. And still others credit Agapito Flores, a Filipino electrician. But no matter the inventor, the fluorescent lamp is one of the most widely used lighting fixtures in the world, as well as a "green" source of energy, made possible through a clever configuration of mercury gas, high energy electrons, and a phosphorus tube.

Basic Configuration

"Light," according to Harris, "is a form of energy that can be released by an atom." To release the light which is created by light photons in an atom, the atom must be excited. When excited, the atom's electron energy is boosted, and moves to a higher orbital, or rings in which the electron moves. As soon as it reaches the higher ring, the electron will move back to its original position, closer to the nucleus of the atom. In an incandescent light, as in the average light bulb, heat is used to excite the atoms. However, in other lighting sources, such as fluorescent light bulbs, the reaction is a chemical one and is far more complex.

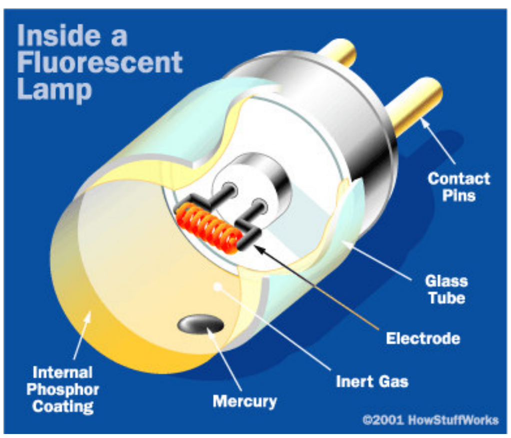


Figure 1: The basic parts of a fluorescent lamp.

Basically, a fluorescent lamp is made up of a bunch of little parts, as shown in Figure 1. The sealed glass tube is covered with a phosphor powder to reduce the energy of the electrons and make the light waves visible to the human eye. The inside of the tube is filled with argon, or another inert gas, and has a small amount of mercury at one end. To heat and excite the atoms, there are two electrodes at either end of the tube, wired to a supply of alternating current.

When the lamp is turned on, the voltage that passes between the electrodes turns the mercury into a gas. When it becomes a gas, the mercury will begin colliding with the charged atoms, and will excite them. Because of the way that the mercury's atom is arranged, it will produce an ultraviolet wavelength, which does not register in the human eye. However, the phosphor powder that coats the tube reduces the light's energy and gives off a visible, white light.

Also in a fluorescent light bulb, there is a gas conductor, rather than the usual solid conductor, which carries the electrical charge by free electrons and ions.

Ions are atoms that have lost or gained an electron, and are therefore electrically charged. However, in gases there aren't many ions or free electrons, and they therefore must be added to the gas through the electrodes. One of the ways to do so is by using the starter switch. As the lamp is turned on, the circuit will pass through both of the electrodes, which are made of the usual filaments (which are found in ordinary light bulbs), and will heat them. As the electrodes get hotter, the electrons will boil off of the metals, and into the gas in the tube.

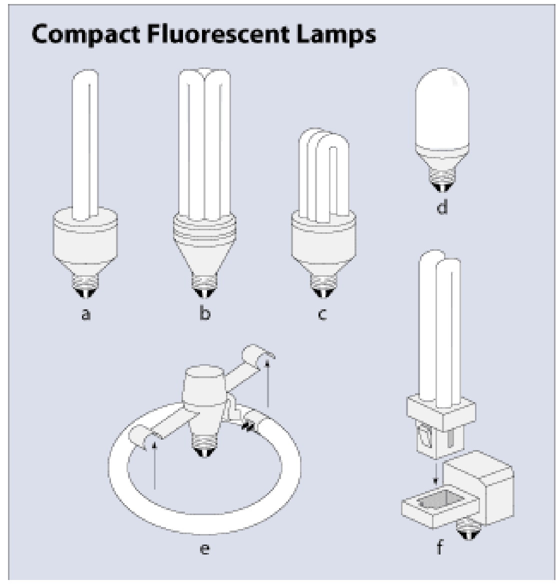


Figure 2: Compact fluorescent lamps (CFLs) come in a variety of sizes and shapes including (a) twin-tube integral, (b and c) triple-tube integral, (d) integral model with casing that reduces glare, (e) modular circline and ballast, and (f) modular quad-tube and ballast. CFLs can be installed in regular incandescent fixtures, and they consume less than one-third as much electricity as incandescent lamps do.

An alternative to the standard bulb is the Compact Fluorescent Lamp (CFL), (See Figure 2) "CFLs work much like standard fluorescent lamps. They consist of two parts: a gas-filled tube, and magnetic or electronic ballast. The gas in the tube glows with ultraviolet light when electricity from the ballast flows through it. This in turn excites a white phosphor coating on the inside of the tube, which emits visible light throughout the surface of the tube," ("Compact").

<u>Rapid-start and Instant-start Lamps</u>

Usually, the process of heating the lamp requires a complicated heating system and starter switch, which takes a few minutes to fully complete. However scientists have created a more popular version, called the rapid start lamp. This version skips the starter switch completely. Instead of using the switch, the current is constantly channeled through the ballast and through both electrodes. To create a voltage, the flow is altered so that the charge is different in both electrodes. In another method, the instant-start lamps use a supremely high voltage to heat the electrodes, which causes the extra electrons on the filaments to force themselves into the gas, which ionize it. There are pros and cons to different lamps: "Instant start ballasts put more stress on the lamp when it's started; therefore slightly reducing lamp life, but they also use less electricity. However, at about 12 or more hours of operation per start, lamps on instant start ballasts have about the same lamp life as those on rapid start ballasts," ("How Fluorescent").

Ballasts and Safety Precautions

Unfortunately, there is a downside to the more-efficient fluorescent lamps. Because of the high gas discharge, there is a risk of explosion if the current is not carefully controlled, mostly by the ballast. Magnetic ballast, the simplest kind, opposes the current flow and stops it from changing because of its inductor-like mechanics. Stern explains the ballast:

> If you have studied electricity, you surely learned there about Ohm's Law, by which the current flowing through a device is inversely proportional to its electrical resistance R. Double the resistance R and only 1/2 of the current gets through, replace it with one 10 times larger and only 1/10 as much manages to flow. It is a bit like water flowing in a pipe--if you make the pipe 10 times narrower, then (other things being equal) only 1/10 as much water flows through." Stern goes on to say that "Well, in case you thought that Ohm's law was a universal law of electricity--think again, because it isn't. Metal wires satisfy it fairly well, although their resistivity varies with temperature: a cold light bulb filament has only 1/5 the resistance of a hot one, so that initially the lamp draws a 5-fold current, which helps switch it on quickly. But plasmas do not satisfy it at all. The resistance of your fluorescent lamp is not fixed, it depends on the current carried: the greater the current, the smaller the resistance.

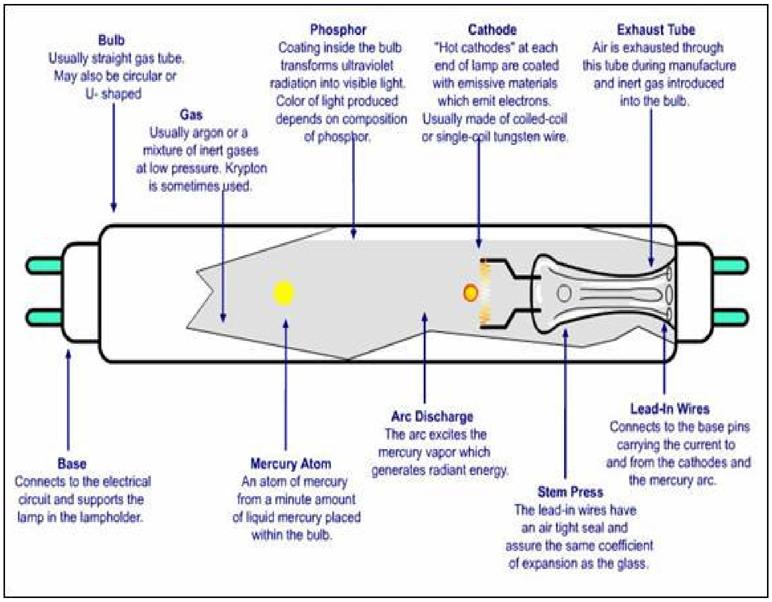
But even so, the multitude of the population uses fluorescent lamps for their "greener" energy practices.

> "Fluorescent lamps are more efficient than incandescent light bulbs of an equivalent brightness. This is because a greater proportion of the power used is converted to usable light and a smaller proportion is converted to heat, allowing fluorescent lamps to run cooler. A typical 100 Watt tungsten filament incandescent lamp may convert only 2.6% of its power input to visible

light, whereas typical fluorescent lamps convert between 6.6% and 15.2% of their power input to visible light - see the table in the luminous efficacy article. Typically a fluorescent lamp will last between 10 to 20 times as long as an equivalent incandescent lamp. The higher initial cost of a fluorescent lamp is usually more than compensated for by lower energy consumption over its life. The longer life may also reduce lamp replacement costs, providing additional saving especially where labour is costly."

<u>Conclusion</u>

All in all, the magic behind the fluorescent lamp is really just simple chemistry. The heated mercury reacts with the inert gas inside the tube, which excites the atoms and releases the light photons, which are filtered and made visible by the phosphor powder. It is found to be a successfully "green" source of energy, through the use of less fueling energy. The variations, instant-start (See Figure 3) and rapid-starts are beginning to make their way as another source of "green" energy—protecting our environment and lighting up our lives.



The alternate lamp, instant-start, are often found in large buildings, i.e. schools, offices, etc.

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