3. Diagnostic equipment

Some of the equipment described in this and the following sections is used in direct contact with patients and can be hazardous to patients if faulty. Such equipment must, therefore, be used only if it is in full working condition. For this reason, only the simplest maintenance should be carried out by hospital staff without specialized training. For more complex problems, the equipment should be referred to fully trained service personnel, the manufacturer or appointed agents. It is the responsibility of the designated medical, nursing or technical staff who use the equipment to ensure that it is functioning satisfactorily before it is used.

Blood pressure machines (sphygmomanometers)

There are three main types of sphygmomanometer in use:

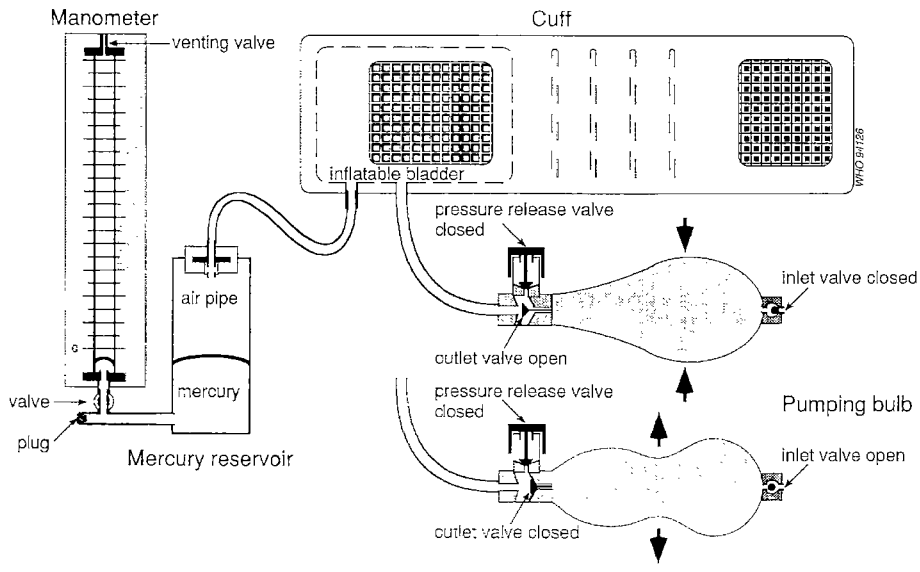
- mercury type,
- aneroid type,
- electronic type.

The mercury type is preferred since it is the most reliable. Descriptions of the other two types are included here since they are in common use.

Mercury type

This is perhaps the most common type of sphygmomanometer. It consists of a reservoir of mercury, which can be pumped into a manometer tube. This tube lies on a graduated scale which is usually calibrated from 0 to 300 mmHg. The blood-pressure cuff is wrapped round the patient's arm just above the elbow, the machine connected up, and air pumped in using the bulb provided. The cuff is, in turn, connected to the top of the reservoir by a rubber tube. The air pumped into the cuff is under pressure, and this same cuff pressure will be transmitted to the top of the reservoir, pushing the mercury up the calibrated tube. When the pumping of air into the cuff is stopped, the reading on the scale will indicate the pressure in the cuff (Fig. 3.1).

Fig. 3.1. Blood pressure machine—mercury type.



The two non-return valves, the inlet and outlet valves, cause the bulb to act like a pump to create the necessary pressure in the cuff. After the outlet valve, a pressure release mechanism is fitted to permit slow release of the pressure in the cuff when finding the blood pressure.

The cuff is inflated until the pressure as shown on the scale is above the expected blood pressure, and a stethoscope is placed on the artery at the elbow. Because the pressure in the cuff is above the expected blood pressure, no sounds will be heard as the blood cannot flow in the artery that is under the cuff. The cuff pressure is now slowly released by opening the valve on the bulb, the pressure in the cuff falling as the air escapes. At some point, the pressure in the cuff will fall below the blood pressure, blood will start to flow in the artery under the cuff and the sounds of the blood circulation will be heard. As soon as these sounds are heard, the reading on the scale is noted; this is the systolic pressure. As the pressure in the cuff falls further, the sound changes at the point where the cuff pressure equals the diastolic pressure.

It is important that the initial mercury level is adjusted to zero, with no pressure in the cuff. If it is higher, the machine will give falsely high readings; if it is less than zero, it will give falsely low readings. Adjust the level of mercury by undoing the reservoir cap, and with a syringe and needle, add or remove mercury until the level is correct.

The mercury should be clean. With time it tends to become oxidized to mercuric oxide, a black powder. When this happens, remove the mercury and clean the system. Aspirate the dirty mercury into a clean syringe, then filter it through a filter-paper, into a clean receiver. Do this several times until the mercury is clean. Replace the clean mercury and top it up to the zero mark with fresh mercury. Finally, replace the reservoir cap.

Do not handle the mercury more than is necessary, and do not inhale the dust; mercury is a cumulative poison and should be handled with care. Store old mercury in a strong glass jar with a little water floating on the top to stop it fuming. When cleaning the tube and reservoir, blow the dust out with an air-line. Do this outside so that the workplace does not become contaminated.

There is a leather seal at the top of the tube to keep the mercury in. This seal is very important. If it is faulty, the machine may give readings that are too high. This is because, as the mercury falls in the tube, air passes in through the washer at the top. If the air cannot enter the tube quickly enough, the mercury is held back slightly as it falls. This means that the pressure in the cuff will be slightly lower than the reading showing on the scale.

This may be checked as follows:

Pump air into the cuff in the normal way, causing the mercury to rise in the tube. When the inflation stops the mercury should stop rising in the tube. If the washer is faulty, the mercury will continue to rise for a short time, as the air above the mercury continues to pass out of the tube, past the washer. The same phenomenon will occur, in reverse, when the mercury is going in the other direction. The problem can be confirmed by taking the washer out, and repeating the test. The mercury should come to a sudden stop the moment the pumping is stopped. Take care not to pump the mercury too far up the tube, as it will "fountain" out of the top.

The solution to the problem is to change the washer. This may have to be done several times before a suitable one is found. If a satisfactory washer is not available,

it is possible to make one out of suitable material, as long as it allows the air to pass at the correct rate, but prevents the mercury from spilling out.

Aneroid type

As the name implies, aneroid sphygmomanometers do not contain any liquid. They are used in the same way as the mercury type, but instead of having mercury in a tube they have a small brass bellows. This is a flat corrugated container into which the air can pass, so keeping it at the same pressure as the cuff. As the pressure inside increases, so the bellows expands, moving a pointer by means of a series of levers and a rack and pinion arrangement. A coiled return spring brings the pointer back to zero when the pressure is released.

This type of machine is much more likely than the mercury type to become damaged and consequently inaccurate. Its accuracy should be checked every 6 months against a mercury machine. The pointer should always return to the zero point when there is no pressure in the cuff.

When checked against a mercury machine, there are two common types of error that may occur with aneroid machines: linear error and non-linear error. With a typical linear error, the two sets of readings might be as follows:

Mercury	*Aneroid*
50 mmHg	60 mmHg
70	80
100	110
150	160

The error (10 mmHg) is the same all the way up the scale.

The following is a typical non-linear error:

Mercury	*Aneroid*
30 mmHg	10 mmHg
50	40
70	70
100	110
150	170

In this case the error changes as the pressure changes.

Correcting either type of error can be time-consuming, and should only be attempted if full details are available in the manual supplied by the manufacturer.

Electronic type

The simplest types of electronic sphygmomanometer have the same cuff and inflation bulb as all the others, and a dial similar to that of the aneroid type. The difference is that in the cuff there is a transducer that picks up the sound of blood flow. This is turned into a note that sounds each time the pulse is detected. These machines are fairly reliable but there may be problems with the connections between the transducer and the instrument; as the units are often sealed, access may be difficult.

The simple electronic machine has no great advantages over the mercury type, and in the long run is likely to be more troublesome. There are more sophisticated types that automatically inflate the cuff at set intervals and give the blood pressure on a digital display. This type of machine does not have a transducer in the cuff,

but a very sensitive detector in the body of the machine detects the pulsations in the cuff. The only parts of this machine that can be serviced are the air pump that inflates the cuff, the tubing between the cuff and the pump, and the cuff itself. Most other repairs to these machines would require specialist knowledge.

Ophthalmoscopes and otoscopes

Ophthalmoscope

An ophthalmoscope has two parts:

- the handle, which holds the batteries, the "on/off" switch, and a rheostat that controls brightness;
- the head, which holds the lenses.

Corroded batteries

If the instrument is not in use for any length of time, remove the batteries to prevent corrosion. Removal of batteries that have corroded can be difficult. If the rheostat assembly can be removed from the handle, soaking the handle in boiling water helps to dislodge the batteries. Some handles have a hole in the bottom; in this case introduce a punch through the hole to tap the batteries out. After removal of the batteries, thoroughly clean the handle.

Faulty "on/off" switch or rheostat

First check that the batteries and the bulb are in good condition. With the instrument turned on, check for voltage at the contacts; if there is no voltage, examine the rheostat more closely (and, if possible, remove the rheostat and check for continuity with a meter). Check the continuity of the handle, and also check for corrosion under the spring contact at the bottom of the handle.

The head

This is the most complicated part of the instrument. It contains many small lenses. Light from the bulb passes through a number of lens systems and a small mirror before entering the patient's eye. Some of these systems have their own adjustments, apart from the beam-focusing lenses. Do not attempt to open the head unless you are already experienced in taking the lenses apart and re-assembling them. If the lenses need to be cleaned, try blowing them free of dust with a powerful blower; such a blower can be made from a sphygmomanometer inflation bulb with a blunted needle on the end. If the lenses are very dirty, clean them with methanol and a piece of soft cloth.

Otoscope

The handle of an otoscope is often the same as that of an ophthalmoscope.

The head

The main part of the head holds the bulb, and may also have a lens. On the front, one of a number of different sizes of speculum can be fitted. A set of five specula is