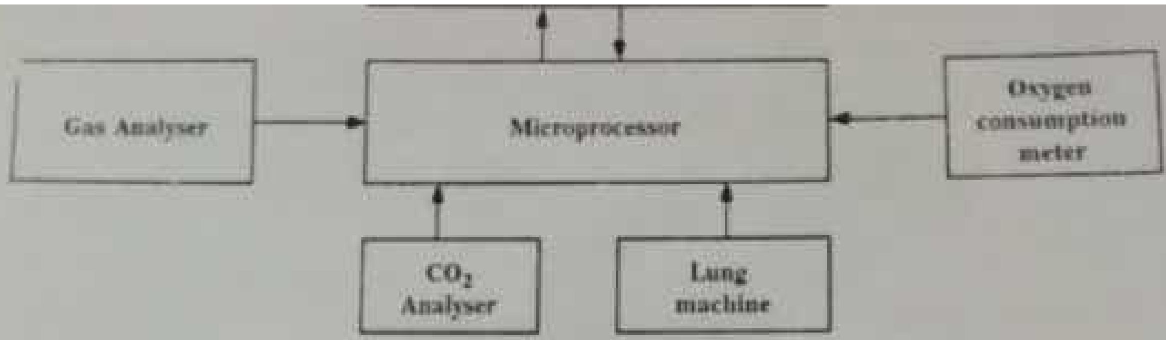


**Fig.6.7. Microprocessor based ventilator**

Figure 6.7 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. The input signals to the microprocessor are obtained from a $CO_2$ analyser, a lung machine, gas analyser, oxygen consumption monitor and the servo ventilator. The proper controlling signals are delivered to the servo ventilator so as to get correct ventilation adjustment in response to a patient's metabolism.

## 6.9 ANESTHESIA MACHINE

Figure 6.8 shows the block diagram of an anesthesia machine. It corresponds to the modern partial rebreathing system. The most commonly used anesthetic is nitrous oxide used in combination with fluorocarbons, such as halothane, enflurane, methoxyflurane, etc. and oxygen. These are nonflammable. This mixture is delivered to the patient on the inspiration cycle. The flow rate is correctly maintained by the flowmeters in the each gas tubing (not shown in the figure). Exhalation passes through a one way valve, through a $CO_2$ absorber and is delivered again to the patient. The anesthetic is constantly monitored and adjusted for the correct mixture by means of controlling circuits using flowmeters like turbine flowmeters or rotameter. A portion of the anesthetic is exhausted and usually delivered to the outside through vent ducts.

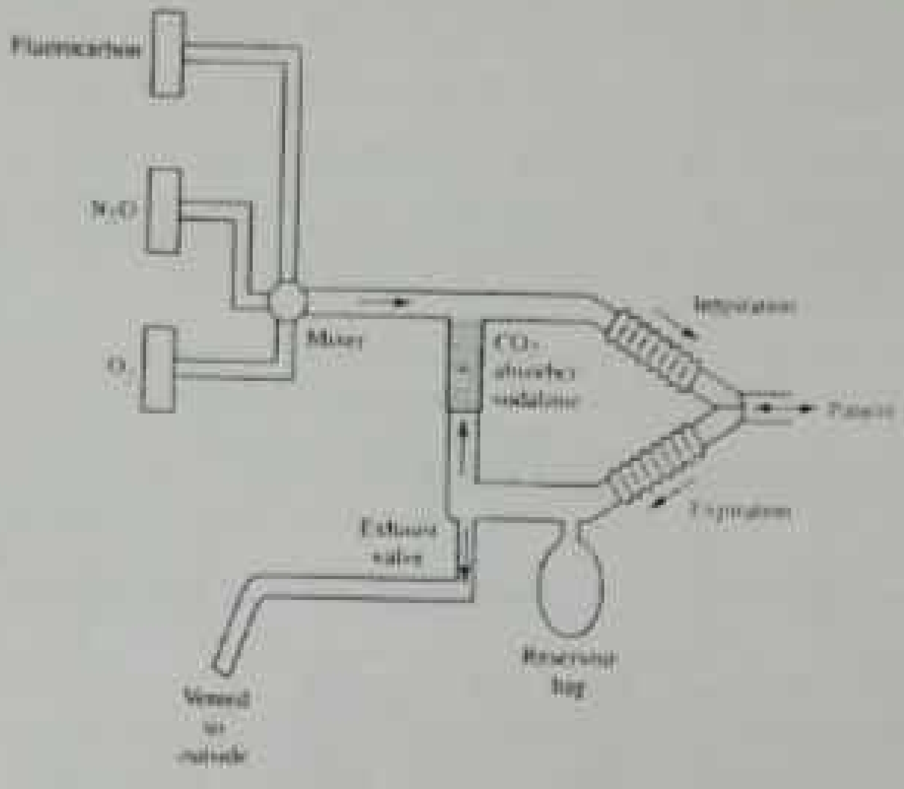


Fig.6.8. Anesthesia Machine

During the supply of anesthesia, the respiration and blood circulation should be monitored eventhough the supplied anesthesia is very small.

### 6.9.1 Flowmeters

#### i) Rotameter

The rotameter is the most extensively used form of the variable area flowmeter. It consists of a vertical tapered tube with a float which is free to move up or down within the tube as shown in figure 6.9. The tube is made tapered so that there is a linear relationship between the flow rate and position of the float within the tube. The fluid to be measured enters the tube from the bottom and passes upward around the float and exit at the top. When the fluid enters the metering tube, the float moves up. The float is pushed up until the lifting force produced by the pressure differential across its upper and lower surface is equal to the weight of the float. The pressure differential is proportional to the square of the flow rate. When the flow rate is maintained as a constant, the float is stationary. Any decrease in the flow rate causes the float to drop to a lower position. A calibration scale prin.ed onthe tube provides a direct indication of flow rate. In addition to flow rate indication at the point of measurement rota meters can be equipped with additional functions such as alarm, pneumatic or electric transmission recording, controlling or totalizing. The accuracy of rota meters is about ± 0.5%. It is more suitable for metering small flows like anesthetic flow.

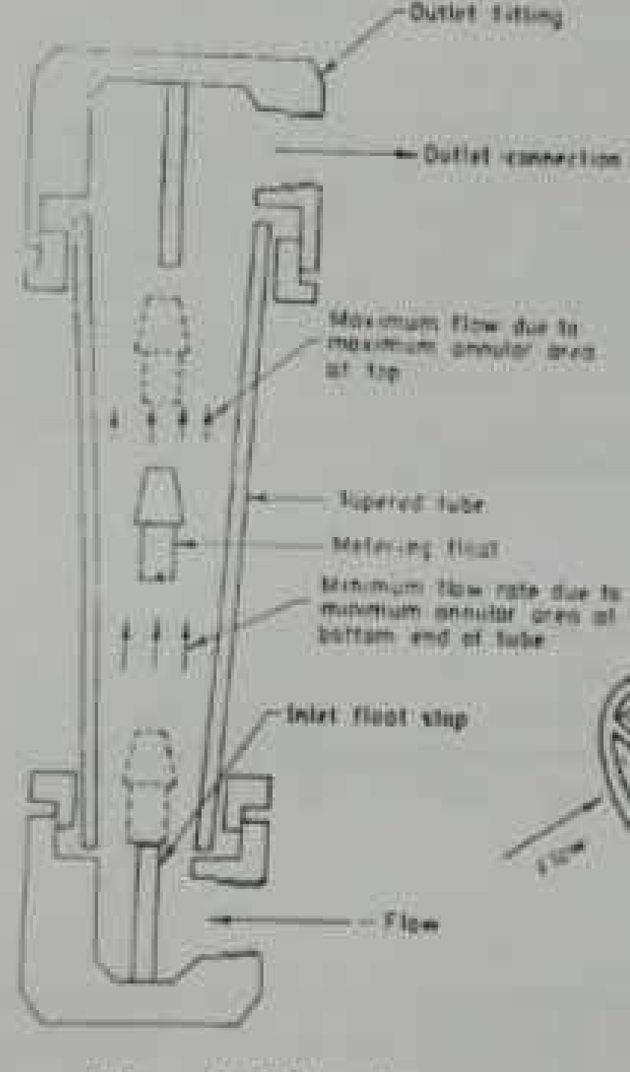


**Fig. 6.9. Rotameter**

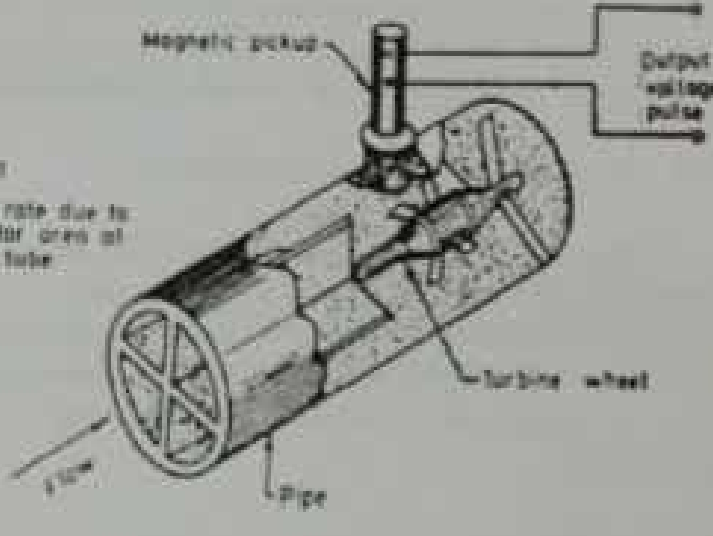


**Fig.6.10. Turbine flowmeter**

### iii) Turbine flowmeter

The turbine flowmeter is used for the measurement of very low flow rates. It works on the basic principle of turbine. It consists of a multibladed rotor called turbine wheel which is mounted at right angles to the axis of the flowing fluid as shown in figure 6.10. The rotor is free to rotate about its axis by means of ball or sleeve bearings on a shaft. The flowing fluid impinges on the turbine blades imparting a force to the blade surface which causes the rotation of the rotor. The rotating speed of the rotor is directly proportional to volumetric flow rate. The magnetic pick up coil, mounted in close proximity to the rotor but internal to the fluid channel, generates a voltage during each rotor blade passes it. Thus the total number of pulses obtained per second is a measure of the total flow. The electrical voltage pulses can be totalled, differenced and manipulated by digital techniques so that a zero error characteristic of digital handling is provided from the pulse generator to the final read out. The accuracy is from 0.25% to 0.5%. This is widely used in the anesthesia monitors, such that when the flow rate is increased or decreased some error signal with suitable phase is given to the anesthetic column at the inlet section to change its flow rate. Whenever there is no error signal, the flow rate is maintained as a constant.

## 6.10 BLOOD FLOWMETERS

Blood flowmeters are used to monitor the blood flow in various blood vessels and to measure cardiac output. The above said flowmeters are not suitable for the blood flow measurements since they require cutting of blood vessel or they may form blood clotting. Currently electromagnetic flowmeters, ultrasonic flowmeters and laser based blood flowmeters are widely used to measure the blood flow rate. We know that temperature gradient in the upstream and the downstream of blood is also a measure of blood velocity. By this way also, one can measure the blood flow rate. But it is not adopted now. In the blood vessel, the blood flow rate is maximum along the axis of the vessel and decreases with the square of the distance from the axis, reaching zero at the wall of the vessel.

### 6.10.1 Electromagnetic blood flowmeters

The electromagnetic flowmeter is at present the most widely used device for measuring pulsatile blood flow. The fundamental quantity measured by these flowmeters is