The Toy Bag

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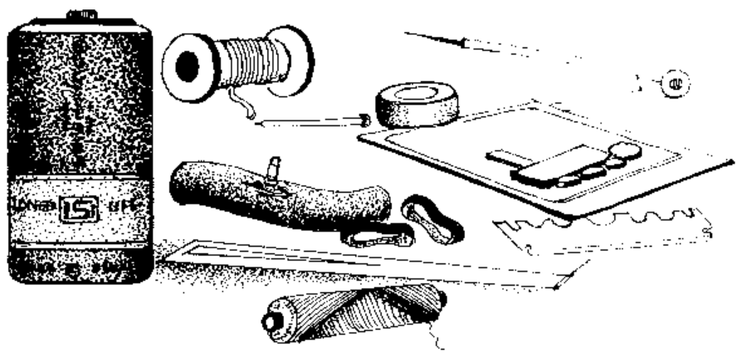
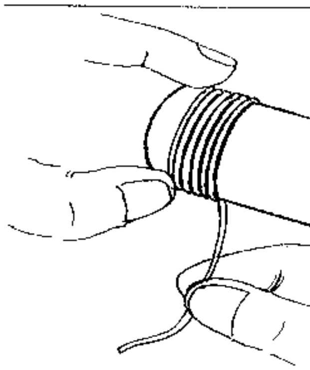
A REVOLUTIONARY MOTOR





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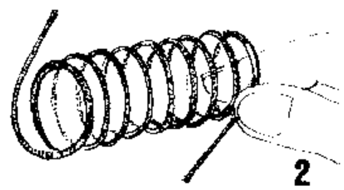

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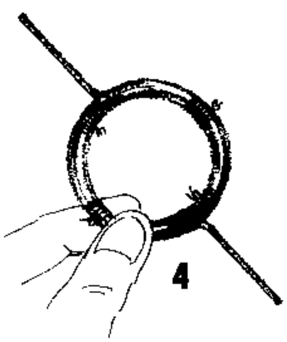

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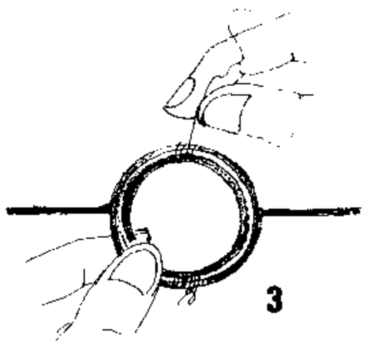

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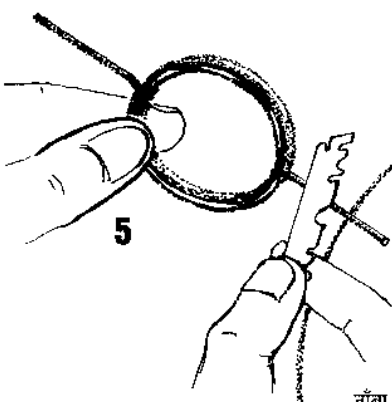

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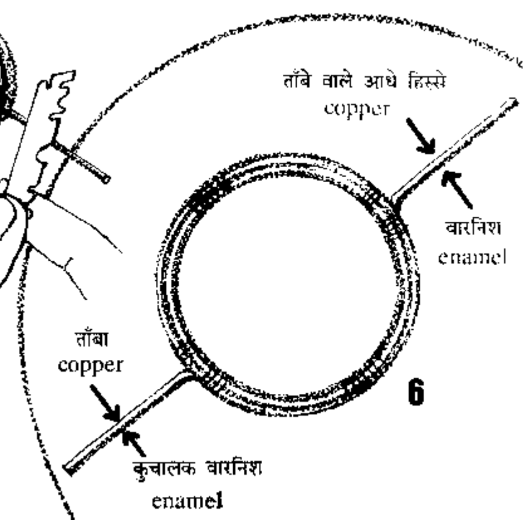

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This motor will not just make one revolution - but many. For, it is by far the simplest electric motor.

Wind a 24 gauge, 1.5 meter long enameled copper wire, on a torch battery Fig (1).
The coil should have between 10 to 20 turns.
When the coil is removed from the battery, it opens up like a spring Fig (2).
Tie the coil at several places with the little bits of string Fig (3).
Instead of string, bits of adhesive tape can also be used.
The two ends of the cold should jut diametrically outward Fig (4).

As it is on these two ends that the coil will rotate, so care must be taken to ensure symmetry and even distribution of weight.

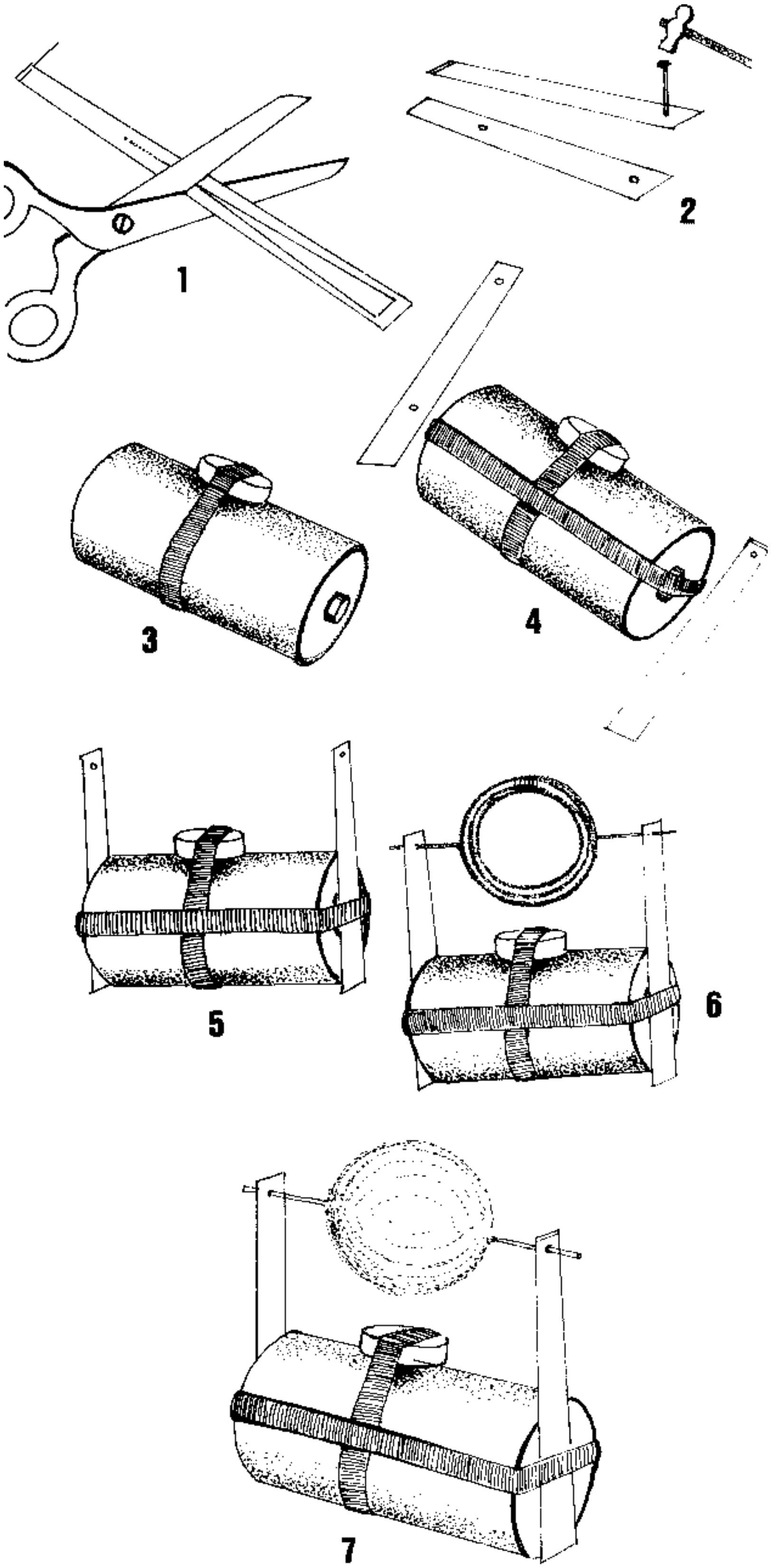
Now, keep the *coil in the vertical position, and scrape off the enamel from the top, the right and the left sides (3-sides).*
Only the bottom end of the leads will have enamel Fig (5).
Do not scrape the entire insulation, but only from 3-sides of each end, otherwise the motor will not work Fig (6).

The copper/enamel sequence leads to make / break of the circuit and ensures that current flows in only half the rotation of the coil.

This commutator, is the heart of this simple electric motor.

(continued on next page)

HOW TO MAKE THE MOTOR?

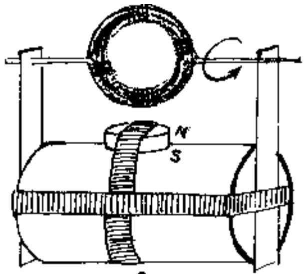


Cut an old stove pin into two equal parts Fig (1).
With a small nail, hammer a hole in each piece near one end. Hammer one more hole in each piece about 2-cm from the other end Fig (2).
Salvage an old radio speaker magnet and place it on a new battery with the help of a cycle tube rubber band Fig (3).
Several such sticker magnets are available in toyshops these days.
Stretch out another cycle tube rubber band along the length of the battery Fig (4).

Now, insert the stove pins in the rubber band so that the pins keep in contact with the positive and the negative terminals of the battery.
The pin with two holes is fixed at the battery bottom.
The second hole bites into this plane end and this ensures good electrical contact.
The stove pins serve three purposes Fig (5).
They act as power leads, supplying current to the coil.
They act as bearing supports for the coil.
Finally, they also make a stand for the motor.
Now pull the stove pins a little apart and slip the coil in there holes Fig (6).

Give the coil a gentle starting push and it will keep rotating.

However, if the push is in the wrong direction, then the coil will stop after a while, flip and rotate in the opposite direction.



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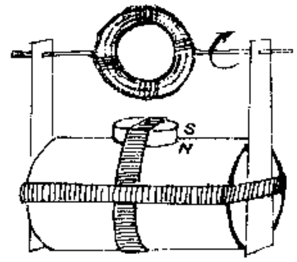

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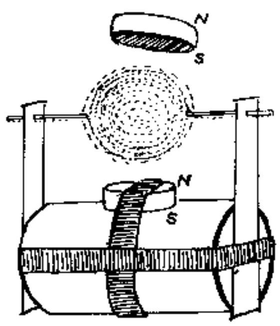

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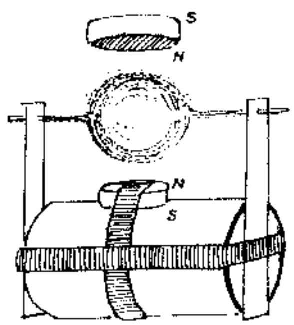

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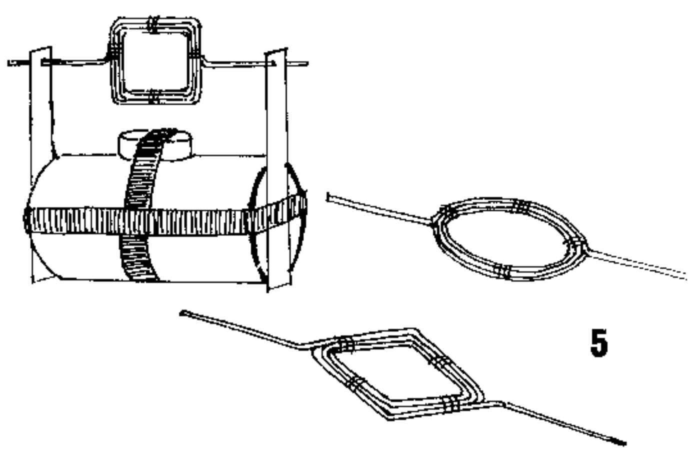
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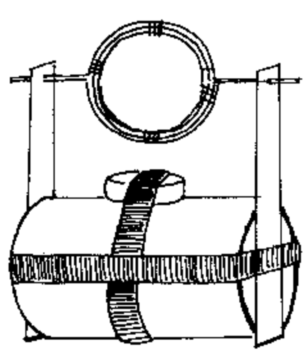
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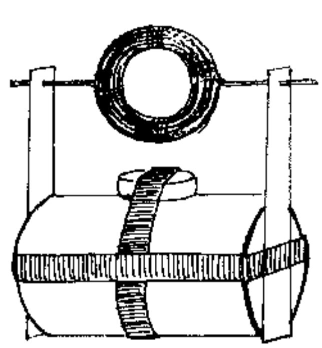
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EXPERIMENTS WITH THE MOTOR

Several interesting experiments can be done with this simple motor.

What happens if you flip the permanent magnet?
If the north and the south poles of the magnet are interchanged, then the direction of rotation of the coil is also reversed Fig (1, 2).

What happens if another magnet is brought close by?

If both magnets have opposite poles facing each other then there is an increase in the magnetic field and a consequent spurt in the speed of the motor Fig (3).

The speed decreases, however, if both magnets have similar poles facing each other Fig (4).

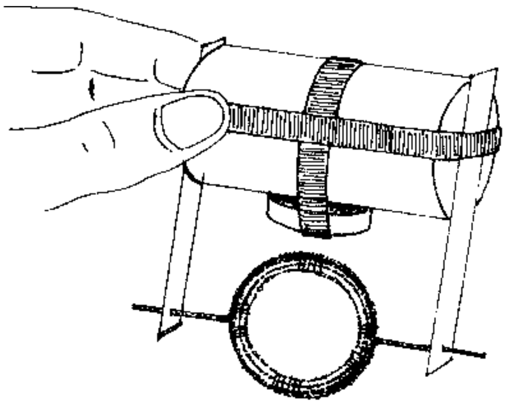
What is the effect of different cross-sections of the coil on the speed of the motor?
Try coils with circular, square, elliptical, diamond shape cross-sections too.

Observe the effect of the air gap between the magnet and the coil on the motor's performance Fig (5).

What happens to the speed/power output of the motor if there are few number of turns in the coil? Fig (6).

What happens if the number of turns are more? Fig (7).

What would be the effect of using thicker/thinner wire for the coil?



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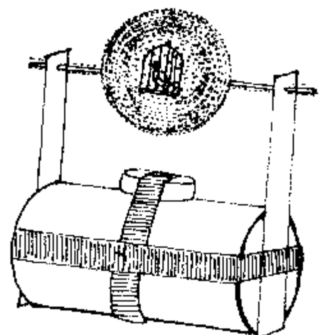

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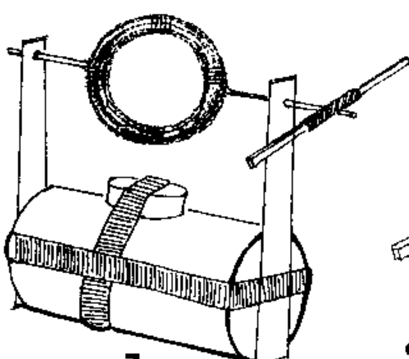

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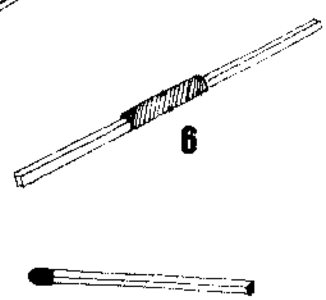

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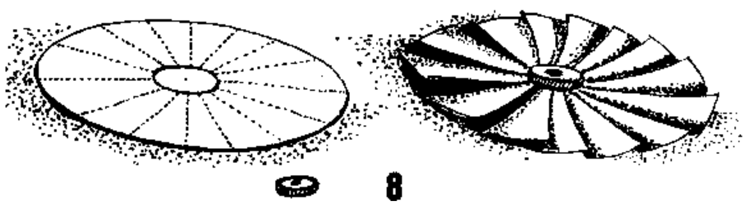

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MOTOR BASED TOYS

How many hours will this motor run on a new 1.5-volt battery?
How can one approximate the speed and power output of this motor?

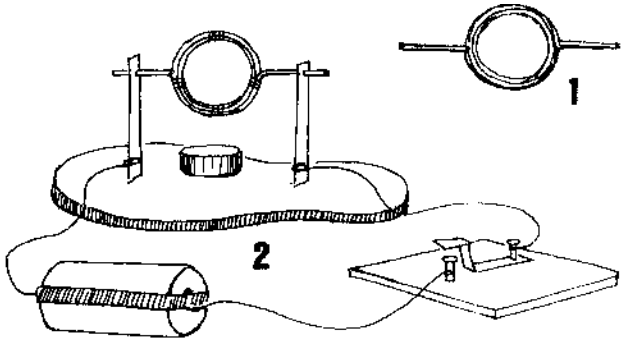
One remarkable feature of this motor is that the brushes are located right inside the bearings.
So, there is little chance of a bad contact.
This also enables you to turn the motor upside-down Fig (1).
What do you observe?
As you invert the rotating motor from its upright position the coil first comes to a stop, then flips, and then starts to rotate in the opposite direction.
Why?

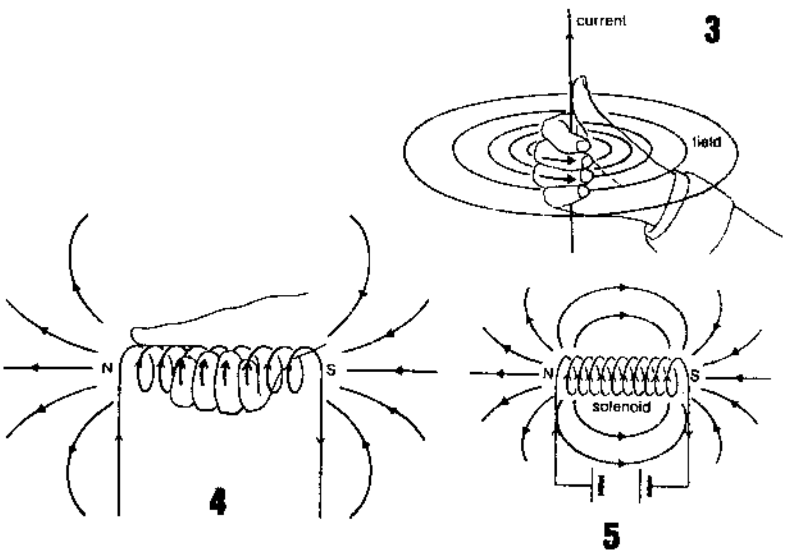
The motor can be converted into some joyous toys.
Fig (2) shows a circular card - the size of the inner diameter of the coil, with a cage in its center.
Draw a bird on the reverse of this card Fig (3).
Fix the card with some adhesive tape in the center of the coil Fig (4).
When the coil rotates, due to persistence of vision, you'll see the bird in the cage Fig (5).

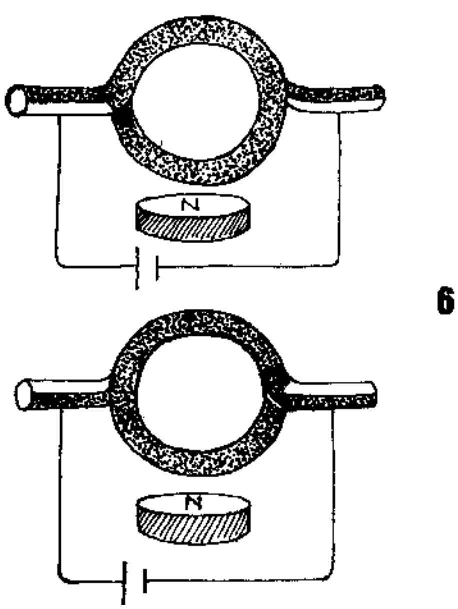
Insert two equal matchstick pieces in the ends of a cycle valve tube to make a twin blade propeller Fig (6).
Insert the valve tube in one end of the coil and see a rotating fan Fig (7).
Cut a circle from a stiff card sheet.
On this, cut equally spaced radial blades and offset them to make a blower fan for your motor Fig (8).

Which other ingenious toys can you make out of this simple electric motor?

HOW DOES THE MOTOR WORK





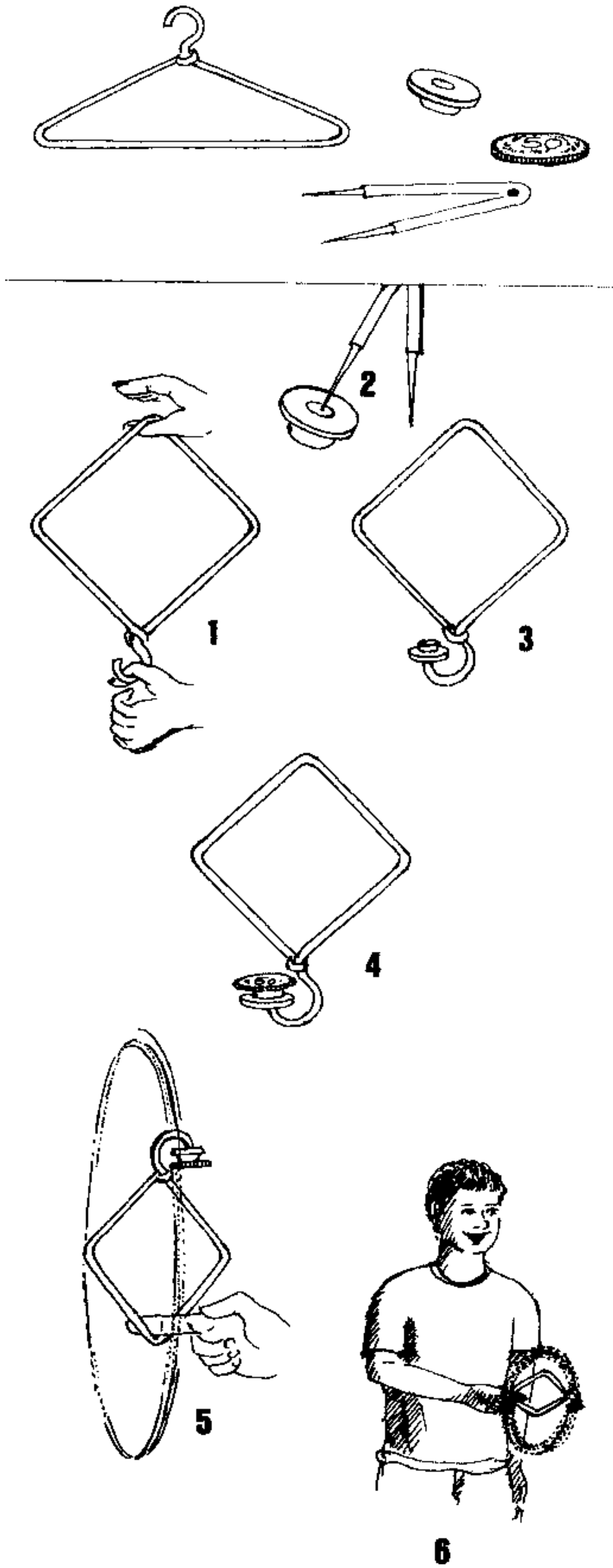


How does a commutator work?
Take a coil and scrape the entire enamel insulation from both its leads Fig (1).
Rig up the motor as shown in Fig (2). Improvise a switch using two nails and a stove pin bent into a 'Z' - shape. Now slip in the coil and press the switch to complete the circuit.
The coil will turn a bit and come to a stop. It will not rotate. However, if you keep, closing / opening the switch repeatedly then the coil will begin to rotate. The earlier coil - with half copper and half enamel did exactly this.

How does this D.C motor work?
When an electric current flows through a wire, it produces a magnetic field around it Fig (3).
The north and south poles of the electromagnet are shown in Fig (4, 5). Gripping the coil as shown your thumb points towards the North Pole.

When a D.C. current goes through the copper half of the coil, it acts as an electromagnet with a N-pole and a S-pole Fig (6). These poles are pulled towards the opposite ends of the permanent magnet. The coil will tend to come to rest once its N and S poles align with the S and N Doles of the magnet. But just as it reaches this point something happens.
The enameled half of the coil lead switches off current to the coil. Momentum propels it on until once again its half-copper leads touch the power leads. Once again the coil becomes an electromagnet. So, round the coil goes, and as it reaches the come to rest point it demagnetizes. Momentum propels it on. In this way the coil continues to revolve, round and round.

FUNNY MONEY



This is a truly dramatic way of demonstrating Centripetal force.

Grasping the hanger by the hook and midway along the longest side, stretch it into a diamond shape Fig (1).

Bend the hook slightly inwards.

Make a hole in an injection bottle rubber cap with a divider point Fig (2).

Insert the rubber cap in the tip of the hanger hook, pig (3).

Place a coin on the rubber cap and then dangle the hanger from your index finger Fig (4).

Slowly swing the hanger back and forth on your finger.

Then build-up a little speed and spin the hanger in a full circle Fig (5, 6).

Continue spinning as fast as you like. The coin will not fall off.

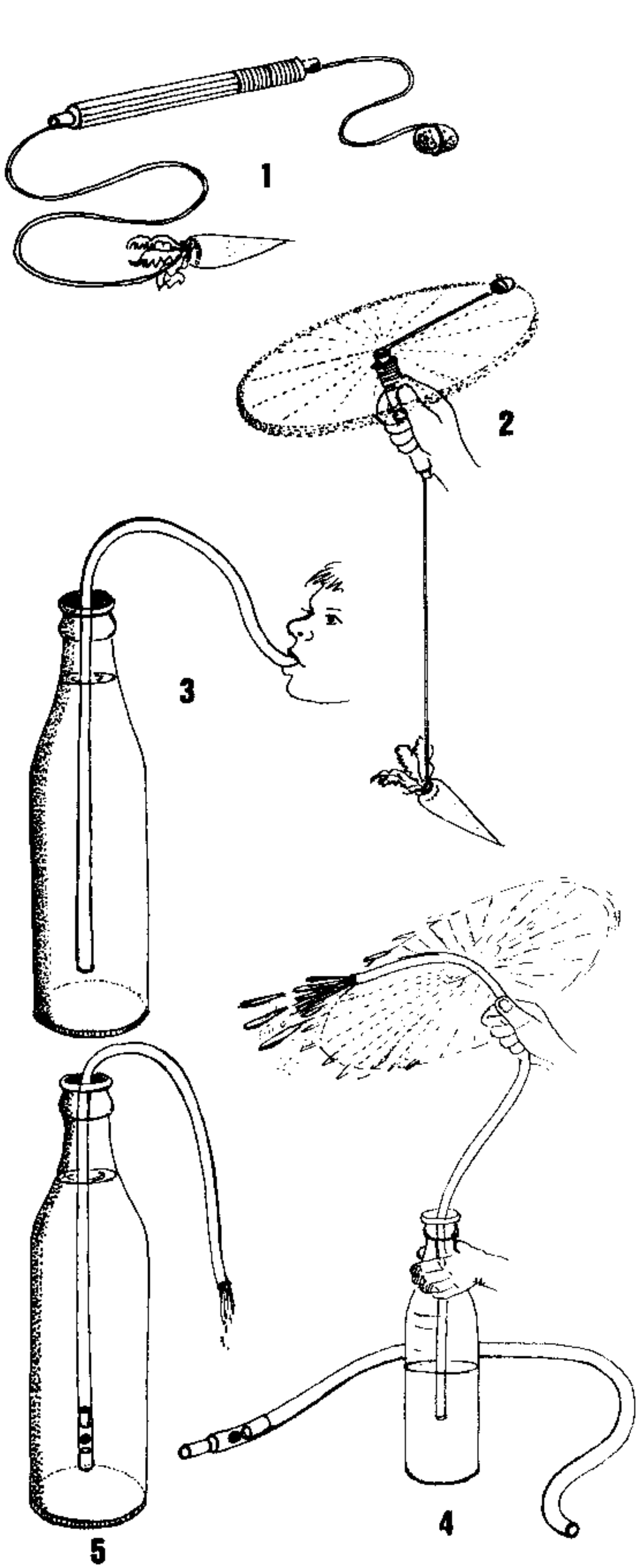
When you want to stop spinning, do it gradually, coming to a slow halt.

The coin still remains perched on the cap, as if it has been glued to it.

It will excite you and your' friends no end.

While the hanger is spinning, the tip of the hook exerts an inward force, which pushes the coin towards the center of the circle.

This force is called Centripetal force and prevents the coin from flying outwards.



SPRINKLER

Tie a piece of string, about one meter long, to the too of a carrot.
Slip the free end of the string through a ball pen body.
Then tie it to a small potato Fig (1).
Hold the pen body in your hand and begin making circular motions - the potato must swing in a circle.
As you increase the speed of rotation, the carrot will rise Fig (2).
There is a force associated with the rotation of the potato.
This force pulls away the center of the circle and is called Centrifugal force.

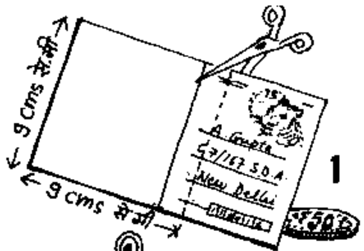
This simple sprinkler designed by Suresh Vaidyarajan, works in a similar way.

Take one meter long flexible plastic tube - the one used as a petrol pipe or as a mason's level tube.
Keep one end of this tube immersed in a bottle of water and suck out from the other end Fig (3).
When water starts flowing from the other end you start rotating it and slowly raise it.
Water will keep sprinkling out as long as you continue spinning the tube.
This way you can drain out the whole bottle Fig (4).

The Centrifugal force of rotation is enough to suck and lift water from a height of almost half a meter.

To prevent the water from falling back in the bottle improvise a simple 'foot valve' like in a *Holi "pichkari" (a pump for throwing colored water)* using a cycle steel ball and a pen body as a seat.

LETTER BALANCE



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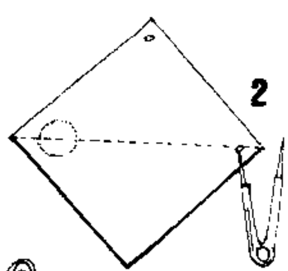

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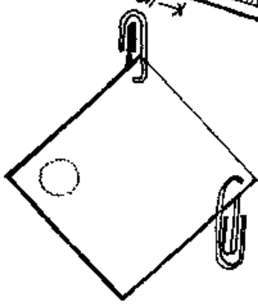

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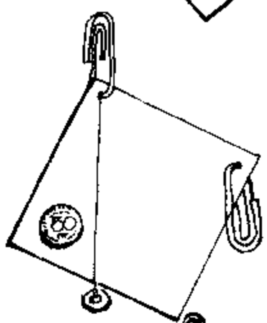

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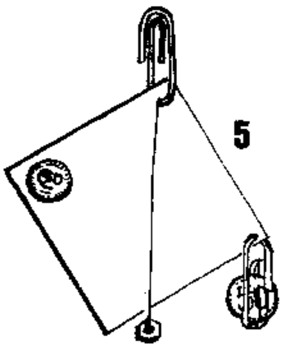

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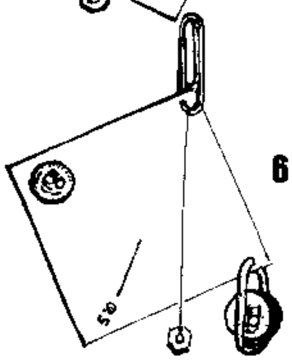

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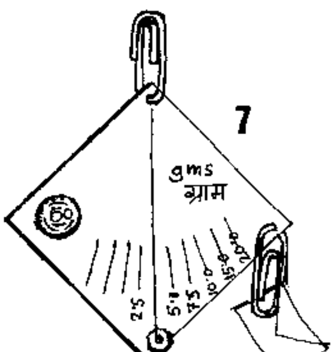

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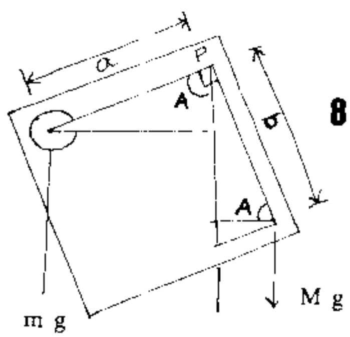

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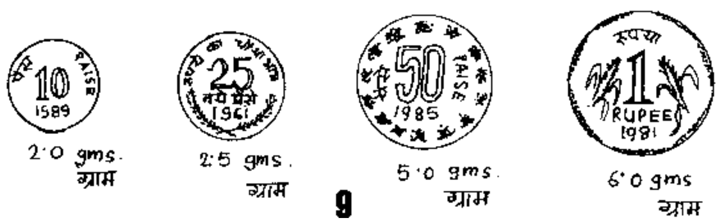

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This letter balance is convenient for weighing small objects.

Post cards are 9-cm wide.
Mark 9-cm along the length and cut a post card square Fig (1).

Draw a diagonal and poke two holes with a divider as shown in Fig (2).
Insert paper clips in the top hole for the pivot and in the right hand hole for hanging letters Fig (3).
Stick an old 50-paise coin (weight 5.0-gms.) in the left hand corner and suspend a small nut tied to a thread from the pivot clip Fig (4).
This is the pointer plumb line.

Now suspend an old 50-paise coin from the right clip and mark the position of the pointer on the card, indicating 5.0-gms Fig (5).

Again hang 7.5-gms. (one old 50-paise and one old 25-paise) from the right clip, and mark its position on the card Fig (6).
Using standard weights of coins given in Fig (9), also indicate 2.5, 10.0, 15.0, 20.0-gms marks on the card Fig (7).

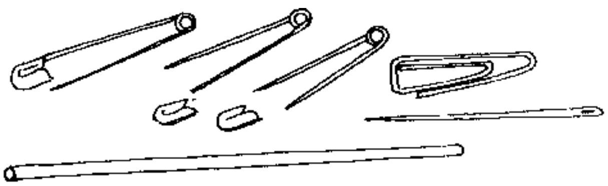
This calibrated balance can be used to weigh letters.

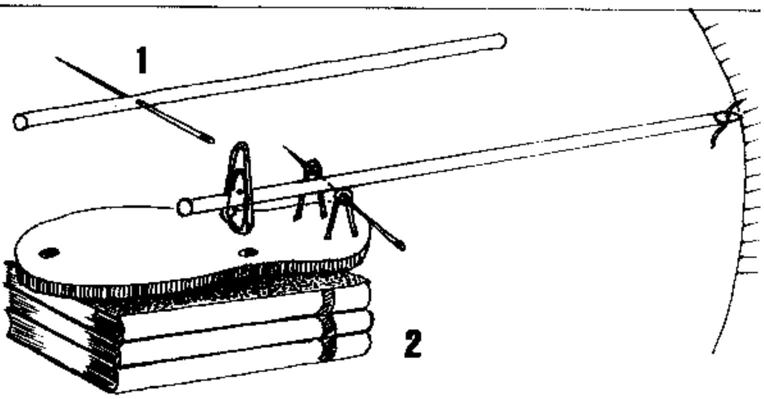
The balance can also be calibrated by taking moments about the pivot P Fig (8).

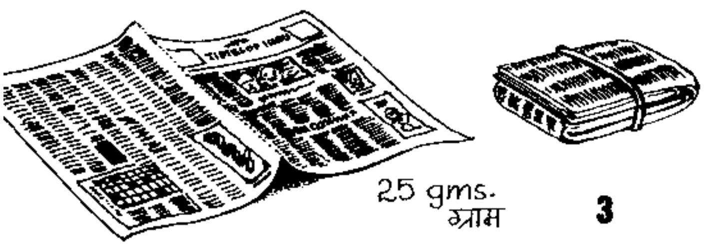
$m\,g\,a \sin A = Mg\,b \cos A$;
$M = a/b\; m \tan A$

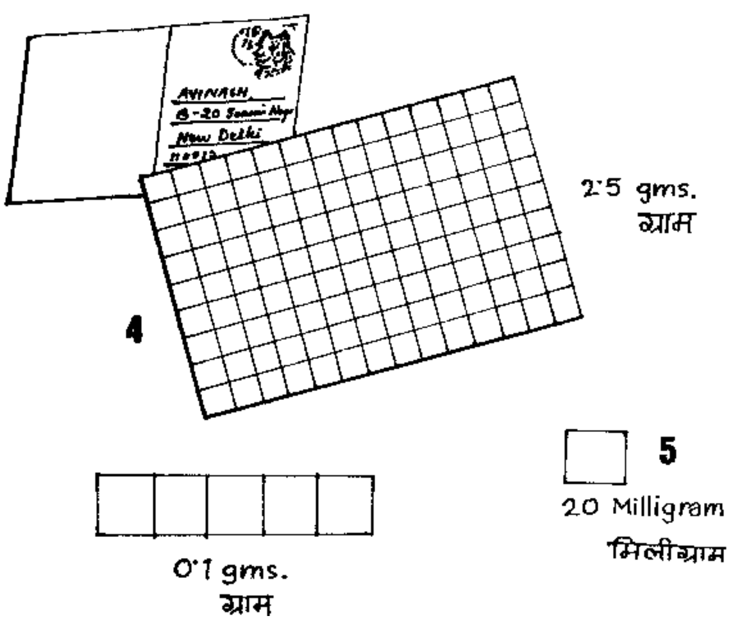
Check whether the tangent of the angle you measure is proportional to the mass of the object being weighed.

MICRO-BALANCE









This is a very sensitive balance. You can easily weigh a human hair with it.

Insert a needle at right angles, at about 5-cm from one end of a soda-straw Fig (1).

The balance must be mounted on frictionless bearings.

The best we can do is to use two safety pins without their latch ends. Poke the prongs of the safety pins at one end of an old rubber slipper.

Place the needle along with the straw in the eyes of the safety pins.

Cut the right end of the straw at an angle to make a pan.

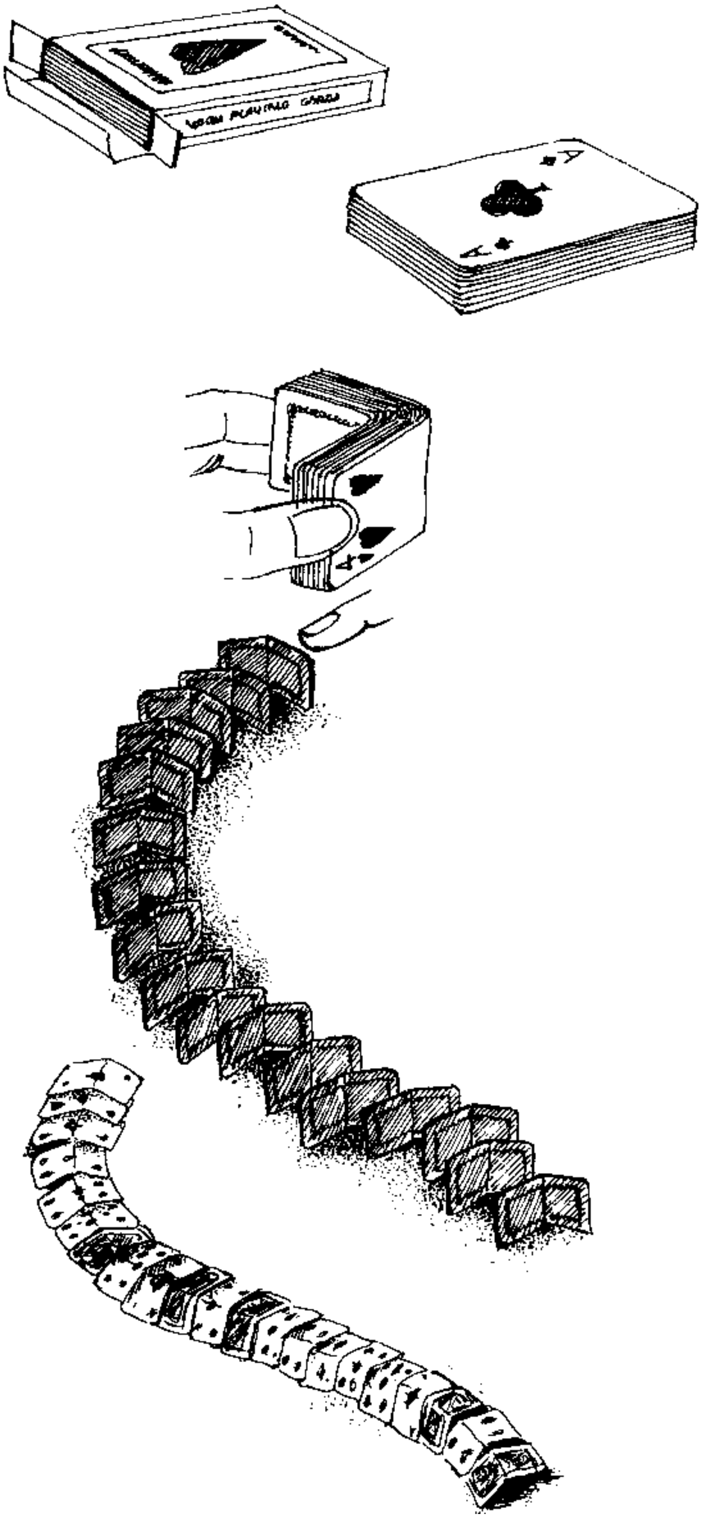
Carefully balance the straw by adjusting the position of the paper clip counter weight Fig (2).

Calibrate the balance by weighing some objects of known weight - 1-cm. x 1-cm pieces of postcard Fig (4, 5).
Now, weigh various light objects - a hair, a stamp, a piece of thread etc.

A single, double spreadsheet of ordinary newspaper weighs approximately 25-gms Fig (3).

Four such double spreadsheets will weigh close to 100-gms.

The weight of an ordinary postcard is around 2.5-gms Fig (4), and its area is 9 x 14 = 126 sq. cm.
Thus each 1-sq. cm. of postcard weighs around 20 milligrams Fig (5).



PASSING THE PUSH

One has to stand in a queue for virtually everything these days.
And what with people pushing and shoving from behind!
Well, a push from someone right behind has a way of getting transmitted right to the front, and it is difficult to identify the person who gave the initial push.

This is part of everyday experience.

Also, on a cycle stand, if one cycle falls down, it brings down the one next to it, which in turn topples the one next to it. The fall continues until all the cycles lie flattened on the ground.

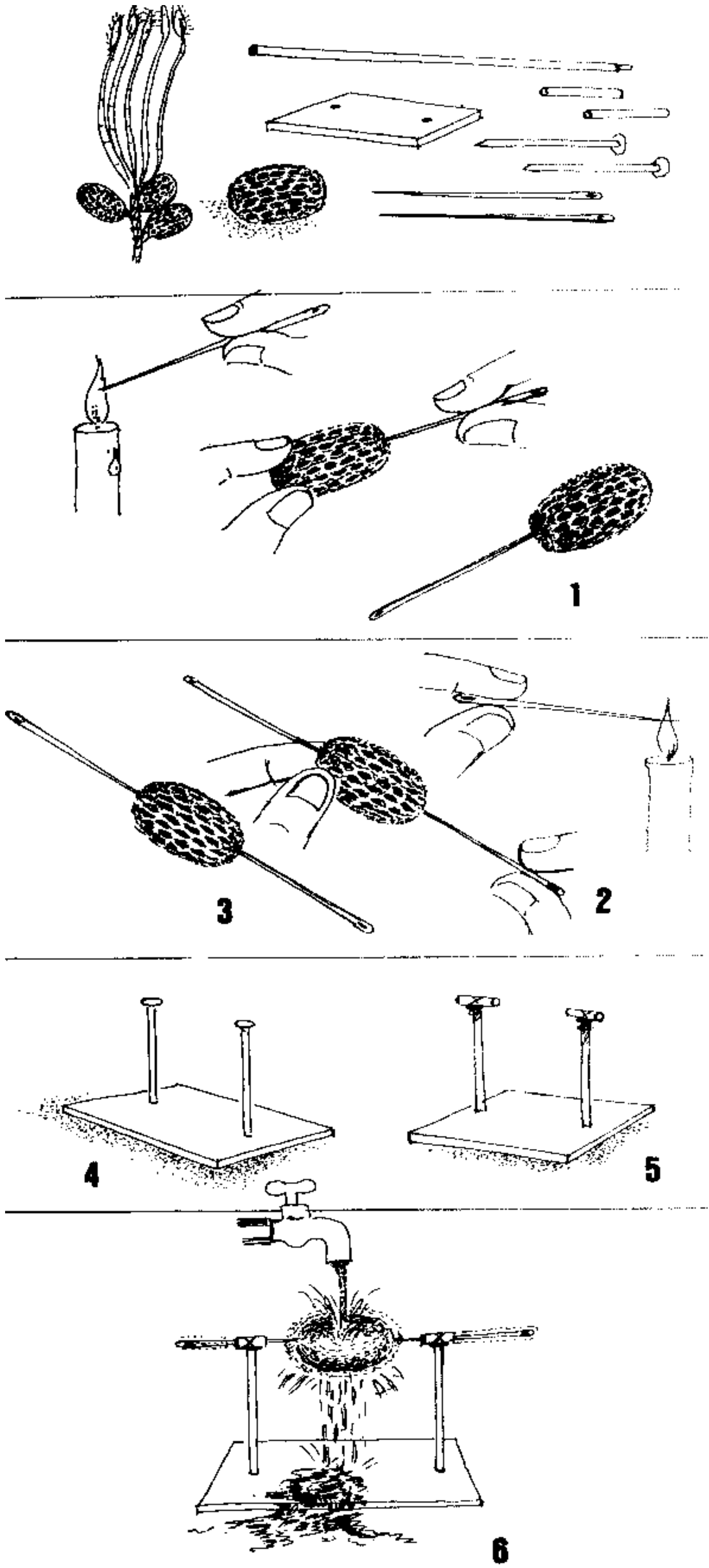
Children often stand bricks and dominoes, like wagons in a train, leaving little gaps in between.
They have great fun tipping one piece and then seeing the whole train come tumbling down in a sequence.
The same thing can be done with a pack of old playing cards.
Hold them and fold them so that there is a crease in the middle.

This enables them to stand upright.
Stand these cards to make a long train.
You can make gentle U and S shape curves too.

On tipping one card the pulse travels until the very last card falls down.

Does it not resemble the propagation of wave?

A FINE TURBINE



I have made several crude water wheels and turbines using odds and bits, but this one is the most sophisticated one of them all.

This is nature's very own turbine - the seed of the CASURINA tree. This tree can be easily mistaken for a pine. However, its seeds are oval, woody, and have a dozen deep furrows running along the length. It is these furrows which simulate the blades of a real life turbine.

Heat a needle tip and poke it along the long axis of the Casurina seed.

You may have to heat the tip a few times before the needle gets firmly embedded Fig (1).

Poke another needle at the other end of the seed Fig (2).

The needles become the axles on which the Casurina turbine will rotate Fig (3).

Cut a piece of old rubber slipper and fix two nails on it Fig (4).

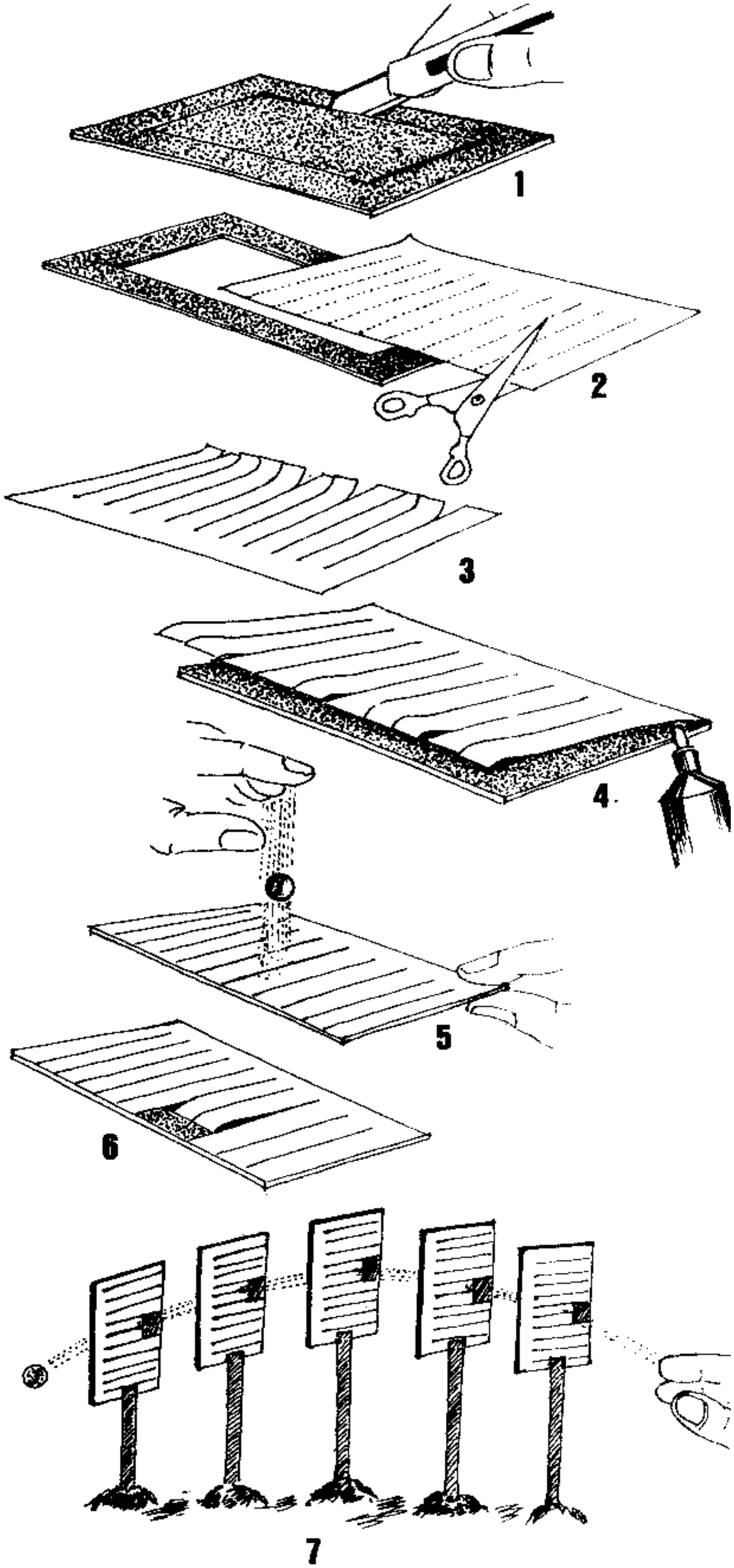
Tie 1-cm. long used refill pieces on the nail heads.

The refill pieces must lie in a line Fig (5).

Now, place the needle in the refill pieces - which act like bush-bearings.

Finally, keep the seed turbine below a running tap such that the water stream falls on one side of the seed.

This elegant turbine will then keep rotating and give you endless joy.



PATH FINDER

This brilliant idea won the national award in China, for the best designed teaching aid, in 1988.

To locate the position of a moving particle you will require some fairly expensive and sophisticated gadgets. The paper reed pathfinder enables you to do that at almost zero cost.

Remove the center from a 10-cm x 20-cm piece of cardboard, leaving a 1-cm. wide frame Fig (1).

Take a 10-cm x 20-cm sheet of paper, and leaving aside 1-cm. along its length, cut parallel strips along its width Fig (2, 3).

Apply glue along the uncut length of this paper reed and stick it along one long edge of the frame Fig (4).

Hold the edge of the frame with one hand and drop a marble into the frame Fig (5).

The marble will strike the reeds and at the point of strike, the reeds will go below the frame Fig (6).

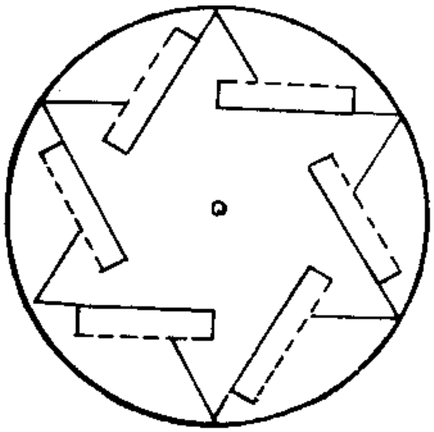
This enables you to locate the position of the particle.

The path of a moving marble can be found by placing several such mounted frames along its approximate trajectory.

**One throwing, the marble will pass through all the frames.
The reeds will go behind each frame at the point of strike.**

Of course, the thinner the strips the more precisely can the position of the particle be located.

AEOLLAN TOP

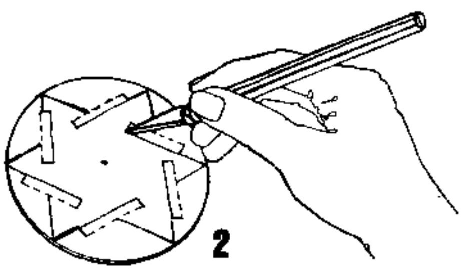


1

Taking its name from the Greek god of the wind, Aeolus, the Aeolian Top is propelled by the wind.

It was popular during the late nineteenth century.

It consists of a thick card disc, 7-cm, in diameter, that has a series of oblique slots arranged symmetrically around its surface Fig (1).



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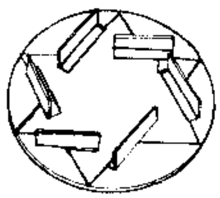
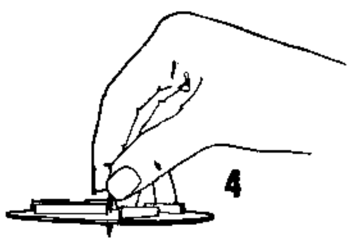


3

Cut along the three sides of the flaps as shown in Fig (2, 3).

Color the top with sketch pens, if you like.



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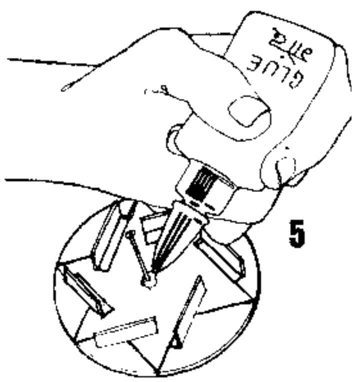

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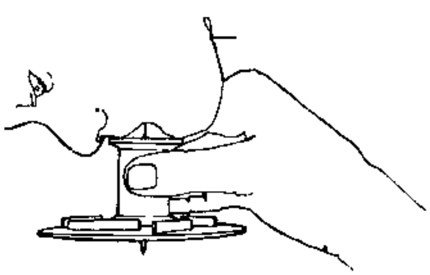
Stick a straight pin or a thin nail through the center of the disc, leaving about 1-cm. projecting below Fig (4).

This will serve as the pivot point for the top. Apply several drops of glue or a dab of *Fevicol* (glue) around the pin to hold it in place Fig (5).



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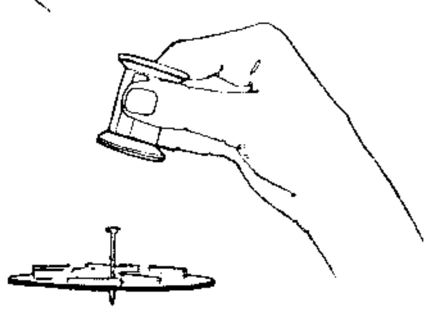
Now, your top is ready.
Hold the disc lightly against one end of an empty thread spool with your finger, letting the long end of the pin stick up through the hole in the spool.

Blow through the other end of the spool Fig (6).



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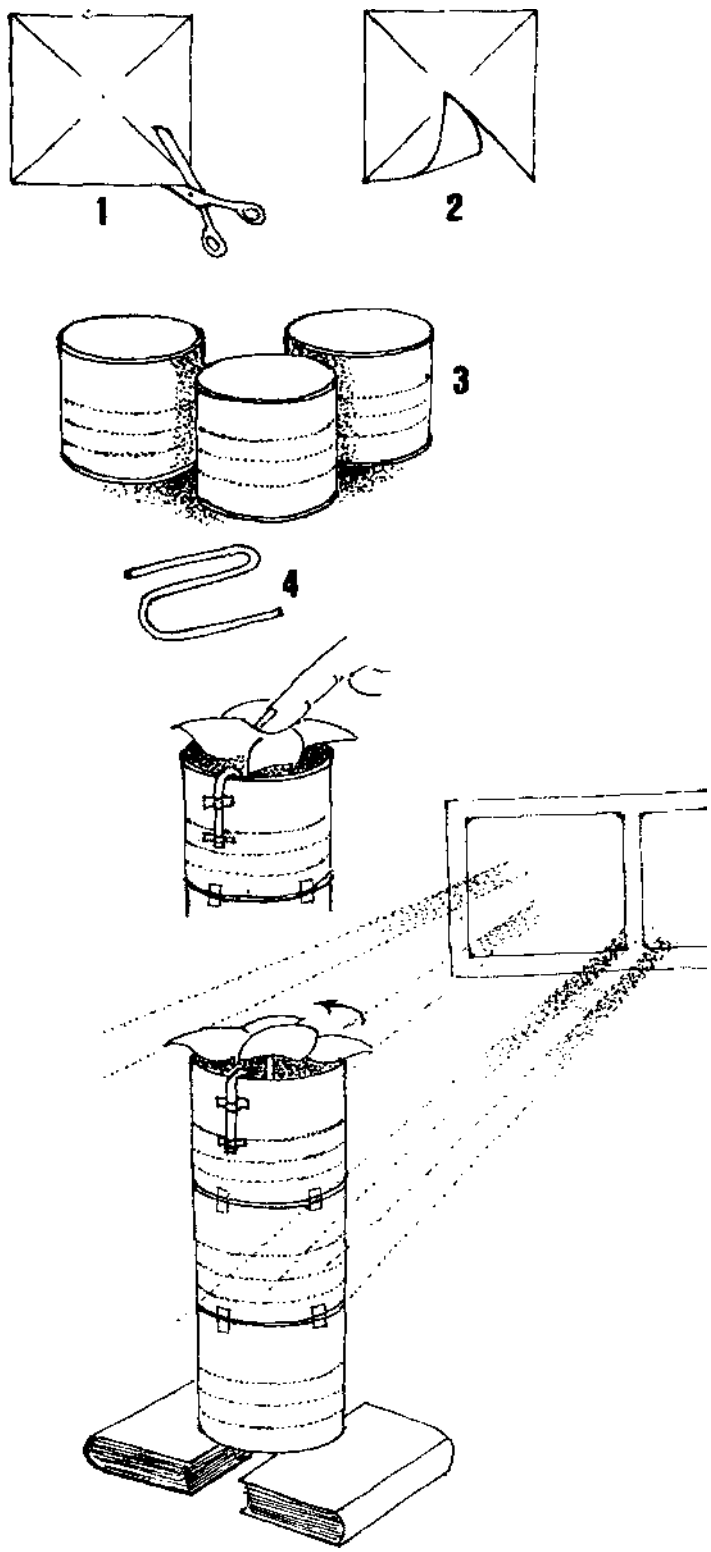
The stream of air you blow strikes the radial vanes and makes them spin.

The stream of air also creates a low-pressure zone that holds the disc against the spool.

If you hold the whirling top over a table or any flat surface and stop blowing, it will drop from the spool and continue spinning!



SOLAR PINWHEEL

This simple device uses the sun's energy to rotate a pinwheel.

Fold a square paper as shown in Fig (1) to make a windmill.

Glue its corners to the center Fig (2). Make a single dent (not a hole) with a pencil at the center of the windmill.

With the help of an adult, cut the bottom out of three old tin cans Fig (3).

Paint the outside of the cans black.

Join the three cans together with some tape, to make a long metallic hoop.

Get a piece of thin wire and bend it as shown in Fig (4).

Tape the wire on the top of the can and balance the windmill on its tip.

Stand the cans on two books on a sunny windowsill.

Watch what happens as the sun warms the cans.

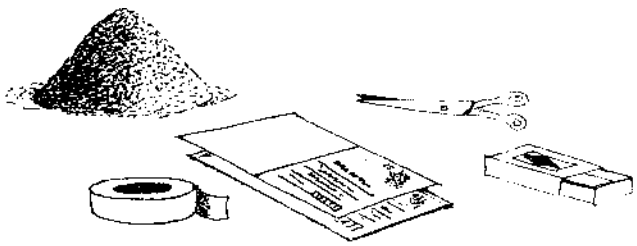
The hot air inside the can rises up, sucking cold air from below.

This continuous convection current keeps the pinwheel rotating.

Instead of joining three tin cans to make a hollow cylinder, you can make use of the metallic hoop at the end of the soft broom - the 'Phool Jhadu'.

How can you make this windmill turn on a day when the sun is not shining?

WHICH HOLDS MORE?



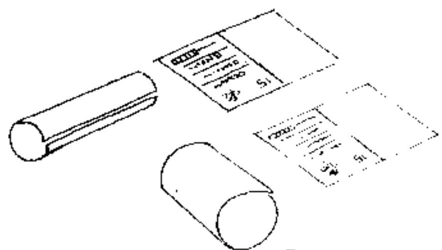
Can two cylinders with the same surface area, have different volumes?

You will need two old post cards, some sticky tape, a matchbox drawer and some sand to do this experiment.

Post cards from the post office come in one standard size – 14-cm long and 9-cm wide.

They have the same area.

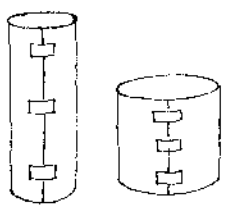
Take two old post cards, and roll each one of them into a tube.



1 2

One the long way Fig (1), and the other the short way Fig (2).

Tape the ends.



3 4

One cylinder will be tall and thin Fig (3).

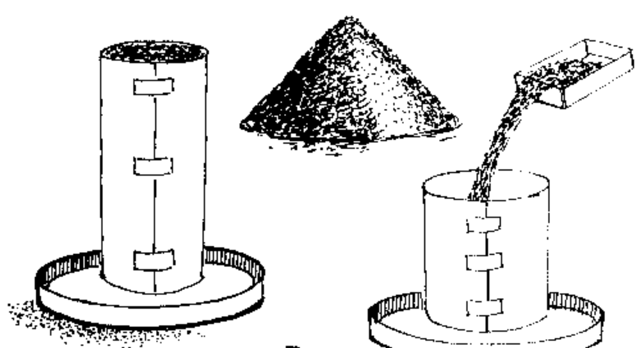
The other will be fat and squat Fig (4).

"Will each cylinder hold the same amount?"

What do you think is the answer?

Try and estimate the capacity of each cylinder by filling it with sand.

Use a matchbox drawer as a measure Fig (5).



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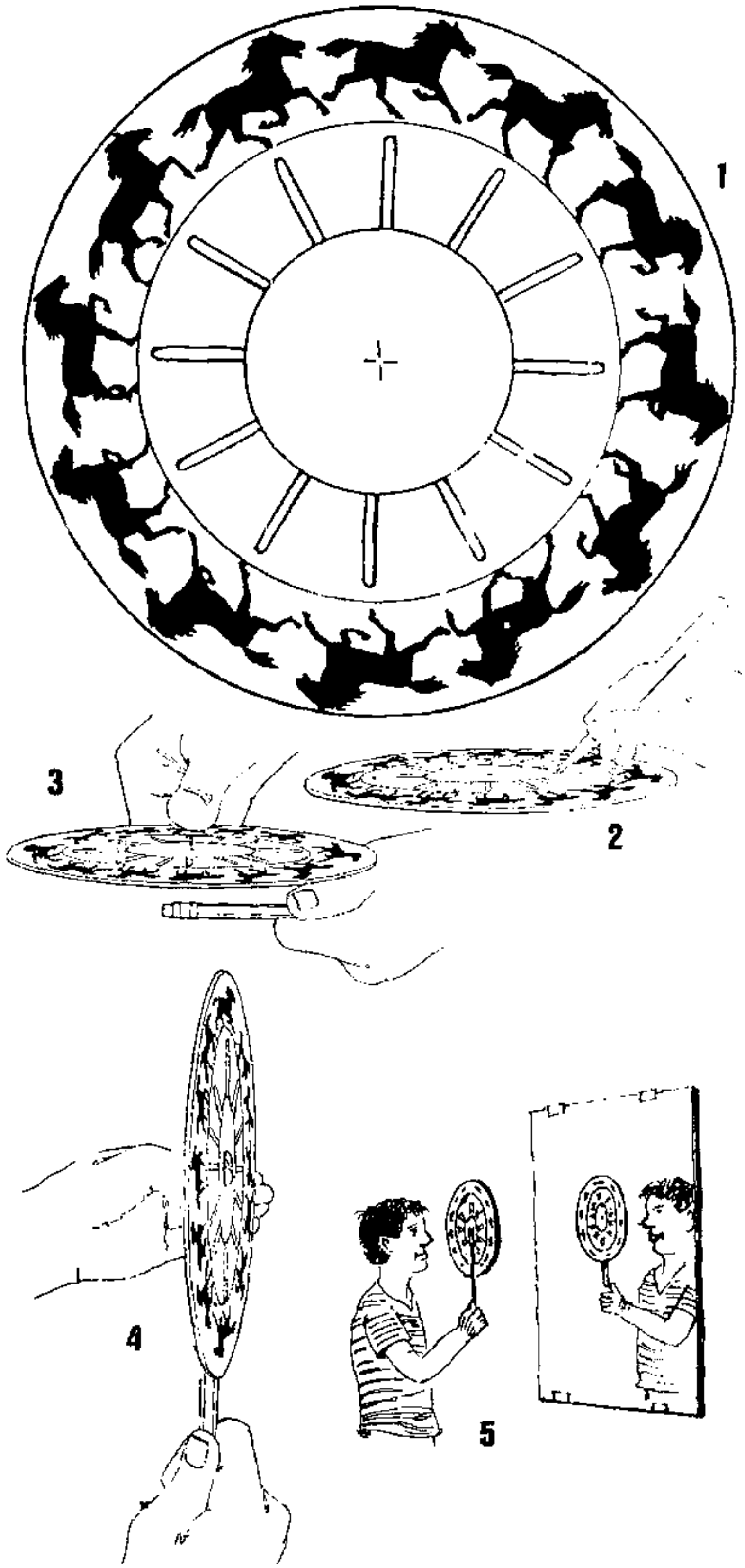
This experiment relates volume to area. Volume is a three-dimensional measure.

Area is a two-dimensional measure. What difference does that make?

THE PHANTASCOPE



A Belgian physicist J.A.E Plateau invented the Phantascope or "Magic Disc" in 1872.
It is supposed to be the first moving picture machine.
The design of the Phantascope is nothing more than a cardboard circle with a series of equispaced slits.
The Phantascope can rotate about a pivot mounted on a handle.
On the other side a set of sequential pictures are placed between slits. When the device is placed in front of a mirror and viewed through the rotating slits, the pictures give the viewer the impression that they are moving.

Trace the pattern in Fig (1) and glue it on cardboard.

Now cut the twelve slits in the center with a sharp knife Fig (2).

Attach the pencil handle to the Phantascope by pushing a thumbtack through the center into the eraser of the pencil Fig (3).

Make sure that the pencil is on the blank side of the cardboard.

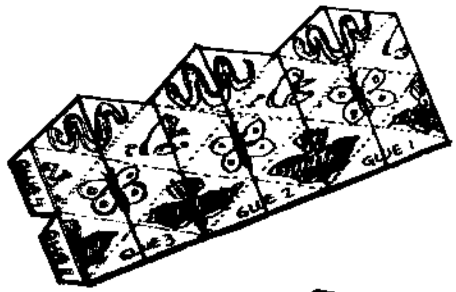
Now your Phantascope is complete Fig (4).

Stand in front of a mirror, holding the Phantascope so that the pictures face the mirror.

Twirl the edge of the disc with your finger.

Do not twirl too fast.

Watch through the viewing slits, as the images become a moving picture Fig (5).



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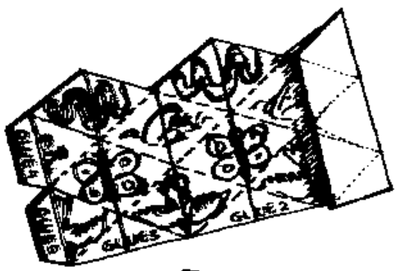

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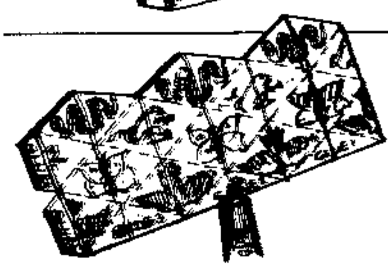

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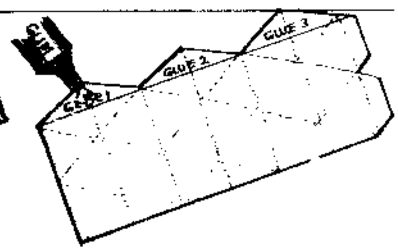

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6

7

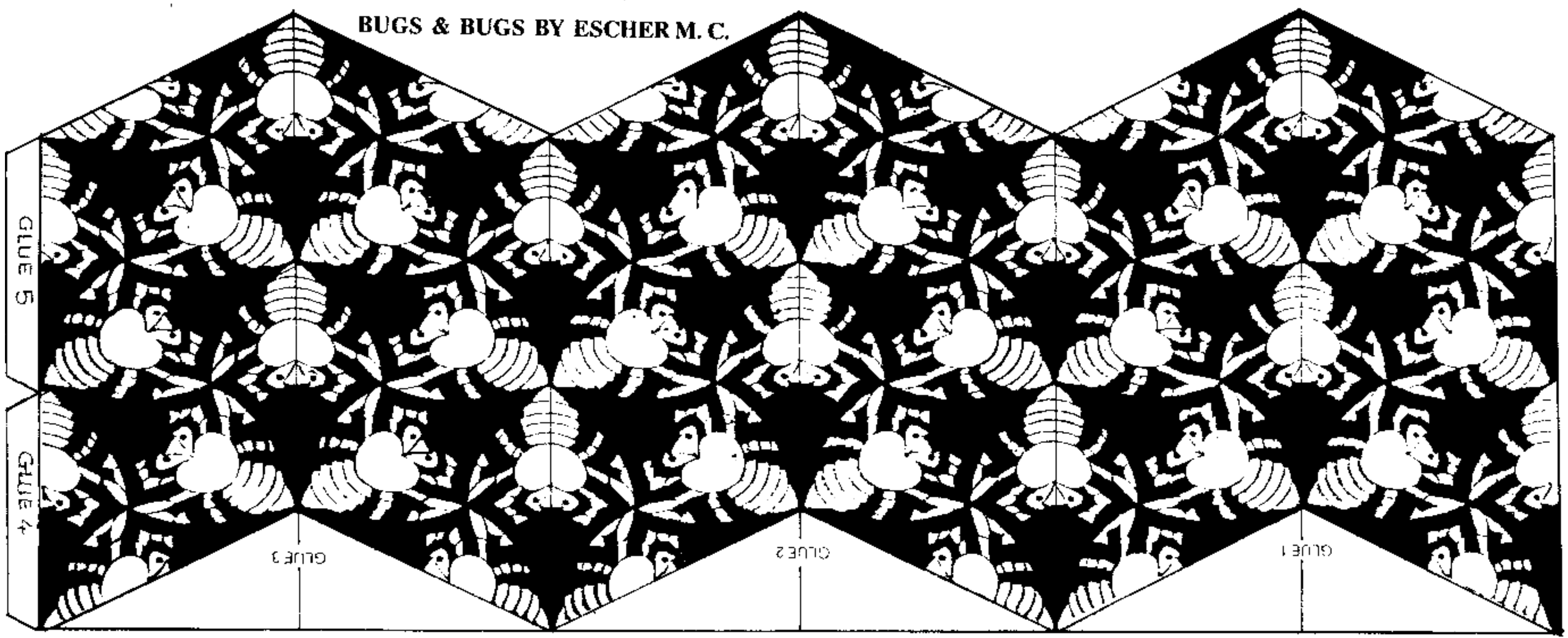
FLEXAGONS

The flexagon is an amazing model. Each time that it flexes about its center a different picture comes into view.
It can be used to depict any four stage cycle or sequence.
Four flexagon networks printed on thin card sheets are stapled in the middle of the book.
The card sheet has the printed network on one side.
The reverse side is plain white.
Make the flexagons as follows:

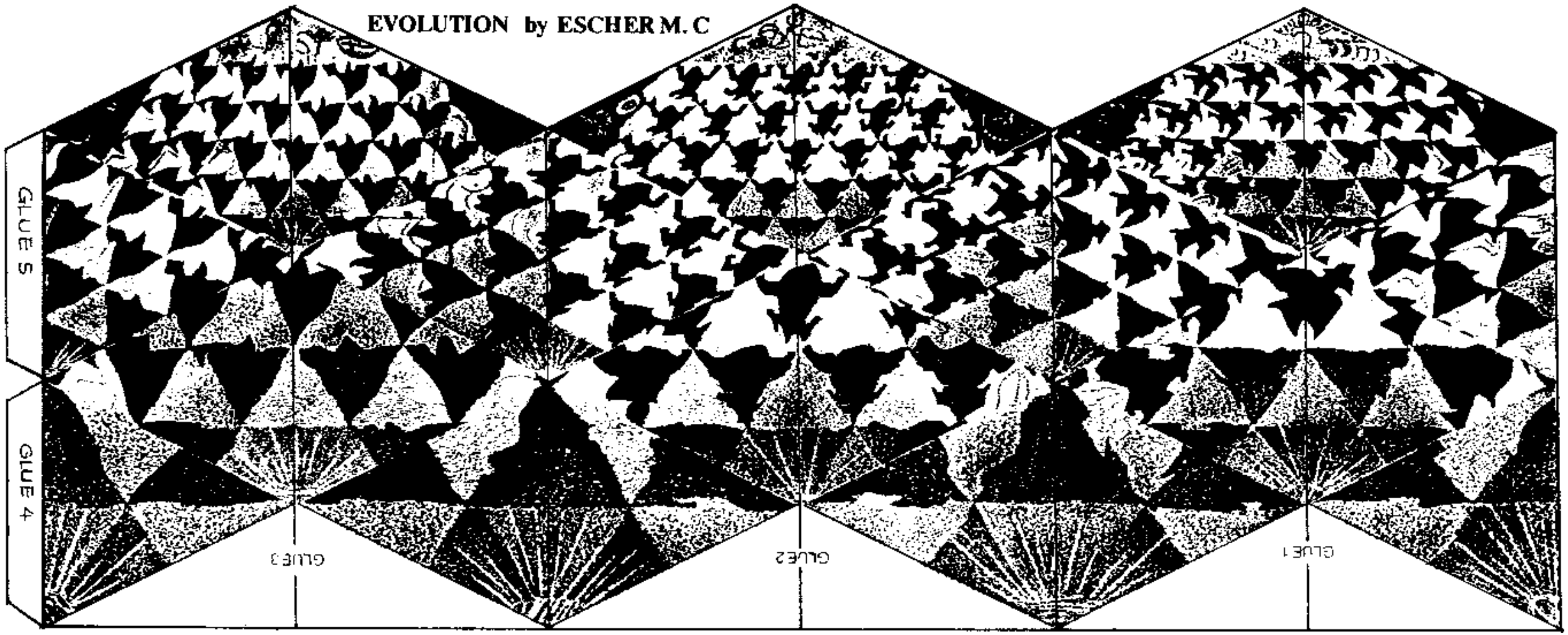
First, cut out the network precisely along the outline Fig (1).
Fold all 8 diagonal lines marked with dashes (-------) away from the picture Fig (2).
Fold all 6 vertical lines towards the picture Fig (3).
First try to assemble the model without applying glue.
When you can see how it fits together glue in order of 1, 2, 3, 4, 5.
Glue 1, 2, 3 on the picture side Fig (4).
Apply glue also to the three triangular hills on the plain side of the sheet Fig (5).
These have not been marked on the network.

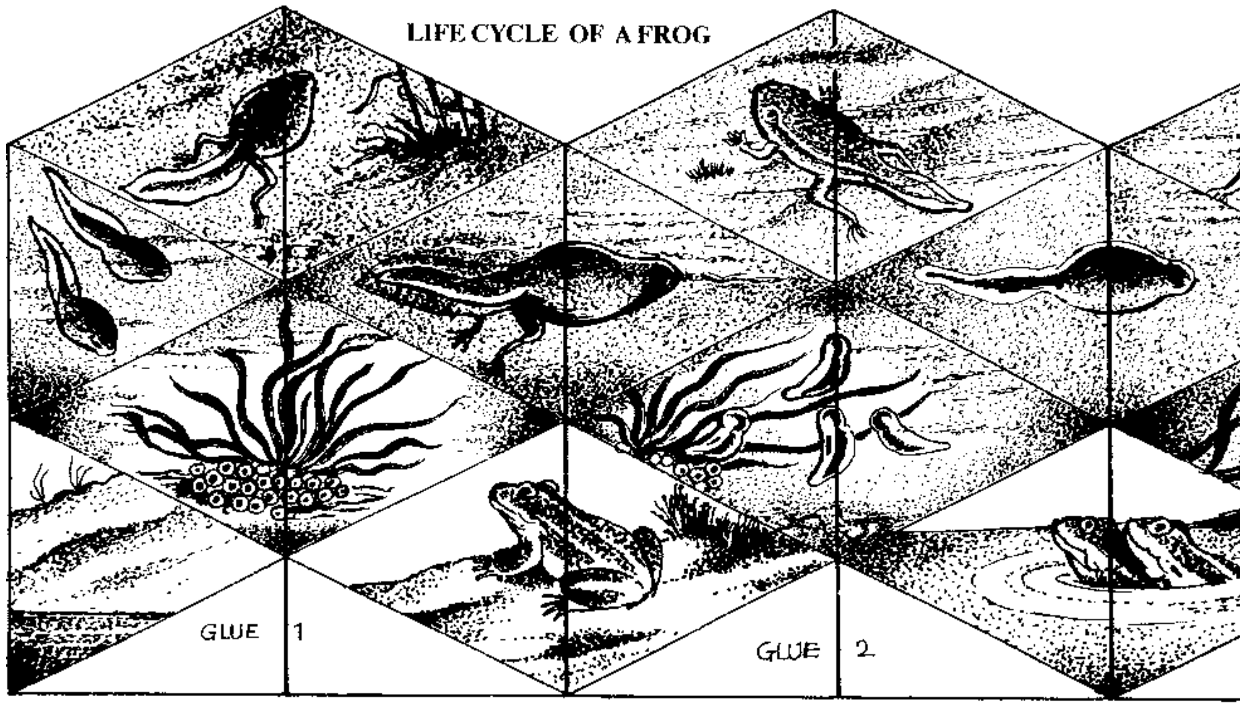
Stick Glue 1 of the picture side on Glue 1 of the plain side.
Do the same with Glue 2 and Glue 3, to get the chain in Fig (6).
Apply glue to flaps 4 and 5.
They go inside the pocket to complete the ring Fig (7).
The use of a quick dry impact adhesive like *Fevibond* gives better results.
Once the model is dry, flex it away to glory.

BUGS & BUGS BY ESCHER M. C.

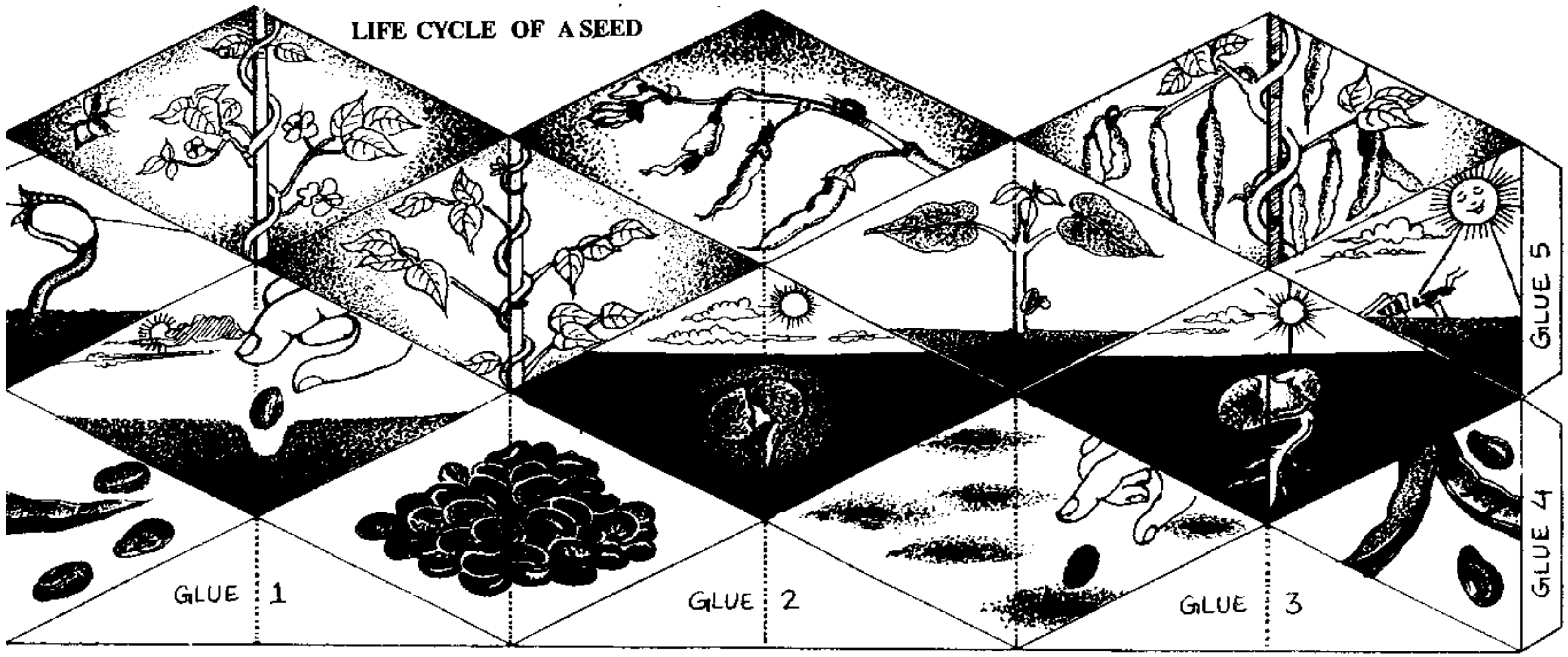


EVOLUTION by ESCHER M. C

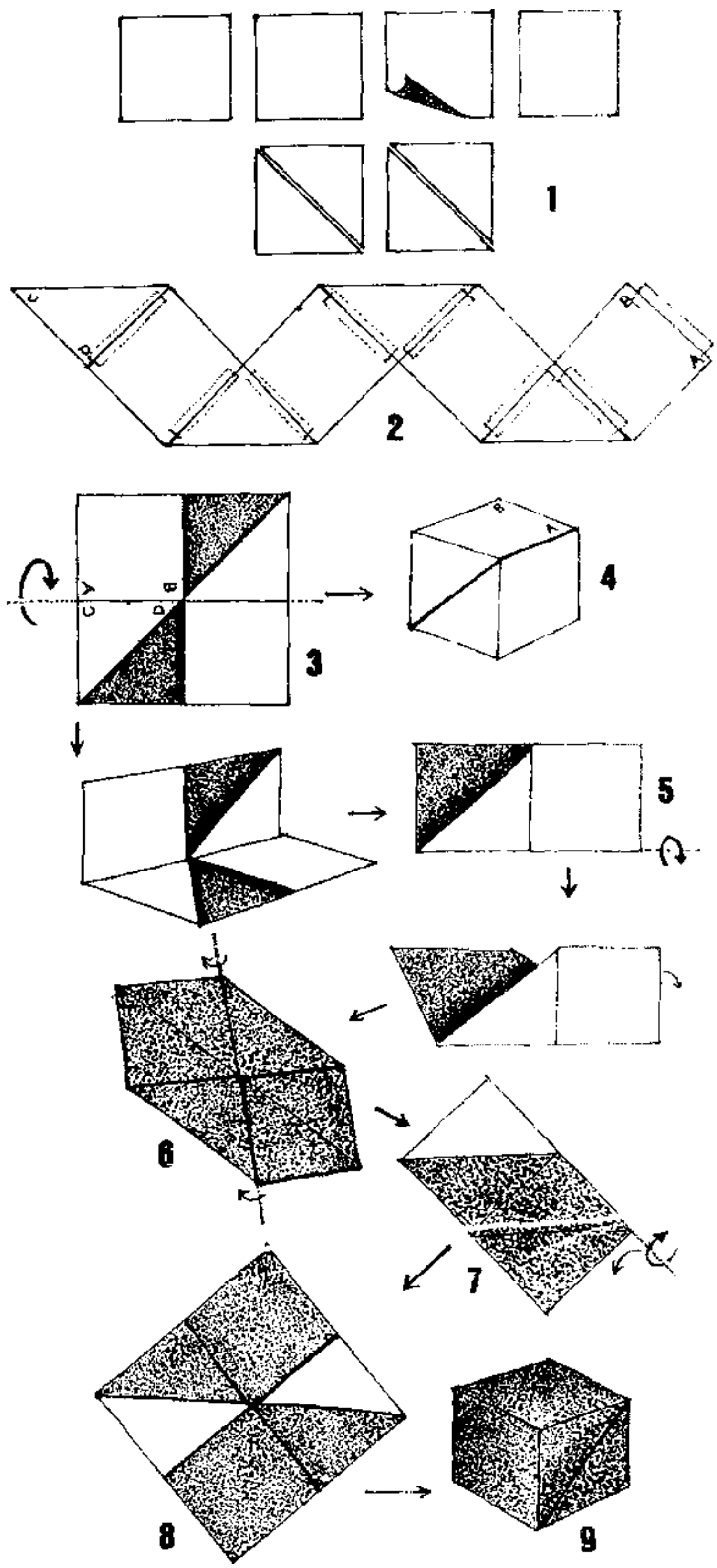



LIFE CYCLE OF A FROG
GLUE 1
GLUE 2

LIFE CYCLE OF A SEED



THE INSIDE - OUTSIDE CUBE



This is very ingenious puzzle. Imagine a box - white on all sides. Give it a few turns and twists, and it is black on all sides!

Using stiff card sheet cut six squares, with a 5-cm edge.

The squares we white on one side, black on the other.

Cut two squares along diagonal to make four triangles Fig (1).

Using adhesive tape stick the four squares and the four triangles into a "W" formation Fig (2).

Now bring edges AB and CD together and join them with tape to get a square formation Fig (3).

Twisting Fig (3) results in an all white cube shown in Fig (4).

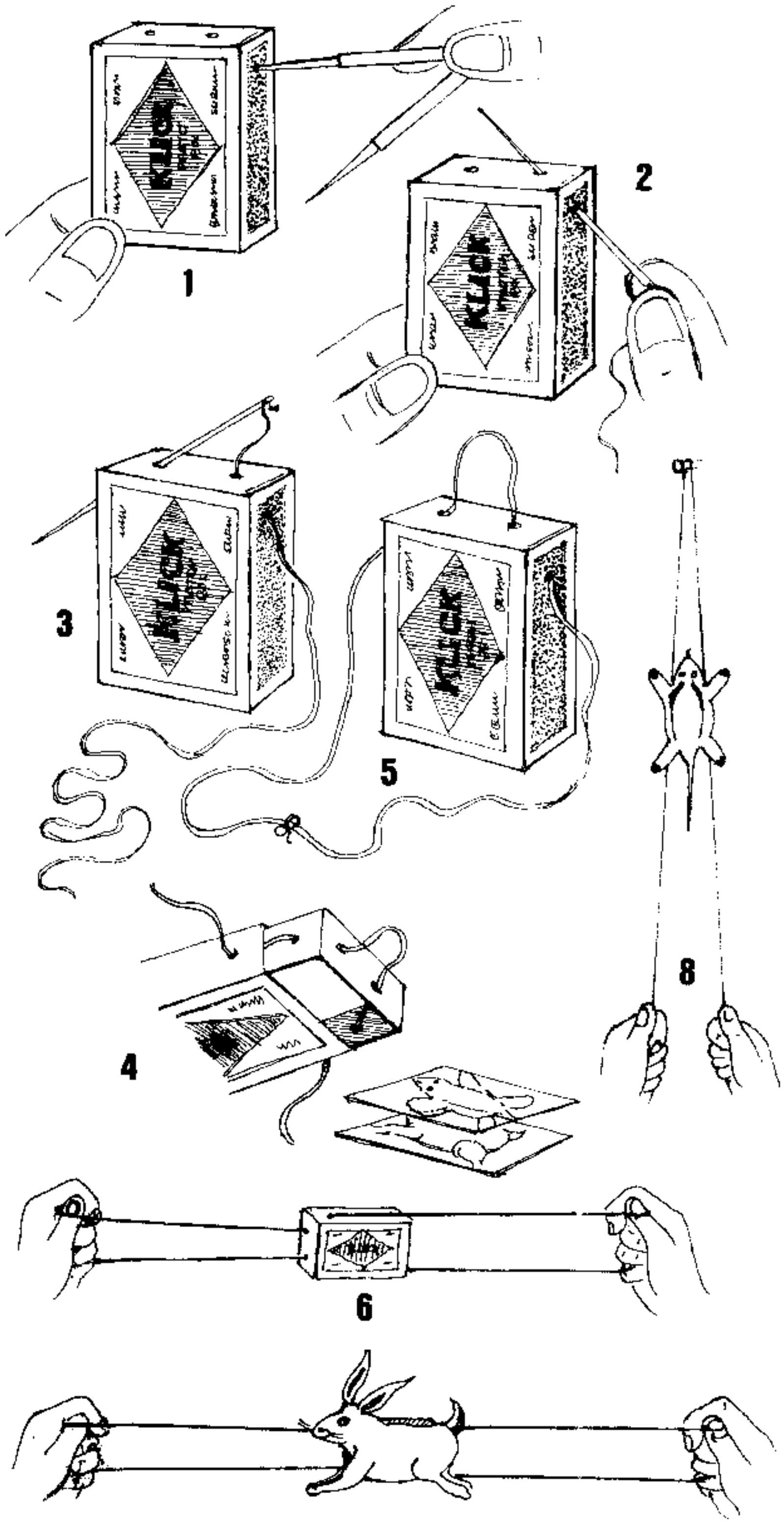
Fold the square in Fig (3) along its middle horizontal line to get the rectangle in Fig (5).

Open out the rectangle in Fig (5) on its bottom edge to get a black hexagon Fig (6), which is closed into a rectangle Fig (7).

When this rectangle is opened up a large square Fig (8) is obtained, which can be twisted to give an all black cube Fig (9).

It is almost magical how a few turns and twists can turn a six faceted cube completely inside-out.

MATCHBOX RIDER



Threading an old matchbox in an ingenious way makes this zero-cost dynamic toy.

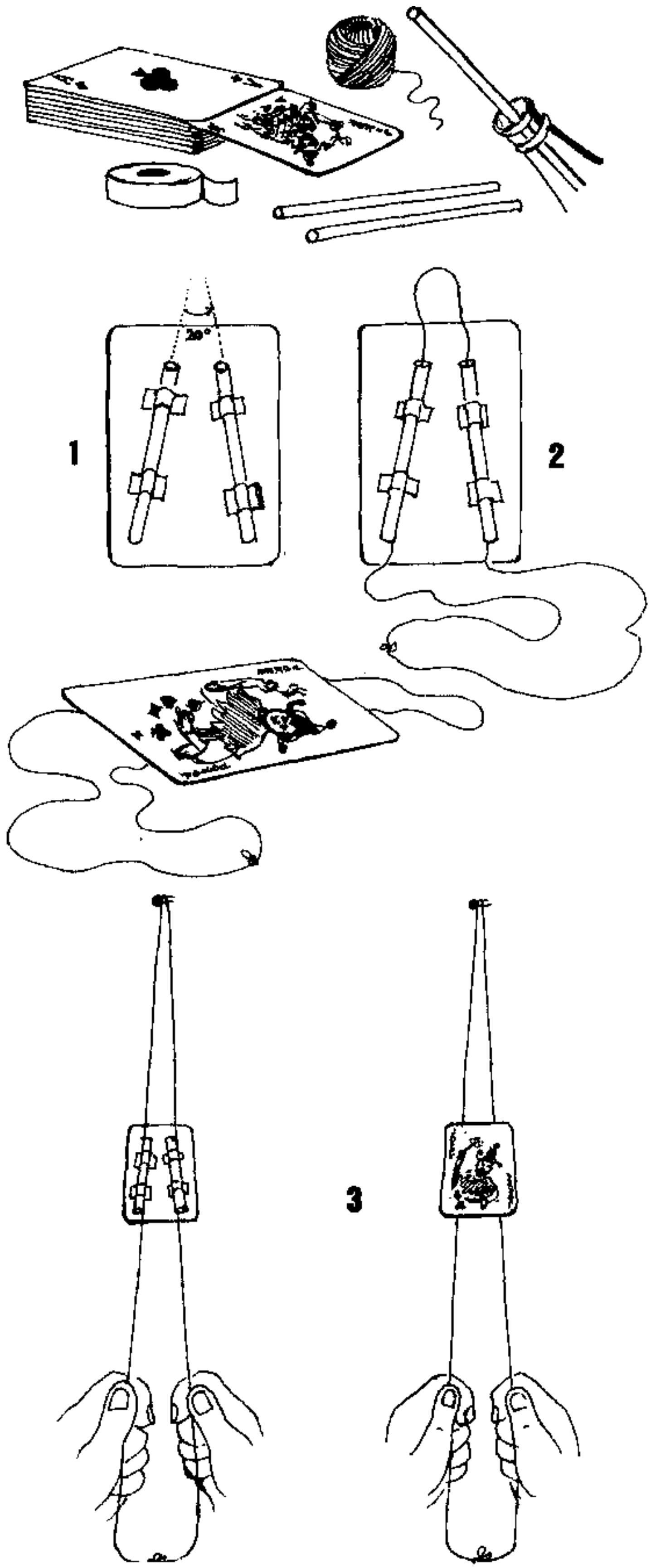
Make a hole each on the strike surface of the matchbox about 1.5-cm from one end.
Make two more holes on the drawer using a divider point Fig (1).
Take a needle with a 1.5-meter long string.
Thread the needle through the strike surface and the drawer hole Fig (2).
Thread the needle through the other holes too Fig (3).

The threaded matchbox is shown in Fig (4).
Now, tie the two ends of the thread to complete the mechanism Fig (5).
Hold the string in both hands as shown in Fig (6).
Turn and twist the left hand rapidly.
The matchbox will travel along the string tracks.

However, it is more interesting if you stick a cutout of a rabbit on the matchbox Fig (7) and enjoy the rabbit hop at your fingertips.
The mechanism moves in one direction only, and you will have to bring it back once it reaches the left-hand end.

Hand the top string loop of the mechanism by a nail and stick a cutout of a lizard on it.
On pulling the left and right-hand strings in succession, the lizard will crawl up Fig (8).

CLIMBER JOKER



The Climbing Joker is quite akin in principle to the Matchbox Rider.

Both these toys are based on friction. Remove the joker from an old pack of playing cards.

Cut two soda-straw pieces, each 6-cm long.

Using adhesive tape, stick these soda-straw pieces at an angle of about 20 degrees, on the backside of the joker card Fig (1).

Thread a 2-meter long string through the straws.

Tie both the ends of the string in a knot Fig (2).

Hang the string by a nail as shown in Fig (3).

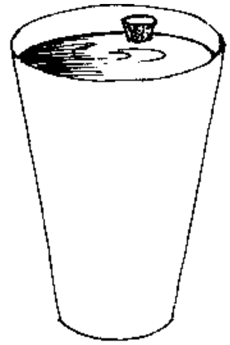
Hold both ends of the string taut. Pull each end of the string alternately and the joker will climb the string.

Before the joker begins to climb the string should have a minimum of tension.

Try to increase and decrease the angle between the straws and see the change in tension required to get the joker climbing.

What would happen if you used old ball pen refills instead of soda-straws?

There is one good thing the string-straw mechanism. Unlike the Matchbox Climber, it does not have to be brought back to its initial position. The joker simply slides down as soon as the tension in the string is released.



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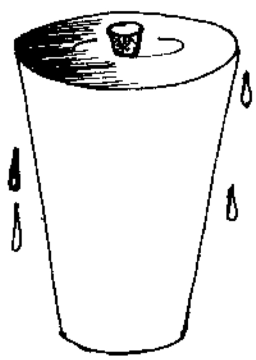
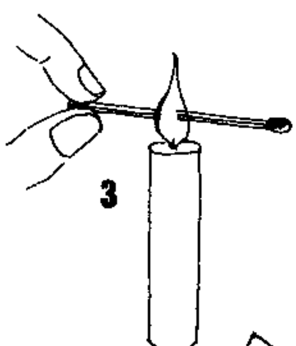


2

BAR ROOM PHYSICS

Fill a narrow drinking glass with water, to about 1-cm from the lip.
Float a cork on the water surface.
No matter how carefully you try to center it, the cork will always move to the edge of the glass Fig (1).
Now remove the cork, and slowly add water to the glass until the water level is slightly above the rim of the glass.
Carefully place the cork on the surface once more.
This time the cork will float in the center Fig (2).
In Fig (1), the water level is slightly higher at the walls than in the middle, so the cork floats towards the rim of the glass.
However, in Fig (2), the water level is slightly convex and the cork floats to the center.



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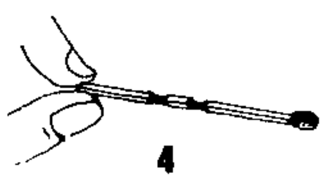

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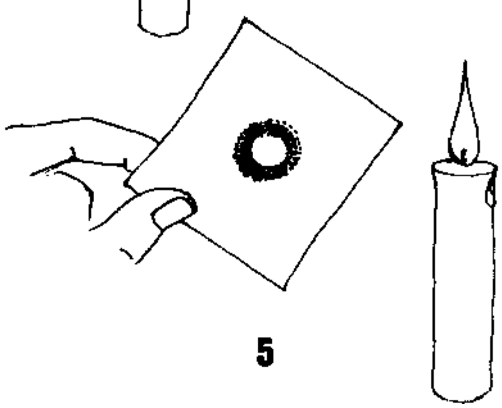

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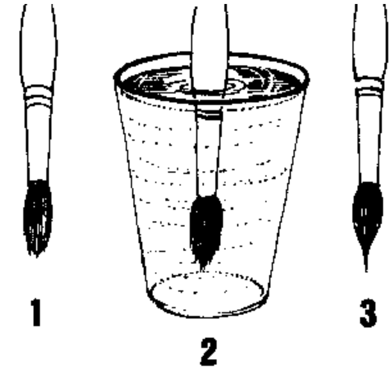
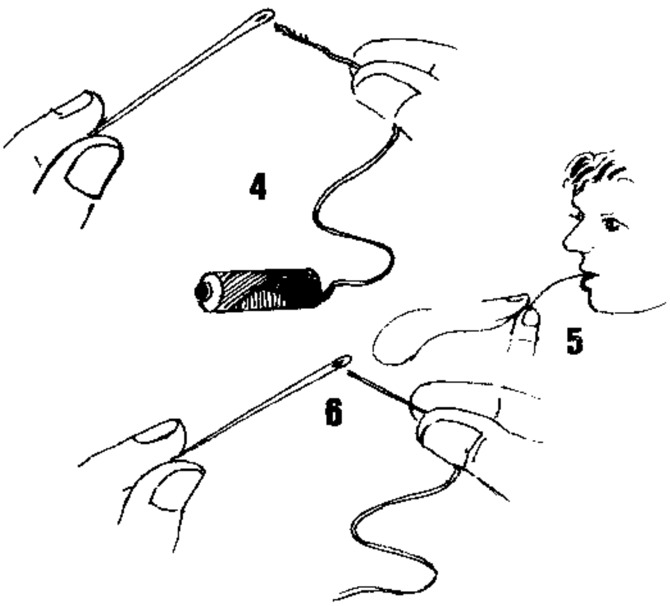
HOT FLAME, COLD CENTRE

This experiment demonstrates a very strange fact about a flame.
Though most of it is too hot to touch without burning your fingers, there is a cold spot in the center.
Hold the middle of a matchstick in a flame for a moment, or two Fig (3).
On removing, you will see that the matchstick has burnt only at the two spots where it touched the flame.
The portion between them has not burnt Fig (4).
You can do this experiment in another way.
Hold a square of stiff paper steady in a flame for a second or two.
On removing, there will be a scorched ring on the paper formed by the hot outside ring of the flame.
The cool center remains unburned Fig (5).

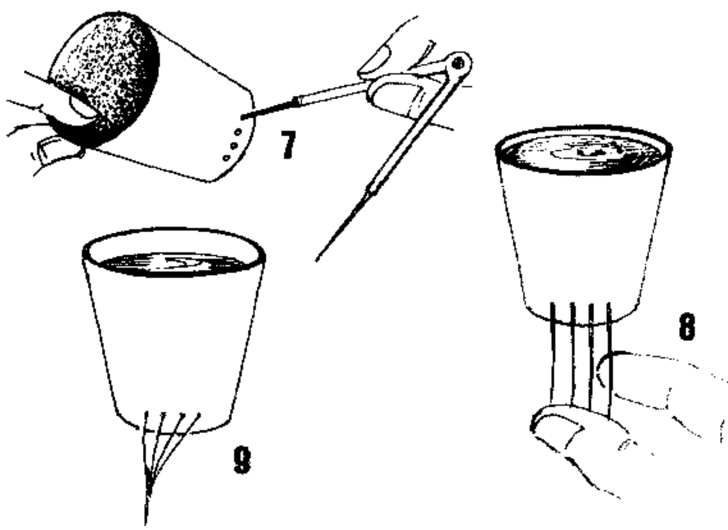
SURFACE TENSION



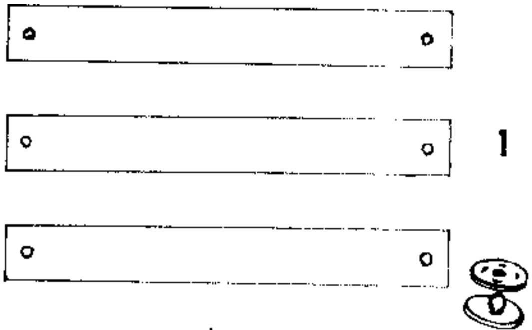
If you look at a dry paintbrush you will see that its hair is frayed and do not cling to a point Fig (1).
Even in water, the hair does not cling and form a tip Fig (2).
However, if you remove the brush from the water then the hair clings to a point Fig (3).
This is because the wet molecules of water form a film, which in trying to minimize its surface area makes the hair cling together.



While threading a needle, we often find that the frayed end of the thread does not enter the eye of the needle Fig (4).
So, we wet the thread end with our spit Fig (5).
The frayed fibers now cling together and ease threading Fig (6).



Make four holes in a plastic or a thermocole cup using a divider point Fig (7).
The holes should be about half a centimeter apart.
On filling the cup with water, four streams of water will spurt out.
Squeeze the streams together, with your thumb and index finger Fig (8).
They will combine to form a single stream of water Fig (9).
This is what happens.
Each of the four streams of water has a film around it.
This film, composed of water molecules, encases the water, but it is quite elastic and allows movement.
When the streams are pinched together, a new film is formed, which is strong enough to hold all the water together.



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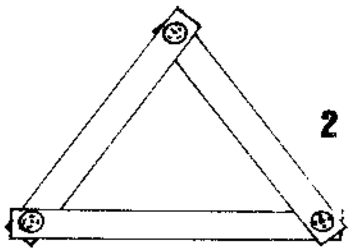

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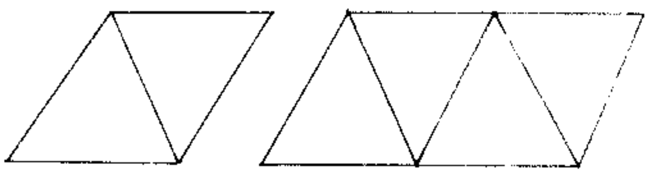
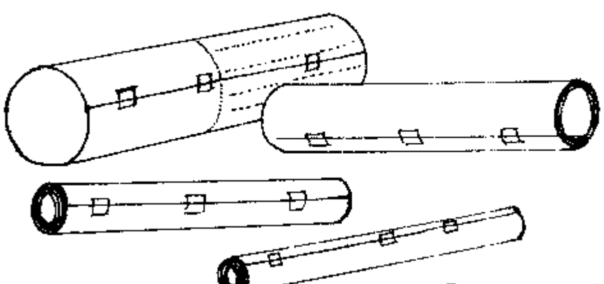


3

RIGIDITY OF TRIANGLES

If you carefully look at steel bridges or roof trusses, you will notice that they often consist of a large number of triangles, joined together.
Cut 1-cm. wide and 10-cm long strips from stiff greeting cards and punch holes on there ends Fig (1).
Using press-buttons as joints, join three card strips into a triangle Fig (2).
Does its shape alter?
Try making squares, pentagons and other polygons.
Are they rigid?
Join several triangles together Fig (3).
Is this new structure strong?
In which other large structures have you seen triangles being used?



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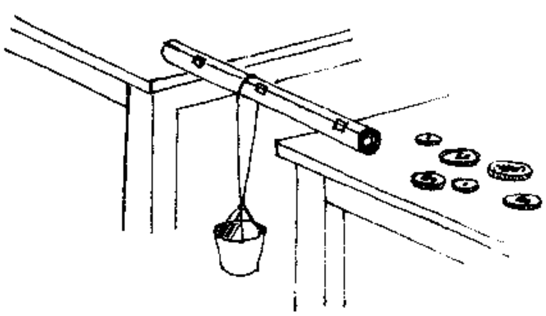
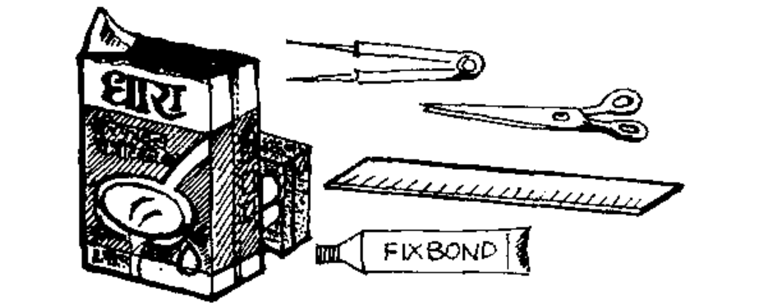
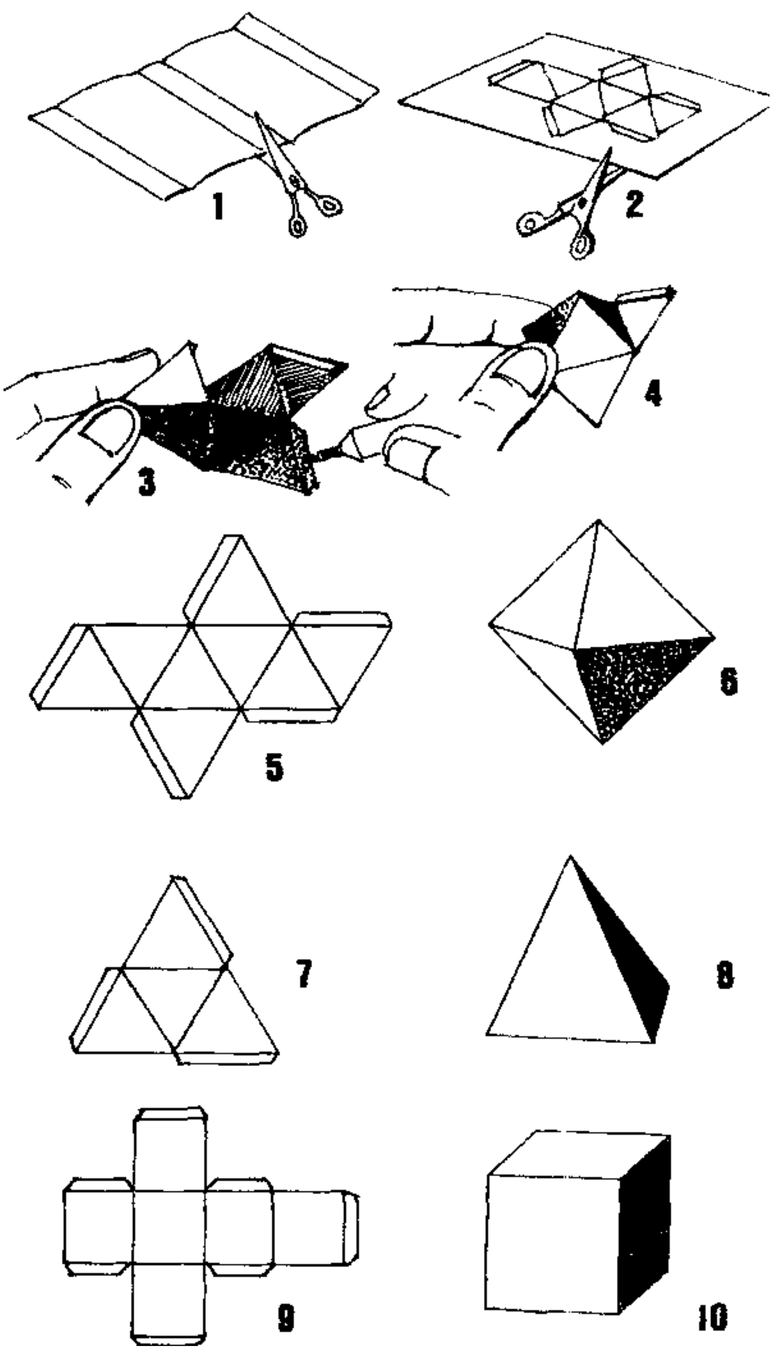


5

THE STRONGEST TUBE

What is the best diameter for a tube?
Given a postcard how can we roll it up to make the strongest tube?
Roll up a few old postcards to make tubes of the same length but different diameters.
Use the same amount of sticky tape to stick each tube Fig (4).
Slip a pan with a string tied around one of the tubes.
Ensure that the same amount of the tube rests on each desk.
See that the pan is in the center of the tube.
Keep adding weights until the tube begins to buckle Fig (5).
Test the other tubes.
Which tube is the strongest?
Now, roll a postcard up so that it forms a solid rod of paper.
Will it be stronger than strongest tube?
Find out.





TETRAPACK MODELS

Tetrapacks have revolutionized packaging the world over.
Now-a-days, cooking oil and several cold drinks are being distributed in tetrapacks.
After use, the cartons are just thrown away.
These cartons are made of composite layers plastic film, aluminum foil and paper fused together.
It is very expensive too.
An empty 200-ml. carton costs about one rupee. You can make wonderful things with old tetrapacks.

Open, clean and straighten a tetrapack Fig (1).
Using a divider and a scale mark out a network of eight equilateral triangles (edge length of 2.5-cm).
The five little flaps will be glued and will hold the model in shape Fig (2).
After cutting the network crease along the edges.
Apply adhesive or glue the flaps Fig (3, 4).
Fold and stick them to complete the OCTAHEDRON Fig (6).
The exact network of the Octahedron is given in Fig (5).
Similarly, using network of Fig (9), fold a CUBE Fig (10).
The tetrapack material takes sharp crease.
The finished silvery models are rigid, waterproof and look almost metallic.

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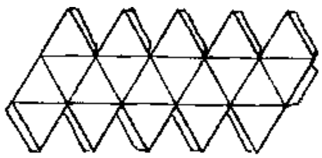

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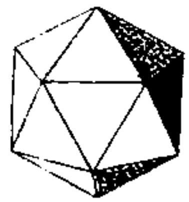

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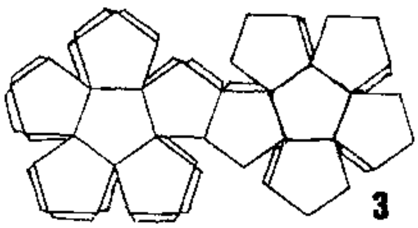

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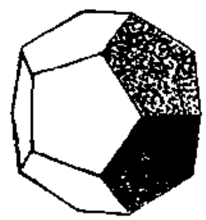

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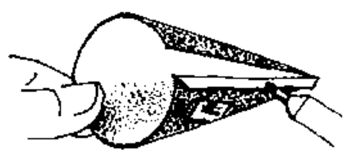

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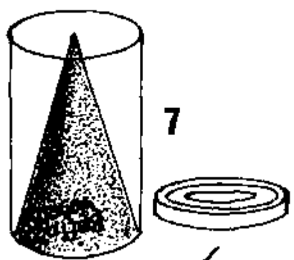

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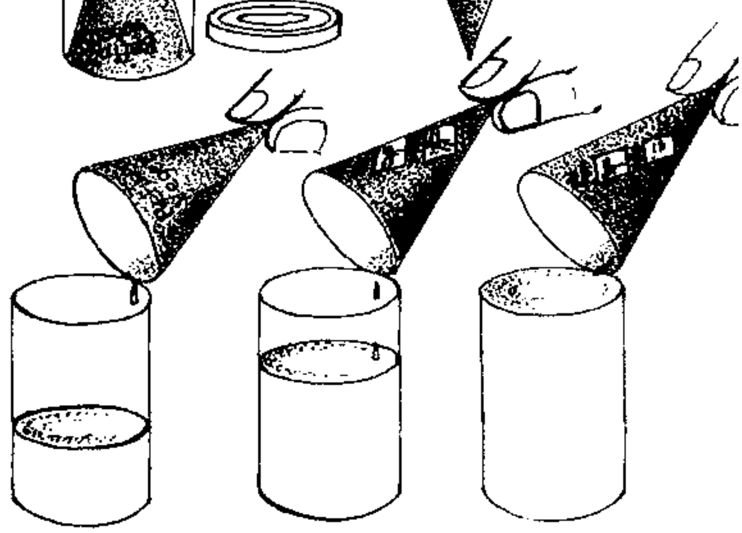

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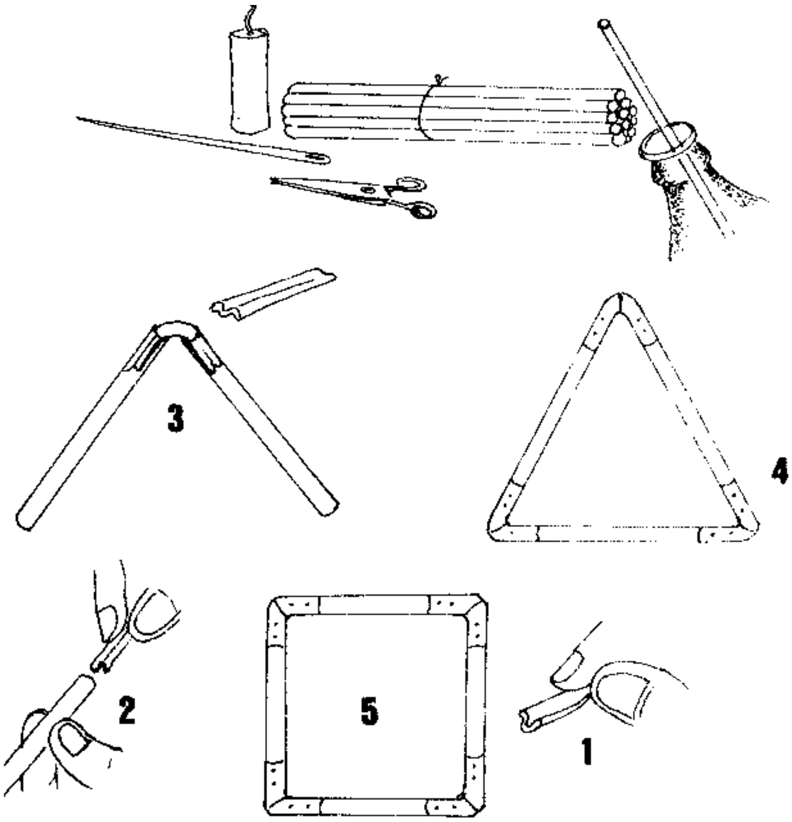
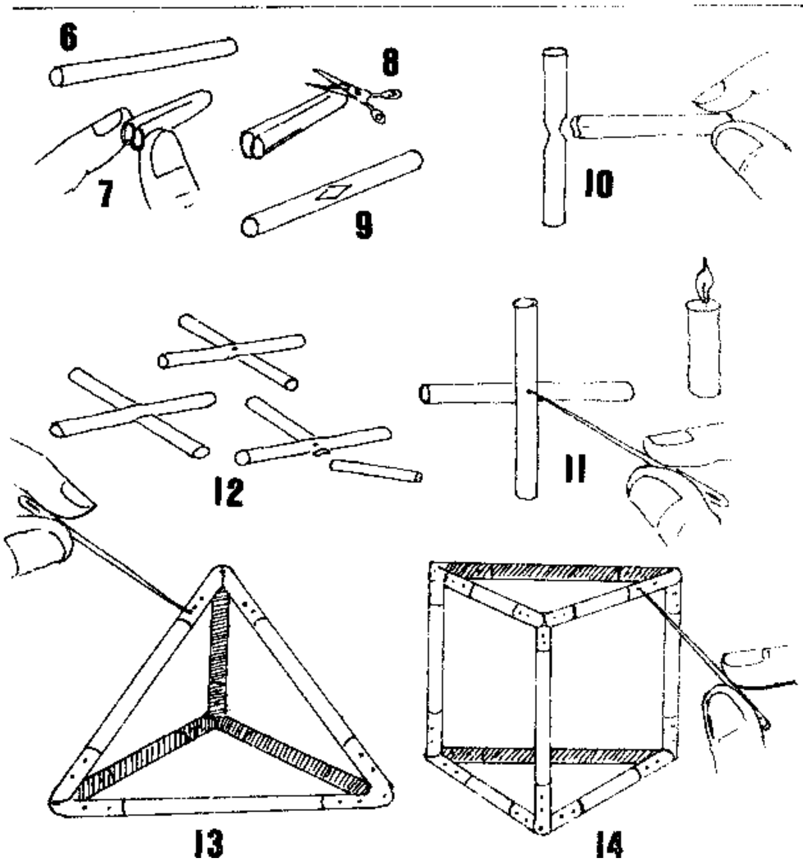
TETRAPACK MODELS
(continued)

Mark network shown in Fig (1) on the tetrapack sheet and fold it into an elegant 20 faceted ICOSAHEDRON Fig (2).
Using the network in Fig (3), make a DODECAHEDRON Fig (4).
Thus, all the five regular convex solids - the Platonic solids - the regular Tetrahedron, Hexahedron (cube), Octahedron, Dodecahedron and the Icosahedron can be made from tetrapacks.
Euler - the famous mathematician discovered a simple relation connecting the numbers of vertices (V), edges (E) and faces (F) of polyhedra.
See whether $V + F = E + 2$, holds true for all the above solids.

Fig (5) shows the sector of a circle with radius 5.0-cm and an angle of 108 degrees.
It is folded and stuck with the silver side inside to make a cone Fig (8).
The base and height of this cone is the same as that of a film roll bottle which is a cylinder.
The cone fits snugly into the bottle Fig (7).
There is a relationship between a cone and a cylinder with the same base and the same height.
The volume of the cylinder is thrice that of the cone.
Test it by pouring one full cone of water in the film bottle Fig (9).
Two cones, Fig (10) and finally three cones to top the film-roll bottle with water Fig (11).

SODA-STRAW STRUCTURES





Using plastic soda-straws you can make some very elegant models. The straws can be used both for joints as well as the structural members.

For the JOINT-OF-TWO take a 2-cm long piece of straw and crimp it with your thumb and finger Fig (1).
Insert one end of the joint in a straw Fig (2).
The other end of the joint is inserted in a second straw Fig (3).
Using three joints and three straws make a triangle Fig (4).
To prevent the joints from coming out of the straw, weld them by poking a hot needle tip.
Assemble a square Fig (5) and a few more polygons.

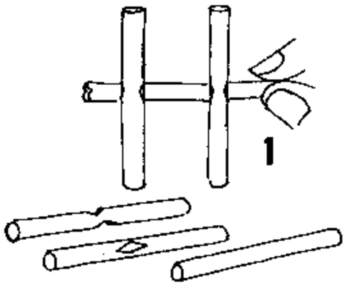
The JOINT-OF-FOUR is made out of two pieces of straw.
Take a 2-cm long piece of straw and bend it double Fig (7).
Slightly nip both long edges at the bend as shown in Fig (8) to make a diamond shape hole Fig (9).
Weave the second piece through this hole Fig (10), to make a cross joint.
To prevent the cross pieces from slipping out, weld them together with a hot needle tip Fig (11).

A JOINT-OF-THREE is got by simply cutting one leg of the "cross" Fig (12).
Assemble a TETRAHEDRON as in Fig (13) and a PRISM Fig (14) using joints-of-three.

Weld the straw members and the joints together to prevent them from coming apart.

(continued)

SODA-STRAW STRUCTURES
(continued)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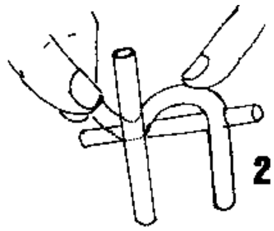
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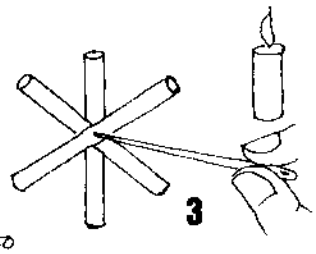
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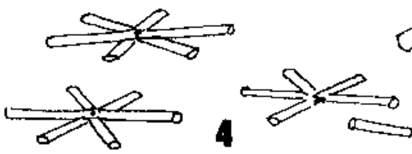
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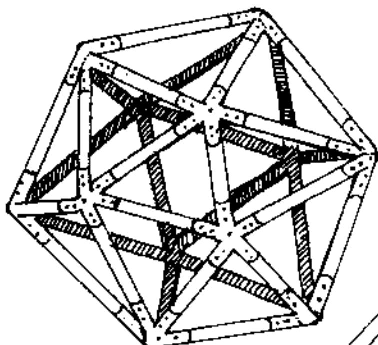
To make a JOINT-OF-SIX cut out diamond holes in the middle of the two straw pieces.
Weave a third straw piece through these holes to make an H shape Fig (1).
Take one leg of the H and weave it through the adjacent joint-of-four, to make a phased out star joint Fig (2).
Weld the straw pieces with a hot needle tip Fig (3).

A JOINT-OF-FIVE is got by simply cutting off one leg of the joint-of-six Fig (4).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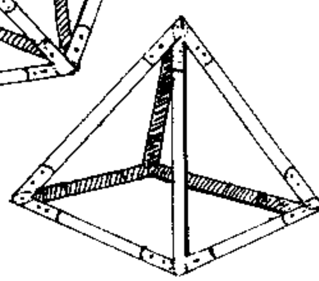
Using 30 straw members and 12 joints-of-five, assemble an ICOSAHEDRON Fig (5).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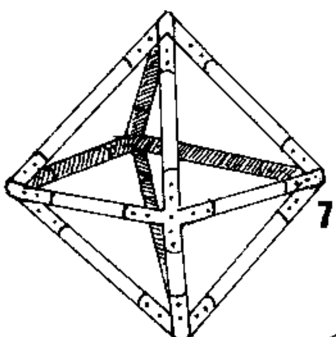
The PYRAMID in Fig (6) is made with 8 members, 4 joints-of-three and 1 joint-of-four.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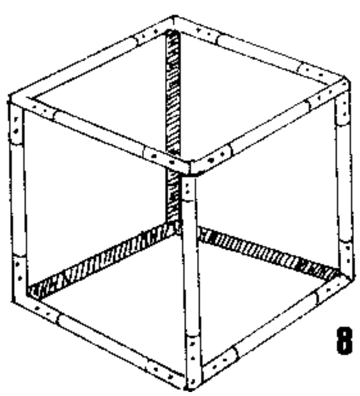
The OCTAHEDRON in Fig (7) looks like two pyramids back-to- back, and can be made using 6 joints-of-four and 12 members.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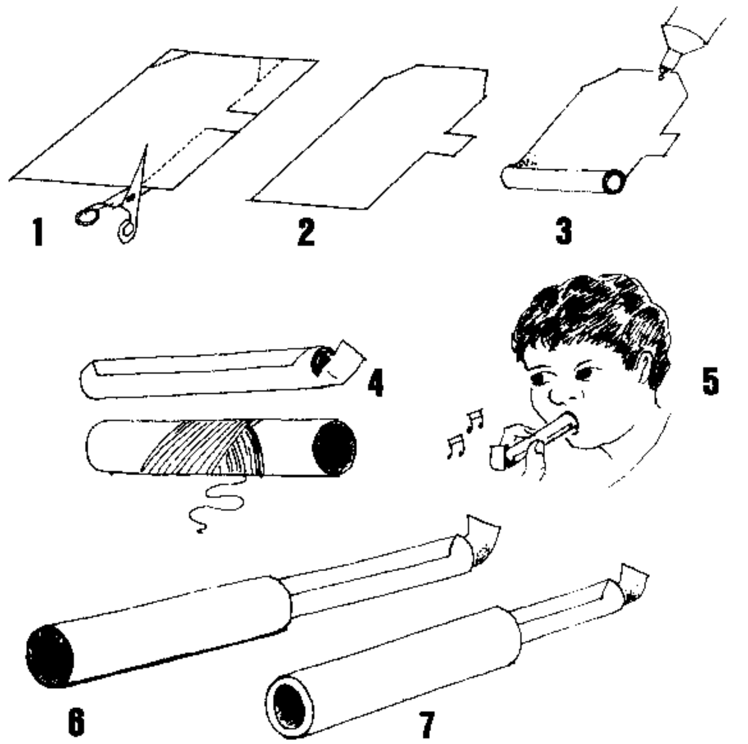
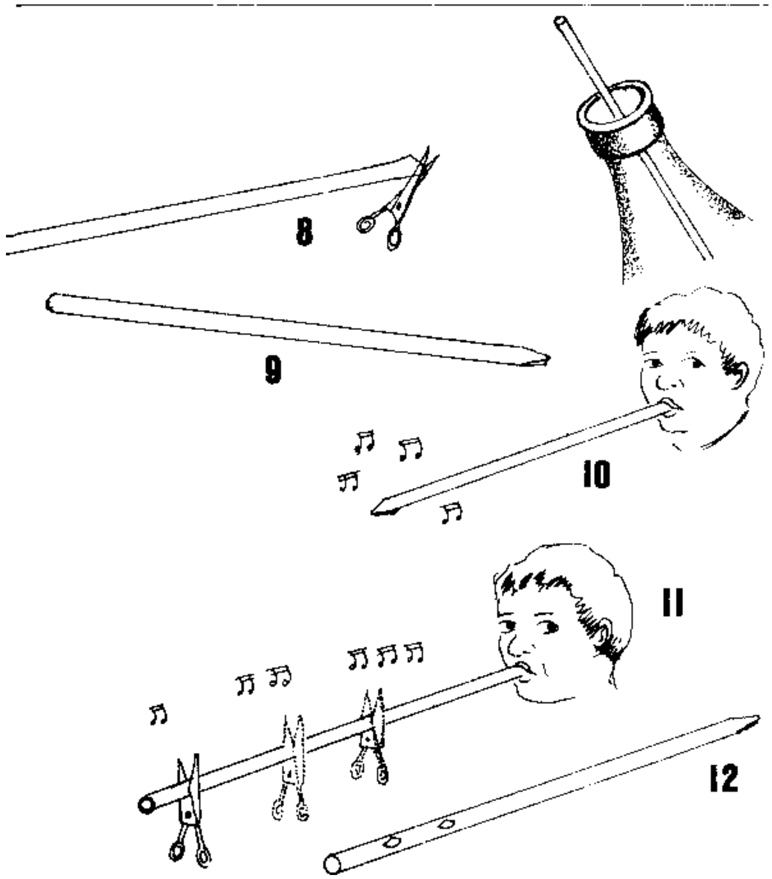
Structures from soda-straw look very neat and elegant.
You can test the relative strengths of these structures by banging weights from their members.
Plastic soda-straw models are also waterproof.
So, you can dip them in soap solution and study the nature of soap films on their facets.





A PAPER FLUTE

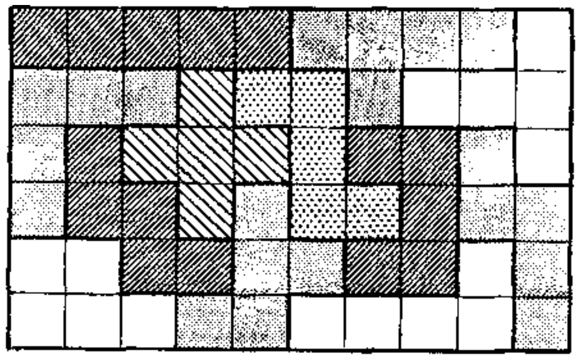
Mark out the pattern in Fig (1) on a piece of paper.
Then cut out the rectangular shape with a small square flap on one edge Fig (2).
Roll the paper like a cigarette, gluing its other edge so it does not open Fig (3).
This simple roll of paper with a little flap bent over one-end makes a nice paper flute Fig (4).
If you place the end with the flap inside your mouth then you have to blow out to play it.
Otherwise, you can have the flap end outside, in which case you suck gently, thus vibrating the flap against the tube Fig (5).
Now, insert the tube inside a used thread reel Fig (6).
Vary the length of the vibrating column and see if there is some change in the sound, Fig (7).

SODA-STRAW FLUTE

Flatten out one end of a soda-straw. Nip, both long edges of this end with a scissors with a "V" point Fig (8, 9).
Keeping the "V" end outside suck air from the other end.
The "V" end will vibrate producing a musical note Fig (10).
You can also keep the "V" end inside the mouth and blow out air.
The straw will again sound a note.
Now keep cutting little lengths of straw with a scissors Fig (11).
As the straw becomes shorter the sound becomes shriller.
Cut a few holes on the straw to make it into a flute Fig (12).
By opening and closing these holes you can play a few notes on the soda-straw flute.

PENTAMINOES

Take a few squares.
Try and make all the possible patterns using five square coins or tiles.
Five squares can be fitted together edge-to-edge in only 12 different ways. These shapes are known as PENTOMINOES and are shown here fined together like a Jigsaw to form a 10 x 6 rectangle Fig (1).
Cut yourself a set of pentominoes from cardboard or shoe sole rubber.
See if you can find other ways of fining them to form 10 x 6, 12 x 5, 15 x 4 and 20 x 3 rectangles.
There are thousands of solutions, but feel happy if you can find one for each rectangle.



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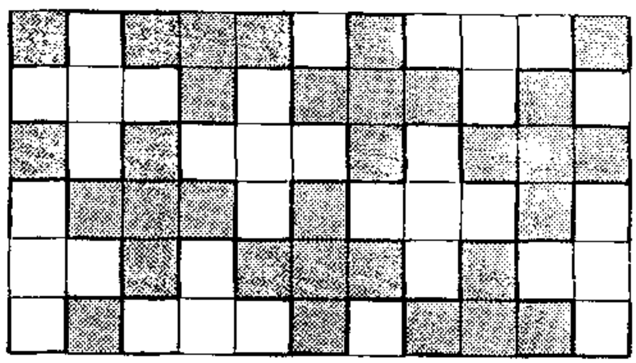
One of the pentomino shapes can form a regular repeating pattern to cover the page without any gaps - that is it forms a tesselation Fig (2).
Draw patterns to show which other pentominoes will tesselate.
The same pentomino lis shown folded in Fig (3) to form an open cubical box.
Find which of the other pentominoes will form a net for the box and shade the square corresponding to its base.



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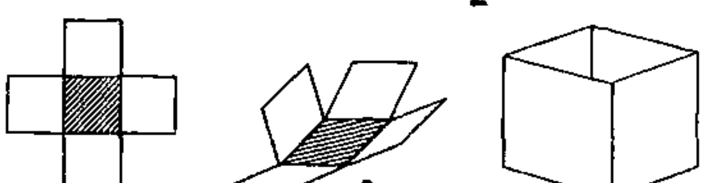

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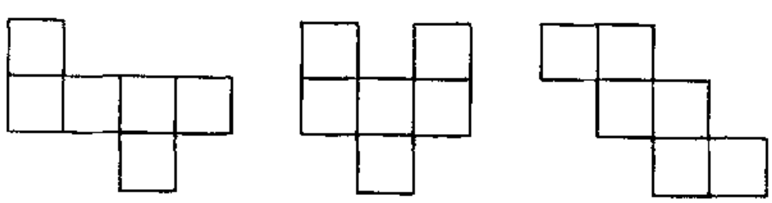
Shapes made from six squares like in Fig (4) are called HEXOMINOES.
Which of the shapes in Fig (4) could be folded to make a cube?
There are 35 hexominoes.
Try to find them all.
It may help if you use squared paper.



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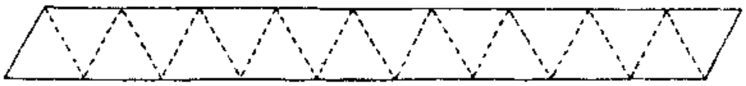
HEXAFLEXAGON

A hexaflexagon is an intriguing arrangement of equilateral triangles folded in such ways that at any time six of them form a hexagon.
The flexagon can be 'flexed' into a new arrangement by pinching together two adjacent triangles and opening out the triangle from the center to reveal a new face.
When you have made a flexagon, mark the corners of the triangles at the center of the visible hexagon with a symbol such as a heart or diamond, or spell out a six-letter word.
Then flex the hexaflexagon and mark the center of the new face with another set of symbols.
You will be surprised just how many different centers you can find!

Take a strip of thin card and draw 18 equilateral triangles as in Fig (1).
You will find 5-cm a good size for the side of a triangle.
Score along each of the dotted sides of the triangle. On one side number the triangles 1, 2, 3; 1, 2, 3,..., and mark the end triangles along the edge as in Fig (2).
Turn the strip over and number the other side with a 4, 4, 5, 5, 6, 6,..., pattern exactly like Fig (3).
Next fold the strip by placing triangle 4 exactly onto triangle 4, 5 onto 5, 6 onto 6 etc. as shown in Fig (1).
This rolls the strip up, see Fig (5).
Now fold the strip again so that the triangles of the same number are all on the top, as shown in.
Stick the two marked edges together using adhesive tape.
Now you can keep flexing the hexaflexagons to glory.



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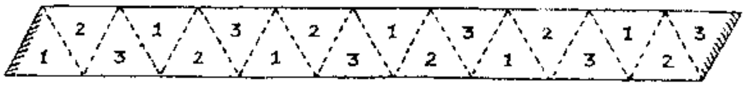

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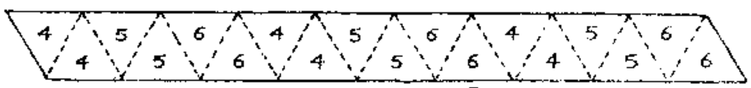

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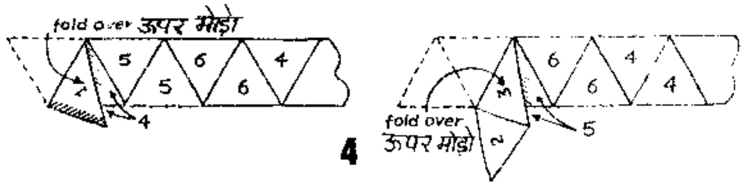

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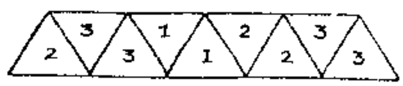

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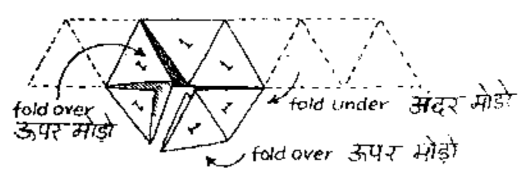

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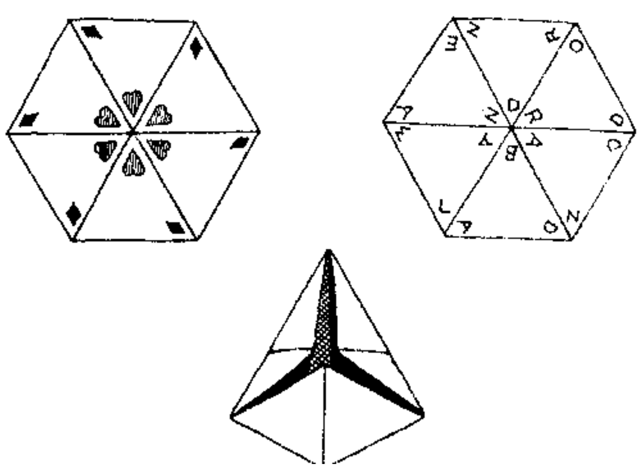


DISSECTION PUZZLES

Many puzzles are based on cutting up one shape in as few pieces as possible, which can be rearranged to form another shape.

An example of this is a 12-sided regular polygon, shown in Fig (1) cut into 6 pieces, which are reassembled into a square Fig (2).

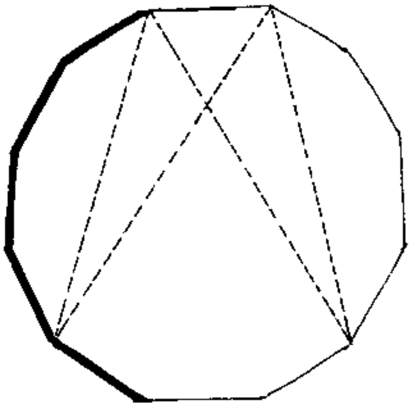
Similarly, the "E" shape as in Fig (3) can be dissected to be reassembled into a square of the same area Fig (4).

Typical amongst the dissection puzzles is to cut the Greek cross into four pieces, which can be rearranged to form a square Fig (5).

If the cross is seen as made up of 5 unit squares then the square into which the cross is to be transformed must also have an area equivalent to 5 square units.

Two solutions are shown in Fig (6, 7). But how are they arrived at? One answer lies in the use of tesselations.

In Fig (8) the Greek cross is shown forming a tesselation and then superimposed on it is a tesselation of squares whose area is 5 square units formed by joining the centers of the adjacent crosses.



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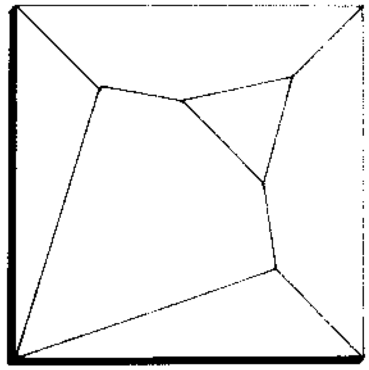

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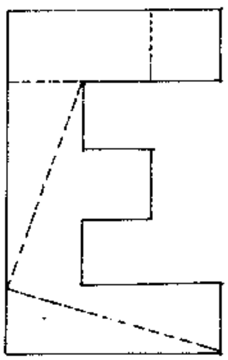

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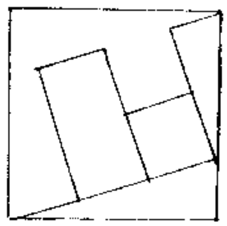

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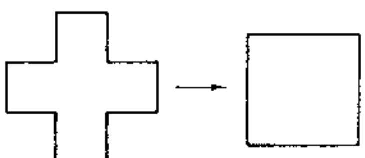

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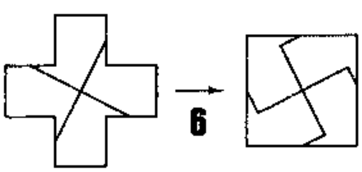

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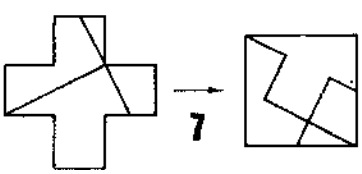

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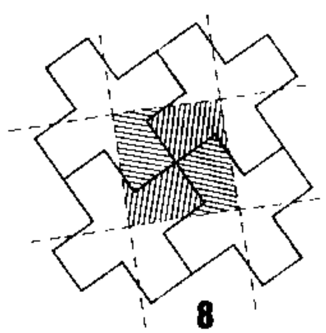

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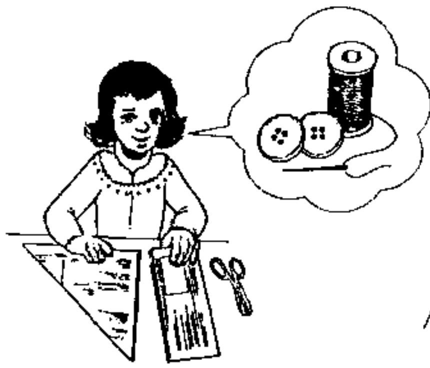
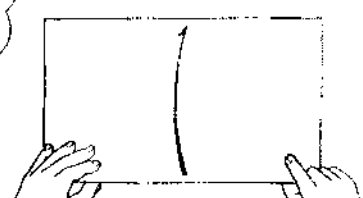
THE IMPOSSIBLE PUZZLE





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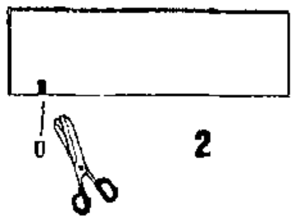

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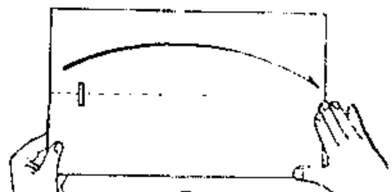

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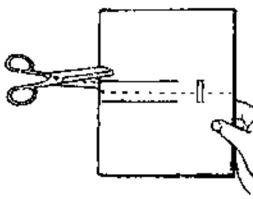

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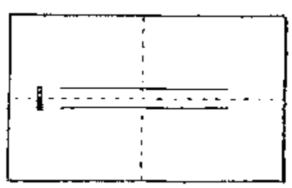

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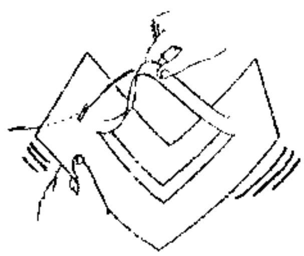

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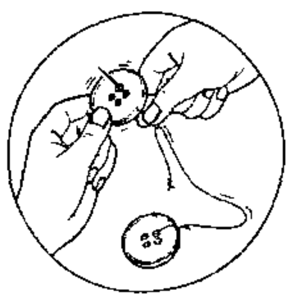

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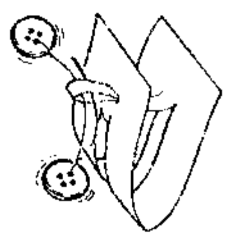

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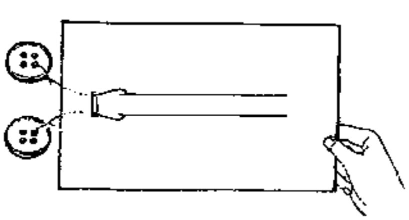

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10

This is a very good puzzle to baffle your friends with.

Take a rectangle of paper about 25-cm long and 15-cm wide.

Fold the rectangle in half from bottom to top Fig (1).

Cut a little slot in one end of the paper as shown in Fig (2).

Then unfold the rectangle.
Now fold the rectangle in half from left to right Fig (3).

From the folded side, mark two parallel cuts that go towards, but do not quite touch the slot Fig (4).

Unfold the rectangle.
This should be your finished result Fig (5).

Now, the ends of the paper towards each other, but not quite together.

Thread the strip made by the two parallel cuts in Fig (4), through the slot, so that you get a little loop sticking out Fig (6).

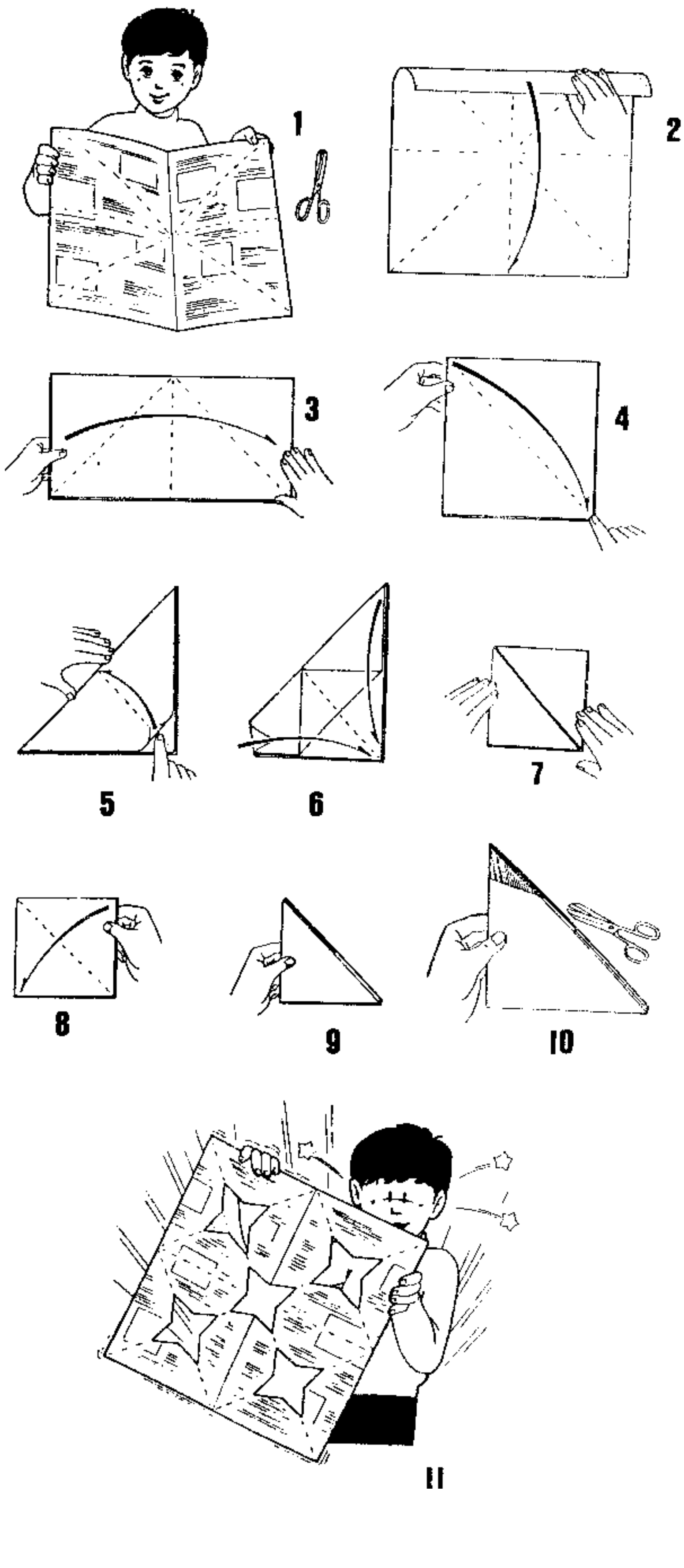
Thread the buttons on to a length of cotton and knot the ends so that the buttons do not fall off Fig (7).

Put one of the buttons through the loop Fig (8).

Fold the paper back into place so that it looks like in Fig (9).

Show the puzzle to your friends.
Ask them if they can remove the buttons without breaking the cotton thread or tearing the paper Fig (10).

The secret is simply to repeat the steps in Fig (6, 8) and to pull the buttons back through the loop.



A FIVE STAR TREAT

With a few, quick folds and with just one cut of the scissors, you can make five stars in one sheet of newspaper.

First, cut out a large square from a double spread newspaper sheet Fig (1).

Fold the square in half from top to bottom Fig (2).

Fold it in half from left to right Fig (3).

Fold the top left-hand corner down to meet the bottom right-hand corners Fig (4).

Fold the top right-hand corner up to meet the middle of the diagonal slope Fig (5).

Fold both the top right-hand and bottom left- hand corners over to meet the bottom right hand corners Fig (6).

Press the paper flat and turn it over Fig (7).

Fold the paper in half, from the top right-hand corner to the bottom left-hand corner, along the diagonal fold line Fig (8).

This way you will be making a triangle Fig (9).

With a scissors carefully cut away the shaded part Fig (10).

Open out the paper carefully and you will have five stars glittering at you Fig (11).