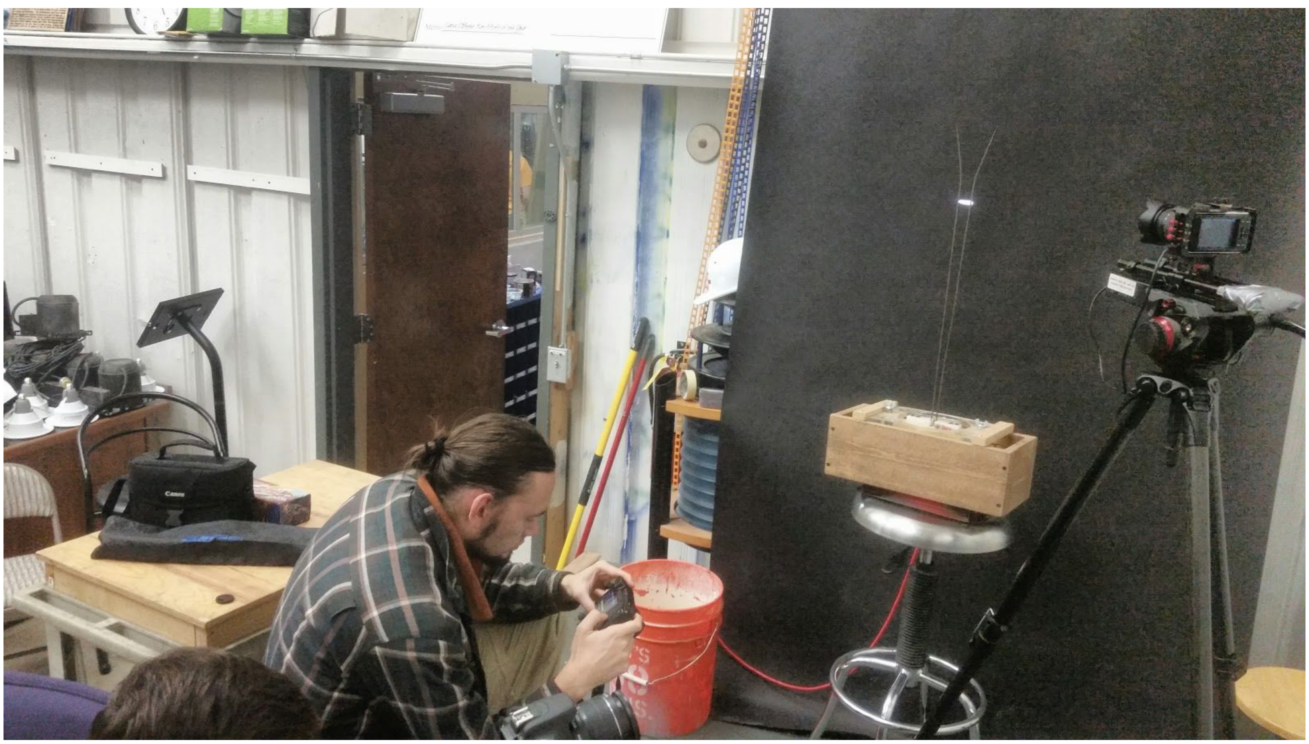
Duncan Lowery - 11/23/2018
With the Help of Greg Collins, Bradley Busek, and Brent Eckles
FILM 4200-001 - Group Third Visualization Report

The impetus for this image came from group member Greg Collins' knowledge of a Jacob's Ladder that a community workshop in Longmont called Tinker Mill allowed us to use, along with the inside of their building. Our goal was to document as clearly as possible the electrical arcs rising up the Jacob's Ladder, and we experimented with long shutter speeds, short shutter speeds, and extreme close-ups. This was the last group project for the Flow Visualization course.

To set up our shoot, the two-foot-tall Jacob's ladder apparatus was placed on a stool in front of a large sheet of black paper. The lights were eventually turned off in the room so that all of the light entering our cameras was emitted by the arc itself, and so the background would be easier to remove when editing our images.



An electric arc emits light by the breakdown of the gases in the air caused by a difference in potential between two electrodes. As this potential increases, the air surrounding each electrode becomes more and more ionized, increasing the conductivity of the air. When the resistance of the air is overcome, an arc made of plasma bridges the air between the electrodes, emitting photons that can be picked up by our eyes and cameras. In a Jacob's Ladder, this potential is held between two wires that are spaced apart more at the top that at the bottom. The arc begins at the bottom at the shortest distance, and rises because of the convective force of the air being heated by the previous arc. As a result, the arcs rise up the ladder before breaking down at the widest part of the ladder. Once the last arc fails, the wires continue to build up potential, and a new arc forms at the bottom.

My images were taken on a Blackmagic Pocket cinema camera, with a Lumix G 14-45mm variable zoom lens. My shutter angle was set to the lowest duration possible, 11.25 degrees, which at 30 frames per second gave me a shutter speed of 0.001 seconds. My intent was to eliminate as much motion blur as possible between frames. The focal length of the lens was 14mm, and my camera was positioned 1.8 feet from the camera. The aperture was set at f/3.5.

To create the composite image, I first loaded a video clip of eight consecutive rising arc paths into my timeline in DaVinci Resolve. I lowered the lift of the clip so that the paper backdrop we used looked completely black, and raised the gain so that the brightest parts of the arcs would be as bright as possible without clipping. I then marked in and out points for the duration that the arc was visible for each of the eight paths, and exported each path as an image sequence in seperate folders. In GIMP, I was able to piece these frames together by using a blending mode called "addition", which treats darker pixels as more transparent. This allowed me to composite together the frames of each arc path into a single image of 1920x1080 resolution, where the arcs are separated by 1/30th of a second. The unneeded black areas of these images were cropped out, and I then arranged them on a black canvas in a way I thought visually appealing. In total, 217 frames of video were composited together.

I am pleased with how my image turned out. The contrast made for a striking image, and the repeated and similar-yet-gradually-changing arc paths give a sense of order to the composite. My image was effective in showing the influence of both the convective force of the rising air, as well as drafts in the room, on the arc path. In the future, I'd want to experiment with a higher frame rate, or a high-speed camera to see the formation of the arcs themselves.

References:

Howatson, A. M. *Introduction to Gas Discharges*. Oxford: Pergamon Press, 1976.