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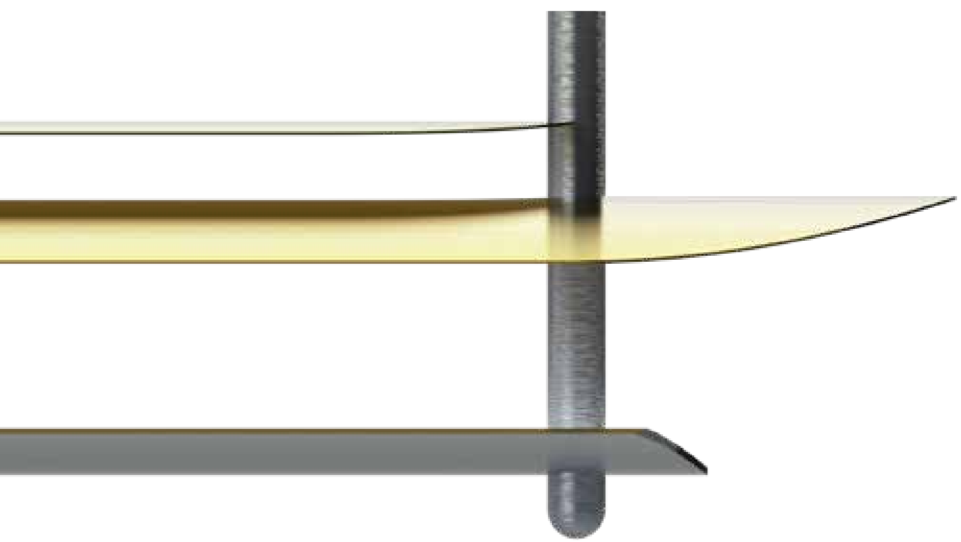


Gabriel Eric Chimienti
Capstone Project
Sherdan College 2022-2023

Content

Chapter 01: Introduction

Background

While we have many different methods for both manufacturing with sheet metal, and casting different metals, we seldom see the combination of these different processes within the manufacturing setting.

Objective

To innovate and expand upon our repertoire of manufacturing techniques by combining two of the most well explored metalworking techniques, casting and sheet metal fabrication.

FIG 1

Motivation

My motivation for this project was to continue exploring the interaction between metal goods and manufacturing methods. I have a shop at home dedicated to metalwork and I am very passionate about learning more and doing my own testing and experimentation.


FIG 2


FIG 3


FIG 4

I find inspiration in common household goods using sheet metal which use the material so well, it becomes innocuous. I find beauty in simple processes or materials being used effectively.

Proposal

For my Capstone Project, I will be exploring sheet metal and metal casting as a material study, investigating the possible interactions of intersecting these mediums, searching for techniques and strengths of combining these materials previously unexplored. I will be conducting research by conducting interviews with those who work with sheet metal as well as casting, such as fabricators, and designers.
I will be conducting my own studio experiments with varying sheet metal goods and casting materials, manipulating these media to uncover unique interactions between the design, manufacturing, and material's strengths.

Chapter 02:
Research

Interview 1: Chris Lovelace, Welder & Fabricator

- The fabrication of parts is quick once everything is set up, the main issue is setting up all the machines.
- When making/designing or reinforcing pieces of sheet metal, the easiest way of doing it is by adding ribs. You can also increase the strength-to-weight ratio of plate stock by using an isogrid.

- You can weld sheet metal to a casting, but ideally, you would braze for that kind of application because it might cause the casting to fracture and break prematurely if you welded it and it warped the wrong way.

- When working with anything that's heat treated, ideally, you fabricate with the raw untreated/untempered stock and then send it off to be heat treated. But with steel sometimes you can get away with working with it after it's already been heat treated since it's not a great heat conductor, but you need to keep in mind that anywhere near the area that you were working with will have lost its heat treat.
- When working with aluminum sometimes you have to send it off to be electroplated so you don't have to worry about galvanic corrosion.

Interview 2: William Delfim, Metal Spinner

- Almost all metals can be spun, though the difficulty and cost per part depend highly on the alloy and its properties. The thickness of the materials that can be spun also varies highly, from as thin as 0.004 inches to as thick as 4-5 inches thick on hydraulic machines with heated materials.
- The size of the parts that can be spun is only limited by the swing of the lathe that they are being formed on, parts can easily be over 10ft across in diameter.
- Metal spinning is an optimal way of making prototypes because of the low price of entry and extremely short lead times. It can also be iterative depending if there is a selection of sleeve/ring chucks available, allowing a technique called ‘spinning on-air’ where a blank can be spun to a shape without the need for a new tool to be made for each iteration of a design.

- Metal spinning is also sometimes combined with other processes to achieve complex parts that wouldn’t be able to be manufactured exclusively on the lathe. Some of these processes include stamping or punching to get internal features on the flat face at the center of a blank, or deep drawing to help spin parts that have a high length-to-diameter ratio.

Interview 3: Erich J. Knoespel, Special Projects Coordinator at Artcast Inc.

- An issue that may come up when casting around another metal is potential warpage or deformation, it would likely be most present when one side of a piece of metal is exposed to the molten metal while the other is not, either against casting sand or ceramic for lost wax casting.
- When casting its a good idea to use the same metal that your pouring for the sheet material as well as it should lead to less problems, but where that is not possible or not desired its best to try and pic a more inert metal as one of the alloys that you're working with, preferable stainless steel because of its corrosion resistance.
- On a similar note, when working with dissimilar metals or when joining steel and aluminum at any point, it's wise to include a sacrificial galvanic anode to prevent galvanic corrosion of the touching materials.
- When casting, it's possible to have a steel inner framework to help provide strength, similar to rebar in concrete, but if you use mild steel, especially in a canadian climate where we can it +40C to -40C the casting may develop small microfractures and allow water to leech in and react with the steel and rust, slowly splitting apart the casting.

- Also depending on the thickness and type of material encasing the framework, it may never be and issue as different metals can have varying amounts of elongation before they break.

- The strength of a casting could be strengthened by having sheet metal encased in it, but it could also be strengthened by the casting geometry to give similar results. Ribs and filets on corners, are a simple but effective way of achieving a structural casting.

- It’s also possible to cast and connect two pieces of metal, that are of the same type, with casting in situ, similar to the thermite welding process to combine railroad tracks.


FIG 5


FIG 7

Similar Products


FIG 6


FIG 8


FIG 9

FIG 10

FIG 11

Displayed to the left is the Bocci 44 light which is produced by pouring molten aluminum over limestone rocks, filling the cavities. After cooled, the limestone is removed and you are left with the negative spaces.

This displays the casting process of Hilla Shamia's cast wood benches, these use moulds surrounding a log, they pour molten aluminum into the moulds, effectively trapping the aluminum around the wood, creating a single piece.


FIG 12


FIG 13


FIG 14


FIG 15


FIG 16


FIG 17

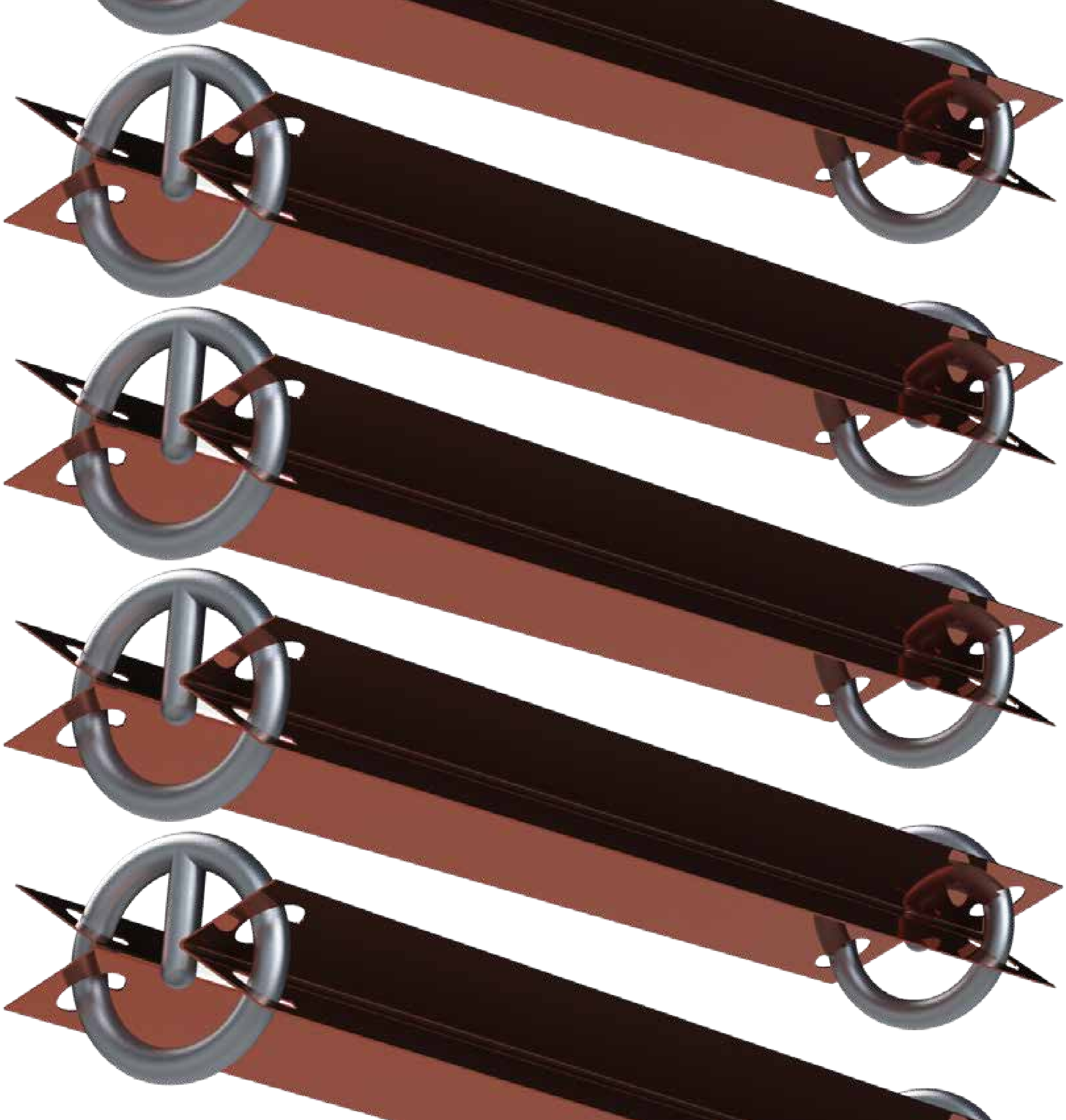
Above displays the work of Julien Carretero, where molten aluminum is cast through a steel-based fabric which allows for flexibility of form and the cast components maintain their visual flow and weight.

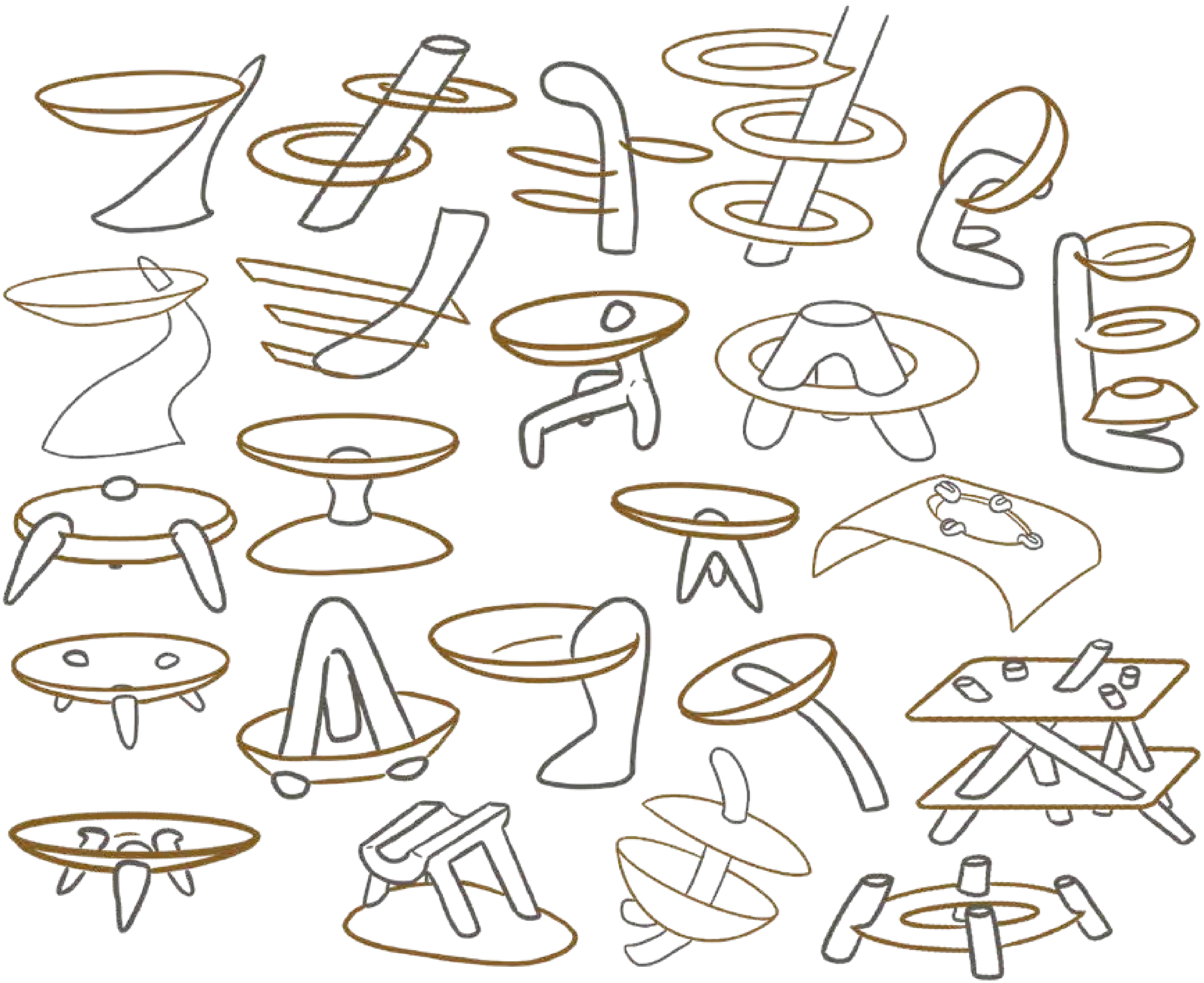
Chapter 03:
Brief

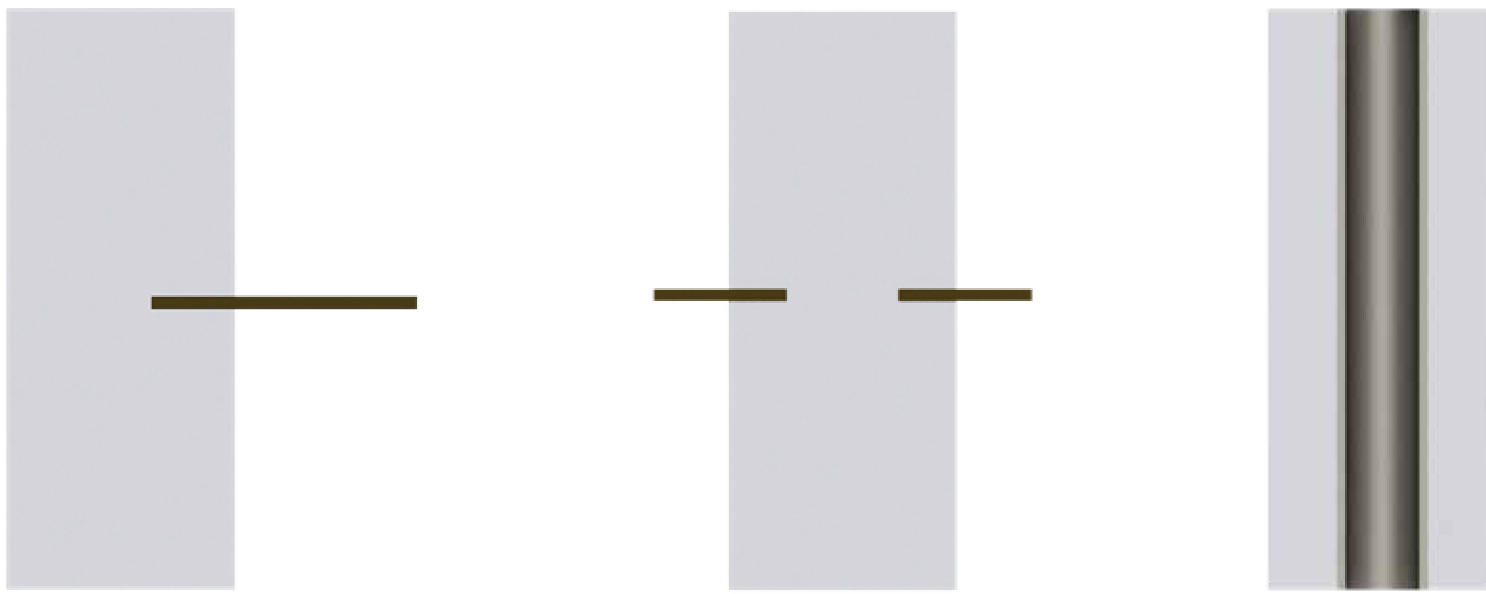
Brief

I aim to explore the intersection of sheet metal fabrication, casting techniques and the unique possibilities that arise from their combination. My experimentation will focus on manipulating the flow of molten aluminum to effectively capture and integrate sheet metal and machined components within a casting, resulting in a permanent connection. Through this innovative manufacturing approach, I hope to create functional objects that push the boundaries of traditional design and fabrication methods, offering new and compelling solutions in the realm of manufacturing.

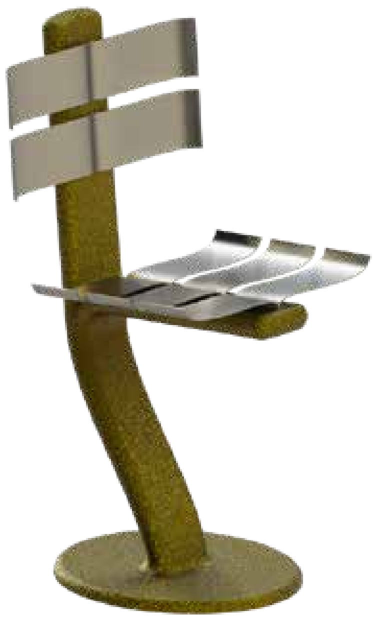
Chapter 04:
Ideation

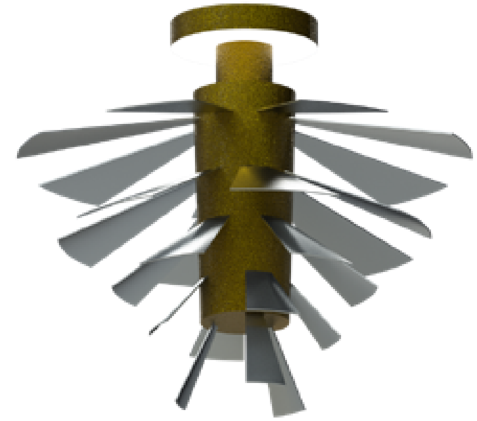




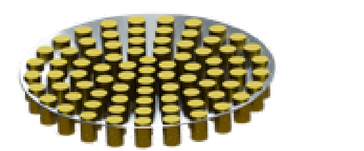


After my initial sketches, I experimented with three different ways in which sheet metal can be trapped within a casting. To the left is a method in which I call ‘biting’, which involves the edge of a sheet metal component is trapped inside a casting, effectively ‘biting’ the piece once cooled and clamping down as the cast component shrinks. The second method is a ‘through-hole’ in the sheet metal where the casting is forced to flow through, then spreading out below to trap the sheet good component. Finally, the core method, this involves a tube or pipe being surrounded by molten metal, effectively creating a hollow core for wires or cords to run through unseen.





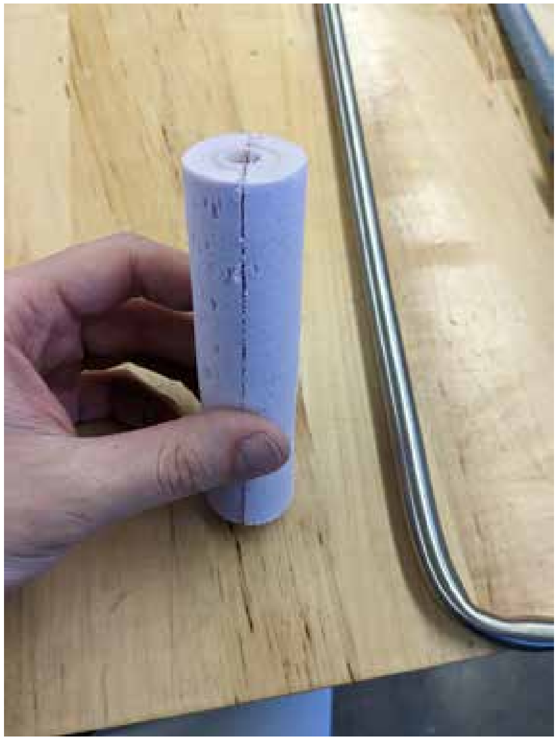


I further developed my earlier ideation, and divided my focus into three different streams. The first exploration avenue was furniture, I was intrigued by pushing my own limits to design something which I may not have been able to cast myself. Next was lighting, this allowed for experimentation with form, but also with light refraction and reflection, using the metal's luster to my advantage in distributing light. Finally, my third concept was that of domestic, homegood collections, this allowed for many, smaller pieces to be experimented with. After this development, I decided to continue forward with the lighting concept, as this avenue appealed the most to me.

To begin my casting experimentation I made small scale tests to prove my theory about the three methods of trapping sheet goods in a casting. After completing the more basic, primary development models, I generated more samples to test some of my other theories such as the flow-through hole size, and how small the hole until the molten metal couldn't flow through enough, as well as edge deformation tests to provide a better grip.

I also completed several tests, including the ‘double capture’ where a single piece of sheet metal is caught twice in a single casting. I also tested different methods of creating hollow cores through a casting, one being using the use of a tapered, wooden dowel, which could be removed once cast. The second method being the use of a steel tube that becomes locked within a casting once cooled.

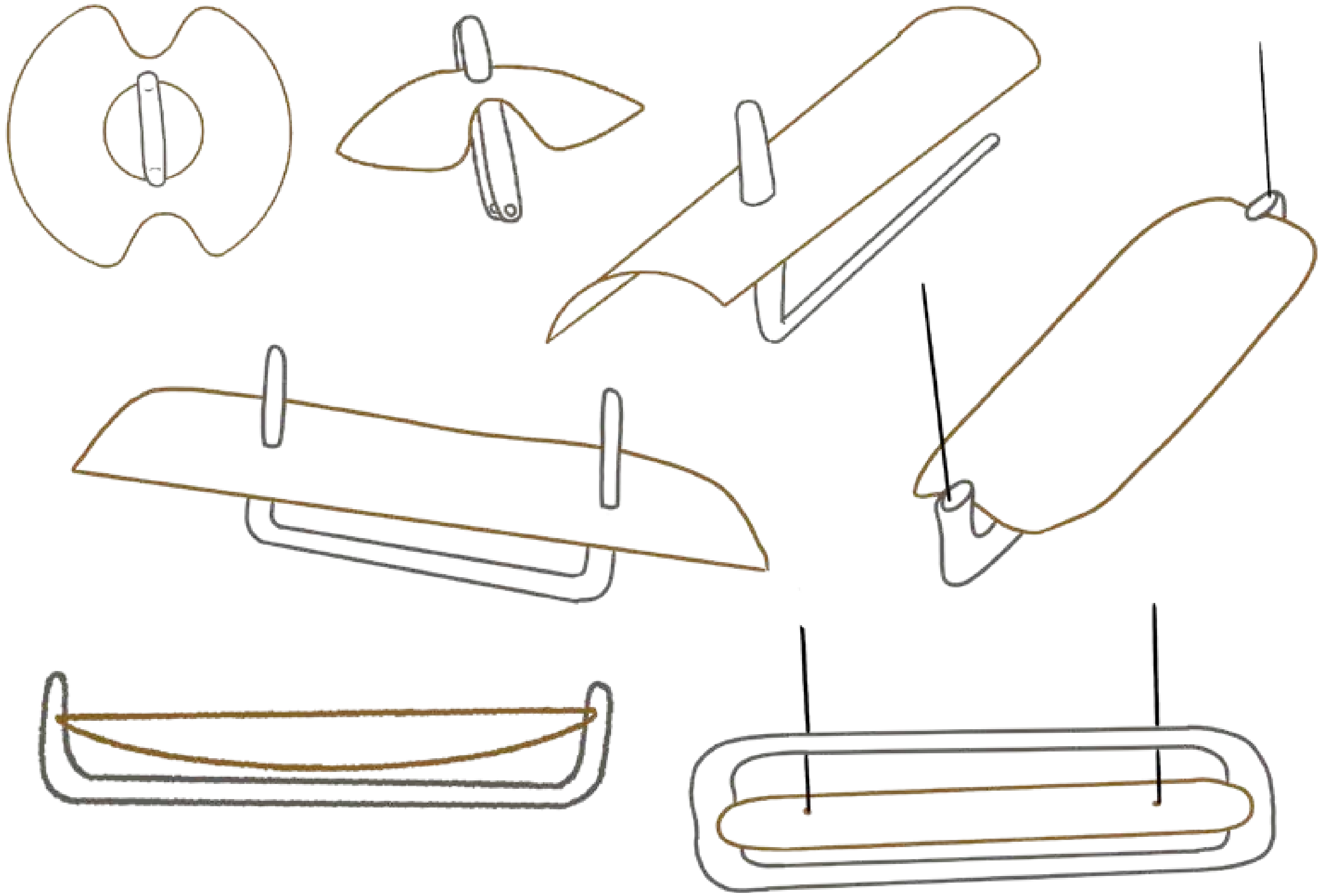


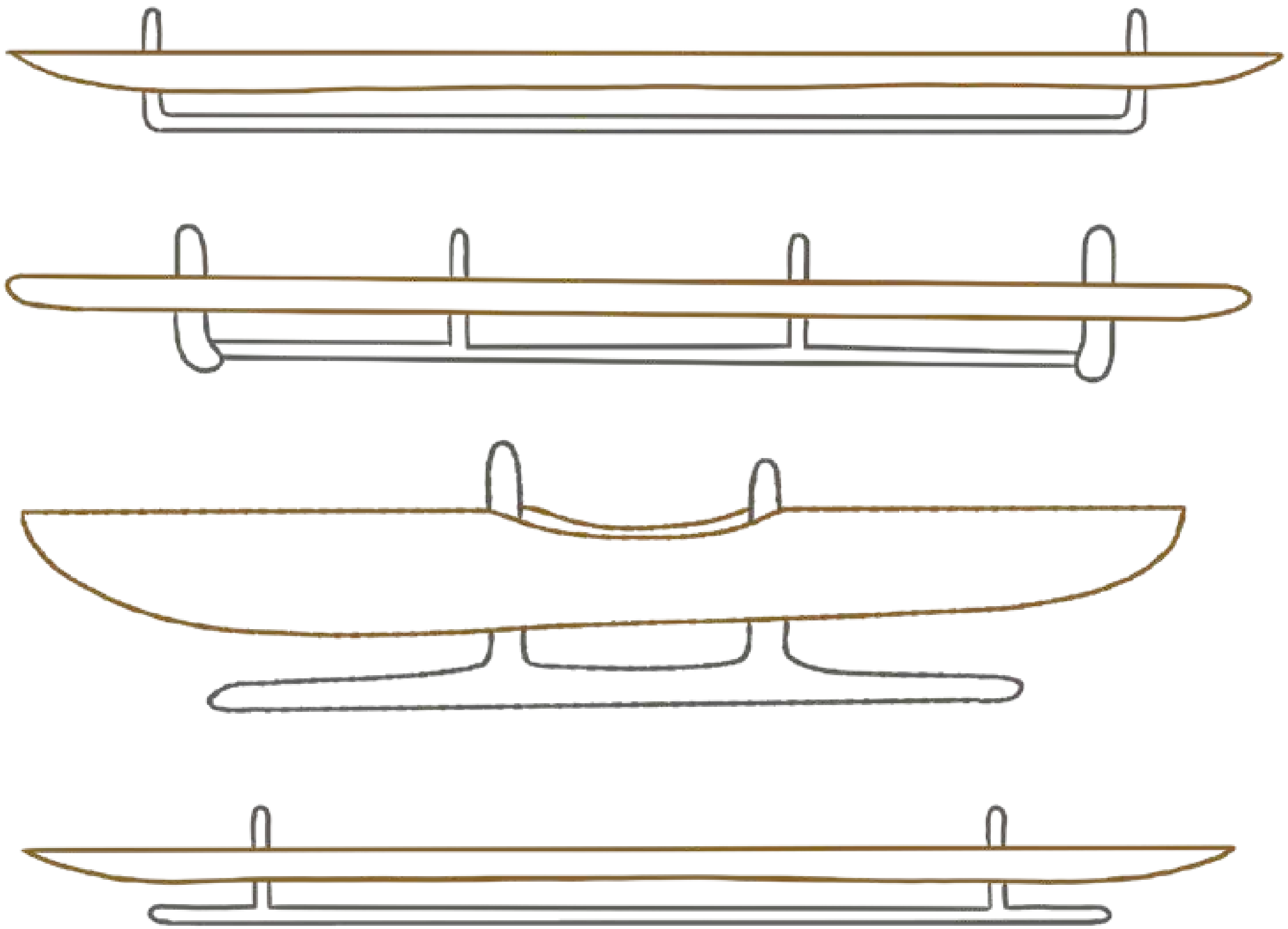



This sample demonstrates the use of a tube core that evacuates from the side, to determine if that would create any problems within the casting or cause cracking. This piece also includes a pre-fabricated aluminum insert with threads so that a threaded component could be attached directly to the casting without the need to drill or tap the cast component itself.

All these samples were successful, except for the wooden taper method, which when burned, released gases which created porosity within the casting. These experiments all proved valuable to my research and testing.





Chapter 05: Development

Devlopment

After further sketches with a focus on lighting, I decided to create some testing components to display how light would react with different metal finishes and capture methods, and how that could impact the appearance of the final piece.

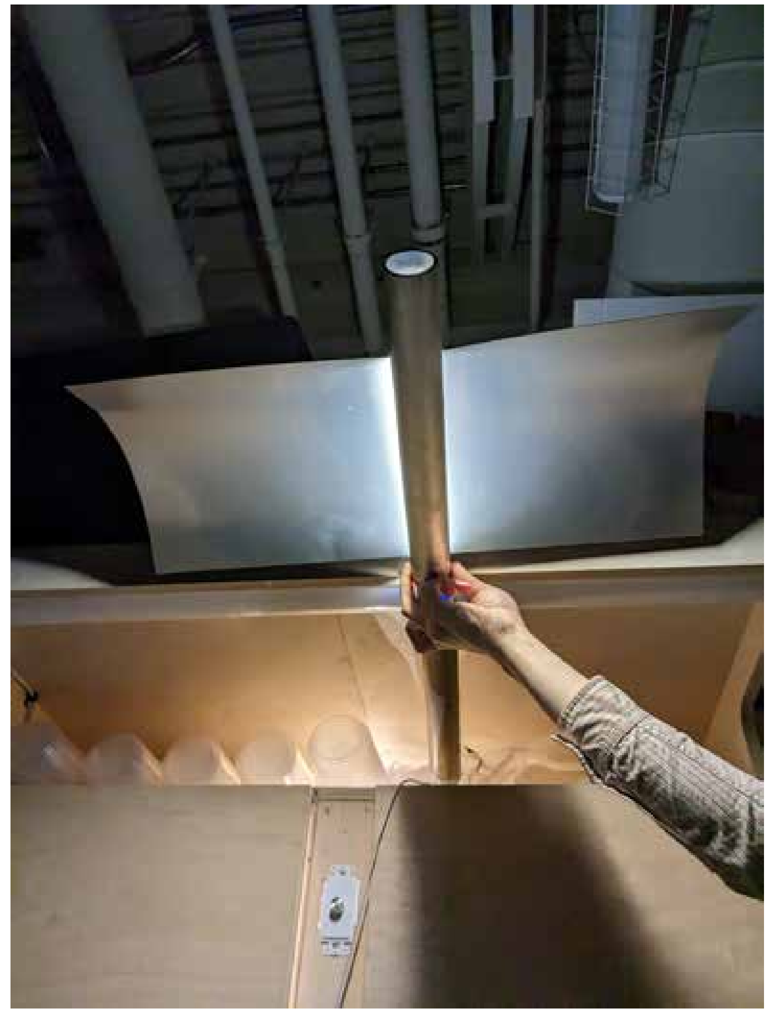
To the right is a steel tube which has a stepped channel, allowing for a metal sheet to be inserted at different steps, creating different curvatures and interations with the light.

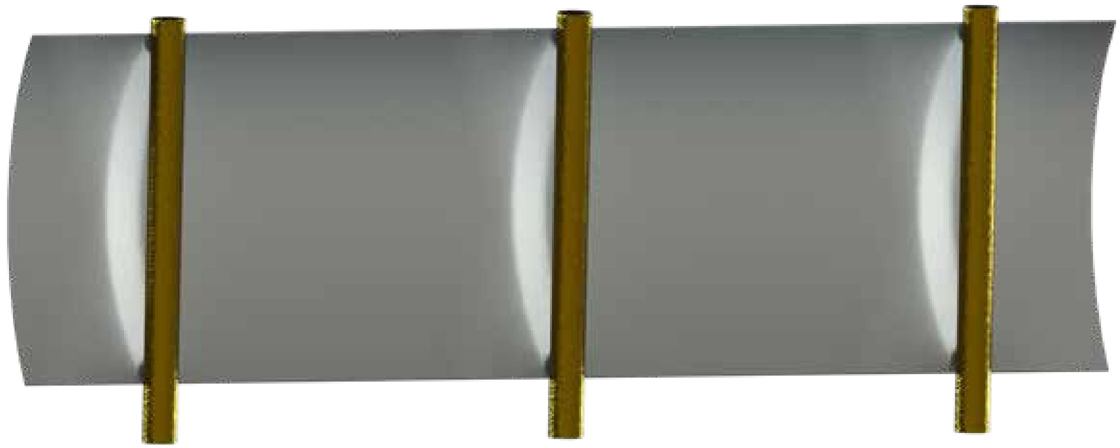
This is one of the first samples generated, by using a sandblasted aluminum sheet, the effect that this produced was a relatively diffused light that provided no direct reflection of light.


This sample displays a polished aluminum sheet, this test shows the direct light bouncing off the metal and creates an interesting arc from the side.

This test uses a sandblasted brass sheet, this diffuses the light similar to the first test, but the warm tones of brass give the light a warmer quality, creating more ambiance.

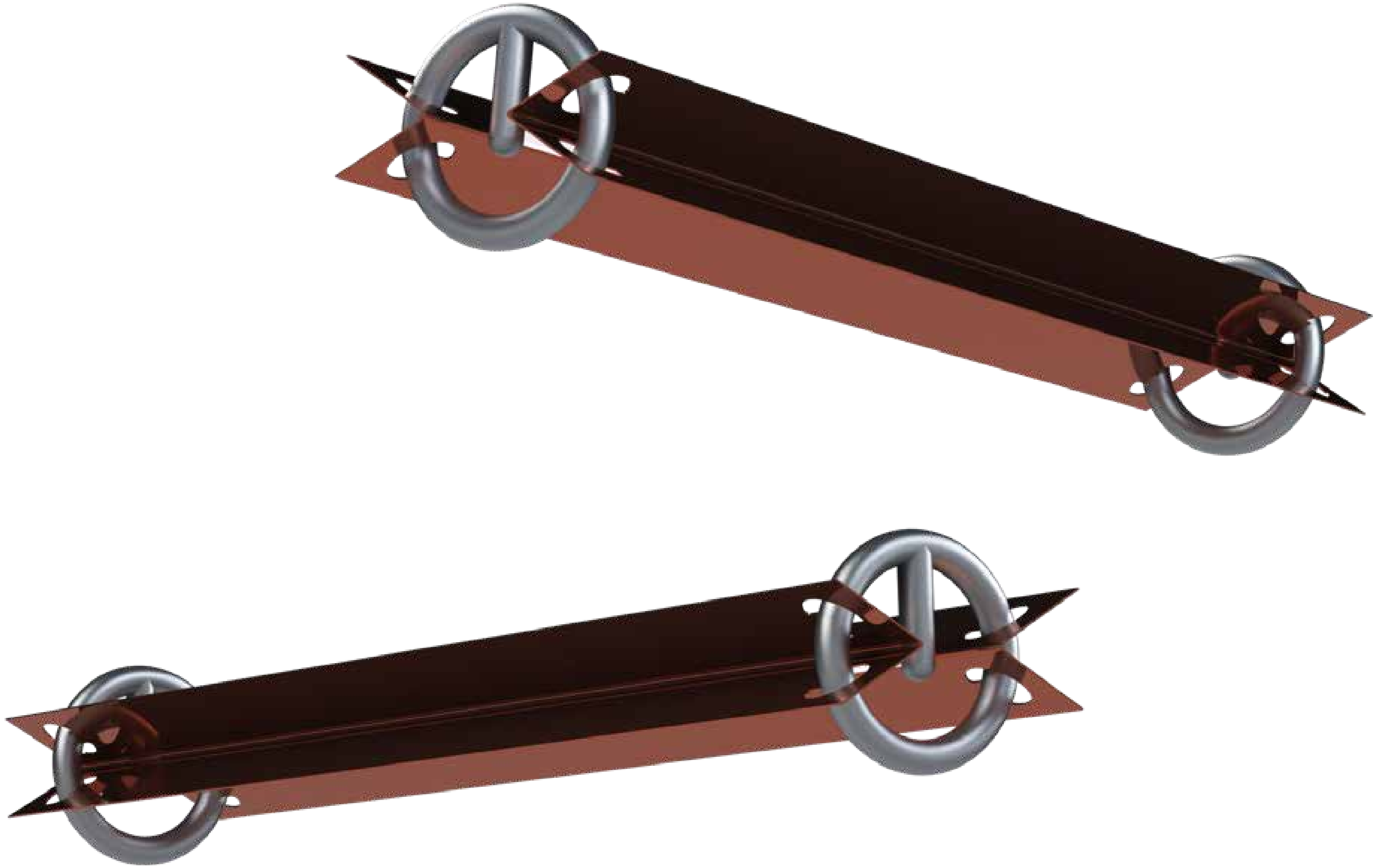
This test is similar to the polished aluminum test, but instead uses a brass sheet, again creating that arc from the side, and providing the light with a warmer tone.

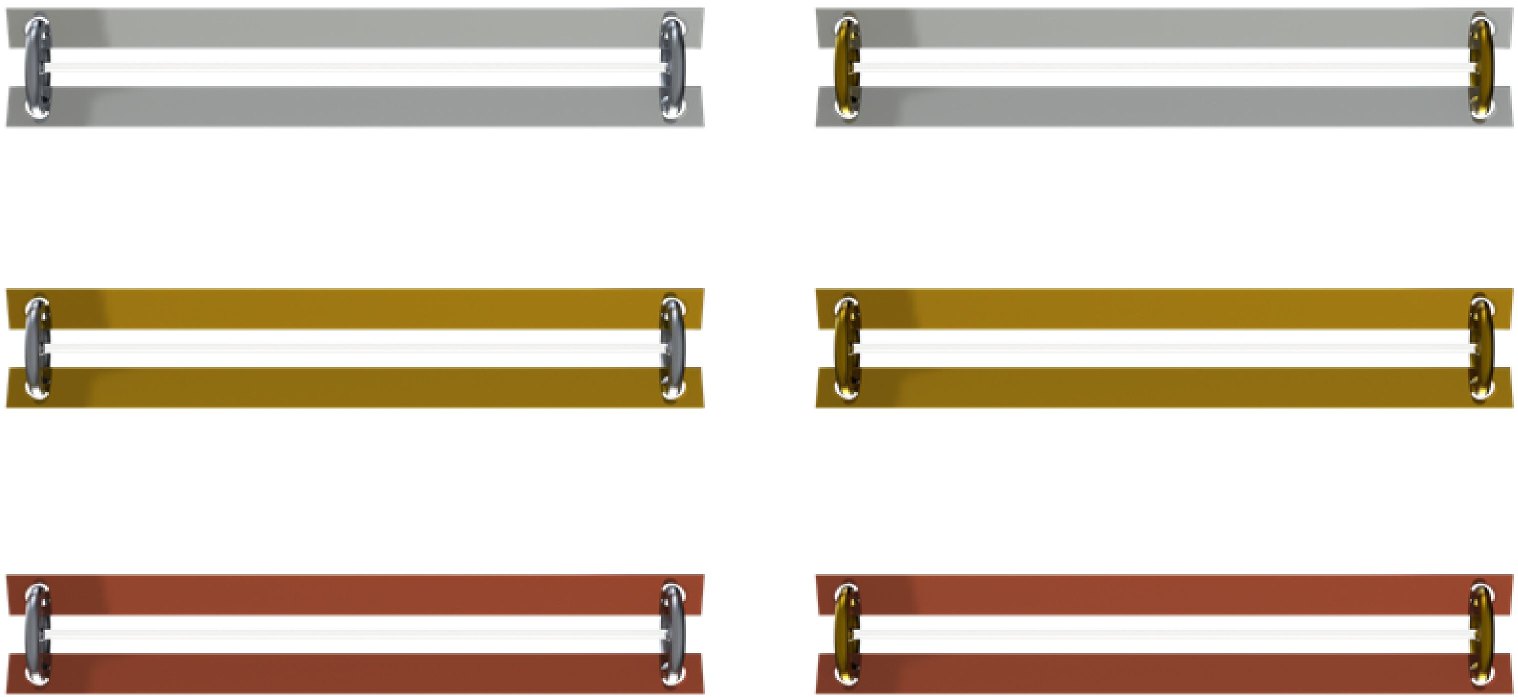




This is my initially developed concept, this included a number of castings which housed individual LED strips directed to reflect off of the sheet metal, similar to the tests.

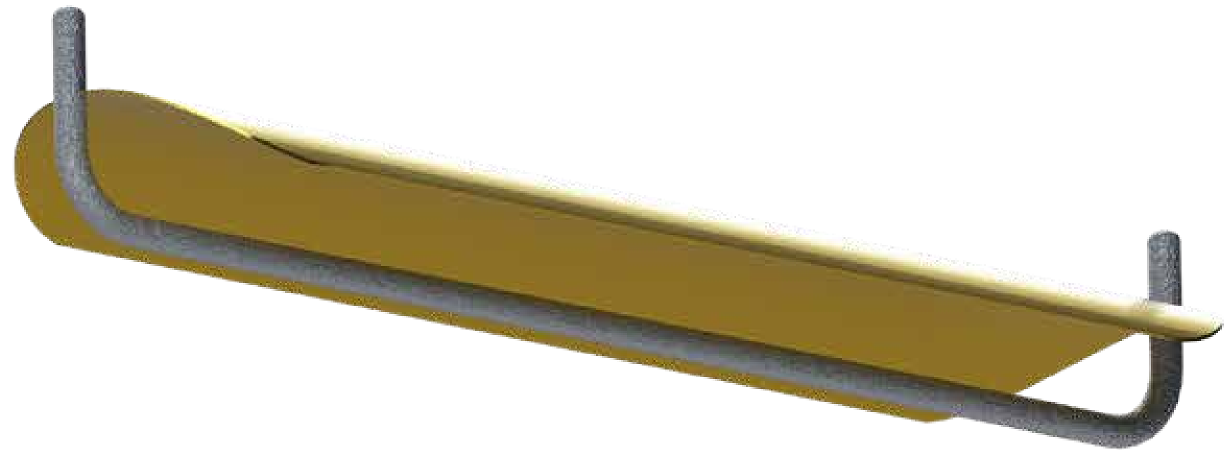
This demonstrates another concept after further development, this uses a different interaction between the light and sheet metal, reflecting off of the flat panels and using a direct light source. This piece also captures the sheet metal and light in a unique method.

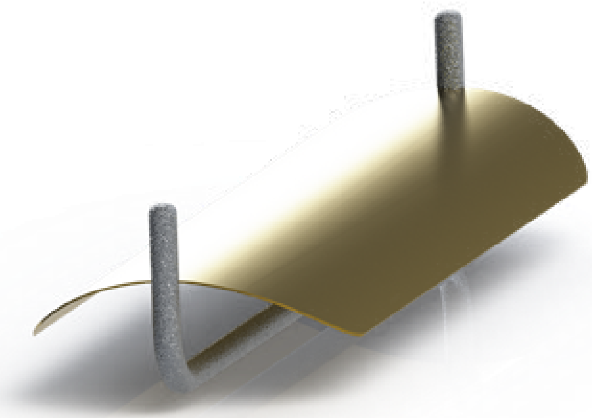


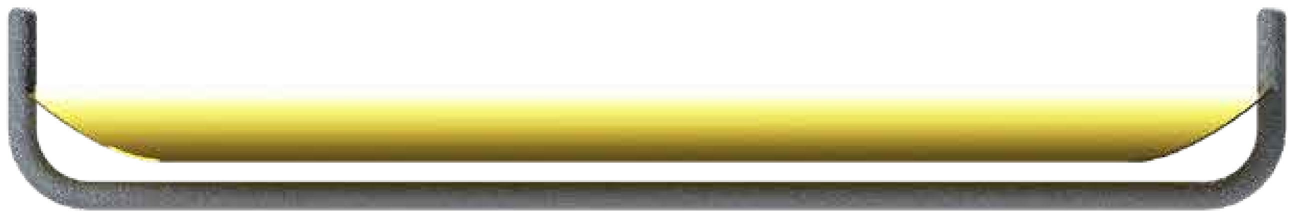


This demonstrates the possible opportunities to use different combinations of casting and sheet metals.

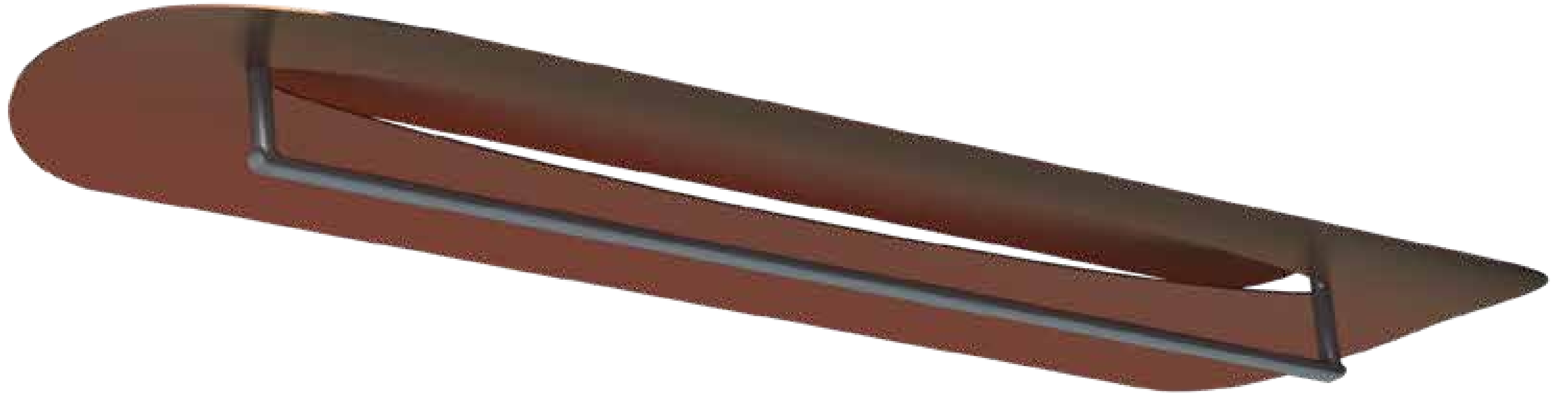
This concept explores the capture of sheet metal using the ‘biting’ method and would need a curved, tube core to allow for seamlessly wire the electrical components of the light. This concept would need to explore the use of a cable connected to the sheet metal in order to support the structure.

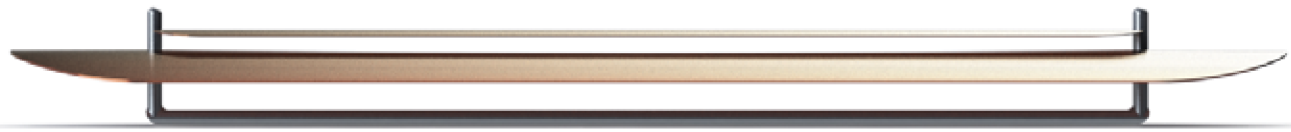




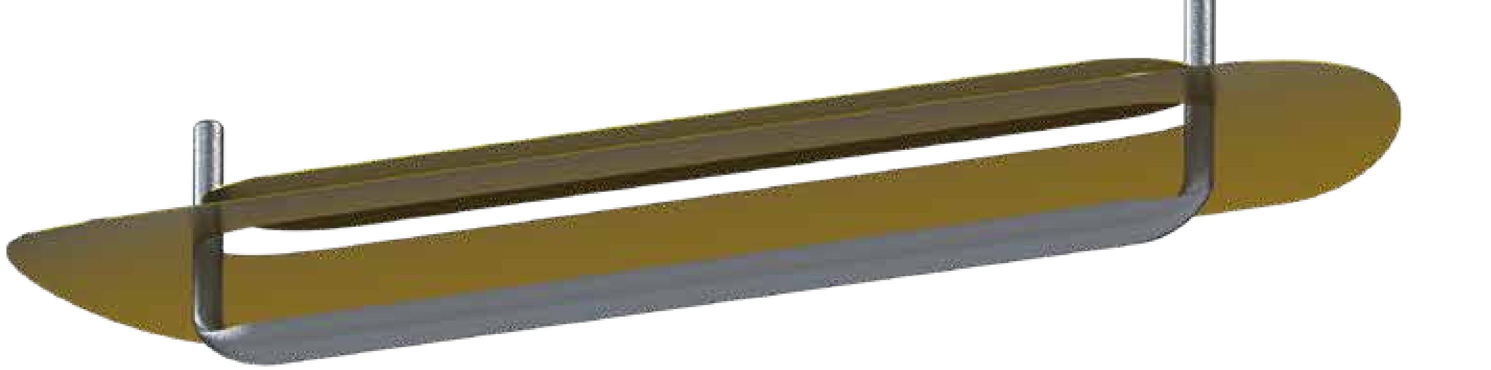


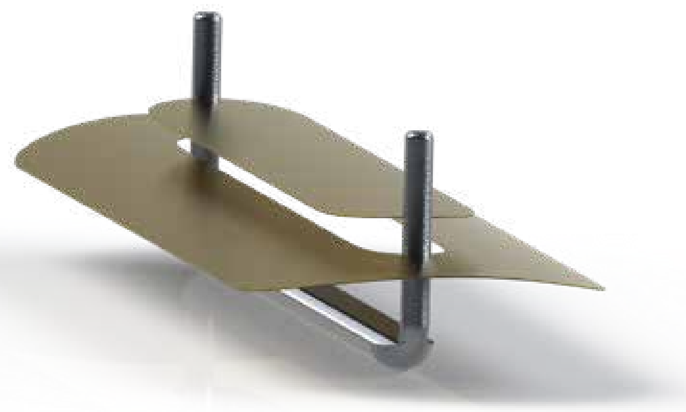
To alleviate the need for a cable, this concept displays a fixture with the cast component going across the length of the sheet metal and providing support on both ends. Though as the light would come from the bottom, this would create a dark spot across the top of the sheet metal.

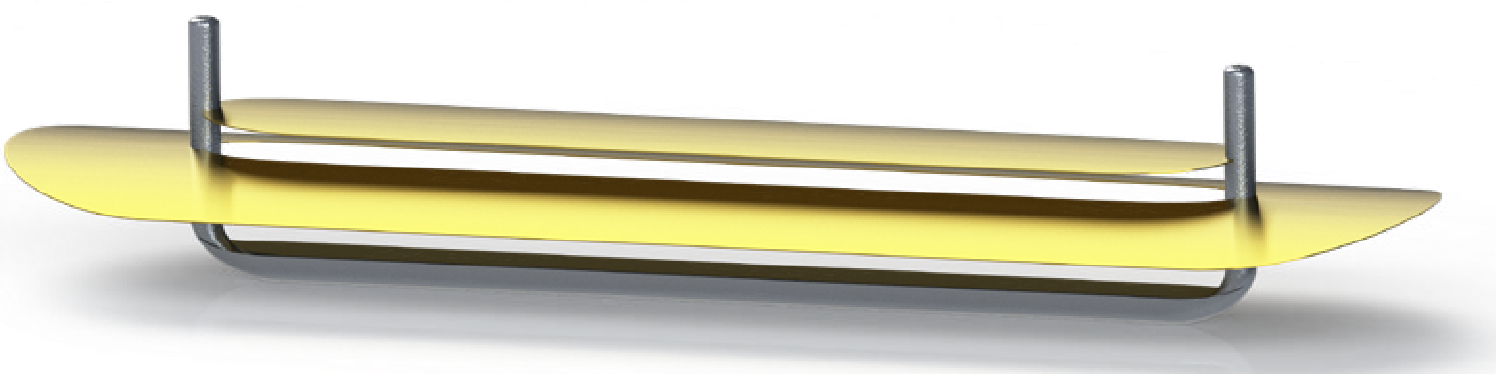


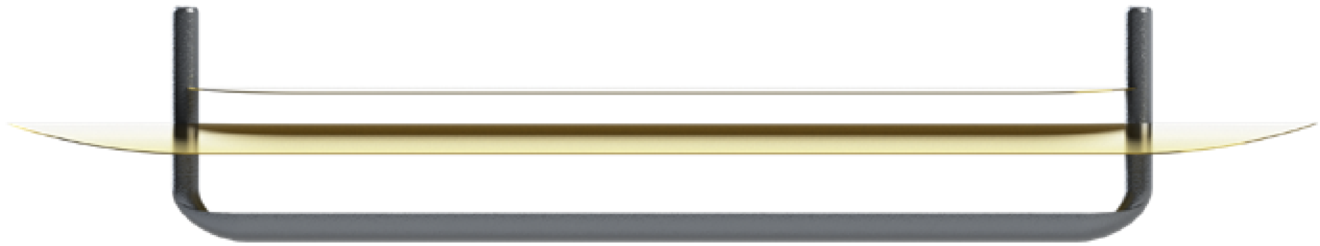


To solve the issue of a dark spot across the top panel, this concept uses a hole in the lower panel and a second, smaller panel above that hole to reflect light back down across the top of the larger sheet. One thing that I didnt like about this concept was the fact that it be fabricated cmopletly out of tubing.

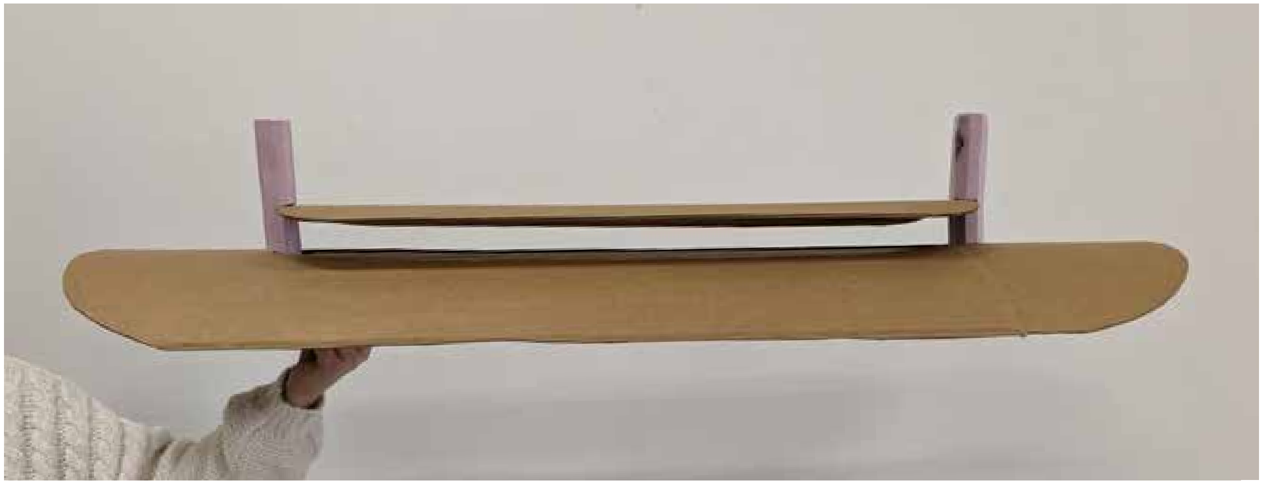


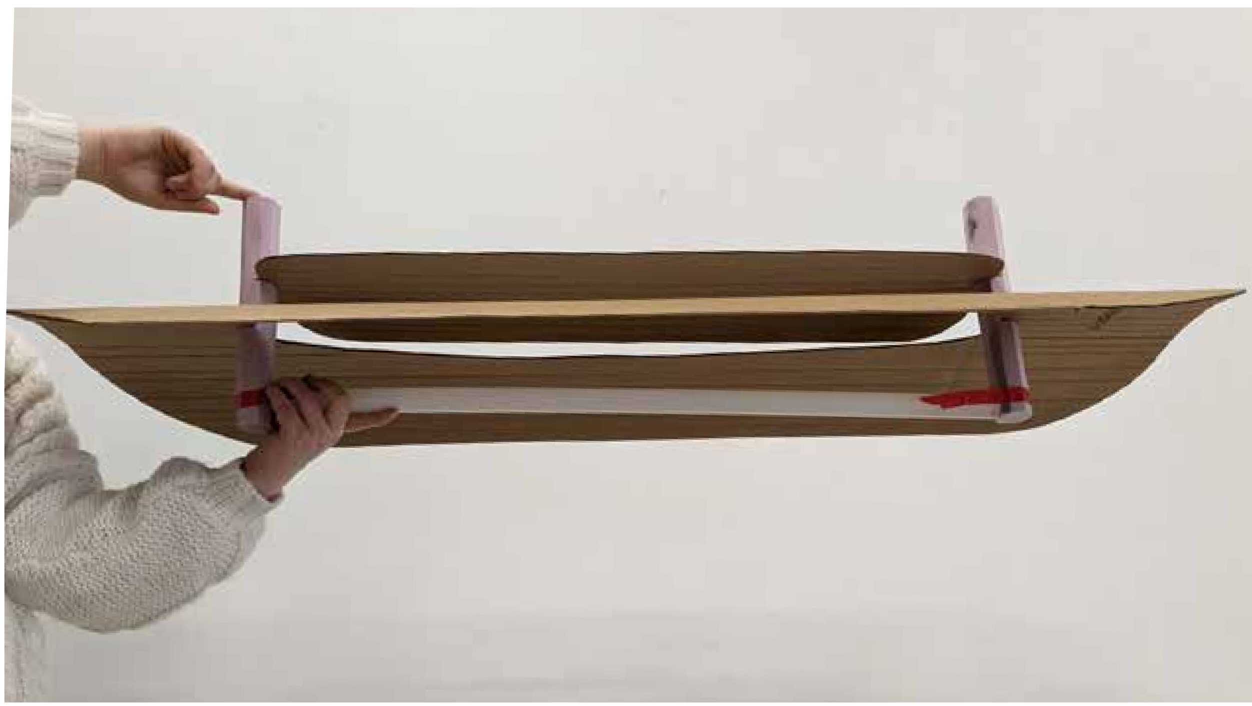






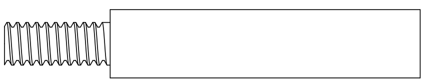
This concept incorporates the same two sheets to provide an interesting ‘glow’ from the large sheet, but also captures the sheet metal components in a way that tube could not, resulting in a form that could only be manufactured with the combination of casting around sheet metal. I increased the diameter of the cast uprights in order to emphasize the seamless nature of the connections. This design also uses a boat-like track across the bottom to contain and conceal the LEDs and directly flow from the uprights in a method that would be difficult to manufacture using another method.

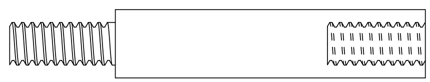




This cardboard model was made to demonstrate scale and visualize the proportions three-dimensionally. This model allowed me to see what the ‘cut out’ would look like from below.

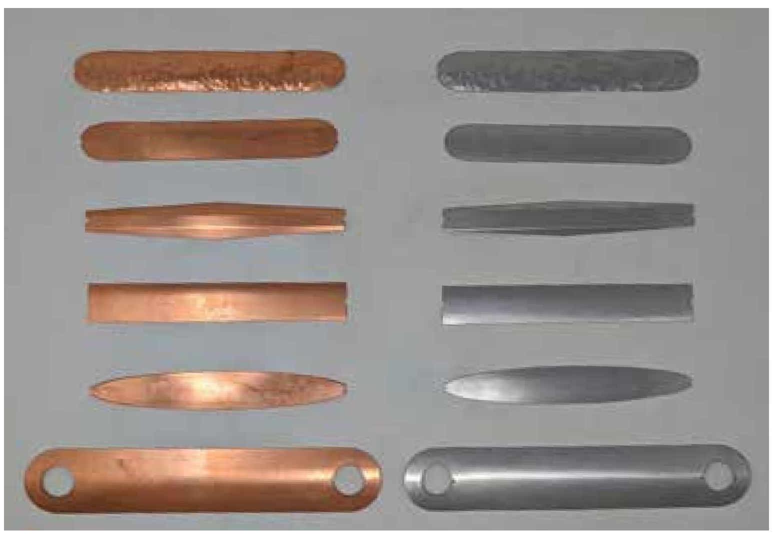
These are renders that display a potencial use scenario, depicted above a dining table.





To play more with the proportions of the fixture, a small-scale system was developed to interchangably adjust the proportions. This system implimented the use of threaded aluminum components and 3D printed pieces.

Above are the component sets I created and their different heights are used to adapt the mini model for different proportions.



To continue the exploration of form, I generated more samples which were then cut on the waterjet, this allowed my mini models to switch out proportions but also test the light effects on different materials and shapes.

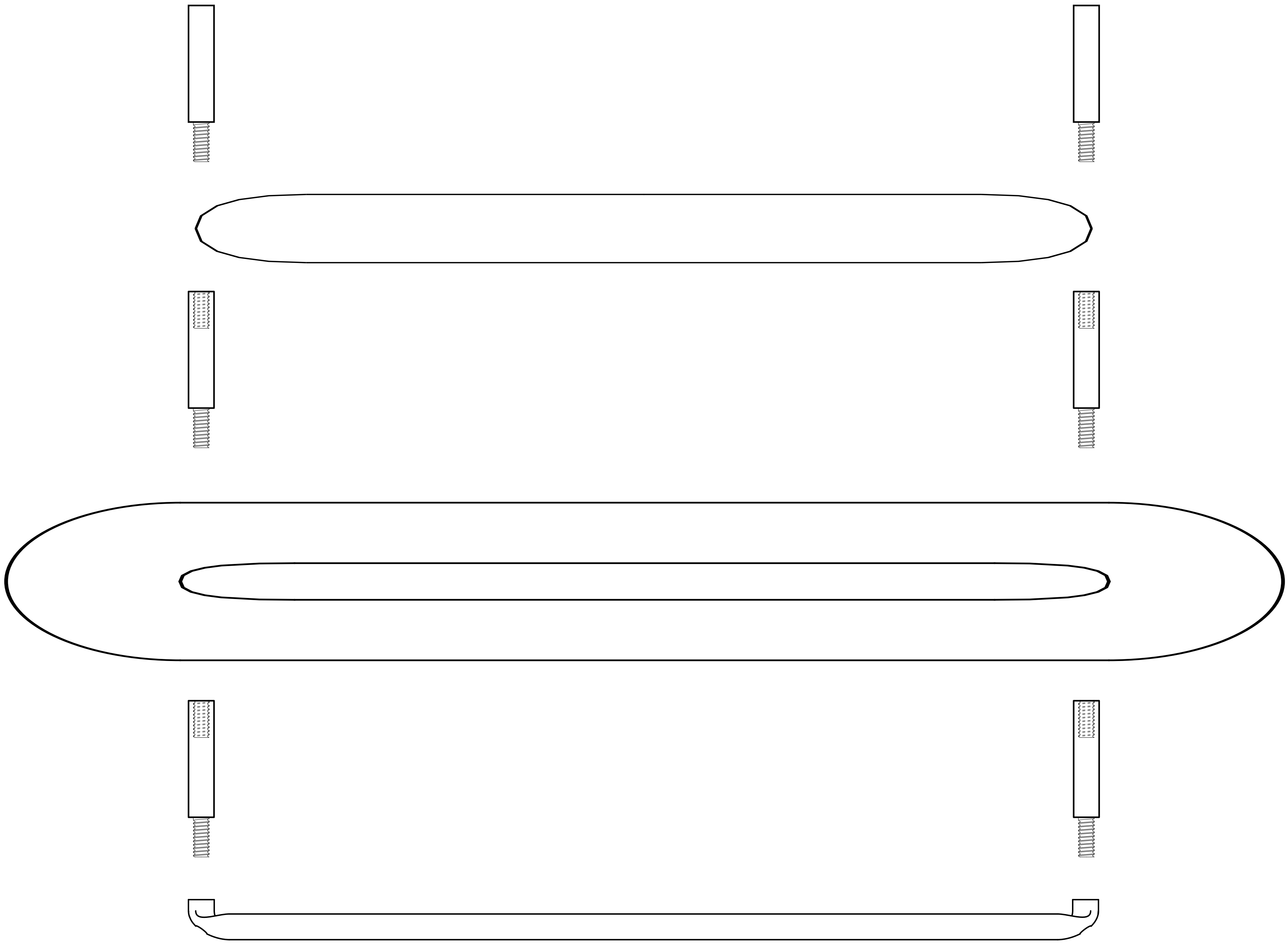
To give all the sheet metal components their relative curvature at this scale, I created a coresponding positive and negative mould to press the sheet metal into my desired curve. This was cut using the CNC.

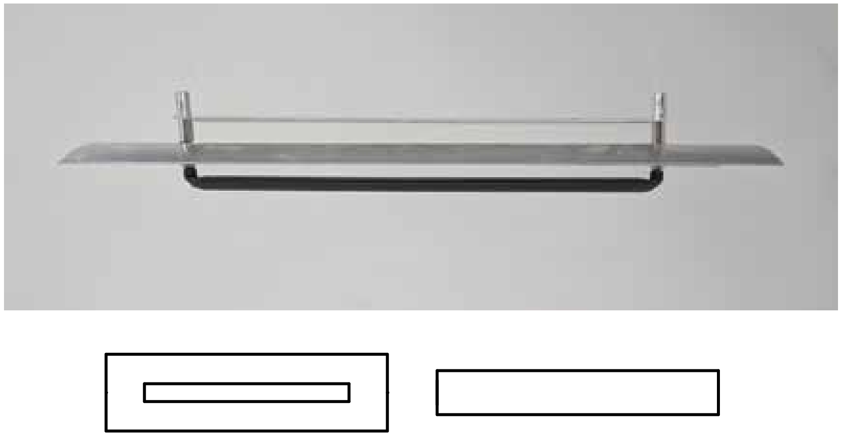
To give the sheet metal components their shape, they were sandwiched between the positive and negative moulds and then beaten with a hammer until they conformed to the mould.

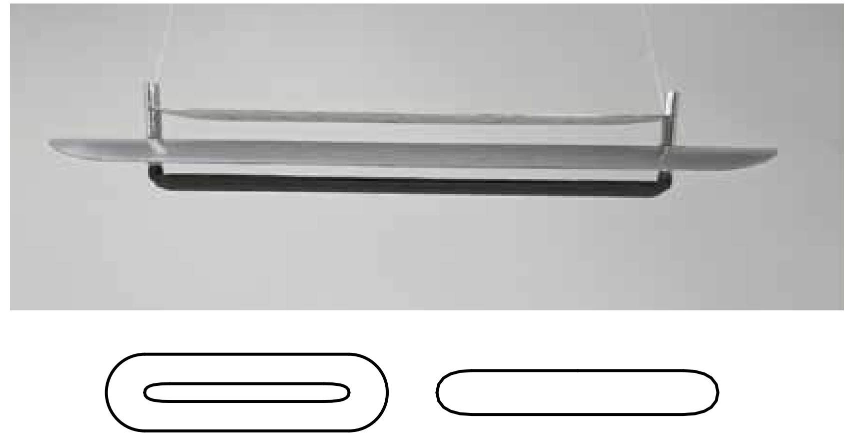
For some tests I used a ball pein hammer for a metal beaten effect, and for another sample, the 'curve' was created using angles bent on the metal brake.

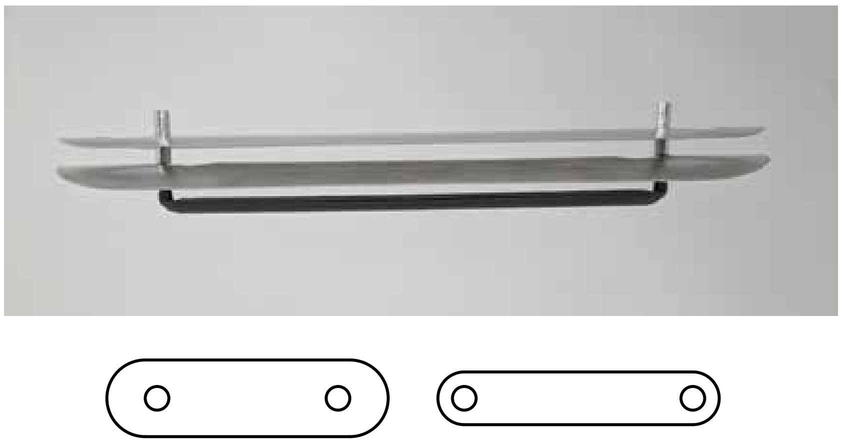
Assembling the models

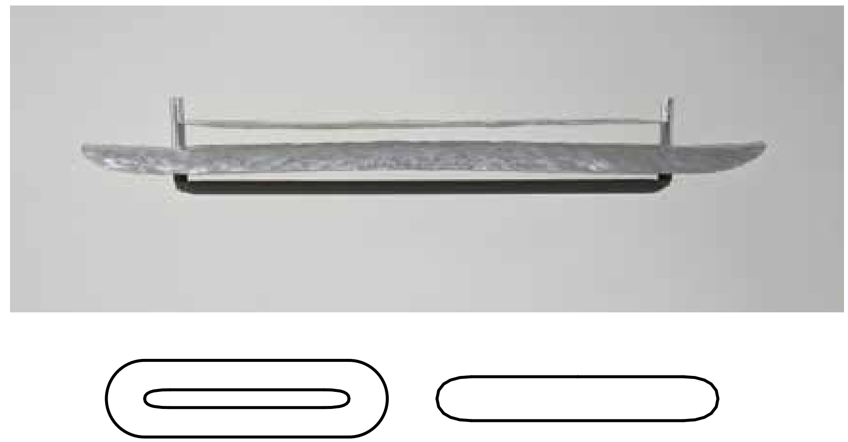
To assemble the models, the respective components were screwed into the 3D printed base, then assembled as pictured to the right.

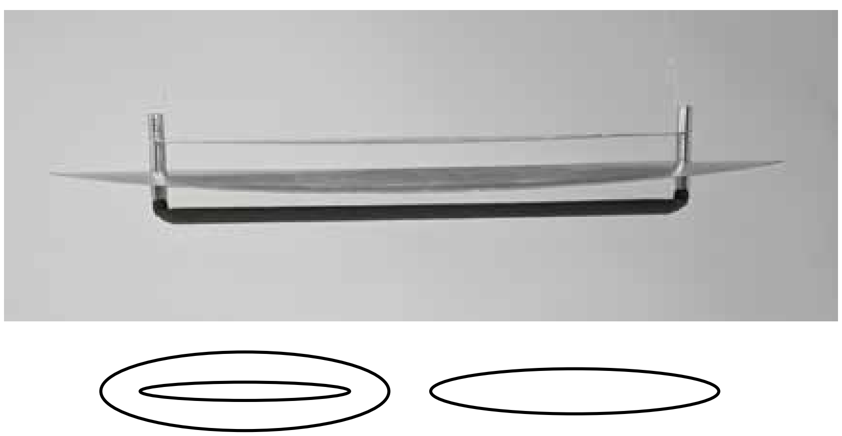


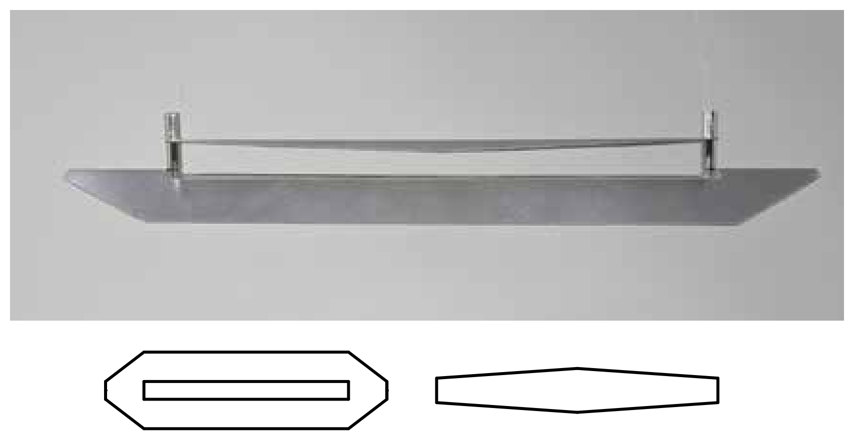




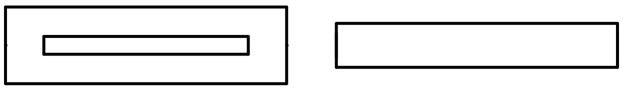
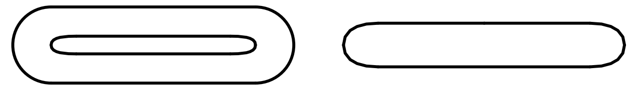


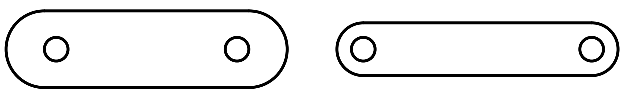
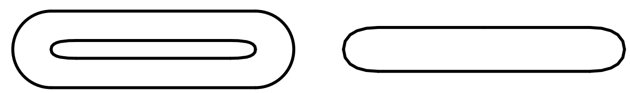


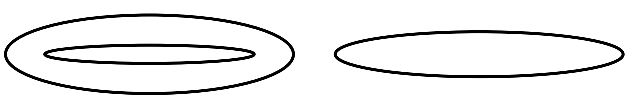
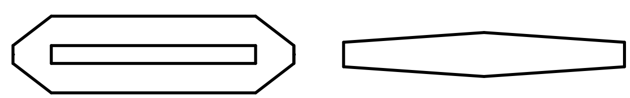






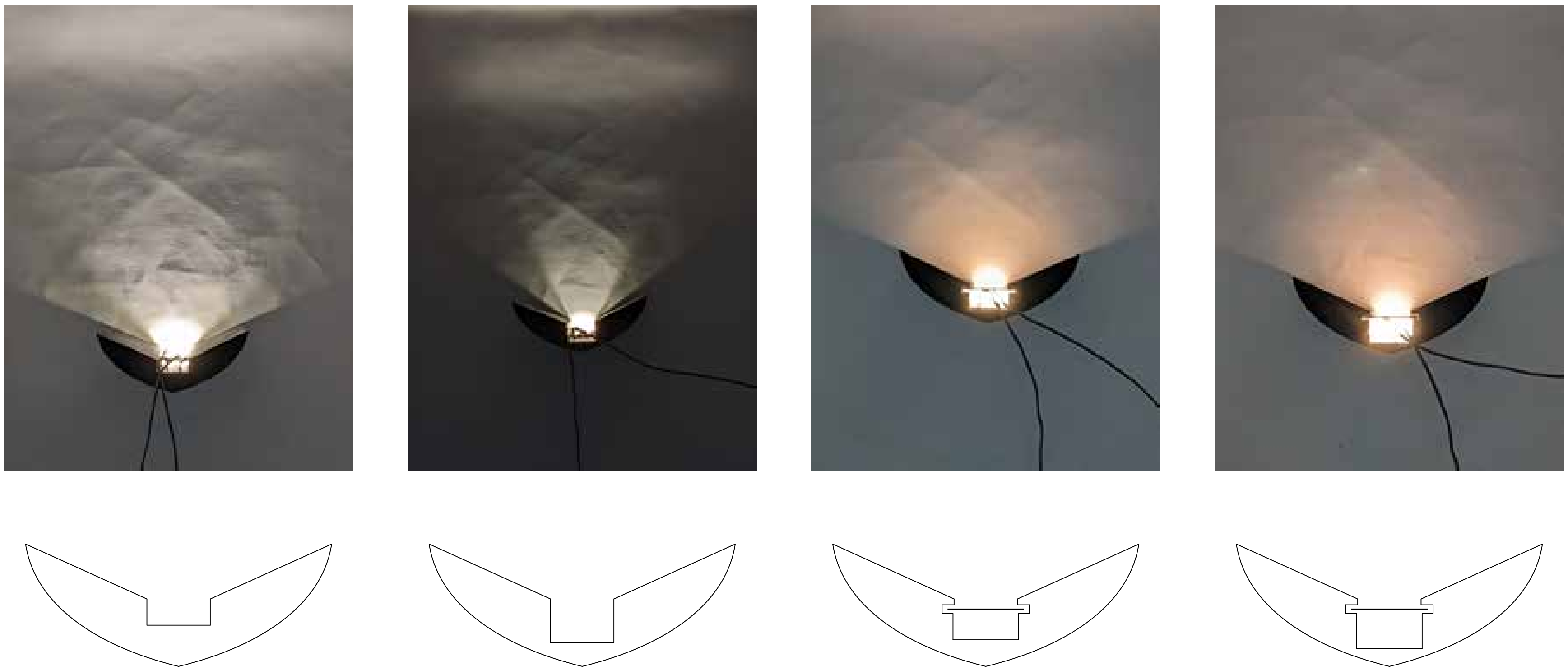





Not only did I adjust the shapes of the shades but I experimented with varied proportions before finalizing the design.

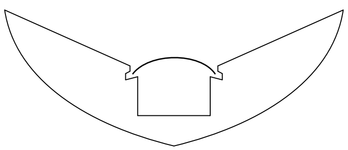
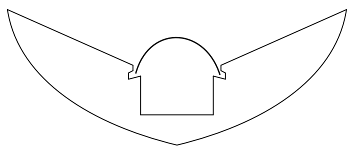
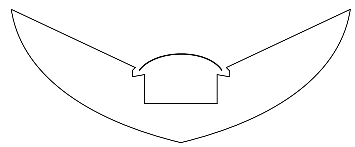
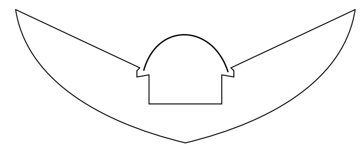
Before finalizing the shape of the boat track, I wanted to explore different profiles and how they would direct the light. I 3D printed six profiles to determine which best suited the light.

To create the diffusers for these profiles, three dowels were vacuum formed and a section of each was marked and cut to demonstrate different curvatures of diffusers.

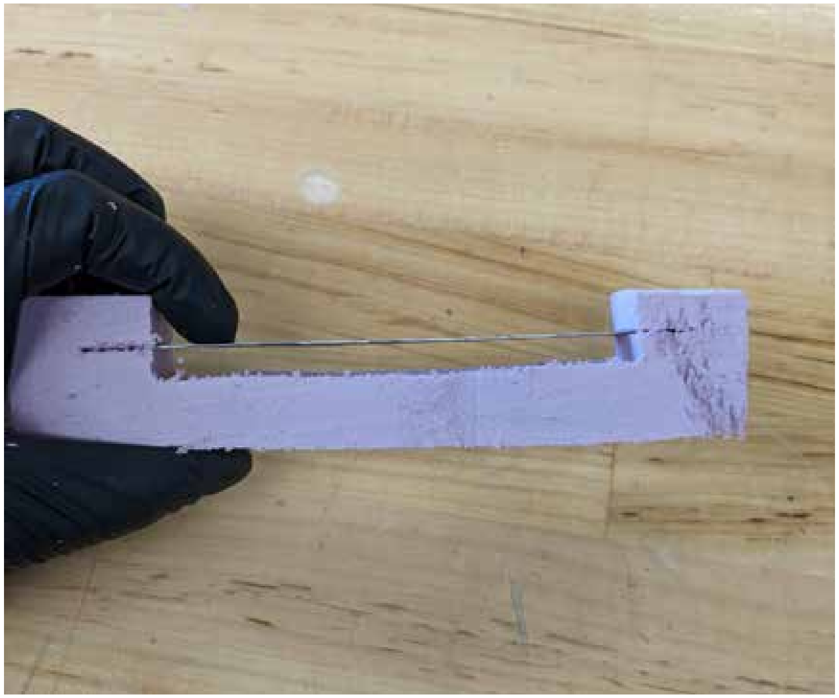


LEDs were inserted into each of the profiles, and placed in a dark room on a piece of paper, in order to visualize the path that light would take emerging from each respective profile.



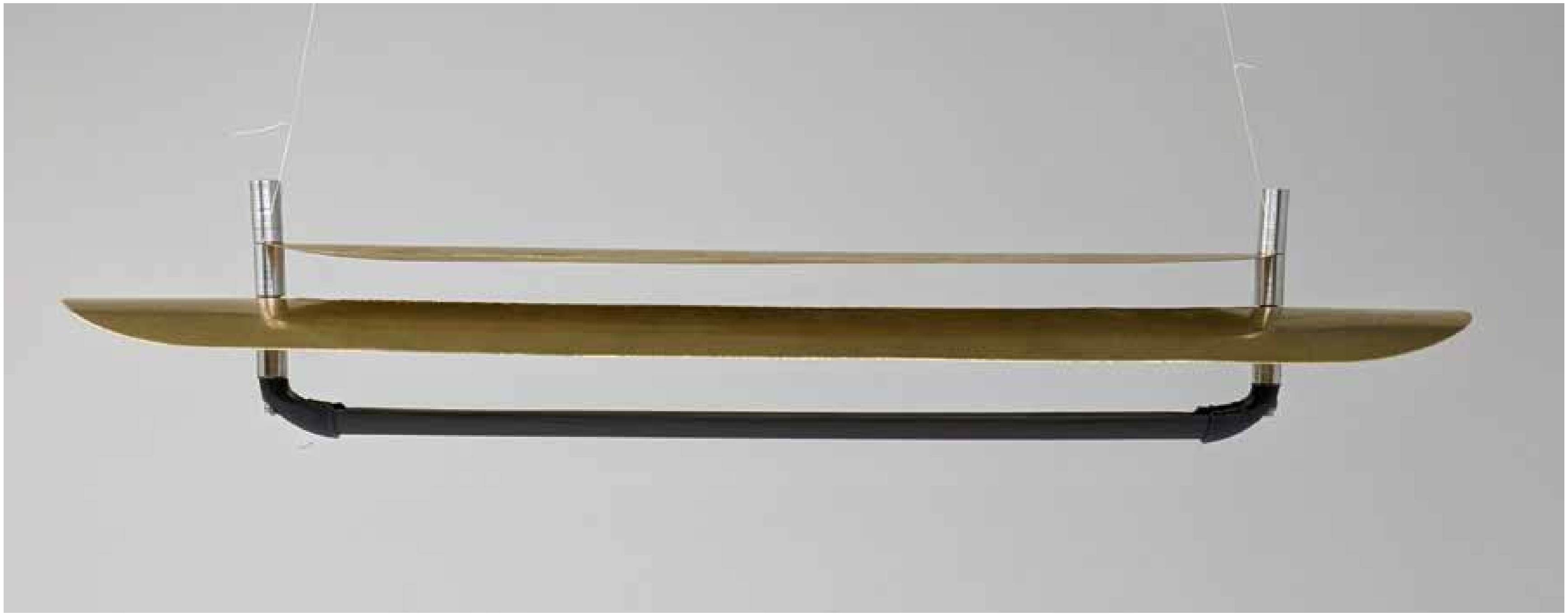






These tests provided me with an understanding of how the light would react to the different diffusers and profiles, and I learnt that the more a diffuser sticks out from the profile, the more diffused the light is.

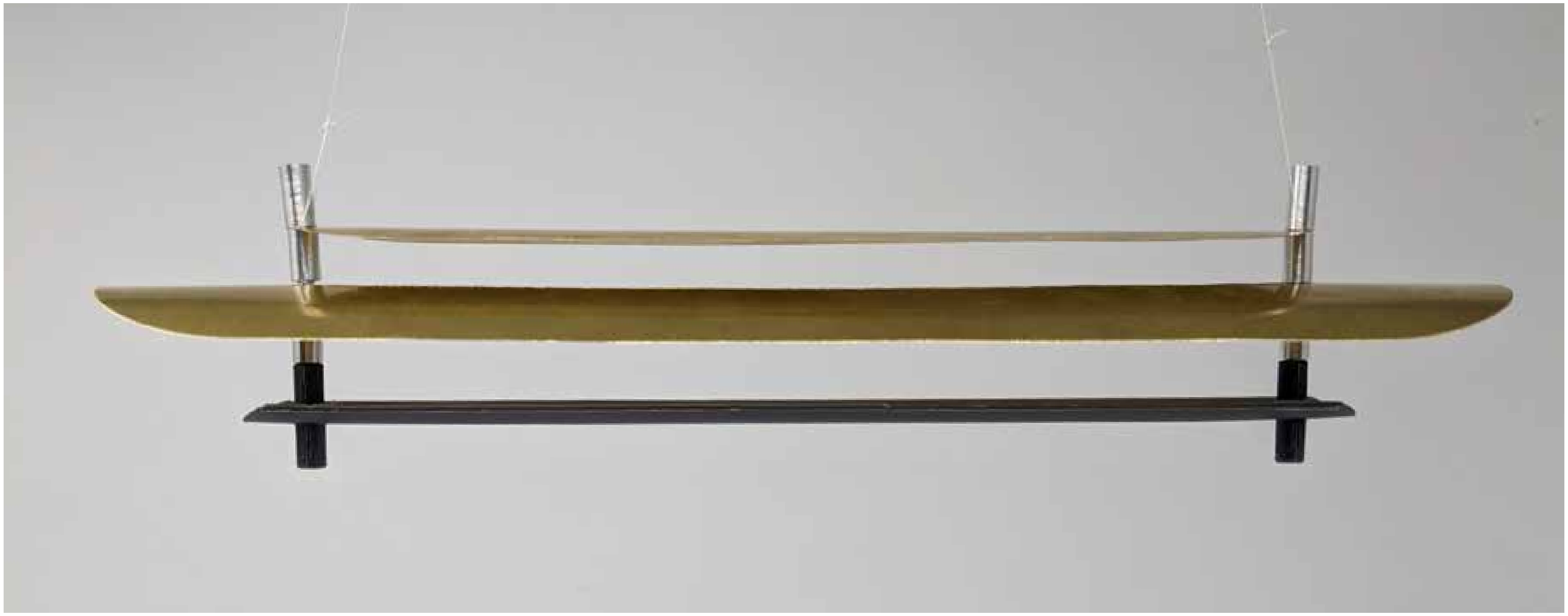


To determine whether the concept elements would work, I did this test involding a piece of sheet metal trapped between two ends of one cast component. From this test, I discovered that my previous design would not work, as once cooled, the shrinkage of the casting serevely deforms the sheet, causing the sheet metal to bow.

If I had proceeded with casting this design in this manner, the resulting bow of the sheets would have resulted in an outcome like this.

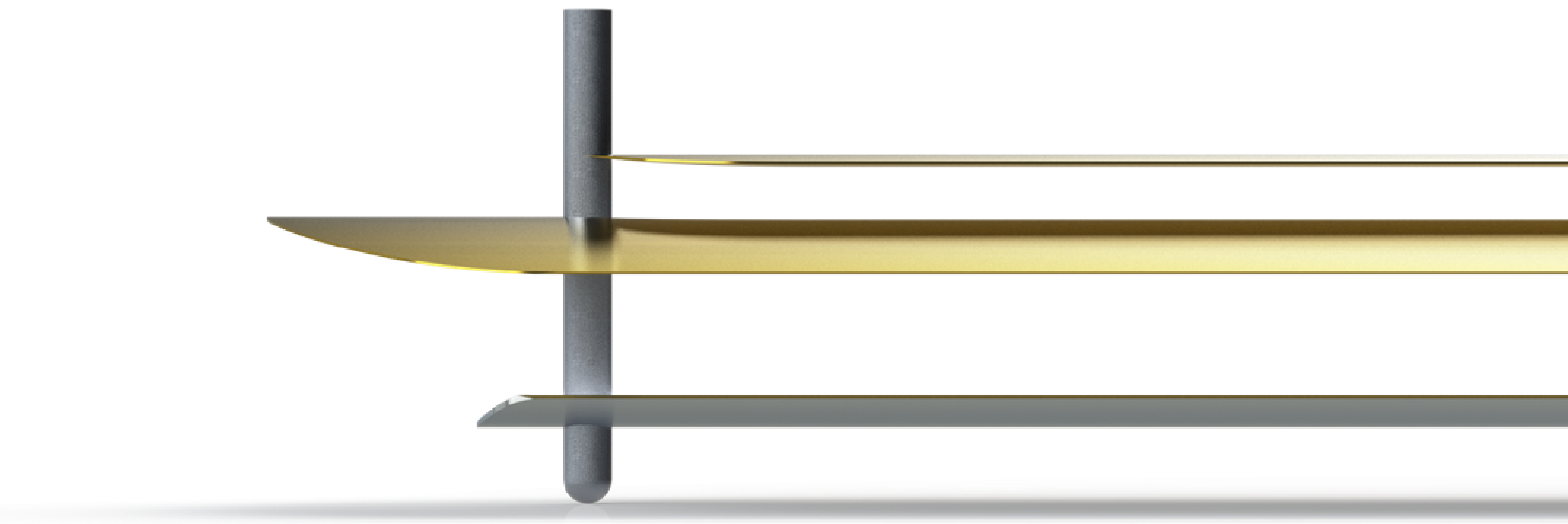


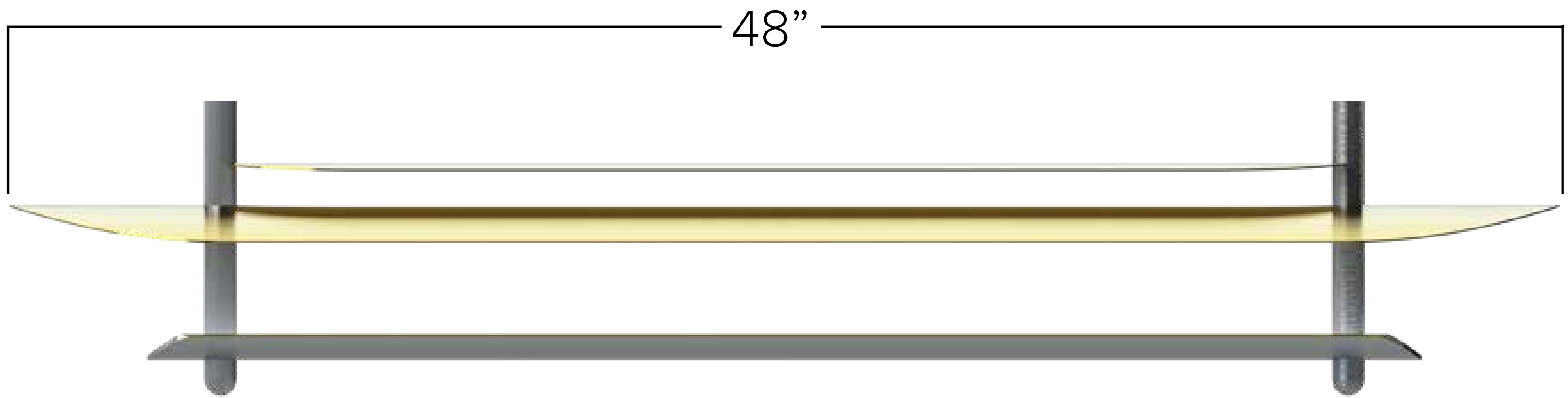
To remedy this, two revised designs were created in order to solve this problem. The first is casting and capturing a third piece of sheet metal to act as the track for the light.

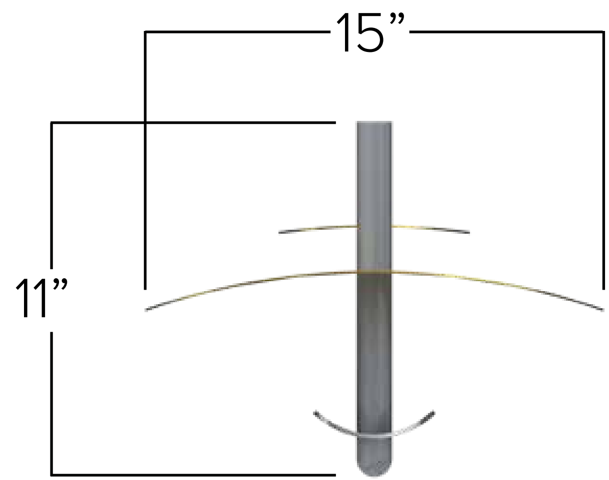


The second is the capture of a sheet which extends across both cast components and mimics the shades above.

Chapter 06: Final Concept




48”


15”
11”

In order to cast the pieces, I needed to create moulds which the molten aluminum would burn away and fill the space. To create these moulds, I used the CNC to cut out the corresponding pieces, assembling these around the hollow steel core.

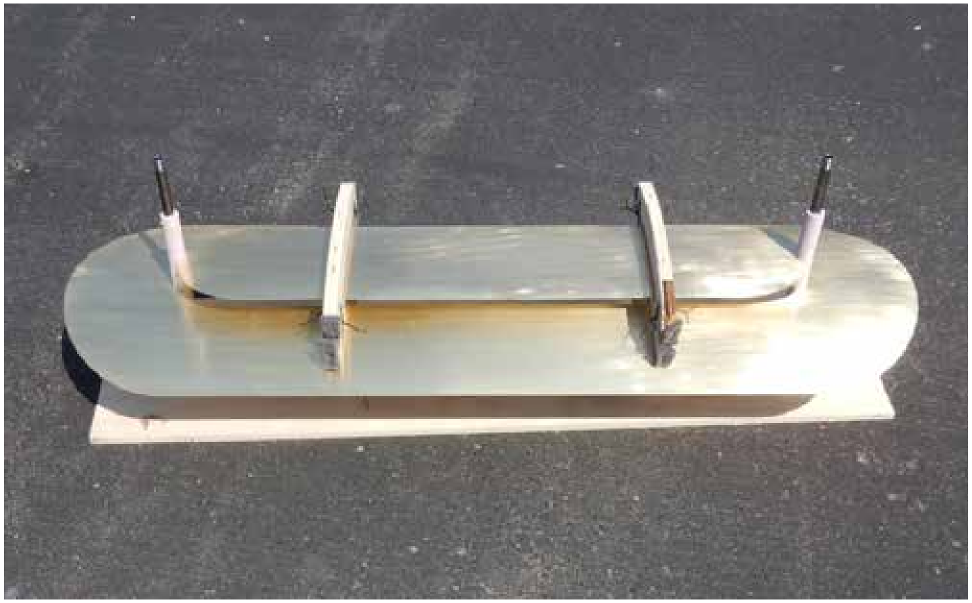




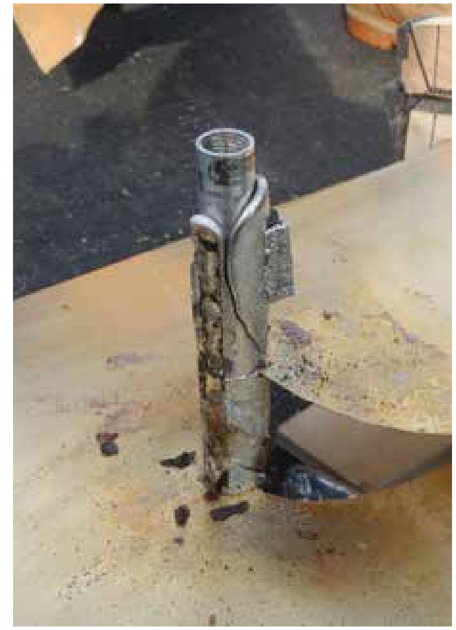

To prepare the sheet metal components, I cut out the pieces and sanded them to give a brushed-like finish. I created a plywood frame with felt pieces to support the sheet metal while casting without scratching or damaging the surface finish. I used a 5'' diameter tube, then cut out the necessary section to act as the track, then rounded the edges. I also machined the inserts needed to suspend the fixture that would be trapped in the casting.

After test-fitting the inserts and bending the tube core, I assembled the frame and created a system to hold the core in place as it was being cast. I also threaded steel pipe into the inserts to hold them in place while trapped in the casting sand, preventing any shifting.



To cast, I prepared a large box and filled this partially with casting sand. I then placed the frame inside and began to pack the sand around the form, ensuring that the sand was pacted especially hard around the steel pipe, to prevent movement while casting. I also built up sand around what would be the sprues. When the aluminum seamed to reach casting temperature, I poured it into the sprue and then let it cool.

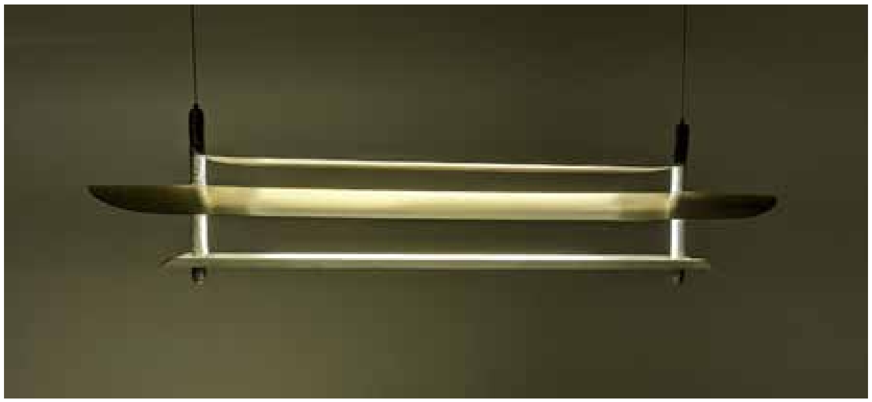
  

After sufficient cooling, I removed the piece from the sand and repeated the process on the other side. Afterwards, I removed the frame and cut off the sprues. I also cleaned the casting to provide a more consistant finish as well as machined mounts for the ceiling, allowing the fixture to be hung.





In order to test how the fixture illuminated a room, I set up the light and it provided a warm, ambient light.



I also photographed the light fixture from different angles to see how the light reflected off the surfaces and different sheet metal reflectors.

Torii

The Torii light utilizes an innovative manufacturing technique involving the casting of molten aluminum around sheet metal components to permanently capture and integrate them into a single part, resulting in a seamless and durable bond. This manufacturing technique offers a unique and sophisticated solution that can be used as a tool to achieve a heightened level of purity of form in object design.

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