

# Sleep Apnea Therapy Device



<http://www.thecapshop.com/fisher-paykel-simplus-full-face-mask-with-headgear>



<http://www.webmd.com/sleep-disorders/sleep-apnea/>

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# Overview

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# Problem Statement

- **Sleep Apnea** is a sleep disorder in which natural breathing stops during sleep
  - Frequent waking often prevents those afflicted from reaching deep sleep
- Current treatments are bulky, loud, uncomfortable, and primarily designed for Obstructive Sleep Apnea
  - Face high rejection rate from users
- **Our client, Dr. John Webster, has tasked us with creating a light, quiet, and comfortable sleep apnea treatment using the variable dead space technique developed in his lab.**

# Background Information

- Sleep apnea
  - An inability to reach deep sleep caused by frequent interruptions in breathing (Young, et al, 2002)
  - Affects roughly 10% of the US population (Young, et al, 2013)
- 3 Primary types
  - OSA, CSA, and combination (Morgenthal, et al, 2006)

# Background Information (Cont.)

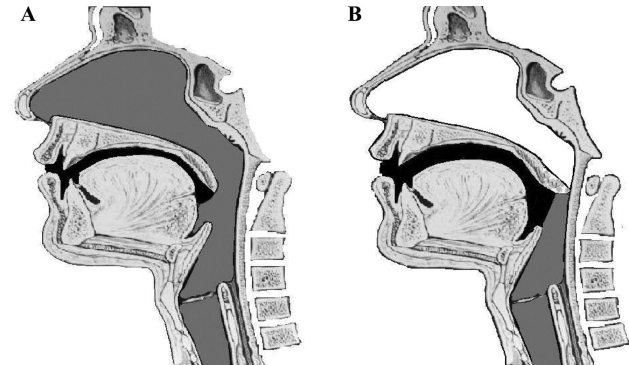
- Current Treatment: CPAP (Constant Positive Air Pressure)
  - Discomfort, dryness, congestion, and pain
  - Up to 50% user rejection rate (Catcheside 2010)
- Potential treatment: “Smart CO<sub>2</sub>” Device
  - Increase patient CO<sub>2</sub> intake



<https://upload.wikimedia.org/wikipedia/commons/7/7f/CPAP.png>

# Background Information (Cont.)

- Increasing dead space increases CO<sub>2</sub> intake
  - Inducing mild hypercapnia improves ventilatory stimulation
  - Improves CSA symptoms (Dempsey, 1985)
- Device designed to automatically control dead space
  - Optimized for minimal apnea occurrence and CO<sub>2</sub> levels



<http://jap.physiology.org/content/105/3/854>

# Product Design Specifications - Summary

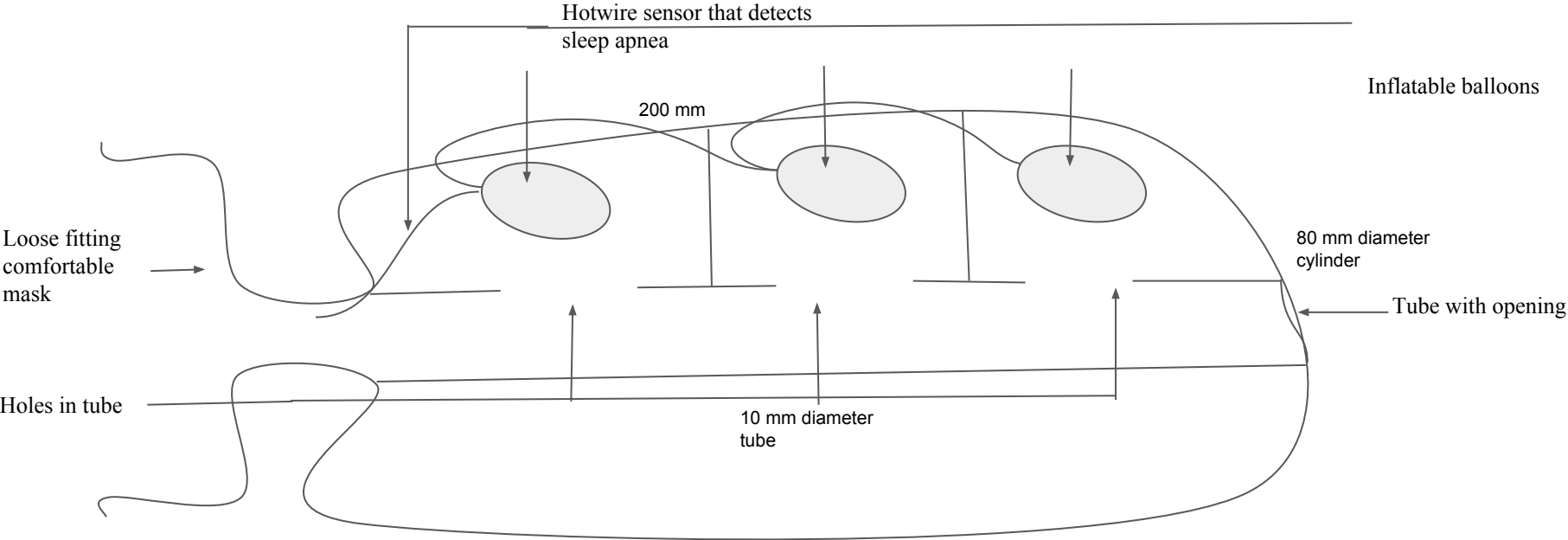
- Lightweight (under 1 kg)
- Compact (80mm diameter and 200mm length) and circular
- Comfortable application of mask to the face and device to the chest
- Battery Operated
- Durable (3-4 months for 8-10 hours per day)
- \$100 budget





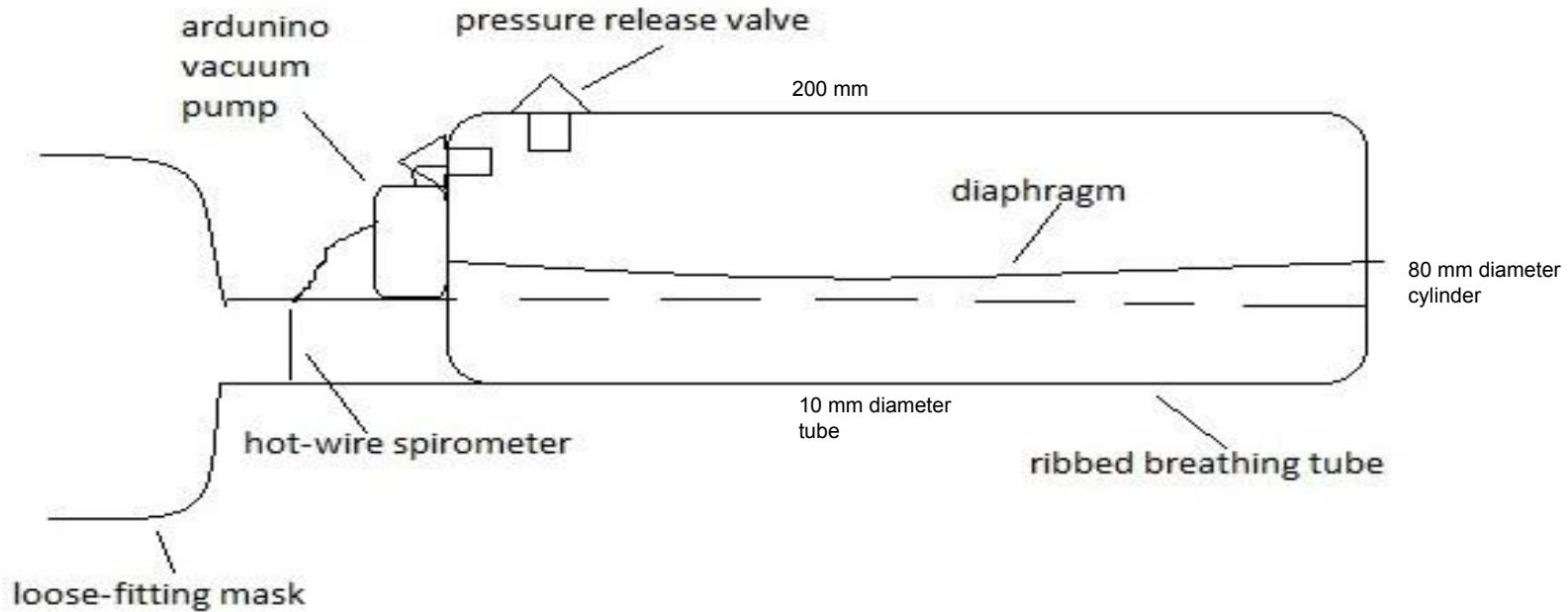
# Design Alternatives (Cont.)

## Design Alternative: Sectioned-off Balloons



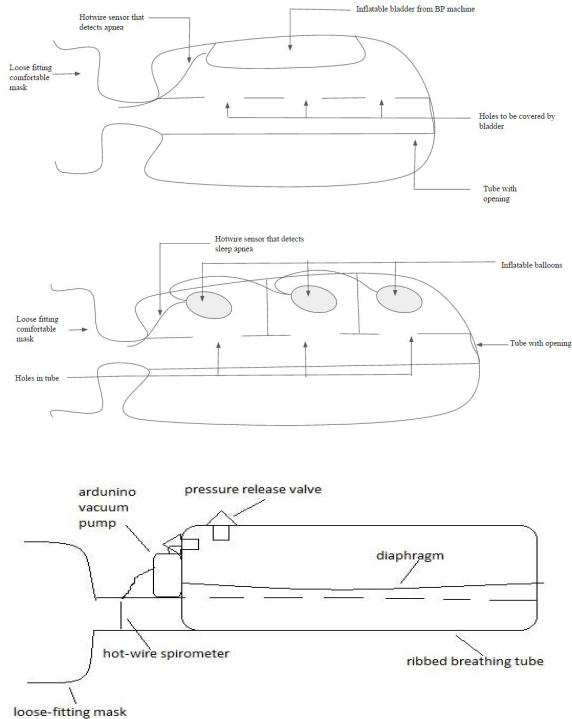
# Design Alternatives (Cont.)

## Design Alternative: Diaphragm



# Design Matrix

Dr. Webster's platform design



	Design A*	Design B*	Design C*
<b>Brief Description</b>	<b>Prof. Webster's Design</b>	<b>Balloon Modification</b>	<b>Diaphragm Modification</b>
<b>Dead Space Variability (15)</b>	(3/5) 9 (or 15, testing required)	(5/5) 15	(4/5) 12
<b>Ease of Fabrication (15)</b>	(5/5) 15	(2/5) 6	(3/5) 9
<b>Safety (10)</b>	(5/5) 10	(5/5) 10	(5/5) 10
<b>Weight (10)</b>	(5/5) 10	(4/5) 8	(5/5) 10
<b>Power Consumption (5)</b>	(4/5) 4	(5/5) 5	(3/5) 3
<b>Durability (15)</b>	(5/5) 15	(3/5) 9	(3/5) 9
<b>Comfort (15)</b>	(5/5) 15	(5/5) 15	(5/5) 15
<b>Cost (15)</b>	(5/5) 15	(2/5) 6	(3/5) 9
<b>Total Value</b>	<b>93</b>	<b>71</b>	<b>77</b>

# Future Work

- Decisions must be made regarding the specific parts to be used
  - Plastic tubing, hotwire sensor, container
  - Sphygmomanometer for inflatable air bladder and pump
- Ordering of parts not available in the BME labs
  - Parts from labs will be used with consent from Professor Webster and Mehdi Shokoueinejad
  - Budget: \$100
- Testing of the efficacy of the device is the end goal

# Future Work (Cont.)

- Programming the variable dead space system
  - Arduino micro-controller
  - LabVIEW software
- Developing an algorithm to detect apnea
  - Hot wire cooling rate calibration
  - Normal breathing
  - Apnea/shallow breathing (threshold)

# Acknowledgments

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