Opening extract from

Inventions: A History of Key Inventions That Changed the World

Written by

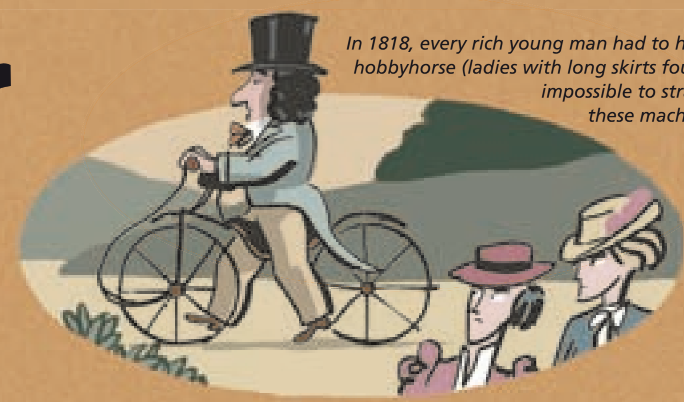
Adam Hart-Davis

Published by

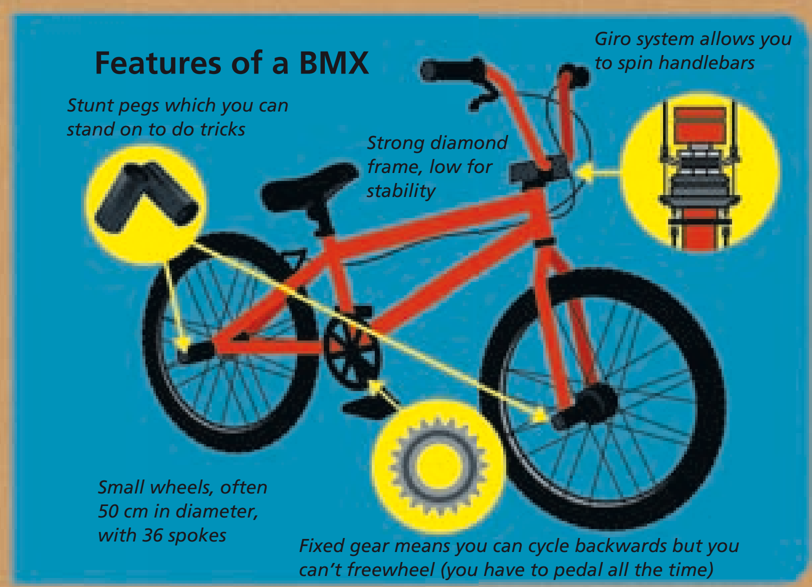
Walker Books Ltd

Pedal Power

One of the great inventions of all time was the wheel, which appeared in Mesopotamia (modern-day Iraq) in the 4th millennium BC. 6,000 years later came the idea of putting two wheels in line to make a bicycle.



In 1818, every rich young man had to have a hobbyhorse (ladies with long skirts found it impossible to straddle these machines).



The Hobbyhorse (1817)

Invented in Germany, the hobbyhorse had a heavy frame, a seat in the middle, a wheel at each end and a primitive tiller (single arm) steering mechanism.

The rider scooted along with both feet on the ground and wore out many pairs of boots. Yet it took more than 20 years for anyone to add pedals and a drive system.

The Penny-farthing (1869)

The penny-farthing first appeared in France in 1869 and soon afterwards in England and America.

The name "penny-farthing" came from the fact that the bicycle seen from the side looked a bit like the English coins penny and farthing.

The front wheel was up to 1.5 metres in diameter, which allowed you to cruise at 24 kph. Riders had to sit almost on top of the large front wheel.

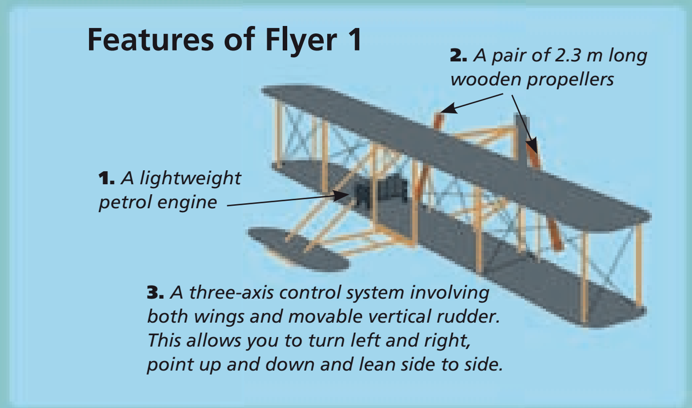
The main features were:

- Wheels built with spokes for the first time.
- Pedals attached to the large front wheel.
- Easy to ride slowly – you could ride it with your hands off at 3 kph.

This bicycle was particularly dangerous if you stopped suddenly: you would be thrown immediately forwards and, because your legs would be caught by the handlebars, you would hit the ground head first; "taking a header" cost riders many teeth.

Up and Away!

Ever since people have walked on earth, they have watched birds and dreamed about flying. Near the end of the 18th century, the dream came true.



The Hot-Air Balloon (1783)

The first flying machine was a balloon, nine metres across, made from sackcloth with three layers of paper inside and held together with buttons. The builders were the French brothers **Joseph-Michel** and **Jacques-Etienne Montgolfier**. On 4 June 1783 the brothers lit a fire under their balloon to fill it with hot air.

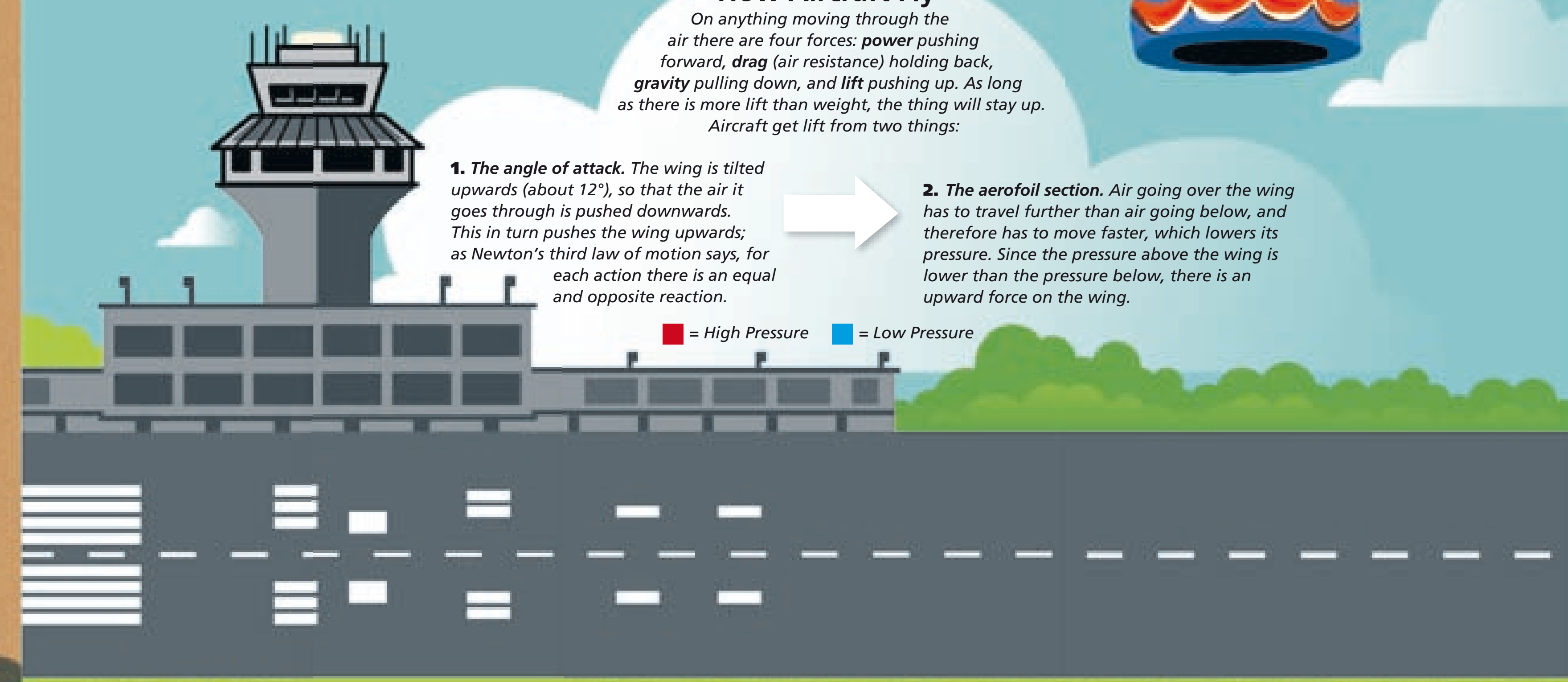
How Aircraft Fly

*On anything moving through the air there are four forces: **power** pushing forward, **drag** (air resistance) holding back, **gravity** pulling down, and **lift** pushing up. As long as there is more lift than weight, the thing will stay up. Aircraft get lift from two things:*

*1. **The angle of attack.** The wing is tilted upwards (about 12°), so that the air it goes through is pushed downwards. This in turn pushes the wing upwards; as Newton's third law of motion says, for each action there is an equal and opposite reaction.*

*2. **The aerofoil section.** Air going over the wing has to travel further than air going below, and therefore has to move faster, which lowers its pressure. Since the pressure above the wing is lower than the pressure below, there is an upward force on the wing.*

= High Pressure *= Low Pressure*



The Stealth Bomber (1993)

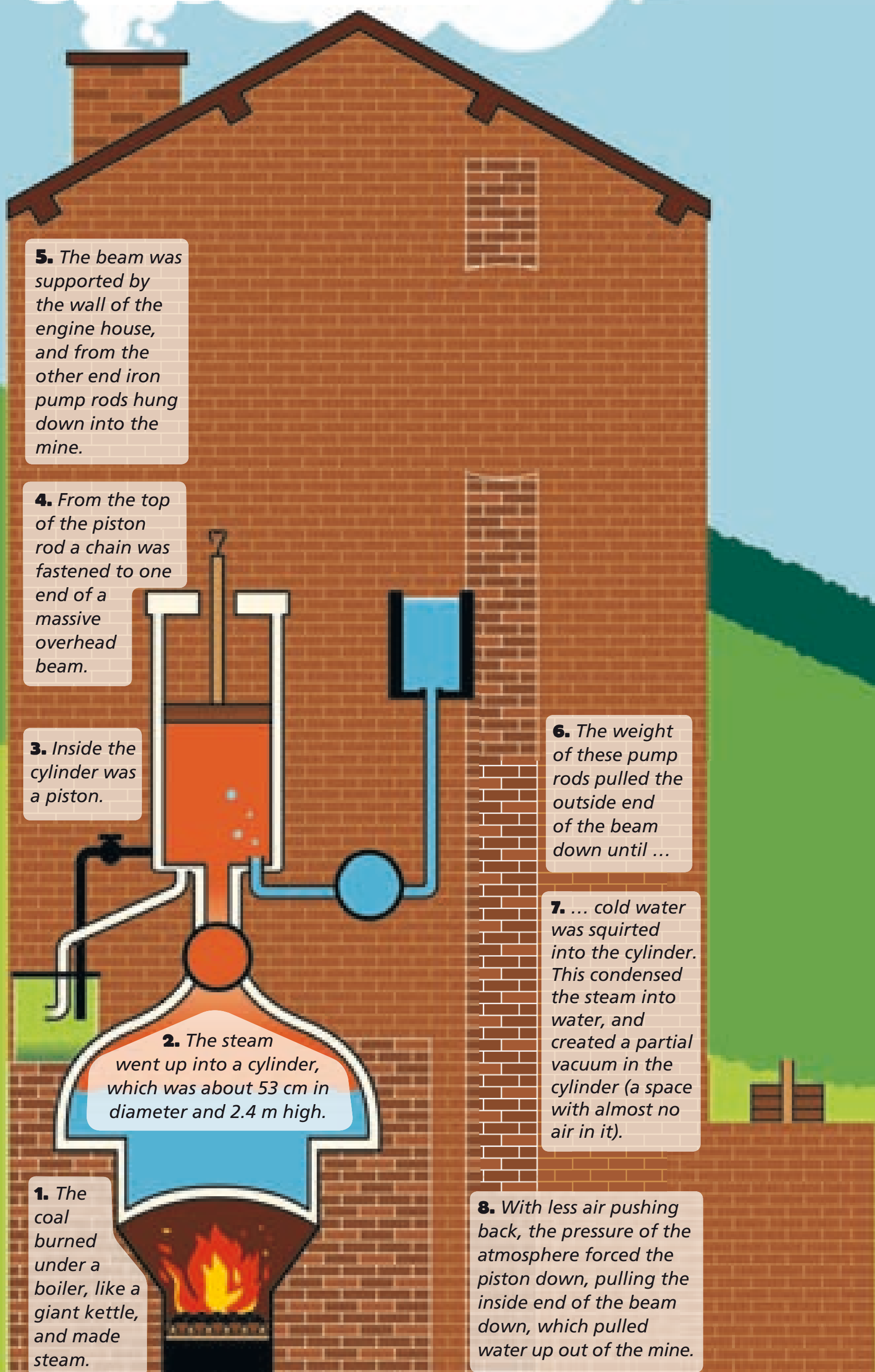
Northrop Grumman B-2 Spirit aircraft, commonly called stealth bombers, cost a billion dollars each, have a crew of two, a range of about 11,000 km and can carry sixteen 1,100 kg nuclear bombs.

They are hard for enemies to detect: their strange shape means radar beams bounce off them at odd angles, and they are coated in a substance which absorbs microwaves. On radar they only look the size of dinner plates. The engines are buried inside the wings to hide the heat of the exhaust.

Modern Aircraft

Letting Off Steam

The grandfather of all steam engines was a Greek toy built in Alexandria around 2,000 years ago, but the earliest useful steam engines were built in the early 1700s. These were the ancestors of all the engines we have today. They provided portable power for the first time, and completely changed the way people lived, worked and travelled.



In 1712 **Thomas Newcomen** built an engine that pumped water out of a coal mine. This was the greatest step forward in the history of technology.

The Steam Carriage (1769)

In 1769, at Void-Vacon in France, **Nicolas-Joseph Cugnot** built a steam-powered carriage to carry heavy guns for the army – but it was hard to steer and not very powerful.

In 1801 Cornishman **Richard Trevithick** built a small but powerful engine, using high-pressure steam, and put it on wheels to make a steam carriage called *The Puffing Devil*. He took some friends for a ride, but they had an accident, and while they were drowning their sorrows in the pub, the boiler ran dry and the carriage burned to a crisp.

But even so, steam carriages became popular in Britain in the 1820s, and later in America.

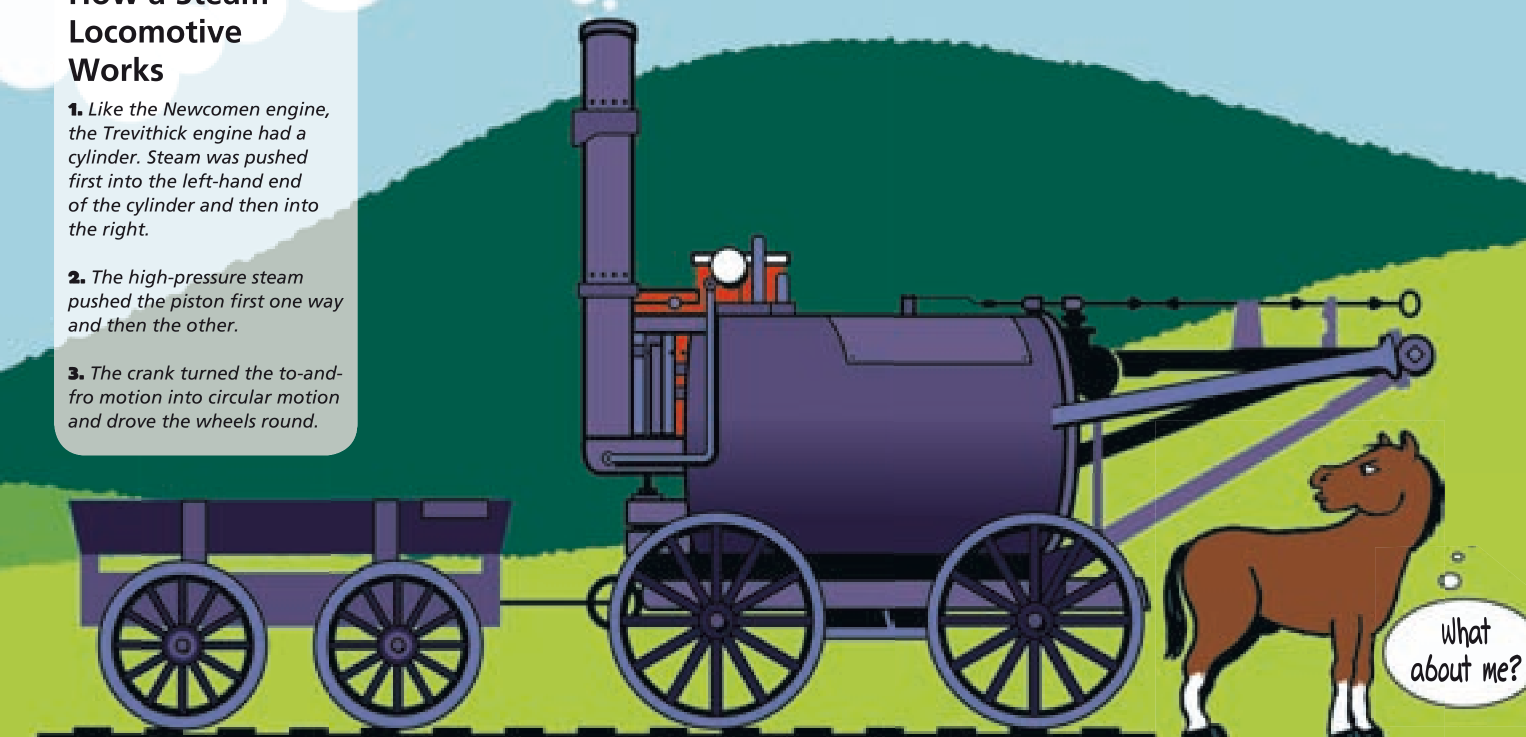
Hero of Alexandria, the great innovator of the 1st century, is thought to have made the first steam engine. He called it an aeolipile, meaning "the ball of Aeolus" (Aeolus was the god of the wind). The way it works is an example of Isaac Newton's third law of motion in action. Newton's law says "to every action there is an equal and opposite reaction": in the aeolipile, the force of the steam coming out anticlockwise pushes the ball around clockwise.

How a Steam Locomotive Works

1. *Like the Newcomen engine, the Trevithick engine had a cylinder. Steam was pushed first into the left-hand end of the cylinder and then into the right.*

2. *The high-pressure steam pushed the piston first one way and then the other.*

3. *The crank turned the to-and-fro motion into circular motion and drove the wheels round.*



The Steam Locomotive (1804)

In 1804 Trevithick put another of his high-pressure engines on wheels at the Penydarren Iron works in South Wales, and on 21 February it pulled 10 tons of iron and seventy passengers down the cast-iron tramway to the wharf on the canal at Abercynon.

On the way he had to cut down several trees that were overhanging the track, and the heavy locomotive broke most of the cast-iron rails, but this was the first time a steam locomotive had pulled a train. When tougher wrought-iron rails became available a few years later, the steam locomotive became an incredibly important method of transport.

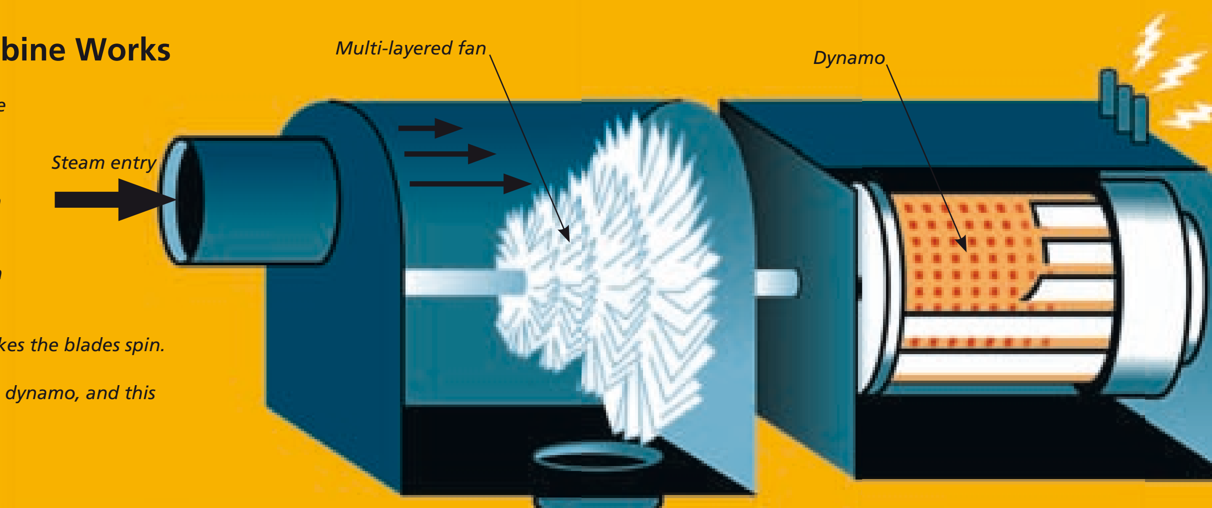
How a Steam Turbine Works

1. *A jet of super-high-pressure steam is blasted into the turbine.*

2. *The steam hits a fan with a series of blades. As the steam passes one set of blades, it meets a larger set, and then a larger set, and so on.*

3. *Energy from the steam makes the blades spin.*

4. *The spinning blades turn a dynamo, and this generates electricity.*



Tick-Tock

People have always tried to keep track of time, using the sun and moon, water, machines, crystal vibrations, and finally atoms.

Sandglasses (14th century)

During the middle ages glass-blowing was developed, and some glass-blowers learned how to make a sandglass. Turn one over and the sand will trickle through the neck to the bottom bulb.

As long as the sand is fine and regular this will always take the same amount of time. Sandglasses (sometimes called hourglasses) were useful for sailors, since they are not much affected by either bad weather or the rolling of the ship.

Sandglasses are still used for timing meetings and cooking boiled eggs. You can buy timers that last for 1 minute, or 2, 3, 4, 5, 10, 15, 30 or 60 minutes.

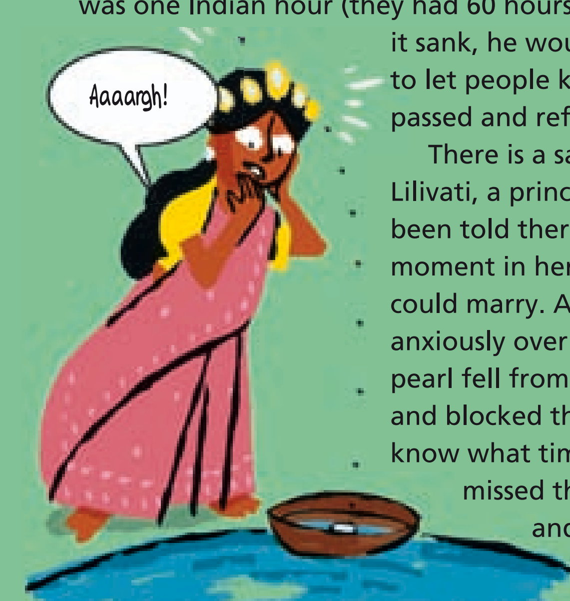
Sundials (c. 2500 BC)

Push a stick ("gnomon") into the ground and it will cast a shadow, as long as the sun is shining on it. The line of the shadow will move steadily around during the day, and you can make a sundial by putting a pebble at the end of the shadow every hour. Noon is when the shadow is shortest. Sundials are accurate, but no use in cloudy weather, nor at night.

The Ghati (3rd century BC)

To tell the time at night and during the cloudy monsoon season, the ancient Indians used a ghati. The simplest form of ghati is a half coconut shell with a small hole drilled in the middle; float it in water and it will gradually fill up and sink. In the temple, a monk would have a bronze ghati that would sink in 24 minutes, which was one Indian hour (they had 60 hours in a day). When it sank, he would strike a gong to let people know an hour had passed and refloat the ghati.

There is a sad story about Lilivati, a princess who had been told there was only one moment in her life when she could marry. As she leaned anxiously over her ghati, a pearl fell from her headdress and blocked the hole; she didn't know what time it was, so she missed the moment, and could never be married.



Quartz Clocks (1930s)

The first quartz clocks were made in the US in the 1930s and the first quartz watches were made in Japan in the 1960s.

Applying an electrical charge to quartz crystals makes them vibrate. The quartz crystal in a clock vibrates exactly 32,768 times a second. This is 2x2x2x2x2x2x2x2x2x2x2x2x2x2x2 or 2^{15}. After 32,768 vibrations a counter moves the second hand on.

Quartz crystals are cheap and can be made just a few millimetres across, so now most clocks use quartz crystals as their regulators. They are precise to within half a second a day.

Atomic Clocks (1950s)

Modern Clocks

The idea of an atomic clock was first suggested by the British scientist **Lord Kelvin** in 1879, but it wasn't until the 1950s that the first ones were made in the US and the UK. Coordinated universal time is based on the average time shown by 260 atomic clocks around the world.

Just as quartz clocks work by making quartz crystals vibrate, atomic clocks keep time using the "vibrations" in atoms of an element called caesium. The official definition of a second is 9,192,631,770 vibrations in an atom of caesium.