EVERYDAY SCIENCE

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PREFACE

Everyday Science has been written to provide a science course for Years seven to ten in Australian schools. This is purely a source book for information and for this reason no attempt has been made to include student experiments; it would make the book too big.

Topics making up the content of the book have been selected because of their everyday interest. The more academic subjects have been omitted.

Each chapter opens with a series of questions which can be answered by reading the chapter. There is also another set of questions which may be answered by referring to the library or by experimenting at home or in the laboratory.

At the conclusion of each chapter there is an objective test. Answers to these tests are in an appendix at the end of the book.

R.G.C.
W.A.D.

COLOUR PLATES

(omitted)

CONTENTS

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1
MAKING MEASUREMENTS

Questions this chapter answers

1. *What is a standard? Why do we find it necessary to have standards?*
2. *What is the standard for measuring lengths of objects?*
3. *How can you reduce errors when using a ruler to measure length?*
4. *What is the standard for weighing things?*

Problems for you to solve

1. Are all 30-centimetre rulers in your class exactly the same length? If not, what is the greatest difference you can find between any two rulers?
2. How thick is a sheet of paper in your exercise book?
3. How wide is the groove on a gramophone record?
4. How many millilitres are there in a teaspoon?
5. What is the volume of the classroom in cubic metres?
6. Is the trip meter on your car perfectly accurate? What could cause its accuracy to vary?

People are constantly making measurements. Some measurements need only be approximate. A cook, for example, measures out cups of flour, teaspoons of sugar and pinches of salt. An engineer, on the other hand, might be expected to measure the diameter of a steel shaft to within one thousandth of a centimetre.

Accuracy is important when things are manufactured. Think of a motor car

***Figure 1.1:** Accuracy in industry. Parts for motor vehicles must be accurate in every detail. Here an operator at the Ford plant at Geelong is checking the accuracy of a machine that automatically grinds the main engine shaft of a Ford Falcon. (Photo courtesy Ford of Australia)*

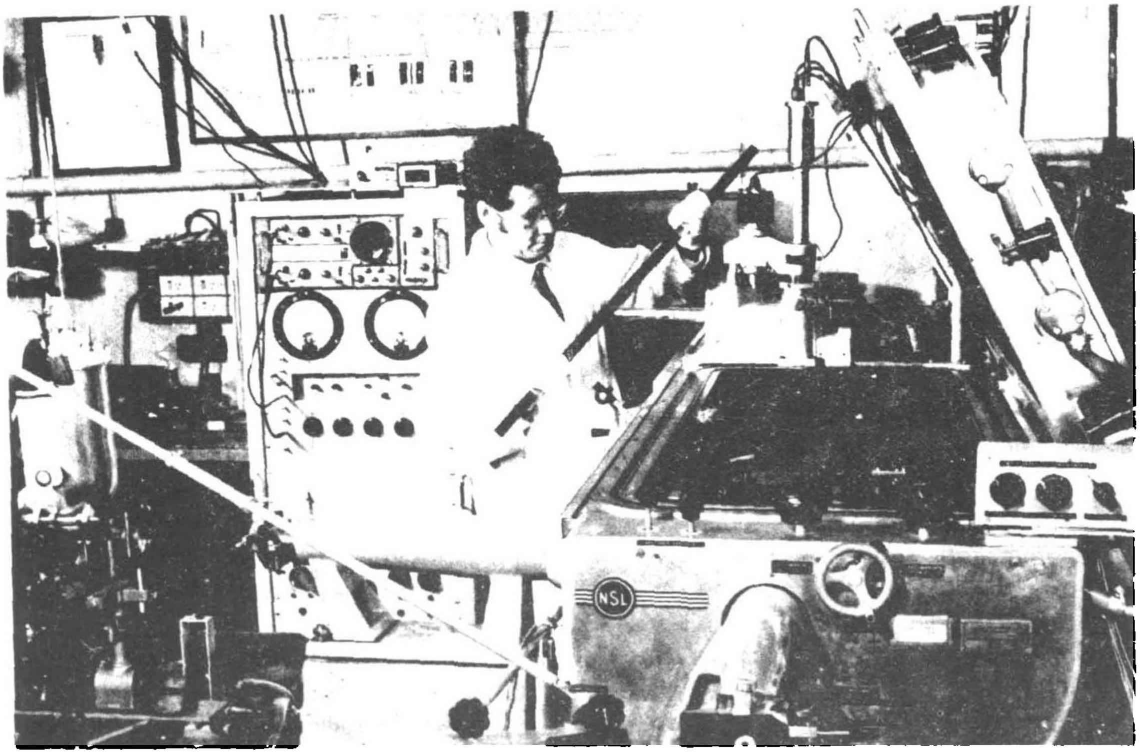

Figure 1.2: Australia's copy of the standard metre. The man is about to place it in a special machine to check that its length hasn't varied with use. (Photo courtesy National Measurements Laboratory)

assembly line. The parts are made in one factory and put together in another. Take pistons as an example. All pistons manufactured must be as close as possible to the same size. Otherwise the pistons won't fit properly into the engine as it is being assembled.

Accuracy in measuring depends on accurate rulers and gauges. These are only accurate because the machines that make them can be checked against a standard metre kept at the National Measurements Laboratory. (See figure 1.2.)

Imagine what it was like years ago, when there were no standards kept in laboratories. A common unit for measuring length was the *cubit*. This was the length of the forearm from elbow to fingertip. The *span* and the *pace* were also used to measure length. And an early traveller might have described two towns as being a day's march apart.

About two hundred years ago the King of France decided to establish a uniform, and more accurate, measuring system. A committee was appointed and after much discussion it chose one ten-millionth of the distance from the Equator to the North Pole as the standard. The committee called this standard of distance the *metre*. A metal bar was then made that measured one metre at 0°C. This bar, called the standard metre, is kept in Paris.

It would be very awkward if every country in the world had to refer to a standard kept in Paris. Therefore, copies of the standard have been made and sent to many parts of the world. It is one of these copies that is kept at the National Measurements Laboratory in Sydney.

Look at the metre ruler in your laboratory. Notice that it is divided into 100

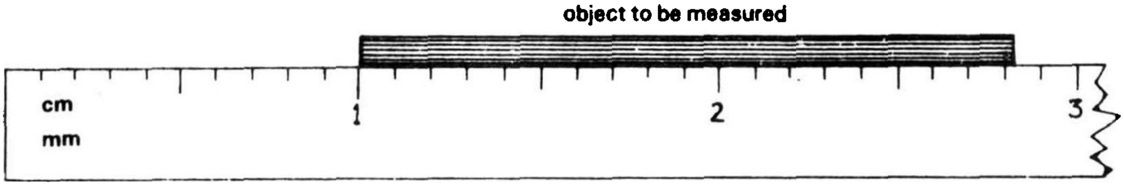

Figure 1.3: Using a ruler to measure the length of an object. This drawing is enlarged to make it clearer. When the scale starts at the end of a ruler you should measure from a point in from the end. Can you explain why? (length of object = 1.8 cm)

equal parts, called centimetres. Each centimetre is divided into 10 equal parts, called millimetres.

$$1 \text{ centimetre} = \frac{1}{100} \text{ metre}$$

$$1 \text{ millimetre} = \frac{1}{1000} \text{ metre}$$

When using a ruler to measure the length of an object, it is best to follow these hints:

- Avoid measuring from the end of the ruler if the scale starts at the end.
- Turn the ruler onto its edge.
- Have your eye directly above the section of the ruler where you are making your reading.

Look at figure 1.3. For practice, write down the length of the object in the figure to the nearest millimetre. How would you write this length in centimetres?

Measuring liquids

Oil companies sell crude oil by the *barrel*. Barrels come in many different sizes but, as you can imagine, the oil companies use a standard barrel. The standard barrel is based on the *litre*. The litre, in its turn, is based on the metre.

You can quickly make a container that holds one litre by referring to figure 1.4. From stiff paper, cut out a square with sides each measuring 30 centimetres. Divide the sides into thirds. Rule up as shown in figure 1.4. Cut away the dotted portions. Fold

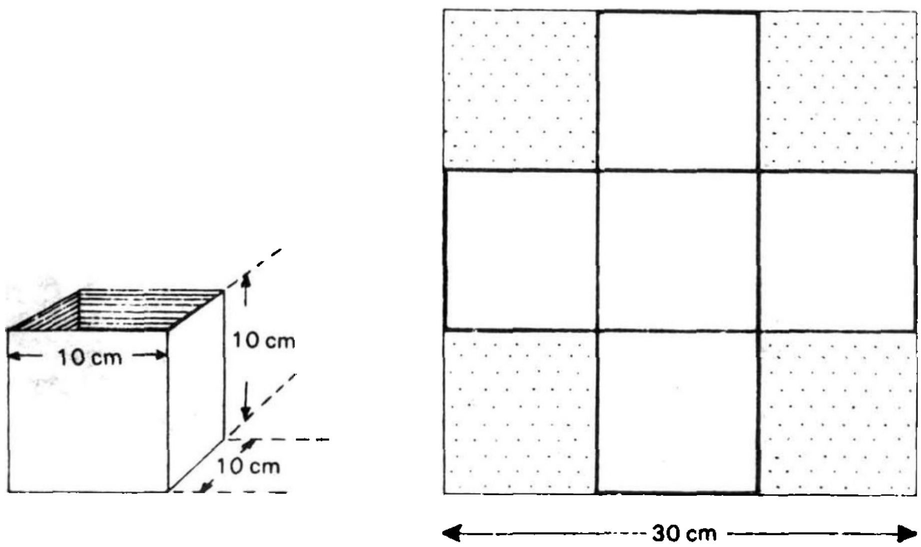

Figure 1.4: Making a box that holds one litre. Cut out a square of stiff paper, with each side 30 centimetres long. Remove the portions shown dotted in the diagram, and fold along the heavy lines.

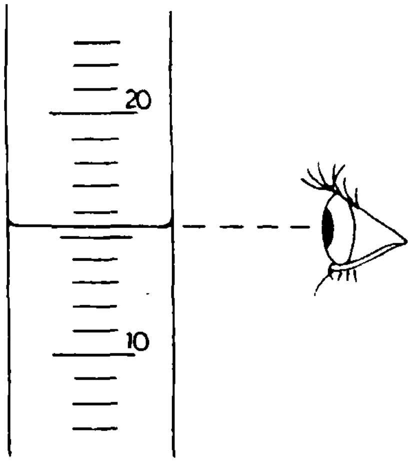

Figure 1.5: Reading the volume of water in a measuring cylinder to the nearest scale mark. (volume = 15 scale units)

along the heavy lines and hold the edges together with sticky tape.

From the measurements we can see that

$$
\begin{aligned}
1 \text{ litre} &= 10 \times 10 \times 10 \text{ cubic centimetres } (cm^3) \\
&= 1000 \text{ cm}^3 \\
&= 1000 \text{ millilitres (mL)}
\end{aligned}
$$

(The millilitre is the same size as the cubic centimetre.)

$$1 \text{ millilitre (mL)} = \frac{1}{1000} \text{ litre (L)}$$

Figure 1.5 shows how to read the volume of water in a measuring cylinder. The curved surface of the water makes it awkward to read the scale. This curved surface is called

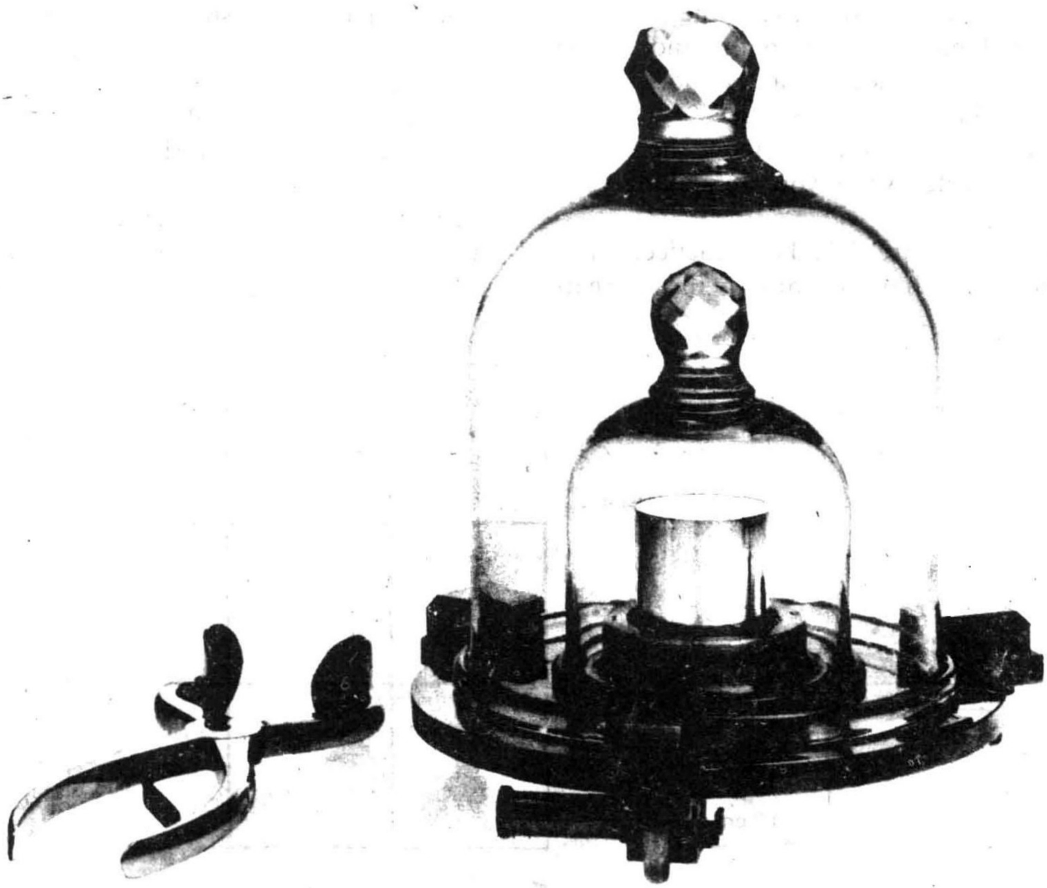

Figure 1.6: Australia's copy of the standard kilogram. Notice the special containers used to store it and the padded tongs used to lift it. (Photo courtesy National Measurements Laboratory)

the meniscus. The manufacturer marks the measuring cylinder so that the correct reading is obtained when you read to the *bottom of the meniscus*.

Use the following rules:

- See that the measuring cylinder is upright.
- Have your eye level with the bottom of the meniscus.
- Read to the nearest scale mark.

Weighing

The standard for weighing is the *kilogram*. The kilogram is the weight of a litre of water. A standard kilogram is kept at the National Measurements Laboratory in Sydney. (See figure 1.6.)

Measurement

1. The standard of length is the metre.
2. Measurements are made by making comparisons with a standard.
3. Measurements are never completely accurate.
4. 1 centimetre (cm) = $\frac{1}{100}$ metre (m)

   1 millimetre (mm) = $\frac{1}{1000}$ metre (m)
5. 1 litre (L) = 1000 cubic centimetres (cm^3)

   1 millilitre (mL) = $\frac{1}{1000}$ litre (L)
6. The standard for weighing is the kilogram.

   1 gram (g) = $\frac{1}{1000}$ kilogram (kg)

Test yourself (chapter 1)

Several answers are suggested for each of the first four questions of this test. Choose the best answer to each question and write its letter in your workbook. Answer all parts of question 5.

1. The standard for the measurement of length is the
   (a) litre
   (b) metre
   (c) kilogram
   (d) centimetre.
2. The viewing positions for the most accurate measurement in figure 1.7, page 6, are
   (a) both x and y (c) both z and x
   (b) both y and z (d) y only.
3. Measuring the length of an object with a metre ruler will give you
   (a) its exact length
   (b) its length with no more than a metre error

(c) its length with no more than a centimetre error
(d) its length with no more than a millimetre error.

4. A person interested in finding the average weight of a nail found that 100 of these nails weighed 200 grams. From this he concluded that one nail weighed
   (a) exactly ½ gram
   (b) exactly 2 grams
   (c) approximately ½ gram
   (d) approximately 2 grams.
5. Look at figure 1.7.
   (a) How much water is in the cylinder?
   (b) How much more water would have to be put into the cylinder to raise the level by one scale mark?
   (c) How much water would have to be added to raise the level to the highest scale mark?

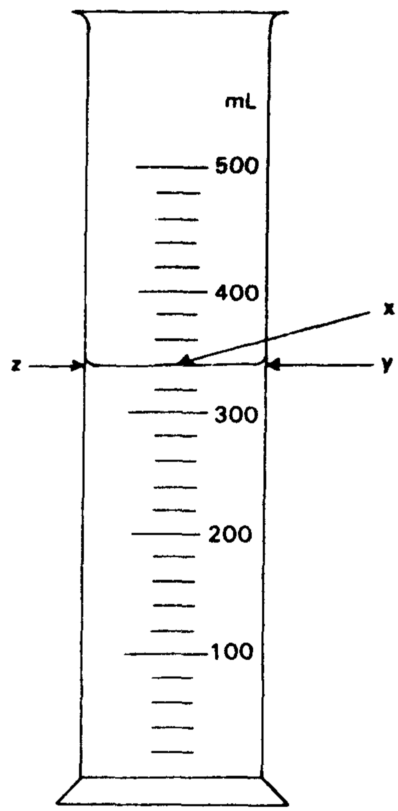

Figure 1.7

2
SEPARATING MIXTURES

Questions this chapter answers

1. *Where is a filter commonly used in the home?*
2. *How can alluvial gold be separated when it is found mixed with sand and gravel?*
3. *How does the cream separator used in a dairy work?*
4. *The salt we use generally comes from sea water. How is it separated?*
5. *How is petrol separated from crude oil at the refinery?*

Problems for you to solve

1. What are some of the utensils and tools used for separating mixtures at home?
2. Can you think of some mixtures used in the kitchen that would be impossible to separate?
3. Why do people generally prefer using instant coffee instead of ground coffee beans? Why use ground coffee beans at all?
4. Given some coffee beans, could you make some instant coffee?
5. Are there any pure substances used in the kitchen — that is, substances that are not mixtures of some sort?
6. The human body has a number of filters. Where are they?
7. Can you separate salt from sand?

Natural substances are rarely single pure substances — most natural substances are mixtures.

For example, air is a mixture of different gases and fine dust particles. It also contains living things, such as bacteria. Soil is a mixture of minerals, rock particles, rotting plant material, air and water, bacteria and other living things. Even the water we drink is a mixture, containing gases and solids as well as water.

Throughout history, people have worked to separate mixtures. For example, thousands of years ago copper ores were separated from other rock material so that copper could be extracted. Have you ever seen pictures of people in Indian villages separating grains of wheat from the husks? This is another example of separating a mixture. In Australia this separation is done by a harvesting machine.

This chapter is about some of the methods used to separate mixtures.

Filtration

Filtration is a method of separating solid particles from a liquid or a gas. The separation is made by passing the mixture through a screen fine enough to retain the solids.

The vacuum cleaner uses filtration. It sucks up dust by pumping a current of air through the carpet. The mixture of air and dust is then passed through a filter bag, which collects the dust before the air is pumped back into the room.

The motor car engine contains a number of filters. A car uses petrol, air and oil. Dust or grit in any of these will cause wear in the engine. The petrol is filtered by pumping it through fine gauze. The air filter is generally a circular container on top of the engine. The engine sucks in air through a sheet of paper or layers of wire mesh in the air filter. The oil, which lubricates the moving parts of the engine, is filtered by circulation through a gauze. Periodically, all these filters are either cleaned or replaced.

Most town and city water supplies are filtered by passing the water through beds of sand and gravel. Figure 2.1 is a diagram showing a small filter of this type, which could also be used to filter the water of a swimming pool.

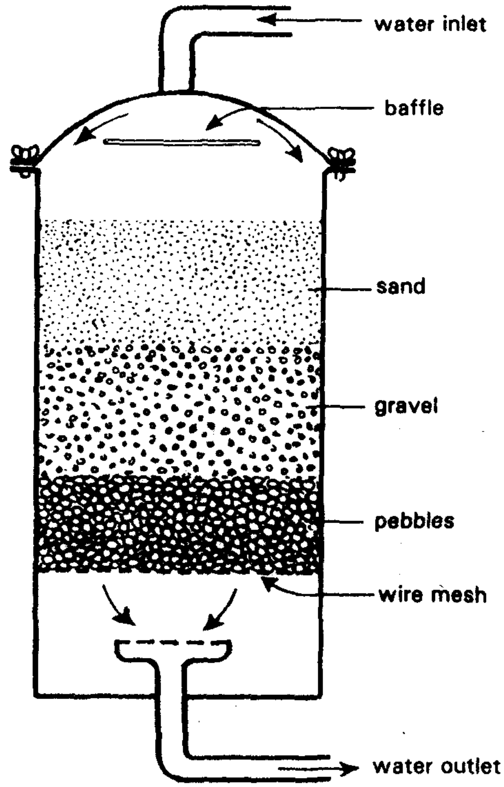

Figure 2.1: A filter. The sand is the actual filter; the gravel and pebbles support it. Periodically the mud that has collected is flushed out of the sand by reversing the flow of the water for a short time.

Gravity separation of mixtures

This is another method that can be used to separate some mixtures. For example, how can we recover clean sand from a mixture of sand and dirt?

To show how this may be done, a small quantity of such a mixture is placed in a screw-top jar. Some water is added, the top is screwed on and the mixture shaken. When the jar has stood for a short time, we observe that the sand particles, which are heavier, have settled to the bottom, while most of the soil remains suspended in the water. This suspension of soil particles is poured off into a beaker. More water is added to the jar and the process is repeated. The jar then contains mostly sand and the beaker mostly soil in suspension. The sand may then be emptied out of the jar and dried in the air.

This sort of gravity separation occurs in nature — for example, on some beaches. Valuable heavier minerals, such as rutile, become concentrated in particular parts of the beach as the receding waves carry back with them the lighter sand and shells, leaving the heavier particles behind. The same process is used in mining rutile. The mixture of sand and rutile is washed through a series of shallow dishes. The rutile settles to the bottom of the dishes, while the lighter sand particles are washed away.

Panning for alluvial gold in sandy streams is a method that depends on gravity separation. As the sand and gravel mixture is swirled around with water in the pan, the heavy particles of gold tend to trail behind.

Separating by centrifuging

Gravity separation may be speeded up by using a centrifuge. Figure 2.2 is a sketch of a centrifuge.

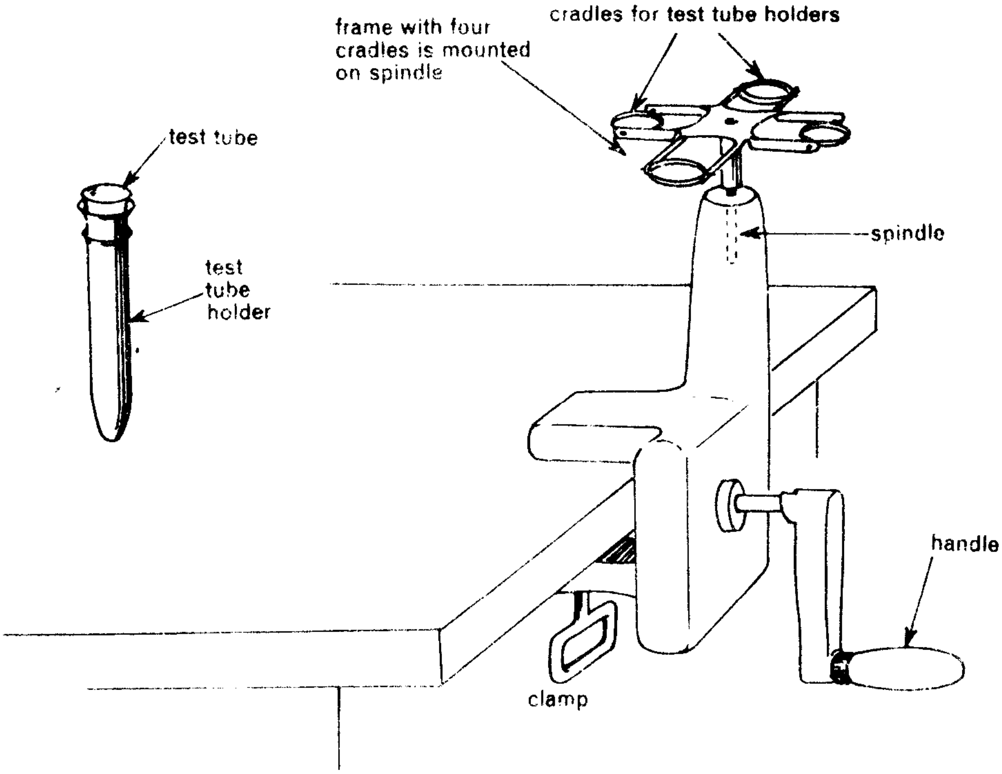

Figure 2.2: The centrifuge. The spindle turns about twenty times for each turn of the handle. The holders, which hang vertically when the centrifuge is not in use, are practically horizontal when the handle is turned.

As an example, let us compare the times taken for a white powder to settle out in water

(a) when it is centrifuged, and
(b) when it is left to stand.

The white powder used is barium sulphate. It is made by adding some dilute sulphuric acid to a solution of barium chloride in a test tube. Because barium sulphate is insoluble in water it is called a ***precipitate***. Part of the solution with the precipitate in it is centrifuged for about half a minute. The white precipitate completely settles to the bottom in this time. The rest of the precipitate, in the solution that has been left to stand, takes at least half an hour to settle out.

Fresh milk is usually centrifuged before being bottled to separate most of the cream. You have probably noticed some cream as a layer on top of the milk delivered to your home. Let us centrifuge some milk to see if this speeds up the rate at which the cream separates out.

First, up-end a bottle of milk several times to thoroughly disperse the cream in it. One sample of this milk is centrifuged for about five minutes. A thin layer of cream forms on the top of this sample. Another sample is allowed to stand. It shows no sign of separation after five minutes. At least half an hour must elapse before a thin layer of cream forms.

Separation by flotation

To illustrate this method we shall separate a mixture of red lead and sand. About 1 gram of red lead is mixed with 20 grams of sand and placed in a small measuring cylinder.

About 50 millilitres of water and 20 millilitres of kerosene are added and the mixture is shaken vigorously. Most of the red lead is carried to the top of the vessel by the kerosene froth. This is called froth flotation and is widely used to separate metallic minerals from unwanted rock material. In the industrial process the finely crushed ore is mixed with water and a small amount of special oil. When air is blown through this mixture, the froth from the oil carries the valuable minerals to the top. Separation occurs because the oil is able to thoroughly wet the mineral, which sticks to it and floats with it to the surface.

Evaporation to recover a dissolved solid

Sea water contains dissolved solids. These may be recovered by evaporation of the water in which they are dissolved. Some sea water is poured into a clock glass set on a beaker of boiling water. The water is kept at the boil so that steam from it will heat the sea water and cause it to evaporate. After some time, only a thin layer of white powder remains in the clock glass. This powder is a mixture of sodium chloride (a white solid) and other substances. Sodium chloride is common salt.

In Whyalla, South Australia, common salt is separated out from sea water by evaporating water from shallow ponds. The energy needed to evaporate the water comes from the sun's rays. Figure 2.3 shows this solar salt works, from which 65 000 tonnes of salt are crystallized each year. Figure 2.4 shows the loading of some of this salt at Whyalla wharves.

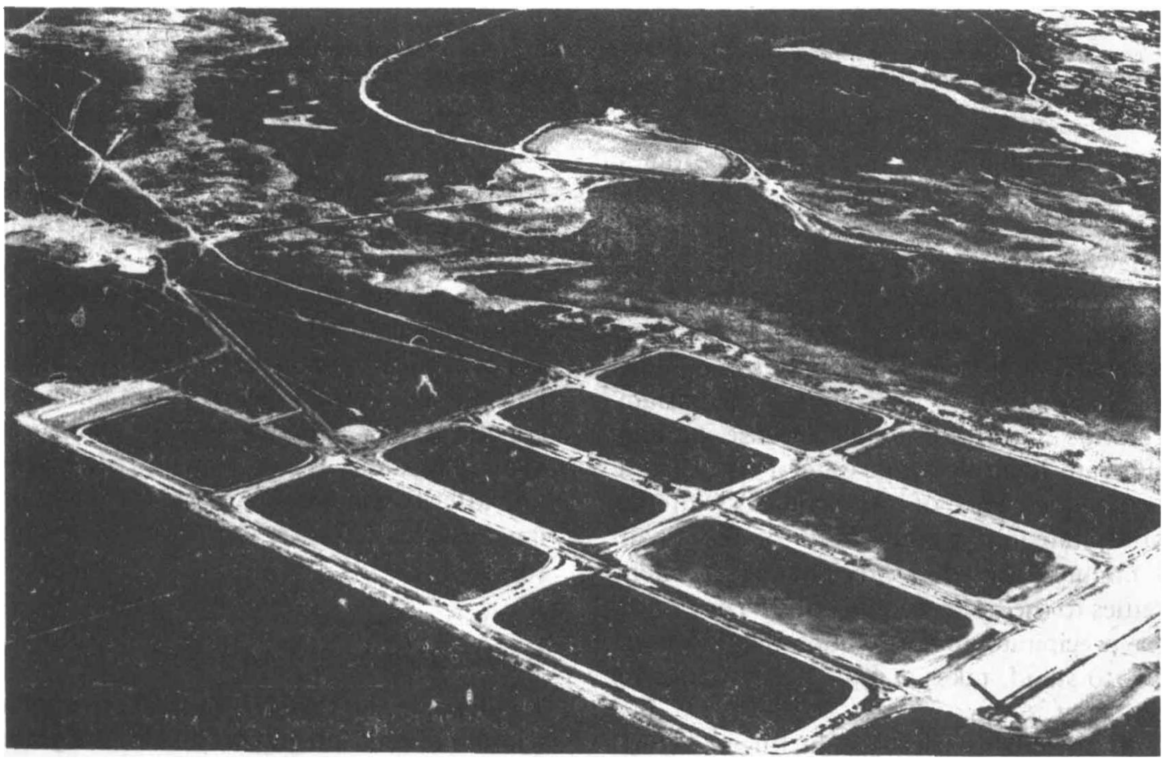

***Figure 2.3:** Solar salt works at Whyalla, South Australia. Nine crystallizing ponds stand out starkly from the sand, mulga, salt bush and coastal lagoons. (Photo courtesy B.H.P. Ltd)*