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The Inventor

■ Using this construction set, you can not only learn about the technical revolutions, but you can experience them live—things that have changed the world. Just put it together and try it out. When you do this, you can assume the role of the inventive tinkerer. Perhaps you will feel the touch of the ingenious spirit, which surrounded the inventor himself, while you are doing this.

Come on get started, or you can learn some more about the people, who are behind the inventions, on this page.

Inventions are all around you. Just take a close look at some things at home. The incandescent light bulb on the ceiling, the television in the living room, the telephone in the hallway; the refrigerator, the vacuum cleaner and so forth. Even letterpress printing had to be invented so that books were available in large numbers. Just the same as this activity booklet that you now have in your hands.

Everything is really simple, you say? However, many of the ideas, which appear to be obvious to you today, had to be thought of first.

Edison— The "Profi-Inventor"



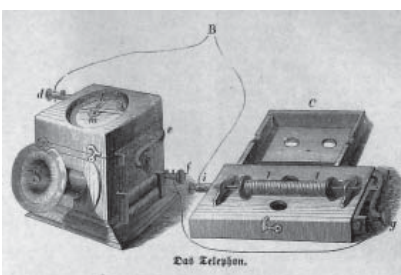
Incandescent light bulb from Heinrich Göbel

■ One of the people, who had a lot of ideas patented, was Thomas Alva Edison. Generally known as the inventor of the incandescent light bulb.

During his lifetime, Edison amassed 2000 inventions and 1093 American patents. However, he didn't make all of these alone, but in his company with the help of many employees.

Many inventions were only further developments of devices of other inventors. For example, including the light bulb. Did you know that? Basically, this was not his idea! But he did improve it to the extent that it became useful for everyday use. And above all, he had it patented right away. This is of course very important. There are many inventors that nobody talks about today because they did not have their invention patented. Or even worse—they simply did it too late.

Gray or Bell?



The Reis telephone

■ It is the year of 1860 and a physics teacher in Friedrichsdorf near Frankfurt am Main (Germany) has built a scientific demonstration object for his students. With a wooden model of an eardrum, he causes an electric circuit to vibrate. He transmits these vibrations by cable to a copper wire coil in a small wooden box, which makes the vibrations audible. In doing this, he succeeded as the first person in constructing a functional electrical telephone connection; his name is Philipp Reis. Never heard anything about him? This is certainly due to the fact that he never applied for a patent for his device and also did not market it as a telephone.

But an American did this about 15 years later. He learned about the device from Philipp Reis, developed it further and applied for a patent. Thus, Elisha Gray did it right. Have you ever heard anything about him—Elisha Gray, the inventor of the telephone? No? Well, in this case this was because he did it too late. Somebody was there before him and also applied for a patent for a telephone—just two hours earlier. His name was Alexander Graham Bell. Since then, he is considered to be the inventor of the telephone. And the strange thing about this is that the device, for which he applied for a patent at that time, didn't even work. Bell only found out that other people were working on a similar device and so he applied for a patent for his half-finished device as a precautionary measure.

■ Have you ever thought about what happens, when you are standing in an elevator and the bearer cable breaks, which is holding the elevator car?



During an international industrial exhibition in New York, a man shocked the crowd, which had gathered, as he was standing high above on an elevator platform and cut the only bearer cable holding this platform. The platform only dropped a short distance before it came to a complete stop. The revolutionary new emergency brake of this clever master mechanic insured that the platform did not crash to the ground. "All safe, gentlemen!" announced the man.

This took place in 1854 and the man on the elevator platform was Elisha Graves Otis, the founder and the namesake of the elevator company, which still exists to this day.

Before this, no one liked to visit the upper floors of a building. With the development of the safety elevator, this trend was reversed. Rooms on the upper floors suddenly became "in" and the demand rose steadily. This accelerated the construction of high-rise buildings and thus changed the

face of major cities. Skyscrapers became symbols for power and respect and continue to be a prominent feature of the cityscape to this day.

As of today, you will now certainly enter an elevator with new feelings. Take a closer look at the keypad (or manufacturer's nameplate). If the name OTIS appears on this, then from now on you will certainly think about this courageous master mechanic from New York.

Task

Play with the rate of fall of the elevator car a little bit. First, let the rope slide through your fingers slowly and then fast. When is the emergency brake triggered? Why does it brake only when you let go of the rope suddenly?



◀ Pull up the elevator ...

... and then let go suddenly ▶



Invention of the safety elevator

The Safety Elevator

"All safe, gentlemen"

Profile

Inventor

Elisha Graves Otis
(1811 - 1861)

Place of Birth

Halifax, Vermont, USA

Profession

Master mechanic

Outstanding Achievement

Invented the safety elevator



The Electric Motor

1819

Hans Christian Ørsted discovered that electricity can generate magnetism.

1821

Michael Faraday proved that electromagnetism moves in a circle around a wire. Without this effect, an electric motor would not rotate.

1822

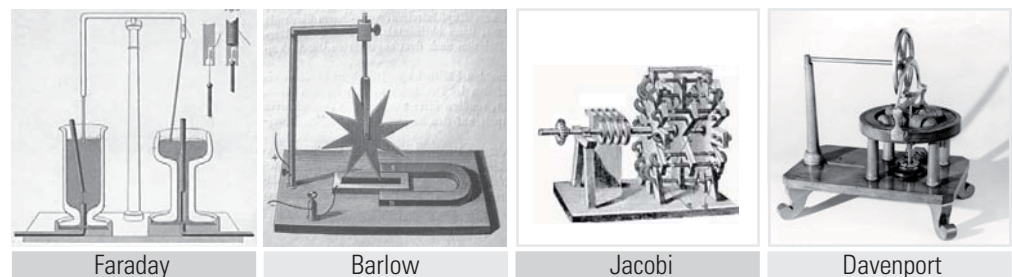
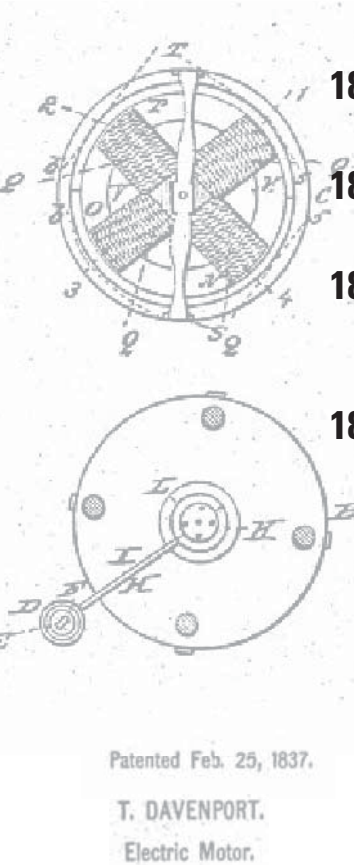
Peter Barlow developed Barlow's Wheel, which is named after him. A sort of forerunner of the electric motor.

1834

The engineer, **Hermann Jacobi**, designed the first technically usable motor. He installed the motor in a six-person ship and cruised across a river with 220 watts of power. This is the first application of an electric motor in practice.

1837

The American, **Thomas Davenport**, received the first patent in the world for an electric motor on February 25, 1837. His motor powered several machines and a carriage.



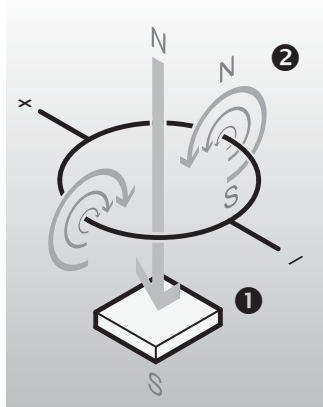
Faraday

Barlow

Jacobi

Davenport

■ When you build the model electric motor then insure that the magnet is directly under the coil and the ends of the wire of the coil are not bent. Otherwise the coil will not run smoothly and the motor will not work properly. When everything is assembled and connected and you push the coil a bit, you will be amazed at how it rotates like crazy and is seemingly driven by an invisible hand. Well okay, you already know that electricity and magnetism play a role here. But what exactly is happening here?



Schematic diagram

The principle is actually very simple. When you have two magnets in your hand then you have certainly noticed that they repel each other or attract each other depending on how you hold them together. The effect here comes from the magnetic fields which surround every magnet. They have a direction of flow and thus determine a north pole and a south pole. Same poles repel each other and different poles attract each other. One magnet is built into the model (1). The other magnet is the coil, which becomes an electromagnet as soon as current flows through it. If you send electricity through the coil then this produces a magnetic field (2) with a north and south pole. Same poles repel each other and so the coil tries to move away and because it can only rotate then it does just this. Before it rotates into the optimal condition, in which the different poles would be across from each other, we just cut off the electricity to the coil (look at the ends of the wire, they are only conducting to one half). However, using the momentum, which has

been attained, the coil rotates a bit further until it again receives electricity and the game starts from the beginning again.

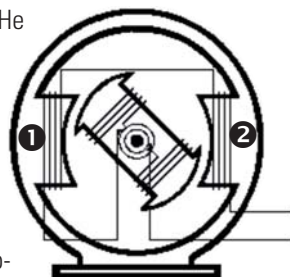
■ The electric motor and the generator are very similar machines, which are only operated as opposites. The electric motor produces a movement from electricity while the generator generates electricity from a rotational movement. Theoretically, you could also generate electricity with your electric motor model. However, in order to do this you would have to rotate the coil very very fast if you wanted to have a mini-light bulb get even close to producing just a little bit of light. This works better with the generator model from the assembly instructions, which can produce a useful rotational speed thanks to the preceding gearbox. However, this is also only just sufficient for a little light bulb. The biggest problem here is the weak magnet.

Brainteaser

Do it like Edison, take an existing invention and improve it:

How can you solve the problem of a magnet, which is too weak? Do you know a magnet that you can make stronger? Go back to the previous chapter and look at the graphic there (schematic diagram). Two different magnets are described. Which one can you strengthen?

Have you figured it out? Then you are just as clever as Werner Siemens. He had the same idea in 1866. Instead of permanent magnets, he installed electromagnets, which he ingeniously supplied with a part of the electricity, which was produced by the generator itself. In this way the magnetic field reinforces itself. More electricity → more magnetic force → more electricity and so forth. This self-energizing is also called the "dynamo electric principle." In the graphic on the side, the coils of the electromagnets 1 and 2 are clearly integrated into the electric circuit.



With the dynamo, much stronger currents could be produced for the first time and also cheaper than was previously possible. This was the start of electrical power engineering. A steadily increasing number of machines could now be effectively driven by electric power. Locomotives, elevators, street cars, mine tramways and works railways were equipped with electric motors and entire streets were brightly illuminated with power lights.



First E-locomotive



Elevator



Street lighting



First electric street car

The Generator and the Dynamo

Beginning of Electrical Power Engineering

Profile

Inventor

*Ernst Werner Siemens
(1816 - 1892)*

Place of Birth
Hanover, Germany

Trained Profession
Artillery Lieutenant

Outstanding Achievement
*Invented the dynamo and is
the founder of the present-day
Siemens AG.*



The Helicopter

■ Heinrich Focke the helicopter pioneer. A restless researcher, who is fascinated by both technology and flying.

He studied mechanical engineering in Hanover. In 1924, at the age of only 34, he founded the Focke-Wulf-Flugzeugbau AG in Bremen and in 1937 the first helicopter factory in the world. By 1933, he had built about 140 fixed wing aircraft. His aircraft were technically highly developed for the conditions at that time and easy to fly. They were even so good that several flying records were made with them!

In 1934, the time has come: The prototype of the first really controllable helicopter lifts off, the FW61. Following this, came the first usable helicopters in the world.



The Secret of Flight

Profile

Inventor

Henrich Focke (1890 - 1979)

Place of Birth

Bremen, Germany

Profession

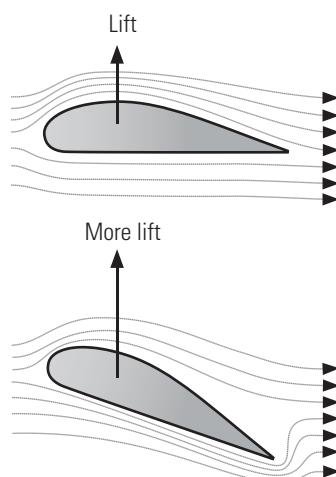
Mechanical engineer

Outstanding Achievement

Designed and built the first usable helicopter in the world.



Wing Form and Lift



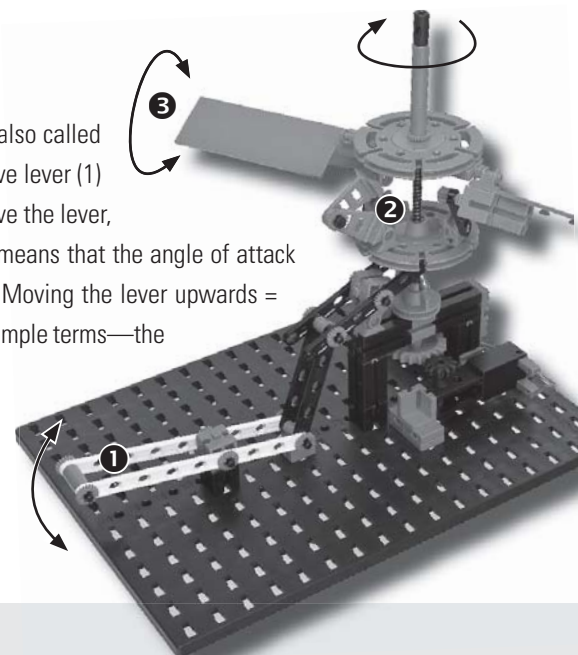
The curvature of a wing diverts the airflow and in this way generates a force, which lifts an airplane upwards; this force is called lift. This is the secret of flight. Birds knew about this long before us. You can increase the lift by tilting the wing a little bit. The experts call this increasing the angle of attack. You can observe this clearly when commercial planes take off and land.

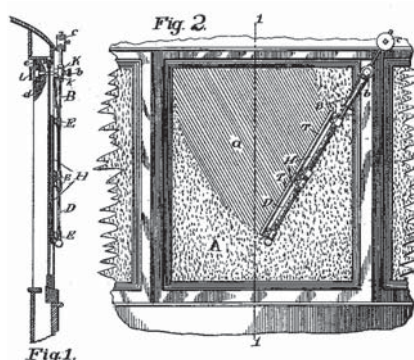
So now let's move to the helicopter. In principle, this works in exactly the same way. The wings, which are called rotor blades here, have a profile like a normal airplane. But how can the helicopter tilt the rotor blades? They are continually rotating and at a terrific speed! When you build the model, then you will have uncovered this secret as well.

The process, which is used to change the angle of attack of the rotor blades together, is called the collective rotor blade adjustment.

Mechanical Solution

The short term for the control of height (higher, lower) is also called the collective or pitch in the pilot's language. The collective lever (1) is normally located to the left of the pilot's seat. If you move the lever, then the collective rotor blade position (2) changes. This means that the angle of attack (3) of all rotor blades changes and thus the lift changes. Moving the lever upwards = increasing the angle of attack = increasing lift. Or in more simple terms—the helicopter climbs.



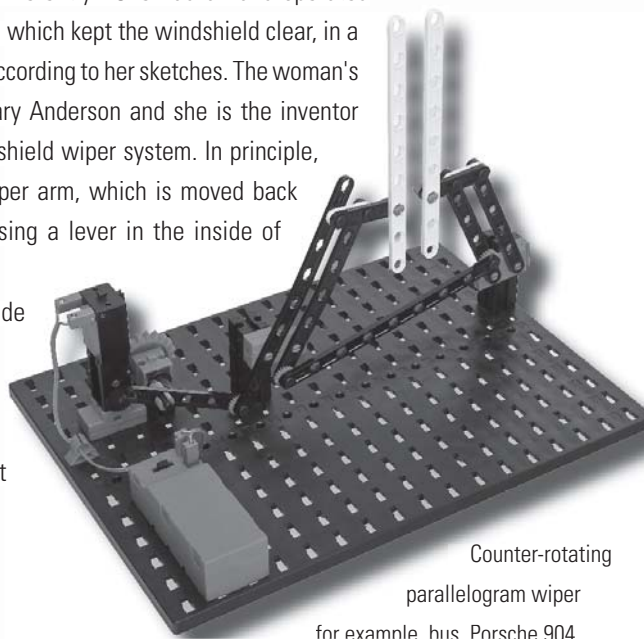


Excerpt from patent document from 1903

■ It is a cold winter day in New York in the year 1902. A young woman is sitting in the street car and sees how the driver is driving with an open windshield to maintain good visibility during the prevailing freezing rain. She thinks "It must be possible to do this differently." She had a hand-operated device built, which kept the windshield clear, in a local shop according to her sketches. The woman's name is Mary Anderson and she is the inventor of the windshield wiper system. In principle, this is a wiper arm, which is moved back and forth using a lever in the inside of

the street car.

"We don't think that a profitable business can be made with this" was the comment of a well-known Canadian company, to which she offered her wiper. In 1920, the automobile industry took over the design as part of the standard equipment, however, Mary Anderson's patent had already expired.



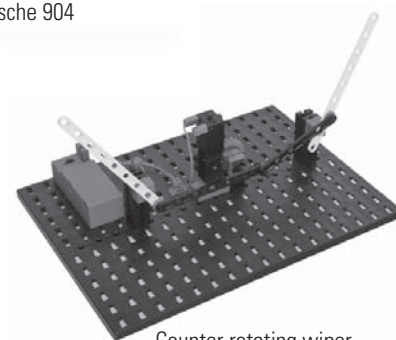
Counter-rotating
parallelogram wiper
for example, bus, Porsche 904

Task

As the last of the three models, put the parallelogram wiper together.

Imagine that you had invented the counter-rotating parallelogram wiper. You go with this to an auto manufacturer and he thinks the idea is really great and would like to buy the wiper from you—however, only if the wipers do not run counter to each other but with each other! Can you supply him with the wiper (modify)?

(For the solution see the last page.)



Counter-rotating wiper
for example, Mercedes-Benz, VW Sharan

Profile

Inventor: *Mary Anderson (1866 - 1953)*

Place of Birth: *Greene County, Alabama, USA*

Profession: *Building contractor, rancher, vintner*

Outstanding Achievement: *Invented the windshield wiper system.*



Synchronous wiper
normal design for passenger cars

The Centrifugal Governor

■ First a small detail: James Watt did not basically invent the steam engine but significantly improved the direct acting steam pump, which was developed by Thomas Newcomens in 1705. With this, he initiated the triumphant progress of the steam engine.

1775: James Watt founded together with Matthew Boulton, the first steam engine factory in the world in England. In 1788, Watt used the centrifugal governor for the first time to maintain a constant working speed for the steam engine, which he had improved. Namely, if it runs too fast then it can easily happen that it destroys itself due to overloading or in other words it will blow up in your face. The centrifugal governor increased the reliability and thus promoted the spread of the use of the steam engine. Textile machines and water pumps were followed by steam locomotives, steam ships as well as locomobiles and trucks. In 1852, the first airship was also powered by a steam engine. The industrial revolution—meaning the change of the working world and society by machines—was triggered by the spread of the use of the steam engine. In honor of James Watt, the unit of measure for power was named the watt.



Profile

Inventor

James Watt (1736 - 1819)

Place of Birth

Greenock, Scotland

Profession

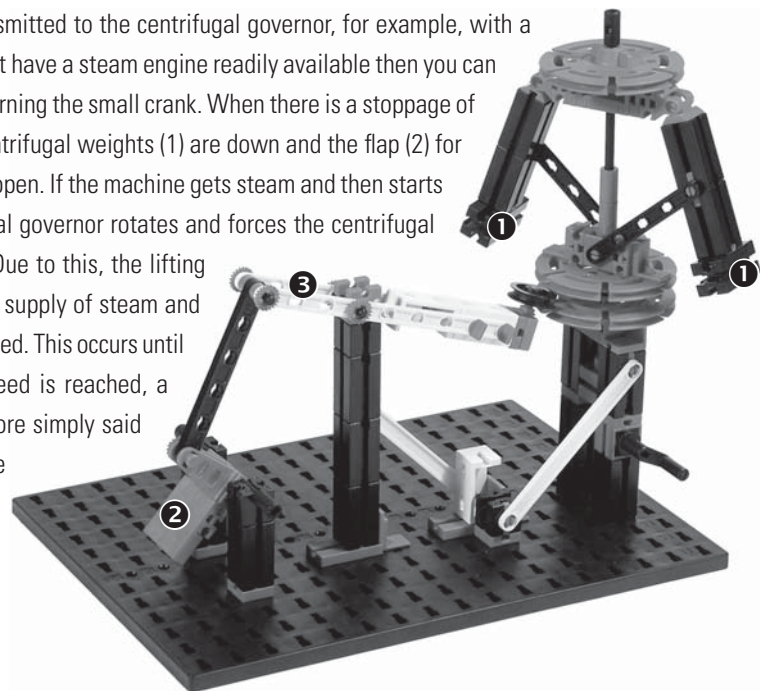
Mechanic

Outstanding Achievement

Increased the efficiency and safety of the steam engine.



■ Now to the mode of operation of your model: Normally, the rotational movement of the steam engine is transmitted to the centrifugal governor, for example, with a belt. Since you likely don't have a steam engine readily available then you can simulate this simply by turning the small crank. When there is a stoppage of the machine then the centrifugal weights (1) are down and the flap (2) for the steam supply is fully open. If the machine gets steam and then starts to run then the centrifugal governor rotates and forces the centrifugal weights to the outside. Due to this, the lifting mechanism (3) slows the supply of steam and reduces the rotational speed. This occurs until a constant rotational speed is reached, a sort of equilibrium. Or more simply said the faster the machine runs the less steam that is supplied to it.



Task

You want to soup it up a bit, tune it up or make the steam engine faster. To do this, you have an eye on the weights for the centrifugal governor. Do you have to make them heavier or lighter?

■ Today, if you want to send a friend a message quickly then you call him up, write an e-mail or exchange information with a chat. In the past, you could only exchange information this fast with people sitting right beside you. A letter took, depending on the distance, a few days or even months.

Later, as electricity could be used, the idea of sending signals through a cable was found. But how should the electrical signals be reproduced at the other end? Here, an American painter

thought of a simple principle. He assigned a series of short and long current pulses to the various letters of the

alphabet—by the way the computer today works in a very similar

fashion but it uses a 1 and 0

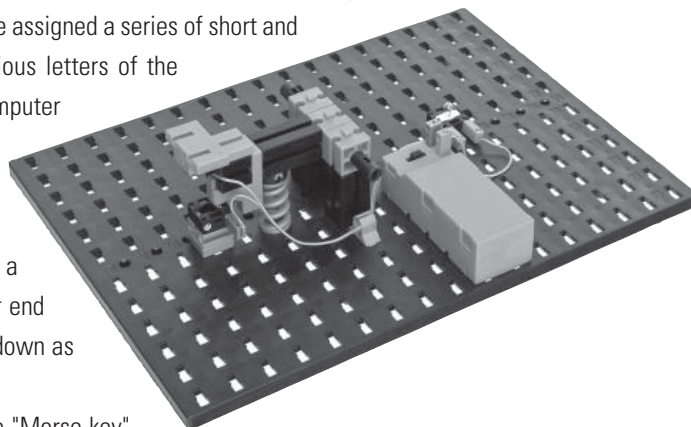
signal instead of the dash and

dot. The signals were sent using a special switch and at the other end of the line these were written down as dashes or dots.

The special switch is called the "Morse key"

and the dash-dot assignment to the letters is

called the "Morse code" after the inventor, Samuel Morse.



■ Actually, Mr. Morse was a professor for painting, sculpture and drawing. In spite of this, he developed not only the Morse code, but in 1837 also the first usable Morse telegraph. However, this was stuck together with scraps of wire, sheet scraps and a wall clock. Five years of experimentation were then necessary until the apparatus was ready for patenting. After his telegraph became successful, he founded his own telegraphy enterprise. Initially, telegraph lines were established between cities and countries and finally even between continents like Europe and America. For this purpose, a deep sea cable was laid across the Atlantic in 1858. Just imagine, what a long cable this was! At that time, there was no ship that was big enough for this. They then divided it and loaded it onto two ships and laid it starting from each continent and then put it back together on the high sea.

Task

What is the meaning of this string of characters: „ “? (See solution below.)

Think up individual words or entire sentences and key them into your Morse telegraph.

Your friend can then read them from the light bulb.

Tip: Get yourself a longer cable and then you can put the light bulb in another room. After you have practiced and are good at sending messages with Morse code, you can exchange secret messages with your friends at night using a flashlight.

Solution for the task on this page: The emergency call SOS

The Morse Telegraph

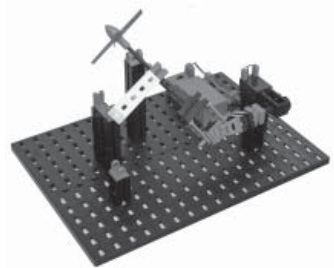
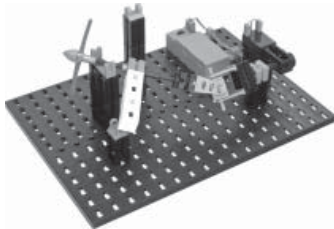
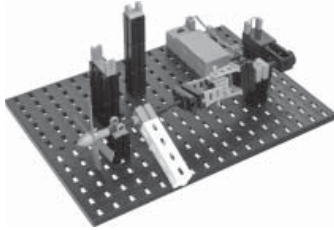
Telegraphy,
the grandmother
of the Internet

The Morse Code

a . -	n - . .
b	o - - -
c - . . .	p
d - . .	q - - . .
e .	r . . .
f	s . . .
g - . .	t -
h	u . . .
i . .	v
j	w . . .
k - . .	x - . . .
l	y - . . .
m - -	z - . . .
Wait	
Beginning	
End	



The Cardan Shaft



■ If we didn't have this nondescript joint, nothing would turn in many areas of our everyday life.

But first let's start at the beginning.

In 1501, a boy was born in Milan, who would later become very famous. It is the time of the Renaissance. It was called this because it was an age of awakening for art, science and society. Many artists and scientists such as Michelangelo, Galileo and Leonardo da Vinci and even Cardano made a name for themselves due to their extraordinary achievements. He was certainly the most famous doctor of his time because kings and princes were his patients. In addition, he was a mathematician and inventor. He made important discoveries concerning the theory of probabilities. However, before he wrote a book about this, he used the knowledge he acquired for gambling until he had earned enough money so that he could pay for his medical studies with this. As you have noticed, he was also clever.

And now to the shaft, which was named after him.

Problem: In drive technology, in most cases there is a motor and a machine, which is to be powered. Often, both elements are a certain distance away from each other, not at the same height or also move back and forth. If you would connect both with a rigid shaft then it would inevitably break. On the other hand, a soft flexible shaft would be too weak to transmit large forces.

Solution: A shaft that is flexible as well as stabile. The propeller shaft with universal joints or the cardan shaft.

Task

Place the shaft in the various positions, turn the motor on and observe the movement, which the joint must make and in particular in a position, which involves significant bending. Isn't it amazing how you can just bend a rotating movement around the corner?

Test the limits. Hold the shaft on the grip, which cannot rotate with the movement, turn on the motor and carefully try to find out how far you can bend the shaft.



Agricultural machines



Ship traffic



Vehicles



Industry

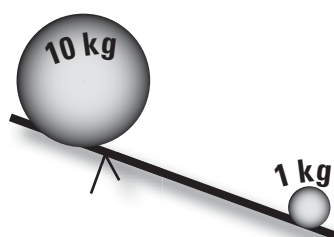
■ Each year, the European Patent Office is still receiving over 100 designs for machines, which once they are started, are to continue to rotate forever and a day. In this respect, so many people have already tried to design a "perpetual motion machine"—a perpetuum mobile and have been trying to do so for hundreds of years. In 748, for example, an Indian astronomer described his idea. Four hundred years later, a countryman of his, Bhaskar II, a mathematician, tried it. They were all bright people and even geniuses have brooded over this: In the 15th century, Leonardo da Vinci left sketches of a rotational solid motion machine. It is very similar to the model in your fischertechnik construction set. Do it once like Leonardo da Vinci.

Task

First think about how it could work.

- **What parts could provide the drive?**
- **Why should the building blocks, which are tilted down, rotate upwards?**

Then put the model together and put it motion with a vigorous shove.



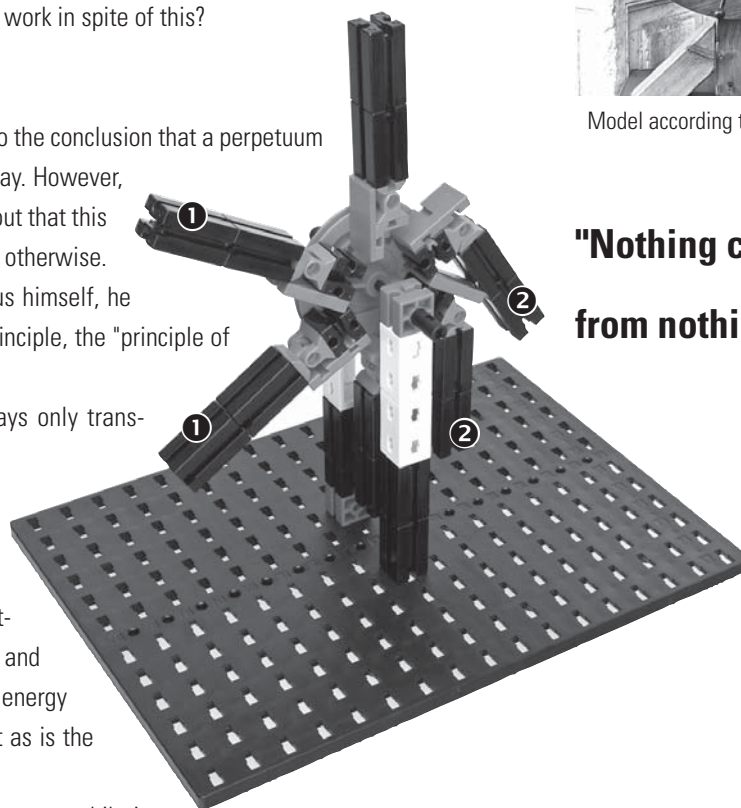
According to the lever principle, the building blocks (1), which project out further, ought to exert a stronger leverage on the rotary disk and thus pull the building blocks (2), which are tilted downwards and have a shorter lever arm, upwards. It sounds real good. But why doesn't it work in spite of this?

■ After some attempts, Leonardo da Vinci came to the conclusion that a perpetuum mobile was not really solvable in a mechanical way. However, in 1845, a doctor, Julius Robert von Mayer, found out that this was also not possible electrically, hydraulically or otherwise. While he was searching for the miracle apparatus himself, he came to a realization and he formulated it in a principle, the "principle of the preservation of energy."

In a closed system, no energy is lost, it is always only transformed.

Therefore, energy such as kinetic energy cannot be created from nothing. Or to put it in less physical terms: Nothing comes from nothing. In the case of movement, some motive power is even "lost." Better said, it is transformed, for example, in friction and thermal energy. This is deducted from the kinetic energy and at the end there is always a standstill—just as is the case for your model.

At the latest after this insight, the topic of perpetuum mobile is crossed off the list—at least from a scientific perspective.



Model according to Leonardo da Vinci

"Nothing comes from nothing"

The Hair Hygrometer



Profile

Inventor

Horace Bénédict de Saussure (1740 - 1799)

Place of Birth

Geneva, Switzerland

Profession

Naturalist, professor of philosophy

Outstanding Achievement

Invented the hygrometer.

First to climb the little Matterhorn.



■ Horace-Bénédict de Saussure studied the natural sciences and was so good that at the age of only 22 he was appointed as professor for philosophy at the University of Geneva. However, he was not only a particularly clever fellow but also a real nature boy. His intellectual curiosity continually drove him to the mountains where he conducted scientific measurements. In 1787, he even conquered the highest mountain in the Alps, Mont Blanc at 4810 meters. At the summit, he measured among other things the boiling point of water, the snow temperature and the pulse of his mountain guide.

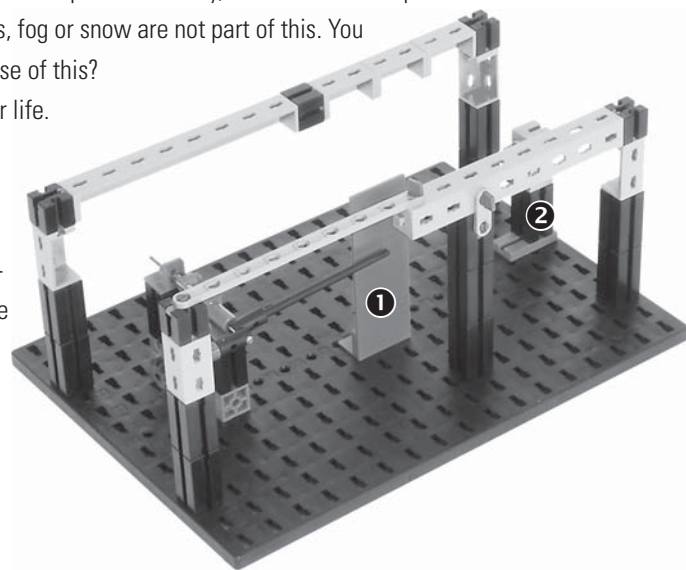
In some cases, he invented the devices, which were needed for the measurements, himself such as the hygrometer. With this, you can measure the atmospheric humidity, which means the percentage of water vapor in the air. Rain drops, fog or snow are not part of this. You will certainly ask yourself what is the purpose of this? The atmospheric humidity has effects on our life.

Low Atmospheric Humidity

- The laundry dries faster.
- The risk of catching a cold increases because the mucous membrane of the nose dries out.
- Fields dry out and plants wither.

High Atmospheric Humidity

- The probability of rain increases.
- Increased risk of mold in apartments.
- At high temperatures, it creates sultriness and nausea.

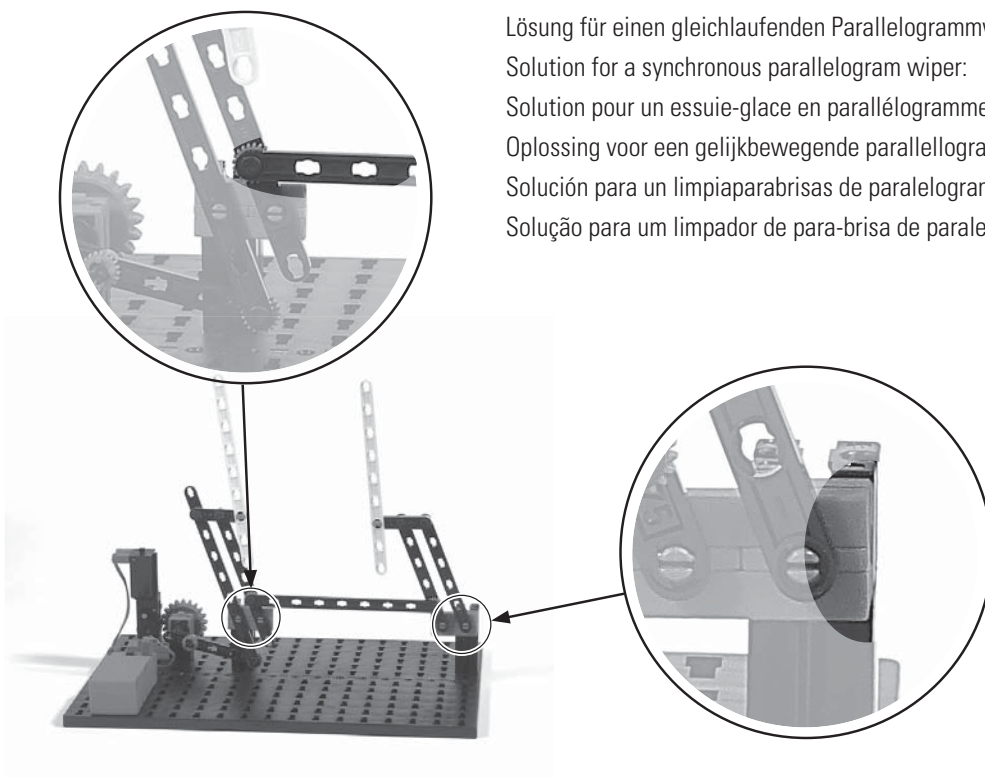


Task

- **Set the indicator of your hygrometer to about the middle of the scale (1). To do this, use the sliding building block (2).**
- **Place a moist dish towel over your model, so that it is completely covered.**
- **After a few minutes, you can remove the towel.**

Where is the indicator now and why did it move in this direction?

The indicator moved upwards. Under the towel the atmospheric humidity increased to a relative value of 95 percent. The hygrometer fiber absorbs the moisture and expands when it does this. When you remove the towel, the fiber dries and becomes shorter. (You can accelerate the drying process using a hair dryer.)



Lösung für einen gleichlaufenden Parallelogrammwischer:

Solution for a synchronous parallelogram wiper:

Solution pour un essuie-glace en parallélogramme synchronisé :

Oplossing voor een gelijkbewegende parallellogramwisser:

Solución para un limpiaparabrisas de paralelogramo de marcha sincronizada:

Solução para um limpador de para-brisa de paralelogramo movendo-se na mesma direção:

Dank und Bildverzeichnis:

Ein Dankeschön an folgende Institutionen für die freundliche Erlaubnis ihre Fotografien abzdrukken. Dabei verwendete Abkürzungen bedeuten:

M = Mitte; u = unten; l = links; r = rechts; o = oben

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Thank you and index of diagrams:

A thank you to the following institutions for the friendly permission to print their photographs. Meaning of abbreviations used for this:

M = Middle u = below l = left r = right o = above

OTIS GmbH & Co. OHG [3lo]
Siemens Pressebild, Siemens AG [5u]
www.oldschoolman.de [8o; 10u]
Simon Eugster, www.granjow.net [9u]