Cornelsen Experimenta

Electric Circuits

Christian Hoenecke

With work-sheets

Cornelsen

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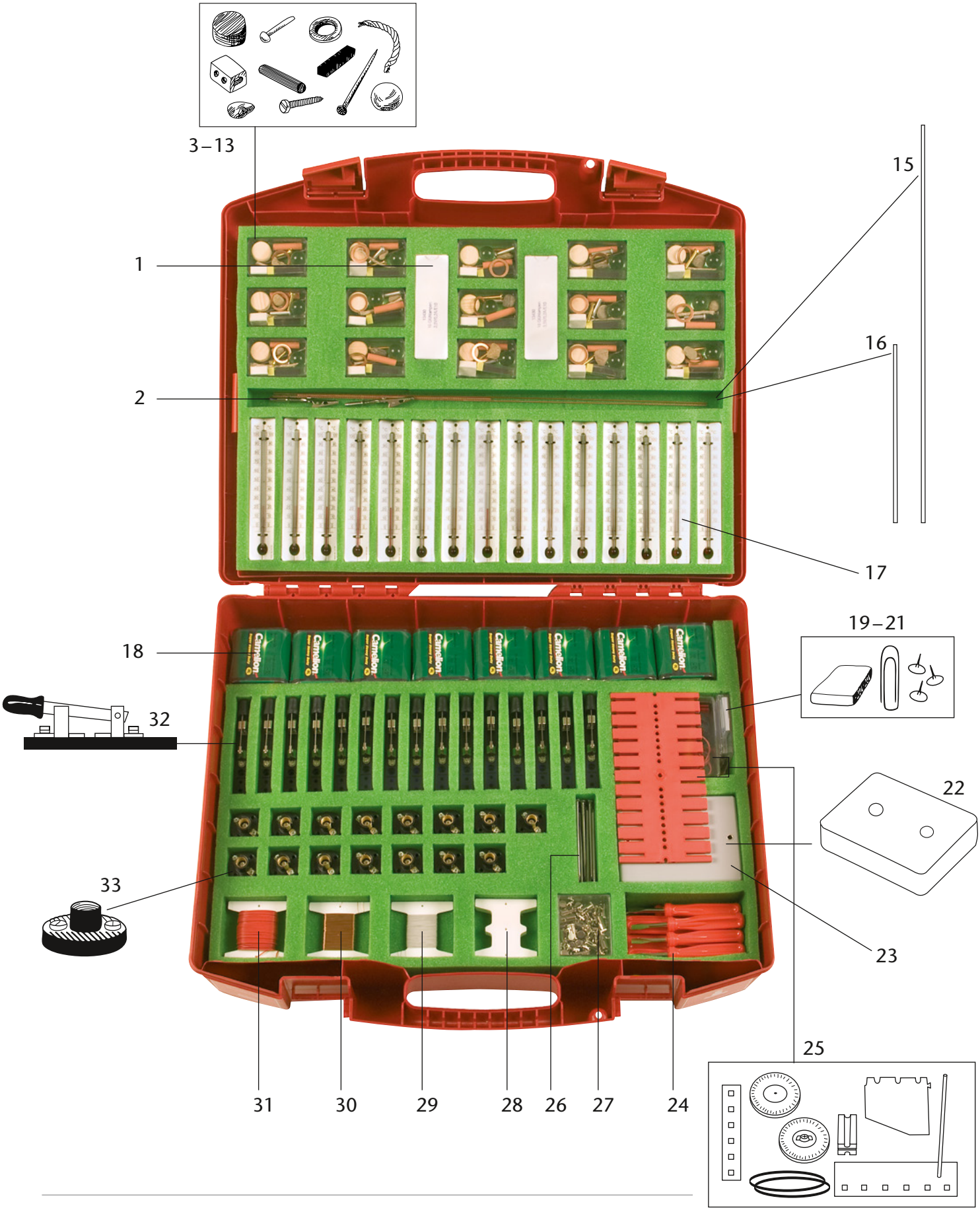
Content

Storing diagram



List of components

Illustr. no.	Qty.	Description	Order no.
1	20	Bulbs, 3.5 Volts, 0,2 Ampere	13430
2	2	Crocodile clips with plugs	15781
3	15	Materials for conductivity examination	
		in plastic boxes (no. 12662) containing:	13561
		1 Piece of porcelain	13650
4		1 Glass bead	13677
5		1 Iron nail	13685
6		1 Piece of string	13669
7		1 Aluminium rivet	13626
8		1 Brass screw	13634
9		1 Wooden disc	12590
10		1 Carbon rod	13642
11		1 Stone	12565
12		1 Copper ring	13588
13		1 Rubber rod	13600
15	2	Copper wires, supple, 1.5 mm dia., 430 mm long	512703
16	1	Copper wire, half-hard, 2 mm dia., 200 mm long	512704
17	15	Thermometers, –3 °C to +103 °C	12735
18	15	Batteries, square, 4,5 Volts	13359
	1	Set of spare parts (in plastic box, no. 43150), containing:	
19		1 BluTack, adhesive bonding compound	15775
20		10 pins	15773
21		20 paper clips	12549
22	1	Plastic base, grey, 120 x 90 mm with 2 terminals	512701
23	1	Wooden board, 120 x 90 mm	15771
24	15	Screwdrivers, insulated, 110 mm	13481
25	1	Construction set for vehicle with fischertechnik components	15760
26	15	Nails, iron, 80 mm	13553
27	32	Terminal clips, 7 mm (in plastic box, no. 12727)	13464
28	7	Spools, for keeping enamelled copper wire pieces	
		after experiment	13510
29	1	Spool of heating wire (20 m) with grey cotton insulation	13545
30	1	Spool of copper wire (60 m) with transparent enamel	
		insulation	13537
31	1	Spool of copper wire (20 m) with red plastic insulation	13529
32	15	Lever switches	13499
33	15	Bulbholders	13448

Enclosed printed material

–	1	Experiment Description / Manual	
		“Electric Circuits”	3177261
–	1	Storing diagram “Electric Circuits”	3177236

Experiments at learning stations: a way to child-oriented learning

'Experimenting at learning stations' follows the principle of learning at stations. It is, however, designed for the special needs of primary schools regarding experiments for pupils: to avoid risks some steps have to be presented more thoroughly, since students carry out all the experiments without the help of the teacher.
With the science box 'Electric Circuits' and the worksheets from this workbook you can set up up to 33 different stations according to your objective, all of which have been proven in teaching. It is also possible to confine yourself to a selection of contents and offer stations on only one specific subject area.
It is crucial that **every child** has the chance to select and work on his / her station. Hence, there might be a situation where each child works on a different station than its classmates. To a large extent pupils should have the opportunity to decide whether they would like to work on their own, with a partner or in a group.
For the children being able to choose, they have to be presented with an overview on the learning stations.
It is advisable to showcase the stations in the classroom a couple of days beforehand and present some of the crucial stations on the first day. The overview (p. 14) should be used. For the first encounter with the material it is recommendable to select the most important stations and assign them specifically or draw.
Although there are stations where the children work in groups, either because they want to or because it is required, experimenting at learning stations is as such not learning within a group: its objectives are different (e.g. identification of individuals with the group, common product, practice of group working skills).
Neither is experimenting at stations free working, since it is an offer within one field of learning and having predetermined (minimal) objectives allows only a limited selection.
Experimenting at stations can be used as a kind of – or part of – weekly work plan, if the stations stay available over a longer period of time and if the children set up a time plan for accomplishing the different parts. Still, the pedagogic meaning of weekly work plan learning (e.g. Freinet) is not carried out through this approach completely, because 'Experimenting with electricity' is limited to the closed, specialist, regarding subject matter, and time restricted arrangement.

Experimenting at stations and the principle of 'Open and distance learning'
Experimenting at stations unites what has been proven in everyday teaching and offers at least for a short amount of time the opportunity to leave behind the principle of pupils of one class making the same learning step at the same time.
Although the teacher sets the range of the stations in advance, pupils nevertheless have the opportunity to choose from a wide pool of possibilities.

- They can choose a station based on its content or its required form of working.
- They can set the order and the revision of stations within the bounds of range or decide on the dwell off time at a station.
- They can opt for the form of working and form of help.
- They can contribute to the range of possibilities by creating further stations with material that they brought from home.
- They can include parents or other classes.

This combination of worksheets and materials for experiments enables the teacher to open up the classroom accordingly. The teacher decides to which extent.

Experimenting at stations: individualized learning
Experimenting at stations is a form of individualized learning. Experimenting at stations ought to

- meet children's individual needs (abilities, skills, previous knowledge),
- show them individual learning pathways,
- take up their special interests,
- promote the ability to get an overview on the learning arrangement and decision making,
- practice age-appropriate responsibility for one's own learning and dealing with learning material, as well as cooperative behaviour and the ability to follow through on something (!),
- promote willingness to fulfill the demands at school independently while using the provided stations and control oneself.

The burden of arranging synchronized learning is taken off the teachers' shoulders by experimenting with stations and shifts the focus of their work onto individual supervision of pupils and groups.
It frees teachers from the responsibility to provide each child with the same medium in teacher-centered

instruction. (However, it does not release you from the obligation to offer each child a medium in general; they can be different, of course.)
The wide 'gap' of performance, knowledge, and skill can especially be observed in social studies. The topic 'Electric Circuits' illustrates this very well. Knowledge and skill depend greatly on non-formal activities. Combined with the box 'Electric Circuits', 'Experimenting with electricity' provides you with written media and the basic equipment and materials for the experiments, helping you to bridge the different preconditions.

Learning theory principles on experimenting at stations

- overview of the entire subject matter
- goal orientation (knowing and pursuing goals)
- activity-oriented learning
- moving while learning
- linking of knowledge
- establishment of favourable learning atmosphere,
- correction, reinforcement, and quick help.

The multimedia conception 'Experimenting with electricity: electric circuits' gives you the opportunity to teach according to these educational principles (and your own), without shifting your focus on obtaining and constructing the material.
The conception of all stations gets a room for activity-oriented learning, partly exploratory learning.
Linking of knowledge, often called for, is established in the numerous connections to the children's pre-knowledge and their environment as well as the chance to discover stations belonging together. The options on working interdisciplinary are diverse and already incorporated into the worksheets.

Comments on aspects of changing the social form and teaching form

Recently schools have been pointed to the fact that forcing pupils to sit for a long time hinders them to learn successfully.
A fact that every teacher knows from further training or conferences …
Experimenting at stations offers a noticeable relief. The children walk to their stations, to the hidden answers, and to the helpers (be it the teacher or classmate).
Another important characteristic of experimenting at stations is the constant change of social form and teaching form: it is advantageous to approach the same subject matter numerous times and from different angles (e.g. in reality, in pictures, in text, and in discussions). As has been proven, it is helpful to change the social form now and then and present some work, which has been produced individually, orally to a partner or a group.

Organizing the stations

Put as many stations on display for each child to find its own. The optimum would be to offer as many stations as there are pupils. If this is not possible in terms of content or economic reasons, you can put up the same station at two different spots or lay out the material of the same station numerous times. It is also possible to construct specific stations from the start as partner or group work activities to save material.
The stations should be spread out in the classroom, for example on the window-sills and shelves or put up on the walls within reach. It is also possible to display them in a suitable spot like a buffet. It is important that

- an unhindered overview and
- free access are guaranteed.

Usually an overview and free access are hindered when the materials are displayed on desks. The stations should **not** be arranged on the desks where pupils work every day.
Experimenting at stations can be carried out in one or several lessons. It can also be put up for several weeks, working on it only one lesson each day – covering a unit, which in more traditional teaching arrangements would have taken up to 12 or more lessons.
In many classes 'Experimenting with electricity' has been put up over a period of about three weeks and used daily as a constant arrangement in the classrooms. In assembling the stations (by setting up the 'material corner' and the stations as well as the worksheets) only once and the pupils getting used to handling and organizing the material as well as ritualizing reporting on results during circle time as well as the growing 'exhibitions' ('Battery museum') and collection of materials, the economic and positive learning atmosphere had room to unfold.
You should remember to clear some space for the 'Battery museum' and the 'Exhibition on bulbs'. A table exhibiting the pupils' finished works is also convenient e.g. for the 'Trembling rollercoaster' or books and objects brought by the children.

Experimenting at stations individually and learning with the collective class (teacher centred instruction and circle time)

Experimenting at stations is a principal of formal teaching which cannot replace others completely, due two different objectives (see above). Under no circumstances

makes it other arrangements redundant in which all children learn together and come to the same conclusions at the same time.
Learning at stations also requires lessons (or parts of it) were interim results are collected and discussed (e.g. appreciation and show of results) or general information is clarified. A lot of colleagues have started the topic with an 'introduction lesson'.
In the course of the introduction some colleagues let the entire class practice the following processes in partner work: attaching the terminal clips to the battery (easy to demonstrate by means of a projector), fastening the wire to the terminal clips, loosening the screws at the fitting of the wires (never unscrew entirely!), removing of insulations (peeling it off with fingernails or rather with lacquered wires scratching it off with scissors). This measure relieved teachers as well as appointing 'helpers' who could be approached if pupils had technical difficulties.
Who wants to impart an optimum of abilities, skills, knowledge, competences, and attitudes, will choose the appropriate teaching arrangement. It is, therefore, necessary to interrupt learning at stations – if they have been put up for a longer period of time – with real stages of group work and of learning with the collective class.
If necessary, the materials in the box 'Electric Circuits' suffice for an one-time teaching arrangement with the entire class in partner work (all parts are present 15 times).

Matter and language
The indispensible connection of subject matter and language should be tied by the teacher as well as initiated and constantly fostered.
That is why within each working stage on a station, a presentation phase should be integrated. In can be included at the beginning, at the end or in the middle of the working stage. At this point one or two pupils can present up to two results. They can show and explain what they have done and found out. Next to the verbalization of the phenomenon, this ritual has other positive effects, only two of which shall be mentioned here:
First, the audience develops some interest in the presented station. Second, the teacher can choose 'the presenters' (in time), making sure that the important stations are presented one at a time. Circle time can be used to connect and accentuate specific points.
The combination of subject matter and language is also facilitated by the results and reports booklet. Due to its free form it is very popular with the pupils. They can replenish it at home with pictures and collages.

Mandatory and optional tasks
The concept of experimenting at stations is built on the idea of individualization and trust that at the end each pupil will have learned as much as their individual potential allows them to. Therefore, it is possible that a child will have taken every offer and in addition contributed with something of its own, whereas another child will have completed half of the stations in the same amount of time.
If you want to lay down a mandatory minimum, you can divide the stations into mandatory and supplementary tasks by marking the stations' worksheets and the overview.

Overview on the arrangements in interdisciplinary learning
- reading and giving an account of texts
- designing posters
- interviewing an adult and reporting on it
- presenting
- coming up with and staging role plays
- designing games
- reconstructing toys
- writing an individual book on a subject matter

It is imperative to have a discussion about the danger of electricity, tying it to the children's experience, knowledge and the mentioned cases at station 30.

It should be made clear that all experiments may only be done with batteries. Sockets in the classroom and at home are taboo (tape them up symbolically).

The Science Box 'Electric Circuits'
In principle the box provides you with all the required materials. In assigning two children to be responsible for putting up the box at the beginning of the class and for checking it at the end, you should not experience any difficulties. Children learn quickly to 'operate' with the materials accordingly.
The worksheet indicates (M) whether additional material is needed or whether the pupils require a copy of the worksheet (K).
It is best to copy the required number of sheets right at the beginning and put them next to the stations.
The box 'Electric Circuits' which this workbook is concerned with, contains all the following parts 15 times

(if not indicated otherwise):

batteries, 4.5 V
bulbs, 3.5 V; 0.2 V
bulbholders,
lever switchers,
terminal clips (30x),
screwdrivers,
thermometers,
materials for conductivity examination in plastic boxes,
spool of copper wire with red plastic insulation (20 m),
spool of heating wire with grey cotton insulation (20 m), spool of copper wire with transparent enamel insulation (60 m), construction set for vehicle with fishertechnik components, BluTack (adhesive bonding compound) (station 29),
wooden board, pins, paper clips (station 25),
plastic base with two terminals, 2 crocodile clips with plugs, 2 supple copper wires (45 cm), 1 half-hard copper wire (20 cm) (station 32).

This workbook can also be worked with, if your school does not have the Cornelsen Experimenta box. The mentioned materials have to be obtained or constructed then.

Answer sheets

You can provide all or specific stations with answer sheets, by filling in additional copies and – for example – putting them in the back of the same transparent poly pockets that the stations' worksheets are in. Another possibility is to collect the answer sheets at one for all pupils known spot or to pin them up upside down and with the text facing the wall ('Hidden answer'). Are there two worksheets belonging to one station, they should be displayed in one poly pocket.

Further ideas of the children

Very quickly the children will start introducing their own ideas on how to implement one or several switches into electric currents. In accordance with the existing materials, you should let them have a go as well as give them the chance to realize their own ideas, for instance, installing lights into the house or the chinese lantern.

Basics on subject matter

Generation of current

Generation of electric current is based on specific physical or chemical processes where energy conversion takes place, mainly by means of generators or galvanic elements.

Generators utilize electromagnetic phenomenon for the purpose of converting mechanical energy into electrical energy. They are used where high amounts of energy are needed (e.g. domestic electricity) and an energy source exists (e.g. reservoir, heating oil, coal, and nuclear power). A bicycle's rotation of the tyres generates electrical current within the dynamo of the bicycle.

Process in the batteries' electric circuit

Due to chemical reactions between used materials, the negative pole of the battery has an excess of electrons over the positive pole.

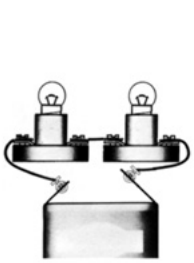
If the two poles are conductively connected, then electrons flow from the negative pole through the line to the positive pole; this is called closed circuit.

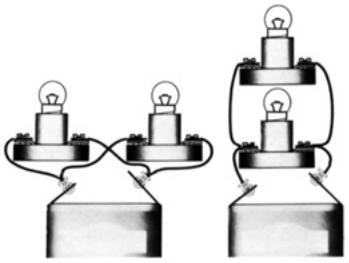
Although the electrons' flow is from negative to positive, technicians reverse the current direction due to conventions: from the positive pole to the negative pole.[1] An electrical appliance included in this flow of electrons converts the electrical energy, according to its construction, into another form of energy e.g. light. The electrical current does not dissipate, meaning that no electrons are lost. The batteries short product life is due to the fact that zinc, ammonium chloride and manganese dioxide or other substances, which modern batteries are made of, are being converted[2]. The flow of electrons only occurs when the electric circuit is closed, so only if there is a closed arrangement of conducting material between both poles. In order to render an electrical appliance within the circuit inoperative, the electric circuit has to be opened at one spot only; that means creating a gap in the wire system. That can be conveniently done by means of switch.

[1] With regard to the children's secondary education, primarily pupils should learn the correct physical current direction.

[2] In non-rechargeable batteries (usually brand articles or batteries with a not rechargeable inscription) this process cannot be launched again – but, in accumulators.

Electrical connections
There are two ways of connecting two or several electrical appliances to a current source: the series connection (connecting in series) and the parallel connection.


series connection


parallel connection

Series connection: In the case of the series connection both bulbs light up darker than with the parallel connection, because their individual resistances add up, so that the current drops correspondingly. If in the series connection one of two bulbs is unscrewed in its holder, then the other bulb also goes out.
Parallel connection: In the case of the parallel connection, however, each lamp is in an individual circuit; the current paths run 'parallel' to each other. For this reason one of the two lamps can be unscrewed without the other going out. The bulbs light up brighter than in the series connection.

Conductors and non-conductors
Materials which conduct the electric current are conductors; those that do not are non-conductors or insulators.
Conductors play a crucial role in electrical engineering. Among them there are differences in quality: Silver conducts very well (has a lower specific resistance), equally copper. Nichrome and constantan are poor conductors, which means that their specific resistance is higher.
According to Ohm's Law, provided that the voltage remains constant, the current is lower the higher the resistance of the conductor. Provided that the current is equal, wire with higher resistance heats up more than the wire with lower resistance. Depending on the desired effect, one would decide on a specific material for the conductor:
High conductivity copper wire is generally used for power supply cables, in order to keep the conversion to heat, therefore, losing electrical energy, as low as possible. Appliances which serve heat generation expressively, however, are provided with a poor conductive wire. Filaments in bulbs have to withstand high temperatures; therefore, they generally consist of the hard-to-melt metal tungsten (melting point: 3350 °C). For the resistance of the filament to be high enough in relation to the power supply cables, the wires being used are very thin (in part thinner than human hair). To prevent the filament from being burned, the bulb (bulbs from 40 watts upward) is pumped dry and filled with an inert gas (argon, krypton). The surface area of the filament affecting the undesirable heat dissipation is reduced by coiling the filament once or twice. A coiled filament, moreover, takes up only a fraction of length than a stretched filament.
Non-conductors or **insulators** also play an important role in electrical engineering. When a contact between two conducting parts is to be prevented or – especially with high voltage – when the touch can be life-threatening, non-conductors are applied. That is why all electric appliances are meticulously insulated.

Electromagnetism
Another important phenomenon is the fact that a magnetic field originates around a wire through which current flows, which can be increased by winding the wire into a coil. If an iron core is added, the magnetic force is concentrated still further; the result is an electromagnet which is effective as long as current flows through the wire.
Most electrical appliances which generate a motion including the electric motor operate on this principle.

Overview of and notes on the stations

Each child should have a copy of this. Here they 'tick' what they have done. You can also enlarge the overview and put it up as a poster in the classroom. Stations which are not offered should be covered up while copying.

The 'book on electricity' can of course have any form, be it a folder or part of the science booklet. The children should read and lengthily discuss the letter 'dear Children'. Those who follow the described directions will have the best possible results.

The great variety in batteries can be economically explored best at the collection point of used batteries. They can be found in supermarkets, hardware stores, recycling centres, but also photo shops and pharmacies (batteries for hearing aids). The battery museum should be started from an early point on and built up over time, so that there are sufficient illustrative objects.

The children can take their posters home in order to use them. It is also possible to exhibit the posters in a small showcase at school.

This worksheet needs to be copied, since the batteries have to be cut out and glued onto it. If you want to do it without gluing, a few copies as a placing game are sufficient.

Of course, it is important that the students get in touch with original objects, which means there should be real battery-powered appliances either brought to class by the teacher or the pupils.

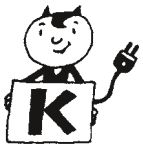
These two stations cannot be made mandatory due to their content and are meant for pupils who are especially interested. It particularly proves the advantage of 'learning at stations' through differentiated arrangements. The reports on rechargeable batteries and the problems on storing the batteries too long should in some way have the opportunity to be held and heard: either in front of the entire class or a group …

This exhibition, of course, is more interesting the more different bulbs (technical term: lighting fixtures) are displayed and the earlier the collection reaches a considerable amount. Therefore: start collecting immediately. To secure the bulbs they should be displayed in lids of shoeboxes or the like. Under no circumstances may fluorescent lamps be part of it. They role away and break easily, are sharp-edged, and filled with gas.

This station requires sharp scissors, a milk carton or juice carton as well as a toothpaste box. Children less skilled with scissors should get some help. Cutting the bottom of a milk cartons is especially difficult. It is important to advise the children on rinsing the milk carton in advance.

Electric Circuits

Name: .....



My book on electricity
1 ..... ☐

Experiments with bulbs and batteries
2 ..... ☐

Batteries

Battery test
3 ..... ☐

Alessandro Volta, the inventor of the 'battery'
4 ..... ☐

Batteries everywhere
5 ..... ☐

A battery museum
6 ..... ☐

'Batteries are positive and negative'
7 ..... ☐

Batt Man
8 ..... ☐

Max has a problem
9 ..... ☐

Batteries in cars
10 ..... ☐

Heat

Heat from the battery
28 ..... ☐

Heat from the socket
29 ..... ☐

Danger

Seven times risk of death
30 ..... ☐

How to protect oneself from an electric shock
31 ..... ☐

Little Projects

Catherine's and Philip's lights in a buttonhole
15 ..... ☐

Murat's Pencil case light
16 ..... ☐

Joanne's fire boat
17 ..... ☐

Frank and Ayla conduct a headlight-test
18 ..... ☐

Sophie has two bulbs on her vehicle
19 ..... ☐

The trembling rollercoaster
32 ..... ☐

Why are our bulbs lighting up? – Electric Circuits I+II
11 ..... ☐

Improving Murat's pencil case light
21 ..... ☐

The robot game
33 ..... ☐

K Write into the copy or cut something out.
M You need to bring something from home for this station.

Bulbs

Bulbs are all around us
12 ..... ☐

An exhibition on bulbs
13 ..... ☐

Mr. Edison invents the bulb
14 ..... ☐

Lights on bicycles

Bicycle light: Riding a bicycle at night – worksheet no. 1
26 ..... ☐

Bicycle light: Experiments – worksheet no. 2
27 ..... ☐

Sasha and Derya test each other's knowledge on electricity
20 ..... ☐

Switches

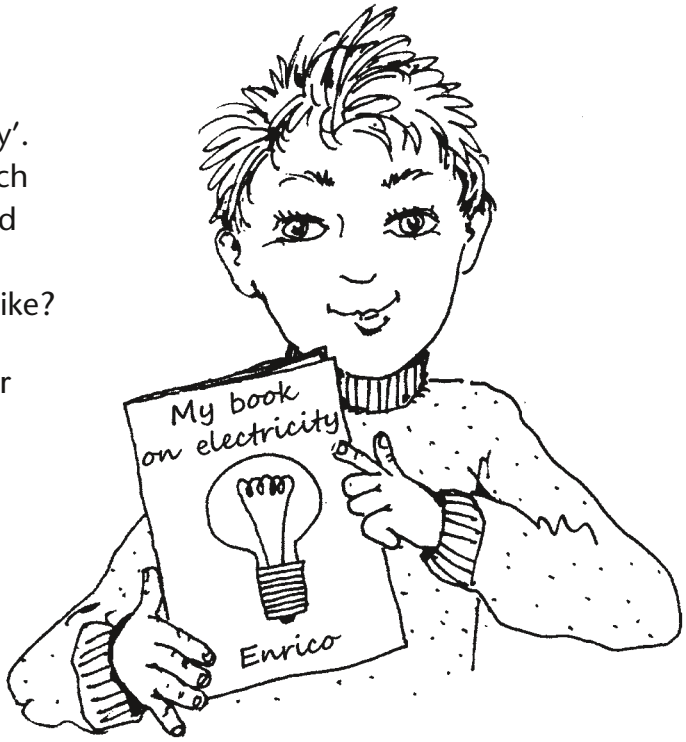
A checklist: switches in our apartment
22 ..... ☐

Safe electricity – for the sake of the environment and your purse
23 ..... ☐

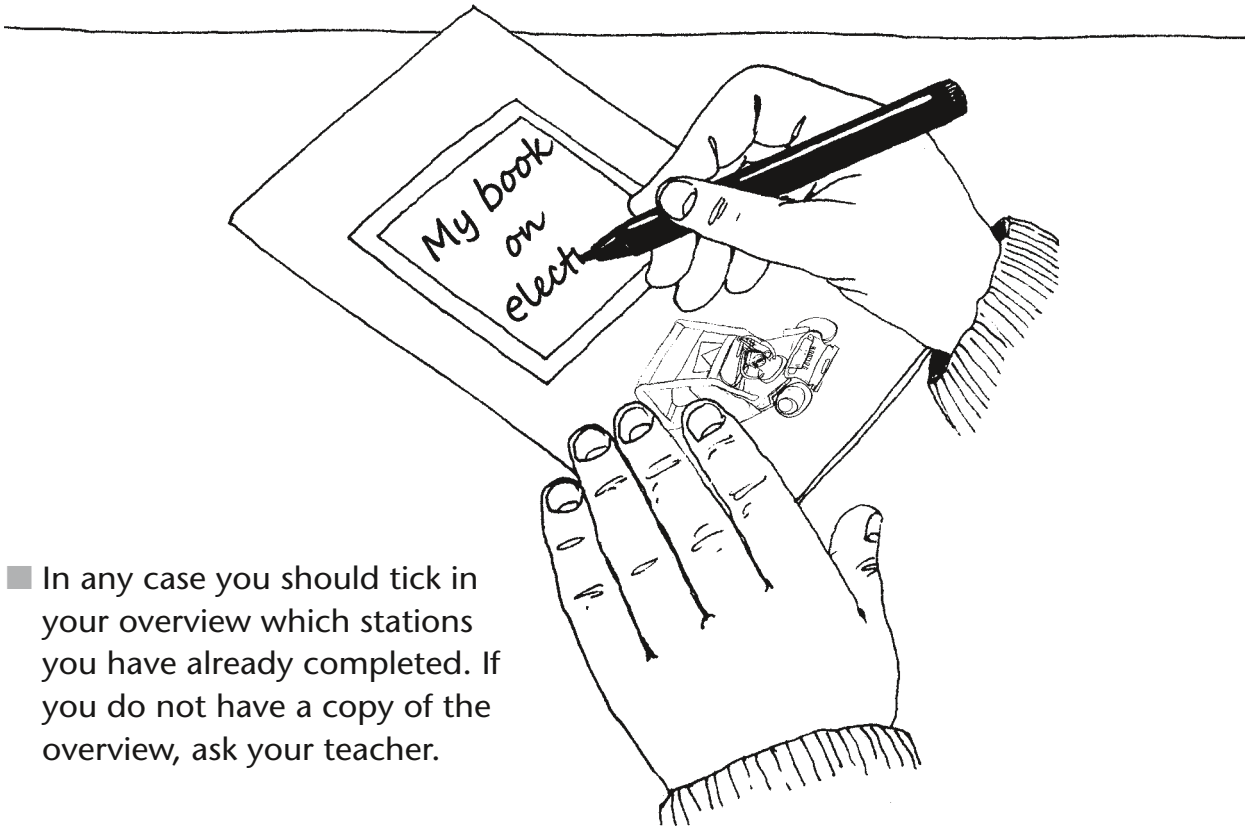
Four switches – on and off
24 ..... ☐

Building our own switch
25 ..... ☐

My book on electricity



- This is Enrico with his 'book on electricity'. He wrote it himself. All experiments which he has done with electricity are described here.
  How will your 'book on electricity' look like?
- Create your own book and collect your daily working results from the start.



- In any case you should tick in your overview which stations you have already completed. If you do not have a copy of the overview, ask your teacher.

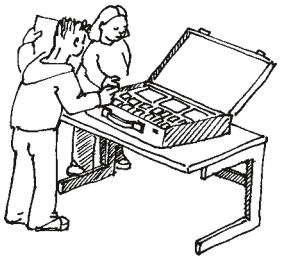
Dear children,

While experimenting with electricity you will make a lot of interesting discoveries.

This is the best way to proceed:

1. Decide on the station alone or with a partner (it works best with a partner).

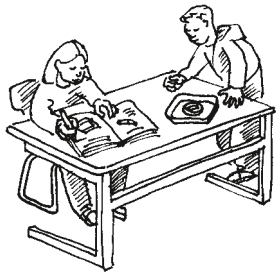
2. Read the text thoroughly at your desk.



3. Compare what you have read with the pictures. Discuss what you have understood and how you want to proceed.

4. Now, get the material and start experimenting.

5. Afterwards, write and sketch into your 'book on electricity'. The worksheet stays at the desk.



6. After that, return the worksheet and the material.

Have you understood an experiment especially well and have you done it without any problems?
Then you can register yourselves as 'experts' at your teacher's desk.
Perhaps she will write down your names on the worksheet.
If other children have any questions about the station, then you can help them and they do not have to wait for your teacher.

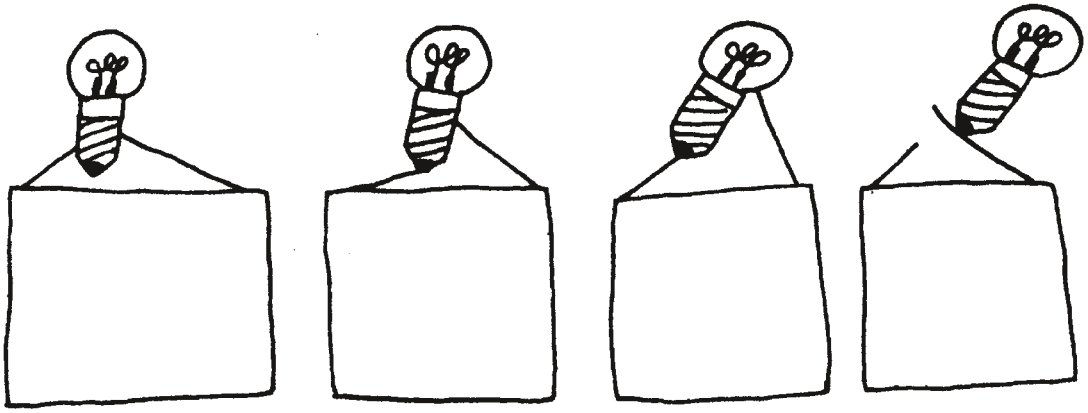
Besides the 'experts' for each experiment, they are two pupils responsible for the box: they make sure that at the end **everything** is returned to its spot.

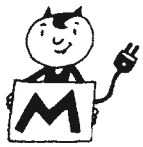
Christian Hoenecke
The teacher who designed these worksheets

Experiments with bulbs and batteries

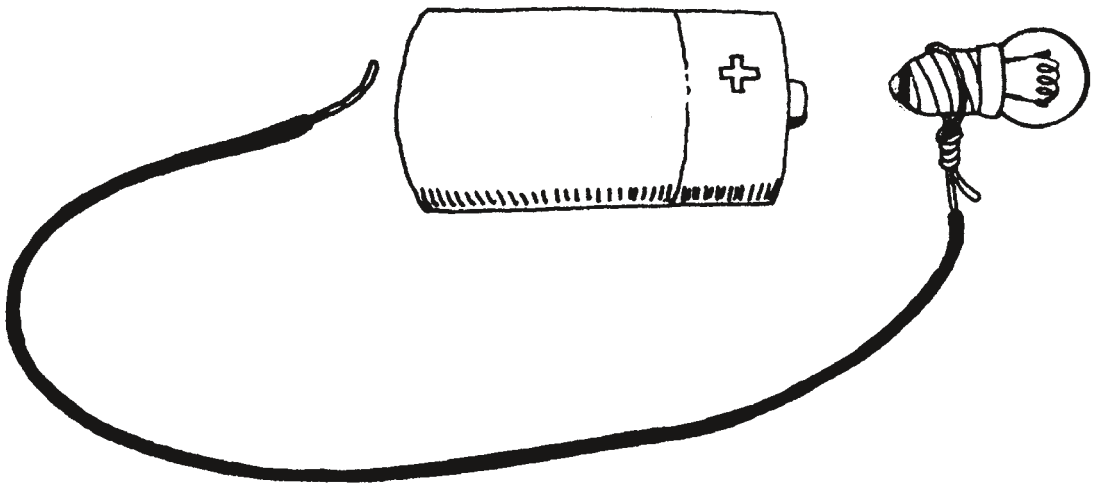
- Light up the bulb by yourself.

- Make an exact sketch of how the bulb touched the battery.





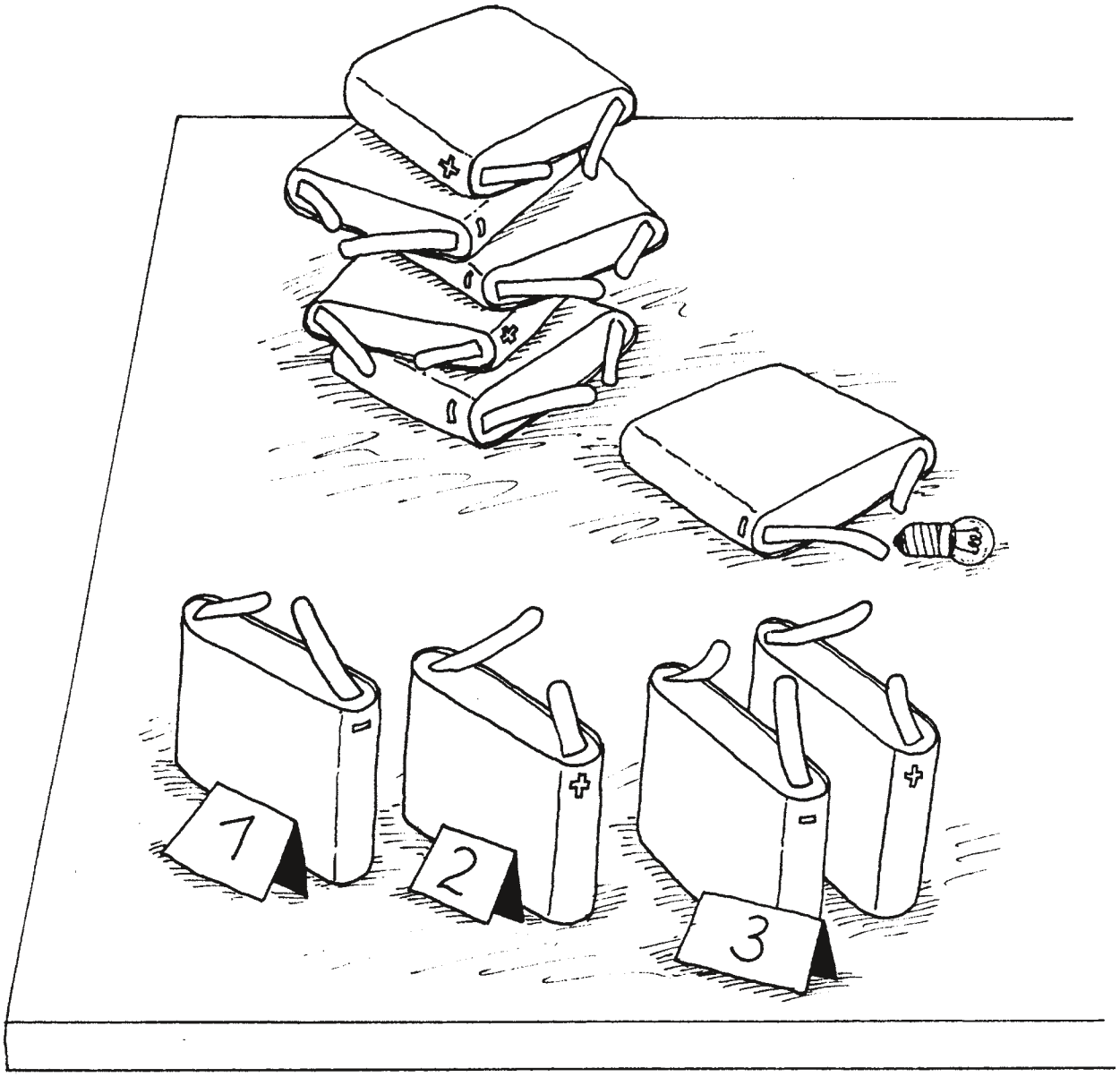
- Try it with another battery.
  Round batteries are not in the science box. You have to bring them from home.



Battery test

- Test several batteries and sequence them: with which battery will the bulb light up brightest, with which will it light up less?

- Of course, you can also use other batteries than depicted here.
  At first, however, read the text about Mr. Alessandro Volta at station 4.



Alessandro Volta, the inventor of the ‘battery’

The ‘V’ on electric appliances is an abbreviation. It means ‘Volt’. Combined with the figure in front of it, it indicates the force which an electric appliance needs or emits.
The word ‘Volt’ reminds us about **Alessandro Volta.** He lived from 1745 to 1827 in Italy.
He was a professor and devised a lot of experiments with electricity. While doing so, he made brilliant discoveries.
Around 1800 he developed the first ‘battery’. Honouring **Alessandro Volta,** the force of electric current is indicated in ‘Volt’.

- Look for the figures with the ‘V’ on different bulbs (also in your ‘bulbs exhibition’) and batteries in your classroom.

- For instance, where do you find find these details?

3.8 V 4.5 V

Important: when connecting a bulb to a battery which Volt figure is much higher than the bulb can take, then the bulb can break down.
For example: battery 9 V / bulb 3.8 V.

Electricity up to 9 V is absolutely harmless.

Forces higher than 9 V e.g. the 220 V from the socket, can be life-threatening!

Batteries everywhere

■ A lot of electrical appliances run on batteries. Write down those, which come to your mind. The list below helps you. But be alert: the list has also appliances which run on electricity from the socket. Write down only those, which need a battery!

iron

remote control

hoover

fridge

torch

coffee machine

camera

oven

clock

speedometer on bike

hairdryer

ceiling light

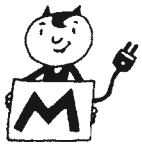
electronic game

radio control for car toys

A battery museum

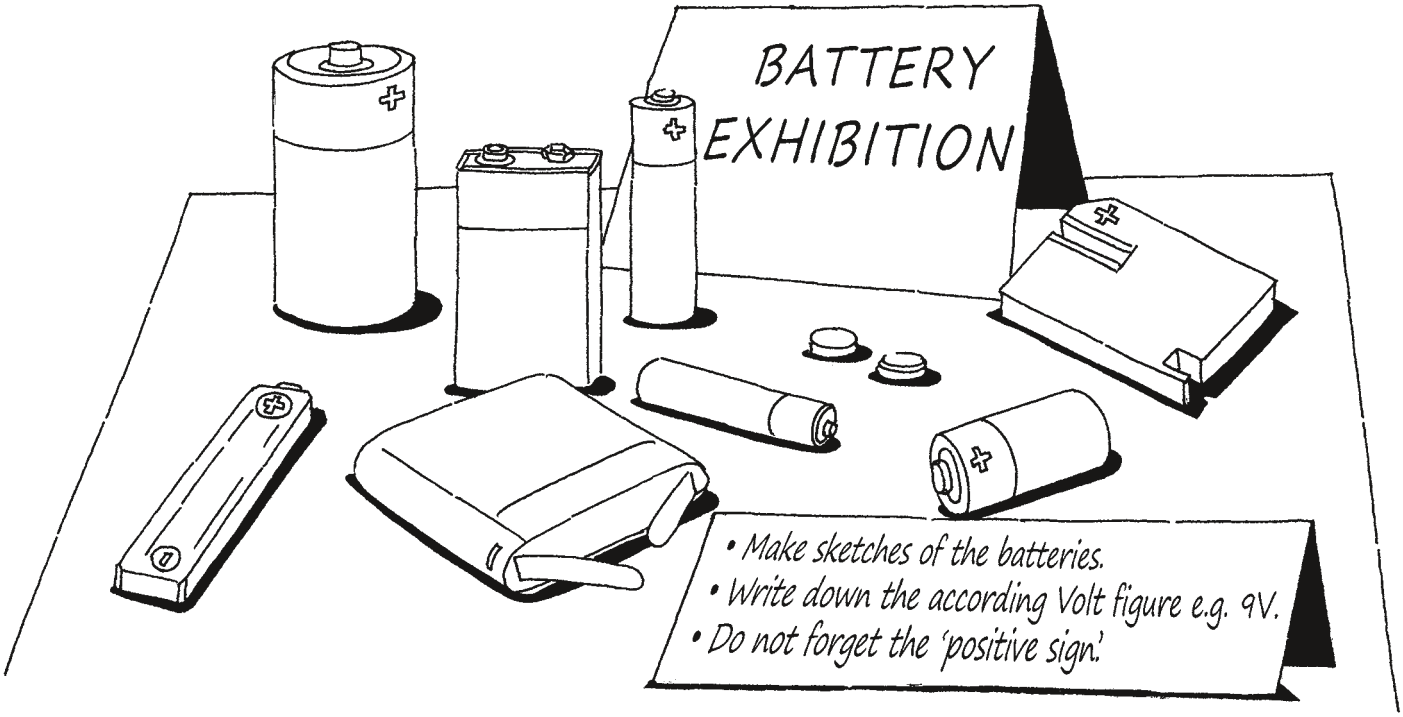
Even old batteries can be used for something:

For an exhibition in our class!



And because the batteries are old, we can call the exhibition a ‘museum’.

■ Everybody in class should try to bring two different batteries to school.

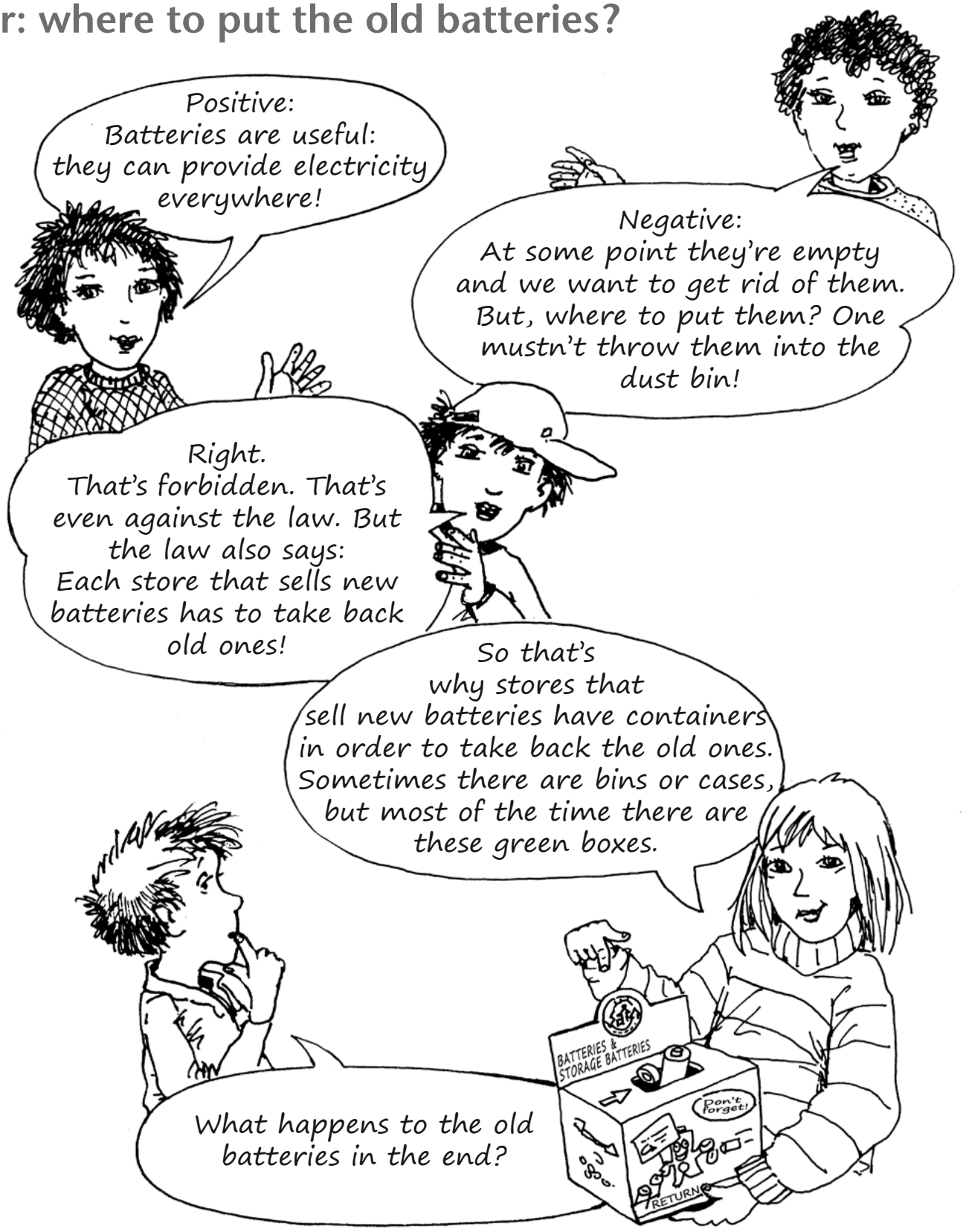


■ Is your battery museum complete?

Then pay a visit and

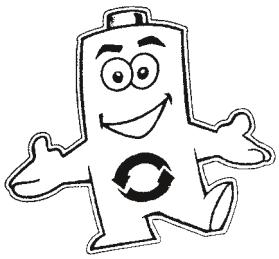
- make sketches of the batteries,
- write down the according Volt figure which is somewhere next to the ‘V’ on the battery e.g. 9 V,
- do not forget the ‘positive sign’.

‘Batteries are positive and negative’ or: where to put the old batteries?

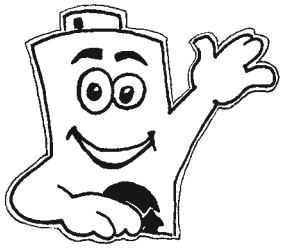


What do you think? What happens to them? Discuss it with your partner. Then work on station 8.

Batt Man

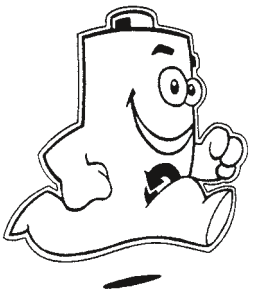


Then we come along, which means our drivers, and pick up the old batteries. I myself am a Batt Man. I promote that you return used batteries. That works great! In one year we collect over one billion batteries in Germany! One billion! These are 1000 millions! Write out the figure. I give you a hint: you need a single One and nine Zeros!



If we arranged the batteries which we collected in the past 10 years one after the other we could circle the earth five times.

What do you do with so many batteries?



We sort and dismantle them. You can make a lot of useful stuff from its components.

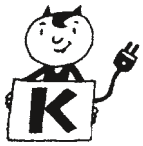
What, for example? Then, even negative might become positive again.

Yes, if you return them! Pay a visit to the internet and look for 'battery recycling'.

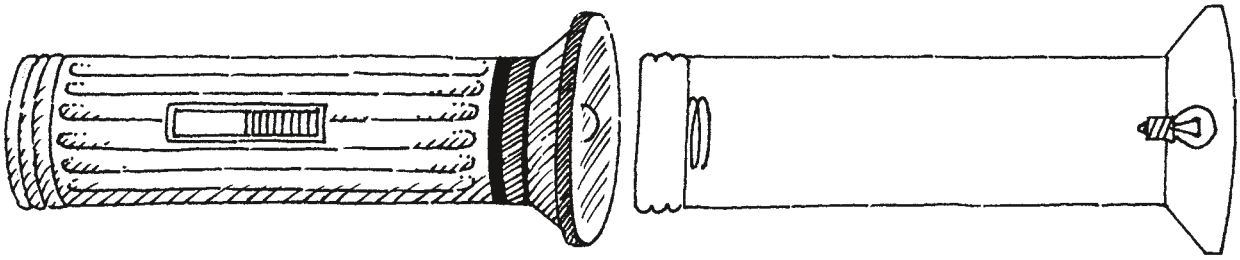
- So that everyone knows how to handle old batteries: design a mini poster and stick it e.g. at home on the lid of your dust bin. Indicate on it where you can return old batteries near your house.
- Recount to each other where you use batteries at home. How many are there? Check it.
- Who will look up Batt Man on the internet?

Max has a problem

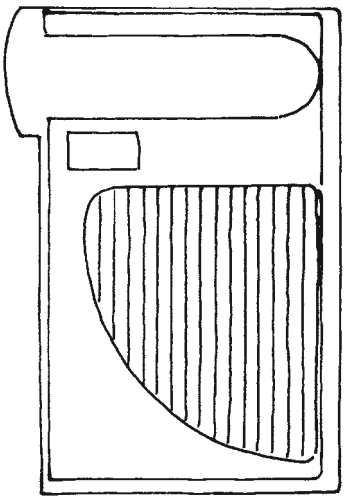
Max has taken out the batteries from the depicted appliances in order to examine them. How is he supposed to put them back in?



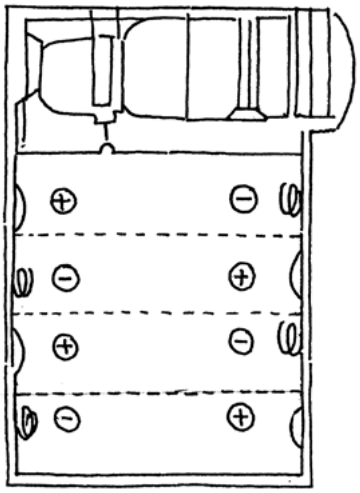
■ Carefully, cut out the depicted batteries below and stick them onto your copy of this worksheet: … but in the right direction!



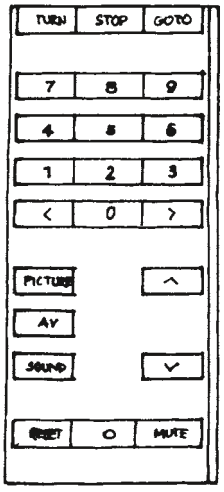
Appliance from the front



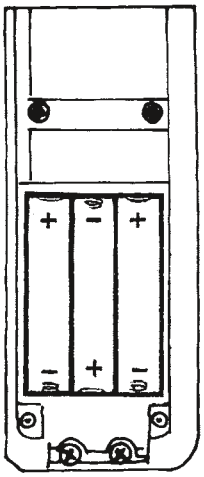
Open battery compartment



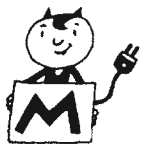
Appliance from the front

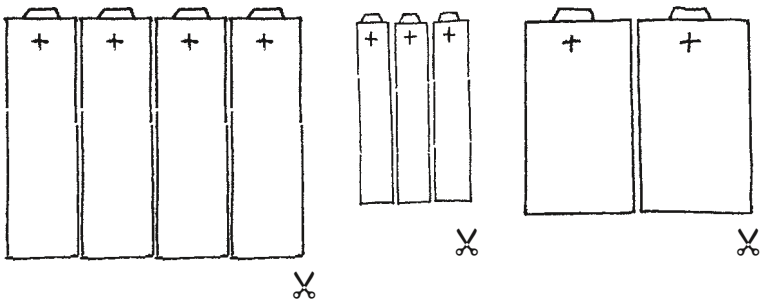


Open battery compartment



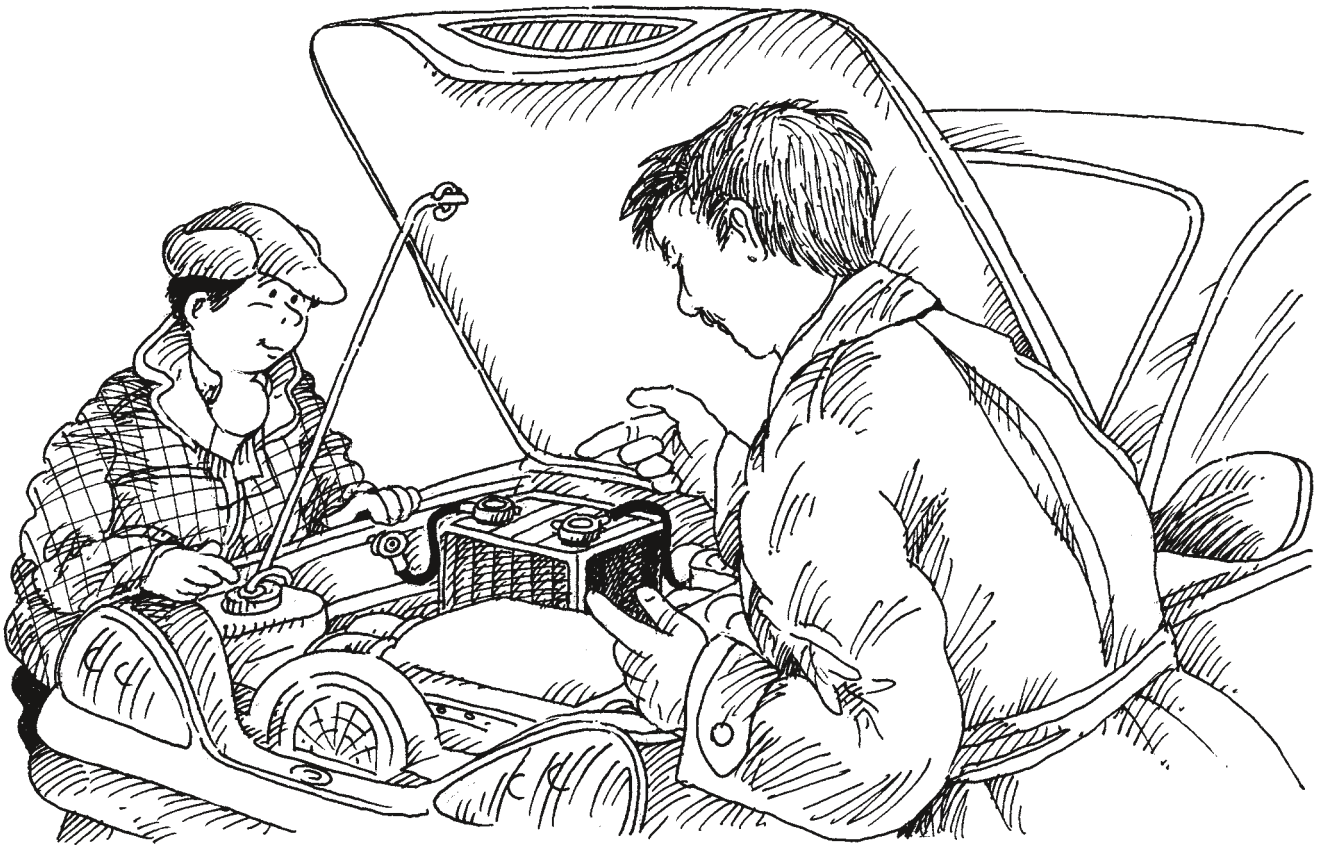
■ Bring with you an appliance from home that has batteries. Demonstrate to the other children how to take them out and how to put them back in correctly.





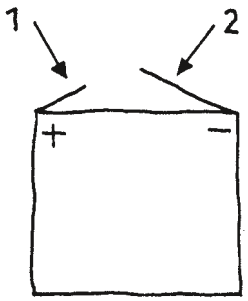
Batteries in cars

"Every car has a battery."
"But cars don't run on electricity. Cars run on petrol or diesel!"
"The car battery is big and heavy, a child hardly being able to carry it."
"And why do all cars need such a battery?"

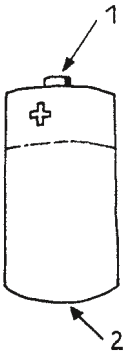


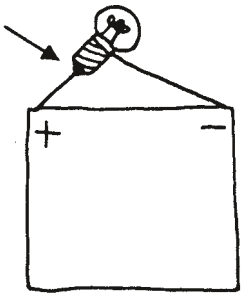
- Do you know it? Just ask car drivers about the battery in the car. Let them show you the battery. How many Volts does it have? How much is a new one? How can you 'throw it away', if you need a new one? Do they discharge entirely or can you recharge them? You probably have many more questions. Write down the answers.
- Make a sketch of a usual battery and a car battery. Try to remember all details.
- Report to your class, what you have found out.

Why are our bulbs lighting up? – Electric Circuits I

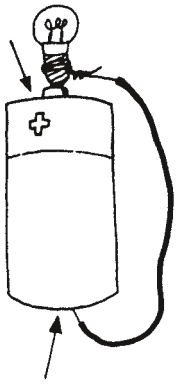


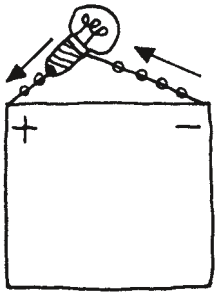
Each battery has two pole terminals: a positive pole and a negative pole.
The negative pole has too many and the positive pole too few electrons.



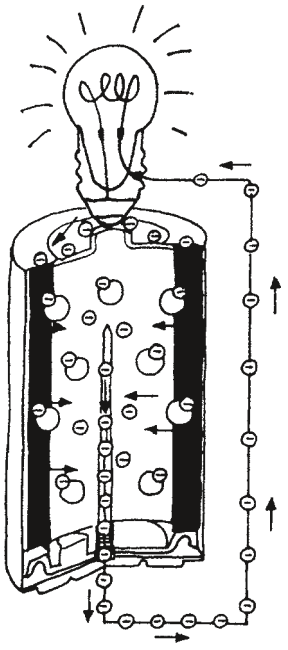


If you connect both poles like this, then …





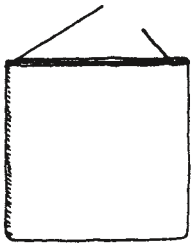
electrons start flowing from the negative pole to the positive pole.



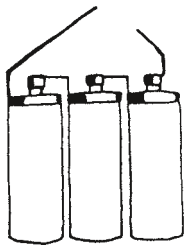
When the electrons flow, it means: “An electric current is flowing.”
You cannot see the electricity. The bulb, nevertheless, is lighting up. This is called a closed circuit.

Why are our bulbs lighting up? – Electric Circuits II

You know this: at some point the bulb stops lighting up. The battery cannot generate any current anymore. Which means: the flowing of the electrons from one pole to another has stopped. **Why?** Because the many electrons at the negative pole and the few electrons at the positive pole have balanced each other out. The battery has run down. It is said: "It's discharged." However, this is not true because everything that has been there before is still there. It has just altered: the electrons are balanced out equally.
And the materials within the battery have changed without the eye being able to see it. It is said: "They altered chemically."
You cannot cancel this alteration. The flowing of the electrons cannot be instigated again, but for batteries which can be charged: storage batteries.

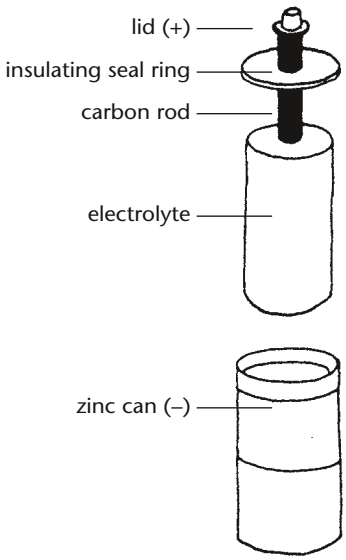


'Our'4.5 Volt battery from the outside.



Our battery without a 'coat'.

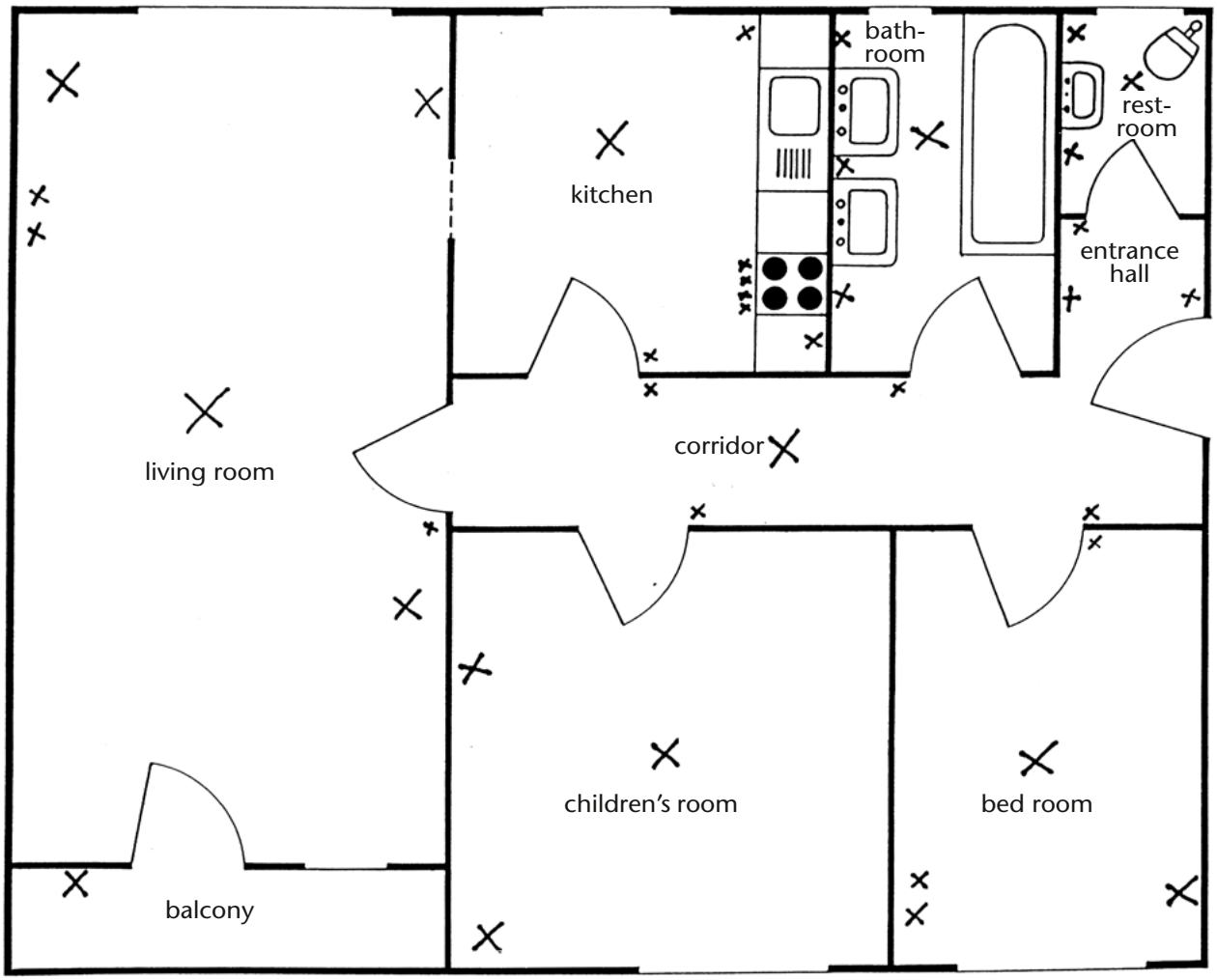
You must not ever dismantle a battery. Its internal components are sticky, stain, and are unhealthy for your skin.
We, therefore, show you how a battery can look like from the inside.
(A lot of other batteries exist, which are made out of other components.)



- Look at all the batteries in your 'battery museum': where are their poles?
- Where can you find the inscription 'not rechargeable' on you batteries? (Under no circumstances are you aloud to do it then!) Look for the inscription 'not rechargeable'.
- Let someone show you rechargeable batteries. How do you do it? What is important here?
- 'Old' batteries cannot be stored for long. You should not leave them in the appliances. Ask a specialist why. Report.

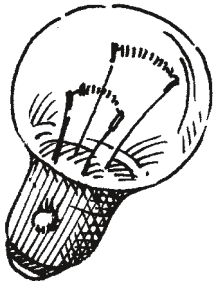
Lights are all around us

Let us close our eyes and take a walk through your flat, marking each electric light with an X in a ground-plan of your flat.
While doing so, we will also record every little indicator light e.g. on the TV or the stove.
Let us not forget the bedside lamp and the mirror lighting in the bathroom and fridge and so on ...
For my flat the solution for this assignment looks like this:

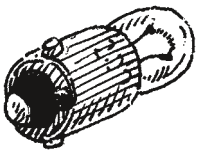


■ Explain to another child your sketch. Tell it, what kind of light you have marked in your ground-plan. What are they for?
Together, count the lights. I have counted 39 in my flat – I never would have guessed! Although I also counted the lights on the fridge, in the oven and each light on the hotplate.

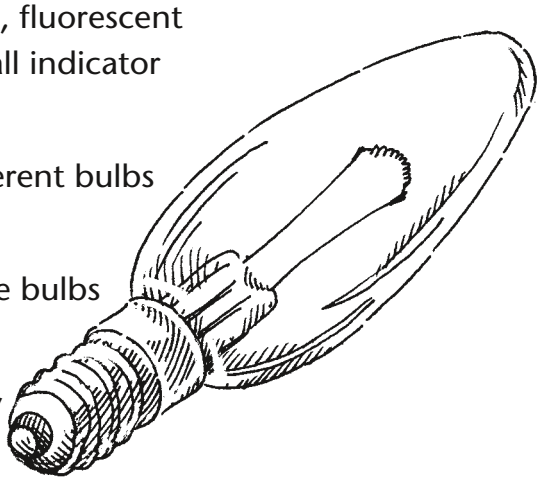
An exhibition on bulbs



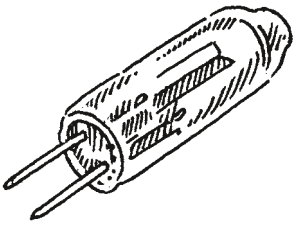
It is worthwhile to collect and exhibit as many bulbs as possible.
Light bulbs from cars, from bicycles, from Christmas trees and from apartments: spots and energy-saving bulbs, fluorescent lamps and halogen bulbs, small indicator lights and so on.



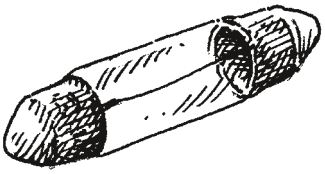
You will be surprised how different bulbs can be.



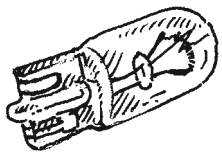
However: where do we get the bulbs from?

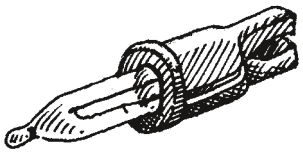


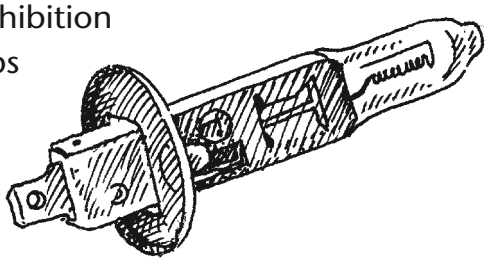
Broken bulbs are thrown away into the trash.
This is usually allowed, since they're rarely dangerous unlike batteries.



That makes it more difficult, however, to get bulbs for the exhibition. We can only ask each child, which means its parents, to bring two different bulbs from home. Please, bring <u>no fluorescent lamps</u> with you. They would be very dangerous in our exhibition. When the exhibition ends, everyone takes their bulbs back home again.



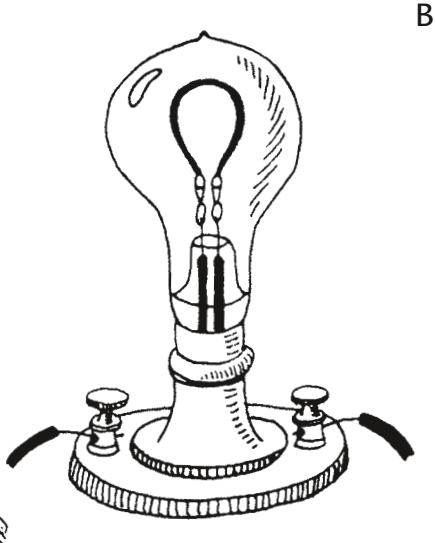




Assignments for visitors of the exhibition:

- Make simple sketches of the bulbs.
- Look for the two terminals and find (with a magnifying glass) the Volt figure, which every bulb has.

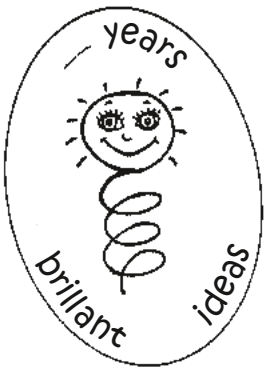
Mr. Edison invents the bulb

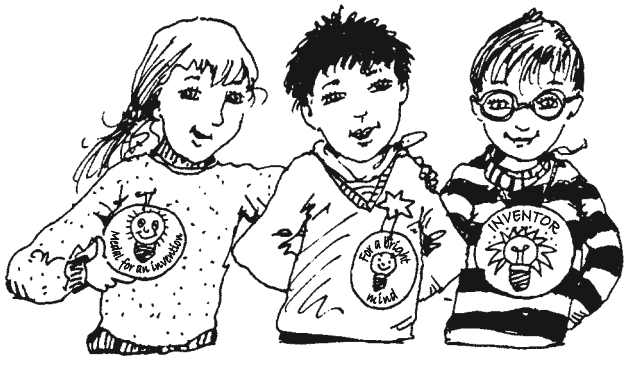


Bulbs were invented in 1879.

The first really serviceable bulb was built by Thomas Alva Edison, an American. His bulb was a glass bulb which was pumped dry. In it was a carbonized thread (filament). It glowed brightly when electric current was flowing through it.
Edison's bulb was technically improved and lights most of our houses until now. Due to its high energy consumption from 2009 on it is supposed to be replaced by energy-saving bulbs.

- Tell this to another child.
- Design a remembrance medallion for this invention.

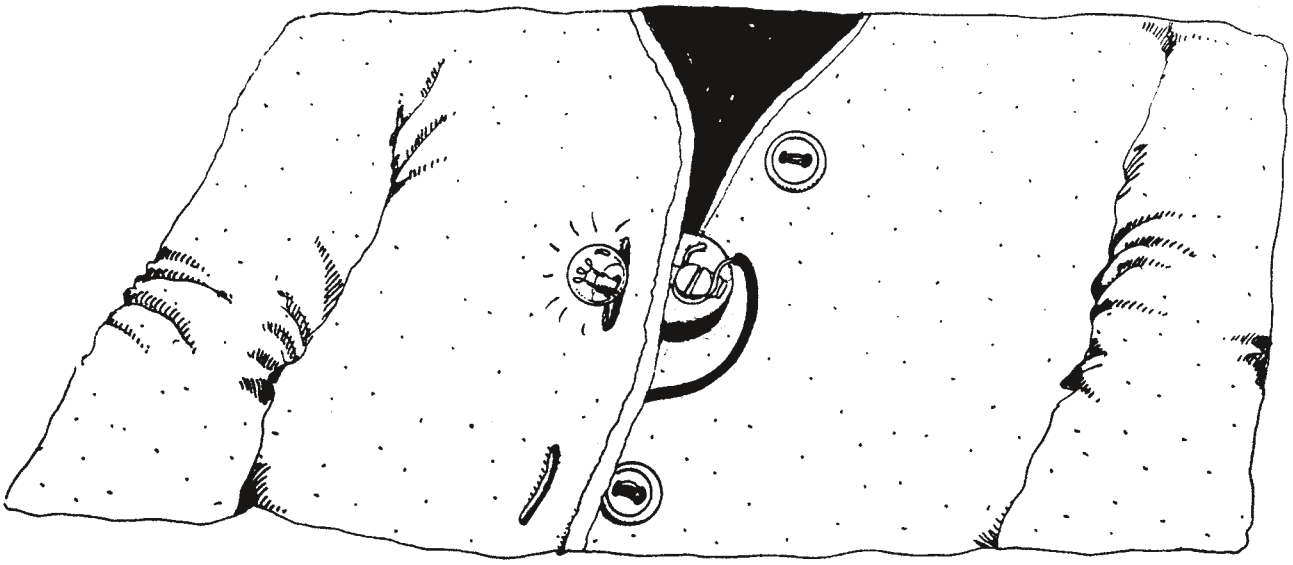




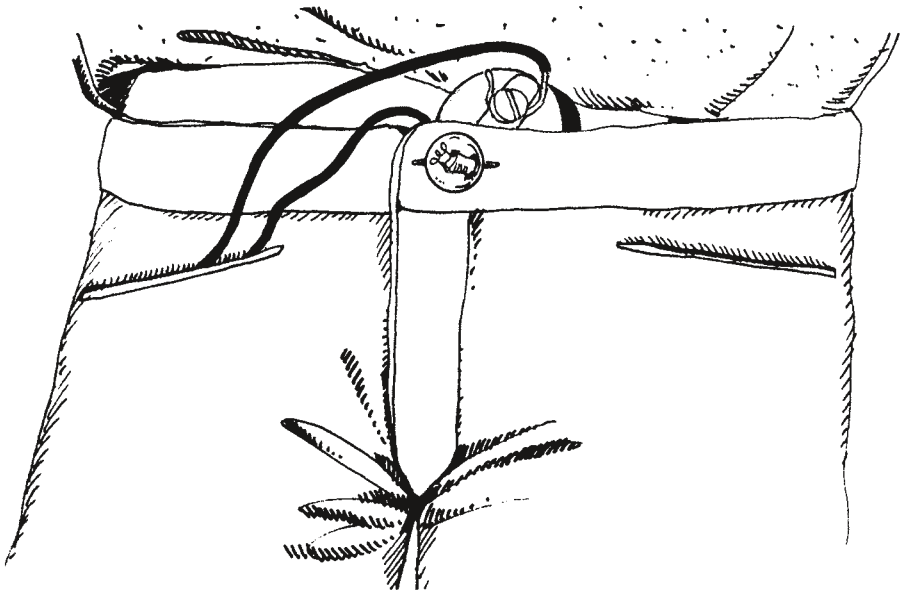
… this is Margaret's. Since it was liked by so many it was decided that each child having a clever idea would get an 'inventor medallion for great minds'.

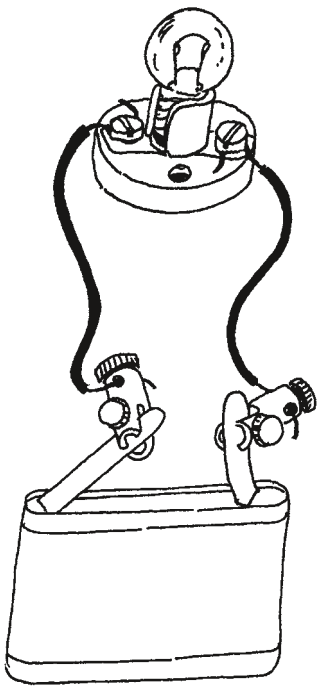
Catherine's and Philip's lights in a buttonhole

Catherine's glowing jewellery which stays flicker free when dancing!



Philip had only one buttonhole on his trousers. He put the ball through it and placed the battery in his trousers' pocket.





Catherine's and Philip's lights required: one battery, one bulb, two wires, two terminal clips, and one bulbholder. They also needed a screwdriver.

Murat's pencil case light

Glows everywhere, wherever it is put down or taken with!

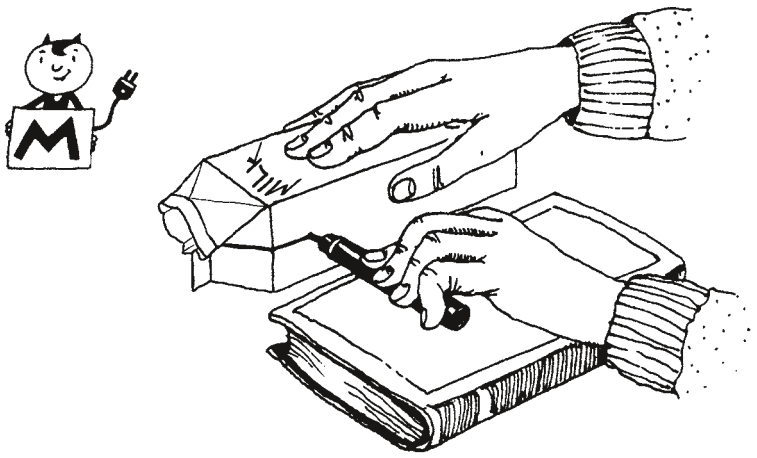
Murat's light required: one battery, one bulb, two wires, two terminal clips, and one bulbholder. He also needed a screwdriver.

Joanne's fire boat

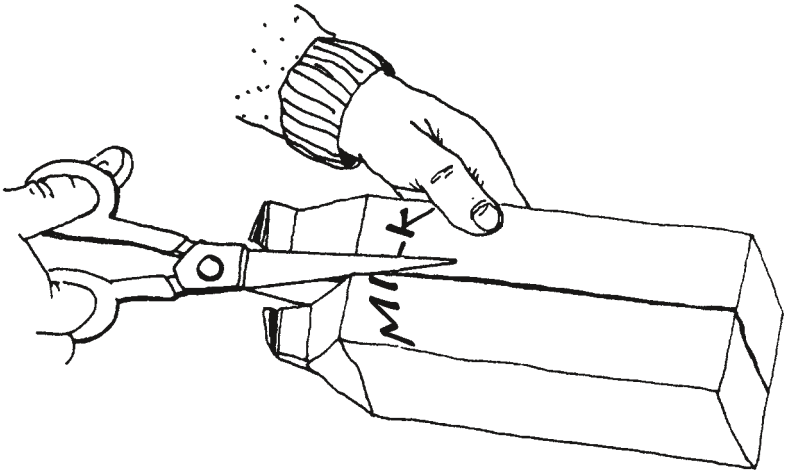
… is one half of the milk carton.

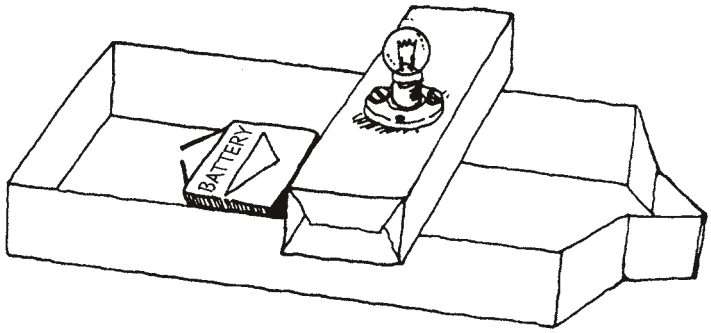
The body of the boat is constructed from an empty and rinsed milk carton.

This trick helps you to draw a line of the same height all around the carton.



Cutting the milk carton along this line, gives you a great body for the boat.
If the top or the bottom is difficult to cut, ask someone for help.

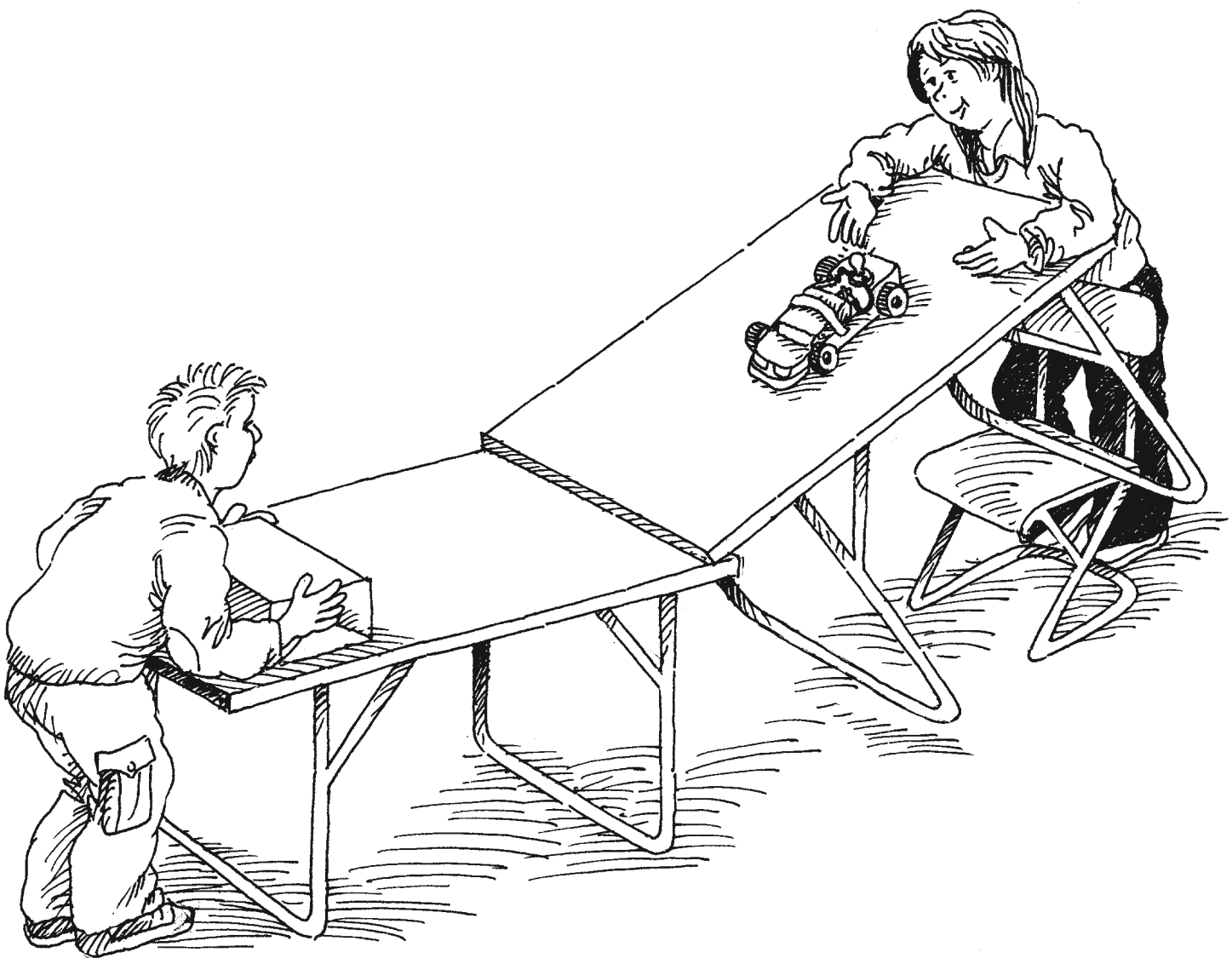




Joanne's boat required:
one battery, one bulb, two wires, two terminal clips, and one bulbholder. She also needed a screwdriver and scissors. She brought the milk carton from home where she had thoroughly rinsed it with water. The toothpaste box is also from home.

Frank and Ayla conduct a headlight-test

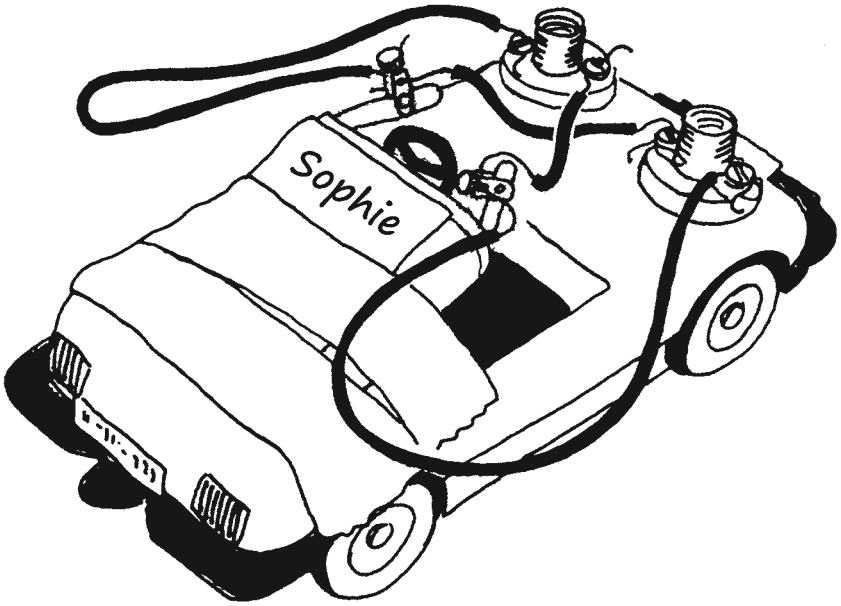
Frank and Ayla used this test to prove the functioning of the car headlights. The headlights must remain flicker free even when the sequel is driving over the ground wave or crashing into a cardboard box. (In this picture Frank holds onto the cardboard box with both hands.)

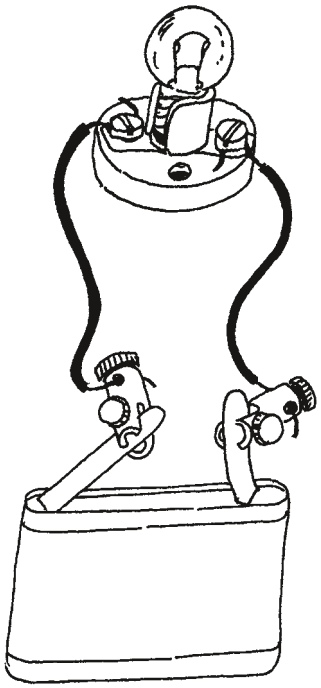


Frank's and Ayla's headlight-test required: one battery, one bulb, two wires, two terminal clips, and one bulbholder. They also needed a screwdriver. Ayla brought the car. The tape was provided by the teacher.

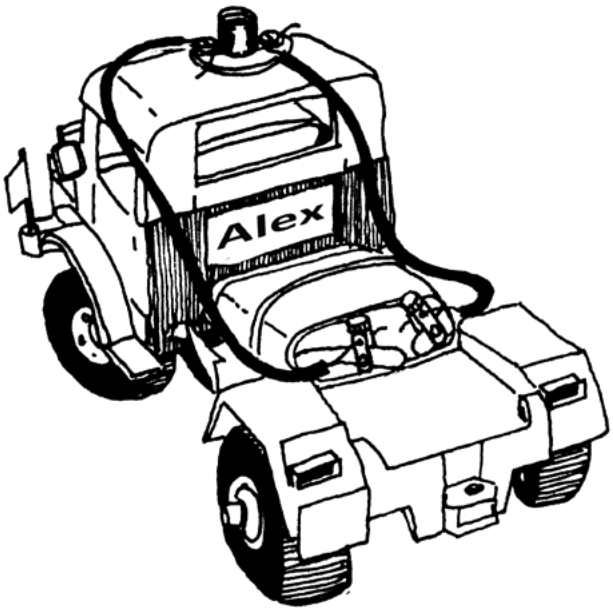
Sophie has two bulbs on her vehicle

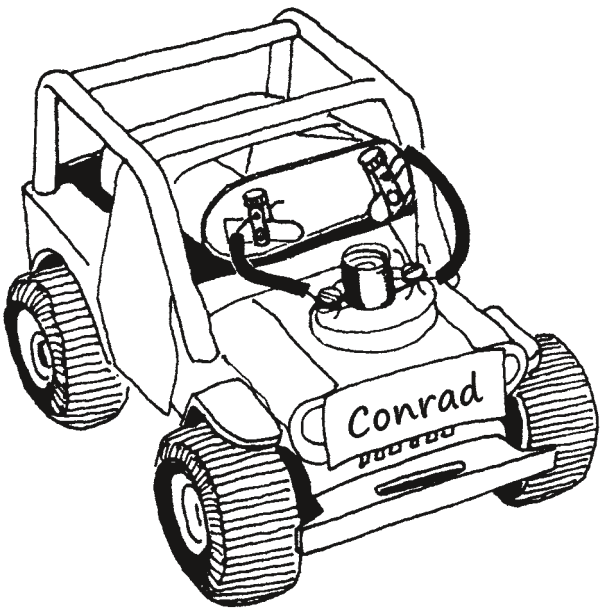
Sophie fastens two bulbholders onto her car.
When she screws in the bulbs, they both light up!



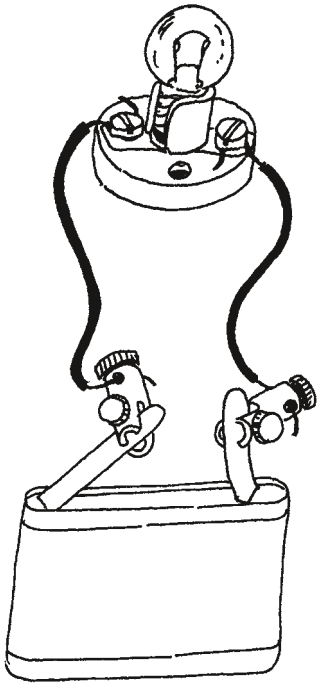


Ms. Franklin, her teacher, says:
"It also works with only three wires."
Sophie gives it a try. It works!
Alex and Conrad want to try it, too!



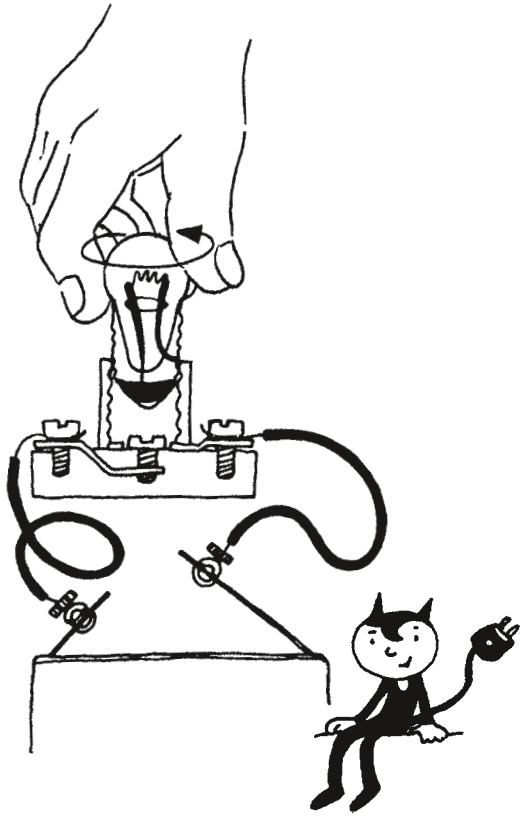


Sasha and Derya test each other's knowledge on electricity – Worksheet No. 1

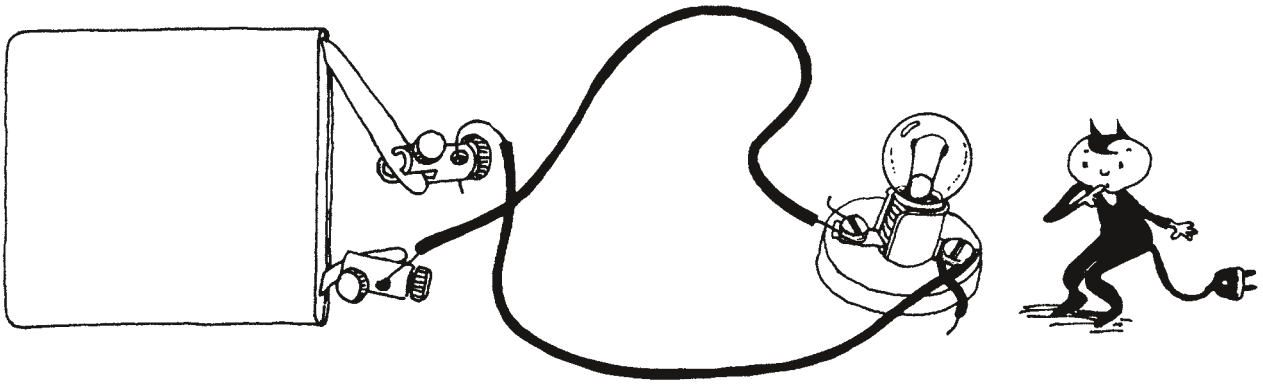


At first Derya connected the bulbs correctly without Sasha's help. It lit up.

Then Derya closed her eyes while Sasha altered something on the construction so that after opening her eyes the ball was not lightening up anymore. Derya, however, quickly found out what the mistake was.
Sasha 'had built' in the following 'mistake':



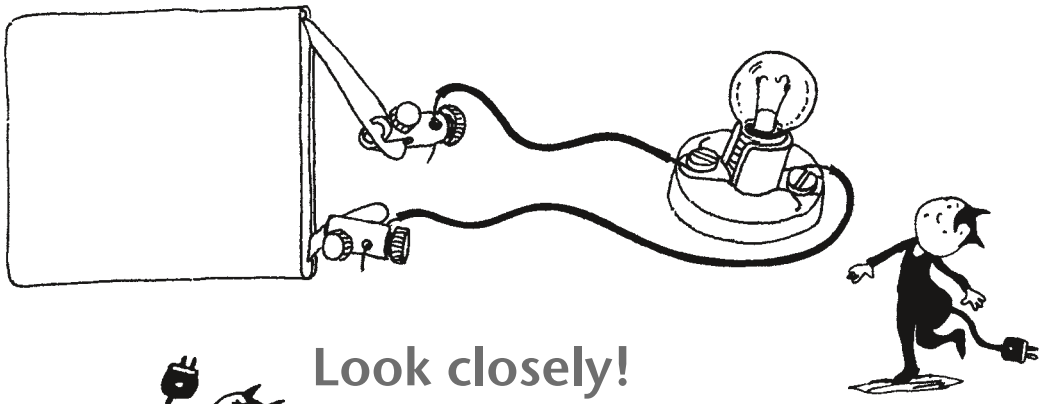
Afterwards Derya corrected everything.
Sasha closed his eyes and Derya 'built in the mistake'.



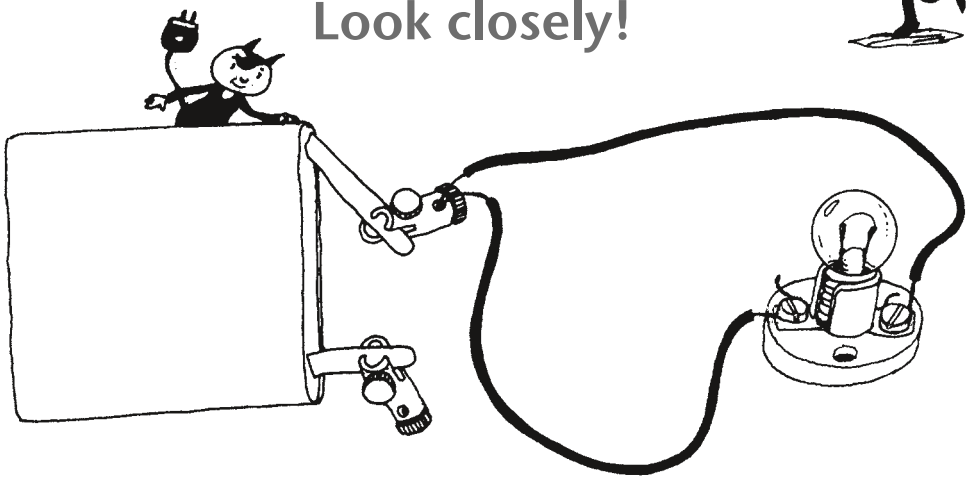
You can imagine, how it continued.
Further 'ideas for mistakes' can be found on the second worksheet.

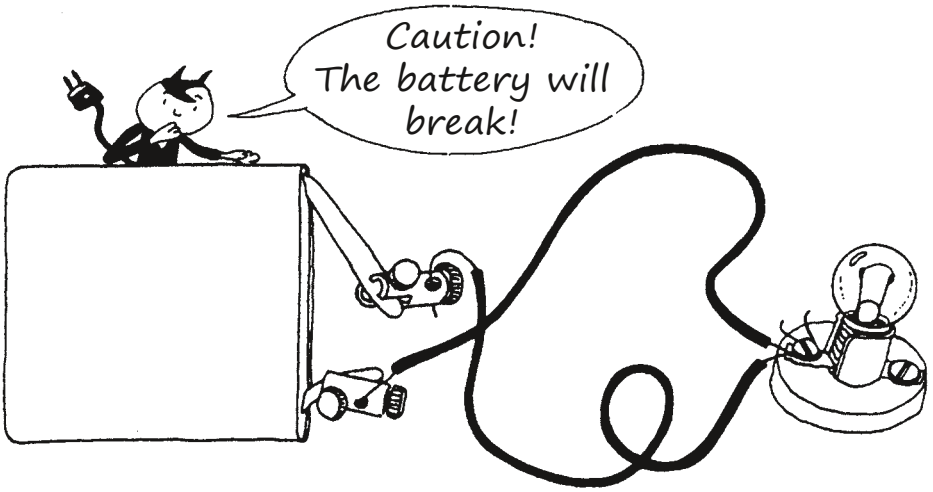
Sasha and Derya test each other's knowledge on electricity – Worksheet No. 2

Take a close look at the bulb!



Look closely!



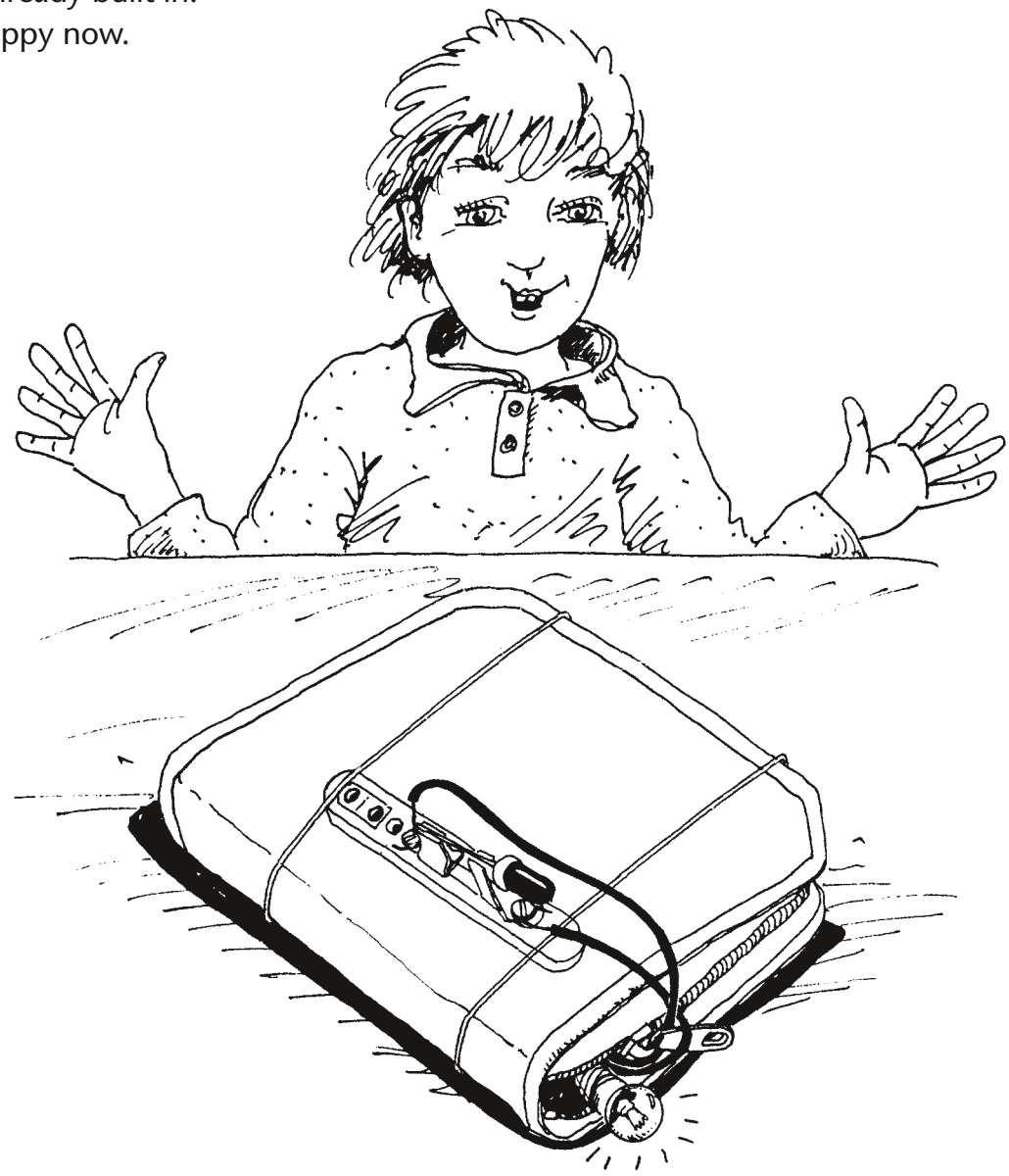


Alert: the last 'mistake' must only take place for a short period of time, since the battery discharges very quickly. It is best to use an old battery which does not have much current left anyway.

Improving Murat's pencil case light

Do you remember? That is Murat's pencil case light from station 16. At first he was quite happy with it, for it glowed very steadily, was flicker free and handy, too.
Now, however, he feels that in one respect it is impractical. Whenever he wants to turn it on or off, he notices: the switch is missing.

Here, it is already built in.
Murat is happy now.
And you?



- You can find help on the worksheet no. 16 and no. 24.
- Make a draft into your 'book on electricity' how Murat connected the bulbholder and the switch with the three wires with the battery.

A checklist: switches in our apartment

Electric current can be turned on and off with a switch. Since a lot of things in our home run on electricity, we have a lot of switches.
But, **how many?**
Close your eyes and take a walk through your apartment. Think of all the things you can turn on and off. For each switch that you operate in your thoughts, draw a line:
For instance, the line for the switch on the TV, for every light-switch on the wall, and for every light switch on the table lamp as well as reading lamp and so on.

children's room _____

living room _____

bathroom _____

kitchen _____

bedroom _____

_____

_____

If there are rooms missing,
complete the list on your own.

Safe electricity – for the sake of the environment and your purse

Mini-reminders

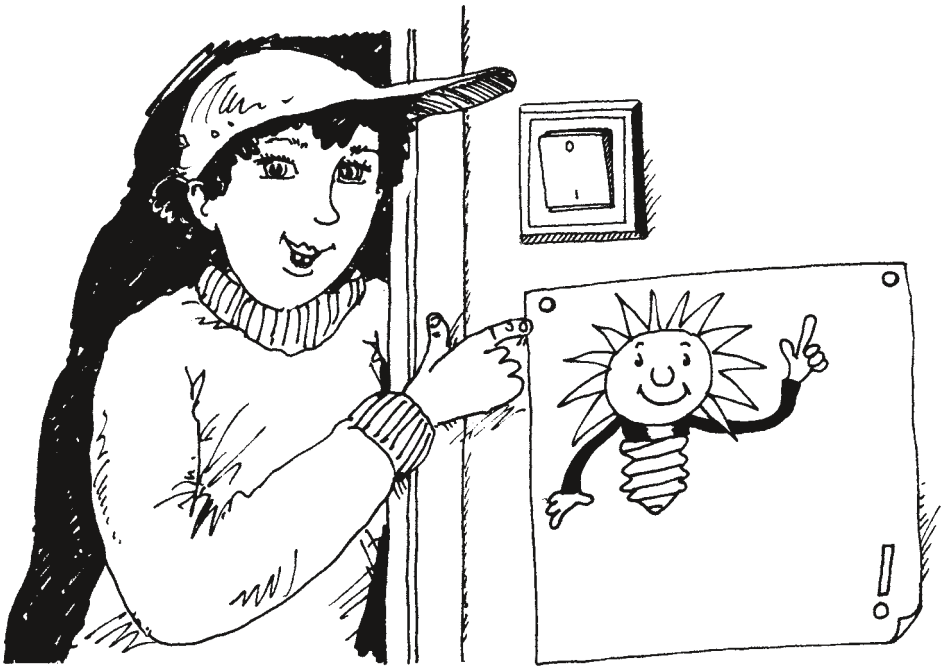
You have probably noticed it already: many people forget the purpose of switches. The always remember that with switches you can turn on the lights and the TV, but they forget to turn them off.

Especially teachers and pupils often forget that you should turn off the light in the classroom when it is not needed anymore.

So the lights and the sun race each other shining in empty classrooms, illuminating boards and desks where no one is writing anymore.

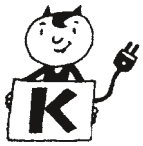
What should be done?

- Ask the facility manager or school administration for the electricity bill of one year. Remember that the bulbs do not work indefinitely – they have to be bought anew.
- Report the results of the interview to your class. Write down the numbers on a thick sheet of paper.
- Design a mini-poster which can be put up on the door of your classroom reminding everyone of the switches.



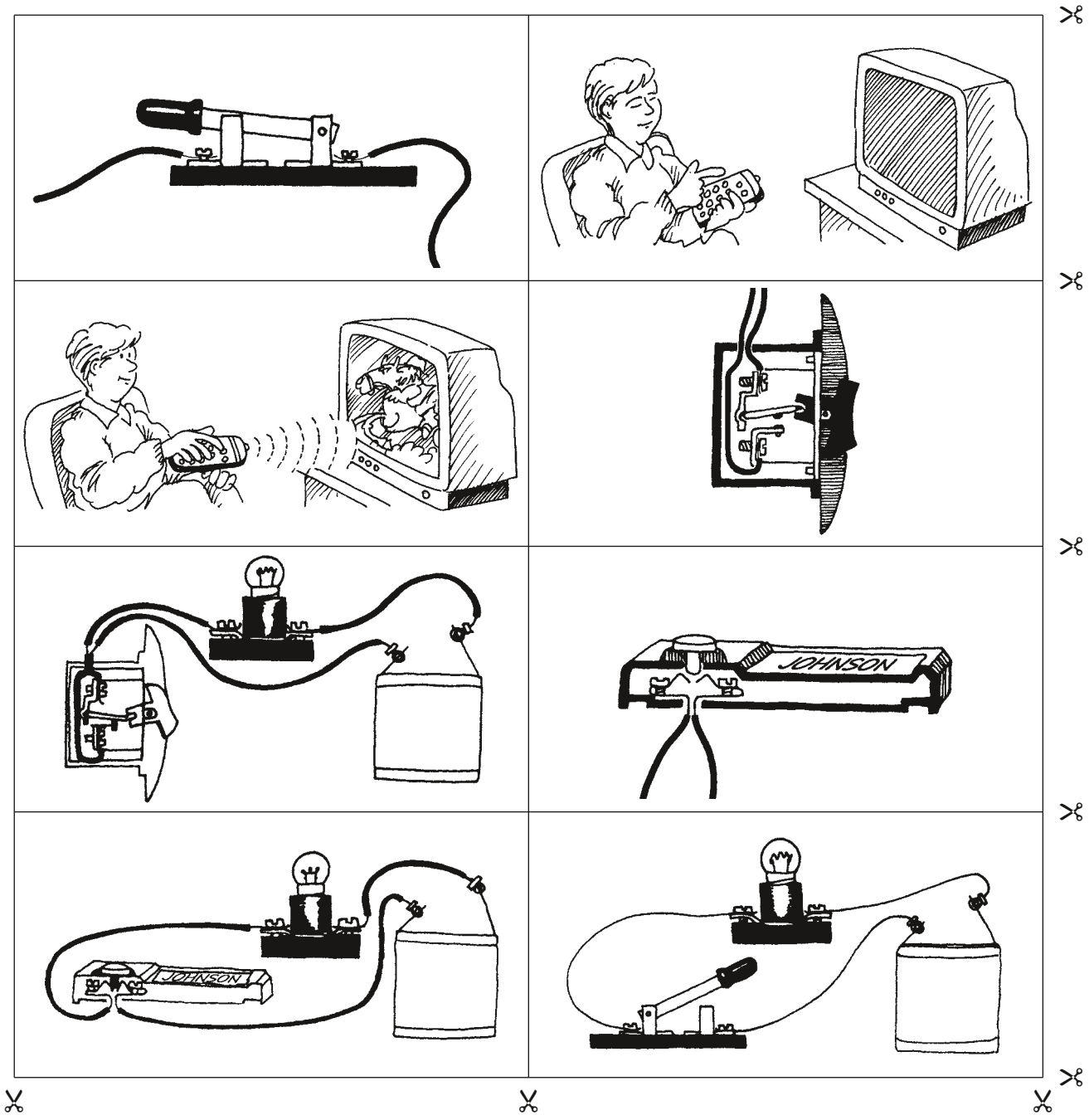
This 'Mini-Poster', designed by Frederick, reminds everyone to turn off the lights during recess.

Four switches – on and off

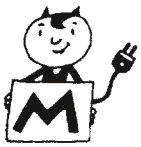


Our illustrator has dismantled four different switches and made a simplified sketch – in it's 'on'-position and in its 'off'-position.

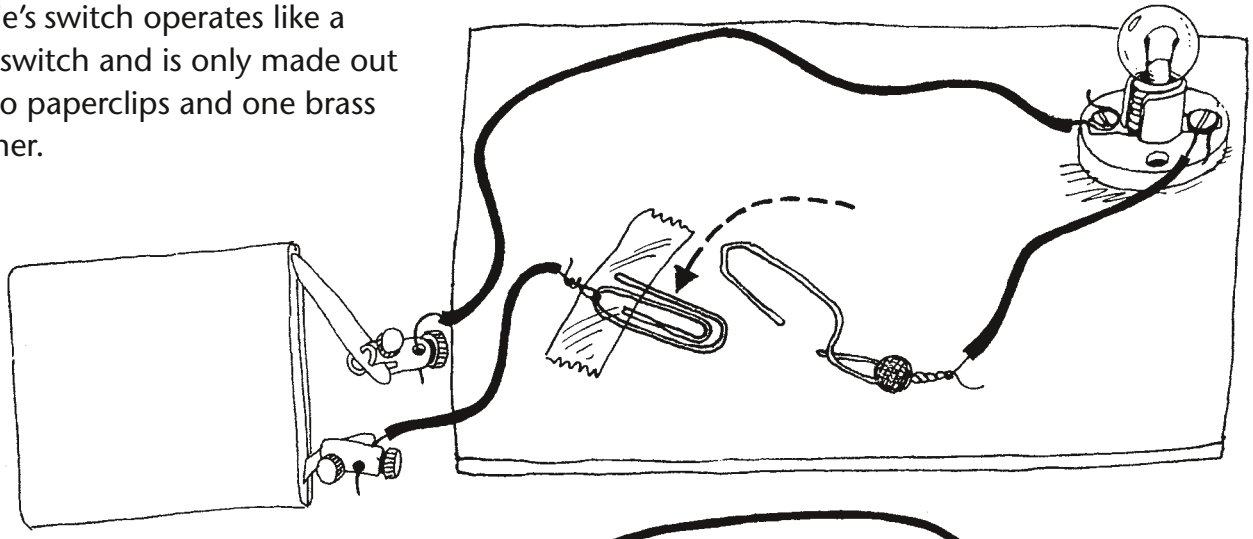
- Cut out the eight pictures.
- Look for the pair of pictures belonging together, stick it side-by-side and write 'on' or 'off' below it.



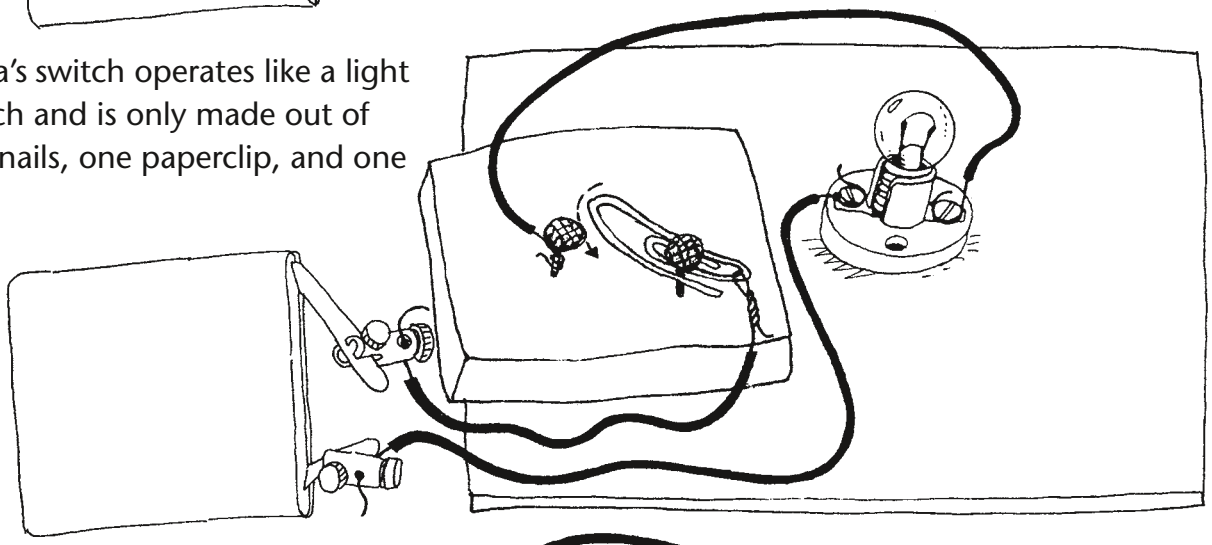
Building our own switch



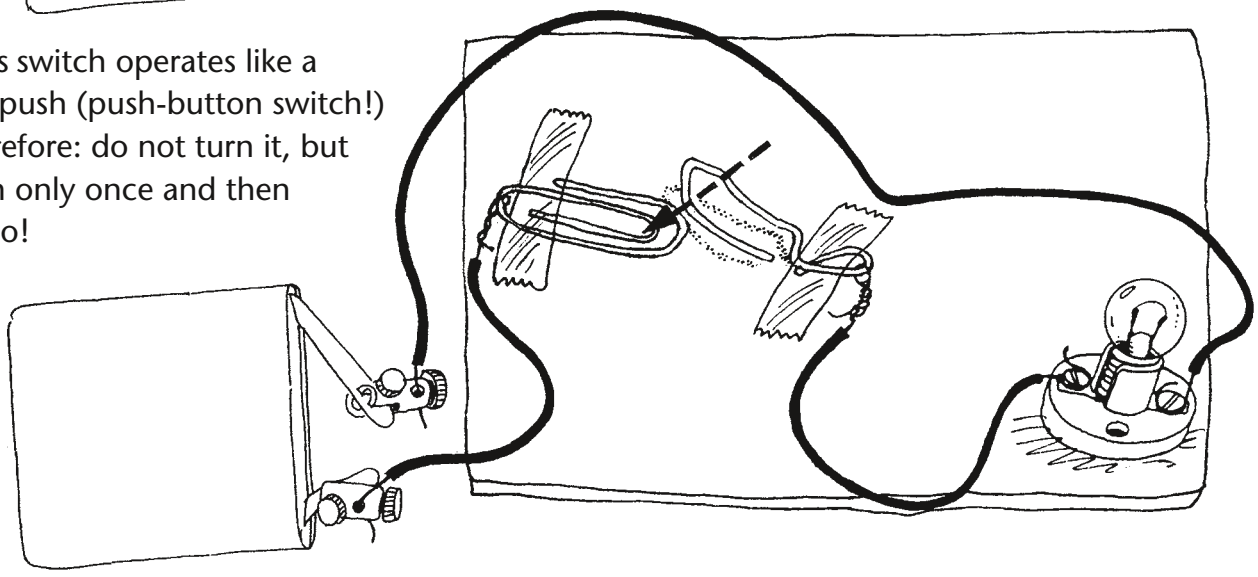
Valerie's switch operates like a light switch and is only made out of two paperclips and one brass fastener.



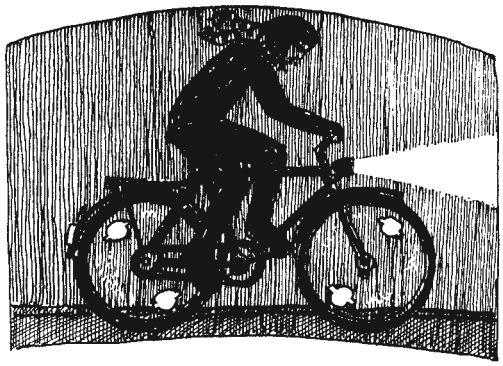
Paula's switch operates like a light switch and is only made out of two nails, one paperclip, and one box.



Tim's switch operates like a bell-push (push-button switch!) Therefore: do not turn it, but push only once and then let go!

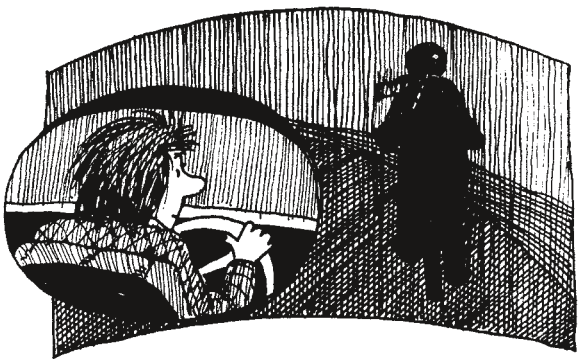


Bicycle light: riding a bicycle at night – Worksheet No. 1

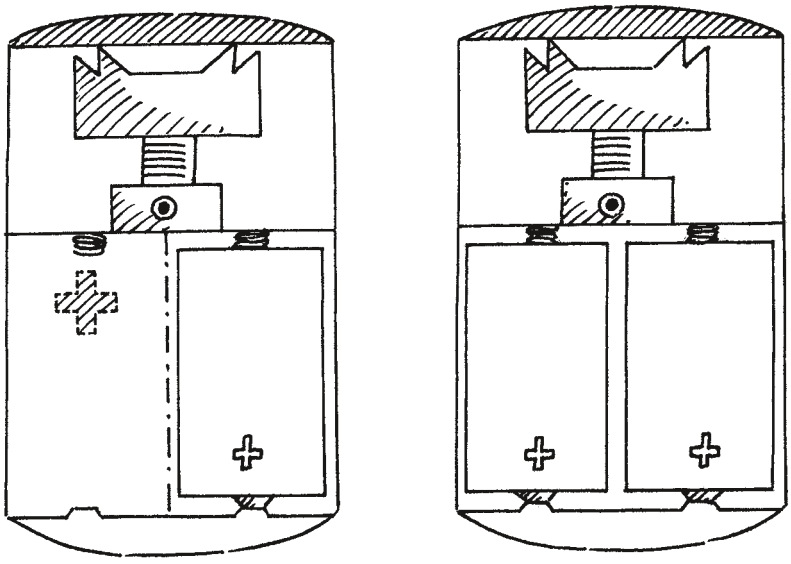


← correct

wrong →



- Imagine you are a car driver. You just got a terrible fright because you had not seen a cyclist. In order to tell him that, you turn your car around, follow the cyclist, and talk to him.
- Act out this dialogue. One classmate is the cyclist. He understands the problem. He explains that he also does not understand why his battery light is not working.
- Can you accept this 'excuse'?
- What might be the reason, why the bicycle light is not working?

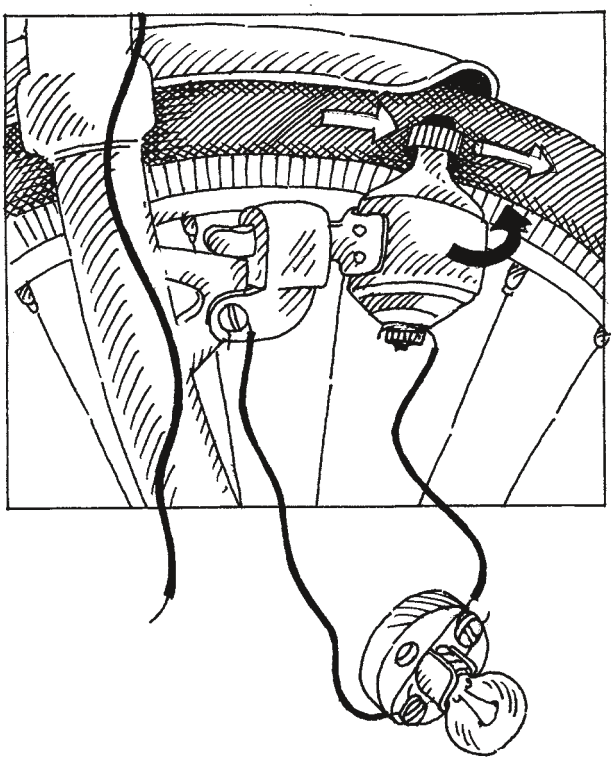


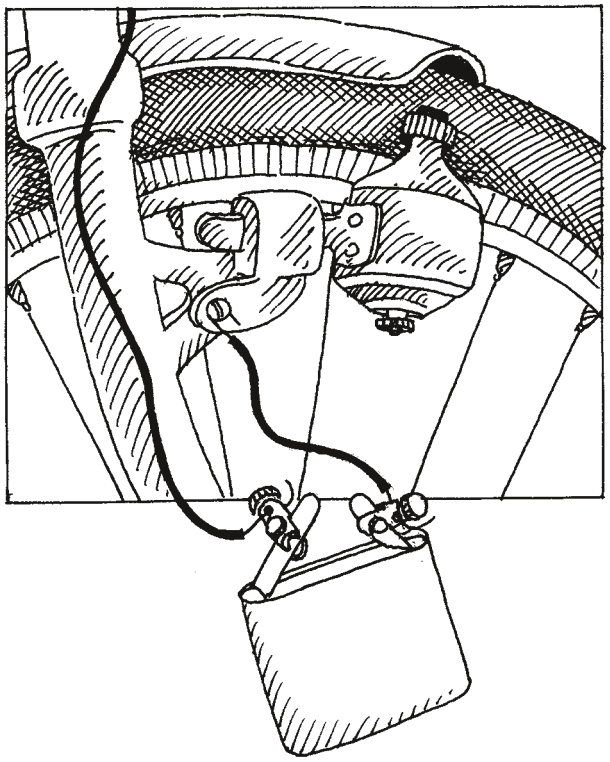
- Explain the reasons to your teacher.

Bicycle light: Experiments – Worksheet No. 2

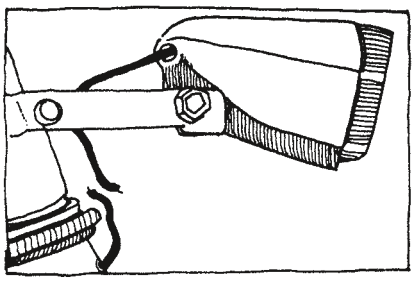
V

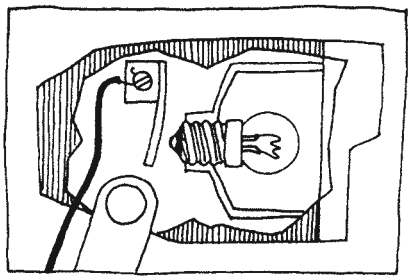
- Here are some experiments with bicycle lights.
  Try them, too!





- That is so typical of bicycle lights!
  The three most common **mistakes:**



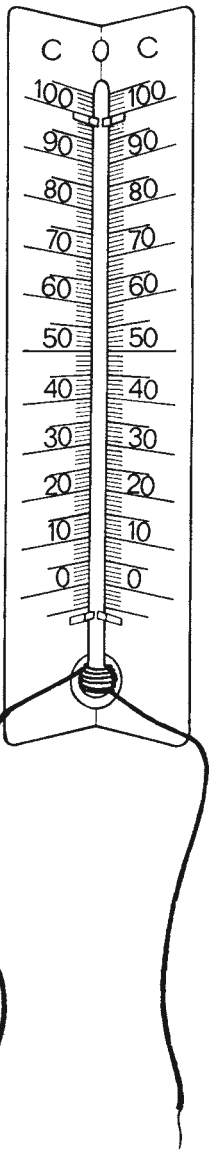


- Present to your class the three most common mistakes made with bicycle lights.
  For you are the traffic policeman, who always instructs the class on traffic.
  Illustrate the mistakes on a bicycle.

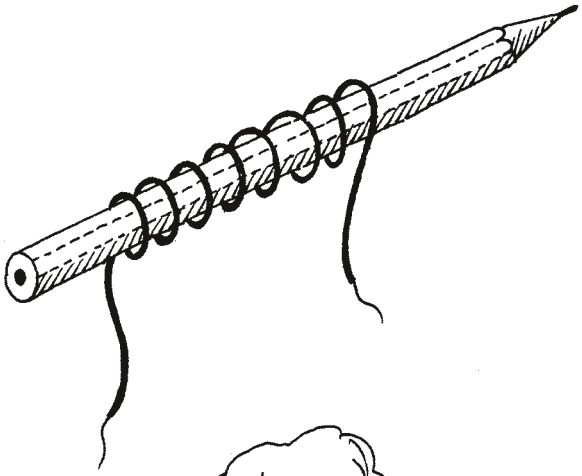
Heat from the battery – Worksheet No. 1

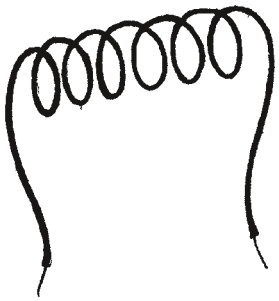
For this experiment you need 30cm of heating wire, a new battery, one terminal clip, a thermometer, and a pencil.

- Scrape the heating wire bare at its ends (with scissors). Ask the teacher or another child for a demonstration.
- Wind the heating wire firmly around the pencil and slip it off again. You made a coil.



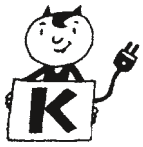
- Slide the coil onto the thermometer bulb as illustrated in the picture.





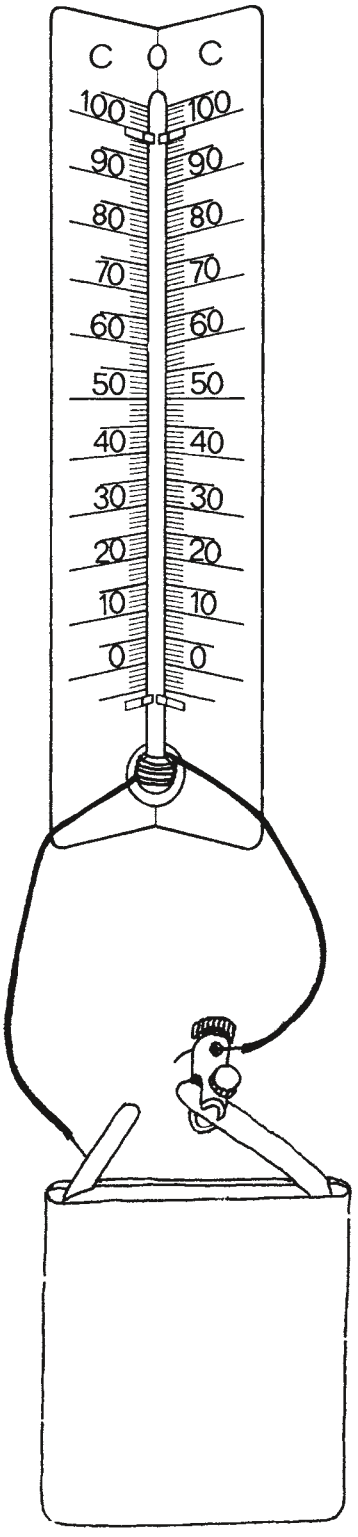
To be continued on the worksheet no. 2.

Heat from the battery – Worksheet No. 2



- Put down the thermometer, with the heating wire wound around the thermometer bulb, on the desk. Which temperature do you read?

  ____° Celsius



- Connect the loose ends of the heating wire with the battery as illustrated in the sketch.
- Wait till the thermometer stops ascending. Should your thermometer rise up to 90° Celsius, you need to cut the current. Mark the end of the red thermometer liquid into the thermometer on this worksheet.

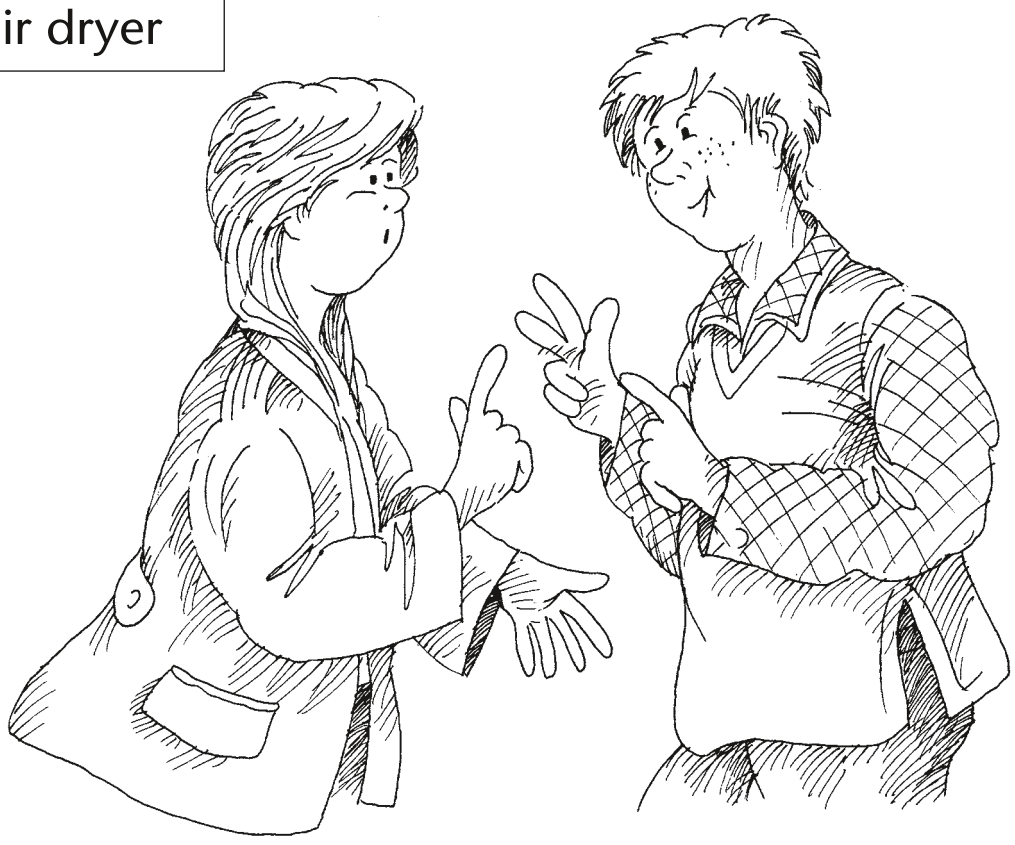
At the beginning of the experiment the thermometer indicated ____° Celsius.

At the end it was ____° Celsius.

Heat from the socket

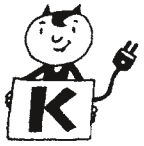
A lot of electric appliances need to generate heat:

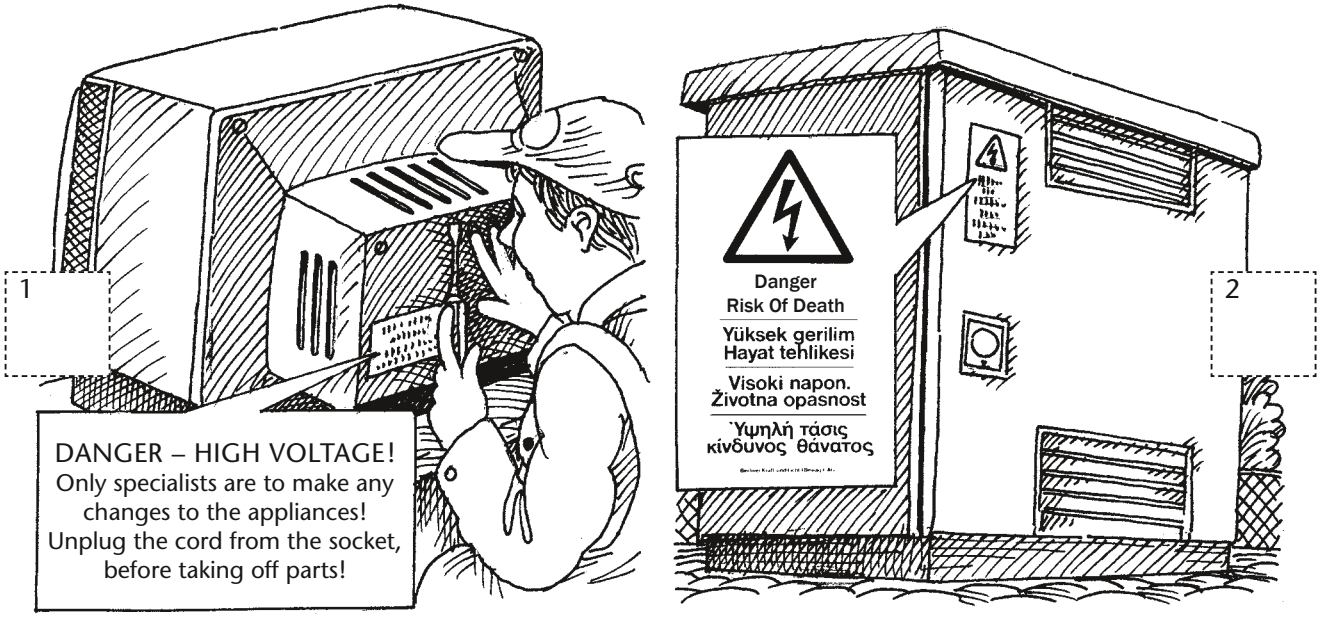
electric kettle
dish washer
iron
washing machine
soldering iron
stove
coffee machine
heating pad
immersion heater
oven
toaster
hair dryer



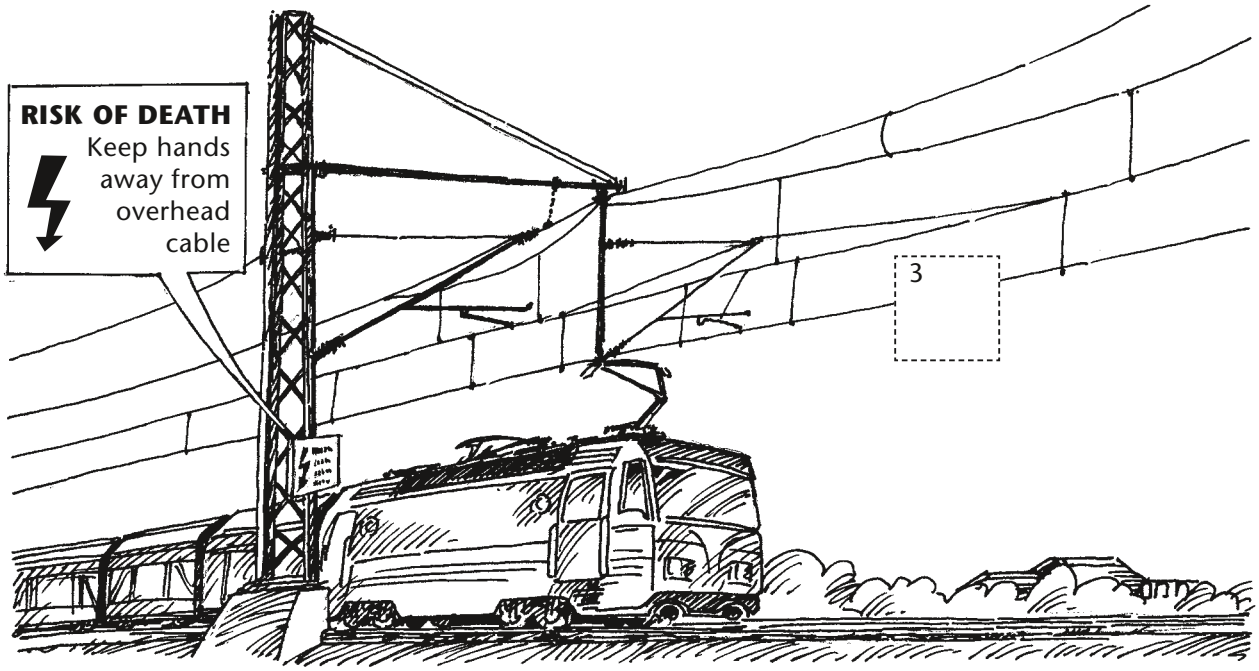
- Which of these appliances do you have at home? Write them down.
- Imagine there is a blackout. Which appliances can you not use anymore?
- Out-count each other.

Seven times risk of death – Worksheet No. 1



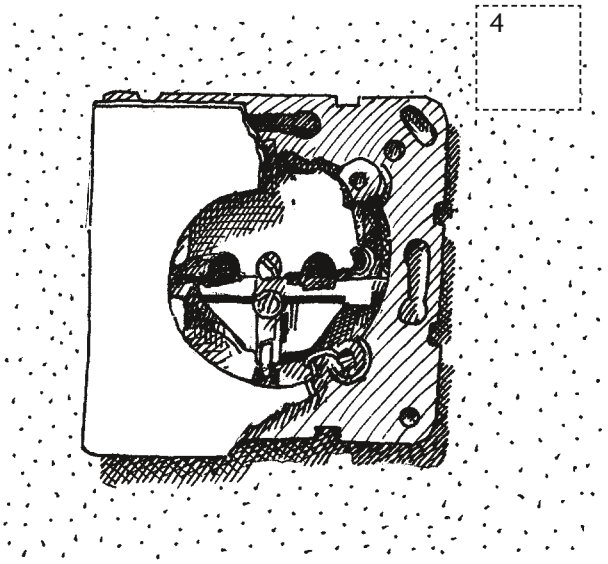


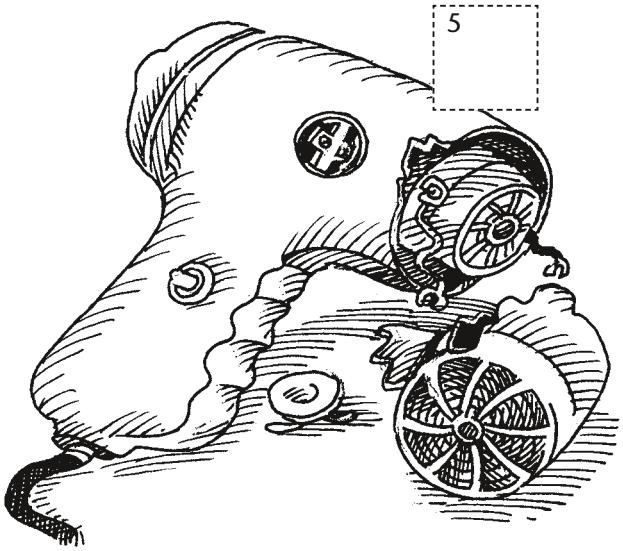
The signs cannot be everywhere. Nevertheless, there is danger.

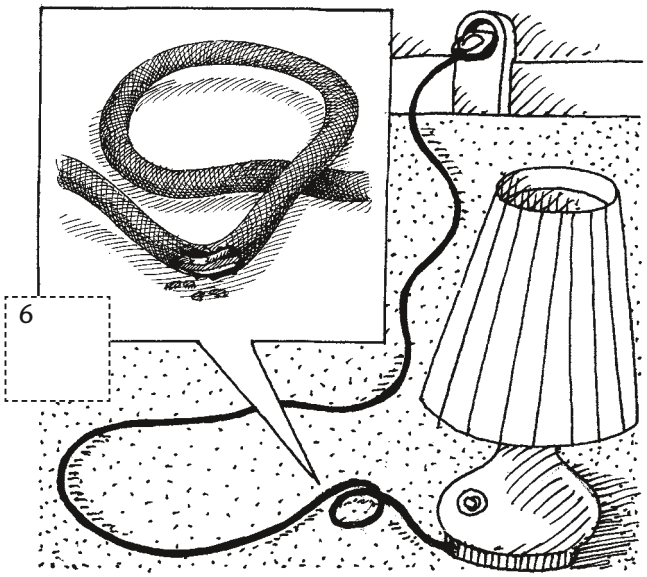


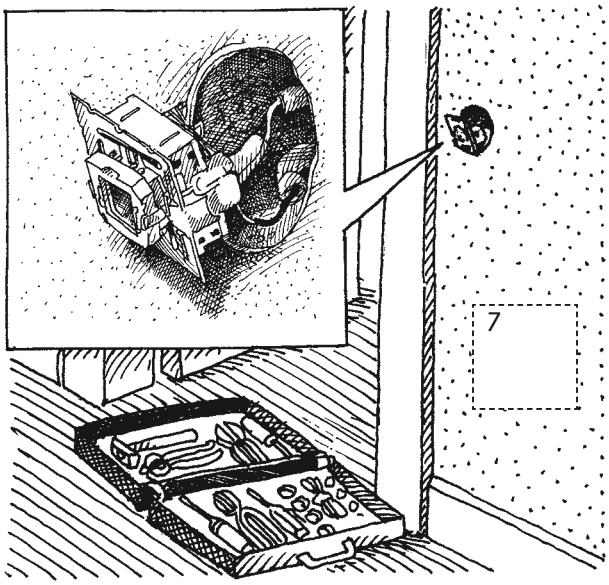
To be continued on worksheet no. 2.

Seven times risk of death – Worksheet No. 2









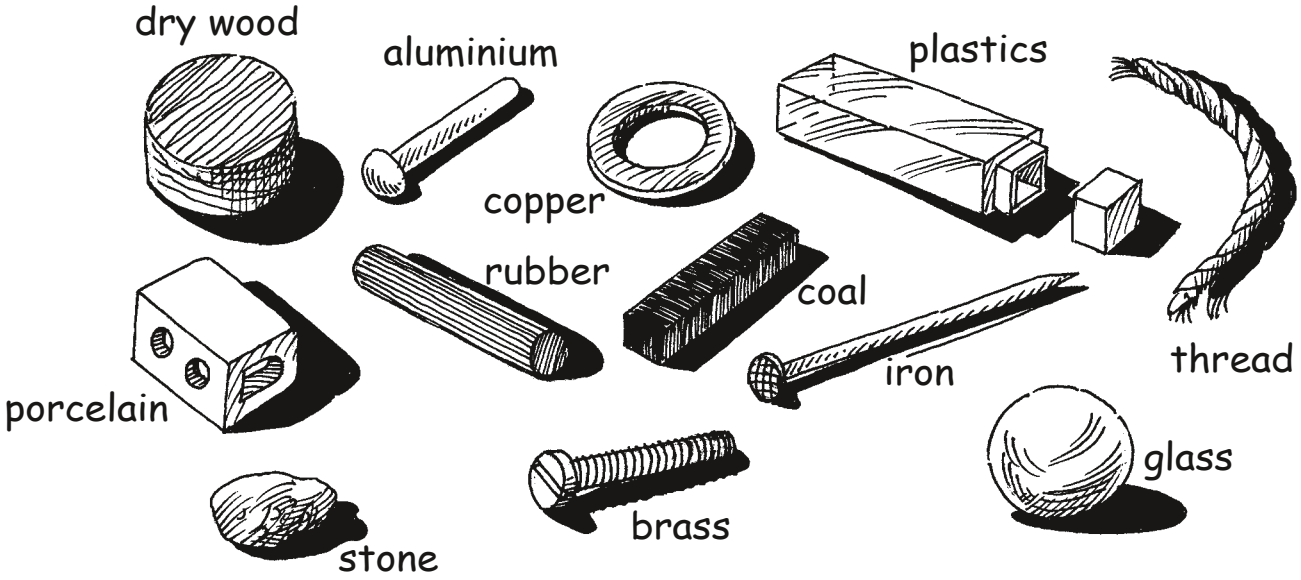
- Cut out the signs with the death's head and stick them on the numbers.
- Discuss with your partner the following questions (and report to the class):
  1. Where can you find signs such as in picture 2?
  2. Where can you find overhead cables or life rails such as in picture 3?
  3. On a lot of appliances there is a warning on taking off parts (picture 1). Which do you know?
  4. Have you ever encountered something similar such as in picture 4, 5, 6, or 7? Report. Ask adults about accidents with electricity. Also about those which they have read about in the newspapers. Report it to the class.

How to protect oneself from an electric shock – Worksheet No. 1

How do you protect yourself from electricity, which can be dangerous?
That is easy: by hiding the electric wiring behind the material which does not conduct the electrical current.

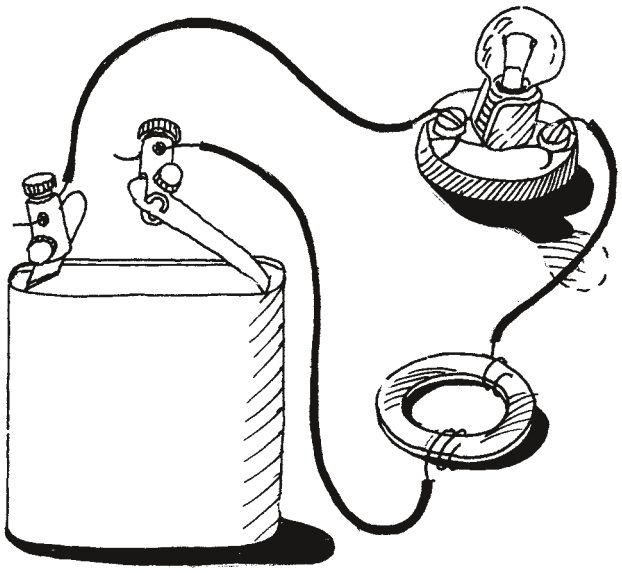
Which materials are suitable?
From which materials should casings of electric appliances, insulations of wires and arms be made of?

Try it with these materials:



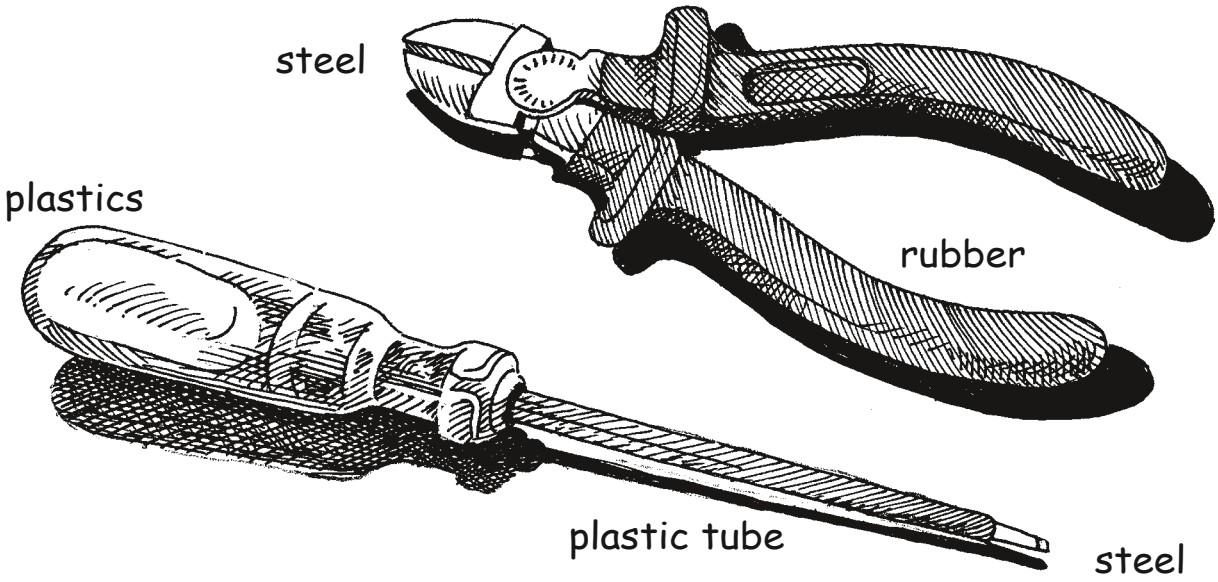
Try it this way:

- Write down separately the materials which conduct electrical current and those which do not.
- Circle the materials which protect (insulate) from electric current.



How to protect oneself from an electric shock – Worksheet No. 2

- This screwdriver and cutting pliers belong to an electrician. Take a close look at the materials. What do you see?
- Examine the screwdriver or the switch from the box. Which parts of our switch or screwdriver conduct electrical current, which do not?
  Try it out.
  Despite these special tools, you may do the experiments only with batteries.
- Bring similar tools from home.



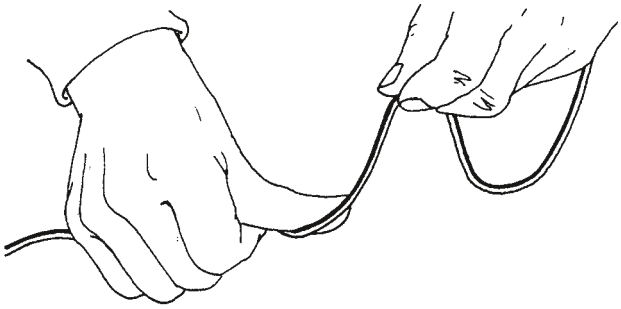
The trembling rollercoaster

This game of skill is called 'trembling rollercoaster' because a player collects penalty points when he or she trembles and touches the wire, consequently, lightening the bulb.

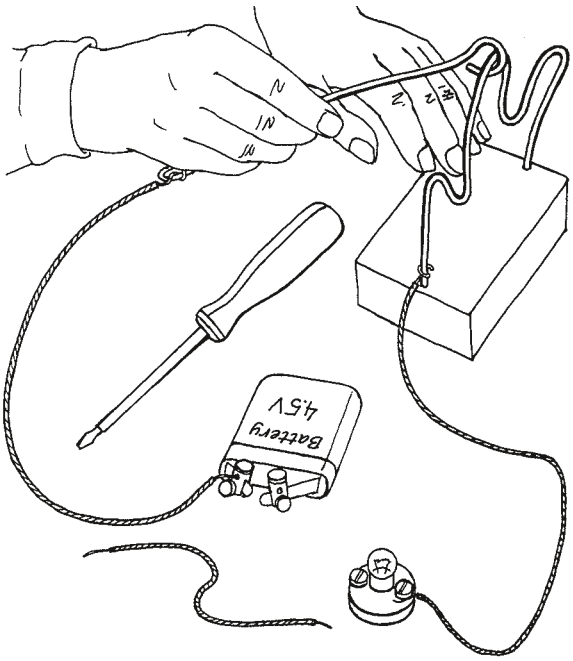
You need:

1. *Two pieces of thick wire (copper wire) free of insulation: the first ca. 50 cm and the second ca. 20 cm long. Bend the wire so that it stays in its formed shape. Ask an adult for help. He or she might cut the hanger made out of wire with the pliers or pull out a core from a thick electric cable and get rid of the insulation.*
2. *You also need a polystyrene block of 15 x 15 x 4 cm. A lot of times packages have such polystyrene material. Everything else is in the box.*

Bend the copper wire (50 cm) into the 'track' and stick the ends into the polystyrene block.



Loop one end of the second copper wire (20 cm), but leave a little opening.



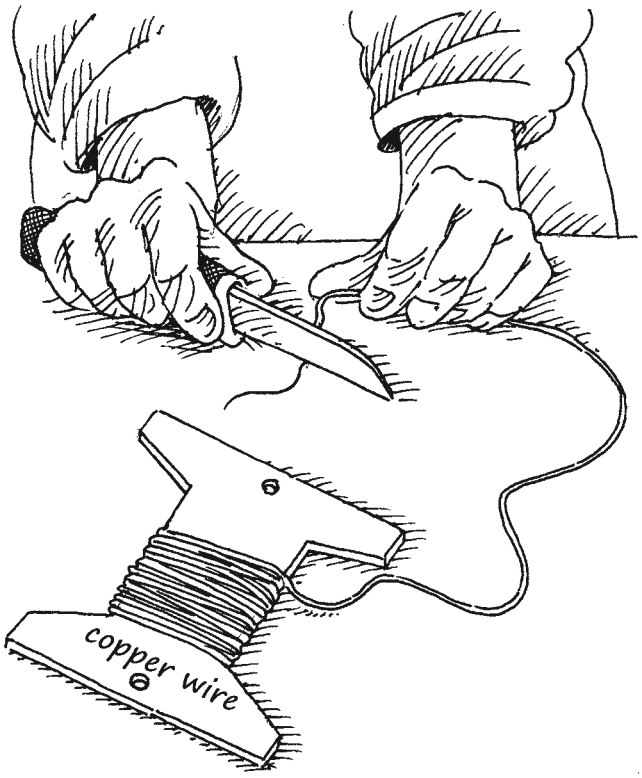
Connect the other end of the loopstick to the battery, using terminal clips and the insulated copper wire. All connections should be firm.

■ Create your own rules. For instance, you can stop the time with a watch having a second hand.

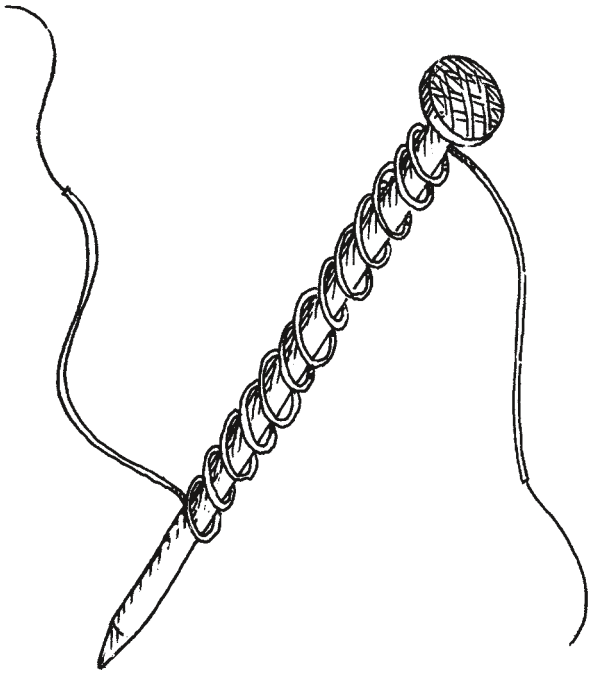
The robot game – Worksheet No. 1

This special game with an electromagnet is for two.

You need:
From the box: 1 m copper wire (the thin, golden wire on the spool), one long and one short nail, one battery, one terminal clip, scissors or knife for scraping, and a piece of tape as well as a sheet of paper and a pen.



Carefully, scrape off the ends of the copper wire.
It will look completely different.

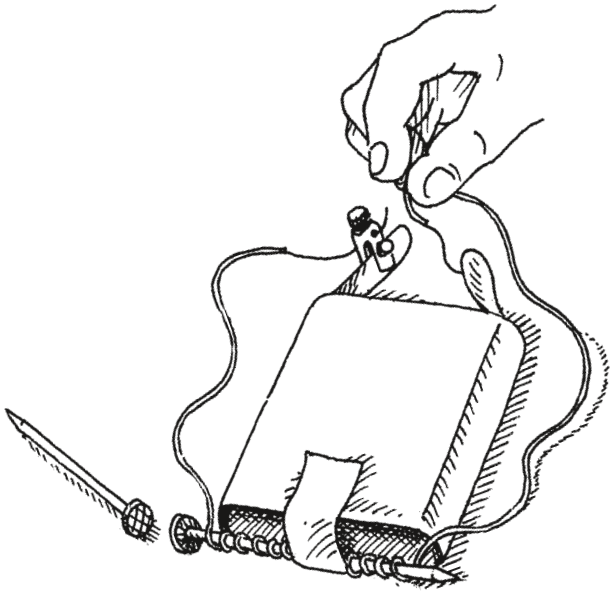


Leave a few centimetres at the ends and wind the rest of the copper wire around the long nail.

To be continued on worksheet no. 2.

The robot game – Worksheet No. 2

- Stick the nail with the tape horizontally onto the battery and connect one end of the wire with the terminal clip to the battery.
- When you touch the battery with the other end of the wire and get closer to the short nail, something happens …
- Lift up the short nail and release the loose end of the wire.



What could you play with the electromagnet? Nezehat and Stephen designed the following game:

They divided a sheet of paper into different fields.

3	5	7	2
8	1	4	6

Into each field they wrote a number representing 'points'.
Then they put down the sheet on the ground. The goal is to push the short nail down from the desk onto the sheet without touching the nail (only by using the electromagnet).
You get the points of the field the nail lands on.
It is your loss, if it lands on two fields.

Teacher's manual
Experiments in workstations / 'Electric Circuits'
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