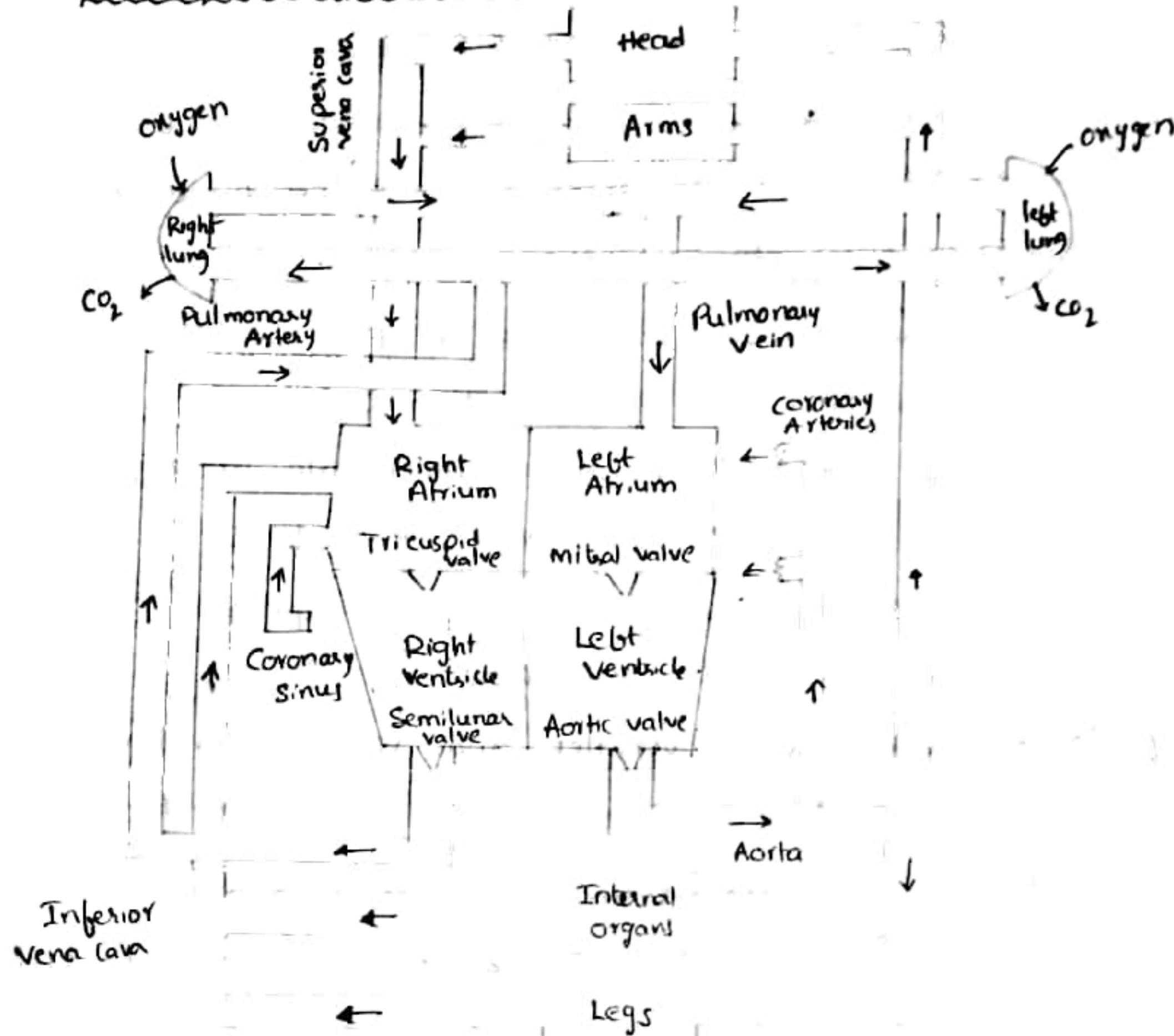


Cardiovascular System



- The heart is considered as a two stage pump, physically arranged in parallel but with the circulating blood passing through the pumps in a series manner.
- The right half of the heart known as right heart is the pump that supplies blood to the rest of the system.
- The circulatory path for blood flow through the lungs is called Pulmonary circulation.
- The circulatory system that supplies oxygen and nutrients to the cells of the body is called Systemic circulation.
- Blood enters the heart on the right side through two main veins, Superior vena cava, which leads from the body's upper extremities, inferior vena cava, leading from body's organs below the heart.
- The incoming blood fills the storage chamber, Right atrium. From the two veins & Coronary sinus blood enters into right atrium.
- The Coronary Sinus contains the blood that has been circulating through the heart itself via the coronary loop.

- When the right atrium is full, it contracts and forces blood through the tricuspid valve into the right ventricle, which then contracts to pump the blood into the pulmonary circulation system.
- When ventricular pressure exceeds atrial pressure, the tricuspid valve closes and the pressure in the ventricle forces semilunar valve to open, causing blood to flow into the pulmonary artery.
- In the lungs an exchange takes place i.e. the red blood cells are recharged with oxygen and give up their CO_2 .
- The pulmonary artery divides many times into smaller and smaller arteries, which become arterioles with extremely small cross sections.
- These arterioles supply blood to the alveolar capillaries, in which the exchange of oxygen and CO_2 takes place.
- Capillaries combine into venules and venules combine into veins, in which oxygenated blood is returned to the heart through pulmonary vein.
- The blood enters the left atrium from the pulmonary vein and from it is pumped through mitral valve, into the left ventricle by contraction of the atrial muscles.
- When the left ventricular muscles contract, the pressure produced by the contraction mechanically closes the mitral valve, and the buildup of pressure in ventricle forces the aortic valve to open, causing the blood to rush from the ventricle into the aorta.
- The heart's pumping cycle is divided into two major parts.
Systole is the period of contraction of the heart muscles, at which time blood is pumped into the pulmonary artery and aorta.
Diastole is the period of dilation of heart cavities as they fill with blood.
- Once the blood has been pumped into the arterial system, the heart relaxes, the pressures in the chambers decrease, the outlet valves close and in a short time the inlet valve opens to restart the diastole and initiate the new cycle of the heart.

Physiology of Heart

- The heart is contained in the Pericardium, a membrane consisting of an external layer of dense fiber tissue and an inner serous layer that surrounds the heart directly.
- The base of the pericardium is attached to the centre of diaphragm and its cavity contains a thin serous liquid.
- The two sides of the heart are separated by the Septum. The Septum also includes Atrioventricular node.
- The right atrium is elongated and lies between the inferior and superior vena cava. Its interior is complex, the anterior wall being very rough, the posterior wall is smooth.
- At the junction of the right atrium and superior vena cava is situated the Sino Atrial node, which is the pacemaker of the electrical impulses that excite the heart.
- The Right ventricle is situated below and to the left of the right atrium. They are separated by a fatty structure of the right branch of the coronary artery.
- Since the ventricle has to perform a more powerful pumping action, its walls are thicker than those of the atrium and its surfaces are ridged.
- Between the anterior wall of the ventricle and the septum is a muscular ridge that is part of the heart's electrical conduction system, known as Bundle of His.
- At the junction of the right and left atrium and the right ventricle on the septum is another node, the atrioventricular node. The bundle of His is attached to this node.
- The right atrium and right ventricle are joined by a fiber tissue known as Atrioventricular Ring, to which are attached the three cusps of tricuspid valve.
- The Left Atrium is smaller than the right atrium. Entry to it is through four pulmonary veins. The walls of chamber are smooth.

4

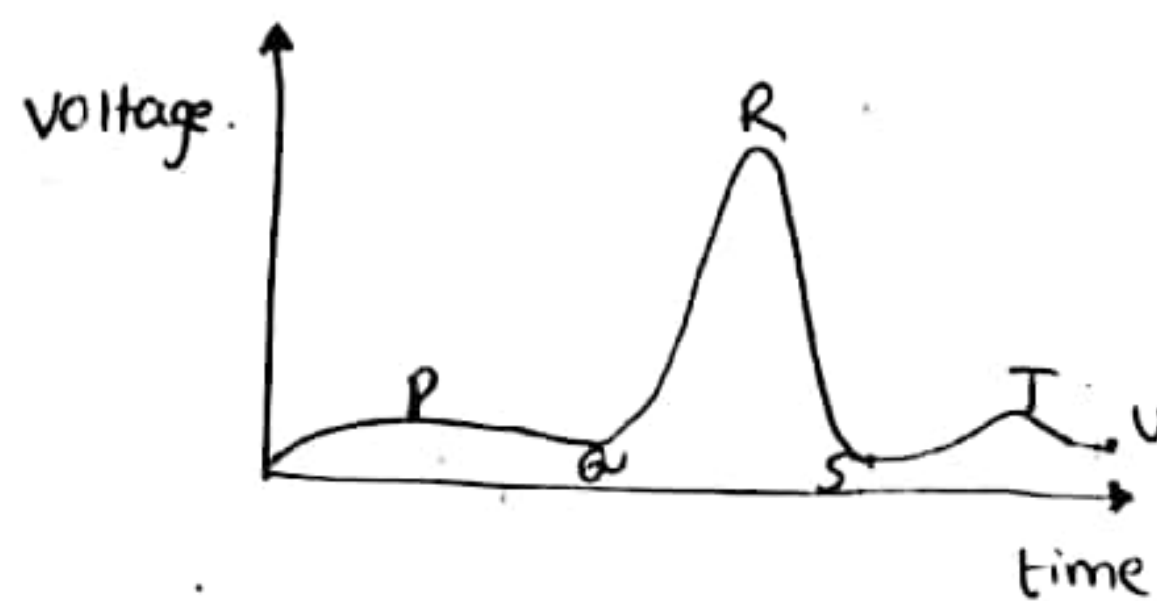
- The left atrium is joined to the left ventricle through the mitral valve. Sometimes called bicuspid valve since it consists of two cusps.
- The left ventricle is the power pump for all systemic circulation. Its walls are approximately three times as thick as the walls of the right ventricle.
- The output from the ventricles are through the aortic and pulmonary valves respectively for left and right ventricles.

Features of the Heart

- * The blood passes through the many divisions of the arteries, vital organs, the brain and the extremities.
- * The last stage of the arterial system is the gradual decrease in cross section and the increase in the number of arteries until the arterioles are reached.
- * The arterioles feed into the capillaries, where oxygen is supplied to the cells and CO_2 is received from the cells.
- * The capillaries join into venules, which become small veins, then larger veins and finally form the superior and inferior vena cava.
- * The blood supply to the heart itself is from the aorta through the coronary arteries into a similar capillary system to cardiac veins.
- * The heart beats at an average rate of 75 beats per minute.
- * The heart rate increases when a person stands up and decreases when he sits down, the range being from 60 to 85.
- * The heart pumps about 5 liters of blood per minute. The volume of blood in the average adult is about 5 to 6 liters.
- * Generally 75 to 80 % of blood volume is in veins and 20 % is in the arteries and the remainder in the capillaries.
- * Systolic blood pressure in the normal adult is in the range of 95 to 140 mm Hg, with 120 mm Hg as an average.
- * Diastolic blood pressure ranges from 60 to 90 mm Hg, 80 mm Hg being an average.

Electrical Activity of Heart

The waveform of the heart signal is



- * The PQRST wave reflects the rhythmic electrical depolarization and repolarization of myocardium associated with the contraction of the atria and ventricles.
- * The P-wave represents the depolarization of atrium. QRS wave is the combined result of repolarization of atrium and the depolarization of ventricle.
- * T-wave is the ventricular repolarization, U-wave is the start of the next cycle.
- * The values for amplitudes and durations of ECG wave are

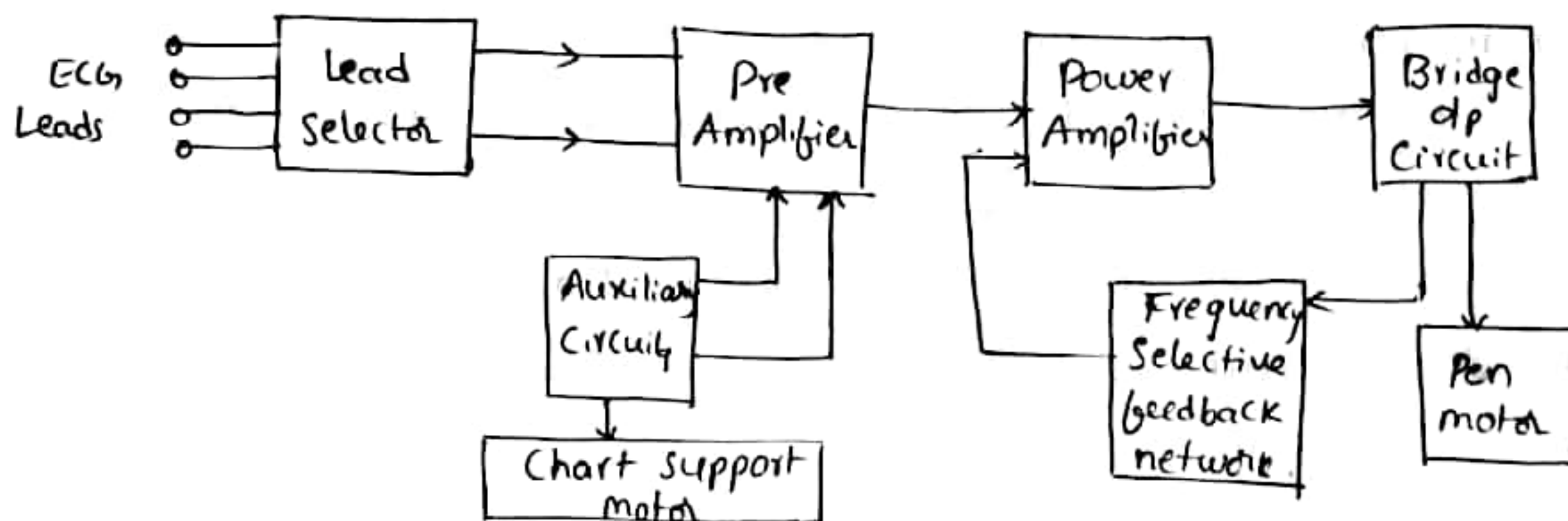
Amplitude ——— P wave — 0.25 mV
 R wave — 1.60 mV
 Q wave — 25% of R-wave
 T wave — 0.1 to 0.5 mV

Duration ——— PR interval — 0.12 to 0.2 sec
 QT interval — 0.35 to 0.44 sec
 ST interval — 0.05 to 0.15 sec
 P interval — 0.11 sec
 QRS interval — 0.09 sec.

- The normal value of heart rate is in the range of 60-100 beats. A rate slower than 60 beats is called bradycardia, a rate higher than 100 beats is called tachycardia.
- If the cycles are not evenly spaced, the condition is arrhythmia. If PR interval is greater than 0.2 sec, it is the blockage of AV node.

Electro Cardiograph

- It is an instrument, which records the electrical activity of the heart. It provides the valuable information about a wide range of cardiac disorders such as the presence of an inactive part or an enlargement of heart muscle.
- The block diagram of ECG Recorder is



- * The potentials picked up by the patient electrodes are taken to the lead selector switch. In the lead selector, electrodes are selected according to lead program.
- * By means of capacitive coupling, the signal is connected to the long-tail pair differential pre amplifier.
- * The pre amplifier is usually a three or four stage differential amplifier having a sufficiently large negative current feedback from the end stage to first stage, which gives stabilizing effect.
- * The amplified output signal is picked up single ended and is given to the power amplifiers of pull-push differential type.
- * The base of one input transistor of the amplifier is generally of the push-pull differential type and is driven by the pre-amplified unsymmetrical signal.
- * The base of other transistor is driven by the feedback signal resulting from the pen position and connected via frequency network.
- * The clip of power amplifier is single ended and is fed to the pen motor which deflects the writing arm on the paper.
- * The auxiliary circuit provide a 1 mV calibration signal and automatic blocking of amplifier during a change in position of lead

Electrodes and Leads

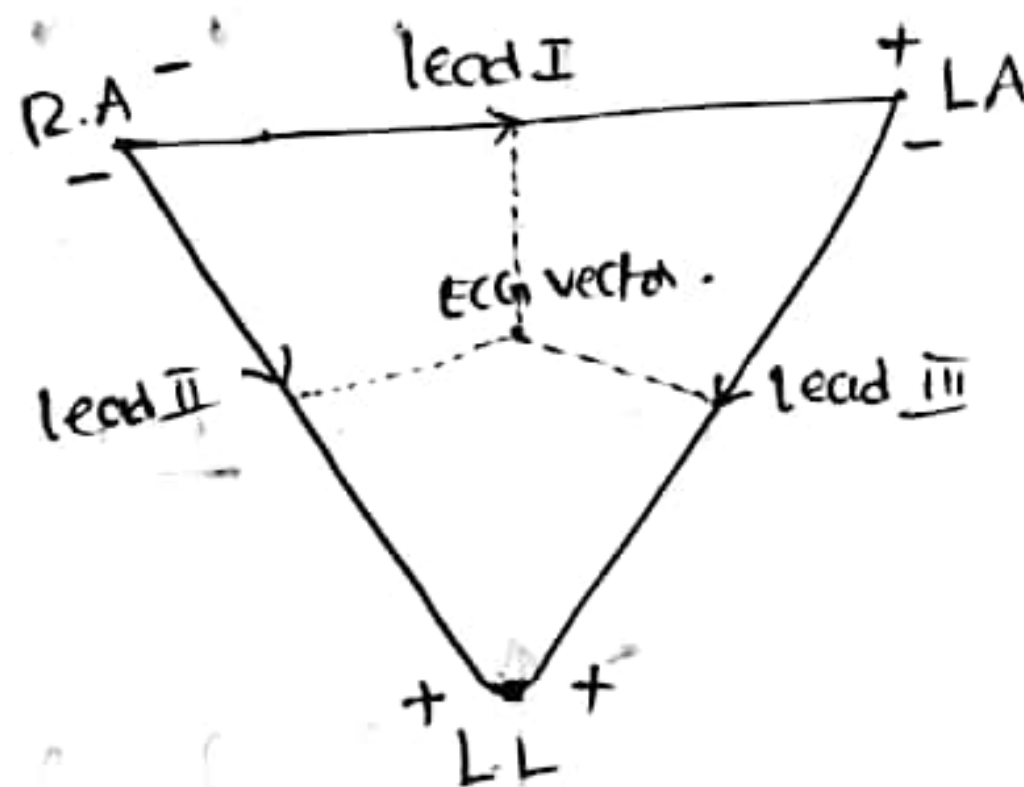
- To record an ECG, a no. of electrodes usually five are connected to the body of the patient. The electrodes are connected to the ECG machine by the same no. of electrical wires.
- These wires and in a more general sense, the electrodes to which they are connected are usually called leads.
- The electrode applied to the right leg of the patient is called RL lead. For recording of ECG, two electrodes or one electrode and an inter-connected group of electrodes are selected and connected to the input of the recording amplifier.
- The placement of the electrodes, as well as the color code used to identify each electrode

<u>Place</u>	<u>Color</u>
Chest	Brown — C
Left Arm	Black — LA
Right Arm	White — RA
Left Leg	Red — LL
Right Leg	Green — RL

- Four electrodes are used to record the ECG, the electrode on the right leg is only for ground reference.
- Because the input of the ECG recorder has only two terminals, a selection must be made among the available active electrodes.
- Totally we are dividing into 12 leads into three types
 - ① Bipolar limb leads
 - ② unipolar limb leads
 - ③ unipolar chest leads.

Einthoven Triangle

- * The Einthoven invented that at any given instant of the cardiac cycle, the electrical axis of the heart can be represented as a two dimensional vector.
- * The ECG measured from any of the three basic limb leads is a time variant single dimensional component of vector.
- * The electric field of the heart could be represented diagrammatically as a triangle, with the heart ideally located at the centre. This triangle is named as Einthoven triangle.
- * The sides of the triangle represent the lines along which the three projections of ECG vector are measured.
- * The instantaneous voltage measured from any of the three limb lead positions is approximately equal to the algebraic sum of the other two on all three lines is equal to zero.



① Bipolar limb leads

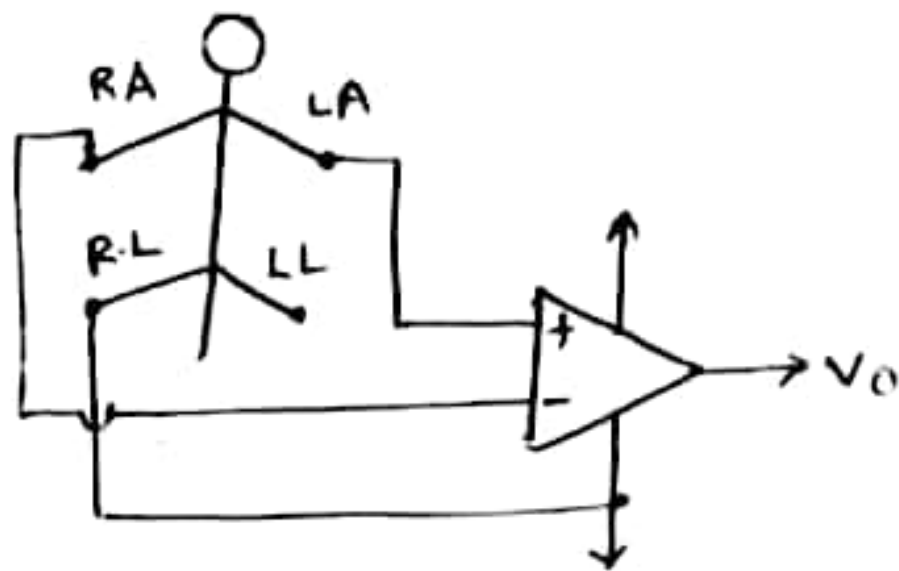
- Here ECG is recorded by using two electrodes such that the final trace corresponds to the difference of electrical potentials existing between them.
- These leads are called bipolar because each lead is recorded from two electrodes and third electrode is not connected.
- The three bipolar limb leads are

Lead I — left arm and Right arm

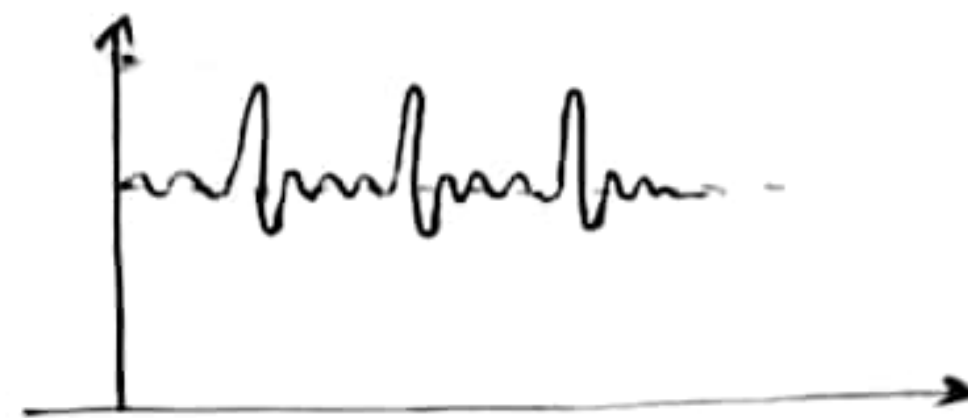
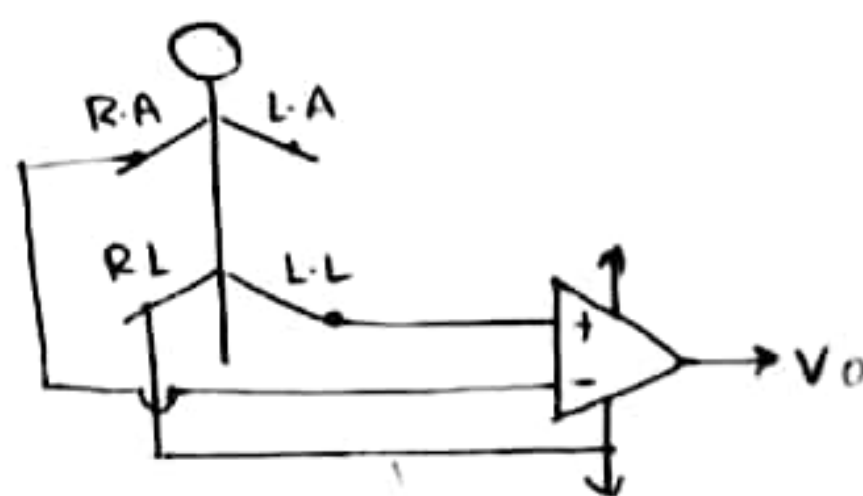
Lead II — Left leg and Right arm

Lead III — Left leg and Left arm.

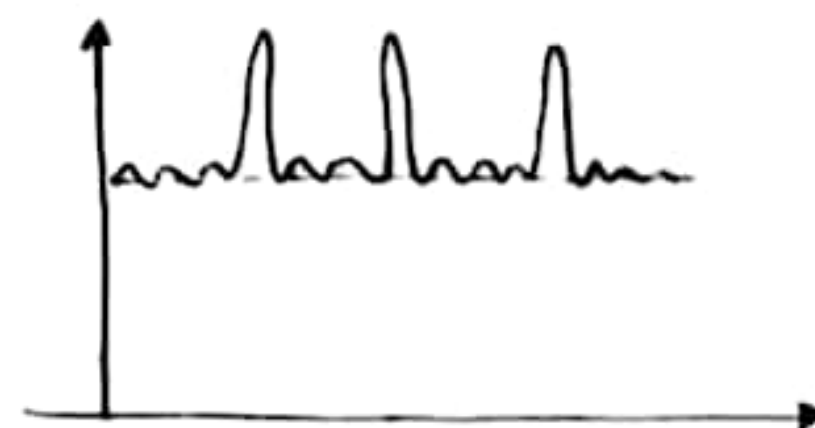
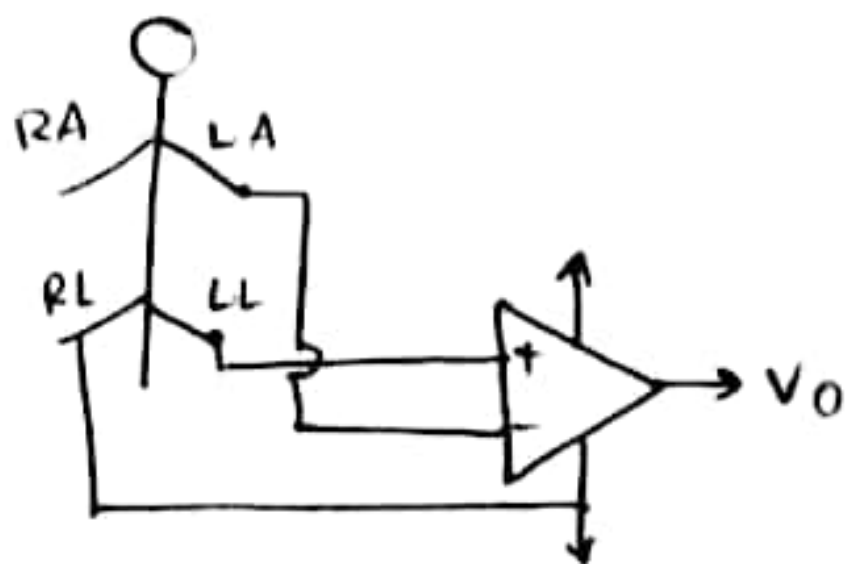
- The connecting procedure of Lead I & waveform is given as



- The connecting procedure & waveform of Lead II is given as



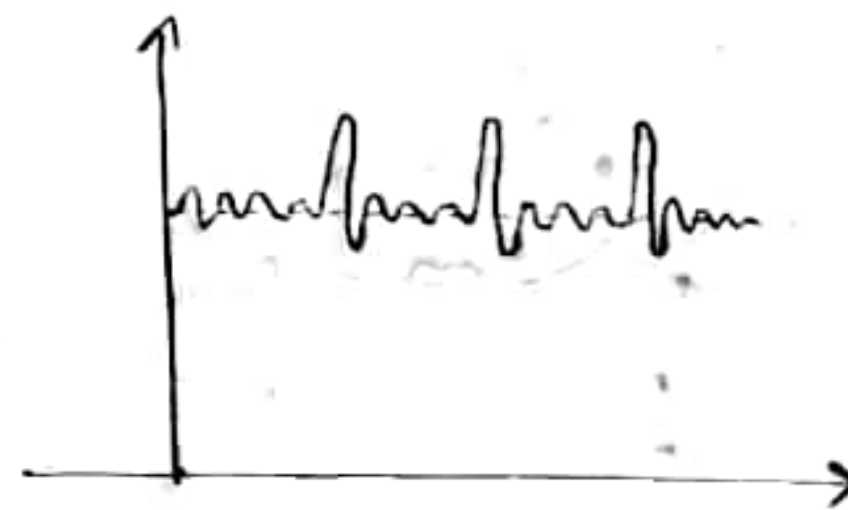
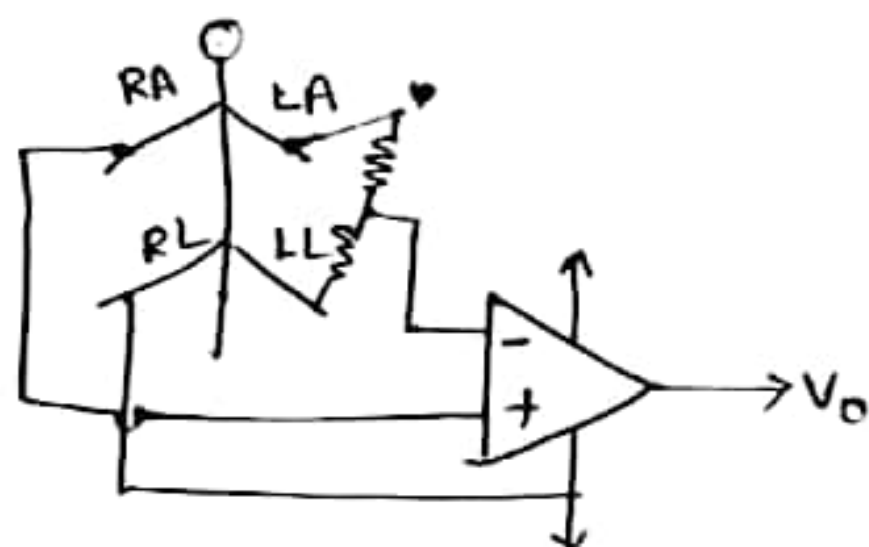
- The connecting procedure & waveform of Lead III is given as



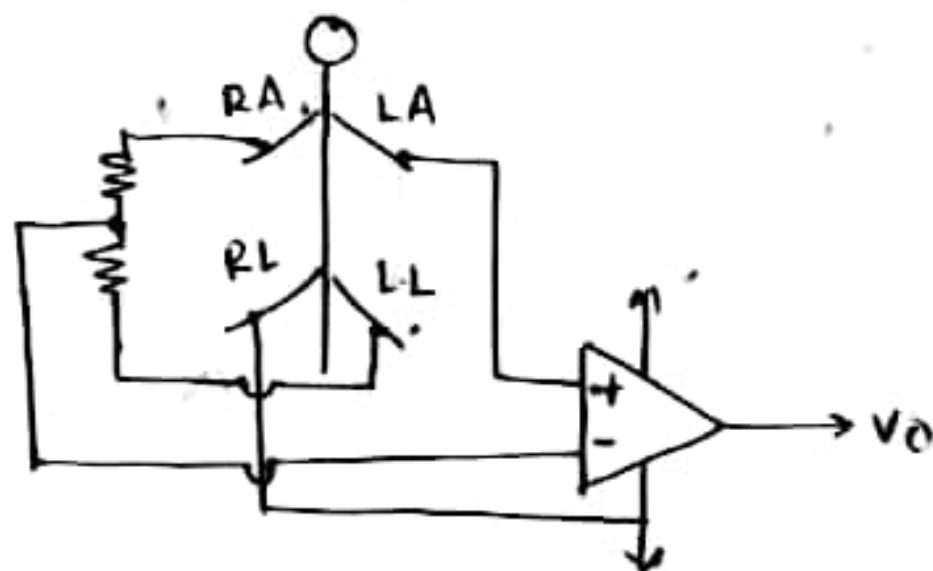
- With the help of three leads, we can form a triangle named as Einthoven triangle.

② unipolar limb leads

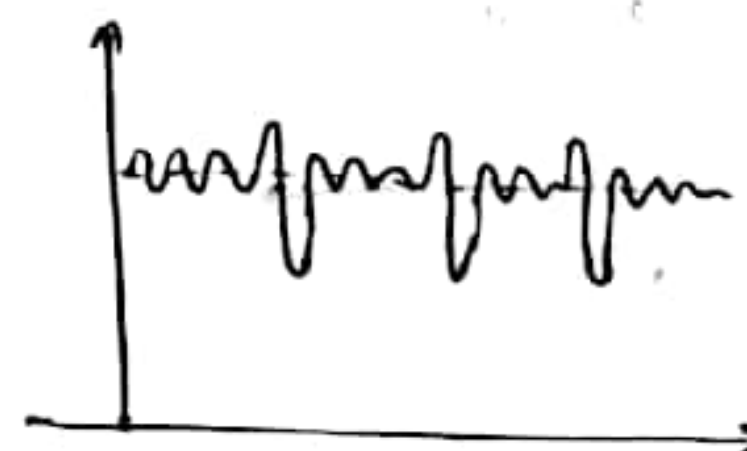
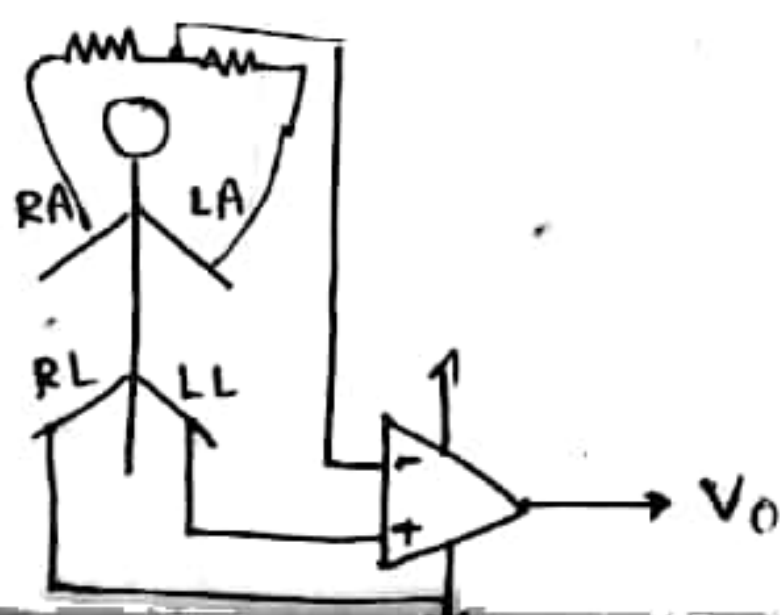
- Here ECG is recorded between a single exploratory electrode and the central terminal, which has a potential corresponding to centre of the body.
- The central terminal is obtained by connecting the three active limb electrodes together through resistors of equal size.
- The potential at the connection point of resistor corresponds to the mean or average of potentials.
- Two of the limb leads are tied together and recorded with respect to the third limb.
- These are called augmented leads or averaging leads. The resistances inserted between the electrodes are called averaging resistances.
- In the Augmented voltage Right, AVR lead, the right arm is recorded w.r.t a reference established by joining the left arm and left leg electrode.



- In AVL, the left arm is recorded w.r.t a common junction of the right arm and left leg.



- In Augmented voltage Foot, AVF lead is recorded with respect to two arm electrodes tied together.



⑧ unipolar chest leads

- * These are also named as unipolar second type leads. It employs an exploring electrode to record the potential of the heart action on the chest at six different positions.
- * These leads are designated by capital letter 'V' followed by a subscript numeral, which ~~represents~~ represents the position of electrode.
- * These are also called as precordial leads

V_1 — Fourth intercostal space at right sternal margin

V_2 — Fourth intercostal space at left sternal margin

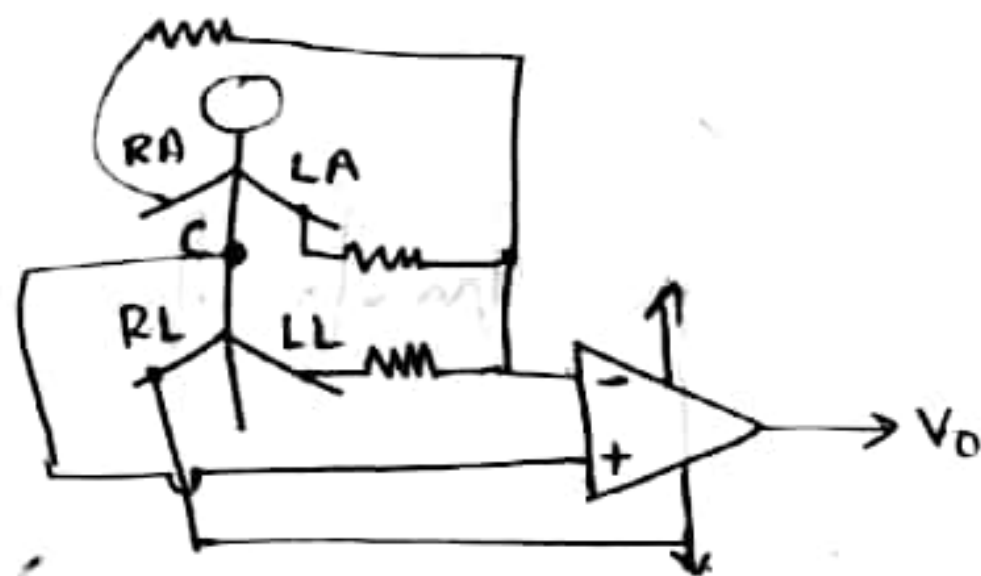
V_3 — Midway between V_2 and V_4

V_4 — Fifth intercostal space at mid-clavicular line

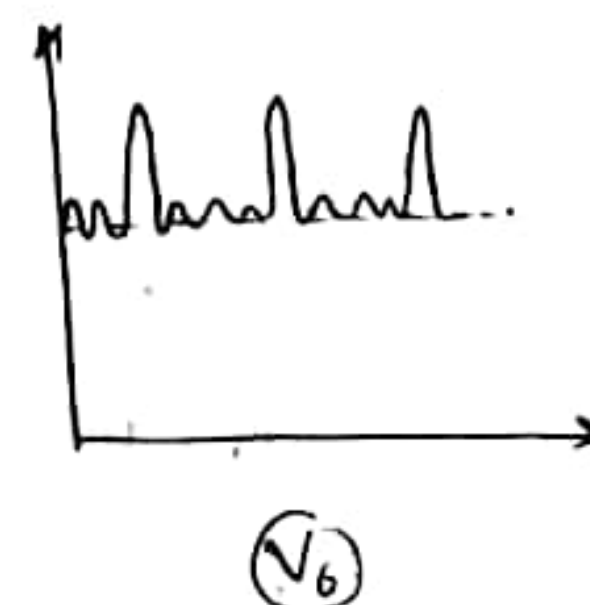
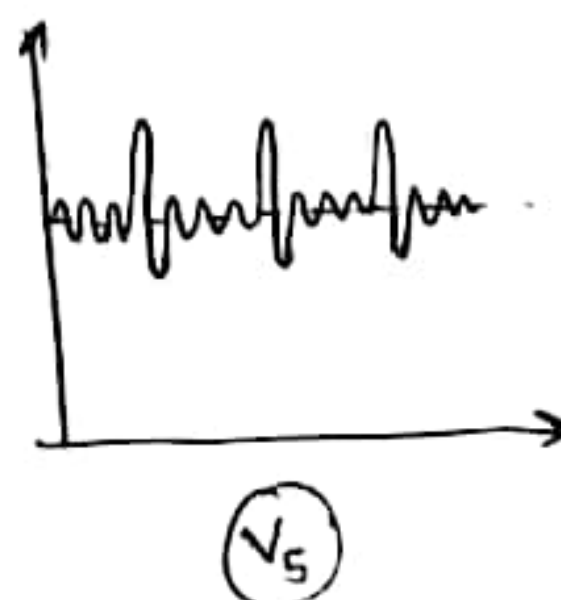
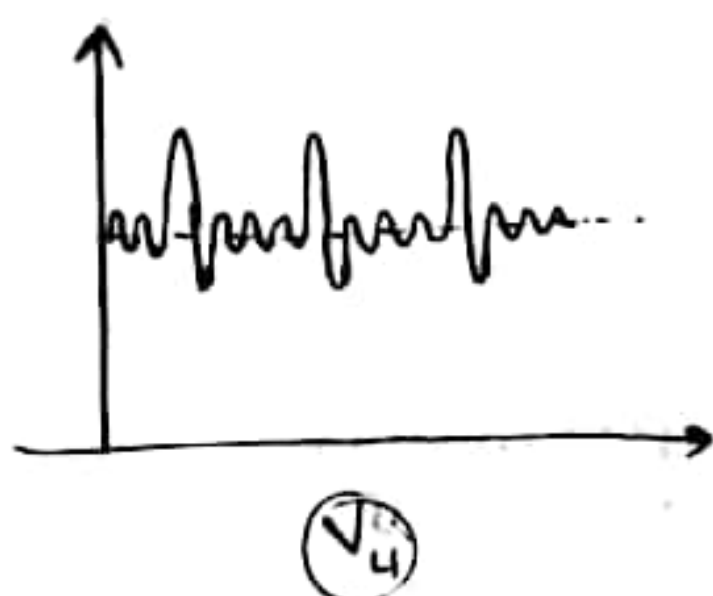
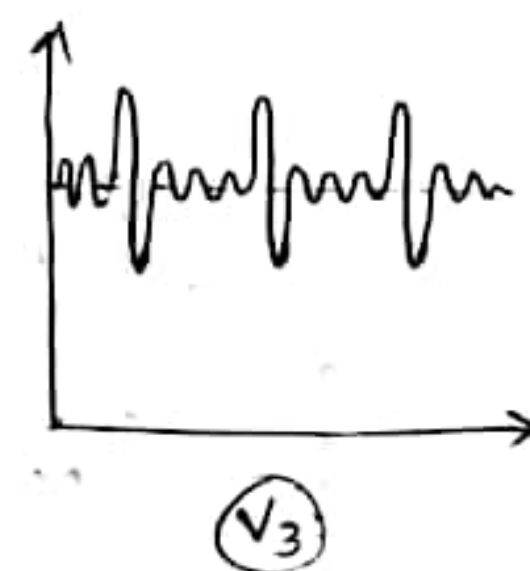
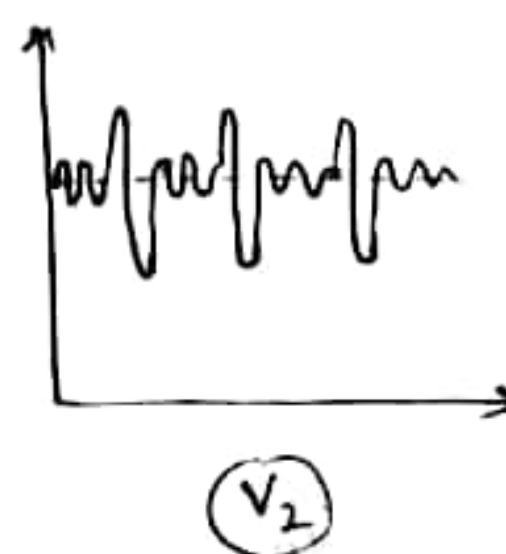
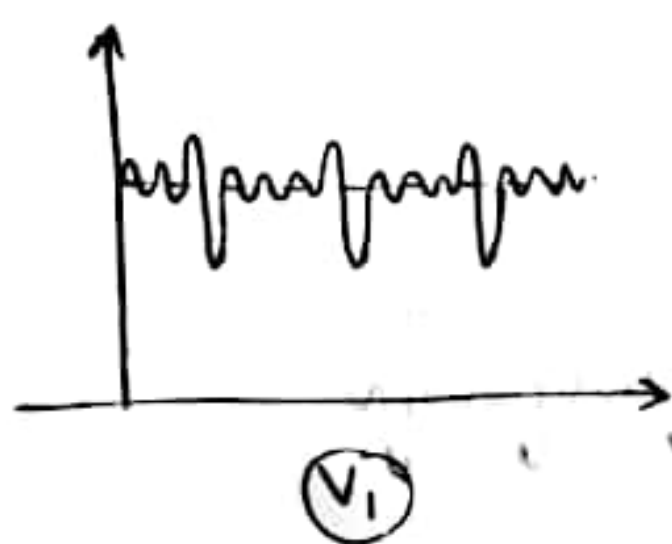
V_5 — Same level as V_4 on anterior auxiliary line

V_6 — Same level as V_4 on mid auxiliary line

- * The connecting procedure of chest lead is given as.



- * The waveforms of chest leads are.



Types of ECG Recorders

There are numerous types of ECG recorders. Many of these are portable units, while others are part of permanent installations. We have two types of ECG recorders

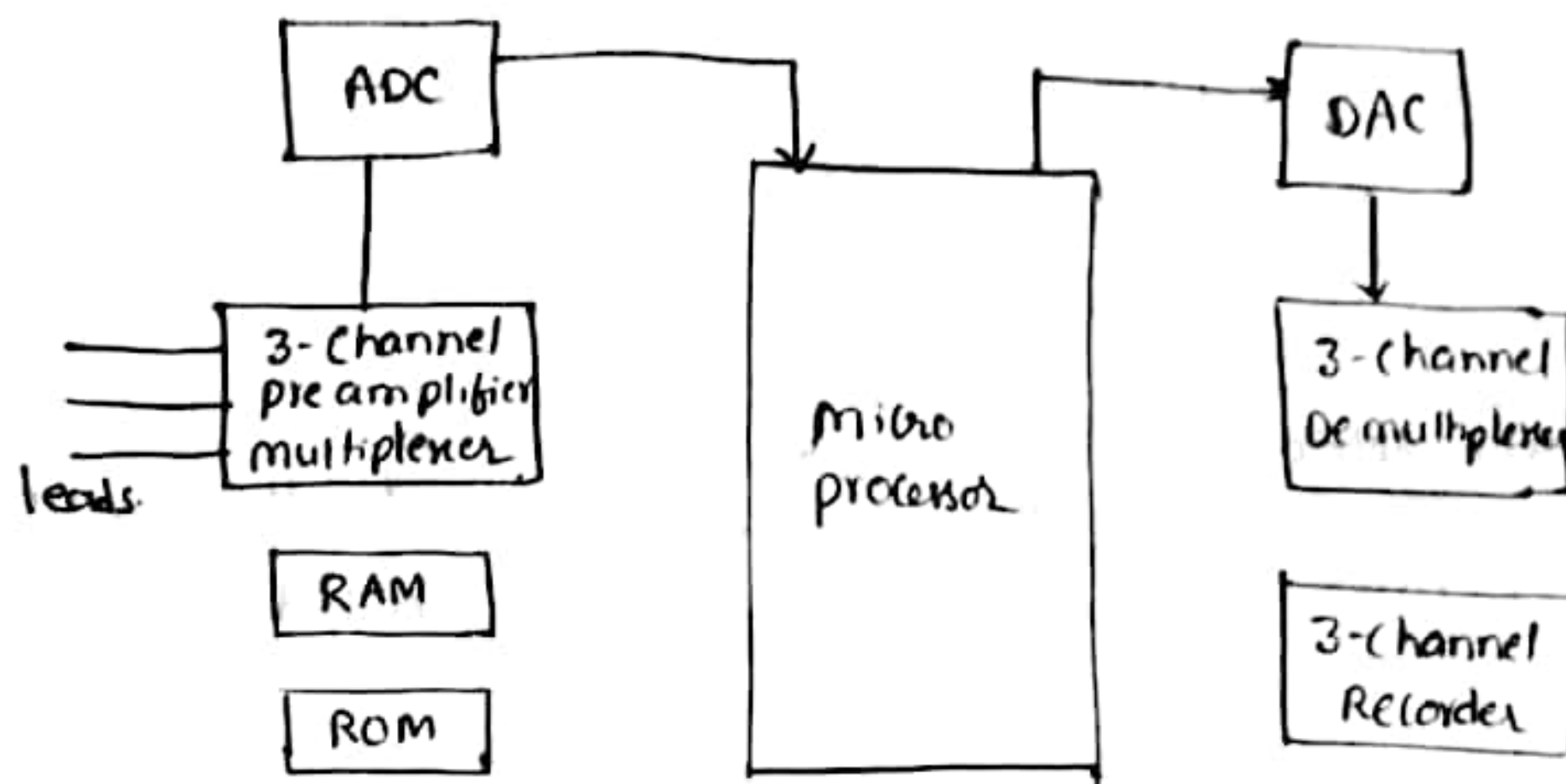
① Single channel recorder

② Three channel recorder

① Single channel recorder

- * It is the portable single channel unit. It is usually mounted on a cart so that it can be wheeled to the bedside of a patient with relative ease.
- * The ECG of a patient is recorded in the 12-standard lead configurations, the resulting paper strip is from 3 to 6 feet long.
- * Because it is easy to mix up the cut sections, the lead for each trace is encoded at the margin of the paper, using the marker pen, during the recording process.
- * The code markers consist of short marks and long marks and look similar to Morse code. No standard code has been established.
- * The cut sections of the ECG can be mounted by inserting them in pockets of a special folder with cutouts to make the trace visible.
- * It should be noted that the recordings from the three limb leads are longer than those from the other lead selections in order to show several QRS complexes, called as Rhythm strips.
- * With the automatic three channel recorders, the mounting is greatly simplified.

③ Three Channel Recorder



- It records the output of three leads at a time and there is automatic switching to record output of next 3 channels.
- An ECG with 12 standard leads can be recorded automatically as a sequence of four groups of three traces.
- The groups of leads recorded and the time at which the switching occurs are automatically identified by code markings at the margin of the recording paper.
- At the end of the recording, standardization pulses are inserted in all three recording channels.
- It is easier to read the output of the three ECG records as compared to single channel recorder.

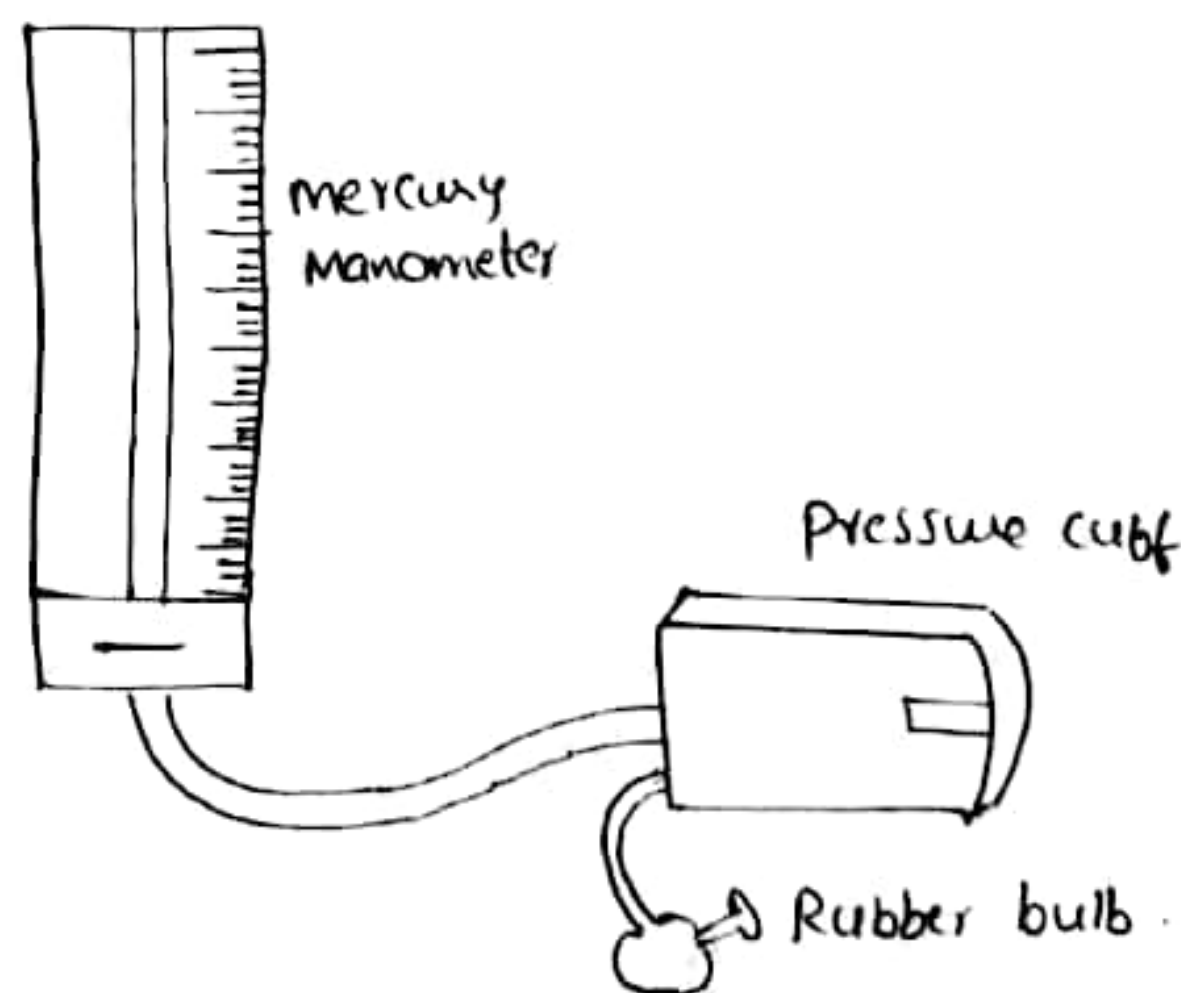
Specifications of ECG Recorder

- ① Sensitivity — 20 mm/mV
- ② I/p impedance — 5 mΩ
- ③ O/p impedance — < 100 Ω
- ④ CMRR — 10000:1
- ⑤ Paper speed — 25 mm/s or 50 mm/s
- ⑥ Frequency response — 0.1 to 60 Hz
- ⑦ Time constant — 3 sec.

Blood Pressure Measurement

- Blood pressure is considered as a good indicator of the status of the Cardiovascular system.
- B.P is generally measured by means of an indirect method using a Sphygmomanometer. It is easy to use and can be automated.
- The indirect method is somewhat subjective and often fails when the blood pressure is very low.
- Methods for direct B.P measurement provide a continuous readout of the B.P waveform and are more accurate than indirect method.
- The direct methods require a blood vessel be punctured in order to introduce the sensor. This limits their use to those cases in which the condition of patient is in serious.

Indirect B.P measurement.



- * The above diagram shows the connection of sphygmomanometer.
- * The indirect method of measuring blood pressure involves the use of a Sphygmomanometer and a stethoscope.
- * The meter consists of an inflatable pressure cuff and a mercury manometer to ~~pressure~~ measure the pressure in the cuff.
- * The cuff consists of a rubber bladder inside an inelastic fabric covering that can be wrapped around the upper arm and fastened with either hooks or a velcro fastener.
- * The cuff is normally inflated manually with a rubber bulb and deflated slowly through a needle valve.

- * This meter works on the principle that when the cuff is placed on the upper arm and inflated, arterial blood can flow past the cuff only when the arterial pressure exceeds the pressure in cuff.
- * When the cuff is inflated to a pressure that only partially occludes the brachial artery, turbulence is generated in the blood as it spurts through the tiny arterial opening during each systole.
- * The sounds generated by this turbulence, Korotkoff Sounds can be heard through a stethoscope placed over the artery downstream from the cuff.
- * To obtain the B.P measurement, the pressure cuff on the upper arm is first inflated to a pressure well above systolic pressure.
- * At this point no sounds can be heard through the stethoscope, which is placed over the brachial artery, for that artery has been collapsed by the pressure of the cuff.
- * The pressure in the cuff is then gradually reduced. As soon as cuff pressure falls below systolic pressure, small amounts of blood spurt past the cuff and Korotkoff sounds begin.
- * The pressure of the cuff that is indicated on the manometer when the first Korotkoff sound is heard is recorded as the Systolic blood pressure.
- * As the pressure in the cuff continues to drop, the Korotkoff sounds continue until the cuff pressure is no longer sufficient to occlude the vessel during any part of the cycle.
- * Below this pressure the Korotkoff sounds disappear, marking the value of diastolic pressure. This procedure of finding pressures is named as Auscultatory method.

17 Direct measurement

Here we have three types of methods.

- (a) Percutaneous Insertion
- (b) Catheterization
- (c) Implantation of a Transducer.

(a) Percutaneous Insertion

- Here a local anesthetic is injected near the site of invasion. The vessel is occluded and a hollow needle is inserted at a slight angle toward the vessel.
- When the needle is in place a catheter is led through a guide. When the catheter is in place in the vessel the needle and guide are withdrawn.
- For measurement a typical type of needle attached to an air tight tube is used, so that the needle can be left in the vessel and B.P sensed directly to by attaching a transducer to tube.

(b) Catheterization

- A catheter is a long tube that is introduced into heart or a major vessel by way of a vein or artery.
- A sterile saline solution is introduced into a catheter so that the fluid pressure is transmitted to transducers outside the body.
- A complete fluid pressure system is set up with provision for checking against atmospheric pressure & for establishing reference point.
- The frequency response of this system is a combination of the frequency of the transducer & fluid column in catheter.

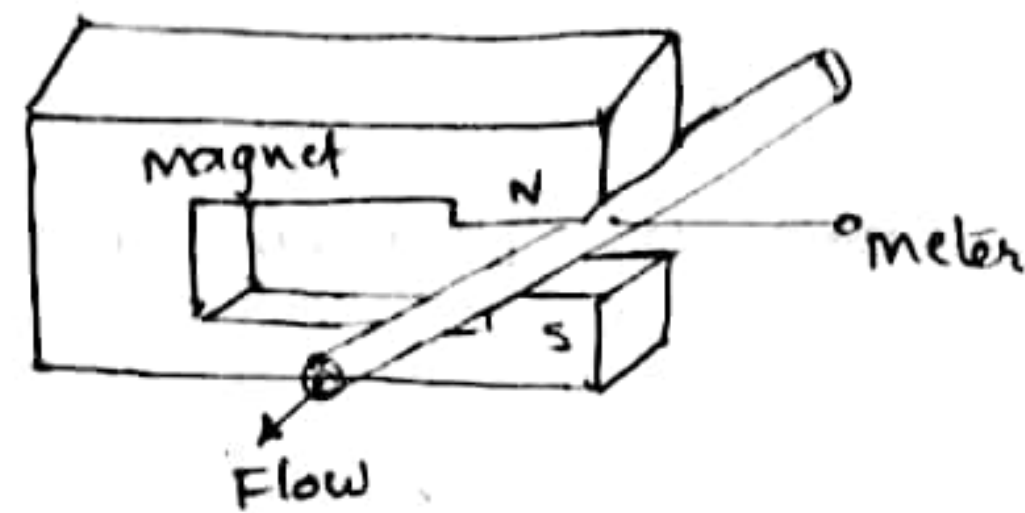
(c) Implantation of transducer

- Here the transducer is introduced into the catheter and pushed to the point at which pressure is to be measured.
- Generally the transducer is mounted at the tip of the catheter. This arrangement is called catheter tip B.P transducer.
- An unbonded strain gauge or a variable inductance transducer is used as a transducer.
- Surgery is need for implantation. so these techniques is used only in research experiments.

Measurement of Blood flow and Cardiac output

- An adequate blood supply is necessary for all organs of the body, in fact an impaired supply of blood is the cause of various diseases.
- The ability to measure blood flow in the vessel that supplies a particular organ would therefore be useful in diagnosing such diseases.
- The rate of flow of a liquid or gas in a pipe is expressed as the volume of the substance that passes through the pipe in a given unit of time.
- Methods used in industry for flow measurements of other liquids, like the turbine flowmeter and the rotameter, are not suitable for the measurement of blood flow.
- The above methods also expose the blood to sharp edges, which are conducive to blood clot formation.
- All types of blood flow meters currently used in clinical and research applications are based on one of the following physical principles:
 - (1) Electromagnetic Induction
 - (2) Ultrasound transmission or reflection
 - (3) Thermal convection
 - (4) Radiographic principles
 - (5) Indicator dilution.
- Magnetic & ultrasonic blood flow meters actually measure the velocity of the blood stream. These methods require that a transducer surround an excised blood vessel, they are used during surgery.
- Plethysmograph which actually indicates volume changes in body segments, can be used to measure the flow of blood in the limbs.

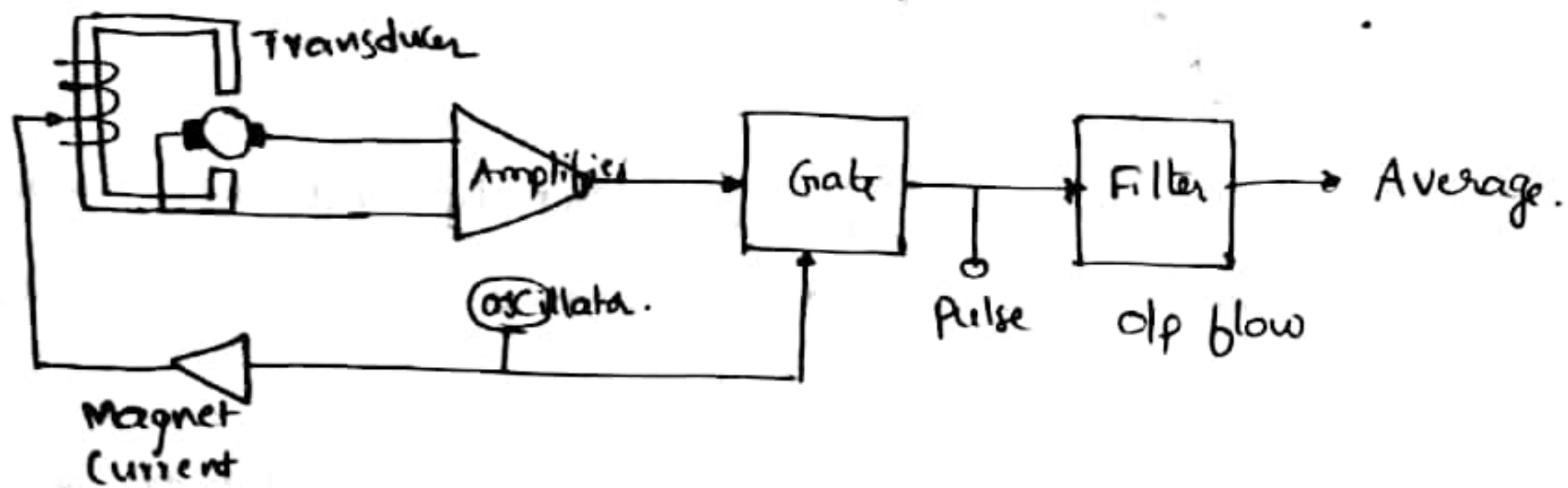
① Magnetic Blood Flow meter



- These are based on the principle of magnetic induction, when an electrical conductor is moved through a magnetic field, a voltage is induced in the conductor.
- A permanent magnet is positioned around the blood vessel generates a magnetic field perpendicular to the direction of the blood flow.
- The voltage induced in the moving blood column is measured with stationary electrodes located on either sides of blood vessel and perpendicular to the direction of magnetic field.
- The Slip-on or C-type is applied by squeezing an encased blood vessel together and slipping it through the slot of probe.
- These probes are manufactured in sets, with diameters in steps of 0.5 or 1mm from about 2 to 20mm.
- In Cannula type transducer the blood flows through a plastic cannula around which the magnet is arranged. The contacts penetrate the walls of cannula.
- It requires that the blood vessel be cut and its ends are slipped over the cannula and secured with a suture.
- In early meters, a constant magnetic field was used, which cause difficulties with electrode polarization and amplifier drift. To overcome this, we use electromagnets that are driven by AC current.
- When doing this, a problem exists that the change of magnetic field causes the transducer to act like a transformer and induces error voltages.
- Thus for recovering signal in presence of error voltage, amplifiers with large dynamic range & phase sensitive have to be used.

→ To minimise the problem, several different waveforms have advocated for the magnetic current. With sine current, the induced voltage is sine but 90° out of phase with flow signal.

→ The block diagram of magnetic blood flow meter is



- * The oscillator drives the magnitude and provide a control signal for the gate, operates at a frequency of 60 to 400 Hz
- * The use of 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 flow pulses, while the mean or average flow can be derived by use of low pass filter.

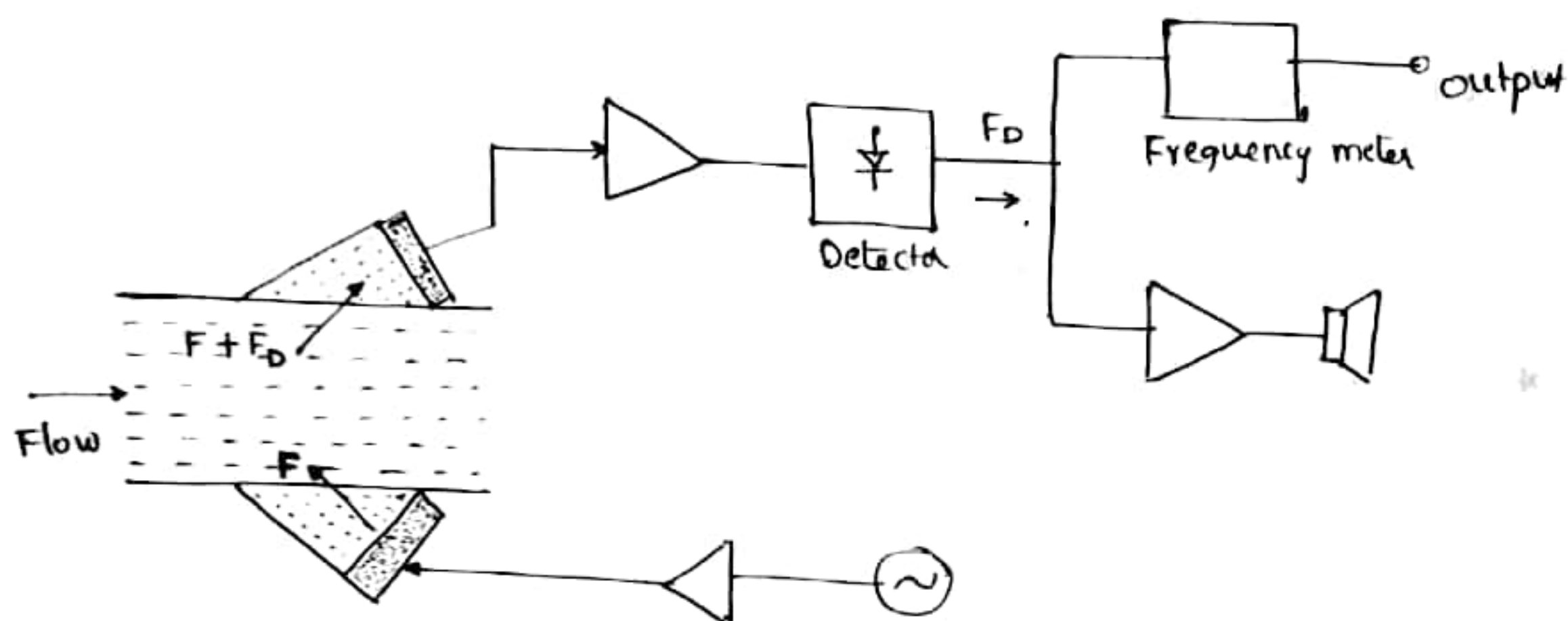
→ Applications

- ① Cardiac Surgery
- ② Peripheral arterial Surgery
- ③ Stent operations
- ④ Organ transplantation

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② Ultrasonic Blood flow meter

- Here a beam of ultrasonic energy is used to measure the velocity of flowing blood. It can be done in two ways.
- In the transit time, a pulsed beam is directed through a blood vessel at a shallow angle and its transit time is then measured.
- When the blood flows in the direction of energy transmitted, the transit time is shortened. If it flows in opposite direction, the transit time is lengthened.
- In the Doppler type, the arrangement is given as.



- * An oscillator operating at a frequency of several megahertz excites a piezoelectric transducer.
- * It is coupled to the wall of an exposed blood vessel and sends an ultrasonic beam with frequency F into flowing blood.
- * A small part of transmitted energy is scattered back and is received by second transducer arranged opposite to first.
- * Because the scattering occurs mainly as a result of moving blood cells, the reflected signal has a different frequency due to Doppler effect.
- * Its frequency is either $F + F_D$ or $F - F_D$ depending on the direction of flow.
- * A fraction of transmitted ultrasonic energy however reaches the second transducer directly, with the frequency being unchanged.

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- * After amplification of composite signal, the Doppler frequency can be obtained at the output of a detector as the difference between the direct and the scattered signal components.
- * With blood velocities in the range normally encountered, the Doppler signal is typically in the low audio frequency range.
- * Because of velocity profile of flowing blood, the Doppler signal is not a pure sine wave, but has more the form of narrow band noise.
- * So from a loud speaker or ear phone, the Doppler signal of the pulsating blood flow can be heard as a "swish-swish".
- * When the transducers are placed in a suitable mount, a frequency meter used to measure the Doppler frequency can be calibrated directly in flow-rate units.
- * Transducers for ultrasonic flow meters can be implanted for chronic use.

Thermal Convection

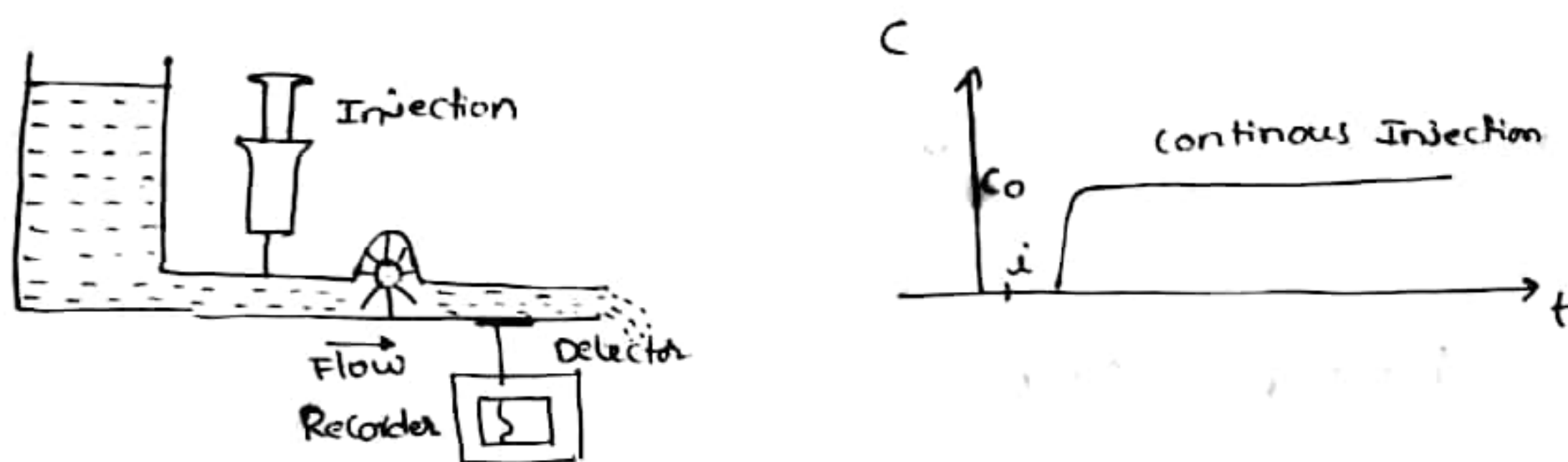
- A hot object in a colder flowing medium is cooled by thermal convection. The rate of cooling is directly proportional to rate of flow of the medium.
- In one application, a thermistor in the bloodstream is kept at a constant temperature by a servo system.
- The electrical energy required to maintain this constant temperature is a measure of the flow rate.
- In another method, an electric heater is placed between the two thermocouples or thermistors that are located some distance apart along the axis of vessel.
- The temperature difference between upstream and downstream sensor is a measure of the blood velocity. A device of this type is called Thermostenometer.
- Thermal convection methods for blood flow determination, although among the oldest ones used for this purpose have now been widely replaced by the other methods.

④ Radiographic method

- Blood is not normally visible on the 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.
- on a sequential record of the X-ray image, the progress of the contrast medium can be followed, obstructions can be detected and blood flow in certain blood vessels can be estimated. This is known as Cine Angiography.
- Another method is the injection of a radio isotope into the blood circulation, which allows the detection of vascular obstructions with an imaging device for nuclear radiation.
- Vascular obstructions in the lower extremities can sometimes be detected by measuring differences in skin temperature caused by the reduced circulation.

⑤ Indicator Dilution method

- This method measures the blood flow and not the blood velocity. Any substance can be used as an indicator.
- The substance must be stable but should not be retained by the body and side effects must not exist.
- Cardiogram an indocyanine dye, used in a isotonic solution was long favoured as an indicator. Its concentration was determined by measuring the light absorption with a densitometer.
- Radioactive isotopes have also been employed for the purpose. The indicator most frequently used today, is isotonic saline, which is injected at a temperature below the body temperature.
- A sensitive thermistor thermometer determines the concentration of the saline after mixing with the blood.
- The principle of dilution method is given as.



- * The diagram shows the blood circulation under the assumption that the blood is not recirculated.
- * The indicator is injected into the flow continuously beginning at time t at a constant infusion rate I grams per minute.
- * A detection measures the concentration downstream from the injection point.
- * At a certain time after the injection, the indicator begins to appear, the concentration increases and finally it reaches a constant value C_0 .
- * From the measured concentration and the known injection rate, I in milligrams per minute the flow can be calculated as

$$F \text{ (Liters per minute)} = \frac{I \text{ (milligrams per minute)}}{C_0 \text{ (milligram per liter)}}$$

Measurement of Heart Sound

- The graphic record of heart sounds is called phonogram. The instrument used to measure the heart sound is called Phonocardiograph.
- The basic aim is to pick up the different heart sounds filter out the heart sounds and to display them or record them.
- Sounds result from the vibrations of heart. Acoustic events of the heart can be divided into two categories.

① Heart sounds — Transient character, short duration

② Heart murmurs — Noisy character, long duration

- Heart sounds are due to closing and opening of the heart valves whereas murmurs are due to turbulent flow of blood in the heart.

- We have totally four sounds

① Valve closure sounds — They occur at the beginning of systole and due to closure of mitral and tricuspid valves. They occur at the beginning of diastole & due to close of aortic and pulmonary valves.

* This heart sound is named as 'Lub'.

② Second heart sound

* It is named as 'Dub'

* It is caused by the sudden block of reversing blood flow due to closure of the semilunar valves at the end of the ventricular systole and the beginning of ventricular diastole.

③ Third heart sound

* It occurs at the beginning of diastole after S₂ and is lower in pitch than S₁ or S₂.

* This sound is not harmful in youth, some trained athletes and sometimes in pregnancy but if it reemerges later in life it may signal cardiac problems.

* It is caused by the oscillation of blood back and forth between the walls of the ventricles initiated by blood rushing in from the atria.

④ Fourth heart Sound

- * This sound occurs just after atrial contraction at the end of diastole and immediately before S1.
- * It is best heard at the cardiac apex with the patient in the left lateral position and holding his breath.
- * Atrial contraction must be present for production of an S4.

Heart Murmurs

- * They are produced as a result of turbulent flow of blood strong enough to produce audible noise.
- * It refers to a sound believed to originate within blood flow through or near the heart.
- * It should be noted that most heart problems do not produce any murmur and most valve problems also do not produce an audible murmur.
- * Murmurs can be heard in many situations in adults without major congenital heart abnormalities.
 - ① Regurgitation through the mitral valve.
 - ② Stenosis of the aortic valve.

→ Normal heart sounds are quite short in duration, approximately one tenth of a second for each, while murmurs usually extend between the normal sounds

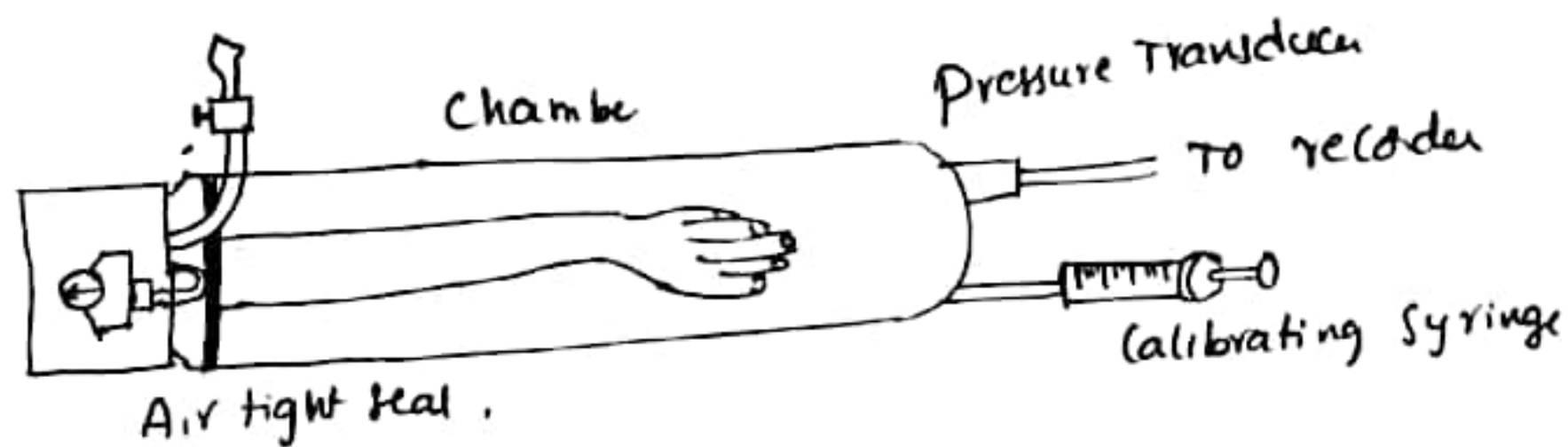
→ The first heart sound is having an energy in the 30-45 Hz range.
The second heart sound with an energy of 50-70 Hz range.
The third heart sound is of energy at or below 30 Hz.
murmurs are in the range of 100-600 Hz range.

→ A graphic record of heart sounds is called Phonocardiogram
The vibrations of the side of the heart as it thumps against the chest wall given as vibrocardiogram.
The tip or apex of the heart hitting the rib cage produces the Apex cardiogram.

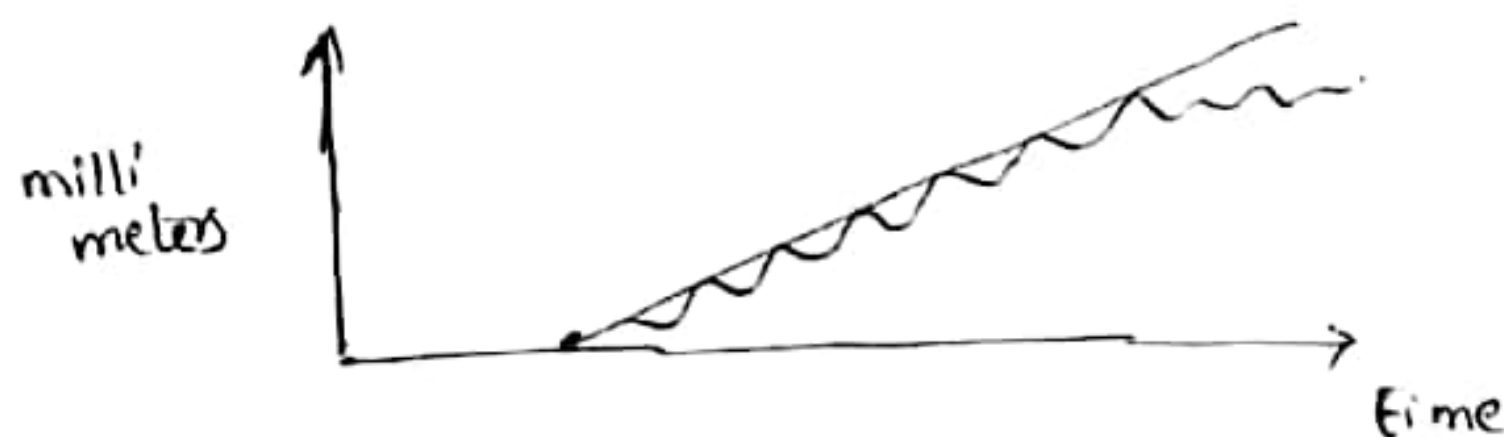
→ The general instrument used is stethoscope. Greek word
Stethos means chest, skopein means to examine.

PLETHYSMOGRAPHY

- Instruments measuring volume changes or providing output that can be used & related to them are called plethysmograph.
- Measurement of volume changes is called as plethysmography.
- This instrument consists of a rigid cup or chamber placed over the limb in which the volume changes are to be measured.



- The cup is tightly sealed to member to be measured so that any changes of volume in limb reflect as pressure changes inside the chamber.
- Either fluid or air can be used to fill the chamber. These are designed for constant pressure or volume within the chamber.
- Some form of pressure or displacement transducer must be included to respond to pressure changes within the chamber and to provide a signal that is calibrated to represent volume of limb.
- The plethysmograph can be used to measure the total amount of blood flowing into the limb being measured.
- By inflating the pressure of cuff just above venous pressure, arterial blood can flow past the cuff but venous blood cannot leave.
- The result is that the limb increases its volume with each heart beat by the volume of blood entering during that beat.
- The output tracing for the measurement is shown as.



The slope of the line, along the peaks of these pulsations represent the overall rate at which blood enters the limb. After a few seconds the slope tends to level off.

Respiratory system

Respiration → The exchange of gases in any biological process.
→ The process of taking in oxygen from the environment, transporting the oxygen to the cells, removing the CO_2 from the cells, and exhausting this product (waste) into the atmosphere.

External respiration

The exchange of gases between the blood and the external environment takes place in the lungs is called external respiration.

Physiology of the Respiratory system

Air enters the lungs through the air passages, which include the nasal cavities, pharynx, larynx, trachea, bronchi and bronchioles.

Thorax → The lungs are elastic bags located in a closed cavity called thorax or thoracic cavity. The right lung consists of three lobes and left lung consists of two lobes.

Nasal cavity → It is a large air filled space above and behind the nose in the middle of face. Each cavity is the continuation of the two nostrils. The lateral wall of each nasal cavity is mainly made up by the maxilla. The nasal cavity is divided into two by a vertical fin called the nasal septum.

Pharynx → It is a part of digestive system and also the conducting zone of the respiratory system. It filters, warms and moistens air and conducts it into lungs.

- * It makes up the part of throat situated immediately posterior to nasal cavity, posterior to mouth and superior to esophagus and larynx.

- * It is divided into naso pharynx, oro pharynx and laryngo pharynx.

Larynx → It is called as voice box. It is an organ in the neck involved in breathing. It manipulates pitch and volume.

- * The muscles of larynx are two types Intrinsic and extrinsic muscles.

- * Intrinsic muscles are again two types. Respiratory and phonatory muscles.
- * Respiratory muscles move the vocal cords apart and serve breathing purpose.
- * Phonatory muscles move the vocal cords together and serve the production of voice.
- * Extrinsic muscles support and position the larynx within the trachea.

Epiglottis → It is attached to the entrance of larynx. It projects obliquely upwards behind the tongue and hyoid bone.

- * It stands open during breathing allowing air into larynx.
- * During swallowing, it closes to prevent aspiration, forcing the swallowed liquids or food to go down the esophagus.

Esophagus → It is a food pipe through which food passes from pharynx to stomach. It is approximately 18-25 cm long.

- * It travels behind the trachea and heart, passes through the diaphragm and empties into the cardia of stomach.

* When food is being swallowed the epiglottis moves backward to cover the larynx, preventing food from entering the trachea.

- * At the same time, the upper esophageal muscle relaxes, allowing food to enter.

Trachea → It is about 1.5 to 2.5 cm in diameter and approximately 11 cm long, extending from the larynx to the upper boundary of the chest. It bifurcates into the right and left main stem bronchi.

Bronchi → It enters into the corresponding lung and divides like the limbs of a tree into smaller branches.

- * The bronchi are of unequal length and at different angles.

Bronchioles → The bronchi are subdivided, where the diameter is reduced to about 0.1 cm as air conducting tubes called bronchioles.

Respiratory Therapy Equipment

- when a patient is incapable of adequate ventilation by natural processes, a mechanical assistance must be provided so that sufficient oxygen is delivered to organs and tissues of the body.
- The procedures and instrumentation involved in providing mechanical assistance in respiration and in supplying proteins constitute a field known as respiratory therapy.
- Instruments for respiratory therapy include devices as inhalators, Ventilators, respirators, resuscitators, humidifiers and nebulizers.

Inhalators

- * Inhalator is a device used to supply oxygen or some other gas to a patient who is able to breathe spontaneously without assistance.
- * These are used when a concentration of oxygen higher than that of air is required.
- * It consists of a source of the gas, equipment for reducing the pressure and controlling the flow of the gas and a device for administering the gas.
- * Devices for administering oxygen to patients include nasal cannulae and catheters, facemasks that cover the nose and mouth.
- * The oxygen concentration presented to the patient is controlled by adjusting the flow of gas into the mask.

Respirator

- * It is a device designed to protect the wearer from inhaling harmful dust, vapors or gases.
- * It exchanges gases: such as oxygen and carbon dioxide.
- * These are most often used in work settings such as construction sites, mines and other sites including those where fires that release harmful toxins may be present.
- * It is a device designed to allow breathing when it would otherwise be hindered, as by a medical condition or the presence of poisonous

- △ Respirators are categorized into two types
- Air purifying respirator, which forces contaminated air through a filtering element.
 - Air supplied respirator, which an alternate supply of fresh air is delivered.

Ventilator

- * It is a 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.
- * It moves air from one place to another place.
- * These are most often used in instances of respiratory failure or when trauma makes it impossible for air to pass through trachea.
- * It is a device that circulates fresh air and expels noxious air. These are chiefly used in intensive care medicine, home care and emergency medicine and in anesthesia.
- * The ventilators can be operated in any of three different modes.
 - ① Assist mode
 - ② Control mode
 - ③ Assist - control mode.
- * Ventilators can be categorized into two basic types.
 - ① Pressure Cycled Ventilator
 - ② Volume Cycled Ventilator.
- * Ventilators are equipped with monitoring and alarm systems for patient related parameters and ventilator function, backup batteries, oxygen tanks and remote control.
- * The delivered gas reaches a predetermined pressure in the upper air ways. A ventilator that operates primarily in this manner is said to be pressure-cycled.
- * A predetermined volume of gas has been delivered to the patient. This is the primary mode of operation of volume cycled Ventilator.

Humidifier

- In order to prevent damage to the patient's lungs, the air or oxygen applied during respiration therapy must be humidified.
- It is a device that increases humidity in a single room or area, which increases patient comfort.
- The equipment belongs to respiratory system have the function of humidifying the air either by heat vapourization or by bubbling an air stream through a jar of water.
- The different type of Humidifiers are
 - ① Evaporative Humidifier
 - ② Natural Humidifier
 - ③ Impeller Humidifier
 - ④ Ultrasonic Humidifier

Nebulizer

- * It is a drug delivery device used to administer medication in the form of a mist inhaled into the lungs.
- * When therapy requires that water or some type of medication be suspended in the inspired air as an aerosol, nebulizer is used.
- * These are commonly used for the treatment of asthma, COPD and other respiratory diseases.
- * They use oxygen, compressed air to break up medical solutions and suspensions into small aerosol droplets that can be directly inhaled from the mouthpiece of the device.
- * Aerosol is a mixture of gas and liquid particles.
Aerosol is a mist, formed when small vapourized water particles mixed with hot ambient air are cooled down and condense into a fine cloud of visible airborne water droplets.
- * Ultrasonic Nebulizer
 - It produces high intensity sound energy well above the audible range.
 - When applied to water or medication, the ultrasonic energy vibrates the substance with such intensity that a high volume of minute particles is produced.

Equipment usually consists of two parts. Generator that produces a radio frequency current to drive the ultrasonic transducer at the nebulizer itself, in which the transducer generates the ultrasonic energy and applies it to the water or medication.

Aspirator

- * They are used to remove mucus and other fluids from airways of a patient.
- * It is a type of ejector jet pump. that produces vacuum by means of the Venturi effect.
- * In this machine, fluid flows through a tube which then narrows. so that fluid's speed increases and because of Venturi effect the pressure decreases. Vacuum is taken from this point.