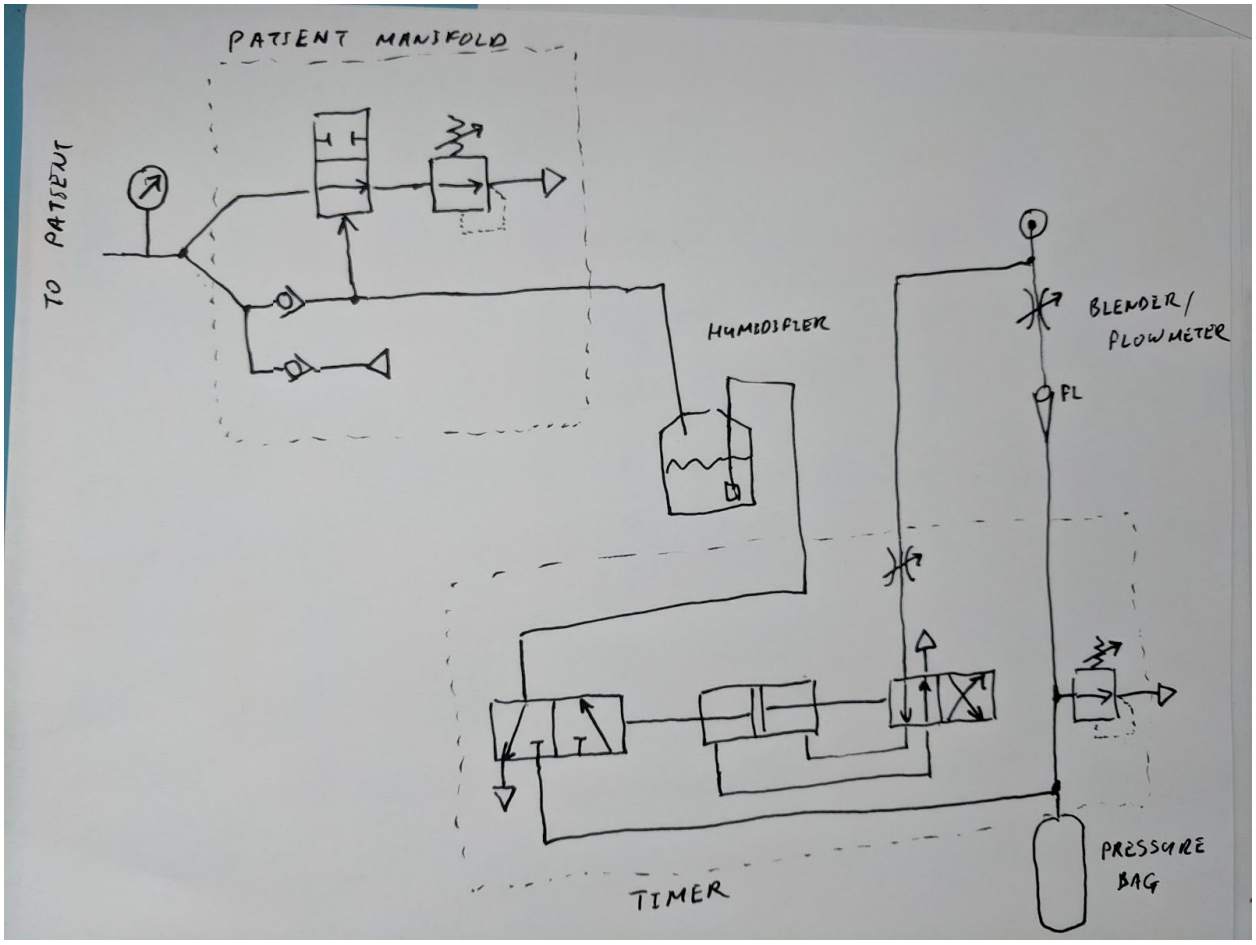
System diagram



Operating principle

A constant flow of oxygen or oxygen/air mix from the source (controlled by blender or needle valve) sets the minute volume. Pressure in the bag increases until outflow matches inflow; in other words the PIP pressure is at the lowest pressure that allows the set minute volume (=Pressure Regulated Volume Control mode). **The minute volume does not depend on lung compliance.**

If the pressure builds up too high, the PIP overpressure valve vents excess pressure from the bag (and sounds an alarm whistle)

The pneumatic timer is driven by a separate oxygen flow at higher pressure but lower volume, about 0.15-0.2 lpm at 10 psi. The timer consists of a double acting cylinder and two piston valves in one body (~4 parts total). At each position of the piston, the valve is set to gradually feed pressure to that side until the piston is released and flips to the opposite side. This

requires a means to hold the piston in place until a set force threshold; this may be implemented as a spring loaded catch, a bistable spring (stamped metal), friction, or (preferably) a magnet at each end of the cylinder.

The cycle time of the timer is set by time needed to reach the force/pressure needed to release the piston at the flow rate coming from the needle valve. The time can be unequal for the two sides, based on either a different holding force, or a different dead volume. **The cycle time does not depend on lung compliance, PIP or minute volume.**

During inspiration, the bag pressure acts to close the output valve in the patient manifold. The valve can be realized as a duck billed valve or a piston and spring valve. The same valve can control the PEEP (~4 parts)

Timer

See "Timer" doc for detailed description

cycle time 10-30 cycles per second
on time : off time ratio 1:2 (can be fixed or adjustable - change the volume on one side of the cylinder or the magnet standoff)
driven from 3.5-4.5 bar supply
should not use more than 0.2lpm

Timer pressure relief valve

fixed 35 cmH2O
(option) adjustable 35 cmH2O-70 cmH2O
must allow >10lpm at 40cmH2O

Patient manifold valve

closes at 10 cmH2O or greater
must remain closed with pressure differential up to 35cm H2O between input and output
full port: 100mm^2 (pref 300mm^2)

Patient manifold pressure relief valve (PEEP valve)

adjustable 5 to 20 cmH2O

Blender

standard equipment

http://www.biomeddevices.com/products/categories/low-flow-air/oxygen-blenders-for-the-nicu-and-l-d/

Can use a needle valve (injection molded) and/or venturi (injection molded). It is expected that in an emergency everyone will be on 100% oxygen.

Can also use oxygen concentrator (preferably two, connected with a Y)

Flowmeter

standard equipment

https://mfimedical.com/products/allied-healthcare-timeter-sure-grip-single-oxygen-flowmeter

If unavailable: can use injection molded rotameter (2 parts)

Pressure monitor

standard equipment - disposable pressure gauge from Mercury Medical
(6 components including one spring, rest is injection molded)

If unavailable: can make a clone from injection molded components, or use a U tube manometer, or connect a gauge to check pressure once in a while

Pressure bag

Anaesthesia bag, 3 liter (standard equipment)

https://serfinitymedical.com/products/portex-anesthesia-breathing-circuit-expandable-tube-87-inch-tube-dual-limb-adult-3-liter-bag-disposable-smiths-medical-453600-nl-653642

Specs are not critical; can use any elastic bag several liters in size and rated to 2-3 psi.

If unavailable: can use a soda bottle; elasticity is preferred but not absolutely required, the main function is of a pressure accumulator.

Flutter valves (check valves)

standard equipment:
https://www.respiratorycarestore.com/carefusion-001802-airlife-one-way-flutter-valve-large-22mm-o-d

If unavailable: can be made from injection molded body and die cut rubber sheet

Connectors

22mm ID/OD slip fit (standard) per ISO 5356-1

Tubing

standard equipment