Code Life Ventilator Challenge

Mechanical Drawings and descriptions

Emergency Mechanical Ventilator

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Emergency Mechanical Ventilator

In that unique situation the world has to face, where every organisations have the same needs, we chose to offer a design that is free of any specialised suppliers or manufacturer. All the following part are wildly available in any countries. This project is a guideline for making a respirators with wiper motors, desktop power supplies and 3d printed and/or laser parts

This Emergency Mechanical Ventilator is composed by four main groups of mechanical systems that will be detailed bellow:

1. The pump system;
2. The tidal volume control system;
3. The control valves system;
4. The safety and PEEP valves systems.

Contents

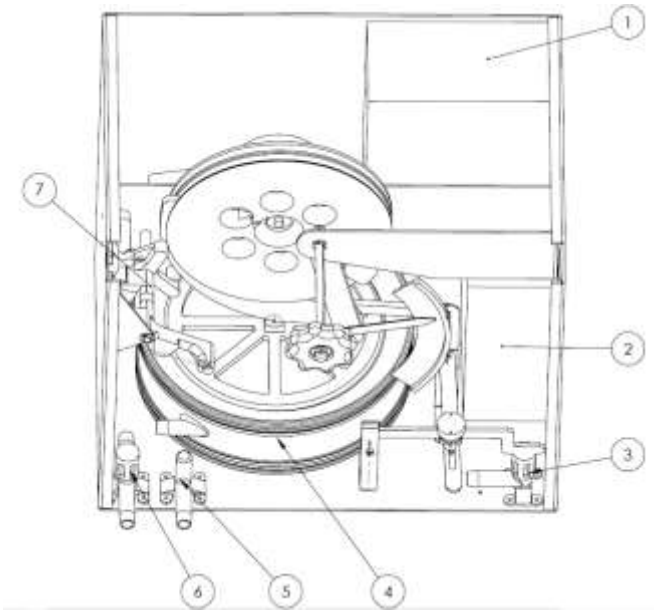

Figure 1

Figure 1, some important parts are identified like the desktop power supply (1), the generic 12V battery (2), the PEEP valve (3), the pump (4), the expiratory connector (5), the safety valve and inspiratory connector (6) and the control valves mechanism (7). You will find bellow all the information to fully understand the main systems.

The pump system

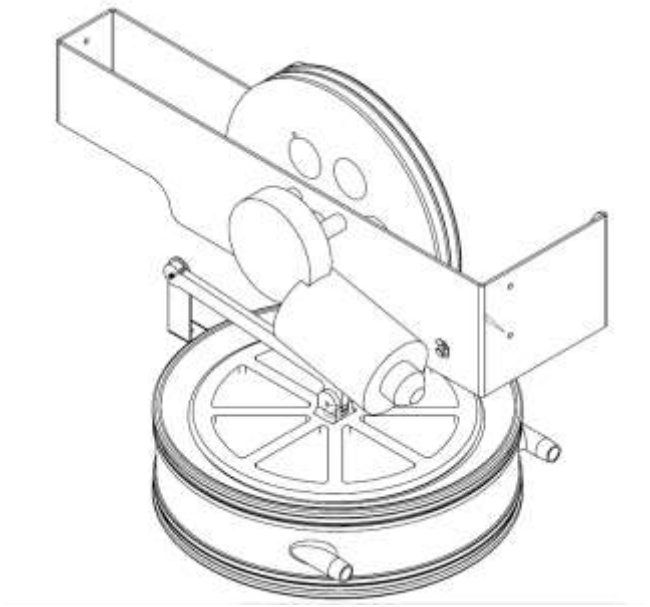

Figure 2 The pump system with its wiper motor

The pump is activated by a wiper motor because it is extremely common around the world, has two speeds integrated and comes back after one turn at his starting position. Also, it is powerful and extremely reliable.

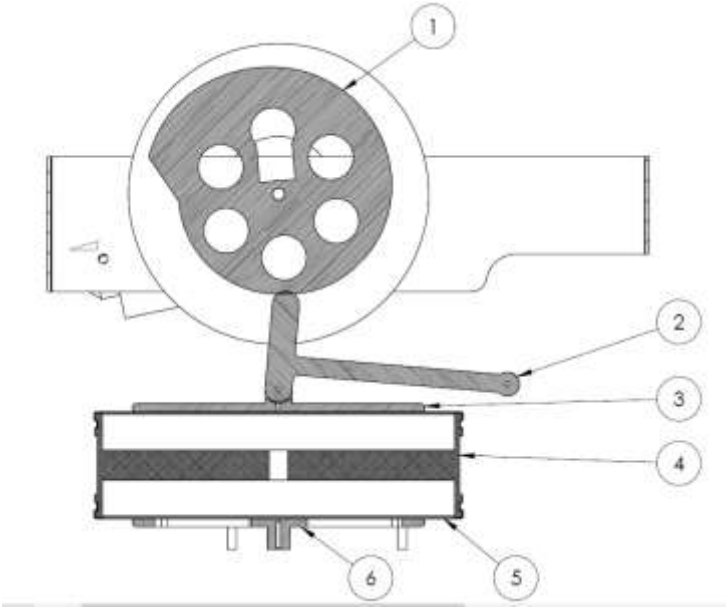

Figure 3. The pump system waiting for the inspiration phase

A cam (1) is connected to the motor, a follower (2) transmits a linear displacement to the pump. The pump is composed by an empty cylinder covered on each face by an elastomer membrane (5). That pump is placed between two compression discs (3; 6) in order to distribute the forces on the membrane.

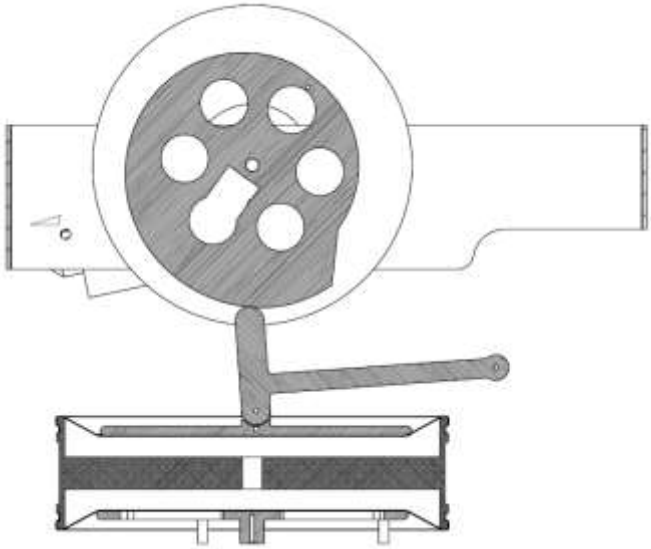

Figure 4. The pump system at the end of its compresion cycle

When compressed, the inner volume of the pump decreases. By using the two integrated speeds of the wiper motor we can set the inspiratory flow at 44 or 57 l/min. That pump acts like a piston but without all the problems of friction and accuracy necessary to ensure the sealing. All the solid parts can be 3D printed or laser cut.

Figure 5. The first pump prototype

Each cycle of pumping displace the maximum tidal volume that we have set at 700ml. The following parts will explain how to set the tidal volume

The control valves system

Figure 6. The control valves system

The control valves system allows to switch between inspiratory and expiratory phase by clamping the selected tubes. It is inspired by some thermostats mechanisms that are cheap to produce and accurate and reliable. Figure 6, the left pictures illustrates the inspiration phase where only the inhale circuit (V2, Figure 7) is open and the tension spring is loaded in order to ensure the return to the expiratory mode. The right picture illustrates the expiratory mode, at that moment only the exhale circuit (V3, Figure 7) and the piston purge/fill circuit (V1, Figure 7) are open.

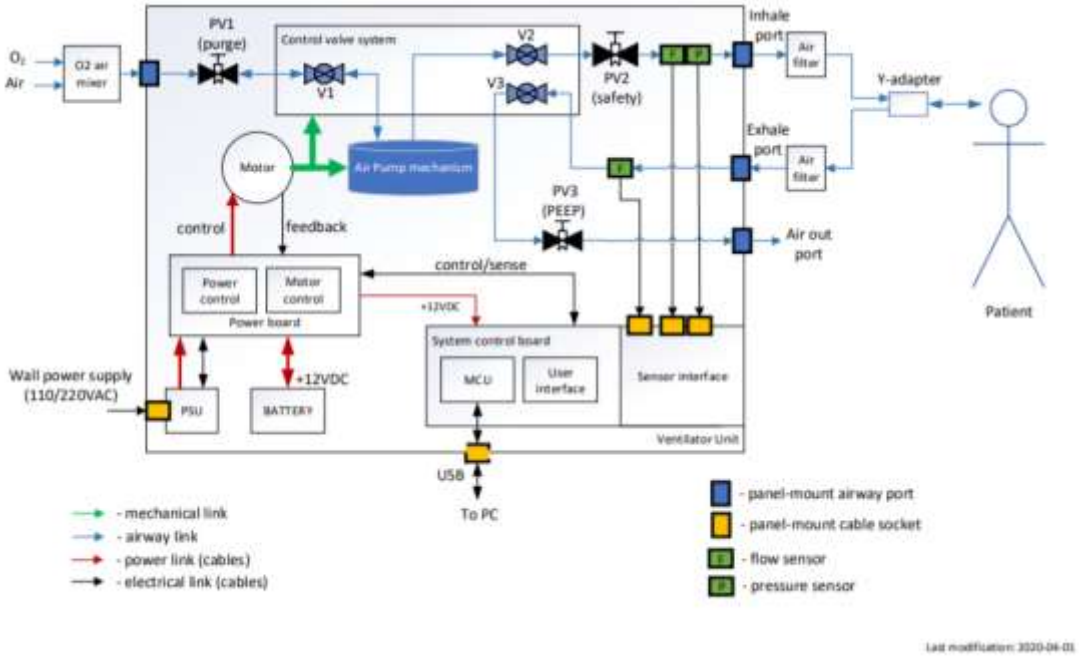

Figure 7. System diagram

Inspiration trigger

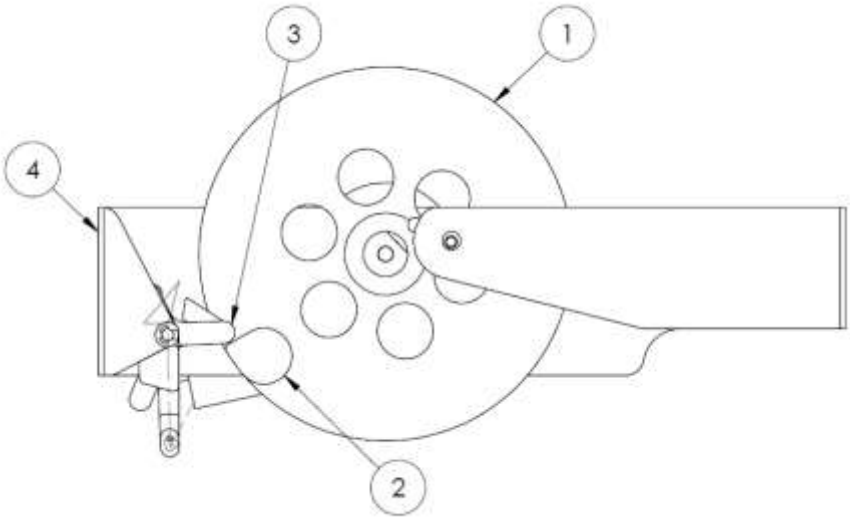

Figure 8. Inspiration trigger system.

Figure 8, at the moment the cam (1) starts rotating clockwise, the follower (2) will push on the valve system inspiratory lever (3). The whole system is mounted on the same folded metal sheet to ensure an easy way to ensure enough accuracy.

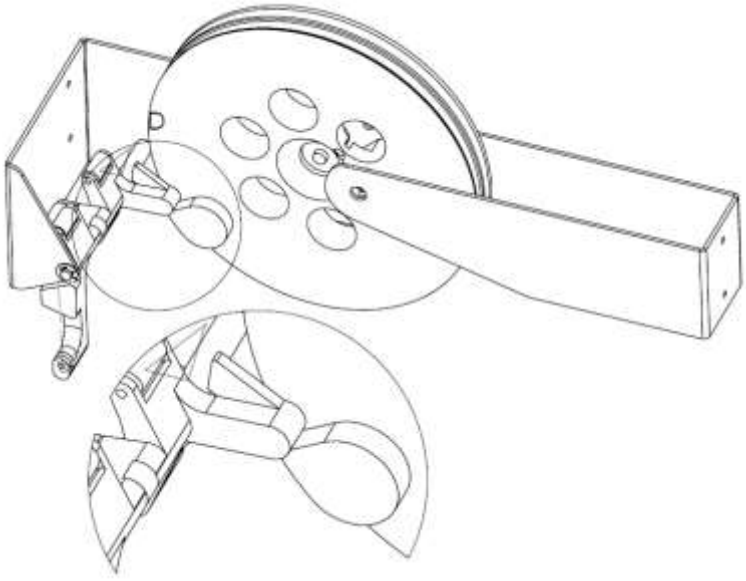

Figure 9. Detail on the interaction between the cam and the control valves system.

Figure 9Figure 9 illustrates how the control valves systems will switch from expiratory to inspiratory mode when the motor will start turning (clockwise).

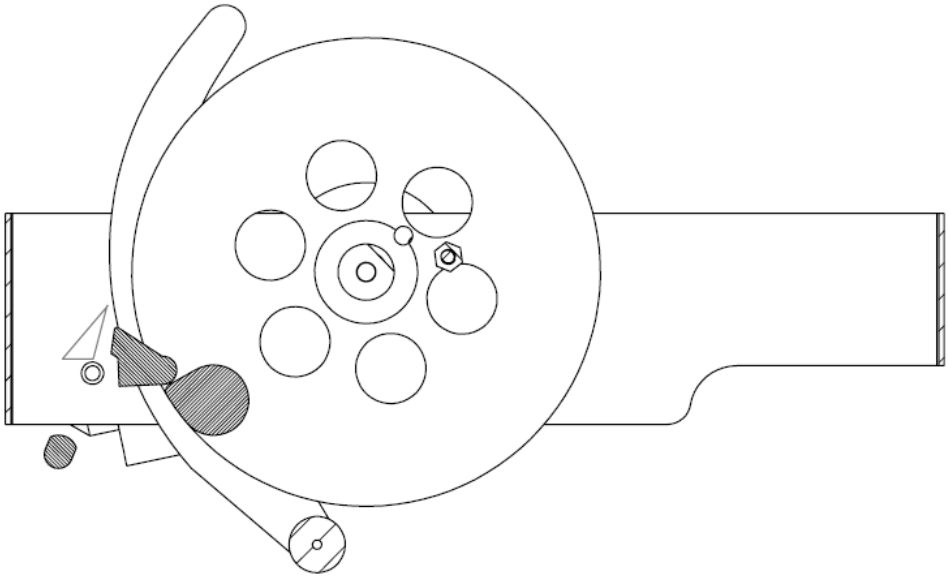

Figure 10, Mechanical interaction between the cam and the control valves system

Tidal Volume control system

The pump displaces the same volume of air (700 ml) at each cycle and it is important to set the tidal volume. The tidal volume control system allows to set the moment of the cycle where the valve will switch to the exhale phase. The rest of the air from the pump will be purge out of the respirator.

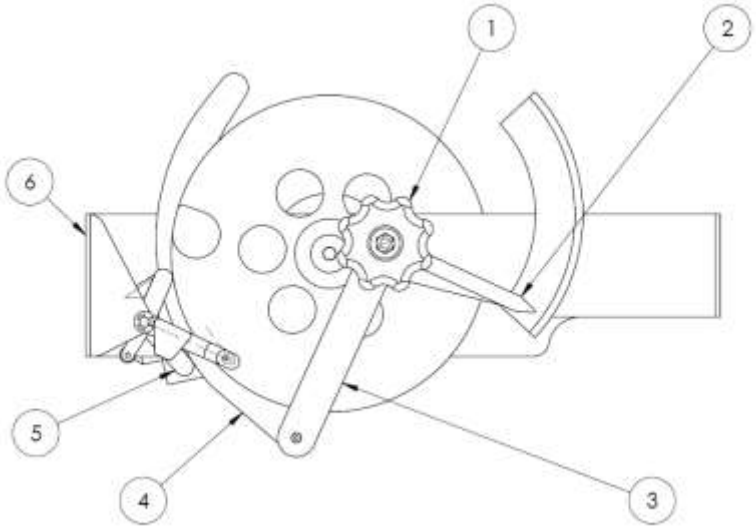

Figure 11. Tidal Volume control system

In order to set the tidal volume, the operator will turn the handle (1) and control the position of the handle (2). The lever (3) will rotate and displace the transmission element (4) relatively to the control valve system expiratory lever (5). The cam has two paths, one for the pump and a second for switching to the expiratory mode. The transmission element (4) ensure a contact between the cam path and the expiratory lever (5).

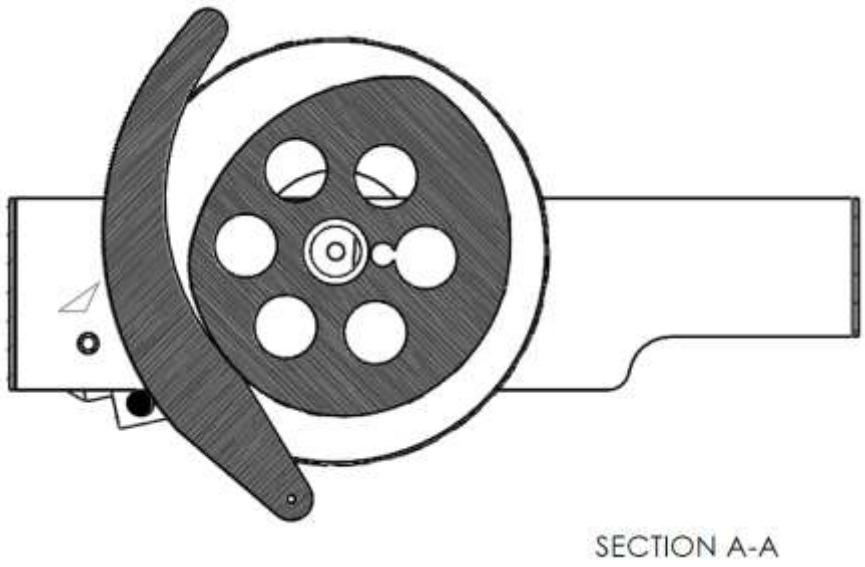

Figure 12. Tidal volume control system set at 200 ml

Figure 12, represents the instant where the control valve system will switch to the expiratory phase when 200 ml have been injected. It happens early in the cycle because the transmission element is positioned at its large portion.

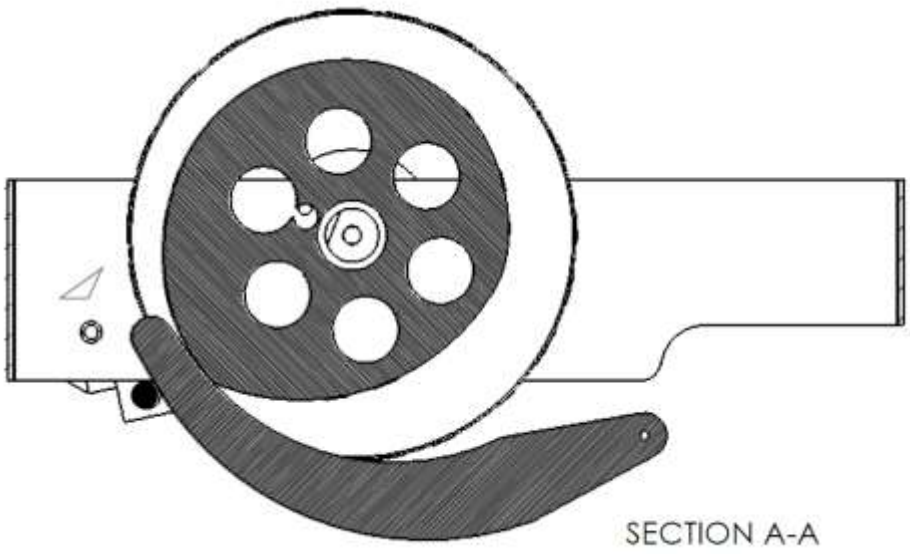

Figure 13.Tidal volume control system set at 700 ml

Figure 13Figure 12, represents the instant where the control valve system will switch to the expiratory when 700 ml have been injected. It happens late in the cycle because the transmission element is positioned at its small portion.

Safety and PEEP Valves

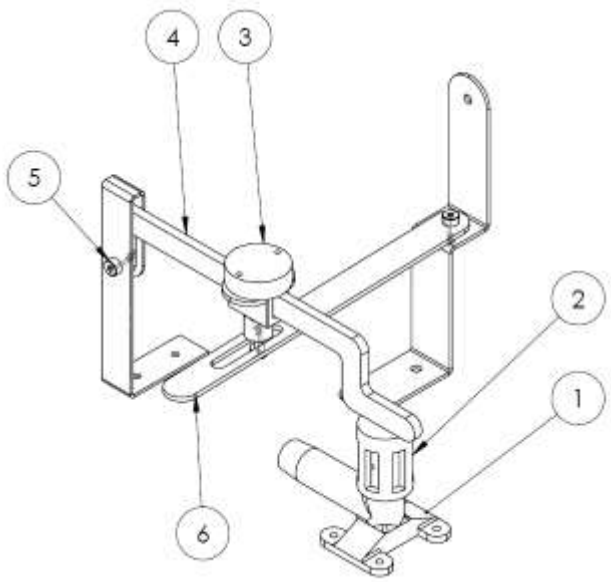

Figure 14. PEEP valve system

The PEEP valve system is composed by a valve body (1), the valve cap (2), a weight of 30 g (3), a linear guide (4) and a pivot (5) for holding the guide. The PEEP lever (6) for translating the weight on the guide.

If the weight is closed to the valve cap it is mainly supported by it and it will necessitate more pressure to lift the valve cap and allow the air to exit. It the weight is close to the pivot, then it is almost not supported by the valve cap and the pressure to open it will be low. The 3d printed prototypes work, their reliability rest.

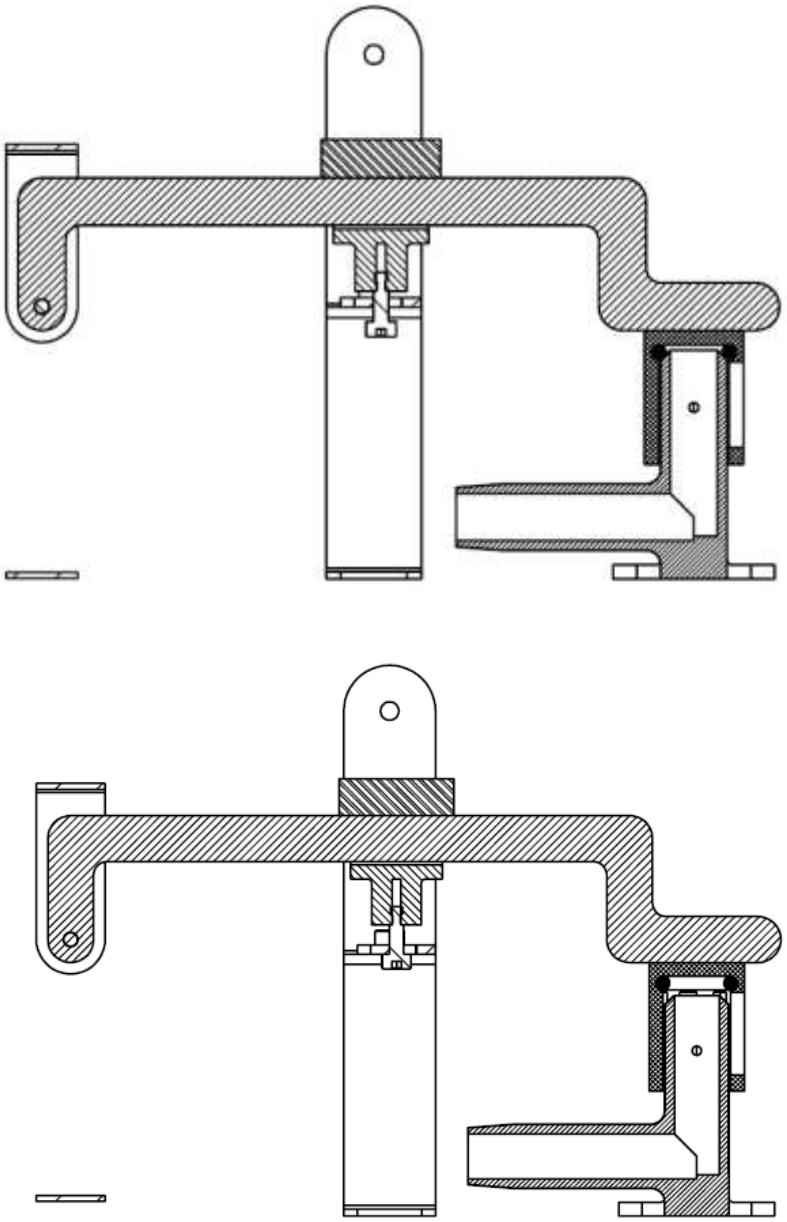

Figure 15.PEEP valve system open and closed

All the others pressure valves are based on the same design but with a fixed weight on the valve cap for a fix opening pressure.


700
600
500
400
300
200 mL
VA
0 5 10 15 20