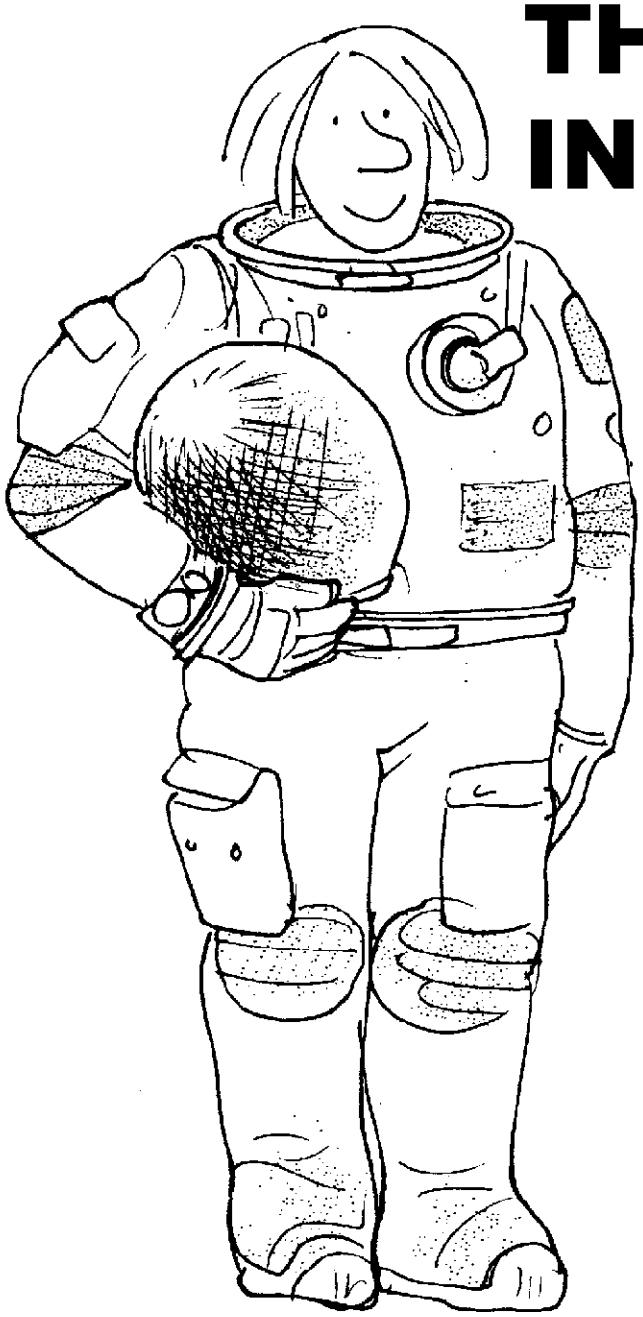
savoir sans frontières

AROUND THE WORLD IN 80 MINUTES



Jean-Pierre Petit

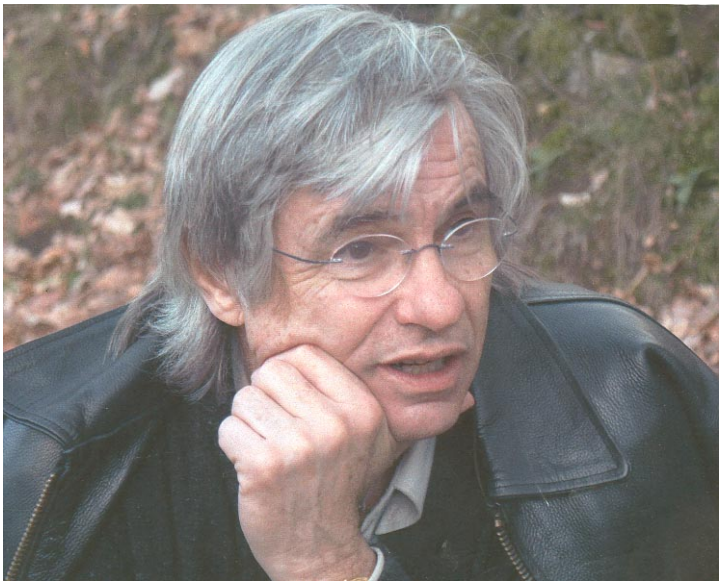
Translated by John Murphy

http://www.savoir-sans-frontieres.com

Savoir sans Frontières

Association Loi de 1901

http://www.savoir-sans-frontieres.com



Jean-Pierre Petit, Président de l'Association

Ancien Directeur de Recherche au Cnrs, astrophysicien, créateur d'un genre nouveau : la Bande Dessinée Scientifique. Crée en 2005 avec son ami Gilles d'Agostini l'association Savoir sans Frontières qui s'est donnée pour but de distribuer gratuitement le savoir, y compris le savoir scientifique et technique à travers le monde. L'association, qui fonctionne grâce à des dons, rétribue des traducteurs à hauteur de 150 euros (en 2007) en prenant à sa charge les frais d'encaissement bancaire. De nombreux traducteurs accroissent chaque jour le nombre d'albums traduits (en 2007 : 200 albums gratuitement téléchargeables, en 28 langues, dont le Laotien et le Rwandais).

L'auteur a entrepris de compléter cette collection par des albums plus simples d'abord (niveau 12 ans). Egalement en cours d'élaboration : des albums « parlants » pour analphabètes et « bilingues » pour apprendre des langues à partir de sa langue d'origine.

L'association recherche sans cesse de nouveaux traducteurs vers des langues qui doivent être leur langue maternelle, possédant les compétences techniques qui les rendent aptes à produire de bonne traductions des albums abordés.

Pour contacter l'association, voir sur la homepage de son site

Coordonnées bancaires pour la France ➔ Relevé d'Identité Bancaire (RIB) :

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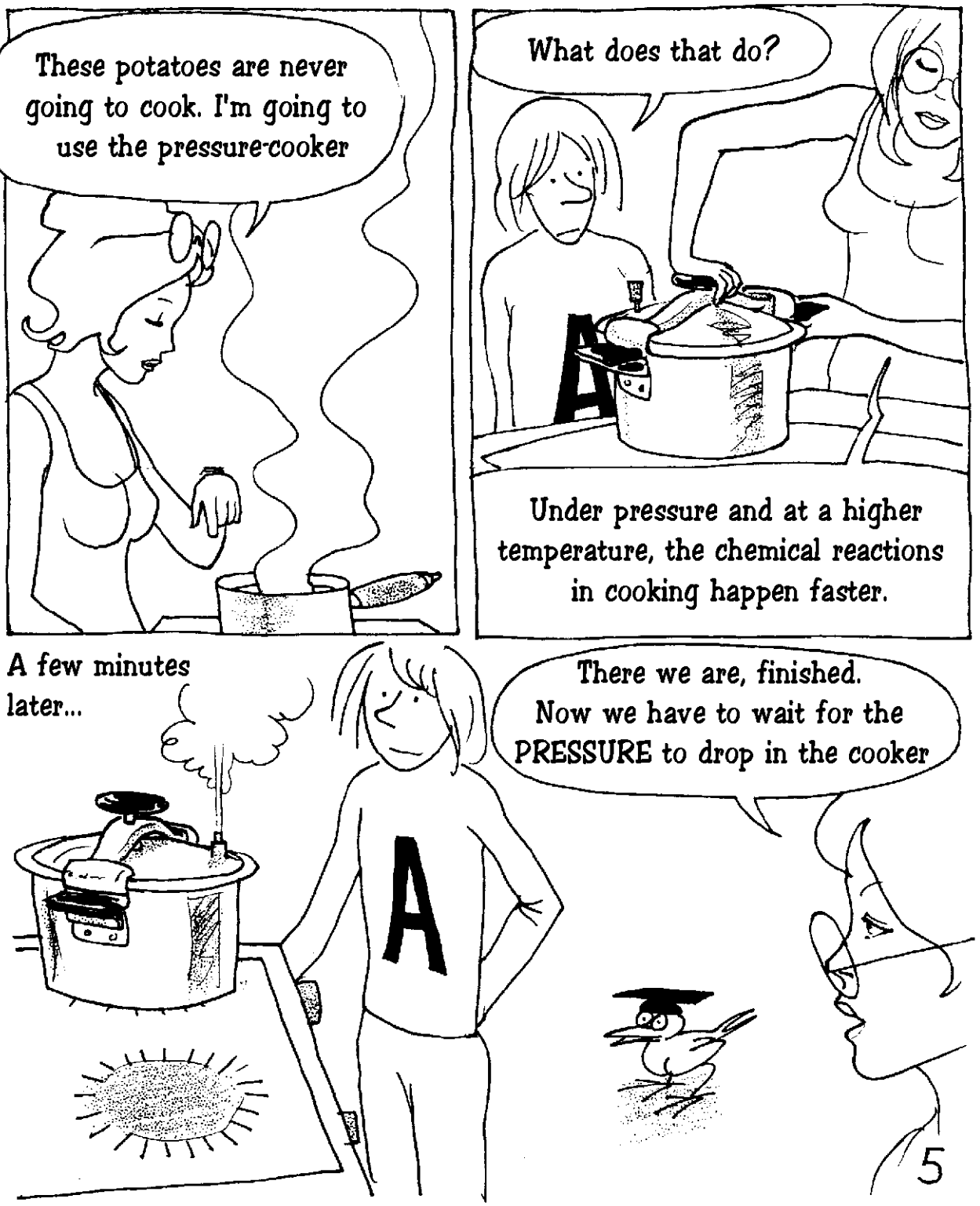
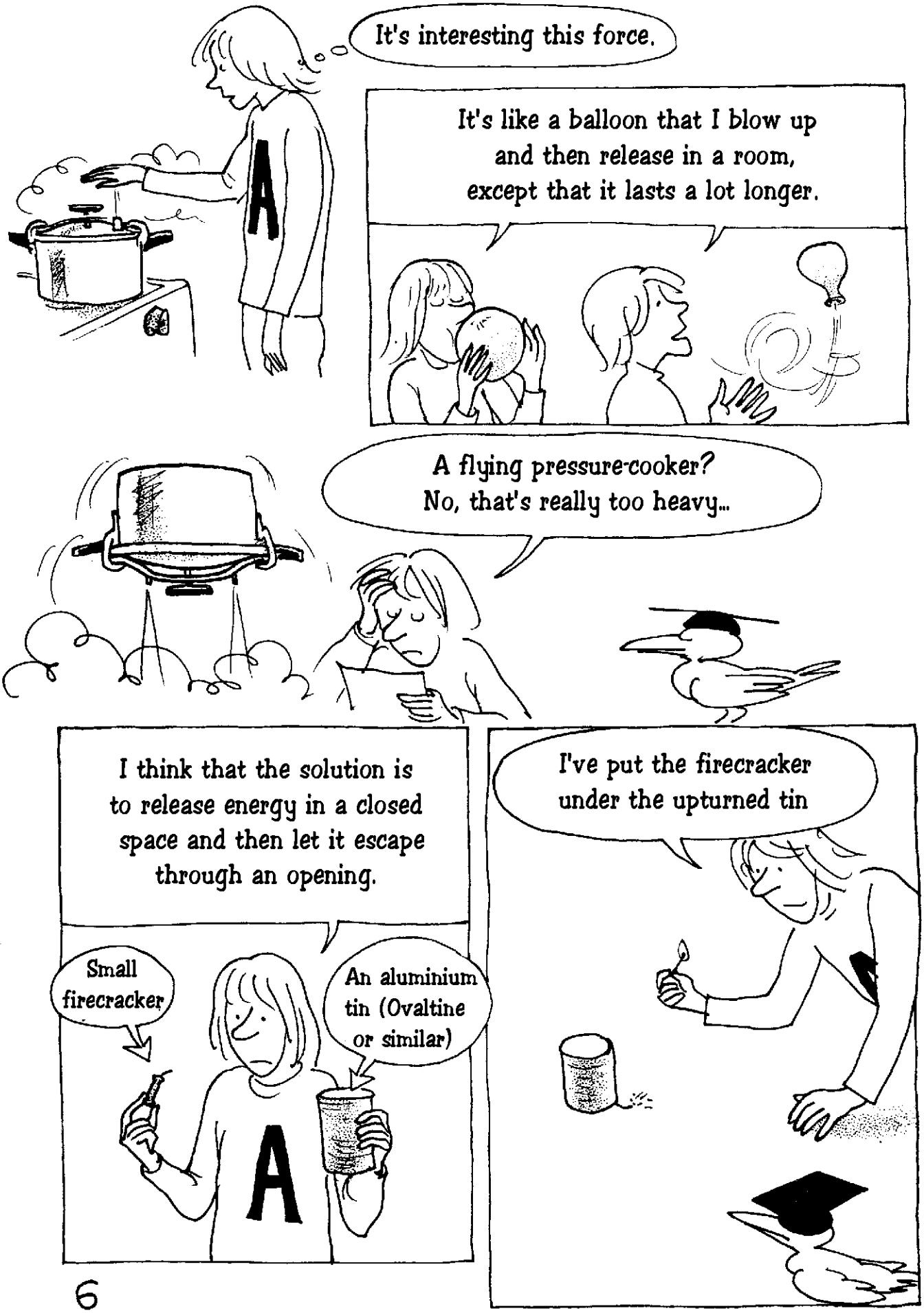
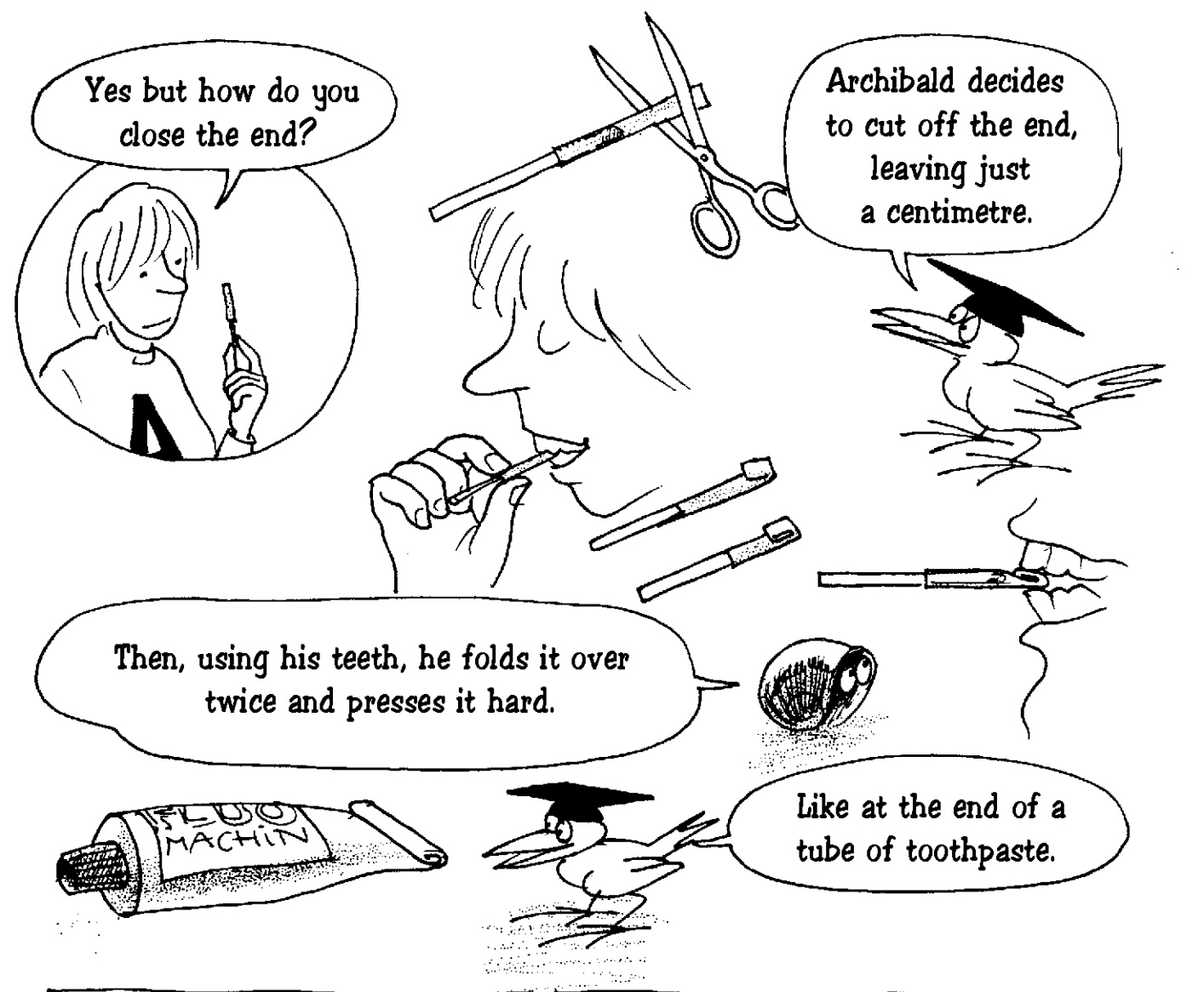
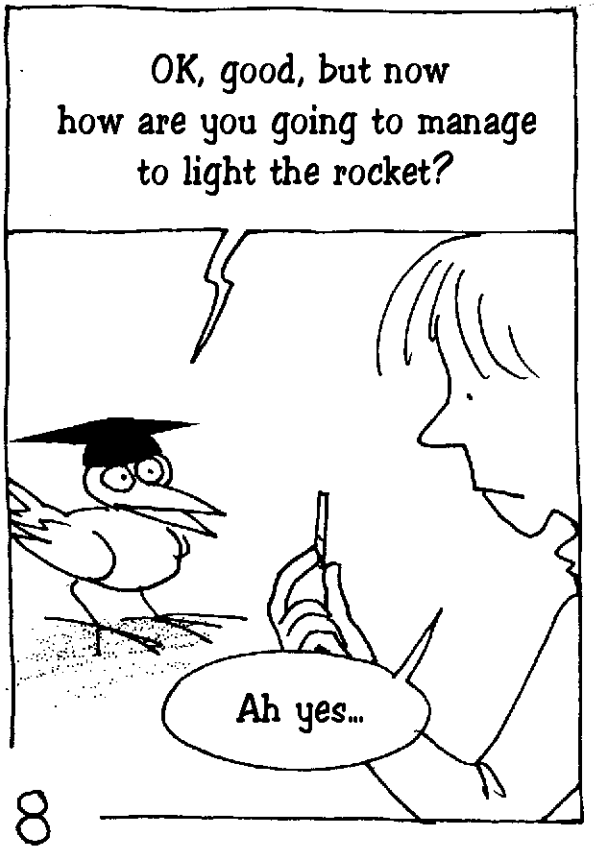
PROPULSION BY REACTION

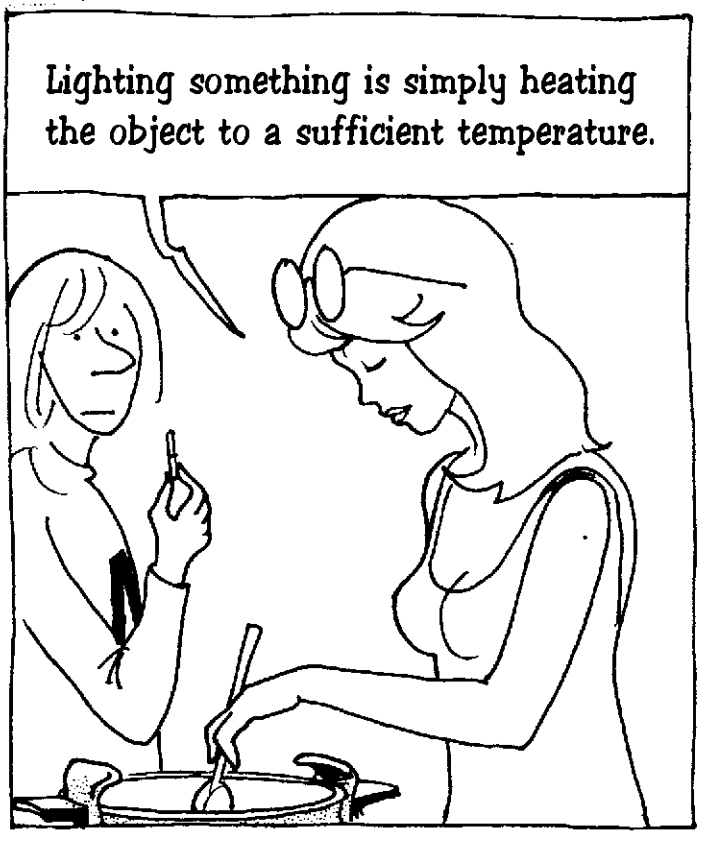


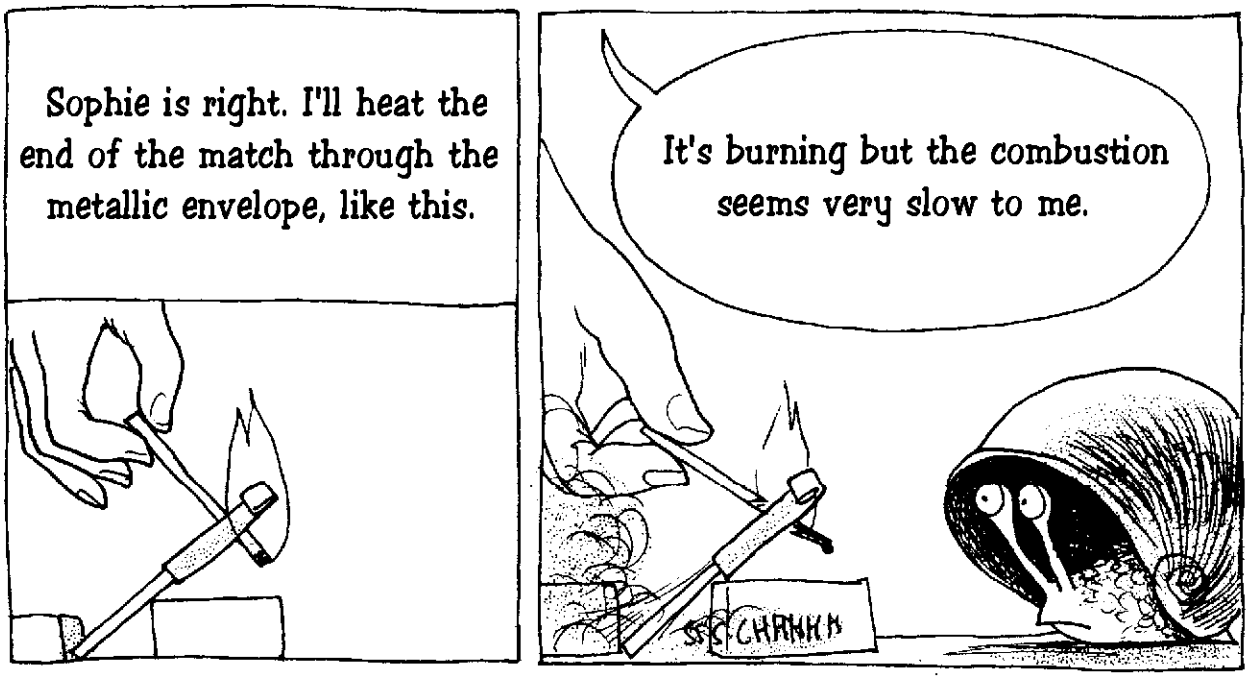

It's interesting this force.
It's like a balloon that I blow up and then release in a room, except that it lasts a lot longer.
A flying pressure-cooker? No, that's really too heavy...
I think that the solution is to release energy in a closed space and then let it escape through an opening.
Small firecracker
An aluminium tin (Ovaltine or similar)
I've put the firecracker under the upturned tin


Goodness, it went up at least twenty metres.
It was a success, but a bit brutal all the same
A
Couldn't I use just the energy contained in an ordinary match?
But what are you going to enclose it in?
I'll use the tinfoil from the top of a pot of yoghurt after smoothing it out with my nail.
Then I'll cut a rectangle of 2cm by 5cm, nice and flat.
Then Archibald rolls the tinfoil very tightly around the match.

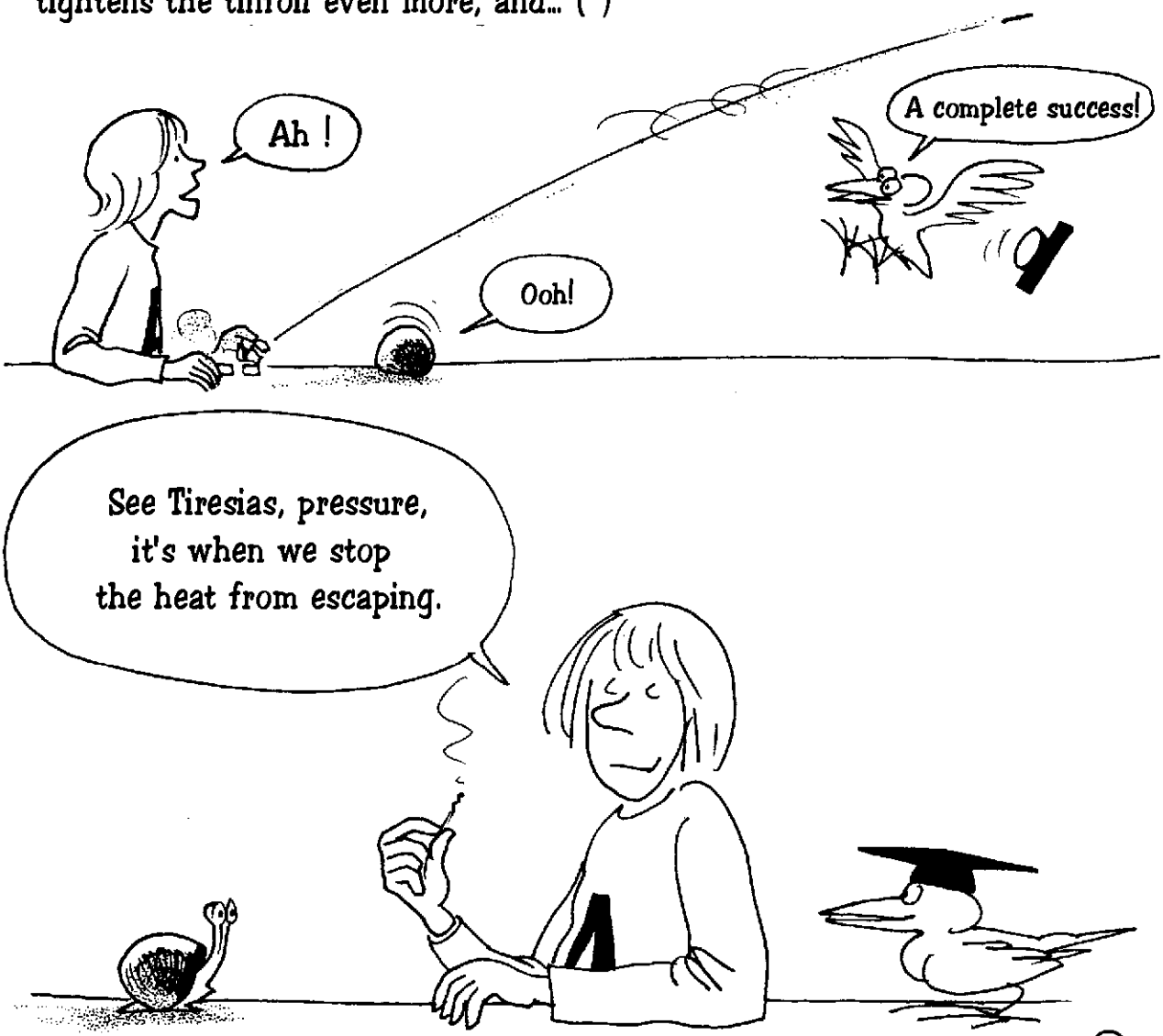

Yes but how do you close the end?
Archibald decides to cut off the end, leaving just a centimetre.
Then, using his teeth, he folds it over twice and presses it hard.
FLUO MACHIN
Like at the end of a tube of toothpaste.


OK, good, but now how are you going to manage to light the rocket?
Ah yes...


Lighting something is simply heating the object to a sufficient temperature.

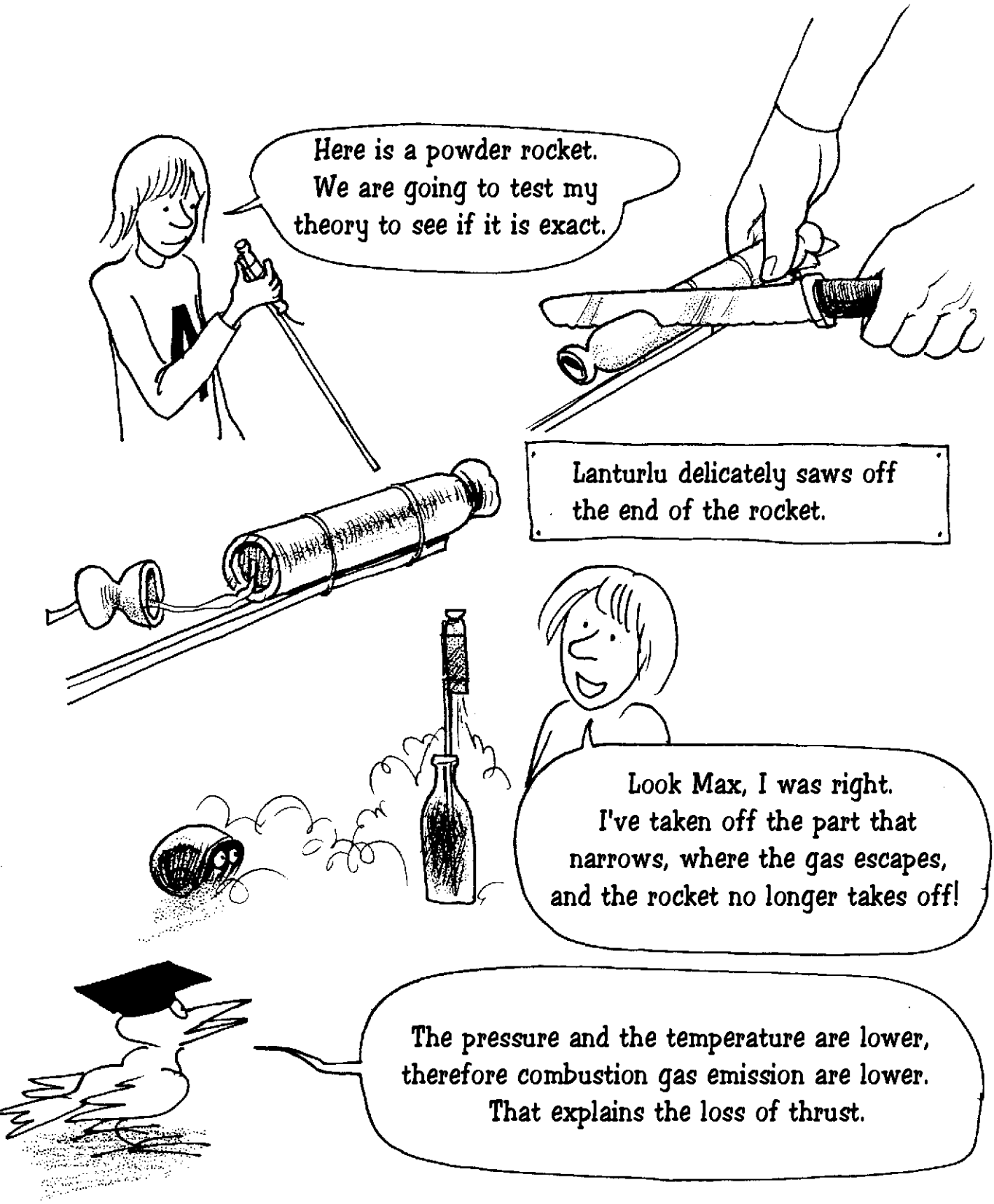


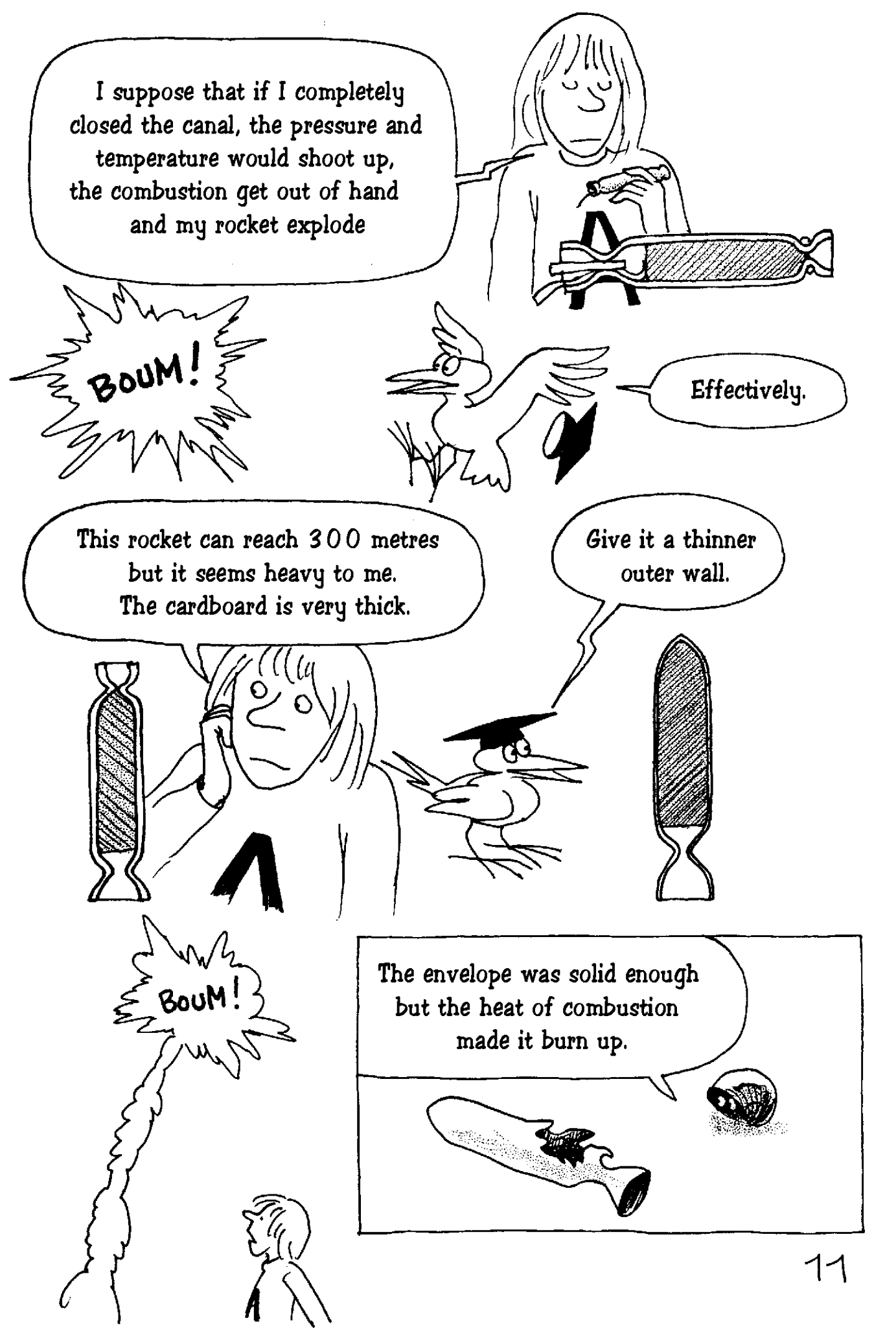
Archibald repeats the operation but tightens the tinfoil even more, and... (*)

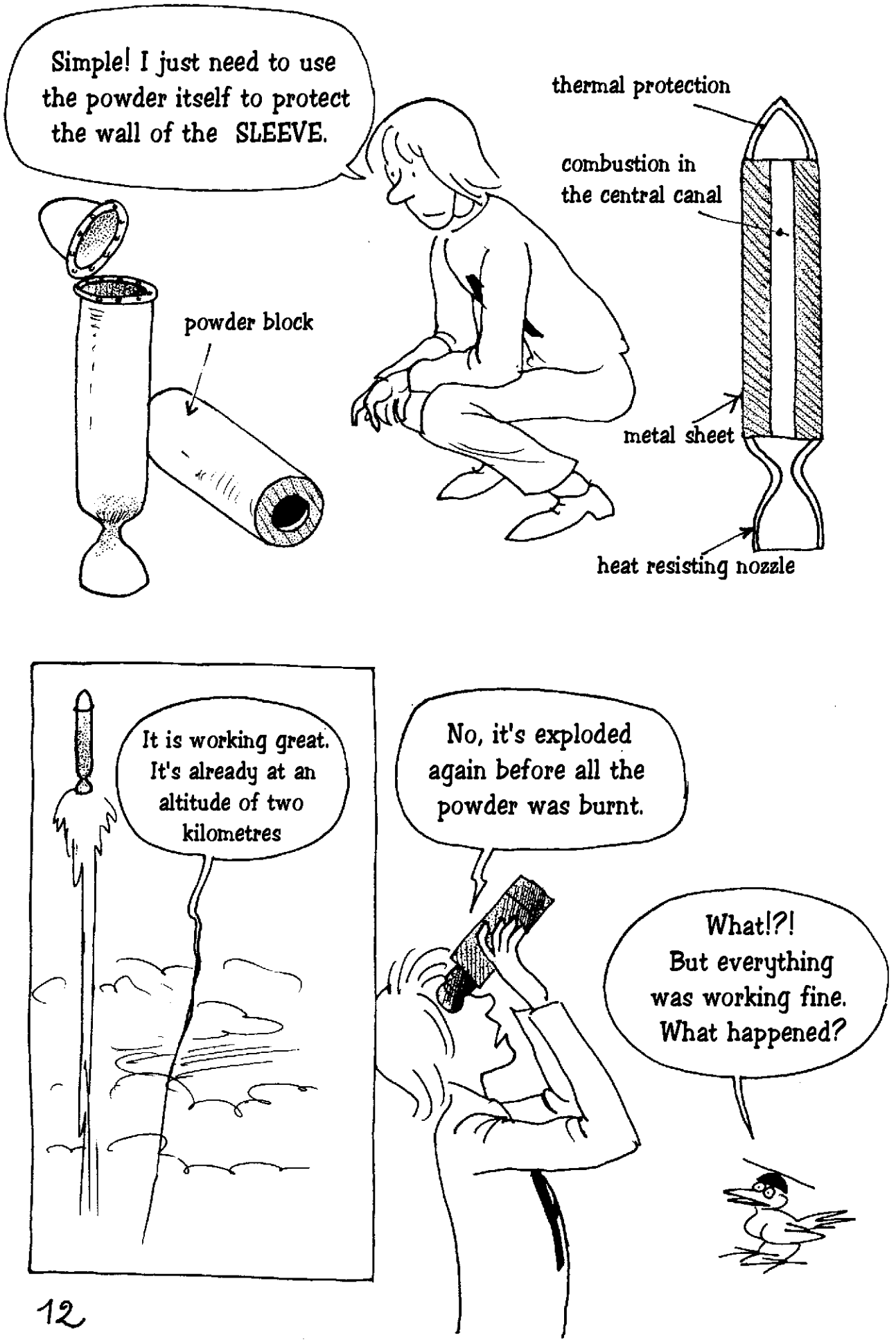


(*) The record is eight metres.

SOLID FUEL ROCKETS

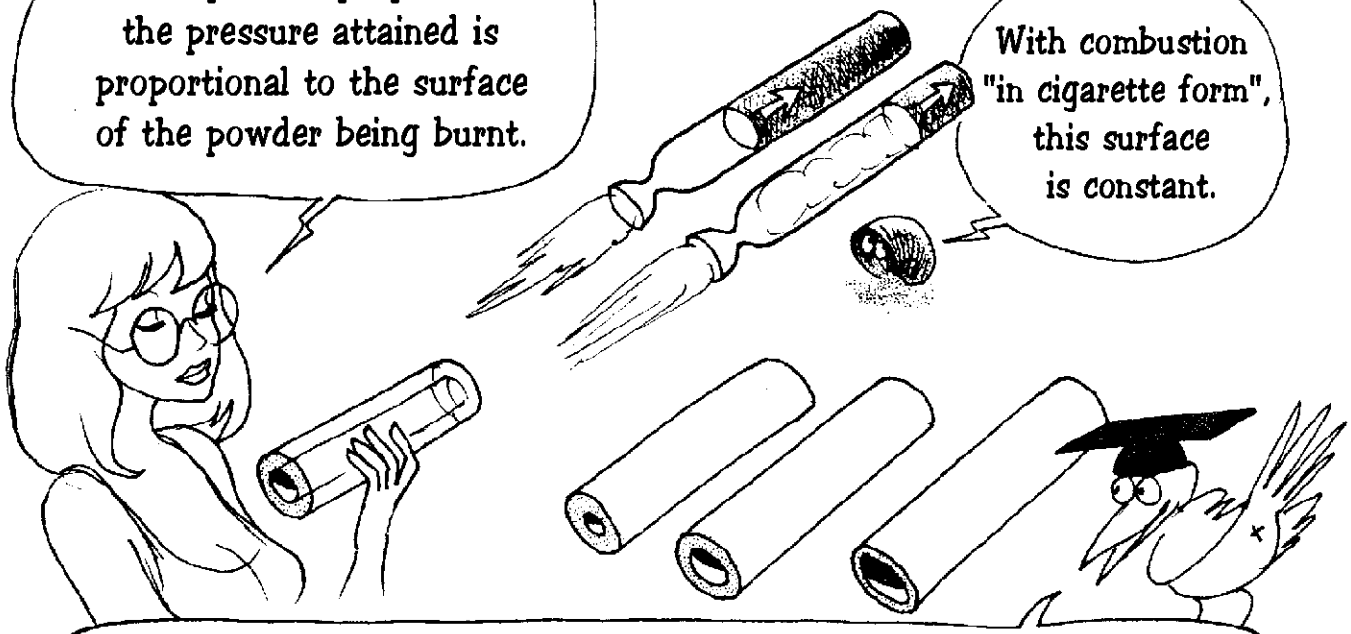



I suppose that if I completely closed the canal, the pressure and temperature would shoot up, the combustion get out of hand and my rocket explode
BOUM!
Effectively.
This rocket can reach 300 metres but it seems heavy to me. The cardboard is very thick.
Give it a thinner outer wall.
BOUM!
The envelope was solid enough but the heat of combustion made it burn up.


Simple! I just need to use the powder itself to protect the wall of the SLEEVE.
thermal protection
combustion in the central canal
powder block
metal sheet
heat resisting nozzle
It is working great. It's already at an altitude of two kilometres
No, it's exploded again before all the powder was burnt.
What!?! But everything was working fine. What happened?

In powder propulsion the pressure attained is proportional to the surface of the powder being burnt.

With combustion "in cigarette form", this surface is constant.

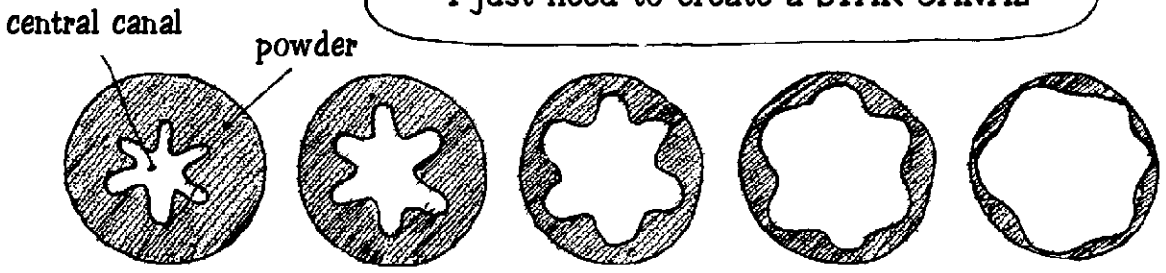


In a system with a central canal, the combustion surface increases with the radius, which increases as time passes. Thus the final explosion.

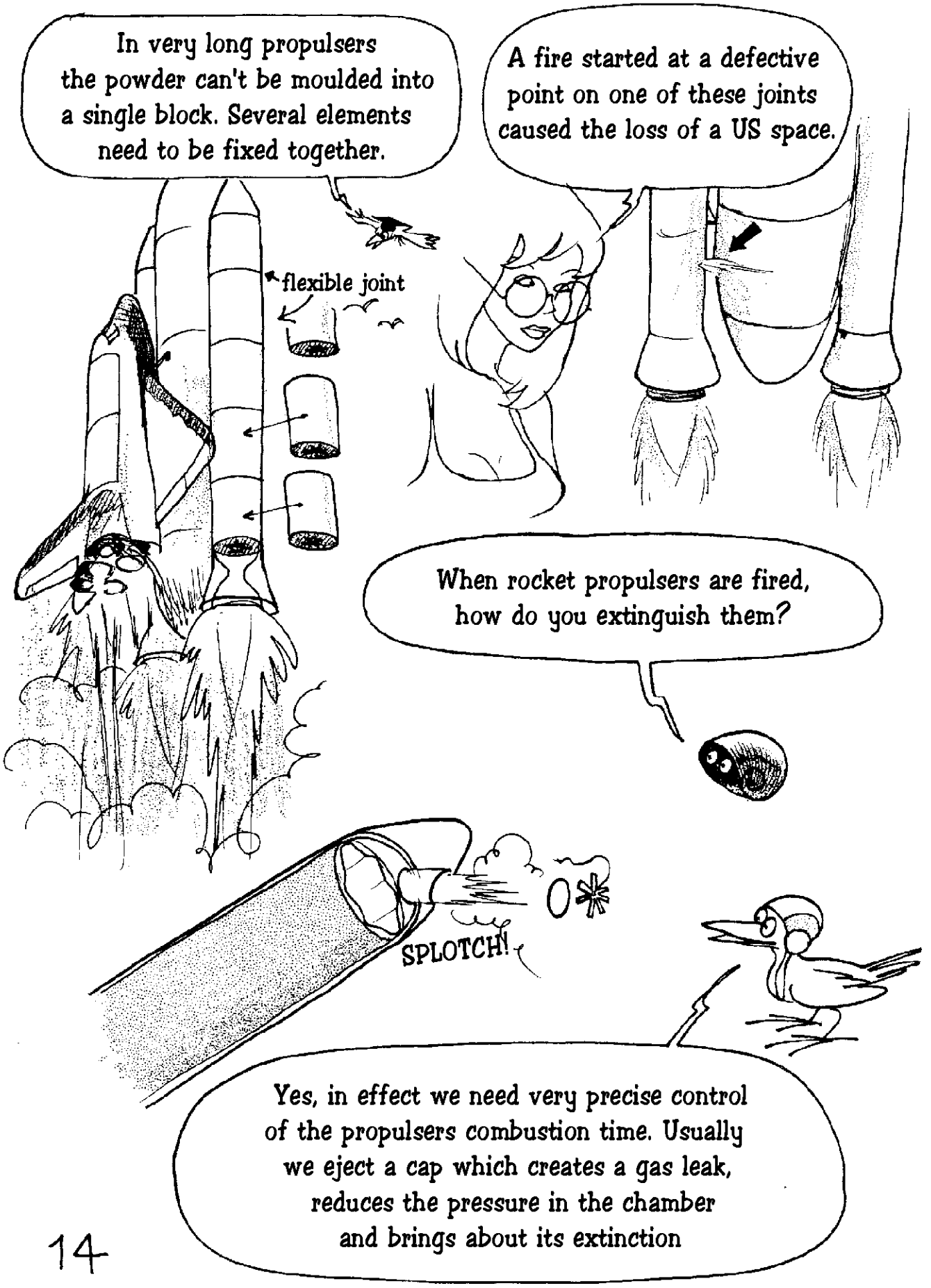
So nothing can be done!

No...idea!

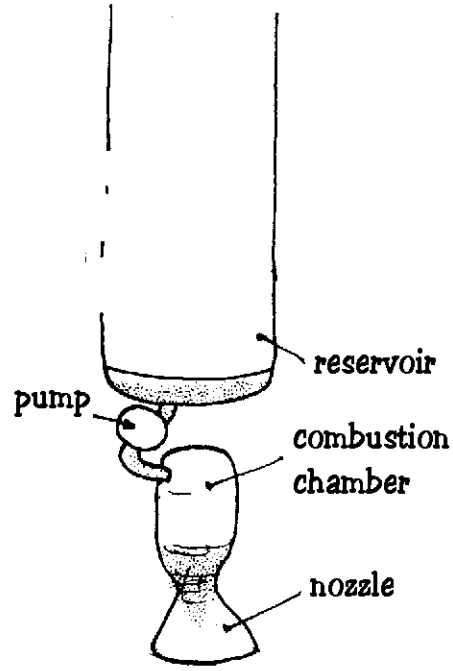
I just need to create a STAR CANAL



It's the way to conserve a more or less constant surface, and so COMBUSTION PRESSURE, over a period of time.


In very long propulsers the powder can't be moulded into a single block. Several elements need to be fixed together.
A fire started at a defective point on one of these joints caused the loss of a US space.
flexible joint
When rocket propulsers are fired, how do you extinguish them?
SPLOTCH!
Yes, in effect we need very precise control of the propulsers combustion time. Usually we eject a cap which creates a gas leak, reduces the pressure in the chamber and brings about its extinction

LIQUID FUEL ROCKETS



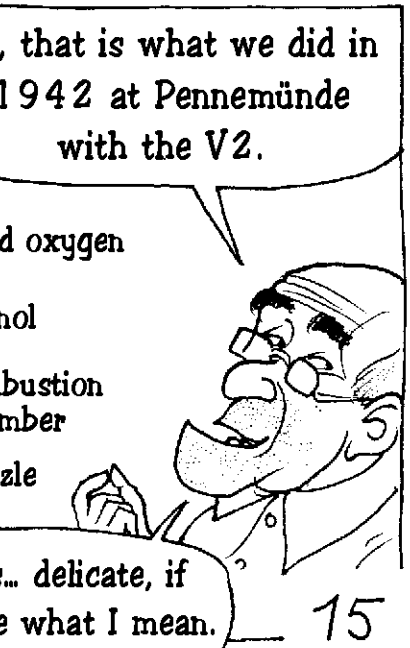
By using a PROPULSIVE in liquid form these problemes are eliminated. It suffices to pump it into a COMBUSTION CHAMBER and protect the chamber from the terrible heat.

But how do you burn the CARBURANT? As it climbs there is less and less air and there is none at all in EMPTY SPACE.

Take the air with you!

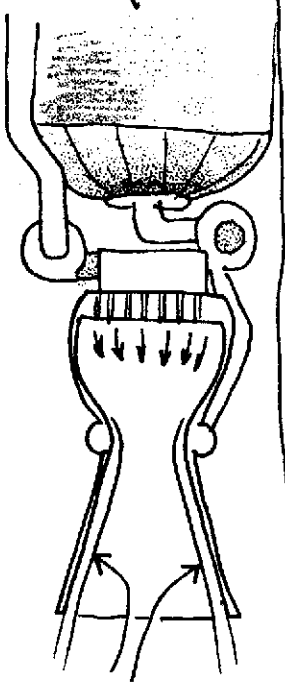
What do you mean?

You keep only the oxygen in the air which you liquify at -193 degrees Celsius. That way you are also carrying a REFRIGERANT.

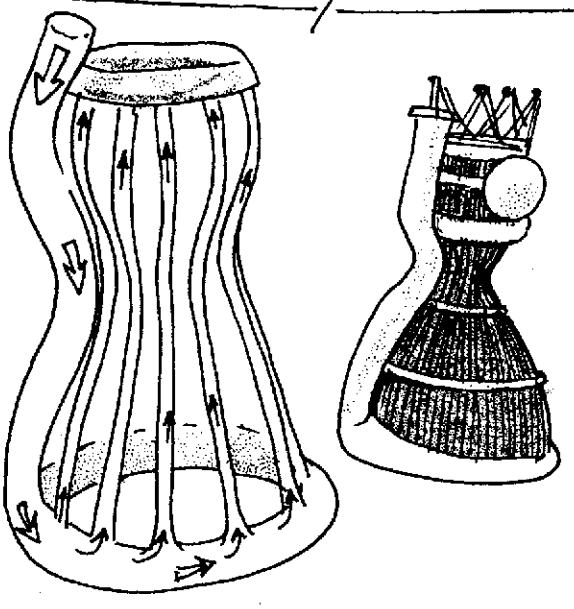


Ja, that is what we did in 1942 at Pennemünde with the V2.

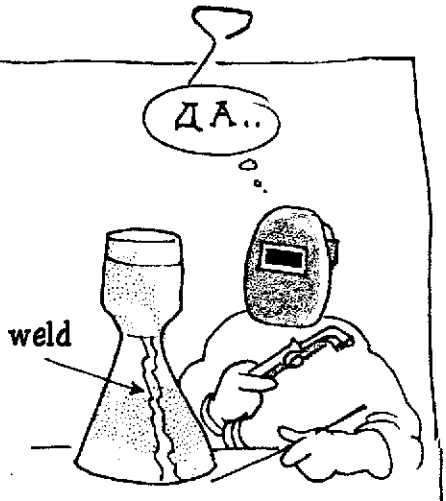
It was... delicate, if you see what I mean.



Refrigeration of the wall by means of a liquid oxygen film (sudation) (France)

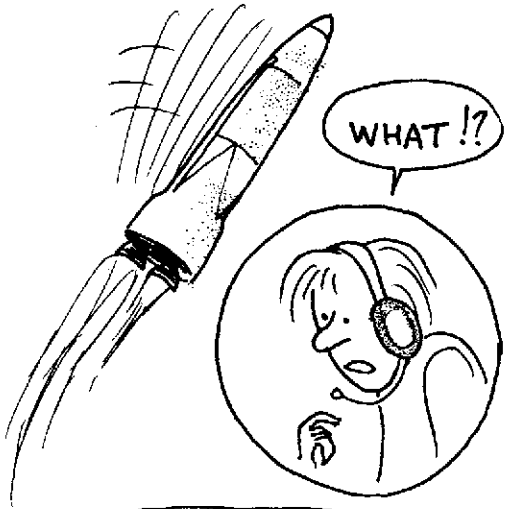


Refrigeration of the entire shell-chamber (USA)



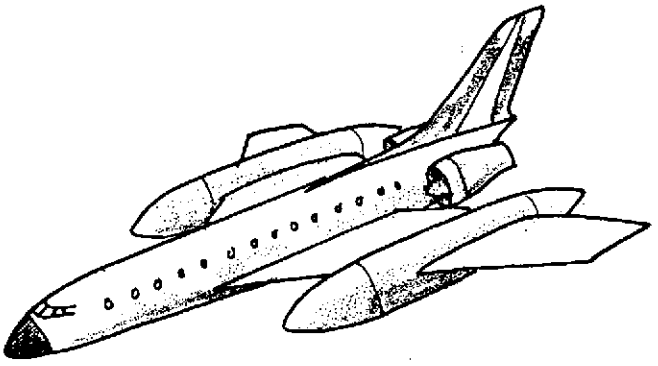
conical stainless steel nozzle (USSR)

Here are various, more or less sophisticated motors



and setting them up was always.... laborious

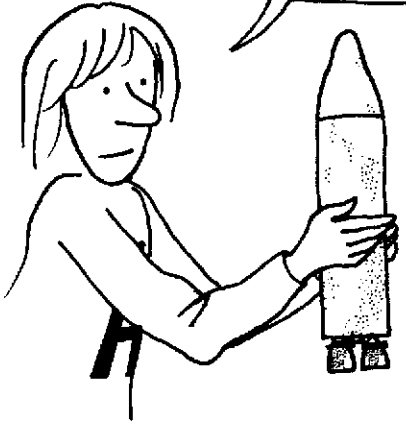

The nec plus ultra is a mix of hydrogen and oxygen. That gives the best output.
Yes but hydrogen only becomes a liquid at minus two hundred and seventy degrees. It isn't easy to pump a fluid that cold.
Don't you find that all these rockets taking off and leaving enormous clouds of smoke cause pollution?
Yes but when it is a hydrogen-oxygen mixture do you know what that gives?
Logically... let's see... it should be hydrogen oxyde.
In other words H_2O, WATER!
?!?

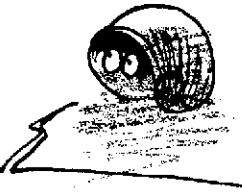


In the future the non-polluting character of this hydrogen-oxygen mix might become an ideal formula for... planes!

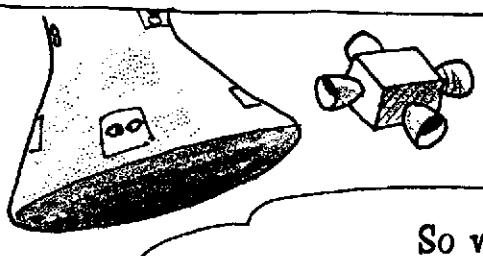
Solid fuel rockets have the advantage of easy storage and use, they are extremely simple.

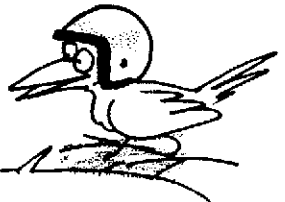
That's why the military likes them, though they are a careful to ignite them OUTSIDE their nuclear submarines





Liquid fuel rockets, on the other hand, are the only type that can be extinguished and reignited at will whereas once there is ignition on a solid fuel rocket, its over...





So we have a whole range of piloting rockets and attitude controllers

STRUCTURES

The sleeves of solid fuel rockets need to be fairly resistant in order to support combustion pressure. In liquid fuel rockets this pressure only exists within the combustion chamber itself. So they've always tried to make the fuel tanks as light as possible.

I had to make this model of a rocket's fuel tank in metal foil to keep it to scale.

The thickness of the walls of the tanks on the Ariane rocket is 1,4mm.

Let's put this sleeve on the table.

The sleeve always collapses under its own weight. We've made it too thin.

Now the upper stage.

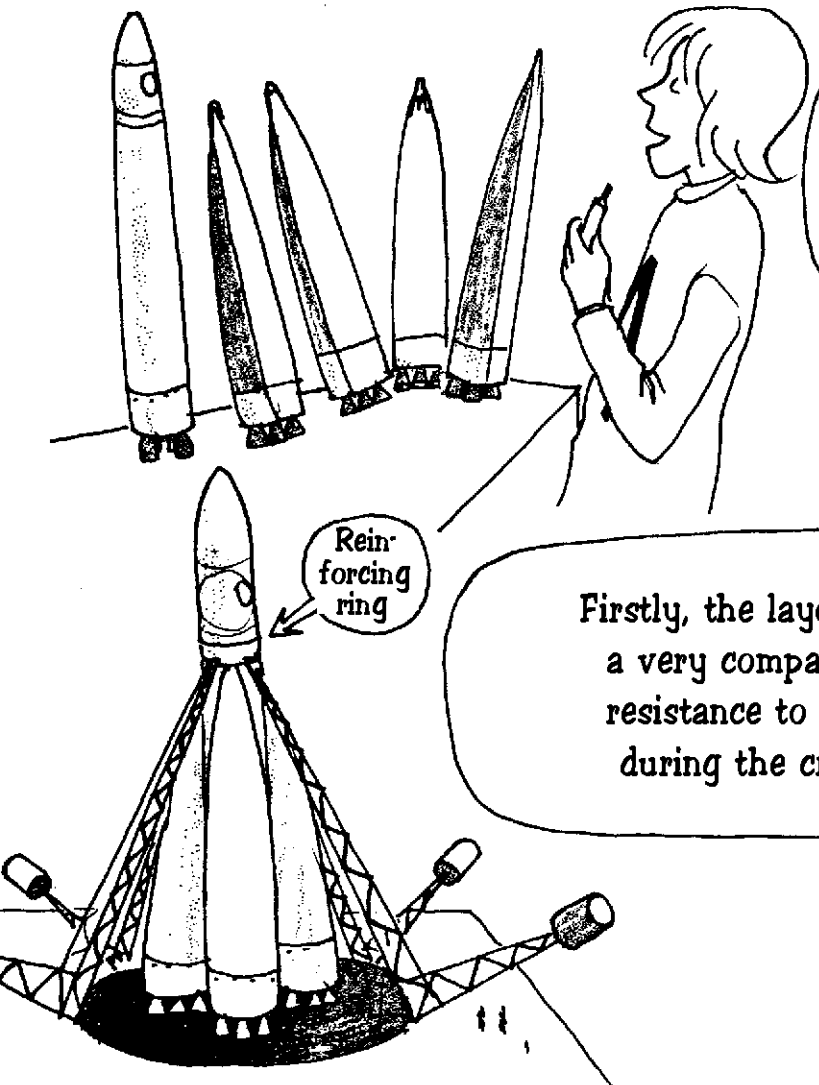
Careful, the tank is collapsing!

No, Tiresias, on a full size rocket we'd have to pressurise it, inflate the tanks to avoid them collapsing under their own weight

Ah, OK...

The conquest of space brought up a multitude of new technical problems, which we often didn't know anything about.

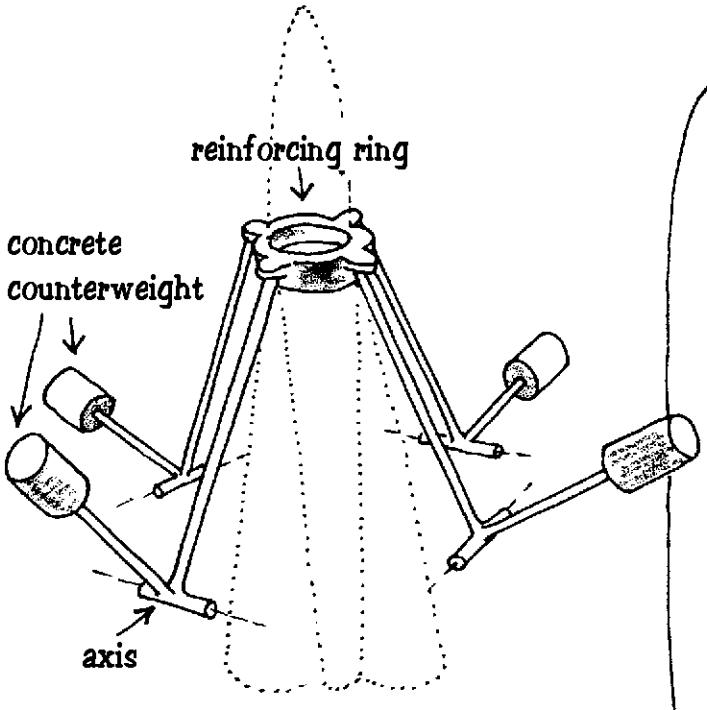
SIMPLICITY...



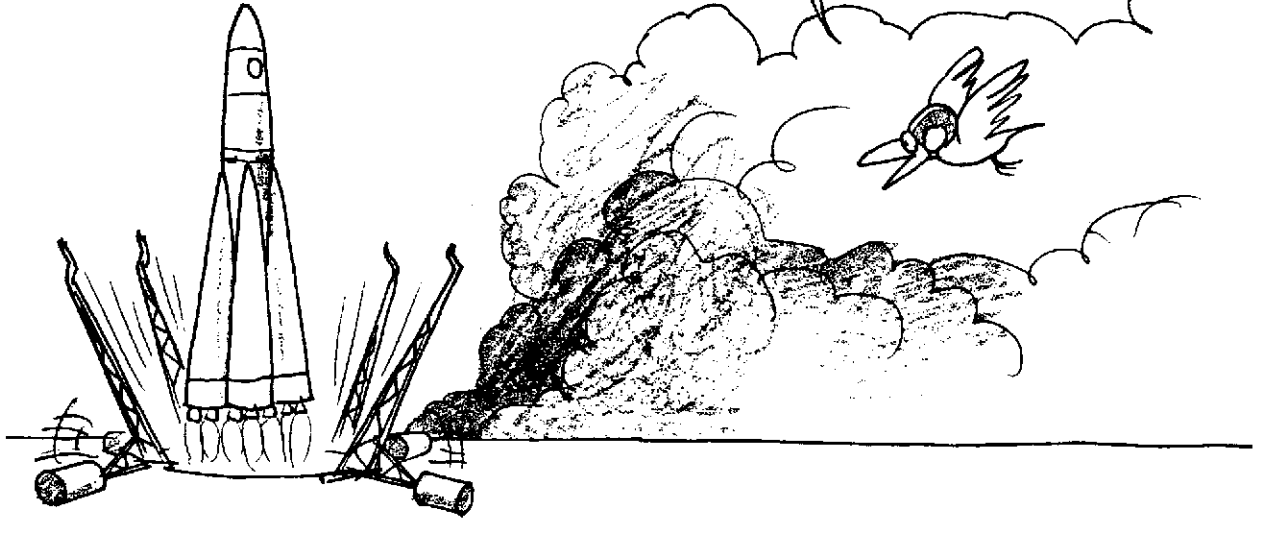
Without doubt the award for simplicity should go to SEMIORKA, the all purpose rocket invented by the Soviet scientist KOROLEV

Rein-forcing ring

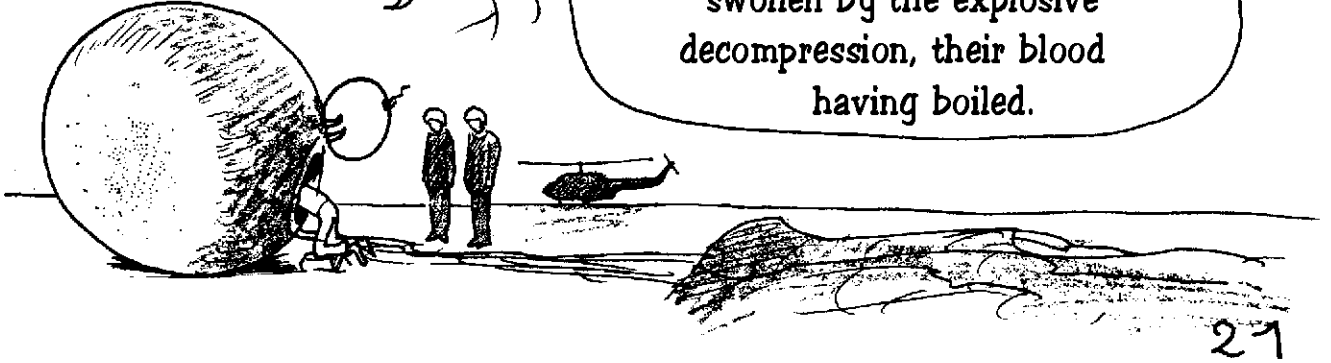
Firstly, the layout of the boosters give it a very compact look and an excellent resistance to vibration and crosswinds during the critical phase of take off.



It's a reinforcing collar that holds in all the thrust effort but it is also this that allows to rocket to be suspended on the launching pad like a ham, using four simple spurs. When the 24 rockets act together the articulated arms move back automatically by pivoting on their axes because of the counterweights

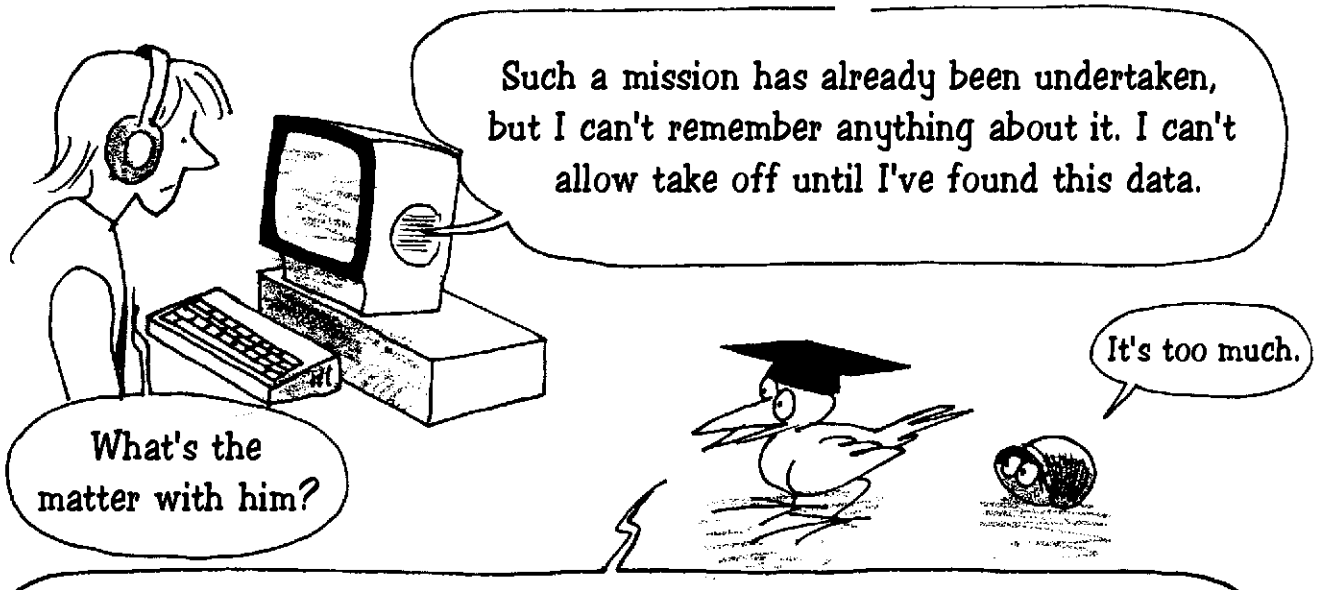


But the Soviets lost three cosmonauts because of the accidental opening of a valve. They arrived back on earth dead, swollen by the explosive decompression, their blood having boiled.

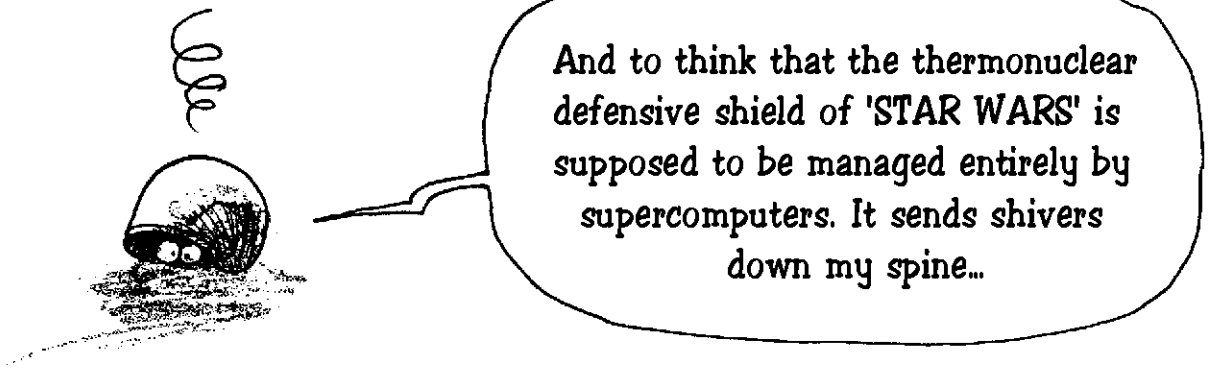


...OR SOPHISTICATION?

Inversely, the Americans multiply the number of control and guiding systems. The American space shuttle is under the control of four computers. Three are of the same type while the fourth, different, is supposed to control the eventual mistakes of the three others. One day the fourth computer broke down and completely blocked the launch procedure...



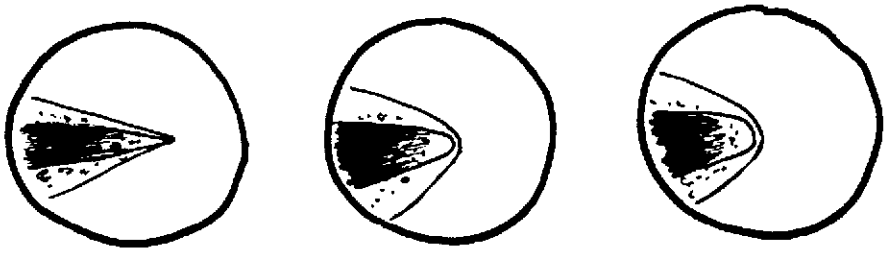
A delay of a few thousandths of a second between this computer's clock and those of the three others made it that the fourth, when receiving data from the other three, confused the FUTURE and the PAST (*).



(*) In psychology, the impression of déjà vu.

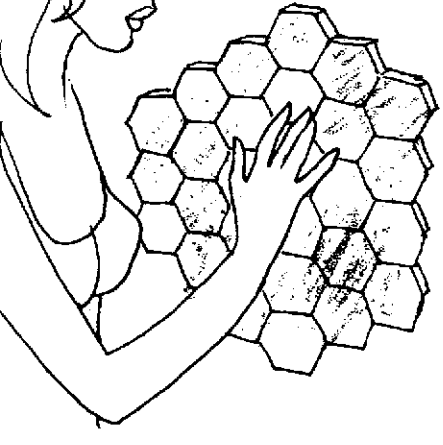
RE-ENTRY INTO THE ATMOSPHERE

All these rockets can get beyond the atmosphere, but if you want to bring something back from up there, you have to think of some way for it to re-enter the atmosphere at 28000 km/h/

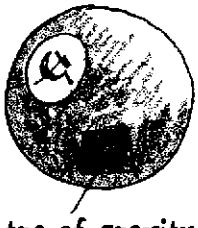


A high entry speed is synonymous with friction and heat. A pointed object could never manage it.

The simplest solution is a HEAT SHIELD which will absorb the heat by evaporating.



We can use a re-entering body in the shape of a sphere.



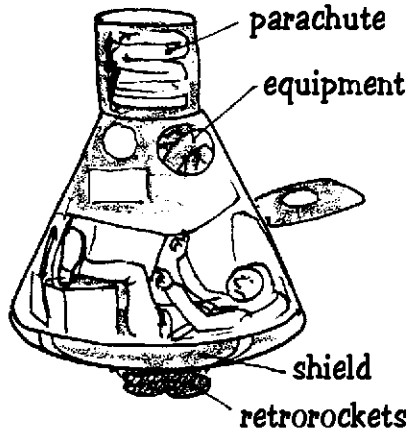
centre of gravity

(*) When a material passes directly from a solid to a gaseous state, it is called SUBLIMATION.

The objects need to remain stable during the RE-ENTRY phase. If they turn it would be absolutely catastrophic.

There is no stability problem with a sphere, the Soviet solution

This sort of object (Mercury, Gemini, Apollo capsule) is just as good, providing its centre of gravity is fairly low



the tiny Mercury capsule

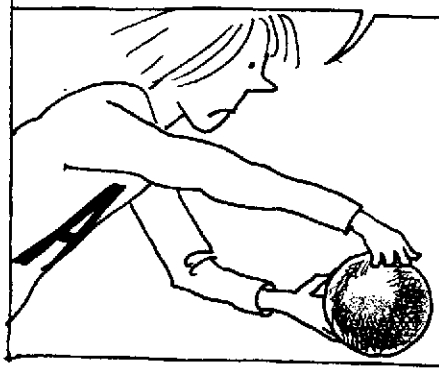
OK, but this said, I don't see how rockets can be maintained in the air and not fall back to earth once their fuel has been used up.

I'm going to have a game of bowls, that'll help clear my thoughts

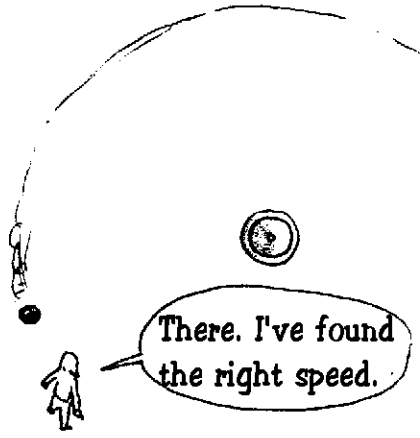
SENDING INTO ORBIT

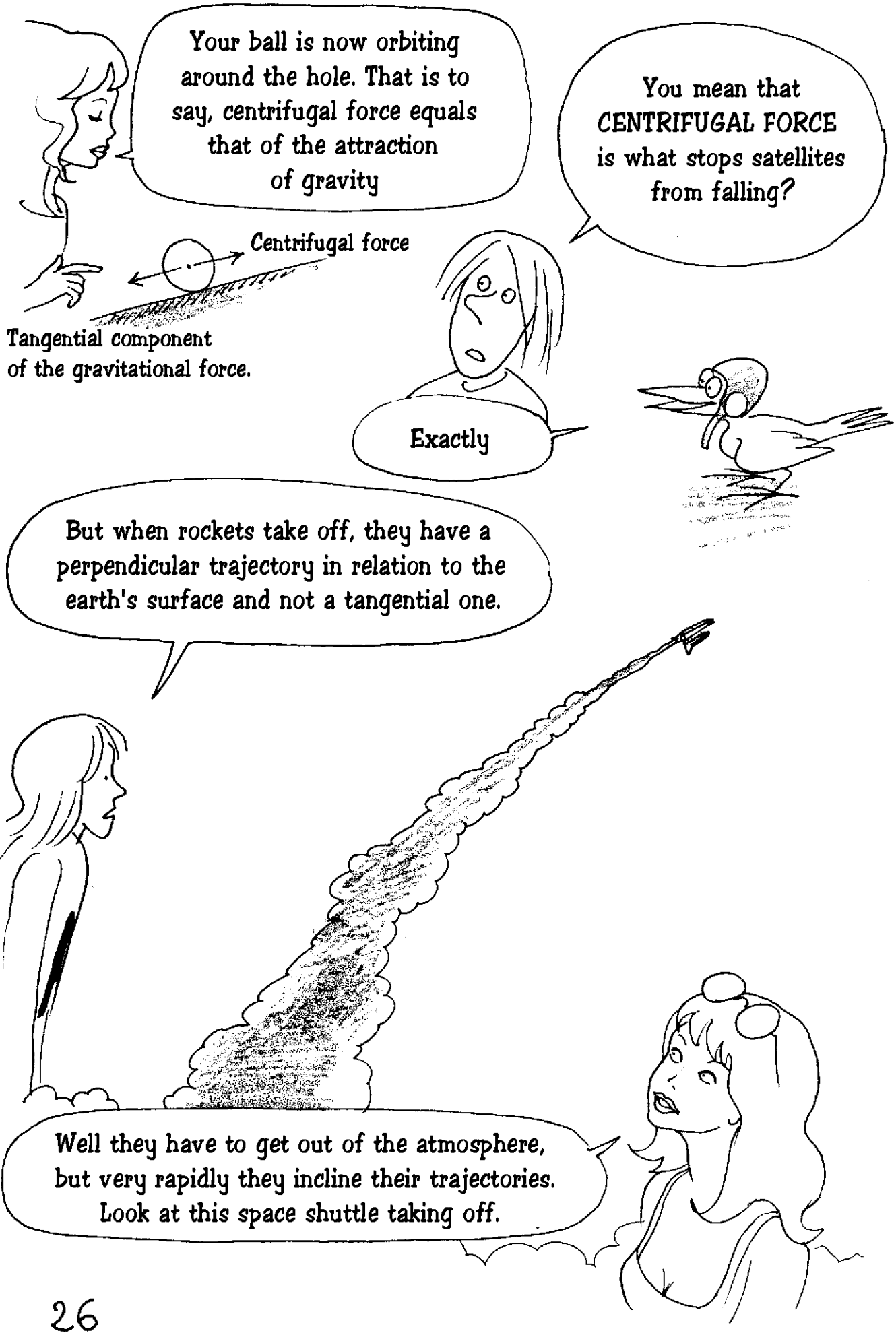
Huh, that's amusing, the strange fountain on the town hall square isn't working. It'll be interesting to play bowls on a curved surface.

Given the form of this surface, I'm going to make it so that my ball returns to its point of departure

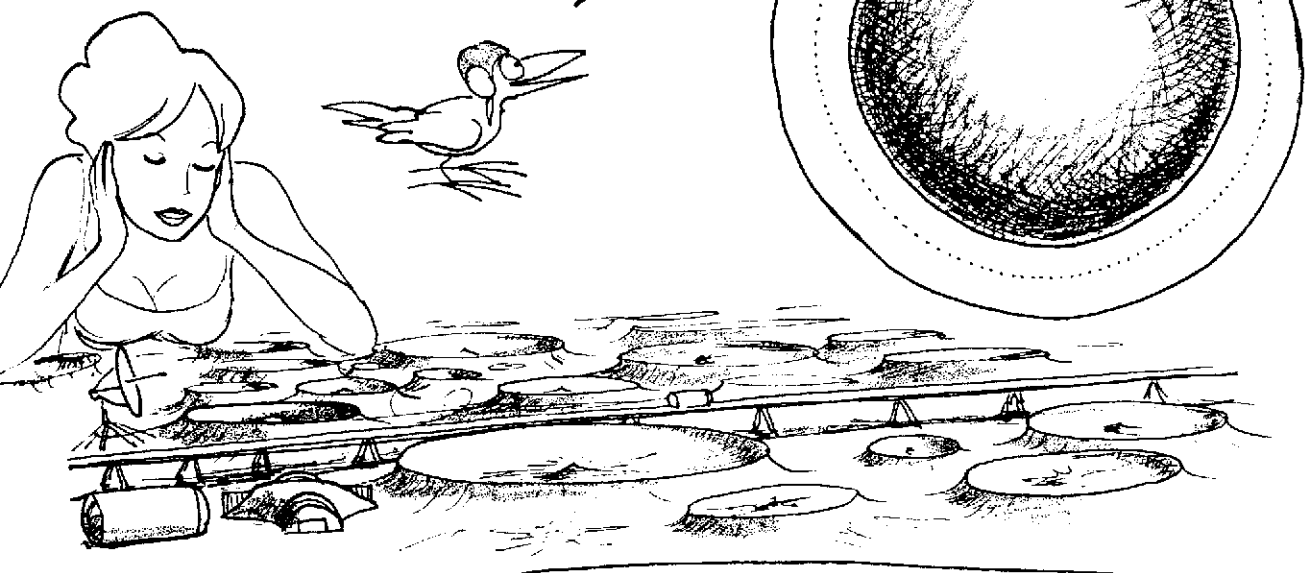


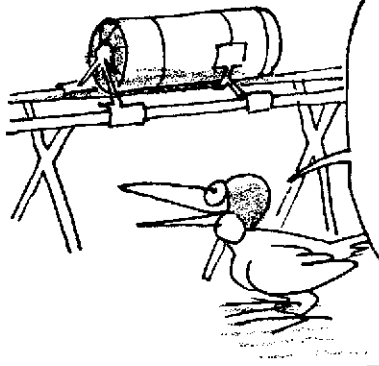
After a few failed attempts




Your ball is now orbiting around the hole. That is to say, centrifugal force equals that of the attraction of gravity
Centrifugal force
Tangential component of the gravitational force.
You mean that CENTRIFUGAL FORCE is what stops satellites from falling?
Exactly
But when rockets take off, they have a perpendicular trajectory in relation to the earth's surface and not a tangential one.
Well they have to get out of the atmosphere, but very rapidly they incline their trajectories. Look at this space shuttle taking off.

Here is a schema of placing in orbit. (In fact, the atmospheric layer is a hundred times thinner). We can see how the rocket tilts after take-off

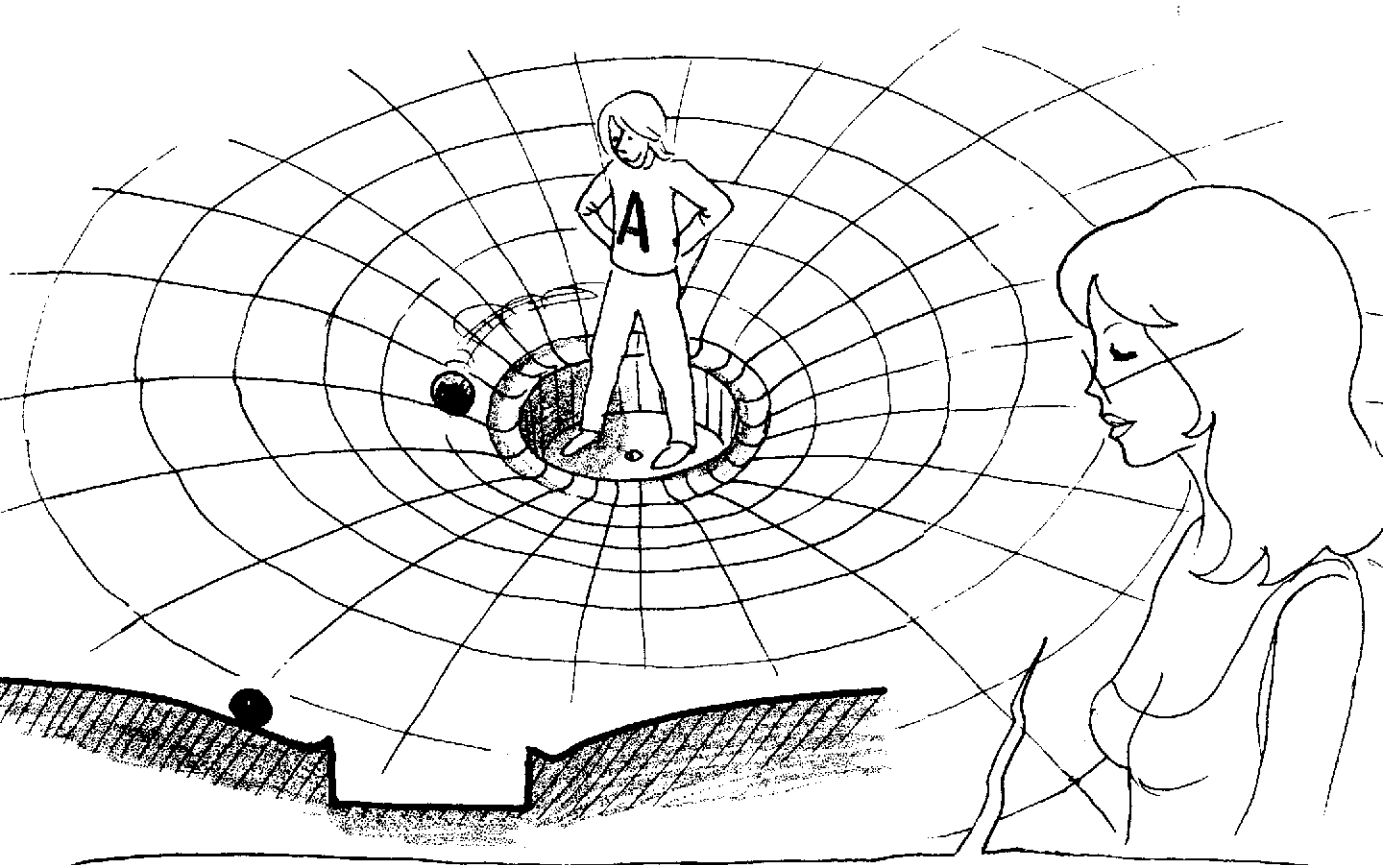




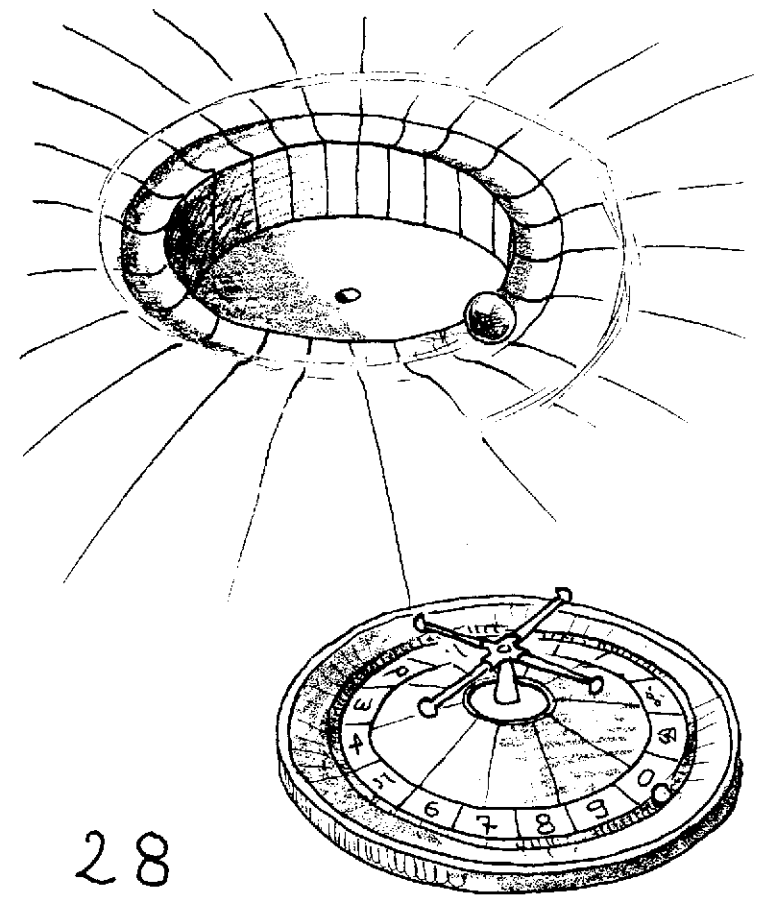
But if we build a base on the Moon one day, as it has no atmosphere, we could satellise objects around it by directly accelerating them from ramps laid parallel to the ground (*).

In the meantime, I have to impart a minimum speed of ninety centimetres/sec for my ball to circle around the central well of the fountain.

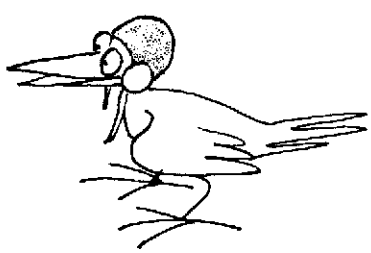
(*) Escape velocity from the Moon: 2,36 Km/s



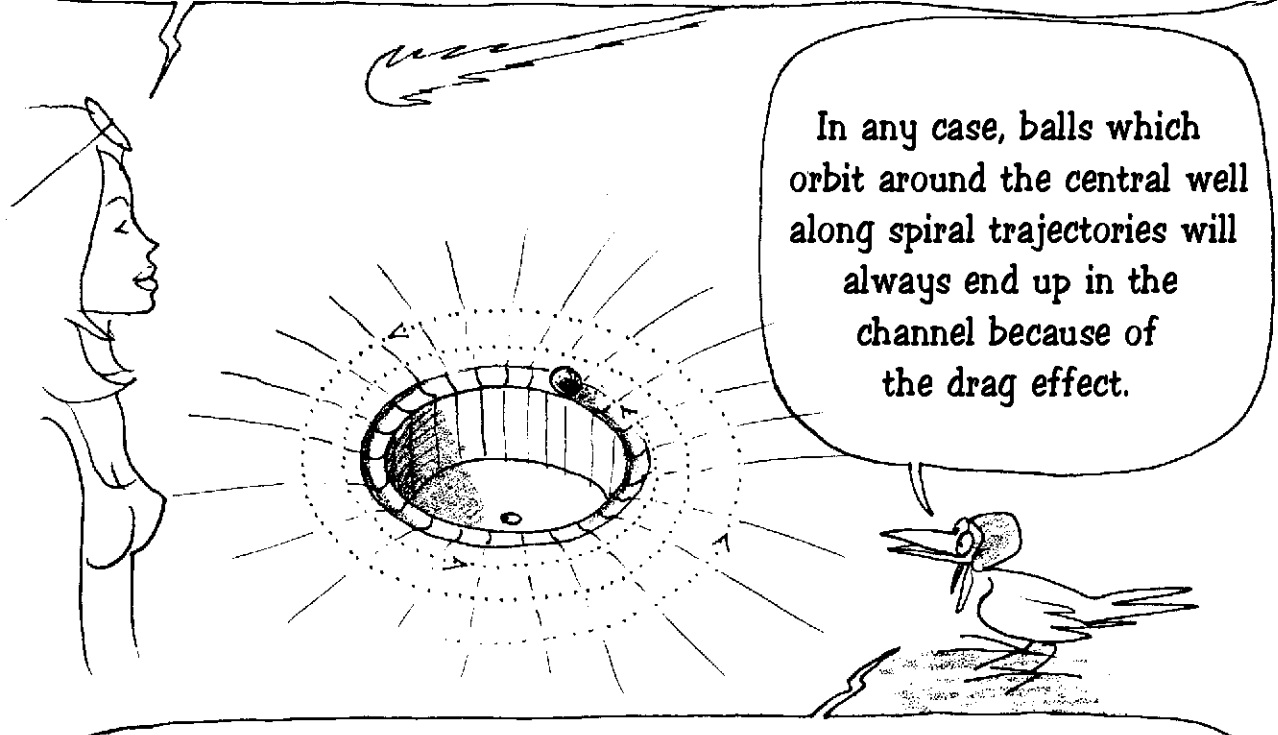
It's equivalent to the CIRCULAR ORBITING VELOCITY or PRIMARY COSMIC SPEED, which is simply ten thousand times higher, that is to say 7.8 kilometres per second.



If the speed is lower, the ball will fall into the channel, like the ball on a roulette wheel, and being dragged by asperities, it'll come to a stop.



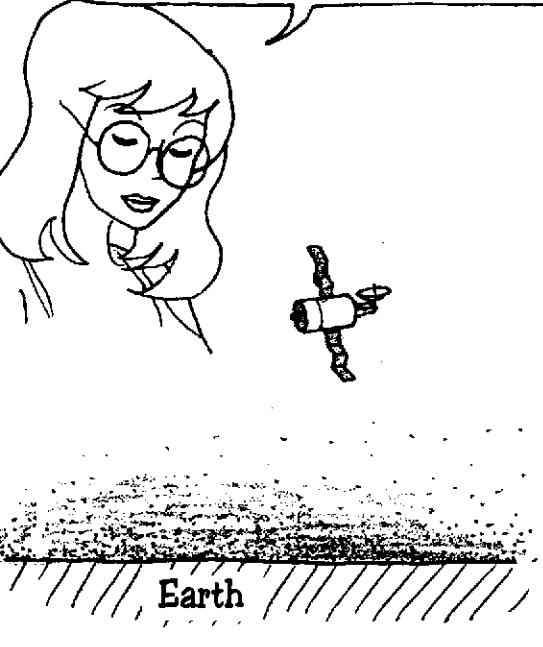
In the same way, if a failure of the upper stage of a rocket carrying it stopped a satellite from reaching this minimum speed of 7.8 Km/s, it would fall back into the lower layers of the atmosphere, which would quickly slow it down.



In any case, balls which orbit around the central well along spiral trajectories will always end up in the channel because of the drag effect.

That corresponds to the LIFETIME of satellites

Twenty years ago we underestimated this braking effect by supposing a STANDARD STATE in the upper atmosphere.



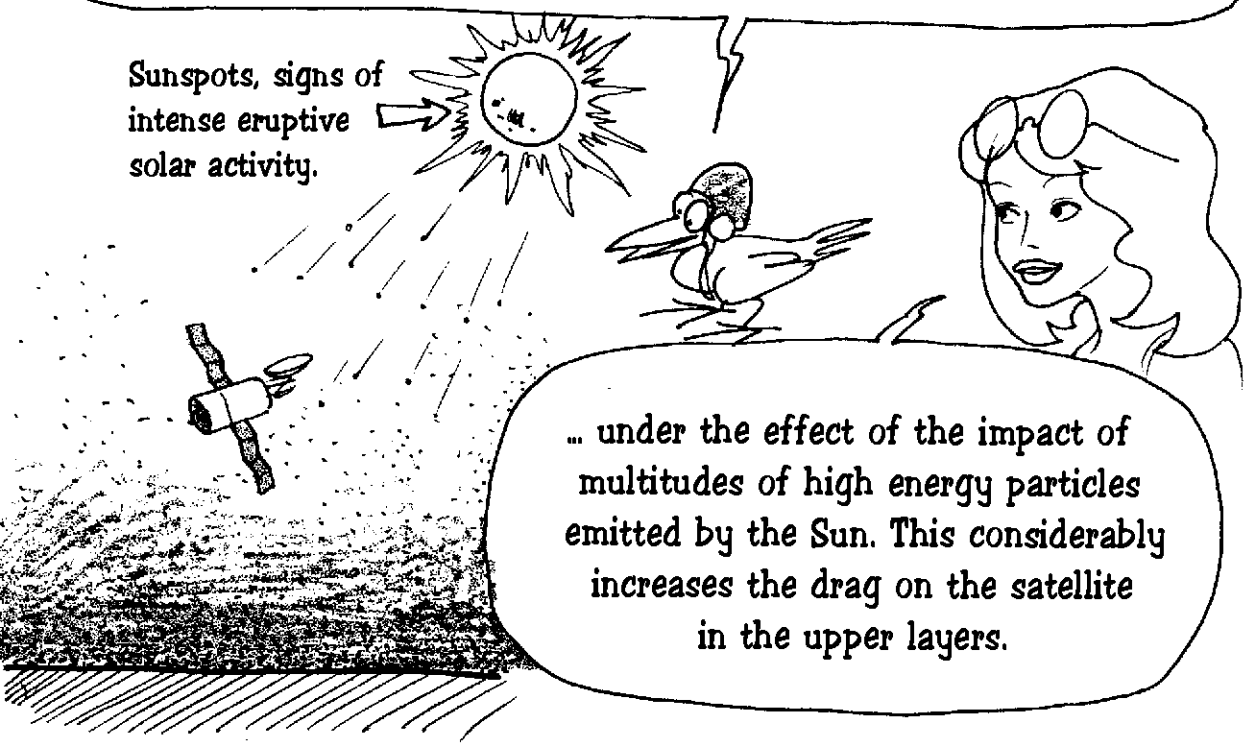
and it was that that caused the subsequent loss of the American space laboratory, SKYLAB (*)

Earth

(*) Placed in orbit in 1973 at an altitude of 435 Km, the space station fell back to earth on the 11th July 1979.

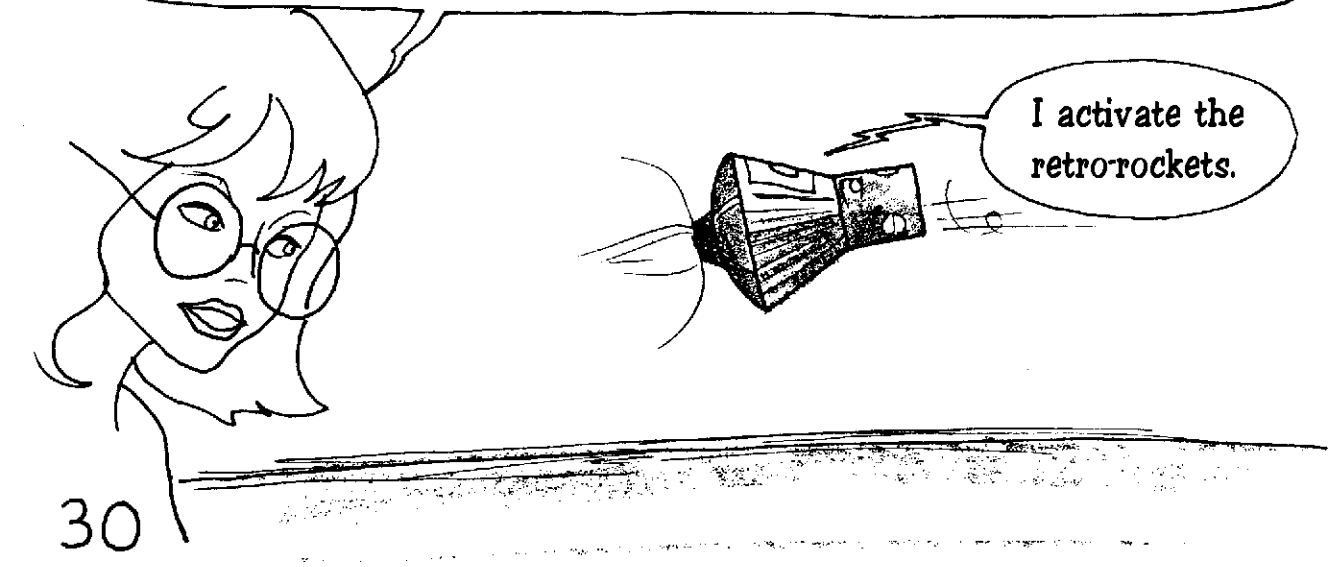
The upper atmosphere isn't static. You could compare it to a sheet of vapour whose vertical extension depends on solar activity. The atmosphere starts to "boil" when there are solar eruptions...

Sunspots, signs of intense eruptive solar activity.

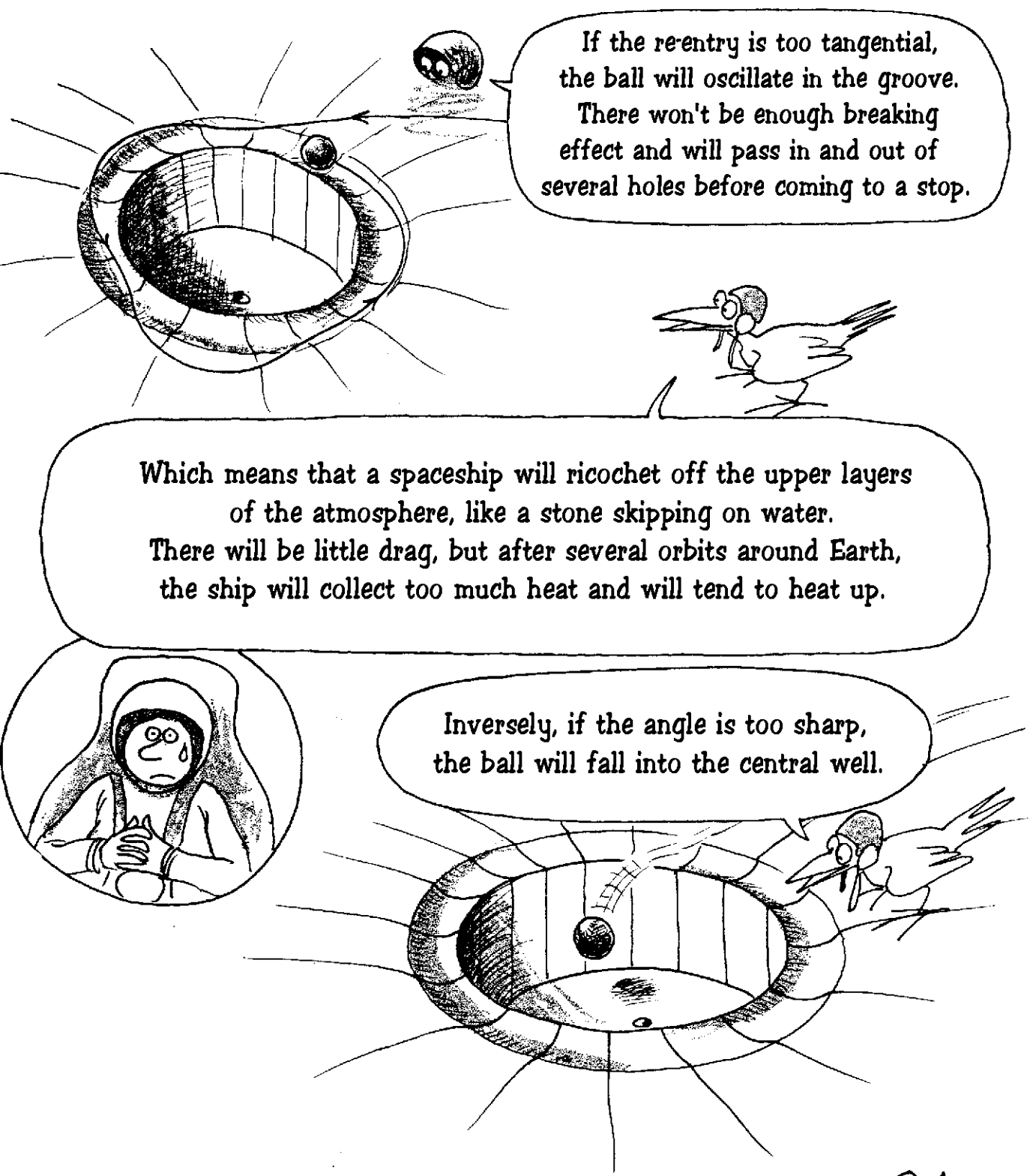


... under the effect of the impact of multitudes of high energy particles emitted by the Sun. This considerably increases the drag on the satellite in the upper layers.

The Earth's atmosphere allows a return to earth without using energy (otherwise it would require as much power to get it back as it took to get it into orbit). But the re-entry must be made at a very precise angle.

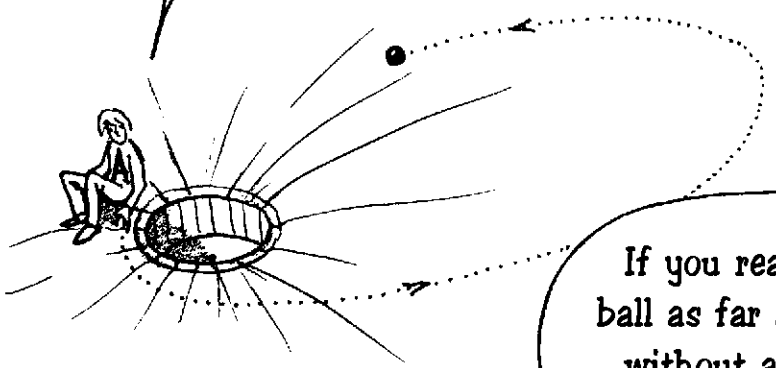


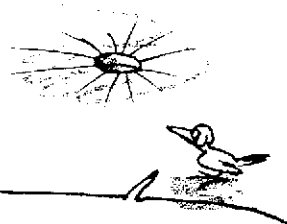
RE-ENTRY WINDOW



In other words: The re-entry will be too brutal and accompanied by a deceleration such that it could bring about the destruction of the spacecraft.

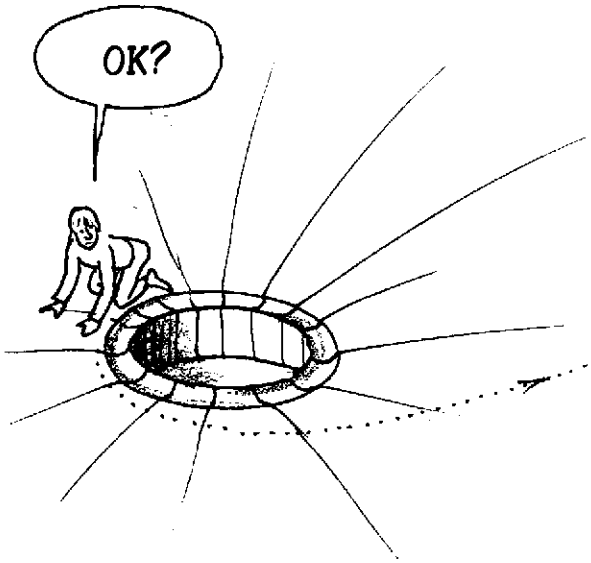
If I give my ball a speed above 80 cm/s, I can make it reach regions further and further out, following elliptic trajectories.

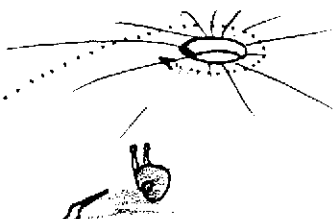




If you really insist you could send the ball as far as the second empty fountain, without a "channel", a smaller central well and smoother sides.

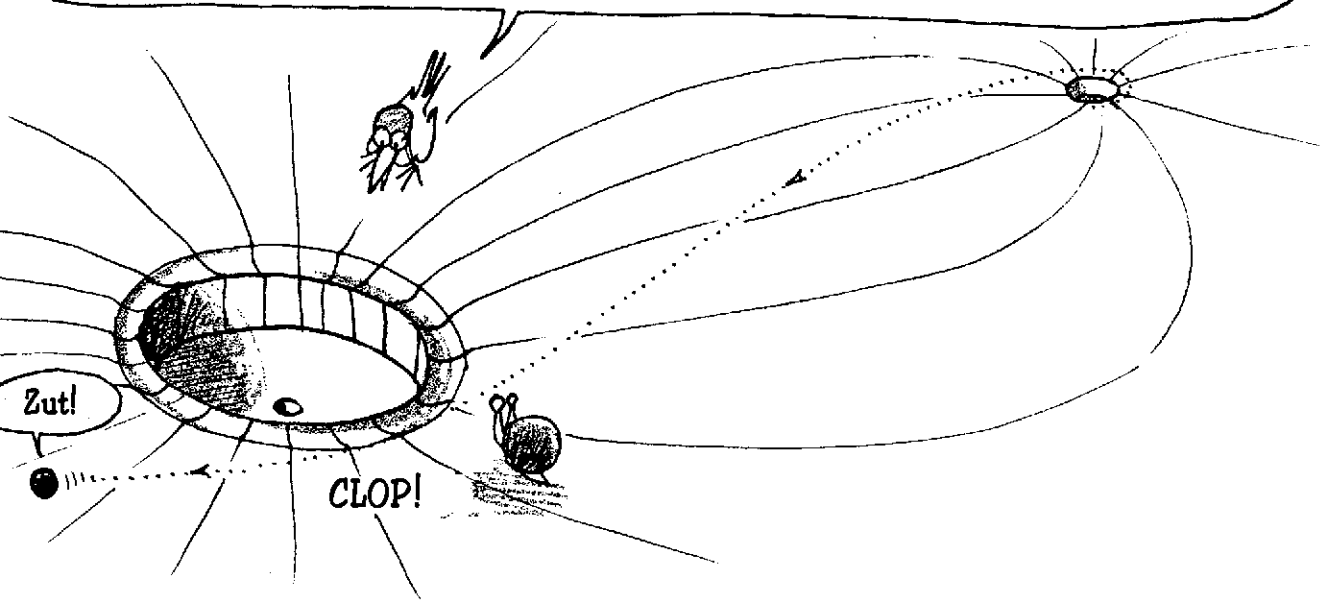
OK?



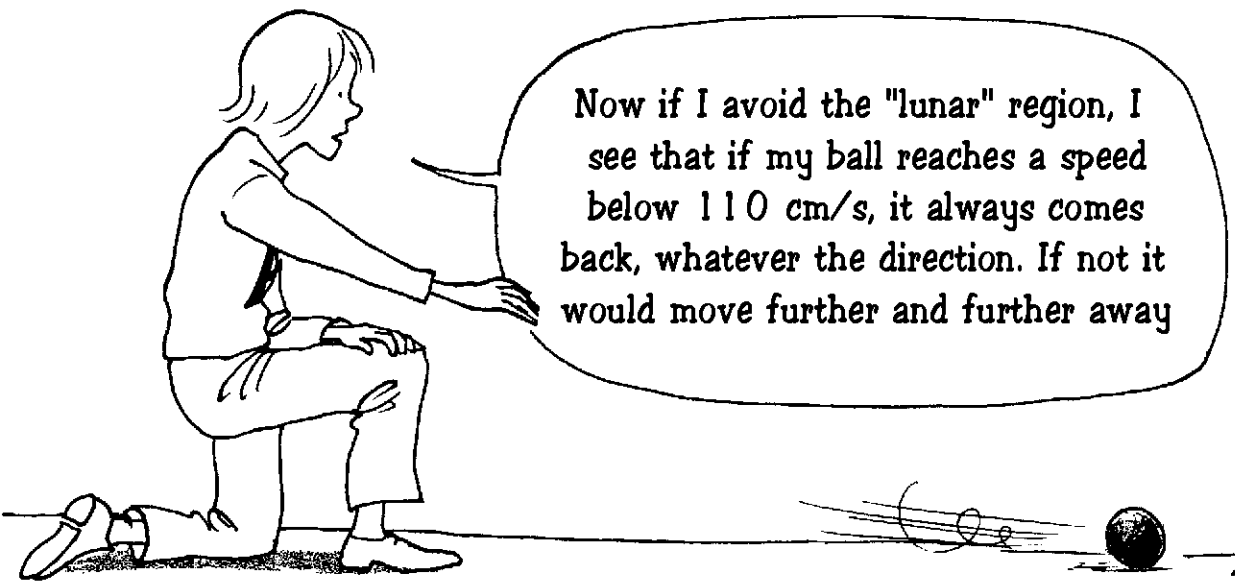


Perfect. You've just succeeded with your LUNAR MISSION.

It's the return that is the most delicate because the spacecraft approaches Earth at eleven kilometres per second instead of 7.8. The slightest error and the astronauts would be flattened like pancakes, or the re-entry module would ricochet off the atmosphere and disappear into the cosmos



ESCAPE VELOCITY



This is equivalent to the ESCAPE VELOCITY, the speed that must be reached to overcome the Earth's attraction, or SECOND COSMIC VELOCITY, which is close to 11 Km/s

But it also means that we have to supply a spacecraft with twice as much energy

We were able to economise a great deal of this energy with the Voyager II spacecraft, by using an exceptional alignment of planets in the solar system.

Jupiter 1979

Earth 1977

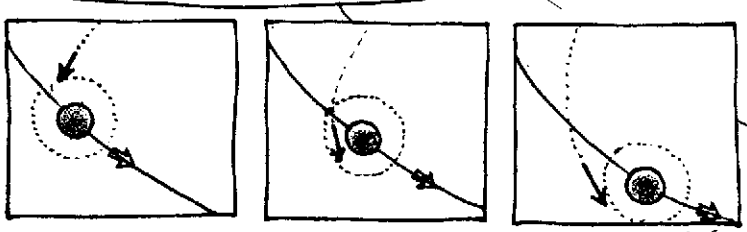
Saturn 1981

Uranus 1986

In effect, when an object passes in the track of a planet, the planet tends to "hitch and tow" it and so give it extra speed.

The successive speed gains allowed the vessels to leave the solar system.

That makes me think of the way my uncle Adolphe drives his little car behind big lorries, so as to go a few kilometers per hour faster.



The vessel penetrates the planet's zone of attraction.

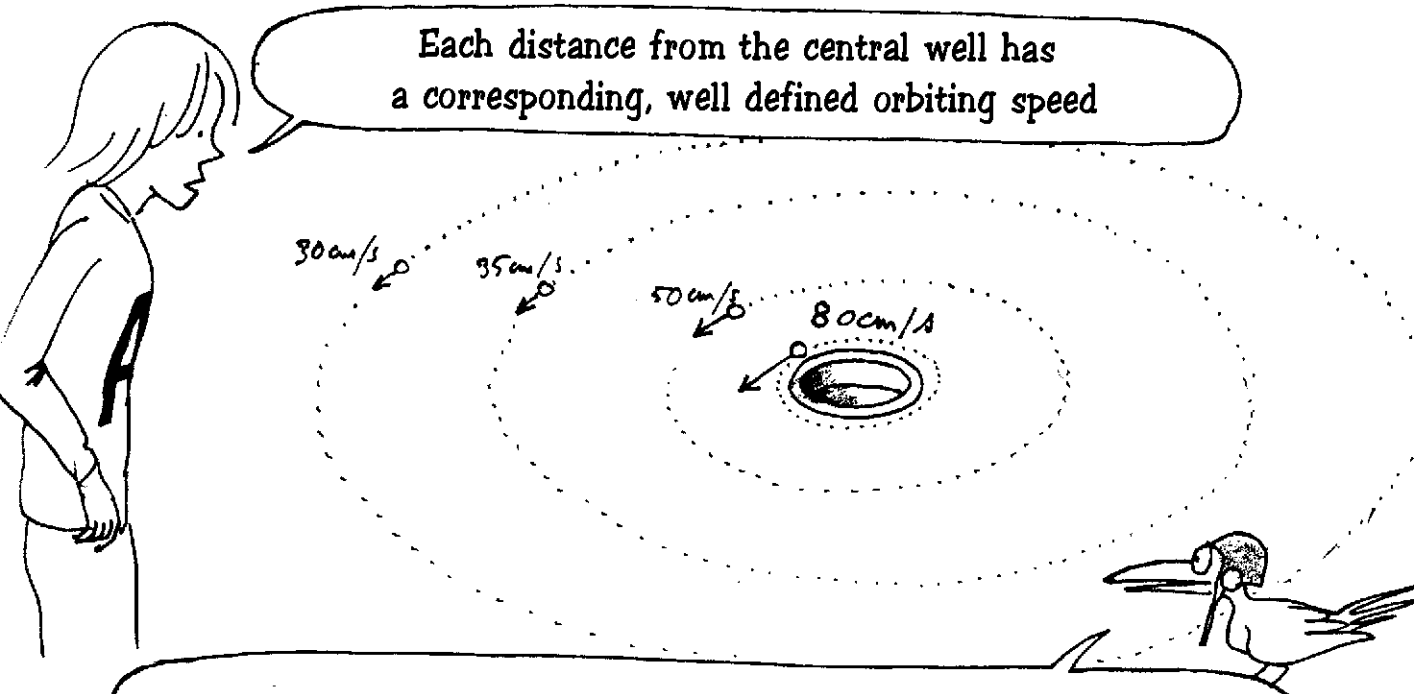
It acquires extra speed.

Then leaves the zone of attraction and continues on its way.

The (kinetic) energy is $\frac{1}{2}mV^2$

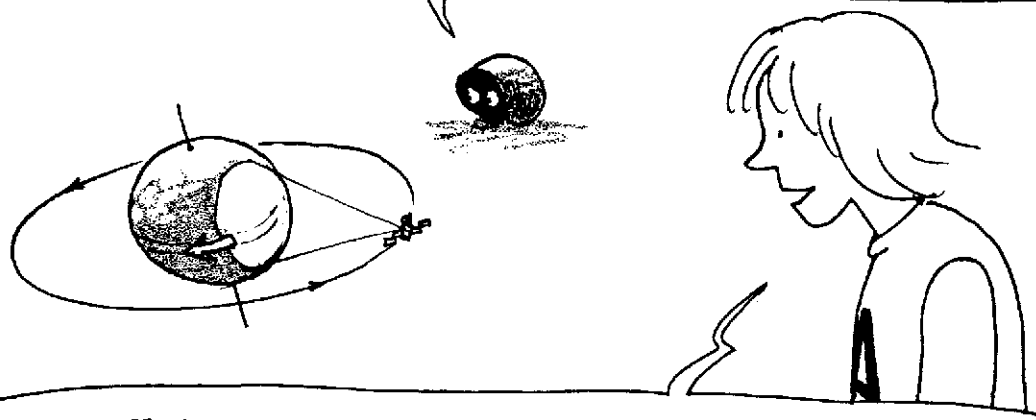
GEOSTATIONARY SATELLITES

Each distance from the central well has a corresponding, well defined orbiting speed



The ORBIT PERIOD increases with the distance from Earth (*). At low altitude a satellite orbits in just over an hour. The MOON takes a month.

Consequently, there must exist an intermediary distance where the orbit is completed in twenty four hours.



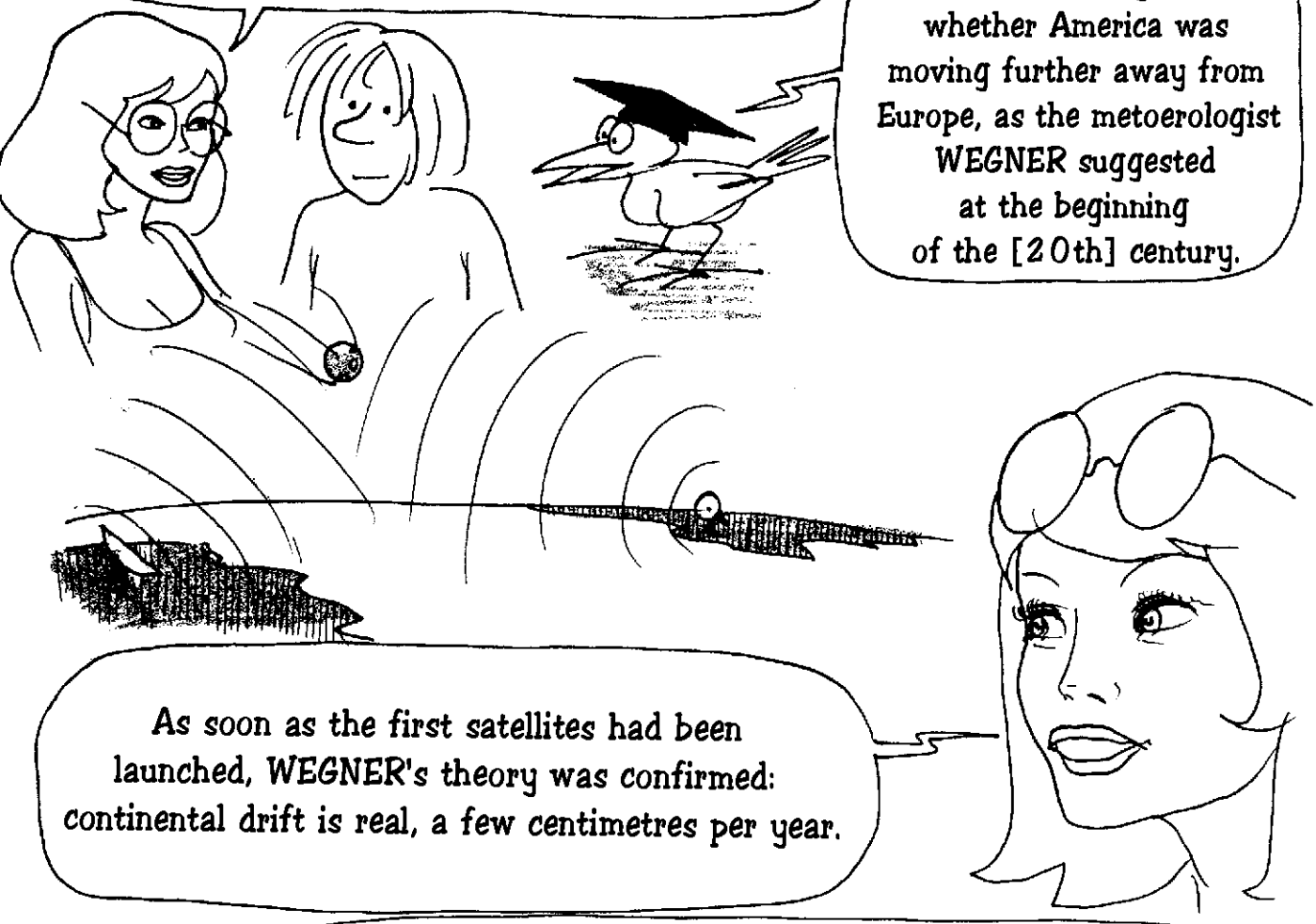
Under those conditions the satellite should always find itself above the same point on the earth's surface.

(*) Kepler's Law: The square of orbit time varies with the cube of the orbit radius.

VIEW FROM SPACE

We've known how to measure the approach or distancing speed of an object for years, very precisely and even over great distances, using the DOPPLER-FIZEAU (*) effect.

People have wanted to know for a long time whether America was moving further away from Europe, as the metoerologist WEGNER suggested at the beginning of the [20th] century.



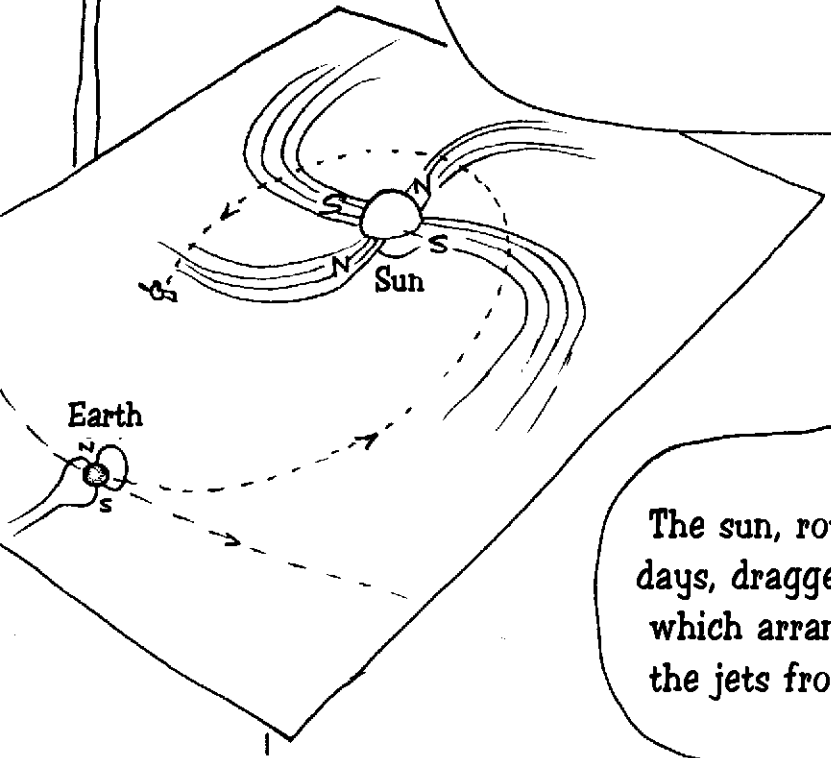
As soon as the first satellites had been launched, WEGNER's theory was confirmed: continental drift is real, a few centimetres per year.

Profiting from WEGNER's absence, because of a death in his family, the geologists, who had always roundly decried him, rebaptised his theory PLATE TECTONICS

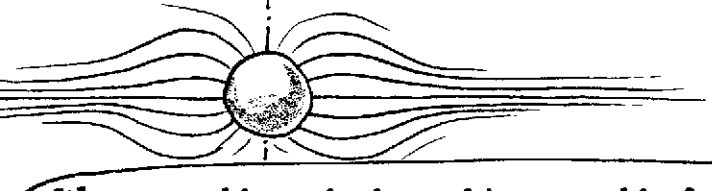
(*) See BIG BANG, page 50.

After the geologists, meteorologists began to benefit from images sent by satellites and were able to make their predictions far more precise. As for our dear military men, they could now watch each other closely.

But one day, a circumsolar satellite transmitted magnetic field data which disconcerted astrophysicians. It had long been known that the sun had a magnetic field, but it wasn't known that the field had two poles, south and north, situated in the plane of the solar equator.

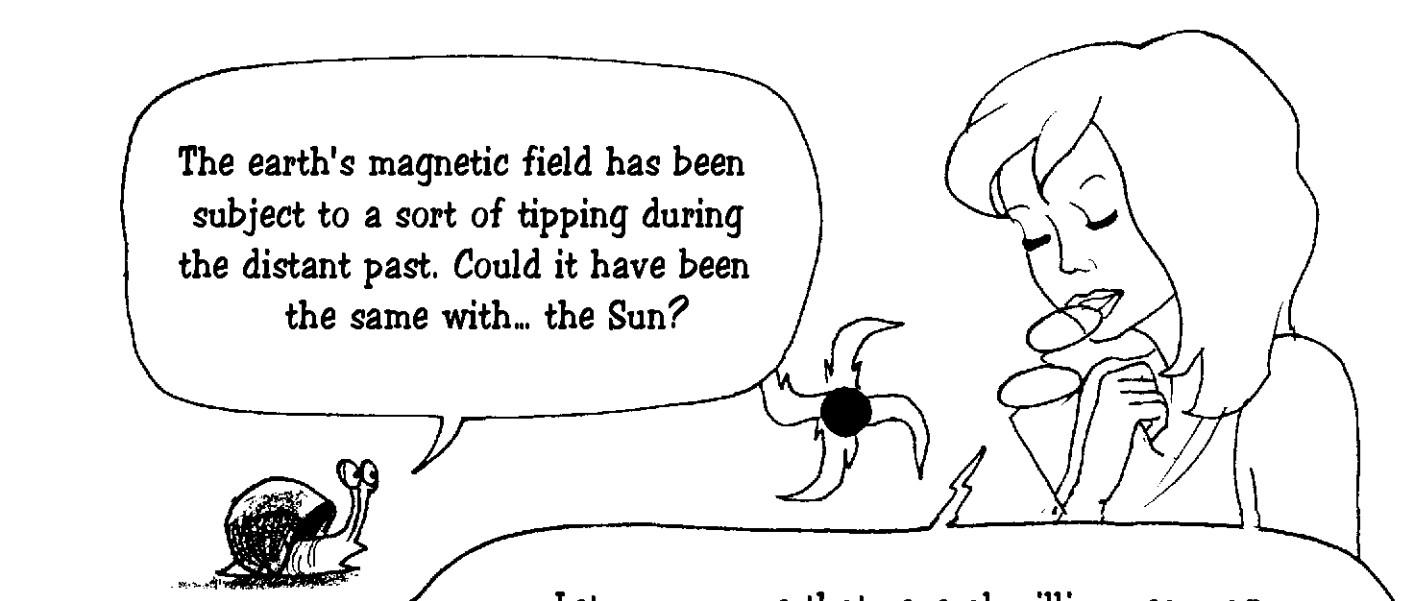


The sun, rotating on itself in about thirty days, dragged magnetic emanations with it, which arranged themselves around it like the jets from a rotating water sprinkler.

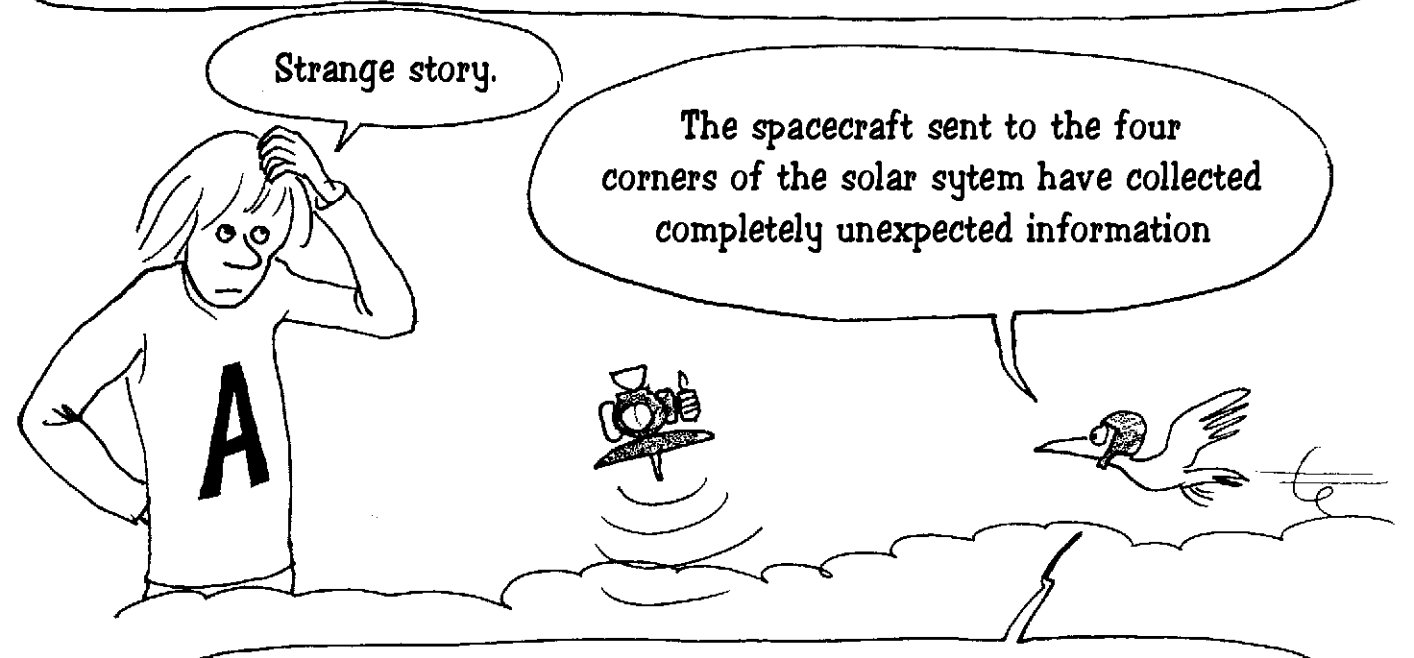


We were able to look at this ensemble from the side, until then we only knew it as in this drawing.

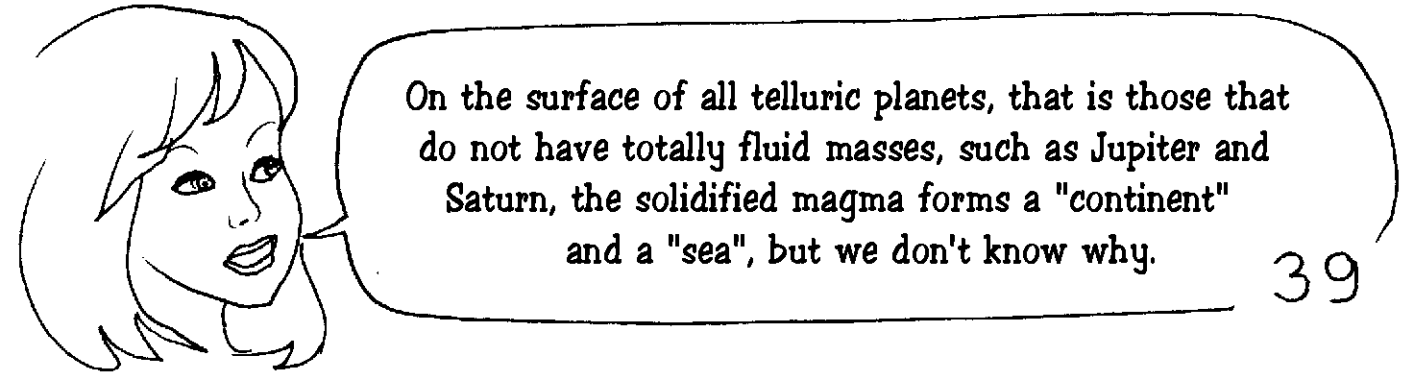
(*) Used for a while to terrible ends by a certain Hitler.



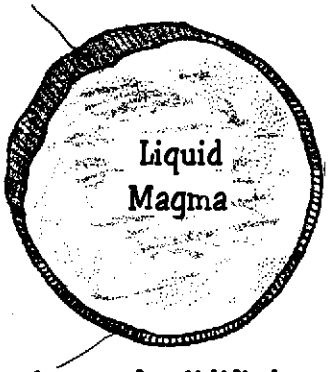
Let us suppose that several million years ago the corona was presented thus during an eclipse, the mystery remains because this corona, at that distance from the sun, would not have been luminous enough to be seen with the naked eye. It would have needed a photographic system with a long delay. Unless, of course, it is a coincidence



Thus the radar waves emitted by an American craft were able to pierce the cloud cover of Venus and give the first indications of its relief.

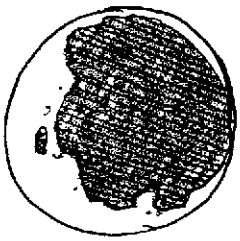


What are you talking about? Mars doesn't have water and Venus is a furnace with a surface at 500 degrees!

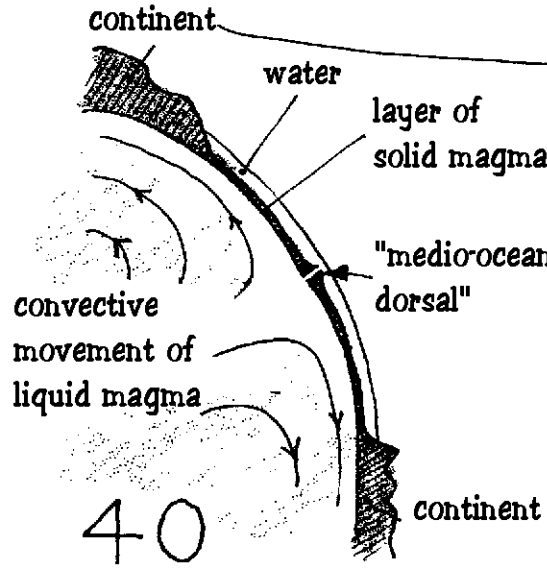


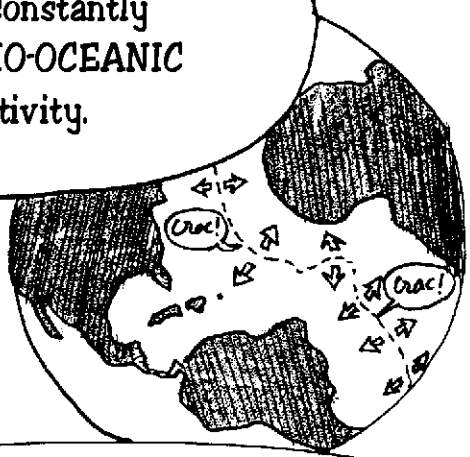
On Earth, water in liquid state fills the low altitude regions and a "continent" is just a mass of solid magma, floating on the surface of a mass of liquid magma.

OK, so Mars, Venus and Mercury have a contienent, so what?



The internal movements of magma on earth exercise a strong pull on the solid layers and break them, provoking CONTINENTAL DRIFT. The upper layer is constantly cracking and magma appears along the MEDIO-OCEANIC DORSALS, areas of intense volcanic activity.



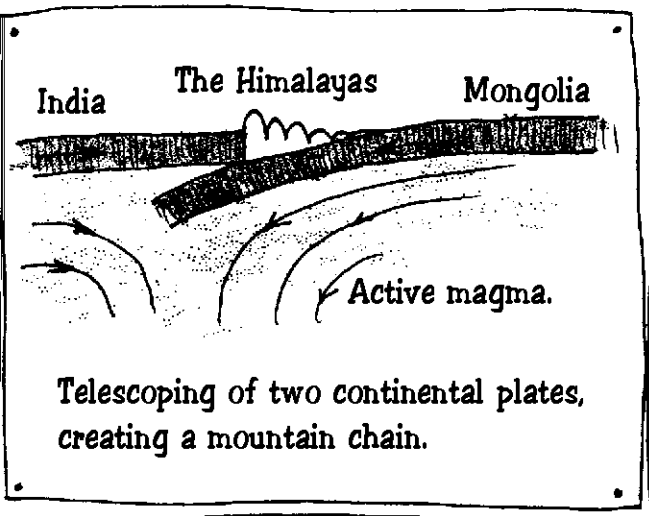


Here's a sort of undersea mountain range, it's halfway between Africa and South America, which are moving away from each other.

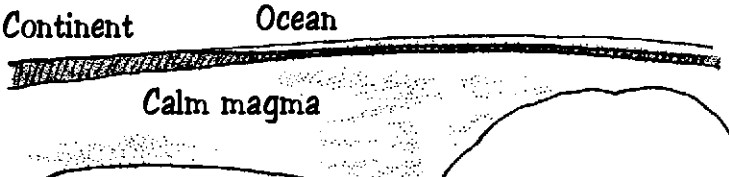
Radar cartography of other planets has revealed that they do not have medio-oceanic dorsals and have not been subject to fragmentation of their primal continent.

That simply means that the magmas of Mars, Venus and Mercury are "calm" in relation to Earth's magma.

Suppose, that around another star, there existed a planet with water in liquid state. It wouldn't take long before rain smoothed down the relief created by meteorite impacts. And as there would be no continental drift, and so the possible creation of new mountains, so this planet would be... as flat as a pancake.



Telescoping of two continental plates, creating a mountain chain.



If LIFE developed on a "smooth" planet, the absence of natural frontiers would oppose separate evolution.

There would be a lot fewer animal species and if a human branch developed, it would be just one race and have a common language .

On the scale of the solar system, continental drift is a rare phenomenon therefore, as it only affects Earth. If it was general, any extra-terrestrial who came would get a few surprises.

Well boss, it seems that they paint things in different colours according to the regions.

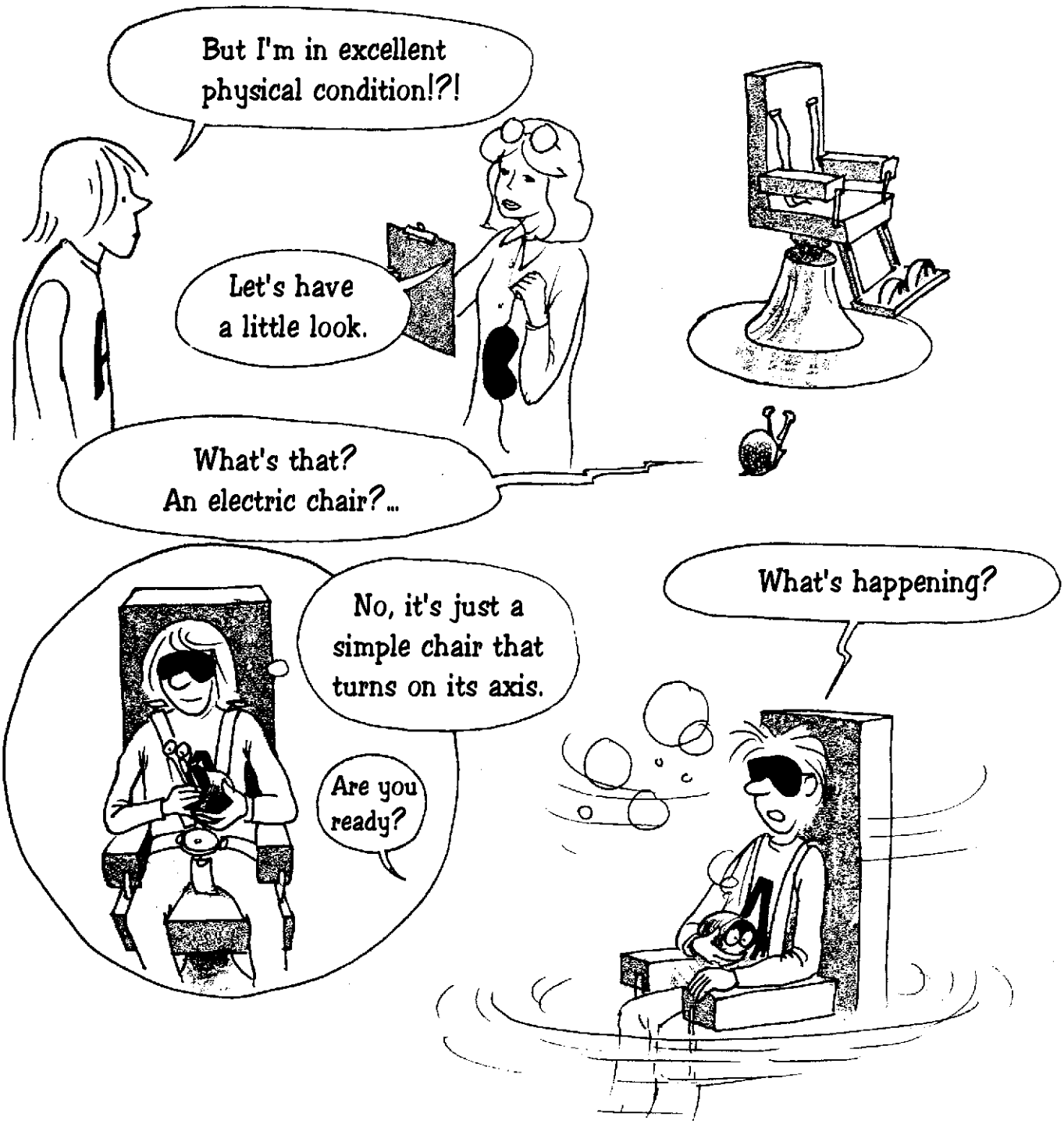
We can look forward to great scientific discoveries from space. How I would love to take part in the adventure!

I've got a HERMES mission on the 15th. Come along if you like.

Wonderful! I'm going to become a man in space, a SPACIAN.

Hang on, you'll have to undergo some serious training.

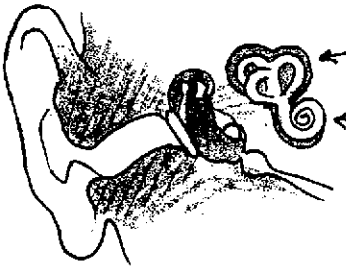
ASTRONAUT TRAINING (*)



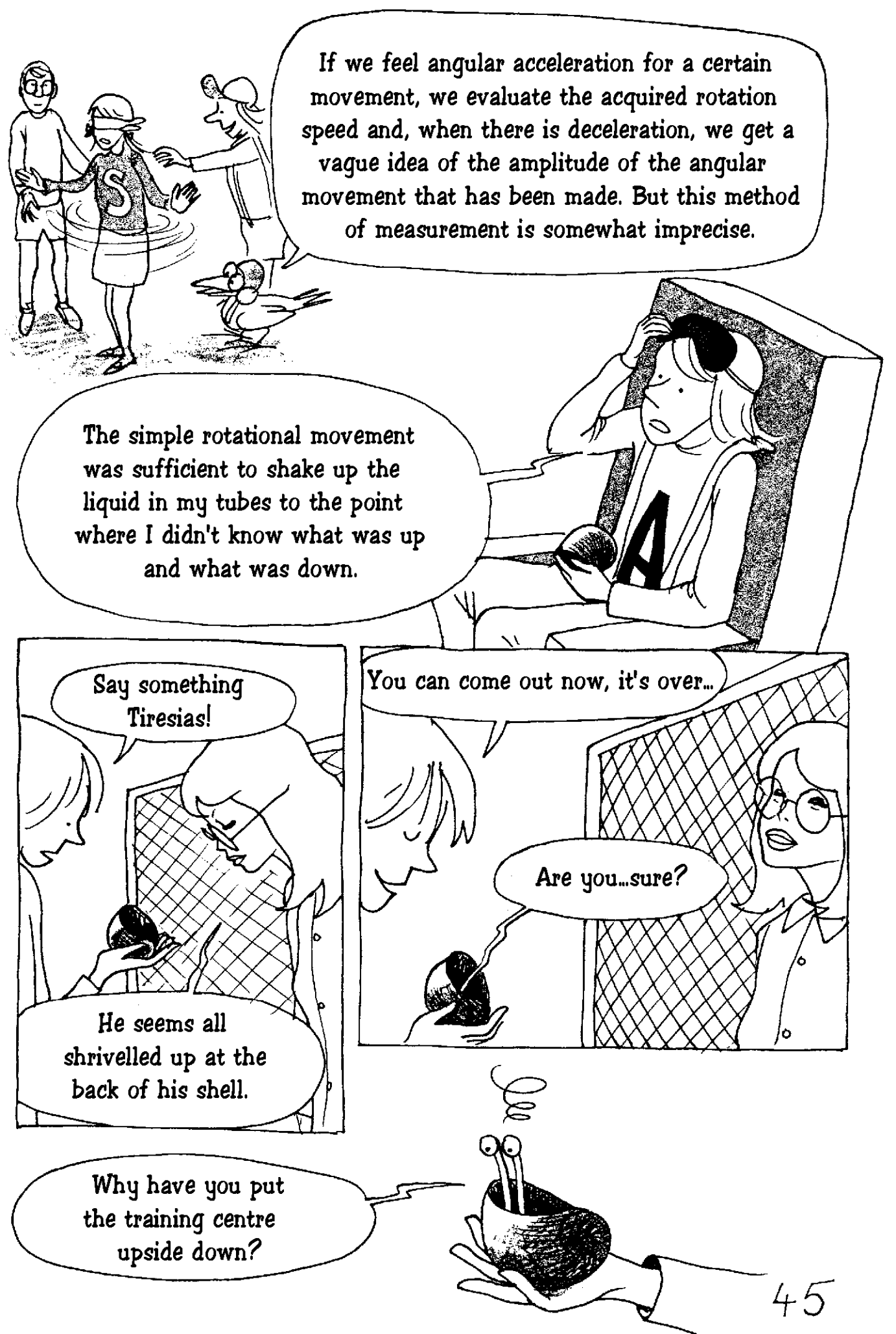
(*) A young "SPACIAN" can discover and use this equipment in the PATRICK BAUDRY SPACE CAMP, in Cannes, France.

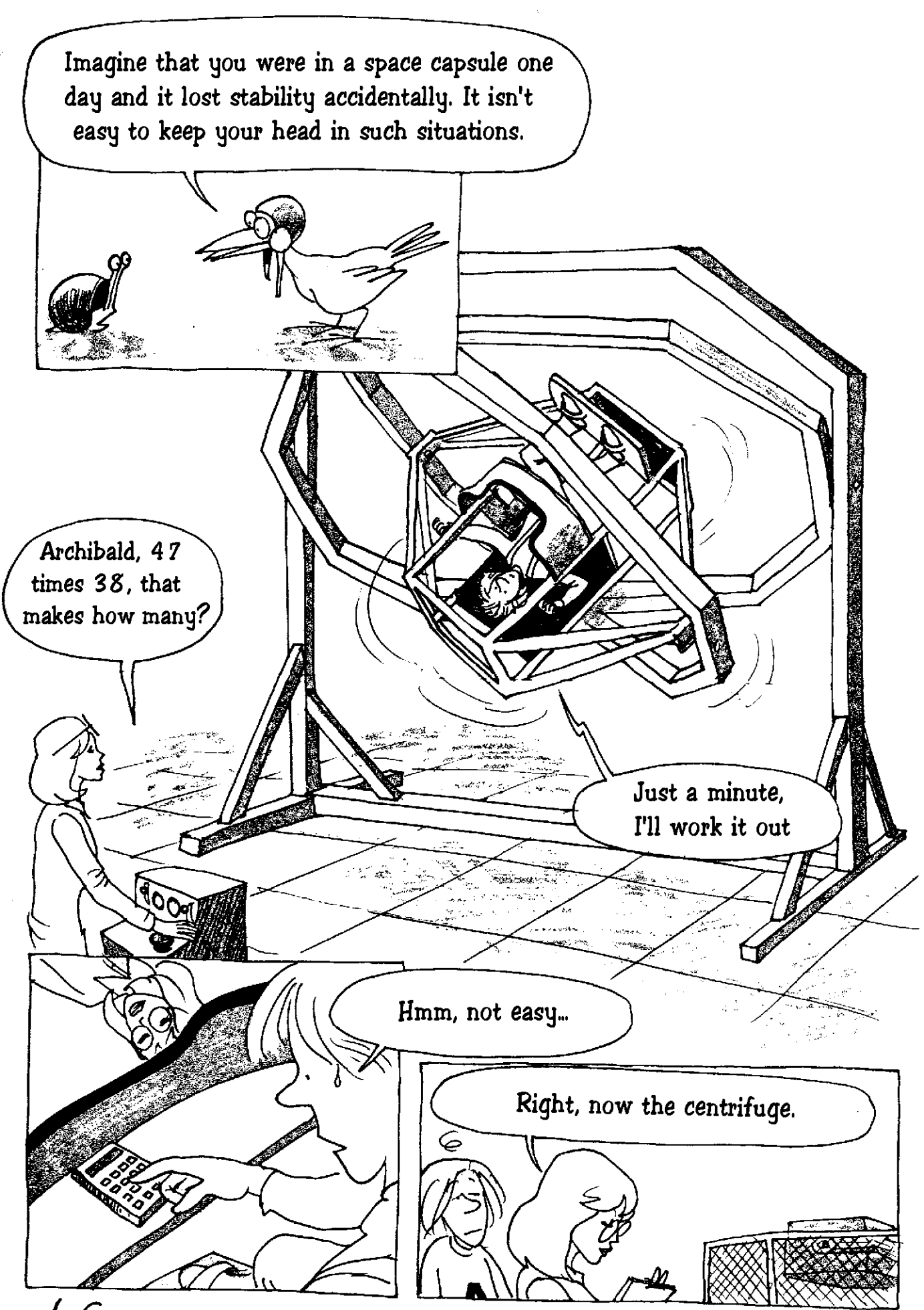
Sophie, what have you done to this chair!?! I feel like I'm on a fairground

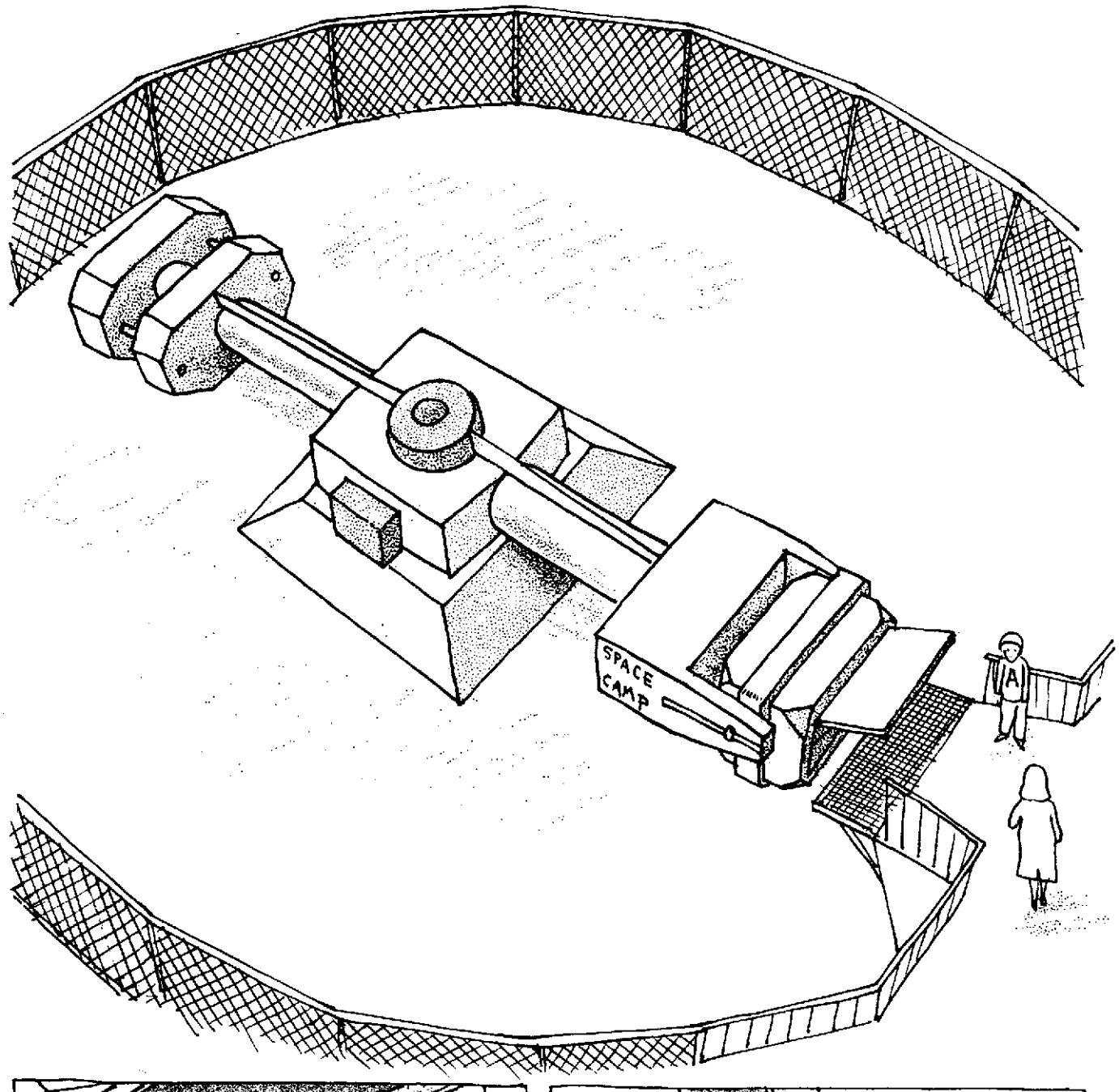
When you have you eyes closed, you use your VESTIBULARY SYSTEM, your INNER EAR, to work out your position in space.

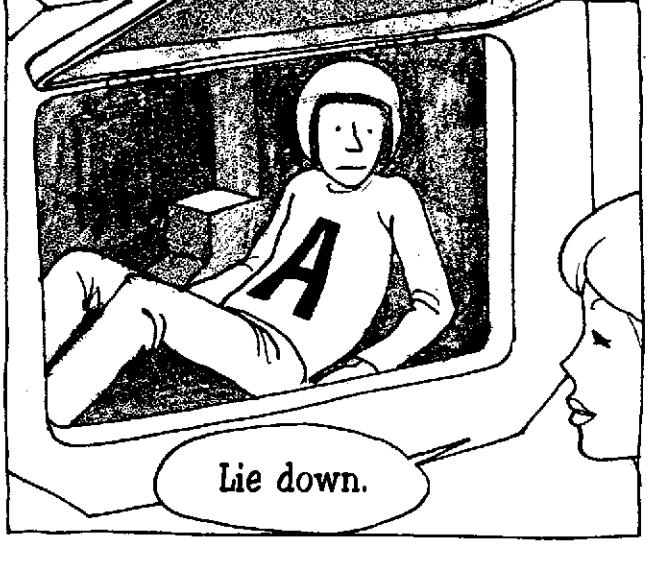


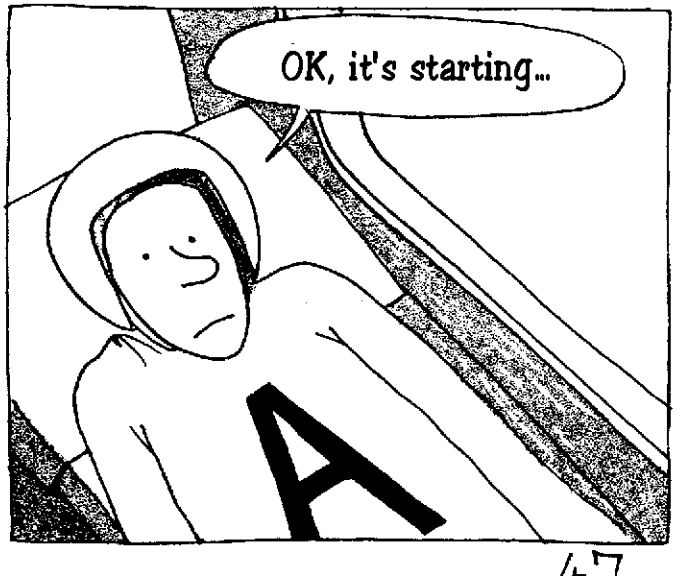
Imagine an inertial system made up of three tubes filled with liquid and set in three perpendicular planes, the inside of the tubes is covered with hairs that act as sensors. When the system is turned on itself the liquid moves and the flow bends the hairs and allows the detection of any ANGULAR ACCELERATION.

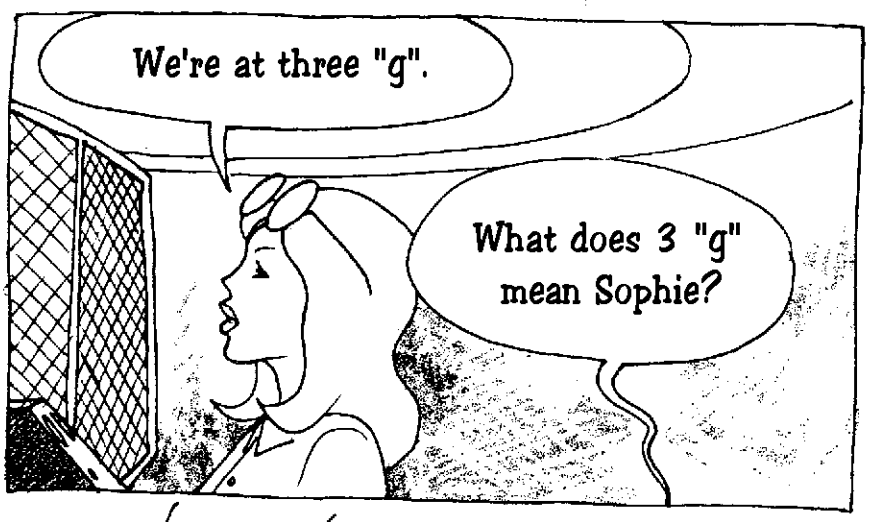

If we feel angular acceleration for a certain movement, we evaluate the acquired rotation speed and, when there is deceleration, we get a vague idea of the amplitude of the angular movement that has been made. But this method of measurement is somewhat imprecise.
The simple rotational movement was sufficient to shake up the liquid in my tubes to the point where I didn't know what was up and what was down.
Say something Tiresias!
He seems all shrivelled up at the back of his shell.
You can come out now, it's over...
Are you...sure?
Why have you put the training centre upside down?


Imagine that you were in a space capsule one day and it lost stability accidentally. It isn't easy to keep your head in such situations.
Archibald, 47 times 38, that makes how many?
Just a minute, I'll work it out
Hmm, not easy...
Right, now the centrifuge.

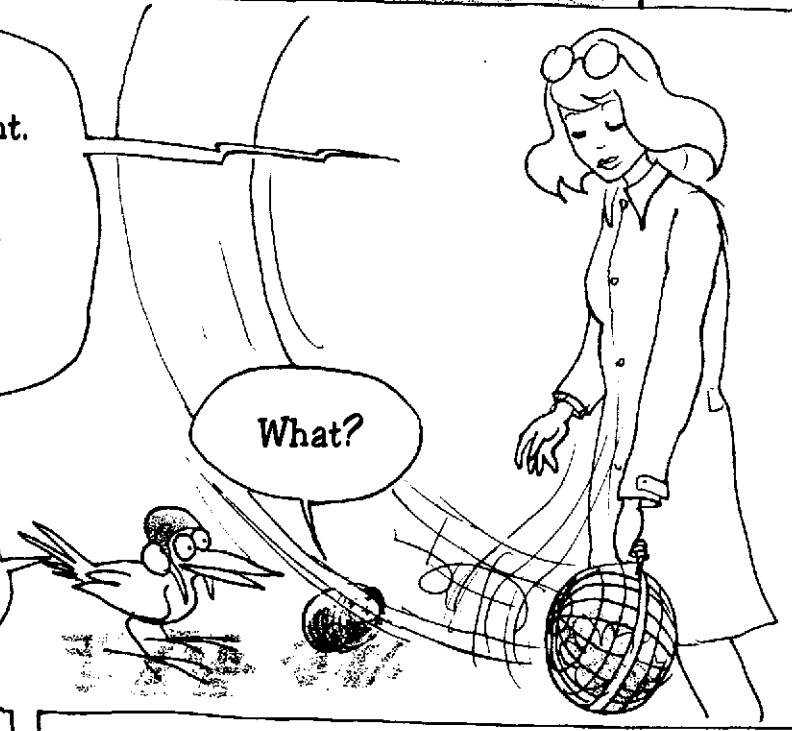

SPACE
CAMP
A


A
Lie down.


OK, it's starting...
A

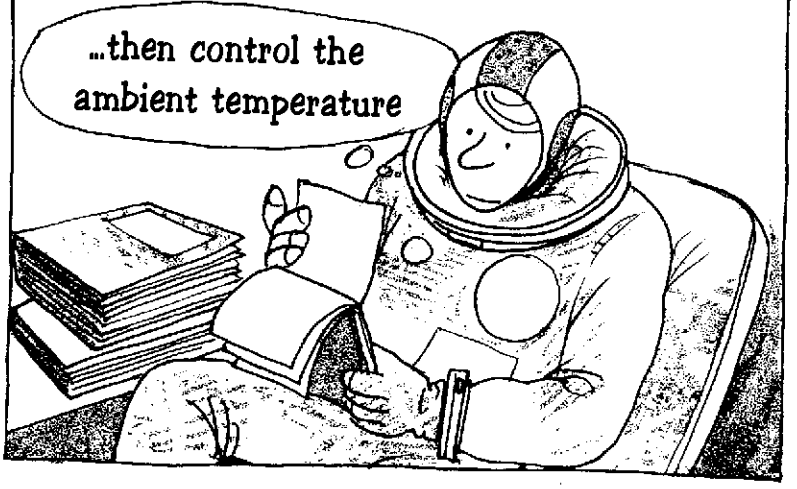


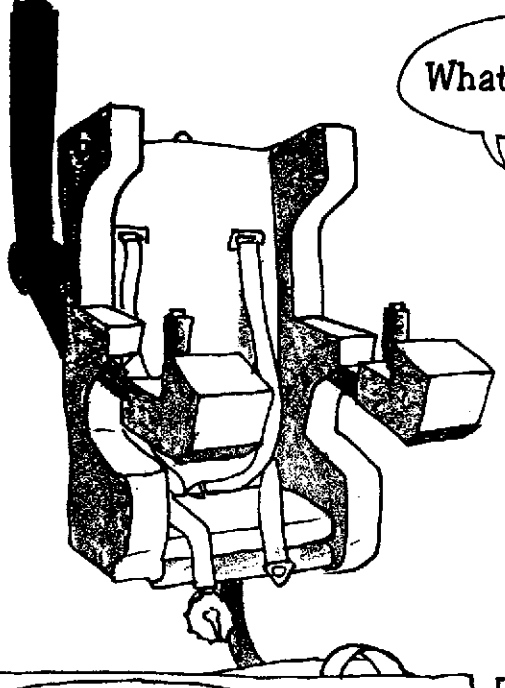
At the moment Archibald weighs three times his weight. If you like, three "g" is the acceleration of lettuce when it is swung round my head in a salad dryer.



Can you imagine yourself in a 3 g salad dryer Tiresias?

During the following weeks Archibald learnt about all the stages of the mission and its procedures and security measures.



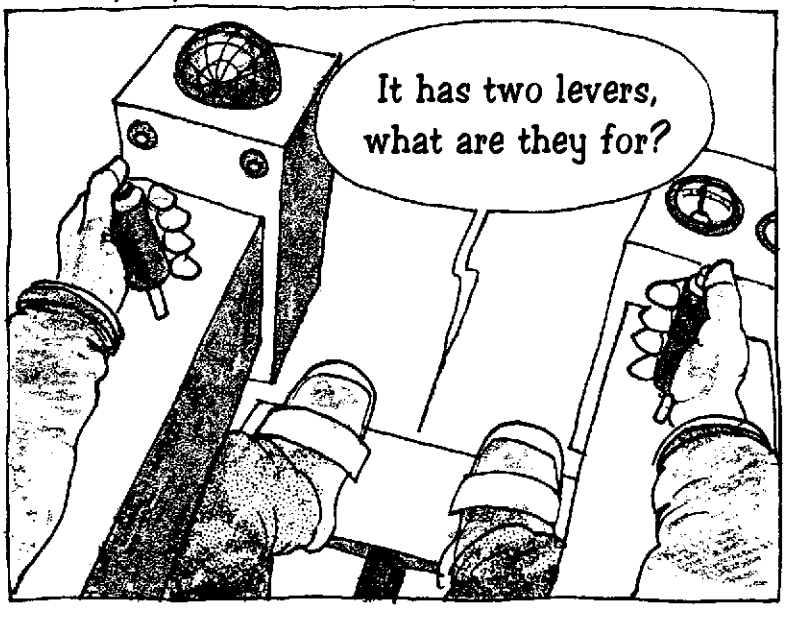


What's that thing there?

It's a 1/1 scale model of the SPACE SCOOTER that you will be using during the mission.

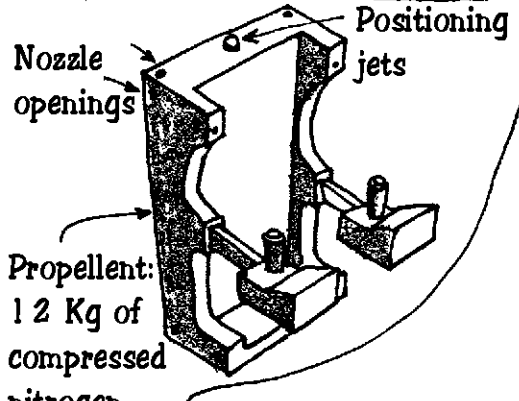
Are we taking it in the shuttle?

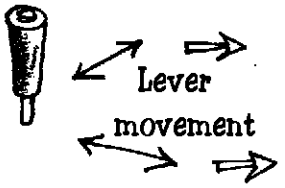
Non, it's already up there, we just have to restock it with propellant



It has two levers, what are they for?

Scooter Controls





Rolling movement

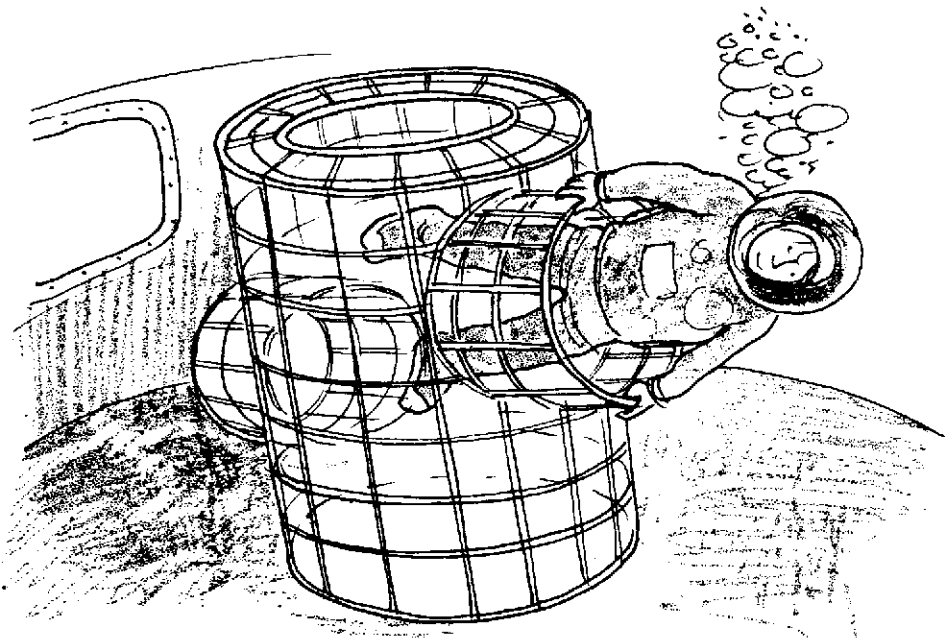
Turning movement

Vertical translation movement

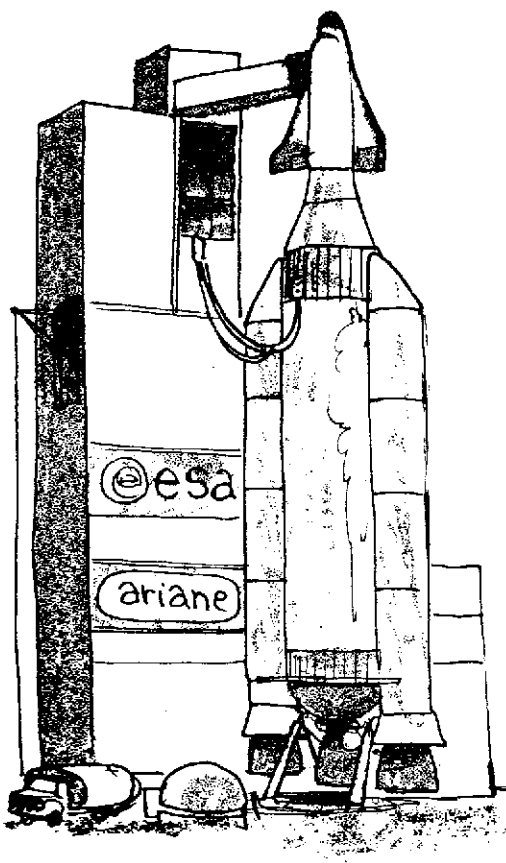
Forward-backward translations
Right-left translations

(*) pressurised nitrogen.

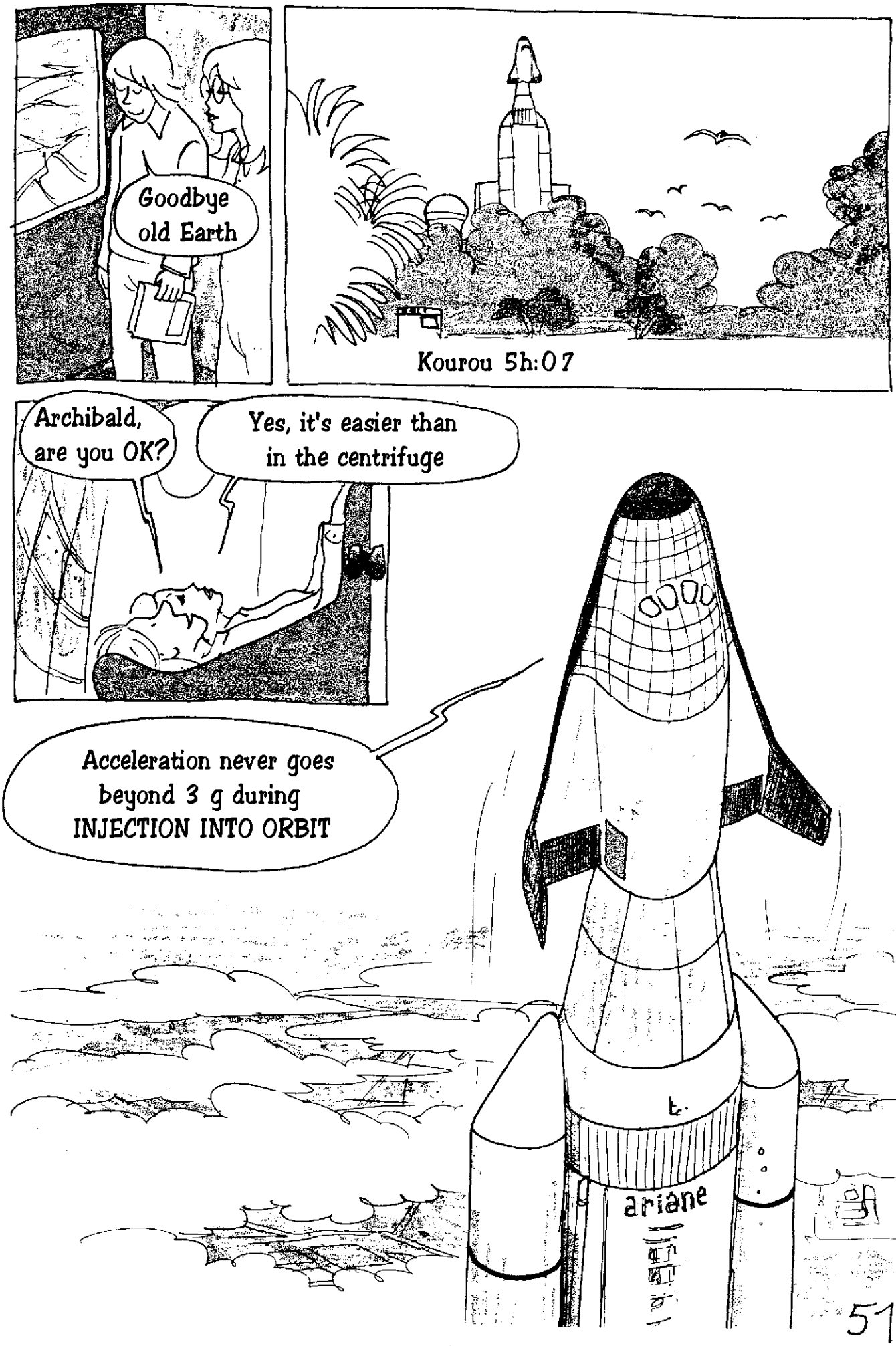
Archibald completed his training by spending hours in the WEIGHTLESSNESS simulation pool, practising the movements he would make during his mission in space.



HERMES



This is the Hermes shuttle attached to an Ariane 5 rocket. It is about 50 metres high in all. The launcher consists of two solid fuel BOOSTERS, each developing 600 tons of thrust, they are set on either side of a propulsor using liquid hydrogen and oxygen and possessing a movable nozzle which is used to pilot the system. It develops 110 tons of thrust, making 1370 tons in all. Together, the laucher and the shuttle weigh 750 tons.

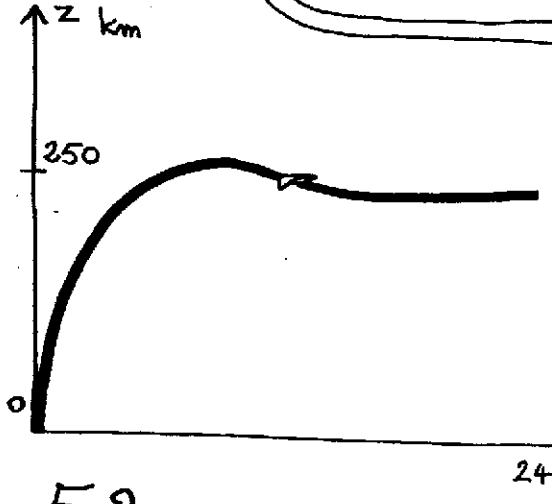


The Ariane setup - Hermes breaks the sound barrier after 50 seconds.

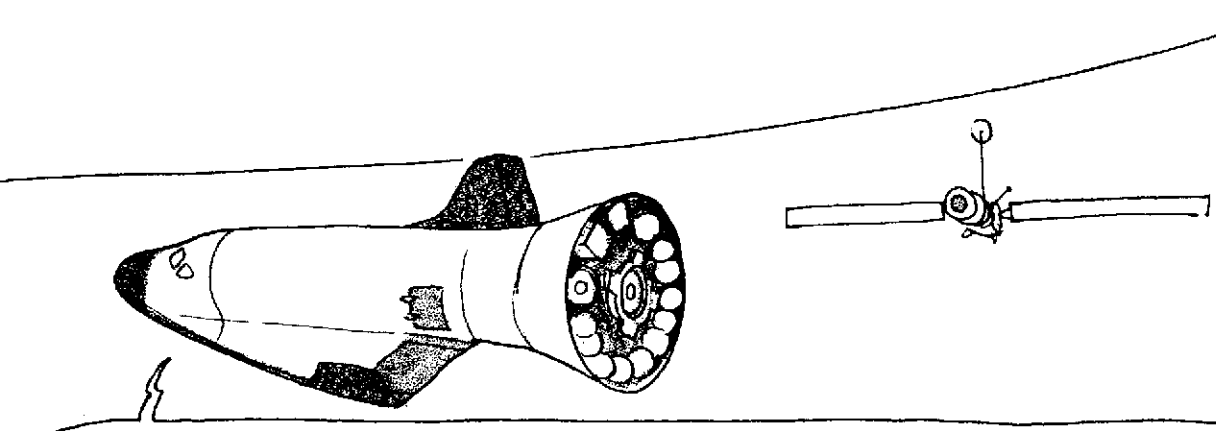
120 seconds.

Altitude 40 Km. We jettison the two boosters that helped us get out of the dense part of the atmosphere.

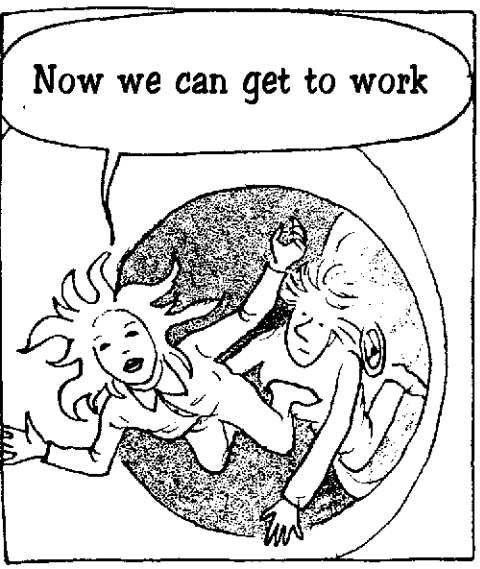
Seconds. We're almost horizontal now. I even have the impression we're going back down. Is that normal?

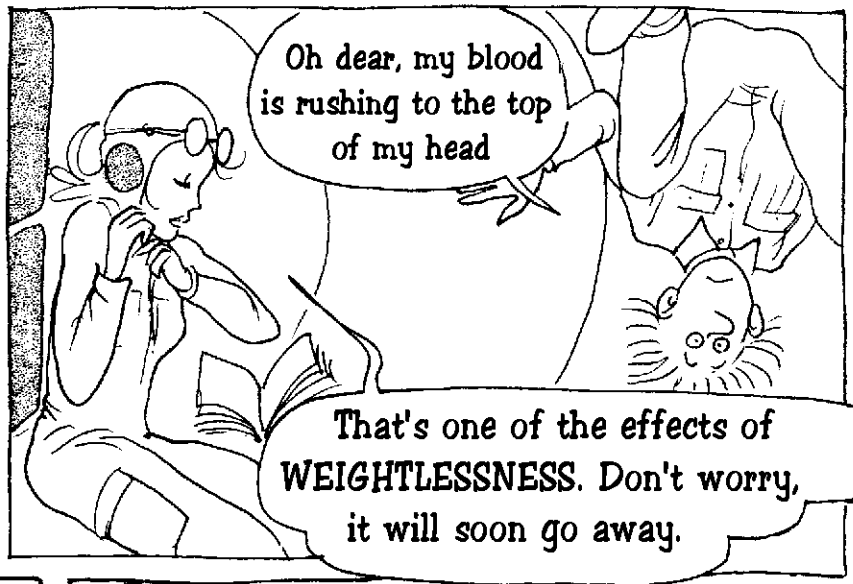


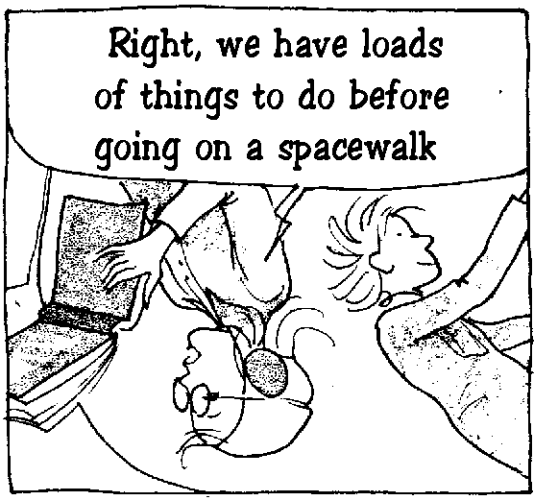
Yes it's normal. In a few seconds the launcher will be detached and the Hermes shuttle's propulsion will take the speed up to 7.8 Km/s which will allow our weight to be counterbalanced by centrifugal force.

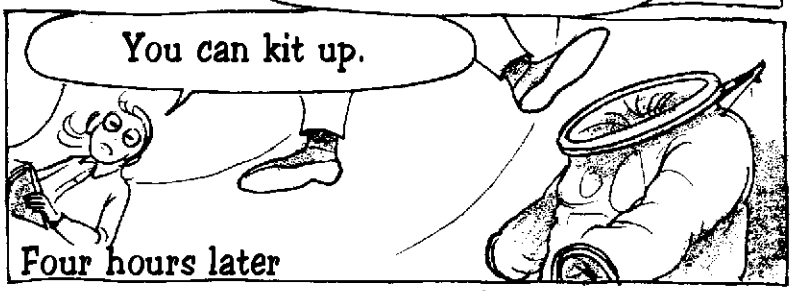


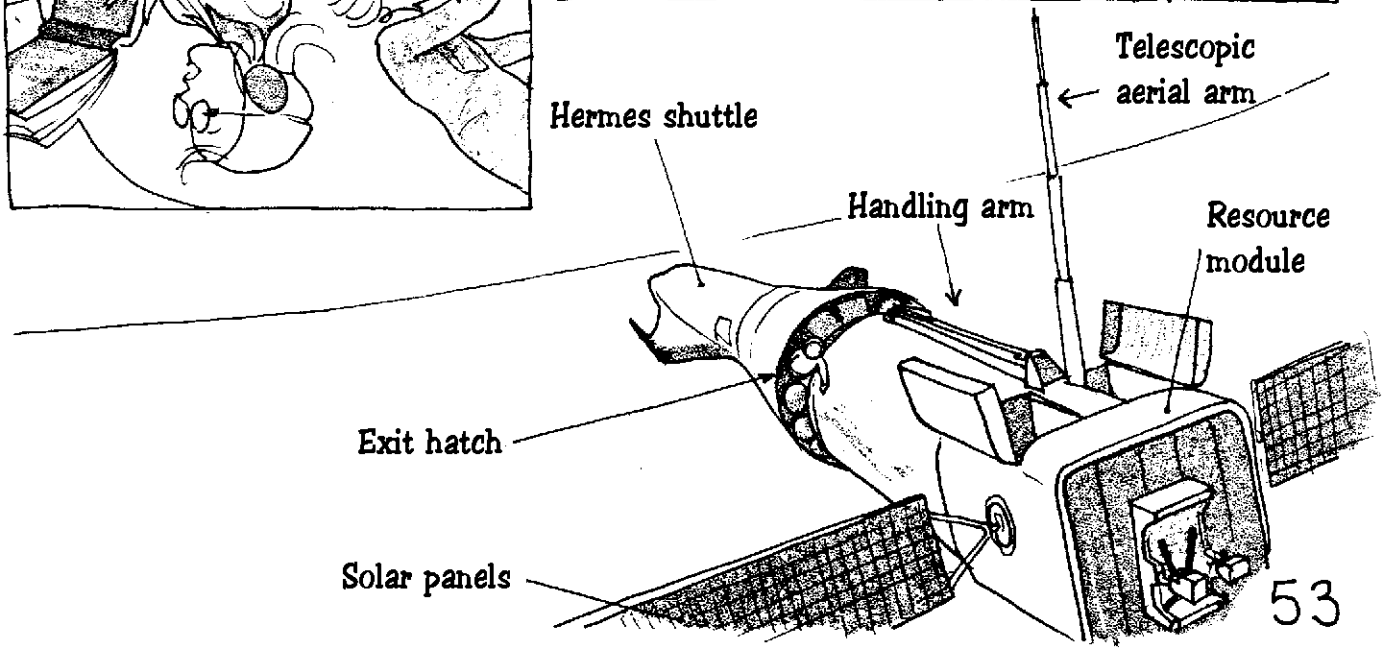
Now we're linking up with the orbital laboratory at an altitude of 250 Km

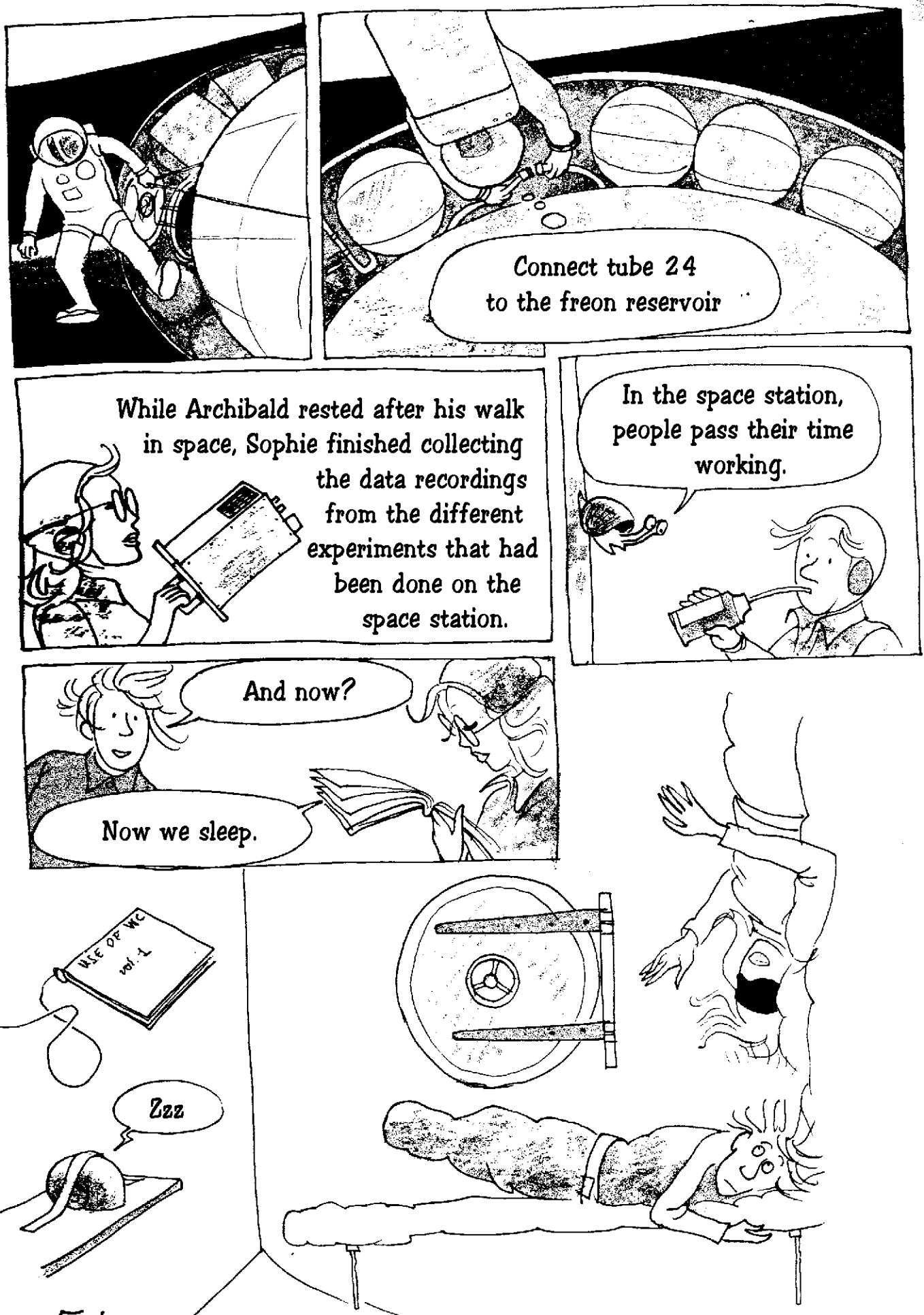


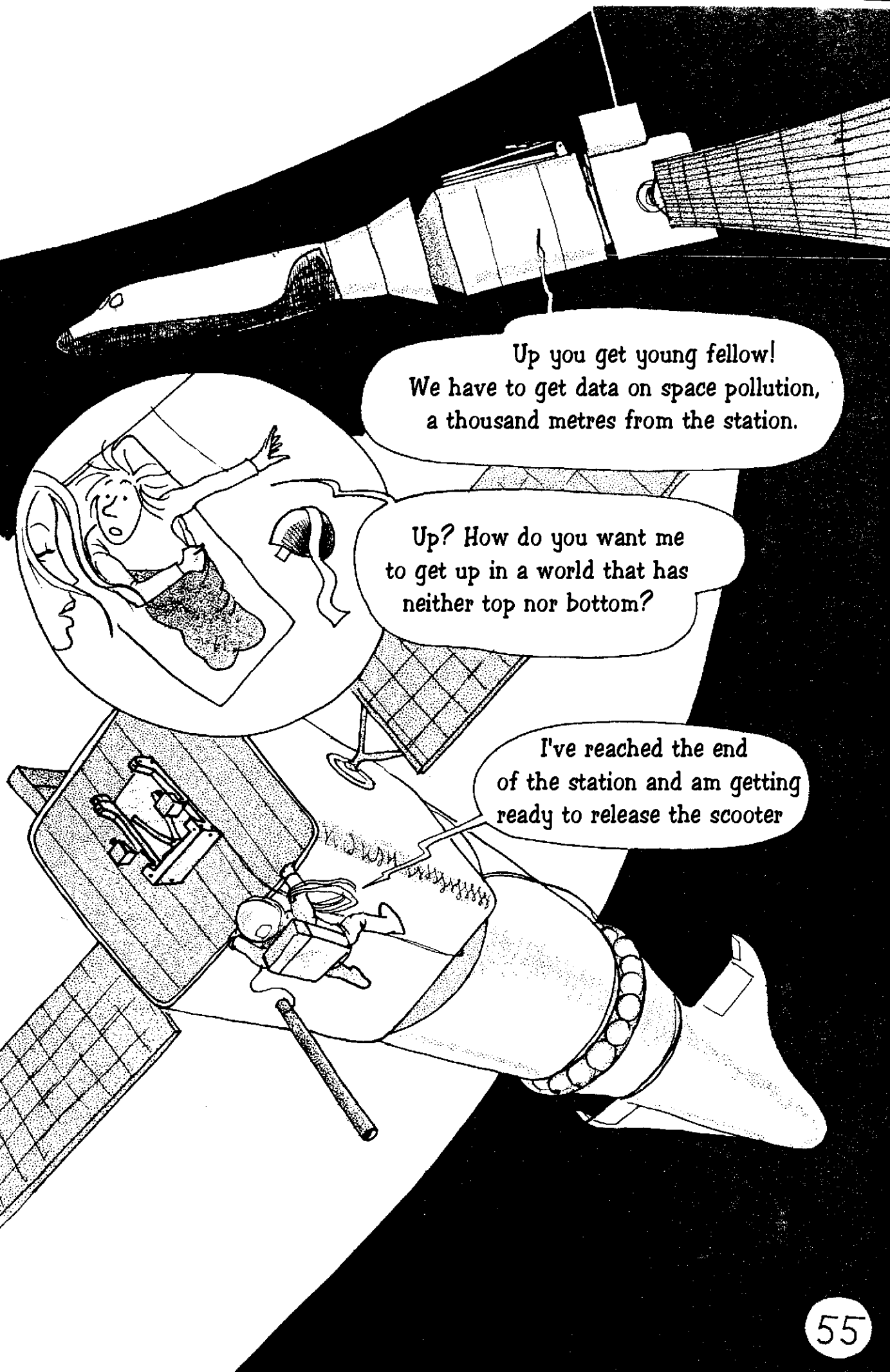


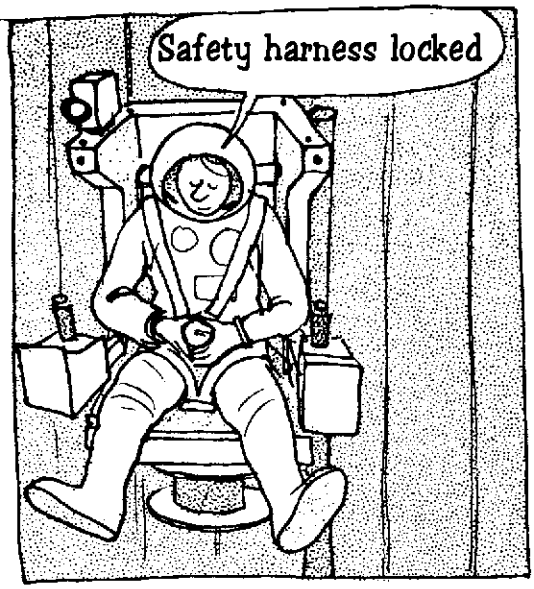


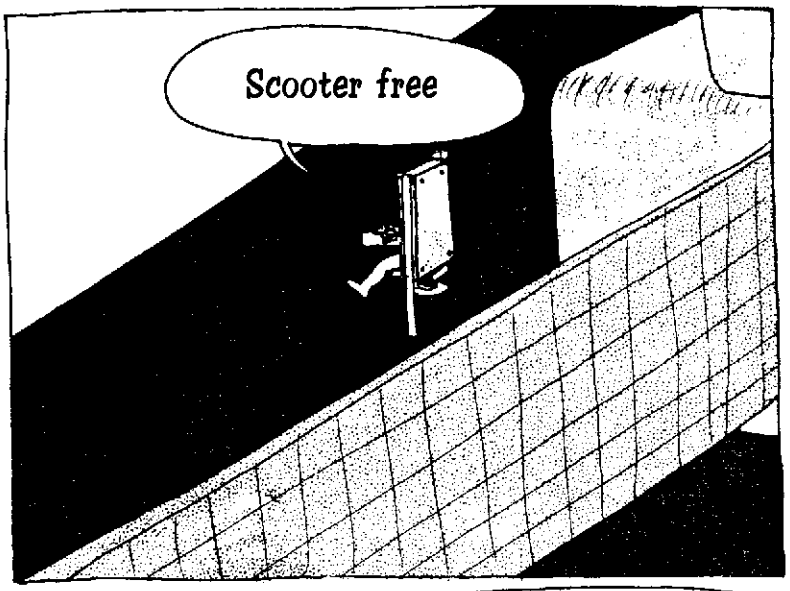


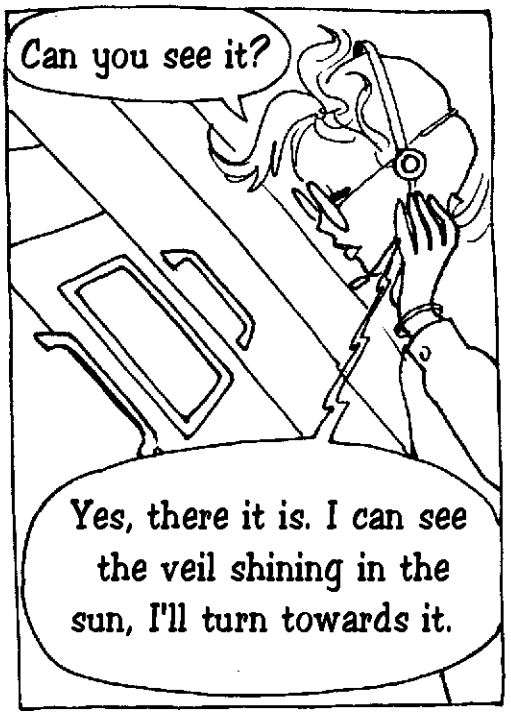


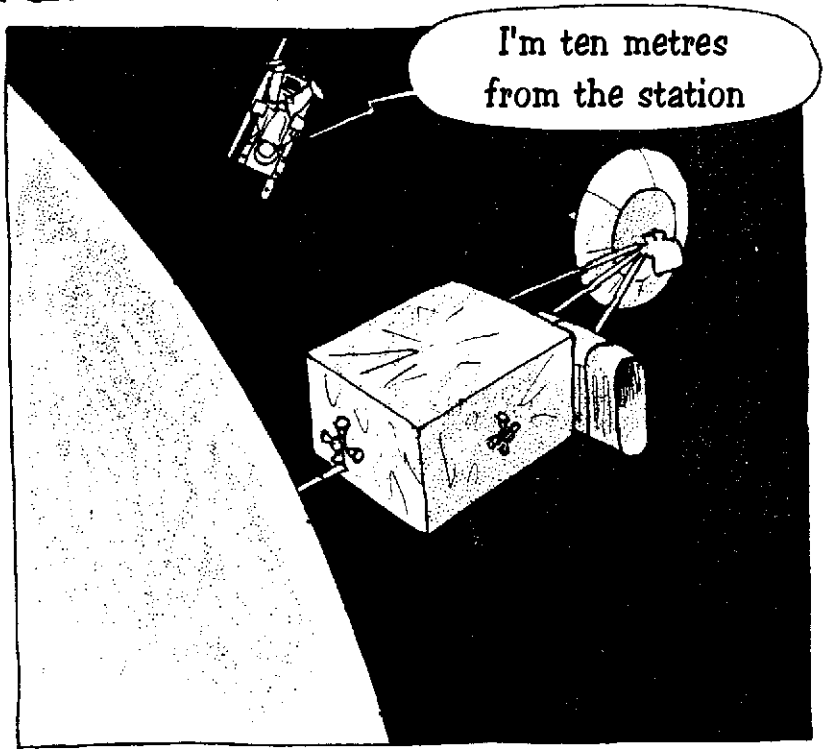

Connect tube 24
to the freon reservoir
While Archibald rested after his walk in space, Sophie finished collecting the data recordings from the different experiments that had been done on the space station.
In the space station, people pass their time working.
And now?
Now we sleep.
WEE OP WC
vol. 1
Zzz

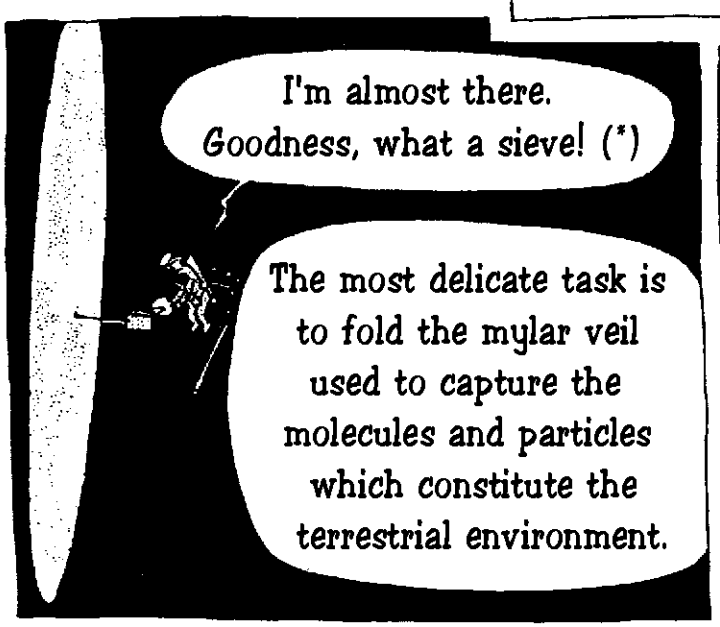

Up you get young fellow!
We have to get data on space pollution, a thousand metres from the station.
Up? How do you want me to get up in a world that has neither top nor bottom?
I've reached the end of the station and am getting ready to release the scooter

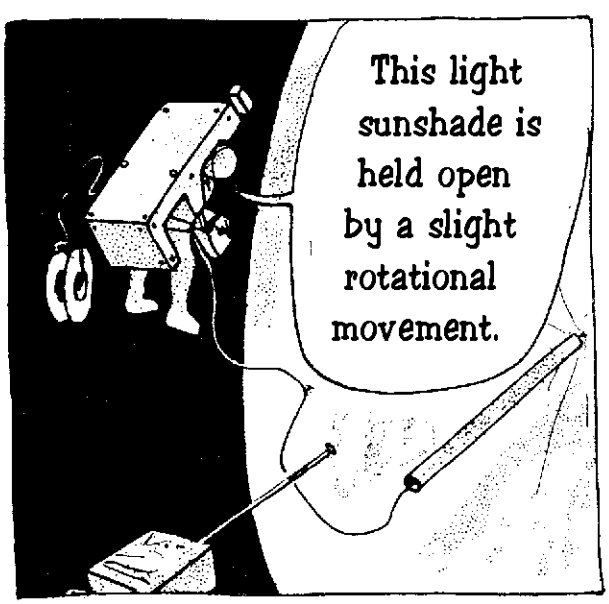




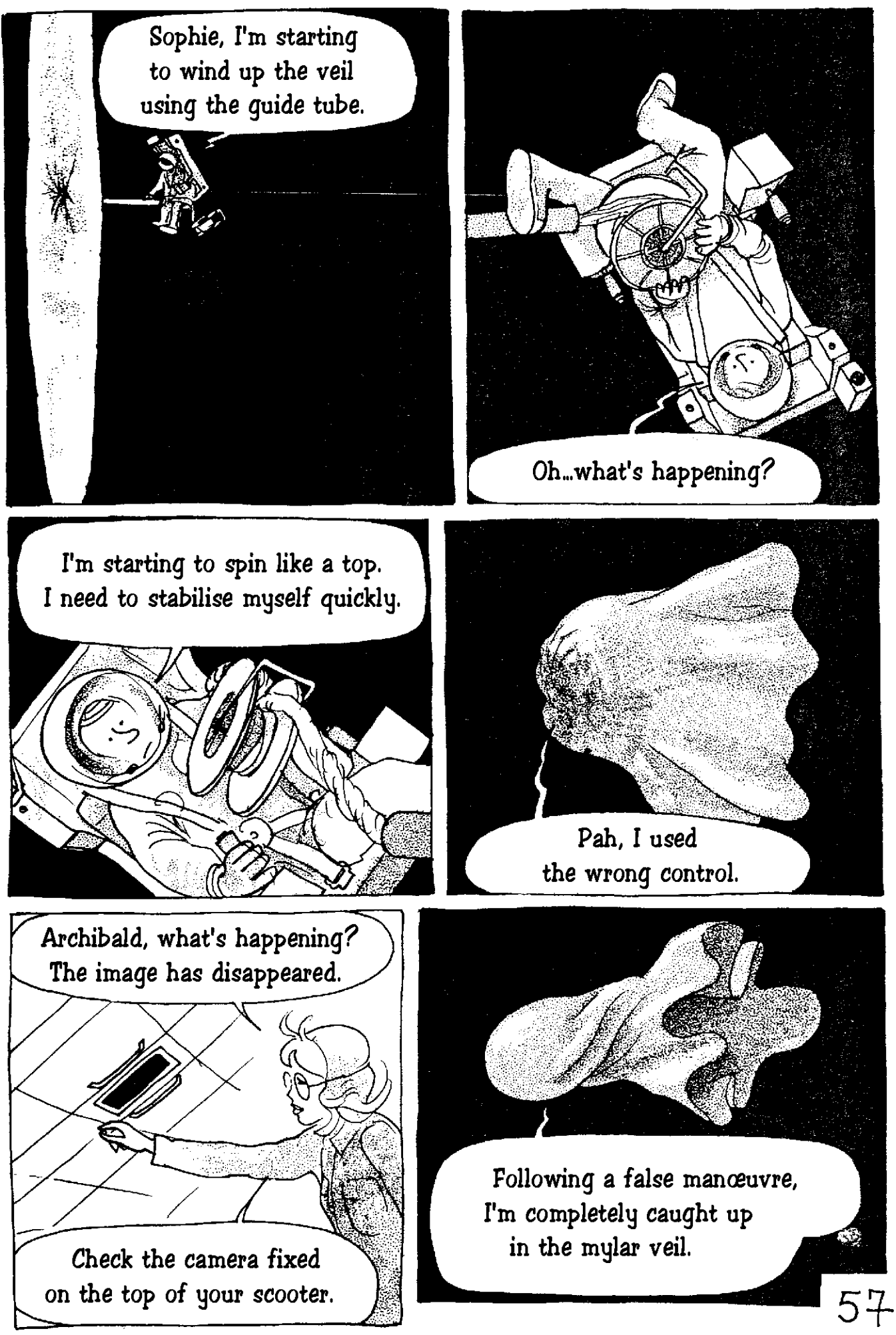








(*) An effect of micrometeorites and lost objects


Sophie, I'm starting to wind up the veil using the guide tube.
Oh...what's happening?
I'm starting to spin like a top. I need to stabilise myself quickly.
Pah, I used the wrong control.
Archibald, what's happening? The image has disappeared.
Check the camera fixed on the top of your scooter.
Following a false manœuvre, I'm completely caught up in the mylar veil.

I'm turning on myself like a spinning top. As well as that I can't get free of this mylar which is sticking to me like a squid.

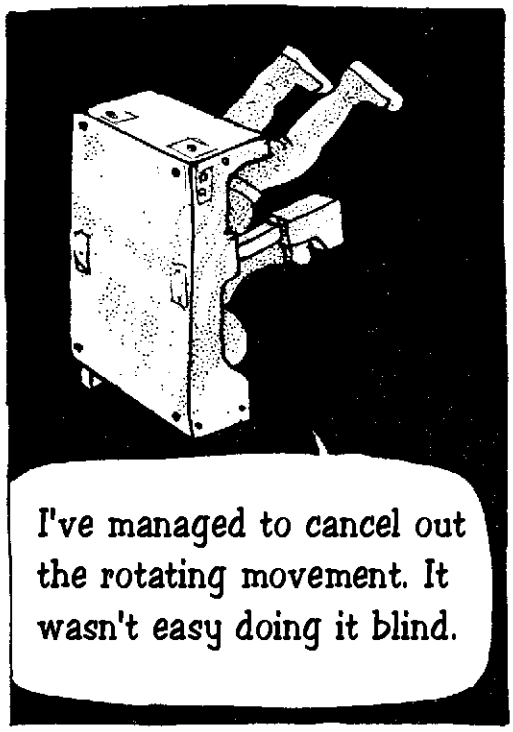
It must be some electrostatic phenomenon.

But why is he going round and round like a top?

While trying to haul in the veil, he picked up the leads' CINETIC ENERGY, like an ice-skater who draws their arms towards their body

Archibald, try and calm down. I can hear you puffing like a horse, you'll use up all your oxygen

OK. I think I've got out of that terrible trap but my visor is covered in condensation. I can barely see anything at all



I've managed to cancel out the rotating movement. It wasn't easy doing it blind.

He's using up all his reserves. If he continues like that he'll never get back to the station.

When the mylar sheet stuck against your spacesuit it must have perturbed the air conditioning system. Calm down, it'll sort itself out.

Sophie, bring me back to the station, I can't see anything.

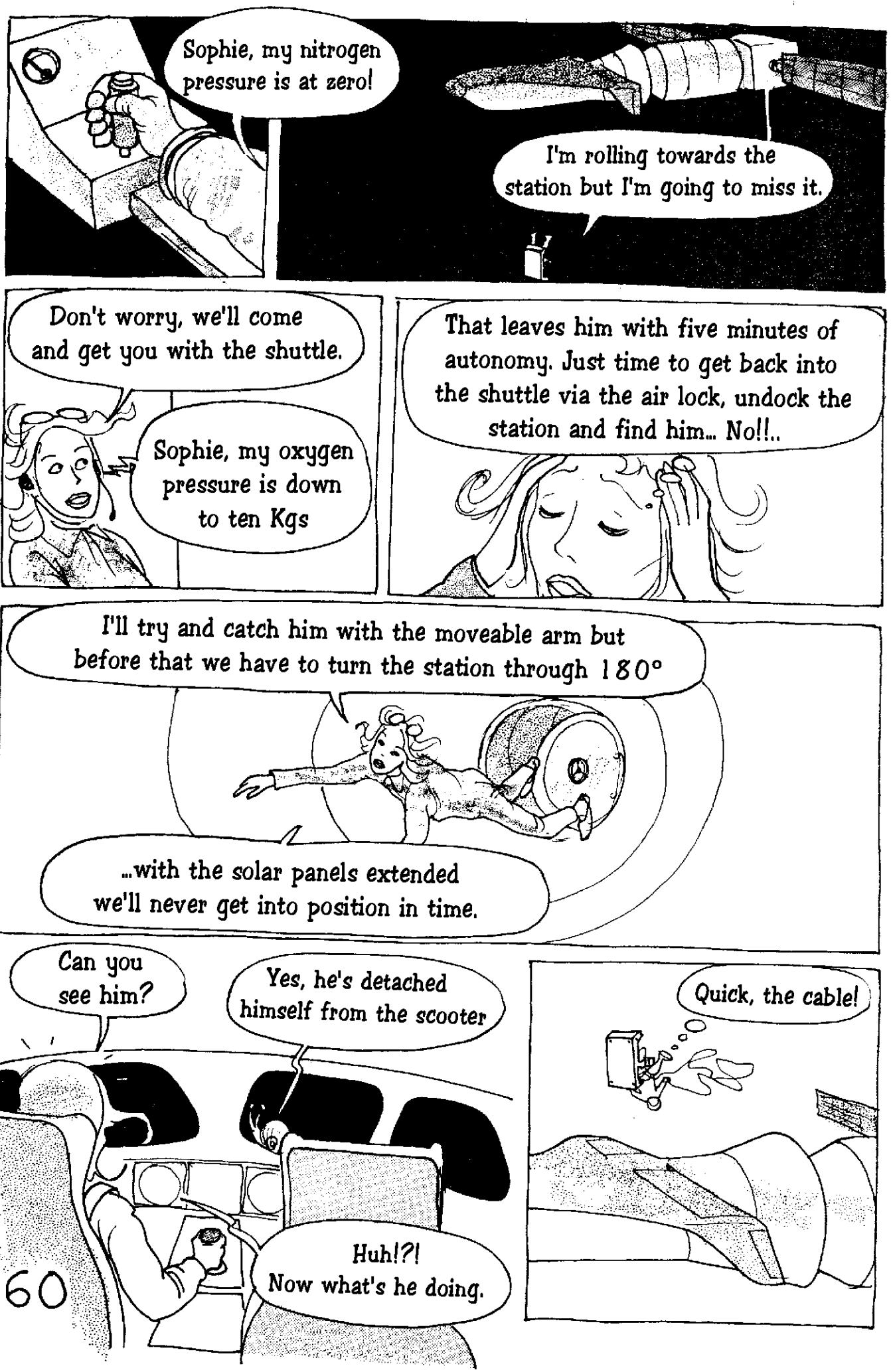
I can see for you. I've got the video from your scooter and I'm following the on-board radar.

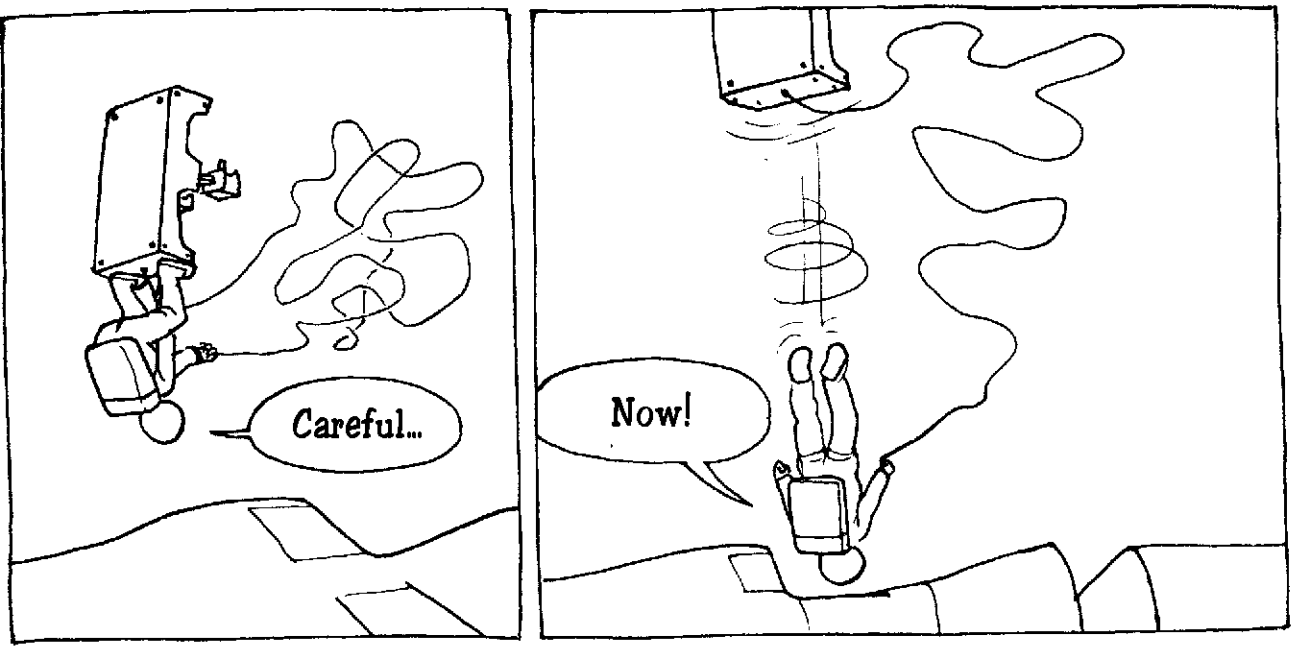
I can't see the shuttle.

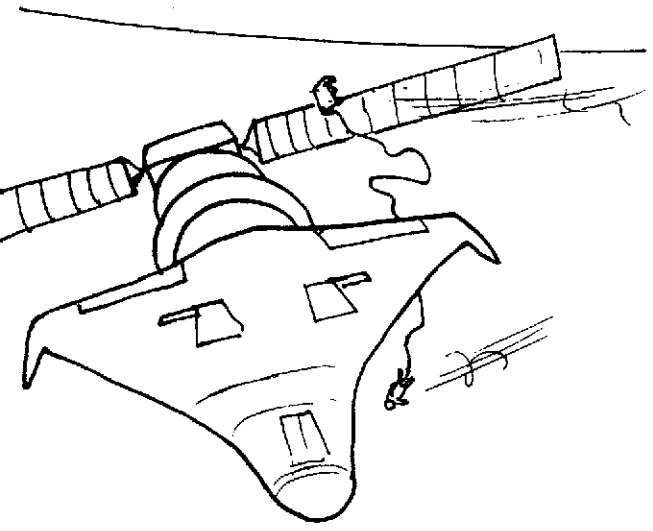
I can see it, carry on like that.

You are almost in the right axis, correct it slightly...

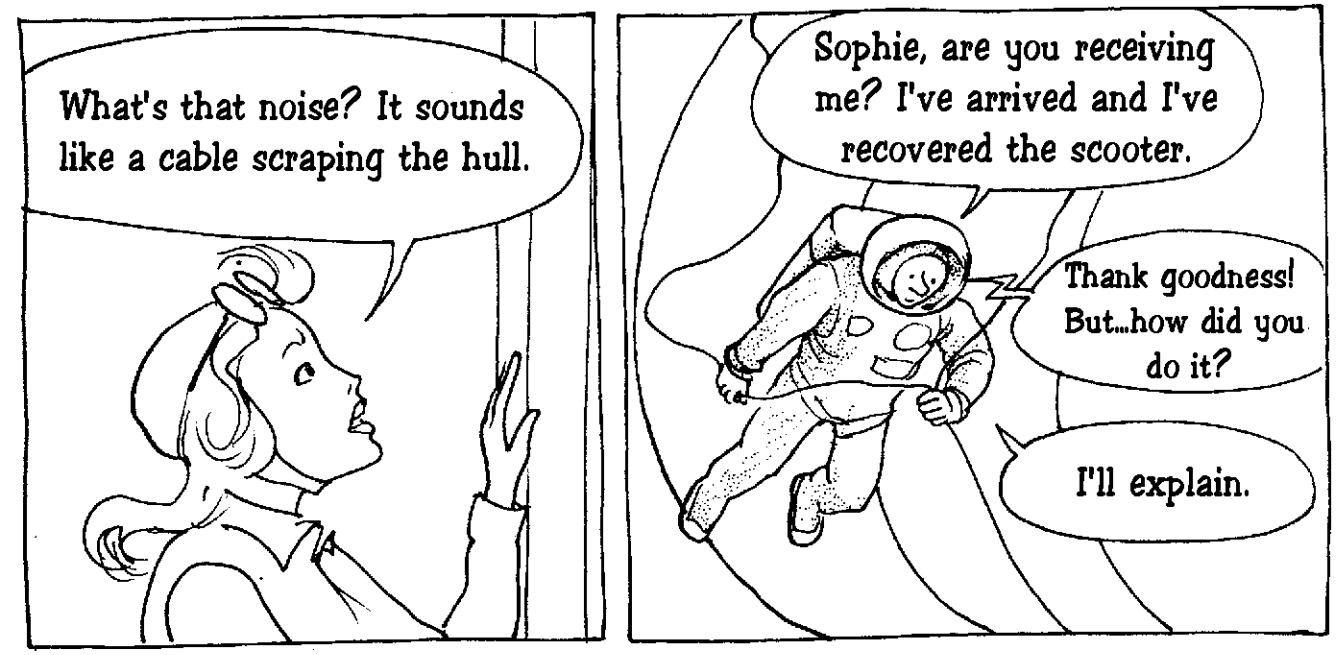
The condensation is disappearing. I'm beginning to make out the station.

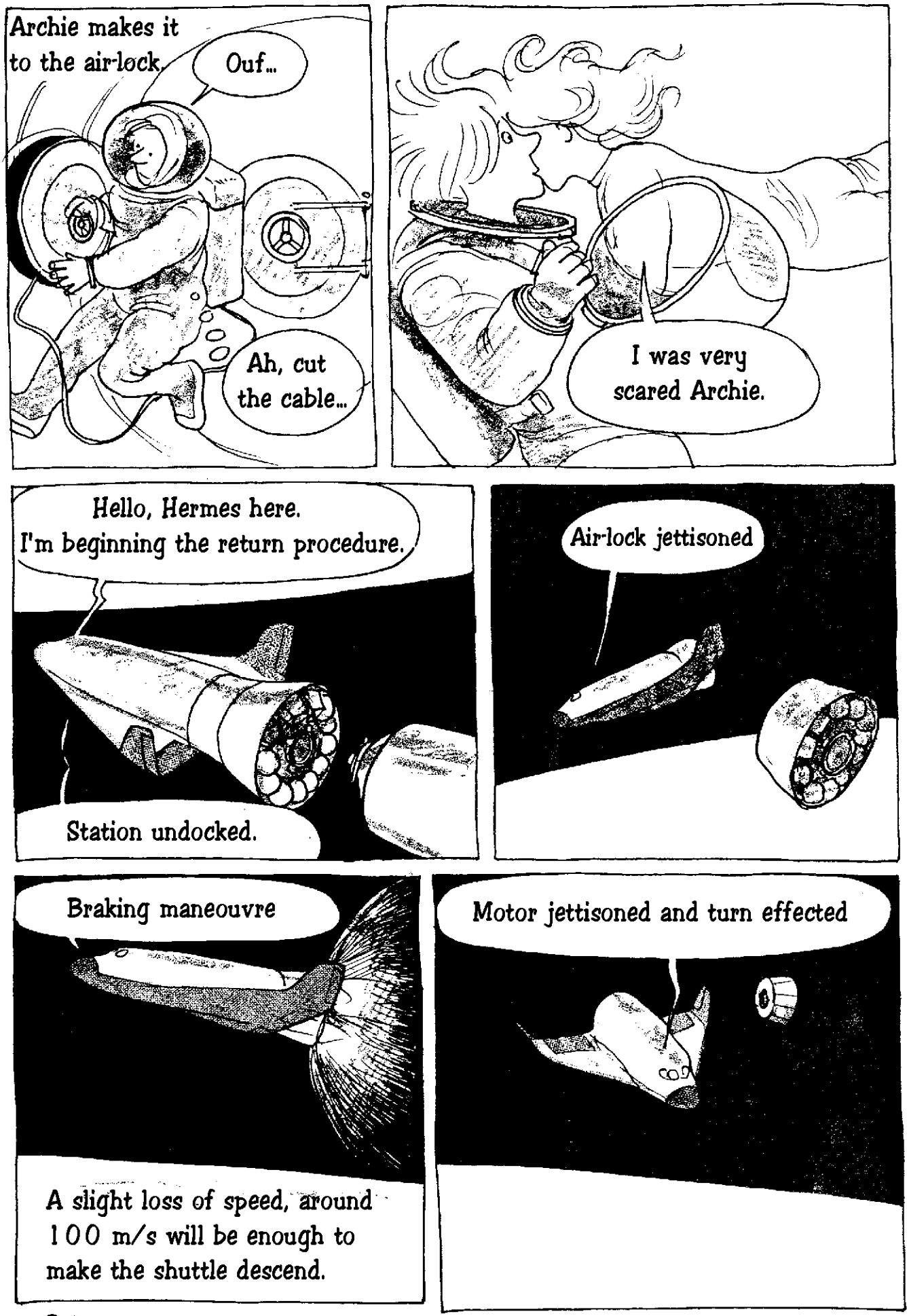

Sophie, my nitrogen pressure is at zero!
I'm rolling towards the station but I'm going to miss it.
Don't worry, we'll come and get you with the shuttle.
Sophie, my oxygen pressure is down to ten Kgs
That leaves him with five minutes of autonomy. Just time to get back into the shuttle via the air lock, undock the station and find him... No!!..
I'll try and catch him with the moveable arm but before that we have to turn the station through 180°
...with the solar panels extended we'll never get into position in time.
Can you see him?
Yes, he's detached himself from the scooter
Huh!?! Now what's he doing.
Quick, the cable!

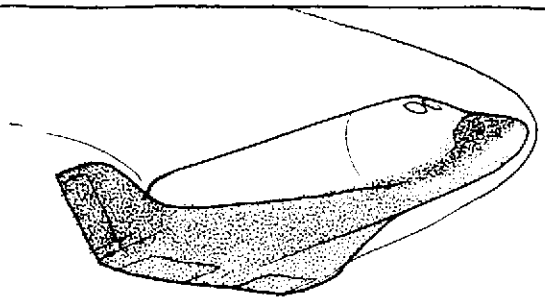




Archibald, by using the ACTION-REACTION principle, pushes against the scooter and so sends it to the side of the station and at the same time pushes himself in the opposite direction.

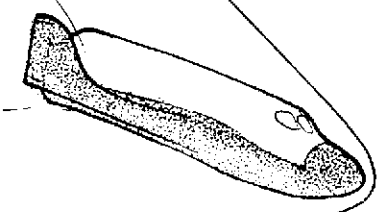


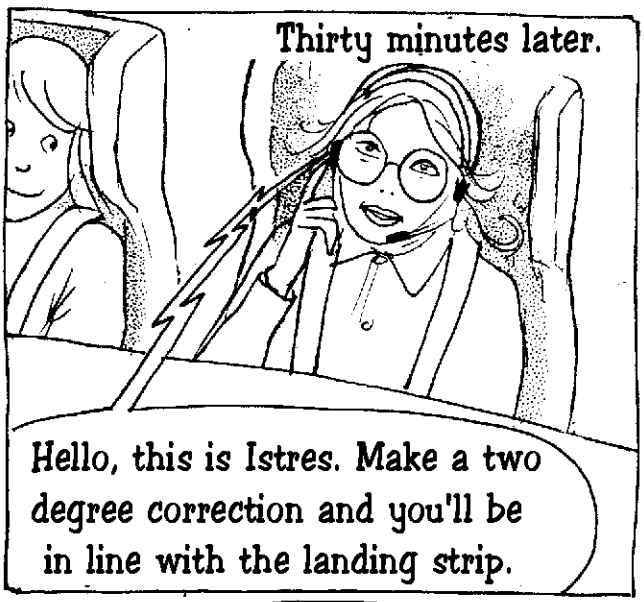

Archie makes it to the air-lock
Ouf...
Ah, cut the cable...
I was very scared Archie.
Hello, Hermes here. I'm beginning the return procedure.
Station undocked.
Air-lock jettisoned
Braking maneouvre
A slight loss of speed, around 100 m/s will be enough to make the shuttle descend.
Motor jettisoned and turn effected



Hermes hits the earth's upper atmosphere at an altitude of 80 Km and a speed of 2770 Km/h. It's at that moment that the heat effects are at their strongest.

Then, once the speed has been sufficiently reduced, at around 30 Km altitude, the shuttle drops towards the ground at Mach 3.

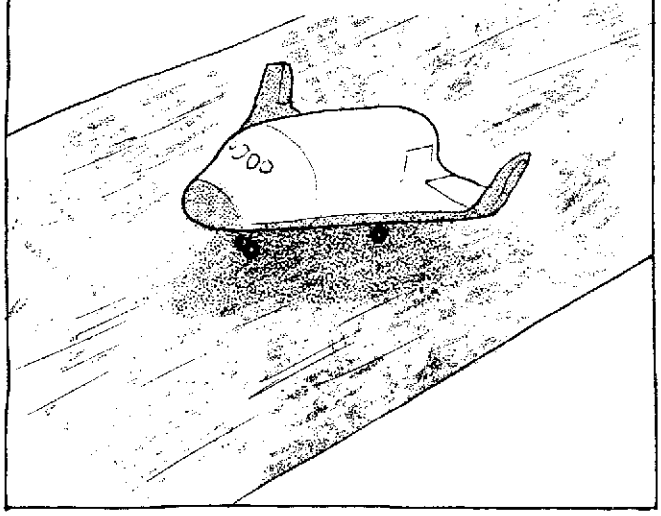




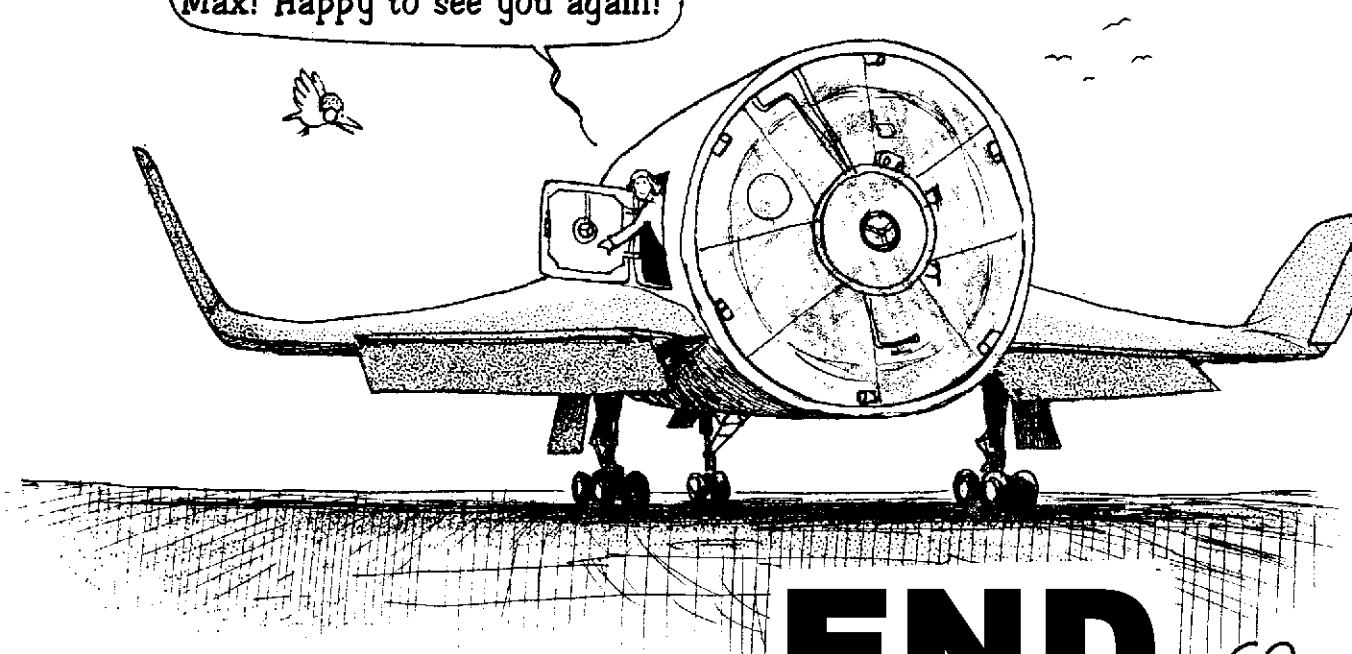
Thirty minutes later.

Hello, this is Istres. Make a two degree correction and you'll be in line with the landing strip.

Landing at 350 Km/h



Max! Happy to see you again!



END