

Glass Looking Water Splash



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By
Paul Sweazey

Special Thanks To:

Wayne Russell
Kelsey Spurr
Zachary Wehner

Introduction

The purpose of this flow visualization assignment was to illustrate and highlight the beauty of two perfectly timed water drops colliding with each other. This final team assignment was used to build an apparatus that allows to accurately adjust timing of the release of water droplets into a reservoir. The first water droplet would fall into the water reservoir and create a Worthington jet, as the jet reaches maximum height, the second droplet would collide with the jet and cause a splash that was captured in an image.

Experimental Setup

This experiment was conducted in the Durning lab welding room of the engineering building on Friday April 19th, 2013. The team used an Arduino controlled servo valve that was attached to a hose and an elevated water reservoir. This apparatus was suspended by a ring-stand with appropriate holding fixtures. The Arduino also controlled the camera flash timing. The timing of droplet dispensing and flash timing could be controlled accurately within milliseconds. At the base of the ring-stand, underneath the droplet dispenser was a black cereal bowl filled with water. The surroundings were covered with black cloth. Several small LEDs were used for a flash, including one large flash device. As the image was taken all lights in the room were turned off and the flash and the glow sticks in the water were the only sources of lighting.

Governing Physics

As a droplet is dispensed from the servo valve the only force acting on it is gravity, neglecting drag by the air. The water droplet is accelerating until it impacts the water surface. Next a crater and a crown are formed on the surface of the water. As the water tries to fill up the crater again and return to equilibrium, the water that is surrounding the crater is rushing back towards the center. When the water rushing back reaches the center, it meets all the water that is coming from all sides. The water has much momentum and nowhere to go but up, so a jet of water rises from the center of the droplet impact. As the impact velocity of the droplet increases, the height of the Worthington jet increases and the likelihood of a droplet being released upwards from the jet increases as well. A picture sequence of this Worthington jet formation can be seen in Figure 1 [1].

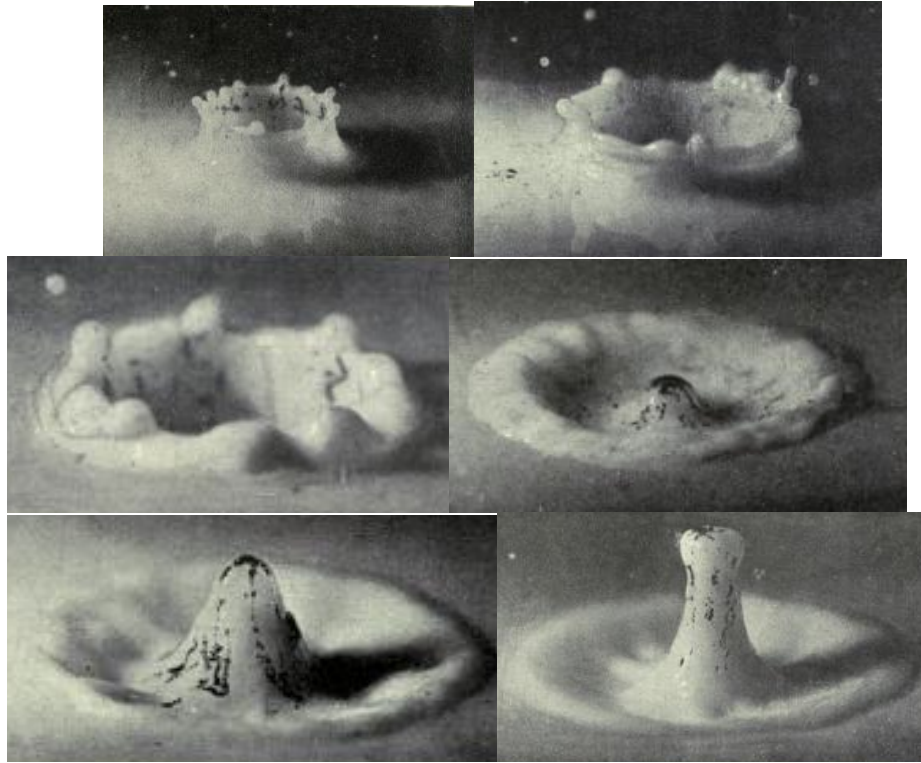


Figure 1: Worthington jet formation

The images in figure 1 were taken from the book “A Study of Splashes” by Worthington where he observed the creation of the Worthington jet using milk as a fluid. In the experiment performed by the team, the fluid was water and the Worthington jet formed by the first droplet reached about the same shape as the last image in figure 1 before the second droplet hit the Worthington jet dead centered. As the second droplet hit the Worthington jet, the fluid coming up and the droplet falling down spread out symmetrically into a thin film of water on top of the jet.

Imaging Techniques

The image was taken with a CASIO EX-ZR 100 point and shoot camera with a shutter speed of 1/3 seconds, ISO of 100, focal length of 11.1mm, and F-stop set at f/4.6. It might seem odd that the exposure time was so long, but the image was taken in a blacked-out room and a timed flash froze the image. There were several flashes set up around the area of interest to illuminate it as best as possible. The original image had pixel dimensions of 4000 by 3000 pixels. For post processing, the original image was cropped to zoom in on the area of interest. A side-by-side comparison of the original and final image can be seen in figure 2. The final image had pixel dimensions of 1809 by 1419 pixels.



Figure 2: Original (left) Final (right)

Conclusion

The final image exceeded my expectation for this final team assignment. During the photo shoot session, hundreds of pictures were taken and almost all of them captured this moment of Worthington jet and secondary water droplet interacting. Several alterations to the setup were made to generate slightly different images, including changing the base reservoir fluid and adding glow sticks. I really liked the image I chose because one can see reflections of the glow sticks in the Worthington jet and the focus was dead on. Much detail can be seen in the mushroom-like top. The crispness of the image and perfect focus leads one to believe that this is some glass stature. Enjoy.

References

[1] Worthington, Arthur M. *A Studie of Splashes*. N.p.: Nabu, 2012. Print.