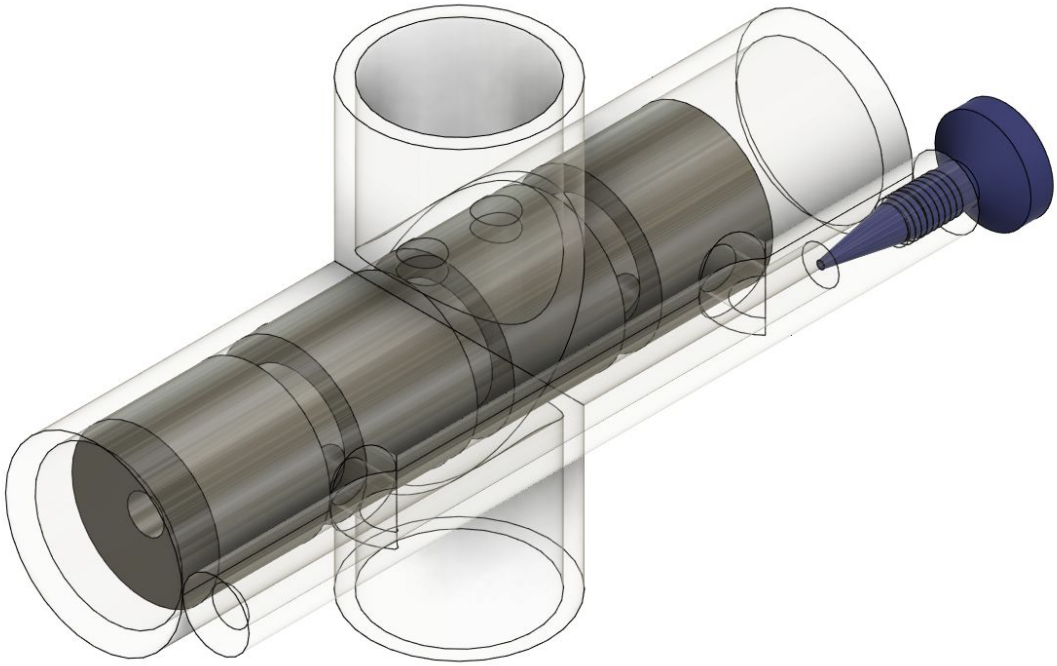
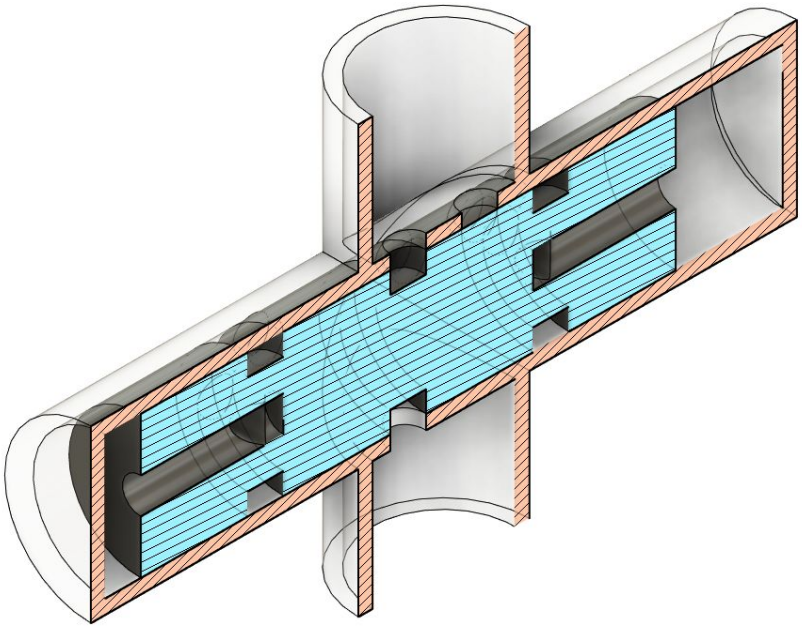
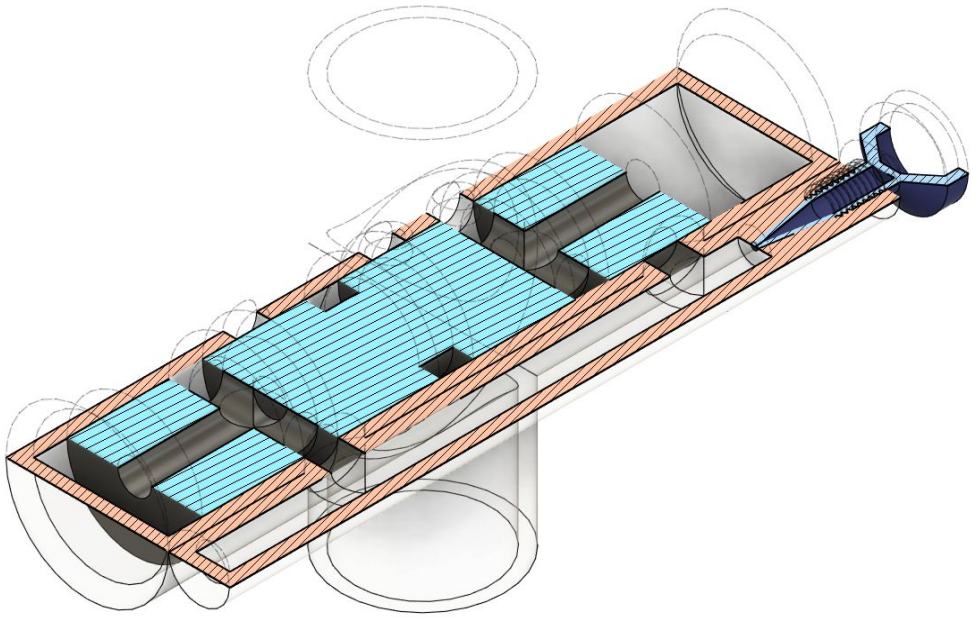
The timer consists of a double acting cylinder and two piston valves in one body (~4 parts total); and a needle valve to control the timing.

Other implementations are possible as long as they have the same bistable functionality. Diaphragm and rotary-type mechanisms were also considered; however the cylinder appears to have the lowest risk / highest likelihood of working on the first iteration.

Simplified model







Connections

Top - to patient manifold
Bottom - to pressure bag
Right (small port) - needle valve controlling cycling speed
(this is shown during inhale; during exhale the piston moves to the opposite side)

Not shown: overpressure relief; connection to O2 feed (these will be combined with another flow controller and rotameter)

How it works

In either piston position: pressure is building up through the needle valve at a controlled rate to flip it to the other position. The other side of it is open to the atmosphere so it won't create a force in the opposite direction

The piston needs some kind of retaining feature at each end - this could be a buckling spring with two positions, a catch, or magnets. Magnets are most likely to have a predictable and repeatable holding force

After the pressure builds above the holding force, the piston flips to the other side (quite fast), the pressure behind it vents to the atmosphere, and the cycle repeats in the opposite direction

Implementation notes

Steel piston; magnets at either end (preferred); or plastic piston with steel washers and magnets; or plastic piston with bistable spring (no magnets)

Plastic cylinder (polycarbonate or K resin, injection molded), or metal cylinder made from a piece of tubing, inside plastic cross piece (pressure fit)

Piston end-stops to control timing/holding force (and cushion)

Metal on metal would allow a closer fit - estimate 0.25mm clearance needed for plastic or 0.1mm free running fit for metal. Trade off is that plastic may either need O ring seals (silicone) or may have a relatively high leakage rate. The design would still operate correctly at leakage rates up to a few liters per minute; the timing valve would just need to be opened wider.

Operating parameters

Operating pressure 2-5 psi (pressure reserve up to 10 psi ensures cycling even if piston sticks)
Flow 150 ml/minute (at 10 cycles/minute)
Holding force at each end 1-2 lbf (this should be significantly more than piston stiction)

Piston area ~3 cm^2
Open port 0.2 cm^2 (can be increased to about 0.5-1 cm^2 by changing port shape, or just scale up the cylinder/piston)