VOLUME 17 STARCH to TOYS

CHILDREN'S BRITANNICA

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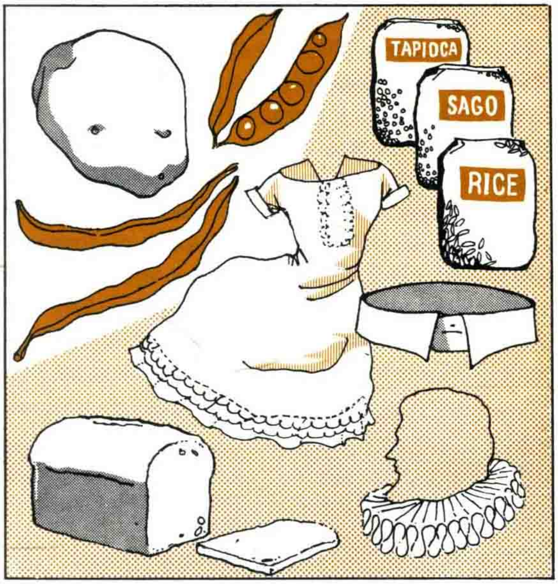
STARCH comes from plants and is a carbohydrate, which means that it is made up of carbon, oxygen and hydrogen. It is important to have starch in the diet because it gives energy. While being chewed, starch is already beginning to be changed by the saliva in the mouth into sugar, which can be easily absorbed by the body. (See DIGESTION.)

Starch is made in the leaves of plants from water taken in by the roots and carbon dioxide gas from the air. However, it can only be made in the presence of light, which produces the energy needed, and a green substance called chlorophyll. Starch is stored in seeds as food for the new seedlings and it may be found in various parts of the full-grown plant to provide energy for the growth of new shoots. Cereals, particularly rice, maize and wheat, are very rich in starch. Other plants that contain a good deal of it are peas and beans, potatoes, cassava (from which tapioca comes) and the sago palm.

Pure starch is extracted from plants like potatoes by a rasping machine which reduces them to pulp. The pulp is washed several times in sieves to separate the starch from the vegetable fibre. It is then liquid and, after further sieving, it is allowed to settle. The rest of the water is removed by machines. Purified starch is a white, glistening powder without taste or smell. This is used in making many food products. It is also used in some pastes, for glazing paper, and for stiffening dresses, collars and cuffs. This use of starch in England dates from the 16th century, when great pleated collars known as ruffs were worn. For use in stiffening cottons, linens and other materials the starch is generally obtained from rice or maize. The action of ironing the material gelatinizes the tiny grains of starch and gives it a glazed finish.



Many foods contain starch. It is also used for stiffening.

STAR CHAMBER. The main room in one of the buildings of the royal Palace of Westminster in London was known as the Star Chamber because of the stars painted on its ceiling. It was constructed in the reign of Edward III and from the first seems to have been one of the regular meeting places of the king's council. There some of the king's councillors and judges used to meet to hold a court of law. In the 16th century this became known as the Court of Star Chamber.

Although various courts of common law—that is, the kind of law that comes from the customs of the people—had arisen in England from the 12th century onwards, the kings had never given up their right to hold their own courts. This right the king exercised through his council. This council dealt with cases in which people sought the king's ruling on matters that were not dealt with by the ordinary courts.

The Court of Star Chamber was not conducted in secrecy—the public were admitted freely. Moreover, anyone with a grievance could apply to the Court for the redress of his wrongs. It was the most popular court in England.

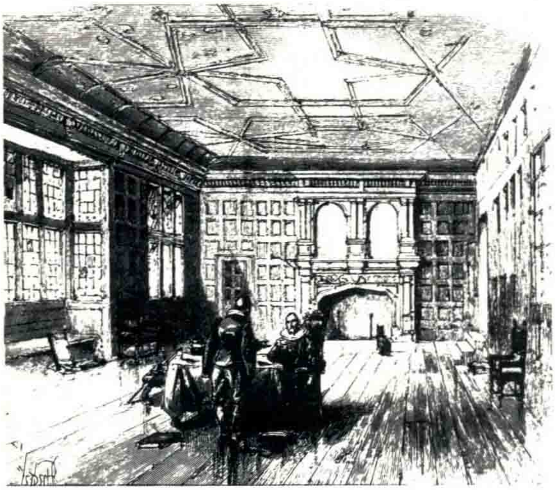
Probably about 43,000 cases came before the Star Chamber in the reign of Queen Elizabeth I. It became a regular part of the machinery for enforcing the law and reached its greatest activity during the reigns of the Tudor kings, especially in the period 1515–1529 when Thomas Wolsey was chancellor.

Originally the court dealt mainly with cases of civil law (see LAW). Under Wolsey, however, criminal cases were increasingly heard in the Star Chamber, where "all cases may be examined and punished if the King will". It was not bound by ordinary law. People accused of crimes were simply put on oath and questioned:

even torture was sometimes used to make the prisoners confess. Nevertheless, the Star Chamber was at first regarded as a just court.

When Henry VII came to the throne after the Wars of the Roses, many of the nobles were so powerful and had so many followers that they were a danger to the king and state. Henry used the Court of Star Chamber to keep them in check and after that the nobles were never a trouble again.

Charles I, however, spoiled the Star Chamber's good name by using it to imprison or fine



Radio Times Hulton Picture Library

The Star Chamber in the old Palace of Westminster.

people who had refused to pay the taxes he demanded. William Laud, who was Archbishop of Canterbury in his reign, held religious trials there. (See LAUD, WILLIAM.) The Star Chamber was hated as a threat to freedom, and parliament abolished it in 1641.

STARFISH. It is easy to see, on looking at a starfish stranded on the shore when the tide has gone out, how it got its name. It has a number of arms, usually five, which resemble a drawing of a star. The common starfish is the one most often seen stranded on British shores, though it lives in deeper waters. It is yellowish in colour, with five arms. If it is turned over it will be seen that on the underside of each arm is a groove, along which are many short, blunt tubes. These are the tube-feet, by means of which the starfish moves about.

Each tube-foot has a sucker at the end which sticks tightly to rock surfaces. The tube-feet are all connected by a series of tubes or pipes inside the body. Through a hole in a tiny round plate on the upper surface of the disk (the round, central body) water can be drawn into the internal tubes and so into the tube-feet, making them stick out. When the tube-feet are to be withdrawn, the water can be driven out by the same way in which it came in. By stretching out the tube-feet and fastening their suckers on to the sea bed, a starfish is able to drag itself about or to cling tightly to the surfaces of rocks.

Starfishes also use their tube-feet to get their meals. They feed mainly on molluscs like mussels and oysters. When a starfish finds one, it wraps its arms round the closed halves of the shell, fastens its tube-feet to them and pulls. The muscle that hinges the mollusc shell together is very strong, but the starfish is able to pull steadily for a long time, and at last it gets the shell open. To eat the soft body of the mollusc, the starfish pushes its stomach through its mouth, which is on the underside, and wraps it round the mollusc, staying like that until it is digested.

From this it can be seen that the starfish has a good muscle system and well developed digestive organs. It has, however, no brain, but there are simple eyes, one at the tip of each arm. The only other sense organ is a combined one for smell and taste, which is probably to be found in the tube-feet.

As well as the common starfish, there is also the spiny starfish, which is grey or mauve with rows of spines on the arms. The little starlet, which is only about an inch across, is more disk than arms, so that it looks more like a cushion than a star. The sun-star, which may have as many as 13 arms, is a large starfish, usually purplish red in colour with white patches.

Relatives of the Starfish

Starfishes are echinoderms, which means that they belong to a group of spiny-skinned animals, and so are not connected with fishes. Echinoderms have their skins protected by stout spines or by chalky plates or nodules (tiny lumps). Besides starfishes, echinoderms include brittle-stars, sea-lilies, feather-stars, sea-cucumbers and sea-urchins.

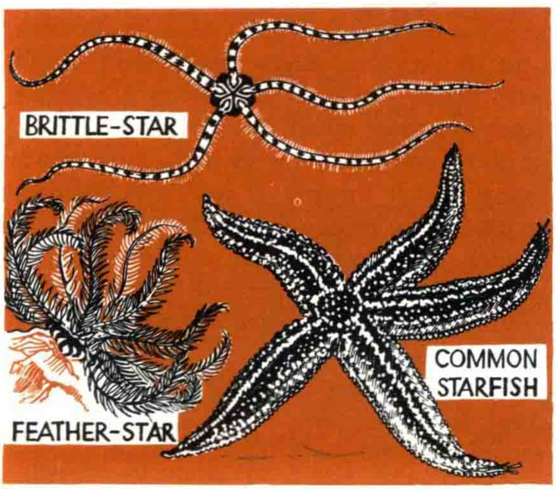
Brittle-stars are shaped like starfish, but the slender arms do not grow out from the disk in the same way and they have no tube-feet. They move quite fast by wriggling their arms like snakes. If caught or picked up, brittle-stars are likely to drop one or more of their arms. They live in shallow water and can sometimes be found when the tide is out.

A sea-lily can best be described as a starfish, with branching arms, perched upside down on a long stalk. Some rocks are made up almost entirely of fossil sea-lilies and they are still very common in the deep seas. The largest are beautiful white flower-like animals, standing over 50 centimetres high.

Feather-stars are simple sea-lilies that have lost the stalk. There is only one in British waters, and it is called the rosy feather-star. It has ten feathery arms which it waves as it walks about on spines growing down from the central disk.

Sea-cucumbers or holothurians are cucumber-shaped and warty. The mouth is at one end and is surrounded by branching tentacles, or feelers. They move by crawling and can entangle enemies by spinning a mass of threads to choke them. Sea-cucumbers are the only echinoderms that are eaten whole, and they also make good soup. The Chinese dry some tropical kinds and eat them. Certain parts of the sea-urchin are also eaten. (There is an article SEA-URCHIN.)

Echinoderms are able to grow lost parts again very easily. A starfish or brittle-star can grow a new arm if it has lost one, and a sea-cucumber can throw out its stomach at an enemy and grow another.



STARLING. Whether you live in a town or in the countryside you are almost certain to see common starlings. These sociable and noisy birds have also been taken to New Zealand and North America, so they are just as familiar there.

Usually starlings seem to be black birds with light spots, but when seen in bright sunshine their plumage is shot with glossy blues, greens and purples. They are about 21 centimetres long, with yellowish-brown legs. Starlings utter all kinds of sounds, from clicks and wheezes to warbles and whistles. They are able to mimic the songs of other birds and even the cries of animals.

Black but glossy, starlings often nest in holes in trees.

At night flocks of starlings settle down to roost together, some in wet, marshy areas where they cling to the stems of reeds, and others on trees or buildings. Thousands of starlings roost every evening on buildings in central London.

Being larger than most of the birds that visit gardens, starlings are able to bully them and to snatch their food away. They themselves eat many harmful insects, including wireworms, which they pick out of the soil with their beaks. They also eat grain and fruit, so they are sometimes regarded as a pest.

Starlings usually nest in holes in trees or buildings, but the untidy straw nests, lined with feathers, may also be found among stones, occasionally in haystacks and in ivy. Sometimes starlings turn other birds out of their nests. The hen starling lays five to seven pale blue eggs and the young birds are brown with whitish markings on their throats.

Common starlings live all over Europe and in many parts of northern Asia, and have a good many relatives. Among these is the rose-coloured starling or rose-coloured pastor, a beautiful bird with a rose-pink body, black head, tail and wings and a crest. This bird lives in southeast Europe, but it has often visited the British Isles.

STATISTICS. The word "statistics" is used in two ways. Firstly, *a statistic* is a piece of information in the form of a number. For example, the attendance at the Manchester United *v.* Ipswich Football League match on 21st October 1979 was 50,816. So several such figures would be called statistics. But statistics is also that branch of mathematics which studies information in the form of figures.

A look at all the attendance figures for football matches played on the same day will show the sort of things statisticians would be interested in.

Division 1	Division 2	Division 3	Division 4
31,591	18,624	7,970	4,895
17,328	5,472	8,347	2,129
27,333	5,151	5,107	3,184
20,152	16,328	3,209	2,319
25,203	6,190	5,122	3,412
52,201	10,297	6,378	23,871
50,816	12,300	6,049	2,618
18,393	11,007	4,850	1,875
18,000	25,201	6,083	5,454
24,564	17,715	13,035	
20,000	25,049	6,207	

It looks, for instance, as if attendance was generally highest in Division 1, and got progressively smaller. We could add up the total figures for each division:

Division 1 : 305,581 Division 2 : 153,334
Division 3 : 72,357 Division 4 : 49,757

These totals seem to bear out what we thought. However, notice that there were only 9 matches played in Division 4, compared with 11 in each of the other divisions. So what we must do to compare fairly is work out the *average* attendance for each division. (See AVERAGES.) To do this we assume that the total attendance is shared out equally among the matches. The results are then as follows:

Division 1 : 27,780 Division 2 : 13,939
Division 3 : 6,578 Division 4 : 5,529

This makes the difference between Division 3 and 4 look a lot less.

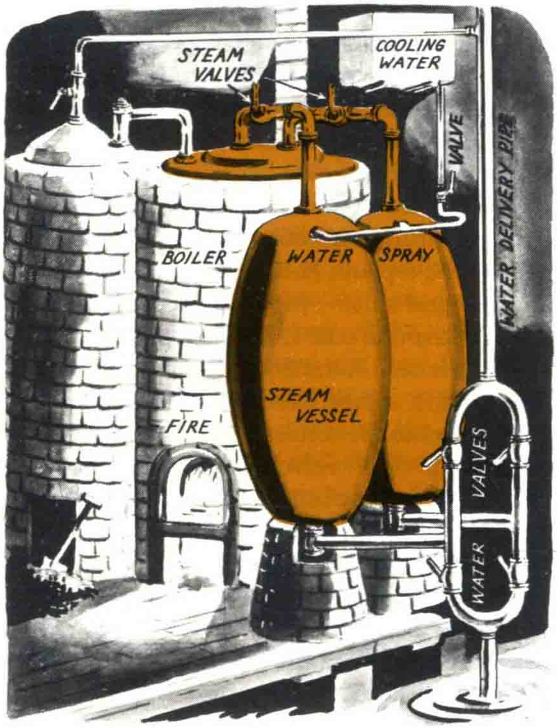
Notice how we approached this problem. We first got a general idea about attendance by looking at the figures. Then we did something more precise by adding up the totals. Then, when we realized that was not completely fair, we worked out averages. Statisticians might also be interested in the variation in attendance in each division. Notice that in Division 4 the figures range from 1,875 to 23,871, but in Division 3 the range is much smaller. Any club would also be interested in how the attendance varied from week to week.

How figures behave is of importance in finance, politics, education, insurance, weather forecasting, science, road accident research, industry, crime prevention, geography, and many other fields. One way of presenting figures so that trends can be seen easily is by drawing a *graph*. (See GRAPH.)

STEAM ENGINE. The steam from the water boiling in a kettle pushes the lid out of its way, showing that it can exert a force. If a cork is placed in the spout and the lid is held down, the pressure inside blows the cork out.

Steam engines are of two main types—the reciprocating engine and the turbine—both of which use the pressure of the steam to do work. In the reciprocating engine, the steam pushes a closely fitting piston to and fro in a cylinder. ("Reciprocating" means "moving to and fro".) The piston and cylinder work in the same way as a pencil held in the lips. If you blow, the pressure inside your mouth pushes the pencil out. If you suck, the pressure inside your mouth is reduced, and atmospheric pressure (pressure of the air outside) pushes the pencil in. (See the article ATMOSPHERE.)

The turbine uses a jet of steam to blow against, and thus turn, blades fixed around a drum on a central shaft. The first steam turbine was described by Heron of Alexandria, Egypt.



Thomas Savery's steam engine for pumping water, 1698.

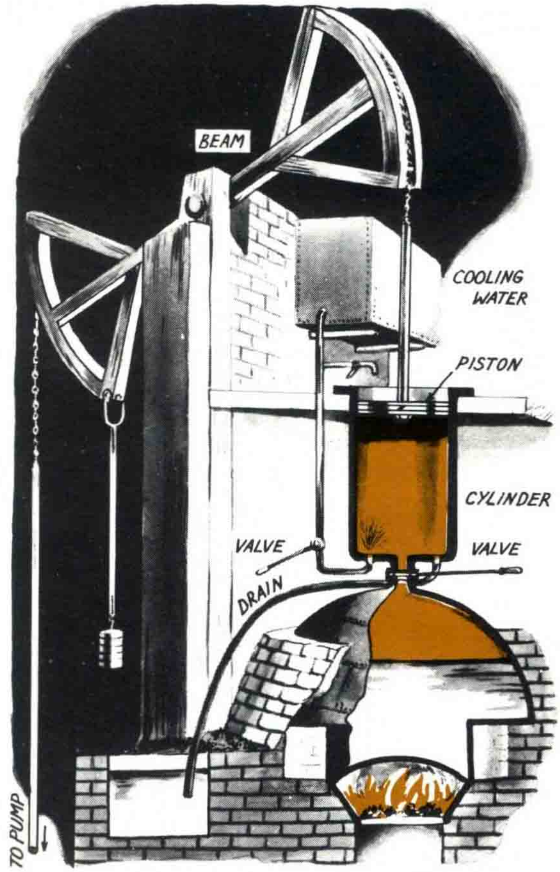
He was a Greek who lived about 2,000 years ago, but his engine seems to have been only a toy. (There is a separate article TURBINE.)

The first practical use of the steam engine was for pumping water out of the shafts and tunnels in mines from which coal and other minerals were obtained. Often the shafts met springs whose flow threatened to flood the mine.

In 1698 the English engineer and inventor Thomas Savery invented a type of engine for pumping out mines. His "fire engine", as it was called, was based on the fact that steam, when cooled, condenses (changes into water). The water takes up much less room than the steam. Savery's engine admitted steam into an egg-shaped vessel which was then cooled by spraying its outside with cold water. This caused the steam inside to condense, forming a partial vacuum, or empty space at reduced pressure. The air pressure outside was therefore able to force water into the vessel through a pipe from beneath. The valve, or tap, controlling this pipe was then closed and more steam was admitted, thereby blowing the water out of the vessel through another valve and pipe at the top of the mine shaft. (There is a separate article VALVE.)

The Newcomen Engine

Savery's engine was inefficient and wasted a lot of steam. In 1690 the Frenchman Denis Papin had planned a different kind of engine. His idea was developed by the Englishman Thomas Newcomen, who by 1705 had built an engine having a piston and cylinder. Steam from the boiler was admitted beneath a piston in a vertical cylinder. Then cold water was squirted into the cylinder, condensing the steam and causing a reduction of pressure inside. The atmospheric pressure outside was therefore able to force the piston down again. The Newcomen engines were widely used in mines from about 1720 until 1800, but they also wasted much steam and used a great deal of coal.

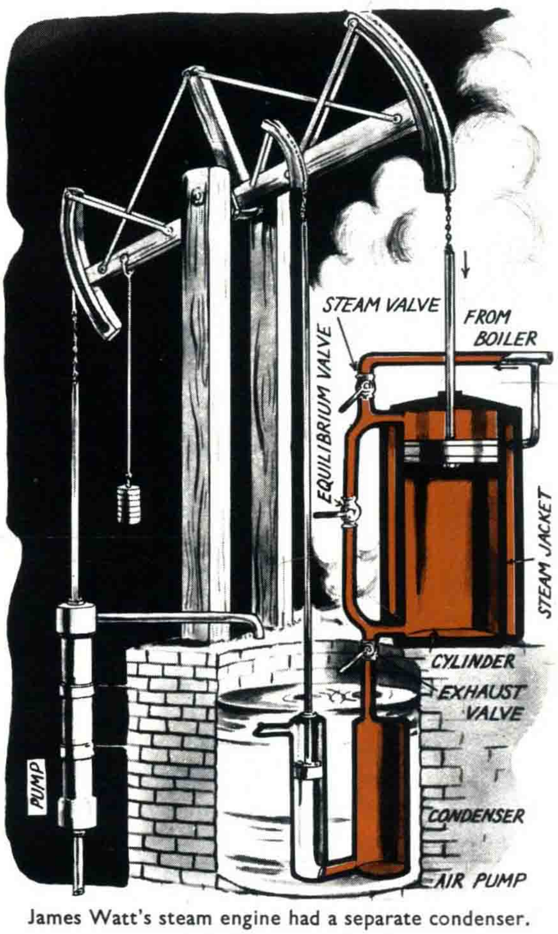


Newcomen's steam engine with cylinder and piston.

Both Savery's and Newcomen's engines were slow-moving affairs and depended for their working on an attendant who had continually to open and shut the valves. This job was usually done by boys, and the story goes that a boy named Humphrey Potter invented an arrangement of catches and cords worked by the beam, so that he could go and play. His idea was simplified and applied in the form of "valve gear" to all the later engines.

James Watt's Engines

In 1763 a Glasgow instrument-maker named James Watt was mending a Newcomen engine. He noticed the waste of steam caused by alternately heating and cooling the cylinder at each stroke of the piston. He decided that the best remedy was to keep that part of the engine in which the steam had to remain steam permanently hot, and the separate chamber where



James Watt's steam engine had a separate condenser.

steam was condensed permanently cold. This separate condenser was a vessel kept cool by cold water. He also arranged a steam-jacket around the cylinder to keep it hot. The steam-jacket was formed by an outside casing with the space between it and the cylinder filled with steam.

Steam from the boiler entered the top of the cylinder through a steam valve. In a pipe connecting the top and bottom of the cylinder there was a second valve—the equilibrium valve. This allowed steam to pass from the top to the bottom of the cylinder. A third valve, the exhaust valve, was fitted in a pipe leading from the bottom of the cylinder to the condenser.

With all three valves open, steam filled the cylinder with the piston at its top position. The equilibrium valve was then closed and the condenser cooled. This drew the steam from the bottom of the cylinder and the piston descended under the pressure (slightly more than atmospheric pressure) of the steam above it. The steam and exhaust valves were then closed and the equilibrium valve was opened, equalizing the pressure above and below the piston, which was thus allowed to return to its top position. The whole cycle of operations was then repeated. A small pump called the air-pump was fitted to extract the water from the condenser, as well as any air that leaked in.

In 1781 Watt adopted various methods for changing the push-and-pull action of his engines into the turning movement needed for most machinery except pumps. The simplest method, of course, is that of the crank, such as is used on bicycles to change the up-and-down movements of the rider's knees into a turning movement. Watt's engines were an improvement on Newcomen's because they were much less wasteful. By 1800 about 40 of them were in use for pumping water out of the Cornish tin mines, where pumping with Newcomen engines had been found too expensive.

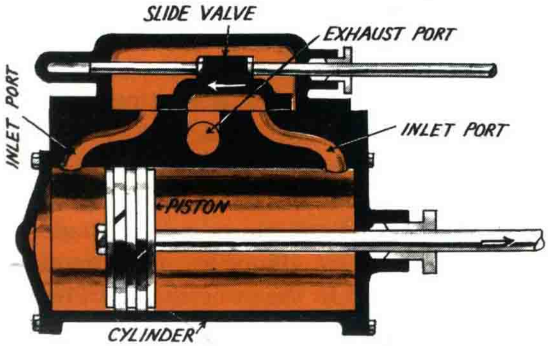
Later Steam Engines

Engines without condensers needed steam at considerably higher pressure and for some time the kettle-shaped boilers used were not strong enough to withstand such pressures. However, in about 1800 both Richard Trevithick in England

and Oliver Evans in the United States developed higher-pressure engines. Both obtained steam from cylindrical boilers of what are called the Cornish type, in which the flames from the fire are led through a single flue, or pipe, passing through the centre of the boiler. (There is a separate article BOILER.)

In these non-condensing engines, the used steam, or exhaust steam as it is called, escaped to the outside air after having done its work in the cylinder. It was because of the noise of this that George Stephenson, in his locomotive "Blucher", led the exhaust steam up the funnel. In this way he greatly increased the draught of air through the furnace and the heat of the fire. (See STEPHENSON, GEORGE AND ROBERT.) In marine steam engines (which are the engines used in ships) condensers are fitted not only to save fuel but also to allow the condensed water to be taken back to the boilers and used again. Used water is less corrosive than fresh.

Watt introduced two other important developments. The first was the double-acting principle, by which steam was admitted first to one side of the piston and then to the other, thus pushing it in both directions. The other development made use of the expansion, or swelling, of steam. He arranged for the steam to be cut off after the piston had travelled only part of the way along the cylinder. For the rest of the distance, the piston was pushed by the expansion of the steam already in the cylinder.

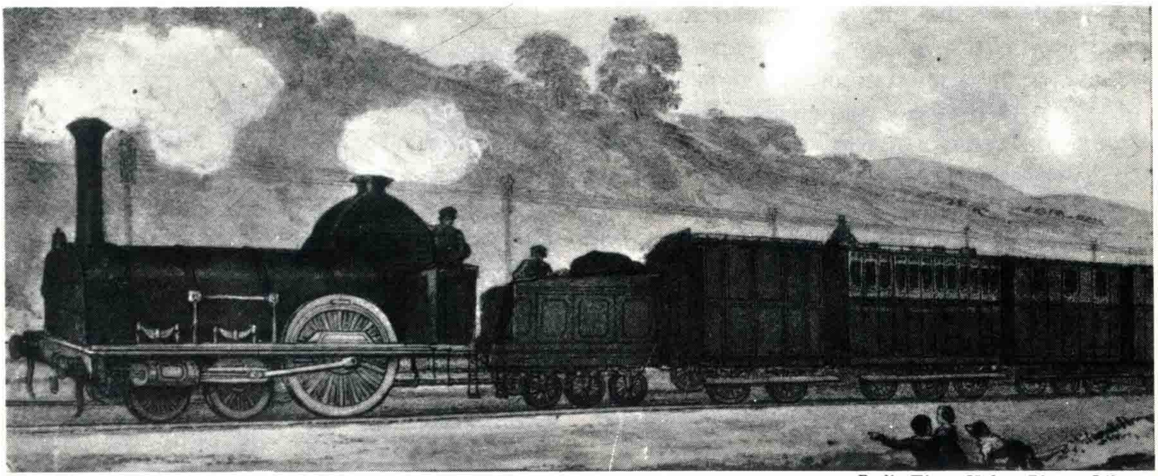


The slide valve controls steam flow to and from cylinder.

This brought about a great saving of steam and, therefore, of fuel. Many steam engines—locomotives, for example—have a "variable cut-off" which can be adjusted by the driver to suit the conditions.

Watt's assistant, a Scot named William Murdock, in 1799 invented a single valve to control the steam flowing into and out of the cylinder. This "slide valve", as it was called, was worked to and fro by means of a fitting on the shaft of the engine known as an eccentric. As it moved, the valve covered and uncovered passages between the ends of the cylinder, the steam supply and the exhaust so that steam was admitted and removed when required.

The link between the eccentric and the slide valve may be designed so that the cut-off can be varied and the engine reversed. The two chief forms of link motion are the Stephenson and the


Radio Times Hulton Picture Library
This drawing, dating from about 1850, shows an engine built on the pattern of George Stephenson's "Rocket". (This design was used for years.) The steam pressure in the "Rocket's" boiler was about 50 pounds to the square inch.

Walschaerts. Although the Stephenson was invented by William Howe in 1842, it was little used before being adopted for the Stephenson locomotives. The Walschaerts was invented by the Belgian, Égide Walschaerts, in 1844 and was used on most later locomotives.

The compound steam engine is one in which the exhaust steam from one cylinder is made to do further work by admitting it to another cylinder connected to the same shaft. In order that the thrust produced on each piston may be the same, the low-pressure cylinder has to be wider than the high-pressure one. Marine engines of reciprocating type are nearly always compound, with three or four cylinders.

The power of any steam engine has to come from the fuel that is burnt beneath its boiler. The fuel has first to change the water in the boiler into steam before its energy can be used. The heat of the fuel cannot be applied direct to the cylinders as it is in the internal combustion engine. (See INTERNAL COMBUSTION ENGINE.) Thus there are bound to be losses of heat between burning the fuel and using the steam, and these losses were considerably greater than the losses in the internal combustion engine. A steam engine used more fuel than an internal combustion engine of the same power.

On the other hand, steam engines were quieter and ran for a long time without needing overhaul because the cylinders were not corroded by the fuel and exhaust gases. One of their great advantages was that they were able to exert their maximum effort in starting, compared with piston-type internal combustion engines which must be started by external means. This means that steam vehicles needed no gearboxes (see GEARS) although requiring the extra complications of boiler and fire. Before World War I, buses driven by steam engines ran in the London streets and there were a number of steam motor cars. These vehicles were notable for their quietness and steam-driven cars reached speeds of over 100 km/h.

Steam engines are still used in preference to internal combustion engines for driving the largest ships and in the larger electric power stations which do not depend on water power. (See ELECTRIC POWER; WATER POWER.) In all existing nuclear power stations, it has been found most convenient to make use of the heat produced by the nuclear reactors by causing it to change water into steam, which is then used to drive turbines. (See NUCLEAR ENERGY.) With the growing scarcity and high cost of petroleum, the steam engine may well be revived for other uses—including perhaps road and rail transport.

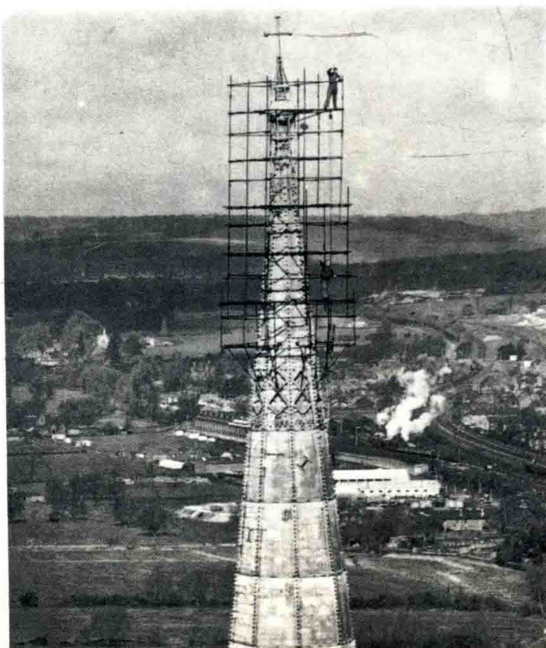
This article shows that most of the important inventions and developments to do with steam engines were British. Great Britain also had good supplies of the iron needed for making engines and the coal required as fuel. In the 19th century, these assets gave Great Britain a tremendous lead over most other countries in the development of manufacturing industries, and cheap factory-made British goods soon became popular all over the world. (For more about this see INDUSTRIAL REVOLUTION.)

The articles MARINE ENGINES; RAILWAYS; and ROAD TRAVEL contain additional information about steam engines.

STEEL is the world's most important metal. It is an alloy, or mixture, of iron and carbon. You can read about it in the article IRON AND STEEL.

STEEPLEJACK. The word steeplejack, which means a man who works on steeples, was first used in the middle ages. In those days steeplejacks' only work was on churches and cathedrals.

Steeplejacks repairing the spire of Salisbury Cathedral.
Radio Times Hulton Picture Library



Nowadays, although they may still sometimes climb up the outsides of steeples to mend them, they are more likely to repair the tall chimneys of factories.

A steeplejack has to be able to climb up a rope like a monkey, to let himself fall short distances without coming to harm and to use both hands with equal ease. This is because his work may involve such jobs as sitting on a thin rope burning away with an acetylene torch to free an obstinate part of a tottering steel chimney, now and then stopping to beat out the smouldering of his own clothes caused by a shower of sparks.

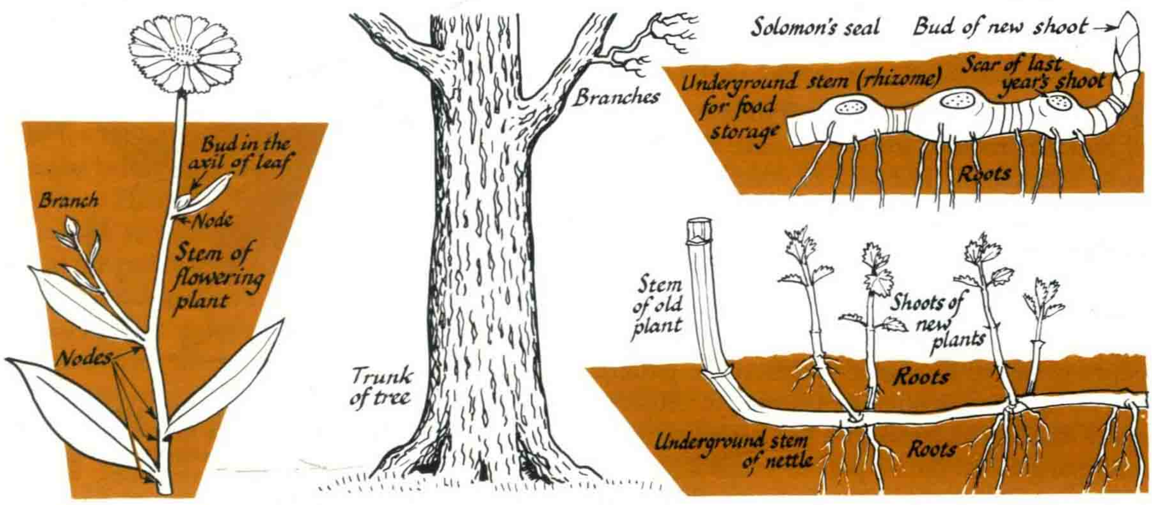
In the 19th century, when factory chimneys were made of brick, the job of replacing one was fairly simple. When a modern factory chimney made of steel is dismantled, however, the boiler beneath is put out of action. Therefore a team of steeplejacks has to replace it as completely as possible during a weekend when the factory is not working. As much of the work as possible is carried out beforehand, and when the work is properly started it goes on, day and night if necessary, whatever the weather.

A similar job is that of the steel erector, who works on modern buildings and has rather different rules and traditions. Steel erectors first came into existence in the United States, where very tall buildings were first built.

STEFANSSON, Vilhjalmur (1879–1962). The Arctic explorer Vilhjalmur Stefansson was born in Manitoba, Canada, of Icelandic parents. He studied at two United States universities before beginning the Arctic travels which made him famous. Between 1906 and 1912 he learned the ways of the Eskimoes who lived at the mouth of the Mackenzie River and on the north Canadian islands. (See ESKIMOES.)

From 1913 to 1918 Stefansson was the leader of the Canadian Arctic Expedition to the little-known Beaufort Sea. He arranged the work of the sections into which his large party was divided. They discovered several islands and in 1918, when Stefansson was ill with fever, one of the parties lived on a drifting ice-floe for six months, obtaining most of their food and fuel by hunting seals. Stefansson urged the importance of the Arctic regions as a source of meat, not only from seals but also from breeding reindeer and musk oxen. He wrote several books, among the best of them being *The Friendly Arctic* (1921).

STEM. All flowering plants have stems, from which grow the leaves and flowers. Generally the stem (which is also called the stalk) is fairly stiff and carries the parts of the plant that are above ground into the light and air. It starts at the top of the root and in a seedling, or very young plant, it is small and thin. However, it gets thicker as the plant grows. The stem is usually green except in woody plants and in trees, where it is brown and is called the trunk. It is most often round and it grows up towards the light except in creeping plants such as ground



ivy where it grows along the ground. Many plants have underground stems that store food. Two of these are the rhizome of Solomon's Seal and the potato, which is the swollen part of an underground stem. Others produce new plants from stems that grow underground and then put out roots and shoots. This is the case in the stinging nettle and the woodruff.

In many plants branches come out from the main stem and they also bear leaves and flowers. The branches grow out at an angle so as to give plenty of light and air to the leaves. They start from a bud in the *axil* of a leaf—the angle between the leaf and the stem. There is therefore always a leaf (or a leaf scar if the leaf has fallen off) immediately below a branch. The places where the leaves grow out are called *nodes*. In most flowering plants the nodes are closer together on the lower part of the stem than they are higher up, where the leaves are more spaced out.

The outside of the stem consists of a skin which is usually quite thin, although in trees it is thick and is called the bark. Inside the stem are a number of tough strands that keep the plant upright, and also vessels or tubes through which water taken up by the roots travels to the leaves. Food made in the leaves travels down through other vessels to the roots and to the other parts of the plant.

Among the plants that do not have flowers, the mosses, ferns and conifers (cone-bearing trees) have stems that bear leaves, but there are no proper stems in fungi (such as toadstools) or seaweed.

STENCILLING. Nearly everyone at one time or another has used stencils to make simple patterns with paint. The idea of stencilling is that holes are cut in a piece of stiff paper so as to form patterns, and paint is then dabbed through the holes with a stiff brush on to a sheet of paper behind. Coloured patterns thus come out on this paper, and by moving the stencil, as the cut-out paper is called, to another position the pattern can be repeated as often as it is wanted. Ready-made stencils can be bought, but it is much more interesting to cut the shapes out yourself.

For example, if you cut out a simple fish shape

Top: The piece of paper A with the fish-shaped hole is used to stencil a coloured fish, while the cut-out fish B is used to give a white fish against a coloured background. Centre: Using a toothbrush for spraying paint. Bottom: Blowing through a spray gun to apply stencil colour.

from a piece of strong paper, you can use both the cut-out fish and the hole left in the paper to make patterns. One way you can make a white fish on a stippled background (the stippled, or mottled, effect comes as you dab the paint on); the other way, a coloured fish on a plain background.

To make the white fish, hold the fish shape in position on your piece of paper and dab the paint on all round it; for the coloured fish, lay the stencil with the hole in it on the paper and dab the paint through the hole. It makes the fish look more interesting if you dab on a lot of paint round the edges but gradually ease off so that the centre of the shape is left almost white. Instead of an expensive brush, use a piece of bandage about two-and-a-half inches square, rolled into a neat pad.

For posters a good method is to get the bristles of an old toothbrush well covered with paint and then flick the colour on to the paper so that it falls in a fine spray. This is the same method that commercial artists use, but with a spray gun instead of a toothbrush. Stencilling is used for other kinds of printing besides posters—for putting the designs on to fabrics, for instance.

STEPHEN, Saint (died *c.* A.D. 35). Chapter six of the Acts of the Apostles tells how Stephen was one of the seven deacons (helpers) whom the Apostles appointed to look after the organization of the early Christian Church and to help the poor. He "did great wonders and miracles among the people" and therefore made many enemies among those Jews who remained loyal to the old faith and refused to become Christians. He was accused of saying wicked things about the Jewish Temple in Jerusalem and was brought before the Sanhedrin—the Jewish court of justice. He made a fearless speech, which was actually a re-telling of the history of the Jews, and at the end of it he accused the Jews of having been so blind to God's will that they had persecuted all the prophets and had even been responsible for the crucifixion of Jesus Christ.

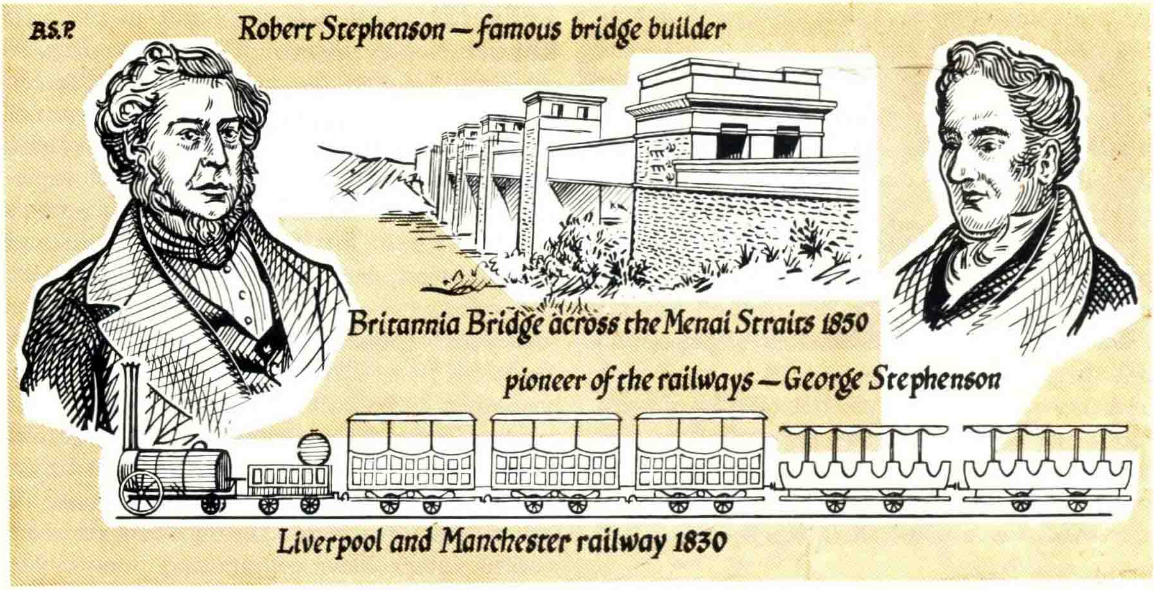
Without more ado Stephen was hurried outside the city walls and stoned to death. He thus became the first of the Christian martyrs (see MARTYR). His day is kept on December 26.

STEPHENSON, George (1781–1848), **and Robert** (1803–1859). The great English engineer George Stephenson, who became known as the "Father of the Railway", was not actually the first person to make a steam engine that ran on rails. That was the Cornish mine-owner, Richard Trevithick, but Stephenson's engines were the first really successful ones and modern steam locomotives work on the same principles.

George Stephenson was born at Wylam, near Newcastle upon Tyne, Northumberland, where his father looked after the steam engine that pumped water from a coal mine. George did not go to school but at the age of eight began work on a farm. When he was 14 he became his father's helper and for the next 20 years he worked with colliery engines and pumps. He studied the engines closely, taking them to pieces in his spare time and teaching himself to read so that he could learn about machinery from books. He earned extra money by cleaning and mending watches and clocks and attended night school. In 1812 he was put in charge of all the machinery of the High Pit at Killingworth Colliery, near Newcastle. It was here in 1815 that he made his first invention, which was a miner's safety lamp. However, Sir Humphry Davy happened to be developing the same invention at the same period, and he is generally given the credit for being first.

In 1813 Stephenson interested his employers in a "travelling engine" to pull trucks of coal from the mine to the port nine miles away. This engine, named "Blucher", was successfully tried in July 1814. Its success was largely due to the fact that, to lessen the noise made by the steam on leaving the cylinders, Stephenson led it through a pipe to the funnel. This "blast pipe", by increasing the draught of air through the furnace, greatly increased the power of the locomotive.

In 1822 Stephenson persuaded the directors of the railway that was then being built between Stockton and Darlington, County Durham, to use steam locomotives instead of horses for pulling the trains. He set up his own locomotive works in Newcastle and on September 27, 1825, the first public passenger train in the world was



drawn by Stephenson's "Locomotion No. 1", which he drove himself.

In 1826, after much opposition, parliament agreed to the building of a railway between Liverpool and Manchester. The railway directors wanted the trains to be pulled by fixed engines hauling on wires, but Stephenson persuaded them to give locomotives a trial. They held a competition on the line at Rainhill, Lancashire, with a prize of £500 for the best engine. It was won by Stephenson's locomotive "Rocket", of which some details are given in the article RAILWAY ENGINE. The railway opened in 1830, using eight of Stephenson's locomotives, and his fame spread abroad.

Among the improvements that Stephenson made to the steam engine were the locomotive boiler, in which a number of tubes led the hot flames from the fire through a cylindrical water container. Later he adopted the famous Stephenson "link motion", by means of which the flow of steam to the cylinders can be controlled and which allows the locomotive to be reversed. (See STEAM ENGINE.)

George Stephenson was consulted about the building of many railways in England and abroad. He refused all the honours that were offered to him and also refused to enter public life. During his last years he lived near Chesterfield, Derbyshire, where he took a keen interest in gardening and farming. He died there in 1848.

His son Robert was born at Willington Quay in Northumberland and, unlike his father, had a good education. In 1823 he went to manage some gold and silver mines in Colombia, South America, returning in time to take charge of the building of his father's "Rocket". As a railway engineer, Robert built the first line into London, and until the end of his life was engaged in railway work. His greatest creations, however, were his bridges, particularly those of the tubular girder type. (See BRIDGES.) Examples of these are the Britannia Tubular Bridge across the Menai Straits between Wales and Anglesey, the old high-level railway bridge across the River Tyne at Newcastle, the Victoria Jubilee Bridge across the St. Lawrence River at Montreal and two others across the River Nile in Egypt. In 1847 he became Member of Parliament for Whitby, Yorkshire, but seldom made speeches except on engineering matters. He is buried in Westminster Abbey.

STEPPES. The Russian word *step* means "plain", and the typical steppes are found in the south of the U.S.S.R. They are open, treeless, grassy plains. The main area of steppe land begins in Romania and stretches eastwards across the southern part of the U.S.S.R. and through Siberia into the very heart of Asia.

In winter the steppes are cold and swept by blizzards; in summer they are hot and dusty. On most steppe land the grass is fairly short, dry and wiry. It grows rapidly when the spring thaw comes and the steppes are then gay with flowers for a time.

Until about 200 years ago the Russian steppes were poor grazing land used mainly for pasturing sheep and horses. The winters there were too severe and the grass too poor to support cattle. The steppes were the home of the famous Cossack horsemen who used to provide the best soldiers in the armies of the tsars, or emperors.

Like the prairies, which they somewhat resemble, the steppes have largely been changed into wheat fields (see PRAIRIE).

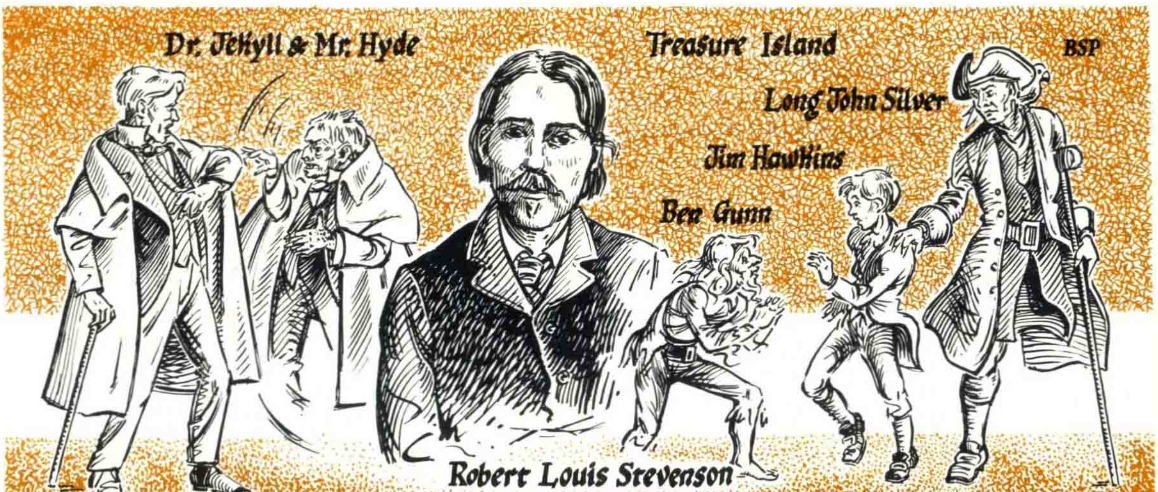
STETHOSCOPE. The instrument used by doctors for listening to the heart and lungs of a patient is called a stethoscope, from the Greek words *stethos* meaning "breast" and *skopos* meaning "watcher". The stethoscope was invented by a young French doctor, René Théophile Laënnec (1781–1826).

Laënnec had tried the usual method of laying his ear against the patient's chest, but this was inconvenient and in stout patients it was difficult to hear anything at all. Then one day he saw some children playing with a log of wood. One child scratched and tapped at one end and the others listened by pressing their ears to the far end. Laënnec hurried to the hospital at which he worked and rolled a few sheets of paper into a cylinder. When he placed one end of the cylinder on a patient's chest and held his ear to the other, he found he could hear the heart beats more clearly than ever before.

The early stethoscopes were wooden cylinders about 30 centimetres long with a hollow channel through the centre. After some years they gave place to the modern type with rubber tubes leading from a cup-shaped vessel to two earpieces.

STEVENSON, Robert Louis (1850–1894). Robert Louis Stevenson was the author of one of the best loved English adventure books, *Treasure Island*. Stevenson's own life, even if not quite as adventurous as his books, was full of travel and voyages, some of them in far-off places. Everyone who knew him fell under the spell of his talk and the wonderful letters he wrote when he was away. He was tall, dark and very thin, with deep, shining brown eyes.

Stevenson was born in Edinburgh, and intended to become a civil engineer like his father. His health was not good enough to do the work, however, and so instead he began studying at Edinburgh University. He decided to be a writer, and when he left the university he set off to travel about Europe and to write about his



Among his most famous books are — The Black Arrow, Kidnapped & A Child's Garden of Verses