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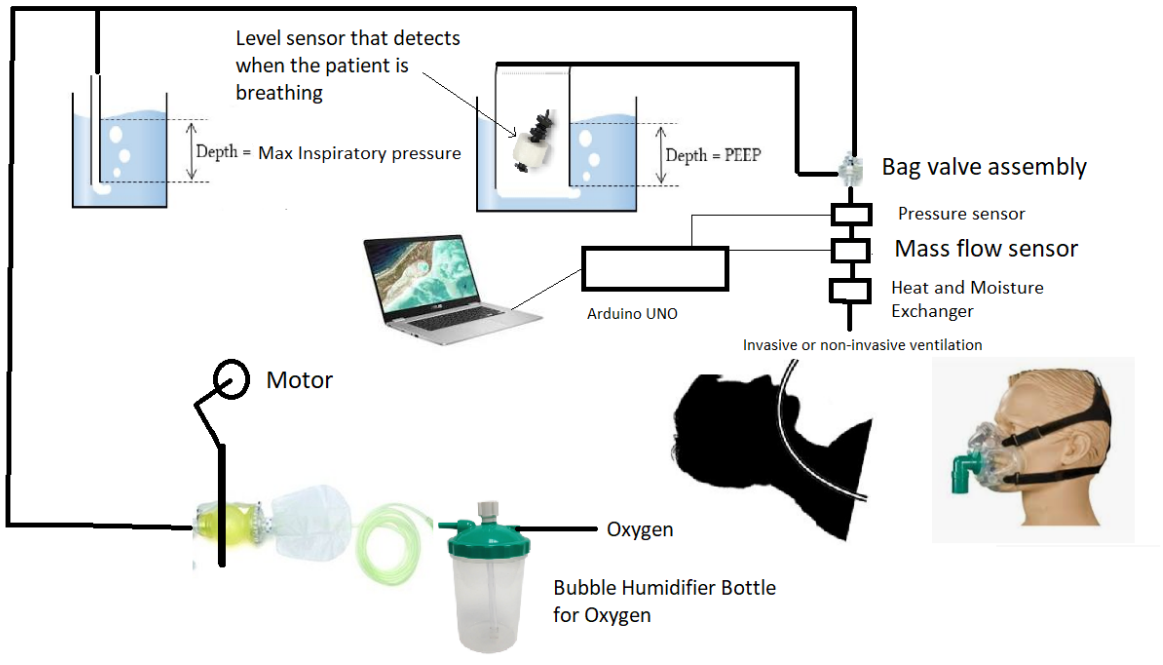
Ch(air) emergency ventilator

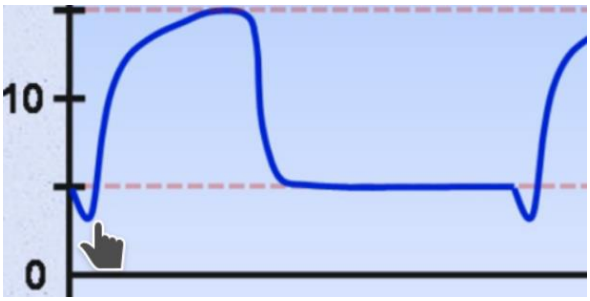
Description

The Ch(air) emergency ventilator is a is a mechanized manual resuscitator bag with water-based PEEP and inspiratory pressure safety water bottles. The design idea is that it should be possible to build this with things that are easily accessible, as well as being completely mechanical without being dependent on software for the control, except for a time relay. Here is a video https://photos.google.com/photo/AF1QipN6ucO4H_iui3RkQ2ipTTL8Zs_BFZcjli6CZV9o showing what we built, click on the image to view the video. The solution is completely mechanical and based on a 12V windshield wiper motor from a car. The windshield wiper motor has been fitted with an arm, that allows the stroke to be changed and so the volume of air to the patient. The voltage to the motor is changed with switches to control the speed/cycle time. The water bottles regulate the air pressure in and out to X cm H2O completely according to the laws of physics without mechanics or software. If you want to run in constant pressure mode, you can select a level in the inspiratory safety valve bottle, which corresponds to the desired pressure eg. 25 cm H2O and increase the volume a little, until you get close to the desired pressure, or when it bubbles out some air in the bottle. This means that if the lung volume decreases overtime, excess air will bubble out into the bottle.



Functional block diagram.

The windshield wiper motor compresses the resuscitator bag when it rotates 180 degrees. After rotating 360 degrees, a switch in the motor gearbox stopes the rotation just before compressing the resuscitator bag. The rotation continues either if the time relay time expires or the patient takes a breath. Since the water level in the tube that is inserted in the PEEP water bottle rises x cm, when the patient is inhaling, it is possible to detect this using a level sensor. Here is a video showing the level switch activated by patent breathing
https://photos.google.com/photo/AF1QipO4qqR1tJuG2iVXSYoYZNrO34yWCAkP31YujgL3

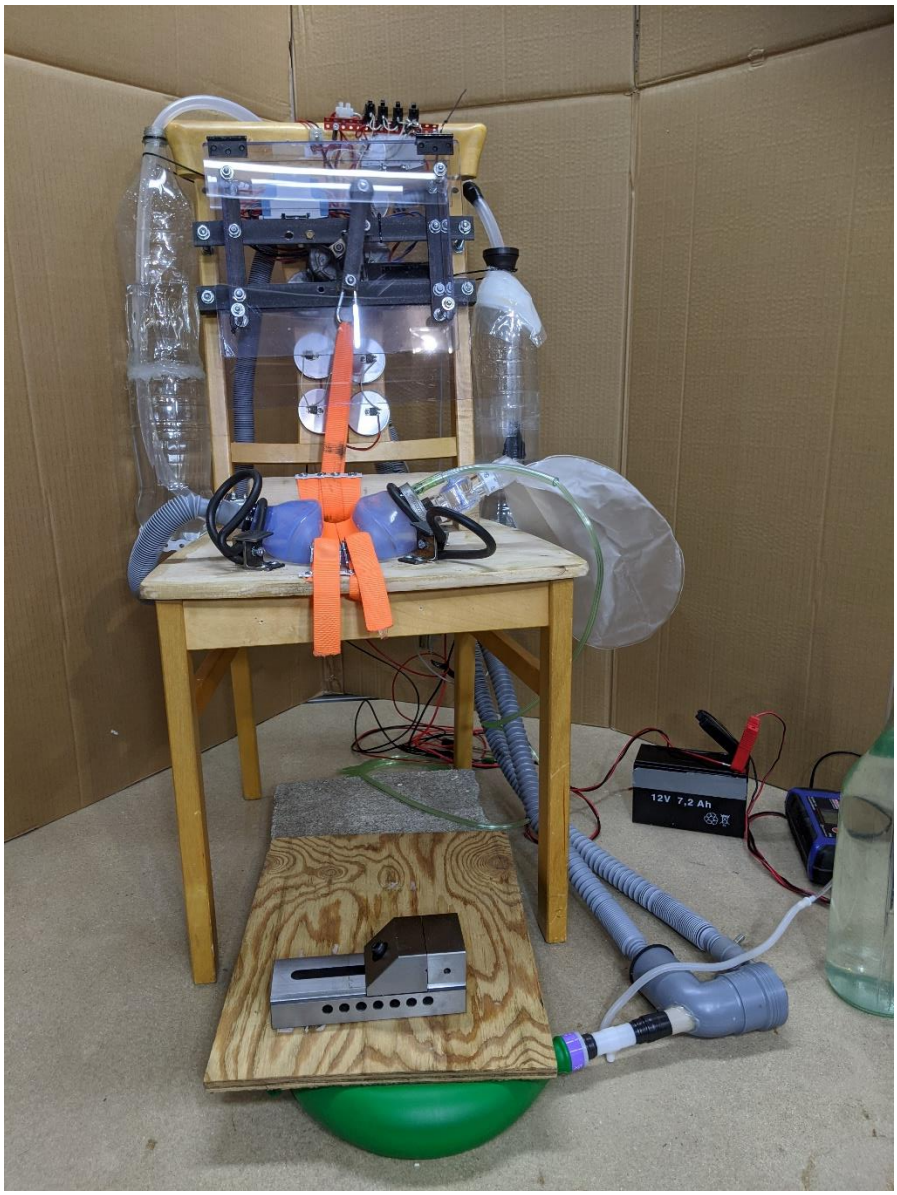


Pressure drop when the patient inhales.

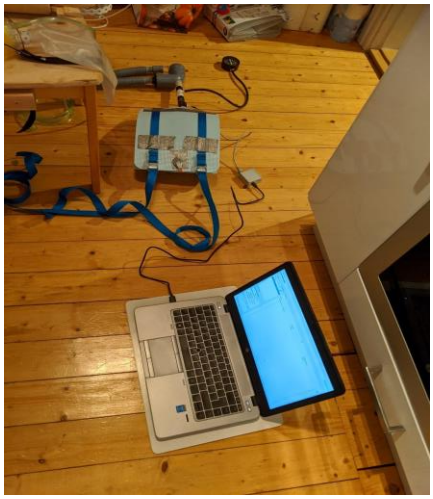
The manual resuscitator bag allows the patient to breathe through the bag valves and valve assembly, even if the bag is not squashed. It is also possible for the patient, to exhale through the valve assembly. The worst case in terms of pressure is when the patient's lungs are filled with air, and that the machine does a inspiratory cycle, however, the water pressure in the driving pressure bottle will limit the pressure to example 25 cm H2O, depending on the water level.

Test method

To test that the Ch(air) ventilator can handle 20 breaths per minute, driving pressure 25 cm H2O (relative room air pressure), PEEP 10 cm H2O (relative room air pressure), inspiratory flow time 0,5 s and pressure control mode, a test was rigged. The volume is set slightly higher than the lung capacity to get constant pressure, the excess air bubbles out in the driving pressure water bottle.

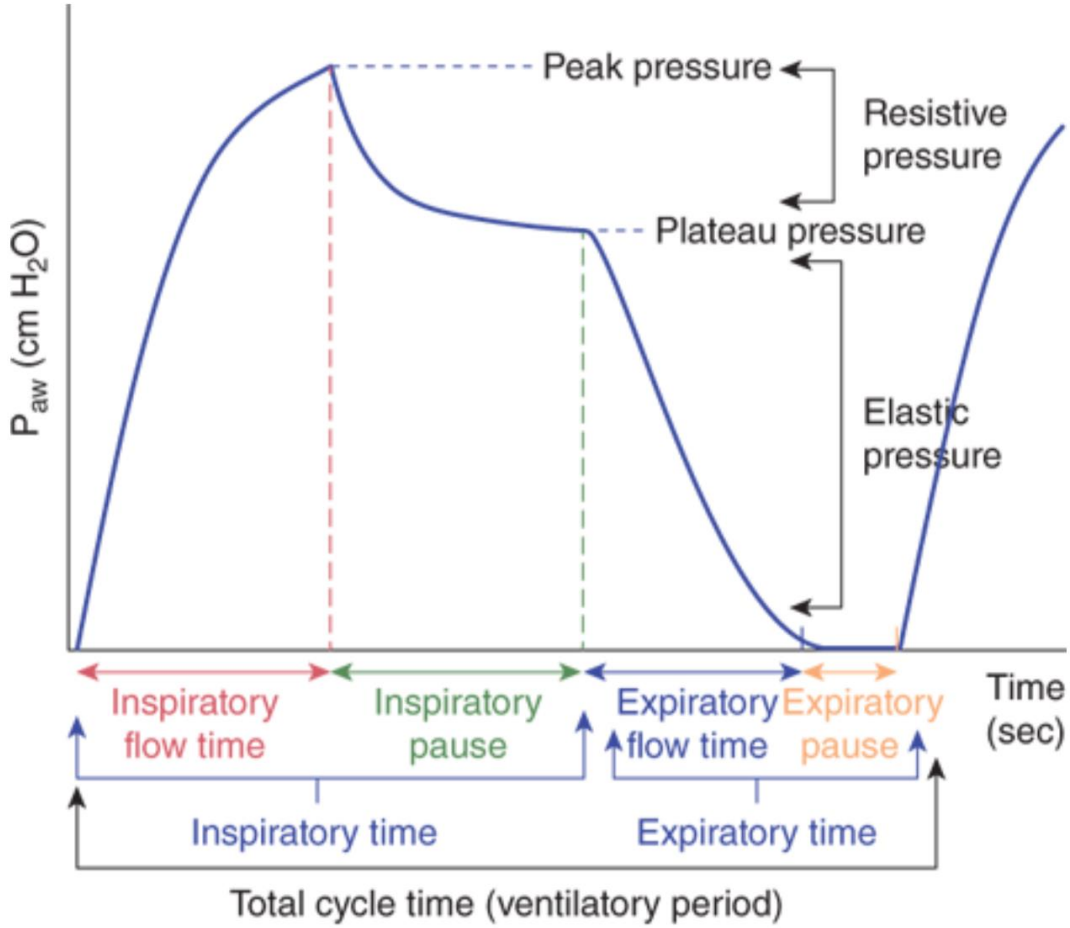


Test setup with DIY test lung and water bottles set for 25 cm H2O driving pressure and 10 cm H2O PEEP.



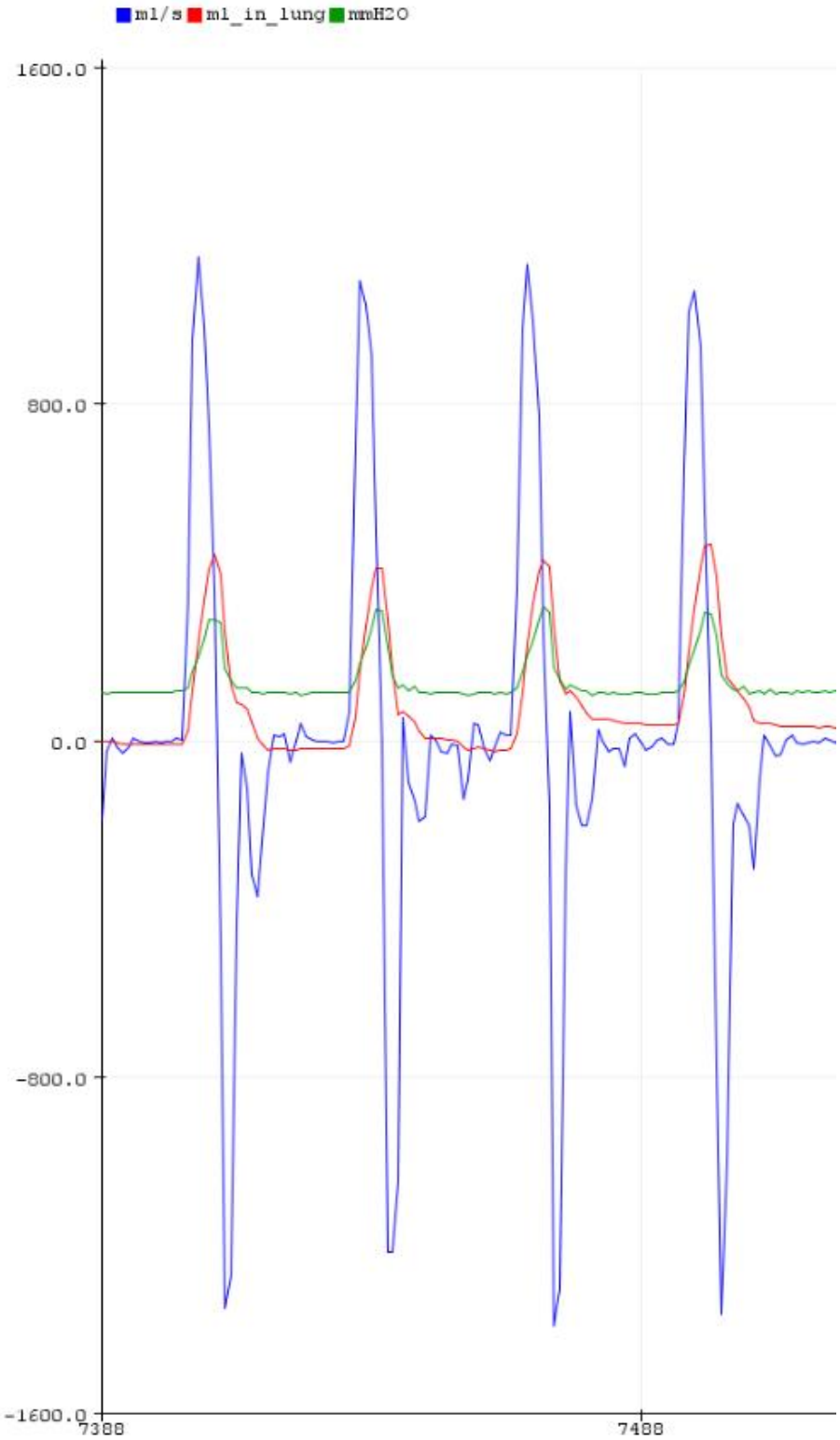
PC with a program that we wrote to plot pressure (Honeywell ABPMRRV001PDAA5), flow and volume (Sensirion SFM3200).

Definitions



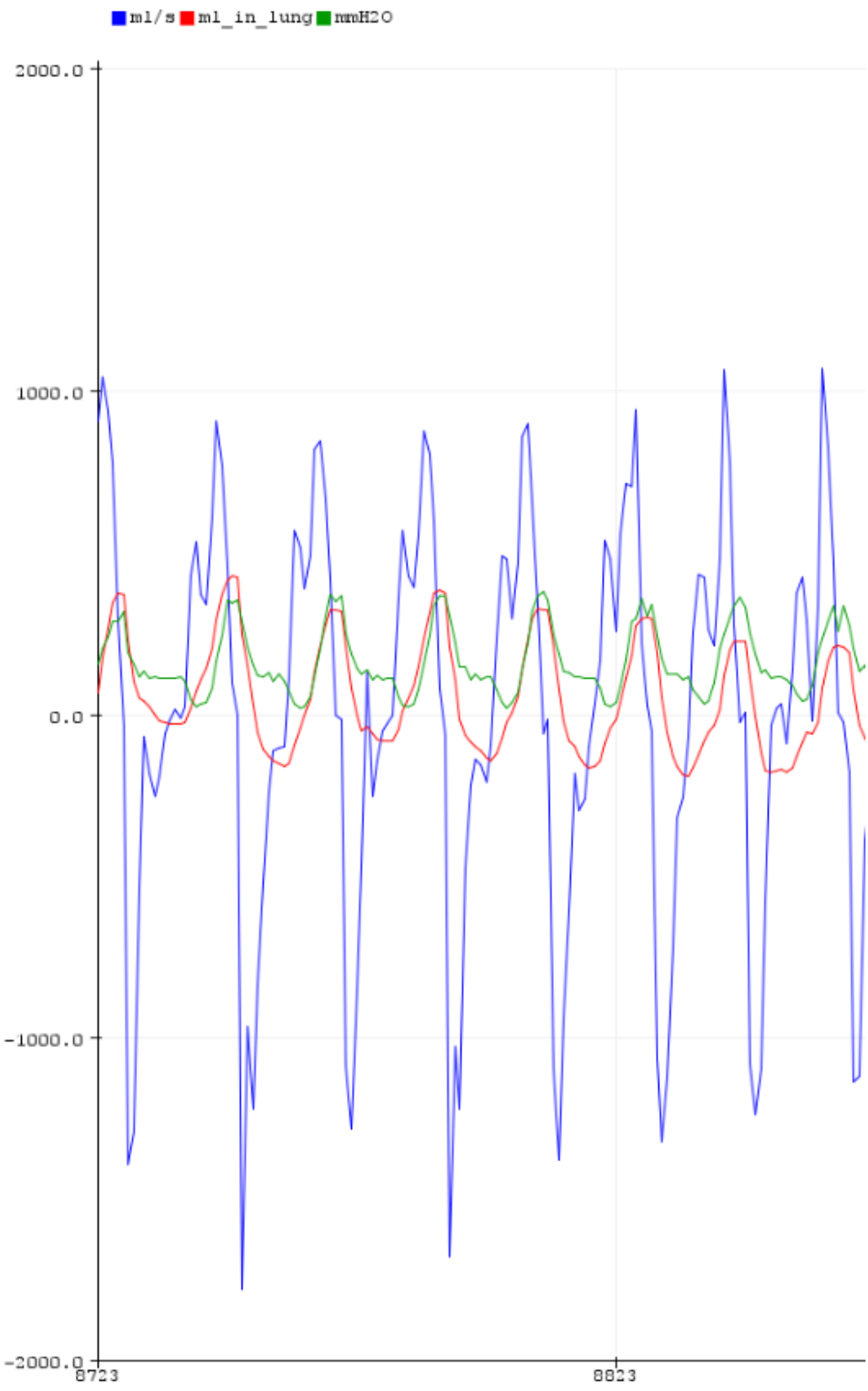
Source: Ronaldo Collo Go
Critical Care Examination and Board Review.

Test result

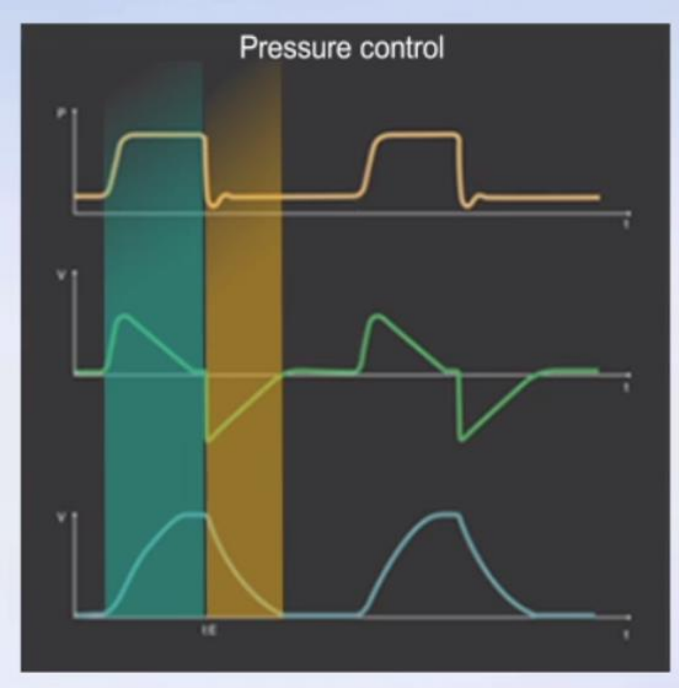


Plot showing flow ml/s (blue), volume ml (red), pressure mmH2O (green), 10 s per column section, patient is not breathing. The volume curve is drifting up and down, since a zero event/trigger is not implemented, the relative volume is correct though.

The plot shows that the time between every breath is about 3 s, that is 20 breaths per minute. From the volume plot the inspiratory flow time can be read out to about 0,5 s. The volume is set higher than the lung capacity to get constant pressure, the excess air bubbles out in the driving pressure water bottle. The side-effect bubble time is about 0,3 s, inspiratory pause is therefore 0,3 s. The inspiratory time is 0,5 + 0,3 = 0,8 s. Expiratory flow time is about 0,9 s. Expiratory pause is about 1,3 s. Expiratory time is about 0,9 + 1,3 = 2,2 s. Total cycle time is about 3 s. The plot shows that peak pressure is about 275 mmH20. Plateau pressure is about 265 mmH20. Positive end-expiratory pressure (PEEP) is about 110 mm H2O. Volume change between every breath is about 460 ml.



Plot showing flow ml/s (blue), volume ml (red), pressure mmH2O (green), 10 s per column section, patient is breathing. The volume curve is drifting up and down, since a zero event/trigger is not implemented, the relative volume is correct though.



Getinge ventilator example pressure control.

The test shows that the ch(air) ventilator has a about similar flow and volume curve as the Getinge ventilator example, and that the test result is as expected.