Unit - II

Bio-chemical and Non-Electrical Parameter measurement

Blood Gas Analyser:

Blood pH measurement

* The chemical balance in the body can be determined by the pH value of blood and other body fluids.
* The pH value of blood is defined as the logarithm of the reciprocal of H^+ ion concentration in the blood

$$pH = \log_{10}\left[1/[H^+]\right] = -\log_{10}[H^+]$$

pH is the measure of acid-base balance in a fluid.

pH = 7, neutral solution
pH < 7, acidic solution
pH > 7, basic solution

pH ⇒ Partial Pressure of hydrogen

* Hydrogen ion concentration ↑ses ⇒ pH value falls
  Hydrogen ion concentration ↓ses ⇒ pH value rises.

pH Measurement

* To measure the pH of a solution, the solution is taken in a beaker.
* A pair of Electrodes one Glass (or) indicating Electrode and the other Reference (or) calomel Electrode is immersed into the solution.

* The voltage developed across the Electrodes is applied to an Electronic amplifier which transmits the amplified signal to the display.

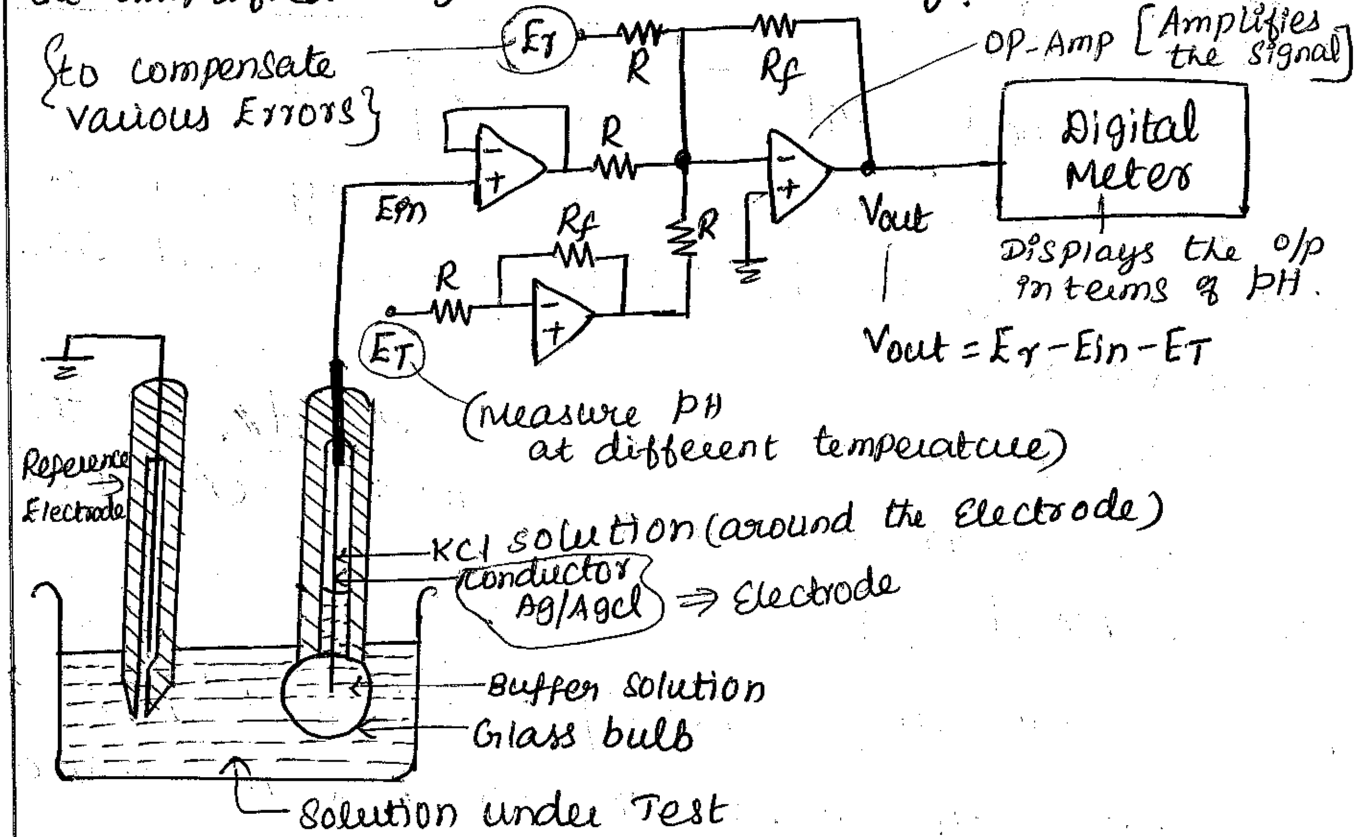


Fig: Digital pH Meter

* The glass Electrode consists of a thin glass membrane that allows only hydrogen ions to pass through it in the form of H_3O^+ (hydronium ions).

* Inside the glass bulb a highly buffered solution is present.

* Ag/AgCl Electrode is used as the reference Electrode due to its smaller and stable half cell potential.

* Both the Electrode are placed in a single glass Enclosure.

* The o/p of pH Electrode is high enough to deflect the voltmeter, but a Electronic circuit is employed to increase the sensitivity and accuracy.

* E_r [External voltage] → is added with the pH Electrode o/p to compensate various Errors.

* E_T → to measure the pH at different temperature, a voltage from a temperature regulator circuit is also added with the o/p of pH Meter.

* The OP-Amp are used to amplify these signals and the final o/p is fed to a digital voltmeter.

* Digital voltmeter → Displays the o/p in terms of pH.

PO_2 Measurement

* (PO_2) ⇒ Partial Pressure of oxygen.

* The Effective functioning of both respiratory and cardiovascular system can be analysed by PO_2 and PCO_2 measurement.

* The platinum wire, which is an active Electrode is Embedded in glass for insulation and only its tip is exposed. It is kept in the Electrolyte Solution.

* Ag/AgCl → is used as reference Electrode.

* A voltage of 0.7V is applied between the platinum wire and the reference Electrode.

* -ve terminal is connected to the active electrode through a micro ammeter and the +ve terminal is given to the reference Electrode.

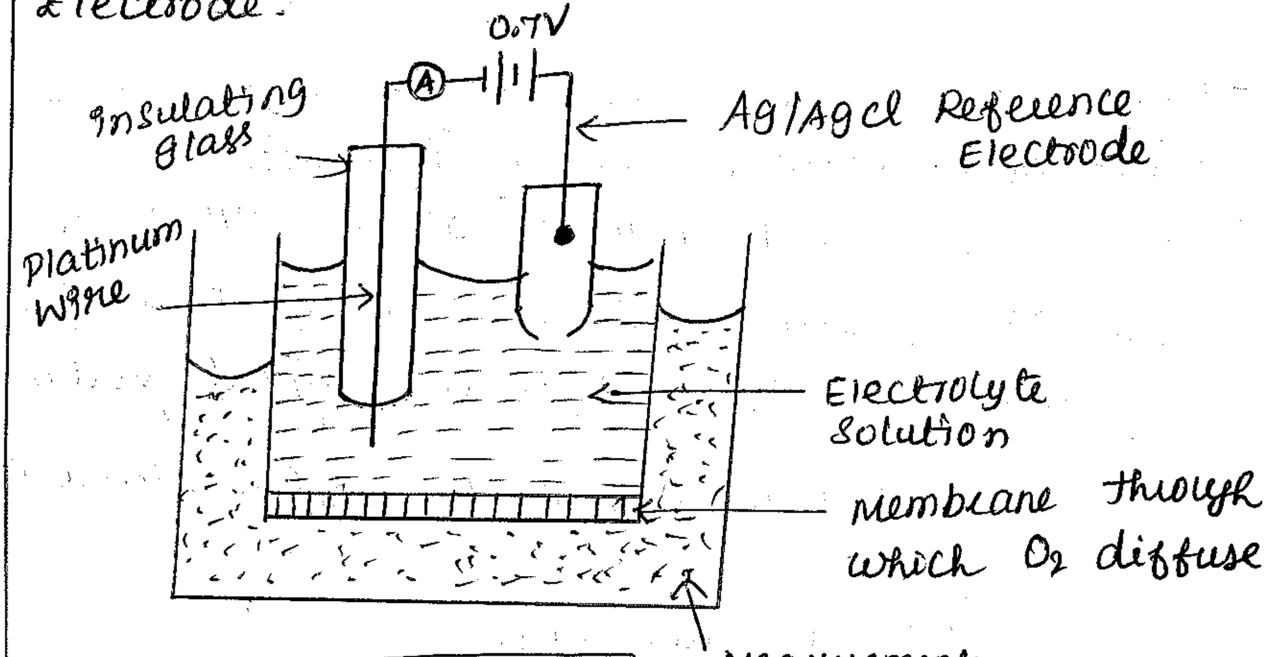


Fig: PO_2 Electrode
(known as Clark Electrode is an oxygen sensor for blood)

* current is Measured by the Ammeter (A).
* current is Proportional to PO_2 diffused into the Electrolyte.

* 2 types of PO_2 Measurements
  - In Vitro
  - In Vivo.

* <u>In Vitro Measurements</u>: In this method the blood sample is taken and the Measurement.

for oxygen is made in the laboratory.

The Electrode is placed in the sample blood solution and the pO_2 value is determined.

In Vivo Measurements:

In this method the oxygen is determined while the blood is flowing in the circulatory system.

A micro version of the pO_2 Electrode is placed at the tip of the catheter so that it can be inserted into various parts of the heart (or) circulator system.

pCO_2 Measurement

pCO_2 → Partial Pressure of carbon di-oxide

* pH Electrode is used as the component of a pCO_2 Electrode → is used to measure the partial Pressure of CO_2.
  * is known as Severinghaus Electrode.

* pCO_2 Electrode consists of a pH sensitive glass Electrode with a Rubber membrane selectively Permeable to CO_2

* The modern improved pCO_2 Electrode is called as Severinghaus Electrode. In this Electrode the membrane permeable to CO_2 is made up of Teflon which is not Permeable to other ions which affects the pH value.

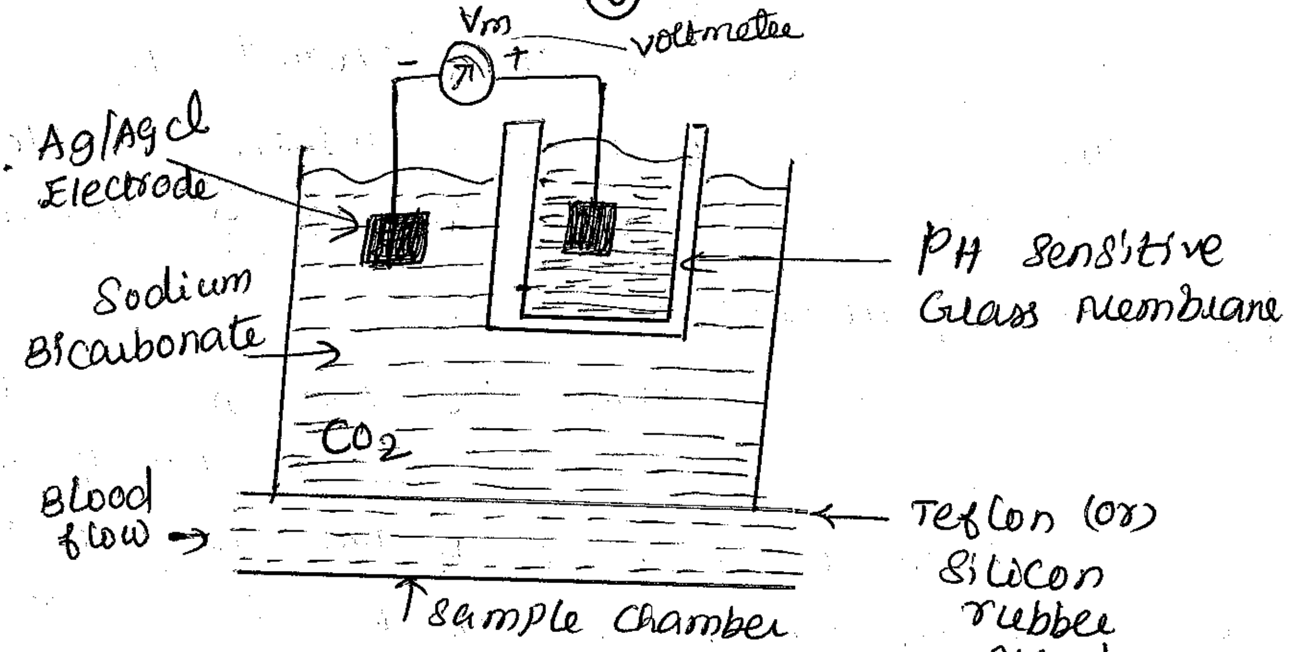
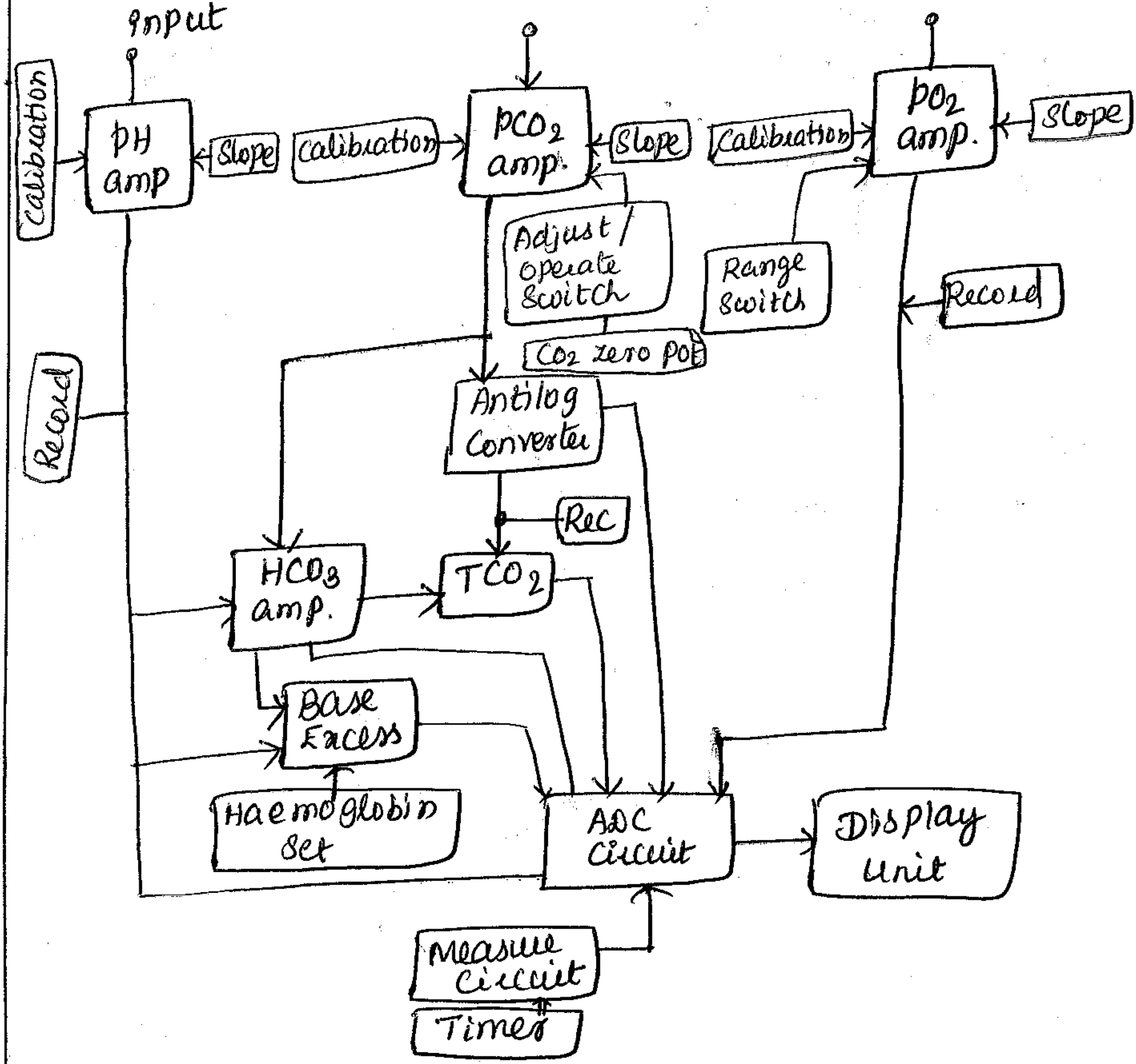


Fig: CO2 Meter

* The CO_2 in the solution combines with water (sodium bicarbonate). So as to produce free hydrogen ions in the sodium solution. This changes the solution pH in propagation to the partial pressure of CO_2 in the blood.
* Vm is proportional to the pH.

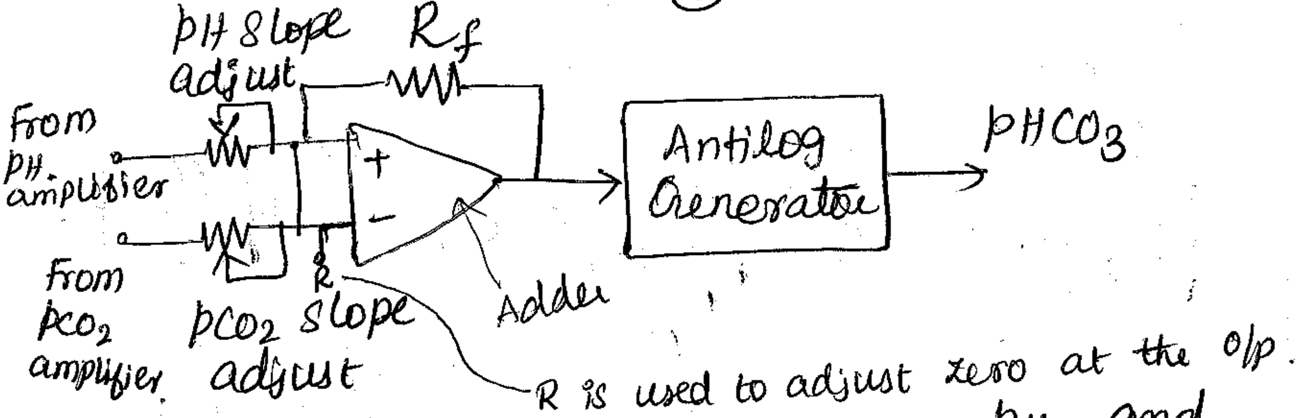
PHCO3 Measurement

* Blood gas analysers are used to measure the content of pH, pCO_2 and pO_2 from the blood.
* $PHCO_3$ → Partial Pressure of Bicarbonate
* Two gases of accurately known O_2 and CO_2 percentages are required for calibrating the analyser in pO_2 and pCO_2 modes.



Block diagram of a Complete Blood Gas Analyser.

* These gases are used with precision Regulators for flow and pressure control.
* Two standard buffers of known pH are required for calibration of the analyser in the pH mode.



Bicarbonate Measurement from pH and pCO_2 circuit diagram.

* I/p signal to the (HCO_3^-) calculator is obtained from the outputs of the pH and pCO_2 amplifiers.

* The o/ps are adjusted by multiplying with a constant and are given to an adder circuit. $pHCO_3 = Antilog(a\,pH + b\,pCO_2)$ a, b ⇒ constants

* The o/p of adder is passed to antilog generator circuit. Then it is passed to A/D converter for display. [giving the $pHCO_3$ value]

* Resistance R is used to adjust zero at the o/p.

* TCO_2 → Total CO_2 is calculated by summing the o/p signals of the (HCO_3^-) calculator and the o/p of the PCO_2 amplifier.

* Base Excess calculator consists of 3 stages

Stage ①: the o/p of pH amplifier is inverted in an operational amplifier, whose gain is controlled by a potentiometer

Stage (2) : The o/p of HCO_3^- calculator is inverted.

Stage (3) : Summer Amplifier whose o/p is given to A/D converter, that gives a digital Read out.

PHOTOMETERS AND COLORIMETERS

* Chemical tests play a major role in identifying the abnormalities in human being.

* The blood serum is a complex fluid that contains a large number of chemical substances dissolved in it.

* These substances have the property of absorbing and emitting the visible light.

* Protein and iron levels in blood can be measured with the help of photometers and colorimeters.

Filter photometer [colorimeter]

* When an interference filter is used to select a given wavelength, it is called filter photometer.

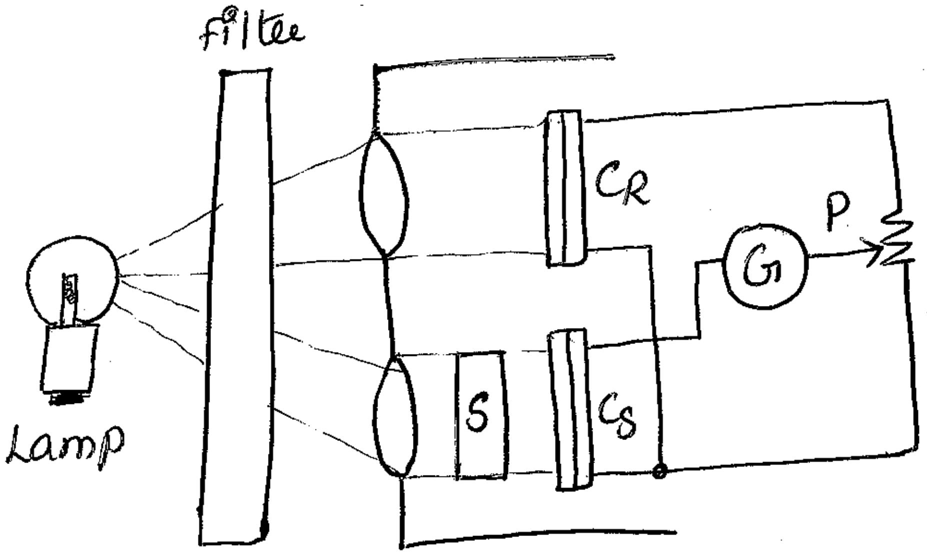
* This is used for measuring transmittance and absorbance of solutions.

* The lamp arrangement emits light of different wavelength and the filter F transmits

only the suitable range of wavelength through it.

* The light beam from the filter is converted into the parallel beams by an optical arrangement.

* The light falls on two photo electric cells [C_R, C_S]



Filter Photometer

C_R ⇒ Reference Selenium PhotoElectric Cell
C_S ⇒ Sample selenium PhotoElectric Cell

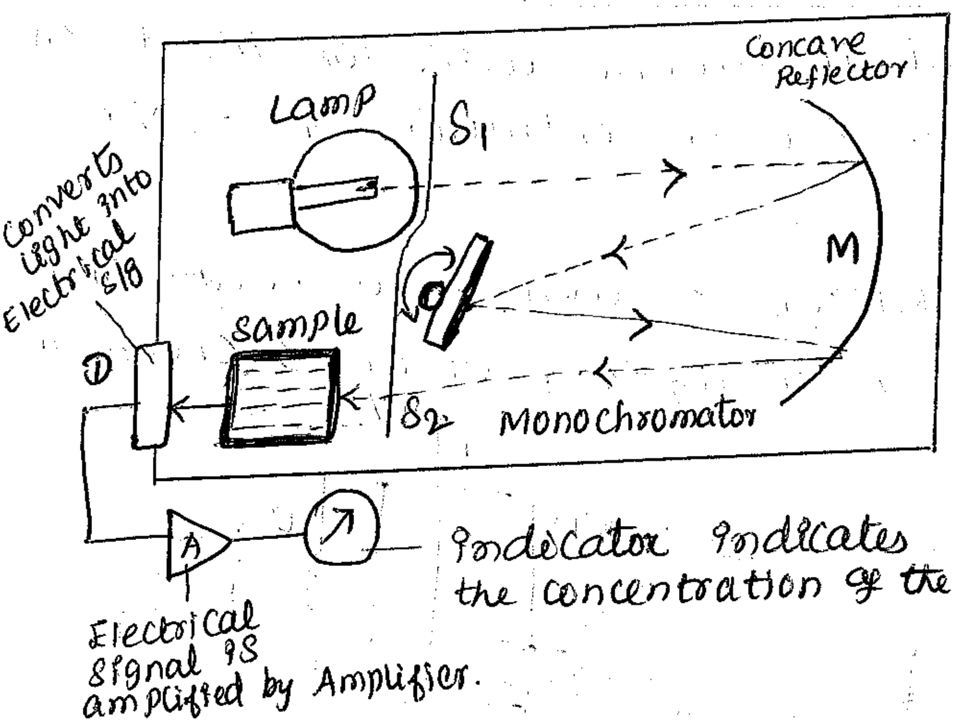
(X) * without the sample, the o/p from both the cells are same.

* when the sample is placed in the path, the o/p of the sample cell is reduced. and hence the potentiometer is adjusted that both the cells C_R and C_S give the same o/p. until a galvano-meter (G) shows a balance.

* since the potentiometer is calibrated in terms of transmittance (or) absorbance units & the concentration of the given substance in the sample can be determined.

Spectrophotometer

* When a diffraction grating (or) prism is used as a monochromator to get different spectral components (or) wavelengths ⇒ Spectrometer



M → Mirror
D → Photodetector
G → Prism (or) Grating
S_1 → Entrance slit
S_2 → Exit slit
A → Amplifier

* Light from a halogen lamp is passed through an entrance slit S_1 and incident on a concave reflector which focuses the light on a diffraction Grating (G) (or) a prism to disperse light

* The selective wavelengths from the dispersed light is allowed to incident on the reflector.

* From the Reflector, the light beam is directed to the sample through a exit slit S_2.

* Photodetector → detects the transmitted light and gives an Electrical o/p corresponding to the intensity of the transmitted light.

Amplifier → Amplifies the Electrical signal

·Indicator → indicates the concentration of the substance.

Flame Photometer

* is used to analyze urine (or) blood in order to determine concentration of K, Na, Ca & Li.

* Here lithium is used as a calibration substance in the analysis of other 3 chemical substances.

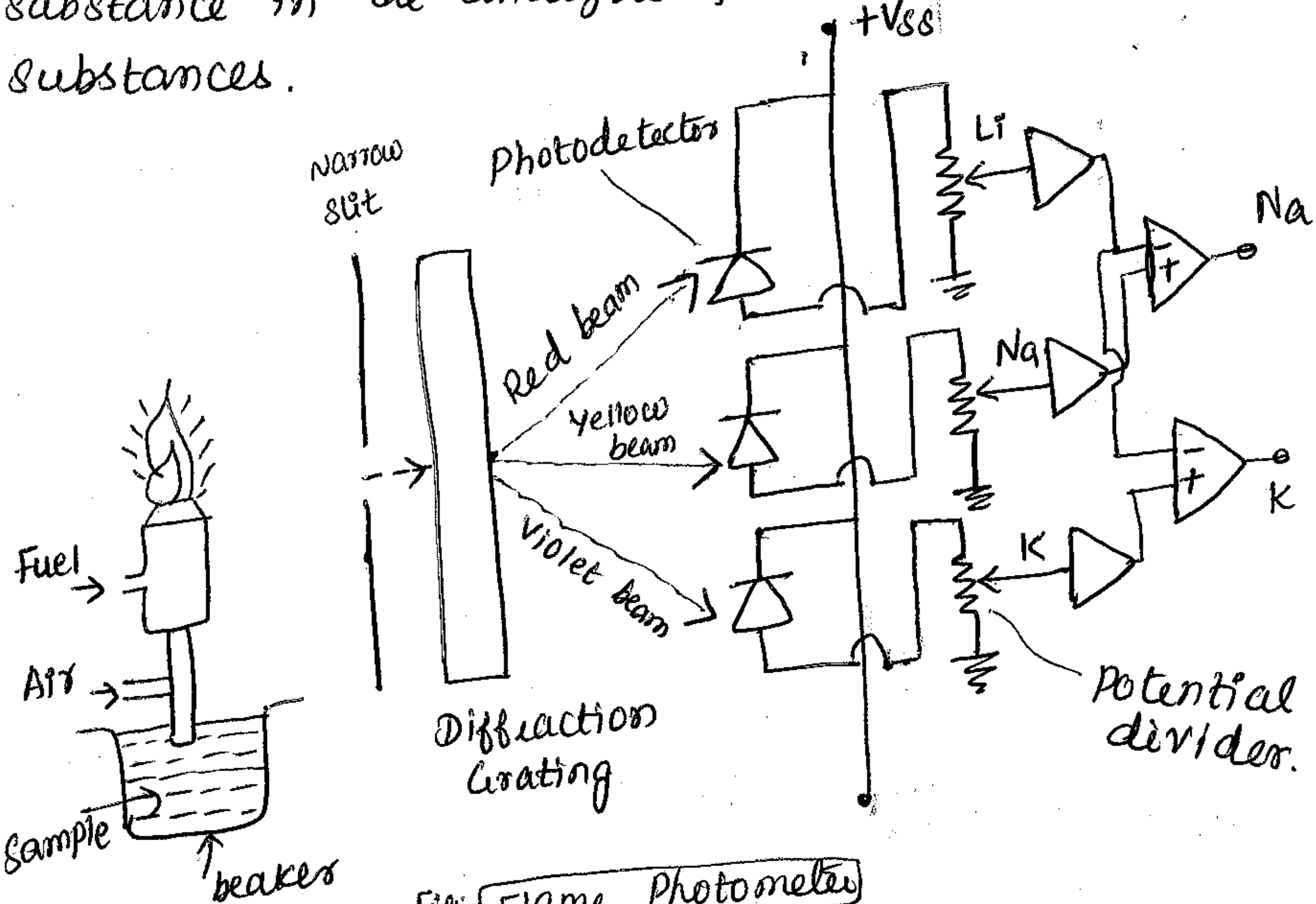


Fig: Flame Photometer

* In this method, fine droplets of the sample is aspirated into a gas flame that burns in a chimney.

* The light Emitted in the flame is

passed through a narrow slit and then to diffraction grating.

* The diffracted colours are incident on various photodiodes.

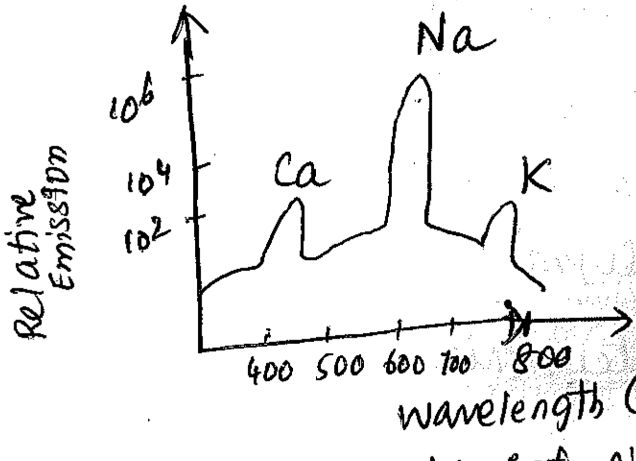
* The photodetector circuit consists of a reverse biased diode in which the current flow increases as the intensity of incident light increases.

* Diffracted colours

	(Wavelength)
For pottassium →	4047A° [Violet]
For sodium →	5890 A° [yellow]
For lithium →	6708 A° [Red]

* A calibration potentiometer is used in every channel. Since the lithium is used as a standard Reference, the o/p of sodium and potassium channel are calibrated interms of differences with the known lithium.

* The o/p can be compared with the spectral illustration.



Graph: Emitted light intensity for different wavelengths.

Auto Analyzer

* Auto Analyzer is used to measure blood chemistry and display that on a Graphic Recorder.

* **Sampler**: samples are feeded into the analyzer by using the sampler.
upto 128 Samples can be placed in the sampler. sampler contains the holes in which the sample tubes can be placed.

* **Mixing (or) Proportioning pump and manifold**

- This is the heart of the autoanalyzer.
- Mixes samples with the reagents so that proper chemical colour reactions can take place, which are then read by the colorimeter.

* **Dialyzer**: separates interfacing substances from the sample by permitting selective passage of sample components through a semipermeable membrane.

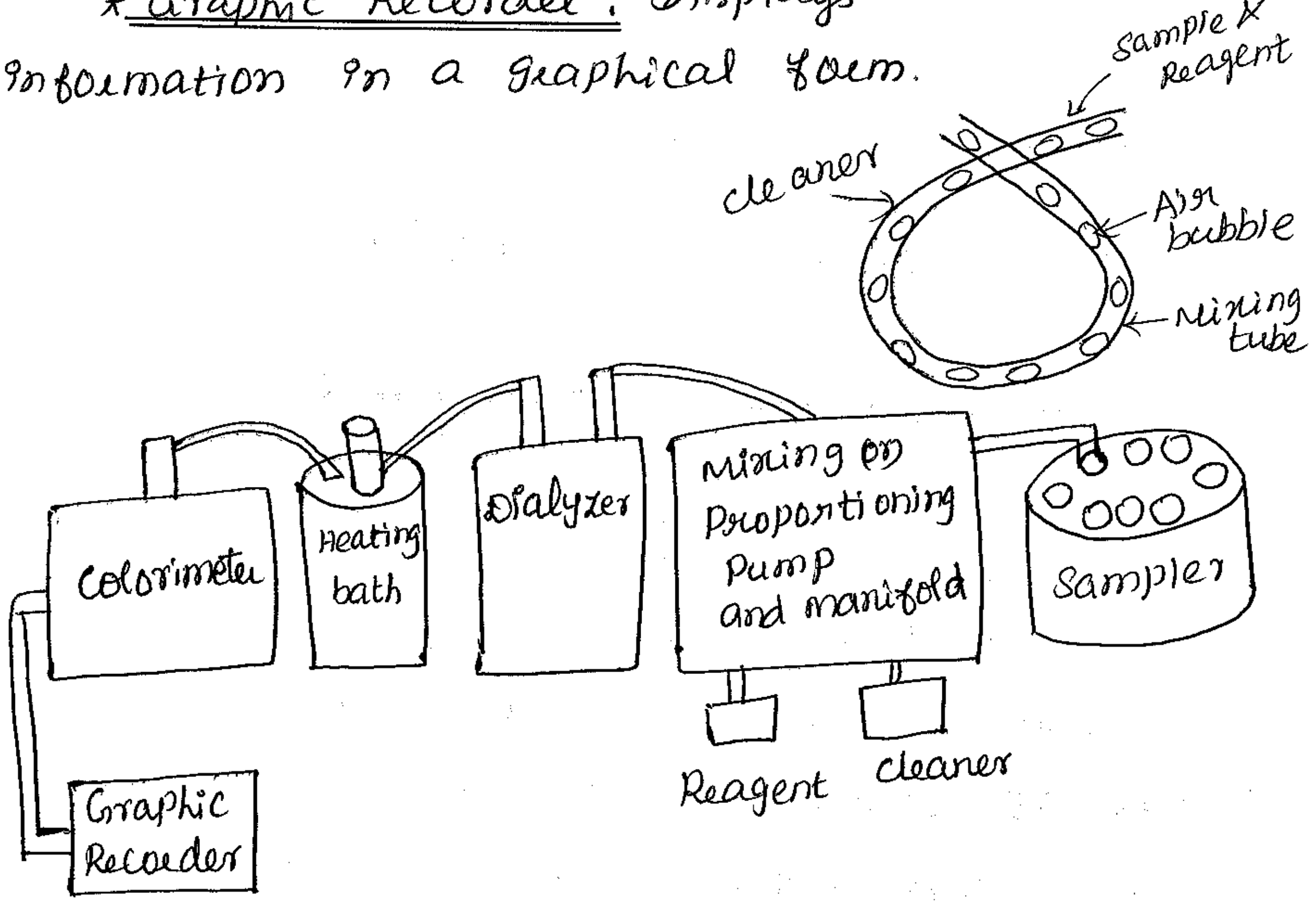
* **Heating Bath**: controls temperature (typically at 37°c), as temp. is critical in colour development.

* **Colorimeter**: Monitors the changes in

optical density of the fluid which flows through a tubular flow cell.

Colour intensity proportional to substance concentration is converted into corresponding electrical voltage.

* Graphic Recorder: Displays the output information in a graphical form.



Auto Analyzer

Pulse Measurement

* when heart muscle contracts, blood is ejected from the ventricles and a pulse of Pressure is transmitted through the circulatory System. This pulse can be measured at various Point.

* This Pulse travels at the speed of 5 to 15 meters/second.

* Photo Electric Method [used to measure pulse]
  - Transmittance Method
  - Reflectance Method.

Transmittance Method

* LED & Photoresistor are used
* Light is produced by the LED. The same light is passed through the finger
* For each heart pulse, blood is forced to the extremities and the amount of blood in the finger is increased.
* So, optical density is changed. So, the light transmitted through the finger is decreased.
* This light is received by the Photoresistor.

* This photoresistor is connected with the part of voltage divider circuit
* The voltage produced by this circuit is directly proportional to the amount of blood flow in the finger.
* The o/p is recorded by using strip chart recorder.

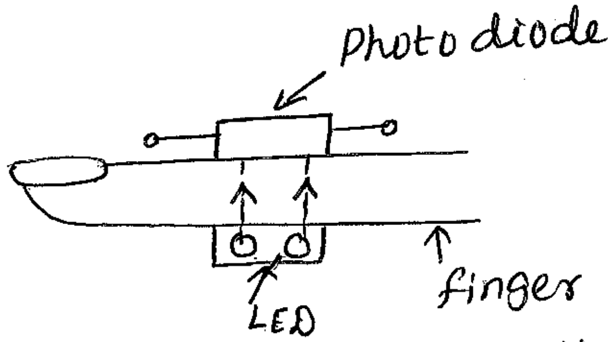


Fig : Transmittance Method.

Reflectance Method

* LED is placed adjacent to the photoresistor
* LED emits the light.
* This light is reflected from the skin and the tissues falls on the photoresistor
* The reflected light varies depending upon the blood flow in the finger.
* The photoresistor is connected as a part of the voltage divider circuit.
* The o/p voltage is directly proportional to the amount of blood in the finger.

* The o/p can be Recorded using Strip Chart Recorder.

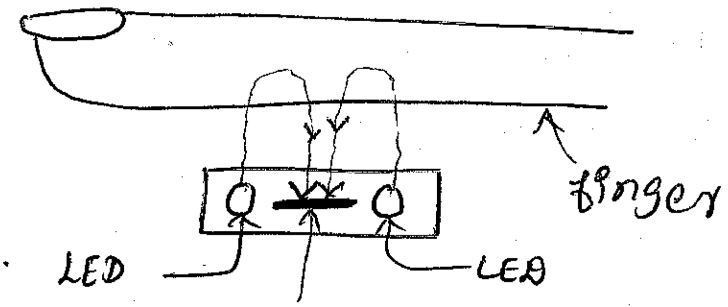


Fig: Reflectance method

cardiac output measurement

* Cardiac output: The amount of blood Pumped out by the heart to the Aorta per minute is called as cardiac o/p.

* For normal Adult, the cardiac o/p is 4-6 litres/min.

* The cardiac o/p is measured by using 3 methods.

① Fick's Method
② Indicator dilution method
③ Measurement of cardiac o/p by impedance change.

① Fick's Method

* In this method, cardiac o/p is determined by the analysis of gas-keeping of the organism.

* cardiac o/p can be calculated by continuously infusing oxygen into the blood (or) Removing it from the blood and measuring the amount of oxygen in the blood before and after its passage.

Let $I = C_A Q - C_V Q$

$I \Rightarrow$ Amount of infused (inspired) (or) removed (expired) oxygen per unit time

$$Q = \frac{I}{C_A - C_V}$$

$Q \Rightarrow$ cardiac o/p interms of litres/minute.

$C_A \Rightarrow$ concentration of oxygen in arterial blood (outgoing blood)

$C_V \Rightarrow$ concentration of oxygen in venous blood (incoming blood).

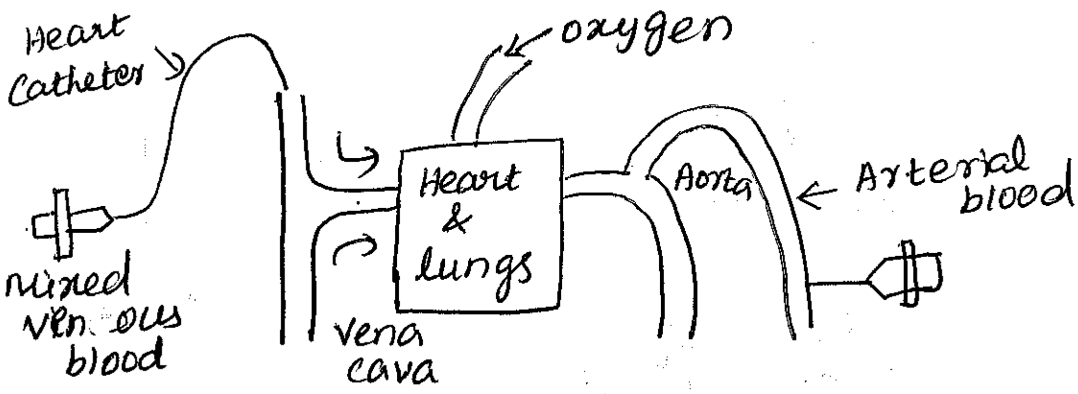


fig: Fick's Method

② Indicator Dilution Method:

* In this method, a known amount of dye (or) radioisotope is used as an indicator in the blood circulation and then measuring the concentration of the indicator with respect to time.

* The concentration of the indicator $(C) = \frac{dm}{dv}$

Sub. dv. then Integrate.

M ⇒ Mass
V ⇒ Volume

here $\frac{dv}{dt} = Q$ → $dv = Q\,dt$

$$\frac{dm}{dt} = Q\,c\,dt \rightarrow ①$$

Integrating eqn. ① over the time

$$M = \int_0^t Q\,c\,dt$$

$$M = Q\int_0^t c\,dt$$

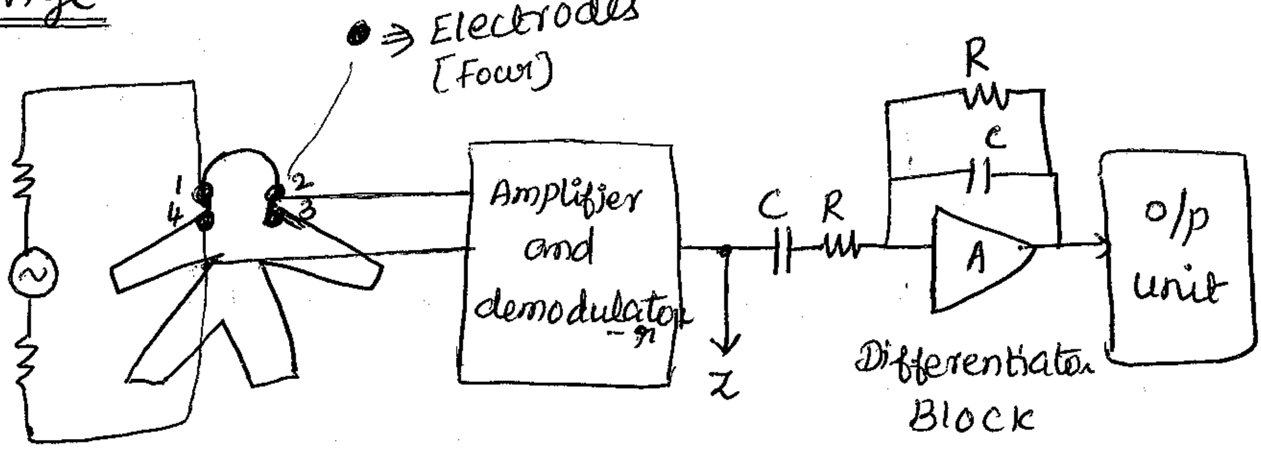
Q ⇒ cardiac o/p.

$$Q = \frac{M}{\int_0^t c\,dt}$$

$$\boxed{Q = \frac{M}{\text{Area of the curve}}}$$

Area of the curve → gives the direct value of $\int_0^t c\,dt$.

③ Measurement of cardiac o/p by impedance change



* Cardiac o/p can be determined Electronically by the impedance method.

* 4 Electrodes are placed, surrounding the thorax.

* Electrodes 1 & 4 → used as current Electrodes.

* Electrodes 2 & 3 → used to pick up the voltage across the thorax.

* The Resistance of the Thorax is given by

$R = \frac{\rho L}{A}$

ρ ⇒ Resistivity of the Patient's

A → cross sectional area of the thorax

L ⇒ separation length b/w the potential Electrodes 2 & 3.

$R = \frac{\rho L^2}{AL} = \frac{\rho L^2}{V}$

$\boxed{V = \frac{\rho L^2}{R}} \rightarrow (1)$

V ⇒ volume of the thorax

Differentiate eqn. (1) w.r.t 'R' [$\frac{u}{v}$ method]

Change in volume $dV = -\rho \frac{L^2}{R^2} dR$

Impedance is used instead of R.

$$\therefore \boxed{dv = -\rho \frac{L^2}{Z^2} dZ}$$

$$\frac{u}{v} = \frac{v\,du - u\,dv}{v^2}$$

$$\frac{dv}{dR} = \frac{R \times 0 - \rho L^2 \times 1}{R^2} = -\frac{\rho L^2}{R^2}$$

Blood Pressure Measurements

Introduction

* Pressure is defined as force per unit area.

$$\boxed{P = \frac{F}{A}}$$

P ⇒ Pressure (in Pascal)
F ⇒ Force (in Newton)
A ⇒ Area (in m^2)

Pressure is increased by increasing the applied force (or) by decreasing the area.

* Hydrostatic Pressure ⇒ If the force in a system under pressure is not varied, then the pressure is known as hydrostatic pressure.

* Hydrodynamic Pressure ⇒ If the force in a system under pressure is varied, then the pressure is known as hydrodynamic pressure.

Blood Pressure Measurement Methods (2 types)

Blood Pressure Measurement
- Indirect Method
- direct Method

Indirect Method of BP Measurement.

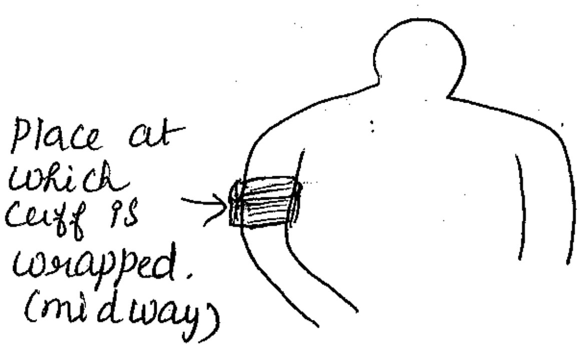
* Sphygmomanometer (↳ Greek word) is used to measure BP indirectly
* sphygmos → meaning pulse

* Sphygmomanometer consists ⇒ inflatable rubber bladder which is known as Cuff, rubber squeeze-ball pump and valve assembly. Pressure is measured using manometer with mercury column.

Procedures to use Sphygmomanometer

* The cuff is wrapped around the patient's upper arm at a point about midway b/w elbow and shoulder.
* The stethoscope is placed over an artery distal (downstream) to the cuff. [Because at this place, brachial artery comes close to the surface.

* The cuff is inflated so, the pressure inside the inflated bladder is increased to a point greater than the systolic pressure. This pressure compresses the artery against the underlying bone. So, blood flow is stopped in the vessel.



* Then the doctor slowly reduces the pressure in the cuff and he watch the mercury column when the systolic pressure exceeds the cuff pressure, then the doctor can hear some crashing, snapping sound through the stethoscope. This sound is known as Korotkoff sound

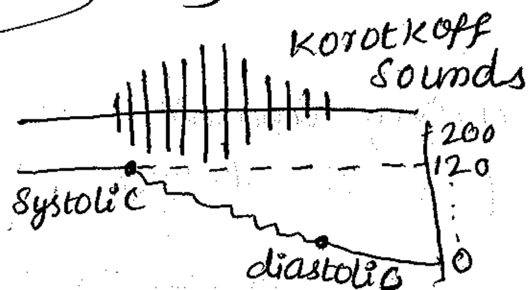
* This Korotkoff sound is vanished when the pressure drops below the diastolic pressure.

* The pressure reading in the mercury column during onset of Korotkoff sound is noted as systolic pressure [120 mm Hg]

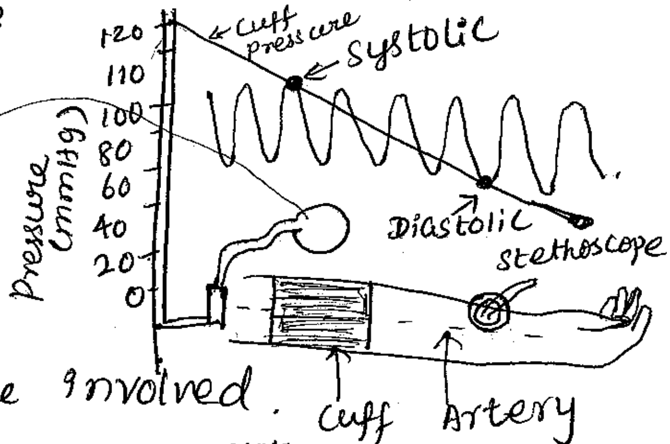
* The pressure reading in the mercury column at which Korotkoff sound is disappeared is noted as diastolic pressure (80 mm Hg)

* Korotkoff sound is disappeared at some point. This is known as muffling

* The use of Korotkoff sound as the indirect indicator for BP measurement is known as auscultation [it means use of hearing]



Advantages



* Very Simple Method
* Painless technique
* No Surgical Procedure involved.

Fig: Pressure measurement with cuff placement & korotkoff sounds.

Disadvantages

* The effective results depends on the fact that, how accurately the doctor read the pressure values when korotkoff sound is heard.

Direct Method of BP Measurement.

↳ used to measure accurate BP.

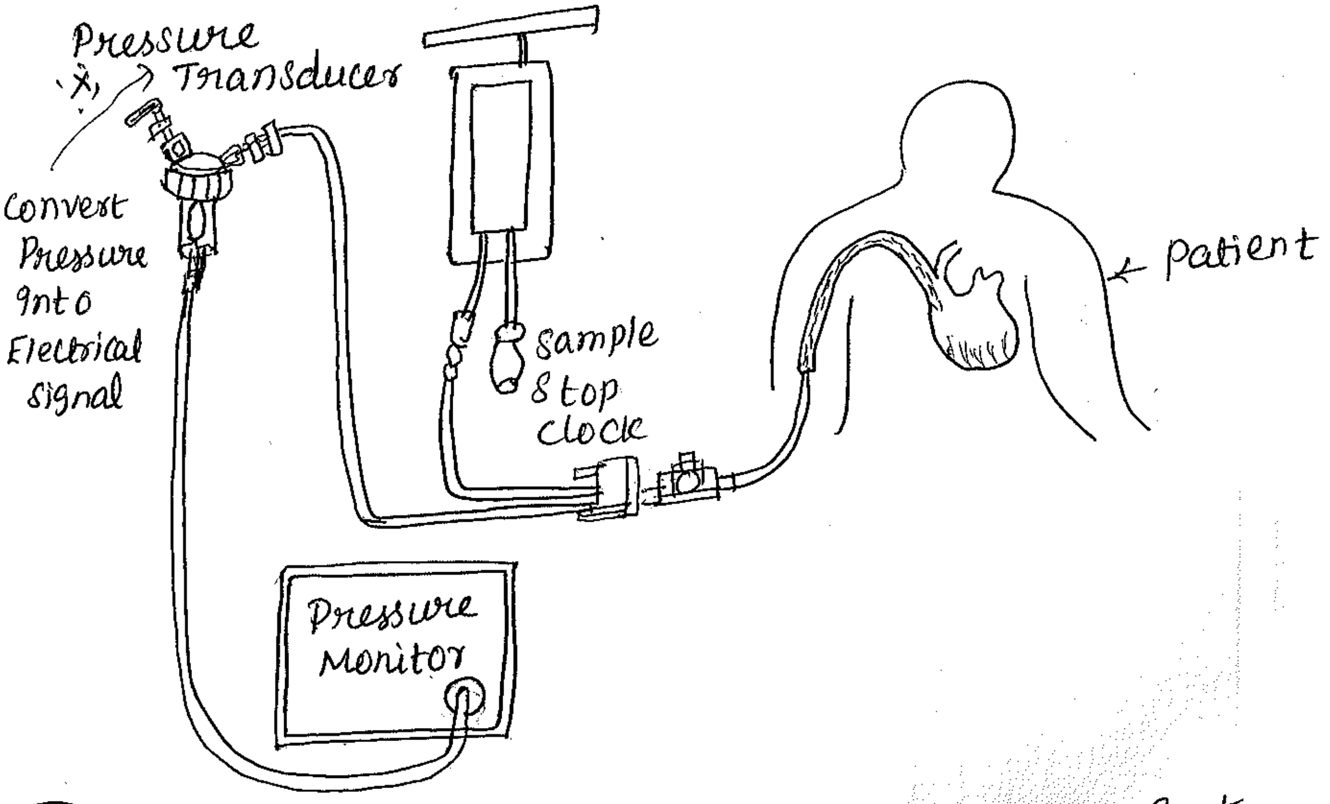


Fig: Typical setup of a pressure measuring system by direct method.

* In direct method, catheter (or) needle type is inserted through a vein (or artery).

* Catheter tip Probe, Sensor is mounted at the tip of the Probe. Pressure exerted on the tip is converted to the corresponding Electrical signal.

* In fluid filled Catheter (is filled with saline solution) type, Pressure exerted on the fluid filled column is transmitted to external transducer
↓
Converts pressure into Electrical signal.

* Catheter to be regularly flushed with saline solution to prevent blood from clotting.

* The o/p of transducer is given to Pressure monitor. Electrical signal is displayed in the monitor.

Blood flow Measurements

Introduction:

* An adequate blood supply is necessary for all organs of the body to perform their function. Improper blood supply results in the case of various diseases. Hence the diseases can be diagonised by measuring the rate of blood flow in the vessel.

* Bloodflowmeters → used to determine blood flow rate.

Magnetic Blood flow meters:

* Based on the principle of magnetic induction.

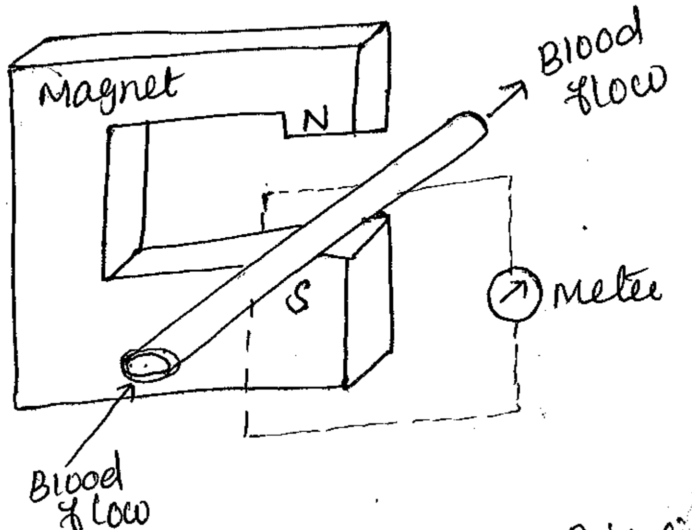


Fig: Magnetic blood flowmeter principle

* A permanent magnet (or) Electromagnet is placed around the blood vessel and it generates a magnetic field perpendicular to the direction of Blood flow.

* The voltage induced in the moving blood column can be measured with the stationary electrodes placed on the opposite sides of the blood vessel and perpendicular to the magnetic field.

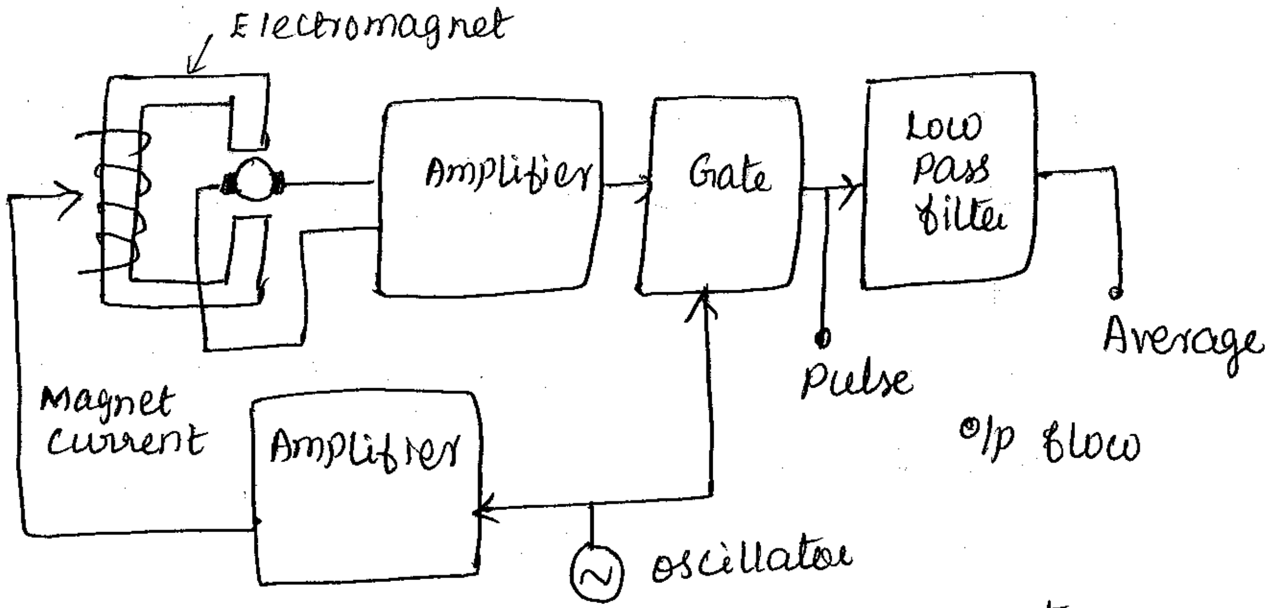


Fig: Block diagram of blood flowmeter

* Consists of electromagnet, oscillator, gate & low pass filter (LPF)

* <u>Oscillator</u> ⇒
  - used to drive the magnet
  - Provides a control signal for the gate
  - Operates at a frequency 60 Hz to 400 Hz.

* <u>gate detector</u> ⇒ . makes the polarity of the o/p signal reverse, when the flow of blood is in reverse direction.

* (LPF) ⇒ average (or) mean flow of pulses can be obtained.

Ultrasonic Blood flowmeters

↳ the velocity of the flowing blood can be determined with a beam of ultrasonic Energy.

(2 types)

- Transit time type
- Doppler type

Transit time type:

↳ ultrasonic beam is directed through a blood vessel and its transit time is then measured.

		Transit time value is
* when the blood flow is in the direction of Energy transmission	⇒	(short)
* when the flow of blood is in opposite direction	⇒	(greater)

Doppler type

* oscillator ⇒ operating at the frequency range of MHz.

* transducer ⇒ sends an ultrasonic beam with a frequency (F) into the flowing blood.

* Transmitted energy is received by the second transducer arranged opposite to the first transducer.

F+FD (or) F−FD { Depending on the direction of blood flow }

FD ⇒ Doppler frequency

* when the blood flow is similar direction to the beam ⇒ the frequency is (F+FD)

* when the blood flow is in opposite direction to the beam ⇒ the frequency is (F−FD)

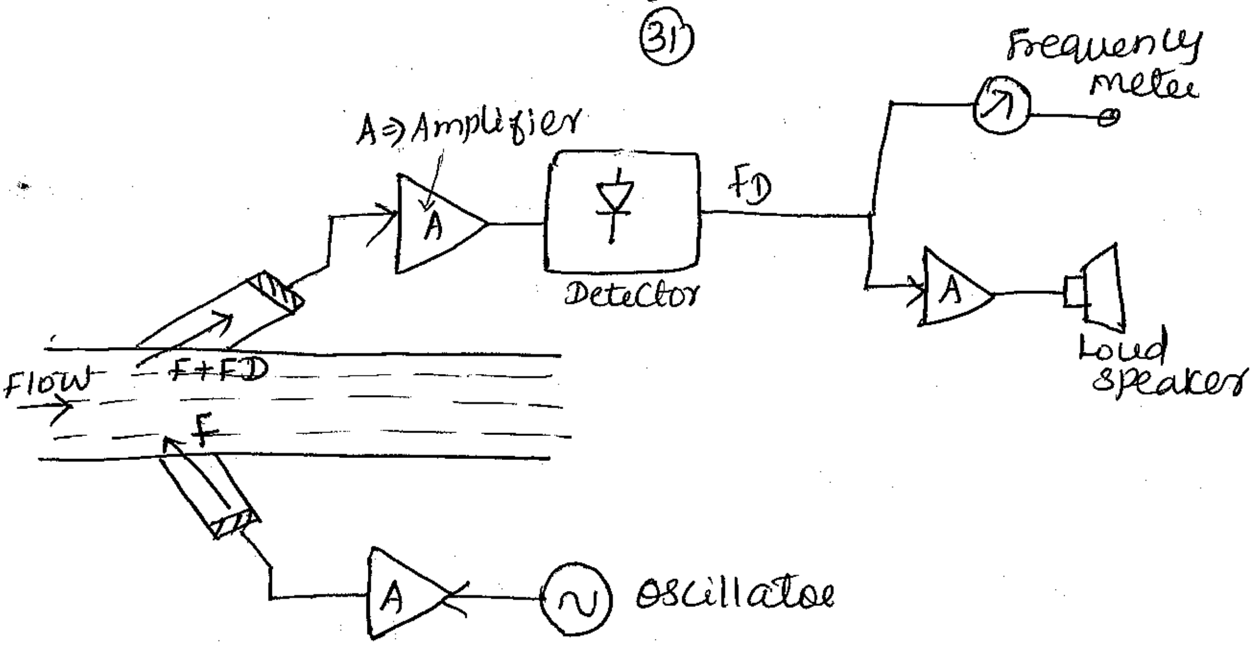
* FD is directly proportional to the velocity of the blood flow.

* Transmitted Energy reaches the 2nd transducer directly with the frequency being unchanged.

* After the Amplification, the Doppler frequency is obtained at the output of the detector

* Frequency meter ⇒ o/p can be obtained

* Loud speaker ⇒ pulsating blood flow can be heard.



(Fig): Doppler type ultrasonic blood flowmeter.

Thermal Convection Method

* A hot object placed in a colder flowing medium is cooled by thermal convection.
* The Rate is cooling is proportional to the rate of the flow of the medium.
* This Principle is used to measure gas flow & blood velocity

<u>One Method</u>

* A thermistor placed on the blood stream is kept at a constant temperature by a servo system. The rate of flow can be determined : by the Electrical Energy required to maintain the constant temperature of the thermistor.

Radiographic Method

* The flow of blood cannot be made visible with the help of x-rays due to their same density as the surrounding tissues.

* Hence to make the bloodflow visible a contrast medium like iodated organic compound is injected into blood vessel so that the circulation pattern can be made to be visible

* Now with the help of x-rays, the progress of the contrast medium, the obstructions and the blood flow in the vessels can be estimated.

* Another Method
injection of a radioactive isotope into the blood circulation which helps in the detection of vascular obstruction (eg. in the lung).

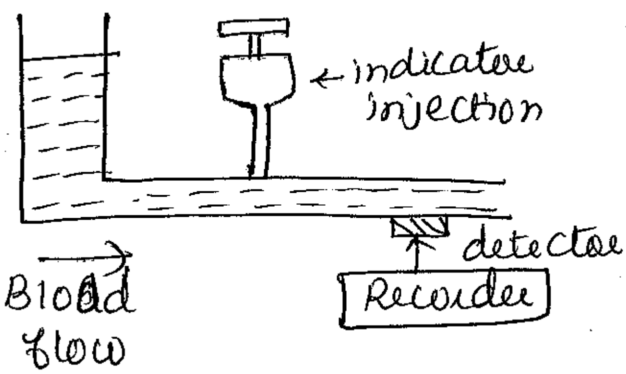
Indicator dilution Method

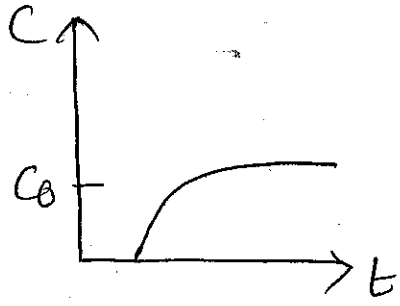
* Indicator + blood (mixing) ⇒ Blood concentration can be easily determined.

2 Methods

- Open circulation method
- Closed circulation method.

Open circulation Method :





C ⇒ concentration
t ⇒ time
Co ⇒ measured concentration.

* In this method

* under the assumption that the blood is not recirculated.

* Indicator is injected into the blood flow continuously at the beginning time 't' with a constant infusion rate of I grams per minute.

* Detector ⇒ measures the concentration

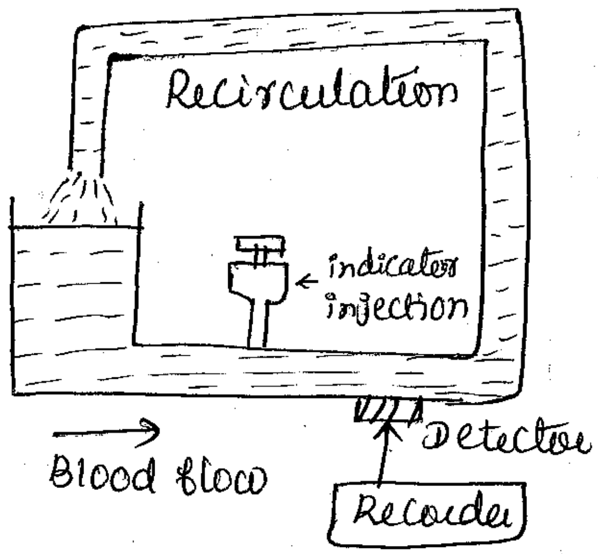
* The o/p of the detector is connected to the recorder

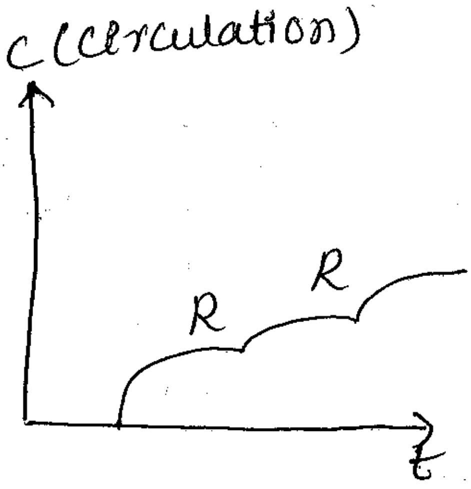
* After injection the concentration increases

$$\text{Rate of flow (litres per minute)} = \frac{I \text{ (milligrams per minute)}}{C_0 \text{ (milligrams per litre)}}$$

I ⇒ Injection Rate.

Closed circulation Method {Blood is Recirculated)





* Dye (or) isotope is used as an indicator
* concentration ⇒ increases in steps [(ie) step by step] whenever the recirculated indicator again passes the detector.
* Detector ⇒ concentration is measured (after indicator is injected)
* The o/p of the detector is connected to the Recorder and the flow can be determined.

Types of Respiration Rate-Measurement

* The primary function of the respiratory system is to supply oxygen and to remove CO_2 from the tissues.

* Various techniques (for measurement)
  ① Displacement Method ② Thermistor method
  ③ Impedance Pnemography ④ CO_2 method
  ⑤ Apnea detectors.

① Displacement Method

* the transducer is hold by an Elastic band which goes around the Chest

* It is connected as one arm of a wheatstone bridge circuit. its o/p various with Chest Expansion

* This output corresponds to the respiratory activity.

② Thermistor Method

* Generally, there is a temperature difference between inspired and expired air. This temperature is sensed by placing thermistor in front of NOStrils. (by using suitable stand).

* The thermistor is connected with the bridge circuit.

* So, unbalance signal is amplified to get the respiratory activity.

Impedance Pneumography (Indirect Method)

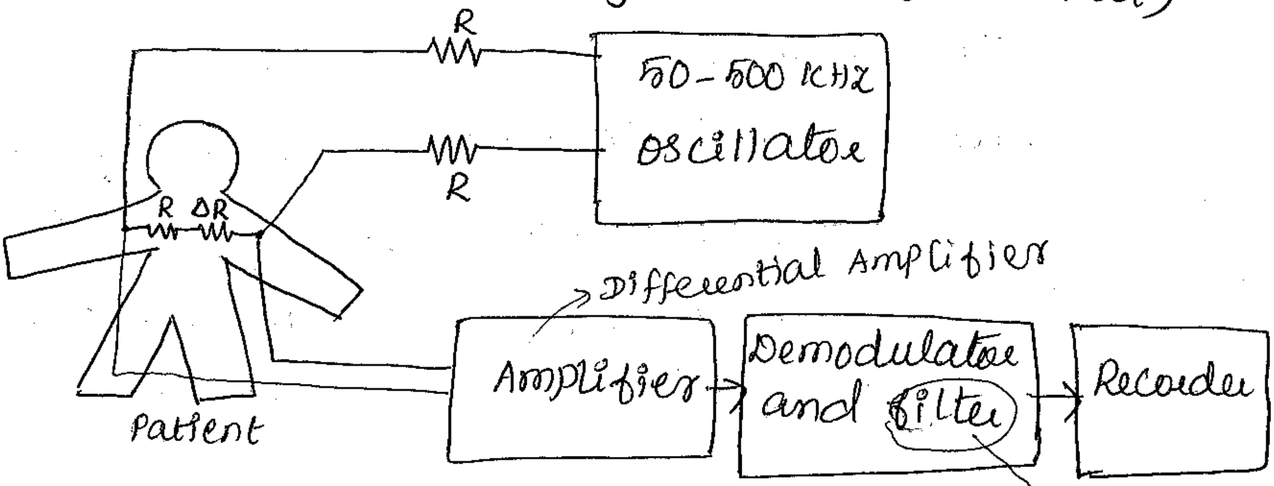


Fig: Impedance Pneumography

* **Oscillator:** 50-50 KHZ a.c signal is produced and it is given to the chest of the patient through electrodes.

* **Amplifier:**

$$V = I(R \pm \Delta R)$$

$V \rightarrow$ o/p voltage $I \Rightarrow$ current through the chest

$R \rightarrow$ Chest impedance without Respiration

$\Delta R \rightarrow$ Change of chest impedance with Respiration

* The o/p of the amplifier is given to demodulator and filter block.

* The o/p of the impedance Pneumograph contains respirating rate data.

CO_2 Method

* Respiration rate can be measured by measuring CO_2 in expired air.
* Measurement is based on the absorption property of infrared rays by certain gases.

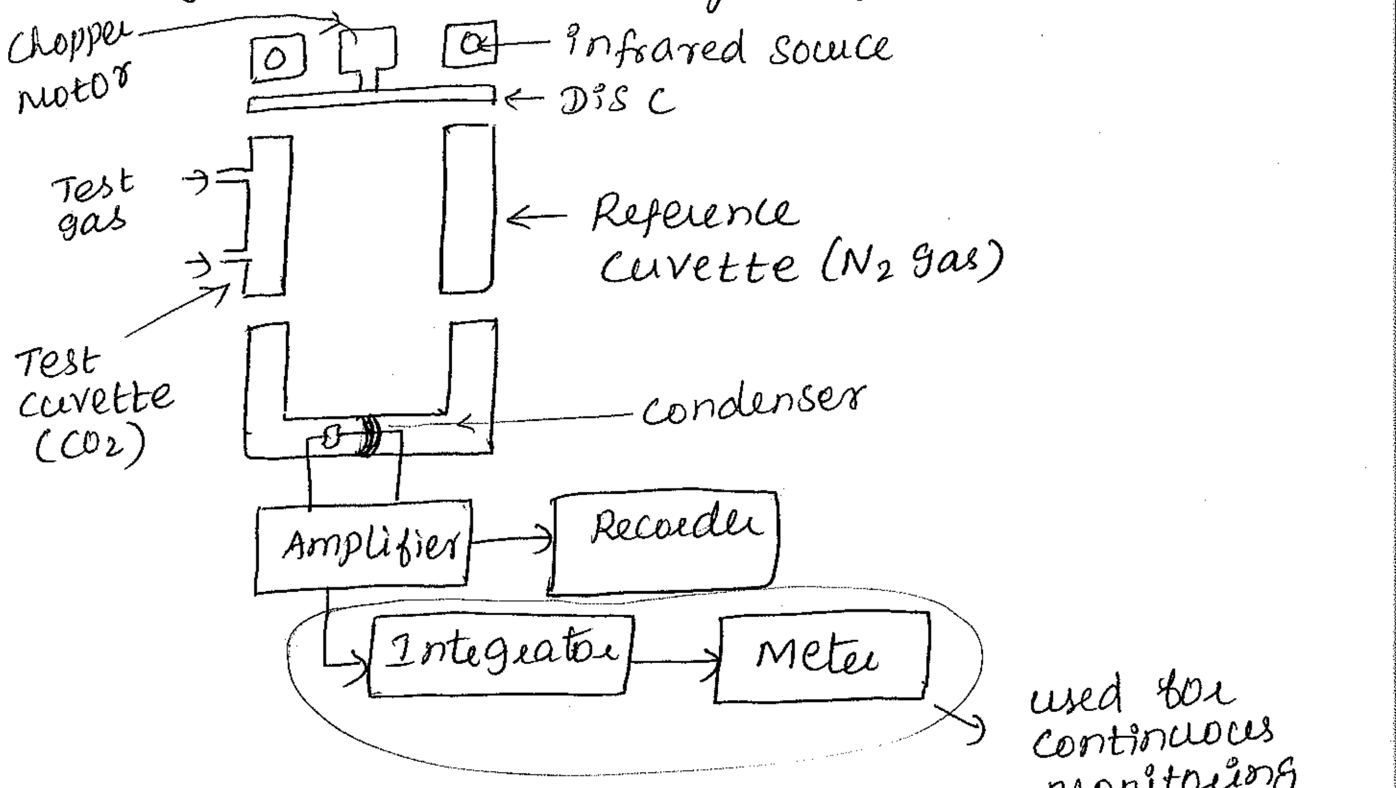
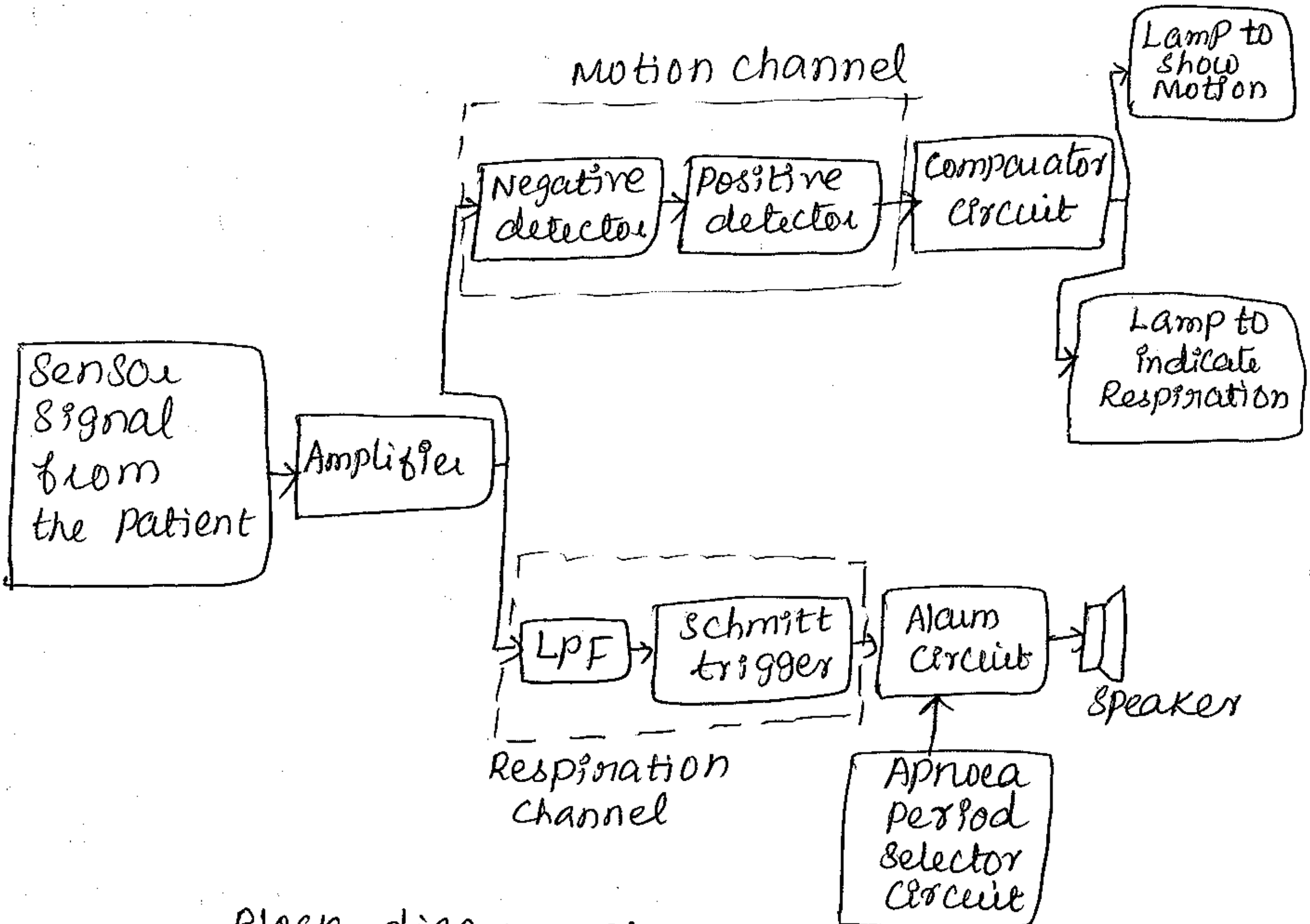


Fig: CO_2 Method

* Infrared source falls on both test and Reference cuvette.
* The beam falling on the test side of the detector is <u>weaker</u> than that falling on the reference side.
* The gas in reference side is heated more than that on the test side.
* The a.c signal appears across the detector is amplified and recorded using recorder.

Apnoea Detectors (Stoppage of breathing)

* occured → head injury, drug overdose, premature babies (immature nervous system).



Block diagram of apnoea monitor

* Apnoea Monitors → audio signal, video signal

* I/p from the sensor is connected with the amplifier circuit.

* Motion channel Block:
→ disturbances [based on the frequency).

Identified as

* The frequency (below 1.5 Hz) → Respiration
* The frequency (above 1.5 Hz) → Motion
* Positive detector → above the threshold is sensed.
* Negative detector → below the threshold is sensed.
* Comparator circuit → • Compares the amplitude of motion and respiration
  • Based on the output corresponding lamp will glow.

* Respiration Channel Block:

* LPF → used to remove high frequency signals.
* Schmitt trigger circuit → if there is no respiration this circuit switch on the alarm.

* Apnoea Period Selector Switch:

* Contains → low frequency alarm oscillator, tone oscillator and audio amplifier
* This circuit drives the alarm circuit
* The o/p of alarm circuit is connected with the speaker.

* when there is no respiration for a period of (10 or 20 s), then audio signal through the speaker and visual signal through the flash light is delivered.