# ANAESTHESIA BREATHING CIRCUITS

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# Definition and functions

- Interface between anaesthesia machine and patient airway
- Conduit whereby fresh gas (oxygen, nitrous oxide or air, inhalation agent) is delivered to patient and carbon dioxide eliminated

# Respiratory physiology

- The function of breathing is to supply oxygen to the lungs (alveoli) for the blood to transport to the tissues and to remove carbon dioxide from the body.
- The volume of gas inspired and expired with each breath is the tidal volume (normally 6-10 ml/kg). Over 1 min is minute volume. ($V_t$ x f)
- The total volume of alveolar gas expired in a minute is the alveolar minute volume and contains about 5% of carbon dioxide
- The volume of gas in the lungs at the end of normal expiration is the Functional Residual Capacity (FRC) - for uptake of oxygen.

# Dead space

- Gas exchange occurs only at the level of the respiratory bronchiole and alveoli
- Dead space is area of lung that does not participate in gas exchange
- Anatomical dead space is respiratory passage down to respiratory bronchiole
- Alveolar dead space is alveoli which are ventilated but not perfused
- Physiological dead space is the total of anatomical and alveolar dead space

# Circuit functionality

- Circuit dead space is the volume gas from patient interface to the exhalation valve
- Circuit should not unduly increase dead space or work of breathing
- Carbon dioxide in circuit is mainly eliminated by high fresh gas flow in rebreathing circuits
- In the non-rebreathing circle circuit by the $CO_2$ absorber

# Breathing circuit: components

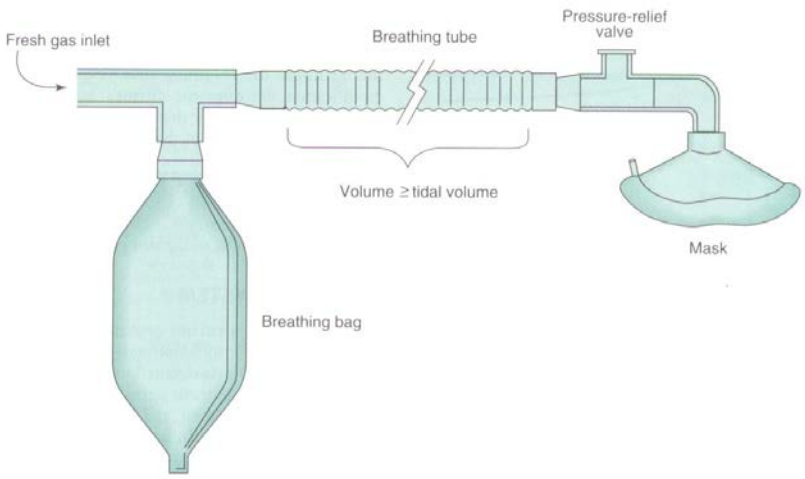
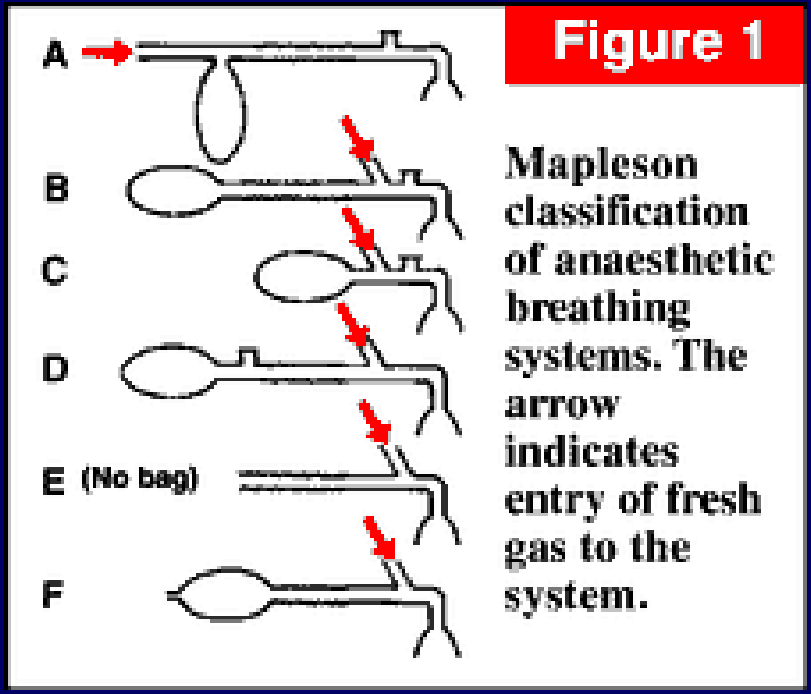



*Figure 3–4.* Components of a Mapleson circuit.

- Fresh gas flow (FGF) inlet
- Reservoir bag (2 liter)
- Corrugated tubing – 1 meter
- One-way pressure relief valve (Heidbrink) (APL valve)
- Elbow or straight connector to face mask or ET tube
- Breathing filter (passive humidification, bacterial and viral filter)

# Mapleson classification of rebreating circuits

- A = Magill system
- D = Bain system
- F = Jackson Rees
- ADE = Humphrey system



# Magill system

- Spontaneous breathing
- Re-breathing prevented by FGF = alveolar minute volume or 70 ml/kg
- Reservoir bag allows for peak Inspiratory flow (30 l/min)

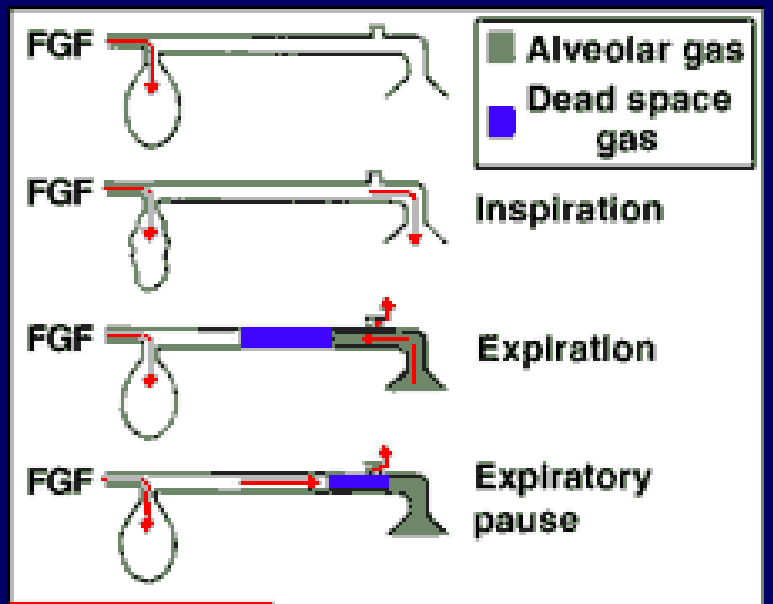



Figure 2 Mode of action of Magill attachment during spontaneous ventilation

# Bain system

- Controlled ventilation
- FGF at patient end
- Re-breathing prevented by FGF of 100 ml/kg during controlled ventilation
- Spontaneous ventilation ineffective – FGF 2.5 x minute volume

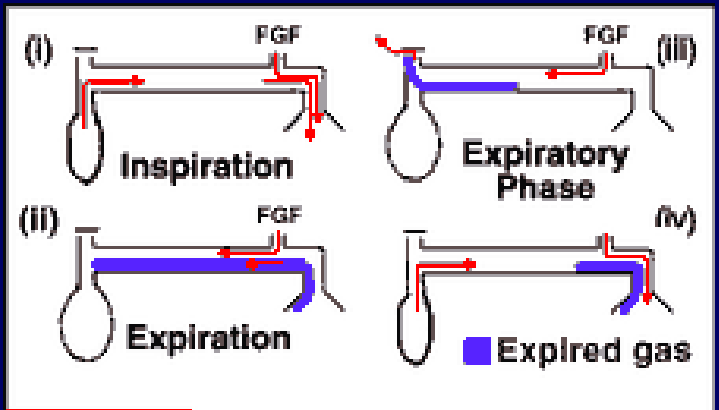



Figure 4 Mode of action of Mapleson D breathing system during spontaneous ventilation.

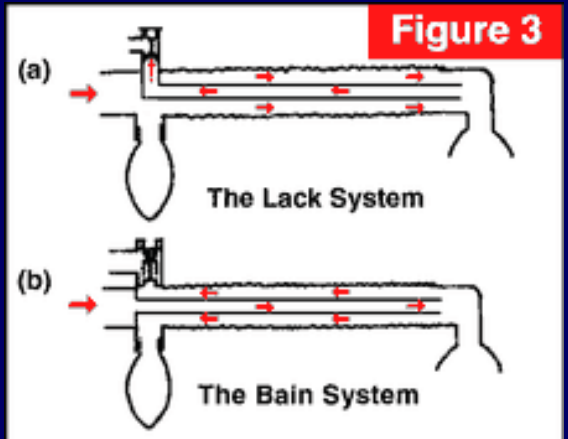
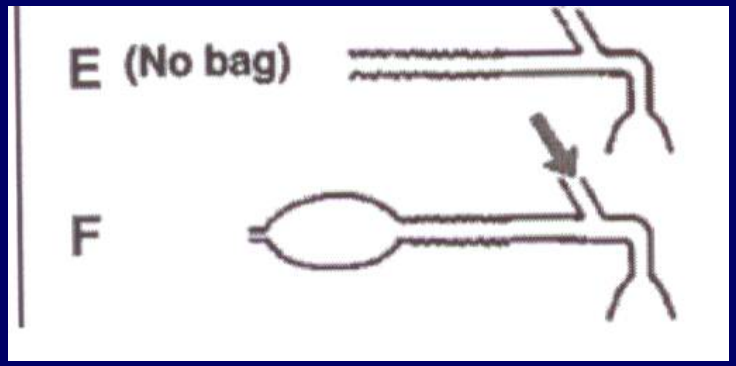



Figure 3 Coaxial anaesthetic breathing systems. (a) Lack system (Mapleson A). (b) Bain system (Mapleson D).

# Jackson Rees system




- Modification of Ayer's T-piece
- Added open-ended bag
- Valveless circuit
- Low resistance
- Paediatric anaesthesia < 20 Kg
- Allows spontaneous and controlled ventilation
- FGF 2.5 x minute volume

# Circle system (Non-rebreathing circuit)

- Differs from Mapleson circuits because of
  - Unidirectional valves
  - $CO_2$ Absorber
  - Allows re-circulation
- Components
  - FGF inlet
  - Reservoir bag
  - Unidirectional valves in inspiratory and expiratory limbs
  - Sodalime Absorber
  - APL valve

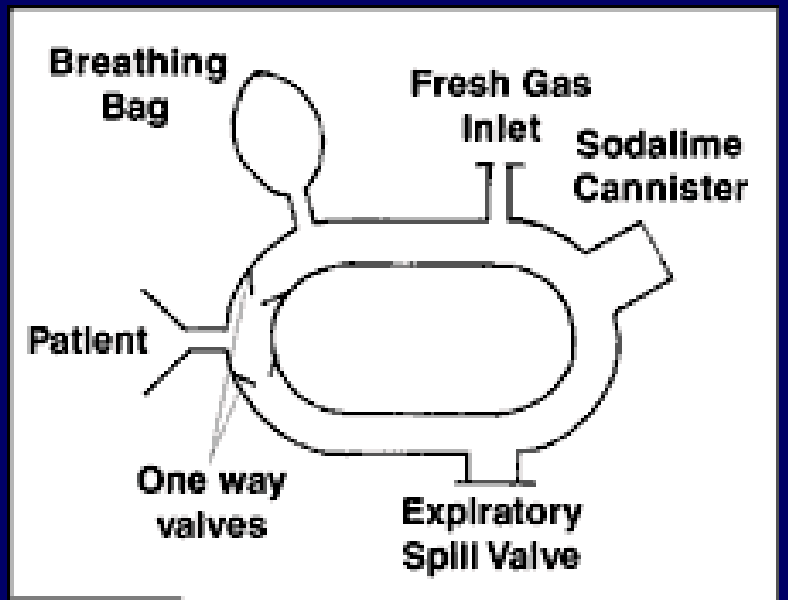



Fig. 6 Arrangement of circle system.

# Circle system

# Advantages of Circle system

- Very economical at low FG flows
- Decreased theatre pollution
- Conservation of heat and humidity
- Buffering of changes in inspired concentration
- Less danger of barotrauma
- Estimation of agent uptake and oxygen consumption

# Disadvantages of Circle

- More bulky, more complex with more connections
- Increased resistance
- Possibility of hypercarbia
- Accumulation of undesired gases in the circuit (if low flow < 1 l/min FGF is employed)
  - Carbon monoxide, acetone, methane, hydrogen, ethanol, anesthetic agent metabolites, argon, nitrogen
- Inability to quickly alter inspired concentrations with low FGF

# $CO_2$ elimination

- $CO_2$ absorber contains Sodalime granules
- Mixture of 94% calcium hydroxide, 5% sodium hydroxide and 1% potassium hydroxide, which reacts with $CO_2$ to form calcium carbonate, water and heat.
- Can absorb 23 liters of $CO_2$ per 100 gm absorbent
- Contains dye which changes colour as pH changes – indicates exhaustion of absorbent and when 75% of the soda lime has changed colour it should be replaced

# Key points

- Vaporizer always out of circle
- At start of anaesthesia nitrogen must be washed out – use 4 l/min FGF for 5 min.
- Then change to low flow – 1 l/min FGF or less.
- Use low flow <u>ONLY with gas analyzer</u> which continuously display $O_2$, $N_2O$ and inhalation concentration
- If FGF is < 1 l/min maintain $FiO_2 \geq 50\%$
- Without gas analyzer maintain FGF > 1.5 l/min

# VOC / VIC

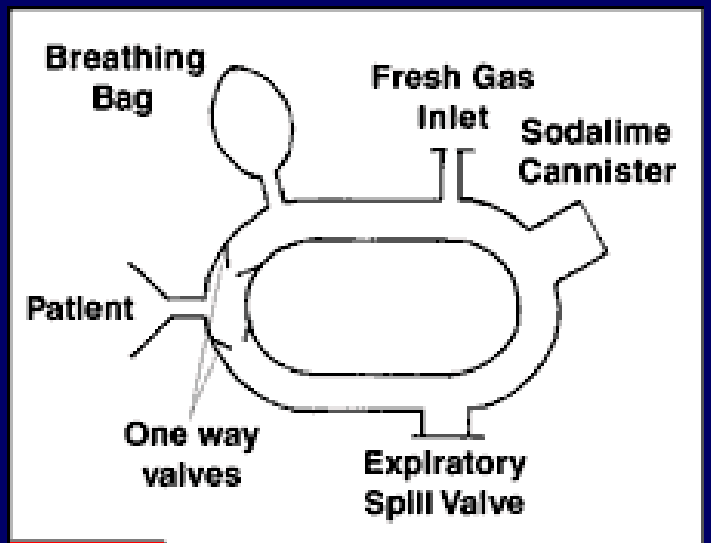
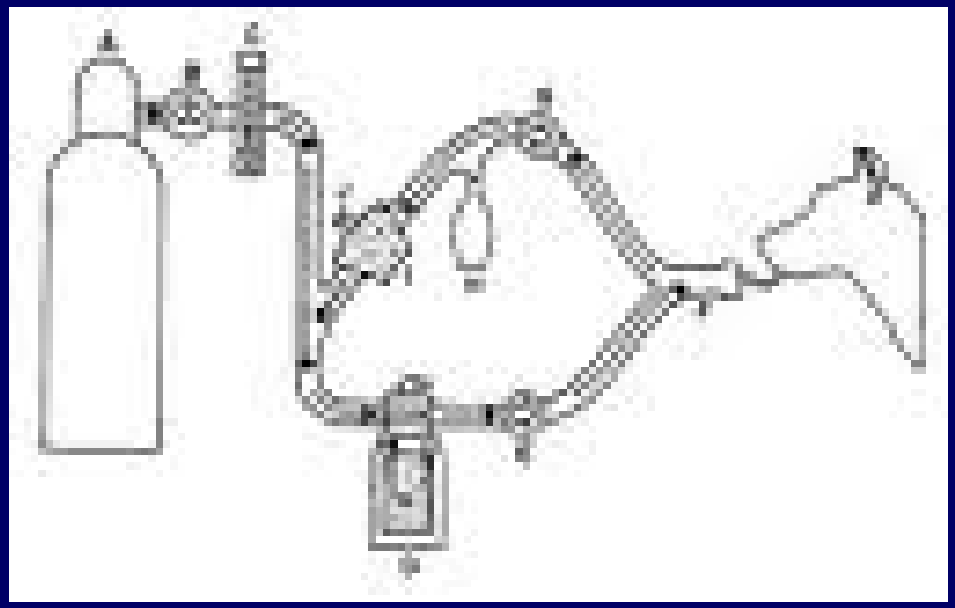



**Fig. 6** Arrangement of circle system.



# Bibliography


- Anaesthesiology – Study Guideline
- Clinical Anesthesiology
  - Morgan GE, Mikhail MS, Murray MJ and Larson CP – 3rd Edition