



Arbor Press Ventilator Project

Theodore Hades | Sarah Mehler | Joshua Yoon
Amanda Christine Jones | Jim Pierce
Rachel Marie Alexander

Team Participants

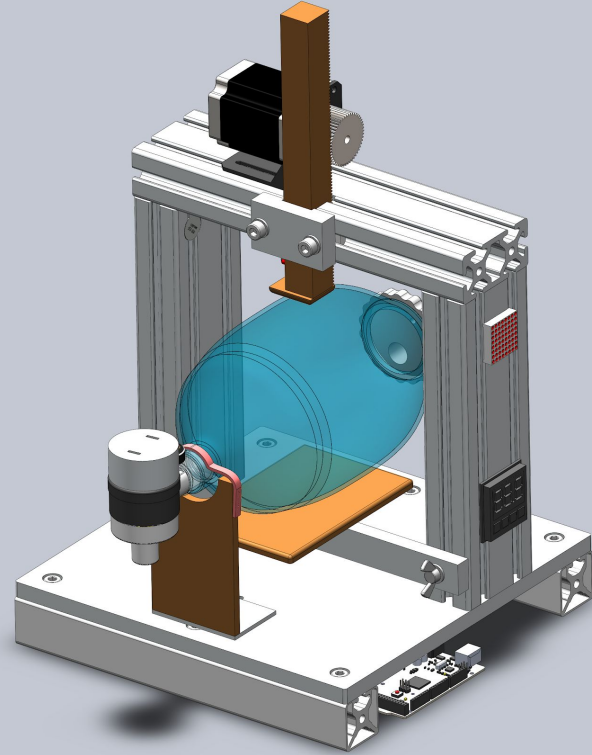
Name	Institution	Contact
Sarah Mehler	Portland State University	971-386-3707 mehler.sn@gmail.com
Joshua Yoon	Cooper Union	201-705-4886 joshyoonbca@gmail.com
Jim Pierce	Portland State University	760-445-9412 pierce300@gmail.com
Amanda Christine Jones	Columbia University	646-926-3486 acj2122@columbia.edu
Theodore Hedges	New York University Columbia University	347-356-3326 theodore.hedges@nyu.edu
Rachel Marie Alexander	Columbia University	301-832-7232 rma2146@columbia.edu

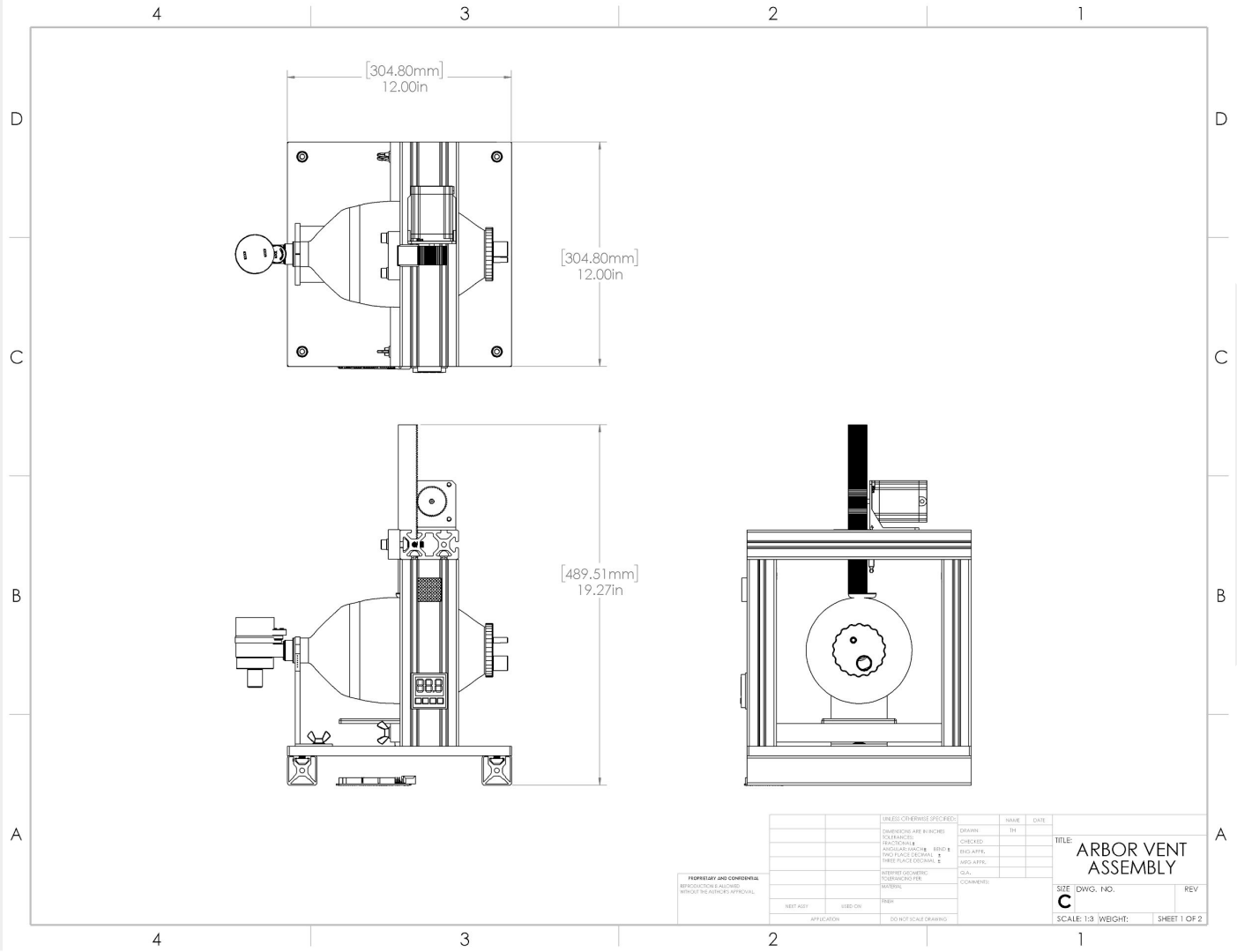
Arbor Vent

A rack-and-pinion-based squeezing tool with a single point of contact on top (like a thumb), and a flat plate on the bottom (like a palm).

Animation:

<https://www.youtube.com/watch?v=rTxBZ2wFJds>





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Concept of Operations

Main features of the device:

- For securing the bag in place
 - an adjustable support frame (for different bag lengths)
 - a rubber buckle strap (for different nozzle diameters)
 - an adjustable resting plate (for different bag diameters)

All bag adjustments can be done by hand; there are no tools required.

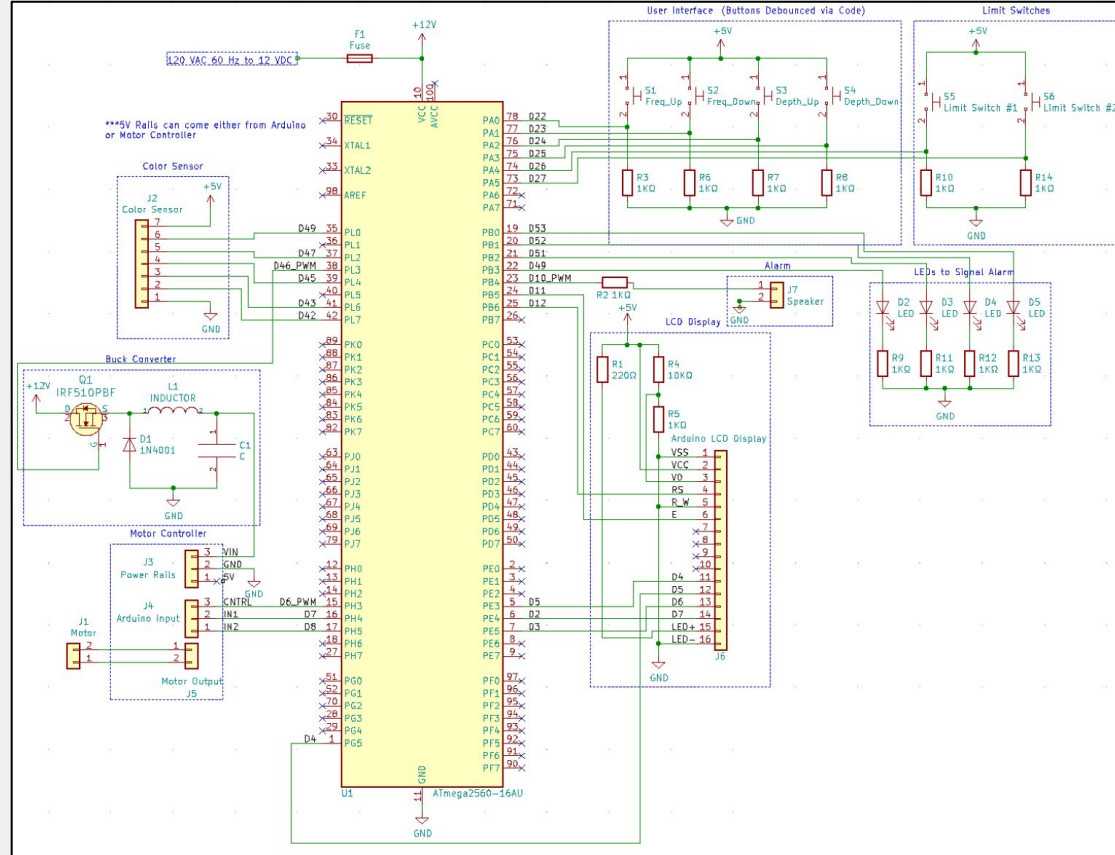
The bag can easily be placed into and removed from frame.

- For compressing the bag, a rack and pinion with a plate attached for increased surface area at contact point.
- The rack and pinion will be controlled by a servo motor and driver. The motor will be powered from a wall outlet and controlled from an Arduino.
- Settings that can be adjusted from a simple user interface (an LCD screen and buttons).
- Initial designs include an analog pressure sensor which will be attached to a color meter, triggering an alarm if pressure drops.

Basic Specifications

- The device will squeeze a standard ambu-bag at a minimum of 10 and maximum of 30 squeezes per minute.
- The frame will accommodate multiple bag sizes, adjusting for bags with a diameter between 5 and 7 inches and lengths variations of around an inch and a half. Bag fit is adjusted manually through the platform track and wingnuts. (No tools required.)
- The device has an amplitude range (stroke depth) of 1 to 6 inches of bag compression. Stroke depth is adjusted using the user interface.
- Alarm sounds and LEDs flash if pressure drops below 5 cmH₂O and above 45 cmH₂O.
- A current sensing device attached to the output of the transformer will function as a kill switch in the event of too much current pull, avoiding damage to electronics.

Circuit Diagram

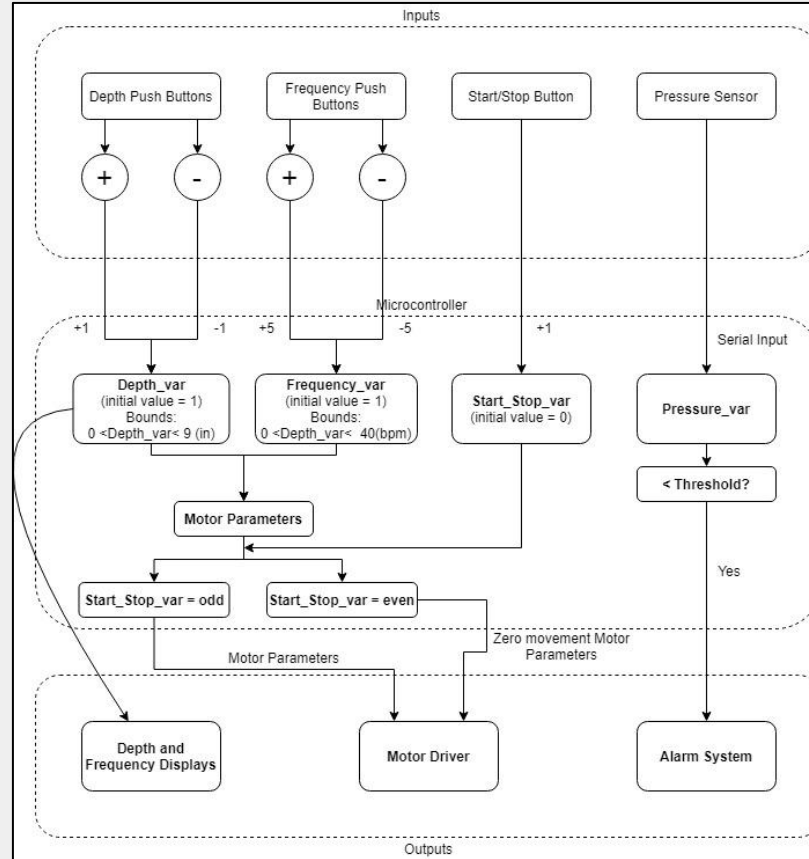


Electronics

→ The main components of the circuit are as follows:

- Arduino Mega Microcontroller
- User Interface (LCD Screen and Buttons to increase frequency and depth that the rack gear moves).
 - Basic Prototype:
https://drive.google.com/file/d/1RkIxzgT7aw8DDEB2SvXfHwiOqj4Z_EfC/view?usp=sharing
- Buzzer and LEDs to signal when an emergency occurs.
- Limit switches for calibration and emergency stops.
- Color Sensor to track pressure from a manometer (more information in “Caveats” section)
- Motor Controller, controls motor via PWM signals from Arduino.
- Buck Converter to convert 12VDC to required motor voltage.
- Transformer to convert wall outlet electricity (120 VAC 60Hz) to desired voltage (12 VDC)
- Fuse to protect the circuit in case motor stalls or pulls too much current.

Arduino Code Diagram



Parts Summary: Bill of Materials

Part	Cost	Source
110 VAC to 12 VDC Transformer	\$38.99	Source
Arduino Mega	\$38.50	Source
Ambu-bag Manometer	\$14.89	Source
Color Sensor	\$7.90	Source
Arduino LCD Panel	\$9.95	Source
Buttons	\$5.85	Source
Loctite	\$16.26	Source
NEMA23 stepper motor KL23H286-20-8B	\$31.95	Source
TB6600 Stepper motor driver	\$18.00	Source
40mm x 80mm x 36in extruded aluminum profile	\$35.21	Source
1/2 x 12 x 12 in aluminum plate	\$65.12	Source
40mm x 40mm x 12in extruded aluminum profile	\$8.66	Source
Scrap aluminum for all other plates	\$30.00	Source
Machining services	\$50.00	Source
Filament for 3D printing	\$22.00	Source
Fasteners (screws, nuts, washers, etc)	\$20.00	Source
Total		\$413.28

Manufacturing

Tools needed for construction:

- CNC machine for cutting aluminum
- 3D printer for manufacturing rack & pinion
- Hand tools for constructing frame
 - Allen keys
 - Torque wrench

Estimated number of hours for construction:

- Assembling frame: 1-2 hours
- Integration and setup: 3 hours
- Testing: 3 hours

Estimated Construction Time: 7-8 hours

Required Funding

Cost of Materials:

- Base Materials: \$413.89
- Replacement Parts / Cushion: \$300

Cost of Test Equipment:

- Test Lungs \$199.99
- Ambu-bag \$32.99

Required Funding Total: \$943.87

Caveats

Issues that will need to be addressed in the future.

Pressure Sensor and Alarm:

- Currently, our model employs color sensor that will read the manometer and trigger an alarm if pressure drops too low.
- This method has yet to be tested for accuracy. A method for testing pressure digitally is still under investigation.
- In the future, the color sensor method will be tested and, if found to be unreliable, a different method will need to be identified.
- Further testing with the Ambu-Bag, and studying its response to different pressures might lead to better pressure testing methods.
- Another option would be to attach a T-junction to the tubing and take a pressure reading with a pressure sensor.

Caveats

Design Trade-Off

Cost of Device:

- The ~\$400 price point of this device is mainly due to the materials used to construct it. While we would have been able to design this device more cheaply, we chose to use quality materials to increase the longevity and reliability of the device.
- If someone at home needed to make this device quickly and with less cost, cheaper materials could be substituted for the aluminum.
- Wood could easily be substituted for aluminum in such cases. If able, aluminum would be recommended because it's more easily sterilised.
- Other methods for reducing the costs of design and testing will be investigated, for example, finding cheaper options for test lungs.

Sources

- This model was loosely adapted from the ApolloBVM from Rice University. More information available at <http://oedk.rice.edu/apollobvm/>
- **CAD source list**
 - Motor mount: <https://grabcad.com/library/nema-17-nema-23-stepper-motor-mounts-1>
 - Limit switches: <https://grabcad.com/library/limit-switch-19>
 - Digital panel: <https://grabcad.com/library/small-digital-panel>
 - LED alarm light: <https://grabcad.com/library/ingram-products-amber-led-alarm-light-1>
- Arduino Libraries
 - Liquid Crystal: <https://www.arduino.cc/en/Reference/LiquidCrystal>

