BLOOD FLOW METER

An adequate blood supply is necessary for all organs of the body, an impaired supply of blood is the cause of various diseases. The rate of flow of a liquid or a gas in a pipe is expressed as the volume of the substance that passes through the pipe in a given unit of time.

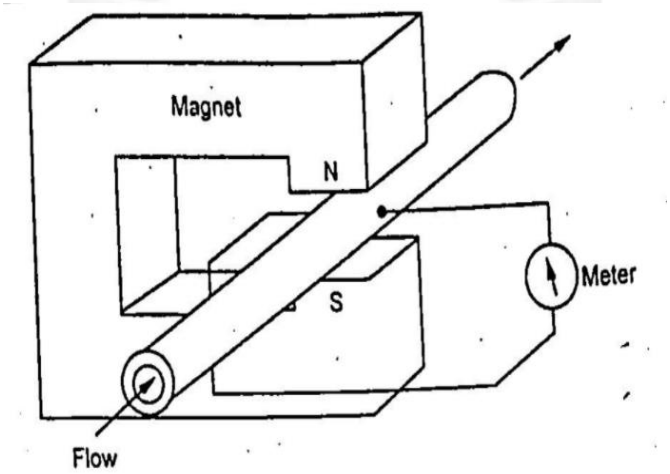
Flow rates are therefore usually expressed in litres per minute or millimetres per minute (cm^3/min). All blood flow meters currently used in clinical and research applications are based on one of the following physical principles.

- Electromagnetic induction
- Ultrasound transmission or reflection
- Thermal convection
- Radiographic principles
- Indicator (dye or thermal) dilution

Magnetic Blood Flow Meters:

Magnetic blood flow meters actually measure the velocity of the blood stream. Because these techniques require that a transducer surround an excised blood vessel, they are mainly used during surgery. When an electrical conductor is moved through a magnetic field, a voltage is induced in the conductor proportional to the velocity of its motion.

The voltage induced in the moving blood column is measured with stationary electrodes located on opposite sides of the blood vessel and perpendicular to the direction of the magnetic field.



The block diagram of a magnetic blood flow meter is given below.

- The oscillator, which drives the magnet and provides a control signal for the gate, operates at a frequency of between 60 and 400Hz.
- The use of a gated detector makes the polarity of the output signal reverse when the flow direction reverses,
- The frequency response of this type of system is usually high enough to allow the recording of the flow pulses, while the mean or average flow can be derived by use of a low-pass filter.

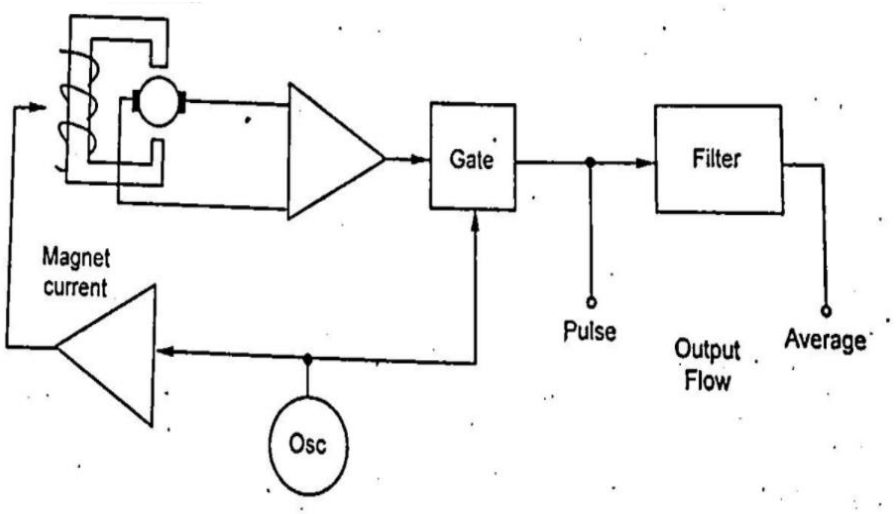


Fig: Magnetic blood flow meter, block diagram

Ultrasonic Blood Flow Meters

In an ultrasonic blood flow meter, a beam of ultrasonic energy is used to measure the velocity of flowing blood. There are two different ways of ultrasonic blood flow meter, they are transit time and doppler type.

Transit time:

In transit time ultrasonic blood flow meter, a pulsed beam is directed through a blood vessel at a shallow angle and it transmit time is then measured. When the blood flows in the direction of the energy transmission, the transit time is shortened, if it flows in the opposite direction, the transit time is lengthened.

Doppler type:

The block diagram of ultrasonic blood flow meter, Doppler type is given below.

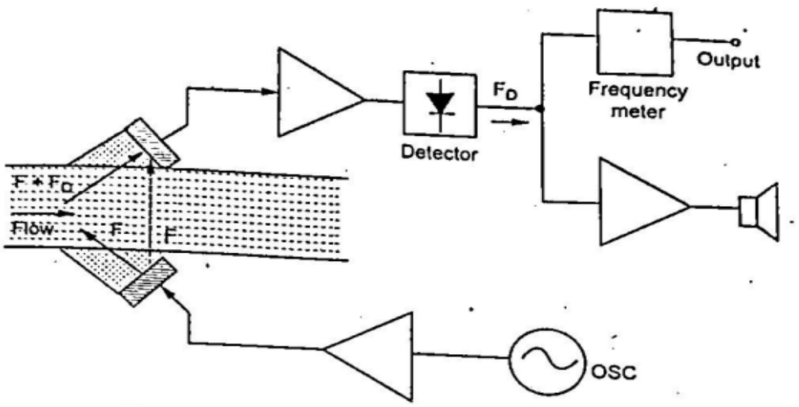


Fig: Ultrasonic blood flow meter, Doppler type

An oscillator, opening at a frequency of several megahertz (MHz), excites a piezoelectric transducer. The piezoelectric transducer is coupled to the wall of an exposed blood vessel and sends an ultrasonic beam with a frequency F into the following blood.

A small part of the transmitted energy is scattered back and is received by a second transducer arranged opposite the first transducer. Because the scattering occurs mainly as a result of the moving blood cells, the reflected signal has a different frequency due to the doppler effect.

The transmitted frequency is either $F+F_D$ or $F-F_D$, depending on the direction of the blood flow. When the blood flow is in same direction to the beam, then the frequency is $F+F_D$, if the blood is in opposite direction to the beam, then the frequency is $F-F_D$.

The doppler component F_D is directly proportional to the velocity of the flowing blood. A fraction of the transmitted ultrasonic energy, with the frequency being unchanged. The measure of blood flow can be obtained with the help of frequency meter. The doppler signal of the pulsating blood flow can also be heard with the help of loud speaker.

Thermal convention methods:

A hot object in a colder-flowing medium is cooled by thermal convection. The rate of cooling is proportional to the rate of the flow of the medium. There are two method of blood flow measurement by thermal convection, they are

- In one method, a thermistor in the blood stream is kept at a constant temperature by a servo system. The electric energy required to maintain this constant temperature is a measure of the flow rate.

- In another method, an electric heater is placed between two thermocouples or thermistors that are located some distance apart along the axis of the vessel. The temperature difference between the upstream and the downstream sensor is a measure of the blood velocity.

Radiographic Methods:

Blood cannot be normally visible on an x-ray image because it has about the same radio density as the surrounding tissue. By the injection of a contrast medium into a blood vessel, the circulation pattern can be made locally visible.

Indicator Dilution Methods:

The indicator or dye dilution methods are the only methods of blood flow measurement that really measure the blood flow and not the blood velocity. The principle states that, any substance can be used as an indicator if it mixes readily with blood and its concentration in the blood can be easily determined after mixing. The substance must be stable and have no toxic side effects but should not be retained by the body.

An Indocyanine dye, cardio green, used in an isotonic solution was long favoured as an indicator. Radioactive isotopes have also been employed for this purpose. There are two methods employed to measure the blood flow by indicator dilution.

Open circulation method:

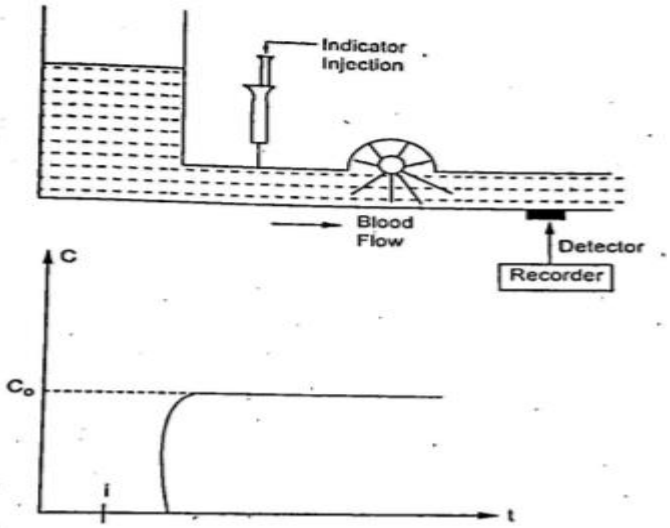


Fig: open circulation method

In this method the measurement is made under the assumption that the blood is not recirculated. The indicator is injected into the blood flow continuously at the beginning time t with a constant infusion rate of I grams per minute. A detector measures the concentration of the downstream from the injection point.

The output of the detector is connected to the recorder and at a certain time after injection the concentration of the indicator increases and finally reaches a constant value C_o milligrams per litre.

Closed circulation method:

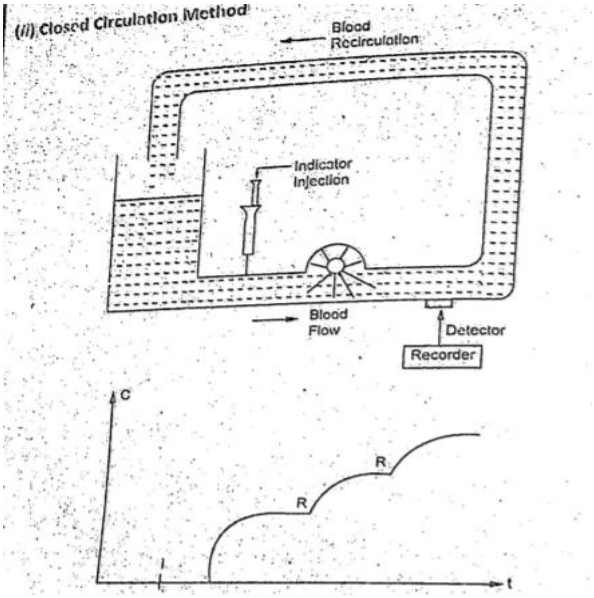


Fig: closed circulation method

Its states that when a dye or isotopes is used as an indicator, the concentration does not assume a steady state instead increases in steps whenever the recirculated indicator again passes the detector. This method is based on the assumption that the blood is being recirculated.

The indicator is injected and its concentration is measured with the help of detector and when the indicator is again recirculated the concentration increases step by step as shown in the graph. The output of detector is connected to the recorder and the flow can be determined.