Project: Low Cost Respirator

Objective

The project is to create a highly replicable, low cost respirator in order to mass produce the unit to minimize de COVID-19 deaths due respirator shortage.

The elements used should be low-cost and easily attainable in order to replicate the unit in every part of the world.

The controller will be based in open source hardware such as Arduino and RasperryPi.

The specification for unit will be based in the minimum requirements for an autonomous respirator.

Minimum Requirements

1. Be reliable. It must work continuously without failure (100% duty cycle) for blocks of 14days - 24 hours a day. If necessary, the machine may be replaced after each block of 14 days x 24 hours a day use.
2. Provide at least two settings for volume of air/air O2 mix delivered per cycle/breath. These settings to be 450ml +/- 10ml per breath and 350ml +/- 10ml per breath.
3. Provide this air/air O2 mix at a peak pressure of 350 mm H2O.
4. Have the capability for patient supply pipework to remain pressurized at all times to 150mm H20.
5. Have an adjustable rate of between 12 and 20 cycles/breaths per minute.
6. Deliver at least 400ml of air/air 02 mix in no more than 1.5 seconds. The ability to
7. change the rate at which air is pushed into the patient is desirable but not essential.
8. Be built from O2 safe components to avoid the risk of fire and demonstrate avoidance of hot spots.
9. Be capable of breathing for an unconscious patient who is unable to breathe for his or herself. Ability to sense when a patient is breathing, and support that breathing is desirable but not essential.
10. Be able to supply pure air and air O2 mix at a range of concentrations including at least 50% and 100% Oxygen. Oxygen shortages are not expected, but the ability to attach a Commercial Off The Shelf (COTS) portable O2 concentrator machine may be a useful feature.
11. Support connections for hospital Oxygen supplies – whether driven by piped or cylinder infra-structure
12. Be compatible with standard COTS catheter mount fittings (15mm Male 22mm Female)
13. Fail SAFE, ideally generating a clear alarm on failure. Failure modes to be alarmed include (but are not limited to) pressure loss and O2 loss.

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Known Issues

This is a list of unresolved issued during the prototype or part of the functionality yet to be resolved:

Schematic



Elements Description

**Electro valves:**

To control the flow of the gas.

*Item List:*

**EV1**: Controlling O2 Input

**EV2:** Controlling Air Input

**EV3:** Controlling Mixed Gas Output

**EV4:** Controlling Input Gas to Patient

**EV5:** Controlling Output Gas of Patient

**Flow Control:**

Either Flowmeter or Rotameter. To control and sense flow.

*Item List:*

**FC1:** Flowmeter to control O2 Flow

**FC2:** Flowmeter to control Air Flow

**FC3:** Flowmeter to control Gas Flow to Patient

**Pressure Sensor:**

Absolute Pressure sensors or Manometers. To sense or control pressure.

*Item List:*

**PS1:** To sense O2 Gas Output pressure/presence

**PS2:** To sense Air Gas Output pressure/presence

**PS3:** To sense Mixed Gas Output Pressure/presence

**PS4:** To sense Input Gas to Patient Pressure/presence

**CO2 Filter:**

To filter CO2 Gas

*Item List:*

**CO1:** To filter CO2 from patient

**HEPA Filter:**

HEPA or Particle filter.

*Item List:*

**F1:** To filter possible particles

**SENSOR:**

Possible pressure sensor with temperature input

*Item List:*

**S1:** To sense that the patient is breathing on its own

**BUBBLER:**

Plastic-Glass canister with Cl-H20 mixture or any other anti-pathogen liquid

*Item List:*

**B1:** To clean de CO2-O2 gas to reduce virus exposal

**AMBU BAG:**

Standard AMBU Breathing BAG

*Item List:*

**AB1:** To hold the gas mixture

**Moisture Filter:**

To filter moisture. Coalescent filter. Filter

*Item List:*

**MF1:** To filter possible humidity from the bubbler

**Actuator:**

Servo or stepper motor.

*Item List:*

**ACT1:** To deflate AMBU bag.

**Check Valve:**

To prevent gas return.

*Item List:*

**CH1:** To prevent Mixed Gas backpressure

Theory of Operation

1. Theory Operation: Overview

The barebones of this project is the Manley Ventilator. The design follows the principle of operation of that ventilator but using more advanced and electronic controlled elements.

The ventilator needs 2 line of gas in order to operate, in this case can be cylinders or supply gas from hospital. It can be either type of gas. It has to be pressure controlled with a cylinder regulator. It cannot exceed (yet TBD) pressure.

The ventilator will have a pressure sensor (*PS1 for O2 and PS2 for Air*) that will detect the presence of the gas cylinder, this will be mandatory check for the start up, so the equipment won’t start if the cylinders are not connected and the pressure is the indicated.

The electro valves (EV1 and EV2) will control the enabling and disabling of the Gas input.

Flow Controllers (FC1 and FC2) will check (or control) the flow of said gases in order to achieve the concentration required for the patient. Electro Valve (EV3) will be in charge of filling the AMBU BAG (AB1) and the pressure sensor (PS3) will check that the pressure is the required for optimal operation (TBD).

AMBU BAG will be filled by the mixture of the gases and then the electro valve (EV3) will close when the pressure sensor (PS3) reaches the desired pressure. The actuator (ACT1) will proceed to “constrict” the back in order to let the air out. The flow controller (FC3) will be used to adjust the flow into the patient, Filter (F1) will filter undesired particles and finally the electro valve (EV4) will be timed open to let the gas into the patient. After a desired timing, the electro valve (EV4) will close and the electro valve (EV5) will be timed open to let the exhalation of the patient go into the CO2 Filter (CO2), the bubbler to clear the pathogens/virus (B1) and through the moisture filter (MF1) to finally reach the mixed gas line through the check valve (CH1) and the reutilize the filtered gas into the mixture.