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Tungsten filament fire

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We safely remove the outer glass bulb from an incandescent lamp and burn up the tungsten filament after the glass is removed. This demonstration dramatically illustrates the necessity of a vacuum or inert gas for the environment surrounding the tungsten filament inside the bulb. Our approach has added historical importance since the incandescent light bulb is being replaced by compact fluorescent and LED lamps.

We present an attention-grabbing demonstration where we safely remove the surrounding glass from an incandescent light bulb and burn the tungsten filament brightly in a darkened classroom. The entire demonstration is performed right before the students' eyes, incorporating audience participation. The eye-catching memorable display energizes students and helps them remember that an operational filament needs a vacuum or inert environment. We provide a video link to the performance [1].

Historical context

Incandescent light bulbs have been commonplace in household and industrial lighting since their popularization in the beginning of the 20th century. These lamps have also been frequently used in physics classrooms and laboratories to facilitate discussions of the visible spectrum, black-body radiation, light circuits, and lighting efficiency. Their design and principles of operation are important learning objectives in many introductory physics courses [2-4].

The incandescent light bulb has been problematic over the decades of its use because it gives off far more infrared light, i.e. heat, rather than visible light. Therefore, these bulbs are being replaced by more efficient lamps that do not rely on incandescence, i.e. the heating of a filament. The incandescent light bulb has added historical importance due to its phase out and replacement by the more energy-efficient compact fluorescent and LED lamps [5].[1,2]

Sketch of an incandescent light bulb

A simple sketch of the incandescent light bulb appears in figure 1. Electrical wires connect to each side of the tungsten filament. A glass bulb allows for the filament to be kept in an environment of a vacuum or inert gas. Electrical current through the filament, either alternating current for a household lamp or direct current for a torch (flashlight), causes the filament to heat up and glow. Without the

[1] For Europe see [5].
[2] For the United States see [5].

glass enclosure, the hot tungsten will burn up in an atmosphere containing oxygen, which can be brilliantly demonstrated in class with the following procedure.

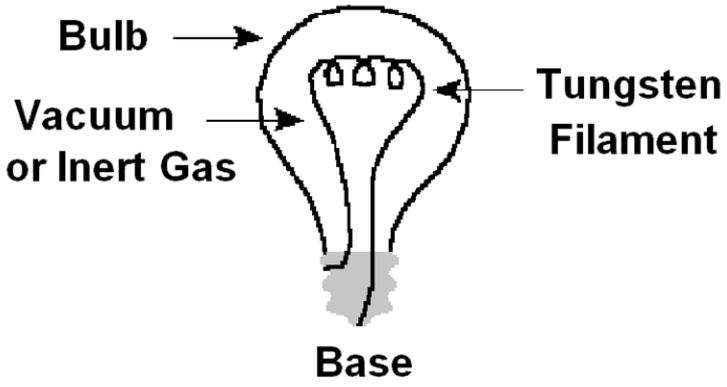


Figure 1. Simple sketch of incandescent light bulb.

Removing the glass bulb safely

When one of us (MJR) was in graduate school, a task as a teaching assistant was to remove the bulb before class without destroying the delicate tungsten filament inside. The method employed was to wrap the bulb in a towel and smack it against a wall to smash the glass.[3] Upon coming to UNC Asheville in 1978 as a new teacher, I (MJR) asked a physics and drama major Chris Mathis to remove the bulb using the towel method. He said he could remove the bulb without smashing it and deliver the bulb intact. From that day on the demonstration has been performed completely in class from start to finish.

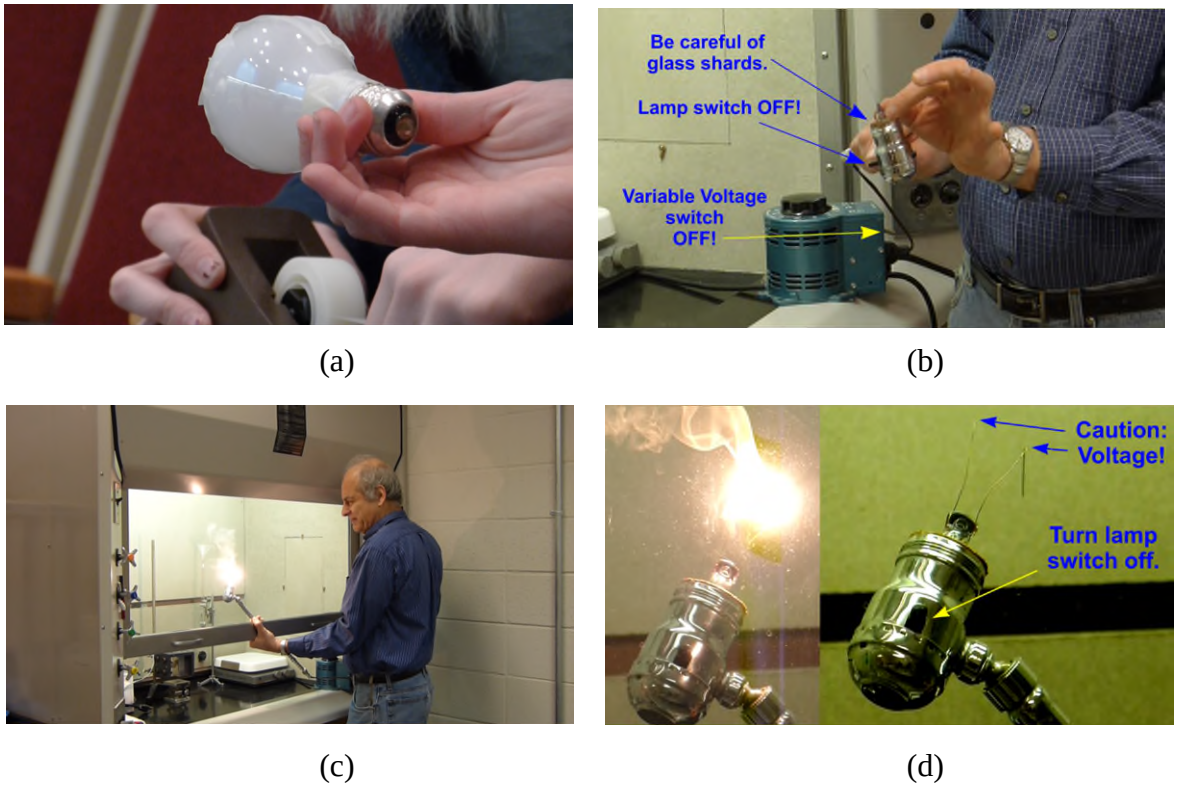
Chris's method is to tape the bulb generously with transparent tape so that the glass is completely covered (see figure 2(a)). You then snap it at the base with vise-grip pliers so the bulb can be gently lifted off. We have the students in class tape the bulb while others are asked to inspect it to be sure the glass is completely covered.

[3] Department of Physics, University of Maryland (College Park, MD, USA) 1970s, working with Professor David Falk

The instructor then proceeds with the rest of the demonstration. Caution should be exercised by performing the vise-grip step over a trash can and being conscious of the broken glass that may still be exposed around the edge of the screw base.

Setting the tungsten filament on fire

The instructor continues with great care, screwing the disassembled bulb into a light fixture with the light switch off and nothing attached to an electrical outlet as a very important double-safety precaution. If your lamp is plugged into a variable-voltage transformer, also have that unit turned off (see figure 2(b)). The instructor is also careful to avoid any small shards of glass at the base (again see figure 2(b)). If you have a fixture with a dimmer or can connect your fixture to a variable AC transformer, the power can slowly be increased until the filament glows dull red just like a stove element. It is best to darken the room for this part and the subsequent suspenseful conclusion.



(a) (b)

(c) (d)

Figure 2. Safety Precautions. (a) Completely cover glass with tape. (b) Note glass shards and turn off switches. (c) Burn tungsten under hood. (d) After the fire, turn lamp switch off.

The red glow allows for a discussion of color temperature and black-body radiation. When a black body is heated one first produces infrared light and then a red glow at higher temperature. As the temperature continues to rise, the color changes according to Wien's Displacement Law. Color temperature has numerous applications from photography to the glow of the artist's kiln.

Turning up the power to maximum quickly causes the temperature to increase and rapid oxidation of the filament follows in a flash of light and smoke. As the tungsten quickly burns, a break occurs in the filament, the current stops, and the dramatic show concludes. We suggest performing this demonstration in a well-ventilated area or even under a fume hood to minimize exposure to tungsten fumes (see figure (c)). Also, be sure to turn off power to the fixture before removing the burnt-out filament to avoid an electrical-shock hazard (see figure (d)).

Conclusion

While there are other methods for removing the outer glass [6] from a light bulb such as using a pipe cutter, a towel, or a paper bag and mallet, we feel that our method is best because it uses household tools, is safe, does not damage the delicate filament, and can be performed in class with the assistance of students. The brief subsequent tungsten fire is a splendid display, one that students talk about after they leave class. If performing the experiment live is not possible, enjoy our video of this exciting demonstration. [1]

Acknowledgment

The authors would like to thank physics major Cory Aiken who shot footage with one of our cameras during the demonstration. We would also like to thank the students in *PHYS 101 Light and Visual Phenomena* (March 2014) for their role.

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