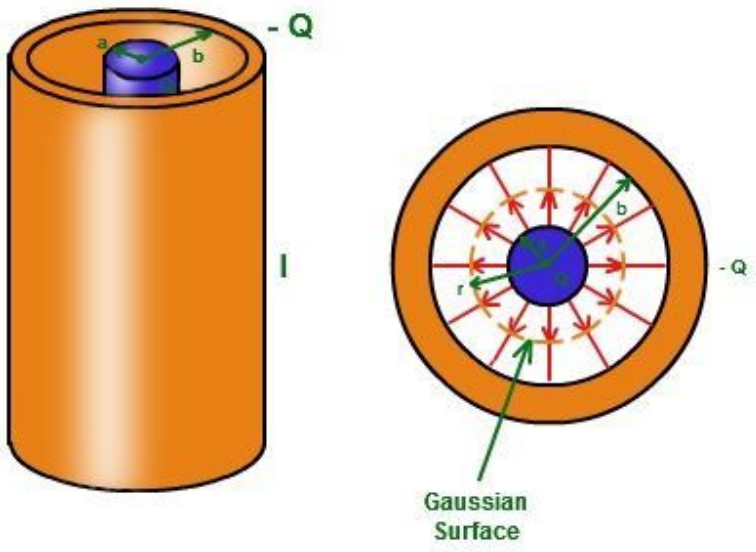
Binary Capacitive Sensor.	
Overview:	This method uses the basic idea of a capacitor and applies it to the physical torch tank. In this case it is not a parallel plate capacitor but rather a modified cylindrical capacitor with a centrally applied charge.
Basic Schematic:	 In the above diagram there are two surfaces that follow the same principle as a parallel plate capacitor. The outer orange surace here would be the torch tank which is wired to the esp32 in the torch in order to detect changes in the state of the tank. The inner surface has a differential voltage offset to that of the outer surface. By adding a dielectric like oil we can observe changes in the RC time constant of the capacitor through the clock of the microcontroller.
Testing methods:	Several low level tests were run with different iterations of this sensor. The first test was with a large aluminum bowl as the outer surface and a twisted pair of wires acting as the core. With the twisted pair of wires roughly half way into the depth of the bowl in theory we could tell exactly when the liquid reached this point. To test this theory we applied an arbitrary voltage to the twisted pair and monitored the esp32 output as the bowl was slowly filled with water. As expected the value observed on the microcontroller did not change until it reached the core. We observed a change from the value of 130 in air to a value of 20 with the core in water.

	 We also ran a test using the actual torch tank. In this test we observed a value of 13 in air and a value of 5 in water.
Issues/solutions:	Unfortunately, the smaller the surface the less of a change is observable. This issue can be fixed by upping the resolution of the timer used to check the RC constant. Or in layman's terms getting a better microcontroller, increasing the observation time, making the core larger and changing the torch tank to something more conductive are all valid methods of improving the performance of the sensor. Heading into the final testing the team discovered that the citronella oil was incapable of carrying the charge necessary to detect the empty and full states of the level sensing.
Future areas of exploration:	This method of detecting liquid is often called electrochemical impedance spectroscopy. Although this version of it is much simpler than most modern applications there is no requirement to make it more complex as a binary value is enough to tell the state of the tank. Something the team wanted to explore as well was the use of ultrasonic sensors and current water level sensors. Now that that idea of having a torch tank is floating around these methods become much more permissible. SEED studio makes a level sensor that could sit inside the torch tank. This method should be carefully tested, though. It is unknown to us how the PCB would react to oil over the water it was designed for. As you already know ultrasonic works well for detecting the level of the central reservoir but as far as size it seems much too large for the torch tanks. Some companies make a much

	more compact sensor than that of the adafruit version but they also cost a good deal more. To combat the issue with citronella oil as well as several other issues more notably with the valve, the best course of action is to design a torch tank with a removable lid. This would allow the users to clean the tanks as well as provide a plethora of options for the valve and level sensor that were unavailable to the team with the tanks current state.