Arbor Press Ventilator Project

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Team Participants

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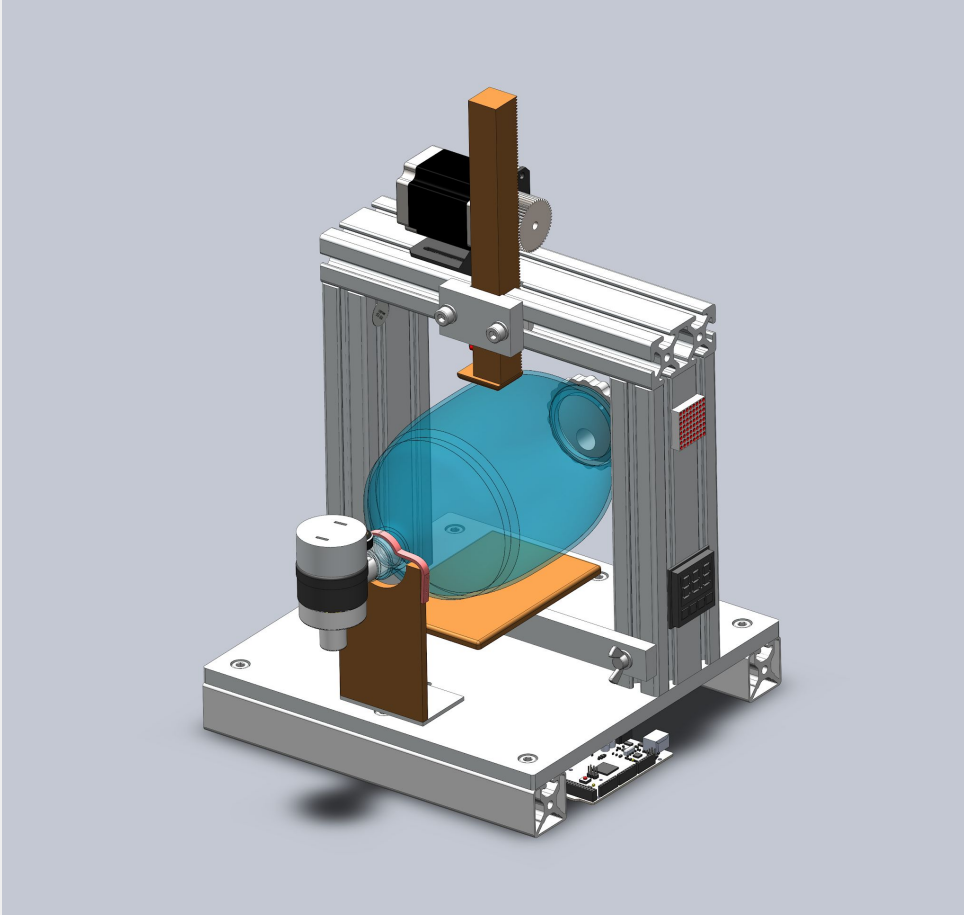
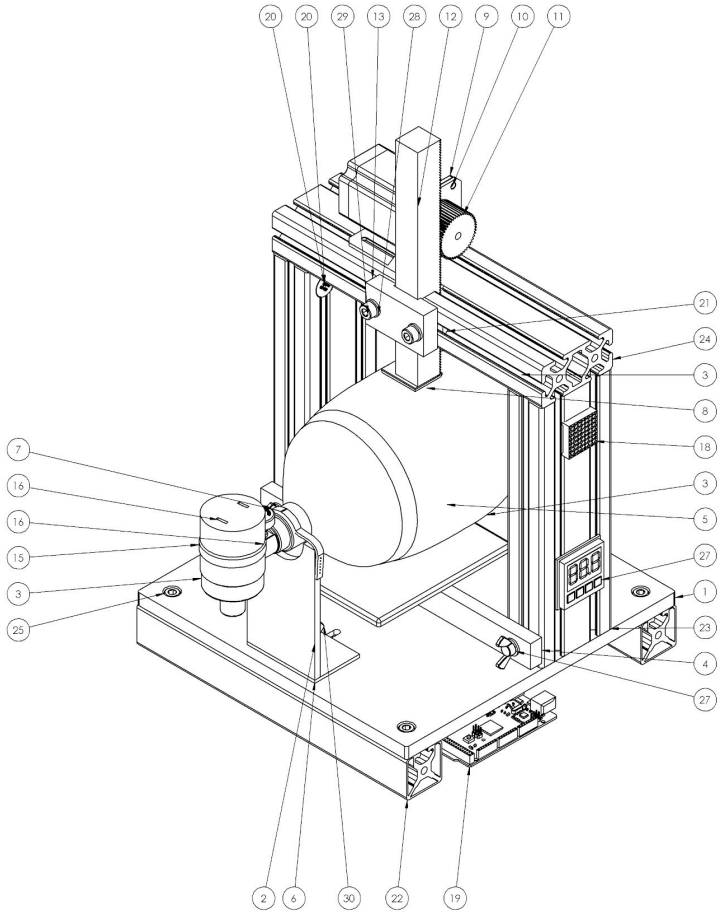
Arbor Vent

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





ITEM NO.	PART NUMBER	QTY.
1	MAIN BASE PLATE	1
2	BVM NOZZLE SUPPORT	1
3	BVM RESTING PAD ("PALM OF HAND")	1
4	BVM LOWER SUPPORT BAR	1
5	BVM BAG	1
6	NOZZLE SUPPORT BASE PLATE	1
7	NOZZLE BELT	1
8	COMPRESSION PLATE ("THUMB")	1
9	NEMA 23HS7430 STEPPER MOTOR	1
10	MOTOR MOUNT	1
11	SPURGEAR	1
12	RACK	1
13	RACK GUIDE	1
14	LIMIT SWITCH	2
15	MANOMETER	1
16	MANOMETER "DARK ROOM" AND LIGHT SENSOR ASSEMBLY	1
27	LCD PANEL	1
18	ALARM LED MATRIX	1
19	ARDUINO MEGA	1
20	UNIVERSAL FASTENER 8020-40-3362	4
21	T-SLOT NUT 8020-40-1984	10
22	BASE PLATE SUPPORT 8020 40-4001 X 4000	2
23	VERTICAL SUPPORT BEAM 8020-4080	2
24	HORIZONTAL SUPPORT BEAM 8020-4080	1
25	91292A150_TYPE 18-8 SS SOCKET HEAD CAP SCREW	10
26	90101A230_TYPE 18-8 SS THIN NYLON-INSERT LOCKNUT	1
27	92625A520_STAINLESS STEEL WING-HEAD THUMB SCREW	2
28	98689A116_ METRIC GENERAL PURPOSE WASHERS	4
29	91292A154_TYPE 18-8 SS SOCKET HEAD CAP SCREW	2
30	92625A516_STAINLESS STEEL WING-HEAD THUMB SCREW	1

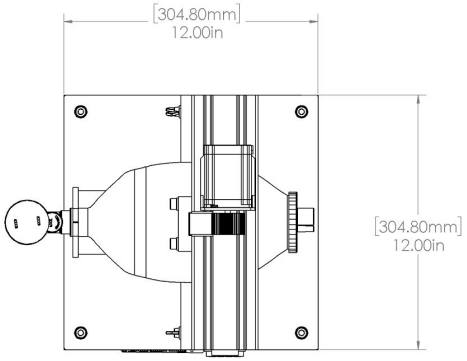
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
FINISH
NEXT ASSY | USED ON
APPLICATION | DO NOT SCALE DRAWING

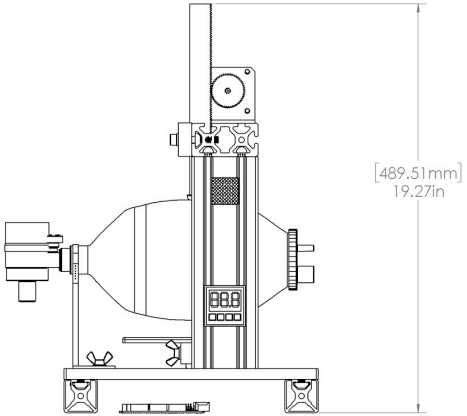
	NAME	DATE
DRAWN	TH	
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		
COMMENTS:		

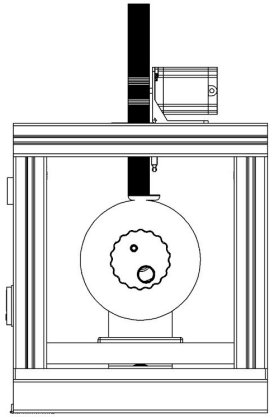
TITLE: ARBOR VENT ASSEMBLY

SIZE C | DWG. NO. | REV

SCALE: 1:2 WEIGHT: | SHEET 2 OF 2







		UNLESS OTHERWISE SPECIFIED:		NAME	DATE
		DIMENSIONS ARE IN INCHES	DRAWN	TH	
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		TWO PLACE DECIMAL ±			
		THREE PLACE DECIMAL ±	QA:		
		INTERPRET GEOMETRIC TOLERANCING PER:	COMMENTS:		
		MATERIAL			
NEXT ASSY	USED ON	FINISH			
APPLICATION		DO NOT SCALE DRAWING			

TITLE:
ARBOR VENT ASSEMBLY

SIZE	DWG. NO.	REV
C		

SCALE: 1:3 WEIGHT: SHEET 1 OF 2

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 stepper motor and driver. The motor will be powered from a wall outlet and controlled from an Arduino.

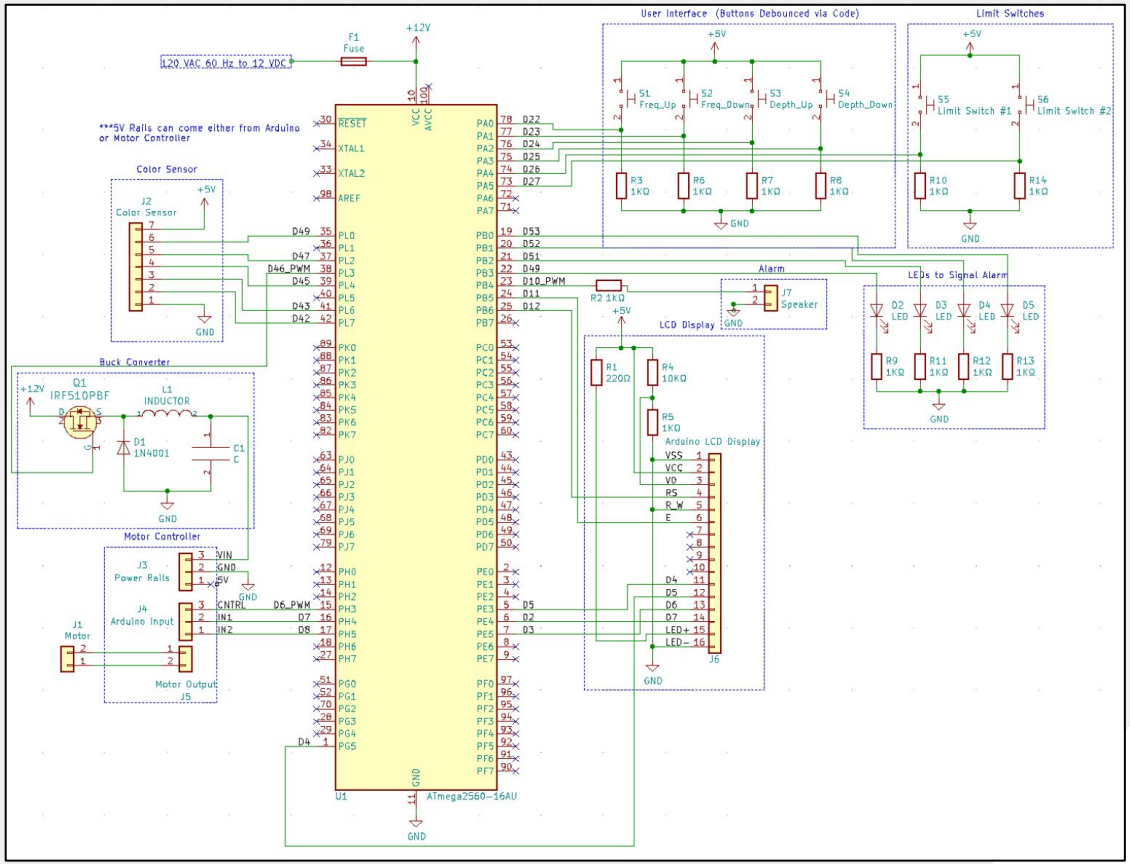
→ Settings that can be adjusted from a simple user interface (an LCD screen and buttons).

→ 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 cmH_2O and above 45 cmH_2O.
- → 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

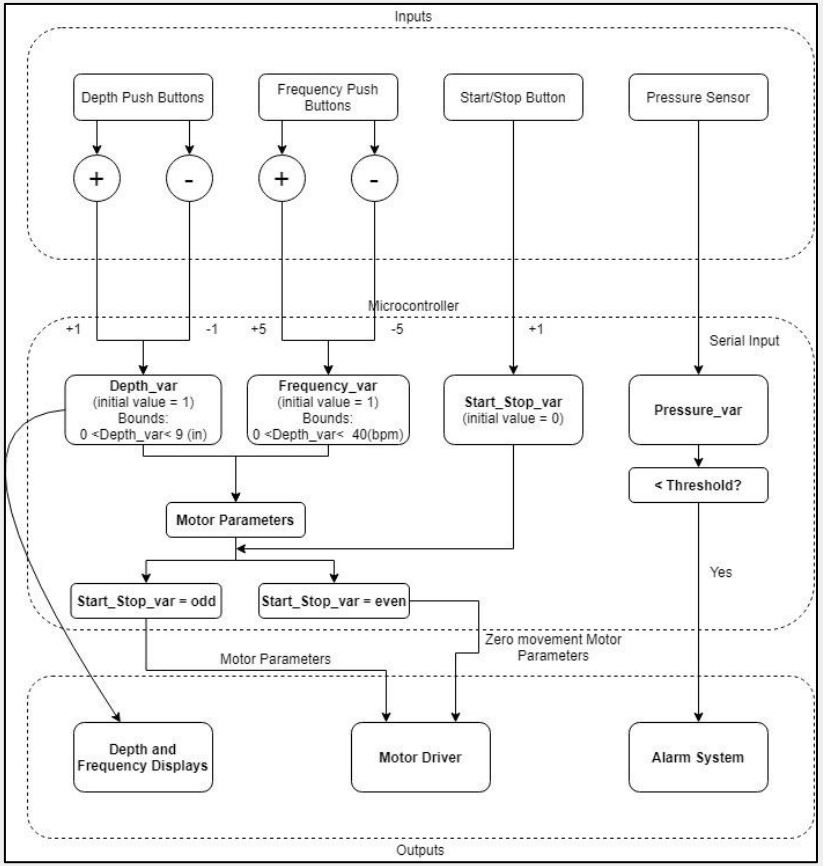


Electronics

→ 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
Locktite	$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