

## **Anesthetic Breathing system (breathing circuit)**

A breathing system is defined as an assembly of components, which connect the patient's airway to the anesthetic machine creating an artificial atmosphere, from and into which the patient breathes. And Delivery O<sub>2</sub> and inhaled An. From anesthesia machine to patient and remove CO<sub>2</sub> from exhaled gases. **Breathing systems must fulfil three objectives:** 1. Delivery of oxygen. 2. Removal of carbon dioxide from the patient. 3. Delivery of inhaled anaesthetic agents.

### **Properties of the ideal breathing system**

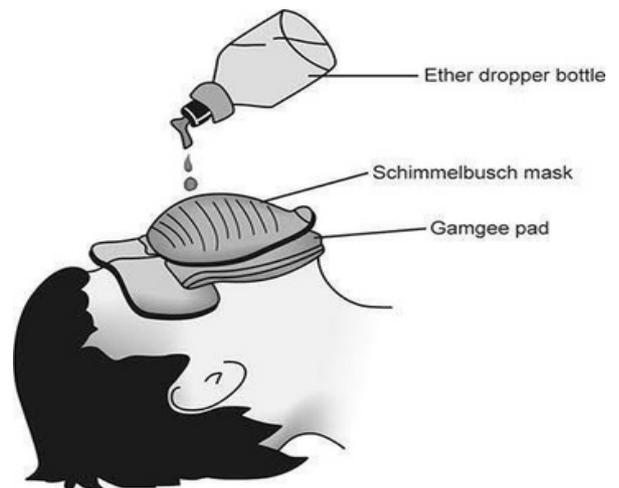
1. Simple and safe to use.
2. Delivers the intended inspired gas mixture.

3. Permits spontaneous, and controlled ventilation in all age groups
4. Efficient, requiring low FGF rates.
5. Protects the patient from barotrauma.
6. Sturdy, compact and lightweight in design.
7. Permits the easy removal of waste exhaled gases.
8. Easy to maintain with minimal running costs.



### **Classification Of Breathing Systems ( McMohan in 1951 ) :**

- **Open:** No **rebreathing** ( Nasal cannula and gauze with drop of anesthesia agent and allow venting)
- **Semiclosed:** Partial **rebreathing** ( Mapleson )
- **Closed:** Total **rebreathing** (circle system) with CO<sub>2</sub> absorber



## **functional classification ( Conway2 ) :**

classified according to the method used for CO<sub>2</sub> elimination as:

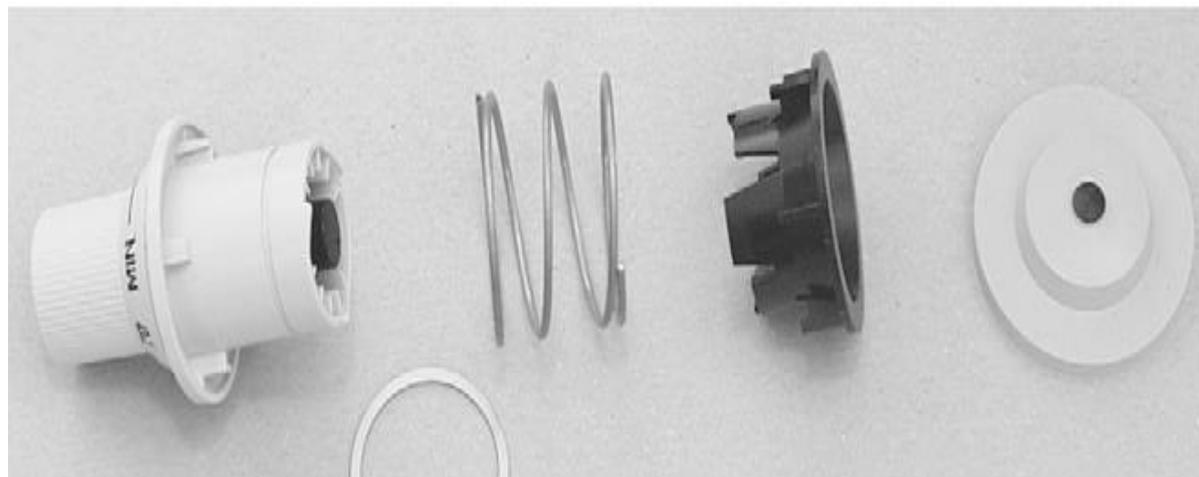
- Breathing systems **with CO<sub>2</sub> absorber**
- Breathing systems **without CO<sub>2</sub> absorber**

### **Componentsofthe breathingsystems**

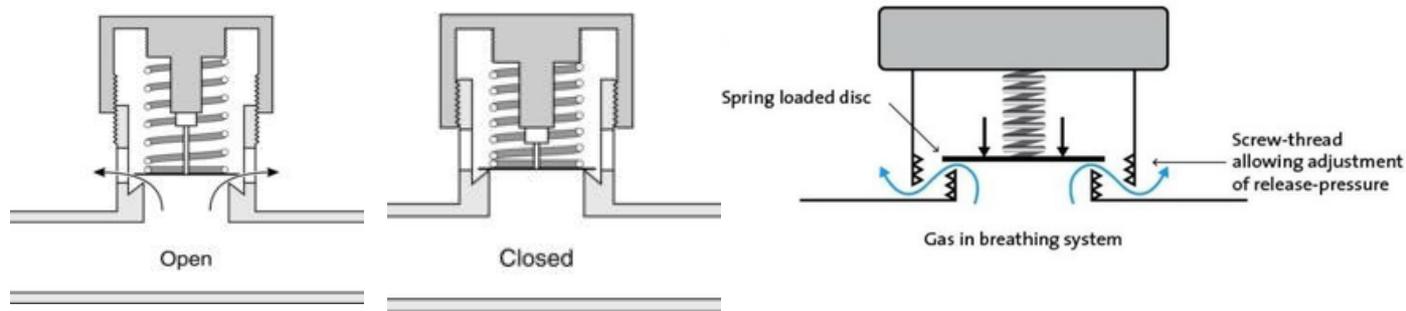
1. Adjustable Pressure Limiting (APL) Valve 2. Reservoir Bag 3. Tubings

#### **1. Adjustable Pressure Limiting (APL) Valve**

This is a valve which allowsthe exhaled gases and excess FGF to leave the breathing system . It does not allow room air to enter the breathing system. Synonymous terms for the APL valve are expiratory valve, spill valve and relief valve.

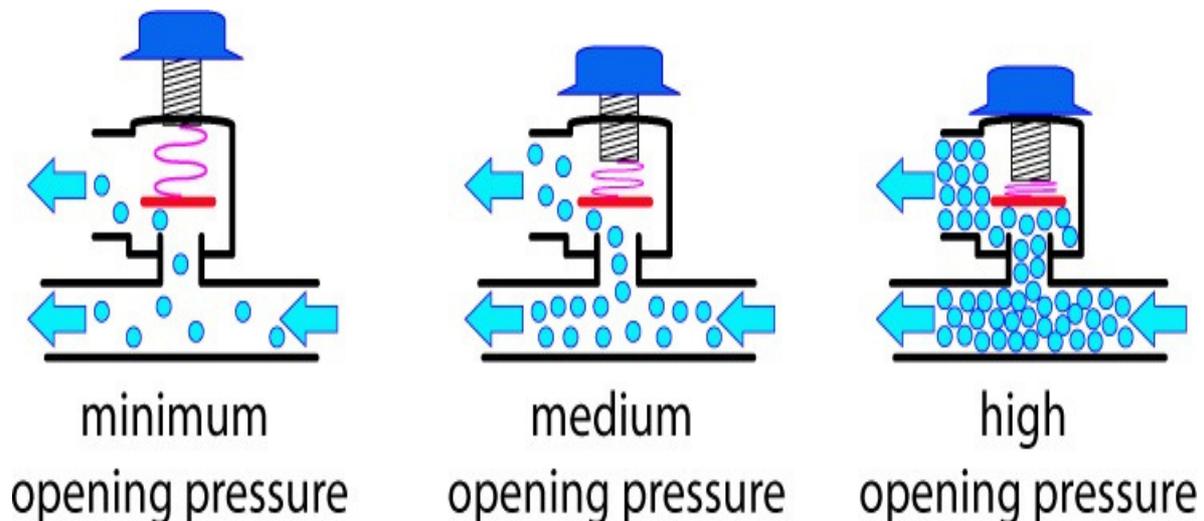


**Components** 1. Three ports: the inlet, the patient and the exhaust ports. The latter can be open to the atmosphere or connected to the scavenging system using a shroud 2. A **lightweight disc** rests on a **knife-edge seating**. The disc is held onto its seating by a spring. The tension in the spring, and therefore the valve's opening pressure, are controlled by the valve dial.



### **Mechanism of action**

1. This is a **one-way, adjustable, spring-loaded valve**. The **spring** is used to **adjust the pressure** required to **open the valve**. The disc rests on a knife-edge seating in order to minimize its area of contact.
2. The **valve allows gases to escape when the pressure in the breathing system exceeds the valve's opening pressure**.
3. During **spontaneous** ventilation, the **patient generates a positive pressure** in the system during expiration, causing the valve to **open**. A pressure of less than 1 cm H<sub>2</sub>O (0.1 kPa) is needed to actuate the valve when it is in the open position.
4. During **positive pressure ventilation**, a controlled leak is produced by adjusting the valve dial during inspiration. This allows control of the patient's airway pressure.



**Problems in practice and safety features** 1. Malfunction of the scavenging system may cause excessive negative pressure. This can lead to the APL valve remaining open throughout respiration. This leads to an unwanted enormous increase in the breathing system's dead space 2. The patient may be exposed to excessive positive pressure if the valve is closed during assisted ventilation. A pressure relief safety mechanism actuated at a pressure of about 60 cm H<sub>2</sub>O is present in some designs 3. Water vapour in exhaled gas may condense on the valve. The surface tension of the condensed water may cause the valve to stick. The disc is usually made of a hydrophobic (water repelling) material, which prevents water condensing on the disc.

## 2. Reservoir Bag

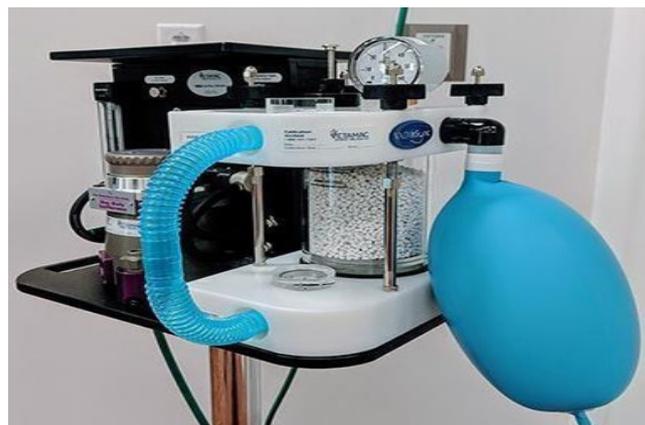
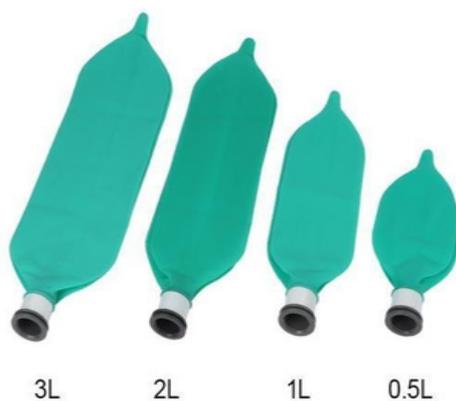
The reservoir bag is an important component of most breathing systems.

### Components

1. It is made of anti-static rubber or plastic. Latex-free versions also exist. Designs tend to be ellipsoidal in shape
2. The standard adult size is 2 L. The smallest size for pediatric use is 0.5 L. Volumes from 0.5 to 6 L exist. Bigger size reservoir bags are useful during inhalational induction, e.g. adult induction with sevoflurane.

### Uses

1. Accommodates the FGF during expiration acting as a reservoir available for the following inspiration.
2. It acts as a monitor of the patient's ventilatory pattern during spontaneous breathing. It serves as a very inaccurate guide to the patient's tidal volume
3. It can be used to assist or control ventilation.



**Problems in practice and safety features** 1. Because of its **compliance**, the reservoir bag can **accommodate rises in pressure** in the breathing system better than other parts. When grossly overinflated, the rubber reservoir bag can limit 2. The **size of the bag depends on the breathing system and the patient**. A small bag may not be large enough to provide a sufficient reservoir for a large tidal volume 3. **Too large a reservoir bag makes it difficult for it to act as a respiratory monitor**.

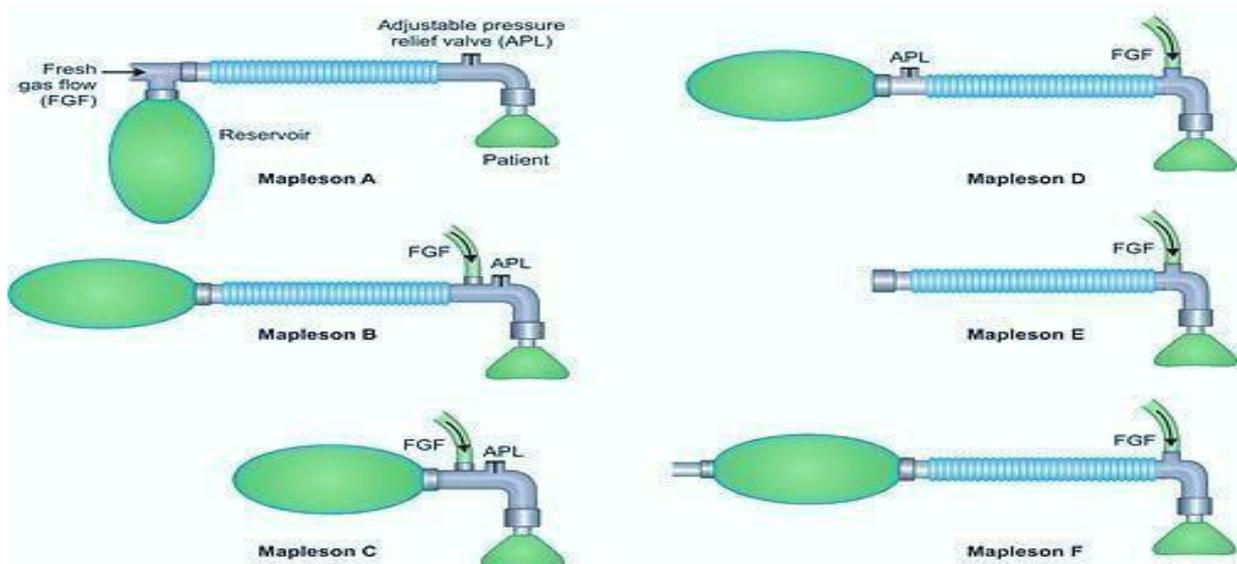
### 3. Tubings

These **connect one part of a breathing system to another**. They also act as a reservoir for gases in certain systems. They tend to be made of plastic, but other materials such as silicone rubber and silver impregnated bactericidal plastics are available. The length of the breathing tubing is variable depending on the configuration of the breathing system used.. The size for adults is 22 mm wide. However, pediatric tubing is 15 mm wide, to reduce bulk. The corrugations resist kinking and increase flexibility



## Mapleson classification (Semiclosed Partial rebreathing)

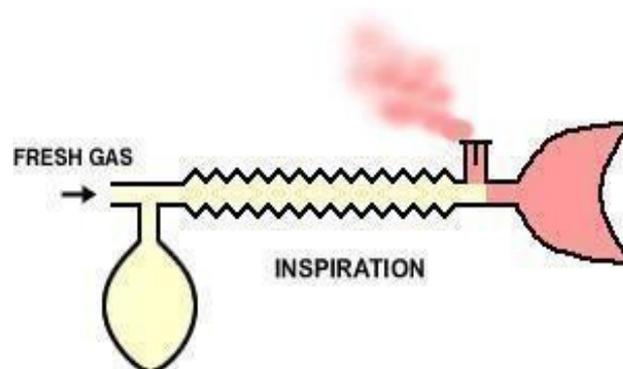
In 1954, Mapleson classified the breathing systems into five configurations (A to E) and a sixth (F) was added later. The classification is according to the relative positions of the APL valve, reservoir bag and FGF. Mapleson systems need significantly higher FGF to prevent rebreathing compared to the circle breathing system and therefore the expensive use of volatile agents. Their use in modern anesthesia is very limited with the wide spread of the circle breathing system.



### Magill system (Mapleson A)

#### Components

1. Corrugated rubber or plastic **tubing** (usually 110–180 cm in length) and an internal volume of at least 550 mL.
2. A **reservoir bag**, mounted at the **machine end**.
3. **APL valve** situated at the **patient end**.



**Uses of magill system** It is a *very efficient system for spontaneous* breathing.

Because there is no gas exchange in the anatomical dead space, the FGF requirements to prevent rebreathing of alveolar gases are theoretically equal to the patient's alveolar minute volume (about 70 mL/kg/min).

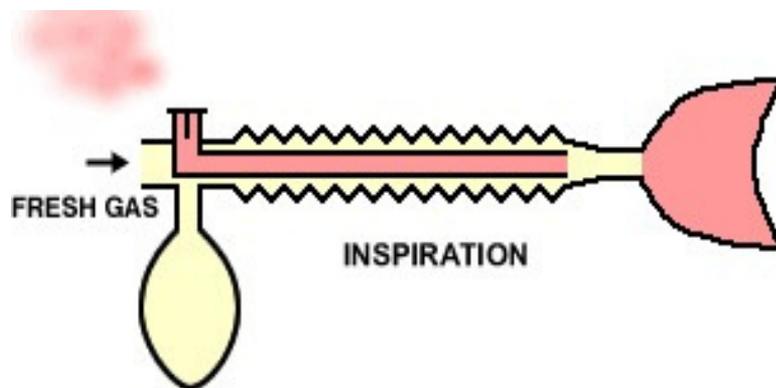
The Magill system is *not an efficient system for controlled ventilation*. An FGF rate of three times the alveolar minute volume is required to prevent rebreathing.

### **Problems in practice and safety features**

- 1- The Magill system is *not suitable for use with children of less than 25–30 kg* body weight. This is because of the increased dead space caused by the system's geometry at the patient end. Dead space is further increased by the angle piece and face mask.
- 2- One of its disadvantages is the *heaviness of the APL valve* at the patient's end (*Not suitable for paediatric practice*), especially if connected to a scavenging system.

### **Lack system (Mapleson A)**

This is a *coaxial* modification of the *Magill Mapleson A system*.



### **Components**

1. 1.8-m length coaxial tubing (tube inside a tube). The FGF is through the outside tube, and the exhaled gases flow through the inside tube.
2. The reservoir bag and APL valve is mounted at the machine end.

**Uses** A FGF rate of about 70 mL/kg/min is required in order to prevent rebreathing.

This

makes it an *efficient breathing system for spontaneous ventilation*.

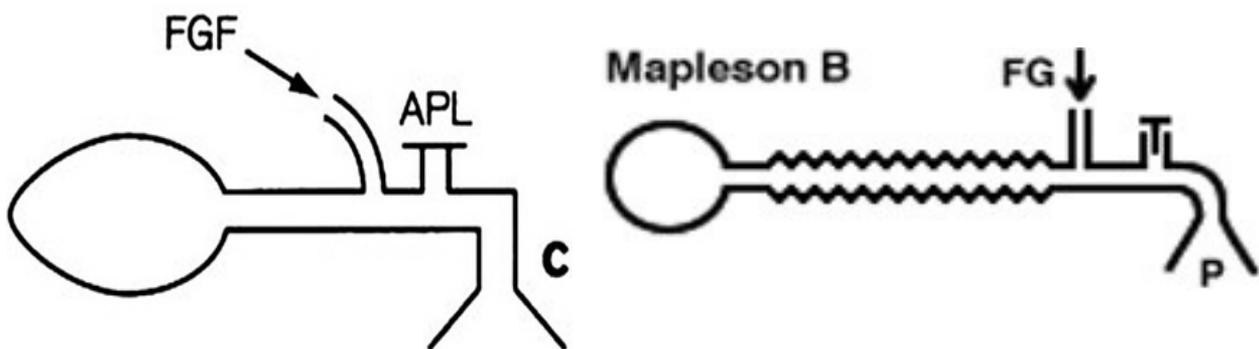
Since it is based on the Magill system, it is *not suitable for controlled ventilation*.

Instead of the coaxial design, a *parallel* tubing version of the system exists. This has separate inspiratory and expiratory tubing, and retains the same flow characteristics as the coaxial version.

### **Mapleson B and C systems**

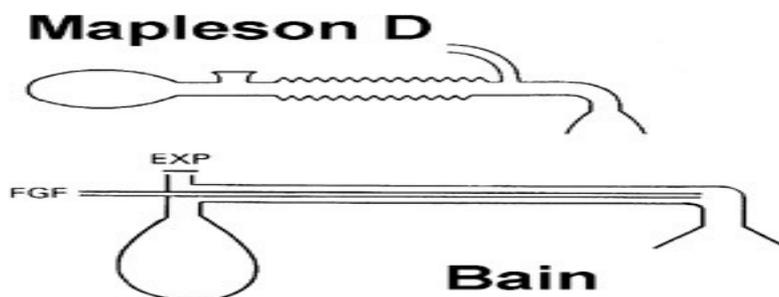
#### **Components**

1. A reservoir bag. In the B system, corrugated tubing is attached to the bag and both act as a reservoir.
2. An APL valve at the patient's end.
3. FGF is added just proximal to the APL.



### **Mapleson D System**

- 1- It consists of fresh gas inlet near the patient end
- 2-a corrugated rubber tubing one end which is connected with expiratory valve and then reservoir bag.
3. It is mainly used for assisted or controlled ventilation.



**Bain system (Mapleson D)** 1- Bain system is a coaxial version (tube inside a tube) of the Mapleson D system. 2- It is lightweight and compact at the patient end.

### **Components**

The usual length of coaxial tubing is 180 cm, but it can be supplied at 270 cm, (for dental or ophthalmic surgery) and 540 cm (for [MRI] scans where the anaesthetic machine needs to be kept outside the scanner's magnetic field).

### **Problems in practice and safety features**

1. The **internal tube can kink**, preventing fresh gas being delivered to the patient.
2. The internal tube can become **disconnected** at the machine end, causing a large increase in the dead space and resulting in **hypoxaemia** and **hypercapnia**.

### **Mapleson E sys (Ayre's T-Piece)**



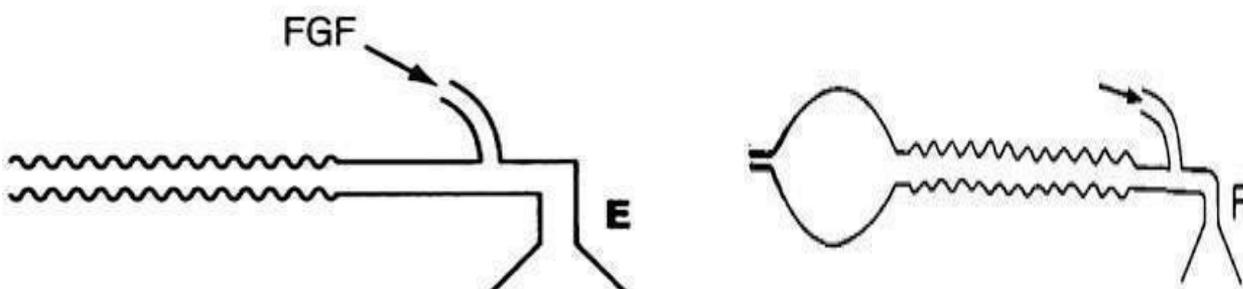
### **Components**

1. A **T-shaped tubing** with three open ports
2. The first port to Fresh gas from the **anaesthetic machine** is delivered via a tube
3. The second port leads to the **patient**.
4. The third port leads to **reservoir tubing**.

A recent modification exists where an APL valve is included before a closed ended 500 mL reservoir bag. A pressure relief safety mechanism in the APL valve is actuated at a pressure of 30 cm H<sub>2</sub>O.

\*No bag, no valve, used in children (low resistance to breathing and minimal dead space).

**Not:** To prevent respiration of room air, the reservoir limb should exceed the VT & to prevent rebreathing, FGF (2-3 MV).



***Mapelson F sys (Jackson Rees modification of the Ayer s T piece)***

A small bag (0.5L) with an open end is attached to the outlet of the reservoir limb. The bag is visual monitor FGF (2-3 MV) in both spontaneous and controlled.

