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# Image 3 Report

## Introduction

This project's goal was to utilize black and white editing, to highlight the form of a fluid phenomena. This was my third flow visualization photo, which builds on post process experimentation with black and white as well as monochromatic edits to highlight form. These experimental edits were never used in my other final images for fear that they would take away from key elements of my previous intentions. As such I set out specifically to highlight the form of a phenomena in order to be able to make use of these post processing techniques. The original phenomena intended for capture was cavitation, as its formation is both physically and aesthetically interesting, but due to set up difficulties I pivoted to boiling water. In order to highlight the form of the water vapor bubbles various techniques were used as detailed below.

## Set Up

In order to create this image, an empty bottle of Hernandez salsa, with its label boiled off was used to house the water. This bottle was selected for its notable width compared to its size and its glass composition, allowing for the bubbles to be visible to the camera. This bottle was filled halfway with water and placed in the microwave till the water was aggressively boiling. The bottle was then removed from the microwave and placed on a plastic sheet on top of a light source pointing upwards. The camera was placed 1 away pointing at the bottle and rapidly took photographs until the boiling had subsided.

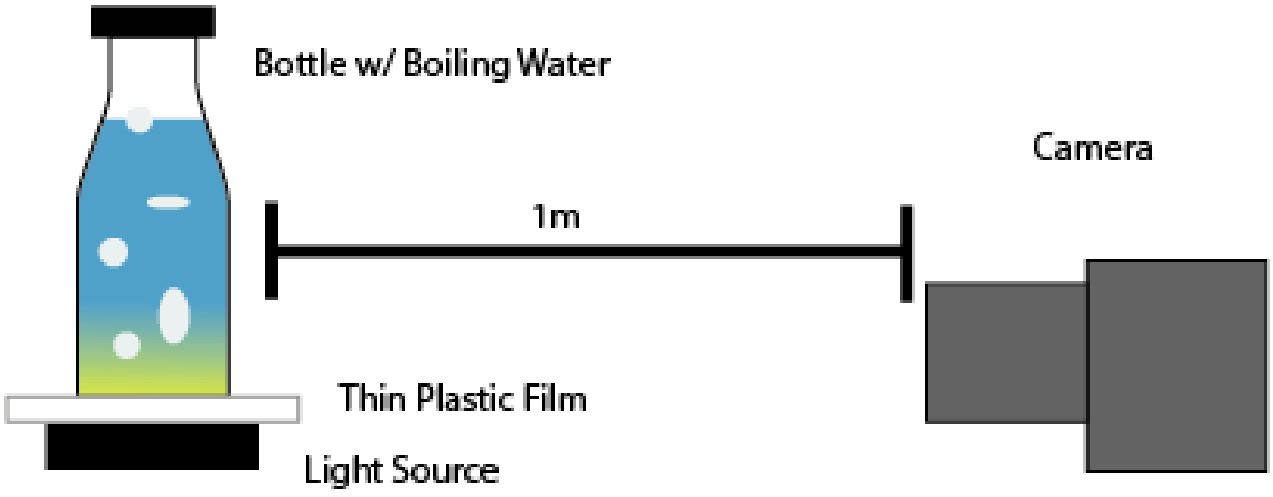


**Figure 1:** Photo setup diagram

## Fluid Dynamics

Water boils, when enough heat is added to the fluid, such that the particles move fast enough to break away from the powerful hydrogen bonds holding them together.[1] They then form a gaseous state and due to the lower density of the gas, if it is submerged in water, an upward force equal to the weight of the displaced water will be exerted on the bubble and it will rise.[2]

In order to describe the size and shape of the bubbles that form, the Bond number can be used. As shown below, the Bond number is a ratio of gravitational force to surface tension. As gravitational forces dominate, larger bubbles moving more rapidly, with more fluctuation in form will occur, whereas when surface tension dominates, smaller more spherical bubbles, moving slower are likely to form. In this experiment, water vapor was the gaseous fluid of choice simply because it was easy to form in the water.[3] Given more time a fluid with a greater density difference could have been inserted into the water to form bubbles with more compositionally interesting forms.

$$Bo=(\Delta\rho g L^2)/T_s$$

**Figure 2:** Bond Equation, where Δρ is the density difference between the two fluids, g is the gravitational constant, L is the characteristic length, and $T_s$ is the surface tension

## Visualization

The only visualization technique used in this setup is the seeded boundary between the liquid and vapor water. An external light was used to light the fluid from below. This may have resulted in some added clarity due to refraction of the light in the two phases, but was not a large factor in visualization. Largely the boundary interface was highlighted by balancing the light levels of the two phases in post processing

**Photographic Technique**

**Figure 3:** Raw image before post processing.

This image was taken from 1m away with a similar focal length of 1m, an aperture of F 32, a shutter speed of 1/250th of a second, and an ISO of 6400. The intention of this setup was to get maximum clarity in the bubbles and to naturally black out the background of the photo. In order to obtain a very high shutter speed to more fully capture the bubbles in focus, a very high ISO was necessary, which did result in some quantity of noise added to the image. An aperture of F 32 was used in order to ensure that the bubbles remained in focus regardless of how precisely the container was placed, as the time in which boiling continued after heating was quite short. This photo was taken from 1 m with a focal length of 1 m because this was as close as it could focus and maximum detail was desired, especially since cropping would still have to be done. The first edit made to this image in post, was a reduction to its field of view. The image was cropped from 4256 x 2832 to 3000 x 2100 in order to remove an excess of empty black space from around the object. From there a set of layer masks were created using a soft round brush to define the targeted area. These layer masks were then assigned to brightness and contrast filters, and were tuned such that any details on the bottle and background that were not relevant to the phenomena were faded to black. Finally, the levels and contrast of the whole image was adjusted so that the bubbles contrasted the water as much as possible, and a black and white filter was applied. Ultimately these changes sought to

highlight the clarity of the seeded boundary, and remove distractions from the background in order to emphasize the form of the phenomena.

## Conclusion

The contrast between the bubbles and liquid water, the lack of details in the background, and the removal of color from the image, thoroughly highlight the form of the phenomena. However, the small size and noise in the image do take away from the unique form of the rising bubbles. The image's clear portrayal of the form of the instability is its highlight and fulfills the initial intention, but the noise and small size subtract from the visual appeal of the image. If this image were to be redone, in order to obtain more detail and clarity, a lower ISO with a more powerful base light would be used, as well as inserting a fluid with a much greater density difference from water into the base of the container. The use of a very low light into the camera, and a focused spotlight on the phenomena made processing the background of the images vastly easier and could be a useful technique for future fluid images. Furthermore, the use of techniques that would highlight different features for the flow phenomena, in a similar way to how the black and white filter highlighted the form, would be interesting to explore.

**Bibliography**

[1]Summers, V. (2020, September 7). The Fascinating Kitchen Physics of Boiling Water. Quirky Science. Retrieved December 3, 2021, from https://www.quirkyscience.com/physics-of-boiling-water/

[2]Encyclopedia Britannica. (n.d.). Archimedes' principle | Description & Facts. Retrieved December 3, 2021, from https://www.britannica.com/science/Archimedes-principle

[3]Li, S. L., Lui, M. L., Hanaor, D. A. A. H. H., & Gan, Y. G. (2018, November). Dynamics of Viscous Entrapped Saturated Zones in Partially Wetted Porous Media. Research Gate. Retrieved December 3, 2021, from https://www.researchgate.net/publication/323335177_Dynamics_of_Viscous_Entrapped_Saturated_Zones_in_Partially_Wetted_Porous_Media