Anaesthesia machine

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Anesthesia machine

- An anesthesia machine is a vital piece of equipment used in medical settings to administer anesthesia to patients during surgical procedures. It allows anesthesiologists to precisely control the delivery of gases (such as oxygen, nitrous oxide, and volatile anesthetic agents) to keep patients unconscious, pain-free, and stable throughout surgery.

Purposes of anaesthesia machine

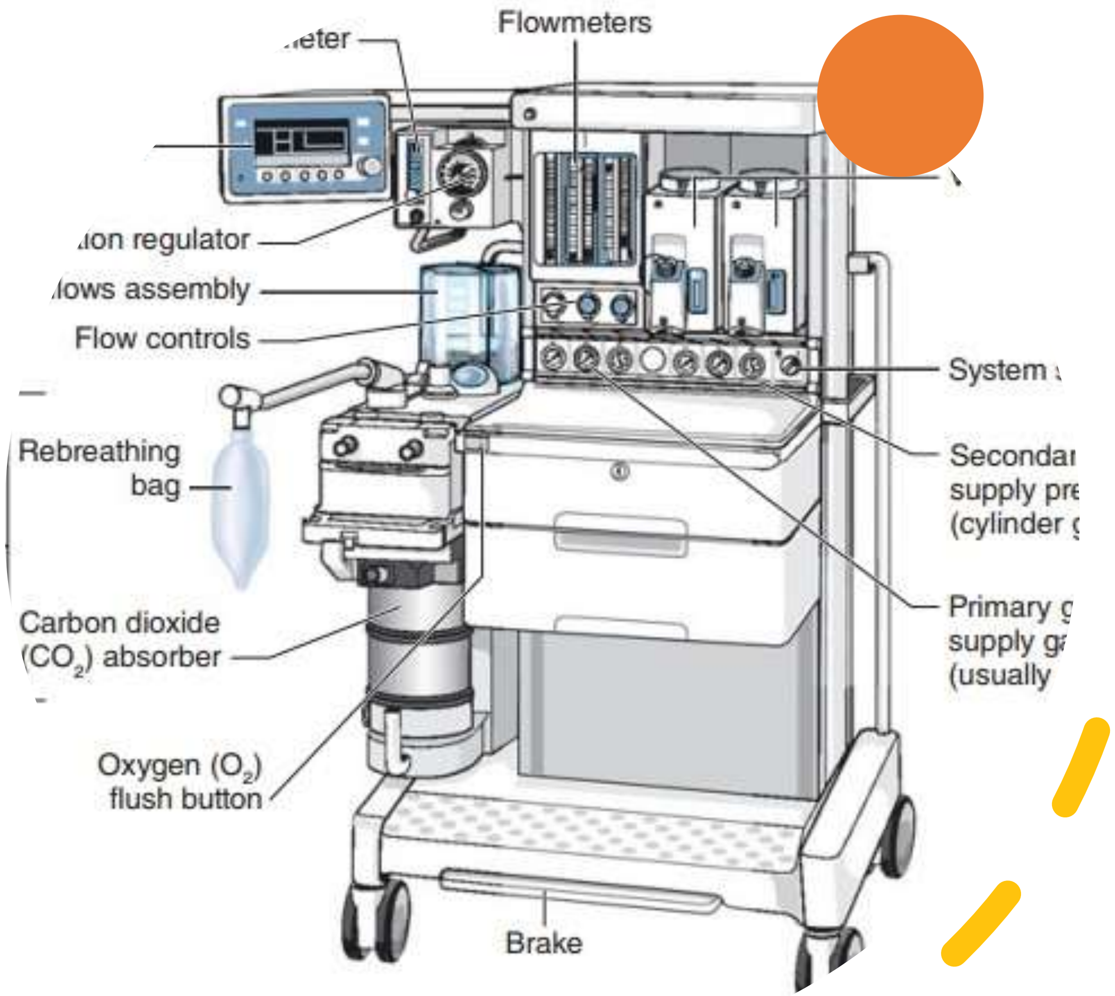
Provides oxygen

Accurately mixes anaesthetic gases & vapours

Enables patient ventilation

Minimizes anaesthesia related risks to patients & staff

- These machines typically consist of several components:
- **Gas Sources:** These machines connect to various gas sources, including oxygen, nitrous oxide, and sometimes compressed air.
- **Vaporizers:** These devices control the concentration of volatile anesthetic agents mixed with the carrier gases, ensuring accurate delivery to the patient.
- **Breathing Circuit:** A system of tubes and valves that delivers the gases from the machine to the patient's airways, often connected to a breathing mask or an endotracheal tube.
- **Ventilator:** Some anesthesia machines have integrated ventilators to assist the patient's breathing during the procedure.
- **Monitoring Equipment:** Anesthesia machines often include monitors for vital signs like oxygen saturation, blood pressure, heart rate, and respiratory rate.
- **Safety Features:** These machines have safety mechanisms to prevent over-administration of gases or other issues that might endanger the patient.

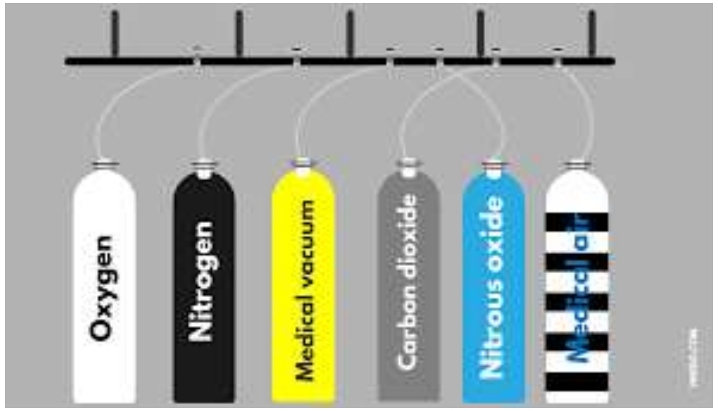


Type of anesthesia machines

continuous Flow Anesthesia Machines: These are the traditional types that provide a continuous flow of gases to the patient. They're characterized by their reliability and steady gas delivery.

Intermittent Flow Anesthesia Machines (IFAMs): are a specialized type of anesthesia delivery system designed to provide controlled intermittent flow of gases to the patient during surgical procedures.

Unlike continuous flow machines, which deliver a constant flow of gases, IFAMs are equipped to deliver gas only during the patient's inhalation phase. They operate using a demand valve mechanism that triggers gas delivery when the patient initiates a breath. This mechanism helps conserve anesthetic gases and oxygen since the flow is synchronized with the patient's breathing

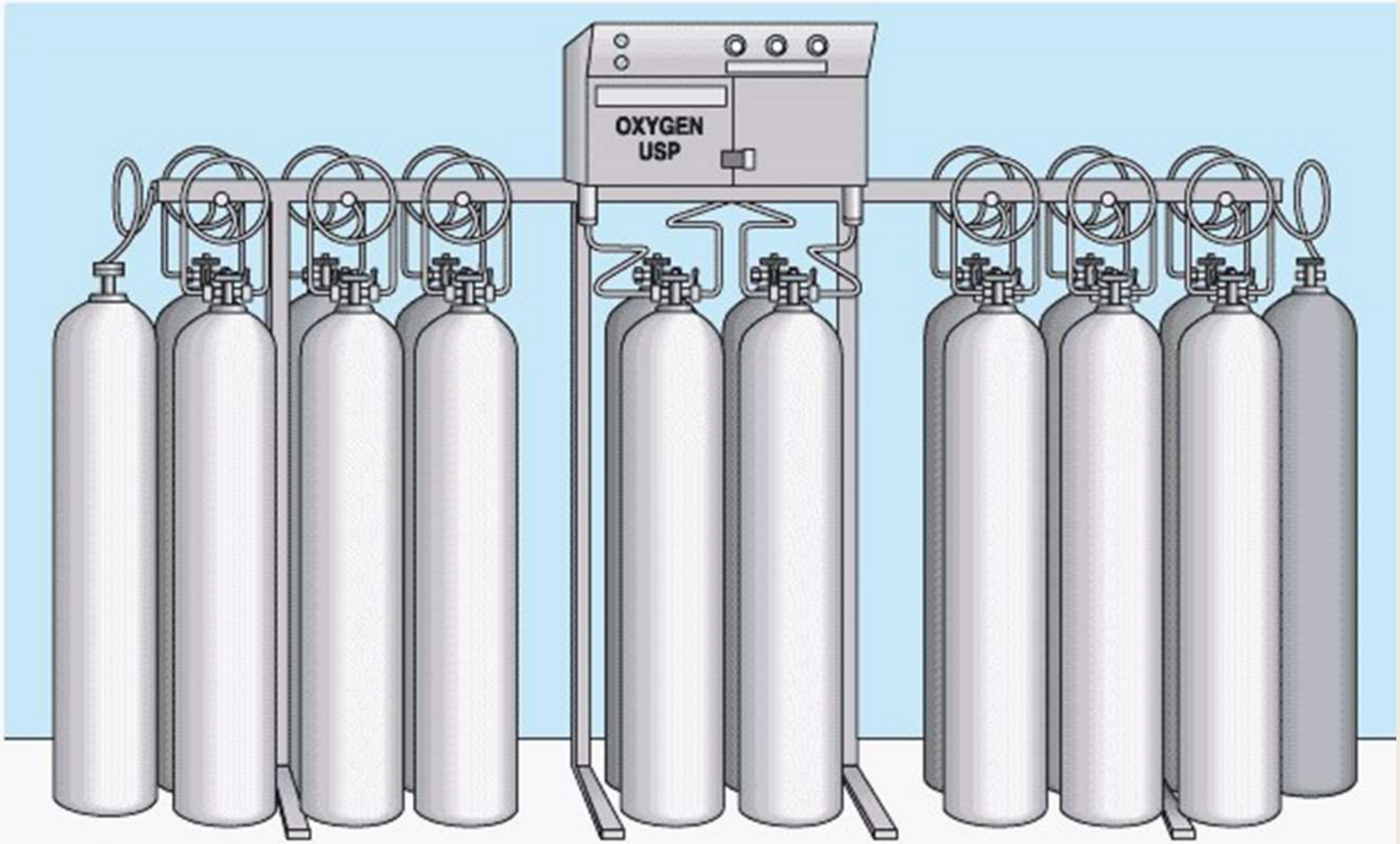


Medical gases

- Medical gases are crucial elements used in various healthcare settings for diagnostic, therapeutic, and life-support purposes. These gases play essential roles in patient care, surgery, emergency medicine, and other medical procedures. Some common medical gases include:

- **Oxygen (O2):** Perhaps the most fundamental medical gas, oxygen is vital for sustaining life. It's used in various treatments, from aiding respiration to supporting patients with respiratory conditions or during surgery.
- **Nitrous Oxide (N2O):** Known as laughing gas, nitrous oxide is often used as an anesthetic agent in dental procedures and certain minor surgeries. It has both anesthetic and analgesic properties.
- **Medical Air:** This is a mixture of oxygen and nitrogen used for various purposes, such as operating pneumatic surgical tools, ventilating patients, and diluting certain medical gases.

Gas	E-Cylinder Capacity[1] (L)	H-Cylinder Capacity[1] (L)	Pressure[1] (psig at 20 °C)	Color (USA)	Color (international)	Form
O_2	625-700	6000-8000	1800-2200	Green	White	Gas
Air	625-700	6000-8000	1800-2200	Yellow	White and black	Gas
N_2O	1590	15,900	745	Blue	Blue	Liquid



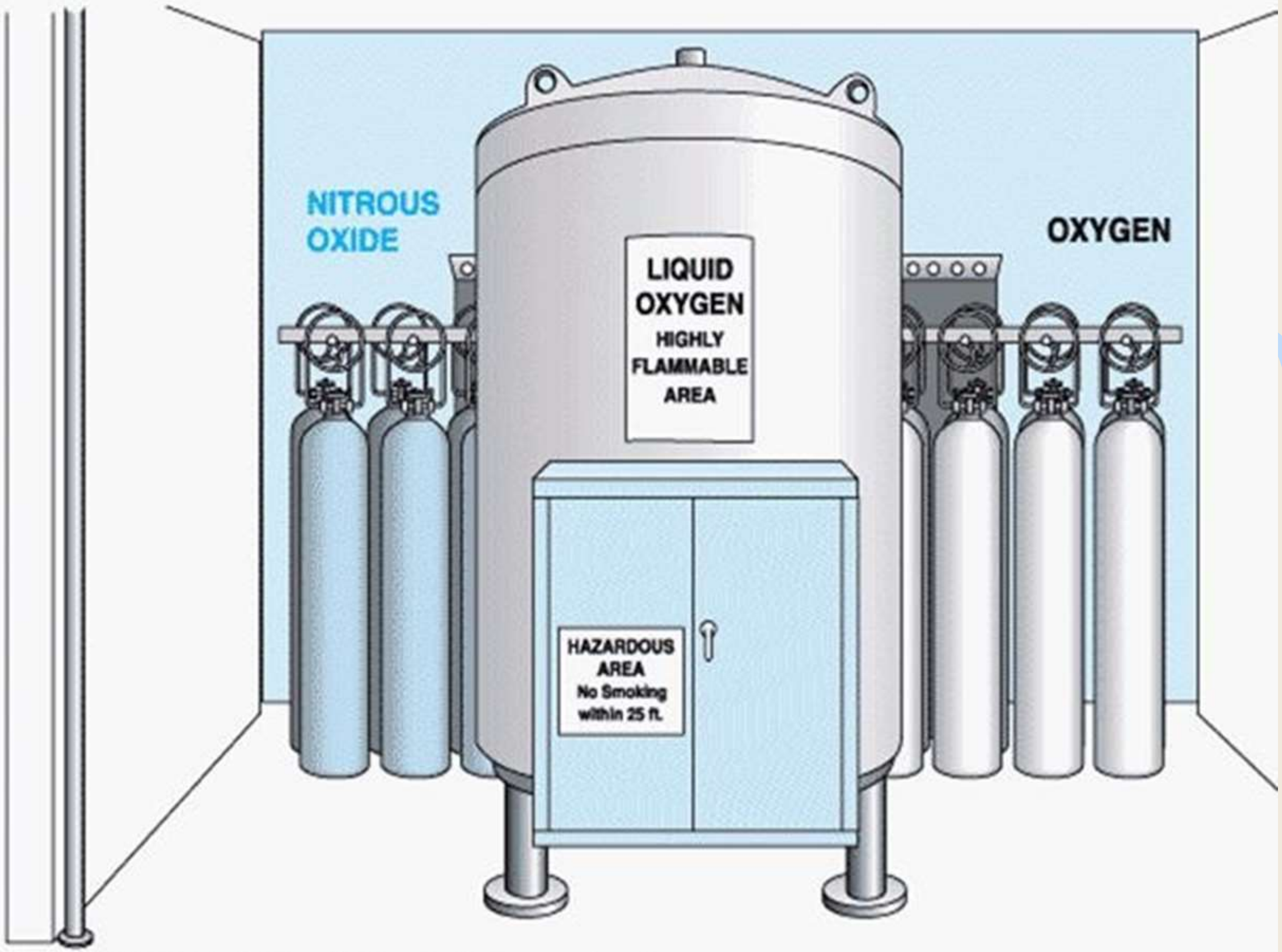
A bank of oxygen H-cylinders connected by a manifold.

Pipelines

Medical gases are delivered from their central supply source to the operating room through a piping network.

The tubing is ***colour-coded*** and connects to the anaesthesia machine through a non-interchangeable ***diameter-index safety system (DISS)*** fitting that prevents incorrect hose attachment.

The anaesthetist should check that the pipeline pressure displayed on the anaesthetic machine should indicate 400 kPa.



A liquid storage tank with reserve oxygen tanks in background.

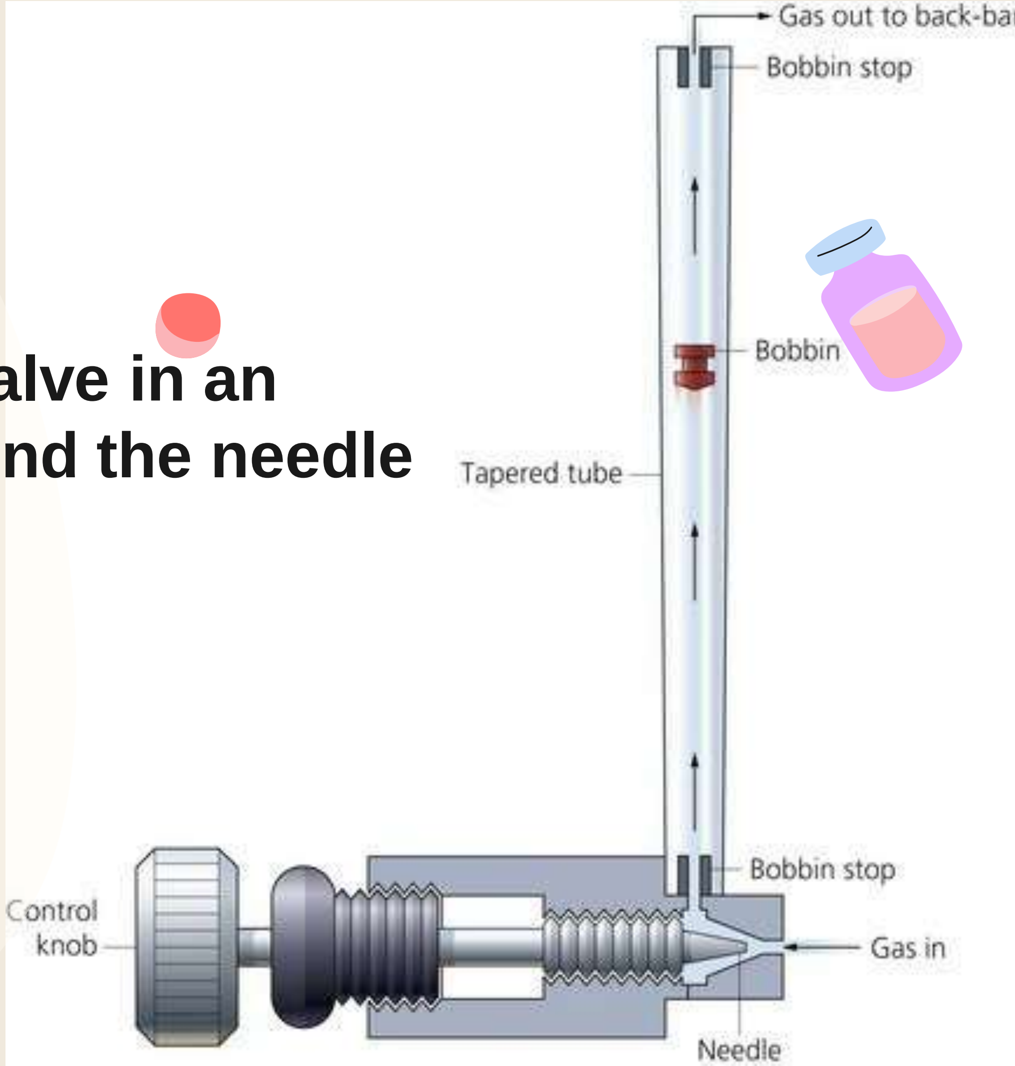
Flowmeters and gas flow regulation

Valves:

- Needle valves (for flow control).

As the valve is opened (by turning the valve in an anticlockwise direction), the orifice around the needle becomes larger and flow increases.

Flow control knobs



Flow control (needle) valve and flowmeter

Flowmeters

- Tapered glass tube containing a bobbin or ball, which floats on the stream of moving gas, to indicate the flow rate of the gas passing through them.
- Flowmeters are specifically constructed for each gas, since the flow rate depends on both the viscosity and density of the gas.
- Inaccuracy in flowmeters are due to:

- The tube not being vertical.

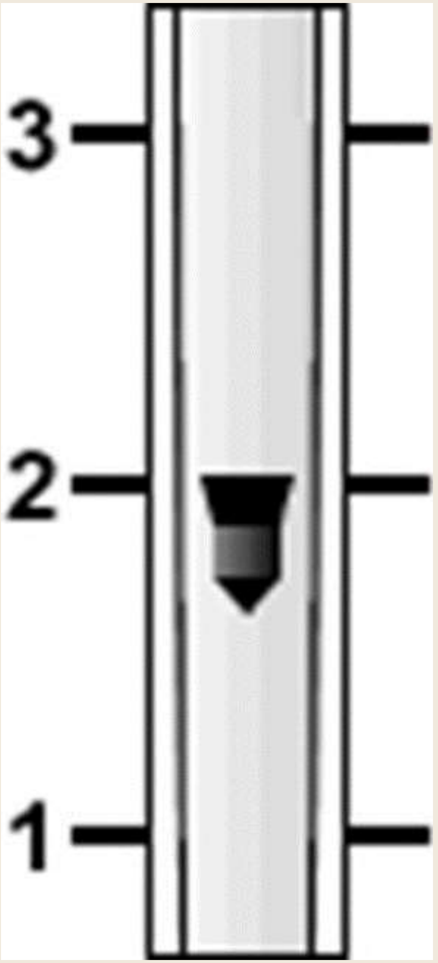
- Back-pressure, from for example, a ventilator.

- Static electricity causing the float to stick to the tube.

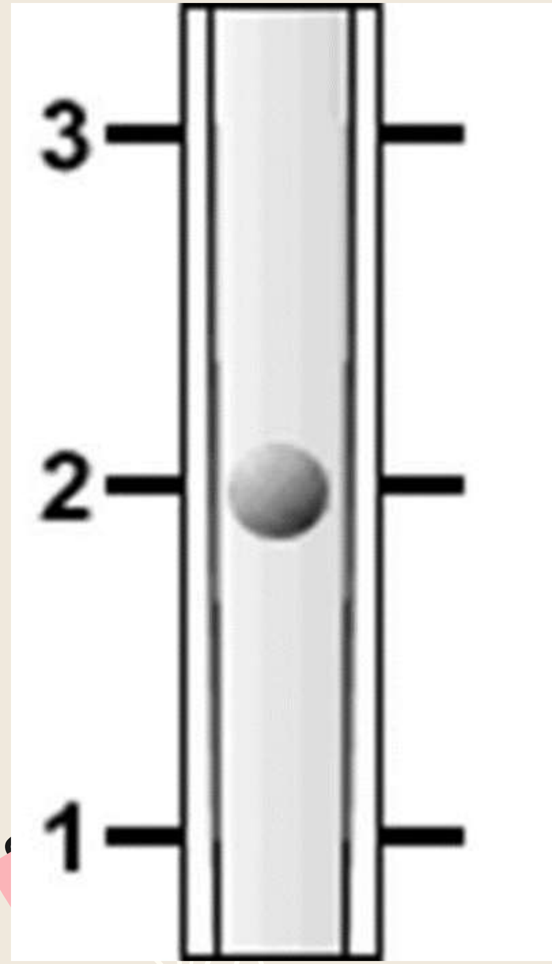
- Dirt causing the float to stick to the tube


O_2
N_2O

Bobbins and balls



Bobbin flowmeter, reading 2 L/min



Ball-float flowmeter, reading 2 L/min

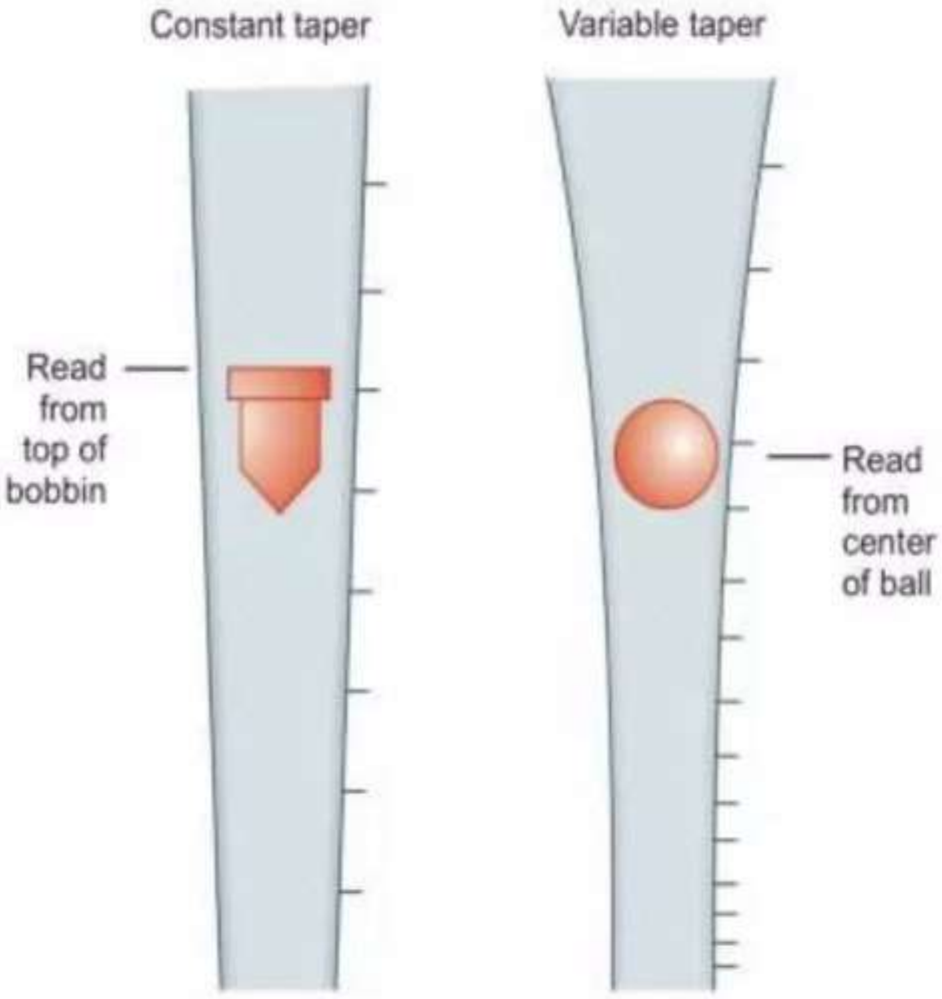


Fig. 7 Rotameters with bobbins

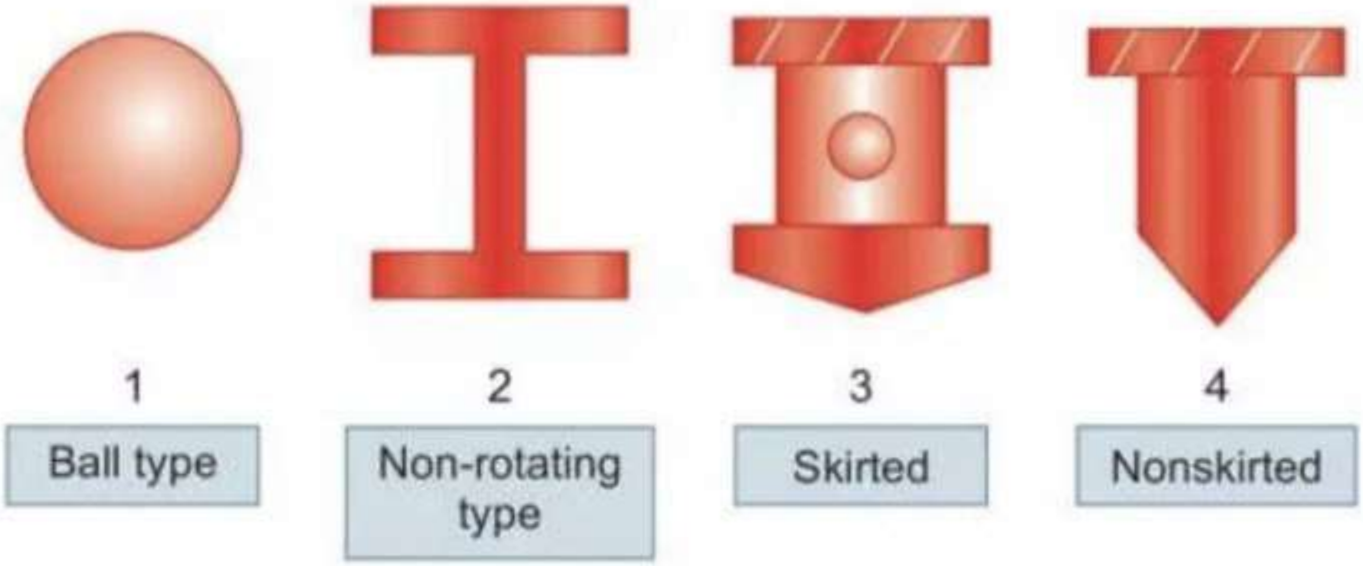
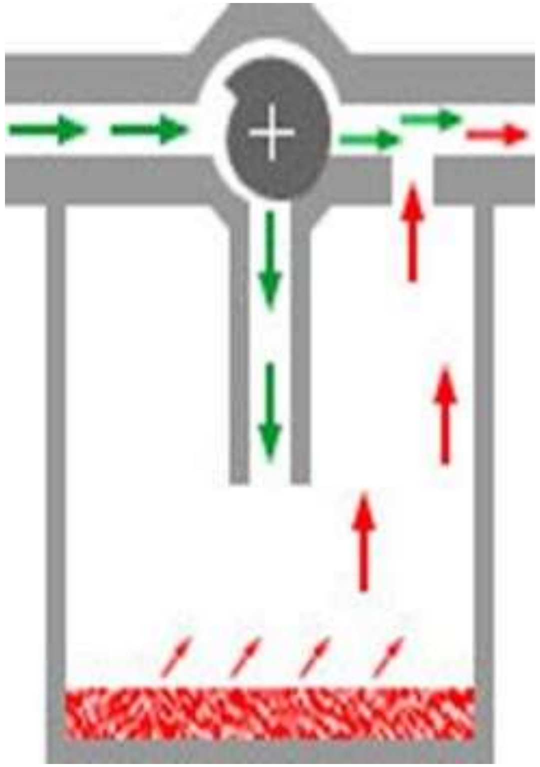


Fig. 8 Reading a flowmeter and different types of bobbins

Vapourisers



The purpose of an anaesthetic vaporiser is to produce a controlled and predictable concentration of anaesthetic vapour in the carrier gas passing through the vaporiser.

Most vaporisers are of the plenum type, which consists of a vaporising chamber containing the liquid anaesthetic, and a bypass.

Gas passing through the vaporising chamber volatilises the anaesthetic and is then mixed with the anaesthetic-free gas bypassing the chamber, the proportion of vapour-containing gas and bypass gas being controlled by a tap.


Tec 7
SEV
Tec 7
ISO
Tec 7
HAL

Factors affecting vaporiser output

Flow through the vaporising chamber

Efficiency of vaporization

Temperature Time

Gas flow rate

Carrier gas composition

Ambient pressure

Breathing Circuits

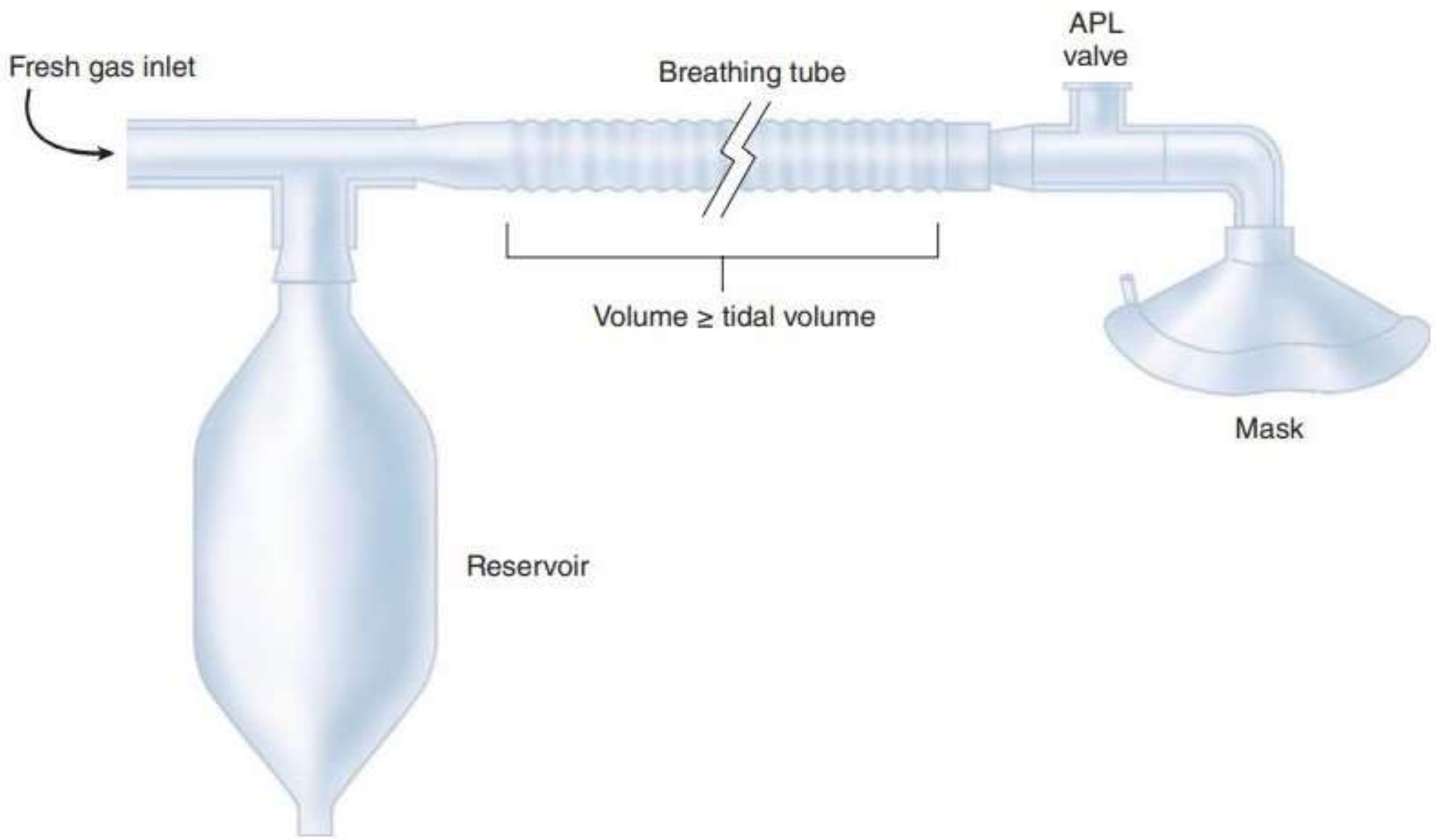
Breathing circuits link the patient to the anaesthesia machine. Therefore, The function of the circuit is to; deliver Oxygen and anaesthetic gases to the patient, providing humidity and warmness to inspired gases, and to eliminate Carbon Dioxide.

Types of Breathing Circuit:

- Mapleson's Circuits
- The Circle System

Mapleson's Circuits

- Mapleson first introduced a classification for anaesthetic circuits in 1954.
- Classified into 6 types (A, B, C, D, E, and F).
- The relative location of these components determines circuit performance and is the basis of the Mapleson's classification.
- It does not include systems with internal valves or soda lime (APL valve only so risk of rebreathing is present).
- Spontaneous ventilation vs controlled ventilation.
- A-D used in adults; E&F used in paediatrics
- The main goal is to assist respiration and prevent rebreathing.



Components:-

1. **Corrugated Breathing Tubes** made of either; rubber (reusable) or plastic (disposable) , this creates a low-resistance pathway and a potential reservoir for anesthetic gases.

2. **Fresh Gas Inlet (FGI)**

3. **Adjustable Pressure-Limiting Valve** (**APL** Valve, Pressure-Relief Valve, Pop-Off Valve) ; allows gases to exit the circuit as pressure rises.

4. **Waste-gas Scavenging System**; for exiting gases.

5. **Reservoir Bag (Breathing Bag)**; a reservoir for the anaesthetic gas, and a method for positive pressure ventilation.

6. **Patient Connection** (I.e., Face Mask)

Mapleson's A (Magill Circuit)

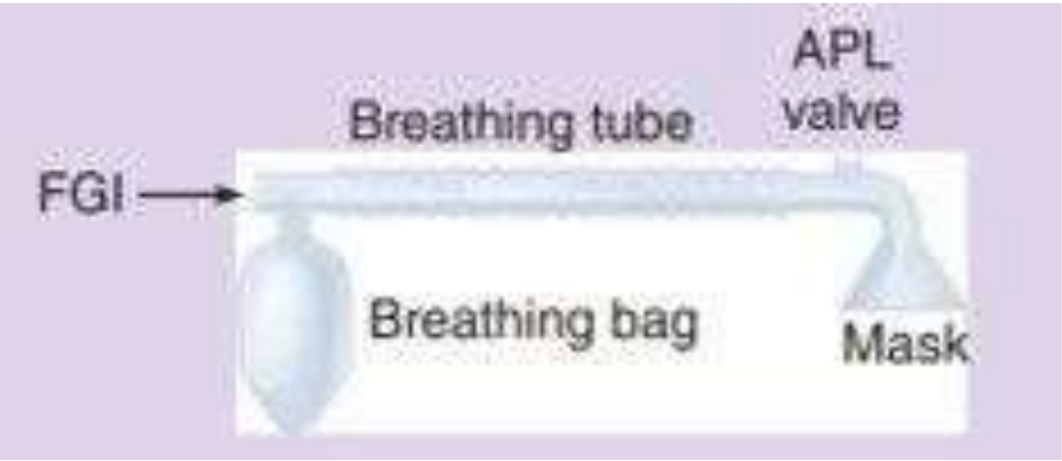
FGI is near reservoir bag, APL valve is near face mask.

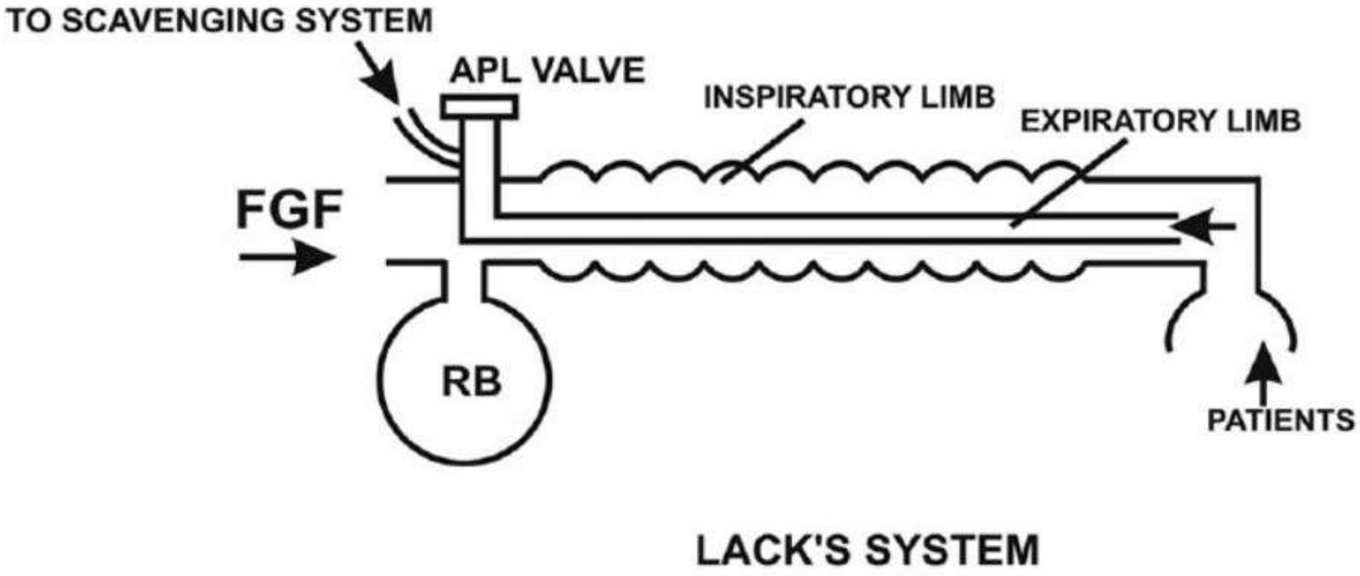
The most efficient Mapleson's circuit for **spontaneous ventilation.**

Poor choice during controlled ventilation.

Enclosed Magill system is a modification that improves efficiency.

Coaxial Mapleson A modification (Lack's Circuit) provides waste gas scavenging.





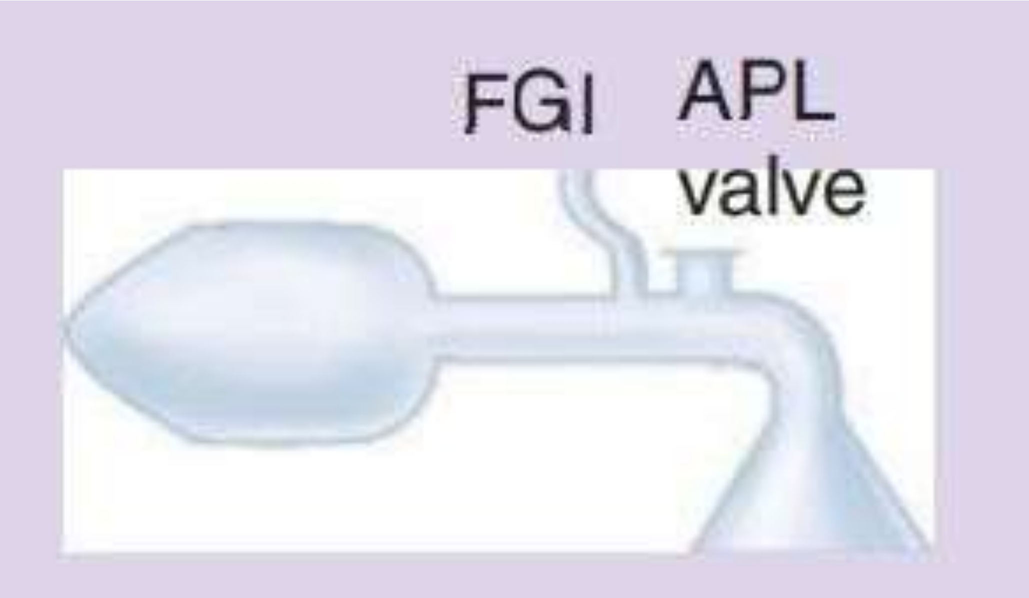
Mapleson's B

- FGI and APL valve are close to face mask (FGI being just distal to APL valve).
- Fresh gas flows are conveniently available because the FGI is near the APL valve.
- In order to prevent rebreathing fresh gas flow should be around 20-25L/min.
- Mapleson's A is more efficient.

Required Fresh Gas Flows	
Spontaneous	Controlled
2 × minute ventilation	2–2½ × minute ventilation

Mapleson's C (Waters' to-and-fro)

- Similar to Mapleson's B, but it has a shorter breathing tube.
- It does not have a corrugated tube.



Required Fresh Gas Flows	
Spontaneous	Controlled
2 × minute ventilation	2–2½ × minute ventilation

Mapleson's D

- Interchanging the position of APL and FGI transforms Mapleson's A into D.
- It is efficient during **controlled ventilation**; since fresh gas flow forces alveolar air away from the patient and toward the APL valve. This alters the fresh gas requirements.
- It is also modified into Bain circuit.

Required Fresh Gas Flows	
Spontaneous	Controlled
2–3 × minute ventilation	1–2 × minute ventilation

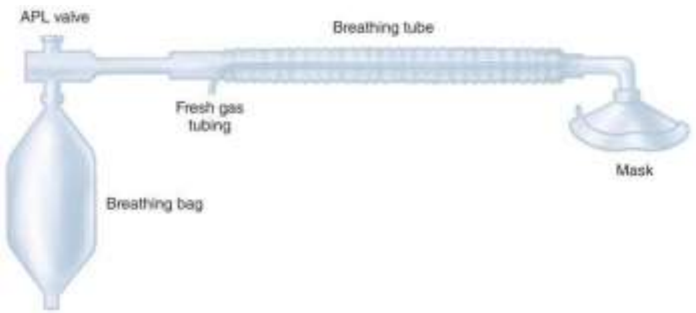
Bain Circuit

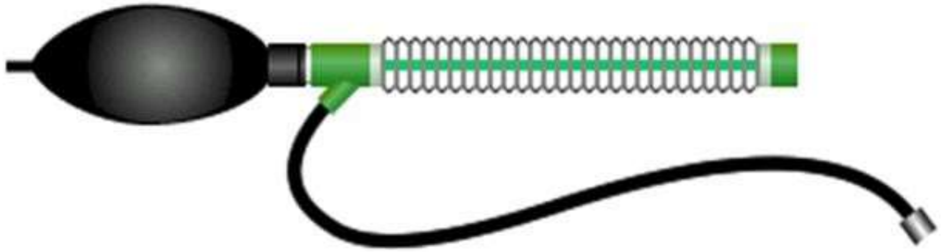
It is a popular modification of the Mapleson's D system.

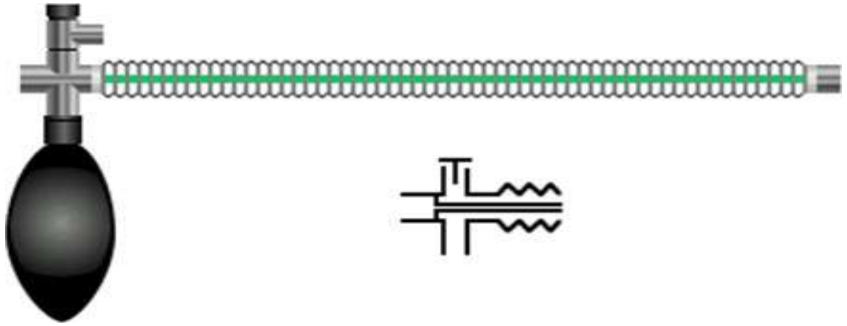
A coaxial version of the Mapleson's D system that incorporates the FGI tubing inside the breathing tube.

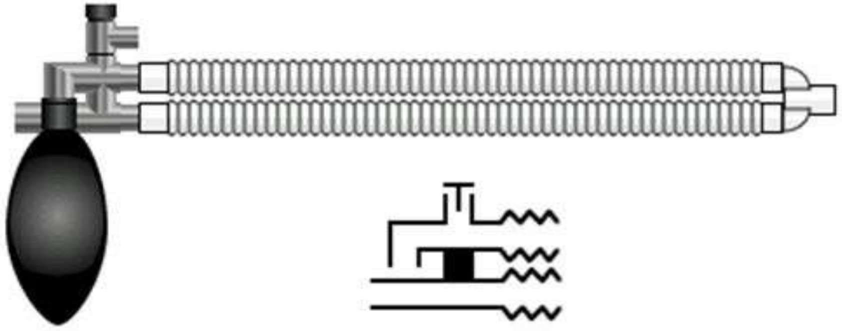
This decreases circuit's bulk and retains efficiently the heat and humidity (inspired gas is warmed by the expired gas).

Disadvantage: the possibility of kinking or disconnection of FGI tube.









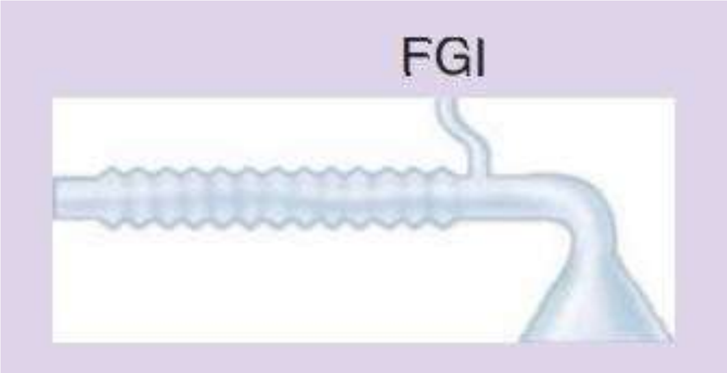
Mapleson's E (Ayre’s T-piece)

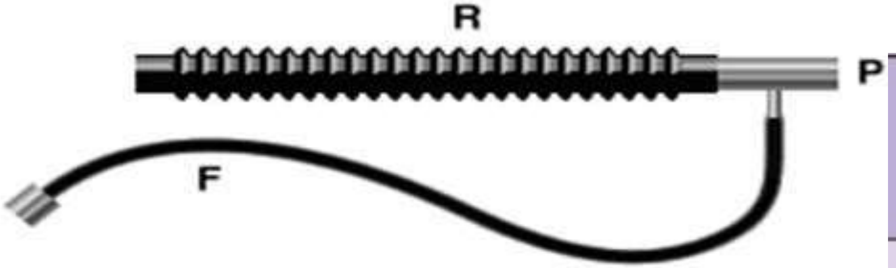
Does not have an APL valve nor a Reservoir bag. FGI is near to patient's mask.

Exhalation tubing should provide a larger volume than tidal volume to prevent rebreathing. Scavenging is difficult.

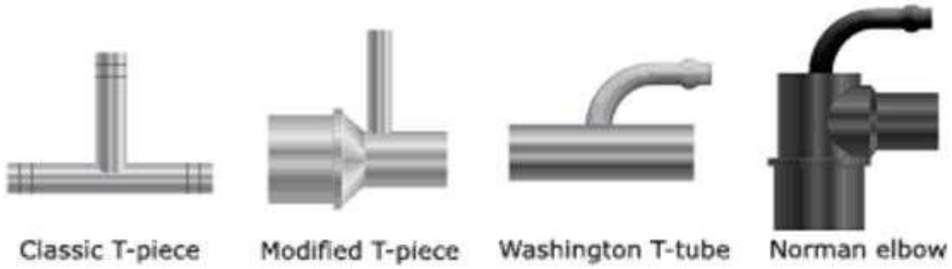
Not good for spontaneous breathing.

Used for pediatric patients weighted up to 30 Kg.





Required Fresh Gas Flows	
Spontaneous	Controlled
2–3 × minute ventilation	3 × minute ventilation (I:E-1:2)



Mapleson's F (Jackson-Rees’ modification)

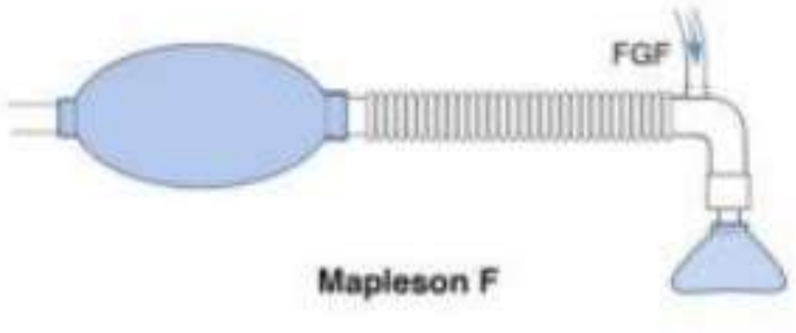
It is a Mapleson E with an open-ended reservoir bag connected to the end of the breathing tube (operator end) , it allows **controlled ventilation** and **scavenging**.

Does not have an APL valve.

Requires higher fresh gas flow.

Not good for spontaneous breathing.

Required Fresh Gas Flows	
Spontaneous	Controlled
2–3 × minute ventilation	2 × minute ventilation



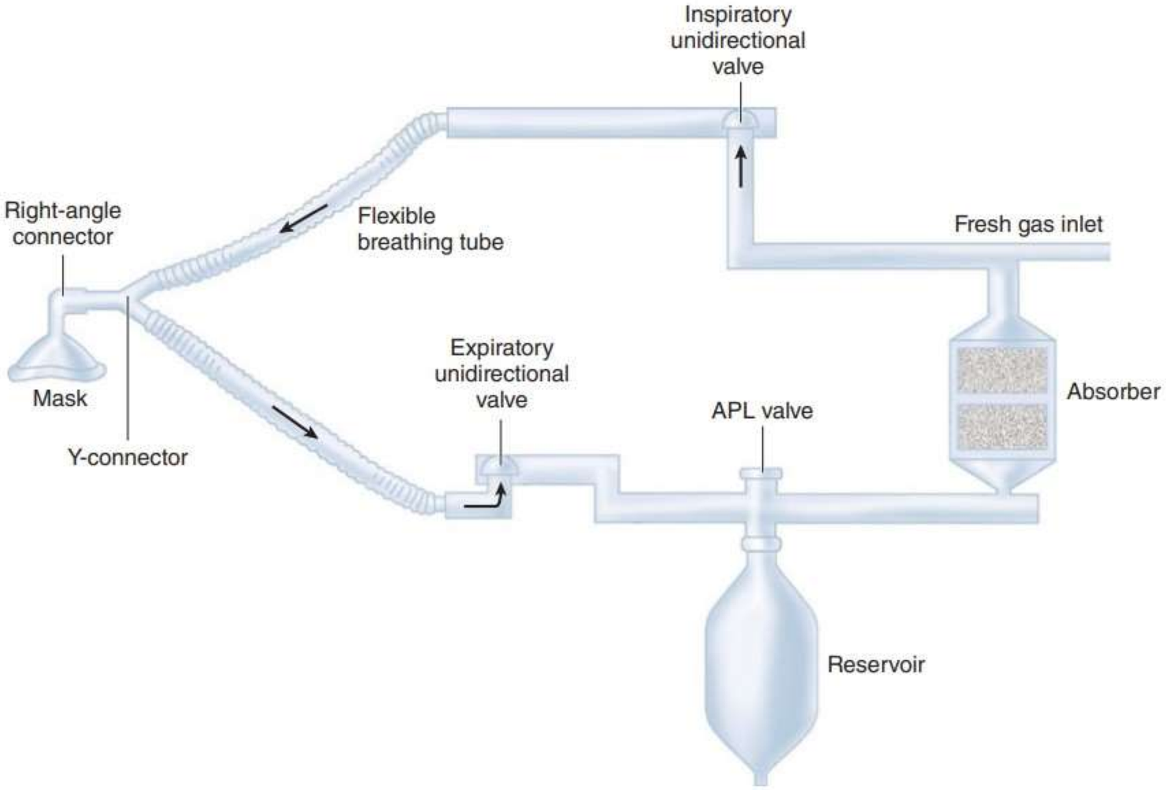
	FGI , APL	Controlled or spontaneous	Adult or pediatric	Modification
Mapleson's A (Magill Circuit)	FGI is near reservoir bag, APL valve is near face mask	most efficient for spontaneous Poorest for controlled	Adult	1. Enclosed Magill system 2. Coaxial (Lack's Circuit) provides scavenging
Mapleson's B	• FGI and APL valve are close to face mask • Mapleson's A is more efficient		Adult	
Mapleson's C (Waters' to-and-fro)	• Similar to Mapleson's B, but it has a shorter breathing tube. • It does not have a corrugated tube		Adult	

	FGI , APL	Controlled or spontaneous	Adult or pediatric	Modification
Mapleson's D	Opposite of A	Most efficient circuit for controlled ventilation	Adult	modified into Bain circuit
Mapleson's E (Ayre's T-piece)	Does not have an APL valve nor a Reservoir bag. FGI is near to patient's mask.	Not good for spontaneous breathing	pediatric	
Mapleson's F (Jackson-Rees' modification)	Same as E + there is Reservoir bag.	allows controlled ventilation and scavenging	pediatric	

The Circle System

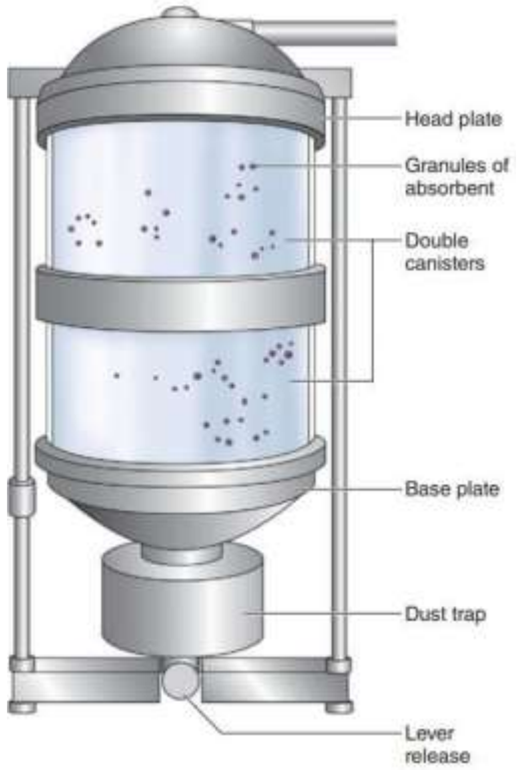
The **Circle System** aids the breathing system by avoiding the problems that are caused the Mapleson's circuits (as; waste of anaesthetic agent, pollution of the Operating Room, loss of patient's heat and humidity) and this is achieved by adding components to the breathing system, as:

- CO_2 Absorber & Absorbent
- FGI
- Unidirectional Valves; Inspiratory & Expira
- Breathing tubes; Inspiratory & Expiratory
- Y-shaped connector
- APL Valve
- Reservoir Bag
- Right angle (90°) connector
- Ventilation Mask

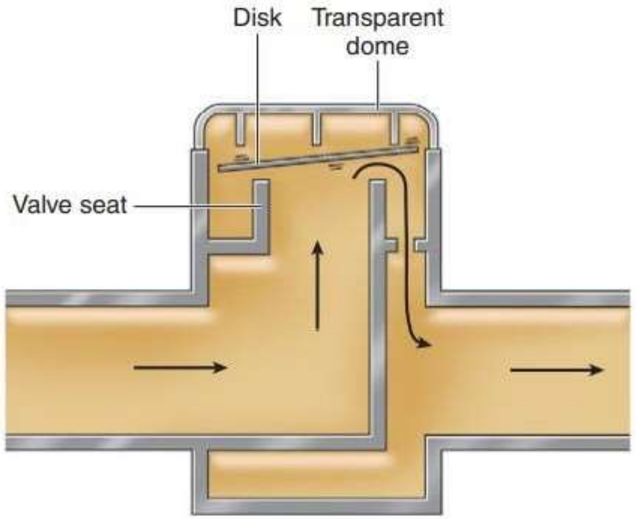


Carbon Dioxide Absorbent: to avoid hypercapnia upon rebreathing alveolar gas (reserves heat and humidity).

Soda Lime (more common) and Barium Hydroxide Lime are known absorbents.

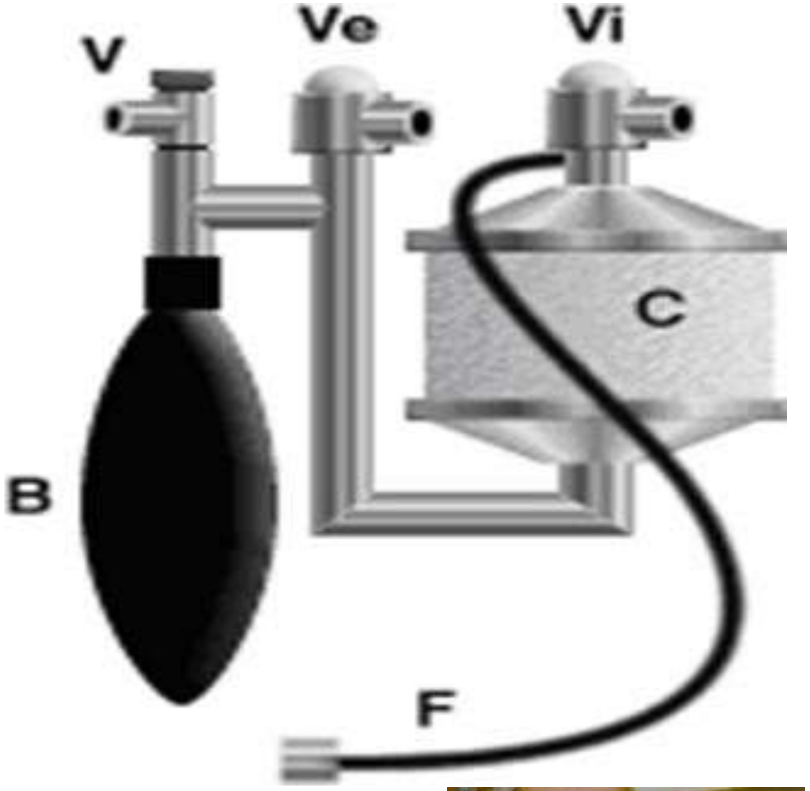


Unidirectional Valves: contains a ceramic or mica disk resting horizontal on an annular valve seat, this prevents reflux of gas in the circuit.



The essential features of the circle absorber are:

- Carbon dioxide absorber canister (C)
- Breathing bag (B)
- Unidirectional inspiratory (Vi) valve
- Unidirectional expiratory (Ve) valve
- Fresh gas supply (F)
- Pressure-relief valve (V)



- **N.B.**

  * The breathing system most used with anaesthesia machines is the **Circle System**.

  * **Bain circuit** is occasionally used.

Mechanical Ventilation

Ventilators generate gas flow by creating a pressure gradient between the proximal airway and the alveoli.

All modern anaesthesia machines are equipped with a ventilator, and they usually have the double circuit system design (Pneumatically powered and electronically controlled).

Older units relied on the generation of negative pressure around and inside the chest (e.g., iron lungs), whereas modern ventilators generate positive pressure and gas flow in the upper airway.

Types:-

- Positive Pressure Ventilators
- Negative Pressure Ventilators

Positive Pressure Ventilators

The lungs are intermittently inflated by positive pressure generated by a ventilator, and gas flow is delivered to the airway.

Able to use endotracheal or tracheostomy tube.

Volume-cycled ventilation

The ventilator delivers a pre-set tidal volume regardless of the pressure generated.

Pressure-pre-set ventilation

The ventilator delivers a pre-set target pressure to the airway during inspiration. The resulting tidal volume delivered is therefore determined by the lung compliance and the airway resistance.

Negative Pressure Ventilators (Iron Lungs)

Applied negative pressure around the body or thoracic cavity; the body of the patient is enclosed in an iron box or cylinder, and the patient's head protruded out of the end.

Humidification

Prevention of cilial damage and reduced drying of secretions.

As prolonged severe dehydration of the bronchial tree leads to encrustation of mucus and bronchial or endotracheal obstruction, particularly in neonates and patients with respiratory infection.

Humidifiers added to the breathing circuit minimize water and heat loss.

Prolonged humidification of gases by the lower respiratory tract leads to dehydration of mucosa, altered ciliary function, and, if excessively prolonged, could potentially lead to inspissation of secretions, atelectasis, and even ventilation/perfusion mismatching, particularly in patients with underlying lung disease.

Types:-

Passive: The simplest designs are condenser humidifiers or heat and moisture exchanger (HME) units. They do not add heat or vapor but rather traps exhaled humidification and heat, which is released upon the subsequent inhalation.

Active: More effective in preserving moisture and heat. They add water to gas, by;

- passing the gas over a water chamber (pass-over humidifier)
- saturated wick (wick humidifier)
- bubbling through water (bubble-through humidifier)
- mixing it with vaporized water (vapor-phase humidifier)

Disadvantages of Humidifiers

- Disconnection
- Overheating
- Overhydration
- Infection
- Circuit resistance
- Interference with other devices

Thank You