VOLUME 12 MOTH to OYSTER CATCHER

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MOTH. About 120,000 species, or kinds, of moths are known to scientists, there being many more species of them than butterflies. As they both belong to the same order of insects, Lepidoptera, it is not always easy to tell moths and butterflies apart. (See BUTTERFLY.) Probably the best way is by watching how they rest. Butterflies close their wings together so that they stick straight up from the back or fan themselves gently with them in the sun. Moths generally spread their wings out flat on the surface on which they are resting. Sometimes the wings lie along the back, folded close together like the blades of a pair of scissors, and sometimes they are folded so as to form an arch over the back.

Moths have a very neat arrangement, which is called the frenulum, for holding the wings together on either side of the body. This consists of a stiff bristle that juts out near the base of the hindwing and slides through a kind of catch situated on the underside of the forewing. It locks the wings together so that they move as one. No butterfly has a frenulum.

The scientific name for butterflies as a whole is Rhopalacera, which means "club-horned", and all butterflies have two club-shaped antennae. Moths, on the other hand, have feathery antennae without knobs.

Another, much less reliable, way of distinguishing moths from butterflies is the fact that butterflies tend to fly by day and moths by night. Even in Great Britain, however, where all the butterflies are day insects, many moths fly by day. In tropical countries some butterflies are also on the wing at twilight or even at night.

Like all small living creatures, moths have plenty of enemies always ready to prey on them. At night they are greedily eaten by bats and owls, but nevertheless they are far safer by night than by day. This perhaps explains why it is that there are such enormous numbers of kinds that only fly at night, for those that acquired this habit stood a much better chance of surviving and, therefore, of breeding.

Moths use three of the same methods as butterflies to escape their enemies—camouflage, mimicry and protective colouring—or they may just hide.

Moths which rely on camouflage are those that either look just like the surface on which they rest or have colours and patterns which blend in some other way with their surroundings. The geometer moths are fond of resting with their wings spread flat on the trunk of a tree. The pattern of the wings matches the bark so perfectly that only someone with much practice in finding moths is at all likely to see them. Other moths look so exactly like bits of stick or dried leaves that only when they move can it be seen what they really are. Among these are some of the hawk moths and also the eggars. Larvae and cocoons may also be camouflaged. The cocoon of the puss moth is hard and woody, resembling a twig. Many moths show flash colouration. When disturbed they suddenly expose brilliantly coloured hind wings which startle and momentarily delay an attacker.

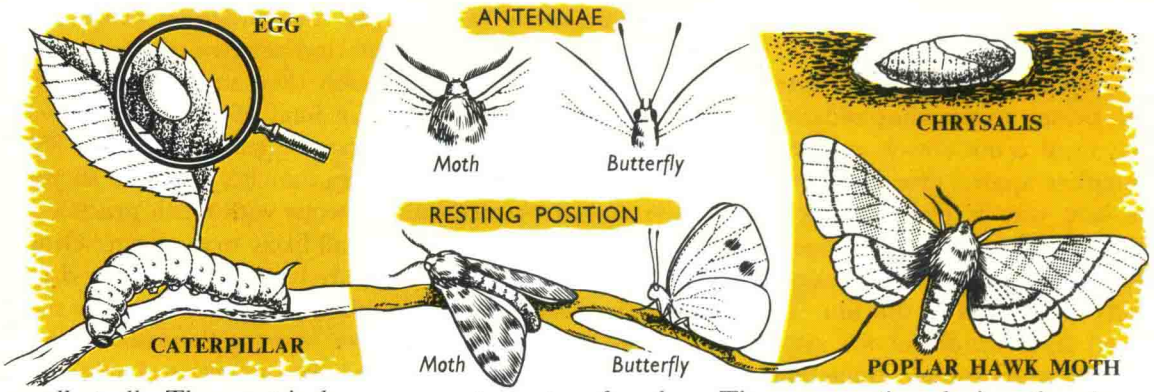
Mimicry is a more rare trick of escape. It means mimicking, or imitating, some other insect—such as a wasp—that is well able to look after itself. Among moths gifted in this way are the clearwings, which have transparent wings.

Moths that have protective colouring include the burnet and cinnabar moths. Burnet moths have greenish forewings spotted with scarlet and scarlet hindwings. Cinnabar moths are dark green with scarlet markings. Like all other moths of this group they fly by day. They are quite safe because they taste so nasty that birds will not eat them. Their bright colours make it certain that they are not mistaken for something more tasty. The caterpillars of many moths carry poison in hollow, barbed hairs and some can spray acid from glands. The death's head and hawk moths are among those which emit a sudden noise when disturbed, startling an enemy long enough for the moth to escape.

Senses, Food and Breeding

The eyes of moths are just like those of butterflies, except that they are better suited to seeing in the dark. The sense of hearing varies a great deal from one group to another.

Scent is very important in the life of a moth, for by means of its sense of smell it finds both its food and its mate. The female oak eggar moth, a yellowish insect with a furry head and body, gives off a scent which human beings cannot



smell at all. The scent is, however, so strong to the smaller and darker male that he can detect the presence of a female from more than a mile away. The male will even fly to an empty box that contained a female long after she has left it.

The food of moths is chiefly nectar, which is the sweet liquid found in flowers. They obtain this by means of a proboscis, or drinking tube, which is kept rolled up under the head when not in use. The pollen of flowers often brushes off on to the moth while it is searching for nectar and so, like many other insects, it helps to fertilize plants, so making it possible for the seeds to develop.

Female moths smell out the plant on which they fed as caterpillars and lay their eggs there. This means that when the eggs hatch the caterpillars are able to start feeding at once.

A very remarkable moth is the tiny white yucca moth of North America. When the time comes for the female to lay her eggs she collects a quantity of pollen from the anthers of the yucca flower, rolls it into a ball by means of specially shaped mouth-parts and carries it to the stigma of another yucca flower. This means that the flower will be fertilized and its pod will form and grow properly. Next she bores into the tissue of the plant with her piercing ovipositor (the pointed tubular organ through which she lays her eggs), and lays an egg close to the young seeds of the plant. In this way she not only ensures that her caterpillars will have yucca seed to feed on but also, accidentally, that the yucca pod grows properly and produces seed.

A number of moths are wingless. Many of the winter moths, whose caterpillars do immense damage to trees, have winged males and wingless females. They are active during the stormy winter weather, and it is perhaps a safeguard to the females not to be able to fly, for they might be blown away and never find places to lay their eggs. Many moths that live on high mountains or windswept islands are wingless.

Different Kinds of Moths

The chief character scientists use to classify moths is the pattern formed by the veins of the wings. The main groups are called families and are generally quite easy to recognize.

The hawk moths are swift-flying insects with stout, torpedo-shaped bodies and long, smooth, pointed wings. Many of them fly at dusk and with their long tongues suck the nectar from tube-shaped flowers.

Hawk moths include the brown poplar hawk moth and the lime hawk moth, which has pink and green forewings with white near the tips. The beehawk moth relies for protection on its resemblance to a bee.

The most striking of the hawk moths is the death's head hawk moth, so called because of the skull-like marking on its thorax, behind its head. It is more than 10 centimetres from wing-tip to wing-tip and is the largest moth in the British Isles.

The emperor moths are very handsome insects. One found in Europe, including the British Isles, has a spot like an eye on each wing. Other emperor moths have transparent patches on their wings. One of the largest has a wing area of 450 square centimetres. The moths whose caterpillars spin threads that are used for silk also belong to Saturniidae, the emperor moth family.

The tiger moths are gaily coloured moths that

Some British moths. (1) Garden tiger moth. (2) Emperor moth (male). (3) Death's head moth. (4) Wormwood pug moth. (5) Broad-bordered bee hawk moth. (6) Ghost swift moth. (7) Five-spot burnet moth. (8) Cinnabar moth. (9) Puss moth. (10) Oak eggar moth (male). (11) Yellow underwing moth. (12) Emperor moth (female). (13) Brindled beauty moth. (14) Burnished brass moth. (15) Wingless female of scarce umber moth. (16) Oak eggar moth (female).

sometimes fly by day. Some tiger moths, particularly in South America, are mimics of butterflies. The common tiger moth of Britain has dark markings on the yellow forewings and scarlet hindwings. Its caterpillar has a furry dark coat and is known as a "woolly bear".

The carpet moths, waves, pugs and thorns are geometrid moths with looper caterpillars; that is, caterpillars that move along by arching themselves into loops. These are the moths that are able to sit on tree-trunks and such places without being seen. They are fragile creatures and not strong fliers, but there are great quantities of them all over the world.

A particularly interesting family of moths is that of the ghost or swift moths, which are found all over the world and are very different in structure from most other moths. Their caterpillars either live underground, where they feed on roots, or they bore in the wood of trees. Often the white males of the European ghost-swift can be seen hovering at dusk over grassy places. The females search for the males instead of the other way round, and scatter their eggs over the grass as they fly. In Australia and South Africa there are many moths belonging to this family. The oddest thing about the Australian ones is that they seem only to fly on the coldest and wettest nights in the year.

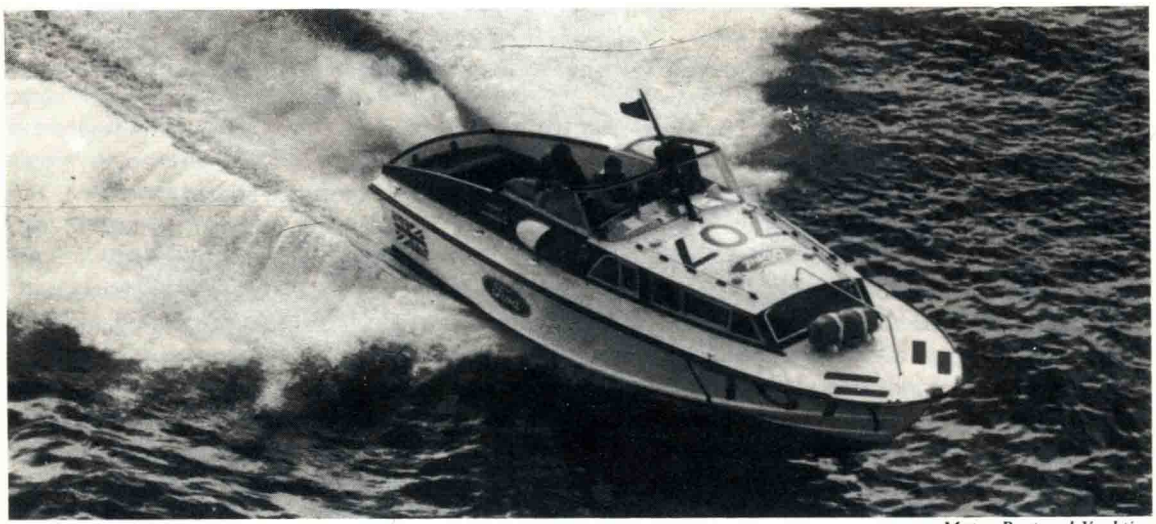
A good representative of the Notodontid family is the puss moth, a fluffy grey and white moth with a rather alarming looking caterpillar, green and red in colour, that rears up its front half when frightened.

Most of the smaller night-flying moths that are attracted to lights belong to the family Noctuidae, which is probably the biggest of all the families of moths. The red and yellow underwings are common moths in Britain and belong to this family. They have brownish forewings which, when they are resting, close down over the brightly coloured hindwings.

There are very many families of the smaller and more primitive kinds of moths. Among these are the flour moths, which are sometimes found in granaries (places where grain is stored); clothes moths, which feed on rubbish of all kinds (see CLOTHES MOTH); and the codling moth, whose caterpillars are a pest in apple orchards.

MOTOR BOAT. Boats and small craft driven by internal combustion engines are called motor boats, and may range from small one-man speedboats to quite large launches and fishing vessels. One of the first was built in Germany by Gottlieb Daimler in 1885 and had a single-cylinder engine of one horse power. The engine turns one or more propellers, driving the boat along as explained in the article MARINE ENGINES.

The hull, or outer body, of a motor boat can be one of three general types. The oldest of these is the round-bottom hull. The vee-bottom type,



Motor Boat and Yachting

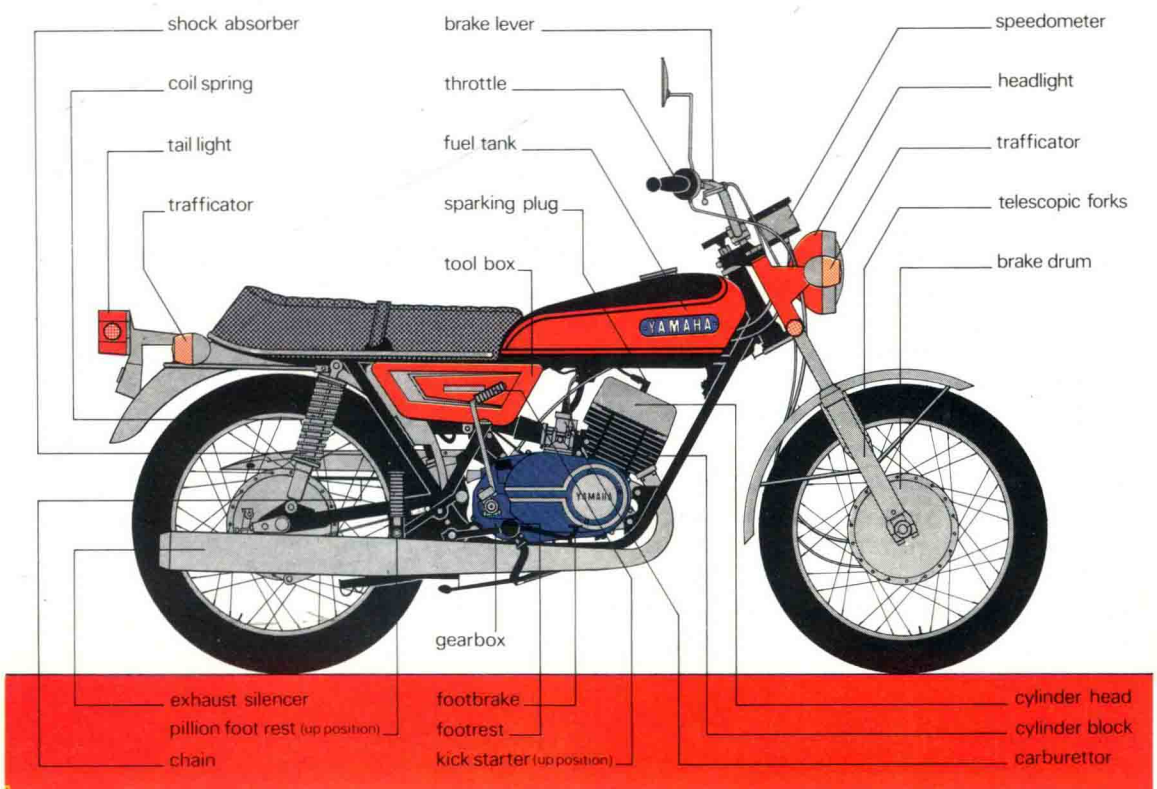
The Fairey Marine Huntsman is a fast cruiser which can be used for offshore racing.

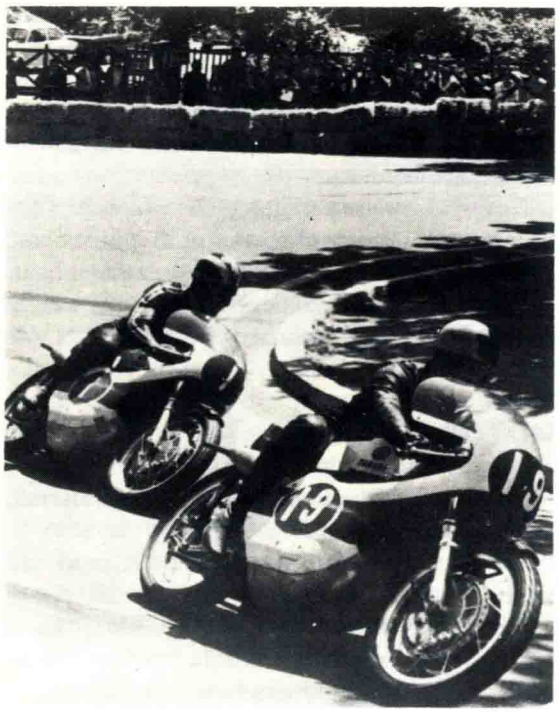
in the shape of the letter V but becoming flatter towards the stern, or rear end, is used for the larger high-speed craft. The third type is the stepped hull of the hydroplane. (*Hydro* is Greek for "water" and a hydroplane planes or skims along the surface of the water.) The underside of the hull has a step about half way along and slopes upwards in front of the step. Thus when the hydroplane gathers speed the water pressure lifts the front part and the boat skims along supported on the step and on the transom at the extreme stern. As very little of the underwater body is touching the water in this condition, high speeds can be reached.

The smaller motor boats often use petrol engines and some have engines which are started with petrol and then switched over to paraffin (kerosine). The diesel engine is much used in life-boats, fishing vessels and small warships such as minesweepers. Gas turbines use more fuel than other internal combustion engines but give very high speeds. Engines of all these types are described in the articles INTERNAL COMBUSTION ENGINE and DIESEL ENGINE. An "inboard" engine is one fixed inside the hull, like that in a ship, but an "outboard" engine is something like that of a motor cycle and is made up complete with propeller and shaft. An outboard engine has a screwed bracket so that it can be clamped on to the transom of almost any boat. The bracket is pivoted so that the propeller can be made to face in different directions by means of the tiller, allowing the boat to be steered without the use of a rudder.

National and international championships are held for racing motor boats of both inboard and outboard-engined types. Inboard-engined boats are divided into classes depending on the weight of the boat and outboard-engined boats are classed by engine size.

MOTOR CYCLE. Power-driven vehicles with two or sometimes three wheels came into being at the end of the 19th century. An Englishman, Edward Butler, made a powered tricycle in 1884, and soon afterwards the German engineer Gottlieb Daimler fitted a small petrol engine in a wooden cycle frame. Many early motor cycles were tricycles and often had pedals to help in starting and climbing hills. Improvements in design, largely as a result of the Isle of Man Tourist Trophy races, first held in 1907, soon brought the motor cycle to something like its present form, with electric ignition, variable gears, and the engine mounted low down between the two wheels.





Keystone

Grand Prix racing attracts many leading motor cycle manufacturers. These are Japanese 250 cc Yamahas taking a bend during the Spanish Grand Prix in Barcelona.

Many present-day motor cycle engines have one or two cylinders, but, even before World War II, some had as many as four. Later machines with three, six and even eight cylinders were developed, mainly for racing. Roadsters with three and four cylinders have become increasingly common. The great majority of motor cycle engines work on the two-stroke or the four-stroke principle, but in the early 1970s several prototypes with Wankel rotary engines were produced. (See the article INTERNAL COMBUSTION ENGINE.) There were also a few mopeds with electric motors.

As with the motor car, a motor cycle's internal combustion engine normally has a carburettor to feed it with a correctly-balanced mixture of air and petrol vapour. The quantity of the mixture supplied and, hence, the speed of the engine in any given circumstances are controlled by a twist-grip throttle on the right handlebar. Inside the cylinder, the mixture of petrol and air is ignited by an electric spark. The current for the spark is supplied by an engine-driven generator or by a battery, usually charged by a generator.

To enable them to run freely, the engine's working parts are lubricated by oil. In all four-strokes and an increasing number of two-strokes, the oil is forced round the parts by an engine-drive pump. Other two-strokes are lubricated by mixing oil with the petrol. A clutch and a gearbox with two or more forward speeds are fitted for the same reason as those in motor cars (see MOTOR VEHICLES). Gear selection is usually by a foot-operated lever, although a twist-grip changer is used on many scooters and mopeds. Few roadster machines have more than five gear ratios (speeds), but, using a combination of foot and hand change, some racing machines have had as many as 18. Several scooters and mopeds, and a very few motor cycles, have gearing which is continuously variable between its lower and upper limits. With these, the ratio in use at any time is selected automatically by a combination of the throttle setting and the amount of work the engine has to do—more when going up hill or moving a heavy load; less downhill or when lightly loaded. Drive from the engine to a normal gearbox is by gears or heavy-duty chain, and from gearbox to the rear wheel usually by chain but sometimes by shaft. (See GEARS.)

A motor cycle frame needs to be strong and stiff. It may be made of metal tubes, sheet-steel sections, often pressed to shape, cast-metal members, or by a combination of these. To cushion the rider over rough surfaces, the forks or arms attaching the wheels to the frame are sprung, so that when the wheels bounce on bumps, the frame remains relatively steady. To control and smooth the bounce and rebound of the wheels, dampers are also fitted. Early motor cycles had stirrup-like brakes, similar to those on a pedal cycle, but internal-expanding hub brakes are now almost universal, and hydraulically operated disc brakes are becoming increasingly common on large-capacity machines. Most motor cycles and scooters have electrical systems similar to those in cars, supplying lights and horn, and although most engines are started by a kick-starter mounted on the gearbox, growing numbers of motor cycles have electric starters.

During the 1920s and 1930s pedals were

retained only on autocycles—cycle-type machines with engines of around 100 cc. With increasing engine efficiency after World War II and the use of lighter, pressed-steel frames, the autocycle developed into the moped, powered by a 50 cc engine. Since the raising of the minimum age for a motor cycle licence to 17 in 1971, mopeds are the only powered two-wheelers which can be ridden by 16-year-olds in Britain. Another step in the development of the moped was the "clip-on", a small, two-stroke engine which could be fitted to a pedal cycle to drive either the front or the rear wheel by a friction roller acting on the tyre. Also designed for use with pedal cycles were replacement rear wheels, incorporating small engines in their hubs. Scooters were popular first in the 1950s, especially in Italy where scooters appeared in swarms on the roads, and again in the 1980s. The scooter usually has a pressed-steel open frame, incorporating a weather-protecting front apron, small-diameter wheels with fat tyres, and an engine mounted near the rear wheel.

Keystone

Motocross is an exciting form of motor cycle sport.

Motor Cycle Sport

Motor cycle sport is controlled by the *Fédération Internationale Motocycliste* (FIM) made up of national organizations, each of which governs motor cycle sport in its own country. Great Britain's organization, the Auto-Cycle Union (ACU), is one of the oldest. The main types of sporting event are road races, scrambles or motocross (races run on rough, cross-country courses), reliability trials (in which competitors try to negotiate several difficult natural obstacles without stopping or putting their feet down), grass-track races, speedway, sprints and hill-climbs.

Most British road races are held on disused aerodromes or on specially-built circuits, since racing is generally forbidden on public roads, except in the Isle of Man, where the Tourist Trophy (TT) races are held. At the first TT, pedals were permitted, a petrol-consumption limit was imposed, and there were two classes—one for single-cylinder machines, won by C. R. Collier on a Matchless at over 61 kilometres an hour, the other for twin-cylinder models, which H. R. Fowler (Norton) won at 58 kilometres an hour. Pedal assistance was dropped in 1909, and in 1911 the TT moved to the 60-kilometre Mountain Course, which includes a climb over the shoulder of Snaefell. One of the world's few remaining genuine road circuits, and the most demanding, the TT is one of several annual world-championship race meetings, each staged by a different country. At various times, it has included races for all world-championship classes (50, 125, 250, 350 and 500 cc solo, and 500 cc sidecar), plus events for solo production machines and sidecars of up to 750 cc. In 1971, the Formula 750 race was introduced, inspired by American race rules for production-based machines, after the American Motorcycle Association joined the FIM.

Apart from road racing, world championship series are also held for 250 and 500 cc motocross titles. There are annual world or

European title contests in speedway, sand-track and ice-racing, and trials. Several long-distance reliability trials are run each year, the most important being the International Six Days Trial.

MOTOR RACING AND TRIALS. From the very start of the motor car era there has been a strong spirit of competition among motorists. Before the end of the 19th century there were races on public roads such as the race from Paris to Amsterdam and back. In 1903 more than 200 cars and more than 50 motor cycles took part in the ambitious Paris to Madrid race. Although cars were by then capable of at least 130 kilometres an hour, their roadholding and braking were not adequate for such speeds. There were several fatal accidents, and the organizers stopped the race at Bordeaux after only 540 of the 1,280 kilometres of the race.

Today motor racing takes place on specially designed circuits or on roads closed to normal traffic. In both cases the racing circuit is much safer than it ever was in the past. Good crowd control is normal and protection for drivers and spectators is provided by barriers of steel to prevent cars from reaching spectator enclosures. The international racing scene includes races for saloon and sports cars of the "production" type, though often modified from showroom condition. There are also races for specially designed sports cars or prototypes, and there are several classes for single seater racing cars. It is in this class, the Grand Prix Formula One Class, that the most advanced design of car is found.

Courtesy, Ford Motor Company Ltd.

A driver makes a pit stop during a Grand Prix race to have the tyres changed and take on more fuel. The whole operation takes only seconds.

Each year Grand Prix drivers compete in a dozen or more races which count towards the world championships for drivers and car constructors. These races are held in Europe, South Africa, South America, the United States, Canada and Mexico. Competition in Formula One is world-wide as far as racing circuits and drivers are concerned but most Formula One cars are made in Europe. From Britain have come such cars as the BRM, Brabham, Lotus, McLaren, March, Surtees and Tyrrell. From Italy there is Ferrari, and from France Matra. The design and development of a Grand Prix car is extremely expensive.

Designers and drivers are always looking for more power, and for better roadholding so that this extra power can be used to best advantage. This has resulted in big changes in the tyres used

Drivers jockey for position at the start of a Grand Prix race. Each driver's place in the starting grid is decided by his speed during practice laps.

Courtesy, Ford Motor Company Ltd.

Courtesy, V.A.G. (United Kingdom) Ltd.
Long-distance car rallies are a tough testing ground for new designs.

for racing, and modern racing tyres are so wide across the tread that they look like rubber rollers. Special rubber "mixes" give the driver tyres that are suitable for wet or dry conditions, but not both at the same time. Races have been won or lost on a gamble on the weather.

To help keep the wheels of the car in contact with the road under all conditions, designers have developed body shapes so that at speed the air passing over the car is used to press the car on to the road. This aerodynamic force is very important and if for any reason the aerodynamic surfaces of the car are badly damaged, the handling characteristics of the car can suddenly change, sometimes with dangerous results.

Track or circuit races take place all over the world, and so do production car rallies. Once the most famous rally was the mid-winter Monte Carlo rally which is still run across Europe. But rugged long distance events such as the East African Safari rally tax the design and manufacture of touring cars to breaking-point.

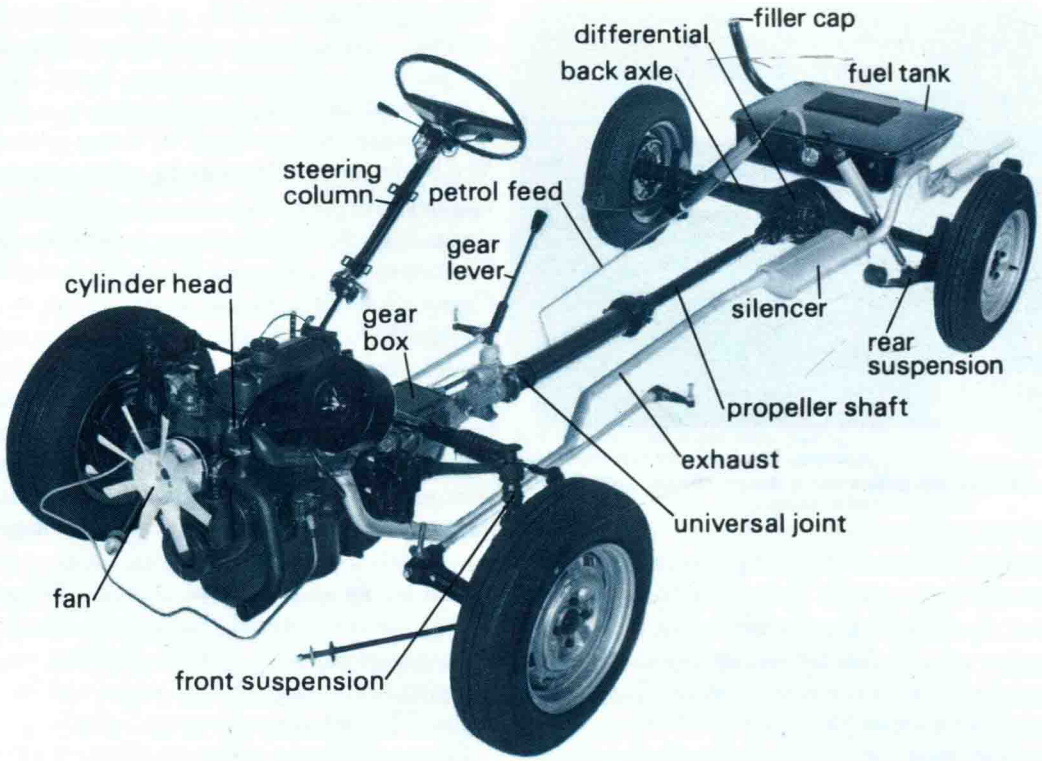
Although the degree of professionalism and the amount of sponsorship of races and cars by manufacturers is increasing, motor sport still attracts large numbers of spectators, as well as amateur designers and car builders. In Britain there are many motor sport events including races, sprints, hill climbs, trials over rough ground and road rallies. The governing body of motor sport in Britain is the Royal Automobile Club.

MOTOR VEHICLES. A vehicle is a wheeled carriage. Until the 1700s such carriages had to be pulled by animals, such as horses or oxen. There was no other form of power available. Then came the invention of steam power (see STEAM ENGINE). As early as 1769, the French engineer Nicolas Cugnot made a three-wheeled steam car which carried two people at about 6 kilometres an hour, and Richard Trevithick of Cornwall made a steam road carriage in 1801. Sir Goldsworthy Gurney, another Cornish inventor, designed a type of steam carriage which in 1831 was used for a regular passenger service between Gloucester and Cheltenham, covering the 14 kilometres in about 45 minutes. However, the owners of horse-drawn coaches and railways did all they could to prevent the development of power-driven road transport. Gurney was stoned by an angry crowd and in 1865 an Act of Parliament ordered that power-driven road carriages must have a man walking in front carrying a red flag by day and a red lamp by night. This act was in force until 1896.

On the continent of Europe there were no such hindrances. The German engineers Nikolaus Otto, Gottlieb Daimler ad Karl Benz developed petrol-driven engines which could be used for road carriages. These early "cars" were like small two-seater horse-carts with an engine behind and were quite open to the weather. But improvements came rapidly and by the early 1900s, motor cars began to look something like those used today. However, motoring remained a pastime for rich people (those who formerly had horse carriages gradually changed to cars). The early cars often looked very like carriages, since the bodies were built by coach-makers.

Inside a Car

There are seven main parts of a car. The *engine* provides the power. The *transmission* links the engine to the wheels. The *steering* directs the car, through the front wheels. The *brakes* act on all four wheels, and there is an extra hand brake for parking. The *electrical system* is provided by a battery; this gives enough power to start the engine, and also to work the lights, windscreen wipers, and other equipment. The *suspension* gives the passengers a smoother,



Courtesy, British Leyland (Austin-Morris) Ltd.

more comfortable ride by soaking up bumps in the road through springs and shock absorbers. The *body* of the car is nowadays made of sections of pressed steel, welded together.

Great attention is paid to economy and safety. Petrol (or "gasoline" as it is called in the United States) is expensive, and cars must be designed to make the best use of this precious fuel. For the protection of passengers, the car body is designed to stand up to a collision. The wearing of seat belts is now compulsory in several countries, and almost all have legal speed limits.

Engine and Transmission

The type of engine most commonly used in motor cars is the petrol engine of four-stroke type, although the two-stroke engine has been used in three-cylinder cars. The gas turbine works rather like a windmill, the "wind" being hot gases produced from burning a fuel such as kerosine. It is smooth running, but produces a lot of hot gas which has to be got rid of through the exhaust. Also it produces little power at low speed, so it needs a different gear-box from an ordinary car. The Wankel engine has a rotary motion (instead of an up and down movement of pistons inside the cylinders) but is not yet an attractive alternative to the piston engine.

The diesel engine has been used for years in buses and trucks. Car makers are starting to produce more small and medium sized cars with improved diesel engines, for greater economy. See DIESEL ENGINE; INTERNAL COMBUSTION ENGINE.

The usual family motor car has an engine with four or six cylinders carried under a hinged bonnet in front of the car, and the cylinders are water-cooled. The largest and most powerful cars may have more than six cylinders. The principal advantages of air-cooled engines are that they are lighter and warm up more quickly, and the driver does not have to worry about the water freezing in winter. The main disadvantages are that the cooling is less efficient, particularly in

hot weather, that each cylinder needs to have a considerable surface area of radiating fins around it (look at a motor cycle engine), and finally that the engine must be placed so that a sufficient volume of air will flow past it.

Electric current is supplied by a battery which is automatically recharged by an engine-driven generator (a dynamo or alternator) while the car is running. Wires from the battery take current to the ignition coil which provides the high voltage (electrical pressure) needed for the spark which explodes the petrol vapour in the cylinders. The lights, horn, indicators, petrol pump, starter, windscreen wipers and some instruments such as the petrol gauge also use electricity. The *starter* consists of a powerful electric motor to which current is supplied by pushing the starter button. The motor then spins round and a toothed wheel on its shaft turns a toothed ring on the flywheel of the engine. In this way the engine is turned until it starts working under its own power.

The transmission connects the engine to the driving wheels. Front-wheel drive has become common in modern cars, whereas at first the transmission was almost always connected to the rear wheels. Between the engine and gear-box is a *clutch* worked by pressing a foot pedal which disconnects the engine from the gear-box so that the driver can "change gear". (See CLUTCH.)

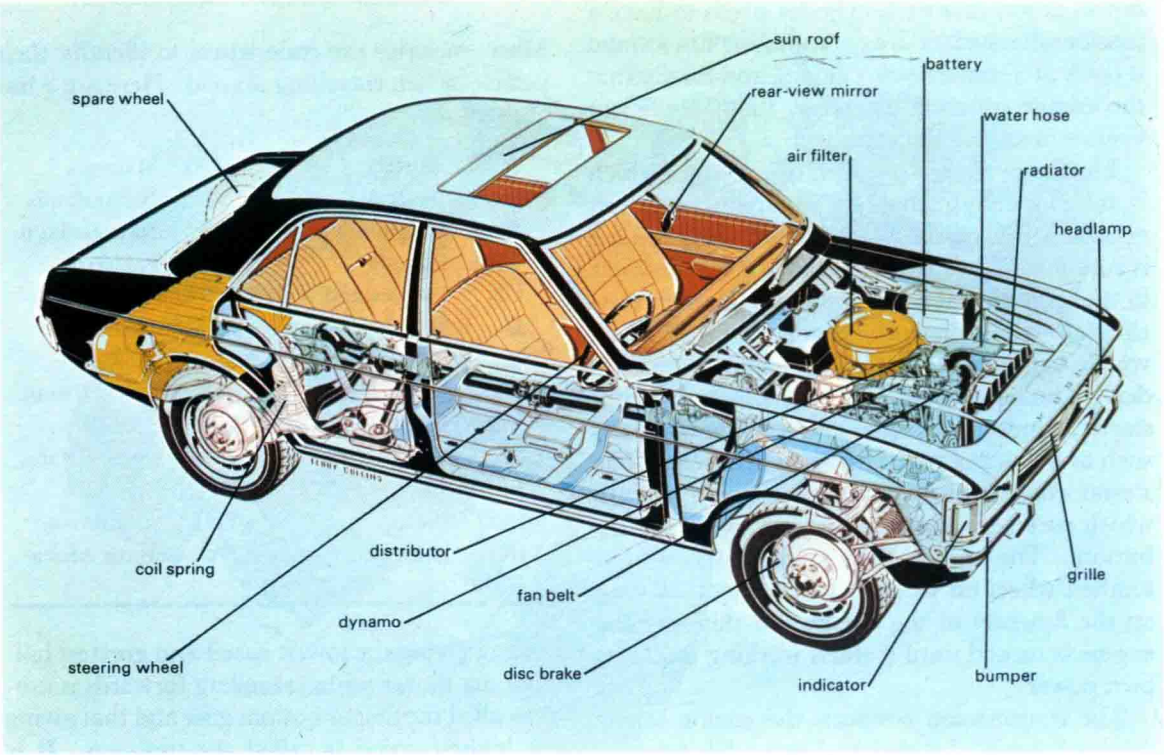
The need for changing gear arises because the internal combustion engine does not run well when turning very slowly. Therefore if the car is required to travel very slowly in traffic without the engine turning too slowly, the connection between engine and road wheels must allow the engine to make a large number of turns or revolutions ("revs" for short) for every turn of the wheels. This arrangement is also needed when climbing a hill, for otherwise the engine would be unable to push the weight of the car up the slope and would stop. When the road is level and clear of traffic, however, the car can travel faster and a different arrangement of gearing is used so that the engine makes fewer revs for each turn of the wheels (see the article GEARS). By moving the gear-lever, the driver of the motor car can choose a different train of gearing in the *gear-box* between engine and wheels. The train of gearing giving the lowest speed and greatest hill-climbing power when travelling forwards is usually called the first or bottom gear and that giving the highest speed is called the top gear. It is common to have four or five forward gears and one reverse gear for going backwards. An *automatic* gear-change changes to a lower gear as the engine slows down and to a higher gear as the engine increases speed, without the driver having to move the gear lever every time. In a car with automatic transmission there are only two foot pedals (accelerator and brake), and no clutch pedal.

The speed of the car is decided partly by the gear in use and partly by the position of the *accelerator*, a pedal controlling the engine speed and worked by the foot.

The gear-box is connected to the driving wheels by a propeller shaft through a special "universal joint" which allows the shaft a small movement relative to the gear-box. This is necessary because the rear axle moves up and down with the wheels on rough roads whereas the gear-box is fixed. In the back axle, an arrangement of gearing called the *differential* carries the power to the road wheels in such a way that, when turning a bend, the inner road wheel turns slower than the outer one. When the car goes straight both wheels turn at the same speed. The

Most countries use code letters to identify their vehicles when travelling abroad. Here are a few of them.

A	Austria	MAL	Malaysia
AUS	Australia	NL	Netherlands
B	Belgium	NZ	New Zealand
CDN	Canada	PAK	Pakistan
CH	Switzerland	ROK	South Korea
D	West Germany	S	Sweden
E	Spain	SGP	Singapore
EAK	Kenya	SU	Soviet Union
F	France	TR	Turkey
GB	United Kingdom	USA	United States
I	Italy	WAN	Nigeria
IND	India	YU	Yugoslavia
IRL	Ireland	ZA	South Africa



Courtesy, Ford Motor Company Ltd.

wheels themselves are pressed from plates of sheet steel and carry pneumatic (air-filled) rubber tyres to reduce the shocks from rough roads (see TYRE).

Steering, Brakes and Suspension

The steering wheel held by the driver is connected by gearing to an arm called the drop-arm, the end of which moves right or left according to the direction in which the steering wheel is turned. The drop-arm is linked to a cross-shaft called the track-rod fixed to arms attached to the stub axles. Each stub axle carries a front wheel and is pivoted on the end of a front axle, which is a fixed bar. Thus turning the steering wheel makes the front wheels point left or right.

The brakes for stopping the car may be either of drum type or disc type and are explained in the article BRAKES. In both types, a fixed surface made of a substance that grips well is pressed hard against a steel surface attached to the wheel and turning with it. The pressure is applied when the driver presses his right foot on the brake-pedal. In hydraulic brakes this pushes a piston down inside a cylinder full of oil and creates a pressure in the oil. Small pipes lead the pressure from this cylinder to a small cylinder connected to the brake on each wheel. The hand-brake, however, works the brakes direct through an arrangement of levers and rods or wire cables and does not depend on oil pressure.

The suspension system prevents the up-and-down movement and bouncing of the wheels from affecting the body of the car. This is done by fitting springs between the axles of the road wheels and the car body. Independent suspension systems allow each wheel to move up and down on its own. Leaf or coil springs, air springs or a system of hydraulically-operated cylinders may be used to control the movement of the road wheels. Shock absorbers are added to reduce the amount of bounce. The shock absorbers are designed to oppose rapid movement. The engine and gear-box are usually supported on rubber pads or blocks so that their noise and vibration are not conducted to the body of the car.

Inside the Body

At one time the body of a car was called coachwork and was supported on a strong steel frame called the chassis. Modern car bodies are usually made of sheet steel pressed into the required shapes. The body is made in as few pieces as possible as this reduces the number of fastenings and increases the strength. A few car bodies are made of glass fibre or plastics (see PLASTICS).

The front seats can usually be adjusted to provide the most comfortable position. Safety belts reduce the risk of serious injury to a passenger. The boot provides space for a spare wheel, tools and luggage.

The switches and instruments are carried below the windscreen in front of the driver. Switches or buttons control the ignition, lights, windscreen wipers, starter, radio and interior heater. The instruments include a speedometer to show the speed of the car and the distance travelled, a temperature gauge and a gauge showing the amount of petrol in the tank. Other instruments or lights show that the engine oil system is working correctly and that the dynamo or alternator is charging the battery.

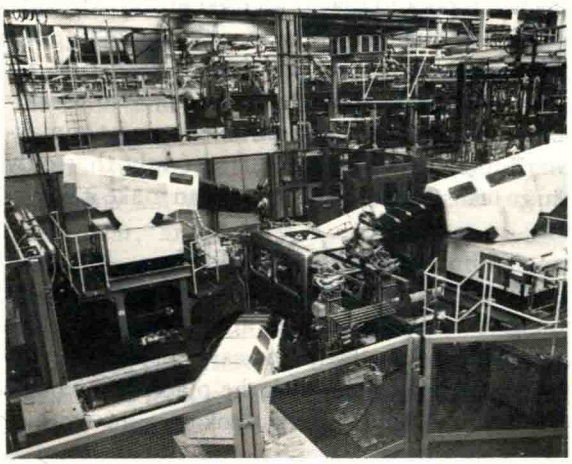
Designers of cars seek to produce an efficient, streamlined body shape, with few "knobs" such as headlamps, handles and petrol-fillers sticking out, single-panel curved windscreens, large windows, and a smaller engine space to give more leg-room to passengers. This in turn has meant smaller engines, sometimes mounted transversely (sideways). To give the same power, they have had to be designed to turn at higher speeds.

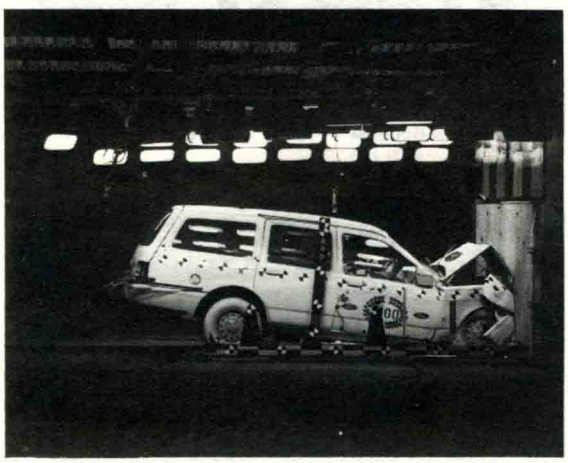
The Motor Industry

By the end of the 19th century motor cars were being made in Great Britain, France, Germany and the United States. They gradually became more reliable but were expensive because they were made one at a time in small workshops by skilled mechanics.

After World War I a new age began. Cars and trucks appeared on the roads in ever-growing numbers. Instead of being built one at a time cars were turned out by the thousands in factories working on the assembly line principle. (See ASSEMBLY LINE.) Small, cheap cars were built in large numbers both in the United States and in Europe, and all over the world people began taking to the road.

The American engineer Henry Ford foresaw the time when motor cars would be part of everyday life. He showed how the parts could be made and put together cheaply and quickly. The method he used is called mass production and it depended on using every person in the factory to the best advantage. The skilled mechanic who assembled or tested the carburettor (the device that changes the liquid petrol into gas) did not have to go and fetch it from another part of the factory. It was either brought to him by another man or it came to him on a conveyor belt,





Courtesy, Ford Motor Company Ltd.

Left: Robots carry out many routine tasks in modern factories. Here the driver's cab of a lorry is being assembled. Right: Tests measure how well a car body stands up to the impact of a crash.