CHAPTER VII SPECIALISED MEDICAL EQUIPMENT

7.1 INTRODUCTION

Many hospitals have a laboratory where the chemical analyses are going on. Measurement of chemical parameters is necessary to monitor the patients, who are in critical conditions. Already some of the clinical laboratory equipment are discussed in the last chapter. In this chapter the remaining clinical laboratory and diagnostic equipment and medical X-ray equipment are discussed.

7.2 BLOOD CELL COUNTER

The blood cells have important functions in our body. The red blood cell is used for the transport of oxygen and carbon dioxide. The white blood cells are part of the body's defenses against infections and foreign substances. The platelets are involved in the clotting of blood. The red blood cells in the blood consist of hemoglobin. When the body produces too many red blood cells, the amount of hemoglobin in the blood increases and a chronic disease called ***polycythemia*** or dehydration is produced. When the hemoglobin in the blood decreases, ***anemia*** is produced. The anemia produces headache and giddiness. The amount of hemoglobin is normally 130-170 g/l for men and 120-160 g/l for women. Due to finite size of blood cells, they make up a portion of the total blood volume. The volume percentage of red cells in a given volume of blood can indicate the various diagnostic informations to the

physician. To determine relative proportion of blood cells in a given volume of blood, **hematocrit** or packed cell volume is used. The blood sample is placed in a test tube which is spun so that the cells are packed at the bottom under centrifugal force provided by the centrifuge. Thus the packed cell volume is the ratio between the height of the packed cells and the height of the blood in the tube. Normal range of packed cell volume for men is 42%-54% and for women is 37%-47%.

The number of red blood cells is also counted using a microscope. Since the density of red blood cells is so large, the microscopic counting is time consuming. Therefore now-a-days automatic red blood cell counters are used. The method is based on the fact that red cells have a higher electrical resistivity than the saline solution in which they are suspended.

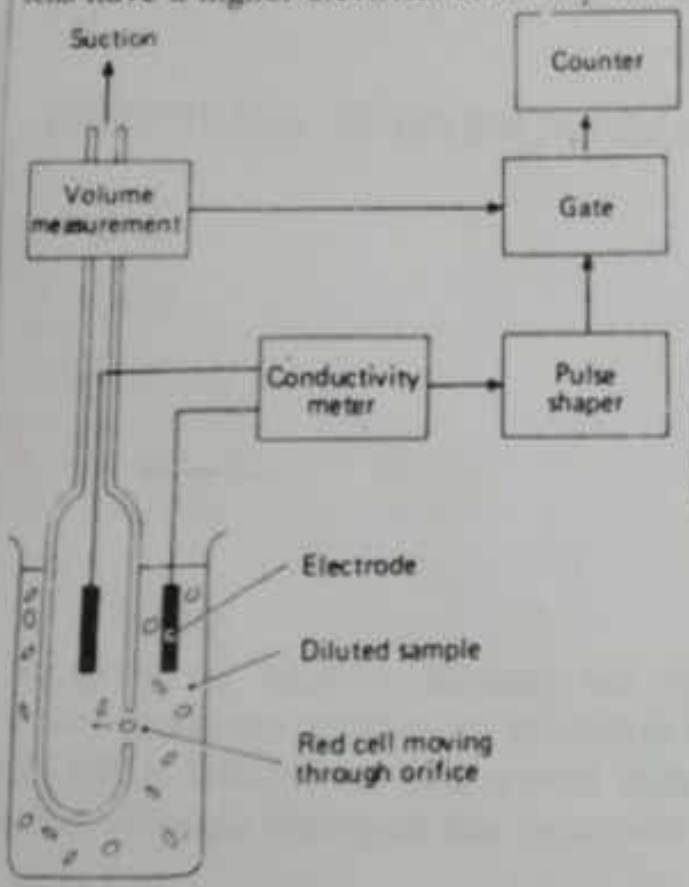

Fig.7.1. **Automatic blood cell counter**

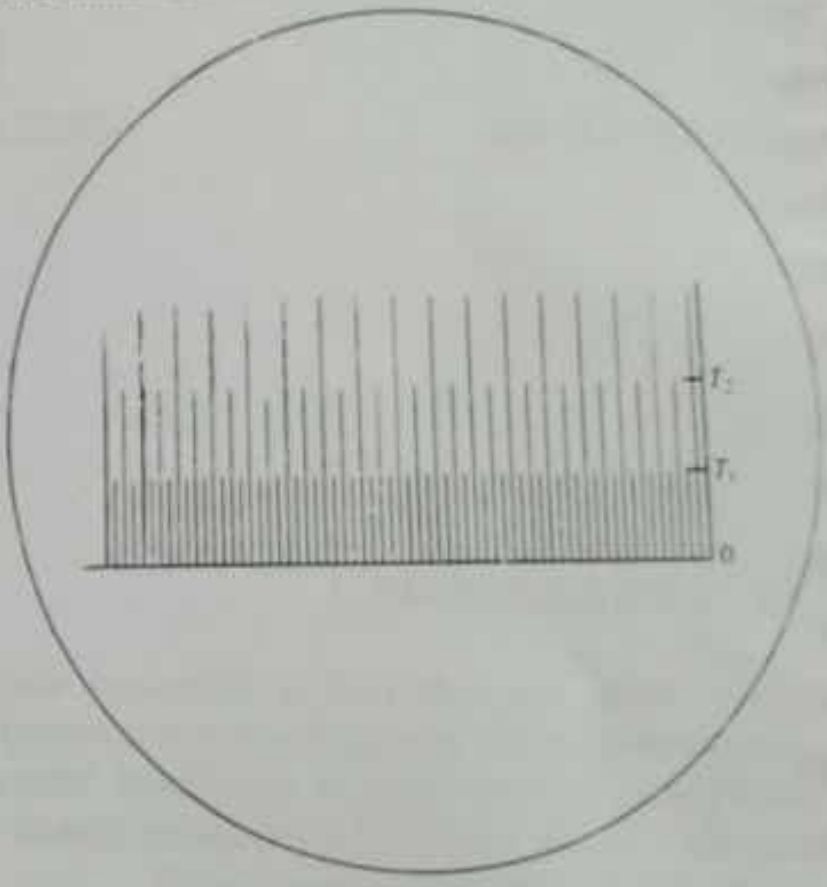

Fig.7.2. **Counter display of impulses**

Figure 7.1 shows the automatic blood cell counter using electronic circuitry. A diluted blood sample is drawn through a small orifice having diameter less than 100 μm by means of a suction pump. The electrodes are placed such that one in the surrounding sample chamber and other in the suctioned blood. The electrodes are attached with the conductivity bridge such that their resistance forms one arm of bridge. Before suctioning, the resistance of the electrode arm is equal to R. After suctioning of blood, each red cell moving through orifice will produce a sudden increase in resistance such that the resistance of the arm is now equal to $(R + \Delta R)$ or R_{out}. Assuming equal resistances R are placed in other arms,

the bridge output voltage, $V_{out} = \left[\frac{R_{out}}{R_{out} + R} - \frac{1}{2}\right] V_{BB}$

$$= \frac{\Delta R}{4R + 2\Delta R} V_{BB}$$

(or) $$V_{out} = \frac{\Delta R}{4R} V_{BB}$$

since $\Delta R << R$. Here V_{BB} is the constant excitation voltage of the bridge. Thus V_{out} is directly proportional to ΔR. The conductivity meter gives the amplified V_{out} as an impulse. The number of impulses is counted by a counter for a certain volume displacement through the orifice and this gives the density of red blood cells. Figure 7.2 shows the counter display interms of impulses. The impulses having highest peaks are fewest in number. These are due to WBCs which make highest resistance change in the orifice. The RBCs are represented by the peaks between threshold T_2 and T_1. During the operation of the instrument, the threshold is first set to zero and the counter output is given by the total number of particles (WBCs + RBCs + platelets) per litre. Then the threshold is set to T_1 and now the counter gives the total number of RBCs and WBCs per litre. After that the threshold is set to T_2 and the counter reads just the total number of WBCs, per litre.

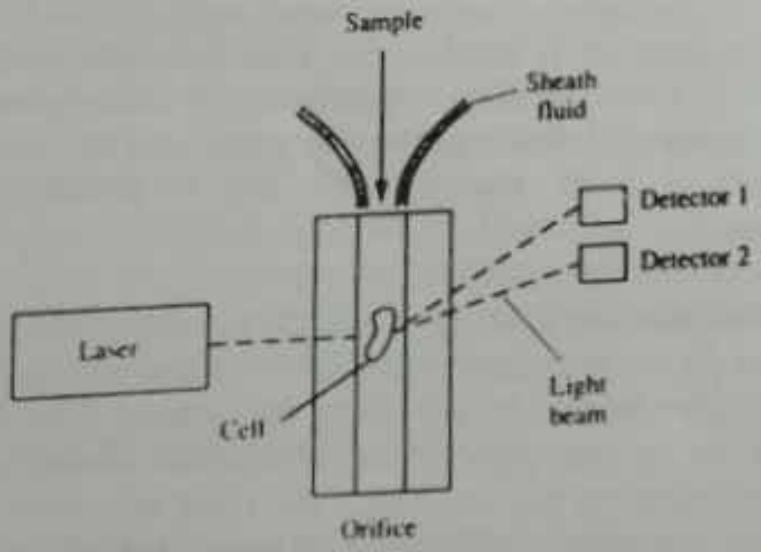

Fig.7.3. Principle of laser based blood cell counting

Figure 7.3 shows the principle of laser based blood cell counting. This is a modern technique which gives the number of RBCs, WBCs and platelets, hematocrit, mean cell volume of red blood cell and concentration of hemoglobin. The basic principle behind this

technique is that the angle of scattered light intensity is different for different sized particles. The sample blood is heavily diluted to reduce the number of particles counted to one at a time. A sheath fluid is directed around the blood stream to confine it to the center of aperture through which a laser beam is passed. Thus the blood cells are illuminated by the laser light and they scatter light. The scattering angles of platelets and red blood cells are having large difference so that the scattered light from these two types of cells are directed into two different photo detectors. The output of the photo-detector is given to a properly calibrated digital voltmeter which gives the density of red blood cells or platelets. To separate white blood cells from red blood cells, it is necessary to destroy the red blood cells with a lysing agent. This also frees the hemoglobin from the blood and the concentration of hemoglobin can also be measured. After separating the hemoglobin, once again measurements are made. By which the concentration of white blood cells can be measured.

7.3 ELECTRON MICROSCOPE

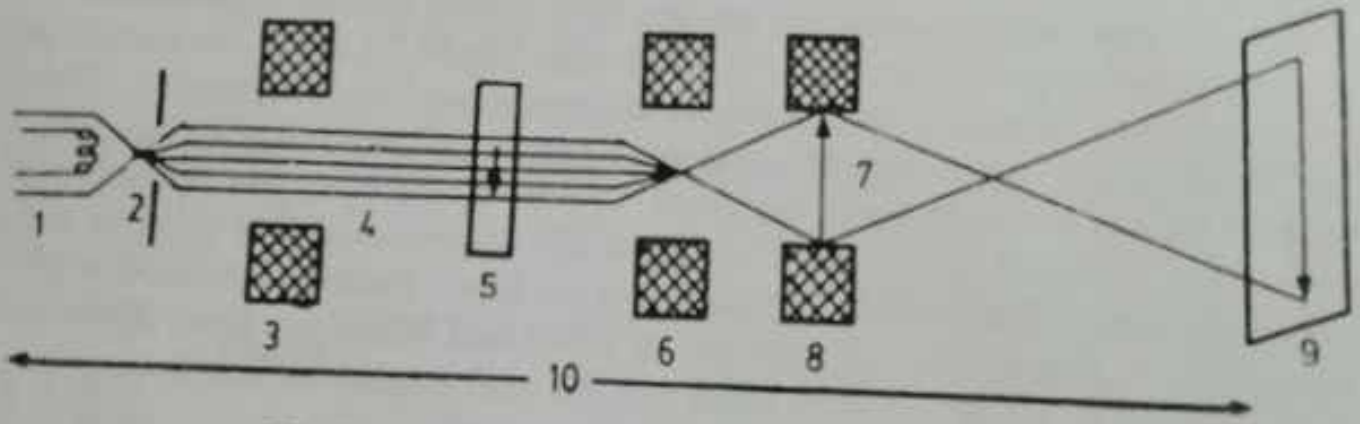

Fig.7.4. Electron microscope (transmission type)

1. Cathode
2. Anode
3. Condensing magnetic lens
4. Electron beam
5. Object (specimen)
6. Objective magnetic lens
7. Intermediate image position
8. Projector magnetic lens
9. Fluorescent screen (or) Photographic plate
10. Evacuated column

Any microscope has two functions (1) to magnify the object, under observation (i.e. to ake it look bigger) and (2) to resolve the object (i.e. to make very close portions look much parated). Magnification is achieved by increasing the number of lenses used. To increase e resolving power is not so easy since if two objects are closer than one third of the velength of light used, they are not resolved. The resolving power of the microscope is ersely proportional to the wavelength of the light used (Refer Problem No.1). Since the velength of visible light is around 6000 A.U., optical microscopes cannot resolve objects er than 2000 A.U. But electron waves are of much

3. The delay monostable triggers the monostable controlling the receiver gate so that the gate opens to allow a voltage which is in effect a sample corresponding to the doppler shift due to the motion in the target volume, to be stored in the sample and hold circuit.

4. The << sample and hold >> is reset immediately prior to being updated by a new sample resulting from the following ultrasonic pulse.

5. The output from the << sample and hold >> is thus a rectangular wave with a long << mark >> and a short << space >>.

6. These rectangular waves are amplified and given to the loud speaker or spectrum analyser for further analysis after passing through the low pass filter.

7. A zero crossing rate meter is a comparator that produces an output pulse every time when the signal crosses the zero line going from negative to positive. Normally the blood flow signal contains a wide frequency spectrum in the audio range. By using pulsed doppler, the received signal can be limited to narrower frequency range. The zero crossing rate meter can measure the blood velocity or the change in blood velocity very accruately.

8. Because of some limitations of the zero crossing rate meter, spectrum analysers are used to derive blood flow velocity information from doppler signals. A spectrum analyser processes short length of audio signal to produce spectral displays which have frequency as abscissa, time as ordinate and spectral intensity represented by record darkening.

6.10.3 Laser based Doppler blood flowmeters

Similar to ultrasonic blood flowmeter, laser based doppler blood flowmeters are used to measure the blood flow velocities in various blood vessels.

Light from a He-Ne laser of 5 mW power and 632.8 nm wavelength (figure 6.16) is coupled into the quartz fiber using a converging lens which results in an increased power density at the skin surface and thus enables to detect flow in more deeply seated veins and arteris. The receiving plastic fiber collects the scattered signal and the collected signal is coupled to the photodiode through a laser line filter. The photo diode is a square law device and gives out current which is proportional to the intensity of the reflected light and to the beating frequency of the shifted and unshifted signals. The diode output is given to the low noise preamplifier and then to the wide band amplifier having wide band performance (40 Hz - 40 kHz). System output is obtained by taking the RMS value of the total signal separating it from the total zero light noise and normalising it for total back scattered light. An audio output of the signal before RMS conversion is also available to hear the flow

pattern. Here the instrument measures an averaged blood cell velocity and not the absolute velocity of the flow. Laser doppler flowmeter is also a noninvasive one and it offers high reproducibility and high sensitivity.

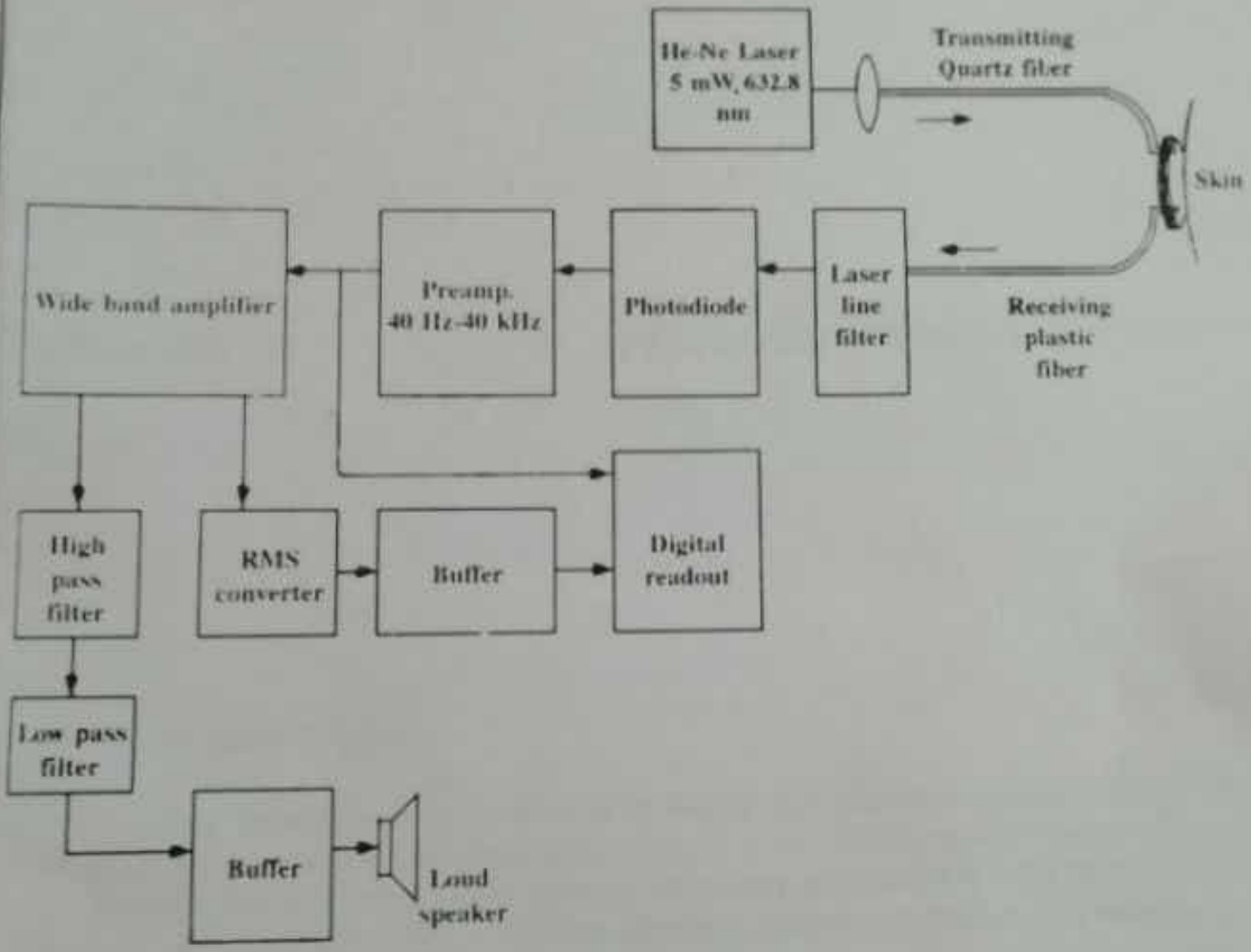

Fig.6.16. Laser doppler blood flowmeter

6.10.4 NMR Blood flowmeters

There is also noninvasive blood flowmeters based on nuclear magnetic resonance principle. But this is very complex and costly. In the presence of an external magnetic field, the magnitude of magnetisation resulting from the alignment of nuclear magnets of hydrogen atoms is proportional to the blood flow rate. Thus measuring the magnetisation one can evaluate the blood flow rate in various blood vessels.