Walter Kraul

Earth, Water, Fire and Air

Playful Explorations in the Four Elements

Floris Books

Translated by Donald Maclean

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Contents

Introduction

Children are drawn instinctively to play with water, air, fire and earth, and given the chance will play imaginatively for hours with these elements. The purpose of this book is to show how this can be encouraged and developed. It is written more for parents and teachers than for the children themselves. The best activities are those in which the child comes into direct contact with earth, water and air, but sometimes it is a toy — preferably home-made — which brings the child into such contact. The construction of some of these toys is described, though not in too great detail.

Some of the simplest toys are suitable for a three-year-old, while others are highly complicated apparatus which will only work properly after patient trial. No special indications are given as to which toy is suitable for which age: this has to be found individually.

The first encounters with the elements will be simple, but as children grow their scope and skill will increase. Older children will play with younger ones, the older ones perhaps constructing something for the younger ones to play with. Mothers and fathers can play with the children or simply watch. It may be that adults will themselves play, for the elements allow serious people to become children again. While this book is not directed at a particular age, some play-activities can be dangerous where the elements are strong, so that adult supervision is necessary.

Playing with water

Splashing about with their hands and feet children first experience the watery element. This does not always please adults of course — when children play with water they get wet; that cannot be helped, and the fun is clearly worth it. No real harm is likely to result if they are properly dried afterwards and do not play too long in very cold water. After paddling and splashing about they may start throwing stones into the water to make it splash; to get flat pebbles to skim is more of an art. When children have a bath they like to take all sorts of floating objects in with them. They submerge them and let them shoot up again.

And then there is the fountain! This is something very special where water is gushing up day and night, surely something can be done here! A bit more difficult to master is the garden hose, but it is a great attraction and lends itself to all kinds of nonsense. However, the ideal place for playing with water is the bubbling brook. It must not be so deep, wide or fast-flowing as to be dangerous, a little harmless brook is best. Round about, there are plenty of things to play with: sand, pebbles, mud, sticks and even bits of wood borne down by the stream. Here children can play for hours without any other toys. You may be surprised to find how many such places still exist, even some with clean water — for pollution usually only occurs lower down once the brook has become a river, or a lake or has flowed into the sea. Here there is too much water for children's activities; not only is it safer, but they want a place where the water is gentle enough to be controlled by the children themselves.

After a time even the best game with water and its surroundings has been played out. But it can be renewed with a little home-made toy. If you are on holiday with a stream nearby there are all sorts of things you can make. Of course it should be mentioned that water *can* be dangerous even where there is only a little of it. Remember that people *have* fallen so awkwardly that they have drowned in a puddle. Therefore it is recommended that an adult should always supervise water-play.

Building dams and channels

Children know instinctively how to play with water. Quite without adult instigation they will begin to build a dam in a watercourse and make a pond. They break open the dam and with great joy watch the water flooding out. Then they divert the flow into another channel. The water becomes muddy and then it clears by itself. It makes interesting swirls and whorls. Little bits of wood float down as boats, the stream has to be changed so that the boats do not get stuck. Harbours are built above and below the works. All too soon evening comes and play has to come to an end, with children dirty, wet and happy.

Once I saw a man in the high mountains playing with the icy water in this fashion. When I spoke to this serious-looking gentleman he told me he was really only playing, he was on holiday. He was a secondary school-teacher. Age is no barrier to the joy of playing with water, thank goodness.

If you cannot easily find such a paradise for playing, something like it can be constructed in the sand-pit: water can be brought in a pail and poured it down the channel which the child has made.

Occasionally one finds public playgrounds with splendid facilities for creative play, such as a hand-pump to pump up water on to a sloping plank, plenty of sand in the sand-pit which can be taken to build dams, gutters to catch all the water and lead it on to the next plank, and so on to a third plank. Any of these ideas can be adapted for the smaller sand-pit.

early engineers
let them build as much as
they can.

Gutters and pipes

Another game with water is to let it flow in wooden gutters. This can be done in any sand-pit. A heap of gravel, a partially dried out river bed, or even a sloping field will also make a good basis. The gutters can be either V-shaped or U-shaped and are made from strips of wood. They should be set up so that they make a proper conduit with little water-falls. To control the flow the gradient of the gutters is adjusted by resting them on forked sticks stuck into the ground at the required height, or by using stones as chocks (see Figure 1). Children will pour water in at the top and enjoy watching it running down along the channels. Adjustments have to be made, and that is all part of the game, as are alterations and extensions. An adult can also make wooden supports to carry the conduit like a ball-run or helter-skelter. These should be movable. If the conduit is mounted too fixedly the game is limited to pouring water in at the top and watching it, but that is inadequate.

Such conduits were often built in real life. The Romans used stones for building their aqueducts whose remains we still admire. Only later did people learn to

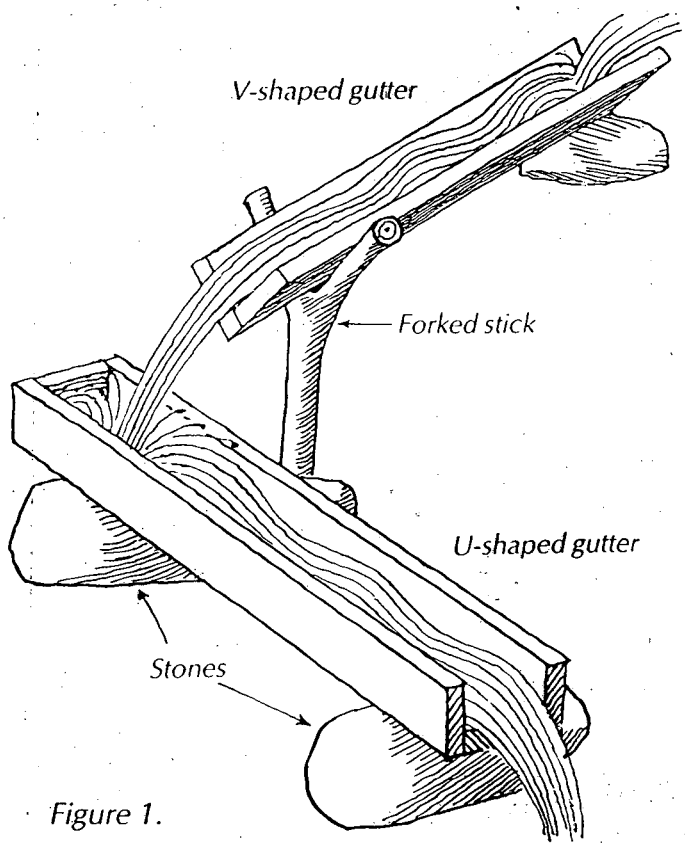


Figure 1.

make pipes by boring out tree-trunks, for example, piping for spa water. Children can do that too in their play: they can pipe water through a heap of sand, through a 'mountain'. Small pieces of piping are easily available. It does not

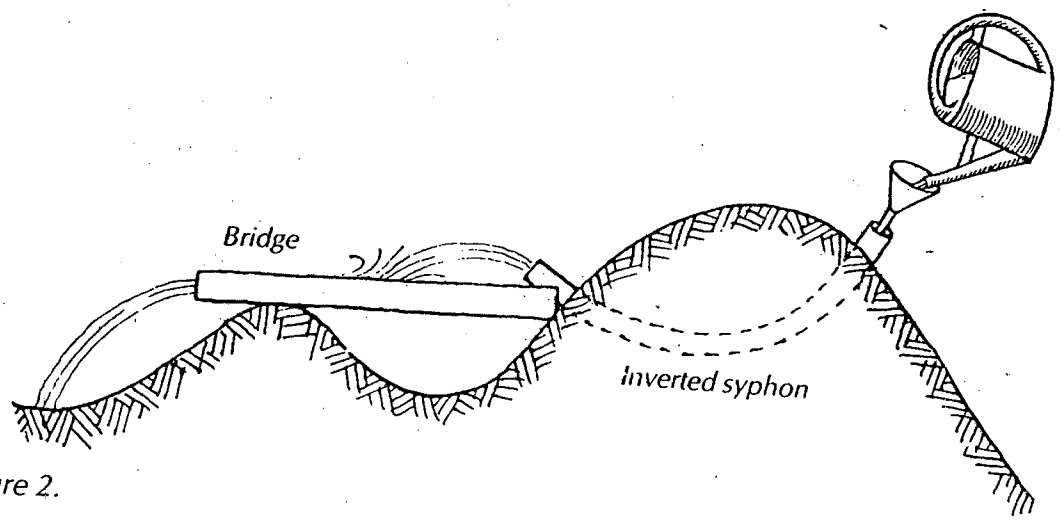


Figure 2.

matter what it is made of; iron, copper, plastic or rubber tubing. Indeed if the pipe is bendable you can make the water flow uphill, once it has gone downhill far enough. The place where it flows out must be lower than the place where it flows in, that is the secret. Civil engineers do this with rivers and call the construction an inverted syphon: an upside-down 'bridge' where the road is not taken over the river, but the river is taken under the level road. Civil engineers also build bridges to carry water. Children can do that too (Figure 2).

If you are clever you can make water flow uphill first and then downhill, this is called a syphon. You need a piece of tubing. There must be no air-lock in it. It must be completely filled with water. Then the flow is started by sucking at the bottom. Once it has started flowing it will go on flowing until the reservoir at the top end has been emptied. In this case too the outflow must lie lower than the inflow (Figure 3). Here rainwater can be used for our ploy if it has been collected in a barrel. There are all sorts of possibilities. Using artificial piping one can also construct water-wheels, and all the wheels turn!

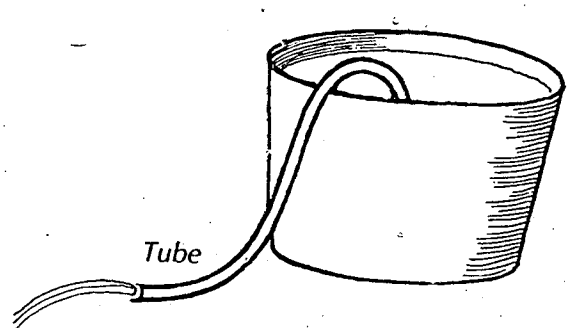


Figure 3.

General remarks about water-wheels

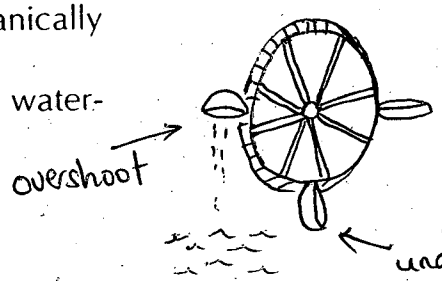
If you are going to make a water-wheel you must take the circumstances into consideration, for these can be very diverse. The fall of water can be steep or gentle. Sometimes there is lots of water available, sometimes only a little. You can construct your water-wheel first and then find a suitable water-flow.

For water with little fall, that is with a weak current, you need a wheel with large paddles: it will turn slowly, but powerfully. The drive is 'undershot' (that is, the water flows under the wheel). The opposite is a little waterfall, a cascade of water, below which the wheel is set. It gets its power from the greater speed and the drive is 'overshot'. There are all kinds of in-between situations. With a moderate fall the water is taken along channels, not just for fun, but to achieve the correct height for the final fall. You can get the wheel to turn by using a garden hose, but you must ensure that the water drains away properly. Of course with the garden hose one may not be harnessing nature power directly as in many flat places tap-water is mechanically pumped up.

It is quite easy to construct a water-wheel. Very simple materials, a little skill, and few tools are required. Do not use glue, but nail it, pin it, and wedge it together. Wood swells in water and so the joints become tight, while glue can sometimes dissolve. A water-wheel which has been allowed to dry out falls to bits quite easily and looks rather derelict. Water-wheels belong in water and should be turning all the time.

The axle of the wheel can lie horizontally, which is the simplest sort, but it can also be vertical, which is harder to build; it is even possible to have the axle lying obliquely. It is important that the wheel should have good bearings. For the horizontal axles you can take a forked branch or suitably shaped stones. Wood does not run so well on wood, it is better to take two different materials, metal and wood or stone. With the vertical axle the bottom of the axle must be pointed and set in a pivot hole. This is called a conical bearing.

I shall now go on to describe examples of water-wheels. Others can be devised. Fortunately water-wheels do not have to be constructed very precisely, they will still work even though they have been clumsily built.



shot - point at which water falls from the cup of the water wheel.

A water-wheel made of box-wood

As well as the wood from a fruit box you will need an axle. A square shaft of wood is suitable for this, then just nail four similar boards on to the sides of the square shaft and hammer in a larger nail at each end as an extension to the axle. For bearings, take suitably forked sticks and drive them into the bed of the stream. Set this simple wheel deep enough to let the current flow undershot and drive the boards round. Another way is to bring a jet of water overshot on to the wheel, in which case the boards should not touch the water below. In the first case the wheel will turn slowly, but in the second it will turn quickly. In either case the wheel needs starting otherwise the wheel can stick midway when no water is catching the boards. This wheel (see Figure 4) can be built in various sizes. The longer the boards the more strongly the wheel will work, because the length increases the leverage. Similarly wide boards catch more water and so increase the power of the wheel.

More boards also increase the power and ensure that the wheel turns smoothly. By planing the edges of the square wooden axle an octagonal piece is formed which makes it possible to build a better wheel, but then there is the difficulty of nailing on the boards, especially the last one. In this case split the axle in half, or even in quarters, nail the boards on and then tie it together again.

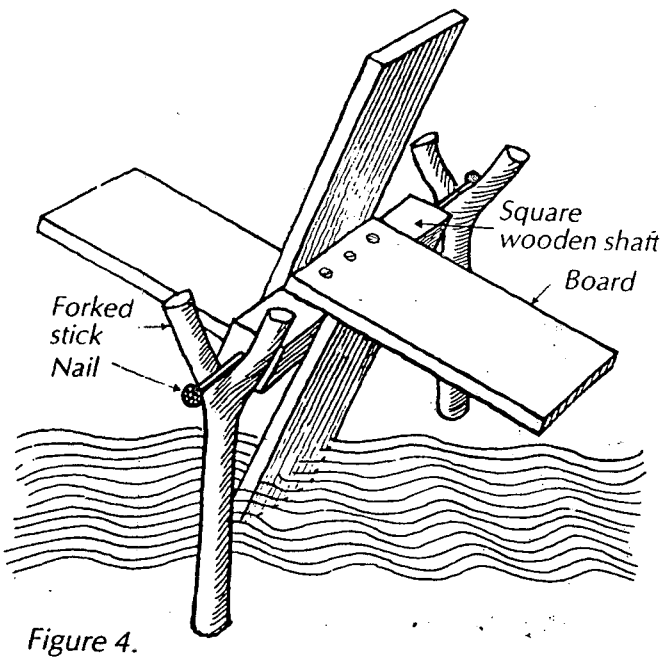


Figure 4.

A water-wheel made of forked twigs

Select at least eight forked sticks with long straight stems. Fix at least six of them into a hub, and use the last two as a bearing. Suitable are willow or alder wands found growing beside water. Both kinds of tree soon grow again so one does no real damage by cutting wands from them. Of course in a conservation area one cannot take them. The size of the wheel can be anything from an inch to three feet (2 cm to 1 m) in diameter, that is, with forked twigs up to 18 inches (50 cm) long.

The hub is a thick log with regularly spaced slits cut in it to take the sharpened forks. For bigger wheels, bore holes instead of cutting slits. For paddles, fix boards or pieces of tin to the forked ends. Leaves or even paper will do for small wheels. The finished wheel should be reasonably balanced, and this should be taken into consideration during construction. Push the last two sticks upright into the bed of the stream as bearings. Drive nails into the ends of the axle to run in the bearings or simply taper the axle at the ends (Figure 5).

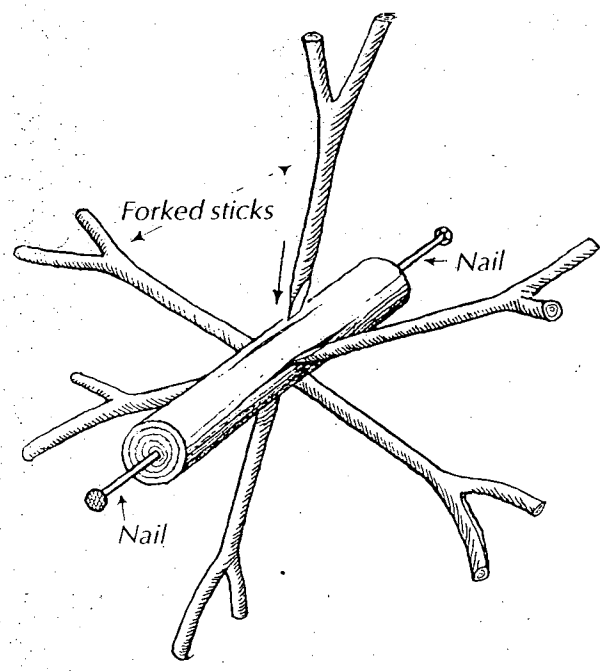


Figure 5. Forked sticks before paddles are fitted.

A wheel of bowls

Water makes particularly beautiful patterns when falling into a vessel. You can fix bowls to an axle. These bowls can be carved out or you can use walnut shells for a small wheel. The problem is how to fix them. The best way is to split willow wands and bore holes in the nutshells. Then tie the nutshells on to the wands (Figure 6). Stick the willow rods into a hub made from a log as described in the last model. Of course you can also use discs with holes in them as a hub. These can be bought in a model-shop.

To drive this kind of wheel a thin jet of water is most suitable. Any tap will give this jet, but it is more fun to make a channel outside as has already been described.

The full-sized wheel is called a 'pelton-wheel'. It is made of metal, is three feet (1 m) or more thick and is driven by a jet as thick as your arm coming from a high reservoir. Unfortunately you cannot watch it in operation as the wheel is enclosed in a housing for safety. But with our kind of wheel you *can* watch it — for hours on end.

Similar wheels, only bigger and with an upright axle, are still to be found for instance in the Balkans. A fairly thin cascade flows against quarter bowls and drives them round. Such a wheel can be copied. The jet has to fall at an angle (Figure 7).

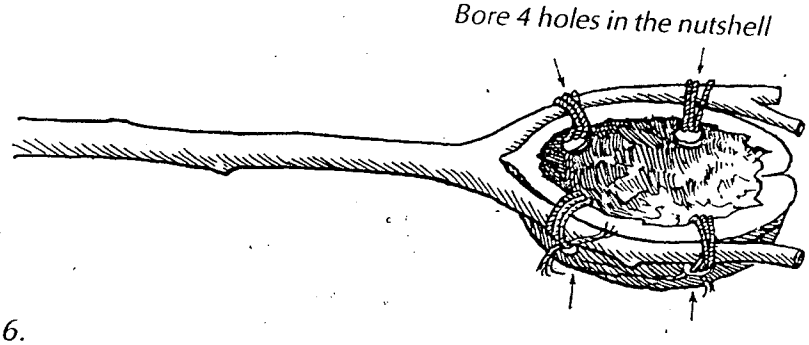


Figure 6.

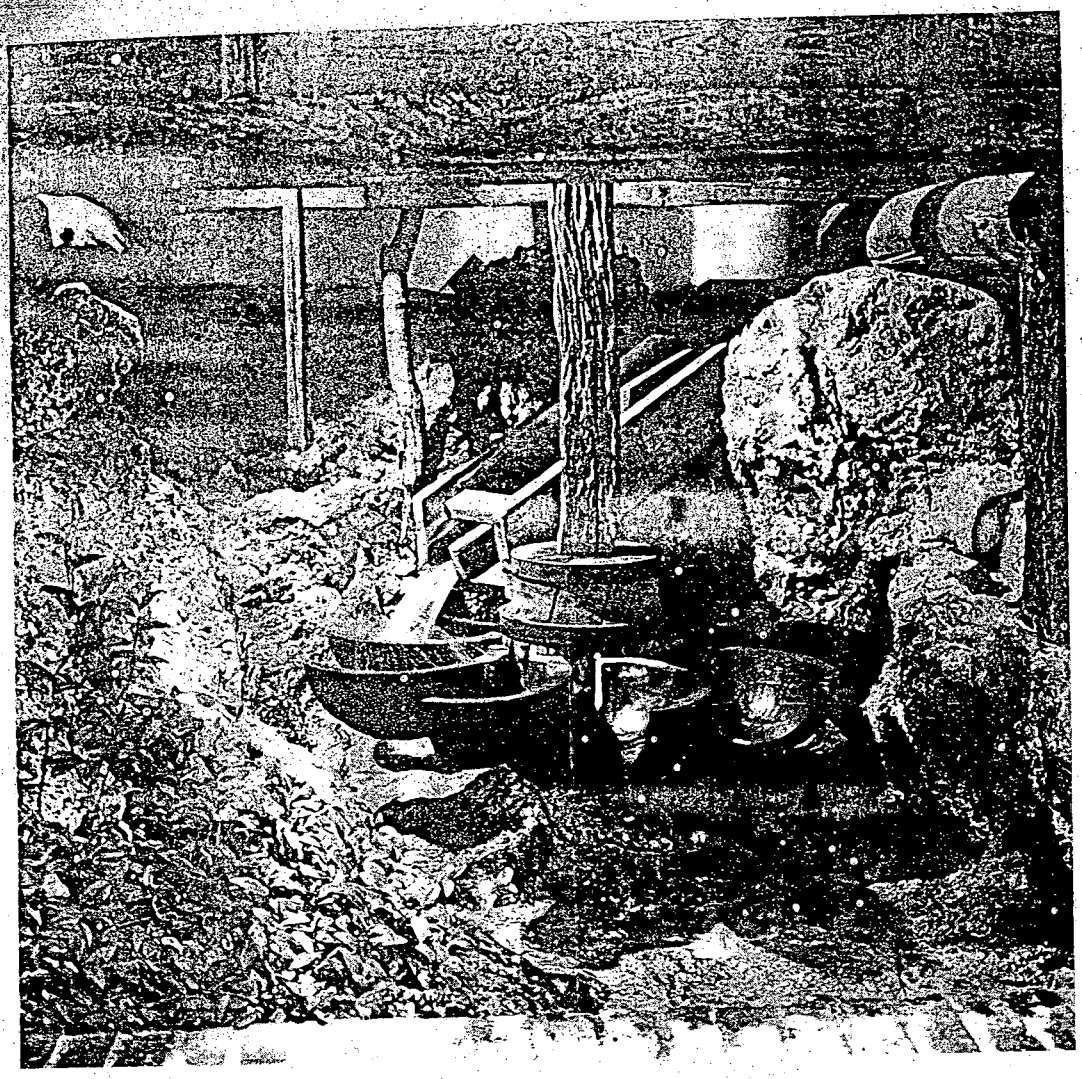


Figure 7. Spoon-wheel of a mill from Romania, 1850.

The wheel with cones

You can also construct a water-wheel using thick paper. Start with a wooden wheel, which can be taken from an old toy, for instance. Make paper cones and fasten them on to the wheel with drawing-pins. Of course this kind of wheel will not take too strong a cascade, nor will it go on working indefinitely, but it will run merrily for a time. If you have tin-snips and the necessary skill you can make the cones from old tins, even soldering them. Then nail the cones on to the rim of the wheel. Such a wheel will last until the axle wears out (Figure 8).

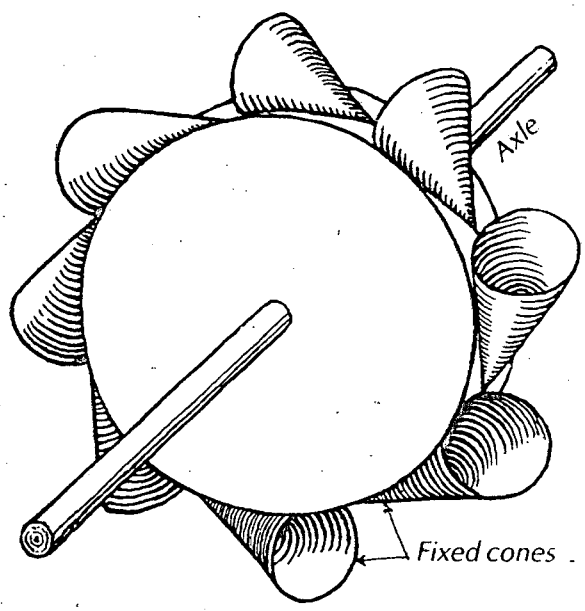


Figure 8.

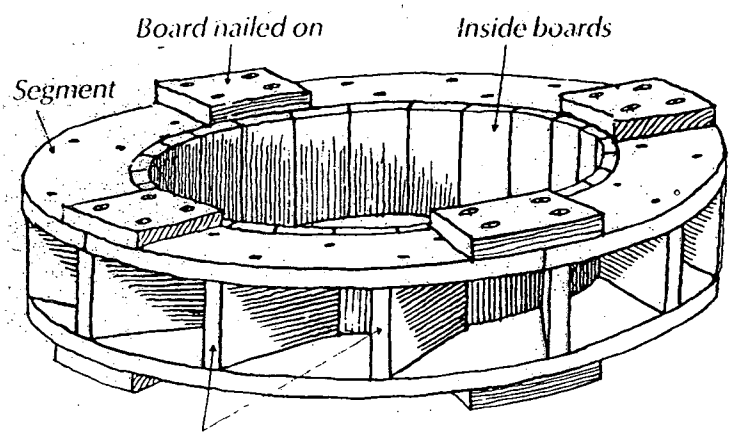


Figure 9.

The water-wheel with compartments

Once the basic principles are understood, it is not really any more difficult to build a larger water-wheel. As models, we can take the real-life wheels which can still be seen in operation in places such as Southern Tyrol. The greatest problem is making the wall-segments of the wheel. These must be cut out from thin boards. Such boards can be obtained from do-it-yourself shops. The ring segments should have an inside radius of about 6 inches (15 cm). Draw the segments on the wood with a pair of compasses. If the compasses will not stretch to the required radius you can use a piece of string. One end is tied to a nail at the centre of the circle. A pencil is tied to the other end of the string. The segments are then cut out with a fretsaw or a band-saw. The number of segments depends on the width of the boards from which they are cut. You will need at least four, but wheels can also be built with more. If you want to do the job professionally the segments will be joined together with tongue and groove, but it is perfectly adequate to join them together by nailing little boards on to them outside (Figure 9). I would recommend zinc nails for this task and for the subsequent joinery.

The two rings must of course be the same size. Between these fix the compartment walls at regular intervals. They must be set at an angle so that the water does not spill out too soon.

The compartments are now closed at the back by boards inside the two rings.

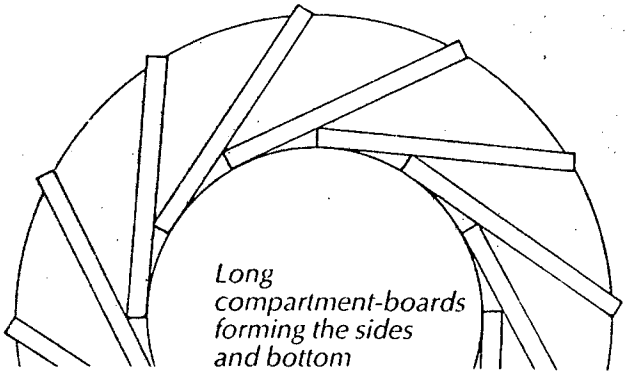


Figure 10. Cross-section.

You can also make the compartment walls so long that they form the bottom of the next compartment (Figure 10).

Fix four 'spokes' right across the wheel in the form of a cross leaving a space in the middle for the axle (see Figure 11). The axle-beam is square and fixed to the wheel by four wedges on each side. This is also done on life-size wheels. This allows the wheel to be set properly and to be removed for repair, and is a very practical arrangement. Thick nails in the axle-beam form the running axle. Of course you can bore a hole in the axle-beam and use screws instead of nails.

Once the wheel is ready it is necessary to construct a mounting for the bearing. Conditions can be so diverse that it is impossible to give any general instructions. Notches cut in two cross-beams are sufficient to make a bearing, but how the cross-beams are held up is left to you.

Such a massive wheel requires a powerful cascade falling into its compartments. You may be lucky to find a little natural waterfall under which the wheel fits, but usually conditions are not so suitable and you will have to build ducts as described at the beginning of the book. The gutters must be supported so that they bring about the necessary fall. This water-wheel works best overshot; that is, with the water coming on to it from above, and the wheel is driven by the weight of the falling water. Such a wheel has power. It should drive something.

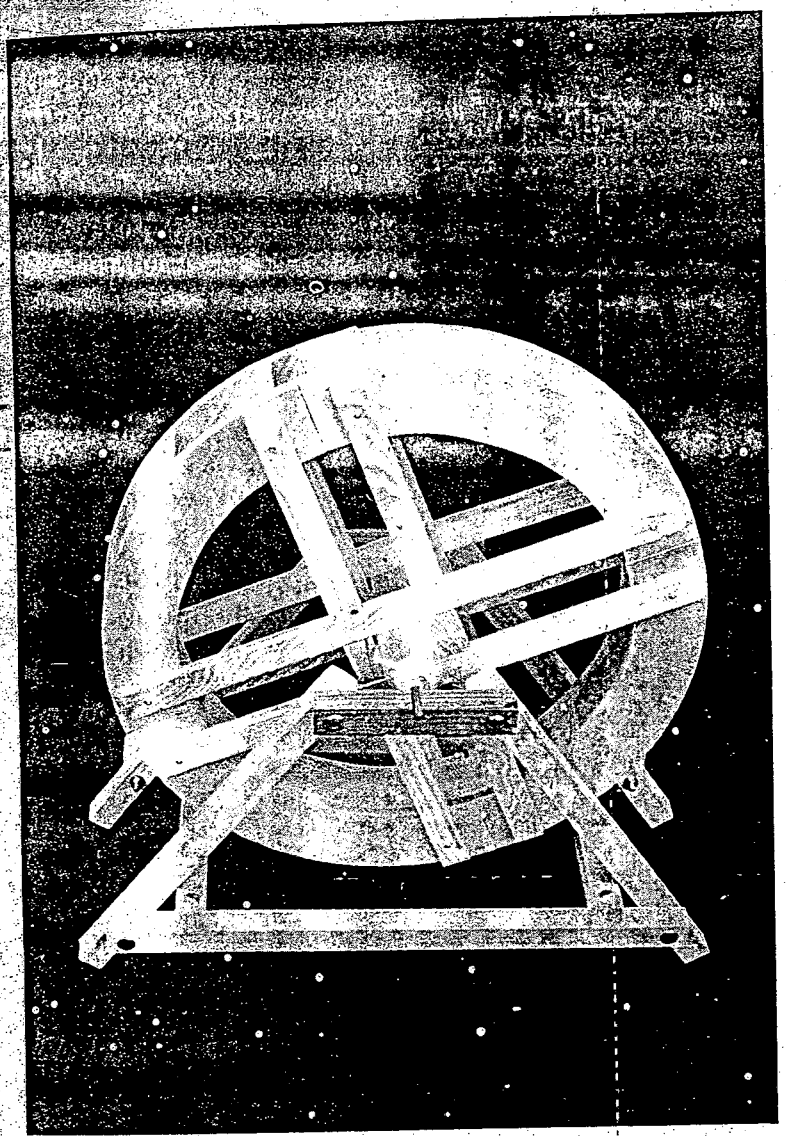


Figure 11.

Making water-wheels work things

Once you have built a water-wheel and got it working you will want to make it drive something. There are all kinds of possibilities, for instance a hammer-works (Figure 12), or a small figure as in Figure 13. You can get the wheel to drive a doll's roundabout and give someone's dolls a ride, or it can drive a great wheel or a cable-railway. Fast-turning wheels can drive a bicycle-dynamo which in turn can light a lamp. You can obtain the necessary speed for the dynamo by 'step-up conversion'; that is, by getting a large wheel to drive a small one. You can take a bicycle wheel and fix it to the water-wheel. The bicycle wheel now drives a belt or cord (in the rim) round a smaller rimmed wheel. Unfortunately it is not easy to obtain a small rimmed wheel in model shops. The little wheel revolves more quickly but it has less power. A 'step down conversion' with more power but less speed is when a little wheel drives a larger one. If the cord or belt slips in the rim rubber bands can be fixed in the rims. Another way is to prolong the axle by joining it to a shaft. A rubber tube over the end of the axle and over the end of the shaft makes the join. The shaft then drives the device. The advantage is that

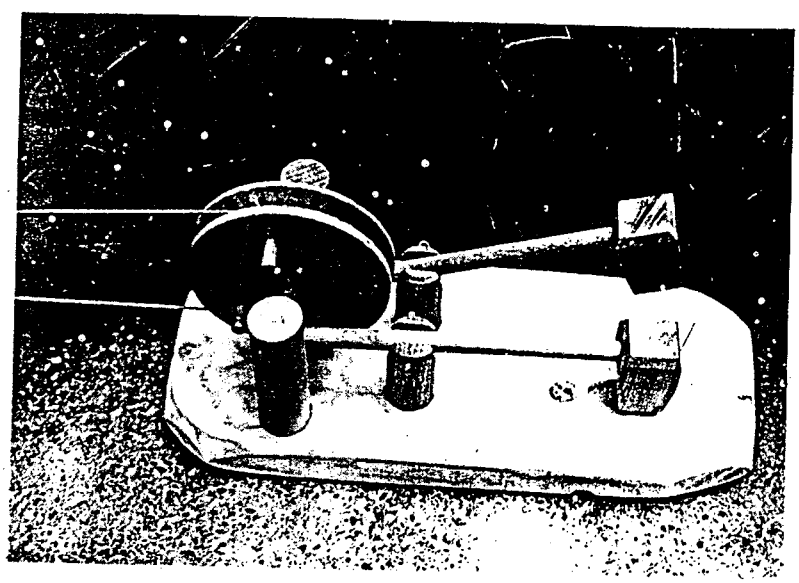


Figure 12.

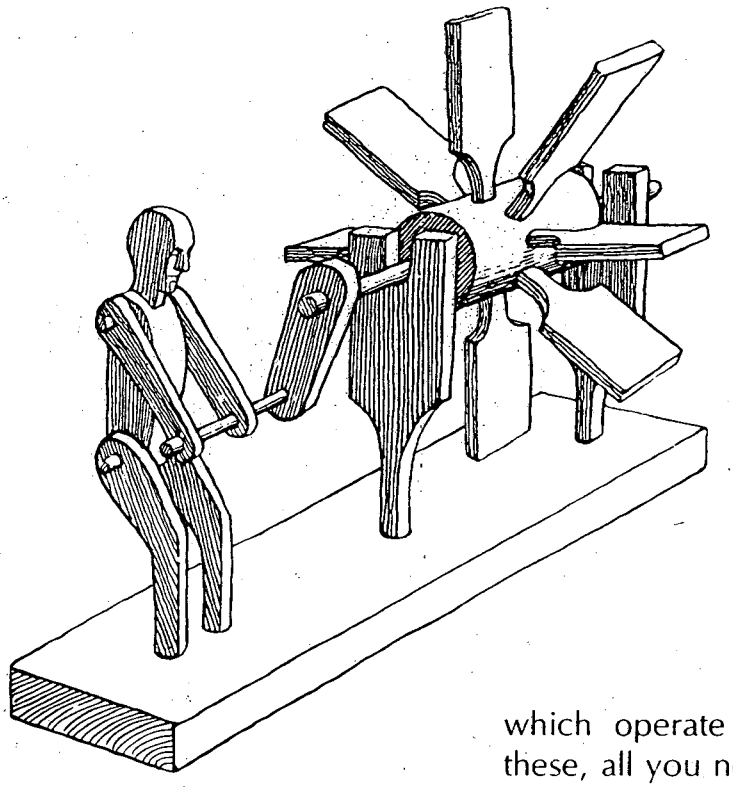


Figure 13.

there is no cord to slip. The disadvantage is that there is no gearing in the transmission.

Once the wheel has been coupled up to the plaything, you can regulate it so that it goes faster or slower or stops altogether. This is done by regulating the flow of water by a sluice. If you can do that you are a master waterworks builder.

Water-wheels can also be set on little boats. If these are anchored or moored in a river the current drives the wheels. There are still mills in the lower Danube which operate in this way. To copy these, all you need is a board on which two bearings are mounted. Lay the axle across and fix two water wheels, one at each end. A cam fixed to the axle can be made to drive hammers. Then in the stream there is a hammering away as if dwarfs or water-spirits were at work ...

Figure 12 shows such a hammer without the boat. The base carries the mountings for the two hammers and the bearings for the axle of the wheel. The wheel carries pegs to lift the hammer shafts. The contraption can only revolve in the one direction (clockwise on the photograph). In this case the wheel is turned by a cord running to the water-wheel.

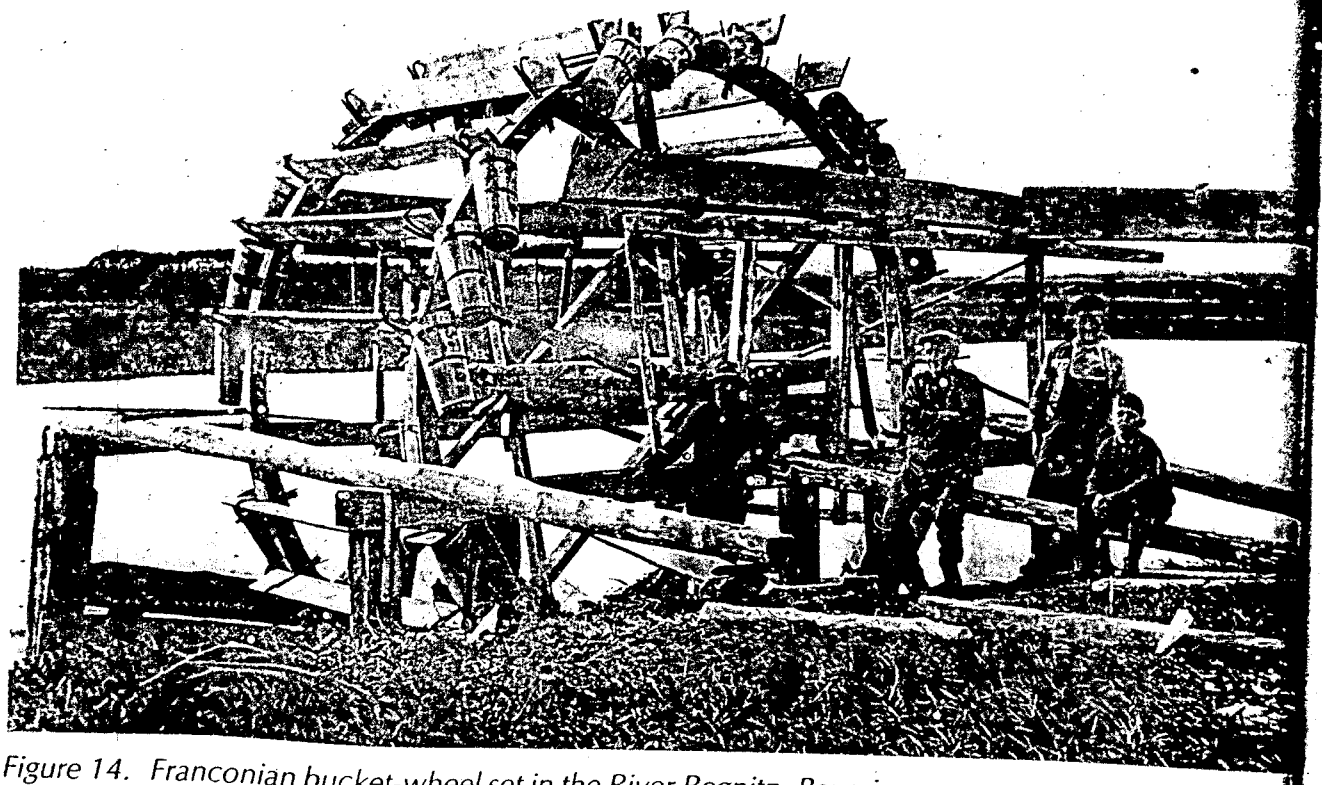


Figure 14. Franconian bucket-wheel set in the River Regnitz, Bavaria.

Bucket-wheels

In playing with water we must not omit the bucket-wheel, an ancient invention. In real life they are used in irrigation. They are driven by flowing water to lift a small amount of the stream to a higher level. Some of these wheels are still to be seen usually preserved as historical monuments, for instance in Bavaria, Germany.

With a little patience you can also build models. At regular intervals fix some containers on to the circumference of a wheel with a horizontal axle. Then take either little clay pots or pieces of bamboo-cane, cut so that a knot forms the bottom of each container. The wheel is undershot by a stream that is not

flowing too fast. The containers dip into the water, are lifted out full, and empty themselves when they reach the top. You can either let the water pour down again freely and enjoy the cascade, or can catch it in a tank with a gutter leading out of it. Watching the water and the forms which it makes is an important part of water play.

The bucket-wheel does not need to be as complicated as the one in the photo. For example the wheel in Figure 8 can be developed by using the cones as water-containers and by adding paddles to drive the wheel. Also the wheel in Figure 11 can be modified to make a bucket-wheel by fitting containers to the outside. Of course this latter wheel will be under-shot.

Underwater-wheels

It is also possible to build a water-wheel that can lie right below the surface of the water. It has a vertical axle, to which is fitted a disc with flaps. The flaps are prevented by a check-cord from flopping over the vertical when they offer the greatest resistance. The current raises the flap and pushes against it to drive the wheel. When the flap comes round against the current it closes, and offers no resistance until it opens again. The axle is pointed below to rest in a conical bearing and held in position above by a

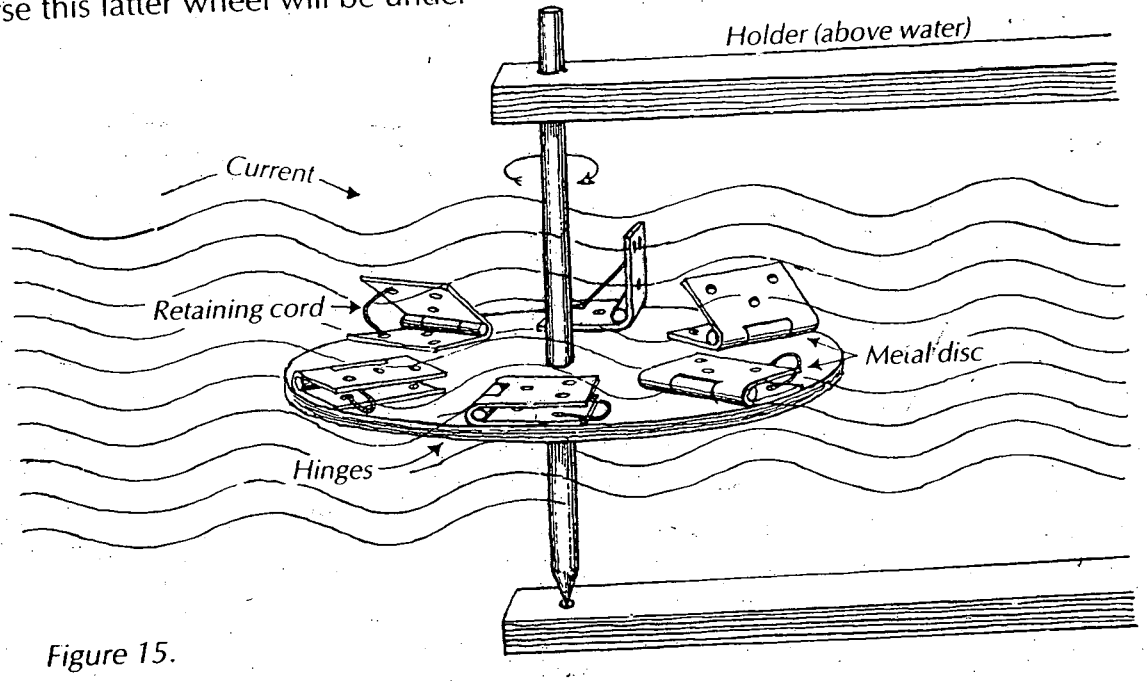


Figure 15.

holder. The whole wheel must have some weight, so that it does not float in the water. Therefore the disc carrying the flaps should be made of iron (Figure 15). The hinges can carry wooden flaps.

You can also make an underwater 'windmill' like a ship's propeller in reverse. Take a square block of wood. Cut an oblique groove on each of four faces and fix a thin board or sheet of tin in each. Use a nail as axle, a bead as spacer, and a thick stick driven into the bed of the stream as a bearing. By using a rimmed wheel and a cord you can transmit the power of the water and drive something (Figure 16).

In real life this contraption is used for measuring the speed of the current, for instance in a water-main. The propeller is protected by a pipe. On a much larger scale a strong propeller with a vertical axle is set in a large pipe. Whole rivers are funnelled into the pipe. This device is called a 'Kaplan turbine' after its Austrian inventor.

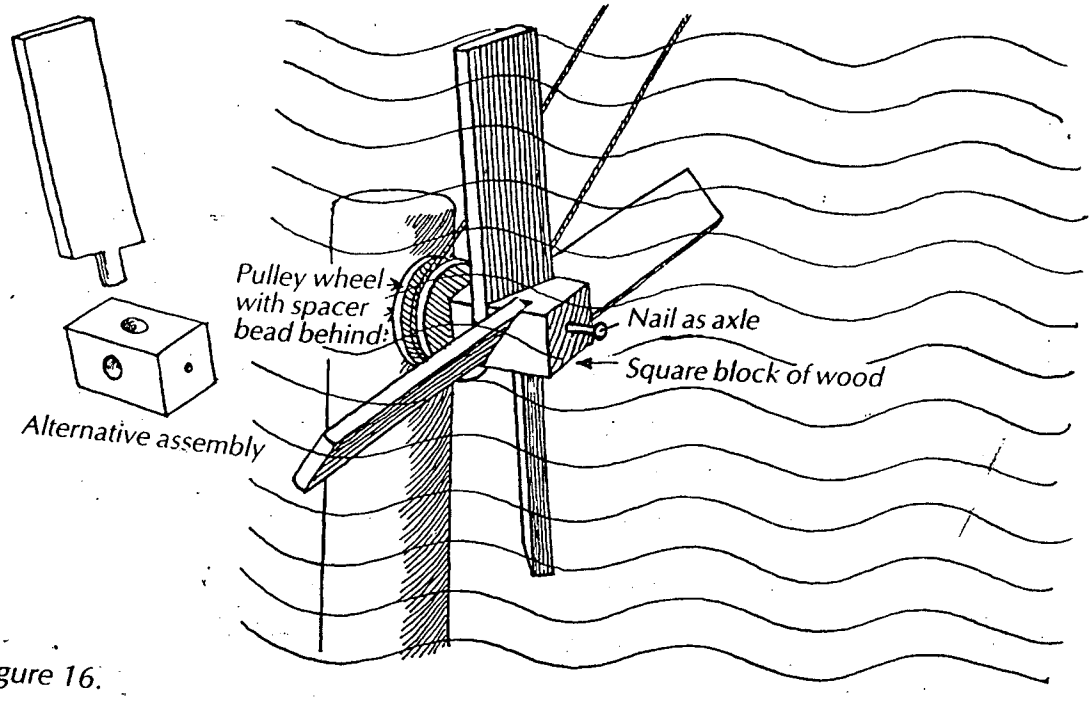


Figure 16.

The 'snipe'

Nowadays the 'snipe' is less well known than the water-wheel. In former times in the mountainous regions of Central Europe the snipe worked as an automatic hammer in the forges. Today you can occasionally see it set up in a museum where it operates with a regular rhythm. The principle is very simple and easily understood: a container is fastened to one end of a see-saw into which water flows until there is enough to make the see-saw tip and the container empties. A counterweight on the other end of the see-saw ensures that it comes back up to the horizontal, and the whole process starts all over again. The snipe must be well-balanced in order to function properly. Make the water container by nailing some boards together. A stone can be used as a hammer-weight. The see-saw dips through an angle of 90° and is prevented from dipping further by a buffer (Figure 17). After some adjustments the snipe will function every bit as well as a water wheel and tap, tap, tap, it goes. You can make it any size, even very small with a nutshell as water-container.

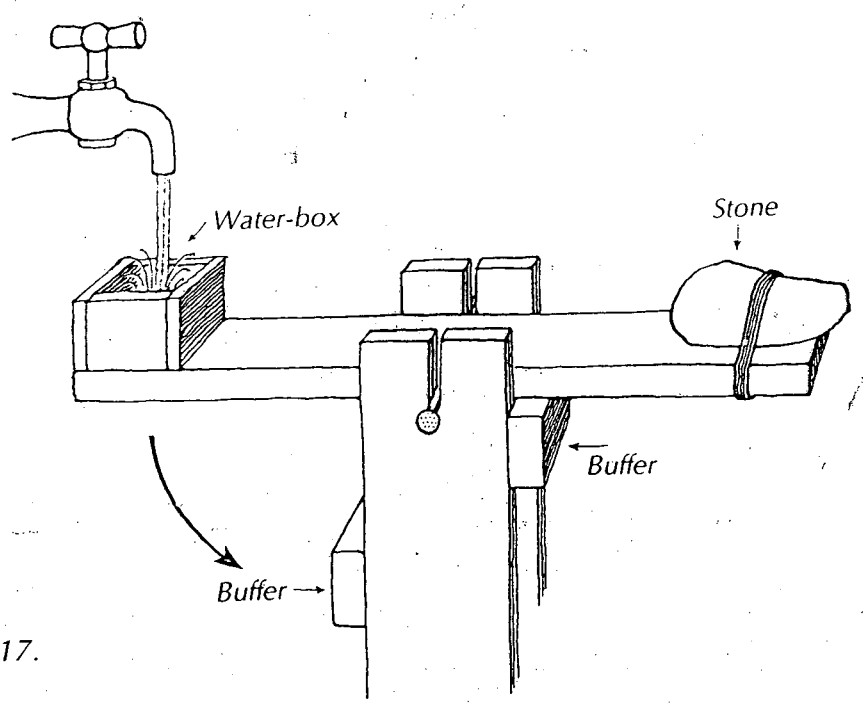


Figure 17.

Hydraulic power transmission

With a plastic surgical syringe not only can children squirt water all over the place and annoy nice people but can also create a hydraulic transmission as used in every car brake and in bulldozers and excavators. As well as two syringes without needles, you need a long piece of valve-tubing which you can buy in cycle shops. One syringe is filled with water. The tube is fitted to the end of the syringe and filled with water by pressing the syringe. On the other end fix the second syringe half filled. Between the two pistons, inside the cylinders and in the tube there must be only water, no air bubbles (Figure 18). When one syringe is pressed in, the other one goes out, and vice-versa: hydraulic transmission. If you have two syringes of different sizes the whole thing becomes more exciting: the smaller piston moves more quickly, but has less power and the larger piston moves more slowly but with more power; ratio transmission. Because the tube is long and adaptable, unlike cog-wheel, belt or rod transmission, surprising effects can be achieved. All that is needed is a bit of imagination!

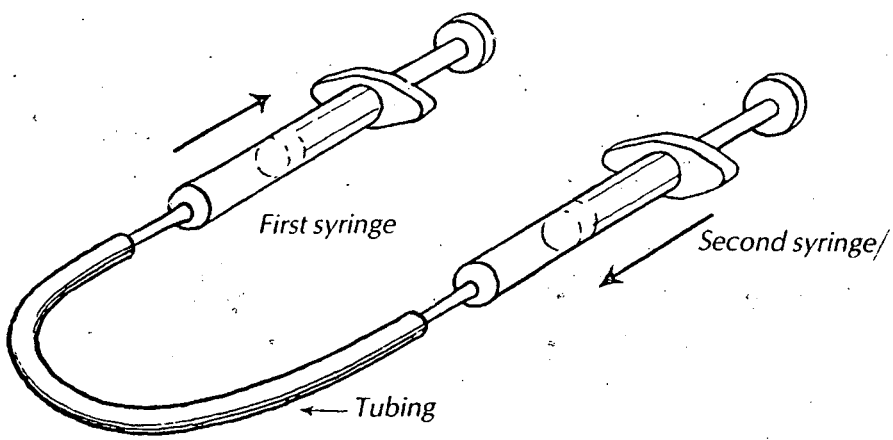


Figure 18.

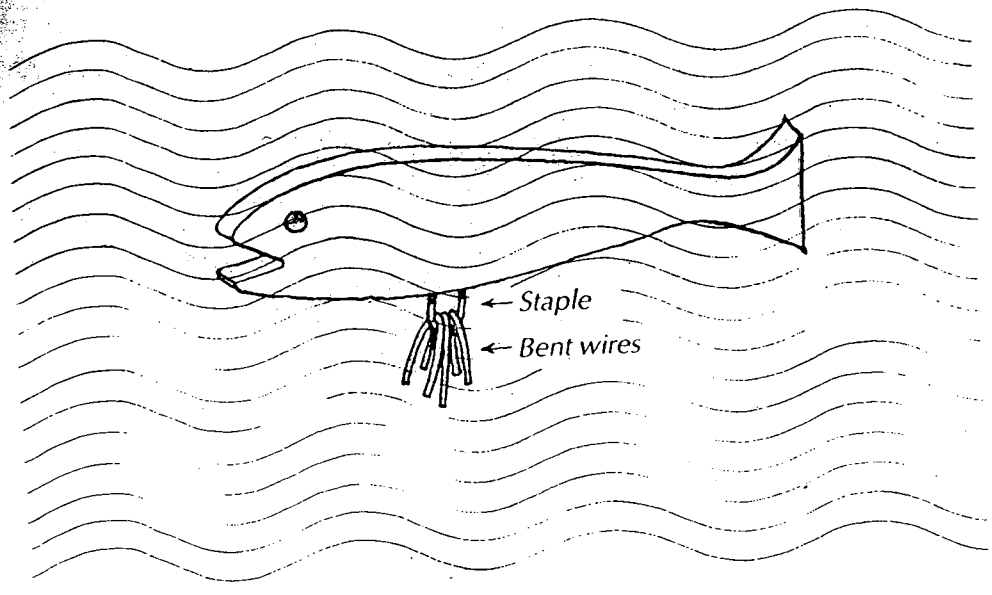


Figure 19.

Submarines and fish

Some things float in water and some sink. But it is possible to create an in-between condition: an object that is in a state of suspension. Fishes are naturally so created that they can maintain their suspension in water. Submarines are built on the same principle. There are various ways of achieving this condition of suspension. You can saw out a wooden fish. In order that it does not just lie on its side in the water, fix a staple underneath. The staple must be right in the middle. It will probably not be heavy enough to suspend the fish until you hang pieces of bent wire from the staple so that the fish really does remain suspended (Figure 19). You can also get any watertight bottle to suspend. Fill it with just enough water so that it neither rises to the surface nor sinks to the bottom. Much patience is needed for this bath-time game.

You can also build a kind of 'water-balloon'. For this you need two empty open tins, one larger and the other smaller. Knock holes along the edge of the tins with a hammer and nail. Suspend the smaller from the larger with wires (Figure 20). The contraption can now be lowered into the water; the little tin fills

up, the larger one upside down remains full of air under water. A bubble is trapped in it. Now fill the lower tin with sand and stones until the whole thing remains suspended. You should be warned that this contraption is very unstable because as it sinks deeper the air bubble in the upper tin is compressed and has less buoyancy. Using this principle men have reached great depths and raised sunken ships.

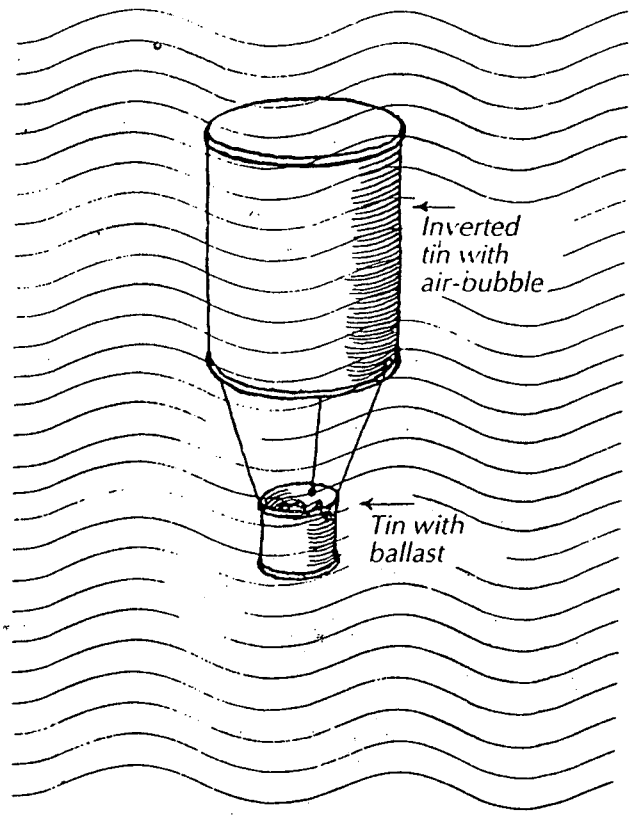


Figure 20.

The water-demon

By putting a medicine-bottle upside-down into a glass jar filled to the brim with water we can make it rise and sink. The medicine-bottle should still have the dropper on it and be filled with so much water that it is just suspended. If you now press the water in the jar with the flat of your hand (the hand must cover the mouth of the jar completely) you compress the air in the bottle, the water fills the space and the bottle sinks. You can also cover the jar with a plastic foil, then you won't get your hands wet. The foil shuts the cylinder like the cellophane on a jar of preserves. Tie it on tightly. There must be no air underneath. The cover must lie flush on the water. In former times instead of the medicine bottle people in Central Europe used a hollow glass called a water-demon, hence the name. You can also paint the bottle in this way and make your demon rise and sink, or keep him suspended in the middle (Figure 21).

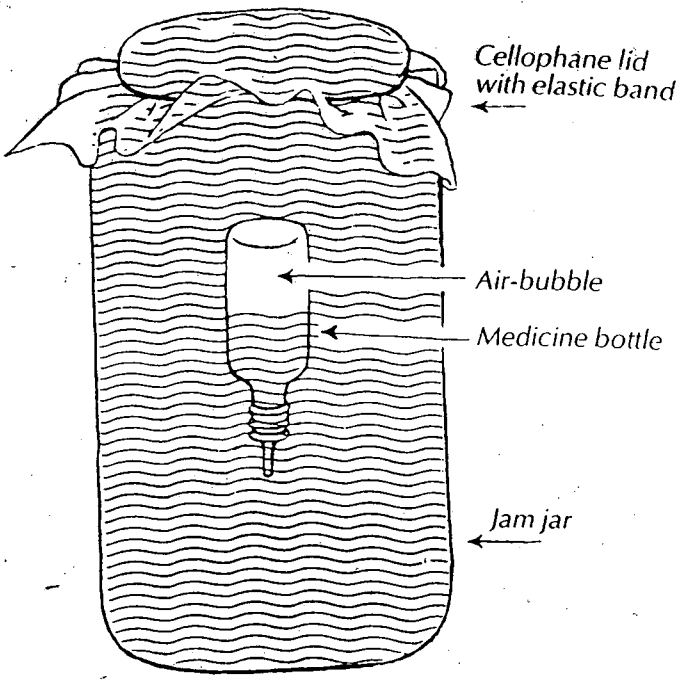


Figure 21.

Little boats

I have already said so much about playing with water, and yet have not mentioned a very obvious ploy, playing with boats. I must emphasise that I shall not describe building model boats, for there are plenty of books and plans already. Exact scale model boats that do not float are fine ornaments for a room but do not have a place in water play. In the same way floating models with remote control do not really constitute play with water.

Playing with boats begins when children throw bits of bark or wood into a stream and run along beside them until the bits get caught in the bank. Then with a stick the ship is freed and the voyage continues. Next the course of the stream is altered so that the little boat no longer gets stuck at the sides, and then playing with the water is under way.

Now we can move from the unformed piece of wood to all kinds of boats, but to enjoy making them it is necessary to know a few fundamental laws.

A boat must float properly and where possible it should have a little doll as crew and where that is the case it must not capsize! You should therefore build flat. A flat board floats with more stability while a log easily turns over — it is unstable. That is to say: board-like boats keep their trim, but log-like boats, however elegantly formed, tip over easily. To prevent capsizing, the boat can be weighted underneath, but in order to compensate for this weight you must

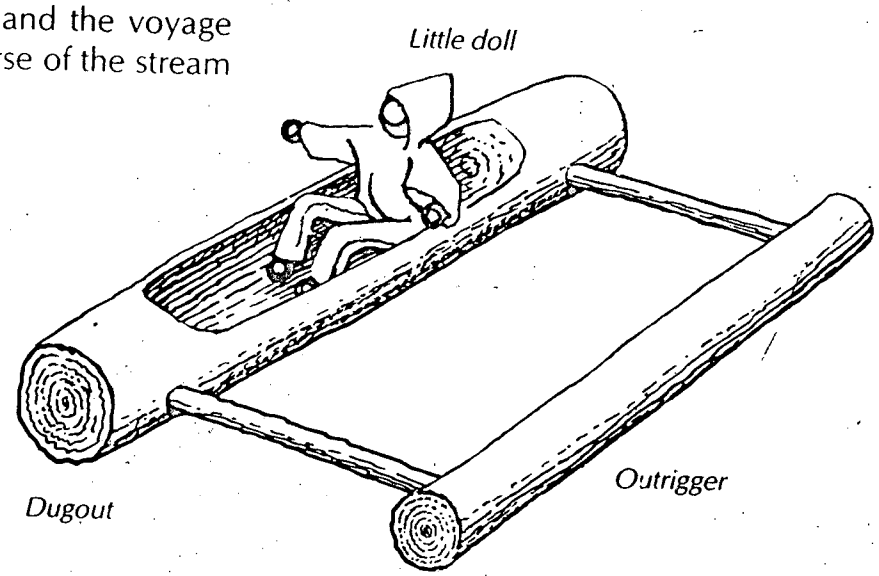


Figure 22.

make the boat lighter or it will sink, even though it is made of wood. Hollow out the boat, and for best results cover it with a watertight deck. To carve a boat symmetrically is not so easy. Home-made carved-out boats usually sail in a circle; but this can be counteracted by a rudder. A further step is building ribs covered with strakes, but here we are in the realm of model-building which is beyond the scope of this book.

It is better if you do not try to copy real boats but build according to this basic law: flat-building without a heavy keel. Even though it is easy to carve a dugout, you will not get much joy out of it without an outrigger such as is used for instance by the South Sea islanders (Figure 22). From this one moves to two equal bodies joined together, the catamaran. These boats maintain their trim so well that they can carry a sail. More of this later (page 63).

A paddle-steamer

For windless days or for playing in the bath you can build a paddle-steamer driven by elastic. Now natural materials are not sufficient, you must do some modelling at home. With a fretsaw cut out a board in the form of a ship (Figure 23), pointed at the prow, square at the stern, and inside, a rectangular hole. Saw out two boards in a rectangular form somewhat smaller than the piece cut out of the waist of the boat. Cut a slot in each of the boards so that they can be fitted together in the form of a cross. This cross makes the paddle-wheel that will drive

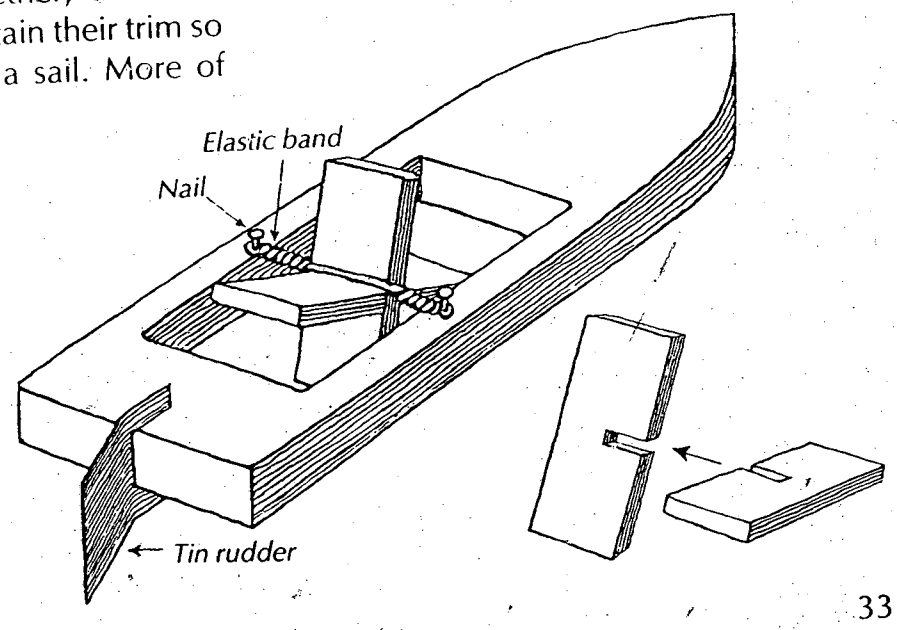


Figure 23.

the steamer forward. Fasten two elastic bands round the paddle and attach them to two pins at the side of the boat (see Figure 23). Now wind up this 'Mississippi paddle-steamer'. With luck and good construction the ship will travel for a few yards. By fitting a rudder, for instance a piece of bendable tin, you can make your vessel travel in a curve or circle. Notice the waves which this little boat sets up when it goes over calm water. If it is big enough it can carry a doll.

A boat to sail against the current

We have already used water power to turn water-wheels. Under certain conditions it is also possible to use water power to drive a ship against the current. The boat however must be attached to a cord by which it can wind itself upstream. The cord winds on to a windlass on board the boat. The windlass is turned by two paddle-wheels driven by the current. The diameter of the paddle-wheels must be quite a bit bigger than that of the windlass; the principle being a matter of leverage (Figure 24a).

Start by taking a board of light wood, fir or pine, cut into the shape of a boat.

Take an ordinary cotton-reel and put it on an axle. The reel and the axle now require a mounting on the board. One way of doing this is shown on Figure 24b. Fix the axle on the mounting, and bolt it in so that it cannot jump out of the bearing. Make two octagonal hubs with slots sawn in. Fix thin boards (of sufficient length!) into the slots and fix to each end of the axle. Now for the cord. The best is nylon line, because it does not absorb water. Fix one end of the line securely on to the windlass and then wind on about thirty feet (10 m). Thread the other end of the line through a fairlead (the fairlead can be a staple or an eye-screw) at the bows of the boat. Now the fun can start. Unwind the line and let the boat drift downstream. Hold on to

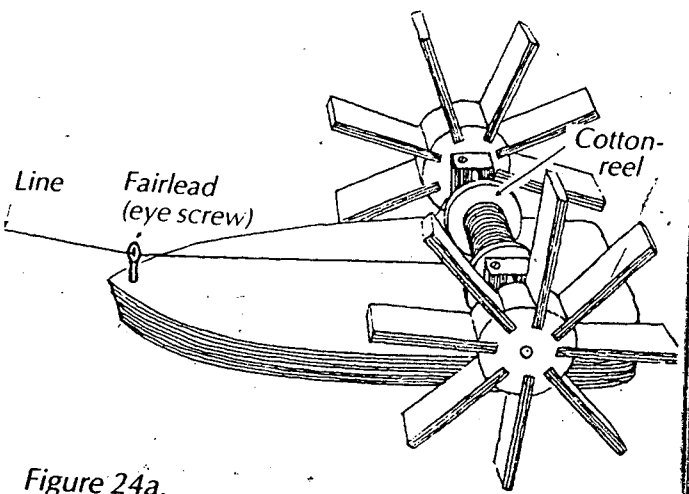


Figure 24a.

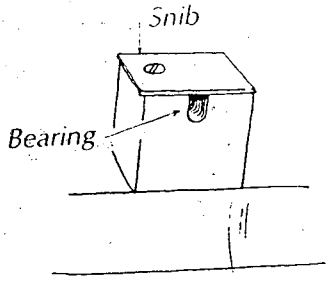


Figure 24b.

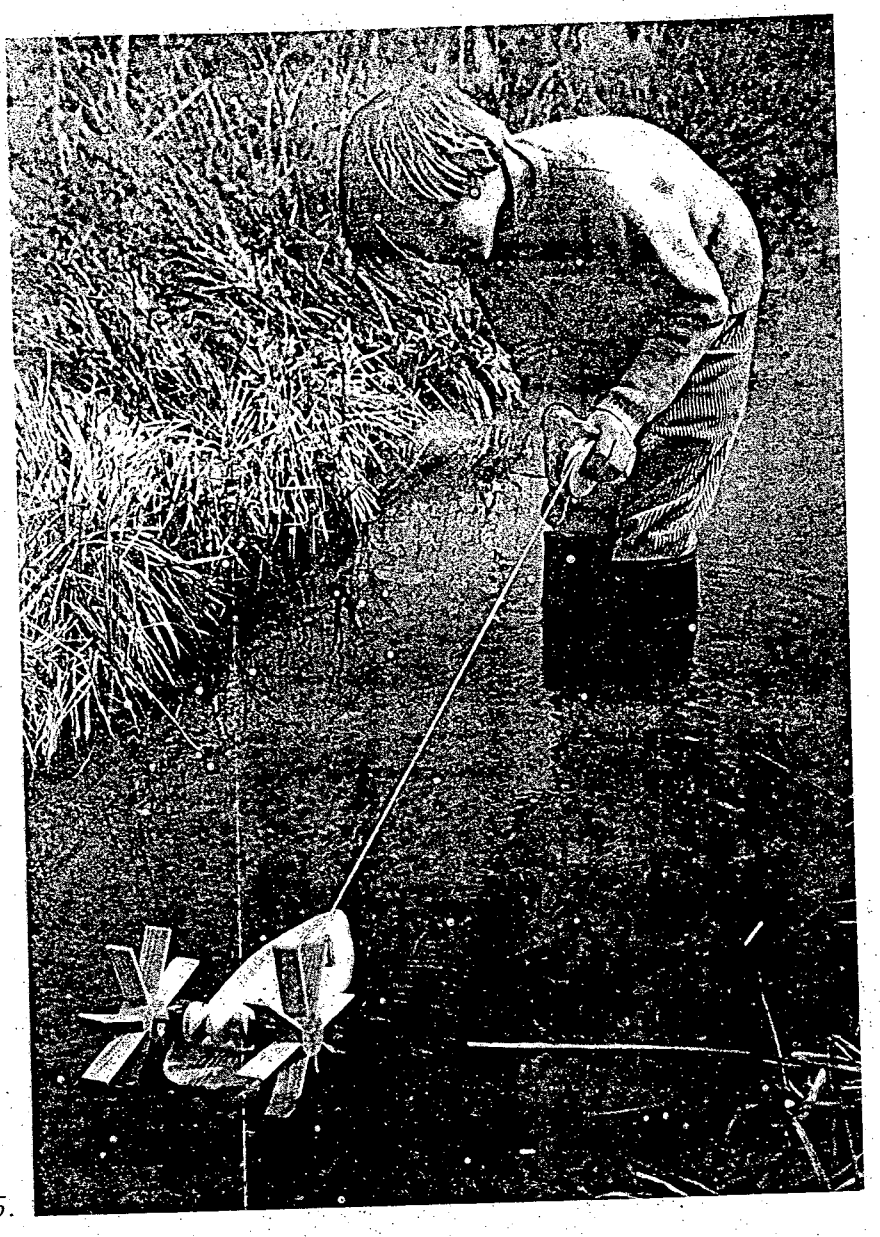


Figure 25.

the end of the line. When the line comes taut the boat will start winding up the line on to the windlass and so paddle its way back to you. You can keep it in the middle of the current by the line (Figure 25).

The ferry

Over a reasonably wide brook a ferry can be rigged up. Stretch a cord with a pulley-wheel on it across the stream. The pulley-wheel runs on an axle which is bent round to form an eye (see Figure 26). The eye must be heavy enough to hang down under its own weight. Next construct the ferry which can be in the form of a narrow raft. Screw in an eye to each side of the raft about a third of the way from the end. Tie a string to the eye on the pulley and tie a hook on the other end of the string. Attach the hook to the eye on the side of the raft nearest the bank, launch the raft, and the current will drive the raft over to the other side of the brook as the raft lies at an angle to the current. Once the raft has reached the other side unhook the string and hook it on to the other eye and the ferry will return to its starting place. Now a harbour can be built on each side of the stream and freight and doll-passengers can be ferried across.

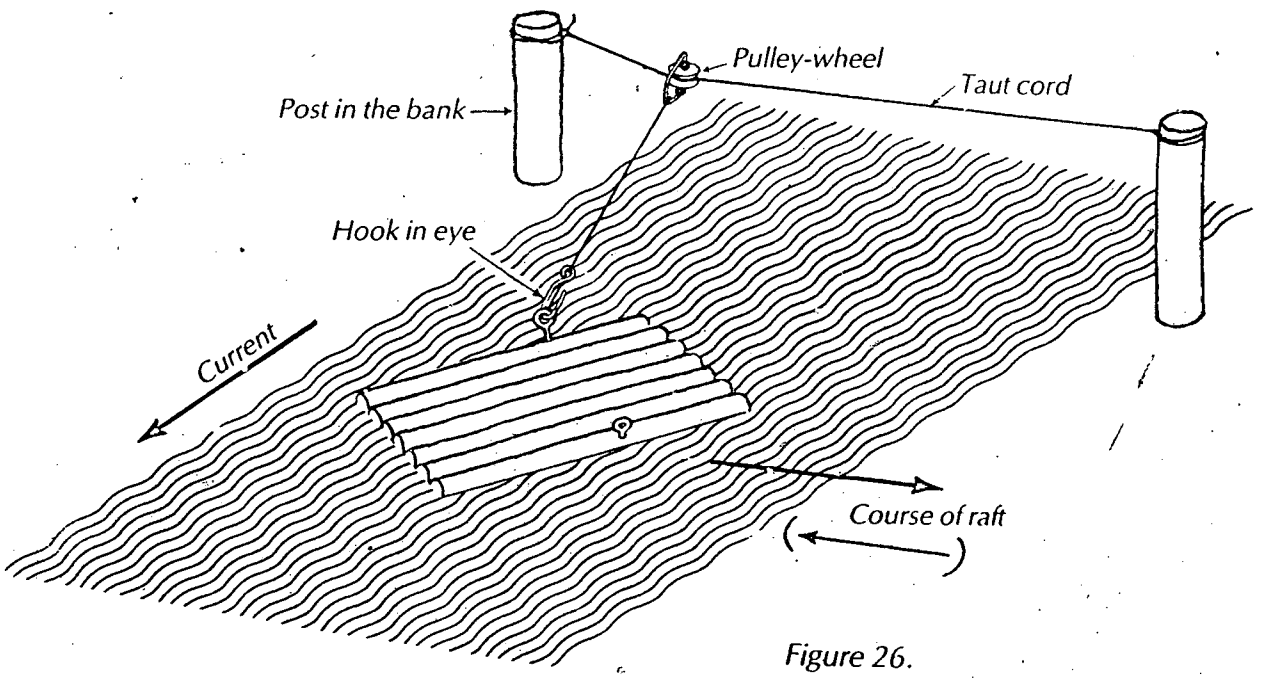


Figure 26.

Playing with air

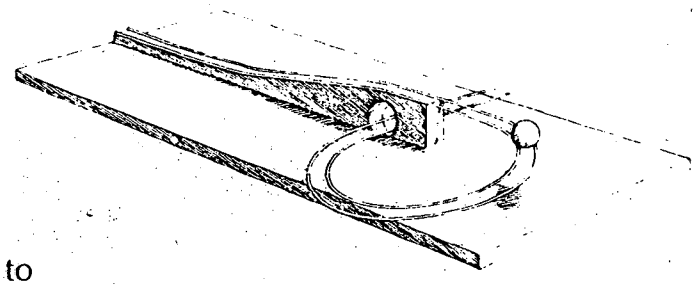


Figure 27.

Just as water invites us to bathe and to immerse ourselves in it, so air invites us primarily to breathe it, testing it for its fragrance and moisture. But breathing out can be real play, for instance: blowing boats and balls over obstacles or along a channel made ourselves with two wires as in mini-golf (Figure 27), or there is an amusing game where everyone sits round a table and on the word 'go' starts to blow some light object like a piece of cotton-wool. When the cotton-wool finally sticks to someone that person has to pay a forfeit. Rather than playing against each other I would recommend trying to achieve a common goal such as keeping a ball for as long as possible on a sloping table by blowing.

Although essentially a light element, air can develop quite a power, as in wind and storm. Sometimes the air is so strong that we can lean against it. It is good to take the children to see the power of the wind and the waves by the sea, an experience long to be remembered. When the air is calm we can create wind by running. Many games need still air, and we can begin with these games.

Figure 28. Albert Anker (1831–1910), The Bubble Blower, *1873.*

Blowing soap-bubbles

These delicate objects are a wonder. As well as the marvel that they can float in the air they glisten in special colours, particularly red and green, but not in all the colours of the rainbow. The following has proved a good recipe for making the soap-solution: cut kitchen soap into shavings and dissolve them in warm water. If possible add some drops of glycerine. Use a drinking straw. Dip it in and blow. With care and practice you will soon be able to send up beautiful big soap-bubbles into the air. The trick is to stop blowing just before the bubble bursts. The bubble is in danger of bursting when colourless patches begin to form. Soap-bubbles will show the least air movement, they will rise above a radiator or over a burning candle.

The air-balloon

The air-balloon is filled with a light gas and held by a string. Indoors you can hang light objects on it such as baskets made of paper in which you can put very light dolls (such as those made of cotton-wool or wool) so that they get carried up to the ceiling. An air balloon of the usual size will not stand carrying much ballast. With some skill and a lot of patience you can get the balloon to float without rising or sinking like the submarine and fish described on page 29. The air in the room must be quite still.

If you let go of the balloon in the open air you will certainly not see it again, for it will go on rising higher and higher, growing smaller and smaller until you can see it no longer. Somewhere and at some time or other it will come down again. Sometimes a competition is run with air-balloons to see whose can be carried the farthest. A label is attached with the sender's address and a request to the finder to inform him of the place where it was found. Sometimes the balloons travel a remarkably long way. (Hot-air balloons are dealt with on page 114).

Sounds from air

By blowing you can also make musical sounds. You only need a key with a hole in it. If you blow sharply across the edge it will give out a shrill whistle; very often you can get more than one note. You can develop this simple principle by arranging a series of pipes of different lengths made of metal or thin bamboo. The pipes must be closed at the bottom. To make a true scale in this way is not easy. In the case of bamboo pipes we have something like a simple Pan-flute. But it is quicker and simpler to take a series of bottles of the same size and fill them to various levels with water. You cannot really play a tune on these, because the bottles are too clumsy and the necks are not close enough together.

This is the way to make a proper pipe: Take a fresh willow twig a good four inches long (10 cm). Cut a little notch in the bark (Figure 29). Now tap the bark all round with the back of a knife and the pith can be withdrawn from the bark. We have to get the air-stream to strike against the hole made by the notch. Now remove the pith from the notch to the mouthpiece, cut the pith flat on top and insert it again into the bark-pipe so that the air-stream strikes exactly against the cut, and the little whistle is ready. You can stick the rest of the pith in the bottom end, and by moving it in and out you can tune the pipe to a given note.

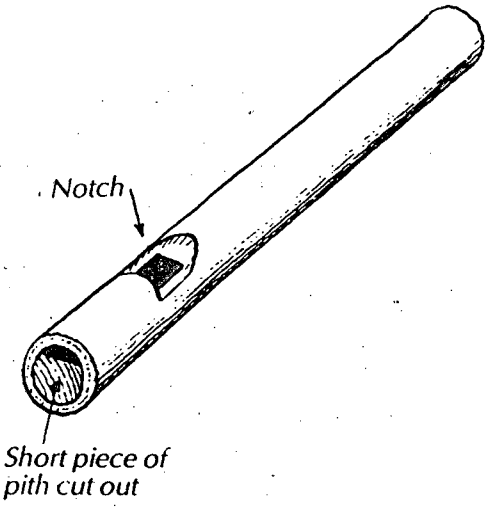


Figure 29.

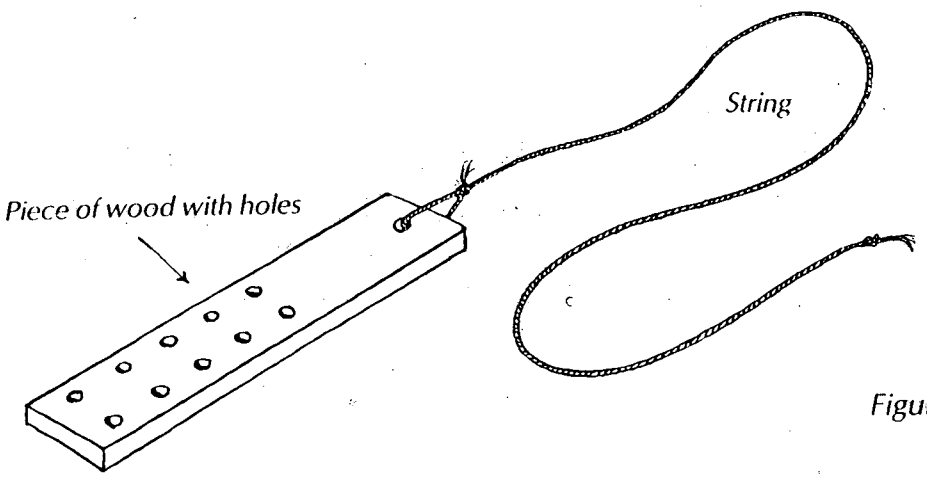


Figure 30.

Humming wood

It is well worth reviving this ancient toy. Simply take a piece of wood, a good hand-span long, and two fingers broad, for instance from the side of an old ladder. Bore a hole in one end and tie a piece of string as long as your arm through the hole. The hole must not be in the middle, but that usually happens anyway. Now swing the wood on the end of the string round and round either horizontally over your head or vertically — it does not matter which — it will begin to sound. Some skill is necessary to learn how to make it hum. After a time it will stop humming because the wood has twisted the string, and you must let it unwind before you can get the wood to hum again. If you bore holes in the wood

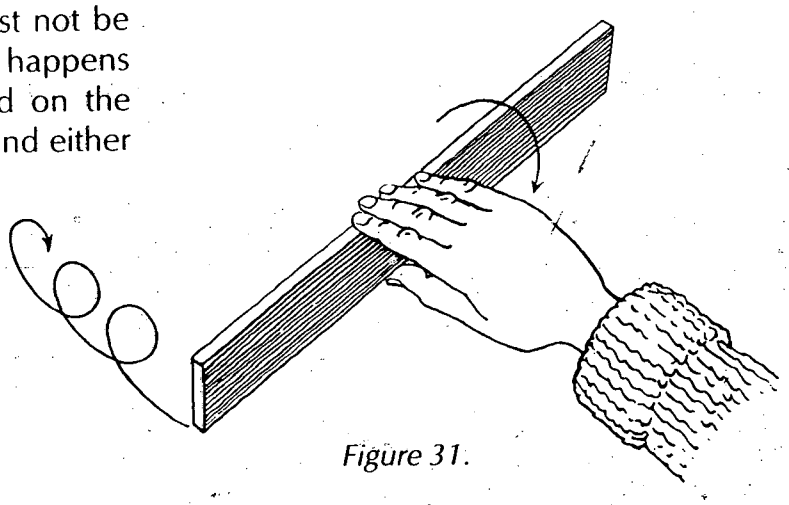


Figure 31.

(Figure 30) you will increase the sound. Whirling is a game for outside.

Quite an ordinary piece of wood can be used for whirling and then cast loose. Shape it like a ruler 8 to 12 inches long (20 to 30 cm), 1½ to 2 inches wide (3 to 5 cm), fairly thin (about ⅕", 5 mm).

The wood must be thrown skilfully. When it is released it must be given a spin (see Figure 31). You will need practice. Once you have mastered the art of throwing, the wood will rise into the air and give off a humming noise. Heavy wood will hum longer than light wood, but light wood will fly longer. Long strips of paper will also fly, rotating fast, and flutter down silently to the ground. That is fun too.

The humming button

An indoor game is the humming button. Take as big a button as possible, thread some good button-thread about two feet long (60 cm) through the holes and tie the ends together so that you now have a loop (see Figure 32). Hold the loop between your hands wound round two fingers on each hand with the button well into the middle. Start the button spinning by drawing the thread tight rhythmically after giving the button a few turns to start it off. The thread will twist itself more and more each time and the button will rotate faster and faster first one way then the other, and it will hum softly but quite clearly. If more holes are bored near the edge of the button it will sing even louder.

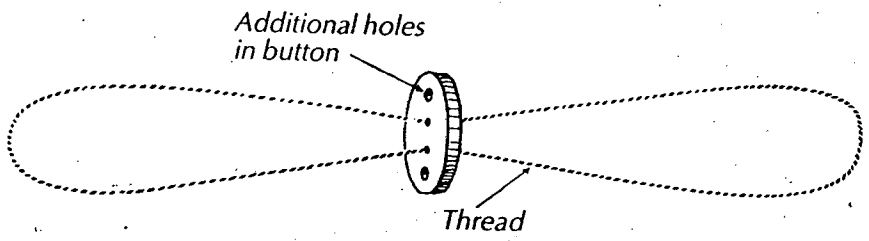


Figure 32.

Mobiles

You can easily make a mobile yourself. Mobiles are pendants which move in the slightest current of air. The motifs can be birds, butterflies, bees, sailing-boats, fish, and so on. Make the objects first and take care that they are not too heavy. Lightweight coloured paper is suitable. Then suspend the motifs by fine thread from little rods or thin wire. If the latter are slightly curved the task is easier. To assemble them begin at the bottom. Take a short rod and hang the first two objects at each end. Tie a thread at the point of balance, and tie the other end of the thread to the end of a somewhat longer rod. Balance this rod with another object at the other end. Continue in this fashion until the mobile is big enough. Take care that the objects suspended cannot touch each other as the rods turn (see Figure 33).

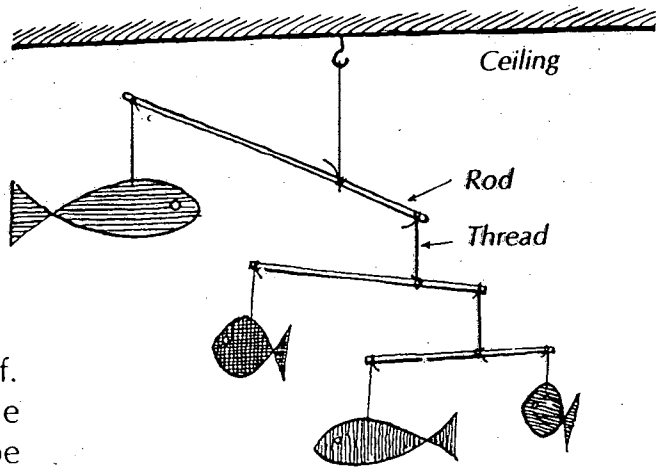


Figure 33.

Paper darts

There are all kinds of paper darts. Even a postcard can fly if it is folded over lengthwise once or twice and weighted with a paper-clip (Figure 34). You have to experiment with patience and learn to launch it, and eventually it will work. If the card plummets down steeply it is too heavy in front: push the clip in or unfold one of the folds. If it will not fly straight pull the clip out a bit. By moving the clip we alter the point of balance: an airman's old adage says, 'You can fly with a barn door if you get the point of balance right.' This rule applies to all paper darts.

To remind you of the art of making paper darts which perhaps you learned at school, Figure 35 shows the sequence of folds for a good model.

If you fly the darts out of the window they sometimes get into an up-current and fly into the window above us. You can only hope your neighbour enjoys the fun!

Finally you may want to build bigger flying models, proper ones with a wooden frame, but you have to be capable of fine workmanship.

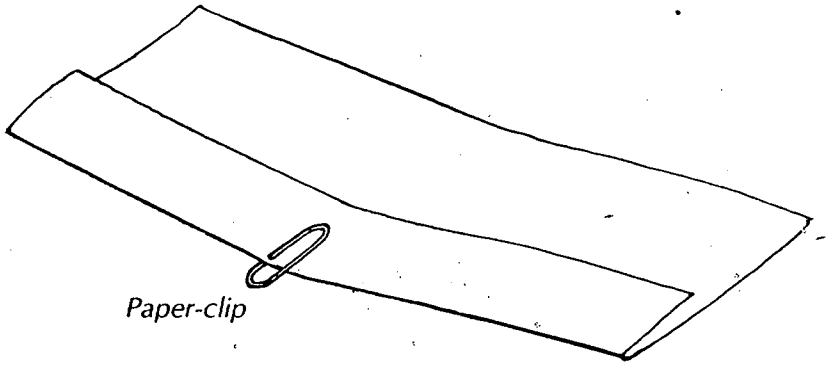
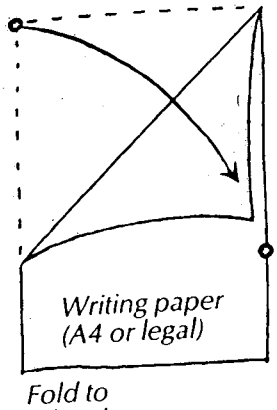
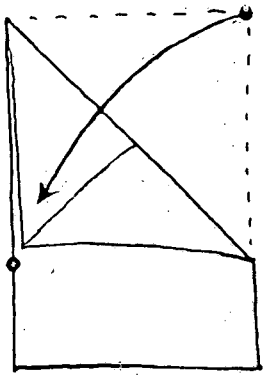


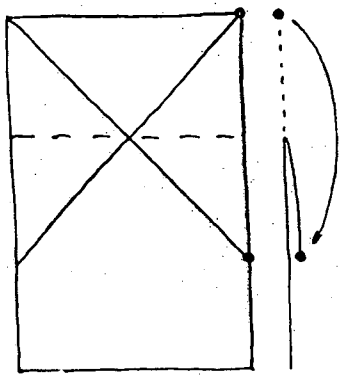
Figure 34.



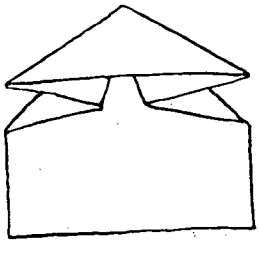
Fold to
the right.



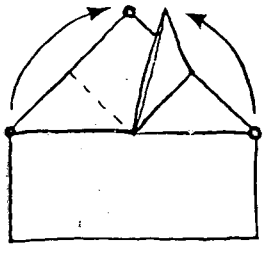
Fold to
the left.

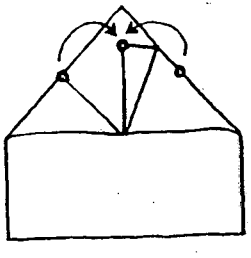


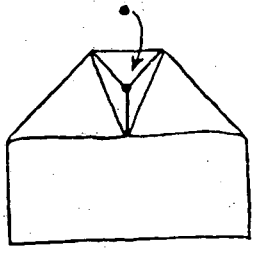
Fold down.



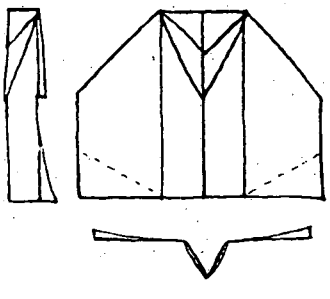
Fold.







Bend the point
back. Stick the
corners into
the pockets.

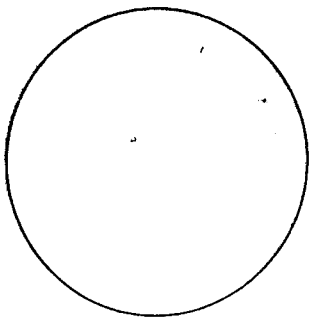


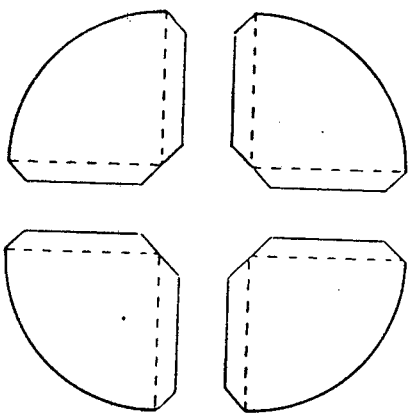
Fold lengthways.
Turn corners
up slightly

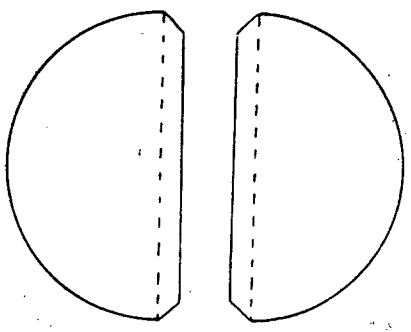
Figure 35.

The wind-ball

You can build a ball which can be borne lightly by the wind and is also suitable as a pendant on a mobile. Cut the parts out of light cardboard (it is good if this is coloured) according to Figure 36 (diameter about 4", 10 cm). Fold along the dotted lines, stick together, and the wind-ball is finished.







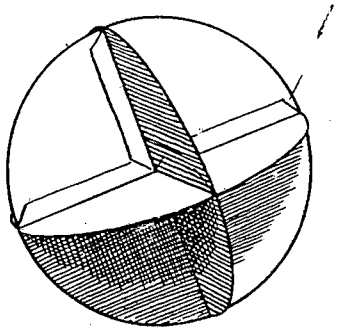


Figure 36.

Parachutes

Before you go into a shop and start buying look around in nature. There are various seeds that can fly. The best example is the dandelion head. When you blow it lots of little parachutes float away. Then there are seeds of trees which you don't need to blow, but just throw them into the air or let them fall: sycamore, maple, fir, spruce and lime. These seeds have wings which cause them to rotate like a helicopter screw.

In the Malay Archipelago there is a plant, the zanonia, whose seeds are real gliders flying long distances like the post-card we have described.

A strip of paper, split at one end, with the flaps folded outwards and slightly twisted will gently fall to the ground turning slowly (Figure 37) just like the seeds mentioned. It is fun to let these spin down whole flights of stairs. You can make a proper little parachute out of a square piece of lightweight cloth about the size of a pocket-handkerchief. Tie a fine thread to each corner, and knot the loose ends of the threads together. Attach a little weight, for instance a nail, which can be the parachutist, or you can use a little doll. But the size of the cloth and the weight must be in relation to each other (Figure 38).

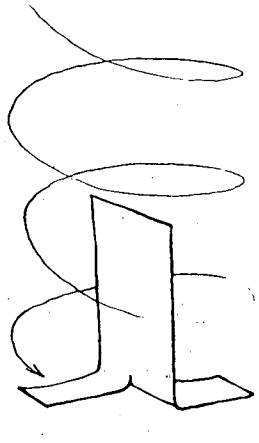


Figure 37.

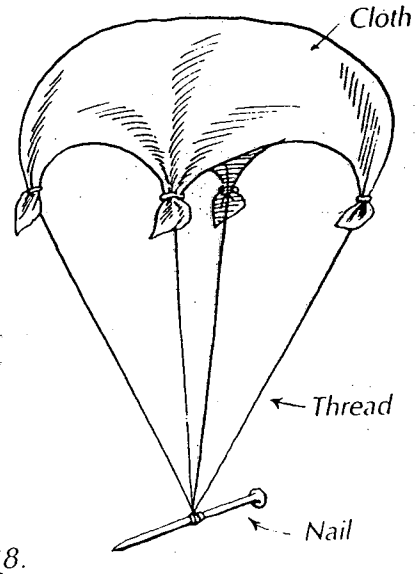


Figure 38.

Helicopters

In Japan there is a simple toy made of bamboo called *Také-tombo*. Sometimes you can find something similar in the West, though none is as simple and effective as the Japanese version. However, it can be made easily at home.

Take a thin board about 4 inches long (10 cm) and cut it out in the shape of a propeller. It does not have to be bamboo, although this kind of wood is particularly durable. Bore a hole in the centre of the propeller and glue the end of a thin round rod into the hole. The rod should be about the same length as the propeller (Figure 39). Now take the rod of the propeller between the palms of your hands and spin it. If you do this quickly and skilfully, when you let go, the propeller will fly up to quite a height before it starts to fall again. This is a simple game for outside, because the spinning propeller can cause damage inside a room.

Another kind of helicopter is quite

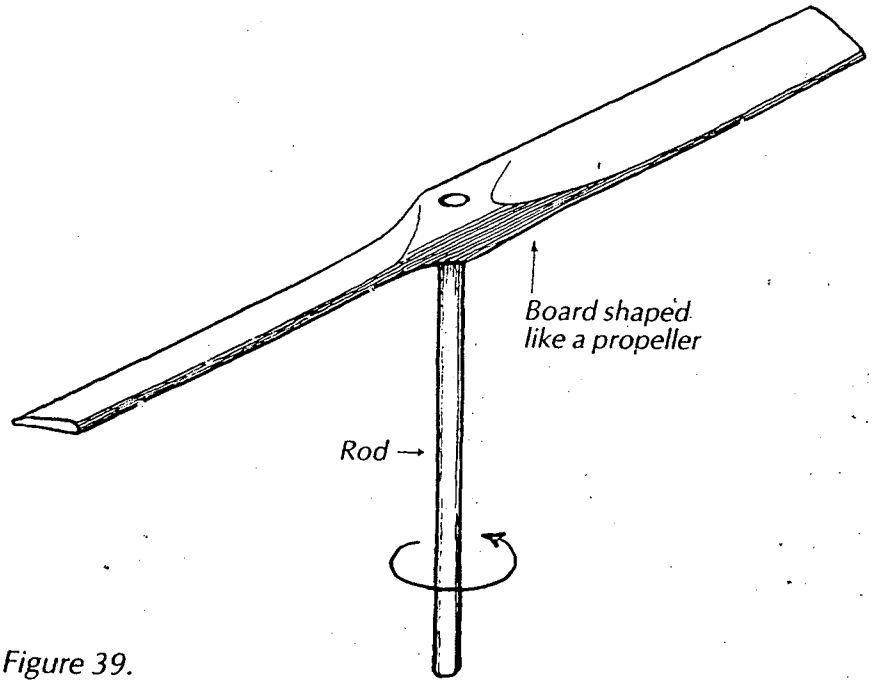


Figure 39.

harmless and can safely be launched inside a room, but it is more difficult to construct. Take a rod about 8 inches (20 cm) long and fix a bent bit of tin at one end as a mounting. A glass bead acts as the axle of the propeller. The axle is driven by an engine made of two elastic bands. These elastic bands are secured to the other end of the rod, where a second propeller is fixed. This propeller must be pitched in the opposite direction (Figure 40). The elastic engine is wound up by turning the movable propeller with a finger. When you let the whole thing go it will fly up to the ceiling where it will try like an insect to crawl along until the elastic bands have unwound, and it falls down again. For the contraption to work as we have described all parts should be made as light as possible. The rod can be made of balsa wood, the mounting from very thin tin, 1/100" (0.2 mm) wire for the axle, bristles with tissue-paper stretched between them for the propellers. The second propeller could alternatively be mounted directly under the first, it turns with the rod in the opposite direction to the first.

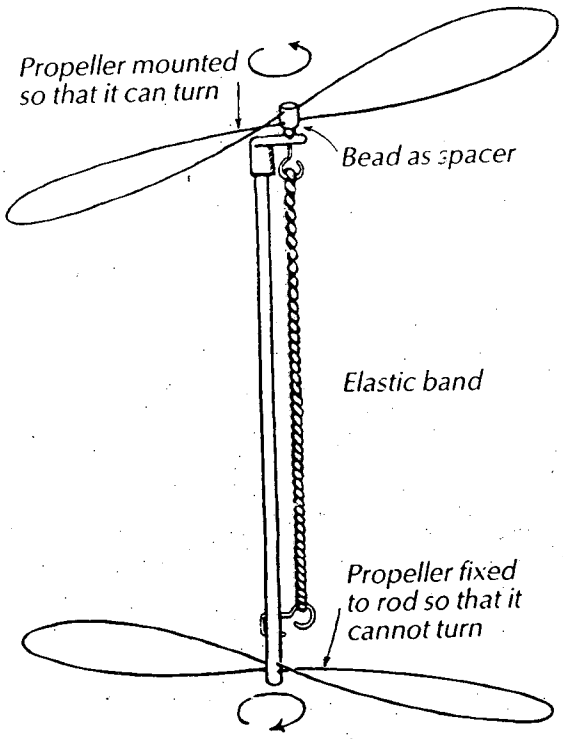
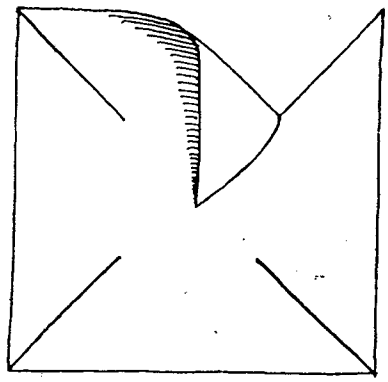


Figure 40.

Wind-wheels and propellers

The 'helicopters' described above actually do have propellers, with a vertical axle, but it is easier to play with propellers with horizontal axles. The simplest is the wind-wheel, which you can buy at the fair. But you can also make it yourself, big, little, coloured or white, just as you like. You need a square tough piece of paper. Cut in at the four corners diagonally and fold over the four flaps (Figure 41a). With a pin pierce each of the four flaps as well as the centre. Insert the pin through a bead to act as a spacer and push the pin into a stick. Then the wind-wheel is ready. It will turn in the wind itself. When there is no wind a child can run with it, holding it up in the air and it will turn too. This is the simplest form of construction. If the toy is to last longer you need a stronger construction.

It was the custom when I was a child



Cut diagonals into square paper, turn flaps turned inwards, insert pin through middle.

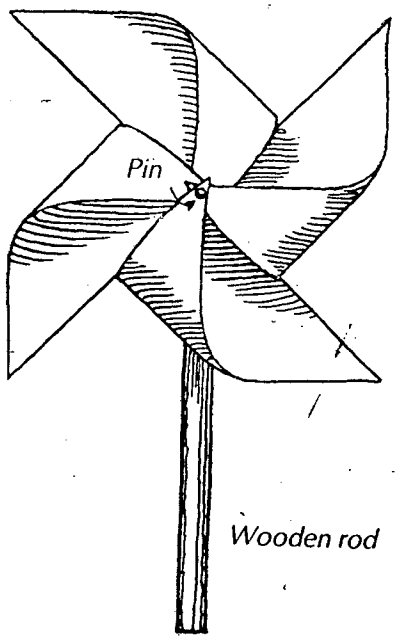


Figure 41.

to have a propeller on your bicycle. The propellor was carved out of a thin piece of wood, with a knife. This will require a little skill. It is harder to fit the axle on to the bicycle and to get the bead to lie so that the propeller turns easily. Don't forget to oil the bearing. Remember also that propellers with little pitch turn faster when you are riding your bike. Of course the propeller does not drive, it is driven.

Windmills

A proper windmill can be built without much trouble. The Dutch ones which you sometimes see in people's front gardens between garden dwarfs are very realistic miniatures. However, the necessary amount of work and cost can easily be underestimated. The windmill illustrated here is a simpler model.

Sail-windmills are recommended as patterns. The mounting can be an old cardboard drum or container. Make it look attractive by painting it or sticking coloured paper over it. Half fill with stones to make it stand firmly and prevent the wind blowing it over. Bore two holes opposite each other to take the axle which is a wooden rod about ½" (10 mm) thick (Figure 42a). On the windward side it needs a spacer (a round bead, for instance) like the wind-wheel, and on the lee side you can fix a rimmed wheel like the water-wheel to drive a model. But first you must make the sails. You need a hub with some holes (you can get them in a model-shop). This is glued on to the axle. Insert rods of equal length into the holes. Cut out the triangular sails from a piece of cloth, sew a thread to each corner, and tie them at the three corners to the rods (Figure

42b). If the bearing lets the axle runs easily the mill will work in a light current of air, and with a fresh wind it will go whizzing round. The workmanship does not need to be exact, but the bearing should be good; you can use metal or synthetic tubes stuck into the cardboard. To roof the mill you can give it a conical hat.

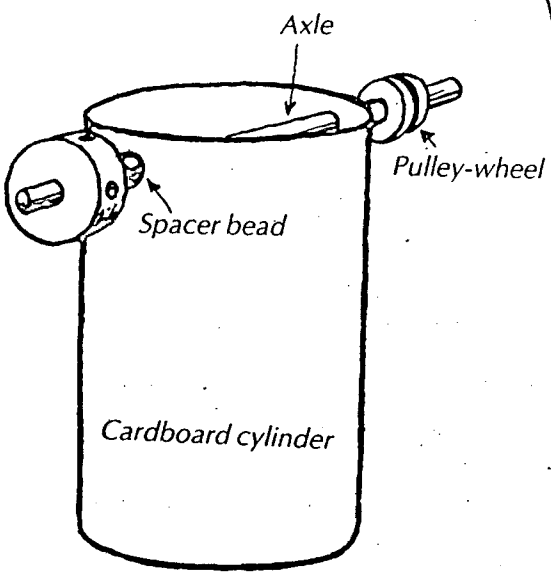


Figure 42a.

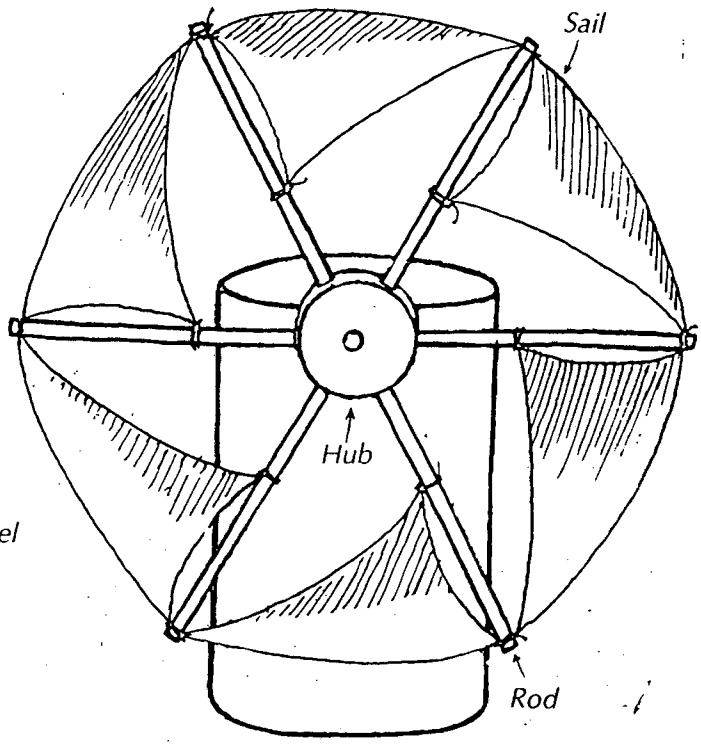


Figure 42b.

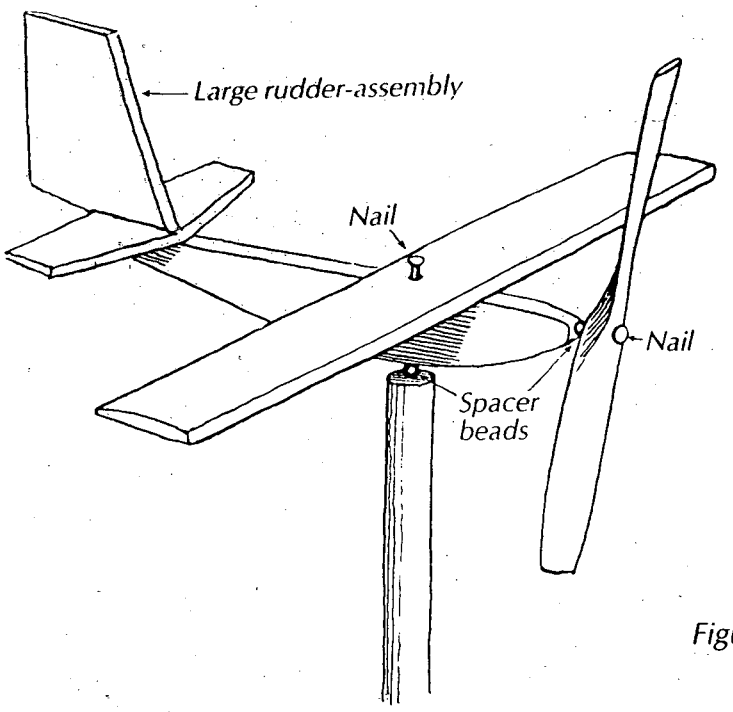


Figure 43.

Weather-vanes

The weather-vane (weathercock) often has the shape of an plane with a propeller. You can make one and put the aircraft on a pole in the garden. To ensure that the plane will point properly into the wind the tail must be relatively large. Behind the propeller and underneath the aircraft put a bead as a spacer to decrease the friction of the axle. The plane should be mounted at its point of balance (Figure 43). Build the plane itself as best you can from wood, paint it in colours or use a transparent varnish to protect it. This is important for the weather-vane should last for some considerable time in wind and weather. You could also make a weathercock, but without a propeiler of course.

While discussing wind and weather we must not forget the cup-anemometer that helps meteorologists measure windspeed. To get four suitable cups you might use two table-tennis balls. You need quite a bit of skill to make a cup-anemometer that works, but on the same principle I would like to suggest curved tin. Flat tin will never spin in the wind, but curved tin will, because the hollow side offers more resistance to the wind than the convex. The axle can be

either vertical or horizontal, only it must be at right angles to the wind (Figure 44). Bend a piece of rectangular tin, not too small, to the right curve. Solder or glue a slender pipe to the sheet of tin. This pipe serves as a casing (bearing) for a shaft. Now the tin will go round in the wind. If the tin reflects the light well the contraption can be used as an excellent scarecrow.

(Alternative)

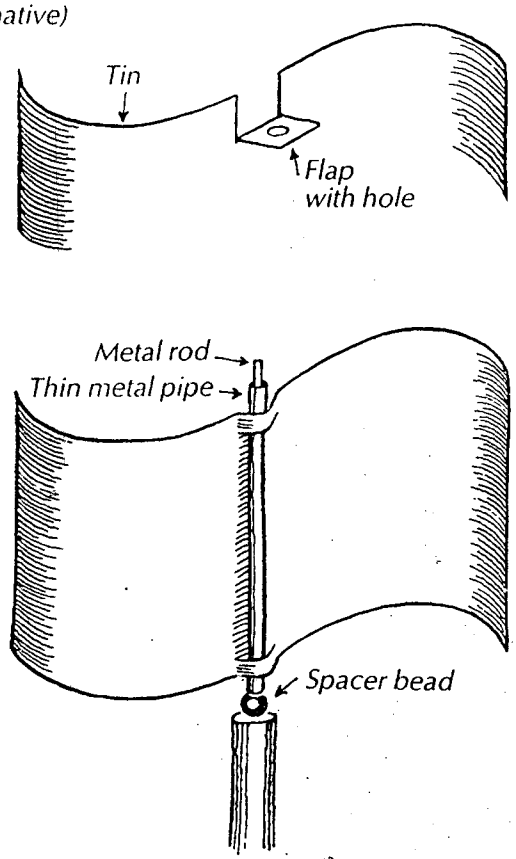


Figure 44.

The klapotez

Another instrument for scaring away unwanted feathered guests is the 'Klapotez'. The wine-growers of Styria in Austria use this type of weather-vane which makes a racket when it turns. Clappers on a crankshaft hammer on to a sounding board. The wind drives eight thin laths, each about three feet (1 m) long, fixed into the axle and set at an angle. The contraption is held into the wind by a broom sticking out behind, and is quite a big unit (see Figure 45).

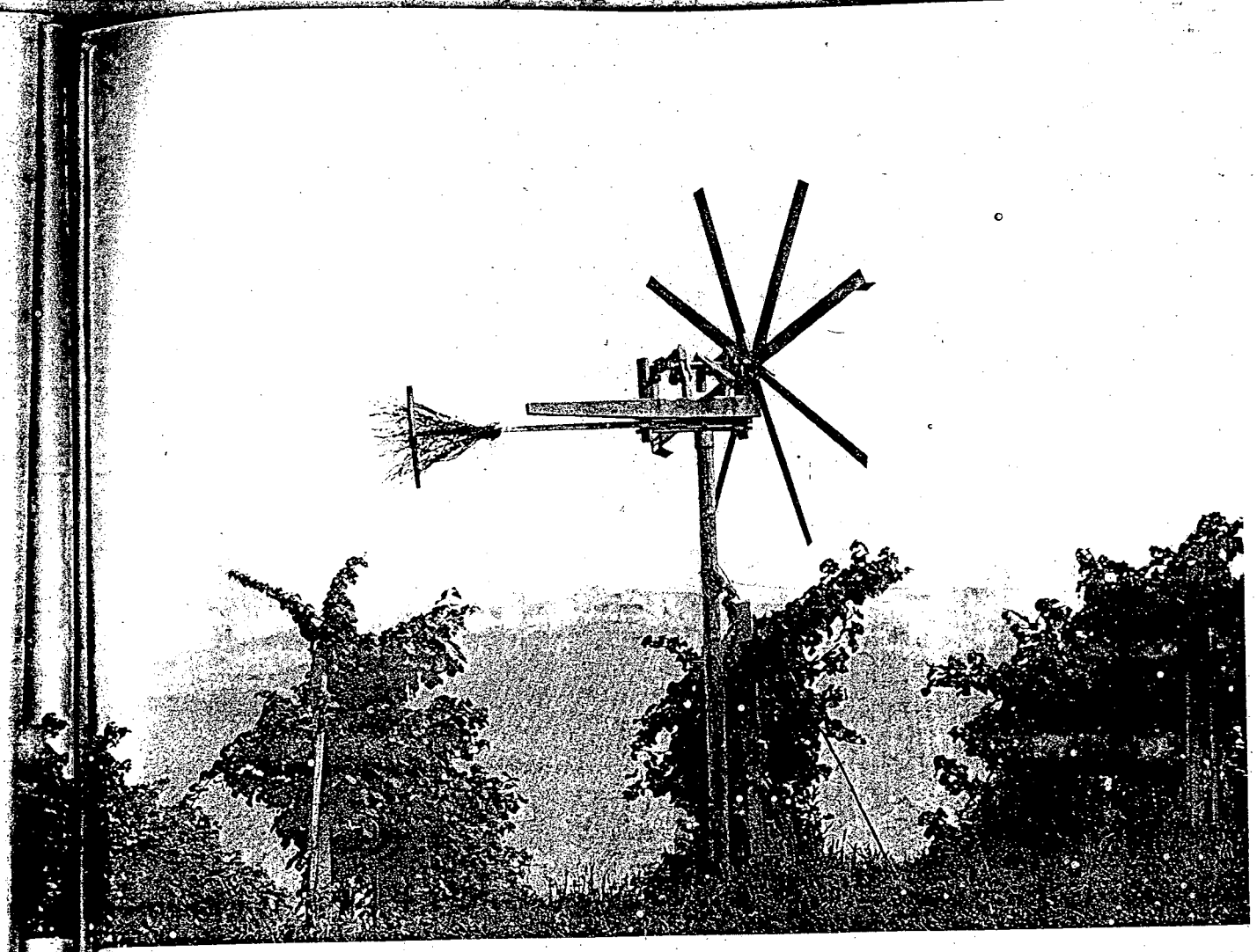


Figure 45. Klapotez, in Styria, Austria.

The running-wheel

The last things which we have described were of a passive kind, that is to say the activity was all in the construction. Once the gadget is finished after much toil and trouble it runs by itself, and you can only watch it. It is quite different with the running-wheel, because you have to run hard with it, as it is blown along by the wind. But you will need not only wind but lots of space, best of all a long stretch of sandy beach. If you go to such a place with your children take a piece of cardboard cut into a circle, the bigger the better. Cut triangles into it and bend out the triangles on alternate sides (see Figure 46). The wind will catch these protruding triangles and blow the wheel along, possibly for miles.

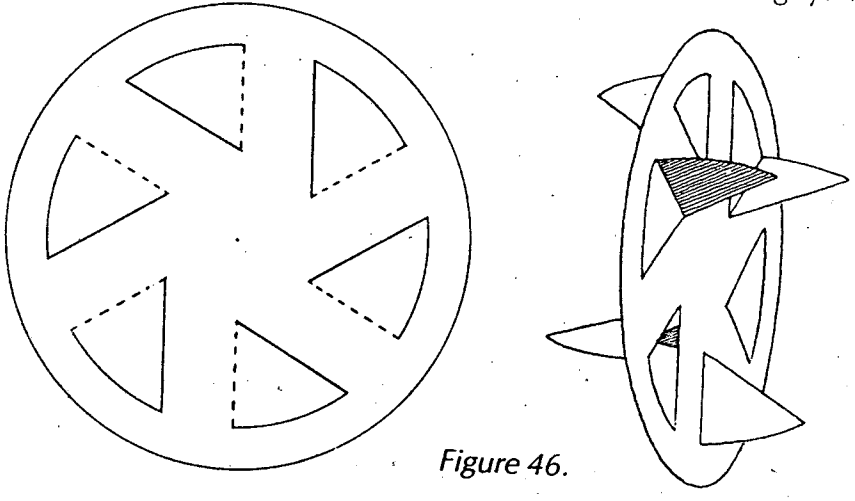


Figure 46.

Wind-driven bogeys

Sail-bogeys are often seen on beaches. You can make model ones. It is important that the wheels, usually three, should be set wide apart, so that the bogey is broad in the beam. You can take either wood or metal for the job. You can also buy kits to make up. The wheels are bought ready-made, and you can get some with solid rubber tyres. The model does not need to have a wheel that can be steered. Set the mast slightly forward of the middle of the bodywork and rig it. It is not difficult to rig a sail, but it must be able to swivel so as to lie to the wind properly. It can be set by adjustable strings (Figure 47). The biggest problem can be finding a good place with wind for the bogey. A sandy beach is often

slightly uneven which does not affect a big craft, but can slow down a small model. A street is very suitable if there are no cars on it. So it is not advisable to start building a sailing-bogey unless you know where you can try it out. A frozen lake or pond is very good. If you mount it on runners instead of wheels you have a sailing-sledge. In this case the sledge will only sail before the wind, as the runners do not prevent side-slip like wheels or a keel in a boat.

A propeller-bogey is also fun. It is constructed on the same lines as the helicopter described on page 48, but instead of the second propeller you construct a wide undercarriage (Figure 48). This contraption will shoot along for quite a distance provide it can run on a smooth flat surface.

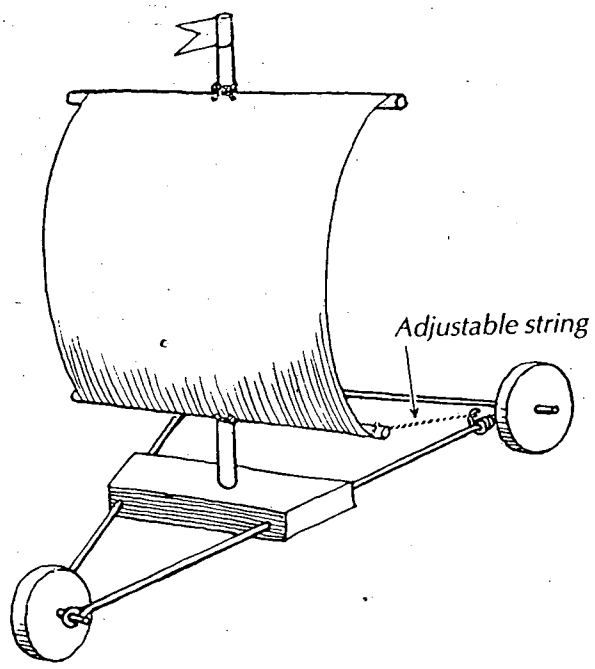
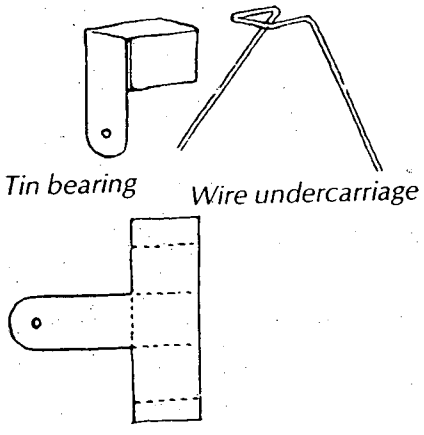


Figure 47.



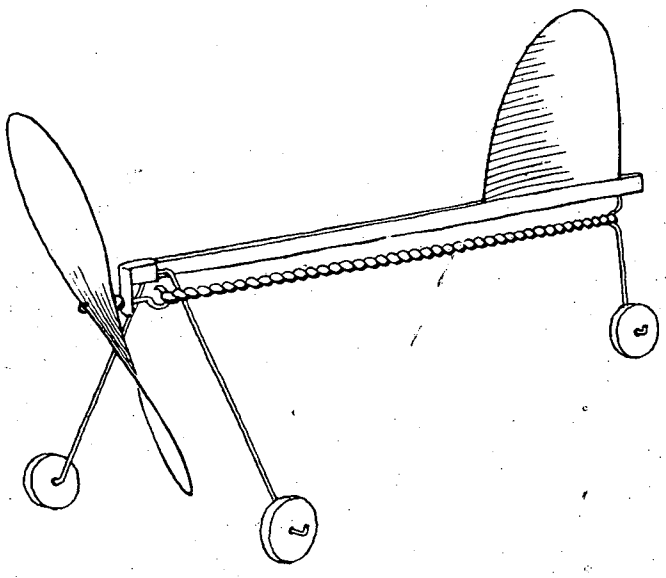


Figure 48.

Kites

Finally we come to the kite. The greatest fun is making it, so resist buying it ready-made. You can make the kite square, rectangular, hexagonal, like a trapeze, round, single-storeyed or double-storeyed, as you choose; you can make it coloured, you can paint it or have it just plain. The frame is built of strong but light rods. Pine-rods or bamboo sticks are suitable. You can take thin bamboo sticks, or you can split thicker ones and use the left-overs in the construction. I shall describe briefly the construction of a kite on classical lines. Tie two rods almost of the same length together in the form of a cross, the shorter rod in the front third of the longer. A taut string tied and glued to the notched ends of the four rods holds the cross in position. Grease-proof paper is then stretched over this frame. This paper is quite light but does not tear too easily. Cloth is stronger but it lets the wind through. It will only work in areas where you can count on strong winds.

Every kite-builder should know that the kite must not be hollow or concave below. By nature this will happen as the fabric tends to belly in the wind. This shape will rise well, but it crashes back down to earth, and you won't get much joy out of it. This defect can be avoided by giving the kite a slight V-form (Figure 49). With this shape it will not rise so well, but once it is up it will hold its position stably in the wind. To prevent the fabric from bellying fix it to the bottom of the frame. To obtain the V-form bend the cross-piece or fix a string to the ends of the cross-piece and draw it tight. Tie a string to the head and tail end. Then tie the line to this string towards the head third. With stronger winds it can be tied nearer the middle, in gentler winds more towards the front.

It is dangerous to fly a kite near power lines or near an airfield.

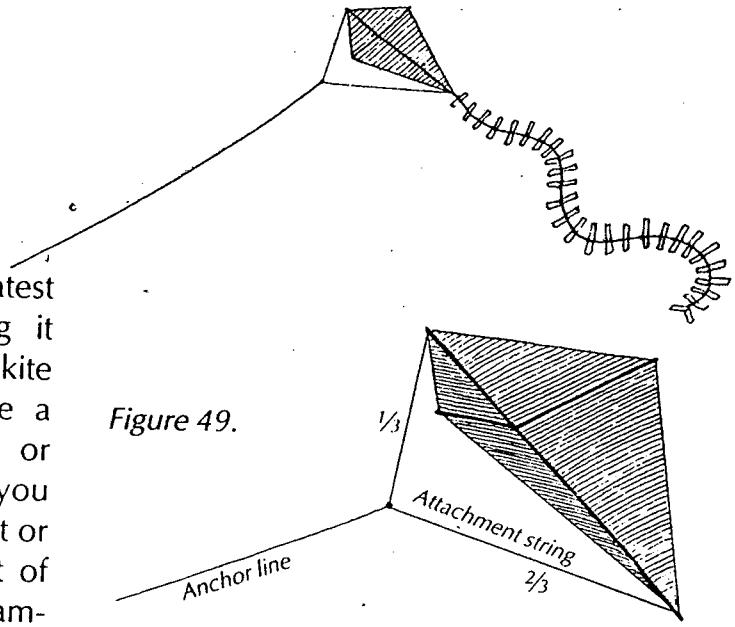


Figure 49.

The boomerang

The boomerang is properly a piece of sporting equipment. It was used by the aborigines of Australia as a hunting weapon. You may be able to find it in sports shops. To learn the art of throwing the boomerang yourself you will need a lot of space. Send away spectators in case you injure them, because initially the boomerang will certainly not come back to the thrower. Once you have some practice, and can gauge the wind your boomerang will fly in a surprisingly wide circle — turning all the time — and come back in a spiral to its starting-point. Some people can catch a boomerang in flight without getting all bruised.

The boomerang phenomenon is physically possible because of the shape of the wood in cross-section which is like the wing of an plane: curved above with a leading edge, and flat below (Figure 50). The rotation causes it to maintain its height. You can try to shape the wood yourself. Good plywood is suitable. Begin with small models in order to gather experience for bigger ones.

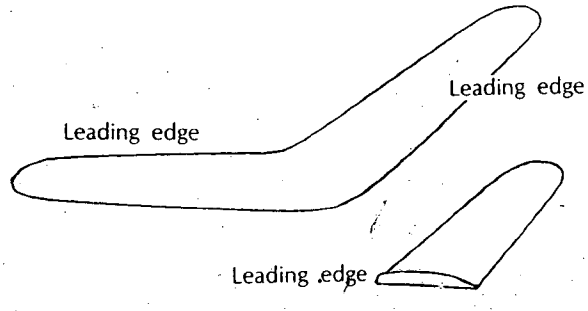


Figure 50. Cross-section: curvature on top.

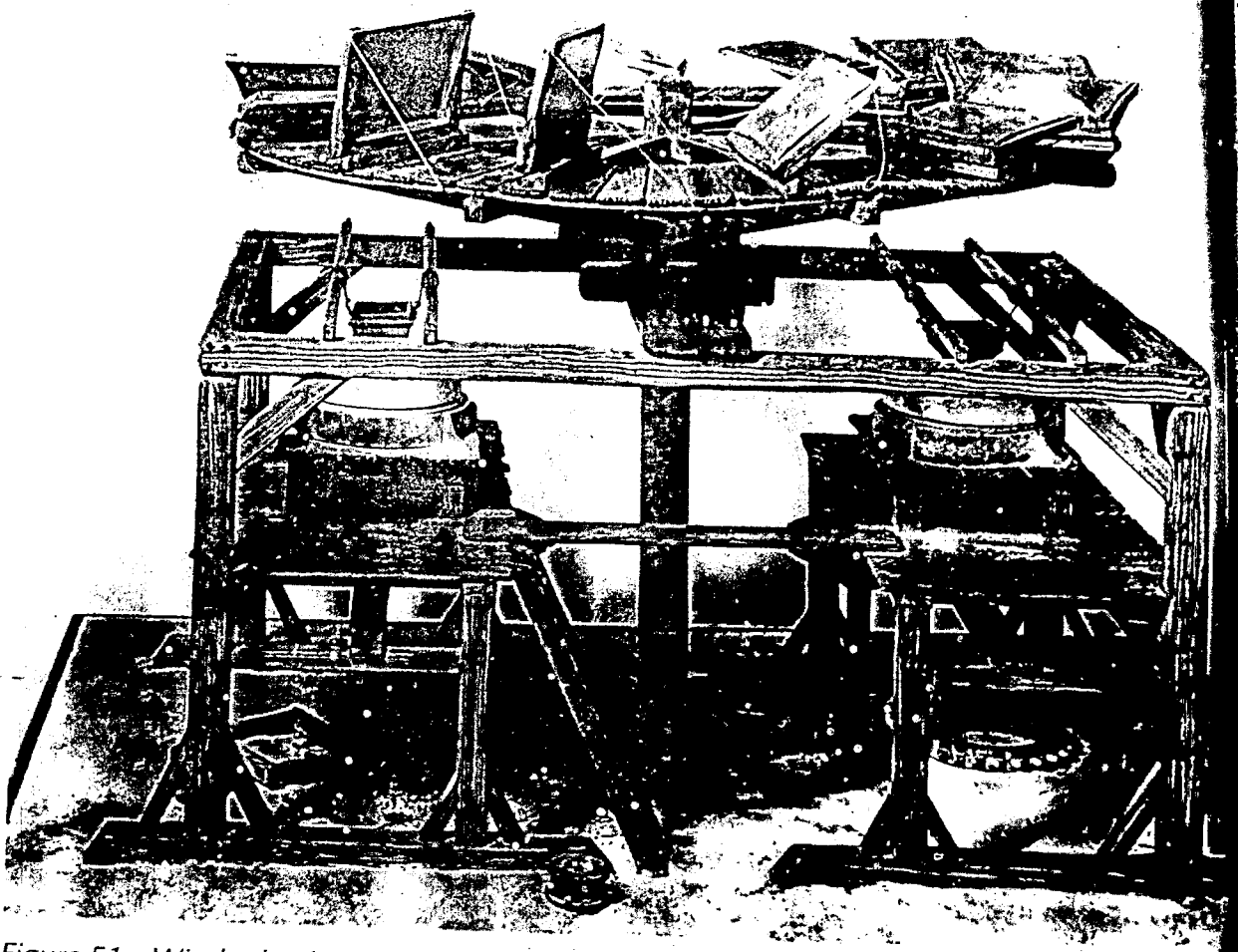


Figure 51. Wind-wheel with flaps, (seventeenth century).

Sailing boats

The possibilities here are endless. The sailing boat combines playing with water and playing with air. There are sailing boats for all kinds of occasions, ages, technical ability, craftsmanship and materials. I shall select a few examples.

You can make a sailing boat from a walnut-shell which is suitable for a bowl or the bath. You can take a match for a mast and fix it with wax or modelling material, some paper for a sail and glue it to the mast (Figure 52) and now you can blow the ship along. Tiny dolls can ride in the boat. If you have a bigger bath or a basin you can build a harbour at each end, an island of moss and stones, a lighthouse on it and already shipping can be in full swing. Many parents will allow a little birthday candle to burn in the nutshell. In this case you can't have a sail and you have to blow with very great care.

Playing outside in the open air by a pool is even better. Already the simplest boat will sail with the wind. You can make the hulls from bits of pine bark, with a little stick as a mast set slightly

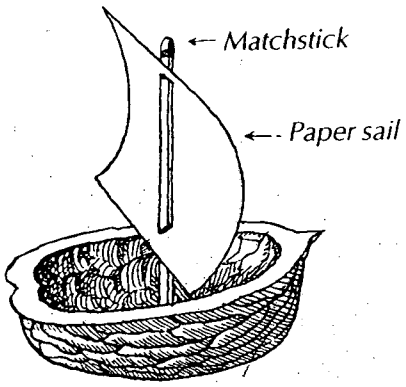


Figure 52.

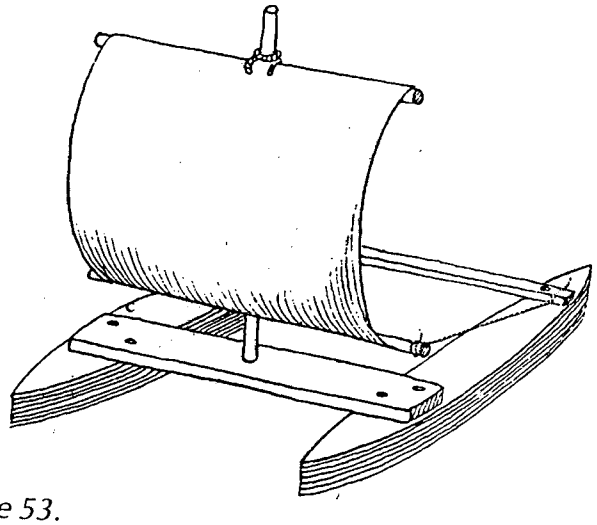


Figure 53.

forward of the ship's middle. You can make the step (the hole to take the mast) with a penknife. A dry leaf is the sail stuck into the mast. If necessary a thin thread can hold mast and sail in position. Do not glue, but tie, that's more natural. You can even use a grass-stalk instead of the thread. With a pocket-knife in your pocket and technical imagination in your head you can build boats by the pond with whatever natural materials are found there. If the wind blows your ship away it doesn't matter for you will soon build another one.

If you have time at home to prepare for playing by the water the boat can look something like this. Cut a board with a pointed end. Bore a hole in it forward of the middle. Put a stick in for a mast. Take a square piece of cloth to make a square-rigged viking sail, or a triangular piece to make a lateen sail or even two sails. At the stern fix a simple rudder which can be turned or bent. You might fit a keel and the boat is ready. The wind will drive the vessel over the water. Again dolls can travel on it if the doll's mother will allow it. But accidents can happen! The wind can blow the boat over to an inaccessible part of the pond. To avoid this you can tie on a long line to the boat and you can pull it back by the line. I once saw a little boat without a line get caught in some weeds and two clever children stretched a line right across the pond and carefully retrieved their boat.

A sailing boat can easily capsize. The outrigger-boats of the South-Sea natives do not capsize, nor do modern catamarans (Figure 53). Once I saw two

brothers, each making a hull. The hulls were then fixed together, with a fine sail, and in this way a boat was built in harmonious partnership. For the catamaran's hulls you can take two plastic bottles which, though not very beautiful, are very much quicker. Of course they must be empty and properly shut. They are joined by three boards, one forward, one aft, and one amidships with the mast firmly fixed to it, and well rigged. Now the craft is ready for launching, but if you are not going to sail with the wind you will need a keel to prevent the boat from being blown sideways.

Here is an interesting variation on this theme. Build four similar boats, they can be nutshells, and tie them together in a cross. The sails must be movable through an angle of 90°. They must only stick out on one side of the mast (Figure 54). When the wind blows, these boats will turn in a circle slowly drifting downwind. A good place for this is a swimming-pool.

You can build a wind-wheel in a similar fashion (Figure 51). This remarkable flap-windmill does not need special instructions, but requires considerable labour.

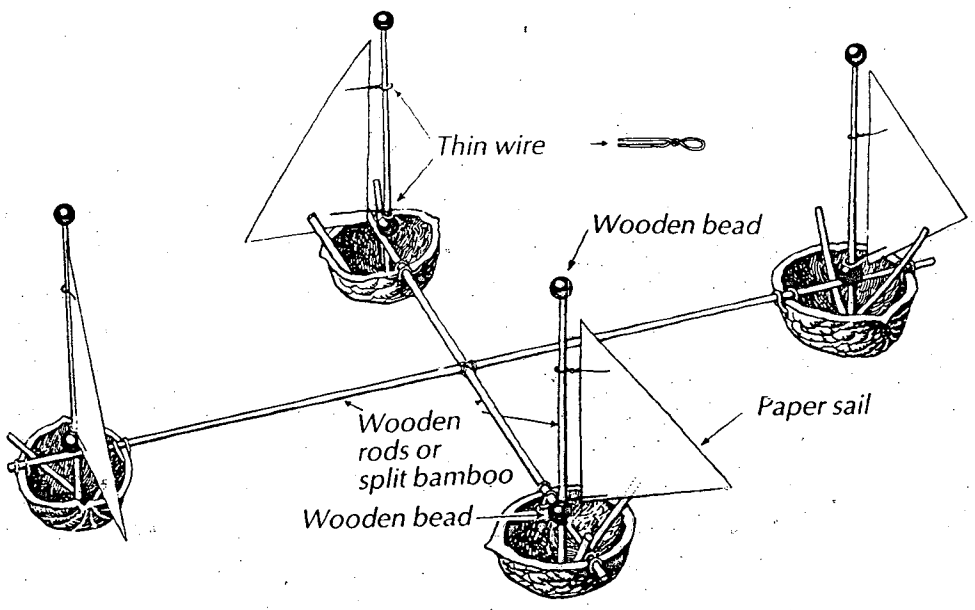


Figure 54.

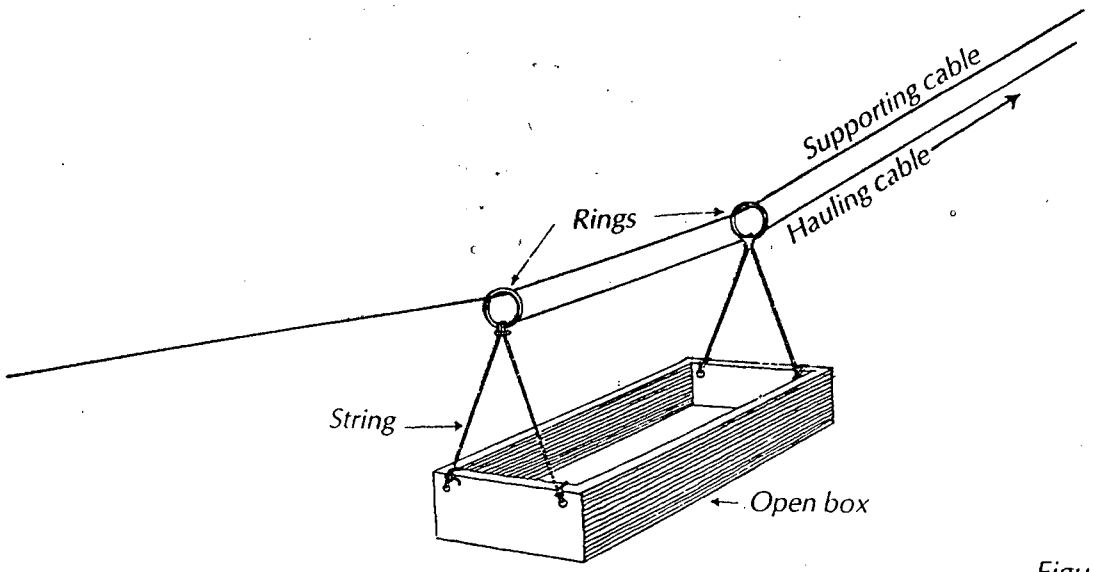


Figure 55.

Cable cars

This subject is treated more fully in the next part 'Playing with the earth', so I shall only mention it here since cable-cars run high up in the air. For the supporting-cable stretch a piece of string from the leg of the table to the window-catch, from a post in the garden to the balcony, from a big stone to a tree, or from one window to another, over a ditch or a hollow. The car is soon built: depending on the size required, as bottom you can take a match-box, a cigar-box, a shoe-box, or even a light wooden vegetable box. At each end of this open container tie a loop of string with a ring in the middle. Pass the cable through the two rings. A second string is fastened to the two rings. This is the hauling-cable (Figure 55). Now the car is ready to convey dolls and small freight. To do this pull the hauling-cable. Admittedly a traveller with pulley-wheels would be better and more realistic, but much more difficult to make. The rings do have one advantage: the ring-traveller rides absolutely surely, it can never come off the cable and fall to the ground. If there is not enough slope on the cable and the car gets stuck you can tie a second hauling-cable to pull the car downhill.

This can be joined to the first cable to make a continuous hauling-cable. You can only have intermediate supports if the car has a traveller with pulley-wheels. That kind of car just rolls down into the valley by itself, but it must be stopped gently.

Finally you can let a traveller run on its own. If a car is attached it must have two pulley-wheels. If the traveller runs by itself one wheel is sufficient, but it will need a weight to stabilise it, as for instance two wooden slats (Figure 56). You can easily make a traveller from one of the usual modelling kits. Now sling up a long cord. It should hang a bit slack then the wheei will run on and up the other end and back down once more. A craftsman can also make a figure such as a cyclist to ride on the cord.

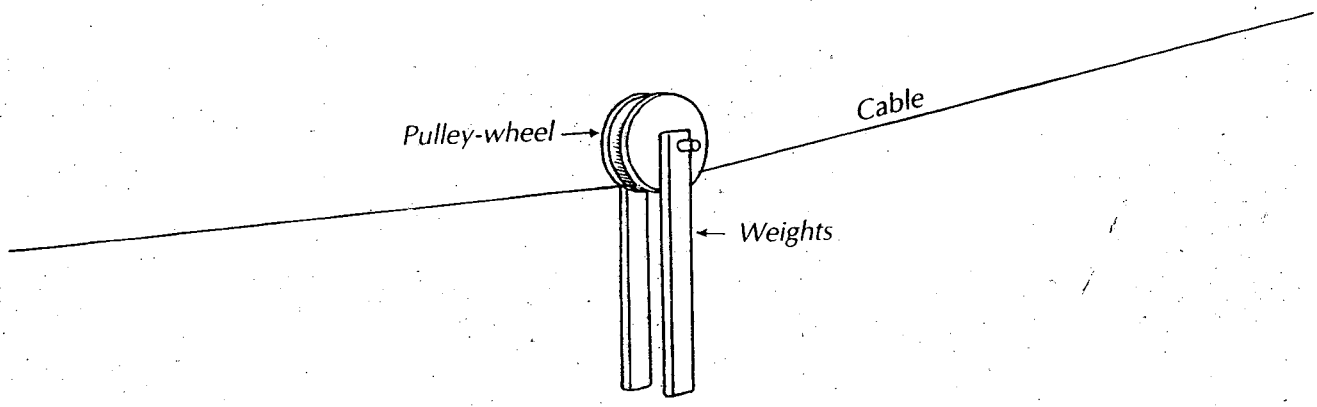


Figure 56.

Playing with earth

Whereas the elements water and air can be played with directly, earth and fire can usually only be played with indirectly; but no less enjoyment can be derived from them on that account. Playing with the elements always involves a certain risk and this risk has to be eliminated, therefore the kind of play must be adapted to the age of the child, and his skill and experience taken into account.

We shall count as playing with 'earth' every activity that has to do with matter, and particularly with weight, whether this weight is used to drive a machine, whether it is overcome intelligently or felt particularly strongly.

Direct play with earth takes place in the sand-pit or on a sandy beach. With this element you can build all sorts of things, and sand mixed with water can be given a certain degree of firmness. Later this play can be transformed into a more serious activity if the child is allowed to look after a bed in the garden. We may take older children to see caves or mines, which are profound experiences of earth.

Any mass which can be modelled, whether it be clay, modelling or beeswax offers the chance of getting to grips with earth. With these substances artistic forms can be created, on a smaller scale to be sure, but with greater possibilities than in the sand-pit. Also different colours are available. In winter where there is snow with shouts of delight the children know how to use it: they make snowmen, snow-castles and caves, and they throw snowballs at each other. All this is playing with earth in so far as earth represents all that is solid.

Then there is wood. Wood can be pictured as earth raised by the plant to bear leaves or needles. Even a less practised hand can carve toys out of wood as used to be done in peasant houses in the long winter evenings, when people were less demanding and children had a powerful imagination. In old books you can still find examples of remarkable toys. In toy museums one can find delightful examples like a herd of cattle made of bits of branches. In Waldorf (Rudolf Steiner) kindergartens

the children play with bits of wood as they appear in nature, or even better with bits of roots. All this is playing with earth in a wide sense.

The earth as a whole is a sphere. It is reflected in miniature by the ball. So really every ball game is playing with the earth, whether it be catching and throwing or whether one is bouncing the ball. It is all playing with gravity. The same applies to playing with solid balls, marbles, bowls, skittles, billiards, croquet, or in winter, curling. There are classic toys which should not become forgotten. For example there is the tumbler in all sorts of variations, and the top in all shapes and sizes, the yo-yo climbing up a string after being jerked, and the hoop to be kept upright as it is bowled along. Apart from the tumbler all these toys require skill and practice. They all overcome gravity and so are cause for astonishment, or are we today so blunted that we can no longer wonder at simple phenomena?

Before I begin to describe individual toys I must mention the swing in all its variations, as see-saw, as rope-swing or at a fair as swing-boat that goes round. On a swing you experience weightlessness for a moment at the highest point and a correspondingly greater weight at the lowest point. There is a similar experience in whizzing downhill in a soapbox on wheels.

Guessing weights

This game is suitable for a child's birthday. Take the kitchen scales, then collect all kinds of objects of different sizes and shapes, all about the same weight but made of different materials: pieces of metal, wood, cardboard, stones, cloth. They can be toys, books, cushions, crockery, articles of clothing and even provisions. Now you need to ask only two questions: which object is the lightest and which the heaviest? The answers can be quite wrong! The biggest article can be the lightest and the smallest the heaviest. The children can weigh them in their hands before the scales determine who is correct.

Domino downfall

Children universally enjoy making things fall over. Dominoes are particularly effective. By setting the dominoes up in a row then letting one fall against the next thus knocking it over, and so on, a whole series with bends and angles in it can be made to fall down. In 1984 a student in Germany took 280 working hours to set up 300 000 dominoes. At night the work had to be protected from mice. It took 18 minutes for most of them to fall over as planned, a new world-record. Even without a record, making things fall over is fun, like knocking down a tower of blocks that took a lot of trouble to build: although the tower falls in a heap while the dominoes fall down in the way that was intended.

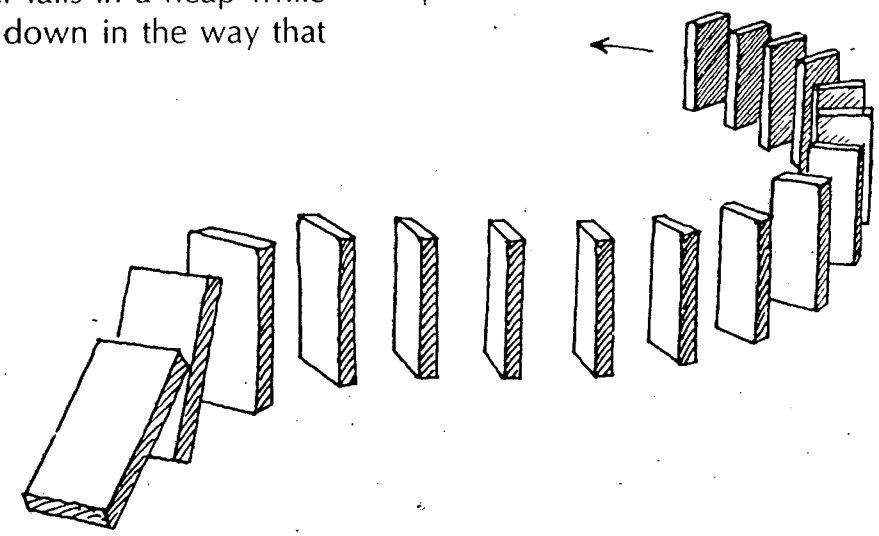


Figure 57.

The tumbler

This toy is the opposite of the dominoes in that it does not fall over. A good handyman can easily make a tumbler, especially if he has a small turning lathe.

The tumbler is round below, ideally a complete hemisphere. The upper part of the tumbler is made as light as possible. You can put a basket on top and let your child put weights in the basket (Figure 58). The tumbler begins to rock more and more slowly until at last it falls over. If you take some of the weights out of the basket it will stand up again.

You can make a simple tumbler with a table-tennis ball. Cut the ball in half, fill one half with sand, close it with a cardboard lid and put a lightweight doll on top.

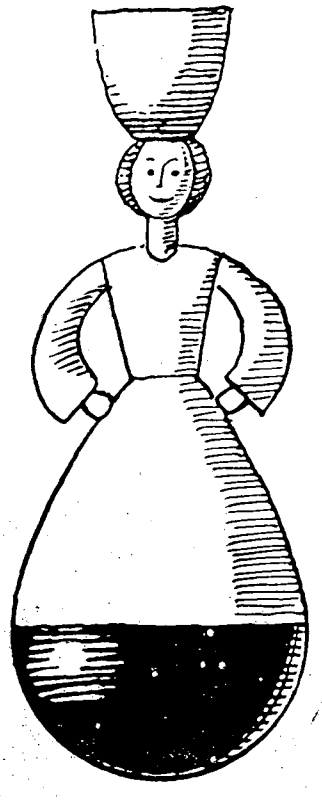


Figure 58.

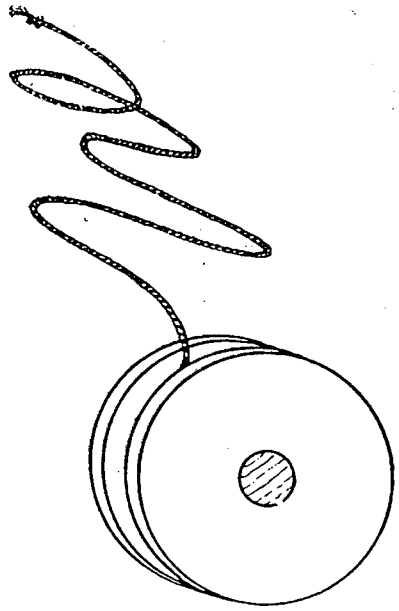


Figure 59.

The yo-yo

It is not difficult to make a yo-yo, and an amateur turner will find it fun. If you do not have a lathe you must find two equal discs, or cut them out with a fret-saw. The discs must not be too thin, for they must act as flywheels to a certain extent to enable the yo-yo to climb up the string. Cardboard discs are not heavy enough. The insides must be perfectly smooth, otherwise the string will rub against them and act as a brake. The discs are joined together by a wooden peg in the middle to which already a piece of string or preferably spun nylon line has been attached. The line should be about three feet (1 m) long with a loop at the other end, and then the yo-yo is made.

Tops

Tops should be made by turning on a lathe. They will spin well and for a long time if a round-headed brass upholstery nail is driven into the bottom. Earlier generations started their tops off and kept them spinning with a whip, or played with a diabolo, also known as 'devil on two sticks', which is a double cone made to spin in the air by means of a string attached to two sticks, one held in each hand. If you do not have a lathe you can take a wooden wheel from an old toy pram and glue a beechwood peg into the axle hole, paint the thing gloriously, and there is your top finished. If you give this type of top a fairly long shaft it will have a remarkable characteristic: spin it inside a box, and the walls do not brake the spin when the top hits them, but instead knock it away. There are games developed from this. Inside a box — an old drawer is very suitable for this — build some partitions with gateways in them and set the box on a slight slant. Wind the string on to the top, place it in a special holder at one end of the box, and set it spinning. The winner is the person whose top gets through most doorways (Figure 60).

Another kind of top can be made from

a wooden sphere. It has the surprising ability to turn over while it is spinning and stand on its point (Figure 61). This little miracle only happens if the upper part of the top is not too heavy, so it should be hollowed out with a thick drill and a little spindle set in it for setting it off. If the top is painted this will give interesting effects before the top stands up.

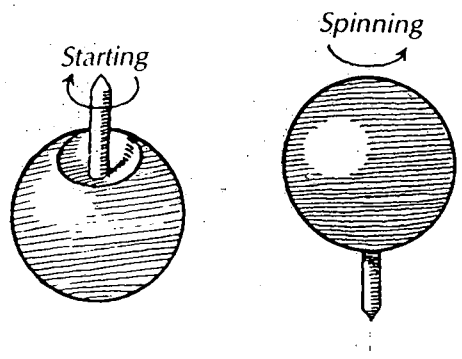


Figure 61.

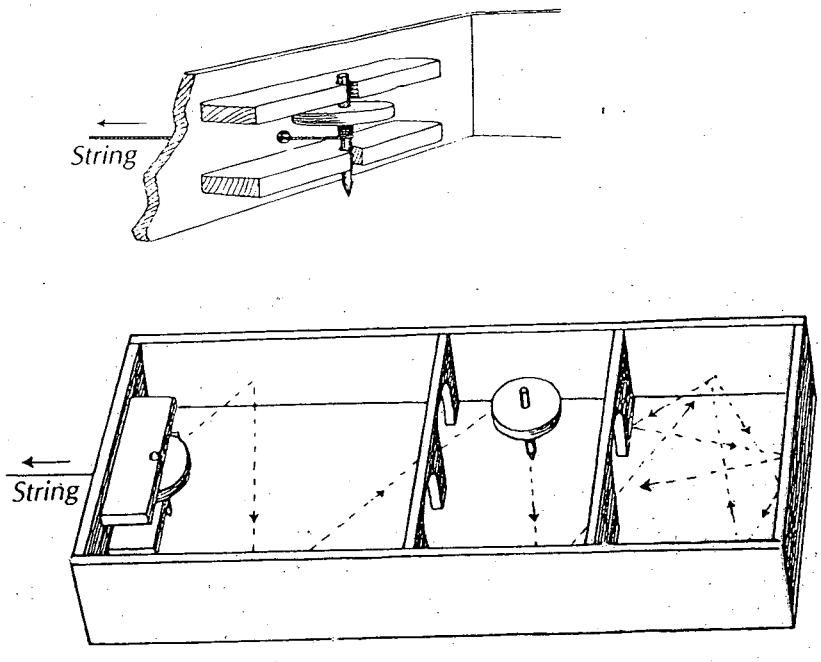


Figure 60.

A Japanese top game

Tops are remarkable things. There is an especially interesting version from Japan: a flat top which spins in the middle of a 'wooden plate' with a raised rim. Along with the top there are two little wooden discs (Figure 62). These are big enough to lie on the top while it is spinning and are taken round by it. Seen side-on the discs are shaped differently and they are also slightly different in size. This causes one to overtake the other by slipping under it. We mention it here only as a curiosity.

Figure 62.

The Zaptarapp

This is simply made: take an orange wrapped in paper, or wrap it in tissue paper. Shape the paper to make a 'hat' that completely covers the orange right down to the table. If you like, paint a face on the paper and there is your Zaptarapp, alive and ready. Give him a push on a smooth table and he will run about in remarkable movements because of the irregularity of the orange.

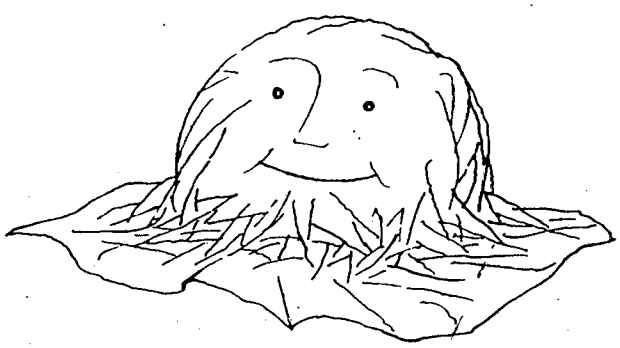


Figure 63.

The cotton-reel

When you are knitting and your ball of wool falls to the floor, you might try to pull it towards you by pulling the yarn so that you can then pick the ball up without having to get up. Usually the ball only unwinds further and runs further away, but it is quite different with a reel of thread, especially if it is nearly empty. If you pull it cleverly by the thread it will come rolling towards you and even wind itself up, but the thread must wind on from below and you must pull very low. Unfortunately large wooden cotton reels are becoming rare. You can make one yourself, out of a round piece of wood and two discs of the same size. The greater the difference between the diameter of the round piece of wood and that of the discs the better it will work. The reel should also have some weight. One might make a game by getting some suitable reels of the same size and seeing who can best wind on the thread.

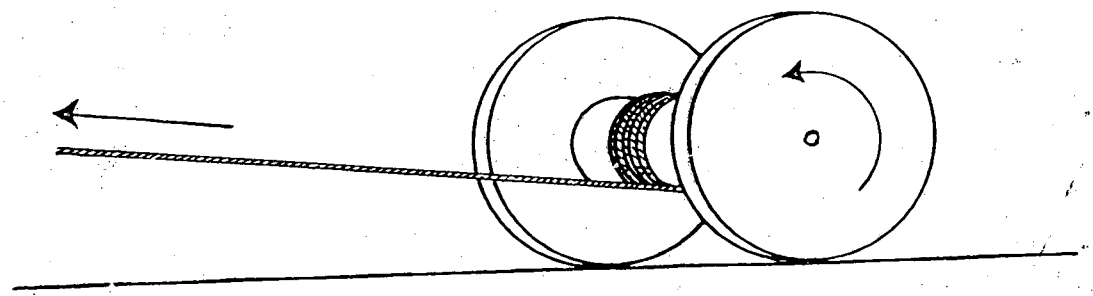


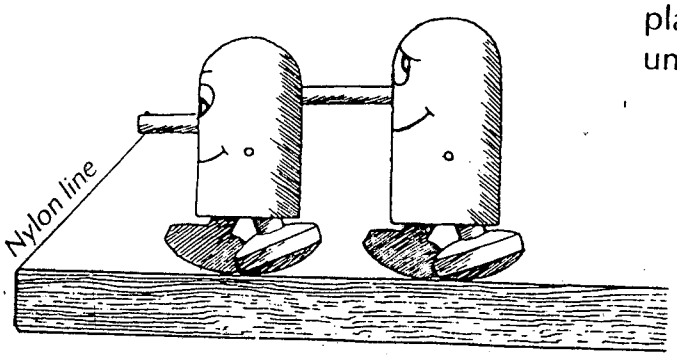
Figure 64.

The walking men

With this toy a weight serves to make two walkers move. Figure 65 shows a model of this kind. The weight hangs by a string over the edge of the table. The two little men are joined rigidly together and wobble from side to side, thus changing their weight from foot to foot. The legs are slightly movable, and so the little men take a step forward every time they wobble until they reach the edge of the table, where they promptly stop. They never fall over the edge.

It is tremendously difficult to make the men, and it may need several attempts, but it can be done. The weight and size of the men, their centre of gravity, the mobility of their legs etc. must all be balanced up exactly. The feet are rounded along the side of the soles. What a triumph for the craftsman when the men finally do walk like clockwork right to the edge of the table.

Another traditional plaything is the walker on the sloping plank (Figure 66). He walks down, having one movable and one fixed leg. He has to be so balanced out that he wobbles slowly downhill like the two men with the weight and string. This time the man's own weight makes him move. This plaything too requires many patient trials until it works perfectly.



Weight

Figure 65.

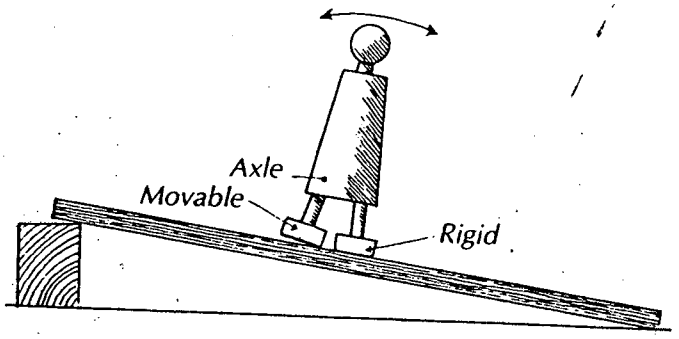


Figure 66.

The acrobat on parallel bars

An ancient toy is the acrobat swinging along two slightly sloping parallel bars. This toy can be bought, but it can also be made without much trouble. The bars are mounted on a board so that they slope gently down. Cut the acrobat out of a piece of plywood. Insert a round rod through him slightly off his point of balance. You can also paint the acrobat on a disc or simply use a disc, but the axle must be set eccentrically, otherwise the disc will just roll smoothly down the bars, not rhythmically which is much more fun. To start him off the acrobat will sometimes need a little push.

You could make the bars quite long so that the ends touch the ground and see what happens when the wheel lands on the ground still rolling.

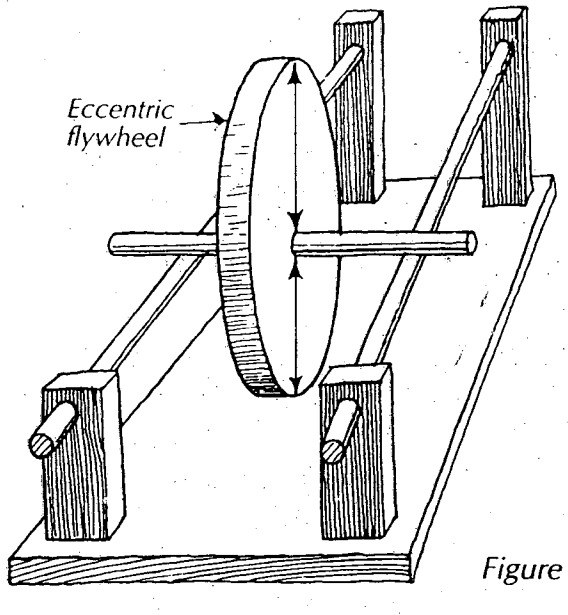


Figure 67.

Ball-runs

It can be fun to make a ball roll down a prescribed route to the bottom of a run. This we shall call a ball-run. You can buy them ready-made, but then you lose the best part of the fun which is trying the thing out to see if it works: can you get a ball to gather enough momentum to clear a level part, or even go uphill again, will it jump out of the run if it is going too fast round a sharp bend? It is exciting to adjust a home-made ball-run until it works properly. There are many wa make one. Firstly you can buy re made conduits with bevelled joints the bends. The conduits are simply end to end in a sandpit. But if you w to make the whole thing yourself you not have to have a router, you can side slats on each side of the flat botto slat, wide enough apart to take the ba which you are going to use. To make t bends just saw the ends off obliquel This kind of gutter gives the balls a ve sure run, and it is almost impossible fo them to jump out. You can make th runs even more economically by nailin or gluing square slats on to the top of

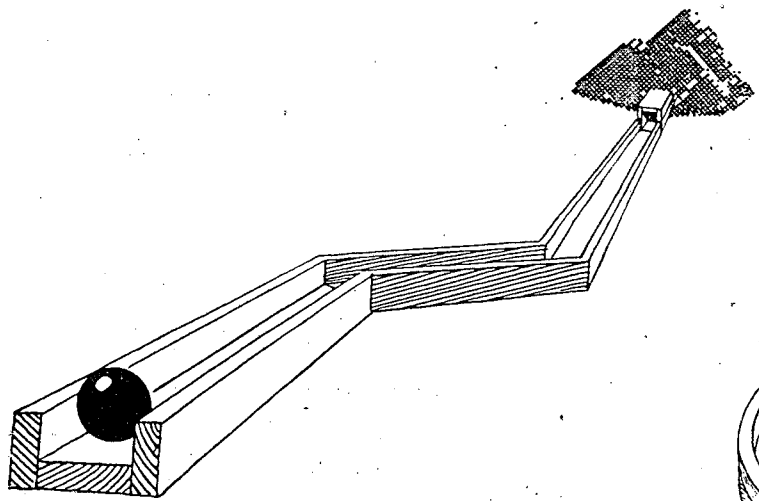


Figure 68.

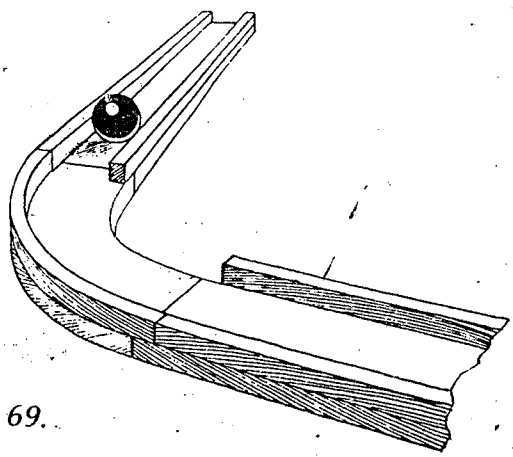


Figure 69.

flat slat at the sides. For the bends it is enough if the far side has a side. With this system the bends are always rather unsatisfactory as they have steps. But for the sand-pit they are quite sufficient. Two conduits, one laid on top of the other, make an excellent tunnel which can be dug into the sand.

The balls can be porcelain or glass marbles or you can get steel ball-bearings of any size. Those of inferior quality are cheaper. Steel balls are heavy and so roll particularly well. But even at home you can find adequate balls, for example, round wooden beads or even peas. As we have said the width of the run must be according to the balls, but it is surprising how wide the run must be for a particular ball.

So far I have dealt with wooden gutters laid end to end, but you can vary the run, although it must be said that the problem lies in the bends. Hoses or tubes are the first variant, and indeed a run can consist entirely of tubes, but then the ball is completely shut in, and there is no risk of it jumping out. A combination is possible: straight pieces as open wooden gutters, and the bends in flexible tubes, for instance electricians tubing or an old garden hose. It is up to the skill of the constructor to join up tubes and gutters. For this rubber bands can be used.

Such a run does not have to be in sand, it can be built on a sloping field and the gutters supported by sticks stuck in the ground. You can do without the bends of tubing if you allow the ball to drop from one gutter to the next.

In winter we can still go on building ball-runs. A snow-mountain is an ideal basis for gutters of all types. But you can also build a ball-run indoors. Every good playroom has building blocks of all kinds, or you can take boxes or books as supports for the gutters. The problem is to make the gutters firm, especially if you are rolling heavy steel balls. Adhesive pads or tape, elastic bands or even paper clips are useful. For use in the house you

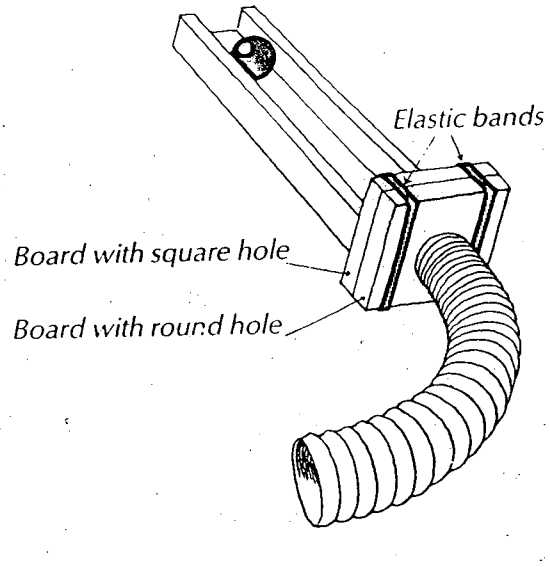


Figure 70.

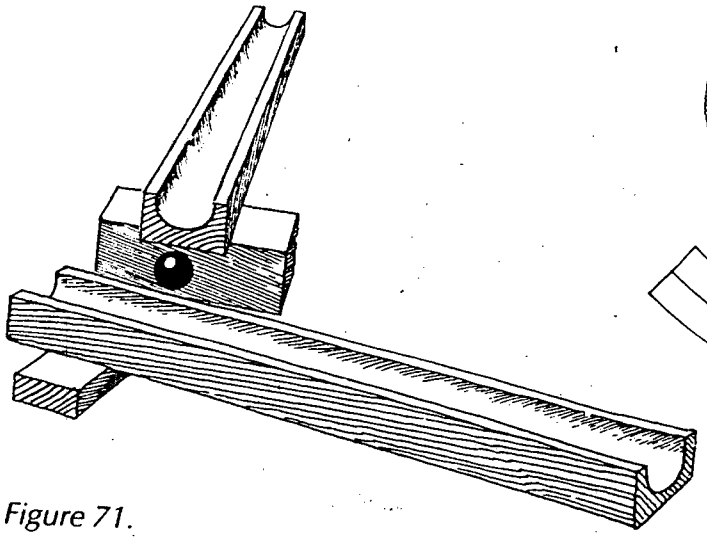
can make good bends with cardboard and stick them on to the wooden gutters.

It is often difficult to keep a sick child in bed but you may succeed by giving him the equipment to build a ball-run. Give him a good platform such as a board, a piece of plywood or even strong cardboard, some stiff paper (such as drawing paper) and a pair of scissors, some glue and some little balls, for instance from a bicycle ball-bearing.

You should always build ball-runs from the bottom upwards, but first the child can make an open box out of the paper for the balls, so that they do not get lost in the bed. The first paper gutter ends in the box. Make the gutters from strips of paper. These can be folded in one of three ways:

1) V-shaped gutters: place a ruler along the centre-line of the strip and fold one half of the strip over the ruler.
2) U-shaped gutters: fold one third of the strip over the ruler, then fold the opposite third over the ruler.
3) Semicircular gutters: wind the strip lengthwise round a pencil or rod.

The supports are also made of paper. To prevent the supports from buckling fold them lengthwise to make an oblong box. In building construction the same technique is used with sheet-metal.



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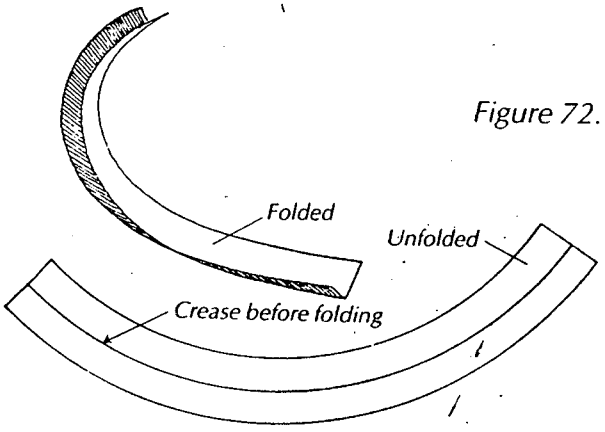

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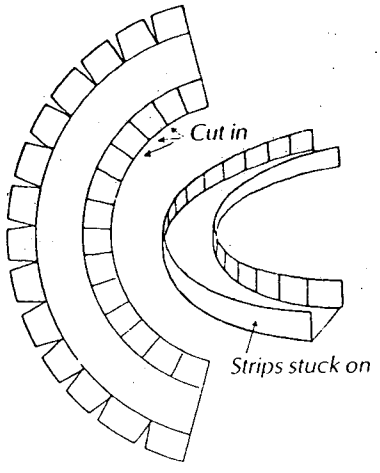

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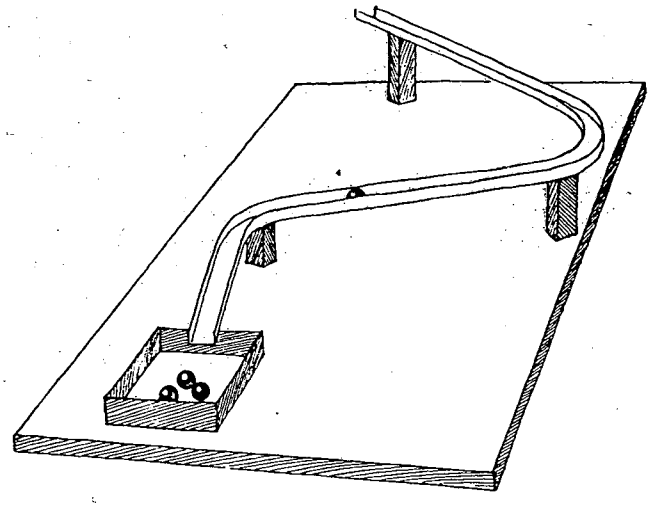


Figure 74.

The child will want to make bends. It is quite easy to bend the V-shape. Cut a piece for the bend out of paper and crease it bit by bit with your hand and bend it and so your bend is ready (Figure 72).

The U-form has to be cut in from the side, bend the flaps up and stick them together with long strips (Figure 73). The semicircular kind cannot be bent easily.

Stick the first bend on to the straight piece and give it a fresh support. Proceed backwards until you have made the whole run. The whole thing looks like a switchback (Figure 74).

Every new piece added to the run must be tried out before proceeding further. Several alterations may be needed. A piece may have been set too steeply and the ball jumps out at the next bend; or it may be that the ball gets stuck somewhere and needs a steeper incline to give it more momentum. To prevent the ball jumping out at the bends the sides of the latter can be heightened by adding extra strips. If the supports collapse they must be strengthened or made more stable by joining them together. Fit a small paper funnel at the top where the ball goes in to give it a better start. If the run will not stand firmly, use a wooden rod here or there to steady it.

Once the run is finished the child can start rolling the balls, one after the other,

and see if one can catch the other up. Usually it is possible to build a second run in the first framework, that makes a splendid complex. There are all sorts of possibilities; fast runs and slow runs. You might like to use bamboo cane which is suitable material for a ball-run made of natural materials.

One good variation for all runs is a little dip. The ball then gathers momentum and goes over the next hump. If you put a ball in the dip and let another equally heavy ball roll in from the top, it will cause the first one to move on, while the second one stays stuck (Figure 75). You can try this out with several balls.

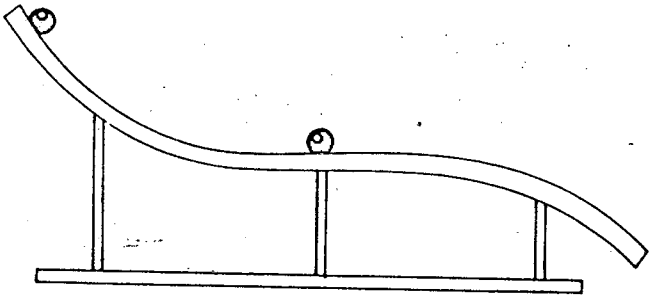


Figure 75.

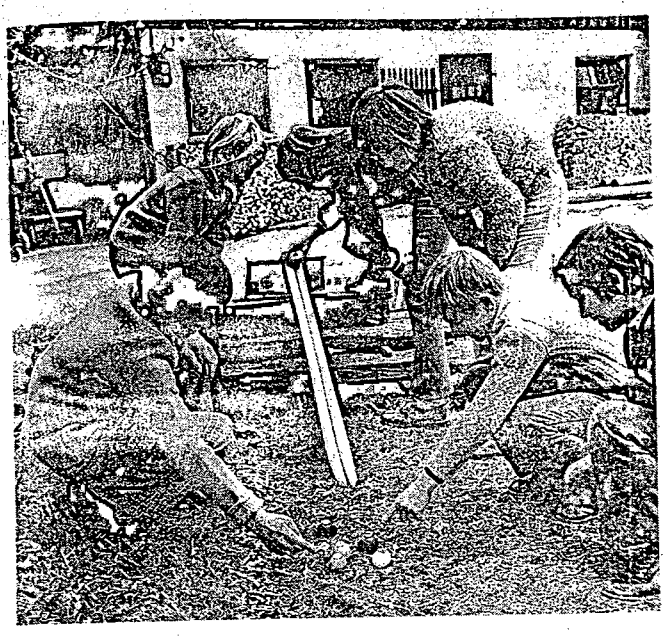


Figure 76.

Rolling eggs

Variations of this game are found in many countries. In one version coloured Easter eggs, as hard-boiled as possible are rolled down a run. The run consists of two similar shafts laid close together. The egg rolls down on to a field where there are already other eggs. Each child lays a penny on his egg. The new egg has to be started with such skill that it hits as many other eggs as possible, knocks the penny off the egg and in the course of this does not get cracked. The height at which the egg is launched and the way it is laid on the run (where the pointed and where the round part lies) determine the way in which the egg rolls in the grass.

The displaced pennies belong to the last child to set off an egg; these he collects and lays one of them on his egg which has now joined those on the grass. The next child takes his egg from the field and sets it off to try the same again. If your egg breaks during the game, you can get another, but you are allowed only one egg at a time in the game.

The slide

Up till now all these rolling balls did not push anything, we just had fun with them, but you can use the tendency of a ball to run downhill to push something. The vehicle can be a matchbox. You can make the run out of strong paper or light cardboard; make a broad U-shaped channel somewhat wider than the matchbox. Try out a straight run first in order to ascertain the required declivity. Behind the matchbox we let a steel ball roll (diameter about ¾", 20 mm). Place a little doll inside the matchbox. Now make the bends. To stop the box from getting stuck the run must be wider at a bend. You do not need an inside wall on the bend as the ball will stay on the outside because of its centrifugal force. A little box, narrower at the front and covered over, looks better, and can be made easily. It is best with an indentation at the back to take the ball. For this kind of run the supports should be built of slats. An even incline is recommended. To make it more attractive you can paint it in colour, and you can make a cash-kiosk, because the dolls are not allowed to go sliding down without paying. It might even be possible for you to make a conveyor-belt to take the vehicle from the kiosk to the top. Then you just put the ball behind it and the journey down begins.

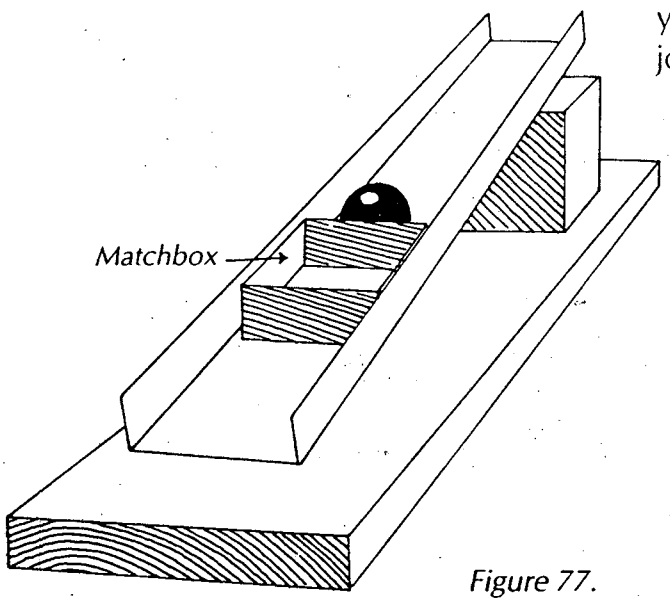


Figure 77.

The gravity-car

The slide can be developed further. Stick a loop of paper in front of the matchbox and put the ball inside. This time use a tray as a base. As you tip the tray slightly the ball runs down and pulls the matchbox after it. A further development might be to fix two little wheels at the back and close the front. The hood covers the heavy ball which is the engine and this makes the whole affair mysterious. The ball will rub against the cover and the sides, so it is a good idea to lubricate these parts on the inside with graphite (lead pencil). Now the gravity-car is finished. Of course, a doll inside reminds us of the go-cars at a fair.

Now the whole thing can be made much more exciting by taking a flat board (plywood is the best) and building obstacles on it: blocks, traffic-cones, traffic-signs, archways, tunnels and even a garage. The board must have a surround to it otherwise the car will easily fall off. And now we can drive through the countryside, without polluting the environment, by moving the board so that gravity works.

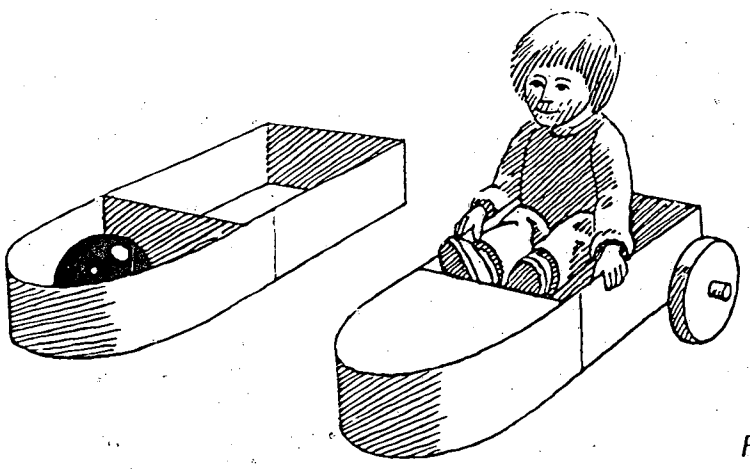


Figure 78.

The somersaulter

The somersaulter is an ancient toy that keeps on coming back into vogue. He will turn somersaults on any inclined plane. What makes it work is a heavy ball in the hollow head. If you make one yourself you will only succeed if you keep the following points in mind.

Take as heavy a ball as possible. For his head take a cardboard cylinder somewhat wider in diameter than the ball and about twice as long. Place the ball inside the cylinder and close the ends by sticking on some strong material.

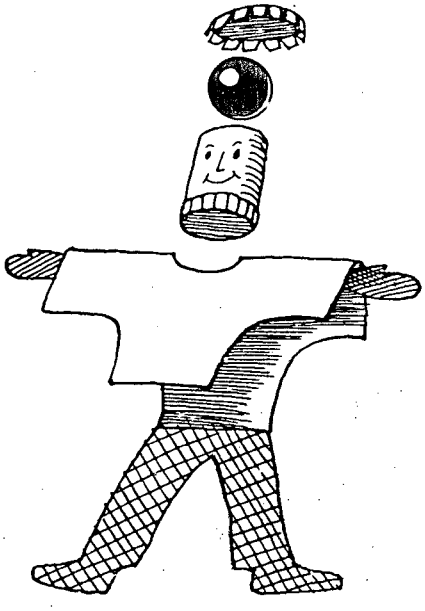


Figure 79.

The rest is a matter of artistic design. Cut out a body with outstretched arms and legs, the top part of the body double. Stick paper over the cylinder and paint a jolly face on it. Now stick the head into the upper part of the body. Sew or stick the body together, adding hands, feet and even a cap or beard and that is the somersaulting dwarf ready (Figure 79).

The incline on which the toy is to turn somersaults must not be slippery otherwise it will just slide and will not turn properly. Any board with a cloth over it will do. It is interesting to try out how much slope is required to make the thing work. The little man will also turn somersaults on a pillow, on the ironing board, on a deck-chair, on a slope in the garden; and children will find other places. You can sometimes buy somersaulters.

You can also have fun experimenting with balls in little boxes of different sizes. The boxes will move in remarkable rhythms down inclined slopes.

The earth-moon game

With wooden balls one to two inches (3 to 6 cm) in diameter, you can make a good and instructive toy. Attach eye-screws to two balls and tie them together with an elastic band (Figure 80). Now hold one ball in your hand and let the other swing round in a circle on a table. In this way the elastic twists up and the toy is wound up. Now place both balls on a table-top and give them a little push. The balls will revolve round each other.

It becomes more interesting if we take balls of different sizes. The little ball makes a big orbit and the big ball a little orbit. The balls revolve round their common centre of mass (Figure 82).

What do we learn from this? We have a model showing the motion of the earth and the moon. The earth (large ball) holds the little moon as on an invisible rubber band and pulls the moon round itself, much more slowly of course as it takes about twenty-eight days.

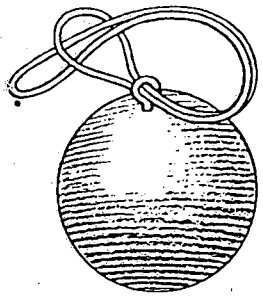
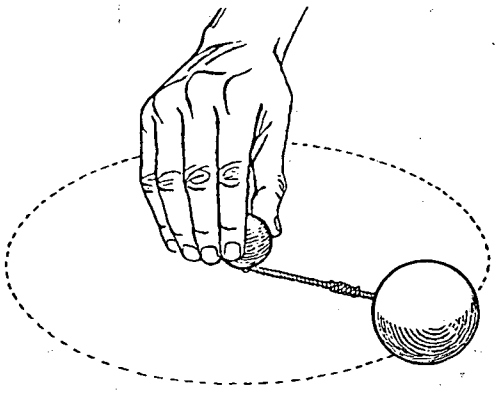


Figure 80.

Figure 81.



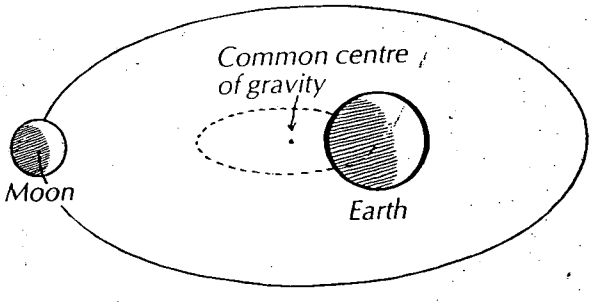


Figure 82.

Funiculars

A funicular is a cable-railway that is on a steep track. The car is hauled by a cable. Usually there is a second car on the other end of the cable, so that when one car is ascending the other is descending. The cable goes round a wheel at the top. You can construct a toy on this principle.

Start with a smooth board. Set it up on an incline, for instance leaning against a table. Then you will need a car that can be loaded. Tie a string on to the car which you have chosen and you can pull the car up the board. You can have a doll sitting in the car. Now make a winch with a pawl and ratchet-wheel so the action can be stopped and the car held at any stage of its ascent (Figure 83).

Now you can winch the car up. For the car to descend into the valley again you disengage the pawl and use a fingers as a brake. The car rolls down by itself due to the force of gravity. Expert engineers will fit a mechanical brake on to the winch. Of course you can build a special car with seats set at the correct angle for the incline, as is the case with real funiculars.

Once you have achieved this you can

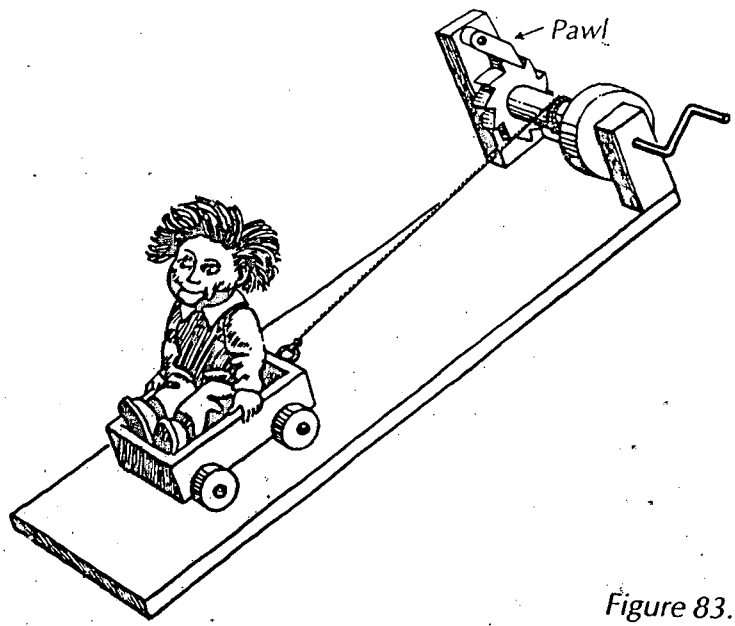


Figure 83.

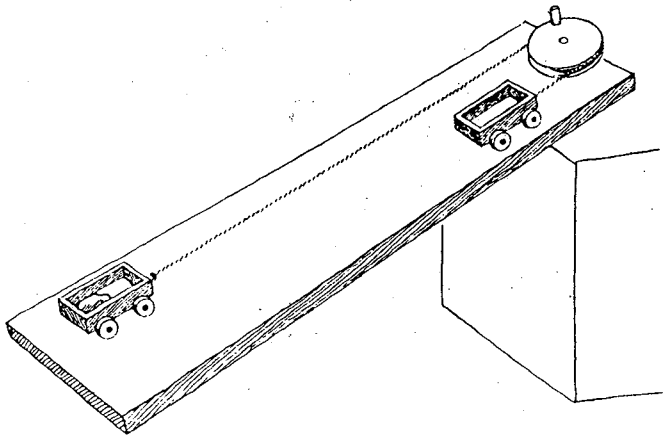


Figure 84.

think of the other funicular which you make with two cars, it does not matter what kind they are. In this situation you don't need the winch, but instead you will need a large pulley-wheel round which you pass the cable, or you can take two smaller wheels set far enough apart to prevent the two cars bumping into each other as they pass. The wheel should have a handle so that you can turn it, and the cars guide-rails, say two cats outside each set of wheels. But if the car has rimmed wheels on one side one rail for each car can be the guide-rail.

Now the traffic up and down can begin. As one car travels up, the other travels down. If the top car is heavier than the bottom one they will both travel self-propelled! As a weight you can use a suitable stone. Once the car has come to the bottom the stone must be taken out, and put in the top car so that the journey can start all over again. Be sure to put the brakes on in time! In real life funiculars are built with one track except at the middle where the cars pass each other. But it is better not to try to copy this; you will not succeed with this kind of model, as the friction is too great.

You could drive your funicular electrically if you have a small motor and the necessary skill.

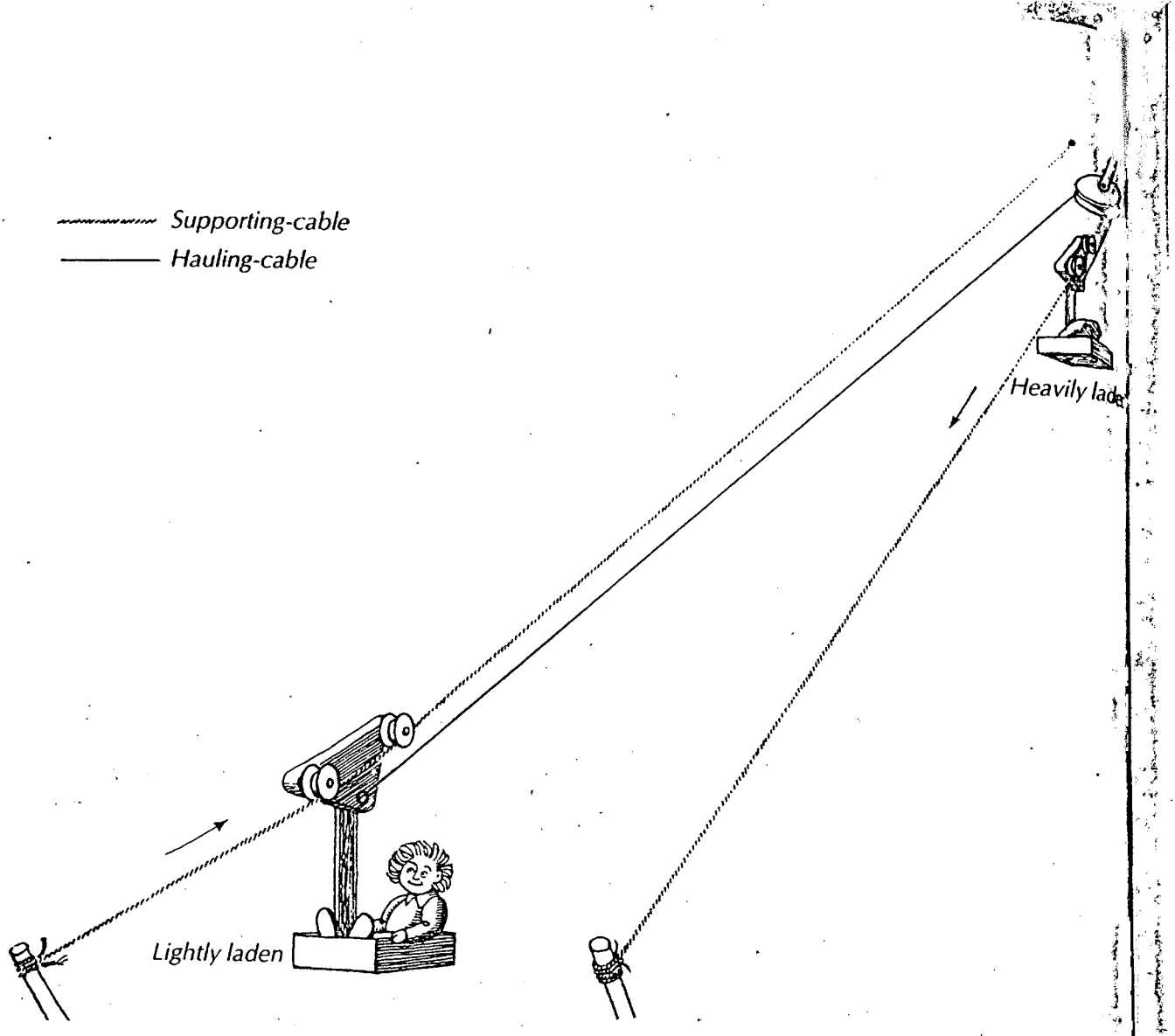

Supporting-cable
Hauling-cable
Heavily laden
Lightly laden

Figure 85.

Self-propelled cable-car

Unlike the funicular these cars run on cables. The cars must be equipped with easily running pulley-wheels (Figure 85). Take care that they hang straight. You can of course make the cars in any shape or size that you choose — even a gondola with a roof can be made. When the car is finished, tie a string tight on to a suspension point. Hold the other end and put the car on it. If you raise the end which you are holding the car will run away from you. If you lower it the car will come back. Its weight makes it go.

Now take a long cord (cable) and stretch it between two points and let the car travel by itself, as in the photograph. At the bottom either the cable is slack and goes up again and the car comes to a stop or if the car does not travel too fast it can be stopped by the branches of a tree. To get the car back up, pull it by a piece of string tied to the traveller. You can build supports for the cable, and if you do this cleverly the car will run over the supports without jumping off the cable.

In a self-driven two-car cable system there is one difficulty. Once they are set off they will accelerate and they will have to be braked before they reach their destinations. Hang the cables slack so that they are steeper at the top and run out more level at the bottom. This makes for good operation. The top car, as already described in the funicular, is loaded heavily and so draws the lighter bottom car up, for they are both attached to the same hauling-cable. This cable also passes round a wheel at the top of the mountain. The top (driving) car when setting off has a good start because of the steepness and it can accelerate both cars. When it comes down to the flatter part of the cable it loses momentum and both cars slow down.

By careful and patient experimenting you can make the cars stop exactly at the

Figure 86.

stations without braking and without any outside interference. Children might like to make houses at the top and bottom stations, or the child sitting at the top can collect a heap of stones and the one at the bottom can set dolls and surprise-packets in the car to be transported automatically up to the top.

Clocks

I am referring here to those clocks which are driven by weights. The weights are hung on chains or cords which wind on to a drum when the clock is wound up. The drum drives the hands of the clock through a set of gears. The hands would whiz round much faster than they should and the weights would crash down on to the floor if there were no escapement. This ingenious invention makes the clock run at the right speed. This mechanism is also helped by a pendulum or balance. That is the principle of the mechanical clock.

Not everyone is logical enough to discern how to make a clock. As a beginner you can buy a kit for making clocks. These kits are manufactured in a series of grades. If you want to become a clock-maker I recommend that you start in this way.

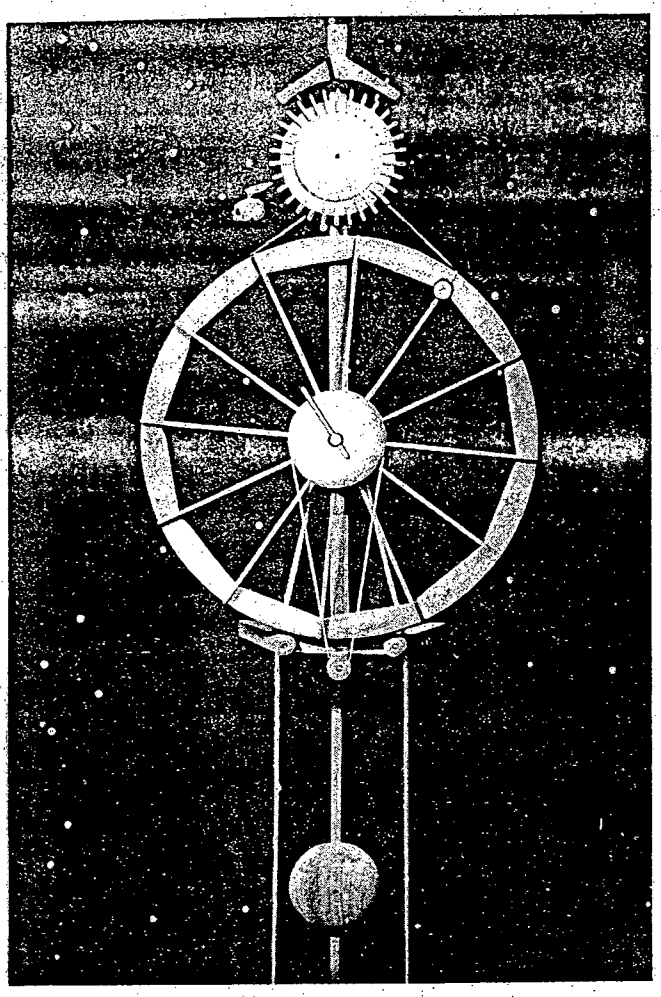


Figure 87. Simple clock (designed by Uwe Bosse). Below on each side is a cord. On the right hangs a weight, and on the left a lighter counterweight, kept apart by two little pulley-wheels. The drive goes directly on to the big minute-wheel on which a button acts as the minute-hand. Above, the escapement regulated by the long pendulum. The arm projecting out to the left keeps the tension on the transmission cord. The reduction transmission 12:1 for the hour-hand goes over the central little wheel below to the disc in the centre. The clock shows 6 minutes past 11.

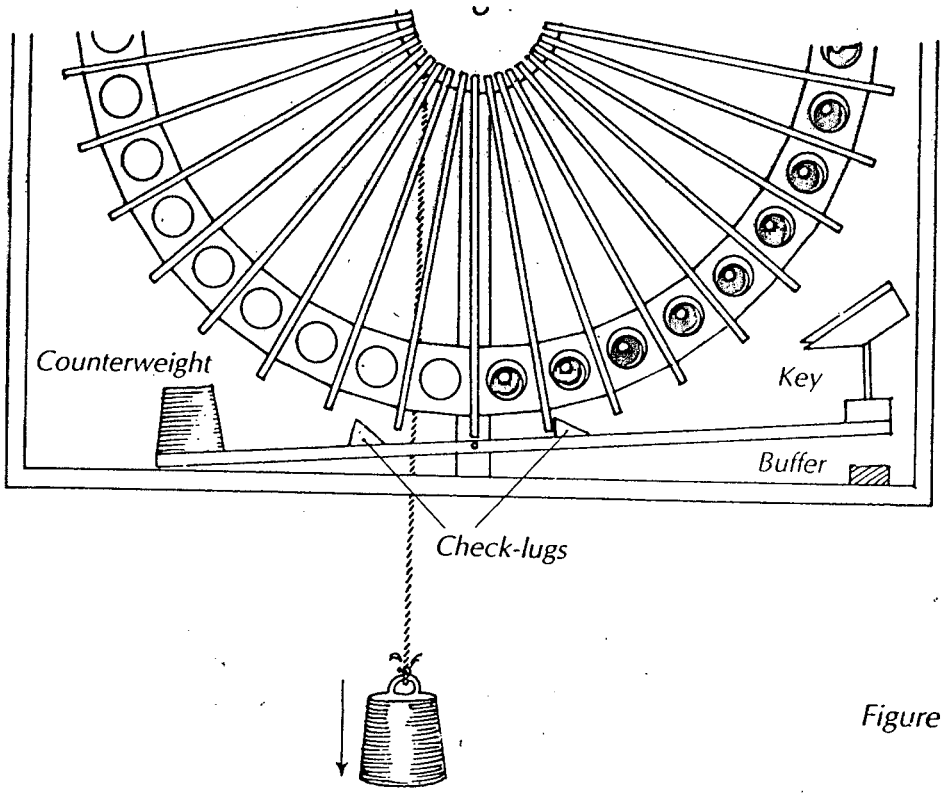


Figure 88.

The ball wheel

A ball wheel is an automatic ball-run. By means of a weight the balls are brought up to the top of the device in compartments of the wheel. The mechanism runs by itself (Figure 89). Before the ball falls into the bottom rill it rolls over a key which it presses down by its weight. This key is mounted on a see-saw, on which there is also a check-lug (Figure 88). This lug catches on a projecting spoke and checks the wheel. As the see-saw dips, the lug releases the wheel. At the same time a second lug on the other side of the see-saw rises and checks the wheel again. Because of a counterbalance the see-saw now returns to its original position and the wheel is again checked by the first lug, but it has moved round by one chamber, and so for the ball which has arrived there is an empty chamber ready.

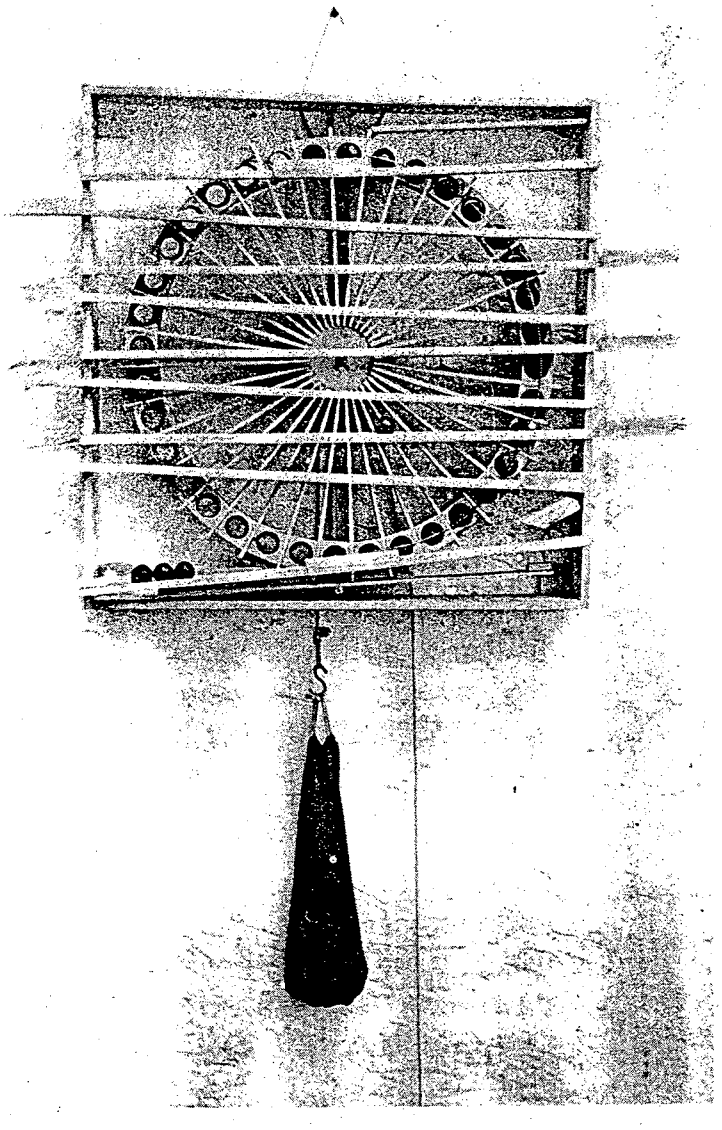


Figure 89.

[illegible] same time all the balls in the [illegible] are raised by one spoke, and a [illegible] drops from the top chamber. If [illegible] has a drop of three feet the contraption will run for about an hour. Of course beforehand many hours of intense experimenting are necessary to make this ball wheel run fairly well.

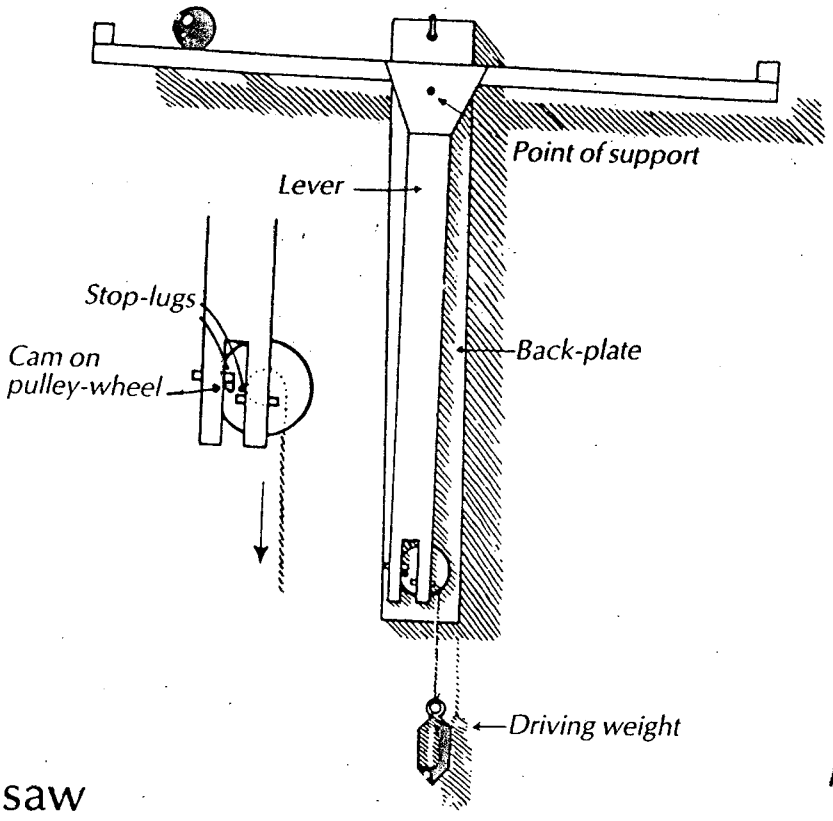


Figure 90.

The ball see-saw

Like the clock this device is driven by a weight. The weight hangs on a cord which causes a little pulley-wheel to revolve. The pulley-wheel has a cam which moves in a slot on the end of the see-saw lever. As the cam revolves it pushes the lever from side to side thus causing the see-saw to tip up and down. The slot is fitted with two lugs which act as stops to the cam.

In Figure 90 the cam has pushed the lever over to the left and has come up against the stop. The see-saw is now held in position left end up and right end down. On top of the see-saw a ball runs from one end to the other in a groove or on two stretched strings. The ball is on the left and starts to roll down to the right. When it reaches the bottom its weight tilts the see-saw even further down to the right, the lever moves further over to the left releasing the cam, and the wheel revolves until the cam comes up against the second stop. By

then it has pushed the lever over to the right, causing the see-saw to tip the other way. The ball rolls back to the left, depressing the see-saw and releasing the cam again. This motion continues until the weight has run down.

How quickly the ball runs and the ensuing rate of the see-saw motion depend on the amount of thrust given to the lever. The thrust can be adjusted by resetting the cam. If the lever is 8 inches long (20 cm) the radius of the cam need only be ⅛" (3 mm). The driving weight must just be heavy enough to be able to lift the see-saw when the ball is right at one end. If the point of support is screwed fairly tight it will brake the see-saw and prevent it from rattling. A rubber washer will ensure that the braking is even.

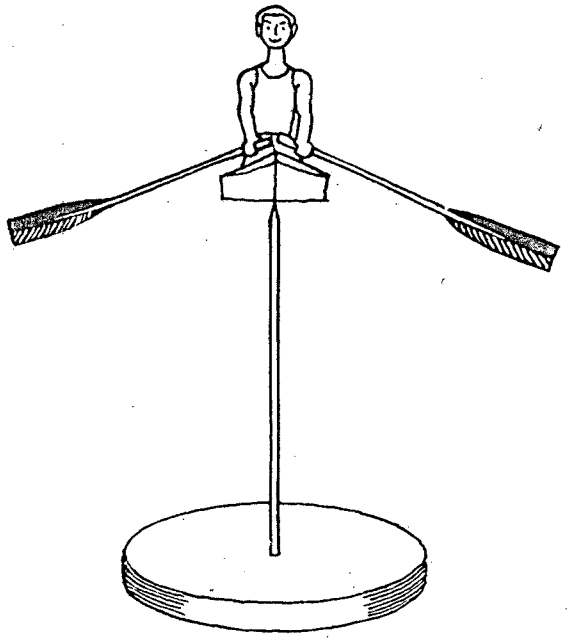


Figure 91.

Concerning balance

Balancing on a tree trunk, on a wall or even on a tight-rope (which does not need to be all that high off the ground) is an unfailing source of pleasure. By holding a long rod in your hands it is easier to keep your balance, or you can balance the rod on one hand. Keeping your balance when doing a head-stand or balancing on the tips of your toes is already the beginning of acrobatics. Also walking on stilts is a matter of balance. All this is playing with gravity. If the opportunity is there children will seize the initiative to experiment with balance.

But even in a small way it is fun playing with gravity. You can build a tower with blocks, higher and higher till it topples over. Then you can start again, building higher and keeping the bottom closer and closer together. You can build the famous house of cards where one outwits the force of gravity.

You can make your own home-made things balance on a point. A suitable point is easily made by sticking a knitting needle into a cork of a bottle. You can balance all kinds of things on the point and make them sway, if their centre of gravity lies below the point. An example

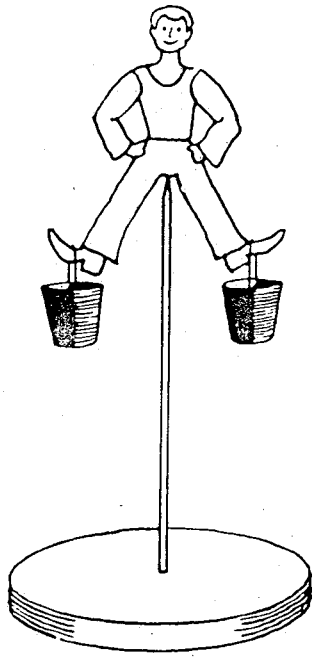


Figure 92.

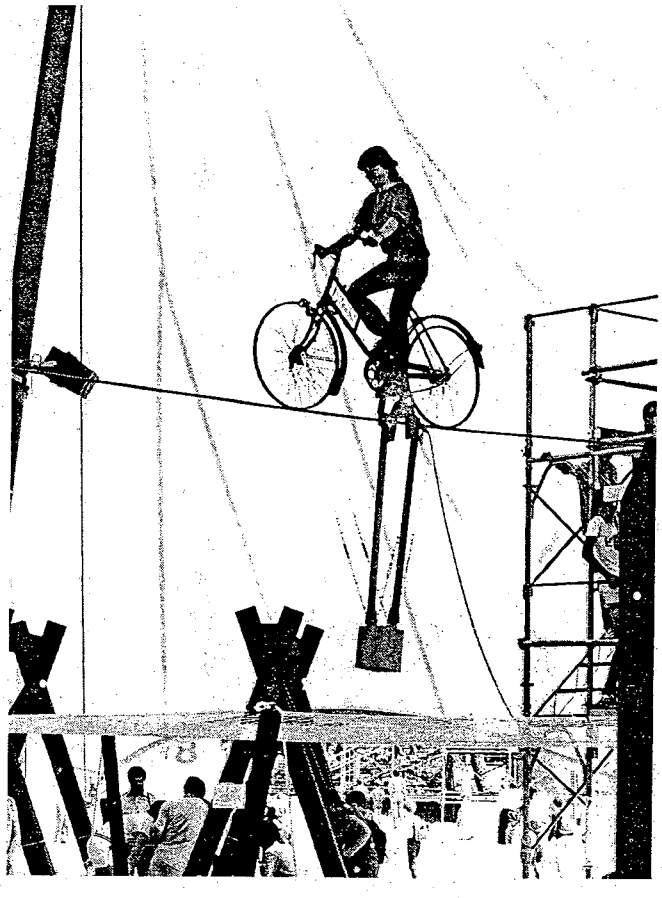


Figure 93.

is a little man sitting in a boat with an oar at each side. If the man is light enough and the weights heavy enough he will wobble after every little touch, so you expect him to fall.

Another suitable motif is a plane. You can hang the weights well below the wings in the engines. The movement appears quite magical.

It is possible to ride a bicycle along a rope where the bicycle has no tyres, only the rims of the wheels, and where the handlebars are fixed so that it cannot be steered. Two weights hanging down are fixed rigidly to the bicycle and then it cannot fall (Figure 93). This is the same principle as that which I have already described: the centre of gravity must be below the point of support, in this case below the rope.

Puzzles

Many puzzles are games with or against gravity. Think of the little boxes in which one or several balls can be moved and which you have to get into special holes by adroitly moving the box. You can make such a little box yourself. You don't need glass on the box, but you mustn't cheat, so keep your fingers out of the box! Even in a matchbox you can make cunning little compartments with strips of paper. Put four little balls in it and try to get one ball into each corner.

A variant is the board with slats glued on to it and holes bored in it. The ball must follow a particular course, the slats help it and the holes make it difficult. Such things can be bought, and then the board usually has two handles by which it can be moved in the box. This is very interesting, but is unnecessary. The board can simply be taken in the hands. You don't even need a box, the balls can be caught in a cloth below. You can then build boards of different difficulty. The edge must always be closed in.

It is also fun to have a maze where the ball does not go along a predetermined course and there are no tricky holes to negotiate, but the lanes can be made narrower and there are dead-ends. You can see who can get the ball to the end quickest.

There is another kind of puzzle which you cannot watch, but which you can

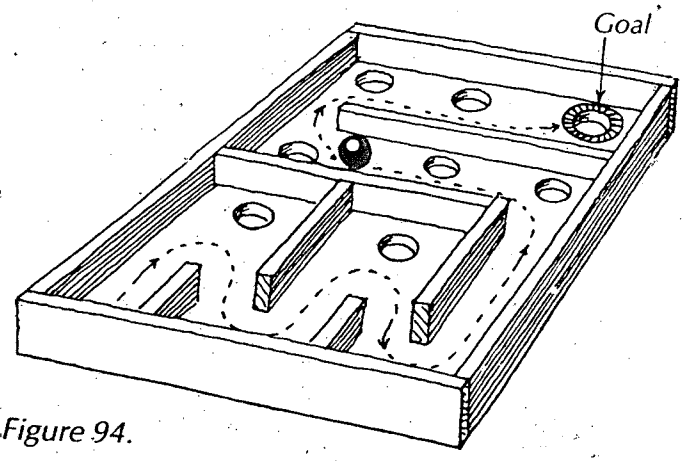


Figure 94.

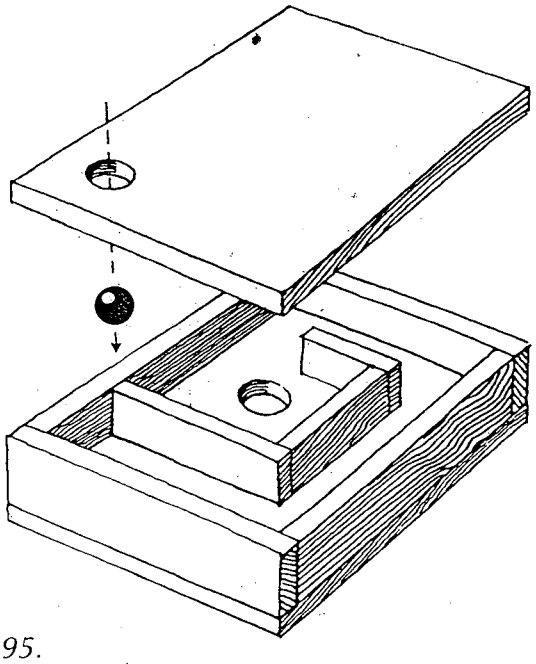


Figure 95.

listen to. Take a little board, smaller than the one described, and with only one hole for the ball. Stick on closed sides, higher than the ball, and some slats of the same height to make a little maze. Now stick a second board of the same size on top, also with a hole for a ball. Of course, the two holes must not be in line (Figure 95). Drop a ball into the top hole and try to move the box in such a way that the ball comes out of the bottom hole. The constructor knows the inside path of the box, but anyone who has not seen him build the maze will have greater difficulty. He can be asked to make a plan of the inside, simply from hearing the ball inside. If that is too easy you can make a second box and stick it under the first, and even a third layer is possible.

The sand-wheel

Sand runs in an hour-glass. But sand, like water, can drive wheels. All the water-wheels described in the first part, 'Playing with Water' can be driven by sand falling from your hand or a funnel. The sand must be dry.

We can develop this further. The sketch (Figure 96) shows a little box with one or both sides covered with glass. A sand-wheel is set inside it with a funnel over it. A channel leads to the funnel. The sand falls through the opening in the funnel, drives the wheel and falls into a heap at the bottom. When the funnel is empty, turn the box in the direction indicated by the arrow, and the sand will flow back along the channel into the funnel once more, the wheel is 'wound up' again and will start running again. The wheel is made of plywood, and the buckets (or shovels) on the wheel are made of paper. Make the funnel and channel out of stronger paper. The bearings must be well made and give little

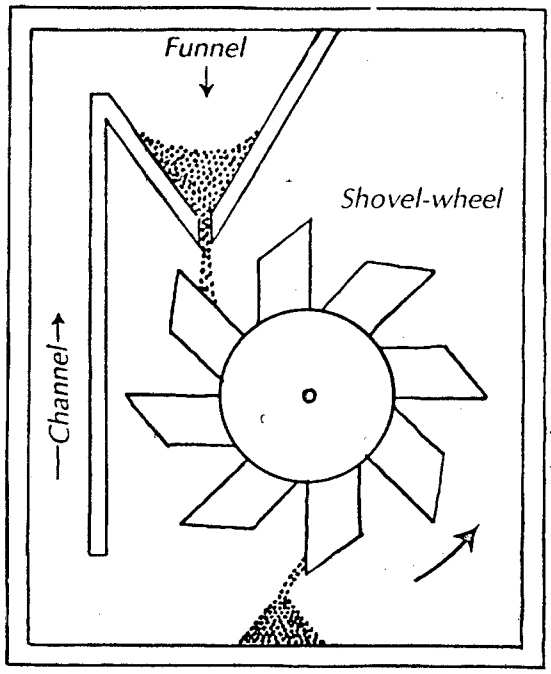


Figure 96. Back view, showing workings.

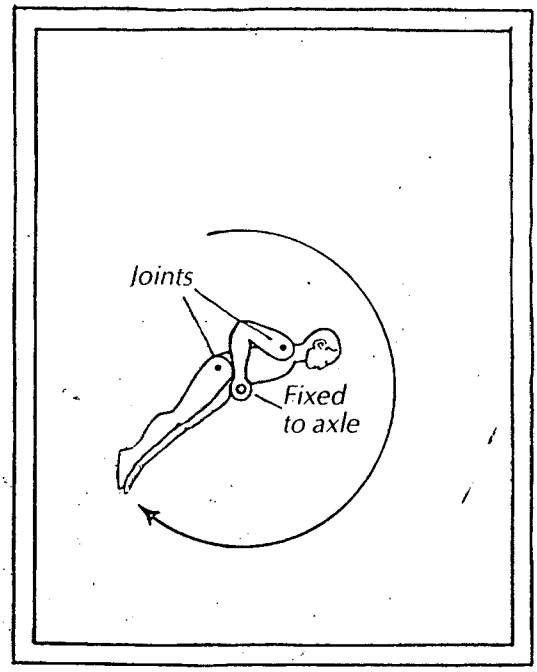


Figure 97. Front view.

friction. The cover can be made of perspex through which holes can be bored. The holes will make good bearings for the axle which is a piece of straight wire. To prevent the wheel slipping sideways set beads as spacers on each side on the axle. The best kind of sand is sand for bird-cages, which you can get in a pet-shop.

If you are very cunning you will keep the mechanism a secret by covering the glass leaving only a window for the wheel. The thing becomes even more mysterious if the wheel is also covered and the axle is allowed to protrude and drive something (you can leave the back open to expose the solution to the mystery). You could fix a nimble, light acrobat. How long will it take uninitiated friends to work out how the thing works!

A roundabout with a sledge

To a certain extent playing on all roundabouts and switchbacks is playing with gravity. With the terrific acceleration and extreme centrifugal force we experience our own weight in an unusual way.

To conclude this section let me describe an unusual roundabout which I once saw in a village. It was a hard winter and the pond was frozen. Some ingenious person had driven an iron bar through the ice where the water was shallow and into the mud at the bottom. The bar now stood upright firmly held in position by the ground and the ice. It protruded quite a bit above the ice. A cartwheel was now laid on this axle so that it could be rotated horizontally, and a long pole was fixed on to the wheel at the outer end of which was tied a sledge. At the opposite side another shorter pole was fixed for pushing the wheel round.

The one or two children sat on the sledge, while others, on skates, pushed the roundabout round. There was a possibility of injury if someone did not watch out, as the pole would strike him in the knee or the sledge crash into him. Nevertheless it was very ingenious and showed great imagination.

Playing with fire

Although I hope it is obvious that 'playing with fire' is not meant literally, still the title of this part is rather startling. Of course matches are not available for children to play with. Quite rightly they like imitating. When they see an adult lighting a match, they want to try out this marvellous work of art. And then the accident happens.

At the right age every child has to learn how to use a match, how to control fire. The most natural way, as with all learning, is in play under a grown-up's supervision. The child who has been carefully introduced to this element will know its potential and its power and will treat it with due caution. Here I shall try to show how such a careful acquaintance with the most dangerous of the four elements can be made.

By playing with fire I mean playing with its effects, with warmth and light, not just kindling a fire. Again such contrivances have been selected in which something is driven by the power of fire or which produce remarkable effects. Here little fires with the flames only big enough to meet the object of the exercise are best. The fire is guarded and kept under control. A sensible treatment of the elements is practised.

First one should take the opportunity of showing the child little fires, making him acquainted with the candle-flame. In many families a candle is lit for festive occasions. Having meals with a lit candle heightens the sense of ceremony. Evening prayers are said by candle-light. Birthdays, Advent and Christmas are celebrated in candle-light. In these customs fire is made sacred and reverence is engendered.

If you use solid-fuel for heating the child will have a direct experience of the heat and light of fire. A sight of the flame of the oil or gas burner in a domestic central-heating system is possible without danger.

If you manage to visit a furnace you will be impressed with the sight through the inspection hole in the furnace. It is hard to visit an iron-smelting works, especially with children. That is understandable, but it is a pity. On the other

hand glass-blowers usually encourage visitors, and that can be an impressive experience seeing the glowing glass ready to be shaped. A smithy with an open coal fire is rare nowadays. If you do have the chance, take your child and he or she will no doubt watch the smith patiently for hours on end. There are also miniature and full-size railways where it is possible to experience the power of the steam engine and its fire. These different forms of technology should help develop the necessary respect for fire.

In many parts of Central Europe fire-wheels are rolled down the mountain at Easter, and at the summer solstice fires are lit on the mountain-tops and in the valleys. Children are allowed to stay up longer on these occasions. They are allowed to take out burning brands and make glowing circles and figures of eight in the night air, although naturally the adults are fully attentive to dangerous possibilities. Similarly, bigger children jump over the fire; here one must be aware that clothing made of artificial fibres can be dangerous.

Picnics are a good opportunity to make a fire with the little ones, and roast sausages, apples and potatoes in the embers. Aspiring scouts can attempt to light the fire without paper as a point of honour, and can cook whole menus in the open air.

At Martinmas, in some countries, in the early November evening children are taken on a lantern procession singing at the same time. The lanterns are made at home using stiff card. On New Year's Eve there is a Continental tradition of going for a walk through the deep snow of the winter forest with burning torches. Children are allowed to carry burning torches as well (wearing old gloves, as the pitch from the torches is inclined to dribble down). In the darkness the torches create a kind of illuminated space which travels with each participant. It is planned so that at midnight the processions come out on an open clearing and converge.

And then of course there are the fireworks of Guy Fawkes or July 4 when some quite spectacular effects of fire can be seen.

Experiments with candle-flame

The great scientist Michael Faraday can teach us much about the versatility of the ordinary candle-flame. His *Lectures on the Chemical History of a Candle* were addressed to young people. Some of the following experiments are taken from his suggestions.

Children love to see how flames spurt out when we squeeze orange peel at a candle-flame. It happens because the etheric oils ignite spontaneously in little cross flames, visible only for a moment, before vanishing. Again we squirt and again the little firework appears and vanishes.

You can show children where the flame is at its hottest by holding the head of a match for a moment right in the middle of the candle-flame before it fires, whereas you cannot hold it at the edge or immediately above without it firing at once. If you hold a matchstick straight through the flame for a short time it will show two brand marks from the edge of the flame but nothing in the middle.

Light a second candle and blow the first one out. 'Smoke' rises. After a few moments hold the still burning candle in the rising gases just above the wick; a flame will spring down on to the extinguished wick and the candle which has just been blown out lights again. The springing of the flame happens as quick as lightning — you hardly believe you saw it. Try it again, see how far the flame will jump. Finally it becomes obvious that hot candle-gases burn.

These gases shine palely. This phenomenon can be observed in dim light. It is difficult to catch sight of this pale light because one's eyes need to be accustomed to the dark but are still under the influence of burning candle. However, if you are curious enough you will find a way of seeing this mysterious incandescence.

If you let a little piece of golden or silver decorating wax dissolve in the pool of molten wax in the candle under the flame, it will show what is happening in the liquid wax: there is a constant spiralling in the middle as the wax is drawn up into the wick. The spiralling on the surface goes outwards, down at the edge and then towards the wick. (In the decorating wax there are minute particles of metal which show up these currents.

It is quite simple and well worth the effort to create the shadow of a candle-flame. Shine an incandescent lamp, or better still the lamp of a projector, on to a lit candle. On the wall behind you will be

able to see the black shadow of the candle and the wick, while the flame appears as light grey with a bright edge, while above it veils like delicate curtains move; that is the warm air rising. You can also blow, or wave your hands and then you will see whirls for a short time.

The spiral

The first and simplest 'warmth-machine' is the gyrating spiral. It does not drive anything, but it gyrates in the warm rising air of a radiator. It is quite simple to make. Take a piece of paper about 8 inches (20 cm) square rather stronger than writing paper. On this draw freehand a good even spiral. When you have managed to produce a good drawing, cut it out and it will undo itself hanging down. Push a press-stud into the middle of the spiral with the hollow part downwards. This is the bearing. Now place the spiral resting on a knitting needle, so that it can revolve freely on it (Figure 98). After that you have only to make the base for the needle which you do by boring a hole in a little board and inserting the needle. Put it on a radiator or a closed stove and it will turn as long as the radiator is warm, right through the winter. The bottom end of the spiral is inclined to curl up. Bend it down otherwise it will act as a brake in the hot air current.

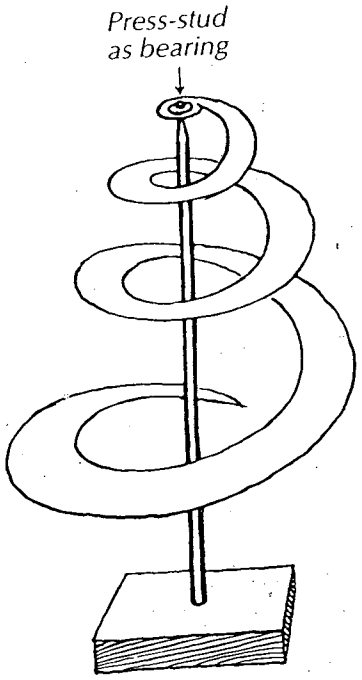


Figure 98.

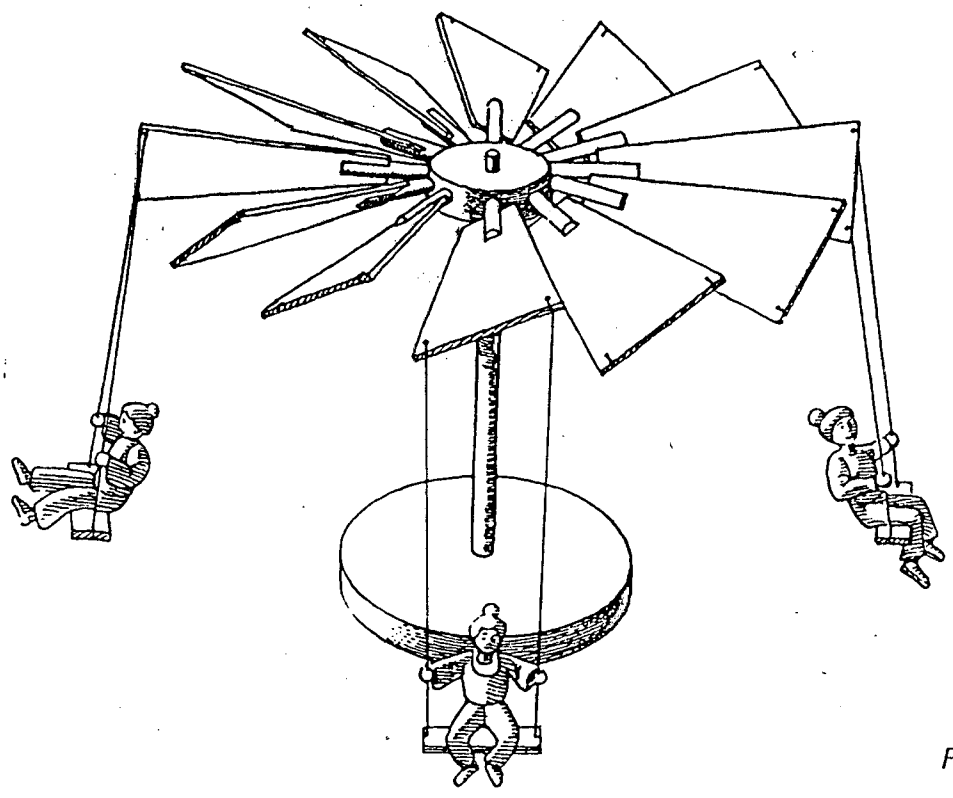


Figure 99.

The hot-air roundabout

Warm air rising from a candle can be used to drive something like a little dolls' roundabout. For this to function properly I must explain the principle.

The most important thing is the bearing, it must allow very easy movement. Here again we can use the press-stud bearing already mentioned, but another kind of bearing is better: the conical bearing where the needle rests in a small round tin (⅛", 4 mm diameter). (You can obtain such a tin at an electrical supplier or modelling shop. The tins have a thread on the outside so that they can be fixed easily. A hub carries the blades that produce the rotation, but the centre of gravity of the rotor must be below the bearing, that means that the tin must project above the hub (see Figure 99).

The blades are made out of thin wood

or tin. Everything that turns must be lightly built, in order to minimise the friction on the bearing. The blades require very little pitch; best if they can be made adjustable, with round pegs fitting into holes in the hub. Tin can be bent and so is more easily adjusted. By trial and error you will find the best pitch.

As with the spiral the needle can be set in a base. Of course you can also just use a pin stuck in a nicely formed shaft. To try the roundabout out place it on a radiator. Once it is turning properly you can tie threads on to the ends of the blades from which are suspended little boards on which can be placed little light dolls. These then rotate. In my house such a roundabout once stood on the radiator and the dolls went round all winter, day and night.

Of course you can make the roundabout revolve by placing lighted candles underneath but then great caution is required.

Here is another suggestion for this construction. Make a tripod out of wire (figure 89). It has a nail on top. On this is set as a kind of hat a concave metal (with no sharp edges) which you can cut out from thin non-combustible metal. It has flaps through which the rising warm air turns the hat. Place a lighted candle beneath and the little roundabout will begin to turn. Or the outside stick

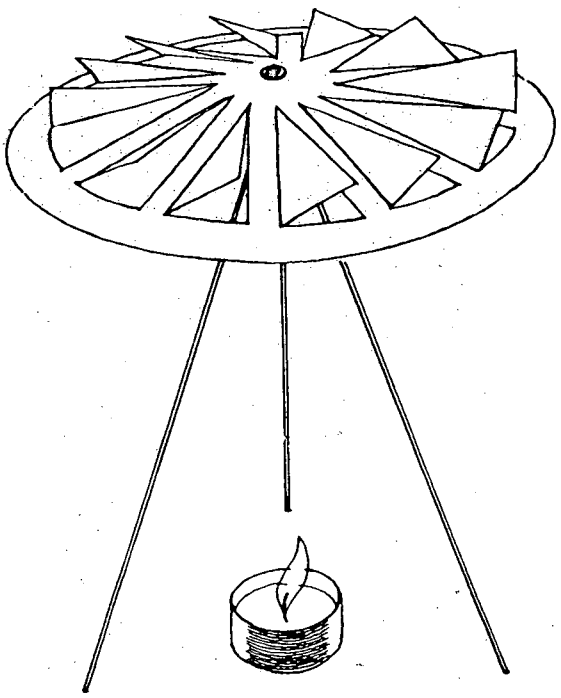


Figure 100.

some pieces of the same material and bend them down to make seats. On these you can let little light dolls ride.

This principle is also used in the Christmas angel-chimes, or in the beautiful wooden Christmas 'pyramid' of the Erzgebirge.

The shadow-roundabout

The shadow-roundabout is a variation of the roundabout. It is constructed in much the same way as the one already described. It is driven by one candle only and for pendants you can cut out people, animals, and so on, from thin card. Round the outside stretch some tracing paper which will catch the shadows of the figures as they revolve. It is also nice to stick cut-outs on to the tracing paper, but these should be of immobile objects such as trees, flowers, hedges and houses. Now the figures will move as shadows among these things. A particularly suitable motif for a Christmas shadow-play is the 'Flight into Egypt'.

For the rotating blades of this model thin tin is recommended. The tracing paper should not reach right down to the bottom otherwise the candle inside will not get any fresh air.

A subsidiary effect of these candle-driven roundabouts is the play of light and shadow on the ceiling.

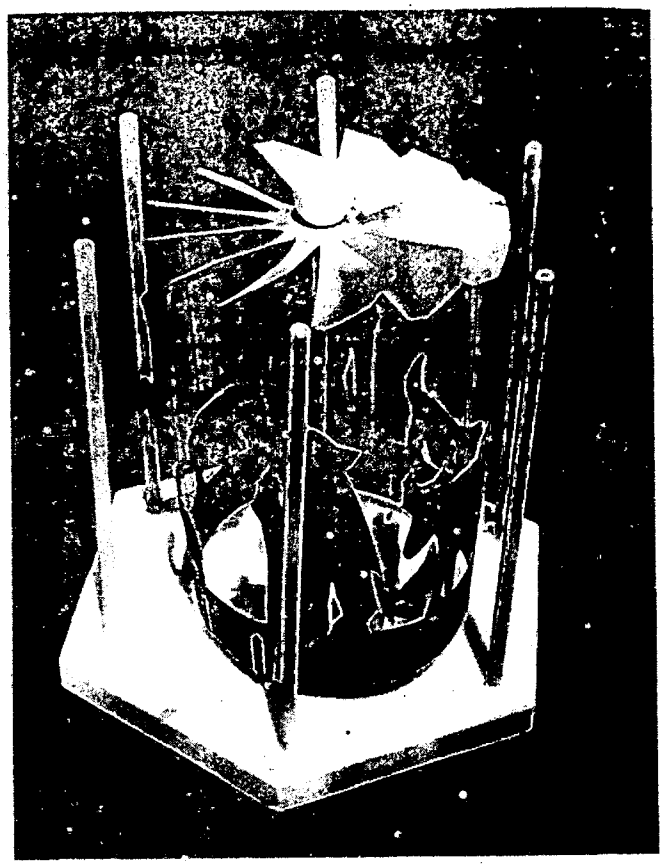


Figure 101.

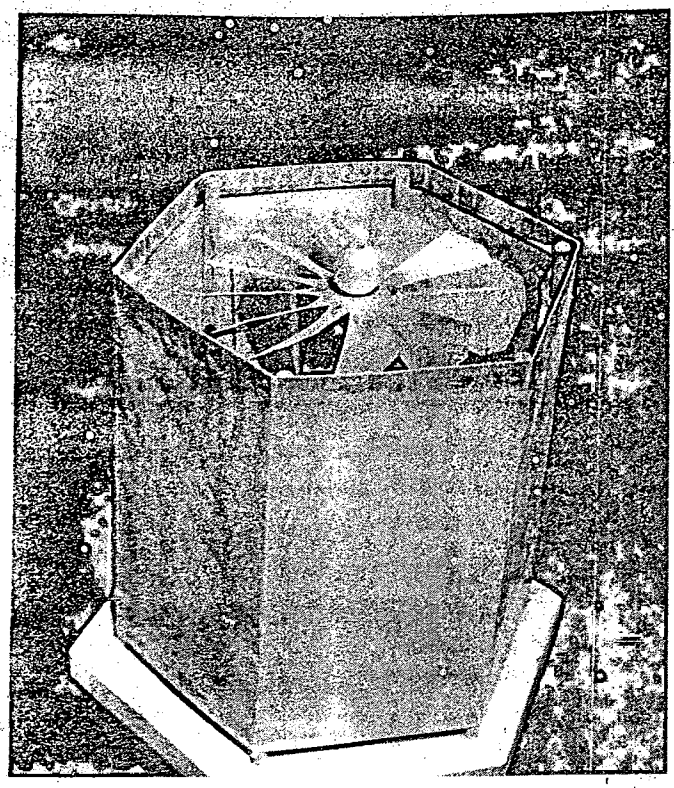


Figure 102.

The hot-air balloon

You can make a hot-air balloon yourself. It is not too difficult but it takes a long time and it is a unique experience once the balloon rises filled with hot air. It is no ploy for little children.

The material for the balloon is ordinary tissue paper, colour according to choice — balloons of two different colours are specially nice. There are six segments making up the balloon. You need to have twelve sheets of tissue paper. The

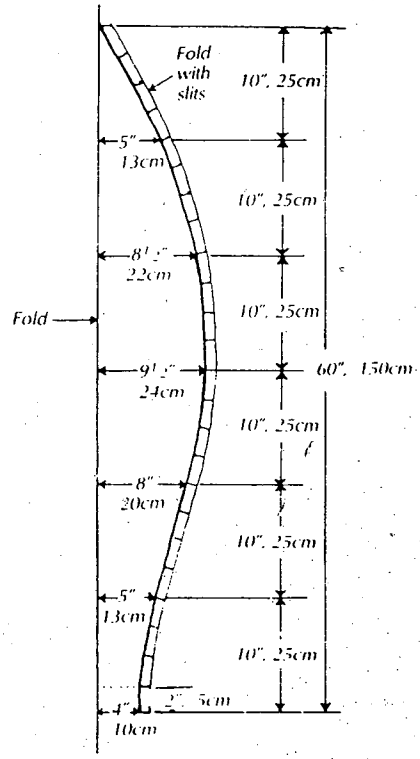


Figure 103.

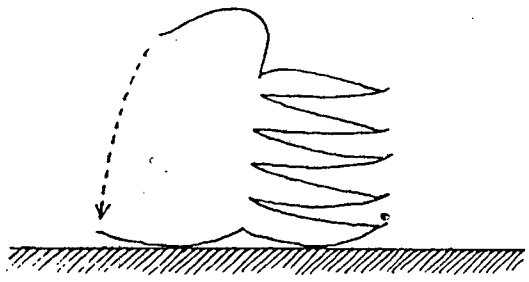


Figure 104. The six segments.

sheets are glued together in pairs along the short edge. It is recommended to make a stencil out of newspaper or large wrapping paper according to Figure 103. (This ensures sirnilarly shaped segments, and saves a lot of preparation if your balloon should go up in flames.) The figure is based on the commonly available tissue paper size of 20 x 30 inches (50 x 76 cm). If your tissue paper is a different size adjust the stencil proportionally. Fold the pairs of tissue paper (now 20 x 60 inches, 50 x 150 cm) lengthwise. As the segments are symmetrical the paper can be cut double. Make a fold along the curved edge about ½ inch (1 cm) wide. When the six segments have been cut stick them together at the folds according to Figure 104. When the last fold is stuck to the first strip the balloon is almost finished. All it now needs is a reinforcement made of strong paper round the opening. The balloon can be transported folded up.

Now open it up over the fire. Here you must be very careful even though nothing much can happen if the balloon catches fire, but it is a pity to waste the work you have put in to it. For the first attempt the flame of a bunsen-burner or a camping stove is suitable. The launch can take place in a high room or on a stairway. Place a non-combustible base under the burner: a baking tray, for instance. Over the burner place a stovepipe with a slit in it. The slit allows fresh air in to the burner.

For launching you need a crew of two. One holds the balloon at the top and one at the bottom. Open the balloon high above the flame, and the hot air will blow it out. Now lower the balloon slowly watching carefully until the flame is inside the balloon. After a few moments it will rise by itself. In the excitement do not forget your naked flame.

Out of doors the launching is not so simple. You can only launch on days when there is no wind, but even on those days there is a faint current of air, so where possible choose a sheltered spot. It is also a help if lots of spectators make a close circle round the launching spot. Use a camping stove, or you can try an open wood fire. In the latter case wait until the flames die down but the embers are still glowing. Rake the embers well together. A good idea is to take a piece of tin bent round to make a pipe

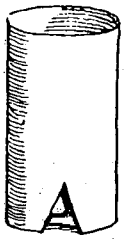
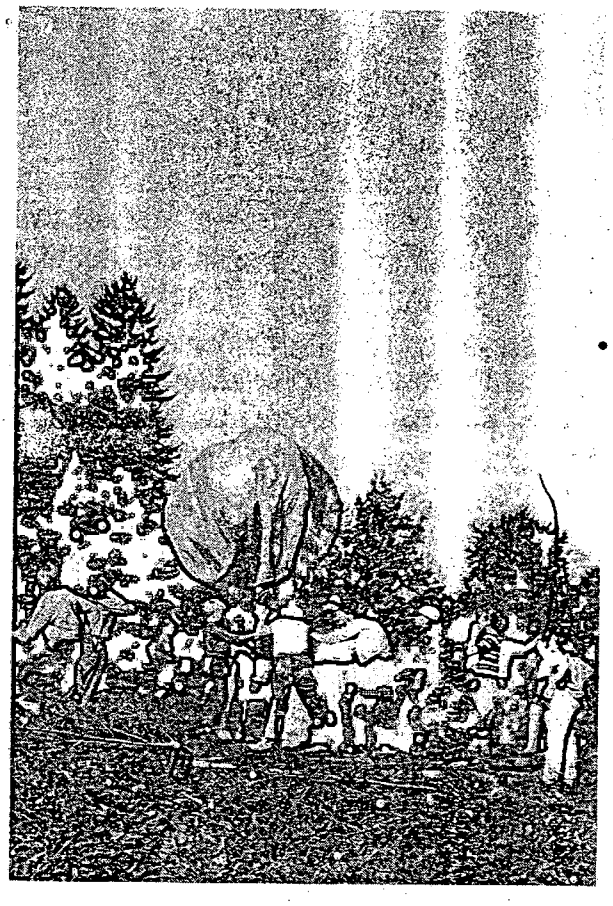


Figure 105.

Figure 106.



with air vents at the bottom. A stove pipe is too narrow. At a garden party I saw a balloon launched successfully over a fire in a barrel.

Naturally one would not make a fire in the woods because of the danger of causing a forest fire, and anyway the ascending balloon (and our view of it) would be caught by the trees. Open countryside is best for this purpose. See that there are no roads nearby as the balloon when it comes down again could distract drivers.

It is possible that the balloon will tilt to one side when it is rising, or even turn upside down letting out all the hot air. In this case the balloon will have to be weighted below, perhaps with a clothes-peg, or with a basket hung by a fine thread in which a light doll rides.

The suggested measurements of the balloon can be increased or reduced on the same scale. Unless you take a lighter kind of tissue-paper, the strips should not be shorter than three feet (1 m), otherwise the balloon will be too heavy in proportion to its volume. If you double the measurements the balloon is four times as heavy but it will take eight times as much hot air. The balloon then rises much better but it is also much more flimsy.

Never launch the balloon with a fire attached below it because it is obviously too dangerous. By taking suitable precautions the trouble of making the balloon will certainly be rewarded by fine flights.

The sun balloon

You may be able to buy this toy ready-made. It is shaped like a thick black sausage made of specially light cellophane. Simply lay the air-filled sausage in the sun. The black colour quickly absorbs the sun's warmth conducting it to the air inside. This expands making the balloon buoyant and it rises. You should keep it anchored by a string so that it does not fly away. It should only be launched when there is no wind. With this balloon the heat is not taken from earthly fire but from the sun.

Bimetallic see-saw

Bimetallic strips are wonderful things. They are metal strips, either wound up like a watch-spring or extended flat. In either case as the name implies the strip consists of two different metals firmly joined together. When they are heated the two metals expand differently with the result that the strip bends or the spiral unwinds or winds up tighter. When the metal cools the opposite movement takes place.

Here is how you can make a fine toy with a bimetallic spiral. Make a see-saw on to which you can later place two little men. Place a night-light over the point of support of the see-saw. Set a wire bow on the see-saw stretched over the night-light. Join one end of the bimetallic spiral to the wire bow. Solder a piece of wire on to the other end of the spiral. Fit a bead on to the other end of the wire. The bead acts as a weight. Now arrange the device in such a way that the spiral is positioned exactly over the wick when at rest and the bead lies to one side with its weight held by a stop (Figure 107). The see-saw will be down on that side. Now light the night-light. The flame will heat the spiral which brings the bead on to the other side and the see-saw goes down on

that side. In that position the spiral cools down as it is now lying beside the flame. The bead goes back to its first position and the see-saw rocks back again. Then the whole thing starts all over again.

It is a pleasant toy to watch, perhaps at tea-time when it is growing dark, but my congratulations to the craftsman who succeeds in constructing this finely balanced contraption.

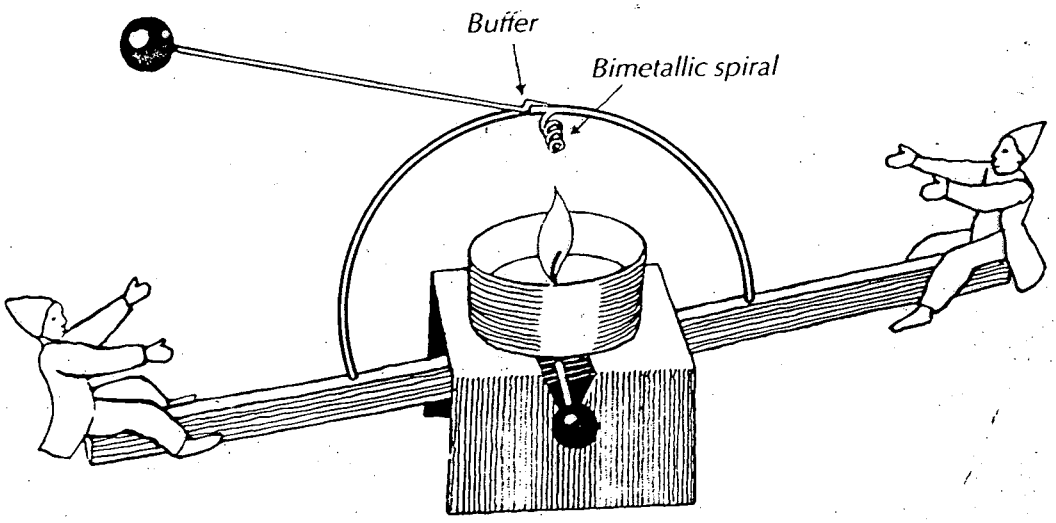


Figure 107.

The sounding pipe

Take a piece of stove-pipe about three feet long (1 m). Take some fine wire-mesh and insert it into one end of the pipe up to about one third of its length. Heat the mesh with the powerful flame of a blow-lamp or a camping gas stove, until the mesh is glowing hot. Now hold the pipe upright and remove it from the flame. In a few moments it will begin to sound, astonishingly long and persistently. The hot air rising in the pipe makes spirals above the mesh and causes the vibrations in the pipe which we hear. You might describe it as an organ-pipe blown by fire.

Shadow games

Everyone has sat in the dark and had a light in front of him. Near at hand was an object, behind the object it was quite dark, and there were shadows. If you moved the light carefully you could see how the shadows always moved away from the light. That is obvious of course, but if you observe this moving of the shadows you may well be tempted to make a game out of it. This is how after much trial and error the forest shadow game came about.

Take a piece of cardboard as the base. Colour it like the ground in the woods. On it paint paths consisting of circles as big as the base of the night-light which you are going to use. Now make some trees, for example by taking two pointed

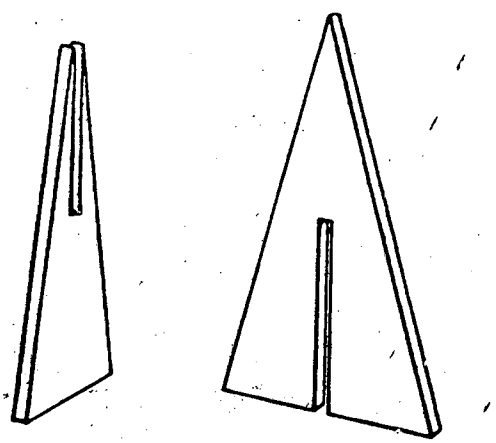
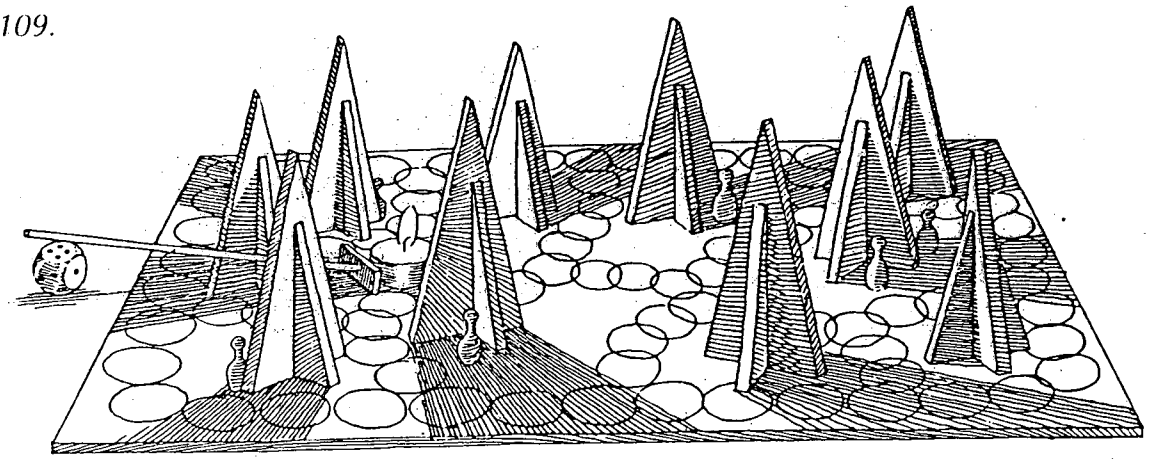


Figure 108.

Figure 109.



bits of plywood with slots so that they can be fitted together in the form of a cross. Paint these trees in the right colours and place them on the base where there are no paths. Take a dice and some counters such as little playing figures from a board game.

When it gets dark in the room we can start. A grown-up directs the light. He lights the night-light and places it anywhere on the path. The trees now cast their shadows. The grown-up directing the game now closes his eyes and the children hide the counters (they are the dwarfs) in the shadows of the trees. After that the light-director throws the dice and [illegible] the light that number of circles in [illegible] direction. If a dwarf is lit up he is [illegible]. Which dwarf can stay hidden the longest?

The game can be developed further. The dwarfs are allowed to run away from the light but they must keep in the shadow. After every move the light-director shuts his eyes and the dwarfs hide again, but they are not allowed to cross any strip of light however narrow on the floor of the wood. If the game does not come to an end it is because there are too many trees and you must take some away.

One tree can be chosen as the den, and any dwarf getting into it by keeping in the shadow is safe. Now try making the condition that all the dwarfs have to meet under a particular tree without coming into the light. If a dwarf does get into the light he can be freed if another can get to him in the shadow. Until then he is under a spell and cannot move.

These are some variations to the 'forest shadow game', a play of light and shadow. Other shadow games can no doubt be invented.

Coloured shadows

To get coloured shadows you need two candles and a piece of transparent coloured cellophane. Near the two candles place an object, such as a matchbox. It will cast two shadows. Where they both overlap it is quite dark: this is called the umbra. The lighter shadows are called penumbrae, the half-shadows, because each is lit up by only one of the lights. The shadows are seen best on white paper laid on the table as a base.

Now hold a coloured cellophane, say a red one, in front of the brighter flame. The surroundings are immediately coloured red including the penumbra of the other candle. The penumbra of the red candle is a faint green even though there is no green light! If one of the candle-lights is coloured green the shadow will be red. Red and green are complementary colours. In a similar way blue and orange, yellow and purple complement each other.

What happens when both candles have a colour-strip held in front of them? Then you have coloured shadows. It is worthwhile playing with them in the way described. You can even colour the light of three candles and the study the many shades of colour. It would be fun to develop this, perhaps making a coloured shadow-theatre.

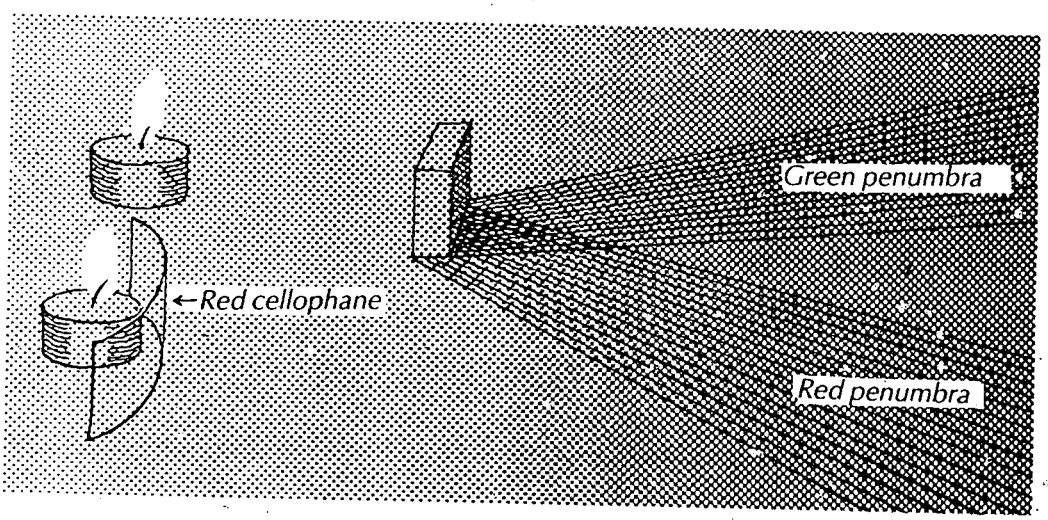


Figure 110.

The rainbow

To conclude this section I would like to mention another remarkable phenomenon. Dewdrops sometimes sparkle in colour in the sunshine, also the rainbow gets its colours from drops, from the falling rain, but there is another way of seeing the seven colours of the rainbow. The flame of a candle appears in the colours red, orange, yellow, green, turquoise, blue and violet when you look at it through a glass prism. To do this you will have to go away from the candle a few yards and look quite a bit to one side turning the prism until you find the coloured flame. In the beginning you will need some patience.

The prism can be made of perspex (plexiglass), which is cheap. Real glass prisms are expensive but give better colours. Look carefully at other things in the surroundings: everywhere where light and darkness meet colours arise. If you watch attentively you will find a new colour which cannot be seen in the candle, a glorious bright purple.

When the room is properly darkened you can do it differently. Place the prism about three feet (1 m) away from the candle, and at some distance further behind the prism and to one side place a white sheet of paper. If everything has been skilfully arranged a delicate part of the rainbow will appear on the paper. The paper should be in the shadow.

This will also be possible in sunlight. Place the prism on the window-ledge and you will see the colours on the floor. It is more beautiful if the prism is held horizontally on an edge. You can make a suitable stand for it. The piece of rainbow appears on the opposite wall and moves with the sun.

Conclusion

In this little book simple and more complicated models for home-construction have been described. They are all designed to bring us in contact with the living elements. I am not concerned with making exact replicas of life-size devices, but simply with making models that work. A replica-model ship belongs in a glass case, it is not a toy, but an object for a museum. The elements themselves are a part of nature and they are all-important. On the other hand we must not underrate our children's powers of imagination. A nutshell really is a little boat for them or a matchbox a cable-car. To make the toys we do not generally need more than simple cheap materials. In the activity of construction you will gather all sorts of experience, for not every toy will work first time, and you will have to think and try out more ideas. Sometimes some expert advice and help will be necessary. But once you have made a mechanism and it functions as it should, that will double your joy, for then you are an expert and have mastered the problems involved.

This little book gives ideas for playing with the four ancient elements, earth, water, air and fire. The impetus to write down these ideas came from observing the joy of children when they encounter the elements and begin to play happily of their own accord.

I was also motivated to write this book because of anxiety concerning the future. While acknowledging the achievements of technology I maintain that what we have not yet learnt is to know how best to use our inventions. The computer is undoubtedly in the wrong place in the play-room, even though one can apparently play with it. It removes our children from reality to the extent that they can no longer do anything with the elements with which nature surrounds us. This book does not inveigh against technology, on the contrary, it demonstrates a whole lot of simple, readily comprehensible technical practices. It shows the fundamental principles and it intends to help to prevent our consciousness of the four elements from becoming lost.

Another purpose underlies this book. We do not do our children any good by

giving them ready-made toys. The child can, wants to and ought to make efforts to succeed in limits which he can master. The whole range of ready-made (and expensive) toy-machinery gives me considerable concern. Children who have been spoilt with these things may later manifest a demanding way of thinking: they will make demands on the outside world, but not on themselves. It is decisive for later life which toys our children experience.

May this book be a contribution to happy and serious playing with the four elements.

Acknowledgements

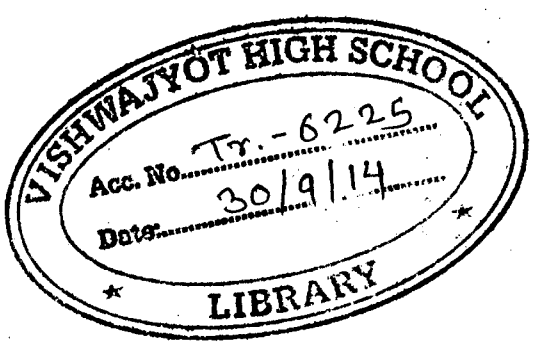
Deutsches Museum, Munich. Figs. 7, 14, 51.
Kunstmuseum Bern. Fig. 28.
Christof Beck, design of Fig. 66.
Erika Groth-Schmachtenberger, Fig. 76.

Toymaking with Children

by Freya Jaffke

The toys surrounding a child during his first five years are of great importance. They awaken the imagination and stimulate creativity. Out of her long experience as a kindergarten teacher Freya Jaffke makes numerous suggestions for making toys from wooden boats, log trains, doll's furniture to rag dolls, puppets, and soft animals.

This is an excellent handbook abounding with ideas for parents of young children.



Making Dolls

by Sunnhild Reinckens

This little book with its many co photographs and simple diagrams scribes how to make seventeen diffe kinds of doll: for instance a cuddly for toddlers, a large baby doll, fi puppets, gnomes, dolls for a d house, and many others. There are c instructions on how to form the h create different hair-styles, indicate features of the face, and make the b of the doll.

Sunnhild Reinckens lives in Hano West Germany. There and in many o places she holds courses for child mothers, fathers and grandparents. believes it is better that people ma simple doll, however modest an a than to buy one in the shop for children.

Floris Books