Invisible Glass Display
Rochester Museum and Science Center
Product Requirements Document
RMSC/Calvin Uzelmeier

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Revisions Level	Date
E	12-11-2017

Rev	Description	Date	Authorization
A	Initial PRD	11-01-2017	HNK
B	Space	11-15-2017	HNK
	Number of Liquids		
	Turnover Time		
	Testing Preferences		
C	Adviser	11-29-2017	HNK
	CAD Model		
	Table of Contents		
	If Time Allows		
D	Timeline	12-11-2017	HNK
E	Addition of Photos	12-15-2017	HNK
	Update Introduction		
	Update Materials		

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Introduction:

The invisible glass display is a designer driven product with approval given from the Rochester Museum & Science Center. The display needs to be based on a locally developed technology and/or highlights a female innovator in optics. The design is inspired by Katherine Blodgett's work on antireflective coatings. Input for the design has been taken from Calvin Uzelmeier, a representative for the museum, as well as Duncan Moore, a past member of the board for the museum as well as the adviser for the project. Its design is dependent on being able to withstand consistent use (and misuse) while being educational, engaging, and entertaining to the public – both children and adults.

Katherine was the first woman to earn a Ph.D. from the University of Cambridge which she was awarded in 1926. She was able to utilize her work at the GE Research Lab in Schenectady, NY on monomolecular coatings to help improve several optics including glasses and cameras. She has been awarded a long list of awards consisting of the following:

1. Progress Medal. The Photographic Society of America
2. Achievement Award of the American Association of University Women
3. Outstanding Woman of the Year. American Woman Magazine
4. Garvan Medal of the American Chemical Society
5. Boston First Assembly of American Women of Achievement honored scientist
6. Honorary Doctorates: Elmira College, Western College, Brown University, Russell Sage College

She has also contributed to work on the improvement of the light bulb alongside Irving Langmuir as well as work in plasma physics. Her invention of non-reflective glass in 1939 which is the inspiration for the museum exhibit, was created by building up a 44 molecule thick film of barium stearate on glass. The concept behind this is the fact that the reflecting waves off of the glass and anti-reflective surface destructively interfere by carefully engineering the thickness of the film.

Vision:

The exhibit engages visitors with the concepts involved with invisible glass. This is meant for the women in science exhibit which is to premier in 2020.

Environment:

As an exhibit, it it must be hands-on for the visitor and be both entertaining and educational, it needs to operate in the following environment:

Temperature

Room temperature (20-25 degrees Celsius)

Relative Humidity

Standard room humidity (40-60%)

Space

Preferably smaller than 9 ft^2 (floor space)

Regulatory Issues:

Needs to be able to withstand misuse in every conceivable way (knocking, pulling, pushing, excessive use of force, etc.) and minimize the need for cleaning and replenishing.

Fitness for use:

The invisible glass display will:

- Use a sturdy container to hold three liquids (able to withstand a force TBD).
- Have a method of a user lowering two glass rods into the liquids without having the opportunity to cause damage to the individual or display.
- Have a method of minimizing the mixing of the three liquids when the glass rods are used consistently over a large period of time with as much force as the system allows (referencing back to the previous requirement to limit the force or speed that an individual can lower the rods).
- Have one liquid cause the first glass rod to be "invisible" and the second glass rod to be visible. Have another liquid that makes the second glass rod "invisible" and the first glass rod visible. The exact desired matching of refractive indices will be determined with experimentation. Pictures will be reviewed with the customer to decide what refractive indices satisfactorily causes the glass rods to become "invisible." The third liquid will make both glass rods visible.
- The liquids are allowed to be flammable and/or inedible. The liquids are not able to be highly toxic with skin exposure.
- The liquids are allowed to be replaced maximum of every two months. It is necessary that the liquids will not harbor bacteria or any undesired contaminants within this time frame.
- Create a caption for the display that offers a simple yet informative explanation of the processes at hand.
- There is no set cost for this exhibit – the museum will determine the amount they are willing to spend after prototyping.
- It is desired that a prototype is brought into the museum for testing. This prototype does not need to be finalized in any way. It is simply meant as a proof of concept and enable the project team to observe visitor use in order to better evaluate its effectiveness and make iterative changes.

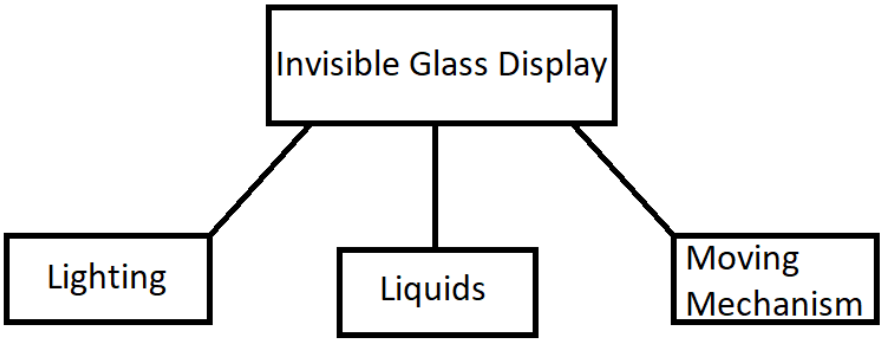

Figure 1: Subsystem Diagram

Figures of Setup:

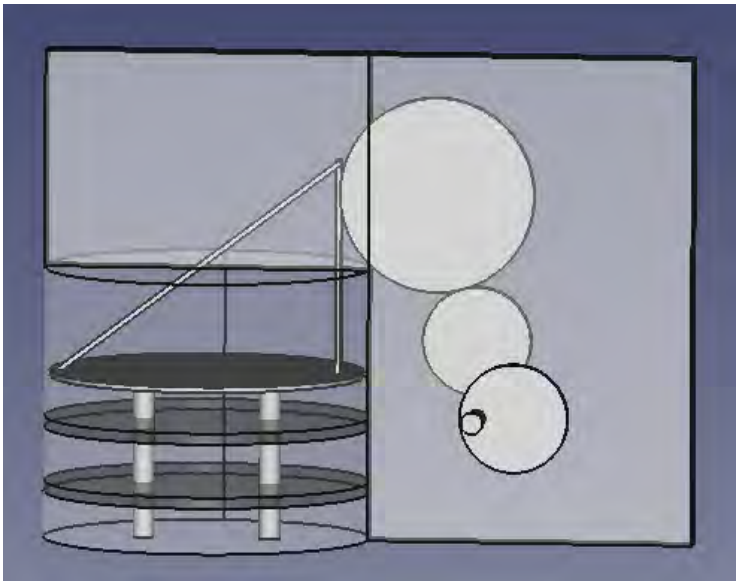

Figure 2: Front view

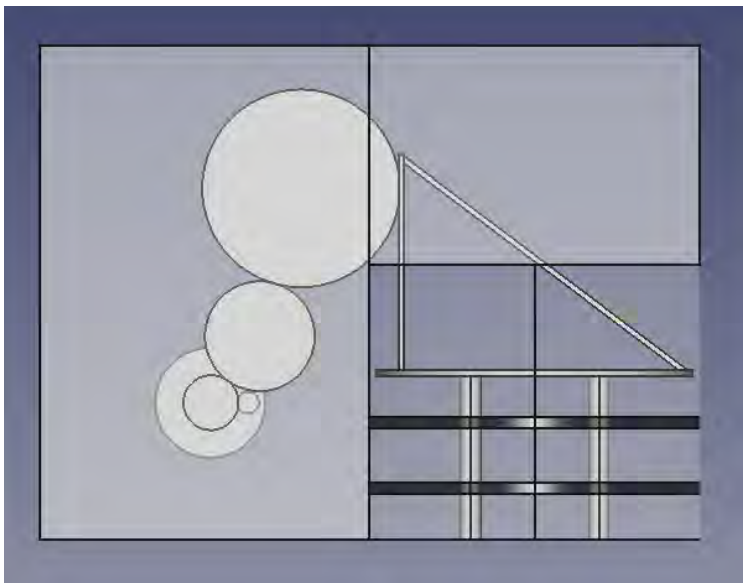

Figure 3: Rear View

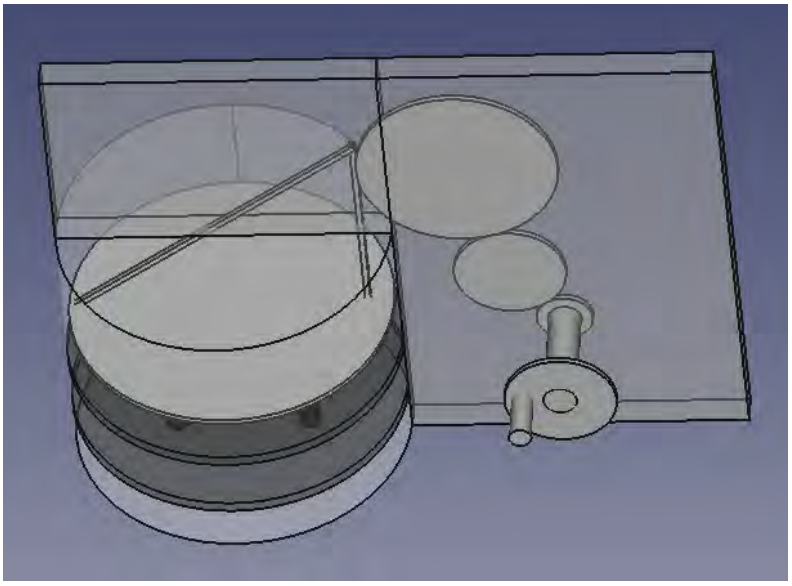

Figure 4: Angled Front View

It is Desirable That

Addition of multicolor LED lights to the Display:

- The glass potentially might be visible or invisible at different wavelengths
- Test materials with Spectrophotometer to determine index over range of wavelengths
- Users will be able to change color of LED to view how wavelength affects index of refraction.
- This will teach them how some coatings and materials need to be chosen based on the primary wavelength used in the system.

Group Responsibilities:

The group is responsible for:

A working prototype and a product description.

The group is not responsible for:

The finalized exhibit that will be displayed in 2020.

Materials:

Materials are subject to change over the course of testing

- Laboratory
- Propylene Glycol
- Cedar Oil
- CaF Glass Rod
- BK7 Glass Rod
- Pyrex
- Vegetable Oil
- Clear Container
- Rubber Bristles
- Gears

Timeline:

- Fall
  - October 25, 2017: Customer Meeting
  - November 1, 2017: PRD 1
  - November 8, 2017: Customer Meeting
  - November 15, 2017: PRD 2
  - November 22, 2017: Customer Meeting

  - November 29, 2017: PRD 3
  - December 5, 2017: Customer Meeting
  - December 11, 2017: PRD 4
  - December 14, 2017: Final PRD
- Spring
  - January 1, 2018: Testing mixing qualities of liquids
  - March 1, 2018: In museum testing of product
  - April 1, 2018: Finalized working prototype

References:

- Whelan, M., and Dr. Edwin Reilly. "Katharine Burr Blodgett." *Katharine Burr Blodgett - Engineering Hall of Fame*, Edison Tech Center, 2014, www.edisontechcenter.org/Blodgett.html.
- "Irving Langmuir and Katharine Burr Blodgett." *Chemical Heritage Foundation*, 30 Oct. 2015, www.chemheritage.org/historical-profile/irving-langmuir-and-katharine-burr-blodgett.

Appendix:

Figure 5: Side lighting Calcium Fluoride in Ethylene Glycol

Figure 6: Front lighting Calcium Fluoride in Ethylene Glycol

Figure 7: Pyrex in Vegetable Oil

Figure 8: Calcium Fluoride in Ethylene Glycol and Ethylene Glycol with Oil

Proof of Customer Approval:

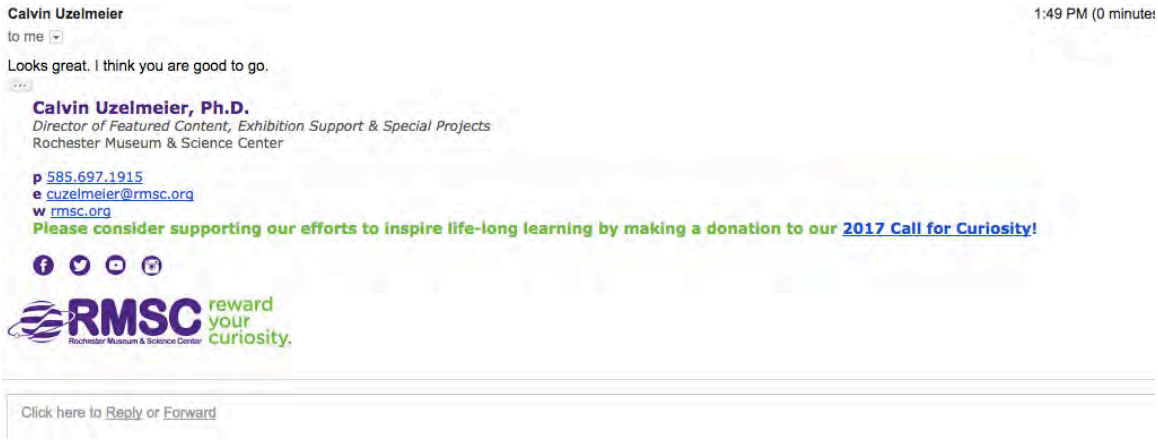

Figure 9: Customer Email giving approval for submission. Full email conversation can be provided upon request.