



The Anaesthetic Machine Explained

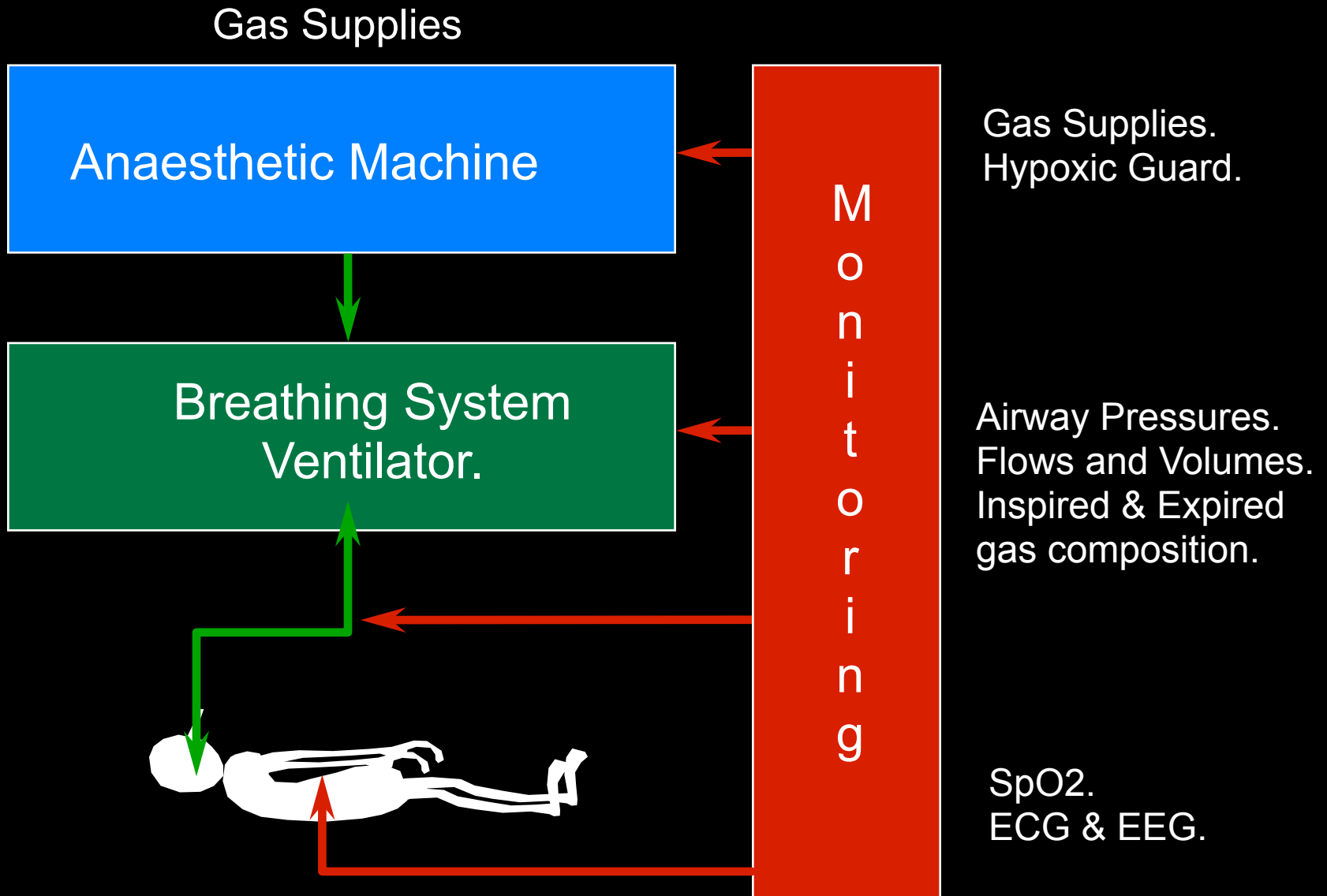
Pre Use Checks

Fran Hegarty

Principal Physicist St James's Hospital
Clinical Teacher in Medicine T.C.D.
Affiliate of the Royal College of Anaesthetists



Components of an Anaesthesia Workstation.





The Anaesthetic Machine Explained

High Pressure System

Intermediate Pressure System

Low Pressure System

Vaporiser

Breathing Circuits

Ventilator

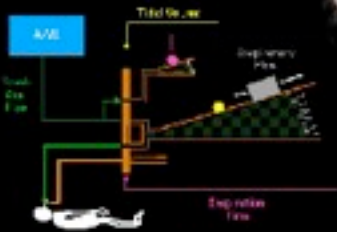
Circle Breathing Circuit

Pre Use Checks

Session Checks

Per Case Checks

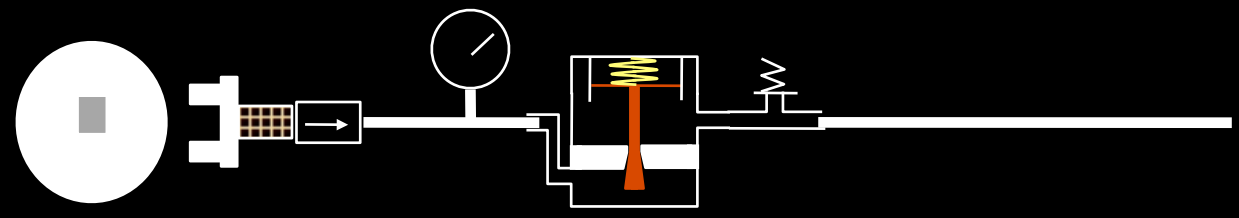
Why?

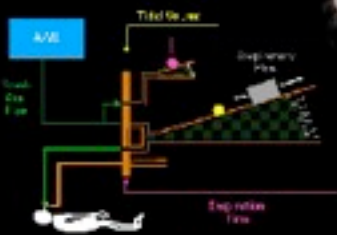


High Pressure System

13,700 KPa

400 KPa

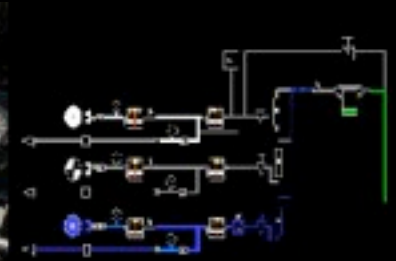
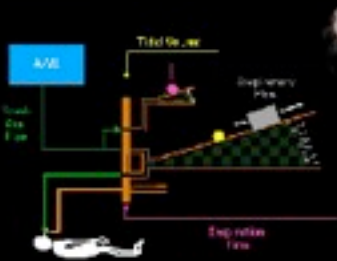




Intermediate
Pressure
System



400 KPa

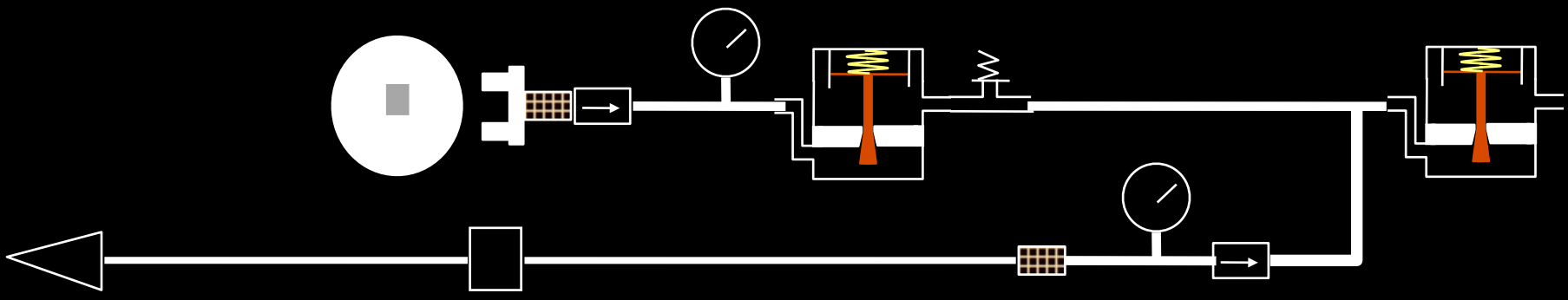


High Pressure System

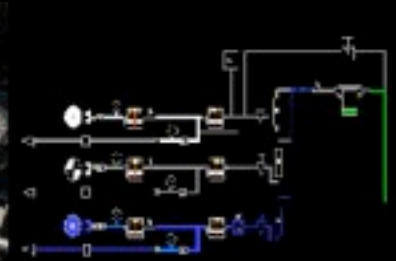
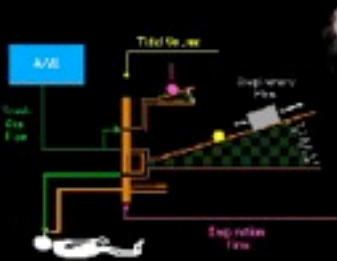
Intermediate Pressure System

13,700 KPa

400 KPa



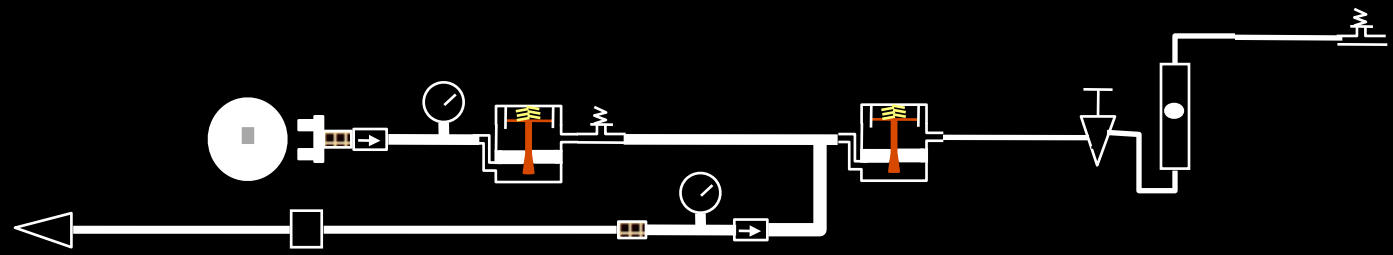
400 KPa

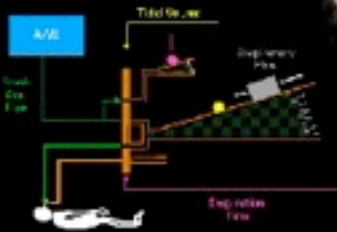


High Pressure System

Intermediate Pressure System

Low Pressure System

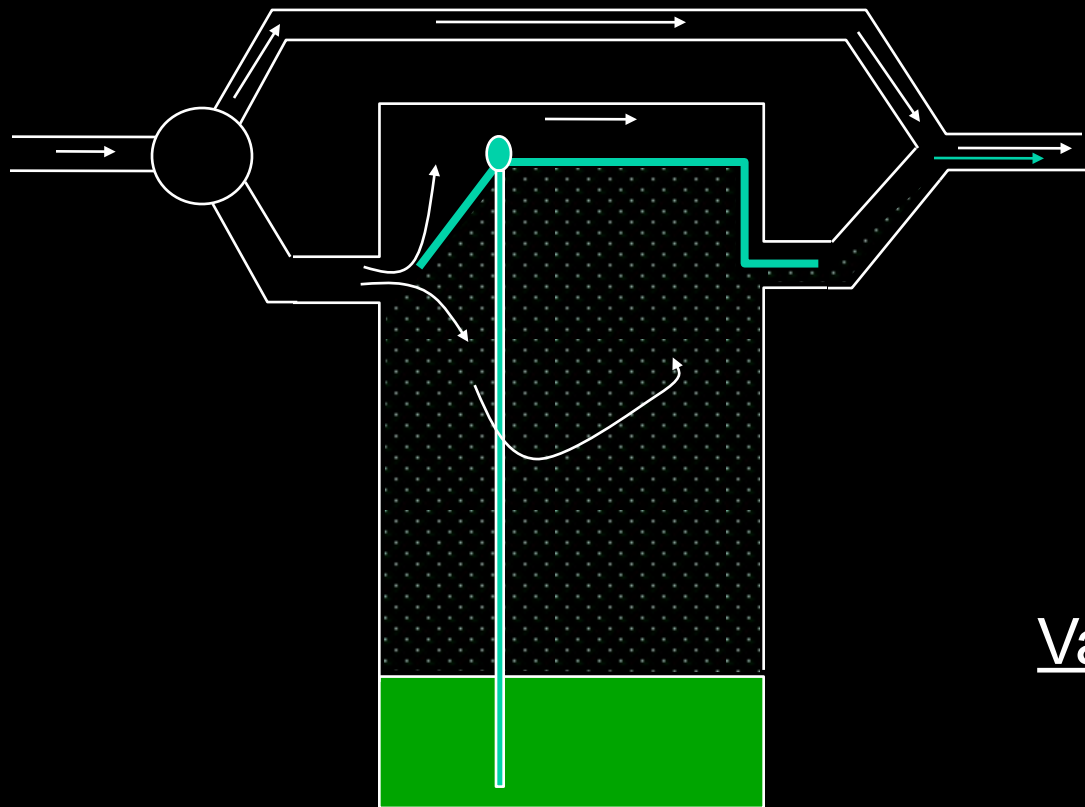




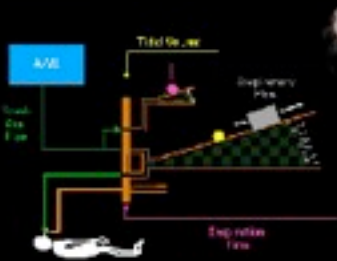
High Pressure System

Intermediate Pressure System

Low Pressure System



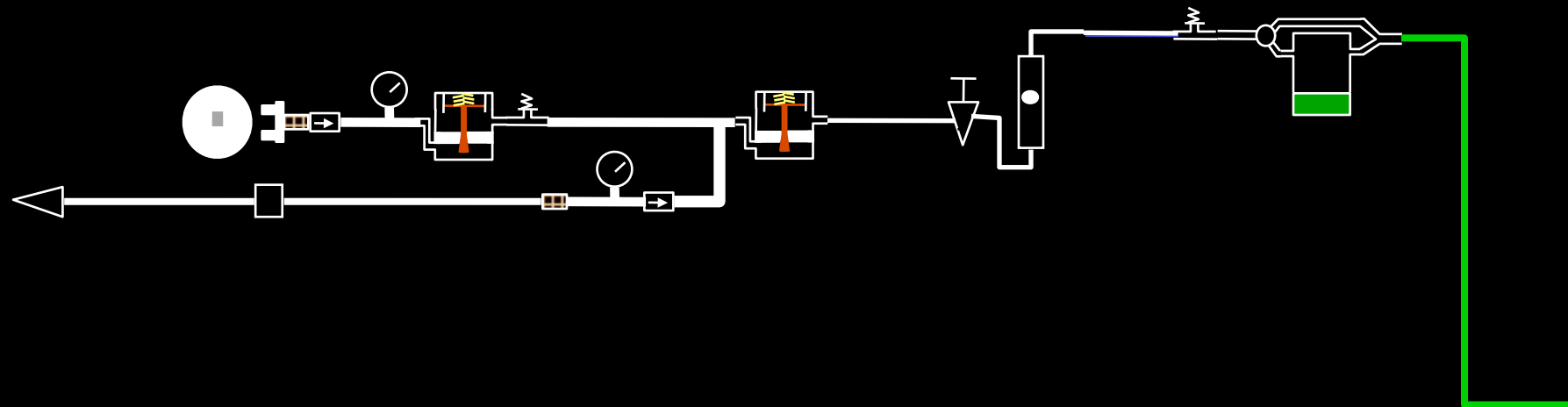
Vaporiser.

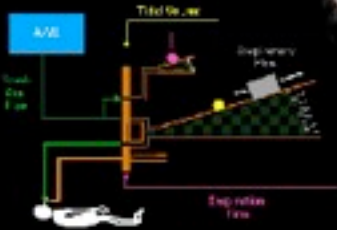


High Pressure System

Intermediate Pressure System

Low Pressure System

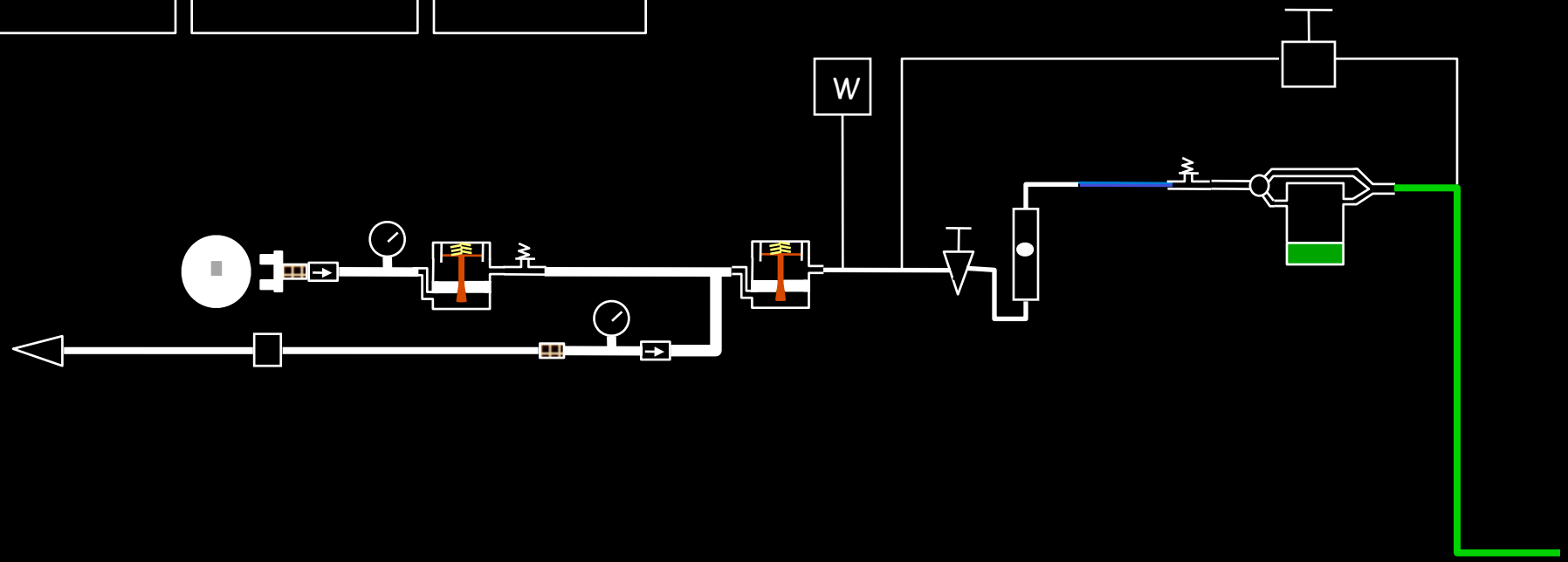


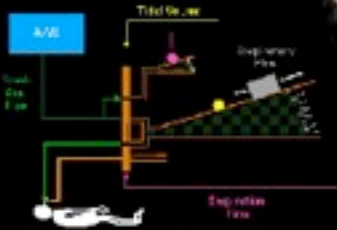


High Pressure System

Intermediate Pressure System

Low Pressure System

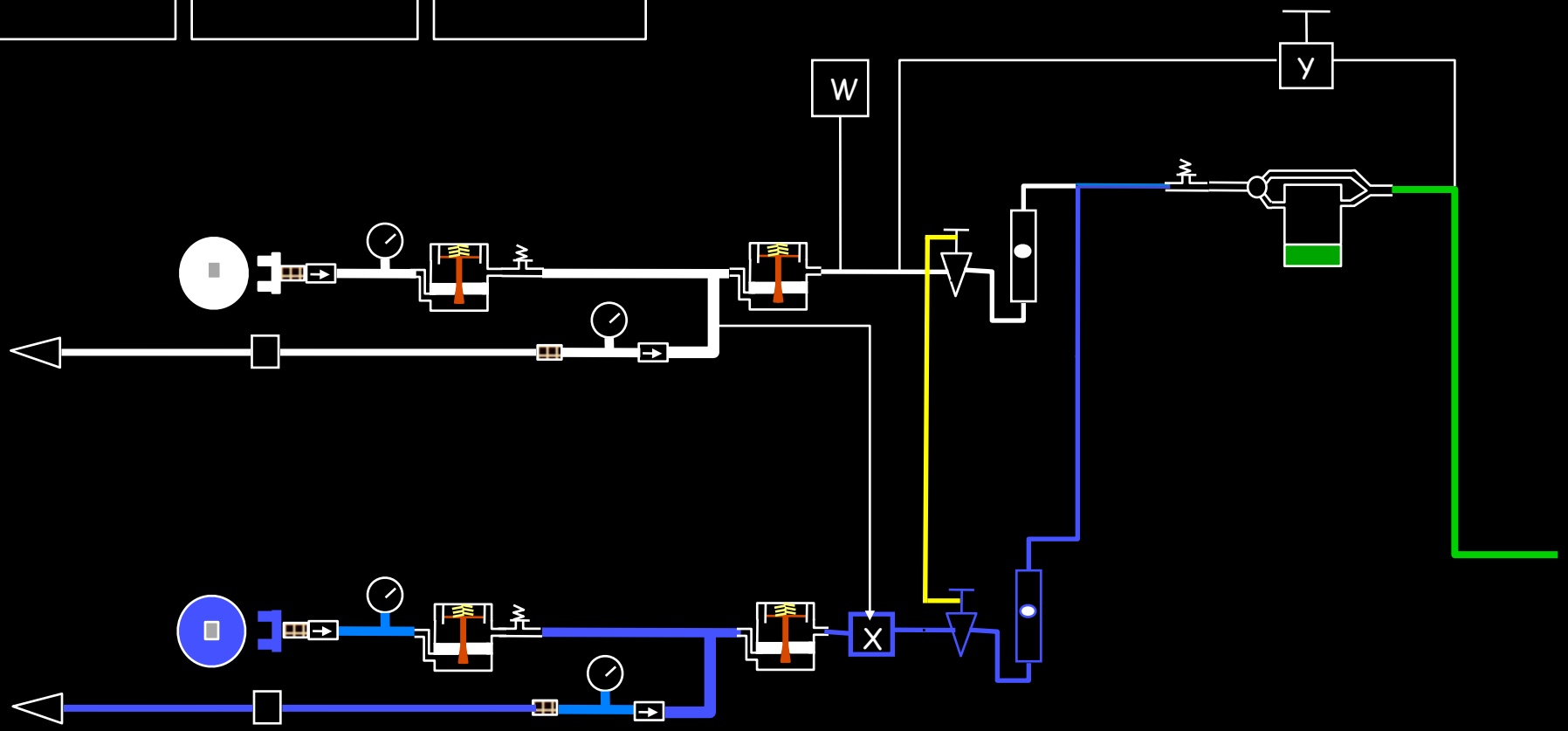




High Pressure System

Intermediate Pressure System

Low Pressure System

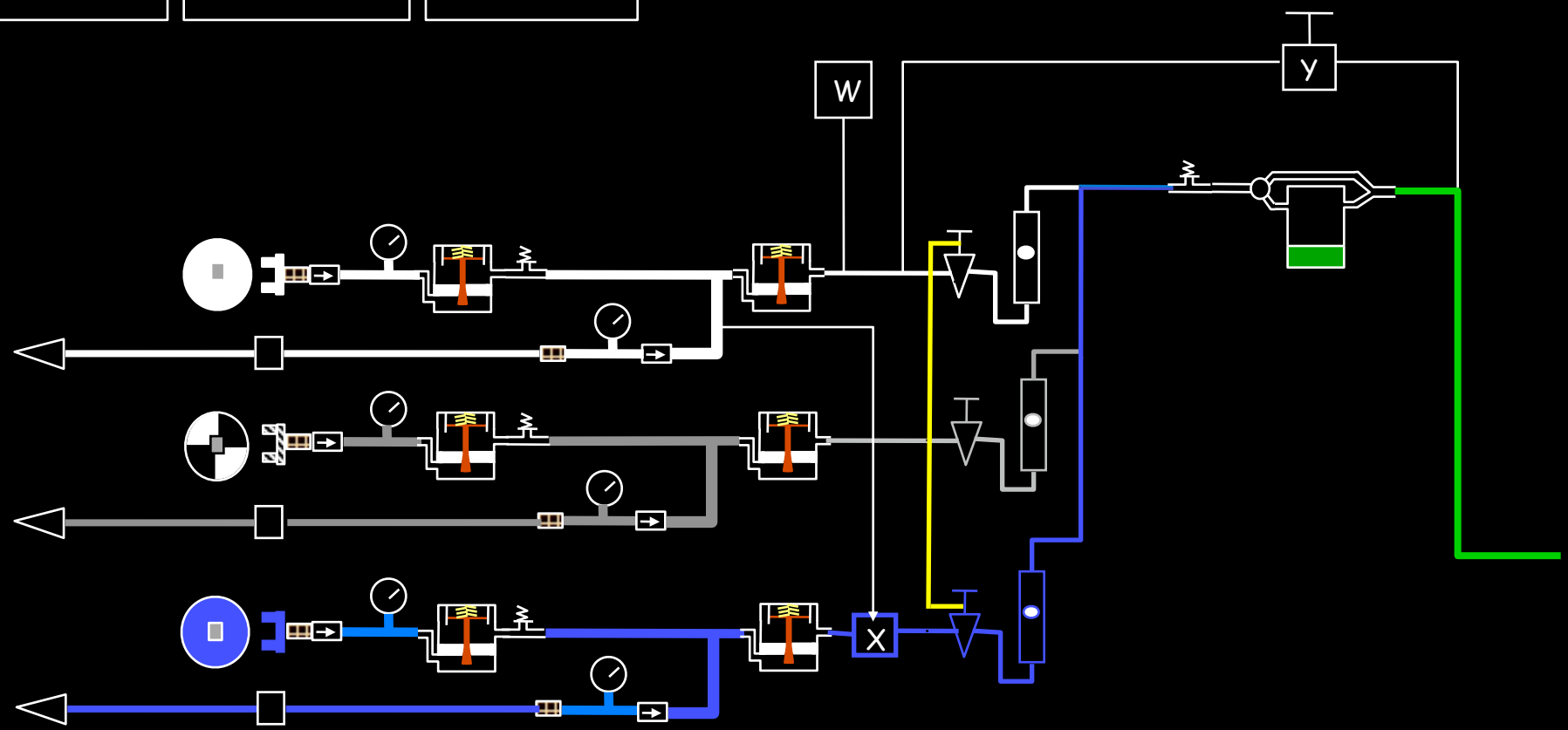


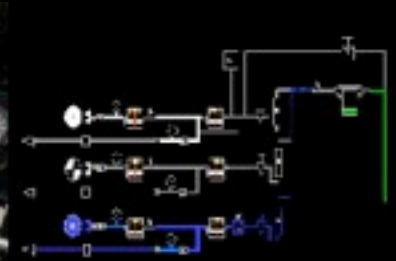
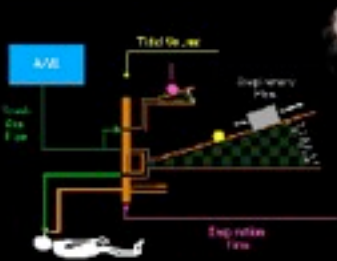


High Pressure System

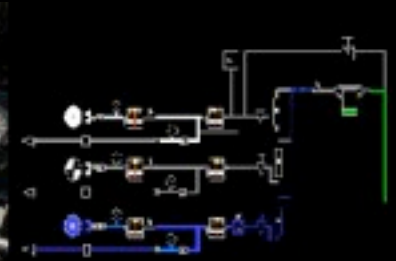
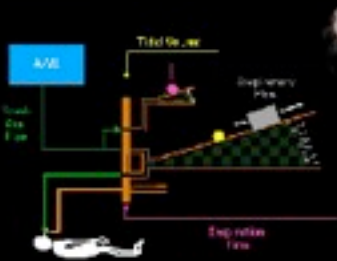
Intermediate Pressure System

Low Pressure System



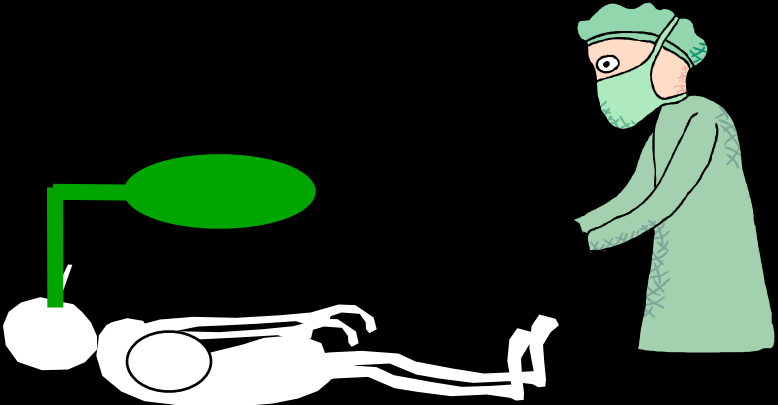


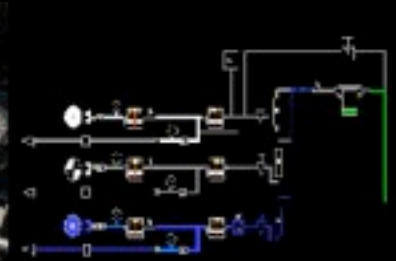
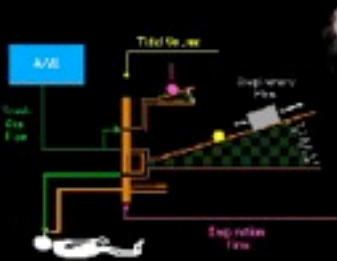
A/M



A/M

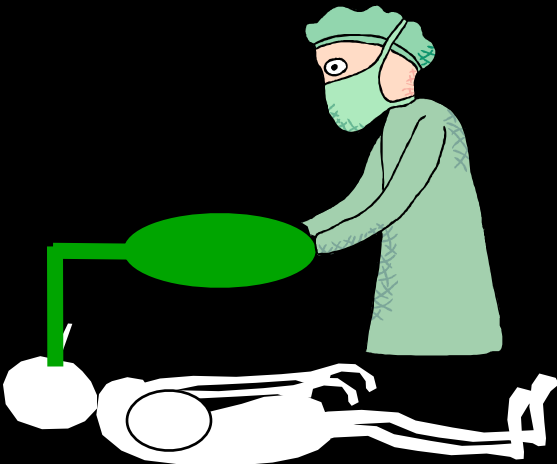
Self inflating Bag

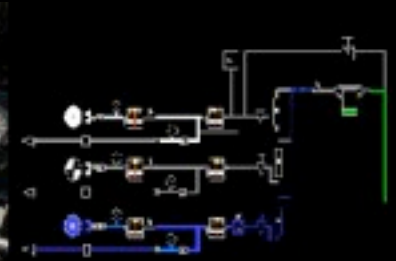
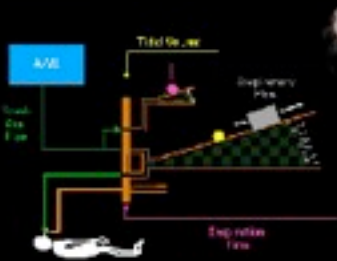




A/M

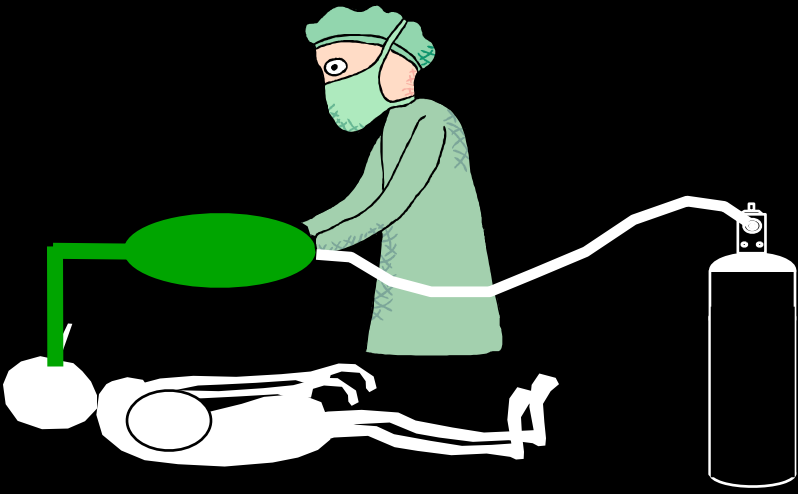
Self inflating Bag





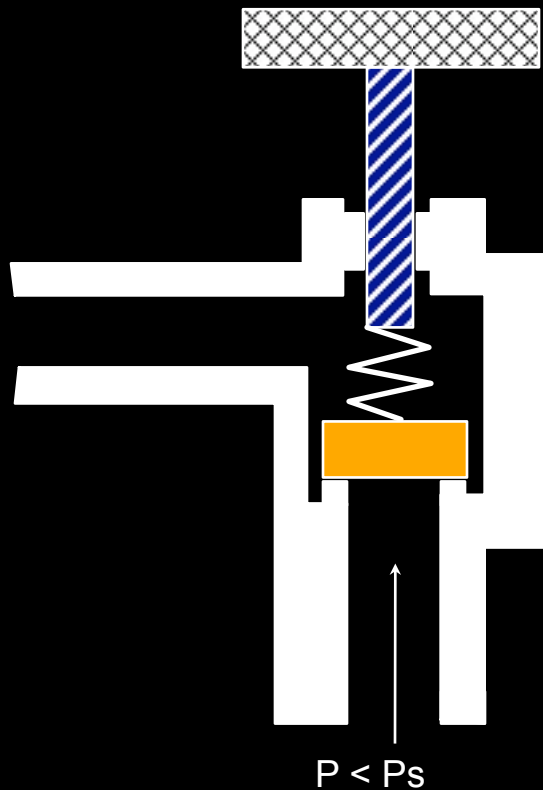
A/M

Self inflating Bag





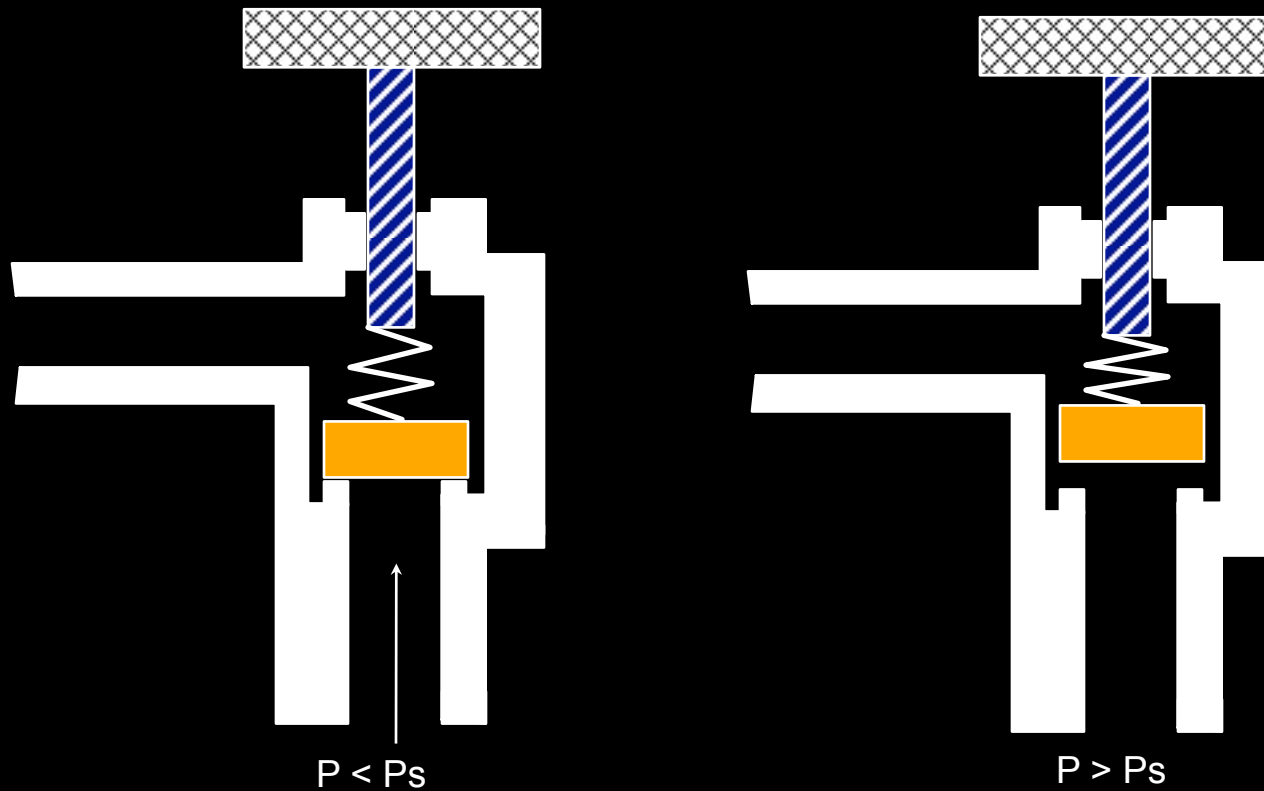
Adjustable Pressure Limiting Valve.

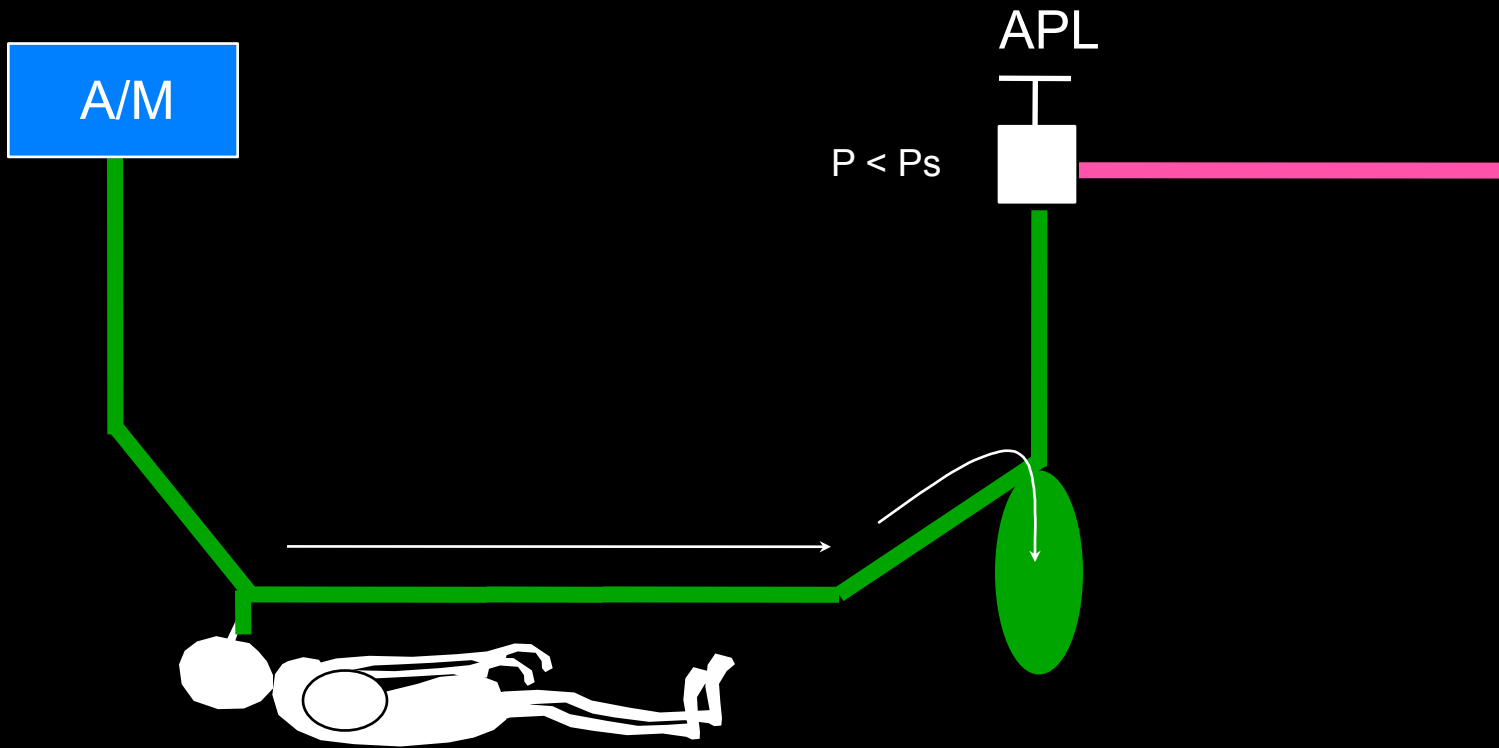
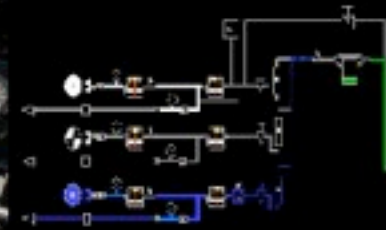
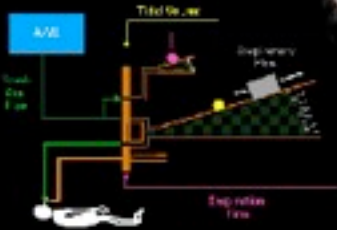


A user adjustable valve that releases gases to the scavenge system once the pressure in the circuit reaches the pressure set on the control of the valve.



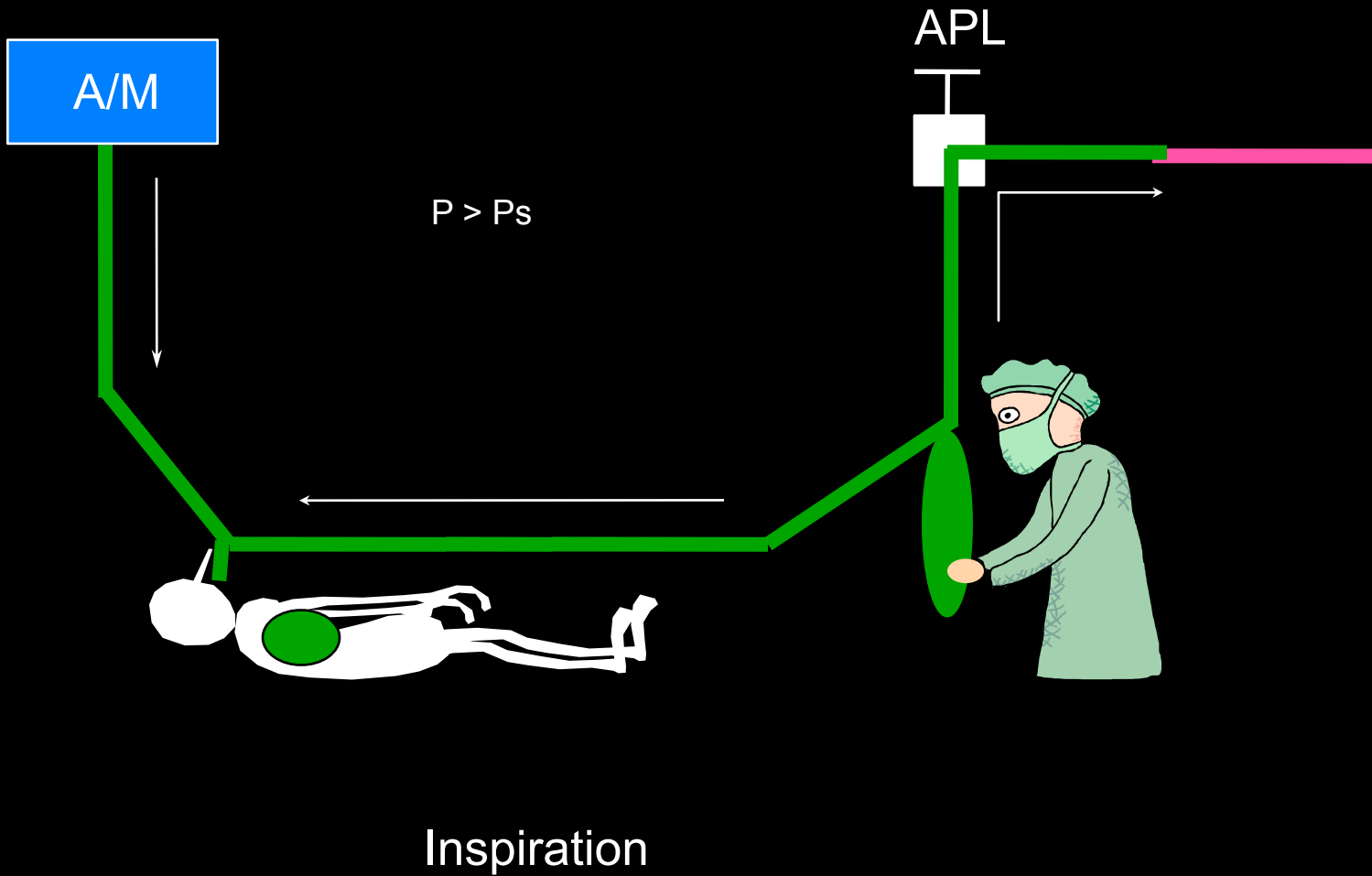
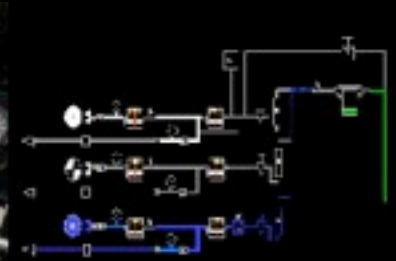
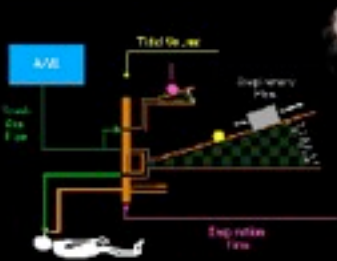
Adjustable Pressure Limiting Valve.

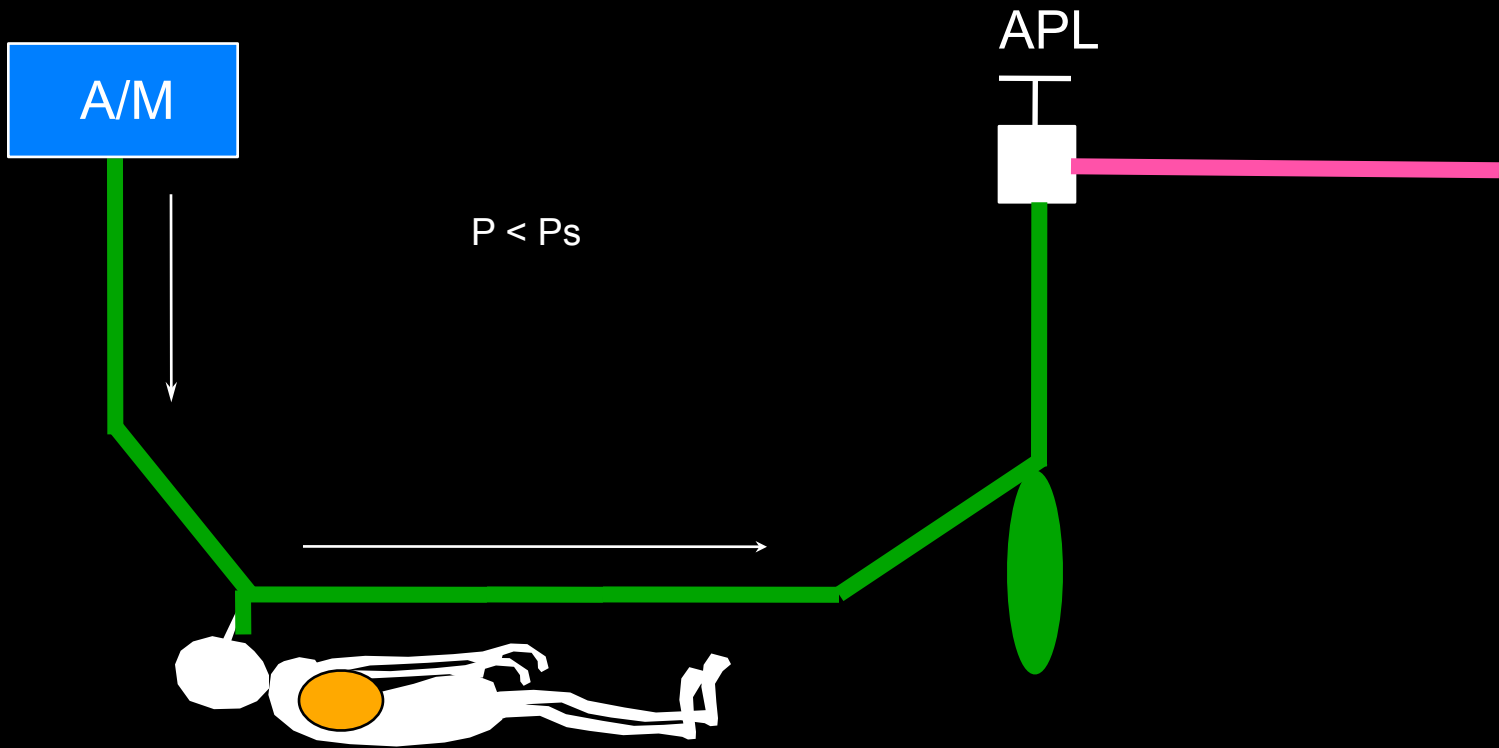
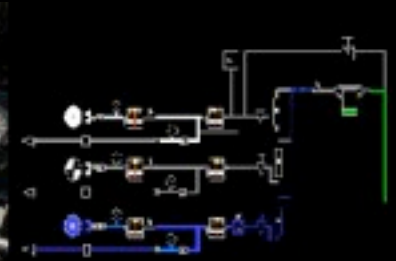
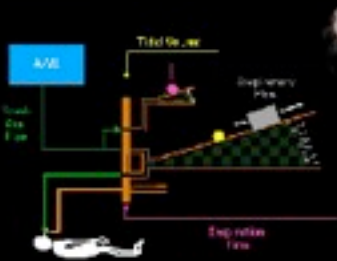


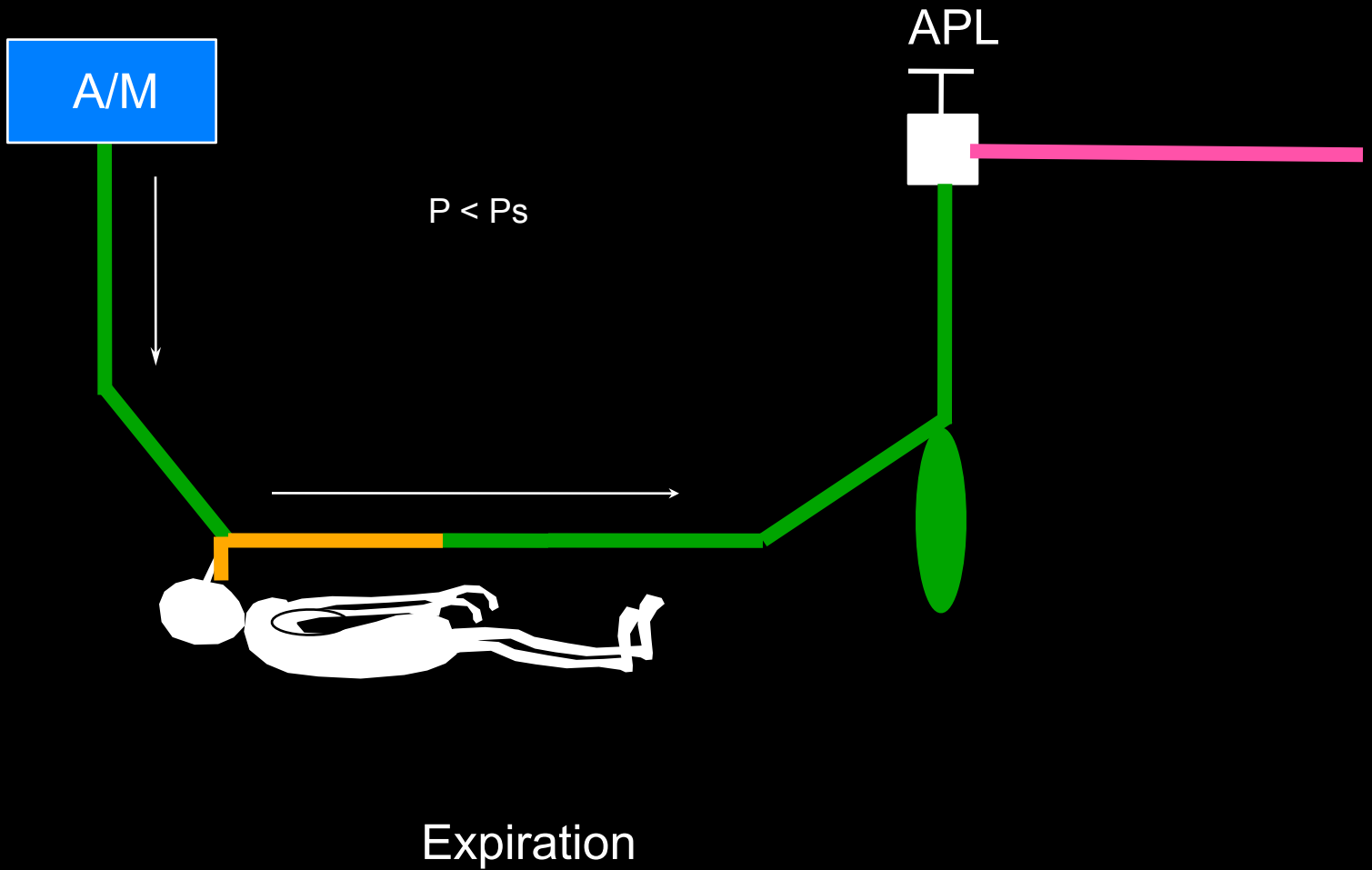
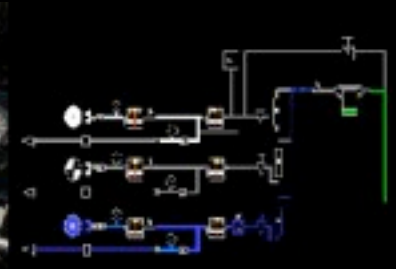
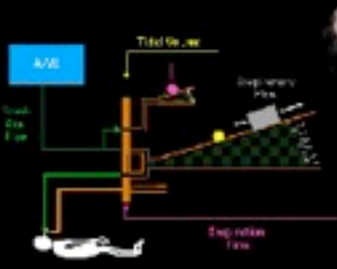


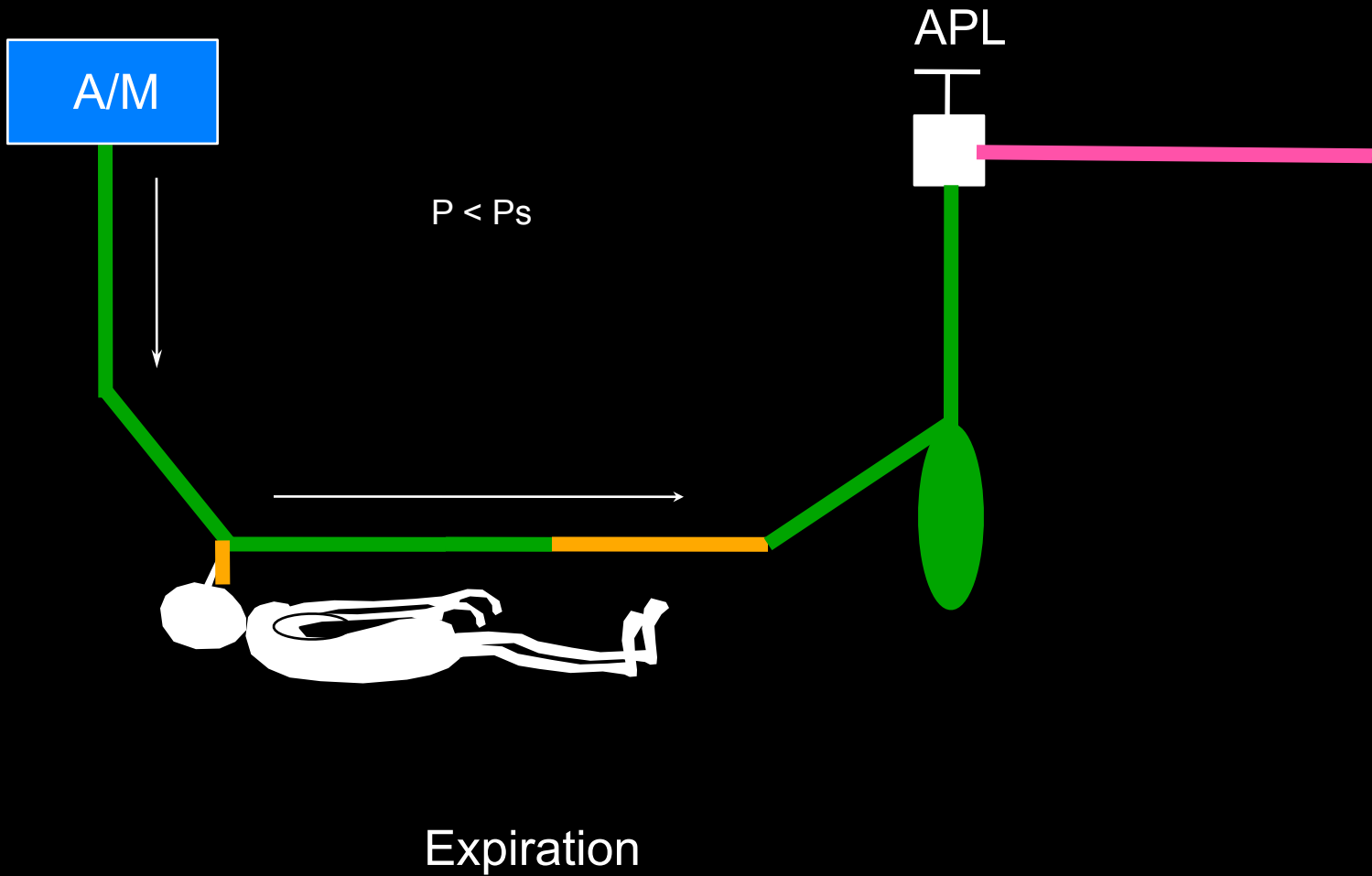
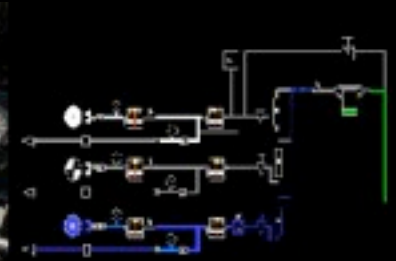
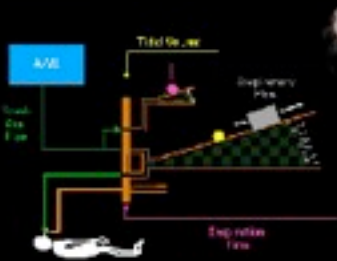
Mapleson D

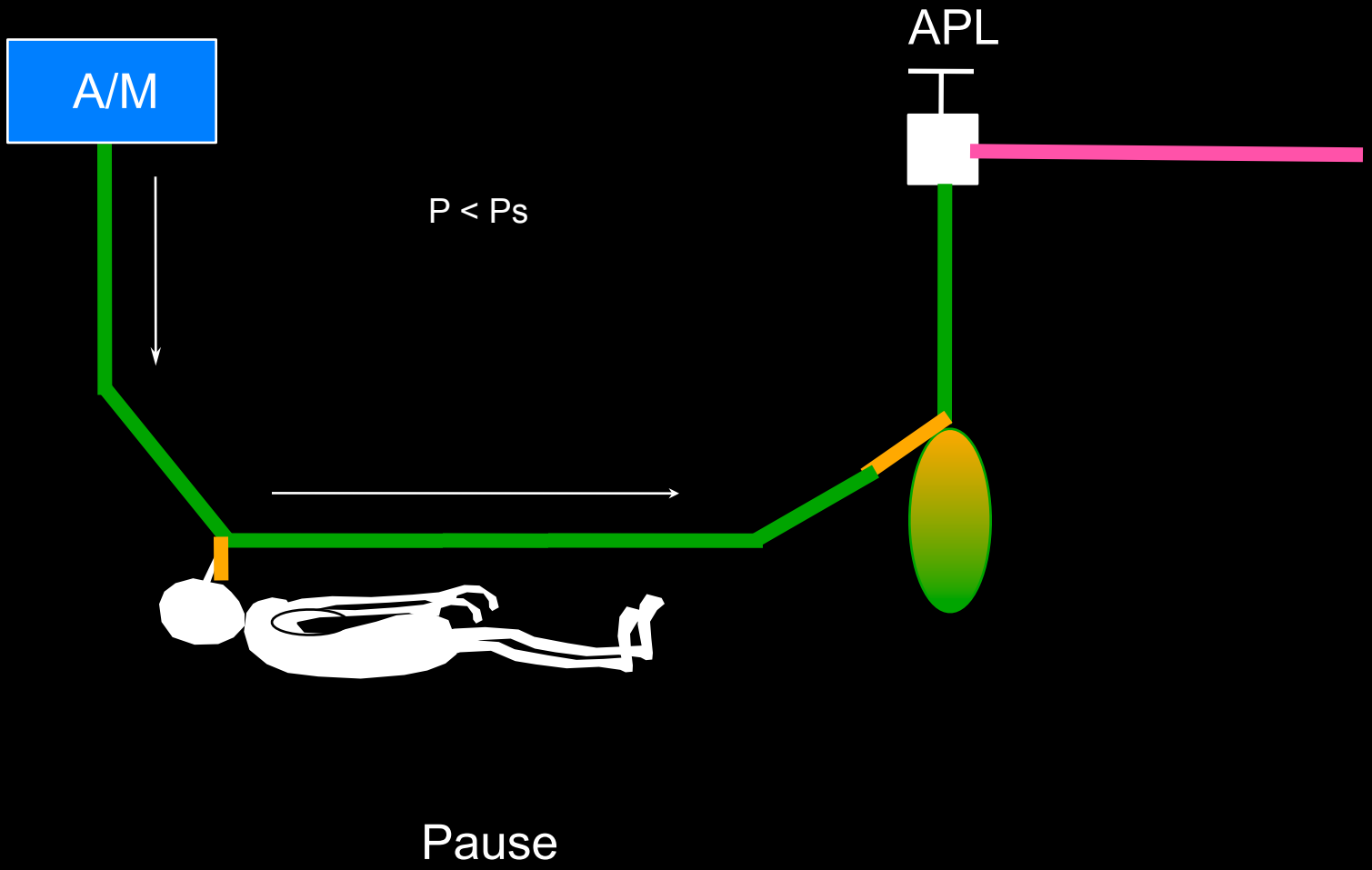
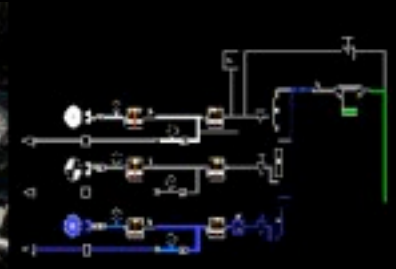
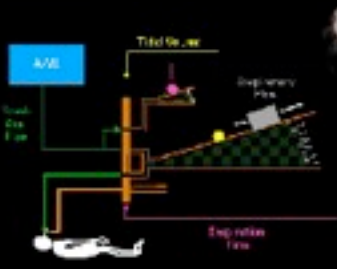
Controlled or Assisted Ventilation.

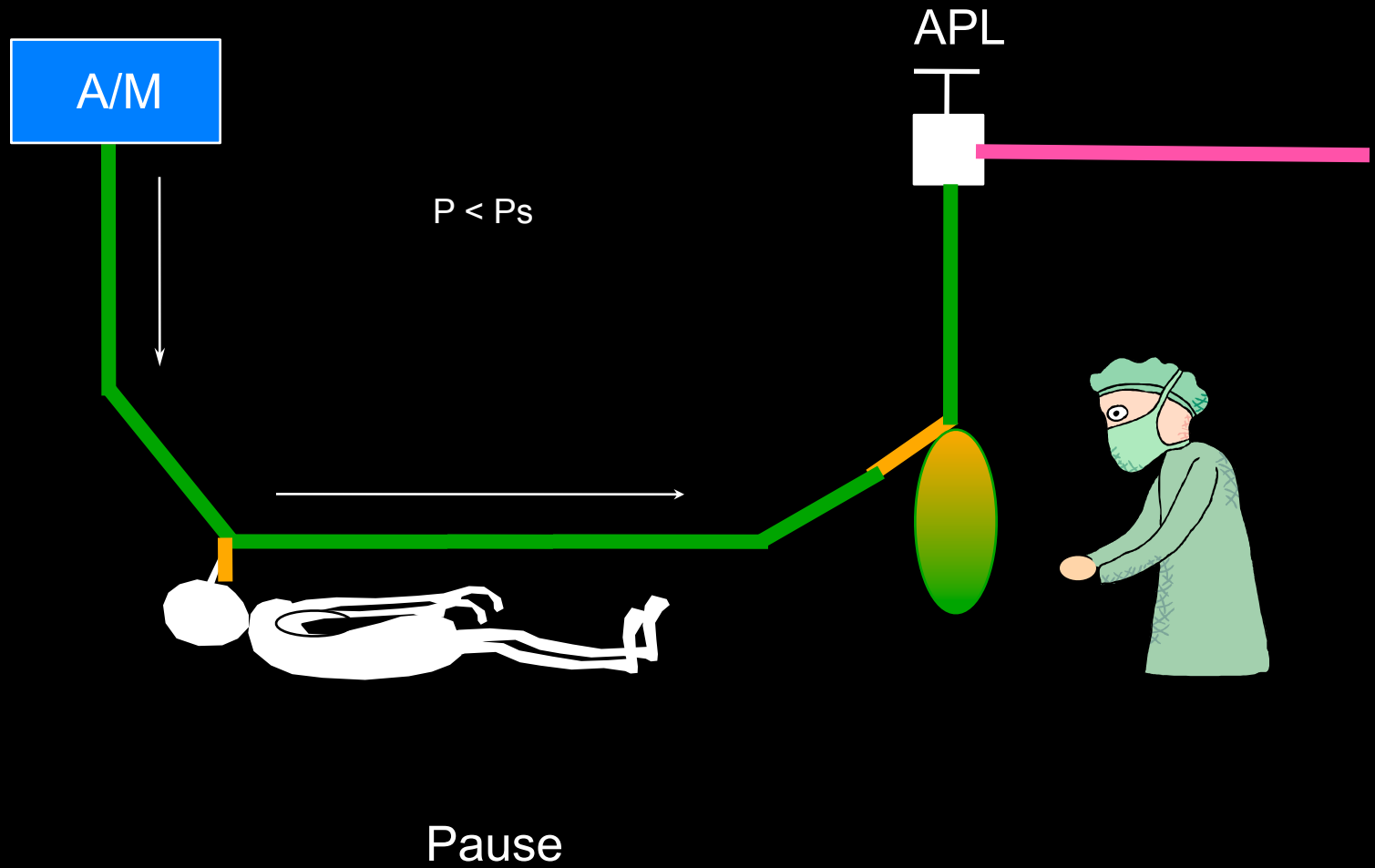
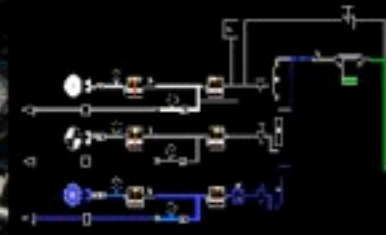
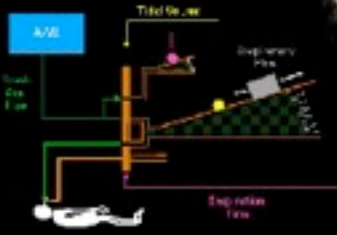


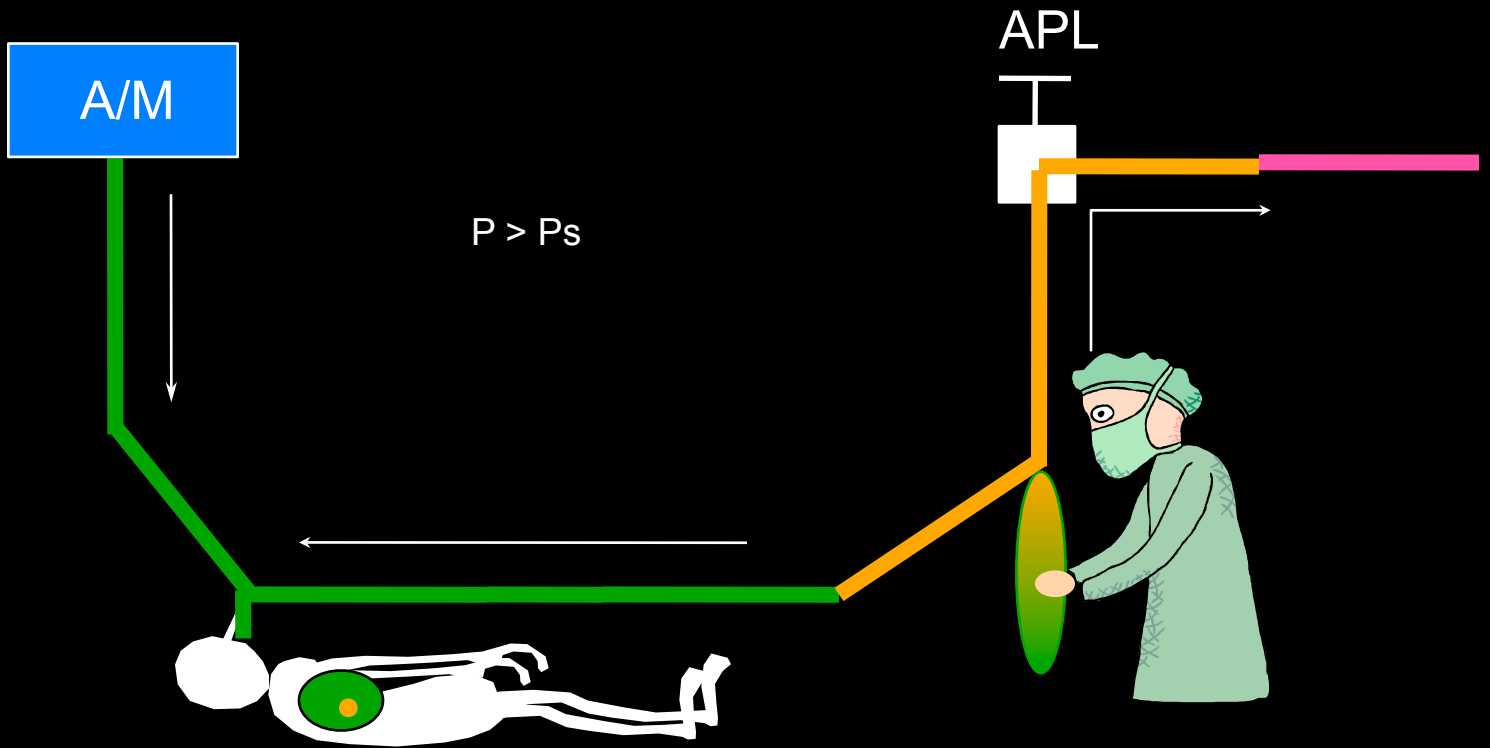
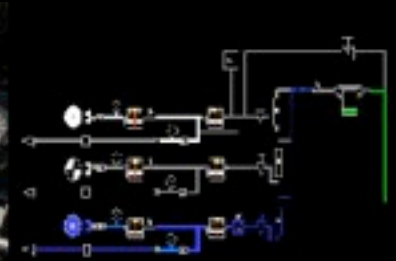
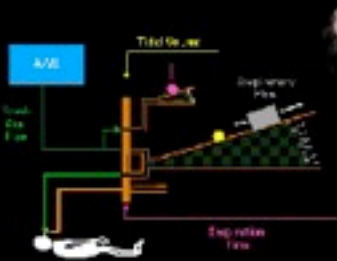


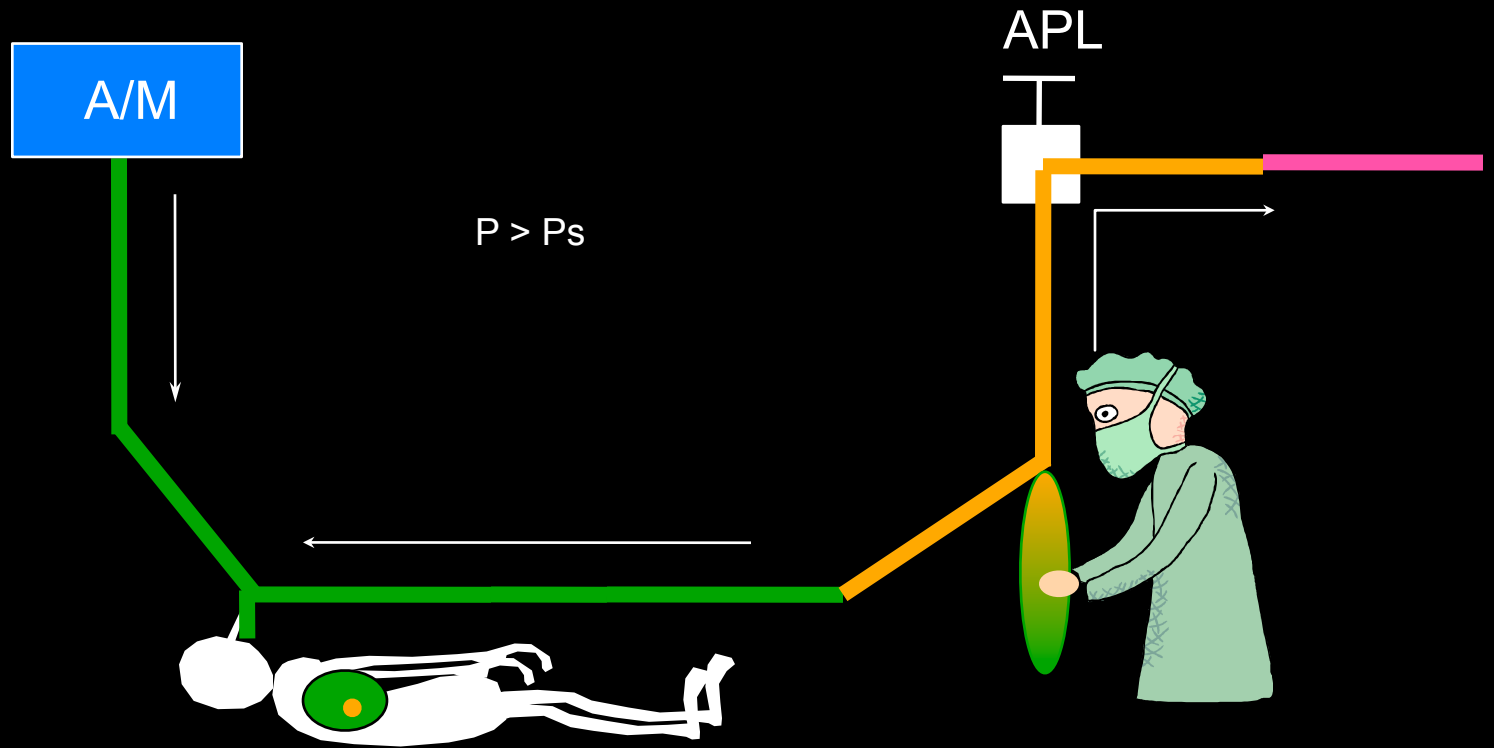












If we can minimise the dead space then we can eliminate the rebreathing.

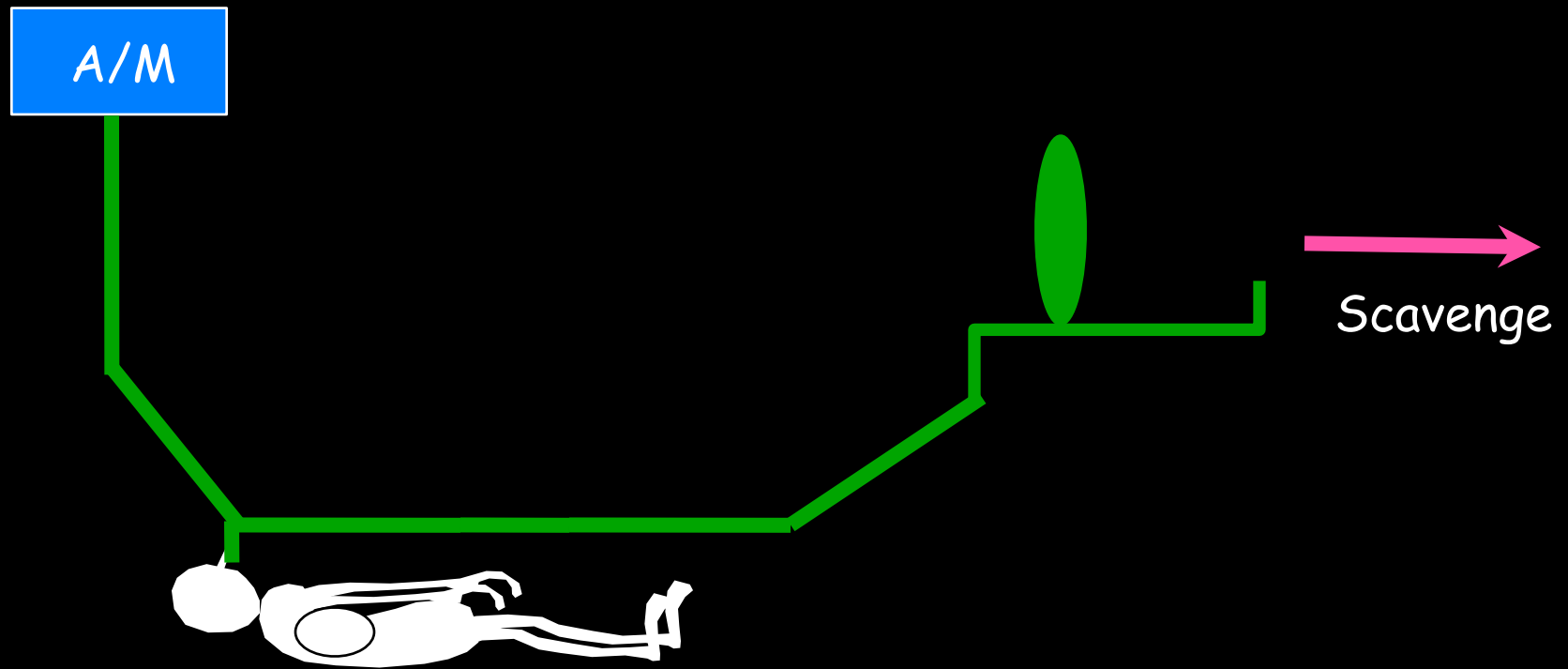
Mechanical Ventilation in Anaesthesia

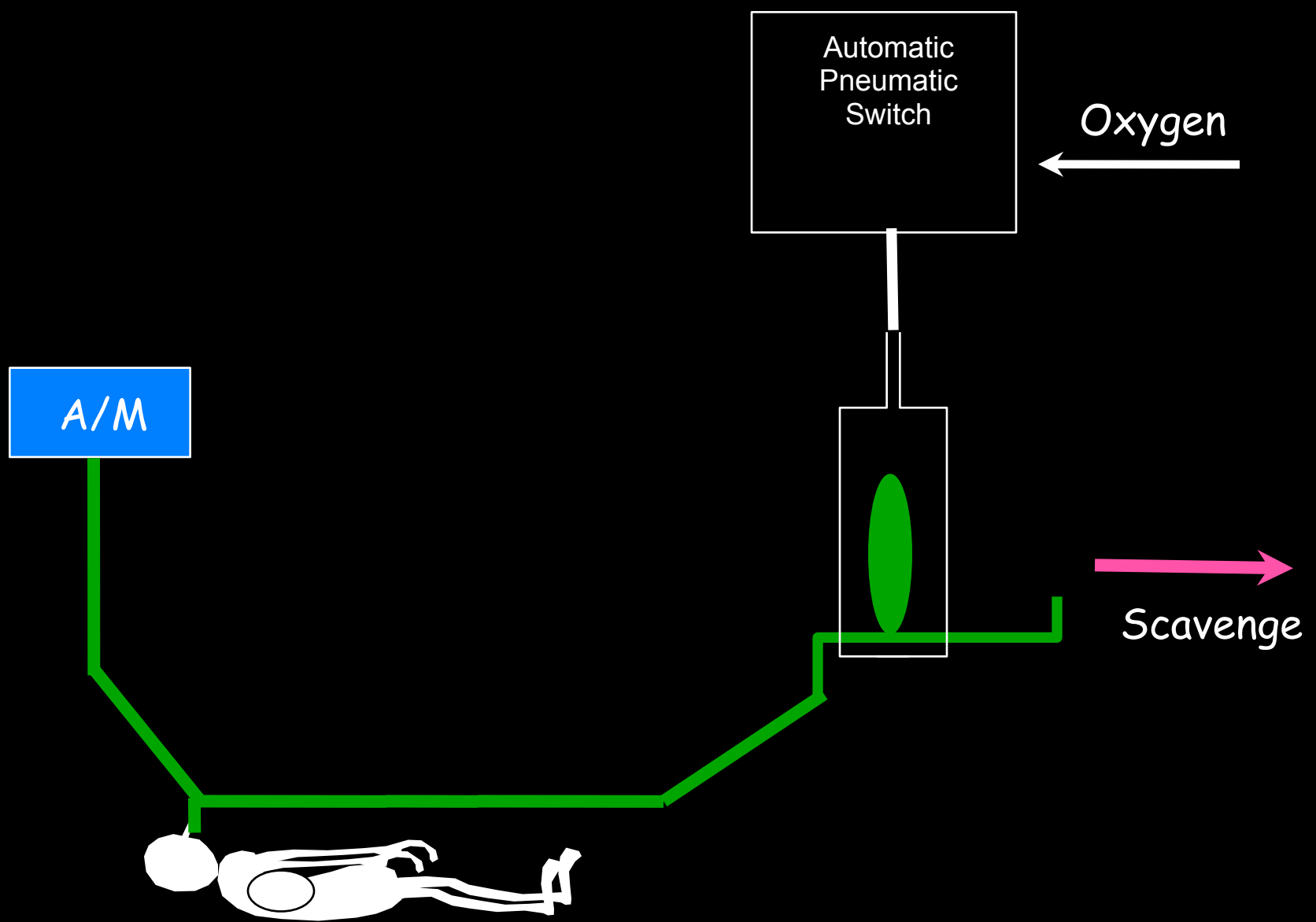
Bag in Bottle Type

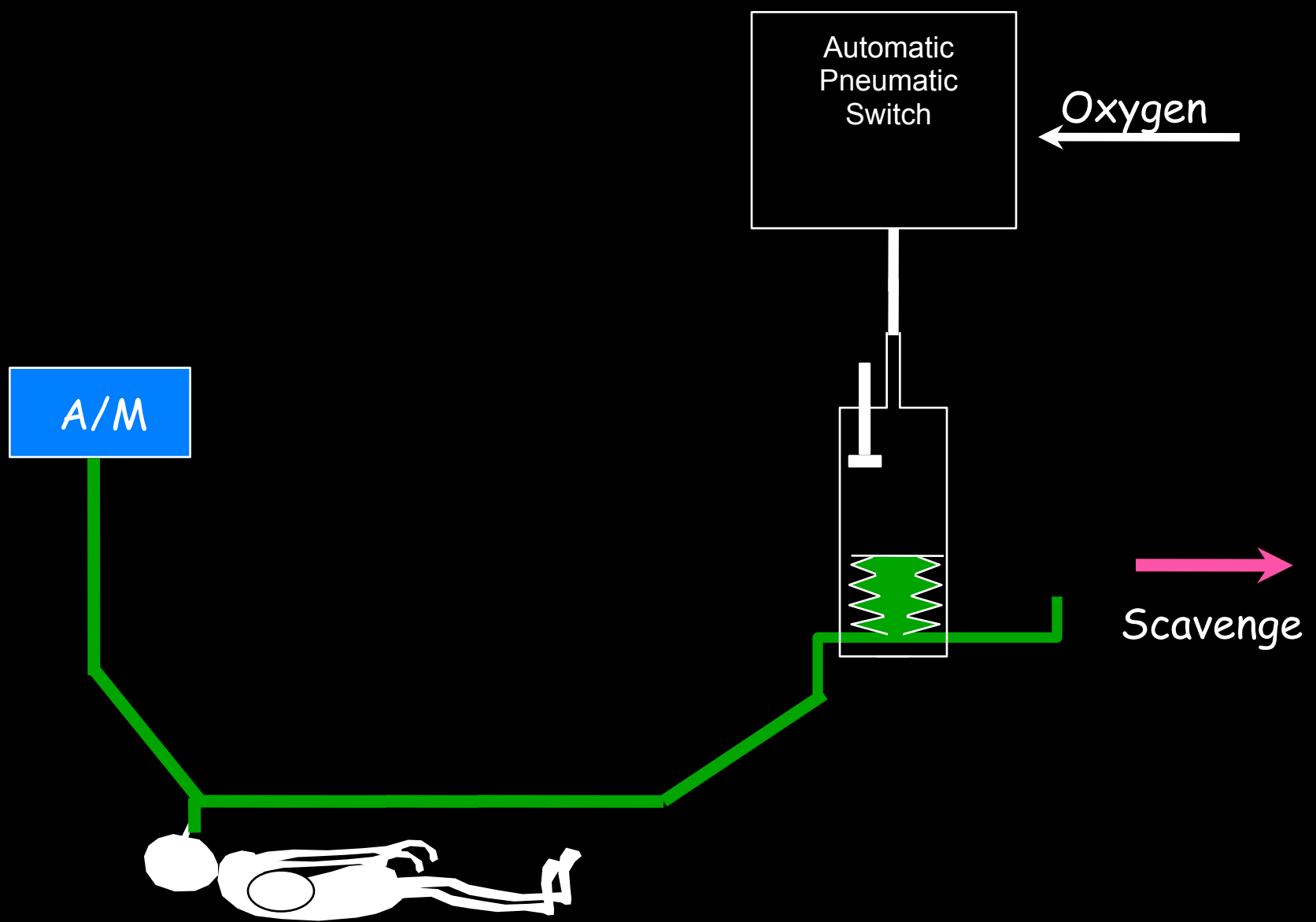
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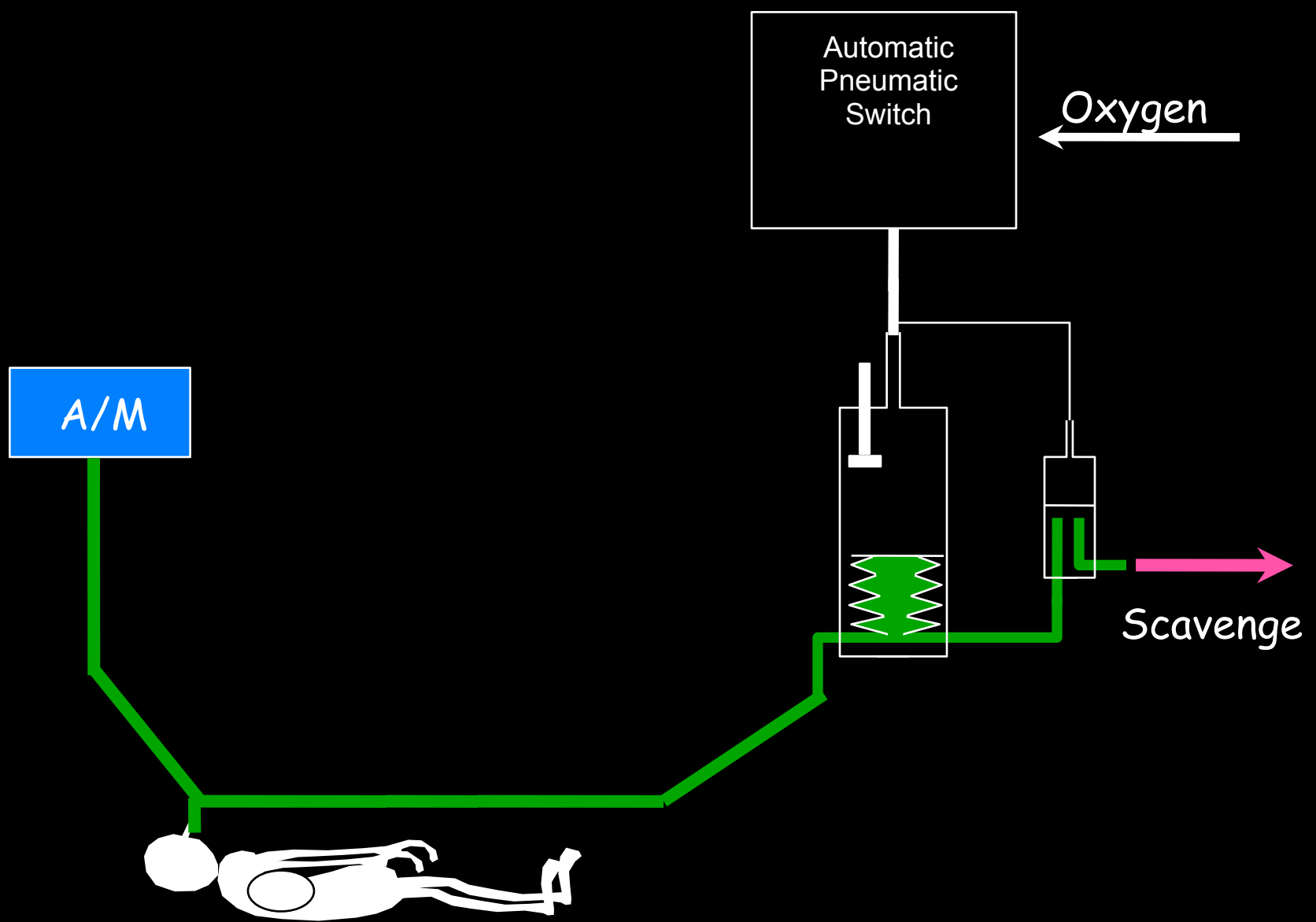
Bag Squeezer.

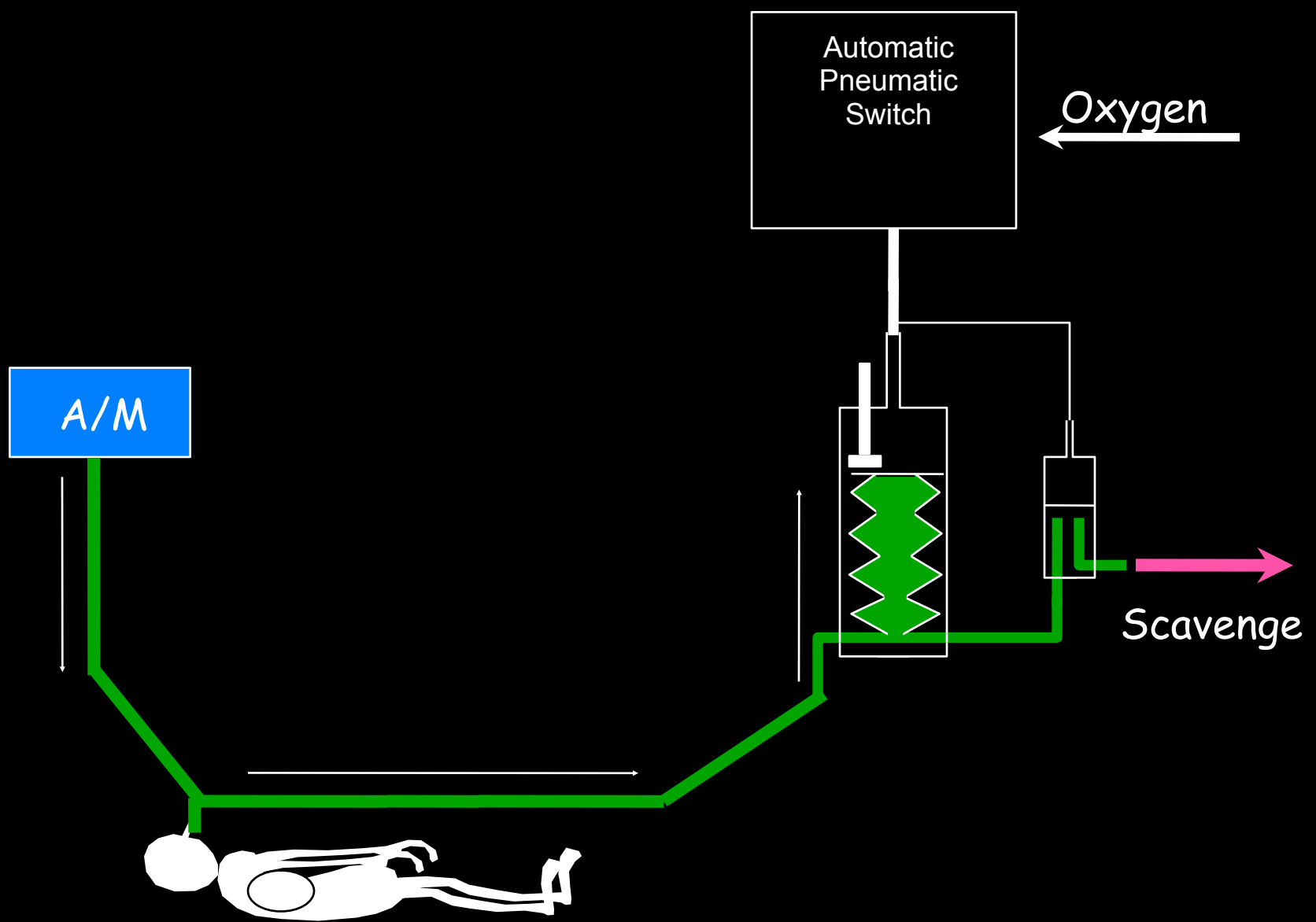


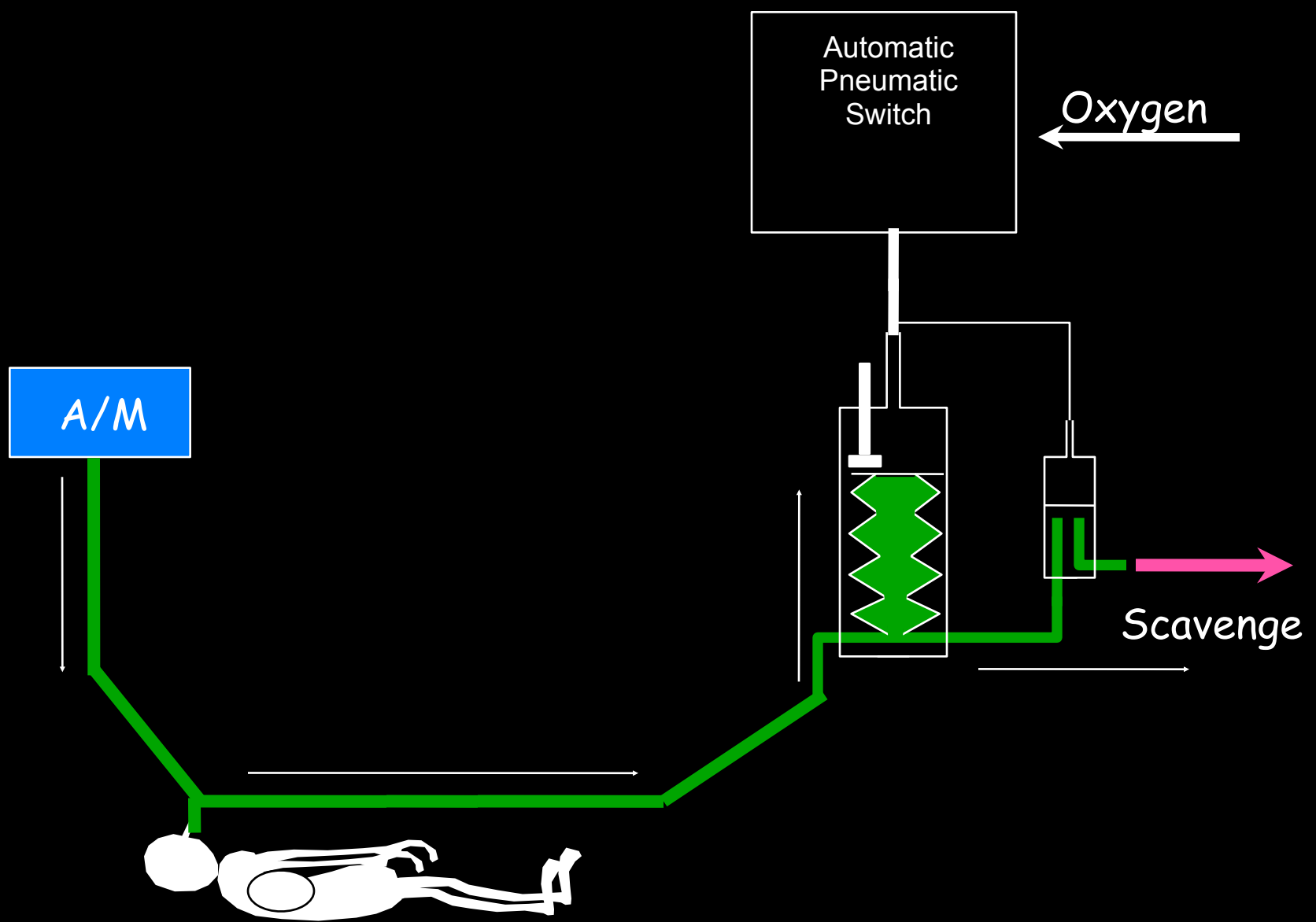




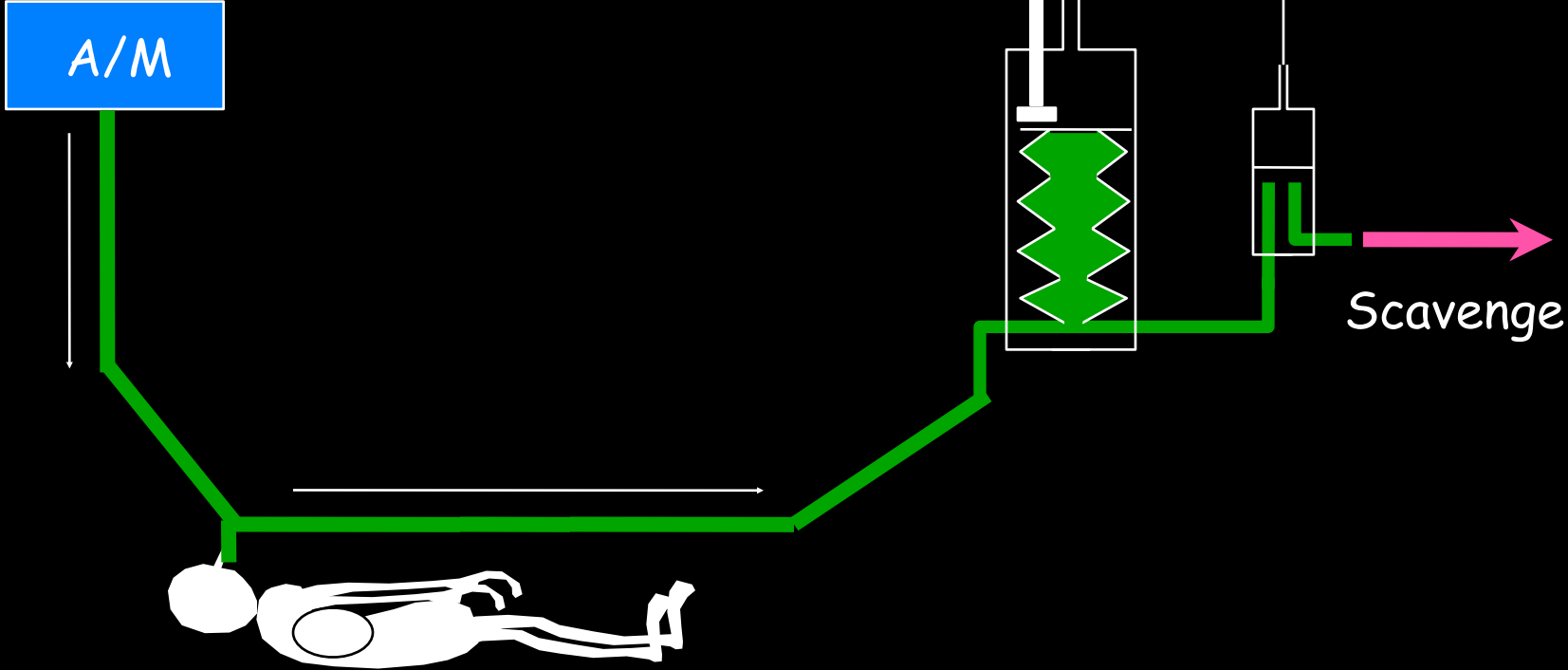




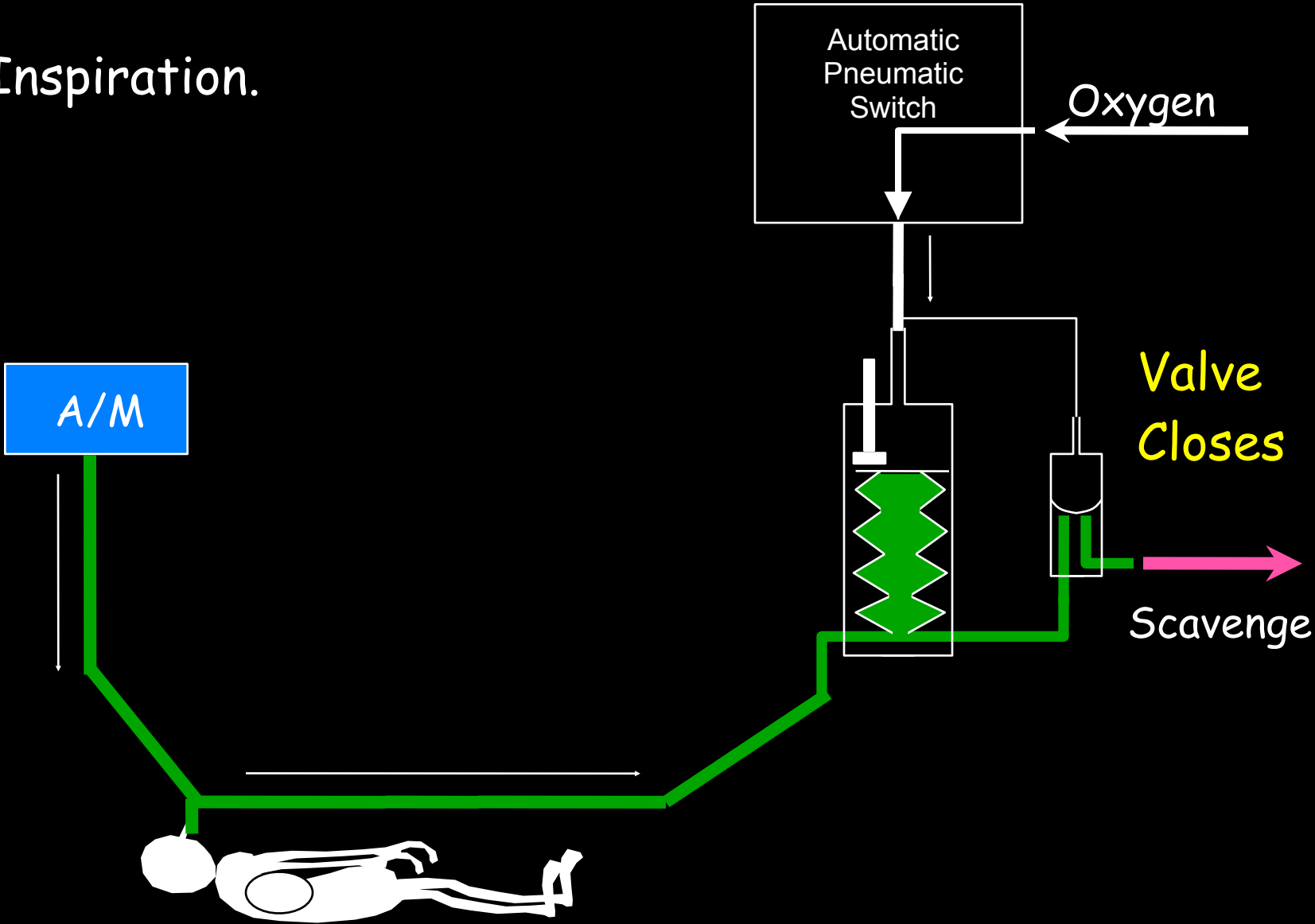




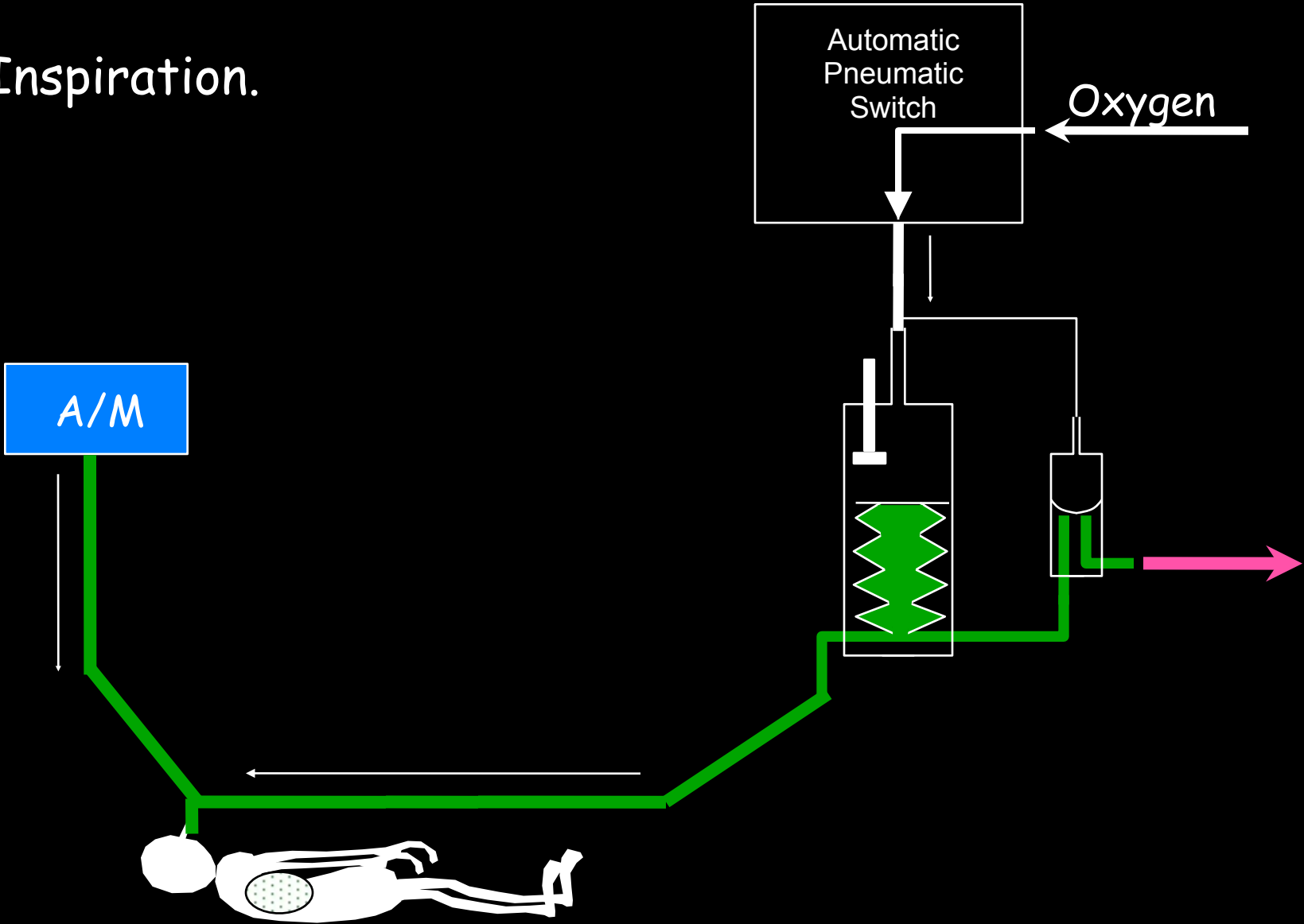
Inspiration.



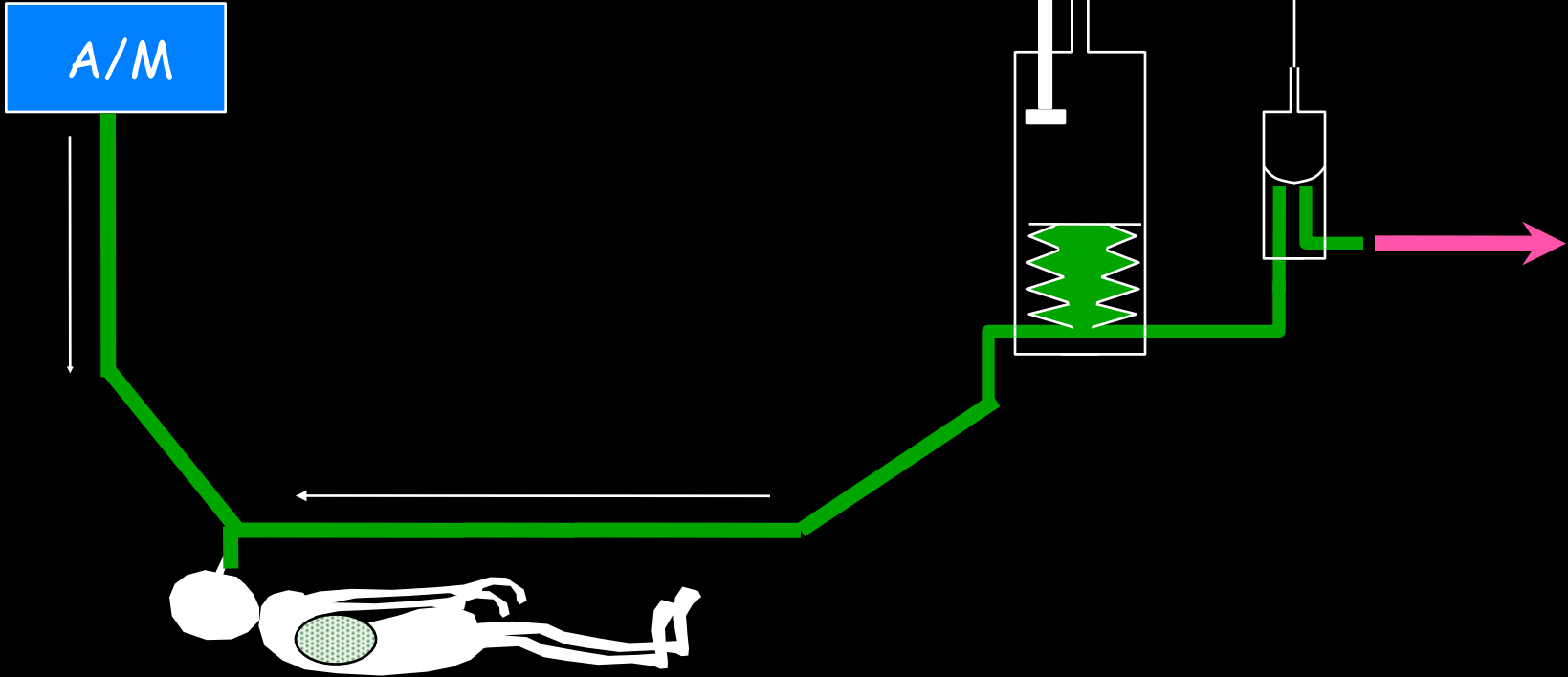
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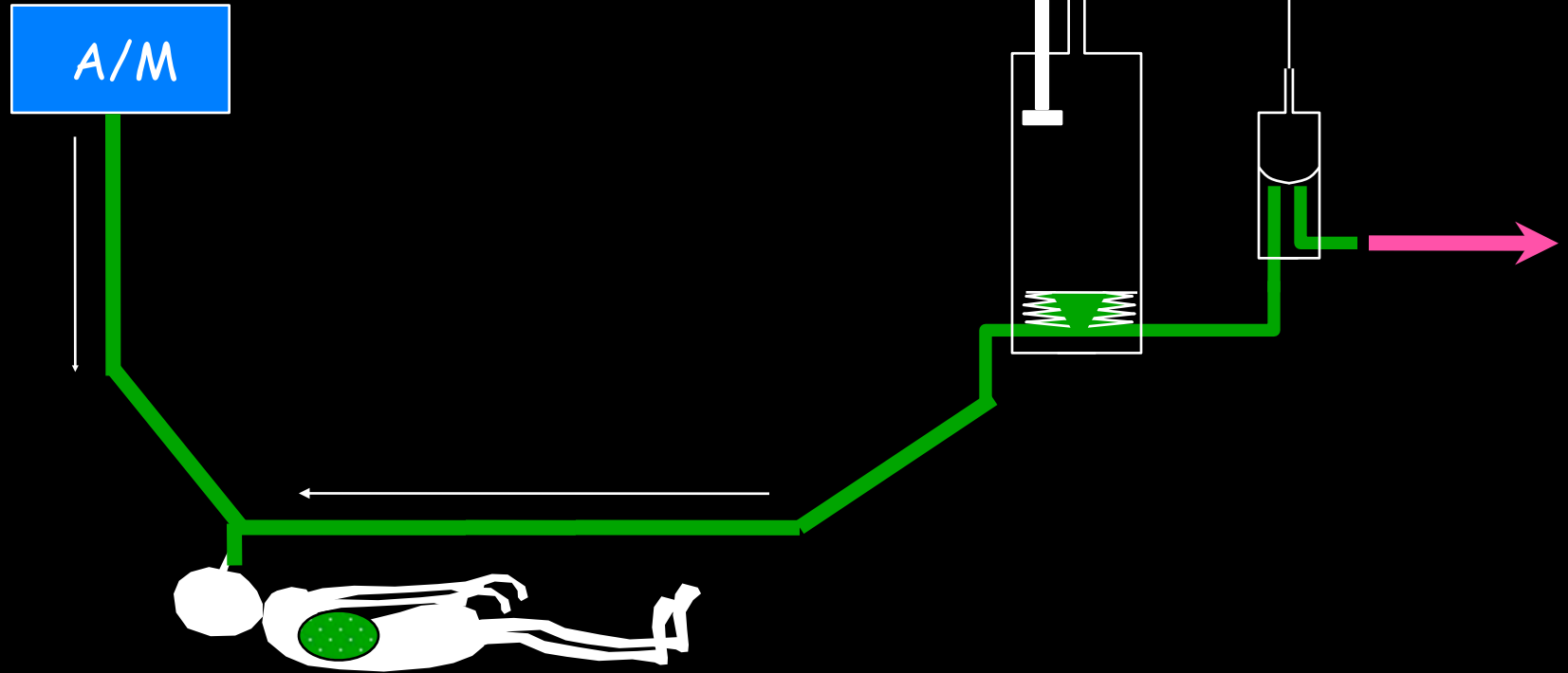
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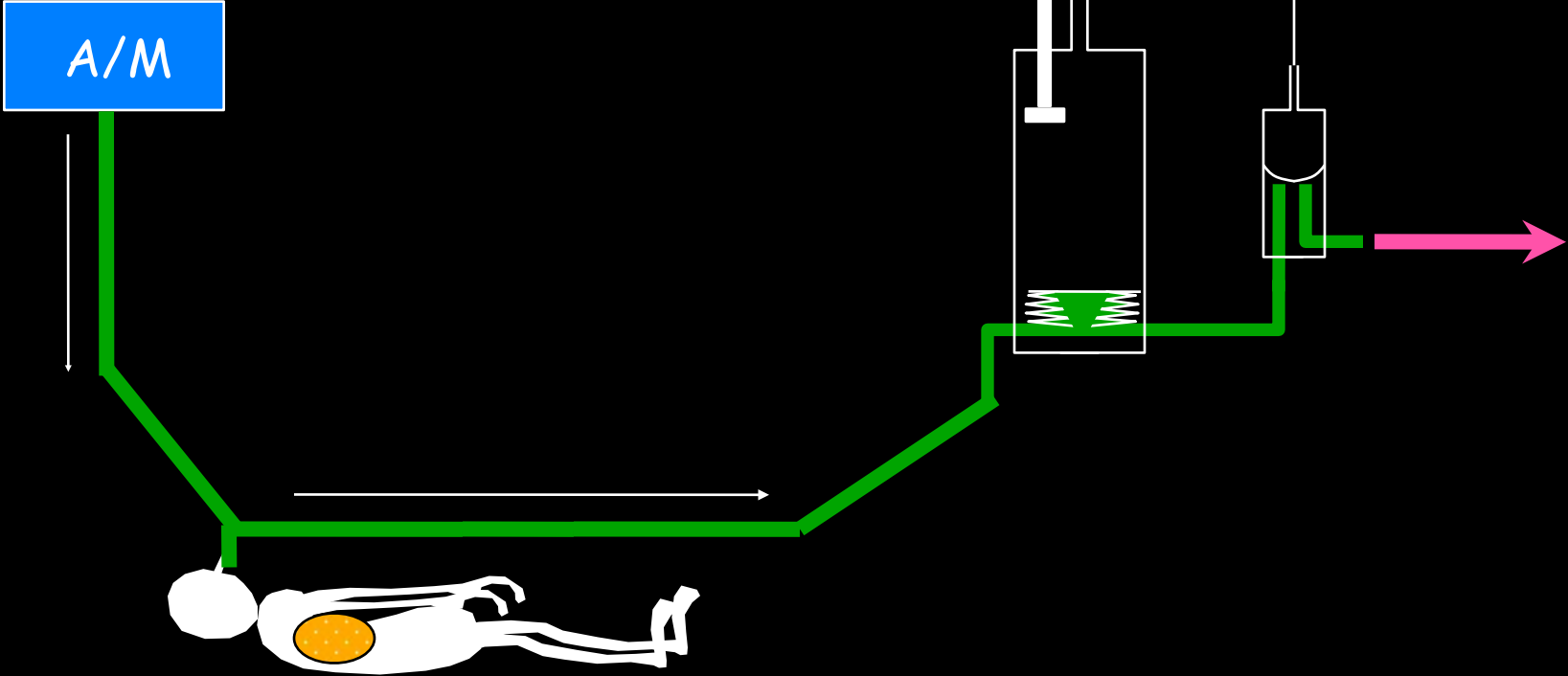
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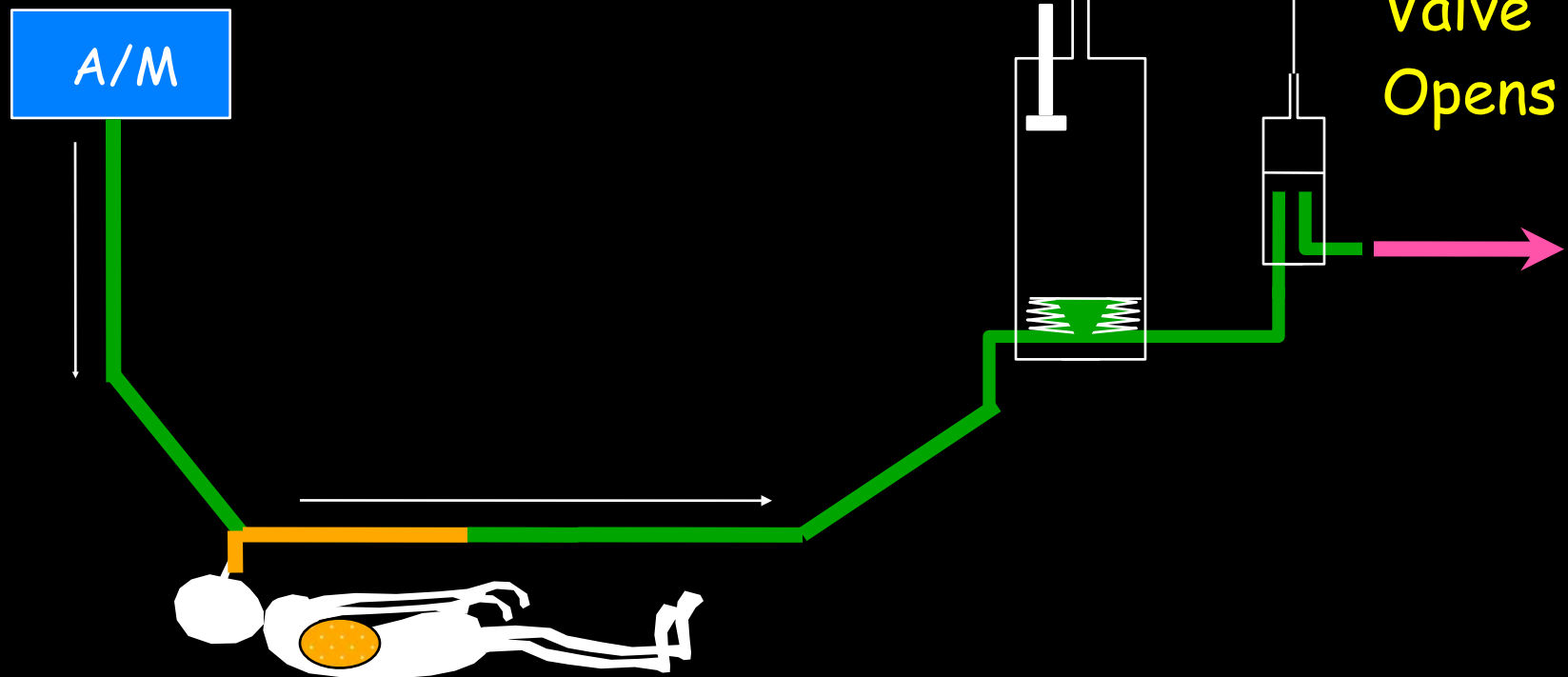
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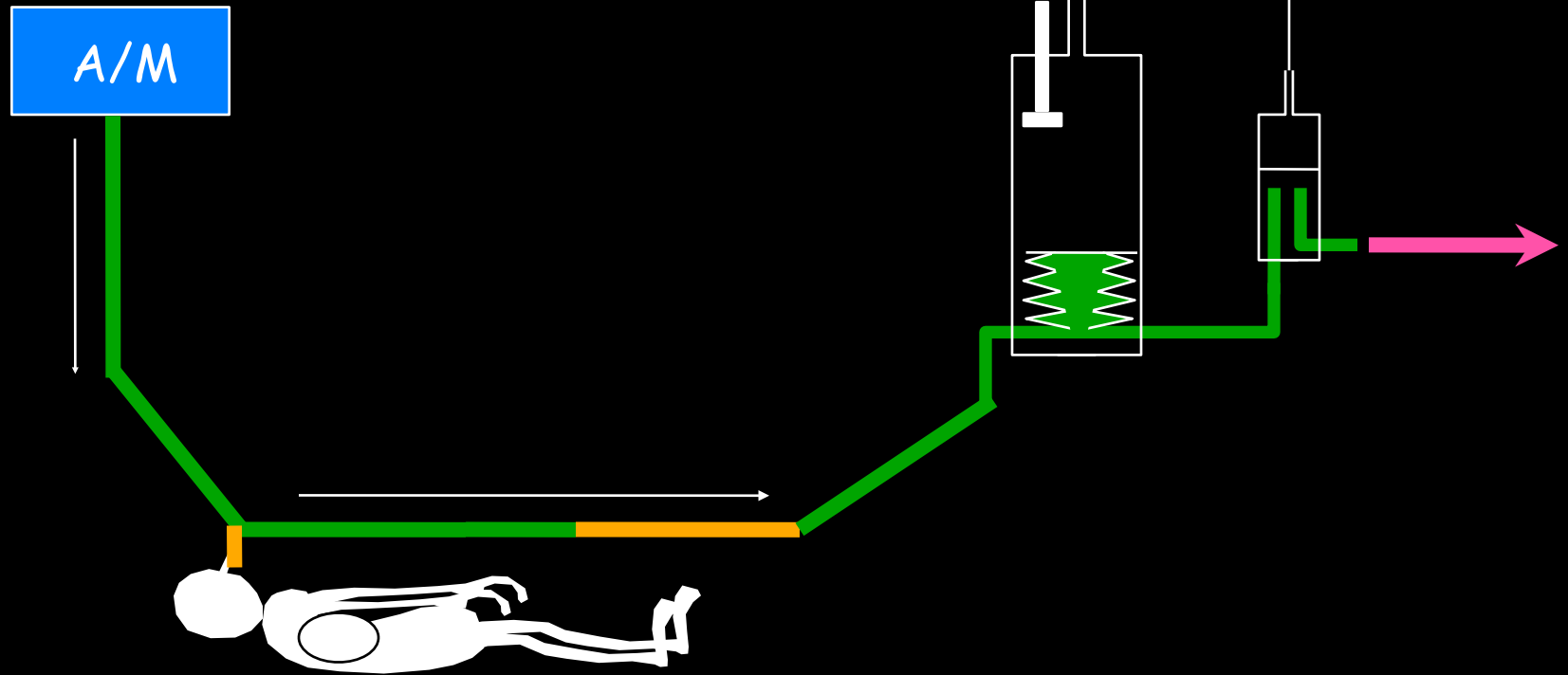
Pause.



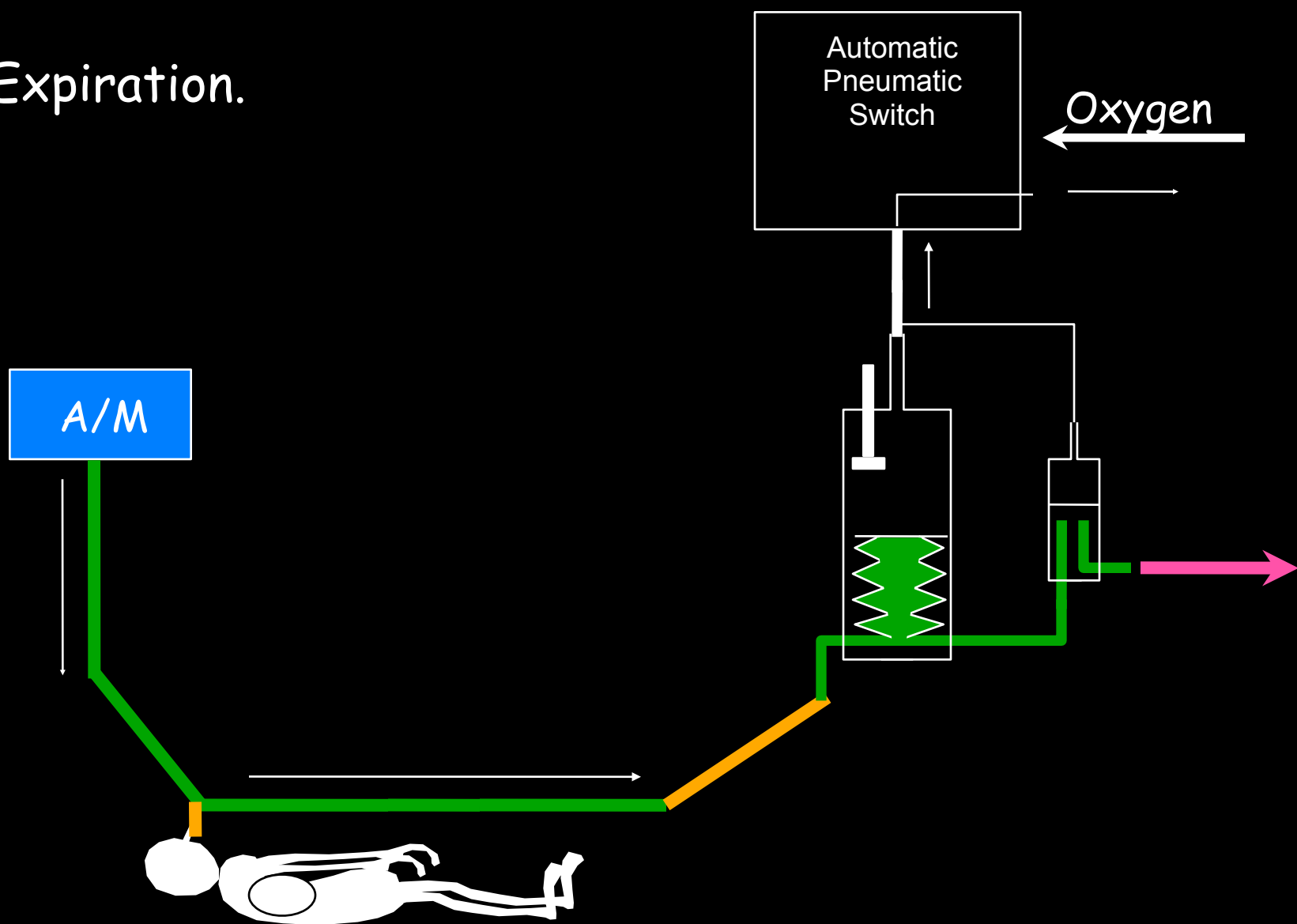
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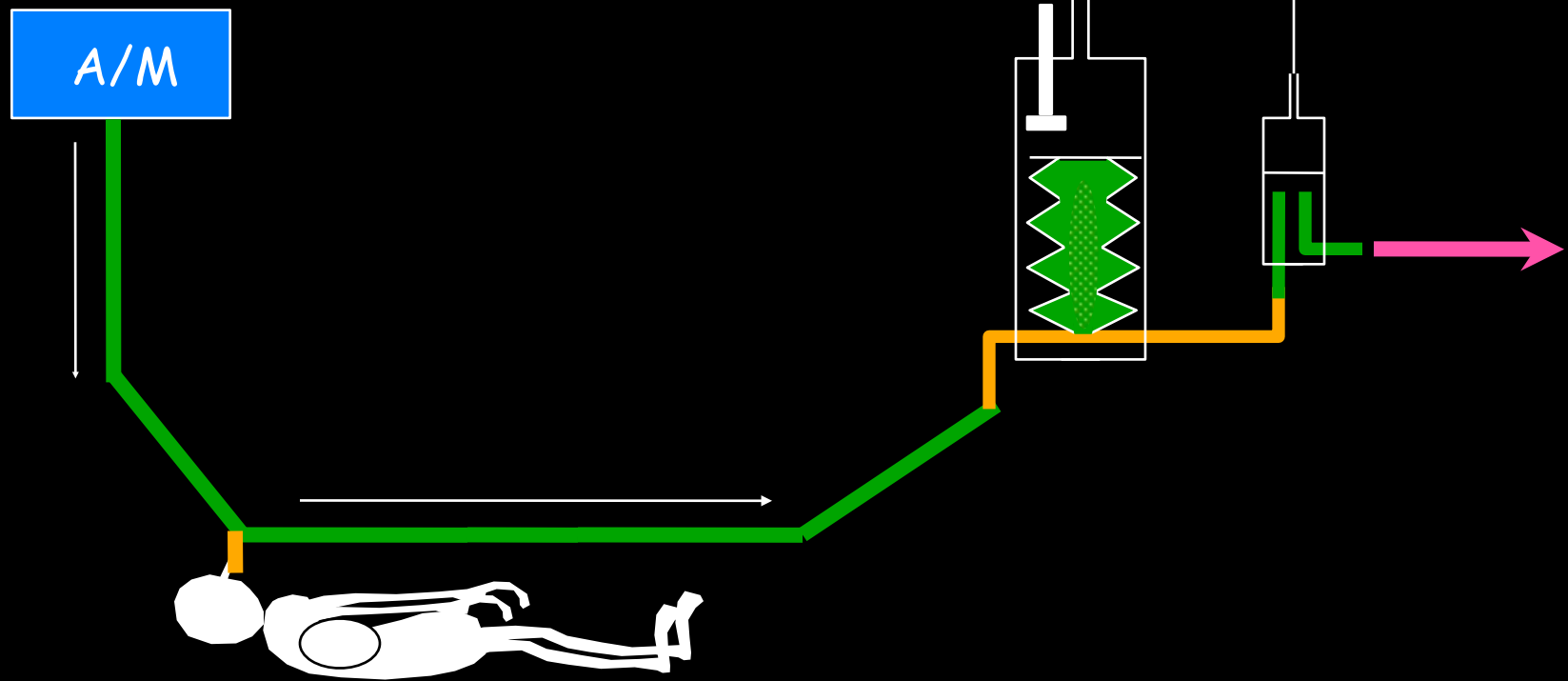
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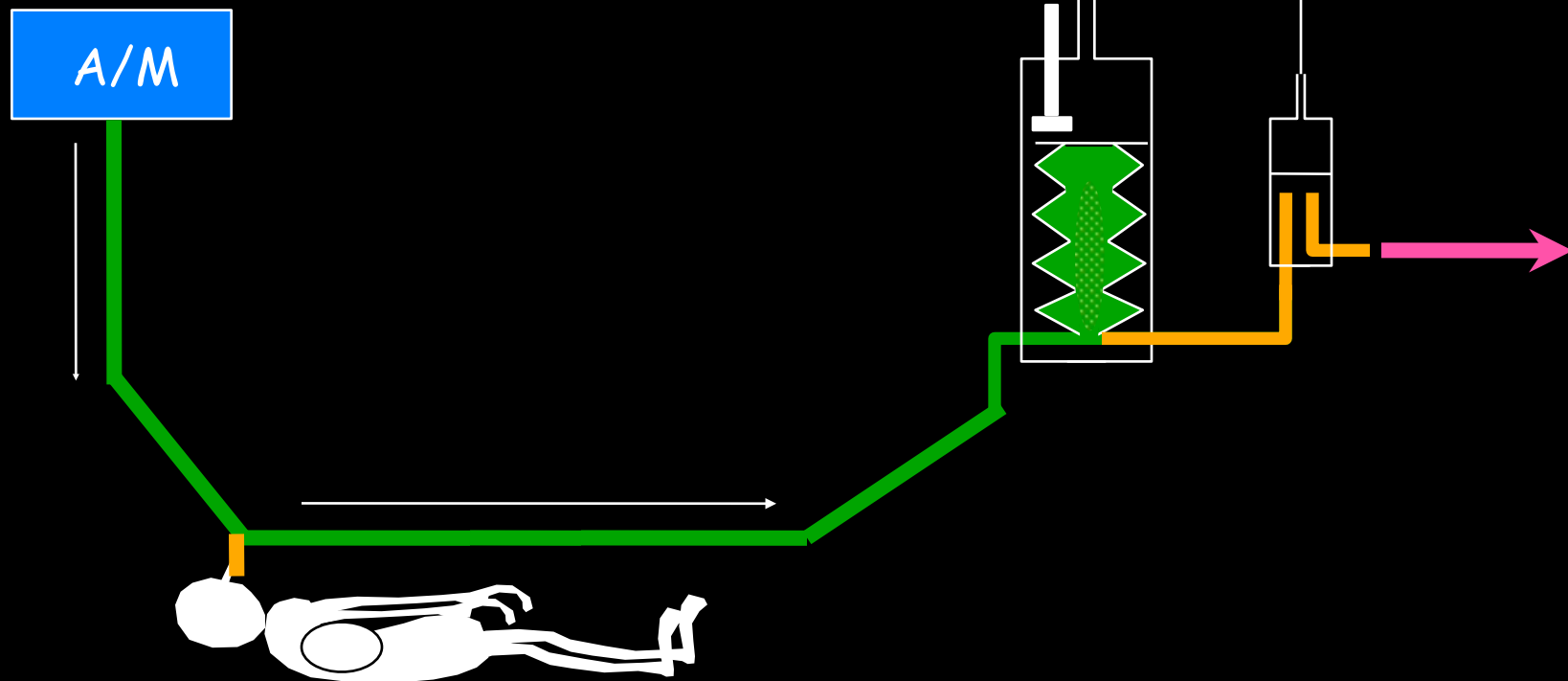
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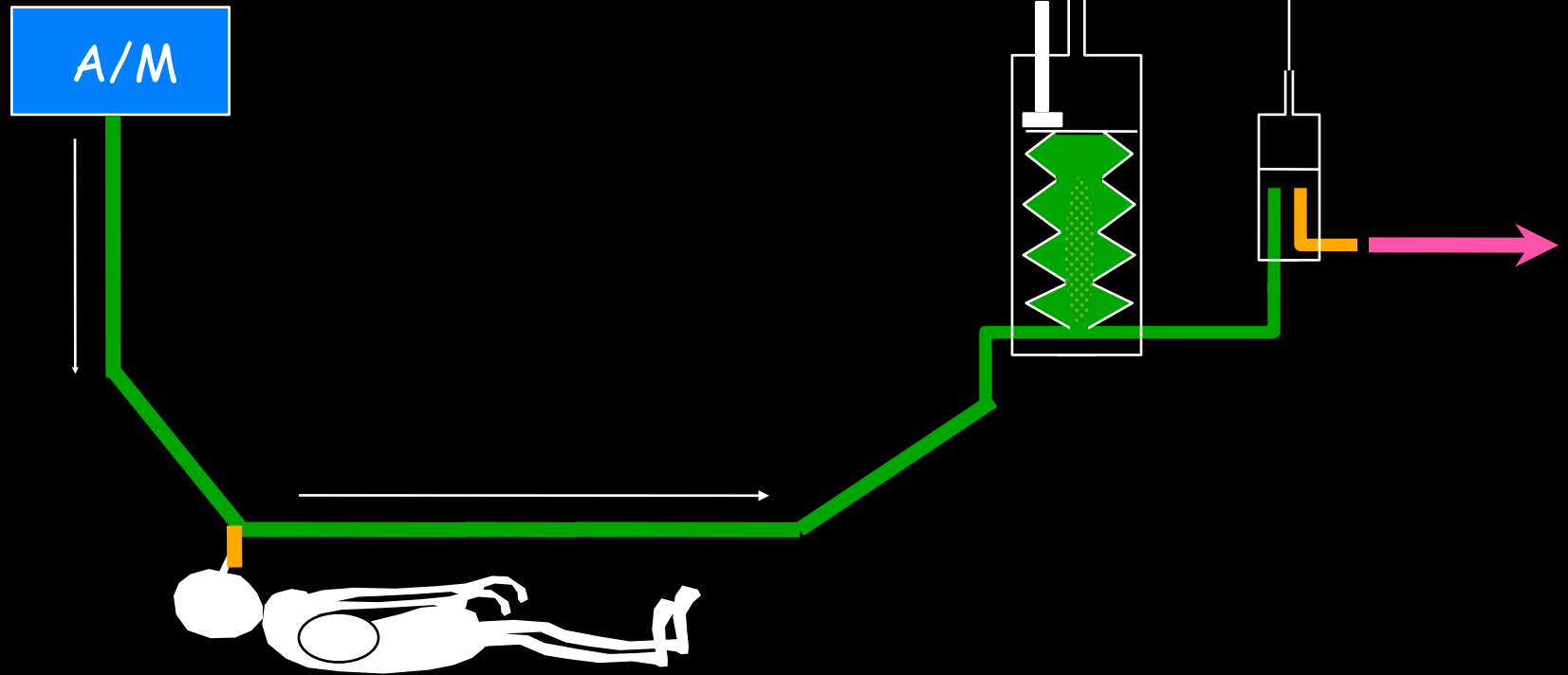
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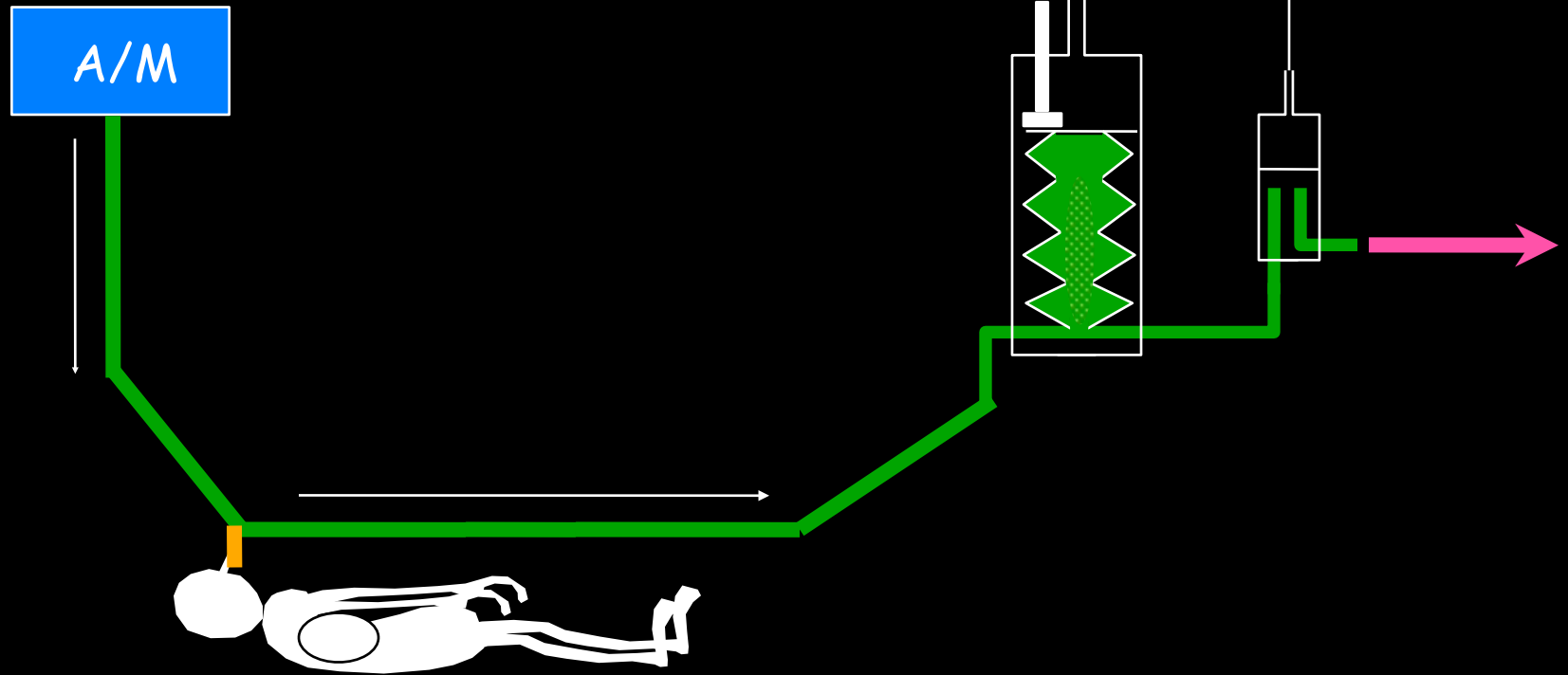
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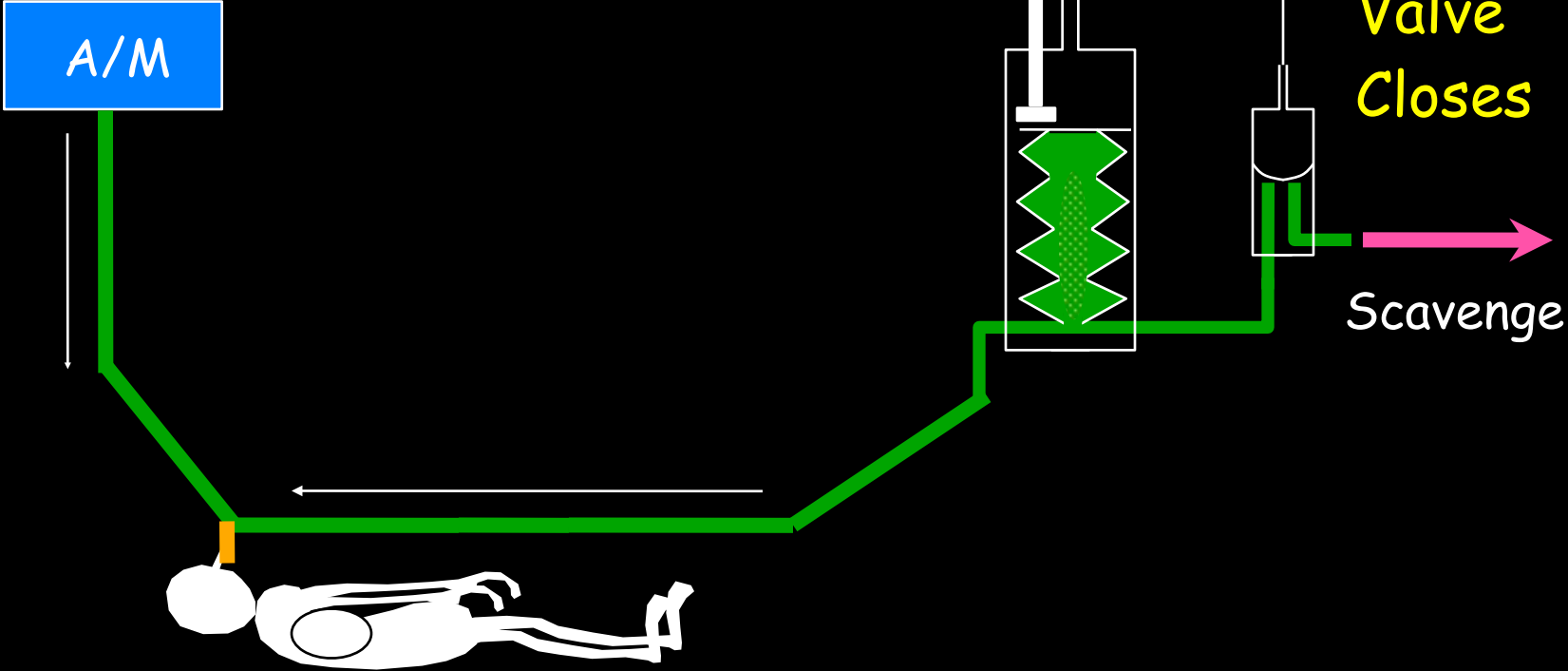
Gap.



Gap.

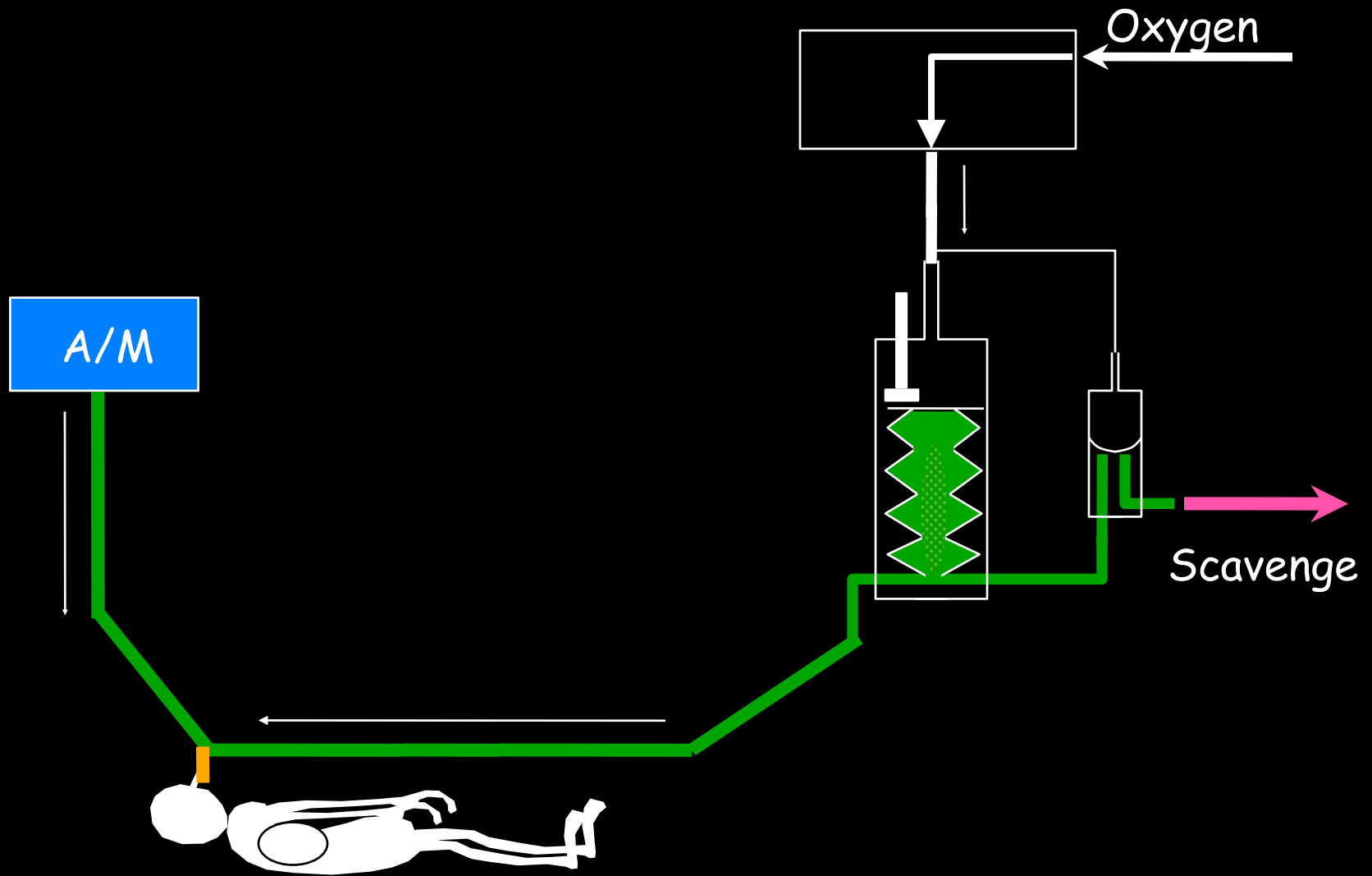


Inspiration.

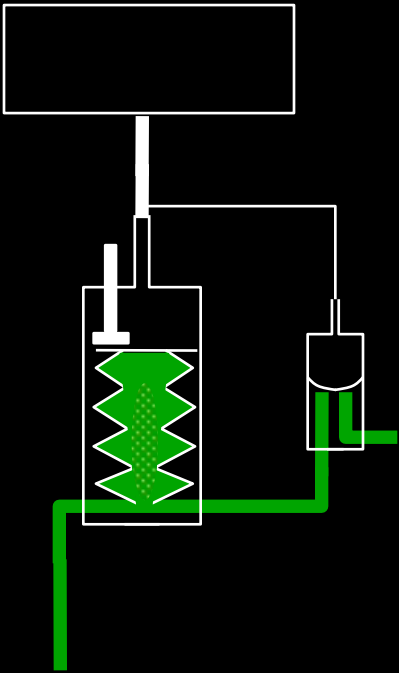


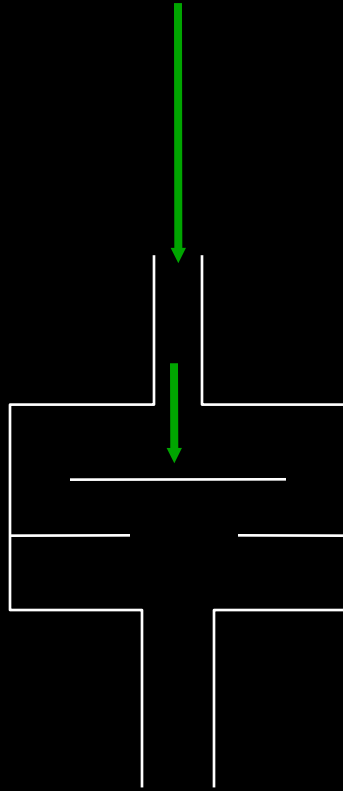
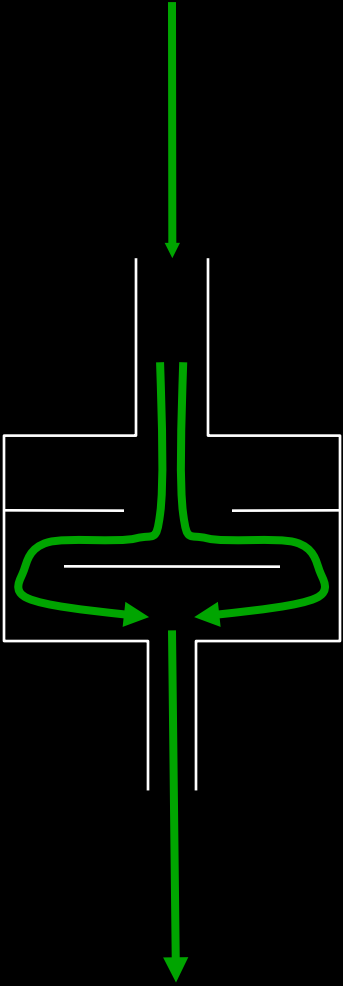
The Circle System

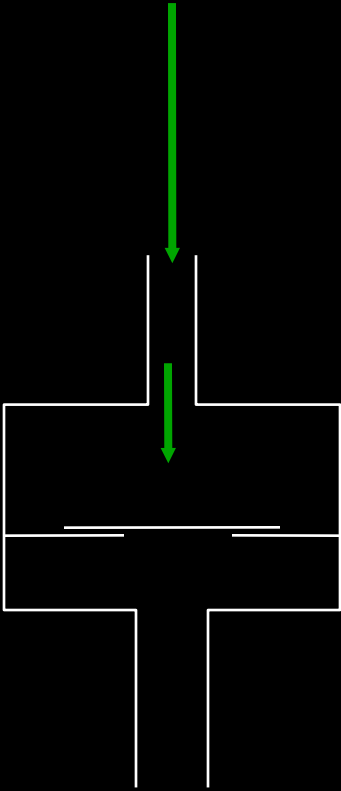
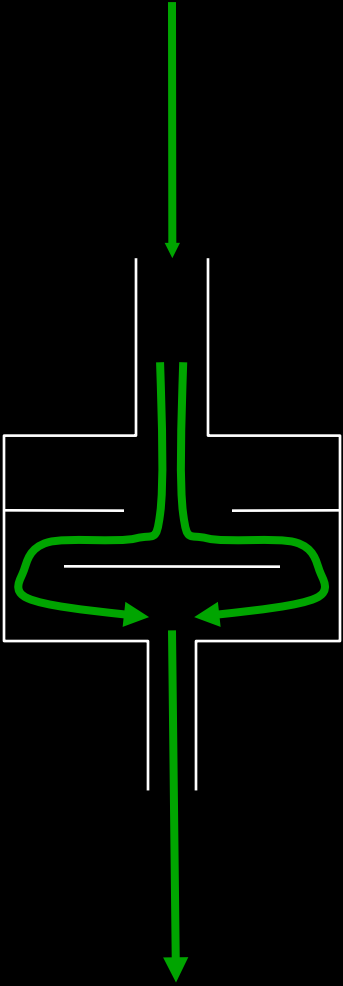
Low Flow Anaesthesia

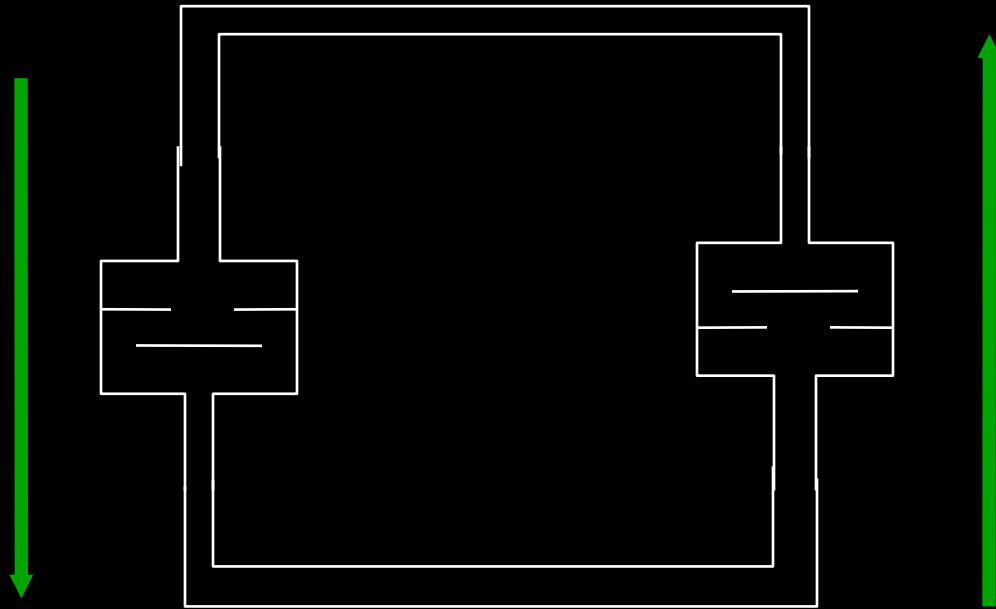


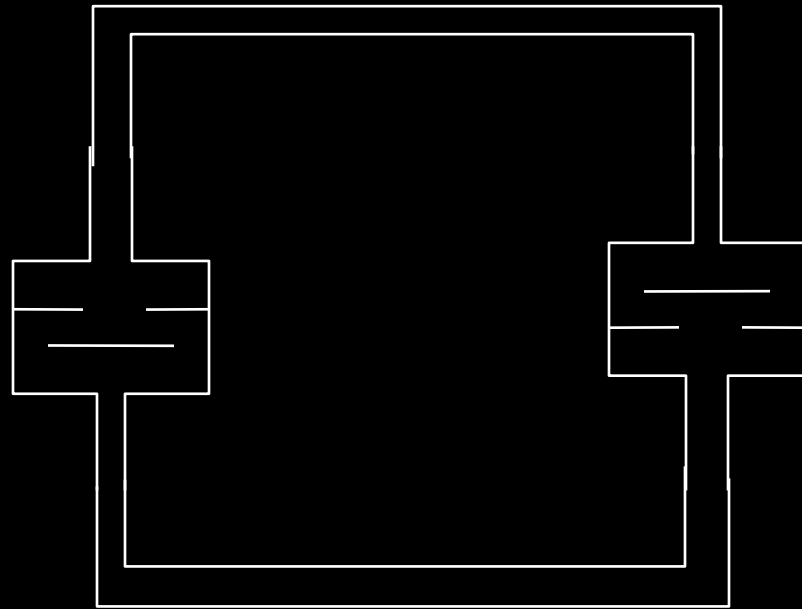
A/M

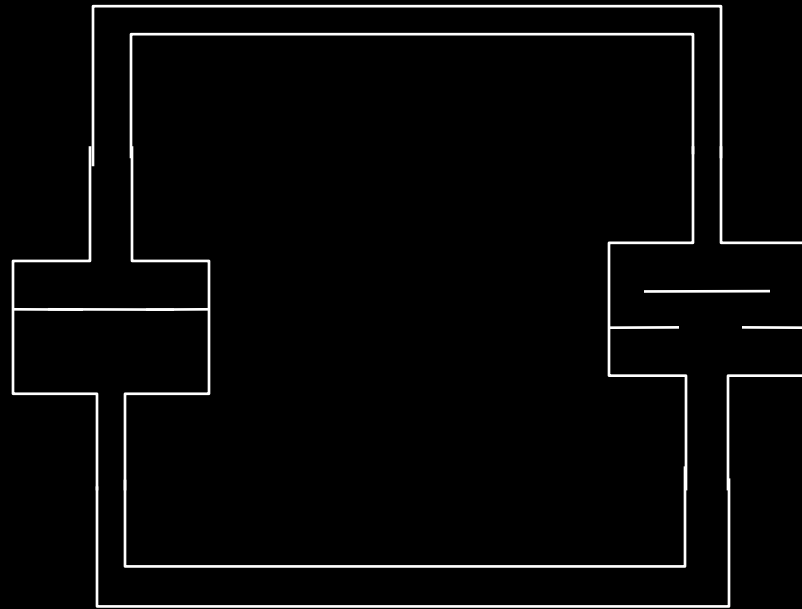


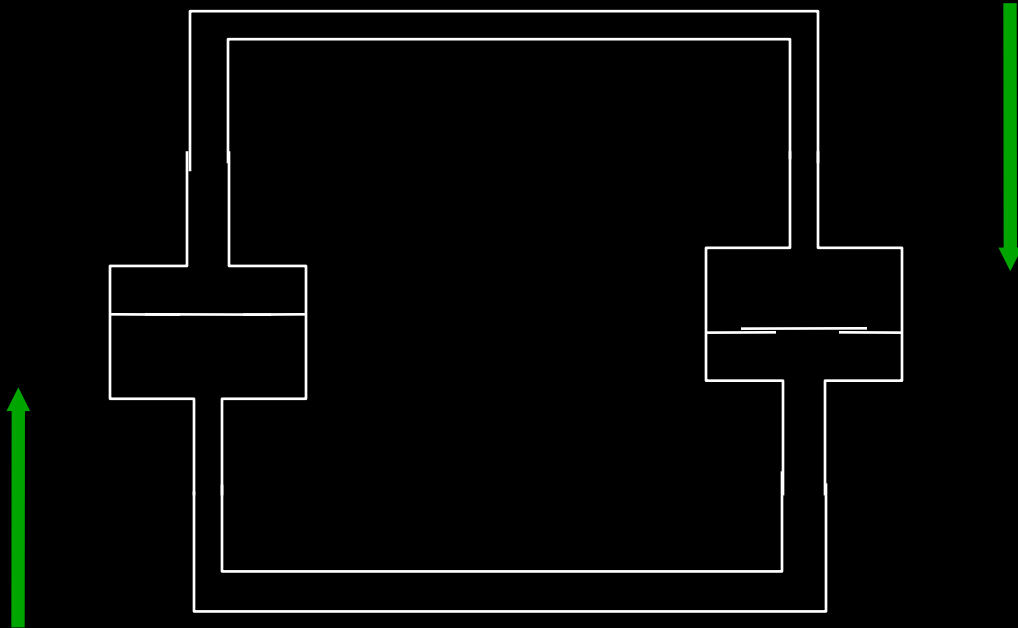




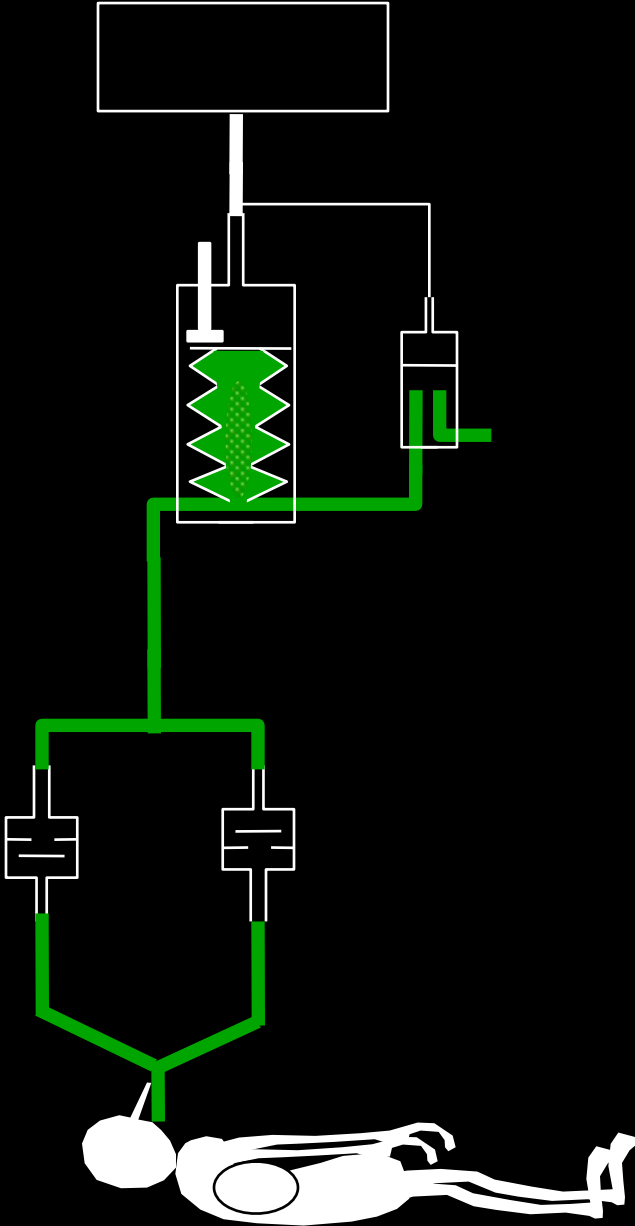




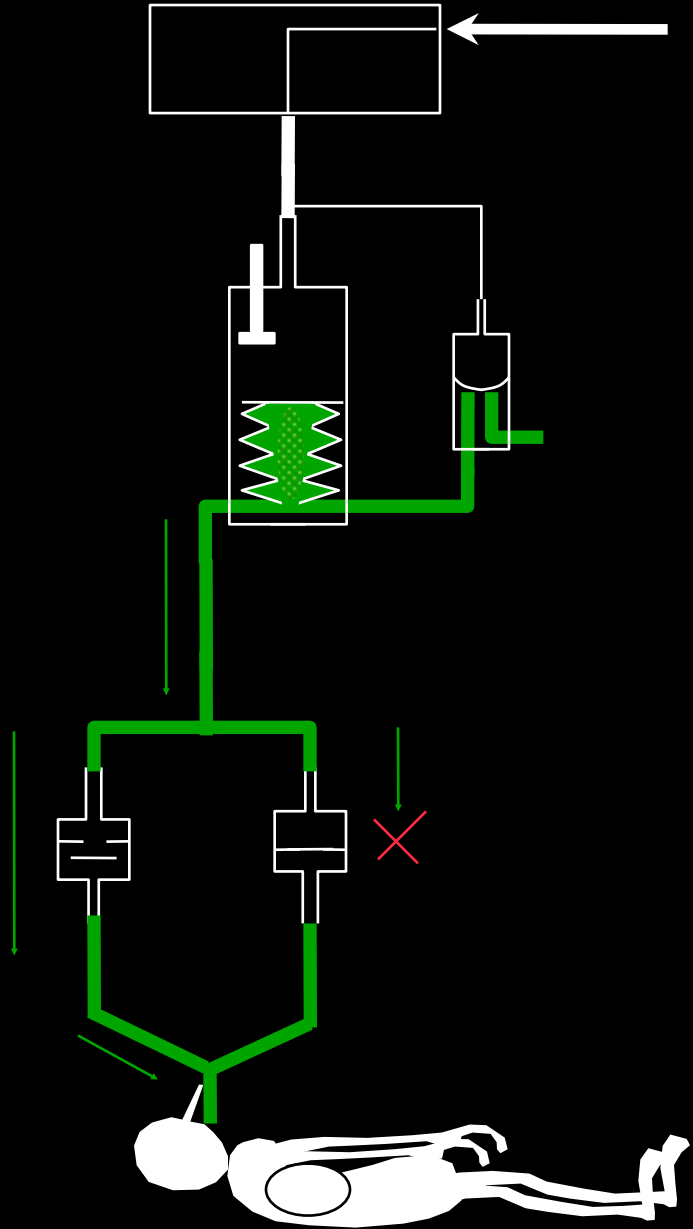




A/M

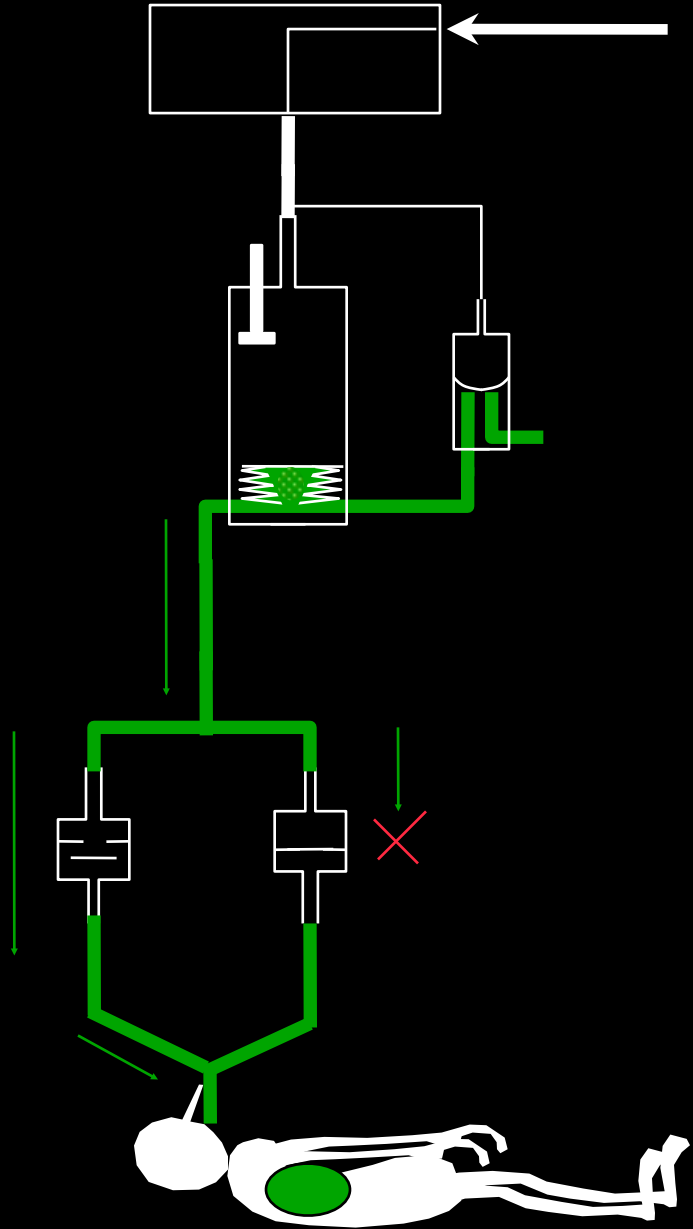


A/M



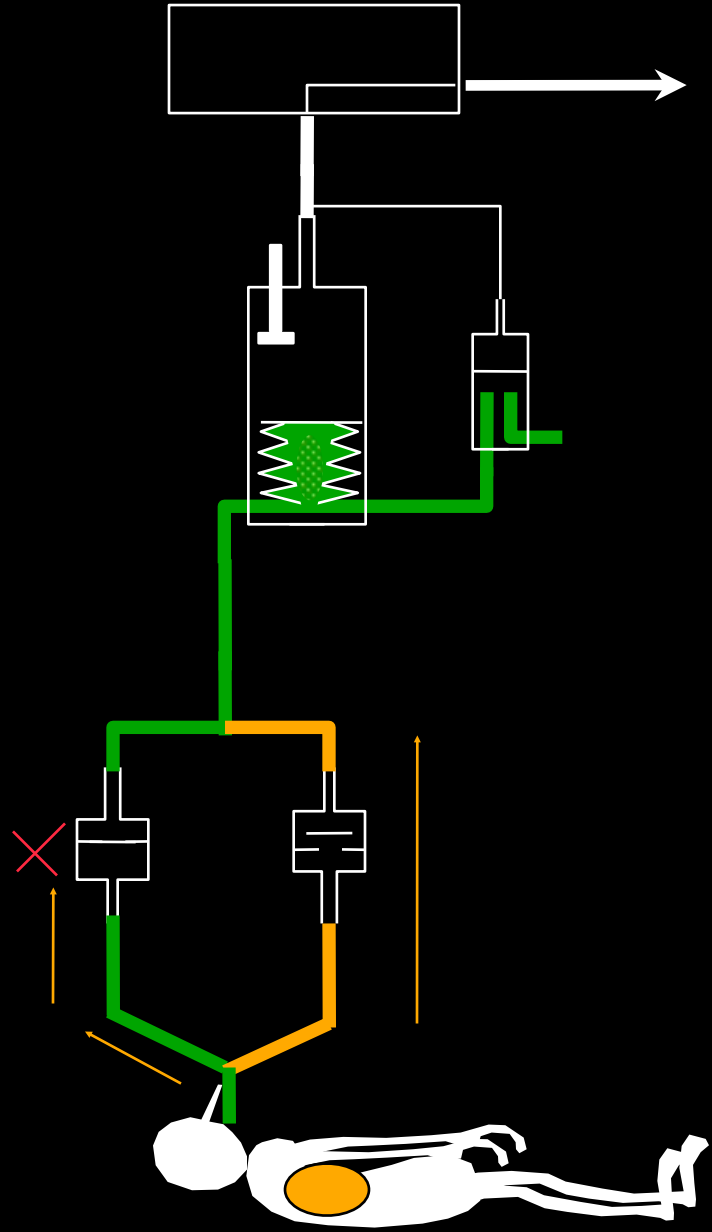
Inspiration.

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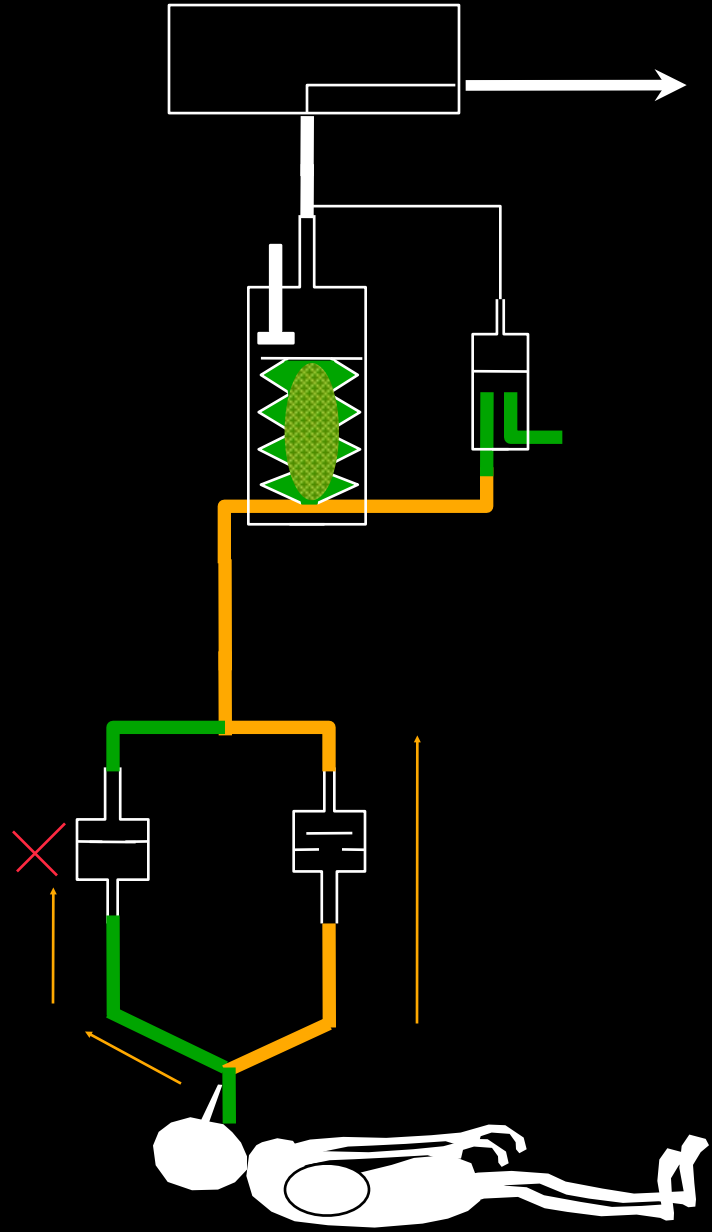
Inspiration.

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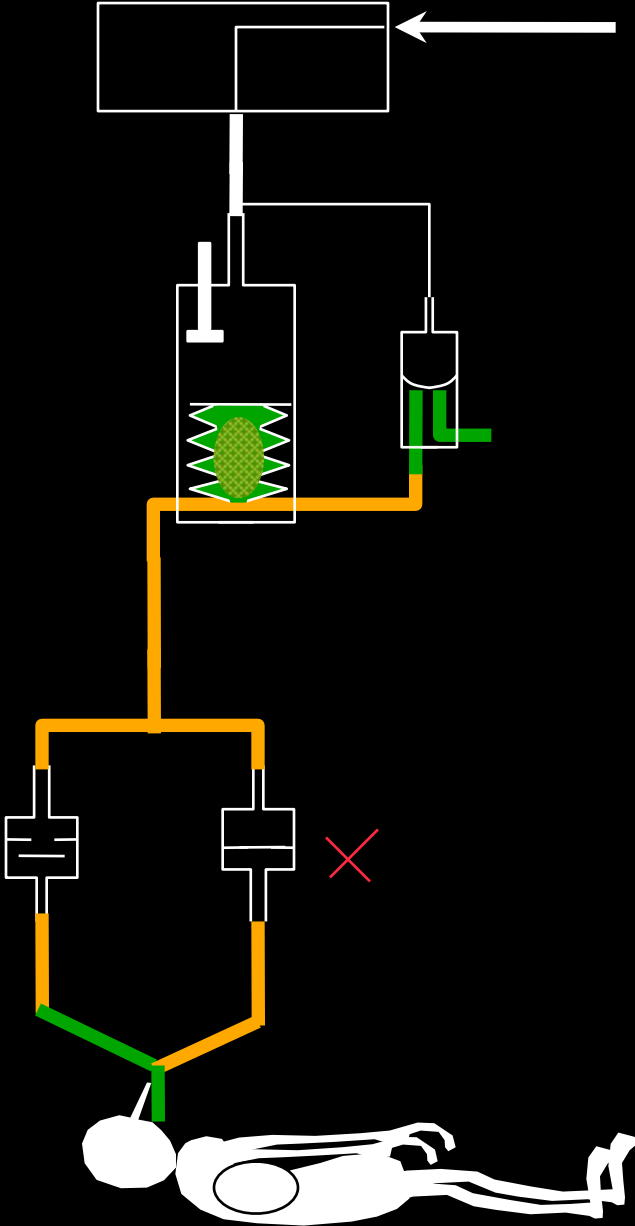
Expiration.

A/M



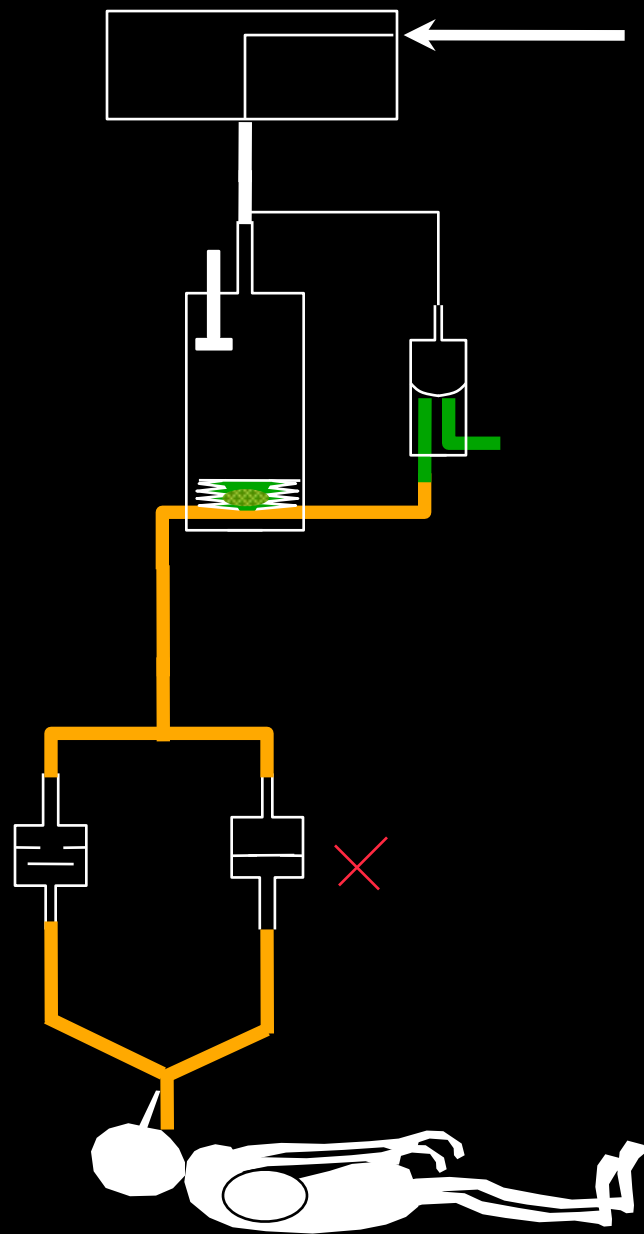
Expiration.

A/M



Inspiration.

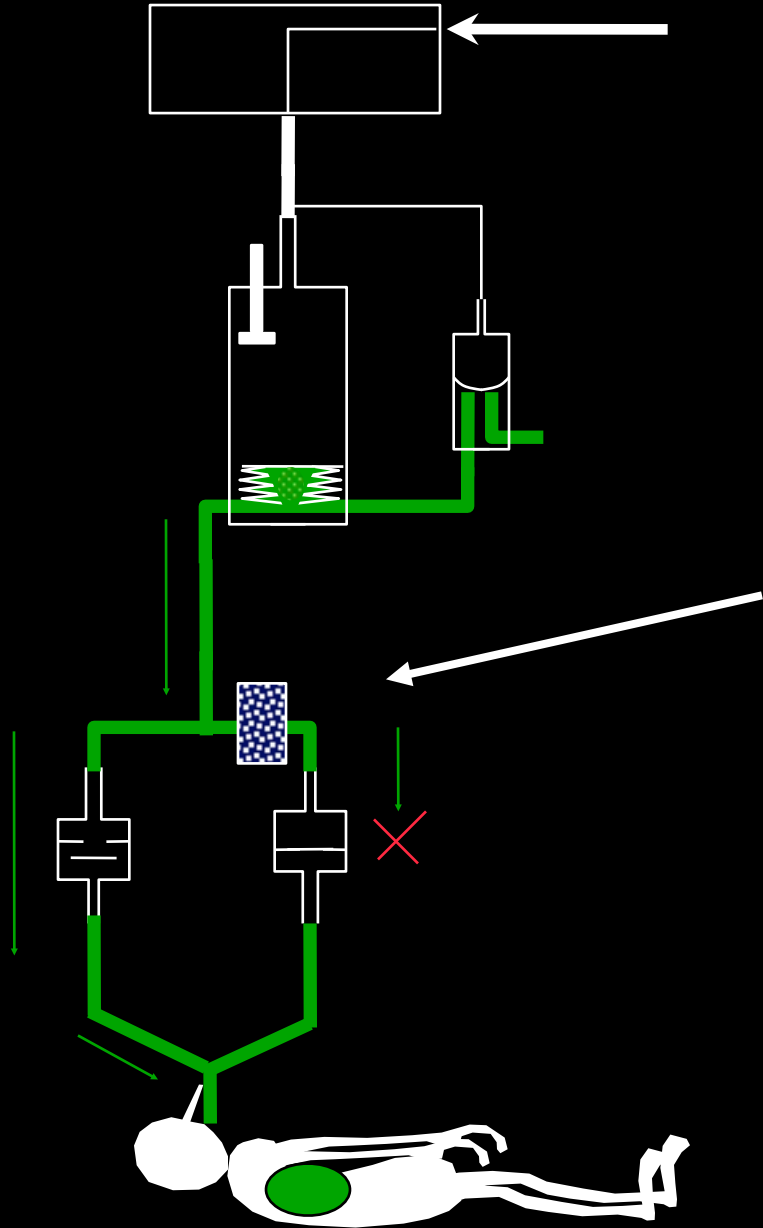
A/M



Very Bad Situation

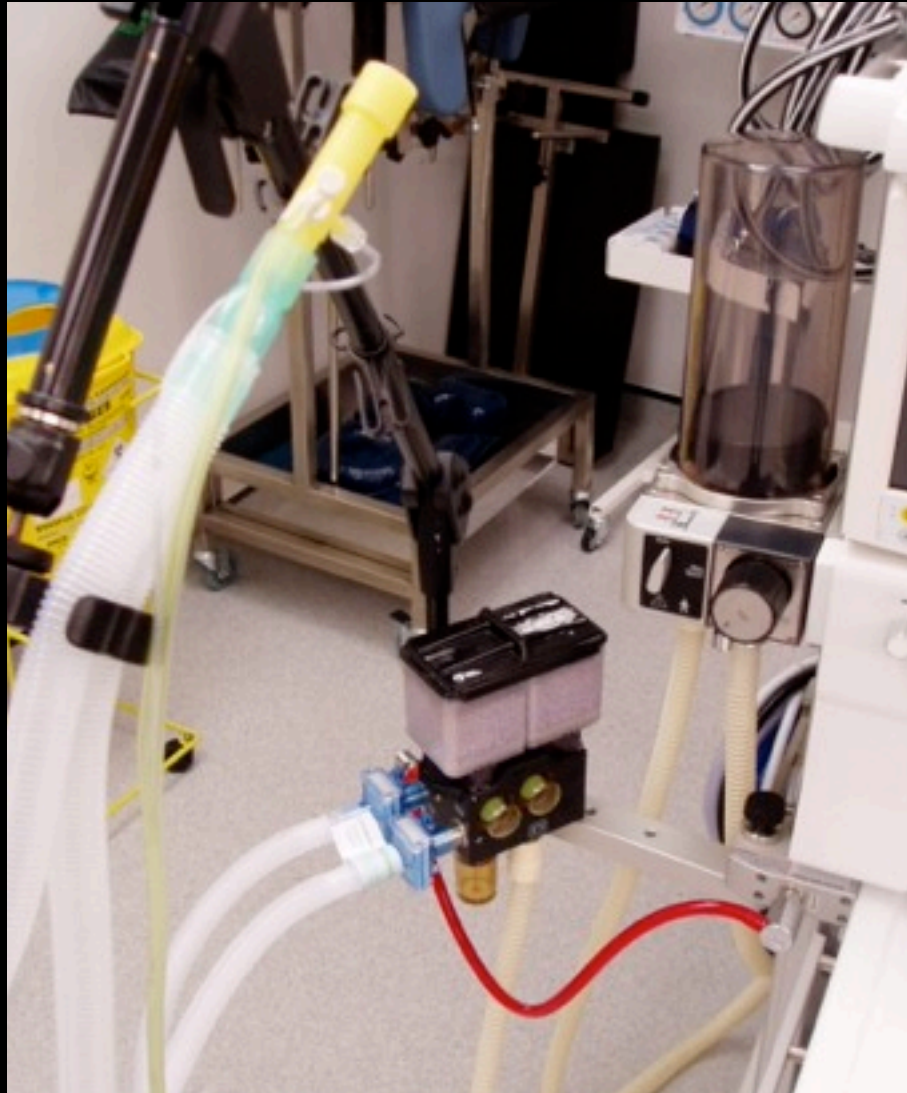
Inspiration.

A/M

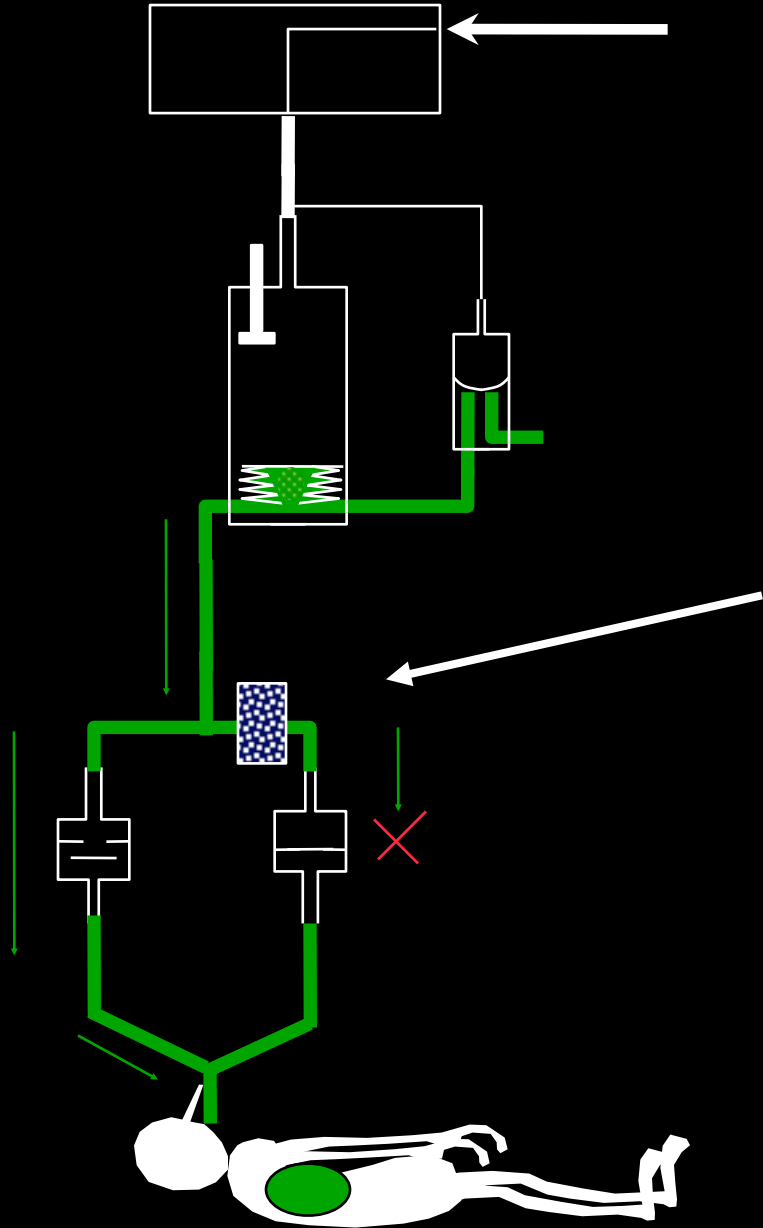


CO₂
Absorber

Inspiration.



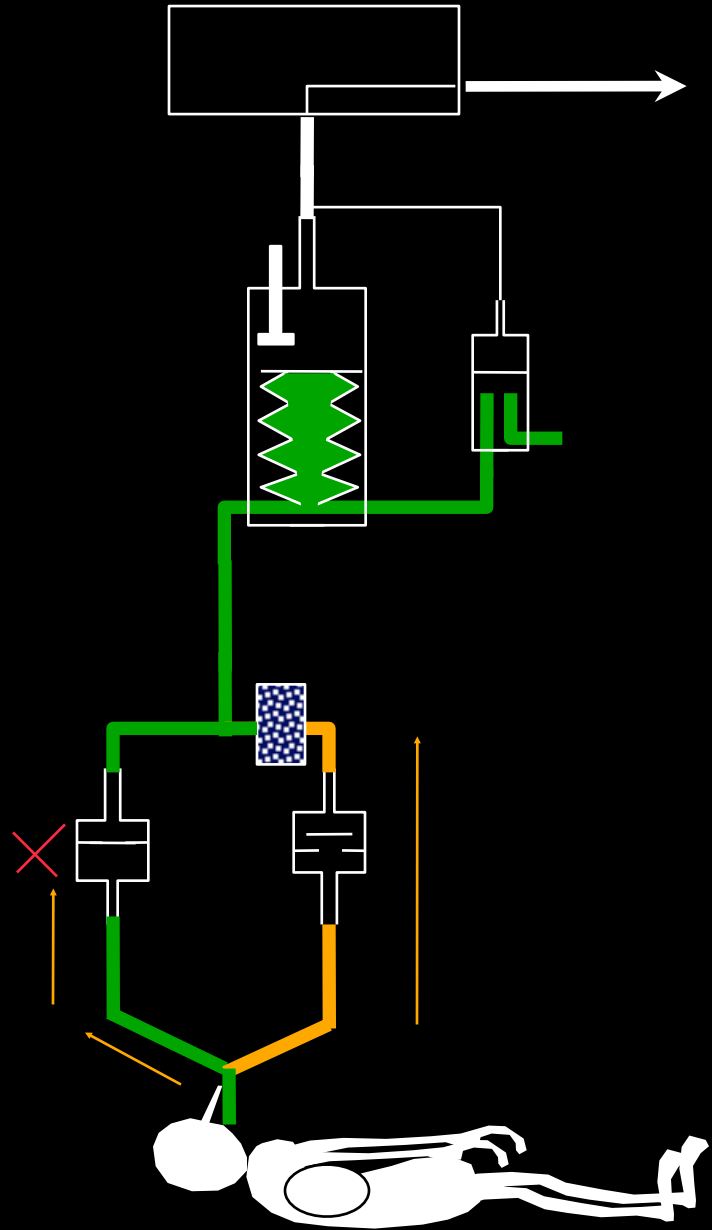
A/M



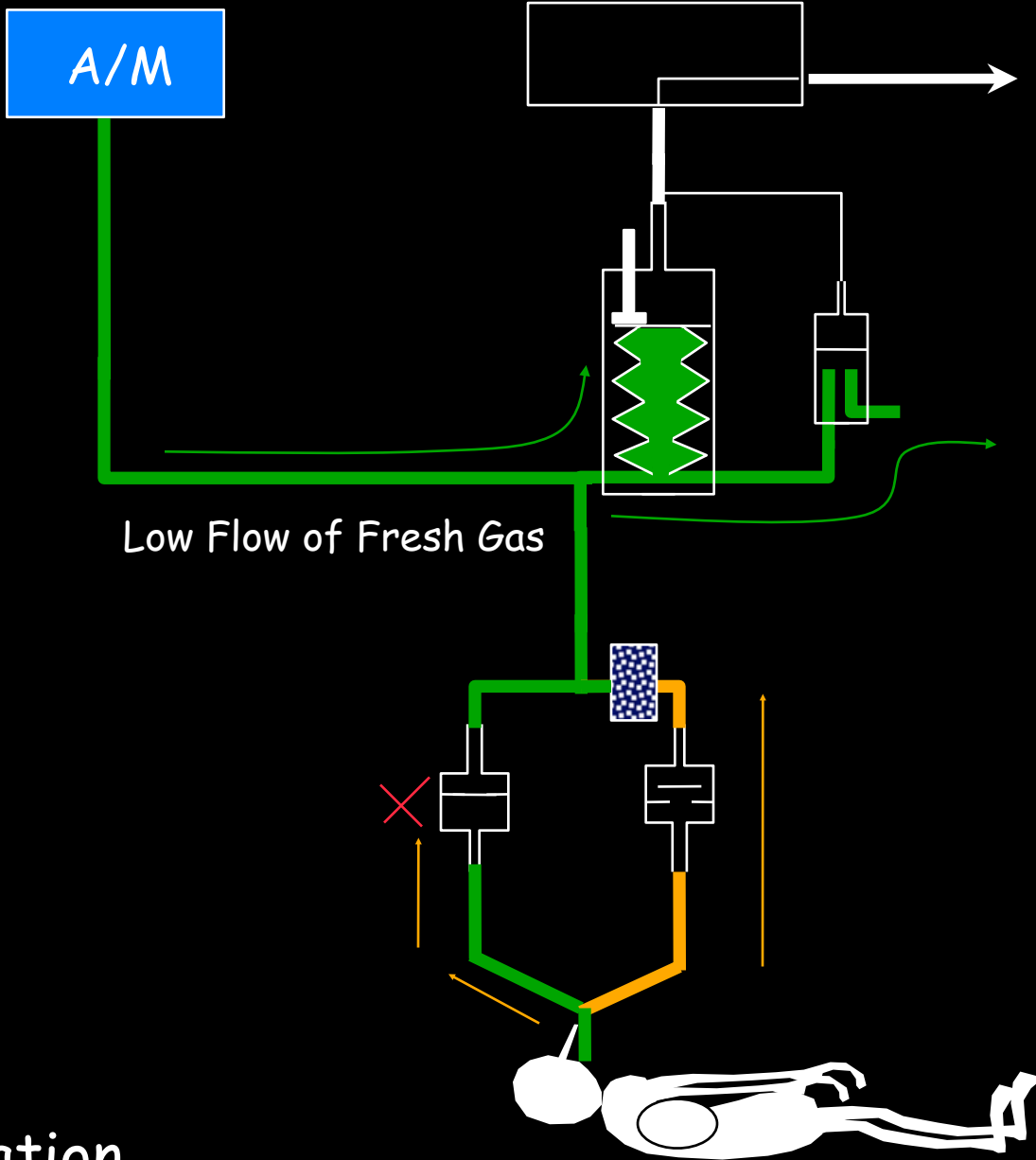
CO₂
Absorber

Inspiration.

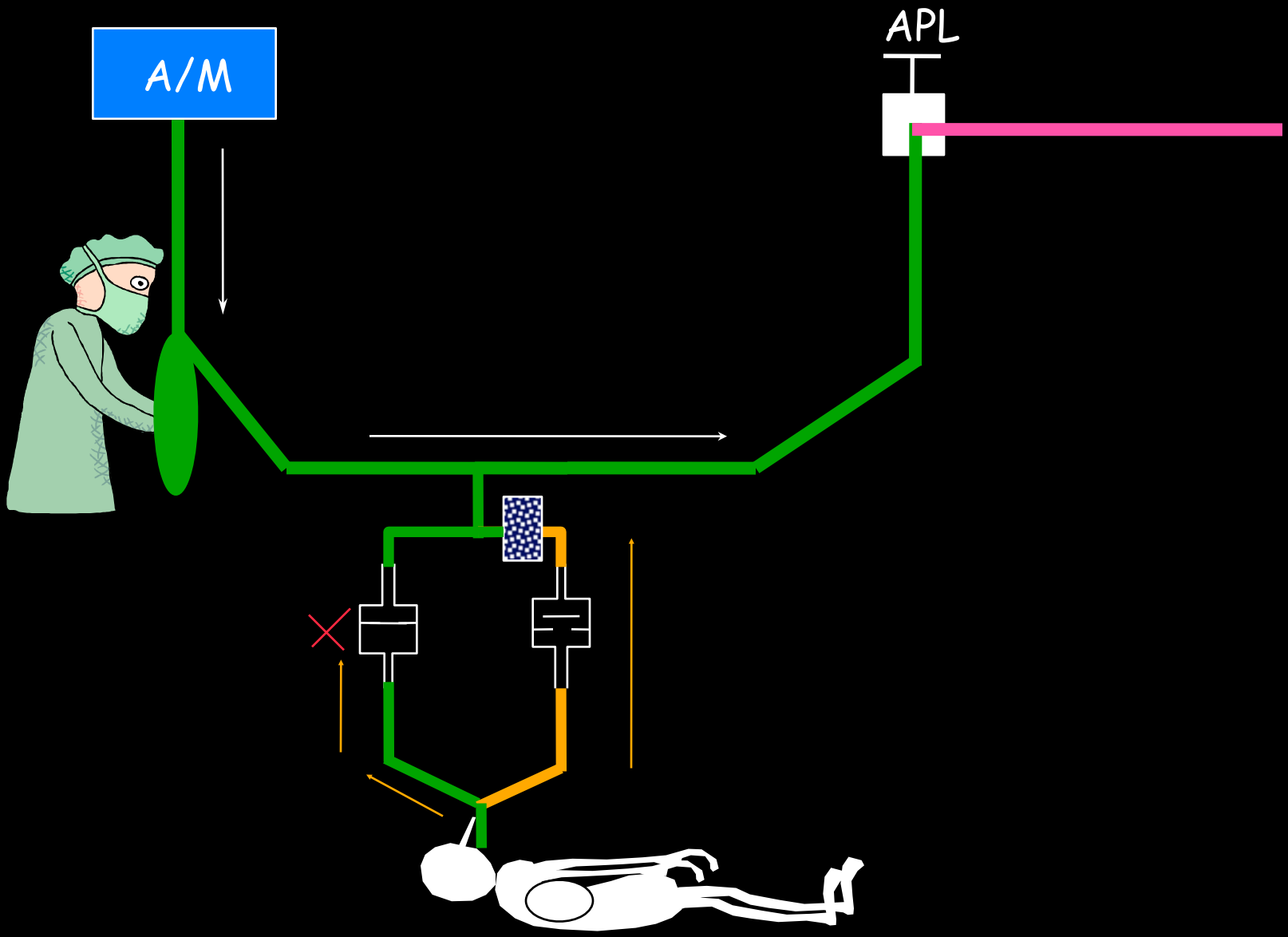
A/M

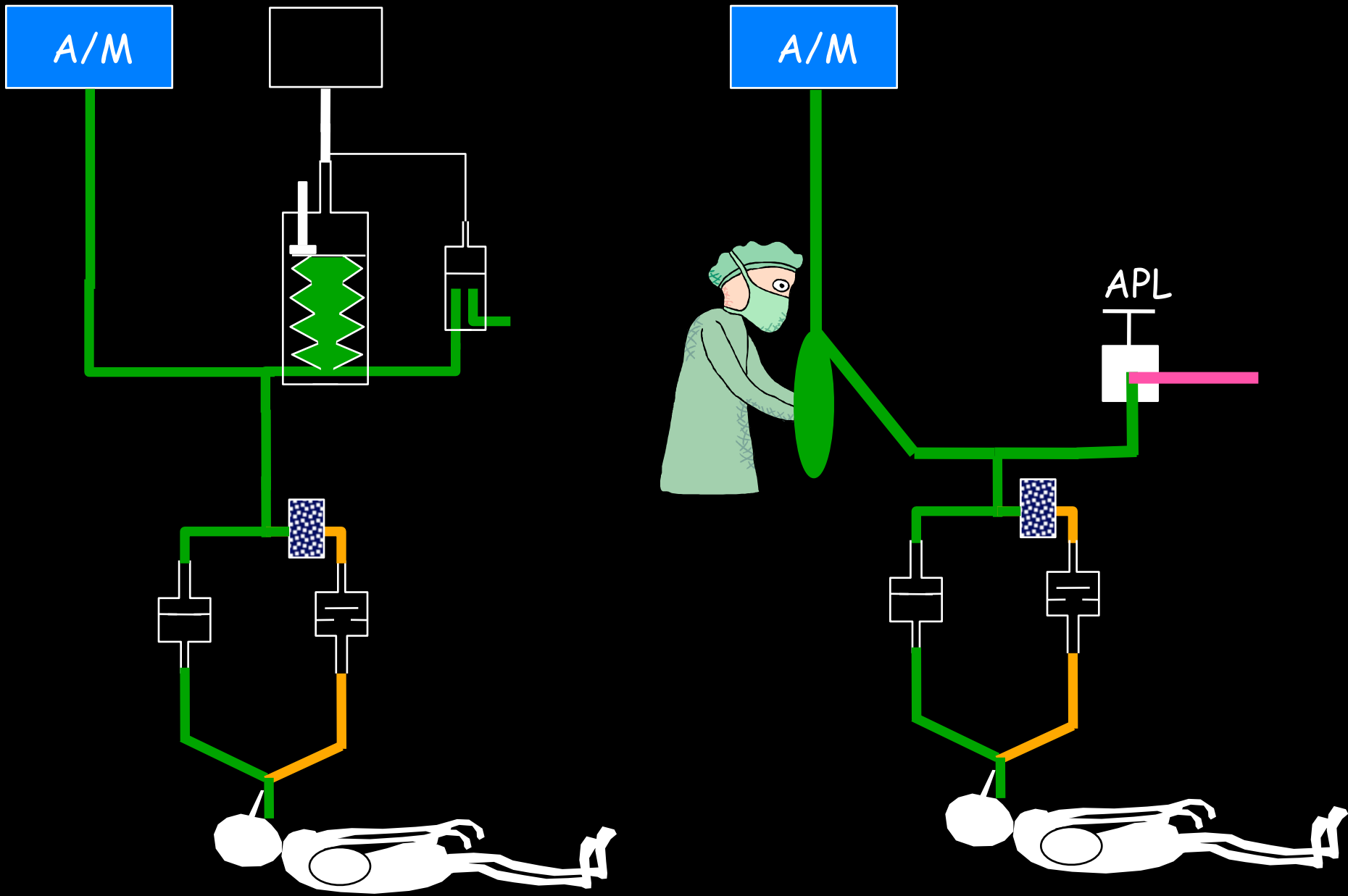


Expiration.

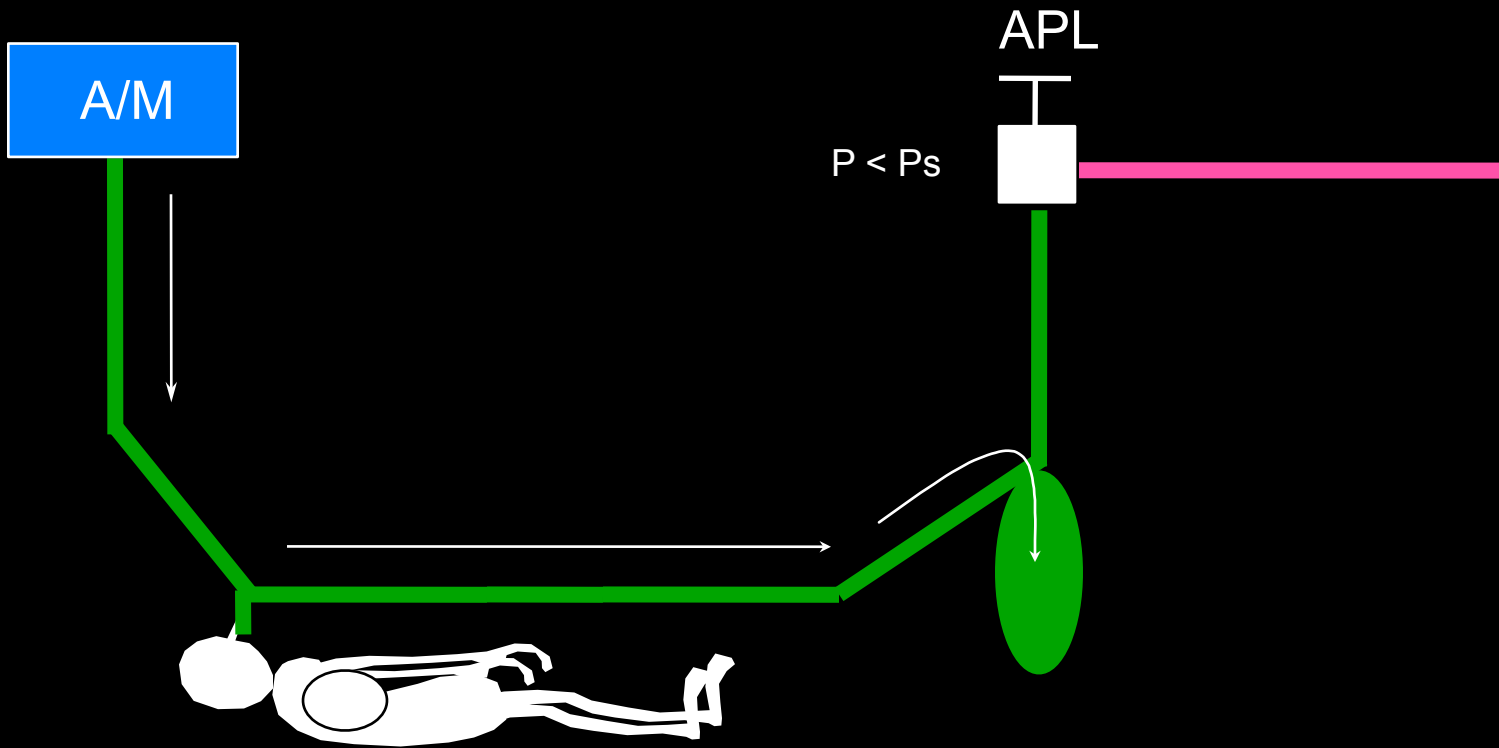
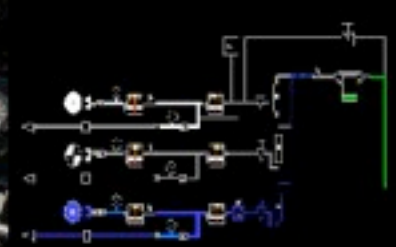
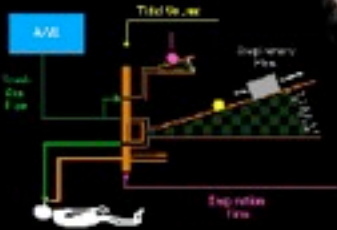


Expiration.





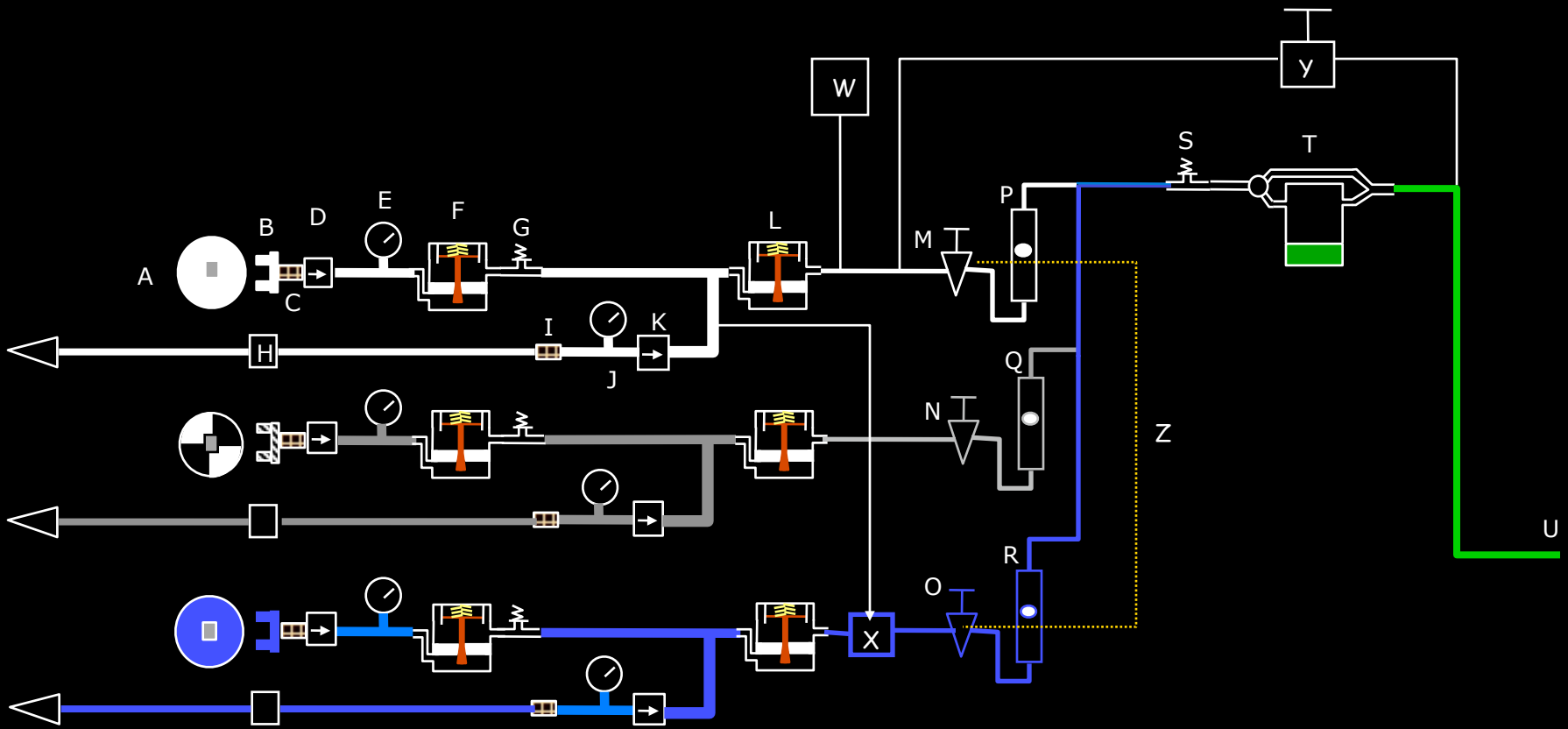




Mapleson D

Controlled or Assisted Ventilation.



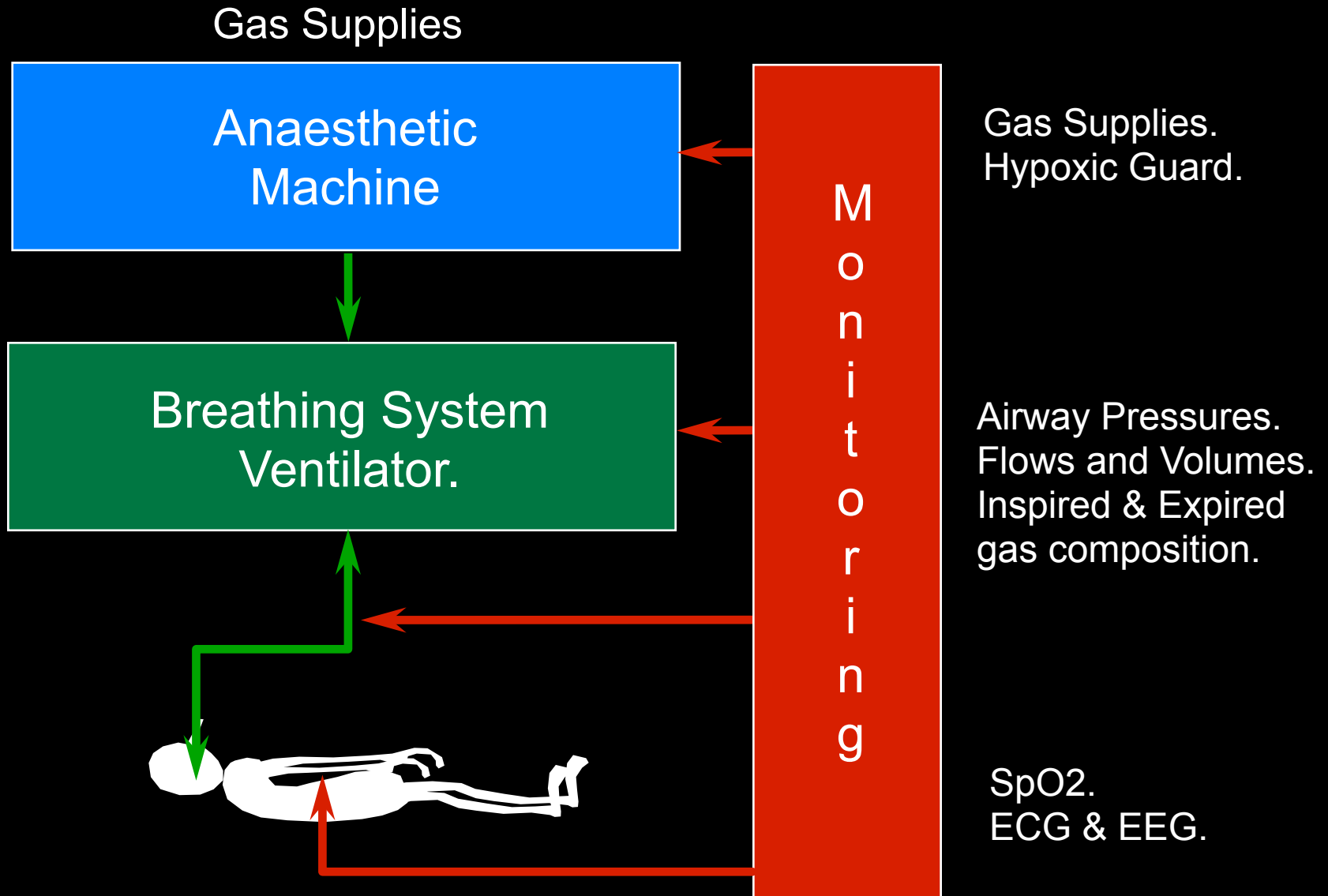


Generic Anaesthetic Machine.

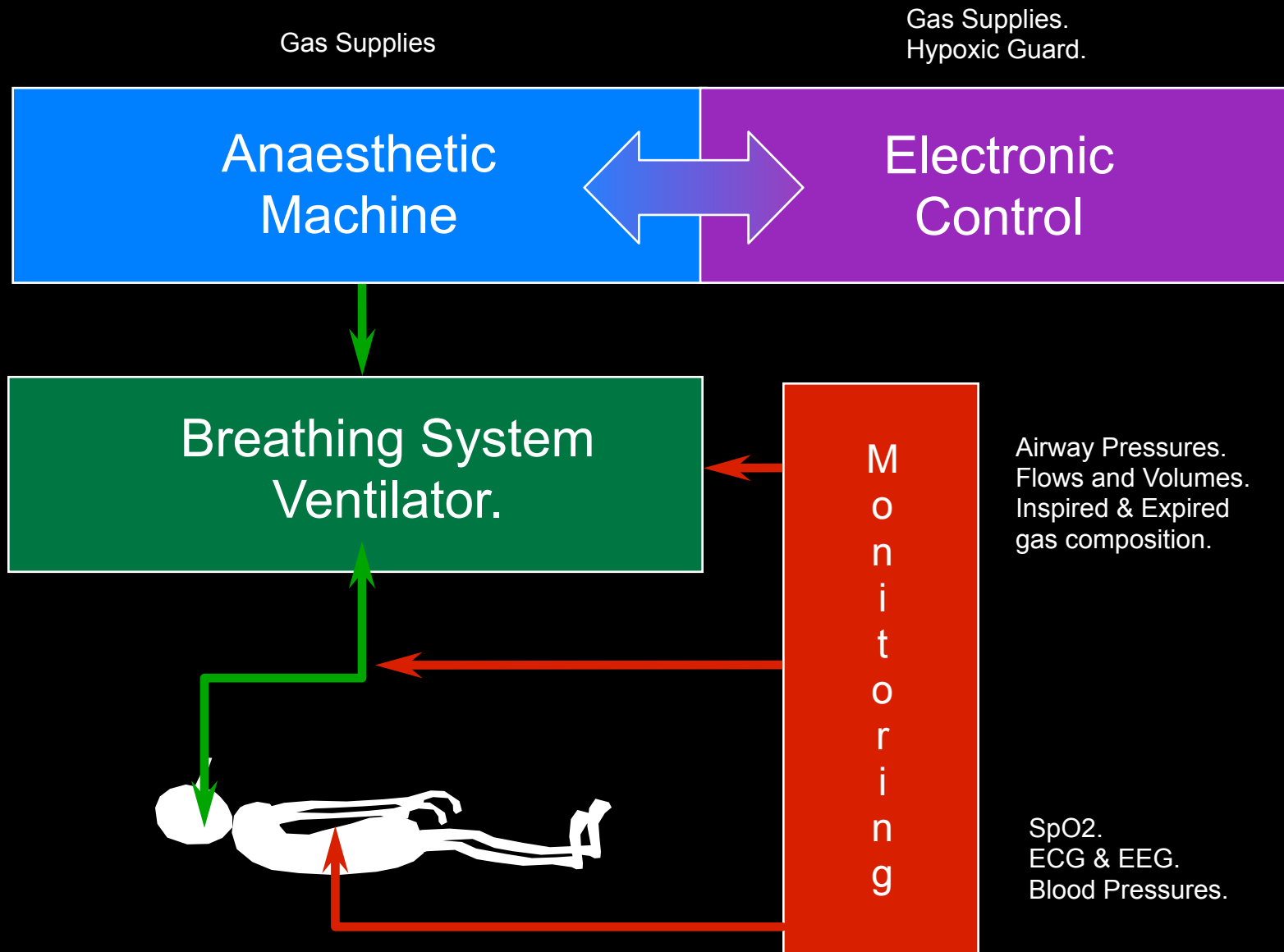
Mechanical
Boyles
Anaesthetic
Machine

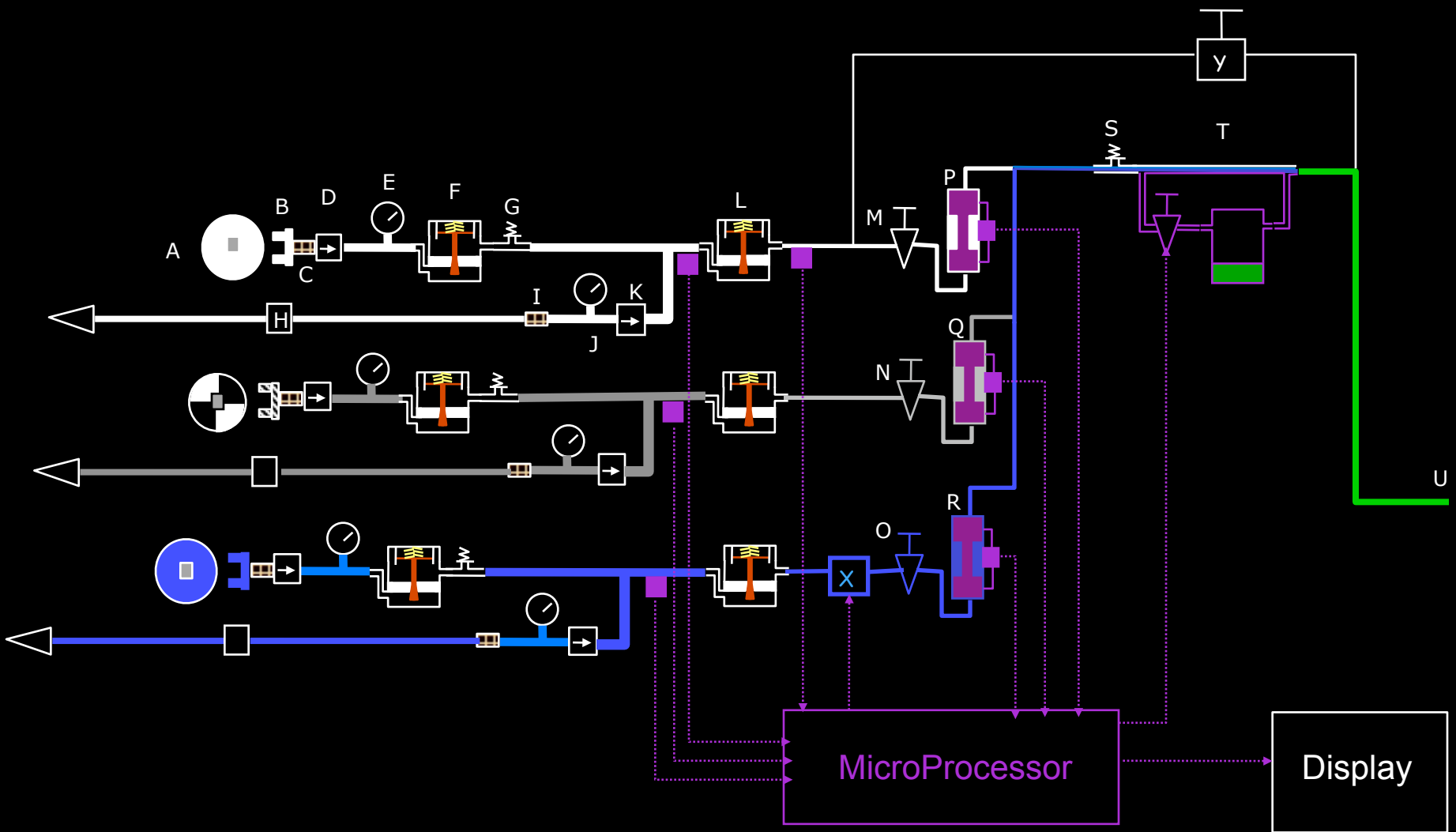


Evolution of the Anaesthesia Workstation.



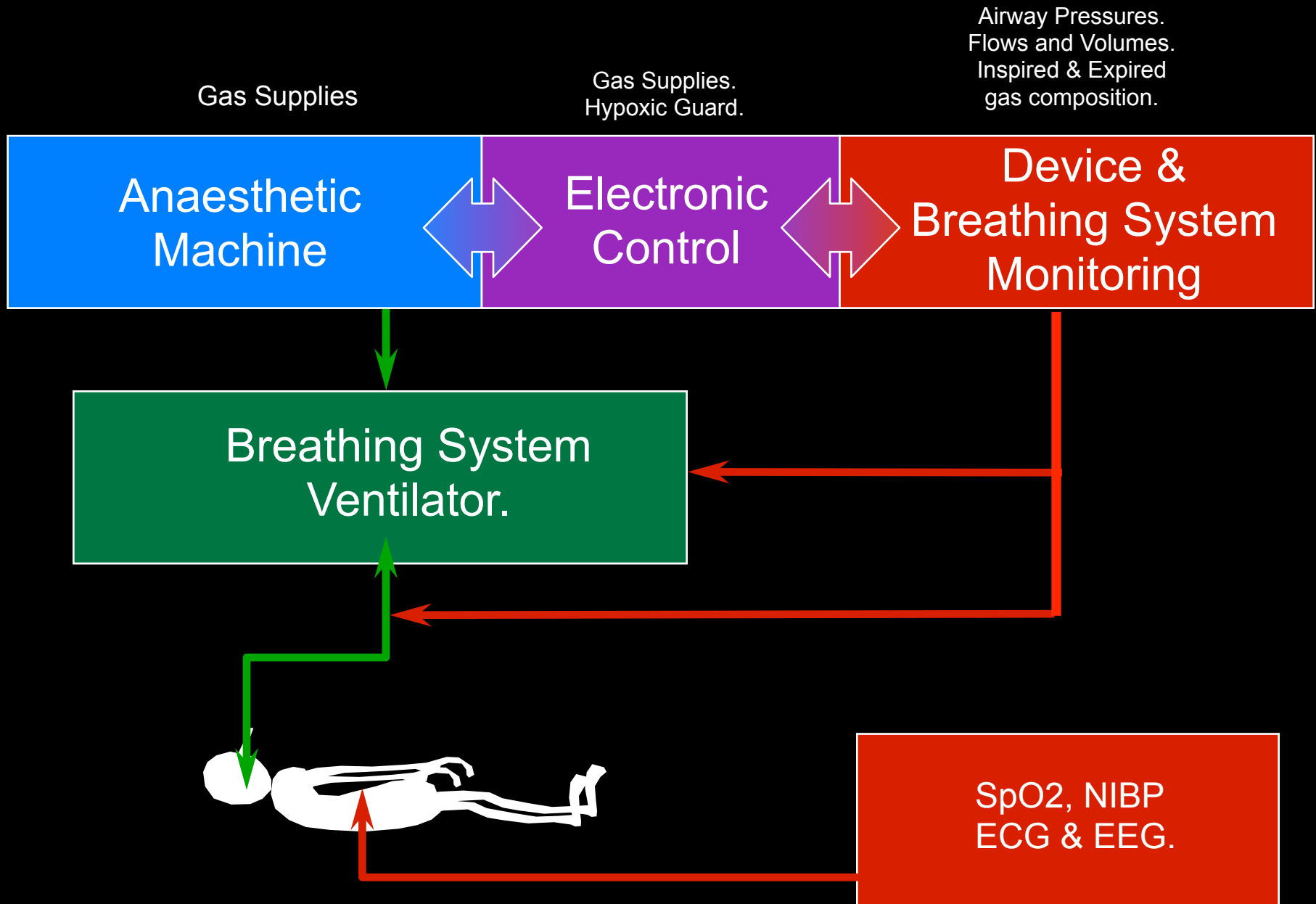
Evolution of the Anaesthesia Workstation.





Electronic Anaesthetic Machine (Datex ADU).

Evolution of the Anaesthesia Workstation.



Evolution of the Anaesthesia Workstation.

Gas Supplies

Gas Supplies.
Hypoxic Guard.

Airway Pressures.
Flows and Volumes.
Inspired & Expired
gas composition.

Anaesthetic
Machine

Electronic
Control

Device &
Breathing System
Monitoring

SpO₂, NIBP
ECG & EEG.

Breathing System
Ventilator.

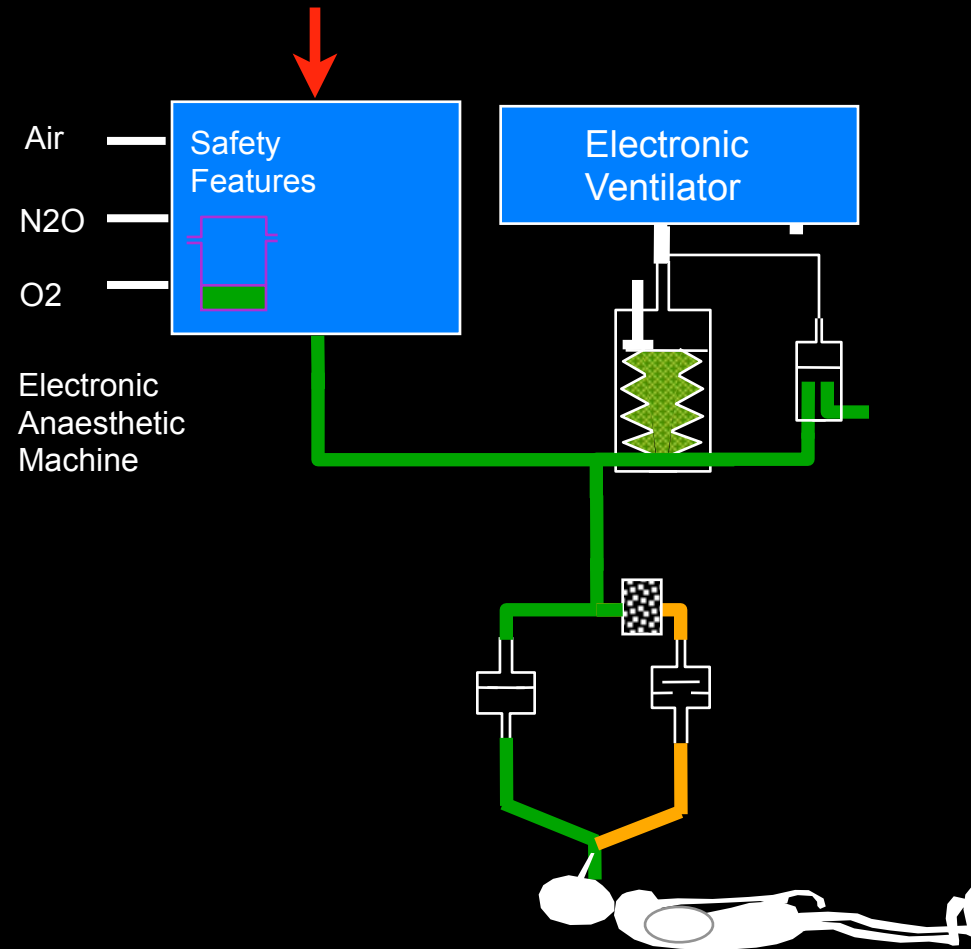


Block Diagram of a Modern Targeted Controlled Anaesthesia Machine

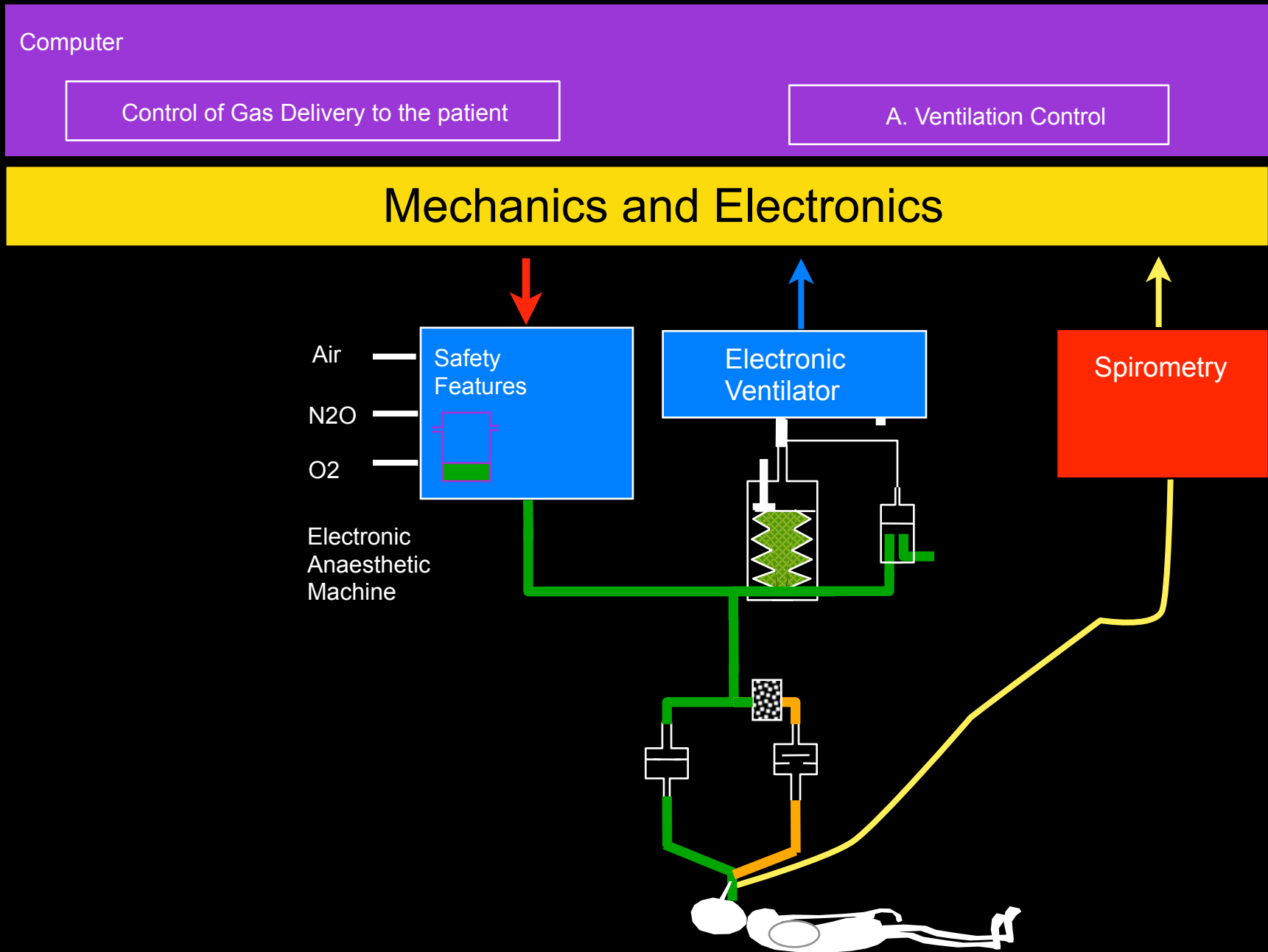
Computer

Control of Gas Delivery to the patient

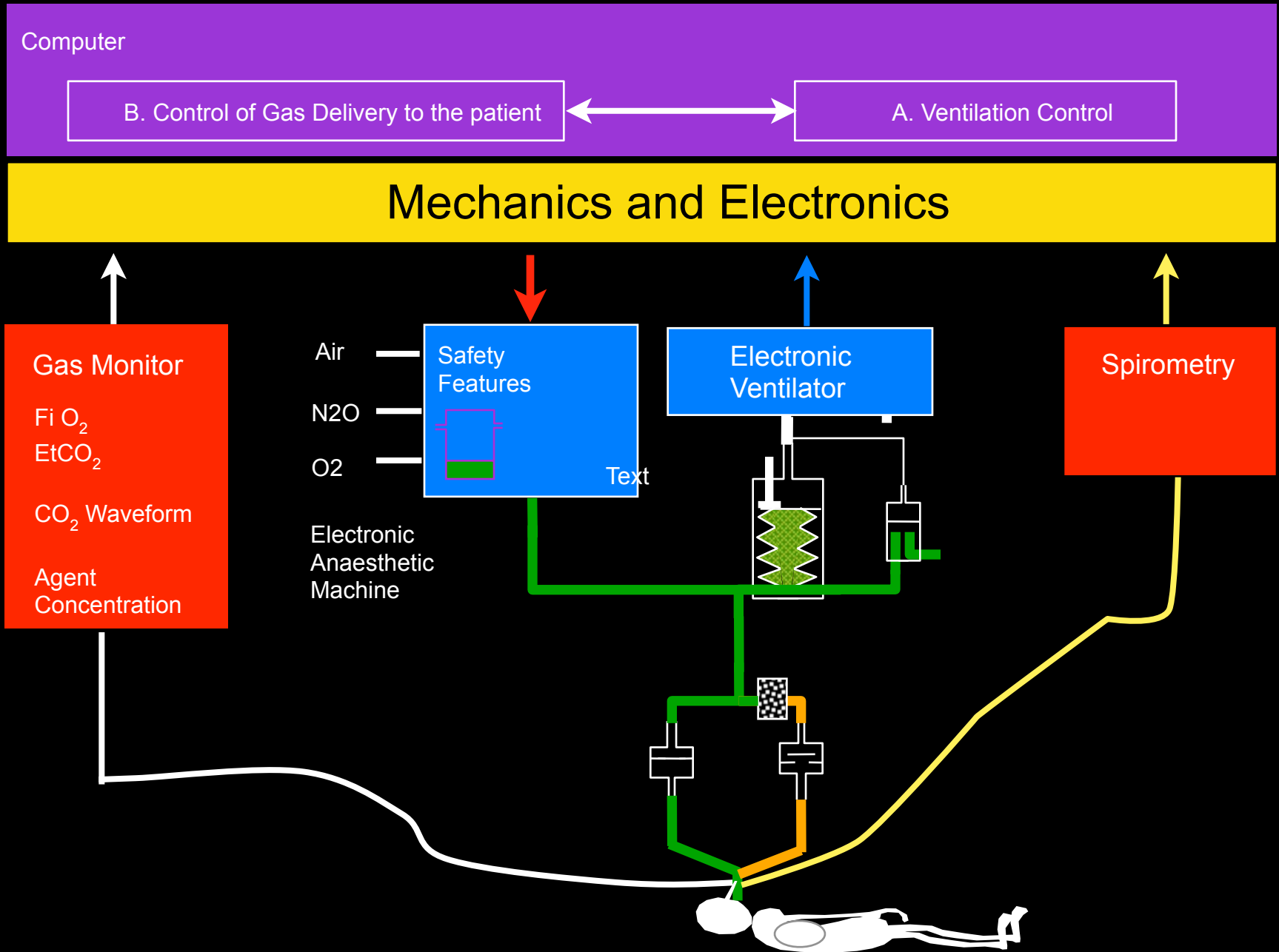
Mechanics and Electronics



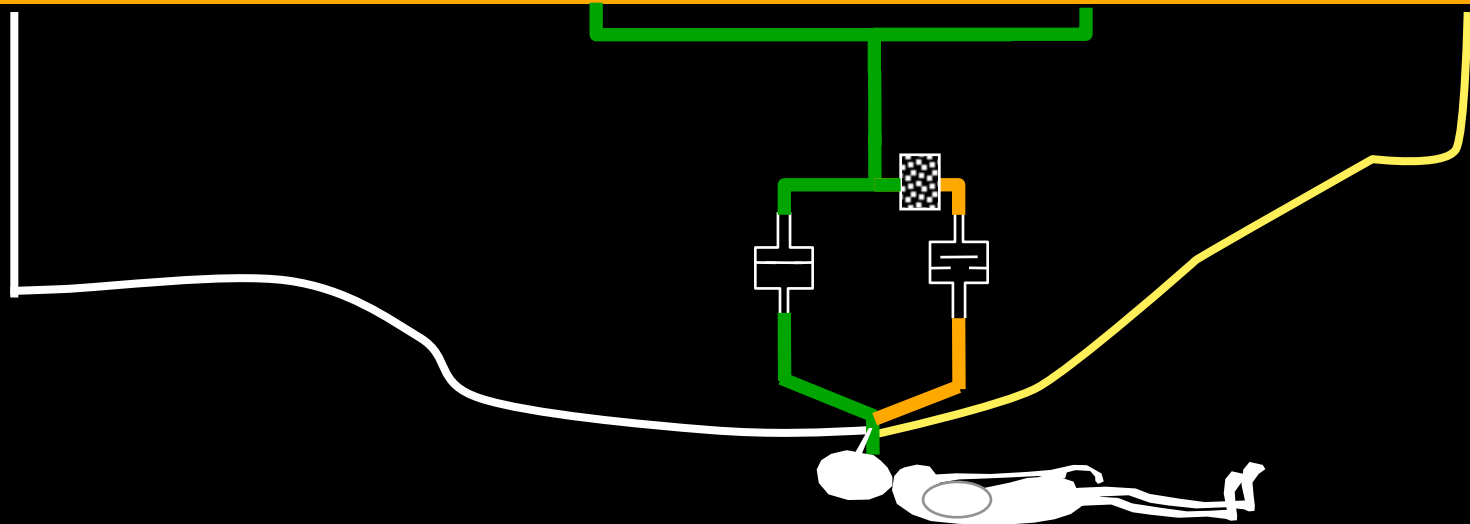
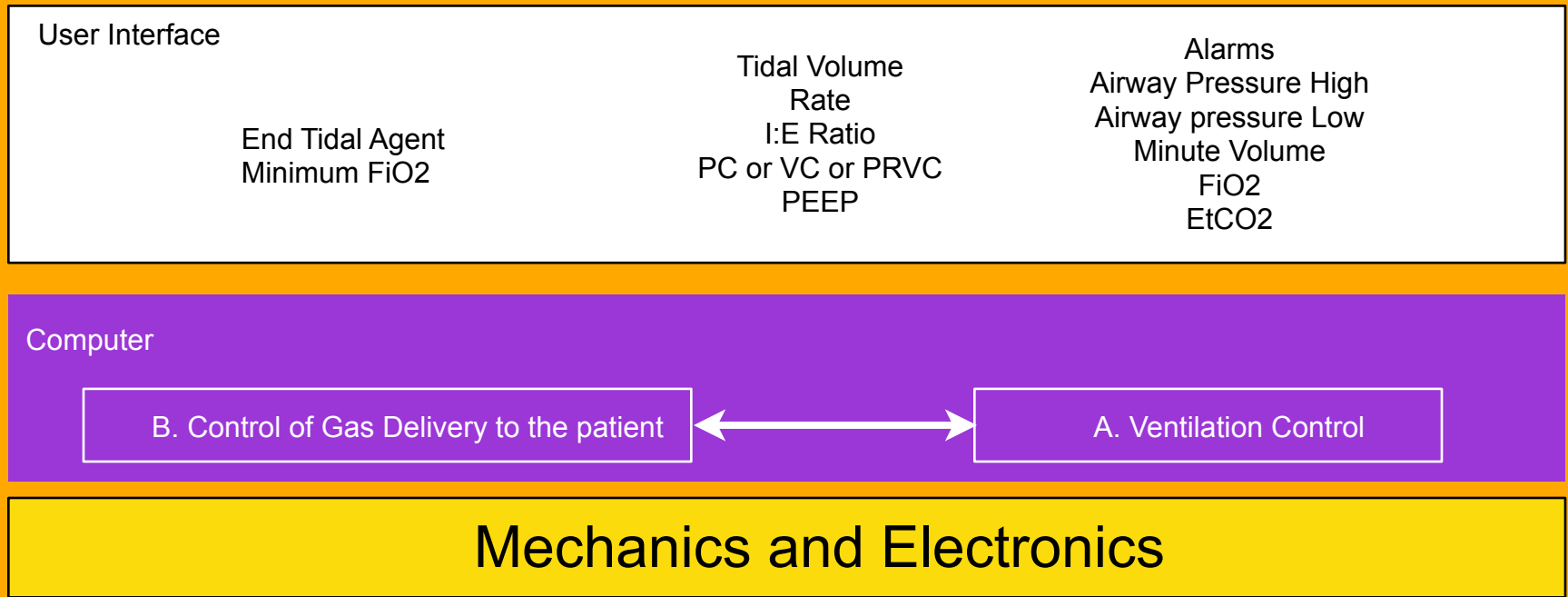
Block Diagram of a Modern Targeted Controlled Anaesthesia Machine



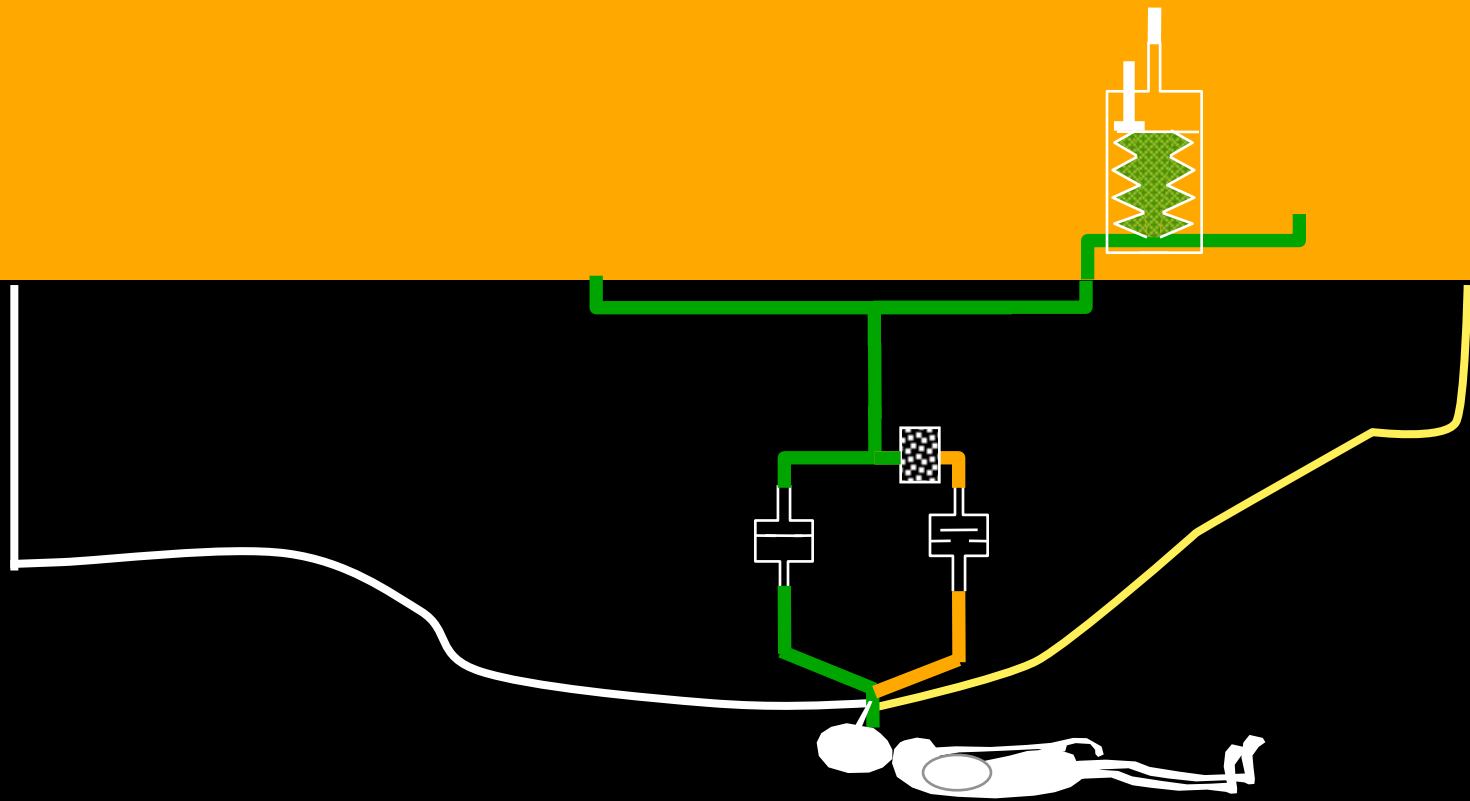
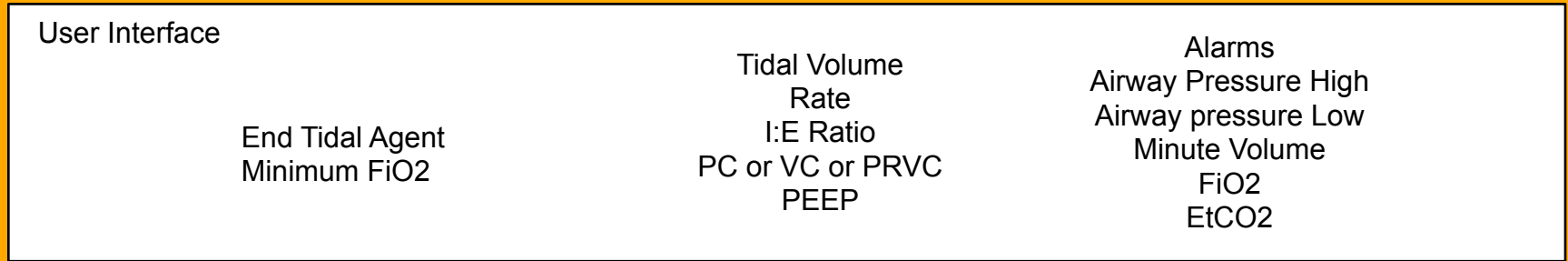
Block Diagram of a Modern Targeted Controlled Anaesthesia Machine



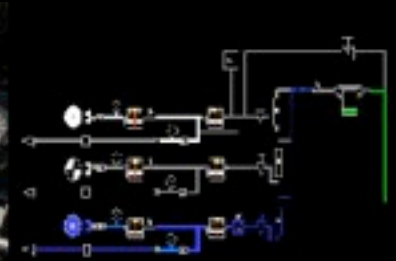
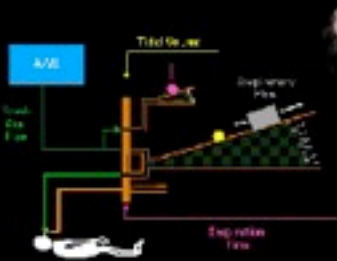
Block Diagram of a Modern Targeted Controlled Anaesthesia Machine



Block Diagram of a Modern Targeted Controlled Anaesthesia Machine







Pre Use Checks

Session Checks

Per Case Checks

Why?



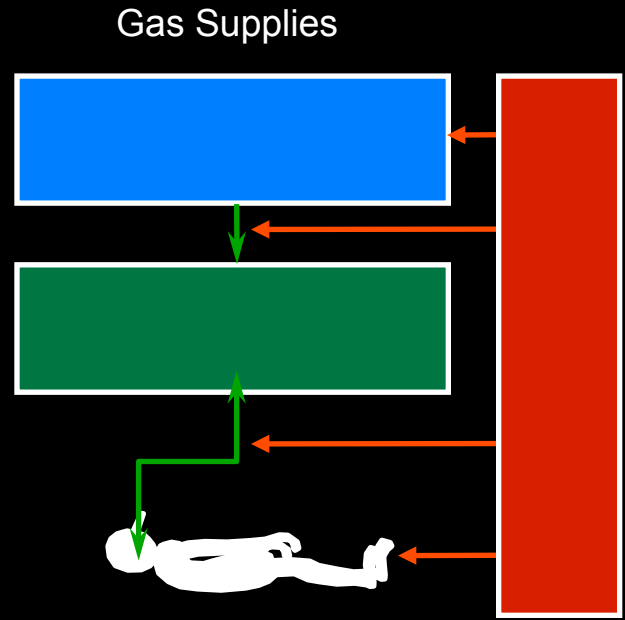
Pre Use Checks

Start of every operating session

1

Learn your Equipment
How to operate it and
how it functions

**Do not use this equipment unless you
have been trained**



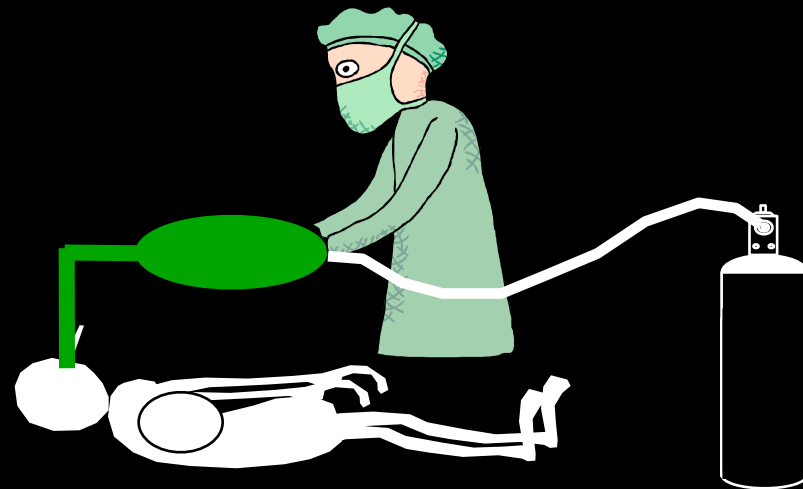
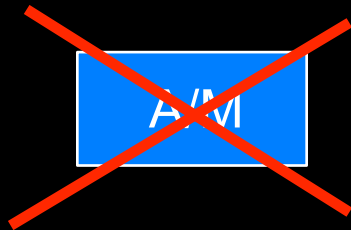
approx 60 %
reported faults
are user error

Responsibility of Anaesthetist.

2

Check a self inflating bag
is available

An alternative source of oxygen
should be readily available



3

Perform the manufacturers automatic self check



4

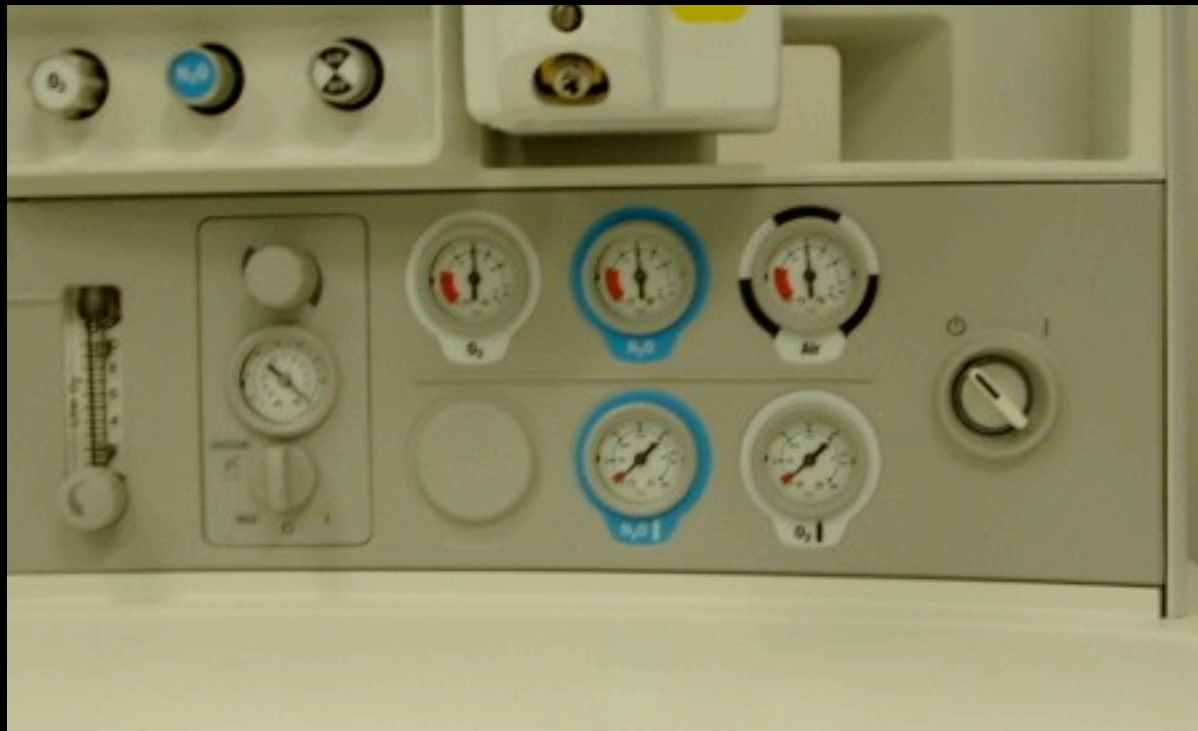
Power Supply

Connected to the mains and turned on.

No extension leads

Battery back-ups checked

System clock is correct



5 Check Gas Supplies



5

Check Gas Supplies

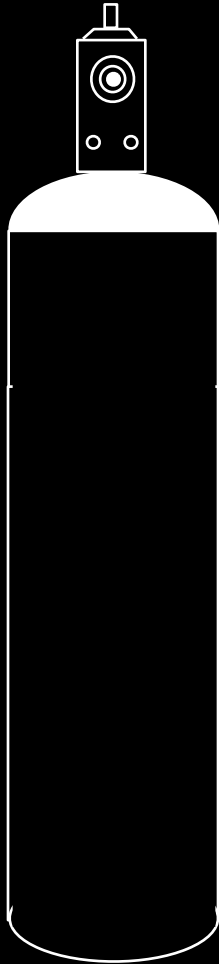
Pipeline supply of Oxygen - Gauges read > 400 kPa.
Tug test on wall connectons

Adequate reserve Oxygen spare cylinder available

Pipeline supply of other gases intended for use.

All cylinders should be securely seated and turned off.

Medical Gas Cylinders.



1. Colour Coded
2. Free from Water Vapour
3. E Size is used on Anaesthetic Machines

Oxygen

Black Body & White Shoulder 13700 kPa

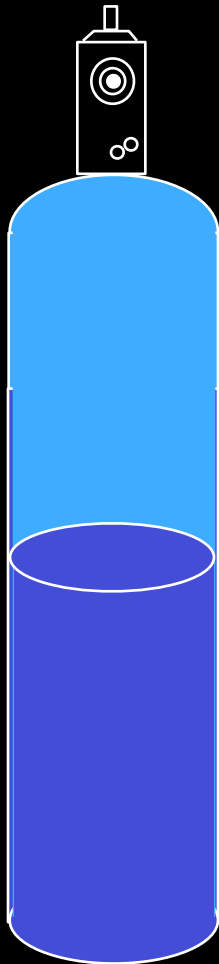
Air

Grey Body & White/Black Shoulder 13700 kPa

Medical Gas Cylinders.

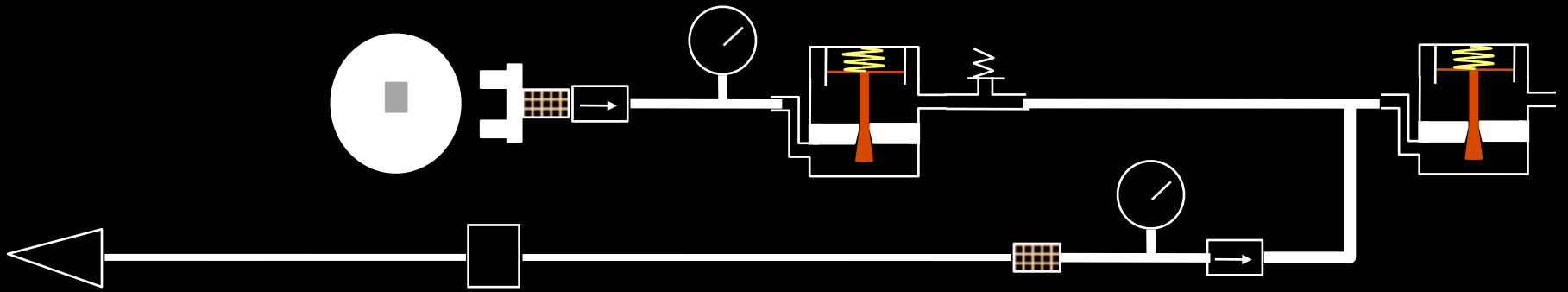
Nitrous Oxide

Vapour



Gas Phase on top
@ 4,400 kPa
(room temperature)

Liquid Phase



5

Check Gas Supplies

Flowmeters

Anti Hypoxia Devices

Oxygen Monitor reads 100% when only Oxygen is flowing

Oxygen Flush

Suction Unit

5

Check Gas Supplies

Oxygen Failure Alarm

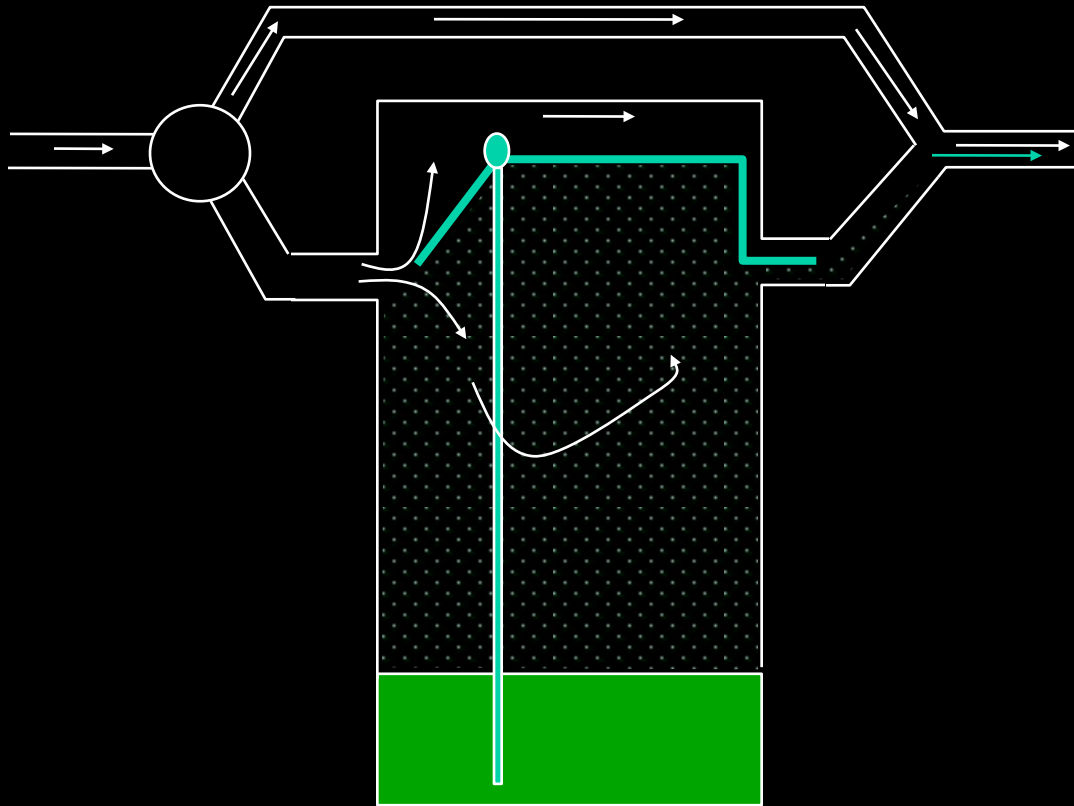
Session - Turn Off the machine

Weekly - Disconnect the wall supply while flowmeter is on

6

Check Vaporizer

Vaporiser.





Pre-Use Checks

5. Check the Vaporizers.

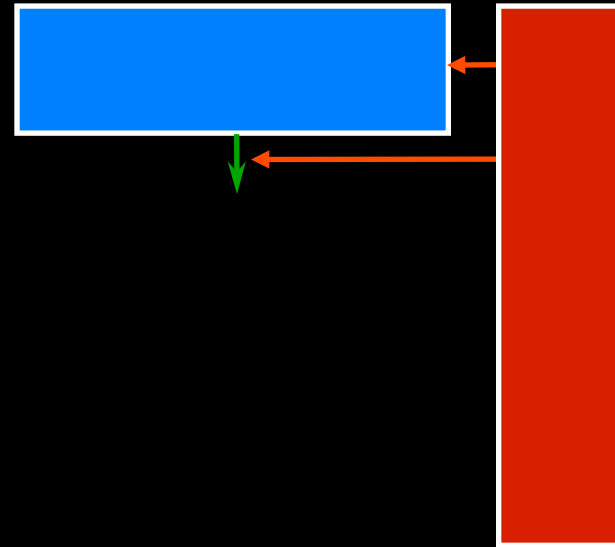
Fitted correctly & Controls Work
Then turn them off.

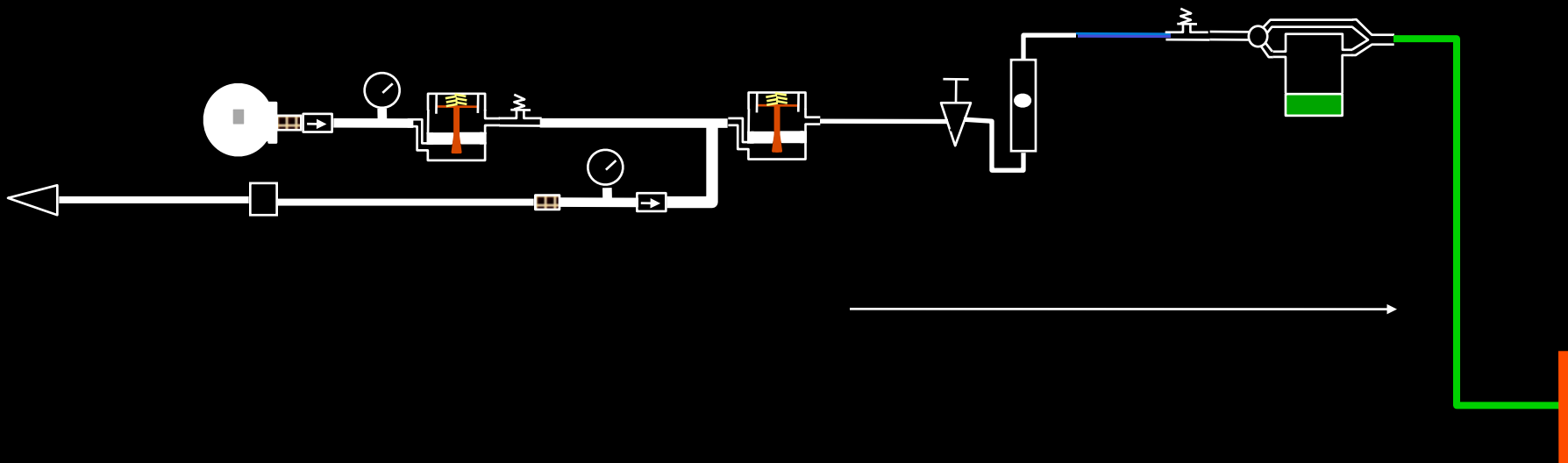
Check they are sufficiently filled
with agent.

Leak Test.

- A. Vaporizer Off – 5 L/min Oxygen
Occlude the common gas outlet
Check for leaks around fittings
- B. Vaporizer On – 5 L/min Oxygen
Occlude the common gas outlet
Check for leaks around filling port

Gas Supplies





7

Check Breathing Circuit

Visual Inspection

No leaks

Pressure test by occluding the tube and squeezing the bag

All breathing systems tested using a two bag test.

8

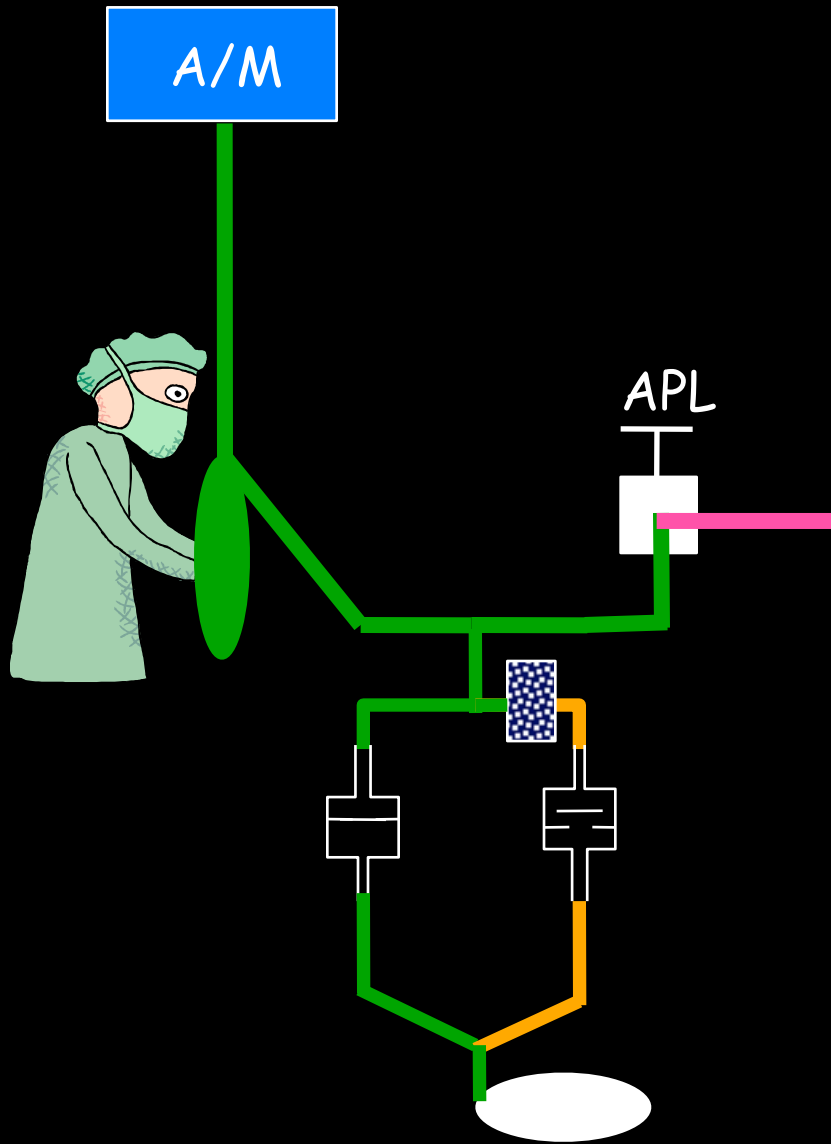
Check the Ventilator

Ventilator tubing is secure

Operate the ventilator and ensure positive pressure during the inspiratory phase

Check alarms

Check over pressure relief valve functions



Two Bag Test

Attach a test lung

Set flow to 5 litres a minute

Check circuit patent

Check one way valves

Check APL valve by squeezing both bags

Two Bag Test

Attach a test lung

Set flow to 5 litres a minute

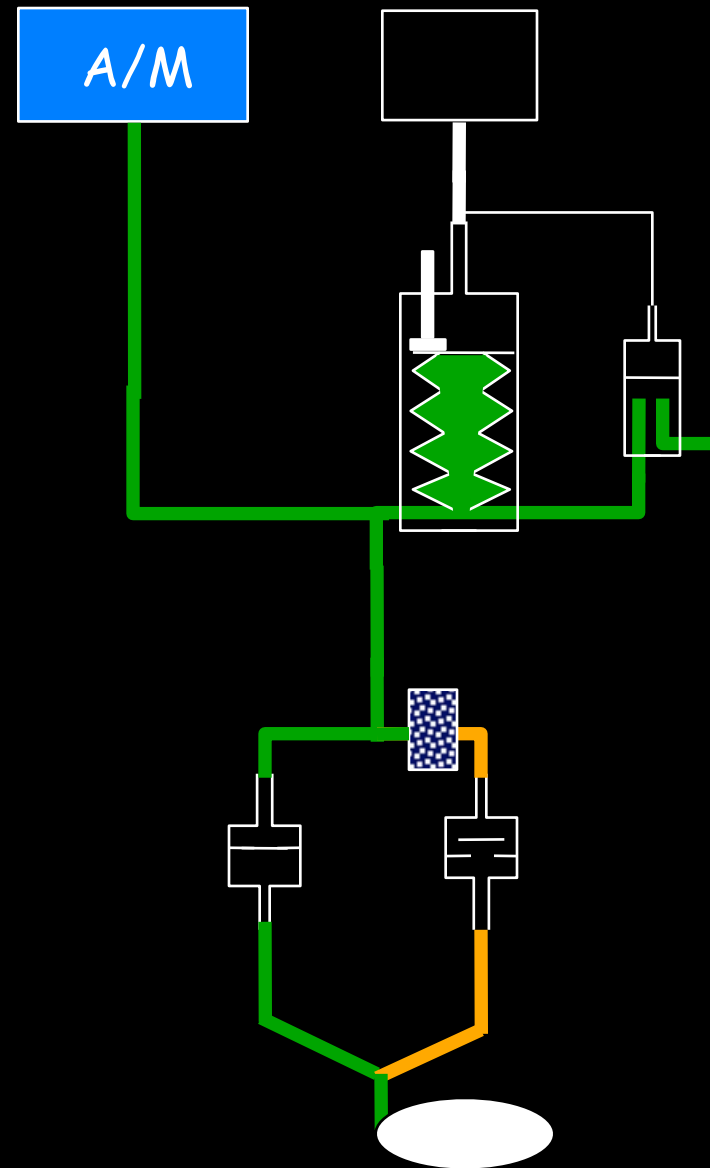
Check circuit patent

Check one way valves

Check APL valve by squeezing both bags

Switch to ventilator and ventilate the test lung

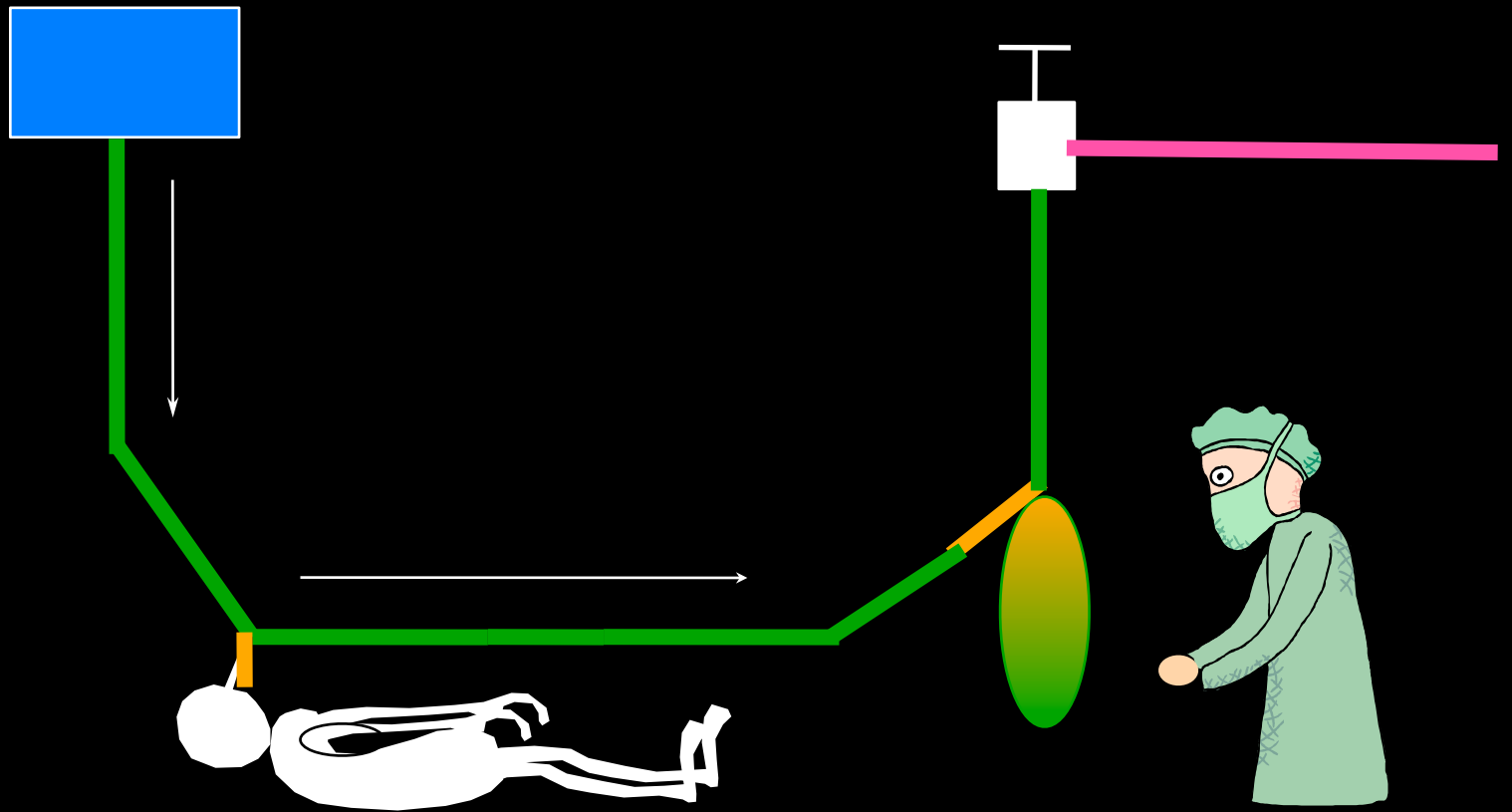
Turn off fresh gas flow and open the vaporisers - no loss of volume



9

Check the **A**bsorber & **A**lternative Breathing System





10 Check the **A**irway Equipment



11

Check the Patient Monitoring



NIBP

Gas Analysis Lines

Oxygen Analyser

Pulse Oximeter

Capnography

Alarm Limits are appropriate

11 Scavenging

Check scavenging is switched on

Check tubing is correct

12

Use **C**hecklists & Protocols

"As I learn more about anesthesia I realize how important protocols and procedures are to increase patient safety. As a lawyer I also see that these procedures can protect the anesthetist.

Should the anesthetist be required to defend himself or herself, it may be difficult to remember the exact details of an anesthetic given years before. Sometimes, it is helpful to be able to testify that certain matters are always done by following careful procedures, even if you cannot remember what happened in a particular case.

If you begin your day or each operation checking out your anesthesia machine according to FDA guidelines, then even if you cannot remember what you did on February 1, 1995, you will know you checked the anesthesia machine because that is what you always do."

Gene Blumenreich *AANA J* 2000;68:107-10.

"Apparatus of reliable appearance engenders a strong feeling of security which is often not supported by facts. A critical attitude often forestalls unpleasant surprises."

Lucien Morris,
in Aldrete Lowe & Virtue
Low Flow & Closed System Anesthesia
Grune & Stratton 1979.

Checklist for Anaesthetic Equipment 2012

AAGBI Safety Guideline



Checks at the start of every operating session

Do not use this equipment unless you have been trained

Check self-inflating bag available

Perform manufacturer's (automatic) machine check

Power supply

- Plugged in
- Switched on
- Back-up battery charged

Gas supplies and suction

- Gas and vacuum pipelines – 'tug test'
- Cylinders filled and turned off
- Flowmeters working (if applicable)
- Hypoxic guard working
- Oxygen flush working
- Suction clean and working

Breathing system

- Whole system patent and leak free using 'two-bag' test
- Vaporisers – fitted correctly, filled, leak free, plugged in (if necessary)
- Soda lime - colour checked
- Alternative systems (Bain, T-piece) – checked
- Correct gas outlet selected

Ventilator

- Working and configured correctly

Scavenging

- Working and configured correctly

Monitors

- Working and configured correctly
- Alarms limits and volumes set

Airway equipment

- Full range required, working, with spares

RECORD THIS CHECK IN THE PATIENT RECORD

Don't Forget!

- Self-inflating bag
- Common gas outlet
- Difficult airway equipment
- Resuscitation equipment
- TIVA and/or other infusion equipment

This guideline is not a standard of medical care. The ultimate judgement with regard to a particular clinical procedure or treatment plan must be made by the clinician in the light of the clinical data presented and the diagnostic and treatment options available.

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CHECKS BEFORE EACH CASE

Breathing system

Whole system patent and leak free using 'two-bag' test
Vaporisers – fitted correctly, filled, leak free, plugged in (if necessary)
Alternative systems (Bain, T-piece) – checked
Correct gas outlet selected

Ventilator

Working and configured correctly

Airway equipment

Full range required, working, with spares

Suction

Clean and working

ONE LINERS

Medicines and Healthcare products Regulatory Agency

MHRA

Issued July 2012

ALL medical devices can fail but an increasing number of incidents that result in significant morbidity or mortality arise out of user error or because of poor practices. This edition highlights common issues in anaesthetic and respiratory device use in an attempt to make users more aware of what can go wrong – it is all too easy to take equipment for granted.

Keep your back covered?

The MHRA is aware of vaporizer leaks due to misplacement on the backbar of the anaesthetic machine.

Ensure that vaporizers are correctly seated on the backbar. Before the induction of anaesthesia the machine must be tested for leaks in accordance with the manufacturer's instructions and the Association of Anaesthetists of Great Britain and Ireland (AAGBI) guidelines.

Bag for life!

The MHRA is aware of reports of re-usable manual resuscitators being misassembled after cleaning.

These devices must only be cleaned and reassembled by appropriately trained staff following the manufacturer's instructions. After cleaning, the resuscitators must be fully checked for correct operation before patient use.

sHaME!

The MHRA is aware of ineffective patient ventilation if breathing system filters, heat and moisture exchangers (HMEs) or heat and moisture exchanging filters (HMEFs) become occluded.

Ensure that filters, HMEs and HMEFs are correctly positioned in the breathing system following the manufacturer's instructions for use. Staff should be aware that occlusion of the filter, HME or HMEF increases the resistance to airflow, resulting in increased airway pressures. Airway pressures should be monitored during use and the filter, HME or HMEF changed as necessary.

Silence of the Alarms

We have received reports of misunderstanding of the alarm operation in older models of ventilators. Older models may not issue an audible alarm if a second high priority alarm condition

Users must ensure that alarms are set appropriately and that they are fully aware of the ventilator's alarm system configuration.

occurs when the alarm has already been

Under pressure

sHaME!

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Ensure that filters, HMEs and HMEFs are correctly positioned in the breathing system following the manufacturer's instructions for use. Staff should be aware that occlusion of the filter, HME or HMEF increases the resistance to airflow, resulting in increased airway pressures. Airway pressures should be monitored during use and the filter, HME or HMEF changed as necessary.

Under pressure

The MHRA is aware of reports of incorrectly assembled respiratory therapy devices, where an expiratory pathway was not provided, resulting in the build-up of excessive pressures causing lung injury.

Ensure that the manufacturer's instructions for use are followed, whenever respiratory therapy devices are connected to endotracheal or tracheostomy tubes. Staff must ensure there is free passage of expired gases.

Silence of the Alarms

We have received reports of misunderstanding of the alarm operation in older models of ventilators.

Older models may not issue an audible alarm if a second high priority alarm condition

occurs when the alarm has already been silenced for two minutes. New models made to modern standards will alarm if a second high priority condition occurs.

Users must ensure that alarms are set appropriately and that they are fully aware of the ventilator's alarm system configuration.

ShockERR

The MHRA received a report of the power cable being damaged when caught between the anaesthetic machine and its monitor arm, resulting in power loss to the anaesthetic machine.

Users must ensure the power cables are free from any danger of entrapment; special care is required when the machine is plugged into an overhead beam.

following the manufacturer's instructions. After cleaning, the resuscitators must be fully checked for correct operation before patient use.

The One Liners editions are published by the MHRA, an executive agency of the Department of Health. Adverse incidents should be reported at the earliest opportunity. We prefer to receive reports via the online reporting system on our website www.mhra.gov.uk

You may also use this online system to send an email copy of your report to your medical device liaison officer.

We also have an adverse incident hotline: 020 3080 7080. You can find detailed reporting guidance on our website.

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