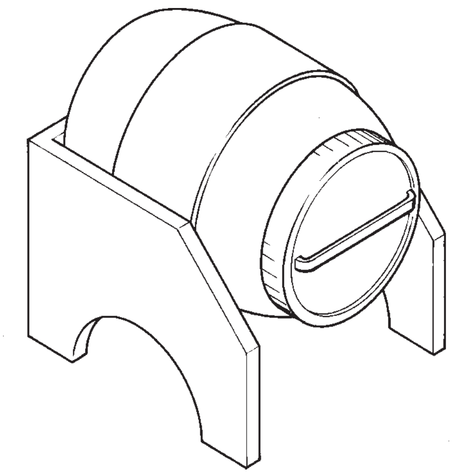
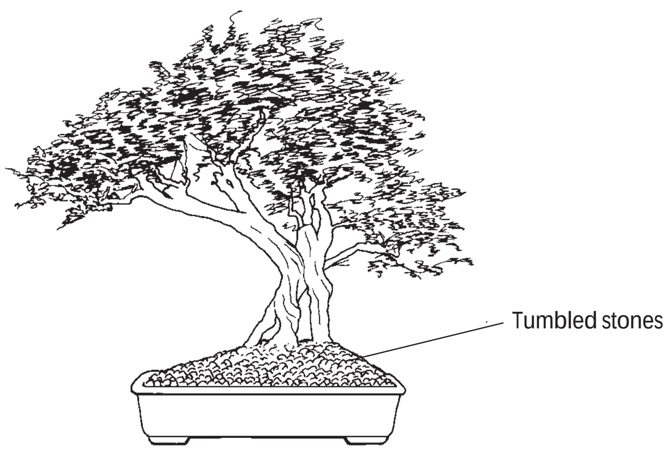
DESIGNING AND MAKING
A STONE TUMBLING MACHINE

In several industries, small component parts are tumbled in a machine either to get rid of rough edges etc. or to polish them. The tumbling machines usually consist of a slow-turning drum which is filled with the parts for finishing. As the drum turns, the parts tumble and rub against each other. Sometimes an abrasive powder is added to speed up the operation. For polishing things, granules of softer material together with a polishing compound can be added.



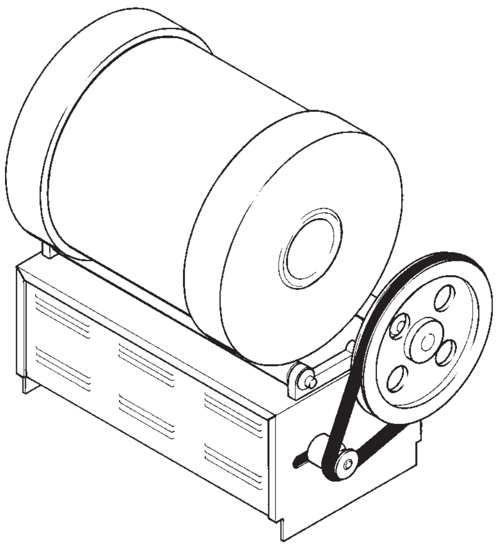
The same process is used for smoothing and polishing stones used in jewellery or for other decorative purposes. Practically any stone can be transformed into a smooth and fascinating object if it is tumbled with other stones and abrasive powder for long enough. This has become an interesting hobby for many people as well as a large industry for “New Age” shops which sell polished stones and gardening centres which sell tumbled stones for display etc.



TUMBLING MACHINES

Most tumbling machines consist of a drum to hold the contents and a motor drive unit that turns it at the correct speed over a period of time. Because the operation is noisy, most industrial tumblers also have an acoustic hood which fits over them to reduce the noise.

Small tumbling machines usually have a removeable drum that sits on rollers connected to the motor unit. This means that different drums can be lifted off and changed very easily. The machines do have to be robust and hard-wearing because the tumbling operation can take many hours.



DESIGNING AND MAKING A STONE TUMBLING MACHINE

Designing and making an inexpensive tumbling machine is not very difficult. However, it does mean solving some of the problems that engineers face when working on larger machines.

YOUR TASK

DESIGN BRIEF

Design and make a tumbling machine for smoothing and polishing up to 500 grams of stones at a time. (As a guide to stone size, aim for those that will pass through a hole 20mm in diameter.) The machine must be able to take different drums which should turn at speeds of between 60 r.p.m. to 80 r.p.m. The machine should be portable and battery powered.

DESCRIBING YOUR TASK

DESIGN SPECIFICATION

First, you need to describe in detail what the product will be like, what it will do and who will use it. This is called a **design specification** and will guide your design work and help you judge how well the outcome works.

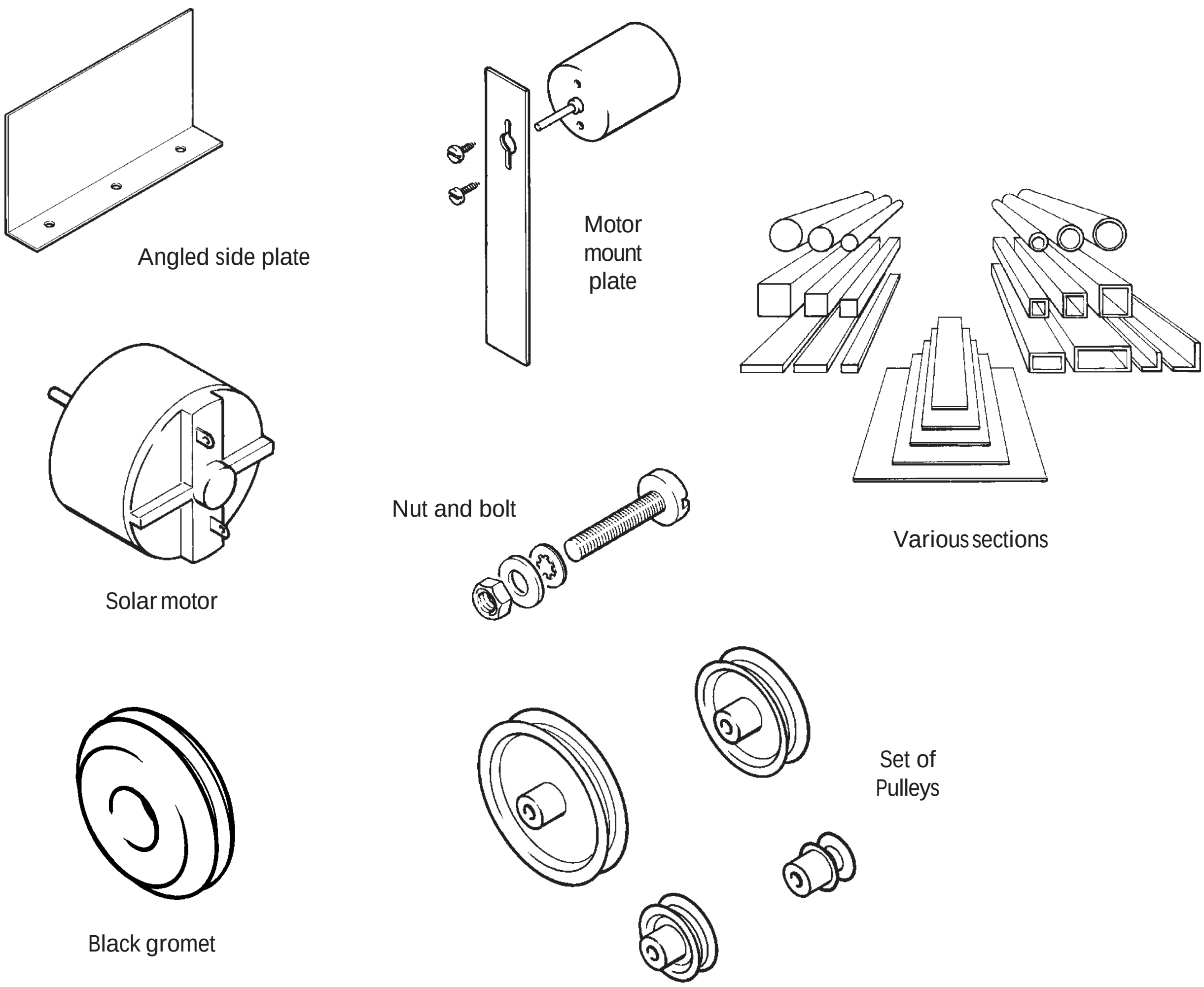
Here are some questions to help you with your design specification:

- *Who will use the tumbler?*
- *What size should it be?*
- *What should it cost?*
- *What power supply will it use?*

MATERIALS AND COMPONENTS PROVIDED

DESIGN CONSTRAINTS

Before you get on with your design work you need to know what materials and components are available. Your teacher will provide you with some of the items shown below. Make a note of what is available and what you think you can supply.



WORKING OUT YOUR DESIGN

When you know what materials and components are available for the tumbler, you need to think in more detail about the design:

- *Set your ideas down on paper.*
- *Experiment with your ideas.*
- *Check your ideas against your specification.*
- *Decide which is the best design.*
- *Do a detailed drawing of the design.*
- *You need to end up with a working drawing which you or somebody else can use to mark out, make and assemble the parts. It will be a good idea to draw your design full size.*

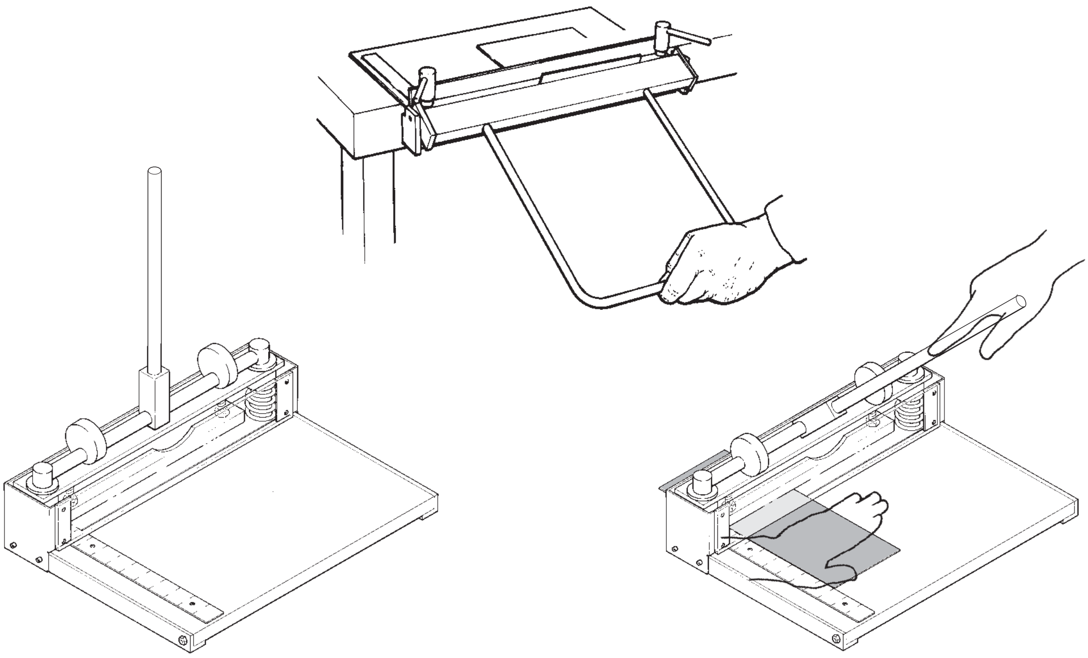
NOTE

See Study File 2 (Communication)

The following notes will give you some ideas about how the tumbler could be designed and made. They do not give you an answer though ! You must make the important decisions and put all the 'ingredients' together so that you end up with a working product.

WHAT WILL THE FRAME OF THE TUMBLER LOOK LIKE ?

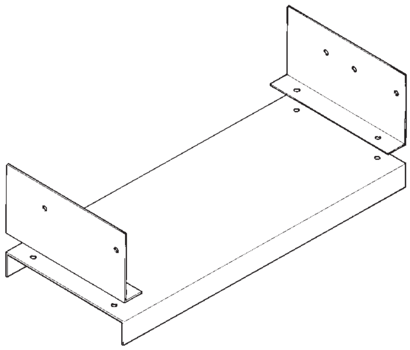
Commercial tumbling machines often use metal parts - pressed or folded into shape. This can be done for a small tumbling machine using a guillotine to cut aluminium sheet up to 1mm thick and a folding unit for producing up to 90° bends.



The basic framework for a tumbling machine with two shafts could be made using a flat base plate, folded to give stiffness, and two end plates. (End plates can be bought ready formed.)

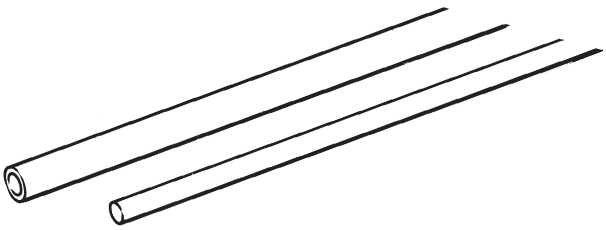
NOTE

See TEP Teaching Resources

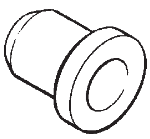


HOW WILL THE SHAFTS BE MOUNTED ?

You need first to choose the material for the shafts on which the driving wheels or tyres are mounted. This might be solid rod or tubing. The shafts must run smoothly in bearings, and these must resist wear over long periods of use. There are several option for bearings - remembering that one of the shafts must be driven by a motor.



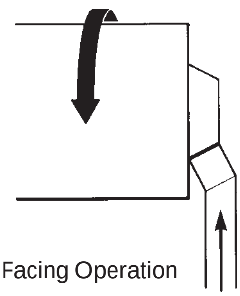
Plain Bearing Bushes
Plastic or metal bearing bushes can be bought - or they can be made using brass.



NOTE

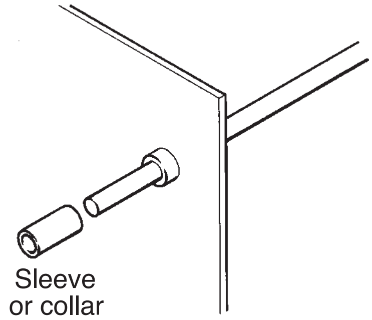
TEP 3mm bore plain plastic bearing bushes are suitable if well lubricated.

If they are made, the brass is drilled and turned down to size on a lathe. All machining is completed before the bearing is taken out of the chuck.

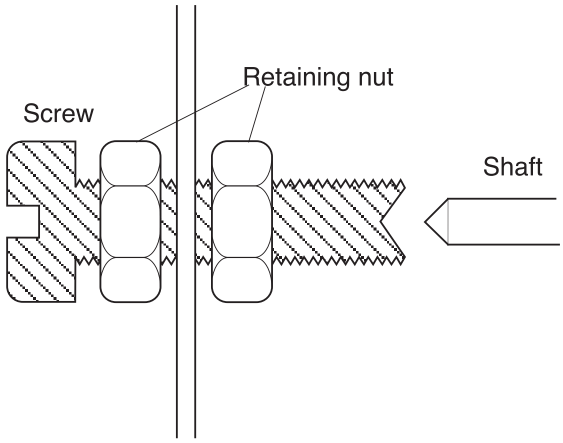


Facing Operation

A light sleeve or collar has to be added to the shafts to prevent end float.

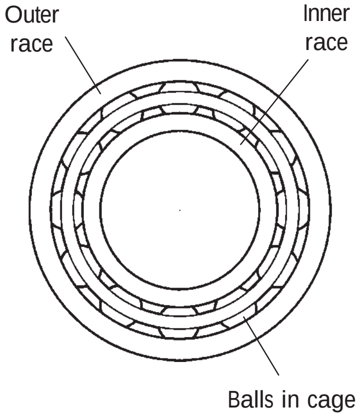


Point Contact Bearings
This type of bearing is often used for light loads and has the advantage that it is adjustable. The shaft ends, if solid, are turned in a lathe to a tapered point. A brass screw, for example, is then drilled with a pilot drill to make a corresponding tapered hole. The screw can be mounted using two nuts and can be adjusted backwards and forwards.



This type of bearing eliminates any **end float -** i.e. the roller moving backwards or forwards along its axis.

Ball Bearing Races
This is the most expensive option but probably the best. Ball bearing races with a flange can be force- fitted into a hole. A safe way of making larger holes in sheet metal is to create a pilot hole (e.g. by punching) and then opening it out with a tapered reamer.

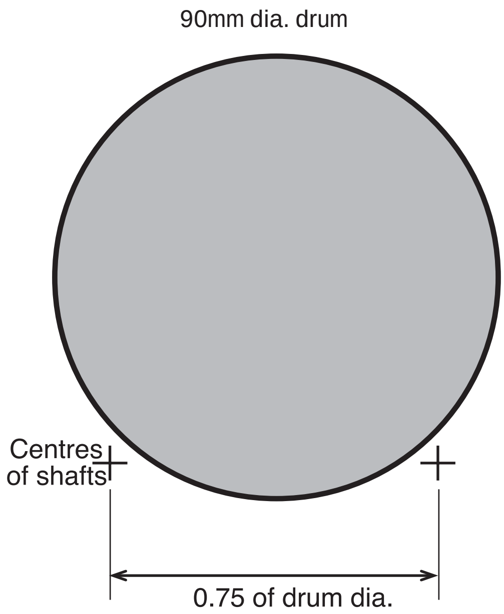


A shaft can be made to fit tightly into the centre of the bearing race to stop **end float**.

QUALITY CHECK

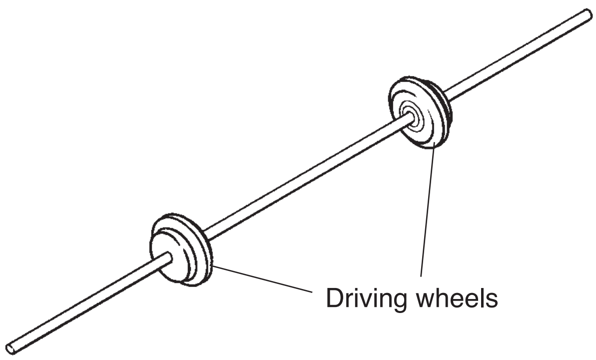
NOTE: The spacing between the shafts is important. If it is too wide, a heavy drum will tend to drop between and force them apart. As a guide, the distance between centres is 0.25 of a drum's circumference.

MATHS OPPORTUNITY



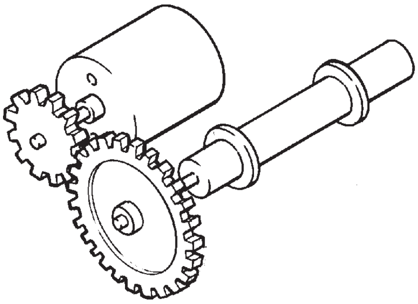
To work out the circumference, measure the diameter and multiply by pi (3.142). E.g. for a 90mm diameter drum the distance between centres is:

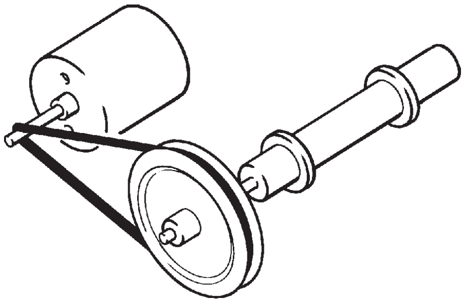
90 x 3.142 x 0.25 = 70 mm (approx.)



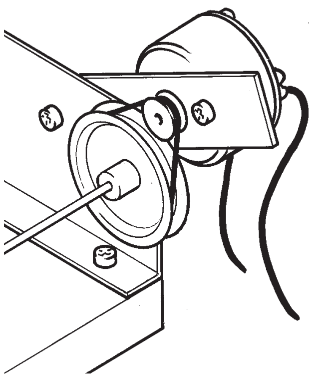
HOW WILL AT LEAST ONE OF THE SHAFTS BE DRIVEN ?

The tumbler will work if only one shaft is driven. This can be connected to a motor using either a pulley drive or gear drive. There are pros and cons for both. A gear drive requires more precision in setting it up but is very positive. The Pulley drive is quieter and simple but the belt may slip. (This can also be an advantage because if something seizes up, the belt can slip and avoid damage.)





Whatever method is chosen, the motor can be mounted on a swinging arm so that it can be precisely positioned for meshing gears or adjusted for pulley belt tension.



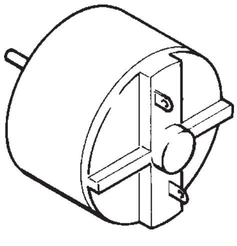
NOTE

This method also accommodates possible lack of accuracy.

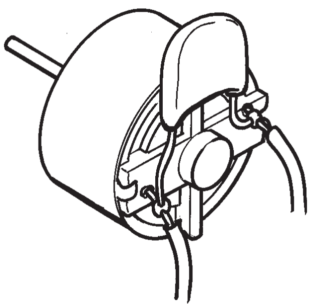
The choice of motor is important. Very cheap low-voltage motors have a limited life. **Solar motors** are more expensive but will last longer and consume less battery energy. (All motors can be given a longer life by connecting a suppression capacitor across the supply near the motor. This reduces arcing at the motor brushes and also helps reduce electrical interference.)

NOTE

Solar motors were used in trialling and proved to be ideal.

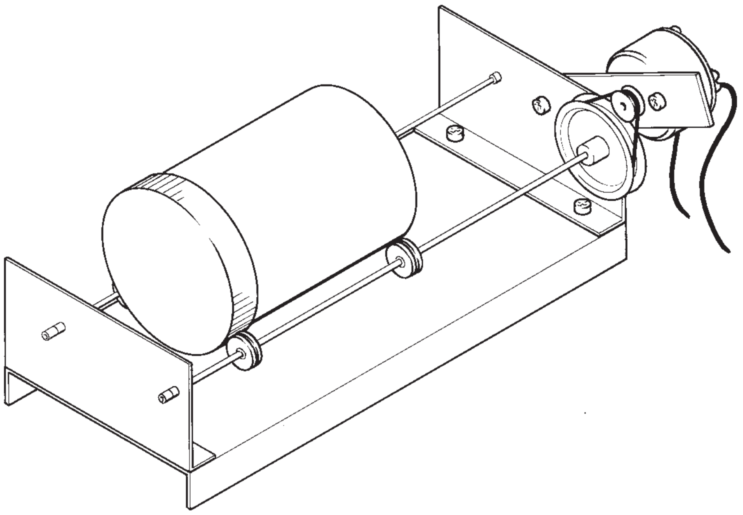


Solar motor



The brief asks you to make the tumbler work within certain speed limits. The speed of the drum (without anything in it) depends on:

- The speed of the motor.
- The gear or pulley ratio.
- The diameter of the shaft wheel or tyre that the drum rests on.



The following are example calculations for a pulley drive and a gear drive. Motor speed quoted in catalogues is for “no load” - e.g. 3000 r.p.m. - when the motor just runs freely. As soon as you make it do work by rotating the loaded drum and overcoming friction in the pulley drive or gears, it slows down. To allow for this, we **derate** the motor speed or assume it will be running slower. For the example calculations, we will assume the motor runs at only 0.8 of the quoted speed.

MATHS OPPORTUNITY

Calculation for a pulley drive

Motor speed = 3,000 r.p.m. × 0.8 = 2,400 r.p.m.

Assume a 5mm diameter pulley driving a 35mm diameter pulley.

Assume a 100mm diameter drum resting on a 14mm diameter shaft wheel.

Step 1.

$$\text{Speed of roller} = \frac{\text{Small pulley diam.}}{\text{Large pulley diam.}} \times \text{motor speed}$$

$$\text{Speed of roller} = \frac{5\text{mm} \times 2{,}400 \text{ r.p.m}}{35\text{mm}} = \mathbf{343 \text{ r.p.m.}}$$

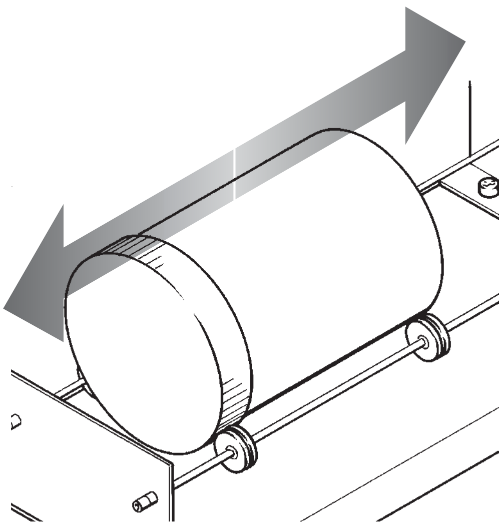
Step 2.

$$\text{Speed of drum} = \frac{\text{shaft wheel diam.}}{\text{Drum diameter}} \times \text{shaft speed}$$

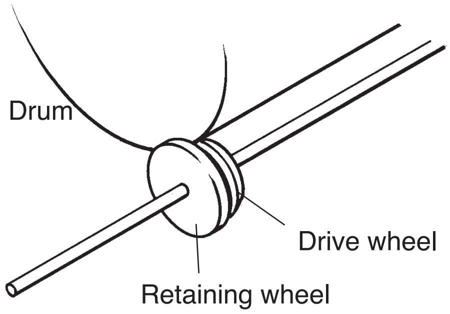
$$\text{Speed of drum} = \frac{14\text{mm} \times 343 \text{ r.p.m.}}{100\text{mm}} = \mathbf{40 \text{ r.p.m.}} \text{ (approx.)}$$

HOW WILL YOU STOP THE DRUM MOVING FROM END TO END OVER THE SHAFT WHEELS ?

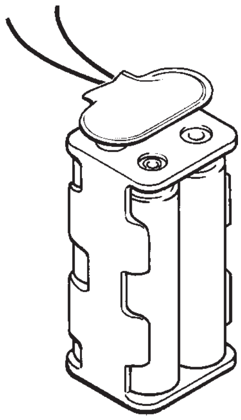
The drum is free to gradually move over the wheels and hit either end of the frame. There are several solutions to this problem. The wheels might be given a special profile - e.g. the type of flange that keeps locomotive and carriage wheels on the track. The frame could be given a slight tilt so that only one flanged wheel is necessary.



A slightly larger diameter wheel could be placed to one side of the carrying wheel to prevent movement.



POWER SUPPLIES



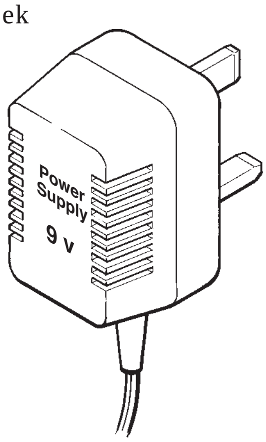
Batteries are rated for energy capacity in ampere hours (Ah). A 1Ah battery means that it can supply a current of IA for 1 hour or 0.5A for 2 hours - and so on. Four "C" size alkaline batteries connected in series to give 6v have an approximate capacity of 2Ah. A solar motor uses very little battery energy - even powering a tumbler with a full 500 gram load. If the tumbler requires 0.1A (a realistic figure) then the batteries will last for about 20 hours.

NOTE

Data derived from actual trialling.

Rechargeable batteries are a cheaper option in the longer term and provide an almost constant voltage until they are discharged. However, they must be used with great care because they can get very hot if short circuited. **If rechargeable batteries are used for the tumbler, a suitable fuse should be connected in the circuit.**

As an alternative to batteries, you can seek advice on low voltage power supplies from your teacher.



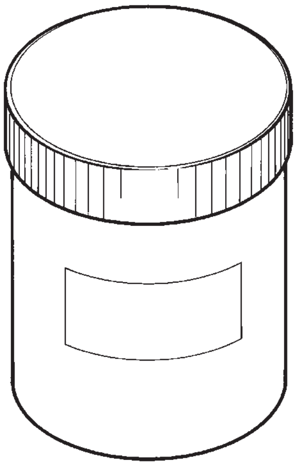
All low voltage power supplies have a maximum output rating. You must therefore measure the current consumption of the tumbler using a battery and meter. (The drum should be full for this test because the greater the load in the drum the harder the motor has to work and the greater the current consumption.)

PUTTING IT ALL TOGETHER

If all the parts have been marked out and cut out accurately, it should be easy to assemble the parts of the tumbler. Remember to lubricate the bearings before testing.

QUALITY CHECK

Find a suitable drum. This might be any discarded cylindrical container with a screw lid. Polythene containers can be bought in most foodshops and supermarkets.



EVALUATING YOUR TUMBLING MACHINE

EVALUATION

To evaluate the success of your machine, you must ask whether it meets your specification. You need to carry out several tests to find out:

- When the drum is fully loaded, does it turn ? If nothing happens, check the motor wiring.
- Does the motor try to run but not turn the drum ? Remove the drum and see if the driving roller turns. If “yes”, check to see if the pulley belt (if used) is slipping and that the rollers turn freely in their bearings.
- Does the drum turn too rapidly or too slowly ? Check your calculations and the gear/pulley ratio and the size of the driving wheels. If there is a serious problem, you could try using a larger or smaller diameter drum !

NOTE: Ideally you should use different grades of carborundum grit in the tumbler with a small amount of water. The stones are first tumbled with coarse grit and then finer grit. If this is not available, use torn up pieces of wet and dry paper which has a covering of grit. For final tumbling, you can use abrasive household cleaner such as “Vim” instead of fine carborundum.