



# INHALENT ANESTHETIC EQUIPMENT AND BREATHING CIRCUITS

Dr. Adarsh kumar

## Anesthetic Machines

An anesthetic machine is used to deliver an anesthetic gas mixture to the patient via an appropriate breathing circuit. The basic anesthetic machine used in veterinary practice can be divided into components serving a special function:-

### ✓ THE HIGH PRESSURE SYSTEM

#### 1) The Fresh Gas Source

**Oxygen** is used for two reasons: Firstly, it is vital for the life of the patient and secondly it is used to vaporize the volatile anesthetic agent and deliver it to the patient..

**Nitrous Oxide** is often used in anesthesia and is supplied as a combination of liquid and gas in cylinders the same size as used for oxygen (the room temperature is below the critical temperature for nitrous oxide).

**Cyclopropane** and **Carbon Dioxide** cylinders may be found on old human hospital machines. These gases are of very little use in veterinary practice.

**Cylinders** are fitted with a number of safety features because of the dangerously high pressures they hold, and to avoid the wrong cylinder being fitted to the yoke of the anesthetic machine.

**a) Colour of Cylinder:** Should follow international standards, but not all countries comply. e.g.;

- Oxygen: Canada: green and white, or green, or white
- U.S.A.: green .
- U.K.: black and white. (This is the International System).
- Nitrous Oxide: blue
- Cyclopropane: orange
- Carbon Dioxide: grey.

**b) Tag Label** indicates whether the cylinder is full, part full or empty.

**c) Pin Index Safety System** is used in small cylinders. The receiving yoke of the anesthetic machine should have the same configuration of pins as the cylinder has holes so that the correct cylinder is attached to the correct yoke. Large cylinders have different thread patterns to prevent improper connections. Cylinders should be properly secured at all times and the valve should never be opened unless the cylinder is secured within the yoke of the anesthetic machine.

#### **2) Pressure Gauges**

There are several types of pressure gauge found on gas cylinders and on anesthetic machines. The pressure gauge show the pressure within the cylinder.

#### **3) Pressure Regulators (Pressure Reducing Valves)**

The reducing valves also serve to keep the pressure in the line constant since the pressure within a cylinder of oxygen will vary depending on how full it is.



## ✓ THE LOW PRESSURE SYSTEM

### **1) Flowmeters (Rotameters)**

The fresh gas passes from the cylinder via the high pressure tubing to the reducing valve. From here, the low pressure tubing carries the gas to the specific flowmeter for that gas. The flowmeter is necessary to measure how much gas is being supplied to the breathing circuit and to the patient.

There are various designs of flowmeters with different type of indicators to indicate the flow. Flowmeters with aluminum balls should be read from the middle of the ball whereas bobbin type indicators should be read from the top of the bobbin.. Flow is measured in liters/minute.

Flowmeter knobs are colour coded for the gas they measure: green for oxygen (white in the U.K.), and blue for nitrous oxide.

### **2) Flush Valves**

Most anesthetic machines are fitted with an oxygen flush valve which delivers oxygen from the reducing valve to the breathing circuit without going through the vaporizer. This allows the circuit to be flushed with 100% oxygen. It should only be used with a circle system.

### **3) Vaporizers**

The fresh gas has to vaporize the volatile agent used to anesthetize the patient. Specially designed vaporizers fitted to the anesthetic machine do this. All of the commonly used, potent general anesthetics are volatile liquids at room temperature and atmospheric pressure. These agents must be transformed into the vapour phase for clinical use.

#### **1. Simple plenum vaporizers**

These are simple containers such as glass jars, which allow a certain amount of fresh gas (oxygen +/- nitrous oxide) through the space above the liquid anesthetic agent. The gradations on the vaporizer do not indicate the actual vapour concentration unlike the more elaborate (and expensive) precision vaporizers.

#### **2. Precision vaporizers**

These vaporizers have adaptations to allow them to compensate for ambient temperatures and the drop in temperature seen during vaporization. Vaporizers are constructed of a highly conductive metal so that heat from the surrounding is transferred to the volatile agent in order to supply the latent heat of vaporization. Precision vaporizers are calibrated for one agent only and several safety mechanisms are included on newer vaporizers to stop the wrong volatile anesthetic agent being placed in the vaporizer. If halothane is placed in a vaporizer designed for methoxyflurane, disaster would result! . In Nutshell these vaporizers deliver known concentration of anesthetic.

## **BREATHING CIRCUITS/SYSTEMS**

### ✓ **General Principles**

The breathing circuit is the system through which the patient breathes and which carries the volatile anesthetic from the anesthetic machine to the patient. There are four principle concerns with all breathing circuits.



## **1) Resistance**

For minimal resistance the gas conducting pathways of a circuit should be of minimum length, maximum internal diameter without sudden narrowing and without sharp bends. However, the resistance offered by the breathing circuit is usually small compared to that of endotracheal tubes and their connections.

## **2) Rebreathing**

To rebreath means to inhale gas which has already been previously exhaled and from which carbon dioxide may or may not have been removed. If expired carbon dioxide is not removed, the arterial carbon dioxide level will increase as a result of rebreathing. Breathing circuits that are designed to 're-use' the expired oxygen and anesthetic gases (cheaper to run) must have facilities to remove the carbon dioxide (discussed later).

## **3) Heat and Humidity**

Medical gases contain no water (or oil, remember oxygen + grease = explosion hazard) to prevent clogging of regulators and valves. The inspired gases are therefore heated and humidified at the expense of the patient's body heat. A number of clinical effects may result from the use of dry anesthetic gases including impairment of ciliary function, loss of body heat and water, decreased water content of mucus and the accumulation of a more viscid secretion. Rebreathing systems conserve body heat and water and this is to the patient's advantage. Incidentally, if oxygen is to be administered to critical care patients over a period of many hours, the oxygen should be bubbled through distilled water (preferably sterile) to humidify it.

The Components of Breathing Circuits

### **1) Connectors and Adaptors**

These are found where two parts of the circuit are to be joined e.g. endotracheal tube to breathing circuit hose. The fittings should be of standardized sizes 22 mm female and 15 mm male openings.

### **2) Reservoir (Rebreathing) Bag**

The bag has the following functions:

- a) It allows accumulation of gas during exhalation so that a reservoir of anesthetic gas is available, and it prevents dilution with room air in non-rebreathing systems.
- b) It provides a means of assisting or controlling the ventilation of the patient.
- c) It allows visual observation of patient ventilation.
- d) It acts as a safety factor, protecting the patient from excessive pressure in the breathing system...up to a point!
- e) It provides a reservoir of gases to meet the flow rate generated by the act of inspiration (higher than the flow of gases entering the circuit).

### **3) Breathing Tubes/Hoses**

These are made of corrugated plastic or rubber to avoid the risk of kinking when the hoses are bent. They have two functions:

- a) To act as a reservoir in certain circuits.
- b) To provide a flexible, low-resistance and lightweight connection from one part of the system to another.



## 4) Valves

Most circuits (except Ayre's T-piece and similar) have exhaust valves (relief valves or 'pop-off' valves) to allow excess pressure to be vented to atmosphere, and to conduct away waste gases.. Remember to open the valve if the circuit pressure builds up! Careful and periodic adjustments of the valve setting may be necessary to achieve the desired level of ventilation and maintain adequate filling of the bag.

### 1) Non-rebreathing Circuits

Fresh gases from the anesthetic machine (with anesthetic vapour) pass into a reservoir and the patient breathes from that reservoir. Exhaled gases pass into the atmosphere, either directly or through an exhaust valve.

### 2) Rebreathing Circuits

In these systems the exhaled gases are re-used and the exhaled carbon dioxide is removed by chemical means, with soda-lime or bara-lyme. They have the advantages of conserving water and heat and being cheap to run. They are more expensive to buy, soda-lime dust may be inhaled and there may be more resistance to breathing.

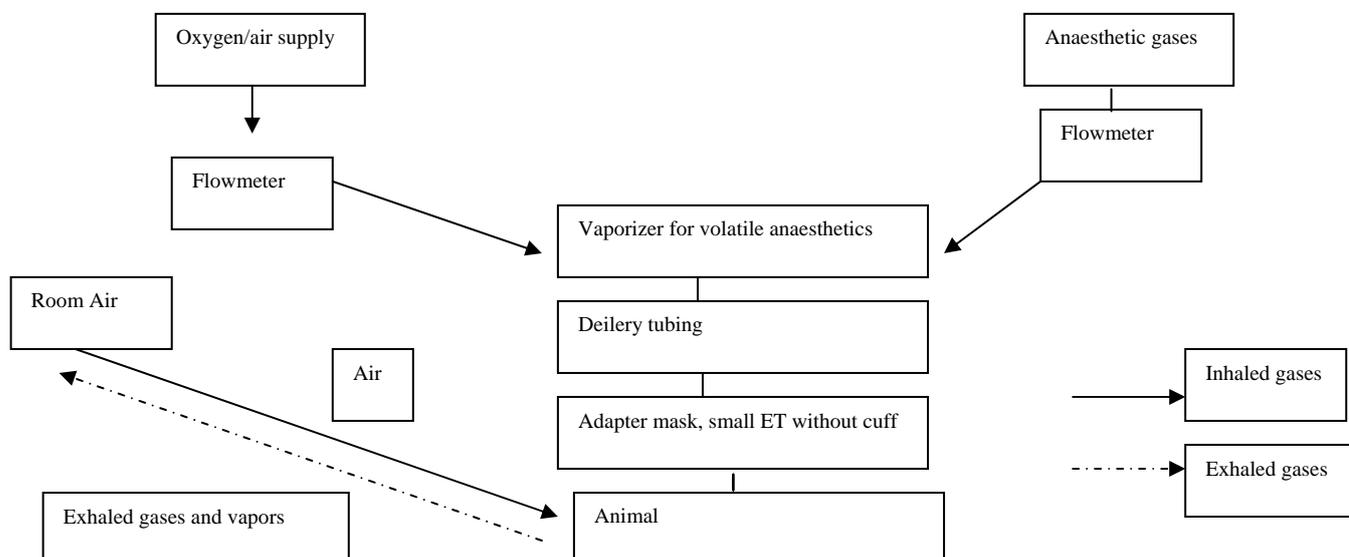
## VARIOUS TYPES OF METHODS USE FOR GIVING INHALENT ANESTHETICS

### 1. Open Insufflation:

1. The anesthetic gas or vapor, together with air and/or oxygen is delivered to the mouth or trachea by a mask or catheter
2. Inhaled gases include room air as well as those from the delivery tubing
3. Exhalation occurs around the catheter or mask

Disadvantages:

1. Waste of gas and anesthetic agent
2. Drying of airway
3. Variable anesthetic concentration due to dilution with room air
4. Pollution of the environment
5. Inability to control or assist breathing





## 2. Semi open systems without nonrebreathing valves

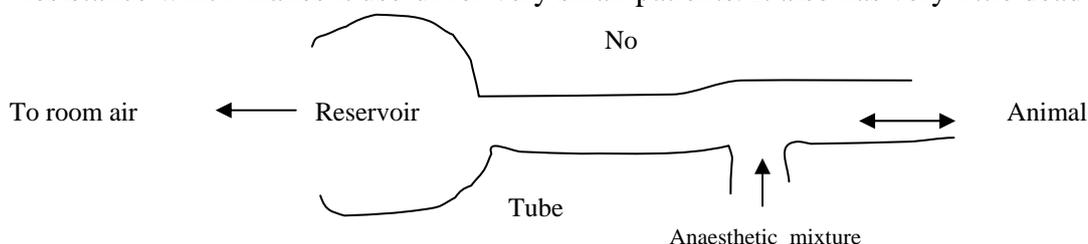
- ✓ Exhaled gases pass to the surrounding atmosphere and some may be rebreathed
- ✓ There is no chemical absorption of Carbon dioxide

### Techniques are

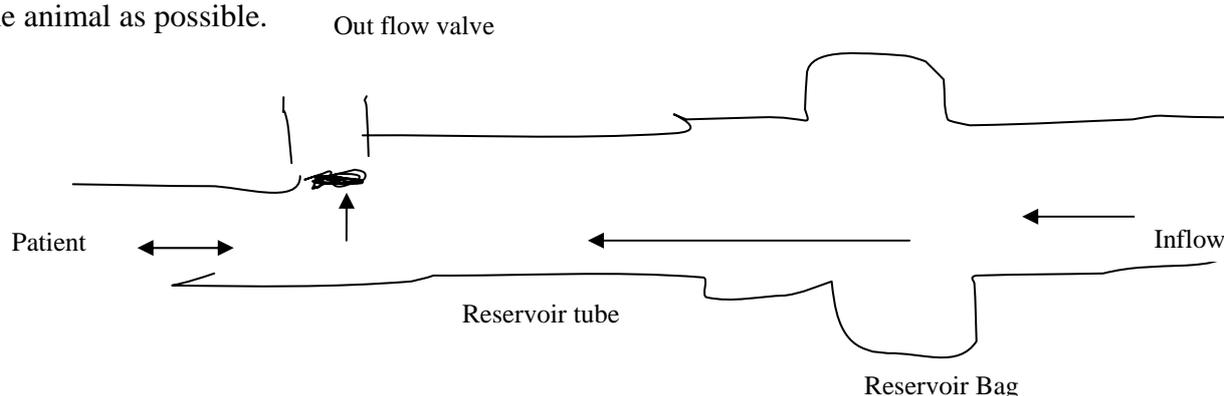
**1. Semi open drop:** A volatile anesthetic is dripped into a towel or absorbent cotton or gauze, placed within a cone or mask. Anesthetic is dispersed by a dropper bottle or syringe and a towel or mask is applied to the face of the animal. Inhalents used are Ether, halothane and methoxyflurane. Used for lab animals for rapid induction

**2. Anesthetic boxes and chambers:** Simple Bell jars, with cotton pledget soaked with anesthetic or chambers that provide constant circulation of gases are used. Advantages are that No restraint is required and maintenance is with some other system

**3. Ayres T- tube:** This simple non-rebreathing system has no valves and so has very little resistance which makes it useful for very small patients. It also has very little dead-space.

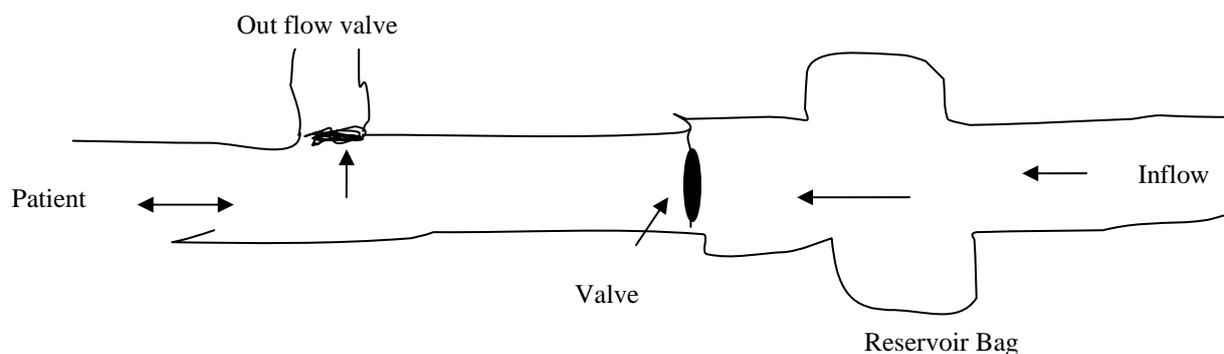


**4. Macgills apparatus:** This system utilizes a constant flow of anesthetic mixture, a reservoir bag, corrugated tubing between the bag and the endotracheal tube, exhalation valve located as close to the animal as possible.

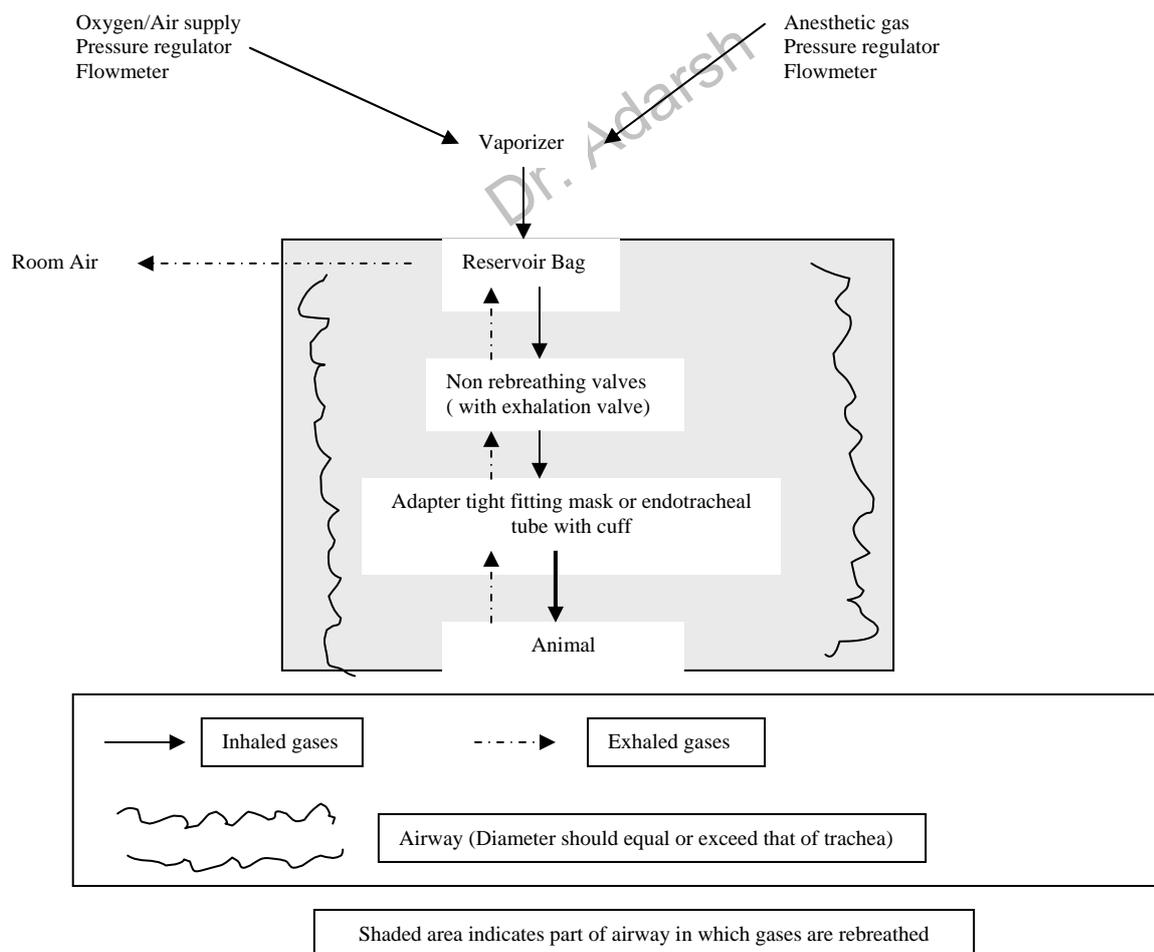


### 3. Semiopen system with nonrebreathing valve

- ✓ In this method , inspired and expired gases are separated by by a vlave as close to the animal as possible,
- ✓ rebreathing is minimal, and the animal breathes only the anesthetic mixture delivered.
- ✓ Use of reservoir bag between the valve and gas source is desirable. In this way anesthetic mixture and oxygen flows into the reservoir bag during expiration and are conserved until they are required during the next inspiration.



#### STEPHEN SLATER VALVE



#### SEMI OPEN NON REBREATHING SYSTEM ↑



#### 4. Semi closed and closed system

- ✓ All conventional anesthesia machines can be used for both semiclosed and closed techniques
- ✓ These techs differ only by extent to which exhaled gases are rebreathed.

**1. Semi closed or Partial rebreathing:** Gases are partly exhaled to the atmosphere and partly rebreathed. So relatively high fresh gas flow is thus required.

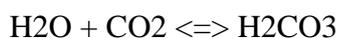
**2. Closed:** Rebreathing of the exhaled gases is complete, CO<sub>2</sub> is absorbed and only sufficient oxygen is added to the system to satisfy the metabolic needs. In comparison to semi-closed tech. it is a low flow system

*Equipment for closed and semi closed administration is assembled as to and fro (Single phase) or circle (two phase systems)*

#### CO<sub>2</sub> Absorber

*The two commonly used absorbent materials are soda-lime ('SodaSorb') and Baralyme. Soda-lime which is more commonly used is composed of 94% calcium hydroxide, 5% sodium hydroxide and 1% potassium hydroxide as its dry weight, but is sold 'wet' with 14-19% water. It has a dye indicator to provide information on its pH and this is used as an indicator of soda-lime exhaustion. The chemical reaction is as follows:*

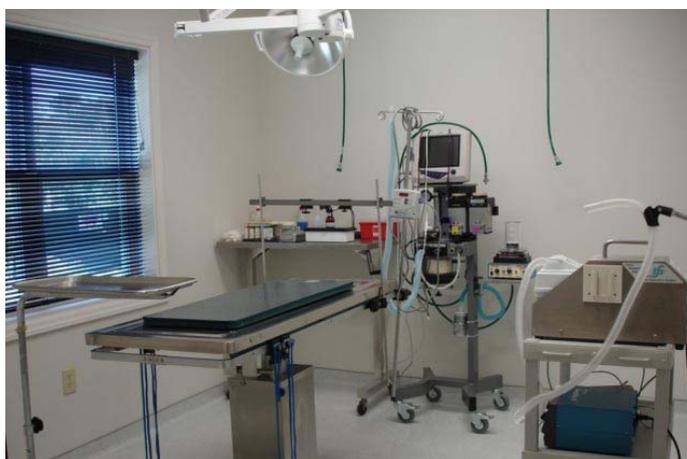
*The CO<sub>2</sub> first dissolves in the water on the surface of the granules prior to the reaction.*



then:

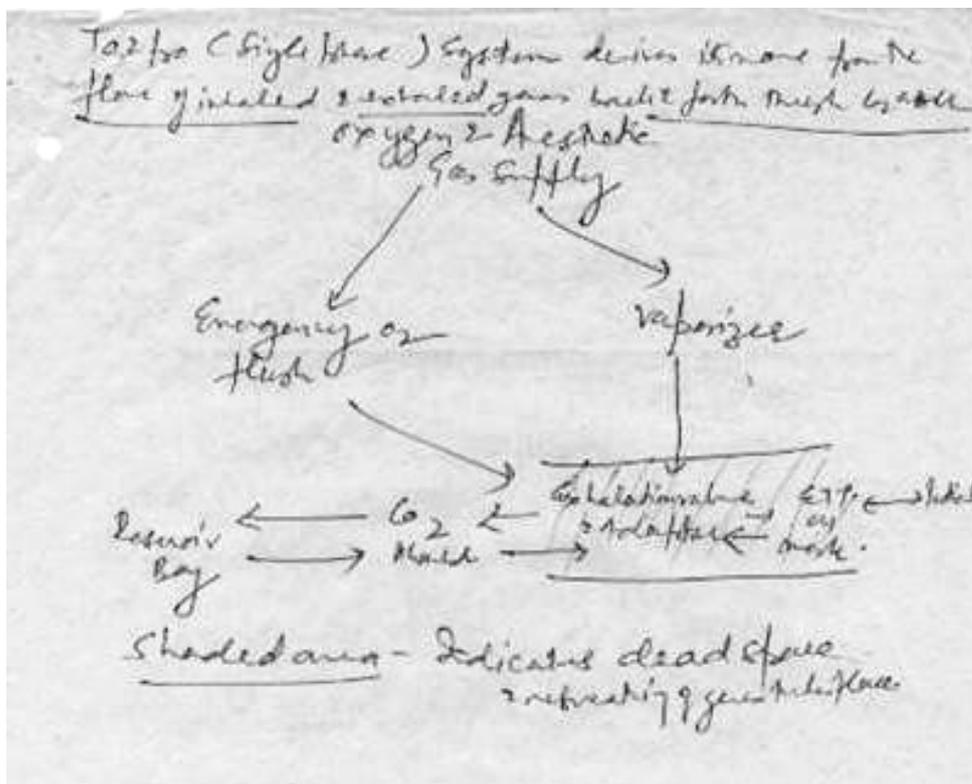


*Baralyme is a mixture of hydrated barium hydroxide and calcium hydroxide which reacts along similar lines to soda-lime. Soda-lime is more dense than Baralyme (104 g compared to 86 g/100 mL) and is 15% more efficient in that 100 g of dry soda-lime will absorb 23 litres of CO<sub>2</sub> while Baralyme can absorb 18 litres CO<sub>2</sub>.*



## A. The Water's To and Fro System

This system was first developed by Waters in 1923. The patient breathes back and forth through a soda-lime canister. Inspired gas comes from the fresh gas flow and the rebreathing bag. The fresh gas is introduced as close to the patient as possible. There are no unidirectional valves



### B. Circle (Two phase system)

