

ILLUSTRATED ENCYCLOPEDIA



# TECHNOLOGY



More than 200 keywords

ILLUSTRATED ENCYCLOPEDIA

# TECHNOLOGY



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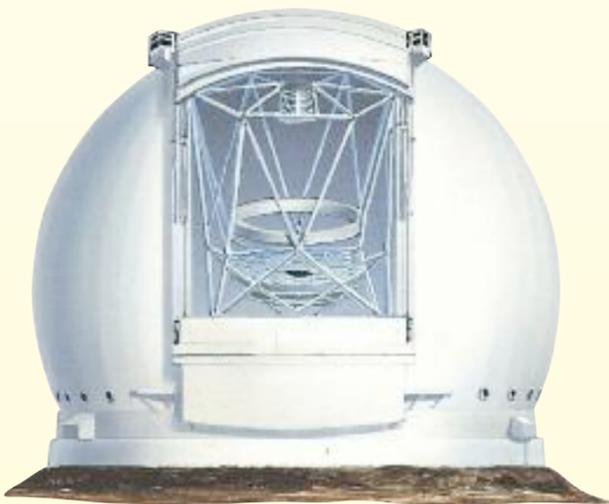
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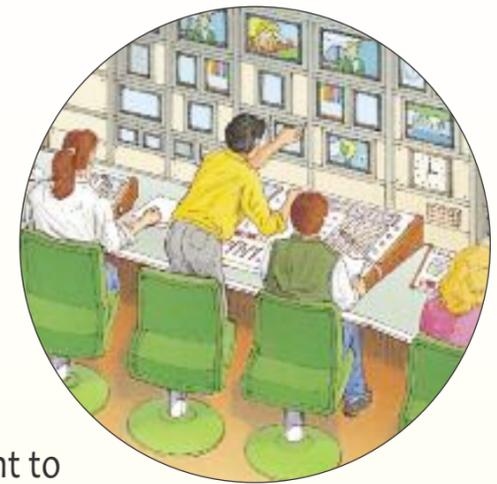


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# ABOUT THIS BOOK

Each double page contains a brief introduction, explaining the general subject, followed by key words arranged in alphabetical order. To look up a specific word, turn to the index at the back of this book: this will tell you which page to go to. If you want to learn more about a subject, take a look at the brief history, or follow the arrows to read related entries.



**INTRODUCTION**  
This explains the general subject and provides some basic knowledge.

**KEY WORDS AND ENTRIES**  
Key words are arranged alphabetically across each double page. Each entry provides a short explanation of what the key word means.

## RADIO & TELEVISION

**Channel A** narrow range of radio frequencies used by a TV or radio station. Audiences tune their receivers to the frequency for the channel that they want.

**Control room** The room in a TV studio where live images and sounds are mixed to create a signal for broadcast.

**Frequency** The number of wave crests that pass a point each second. Different TV and radio stations are broadcast on carrier waves of different frequencies so they do not interfere with one other.

**High Definition TV (HDTV)** A high-resolution TV screen with up to 2 million pixels (1080) per frame—around five times more than a standard TV.

**Liquid Crystal Display (LCD)** A type of picture display. An LCD screen contains a backlight, a layer of liquid crystals and a layer of colour pixels. When electricity passes through the crystals, they act as tiny shutters, varying the amount of light that each pixel transmits.

**Modulation** The shaping of a radio wave to make it carry information. Modulation is achieved by using an electrical signal to change either the strength of a wave—amplitude modulation or AM—or the frequency of a wave—frequency modulation or FM.

**Plasma screen** A type of TV screen containing a layer of cells filled with gas. An electric current causes the gas to give off energy, making the cell glow.

**Receiver** A device that detects signals, such as radio waves. For example, a radio receiver picks up radio waves and demodulates them to get back the original electronic signal. It uses a tuning circuit to pick out the signal from one radio station.

**Colour filter**

**Backlight**

**LED SCREEN**

**Pixels illuminated**

**Liquid crystals**

**Electric current supply**

**Transmitter** An electronic device that gives out signals such as radio waves. A carrier wave is fed to a transmitter, which turns it into a radio wave.

**Waveband** A range of radio wavelengths, for example long wave and short wave. Short waves bounce between the Earth's surface and a layer of the atmosphere called the **ionosphere**. Medium waves bounce off the bottom of the ionosphere (see diagram, left). Long waves travel flat above the surface of the Earth.

**Wavelength** The distance between two crests or two troughs on a train of waves.

**Zworykin, Vladimir (1888-1982)** Russian-American inventor who patented the cathode ray tube television in 1928.

**A BRIEF HISTORY**

- 1888 German physicist Heinrich Hertz confirms the existence of radio waves.
- 1896 John Logie Baird gives the first demonstration of television.
- 1896 Italian inventor Guglielmo Marconi makes the first long-distance radio transmission.
- 1925 Radio broadcasting begins.
- 1928 John Logie Baird gives the first demonstration of television.
- 1928 Cathode ray tube technology is invented.
- 1928 TV broadcasting begins.

Terrestrial TV signals are broadcast from transmitters (1) and detected by aerials (2). Satellite TV signals are detected by aerial dishes (3) pointed towards the satellite.

**PAGE NUMBER**  
Page numbers are easy to find at the side of the page.

**ARROWS**  
These arrows show you where to look up other words mentioned in the entry. For example, (26) tells you to go forward to page 26 and (6) tells you to turn back to page 6.

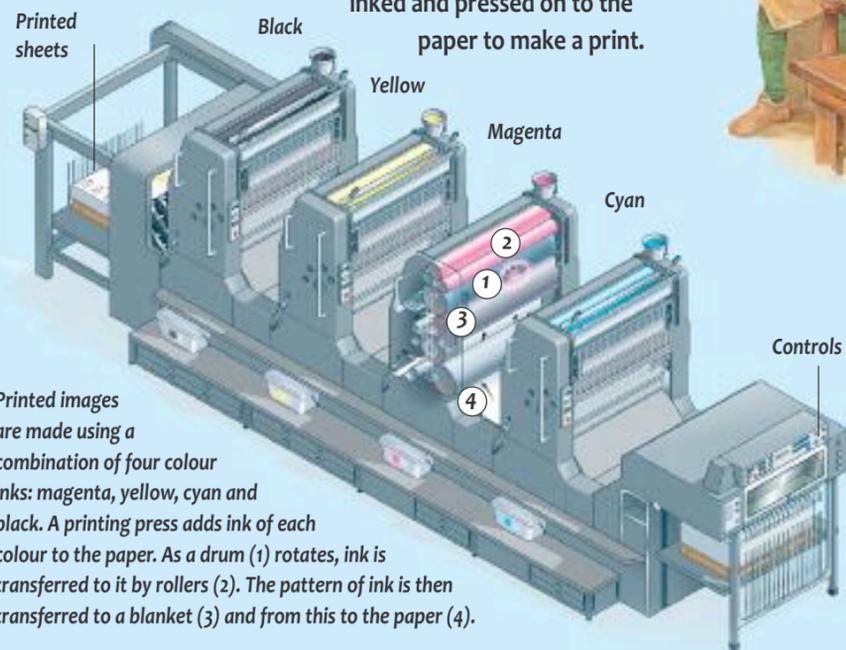
**BOLD WORDS**  
These highlight useful words that do not have their own entry.

# GREAT INVENTIONS

We may not think of something so commonplace as a clock or light bulb as a great invention, but when these objects were first developed, they completely changed the way that people lived. Even as modern technology advances, we continue to use many inventions that have been around for hundreds of years.

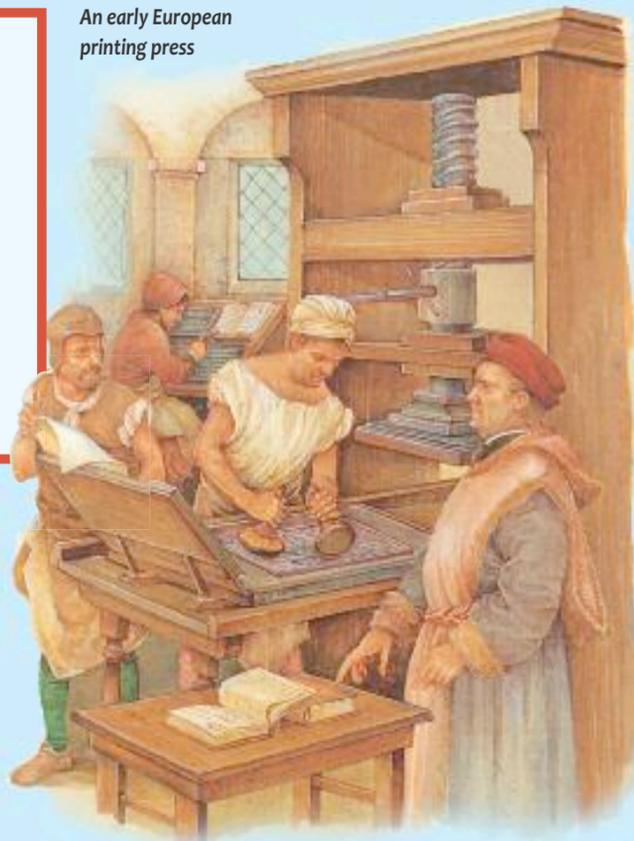
## PRINTING PRESS

A printing press is a machine used to make many copies of a document. Text or pictures start as patterns on a plate. The plate is inked and pressed on to the paper to make a print.



Printed images are made using a combination of four colour inks: magenta, yellow, cyan and black. A printing press adds ink of each colour to the paper. As a drum (1) rotates, ink is transferred to it by rollers (2). The pattern of ink is then transferred to a blanket (3) and from this to the paper (4).

An early European printing press



Printing with ink-covered wooden blocks was first developed in China in about 650. Two of the most important inventions in printing were moveable metal type (which allowed words and paragraphs to be built up from individual metal blocks with letters on them) and the printing press. In Europe these were both developed in about 1440 by German printing pioneer Johannes Gutenberg. They enabled books to be printed in large quantities.

## MEASURING TIME

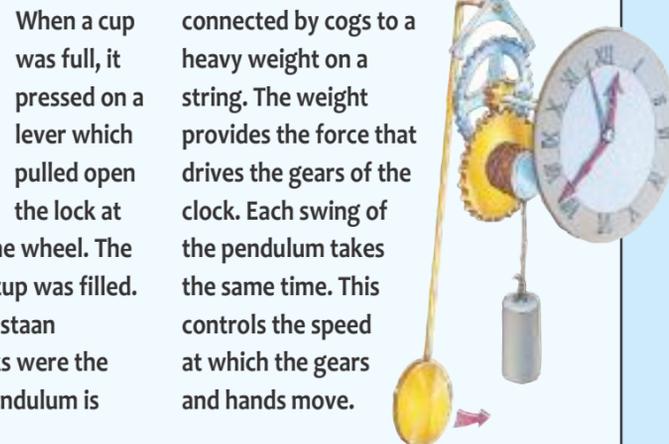
The first simple devices to indicate the passing of hours were sundials, which were first used in ancient Egypt. As the Earth turns, the shadow cast by a pointer moves across markings on a dial, giving the time.

The first mechanical clock was invented in China 1000 years ago. A waterwheel had cups, filled with water,



connected by cogs to a heavy weight on a string. The weight provides the force that drives the gears of the clock. Each swing of the pendulum takes the same time. This controls the speed at which the gears and hands move.

Invented in 1657 by Christaan Huygens, pendulum clocks were the first accurate clocks. A pendulum is

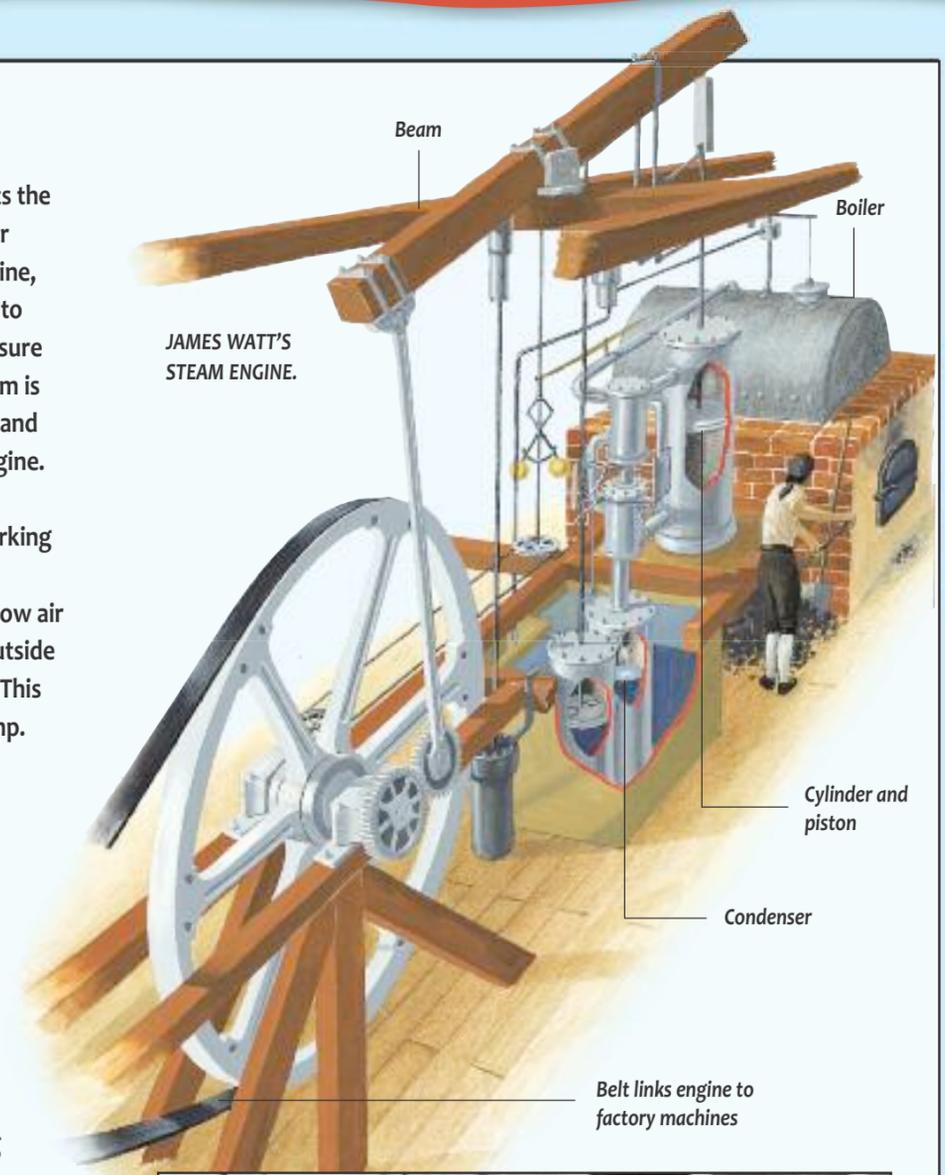


## STEAM ENGINES

An engine is a machine that converts the energy stored in fuel into energy for operating machines. In a steam engine, burning fuel heats water, turning it to steam, which builds up to high pressure inside a boiler. The pressurized steam is used to drive a piston up and down and operate the moving parts of the engine.

In 1712, English engineer, Thomas Newcomen, completed the first working steam engine. Steam was fed to a cylinder, then condensed, creating low air pressure. The higher air pressure outside the cylinder pushed a piston down. This rocked a beam which worked a pump.

In 1776, Scotsman James Watt developed a much more efficient steam engine. Steam was condensed outside the main cylinder, which allowed the main cylinder to remain hot. The piston was moved both up and down by steam, which increased the power of the engine. Wheels and belts linked the engine to spinning and weaving machines in factories.



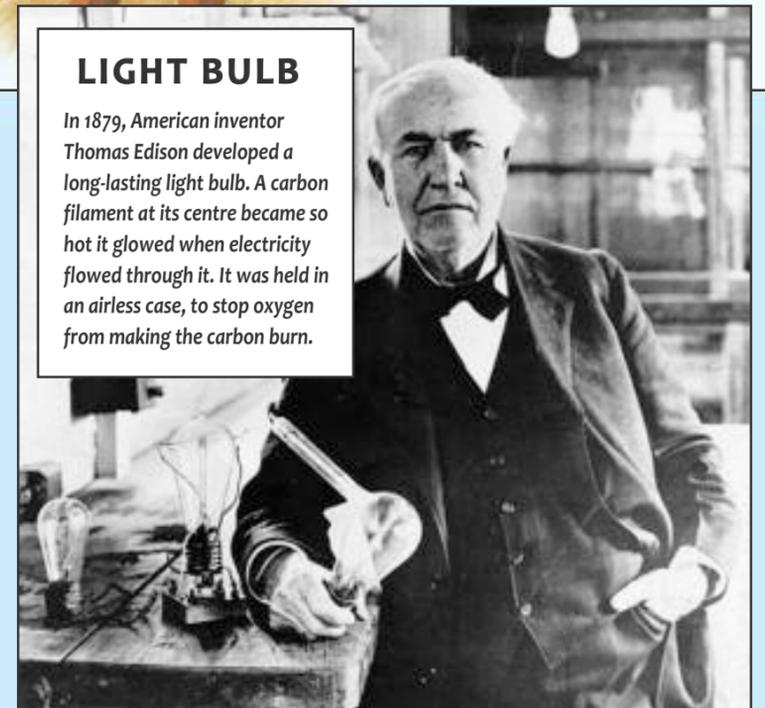
## ELECTRICAL TELEGRAPH

The very first telecommunications device was the telegraph. Messages travelled as pulses of electricity along wires, using a code that both the sender and receiver could understand. In 1844, American inventor Samuel Morse (above) established a system of dots and dashes to represent numbers and letters. This system, known as Morse Code, became widely used in electric telegraphs.

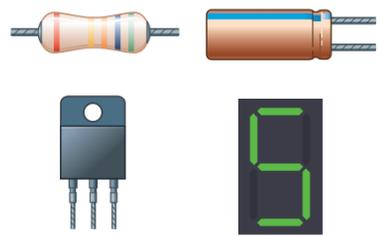


## LIGHT BULB

In 1879, American inventor Thomas Edison developed a long-lasting light bulb. A carbon filament at its centre became so hot it glowed when electricity flowed through it. It was held in an airless case, to stop oxygen from making the carbon burn.



# ELECTRONICS



Electronic components clockwise from top left: resistor, capacitor, LED display and transistor.

**E**lectronics is the study of how electrons behave and how they can be made to do useful jobs. Electrons are tiny particles inside atoms, the building blocks of matter. In some materials, such as metals, they can move easily from one atom to another. If electrons are made to flow along a pathway, such as a wire, an electric current is produced. By controlling electric currents, an electronic device can carry out a wide range of tasks.

**Amplifier** An electronic circuit that increases the strength of an electric signal. For example, an amplifier can convert the weak signal from a radio tuner (▶14) into a signal strong enough to power a speaker.

**Analogue** Whereas digital systems use only two values, 1 or 0, to store data, analogue, or non-digital systems, use an infinite range of values. In an **analogue circuit**, current can be of any strength, while in a digital circuit, current can only be on or off.

**Binary** A number system that uses only the digits 0 and 1. This can be represented in digital circuits by turning currents on (1) or off (0). A binary “word” uses multiple binary digits to represent decimal numbers (see illustration right). Almost any information can be represented in binary.

**Bit** The basic unit of information in digital electronics. A “bit”, short for “binary digit”, is represented either by 1 or 0.

**Byte** A sequence of eight bits, the number needed to represent a number or letter on a computer. Bytes are often used to measure the size of a computer’s memory.

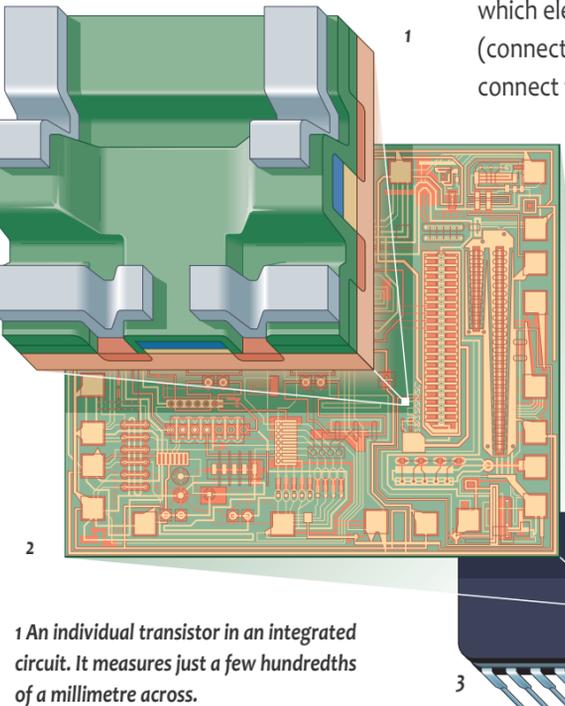
**Capacitor** An electronic component that stores electric charge. It consists of an insulator between two conducting plates.

**Circuit board** An insulating board on to which electronic components are soldered (connected by metal). Metal tracks connect the components to form a circuit.

**Digital** Information that is stored as binary numbers only. In a **digital circuit** current can only have two strengths—on and off.

2 The integrated circuit or microchip itself. It contains thousands of transistors and other electronic components.

3 The delicate integrated circuit is encapsulated in a plastic case to protect it.



1 An individual transistor in an integrated circuit. It measures just a few hundredths of a millimetre across.

16	8	4	2	1	
0	0	0	0	0	0
0	0	0	0	1	1
0	0	0	1	0	2
0	0	0	1	1	3
0	0	1	0	0	4
0	0	1	0	1	5
0	0	1	1	0	6
0	0	1	1	1	7
0	1	0	0	0	8
0	1	0	0	1	9
0	1	0	1	0	10
0	1	0	1	1	11
0	1	1	0	0	12
0	1	1	0	1	13
0	1	1	1	0	14
0	1	1	1	1	15
1	0	0	0	0	16

BINARY DECIMAL

This diagram shows how binary numbers combine bits of 0 and 1 to represent decimal numbers.

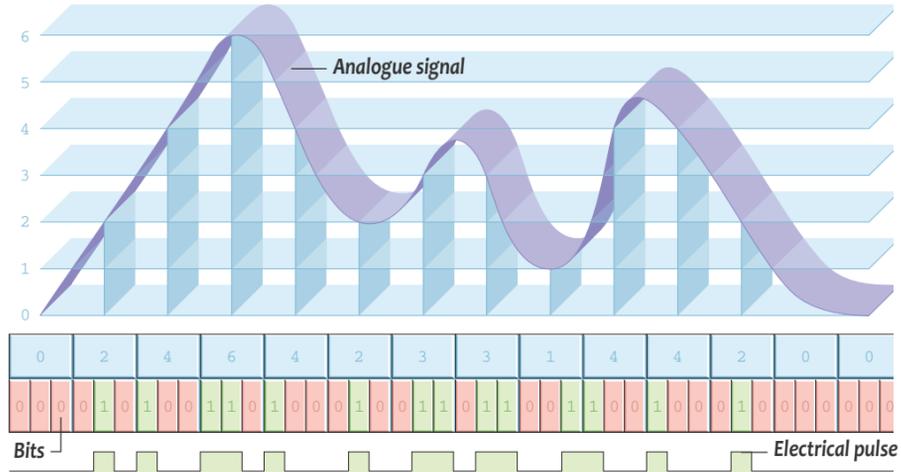
**Digital picture** An image on a computer, made up of pixels in a grid pattern. Each pixel has a position, colour and brightness, stored as binary on the computer.

**Digitization** The process of turning analogue information into digital form. Analogue information must be turned into digital form before it can be handled by digital circuits.

**Diode** A semiconductor device that allows an electric current to flow through it in one direction but not the other.

**Electric conductor** A material that allows electrons to flow through it freely.

**Electric insulator** A material that reduces or stops the flow of electricity.



An analogue electrical signal is converted to digital. The bits become electrical pulses: on (1) and off (0).

**Electrode** An electric conductor that leads electricity to or from the non-metallic parts of a circuit, such as plastic in a capacitor.

**Electronic circuit** An electric circuit made up of electronic components. By combining different components in different ways, it is possible to make electronic circuits which can do almost any job.

**Electronic component** A basic part of an electronic circuit, such as a resistor or diode. Components control the flow of electric current in order to carry out tasks.



**Electronic signal** A signal made by continuously changing the strength and direction of an electric current. Digital signals use pulses of electricity to represent binary numbers.

**Integrated circuit** An electronic circuit made of microscopic components built into a small piece of silicon. Components are built in using chemical and photographic processes (▶18). Integrated circuits are often called silicon chips or **microchips**.

**Light emitting diode (LED)** A diode that makes light when an electric current flows through it.

**Pixel** A tiny coloured dot, which is the smallest part of a digital image. Pixel is short for “picture element”.

**Resistor** An electronic component that restricts the flow of current in a circuit.

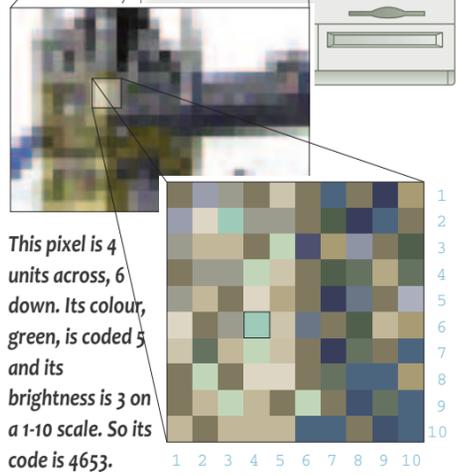
**Resolution** The concentration of pixels in a picture. High-resolution, or “hi-res”, graphics, made up of millions of pixels, can be viewed on a large screen without individual pixels becoming visible.

**Semiconductor** A substance that can act either as an electric conductor or as an insulator.

**Silicon** A non-metallic element found in many rocks. It can be extracted from the rocks, purified and treated to make a semiconductor. Silicon is widely used as a semiconductor in integrated circuits.

**Switch** An electronic component that can be used to break the flow of electrons around an electronic circuit.

An image on a screen is made up of tiny pixels. Each has a position, colour and brightness, that is stored in binary code.



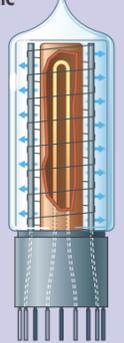
This pixel is 4 units across, 6 down. Its colour, green, is coded 5 and its brightness is 3 on a 1-10 scale. So its code is 4653.

The pixel code is stored as a binary number which is represented as electrical signals. 1 means an electrical pulse, 0 means no pulse.

**Transistor** A semiconductor device that can act as a switch or an amplifier. The current flowing between two connections is controlled by a current flowing into a third.

## A BRIEF HISTORY

- ★ 1904 English engineer John Ambrose Fleming invents the thermionic valve, also known as the vacuum tube. It is a basic device used to alter electronic signal by controlling the flow of electrons.
- ★ 1950s Thermionic valves are quickly replaced by semiconductor devices.
- ★ 1959 The first integrated circuit is built by Texas Instruments in the USA. From this point, the number of components that can fit on a chip increases rapidly.



A thermionic triode valve

# COMPUTERS

A computer is an electronic machine that can interpret data to perform useful tasks. It can do hundreds of jobs, from relatively simple tasks, such as word processing, to highly complex tasks, like flying aircraft. It does each job because it is fed a set of instructions called a program. Computers store data such as numbers, words, sounds and pictures in digital form as binary numbers (♣8). Personal computers are found in most homes and offices. Other type of computers include mainframes and supercomputers.

**Central processing unit (CPU)** The main part of a PC, which carries out instructions from a computer program. It acts as the computer's "brain".

**Computer graphics** Images made or displayed on a computer. This can be text or complex animated 3-D images.

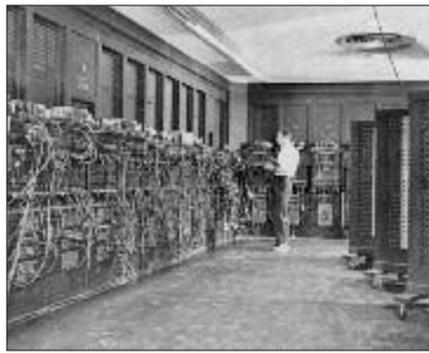
**Computer generated imagery (CGI)** is often used to add effects to movies (♣20).

**Core** The part of a microprocessor that carries out its functions. The more cores a microprocessor has, the more tasks it can perform at the same time.

**Dedicated computer** A computer built for one specific task. Dedicated computers are often built into electronic devices such as personal music players. These are sometimes called **embedded computers**.

**Download** To transfer data from another computer to the one being used.

**Hard disc drive** The part of a computer that stores programs and data, otherwise known as its **memory**. Data is stored on a number of magnetic discs inside the hard disc drive, which can read information off a disc or write information on to one.



ENIAC, the first general purpose computer.

**Hardware** The physical parts of a computer, such as its electronic circuits and disc drives, and peripherals, such as monitors, scanners and printers.

**Keyboard** A set of keys, printed with numbers and letters, used to enter information into a computer. Pressing a key completes an electronic circuit (♣8) and sends an instruction to the computer.

**Laptop** A type of PC that can run on battery or mains electricity (♣16). A **tablet** is a flat, touch-screen device that performs many of the same functions as a laptop.

**Mainframe** A large, powerful computer, made up of several CPUs, each handling a different task. Mainframes are used to store large amounts of data and can be accessed by thousands of users.

**Memory card** A removable storage device used to transfer data. For example, a memory card can be moved from a digital camera to a computer to transfer images.

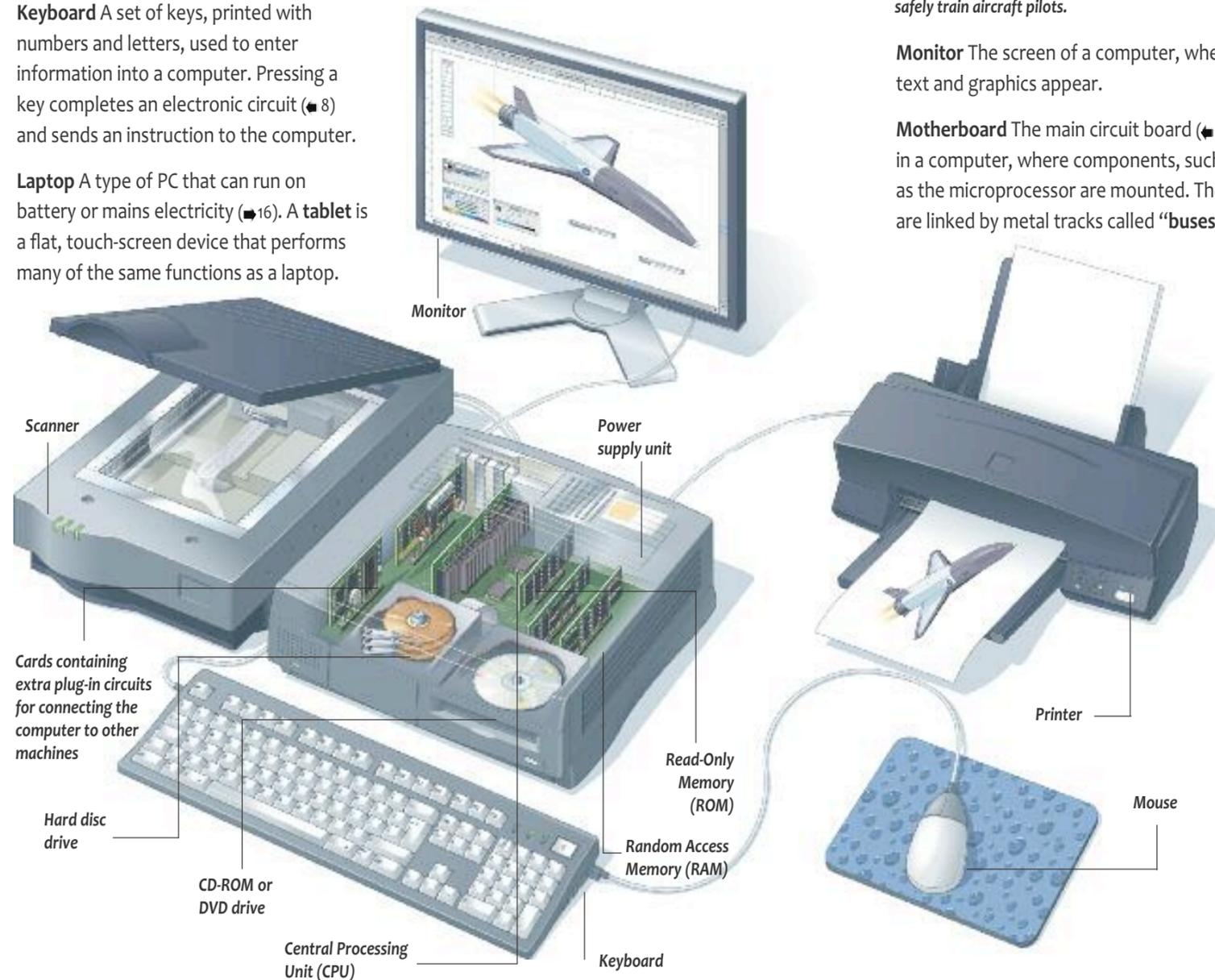
**Microprocessor** An integrated circuit (♣9) that contains the CPU of a PC. Different types of microprocessor are also used inside electronic devices such as mobile phones and digital watches.



A flight simulator, a form of virtual reality used to safely train aircraft pilots.

**Monitor** The screen of a computer, where text and graphics appear.

**Motherboard** The main circuit board (♣8) in a computer, where components, such as the microprocessor are mounted. They are linked by metal tracks called "buses".



**Personal Computer (PC)** A computer comprising a processor, memory, disc drives, keyboard, monitor and software. PCs can be used to make documents, browse the Internet, play games and much more.

**Program** A set of instructions that control what a computer does.

**Random Access Memory (RAM)** A computer's working memory, which stores programs and holds data from the programs it is running. The data is lost when the computer is switched off. It is called "random" because the data can be accessed in any order.

**Read-Only Memory (ROM)** A computer's permanent store of instructions, used for basic tasks such as starting up. It is called "read-only" because it cannot be altered or re-written. Its contents are not lost when the computer is turned off.



Robot welders, used in car manufacturing, are controlled by computers.

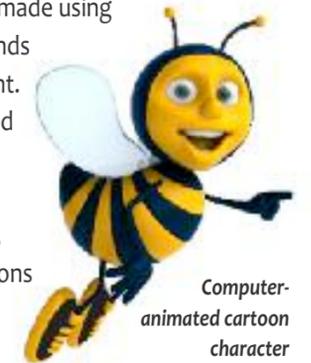
**Software** A program, or set of programs, that a computer stores and uses. **System software** controls basic functions, such as printing. **Application software** makes a computer do specific jobs, such as create a database or play a computer game.

**Supercomputer** A powerful computer used for scientific research. One supercomputer can complete the same work as thousands of PCs but takes up a very large space.

**Universal Serial Bus (USB)** A device used to connect peripherals, such as a printer or mouse, to a computer.

**Upload** To transfer data from the computer being used to another computer.

**Virtual reality (VR)** A computer-generated environment made using graphics, sounds and movement. VR can be used for gaming or to train professionals, such as surgeons and pilots.



Computer-animated cartoon character

## A BRIEF HISTORY

- ★ 1832 English inventor Charles Babbage patents the first mechanical computer.
- ★ 1940s Electronic computers are developed. They are huge machines that use thousands of thermionic valves (♣9). The first successful electronic computer is the ENIAC, completed in 1946.
- ★ 1960s The invention of integrated circuits (♣9) enables computers to be built on a smaller scale.
- ★ 1952 Noughts and crosses, the first computer game with a graphics display is made at Cambridge University in the UK.
- ★ 1977 The first home computers appear on the market.
- ★ 1980s The lightweight laptop is developed.

# TELECOMMUNICATIONS

The sending and receiving of information using electricity, radio waves (▶ 14) or light is called telecommunications. The information can be phone calls, radio programmes, television pictures or computer data. Most forms of telecommunication require transmitting and receiving machines (▶ 14), and a network to link them together. All information is turned into signals that can travel through the network.

**Bell, Alexander Graham (1847-1922)** Scottish-American inventor who invented the telephone in 1876.

**Broadband** A high-speed communications link along which multiple streams of data can pass at once. Broadband Internet provides fast upload and download speeds (▶ 10).

**Coaxial cable** An insulated copper wire along which signals are sent as pulses of electricity. Coaxial cables are used in TV, telephone and computer networks.

**Email** A system for sending messages almost instantly between any two Internet users. Email is short for "electronic mail".

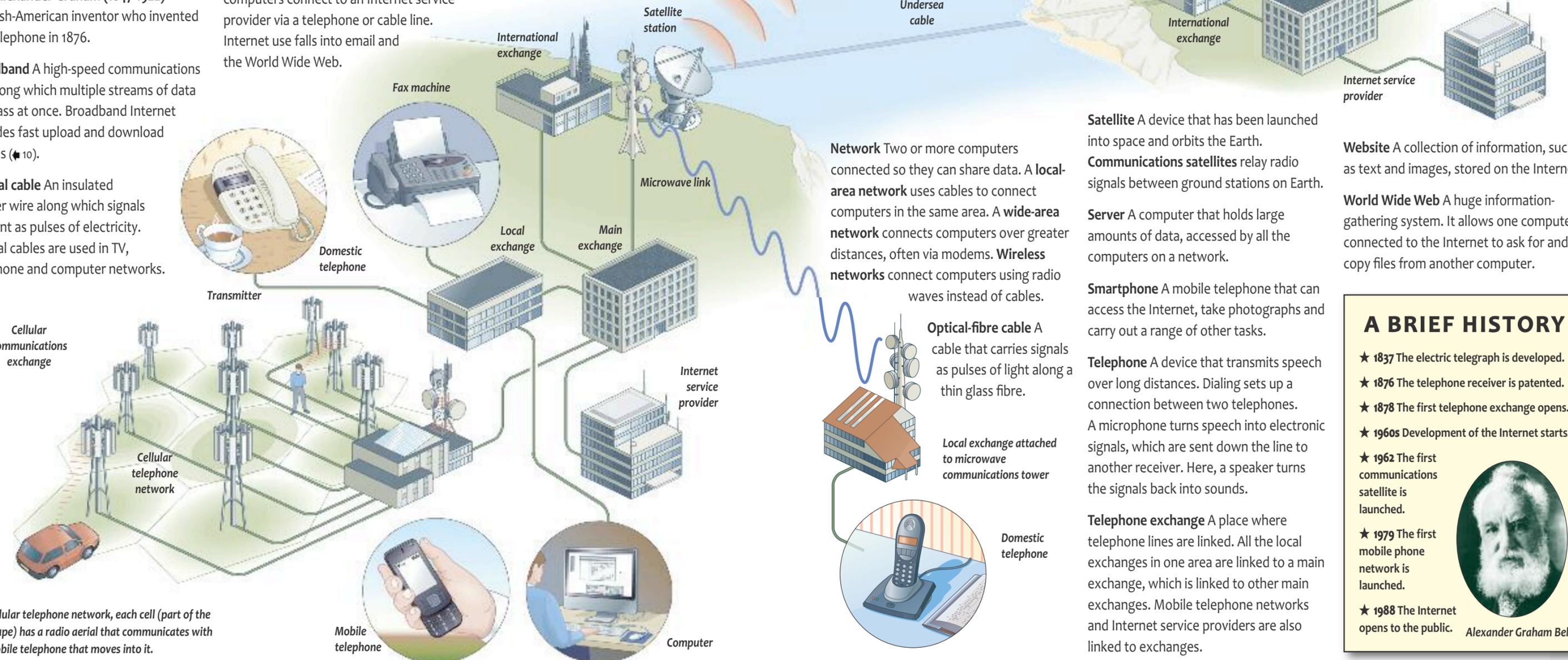
**Fax** Data sent between two machines via a telephone line. Fax is short for "facsimile". A fax machine scans a document, detects its ink pattern and sends this as a signal down a phone line. The receiving machine reads the signal and rebuilds the document.

**Internet** A communications network that links computers around the world. Most computers connect to an Internet service provider via a telephone or cable line. Internet use falls into email and the World Wide Web.

**Mobile telephone** A wireless telephone that connects to the telephone network by radio. The landscape is divided into cells, each with a fixed transmitter and receiver that mobile phones connect to.

**Modem** A device that connects computers to the Internet via a telephone line. It converts analogue signals from the line into digital signals and back again.

**Multiplexing** A technique that increases the amount of data a network can carry. It does this by merging data streams into one large signal to be carried down a single cable. At the other end, the data is sorted into separate streams.



In a cellular telephone network, each cell (part of the landscape) has a radio aerial that communicates with any mobile telephone that moves into it.

**Satellite** A device that has been launched into space and orbits the Earth. **Communications satellites** relay radio signals between ground stations on Earth.

**Server** A computer that holds large amounts of data, accessed by all the computers on a network.

**Smartphone** A mobile telephone that can access the Internet, take photographs and carry out a range of other tasks.

**Telephone** A device that transmits speech over long distances. Dialing sets up a connection between two telephones. A microphone turns speech into electronic signals, which are sent down the line to another receiver. Here, a speaker turns the signals back into sounds.

**Telephone exchange** A place where telephone lines are linked. All the local exchanges in one area are linked to a main exchange, which is linked to other main exchanges. Mobile telephone networks and Internet service providers are also linked to exchanges.

**Website** A collection of information, such as text and images, stored on the Internet.

**World Wide Web** A huge information-gathering system. It allows one computer connected to the Internet to ask for and copy files from another computer.

## A BRIEF HISTORY

- ★ 1837 The electric telegraph is developed.
- ★ 1876 The telephone receiver is patented.
- ★ 1878 The first telephone exchange opens.
- ★ 1960s Development of the Internet starts.
- ★ 1962 The first communications satellite is launched.
- ★ 1979 The first mobile phone network is launched.
- ★ 1988 The Internet opens to the public.



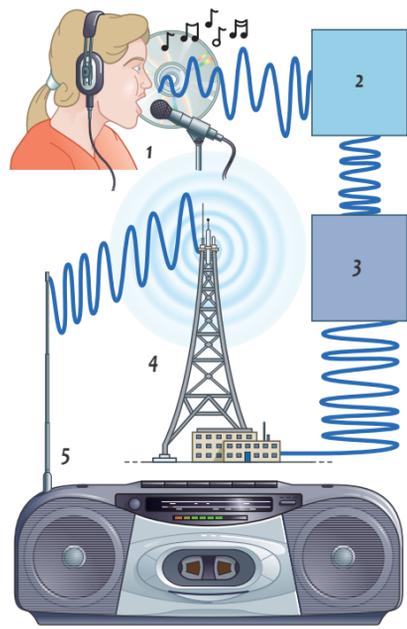
Alexander Graham Bell

# RADIO & TELEVISION

**R**adio waves are a type of invisible energy wave. They can travel through air, space and solids. On their own, radio waves do not carry information, but they can be shaped, or modulated, in order to carry information for a wide range of applications. Radio waves are used in the telephone network, for remote control of machines, and for broadcasting television and radio programmes. TV programmes can alternatively be broadcast along cables, and both radio and TV programmes can be broadcast over the Internet (12).

**Amplitude** The strength of a wave, such as a radio wave.

**Broadcasting** The transmission of radio and TV programmes via cables, ground-based transmitters and satellites (13), and the Internet.



At a radio station, sound is converted into an electronic signal (1). The signal is modulated (2), amplified (3), and sent to a transmitter (4). Radio waves are spread out and picked up by receivers.

**Cable television** Television that is transmitted through a network of underground cables. Cables link to televisions via special receivers.

**Carrier wave** A radio wave that can be modulated in order to carry information. The carrier wave, once modulated, carries information to a transmitter.

**Cathode-ray tube** The picture display technology used in older televisions. It is a sealed glass tube containing "guns" that fire beams at a screen. The beams make coloured dots on the back of the screen glow. The brightness of each dot is controlled by the TV signal. The lines of dots create a full-colour image on screen.

**RADIO WAVEBANDS:** Short waves bounce between the Earth and a layer of the atmosphere called the ionosphere. Medium waves bounce off the bottom of the ionosphere. Long waves travel flat above the Earth's surface. Microwaves are relayed by satellite.

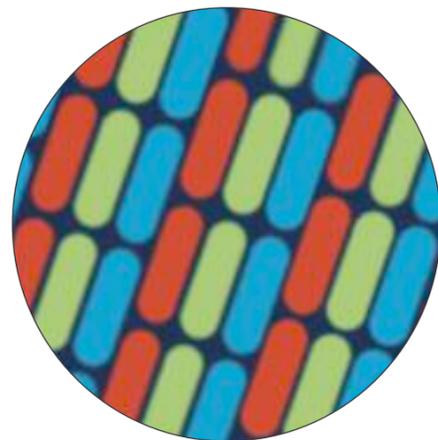
**Channel** A narrow range of radio frequencies used by a TV or radio station. Audiences tune their receivers to the frequency for the channel that they want.

**Control room** The room in a TV studio where live images and sounds are mixed to create a signal for broadcast.

**Frequency** The number of wave crests that pass a point each second. Different TV and radio stations are broadcast on carrier waves of different frequencies so they do not interfere with one other.

**High definition TV (HDTV)** A high-resolution TV picture with up to 2 million pixels (9) per frame—around five times more than a standard TV.

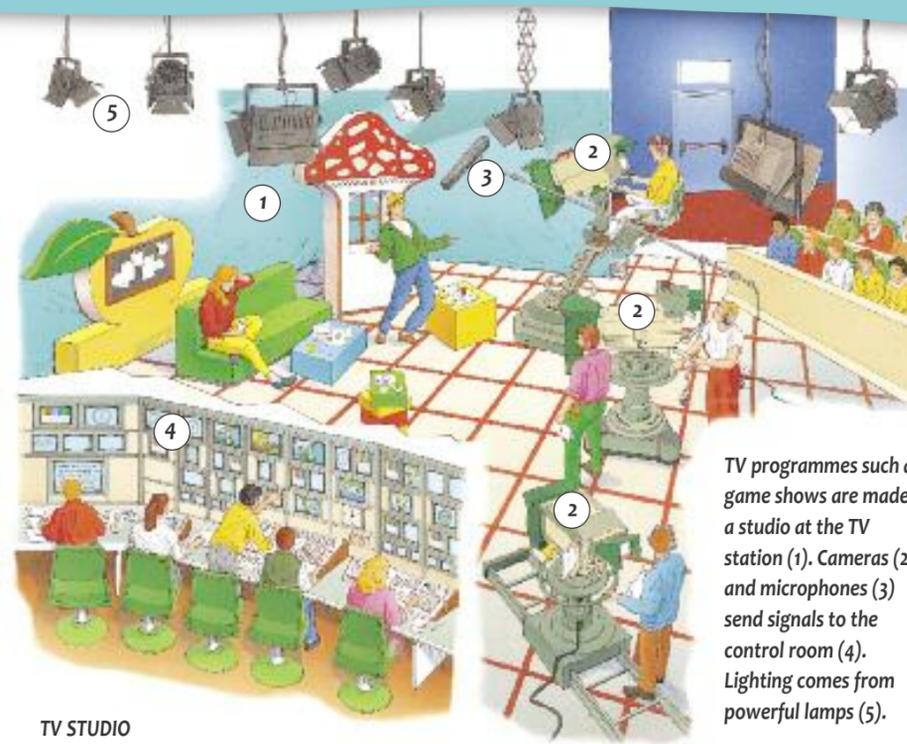
**Liquid Crystal Display (LCD)** A type of picture display. An LCD screen contains a backlight, a layer of liquid crystals and a layer of colour pixels. When electricity passes through the crystals, they act as tiny shutters, varying the amount of light that each pixel transmits.



Close-up view of a cathode-ray TV screen

**Marconi, Guglielmo (1874-1937)** Italian inventor who, in 1896, became the first person to make a long-distance radio transmission.

**Microwaves** Super high-frequency radio waves. Microwaves carry signals between transmitters and receivers, and to and from communications satellites (13).



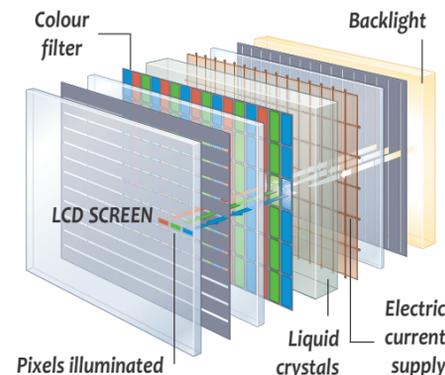
TV STUDIO

TV programmes such as game shows are made in a studio at the TV station (1). Cameras (2) and microphones (3) send signals to the control room (4). Lighting comes from powerful lamps (5).

**Modulation** The shaping of a radio wave to make it carry information. Modulation is achieved by using an electrical signal to change either the strength of a wave—amplitude modulation or AM—or the frequency of a wave—frequency modulation or FM.

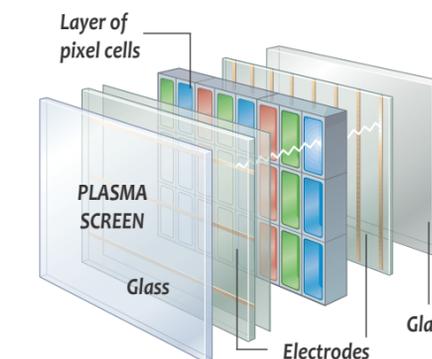
**Plasma screen** A type of TV screen containing a layer of cells filled with gas. An electric current causes the gas to give off energy, making the cell glow.

**Receiver** A device that detects signals, such as radio waves. For example, a radio receiver picks up radio waves and demodulates them to get back the original electronic signal. It uses a tuning circuit to pick out the signal from one radio station.



**Satellite television** TV broadcast via satellite (13). Signals are beamed to a satellite from a ground station. The satellite detects the signals and re-transmits them to receivers on Earth. They are received by aerial dishes pointed towards the satellite from people's homes.

**Studio** A room in which a TV or radio programme is recorded to be broadcast.



**Television camera** A camera that takes 25 to 30 photographs (frames) a second and creates electronic signals representing the pattern of colours in the frame.

**Terrestrial television** TV broadcast by radio from ground-based transmitters. The signal can be detected by the aerial of any receiver within range of the transmitter.

## A BRIEF HISTORY

★ 1888 German physicist Heinrich Hertz confirms the existence of radio waves.

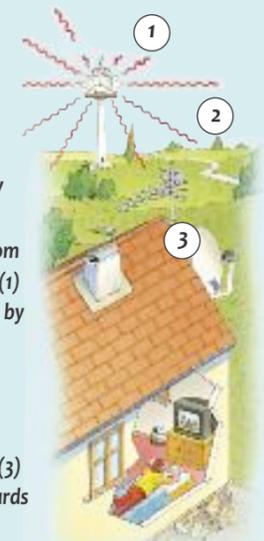
★ 1896 Italian inventor Guglielmo Marconi makes the first long-distance radio transmissions.

★ 1920s Radio broadcasting begins.

★ 1926 John Logie Baird gives the first demonstration of a television.

★ 1928 Cathode ray tube technology is invented.

★ 1930s TV broadcasting begins.



Terrestrial TV signals are broadcast from transmitters (1) and detected by aerials (2). Satellite TV signals are detected by aerial dishes (3) pointed towards the satellite.

**Transmitter** An electronic device that gives out signals such as radio waves. A carrier wave is fed to a transmitter, which turns it into a radio wave.

**Waveband** A range of radio wavelengths, for example long wave and short wave. Short waves bounce between the Earth's surface and a layer of the atmosphere called the **ionosphere**. Medium waves bounce off the bottom of the ionosphere (see diagram, left). Long waves travel flat above the surface of the Earth.

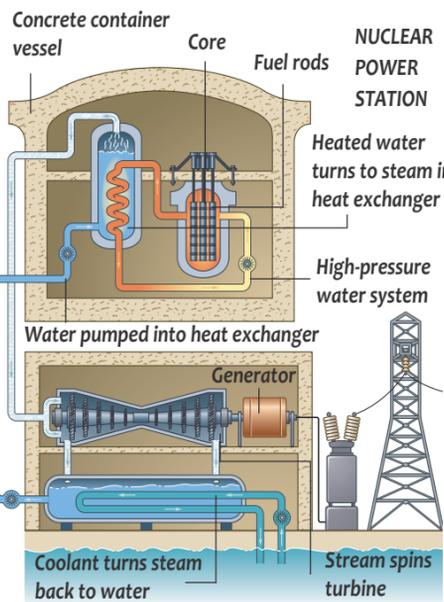
**Wavelength** The distance between two crests or two troughs on a train of waves.

**Zworykin, Vladimir (1888-1982)** Russian-American inventor who patented the cathode ray tube television in 1928.

# ELECTRICAL POWER

**E**lectricity, or electrical power, is energy produced in power stations. It is sent out via a grid of cables to homes and businesses, where wires direct it to individual rooms. When an electrical appliance is plugged in and switched on, an electric current runs through the appliance and makes it work. This converts electricity into other sorts of energy, such as light, sound, heat or movement.

**Alternating current** An electric current in which the flow of electrons changes direction regularly. It is produced in power stations, and is useful because its voltage can be changed easily by a transformer.



Nuclear reactions in the core heat water that is then pumped to the heat exchanger. Its heat is used to boil water, making steam to drive turbines.

**Circuit breaker** A switch that cuts the flow of electricity round a circuit if too much current flows through it. Unlike a fuse, it can be used again.

**Current electricity** Electricity that flows from one point to another, for example along metal wires. The flow of current is measured in **amperes**, or amps (A).

**Direct current** An electric current that always flows in one direction. This type of current is produced by batteries.

**Electrical appliance** A device that converts electricity into another form of energy. For example, a light bulb converts electricity into light; an electric motor converts electricity into movement.

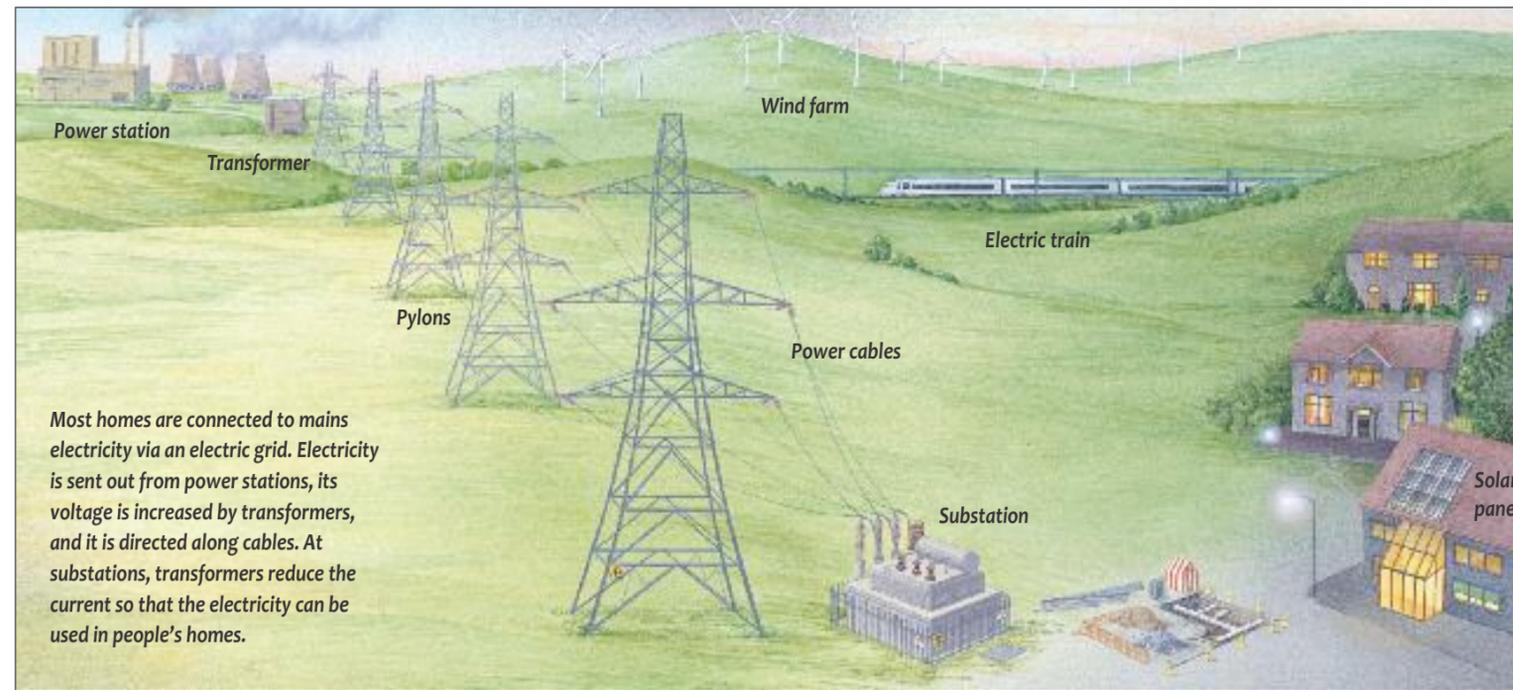


A "solar furnace", which uses mirrors to focus the sun's rays on to one spot, producing temperatures of up to 3500°C. In some furnaces, heat boils water to drive turbines and generate electricity.

**Electric grid** A network that supplies electricity from power stations to homes, factories and businesses. The electricity flows along insulated power cables.

**Electric motor** A device that turns electric current into rotary (spinning) movement. When electricity flows through a coil of wire placed between opposite magnetic poles, the coil produces its own magnetic field. The two magnetic fields interact, pushing opposite sides of the coil in opposite directions and making it spin.

**Electromagnet** A temporary magnet produced by sending an electric current along a wire. **Electromagnetism** is used to make generators and electric motors work.

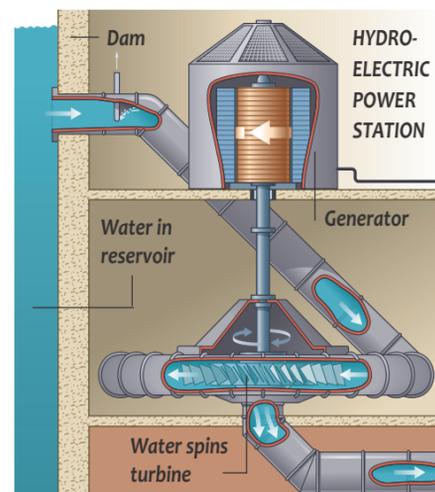


Most homes are connected to mains electricity via an electric grid. Electricity is sent out from power stations, its voltage is increased by transformers, and it is directed along cables. At substations, transformers reduce the current so that the electricity can be used in people's homes.

**Fuse** A length of wire that melts to stop the flow of electricity round a circuit if too much current flows through it.

**Generator** A device that turns rotary (spinning) movement into electric current. It consists of a magnet surrounded by a coil of wire. When the magnet spins, it produces a current in the wire. Generators are used to produce electricity in power stations.

**Geothermal power** Electricity generated by heat from inside the Earth. Geothermal power stations pump water deep underground, where it boils and rises as steam, which is used to drive turbines.



**Hydroelectric power** Electricity generated by moving water. Water flows from behind a dam, rushes downhill through turbines and turns generators.

**Mains electricity** The electricity that is supplied to lights and sockets in buildings such as homes and offices.

**Nuclear power** Electricity generated by splitting the nuclei (cores) of uranium atoms, a process called **fission**. This produces huge amounts of energy, used to heat water and drive steam turbines.

**Power cables** Thick wires along which electricity is sent from place to place, supported by pylons or laid underground.

**Power station** A place where mains electricity is generated. Many are **thermal power stations** that use heat to boil water, producing steam which powers turbines and drives a generator.

**Solar power** Electricity generated from the light and heat energy of the Sun, via **solar cells** or a thermal power station.

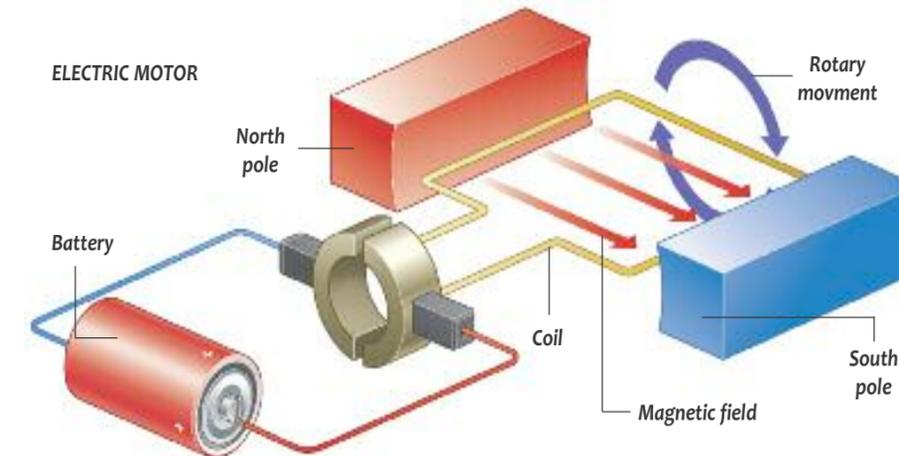
**Substation** A structure where the voltage of mains electricity is reduced before it is sent to homes and businesses.

**Tidal power** Electricity generated by the movement of the tides. A tidal power station, called a **barrage**, uses underwater turbines to drive a generator.

**Transformer** A device that changes the voltage of alternating current. Transformers increase the voltage of electricity as it leaves a power station and reduce it again before it enters homes.

**Turbine** A machine that is caused to rotate by a fluid (including liquids and gases such as steam) in order to drive a generator.

**Voltage** The force needed to make electricity flow. Voltage is measured in units called volts (V).



## A BRIEF HISTORY

★ 1882 The first power station is opened by Thomas Edison. In order to send power to customers' homes, Edison also creates the first electric grid.

★ 1883 The first solar cell is made by American inventor Charles Fritts.

★ 1884 The steam turbine is invented by British engineer Charles Parsons.

★ 1942 The first nuclear power station is built at the University of Chicago, USA.

★ 1982 The first wind farm is put into use in Washington, USA.



Light is produced in a bulb when the wire filament inside it is heated by an electric current.

**Watt** The unit used to measure power, for example the amount of electricity generated by a power station.

**Wave power** Electricity generated by the up-and-down movement of waves, using floating turbines.

**Wind power** Electricity generated by the movement of the wind. **Wind turbines** use the motion of the wind in order to drive a generator. A group of wind turbines is called a **wind farm**.

# CAMERAS

**A** camera is a device that records an image of a scene electronically or on photographic film. The main features of a camera are a lens and a shutter. Light from a scene is let into the camera when the shutter opens. The lens focuses the light on to the back of the camera. In this way it makes a small copy of the scene called an image. The image is captured on a memory chip or on a strip of photographic film.

**Aperture** An opening behind the lens of a camera. Its size can be adjusted to control how much light enters the camera.

**Charge-coupled device (CCD)** A device that divides an image into pixels (➦), measures the brightness and colour of each one, and digitizes the readings.

**Daguerre, Louis (1787-1851)** French chemist who developed the **daguerreotype**, an image fixed on a copper plate using salt.

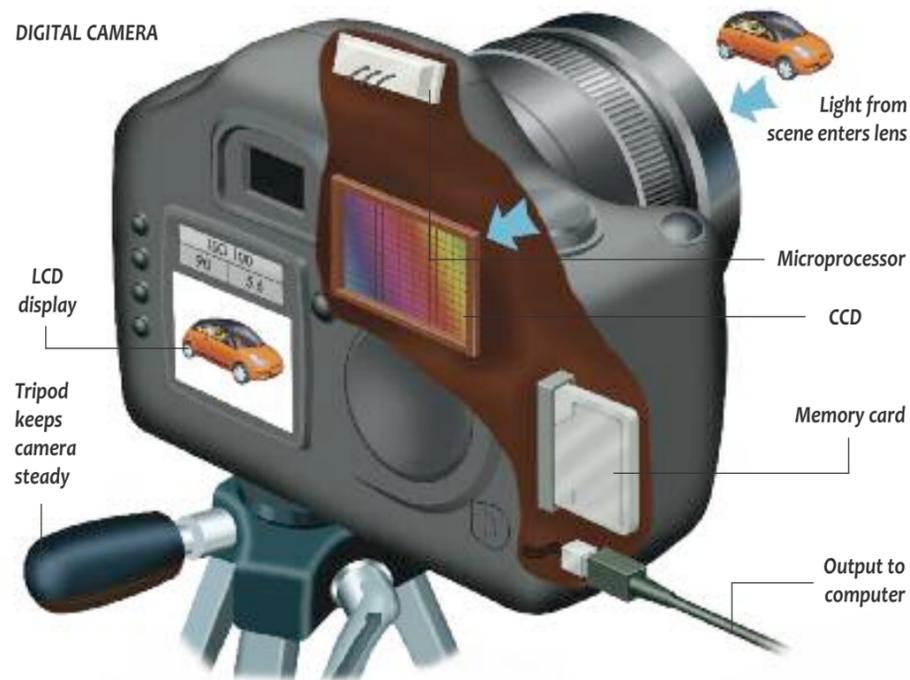
**Dark room** A room where photographs are developed. Dark rooms are often lit by red light, because most photographic paper is sensitive only to blue and green light.



Niépce's earliest surviving photograph

**Developing process** The process by which photographic film and paper is treated to create a fixed image. It is first soaked in chemicals called **developer**, which reveal the images. Then it is soaked in a **stop bath** to halt the developer, and washed in water.

## DIGITAL CAMERA



Below: The first Kodak box camera, invented by George Eastman in 1888.



**Digital camera** A camera that stores images on a memory chip or a disc.

**Eastman, George (1854-1932)** American inventor who developed flexible, photographic film. Films could easily be sent away for developing, which helped to make photography a popular hobby.

**Enlarger** A device used to make photographic prints. It projects light through a negative on to photographic paper. The projected image can be focused and its brightness altered.

**Exposure** The amount of light that reaches the film or CCD in a camera. It can be controlled by adjusting shutter speed or aperture size. Exposure must be just right or the image will be too bright or too dark.

**Flash** A device on a camera that produces a brief flash of light to illuminate a scene.

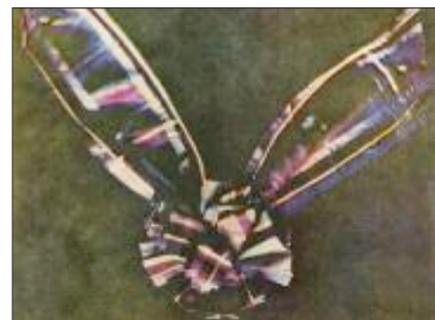
**Focus** The clarity of an image, controlled by the position of the lens, which directs light rays on to the CCD or film.

**Fox Talbot, William (1800-1877)** English inventor who developed the negative-positive process in photography.

**Lens** A shaped piece of glass or plastic that bends light rays. Cameras use a convex (bulging) lens to focus light.

**Light meter** A device that measures light levels to calculate the right exposure.

**Megapixels** One million pixels (➦). Megapixels are used to measure the resolution (➦) of a digital camera.



The first colour photograph, made in 1861 by James Clerk Maxwell. It shows a piece of tartan ribbon.

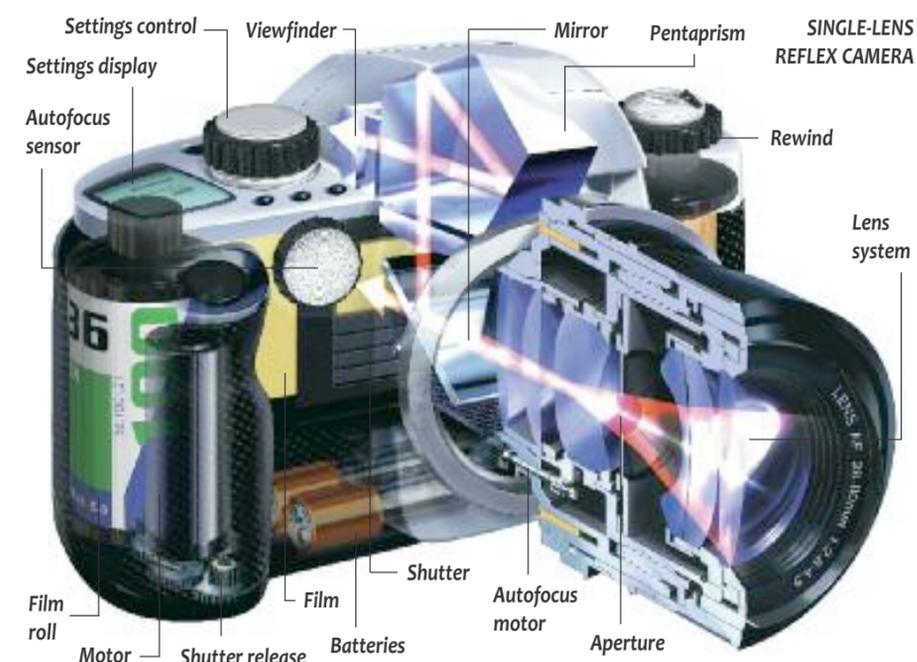
**Negative** An image where light and dark tones are inverted.

**Negative-positive process** The process in which a negative is used to print a positive image. Lighter areas in negative film allow more light through them than dark areas do. The photographic paper beneath these areas is therefore exposed to more light, so will turn dark when developed.



Black and white negative film (above) and its positive print (right).

**Niépce, Nicéphore (1776-1833)** French inventor who took the first photograph in 1825 and the earliest surviving photograph in 1827.



**Photographic film** A strip of plastic coated with light-sensitive chemicals. When light from a scene is focused on the film, chemicals in bright parts of the image change, forming a pattern. This becomes visible when the film is developed. Colour film contains three layers of chemicals to record red, green and blue light.

**Photographic paper** Paper coated with chemicals that change when exposed to light. The changes become visible when the paper is developed.

**Shutter** A device that opens and closes to control the length of exposure.

A darkroom showing (from left) an enlarger and trays of developer, stop bath and water.

**Single-lens reflex camera (SLR)** A camera that uses a mirror to reflect light from its lens to the viewfinder, so the photographer can see exactly what the image on the film will be. When the shutter-release is pressed, the mirror flips out of the way.

**Viewfinder** The lens that a photographer looks through to compose a photograph.

**Zoom** A device that can enlarge or minimize an image. Optical zooms use a lens that moves forwards or backwards. Digital zooms electronically crop or enlarge an image, resulting in lower resolution (➦).

## A BRIEF HISTORY

- ★ **c.900** The first type of camera, the **camera obscura**, is used. A hole in the wall of a room enabled an image from outside to be projected on to the opposite wall.
- ★ **1827** Nicéphore Niépce takes the earliest surviving photograph.
- ★ **1839** William Fox Talbot makes the first photographic negative.
- ★ **1861** Scottish physicist James Clerk Maxwell takes the first colour photograph.
- ★ **1884** George Eastman patents flexible film that can be rolled inside a camera.
- ★ **1980s** The first digital cameras are sold.

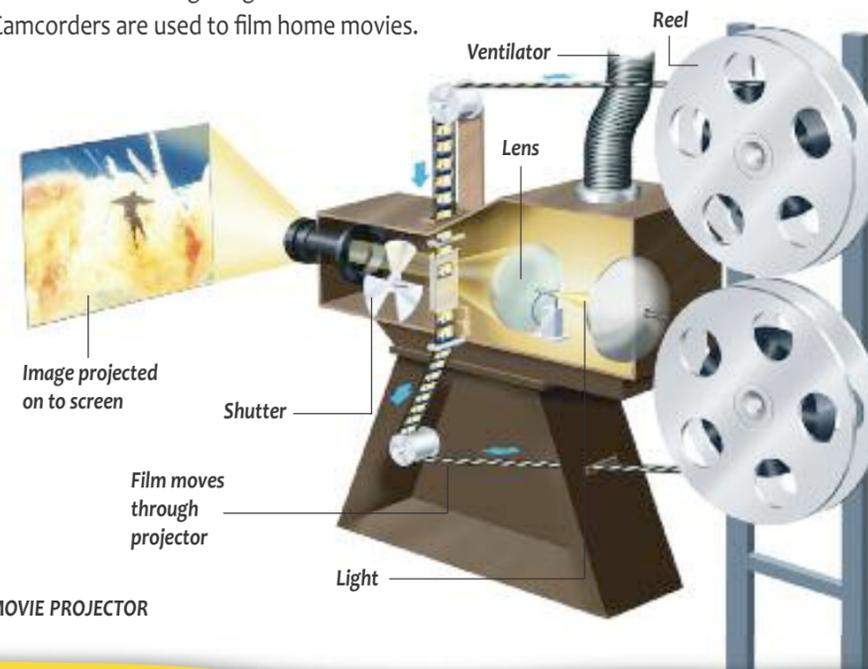
# MOVIES

**A** motion picture or “movie” is made up of thousands of images. When played in quick succession, they create the illusion of movement. The first movie was shown in Paris in 1895. Since then, cinema has become popular all over the world. Thousands of people work in the movie industry, involved in every part of making a movie, from working the cameras or acting in front of them to making costumes and writing the script.

**Animation** The technique that creates the illusion of movement by showing a sequence of drawings or photographs of moving models. Computers are now used for most animation.

**Blue-screening** A technique used to replace the background of an action shot. Actors perform in front of a blue screen. The blue parts of the image are then replaced with other footage. This is used to create shots that are dangerous or impossible to shoot.

**Camcorder** A small electronic device that records both moving images and sound. Camcorders are used to film home movies.

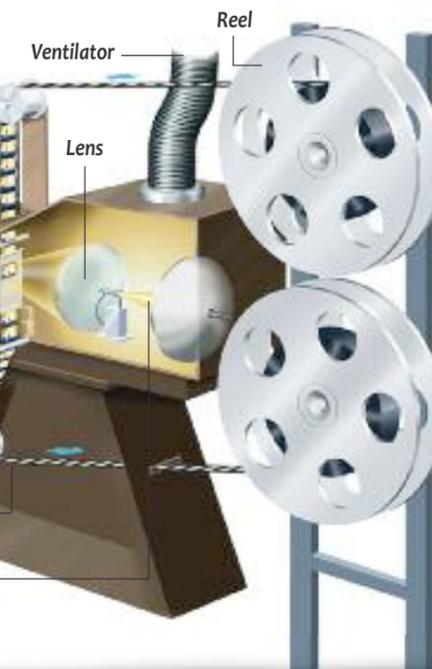
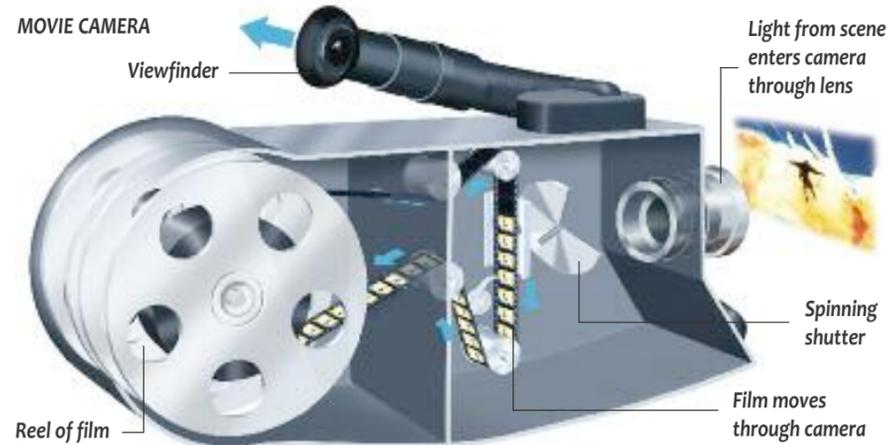


MOVIE PROJECTOR



Thomas Edison built his kinetoscope (left) in 1891 to show films shot by his kinetograph. The viewer watched the film through a slot in the top of the kinetoscope.

**Digital cinema** The use of digital electronics (8) to store and project movies. Some movies are shot and projected digitally, but others are shot with traditional film then digitized. Digital techniques eliminate scratches or flicker, and enable movies to be sent via Internet or satellite connections.



**Dubbing** The process of adding new sounds or dialogue to a movie's soundtrack. Dialogue is dubbed in different languages if a movie is released in another country.

**Editing** The process of mixing sounds and pictures together to produce the final movie, usually done using a computer.

**Frame** An image in a series of images that makes up a moving picture. Movie film moves at 24 frames per second, so our eyes see continuous moving action.

**IMAX** A type of large-format film, projected on to a screen much larger than normal cinema screens.

**Live action film** A movie that features real actors rather than animation.

**Lumière brothers** Auguste Lumière (1862-1954) and Louis Lumière (1864-1948), French brothers who made some of the first movies. They invented the movie projector and showed the first movie in 1895.

**Matte** A visual effect where a painted background is added to footage after shooting. This is used to create images that are too expensive or complicated to achieve with a set or backdrop.

**Movie camera** A camera used to capture moving images. A shutter opens to let light hit the film, creating a frame. Then it closes and the film is moved into position for the next frame. This is repeated 24 times per second.



A busy film set. The studio looks like an 18th century street. Outside the studio, actors are fitted with their costumes and have their make-up done.

**Movie projector** A machine used to show a movie. A bright light shines through each frame and projects its image on to a screen. While the shutter is closed, the film moves on a frame. The frames pass so quickly that the image appears to move.

**Props** Short for properties, props are objects such as furniture, glasses or weapons used by actors on a set.

**Score** The music written to accompany a movie. The score is composed and edited to fit exactly to the visual action.

**Set** The place where a movie is shot, inside a studio, or outside, “on location”. Inside a studio, backdrops, props and models can be used to create any scene, from a historical street to a futuristic city.

**Soundtrack** The dialogue, score and sound effects that accompany a movie or TV programme. The soundtrack is usually recorded on a narrow strip down the edge of the movie film.

**Special effects** Techniques, such as puppets, wires or weather machines, that are used to create illusions during filming. Effects added after filming are visual effects, but may be called special effects.

**Talkies** Talking pictures, or “talkies” were first made in the 1920s. They were the first movies to combine live action and sound.



Digital camcorder

**Visual effects** Techniques such as blue screening, matte painting and CGI (10), that add illusions after a film has been shot.

**Zoetrope** A 19th century device, used to give the illusion of a moving image. It was a slotted cylinder, lined with a strip of images. When the cylinder spun, the viewer looked through the slots and the images appeared to move.

## A BRIEF HISTORY

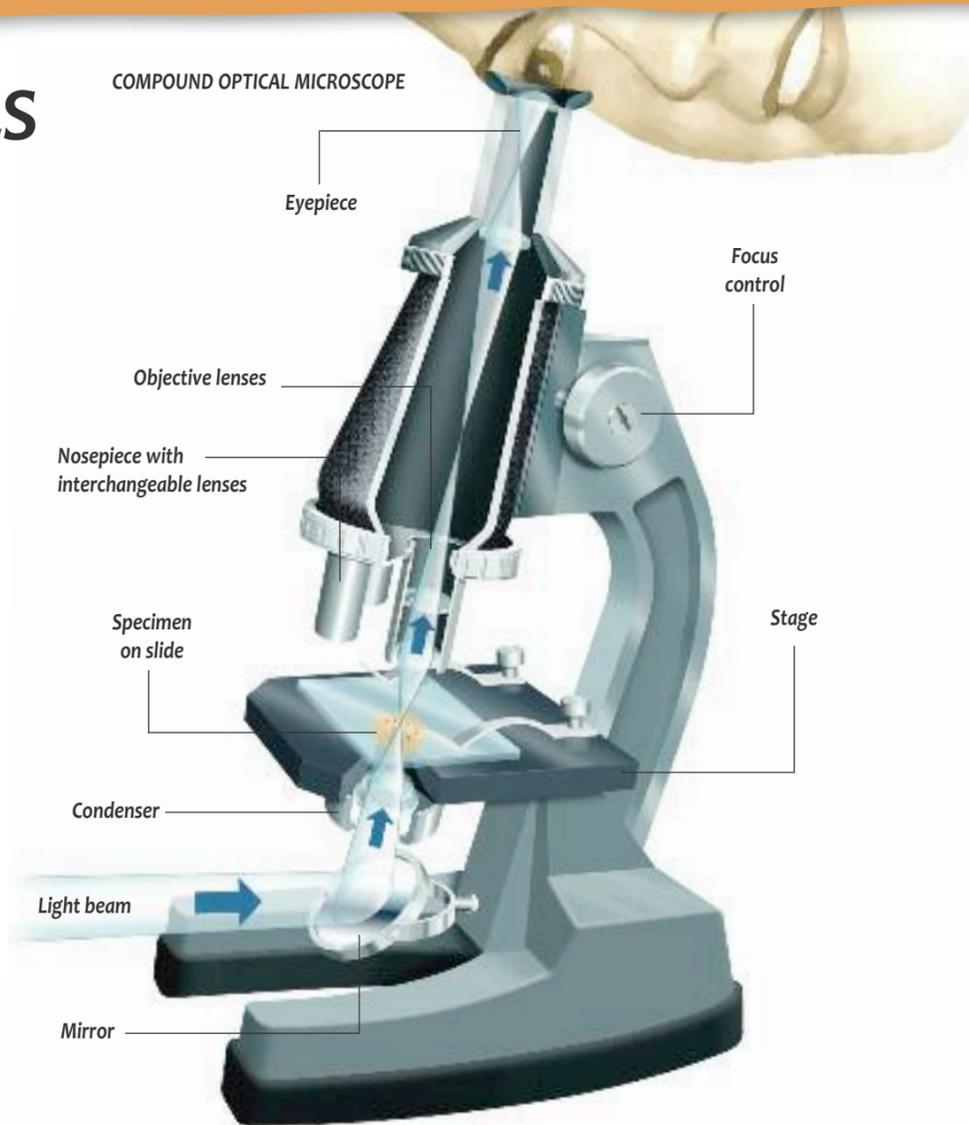
- ★ 1888 Louis Aimé Augustin Le Prince invents the first motion picture camera.
- ★ 1891 The kinetoscope is developed by Thomas Edison. It is the first commercially successful movie projector.
- ★ 1895 The first movie is shown in Paris by the Lumière brothers.
- ★ 1905 The first cinema opens in the USA.
- ★ 1927 *The Jazz Singer*, the first full-length film with sound is released. The talkies quickly gain popularity.
- ★ 1935 *Becky Sharp*, the first full-length technicolour film is released.
- ★ 1983 Sony bring out the first commercial camcorder, which is carried on the shoulder.
- ★ 1995 *Toy Story*, the first completely computer-animated film, is released.

# MICROSCOPES

A microscope is an instrument that magnifies very small objects, allowing the viewer to see detail that is invisible to the naked eye. The early microscopes of the 17th century enabled scientists to view microorganisms such as bacteria for the first time, helping to understand the cause of some diseases. In the modern world, microscopes are used mostly, but not only, in biology and medical research. There are two types of microscope—optical microscopes and electron microscopes.

**Binocular microscope** A microscope with two eyepieces both showing the same view.

**Compound microscope** An optical microscope that contains more than one lens. A standard compound microscope has two lenses: an objective lens and an eyepiece. If the objective lens has a magnifying power of x8 and the eyepiece has a power of x10, the total magnifying power of the microscope will be x80.



**Electron microscope** A microscope that uses tiny particles called electrons (➤ 8) to magnify objects. Electron microscopes include: scanning electron microscopes (SEMs), transmitting electron microscopes (TEMs) and scanning tunnelling electron microscopes (STMs). Electron microscopes can magnify objects many more times than optical microscopes can.

**Eyepiece** The lens in a microscope or telescope (➤ 24) that the viewer looks into. It magnifies the image made by the objective lens.

**Janssen, Zacharias (1580-1638)** Dutch spectacle-maker who is thought to have built the first compound microscope in about 1590. Early microscopes had poor-quality lenses and gave blurred images.

**Leeuwenhoek, Anton van (1632-1723)** Dutch scientist who began making single-lens microscopes in the 1670s. He was the first person to observe microorganisms, such as bacteria.



An optical photomicrograph of a snowflake, magnified x20.



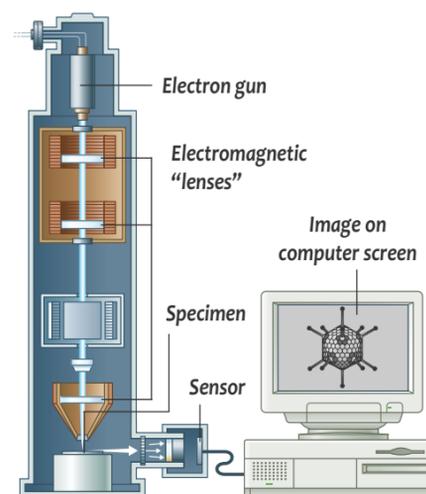
French microbiologist Louis Pasteur studying bacteria under a microscope.

**Condenser** A lens that concentrates light on to the specimen.

**Digital microscope** An optical microscope that uses a digital camera (➤ 18) to display the magnified image on a computer.



**Magnifying power** The magnification achieved by a microscope, for example x10 or x100. If an object is magnified x100 it will appear 100 times larger than it is.



A scanning electron telescope. A beam of electrons is focused by electromagnetic "lenses". Electrons scatter off the object on to a sensor.

**Nosepiece** The part of an optical microscope that holds the objective lens.

**Objective lens** A lens in a microscope or telescope (➤ 24) that is closest to the object being studied. In an optical microscope, the objective lens gathers light from an object and focuses it to create a magnified image of the object.

An SEM photomicrograph of a snowflake x3000. Colour has been added to make the details clearer.

**Optical microscope** A microscope that uses light to create a magnified image of an object. Optical microscopes can only magnify objects up to 1500 times.

**Photomicrograph** A photograph taken using a microscope.

**Scanning electron microscope (SEM)** An electron microscope that uses a narrow beam of electrons to build up a three-dimensional image. The beam scans across the object's surface and a sensor detects the electrons bouncing off. Unlike other electron microscopes, it can be used to view whole objects, such as insects. SEMs magnify objects more than 250,000 times.

**Scanning tunnelling electron microscope (STM)** An electron microscope that can magnify specimens up to 100 million times, which is enough to see individual atoms. It scans a charged metal pen over the surface of a specimen, so that electrons jump or "tunnel" between the pen and the surface. This creates a "map" of high points (atoms) and low points (the gaps between them).

**Slide** A thin piece of glass upon which an object or specimen is fixed to be viewed.

## A BRIEF HISTORY

★ **c.1590** Zacharias Janssen builds the first compound microscope.

★ **1665** English scientist Robert Hooke publishes *Micrographia*, a collection of his observations using a microscope.

★ **1683** Anton van Leeuwenhoek develops a high-precision microscope.

★ **1932** The first electron microscope is built by Ernst Ruska and Max Knoll. It is a transmitting electron microscope (TEM).

★ **1935** The first scanning electron microscope (SEM) is built by Ernst Ruska.

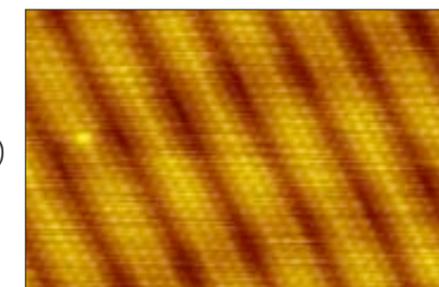
★ **1981** German physicist Gerd Binnig and Swiss physicist Heinrich Rohrer develop the first scanning tunnelling electron microscope (STM).

**Stage** The part of a microscope where an object is placed to be viewed. A hole in the centre of the stage allows light to be directed at the object or specimen.

**Stereo microscope** An optical microscope that produces a three-dimensional image. Two eyepieces are used, meaning each eye sees a slightly different view, creating a 3-D view of the magnified object.

**Transmitting electron microscope (TEM)** An electron microscope that fires a beam of electrons through a thin slice of specimen. The electrons scatter off dense areas of specimen but pass through less dense areas, creating a "shadow" image. TEMs magnify objects up to 50 million times.

A scanning tunnelling electron micrograph reveals the individual atoms of a specimen (below).



# TELESCOPES

A telescope is an instrument that makes distant objects appear closer, allowing the viewer to see details that are not visible with the naked eye. Objects on Earth and in space can be observed using optical telescopes, which collect light from distant objects and use it to produce images. They can also be observed using telescopes that gather other energy waves, such as radio waves (14), infrared rays, x-rays and gamma rays. The development of telescopes has helped mankind to make many discoveries about the Universe.

**Astronomical telescope** A telescope used to study objects in space. Astronomical telescopes include optical telescopes, radio telescopes and space telescopes.

**Binoculars** A pair of telescopes fixed side by side, with one telescope for each eye. Binoculars can magnify objects to look up to 20 times their size.

An observatory (below). The doors slide open to give a view of the stars.

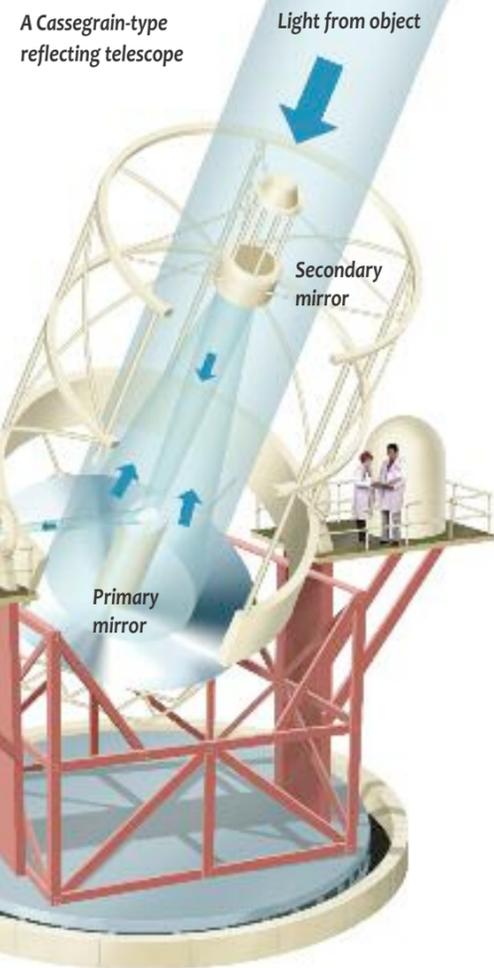
**Catadioptric telescope** A telescope that combines lenses and mirrors to minimize image distortions. The most famous type are **Schmidt-Cassegrain** telescopes, which were invented in 1940.

**Cassegrain-type telescope** A reflecting telescope that uses two mirrors. Light is focused by a large primary mirror on to a smaller secondary mirror. From there it reflects to the viewer or light sensor.

**Galileo Galilei (1564-1642)** Italian astronomer who, in 1609, used the first astronomical telescope, with which he discovered four moons around Jupiter.

**Gran Canaria Telescope** The world's largest telescope, positioned atop a 2400-m peak on an island in the Canaries. Its mirror, measuring 10.4 m across, consists of 36 hexagons fitted in a honeycomb pattern.

**Hubble Space Telescope** A reflecting space telescope that orbits Earth. It can detect visible light, infrared and ultraviolet rays. It can see 10 times more detail than Earth-based telescope and objects 50 times as faint. Solar panels provide its power and images are transmitted back to Earth by radio.



**Interferometry** A technique that combines results from several telescopes to increase their resolution (9). If two telescopes are placed 50 m apart, their combined power will be the same as a telescope 50 m across. Interferometry is used because it is cheaper to erect several small telescopes than to build one large one.

**Lippershey, Hans (1570-1619)** German-Dutch lens-maker who is thought to have made the first telescope in 1608.

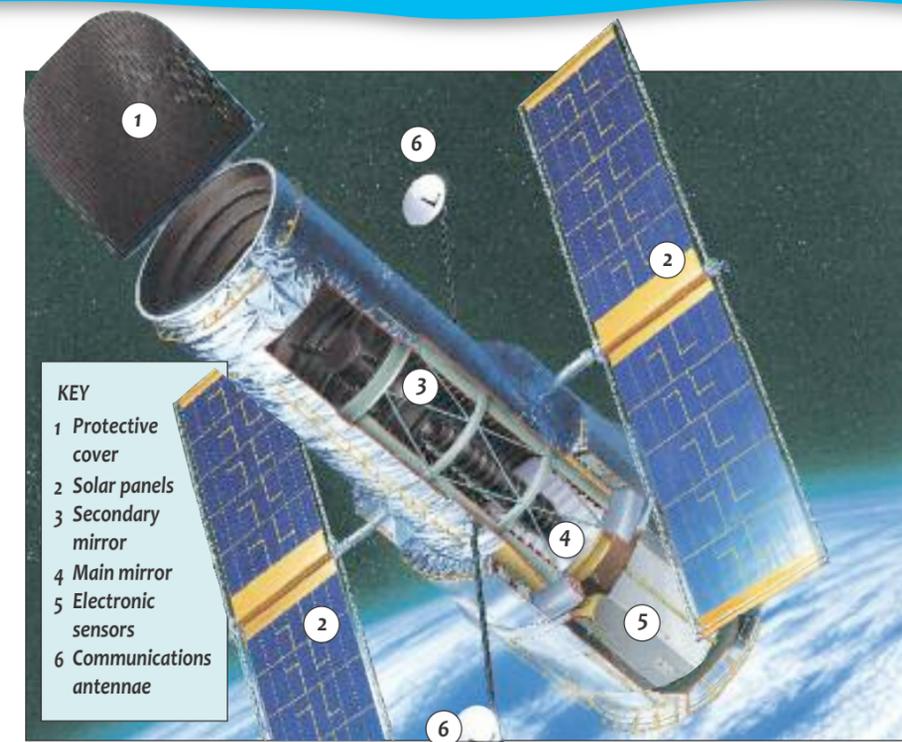
**Observatory** A building where a telescope is housed. Observatories are usually sited on mountaintops where light and air pollution is at a minimum and where viewing is least affected by cloudy skies or atmospheric disturbance.

**Optical telescope** A telescope that collects light coming from distant objects and uses it to produce images of the objects. The two main types of optical telescope are refracting and reflecting telescopes.



**Radio astronomy** A branch of astronomy based on the study of radio waves given off by objects in space. Many celestial, such as stars and galaxies, emit radio waves and other sorts of radiation as well as light. Radio astronomy has led to the discovery of new celestial objects, such as pulsars, that would be otherwise invisible.

**Radio telescope** A telescope that collects radio waves given off by celestial objects, such as stars. It has a large dish that collects radio waves and focuses them on to a receiver. It can be turned to collect rays from any part of the sky.



The Hubble Space Telescope

**Reflecting telescope** An optical telescope that uses a concave (dish-shaped) mirror to collect light from an object and focus it to form an image. Larger telescopes are usually reflecting telescopes because mirrors are lighter than lenses and more compact than refracting telescopes.



Looking at the stars through a refracting telescope.

**Refracting telescope** An optical telescope that uses a convex (bulging) lens to collect light from an object and focus it to form an image. The larger the lens, the more distant the objects that can be observed and the brighter their image will be.

**Space telescope** A telescope in space, used to study radiation that is blocked by Earth's atmosphere. Space telescopes use special mirrors to reflect radiation, and electronic detectors to record images. Optical telescopes also work better in space as they are unaffected by the atmosphere. All ground-based telescopes are affected by the atmosphere, which distorts light rays as they pass through it.

**Terrestrial telescope** An optical telescope used for viewing objects on Earth.

## A BRIEF HISTORY

- ★ 1608 Hans Lippershey builds the first refracting telescope
- ★ 1609 Galileo Galilei uses the first astronomical telescope.
- ★ 1688 The reflecting telescope is invented by English scientist Isaac Newton.
- ★ 1931 The first radio telescope is built by American physicist Karl Guthe Jansky.
- ★ 1940s Interferometry is developed.
- ★ 1990 The Hubble Space Telescope is launched into orbit.

# LASERS & RECORDING

**A** laser is a device that creates an intense beam of light. The light waves in a laser beam all have the same wavelength (15) and are all “in phase”: their crests and troughs line up. The word “laser” is short for **Light Amplification by Stimulated Emission of Radiation**. The atoms of the material inside a laser are “stimulated” by giving them light or electrical energy. This makes them emit an intense beam of light. Lasers are used to play and record music, to cut metal, perform surgery and carrying data along optical fibres (13).

**Analogue recording** A recording technique that makes a physical copy of sound waves. For example, the grooves in a record are a copy of the vibrations in an original sound.

**Barcode** A black and white pattern, scanned by a laser to reveal coded data. Black areas absorb the laser beam, but white areas reflect it back. The pattern is then recognized by the scanner.



A laser used to perform eye surgery. The heat of the laser is used to “weld” together burst blood vessels or to stick a detached retina back in place.

**Blu-ray disc** A disc similar to a DVD but read using blue laser light. Because blue light has a short wavelength it can read very tiny pits. Blu-rays have many more pits than DVDs and hold over five times more data.

**Compact Disc (CD)** A plastic-coated aluminium disc used to store digital data such as sounds. On the surface of a CD, flat areas called **lands** and shallow dips called **pits** represent binary digits (8). These are detected by a laser beam in a CD player.

**CD player** An electronic device that plays back sound recorded on a CD. As the disc spins, a laser detects the pattern of pits and lands on the CD’s surface. This is converted back into the original electric signal, which is amplified and sent to speakers.

**CD-ROM (Compact Disc Read-only)** A type of CD holding data that can be read by a computer but cannot be changed.

**Digital recording** A recording technique that converts sound waves into an electrical signal, digitized to create a string of binary numbers (8).

**DVD (Digital Versatile Disc)** A plastic-coated aluminium disc, used to store digital sounds and images. Because the laser beam of a DVD player is very fine, it can focus on tiny pits and lands. This means a DVD can have more pits and lands than a CD and contain seven times more data.



Barcodes are attached to items in shops. A scanner reads the barcode to identify the product.

**Gramophone** An early recording device, invented in 1877 by Thomas Edison. To record, a sound vibrated a needle, cutting a groove in a foil surface. To play back, the needle moved along the groove, vibrating a diaphragm to reproduce the sound.

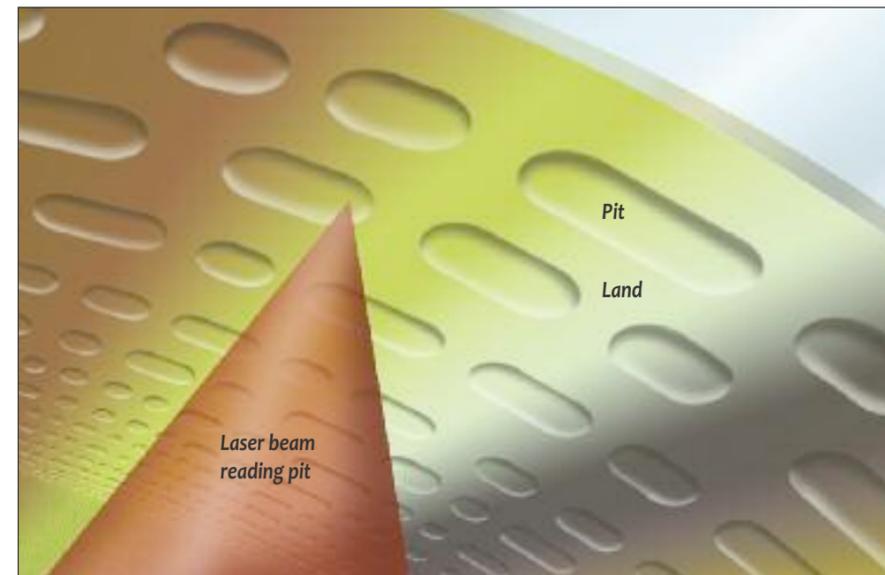
**High-power laser** A laser that can be focused to create intense heat. High-power lasers are used in for accurate cutting in industry and medicine.

**Hologram** A three-dimensional image, created by lasers. To form a hologram, a laser beam is divided in two. One beam is shone at photographic paper (19); the other is directed at the object, from where it bounces on to the paper. Here it crosses the first beam, forming a pattern. When the film is developed and lit in the correct way, a 3-D image can be seen.

**Lasing material** The substance inside a laser. This can be a solid, a liquid or a gas. The lasing material is contained in a tube with a mirror at one end and a half-silvered mirror at the other. Light bounces through the material, gaining strength to form an intense beam.

**Loudspeaker** A device that turns electric signals into sound waves. Most speakers consist of a coil of wire held between two magnets. An electric current creates a magnetic field in the wire, which is alternately attracted to or repelled by the magnets in rapid succession. The coil vibrates, moving a cone, which sends sound waves into the air.

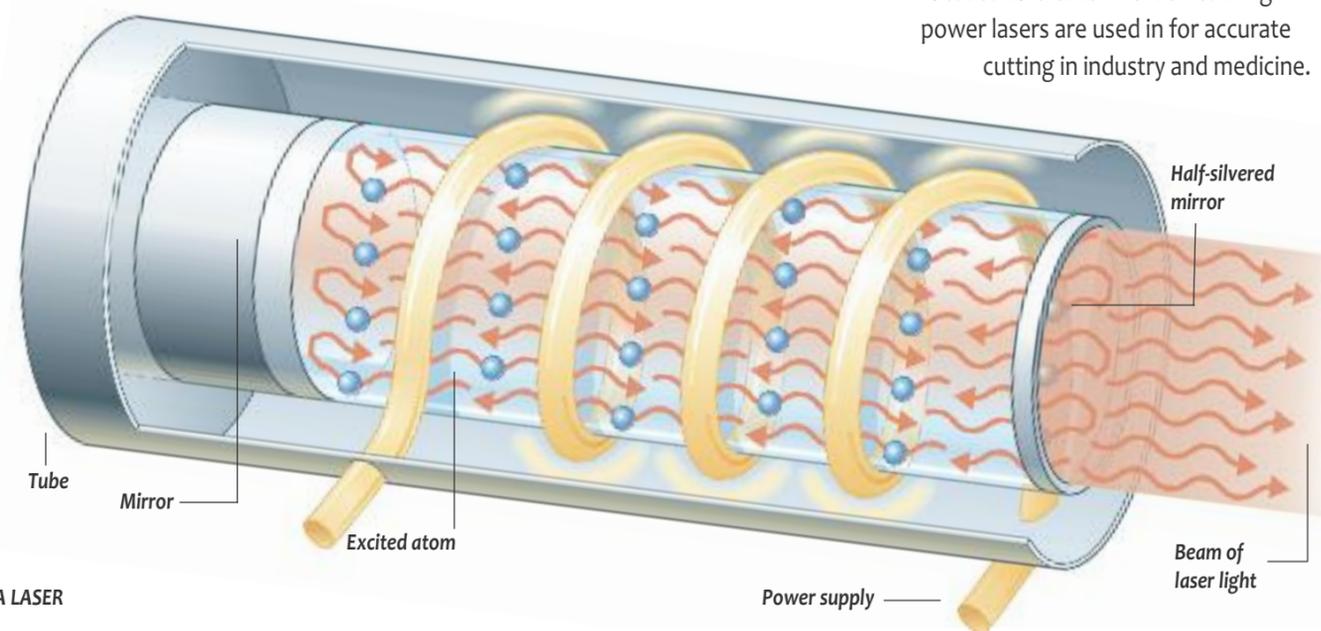
**Low-power laser** A laser used to play CDs, read barcodes and send fibre-optic signals. Low-power lasers are normally red lasers that use semiconductor (9) materials.



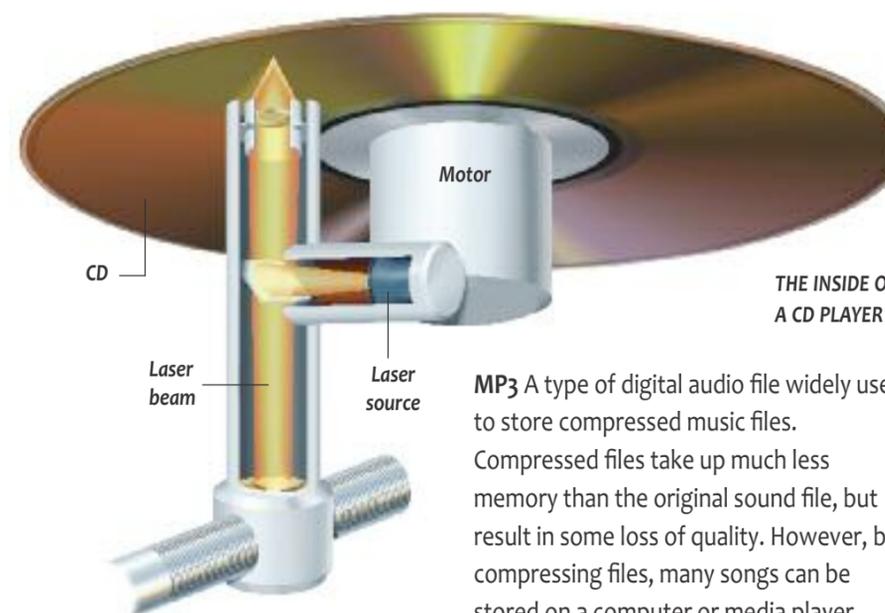
The pattern of pits and lands on a CD are read by a laser beam (above).

**Maiman, Theodore (1923-2007)** American physicist who built the first working laser in 1960. His laser used a ruby crystal as its lasing material.

**Microphone** An electronic device that turns sound waves into electric signals. In a **condenser microphone**, electricity flows between two metal plates. When sound waves vibrate the outer plate, the electric field between the plates changes, creating an electric signal. In a **dynamic microphone**, sound waves vibrate a wire coiled around a magnet, creating an electric signal in the wire.



A LASER



THE INSIDE OF A CD PLAYER

**MP3** A type of digital audio file widely used to store compressed music files. Compressed files take up much less memory than the original sound file, but result in some loss of quality. However, by compressing files, many songs can be stored on a computer or media player.

## A BRIEF HISTORY

- ★ 1877 Thomas Edison demonstrates the gramophone, the first recording device.
- ★ 1935 The first practical tape recorder is developed in Germany.
- ★ 1948 The bar code is invented by Norman Woodland and Bernard Silver in the USA
- ★ 1960 Theodore Maiman builds the first laser.
- ★ 1965 The first three-dimensional holograms are made in the USA.
- ★ 1982 The first music CD is sold in Japan.
- ★ 2001 The first portable media players are sold.



A gramophone

**Tape recording** A way of recording sound on to a length of magnetic tape. An electrical signal from a microphone is sent to an electromagnet (17), which creates a pattern in the tiny magnetic particles that coat the tape. A tape player converts the magnetic pattern into an electric signal, which is amplified and sent to a speaker.

# BUILDINGS

**B**uildings belong to one of two types. The first has solid, load-bearing walls that support the floors and roof of the building. The second type has a framework of wood, steel or concrete that bears the weight of the building. An architect plans the design of the building, while engineers work out how to make it strong and safe. Then builders follow careful plans to construct the building.

**Beam** A horizontal part of a building's structure, made of steel, wood or reinforced concrete.

**Brick** A block of hardened clay used to construct some buildings.

**Bulldozer** A vehicle used to demolish old buildings and clear areas for new ones. At its front is a metal shovel, used to scoop up rubble or earth and push it aside.

**Caisson** A steel or concrete-walled hollow tube, which is driven deep into the ground. When in place, it is filled with concrete to create strong foundations. Caissons are used to support skyscrapers and other structures.



Pumping concrete from a concrete mixer into the foundations of a building (above).

**Caterpillar tracks** Metal belts used instead of wheels on heavy vehicles such as diggers or bulldozers. Their large surface area spreads the weight of the machines, enabling them to move over soft or uneven ground without getting stuck.

**Cement** A powder that goes hard when mixed with water. It is mixed with sand to make mortar for bricklaying, or with sand and aggregate to make concrete.

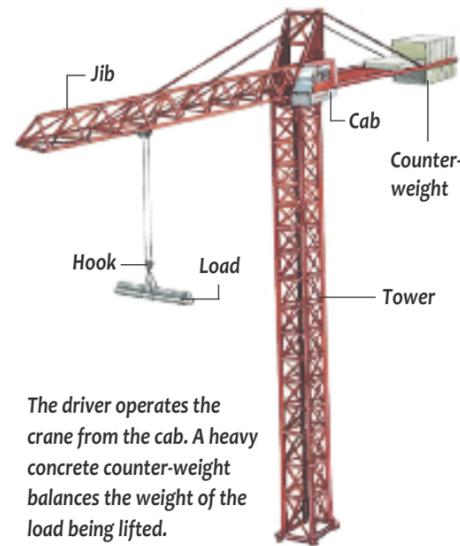
**Cladding** The non-load-bearing exterior surface of a building.

**Column** A vertical structure in a building's frame.

**Concrete** A building material made by mixing aggregate (sand or crushed rock), cement and water. It sets to form a strong, stone-like material.

**Concrete mixer** A vehicle with a revolving drum on its back, used to mix concrete and keep it moving so it does not set.

**Crane** A tall machine used to lift building materials, such as steel beams. Some cranes are fixed to the ground, some are fixed to lorries and some can "creep" up the side of buildings as they are built.



The driver operates the crane from the cab. A heavy concrete counter-weight balances the weight of the load being lifted.

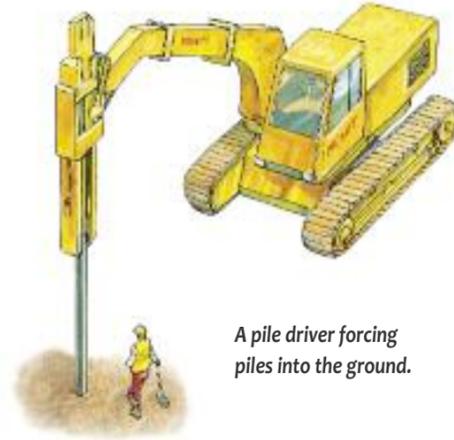
**Cross-bracing** Diagonal steel beams fixed in each panel of a truss. Cross-bracing helps keep a building stable in high winds.

**Curtain wall** The outside of a large building, usually made of glass or metal panels. It is fixed to the structural frame but does not support any weight.

**Digger** A construction vehicle used to scoop holes in the ground using a toothed metal shovel at its front.

**Duct** A vertical space running through the core of a building. Electricity, water and other services may run through ducts.

**Foundations** The lowest part of a building, which ensures its weight is supported on firm ground so the building cannot sink or fall. Foundations can be footings (underground walls), piles or caissons.



A pile driver forcing piles into the ground.

**Frame** The structure of wood, steel or concrete that bears the weight of a building. A **skeleton frame** uses a lattice of vertical columns and horizontal beams to spread the weight of a building.

**Girder** A large horizontal structure. It may support smaller beams, form the roof of a building or form the road deck of a bridge.

**Load-bearing wall** A solid wall that supports the floors and roof of a building.

**Pile** A pillar that provides the foundation for a building. It may be made of wood or metal driven into the ground by a machine called a **pile driver**, or from concrete poured into a deep hole.

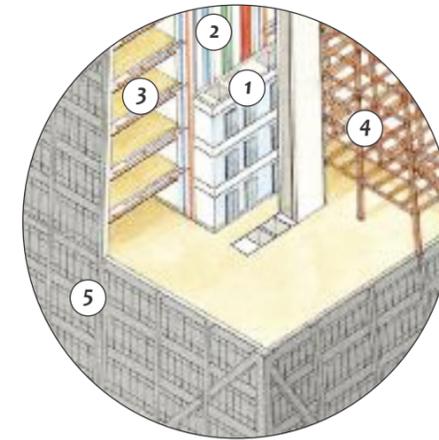
**Reinforced concrete** Concrete with steel bars or wires embedded in it to make it much stronger.

**Skyscraper** A very tall building, usually more than 20 storeys high. Skyscrapers are a feature of many large cities.

**Steel** A type of iron that is mixed with carbon to make it stronger. It can be easily mass-produced. This makes it ideal for use in skyscrapers, which may require thousands of identical girders and columns.

**Storey** One level or floor of a building.

**Tipper truck** A vehicle that carries heavy material in a container behind the cabin. To unload, its body tips up, the tailgate swings open and the load slides out.



Inside a skyscraper: 1 lift shaft 2 central duct 3 concrete beams 4 steel frame 5 curtain walls

**Truss** A framework made up of beams joined at their ends to form triangles. It is used to support a roof, bridge or other structure.

## A BRIEF HISTORY

★ **c.3000 BC** Concrete is first used by the Ancient Egyptians, Chinese and Greeks.

★ **600 BC** The first cranes are used in Ancient Greece.

★ **1770** British inventor Richard Edgeworth invents the caterpillar track.

★ **1867** Reinforced concrete is invented by French gardener Joseph Monier.

★ **1884** The first skyscraper, the Home Insurance Building, is built in Chicago.

★ **1920** The first dumper truck is built in Canada by Robert T. Mawhinney.

★ **1923** The first bulldozer is constructed in the USA.

The John Hancock Center in Chicago, USA (right), a skyscraper with both offices and residential apartments.



### BUILDING A SKYSCRAPER

- 1 Pile drivers press caissons into the ground
- 2 The steel frame and concrete lift shafts are built up above the foundations
- 3 Curtain walls are added to the exterior



An old building is knocked down on a demolition site.

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