Designing and Building a High Energy Discharge Unit and Camera Triggering Unit

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Project Background

In the Krechetnikov fluid physics lab, we do experiments with high speed fluid mechanics, and all of our experiments share a particular set of requirments:
•All of the experiments occur at high speeds (~1μs=1 millionth of a second)
•They have large current requirements (~300*amps*).
•Each experiment also includes being photographed, so we are using a high resolution (8 megapixel) camera to take a single picture of an instant in time.
Goals: We need to build one device that can discharge energy into the experiment, and the other that takes a high resolution, color, photographs

Experimental Set-up Parts

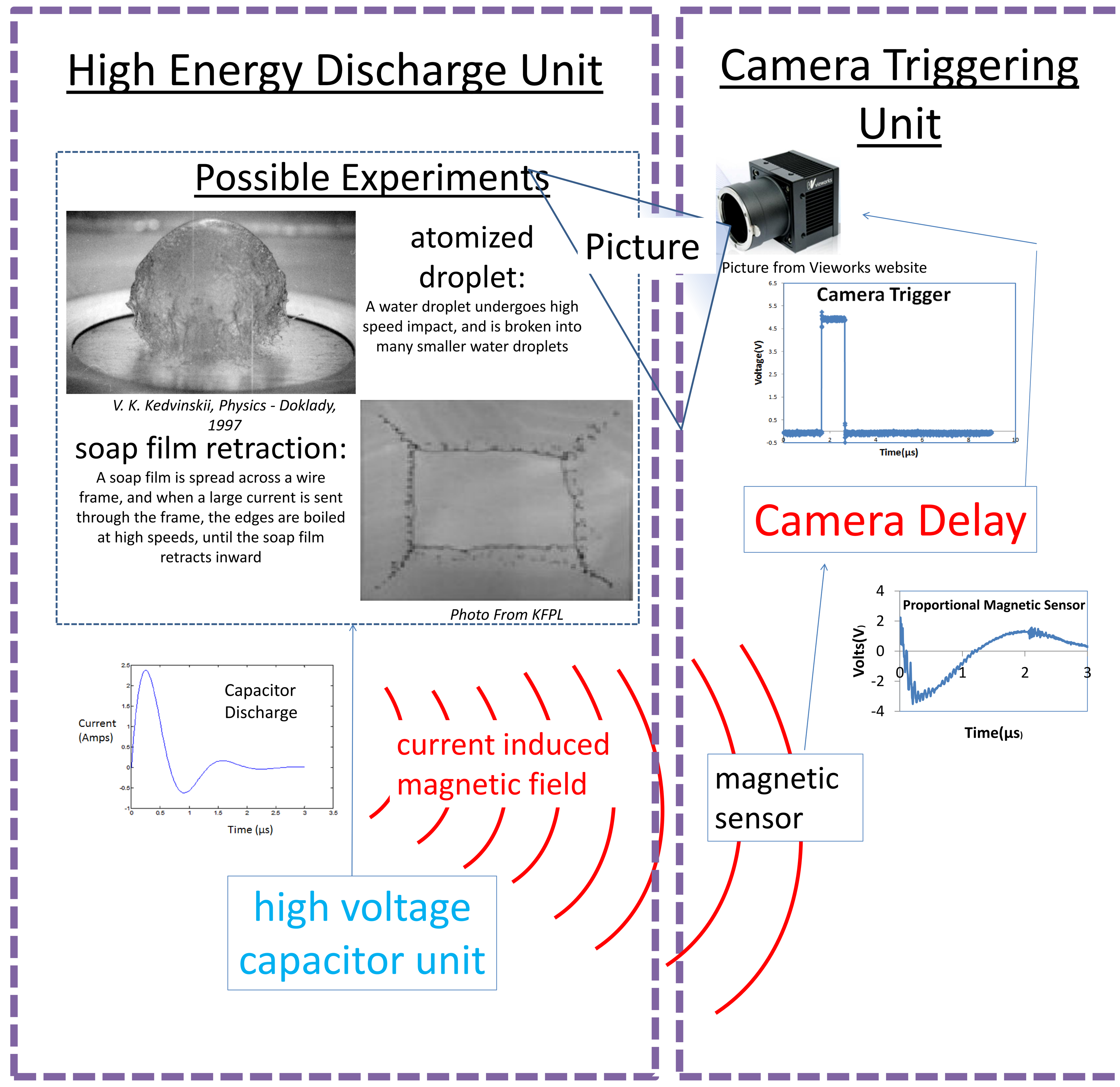
high voltage capacitor unit
•Our capacitor is an ultra low inductance, 8μf capacitor, capable of storing up to 4kV.
•We are using a high voltage switch (thyristor) that makes it possible to release up to 2kV at high speeds, and precisely, with a simple 3V power source.

magnetic sensor
•Using a proportional magnetic sensor (Hall effect sensor), we are able to output a signal to the camera delay unit, proportional to the current induced magnetic field.

camera delay (BNC 575)
This is a programmable trigger, and time delay which can send a signal to the camera, to take a picture. The time delay allows image capturing at a set time after the delay unit triggers on the magnetic sensor signal.

Camera
The camera takes 8 megapixel, color, pictures.

Experimental Set-up



Experimental Results

• First we did calculations to optimize current to create one large impulse. Our lab decided that 1 large impulse was defined by the initial peak five times larger than the initial valley. With that ratio, the current pulse discharges through under damped oscillation. So using the standardized current (i(t)) equation for an under damped circuit with resistance, inductance and a capacitive element:

$$i(t) = B_1 e^{-\alpha t}\cos(\omega_d t) + B_2 e^{-\alpha t}\sin(\omega_d t)$$

Where B1 and B2 are constants, ω_d is the decaying frequency of oscillation, α is the attenuation of the rate of decay, and t is time in seconds. We modeled our current pulse.

•Once we modeled the current signal, then we collected and compared the calculated current with the initial data taken with the remote, current, and magnetic sensor of the capacitor discharge. This happens so that when the results are compared, we can adjust our calculated current equation to account for any other variables. We found that there was a significant change in inductance depending on the orientation of the high voltage leads.

•Using that initial comparison, we explored different magnetic sensors. Starting with a latching sensor that, latches on or off depending on the magnetic field. The data we uncovered (fig. 1) varied from run to run, making triggering the camera in repeated trials, incredibly difficult. Then we decided to try a proportional magnetic sensor. This sensor outputs a signal, proportional to the signal strength (fig. 2). Once this sensor was used, the readings we received were consistent, and more simple to interpret and there fore easier to trigger the camera.

•Once we decided that the proportional sensor was best suited for the situation, we tested how, distance away from the source, height, and orientation affected the magnetic readings. We found that the best position for the sensor was right next to one of the high voltage leads, with the top face against the wire sheath, and as far from any other magnetic field sources as possible.

•Finally, we found that our high voltage capacitor unit wasn't delivering enough energy for our experiment (atomized droplet), and since the high voltage switch (thyristor) is what restricts the voltage out put to 2KV. We tested an alternate switch called a spark gap at high voltages, to observe if the readings began to diverge from one another, but we found was that the spark gap had a similar standard deviation at high voltages(fig. 3) as it had at low voltages.

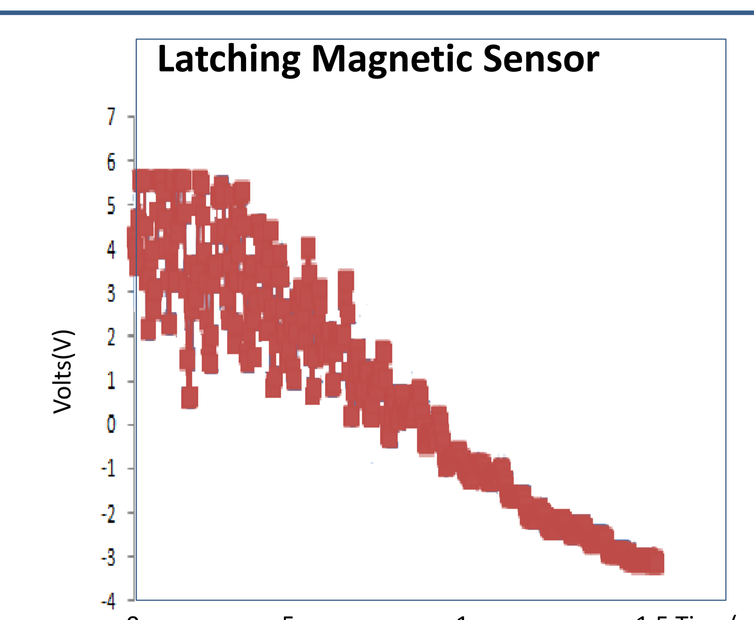


Figure 1

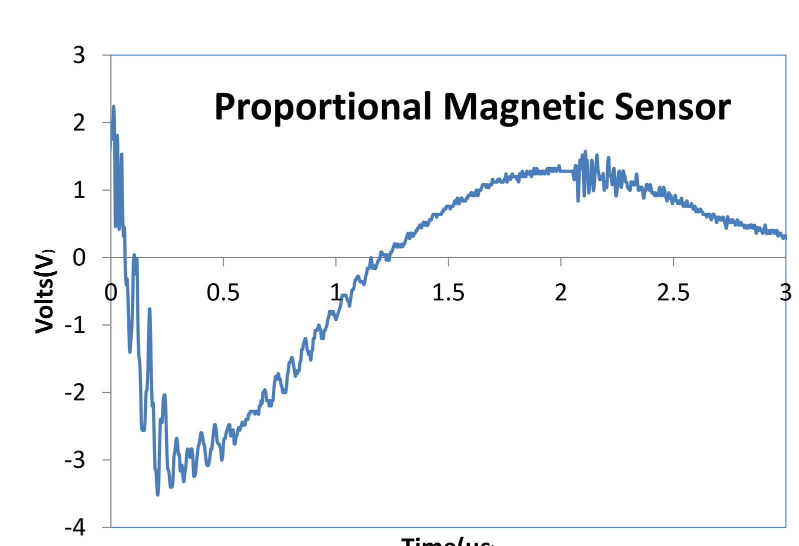


Figure 2

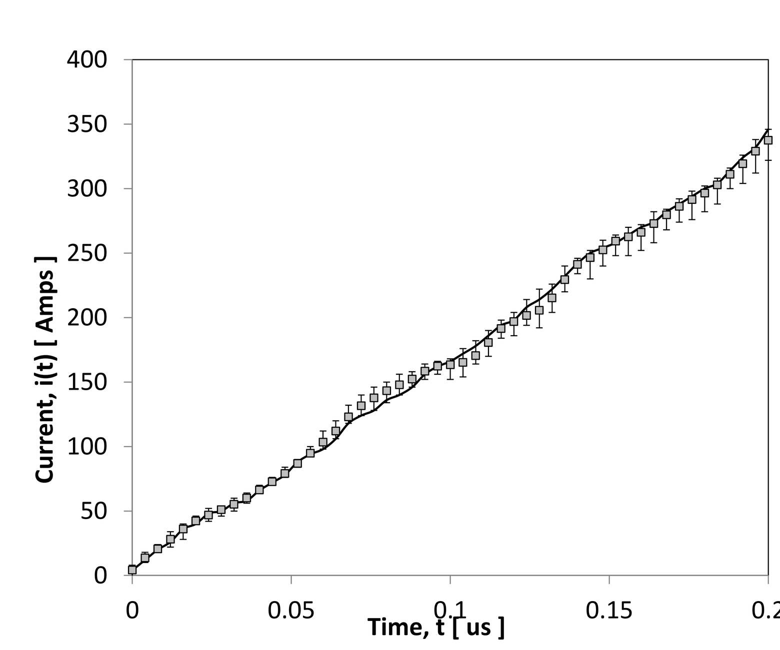


Figure 3

Conclusions

What we found was that the ideal current pulse, shape, wasn't too hard to acquire, but it makes sense to use a spark gap over a thyristor because of the higher energy capability of the spark gap.

We found that the proportional sensor worked the best out of all the sensors, and the position it worked best in was against the high voltage leads.

To cut down on the static noise with the signal, it would make sense, in the future, to magnetically shield the sensor and wire section. To ensure that the sensor reads the signal only.

Bibliography

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[2] Dion, S.; Hebert, C.; Brouillette, M. Comparison of methods for generating shock waves in liquids. *Department of Mechanical Engineering, Universite de Sherbrooke, Canada J1K 2R1,* **2009**, Part XI, 851-856