

## Patient Care and Monitoring :

(64)

The basic elements of intensive care monitoring unit are: (i) skin electrodes to pickup ECG potentials.

(ii). Amplification unit for electrocardiograph.

(iii). CRT display for observation of ECG waveforms.

The central nurse station normally can have CRT display of several patients on the same screen.

(iv) A rate meter to indicate heart beat, it can have continuous indication with audible beep or flashing light at each heart beat.

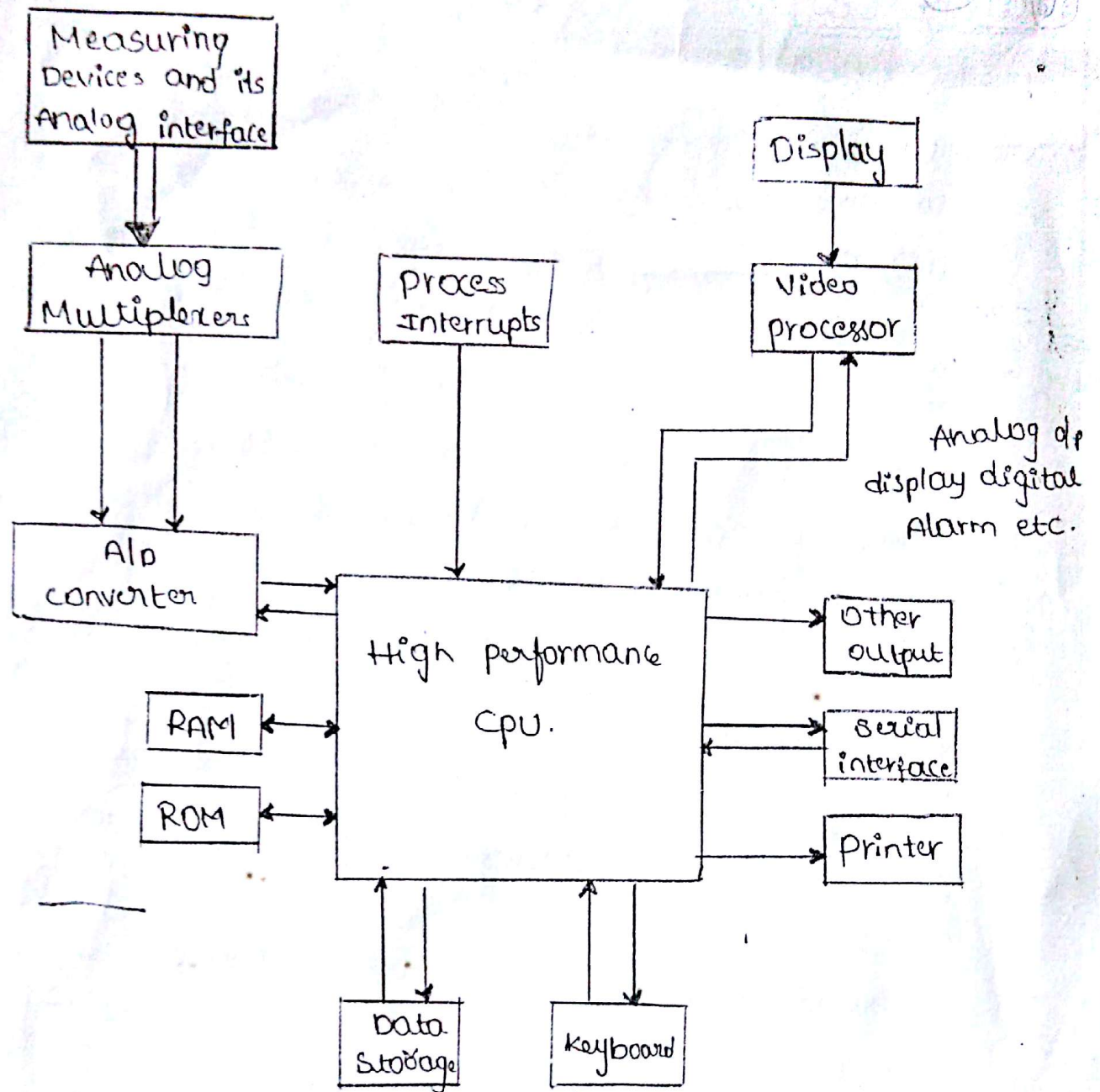
(v) An alarm system is actuated by the rate meter to alert the nurse.

(vi). A direct wired-up device for electrocardiograph.

(vii). A memory tape to record the playback of ECG for 15 to 60 sec.

(ix). Electrical circuit to indicate that electrode connections have become disconnected which may be due to mechanical failure.

(x). A closed circuit monitoring system is also employed to provide visual coverage using cameras focused on each patient. Noise and movement of artifacts may give false alarms sometimes. Special measures such as electrode placement pattern can be looked into improve. There is no standard pattern existing.



- \* Patient Monitoring Display : CRT Displays are 3 types.
- (i) conventional display : This is conventional CRT with horizontal sweep driven by a slow-speed sweep generator which causes the electron beam to move from left to right at a predetermined rate say 25 to 50 mm/sec.
  - (ii) Bouncing ball display : This is also CRT arrangement wherein sweep rate is very high such that display appears to be continuous display. Each spot of light

Seems to be bouncing up, hence, bouncing ball display - name.

(iii) Nonfade display: It also uses CRT display, but the electron beam rapidly scans the entire screen of the CRT by x-axis modulation. This gives trace pattern, i.e. a series of dots on the screen, see figure 6.2.



fig: ECG pattern mode of dots.

\* The brightening signals are produced from a digital memory in which several seconds of data from each channel of the patient monitor are stored.

\* Diagnosis, calibration and Repairability of patient - Monitoring equipment:

Engineers and technicians need to diagnose the problems of monitoring equipments. (It is essential)

\* The manuals must be obtained for installation, operation, and maintenance, critical spares may be procured if backup by suppliers is hard to get potential maintenance points:

(1) Environment conditions of the instrumentation should generally be good, however temperature, dust, humidity should be in tolerance limit.

(ii) No heavy machinery should be around like presses, compressors and such other machines which generate and transmit vibrations. (67)

(iii) It should not be connected to the same electrical line which supplies power to machines drawing heavy intermittent currents.

\* The basic electrical equipments required for installation and maintenance are:

- (i) Multimeter
- (ii) Oscilloscope
- (iii) Temperature controlled soldering equipments
- (iv) Extender cards and spares.
- (v) Digital multimeter and ammeter
- (vi) Logic probe.

\* Real time diagnostic are active during system usage :  
though real time diagnostic gives an indication of the problem, special ~~skill~~ skill is still required to probe further and findout the ultimate cause.

\* The Off-line diagnostic which can be used to call one programme at a time, like:

- \* CPU diagnostics
- \* Memory diagnostics
- \* CRT diagnostics
- \* D/A and A/P diagnostics
- \* I/O diagnostics.

## \* Vibration and Oxidation:

The bio medical instrumentation suffer when subjected to excessive vibration;

1. Friction connections (circuit board socket or plug socket) can move from areas of low resistance to oxidized high resistance.
2. circuit boards can gradually vibrate out of their sockets.
3. Lead connections can be sheared.

## \* Other instrumentation for monitoring patients

### 1. Surgical Monitoring System?

These are large multichannel oscilloscopes with an EEG record on chart also.

Such equipments have plug-in signal conditioning module that provide versatility and choice of measurement of parameters. These biomedical signal conditioner units include an universal unit for bioelectric signals, an EEG unit, an EEG unit, an EEG unit, a biotachometer, a transducer unit, an integrator, differentiator, and an impedance unit. All these units are compatible.

### 2. Arterial Diagnostic Unit (ADU)?

It provides automated pressure-cuff inflation for rapidly determining segmental pressures and post exercise pressure trends in non-invasive peripheral arterial evaluation.

### 3. Catheterization lab

It is a lab where cardiologists perform diagnostic catheterization. For a patient having blockage in one of the coronary arteries, must be brought into the cath lab.

\* Organization of the hospital for patient - care monitoring - the technical personnel must be familiar with the hospital organization such as which diagnostic equipments are available in what part of the hospital. Generally equipments are divided on the following lines:

#### 1. Surgical equipments :

These are placed in the operating room where surgery is actually performed.

#### 2. Non-surgical equipments :

The monitoring equipments made available in operation room are heart rate meter, Venous and arterial blood pressures, ECG, EEG, various respiratory therapy device.

It may also have emergency equipments like defibrillators and pacemakers, stimulation equipment etc

#### \* Pacemakers :

The rhythmic action of the heart is due to regular recurring action potentials ~~exp~~ originating at natural cardiac pacemaker located at the sinoatrial (SA) node.

Heart block occurs whenever the conduction fails to transmit the pacing impulses from atria to the ventricle properly. In such cases an artificial method of pacing

is generally required to ensure the heart beats.

(i) Internal pacemakers :

Internal pacemakers are defined as the one having entire system inside the body.

(ii) External pacemakers :

• These are used on patients with temporary heart irregularities. This may be due to coronary patient and heart blocks. This may also be used in post operative periods after cardiac surgery. External pacemakers include pulse generators located outside body which are normally connected through the wires introduced into right ventricle via a cardiac catheter. The portable pulse generator is hangs on the body fixed with some straps.

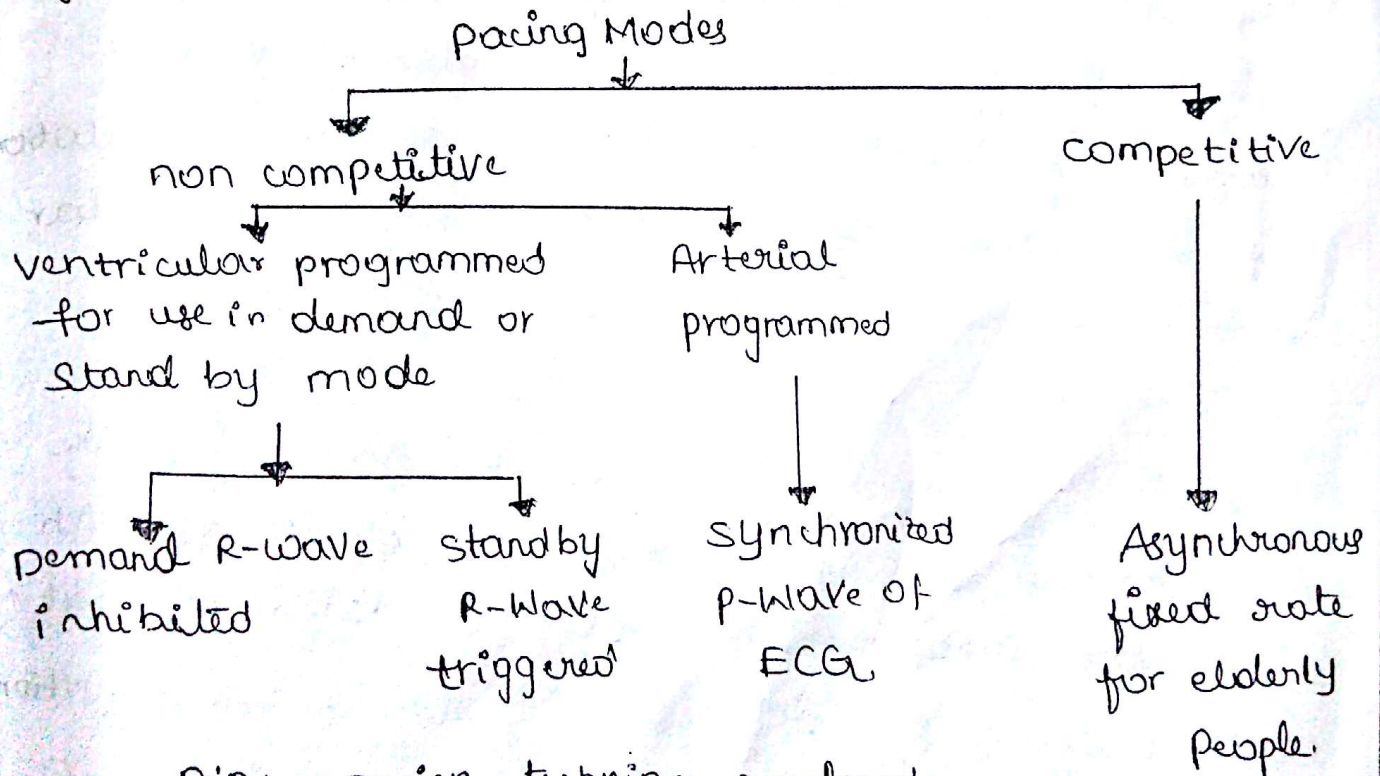


Fig : pacing techniques employed.

## \* Defibrillators:

Action of the heart muscle fibers if precisely synchronized leads to proper performance of heart in its per pumping function. the two chambers of the heart contract together and pump blood through the two atrioventricular valves into the ventricles due to rapid spread of action potentials over the surface of the atria.

Heart massage for defibrillation of patients have been quite common. The duration of the electrical shock is 0.25 sec to 1 sec at 50 Hz ac at an intensity of about 5A to the chest of the patient through appropriate electrodes. This method of an electrical shock to resynchronize the heart is also called countershock. In the event of patient not responding, the electrical shock is repeated until defibrillation starts. This method of defibrillation is called ac defibrillation. Attempts to correct atrial fibrillation by ac method may lead to more serious ventricular fibrillation and therefore, ac defibrillation is no more used.

A dc defibrillator circuit is shown in figure. The capacitor is charged to a high dc voltage which is rapidly discharged through electrodes across chest of the patient. The dc method requires less repetitions and is less harmful to the patient.

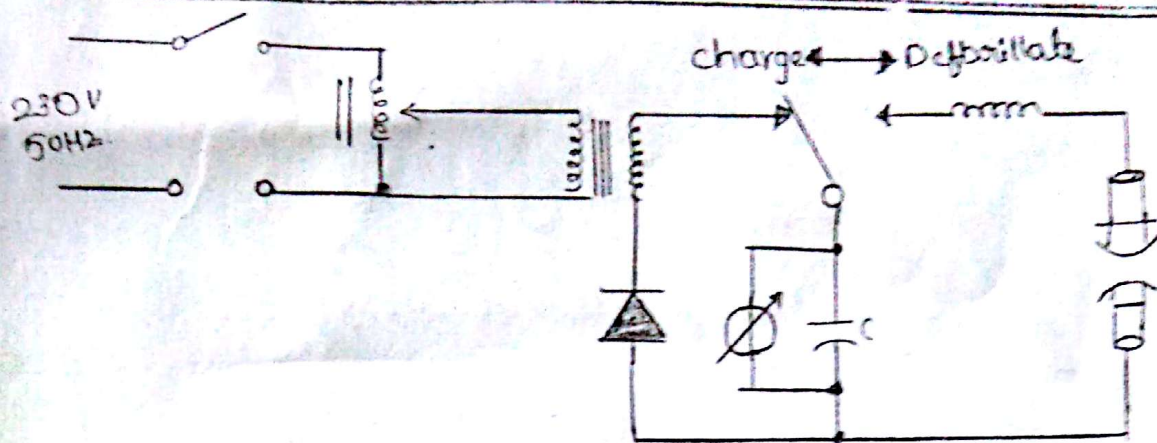


fig: circuit of dc defibrillator.

The electrical energy discharged by the capacitor may vary between 100 to 400 W-sec or joules and duration of the effective period of discharge maybe about 15 m sec. The energy delivered is shown in figure. The plot of current vs time has peak value of current of 20A. The wave is essentially monophasic as most of its excursion is above baseline.

fig: Dual peak dc defibrillator discharge waveform

Applied current (A)

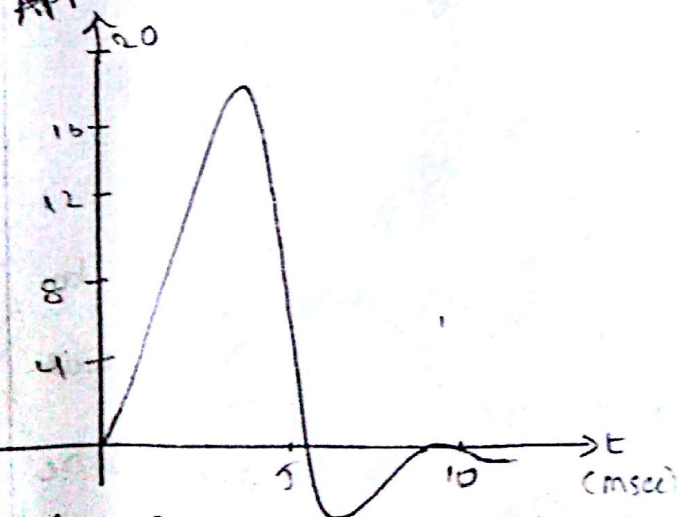


fig: Discharge waveform of dc defibrillator

Applied voltage (V)



Special insulated handles are used to avoid electric shock. Thumb switch if used in handles is useful to control discharge.

Defibrillators are also helpful to convert other potentially dangerous arrhythmias to the manageable case and this is known as cardioversion.

The maximum energy delivered is about 300 watts delivered into  $50\ \Omega$  load which is equivalent to about 400 watts of stored energy.

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#### \* Audiometer:

The device, used to test the (auditory) response is known as audiometer a basic audiometer is an oscillator driving a pair of earphone and is calibrated in terms of frequency and acoustic power, which can be adjusted over the audio range.

A permanent record of an audiometer is called audiograph. Audio graphs are classified into

- (i) pure tone audiometer
- (ii) speech audiometer.

#### 1. pure audiometer:

It generates test tones in octave steps from 125 Hz to 8 kHz with signal intensity ranging from 10 dB to 120 dB. Hearing loss, associated with middle ear disease, can be evaluated with pure tone more accurately than speech test as the frequency and intensity can be controlled with high degree of precision.

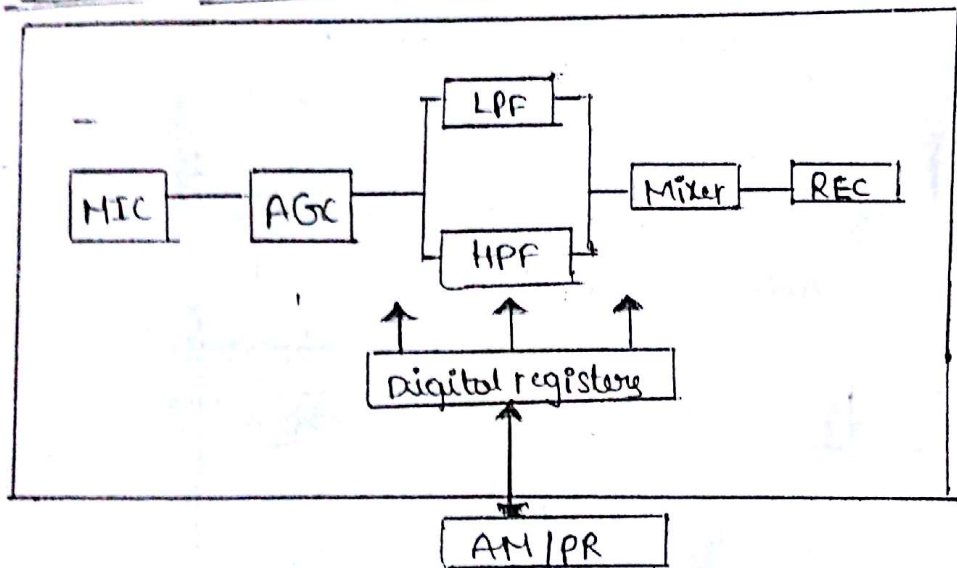
## 2. Speech Audiometer :

Speech audiometer is used in the differential diagnosis of hearing disorder and in the assessment of social handicap. pre-recorder speech is used as a test signal.

## 3. Hearing Aids :

There are several types of hearing loss. one is related to the body aging process due to long term exposure of the ear to sound energy.

### 4. conventional hearing Aid



-fig : conventional hearing aid and block diagram

The functional parts are :

MIC - Microphone and associated preamplifier

AGC - Automatic gain control circuit

LPF and HPF - a set of active filters, i.e. low pass filter and high pass filter.

Mixer - A mixer and power amplifier

REC - a transducer or receiver

AM/PR - audiometer / programmer.

The complete circuit works on a battery. The multiple channel helps in different frequency range which can be adjusted with potentiometer. Latest hearing aids are electronically programmable.

#### \* Digital Hearing Aid :-

It gives greater dynamic range with less power consumption and greater complexity. A digital hearing aid block diagram is as shown in figure

MIC - Microphone

ADC - Analog to digital converter.

DSP - Digital sig processor

REC - Receiver

AM/PR - Audiometer / programmer.

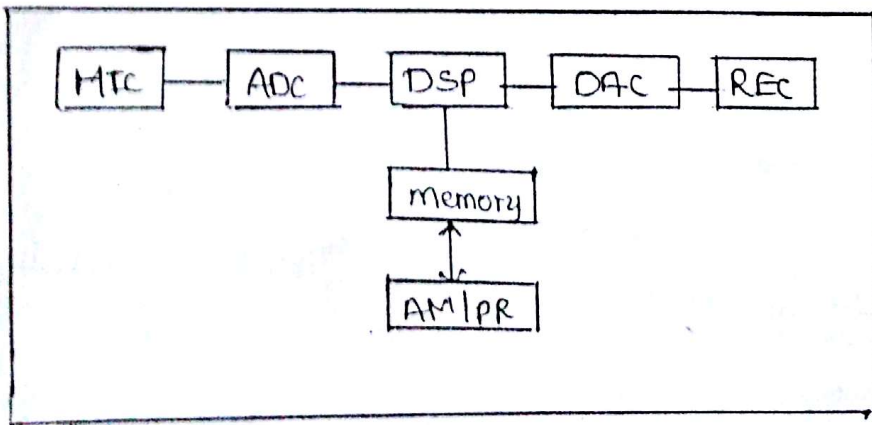


Fig: Digital hearing aid and block diagram.

The sound waves are picked up by the microphone which is transformed into electrical signals. The electrical signals are converted into digital form.

## \* MYOELECTRIC ARM

The difference between inanimate and animate objects is that the animate move, i.e., respond to their environment and show changes in their body functions. These properties are called behaviour which are controlled by the nervous system known as neurology. The body parts are connected to the brain through nerve fibers. Nerves that carry sensory information from the various parts of the body to the brain are called afferent nerves and the ones that carry signals from the brain to operate various muscles are called efferent nerves.

The myoelectric arm can be divided in two parts.

1. Animation control systems (ACS).
2. prosthesis configuration unit (PCU).

## \* prosthesis configuration unit PCU :-

The PCU devices are basically a window into the prosthesis, they communicate with ACS via wireless communications links to gather data from the arm and display it during experimentation.

The PCU allows the medical professional to "see" what is happening inside the prosthesis, in real time, while patient is wearing the myoelectric arm.

A digital wireless communication link allows the PCU to communicate with the prosthesis upto about 50 feet away.

## \* Animation control system (ACS) :

The ACS monitor and control all the functions related to the operation of the hand and wrist. These are microcomputer based systems which interpret patient commands, determine the best method of operating the hand and wrist to match the command, and then drive the hand or wrist in an energy efficient manner.

ACS use radio telemetry to transfer information to and from the prosthesis. ACS module is small and mechanically designed to snap into the wrist of a prosthesis designed.

## \* Rechargeable lithium Battery

Artificial prostheses use rechargeable lithium battery. The rechargeable lithium batteries have proved to be the best choice primarily because they have two to four times more energy for a given size and weight than technologies such as nickel cadmium and nickel metal hydride. These batteries do not have the "dreaded effect" and can be recharged at any point of discharge. The recharge time for a fully discharged battery is about 2 to 3 hours.

## \* LAPAROSCOPE :

Laparoscopic surgery is very intensive technologically and is completely different approach to operative intervention. The response to this innovative method of instrumentation has revolutionized the medicine. The vigorous research development and challenging problem solving efforts are continuing in this field. The technological growth in this

area is rapidly expanding.

The laparoscopic surgery can be for diagnostic purposes such as:

- ① Diagnosis of occult abdominal pain.
- ② Assessment for resectability of tumors.
- ③ Assessment of abdominal trauma.

The therapeutic uses of laparoscopy:

- ① Gynaecological surgery of hysterectomy.
- ② Thorax video assisted ~~of~~ thoracoscopic surgery.
- ③ Retroperitoneal surgery
- ④ Abdomen - cholecystectomy, appendectomy, inguinal hernia repair, fundoplication, small bowel and large bowel resection, splenectomy, etc.

#### \* Basic Instrumentation configuration:

The surgical theatre becomes intra-abdominally, therefore, it has to have space for visualization and movement of instruments.

#### \* Imaging system:

The laproscopic telescope provides the means of acquiring an image of the abdominal cavity. Light is sent into the abdominal cavity through the fiber bundle surrounding the rod lens. The light comes out of the scope as a ring at the tip of the instrument. The diameter of the telescope used these days are 5 or 10 mm instrument.

## Insufflator and Irrigator :

The exposure is achieved by insufflation of the peritoneal cavity with gas such as carbon dioxide ( $\text{CO}_2$ ). This permits safe introduction and manipulation of channels to accommodate the laparoscopic telescope and laparoscopic instruments.

## Dissecting and Manipulating Instruments :

Laparoscopic surgeon has choice of a several no. of instruments and may times in combination to perform the tasks of manipulation and dissection. Many instruments have connectors and are insulated for electrocautery.

## Suturing and Ligation Instruments :

Intracorporeal suturing and knot tying instruments are available with laparoscopic system.

## Applications of Laparoscopic System :

Laparoscopic equipments are very expensive as surgeon has to operate remote from surgical field using imaging system with hand-eye co-ordination. Naturally, it is still not widely available.

## \* Electrophysiological Tests :

The electrophysiological tests of the eye allow objective evaluation of the retinal functions. These include

- (a) Electroretinography (ERG)
- (b) Electrooculography (EOG)
- (c) Visually Evoked Response (VER)

### 1. Electroretinography :

Electroretinography gram (ERG) is a measure of response of the retina of the eye to light i.e., changes in the resting potential of the eye from darkness to fall of light on the retina. ERG signals are more complex as compared nerve action signal because it is the sum of many effects taking place within the eye. The amplitude of ERG signal is 0.5 mV to 1 mV and frequency from DC to 20 Hz.

Normal ~~also~~ record of ERG consists of the following waves which are may be seen in fig.

1. a-wave : Initial negative wave from photoreceptors (Rods and cones)
2. b-wave : Large cornea-positive wave generated by muller cells, but represents the activity of bipolar cells.
3. c-wave : It is also a positive wave with lower amplitude representing metabolic activity of pigment epithelium.

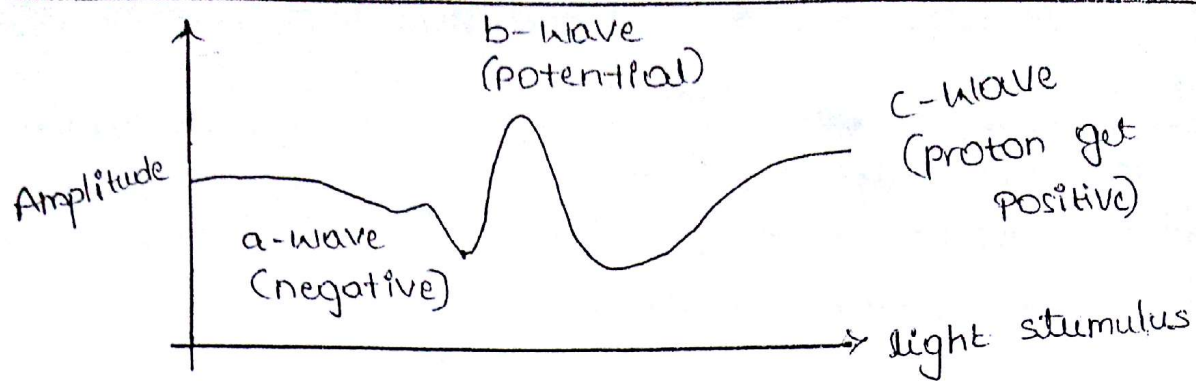


fig: Normal ERG Component.

### \* Electro Oculogram (EOG):

It records biopotentials generated by the movement of the eyeball, i.e., changes in the resting potential of the eye existing between cornea which is positive and back of the retina which is negative. The EOG signal amplitude range is between 50  $\mu$ V to 4000  $\mu$ V and the frequency range is between 0.1 to 100 Hz.

A pair of electrodes are placed over the orbital margin near the medial and lateral canthi.

\* Light Peak: It is the potential rise due to light when both rods and cones contribute. It represents the maximal height of the potential in light.

\* Dark Through: It is light insensitive component and occurs from Retinal pigment Epithelium (RPE), Photo receptors and inner nuclear layer.  $E_{\text{ft}}$  represent the level of minimal height of the potential in darkness.  
(Normally the resting potential of the eye decreases progressively during dark adaptation)

reacting to dark through in 8 to 12 minutes. In the light the light adaptation the amplitude starts and rising and reaches a light peak in 6-9 minutes. The recording is done first in the dark adapted stage and then repeated in light adapted stage.)

The results of EOG are interpreted by finding out the Arden ratio as follows:

$$\text{Arden ratio} = \frac{\text{Maximum height of light peak}}{\text{Maximum height of dark through}} \times 100.$$

### \* Ophthalmoscope :-

Ophthalmoscope is a clinical examination of the interior of the eye by means of an ophthalmoscopy. It is primarily done to assess the condition of fundus and detect the opacities of ocular media. The ophthalmoscope was invented by von Helmholtz in 1850.

Three methods of examination are in use.

- (a) Distant Direct ophthalmoscope (DDO)
- (b) Direct ophthalmoscopy
- (c) Indirect ophthalmoscopy.

### \* Distant Direct ophthalmoscopy (DDO) :-

It should be performed routinely before the direct ophthalmoscopy and gives a lot of useful information. It can be performed with the help of a self-illuminated ophthalmoscope or a simple

plain mirror with a hole in the centre.

The light is thrown in the patient's eye sitting in semi-dark room from a distance of 20-25 cm and the features of the red glow in the pupillary area are noted.

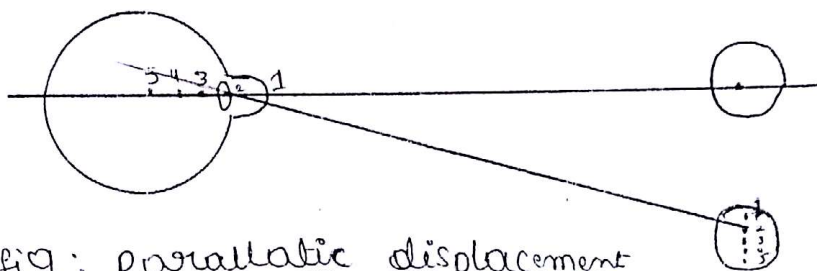


fig: parallax displacement  
in distant direct ophthalmoscopy.

#### \* Direct Ophthalmoscopy:

It is the most common method for routine fundus examination. The modern direct ophthalmoscope shown in below figure works on the optical principle of glass plate ophthalmoscope invented by the von Helmholtz.

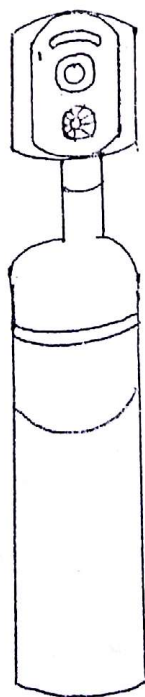


fig: Direct ophthalmoscope



Direct Ophthalmoscope

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### Indirect ophthalmoscope :-

Indirect ophthalmoscope was introduced by Nagel in 1864. This is now very popular method for examination of the posterior segment.

The optical principle of Indirect ophthalmoscopy is to make the eye highly myopic by placing strong concave lens in front of patient's eye so that the emergent rays from an area of the fundus are brought to focus as a real inverted image between the lens and the observer's (Doctor's) eye which is then studied.

### \* Tonometer FOR EYE PRESSURE MEASUREMENT :-

The Intraocular pressure (IOP) is measured with the help of an instrument called tonometer. Two basic types of tonometers available are indentation (Scholze) Tonometer and Applanation (Goldmann) Tonometer.

## Indentation (Scholtz) Tonometry :-

(85)

Scholtz tonometer shown in below fig: It consist of

a, handle for holding the instrument vertical position on the cornea.

b, A foot plate which rest on the cornea

c, plunger which moves inside the foot plate.

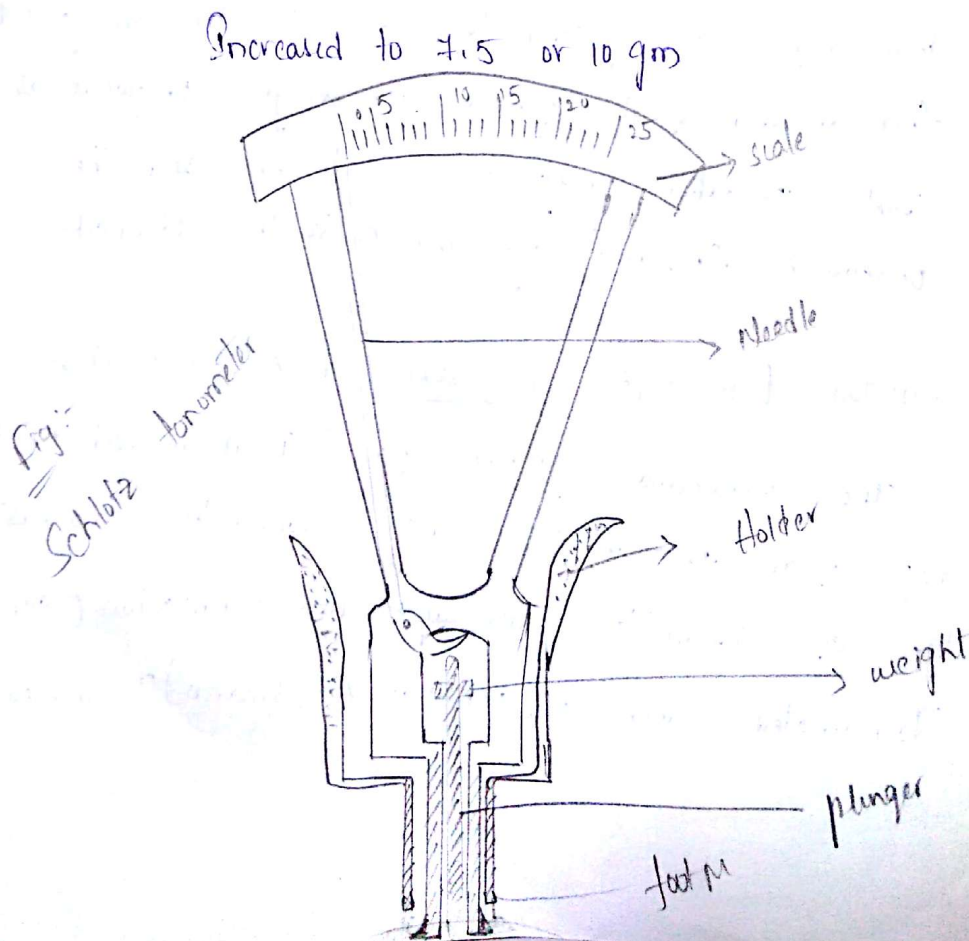
d, Bent lever whose short level rest on ~~the~~ plunger

and long arm acts as a pointer needle. The

degree to which plunger indents the cornea is

Indicated by the movement of needle on a scale.

e, 5 gm is permanently fixed to the plunger and is



## Applanation (Goldmann) Tonometry:-

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This is most popular and accurate tonometry. It consists of a double prism mounted on a slit lamp. The prism applanates the cornea in an area of 3.06 mm diameter.

For measuring eye pressure the cornea is anesthetized with a drop of 2% xylocaine. The patient is asked to sit in front of the slit lamp. The cornea and biprism is then advanced until it just touches the apex of the cornea.