

Ventilators (Respirators)

- Ventilator may be defined as any machine designed to mechanically move breathable air into and out of the lungs to provide the mechanism of breathing for a patient who is physically unable to breathe.
- When artificial ventilation is required for a long time, a ventilator is used to provide oxygen enriched, medicated air to a patient at a controlled temperature.

Modes of operation:

- There are three different modes and modes differ by which type of inspiration is initiated (i.e) positive and negative.

➤ Negative pressure:

In this design, the flow of air to the lungs is created by generating a negative pressure around the patient's thoracic cage.

The negative pressure moves the thoracic walls outward expanding the intra-thoracic volume and dropping the pressure inside the lungs. The pressure gradient between the atmosphere and the lungs causes the flow of atmospheric air into the lungs.

1. Assist mode
2. Control mode
3. Assist-control mode

1. Assist mode:

- ❖ Assist mode inspiration is triggered by the patient.
- ❖ Respirator helps the patients when they want to breathe.
- ❖ A sensitivity adjustment is provided to select the amount of patient effort required to trigger the machine.
- ❖ It is used by those who are able to control their breathing but unable to inhale sufficient of air without assist.

2. Control mode:

- ❖ Breathing is controlled by a timer set to provide the desired respiration rate.
- ❖ Controlled ventilation is required to patient who are unable to breathe on their own.
- ❖ Respirator has complete control over the patient respiration.

3. Assist-control mode:

- ❖ The apparatus is normally triggered by the patient's attempt to breathe like assist mode.
- ❖ If patient fails to breathe within the predetermined time, timer automatically triggers the device to inflate the lungs, like control mode.

This mode is most frequently used in critical care settings

Positive pressure:

- ❖ Positive-pressure ventilators generate the inspiratory flow by applying a positive pressure (greater than the atmospheric pressure) to the airways.
- ❖ During inspiration, the inspiratory flow delivery system creates a positive pressure in the tubes connected to the patient airway, called patient circuit,

and the exhalation control system closes a valve at the outlet of the tubing to the atmosphere.

The ventilator treatment gives the following.

- **Adequate ventilation** by which enough oxygen is supplied and the right amount of carbondioxide is eliminated.
- **Elimination of respiratory work**
- **Increase intrathoracic** pressure which prevents atelectasis that is collapse of portions of the lung and counteracts edema of the lungs.
- Every ventilators operates cyclically. During insufflation or inspiration air or some other gaseous mixture is pumped into the lungs. During expiration the pressure ceases. This cycle is regulated by mechanical, pneumatic or electronic circuit. The regulation is obtained by **pressure limited, volume limited and servo controlled systems.**

Pressure limited ventilators:

- Pressure limited ventilators are based on the principle that the insufflation is terminated when the gaseous mixture pumped into the patients lungs reaches a pre-set pressure.
- Pressure limited ventilators are driven by the compressed gaseous mixture used for ventilation.
- These are simple in design and reliable in operation.

volume limited ventilators:

- volume limited ventilators are based on the principle that for each breathe, a constant volume of air delivered. During insufflation, the constant volume of air is sent into the lungs by applying pressure to a chamber containing constant volume.

servo controlled ventilators:

- This is based on the modern usage of modern electronic control techniques such that the flow to and from the patient is controlled by the feedback circuits.
- The electronic circuit controls the amplifiers and the logic circuits that control the ventilation. It also monitors pressure, activates alarms and computes mechanical lung parameters.

Block Diagram of a Ventilator with its Accessories

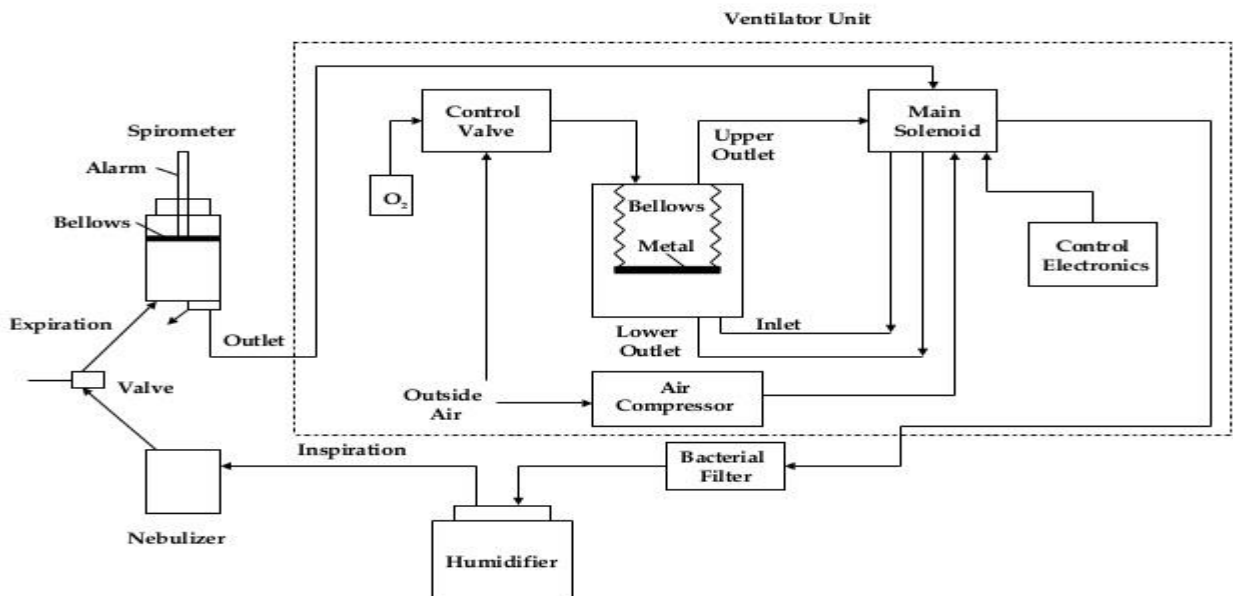
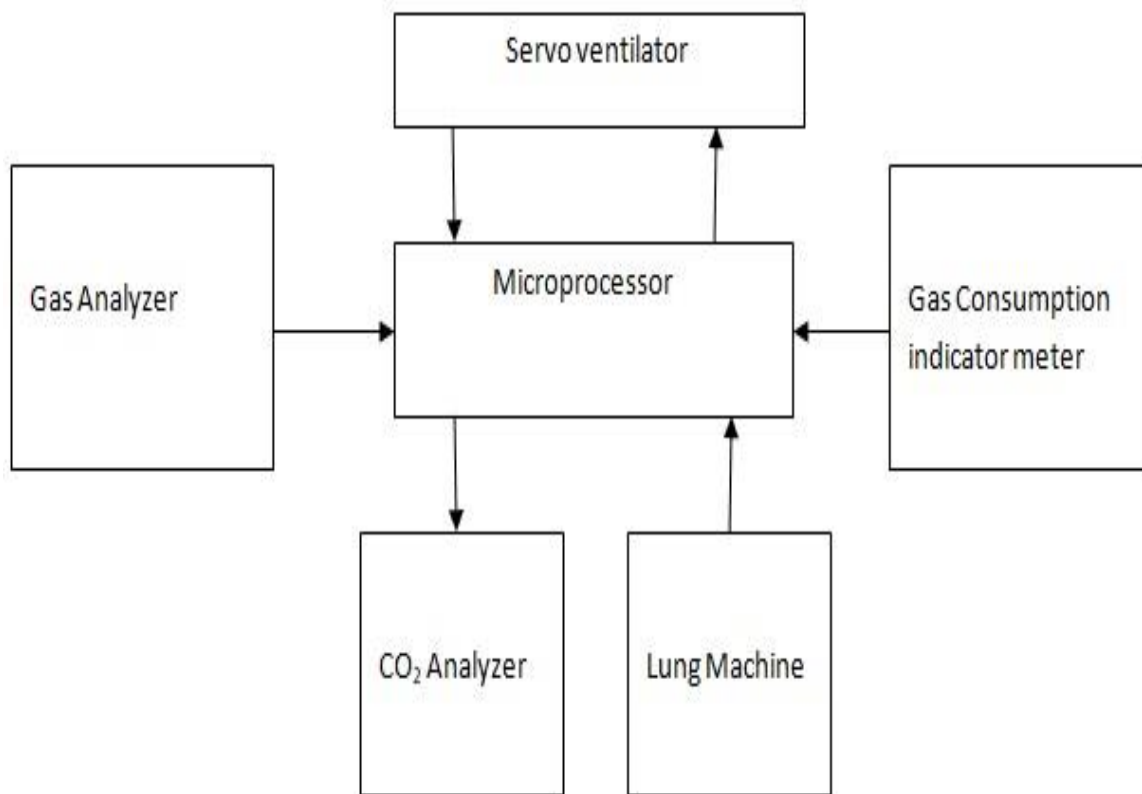


Fig 3. 1: Block Diagram of Ventilators with its accessories

Source: Web

- Figure shows the ventilator unit along with other accessories .
- During patient inspiration, the air compressor draws room air through an air filter and passes it to main solenoid.
- Main solenoid forces the bottom inlet valve of the internal bellows chamber to open and the lower outlet valve to close.
- Oxygen is passed into bellows chamber in a controlled manner by means of a control valve.
- Humidifier: In order to prevent damage to the patients lungs, the applied air or oxygen must be humidified either by heat vaporization or by bubbling an air stream through a jar of water.
- Nebulizer: A nebulizer compressor produces a fine spray of water or medication into the patients inspired air in the form of aerosols . In nebulizer the water or medication picked up by high velocity jet of oxygen enriched air and thrown against one or more baffles or other surface to break the substance into controllable sized droplets which are then applied to patient.
- A sensitivity control monitors the negative pressure necessary to initiate inspiration when the ventilator is used in the assisted mode. An aspirator or other types of suction apparatus is often included as a part of the ventilator to remove mucus and other fluids from the airways.
- When the medicated air forced into lungs through the valve number 1, the spirometer is closed condition. When the inspiration is complete, the main solenoid switches the directions of the pneumatic air to do the expiration cycle.
- Spirometer is used to measure the volume of exhaled air so as to give alarm to stop expiration and to initiate inspiration in the ventilator unit.
- Now a days the microprocessor based control circuits based control circuits are used in ventilator system to improve systems accuracy and reliability.



- Fig:4.2 shows the microprocessor based automatic feedback control of a mechanical ventilator. It consists of a microprocessor with RAM, EPROM, A/D converter and a CRT controller.

- **ADVANTAGES:**

- Better gas distribution
- Lower mean airway pressure
- Weaning is easier

APPLICATION AND DURATION OF VENTILATION

- ❖ It can be used as a short term measure.
- ❖ Long term ventilator assistance is required in chronic illness and may be used at home, or in nursing or rehabilitation centres.

- ❖ In positive pressure ventilator additional measure can be required to secure airway .The common employed method is intubation which provides clear route of the air.
- ❖ In negative pressure or non invasive ventilator, there is no need to use any adjunct.

