

# Group Project #1



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MCEN 4151  
Professor Hertzberg  
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## **Purpose and Intent**

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The purpose behind this visualization was for the first group assignment for the Flow Visualization course taught at the University of Colorado, Boulder. This course, taught by Professor Hertzberg, serves to bring together the phenomena of physics with the aesthetics and visualization of art. This image and setup came from the collaborative ideas of myself (Christopher O'Brien), William Olson, Ian Macfarlane, and Gamal Elbially. I personally wanted to capture an image where it was possible to see the details within a flame so that the tornado effect is very visible.

## **Safety**

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Due to the fact that the use of flames and combustion fluids were used in order to capture our images a few safety precautions were necessary. First the experiments were conducted outside; this provided an area that can be considered well ventilated, which diluted any fumes that may be inhaled and dangerous. Along with conducting the experiment outdoors a fire extinguisher was kept nearby in the case that any non-desired objects were set aflame. Along with these oven mitts were used when handling any objects that may have been heated from being near the flame. Lastly in order to achieve the desired colors of flames different chemicals were added to the fuel. These chemicals include: Copper Sulfate, Ammonium Chloride and crystalline silica. According to the MSDS these chemicals have the possibility of irritating the nose, mouth and throat when ingested but by conducting the experiment outside we eliminated this risk. The full MSDS breakdown can be seen at the end of the report. [2] Along with these chemicals a gelled fire starter was used as our main fuel. Again this fuel was safe to burn in a ventilated area as long as it is not ingested.

## **Flow Apparatus**

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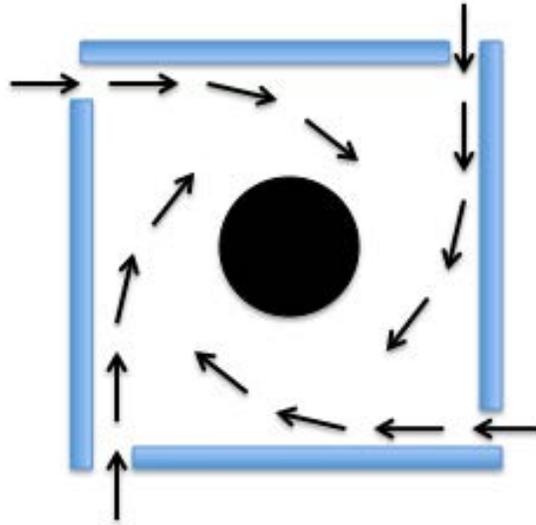
The device used to create the flame is a Tempest Table Top Torch device. This device, which can be purchased at [www.tempesttorch.com](http://www.tempesttorch.com), creates a nice controlled fire tornado.



The image above shows the apparatus used for our experiment. The Tempest torch is 2 feet tall with 1.5 feet of the height being the glass, which contains the flame. As seen in the image, there are openings at the corners of the glass, which is what allows the device to create a tornado like flame. Their website describes this phenomena as a Natural Venturi Effect.

A Venturi Effect is an effect caused by a pressure difference. Pressure decreases as the air is forced into the small openings in the side of the glass which leads to an increase in the velocity of the air [1]. By increasing the amount of circulating air outside the apparatus by the use of a fan, we were able to increase the amount of air being pushed into the openings therefor increasing the

Venturi Effect. The Venturi Effect along with the placements of the slots in the glass are what creates the vortex shape of the flame.



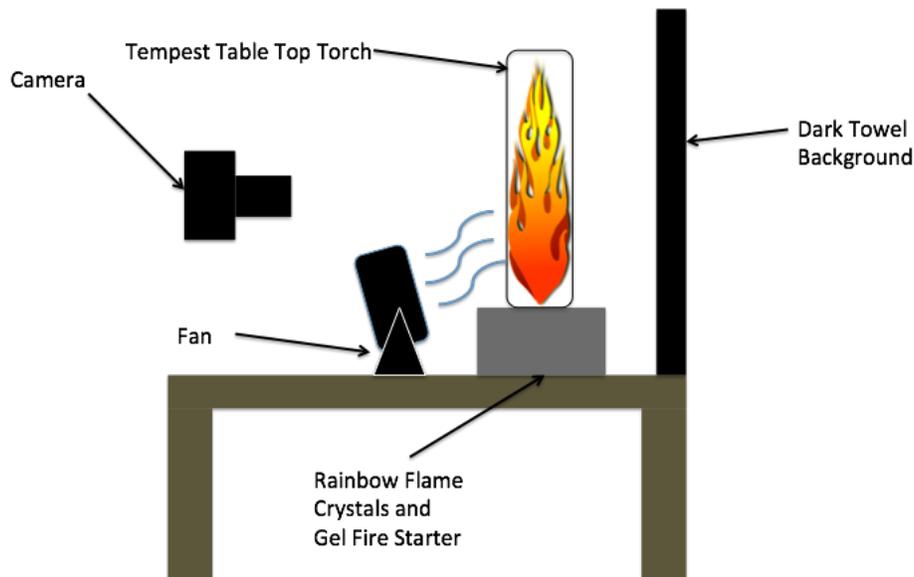
The diagram above helps show how the use of the Venturi Effect and the slots in the glass come together to create a vortex. Once the wind vortex has been created and the fire is lit, the flames follow in the wind pattern creating the fire tornado captured in the images.

## **Visualization Technique**

The following materials were used for this experiment: The Tempest Table Top Torch, one BIC Multipurpose Lighter, RUTLAND one match Gelled Fire Starter, a Westpointe Table Top Fan, and RUTLAND Rainbow Flame Crystals. For this experiment we acquired the Tempest Table Top Torch from our professor and then everything else from McGuckin's Hardware Store.

For this experiment we decided to place the Tempest Table Top Torch apparatus outside on a second story balcony to conduct the experiment. Since we are using flame we decided to not use any light for our image. We waited for the sun to go down at around 8:00 PM on Sunday the 18th of October. It was partially cloudy that day so there was little to no light from the Moon.

The flame was then started. Once the flame stabilized, the crystals were then added. These crystals contain metallic compounds which each give off different colors as they heat up. This heat causes electrons within these crystals to gain energy and jump up in energy levels. This excitation is not stable, and therefore as the electrons fall back to their ground state, energy is released in the form of light. Each crystal emits a different color; this is because the gaps between the different energy levels is not the same between all of them. Small energy gaps lead to low energy light, while large energy gaps lead to high energy light. [3]



## **Photographic Technique**

For this image, I used a Nikon 3100 DSLR camera to take the picture. I held the camera sideways and in the middle of the flame to be able to capture the whole vertical length of the flame. I held the camera approximately 1.5 feet away from the Table Tempest and had the focal length set to 22mm. Since I took the picture outside at night and needed to capture as much light as possible, I set

the ISO 10 3200 and the f value to 5.6. This allowed me to use a shutter speed of 1/60 to avoid motion blur while still letting light in. These settings allowed me to get the original image which can be seen below next to the final image.



**Figure 1: My original image (left) and my final image after post processing (right)**

Once I had my original image some post processing was done to get an image that I found to be more aesthetically pleasing. I raised the contrast and brightness to bring out the colors in the image more and to make the twisting lines become more distinct. I did not crop the image so both images are at the original dimensions of 3072 x 4608 pixels.

**Sources:**

[1] <http://www.tech-faq.com/venturi-effect.html>

[2] [http://www.wildwoodovens.com/wp-content/uploads/Rainbow\\_Stick\\_msds.pdf](http://www.wildwoodovens.com/wp-content/uploads/Rainbow_Stick_msds.pdf)

[3] <http://www.chemicalconnection.org.uk/chemistry/topics/view.php?topic=3&headingno=5>

**Material Safety Data Sheet**

May be used to comply with  
OSHA's Hazard Communication Standard,  
29 CFR 1910.1200 Standard must be  
consulted for specific requirements.

**U.S. DEPARTMENT of Labor**

Occupational Safety and Health Administration  
(Non-Mandatory Form)  
Form Approved  
OMB No. 1218-0072

**IDENTITY (As Used on Label and List)**

Code 715, 715S  
Rainbow Flame Crystals & Sticks

*Note: Blank spaces are not permitted. If any item is not applicable, or no  
information is available, the space must be marked to indicate that.*

**Section I****Manufacturer's Name**

RUTLAND PRODUCTS

Address (Number, Street, City, State, and Zip Code)

7 CRAB TREE ROAD  
JACKSONVILLE, IL 62650

**Emergency Telephone Number**

CHEMTREC 800-424-9300

**Telephone Number Information**

217-245-7963

Date Prepared

July 1990

Date Revised

Sept. 04

Signature of Preparer (optional)

**Section II - Hazardous Ingredients/Identify Information**

Chemical Identity	CAS#	OSHA PEL	ACGIH TLV	Other Limits Recommended	% (optional)
Copper sulfate, tri basic	07758-98-7	1mg/m <sup>3</sup>	1mg/m <sup>3</sup>		
Ammonium Chloride	12125-02-9	10mg/m <sup>3</sup>	10mg/m <sup>3</sup>		
Silica, crystalline	14808-60-7	0.1mg/m <sup>3</sup>	0.1mg/m <sup>3</sup>	(respirable)	

(Silica is present in low concentrations as an impurity only. See section VI for discussion of health hazards.)

HMIS Rating - Health: 2 Flammability: 0 Reactivity: 0

**Section III - Physical/Chemical Characteristics**

Boiling Point	N/A	Specific Gravity (H <sub>2</sub> O = 1)	N/A
Vapor Pressure (mm Hg)	N/A	Melting Point	N/A
Vapor Density (Air = 1)	N/A	Evaporation Rate (Butyl Acetate = 1)	N/A
Solubility in Water	Parts of mixture are soluble in water.		

**Appearance and Odor**

Granular solids, no odor.

**Section IV - Fire and Explosion Hazard Data**

Flash Point (Method Used)	N/A	Flammable Limits	LEL	UEL
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**Extinguishing Media**

Carbon dioxide, dry chemical, foam.

**Special Fire Fighting Procedures**

Use self-contained breathing apparatus in confined spaces.

**Unusual Fire and Explosion Hazards**

None

The information presented herein is based either on data or opinion. Such data is, to the best of our knowledge, true and accurate. Such opinion is believed to be expert, and therefore generally reliable, but in some instances there are conflicts in expert opinion and in these instances we have relied on the opinion which, in our best judgment, appeared the most reasonable. All information herein is presented without guarantee or warranty and Rutland Products disclaims any liability incurred from the use thereof.

**Section V - Reactivity Data**

Stability	Unstable	Conditions to Avoid
	Stable	
Incompatibility (Materials to Avoid)	X	Bromine trifluoride, silver salts, iodine heptafluoride, potassium chlorate

ammonium nitrate, acids, alkalis, oxidizing and reducing agents.

**Hazardous Decomposition or Byproducts**

Thermal or acid decomposition may release toxic and hazardous

fumes of chlorine, hydrogen chloride, ammonia and oxides of nitrogen.

Hazardous Polymerization	May Occur	Conditions to Avoid None
	Will Not Occur	
X		

**Section VI - Health Hazard Data**

Route(s) of Entry	Inhalation?	Skin?	Ingestion?
	Yes	Yes	Yes

**Health Hazards (Acute and Chronic)**

Ingestion: irritation of mouth, esophagus and gastric system.  
 Inhalation: may irritate nose, throat and lungs.  
 Eyes: direct contact may irritate or burn eyes.  
 Skin: may cause irritation, especially under prolonged contact. May result in dermatitis.

Carcinogenicity: NTP? No IARC Monographs? OSHA Regulated? No

Respirable crystalline silica from occupational sources is listed by IARC as a human carcinogen.

Signs and Symptoms of Exposure

See health hazards.

Medical Conditions Generally Aggravated by Exposure

Respiratory or skin disorders.

Emergency and First Aid Procedures

Ingestion: drink large amount of water. Call a physician.  
 Inhalation: move to fresh air. If breathing ceases, begin artificial respiration. Contact a physician.  
 Eyes: flush with water for 15 minutes. Contact an eye doctor.  
 Skin: flush with water. If irritation persists, contact a physician.

**Section VII - Precautions for Safe Handling and Use**

Steps to Be Taken in Case Material is Released or Spilled

Sweep up. Avoid breathing dust.

Waste Disposal Method

Dispose of in accordance with local, state, and federal regulations.

Precautions to Be Taken in Handling and Storage

Protect from moisture. Store tightly closed in cool dry place.

Other Precautions

Keep out of sewer or stream, may be harmful to water organisms.

**Section VIII - Control Measures**

Respiratory Protection (Specify Type)

NIOSH/MSHA approved respirator for dust.

Ventilation	Local Exhaust	Special
	Sufficient to keep dust below TLV	As needed.
	Medical (General)	Other
	Sufficient to keep dust below TLV	As needed.

Protective Gloves

Rubber gloves.

Other Protective Clothing or Equipment

Work clothes designed to minimize skin exposure.

Work Hygienic Practices

Wash with soap and water before eating, drinking or using toilet facilities.

Rainbow Flame Crystals

NAME OF PRODUCT: Rainbow Flame Sticks

This product contains the following chemicals subject to the reporting requirements of the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA). These chemicals are also subject to reporting under Section 304 of Title III, SARA.

CAS Number	Chemical	% WT	Reportable Quantity
12125-02-9	Ammonium Chloride	15	5,000 lbs.
01344-73-6	Copper Sulfate, tri-basic	15	*****

\*\*\*\*\*No reportable quantity is assigned to the broad class of copper compounds