How a car works

www.howacarworks.com

Contents

Basics

Bodywork

Brakes

Electrical systems

Cooling systems

Accessories

Engine

Fuel systems

Ignition System

Steering

Suspension

Transmission

Wheels and Tyres

How the braking system works / 1

Modern cars have brakes on all four wheels, operated by a hydraulic system. The brakes may be disc type or drum type.

The front brakes play a greater part in stopping the car than the rear ones, because braking throws the car weight forward on to the front wheels.

Many cars therefore have disc brakes, which are generally more efficient, at the front and drum brakes at the rear.

All-disc braking systems are used on some expensive or high-performance cars, and all-drum systems on some older or smaller cars.

Brake hydraulics

A hydraulic brake circuit has fluid-filled master and slave cylinders connected by pipes.

When you push the brake pedal it depresses a piston in the master cylinder, forcing fluid along the pipe.

The fluid travels to slave cylinders at each wheel and fills them, forcing pistons out to apply the brakes.

Fluid pressure distributes itself evenly around the system.

The combined surface 'pushing' area of all the slave pistons is much greater than that of the piston in the master cylinder.

Consequently, the master piston has to travel several inches to move the slave pistons the fraction of an inch it takes to apply the brakes.

This arrangement allows great force to be exerted by the brakes, in the same way that a long-handled lever can easily lift a heavy object a short distance.

Most modern cars are fitted with twin hydraulic circuits, with two master cylinders in tandem, in case one should fail.

Sometimes one circuit works the front brakes and one the rear brakes; or each circuit works both front brakes and one of the rear brakes; or one circuit works all four brakes and the other the front ones only.

Under heavy braking, so much weight may come off the rear wheels that they lock, possibly causing a dangerous skid.

For this reason, the rear brakes are deliberately made less powerful than the front.

Most cars now also have a load-sensitive pressure-limiting valve. It closes when heavy braking raises hydraulic pressure to a level that might cause the rear brakes to lock, and prevents any further movement of fluid to them.

Advanced cars may even have complex anti-lock systems that sense in various ways how the car is decelerating and whether any wheels are locking.

Such systems apply and release the brakes in rapid succession to stop them locking.

Power-assisted brakes

Many cars also have power assistance to reduce the effort needed to apply the brakes.

Usually the source of power is the pressure difference between the partial vacuum in the inlet manifold and the outside air.

The servo unit that provides the assistance has a pipe connection to the inlet manifold.

A direct-acting servo is fitted between the brake pedal and the master cylinder. The brake pedal pushes a rod that in turn pushes the master-cylinder piston.

But the brake pedal also works on a set of air valves, and there is a large rubber diaphragm connected to the master-cylinder piston.

When the brakes are off, both sides of the diaphragm are exposed to the vacuum from the manifold.

Pressing the brake pedal closes the valve linking the rear side of the diaphragm to the manifold, and opens a valve that lets in air from outside.

The higher pressure of the outside air forces the diaphragm forward to push on the master-cylinder piston, and thereby assists the braking effort.

If the pedal is then held, and pressed no further, the air valve admits no more air from outside, so the pressure on the brakes remains the same.

When the pedal is released, the space behind the diaphragm is reopened to the manifold, so the pressure drops and the diaphragm falls back.

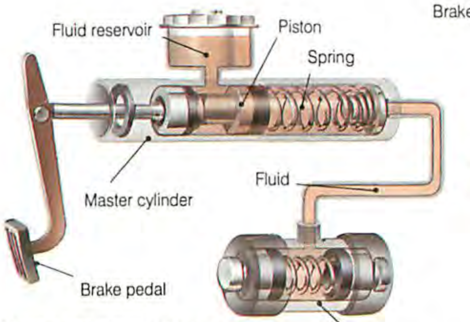
If the vacuum fails – because the engine stops, for example – the brakes still work because there is a normal mechanical link between the pedal and the master cylinder. But much more force must be exerted on the brake pedal to apply them.

Some cars have an indirect-acting servo fitted in the hydraulic lines between the master cylinder and the brakes. Such a unit can be mounted anywhere in the engine compartment instead of having to be directly in front of the pedal.

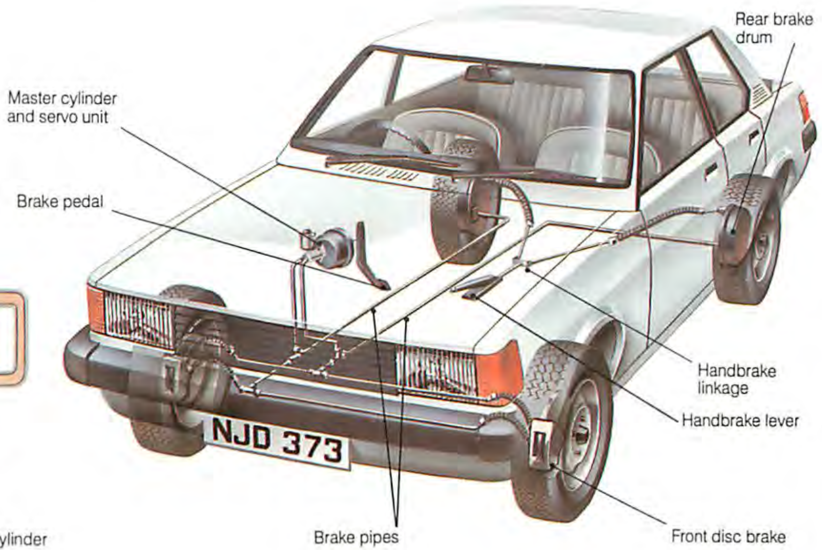
It, too, relies on manifold vacuum to provide the boost. Pressing the brake pedal causes hydraulic pressure build up from the master cylinder, a valve opens and that triggers the vacuum servo.

Dual-circuit braking system

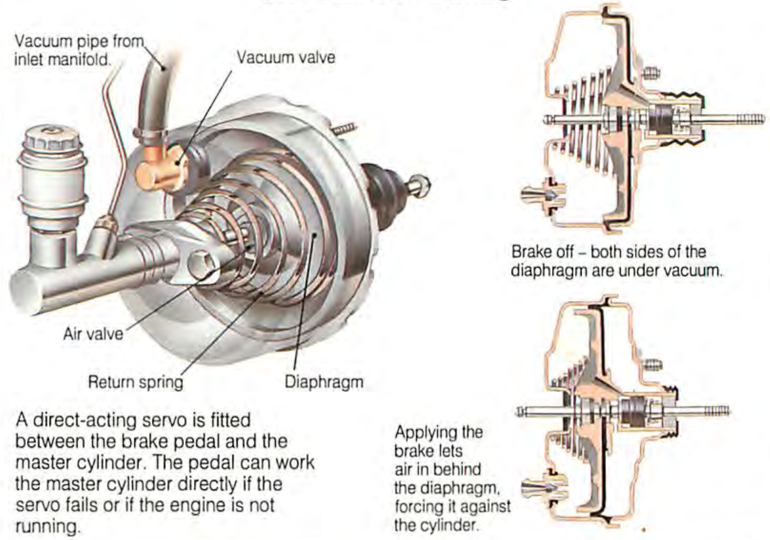
A typical dual-circuit braking system in which each circuit acts on both front wheels and one rear wheel. Pressing the brake pedal forces fluid out of the master cylinder along the brake pipes to the slave cylinders at the wheels; the master cylinder has a reservoir that keeps it full.



Master and slave cylinders
The master cylinder transmits hydraulic pressure to the slave cylinder when the pedal is pressed.



Servo-assisted braking



A direct-acting servo is fitted between the brake pedal and the master cylinder. The pedal can work the master cylinder directly if the servo fails or if the engine is not running.

Brake off – both sides of the diaphragm are under vacuum.

Applying the brake lets air in behind the diaphragm, forcing it against the cylinder.

How the braking system works / 2

Disc brakes

A disc brake has a disc that turns with the wheel. The disc is straddled by a caliper, in which there are small hydraulic pistons worked by pressure from the master cylinder.

The pistons press on friction pads that clamp against the disc from each side to slow or stop it. The pads are shaped to cover a broad sector of the disc.

There may be more than a single pair of pistons, especially in dual-circuit brakes.

The pistons move only a tiny distance to apply the brakes, and the pads barely clear the disc when the brakes are released. They have no return springs.

Rubber sealing rings round the pistons are designed to let the pistons slip forward gradually as the pads wear down, so that the tiny gap remains constant and the brakes do not need adjustment.

Many later cars have wear sensors – leads embedded in the pads. When the pads are nearly worn out, the leads are exposed and short-circuited by the metal disc, illuminating a warning light on the instrument panel.

Drum brakes

A drum brake has a hollow drum that turns with the wheel. Its open back is covered by a stationary backplate on which there are two curved shoes carrying friction linings.

The shoes are forced outwards by hydraulic pressure moving pistons in the brake's wheel cylinders, so pressing the linings against the inside of the drum to slow or stop it.

Each brake shoe has a pivot at one end and a piston at the other. A leading shoe has the piston at the leading edge relative to the direction in which the drum turns.

The rotation of the drum tends to pull the leading shoe firmly against it when it makes contact, improving the braking effect.

Some drums have twin leading shoes, each with its own hydraulic cylinder; others have one leading and one trailing shoe – with the pivot at the front.

This design allows the two shoes to be forced apart from each other by a single cylinder with a piston in each end.

It is simpler but less powerful than the two-leading-shoe system, and is usually restricted to rear brakes.

In either type, return springs pull the shoes back a short way when the brakes are released.

Shoe travel is kept as short as possible by an adjuster. Older systems have manual adjusters that need to be turned from time to time as the friction linings wear. Later brakes have automatic adjustment by means of a ratchet.

Drum brakes may fade if they are applied repeatedly within a short time – they heat up and lose their efficiency until they cool down again. Discs, with their more open construction, are much less prone to fading.

The handbrake

Apart from the hydraulic braking system, all cars have a mechanical handbrake acting on two wheels – usually the rear ones.

The handbrake gives limited braking if the hydraulic system fails completely, but its main purpose is as a parking brake.

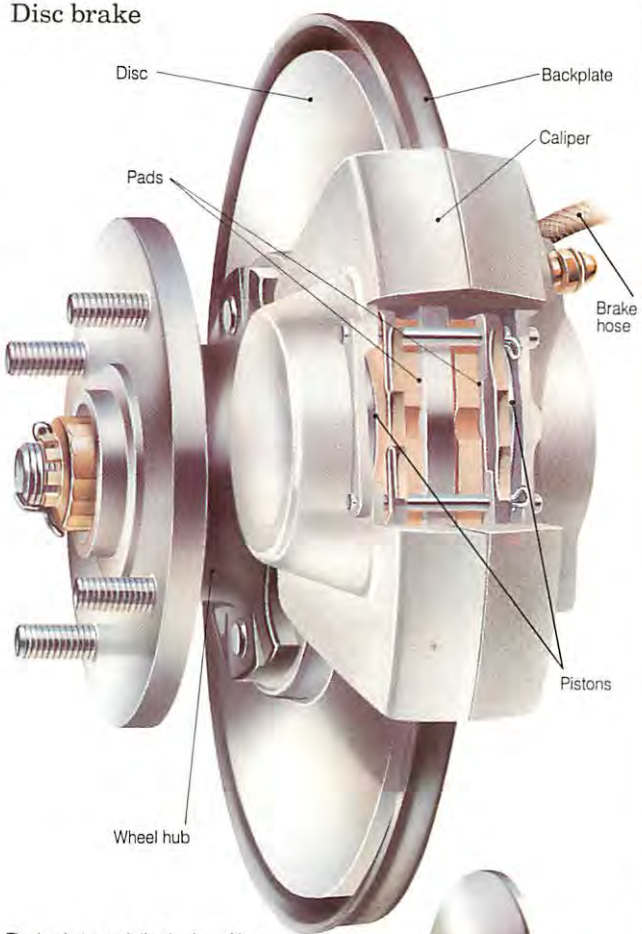
The handbrake lever pulls a cable or pair of cables linked to the brakes by a set of smaller levers, pulleys and guides whose details vary greatly from car to car.

A ratchet on the handbrake lever keeps the brake on once it is applied. A push button disengages the ratchet and frees the lever.

On drum brakes, the handbrake system presses the brake linings against the drums.

Disc brakes sometimes have a comparable handbrake arrangement, but because it is difficult to place the linkage on a compact caliper, there may be a completely separate set of handbrake pads for each disc.

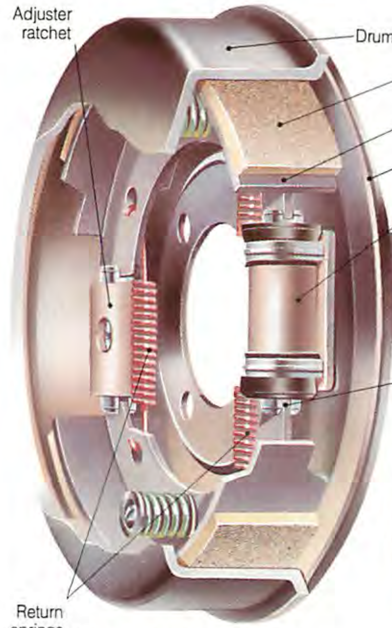
Disc brake



The basic type of disc brake, with a single pair of pistons. There may be more than one pair, or a single piston operating both pads, like a scissor mechanism, through different types of calipers – a swinging or a sliding caliper.

When the brake is applied, fluid pressure forces the pads against the disc. With the brake off, both pads barely clear the disc.

Drum brake

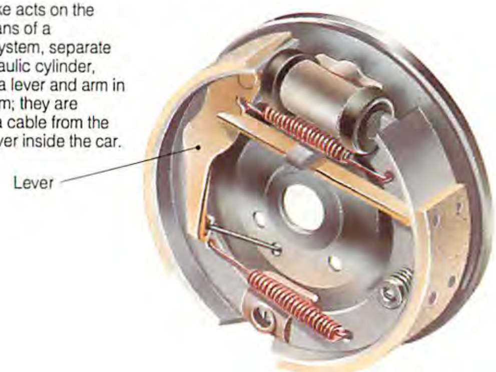


A drum brake with a leading and a trailing shoe, which has only one hydraulic cylinder; brakes with two leading shoes have a cylinder for each shoe and are fitted to the front wheels on an all-drum system.

With the brakes on, the shoes are forced against the drums by their piston.

The handbrake mechanism

The handbrake acts on the shoes by means of a mechanical system, separate from the hydraulic cylinder, consisting of a lever and arm in the brake drum; they are operated by a cable from the handbrake lever inside the car.



How the charging system works

A car uses quite a lot of electricity to work the ignition and other electrical equipment.

If the power came from an ordinary battery, it would soon run down. So a car has a rechargeable battery and a charging system to keep it topped up.

The battery has pairs of lead plates immersed in a mixture of sulphuric acid and distilled water.

Half of the plates are connected to each terminal. Electricity supplied to the battery causes a chemical reaction that deposits extra lead on one set of plates.

When the battery supplies electricity, exactly the opposite happens: the extra lead dissolves off the plates in a reaction that produces an electric current.

The battery is charged by an alternator on modern cars, or by a dynamo on earlier ones. Both are types of generator, and are driven by a belt from the engine.

The alternator consists of a stator – a stationary set of wire coil windings, inside which a rotor revolves.

The rotor is an electromagnet supplied with a small amount of electricity through carbon or copper-carbon brushes (contacts) touching two revolving metal slip rings on its shaft.

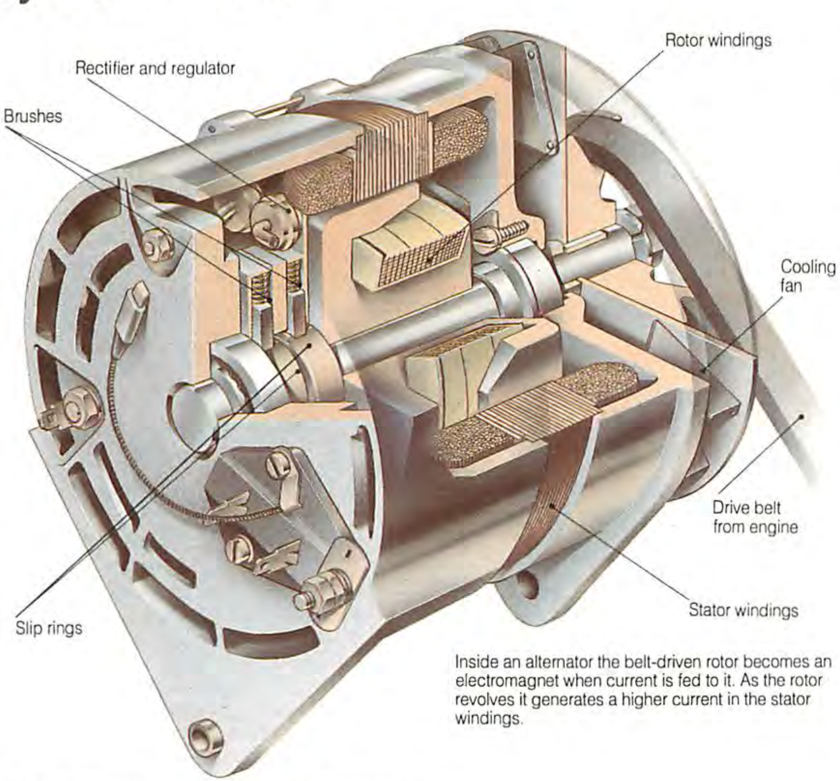
The rotation of the electromagnet inside the stator coils generates much more electricity inside these coils.

The electricity is alternating current – its direction of flow changes back and forth every time the rotor turns. It has to be rectified – turned into a one-way flow, or direct current.

A dynamo gives direct current but is less efficient, particularly at low engine speeds, and weighs more than an alternator.

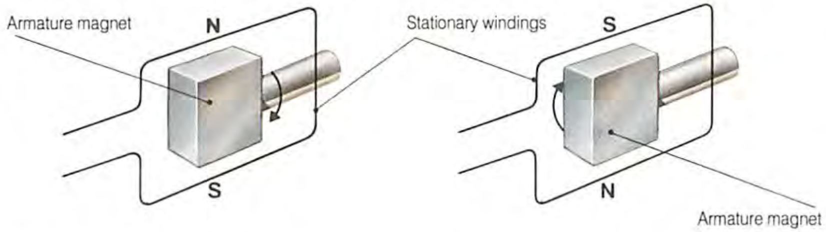
A warning light on the dashboard glows when the battery is not being adequately charged, – for example, when the engine stops.

There may also be an ammeter to show how much electricity is being generated, or a battery-condition indicator showing the battery's state of charge.



Inside an alternator the belt-driven rotor becomes an electromagnet when current is fed to it. As the rotor revolves it generates a higher current in the stator windings.

How current flows in an alternator



How the alternator works

Moving a magnet past a closed loop of wire makes an electric current flow in the wire. Imagine a loop of wire with a magnet inside it.

The north pole of the magnet passes the top of the loop as the south pole passes the bottom of it. Both passes make current flow in one direction round the loop.

The poles move away, and current stops flowing until the south pole reaches the top and the north pole the bottom.

This makes current flow again, but in the opposite direction.

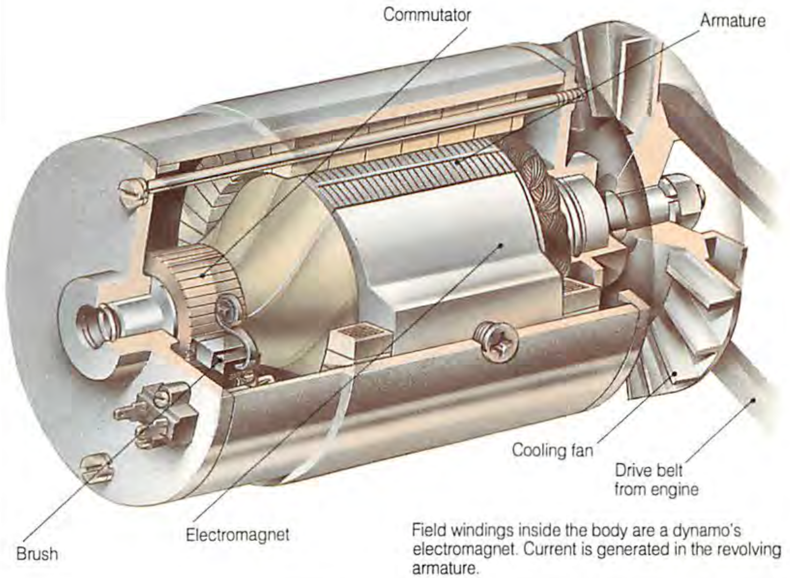
A car alternator uses an electromagnet in order to boost output of electric current.

How a dynamo works

In a dynamo the electromagnets are stationary, and are called the field coils. The current is produced in an armature – another set of coils wound on to a shaft and turning inside the field coils.

The principle is the same as that of the alternator, but the current goes to a commutator – a metal ring split into segments that are touched by carbon brushes fitted in spring-loaded guides. Two segments touch a pair of brushes and feed current to them.

As the armature turns, the current changes direction. But by then another pair of commutator segments has come under the brushes, and this pair is wired up the other way round – so the current coming out always flows in the same direction.



Field windings inside the body are a dynamo's electromagnet. Current is generated in the revolving armature.

Regulating the current to the battery

The current from an alternator is rectified into direct current by a set of diodes that allow current to flow through them in one direction only.

To charge the battery the voltage supplied to it must not be too low or too high.

The alternator has a transistor-operated control device that regulates the voltage by supplying more or less current – as required – to the electromagnet.

The rectifier and regulator are usually inside the alternator housing, but on some alternators they are outside, mounted on the alternator body.

A dynamo does not need a rectifier – there is a voltage regulator in a separate box, which has relays.

One relay controls the voltage level by briefly cutting off the current in the field coils.

The second relay prevents the dynamo from overcharging and damaging the battery.

The third relay stops the battery discharging when the dynamo is turning too slowly to charge it.

How the starting system works

To make an engine start it must be turned at some speed, so that it sucks fuel and air into the cylinders, and compresses it.

The powerful electric starter motor does the turning. Its shaft carries a small pinion (gear wheel) which engages with a large gear ring around the rim of the engine flywheel.

In a front-engine layout, the starter is mounted low down near the back of the engine.

The starter needs a heavy electric current, which it draws through thick wires from the battery. No ordinary hand-operated switch could switch it on: it needs a large switch to handle the high current.

The switch has to be turned on and off very quickly to avoid dangerous, damaging sparking. So a solenoid is used – an arrangement where a small switch turns on an electromagnet to complete the circuit.

The starter switch is usually worked by the ignition key. Turn the key beyond the 'ignition on' position to feed current to the solenoid.

The ignition switch has a return spring, so that as soon as you release the key it springs back and turns the starter switch off.

When the switch feeds current to the solenoid, the electromagnet attracts an iron rod.

The movement of the rod closes two heavy contacts, completing the circuit from the battery to the starter.

The rod also has a return spring – when the ignition switch stops feeding current to the solenoid, the contacts open and the starter motor stops.

The return springs are needed because the starter motor must not turn more than it has to in order to start the engine. The reason is partly that the starter uses a lot of electricity, which quickly runs down the battery.

Also, if the engine starts and the starter motor stays engaged, the engine will spin the starter so fast that it may be badly damaged.

The starter motor itself has a device, called a Bendix gear, which engages its pinion with the gear ring on the flywheel only while the starter is turning the engine. It disengages as soon as the engine picks up speed, and there are two ways by which it does so – the inertia system and the pre-engaged system.

The inertia starter relies on the inertia of the pinion – that is, its reluctance to begin to turn.

The pinion is not fixed rigidly to the motor shaft – it is threaded on to it, like a freely turning nut on a very coarse-thread bolt.

Imagine that you suddenly spin the bolt: the inertia of the nut keeps it from turning at once, so it shifts along the thread of the bolt.

When an inertia starter spins, the pinion moves along the thread of the motor shaft and engages with the flywheel gear ring.

It then reaches a stop at the end of the thread, begins to turn with the shaft and so turns the engine.

Once the engine starts, it spins the pinion faster than its own starter-motor shaft. The spinning action screws the pinion back down its thread and out of engagement.

The pinion returns so violently that there has to be a strong spring on the shaft to cushion its impact.

The violent engagement and disengagement of an inertia starter can cause heavy wear on the gear teeth. To overcome that problem the pre-engaged starter was introduced, which has a solenoid mounted on the motor.

As well as switching on the motor, the solenoid also slides the pinion along the shaft to engage it.

The shaft has straight splines rather than a Bendix thread, so that the pinion always turns with it.

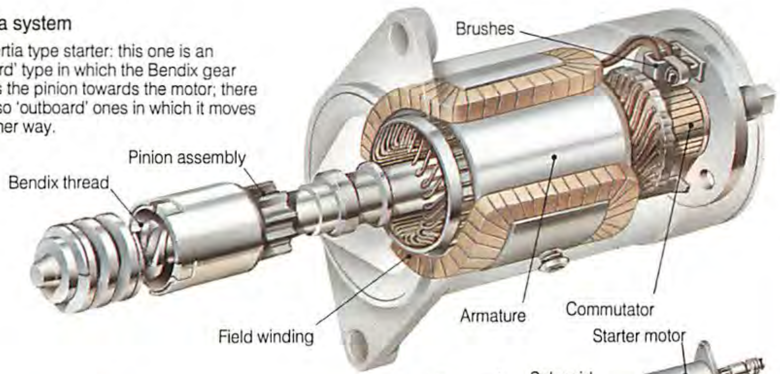
The pinion is brought into contact with the toothed ring on the flywheel by a sliding fork. The fork is moved by a solenoid, which has two sets of contacts that close one after the other.

The first contact supplies a low current to the motor so that it turns slowly – just far enough to let the pinion teeth engage. Then the second contacts close, feeding the motor a high current to turn the engine.

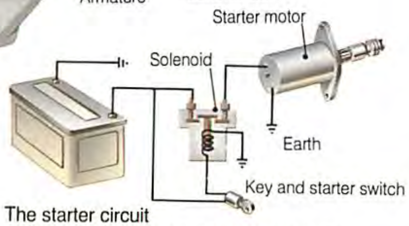
The starter is saved from overspeeding when the engine starts by means of a freewheel clutch, like the freewheel of a bicycle. The return spring of the solenoid withdraws the pinion from engagement.

Inertia system

An inertia type starter: this one is an 'inboard' type in which the Bendix gear throws the pinion towards the motor; there are also 'outboard' ones in which it moves the other way.



The inertia of the heavy pinion assembly prevents it from spinning immediately when the motor shaft turns, so it slides along the thread and into engagement; when the engine starts, the pinion is turned faster than its shaft, so it is thrown back out of engagement.

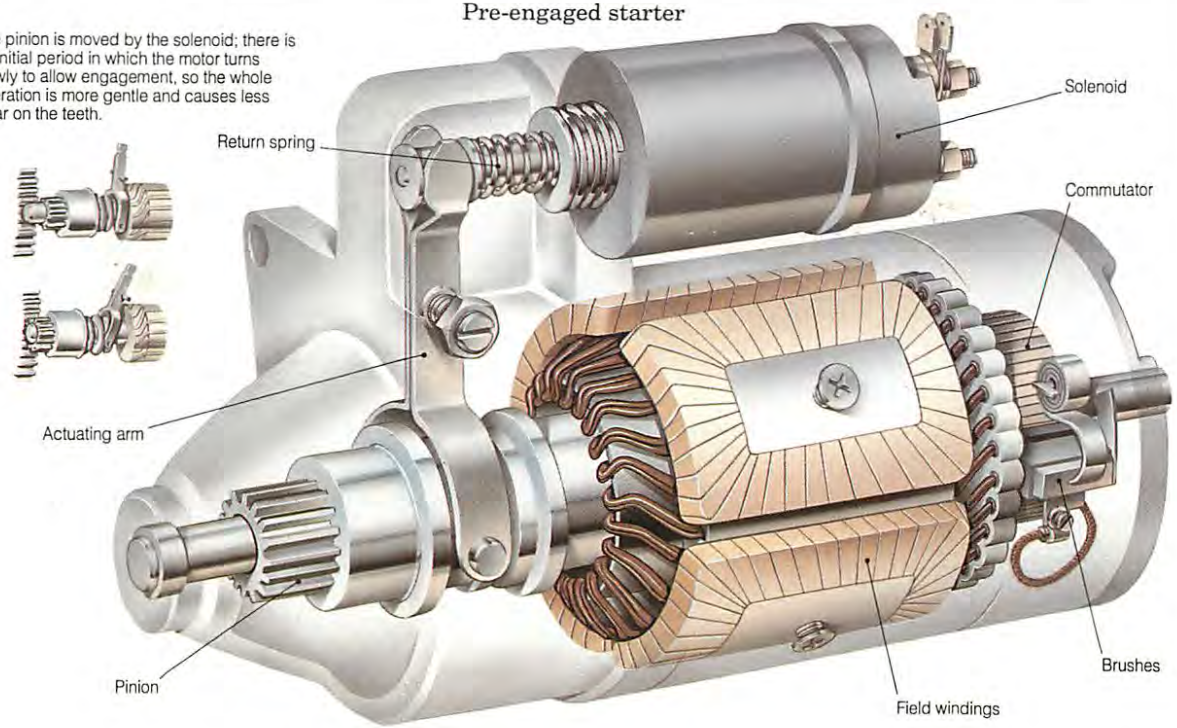


The starter circuit

All the components are earthed to the metal car body. Only one wire is needed to carry current to each component.

Pre-engaged starter

The pinion is moved by the solenoid; there is an initial period in which the motor turns slowly to allow engagement, so the whole operation is more gentle and causes less wear on the teeth.



How the cooling system works

A car engine produces a lot of heat when it is running, and must be cooled continuously to avoid engine damage.

Generally this is done by circulating coolant liquid – usually water mixed with an antifreeze solution – through special cooling passages. Some engines are cooled by air flowing over finned cylinder casings.

A water-cooled system

A water-cooled engine block and cylinder head have interconnected coolant channels running through them. At the top of the cylinder head all the channels converge to a single outlet.

A pump, driven by a pulley and belt from the crankshaft, drives hot coolant out of the engine to the radiator, which is a form of heat exchanger.

Unwanted heat is passed from the radiator into the air stream, and the cooled liquid then returns to an inlet at the bottom of the block and flows back into the channels again.

Usually the pump sends coolant up through the engine and down through the radiator, taking advantage of the fact that hot water expands, becomes lighter and rises above cool water when heated. Its natural tendency is to flow upwards, and the pump assists circulation.

The radiator is linked to the engine by rubber hoses, and has a top and bottom tank connected by a core – a bank of many fine tubes.

The tubes pass through holes in a stack of thin sheet-metal fins, so that the core has a very large surface area and can lose heat rapidly to the cooler air passing through it.

On older cars the tubes run vertically, but modern, low-fronted cars have crossflow radiators with tubes that run from side to side.

In an engine at its ordinary working temperature, the coolant is only just below normal boiling point.

The risk of boiling is avoided by increasing the pressure in the system, which raises the boiling point.

The extra pressure is limited by the radiator cap, which has a pressure valve in it. Excessive pressure opens the valve, and coolant flows out through an overflow pipe.

In a cooling system of this type there is a continual slight loss of coolant if the engine runs very hot. The system needs topping up from time to time.

Later cars have a sealed system in which any overflow goes into an expansion tank, from which it is sucked back into the engine when the remaining liquid cools.

How the fan helps

The radiator needs a constant flow of air through its core to cool it adequately. When the car is moving, this happens anyway; but when it is stationary a fan is used to help the airflow.

The fan may be driven by the engine, but unless the engine is working hard, it is not always needed while the car is moving, so the energy used in driving it wastes fuel.

To overcome this, some cars have a viscous coupling – a fluid clutch worked by a temperature sensitive valve that uncouples the fan until the coolant temperature reaches a set point.

Other cars have an electric fan, also switched on and off by a temperature sensor.

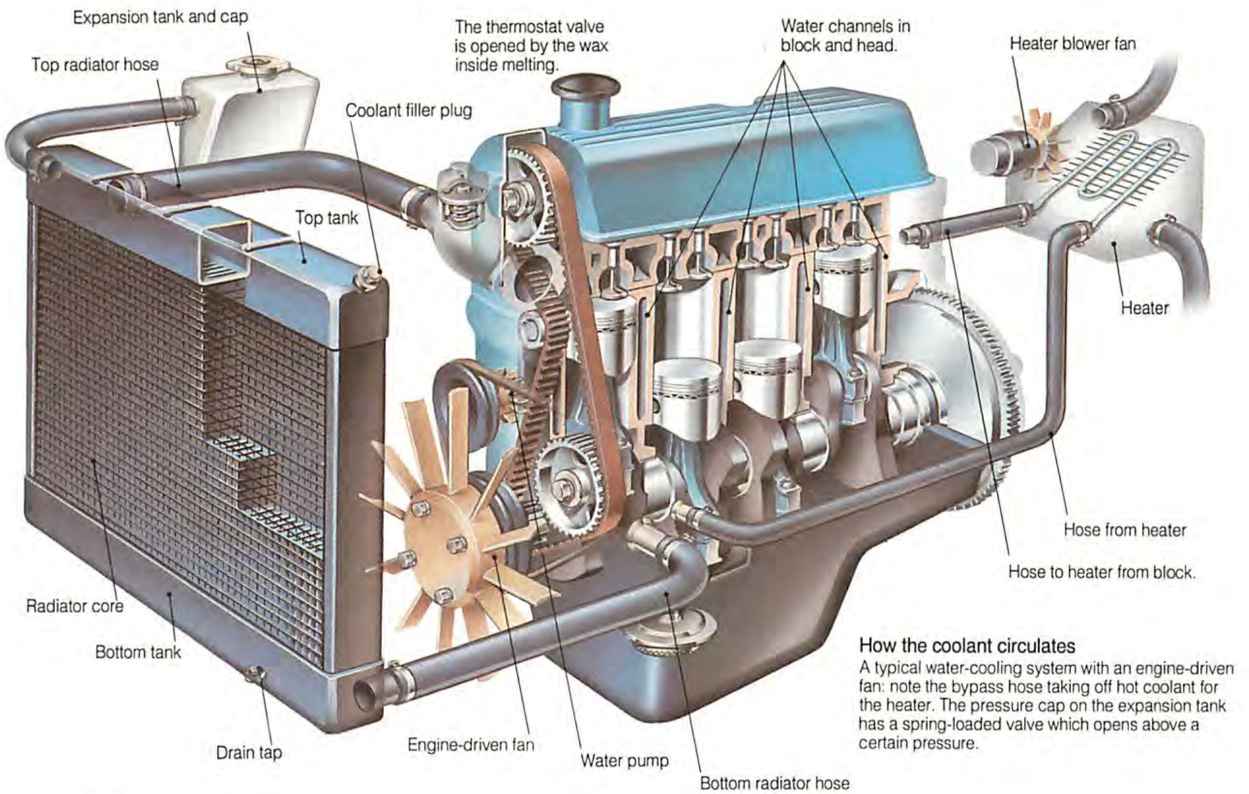
To let the engine warm up quickly, the radiator is closed off by a thermostat, usually sited above the pump. The thermostat has a valve worked by a chamber filled with wax.

When the engine warms up, the wax melts, expands and pushes the valve open, allowing coolant to flow through the radiator.

When the engine stops and cools, the valve closes again.

Water expands when it freezes, and if the water in an engine freezes it can burst the block or radiator. So antifreeze – usually ethylene glycol – is added to the water to lower its freezing point to a safe level.

Antifreeze should not be drained each summer; it can normally be left in for two or three years.



How the coolant circulates
A typical water-cooling system with an engine-driven fan: note the bypass hose taking off hot coolant for the heater. The pressure cap on the expansion tank has a spring-loaded valve which opens above a certain pressure.

Air-cooled engines

In an air-cooled engine, the block and cylinder head are made with deep fins on the outside.

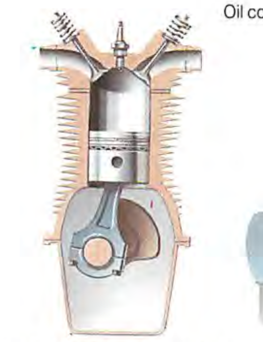
Frequently a duct runs all around the fins, and an engine-driven fan blows air through the duct to take heat away from the fins.

A temperature-sensitive valve controls the amount of air being pushed around by the fan, and keeps the temperature constant even on cold days.

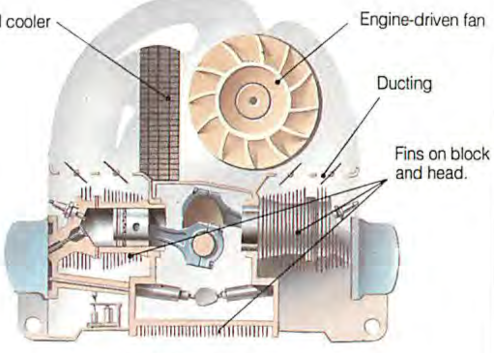
Cooling the oil

Air-cooled engines and high-performance water-cooled engines may have in addition to a water radiator a small extra radiator, through which engine oil flows to be cooled.

Air cooling through fins

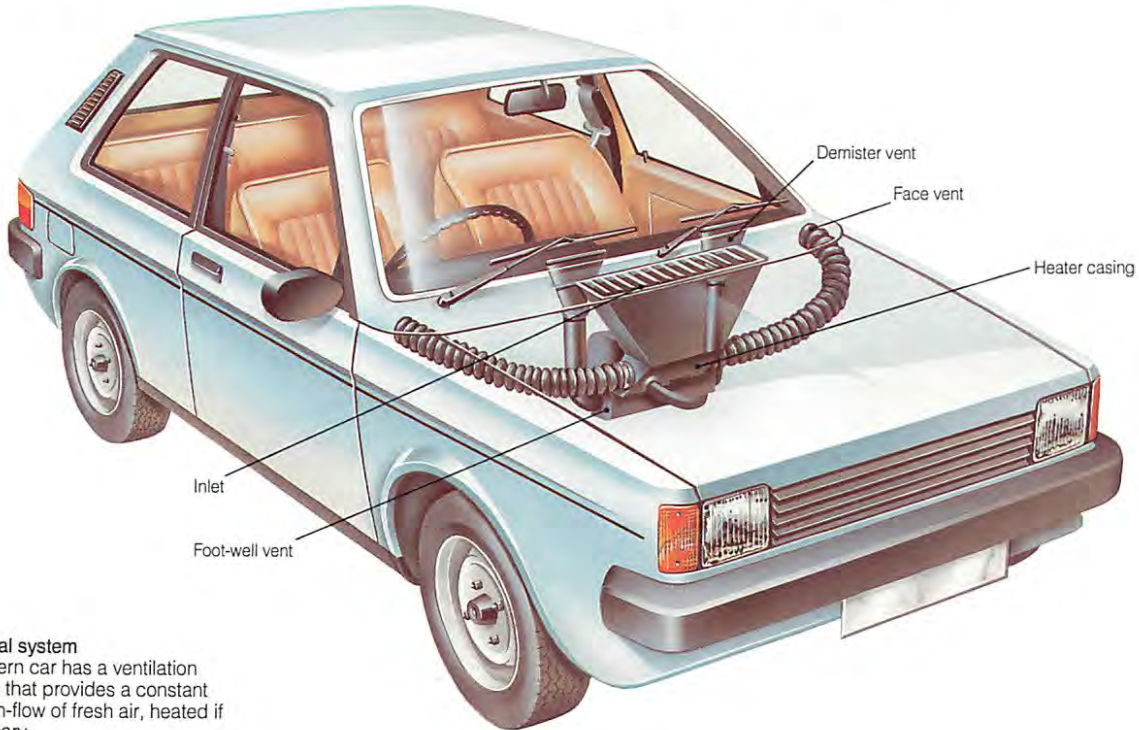


Fins on an air-cooled cylinder are wider at the top, where most heat is generated.



Horizontal air-cooled engines have cooling ducts to the fins.

How the heating and ventilation systems work



A typical system
A modern car has a ventilation system that provides a constant through-flow of fresh air, heated if necessary.

Modern cars are designed to have a constant through-flow of fresh air that keeps the interior atmosphere pleasant even with all the windows shut. The incoming air can be heated by the engine to keep the windows clear of mist and the car interior at a chosen temperature.

Air flow

Air enters a large duct at the front of the car, placed so that when the car is moving the entry point is in a high-pressure area and air is forced in. From there it goes to the heater, which warms it if required. Another common entry point is through grilles on top of the bonnet.

Air enters the car interior through the front foot-wells and through vents on the dashboard. The vents can be adjusted to point at the faces of the front-seat occupants.

Some cars also have ducts to the rear-seat area.

Slots in the ledge at the bottom of the windscreen – and, in later cars, by the front side-windows – allow a stream of warm air to be blown on to the glass to prevent misting.

On later cars, all the entry points have flaps for opening and closing them as needed.

At the rear there are exit vents to the outside. They are in an area of low pressure when the car is moving, and so extract air, thus giving a constant through-flow.

The heater

In a water-cooled car, the heater casing contains a matrix – a small radiator – that takes hot water from the engine through a hose.

Incoming air goes through the water-heated matrix and is warmed.

There is also an electric fan, which can be switched on to blow air through the system when the car is stationary, or when extra ventilation is called for.

The fan can be adjusted to run at different speeds, according to need.

The temperature to which the air is warmed is controlled by either a water valve or an air-blending system. The water-valve type is found mainly on earlier cars.

The temperature control on the dashboard works a tap which lets either more or less hot water through the matrix. The setting is slow to respond to change and difficult to regulate exactly.

The air-blending system has a matrix that is heated constantly. The temperature control opens and closes flaps that blend heated air with cold air from outside.

With either system there may be extra flaps to admit a separate supply of cold air to the face vents, even when the rest of the system is supplying warm air.

The air-control flaps inside the heater box may be moved mechanically by sliding knobs on the control panel, which are linked to the flaps by cables.

More expensive cars may have power-assisted controls worked by the vacuum in the inlet manifold acting on a diaphragm, as in a power-brake servo (SHEET 17).

Air-cooled cars

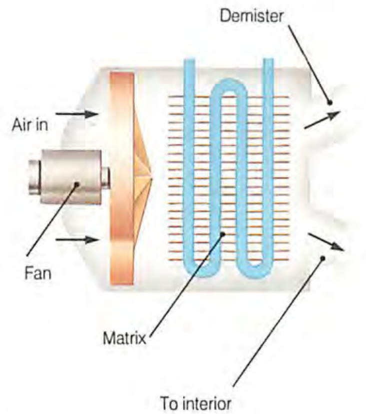
In cars with air-cooled engines, air for the interior heater can be warmed by ducting it around fins on the hot exhaust manifold.

The warmed air is mixed to the right temperature by an air-blending system, including a heat-sensitive valve that keeps the temperature steady and at a comfortable level for the occupants.

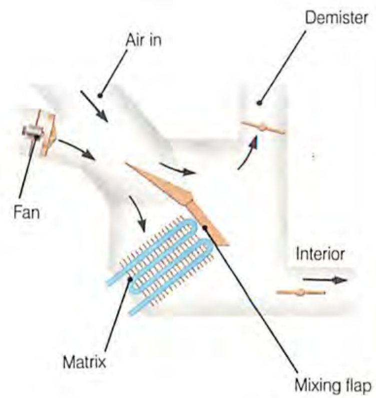
If necessary, the air may be warmed further by an electrically ignited petrol-burning heat exchanger.

The heat exchanger also allows the heater to work with the engine off – unlike a water-heated type. The rest of the system, the way in which the heat is distributed, is like that of any other car.

Two methods of heat control



Water-valve system
In a heater worked by a water valve, all the air goes through the matrix. The matrix temperature is controlled by regulating the amount of hot water going through it.



Air-blending system
In an air-blending heater the matrix is at a constant temperature – warm air from it is mixed with cool air as temperature-controlled flaps open and close.

The engine – how power is created

The conversion of fuel energy into power in an engine starts when petrol is mixed with air in a device called a carburettor, to form a highly combustible mixture.

The mixture is drawn into the cylinders through valves, compressed to about an eighth or ninth of its original volume by a piston, and then ignited by a sparkplug.

Rapid expansion of the burning gas, the combustion, drives the piston down the cylinder.

The downward thrust is changed by the connecting rod to rotary movement of the crankshaft in much the same way as a cyclist pressing his foot on the pedal turns the chain wheel.

The downward stroke of the piston is known as the power stroke in a four-stroke cycle – it occurs only once in every four strokes of the piston's up-and-down movement.

The cycle starts with the induction stroke. With the exhaust valve closed, a downward movement of the piston sucks fuel mixture from the carburettor into the cylinder. The mixture enters through the inlet valve, which has been opened by the camshaft turning.

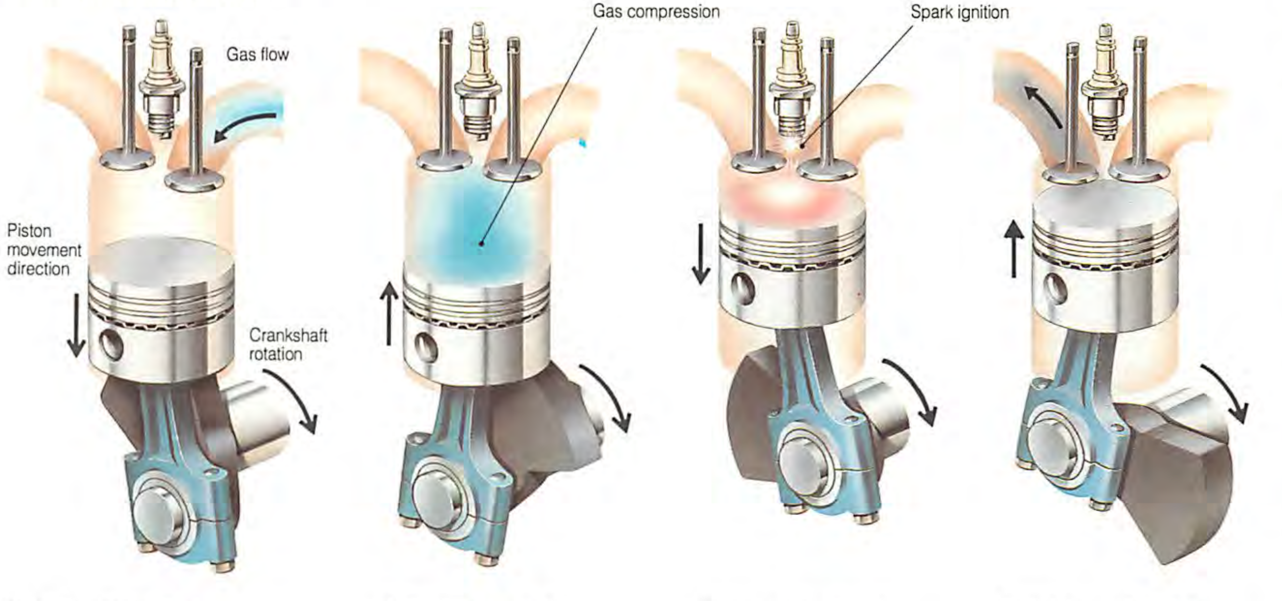
The upward movement of the piston which follows is the compression stroke. The exhaust valve remains closed and the inlet valve also closes, so the mixture in the cylinder is compressed by the rising piston into a small space known as the combustion chamber – usually in the cylinder head or in the top of the piston.

A spark from the sparkplug ignites the mixture and causes it to expand rapidly, driving the piston down in the power stroke.

As the piston rises once more, the inlet valve remains closed but the exhaust valve opens. This movement allows the waste products of the burned mixture to escape through the exhaust system, and is called the exhaust stroke.

The camshaft continues to rotate, the exhaust valve closes and the inlet valve opens – and the four-stroke cycle starts again.

The four-stroke cycle



On the induction stroke the piston is descending, the inlet valve is fully open and the exhaust valve closed.

As the piston rises on its compression stroke the exhaust valve is still closed and the inlet valve is closing.

The power stroke drives the piston downwards as the ignited gases expand. Both the inlet and exhaust valves are closed.

The hot gases in the cylinder escape through the open exhaust valve as the piston rises again for the exhaust stroke.

Compression ratio

The difference between the volume of air and fuel mixture sucked into the cylinder by the induction stroke and its eventual volume when compressed fully is called the compression ratio.

If the mixture is reduced to one-ninth of its original volume, the engine has a compression ratio of 9:1.

The firing order

The sequence in which the sparkplugs ignite the mixture in each of the engine cylinders is known as the firing order.

This is controlled by the distributor, which directs the flow of current to each plug at the correct time during the engine's four-stroke cycle. The camshaft is designed to open and shut the valves in the required sequence.

The spark occurs just before the piston reaches top dead centre (TDC) on the compression stroke.

The cylinders of an in-line engine are usually numbered from front to rear, starting with No. 1 cylinder.

If the plugs were fired in numerical order from one end to the other, the successive power impulses from the pistons would cause the engine to run very unevenly and vibrate excessively.

In a four-cylinder engine, vibration is reduced with a firing order 1, 3, 4, 2 or 1, 2, 4, 3.

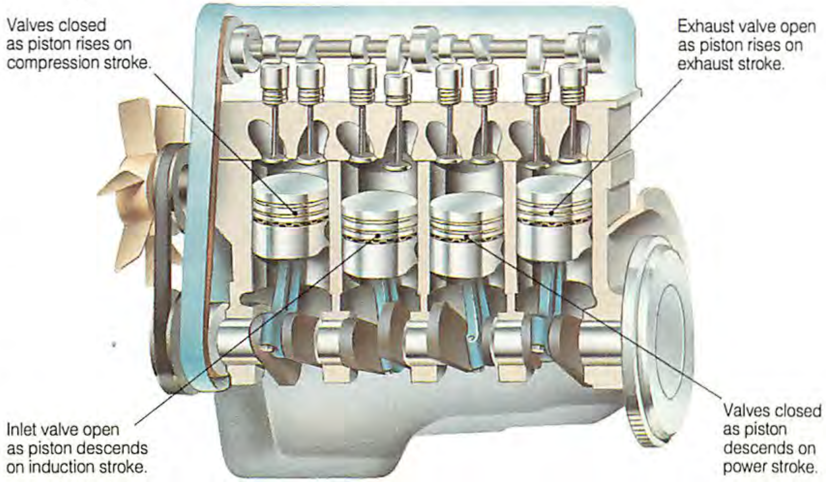
Whenever the high-tension leads are removed from the sparkplugs they must always be reconnected in the correct sequence, to maintain the proper firing order.

If in any doubt, label the leads with their cylinder numbers on pieces of sticky tape.

The inertia of the rotating flywheel also helps to smooth out the cyclic variations and minimises vibration of the engine.

Additional balancing may be provided by balance weights incorporated in the crankshaft. Some four-cylinder engines have additional balancing shafts to give the engine the smoothness of a six-cylinder engine.

Valve positions in a 1, 2, 4, 3 firing order



The engine – how the valves open and close

The valve which allows mixture into the cylinder is the inlet valve; the one through which the spent gases escape is the exhaust valve. They are designed to open and close at precise moments, to allow the engine to run efficiently at all speeds.

The operation is controlled by pear-shaped lobes, called cams, on a rotating shaft, the camshaft, driven by a chain, a belt, or a set of gears from the crankshaft.

Where the camshaft is mounted in the engine block, small metal cylinders – tappets – sit in channels above each cam, and from the tappets metal pushrods extend up into the cylinder head. The top of each pushrod meets a rocker arm which bears against the stem of a valve, which is held in a raised (closed) position by a strong coiled spring – the valve spring.

As the pushrod rises on the cam it pivots the rocker arm, which pushes the valve down (open) against the pressure of its spring. As the cam lobe rotates further, the valve spring acts to close the valve. This is called an overhead-valve (OHV) system.

Some engines have no pushrods; the valves are operated more directly by single or double camshafts in the cylinder head itself – the overhead-cam system.

As there are fewer moving parts between the camshaft and the valve, the overhead-cam (OHC) method is more efficient and produces more power for a given engine capacity than an engine with pushrods, because it can operate at higher speeds. With either system, there must be some free play in the operating gear, so that the valve can still close completely when parts have expanded through heat.

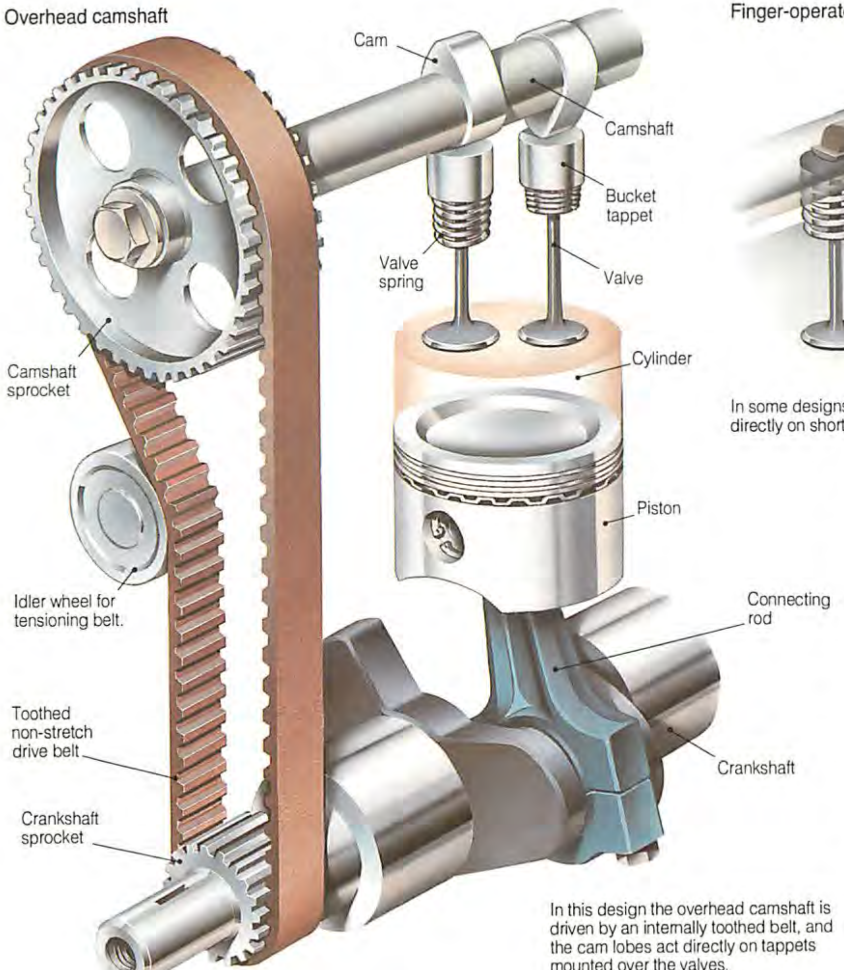
A pre-set gap – tappet clearance – is essential between the valve stem and the rocker arm or cam, to allow for expansion. Tappet clearances vary widely on different cars, and faulty adjustment can have serious effects.

If the gap is too large, the valves open late and close early, reducing power and increasing engine noise.

Too small a clearance prevents the valves from closing properly, with a consequent loss of compression.

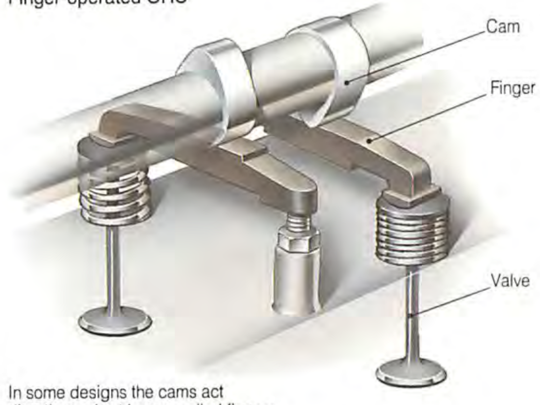
Some engines have self-adjusting tappets, which are hydraulically operated by the engine oil pressure.

Overhead camshaft



In this design the overhead camshaft is driven by an internally toothed belt, and the cam lobes act directly on tappets mounted over the valves.

Finger-operated OHC



In some designs the cams act directly on short levers, called fingers.

Engine with overhead camshaft

An overhead-cam (OHC) engine needs fewer parts to operate the valves. The cams act directly on bucket tappets or on short levers – known as fingers – which in turn act directly on the valve stems.

The system dispenses with the extra weight and mechanical complexity of pushrods and rocker arms.

A long chain is frequently used to drive the camshaft from a sprocket on the crankshaft, but such a long chain tends to 'whip'. The problem is overcome in some designs by fitting intermediate sprockets and two shorter drive chains, kept under tension.

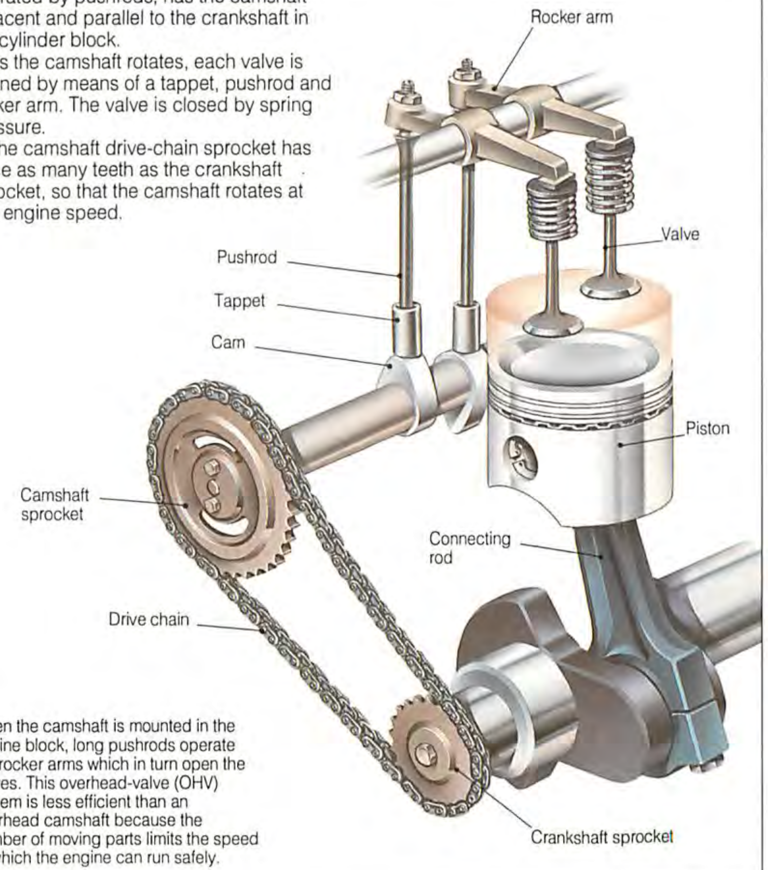
Another method uses a non-stretch, oil-resistant, toothed rubber drive belt, which engages with toothed sprockets on the camshaft and crankshaft.

Camshaft with pushrods

The overhead-valve (OHV) system, operated by pushrods, has the camshaft adjacent and parallel to the crankshaft in the cylinder block.

As the camshaft rotates, each valve is opened by means of a tappet, pushrod and rocker arm. The valve is closed by spring pressure.

The camshaft drive-chain sprocket has twice as many teeth as the crankshaft sprocket, so that the camshaft rotates at half engine speed.



When the camshaft is mounted in the engine block, long pushrods operate the rocker arms which in turn open the valves. This overhead-valve (OHV) system is less efficient than an overhead camshaft because the number of moving parts limits the speed at which the engine can run safely.

The engine – how it drives its ancillary parts

The engine is, in many respects, self-sustaining: it supplies the power that drives a number of ancillary – subordinate – components without which it could not work.

It requires a controlled fuel supply, a timed electric spark to ignite the air-and-fuel mixture, a means of dispersing heat, and lubrication to reduce friction. These ancillary functions are carried out mainly by mechanically driven components. The crankshaft is their main power source, through gears and sprockets or pulley-driven chains or belts.

Starting the engine

A powerful electric motor connected directly to the battery is used to rotate the crankshaft at a speed high enough to initiate the four-stroke cycle and start the engine.

Starting the car, particularly from cold, therefore makes the heaviest demand on the battery, since the starter motor has first to overcome the inertia of the engine. There is also a high demand from electrical equipment such as flashers and lights, so the battery needs constant replenishing in order to maintain its charge of about 12 volts.

Charging the battery

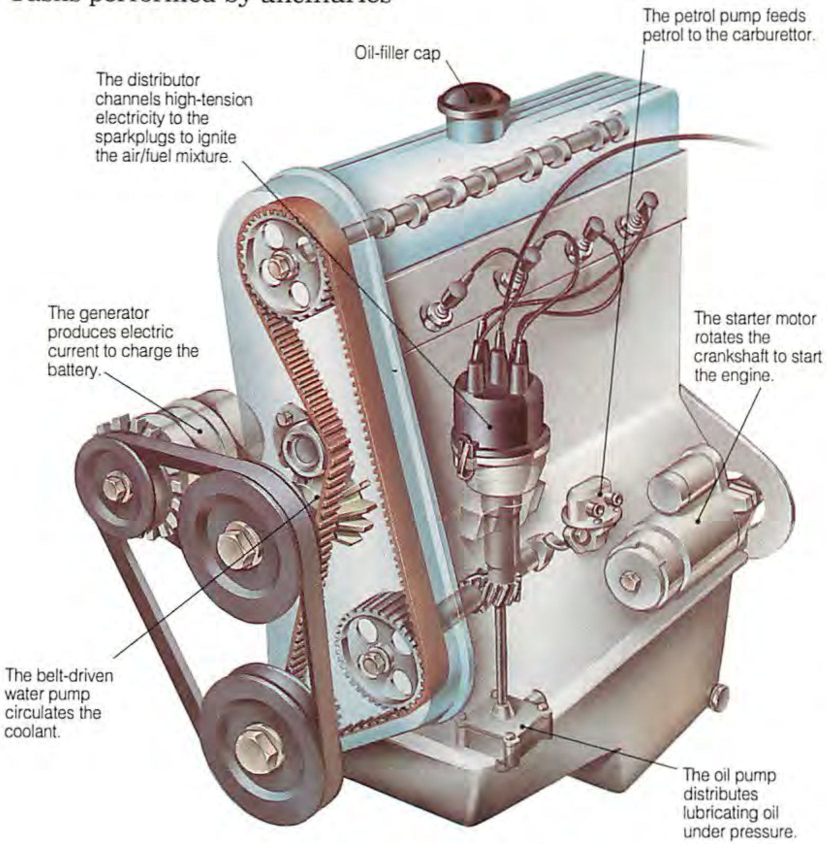
Charging is accomplished by a generator – a dynamo in earlier cars, or an alternator in later ones – driven by the crankshaft. The generator output is controlled by a charging circuit which ensures that the battery receives the correct amount of current necessary to keep it fully charged.

Producing the spark

To produce the timed electric spark needed to ignite the fuel mixture, the low voltage from the battery is boosted to a very high voltage, about 30,000, by the ignition coil – a form of transformer.

The low-tension (LT) voltage passes through a primary winding in the coil and then to the contact-breaker points in the distributor.

Tasks performed by ancillaries



Each time the low-tension-current circuit is interrupted by the opening of the contact-breaker points in the distributor, the electrical surge as the current suddenly collapses induces high-tension (HT) voltage in a secondary winding in the coil.

The distributor then feeds the high-tension voltage to each of the sparkplugs in turn at the correct time. Each sparkplug has two electrodes at its tip, with a gap between them. The high-tension voltage jumps this gap and produces the spark that ignites the air and fuel mixture.

Driving the pumps

The petrol pump that feeds the carburettor is either a mechanical one operated by an off-centre disc – a sort of circular cam – on the engine camshaft, or an electric pump remotely mounted, sometimes close to the petrol tank.

In water-cooled cars, the water pump that circulates water through the cooling passages of the engine is belt-driven from a pulley on the crankshaft.

The oil pump that pressurises oil for engine lubrication works directly from the crankshaft or camshaft.

How the engine is lubricated

Friction between moving metal parts in the engine is minimised by a thin film of oil.

Stored in a reservoir, called the sump, at the bottom of the engine, the oil is sucked into the pump, which sends it under pressure through various feed pipes and channels to the moving parts of the engine and then back to the sump.

The oil is circulated under pressure at a rate of several gallons per minute. The pressure is controlled in the pump by a relief valve; when the pressure is excessive, it leaks some of the oil back to the sump.

Oil forced out of the crankshaft journals is thrown against the cylinder walls. This is known as 'splash lubrication'.

Before reaching the engine, the oil passes through a filter attached to the pump, which removes sludge and potentially abrasive particles such as debris resulting from engine wear.

If the pressure drops – usually through mechanical failure – or if there is an oil deficiency, the moving parts of the engine wear rapidly and eventually seize.

How the oil is pumped

There are two basic types of oil pump – a rotor type and a gear type.

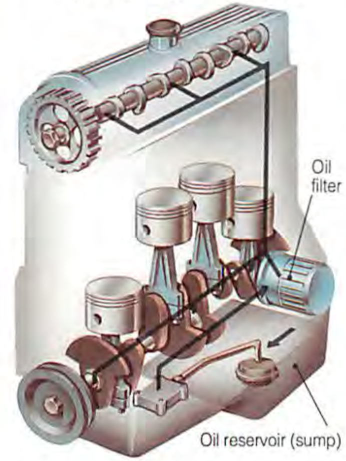
The rotor pump has two multi-lobed rotors – an inner one and an outer one, revolving on different axes. The gear type has two adjacent meshing gears. The pump may be mounted internally or externally.

Oil sucked from the sump is pressurised as it passes through the decreasing gap between the rotor lobes or meshing gears.

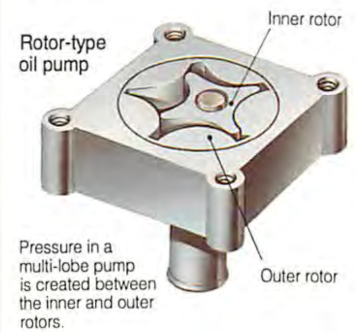
The commonest filter element used to trap the sludge and debris that collects in the sump is made from resin-impregnated, pleated paper.

It cannot be cleaned, and the whole filter should be renewed regularly during routine servicing, to prevent it becoming clogged and so reducing the rate of flow of clean oil.

The lubrication system



Oil from the pump passes through passages in the crankshaft, block and camshaft bearings.



How the electrical system works / 1

The electrical system of a car is a closed circuit with an independent power source – the battery. It operates on a small fraction of the power of a household circuit.

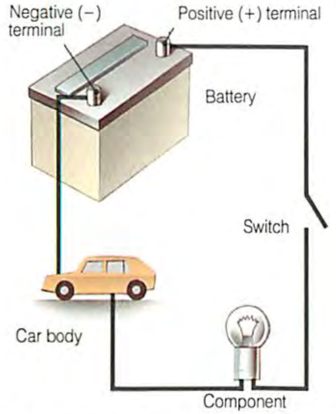
Current flows along a single cable from the battery to the component being powered, and back to the battery through the car's metal body. The body is connected to the earth terminal of the battery by a thick cable.

This type of circuit is called an earth-return system – any part of it connected to the car body is said to be earthed.

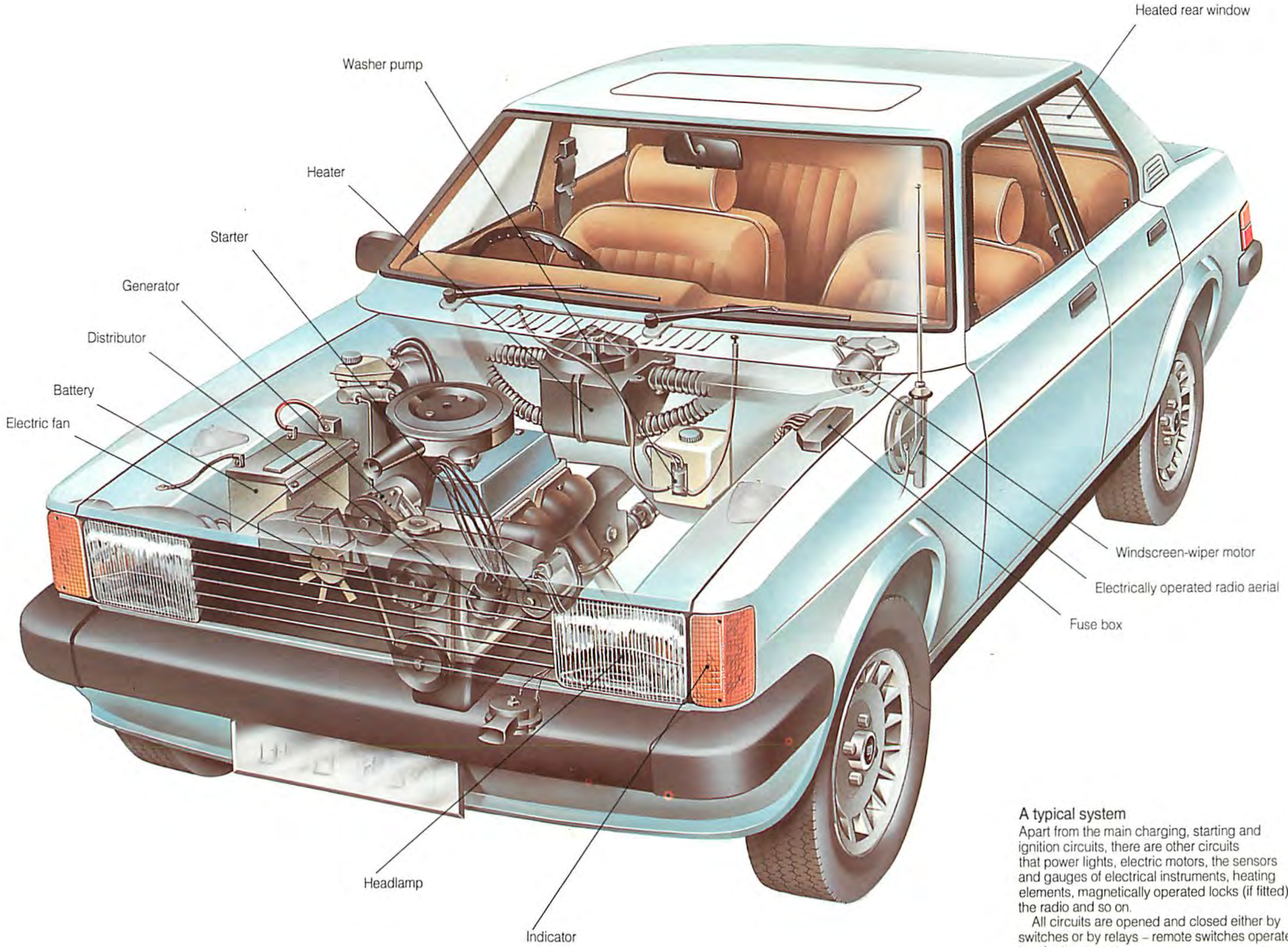
The strength of the current is measured in amperes (amps); the pressure that drives it round the circuit is called voltage (volts). Modern cars have a 12 volt battery. Its capacity is measured in amp/hours. A 56 amp/hour battery should be able to deliver a current of 1 amp for 56 hours, or 2 amps for 28 hours.

If the battery voltage drops, less current flows, and eventually there is not enough to make the components work.

Earth-return system



In a negative (−) earth-return system, the current flows from the positive (+) terminal of the battery to the component being operated. The component is earthed to the car body, which is earthed to the negative (−) terminal of the battery.



A typical system
Apart from the main charging, starting and ignition circuits, there are other circuits that power lights, electric motors, the sensors and gauges of electrical instruments, heating elements, magnetically operated locks (if fitted), the radio and so on.

All circuits are opened and closed either by switches or by relays – remote switches operated by electromagnets.

How the electrical system works / 2

Current, voltage and resistance
The extent to which a wire resists the flow of current is called resistance, and is measured in ohms.

Thin wires conduct less easily than thick ones, because there is less room for the electrons to travel through.

The energy needed to push current through a resistance is transformed into heat. This can be useful, for example in the very thin filament of a light bulb, which glows white hot.

However, a component with a high current consumption must not be connected using wires which are too thin, or the wires will overheat, blow a fuse, or burn out.

All the electrical units of measurement are interrelated: a pressure of 1 volt causes a current of 1 amp to flow through a resistance of 1 ohm. Volts divided by ohms equal amps. For example, a light bulb with a resistance of 3 ohms, in a 12 volt system, consumes 4 amps.

This means it must be connected using wires thick enough to carry 4 amps comfortably.

Often the power consumption of a component will be stated in watts, which are found by multiplying amps and volts. The lamp in the example consumes 48 watts.

Positive and negative polarity
Electricity flows from a battery in one direction only, and some components work only if the flow through them is in the correct direction.

This acceptance of a one-way flow is called polarity. On most cars the negative (–) battery terminal is earthed and the positive (+) one feeds the electrical system.

This is called a negative earth system, and when buying an electrical accessory – a radio, for example – check that it is of a type suitable for your car's system. Fitting a radio with the incorrect polarity will damage the set, but most car radios have an external switch for setting the polarity to suit that of the car. Switch to the correct setting before fitting.

Short circuits and fuses
If the wrong-sized wire is used, or if a wire becomes broken or disconnected, this can cause an accidental short circuit which bypasses the resistance of the component. The current in the wire may become dangerously high and melt the wire or cause a fire.

To guard against this, ancillary circuits have fuses.

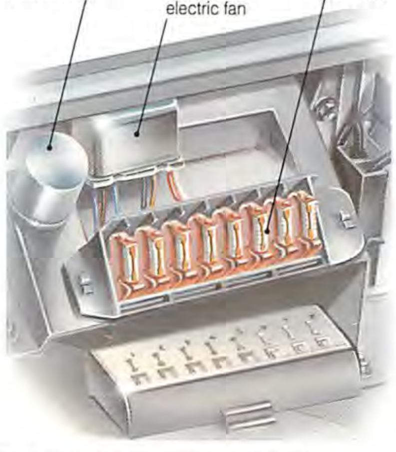
The most common type of fuse is a short length of thin wire enclosed in a heatproof casing – often glass.

The size of the fuse wire is the thinnest that can carry the normal current of the circuit without overheating, and it is rated in amps.

The sudden surge of high current in a short circuit makes the fuse wire melt, or 'blow', breaking the circuit.

When this happens, see if there is a short circuit or a disconnection, then install a new fuse of the correct amperage rating (SHEETS 123–124).

There are many fuses, each protecting a small group of components, so that one blown fuse does not shut down the whole system. Many of the fuses are grouped together in a fuse box, but there may also be line fuses in the wiring.



The fuse box is often located in a cluster of components, as illustrated here. The box is shown with the cover off.

Wires and printed circuits
Wire and cable sizes are classified by the maximum amperage that they can carry safely.

A complex network of wires runs through the car. To avoid confusion, each wire is colour-coded (but only within the car: there is no national or international system of colour-coding).

Most car handbooks and service manuals include a wiring diagram which can be difficult to follow.

The colour-coding, however, is a useful guide to tracing wiring.

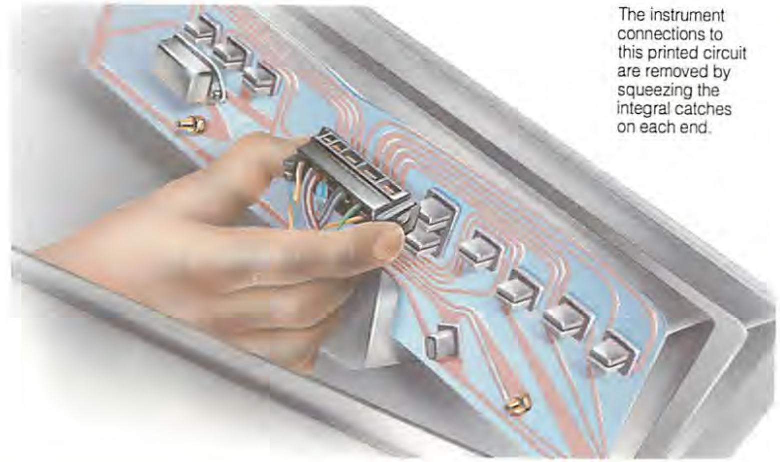
Where wires run side by side they are bound together in a bundle, in a plastic or fabric sheath, to keep them tidy and less difficult to fit.

This bundle of wires stretches over the length of the car, with single wires or small groups of wires emerging where necessary, and is called the wiring loom.

Modern cars often need room for many wires in confined spaces. Some manufacturers now use printed circuits instead of bundles of wires, particularly at the rear of the instrument panel.

Printed circuits are plastic sheets on which copper tracks have been 'printed'. Components are plugged directly into the tracks.

A few modern cars have flexible printed circuits. The copper tracks are printed in ribbons of flexible plastic, which replace the whole wiring system.



The instrument connections to this printed circuit are removed by squeezing the integral catches on each end.

Series and parallel circuits
A circuit usually includes more than one component, such as bulbs in the lighting circuits. It matters whether they are connected in series – one after the other – or in parallel – side by side.

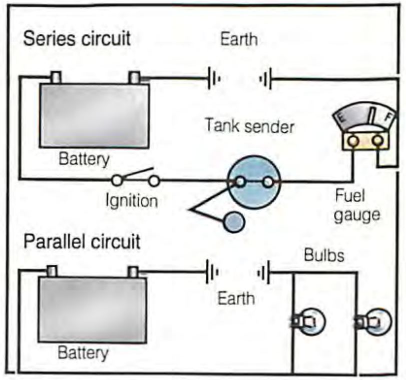
A headlamp bulb, for example, is designed to have a degree of resistance so that it consumes a certain current to glow normally.

But there are at least two headlamps in the circuit. If they were connected in series, electric current would have to go through one headlamp to get to the other.

The current would encounter the resistance twice, and the double resistance would halve the current, so that the bulbs would glow only feebly.

Connecting the bulbs in parallel means that electricity goes through each bulb only once.

Some components must be connected in series. For example, the sender in the fuel tank varies its resistance



according to the amount of fuel in the tank, and 'sends' a small electrical current to the fuel gauge.

The two components are connected in series so that the varying resistance in the sender will affect the position of the needle on the gauge.

Ancillary circuits
The starter motor has its own heavy cable, direct from the battery. The ignition circuit furnishes the high-tension impulses to the sparkplugs; and the charging system includes the generator, which recharges the battery. All the other circuits are called ancillary (subsidiary) circuits.

Most are wired through the ignition switch, so that they work only when the ignition is switched on.

This prevents you accidentally leaving something switched on which might cause the battery to go flat.

The side and tail lights, however, which you may need to leave on when the car is parked, are always wired independently of the ignition switch.

When fitting extra accessories, such as a rear window heater which consumes a heavy current, always wire it through the ignition switch.

Some ancillary components can be operated without the ignition turned on by turning the switch to the 'auxiliary' position. A radio is usually wired through this switch, so that it can be played with the engine off.

How the fuel system works – petrol pumps

A car engine burns a mixture of petrol and air. Petrol is pumped along a pipe from the tank and mixed with air in the carburettor, from which the engine sucks in the mixture.

In the fuel-injection system, used on some engines, the petrol and air are mixed in the inlet manifold.

Keeping the petrol tank safe

For safety, the petrol tank is placed at the opposite end of the car from the engine.

Inside the tank, a float works an electrical sender unit that transmits current to the fuel gauge, signalling how much petrol is in the tank.

The tank has an air vent - usually a pipe or a small hole in the filler cap - to allow air in as the tank empties. Some of the latest systems have a carbon filter, so that fuel fumes do not escape.

Pumping the petrol

A fuel pump draws petrol out of the tank through a pipe to the carburettor.

The pump may be mechanical - worked by the engine - or it may be electric, in which case it is usually next to or even inside the fuel tank.

How a mechanical pump works

A mechanical fuel pump is driven by the camshaft, or by a special shaft driven by the crankshaft. As the shaft turns, a cam passes under a pivoted lever and forces it up at one end.

The other end of the lever, which is linked loosely to a rubber diaphragm forming the floor of a chamber in the pump, goes down and pulls the diaphragm with it.

When the lever pulls the diaphragm down, it creates suction that draws fuel along the fuel pipe into the pump through a one-way valve.

As the revolving cam turns further, so that it no longer presses on the lever, the lever is moved back by a return spring, relaxing its pull on the diaphragm.

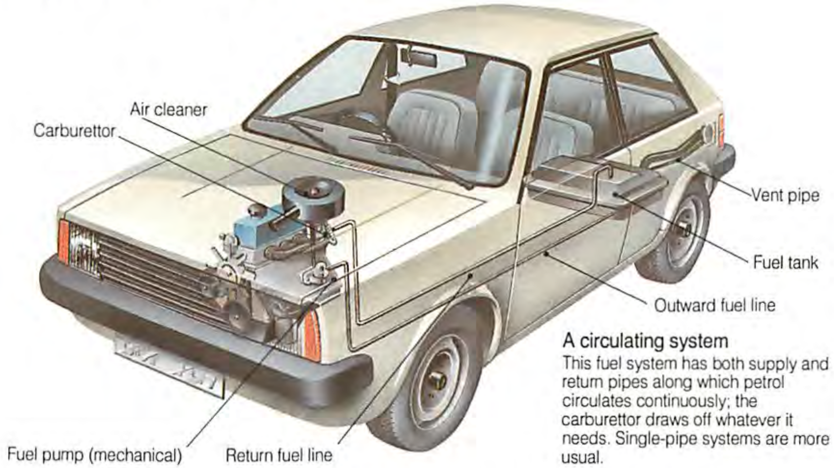
The loosely linked lever does not push the diaphragm up, but there is a return spring that pushes against it.

The diaphragm can move up only by expelling petrol from the chamber. The petrol cannot go back through the first one-way valve, so it goes out through another one leading to the carburettor.

The carburettor admits petrol only as it needs it, through the needle valve in its float chamber (SHEETS 30–31).

While the carburettor is full and the needle valve is closed, no petrol leaves the pump. The diaphragm stays down, and the lever idles up and down.

When the carburettor accepts more petrol, the return spring pushes the diaphragm up and, by taking up the slack in the loose linkage, brings it back into contact with the lever, which again pulls it down to refill the pump chamber.



A circulating system
This fuel system has both supply and return pipes along which petrol circulates continuously; the carburettor draws off whatever it needs. Single-pipe systems are more usual.

How an electric pump works

An electric pump has a similar diaphragm-and-valve arrangement, but instead of the camshaft, a solenoid (an electromagnetic switch) provides the pull on the diaphragm.

The solenoid attracts an iron rod that pulls the diaphragm down, drawing petrol into the chamber.

At the end of its travel the iron rod forces apart a set of contacts, breaking the current to the electromagnet and relaxing the pull on the diaphragm.

When the diaphragm return spring raises the diaphragm, it also pulls the rod away from the contacts; they then close so that the solenoid pulls the rod and diaphragm down again.

Circulating petrol continuously

Most mechanical and electrical systems pump fuel only when the carburettor needs it. An alternative system has a complete circuit of pipes, from the tank to the carburettor and back again. The pump sends petrol continuously round this circuit, from which the carburettor draws petrol as it needs it.

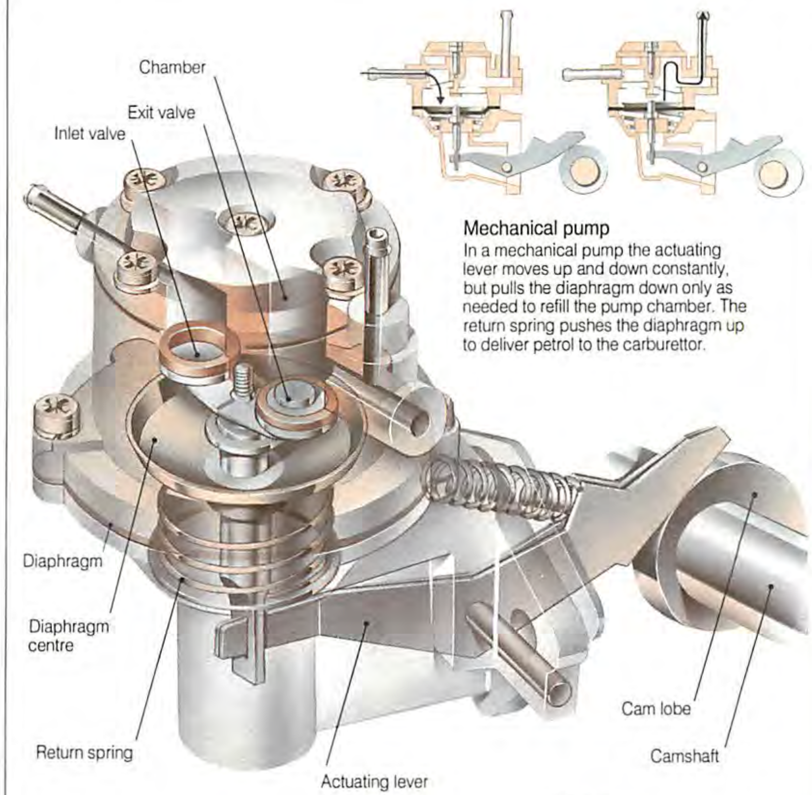
Filtering petrol and air

Both petrol and air are filtered before passing into the carburettor.

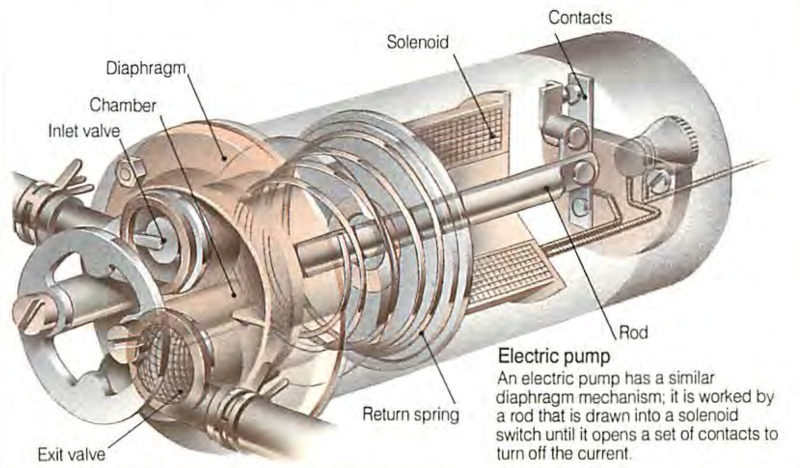
The petrol filter may be a replaceable paper one inside a plastic housing in the fuel line. A pump may include a wire or plastic gauze filter, and sometimes a bowl to catch sediment.

The air cleaner is a box fitted over the carburettor air intake, usually containing a replaceable paper-filter element.

Some older cars are fitted with an oil-soaked wire-gauze element, which needs washing from time to time in petrol or paraffin, and re-oiling.



Mechanical pump
In a mechanical pump the actuating lever moves up and down constantly, but pulls the diaphragm down only as needed to refill the pump chamber. The return spring pushes the diaphragm up to deliver petrol to the carburettor.



Electric pump
An electric pump has a similar diaphragm mechanism; it is worked by a rod that is drawn into a solenoid switch until it opens a set of contacts to turn off the current.

How the fuel system works – variable-jet carburettors

A carburettor mixes fuel and air in the proportions and quantity the engine needs at any time.

It does this by spraying the fuel into the moving air stream through a jet, so that the fuel vaporises and makes an explosive mixture.

The faster an engine runs, the more air it sucks in. The air passes through a narrowed neck inside the carburettor (called a venturi), which speeds up its flow at that point.

As air flows faster its pressure drops, so there is a slight vacuum inside the venturi. The fuel jet opens into the venturi, and the partial vacuum sucks fuel through the jet into the air stream.

The speed of the engine is controlled by a throttle, a movable circular flap linked to the accelerator pedal which partly blocks the venturi to admit variable amounts of air.

There has to be some way of governing the fuel flow through the jet so that the mixture is right – so that the fuel is in the right proportion to the air. The simplest way of doing this is with a variable jet.

The variable-jet carburettor

The fuel jet is partly blocked by a tapered needle, which can be raised progressively to unblock it.

The needle is fixed to a piston, which is free to slide up and down in a chamber above the jet. The top of the chamber is linked to the inlet manifold through a narrow passage.

When the engine is idling, low manifold depression and a light spring causes the piston to sit at the bottom of the chamber, and the needle almost completely blocks the jet. Little fuel flows.

As the throttle opens, air flow to the engine increases. The engine speeds up and sucks in yet more air.

This suction creates a partial vacuum in the inlet manifold, and therefore also in the top of the chamber, which is connected to it.

The vacuum is more powerful than the slight vacuum in the venturi under the piston, so it draws the piston up, unblocking the jet and letting more fuel flow.

A sudden burst of acceleration causes a sudden rush of mixture into the inlet manifold, so that the vacuum there lessens for an instant.

That would allow the piston to fall, closing the jet and weakening the mixture; but the problem is avoided by having an oil-filled damper attached to the piston, which prevents it from moving quickly. Therefore, the mixture does not suddenly become too weak for smooth combustion.

Starting from cold

An engine needs an extra-rich mixture – more petrol, less air – for starting from cold.

On some variable-jet carburettors, this is provided for by the jet being lowered a short way, so that it is less blocked by the needle and dispenses more fuel than usual.

On others, neat fuel is atomised by the rotation of a disc of progressively larger-sized holes.

On a fixed-jet carburettor (SHEET 31) the opposite happens: instead of more petrol being supplied to the carburettor, the air supply is partly blocked off by a choke flap above the throttle.

However, both systems are referred to as 'choke' mechanisms, or cold-start enrichment systems.

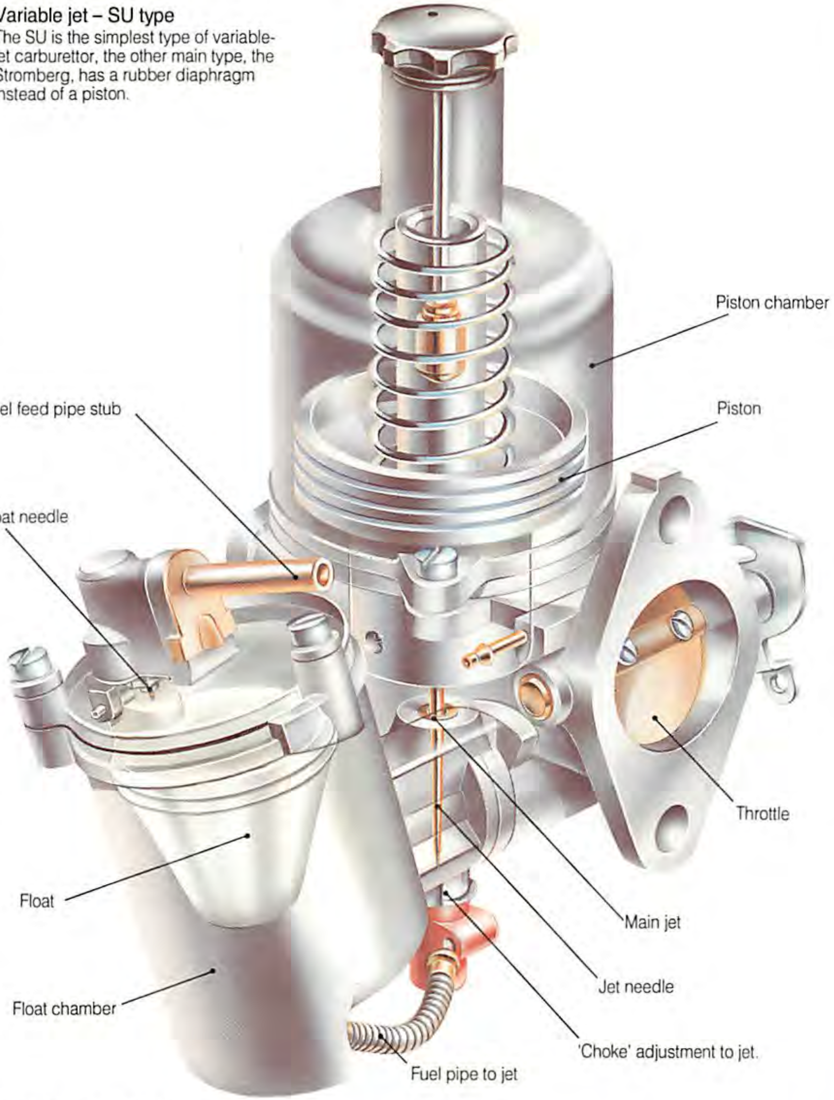
On some cars you have to set the choke yourself before starting, usually by means of a pull-push control in the dashboard, or steering column or floor pan.

Other cars have an automatic choke which uses a bimetallic coiled strip – a strip made of two different metals brazed together – attached to the choke lever.

When the engine is cold, the choke is 'on'. As the engine warms, so does the strip.

It expands with heat, but one of the metals expands more than the other, so that the coiled strip bends and uncurls and progressively moves the choke lever to 'off'.

Variable jet – SU type
The SU is the simplest type of variable-jet carburettor, the other main type, the Stromberg, has a rubber diaphragm instead of a piston.



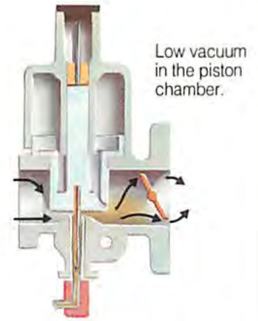
The float chamber

For a carburettor to maintain a steady fuel flow, it needs to draw on a supply of fuel which is always kept at the same level.

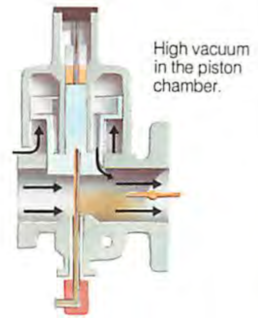
That supply is provided by a float chamber attached to the carburettor. The float chamber contains a pivoted float which bears against a needle valve through which fuel enters the chamber.

When the float drops, the needle valve opens. As the fuel level in the chamber rises so does the float, until, at a pre-set level, the needle closes.

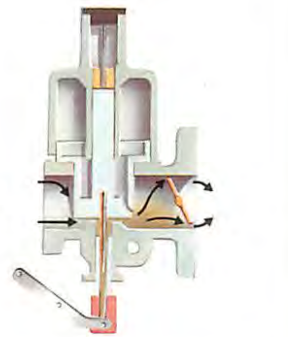
Controlling the mixture



The engine idling with the throttle closed and the needle down in the jet.



At full throttle the throttle butterfly is fully open.



Operating the choke lowers the jet, which allows more fuel to be drawn in.

How the fuel system works – fixed-jet carburettors

The fixed-jet carburettor resembles the simpler variable-jet type (SHEET 30) in having a venturi – a constricted neck – through which air flows on its way to the engine.

The partial vacuum caused by increased air speed through the venturi sucks fuel through a jet to mix with the air.

Similarly, air flow is controlled by a throttle flap linked to the accelerator pedal, to regulate engine speed.

Above the throttle a choke flap partially blocks the air flow, to give a richer mixture for starting. As in all carburettors, a float chamber provides a steady supply of fuel.

Changing from jet to jet

The fixed-jet carburettor has open jets to regulate fuel flow through them. Consequently there must be several jets of different sizes to provide the different amounts of fuel needed at any moment.

When the engine is idling, very little fuel is required. There is not much air flow through the almost closed throttle – too little to draw any fuel through the main jet in the venturi.

But there is a high vacuum underneath the throttle flap, where there is a tiny slow-running jet that forms part of the often complex slow-running (idling) circuit. The vacuum pulls a trickle of fuel through this jet to keep the engine idling.

When the throttle is opened, the air flow suddenly speeds up. An accelerator pump linked to the throttle provides a brief squirt of extra fuel to enrich the mixture temporarily to prevent a flat spot – a momentary hesitation – which is the inability of the carburettor to provide the correct mixture to meet the sudden power demand.

The pressure to supply this squirt comes from a rubber diaphragm open to the air on one side. Normal air pressure, higher than the partial vacuum inside the carburettor, pushes the diaphragm inwards against a piston, which pumps fuel.

Afterwards, the fast air flow sets up a vacuum in the venturi which draws fuel from the main jet. The faster the flow, the more fuel is sucked out. Most carburettors have one or more non-return valves, usually a small ball seating on a conical hole. This prevents wasted flow-back of fuel.

Fine adjustment

By itself the main jet is not accurate enough to supply exactly the right amount of fuel over the full range of engine speeds. It tends to provide too much at high speeds.

There are several devices for avoiding an over-rich mixture. Depending on type, a fixed-jet carburettor may have one or more of them.

In the compensation system, the fuel supply from the float chamber is split in two. One branch leads straight to the main jet. On the other branch, air leaks into the fuel through a small jet. The faster the fuel flow, the more air leaks in and the weaker the final mixture.

In the air-correction system all the fuel goes through the main jet, but instead of going directly into the venturi it first passes through a vertical well containing a perforated emulsion tube.

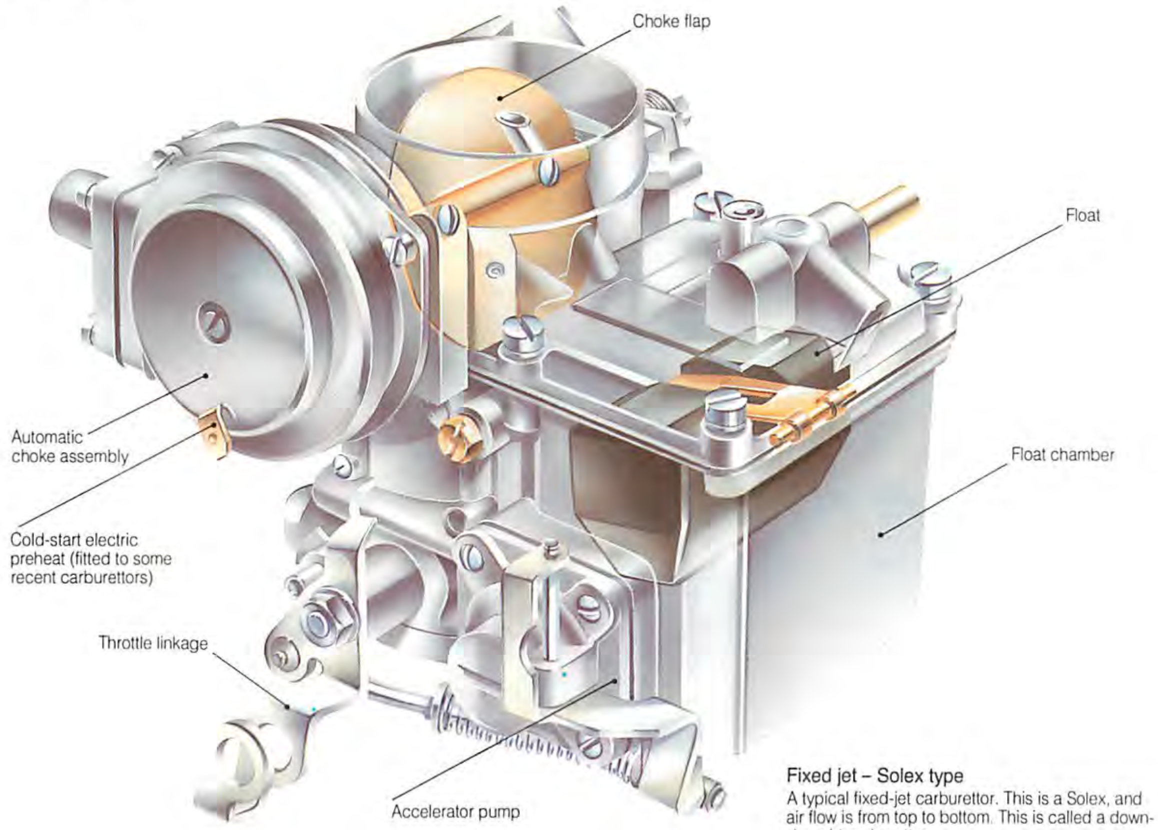
At the top of the emulsion tube is a small jet, open to the air. It allows air to bubble into the fuel through the holes in the tube.

When the car is cruising, engine speed is high but the throttle is not wide open. Some carburettors have an economy device with a rubber diaphragm connected on one side to the venturi and open to the air on the other.

The increased vacuum under the throttle in these conditions makes the diaphragm bulge inwards, opening a valve to blend extra air into the fuel and weaken the mixture slightly.

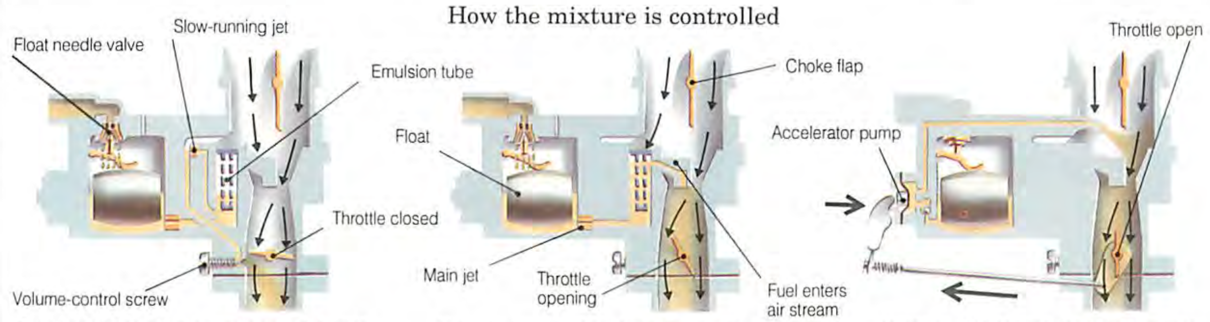
Fuel injection

Some high-performance engines do not have carburettors. Instead, fuel is injected through nozzles directly into the air passages ahead of the cylinder inlet valves.



Fixed jet – Solex type
A typical fixed-jet carburettor. This is a Solex, and air flow is from top to bottom. This is called a down-draught carburettor.

How the mixture is controlled



The engine idling with the throttle closed. A small amount of mixture passes through the gaps on each side of the throttle flap, or butterfly.

The engine running fast at wide throttle. The butterfly is almost vertical, allowing free passage of the mixture.

During sudden acceleration the accelerator pump comes into action and supplies a richer mixture.

How the ignition system works

The purpose of the ignition system is to generate a very high voltage from the car's 12 volt battery, and to send this to each sparkplug in turn, igniting the fuel-air mixture in the engine's combustion chambers.

The coil is the component that produces this high voltage. It is an electromagnetic device that converts the low-tension (LT) current from the battery to high-tension (HT) current each time the distributor contact-breaker points open.

The distributor unit consists of a metal bowl containing a central shaft, which is usually driven directly by the camshaft or, sometimes, by the crankshaft.

The bowl houses the contact-breaker points, rotor arm, and a device for altering the ignition timing. It also carries the distributor cap.

Distributing the current

The distributor cap is made of non-conductive plastic, and the current is fed to its central electrode by the HT lead from the centre of the coil.

Inside the cap there are more electrodes – often called segments – to which the sparkplug leads are connected, one per cylinder.

The rotor arm is fitted on top of the central shaft, and connects to the central electrode by means of a metal spring or spring-loaded brush in the top of the distributor cap.

The current enters the cap through the central electrode, passes to the centre of the rotor arm through the brush, and is distributed to each plug as the rotor arm revolves.

As the rotor arm approaches a segment, the contact-breaker points open and HT current passes through the rotor arm to the appropriate sparkplug lead.

The contact-breaker points are mounted inside the distributor. They act as a switch, in synchronisation with the engine, that cuts off and reconnects the 12 volt low-tension (LT) circuit to the coil.

The points are opened by cams on the central shaft, and are closed again by a spring arm on the moving contact.

With the points closed, LT current flows from the battery to the primary windings in the coil, and then to earth through the points.

When the points open, the magnetic field in the primary winding collapses and high-tension (HT) current is induced in the secondary windings.

This current is transferred to the sparkplugs through the distributor cap.

On a four-cylinder engine there are four cams. With each full rotation of the shaft the points open four times. Six-cylinder engines have six cams and six electrodes in the cap.

The position of the points and the distributor's body in relation to the central shaft can be adjusted manually.

This alters the timing of the spark to obtain an exact setting (see next sheet).

Further changes occur automatically as the engine speed varies according to the throttle opening.

In some modern ignition systems, micro-electronics ensure the optimum ignition timing for all engine speeds and engine load conditions (see next sheet).

Completing the circuit

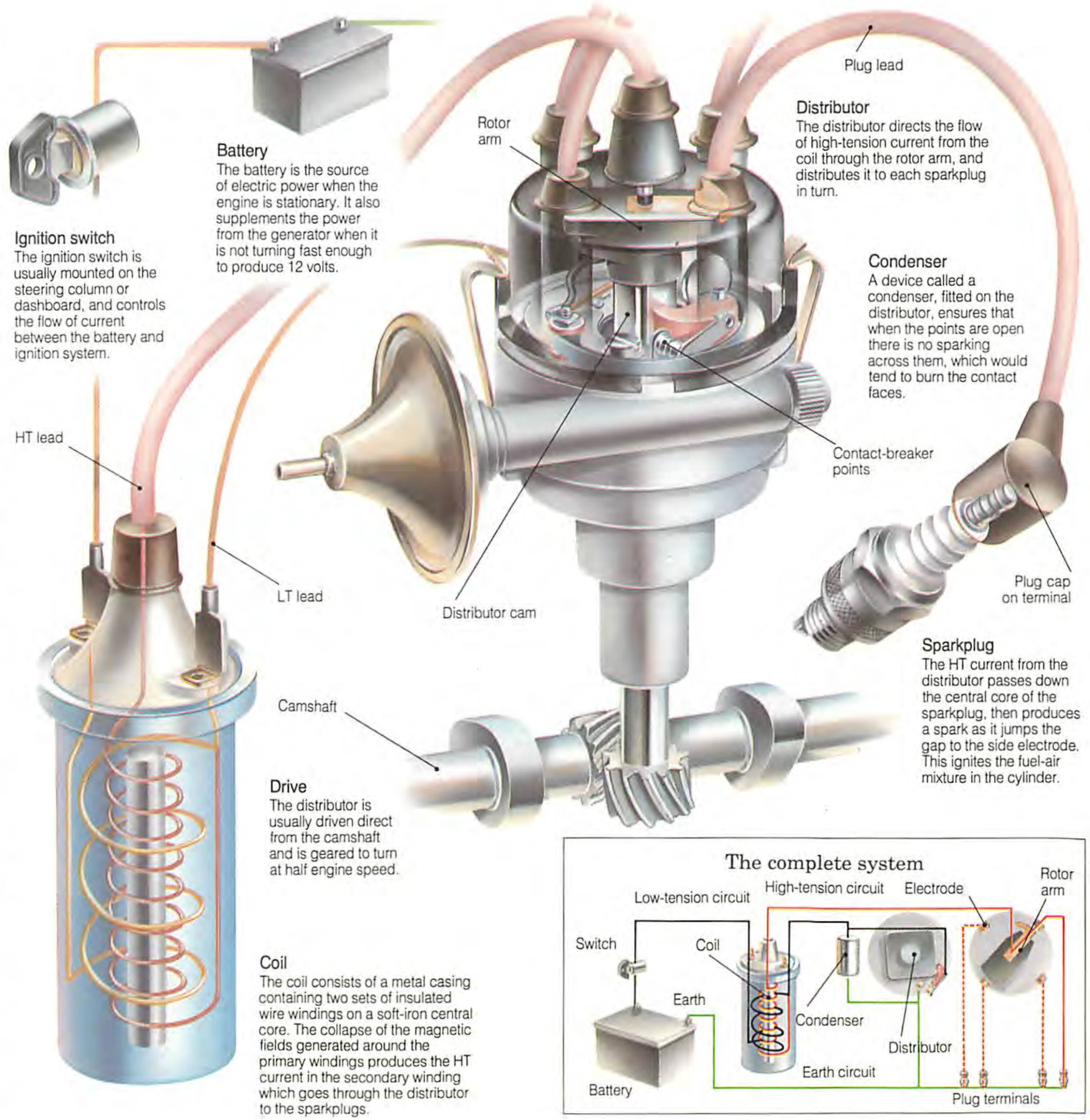
The sparkplugs are screwed into the combustion chambers in the cylinder head.

HT current passes from each segment on the distributor cap down the plug leads to the plug caps.

It then passes down the central electrode, which is insulated along its length, to the nose of the plug.

A side electrode connected to the plug body protrudes just below the central one, with the gap between the two usually set from 0·025 in. (0·6 mm) to 0·035 in. (0·9 mm).

The current sparks across this gap, flows along the side electrode, through the plug body and the engine, then back to the coil, completing the circuit.



How the ignition system works – timing

For an engine to work at its best, the fuel/air mixture in each cylinder must fire just as the piston reaches top dead centre (TDC).

It takes a certain time for the sparkplug to ignite the mixture and for the combustion to build up. This time stays roughly the same no matter how fast the engine is running.

The timing mechanism is set to fire the plug a short time before the TDC. But because the mechanism is worked by the motion of the engine, this time would normally decrease as the engine ran faster, and the plug would fire too late.

So a mechanical device is fitted to advance firing – make it happen earlier – with increasing engine speed.

The load on an engine – whether it is pulling hard or cruising – also affects the timing.

A lightly loaded engine works best if the ignition is advanced an extra amount. A second vacuum-operated device controls this independently of the first.

Centrifugal advance mechanism

The centrifugal advance mechanism responds to engine speed. It is usually in the bottom of the distributor body under the contact-breaker baseplate.

Two steel weights are attached to a revolving plate on the distributor shaft by pivots, and held in the closed position by strong springs.

As the engine speeds up, centrifugal force throws the weights outwards.

They turn on their pivots, twisting the contact-breaker cam forwards so that the points open earlier, and the sparkplug fires earlier as the speed increases.

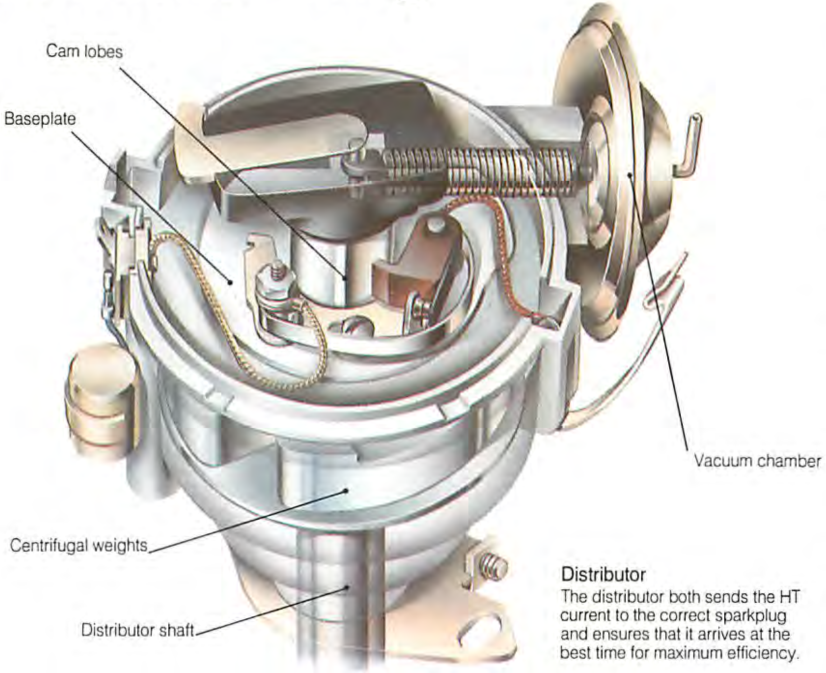
Vacuum advance mechanism

The vacuum advance mechanism responds to the vacuum in the engine inlet manifold, which is caused by the suction of the moving pistons. When the engine is lightly loaded the vacuum increases.

A narrow pipe runs from the manifold to a vacuum chamber on the distributor, inside which there is a flexible diaphragm.

As the vacuum increases, the diaphragm bends, moving a rod connected to its centre which causes the contact-breaker baseplate to swivel slightly. This moves the contact-breaker heel relative to the distributor cam and advances the ignition.

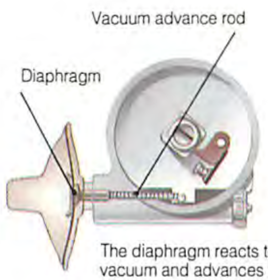
When the engine is under load, vacuum decreases, the diaphragm springs back and the ignition is retarded to suit the changed conditions.



Distributor
The distributor both sends the HT current to the correct sparkplug and ensures that it arrives at the best time for maximum efficiency.

Slow
The centrifugal weights are held in by the springs at low engine speed.

Fast
The centrifugal weights move outwards against the spring tension, advancing the ignition.



The diaphragm reacts to a high vacuum and advances the ignition.

Adjusting the timing

The usual way of adjusting the timing is to slacken the clamping bolt of the distributor and turn the whole unit slightly.

The amount by which the two advance mechanisms change the timing is not adjustable.

Some earlier distributors have a knurled nut on the vacuum advance mechanism, by which you can alter the timing as a whole (not just the action of the mechanism).

How electronic ignition works

Many newer cars have an electronic ignition system which times the spark more precisely than a mechanical system.

It also wears less, so that it is always at peak efficiency, and it overcomes one problem of a mechanical system: at high engine speeds a mechanical system does not work at peak efficiency.

Electronic systems may be of the inductive discharge or capacitive discharge type.

An inductive discharge system is the type usually fitted as original equipment on cars with electronic ignition. It produces high-tension (HT) current in the normal way: by switching low-tension (LT) current off and on in a coil.

In the simplest inductive discharge system, the transistor-assisted contacts (TAC) type, there is also a normal contact breaker.

It carries only a very small current, which is fed to a power transistor which switches on and off the heavier LT current to the coil.

The contact-breaker points are not eroded by the small current, so they stay clean for longer, and the gap seldom needs resetting.

More advanced, fully electronic systems may not have points. Instead, the distributor contains another form of triggering device for the power transistor which relies on electrical pulses instead of a mechanical make-and-break method.

In one type there is an electromagnetic coil and a revolving spiked rotor with one steel spike for each cylinder.

Every time a spike moves past the coil it creates a small voltage which triggers the transistor.

Some other types may have optical or magnetic triggers – they all perform the same function.

A capacitive discharge (CD) system – used in some do-it-yourself kits – produces HT current in the coil by sending a large pulse from a capacitor through the primary winding.

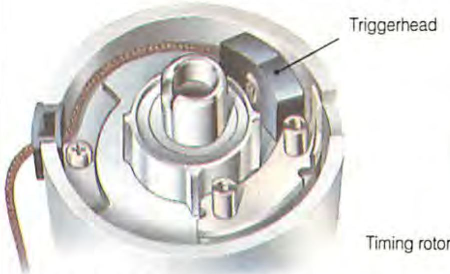
The capacitor is an electrical storage device which can be charged and discharged very rapidly.

The secondary windings of the coil produce HT current both at the moment when the LT current in the primary windings is switched on, and at the moment it is switched off.

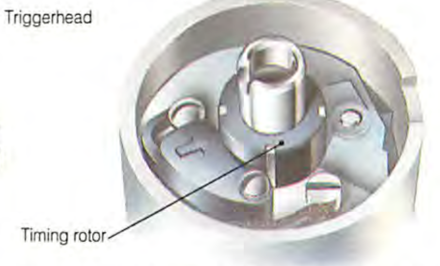
Because a capacitor can give a very large pulse very fast, there is always a strong spark, irrespective of the speed of the engine.

The timing in this system may again be fully electronic or it may use the contact-breaker points.

Two types of triggering mechanism



In this electronic ignition system, steel ridges on a rotor create a small voltage as they pass through the magnetic field of the triggerhead.



Magnetic strips embedded in the rotor create the voltage in this system each time they are opposite the triggerhead, which triggers a power transistor.

How the steering system works

The steering system converts the rotation of the steering wheel into a swivelling movement of the road wheels in such a way that the steering-wheel rim turns a long way to move the road wheels a short way.

The system allows a driver to use only light forces to steer a heavy car. The rim of a 15 in. (380 mm) diameter steering wheel moving four turns from full left lock to full right lock travels nearly 16 ft (5 m), while the edge of a road wheel moves a distance of only slightly more than 12 in. (300 mm).

If the driver swivelled the road wheel directly, he or she would have to push nearly 16 times as hard.

The steering effort passes to the wheels through a system of pivoted joints. These are designed to allow the wheels to move up and down with the suspension without changing the steering angle.

They also ensure that when cornering, the inner front wheel – which has to travel round a tighter curve than the outer one – becomes more sharply angled.

The joints must be adjusted very precisely, and even a little looseness in them makes the steering dangerously sloppy and inaccurate.

There are two steering systems in common use – the rack and pinion and the steering box.

On large cars, either system may be power assisted to reduce further the effort needed to move it, especially when the car is moving slowly.

Power-assisted steering

On a heavy car, either the steering is heavy or it is inconveniently low geared – the steering wheel requiring many turns from lock to lock.

Heavy gearing can be troublesome when parking in confined spaces. Power-assisted steering overcomes the problem. The engine drives a pump that supplies oil under high pressure to the rack or the steering box.

Valves in the steering rack or box open whenever the driver turns the wheel, allowing oil into the cylinder.

The oil works a piston that helps to push the steering in the appropriate direction.

As soon as the driver stops turning the wheel, the valve shuts and the pushing action of the piston stops.

The power only assists the steering – the steering wheel is still linked to the road wheels in the usual way.

So if the power fails, the driver can still steer but the steering becomes much heavier.

The rack-and-pinion system

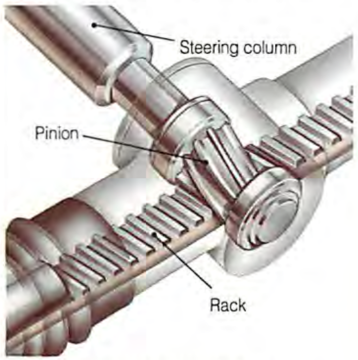
At the base of the steering column there is a small pinion (gear wheel) inside a housing. Its teeth mesh with a straight row of teeth on a rack – a long transverse bar.

Turning the pinion makes the rack move from side to side. The ends of the rack are coupled to the road wheels by track rods.

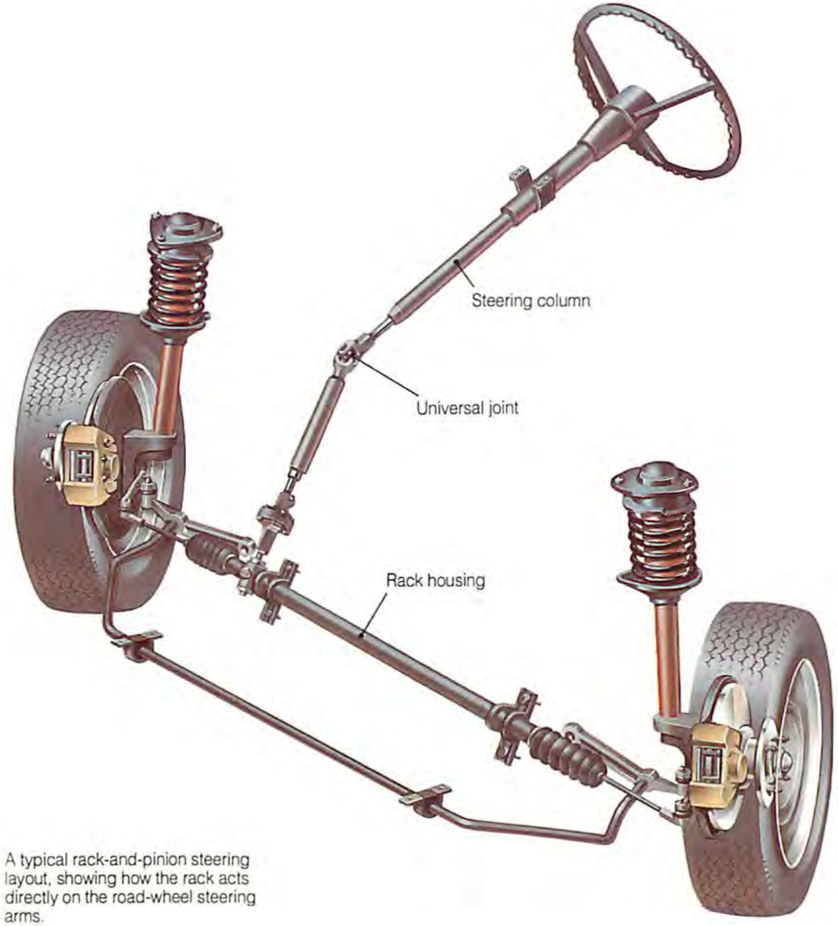
This system is simple, with few moving parts to become worn or displaced, so its action is precise.

A universal joint in the steering column allows it to connect with the rack without angling the steering wheel awkwardly sideways.

Rack-and-pinion gear



The pinion is closely meshed with the rack, so that there is no backlash in the gears. This gives very precise steering.



A typical rack-and-pinion steering layout, showing how the rack acts directly on the road-wheel steering arms.

The steering-box system

At the base of the steering column there is a worm gear inside a box. A worm is a threaded cylinder like a short bolt. Imagine turning a bolt while holding a nut on it; the nut would move along the bolt. In the same way, turning the worm moves anything fitted into its thread.

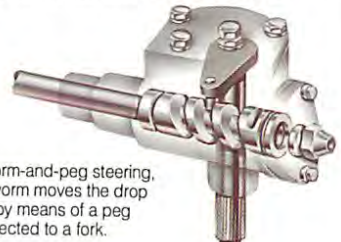
Depending on the design, the moving part may be a sector (like a slice of gear wheel), a peg or a roller connected to a fork, or a large nut.

The nut system has hardened balls running inside the thread between the worm and nut. As the nut moves, the balls roll out into a tube that takes them back to the start; it is called a recirculating-ball system.

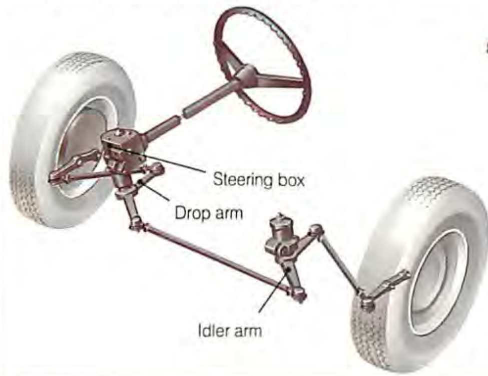
The worm moves a drop arm linked by a track rod to a steering arm that moves the nearest front wheel.

A central track rod reaches to the other side of the car, where it is linked to the other front wheel by another track rod and steering arm. A pivoted idler arm holds the far end of the central track rod level. Arm layouts vary.

The steering-box system has many moving parts, so is less precise than the rack system, there being more room for wear and displacement.



In worm-and-peg steering, the worm moves the drop arm by means of a peg connected to a fork.



In recirculating-ball steering, the thread between the worm and nut is filled with balls.

How the suspension works / 1

There are various ways of attaching the wheels of the car so that they can move up and down on their springs and dampers, and do so with as little change as possible in the distance between adjacent wheels or in the near-vertical angle of the tyres to the road.

The front wheels must be free to pivot on their steering swivels. The driven wheels, whether front or rear, must also be free to rotate with the drive shafts.

Non-independent suspension

A rear-wheel-drive car often has a live axle, a tube containing both the drive shafts (half shafts) and the differential gears. A four-wheel-drive car may have a live front axle as well.

A dead axle – a rigid beam – is now used at the front on vans and trucks only. Some front-wheel-drive cars have a dead rear axle.

A rigid axle will have springs and links to prevent sideways movement.

Independent suspension

Instead of sharing a common axle, each wheel on a car with independent suspension is independently attached to the body or subframe. Different spring combinations may be used.

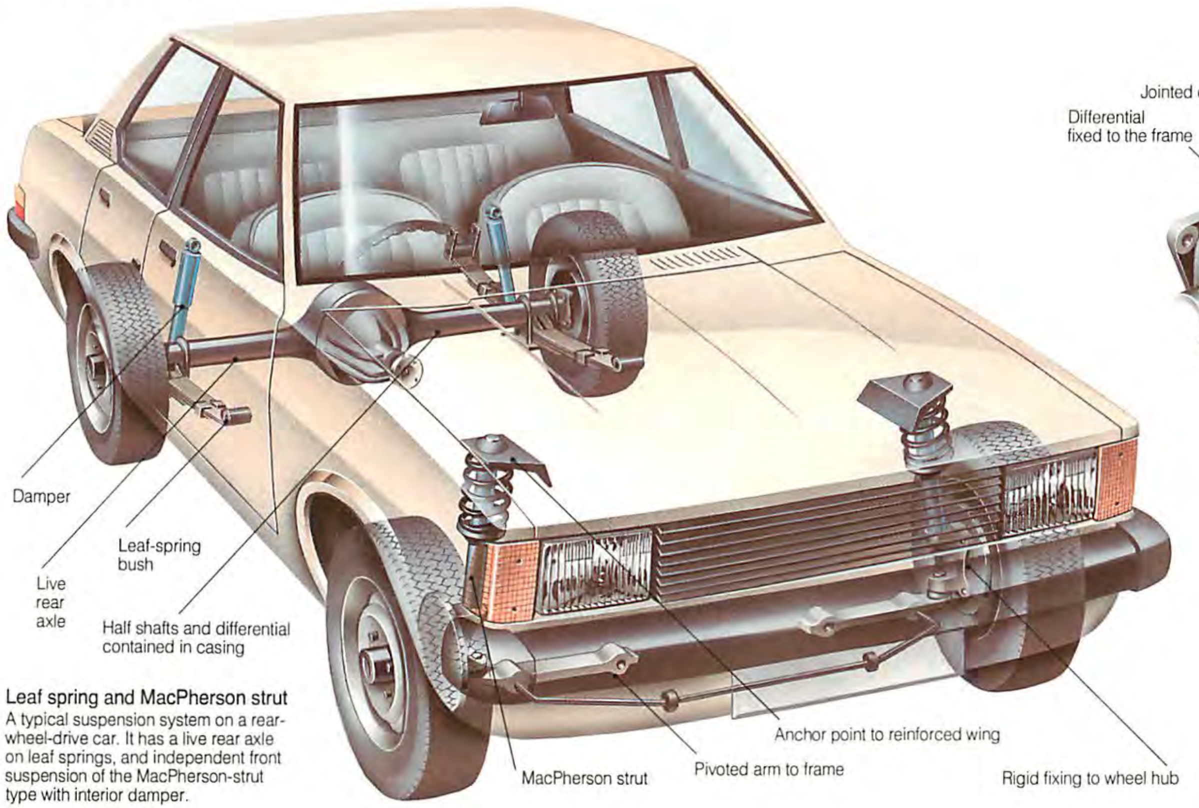
When driven wheels are independently suspended, the differential is fixed to the frame and drives the wheels by jointed drive shafts.

There are five types of suspension system in common use.

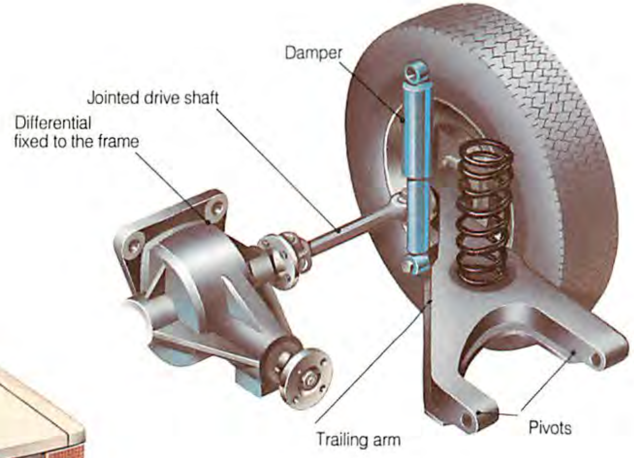
Double wishbones are used mostly at the front. There are two wishbones, one above the other, to keep the wheel upright as it rises and falls.

MacPherson-strut suspension can be used at both front and rear. The wheel hub is fixed rigidly to an upright, telescopic, tubular strut which has its top end anchored to the frame or to a reinforced wing.

On front wheels, the whole strut swivels to allow steering. Pivoted arms extend inward and forward to the frame in order to keep the wheel upright and resist accelerating and braking forces.



Leaf spring and MacPherson strut
A typical suspension system on a rear-wheel-drive car. It has a live rear axle on leaf springs, and independent front suspension of the MacPherson-strut type with interior damper.



Trailing-arm suspension
A trailing-arm suspension on a rear-wheel-drive car. The arm is attached to the rear wheel hub and broadens into a V whose two arms extend forward to pivot on the frame. The differential is fixed to the frame and the drive shafts have universal joints.

A trailing arm is attached to the wheel hub at one end, and extends forward to a pivot on the frame.

The arm may be broadened into a V shape with two pivots, either side by side or with the inner pivot slightly behind the front one – a semi-trailing arm. Trailing arms are usually found at the rear only.

A leading arm, used only at the front, is the opposite of a trailing arm, with the wheel in front of the pivot.

Swing axles may be at the front or rear. The system is like a beam axle cut in half and attached to pivots on the frame.

Usually the half-axle is broadened into a V with front and rear pivots to keep it from twisting.

Anti-roll bars

To restrain cars from rolling – leaning over on corners – an anti-roll bar is used, often at the front, sometimes at the back and sometimes at both front and back.

It is a torsion bar crossing the car through two pivots on opposite sides of the frame.

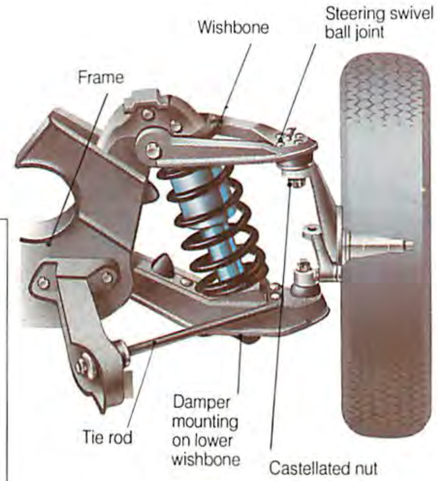
Outside the pivots the bar bends back and one end is attached to each wheel, usually through one or two flexible rubber bushes.

When one wheel moves up it pulls up one end of the bar and the other end pulls up the other wheel, keeping the car level.

Limited roll is allowed by the twisting of the bar.

Anti-roll bar

Pivots allow the bar to twist, but to a limited degree so that rolling is controlled.



Wishbone suspension
A double-wishbone suspension. Wishbones are fitted at their outer ends to the top and bottom of the steering swivel member. The two forks of each wishbone extend inward to pivot on the frame. A tie rod – a steadying bar – is connected between the frame and the lower wishbone.

How the suspension works / 2

The suspension system affects both the driver's control of the car and the comfort of the occupants. The springs allow the wheels to move up to absorb bumps in the road and reduce jolting, while the dampers prevent bouncing up and down. Various mechanical links keep the wheels in line.

Types of spring

Most cars have steel springs, and the oldest type is the leaf spring. The topmost and longest strip, the master leaf, is curled at each end into an eye by which it is connected to the frame. The leaves below are progressively shorter and less curved.

As the spring deflects, it flattens, causing the second leaf to touch the master leaf, then the third to touch the second. The spring thus becomes progressively stiffer. Such a spring gives a smoother ride than a stiff, plain single leaf could.

In some cars the multi-leaf spring has been replaced by a special single leaf that is tapered in section and has progressive stiffness as it is deflected.

A coil spring is simply a spiral of resilient steel rod. It is stretched or compressed by the vertical movement of the wheels.

The torsion bar is a length of spring steel with splined or square ends. One splined end is fixed to a lever arm that forms part of the suspension. The bar rotates as the lever arm moves up and down.

The other splined end is fixed to the frame. The splines stop the bar turning in its fixings. Instead, the bar has to twist as the suspension deflects.

In all forms of steel spring, the forces set up by road shocks are stored by the spring deflection rather than passed on to the passengers. The forces are then released gradually to restore the car to a level ride.

Rubber springs can perform the same function, but they do not store as much energy and are therefore used on light vehicles only.

A form of hydraulic suspension can be combined with rubber springs to refine the system. Up-and-down movement of the wheel pumps fluid from one chamber to another through a damper valve. Each chamber has a flexible diaphragm with compressed gas on the other side of it.

The gas is compressed further as fluid comes into the chamber through the valve. In effect the gas is acting as a pneumatic spring.

There is usually a link tube through which some of the fluid pumped out of a front-wheel chamber travels to the rear wheel on the same side to equalise the suspension.

Citröen hydraulic suspension can be pumped up and down to raise or lower the car to a desired height.

Dampers

Springs deflect as the car goes over a bump, then bounce back. The car would continue to bounce up and down if the energy stored in the springs were not dissipated in some way.

Dampers – commonly called shock absorbers – perform this function. A damper has a piston which moves inside a sealed, oil-filled cylinder with the up-and-down movement of the wheel.

There are narrow control passages and one-way valves in the piston, which allow oil to flow through it from one chamber to another – but only very slowly.

This action slows down the spring oscillations and returns the car to a level ride.

There are three types of damper. Telescopic dampers look like telescopes and shorten in the same way. One end is bolted to the axle, the other to the body.

Strut inserts are similar, but are designed to fit inside a MacPherson strut (SHEETS 244–245).

Lever-arm dampers resemble hydraulic door closers. The damper, which contains one or two pistons, is fixed to the car body or frame, and a pivoted lever extends from it to the axle.

Some cars have dampers that contain both oil and gas. These act more efficiently than oil-filled dampers.

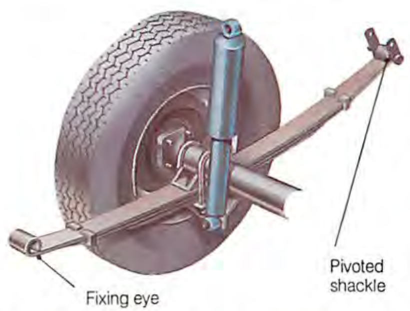
Hydraulic suspension
Hydraulic suspension combines rubber springs with a damper system linking the front and rear wheel on the same side of the car.

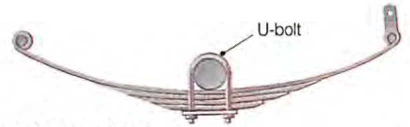
As the front wheel rises over a bump, some of the fluid from its suspension unit (known as a displacer unit) flows to the rear-wheel unit and raises it, so tending to keep the car level.

In each of the displacer units, the fluid passes through a two-way valve, which provides the damping effect.

Once the rear wheel has passed over the bump, the fluid returns to the front displacer unit and the original level is restored.

Three main types of spring

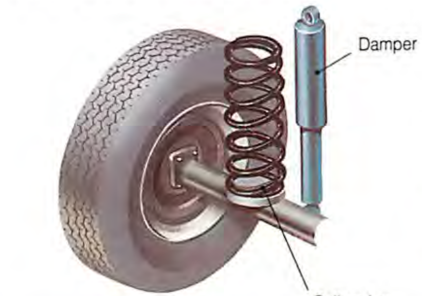




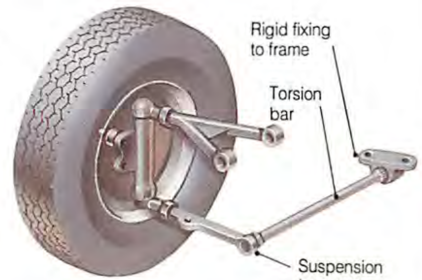
Leaf spring at rest

Leaf spring under load

A leaf spring is fixed to the axle by U-bolts that clamp the centre of the stack of steel strips. As the spring deflects, its leaves flatten, make greater contact with one another and stiffen the spring. As the spring flattens it lengthens, so one end has a pivoted shackle.

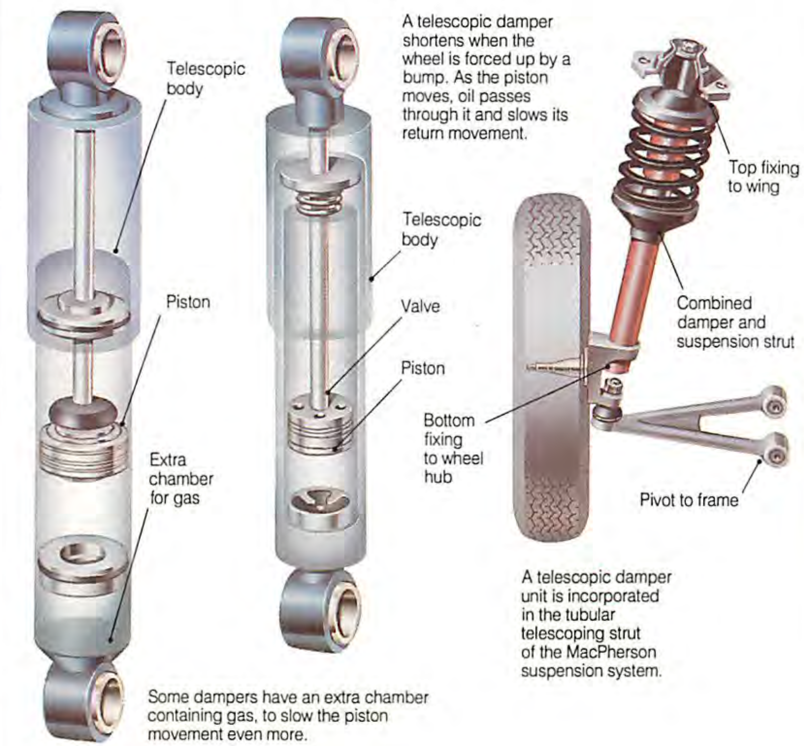


A coil spring is made of resilient steel rod. It extends as the wheel moves down and compresses as the wheel moves up, so the car body remains reasonably level.



A torsion bar is of spring steel with one end rigidly fixed to the frame. The bar twists as the other end rotates with movements of the suspension lever arm.

Various types of damper



A telescopic damper shortens when the wheel is forced up by a bump. As the piston moves, oil passes through it and slows its return movement.

Some dampers have an extra chamber containing gas, to slow the piston movement even more.

A telescopic damper unit is incorporated in the tubular telescoping strut of the MacPherson suspension system.

How the transmission works

Driving through a propeller shaft

In a front-engined rear-wheel-drive car, power is transmitted from the engine through the clutch and the gearbox to the rear axle by means of a tubular propeller shaft.

The rear axle must be able to move up and down on the suspension according to variations of the road surface.

The movement causes the angle of the propeller shaft, and the distance between the gearbox and the rear axle, to change constantly.

To allow for the constant movement, splines on the front end of the propeller shaft slide in and out of the gearbox as the distance changes; the shaft also has universal joints at each end, and sometimes in the middle.

The universal joints allow the propeller shaft to be flexible, while constantly transmitting power.

The last part of the transmission is the final drive, which incorporates the differential and is sometimes called the differential.

The differential has three functions: to turn the direction of drive through 90 degrees to the rear wheels; to allow either rear wheel to turn faster than the other when cornering; and to effect a final gear reduction.

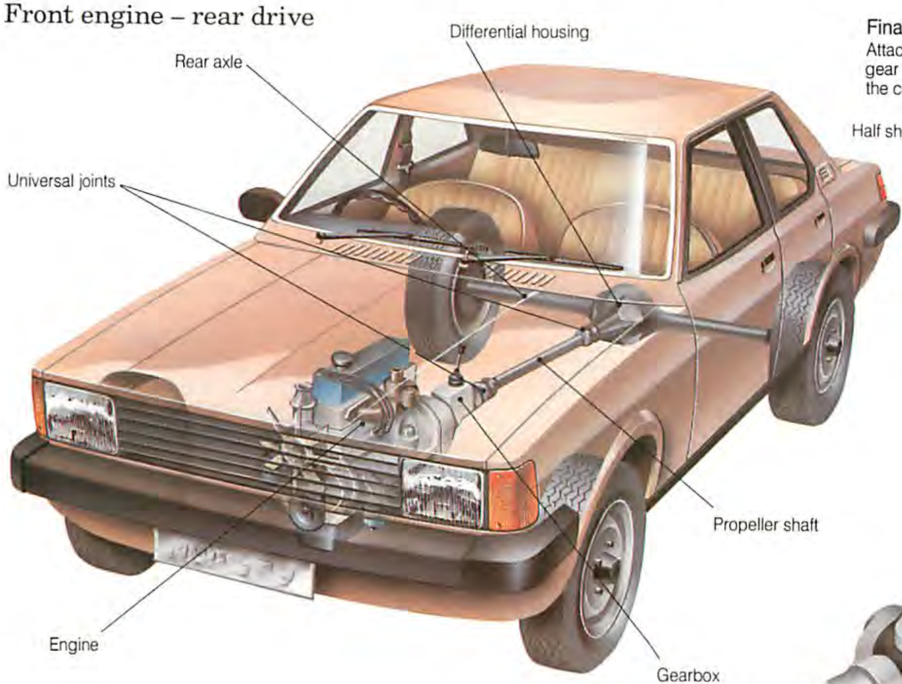
A pinion gear inside the differential is driven by the propeller shaft and has its gears bevelled – cut at an angle. It meshes with a bevelled crown wheel so that the two gears form a 90 degree angle.

The crown wheel usually has about four times as many teeth as the pinion gear, causing the wheels to turn at a quarter the propeller-shaft speed.

The drive is transmitted from the differential to the rear wheels by means of half shafts, or drive shafts.

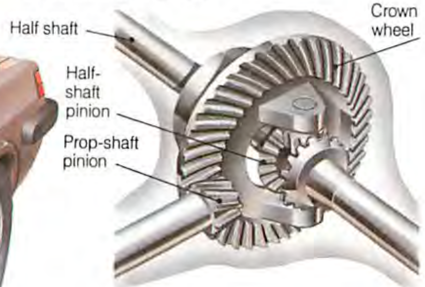
At the differential end of each half shaft, a bevelled pinion gear is connected to the crown wheel by means of an intermediate set of bevel pinions.

Front engine – rear drive



The engine and the gearbox are bolted together, with the clutch between them. The engine is rigidly mounted, but the propeller shaft must be flexible to allow for movement of the back axle.

Final drive
Attached to the propeller shaft is a pinion gear that enters the differential housing in the centre of the rear axle.



The differential
Bevelled pinion gears inside the differential turn with the crown wheel and drive the half shafts to the rear wheels, usually both at the same speed. During cornering, they allow one road wheel to turn faster than the other.

Universal joint
The commonest type of universal joint, the Hooke joint, uses a cross-shaped 'spider' across the axis of the drive shaft. The 'spider' runs on needle-roller bearings to minimise friction.

Driving through the front wheels

Front-wheel-drive cars use the same transmission principles as rear-wheel-drive cars, but the mechanical components vary in design according to the engine and gearbox layout.

Transverse engines are normally mounted directly above the gearbox, and power is transmitted through the clutch to the gearbox by a train of gears.

In-line engines are mated directly to the gearbox, and drive passes through the clutch in the normal manner.

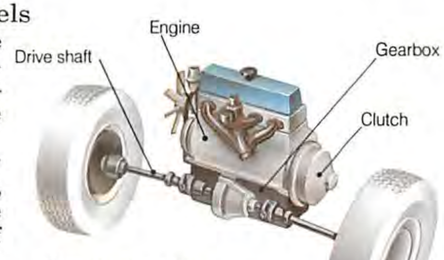
In both cases, drive passes from the gearbox to a final-drive unit.

In a transverse-mounted engine, the final-drive unit is usually located in the gearbox. In an in-line engine, it is usually mounted between the engine and the gearbox.

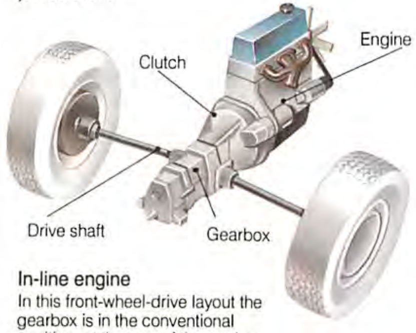
Power is taken from the final-drive unit to the wheels by short drive shafts. To cope with suspension and steering movement in the wheels, the drive shafts use a highly developed type of universal joint called a constant-velocity (CV) joint.

A CV joint uses grooves with steel ball bearings in them instead of the 'spider' found in a universal joint, and transmits power at a constant speed, regardless of the angle and the distance between the final-drive unit and the wheels.

Some cars, such as earlier Minis, also have drive-shaft couplings which are 'spider' joints, and do the same job as universal joints in rear-wheel-drive cars, allowing up-and-down movement of the suspension. They are usually made of rubber bonded to metal.



Transverse engine
The gearbox is built into the crankcase, and drive is transmitted to the front wheels by universally jointed shafts.



In-line engine
In this front-wheel-drive layout the gearbox is in the conventional position, at the rear of the engine.

Constant-velocity joint
The joint is designed to cope simultaneously with drive and steering action on front-wheel-drive cars.

Rear engine driving rear wheels

Some cars, such as VW Beetles and smaller Fiats, have rear-mounted engines and gearboxes, driving the rear wheels.

Power is transmitted through the clutch to the gearbox, passing to the wheels through drive shafts.

The layout is similar to some front-wheel-drive cars, except that no allowance need be made for steering movement of the wheels.

Sometimes the shafts are connected to the flanges at the gearbox by 'doughnut' couplings.

The shafts and flanges are bolted on either side of the couplings, and drive is transmitted through the flexible rubber.

How the transmission works – the clutch

The first stage in the transmission of a car with a manual gearbox is the clutch.

It transmits engine power to the gearbox, and allows transmission to be interrupted while a gear is selected to move off from a stationary position, or when gears are changed while the car is moving.

Most cars use a friction clutch operated either by fluid (hydraulic) or, more commonly, by a cable.

When a car is moving under power, the clutch is engaged. A pressure plate bolted to the flywheel exerts constant force, by means of a diaphragm spring, on the driven plate.

Earlier cars have a series of coil springs at the back of the pressure plate, instead of a diaphragm spring.

The driven (or friction) plate runs on a splined input shaft, through which the power is transmitted to the gearbox. The plate has friction linings, similar to brake linings, on both its faces. This allows the drive to be taken up smoothly when the clutch is engaged.

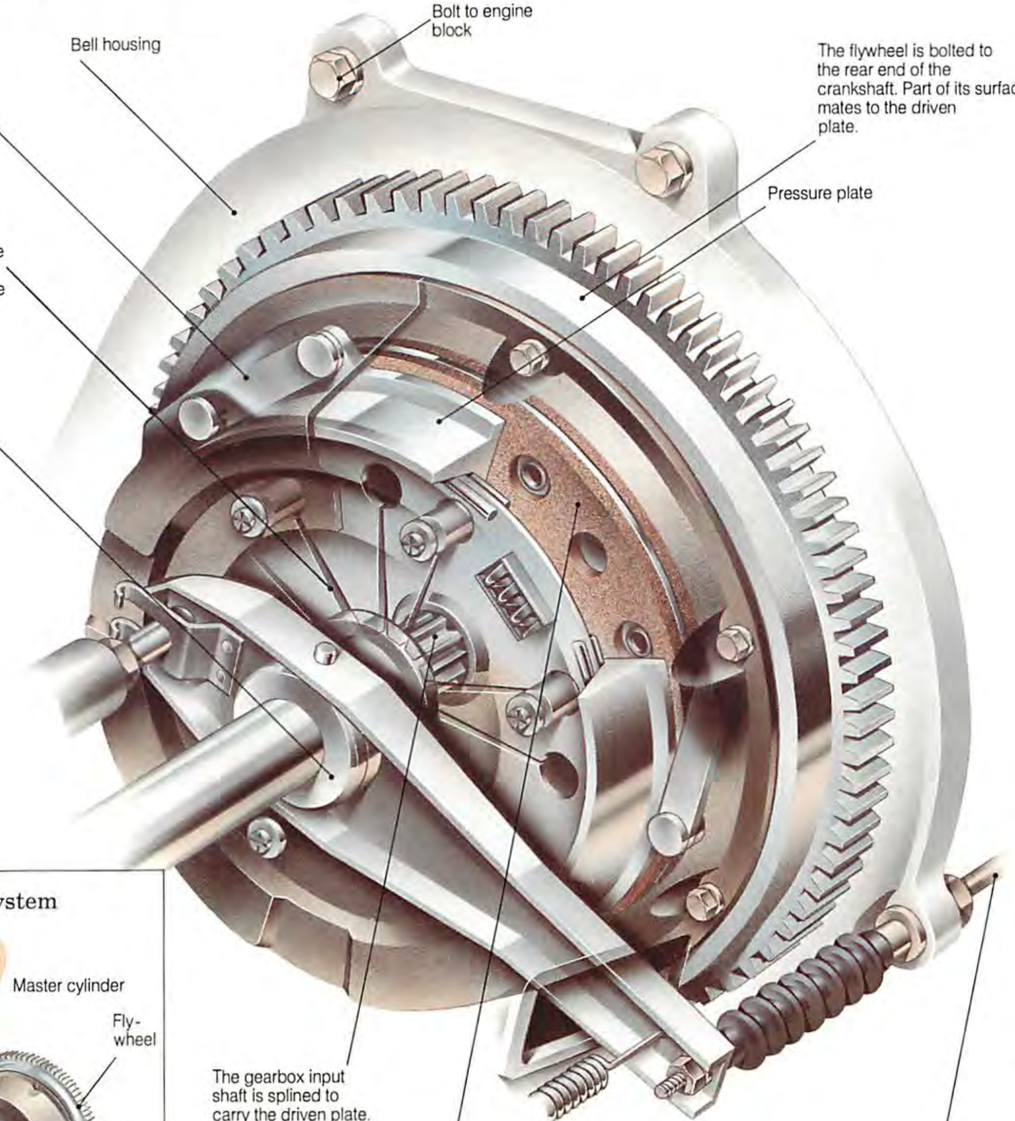
When the clutch is disengaged (pedal depressed), an arm pushes a release bearing against the centre of the diaphragm spring which releases the clamping pressure.

The outer part of the pressure plate, which has a large friction surface, then no longer clamps the driven plate to the flywheel, so the transmission of power is interrupted and gears can be changed.

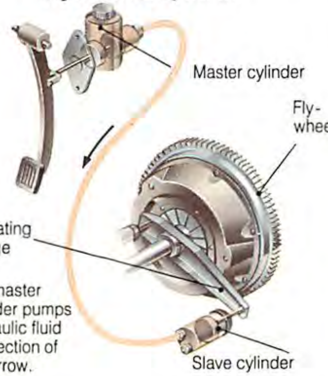
When the clutch pedal is released, the thrust bearing is withdrawn and the diaphragm-spring load once again clamps the driven plate to the flywheel to resume the transmission of power.

Some cars have a hydraulically operated clutch. Pressure on the clutch pedal inside the car activates a piston in a master cylinder, which transmits the pressure through a fluid-filled pipe to a slave cylinder mounted on the clutch housing.

The slave-cylinder piston is connected to the clutch release arm.



Hydraulic system

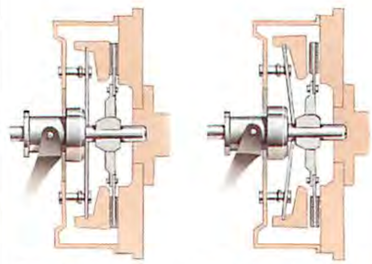


The diaphragm spring

Most modern cars use a diaphragm spring to exert pressure on the driven plate.

The clutch is shown engaged (below left) with the release bearing away from the diaphragm.

When the release bearing is pushed against the centre of the spring (below right), pressure is interrupted and the driven plate is freed from the flywheel.



Clutch engaged. The diaphragm spring is holding the driven plate.

Clutch disengaged. The release bearing has depressed the diaphragm spring.

Parts of the clutch

The modern clutch has four main components: the cover plate (which incorporates a diaphragm spring), the pressure plate, the driven plate, and the release bearing.

The cover plate is bolted to the flywheel, and the pressure plate exerts pressure on the driven plate through the diaphragm spring – or through coil springs on earlier cars.

The driven plate runs on a splined shaft between the pressure plate and flywheel.

It is faced on each side with a friction material which grips the pressure plate and flywheel when fully engaged, and can slip by a controlled amount when the clutch pedal is partially depressed, allowing the drive to be taken up smoothly.

The release bearing is pushed hard against the diaphragm spring, either hydraulically or by a cable and lever, and releases spring load to interrupt power transmission.

How the transmission works – manual gearboxes

Internal-combustion engines run at high speeds, so a reduction in gearing is necessary to transmit power to the drive wheels, which turn much more slowly.

The gearbox provides a selection of gears for different driving conditions: standing start, climbing a hill, or cruising on level surfaces. The lower the gear, the slower the road wheels turn in relation to the engine speed.

The constant-mesh gearbox

The gearbox is the second stage in the transmission system, after the clutch. It is usually bolted to the rear of the engine, with the clutch between them.

Modern cars with manual transmissions have four or five forward speeds and one reverse, as well as a neutral position.

The gear lever, operated by the driver, is connected to a series of selector rods in the top or side of the gearbox. The selector rods lie parallel with shafts carrying the gears.

The most popular design is the constant-mesh gearbox. It has three shafts: the input shaft, the layshaft and the mainshaft, which run in bearings in the gearbox casing.

There is also a shaft on which the reverse-gear idler pinion rotates.

The engine drives the input shaft, which drives the layshaft. The layshaft rotates the gears on the mainshaft, but these rotate freely until they are locked by means of the synchromesh device, which is splined to the shaft.

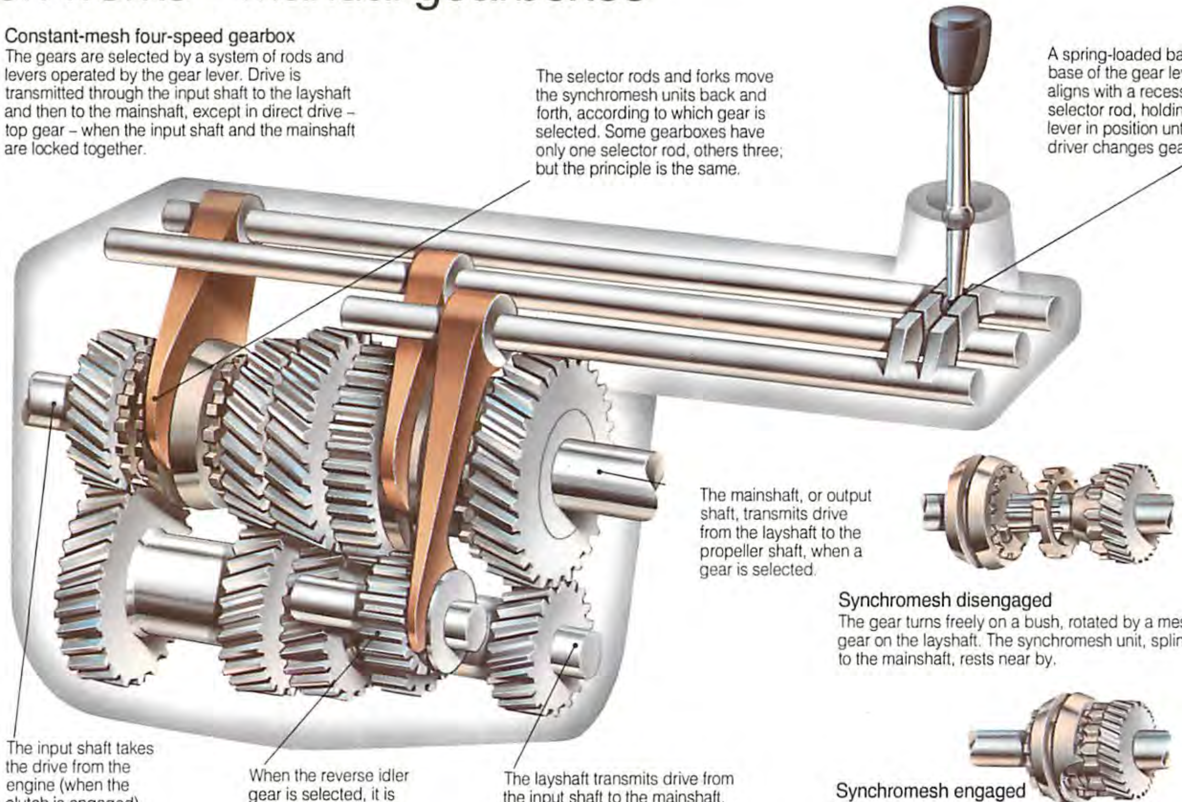
It is the synchromesh device which is actually operated by the driver, through a selector rod with a fork on it which moves the synchromesh to engage the gear.

The baulk ring, a delaying device in the synchromesh, is the final refinement in the modern gearbox. It prevents engagement of a gear until the shaft speeds are synchronised.

On some cars an additional gear, called overdrive, is fitted. It is higher than top gear and so gives economic driving at cruising speeds.

Constant-mesh four-speed gearbox

The gears are selected by a system of rods and levers operated by the gear lever. Drive is transmitted through the input shaft to the layshaft and then to the mainshaft, except in direct drive – top gear – when the input shaft and the mainshaft are locked together.



Synchromesh disengaged
The gear turns freely on a bush, rotated by a meshing gear on the layshaft. The synchromesh unit, splined to the mainshaft, rests near by.

Synchromesh engaged
The fork moves the synchromesh towards the selected gear. Friction surfaces synchronise the shaft speeds, and synchromesh and gear lock together.

Synchronising the gears

The synchromesh device is a ring with teeth on the inside that is mounted on a toothed hub which is splined to the shaft.

When the driver selects a gear, matching cone-shaped friction surfaces on the hub and the gear transmit drive, from the turning gear through the hub to the shaft, synchronising the speeds of the two shafts.

With further movement of the gear lever, the ring moves along the hub for a short distance, until its teeth mesh with bevelled dog teeth on the side of the gear, so that splined hub and gear are locked together.

Modern designs also include a baulk ring, interposed between the friction surfaces. The baulk ring also has dog teeth; it is made of softer metal and is a looser fit on the shaft than the hub.

The baulk ring must be located precisely on the side of the hub, by means of lugs or 'fingers', before its teeth will line up with those on the ring.

In the time it takes to locate itself, the speeds of the shafts have been synchronised, so that the driver cannot make any teeth clash, and the synchromesh is said to be 'unbeatable'.

Most modern cars have synchromesh on all forward gears, but on earlier cars it is not provided on first gear.

How gear ratios are changed

Neutral
All the gears except those needed for reverse are constantly in mesh. Gears on the output shaft revolve freely around it, while those on the layshaft are fixed. No drive is being transmitted.

First gear
In first gear, the smallest gear on the layshaft (with the fewest teeth) is locked to it, passing drive through the largest gear on the mainshaft, giving high torque and low speed for a standing start.

Second gear
In second gear, the difference in diameter of the gears on the two shafts is reduced, resulting in increased road speed and lower torque increase. The ratio is ideal for climbing very steep hills.

Third gear
In third gear, a still larger gear on the layshaft increases forward speed still further but reduces torque increase. Third gear is suitable for climbing low gradients, and provides agility in city driving.

Fourth gear
In fourth gear, the input shaft and mainshaft are locked together, providing 'direct drive': one revolution of the propeller shaft for each revolution of the crankshaft. There is no increase in torque.

Reverse
For reversing, an idler gear is interposed between gears on the two shafts, causing the mainshaft to reverse direction. Reverse gear is usually not synchronised.

How the transmission works – automatics

Most modern automatic gearboxes have a set of gears called a planetary or epicyclic gear train.

A planetary gear set consists of a central gear called the sun gear, an outer ring with internal gear teeth (also known as the annulus, or ring gear), and two or three gears known as planet gears that rotate between the sun and ring gears.

The drive train is coupled to a mechanism known as a torque converter, which acts as a fluid drive between the engine and transmission.

If the sun gear is locked and the planets driven by the planet carrier, the output is taken from the ring gear, achieving a speed increase.

If the ring gear is locked and the sun gear is driven, the planet gears transmit drive through the planet carrier and speed is reduced.

With power input going to the sun gear and with the planet carrier locked, the ring gear is driven, but transmits drive in reverse.

To achieve direct drive without change of speed or direction of rotation, the sun is locked to the ring gear and the whole unit turns as one.

The same effect can also be achieved by locking the planet gears to the planet carrier.

Most automatic gearboxes have three forward speeds, and use two sets of epicyclic gears.

The locking sequences of the epicyclic gear train are achieved by hydraulic pressure operating brake bands or multi-plate clutches.

The bands are tightened round the ring gear to prevent it turning, and the clutches are used to lock the sun gear and planets.

The correct sequence of pressure build-up and release is controlled by a complex arrangement of hydraulic valves in conjunction with sensors that respond to engine load, road speed and throttle opening.

A mechanism linked to the throttle – known as a kickdown – is used to effect a change-down for rapid acceleration. When you press down the accelerator suddenly to its full extent, a lower gear is selected almost instantly.

Most automatic gearboxes have an override system so that the driver can hold a low gear as required.

Epicyclic gearing made simple

With central sun gear locked, planets turn round it; carrier and outer ring turn same way.

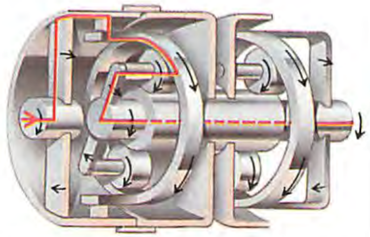
If sun gear is locked to outer ring gear, planets cannot turn, so carrier turns whole unit.

With planet carrier locked, sun gear turns planets to drive ring gear opposite way.

Drive one (first gear) The forward-drive clutch is engaged and the engine turns the first ring gear.

This causes the planet gears to drive the common sun gear in the opposite direction.

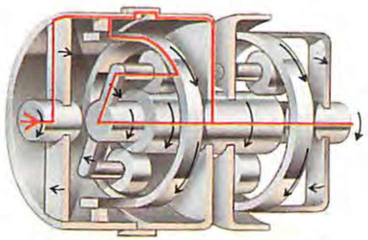
The second planet carrier is held by a brake band, so the planets drive the second ring gear and output shaft thus producing two reductions in the speed of the engine.



Drive two (second gear) Drive two provides an intermediate ratio. The forward-drive clutch is engaged so the engine drives the first ring gear.

The sun gear is braked and the planet gears revolve round it. This causes the carrier to be driven in the same direction.

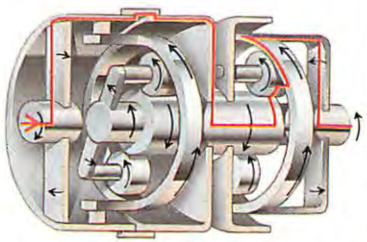
The carrier shaft is the output shaft, so one reduction is used. The second planet gears and their carrier freewheel.



Drive (top gear) The forward-drive clutch is engaged and the engine drives the first ring gear.

The reverse clutch is also engaged, which locks the ring gear to the sun gear and both turn at the same speed.

The planet gears cannot turn, so the carrier also turns at engine speed. Output is taken from the carrier shaft, which turns at engine speed (direct drive).



Reverse Reverse gear is usually marked 'R' on the selector. The forward-drive clutch is disengaged and the first ring gear freewheels.

The reverse clutch is engaged and the engine drives the sun gear.

The second planet carrier is braked and the sun gear causes the planet gears to drive the second ring gear in the opposite direction to give reverse drive.

How the torque converter works

A torque converter is a fluid coupling that acts like a clutch, except that drive is by hydraulic pressure.

The converter has three main components – the impeller, bolted to the flywheel; the turbine, connected to the gearbox input shaft; and the central reactor between the two, which has a one-way clutch called a freewheel.

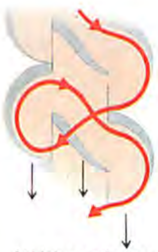
As the engine speed is increased, the centrifugal force acting on the hydraulic fluid via the impeller vanes transmits the torque, or turning effort, to the turbine.

The central reactor converts this turning effort by redirecting the flow of fluid back to the impeller to give higher torque at low speeds.

Once the engine speeds up and develops more power, the need for this torque amplification decreases and the reactor freewheels. The torque converter then acts as a fluid flywheel, connecting engine to gearbox.

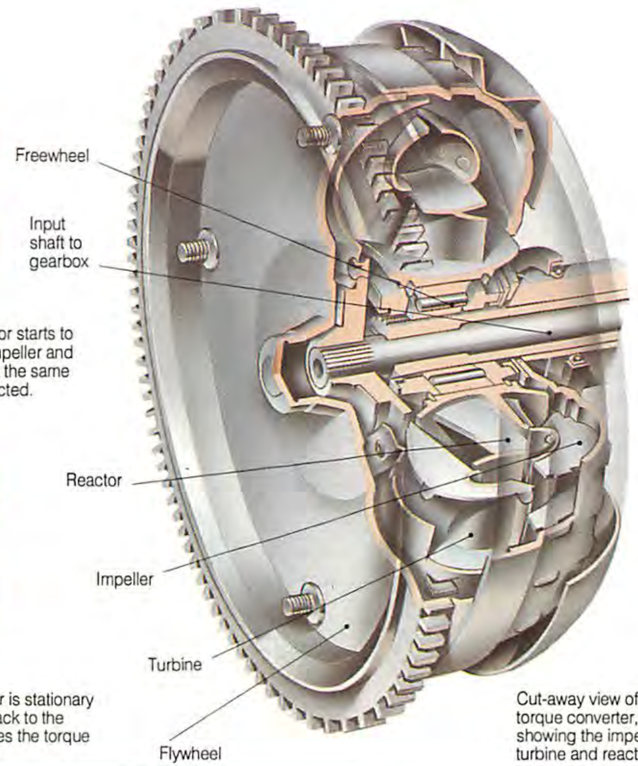
The main components of a torque converter are shown in the diagram on the right – the impeller, reactor (or stator) and turbine.

The smaller diagrams, on its left, show the direction taken by the hydraulic fluid under centrifugal forces.



At high revs the reactor starts to turn. When turbine, impeller and reactor are running at the same speed, oil is not deflected.

At low revs the reactor is stationary and deflects the oil back to the impeller. This increases the torque applied to the turbine.



Cut-away view of a torque converter, showing the impeller, turbine and reactor.

Equipping yourself to work with confidence

No car can be properly serviced and maintained without the necessary tools and equipment. A basic kit is the minimum number of tools and aids required for simple service jobs. Others can be obtained as you need them.

Buy tools of a reputable brand whenever possible. They need not be the most expensive, but avoid very cheap tools, which may soon wear out or even fail and be dangerous.

There are some essential tools that you will need only occasionally – a hub puller, for example. Such tools, which may be expensive to buy, can usually be hired (see below). Not all makers call the same tool by the same name. The descriptions on the following pages will give you an idea of what is available.

Always check in the appropriate car service manual what sizes are needed for your car – particularly before buying spanners (see *Nut and bolt sizes* below).

Hiring tools

To find a tool-hire specialist, look in the *Yellow Pages* directory under Hire Contractors – Tools and equipment.

Tools for hire are normally of high quality and can usually be hired for a day or a week. As well as the hiring fee you will have to pay a fairly large deposit, but this is refunded when you return the tool undamaged.

Always check the condition of a hired tool before you leave the shop. If it is damaged or deficient it will not only affect your work, but you may be held responsible when you take it back. Return tools in a clean condition.

Looking after tools

To get the best from tools and equipment, keep them clean, dry and properly stored. For long-term storage, use a thin smear of oil to keep metal parts rust free.

Never jumble tools together, especially those with a cutting edge. A tool roll with individual pockets is convenient for carrying in the car, and holds enough for roadside repairs. Keep cutting tools sharpened and do not use tools that are damaged – a hammer with a loose head, for example.

Protecting yourself from dirt and grease

When working on a car, you cannot avoid grease and dirt, so wear a pair of mechanic's overalls. For some jobs you need protective goggles to keep grit and dirt from your eyes – when working on the exhaust, for example, where there is often flaking rust.

Take care to protect your hands. Sensitive skin can be badly affected by some of the fluids used in cars, such as brake fluid. A barrier cream rubbed into your hands before you start work helps to protect them from harsh chemicals and also makes it easier to wash off grease and dirt when you finish.

You can use a lanolin-based workshop soap – sold in tins and applied without water – to clean off most dirt and grease from your hands before washing. Have some rag or paper towels handy for wiping the soap and grease from your hands.

Nut and bolt sizes

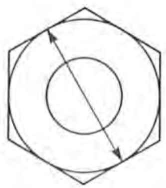
On most modern cars, nuts and bolts are measured in metric sizes. There may be imperial sizes on earlier British cars.

Most nuts and bolts have hexagonal heads. For fitting to a spanner, the size of the head is generally measured across the flats – that is, between two opposing flat sides of the hexagon.

Metric sizes across the flats are given in millimetres, the commonest imperial sizes (known as AF sizes) in fractions of an inch. Some spanners can still be bought in Whitworth sizes – obsolete on modern cars; these give measurements in fractions of an inch, but refer to the shank diameter of the bolt.

Small bolts used mostly for electrical equipment are made in BA (British Association) sizes. The bolts are measured by the thread size in thousandths of an inch and are referred to by number; the larger the number the smaller the size. The size range is generally from 0·117 in. (number 10) to 0·412 in. (number 0).

When buying tools, remember that there is no exact conversion between metric and imperial sizes. You cannot convert the size of a metric nut to an imperial measurement and expect an appropriate size of AF spanner to fit it, or vice versa.



The size of a hexagonal nut or bolt is measured between two opposing flat sides, or across the flats.

Basic tool kit

Spanners and wrenches
Open-ended spanners
Ring spanners
  Sizes as needed for the car. Useful sizes:
  AF $\frac{3}{8}$ $\frac{7}{16}$ $\frac{1}{2}$ $\frac{9}{16}$ $\frac{5}{8}$ $\frac{3}{4}$ $\frac{15}{16}$ in.
  mm 10 12 13 17 19 23
Socket spanners
  Set with AF or mm sizes as needed; $\frac{1}{2}$ in. square drive
Adjustable spanner
Brake spanner
Sparkplug spanner
Sump-plug key (or drain-plug wrench)

Screwdrivers
Engineer's screwdrivers:
  8 in. or 200 mm flat blade
  8 in. or 200 mm cross-head
  4 in. or 100 mm flat blade
  4 in. or 100 mm cross-head
Electrician's screwdriver:
  Insulated, 8 in. (200 mm)

Pliers and grips
Combination 7 in. or 180 mm
Self-locking 7 in. or 180 mm

Tools for checking
Feeler gauges
Circuit tester or test lamp

Driving tools
Ball-pein hammer 1 lb

Cleaning tools
Wire brush
Scraper

Useful extra tools to buy or hire

Spanners and wrenches
Combination, useful sizes:
  AF $\frac{3}{8}$–$\frac{11}{16}$ in. mm 10–17
Sockets, extras and accessories
Torque wrench
Allen or hexagon keys
Strap or chain wrench

Screwdrivers
Chubby – flat blade
  cross-head
Angle 5 in. (125–135 mm)
Impact driver

Pliers and grips
Long-nosed pliers 6 in. (150 mm)
Circlip pliers
Crimping pliers

Tools for checking
Tread-depth gauge
Tyre-pressure gauge
Foot pump
Vacuum gauge
Test meter or analyser (amps, volts, dwell, rpm)
Compression tester
Timing (stroboscopic) light
Hydrometer: battery
  antifreeze

Cutting tools
Files 8–10 in. (200–250 mm)
  second cut: half round
  round
  flat
Hacksaws: adjustable
  mini

Cutting tools continued
Metal cutter:
  round-hole punch

Tools for driving, levering and extracting
Copper-nylon hammer (soft-faced hammer)
Slide hammer
Screw extractors
Stud remover
Nut splitter
Ball-joint separator
Punches (centre/pin)
Drifts
Hub puller (arm type)
Pulling tool
Tyre levers

Electric tools
Soldering iron:
  150 watts, broad tip
Electric drill (not impact)
  two-speed or variable speed
Electric drill attachments:
  Twist drills
  Tapered grinder/cutter
  Hole saw
  Wire brushes
  Abrasive discs
  Polishing discs

Tools for special uses
Cylinder-head-bolt key
Bendix-spring compressor
Valve-grinding tool
Coil-spring compressors
Valve-spring compressor
Carburettor-adjusting tool

Basic equipment and a few extras

For raising the car
Jack
Axle stands
Drive-on ramps
Wheel chocks

For servicing and repairs
Crawler or creeper
Inspection lamp and torch
Oil can
Grease gun (some cars)
Oil syringe
Penetrating oil

Servicing and repairs continued
Battery charger
Vice, mechanic's
Containers: used oil
  bleed jar
  petrol cans
  miscellaneous
Tubing, rubber/plastic
Siphon pump
Plugs and sealants
Abrasive papers
Adhesive tape

For cleaning parts and bodywork
Solvents: degreaser, petrol, paraffin, white spirit, methylated spirit
Old brushes
Rags, absorbent, lint-free
Vacuum cleaner
Wash brush/cloth/sponge
Chamois leather
Car shampoo and polish
Proprietary cleaners
Hose and buckets

Spanners and wrenches / 1

Good spanners are forged from chrome vanadium. It is not worth buying cheap ones, which are likely to widen under pressure. If you want more than two or three ring or open-ended spanners, it is usually cheaper to buy a set, with probably five or eight spanners of AF, mm or BA sizes.

Most spanners are double ended, with consecutive sizes increasing mainly by sixteenths of an inch (AF) or 1 mm at each end. Some spanners have one size duplicated on the spanner of the next consecutive size, so that two nuts of the same size can be turned at the same time.

There is no clear distinction between a spanner and a wrench. Different tool catalogues may use either term for the same tool. The word wrench is also sometimes used to describe grips (SHEET 47).

Open-ended spanner

Because it does not grip all round a nut, an open-ended spanner is likely to slip and round off the edges of a tight nut unless it is an exact fit.

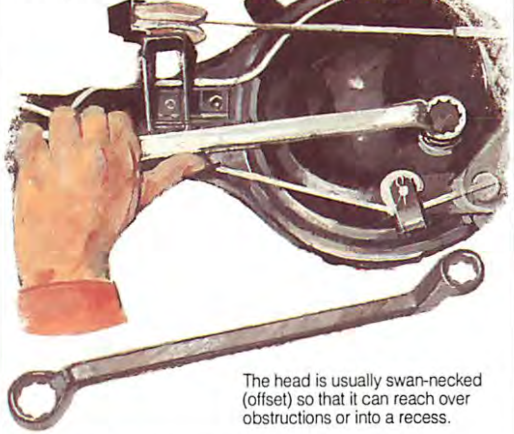
Where possible, use a ring spanner to loosen a nut, then an open-ended spanner, which is faster to use, to undo it if the nut is still more than finger tight.

Combination spanner

A combination spanner has a ring at one end and is open-ended at the other. Both ends are the same size, so the ring end (which may be slightly offset) can be used to loosen the nut and the spanner turned to undo the nut faster with the other open end.

Because only one size is covered in each spanner, a set of combination spanners is relatively more expensive than a set of individual ring or open-ended spanners.

Ring spanner



The head is usually swan-necked (offset) so that it can reach over obstructions or into a recess.

The head of a ring spanner encircles a nut completely; it is generally 12-pointed in shape (often referred to as bi-hex) and will locate on a square or hexagonal nut with a very secure grip.

Because the spanner cannot slip, it allows the maximum turning pressure to be applied, and should be used wherever possible to slacken a nut. But it can be used only where there is access over the top of the nut, and cannot be used to undo nuts on pipe unions, for example.

Torque wrench

Many nuts have to be tightened to a specific torque setting given in lb/ft (imperial) or kg/m (metric) – or Newton metres (Nm) on more recent cars. If a nut is over-tightened, the bolt may be damaged or shear off; if it is not tightened enough, the nut may work loose. Cylinder-head nuts, for example, need tightening in sequence to equal pressures to avoid head distortion.

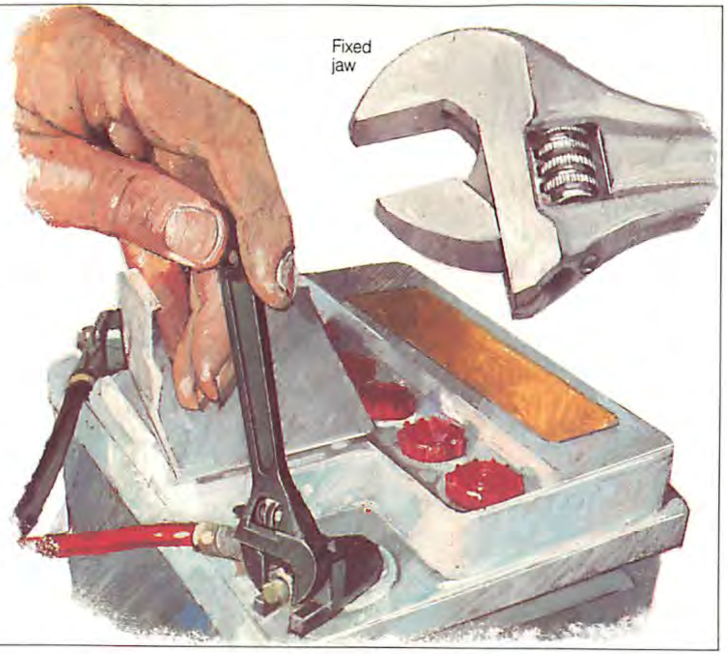
The torque, or turning power, can be measured on a torque wrench, which has a handle with a square drive that fits into a socket spanner, and a measuring or setting scale, sometimes up to 150 lb/ft (21 kg/m). The commonest type has a scale and pointer. More expensive wrenches have a dial indicator or a micrometer scale that can be preset to the required torque, and give an audible 'click' when it is reached.

Adjustable spanner

An adjustable spanner is open ended, with one movable jaw that can be screwed in or out to fit a number of nut sizes. Use it only if the correct ring or open-ended spanner is not available.

Buy one that gives a wider opening than your largest ring or open-ended spanner. A 12 in. (300 mm) crescent-shaped spanner is likely to have a maximum opening of 1⅜ in. (34 mm). Make sure the jaws fit well together, with no free play or any tendency to rock or back off when pressure is applied.

Unless properly fitted on a nut, the spanner may be strained, or slip and round off the nut edges. Fit the spanner jaws as far on to the nut as possible, and position it so that the main pressure is exerted on the fixed jaw.



Allen keys

Some Allen keys are sold on key rings, each key having a retaining spring.

Hexagon or Allen keys are only a few inches long. The hexagonal heads fit into small recesses in bolts or set-screw heads used in confined spaces. They are available separately or in 8 or 10-piece sets. Sizes generally range from 1/16 to 3/4 in. or 1·5–19 mm. Long-reach sets are available.

Brake spanner

The heads may be flat, or swivel to reach awkwardly placed adjusters.

On cars fitted with drum brakes, a special spanner may be needed for adjusting the brake shoes. The adjuster screw is usually square, and the size varies with the car; check the size you need. Brake spanners are usually double-ended, often with a 1/4 in. head at one end and a 5/16 in. head at the other; some have a 1/4 in. head and a 9 mm head.

Spanners and wrenches / 2

Sparkplug spanner

A plug spanner is a box spanner or deep socket that should fit securely over a sparkplug without touching the ceramic insulator. Ideally, use one that has a rubber insert to protect the insulator, and that also grips the plug so it can be lifted out with the spanner.

Most plugs are angled in the cylinder head, so the plug spanner should have a swivelling handle. If it does not, it cannot easily be held square over the plug to unscrew it, and there is a risk of breaking the plug. The handle must be long enough to clear the components around the cylinder head, but short enough to get at the rear of the plug.

Most spanners are 14 mm, but some are 10, 12 or 18 mm. This is the thread size, not the width across the flats. Before buying, check the size needed for your car.

Strap or chain wrench

Useful for removing an obstinate oil-filter cartridge or radiator cap, a strap wrench has a loop of canvas webbing slotted through a metal handle. The loop, or strap, clamps round the filter or cap to grip it so that it can be levered off. A chain wrench has a length of bicycle chain forming the loop. It may have a grip handle or a tightening nut for use with a socket drive.

Sump-plug key or wrench

A sump-plug or drain-plug wrench or key usually has a range of probably 5–10 head sizes for undoing and tightening various sizes of sump, rear axle, or gearbox drain plugs. Some wrenches have spanner-type heads for fitting over projecting plugs; others have key-type heads for fitting into recessed drain plugs. Combination wrenches have a mixture of both types.

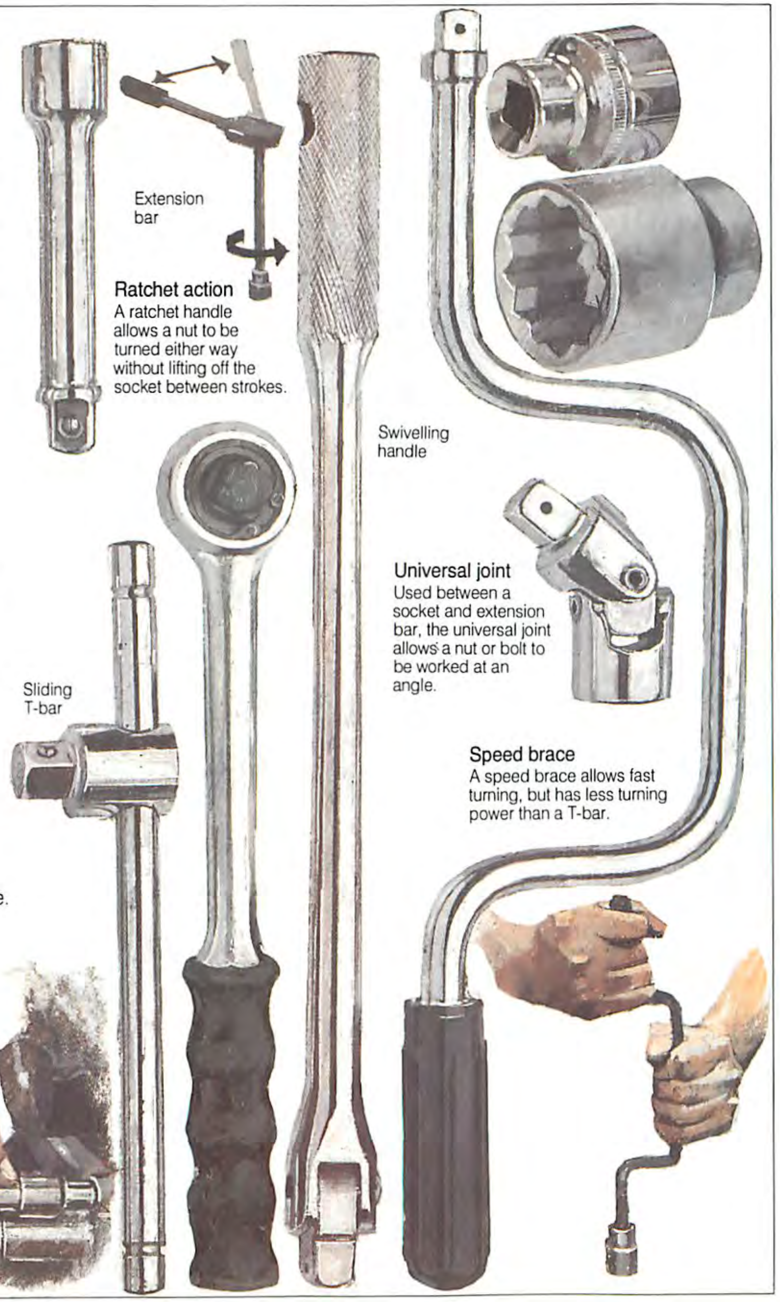
Socket spanners

Generally bought in sets, which may vary from about 10 to 56 pieces, socket spanners each have a square drive end that fits into a handle, and a 12-pointed (bi-hex) socket end that fits over a nut or bolt head. A different socket is used for each nut or bolt size.

Socket drives may be $\frac{1}{4}$, $\frac{3}{8}$, or $\frac{1}{2}$ in. square, or $\frac{3}{4}$ in. square for larger sockets such as $1\frac{1}{4}$ in. The sockets in a set may be all metric sizes, all AF (imperial), or a mixture. Some sets include a deep 14 mm socket for sparkplugs, or they can be bought separately.

A socket set may include a swivelling handle or universal joint, a reversible ratchet handle, a sliding T-bar, an extension bar and a cranked speed brace.

The advantage of sockets and handles is their ability to reach awkward places. They can also be used with a torque wrench. Their use may be limited by the depth of the socket, which may not reach over a long, protruding bolt, but extra-deep sockets are obtainable.



Screwdrivers

The best screwdrivers have shafts made from good-quality steel, and handles of tough moulded plastic.

Buy a tool with a reputable brand name. Cheap tools with brittle plastic handles can be dangerous, as they may break under pressure.

Use a screwdriver with a blade that fits exactly into the screw slot – if it is flat-bladed it should be no wider than the slot. If the blade is ill-fitting, the tool is more likely to slip or open out the screw head. Keep flat blades ground square, with the edge evenly tapered.

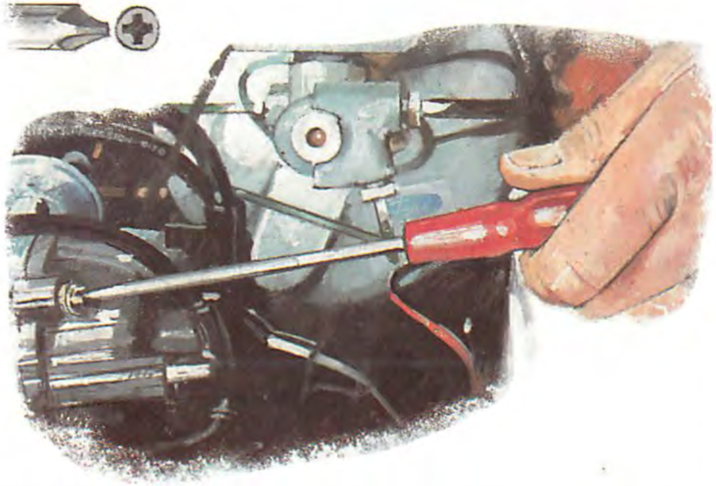
A very tight screw can sometimes be shocked loose by tapping the end of the screwdriver with a hammer. A few drops of penetrating oil and a firm tap may free a rusted screw.

Engineer's screwdriver

Strong-shafted engineer's screwdrivers are designed for heavy mechanical work. The longer the shaft and the thicker the handle, the greater the turning effort that can be applied.

The blades may be flat to fit into a straight (or plain) slot screw, or cross-headed (such as Phillips or Pozidriv) to fit into a cross-slot screw. Use the correct type of cross-head for the screw, or its slot may be damaged.

Shafts generally range in length from about 4 to 12 in. (100–300 mm) plain, or 3 to 8 in. (80–200 mm) cross-head. Shafts may be squared or have a hexagonal shoulder at the base so that a spanner can be fitted to help with stubborn screws.



Chubby screwdriver

Short-handled, short-shafted chubby or stubby screwdrivers are designed for use in confined spaces. Some have handles that can be fitted with a T-bar to give extra leverage.

Shafts are generally about $1\frac{1}{2}$ in. (35–38 mm) long, and both flat-head or cross-head blades are available.

Electrician's screwdriver

Screwdrivers for electrical work have slim shafts varying in length from about $2\frac{1}{2}$ to 8 in. (60–200 mm). The handle is rubber or plastic for insulation, and the upper part of the shaft is sometimes insulated also. Never use an electrician's screwdriver with a cracked or broken handle.

Impact driver

An impact driver has spring pressure to give strong turning power and also shock action when the end is tapped with a hammer. It is therefore very useful for loosening stubborn screws, bolts and nuts, and for extra force when turning. There are interchangeable heads, or bits, of various types and sizes, and it can be fitted with an adaptor for driving sockets.

Angle screwdriver

Angle, right-angle or offset screwdrivers are useful for reaching screws in awkward positions. They are generally 5 to 6 in. (125–150 mm) long. Normally, angle screwdrivers have a blade at each end; both may be the same type – flat or cross-head – or there may be one end of each type.

Pliers and grips

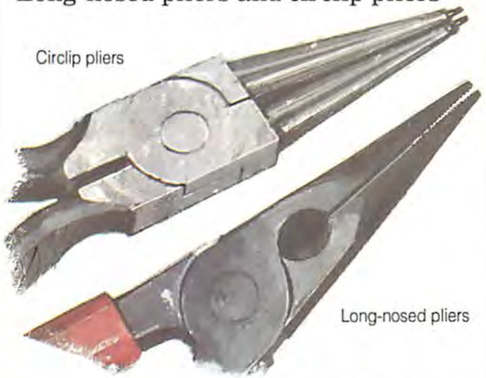
Pliers are for gripping and bending metal. They should never be used in place of a spanner for undoing nuts, as their serrated jaws can damage or round off a nut.

If you need to avoid marking the metal to be gripped, wind adhesive tape round the jaws of the pliers.

Combination pliers

Combination, or engineer's, pliers have serrated jaws with a flat section for gripping sheet metal and a curved section for gripping metal rods. They also have side cutters – two blades for cutting soft metal – just in front of the jaw pivots. Many also have a shearing notch, for cutting wire, beside the pivot.

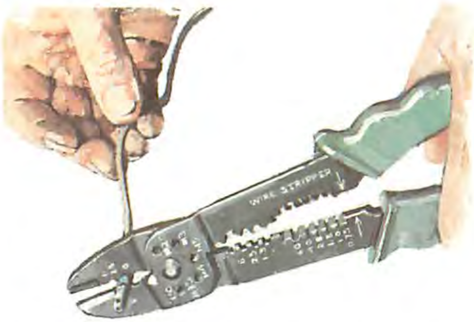
Long-nosed pliers and circlip pliers



Also called needle-nosed or snipe-nosed pliers, long-nosed pliers have long, tapering flat and serrated jaws for use in narrow spaces. Many also have side cutters.

Circlip pliers make circlip removal easy. Straight-tipped pliers for inside circlips, capacity 8–25 mm, are generally suitable. There are dual-purpose tools for inside or outside clips, with interchangeable tips.

Crimping pliers



Useful for electrical work, crimping pliers can be used for joining – crimping or pressing – wires together in a crimp terminal. Their jaws also have notches for cutting wire and stripping off the insulation, usually up to a diameter of 6 mm. Some also have bolt-cutting holes suitable for small bolts, usually up to 5 mm or 6 BA thread size.

Self-locking grips

The advantage of self-locking grips or wrenches, such as Mole grips, is that they will lock on whatever they are gripping, leaving hands free. An adjuster alters the width of the jaw opening, and squeezing the handles together locks the jaws in position. Jaws are released by a lever.

Some grips can be fitted with a specially designed bench clamp, and used as a small vice. There are versions with various jaw designs for special uses, but the standard serrated jaws are the best for car maintenance work.

Cutting tools

Files

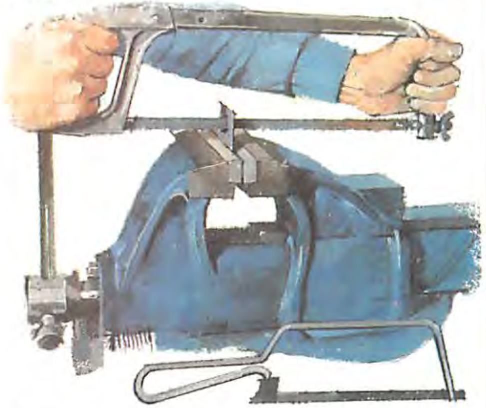
A flat file may have a safe edge (one side free of teeth) for working into corners where no cutting is needed.

An engineer's file is used for smoothing metal or enlarging holes in metalwork. Use a half-round file for smoothing curved surfaces and a flat file for flat surfaces. For enlarging holes such as an aerial hole in a car body, use a round (or rat-tail) file, which is thin and tapered.

Engineer's files are generally single cut – that is, with parallel, not criss-crossed, teeth. Depending on the density of the teeth – generally 26, 36 or 60 per 25 mm – their cut may be bastard (medium coarse), second (medium smooth) or smooth. The denser the teeth, the smoother the cut.

Files are often sold without handles, which can be bought separately. For safety, always fit a permanent handle to an 8 to 10 in. (200–250 mm) file; do not use the same handle for different files. Store files carefully, not jumbled with other tools such as spanners, or the cutting edge may be damaged.

Hacksaws



A hacksaw for cutting metal has detachable blades that can be fitted into the saw frame and renewed as necessary. An adjustable hacksaw can be fitted with 10 or 12 in. (250 or 300 mm) blades. Mini or junior hacksaws for work in confined spaces usually take 6 or 8 in. (150–200 mm) blades.

General-purpose blades mostly have a medium cut – 24 tpi (teeth per inch). Coarse blades for soft metal have 18 tpi, and fine blades for thin and hard metal have 32 tpi. Fit blades with teeth pointing forwards.

Some hacksaws have a blade-tensioning screw. To tension correctly, take up the slack with the nut, then give it a few more turns to get the blade taut.

Round-hole punch

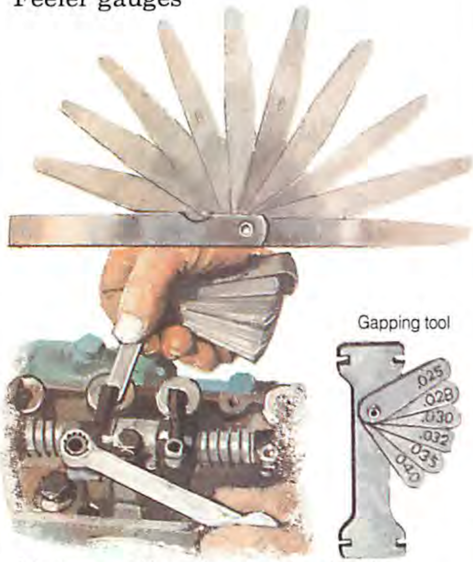
A round-hole punch is the easiest way of cutting a hole in metal bodywork – to fit an aerial, for example. Its central bolt fits through a drilled pilot hole and clamps together two circular cutting pieces, one on each side of the metal. The hole is cut as the bolt is tightened – often with an Allen key.

A different punch is needed for every hole size. The usual size range is ⅜ to 3 in. (10–75 mm).

SEE ALSO ELECTRIC DRILL ATTACHMENTS

Tools for checking

Feeler gauges



A feeler-gauge kit consists of blades of varying thicknesses used mostly for measuring the gap between contact-breaker points and sparkplug electrodes, and for checking valve clearances. Gauges measure in either imperial or metric sizes; most car service manuals give an alternative for either system. The range of measurements covered is usually between 0·001 and 0·025 in. (often marked $1\frac{1}{2}$–25 thousandths) or 0·05–0·80 mm. Make sure you buy a gauge suitable for the clearances on your car.

A sparkplug gapping tool has stiffer, thicker blades (or wires) than a feeler gauge, and is more likely to give an accurate measurement for a sparkplug gap. It also has hooks for levering the electrode. On some cars, the sparkplug gap may be larger than the range of sizes on a feeler gauge – 0·04 in. (1 mm) for example. Although you can use two or three feeler blades together, a gapping tool is preferable.

Tyre gauges

A tread-depth gauge has a flat base that fits across the top of a tyre tread, and a probe that is pushed into the tread grooves to register their depth in millimetres on the scale above it.

A tyre-pressure gauge is generally about the size of a pencil, although types with a large dial are available. It measures pressures in either imperial or metric units, usually with a range of 6–50 psi (0·5–3·5 kg/cm^2). Most gauges are fitted with a valve remover. A foot pump with a pressure gauge is more useful for measuring tyre pressures, as it enables you to adjust them at the same time. A foot pump can also be used for blowing dust from parts such as a paper-element filter.

Circuit tester and test lamp

Use a 6–12 volt circuit tester for checking a car circuit. It has a short metal probe, and the translucent, insulated handle contains a 12 volt bulb and has a length of cable attached that can be clipped to the car body as an earth. The probe is used to test the live side of the circuit. Where there is current, the bulb lights up.

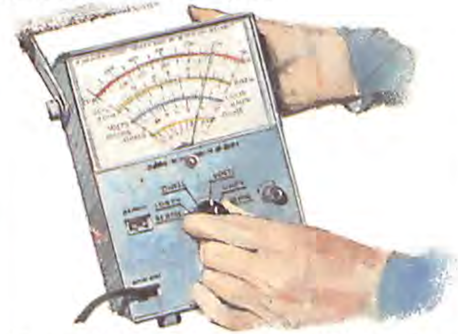
To make a simple test lamp, use a single-filament bulb and two lengths of low-current carrying wire (14/·30). Solder one length to the bulb basecap metal (earth), the other to the single centre contact (live). Fix crocodile clips to the wire ends.

Vacuum gauge

A vacuum gauge can be used on some cars for carburettor setting or fault diagnosis. If the car has a brake servo or manifold take off, the gauge can be linked in here to measure the vacuum flow rate through the inlet manifold. The gauge is fitted with a hose and adaptor, and is calibrated in mercury inches (in. Hg); it is sold with a diagnosis chart for interpreting the gauge readings.

At idling speed, for example, the reading should be 17–21 in. Hg. Low readings can indicate a leak in the inlet manifold, retarded ignition or weak compression; a fluctuating reading may mean an ignition fault or lack of compression. Some gauges are combined with an oil-pump tester that registers the oil-pump pressure in pounds per square inch.

Test meter or analyser



Various electronic test meters are available. They have several functions, usually including a voltmeter, ammeter, ohmmeter, dwell meter (for measuring the dwell angle, see SHEET 197) and tachometer (for measuring engine speed in rpm).

A tachometer – preferably an instrument with a fine scale (0–3,000 rpm, say) – can be useful for tuning the carburettor. When it is connected to the coil, the slightest twist of the mixture-adjustment screw alters the engine speed. To adjust the mixture, set the screw to give the highest possible rpm consistent with the smooth running of the engine.

Compression tester

A compression tester is used to measure the compression pressure in an engine cylinder while the engine is at normal operating temperature (SHEET 164). During use, all sparkplugs should be removed, and the accelerator kept pressed to the floor.

The tester is screwed or pressed into an empty sparkplug socket, and its dial – usually calibrated in 5 lb steps up to 200–300 psi – registers the pressure in that cylinder as the engine is turned over. Testers usually have an adaptor for different sparkplug sizes, and some have a release button for resetting the dial.

Timing or stroboscopic light

Checking the ignition timing while the engine is idling can be done with a stroboscopic lamp, or timing light, which is clipped between the sparkplug used for timing and its lead. The head is directed at the engine timing marks, and each time the plug sparks, the lamp lights up the timing marks so that you can check whether the spark occurs at the specified setting before top dead centre (SHEET 203).

A neon timing light, which relies solely on the HT voltage, is often sufficient as long as the timing marks are accentuated (with white paint, say) and the work is carried out in a shaded place. More expensive timing lights, such as Xenon-tube lamps, are powered from the battery or mains as well, and give a brighter light. An induction-type strobe light can be clipped to the plug lead without disconnecting it.

Hydrometer

Two types of hydrometer are used in car maintenance, a battery hydrometer and an antifreeze hydrometer.

Both measure the specific gravity of the liquid (battery-cell electrolyte or antifreeze mixture), but are scaled differently and are not interchangeable.

Just enough liquid to move the float is sucked into the hydrometer float chamber; the reading is taken where the float breaks the surface of the liquid. There may be a figure scale or a colour or letter code, or both.

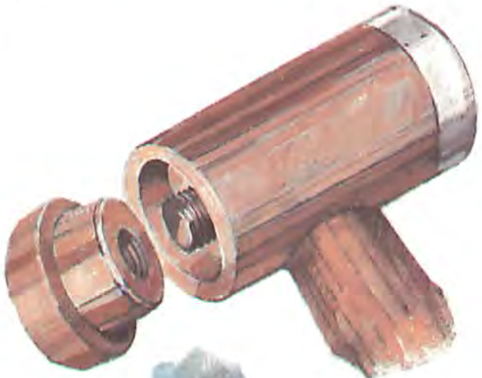
On an antifreeze hydrometer, the reading has to be converted to a percentage of antifreeze concentration, for which a chart is supplied with the hydrometer.

Tools for driving, levering and extracting

Ball-pein hammer

The head of an engineer's ball-pein hammer has a flat end for striking punches, drifts or cold chisels, and a rounded end for spreading a rivet head. The best tools have a head of drop-forged steel and a handle of ash or hickory wood.

Copper-nylon hammer

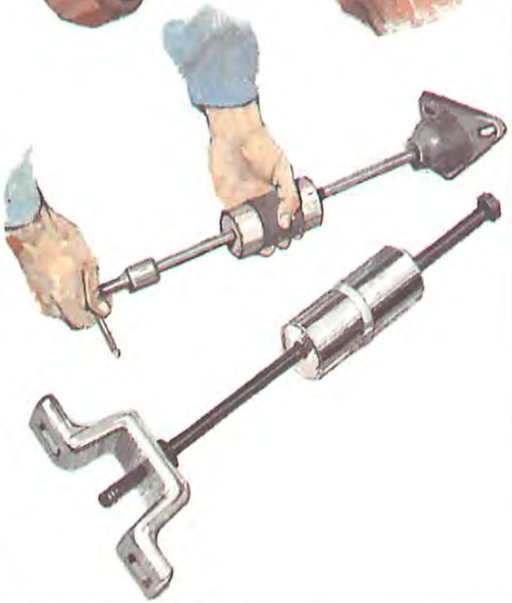


Car parts such as brake drums, which would be damaged by a blow from a steel hammer, can, if necessary, be struck with a flat-ended, soft-faced nylon (or rawhide) hammer.

For some parts, such as threaded components, a slightly harder copper-faced hammer is useful.

Hammers with copper or nylon faces can be bought separately, or there are dual types with a copper face and a nylon face.

Slide hammer



If you have to remove a rear-wheel half shaft to change an oil seal, you may need to hire a slide hammer. It has a long shaft with a stop block at one end, and a plate for bolting to the wheel hub at the other. There is a heavy sliding weight on the shaft.

To use the hammer, the weight is pushed with force along the shaft from the hub end, and its momentum helps to withdraw the half shaft.

The bolt plate must be suitable for the wheel hub of the make of car concerned. Universal tools with adaptable bolt plates are available.

Screw extractor

Sheared-off screws, bolts or studs can be removed with a corkscrew-like screw extractor, often known as an 'easy-out'. Using a twist drill about three-quarters the size of the screw diameter, drill a hole in the shaft of the broken screw for most of its depth. Screw the extractor into the hole anti-clockwise, using a spanner on its square head.

The extractor bites into the side of the screw, and as you continue turning it should eventually start the screw turning anti-clockwise on its own thread, and so withdraw it. Extractors can be bought in sets containing five or six pieces, in sizes ranging from $\frac{1}{8}$ to $\frac{3}{4}$ in. (3–19 mm). Some sets include drills, drill guides and a suitable spanner.

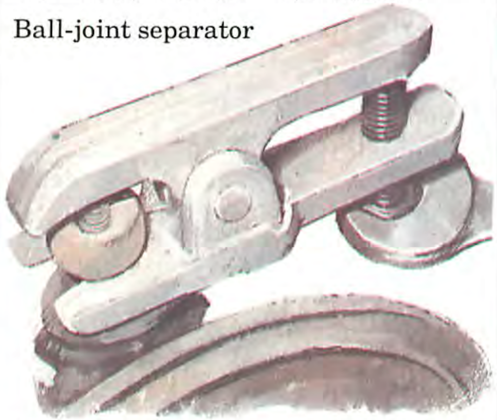
Stud remover

A stud remover can be used with a socket drive to remove difficult studs. Square or hexagonal $\frac{1}{2}$ in. drive tools are available. The remover has a socket that fits over the stud, and as the drive is turned an eccentric knurled nut clamps on the stud to grip and withdraw it. The remover can generally be used for studs up to $\frac{1}{2}$ or $\frac{3}{4}$ in. (13 or 19 mm), with left or right-hand threads.

Nut splitter

A nut splitter is useful for releasing seized nuts that cannot be freed by normal means without damage to the bolt thread, but you need working room to use the tool. The splitter is clamped and tightened round the nut using the adjusting screw on the handle. One side of the clamp is a powerful blade that bites into the nut to split it. Splitters can be hired. Check the capacity, they will usually fit nuts up to 1 in. (25 mm) across.

Ball-joint separator



It is very difficult to separate a suspension or steering ball joint without a ball-joint separator; there are two types. Fork separators have two wedge-shaped prongs that can be hammered between the joint and arm to prise out the joint. Their disadvantage is that the rubber gaiter covering the joint may be split, or the joint damaged, so that the joint has to be renewed.

More satisfactory is the screw-operated scissor-type separator. It has a fork opening that fits round the arm above the ball joint, and a lever arm that is tightened until it presses the joint out of its tapered seat.

Punch

A punch is a metal bar about 4 in. (100 mm) long, often tapered, that is tapped with a hammer to indent metal or push out a pin. A centre punch is used for marking holes before drilling. Tip sizes may vary from $\frac{1}{16}$ to $\frac{1}{4}$ in. (1·5–6 mm) in diameter. A pin punch should be the same diameter as the pin, or only slightly narrower. Tip diameters are usually $\frac{1}{16}$–$\frac{3}{16}$ in. (1·5–5 mm).

Drift

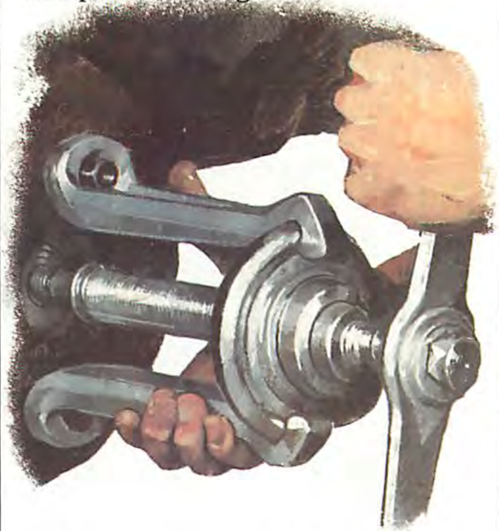
A drift is a straight metal bar used with a hammer to tap out (or in) bolts and bushes that are under load, such as in suspension parts.

Any suitable metal bar or tube can be used. Its diameter should be slightly smaller than that of the part to be removed. Use an alloy drift for soft metals such as brass, a steel drift for harder metals.

Make sure the driven end is sound, or it may splinter and fly off under the hammer. If you cannot find a suitable drift, you can use a socket, but take care not to damage it when hammering.

Tools for driving, levering and extracting continued

Hub puller/Pulling tool



Three types of hub puller can be used for removing a wheel hub – a bar type, a screw type and an arm type. All bolt on to wheel studs and have a centre screw that bears on the stub axle; the screw is turned to withdraw the hub. Bar types are cheapest; screw or arm types can be hired.

Bar and screw types usually fit over only two wheel studs and are turned with a socket spanner. Of the two, screw types are more versatile and more satisfactory.

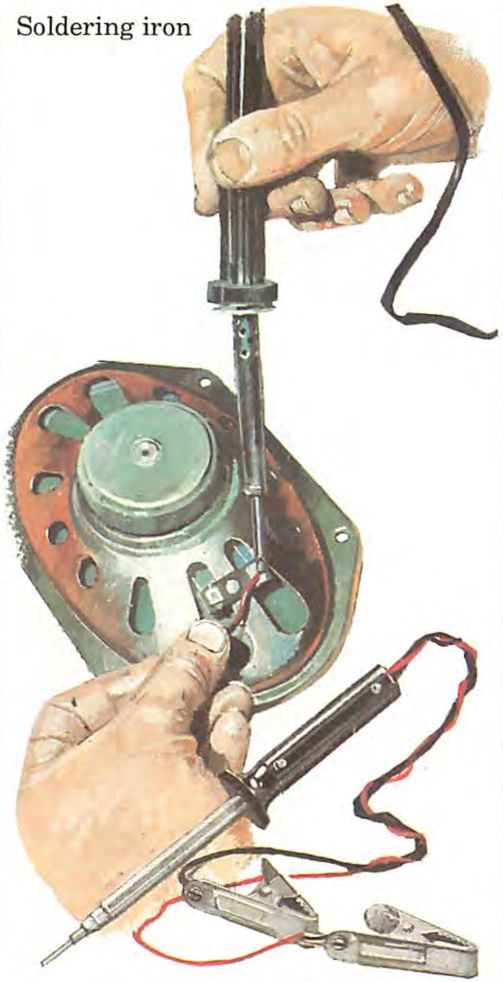
The best tool is an arm puller, which has two, three or four adjustable pulling arms that each bolt on to a stud, and a turning handle with a centre screw. Spare arms can be fitted. Multi-purpose pullers that work in the same way but have hooked arms for gripping parts such as gears and pulleys (SHEET 108) are also available. They include triple-grip pullers for removing a steering wheel.

Tyre lever

A good, strong tyre lever is useful as a lever for jobs such as checking wear in steering ball joints or adjusting the generator. Home car mechanics do not need levers for tyre removal and refitting, a job for a tyre specialist.

Electric tools

Soldering iron



For permanent repairs to electrical connections, use an electric soldering iron. A pencil-tip iron of 15–25 watts is suitable for small connections, but a large iron of about 150 watts is preferable. It is best to run the iron off the mains, but irons that can be run off a 12 volt car battery are available if necessary.

To solder a connection, heat the iron for a few minutes until it is hot enough to melt the solder. Clean the connection and prepare it with soldering flux to remove surface coating. If you use cored solder wire, which has flux running through it, you do not need separate flux.

Apply the solder – cored solder wire or solder paste – and use the iron to melt it and fuse the metals.

Electric drill and attachments

An electric drill is useful for drilling pilot holes when fitting parts such as an aerial. With the right attachments it can also be used for cleaning carbon deposits from the cylinder head, for enlarging or cutting holes and for rubbing down and polishing bodywork.

You do not need an impact drill, but a variety of speeds is useful. A chuck size of up to $\frac{1}{2}$ in. (12 mm) is usually large enough.

SEE ALSO VALVE-GRINDING TOOL (SHEET 51).

Twist drills High-speed drills or bits for cutting through metal are available in imperial or metric sizes, and can be bought in sets. Useful sizes include $\frac{1}{8}$, $\frac{1}{4}$ and $\frac{3}{8}$ in. (3, 6 and 10 mm). Choose sets carefully. Sizes often go up by 32nds or 64ths, so you would have to buy two seven-piece sets to include both a $\frac{1}{16}$ in. and $\frac{3}{8}$ in. drill.

Tapered grinder/cutter A tapered grinder or cutter can be used to enlarge a drilled pilot hole up to the maximum diameter of the grinder head. For aerial or wing-mirror holes, a head $\frac{3}{4}$–$\frac{7}{8}$ in. (19–22 mm) diameter is usually suitable.

Hole saw A hole saw cuts a hole of one size only, a different saw being needed for each size of hole. Sizes usually range from $\frac{5}{8}$ to 2 or 3 in. (16–50 or 75 mm). Blades may be short reach – with a 5/32 in. (4 mm) cut – or long reach with a $\frac{9}{16}$ or $\frac{7}{8}$ in. (14 or 22 mm) cut. Blades can be removed and changed.

Wire brushes and sanding and polishing discs Wheel-shaped and cup-shaped wire brushes can be fitted for metal cleaning, also narrow brushes for decarbonising. Abrasive paper discs – 24, 40, 80 and 100 grit – can be used for initially rubbing off rust and paint from bodywork; the lower the number the coarser the grit. A flap wheel is a long-lasting abrasive wheel made with dozens of flaps of abrasive materials. Calico mops are useful for buffing and polishing bodywork, and can be fitted with lambswool bonnets for finishing to a high shine. Some fitments need a carrier and clamp (arbor).

Tools for special uses

Cylinder-head-bolt tool

On some Ford cars, the cylinder-head bolts are unscrewed with a special tool. It may vary according to the year of manufacture.

Some bolts, for example, have multiple cross-heads for which a splined key is needed.

The tool is available from Ford distributors.

Valve-grinding tool

A valve-grinding stick has a rubber suction pad at one or both ends for lifting the valve while grinding.

Make sure you buy a tool with a sucker head that is about the same diameter as the valves on your car. Kits may include grinding paste.

Electric-drill attachments are available for grinding valves. They have a reversing action.

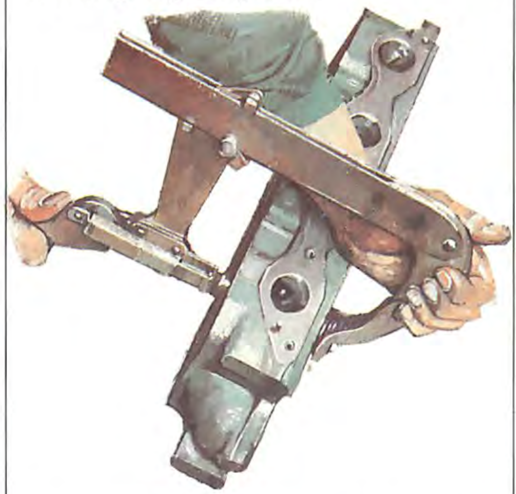
Bendix-spring compressor

A Bendix-spring compressor is used to compress and remove the spring in a starter motor Bendix gear as necessary for repairs. It has two C-shaped plates joined by two threaded bolts. To fit the tool, separate the plates and place one at the top and one at the bottom of the spring, with the C arms overlapping to form an O. Replace the bolts and tighten them gradually and evenly until the top circlip can be removed. Gradually loosen them to remove the tool and lift off the spring.

Coil-spring compressors

Coil-spring compressors are essential for removing and refitting coil springs in suspension systems. A compressor is usually a long, threaded bolt with a hooked section at each end that fits over the coil. You need a pair – one for each side of the spring, or even three for large-diameter springs. Always use good-quality compressors, or the bolts may strip under pressure. They can be hired.

Valve-spring compressor



A valve-spring compressor is used to compress a valve spring in the cylinder head while the valve-retaining cotters are removed. It is clamped over the top of the spring-retaining cap and underneath the cylinder head.

Without a proper compressor, there is a risk of the cotters being fired out at speed and lost, or causing injury. Some compressors have a G-clamp screw, others a cam-and-lever action. Check in a service manual for your make of car for the best type to use.

Carburettor adjusting tool

For some carburettors, Strombergs particularly, a special tool is needed to adjust the mixture. It varies according to the year of manufacture, and can be obtained from a franchised agent. Check exactly which tool is needed for your car in the car service manual. Some carburettors are 'tamper-proofed' – they have a seal that must be broken before an adjusting tool can be used.

Cleaning tools

Wire brush

A stiff wire brush is useful for cleaning off stubborn dirt and rust by hand. Brushes may have two, three or four rows of wire, and some have a metal scraper attached. Smaller brushes with brass wire are intended for cleaning electrical connections, such as battery terminals. Handles are usually wooden, but some brushes have plastic handles that can be cleaned with degreaser without damage. Clean clogged and greasy wire bristles with petrol.

SEE ALSO ELECTRIC DRILL ATTACHMENTS (SHEET 50).

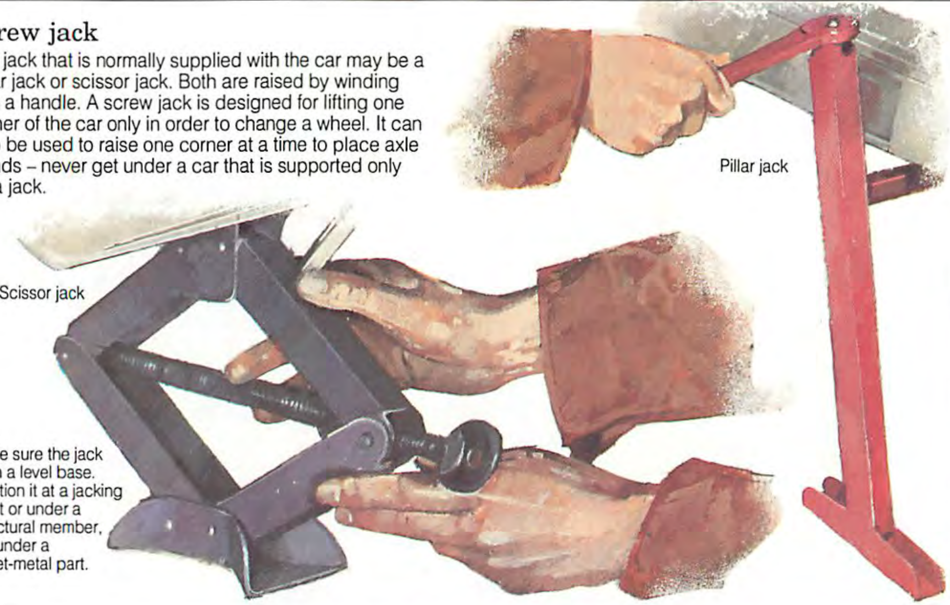
Scraper

A hand-held scraper is needed for removing stubborn dirt and grease. It is not usually worth buying a scraper – use an old screwdriver or kitchen knife, or a broken hacksaw blade. A wallpaper scraper with a sharp, straight edge is useful for cleaning off old gaskets and cement.

Equipment for raising the car

Screw jack

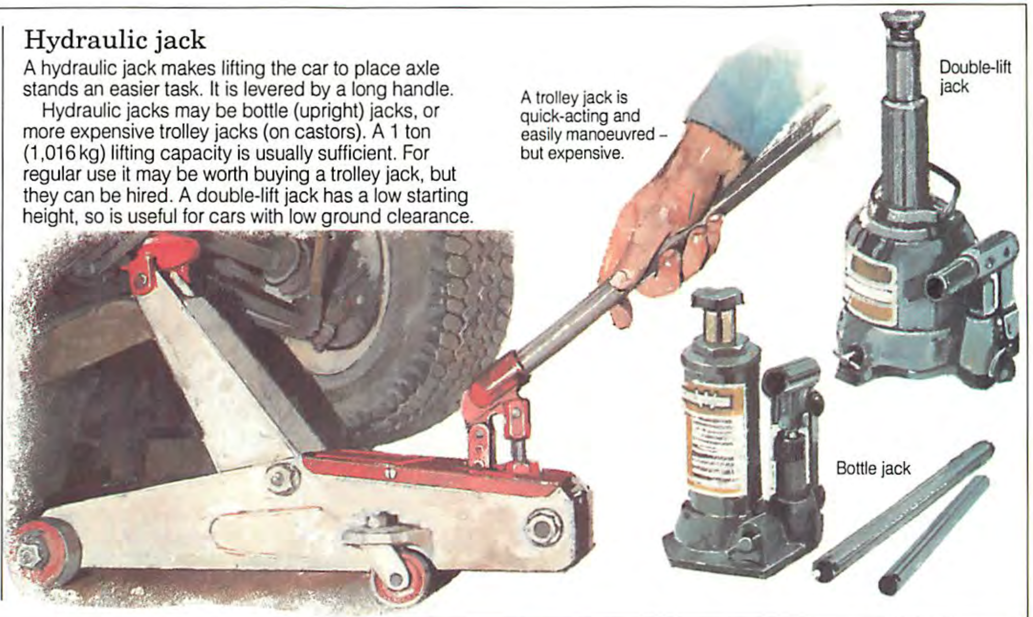
The jack that is normally supplied with the car may be a pillar jack or scissor jack. Both are raised by winding with a handle. A screw jack is designed for lifting one corner of the car only in order to change a wheel. It can also be used to raise one corner at a time to place axle stands – never get under a car that is supported only by a jack.



Hydraulic jack

A hydraulic jack makes lifting the car to place axle stands an easier task. It is levered by a long handle.

Hydraulic jacks may be bottle (upright) jacks, or more expensive trolley jacks (on castors). A 1 ton (1,016 kg) lifting capacity is usually sufficient. For regular use it may be worth buying a trolley jack, but they can be hired. A double-lift jack has a low starting height, so is useful for cars with low ground clearance.



Axle stands

Axle stands have sturdy tripod legs and can be adjusted to different heights.

They enable you to support the car off the ground safely, with sufficient clearance for working underneath.

Position stands under axles or structural members, not under unsupported sheet metal. It is unsafe to fit them under a car that is tilted.

Axle stands that give maximum ground clearance of about $14\frac{1}{2}$ in. (370 mm) and will support a weight of up to 1·5 tonnes are usually sufficient.

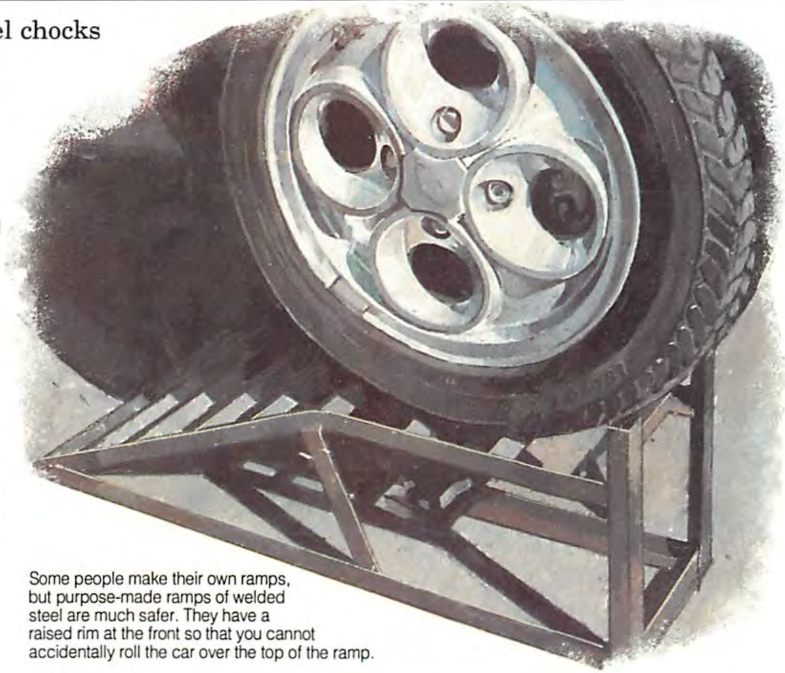
Buy stands that are securely welded all round at load-bearing points, not just spot welded in a few places. Make sure the platform fits firmly in the stand and cannot be rocked from side to side.

Ramps and wheel chocks

A pair of drive-on ramps allows you to raise one end of a car without using a jack. They are convenient for jobs that do not require wheel removal. Most give a ground clearance of about 9 in. (230 mm) and will support up to about 3 tonnes per pair.

Ramps that have a detachable run-up section allow more access for working near the road wheels. The detachable parts can also be used as wheel chocks.

However, the run-up slope may not be steep enough to give secure chocking. A triangular wooden block with a 45 degree slope is often more effective. Wheel chocks are available as accessories with some makes of car.



Equipment for servicing and repairs / 1

Crawler

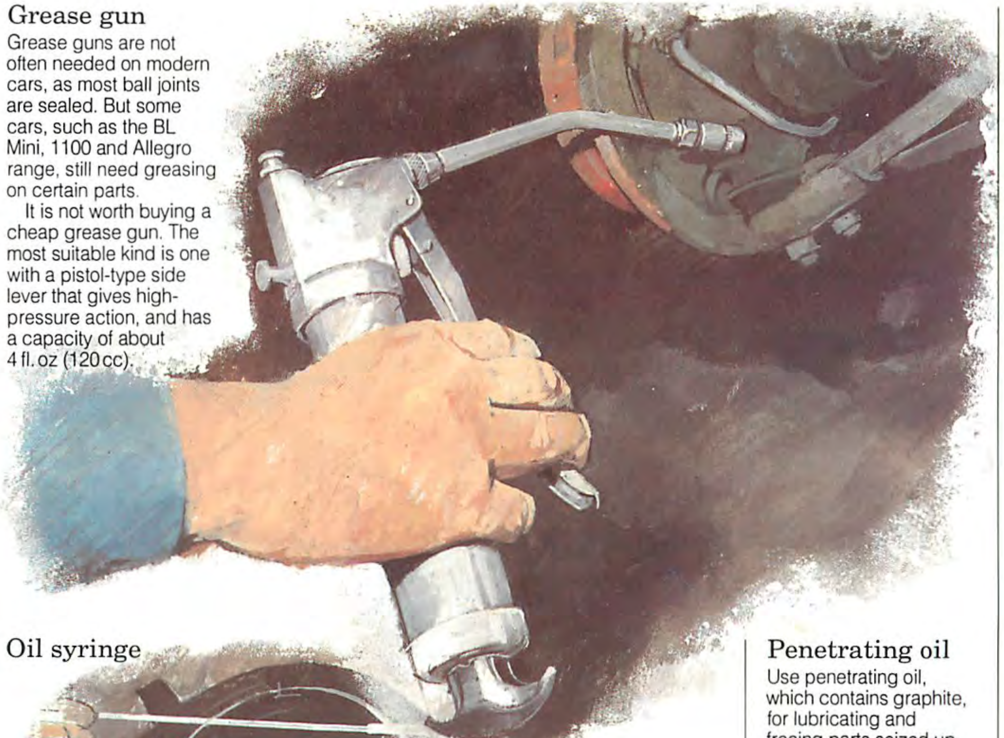
A crawler, also called a creeper or repair cradle, is a wooden or metal frame on castors with about 2 in. (50 mm) ground clearance.

Although not essential equipment, it makes moving about under the car simpler and more comfortable. Some have a padded head rest.

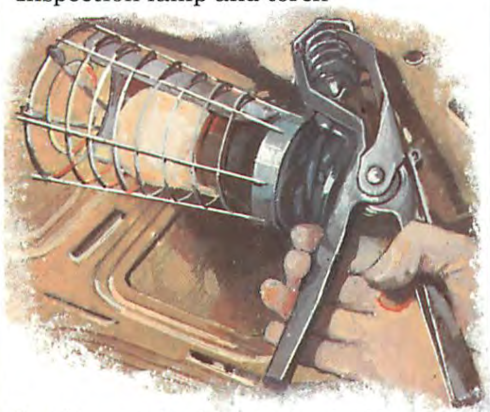
Grease gun

Grease guns are not often needed on modern cars, as most ball joints are sealed. But some cars, such as the BL Mini, 1100 and Allegro range, still need greasing on certain parts.

It is not worth buying a cheap grease gun. The most suitable kind is one with a pistol-type side lever that gives high-pressure action, and has a capacity of about 4 fl. oz (120 cc).



Inspection lamp and torch



If you have to work on the car engine at night, or inspect under the car in daylight, an inspection lamp can be invaluable. Most can be run off the mains or the car battery, and take bulbs up to 100 watts. The bulb is protected by a wire guard. Lamps usually have a clamp for fitting to the bodywork so that your hands are free.

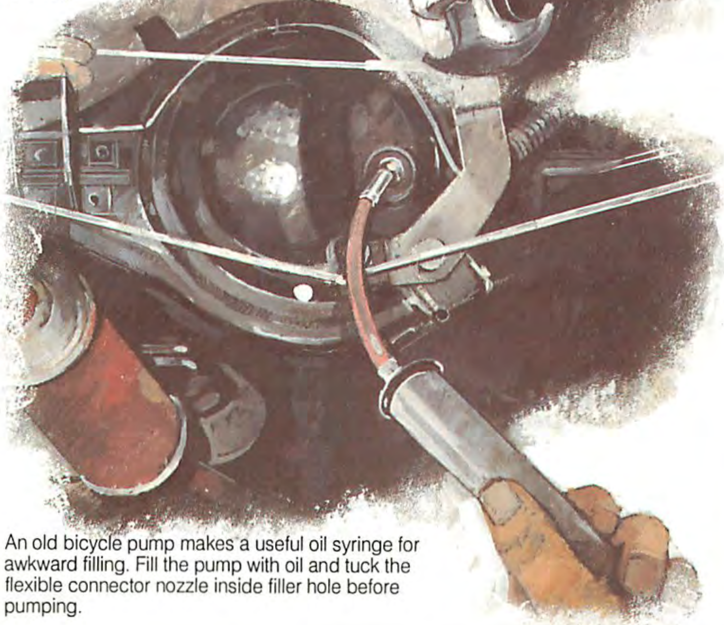
But there are times when you need a torch rather than an inspection lamp – when inspecting under the car for leaks, for example. If a cool liquid drops on the hot, exposed bulb of the lamp, the bulb may shatter.

Oil can

General oiling can be carried out with a small tin of multi-purpose machine oil. Or you can use an oil can filled with engine oil, which is also useful for topping up the carburettor dashpot. A ½ pint (280 cc) oil can is a useful size. Most oil cans have lever-operated pump action.

Some cans have a fixed or flexible metal spout, others a detachable plastic spout. Flexible spouts can be useful for getting into awkward corners, but are designed for garage work – oiling near revolving parts. A plastic spout may soon be damaged or wear out, and it may not be easy to get a replacement.

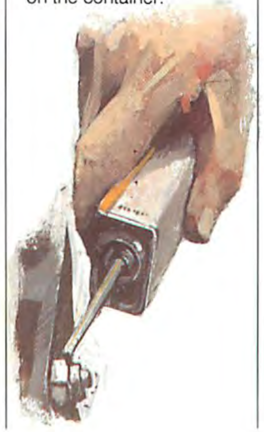
Oil syringe



An old bicycle pump makes a useful oil syringe for awkward filling. Fill the pump with oil and tuck the flexible connector nozzle inside filler hole before pumping.

Penetrating oil

Use penetrating oil, which contains graphite, for lubricating and freeing parts seized up by dirt and rust. Always leave it to soak in for an hour or two at least. Follow the instructions on the container.



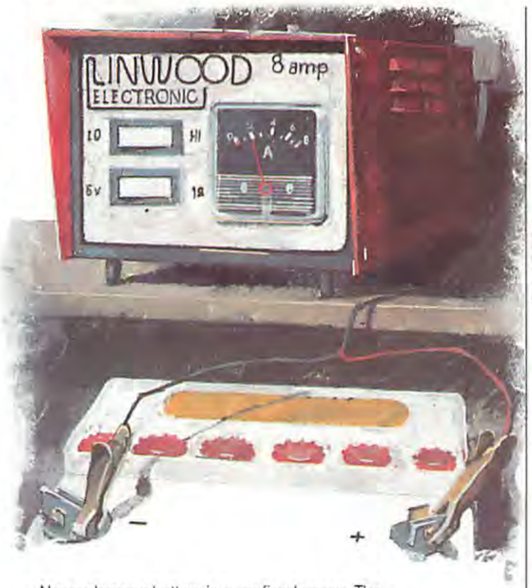
Equipment for servicing and repairs / 2

Battery charger

A car battery charger generally has an output of 4, 6 or 8 amps, and can be plugged into the mains to recharge a 6 or 12 volt battery. It includes an ammeter to register the charge, and may have an overload control to prevent a blown fuse.

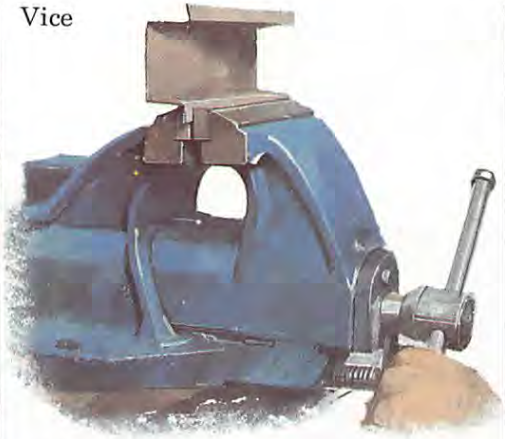
Unless a battery is very flat, it is normally charged after 18–24 hours. The charger shows a high reading at first, then trickles at 1–2 amps.

A battery to be charged should be clean and topped up. Remove individual cell caps, but leave a trough cover in place. Use in a dry place off the floor, and make sure the cooling vents are not obstructed.



Never charge a battery in a confined space. The fumes given off can be explosive when mixed with air.

Vice



A vice that bolts or clamps to a workshop bench is a necessity for many repair jobs. Ideally, use a mechanic's (or engineer's) vice, which has close-fitting jaws that are grooved for gripping pipes. Jaw openings generally vary from 3 to 6 in. (75–150 mm).

Jaw pads of softer material can be obtained; they prevent damage to components, but still hold them in a firm grip. Otherwise, pad the vice jaws with wood.

Containers

Used oil A large, disused washing-up bowl is ideal for catching the old oil when you drain the sump or gearbox. You can buy a purpose-made oil drainer that fits under the sump of most popular makes of car. It is plastic, but able to hold about 1¾ gallons (8 litres) of hot engine oil.

It is illegal to put oil in a container that might be recirculated and used for food or drink – such as a milk bottle.

Never tip oil down the drain – it contaminates the water-supply system and is also illegal. The local council will tell you where to dispose of it.

Bleed jar A jar such as a jam jar is sufficient for use with a bleed tube when bleeding the brakes or clutch.

You can buy bleeder kits that include plastic containers. Most have tubing with one-way valves that allow one-man operation.

Petrol cans If you need to store petrol, you must, by law, use purpose-made, marked containers, which must not be kept in the house.

You can store up to two metal cans each of 2 gallons (9 litres) capacity, or up to two plastic containers each of 5 litres (1.1 gallons) capacity.

Miscellaneous A large jug and funnel come in handy for filling the radiator with antifreeze mixture. A wide, shallow pan such as an old frying pan is convenient for washing small parts in degreaser or other solvent.

Plugs and sealants

It is sometimes necessary to seal off the end of a fluid pipe during repairs. Keep a collection of bungs or corks. Old pencil stubs are useful for corking the ends of narrow pipes.

Various proprietary hardening or non-hardening sealants are available for sealing joints – such as gasket compounds and thread-locking liquid for securing nuts and bolts.

Do-it-yourself underbody sealants for protection against rust are generally either bitumastic or rubberised compounds, sold for either spray or brush application. If you intend patching in, some of these compounds are not compatible with factory-applied PVC sealants. Read the manufacturer's instructions carefully.

Tubing

You need plastic or rubber tubing for bleeding the brakes or clutch if you are not using a proprietary kit. Clear plastic is best for siphoning petrol from the petrol tank. A length of about 2 ft (600 mm) is useful for both bleeding and siphoning. Bleed tubing must fit closely over the bleed nipple.

Siphon pump

If you have to siphon petrol from the petrol tank during repairs, the task is made easier by using a plastic siphon pump connected to a length of clear plastic tubing. It also saves you getting a mouthful of petrol.

Abrasive papers

Use a coarse abrasive paper for cleaning off rust and paint from metals (see Electric drill attachments, SHEET 50).

Use medium to fine wet-and-dry paper (320–600 grit) for rubbing down and shaping.

Medium or fine emery cloth is used for further cleaning of unpainted metal.

If you clean parts with glasspaper, use medium grade (1).

Adhesive tape

Use insulating tape for binding soldered electrical joints; a waterproof plastic tape is best.

Apart from its normal use when painting panels, masking tape is also used to protect the bodywork when drilling.

Equipment for cleaning

Degreaser and other solvents

Before working on a part of the car, you may need to clean off heavy, greasy dirt. This task is easier if you use a proprietary degreaser, which dissolves oil and grease.

Some are sold in aerosol spray cans, but are relatively expensive and can be unpleasant if used in a confined space for any length of time.

Buy degreaser in 1 gallon or 5 litre drums and pour it into a smaller container – ideally a wide, shallow one – as you need it.

Apply with an old paintbrush, and make sure electrical parts such as the distributor are protected by plastic bags or sheeting.

Degreaser can be washed off with water, but quite often leaves a thin, milky film that can be removed with petrol or paraffin.

For washing dismantled parts, use paraffin or petrol in a shallow pan. An old toothbrush is ideal for cleaning small parts. Beware of the fire hazard – do not smoke or use a naked flame.

Rags

Always keep a good supply of clean, absorbent, lint-free rags on hand. You will need them for wiping the part of the car you are working on, drying washed or degreased parts, wiping your hands and mopping up spills.

Keep old cotton sheets and tea towels, for example. But avoid man-made fibres, which are not usually absorbent, as well as rags that leave fluff behind, as fluff can clog delicate parts.

Vacuum cleaner

A vacuum cleaner is the best way of thoroughly cleaning dirt from the inside of the car. A mains-powered cleaner is best, but if necessary, use a small cleaner of about 60 watts that can be run off the car battery.

Washers and polishers

A wash brush, soft cloth or sponge is the basic equipment for car washing. Wash brushes are usually made for connection to a garden hose. Some have a pressure jet for forcing dirt from wheels and chassis corners.

A stiff handbrush is also useful for getting stubborn dirt from

awkward corners. Use a chamois leather for window cleaning and leathering bodywork before polishing.

A garden hose connected to a household tap allows a steady flow of tepid or cold water for washing and rinsing. But you need a bucket of water for leathering.

Without a hose you need two buckets, one for tepid and one for cold water.

There is a very wide selection of car shampoos and polishes available, as well as special cleaners for chrome, upholstery, vinyl, removing haze and removing tar. White spirit also removes tar.

A coating of wax or silicone polish is usually effective for up to three months. Polymer polishes last longer but are harder to buff to a shine (SHEET 61).

Apply polish with a soft cloth. Keep it clear of the windscreen, as it will smear.

Take care – save time and trouble

The instructions in this Course tell you the most practical and trouble-free methods of tackling the jobs listed. Sometimes the procedures described may appear to be more time consuming or complicated than necessary. For example, you may feel that supporting a car on axle stands in order, say, to check rear-suspension components is unnecessary when you can simply jack it up. But axle stands are essential in this instance.

The jack in the average car toolkit, although perfectly adequate for changing a wheel, is not designed to support the vehicle while you are exerting a force on it. The wheel nuts are loosened *before* jacking up the car when changing a wheel, so little force is exerted while the car is on the jack; and you do not work under the vehicle.

However, levering hard on shackles or bushed joints to check for wear may require sufficient force to rock the car. This can cause the car to fall off the jack – and on to you, as you will be underneath. Jacks have also been known to collapse by themselves, due to wear or damage, or to being loaded beyond their design capabilities.

That example illustrates one of the most important rules to follow when working on your car: never crawl underneath a vehicle when it is supported only by a jack – or by temporary arrangements such as bricks or blocks of wood.

The precautions that are stressed throughout the Course may add a few minutes to the job; you may occasionally have to buy or hire a piece of equipment to do a job properly. The time and the sums involved will be well spent.

It is never advisable to rush into a job. Read the instructions before you start, and make sure you have all the required tools and parts to hand. Check also that you can identify all the relevant parts of the car before you begin.

When the engine is running

If for any reason you inspect or work inside the engine compartment while the engine is running, take great care that hair or clothing do not become trapped in moving parts such as belts and pulleys – this can cause injuries.

Tuck your hair under a hat, remove your tie or tuck it away, and roll up your sleeves if necessary. Remove a wrist-watch, rings and other jewellery when working on the car. Jewellery, like long hair, can get caught in the moving parts – and can also cause electrical short circuits (see overleaf).

Do not smoke while working on a car, whether the engine is running or not.

Removing the radiator cap

Engine cooling systems are pressurised. The coolant becomes very hot when the engine is running, and the cap is a pressure cap that keeps the coolant below boiling temperature.

If you have to remove the cap when the engine is at working temperature, let it cool off

Working in your driveway usually gives you more light and space than in the garage. If you need to work at the roadside, check that local bye-laws permit it.

Take care – save time and trouble

for about 15 minutes first; then cover the cap with rags or a newspaper and remove it with care. Do not remove the pressure cap immediately if the engine has overheated. If you do, scalding steam and coolant will spurt from the radiator.

Working on exhaust systems

The exhaust system also becomes very hot while the engine is running. Do not attempt to work on it while it is hot, and take care not to touch the manifold and downpipe in particular.

False economy is never a good idea in car maintenance, and this is especially true of the exhaust system. The problems with a faulty exhaust pipe or silencer are not only noise and reduced engine efficiency; there is a danger of poisonous carbon monoxide gas entering the car interior. If you make a temporary repair to the exhaust system, replace the part as soon as possible.

Avoiding electrical shocks and damage

Electric shocks (from the high-tension circuit), burns, or damage to the car electrical equipment can result from short circuits caused by working on the vehicle while wearing a wrist-watch or metal jewellery. Make it a rule to remove them when working on your car.

If you are working on or near the battery, make sure you do not accidentally touch both battery terminals at once with a metal tool. Take care also not to touch the live terminal with a tool you are using on a bare-metal nut, bolt or other earthed component near by. In both cases there will be a short circuit and considerable sparking, and the tool will heat up rapidly, or even melt.

Disconnect the battery (earth terminal first) when you are working on the car electrical system, unless you are making a test with the ignition switched on or with the motor running. Modern cars have an alternator type of generator, which has solid-state electronic parts. Many cars also have electronic ignition.

Accidental short circuits or wrong connections can instantly cause expensive damage to electronic components.

If you are disconnecting several electrical wires or cables at once – the sparkplug leads, for example – take time to label them to avoid confusion when reconnecting. Use numbered pieces of masking tape.

The electrical wiring in a modern car is complicated, but is colour coded to make it easier to follow. The colour coding is not, however, standardised, and can vary not only between makes of car but also between different models from the same manufacturer. If in doubt, take the car to an auto-electrician.

Replacing and renewing parts

If you remove several washers, spacers and lock washers at once – for example, when replacing a distributor – keep them in order on their bolts or screws so that you refit them in the correct sequence. If necessary, make notes and diagrams of the order when dismantling components.

Always replace a split pin with a new one of the correct size. The bent ends of a used split pin are already subject to metal fatigue, and will break easily. Carefully examine parts such as clevis pins to see if they are worn. If a clevis pin is 'waisted' (worn round the middle), for example, it will eventually break; fitting a new one will avoid such a failure.

If you are renewing any part of the car suspension, or any part affecting the handling or steering, it is usually necessary to replace the same part on both sides in order to preserve balance. For example, dampers, track-rod ends, brake pads and brake linings should be renewed on both sides of the car.

Taking precautions with petrol

Petrol vapour is highly flammable, so do not smoke while working on the carburettor or any other part of the fuel system, or when cleaning components with petrol. When working on the carburettor and fuel pump remember also that they are delicate mechanisms – take care not to lose small parts, and never blow through them with compressed air, because you may blow a hole through a thin membrane.

Keep any naked flames and live electrical wires, which could cause a spark, well clear of petrol or petrol vapour. If you use an inspection lamp on an extension cord, make sure it has a wire guard to protect the bulb – the hot filaments of a broken bulb could cause a fire.

If you break down on a motorway

Should your car break down on a motorway, steer on to the hard shoulder as far from the traffic lanes as possible. Switch on the emergency flashers (day or night) and place your warning triangle about 150 yds (140 m) behind the car in the centre of the hard shoulder, so that it is in plain sight.

If possible, get the occupants out of the vehicle on the nearside, and on to a bank or any other space beyond the hard shoulder. See that the car is always between them and the carriageway; also that they stay together and do not stray near the road. If there is no space beyond the hard shoulder, they should stay inside the car.

Do not attempt diagnosis or repairs on the motorway unless you know exactly what is wrong and you have the tools and the parts on hand – such as replacing a flat tyre with the spare wheel. The motorway is a dangerous place, and your car could be a hazard to other drivers.

You must get help so that the car can be driven or towed to a place of safety. Use the door furthest from the traffic to get out of the car. Never leave the car unattended on the motorway, except to make a telephone call to the emergency services.

The motorway emergency telephones are located at 2 kilometre intervals, and the arrows on the distance-marker posts (100 m apart) will show you in which direction to walk to the nearest one. It is an offence to cross the motorway to get to a nearer telephone – and is also extremely dangerous.

If you are an AA member, the motorway emergency centre will contact the AA for you.

Breakdowns on other roads

If your car breaks down on a road other than a motorway, your immediate objective must still be to get the car off the road, if possible. Push or drive it on to a verge or forecourt where it will no longer obstruct traffic, and where you will be able to assess the situation in safety.

If you cannot get the car well off the road, keep the emergency flashers on and put your warning triangle at least 50 yds (45 m) behind the car. On many roads there are telephones for the use of AA members. Otherwise, if you need help you will have to find the nearest public telephone.

Tools and aids to carry in the car

It is wise to be prepared for minor breakdowns by carrying a small set of tools in the car at all times – at least some ring and open-ended spanners, plain and cross-head screwdrivers, pliers and ball-pein hammer.

For emergencies, carry a warning triangle and a first-aid kit, and also a torch or lantern and a small fire extinguisher. Although fire in a car is fairly rare, it can occur; certain parts become very hot while the car is running, and petrol and high-tension sparks are present.

Make sure you know how to use the fire extinguisher. Putting a fire out quickly will keep costly damage to a minimum. It may also save lives.

On a long journey, especially if you are travelling abroad, you could have difficulty in getting parts for your car in the event of a breakdown. Be prepared by carrying with you a selection of spares. You can assemble these yourself, or you can hire a spares kit from a local garage dealing in your make of car, or from the AA.

For a garage or AA kit you pay a deposit at the time of hiring, and the daily hire rate is deducted from the refund when the kit is returned. You do of course also have to pay for any parts that have been used. The kit is compact enough to fit into the car boot, and may include parts such as sparkplugs and other ignition components as well as hoses, bulbs, fuses and drive belts.

For any journey, always carry spare bulbs for small lamps, spare fuses and a drive belt. For temporary roadside repairs it is also useful to carry various odds and ends that are not specifically car parts, but which may come in handy.

For example, baling wire (made from soft iron) can be used for holding many parts together as a temporary repair; hoses or exhaust parts, for instance, and small springs such as a broken accelerator spring. Stout rubber bands or pieces of old inner tube, a small tube of superglue, insulation tape and other such items can also prove useful.

Making emergency repairs

It is vital that a temporary repair be made permanent as soon as possible. Not only for safety, but also because the cause of the breakdown may be only a symptom of something more serious and potentially more costly.

Often, however, there are things you can do in order to keep going for a short distance after a breakdown. These are covered in the *Glovebox guide to car emergencies*, which is provided with the Course.

Lubricating hinges, pedals and locks

At regular service intervals clean and lubricate hinges on moving panels and foot-pedal pivot points. Check the accelerator cable for stiffness.

Door hinges should be checked more often than boot and bonnet hinges – they take more weight and get more use.

Oil metal-to-metal parts on door locks, and keep keyholes clean.

Tools and equipment

ENGINE OIL • CLEAN RAG • TORCH • VICE • SCREWDRIVERS • PLIERS • HEAVY GEAR OIL • PENETRATING OIL • PETROLEUM JELLY • METHYLATED SPIRIT • PLASTICINE • GRAPHITE POWDER • NEWSPAPER

Oiling foot pedals

Most brake and clutch pedals have a pendant action, and the pivoting parts will be above them, behind the dashboard. Use a torch to see them if necessary.

Pedals with nylon bushes do not need oiling. Pedals that swing on a steel rod need a regular injection of engine oil at pivots and on rubbing surfaces.

Place old newspaper under the pedals to catch drips, and clean off any surplus with a cloth. Wipe off oil that drips on to pedal rubbers with methylated spirit on a cloth.

Most accelerators have pendant pedals. Locate the pivot point – it is probably under the dashboard or beneath the bonnet. Lubricate metal-to-metal points with clean engine oil.

Some cars have accelerator pedals pivoted at the floor. Lift the carpet to avoid marking it, then lubricate the metal hinge with clean engine oil. If a floor-pivoted pedal is fixed to a shaft that operates through a metal tube, lubricate the inside of the tube.

Another type of accelerator pedal is called an organ pedal. It is hinged to the floor, and the pedal operates a normal pendant linkage. Lubricate the metal-to-metal links.

Rubber hinges do not need maintenance. Pedals bearing on a roller or pad do not need oiling, but keep them free from dust and fluff.

Where to oil hinges, restrainers and pedals

A plain hinge can be sprayed with lubricant.

Lubricate the restrainer with clean engine oil.

Put a little clean engine oil on the pivot point above a pedal with a pendant action.

Take the cap off a hollow hinge and fill the pin with heavy oil.

Lubricating the hinge on a hatchback type of boot lid.

Oiling hinges and restrainers

On door hinges lubricate friction surfaces and hinge pins with clean engine oil, wiping away any residue with a cloth.

Most car hinges have hollow, rolled-steel hinge pins with plastic caps top and bottom. Prise off the upper cap with a screwdriver and fill the pin with heavy gear oil – rear axle oil is ideal. Replace the cap, and wipe the hinge clean.

Hinges that are not hollow and do not have plastic caps can be sprayed with penetrating lubricant from an aerosol can if the hinge has stiffened. Once the action has eased, lubricate the hinge regularly with clean engine oil.

The door restrainer, or check strap, is designed to prevent the door being opened too far, which damages the hinges so that the door no longer closes properly.

Some door restrainers include a mechanism for spring pressure against a peg, to keep the door open and prevent the wind from closing it when people are getting in and out. A little clean engine oil will prevent the action of the restrainer from becoming rough and noisy.

Check the free movement of boot and bonnet hinges by opening and closing them. Most need only occasional lubrication.

When necessary, apply engine oil to pivot pins and wipe off any surplus.

Before oiling boot hinges, line the boot with old newspaper to catch any drips. Before removing the newspaper, check hinges and pins for tightness and boot and bonnet panels for alignment.

If adjustments are necessary, consult SHEET 74.

Rear-hanging bonnets usually have a dovetail bolt which locks at the front to a circular striker plate. If the dovetail is stiff, lubricate with engine oil. Smear petroleum jelly on the striker, where the dovetail lock makes contact.

Front-hinged bonnets usually have a pin-and-striker locking mechanism fitted to the bulkhead. Smear petroleum jelly over metal-to-metal parts.

Changing pedal pads

Peel off old rubber pads and clean the pedal and its stem with a cloth moistened with methylated spirit.

Wet new pads if they are hard to fit. If necessary, use a small-bladed screwdriver as a lever to ease the rubber into place.

Some pads are held by a metal clip. Fit a new clip, bending the fixing pads over the pedals.

Use a screwdriver if necessary to remove or to fit a pedal pad.

Freeing a sticky accelerator cable

If your car has a cable-operated accelerator and the action becomes sticky, the inner cable may have broken strands, which are snagging the outer casing. Loosen the cable at the carburettor end, detach it from the pedal end, and withdraw it.

Renew a damaged cable as soon as possible. As a temporary measure, unravel broken strands and nip them off with pliers.

Thread a new inner cable from the pedal end. Connect and tighten at the carburettor end, then at the pedal end. Check that it operates correctly at full throttle and the engine idles correctly. If it does not, adjust it, usually at the carburettor end. If the inner cable is stiff but undamaged, inject engine oil into the casing before reassembly.

Place the outer cable vertically in a vice, gripping it lightly. Mould a Plasticine funnel at the top.

Fill the mould with clean oil and allow it time to seep into the cable assembly – overnight if possible. Do not oil cables with nylon inserts.

Lubricating locks

Smear petroleum jelly on to the parts of the striker assembly where there is metal-to-metal contact. Wipe off surplus.

Nylon striker assemblies must not be oiled. Treat them with a silicone lubricant.

Do not use greasy lubricants on keyholes. Such lubricants attract dust and fluff which can hamper the movement of the tumblers.

Ease sticky locks by putting a little graphite powder on to the key before inserting it. Lock lubricant can be bought in an aerosol spray can.

Smear a little petroleum jelly on the metal-to-metal parts of the door latch.

Use graphite powder on the key to lubricate a lock.

Cleaning the interior and checking seat belts

Car interiors collect a lot of dust and grit, particularly on the carpet. Regular cleaning cuts down wear and discoloration, and gives the carpets and upholstery a longer life.

As dirt and grit builds up on the floor, it is embedded in the pile, accelerating wear and eventually cutting through the woven backing.

Stains or smears on upholstery or panels are more difficult to remove if left a long time, even on plastic.

At least once a year, give the inside of the car a 'Spring clean'.

Remove the carpet if possible, and check the floor for rust and leaks – carpets and underfelts tend to absorb moisture which can cause rusting.

Cleaning carpets, seats and headlining

Clean carpets with a vacuum cleaner if possible, or use a dustpan and stiff brush.

Lift off or slide the front seats to get underneath them. Remember to clean carpeting on door trims or a rear parcel shelf.

If the carpet can be removed, beat it thoroughly every six months or so. Most later cars have carpets screwed or glued in position.

Loose or torn carpet under the pedals can cause an accident. Use an impact adhesive to stick it firmly to the toe board.

Place a rubber mat over the carpet under the driver's heels, to reduce wear.

Ideally, clean cloth seats with a vacuum cleaner, using a narrow nozzle for deep joints in the seats and backrests.

Occasionally clean the upholstery with a thin layer of carpet shampoo and water, applied with a small, stiff brush. Do not soak the cloth – if the interior foam is wetted it takes days to dry.

Remove stubborn stains with a proprietary stain remover or strong solution of shampoo, but test first on a hidden area.

If the cloth changes colour, use a milder cleaner.

Wipe vinyl or leather seats with a damp cloth. If grimy, clean them with soap and water and wipe off suds with a clean, damp cloth. Remove stains with a vinyl cleaner.

Do not overlook the headlining.

Remove dust with a vacuum cleaner or soft brush. Do not press a suspended lining too hard, or the material will stretch and the lining will sag.

When removing stains, you may be left with a lighter area and so have to treat the whole lining.

On plastic linings, remove stains with a light application of vinyl cleaner on a damp cloth.

On cloth linings, use carpet shampoo very lightly applied with a soft brush. Do not press hard.

Cleaning glass, the dashboard and trim

Remove fingermarks and stains from glass, including instrument glass, with neat windscreen-washer additive on a damp cloth.

For the residue from stickers, use a little methylated spirit on a damp cloth.

A mixture of half methylated spirit and half water will remove tobacco stains.

Regularly clean all glass, including the rear-view mirror, with a chamois leather wrung out in clean, warm water.

Lower the side window to get at the top edge of the glass that fits in the window channel.

To clean a heated rear window, with a surface element, remove any rings and wear rubber gloves. Make sure there is no grit on the leather. A tiny scratch across one element can put the heater out of action.

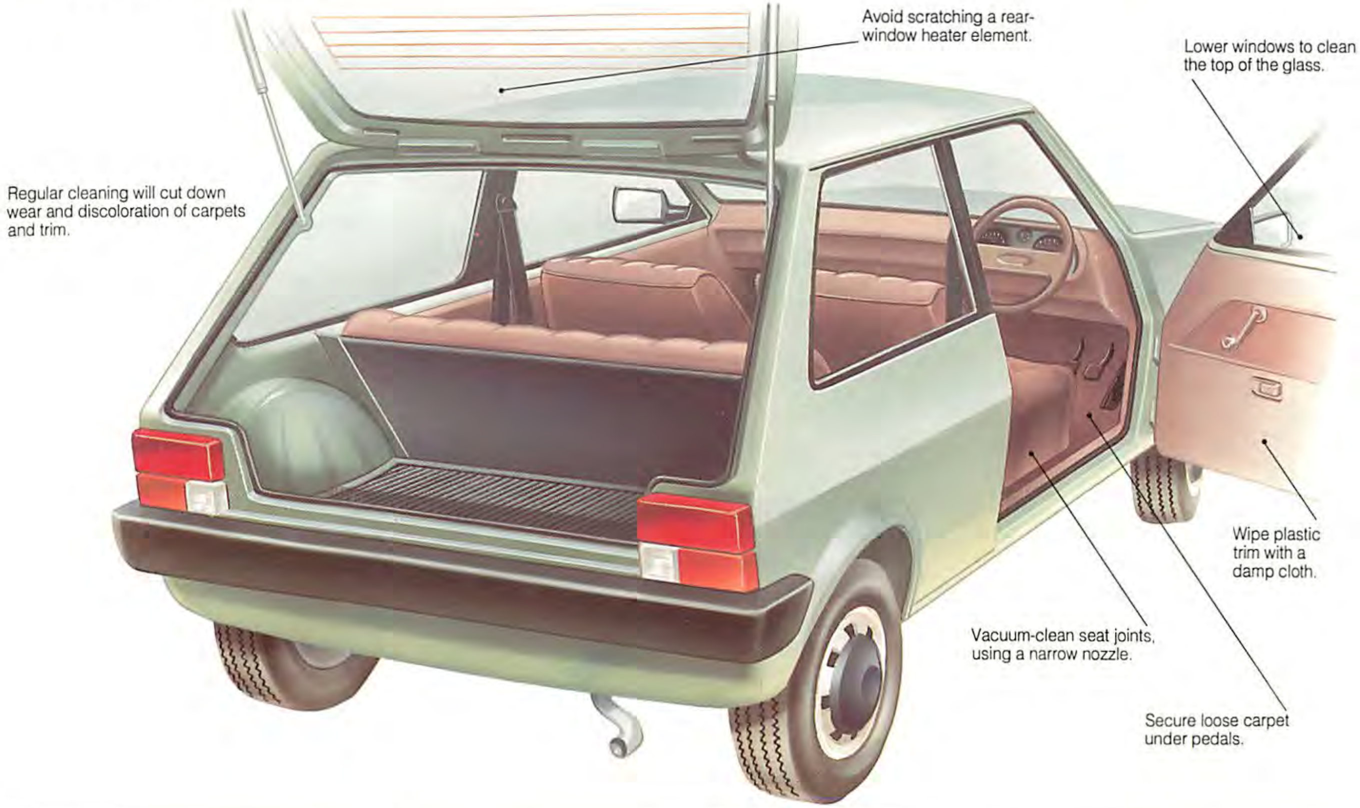
Once a year use a proprietary window-cleaning liquid to clean the inside of all window glass.

To clean the dashboard, wipe plastic with a damp cloth, and wood with a dry cloth. Mop up any water drops with a chamois leather wrung out in clean, warm water.

Wipe plastic trim with a damp cloth. Do not use too much water.

The board backing on panels distorts if wetted. Use vinyl cleaner for stubborn stains.

Points to clean and check

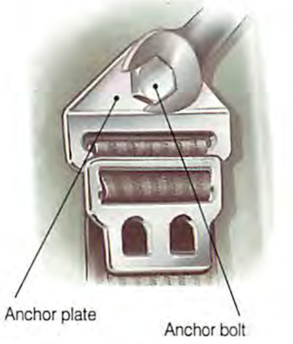


Checking seat belts

Use a spanner to check that all belt mountings are really tight. Make sure that an anchor plate can pivot freely on its bolt.

Check that belts are not twisted, and that the webbing sits flat when buckled against the wearer.

Renew seat belts if the webbing is frayed, torn or coming unstitched at the mountings. Do not worry about traces of fluff where the belt slides through the mounting buckle.



Check tightness of belt mountings.

For safety and to avoid wear, make sure belts can be parked on an upper hook when not in use. If the parking hook breaks, make another with plastic-covered wire.

Pull the webbing to test that an inertia-reel belt retracts properly. To work correctly, the reel must be horizontal when the car is level. Mountings may be kicked out of true by rear passengers. Check them with a spirit level while the car is unladen on a level surface.

If a mounting is off level, loosen and reposition it so that the spirit-level bubble is central, then retighten. On many reels, only limited movement is possible. Inertia-reel belts can be properly tested only with the car on the move (SHEET 274).

Use a spirit level to check if an inertia-reel mounting is out of true.

Cleaning the outside and checking for rust

To remove the film of grime which forms on the bodywork use plenty of clean water. Do not wipe with a dry cloth – the dirt will scratch the paint.

Never wash the car when the bodywork is in hot sunshine, as smears will form as it dries out too quickly.

Make sure all the doors and windows are shut before you start. Soak the car thoroughly with clean, cold water; ideally use a garden hose.

After soaking, wash the car body with a solution of car shampoo and tepid water.

Tools and equipment

HOSE • BUCKET • CAR SHAMPOO • STIFF BRUSH • CLOTH • SPONGE • TAR REMOVER • CHROME CLEANER • WINDSCREEN-WASHER ADDITIVE • CHAMOIS LEATHER • PAINTWORK RESTORER • WAX POLISH • THIN SCREWDRIVER • TOUCH-IN PAINT

Washing the car

Start with the roof and liberally apply the shampoo solution until the dirt floats away.

After the roof, shampoo the bonnet and boot lid, sides, front and rear, including chromework and plastic fittings.

If you are using a wax or silicone shampoo, avoid getting it on the windscreen as the wipers will smear when next used.

Use a stiff brush to clear trapped dirt from behind plastic bumpers, mouldings, number plates and crevices around front and rear lamp clusters. Wipe anodised aluminium, which has a coloured or gleaming silver finish, and other brightwork with a damp cloth.

Open the doors and sponge the inside metalwork and apertures.

Finish with the wheels. If they have complex surfaces, use a small, stiff brush to get into the crevices.

Rinse off all suds with a hose, or with buckets of cold water. If you are using a hose, now is a good time to wash underneath the wings and wheel arches.

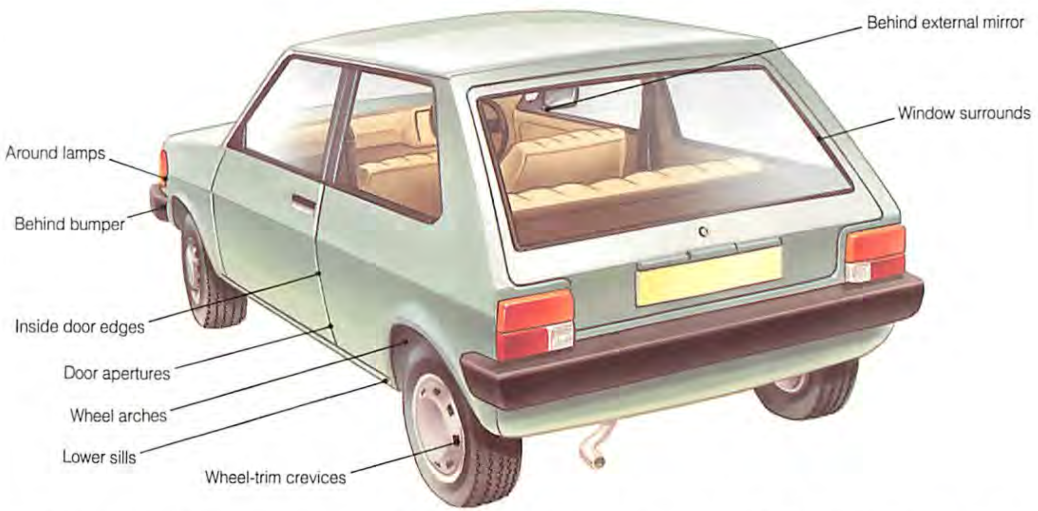
Check for tar spots and oil patches which have resisted the shampoo. Remove with white spirit or a proprietary tar remover. Sponge off the residue with shampoo solution and rinse again.

Clean the windscreen, windows and external mirrors with clean, warm water with a few drops of windscreen-washer additive mixed in. Apply with a clean sponge – not the one used on the bodywork.

Lift the windscreen wipers clear of the glass and sponge the edges of the blades with the solution.

Rinse all glass with clean, cold water. Mop up droplets on the bodywork with a good, clean chamois leather, frequently wrung out in clean, tepid water.

Checking for rust



Look for rust patches every time you clean the car. Treat them as soon as possible (SHEET 68).

Look particularly in corners and cavities of the bodywork, such as around headlamps, in corners of doors and window apertures, and inside door edges where the outer metal wraps over.

Small blisters on paintwork mean that rust has formed underneath.

Repairing blistered paintwork involves stripping the paint back to bare metal and treating the damaged area (SHEET 71).

Reviving dull paintwork

Paintwork which stays dull is usually covered with a haze caused by chemical pollution in the atmosphere, or has faded with age or in sunlight.

The shine can be restored with a mild abrasive cleaner, usually called a compound, which contains a cutting agent. It lifts a thin surface film of paint to uncover a clean layer beneath.

An abrasive cleaner damages some metallic finishes. Check with a dealer whether it is safe to use one on your type of paintwork.

Do not use a paintwork restorer regularly – it has a mildly abrasive effect on the paint. Once the shine has been restored, seal the paintwork with a good-quality wax or silicone polish and wash the car regularly to keep it shiny.

Never use old clothing torn up as rags when working on the bodywork. Zips and buttons can badly scratch the paint.

Wash the car and let it dry before applying paintwork restorer. If the compound is in liquid form, shake the tin thoroughly. Use a damp cloth or piece of muslin and cover about 18 in. (450 mm) square at a time. Do not rub too hard, particularly on corners where paint may be thin. You can easily cut through to the undercoat.

Paintwork restorers usually contain powdered chalk, which holds the haze in suspension. When you remove the chalk, you also remove the dirty paint. Wipe off with a clean, dry cloth.

Cleaning tarnished brightwork

Use a chrome cleaner to remove rust stains and other impurities from chrome.

Take care that it does not rub against the paint. Chrome cleaners contain strong abrasives and could permanently damage the paint.

After cleaning chrome, coat it with wax polish to prevent further rusting.

Untreated aluminium dulls with age. Brighten it up with a proprietary alloy polish. A coat of clear lacquer gives long-lasting protection.

Clearing drain holes

In places where water entry is unavoidable, such as a bonnet-top heater intake, the insides of doors and a sun-roof surround, drain holes are provided to allow water to escape.

Make sure they are clear, and probe them with flexible wire if necessary.

The heater intake has slit-ended rubber drain-pipes, usually two, which discharge under the bonnet. They may get blocked, and can usually be removed for checking and cleaning. The heater intake often gets blocked with leaves and should also be cleared regularly.

Use a thin-bladed screwdriver to poke out dirt blocking drain holes in the bottoms of doors.

Waxing or sealing the bodywork

Modern cars do not need regular waxing of painted panels.

Wax coating is usually effective for up to three months. Detergent in car shampoos, and the weather and industrial fall-out, eventually erodes it.

Some polymer sealants remain intact for longer, even if the car is washed regularly. They contain silicones and additives which are adherent to paint and metal surfaces, and form a bond that is fairly resistant to detergents.

Wax polishes are usually pastes or fluids, and most polymers are fluids. All are applied in the same way, and should be kept clear of the windscreen because they will cause smears on the glass when it rains.

They contain solvents to clean off grease and dirt, and leave behind a thin protective coating.

Wax polishes are relatively easy to apply, whereas polymers are harder to work up to a gloss.

Before polishing, wash the car thoroughly. Leather the paintwork and leave it to dry. On dull paintwork use a paint restorer to restore the gloss.

Do not polish in direct sunlight or on a warm bonnet. The mixture will dry too quickly and be difficult to remove.

Apply the polish with a soft, clean cloth, such as mutton cloth. Work in small sections about 18 in. (450 mm) square, and use a soft clean and dry cloth to remove the powder from each section before moving to the next.

The powder is difficult to remove if left too long.

If you accidentally smear the windscreen with wax or polymer, remove it with a cloth dipped in white spirit.

Touching in chipped paint

Stones thrown up from the road often chip paintwork. Touch in with new paint immediately, and repair properly as soon as possible (SHEET 71).

Areas particularly vulnerable are the front, the side sills behind the front wheels and the edges of wheel arches.

Seal with a dab of touch-in paint on a small brush, or use nail varnish in an emergency. Do not leave any metal bare.

Seal small chips or scratches with touch-in paint, using a camel-hair brush.

Replacing and adjusting windscreen wipers

Wiper blades are fitted bayonet-style to the end of the arm, or the end of the arm is hooked or has a side locking pin. If you renew just the rubber part, be sure to get the right one and follow the maker's instructions.

Wiper arms are fixed to their drive spindles by a clip, fixing nut or a screw. Usually the spindle is splined and the arm mounting cap is serrated.

When renewing wiper arms ensure that the new arm is fitted in exactly the same place as the old one was, so that it parks in the same position.

Do not fit the arm so that the blade parks against the windscreen surround – the blade will hit the rubber, accelerating wear and making a lot of unnecessary noise.

Tools and equipment

SPANNER • SCREWDRIVERS • PLIERS • REPLACEMENT BLADES

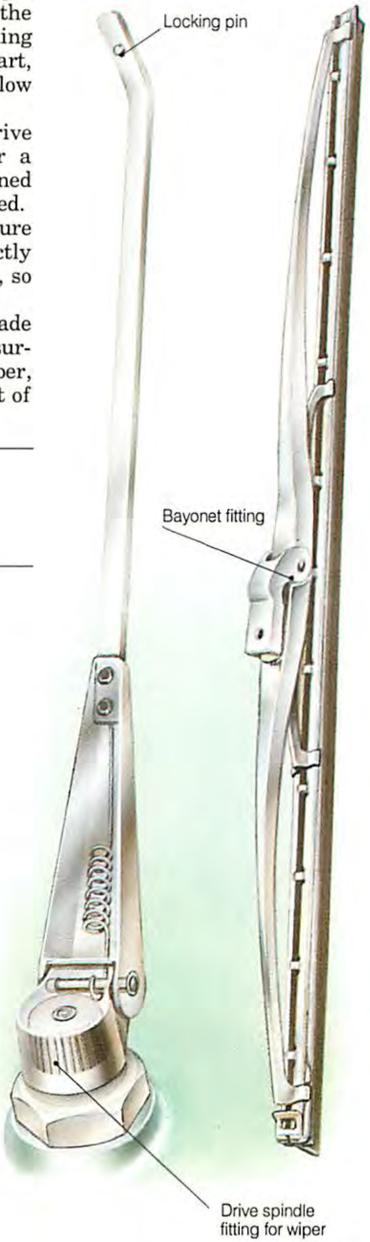
Adjusting the wipers

Before you start, make sure the blades are correctly parked and mark the position of the tip of each blade on the windscreen with a small piece of masking tape.

When the new arm and its blade are fitted, the blade tip should be in the same position on the windscreen.

If it is not, remove the arm again and realign, moving it one serration at a time on the spindle.

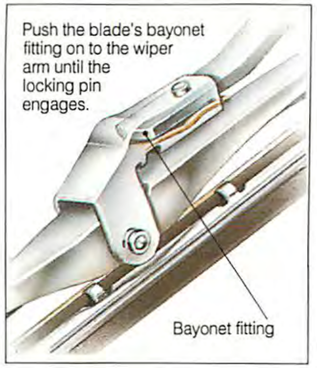

Mark the park position with tape.



Replacing wiper blades

Bayonet type The blade is a push fit on the end of the arm, which has a small raised pin that engages a hole in the blade mounting.

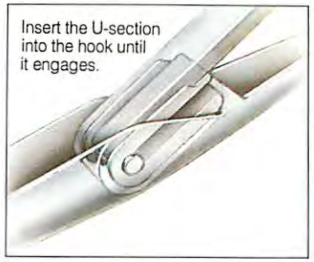
Disconnect by pressing the blade against spring pressure until the pin is disengaged. Some blades have a locking clip which must be moved to one side. The new blade simply pushes in.



Push the blade's bayonet fitting on to the wiper arm until the locking pin engages.

Hooked arms The blade carries a U-shaped plastic piece pivoted on a pin. The plastic fits inside the hooked end of the arm. To remove the blade, squeeze the ends of the U-shape together and move the blade down the arm to the open end of the hook; disconnect the U-piece from the hook.

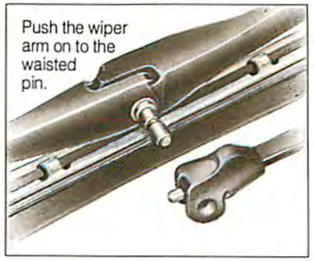
When fitting the new blade, thread the hooked arm through an aperture above the U-piece. Insert the U-section into the hook until a locking piece of plastic engages a cutout or notch in the hook.


Insert the U-section into the hook until it engages.

Sidelock blades Sidelock blades have a waisted pin on one side which engages in a transverse hole at the end of the arm. Press the locking clip away from the pin and withdraw the pin sideways.

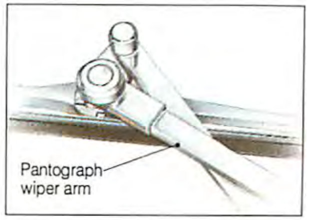
To insert a new blade, simply push the pin into the hole – but make sure the blade is above the arm. It can be fitted the wrong way round.

Some hook-ended arms are converted to take sidelock blades by inserting shaped plastic locking pieces into the hook.


Push the wiper arm on to the waisted pin.

To remove the blade, press the plastic insert towards the open end of the hook by bearing on the piece that overlaps it. Spread apart the two halves of the insert to release the blade. To fit the new blade, enclose the pin in the two halves of the insert and slide the assembly into the hook until it locks.

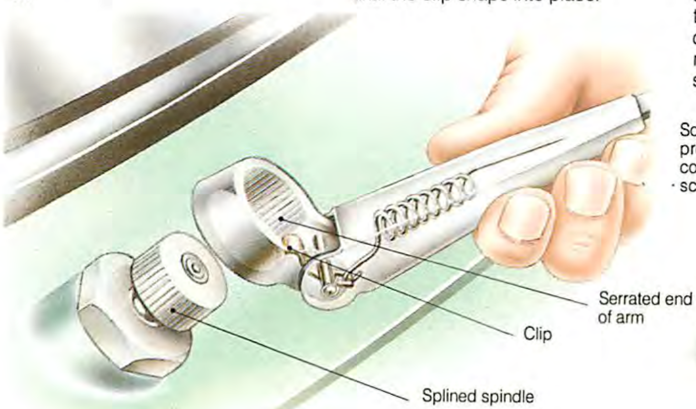
Pantograph type Some cars use a double pantograph arm. The blade will be fixed to two pivots, usually by locknuts. Unscrew or prise off any covers, and release the nuts to detach the blades.



Adjusting wiper arms

Arms held by clips The clip is fitted behind the arm, and bears on the spindle near the hinge pin. Once you can see the clip, use a screwdriver blade to prise it away from the spindle, and pull the arm off.

Fit the new arm with a blade attached to it, so that you can see that it is in the correct position. Push it partway on at first, and check the position. If it is correct, push the arm on the spindle the rest of the way until the clip snaps into place.



Arms held by a nut or a screw A screw at the spindle end of the arm is used instead of a clip in some systems. Remove the screw and pull the arm off the spindle.

Fixing nuts are not always so obvious, because car makers protect them with a hinged metal or plastic cover or a cap. Caps usually have a recess in the edge – use a screwdriver blade to prise them off.

Checking windscreen wipers and washers

Windscreen washers and wipers must, by law, be in working order. Keep the washer bottle topped up with water and ensure that the wiper blades and arms are in good condition.

Worn blades smear the windscreen and impair visibility. The makers recommend replacement every 12 months.

To keep the screen clear of oil and other pollutants, put some proprietary anti-smear additive in the washer bottle. Do not use washing-up liquid, which collects in the bottom of the bottle and clogs the non-return valve.

In winter, add screen-washer anti-freeze to the bottle. Do not use radiator antifreeze mixture, which will damage paintwork.

Tools and equipment

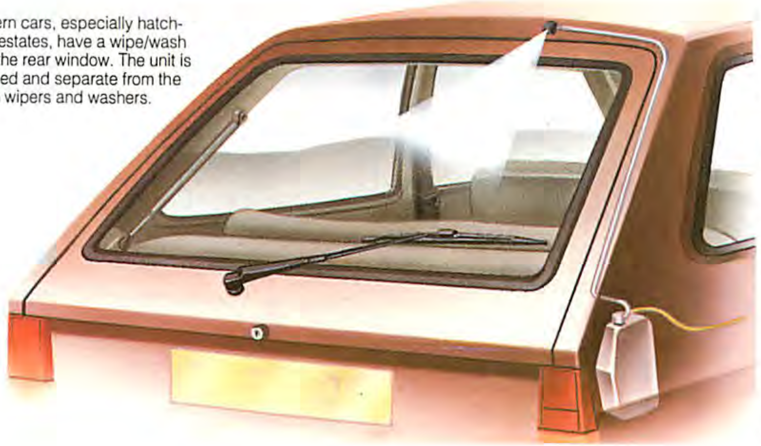
THIN WIRE • CIRCUIT TESTER OR TEST LAMP • SCREWDRIVERS • SPANNERS • EMERY CLOTH • TOOTHBRUSH • METHYLATED SPIRIT • CLEAN WATER • WASHER ADDITIVE • SIDE CUTTERS • HOT WATER • LIGHT OIL

How the washer system works

Fluid for screen washing is drawn by a pump from the washer bottle and fed to the spray jets.

Most systems incorporate a switch-operated electric pump, but some have hand-operated push-button pumps. Many washer bottles have a non-return valve at the foot of the pick-up pipe.

Many modern cars, especially hatchbacks and estates, have a wipe/wash system for the rear window. The unit is self-contained and separate from the windscreen wipers and washers.



Checking the pump and jets

On a manual pump the push button operates a spring-loaded diaphragm in a bottle with two nozzles attached to pipes. One pipe draws fluid from the washer bottle and the other feeds it to the jets.

If the pump does not work when the washer bottle is full, make sure there are no disconnected pipes, and check with a piece of thin wire that the non-return valve or jets are not clogged.

To check the pump, disconnect and remove it. Push in the plunger, block both nozzles with a wet finger and then let it go.

The plunger should stay in. If it returns to the at-rest position, the pump is damaged and a new one must be fitted.

Never operate an electric pump when the washer bottle is empty. The electric motor drives a flexible impeller to pump the water, and if it is continuously spun when dry, the blades can be damaged.

If the bottle is full but no fluid is delivered when the motor is running, check that no pipes are disconnected and that the pick-up pipe in the washer bottle is undamaged and immersed in fluid.

Check that the non-return valve or the jets are not blocked.

If the motor does not run when switched on, check that its electrical connections are secure.

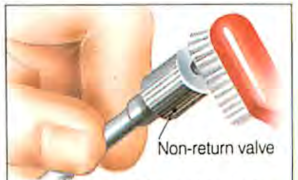
If the connections are good, switch off the ignition and disconnect the feed wire. Connect a circuit tester (SHEET 48) between the pump and the earth.

Ask a helper to switch on the ignition and the washer switch. If the lamp lights, there is current available and the motor needs renewing (SHEET 78).

If the lamp does not light, check the wiring and switch connections for faults (SHEETS 133-134).

If the flow rate through the jet is poor, remove the non-return valve and clean it with an old toothbrush dipped in methylated spirit. Wash the bottle and refill with clean water. Use only additives that are recommended by the manufacturer.

Check that the pipes linking the



Clean the non-return valve with a toothbrush and methylated spirit.

washer bottle, pump and jets are not kinked or flattened.

Sometimes a misplaced pipe is squeezed by the bonnet lid. If this is happening, re-route or shorten the pipe.

If a pipe is disconnected and the end no longer fits securely, cut $\frac{1}{4}$ in. (6 mm) fom the end.

Soften the pipe end by dipping it in hot water. Reconnect it.

Most jets are the 'eyeball' swivel type, mounted in a socket in a plastic housing. Some types have screws which adjust jet size and direction, and a few are just flattened tubes.

Water from the jets should hit the windscreen about 2 in. (50 mm) from the top of the wiper-blade sweep in mid-arc.

If the jets are wrongly aimed, use a pin in the jet hole to swivel an eyeball jet into the correct position. Adjust screw-type jets with a small screwdriver. Make sure tubes leading to the jets are not pinched or kinked.

Adjust an 'eyeball' jet with a pin inserted in the jet hole.

To clear a blocked jet, undo the plastic supply pipe and use a piece of thin wire or a bristle from a stiff brush to probe out the dirt.

Checking the wipers

Look carefully at the wiping edge of the rubber blade every time you clean the car. The rubber flexes sideways each time the blade changes direction, and eventually cracks near the edge.

The first sign is usually a split at the end of the rubber or an obvious wavy edge. Fit a new blade or new rubbers (SHEET 62).

Replacement rubbers vary according to the make of car. Make sure you buy the correct type for your wiper blade – use the old one as a guide. Follow the maker's instructions when fitting.

If the wiper blades skate over water on the windscreen, the probable cause is a faulty wiper arm. Fit a new arm.

Oil the hinge pin on the wiper arm every time the car is serviced.

A seized hinge pin prevents the springs from pressing the arm hard on to the windscreen, and the blade may skate over it.

Check that the hinge pin is not seized or worn.

Check the hinge pin for wear by gripping the wiper base in the left hand and sweeping the arm back and forth on the windscreen with the right hand.

Slight looseness at the hinge pin is acceptable, but if it is sloppy, fit a new arm.

If the hinge pin is sound and the wipers are still not pressing properly on the screen, the spring in the wiper arm has weakened. Fit a new arm.

If a wiper blade judders across the windscreen, something is out of alignment. Check that the hinge pin on the wiper arm is sound and that the nuts on the spindle bosses are tight.

Check the nut on the spindle boss for tightness.

If the parts are secure, switch on the wipers and, when the juddering arm is vertical, turn off the ignition so that the arm remains in that position. Remove the blade and let the arm end rest on the glass.

The flat part of the end, viewed end on, should lie parallel with the glass. If it does not lie parallel, use pliers or a small adjustable spanner to twist the arm gently into alignment.

Twist the wiper arm gently into alignment with pliers.

Cleaning and checking the underside

Mud and dirty water thrown up by the wheels is the principal cause of body rust on cars. If the underside is unsealed, keep underbody dirt to a minimum to reduce the chance of rust damage.

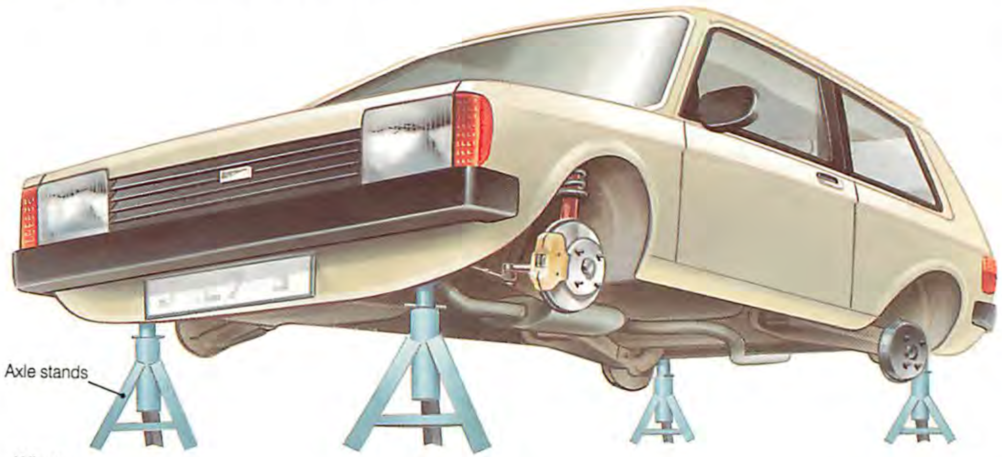
Dirt collects in corners and crevices, and absorbs water like a sponge. Impurities in the caked mud react with the metal and cause rust. Corrosive salt – put down in winter to prevent icing – is particularly harmful.

The most common areas of underbody rust are where dirt tends to stick, such as the front wings, particularly around the headlamps and the top rear corners just in front of the windscreen. Some cars also rust round the edge of the wheel arch.

Once caked dirt has been removed, hose the underside with a powerful jet at least once a month.

Tools and equipment

HOSE • PLASTIC SHEETING • ADHESIVE TAPE • CHAMFERED WOODEN BATTEN • WIRE BRUSH • PAINT BRUSH



Wings
The wings collect dirt and moisture thrown up by wheels.

Oil
The underside becomes coated with road grease which harbours moisture.

Box sections
Box sections of car's structure have drain holes which must be kept clear.

Sealant
Look for scrapes, cracks and lifting sections in underbody sealant.

Looking for trouble
Trouble spots are easier to check with wheels off and the car on axle stands.

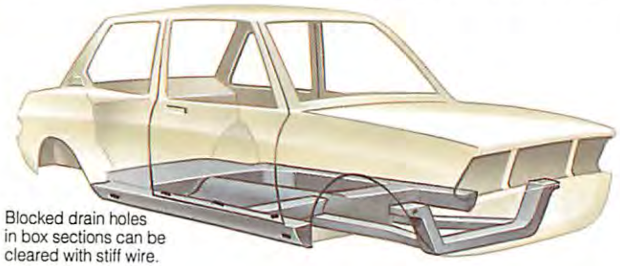
Checking box sections

Most modern cars owe their structural strength to box sections – hollow metal struts – on the floor pan. Because box-section metal is thin, it can soon rust through, so makers provide drain holes to let out any water that seeps in.

On late-model cars, most box sections are sprayed inside with a wax rust inhibitor.

Drain holes may be round or narrow slots next to a welded seam. Make sure they are not blocked with sealant or dirt. If they are, use a piece of wire to clear them.

The box sections under the doors are the most likely to rust. Other box sections are those which provide mountings for suspension and steering parts and power units.


Blocked drain holes in box sections can be cleared with stiff wire.

Removing oil

Most cars pick up a coating of oil on the underside of the floor.

To remove a heavy coating of oil, which could harbour moisture and dirt, brush or spray with an engine cleaner, and wash off with a hose.

Let a thin film remain. It will give some protection against rust.

If oil is dripping off, look for a leak (SHEETS 145–146 AND 247–249).

Cleaning under the wings

Loosen the wheel nuts and raise the car securely on to axle stands. Remove the wheels and cover the brake assemblies with plastic sheeting taped in place.

If the car has inner plastic mudguards which follow the curve of the wheel arch, the underwings need not be hosed. If mudguards are fitted only to the front wings, hose the rear wings.

Connect the hose firmly to a main tap and turn it full on. Adjust the nozzle to the most powerful jet, and aim the hose under a front wheel arch at the top rear corner.

As the water runs down you should see a river of dirt coming from inside the wing. Keep the hose trained on the area until the water runs clear.

Repeat the treatment in the top front corner of the wing interior, around the back of the headlamps.

If the car has MacPherson-strut suspension, play the hose round the upper mounting to remove dirt packed round the spring seating.

To clean the wheel-arch ledge, put the hose inside the wing and train it on the ledge from above. Remove any other areas of dirt under the wing with the jet.

Repeat the procedure on the other wings.

Turn off the hose and inspect under the wings with a torch. Do not use an unprotected inspection lamp, as dripping water can shatter a hot bulb.

Look for any pockets of dirt. Use a chamfered wooden batten to poke dirt out from crevices and the wheel-arch ledge.

Remove the final film of dirt with a stiff brush dipped in hot water.


Use a powerful jet of water. Spray in corners until water runs clean.

Checking and repairing underbody sealant

The two main types of underbody sealant are a bitumastic compound which dries hard, and a waxy compound which remains soft.

Mastic-based sealant has good resistance to abrasion, and it is particularly useful for protecting the front underwings against stone chippings. In time it cracks or lifts, and water can seep underneath.

Waxy sealants give less protection against abrasion, but do not crack. If the surface is scratched, the surrounding sealant creeps in to cover the area again.

Many car makers now use a PVC coating. It bonds securely to the metal, does not crack and is very resistant to abrasion.

Regularly check the condition of the underbody sealant. If it is damaged it must be repaired to prevent rust. Try to use the same type of sealant – not all types are compatible (SHEET 73).


Remove loose sealant and clean the spot with a stiff wire brush.


Use anti-rust preparation on bare metal and follow maker's instructions.


Applying primer to the bare metal gives added protection. Allow it to dry.


Apply brush-on underbody sealant thickly, working it into crevices.

Removing a door trim panel

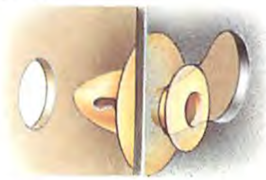
Before a door-trim panel can be removed, the window winder and interior handle must be taken off, and probably also the push-button lock and an arm rest, if fitted.

A variety of fixing methods are used for the fittings, including screws, clips, press studs and lugs.

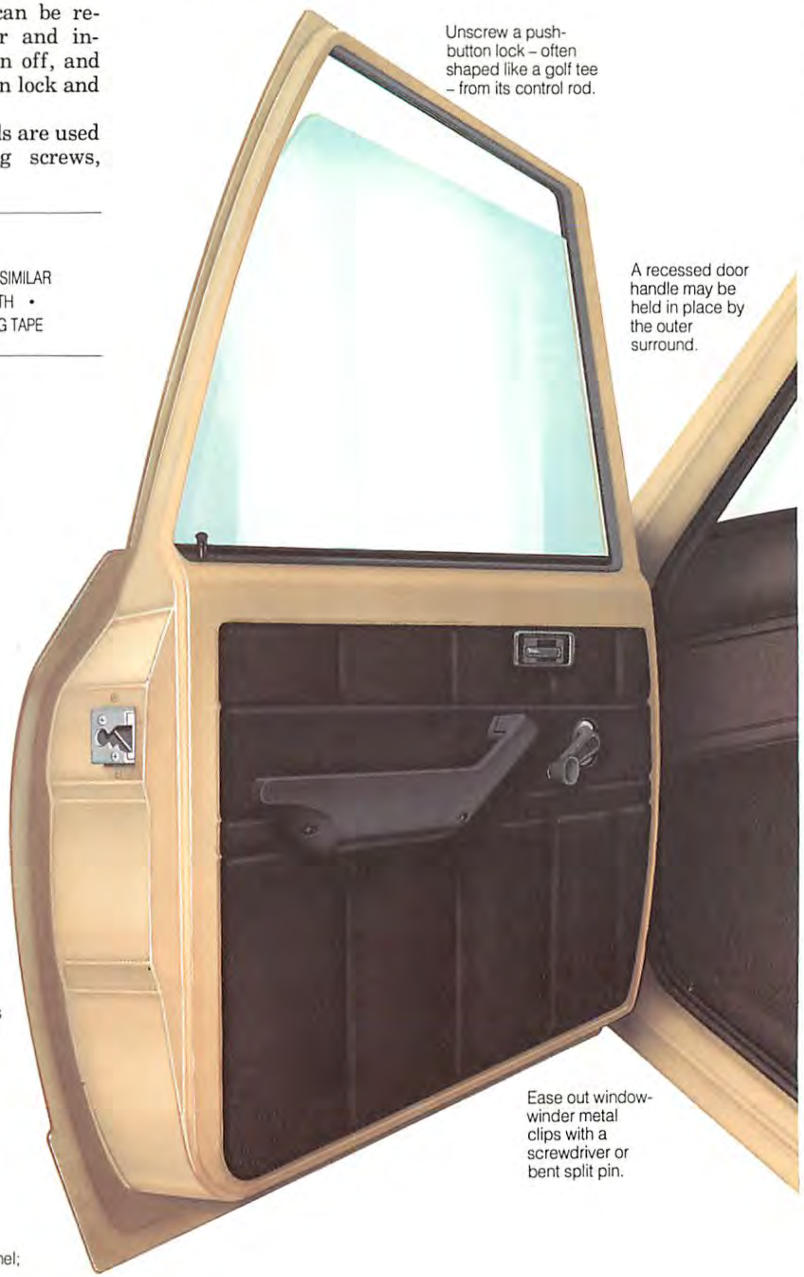
Tools and equipment

SCREWDRIVERS • KNITTING NEEDLE OR SIMILAR IMPLEMENT • BENT SPLIT PIN • CLOTH • DOUBLE-SIDED ADHESIVE TAPE OR MASKING TAPE

Push-in metal clips are sometimes used to fix trim panels.



Plastic press studs are the commonest method of panel fixing.



Unscrew a push-button lock – often shaped like a golf tee – from its control rod.

A recessed door handle may be held in place by the outer surround.

Arm-rest screws – usually cross-headed – are sometimes concealed underneath.

Ease out window-winder metal clips with a screwdriver or bent split pin.

A typical interior door-panel layout, showing the fittings attached on most cars. Take care when removing the panel; it is flimsy and can easily be damaged.

Removing a window winder

There are three common ways of securing window winders. The simplest is with a central screw, often concealed by trim.

If there is no screw, press the panel towards the door and look behind the winder to its spindle.

Turn the winder and watch for either a fixing pin or a bent metal clip holding it to the spindle.

With the panel still pressed back, remove the pin or slide back the clip. Force out a pin with a slim implement such as a knitting needle.

To unfasten a metal clip, use a screwdriver to ease it from its slot, or hook it back with a bent split pin.

Prise off the trim.

Push out fixing pin with a knitting needle.

Slide a metal clip back out of its slot.

Removing a door handle and a push-button lock

Recessed interior door handles are often held by countersunk screws. Remove the screws, swing the assembly away from the door and unclip it from the control rod.

If there are no screws, the handle is normally held in place by the outer plastic surround. This is sometimes pressed into the trim and can be prised out with a screwdriver.

Alternatively, it may be a slide-on fit over lugs, removed by sliding and levering with a screwdriver.

If levering fails to shift the surround, consult your local main dealer or a service manual to find out how it is fitted.

If a push-button lock has to be removed, you can usually unscrew it from its control rod.

Sliding out a door-handle surround.

Removing arm-rests and luggage bins

Most arm rests are held in position by large self-tapping screws that tighten into nylon fasteners fixed in the door frame.

Look underneath the arm-rests for the screw heads. They are often concealed under a flap of plastic trim. If there are no screws, the arm-rest probably comes away with the panel.

Luggage bins are usually fixed in the same way as arm-rests.

Undoing the trim fixings

The commonest way of fixing trim to a door is with plastic press studs on the panel that plug into retaining holes in the door frame. Alternatively, metal clips may be used.

Protect the paintwork with a folded cloth and insert a wide-bladed screwdriver under the panel at the bottom rear corner. Lever it until you can see the nearest stud.

Protect paintwork with a folded cloth as you gently lever out trim panel.

Insert the screwdriver beside the stud and twist gently to lever it out. Repeat for each stud.

On some cars the upper edge of the trim fits into a channel, and can usually be pulled out once the press studs have been removed.

If you still cannot remove it, the upper edge may additionally be held by lugs that fit into slots on the frames. Gently manoeuvre the panel until it comes free of the lugs.

Beneath the panel, plastic sheets will be taped to the door frame as a condensation barrier.

The sheets are held with double-sided tape. Check their positions and remove them. Always replace them before refitting the panel.

Refitting the trim panel

Seal the condensation barrier in position with adhesive tape.

To refit the trim panel, slot it into position, then engage each stud by striking the panel with the palm of your hand.

Align studs with holes in the door.

Adjusting and replacing window-winding mechanisms

There are three basic systems used to raise and lower car windows: mechanical linkage with scissor action; cable and pulley; or rack and pinion.

No two manufacturers use exactly the same design for window-lifting systems of the same basic type. Details vary from car to car.

If you need to fit a new mechanism because of accident damage, breakage or wear on the old one, obtain the correct replacement from the spares department of a main dealer for the car.

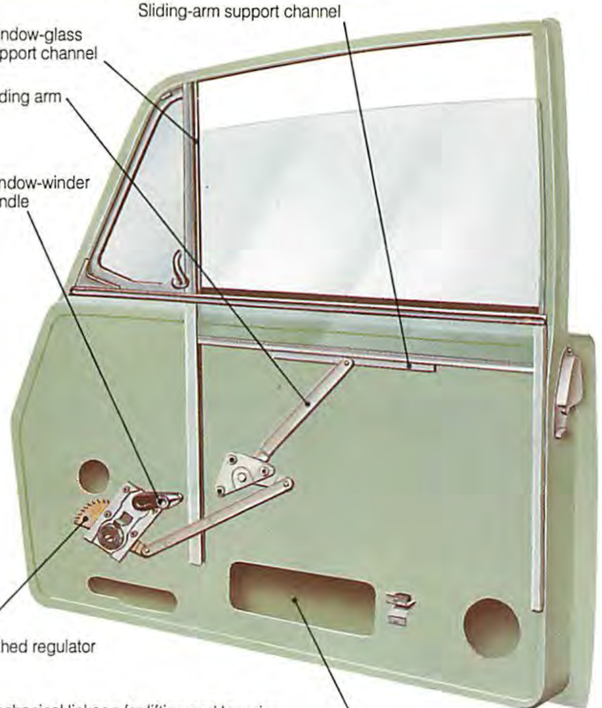
Tools and equipment

SCREWDRIVER • SPANNERS • PIN PUNCH • SMALL HAMMER • PLIERS • ADHESIVE TAPE • GREASE • ENGINE OIL • REPLACEMENT PARTS

Undo the toothed regulator, and reach through the access aperture to disconnect the sliding arm.

After disconnecting the arm, withdraw the linkage through the access aperture.

Renewing a link-type mechanism



Mechanical linkage for lifting and lowering the window glass includes a sliding arm that operates by scissor action.

Fully close the window and tape the glass to the top of the window frame. Use strong tape, as this must hold the glass to prevent it dropping when the mechanism is removed.

Take off the door fittings and trimmings and the inner door panel (SHEET 65). Carefully remove the polythene condensation-barrier sheet behind the panel and set it aside for reuse.

Undo and remove the screws holding the toothed regulator to the door frame and put them in a safe place. Push the regulator into the door interior.

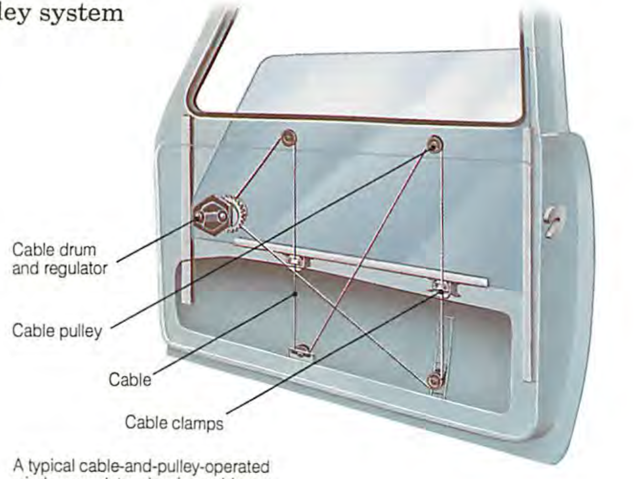
Reach through the door access aperture to disconnect the sliding arm. It may fit into a bottom channel, or it may be held by a centre pivot secured by three screws.

After disconnecting the sliding arm, move the regulator and the arm sideways in both directions until the upper end comes away from the sliding channel at the bottom of the glass. Lift out the mechanism through the access aperture.

Before fitting the new mechanism, grease the pivot and sliding bearings, and the gear teeth on the regulator. Lightly smear the whole mechanism with petroleum jelly which will act as a protection against rust.

To refit the new assembly, which includes the regulator and sliding arm, follow the removal procedure in reverse. Retape the polythene sheet in position. Test the mechanism before refitting the door panel and trim.

Adjusting a cable-and-pulley system



A typical cable-and-pulley-operated window regulator showing cable run.

The cable may slacken after long use, causing play in the winder mechanism as the handle changes direction between up and down. Adjusting a pulley to take up the slack in the cable will correct the fault.

Take off the door fittings and trimmings and the inner door panel, including the polythene condensation-barrier sheet (SHEET 65). Check the condition of the cable; even if it is only slightly frayed, it must be renewed. If not frayed, it can be adjusted.

Look for the adjustable pulley, which slides sideways on a mounting in the door frame to alter the cable tension.

Loosen the pulley mounting and move it to take up the slack in the cable. Retighten the mounting and check that the winder action is smooth. If necessary, readjust the pulley until it is. Take care not to over-adjust, which will strain the cable and regulator

If the cable is broken or frayed and needs renewing, you will probably have to buy it as part of a complete assembly with a new regulator.

There are different assemblies for right-hand doors and left-hand doors. Make sure you buy the correct one.

To fit a new cable, take the cable clamps off the bottom of the window glass, push the window closed, and tape it to the top of the frame.

Undo the fixing screws to remove the regulator and cable drum, and the cable. Slacken the adjustable pulley. Screw the new regulator and its loop of cable in position.

To wind the cable on to the grooves of the cable drum, take the length fixed to the drum on the side nearest to the middle of the car. Loop it round the furthest bottom pulley.

Fit the winder to the regulator and drum. Keeping the cable taut, wind it on to the drum. Turn the winder anti-clockwise on a right-hand door, clockwise on a left-hand door.

Take care that the spare part of the cable does not wrap round the drum, and wind until all the grooves in the drum are filled and the upper part of the cable is vertical.

Keeping the cable taut, loop it round the rear upper pulley, the front lower pulley, and the front upper pulley. Make sure it does not kink.

Tension the cable by moving the adjustable pulley. Oil the pulley spindles with engine oil, and grease the cable.

To re-attach the window glass to the mechanism, wind the cable fully down, then up again one full turn of the winder. Some regulators have an indicator to mark the point. Untape the glass, lower it fully and re-clamp it to the cable.

Test the winding action several times. If the glass does not move up and down smoothly, reposition it on the cable until it does. Replace the polythene sheet and refit the door panel and trim.

Replacing a rack-and-pinion system

Take off the door fittings and trimmings and the inner door panel, including the polythene condensation-barrier sheet.

Wind the window down until you can undo the plate holding the glass to the rack. Push the glass to the top of the frame and secure it with tape.

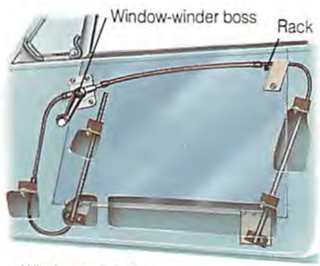
To remove the rack, undo the screws at its top and bottom and at the winder-handle boss.

The bottom screws of the rack may be on the underside of the door. Lift out the rack and winder boss through the access aperture.

Grease all the moving parts of the new rack assembly before fitting.

Position the handle-fixing holes on the boss to align with the winder handle. Refit the handle and wind the mechanism fully down. Untape the glass and refit it on the rack.

Check that the glass moves smoothly up and down. If not, adjust its position on the rack until it does.



Window regulator using rack-and-pinion system.

Drilling holes in the bodywork

Drilling one or more holes in the car body is necessary for fitting extras such as an aerial, wing mirror or tow bar.

Although it is not difficult, mistakes are expensive. One slip of a power drill can cause £100 damage to paintwork in a matter of seconds.

Before picking up a tool, plan exactly what you are going to do, and the best way to do it.

Never drill a hole without considering what is behind it, and so avoid accidents such as piercing the radiator when fitting a badge to the grille, the petrol tank when fitting a reversing light, or causing a short circuit when fitting an extra gauge.

Most holes can be made with a power drill and a suitable bit. Always use a small bit to start with, to make a pilot hole. For larger holes there are power-drill attachments such as cone-shaped grinders and cutters.

Metal cutters or punches can usually be hired from specialist firms. Where blades are fitted, make sure you have a supply of spares.

Tools and equipment

CENTRE PUNCH • HAMMER • POWER DRILL AND BITS • RAT-TAIL FILE • SUITABLE METAL CUTTER WITH SPARE BLADES IF USED • MASKING TAPE • PENCIL • MEASURING TAPE

Enlarging a drilled hole with a file

Most aerials need a hole about ¾in. (19mm) across. It is impractical to drill a hole as large as this, but a smaller hole can be enlarged with a file.

Mask the area and mark the hole in outline. Drill a ⅜in. (10mm) hole in the manner described.

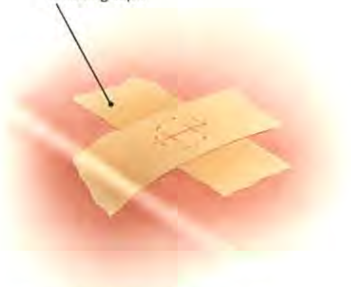
Take a ¼in. (6mm) rat-tail file and wrap five or six layers of masking tape round the tip, overlapping it at the end.

The tape will prevent the file from damaging the paintwork if it accidentally slips from the hole while you are working.

Use the file vertically in the hole to enlarge it, working evenly around so as to get a true circle.

Work evenly round the hole, keeping the file upright.

Drilling a hole



Protect the bodywork with a cross of masking tape and mark the spot to be drilled in pencil.

Use a centre punch to indent the metal ready for drilling. Make a light indentation only.

Use a small bit for the pilot hole. Keep the drill upright and run it at a fast speed if the speed is variable.

Car bodywork is curved and shiny, and scratches easily. To prevent the marking tool or drill sliding off course, put a cross of 1 in. (25mm) wide masking tape over the place to be drilled.

Carefully choose, measure and mark the exact spot lightly with a pencil. Use a hammer and a sharp centre punch to make a light indentation in the metal.

If your power drill has variable speeds, set it at a fast speed.

Select a small bit, not larger than ⅛in. (3mm) to drill a pilot hole through the punch mark. The pilot hole will provide a centre for a larger bit.

Use a series of larger bits to drill the hole to the size needed. In general, each size of bit used should be no more than twice the diameter of the one before.

So after drilling a ⅛in. (3mm) pilot hole, use a 3/16in. (5mm) or ¼in. (6mm) bit to enlarge it.

To extend the hole again use a ⅜in. (10mm) bit.

Nibbling large apertures

A nibbler or sheet-metal cutter is used for removing large areas of metal, such as cutting window apertures in the side of a van.

Mark the aperture in outline. By the method described, drill a ¼in. (6mm) hole at any point just inside the aperture outline.

Insert the nibbler blade in the hole. When you squeeze the nibbler handles, the blade cuts a slot about 3/32in. (2mm) wide. Each squeeze advances the slot about ¼in. (6mm).

The blade is very hard, but can easily snap when negotiating a corner. Make sure you have spare blades available.

Using a tank cutter

A small tank cutter with an adjustable blade can be fitted to a carpenter's hand brace to cut a hole for an aerial or wing mirror.

It is not the easiest way of cutting a hole in a car body, and may prove less accurate for larger hole sizes. A round-hole punch is preferable.

The blade of a tank cutter can be adjusted to the diameter of the hole required. It revolves round the drill bit to cut out a circle of metal.

Start by drilling a pilot hole in the centre of the cutting circle. Keep the hand brace upright while cutting the hole.

Using a round-hole punch

A round-hole sheet-metal punch has two interlocking pieces that fit on each side of a metal panel to punch a fixed-diameter hole when tightened (SHEET 47).

It can be used for aerial or wing-mirror holes. A different punch is needed for every hole size. Unless the punch blade is very sharp, it will crinkle the hole edges.

Mask the metal and mark the centre of the hole required. By the method described, drill a hole large enough to take the punch bolt.

Assemble one half of the punch on each side of the panel. Pass the bolt through to join them. Tighten the bolt to punch the hole.

To dismantle, undo the bolt and separate the halves.

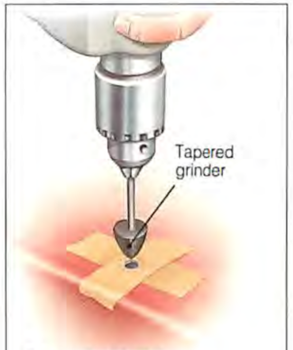
Turn with an Allen key.

Using a tapered grinder

A cone-shaped tapered grinder or cutter (SHEET 50) can be fitted to a power drill. It will make holes of different sizes up to the maximum of its diameter. Used at an angle it will make oval holes.

It is useful for making holes such as aerial or wing-mirror holes.

Mask the area and mark the outline of the hole. Drill a central pilot hole in the way described.



Enlarge the pilot hole.

Enlarge it with the cutter or grinder until it reaches the outline mark. Be careful not to go beyond.

Do not try to speed up cutting by forcing the tool. The very thin metal often used for car wings will easily distort.

Eliminating rust before painting

Steel exposed to damp air begins to rust in minutes. If there is any rust on it when it is painted, the rust will spread under the paint.

Car makers treat their body shells before painting by spraying them with a form of phosphoric acid, which is then thoroughly rinsed off.

Most rust preventatives on sale have an acid base. There are two types: rust-removing fluids and rust-resistant primer paints.

The acid used is usually phosphoric, but hydrochloric or tannic may also be used.

You apply the fluid, leave it to act for a certain time, wipe it off, then rinse carefully with clean water and dry thoroughly before priming and painting the treated area.

Some removers are in jelly form so that they do not drip on to sound paintwork, which would be damaged by the corrosive action of the acid.

If you do spill such a fluid on paintwork – or on anything else, including your skin – wash it off at once with plenty of water.

Rust-resistant primers have a less drastic action. The makers recommend that you remove most loose rust before using them. You apply the primer and allow a specified time for it to take effect.

Some kinds do not dry fully when applied to a non-rusty surface – you wipe off the excess and, if any bare metal is exposed, apply a normal primer.

Tools and equipment

WIRE BRUSH OR ELECTRIC DRILL WITH SANDING DISC OR FLAP WHEEL • FLEXIBLE KNIFE • GOGGLES • RUBBER GLOVES • RUST-REMOVING FLUID OR RUST-RESISTANT PRIMER PAINT • WET-AND-DRY ABRASIVE PAPER • CELLULOSE STOPPERS • PAINT BRUSHES • WHITE SPIRIT OR METHYLATED SPIRIT • RAG • PLASTIC SHEETING • JAR

Treating severe rusting

Use an electric drill fitted with a sanding disc or a flap wheel to cut away the surface rust. Take care not to go through good metal.

Treat deep or widespread rust with an acid rust-removing fluid. Read the maker's instructions before using it.

Clean off loose rust or paint with a wire brush or coarse emery cloth, or use an electric drill fitted with a sanding disc or flap wheel.

Wear protective goggles to guard your eyes against flying grit and dust. Wipe away grease and wax with a cloth moistened with white spirit.

If there is any risk of rust-removing fluid dripping on to sound paint or other parts, cover these with plastic sheet.

Wear rubber gloves and work in a well-ventilated place.

Pour a little fluid into a glass or plastic jar. Apply it only to the rust area, with an old paintbrush. After a few minutes, work it into the metal with wire wool or a small wire brush. Leave it on for the recommended time, and wash it off with water or methylated spirit or wipe it away with a clean cloth, as instructed by the manufacturer.

When the area is completely dry, apply primer paint and, if necessary, cellulose stopper to level the surface, as with smaller rust patches.

Apply rust-removing fluid with a paint brush – do not let it splash on to good paint. If it does, wipe off immediately.

Treating small rust patches

Clean up small chips in paintwork with a scrap of coarse wet-and-dry paper, used dry. Work until you get on to good, firm paintwork around the chip.

Small, shallow rust patches such as those caused by flying stones can be treated with rust-resistant primer.

Wipe the area and about an inch all round it with a cloth moistened with white spirit, to remove any wax.

Scrape away all the loose paint and rub down the rusty area with a scrap of coarse wet-and-dry abrasive paper, used dry.

Rub down until you reach sound paint all round, but not beyond. Wipe away dust with a clean cloth.

Brush on the primer, overlapping the sound paint by about ¼ in. (6 mm) all round. Let it dry.

If it is the type that does not dry on non-rusty areas, wipe off the surplus with a clean cloth moistened with methylated spirit.

Bring the damaged area up to the level of the surrounding paint by smoothing on a thin layer of bare-metal cellulose stopper, using a flexible knife. Use grey stopper for light paint, red for dark. Let it dry completely.

Apply a rust-resistant primer with a small paint brush.

Smooth the stopper with 400-grit wet-and-dry paper dipped in water, so that it blends into the surrounding paint. When working on broad, flat areas, wrap the paper around a sanding block.

If you expose bare metal, you need to prime it again.

When the primer is dry, use cellulose stopper to bring the area up to the level of the surrounding paintwork.

When the stopper has hardened, flatten it down with medium and fine grades of wet-and-dry, used wet.

Smoothing out a dent

The best way to treat a dent is to raise the metal almost to its original level, then to level the surface with a thin layer of plastic body filler. You can do this with most of the plastic filler kits available.

There are two types of filler – powder which you mix with resin and sometimes with hardener as well; and ready-mixed paste to which you add hardener.

The paste is easier to use although a little more expensive than resin and powder. With either, be sure to follow the maker's instructions carefully.

Work in a dry, warm atmosphere, at a temperature of 60°F (16°C) or above. If it is colder, use an electric heater or hair dryer to help the filler to cure (harden).

Tools and equipment

BALL-PEIN HAMMER • CLAW HAMMER • WOOD BLOCK • ELECTRIC DRILL • ABRASIVE DISC • FILLER • RASP • STOPPER • WET-AND-DRY PAPER • PLASTIC SPATULA • SANDING BLOCK

Preparing the surface

Make the dent as shallow as possible. If you can reach behind the panel, push it out by hand or, by gentle use of a ball-pein hammer with a piece of wood held against the outside. Leave the dent slightly below the surrounding surface.

If you cannot reach behind the panel, drill a small hole in the deepest part of the dent. Screw in a self-tapping screw, but leave it protruding about ½ in. (13 mm).

Hook a claw hammer under the screw head. Pull the hammer to raise the dent. For a harder pull, lever with the hammer head resting on a broad piece of wood. For small dents, grip the screw with self-locking grips and pull to raise the dent.

Hold a flat piece of wood over the outside of the dent. Use the rounded end of a ball-pein hammer to gently tap out the dent from the inside.

To pull out a large dent, screw a self-tapping screw in the centre and use a claw hammer under the head of the screw and lever against a piece of wood.

Small dents can often be pulled out more easily, depending on their location. Drill a small hole in the centre of the dent and screw a self-tapping screw in, but leave the head and a few threads exposed. Grip the head with self-locking grips and pull outwards.

Applying the filler

Use an electric drill with a wire brush, abrasive disc or flap wheel to remove all the paint down to bare metal in the dent and for about 1 in. (25 mm) around it. Score the metal with a spike to help the filler 'key' into it.

Mix the filler according to the instructions. Try not to mix more than you will need. Apply it quickly once you have added the hardener, using the plastic spatula supplied or a flexible wallpaper scraper.

Spread it firmly and evenly into the dent so that the surface is slightly higher than the surrounding bodywork.

Leave it to harden completely. The hardening time will depend on the amount of hardener added and the air temperature. In a warm atmosphere and mixed to the manufacturer's instructions, most fillers will set within 30 minutes. Do not try to sand it while it is still soft: that might pull it away from the metal.

Use a rasp or a multi-bladed plane, such as a Surform, or an electric disc sander to roughly shape the surface – but still leave it a little higher than the surrounding bodywork.

Wrap coarse (80 or 100 grit) wet-and-dry abrasive paper around a hard rubber sanding block.

Dip it in water, and start shaping the filler: take your time. As it nears the right shape, change in stages to medium (240 grit) and the finer (320 grit) paper.

Use fine (400 grit) paper for the last stages. Always keep the paper well rinsed and wet.

When the shape seems right and smooth, wipe away dust with a cloth, let the repaired area dry, and inspect the surface. Run your fingers lightly along the edge of the filled area to feel for a ridge which will show when painted.

Fill any air holes or scratches with a little stopper, and let it harden. Rub down with very wet 400-grit paper, then clean the whole area with a dry cloth.

Allow plenty of time for the area to dry out completely before priming and painting (SHEETS 71-72).

Use a drill and disc or flap wheel to sand down to bare metal for about 1in. (25mm) in and around the dent.

Once the surface has been prepared, mix up sufficient body filler and smooth over with the plastic spatula.

Roughly shape the hardened surface with a rasp, then change to a hard rubber sanding block wrapped with a sheet of coarse wet-and-dry abrasive paper.

Fill small dents and scratches with stopper, and lightly rub down.

Use progressively finer grades of wet-and-dry paper to get a smooth finish.

Patching rust holes

If a hole in the bodywork is not in a load-bearing area, such as a section of the chassis, it may be repaired with glass fibre, body filler or the more recently introduced filler-fibre mixture.

There are proprietary kits available which contain all the materials necessary for making repairs. Many of the materials can also be bought separately from accessory shops, garages or specialist firms.

Use an electric drill fitted with a wire brush, sanding disc or flap wheel to take off the paint for about 2 in. (50 mm) all round the hole. Wear protective goggles to guard your eyes against flying grit and paint dust.

Cut out any weak and rusted metal with tin snips. If any traces of rust remain, treat the metal with a rust preventative (SHEET 68).

Tools and equipment

ELECTRIC DRILL • ROTARY WIRE BRUSH • SANDING DISC OR FLAP WHEEL • TIN SNIPS • SMALL BALL-PEIN HAMMER • RUST PREVENTATIVE • SCISSORS • RUBBER GLOVES • GOGGLES • METHYLATED SPIRIT • RAGS • BODY-REPAIR KIT • MASKING TAPE

Bridging the gap

Tap the edges of the hole inwards with the ball of a small ball-pein hammer (SHEET 49) until they are about ¼ in. (6 mm) below the level of the panel.

Body filler can be supported by a sheet of expanded zinc metal fixed behind the hole. A suitable piece is usually supplied in the repair kit.

Use tin snips to cut the expanded metal so that it is about 1 in. (25 mm) larger than the hole all round.

Mix a small amount of body filler paste with the hardener from the filler kit. You can make it set quicker than normal by adding a little more hardener than the kit instructions suggest. But do not deviate too far from the maker's instructions.

Put the metal sheet behind the hole and fix it in position with small amounts of filler.

If you cannot hold the sheet from behind the hole, use wire hooks to pull it against the back edge until the filler that is fixing it has set or, depending on the type of hole, roll the mesh into a tube shape and fix it firmly into position. Add filler to build up the contour (SHEET 69).

Cut a piece of the expanded metal to the shape of the hole, but about 1 in. (25 mm) larger all round. Put it under the hole and fix it in place with small lumps of filler containing extra hardener for quick setting. Add filler to build up the contour.

Laying up the glass fibre

Cut a piece of glass-fibre mat the same shape as the hole, but ¼ in. (6 mm) larger, and lay it behind the hole. Brush liquid resin on to the mat until it is saturated. Lay a second layer of glass-fibre mat behind the first and brush more resin on. Let the resin set hard before final filling.

Glass fibre can cause skin irritation to some people – wear rubber gloves when you handle it.

Use scissors to cut out two pieces of the glass-fibre mat so that they overlap the edges of the hole by ¼ in. (6 mm) all round.

Mix the liquid resin, following the instructions given with the kit.

Put a layer of glass-fibre mat in the hole from behind. Use an old paintbrush to dab the resin mixture on to the mat – both sides if possible – until the mat goes translucent.

If any resin drips on to the paintwork, wipe it off at once with a rag soaked in methylated spirit.

Put the second piece of mat over the rear of the first and add more resin with the brush. Let the resin set hard. Fill in the remaining slight hollow with filler (SHEET 69).

Using a filler-fibre mixture

Put the plastic sheet over the hole and tape down one side. Trace the shape of the hole on to the sheet with a pen.

Some repair kits do not use a mesh backing. They reduce the stages involved by using a plastic cover sheet to hold the combined filler and glass-fibre mixture to the same contour as the body.

Prepare the hole in the way already described under Bridging the gap (left).

Put the plastic sheet over the outside of the hole and fix one edge with a strip of paper masking tape.

Trace the outline of the hole on the plastic sheet, then fold the sheet back.

Add hardener to the filler mixture as directed by the instructions with the kit. Put the mixture on to the plastic sheet, inside the marked area. Dab more mixture on the edges of the hole.

Hinge the plastic sheet back over the hole, press it against the hole, and tape down the other three edges. The plastic sheet should follow the body contours.

When the filler mixture has set hard, peel off the plastic sheet. Small marks left on the surface of the repair can be filled with small amounts of the mixture or can be filled with paintstopper before the repaired area is sprayed.

Filler-fibre mixture can also be obtained in cans, without plastic sheeting.

Mix up a quantity of filler-fibre mixture and use it to pad around the edges of the hole until they are well coated. Fold back the plastic sheet and support it with one hand while you put filler mixture inside the traced outline.

Fold the plastic sheet back over the hole, and press firmly to squash the filler-fibre mixture into the shape of the metal panel.

Smooth the plastic sheet all round to match the lines of the panel being repaired and tape the other three edges to hold it.

When the filler mixture has set hard, remove the tape and lift off the plastic sheet. Fill in any small marks with a small amount of the mixture.

Painting / 1

Small chips and blemishes are best repaired with a can of touch-in paint and a brush. For larger jobs, use an aerosol spray. If possible, work in a dry, warm, dustless but well ventilated atmosphere.

Metallic paint finishes contain minute flakes of bright metal, possibly covered by a coat of transparent lacquer. Aerosol and brush-on kits for these types of finish are available, but it is almost impossible to reproduce the exact shade because the mixture of paint and flakes is critical, as are the temperature and conditions in which spraying is carried out.

Except for small jobs, or spraying less obvious areas such as front-bumper aprons, it is better to have the work done professionally.

Plain finishes are easier to match, but you must obtain the exact shade recommended by the car manufacturer – a slight colour variation is obvious.

Often the code number of the paint is stamped on the car identification plate, and a retouching kit can be bought from a main dealer for the make if not available from an accessory shop. If the code number is not on the plate, quote the car make, model and year, the colour name, and the chassis number (always on the plate).

Tools and equipment

KNIFE • ARTIST'S BRUSH • WHITE SPIRIT • CLOTH • 600-GRIT WET-AND-DRY PAPER • MASKING TAPE • PAPER SHEETS • PAINT • CUTTING COMPOUND

How to spray aerosol paint

Some aerosols contain solvents which attack and crinkle existing paint. Always test an aerosol on a hidden area of paintwork as a check.

If the paint crinkles do not go ahead with painting the car, have the repair done by a professional paint-sprayer.

Before spraying shake the can hard for at least three minutes after the agitator balls inside begin to rattle.

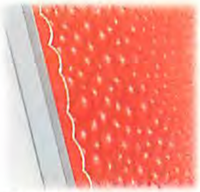
Practise on a piece of metal before you begin spraying in earnest. Try a brief spray from a distance of about 12 in. (300 mm) and look at the results.

If there are specks in the paint which do not join up, the spray is too far away and will have a rough finish when dry. If the paint drips and runs, the spray is being held too close.

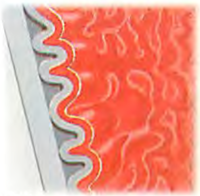
At the right distance the result should be a smooth, glossy coat without runs.

After spraying, always clear the jet by turning the can upside-down and pushing the button for two seconds or until the jet blows clear. Otherwise the valve and jet will become clogged.

Runs
If the paint starts to run you are spraying the area too much, or from too close a distance. Move the aerosol back a little and avoid concentrating on one area.



Orange peel
If the paint surface has a texture which looks like orange peel, you have sprayed on too much paint without letting it dry between passes.



Lifting
Instead of laying flat and sticking to the surface, the paint may crinkle and break away in uneven patches. The cause is probably dirt, grease or polishing wax left on the surface.

Fish eyes
Circular patches, called fish eyes, where the paint does not flow over the painted surface, but leaves thin, patchy areas, are usually due to specks of polish or moisture on the surface.

Preparing the surface

After dealing with any rust or dents (SHEETS 69 and 70), remove grease and wax from the surrounding paintwork, using a cloth moistened with white spirit.

Take the gloss off the paintwork with 600-grit wet-and-dry paper used wet. Rinse with plenty of clean water, and wipe dry with a chamois leather.

Masking the area

Remove all the badges and trim if you can. Badges may have push-on steel or plastic clips holding them on behind the panel. You can usually prise the clips loose with a screwdriver.

Some badges are simply pushed into plastic sockets and can be pulled off.

A few are fixed by nuts behind the panel. Trim strips are generally sprung over a row of clips or studs. Some trim and badges are glued on.

Use masking tape to cover a grille, name plate or any other small item attached to a panel you are spraying.

Cover any you cannot remove with masking tape, exactly fitted along the edge. Wrap projecting items, such as mirrors, aerial, door handles and bumpers, with paper taped in place.

Try to make the boundaries of the new paint at panel edges, trim strips or other clear lines.

Lay a double sheet of paper on the roof, and stick a strip of 1 in. (25 mm) wide tape along one edge and overlapping it. Peel it off and stick the tape along part of the boundary tape. Repeat until the whole boundary is well masked. Remember that spray drifts through the smallest gap.

Before masking an area for painting, make sure it is free of grease and dirt. Lightly rub the area with fine-grade wet-and-dry paper and rinse thoroughly with water and a clean cloth. Let the surface dry out before masking.

Use masking tape and paper to protect light clusters and other fittings from paint spray.

Use plenty of paper and masking tape when masking off the area you are about to spray. Leave a large overlap of paper on the surrounding bodywork, to guard against spray drifting on to it. Protect the wheels if necessary.

Lay paper on the roof and fix masking tape half on, half off, the paper's edge. The paper can then be transferred to the panel you are going to spray.

Use masking tape to make an accurate spray line. Tape newspaper or brown paper sheets over surrounding bodywork or glass to protect it.

Painting / 2

Priming, spraying the top coat and finishing the surface

Shake the can of aerosol primer hard and long. It is thicker than top coat, but easier to spray on.

Spray a thin coat on to the repaired area only – not right up to the boundary. Let it dry for a few minutes, then apply another thin coat, and go on until the repair is evenly coated and the primer blends into the sound paintwork.

Let the primer dry completely, then remove any blemishes by lightly rubbing with 600-grit wet-and-dry paper, used wet.

In the same way, remove primer from the existing paint near the masking tape, being careful not to rub through the paint. If you expose any bare metal, re-prime it and rub down again.

To spray the top coat, shake the aerosol and hold it perfectly upright. Push off the plastic cap protecting the spray button. Point it at a piece of masking paper in case it splutters when you push the button.

As soon as the spray has stabilised to a fine jet, spray a horizontal line across the top of the repair keeping the button fully depressed and moving slowly and steadily. Release the button.

Repeat slightly lower down, so that the second line just overlaps the first. Continue until the whole area is covered with a thin layer.

Do not try to make the first coat fully cover, or it will certainly run. And do not stop or start spraying on the area being painted. Wait a few minutes before applying the next coat to let it partly dry.

Apply a second coat, and go on in the same manner until you are satisfied.

As you spray on more coats, the paint will begin to blend with the existing paintwork. It may take six or more coats to give a good depth of colour.

If the paint runs, let it dry completely – wait at least an hour on a hot day.

Rub down with 400-grit wet-and-dry paper, used wet, until the surface is flat again. Dry off the water and continue painting.

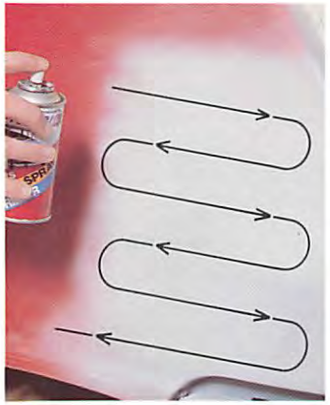
Let the last coat become touch dry, then pull off the masking tape at an outward angle to avoid lifting off the edge of the new paint.

Leave the new paint to harden for a day or two, then blend in the edge by rubbing it gently with a damp cloth primed with a mild cutting compound – available from accessory shops.

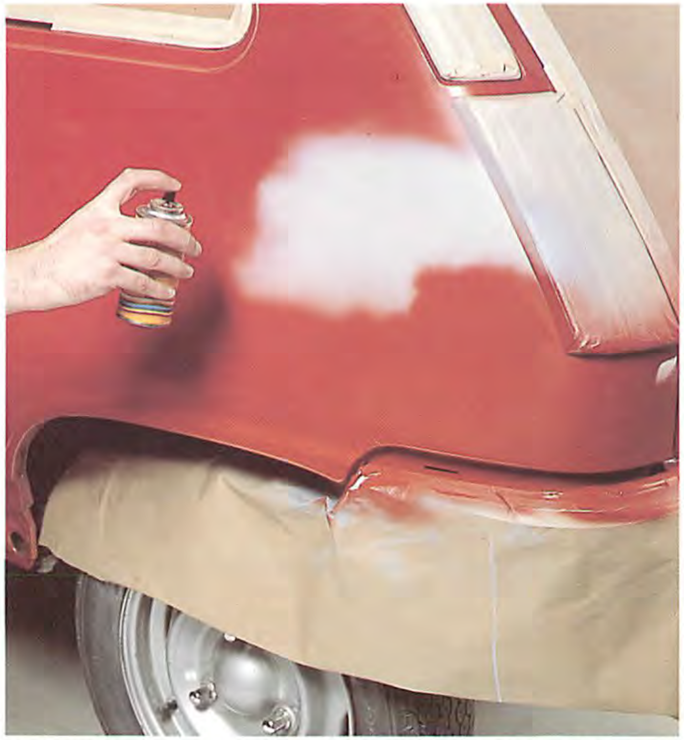
If the new paint is dull, rub all over – but not too hard or you may go through to the primer coat.

Leave the new paint to weather for six weeks before wax polishing it, which should bring it to full gloss.

When the paint has fully hardened prime a damp cloth with a proprietary cutting or polishing compound, and use it to blend the newly sprayed area with the old, take care not to rub through the relatively soft new paint to the primer coat below.



Shake the aerosol paint can hard and long to mix the primer paint thoroughly – follow the instructions on the can. Apply a coat of paint to the damaged area, but do not go over the edge on to the surrounding paintwork at this stage. Let it dry, then put on another coat, moving the spray in longer, horizontal sweeps to cover the whole area.



Do not try to spray in damp, cold or windy conditions. When spraying on the top coats keep the aerosol can moving horizontally, and do not stop or start when you are over the areas being painted. Allow sprayed lines of paint to just overlap, but do not try to make the first top coat cover fully. Have patience – allow the paint 10–15 minutes to partly dry between coats. Six or seven coats may be needed to achieve a good blend of colour. Leave the paint to harden before blending new and old paint at the edges.

Let the paint become touch dry before removing the masking tape. Pull it away from the new paint at an outward angle.

If the paint runs, let it dry off thoroughly before trying to rub down the run with wet-and-dry paper. Drying may take several hours, but it is important to let the paint harden thoroughly. Attempting to rub down soft paint will ruin the finish.

Brush-painting a small area

Before carrying out a small paint repair, always remove any loose or cracked paint with a small knife blade. Hold the blade flat to prise off cracked paint.

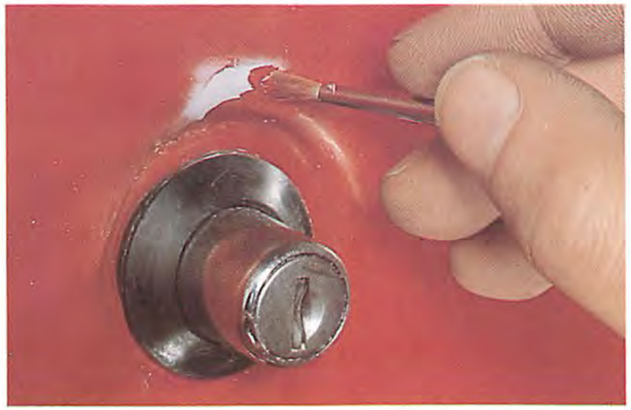
Shake the can of paint thoroughly. Remove the screw-top and stir the paint with a piece of wire. Try not to use the rather basic brush fitted in the screw-top. Use an artist's brush – it can be cleaned later with cellulose thinners.

Apply the paint quickly but not thickly, with the minimum of brush strokes. Overlap the sound paintwork by about ¼ in. (6 mm).

Let the paint dry, then apply a second light coat.

Too heavy use of the brush risks stirring up the layers already painted and spoiling the surface finish.

Let the paint dry for at least 24 hours, then polish it gently with a mild cutting compound – not a heavy paste one – to blend the edges into the original paintwork.



Touch in small chips with a brush, using a can of touch-in paint. Or spray a small amount of paint from an aerosol into the can lid, and dip the brush in that. Tins of touch-in paint have a brush in the lid, but an artist's brush is preferable.

Applying underbody sealant

On a fairly new car, covering the underbody with sealing compound will discourage corrosion. It can be sprayed on under pressure or brushed on.

But if there is already considerable rust, applying a sealant will accelerate corrosion rather than protect the underbody against it, because the corrosion will spread unseen and unchecked beneath the covering layer.

Raise the car securely on ramps or axle stands, and check the underside. If the floor and the insides of the front and rear wings are already rusty, do not attempt to seal.

A sealant will be effective only if the underside of the car is completely clean. Wash it thoroughly with hot water containing a small amount of detergent, and when it is dry apply a proprietary engine-cleaning solvent with a stiff brush. Use a hose to remove the residue.

When the underbody is dry, clean off any remaining film of dirt, oil or grease with a clean cloth moistened with white spirit.

After cleaning, treat any small areas of rust with a proprietary rust remover. When it is dry, apply a coat of pure zinc primer or a rust inhibitor.

Parts of systems attached to or passing beneath the underbody, such as the exhaust system, hydraulic pipes, and the moving parts of the braking and suspension systems, need to be masked before the sealant is applied.

Professionals apply underbody sealant with a spray gun. The best way to do the job at home is with an old 2in. (50mm) paintbrush.

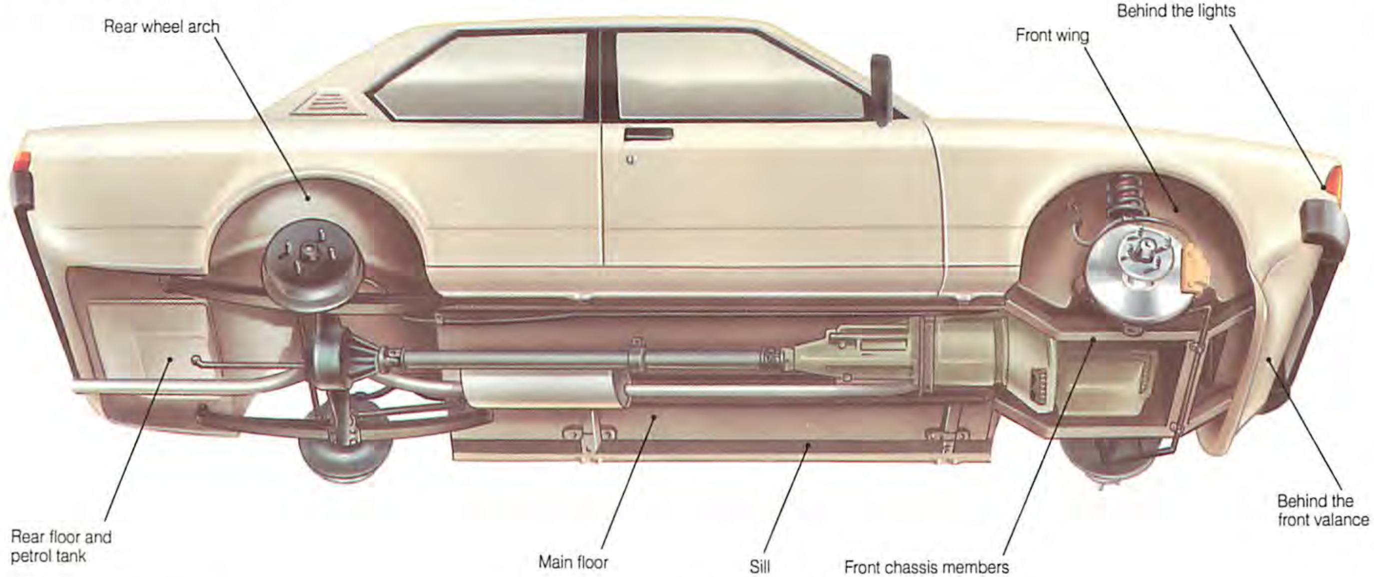
Sealants are sticky to use, and difficult to remove from your skin. Wear old clothes that can be thrown away afterwards, a head covering, protective goggles and rubber gloves.

Cover your working area, such as a concrete drive, with old newspapers, an old dust sheet or plastic sheeting to catch the drips.

Tools and equipment

RAMPS OR JACK AND AXLE STANDS • MASKING TAPE • OLD NEWSPAPERS, BROWN PAPER, CARDBOARD • RAGS • ENGINE-CLEANING SOLVENT • STIFF BRUSH • PROPRIETARY RUST REMOVER • OLD PAINTBRUSH • WHITE SPIRIT • HOSE • TORCH • KNIFE • PROTECTIVE CLOTHING • UNDERBODY SEALANT

Where to apply sealant



Applying the sealant

Prepare the sealant as directed on its container. Following the maker's instructions, start applying the sealant under the floor area starting at one end of the car and working methodically to the other.

Apply generously, painting all unmasked parts. Work in sections, and check each section with a torch to make sure it is completely covered before you move on.

When coating the wings, start at the front with the difficult areas – the top front and top rear corners. Check with a torch that these areas are completely sealed.

Coat the rest of the underwing areas, making sure the wheel-arch edge is well covered. Front wings with a built-in plastic underwing do not need treating.

On completion, remove all the masking when the sealant is set, not forgetting the tape covering the drain holes.

If you have accidentally applied sealant to the paintwork, clean it off with white spirit while it is still soft.

Patching uncoated areas

New, unsealed parts fitted to a sealed underbody should be treated with sealant as soon as possible. If an existing sealing coat has begun to lift, the damaged areas should also be re-treated at once.

If possible, use the same type of sealant as that already applied. Mastic-based sealants are not always compatible with factory-applied underbody sealants.

If you patch the sealing coat with a product that is not approved by the car manufacturer, the corrosion warranty may be invalidated.

Peel off damaged or lifting sealant with a knife blade. Work round the area until you reach a sound part. Remove any dirt on the metal with a stiff brush, and use a neutraliser on any rust patches (SHEET 68).

Clean the area with a cloth moistened with white spirit, and wipe dry. Mask any moving parts near by, or parts that heat up, before applying the sealant.

For small patches, sealant in an aerosol can is easy to apply.

Preparing the car

Components that get hot or have moving parts must not be coated with sealant. Use newspaper, brown paper, pieces of cardboard and old rags, held in place with masking tape,

Mask the exhaust system with cardboard and newspaper held with masking tape.

to protect them. Large parts such as the engine, gearbox and back axle are easy to avoid and need not be masked.

Wrap cardboard around smaller transmission parts such as the propeller and drive shaft.

Remove the wheels, and where sealant is to be applied close to the suspension, tape newspapers over the pivots and cover any grease nipples with tape. Wrap pieces of rag around ball joints in the steering system.

Wrap cardboard round coil springs and telescopic dampers. Mask leaf springs and lever dampers with newspaper or old rags. Also wrap cardboard and newspaper round the exhaust system.

Do not apply sealant to any brake pipes. It prevents thorough inspection of the pipes for rust, and if the sealant is penetrated, local corrosion will be accelerated.

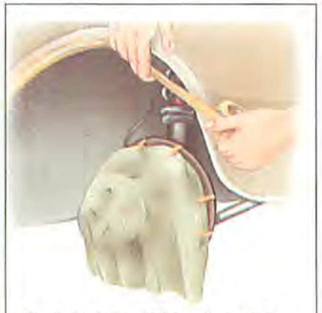
Do not coat the handbrake linkage; wrap the cables securely with brown paper and make sure the pivots are masked.

When working inside the wings, drape the brake disc or drum assembly and the suspension arms with an old cloth or plastic bag.

Under the wings, mask the backs of any lights, such as headlights, sidelights, side markers and direction indicators.

Do not seal any areas that are used as jacking points. Tape over all box-section drain holes to prevent them becoming blocked with sealant.

Use masking tape to give a clean



Mask the edges of the underbody to obtain a clean edge where the sealant ends.

edge where the sealing coat ends. Apply it all round the edge of the underbody, at wheel-arch edges, on box sections under doors, and under the front and rear bumpers.

Adjusting catches and hinges

Doors or bonnet and boot lids that do not close properly may have moved out of alignment and need adjustment to the hinges or catch.

Many hinges are welded to the bodywork and cannot be adjusted, but worn hinge pins can be changed (SHEET 75). Bolted hinges can usually be adjusted.

Catch adjustment is mostly to the striker plate rather than the door or lid lock that fits into the plate.

Most hinges and striker plates have space around them to allow for movement up, down or sideways.

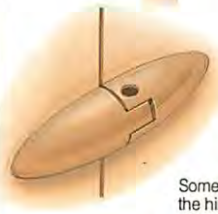
Tools and equipment

SPANNERS • SOCKETS • SCREWDRIVERS • SELF-LOCKING GRIPS/IMPACT DRIVER • PENCIL/PLASTICINE

Bolted hinges

A hinge may have a hollow rolled pin in the centre for lubrication, with plastic caps top and bottom.

This hinge is combined with a restrainer, to keep the door from opening too far.



Some small cars have the hinge on the outside of the door. It cannot be adjusted.

Adjustments to doors

To adjust the door hinge bolts, you may need to loosen the door-lock striker assembly and remove a panel on the door pillar.

Bolts may have hexagon or cross-slot heads. They will be very tight; loosen them with a socket and bar, a large screwdriver and self-locking grips or an impact driver.

Leave one bolt tight enough to hold the hinge. Close the door gently, easing it up and down until you get a good fit.

Align the door against bodywork moulding lines or trim strips. Open the door, taking care to hold it in the new position.

Tighten the bolts. Re-check the door movement and then adjust the striker plate.

To adjust the striker plate, open the door and mark on the door pillar with a pencil the height at which the lock passes it.

Use this mark to judge whether the striker plate needs to be slightly raised or lowered to give the door a close fit. The lock striker should enter the slot on the plate centrally without rubbing the sides.

If it does not, loosen the striker plate and raise or lower it as necessary.

To adjust a claw-and-pin catch, place some Plasticine on the striker pin and shut the door. Open it, and the impression will show whether the claw on the door lock grips the pin in the centre.

If it does not, loosen the striker pin and move it as necessary, then retighten it.

Some pins are held by a hexagon nut, some are turned with an Allen key. Others may have a cross-slot head that can be turned with a heavy screwdriver and self-locking grips or with an impact driver.

Hinge
Most hinges have cross-head screws that require a large screwdriver. Use self-locking grips to help turn it, if necessary.

Striker plate
Adjust the striker plate so that the door-lock striker enters it centrally without rubbing the sides.

Claw-and-pin catch
Check to see that the lock claw grips the pin in the centre.

If it does not, adjust the pin.

Adjusting bonnet catches and locks

Cars with front-hinged bonnets often have a horizontal striker that hooks into a plate with a hook-retracting spring on the bulkhead.

Lift the bonnet lid slightly to see whether the striker makes contact with the centre of the plate.

If it does not, check the bonnet alignment and adjust the hinges if necessary.

Otherwise, loosen the bolts securing the striker-plate and adjust the plate until the striker makes a clean entry.

Tighten the bolts and re-check the shutting action.

Most rear-hinged bonnets have a lock with a dovetail bolt that can be adjusted. On some cars, however, it is the striker plate that has to be adjusted.

To adjust the dovetail bolt, open the lid and loosen the nut securing the bolt.

Partially close the lid and slip a hand through the gap. Move the bolt until it aligns with the centre of the striker plate. Open the lid and retighten the nut.

Most dovetail locks can also be adjusted in or out to hold the bonnet lid tightly shut.

Loosen the nut and turn the bolt using a screwdriver in the slot at the bolt end.

Turn clockwise for a tighter fit, anticlockwise for a looser fit.

Tighten the nut and re-check the shutting action.

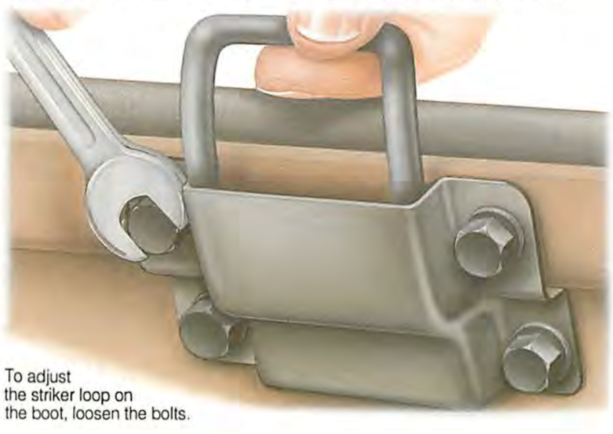
Loosen the locknut and adjust the dovetail lock for length.

Adjusting boot catches

Most boot lids and tailgates are held by a striker loop and plate.

To get a tighter fit, loosen the plate bolts and slide the plate towards the floor, then retighten.

Sometimes the loop has to be moved forwards slightly by packing behind the plate bolts.



To adjust the striker loop on the boot, loosen the bolts.

Adjusting bonnet and boot hinges

Some bonnet and boot hinges are welded or bolted to the lid by an anchor plate.

Before adjusting a bonnet hinge, slacken the dovetail bolt on the bonnet lock. Before adjusting a boot hinge, loosen the striker plate of the lock.

Loosen the hinge nuts, leaving one tight enough to hold the lid. Close the lid and ease it into a tight shutting position.

Keep the lid in the new position as you open it to tighten the hinge nuts. Check the shutting position and readjust the hinges as necessary.

Finally, adjust the bonnet lock or boot striker plate.

Loosen the hinge nuts, leaving one tight enough to hold the hinge.

Renewing hinge pins and hinges

Many hinges are welded to the car bodywork and cannot be adjusted or renewed. But if a door or a boot or bonnet lid becomes slack and badly fitting, the cause may be a worn hinge pin which can be renewed.

Hinges that are bolted to the bodywork can be adjusted (SHEET 74). If they are badly worn, the hinge pin can often be renewed, or alternatively the whole hinge renewed. It is usually simpler to renew a pin than a hinge.

Tools and equipment

BALL-PEIN HAMMER • RAWHIDE HAMMER • PIN PUNCH • DRIFTS OR HINGE-PIN REMOVER AND REPLACER • SCREWDRIVERS • SOCKET SPANNERS • SELF-LOCKING GRIPS • AXLE STAND AND PADDING • OIL

Worn hinge pins occur most often on front doors, where the hinges get the most use.

Renewing a worn hinge pin

Ask a helper to hold the door open, supporting it underneath. Use a padded support such as an axle stand as well; if the door drops, a hinge may be distorted.

Some hinge pins are solid, but many are hollow with plastic caps.

You may be able to tap out a solid pin with a hammer and drift. Use the oiled new pin as a drift, driving it in as you force the old one out. But on some cars it is difficult to use a hammer and drift without damaging the bodywork.

If a pin has a projecting head, lever under the head with a screwdriver and tap out the pin using a rawhide hammer on the screwdriver shaft.

You may be able to remove a hollow pin by tapping it out with a drift of the same diameter as the pin. Oil the outside of the new pin before you tap it in, using the same drift.

Alternatively, hire a special tool – a hinge-pin remover and replacer. Remove the pin cap and thread the tool into the pin shaft. When it is through, screw on the tool cap and tap the handle with a hammer to withdraw the pin.

It is usually easiest to withdraw a top hinge pin downwards and a bottom hinge pin upwards.

To insert a new pin, oil the outside of the shaft, thread it on to the tool and ease it into the hinge, tapping the handle with a hammer.


Solid pins with projecting heads can often be levered out with a screwdriver inserted under the head of the pin.

Renewing bolted door hinges

Wind the window shut and remove the door fittings and trim panel (SHEET 65).

Disconnect the door check strap or restrainer. Some have a pivot pin that can be tapped out with a hammer and punch. On others the pin is held by a clip at the bottom; prise the clip off with a screwdriver and lift out the pin.

Uncover the hinge fixings inside the door pillar. You may have to remove floor covering or side trim to reach them.

Ask a helper to support the open door at the bottom. Use a padded support such as an axle stand under the door to make sure your helper does not lower the door too much on one hinge and distort the mountings.

With the door restrainer removed, you may have sufficient room to get at all the hinge bolts. If not, undo those on the door pillar and take off the door.

Bolts may have hexagon heads or cross-slot heads, and will be tight. Undo them with a socket and bar or large cross-head screwdriver and self-locking grips; alternatively use an impact driver.

Undo the lower hinge first, then slacken the bolts on the top hinge. Ask your helper to lift the rear bottom corner of the door while you take off the bottom hinge.

Have the door lowered back into place while you fit the new hinge.

Oil the bolt holes, then place the new hinge so that its outline fits into the marks of the old hinge. Half tighten the bolts on the bottom hinge while you remove and fit the top one. Make sure the door is properly positioned before you tighten all the bolts.

Check the door alignment and closing action. If necessary, adjust the hinges and the door-lock striker plate (SHEET 74).

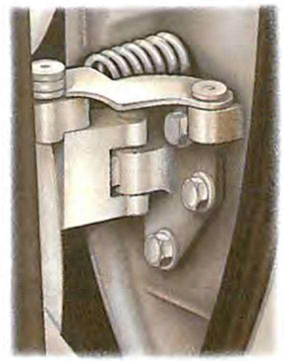

To avoid distorting hinges, support the door with a padded axle stand.


A door check strap (restrainer) is often held with a pivot pin. Release the strap by tapping out the pin with a hammer and punch.


To undo cross-slot hinge bolts you may need to use an impact screwdriver.


On some cars you can reach the bolts on the door side of the hinge with a socket and bar, after removing all or part of the trim.

Hinges with springs


On cars that have hinge springs, make sure the spring does not push the door out of line as you take off the hinge.

Renewing the exhaust system / 1

A damaged or worn exhaust system allows waste gases from the engine to escape before they have passed safely to the rear of the car.

The escaping gas makes a chuffing noise that gets gradually louder as the holes or cracks get larger.

Leaks must be sealed quickly. Exhaust fumes can be lethal, and if they seep into the car may cause drowsiness and perhaps an accident.

It is also illegal to use a car on the road with a defective exhaust system.

Most exhaust systems consist of several parts held together by clamps or bolted flanges. A few cars have a one-piece system.

Before buying any parts, raise the car on ramps or axle stands so that you can examine it underneath with a torch or inspection lamp.

Work from the rear of the car towards the engine, noting obvious damage such as holes, cracks or split seams. Badly rusted parts should be renewed. Check the condition of clamps and mounting bolts or nuts, gaskets and exhaust hangers.

On some one-piece exhaust systems, there are often leaks at the joint with the manifold. If the clamp here is secure, the pipe may have been broken by excessive engine movement caused by worn engine mountings or steady-bar bushes (SHEET 154).

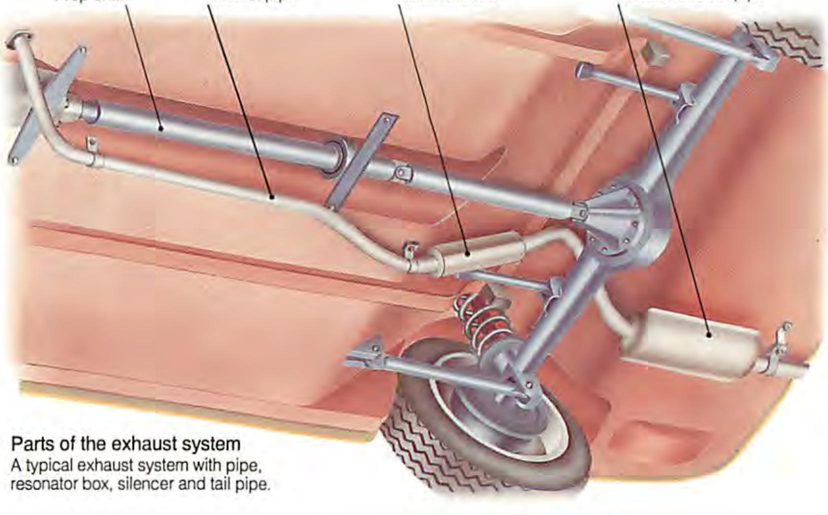
The mountings or bushes should be renewed as well as the exhaust system.

Before dismantling the exhaust, make a sketch of the layout, noting particularly where it is fitted in relation to the handbrake linkage and suspension. Sometimes a new system has to be threaded through an aperture in the chassis underframe.

Note also the way rubber hangers or mountings are fitted. If assembled incorrectly, there could be excessive movement in the system, causing annoying rattles and shortening its life.

Tools and equipment

LARGE SCREWDRIVER • WIRE BRUSH • SOCKETS • MINI-HACKSAW • SPANNERS • PENKNIFE OR SCRAPER • HALF-ROUND FILE • ½ IN. (13 MM) COLD CHISEL • MEDIUM HAMMER • RAMPS OR JACK AND AXLE STANDS • EMERY CLOTH (COARSE AND MEDIUM) • PENETRATING OIL • ENGINE OIL • FIRE-RESISTANT COMPOUND • JOINTING COMPOUND • NOTEBOOK/PENCIL • TORCH/INSPECTION LAMP • GASKETS • GOGGLES • TIMBER PIECES/BRICKS • REPAIR KIT FOR SMALL HOLES • SOFT IRON WIRE



Parts of the exhaust system
A typical exhaust system with pipe, resonator box, silencer and tail pipe.

Undoing a manifold joint

The exhaust system is connected to the engine at the manifold. The connection may be a clamp or flange joint.

To make it easier to get at the joint you may have to raise the car securely on ramps or axle stands. The nuts are often badly corroded and difficult to undo.

Before trying, clean any exposed threads with a wire brush and lubricate the fixing with penetrating oil. Leave it to soak while you remove the exhaust mountings.

Use a socket or ring spanner to undo the nuts. Take care not to round off their edges. If necessary, use a long extension on the socket to get leverage.

After parting the joint, remove the old pipe and use a penknife or scraper to clean away any traces of gasket or jointing compound on the manifold. Finish off with a wire brush or medium emery cloth.

Many manifold joints are clamped metal to metal, using fire-resistant compound.

A flange joint has studs that fit through holes in the mating surface.

Reconnecting a manifold clamp and flange joint

Use a wire brush to clean the clamp of any fire-resistant compound. Oil the threads of the bolts until the nuts can be tightened by hand.

Coat the mating surfaces of metal-to-metal joints (such as on a Mini) with fire-resistant compound, obtainable from most motor accessory shops.

Ask a helper to press the joint firmly together or jack the pipe into position, while you assemble the clamp around it.

Position one half of the clamp with the bolts attached, then fit the other half over the bolts. Make sure that any extra components are attached – some makers hook the throttle spring on an anchor attached by one clamp nut.

Add the washers and any other fittings, screw on the nuts by hand, then tighten lightly with a spanner until the clamp holds the pipe securely but is not fully tight.

Do not tighten completely until the whole system has been fitted.

A flange joint has studs on one surface that fit through holes on the mating surface and are secured by nuts. A gasket seals the joint.

Use a wire brush to clean the threads of the fixing studs. Check that the nuts will screw on easily by hand. Heat destroys nuts, use new ones when possible. To make steel nuts screw on easily, clean the threads and apply a little oil.

Make sure that the surfaces the gasket bears upon are clean, and fit a new gasket. If necessary, stick the gasket to the flange with a thin smear of jointing compound while you assemble the joint.

Tighten the fixing nuts evenly until the flanges make contact with the gasket but do not compress it. Do not tighten fully until the whole system has been mounted.

Replacing exhaust mountings

The pipes and boxes of the exhaust are held to the car underside by mountings that allow the system some flexibility.

The mountings may be made of rubber bonded to metal plates that have studs or other fasteners to fix them to the car body at one end. Most bracket on to the exhaust pipe at the other.

Some systems are held by rubber loops from a hook on the body to a hook on the exhaust.

Replace mountings that are rusted or that have chafed or cracked rubbers. Check rubber loops by levering them with a screwdriver.

If you are fitting new clamps and mountings to a new exhaust pipe, cut through the old pipes and mountings with a mini-hacksaw. Wear goggles to protect your eyes.

Cutting the system into short lengths makes it easier to dispose of.

Exhaust mountings may be metal clamps fastened to the underside of the car.

Rubber loops on hooks support the system firmly but flexibly, allowing for some vibration.

Some designs use a combination of bracket, clamp and rubber bush.

Some clamps are secured directly to a metal bracket.

Renewing the exhaust system / 2

Fitting a multi-part system

Lay the new system alongside the car and assemble it temporarily. You may find that the silencer will not fit on the pipe and that various other overlapping joints are tight.

The silencer stub may have small metal burrs on the inside edge. Remove them with a half-round file and refit. If there is still difficulty, use a strip of coarse emery cloth wrapped round the pipe end to remove the paint from the last few inches of pipe.

If the silencer still will not fit, put a piece of round timber such as a broom handle into the stub and lever it sideways in all directions to bell out the end. Most silencer stubs and outer pipes have slits at the end to allow for such expansion.

Follow the same process as needed for fitting overlapping pipes.

Work on each joint in turn until it can be fitted easily by hand.

Raise the car securely on ramps or axle stands, and fit the front section of the new system to the engine manifold.

Support the next section under the car with pieces of timber or bricks. Thread the clamp on the forward pipe and smear a little fire-resistant compound on the mating surfaces before making the joint. Do not tighten the clamp yet.

If the section has a mounting to the underbody, fit this next: fit nuts and bolts finger-tight; for rubber loops, pack the exhaust as close as possible to the underside to give good clearance.

Fit the loop to the body hook, and if necessary use an old, long screwdriver to lever the loop on to the exhaust hook.

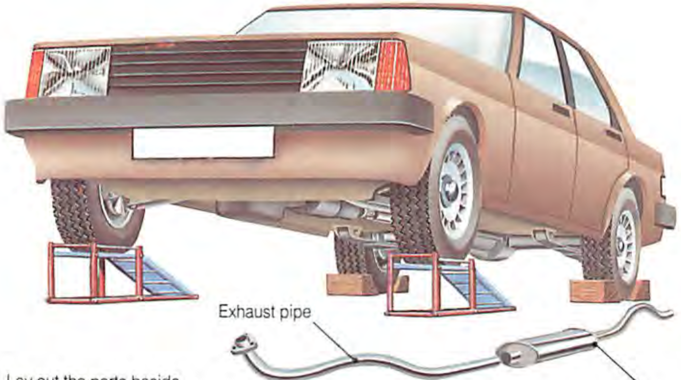
Continue supporting and fitting sections in the same way rearwards until the whole system is loosely assembled on the mountings.

If a rear section has a loop that fits over the rear axle, fit it at an early stage so that it is roughly in position and ready to mate up with the centre section.

Check your layout plan and arrange the joints as necessary to clear the underbody and avoid side strain on the mountings.

Starting at the manifold, tighten the clamps and any mounting nuts.

Run the engine and check for leaks. The new system may smell of burning paint for the first few days, until it is all burned off.



Lay out the parts beside the car, and see how they fit together.

Using a U-clamp

The U-clamp is one of the commonest clamps used on the exhaust system. It is usually positioned about ½ in. (13 mm) from the end of an outer pipe.

U-clamps are sold complete with nuts and washers.

Fitting a one-piece exhaust system

Raise the car securely on ramps or axle stands and push the new exhaust underneath from beneath the rear bumper.

Get under the car and feed the front of the system up to the manifold joint on the engine. Support it roughly in position with a box, pieces of timber or bricks.

Lift the heaviest part of the system – usually the silencer – to the underbody and connect it to the nearest mounting. If the mounting has fixing nuts, fit them loosely.

Loosely fit the rest of the exhaust to the mountings.

Check the fit of the exhaust pipe at the engine manifold. The two halves of the joint should mate easily by hand.

If they do not, re-check the position at all the mountings and move the system forwards, backwards or up and down as necessary until you can fit the joint together with ease.

Some systems have packing pieces at the forward mounting to allow the exhaust to be manoeuvred until there is a snug fit at the manifold. Clamp the manifold joint together.

Make any minor adjustment needed to the exhaust mountings before fully tightening their nuts. Check that none is under any strain.

Fully tighten the clamps at the engine manifold.

Separating pipes in a multi-part system

When renewing part of an exhaust system, the main problem is removing the damaged part without damaging the attached pipe.

Unbolt or cut off the old clamp with a hacksaw, and clean the joint with a wire brush. Smear the joint edges with penetrating oil and leave to soak for at least an hour.

Disconnect any mountings holding the part to the body. Twisting the part back and forth may be sufficient to remove it.

If you cannot separate two parts after oiling and twisting, and you wish to reuse one of them, spread open the outer pipe with a ½ in. (13 mm) cold chisel.

Insert the chisel into the joint between the two pipes, and tap with a medium hammer. Taking care not to damage the inner pipe, gently lever the outer pipe outwards with the chisel, belling it out as much as you can – all round if possible. Try twisting the pipes apart.

If they will not part, find the slits on each side of the outer pipe and lightly tapping the chisel use it to gently peel the pipe open at the slits.

If removal is still difficult, carefully extend the slit with a corner of the chisel until it is clear of the inner pipe.

If pipes will not twist apart, try to spread the outer one with a chisel.

If spreading fails, try to lengthen the slits in the outer pipe.

Making a temporary repair

Most proprietary exhaust repair kits contain a bandage to stick over the broken area. Heat-resistant adhesive compound may be supplied separately, or the bandage may be already impregnated; it may be fitted over a tinfoil strip.

Use a wire brush to clean loose or flaking rust from the area.

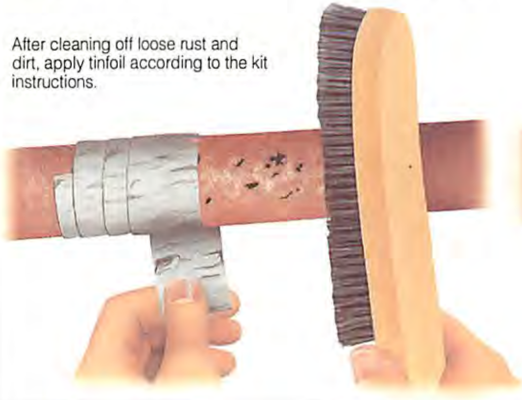
Following the instructions on the kit, wrap the bandage over the damaged part, overlapping it as much as possible. Wrap soft iron wire round the outside to hold it firmly in place until stuck.

After bandaging, start the engine and let it idle to warm the exhaust slowly and harden the compound.

Provided that the repair is gas-tight and not on a load-bearing part of the exhaust – perhaps where it is attached to the chassis – it is allowable for the MoT test.

Fit a new part as soon as possible. A sound exhaust allows optimum engine performance and so saves fuel.

After cleaning off loose rust and dirt, apply tinfoil according to the kit instructions.



Secure the bandage with soft iron wire until the compound has set.

Fitting a new windscreen-washer motor

Cars with electrically operated windscreen washers sometimes have a switch controlling the motor incorporated within the windscreen-wiper switch. If the motor does not work, check first that the switch is functioning; if it is, check the wiring to the washer motor (SHEETS 133–134).

If electrical power is reaching the washer motor but it still refuses to work, the fault may be a poor earth return, corroded terminals, dirty or damaged wiring, or the motor may be too tight in its mounting.

Check all these items and rectify them as necessary (SHEETS 137–138). If the motor still refuses to work, it must be replaced. Fit a new non-return valve in the reservoir when renewing the motor.

A motor replacement kit can be bought from an accessory shop. Alternatively, you may be able to buy an exact washer motor replacement unit from the local dealer for your make of car.

Some motors are separate from the reservoir but fitted close by. Others are combined with the reservoir. If you buy an exact replacement, it will match the existing fittings and can be fitted in place of the old one without any alterations to the mounting or connections.

If you have to fit a new motor of a different pattern, you can probably leave the old motor in position and bypass it, fitting the new one close by in a new mounting. You may have to lengthen the hoses and wiring in order to reach the new motor.

If replacing a different type of motor is not practicable, the whole washer assembly will have to be replaced. Make sure it is the correct type for your car.

Tools and equipment

CIRCUIT TESTER OR TEST-LAMP • BRASS WOODSCREW • DRILL AND BITS • SCREWDRIVER • REPLACEMENT MOTOR OR WASHER UNIT • TUBING • WIRE • NON-RETURN VALVE

Fitting a separate motor of a different pattern

Disconnect the battery. Remove the wiring from the old motor.

Leave the old motor and its inlet pipe in position, and disconnect the water outlet pipe. Plug the outlet stub of the old motor – a brass woodscrew is an ideal plug.

Decide on the location for the new motor. Make sure there is nothing behind the panel where you intend to drill screw holes.

Drill holes (SHEET 67) for the self-tapping screws provided for the motor mountings. Hold the bracket and motor in position, and fix it in place.

The two stubs for the water pipes on the new motor are usually marked with arrows indicating the direction of water flow. Connect the detached outlet pipe to the outlet stub.

In place of the old inlet pipe, fit a length of suction pipe from the new motor to the reservoir. Connect one end to the inlet stub on the motor, and fit the other into the reservoir.

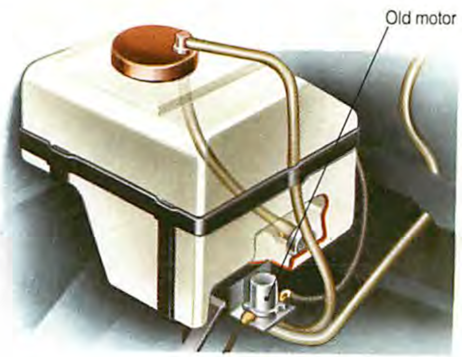
On some reservoir-motor assemblies, you may be able to utilise part of the existing fitting. On others you will have to drill a new hole in the top of the reservoir.

Make sure there is a non-return valve and filter at the bottom end of the pipe in the reservoir.

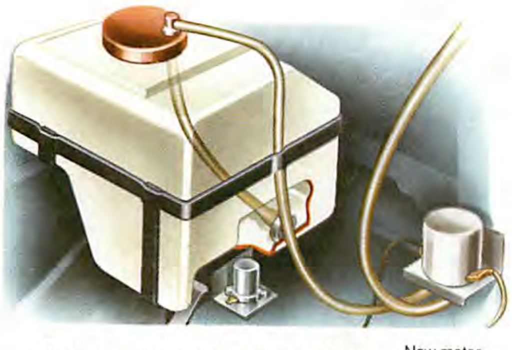
Check that the reservoir and valve are clean.

Connect the wiring to the motor. If the car has a negative [–] earth, connect the negative terminal of the motor to the car bodywork. If the earthing is positive [+] connect the positive terminal to the bodywork.

Reconnect the battery, switch on the ignition, and operate the washers to test the system.



The motor and the pump are usually a single unit, the pump being a simple device. If the non-return valve and the hoses are sound, the old motor can simply be bypassed.



The new motor is mounted near by, and the old one left where it is. You may, however, have to lengthen both the hoses and the electrical wiring to the motor to reach its new position.

Fitting a new system on the old bottle

If you have to replace the filter and non-return valve, as well as the motor, it is easy to drill a hole in the top of the plastic container.

Use a drill bit the right size for the new tube, so that the hole is no bigger than necessary.

Whenever you are servicing the washer system, check the filter and the non-return valve to see that they are free of dirt and sediment. Make sure also that there is no dirt or debris in the bottom of the container.

Use a drill bit no bigger than necessary. Or use a smaller bit and open up the hole with a round file until it is just large enough to take the new tube. If necessary, take off the container and shake out any drilling or filing debris that has dropped inside and could block the filter or non-return valve later.

Remove the multi-connector plug from the leads and refit them to the new motor with push-on terminals. Plug the outlet stub of the old motor – a brass woodscrew makes an ideal plug.

Repairing a washer unit on a current model

If the windscreen-washer system in your car is a current model, the motor and the impeller assembly can each be removed and replaced, at a relatively low cost.

But obtaining individual parts or making a repair can prove difficult. It is often easier to buy a complete replacement unit from a dealer.

On current models the motor and impeller unit fits on top of the washer container.

Looking for leaks in the brake system

A spongy feel or increased pedal travel as you apply the footbrake could indicate a leak or air bubbles in the hydraulic brake system.

If the level is low in the master-cylinder reservoir, the problem is a leak.

The master cylinder is usually mounted on or near the bulkhead of the engine compartment. The recommended fluid level is marked by a line on the outside of the reservoir.

If the reservoir is made of plastic, the level of fluid inside is visible; if it is metal, unscrew the reservoir cap and look inside.

A regular inspection of the fluid level is advisable – it could be your first warning if the leak is only a slight 'weep' in the system.

Any brake-fluid leak must be traced and remedied as soon as possible. Most likely sources are the seals of the master cylinder or – in a drum brake – the wheel cylinder.

Less likely – but not unknown – is a leak past a piston seal on a disc-brake caliper.

Other possible sources include split or perished flexible hoses, cracked or rust-pitted brake pipes, or loose screw-in pipe unions.

These unions are used to attach the piping to various components of the system, such as the master cylinder or the disc-brake caliper.

Inspect them carefully and feel behind them, too, in case the weep is not visible from the front. Tighten the nut if there is any evidence of leaking.

Have a helper press hard on the brake pedal when you inspect the system again – the extra pressure may reveal a slight leak that would not show otherwise. If it does, the joint is damaged and must be repaired professionally at a garage – drive there slowly.

If you fail to find a leak (and if bleeding the system – SHEET 90 – does not cure the problem) suspect an internal seal leak in the master cylinder or one of the slave cylinders.

Brake linings that have been contaminated by leaking hydraulic fluid or grease must be renewed (SHEET 87). Do not attempt to clean them.

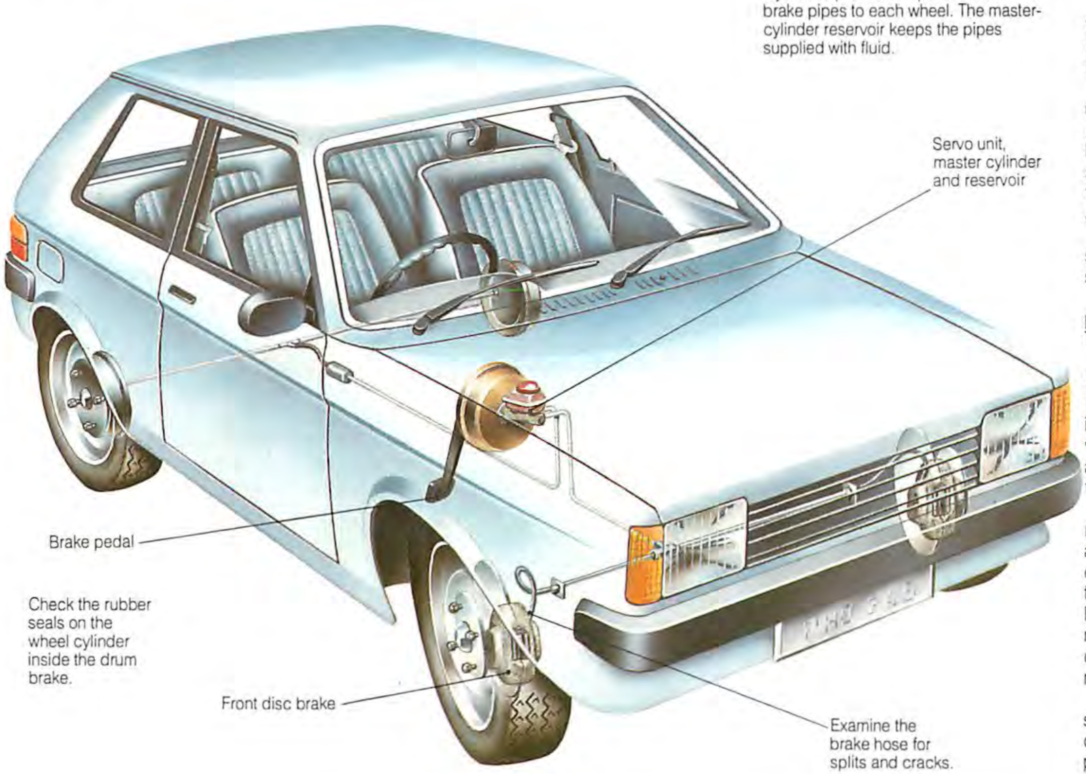
Furthermore, the linings on the opposite wheel must also be renewed, otherwise the stopping power of the two brakes will differ and you will have unbalanced, dangerous braking.

Brake shoes – or disc-brake pads – are always sold in 'axle sets', for either the two front wheels or the two rear ones. Never renew just one.

Tools and equipment

SPANNERS • HOSE CLAMP • WIRE BRUSH • PENETRATING OIL

Braking system



Hydraulic pressure is passed down the brake pipes to each wheel. The master-cylinder reservoir keeps the pipes supplied with fluid.

Using a hose clamp

A hose clamp can often be used to pinpoint obscure faults in brake pipes – when, for example, there is a spongy feel to the pedal but no visible cause.

Use a hose clamp to seal off each flexible brake hose in turn.

When the feel of the pedal improves, the cause will be in the hose you have clamped, or the piping or components.

Checking wheel cylinders

A bad leak from the wheel cylinder in a drum brake may show itself by streaks of fluid on the backplate, the wheel or sometimes the tyre wall.

Another indication can be the car's behaviour under braking. If it pulls to one side, that may mean the brake linings on the other side are contaminated with escaped fluid and not working properly.

Renew a leaking wheel cylinder (SHEETS 92–93) and brake shoes that are contaminated as soon as possible (SHEETS 87–89).

Checking pipes and unions

When examining brake pipes and unions, do not overlook those that incorporate a pressure switch to work the brake lights.

Look also for a pressure-limiting valve – a device that governs the hydraulic pressure on the rear brakes, to balance the braking between front and rear.

Look for the pressure switch in the engine compartment – it will have wiring attached. The limiter will usually be underneath the car and at the back.

Where there is rust or corrosion, clean the pipe or union with a wire brush before inspection.

Surface rust only is not a problem, but deep pits in a pipe mean that it should be renewed. If brushing brings it up bright and smooth, it is usually sound.

But deep pitting weakens it seriously – the rust will return anyway and go on eating through the metal.

Renewing brake pipes is best left to a specialist. If you do need to disturb any unions on older cars, take great care.

Often corrosion will have seized the union nut to the pipe or component. Attempts to loosen it may fracture the pipe.

To prevent this, wire-brush the union, then soak it with penetrating oil. Leave it for an hour, then ease the nut loose very slowly, working it backwards and forwards a little at a time until you are sure it can be freed.

Be sure to use the correct spanner, as the nut is made of soft metal and easily damaged.

NOTE: Badly rusted brake pipes will not pass a Ministry of Transport Test (SHEET 275).

Inspecting hoses

Flexible brake hoses must be inspected with care. They have to withstand considerable pressure and any weakness can result in total brake failure.

Examine closely any hose that runs close to other components and may chafe against them; or one that may have been wrongly fitted, and is twisted or bent. Any hoses so fitted should be repositioned. If there are signs of chafing, the hose must be replaced.

Taking a hose and bending it sharply may reveal dozens of tiny cracks in the casing caused by perishing, which might not show when the hose is straight. Whether leaking or not, such a hose is dangerous and should be replaced immediately.

Checking the master cylinder

A master-cylinder leak may be spotted by traces of fluid on the bulkhead or adjacent components in the engine bay. It may even leak down the toe board inside.

However, a slight leak may be revealed only when you peel back the rubber dust seal and look where the operating rod enters the cylinder. Renew a leaking cylinder (SHEETS 95–96).

Master cylinder and reservoir

Checking disc-brake pistons

A fluid leak past the pistons in a disc-brake caliper is unlikely but possible. Check by removing the brake pad (SHEET 84) and feeling the piston-sealing ring for leaking fluid. Replace the ring if necessary (SHEETS 84–86).

Peel back the dust seal.

Adjusting the brakes / 1

A typical braking system uses disc brakes at the front of the car and drum brakes at the rear.

Usually the handbrake operates on the rear shoes by means of a mechanical linkage – a cable and some levers and pivots.

Wheels are always raised – and in many cases removed – to make brake adjustments. Raise the car at the jacking point nearest to the wheel you are working on, and support it on an axle stand.

The brake pads on disc brakes adjust automatically for wear, whether the car has disc brakes on the front wheels only or on all four.

On some cars with rear drum brakes, there is automatic adjustment of the shoes as the linings wear down, so keeping the contact surface of the shoes close to the drum and reducing brake pedal travel.

Where the drum system is not self-adjusting, you can move the shoes closer to the inner surface of the drum as the lining material wears down.

They need adjusting when there is an increase in the travel of the brake pedal before the brakes come on.

Drum-brake shoes are adjusted so that each shoe almost touches the drum inside. A touch on the brake pedal makes each shoe press against its drum instantly.

As the brake linings wear down, the footbrake pedal travel increases, so adding to your braking time.

Brake pedal travel is excessive if the pedal reaches the floor before the brakes lock, and you need to pump the pedal to restore full braking power.

Most manually adjusted drum brakes have a single adjuster, but some – especially if they are on the front wheels – have two.

Look at the brake backplate, behind the wheel and drum. If there are two brake pipes, or a bridge pipe across the backplate, it has two hydraulic wheel cylinders and may have two adjusters.

Frequently the end of the adjuster is a square-ended rod that comes out of the backplate, and the adjuster may be a wedge or snail-cam type. Some may have a hexagonal end.

The ends are often partly recessed or otherwise obscured, making them difficult to adjust with an open-ended spanner. To avoid damaging the adjuster, always use the correct brake spanner for the car.

The adjuster may also be a star wheel accessible through a hole in the backplate or the front of the brake drum. You may have to take the wheel off to reach it.

The adjusters are exposed to weather and dirt, and are prone to seizure. Lubricate them with penetrating oil an hour or two before you start work, and again just before you turn them.

Disc-brake pads are always in light contact with the brake disc. This can be felt or heard if you spin the front wheel with the car jacked up.

As the friction material wears down, the piston or pistons in the brake caliper moves towards the disc, thereby taking up the wear on pads or discs or both. No adjustment is possible.

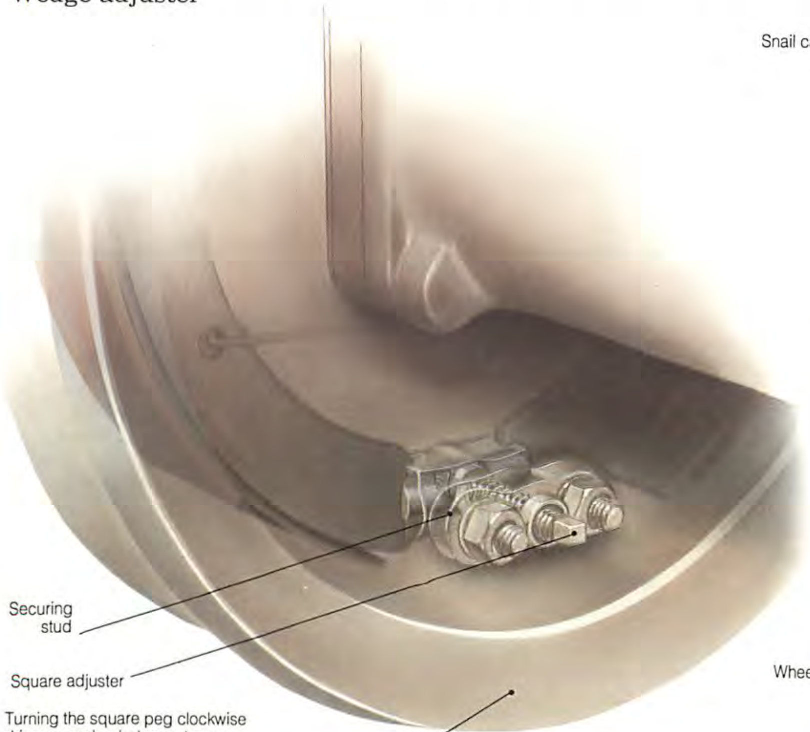
But such a system is not always perfect. The piston can partly or totally seize in the caliper, so that when you press on the footbrake it does not readily push the disc pad against the disc.

When the piston is partly seized, it may be jerked free at full pedal pressure. During the delay, uneven braking may cause the car to slew or start to spin, particularly on slippery surfaces when only moderate braking effort is applied.

Tools and equipment

JACK • AXLE STANDS • SPANNERS • BRAKE SPANNER • SCREWDRIVER • PLIERS • LIGHT OIL • PENETRATING OIL

Wedge adjuster



Turning the square peg clockwise drives a wedge between two pistons and forces the shoes apart.

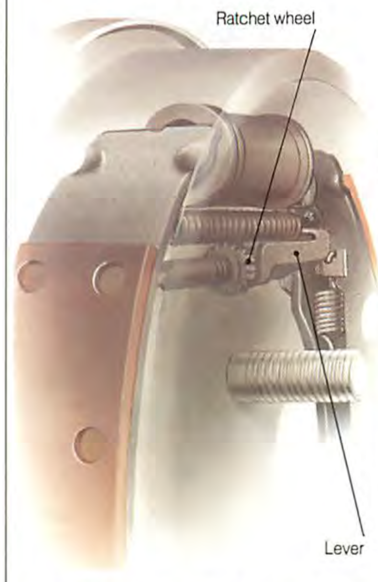
Cam adjuster

An adjuster peg through the brake backplate turns a snail cam against a peg on the brake shoe.

Star-wheel adjuster

A star-wheel adjuster turns on a threaded rod which pushes the brake shoes apart.

Automatic adjuster



Automatic adjusters work from the handbrake or footbrake. Each time the brake is applied a lever turns a ratchet wheel and adjusts the brake shoes. The adjuster has a device to prevent over-adjustment.

Adjusting the brakes / 2

Adjusting a star wheel

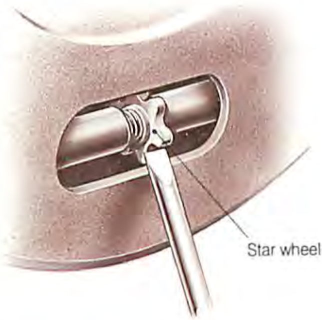
If you have to take the wheel off to reach the adjuster hole, loosen the wheel nuts before raising the car at the nearest jacking point, and supporting it on an axle stand.

Remove the plug in the backplate if the access hole is on that side, and turn the star wheel with the tip of a large flat screwdriver.

Check with your car handbook to find the direction to turn the adjuster. Otherwise, move it several teeth. This should be enough to make the brake shoes jam against the drum, and no further movement is possible. If the brake does not jam, move the star wheel the other way.

Back off one or two clicks, or until the wheel just spins freely.

Remove the plug in the backplate to gain access to the star-wheel adjuster.



Use a large screwdriver to turn the star wheel.

Backing off an automatic adjuster

Automatic adjusters keep the brakes in correct adjustment all the time, but if you have to remove the brake drum for any reason, you may want to back off the adjustment a little to make the job easier.

Some cars, notably Vauxhalls, make allowance for this.

With the car raised and supported on axle stands, and the wheel removed, turn two hexagonal bolts on the rear of the backplate. The bolts are turned towards each other, backing the shoes away from the drum. Only a little adjustment is necessary.

After reassembly, it is necessary only to operate the foot and handbrake to restore the proper brake adjustment.

Turn the hexagonal bolts on the backplate to back the shoes off the drum

The brake drum can then be removed to reveal the shoes and automatic adjustment mechanism.

Adjusting a snail cam

Press hard on the footbrake several times to centralise the brake shoes inside the drum. Raise the car at the nearest jacking point and support it on an axle stand.

Lubricate the adjuster with light oil. To move the shoes closer to the drum, turn the adjuster clockwise, as viewed from behind the backplate. (This is the usual direction, but may not be true for every type – consult your car handbook.)

Turn until you feel resistance, then try to turn the wheel. It should be locked.

Turn the adjuster back one click setting at a time until you can spin the wheel freely; a slight sound as the shoes touch a high spot inside the drum is permissible.

Remember that there will be a certain amount of drag on the driven wheels caused by the transmission gearing. Spin the wheel before making the adjustment so that you will recognise the amount of drag.

Repeat the adjustment on the other wheel or wheels of the car as necessary to ensure braking balance.

Turn each adjuster clockwise a small amount at a time to bring the shoes closer to the drum.

Turning a wedge adjuster

Wedge adjusters are similar to the snail-cam type in that a square shaft protrudes from the backplate.

Inside the drum, the wedge adjuster has a tapered inner end. As this is screwed in or out, it moves the shoes further apart or allows them to close up.

To adjust, raise the wheel affected and support the car on an axle stand.

Make the adjustment with a brake spanner. The direction of the turn may be clockwise or anticlockwise.

On the front wheel, turn the adjuster in the direction of forward wheel rotation. On a rear wheel, turn in the direction specified by the manufacturer in the car handbook or a service manual.

The amount of turning required is normally very small.

Lubricate the exposed part of the adjuster shaft with light oil. Turn the shaft while spinning the wheel. When the wheel locks, back off the adjuster until you can hear the shoes just touching and the wheel spins freely.

As you adjust, spin the wheel until it locks, then readjust gradually until the wheel rotates freely.

Freeing a disc-brake piston

Jack up the suspect wheel and spin it by hand. If it spins freely, with no drag (except perhaps from the final drive), get a helper to press gently on the footbrake pedal. The wheel should stop almost as soon as the pedal is touched.

If it does not, remove the wheel and look at the brake pads. If you see a gap between one or both pads and the disc surface, the piston is stuck in.

The piston can also jam in the 'on' position, so that the pads are held tightly against the disc.

This causes drag on that wheel, uneven braking, rapid pad wear and increased fuel consumption.

To check for jamming, apply the footbrake, release it and try to turn the wheel. After a slight stiffness for part of a turn, it should spin freely. If it does not, the brake has jammed in the on position.

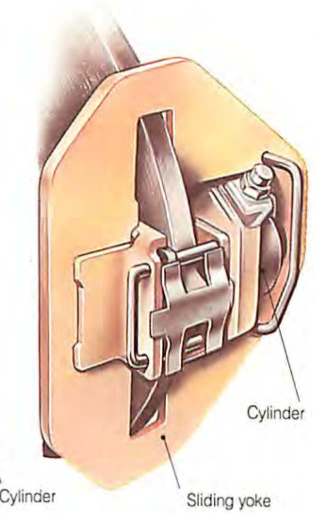
The only cure for a seized piston is to dismantle and clean the unit, a job best left to a garage. Often the jamming is caused by bad wear, corrosion or scoring on the piston and internal parts or both, and a new caliper assembly is needed.

There is a second cause of lack of pad contact, or too much contact, if your car is fitted with 'moving' calipers – alternative names are 'floating', 'sliding' and 'swinging' calipers.

With this type the pistons are on one side of the caliper and there is a little movement of the caliper body to keep the pad pressure balanced in use. Dirt and corrosion can cause the action to stick.

To cure it, clean all external moving parts and apply a proprietary grease recommended by the manufacturer; consult the agent for that make.

On a fixed-caliper disc brake, two cylinders placed one on each side of the disc operate the pads.



The sliding-caliper system has one cylinder with two pistons. One piston applies one pad and the other works the second pad through a sliding yoke.

Adjusting the handbrake / 1

If you have tightened the brake shoes so that there is no excess travel before they come on, yet the handbrake lever still pulls up a long way, the cable has probably stretched and must be adjusted.

There are many types of adjuster, but they all have the same effect – that of shortening or lengthening the cable.

Some are inside the car, at the base of the handbrake lever. Most, however, are underneath the car – and are probably dirty and rusty.

Whenever you work under the car, always put it on firm supports such as axle stands. Chock the wheels remaining on the ground.

About two hours before you plan to do the job, squirt penetrating oil on to all the nuts and screw threads you will unscrew. This gives the oil time to free any seized parts.

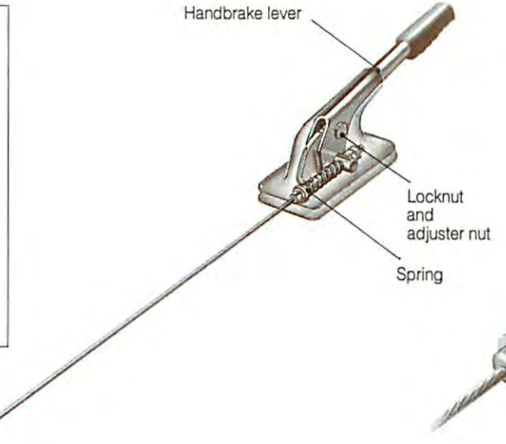
Also lubricate with engine oil all the pivots and linkages that are operated when the handbrake is applied – they tend to seize due to road dirt, grit and corrosion. Make sure that the cable or rods move freely in their covering sleeves or gaiters.

Tools and equipment

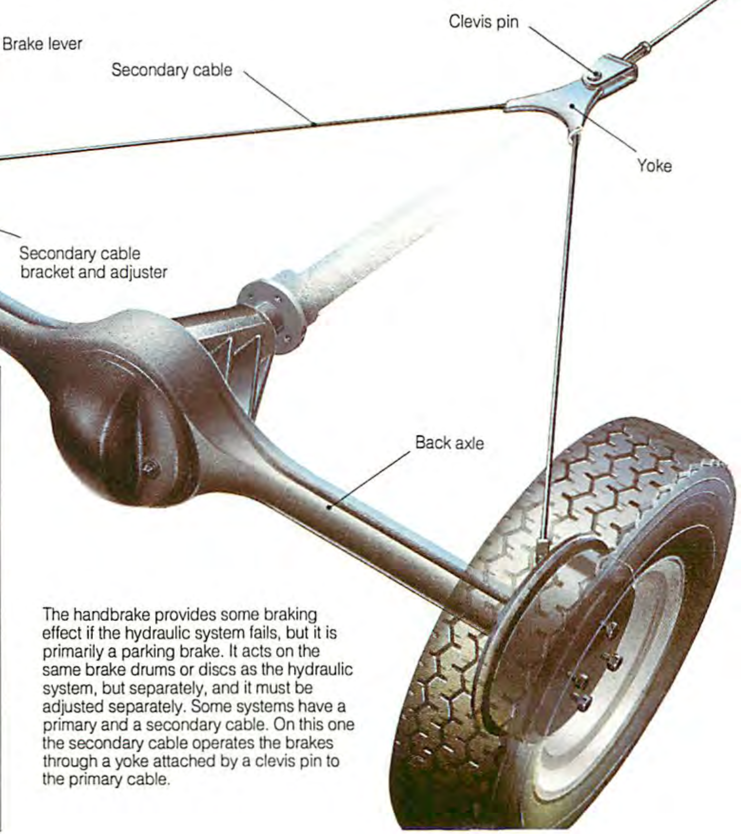
AXLE STANDS • PENETRATING OIL • ENGINE OIL • SPANNERS • PLIERS • SCREWDRIVER

Bowden cable

The adjustment for the enclosed Bowden cable is located on a bracket.

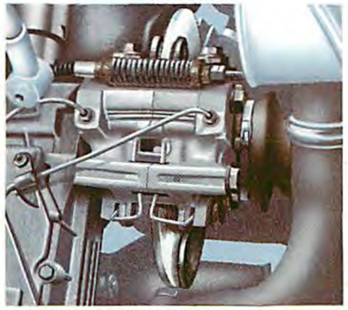


The adjustments for a twin-cable handbrake are at the brake-lever end. Each cable is adjusted separately.



The handbrake provides some braking effect if the hydraulic system fails, but it is primarily a parking brake. It acts on the same brake drums or discs as the hydraulic system, but separately, and it must be adjusted separately. Some systems have a primary and a secondary cable. On this one the secondary cable operates the brakes through a yoke attached by a clevis pin to the primary cable.

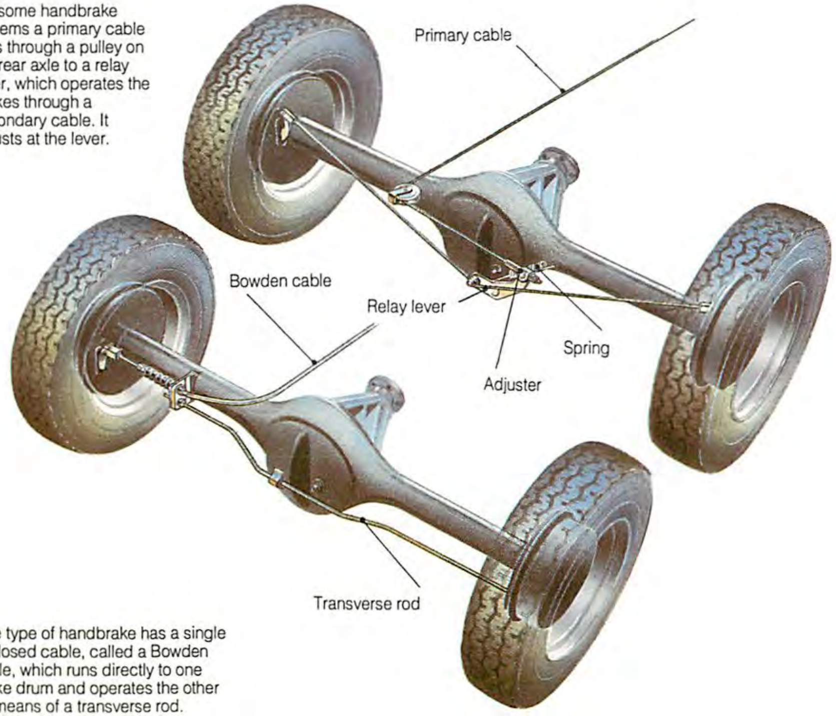
Disc brakes



The handbrake pads on some disc brakes are separate from the pads operated by the hydraulic system. A single adjustment compensates for wear on separate pads and for cable stretch.

How other systems work

On some handbrake systems a primary cable runs through a pulley on the rear axle to a relay lever, which operates the brakes through a secondary cable. It adjusts at the lever.



One type of handbrake has a single enclosed cable, called a Bowden cable, which runs directly to one brake drum and operates the other by means of a transverse rod.

Adjusting the handbrake / 2

Adjusting twin cables

Raise the rear wheels clear of the ground and support them on axle stands. Chock the front wheels and fully release the handbrake.

The adjusters are inside the car, at the lower end of the handbrake lever. Pull away the covering or carpeting.

The threaded end of each cable has one or two nuts. If there are two, grip each with a spanner and screw them apart, freeing the locknut.

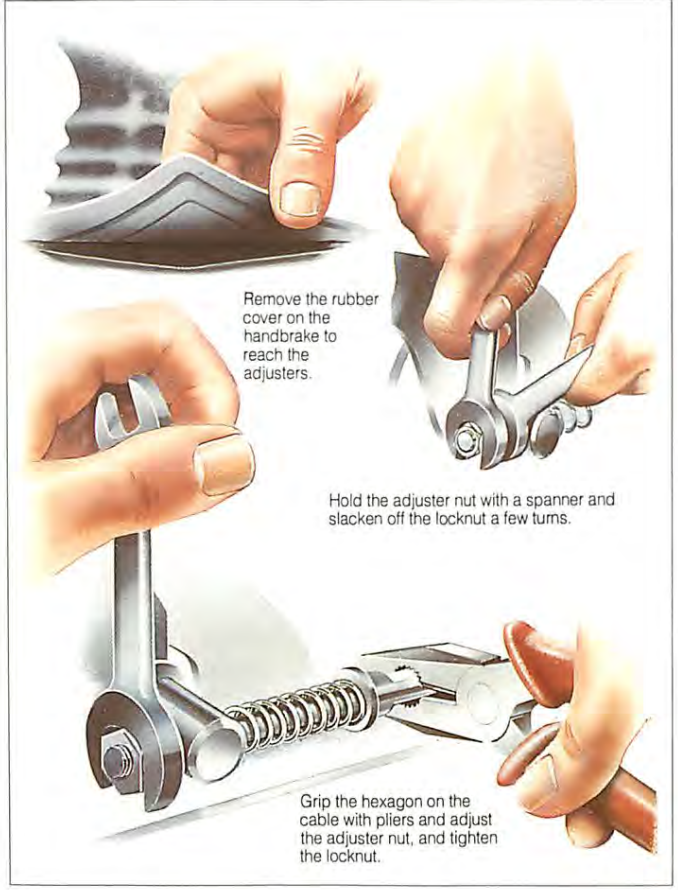
Hold the lower end of one rod with a pair of pliers to stop it turning, or fit a screwdriver into the front end of the rod if that is slotted.

Turn the lower nut clockwise down the thread, drawing the rod forward. Stop turning when the handbrake lever can be pulled up only three to five 'clicks'. Adjust the other rod by the same amount.

Pull the handbrake lever 'on' until slight resistance is felt at the lever; then try turning each rear wheel. Each should turn with equal resistance.

If they do not, tighten the cable on the slacker side until both feel equal. Tighten the locknuts.

Check that, with the handbrake released, both wheels turn freely. If not, ease back the adjustment and re-check.



Remove the rubber cover on the handbrake to reach the adjusters.

Hold the adjuster nut with a spanner and slacken off the locknut a few turns.

Grip the hexagon on the cable with pliers and adjust the adjuster nut, and tighten the locknut.

Screwed sleeve adjuster

Raise the rear wheels clear of the ground, and support them on axle stands. Chock the front wheels.

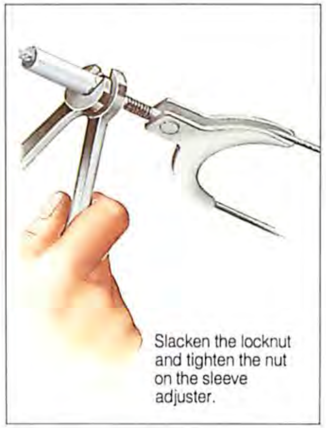
The adjuster is underneath the car, in the centre and just in front of the rear wheels.

Put the handbrake lever to 'off'. Without pressing the release button, pull it on three clicks.

Exact details of the adjuster vary considerably from car to car, but there is probably a pair of nuts on the adjuster rod – one an adjuster nut on a screwed sleeve, the other a locknut to hold it firmly. Loosen the locknut and screw it back three or four threads.

Turn the adjuster nut clockwise until the raised wheel can be turned only with firm hand force.

Apply the handbrake and check that the wheels do not bind when it is released. If they do, readjust. Tighten the locknut.



Slacken the locknut and tighten the nut on the sleeve adjuster.

Bowden cable adjustment

Raise the wheels on which the handbrake operates clear of the ground, and support that end of the car on axle stands. Chock the other wheels. Pull the handbrake lever on three clicks.

Loosen the locknut and screw it back along the threaded part of the outer casing a few turns. Screw the adjuster nut in the same direction until some resistance is felt on the cable.

Turn a wheel – it should turn only with firm hand force. Move the adjuster again if necessary, until it does.

When the wheel movement is correct, hold the adjuster nut with one spanner and tighten the locknut on to it with another.

Screw the adjuster nut along the cable casing until there is resistance.

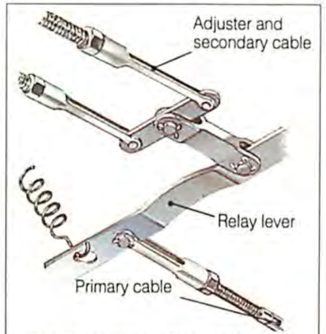
Adjusting primary and secondary cables

Some cars have a pair of handbrake cables separated by a relay lever located under the car.

A primary cable runs from the handbrake lever to the relay lever; a secondary cable goes from the relay lever to the brakes.

Set the handbrake lever one or two clicks 'on'. Jack up the car and support it securely on axle stands. Chock the unbraked wheels.

Free any locknuts, then tighten the cable that has the most slack until it is taut. Repeat the procedure with the second cable, then tighten the locknuts.



Some systems have three cables, one from the handbrake and two going to the wheels, which are connected to an equaliser. All three can be adjusted.

Equalising cable

Sometimes the adjustment is on an equalising unit mounted on the rear axle, or on a fork at the end of a rod or cable just before it reaches the brake backplate.

A clevis pin holds the fork to a lever on the backplate. Take out the split pin which holds the clevis pin: remove the clevis pin.

Pull the handbrake lever until it engages on the second notch.

Loosen the locknut and screw back the adjuster nut until the clevis-pin holes in the fork are just in line with the hole in the lever on the backplate.

Tighten the locknut and refit the clevis pin with a new split pin.

Pull out the split pin and remove the clevis pin to release the fork.

Screw back the adjuster nut behind the clevis-pin fork.

Disc-pad handbrake

On most cars with all-round disc brakes, the handbrake operates on the rear discs, but on a few cars it operates on the front discs. A single adjustment takes up stretch on the handbrake operating cable, and compensates for wear on the pads (if the pads are separate from those operated by the hydraulic system).

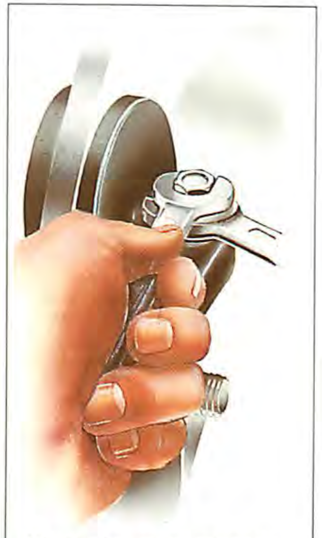
Raise the wheels clear of the ground, and support the vehicle on axle stands. Chock the other wheels. Set the handbrake to off.

With a large, open-ended spanner, loosen and unscrew a few turns the large, thin locknut on the back of the brake caliper.

With a smaller open-ended spanner, turn the adjustment nut clockwise until it becomes stiff.

The heel of the cast-metal lever arm should press against the back of one pad, and the wheel should be hard to turn by hand.

Unscrew the adjuster nut by half to three-quarters of a turn. Hold the adjuster nut steady and tighten the large locknut. Re-check the adjustment. Repeat the adjustment on the opposite brake caliper.



After adjusting, hold the adjuster nut steady while tightening the locknut.

Renewing disc-brake pads / 1

It is vital to know when disc-brake pads need replacing. Some makers state a minimum safe thickness of $\frac{1}{16}$ in. (1·6 mm), others $\frac{1}{8}$ in. (3·2 mm).

In any case it is better to replace them at the larger figure. There is very little wearing time between $\frac{1}{16}$ in. and nothing.

Once the pad wears down to its metal backing, the brakes could fail to work properly – and the disc can be badly scored by the backing and possibly ruined.

You may be able to see the edge of the brake pad through a hole in the wheel. Some cars have a special viewing hole in addition to the usual slots. Otherwise, you have to remove the wheel for inspection.

A slight fall in the fluid level in the master-cylinder reservoir is another sign of wear; as the pads wear, the caliper pistons move inwards, lowering the level in the reservoir. A low fluid level can also mean a leak (SHEET 79).

Disc-brake designs vary. Even two seemingly identical cars may have different brakes because the factory used alternative suppliers. It is important to note exactly how parts fit together as you remove them – make a drawing for reference if necessary.

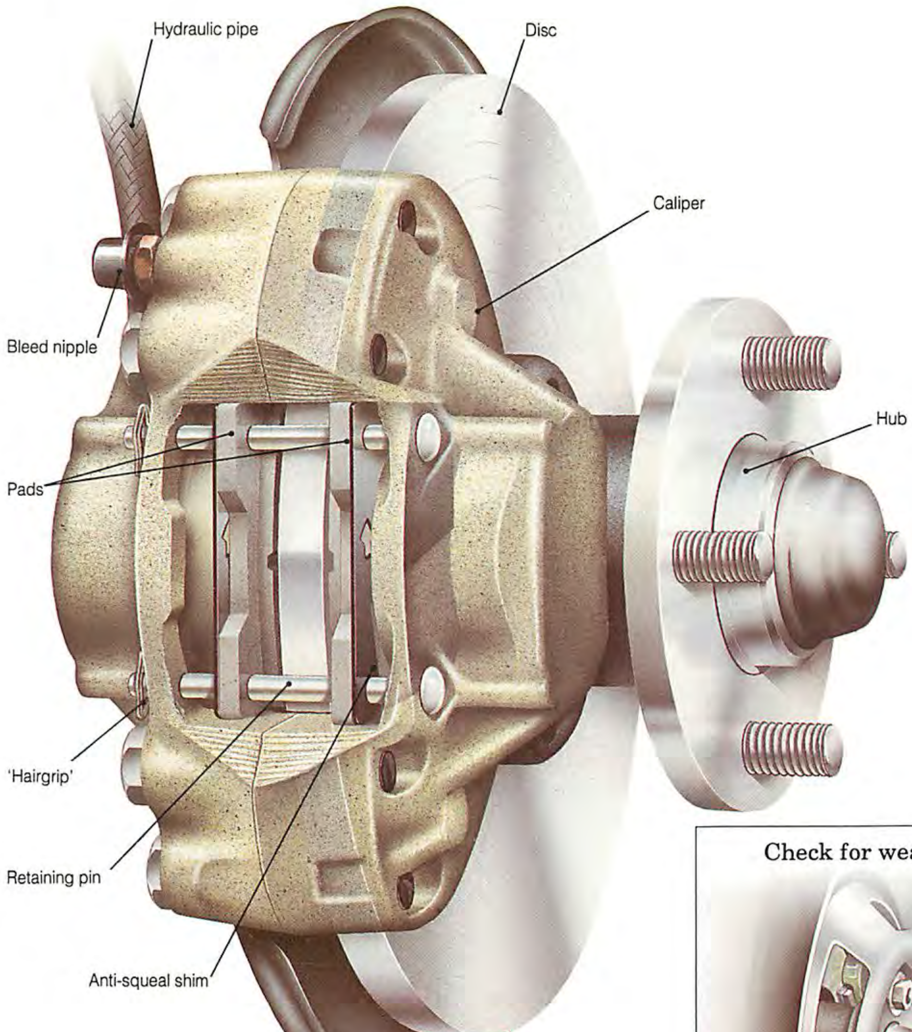
Buy only reputable makes of pads. The box should be clearly marked with a well-known maker's name.

Pads should come in boxed kits in 'axle sets' – for two wheels. Never replace the pads on one wheel alone.

The set should include all the parts you need: pads, pins, shims, springs and clips.

Tools and equipment

COMBINATION PLIERS • LONG-NOSED PLIERS • SMALL SCREWDRIVER • MEDIUM SCREWDRIVER • ELECTRICIAN'S SCREWDRIVER • SPANNER • VALVE-SPRING COMPRESSOR • HUB PULLER OR G-CLAMP • TYRE LEVER • LINT-FREE RAG • ABSORBENT RAG • BRAKE CLEANER OR METHYLATED SPIRIT • BRAKE GREASE OR ANTI-SQUEAL COMPOUND • SMALL PAINTBRUSH OR TOOTHBRUSH



A piston-opposed caliper-type disc brake is fitted to many small and medium cars.

Check for wear

Look through the hole in the wheel rim to check pad thickness.

Removing pads

On most brakes the calipers remain in place while you change the pads, and the pads slide out. They are usually retained by pins passing through them and the body of the caliper.

The pins are secured by small wire clips called 'hairgrips' (because of their shape). Extract the 'hairgrips' and pull out the pins.

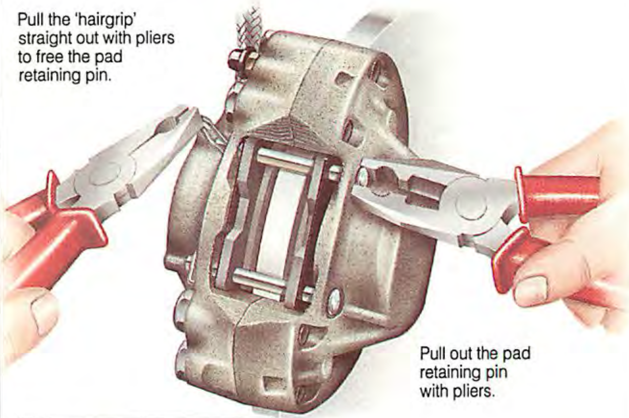
Remove each pad with two pairs of pliers, gripping the top and bottom of the pad backing plate for an even pull. If you have only one pair of pliers, pull the top and bottom alternately.

If the pad sticks, 'wiggle' it out with a side-to-side movement.

On calipers which swing down or come off completely for pad renewal, the pads lift out.

There may be metal anti-squeal shims behind the pads, usually held in place by the pad retaining pins or spring clips. Note how these are placed as they come out.

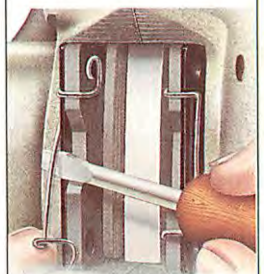
The two pads may be different shapes. Note which is which.



Pull the 'hairgrip' straight out with pliers to free the pad retaining pin.

Pull out the pad retaining pin with pliers.

Take off spring clip



Spring clips may hold anti-squeal shims. Lever off with a small screwdriver.

Pull each side evenly, together or alternately.

Renewing disc-brake pads / 2

Cleaning disc and caliper

Thoroughly clean the pad housing and the exposed part of the piston. If any dirt gets into the cylinder bore it can ruin the whole caliper.

Scrape away the worst of the dirt gently with a screwdriver blade. Take care not to scratch any parts or damage any dust seal around the piston.

Finish cleaning with a small paintbrush or toothbrush dipped in proprietary brake cleaner or methylated spirit.

Clean the rim of the brake disc if it is badly rusted. Stick a screwdriver through the caliper so that the edge of the blade lies flat against the rim of the disc, and spin the disc by hand. Finally clean the edges by pinching them with emery cloth.

Wipe the disc with a lint-free rag moistened with brake cleaner or methylated spirit.

Clean the outer edges of the disc by pinching it with emery cloth.

Replacing the pads

New replacement pads are thicker than the old, worn ones. You need to push the pistons back to make room for them.

To do this, you can use a valve-spring compressor or a carpenter's G-clamp.

On calipers that are fixed in place, you need to lever the pistons back with a strong flat bar, such as a tyre lever. But be very careful not to scratch them.

Pushing the pistons back forces fluid back into the master-cylinder reservoir. If fluid spills on to the paintwork it will cause damage, so wrap an absorbent rag around the mouth of the reservoir.

If any fluid is accidentally spilled, wipe it off at once.

You may need to scrape the paint off the edges of the backing plates of the new brake pads to allow them to move freely in their housings. They must not stick.

However, do not remove paint unless it is really necessary – it can lead to corrosion and sticking brakes.

A strong but careful pressure is needed to lever the piston back.

When applying brake grease or anti-squeal compound, take great care not to get any on the friction material or the disc.

Lever the pistons back with a flat bar. Forcing one piston back can cause the other to move forward or even fall out.

Avoid this by reinserting the old pads temporarily – clean them first.

Using a G-clamp

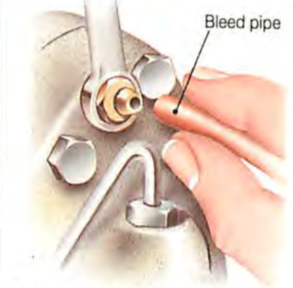
You may be able to use a G-clamp to press the piston back. Screw up the clamp against the outside of the caliper.

Wrap some rag around the mouth of the reservoir to absorb any brake fluid that may overflow.

Lever between the pad and the disc.

Take the top off the master-cylinder reservoir to allow fluid to run back into it from the system. Guard against fluid spills.

Loosening the bleed nipple



Another way of releasing brake fluid is to open the bleed nipple slightly, with a bleed pipe fitted.

Alternatively, open a bleed nipple on the caliper – but close it while fluid is still running out, or air may get in. If this happens, you will have to bleed the brakes.

Preparing and fitting new pads

Smear pad backs and shim fronts with special anti-squeal grease. Do not get any on the friction material.

Replace anti-squeal shims with the arrow pointing in the direction of forward rotation.

Align all the holes to admit the pad retaining pin.

Once you have made sure that the new disc-brake pads fit in smoothly, smear the backs of the pads and the fronts of the anti-squeal shims (if any are fitted) with either brake grease or an anti-squeal compound.

Do *not* smear the fronts of the pads with grease, or anti-squeal compound, and make sure none of it gets on to the friction material or disc.

Refit the pads and any shims or spring clips. If the shims are marked with arrows, fit them with the arrow pointing in the direction of forward rotation.

Replacing clips

Replace spring clips on the anti-squeal shims, if fitted.

Use a slim electrician's screwdriver to line up the holes in the pads and anti-squeal shims.

Push in the new pins and fasten them with new 'hairgrips'.

Refitting and checking

Reconnect any electrical sensor leads there may be, and refit the wheels. Press the brake pedal several times to position the pads and restore the correct pedal travel.

Check the fluid level in the master-cylinder reservoir and top it up if necessary.

Drive with extra care for the next few hundred miles. It takes a while for the new pads to bed in fully and give the full braking effect.

Top up the brake fluid if necessary.

Renewing disc-brake pads / 3

Girling A brakes

The Girling A brake system is known as a two-piston sliding-yoke type, and is fitted to a number of popular cars.

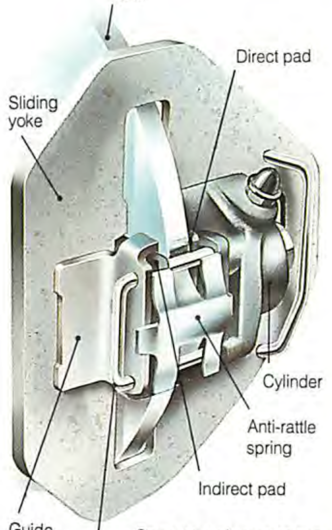
The two pistons are both on the inner side of the disc, in a cylinder housing bolted rigidly to the hub. A yoke bridging the disc is free to slide sideways.

Applying the brakes forces the pistons apart. One piston pushes a brake pad against the disc, the other moves the yoke towards the disc to pull the pad on the other side against the disc.

The pads are retained by a pin (or pins) that also secures an anti-rattle spring. There may be a single two-pronged pad-retaining pin through the yoke and the pads, secured by a clip held down by a bolt.

Or there may be two separate pins secured by hairgrip clips or a wire clip.

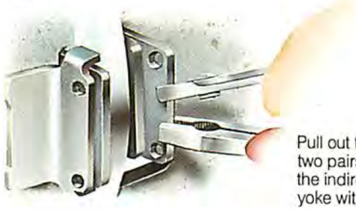
If one of the pads has a wear sensor, this should be fitted on the direct side – that is, the side that has the cylinder.



Some types have one two-pronged pad-retaining pin as shown; types with two pins are very similar.

Loosen the bolt of the pin-retaining clip and remove the nut, bolt and clip. Use a screwdriver to lever the anti-rattle spring off the pin.

To ensure an even pull, use two pairs of pliers to draw out the pin.



Pull out the direct pad with two pairs of pliers. To free the indirect pad, lever the yoke with a screwdriver.

Girling XD48 brake

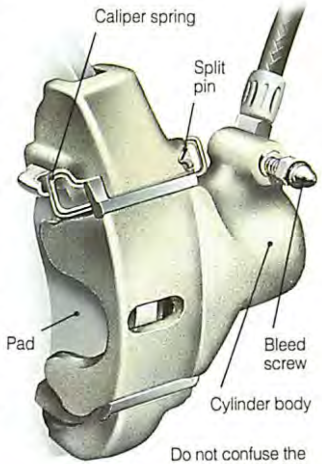
The Girling XD48 brake has a single piston operating in a cylinder body that slides sideways.

The piston presses one pad against the disc, and pulls the body across to apply the pad on the other side of the disc.

The body slides along guides retained by split pins. Remove the split pins, push down on the body and pull the guides out sideways – if necessary tap them out with a drift. Lift off the body to expose the pads.

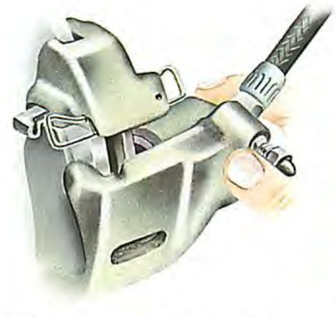
Support the body by attaching it with string to a convenient point. Do not leave it hanging on the hose end; this can damage the hose.

Note that each pad has a spring at the end nearest the bleed screw. When refitting the pads, take care to slide these springs back carefully and at the right end.



Do not confuse the wire caliper springs with the flat guides.

Pull out the split pins and push down on the body to free the guides, which slide out sideways.



To lift the body clear, push down one end then pull up the other. Support the body to avoid straining the hose.

Pull out the pads in opposite directions.

Girling Colette brakes

Girling Colette and certain ATE brakes are fitted to some British and European cars, and also built under licence for Japanese cars.

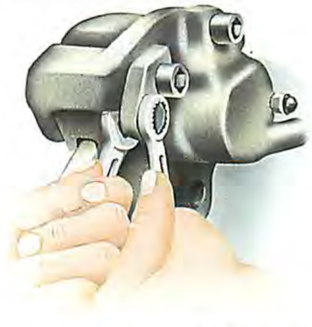
Like the Girling XD48, they have a single piston and a body sliding on two pins; when the bolt from one pin is removed, it swings out on the other pin to expose the pads.

The pins have dust seals, which must not be twisted. Each pin has flats under the head of the pin-retaining bolt; the flats enable you to hold the pin steady with an open-ended spanner while you unscrew the bolt.

Instead of pin-retaining bolts, some front-wheel-drive cars with similar brakes have socket-headed bolts that need a 7 mm Allen key.

When you swing the body out, support it to avoid straining the hose.

Some pads have a separate damping spring fitted over the top. Others have built-in springs. If one pad has a wear-sensor lead, this is fitted on the inner side.



Unscrew the pin-retaining bolt to free the pin.

The body swings out on the other pin to expose the pads.

Lockheed brakes

The Lockheed Light Duty brake, as well as Bendix or ATE opposed two-piston types, is fitted to a wide range of European cars.

The design is basically similar to the Girling brake; the pads slide out in the same way. Sometimes there are anti-squeal shims behind them.

Large split pins are used to hold the Lockheed cylinder body, and there is an anti-rattle spring (or springs) under the pins.

Straighten the pins, and pull out and discard them. Use new split pins for reassembly, and remember to splay their ends.

Bendix and ATE types, however, use solid pins, some of which have to be removed with a drift (SHEET 49) gently tapped with a hammer.

The Lockheed 4X36MB brake has four pistons in its caliper, each pair worked by a separate brake hose – a dual-system safety device.

When removing the pads, first disconnect the wear-sensor lead.

Freins Girling and Bendix brakes

Freins Girling and Bendix brakes are fitted to various French and Italian cars. They resemble the Girling XD48, but instead of body guides retained by split pins they have wedges held by a hairgrip clip at each end.

Note which way round the wedges fit before removing the clips. Tap out the wedges with a drift (SHEET 49). Remove the body in the same way as for the XD48.

Push back the piston with a valve-spring compressor or G clamp (SHEET 85) to make room for the thicker, new pads.

Japanese units

Most Japanese brakes are much the same as the types covered.

The single-piston or double-piston sliding-caliper brakes fitted to some Datsun models may differ in detail from the Girling XD48 or A. The pads are secured by pins, sometimes with hairgrip clips, and may have an anti-rattle spring plate or an anti-squeal spring fitted over them.

More recent Japanese models have different ways of retaining the pins – with a coil spring, for example.

Renewing drum-brake shoes / 1

Check drum brakes at least every six months, 6,000 miles or 10,000 km, or as recommended in the car's normal service schedule. Look for worn brake linings.

Later cars often have a plugged inspection hole in the backplate. On other cars you need to remove the drum.

Linings may be riveted or bonded to the brake shoes. With riveted linings, replace the shoes well before the lining wears down to the level of the rivet heads. Exposed heads score and ruin the brake drums.

Shoes with bonded lining should, for safety, be replaced when the lining is worn to $\frac{1}{8}$ in. (3 mm) thick, even if a minimum thickness of $\frac{1}{16}$ in. (1·5 mm) is quoted in the car handbook.

Always renew brake shoes on both wheels on an axle, even if the lining on one wheel is less worn than on the other. Renew on both wheels also if one lining has been fouled by oil or brake fluid. Otherwise, braking will be unbalanced.

Buy only brake shoes that have a well-known maker's name clearly marked and correctly spelled on the box. Dangerous fakes are common – they often have names only slightly altered from a well-known make.

If you have to get under the car, to look through the inspection hole in the backplate, for example, raise the car and support it on axle stands, not just on jacks.

When working on brakes, take care not to inhale brake dust from drums – it contains poisonous asbestos, used in the manufacture of the linings.

Work on rear brakes has to be done with the handbrake off – be sure to chock the wheels on the ground firmly on both sides.

When dismantling brakes, have a pencil and paper ready to draw the sometimes complicated way in which certain parts fit together.

Vital details include which way round brake shoes fit; the holes into which springs fit (there may be several similar-looking holes near the correct one); which way round springs go (the ends are often not the same length); the position of retaining pins and automatic adjustment parts; and the order in which washers are fitted.

If the brakes are adjusted manually, slacken them (SHEETS 80–81) before you remove the drums. With self-adjusting brakes, slackening is usually neither necessary nor possible.

A few cars have a hole in the drum through which you can use two screwdrivers to lift the pawl off the adjusting ratchet wheel and turn the wheel back.

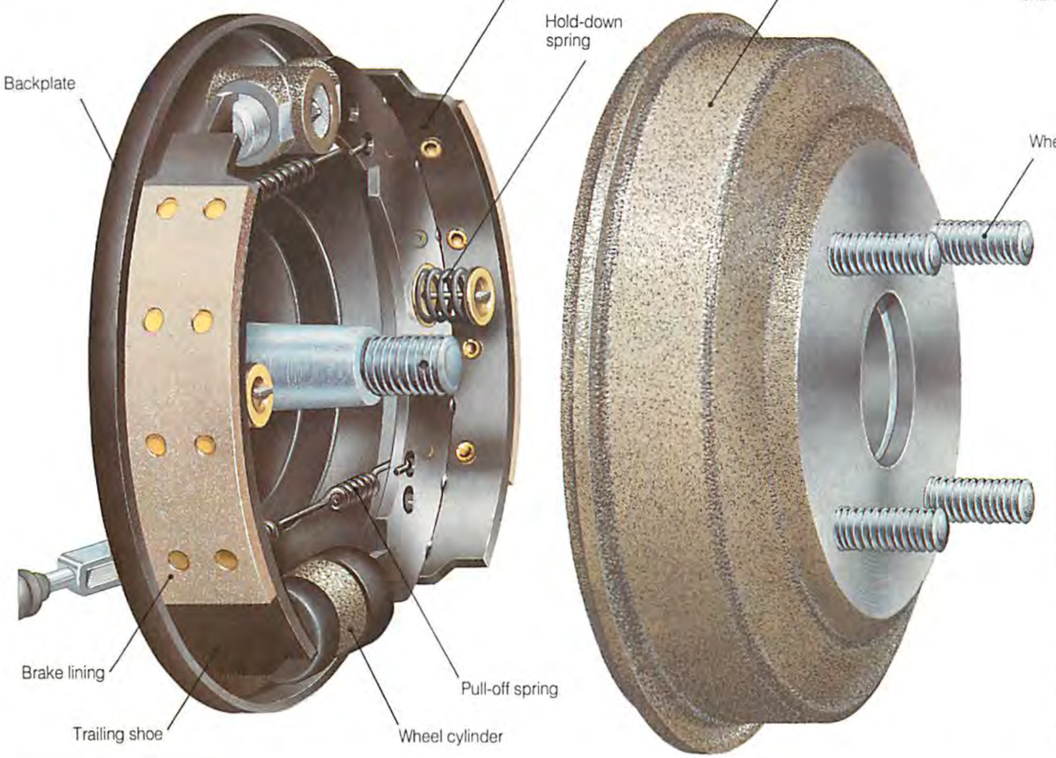
The brake drum may be integral with the wheel hub, or separate.

Tools and equipment

AXLE STANDS • SPANNERS • SCREWDRIVER • PENCIL AND PAPER • TYRE DEPTH GAUGE • RULE • SHOE HORN • SPRING PULLER • PLIERS • BRAKE SHOES • HUB PULLER • COPPER-RAWHIDE HAMMER

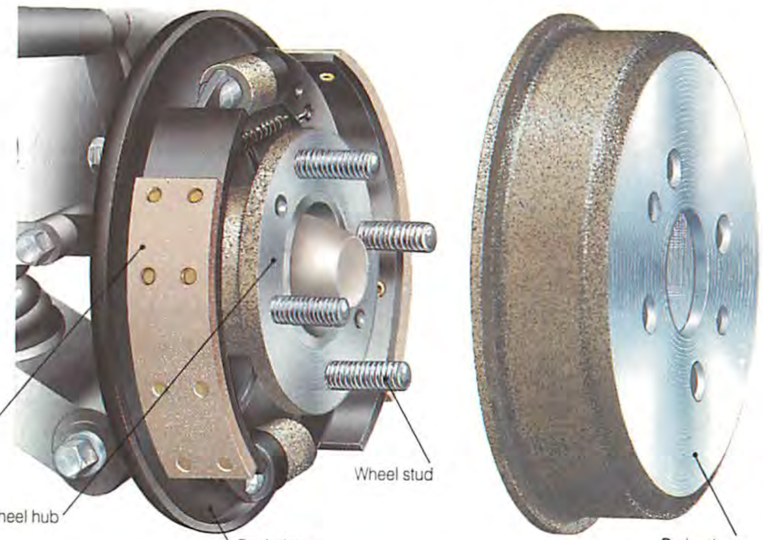
Integral drum

A rear brake with an integral hub and brake drum. The riveted lining on the leading (rear) shoe is positioned off centre in the direction of wheel rotation.



Separate drum

A front brake with a drum separate from the hub. The hub stays in place when the linings are changed.

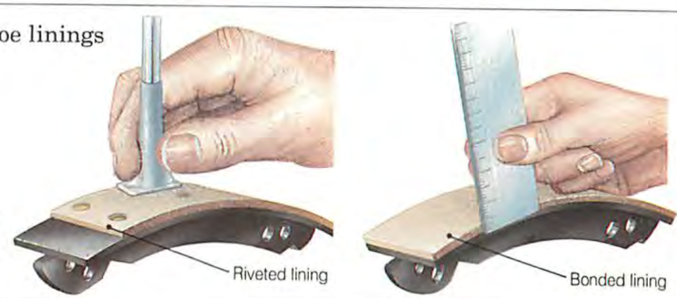


Checking wear on brake-shoe linings

Check the wear on riveted linings with a tyre tread-depth gauge. The linings should be renewed when they are worn to $\frac{1}{16}$ in. (1·5 mm) above the rivet heads.

Use a rule to check the thickness of a bonded lining, measuring from the face of the shoe to the top of the lining.

Replace shoes with the lining worn to $\frac{1}{8}$ in. (3 mm) thickness.



Renewing drum-brake shoes / 2

Removing an integral drum

Prise off the central cap with a screwdriver if you can; lever evenly round the edge – if it becomes crooked it will stick.

If levering fails, try tapping gently round the edge of the cap with a hammer and chisel.

If the cap has no lip to give you leverage, drill a hole in it, insert a self-tapping screw and pull it with a claw hammer. Plug the hole before refitting the cap.

If all else fails, knock off the cap with a hammer and chisel – new caps are inexpensive.

Under the cap there may be a castellated nut, or a castellated cap over a plain nut, held by a split pin.

Straighten the legs of the split pin and pull it out, starting by tapping it with a hammer if necessary.

Always use a new split pin when reassembling.

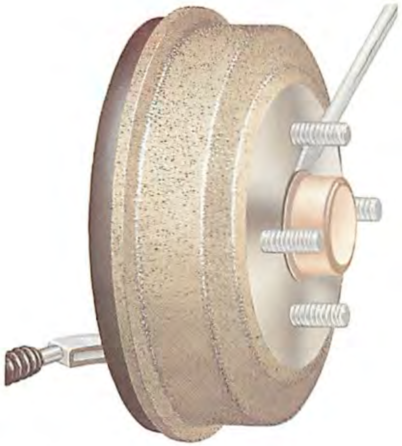
Examine the nut carefully to see if it has a left-hand thread. It is tightened to a precise torque, which varies greatly from car to car. Before refitting, check the figure with your local dealer or the car service manual.

For very tight nuts, ask a helper to apply the brakes while you unscrew the nut using a length of pipe over the socket-wrench handle to give extra leverage.

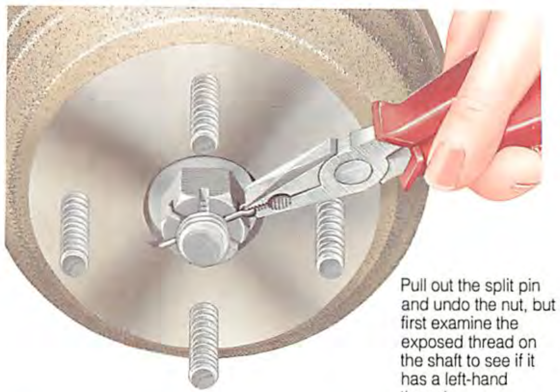
With the nut removed, you may be able to pull the drum and hub off by hand. Spread a clean rag on the ground – sometimes a bearing falls free as the hub comes off.

If the assembly is stiff, try refitting the wheel and pulling that. But do not lever the lip of the drum, or you may damage it. In severe cases you may need a hub puller (SHEET 50), which you can hire if necessary.

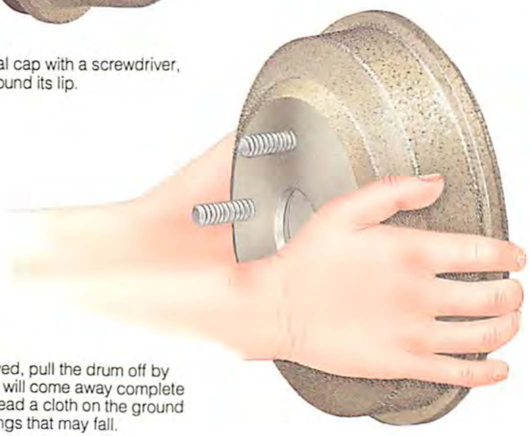
You may also need a hub puller if the inner track of the inner wheel bearing stays fixed on the axle, as it sometimes does. Put a hose clip round or behind it to give the puller legs a good grip.

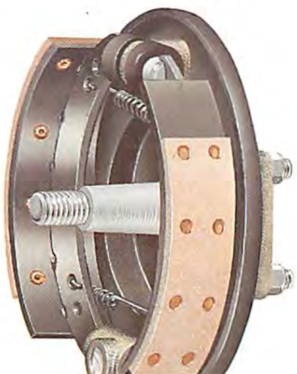


Prise off the central cap with a screwdriver, working evenly around its lip.



Pull out the split pin and undo the nut, but first examine the exposed thread on the shaft to see if it has a left-hand thread.





With the nut removed, pull the drum off by hand if possible. It will come away complete with bearings. Spread a cloth on the ground to catch any bearings that may fall.

Removing a separate drum

The drum may be held on by one or two set-screws or hexagonal-headed bolts. Remove them.

Alternatively, the drum may be held by a spring clip on one wheel stud, or there may be no fixing at all.

So that you can refit the drum in the same position, paint a mark on one wheel stud and against the hole in the drum through which it fits.

If the wheel has been balanced on the car, the balance of the brake drum will have been taken into account. Refitting it in the same position will avoid upsetting it.

Pull the drum straight off if you can. If it sticks, try tapping all round the edge of the drum – not the lip – with a soft-faced hammer.

Do not try to lever the lip away from the backplate – you may damage it.

If tapping fails to move the drum, put penetrating oil on the studs and the joint between the drum and hub, and leave it for a while. Do not get oil in the drum.

Another method is to wrap the drum in rags and pour boiling water over it to make the drum expand.

Remove the bolts or screws securing the drum. Tap stubborn set-screws with a centre punch, offset from the slot, in the unscrewing direction. Or use an impact driver.

Once the stubborn set-screw is loosened, finish unscrewing with a screwdriver.

Mark one wheel stud and hole with paint so that you can refit the drum in the same position.

If the drum sticks, tap round the edge with a soft-faced hammer. Take care not to hit the lip of the drum or the backplate.

Renewing drum-brake shoes / 3

Removing brake shoes

To take off any type of brake shoe, the hold-down springs and sometimes the pull-off springs have to be removed. The procedure for removing twin leading shoes varies slightly from that for removing leading-and-trailing shoes.

Make detailed notes and drawings, or take photographs, of all parts before you remove anything.

Generally, refitting is in the reverse order of dismantling.

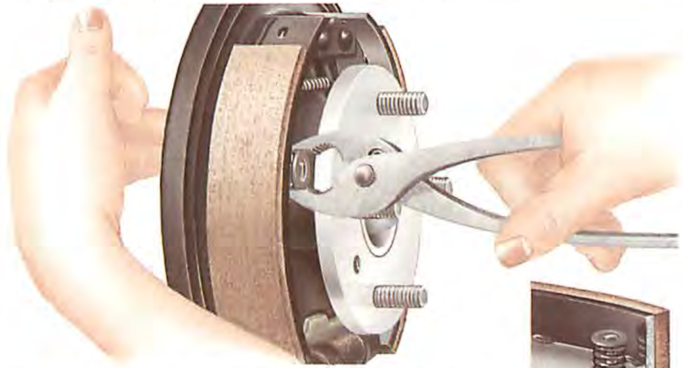
The shoe hold-down springs may be either small coil springs or spring clips.

They fit over pins, one on each shoe, that pass through the backplate and the shoe.

Each coil spring fits under a small dished cap with a slot in it. The end of the pin is flattened and fits through the slot in the cap and lies at right-angles to it.

To remove, grip the cap with pliers and push it down while you hold the pin from the rear of the backplate.

Turn the cap until the flattened pin end aligns with the slot. Pull the cap off. To remove a spring clip, press it down with pliers until you can pull its forked end clear of the flattened head of the pin.



Remove a coil hold-down spring by holding the pin from the rear and pushing and turning the cap with pliers until the pin end lines with the cap slot.

A capped coil spring may secure the pin holding the brake shoe to the backplate.

Removing a spring clip

Remove a spring clip by pressing it down with pliers until the forked end can be pulled clear of the pin head.

The forked end of the clip secures the T-shaped pin holding the brake shoe to the backplate.

Removing pull-off springs

On most cars you do not need to remove the pull-off springs before taking off the shoes. The shoes with springs attached can be lifted over the hub as a pair. But on a few types of car the hub is rather wide and covers the springs, so they have to be unfastened.

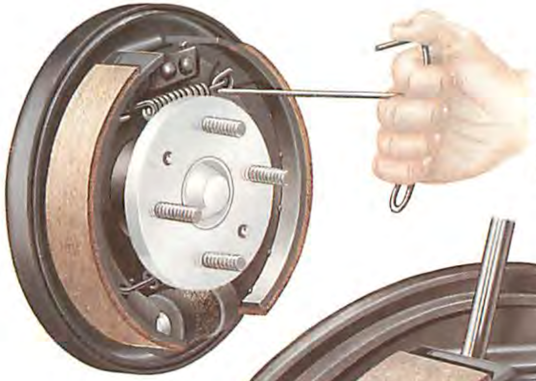
Pull them off with a strong hook. You can make one by driving a 4 in. (100 mm) nail sideways through a length of broom handle and bending the point.

If necessary, use pliers and a screwdriver to force the hook inside the hole in the shoe web, in the right place to grip the spring.

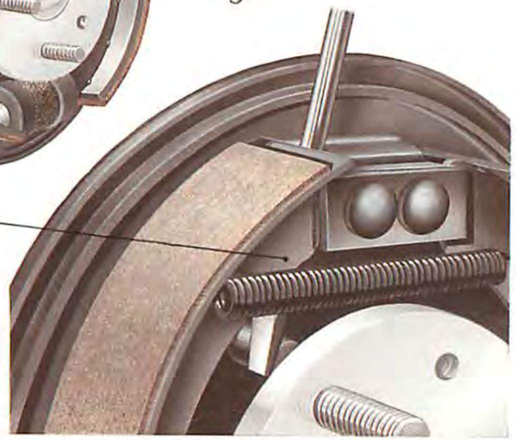
There may be a cut-out in the hub edge that you can turn in line to make it easier to reach into the hole.

The springs hold the shoes so that the ends fit into slots in the cylinder, and the shoes must be freed from the slots before you pull them off.

For freeing the shoes there is a special tool called a shoe horn, but if you do not have one you can lever them away from the cylinder with a screwdriver braced against a bolt on the backplate. Or use pliers or a self-locking wrench.



If you have to remove pull-off springs, use a strong hook and force it into the web hole to grip the spring.



Use a screwdriver braced against a bolt on the backplate to lever the shoe free from the slot in the cylinder. Then lever the shoe away from the backplate.

Using a shoe horn

A tool known as a shoe horn frees the shoe more easily.

Removing the shoe and securing the cylinder

Once the shoe is clear of its retaining slot, pull it off towards you.

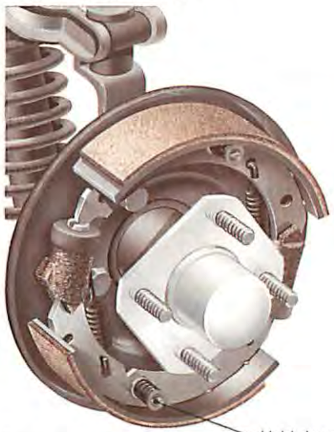
On brakes with twin leading shoes, remove each shoe in turn, detaching its spring.

Leading-and-trailing shoes have a spring stretched between them. If you lever the trailing shoe out of the cylinder, you can usually remove both shoes at once.

The leading shoe of a rear brake is slotted over the handbrake lever, and there is often a support plate in the slot. Keep this plate for fitting to the new shoe.

As soon as the brake shoes are off, put string or strong rubber bands securely round the wheel cylinders to stop the pistons falling out.

Be very careful not to get oil on the linings of the new shoes. If necessary, protect them with adhesive tape while you are fitting them. Remember to peel it away before replacing the drum.



On brakes with twin leading shoes, remove the hold-down springs and then unhook each pull-off spring to take off each shoe separately.

To remove the pull-off spring, you may first have to ease the pressure on the spring by releasing the shoe from its wheel-cylinder mounting.

Tips for reassembling brake shoes and drums

1 Clean brake dust from the linings and the drums before refitting. It often causes brake squeal.

Take care – asbestos used in the manufacture of brake linings is extremely poisonous, and is present in the dust. Use a vacuum cleaner to remove it if possible.

2 Make sure that any brake or handbrake adjustment mechanisms are retracted and will not be in the way when you refit the drums to the wheels.

3 Make sure the shoes are central, or the drum will not fit.

Hold the drum against the shoe assembly and adjust the shoes slightly until you can slip the drum over them easily.

4 After fitting the drums, and before you adjust the brakes (SHEET 80), press the brake pedal a few times to centralise the brake shoes within the drum.

Bleeding the brakes / 1

Most car manufacturers recommend renewing the hydraulic brake fluid every 18 to 24 months.

The fluid is hygroscopic, which means that over a period of time it absorbs water from the atmosphere, and its boiling point is lowered.

Friction caused by continual heavy braking heats the fluid in disc calipers or wheel cylinders, and its water content turns to steam. The brake pedal feels 'spongy' when you press it, and in severe cases the brakes will fail completely.

Air leaking into the hydraulic system makes the pedals spongy because, unlike brake fluid, it can be compressed.

If the pedal feels spongy before the fluid is due for replacement, check the system for leaks. Air can be drawn in through leaking seals or faulty brake pipes (SHEET 79).

If you find a leak, first replace the faulty components and then renew the brake fluid by bleeding the complete hydraulic system.

The fluid is drained from the system by opening bleed nipples – which are small valves – on each caliper or wheel cylinder in turn and pumping the brake pedal.

At the same time the master-cylinder reservoir has to be topped up with new fluid at frequent intervals, because its level drops as the old fluid is drained off.

If the reservoir empties, air will get into the system and the whole process will have to be repeated until all air is expelled.

Keep it topped up as near as possible to the level mark on the side – you need a helper, unless you have a bleed pipe with a non-return valve in it (SHEET 257).

Avoid spilling brake fluid on paintwork – it will start to penetrate within a few seconds. If any splashes on, hose it off immediately and wipe the area with a clean rag. Wash your hands thoroughly if it gets on your fingers.

On many cars you can reach the bleed nipple with the road wheel in place. But it is usually simpler to remove the wheel (SHEET 266).

On dual-circuit brake systems, it is usual to start bleeding at the front-wheel brake which is nearest to the master cylinder – normally the one on the driver's side.

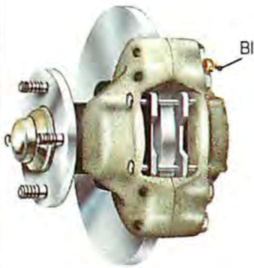
Bleed the other front wheel and then the rear wheels, ending with the one furthest from the master cylinder.

Cars with servo-assisted brakes (SHEET 95) may have a bleed nipple on the servo unit. If so, start with that.

Tools and equipment

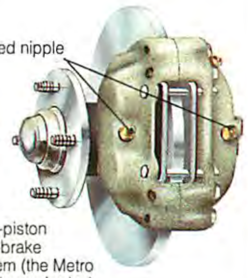
JACK • AXLE STANDS • WIRE BRUSH • RING SPANNER • PLASTIC TUBING • BLEED JAR • HYDRAULIC BRAKE FLUID • RAG • DUST CAPS

Locating bleed nipples



Disc brake

Drum brake


Four-piston disc-brake system (the Metro has three nipples).

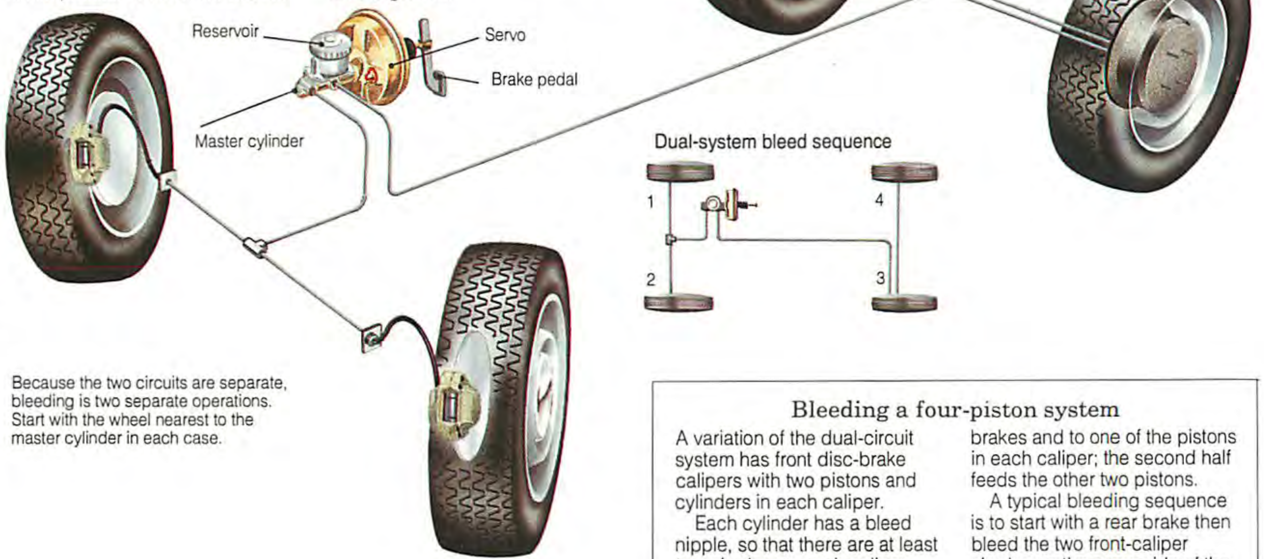
Bleeding a dual-brake system

The front and rear brakes of a dual-brake system have separate hydraulic circuits.

The configurations can vary depending on the manufacturer.

The brake pipes also pass through a balance unit which limits pressure to the rear brakes to prevent the back wheels locking when the weight of the car is thrown forwards during braking.

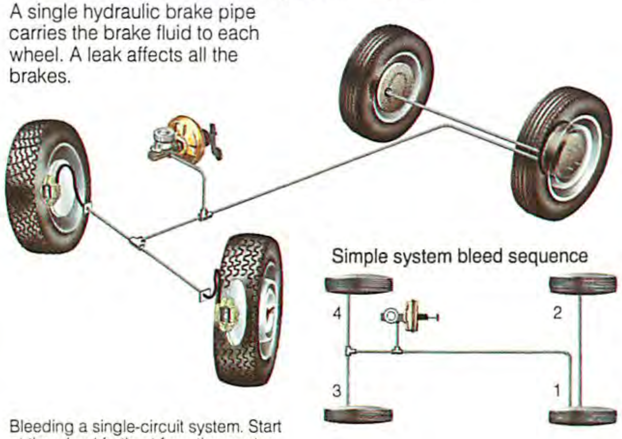
On some cars, the rear brakes cannot be bled if the weight is taken off the wheels, and the job must be carried out with the car on the ground.



Because the two circuits are separate, bleeding is two separate operations. Start with the wheel nearest to the master cylinder in each case.

How a single-circuit system works

A single hydraulic brake pipe carries the brake fluid to each wheel. A leak affects all the brakes.



Bleeding a single-circuit system. Start at the wheel furthest from the master cylinder, and end at the nearest.

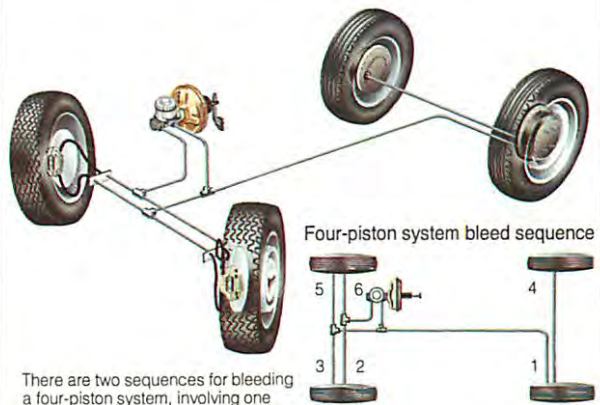
Bleeding a four-piston system

A variation of the dual-circuit system has front disc-brake calipers with two pistons and cylinders in each caliper.

Each cylinder has a bleed nipple, so that there are at least two nipples on each caliper.

One half of the master cylinder feeds fluid to the back brakes and to one of the pistons in each caliper; the second half feeds the other two pistons.

A typical bleeding sequence is to start with a rear brake then bleed the two front-caliper nipples on the same side of the car. Repeat the sequence on the other side.



There are two sequences for bleeding a four-piston system, involving one nipple at the rear and two at the front.

Bleeding the brakes / 2

Removing air from a brake system

The bleeding method for drum brakes, disc brakes and combination systems is the same. Different brake types on the same car may have different nipple sizes, and you must use the correct size of ring spanner for each one.

If a road wheel has to be removed, support the car on axle stands and chock the other wheels.

Remove dirt and corrosion from the bleed nipple with a wire brush, take off the dust cap (if there is one) and put a ring spanner of exactly the right size over the nipple.

Leave the spanner in place and attach a length of clear plastic tubing to the nipple. The tubing should be about 2 ft (600 mm) long, and an airtight fit on the nipple.

Place a clean glass container, such as a jam jar, under the nipple, and put the free end of the tube into it. Pour enough fresh brake fluid into the jar to cover the end of the tube.

Take care when opening the bleed nipple. They are often difficult to turn, and fragile enough to fracture if excessive force is used.

The nipple is made of soft metal and can be damaged easily if the spanner is a little too large.

A corroded nipple can easily break off; if it does, the remains may come out with a screw extractor. Otherwise you may have to buy a new brake caliper or wheel cylinder.

If the nipple does not turn with a reasonable amount of force, put a drop of penetrating oil on the thread and allow a few minutes for the oil to penetrate.

Loosen the bleed nipple about half a turn, and leave the spanner in place. Brake fluid should begin to ooze from the nipple and flow down the tube into the jar. If it does not, the nipple may be blocked, and you must open it (see top right).

When the brake fluid is flowing, ask your helper to pump the brake pedal while you watch the fluid run through the clear tubing. More than a few strokes may empty the master-cylinder reservoir, so remember to keep checking it and top it up if necessary.

If you see bubbles – they may be quite small, like froth – there is air in the system. Continue pumping (and topping up) until there are no more.

Tell your helper to pump twice more, then keep the pedal depressed. Close the nipple by tightening it with the spanner. Remove the tubing and the spanner, replace the road wheel and move to the next nipple.

Bleeding brakes using a tube with a non-return valve (SHEET 257) involves exactly the same procedure, but you do not need a helper. Frequent checks must be made to see if air bubbles are passing through the tube.

The same methods are used if you are bleeding the system simply to replace fluid, and not expel air.

Six strokes of the brake pedal with each nipple open in turn should pump out the old fluid and replace it with new in each part of the system. Make sure you retighten each nipple before moving to the next.

The pumping sequence may vary with different types of master cylinder (see lower right).

When you have bled all the nipples, apply hard foot pressure to the brake pedal. It should no longer feel spongy. If it does, there is still air in the system. Repeat the bleeding process, possibly in a different sequence, until the pedal feels firm.

It should remain equally firm under hard and prolonged pressure, without sinking to the floor.

To test the brakes on the road, wait until there is no traffic, drive slowly for a short distance and press the brake pedal as you would normally.

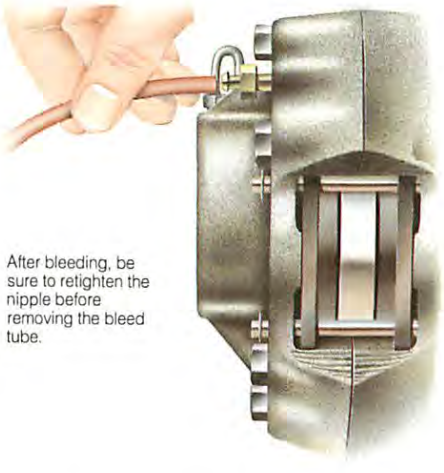
The car should pull up quickly and in a straight line, and the pedal should not feel spongy.

Drive on at normal speed and apply the brakes firmly. Again, the car should stop quickly, in a straight line and in about the same distance.

Try a few more applications – if the sponginess returns, there is still air in the system. Repeat the bleeding process until you are satisfied that the brakes are operating correctly.

If your bleed nipples are not fitted with dust caps, buy some and fit them after bleeding.

Clean off dirt and corrosion around nipple with a wire brush. Wipe the nipple clean with a piece of rag.



After bleeding, be sure to retighten the nipple before removing the bleed tube.

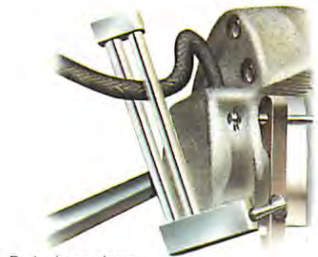
Fit the correct size of ring spanner over the nipple, then attach the bleed tube. Loosen the nipple about half a turn – fluid should flow into the jar. Make sure that the end of the tube is below the fluid in the jar.

Opening blocked nipples

If bleeding does not begin when you open a nipple, it is probably blocked. Use a brake-hose clamp (SHEET 79) to seal the flexible hose leading to that brake, take off the tubing and unscrew the bleed nipple completely.

Carefully poke the nipple clear with a piece of stiff, thin wire.

Replace the nipple tightly, refix the flexible tubing to it and remove the hose clamp. Do not attempt to clear a blocked nipple without removing it; dirt dislodged could find its way into the slave cylinder. Loosen the bleed nipple half a turn, and the fluid should begin to flow.



Brake-hose clamp.

Carefully poke the nipple clear with a thin wire.

Pumping correctly for different master cylinders

There are two types of master cylinder – the aluminium-bodied centre-valve (CV) type and the cast-iron compression-barrel (CB) type.

Each calls for a different pump action in the brake pedal when you bleed it. That applies whether they are single or dual-system units.

With the CV type, push the pedal down fully, then give it three short, quick strokes near the bottom of its travel and release it fully.

Repeat at once, and continue the sequence until there is no more air coming from the bleed nipple.

With the CB type, push the pedal down fully to the floor, then let it rise slowly. Wait for three or four seconds, then repeat the process until all air has been expelled.

If one method of pumping does not clear bubbles from the fluid, and you have tried a different bleed sequence, use the other pumping action.

An aluminium-bodied centre-valve (CV) master cylinder (single-circuit type).

A cast-iron compression-barrel (CB) master cylinder (dual-circuit type).

Replacing a drum-brake wheel cylinder / 1

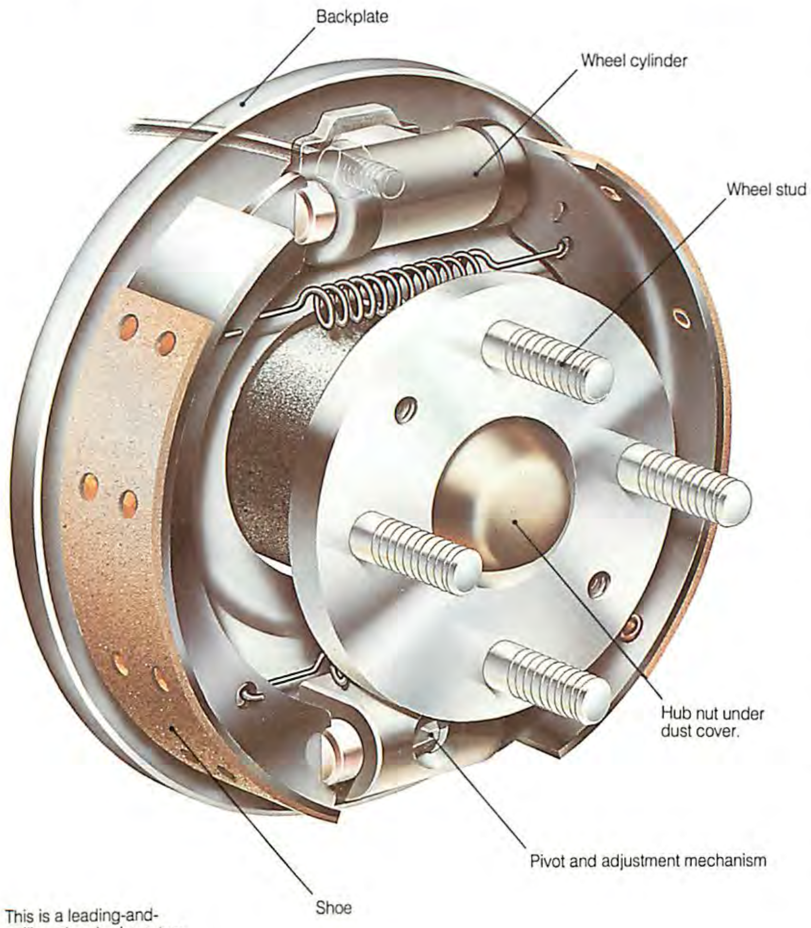
Brake fluid is generally renewed (SHEET 90) when a leaking or sticking wheel cylinder on a drum brake is replaced with a new one.

However, if the fluid has been renewed recently, or it is not convenient to replace it, you can take steps to keep fluid loss to a minimum while replacing the cylinder.

Such precautions also make the system easier to bleed after it has been reassembled.

Tools and equipment

THIN PLASTIC SHEET • BRAKE HOSE CLAMP • JACK • AXLE STAND • SPANNERS • SCREWDRIVER • PENETRATING OIL • SOCKETS • HAMMER • POLYTHENE BAG • WIRE BRUSH • CHOCKS



This is a leading-and-trailing-shoe brake: a two-leading-shoe brake has two cylinders.

Detaching the cylinder

Take off the master-cylinder reservoir cap and, if possible, screw it back on over a sheet of thin plastic stretched over the mouth of the reservoir.

The plastic sheet blocks the breather hole in the cap and creates a vacuum when the fluid level drops, preventing all but a little of the fluid from escaping.

If there is a flexible hose leading into the brake, clamp it off with a brake-hose clamp, taking care not to damage the hose.

With rear brakes on a live axle, clamp the flexible hose(s) connecting the brake pipe on the chassis to the one on the axle.

Remove the brake drum and shoes (SHEET 87). Loosen the brake-pipe union at the rear of the wheel cylinder, and unbolt or unclip the wheel cylinder *before* uncoupling the brake pipe from it.

The method varies according to type, but fixings with bolts or nuts are likely to be stiff, and it is best to apply penetrating oil to them a few hours beforehand. Make sure none gets into the drum.

Screw down the reservoir cap over a sheet of thin plastic.

Seal off the flexible brake hose with a hose clamp.

Loosen the union before freeing the wheel cylinder.

Removing an E-clip, single and double bolts

If the cylinder is fixed by a single stud, you need remove only one nut and lock washer to free it. The cylinder has a projection which fits into the backplate to stop it from turning.

If the cylinder is held by two bolts, remove both to free it.

There may be a gasket between the cylinder and backplate; the gasket must be renewed – a new one should be supplied with a new cylinder.

The circular base of the cylinder projects through the backplate. A pin prevents it from turning. Outside the backplate a spring clip shaped like a round capital 'E' fits around a groove in the projection to hold the cylinder in place.

Lever off the clip with a screwdriver and discard it.

Renew both the clip and the gasket under the cylinder: replacements should come with the new cylinder.

After fitting the new cylinder and gasket to the backplate, drive the new clip on to the projection by pressing it on with a suitable-sized socket and tapping this with a hammer. The concave side of the clip goes next to the backplate.

Two-bolt fixing method – remove both.

The E-clip fits on concave side first.

Removing a sliding cylinder

The base of the cylinder projects through a slot in the backplate, in which it is free to slide.

Outside the backplate two interlocking spring clips, pushed on to the projection from opposite sides, hold the cylinder in the slot.

Sometimes there is a single spring plate with two non-springy clips. There is usually a dust cover to seal the slot.

Pull back the dust cover. If there are two spring clips, slide off the outer one by tapping each of its two legs alternately a short way with a screwdriver and hammer.

Slide off the inner clip in the opposite direction.

Sometimes you have to remove the handbrake lever arm so that you have room to remove one of the clips.

If there are two clips under a spring plate, slide the clip next to the handbrake lever as far towards the lever as possible.

Push the other clip in the same direction until you can ease its end under the spring.

Push the first clip down to lift the spring off the second clip. Pull the second clip free, and lift off the plate and the first clip.

Again you may have to remove the handbrake-lever arm or bleed nipple to free the cylinder from the backplate.

Clean both sides of the slot in the backplate and smear with a little brake grease. On reassembly make sure the dust cover fits properly and securely so that no dirt or spray can enter and cause the cylinder to seize.

Slide off the clip by tapping each leg with a hammer and screwdriver.

Replacing a drum-brake wheel cylinder / 2

Removing the brake pipe

When removing the brake pipe, loosen the union nut before taking off the wheel cylinder.

When the cylinder is free, use it to pull an inch or two of brake pipe through the backplate.

Hold the union nut steady with a spanner and unscrew the union by twisting the cylinder. This method of removal avoids twisting the brake pipe.

Unions tend to be stiff and corroded. Apply penetrating oil a few hours before unscrewing one – make sure none gets into the drum.

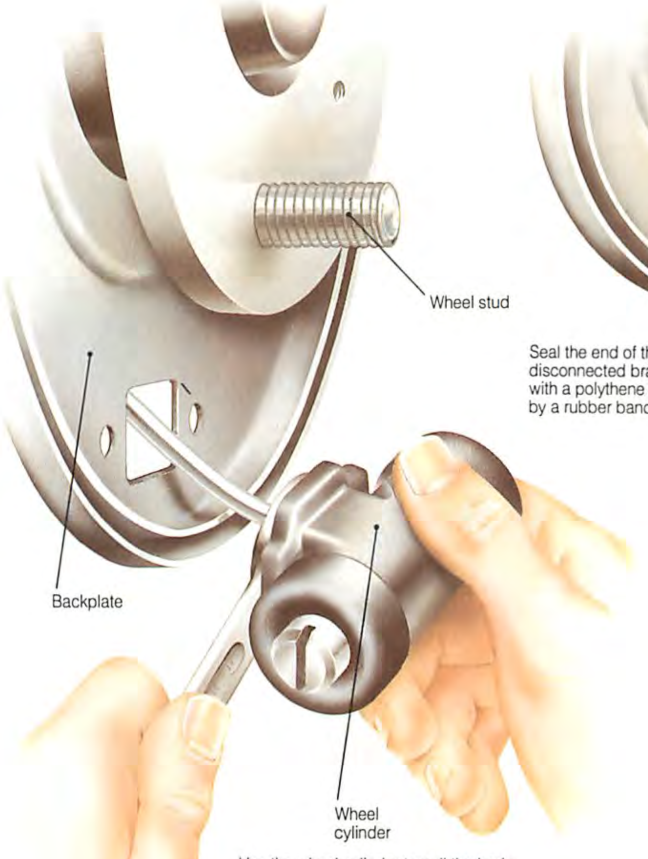
When you unscrew the union nut, always take care not to twist the pipe or hose. With a metal pipe, make sure that the nut is turning on the pipe and not twisting the pipe with it. Also, brake-pipe union nuts are soft, so use a well-fitting spanner of the correct size and ensure that the nut is fully in the jaws.

A difficult nut may need a self-locking wrench to start it.

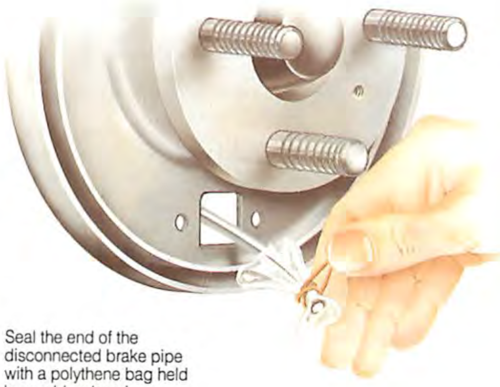
Seal the end of a disconnected pipe or hose temporarily with a rubber plug, or a polythene bag held on with a rubber band. Do not touch the brake pedal.

If a nut seizes, do not try to force it off with a spanner or you may 'round' the corners and make it even harder to turn, and the spanner will begin to slip.

Instead, apply penetrating oil, leave it to soak in for a while, then use a self-locking wrench.



Use the wheel cylinder to pull the brake pipe through the backplate. Hold the union nut steady with a spanner, and twist the cylinder to free the union completely.



Seal the end of the disconnected brake pipe with a polythene bag held by a rubber band.

Releasing the bleed nipple

Sometimes the bleed nipple must be removed before the brake pipe can be pulled through. Save its small cap.

Reassembling the cylinder

Clean the backplate, and wire-brush the pipe union(s) and nut(s). Wipe away grit and flakes of rust.

Screw the union(s) together finger-tight, taking care to avoid cross-threading.

Fit the new cylinder by reversing the steps you took to remove it. Tighten the union(s), being careful to avoid twisting a pipe or hose.

Refit the brake shoes (SHEET 89), bleed the brakes (SHEET 90), and adjust them if they are not self adjusting. Uncover the reservoir.

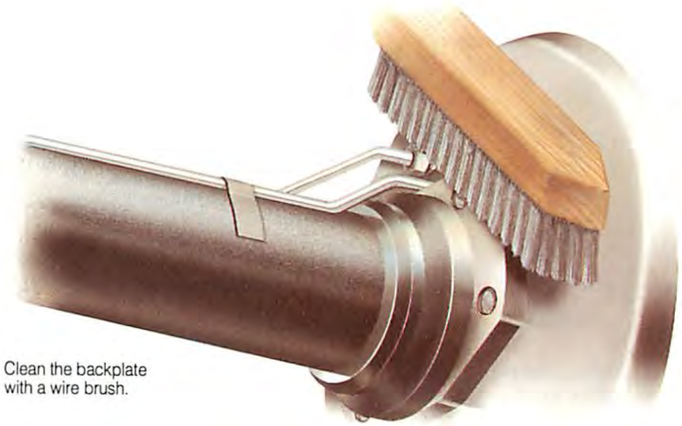
Two unions on one wheel cylinder

Sometimes there are two unions to disconnect from a wheel cylinder – as on two-leading-shoe brakes, where there is a bridge pipe from one wheel cylinder to the other.

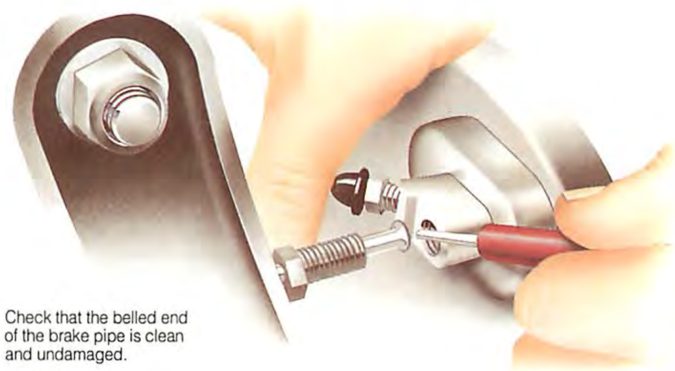
Disconnect the bridge pipe first, and plug the end with a bung to prevent dirt entering.

Slacken the second union – usually a brake hose – and remove the cylinder by drawing it through the backplate and unscrewing it, while holding the brake-hose union with a spanner.

On a two-leading-shoe brake, disconnect the bridge pipe at the cylinder to be removed.



Clean the backplate with a wire brush.



Check that the belled end of the brake pipe is clean and undamaged.

Screw the brake-pipe union on finger-tight before fitting the wheel cylinder. When the wheel cylinder is fitted, tighten the union.

Checking and renewing brake cables

Handbrake cable layouts vary from car to car, but have only a limited range of types of component.

Although you may, for example, find an adjuster screw almost anywhere between the brake lever and the wheels, it can be treated in much the same way.

Even on the few cars where the handbrake works on the front wheels the system is similar.

Cables stretch slightly with use. They need regular checking and lubrication, and adjustment when necessary (SHEETS 82-83).

Check every six months, 6,000 miles, or 10,000 km – or if you feel that the handbrake has become weak.

A more serious problem is fraying cables, which can suddenly break. Moving parts may also rust and stick, so that the handbrake cannot be applied or released fully.

Loosen the wheel nuts of the (handbraked) wheels before raising that end of the car, and chock the other wheels on both sides. Raise the car on axle stands placed so as not to get in the way of the mechanism. Remove the raised wheels.

Look over the whole length of the cables for fraying, particularly at sharp bends.

Check for cracks where cables run inside a flexible outer casing – they can let in water and cause rusting.

See that all parts are clean, sound and lubricated. If necessary, smear them with brake or anti-seize grease.

At longer intervals – about every two years – dismantle all the moving parts, using the same method as for renewing a cable.

Clean everything thoroughly and check it for wear.

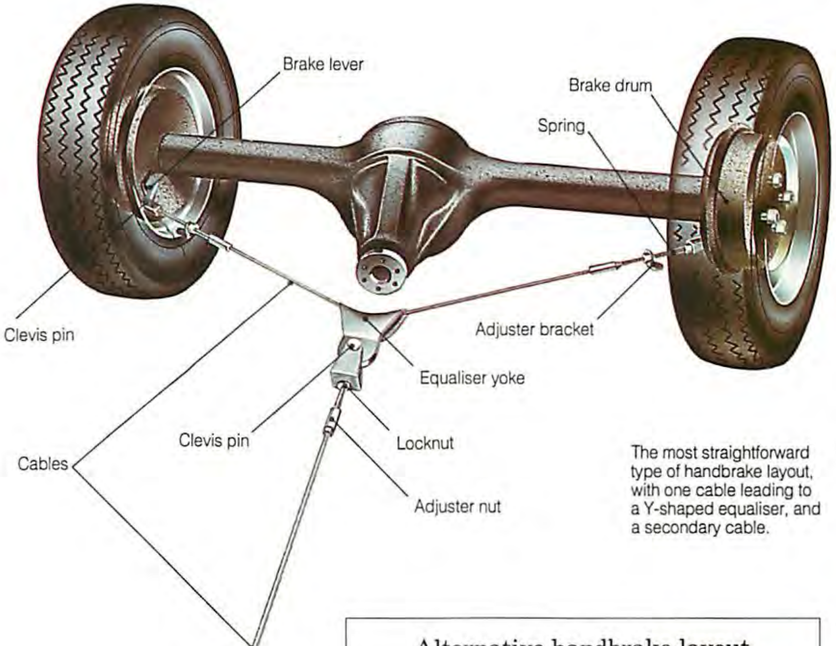
One common trouble, which reduces braking power, is clevis pins becoming 'waisted' – worn away in the middle.

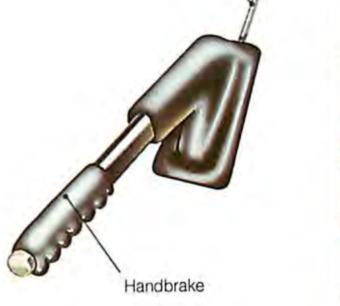
Renew a waisted pin and always use a new split pin or spring clip when reinserting a clevis pin.

Grease all parts during reassembly, including the threads of adjusters.

Tools and equipment

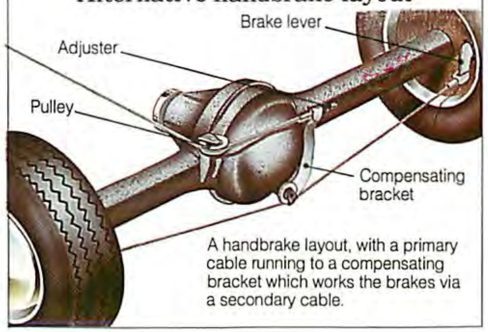
AXLE STANDS • GREASE • PENETRATING OIL • SCREWDRIVER • PLIERS • SPANNERS • BRAKE OR ANTI-SEIZE GREASE





The most straightforward type of handbrake layout, with one cable leading to a Y-shaped equaliser, and a secondary cable.

Alternative handbrake layout



A handbrake layout, with a primary cable running to a compensating bracket which works the brakes via a secondary cable.

Renewing the cable

Cable layouts vary, so make careful notes or drawings as you dismantle one, to avoid confusion later.

One or two cables may run back from the lever. They usually start above the floor and pass through it at points covered by a fixed guide plate.

Twin cables are fixed, usually via adjuster screws, to either side of the lever. Each cable goes to one of the brakes. They are adjusted separately.

A single (primary) cable is fixed to an arm below the lever, usually

Twin cables are usually fixed to the handbrake adjusting screws.

by a clevis pin. There may be an adjuster here. Sometimes there is a rod rather than a cable.

The rear end of the cable may carry an 'equaliser yoke' – a transverse sliding guide.

Another (secondary) cable runs freely across the equaliser, each of its ends being connected to one of the brakes so that this Y-shaped arrangement divides the pull equally between them.

There is usually an adjuster for the primary cable in front of the equaliser, and for the secondary cable on one side only.

Often, you remove an equaliser

An equaliser yoke fitted to a rod on the handbrake lever.

to free the cable from it.

Parts of either cable may run inside flexible outer casings. The casings are held at their ends by abutment brackets on the frame.

Usually, one end of a casing is a long, threaded tube which can be adjusted on the bracket by locknuts.

Some cars – for example the VW Beetle – have rigid outer tubes instead. When removing a cable from such a tube, tie a string to the cable, draw the string through the tube and leave it in place to pull the cable back.

Instead of a Y-shaped equaliser layout, some cars have a single cable linking the brakes around an equaliser fixed to an adjustable rod on the handbrake lever.

On other cars the primary cable runs either directly to the rear axle, or to an adjustment point where it works a secondary cable leading to the rear axle.

The cable runs around a compensating bracket, sometimes via a pulley, and to one of the brakes.

From the bracket a third cable (or sometimes a rod) runs to the other brake, in such a way that the compensating bracket equalises the pull between the brakes.

A cable may be connected to

Removing a clevis pin.

the brake itself outside the drum or caliper, usually by a clevis pin.

Often a drum has an inside connection, in which case you have to remove the drum (SHEETS 87-89), and also usually a spring and sometimes a clip inside the drum.

Whatever the details, all connections are by normal clevis pins with split pins or spring clips, by ordinary nuts, bolts and screws.

So long as you note the details, handbrake reassembly should not be a problem. Always renew all split pins and spring clips.

Mini cable

Early Minis and similar Leyland front-wheel-drive cars have cables running through channels and around quadrant-shaped sectors on the rear radius arms. The system is prone to rust and sticking.

To release a seized sector, treat it with penetrating oil. Disconnect the cable from the brake backplate. Tap or lever the sector back and forth.

Grease the sectors and channels well before reconnecting the cable.

Note if you remove the cable that the sector is nipped in two places to hold it. Lever the nipped parts open to remove the cable; close after reassembly.

On a Mini, the cable is held in a sector on the rear radius arm. Keep the sector pivot oiled to prevent it seizing.

Replacing a master cylinder and servo unit / 1

If a master cylinder is leaking (SHEET 79) replace it. The cylinder is usually mounted on the bulkhead separating the engine and car interior. It may be fitted with a vacuum servo unit.

The master cylinder is normally connected to the brake pedal by a pushrod. On some cars, particularly those originally designed for left-hand drive, it may be positioned on the nearside of the engine compartment and linked to the pedal by a cross rod.

A leaking or faulty servo unit should also be replaced. It may be faulty if the brake pedal is hard to push down, and all other brake faults have been eliminated (SHEETS 90-94).

Before replacing it, check the condition of the air filter, which may be causing sluggish operation. It should be changed every three years, 36,000 miles or 60,000 km.

Before you disconnect brake lines or electrical leads, such as those to the stop-lamp switch or fluid-level warning light, make a sketch of where each fits. If the car has twin brake lines, this is vital. Tag them, and mark the cylinder body accordingly.

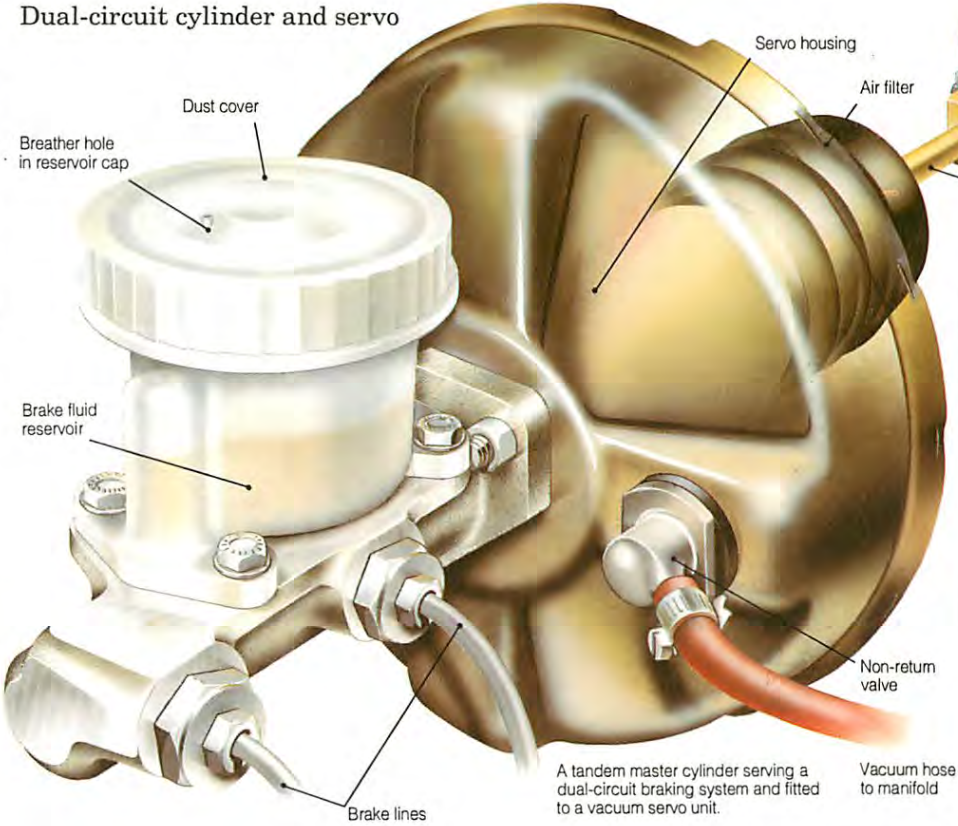
Be careful to note the positions of washers, bushes and pedal return springs. Check how the pushrod is fitted to the brake pedal – there may be more than one hole in the pedal arm.

If you empty the brake fluid from the master cylinder, do not use the fluid again.

Tools and equipment

SPANNERS • JAR • ADHESIVE TAPE • RAGS • PLIERS • SCREWDRIVER • SHARP KNIFE • BLEED TUBE

Dual-circuit cylinder and servo



A tandem master cylinder serving a dual-circuit braking system and fitted to a vacuum servo unit.

One-circuit cylinder

A master cylinder serving a single-circuit braking system, and with no servo unit.

Preparing to remove the master cylinder

The brake fluid can either be drained from the reservoir or left in and sealed. Generally it is better to drain the complete system.

To drain the cylinder, open the offside front-wheel bleed nipple. If the car has a split system, open the offside rear-wheel nipple as well. If in doubt, open each bleed nipple in turn, front first then rear.

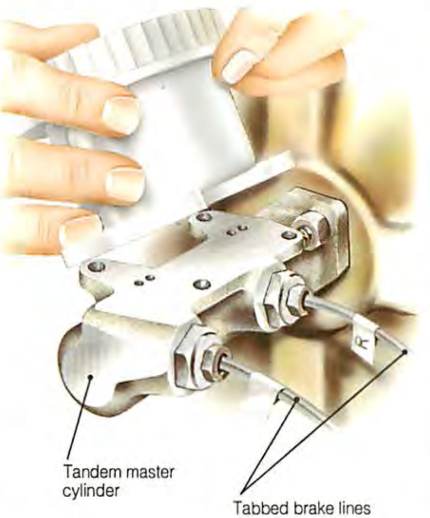
Put a jar under each nipple and pump the brake pedal until the cylinder is empty. Avoid spilling brake fluid on the car paintwork, for it is corrosive. If some is accidentally spilled, wipe it off at once.

If you leave the master cylinder full, seal the breather hole in the breather cap with adhesive tape. Or screw the cap down over a thin sheet of plastic.

A small amount of fluid will still escape, so put plenty of rags under the cylinder and the brake lines.

On some cars the reservoir is a separate unit that can be unplugged from the cylinder and refitted to the replacement.

If it is full, seal the breather hole, and as you remove the reservoir quickly seal off the bottom outlets with your fingers, to catch drips.



If the reservoir can be unplugged, remove it from the master cylinder. If it has not been emptied seal the bottom outlets with your fingers to catch any drips.

Disconnecting a pushrod

On most cars, the pushrod is linked to the brake-pedal arm by a clevis pin that is held in place by a split pin or clip.

The linkage may be so high up the pedal arm that you have to remove a parcel shelf or trim panel to reach it.

Straighten the split pin and pull it out with pliers. Push the clevis pin out sideways.

When reassembling, use a new split pin, and be sure to link the rod to the correct hole.

If the linkage is hard to reach, try pushing the pin through a strip of adhesive tape, then wrap the tape round your finger to hold it while you locate the hole.

To disconnect the pushrod, straighten the split pin and pull it out with pliers. Push the clevis pin out sideways.

Disconnecting a VW pushrod

On some VW cars, the pushrod can be pulled straight out of the master cylinder; it does not have to be detached from the brake pedal. Check the type in the workshop manual.

When reassembling, you may have to adjust the length of the pushrod. Slacken the locknut and turn the rod so that there is about 1/25 in. (1 mm) of free play between the ball end of the rod and its seating in the cylinder piston.

On cars with a tandem master cylinder, make sure the pedal-stop adjustment allows the pedal full movement, so if one system fails it can operate on the other.

On some VW cars, the pushrod can be pulled straight out of the master cylinder. On reassembly, its length may need adjusting by means of the locknut.

Replacing a master cylinder and servo unit / 2

Removing the master cylinder

Uncouple the brake pipes to the master cylinder; seal the pipes to prevent spillage, or allow the fluid to drain into a jar.

Disconnect any electrical leads, such as those to the fluid-level warning light or stop-lamp switch.

You may also have to disconnect any other parts that are in the way, such as the choke or throttle cables.

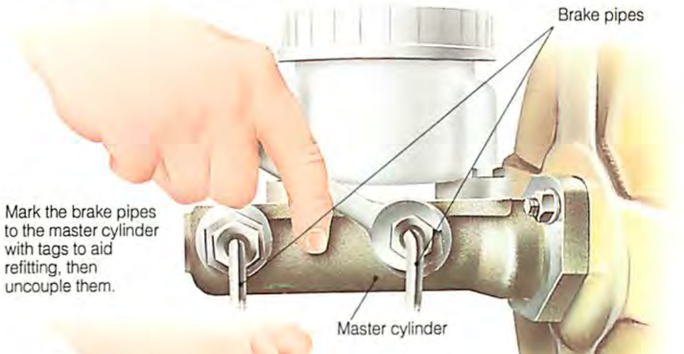
Generally, the master cylinder is secured by two nuts and studs, or nuts and bolts. Sometimes there is also a bracket holding it to the inside of the wing.

On VW Beetles, the master cylinder is inside the front luggage compartment and is unbolted from inside the front wheel arch. Remove the wheel to get at the nuts.

Remove the bolts holding the cylinder and lift it off, taking care not to drop any washers.

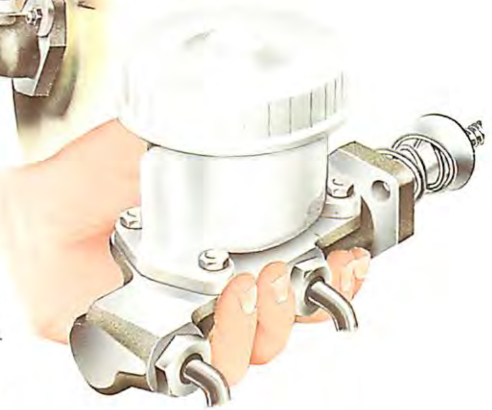
After fitting the new master cylinder, screw up pipe unions by hand at first, then tighten them with a spanner – they are easily cross-threaded.

When reassembly is completed, refill an empty reservoir with brake fluid. Whether or not the reservoir has been emptied, bleed the brakes (SHEETS 90-91). Top up the reservoir.



Mark the brake pipes to the master cylinder with tags to aid refitting, then uncouple them.

Undo the bolts that hold the master cylinder to the servo unit or the bulkhead.



Often the cylinder can be removed with the pipes still in place – as shown – if they are long enough to let you move it to one side. Take care not to drop washers. Check any seal between it and the servo unit.

Replacing a servo unit

When renewing the servo unit alone, it may be possible to dismount the master cylinder without disconnecting the brake pipes – they may be long enough to allow it to be moved to one side.

If so, there is no need to drain the master cylinder. If not, disconnect the pushrod and remove the master cylinder as described.

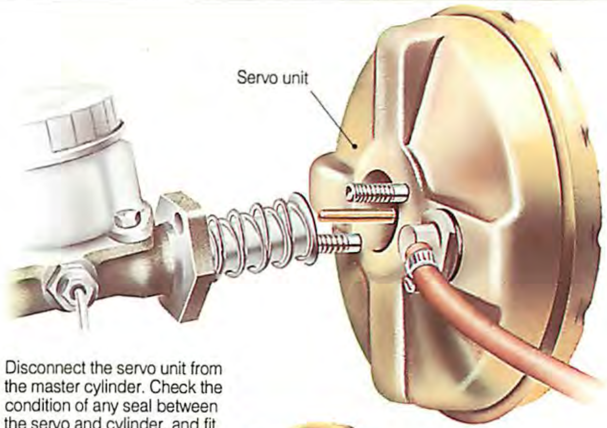
If there is a seal between the servo and master cylinder, check its condition and renew if necessary.

Make a sketch of the way the servo pushrod is connected to the brake pedal, and how the vacuum hose is connected to the servo. Disconnect them both.

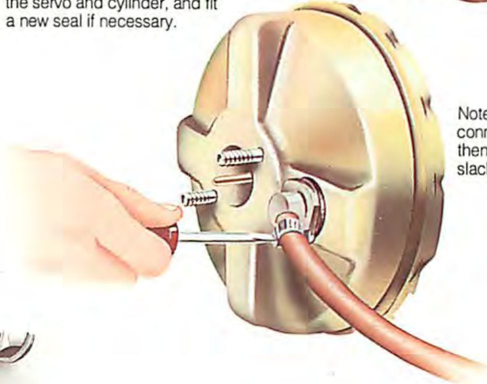
Unbolt the servo unit from its bracket on the bulkhead and withdraw it. If there is a gasket between the servo and the bulkhead, check whether it is worn; renew if necessary.

When refitting a new unit, inspect the condition of the vacuum hose and renew if necessary. Make sure that hose clips are tight.

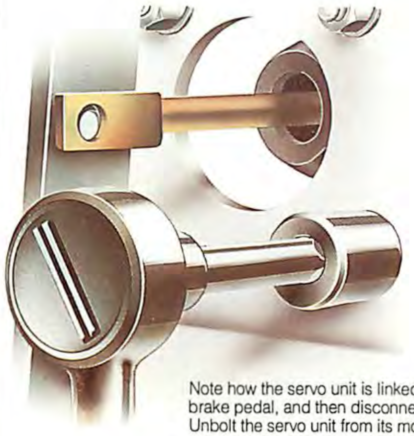
If the master cylinder has been disconnected, bleed the system (SHEETS 90-91) after reassembly is completed.

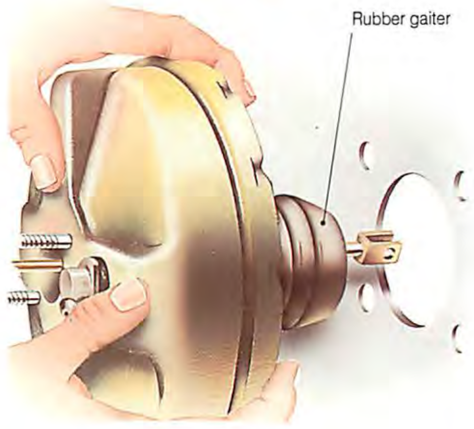


Disconnect the servo unit from the master cylinder. Check the condition of any seal between the servo and cylinder, and fit a new seal if necessary.



Note how the vacuum hose is connected to the servo, and then disconnect it by slackening the hose clip.





Note how the servo unit is linked to the brake pedal, and then disconnect it. Unbolt the servo unit from its mounting bracket. Withdraw the servo unit. If there is a gasket between the servo and its mounting, check its condition and renew if worn.

Renewing a servo air filter

On most later cars, there is a felt air filter fitted on the rear of the servo unit, encircling the pushrod.

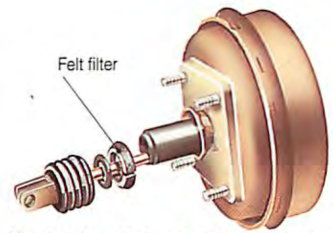
It is not usually necessary to take off the servo in order to renew the filter. You should be able to reach it either between the rear of the unit and the bulkhead, or from inside the car.

The filter is covered by a rubber gaiter. Slide the gaiter along the pushrod to expose the filter, and prise the filter off.

Use a sharp knife to slit the new filter across its radius, making the cut at an angle of approximately 45 degrees.

Slip the filter over the pushrod, position it in its housing, and press the two ends of the filter together. Replace the rubber gaiter over the filter.

On some cars, there is a foam-plastic ring instead of a felt ring. It is not renewable; wash it in a mild water and detergent mixture if it is clogged with dirt, and replace it.



You do not usually have to remove a servo unit to get at the air filter. Reach it from inside the car or between the rear of the unit and the bulkhead.

Use a sharp knife to cut a new felt filter across its radius, making a sloping cut at an angle of about 45 degrees, in order to fit it to the pushrod.

Checking and topping up the battery

Some car batteries are 'sealed for life' – apart from a small vent hole which allows gas to escape. They never need topping up.

The fluid level in other batteries should be checked at least once a month and topped up if it drops below the correct level – just above the tops of the battery plates.

Never top up with tap water, which contains minerals which may damage the battery. Use distilled or otherwise purified water, or a proprietary topping-up fluid.

Avoid over-filling, which causes the electrolyte to leak out through the cell-cap vents as the battery is charged.

Do not use a naked flame when checking the battery. The fluid inside – called the electrolyte – can give off explosive gas, especially soon after the battery has been charged.

The electrolyte is a mixture of sulphuric acid and purified water, and is corrosive and dangerous. Do not allow any to splash on to your skin or your clothing.

If you are splashed, wash the affected skin area immediately. If it goes in your eye, wash thoroughly in running water and call a doctor.

If electrolyte splashes on to your car, hose it off immediately.

A drop in the battery fluid level is caused – provided that there are no leaks – by evaporation of the water in the electrolyte mixture.

Once the level falls below the tops of the battery plates, the cell concerned starts to lose efficiency.

If the cell is left for some time with the plates exposed, it can be damaged. That in turn will ruin the battery, which needs all its cells functioning to retain its full electrical charge and deliver power. The battery must be replaced.

How quickly the electrolyte evaporates depends a great deal on two factors: the under-bonnet temperature (if the battery is located there); and whether the generator is overcharging the battery.

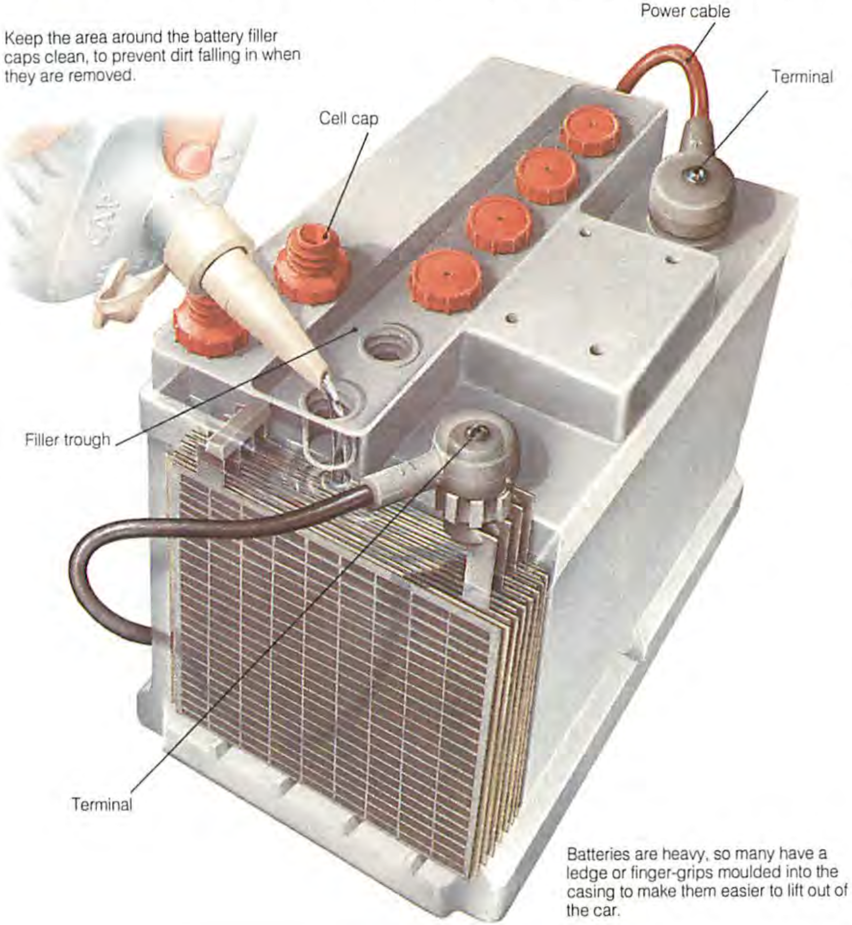
Generally, the higher the temperature the more frequently a battery may need topping up. In most cases, the monthly check is enough – but check more often in hot weather, or if the level is well down at the monthly check. Battery cases rarely leak. If more than the usual amount of topping up suddenly becomes necessary, look for the cause.

If a charging-system fault is overcharging the battery, you may find damp patches around the cell caps – and even droplets of electrolyte on the battery top (SHEETS 102–104).

Tools and equipment

BATTERY • HYDROMETER • DISTILLED WATER OR TOP-UP FLUID

Keep the area around the battery filler caps clean, to prevent dirt falling in when they are removed.



Batteries are heavy, so many have a ledge or finger-grips moulded into the casing to make them easier to lift out of the car.

How to top up

Remove the cell caps or trough cover and fill each cell to the level marked on the battery case. If there is no mark, fill until the electrolyte just covers the battery plates, which you can see through the filler holes.

Apart from distilled or otherwise purified water, proprietary topping-up fluids are available from garages, accessory shops and sometimes chemists. Buy them only in sealed containers, to be sure that they are not contaminated.

As an alternative, water from a de-frosted refrigerator can be used, but it must be kept in a clean glass jar or bottle.

Always keep the battery top clean – wipe it before removing the cell caps or trough cover, when dirt is liable to fall into the cells.

The cell caps or cover have ventilating holes to allow the escape of gases when the battery is being charged. Make sure these holes are clear.

After topping up, wipe away any water spilled on the top of the battery.

Automatic filling

Some batteries have a covered trough in the top, so that they can be filled automatically.

Remove the cover and carefully pour distilled water into the trough, where plastic level-finders allow the correct amount into each cell, before closing.

Automatic filling is especially useful where the battery is in an awkward place, and the electrolyte level is difficult to see.

For conventional batteries, automatic filler bottles are available. You put the spout into the battery filler hole and a valve cuts off the water at the correct level.

Batteries with trough covers usually have plastic level finders to cut off distilled water when topping up.

Using a hydrometer

You can find out how well a battery is charged by measuring the specific gravity – or density – of the electrolyte, which varies according to the state of charge.

The specific gravity is the weight of a specific volume of liquid compared with that of the same volume of water.

The figure for electrolyte in a fully charged battery is between 1·270 and 1·290 – meaning that it is 1·270 times heavier than water.

However, as the battery loses charge, the specific gravity drops to 1·130 or lower.

The instrument for measuring specific gravity is a hydrometer, (SHEET 48) which contains a weighted float. The float is marked with a graduated scale, usually reading from 1·10 to 1·30.

Insert the syringe into a cell, then squeeze and release the bulb to draw up a sample of electrolyte – enough to raise the float but not enough to make it touch the bulb.

Read off the graduation mark which is level with the surface of the electrolyte.

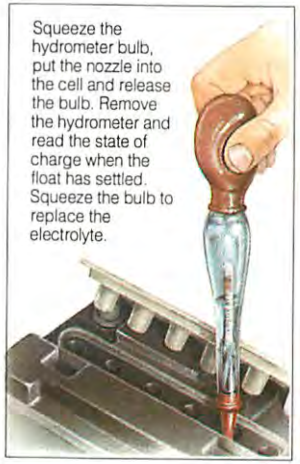
The state of charge can be gauged from how much the figure is below 1·290. A reading of, say, 1·200 would show the battery to be about half charged.

The float may be graded red, yellow and green to show low, half or full charge. Some hydrometers have three small balls of different weights instead of a float. The number of balls that float to the top of the sample indicate the state of charge.

After taking the reading, squeeze the bulb to return the electrolyte to its cell, and test the other cells in turn. All should give similar readings within about 0·04 of each other – any greater variation indicates a defective cell, and the battery must be replaced.

The best time for testing is after the battery has been charged or the car run for about 30 minutes. Switch off the engine and lights.

Readings taken immediately after topping up are not correct.



Squeeze the hydrometer bulb, put the nozzle into the cell and release the bulb. Remove the hydrometer and read the state of charge when the float has settled. Squeeze the bulb to replace the electrolyte.

Checking battery leads and connections

A faint click or total silence when the starter key is turned usually means that the battery is almost or completely flat. If, however, the battery is fully charged, the trouble is probably in the circuit between the battery and starter.

Either way, lack of power is preventing the starter motor from working – though there may be just enough current to work the solenoid, which makes a faint click or chatter.

If you suspect the circuit, look first at the battery-terminal connections. Unless they are in good condition, the current cannot flow through them properly – and sometimes not at all.

The most common types of connector are a clamp that fits around the battery post, or a cup that fits over it. The clamp is secured by a bolt; the cup by a screw into the top of the post.

The Ford type has a flat cable connector bolted to a flat battery post.

The mating surfaces of both connectors and battery posts must be free from dirt and corrosion.

Any green or white powdery deposits must be removed, and the metal surfaces beneath brightened.

Remove these deposits also from the battery carrier or any other metal parts – they are very corrosive.

If cleaning the terminals does not cure the trouble, examine the earth lead – particularly where it is attached to the body or chassis, and clean if necessary. There must be a bare-metal contact for proper earthing.

Some cars have another earth lead between the engine and the body or chassis. Be sure to examine it also.

Look also at the starter motor and solenoid for loose connections, which can cause sparking. This is a fire hazard in any circuit, but becomes an even greater one in the battery-starter circuit, which has around 300 amps flowing through it.

Make sure that the battery is not loose in its mounting, or electrolyte may spill out and cause corrosion.

The battery leads can also work loose, or the case may crack through being bumped about. A loose clamping bracket can touch the live terminal of the battery and cause a short circuit.

Tools and equipment

SCREWDRIVER • SPANNERS • HOT WATER/SODA SOLUTION • EMERY CLOTH • WIRE BRUSH • SMALL FILE • SOLDER WIRE • COMBINATION PLIERS • SELF-LOCKING CLIPS • PETROLEUM JELLY

Removing battery connectors

Clamp or cup connectors can be removed after unscrewing the securing bolt or fixing screw. But take care if the connectors have become tightly fixed on.

Avoid prising them off or trying to twist them loose – undue force can damage the battery posts or their seal with the top of the case.

A screwdriver can be used to force apart the jaws of a clamp connector.

The Ford type is removed simply by unscrewing its nut and bolt.

Similar precautions should be taken when refitting. Do not hammer the connector down over the post.

When you use a spanner on a clamp or connector bolt, take care to keep the free end away from the car bodywork, where it can cause a short circuit – even if the engine is switched off.

Loosening the bolt of a clamp connector.

A cup connector secured to the terminal post by a screw through the top.

Prise the jaws apart with a screwdriver.

Unscrew the nut and bolt of a Ford-type connector.

How to clean the terminals

Use hot water and domestic soda to start removing the powdery deposits that may form on terminals. But be sure that none of this solution finds its way into the battery cells.

The battery posts can be 'brightened' with a wire brush or emery cloth; the connectors filed, scraped or cleaned with emery cloth.

Do not, however, remove so much metal that the cup or clamp becomes a loose fit on the post.

If that does happen, some metal can be filed from the jaws of the clamp, or the sides of the cup can be squeezed in a little, so that it grips the post once more. Alternatively, replace a cup connector with a clamp type.

'Brighten' the battery posts with emery cloth.

Clean up the connector with a wire brush.

Filing metal from the jaws of a clamp connector.

Cleaning the inside of a cup connector.

Refitting the connectors

Smear a thin coat of petroleum jelly (not grease) on the mating surfaces of both the battery posts and connectors before refitting, to deter corrosion and ensure good conductivity.

Ideally, the cup or clamp should be an easy push fit over the post. Tighten the securing bolt or screw enough to stop the connector moving on the post, but do not overtighten.

If a cup-connector screw does not tighten because the thread has been stripped, put a length of solder wire into the hole to fill it partly.

A self-tapping screw should then cut a new thread with enough bite to hold the screw firm. Or simply use a larger self-tapping screw.

Smear petroleum jelly also on the connections at the other ends of the battery leads – in most cases the starter solenoid and the earthing point on the body/chassis.

Use solder wire to fill out the screw hole in a battery post, if the hole is too large.

Smear petroleum jelly over the battery posts.

Squeezing in the sides of a cup connector to tighten the fit.

Using a battery charger

Frequent short trips, with constant stopping and starting, make your battery work very hard, especially in winter when heater, headlights, heated windows and wipers may be working most of the time.

Eventually, because more current is being drained from the battery than the generator can put back, the battery will not have enough power left to turn the starter motor. A battery in that state of discharge is said to be 'flat'.

A flat battery can be avoided if you have a battery charger – a relatively cheap, but worthwhile accessory.

It uses mains current to replace the battery's lost charge through positive and negative leads that clip to the corresponding battery posts.

An average car battery has a capacity of around 48 amp hours which means that, fully charged, it delivers 1 amp for 48 hours, 2 amps for 24 hours, 8 amps for 6 hours and so on.

There is no need to buy costly equipment – but always see that it has a British Electro-technical Approvals (BEAB) sticker, which means that it is electrically safe.

A basic charger usually charges at around 2 amps – and so needs 24 hours to deliver the 48 amps needed to fully charge a flat, 48 amp hour battery.

But there is a wide range of chargers with different charge rates on the market – from 2 to 10 amps. The higher the charge output, the faster a flat battery is recharged. Fast charging, however, is undesirable as it can buckle the battery plates.

The loads imposed on your battery may be gauged from the amount of current used by the various electrical components: headlights take about 8 to 10 amps, a heated rear window about the same.

Theoretically, a fully charged battery, without taking in current from the generator, should work the starter for about ten minutes, or the headlights for eight hours, and a heated rear window for 12 hours. As the battery nears full discharge, the lights gradually grow dimmer and finally go out altogether.

There are also causes other than short trips and cold weather which can affect the state of your battery. Failure is more common on cars equipped with a dynamo rather than an alternator, because the alternator produces more electricity and charges better at low engine speeds (SHEET 19).

The answer in all these cases is frequent testing with a hydrometer (SHEET 97) to see how much capacity is left in the battery, and using a battery charger to top up its charge when necessary.

Types of charger

A basic home battery charger incorporates a transformer and rectifier, to change the mains 240 volt alternating current to 12 volt direct current, and allows the mains supply to provide a charging current at a rate determined by the state of the battery.

In the case of a battery in good condition, the rate of charge may be around 3 to 6 amps with a normal home charger.

A battery at the end of its useful life may not accept any recharging, and will not, in any case, hold a charge.

Some chargers are fitted with a high and low (Hi-Lo) switch to give a choice of two charging rates – typically 3 or 6 amps – in case you want to give the battery a short overnight boost at 6 amps rather than a longer charge at 3 amps.

Many have a charge indicator which may be a warning light, or a gauge showing the charge rate in amps.

Note that the mains lead on all chargers should be fused. If it is not, use a three-pin fused plug. As an extra precaution, fit a line fuse (SHEET 124) to the positive (+) cable lead to the battery.

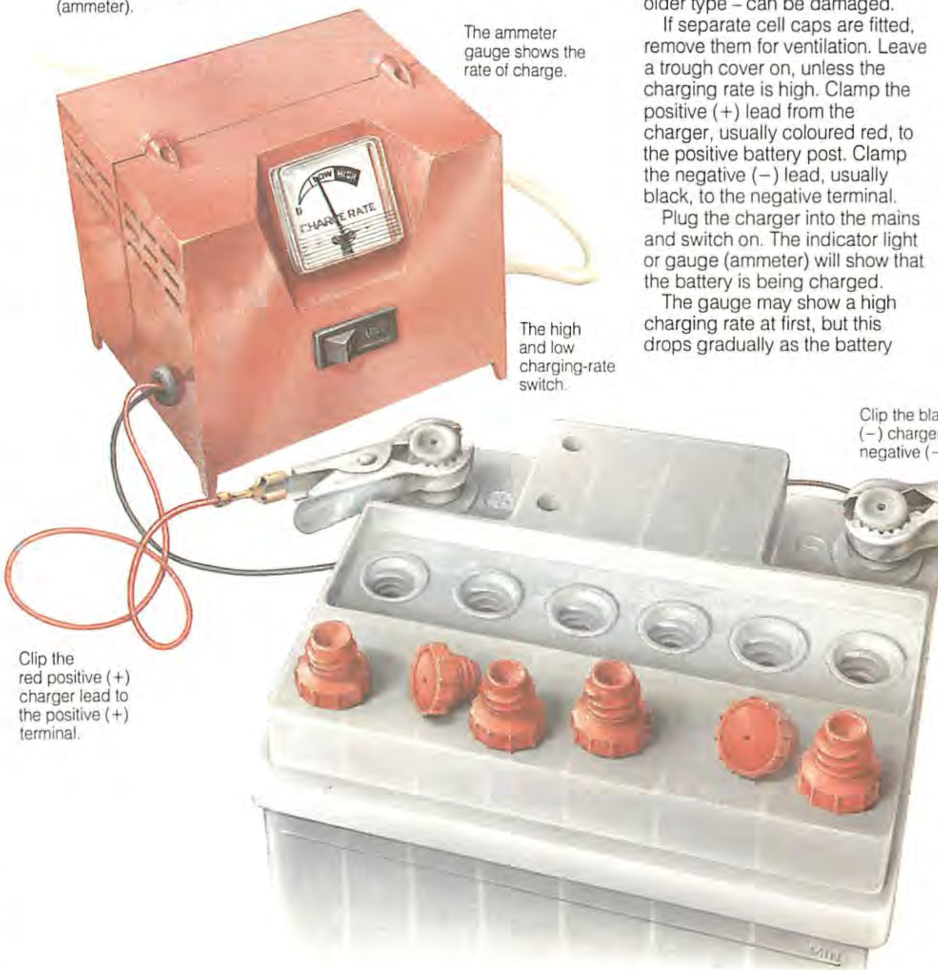
Tools and equipment

BATTERY CHARGER • SPANNER • DISTILLED WATER • FINE EMERY CLOTH • HYDROMETER

Unplug before disconnecting

After charging, always switch off at the mains and unplug the charger before removing its terminal clips – otherwise the clips may spark as you take them off and ignite gas given off during charging.

Make sure also that no electrical circuits are switched on in the car when you reconnect the battery – a spark may occur as you replace the second battery terminal and ignite battery gas.



Connecting the charger

Always check the electrolyte level before connecting the battery to the charger. Top up if necessary (SHEET 97) and clean the battery posts.

If there is a power point handy, the battery can be left in the car, so long as the charge rate is only 3 or 4 amps.

However, if the car has an alternator, disconnect the battery terminals beforehand: otherwise some alternators – generally the older type – can be damaged.

If separate cell caps are fitted, remove them for ventilation. Leave a trough cover on, unless the charging rate is high. Clamp the positive (+) lead from the charger, usually coloured red, to the positive battery post. Clamp the negative (–) lead, usually black, to the negative terminal.

Plug the charger into the mains and switch on. The indicator light or gauge (ammeter) will show that the battery is being charged.

The gauge may show a high charging rate at first, but this drops gradually as the battery becomes charged.

If it was very flat, charging is likely to take a long time; check periodically with a hydrometer, while continuing the charge.

In the final stages, the cells bubble and give off gas. If any of them begin gassing before others, or do so more violently, the battery is probably defective and should be checked by a garage or battery specialist.

Some batteries have a one-piece cell-cap cover fitting in a central trough.

A high charging rate

If the charging rate is much more than 4 amps, take off the cell caps or covering trough to assist the gas to escape.

Checking, adjusting and refitting drive belts / 1

Drive belts always stretch a little in use, because of the strains put on them by driving the water pump and generator, as well as the fan itself if it is in the system. Age and continual flexing also cause belts to crack and deteriorate.

Stretching slackens a belt, so that it slips on the pulleys. A cracked belt will eventually break. The tension and general condition of the belt should therefore be checked at least monthly.

The ignition light comes on to give immediate warning of a broken belt, as the generator stops working.

But the first warning of a slipping belt may well be overheating of the engine or a flat battery – or both.

The belt often starts to slip only when the load on the generator is heavy – for example, when the headlights and rear-window heater are both on – and it becomes more difficult to turn. The fault does not show on the ignition light, but the battery is not getting its full charge and will eventually run down.

Overheating is caused by the slipping belt failing to drive the fan or the water pump properly.

Apart from these effects, a slipping belt is itself worn more rapidly by the heat generated as it slips. The inner face usually cracks first.

A belt that is too tight puts an extra strain on the generator and water-pump bearings, and often causes the premature failure of these bearings.

Before checking a belt always remove the ignition key, to avoid any possibility that the engine might turn over and injure your fingers.

You can make a reasonable check by looking carefully all round the belt, and by feeling around the inner face for damage. To check thoroughly, take off the belt (SHEET 101) and bend it back a section at a time, so that any cracks there may be are opened and easier to see.

Cracks, scuffs, tears and bumps anywhere on the belt mean that it must be replaced. The Vs of the pulleys in which it runs should also be examined, to make sure they are not the cause of the damage. They must be clean, smooth and free from the slightest distortion, as well as perfectly aligned so that the belt does not suffer from twisting.

Any misalignment is usually caused by mounting the generator wrongly.

Occasionally a high-pitched squealing sound is made by a belt that is loose or out of line. The sound may vary with the speed of the engine.

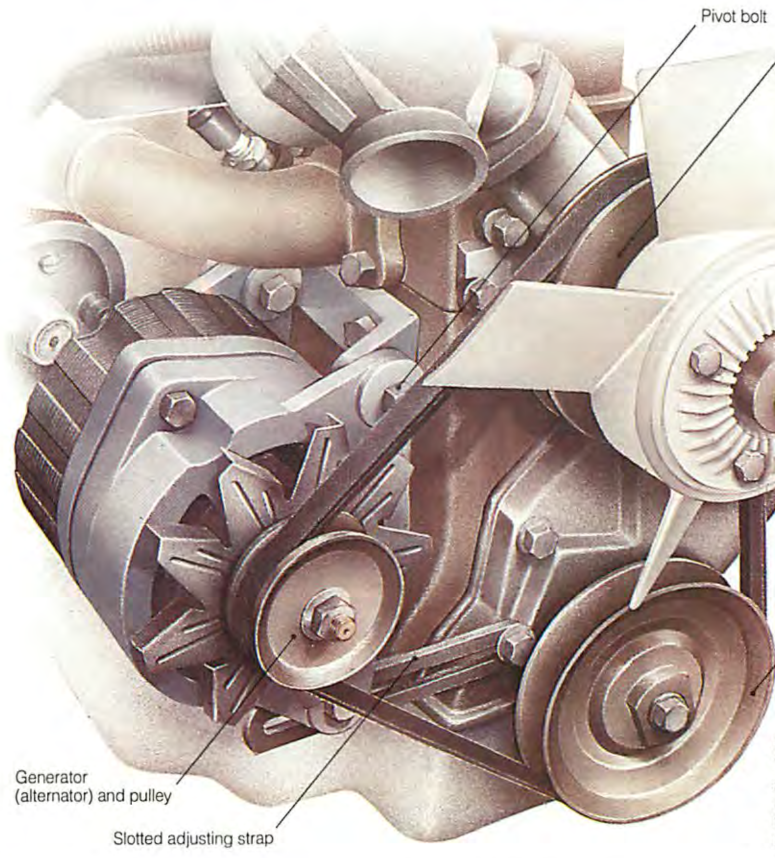
Do not try a makeshift cure by lubricating the belt with oil. Doing so will damage the belt and cause it to fail – and a belt swollen or sticky with oil may still squeal, even after the original cause has been properly corrected.

A broken belt, though indicated through the ignition light, can still do much damage in a short time.

The flailing ends can tear out electrical cables, cut hoses or even damage the radiator. So switch off the engine as soon as possible if your belt breaks.

Tools and equipment

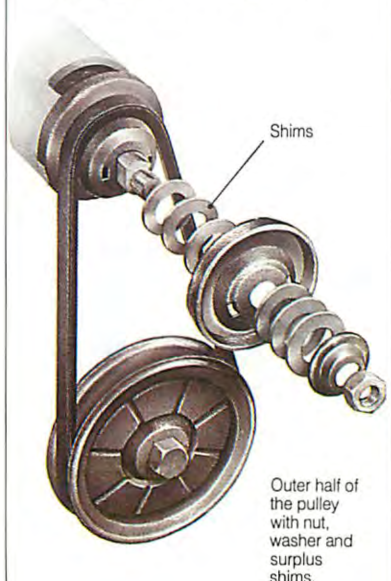
SPANNERS • RULE • SHORT LENGTH OF WOOD • NEW DRIVE BELT IF REQUIRED



How the drive belt runs
The belt runs in V-pulleys and drives the generator and water pump, with its fan, from the crankshaft pulley.

Split pulley

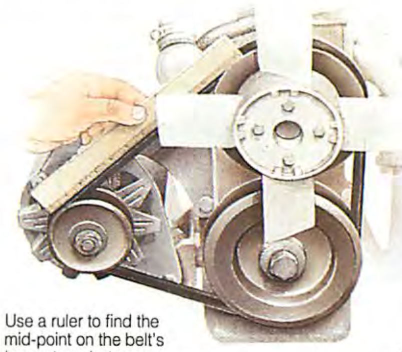
Where the generator is on a fixed mounting – as in a Volkswagen Beetle – the belt can usually be removed or adjusted by means of a split pulley. It has two dished discs bolted together, with a number of spacer washers – or shims – between. Removing and adjusting methods are on SHEET 101.



Checking the tension

Use a ruler to find the midway point on the belt's longest run between pulleys. Hold the belt between finger and thumb at this point and move it from side to side.

If it moves more than ½ in. (13 mm) it is too slack – any less movement and it is too tight. Check the exact deflection recommended in the car handbook.



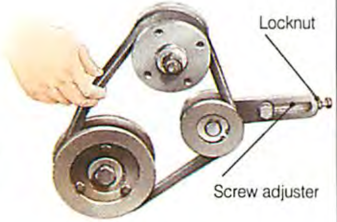
Use a ruler to find the mid-point on the belt's longest run between pulleys.

See how much it deflects at the centre of the run.

Idler-wheel tensioner

Some cars are fitted with an idler-wheel tensioner, which gives simple and accurate adjustment of the belt tension.

Slacken the locknut on the adjuster screw and turn the adjuster until the belt tension is correct. Retighten the locknut and re-check the tension.



Checking, adjusting and refitting drive belts / 2

Adjusting the drive belt

A drive belt is usually tightened or slackened by means of an adjustable pivot where the generator is mounted on the engine.

The generator itself is made to pivot on the two bolts holding it, so that it can swing out and away from the engine. But its movement is governed and can be restrained by a slotted metal strap bolted to the free side of the generator.

Belt adjustment is made by slackening off the pivot bolts, then those on the slotted strap, so that the generator is free to move.

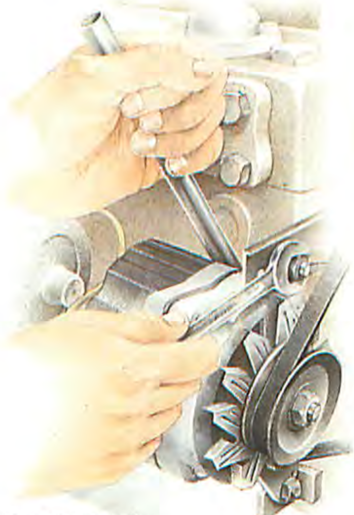
To tighten the belt, use a strong piece of wood to pull the generator away from the engine – a hammer handle will do – while you test the belt tension with the other hand.

When the tension is correct hold the generator firmly in that position and tighten the adjusting strap bolts. Re-check the tension and, if it is still correct, tighten the pivot bolts.

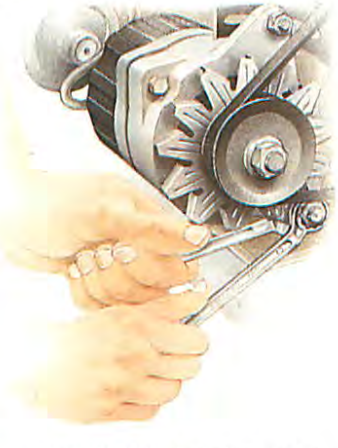
To slacken the belt, loosen the pivot bolts so that the generator is just movable by hand. Move the generator towards the engine a little at a time while feeling the tension on the belt with your other hand.

When the tension is correct, tighten the adjusting strap bolts and the pivot bolt.

Some cars have an idler-wheel pulley (SHEET 100) which presses on the belt. If yours does, turn the screw adjuster to move the wheel and alter the belt tension. This is often simpler than moving the generator.



To tighten the belt, lever the generator outwards with a piece of wood or tubing.



Loosen the pivot bolts on the generator, then on the adjuster strap.

Hold the generator steady and check the tension. When it is correct retighten the bolts.

Adjusting a split-pulley belt

Take off the front half of the pulley and remove or add to the shims between the two halves, so narrowing or widening the V between them.

As the V narrows, the belt is forced further from the centre, up the shoulders of the pulley, and becomes tighter. As it widens, the belt runs closer to the centre and slackens.

Take care not to trap the belt between the two halves of the pulley when tightening them again after adjustment.

Tighten the nut a little, turn the engine over one-third of a revolution, then tighten a little more, and so on until the halves are firmly clamped together.

Finally, turn the engine over one more time and re-check the belt tension.

Unscrew the nut or nuts to split the two halves of the pulley.

Remove the front half of the pulley and take out one shim to tighten the belt or add one to slacken it.

Replace the pulley front half with the shim on the outside of the pulley, between it and the nut or nuts.

Replacing a drive belt

Garages and shops selling fan or drive belts have a list of the correct types for most popular cars. Buy one of the right size and quality.

Belts for alternators are usually made of stronger material than dynamo belts. They are also usually more expensive – but if you use a cheaper dynamo belt to drive an alternator it will probably wear out quickly and perhaps suddenly.

If the correct belt for your car is not on the garage list ask your local dealer for advice, or take the old belt with you for comparison. Even then, make sure the new belt is of the same specification as the old one, or better.

Fitting a new drive belt is usually simple if the pulleys are at the front of the car. But it can be more difficult if the engine is mounted across the car, as on the Mini – because the fan is shrouded or the belt is otherwise harder to get at. On some cars you must remove the shroud surrounding the cooling fan, or at least part of it.

To take off the old belt, slacken the adjustment bolts on the generator mounting and push the generator in towards the engine as far as it will go.

You should now be able to pull the belt off the topmost pulley – usually that on the water pump. Unhook the belt from the generator and crankshaft pulleys and lift over the fan. On cars with a shrouded fan, it is usually possible to feed the belt out over the blades one at a time, between blade and shroud.

Put on the new belt by the same methods, but in reverse order. Often, however, the belt has to be 'wound' over the top pulley.

To do this, feed it over the fan and on to the lower pulleys, making sure it is properly located in the V of the pulleys. Now stretch it as far as possible over the top one, and wind it on by slowly turning the fan and at the same time pressing it against the pulley rim with your thumb. Take care not to trap your fingers between the belt and pulley.

If your car has an electric or viscous-coupled fan (SHEET 21), you may have to turn the engine to wind on the belt, because the fan pulley will not turn the crankshaft pulley and the belt does not wind on.

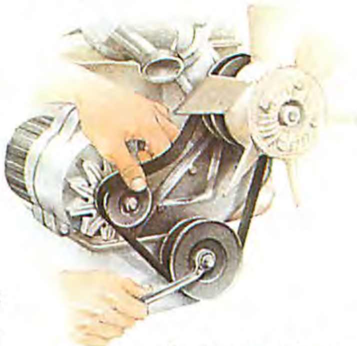
Normally the engine can be turned by using a spanner on the crankshaft pulley.

Do not use a screwdriver or similar tool to lever the belt over the pulley. If the belt is too tight to be fitted by the winding method, it is too small anyway, and you must get one of the proper size.

Remove the old belt on a shim-adjusted pulley in the same way as that used for adjustments. Use all the spacer shims between the pulley discs when fitting a new belt, then remove as many shims as necessary to obtain the correct belt tension.

All new drive belts stretch when first used, so re-check the tension after about 200 miles (300 km) – or sooner if the manufacturer recommends doing so.

'Winding' on a new belt over the top pulley. Do not use a screwdriver to lever it on.



Turn the crankshaft pulley to wind the belt on if the fan is viscous coupled.

Checking generator output and battery condition

If your car's instrument panel includes an ammeter, it will tell you how well the charging system is working – the difference between the charge going into the battery and the power being used from it.

A battery-condition indicator shows only that the generator is charging, by the rise in the voltage. It does not tell you how high or low the charging rate is – though normally any rise means that the charge is adequate.

Many cars have only an ignition warning light, a red warning signal that should go off after the engine starts.

This tells you that the generator is producing electricity – not whether it is producing enough to keep the battery charged. But any abnormal behaviour of the light means that something is wrong somewhere.

Before making checks on the charging system, check that the battery is free of any defects which could produce symptoms similar to those of a faulty generator.

If the engine will not turn over, check for loose or broken starter motor, solenoid or earth connections.

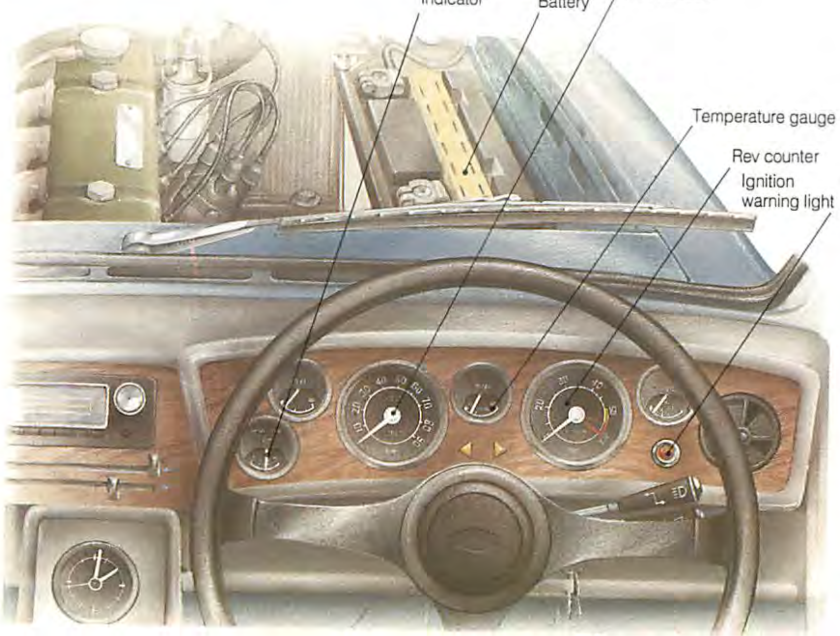
Inspect the battery for loose, dirty or corroded terminals. Clean corroded terminals and leads with very hot water. Protect them with a little petroleum jelly, not grease, and refit the leads tightly.

Remember that battery acid is highly corrosive and poisonous. Avoid getting it on your clothes. Wash off immediately if it contacts your skin.

When carrying out any tests on the engine while it is running or turning over, keep hair and loose clothing away from belts and pulleys.

Tools and equipment

HYDROMETER • VOLTMETER OR MULTI-METER • SMALL INSULATED SCREWDRIVER



Hydrometer check

Check the battery's state of charge with a hydrometer (SHEET 48), which measures the strength of the acid in the electrolyte, or battery fluid.

This gives no clue, however, to the battery's capacity – its ability to sustain a charge well enough to perform its tasks.

Battery capacity depends on the size and number of the plates in each cell. If any plates are damaged, that cell's capacity is reduced. The electrolyte in a sealed-for-life battery cannot be checked readily.

Check the electrolyte in one cell at a time. Put it back in the cell that it came from.

Battery-condition indicator

Some cars are fitted with a battery-condition indicator, which is a form of voltmeter. It may be calibrated in volts, by a sliding coloured scale, or by three bands of red-green-red.

When you switch on the ignition, the indicator shows the battery voltage, just over 12 volts for a 12 volt battery or about the red-green division.

A lower reading means that the battery is not fully charged.

If the reading is well down – while all the circuits and lights are switched off – the battery is not holding its charge, or is 'flat'.

When you start the engine, the indicator shows the generator output. It should move slowly to around the 14 volt mark, or midway into the green sector.

A battery-condition indicator calibrated in volts, and with a red-green-red scale.

It should stay steady at all engine speeds if the car has an alternator, or at speeds higher than idling if there is a dynamo.

If the indicator drops to 12 volts or lower, check the fan belt (SHEET 100) or the generator output.

The ammeter

Some cars still have ammeters fitted on the instrument panel. An ammeter tells you how well the charging system is working, and gives more immediate information than a voltmeter.

The ammeter shows the amount of current going into or out of the battery, or the difference between the two. Thus it tells you at a glance whether the battery is being charged by the generator or discharged by a heavy load.

In practice, if the charging system is in good condition the reading should always be strong.

The ammeter shows the amount of current flow to or from the battery.

If the ammeter shows a very low or negative reading, you know immediately that something is wrong, whereas a voltmeter gives less information and is much slower to respond to a problem.

The only disadvantage of an ammeter is that it is connected in series with the battery and the generator. It requires a heavier cable, and if the ammeter circuit develops a fault, there is more danger of damage to an alternator.

Checking with a voltmeter

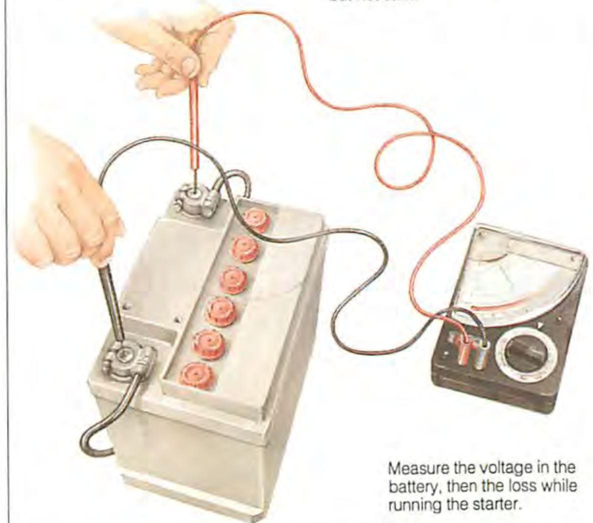
You have to put a heavy load on a battery to test its capacity. Some garages use a heavy discharge tester; a similar test, though less conclusive, can be made with a standard voltmeter.

Remove the high-tension lead from the coil so that the engine turns but will not start. Connect the voltmeter across the battery terminals.

Note the reading – which should be 12 or 13 volts, or possibly more if the battery has just come off charge.

Now have a helper work the starter for 10 – 15 seconds while you note the reading. If the battery is good, the drop in voltage should not be more than about 2 volts.

Remove the high-tension lead from the coil, so the engine will turn over but not start.



Measure the voltage in the battery, then the loss while running the starter.

Testing an alternator and checking output

Alternators have replaced dynamos as generators on modern cars; they can produce more current.

Any short or open circuit or wrong connection can cause a sudden surge of voltage that will damage electronic parts. Never make or break any connection while the engine is running.

Checking alternator output using an ammeter in series with the charging system should be done only by an auto-electrician. A safe test can be made with an induction ammeter held parallel to the output cable, but it is less reliable.

Tools and equipment

INDUCTION AMMETER • VOLTMETER OR CIRCUIT TESTER/TEST LAMP • SPANNERS • SCREWDRIVERS • RULER

Checking the alternator output leads

Check that all connections are secure. Start the engine and connect a voltmeter or tester across the battery terminals.

Have a helper rev up the engine from idling speed. If the voltage does not rise (or the tester lamp or headlamps do not brighten) as engine speed increases, alternator output is too low or is not reaching the battery. Check that the alternator is actually turning.

Switch off the engine and check the tension on the drive belt. Check that wiring to the alternator is not broken or disconnected.

If these checks do not reveal a fault, disconnect the battery earth terminal and check the alternator leads with a voltmeter.

There is one thick output cable from the alternator to the starter solenoid, and a smaller lead or leads. Some or all of the leads may be connected by a multiplug.

If the heavy lead to the starter is separate (not on a multiplug), you do not have to disconnect it, and you can test it any time the battery is connected, using a test lamp. It should be permanently live.

Disconnect the smaller leads and/or the multiplug.

If the alternator has an external voltage regulator, there will be separate connections to it; do *not* undo these connections, even if you have to unfasten the regulator and move it aside.

Reconnect the earth terminal on the battery, and switch on the ignition. Test the alternator leads by connecting each in turn with the voltmeter to an earth.

If there are any leads which fit on to terminals marked with an earth symbol or E, N, –, or D, do not test them. They are earth connections.

All the positive leads should give readings of battery voltage.

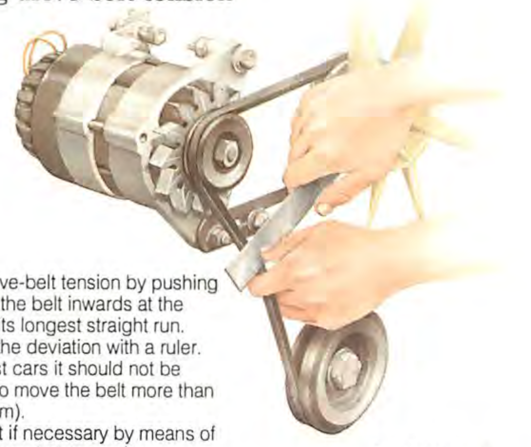
If there is a small lead marked 'Ind' for the ignition warning light, and it alone remains dead when the ignition is switched on, the light may have blown or be disconnected.

If any other wire which ought to be live is not, check it for a loose connection, or a breakage or faulty insulation causing a short circuit.

If all the wires are live and there is still a fault in the charging system, it is probably in the alternator or the regulator. Take the car to an auto-electrician.

Disconnect the earth terminal on the battery before reconnecting all the leads. Make sure everything is reconnected securely and correctly before starting the engine.

Testing drive-belt tension



Check drive-belt tension by pushing or pulling the belt inwards at the centre of its longest straight run. Measure the deviation with a ruler.

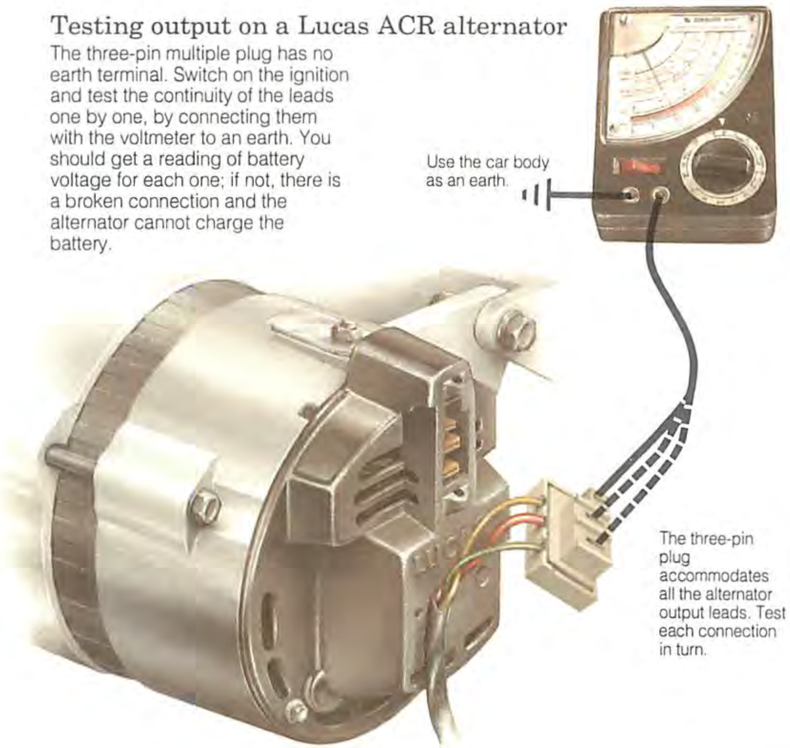
On most cars it should not be possible to move the belt more than ½ in. (13 mm).

Adjust it if necessary by means of the adjustment strap on the alternator. If it is cracked or perishing, replace it.

Check drive-belt tension on the longest straight run.

Testing output on a Lucas ACR alternator

The three-pin multiple plug has no earth terminal. Switch on the ignition and test the continuity of the leads one by one, by connecting them with the voltmeter to an earth. You should get a reading of battery voltage for each one; if not, there is a broken connection and the alternator cannot charge the battery.



Use the car body as an earth.

The three-pin plug accommodates all the alternator output leads. Test each connection in turn.

Multiple fittings

Lucas, Motorola, Femsa and Bosch alternators use a three-pin connector which accommodates all the leads. Hitachi use a two-pin plug and another, separate lead.

Three-pin multiplug

Two-pin multiplug

Terminals under a flexi-cover

Some alternator leads, particularly continental ones, have terminals that are protected by a rubber or plastic flexi-cover.

Remove the cover by prising it gently away from the lead terminal with a screwdriver.

Disconnect the lead or leads from the alternator for testing by undoing the nut and taking it off the terminal.

Prise off the flexi-cover with a small screwdriver.

Undo the lead by removing the nut.

Other alternators

Alternator manufacturers each have their own system of connecting output leads. There is also colour coding, but it varies not only among alternators but also among car makers who use the same make of alternator.

Ducellier alternators use flexi-covers on terminals (see left).

The Hitachi alternator is fitted to various makes of Japanese and European cars. The wiring connections are a double-pin multi-connector and block carrying the smaller cables, and one large terminal post carrying the heavier load-carrying cable, with an eyelet secured by a nut.

The AC Delco alternator is fitted to many Vauxhall and General Motors cars of both British and continental manufacture. It has two terminal posts, one larger than the other, both cables carrying eyelets secured by nuts.

The Mitsubishi alternator is found on some European cars, and a wide range of Japanese cars. It has a spade-type terminal on which the smaller cable is a push fit, and a large terminal to which the load-carrying cable is connected with an eyelet secured by a nut.

Testing a dynamo and checking output

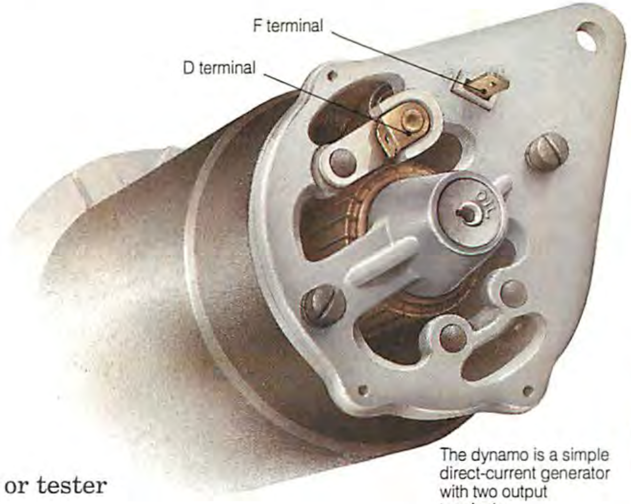
The dynamo is a robust and simple type of generator which was fitted to many earlier cars. Most modern cars are fitted with an alternator.

If you suspect a fault in the dynamo, check all the connections to it with a circuit tester.

Check also that the dynamo actually turns when the engine is running, and that the drive belt is adjusted to its correct tension, and is not slipping (SHEETS 100–101).

Tools and equipment

VOLTMETER OR CIRCUIT TESTER/TEST LAMP • SPANNERS • SCREWDRIVERS • MASKING TAPE • PENCIL • 12 IN. (300 MM) LENGTH OF HEAVY CABLE WITH CROCODILE CLIPS



The dynamo is a simple direct-current generator with two output terminals.

Checking output with a voltmeter or tester

Make these checks with a voltmeter if possible. If not, use a circuit tester or test lamp.

The instructions are for a car with a negative (−) earth system. For a positive (+) earth system, read negative for positive, and positive for negative.

Connect a voltmeter across the battery terminals while the engine is running. Have a helper rev the engine up from idling speed.

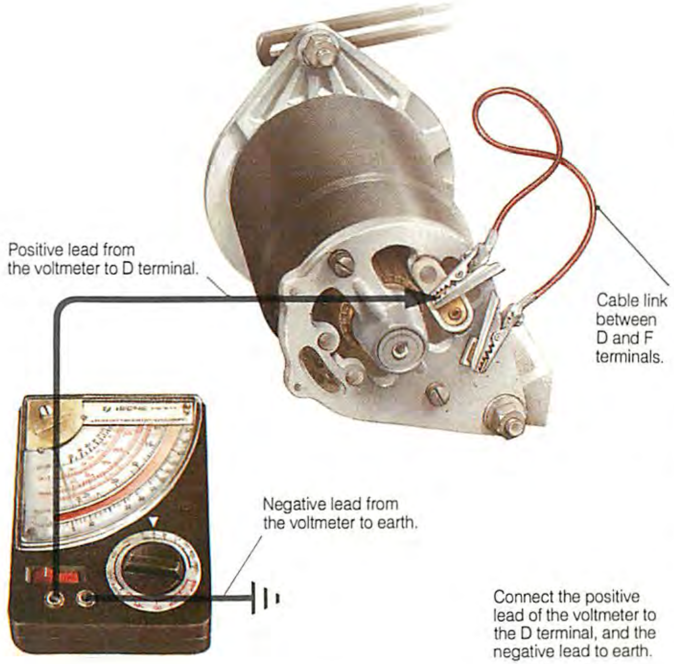
The battery voltage should rise, or the tester lamp (or headlamps) should brighten.

If it does not, and if checks on connections and the drive belt have been satisfactory, switch off the engine and disconnect the two cables from the endplate of the dynamo.

The terminals are usually marked D and F. They are of different sizes, but label them if necessary, to avoid confusion.

Use a short length of fairly heavy cable to clip the D and F terminals of the dynamo together. Start the engine and let it idle at not more than 1,000 rpm.

Connect the positive lead of the voltmeter to the D terminal and the negative lead to earth. The meter should read about 14 volts (or the 12 volt bulb should shine brightly). If so, the dynamo is working.



Connect the positive lead of the voltmeter to the D terminal, and the negative lead to earth.

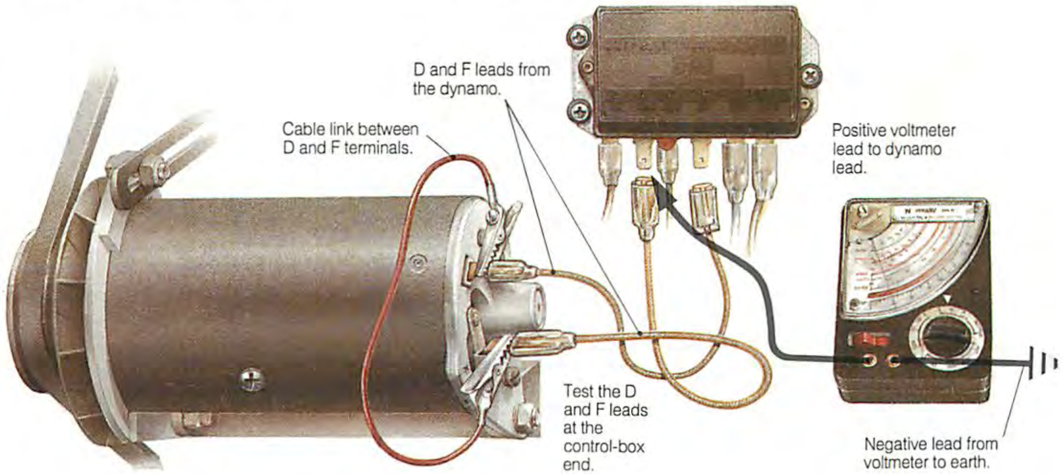
Testing the cables

Reconnect the dynamo cables, leaving the short bridging cable in place. Disconnect the cables at the control-box end, where they are also labelled D and F.

Start the engine and allow it to idle at not more than 1,000 rpm. Connect the positive lead from the voltmeter to the cable disconnected from the D terminal at the control box to see if it is sound.

Then do the same with the cable from the F terminal at the control box.

If the cables are sound, and if the dynamo is charging as previously checked, the meter should read about 14 volts and any fault must be in the control box.



Checking a low charge rate or failure to charge

If the first output test (see left) showed that the dynamo was not charging, disconnect the D and F terminals at the dynamo endplate again, but remove the link between the terminals.

Start the engine and have your helper run it up to 2,000 rpm (medium speed).

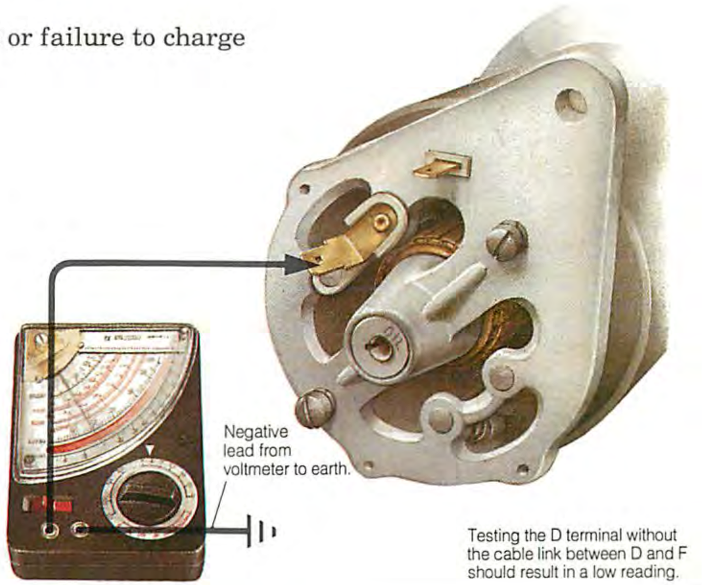
If the car is not fitted with a tachometer (rev counter), 2,000 rpm is about the speed of the engine when the car is travelling at 30 mph in top gear.

Reconnect the voltmeter between the D terminal and earth.

If the voltage reading is 2 to 4 volts – enough to light a torch bulb but not a 12 volt car bulb in a circuit tester – the fault is in the field coil or the brushes.

If there is no voltage the fault is in the armature or the output brushes.

In either case, check the brushes and commutator (SHEETS 106, 107).



Testing the D terminal without the cable link between D and F should result in a low reading.

Cleaning and replacing a control box

On cars with dynamos, faults in the control box show up in various ways, some of which are described on SHEET 104.

Others may be revealed by the ignition warning lamp. If the lamp does not go out as the engine speed rises, the cutout points are not closing.

If the lamp glows dimly at low speeds and brightens as speed increases, the fault is probably dirty, oxidised or burned cutout points.

If the lamp goes out at an abnormally high (or low) speed, it may be a sign of the same trouble in the voltage regulator points, or that either set of points is wrongly adjusted.

The points are tricky to deal with, and the job should be entrusted to an auto-electrician.

Before you do that, check that the underside of the control box is not wet or dirty, which can sometimes produce the same symptoms.

Many control boxes have resistors under the baseplate which, if short-circuited by dirty water, can allow overcharging.

Clean the baseplate and terminals once a year, particularly if the control box is mounted in a place exposed to damp and dirt. Also check that the lid fits tightly.

Removing the box for cleaning and fitting a replacement box are similar jobs, so follow the appropriate parts of the instructions.

Do not buy a new control box until you have made sure that it is not the dynamo or the wiring which has caused the trouble; even then do not fit it until you have rectified any faults that could damage it.

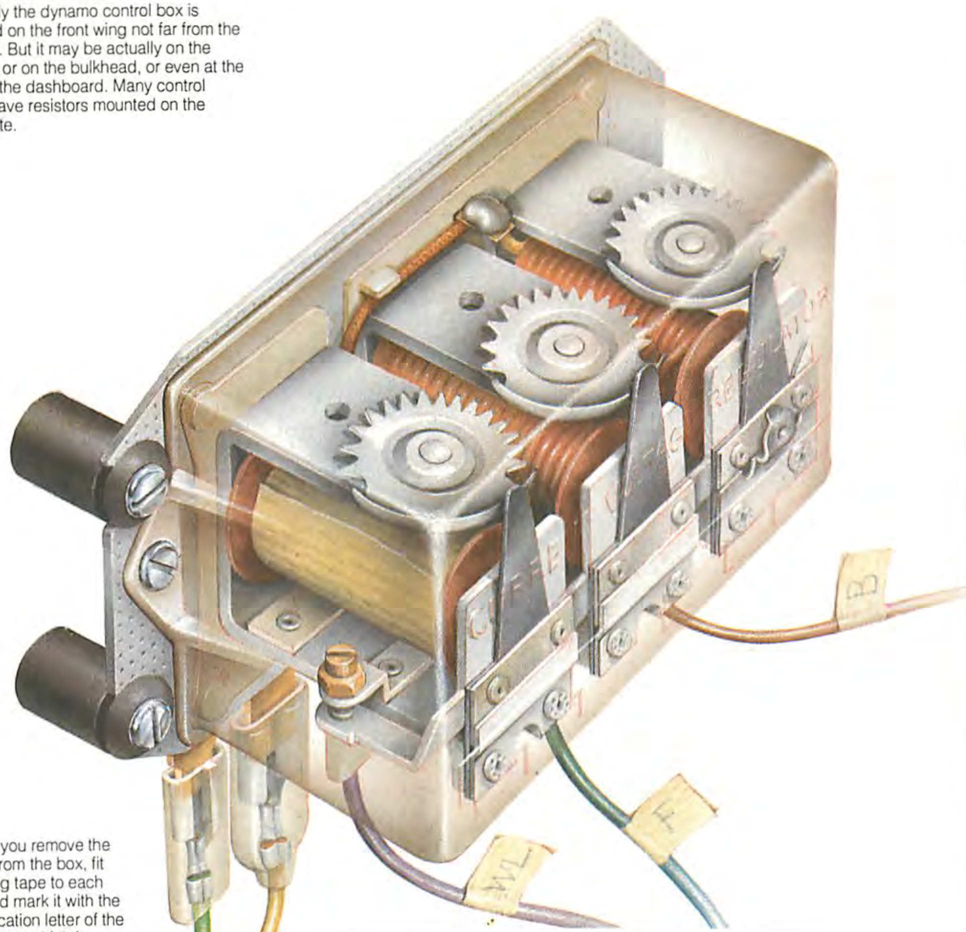
Be sure that the replacement is identical, or the approved successor, to the original. Boxes with different specifications may look alike, so check the model number.

Tools and equipment

SMALL SCREWDRIVER • CLEAN RAG • MASKING TAPE • PARAFFIN • METHYLATED SPIRIT

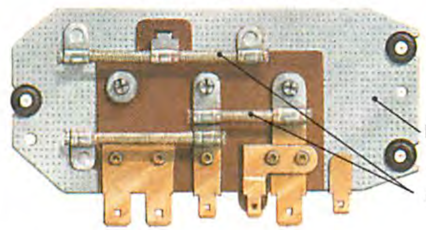
A typical control box

Generally the dynamo control box is mounted on the front wing not far from the dynamo. But it may be actually on the dynamo or on the bulkhead, or even at the back of the dashboard. Many control boxes have resistors mounted on the baseplate.



Before you remove the leads from the box, fit masking tape to each one and mark it with the identification letter of the terminal to which it belongs.

Control-box underside



The back of a typical control box, showing three resistors.

Replacing the control box

Disconnect the battery before starting work. Mark the control-box leads with the letters of the terminals where they fit, then pull them off or unscrew them. See that the connectors are sound and clean.

The box is usually fixed by two or three screws, which may pass through a rubber mounting; or there may be some other kind of backing.

Remove the screws and lift off the box. Take care not to damage the frail resistors mounted on its underside.

The backing acts as an insulator and seal; make sure it is keeping out water and dirt. Clean the area under the control box, and the box itself unless you are renewing it.

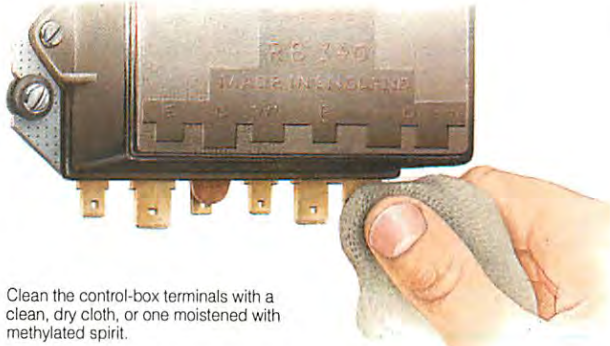
Refit the box, making sure that it sits snugly against its backing and that the lid fits tightly. Reconnect the leads, then the battery. Start the engine and test the box (SHEET 104).

The control box is usually held by two or three screws – remove them.

Cleaning the control box

Wipe the underside of the box carefully; the resistors are easily damaged. Use a clean, dry cloth, or one moistened with paraffin if necessary, to remove dirt.

Keep paraffin away from rubber parts. Also clean the terminals using a soft rag and methylated spirit. Allow the back of the box to dry before refitting.



Clean the control-box terminals with a clean, dry cloth, or one moistened with methylated spirit.

Checking dynamo brushes and commutator / 1

Wear on the carbon brushes and commutator is the most common cause of dynamo failure.

Normally the brushes wear first, but as they become smaller the spring pressure holding them in contact with the commutator weakens.

This leads eventually to continuous sparking – known as arcing – between brushes and commutator.

Arcing causes rapid wear on the commutator, pitting the surfaces of the segments. In bad cases the solder between the commutator segments and windings melts, causing output to drop and finally to cease.

Loss of generator output eventually drains the battery – because the current taken from it by various components is not replaced by the generator.

Warning of a drop in generator output is sometimes given by the ignition light, which glows faintly.

If the light comes on and stays on, check the fan belt (SHEET 100). If the fan belt is intact and properly adjusted, check the dynamo output (SHEET 104).

If the problem is in the brushes or armature, remove the dynamo for further checks and, possibly, repairs.

Checks are made easier if the dynamo is clamped securely in a vice – pad the vice jaws with wood so that the unit is not damaged.

To check the brushes on most modern dynamos, remove the endplate on which they are mounted.

However, some, especially older types, have windows cut in the casing through which you can reach the brushes. The windows are usually covered by a removable metal band around the casing.

The dynamo is generally held together by two long bolts through the length of the casing.

The bolt heads protrude from the endplate, and have screwdriver slots. Unscrew them to remove the endplate. You may have to give the endplate a light tap with a soft-faced hammer to get it off, or gently prise it free with a thin-bladed screwdriver.

Most dynamos have a lug under the endplate to locate it correctly. If yours does not have one, scratch some alignment marks on the endplate and casing, to aid reassembly.

Before reassembly

Always clean inside the casing and around the field coils before reassembling the dynamo. Use a soft brush to remove any dust or dirt from the armature. Be sure, too, that the endplate and front plate are clean, and that the ventilation holes are clear.

The field terminal often has an insulating sheath fitted where it passes through the endplate: do not forget to replace it.

Also check the endplate bush for wear (bushes and bearings on a dynamo are the same as those on a starter motor – SHEET 210). Look, too, at the armature shaft. Lubricate it lightly with high-melting-point grease.

Look at the armature, if there are signs of rubbing on the field poles, double-check the bearing and bush for wear. Check the bearing on the front plate – spin the plate while holding the armature.

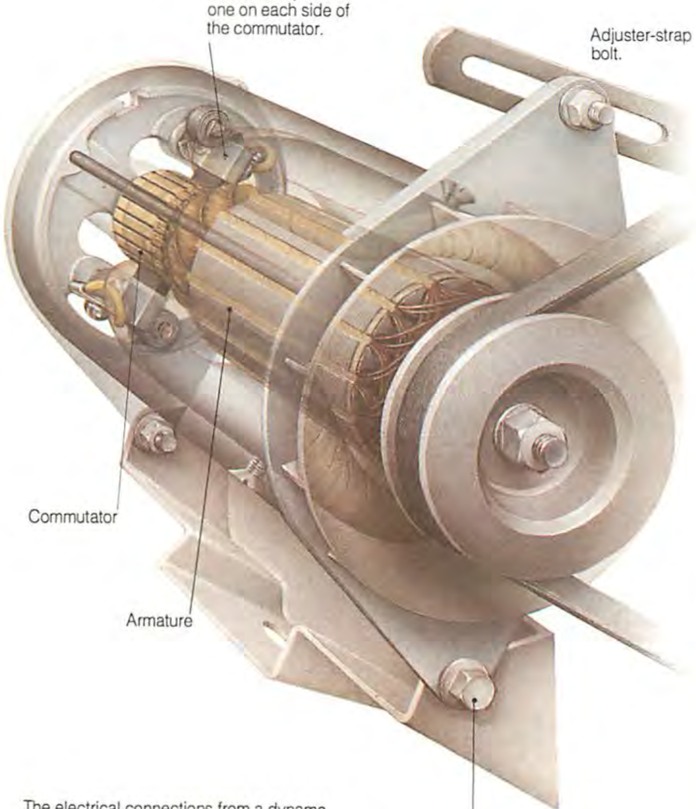
Test the field windings for continuity. A circuit tester used between the battery 'live' terminal and the field terminal will light up if they are intact.

If it does not, there is a breakage and the armature must be renewed.

Tools and equipment

RING SPANNERS • SCREWDRIVER • VICE • GLASSPAPER • HACKSAW BLADE • PAINTBRUSH • CIRCUIT TESTER • RAGS • PETROL

A typical dynamo



The electrical connections from a dynamo are on the rear endplate. Current generated in the armature is passed through the commutator to spring-loaded brushes and thence to terminals on the endplate.

Removing the dynamo

Disconnect the battery to prevent accidental short circuits.

Slacken the pivot bolt and the adjuster-strap bolt, push the dynamo to one side, and slip the belt off the pulley.

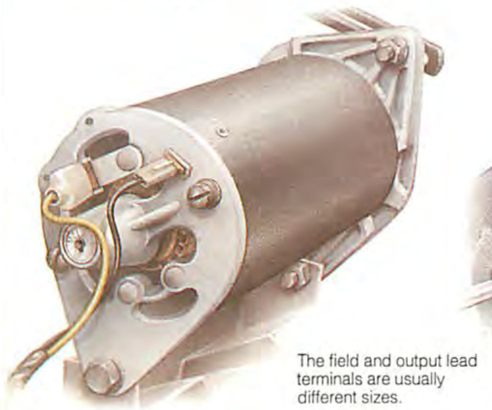
Disconnect the output and field cables: these connections are generally of different sizes; if they are not, label them first with pieces of sticky tape.

Disconnect also any radio-suppression equipment that may be fitted (SHEET 141).

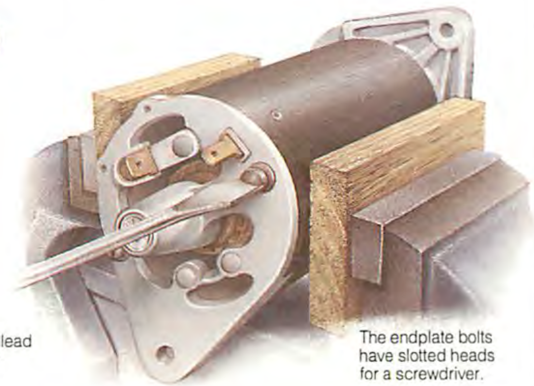
Support the dynamo while removing the pivot and adjuster-strap bolts completely, then lift it out of the car.

Loosen the pivot bolt.

Loosen the adjuster-strap bolt and remove the drive belt.



The field and output lead terminals are usually different sizes.



The endplate bolts have slotted heads for a screwdriver.

Checking dynamo brushes and commutator / 2

The carbon brushes are a sliding fit in oblong holders on the dynamo endplate. Coiled springs bear against the tops of the brushes to hold them in contact with the commutator.

Each brush also has a braided wire or cable attached by a screw. The cable from one brush leads to earth, and that from the other to the dynamo output terminal.

Undo the screws holding the cables, push the ends of the coiled springs to one side of the brush holders, and pull the brushes out.

Removing the brushes

Note exactly how they were fitted, so that if you refit the same ones later, each goes back as before.

If a brush is reversed, it may not seat properly on the commutator.

Measure the length of the brushes. If the carbon is worn down to a thickness of $\frac{3}{8}$ in. (10 mm) or less, fit new brushes.

However, even if the carbon thickness is down to $\frac{1}{2}$ in. (13 mm) it is still best to replace the brushes.

If the brushes are not too worn – they are normally about 1 in. (25 mm) long – they may have been sticking in their holders and not contacting the commutator properly.

Use a fine file to remove any raised spots from the surfaces of the brushes. Clean out the holders with a petrol-soaked rag. Replace them in their holders and check that they slide freely and do not rock from side to side.

Undo the screws holding the brush cables.

Push the spring to one side and remove the brush.

Before refitting the endplate, push the end of the coiled spring from the top to the side of the brush to wedge it in the holder.

Refitting the brushes

Always clean the brush holders thoroughly before fitting new brushes.

The ends of the brushes must be shaped to match the curve of the commutator.

If they are not, remove the armature and wrap fine glasspaper around it, abrasive side outwards (do not use emery paper).

Fit the endplate over the commutator, and turn it so that the brushes bear against the glasspaper and are shaped to match the curve of the commutator.

Replace the brushes in their holders and reconnect their cables to the output and earth terminals.

Check that the brushes are a smooth, sliding fit in the holders.

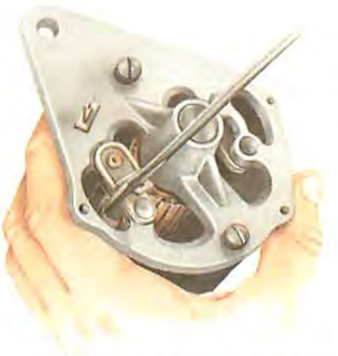
If they are too loose they might tilt and jam in the holders.

Make sure the brushes do not stick out of the inner ends of the holders. Wedge them in place by adjusting the ends of the coiled springs to bear against the sides of the brushes instead of the top.

Doing so enables you to refit the endplate and brush-holder assembly without damaging the inner ends of the brushes, which would otherwise catch on the commutator.

With the endplate refitted, reassemble the dynamo with its two long bolts.

Take a small screwdriver, and working through the ventilator holes in the endplate (or the inspection 'windows'), move the ends of the coiled springs from the side of each brush to the top, so pushing it down into contact with the commutator.



Use a screwdriver through the hole in the endplate to move the end of the coiled spring from the side to the top of the brush, to push it into contact with the commutator.

Inspecting the commutator

Check the condition of the commutator every time you remove the dynamo from the car – even if you are doing so only to inspect the brushes.

The job is best done with the armature removed from the dynamo. Remove the endplate. Scratch alignment marks on the front plate and casing to ensure that they can be reassembled correctly later.

Push out the armature, together with the front plate and pulley.

Wipe the commutator clean with a petrol-moistened cloth and inspect it thoroughly.

Major defects to look for are glazed, scored and pitted segments, or faulty insulation between them; soldered connections that have broken or melted together; and segments that have come loose.

All but the loose segments can be repaired fairly easily, so long as they are not too worn or badly damaged.

Even loose segments can be re-soldered, but that is delicate work which has to be done with a powerful soldering iron because of rapid heat loss through the copper. It is best left to an auto-electrician.

Glazing The commutator segments have a varnished look. This coating may be due to dust and water inside the casing, or to particles worn from the brushes or the mica insulation strips between segments.

Scores and pits Usually pitting and scoring of the commutator segments are caused by electrical arcing between the commutator and badly fitted, poorly seating or worn-out brushes.

Melted solder Overheating can melt the solder connections between the segments and the armature windings. Severe cases show as a ring of melted solder around the inside of the casing.

Faulty insulation The mica strips stick up between segments, stopping the brushes making contact. This is caused by wear or arcing removing surface copper. One of the segments has also cracked.

Cleaning the commutator

Grip the whole armature in a vice fitted with padded jaws.

Put a strip of fine glasspaper – not emery cloth – over the commutator in a half loop, then pull the ends of the strip backwards and forwards until the copper becomes bright and clean.

Rub evenly all around the commutator and along its length.

If the commutator is too worn or damaged for this treatment, you may be able to have it skimmed on a lathe. Consult an auto-electrician.

After cleaning or skimming, the mica insulation strips between the segments may need cutting back, as they will be level, or nearly level, with the faces of the segments.

They should be about 1/32 in. (1 mm) below the level of the faces. If they are higher, cut them back evenly along the whole length of each strip, to give a square groove.

A ground-down screwdriver can be used to clean between the segments. Remove dust and filings with a clean cloth.

Clean the copper segments with a strip of fine glasspaper.

Use a fine hacksaw blade to cut down the mica insulation.

Use a screwdriver with a fairly thick blade to clean out grooves.

Removing and refitting a dynamo pulley

The most common reason for removing a dynamo pulley is to fit it on a new dynamo – most replacement dynamos are supplied without one.

When refitting an old pulley, or fitting a new one, be careful not to bend or damage it. The surfaces inside the V where the belt runs must be smooth.

In many cases the pulley incorporates the dynamo cooling fan: its fins must not be bent or broken.

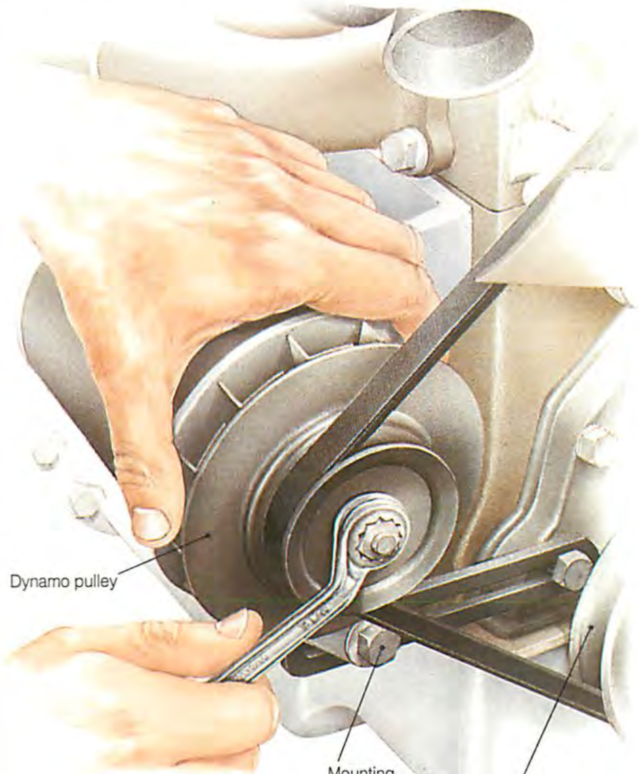
Usually it is best to take the dynamo out of the car (SHEET 106) before removing the pulley, though sometimes there is enough room to work with it still fitted.

Tools and equipment

SPANNER • SOFT-FACED HAMMER • VICE AND PADS • SCREWDRIVERS • PULLER • FILE

Using vice pads

If you have to hold the armature in a vice to free the nut, pad the jaws of the vice.



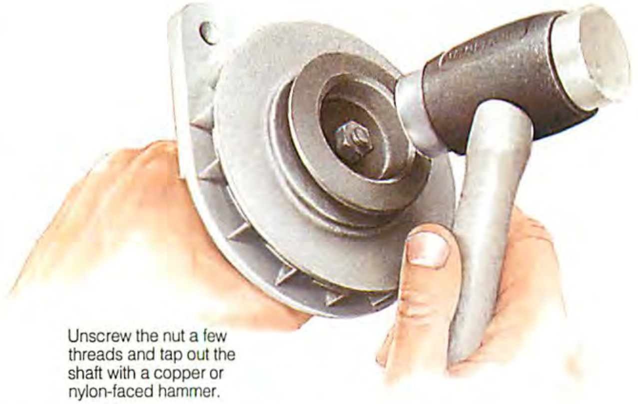
If the dynamo is still on the car, free the nut before taking the fan belt off.

Removing a pulley with the dynamo out

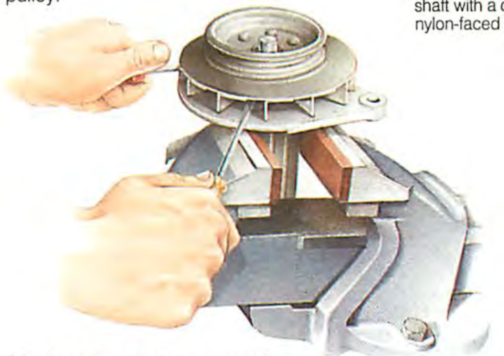
Undo the pulley nut by just a few threads, then, holding the armature in one hand, gently tap the nut with a soft-faced hammer to force the shaft out of the pulley.

If this fails, reassemble the dynamo, so that the front cover is supported, and grip it in a vice, then remove the nut.

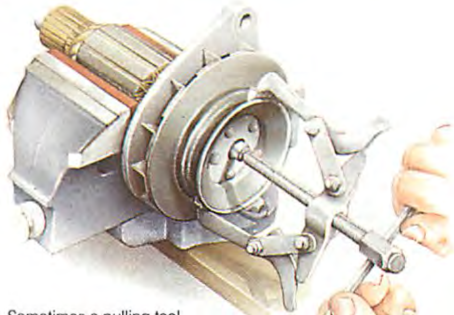
To prise off the pulley, insert two screwdrivers between the back of the pulley and the front plate. Gently force the pulley up at the centre – not the rim, which could damage the pulley. If this method fails you will have to use a pulling tool (SHEET 50), taking care not to damage the pulley.



Unscrew the nut a few threads and tap out the shaft with a copper or nylon-faced hammer.



Prise the pulley off with two screwdrivers. Bring them to bear only at the centre of the pulley.



Sometimes a pulling tool is needed to remove the pulley – take care not to damage the pulley.

Removing the pulley nut

On most dynamos the pulley is a tight fit on the end of the armature shaft. It is held in place by a movable metal key between pulley and shaft, and secured by a nut.

The shaft may be tapered or parallel and is slotted to take half the key. The hole in the centre of the pulley is also slotted in order to take the other half.

That type of locating device is called a Woodruff key.

It is shaped like a shallow half moon and is about $\frac{3}{16}$ in. (5 mm) thick.

The pulley nut is usually very tight and is recessed into the pulley. Use a socket or ring spanner to free it.

If the dynamo is still on the car, free the nut before removing the fan belt, which helps to hold the pulley steady against the force of the spanner.

You may also need to engage bottom gear to stop the engine turning – but be sure that the ignition key is out.

If you fail to move the nut, remove the dynamo from the car and dismantle it (SHEET 106).

Clamp the armature in a vice, using pieces of wood or some other form of packing in the vice jaws to protect it. They should hold it firmly enough for you to free the nut.

Do not lose the Woodruff key.

The Woodruff key locates the pulley on the shaft. It can be prised out with a small screwdriver.

Replacing the pulley

Before refitting the pulley, tap the Woodruff key well into its slot (curved edge down), with the front end slightly lower than the back, so that the slot in the pulley hole engages with it easily.

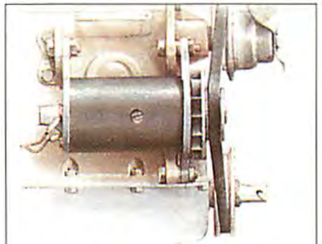
Take care when tapping it in not to make any burrs which may stop the pulley fitting over the key. It is a good idea to clean the sides of the key with a file before tapping it in, to ensure that there are no burrs.

Line up the slot in the pulley with the Woodruff key in the shaft, then push the pulley home on the shaft. Usually it will be forced fully home as you tighten the pulley nut; however, it may be necessary to tap the pulley on to the shaft with a soft-faced hammer far enough to start the pulley nut.

Some dynamos may have a spacer or shim between the pulley and front plate: do not forget to replace it.

After refitting the dynamo, check that the pulley is in line with the fan and crankshaft pulleys.

Sometimes the dynamo can be mounted on the wrong side of its pivot bracket: if it is put on the wrong way, its pulley could be out of line with the others. There may also be spacer washers between bracket and dynamo. These, too, must be replaced in their original positions, or the pulley will be out of line.



After fitting, check that it is in line with the fan and crankshaft pulleys. Spin the dynamo pulley to check that it is not distorted and runs true.

Renewing alternator brushes / 1

Unlike dynamo brushes, alternator brushes normally last for several years. Electrical arcing between brushes and commutator, a major cause of dynamo wear, is far less common.

Alternators carry only the field current of 2 or 3 amps. The brushes are in contact with slip rings, which have a smaller, smoother surface than a dynamo commutator. The slip rings are solid rather than segmented, as in a dynamo. The clicking over the segments is another cause of brush wear in a dynamo.

The brushes are longer than those on a dynamo. Some alternator brushes are marked with a wear limit, but generally they should be renewed when worn about halfway down.

Before starting work, check which make of alternator is fitted to your car. The maker's name should be marked on it – the types used most are illustrated in this section.

Brush-wear limits – the minimum acceptable length protruding from the housing – are detailed for different types on SHEETS 110–111.

Depending on the type of alternator and regulator, worn or damaged brushes or slip rings may be indicated by the ignition warning light not coming on, not going out, or just staying dim. Check to find the cause of the problem (SHEET 103).

Before doing any electrical work other than circuit testing on the alternator, disconnect the battery.

Generally you need to take the alternator out of the car to replace brushes. Remove it in the same way as a dynamo (SHEET 106).

The way in which the brushes are fitted varies according to the make or model. On some alternators the brush holder can be removed from outside. On others the end cover must be removed. Guidance for different types is detailed below and on SHEETS 110–111.

Slip rings are seldom worn or scored enough to need serious repair or renewal. If they are slightly damaged, smooth them in the same way as a dynamo commutator (SHEET 107), although there are no insulation strips to cut back. Be careful, however, because the metal on the slip ring is far thinner than on a commutator.

Usually, it is only necessary to clean a slip ring in position. Use a cloth or soft brush damped with methylated spirit.

Clean the brush housing and guides at the same time in the same way.

The brushes must slide freely into their holders. Carefully rub down any high spots on them with a fine file.

Always fit the correct type of replacement brushes and springs (check with the car handbook); make sure all connections and terminals are tight.

Tools and equipment

SMALL BOX SPANNER • SCREWDRIVER • RULE • SOFT BRUSH • METHYLATED SPIRIT • FINE FILE • SOLDERING IRON (BOSCH) • REPLACEMENT BRUSHES AND SPRINGS

Renewing Lucas ACR brushes

Take off the moulded cover at the rear of the alternator; it is held by two recessed bolts. Use a box or socket spanner size 4BA, or an equivalent size.

Locate the cable connections to the brush terminal strips, and note where each of the four leads goes, so that you can replace them correctly.

Remove the four terminal-retaining screws and disconnect the leads.

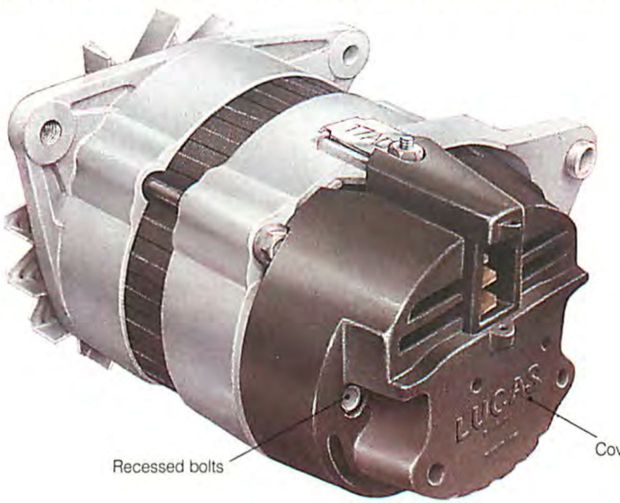
Some units also have a regulator field link. Loosen the bolt holding the link so that you can push it aside.

You can renew the brushes without removing the brush box, but you must take it off to expose the slip rings for cleaning.

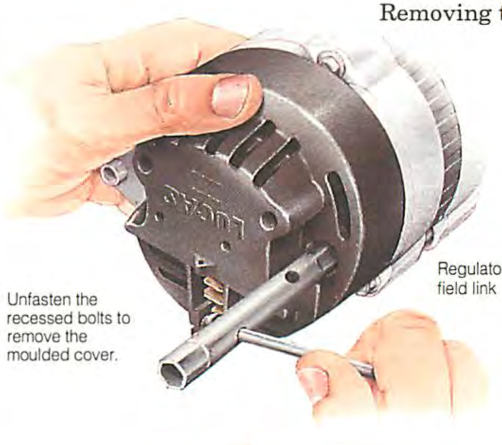
Take out the two screws holding the brush box and lift it off. The regulator earth lead may be secured by one of the screws; note how it fits.

Remove the brushes from the box complete with their terminal strips and springs. There is a small leaf spring fitted to one side of the inner brush; note which side it is for reassembly.

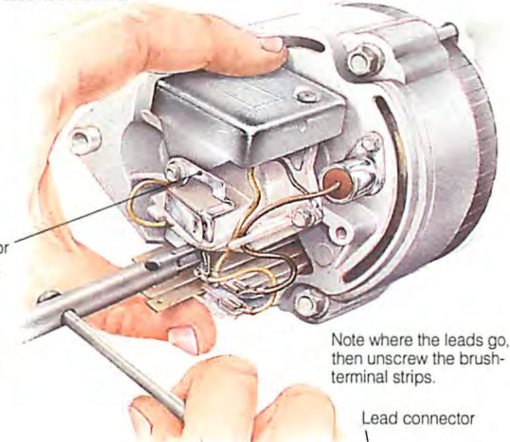
Clean the brush housings and insert the new brushes. Reassemble the unit in reverse order of dismantling, making sure that all connections are correct and secure.



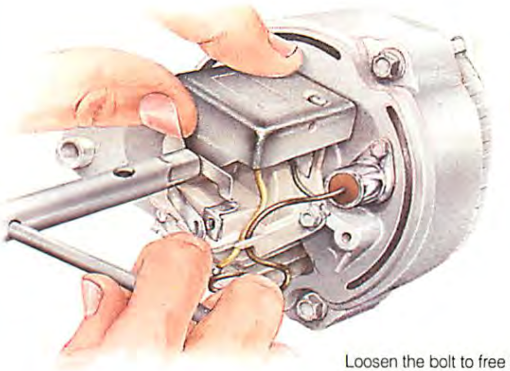
Removing the brushes



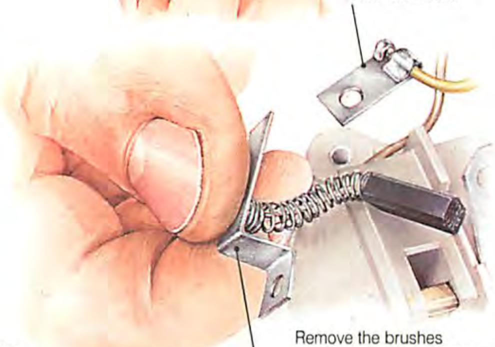
Unfasten the recessed bolts to remove the moulded cover.



Note where the leads go, then unscrew the brush-terminal strips.

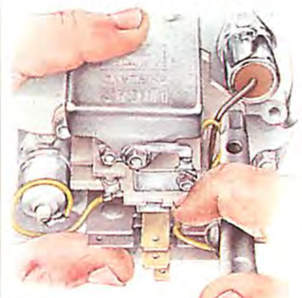


Loosen the bolt to free the regulator field link.

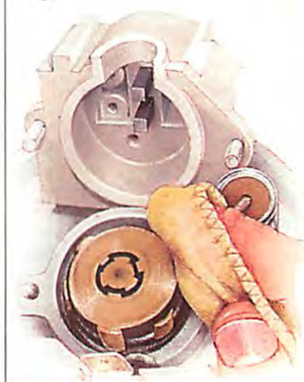


Remove the brushes together with their terminal strips and springs.

Cleaning slip rings



Remove the brush box to expose the slip rings.



Wipe the rings with methylated spirit on a soft brush or cloth.

Renewing alternator brushes / 2

Renewing Lucas AC brushes

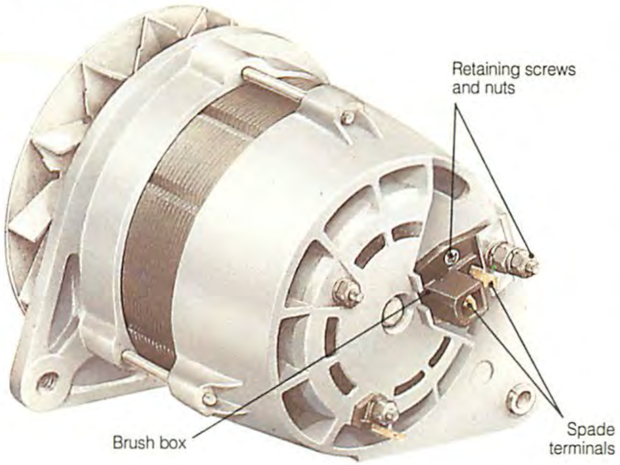
Take out the screws securing the brush box and remove the box complete with the brushes.

To remove the brushes from the box, use a small screwdriver to press each spade terminal downwards and inwards towards the brushes.

Pull out the brushes and clean the brush housings. Clean the slip rings also.

To fit new brushes, insert each spade terminal from the back of the box – the brush end. Use long-nosed pliers to pull the spade through from the other end until the retaining tag locks. Refit the box.

Brush-wear limit: A minimum of $\frac{3}{16}$ in. (5 mm) should be protruding from the housing, or the brushes should be replaced.



Renewing typical Motorola brushes

The brush box is under a cover plate at the rear of the alternator, held on by two screws.

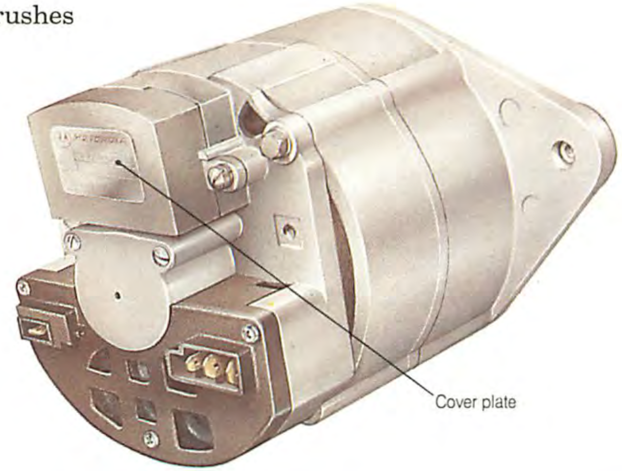
Take out the screws and carefully lift up the cover plate without straining the wires attached inside.

Note how the spade connectors of the leads are fitted before removing them. Remove the two screws securing the brush box and lift the box clear.

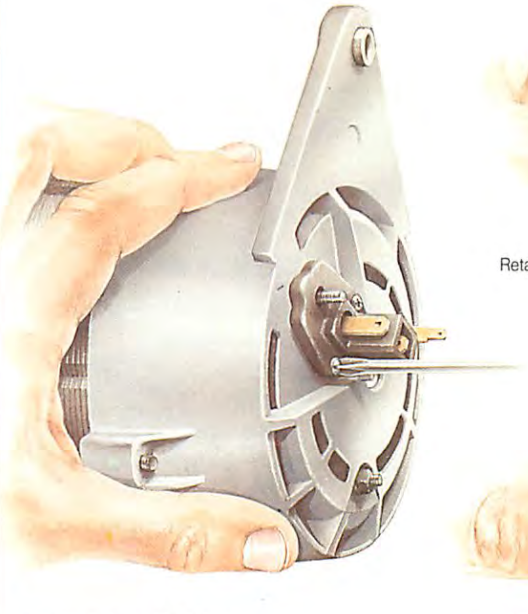
The brushes are fixed by a screw or a bolt. They are easily damaged – take care when removing or replacing them; do not use force.

Clean the brush housings and insert new brushes. Clean the slip rings before replacing the box, leads and cover plate.

Brush-wear limit: $\frac{5}{16}$ in. (8 mm).

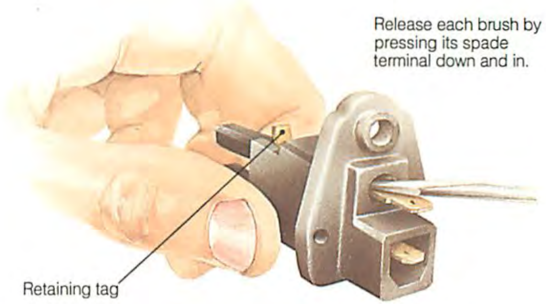


Changing the brushes



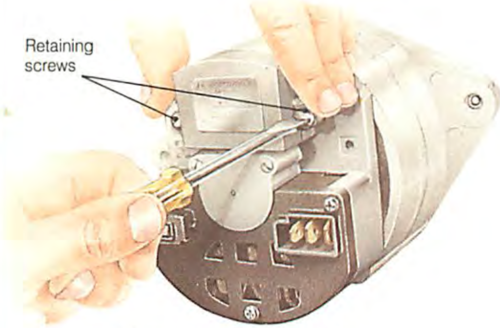
Remove the nuts and screws and lift out the brush box.

Release each brush by pressing its spade terminal down and in.

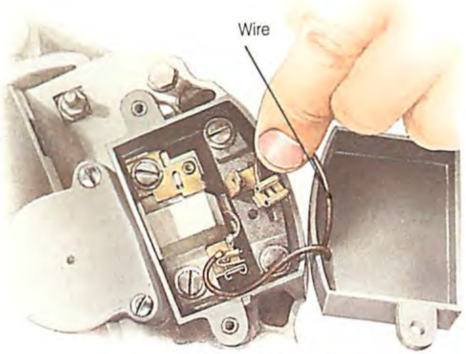


Insert the new brush from the back. Pull the terminal through with long-nosed pliers.

Removing the brushes

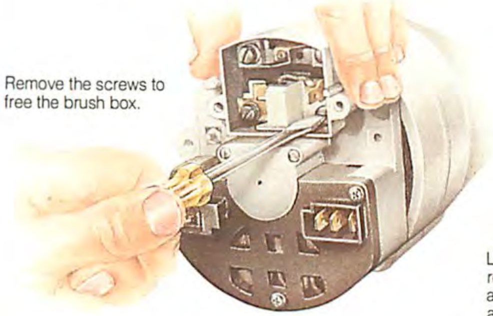


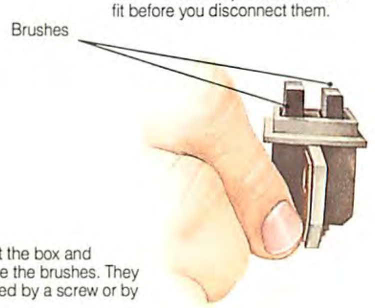
Remove the screws securing the cover plate; lift it carefully.



Note where the spade connectors fit before you disconnect them.

Remove the screws to free the brush box.





Lift out the box and remove the brushes. They are fixed by a screw or by a bolt.

Renewing alternator brushes / 3

Ducellier

There is no brush box. The brushes are fixed individually, one by a screw, the other by a bolt.

Unfasten the screw or bolt and pull each of the brushes out.

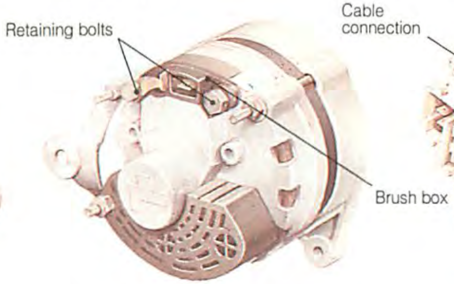
Clean the housings and slip rings with a soft paintbrush before inserting the new brushes.

Brush-wear limit: $\frac{5}{16}$ in. (8 mm).

Undo each brush fixing to remove it separately.

Each brush fixing is removed with its spring-loaded brush.

Paris Rhône



The brush box is at the rear of the alternator, held by two bolts. Remove them and lift the box out.

Take out the old brushes, clean the housing and fit the new brushes into the box.

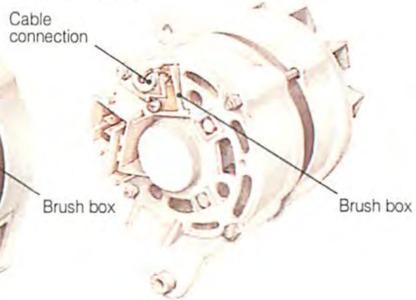
Clean the slip rings with a soft paintbrush before you bolt the brush box back in position.

Brush-wear limit: A minimum of $\frac{5}{16}$ in. (8 mm) should protrude.

Unfasten the brush box from the rear of the alternator.

After cleaning the housing and fitting new brushes, refit the brush box.

Femsa



The brush box is a separate unit at the back of the alternator, held by one screw.

Undo the single cable connection then remove the screw and lift out the box. The brushes are easy to remove from the box.

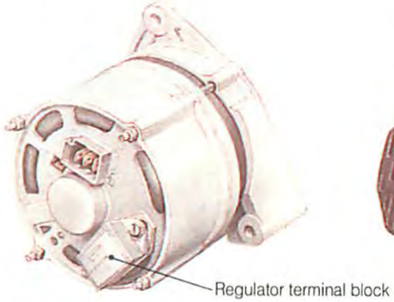
Clean the housings and slip rings, then press new brushes into the box. Refit it to the alternator and re-connect the cable.

Brush-wear limit: Minimum brush length 9/32 in. (7 mm).

Undo the cable and remove the brush-box screw. Lift it out.

The brushes are easy to remove. Press new ones into the brush box.

Bosch



The brush box is part of the regulator terminal block at the back of the alternator, fixed by two screws.

Take out the screws and lift out the complete unit.

To remove the old brushes, use a soldering iron to melt the solder that holds their lead to the brush-holder terminals.

Pull out the brushes and springs together. Clean the brush housings and slip rings.

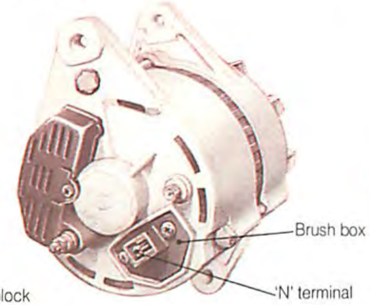
Make sure the new brushes slide freely in their housings. With the brushes and springs reinserted, solder the leads into place. Refit the unit to the alternator.

Brush-wear limit: $\frac{1}{12}$ in. (2 mm) protruding from housing.

Remove the regulator terminal block. The brush box is part of it.

The leads are soldered to the brush-holder terminals.

Hitachi



The brush box is at the rear of the alternator, held by two screws.

Remove them and lift it out. Do not disconnect the terminal marked 'N' from the stator-coil lead wire.

Pull out the brushes and clean their housings and the slip rings. Fit new brushes and replace the unit.

Brush-wear limit: There is a wear mark on the brushes.

Unfasten the brush box but do not disconnect the 'N' terminal.

Clean the brush housing and slip rings, fit new brushes and refit the brush box.

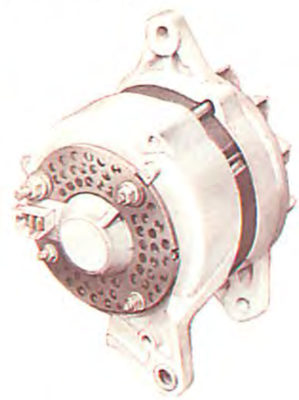
AC Delco

To replace the brushes on this type of alternator, the whole unit has to be dismantled.

Repairs are therefore best left to a professional repairer or auto electrician.

The alternator's life is much longer than that of the old-fashioned dynamo, but the internal parts are more precise and delicate. Overhaul should be left to an expert.

Denso, Delco Remy, Mitsubishi



The Denso, Delco Remy and Mitsubishi alternators are very similar in appearance. The brushes on these alternators are mounted internally on the rectifier holder.

Replacement of the brushes involves dismantling the entire alternator.This is a job best left to a professional repairer.

Fitting a new voltage regulator

When you have tested the charging system of a car fitted with an alternator, and the checks on SHEET 102 point to a fault in the voltage regulator, make sure that you need to replace it. The fault may be elsewhere.

If the simple tests described here do not work, take the car to an auto-electrician; alternators fitted to modern cars are easily damaged.

Before doing any work on an alternator system other than testing, disconnect both terminals of the battery.

Incorrect charging or no output may be due to a badly earthed regulator. Make sure that the connections are clean and tight. The unit may be earthed through its mountings or by a separate lead.

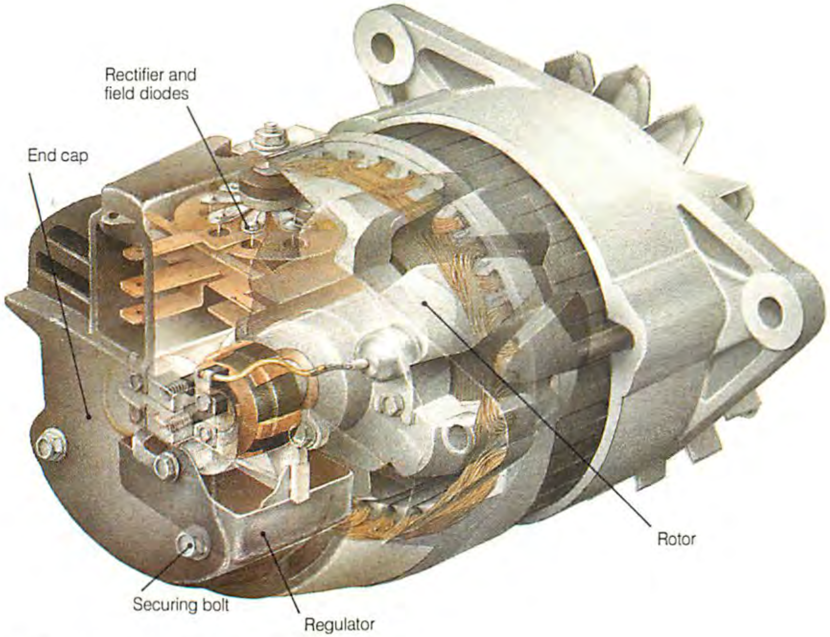
Undercharging may be caused by faulty alternator brushes and slip rings (SHEET 109), as well as by a faulty regulator.

A simple way to check the alternator is to start the engine and connect a voltmeter across the battery terminals. If it registers battery voltage only, the fault is in the alternator or its wiring, or in a field isolating relay if fitted.

If it registers an excessive charge (15 volts or more) the regulator is faulty and you should replace it.

Tools and equipment

VOLTAGE REGULATOR • SCREWDRIVER AND/OR SMALL SPANNERS • MASKING TAPE FOR LABELS • EMERY PAPER AND/OR WIRE BRUSH



The Lucas ACR alternator, like many alternators fitted to British cars, has the voltage regulator mounted inside. This is possible because the modern voltage regulator is a solid-state device.

Replacing a Lucas ACR internal regulator

With the battery disconnected, remove the rear cover of the alternator. On most cars you must take the alternator off to reach it (SHEET 103). Unfasten the leads – there are two, three or four and a metal connecting tag – noting where they fit.

The regulator may be fixed by two screws, or by one screw and locating slots: note how these slots fit so that you can install the new unit correctly. Take care not to drop any screws or washers.

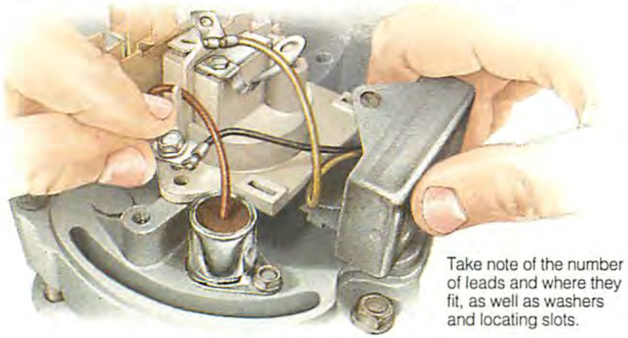
Some internal regulators have a field connecting link from a terminal to the regulator body.

The link protects the alternator from the battery when the ignition is switched off. You may need to slacken the link screw and move the link aside. Note the small plastic spacer.

The new unit may not be identical in all its respects to the old one – for example, it may have more or fewer connecting wires.

Follow the maker's instructions carefully; they will tell you how to connect the unit to various types of alternators.

Reassemble the alternator, reconnect the battery, start the engine and test (SHEET 102).



Take note of the number of leads and where they fit, as well as washers and locating slots.

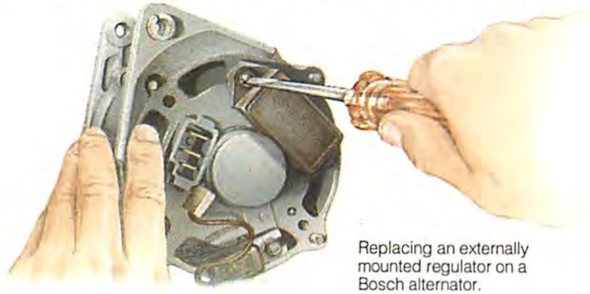
Replacing a separate regulator

Replacing a separate regulator outside the alternator is straightforward, whether it is a modern transistor type or one of the electromagnetic kind fitted to some imported cars.

With the battery disconnected, take the connections off the regulator. Label the leads to avoid confusing them.

Remove the fixing screws and take off the regulator. Clean the area behind it to ensure a good contact if the regulator is earthed through its mountings.

Fit the new unit, reconnect the leads, and then the battery. Start the engine and test the regulator.



Replacing an externally mounted regulator on a Bosch alternator.

Independent regulators

Although the trend is towards designing the electronic regulator into the alternator, some are still separate.

An older car may have a dynamo instead of an alternator. A dynamo has a separate regulator, the control box (SHEET 105), which has three electromagnetic switches for controlling the current, the voltage and for cutting out when necessary, to prevent the battery from discharging through the dynamo.

Some alternators have separate electromagnetic regulators, and some have a separate field isolating relay, an electromagnetic switch which protects the alternator when the ignition is switched off.

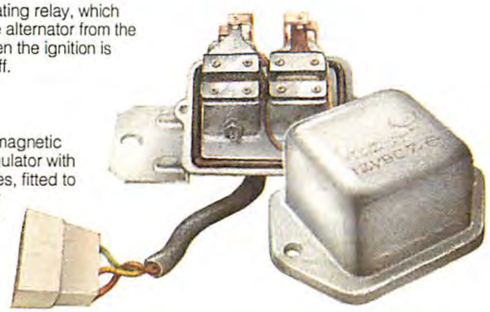
Some cars have a separate control in the circuit for the warning light on the instrument panel.

Separate components are usually mounted on the engine bulkhead, or sometimes on top of the alternator itself.

A typical separate type of electronic regulator.

A field isolating relay, which isolates the alternator from the battery when the ignition is switched off.

A separate warning-light relay.



An electromagnetic voltage regulator with two switches, fitted to some older alternators.

Checking hoses and the radiator cap

The parts of the cooling system most likely to give trouble are water hoses. Age and the movement of the engine on its mountings will eventually cause cracks, or their inner fabric may deteriorate due to the hot water.

Inspect them when the engine is cold. Any sign of wear or deterioration is a danger signal: the sudden loss of coolant from a burst hose can result in rapid overheating and a seized engine.

A worn or damaged hose should be replaced as soon as possible.

Before this can be done, you need to drain the cooling system. Remove the radiator cap and open the radiator drain tap. If there is no tap, disconnect the bottom hose. If the coolant contains antifreeze that you wish to use again, drain it into a clean container; do not drain it on to the road, it is poisonous (SHEET 117).

Before fitting a new hose, make sure it is the correct replacement. Some have built-in curves, others have different internal diameters at each end. Old clips should also be replaced – preferably with worm-drive ones, which have a larger contact area and make a more effective seal.

Never overtighten any type of clip: it may cut into the rubber.

Once the hose has been replaced, turn off the radiator tap (or reconnect the bottom hose) and slowly refill with a water and antifreeze mixture.

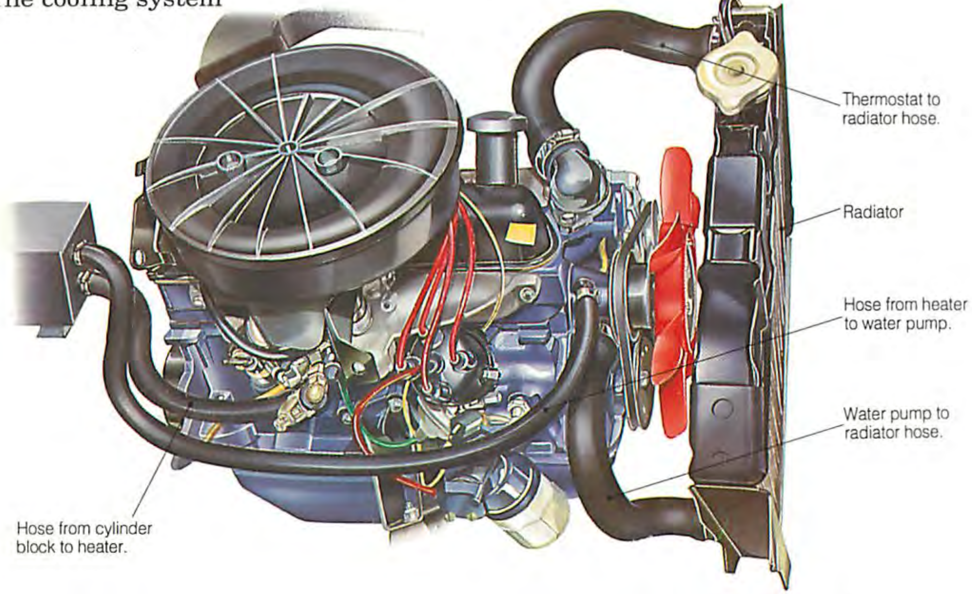
When reusing coolant with antifreeze, strain it through muslin or a plastic tea strainer. Replace the radiator cap and run the engine up to working temperature. Check for leaks, and tighten clips if necessary.

When the engine has cooled, make sure the system is topped up to the correct level. Never remove the pressurised cap while the engine is hot. It will release a jet of scalding liquid.

Tools and equipment

SCREWDRIVER • KNIFE • MIRROR • THICK CLOTH • TORCH • GLOVES • ADHESIVE TAPE • LIQUID SOAP

The cooling system



Where to look

Look particularly at bends, junctions and where a hose clips on to a stub. Signs of swelling mean the inner reinforcing fabric is damaged and the hose may burst at any time. Feel for weak spots, which also indicate internal damage. Use a torch and mirror to look underneath or behind hoses.

A brown rust deposit on the stubs indicates that the hose may be leaking when under pressure. Tighten the hose clips.

Press or pinch the hose to widen any cracks so that they are easy to see.

Testing the radiator cap

When you check the coolant level in the radiator, inspect the radiator cap as well.

Ensure that the rubber or fibre sealing ring is not damaged, and test the large pressure relief valve by pressing it in against its spring – some effort is needed! Make sure also that the small valve in the centre of it moves freely.

A rough check on a cap's working efficiency is to warm up the engine, wrap the cap in a thick cloth, and then, wearing a stout glove, loosen it to its first stop. **Do not remove the cap.**

If there is no hiss of escaping air or steam, the cap is probably not maintaining the correct pressure in the system, and should be renewed.

Make sure that the new cap has the correct pressure rating, which is marked on it. A pressurised system raises the boiling point of water, but if the valve is too weak the pressure will not be maintained. If it is too strong the system may become over pressurised when the engine is hot.

Removing and refitting hoses

The quickest way to remove a perished hose that will not pull free easily is to cut one end where it fits over a stub.

Loosen the clip, slide it back, then slit the hose horizontally, using a sharp knife with a pointed blade.

Be very careful if the stub is plastic. A sharp knife may cut through the stub or score it badly.

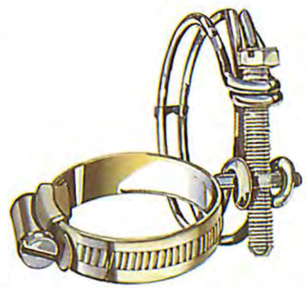
This end can now be removed, and by loosening the other clip and twisting the hose back and forth, the hose should come away easily. Clean any corrosion from the stubs before fitting a new hose.

Slip the clips loosely on to the hose making sure that the screw heads will be easily accessible when you come to tighten them. Push the hose ends well on to the stubs. If that is difficult, soften the ends in hot water and smear the stubs with liquid soap.

If wire clips are used, wind adhesive tape around the hose underneath them, so they do not cut into it.

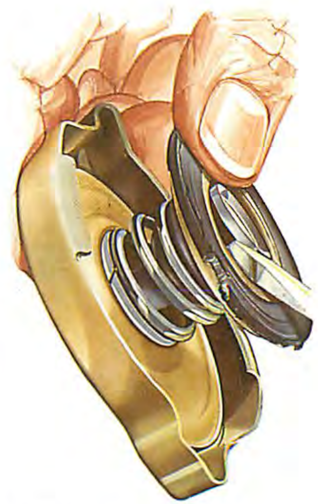
Unscrew the hose clip and slide it back. Always replace a wire clip like this with a worm-drive clip (see right).

Cutting free a stubborn hose.



Two types of hose clip – the worm drive, which is the best, and the wire type which is liable to cut into the rubber.

If you use wire clips, wrap adhesive tape round the hose to stop the wire cutting in.



Make sure the small valve moves freely.

Checking for coolant leaks

A leak in the water-cooling system can be hard to trace – especially if it is internal, say in the cylinder-head gasket between cylinders.

A rising temperature gauge, a pool of coolant beneath the car and a drop in the radiator level are signs of a leak. So are rust-coloured stains in the engine bay.

But if you cannot actually see the leak, a systematic check is called for.

Always work when the engine is hot, and pressure in the cooling system has built up – forcing out coolant at any weak spot.

The likely sources of leaks are where a hose is flexed by engine movement over the end of the stub to which it is fitted, or where an overtightened clip has bitten into the rubber.

Seams at the top and bottom of the radiator are also danger spots.

Small leaks can sometimes be cured by sealing preparations available from shops and garages. But leakage from a radiator seam is best left to a garage.

Some cars have plastic coolant tanks, and leaks in them are also beyond do-it-yourself repair.

Always treat them gently – using a screwdriver to lever off an old hose can easily break off the stub.

Inspect hoses carefully at bends and joints, as well as where they clip on to stubs (SHEET 113).

Core plugs, which fill holes left in the cylinder block when it is being cast, are other likely sources of leaks. They may be blown loose by pressure from the system, corroded, or even loosened by vibration.

Use a mirror and torch to find if there is one hidden behind the engine, made inaccessible by the bulkhead.

If a thorough search fails to locate the leak, suspect a damaged gasket between the cylinder head and the cylinder block, or a cracked head or block.

If the cooling system springs a small leak when you are on the road, you may be able to drive home slowly by releasing the radiator cap to its first catch, or by putting a match under the vacuum valve of the cap to relieve the pressure. Watch the temperature gauge; if it goes into the danger area, stop and allow the engine to cool.

If you suspect an internal coolant leak, allow the radiator to cool, take off the cap, and look for signs of oil or frothy bubbles in the radiator or header tank.

With the engine running, smell the coolant itself – if there is a whiff of exhaust gas, the cylinder-head gasket may be leaking. To make certain this is the cause, before removing the cylinder head (SHEETS 156–157) to investigate, have a garage test the cooling system pressure.

Tools and equipment

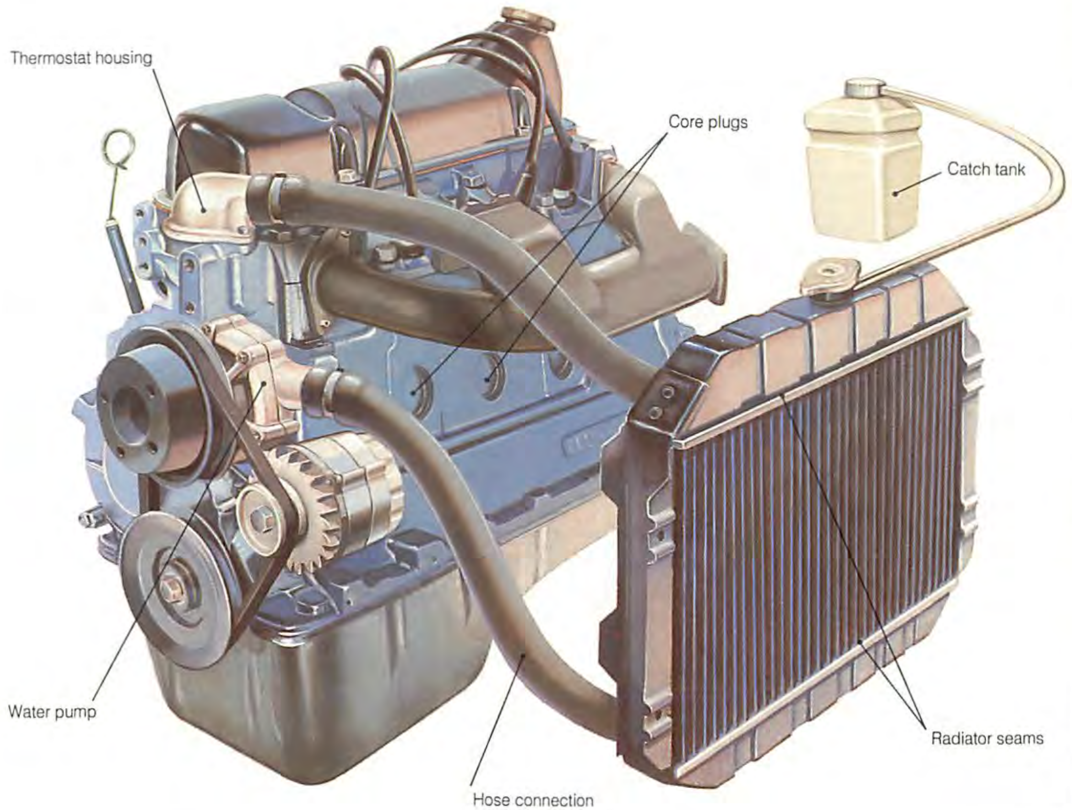
MIRROR • TORCH

Areas of the cooling system to check for leaks

Check the core plugs in the side of the cylinder block. Check all hose connections for tightness, but ensure that the clips are not cutting into the rubber. Look along the hose for cracks, especially at points where the hose is flexed by engine movement.

Inspect the radiator seams for splits, also the catch tank and its pipe. Watch for leaks at the water-pump bearings and from the pump gasket.

Check the thermostat housing for cracks, and the housing gasket for leaks.



Hidden core plugs

Use a mirror to locate hidden plugs.

Inspecting the water pump

To check the water-pump bearings, loosen the drive belt (SHEET 100) then try to rock the fan blades backwards and forwards.

Any movement means that there is wear in the bearings. This will lead eventually to rupture of the water seal on the pump shaft, and a leak will occur. Look also for leaks around the pump flange, tightening the flange bolts or replacing the gasket may stop the leak. If the fan is not mounted on the water-pump pulley, rock the pulley instead.

A worn or leaking water pump must be replaced – it is false economy to have it repaired.

Another sign of wear is noise, but a screech when starting from cold or accelerating quickly may also be caused by the belt, generator bearings or a power-steering pump.

The most frequent cause of water pump failure is a loose, slipping, worn or damaged drive belt. This usually leads to overheating, a reduced charging rate – and eventually a broken belt.

The belt usually drives the generator, as well as the pump, and the tension on it is critical: too slack and it cannot turn the generator and water pump; too tight and it may damage the bearings of both.

To check and adjust the drive belt, see SHEET 100.

If the fan is on the water pump, loosen the fan belt and rock the fan blades – any movement means worn bearings.

If the fan is not on the water pump, rock the pulley instead.

Checking antifreeze strength and refilling

Always use the right kind of antifreeze for your car and keep it at the correct strength, otherwise internal rust or sludge may result.

A good-quality antifreeze of the ethylene-glycol type, with full anti-corrosive additives, should be left undisturbed in the cooling system for about three years – summer and winter.

After that time, flush the system (SHEET 117) and replace the coolant with fresh antifreeze mixture. Do not drain the system during summer and replace the mixture with water – that leads to rapid corrosion.

If you do not know how long the coolant mixture has been in the system, or if you have any doubts about its effectiveness, drain and discard it.

In time the mixture loses its anti-corrosive properties. Replace it with a new mixture of the strength specified in your car handbook.

For driving in Europe, the proportion rarely exceeds half water and half antifreeze.

Note that antifreeze is poisonous and must be disposed of properly, not poured down a drain. Check with your council waste-disposal department where it can be dumped.

There have been two types of antifreeze in use. The cheapest is based on methyl alcohol (methanol), which can evaporate during use, resulting in a progressive loss of effectiveness. It is also inflammable, and is no longer recommended by car makers.

The ethylene-glycol type is more stable and does not evaporate. You can weaken it only by topping up with plain water.

Whichever brand you choose, make sure that it is approved by the car manufacturers for your type of engine.

Choose one that contains corrosion inhibitors. The container should state that the contents are suitable for all types of engine, including aluminium blocks or cylinder heads.

Replace hoses that show signs of cracking when squeezed. Check all the hose clips (SHEETS 113–114).

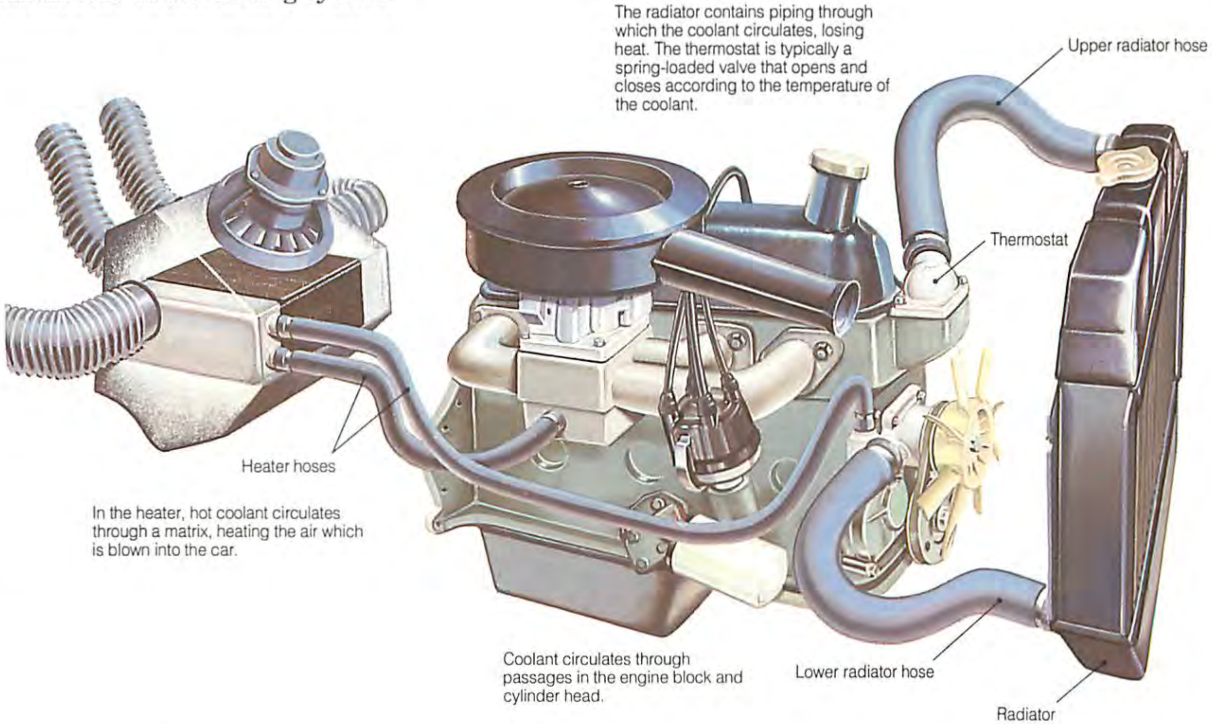
If there is corrosion at any junction, remove the hose and clean the metal pipework. Consider renewing the hose.

If you can see slime or dirt in the cooling system, take the opportunity to flush it out. If you have any doubts about the correct operation of the thermostat, check it (SHEET 119), and renew if faulty.

Tools and equipment

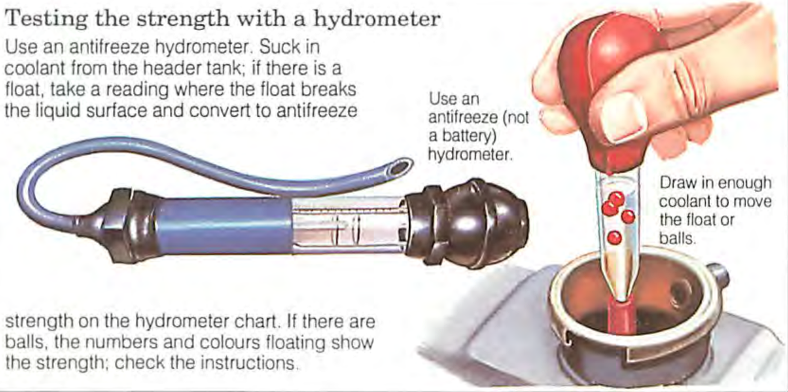
LARGE CONTAINER • 2 GALLON WATERING-CAN • NEWSPAPERS • RAGS • CLEAN WATER • ANTIFREEZE HYDROMETER

Antifreeze in the cooling system



Testing the strength with a hydrometer

Use an antifreeze hydrometer. Suck in coolant from the header tank; if there is a float, take a reading where the float breaks the liquid surface and convert to antifreeze strength on the hydrometer chart. If there are balls, the numbers and colours floating show the strength; check the instructions.



Draining and refilling the system

Let the engine cool and place a container under the drain point. If there is no drain tap on the radiator – or if the tap has stuck – unclip and pull off the bottom hose. Remove the radiator filler cap to speed the flow.

Before you start to refill the system, make sure that you have checked and refitted all the hoses, tightened all the hose clips, and closed all drain taps.

Pour in the correct amount of antifreeze, then top up with water or mix the antifreeze solution in a watering-can and use that to pour it in.

If your car has an expansion tank, replace the coolant there with the correct mixture, but do not fill the expansion tank to the top.

With the radiator cap off, run the engine until the coolant in the radiator is warm.

Top up until the level remains constant. Refit the radiator cap.

Spread some newspapers on the ground and park the car with the engine and radiator over them, to isolate any leaks.

Topping up antifreeze

If you have a coolant loss, top up with the correct strength of antifreeze mixture. Adding plain water weakens the mixture.

Avoiding leaks

Coolant mixture finds its way through leaks or weak hoses more quickly than water, so make sure that all connections are tight. Take care not to overtighten hose clips, because this can damage the rubber and cause a leak. Smear washing-up liquid in a new hose; it will slip on more easily.

Taking precautions

Antifreeze damages paintwork. Wrap rags around the filler neck to contain spillage. If any does get on to the paintwork, wash it off with plenty of water at once.

A kitchen utensil used for draining antifreeze must not be used again in the kitchen.

Checking heater and ventilator output

The flow of air into the car can be blocked by leaves or road debris in the supply tubes or in the plenum chamber.

The plenum chamber is a box fitted on the bulkhead beneath the windscreen. It takes in fresh air from a grille on the outside of the car.

Inside the chamber, movable flaps connected by cables to the heating and ventilation controls of the car divide and direct the air to the different parts of the interior.

Incoming air is warmed by passing it over the fins of a small radiator, called a matrix, which takes hot water from the engine. The matrix is usually inside or next to the plenum chamber.

Sometimes the supply tubes slip off their connections, or the interior lining of a tube may collapse and block it.

There is usually a simple valve at the base of the plenum chamber which allows water to drip out – either through a flap or a rubber tube with lips that just touch each other. Remove the valve or the tube to clear leaves or debris from the chamber.

To check the trunking, pull it off in sections and look through it. If it is a loose fit on its connector stub, push the trunking well home then bind the joint with sticky tape.

Alternatively, use tape to build up the stub, which will then make a tighter fit with the tube. Trunking that is loose fitting reduces the efficiency of the heating or ventilation.

An incorrect flow of water through the heater matrix may be due to stretching in a cable which operates a water valve on the engine.

Ask a helper to work the hot-cold lever in the car while you check that the lever on the valve is turning through its full travel.

A kink in the heater hoses can also restrict the water flow. If a hose feels squashy it may have collapsed internally, and should be replaced.

An airlock in the heater system or a build-up of sludge in the matrix also reduces heating efficiency.

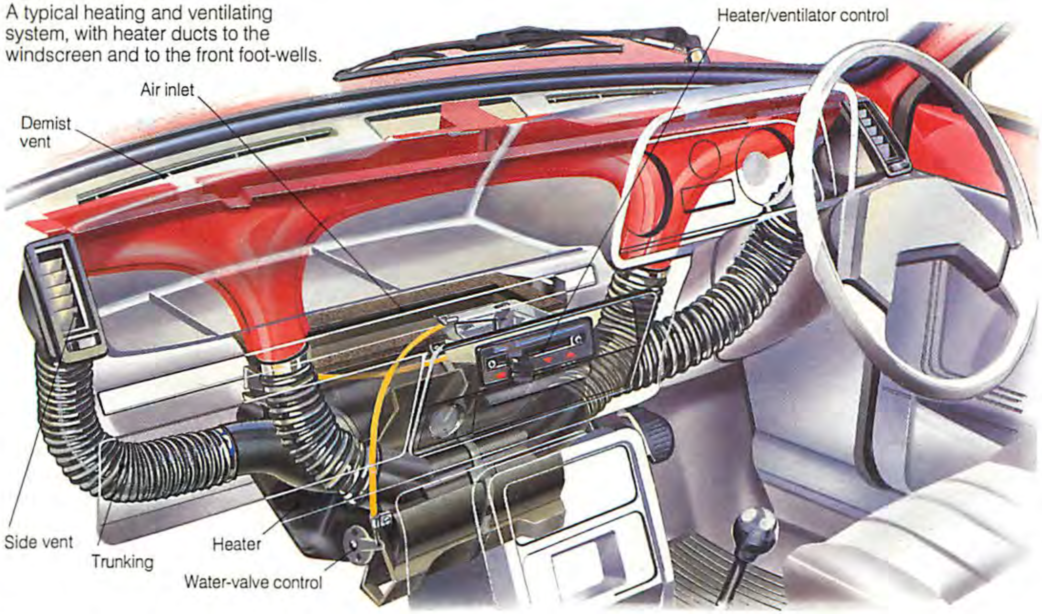
Disconnect the heater-return hose at the bottom of the heater or at the water pump and run the engine. There should be a good flush of water. A trickle means the matrix is blocked.

Tools and equipment

SCREWDRIVER • SPANNERS • GARDEN HOSE • JAM JAR

Heater/ventilator system

A typical heating and ventilating system, with heater ducts to the windscreen and to the front foot-wells.



Checking air and water flow

Air is forced into the car by road speed, or sucked in by blower. Normally, fresh air enters through a grille in front of the windscreen, and is ducted into the plenum chamber. The chamber channels some through the heater matrix. Stale air is removed through extractors at the rear. Part of the airflow can be deflected to demist or defrost the windscreen.

To check the demist vents, tape narrow strips of tissue paper to the vents. Switch on 'demist' and then 'defrost' with the blower switched on. Both strips should be blown upright. If they are not – or if only one moves – make sure the trunkings from the heater box are firmly connected at both ends. Reconnect any that have slipped off.

An external water valve controls the flow of hot water to the heater (SHEET 22). Make sure its operating lever can turn easily through its range.

Check the tightness and adjustment of the operating cable and linkages. Check for leaks at the hose connections. Follow the hoses through to the heater, and look for signs of rubbing, kinks, cracking or spongy areas.

If you need to change a section, take the old length along to the spares shop and buy one the same size. There are many variations in diameters and fittings depending on the make, model and year of your car.

It is possible to flush the heater matrix without removing it from the car – which may sometimes be difficult.

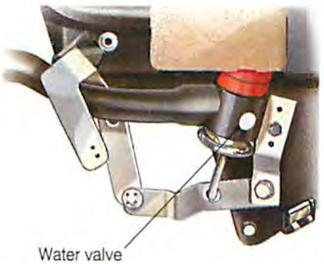
Disconnect both heater hoses at the engine end. The water that pours out can then be directed away from the engine. Move the heater control to 'hot', then connect a garden hose to the return pipe – the one attached to the radiator bottom hose or water pump.

Turn on the tap and flush the matrix until water collected in a jam jar is free of sediment. Repeat with the garden hose connected to the feed pipe.

If an airlock is restricting the flow of water, bleed the whole system. Disconnect the return hose at its most convenient end, top up the radiator and start the engine.

Seal the hose with your thumb, then wait until the water runs freely from the heater with no air bubbles. This normally takes from five to ten seconds. Reconnect the return hose, tighten its retaining clip and top up the radiator.

Always bleed the system when the engine is cold to avoid being scalded by coolant. A cold engine also means the thermostat is closed, so more water is forced through the heater.



The water valve may be on the heater box, as here, or on the cylinder head.

Disconnecting the heater return hose

Disconnect at the engine end and direct water away from engine.

Clearing debris from a plenum chamber

First remove the plenum-chamber drain valve by slackening the hose clip. With the valve removed, tip out any debris blocking the valve and clear the drain tube. This type drains into the engine bay.

The lips of the valve are shaped so that they remain closed when water is not draining through them. Flick open the lips of the valve to see that they close. If they do not, replace the valve and hose clip.

Remove the drain tube to clear out dead leaves and debris.

Test the drain valve with a forefinger.

Flushing the radiator and engine block

Over a period of years, sediment builds up in a car's cooling system – even if antifreeze containing corrosion inhibitors is left in all year round.

Eventually the sediment will start to obstruct the water passages in the radiator and engine. Such obstruction causes overheating of the engine which, if it becomes severe, can lead to engine seizure.

If your engine is overheating and you have eliminated other possible causes, such as leaks (SHEET 114), a broken fan belt, blocked radiator fins or incorrect ignition timing (SHEETS 203-204), the water passages are probably choked or narrowed by sediment. To clear them, thoroughly flush the radiator and engine.

Before flushing, drain the old coolant from the system and discard it – the sediment deposits will have contaminated it. Remember, however, that the antifreeze contained in the coolant is poisonous. Have a large container ready to collect it, for disposal later at your nearest dump for poisonous wastes.

With the engine cold, remove the pressure cap from the radiator or expansion tank. Turn the heater control to 'hot'.

If the radiator has a drain plug, remove it; if there is a drain tap, open it – look in your car handbook to see which way it turns, as it can be broken easily.

If no coolant runs out, gently poke the hole clean with a piece of wire, or unscrew the tap completely.

If there is no tap or drain plug, disconnect the bottom hose at the radiator end.

There may also be a drain tap on the engine block. If so, open it.

Tools and equipment

LARGE CONTAINER • SPANNERS • SCREWDRIVER • GARDEN HOSE • NYLON BRUSH • OIL SOLVENT • RAGS • THERMOSTAT GASKET • NON-SETTING SEALANT • ANTIFREEZE • HOSES AND CLIPS AS REQUIRED • GLASS JAR • PLASTIC BAGS

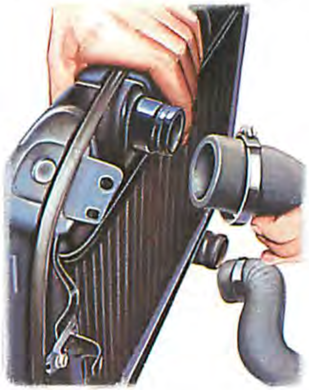
Flushing the radiator

Disconnect both hoses from the radiator. Push the end of a garden hose into the top radiator connection stub, and seal it with rags.

Refit the radiator pressure cap and turn the water on full. Flush until the water runs clear.

Check by catching some water in a glass jar and looking for sediment, which you can see only in still water.

If the water does not clear in a few minutes, 'reverse flush' the radiator. Seal the hose into the bottom stub. Tie a long plastic bag with a hole in the bottom to the top stub, to direct the coolant away from the engine and electrical components. Flush until the water runs clear.



Fully loosen the hose clips and pull them back along the hose. Pull off the hoses, taking care not to strain the metal stub pipes.

Protecting the electrics

Check whether there is any risk of wetting electrical components, including an electric cooling fan. Protect such components by covering them with a plastic bag. It is vital to do this before rinsing dirt from the outside of the radiator.

Use plastic bags to cover the nearby electrical components.

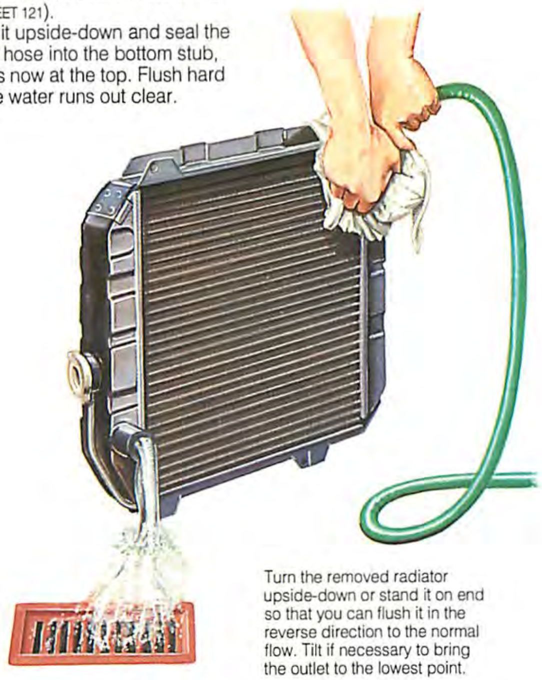
Make the hosepipe a tight fit by jamming it in with rags.

Flush the water through until it runs out clear.

Reverse flushing with the radiator removed

If simple reverse flushing does not clear the radiator, take it out of the car (SHEET 121).

Prop it upside-down and seal the garden hose into the bottom stub, which is now at the top. Flush hard until the water runs out clear.



Turn the removed radiator upside-down or stand it on end so that you can flush it in the reverse direction to the normal flow. Tilt if necessary to bring the outlet to the lowest point.

Flushing the engine block

Disconnect the top hose from its stub on the thermostat housing above the water pump.

Unbolt the top of the housing and lift out the thermostat, noting which way up it fits. Refix the top of the empty housing.

Seal a garden hose into the housing stub. Flush until water runs clear from the bottom hose. This is reverse flushing: water normally flows up the engine.

Refit the radiator if you removed it, and put back the thermostat. Fit a new gasket in the thermostat housing, after smearing both sides of it with non-setting sealant. Bolt back the top.

Reconnect the hoses, renewing any damaged hoses or clips or any that are more than four years old.

Refill the system with clean water. Run the engine up to its normal working temperature and check for leaks.

Add antifreeze (SHEET 115) only when you are satisfied that there are no leaks.

Even in summer, use an antifreeze mixture – it contains anti-corrosion additives. Ordinary tap water can cause rapid corrosion and partial blocking of the cooling system.

The coolant mixture is usually good for two or three years' winter and summer use, after which it should be replaced.

Cleaning radiator fins

Brush loose dirt from the fins of the radiator core with a nylon brush – not a wire brush, as the soft metal core is easily damaged. Do not poke it with wire or a screwdriver.

If the core looks oily, spray it with a proprietary oil dispersant or apply an oil solvent with a soft brush.

Protect the electrics, then hose water through the fins from back to front.

Hose water through the radiator fins from the back of the radiator to the front, to clean them thoroughly.

Remove the thermostat

Remove the thermostat before flushing, noting how it fits.

Draining and refilling a fully sealed cooling system

In a fully sealed cooling system, the cap on top of the radiator is not usually opened for topping up the system.

Instead, a pressure cap is fitted to the system, and a tube leads from the top of the radiator to a glass, plastic or metal tank or container.

Coolant which has expanded as the system warms up passes down the tube into this tank, and is drawn back into the radiator when it has cooled.

The system is supposed to be maintenance-free, and is drained only when a hose or the coolant is due for replacement.

When draining and refilling the system, if the coolant is to be reused, place clean containers beneath the drain points.

Note that the coolant is poisonous. Do not use containers which will be used in or near the kitchen. If you do not want to use the coolant again, do not pour it down a drain – ask your local council how to dispose of it.

If you intend to reuse the coolant, have a little extra to hand for replacement, as a little spillage is inevitable.

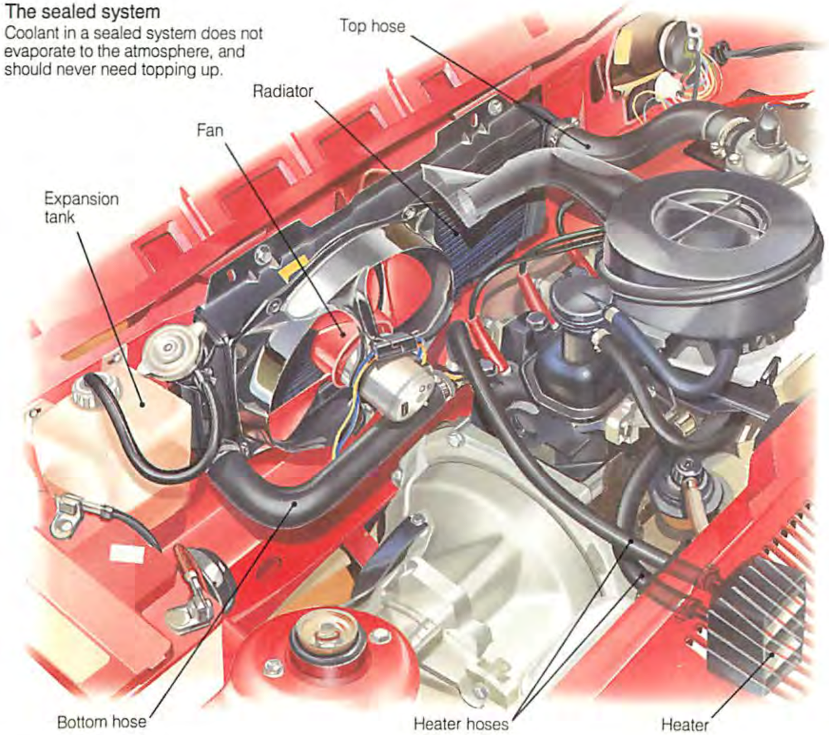
Most manufacturers recommend a 60 to 40 per cent water and antifreeze mixture. Some specify a 50–50 mix.

Use antifreeze made to BS (British Standard) 3152, or as specified by the car manufacturer. The standard number, if it applies, is printed on the container.

Tools and equipment

CONTAINERS • ANTIFREEZE • SCREWDRIVER • SPANNER • FABRIC TAPE • PLASTIC SHEETING

The sealed system
Coolant in a sealed system does not evaporate to the atmosphere, and should never need topping up.



Checking and maintaining the system

A glass or plastic expansion tank allows you to check the level at a glance. Make sure that it is topped up with antifreeze mixture to its maximum level mark.

Check the rim and seal on the pressure cap for dirt and deterioration every time that you open it.

If the cap has a pressure-relief valve, never get it wet; replace it if it does become wet or dirty.

Examine the condition of the hoses where they are held by clamps or hose clips.


Make sure the expansion tank cap is clean and sound if you should have to top up.

Reinforce them with fabric-based tape under the clamps or clips if they are wearing – or, better still, replace them.

Check all the clips for tightness, but do not overtighten them and so distort the hose.

Tighten all the hose clips and close all the bleed screws. With the engine running and hot, keep topping up the radiator as the air bubbles are dispersed.

Trapped air tends to collect at the highest point of the system. Where there are no bleed valves, slacken the return hose of the heater unit – the bottom hose – and allow the air to escape. As soon as there is a steady stream of bubble-free coolant, tighten the hose.

Antifreeze, or a combination of water and antifreeze, will stain and discolour paintwork if allowed to dry on it. Use plastic sheeting or absorbent rags to protect wings and other exposed parts of the paintwork. If coolant is spilled on to paintwork, rinse it off immediately with clean water.

Draining and refilling the system

To empty the system, let the engine cool, take the cap off the expansion tank, put the heater control inside the car on 'hot', and open the drain tap or remove the bottom hose.

Open the bleed screws on the hoses and connections. They are usually thumbscrews and can be opened with the fingers. Those on the water pump or other metal fittings may need a small spanner to open them.

When refilling, raise the front of the car on axle stands to make the top of the radiator the highest point in the system.

Check all the hose clips for tightness and close all the drain plugs, except the bleed screw at the top of the heater hose. Make sure the heater control inside the car is set to 'hot'.

Pour the coolant mixture into the expansion tank until it reaches 1 in. (25 mm) above the top level line. Replace the cap.

Remove the radiator cap and fill the main system with coolant through the radiator opening until it will take no more and there is a trickle of coolant from the heater bleed screw. Close the screw.

Run the engine until it reaches its normal temperature, when the top hose becomes hot as the thermostat opens. If you have a bleed screw on the water pump, undo it a turn. Close it as soon as a steady, bubble-free stream of coolant comes out.

Take care – the coolant is hot and there are moving drive belts near by.

Top up the radiator. Open and close the bleed screws on the various hoses and connections in turn, ending with the heater-system screw.

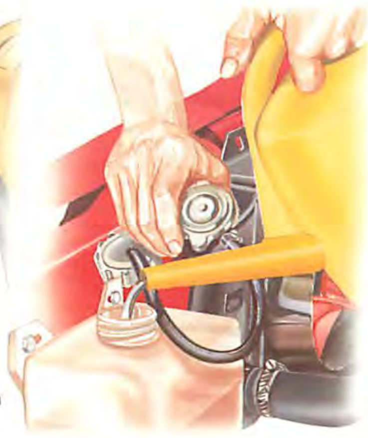
Close each of them as soon as there is a good flow of air-free coolant. Lower the car.

After a few days, with the engine hot and running, set the heater to the 'hot' position and carefully open the heater-pipe bleed screw, or the one at the highest point in the system.

Any traces of air collect here, and will be expelled. When the engine has fully cooled, check and top up the expansion tank if necessary.


When refilling, raise up the car on axle stands so that the top of the radiator is the highest point of the system.


After a few days bleed air from the heater-hose bleed screw.


Top up the expansion tank if necessary when all air is out of the system.

Checking and changing a thermostat

If the engine warms up very slowly, or never reaches normal temperature, or if it overheats quickly, the thermostat is probably faulty.

In most cars the thermostat is placed under a housing near the water pump on the cylinder head; the housing is connected directly to the top radiator hose. In a few cars the thermostat is housed near the bottom hose.

Test the thermostat quickly by starting the engine from cold. Put your hand on the radiator or top hose – keep clear of the fan.

If the thermostat works properly, the hose will stay fairly cool for a few minutes, then will quickly warm up.

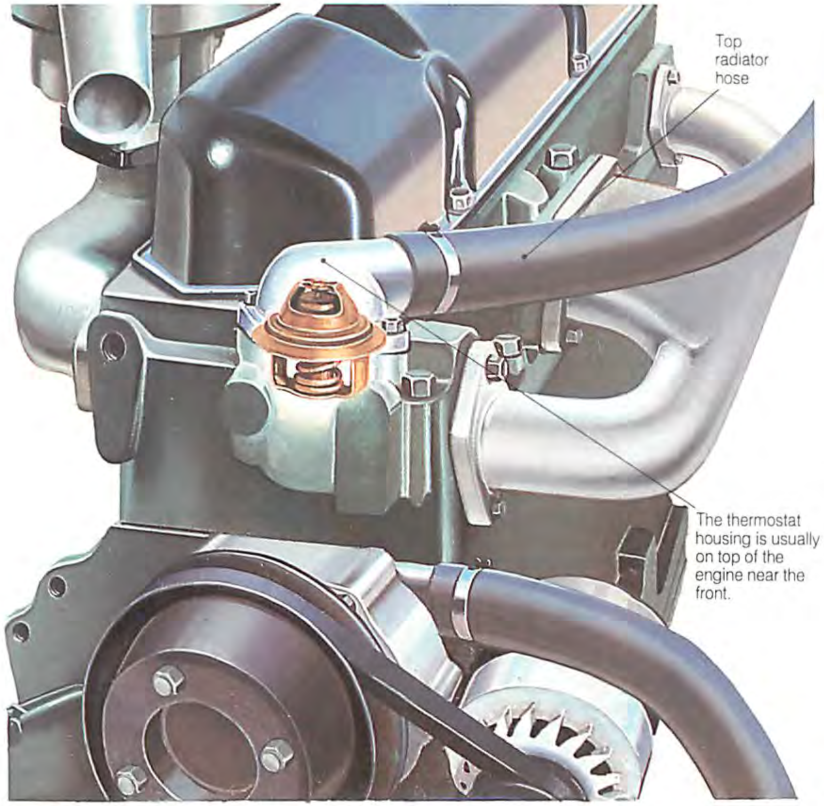
If the hose warms gradually from the start, the thermostat has stuck open. If the hose does not warm much, but the engine soon gets hot, the thermostat has stuck closed.

Make sure a new thermostat is the correct one for your car. The temperature at which it starts to open is usually stamped on it.

Tools and equipment

SCREWDRIVER • SPANNERS • CONTAINER • NAILBRUSH • NON-SETTING GASKET SEALER • THERMOMETER • NEW THERMOSTAT • SCRAPER

Locating the thermostat



Removing and replacing the thermostat

With a normal top-mounted thermostat you need drain only part of the cooling system.

Do not drain it while the engine is hot – you may be scalded. Wait for the engine to cool.

Drain the coolant from the radiator tap, or from the bottom hose, until it is below the level of the thermostat housing.

Drain it into a clean container if you want to reuse it, and filter it through muslin before pouring it back.

Disconnect the top hose from the thermostat housing by loosening the hose clip and carefully easing the hose off.

Remove the nuts securing the housing. If the housing does not lift off easily, tap it free with a piece of wood. Do not prise it off with a screwdriver which might damage it and cause it to leak later.

Lift out the thermostat. If the engine is cold but the thermostat is open, it is stuck and must be renewed. Otherwise, test it in a pan of water.

Before inserting a new thermostat, use a scraper to remove all traces of the old housing gasket; take great care so that you do not damage the housing.

Use a nailbrush or a piece of wood to avoid scratching the metal. Block the opening with rag while you do so, to stop bits of old gasket falling in.

Insert the new thermostat then smear the new housing gasket lightly with a non-setting sealing compound. Fit it and the housing in place. Tighten the housing nuts alternately, to avoid distorting the housing. Be careful not to overtighten them.

Top up the cooling system and repeat the hose-touching test while watching for leaks.


Loosen the top hose clip, then ease off the hose. Partially drain the cooling system first.


Remove the nuts securing the housing.


If the housing does not lift off easily, tap it free gently with a piece of wood, taking care not to damage the housing.

Fitting a thermostat

Many thermostats are fitted a certain way, with one side marked 'front', 'rad', or with an arrow pointing towards the radiator. The opening temperature is usually marked on the thermostat rim.


Lift off the housing and remove the thermostat.


Remove all traces of old gasket from both faces.

Testing in a pan

Suspend the thermostat on a string in a pan of water and heat the pan. The thermostat must not touch the sides or bottom – heat from the metal would spoil the test.

Immerse a cook's thermometer in the water and note the temperature at which the thermostat starts to open. It should be within three or four degrees of the figure marked on the thermostat.

Continue heating to check that the thermostat valve opens fully.


Neither thermostat nor thermometer should touch the bottom.

Thermostat in a top hose

On most Renaults the thermostat is inserted in the top hose, where it joins on to the water pump. The thermostat is held in the hose by a screw clip, and another clip holds the hose on to the water pump.


Renault thermostat in the hose connection to the water pump.

Replacing a water pump

Water pumps wear out through age, through lack of lubrication on older types – which need greasing – or because the drive belt is too tight.

A worn pump may leak around the spindle, in which case there are leak trails down the front of the engine and a slow loss of coolant.

The pump may also rattle as it turns – do not confuse this noise with the screech of a loose, slipping belt.

To check for wear, loosen the belt and, if a mechanical fan is mounted on the pump, grasp opposite blades and try to rock them.

They should not move more than a small amount. If the fan is not fitted directly to the pump, clamp a self-locking wrench on to one of the pump pulley bolts and rock that.

Replace a worn pump. Buy a new gasket too, and some gasket sealant.

Examine the radiator and header-tank hoses for splits or signs of perishing. Replace, along with the clips.

Disconnect the battery. Drain the coolant, saving it if it contains anti-freeze. Catch in a clean container and filter through muslin before replacing. Check the strength (SHEET 115).

Disconnect the hose(s) from the pump by loosening the clip and gently twisting the hose to and fro to free it.

There may be other parts you need to remove to reach the pump.

Tools and equipment

SPANNERS • SCREWDRIVER • PIECE OF WOOD • TORQUE WRENCH • GASKET SEALANT • SELF-LOCKING WRENCH • SOFT-FACED HAMMER

Parts which you may have to remove

On some cars you must take out the radiator (SHEET 121) to reach the pump. They include the Talbot Avenger and BL Maxi.

On the original Mini you need not, removing only the top part of the fan cowl allows enough access.

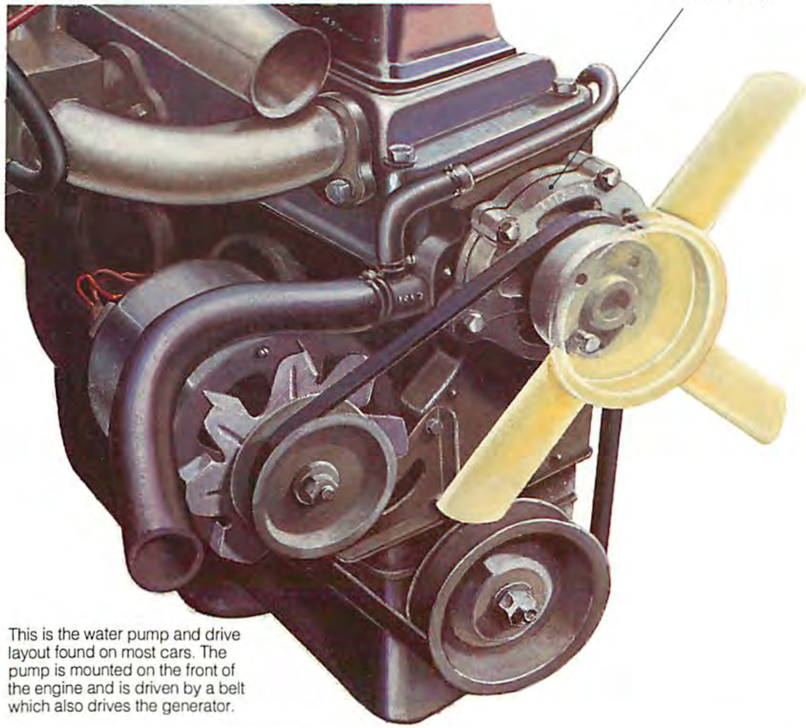
When replacing the pump on a Mini it is advisable to replace also the bypass hose, unless it is in perfect condition – it is difficult to reach with the pump in place.

The Talbot Alpine has a pump reached by unbolting a side panel under the front offside wheel arch. Remove the wheel to expose the panel.

On some cars you must take off the radiator to get at the water pump.

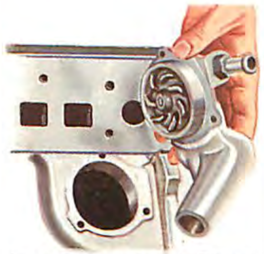
On early Minis the pump can be reached by removing the top part of the fan cowl.

Typical water pump and drive layout



This is the water pump and drive layout found on most cars. The pump is mounted on the front of the engine and is driven by a belt which also drives the generator.

Layout variations



On some cars, such as the Triumph Dolomite Sprint and Saab 99, the pump is mounted vertically at the rear of the engine block.

The water pump on the VW Golf is driven by the camshaft drive belt.

Removing and refitting the pump

Slacken the drive belt. Unbolt the fan (if fitted) and pulley from the pump hub.

Mark the side of the fan which faces the radiator: it only works properly one way round.

Some pumps have a drain plug. Unscrew this to insert it in the new pump.

Remove the pump retaining bolts. Some may be longer than others. Note which bolt goes where – it is important when refitting.

Pull off the pump carefully.

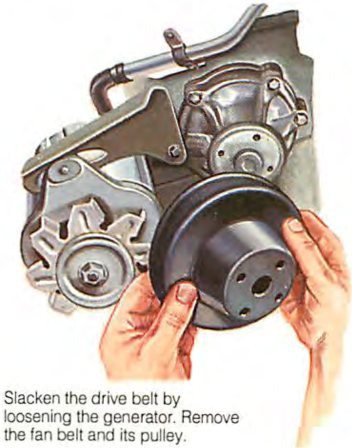
If it sticks do not lever it away from the engine block with a screwdriver, because you might damage the block and cause a leak.

Scrape the remains of the old gasket off the block with a piece of wood.

Fit the new gasket (smeared on both sides with sealant, if used) and the pump. Tighten the bolts in diagonal sequence in order to avoid distorting the pump flange.

There may be a recommended torque setting for them – consult a service manual if in doubt.

Refit the hoses and tension the belt (SHEET 100). Refill the cooling system. Run the engine up to normal temperature and check for leaks.



Slacken the drive belt by loosening the generator. Remove the fan belt and its pulley.

Use a socket spanner and extension to remove the pump retaining bolts. Note the position of each bolt if they vary in length.

If the pump is stuck to its mounting by gasket sealant, free it by tapping gently with a soft-faced hammer.

Removing the radiator

Radiators on earlier cars were made of copper and brass alloys. They could be repaired by soldering.

But a number of later cars – including the Mini Metro – have radiators with aluminium cores and plastic top and bottom tanks. Such radiators can be damaged by forcing off a hose or pressure cap, or overtightening a clip.

The damage is impossible for a home mechanic to repair, and usually the radiator must be replaced.

Aluminium does not dissipate heat as well as copper, so there have to be more fins on the core, which is therefore easily clogged by dirt thrown up from the road. Hose it clean at least once a year (SHEET 117).

There is one advantage, however: lightweight radiators generally have simple fixings and are easy to remove.

Tools and equipment

SCREWDRIVER • SPANNERS • CONTAINER • POLYTHENE BAGS AND RUBBER BANDS

Disconnecting hoses and fittings on the radiator

Before you remove a radiator, check the hoses and clips. Buy replacements if the hoses are cracked or deteriorated, or if the clips are corroded. Always replace wire-type clips with screw clips.

If necessary, make notes or drawings of how all the radiator connections fit.

Apart from the top and bottom hoses, there may be pipes to an expansion tank, and electrical leads to a temperature gauge or automatic electric-fan switch, which must be disconnected.

An electric fan may be bolted to the radiator. Depending on the design, you either remove it to free the radiator, or remove it together with the radiator. Check with the car service manual.

With both electrical and mechanical fans, you may have to take off a fan cowl in order to free the radiator.

Some cars have a splash shield under the radiator, which must be removed. Cars with automatic transmission may have a gearbox oil cooler set in the bottom of the normal radiator, with screw-on unions for the oil pipes.

Disconnect the battery before starting to remove any radiator which has electrical connections. Then remove the pressure cap and drain the radiator.

Loosen hose clips and ease off the hoses by twisting them gently to and fro.

Do not try to lever off a hose with a screwdriver: you may damage both the hose and the radiator stub – particularly if the stub is plastic.

If a hose is stuck fast, slit it at the stub end with a sharp knife and renew the hose. Unfasten any electrical connections and check that they are clean and sound.

Before you unscrew any oil-pipe unions (used on automatic-transmission radiators) have a container ready to catch the oil. Do not use the oil again – top up the transmission with fresh oil afterwards (SHEET 250).

Seal disconnected oil unions, both on the radiator and on the pipes, with polythene bags and rubber bands to keep out dirt.

When you refit the oil unions take great care not to get the nuts cross-threaded, and tighten them well to prevent leaks.

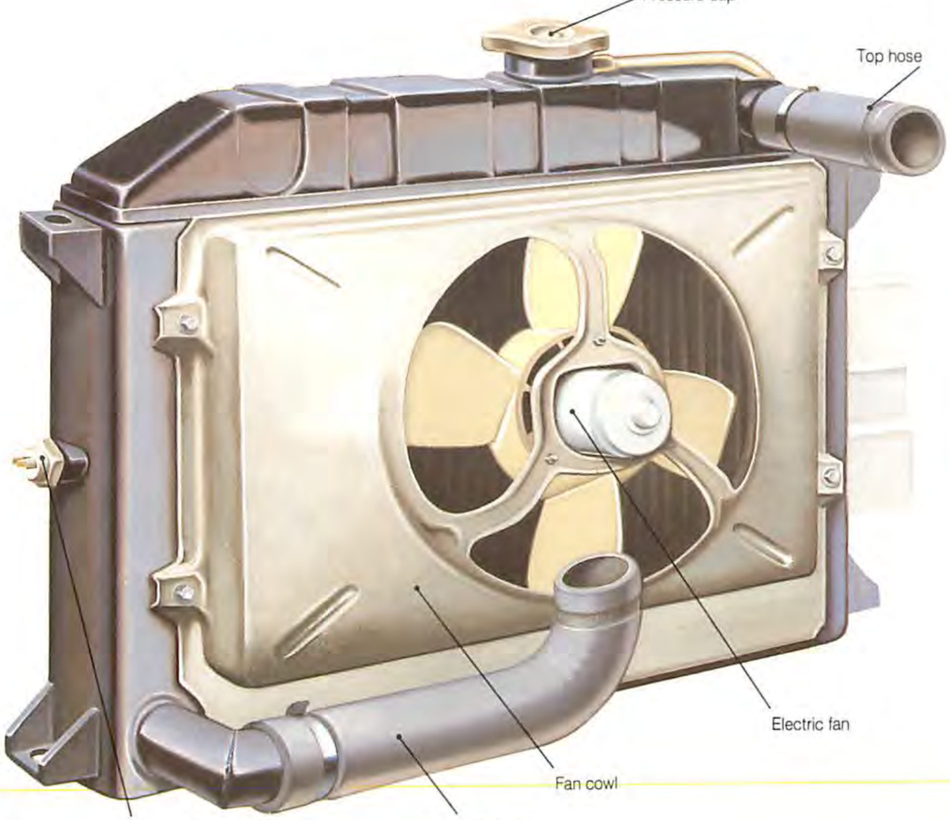
Unscrew the radiator mounting bolts and ease the radiator out, removing such parts as may be necessary to clear the way.

Remember the order in which you removed them, so that you can reverse the sequence when refitting Take care not to crush the soft metal radiator fins or otherwise damage them or the fan blades.

When refitting hoses, tighten the clips firmly but not too much – overtightening could cause the clips to cut the hoses or crush the plastic stubs to which they are sometimes fitted.

A typical radiator

On most modern cars the radiator has four side mountings and a top and bottom hose. The electric fan may be bolted to a fan cowl and enclosed, particularly on some transverse-engined cars where the radiator is mounted at the side of the engine bay.



Draining the radiator

With the engine cold, take off or release the pressure cap on the radiator – or on a separate tank if one is fitted.

Some cars have a tap or drain plug in the bottom of the radiator – open it and the radiator should empty.

If no water flows, poke a drain-plug hole gently with wire, or unscrew and remove a tap. If there is no tap or plug, or if you are unable to clear a blockage with wire, disconnect the bottom hose at the radiator end.

Save coolant with antifreeze in it for re-use. Drain it into a clean container, then strain it through muslin to remove rust or dirt before you put it back.

Afterwards, ask a garage to check the strength of the solution. Or you can check it yourself if you have an antifreeze hydrometer (SHEET 48).

There may be a drain tap or plug at the bottom of the radiator.

Disconnect the bottom hose if there is no drain plug or tap.

Slide it out

Some cars have unusual radiator mountings: look carefully all over the radiator and find where the mounting points are – they are not always obvious.

Those on Vauxhall Cavaliers and Opel Asconas have just one bolt set in a rubber bush at the bottom. When the bolt is removed the radiator can be slid upwards and out.

Remove the nut from the single bolt and the radiator lifts off through the two sliding guides.

Replacing core plugs

Core plugs are also known as expansion plugs, welch plugs and sealing discs – a point to remember when buying one.

The plugs are set in various places around the engine block and cylinder head.

Their purpose is to seal holes left in the block and head when those components were cast.

They also provide weak points which can give way under the pressure of expanding coolant if the engine freezes or overheats. They could possibly prevent frozen coolant cracking the casting.

Typical plug sites are in the side of the block under a manifold; at the back, inside or above the clutch housing – awkwardly near the bulkhead; and in the top of the cylinder head, often hidden under an overhead camshaft.

Plugs can blow out completely, resulting in a sudden loss of coolant. They can also leak slowly through rust holes or around the edge. A slow leak usually leaves a stain down the block. Look all over the engine for such a mark.

Some of the plugs are difficult to find – use a mirror to look in hidden spots – such as the back of the block, next to the bulkhead. An engine may also use more than one size of plug, so measure the hole when buying a replacement.

Access is the next problem. You may have to disconnect the carburettor (SHEET 178) and remove the inlet or exhaust manifold (SHEET 155) or both, or remove the distributor (SHEET 201) or the camshaft (SHEETS 158–159).

Plugs facing the bulkhead may be unreachable without lifting out the engine, so you may have to have the job done at a garage.

Do not cut a hole in the bulkhead. It is load-bearing and, unless you weld a plate back over the hole, weakening it might invalidate your insurance. Riveting the plate on will not suffice.

Disconnect the battery and drain the engine block, saving the coolant if you want to reuse it (SHEETS 113, 117).

Catch the coolant in a clean container, and filter it through muslin before pouring it back. Check the strength of the solution (SHEET 115).

There are two common types of core plug, the cap type and the domed-disc type, which are inserted in different ways.

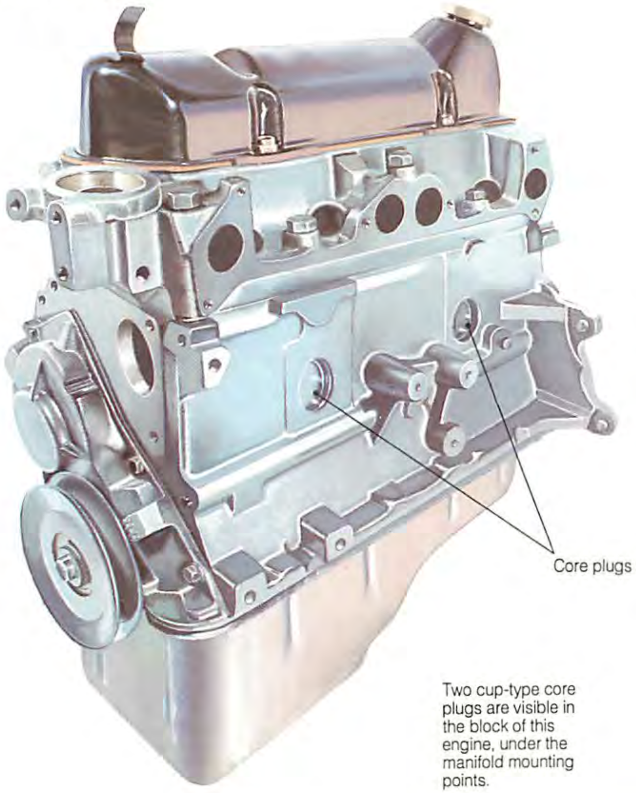
Tools and equipment

CLEAN CONTAINER • SMALL SCREWDRIVER • PLIERS, TWO PAIRS • PIECE OF WOOD • GASKET SEALANT • FLAT-HEADED PUNCH • BALL-PEIN HAMMER • SOFT-FACED HAMMER • MIRROR • 2 IN. (50 MM) BOLT, WASHER AND NUT • SOCKET

Two types of core plug

The domed-disc plug fits against a shoulder. The cup-type plug is driven in until only a little of the lip protrudes.

Locating core plugs



Two cup-type core plugs are visible in the block of this engine, under the manifold mounting points.

Removing a core plug

With either type of plug, the usual way of removing it is to carefully drive a small screwdriver blade through the middle of the plug and prise it out.

Take care to pull out a cup-type plug straight, or it may jam.

The edges of a cup plug may project far enough for you to pull it out with two pairs of pliers. Grip the edges firmly and pull with an even amount of force on both pairs of pliers. Do not lever against the block – you may damage the plug seating.

Scrape the remains of the old sealant from the hole with a piece of wood.

You may be able to pull out a cup-type plug with two pairs of pliers.

Drive a screwdriver through the old plug and prise it out.

Replacing a core plug

Smear the mating surfaces of both plug and hole with gasket sealant.

Insert a disc-type plug with the domed side outwards. Make sure it rests squarely on the shoulder inside the hole. Tap it in the middle with a flat-headed punch to expand it. It must be a firm fit.

For a cup-type plug, find a socket which fits snugly inside the cup. Hold the cup absolutely square and flat against the hole, and drive it home by tapping the socket with a soft-faced hammer.

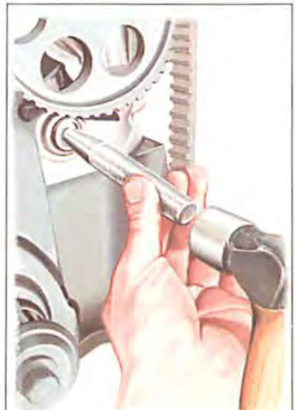
Do not let the plug get crooked, and leave a little of the rim protruding in case you have to remove the plug later.

There may not be room to swing a hammer. For example, the Leyland 'B'-type engine (fitted to older 1,500–1,800 cc cars) has a disc plug just in front of the bulkhead and masked by the engine backplate. But there is a hole in the backplate facing the plug.

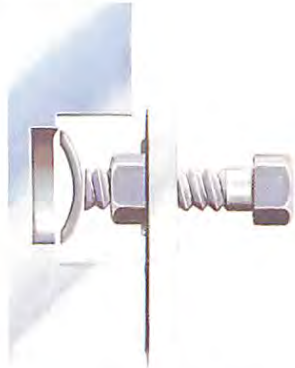
Insert the new plug, put a 2 in. (50 mm) bolt through the hole in the backplate, and fit a washer and nut to it on the other side. Screw up the bolt to press the plug firmly home.

You may be able to adapt this method for replacing other awkward plugs.

Use a socket of a suitable size to drive in a cup plug.



Use a flat-headed punch to press home a disc plug.



On some BL engines, use a bolt to press home the core plug behind the engine backplate.

Checking and replacing fuses / 1

When an electrical component stops working the fault may be in the component, in the electrical circuit or in the fuse that protects them. Because the fuse is a likely cause, and the easiest to check, look at it first.

The fuses are usually grouped in a box or on a panel with a cover. Ideally, the box should be fixed in an accessible place – such as the bulkhead under the bonnet.

Often, however, it is hidden away, perhaps under the dashboard or down in the front knee-well.

The car handbook usually gives the location, but without a book finding the box can prove difficult. Get to know where it is before anything goes wrong.

The individual fuses in the box are usually numbered, so that sorting out which one may have blown is simplified by referring to the numbered list in the handbook. This should tell you which fuse protects which circuit.

Where they are not numbered, take out each fuse in turn and see which component stops working.

Checking fuses

Depending on the fuse design, it is sometimes possible to tell whether it has blown by holding it up against a light; a break in the wire inside may be visible. Another clue is blackening of the glass cover.

If there is no visible sign, check by fitting another fuse of the same rating; if that cures the trouble, then the fuse was to blame.

However, it is always advisable to check the circuit also, in case a fault in it caused the fuse to blow. For example, failure of an electrical component or damaged insulation on a cable can cause a short circuit, resulting in a sudden massive increase in current.

If the cable overheated, there could be a fire. The fuse prevents that happening, because its thin wire will melt and break the circuit long before the cable itself can heat up and burn.

Some cars have only two fuses. One rated at about 30–50 amps protects components wired through the ignition switch – flashers, wipers, heater-motor and instruments.

The other, probably rated at about 20–30 amps, protects components not wired through the ignition – horns, interior lights and the cigarette lighter.

Where a single fuse protects a number of circuits and keeps blowing, each circuit must be checked individually to discover which one is faulty.

To find the faulty one, fit a sound fuse while all the relevant components are switched off. Now switch them on one at a time – the circuit with the fault will blow the fuse.

Always replace a fuse with one of the same rating. Replacing, say, a 10 amp fuse with a 30 amp one could result in considerable damage.

The 10 amp fuse would normally protect a circuit carrying 7 amps: a 30 amp fuse would allow a 30 amp current to flow through, with possibly a disastrous effect on the unit or cable it was supposed to protect.

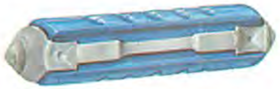
Tools and equipment

FINE EMERY PAPER

Types of fuse

The shape and construction of fuses varies from car to car. The three types of fuse in general use are as shown below.

The clear-glass type. A wire running through breaks when overloaded.

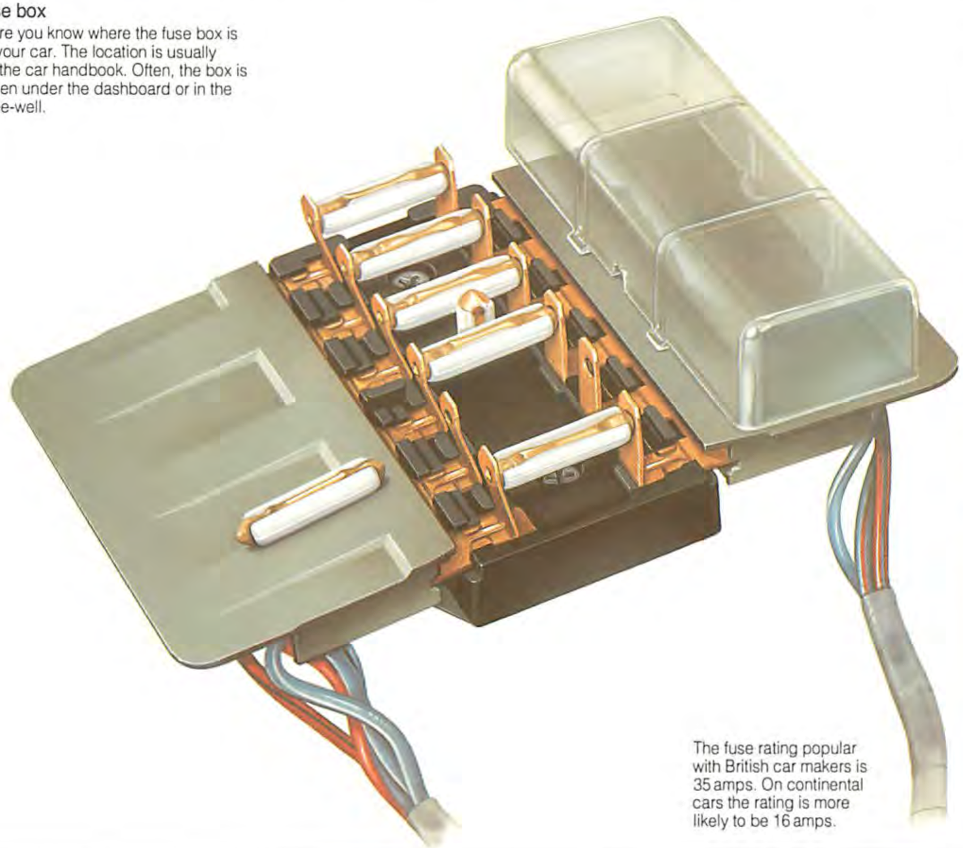


The continental type. A shaped metal strip set in one side melts under excessive load.

A rectangular type found on Vauxhalls and Opels. It has two push-in connectors linked by a visible fuse wire. It is also being adopted on the latest Fords.

The fuse box

Make sure you know where the fuse box is fitted in your car. The location is usually given in the car handbook. Often, the box is half hidden under the dashboard or in the front knee-well.



The fuse rating popular with British car makers is 35 amps. On continental cars the rating is more likely to be 16 amps.

Changing a fuse

In most fuse boxes, the fuses simply push into a pair of spring-clip contacts.

Pull out the suspect fuse and, using fine emery paper, clean off any dirt or corrosion from the inside contact surfaces of the clips.

Make sure the new fuse has the correct amp rating for the circuit (SHEET 27); use fine emery paper to brighten the metal caps at each end.

Push the fuse into the vacant clips and try the circuit to see if power is restored.

If it is not, check by fitting a fuse of the same rating from a circuit you know is working.

If this does not work, the fault is not in the fuse, but elsewhere in the circuit.

Each fuse is held between two clips in the fuse box; these are also the fuse contacts. The clips are sprung, and should hold the fuse tightly in place.

Brighten the caps of a new fuse with emery paper. This will remove any tarnish that may have formed and ensure a good contact with the spring clips.

Checking and replacing fuses / 2

How fuses are marked

The amp ratings of all fuses are printed on them, but there are two systems of rating in use.

In the latest system, the rating marked on a fuse indicates the continuous current it can carry, while also withstanding brief surges of up to double that strength. It is usually called the CR (continuous resistance) rating.

A 10 amp fuse of this sort will carry a continuous 10 amps, and take brief surges up to 20 amps without blowing.

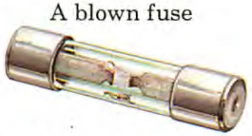
An earlier system marks the fuse with the maximum current it can carry before blowing – it will carry only half that figure continuously.

A 10 amp fuse of this sort will take a continuous load of 5 amps, and only short surges up to 10 amps, beyond which it blows.

Some fuse manufacturers are now marking fuses both ways. For instance, 20 amps (10 amps CR).

The amp rating is often stamped on the end cap of the fuse. Rating systems vary.

A blown fuse

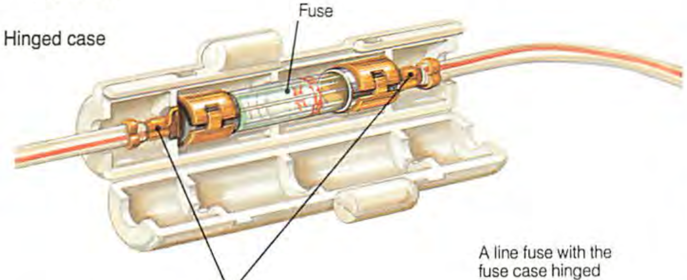


A fuse is 'blown' when the connector between its two ends melts under an overload of current.

Types of line fuse

Bayonet fittings

Hinged case



A line fuse with the fuse case hinged along its length.

Sometimes it is necessary to individually protect a circuit not covered by the main bank of fuses. For this, a manufacturer may use a line fuse.

A typical example is in BL cars where they are fitted to protect sidelight and tail-light circuits and the rear-window heater.

Mostly, however, they are used when an accessory such as a radio or tape deck is being fitted – the fuse being linked into the power-supply lead near the set.

A line fuse is simply a two-part plastic holder with a terminal at each end. Each terminal is connected to an end of the cable, where it is cut to accommodate the fuse.

One terminal is usually lightly spring-loaded to hold the fuse in contact.

The fuse fits between the two terminals and is held in place against the contacts by twist-locking or screwing together the two halves of the case.

The amp rating of a fuse protecting a radio or tape deck is specified by the makers of the equipment.

Bayonet lock

A line fuse in a screw-together plastic holder, with a bayonet-jointed fixed contact at one end and a spring-loaded contact at the other.

Hinged case

When the case sides snap together, they hold the fuse secure between the contacts.

Thermostatic interruptor

The sudden loss of headlights because a fuse has blown can be dangerous, so such circuits may be protected by a thermostatic interruptor.

This device is not quite a fuse, but works rather like one. It operates on the principle that a metal strip, when heated, bends away from a contact that it would normally be touching, and so breaks the circuit.

As the strip cools it returns to shape and touches the contact again, restoring the circuit.

If the headlight-circuit fuse blows, the thermostatic interruptor allows the lights to work on reduced power so that a journey can perhaps be completed. The lights and their circuit can be checked thoroughly later.

Thermostatic interruptors may also be fitted into circuits prone to occasional overloads.

A good example is an electric window-winder circuit; a jamming window could overload the winder motor, but a thermostatic interruptor stops the motor burning out and also eliminates the need for a conventional fuse.

A thermostatic interruptor not only protects the circuit, but also, like a fuse, serves as a warning that there is a fault in the circuit. Whenever an interruptor comes into operation, therefore, the related circuit should be checked thoroughly at the first opportunity.

A thermostatic interruptor acts like a fuse, but allows reduced power to essential circuits.

Replacing fusible links

In certain modern cars, a special type of high-resistance fuse is fitted into the main battery feed – usually where it passes out of the starter solenoid.

Such a fuse is called a fusible link, and comprises lengths of copper wire of varying thicknesses between two two-pin plugs. The wires will melt in succession under a massive overload of current.

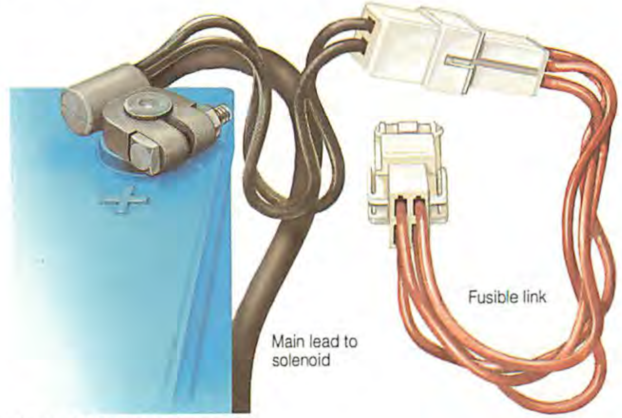
A fusible link is fitted in addition to the normal bank of fuses, and is designed to protect all the electrical circuits in the car except the starter – which needs maximum power.

The protection it provides is invaluable if the car is in a crash, and the wiring is crushed together or the insulation chopped through.

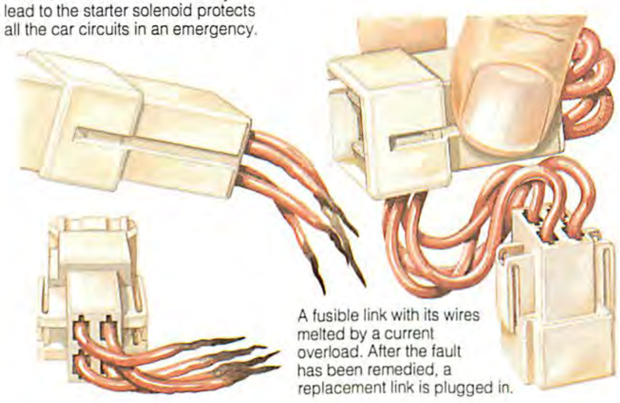
The magnitude of the short circuit that could result is such that rapid overheating would almost certainly be followed by fire.

However, a fusible link will melt even quicker – and break the circuit before that can happen.

If a fusible link has to be replaced, it needs very careful soldering to avoid damage by overheating. Generally the job is best left to an expert.



A fusible link fitted in the battery lead to the starter solenoid protects all the car circuits in an emergency.



A fusible link with its wires melted by a current overload. After the fault has been remedied, a replacement link is plugged in.

Checking headlamps and lights / 1

It is an offence in law not to have all obligatory lights working. Check them frequently, especially before a night journey. Walk round the car while someone works the switches.

Obligatory lights are side and tail lights, headlamps (main and dipped beams), direction indicators, stop lights and a rear number-plate light. When fitted, reversing lights, fog lights (front and rear), long-range driving lights and hazard warning lights should also be working.

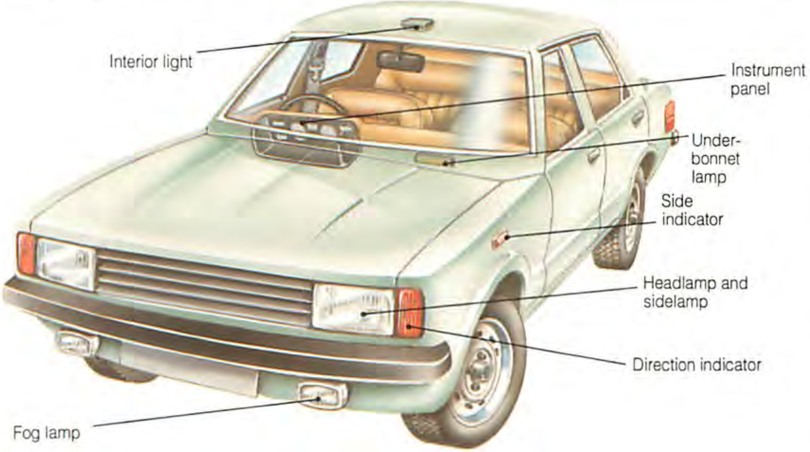
Wipe all the lenses with a clean cloth, checking them for damage.

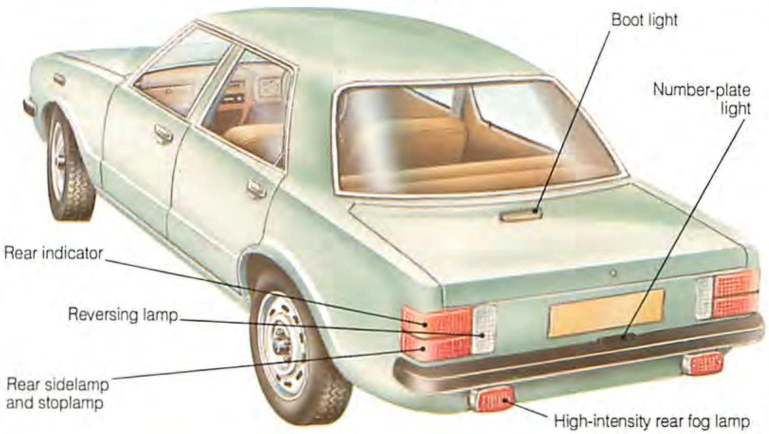
If a lens is cracked, seal it temporarily with clear adhesive tape, taking care not to obscure more of the glass than absolutely necessary.

Damaged lenses must be replaced as soon as possible, both for safety and to prevent moisture entering the lamp fixture. Water will tarnish the reflector, and corroded connections will soon put the lamp out of action.

Tools and equipment

CLOTH • ADHESIVE TAPE • SCREWDRIVER • TEST LEAD • METHYLATED SPIRIT • WIRE BRUSH • CIRCUIT TESTER OR VOLTMETER • EMERY PAPER





Checking headlamps

On many modern cars the headlamp bulb can be reached from inside the bonnet; on others it is necessary to remove the lamp bezel or grille on the front of the car. Access to headlamps is described in SHEET 128.

Failure of a single headlamp is usually confined to either the main beam or the dipped beam.

In a lamp unit fitted with a bulb, this is easy to check: remove the bulb, hold it up to the light and see if any filaments are broken.

If the bulb is of the halogen type, it should not be touched with the fingers. Use a clean, dust-free cloth to keep fingermarks off it and avoid premature failure. Clean it with methylated spirit on a cloth if necessary.

Filament damage cannot be seen in a sealed-beam unit, and a different method is needed to check if it is faulty (see panel on right). Checks on wiring and connections must include the spring-loaded contacts, where that type of bayonet bulb holder has been used.

A sticking plunger could result in the failure of the lights in that unit, while failure of an insulating washer could mean a short circuit and a dimming of all the lights, or cause a fuse to blow.

A dim yellow light on one side is usually a faulty earth connection between the headlamp and the body of the car.

The connection is often simply a wire lead attached to the body; corrosion or dirt may cause a high resistance in the connection which results in a dim light.

Unbolt the connection, and use emery cloth to clean the terminal and washers. Use a wire brush on the bolt. Clean the surface of the metal where the hole is drilled. Reassemble and tighten firmly.

The same fault can occur on both headlamps when they are interconnected. However, when both lamps are dim, another possible cause is rust under the locating flange of one or both of the bulbs. Clean away dirt and corrosion wherever you find it.

Total failure of all the headlamps – both main and dipped beams on both sides – means a failure in the feed to the main lighting switch or between that and the dipswitch.

Where there is a fuse fitted in the headlamp circuit, check it to see if it has blown (SHEET 123). If the new fuse blows as soon as the lights are turned on, look for signs of a short circuit caused by damaged wiring (SHEET 137).

Circuits can be overloaded by adding extra driving lamps, or installing bulbs that are too powerful in the main lamps. Another possible cause of fuses or lamps blowing is a faulty voltage regulator (SHEET 102) in the charging circuit.

A tungsten headlamp is similar to a smaller lamp, but may use up to 45 watts.

A halogen headlamp uses more power, but gives more than twice the illumination.

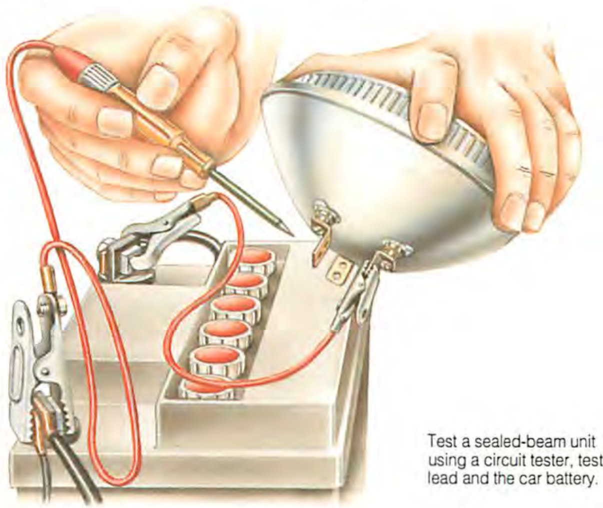
Testing a sealed-beam unit

Use a plain test lead with crocodile clips to link the earth terminal on the battery to the earth tag on the sealed beam.

Connect the crocodile-clip end of a circuit tester to the live battery terminal, and touch the probe to the other terminal or terminals on the sealed-beam unit in turn.

Use the car headlamp switch in the right positions. A sealed-beam unit with three terminals contains filaments for both main and dipped beam; if it has only two terminals, one is the earth and the other works on main beam only.

If any live terminals do not work, the lamp has failed. If they all work, check the connector block and wiring back to the snap connectors on the car's main wiring loom.



Test a sealed-beam unit using a circuit tester, test lead and the car battery.

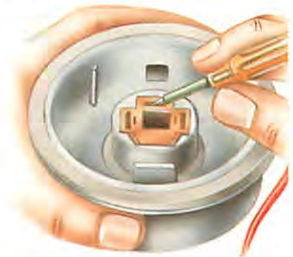
Testing the headlamp connectors

The connector block at the back of the headlamp may be covered with a large rubber protector. Prise it off complete with the two-pin or three-pin multiple plug.

Switch the headlamps on. Connect the earth lead of a circuit tester to a suitable earth, such as the car body, and with the probe check each of the connector terminals in turn.

One of them is the earth. If there is only one other terminal, it is for the main beam. If there are three terminals altogether, the connector is for both main and dipped beam. Use the car's headlamp switch to check all the terminals.

If any of the positive terminals do not work, check the wiring and the snap connectors back along the wiring loom to the bulkhead. Clean all the terminals before refitting.



Test headlamp connectors by earthing the tester and probing the terminals.

Checking headlamps and lights / 2

Checking small bulbs

If one of the smaller lamps on the car fails to work, check whether the bulb is sound; if it is, check the fuse (SHEET 123).

Never connect a plain test lead from a lamp-fitting terminal to earth. This will cause a short circuit and fuse failure. Always use a circuit tester or a voltmeter to test a fitting.

If the fault is in the bulb, usually it is possible to see a break in the filament, which may be accompanied by blackening of the glass.

There are many types of bulb in use – threaded types known as LES and MES; bayonet types with a centre contact (MCC and SCC); a bayonet type with more than one filament and more than one contact (SBC); and a wedge base or capless bulb which is used mainly for panel lighting, sidelights and number-plate illumination.

One of the later types is the festoon bulb, which is used mostly for interior lighting, but also in direction indicators and sidelights on some continental cars.

Obtain the correct replacement bulbs, as specified in the car handbook – the wrong bulb may not work properly or may not fit in the holder, and there are legal restrictions on the power of bulbs used for certain functions.

The SBC bulbs with double filaments used in brake lights have offset pins so that they can only be fitted the correct way.

If there is any doubt about a bulb, check by connecting it across the battery terminals. Use separate test leads from each terminal on the battery to the appropriate point on the base of the bulb.

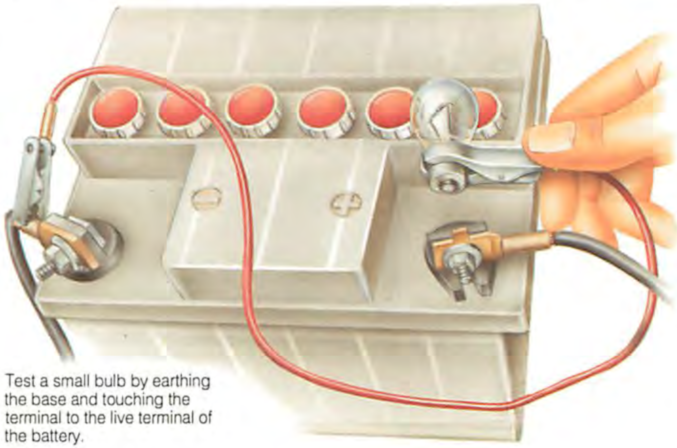
If bulb and fuse are both sound, or if the fuse blows repeatedly, look for a loose or broken connection causing a short circuit, or a poor earth connection.

Types of small bulb

Testing small bulbs

To test a small bulb, connect a test lead from the earth terminal on the battery to the bulb stem casing, and touch the bulb's pole connection to the live terminal of the battery. Test a capless bulb by attaching two leads to the exposed wires on the glass casing.

If the bulb does not light, discard and replace it. Even if the filament appears to be intact, there must be a visually undetectable fault.


Test a small bulb by earthing the base and touching the terminal to the live terminal of the battery.

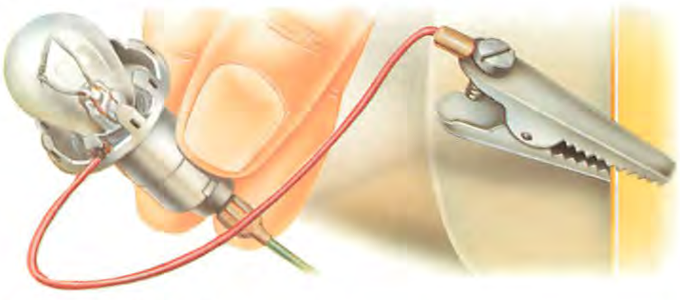
Testing bulb holders

To test a push-in removable bulb holder, remove the holder with its connected wiring from the back of the lamp fitting.

Test the bulb separately to make sure it is sound, and then refit it to the holder.

Connect a test lead from the holder to a suitable earth on the car body. Operate the switch to the light in question. If the light now works, while it did not previously, the lamp fitting in the car body is badly earthed.

The fitting may be earthed where it touches the body, or there may be a separate earth strap bolted to the body. Look for dirt, corrosion or loose connections. Clean and refit the earth connection, using a wire brush and emery paper.


Test a bulb holder by connecting a test lead from the holder to earth, and operating the switch.

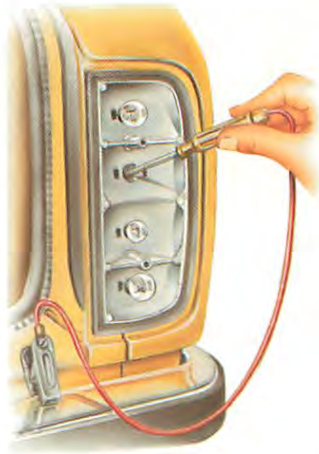
Testing multiple clusters

Many modern cars do not have separate bulb holders. All the lamps, particularly in the rear, and including sidelights, brake lights, reversing lights and turn indicators are clustered in a single fitting.

If a particular lamp in the cluster is not working, remove the lens to gain access to the bulb; remove the bulb and test it separately.

If it is good, clip the earth terminal of a circuit tester to a suitable earth on the car body and probe the internal contact spring in the lamp cluster. If the tester lights up, current is present at the connector and the problem is a poor earth on the lamp cluster.

To remove the cluster, first take out the other lamps to avoid damaging them. Undo the screws holding the cluster and withdraw it. Disconnect the lamp connections at the rear, making a note of where they go so that you can refit them in the correct position.


Test a terminal in a multiple cluster by connecting a circuit tester to earth and probing the spring contact.

Carry a 'lights' first-aid kit on the road

Because it is an offence not to have lights working properly, it is advisable to carry a small selection of bulbs in the car. Keep the bulbs in a tin packed with foam rubber to avoid damage.

Your car manual should tell you which bulbs your car uses.

Use a small tin box, such as a tobacco tin. Line the bottom with a thin piece of foam rubber, cut slots to hold bulbs in a second layer of foam rubber, and cover with a third layer. Keep halogen bulbs in a separate container and avoid touching the glass.


Keep your bulb kit well stocked.

Aligning the headlamps

Only a garage with special equipment can align headlamps accurately. However, you may need to do it temporarily yourself if you have had to remove the lamp unit or fit a new one.

You may also need to do so if you have to make a night journey with the car so heavily loaded at the back that the beams are angled upwards.

Do not try to adjust four-headlamp systems. They are too complicated for the simple method outlined here.

To do the job, load your car to the level at which you propose driving it, then drive to level ground with a plain wall (or garage doors) at one end.

Tools and equipment

SCREWDRIVER • RULE • CHALK

Marking the wall

Drive the car close to the wall, facing it at right-angles. Bounce the car to settle the suspension, then chalk a vertical line on the wall opposite the centre of the car.

Measure the distance between the headlamp centres, halve this figure and draw two more vertical lines at the same distance on each side of the centre line.

Measure the height of the lamp centres and draw a horizontal line at this height across the three vertical lines.

The outer crosses should now be exactly in front of the lamp centres. Emphasise them with chalk so they stand out clearly.

Back the car straight from the wall for 25 ft (8 m). Make sure it is pointing exactly at the centre cross. Bounce it again.

Chalk a vertical line on the wall or the garage doors, opposite the centre of the car bonnet.

Draw two outer lines equidistant from the centre line and the same distance apart as the headlamp centres.

Measure the height of the lamp centres from the ground. Draw a horizontal line on the wall at this level across the vertical lines already in position.

Adjusting the headlamps

The adjuster screws may be at the front of the lamp units, in which case remove the bezel (decorative rim) to reach them.

On single, round headlamps of the earlier pattern there is one self-tapping screw underneath the bezel. Take it out, pull the bezel forward and lift it off two lugs at the top.

On a few cars you need to remove the radiator grille – it may be held by self-tapping screws or clips. But many later cars have adjuster screws, turn-buttons or levers that can be reached from inside the bonnet. Consult your handbook if in doubt.

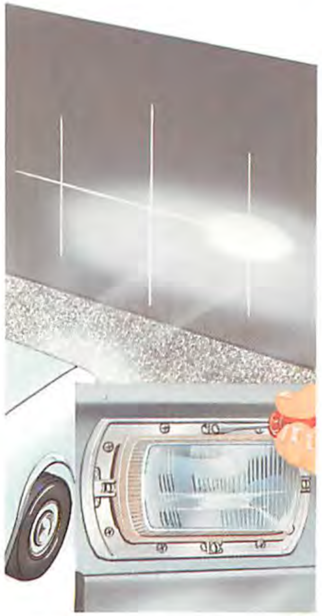
There may be one top adjuster, which moves the beam up and down, and one or two side adjusters, which move it sideways.

Switch the headlights on, set them to main beam and cover one – for example, with a coat.

Turn the side adjuster(s) on the other to centre the brightest patch of light on the vertical line on that side. Use the top adjuster to bring the patch on to the horizontal line.

When the patch is centred on the cross, turn the top adjuster to move it 2 in. (50 mm) down the wall. Repeat with the other lamp.

With one headlamp covered, turn the side adjuster(s) of the other to centre the bright spot on the vertical line.



Turn the top adjuster of the headlamp until the bright spot is centred on the horizontal line as well.

Use the top adjuster to lower the spot 2 in. (50 mm) below the cross. Cover the lamp and align the other in the same way.

Other methods of adjustment

Cars with rectangular headlamps and those imported from mainland Europe have an asymmetric dipped beam – straight ahead it is sharply cut off above a horizontal line, but it fans out to the left (for British roads).

On main beam, such lamps do not give an easily found bright spot. Adjust them on dipped beam.

There is a broad 'V' at the top of the dipped beam, where the horizontal cut-off angles up at the side. Align the point of the 'V' 2 in. (50 mm) below the cross centre.

Some cars – mainly French ones with Cibie lights – have headlamps that can be set to dip left for Britain and right for abroad. They have a two-headed arrow marking.

Change the dip from one side to the other by taking out the bulb and fitting it into a set of alternative slots in its holder (SHEET 126).

Some cars – again mostly French – have two-position levers. When switched to the down position, they lower the beams by a set amount to compensate roughly for heavy loads. Certain estate cars have as many as five positions. In some modern cars, the driver can adjust the beam aim from inside the car.

If you need to align headlamps on a car with compensating levers, set the control in the fully raised position before adjusting.

With an asymmetric dipped beam, align the point of the broad V at the top of the dipped beam so that it is 2 in. (50 mm) below the cross.

Fitting new lamps or sealed units

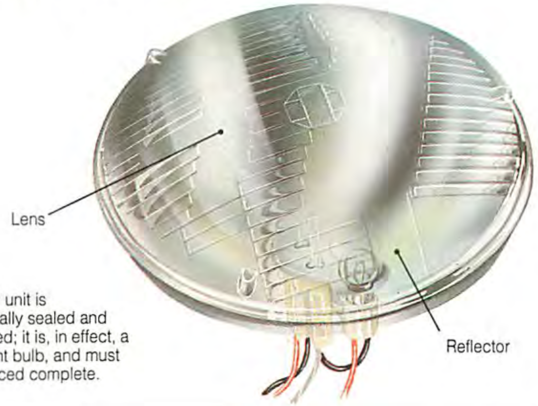
Sealed-beam headlamps are simple to change, but the way of gaining access to them varies from car to car.

To remove a traditional round bezel (outer rim), undo the single self-tapping screw at the bottom, pull the bottom of the bezel forward and lift it off two lugs at the top.

On some cars you need to remove the front grille, which may be held by self-tapping screws or clips.

Tools and equipment

SCREWDRIVERS • SPANNERS • NEW LAMP UNIT



A sealed unit is hermetically sealed and evacuated; it is, in effect, a large light bulb, and must be replaced complete.

Sealed-beam unit and other round headlamps

The sealed unit is clamped into its metal 'bucket' by a retaining ring, which may be fixed by three small screws. Make sure you do not undo the nearby adjuster screws (SHEET 127) by mistake.

Remove the ring and pull the sealed unit forward, revealing the three-pin connector on the back.

Pull off the connector to free the unit.

On some lamps the retaining ring is not screwed on, in which case only the adjuster screws at the top and side are visible. Push the lamp assembly inwards against spring pressure, then turn it anti-clockwise to line up holes with the adjuster screws and free the ring.

When you fit the replacement unit, be sure to fit it right way up, which is clear from the lettering on the front.

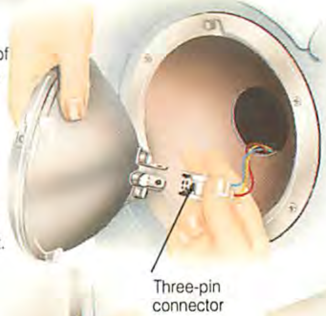
Round headlamps with bulbs are generally attached in the same way as sealed units; but here, when renewing the lens and reflector, remove the bulb, which is held by a retaining clip, not just the connector.

A sidelamp may be fitted into the back of the reflector. Turn it anti-clockwise and pull it out, together with its rubber seal.

On cars with levers for adjusting the beam to allow for heavy loads, make sure you leave the lever in the right position. In any case, set the beam as shown in SHEET 127 or have it set at a garage.

With the bezel removed, take out the screws of the sealing ring.

Remove the ring, after which the headlamp can be lifted clear.



Remove the lamp and disconnect it.

A small sidelamp may be fitted, using the back of the unit's reflector. Remove it by turning anti-clockwise.

In a non-sealed unit, remove the rubber cover and retaining clip.

Rectangular headlamps

Fixings vary from car to car, but in general they are simpler than those of round lamps and can be reached from under the bonnet.

Typically, the whole assembly is held in place by a single screw – the one which holds the upper adjuster to the front panel. Remove the screw and lever the adjuster away from its bracket with a screwdriver.

Try not to alter the adjuster setting. Pull the lamp forward and up off its bottom lugs.

Pull the three-pin connector off the bulb, then remove the rubber sealing cover and the bulb holder (twist both anti-clockwise). Take out the sidelamp; it is a bayonet fitting (twist anti-clockwise) and comes off in one piece with its cover.

Unclip the two adjusters and the lower fitting guide from the old lamp unit and fit them to the new one, then put in the bulbs, refit the connections and lower the unit into place. Engage the lugs at the bottom with the slots, then push the lamp home and refit the single screw.

When fitting a quartz halogen bulb, do not touch the glass part with your bare hands – this could cause it to fail prematurely in use.

On cars with levers for adjusting the beam to allow for heavy loads, make sure you return the lever to the right position. In any case, set the beam as shown in SHEET 127.

Remove the screw holding on the top adjuster, and prise it away from its bracket.

Lift out and disconnect the lamp unit.

Small lamps

The plastic lenses of small lamps often get broken, particularly on some cars with lamps in exposed positions. Replace a broken lens quickly; otherwise water will get in and soon you will have to replace the whole lamp. Corrosion is the main reason for failure of lamps.

On most lamps, lenses are fixed by small screws on the outside, and you replace bulbs from outside too. On others the bulbs are replaced from the back, for example inside the boot.

Here you may have to remove the whole lamp to free the lens. Usually this involves undoing several nuts or screws and pulling the lamp free, after which its lens lifts off.

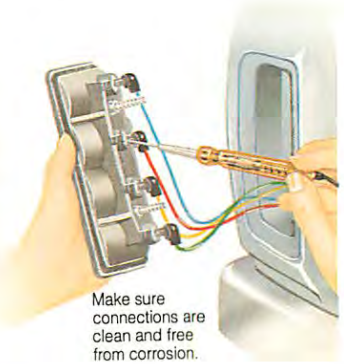
The metal backplate of a lamp with a front-fitted lens usually has studs fitting through holes in the car body, held by nuts or spring clips reached from behind. They are likely to be corroded, and you may need to use penetrating oil.

When refitting a lamp of any type make sure that the lamp itself, its mounting point and connections are clean and not corroded. Earthing is usually through the fixing screws, either via the lamp or by a separate earth lead, and if there is dirt or corrosion anywhere the lamp may not work.

Take care to fit rubber sealing gaskets properly. When replacing a combined stop/start bulb, take care to refit the connectors to the correct terminals.

Undo the screws holding the lens to change the bulbs.

The lamp backplate is held on by nuts inside the bodywork.



Make sure connections are clean and free from corrosion.

Testing and replacing a flasher unit

There are two basic types of flasher unit. One is operated by a piece of wire or a bimetallic strip which expands and contracts as it is heated by the current; the other is a relay operated by a transistorised circuit.

The first type is easy to locate if it is working at all because of the clicking sound it makes. To check whether it is faulty, use a circuit tester or test lamp in the way described below.

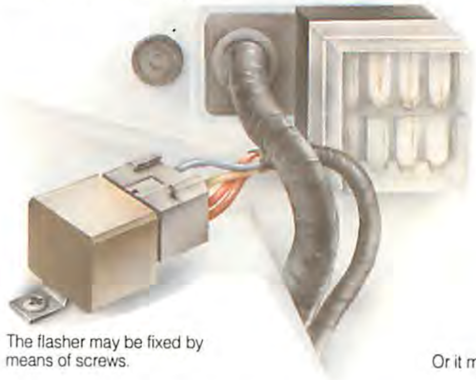
The transistorised type does not make a clicking sound, and cannot be checked with a circuit tester. It can be damaged by a short circuit.

The only way to determine if a transistorised type is faulty is by eliminating all the other components in the circuit.

Tools and equipment

CIRCUIT TESTER OR TEST LAMP • SCREWDRIVER

Flasher fittings



The flasher may be fixed by means of screws.

Or it may fit into a spring clip.

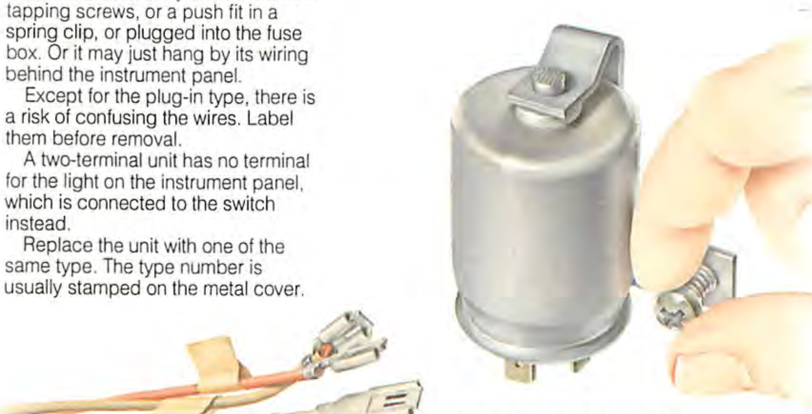
Changing the flasher unit

The flasher unit may be fixed by a small bracket held by one or two self-tapping screws, or a push fit in a spring clip, or plugged into the fuse box. Or it may just hang by its wiring behind the instrument panel.

Except for the plug-in type, there is a risk of confusing the wires. Label them before removal.

A two-terminal unit has no terminal for the light on the instrument panel, which is connected to the switch instead.

Replace the unit with one of the same type. The type number is usually stamped on the metal cover.



Label the leads when changing this type of unit, to avoid confusing them.

Tracing faults

If the indicators stop working completely, first check the fuse (SHEETS 123–124). An indication of a blown fuse is that other components in the same circuit stop working.

Your car handbook or service manual should tell you which components are in the circuit.

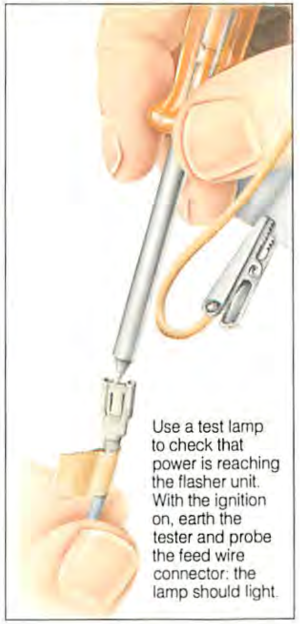
Fit a new fuse. If it blows again, look for a short circuit.

If the fuse is sound, look at the stalk and hazard-warning switches and the flasher unit. Remove the stalk-switch cover to test the unit.

The flasher unit may be near by, or behind or under the bonnet or plugged into the fuse box (SHEET 28). Check that all the connections are sound and the wires unbroken.

Testing the flasher unit

To test the conventional type of flasher unit, use a circuit tester (SHEET 48) between the terminal marked B on the unit and the earth. Turn on the ignition.



Use a test lamp to check that power is reaching the flasher unit. With the ignition on, earth the tester and probe the feed wire connector: the lamp should light.

The switch on the steering column

On some modern cars with multi-function switches on the steering column, the connections are complicated – patience is needed to check them.

The switch may have bent, broken or dirty connections which prevent it from working on one or both sides.

Connect the tester between one output terminal of the switch and the earth. With the ignition on, turn the switch to that side. The lamp should light.

If it does not, the switch is faulty. If it does, look for a wiring break between the switch and the lamps on that side.

Carry out the same checks on the other side of the switch if necessary.

A hazard-warning switch can often be pulled out for testing.

If the supply side of the unit is working, the bulb should light. If it does not, look for a break in the wiring between the unit and the fuse box.

If the tester lights, test between the terminal marked L and the earth. The lamp should light; it may flash.

If it works, the fault is in the switch or the wiring; if not, the flasher unit is faulty.

Fast or slow flashing

Flashers are required by law to flash between 60 and 120 times each minute – that is, between once and twice a second.

If the speed of flashing becomes unusually fast or slow, you have a conventional type of unit – in the transistorised type the speed is constant.

If you have a three-terminal unit, flashing that is faster than normal indicates one blown bulb, or a corroded or disconnected bulb holder.

Flashing that is slower than normal indicates that there is a partial short circuit.

With a two-terminal unit, slow flashing indicates a blown bulb; fast flashing means a partial short circuit.

Hazard warning lamps

Hazard warning lamps are fitted to all modern cars, for use only when the car is stationary and a hazard to other drivers.

Operation of the hazard warning switch bypasses the normal switch, using the flasher unit to send signals to all the trafficator lamps simultaneously.

Heavy-duty flashers

If a car is to be used for towing a caravan or other type of trailer, an electrical connecting socket must be fitted for the trailer's lights, along with the tow bar.

The existing flasher unit is not powerful enough to serve the extra lamps, and so a heavy-duty unit (or an extra remote unit) must be fitted.

The heavy-duty unit operates the car's normal flashers when driving without the trailer, with no effect on flashing speed and with no extra load on the lamps.

The unit has an extra terminal prong for the extra flasher warning lamp (also required by law) for the trailer connection.

The terminal prong may have to be bent to a 90 degree angle and the warning-lamp terminal fitted on to it before plugging in the heavy-duty flasher unit.

The additional warning lamp can be fitted permanently into the instrument panel, or mounted on a bracket where the driver can see it.

If the car flasher unit is located in an inconvenient place, such as inside the instrument panel, tow-bar centres can supply an additional remote flasher unit instead of a heavy-duty unit.

A remote unit can be placed anywhere convenient, such as in the boot. It must be wired into the existing flasher system. Follow the maker's instructions when fitting it.

A heavy-duty flasher: bend back the fourth terminal.

Checking and adjusting the horn

Cars are usually fitted with a high-frequency (HF) or windtone horn as standard equipment, normally located behind the front grille. A vibrating diaphragm makes the sound in both types.

The diaphragm is moved by an electromagnet and contact breaker, like that of an electric bell.

In an HF horn, a resonator plate is fixed to the diaphragm to amplify the sound.

In a windtone, the diaphragm makes air vibrate in a trumpet, giving a lower pitched and more musical sound. The length of the trumpet fixes the pitch.

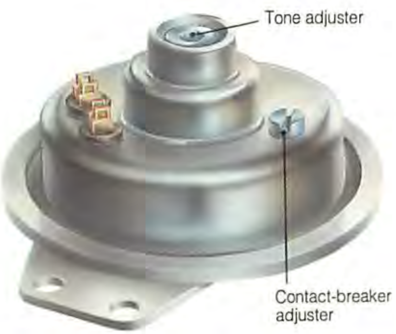
In some cars there is a pair of windtones, tuned to give two notes. They are marked 'L' for low notes and 'H' for high.

A third type of horn, the air horn, uses a compressor, and is fitted only as an accessory. It has a loud and distinctive note and is sold with fitting instructions.

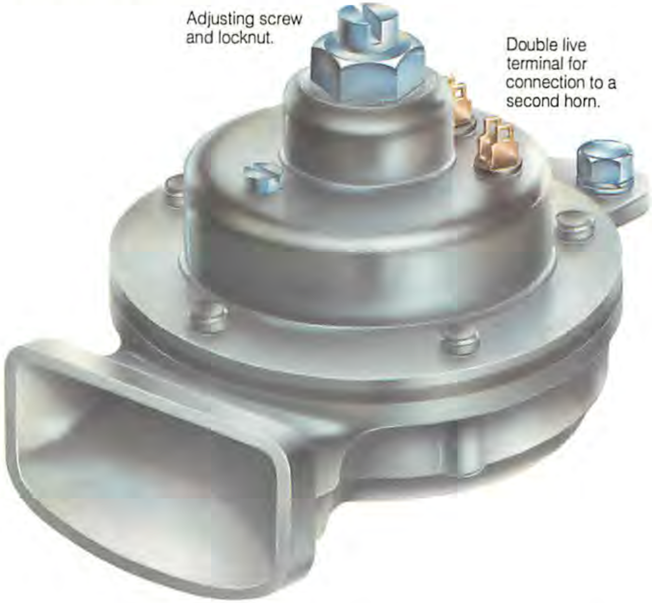
Note that an audible warning device is a legal requirement for all vehicles, and strident horns sounding fluctuating notes are allowed on emergency-service vehicles and police cars only.

Tools and equipment

SMALL SPANNER • SCREWDRIVER • TEST LEAD • CIRCUIT TESTER OR TEST LAMP • PENETRATING OIL



Adjusting a windtone horn



The pitch is governed by the trumpet shape and length, but if the horn fails to sound, the contact breaker may need adjustment.

The adjuster screw is on top of the casing in the centre. Do not turn the screw opposite the terminals, as this holds the contact-breaker assembly inside the body.

Slacken the locknut on the adjuster and turn the screw back while a helper sounds the horn. When the sound stops, turn the adjuster in a quarter turn, then tighten the locknut.

On older windtones the adjuster may be inside the horn body, reached by unscrewing the top.

Adjusting an HF horn

If you want to change the sound of the horn, there is sometimes a slotted adjuster in the centre of the resonator disc at the front.

Turn it until you get the sound you want. Do it in a deserted place to avoid causing a nuisance.

If there is a fault in the horn, adjusting the contact breaker is often the remedy. The adjuster screw is to one side on the front or back.

Ask a helper to sound the horn while you unscrew the adjuster. When the sound stops, turn the screw back a quarter turn.

Changing the horn

Disconnect the battery and the electrical connections to the horn. Unbolt it from its brackets – use a penetrating oil if the bolts are badly corroded.

Clean the bracket, bolts and connections, and also the horn itself – unless you are fitting a new one – before reassembling.

One way to change the sound of the horn is to fit a second horn with a contrasting note alongside it.

However, the current capacity of the cable feed and switches must be sufficient to carry the extra load. Generally this rules out wiring an extra-powerful or commercial-vehicle horn into the existing system. If in doubt, consult a service manual or your local dealer.

If you can fit an extra horn, mount it either beside the existing one or in the corresponding place on the other side of the car.

Use 28/·30 cable to connect the input terminals of the two horns together, and the two output terminals if there are any. If earthing is through the horn body, make sure there is a good earth connection between the mounting bolts and the mounting point.

Tracing circuit faults

If the horn fails, check whether the fuse is sound (SHEET 123). If it has blown, fit a replacement and check the horn again.

If the fuse is sound, or if a replacement fuse blows, there is a fault in the circuit or the horn itself.

Because they are low down at the front of the car, horns often get wet and dirty, and the connections may rust.

Usually the horn is earthed through its metal body and the mounting bracket. Rust here or in the connections can break electrical contact, and is the most frequent cause of horn failure.

Remove a failed horn and clean it by brushing or wiping – do not immerse it in a liquid.

While the horn is removed, check it by connecting it directly to the battery.

Place the horn with its metal casing (or a terminal if there are two) against the battery negative terminal. Clip a test lead between the other horn terminal and the other battery terminal.

If the horn works, refit it. If not, repair it if possible or replace it.

If, however, the horn does not work when refitted, look for other connections that may be loose or broken – especially the horn button or the multiple switch on the steering column.

Test that power is reaching the circuit by connecting a test lamp between various points and earth, then pressing the horn button. If there is power, the lamp will light.

If power is reaching the circuit, the fault may be a break in the wiring between the fuse box and the switch.

Find the switch input terminal by connecting a test lamp between each of the terminals and earth; the terminal that lights the lamp is the input terminal.

Connect the test lamp between the switch input terminal and earth. If there is a break in the wiring, it will not light.

If it lights, the horn-button switch may be faulty. Connect the test lamp between the output side of the switch and earth, and press the switch. If the test lamp does not light, the switch is faulty.

Often the horn-button switch forms part of a multiple-function stalk switch on the dashboard or steering column, and the complete switch must be replaced.

Repairing the horn

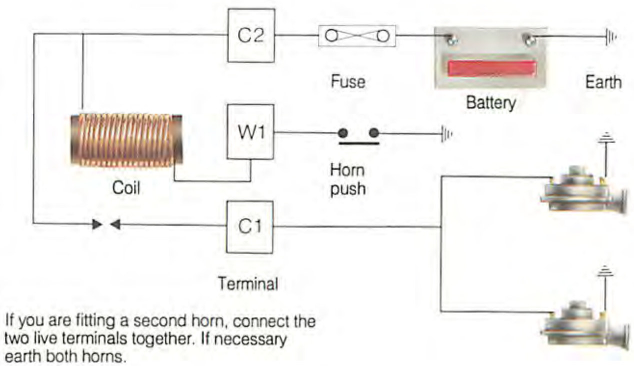
If the fault is in the horn itself, you may be able to dismantle the horn and find what is wrong. Cleaning the contact breaker might work; or there might be a broken or disconnected wire inside.

Horns that are riveted together cannot be dismantled easily, and must be replaced with new ones. Most types can be obtained from garages, accessory shops, or auto-electricians.

The horn may be operated by a stalk on the steering column or button in the centre of the steering wheel.

The stalk is wired to a multi-pin connector – see that it is clean and a good fit.

Clean and adjust the spring contacts of a steering-wheel horn button.



If you are fitting a second horn, connect the two live terminals together. If necessary earth both horns.

Checking the instruments / 1

A car usually has up to six main instruments – speedometer and tachometer (rev counter); fuel, oil-pressure and water-temperature gauges; and voltmeter or ammeter (depending on whether the car has an alternator or a dynamo). There may also be a battery-condition indicator, which is a form of voltmeter.

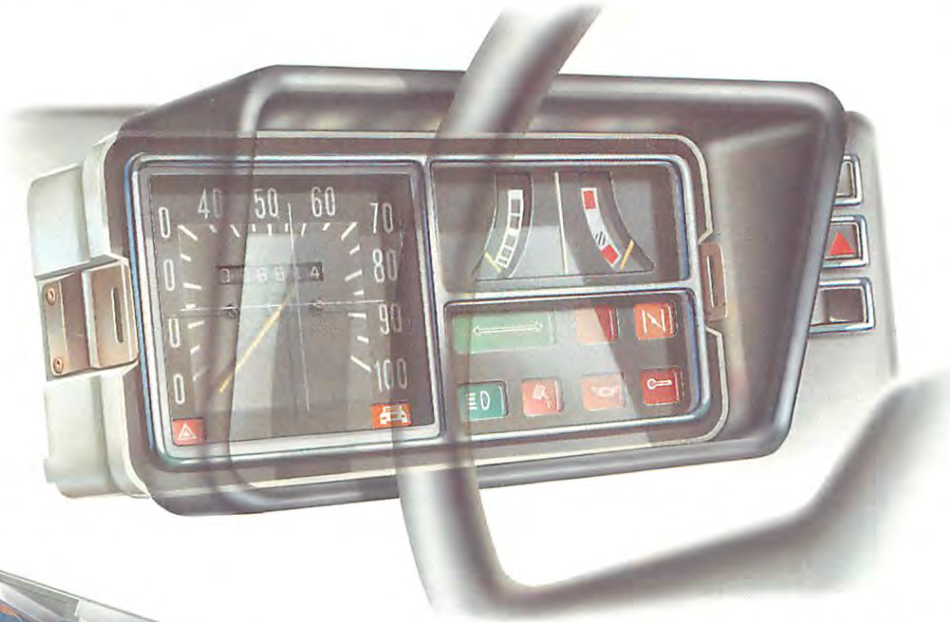
Clocks, radios and other accessories are usually beyond the scope of home repair, but you can check their connections and remove them if you have to take them for repair.

Always disconnect the battery before removing an instrument or the panel, to avoid short circuits.

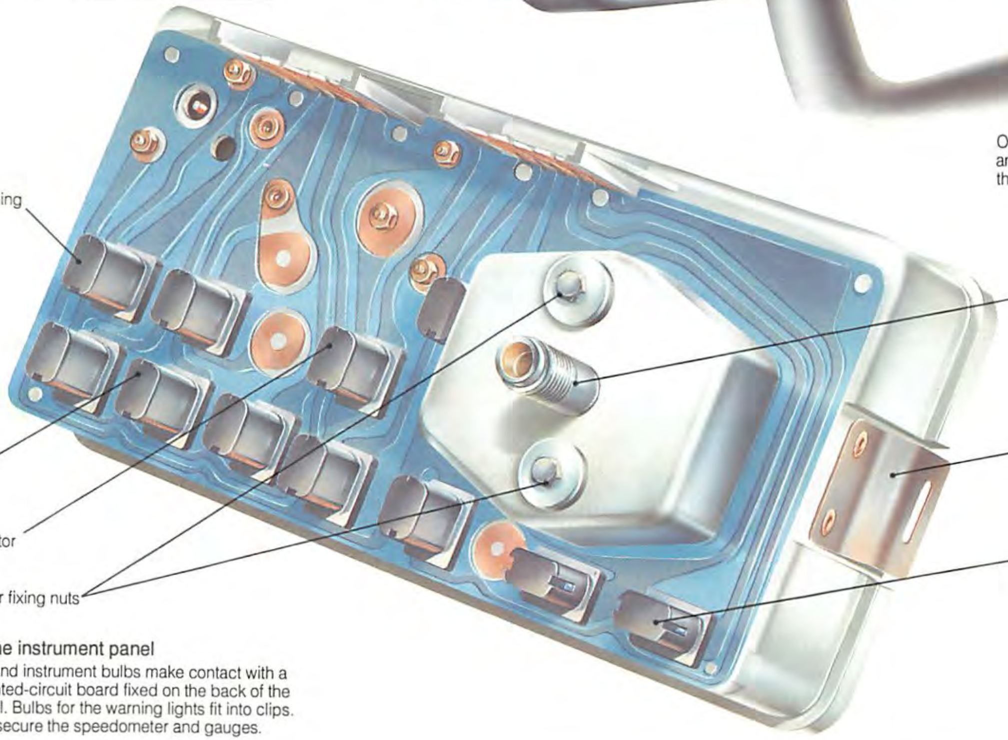
Tools and equipment

SMALL SCREWDRIVER • CROSSHEAD SCREWDRIVER • CIRCUIT TESTER OR TEST LAMP

Typical instrument panel



On many modern cars all the instruments and warning lights are on a display panel that lifts out in one piece.



The back of the instrument panel

Warning lights and instrument bulbs make contact with a replaceable printed-circuit board fixed on the back of the instrument panel. Bulbs for the warning lights fit into clips. Nuts or screws secure the speedometer and gauges.

Removing the instrument panel

An instrument can sometimes be taken out from the front after any clip-on plastic trim has been removed to reveal the screw heads round the edge.

On many cars, all the instruments and warning lights come out together on a panel with a printed-circuit board on the back.

Earlier cars may have individual round instruments, each held by a U-shaped clamp fitted round the back of the instrument and pressing its front rim against the panel.

Serrated fasteners fitted to one or two studs in the back of the instrument hold the clamp in place. Undo them by hand, feeling at the back of the panel; take care not to cut your hands on sharp objects you cannot see.

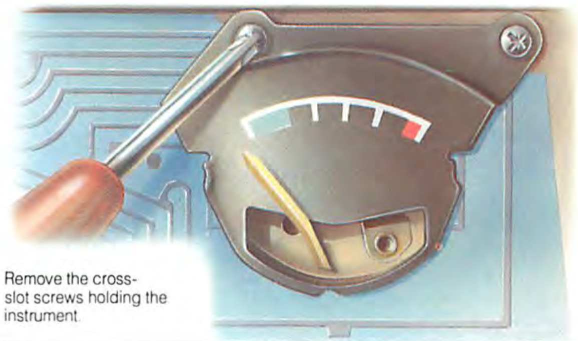
Take care also not to strain wires or damage printed circuits, and do not force anything apart or together when you replace instruments.

On some cars you have to remove a cowl or dismantle the steering-column shroud to remove the instrument panel. You may have to remove the whole dashboard panel, which can be a long and complicated job.

A service manual for your car will tell you where all the screws are, and what the sequence is for doing the work.

Gently prise the cowl off its clips with your hands or a screwdriver, then draw it out.

Use a thin screwdriver to ease the panel lip out of the clip that holds it at each side.



Remove the cross-slot screws holding the instrument

Checking the instruments / 2

Testing the speedometer

A speedometer seldom goes wrong – usually only its mechanically operated drive cable gives trouble (SHEET 139).

Any noises are generally caused by the cable, but if you are sure that a ticking noise is in fact coming from the instrument, or if it starts screeching loudly, the only cure is to fit a new unit or have it repaired.

Ask your local garage for the nearest repair specialist.

Test that the speedometer drive cable is turning normally by disconnecting it at the gearbox end (SHEET 139) and turning it by hand while a helper watches the speedometer needle.

If the speedometer fails to register although the cable is turning normally, fit a new instrument.

Sometimes the speedometer responds sluggishly or the pointer swings unsteadily. The cause is oil from the cable getting into the mechanism.

Testing the tachometer (rev counter)

Most later models of car have electronically operated tachometers. Earlier types were mechanically driven, and some worked through a voltmeter. You cannot repair any type of tachometer yourself.

If, however, the tachometer reads wrongly but the engine runs normally, the fault may be in the wiring to the instrument.

Use a battery and circuit tester (SHEET 48) to check that the wires are unbroken. Clean and tighten all the connections.

If the instrument is still faulty, remove it and take it to an auto-electrician for testing and repair or exchange.

Testing an instrument across the battery

Connect one side of a circuit tester to the battery earth terminal.

With the instrument removed from the car, touch one of its terminals to the other battery terminal. Connect the tester to the other instrument terminal. The lamp should light and the instrument needle should register. If there is no light or no movement, the instrument is faulty.

Testing the voltmeter or ammeter

One or other of these instruments is connected to the main feed to all the car electrics.

If these work therefore, the circuit is sound. If the instrument reading is obviously wrong, it is faulty. Fit a new one.

Testing the battery-condition indicator

The indicator is a voltmeter connected to the battery. If it gives an obviously wrong reading, remove it and connect it directly across the battery terminals.

It should register full battery voltage; if it does, check the wiring for a faulty connection or a break. If it still reads the same as before, the instrument itself is faulty. Replace it.

Testing fuel, oil and temperature gauges

In modern cars the fuel, oil-pressure and coolant temperature gauges all work in the same way, and the only difference between them is the marking on the dial.

Earlier cars have mechanical oil-pressure gauges connected to the engine by a thin metal tube.

Modern instruments, known as 'hot wire' instruments, respond to changes in electric voltage received from a remote transmitter – the sender unit in the fuel tank, a heat sensor in the cooling system and a pressure sensor in the engine main oil gallery.

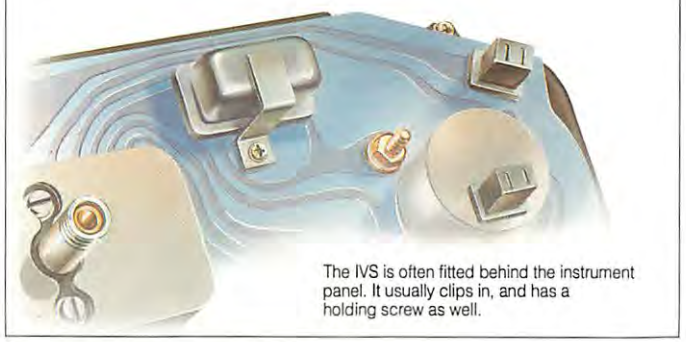
Inside the instrument, the current heats a wire which expands and moves a small needle.

Fluctuations in battery voltage would affect the hot-wire instrument reading, so the instruments are fed with voltage stabilised at 8 or 10 volts by an instrument voltage stabiliser (IVS) fitted either behind the instruments or on the bulkhead.

If all three instruments of this group read too high or too low (find the correct temperature and oil-pressure readings in your handbook) the fault must be with the IVS.

If all are registering zero, check whether current is reaching them.

Locating the instrument voltage stabiliser



The IVS is often fitted behind the instrument panel. It usually clips in, and has a holding screw as well.

Connect a small test lamp with a 12 volt, 2·2 watt panel-light bulb (not larger) between the feed terminal of the IVS and earth. Provided the ignition is on, the lamp should light.

If the current is available, check between the output terminal and earth. If there is no light, the IVS has failed and must be renewed.

If the instruments are all registering much too high, the IVS earth connection is probably faulty. Connect another earth wire between one of its fixing screws and the car body.

If only one gauge is giving trouble, the fault is in either the gauge, its sender or sensor unit, or its wiring.

To check the gauge, swap its connecting leads with those of another IVS-supplied gauge. If the gauge still does not register but the other one does, the gauge itself is faulty. Fit a new one.

Where there is only one IVS-supplied gauge, disconnect the wire at the sender or sensor unit and earth it. Switch on the ignition, and watch the gauge.

If the needle moves, switch off quickly before it reaches maximum. It may become bent if it strikes the gauge end-stop. Movement means that the gauge and wiring are sound, so the sender or sensor unit must be where the fault lies. Fit a new one (see below, or SHEET 189 for the fuel-tank sender unit).

If the needle does not move, disconnect the wire from the gauge and clip a test lead between the output terminal of the gauge and the earth, to cut out the wiring.

If the needle now moves, with the ignition on, the wiring is faulty. If it does not move, the gauge is faulty. Fit a new one.

Fitting a new sensor unit

Check the position of the unit – whether an oil-pressure sensor unit or a coolant-temperature sensor unit – in a workshop manual for the car.

Remove and replace the unit when the engine is cold. On most cars, each unit is screwed into the cylinder head or engine block.

To remove a coolant-temperature sensor, first drain off the coolant to below the level of the sensor.

Changing bulbs

On later cars, warning-light bulbs, and sometimes instrument bulbs, fit into a printed-circuit board.

The board is behind the instrument panel and comes off in one piece. It usually has to be removed from the panel for bulbs to be changed.

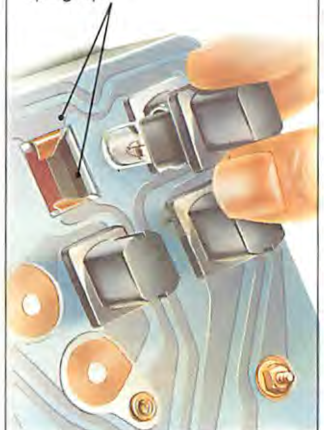
Handle the delicate circuit board with care and do not pull the mult-pin connector that links it to the main wiring.

The bulbs are usually capless (SHEET 126) and are a push-fit into a holder. The holder is a bayonet-fit into the circuit board. Turn it a little anti-clockwise to lift it out.

In some cars, capless bulbs are a push-fit directly into spring clips on the board. They pull straight out.

Earlier cars have bulbs with a screw or bayonet base fitting into a holder. The holder pulls straight out from behind its instrument for removal of the bulb.

Any light fitting can fail because of dirty, loose or bent contacts. Look closely at the contacts as well as at the bulb.



Bulbs pull straight out from spring-clip holders. Some cars have bayonet holders.

Testing electrical circuits / 1

If there is trouble without an obvious cause in any electrical component, test the circuit to find the cause.

A circuit tester (SHEET 48) is a useful and inexpensive tool for making electrical tests.

Checking a simple circuit is straightforward – the lighting circuits are among the simpler ones – but the electrical wiring in a car contains many interlinking and branching circuits, which bring complications.

All car wiring is colour-coded; unfortunately there are no national or international standards for colours. Colour codes for individual cars can be found in wiring diagrams, in the car handbook or in a service manual.

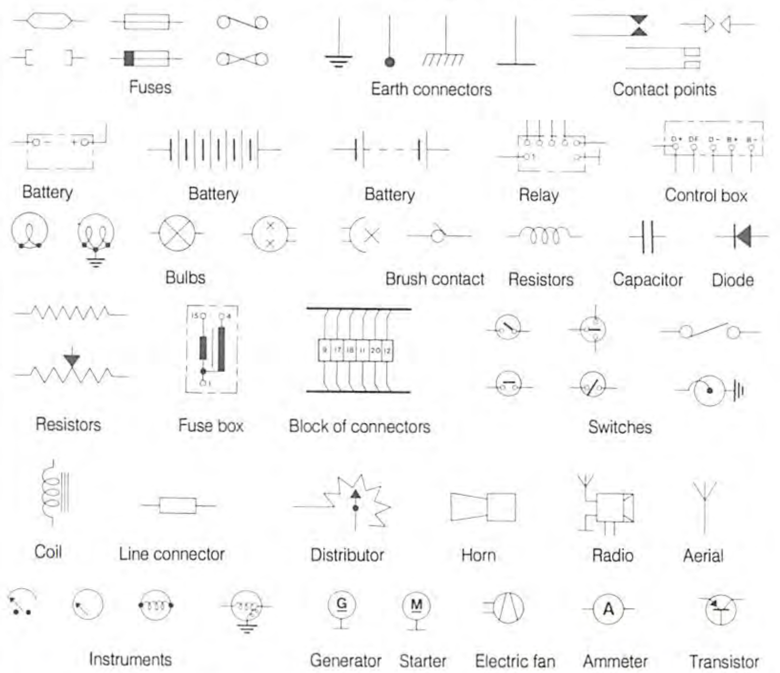
Study these diagrams so that you can find short cuts which save you having to check an entire circuit.

For example, if you know that the power for a suspect circuit comes from the ignition switch, and if other items fed from that switch are working, there can be no fault between the battery and the ignition. So you can save time by starting at the ignition switch.

Tools and equipment

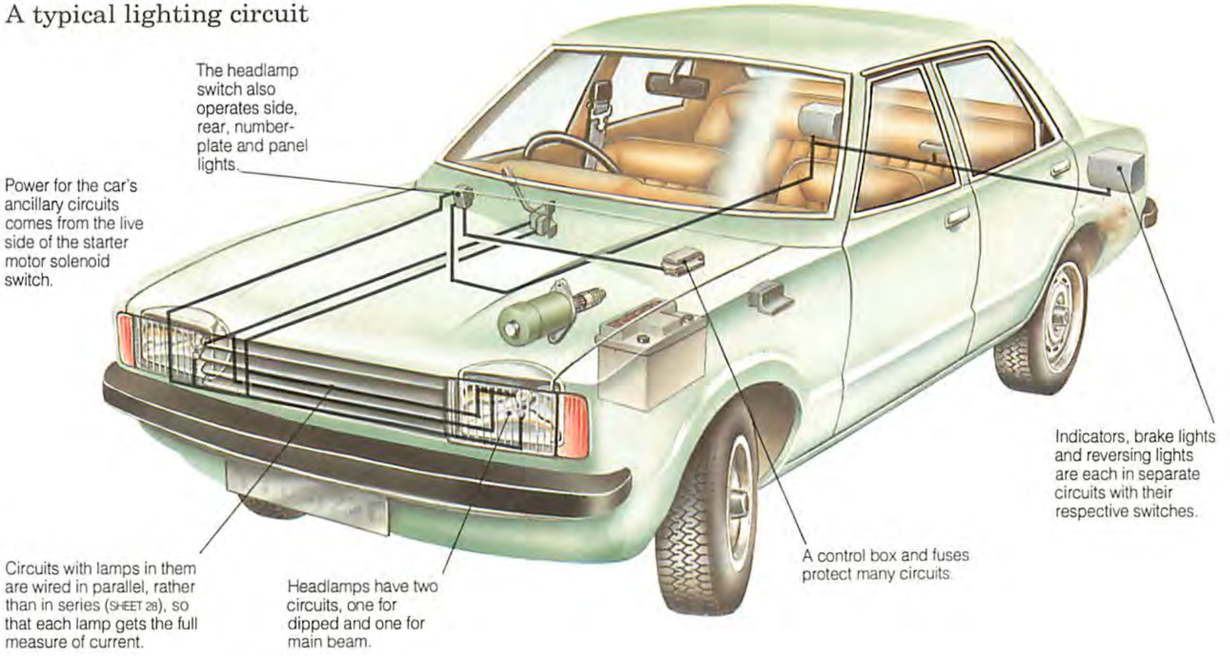
CIRCUIT TESTER • TEST LEAD: 10ft (3m) LENGTH OF WIRE WITH CROCODILE CLIPS

Some symbols used in wiring diagrams



Symbols are used to represent electrical components in wiring diagrams, and they are seldom labelled for clarity. Different symbols may also be used for the same component in different wiring diagrams. This chart shows the commonest symbols you will encounter, plus some alternatives.

A typical lighting circuit



Checks to make with a circuit tester

Connect the tester clip to the negative terminal of the battery and touch the probe to the positive one.

If the tester lamp does not light, the battery is dead (or the bulb in the tester has blown).

If it lights, try again with the clip earthed to the car body: if the lamp fails to light, the battery negative terminal is not earthed properly.

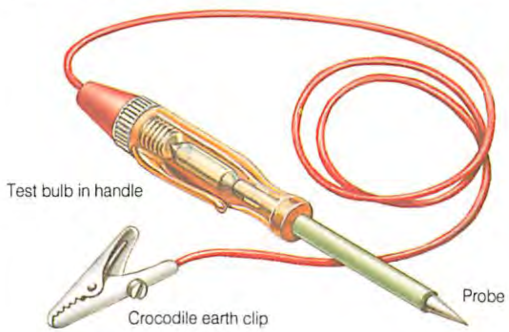
Earth the clip near the switch of the circuit being tested and touch the probe to the 'live' (battery) side of the switch. If the lamp does not light, the wiring between the battery and the switch is faulty, or a fuse has blown.

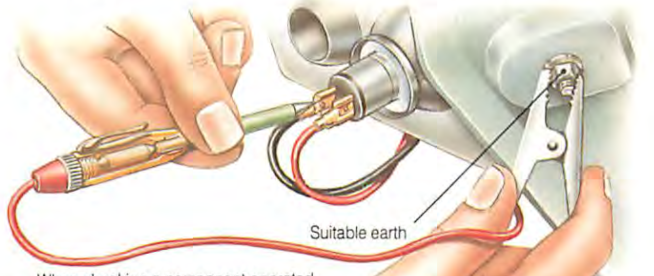
If the lamp lights, turn the switch on and probe its other side: if the lamp does not light, the switch is faulty.

If the switch works, leave it on, earth the clip near the component and probe the live side of the component. If the lamp does not light, the wiring from switch to component is faulty, or a fuse has blown.

If all of the checks so far are satisfactory, transfer the clip to the live side of the battery.

Now probe the earthed side of the component (it may be earthed by its metal body being fixed to the car body). If the lamp does not light, the component is badly earthed. If it does light, the component itself is faulty.





When checking a component operated by the ignition switch, be sure that the switch is on.

Testing electrical circuits / 2

Checking relays

If a component that is fed with electricity through a relay (SHEET 27) does not work, run a separate wire from the positive (+) terminal of the battery to the feed terminal on the component, thereby bypassing the relay and supply wiring.

If the component still does not work, it is faulty; if it works, then the supply is faulty and the fault will be in the relay or the connections to it.

Trace the supply wire back to find the relay – this is a small metal or plastic box which usually has four spade terminals and is located near the battery.

Check that a supply wire has not become detached from a terminal. Check each terminal for corrosion, especially the thin wire from one terminal which goes to earth on the car body – probably fastened under a screw or bolt near by.

Remove the screw and clean the terminal and the underside of the screw head.

The relay has one thick cable coming from the positive (+) pole of the battery. A second thick cable goes from the relay to the component. A thin wire runs from the control switch on the steering column or dashboard, while a second thin wire goes to an earthing point.

Use a circuit tester to check whether current is reaching the relay. Clip one wire to earth on an unpainted part of the car and probe the feed terminal on the relay.

If the tester lights, there is power arriving at the relay. If it does not light, check the connection at the battery.

If the tester lights, turn on the switch inside the car which controls the component and use the tester again to check for power on the thin wire leading from the switch to the relay.

If there is no power, use the lamp to check the input and output terminals on the switch. This will tell you if current is reaching the switch from the battery, and if the switch is passing the current when switched on.

If there is power at the relay, use the tester on the relay earth terminal – the second thin wire. No current flowing to earth means that the relay unit is faulty and must be replaced.

If the relay is earthing properly, leave the control switch on and use the tester on the relay terminal which feeds the component.

If there is no power, the fault is in the relay again – probably the contacts are burned or stuck in the open position.

Burned contacts can also fuse together, so that they stick in the closed position, so the component does not switch off. In either case, replace the relay.

Some relays have small pin connectors and plug into an enclosed socket.

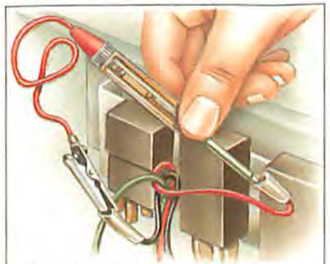
Remove the suspect relay and replace it with another of the same type. If the component works, the original relay is faulty.

If the component still does not work, check the terminals in the base of the relay connector block with the circuit tester probe. For the tester bulb to light there must be a good contact at the test points. That is the reason for the sharp probe, and for the sharp teeth on the clip.

The probe is useful for poking under the plastic covers of spade terminals and snap connectors without the need to disconnect them.

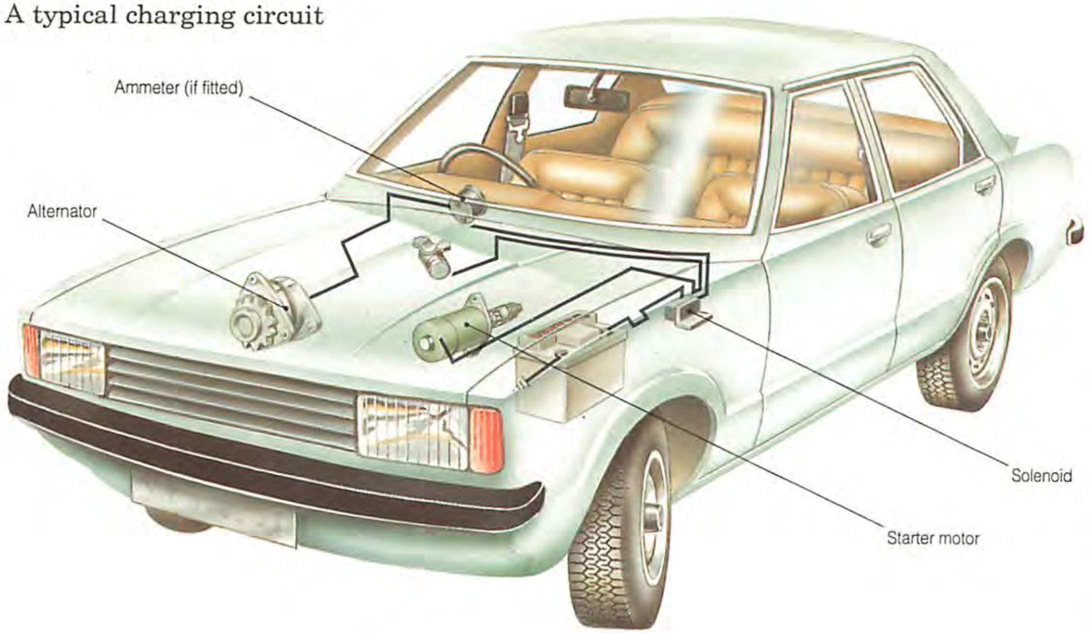
Sometimes it is convenient to use the probe to prick through the insulation of a wire if other access is difficult.

Apart from the circuit tester, another useful aid is a test lead – a 10 ft (3 m) length of wire with a crocodile clip at each end. This allows you to make direct connections from the battery to components which are some distance away, for example the rear lights, rear-mounted electric fuel pump and fuel-tank sender units.



Checking relay connections with a circuit tester

A typical charging circuit



The battery is earthed to the body by a short, heavy cable or by a braided wire strap.

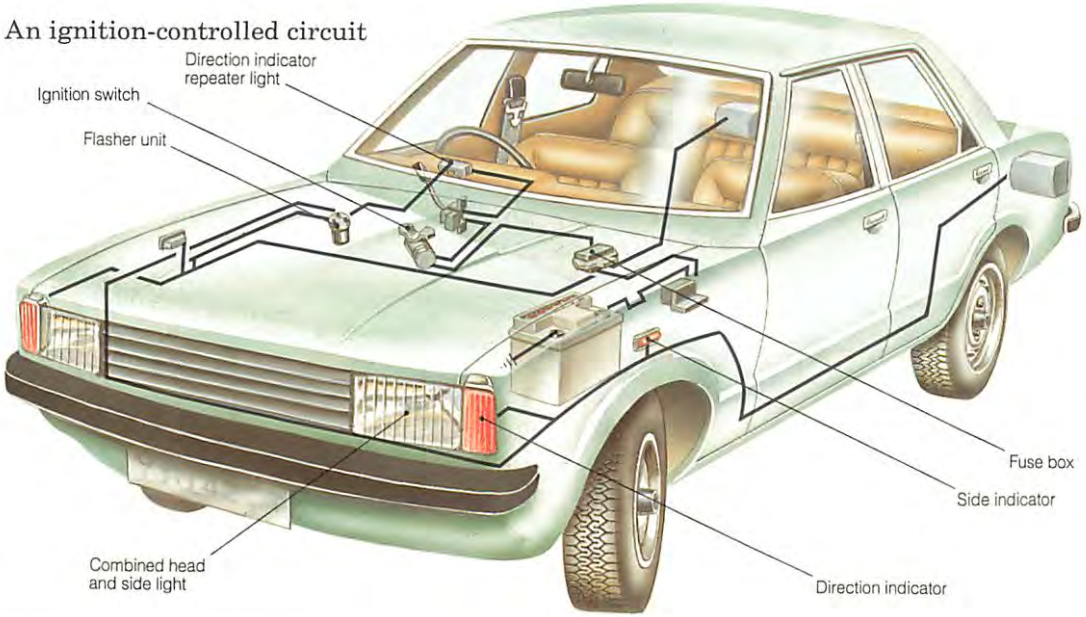
On most cars the negative battery terminal is earthed. From the positive terminal another heavy cable goes to the starter solenoid switch, which feeds current to the starter along a third heavy cable.

A wire leads from the live side of the solenoid (not through the switch itself) to the ignition switch.

Another wire leads from the live side of the solenoid to the ammeter (if fitted) on the instrument panel. Thus, the ammeter is always live, and always shows whether any power is being discharged. This circuit is then completed to the generator, so that current in the opposite direction causes the ammeter to show how much the battery is being charged.

From a point after the ammeter, another wire (not shown) goes to the lighting switches and to the fuse box, where it supplies power for circuits not controlled by the ignition switch.

An ignition-controlled circuit



If the car circuits could be accidentally left 'live' when the car is not running, the battery would be discharged unnecessarily. For this reason, most circuits are operated through the ignition switch. (The exceptions are those which might be needed for safety – chiefly headlamps, sidelights and emergency flashers.)

From the ignition switch a plain wire runs to the fuse box, where it is connected to the fuses of all those circuits which come on with the ignition.

From each fuse a plain wire runs to each of the circuits, picking up a trace colour after its first connection.

For example, the wire to the indicator switch might be plain green, and from the switch to a bulb it might be green/purple.

The diagram shows only a simple circuit; the earth connections and the power supply to the ignition switch are left out for clarity.

Servicing the windscreen-wiper mechanism

The windscreen-wiper mechanism needs little maintenance. At service intervals drip a little oil down the wiper spindles from outside. If they stick, the motor could burn out.

Most problems arise in the linkage, of which there are two types – a rack and wheelbox and a pushrod.

The rack-and-wheelbox linkage has a long, flexible rack – a rod with a screw thread – encased in a tube and pulled back and forth by the gear and connecting rod of the motor.

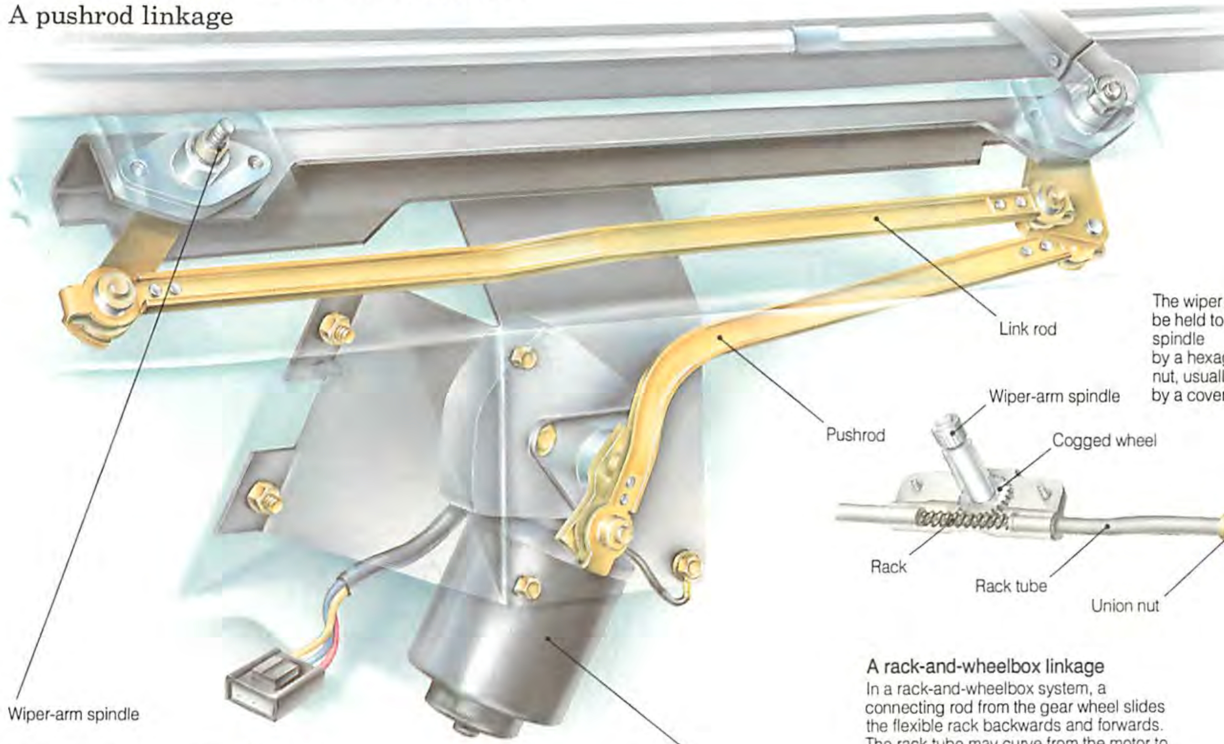
Wheelboxes (usually two) mounted on the tube each have a gear wheel that meshes with a stretch of exposed thread on the rack. The wheels convert the rack movement to the swinging action of the wiper arms mounted on the wheel spindles.

The other type of linkage has a pushrod pivoted to the gear crank. The pushrod pushes and pulls a rigid horizontal link rod (or two parallel rods) with a wiper-arm spindle at each end.

Tools and equipment

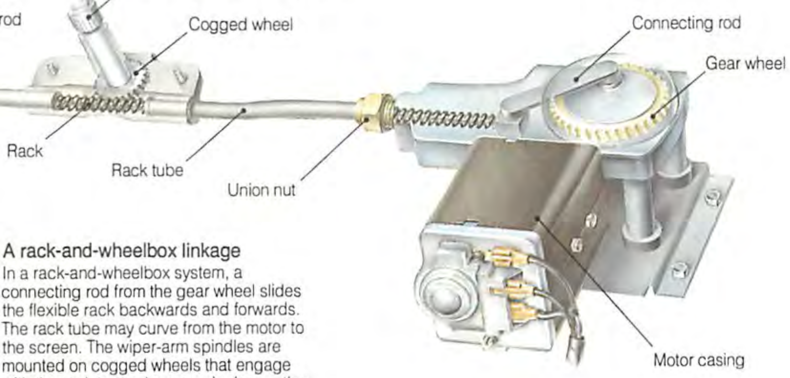
SCREWDRIVERS • SPANNERS • SPRING BALANCE • CIRCUIT TESTER • OIL • HIGH-MELTING-POINT GREASE • FINE FILE • METHYLATED SPIRIT • LINT-FREE CLOTH • FINE EMERY PAPER • 5 AMP FUSE WIRE • SOLDERING IRON

A pushrod linkage



In a pushrod wiper system, a gear turns a crank that operates the pushrod. Pivoted to it is a link rod that carries the wiper arms.

The wiper arm may be held to its spindle by a hexagonal nut, usually hidden by a cover.



A rack-and-wheelbox linkage

In a rack-and-wheelbox system, a connecting rod from the gear wheel slides the flexible rack backwards and forwards. The rack tube may curve from the motor to the screen. The wiper-arm spindles are mounted on cogged wheels that engage with the rack to produce a swinging motion.

A spring-clip wiper arm

Some arms are held by a spring clip. To remove, lever the clip up and out.

Servicing the wiper linkage

A wheelbox mechanism can become prone to sticking, or the wheels can wear and allow excessive play so that the wiper arms move too far.

To check whether a wheelbox is sticking, lift the wiper arms off the screen and remove the motor gearbox cover. Unscrew the nut locking the tube to the gearbox, and unfasten the rack from the connecting rod by removing a circlip and washer. Lift the rack clear.

Hook a spring balance to the end of the rack, hold the tube and pull the rack until the wiper arms move. Measure the weight of the pull.

The force needed should not be more than 6 lb (2·7 kg). If more force is needed, the wheelbox and rack may need lubrication, or the tube may be curved too sharply away from the motor. No bend should have a radius smaller than 9 in. (230 mm). You can shape the bend by hand.

To lubricate the rack, withdraw it from the tube and grease it with high-melting-point grease. When rethreading, reposition it so that the unworn threads are against the wheelbox gear wheels.

Lubricate the wheelboxes with the rack removed. Take off the wiper arms and the nuts securing each spindle, noting how washers and spacers under the nuts are arranged.

Undo the two screws holding each wheelbox together and pull out the tube from each side. Pack the boxes with high-melting-point grease and reassemble.

If the wheel teeth are worn, turn the wheels through a half circle so that unworn teeth mesh with the rack.

On a pushrod linkage, the wipers lose efficiency because of wear or damage to the linkage pivots. Replace any faulty parts.

The rack tube is secured to the motor by a nut. Loosen it to free the tube.

To remove the rack, unclip it from the connecting rod and lift it upwards to free the U-shaped retainer from its slot.

Remove the two screws holding the wheelbox together. Pack the box with high-melting-point grease.

Electrical faults

If the wiper motor remains dead or blows the fuse repeatedly, look over the wiring for poor or broken connections.

If you find none, use a circuit tester to check if current is reaching the motor. Clip the lead of the lamp to earth and hold the probe to the live terminal of the motor. If there is current, the tester will light.

If it does not, check if current is reaching the switch. If it is, search for a wiring fault between the switch and motor or within the switch.

If necessary, continue checking back to the ignition switch and fuse box. If the motor is receiving current but does not work, take it out and check it (SHEET 136).

Servicing a windscreen wiper motor

Removing the wiper motor

Disconnect the battery. Remove the electrical connections from the motor, preferably labelling them so that you can refit them to the right terminals.

With a rack-and-wheelbox system, disconnect the rack from the motor gearbox and unbolt the motor.

With a pushrod system, it is usual to take out the motor and linkage in one piece. Often they are mounted together on a plate that can be unbolted and removed.

On some cars you unbolt the pushrod at the motor spindle, remove the bolts that hold the motor and lift it out on its own.

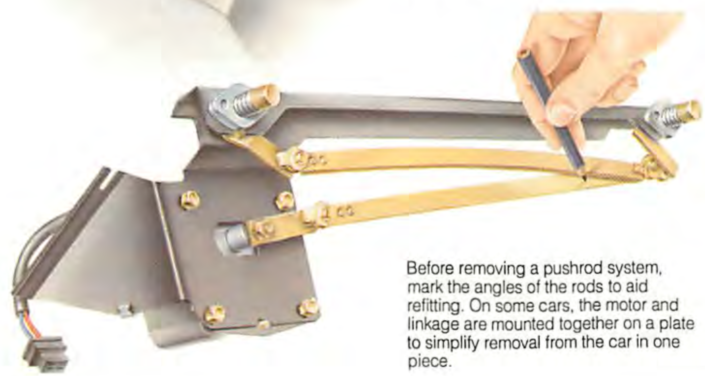
Before removing the motor and linkage, free the wiper spindles by removing the arms and unscrewing the spindle nuts. Note the position of any spacers and washers.

Mark the linkage to show how its parts are angled when the blades are in the park position.

If the motor failed when the wipers were not parked, mark the positions of the blades on the windscreen as well as the angles on the linkage, as a guide when refitting.

With the mechanism removed, disconnect the linkage from the motor.

On pushrod systems, you can usually lift out the motor and linkage together. Disconnect the wiper arms and unplug the electrical connections, then remove the bolts holding the motor to the bulkhead.



Before removing a pushrod system, mark the angles of the rods to aid refitting. On some cars, the motor and linkage are mounted together on a plate to simplify removal from the car in one piece.

Servicing the motor

Two types of Lucas wiper motor are in general use on English cars. Other motors are very similar, but you may not be able to get new brushes or other parts for them. If you cannot get parts, buy and fit a new motor.

The earlier (wound-field) Lucas motor is square. Take out the long bolts securing the endplate.

Pull the fibre lock plate free from the brushes, open the jaws of the spring-loaded brush holder and slide it off the commutator.

Look at the brushes – if they are worn down to about ⅛ in. (3 mm), fit new ones, making sure these slide freely. Use a fine file to remove any roughness.

Take out the armature and main gear wheel, and clean them with methylated spirit on a lint-free cloth.

If the commutator is slightly burned or corroded, clean it with fine emery cloth; if however, it is badly pitted or scored, fit a new or exchange motor.

If the gear teeth are worn, fit a new gear spindle.

Reassemble the motor, packing the gearbox with plenty of high-melting-point grease.

The casing of the later (permanent-magnet) Lucas motor is round. Before you unbolt the casing mark its position on the gearbox. If you replace it the wrong way round, the motor will turn backwards.

There may be more than two brushes if the motor has more than one speed. Inspect the brushes, and if they are worn to ⅛ in. (3 mm), fit new brushes and holders.

Remove and clean the armature and main gear wheel with methylated spirit on a lint-free cloth. The gear has a dished washer under it; refit it the right way round. Clean the commutator with fine emery cloth.

If you have to fit a new gear, buy a replacement with the same sweep angle, which is marked on the wheel – 110 degrees, for example.

When you reassemble the motor, the brushes have to be pressed back into their holders while you fit the commutator.

Tie them back with 4 in. (100 mm) lengths of 5 amp fuse wire. Twist the ends and let them stick out.

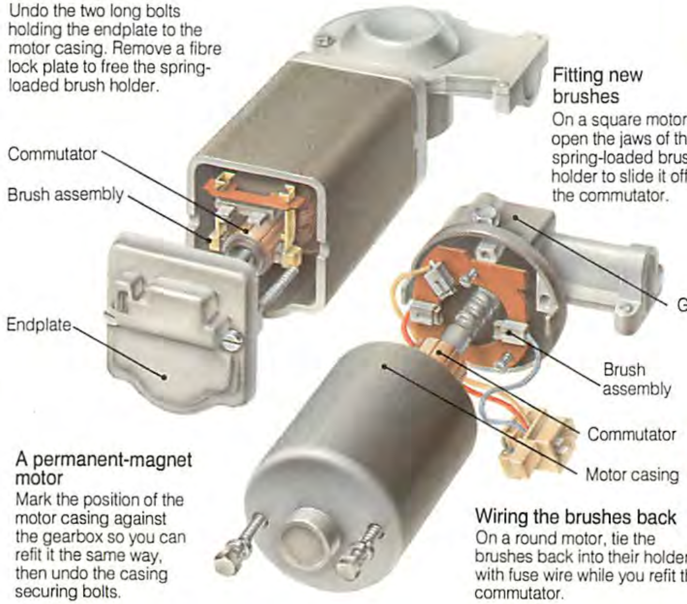
Push in the commutator until it just enters the space between the brushes, then slip off the wires and slide the commutator home.

On some makes of motor, brushes are soldered into place. Solder one brush at a time.

Cut off the old lead, carefully noting its route, and match it with the new one. Melt a little solder on a new lead and the contact point, then solder on the lead.

Do not let solder run along the lead and stiffen it.

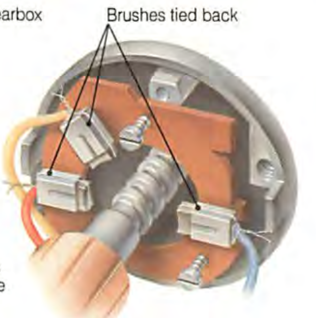
Some motors have exterior screws for adjusting armature end float (that is, lengthwise free play), which should be only fractional. Other motors have springs to take up end float.



A wound-field motor
Undo the two long bolts holding the endplate to the motor casing. Remove a fibre lock plate to free the spring-loaded brush holder.

A permanent-magnet motor
Mark the position of the motor casing against the gearbox so you can refit it the same way, then undo the casing securing bolts.

Fitting new brushes
On a square motor, open the jaws of the spring-loaded brush holder to slide it off the commutator.



Wiring the brushes back
On a round motor, tie the brushes back into their holders with fuse wire while you refit the commutator.

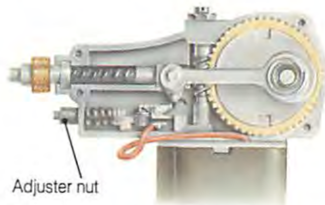
Refitting the motor

When reassembling a pushrod linkage, use the guide marks you made to position rods at the correct angles.

Once the motor is back in place, test the wipers with the blades lifted off the screen. Then wet the screen with the washer and test with the blades in the wiping position.

If necessary, take the arms off their spindles and realign them. Some motors have an adjuster nut for adjusting the parking position. On the earlier Lucas-type motors, adjustment is made by rotating the domed switch cover above the gearbox.

Adjusting the parking position



Some wiper motors have a knurled nut for adjusting the parking position.

On certain wiper motors, turning the domed switch cover above the gearbox adjusts the parking position.

Working on the wiring system / 1

The electrical wiring in a car is a system of colour-coded wires called the loom (SHEET 28). Where several wires run side by side they are bound together with insulating tape or plastic sleeving.

Several modern cars have separate thin wires embedded in flat plastic strips. These strips are very compact, and are used mainly for accessories and relay controls that require little power.

Wires and bundles of wires are clipped to the bodywork to keep them out of the way. Where they run through a hole, the sharp edges are lined with a rubber grommet.

Sometimes the loom is divided into sections joined by multi-pin plugs and sockets, so that it can be removed and refitted section by section.

Joins in individual wires are usually made with crimp connectors. The colour on the sleeve of a connector denotes the size of wire it will take.

The bared ends of each wire are pushed into opposite ends of the metal-lined plastic sleeve, and squeezed with crimping pliers. There are multiple sleeves or other special connectors where a wire branches off.

Wires are usually connected to components by plastic-covered terminals which push on to a blade on the unit called a spade terminal.

Nearly all types of terminals should be fitted to the wire with crimping pliers (SHEET 47).

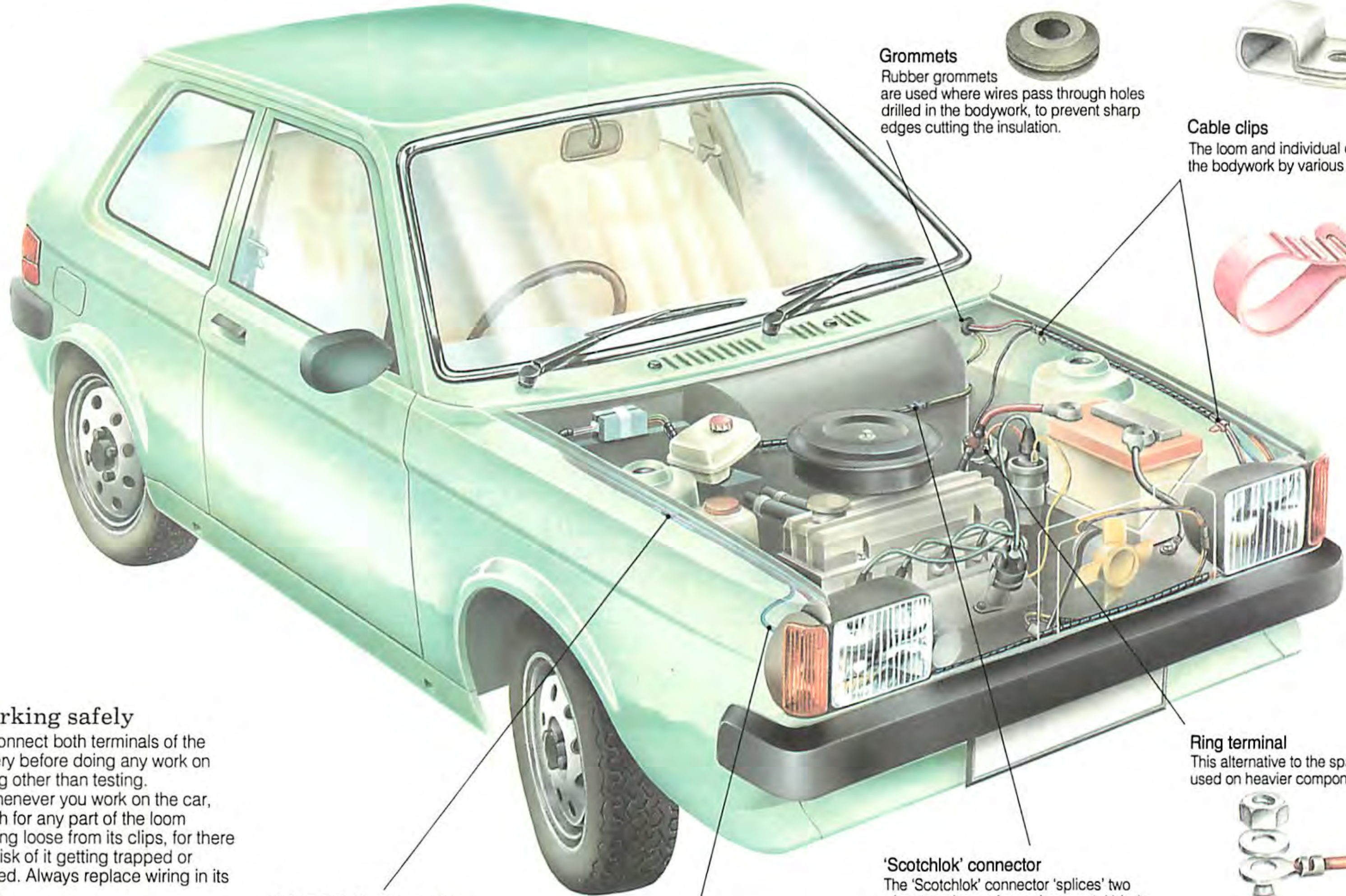
There are a few types such as the 'Scotchlok' which are secured by clips.

For additional security, you can add solder to the wire.

Use a 25-65 watt iron for most work, and a 150–250 watt one for large cables, or an 8 oz (225 g) gas-heated iron.

Tools and equipment

SOLDERING IRONS • SOLDER • INSULATING TAPE • RAZOR BLADE OR CRAFT KNIFE • WIRE STRIPPER • CRIMPING PLIERS • CIRCUIT TESTER OR TEST LAMP • SCREWDRIVER



Grommets
Rubber grommets are used where wires pass through holes drilled in the bodywork, to prevent sharp edges cutting the insulation.

Cable clips
The loom and individual cables are held to the bodywork by various types of clips.

Ring terminal
This alternative to the spade terminal is used on heavier components.

Working safely

Disconnect both terminals of the battery before doing any work on wiring other than testing.

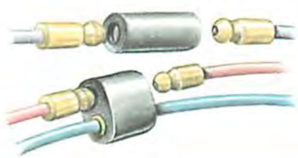
Whenever you work on the car, watch for any part of the loom coming loose from its clips, for there is a risk of it getting trapped or burned. Always replace wiring in its clips.

Also look for grommets that have come out of their holes. The sharp edge of the hole will soon chafe through wire insulation and cause a short circuit.

Whenever you pull a connection apart, look for corrosion which might cause bad contact.

If necessary, clean contacting metal surfaces with a fine file or emery cloth. But it is better to replace the terminal once corrosion has destroyed the surface coating.

Crimp or bullet connector
The crimp connector is used for joining single wires to each other. It may be a single or double connector, or a multi-connector carrying several wires.



Spade terminal
The spade terminal is the usual way of fixing wires to components.

'Scotchlok' connector
The 'Scotchlok' connector 'splices' two wires together, using a sharp metal blade which pierces the insulation. This is clamped using a pair of pliers, and covered with a plastic clip.

Working on the wiring system / 2

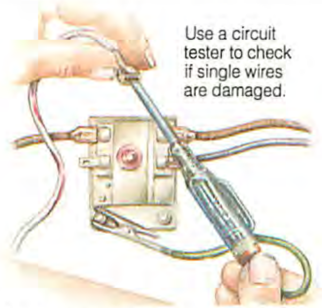
Making repairs to the loom

The wiring loom itself seldom goes wrong, but after other repairs have been made, a cable may be trapped and its insulation cut through, causing a short circuit.

If this does not blow a fuse the wiring overheats and melts insulation, perhaps starting a fire. A similar result can come from fitting accessories incorrectly, or if power demand is too high for the size of the wire being used.

After many years, insulation may become hard and brittle, particularly where it is exposed to heat, as in the engine bay. Sections, or all of the loom, may need replacing.

The damage caused by overheated wires is easy to find; but if only a single wire has overheated and melted at some point, you may have to use a circuit tester (SHEET 48) to find the break.


Use a circuit tester to check if single wires are damaged.

If the damage is in an open run of wiring, you may be able to mend separate wires without taking out a section of the loom.

If it is in any part of the covered sections, you need to remove at least part of the wiring loom.

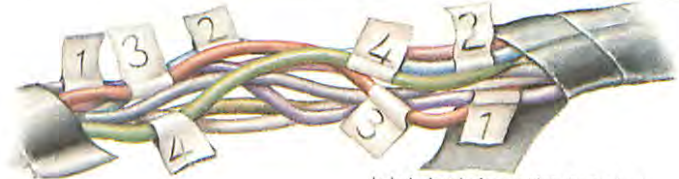
Before you disconnect anything, make absolutely sure you know how to put it back. Number both sides of each connection with labels made of masking tape.

If necessary, make drawings of cable routes and how clips fit.

Use a craft knife or razor blade to cut away the wrapping from the damaged section. Take care not to cut into the plastic cable insulation.

Even if only one wire has overheated, inspect all the others to make sure their insulation is not damaged.

Before cutting out damaged wires, make sure that the colour coding is the same at each end of the damaged section of each wire, and that it is not so discoloured that it is unrecognisable.



Label wires before cutting them when working on a section of the loom.

If there is any chance of confusion, label both ends.

Cut out all the damaged wires with wire cutters. Spread out the cuts across a bundle of several wires: if many joins are opposite each other their bulk may make it difficult to fit the loom into the car.

If possible, replace wiring with new wire of the same colour. The new wire must be the right size: there are five sizes, depending on current rating.

Repairs in wrapped sections of the loom are the only places where you may join wires by twisting them together and soldering the joint – mainly because there may not be room for any other method.

If possible, use an insulated in-line crimp connector.

Test each mended wire with a circuit tester and battery, connected to the nearest connectors either side of the mend.

Re-wrap the exposed section of the loom with self-adhesive or 'clingfilm' PVC insulating tape. Put some layers between the exposed section and adjoining wires – not merely a cover over the top – then fit the loom back into the car.

Reconnect all terminals and clips, then test all the electrical components involved.

If an outlying part of the loom with few wires has been damaged, it may be simpler to replace each wire to the end of the loom instead of inserting a section. If so, use the old, damaged wire as a guide to the length of the new. In an open area of wiring, join old and new with snap connectors.

Fitting new wiring

When you fit accessories you must use large enough cables. As far as you can, route the new wiring along the course of the existing loom, using the same clips and grommets.

Push a screwdriver blade through the grommet carefully to enlarge it for the new cables, taking care not to damage insulation on existing wires.

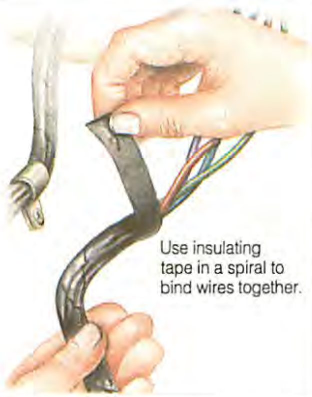
If you pass a cable through a new hole, fit the hole with a grommet.

To pass wires up door pillars or behind trim, tape them to a piece of fairly stiff wire, poke it carefully behind the trim or up the pillar, and pull it through at the far end, bringing the wire with it.

If you have to lead a new wire along a difficult route – to the rear of the car, for example – you could take the opportunity to lead a spare wire at the same time, for any accessory you might want to fit later.

Cover the end of a spare wire with insulating tape to prevent an electrical short circuit.


Fit a rubber grommet when passing wires through a new hole in the bodywork.


Use insulating tape in a spiral to bind wires together.

Identifying cable sizes

Cable sizes are given by two numbers. The first one is the number of strands. The second (which is always the same in car wiring) is the diameter of each strand in millimetres.

For main feed cables from battery to ammeter and the alternator circuit, use 65/·30 cable.

For dynamo and control-box wiring, use 44/·30 cable.

For headlights, horn and heated rear-screen wiring, use 28/·30 cable.

For everything else (other than large auxiliary lights and horns), use 14/·30 cable.

On some cars a few very lightly loaded circuits such as panel lights, have 9/·30 cable.


14/·30 cable


65/·30 cable


High-tension (HT) lead


The starter cable is a very heavy one, for doing the battery's hardest work.

Twisting wires together and fitting spade terminals

To connect two wires, use a wire stripper to remove about $\frac{3}{4}$ in. (19 mm) of insulation from each wire.

Twist the bare ends together, then use pliers to press the twisted section into a compact shape.

Solder the wires together so that they cannot be pulled apart, using only a little solder to avoid making the joint bulky.

Wind insulating tape in a spiral over the joint.

To fit a spade terminal, slip the insulating cover over the wire and push it up the wire, out of the way. Use a wire stripper to remove about $\frac{1}{8}$ in. (3 mm) of insulation from the end of the wire.

Lay the bare strands in the inner section of the connector. Use crimping pliers to tighten the two small tongues firmly around the insulated part of the wire.

On the other side of the connector, push the wire strands back and down flat. Hold the connector blade upwards to avoid solder running into the spade part.

Solder the wire to the connector with just enough solder to secure all the strands. Let the connector cool before sliding the cover back.


Tag connectors are closed round the bare wire with pliers, then soldered.


Twist bare ends together and solder them. Cover the joint with insulating tape.


A spade terminal is easy to disconnect and reconnect.

Fitting a bullet connector

Use a wire stripper to remove about $\frac{3}{8}$ in. (10 mm) of insulation from the end of the wire.

Push the wire into the connector so that the strands just protrude from the round end.

Grip the cable, connector uppermost, in a vice or self-locking pliers, so that the connector rests on top of the vice and cannot slide down the wire when soldering.

Apply solder on the top of the connector, and let it melt and run down inside.

Trim off the protruding strands with wire cutters.


Remove insulation with a wire stripper.


Inside a bullet connector.

Fitting a new speedometer cable

Speedometer failure is likely to be caused by a fault in the cable that runs from the gearbox to the back of the speedometer gauge.

If the gauge needle does not move at all, the inner cable or drive may be broken; or the cable's square ends may have become rounded with wear and fail to engage in the sockets.

The fixings at the ends can work loose or be wrongly fitted.

If the gauge needle swings or moves sluggishly, gearbox oil may have seeped up the cable and got into the speedometer itself. In that case, you must replace the speedometer.

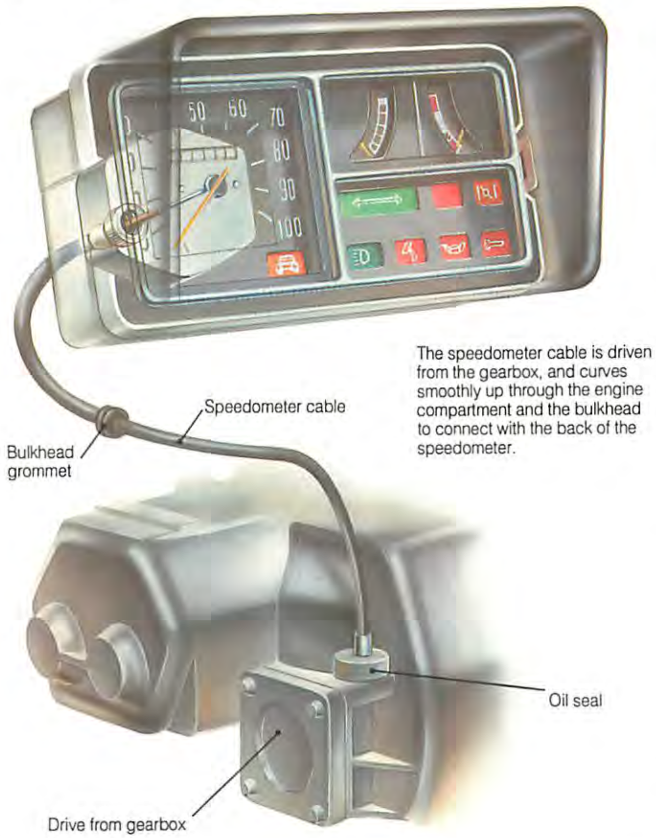
If the needle twitches rapidly, see whether the cable is crushed, kinked or too sharply bent. Intermittent twitches can be caused by loose connections or by worn and slipping ends on the cable.

A tapping noise is a sign of a damaged drive or lack of lubrication.

To examine the cable for any of these faults, support the car securely on axle stands or ramps.

Tools and equipment

JACK • AXLE STANDS • LARGE GRIPS • CIRCLIP PLIERS • SCREWDRIVER • GREASE • LIGHT OIL • PETROL



The speedometer cable is driven from the gearbox, and curves smoothly up through the engine compartment and the bulkhead to connect with the back of the speedometer.

Cable connections to the gearbox

Speedometer cable connections to the gearbox fall mainly into three types.

The knurled thimble-nut connection is threaded inside, and screws on to the gearbox speedometer outlet – which is also threaded – up to the shoulder.

The circlip connection fits over the cable and into a recess in the gearbox output sleeve, securing both.

The fork connection – an older type – is simply a shaped fork that holds the cable end in the gearbox by means of spring pressure. It is secured by a screw.

Sleeve connection

A knurled thimble nut screws on to a threaded outlet.

Circlip connection

A circlip on the cable fits into an outlet.

Fork connection

The cable end is held by a shaped fork.

Disconnecting and checking the cable

First look over the whole length of the outer cable to see if the casing is broken anywhere.

Make sure that the cable follows a smoothly curved route and is not kinked or crushed. There should be no bend within 2 in. (50 mm) of either end. Bends elsewhere should have a radius of not less than 6 in. (150 mm).

On some cars, guide clips hold the cable in place. Make sure that it has not worked loose.

The cable is connected to the gearbox by a knurled thimble nut, a circlip or a forked plate.

Unscrew a thimble nut with your fingers, starting it with large grips if necessary. Squeeze a circlip free with circlip pliers.

A single screw holds a forked retaining plate. Unscrew it.

The top end of the cable is harder to reach. If you cannot reach it, remove the speedometer or the instrument panel (SHEET 131).

The top connection is a knurled thimble nut, or one of several types of clip. Most clips release when they are pushed in and turned sideways; one type has a ribbed area on one side, which you depress to release the clip.

Examine the square ends of the drive for wear and check that the fixings are sound.

Turn one end of the drive by hand while a helper watches the other end. If the other end does not turn, the drive is broken. If the drive turns stiffly or you feel it snagging, check that it is not kinked or crushed by a sharp bend or a guide clip.

If one end of the drive moves in a circle instead of revolving on the spot, the drive is kinked.

If the drive seems undamaged but is generally stiff, it may need lubrication.

Pull the drive out of the casing.

Clean the drive with petrol, smear it sparingly with grease and slide it back.

Some inner cables, however, have captive ends and you cannot pull them out. In that case, feed light oil between the cable and outer sheath.

Disconnect the cable from the speedometer and check for loose fixings and worn drive ends.

Fitting the new cable assembly

Find and release all the guide clips, and lever out the rubber grommet where the cable passes through the bulkhead. Pull the cable out into the engine compartment.

Check again that you need a new cable. Repeat the turning test to see if the drive is kinked; or pull out the drive and roll it along a flat surface. Hold the cable in a 'U' shape about 9 in. (230 mm) wide. Turn one end of the drive. It should move smoothly without catching inside the casing.

Sometimes you can renew the drive alone, but makers now tend to supply only complete cables. In any case, take the old cable to the parts store to make sure that the new one is identical. It is a good idea to buy a new gearbox oil seal at the same time.

Push the top end of the new cable through the bulkhead. Use a thin screwdriver to ease the grommet into place.

Refit the cable into its guide clips. Some clips have bands to mark the points that should fit into the clips. They are a useful check that you are routing the cable correctly.

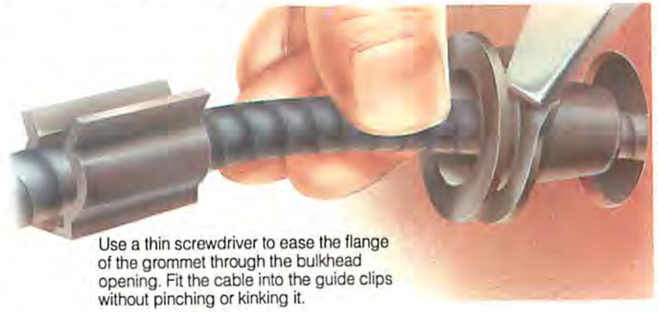
In any case, make sure that the route is smoothly curved. Add extra clips or bands only if they are really needed. Make sure that clips do not squeeze or pull the cable.

To fit the new gearbox oil seal, lever out the old one with a screwdriver and press in the new one, making sure it seats well.

Refit the lower drive connection, taking care that the square drive end is engaged. Tighten a thimble nut only finger tight, and be careful not to cross-thread it.

The top connection is slightly harder to refit, because it is more difficult to get the second end of the drive engaged.

Refit the speedometer if you had to remove it, and test it by taking the car on a short run.



Use a thin screwdriver to ease the flange of the grommet through the bulkhead opening. Fit the cable into the guide clips without pinching or kinking it.

Overhauling a thermostatically controlled fan

Electric radiator-fan motors are switched on either by the ignition switch – and run while the engine is working – or by a thermostatic switch.

Thermostatically controlled motors do not work the fan until the engine coolant rises above normal operating temperature, and then switch off when it has cooled down again.

To check that the fan is working, listen for it cutting in and out, and watch the temperature gauge.

If the engine shows signs of overheating, stop and look to see if the fan is working. With the type operated by the ignition switch, keep the engine running.

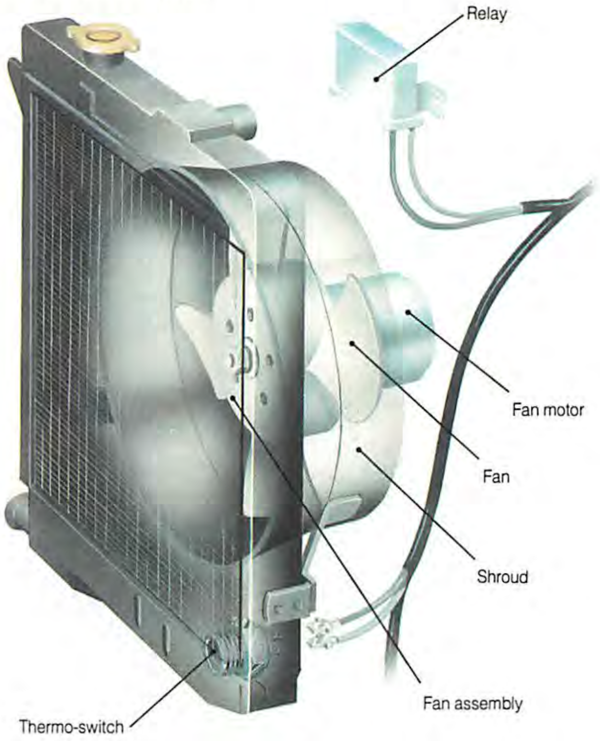
Where there is a thermostatic switch in the circuit, start the car and let it run at fast idle. With no airflow through the radiator, it will soon warm up to the temperature at which the fan should cut in.

The assembly usually has only three components – fan motor, thermostatic (or thermo) switch, and relay. If the fan is not working, these units or the wiring to them may be at fault.

Tools and equipment

CIRCUIT TESTER OR TEST LAMP • SCREWDRIVER • SPANNERS • TEST LEAD

How the fan is fitted



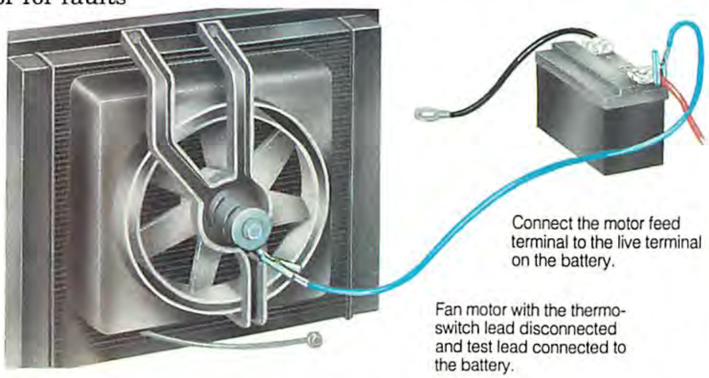
Checking the circuit and motor for faults

Look at the fuse box for a blown fuse. If the fuses are intact, switch on the ignition and use a circuit tester (SHEET 48) to find if there is current at the motor terminals.

Alternatively, connect the feed terminal on the motor direct to the battery positive terminal if the motor is fed via a thermo-switch.

In either case, if there is a current at the motor, the motor is at fault.

If the thermo-switch does not operate, the earthing point of the circuit may be faulty. Check that the earthing point is clean and tight. Check also the functioning of the thermo-switch.



Connect the motor feed terminal to the live terminal on the battery.

Fan motor with the thermo-switch lead disconnected and test lead connected to the battery.

Changing the fan motor

Disconnect the battery, and take off the wiring terminals to the motor or disconnect the plug. Free the wires from clips or other fixings on the fan shroud or nearby bodywork.

The motor and fan normally come off as an assembly, but you may also have to remove the shroud and sometimes the radiator.

Separate the components. Clean the parts that are to be reused, simply by degreasing or even by repainting.

A new motor is supplied without a fan, which must be refitted from the old one.

Checking the new motor

When you fit a replacement motor, check it by connecting its leads directly to the battery. Be sure to connect the positive (+) and negative (–) leads to the corresponding battery terminals.

Take care – the motor will kick as it starts and there will be a large spark when it is connected.

Checking the switch for faults

If the fan motor is not at fault, leave the ignition switched on, take the connections off the thermo-switch and briefly touch them together.

If the fan motor now works, the switch is faulty. If it does not, check to see that there is current flowing to the switch by using a circuit tester on the feed wire to the thermo-switch.

If the tester does not light, trace the lead from the thermo-switch back to its power supply; the car handbook may have a wiring diagram.

If the tester lights, trace the lead from the thermo-switch through to the relay and check the terminals for tightness and cleanliness. Clean and tighten as necessary.

A thermo-switch with push-on connections. The switch is threaded and has a sealing washer which must be renewed.

Touch the switch leads together to bypass the switch.

Changing a thermo-switch

The thermo-switch is normally located in the radiator bottom tank, in the thermostat housing, or in the cylinder head.

To remove the switch, drain the radiator (SHEET 117) until the coolant is below the level at which it is fitted. Catch the coolant in a clean container if you plan to reuse it.

If a rubber cover is fitted over the back of the switch, ease it off, then disconnect the electrical connections.

The switch can now be unscrewed from its mounting point with an appropriate spanner. It may, however, be very tight, so take care not to distort the surrounding metal if it is fitted in the radiator bottom tank. Always fit a new sealing washer.

Checking the relay for faults

With the ignition switched on, short-circuit the thermo-switch by putting a screwdriver across its two terminals; do not disconnect the leads. You may be able to hear a click from the relay as it operates.

Test for current with a test lamp or circuit tester at the 'live' lead to the relay – again with the ignition switched on.

If there is current here but, when the thermo-switch is bypassed, none at the terminal for the fan-motor lead, the relay is faulty and must be replaced.

Short-circuit the thermo-switch terminals to test the relay. You may have to withdraw the lead connectors partly to bare the terminals.

Checking the T-piece

On the Datsun Cherry the thermo-switch and connections are in a T-piece on the bottom radiator hose, so look there if the switch is not on the radiator.

Identifying and suppressing radio interference / 1

Car radio interference originates usually in the ignition system, the charging circuit or among electrical accessories. There are several checks you can carry out to trace the source of the interference.

Interference is either radiated – that is, picked up by the aerial – or conducted to the set by its own wiring.

Before looking for the source, make sure that the set itself is properly earthed to the car's metal bodywork.

Examine the aerial mounting – it must have clean, firm contact with the underside of the bodywork to provide a satisfactory earth connection.

Some interference is fairly easy to identify. A rapid crackling, or a ticking noise, that intensifies with engine speed almost certainly is conducted, from the ignition system – the most common source of interference.

The crackling usually originates from the high-tension (HT) side and the ticking from the low-tension (LT) parts.

An alternator or dynamo not fitted with a suppressor will produce a whining sound, rising in pitch as the engine speed increases.

Interference from electrical components such as windscreen wipers, fan heater and direction indicators can be identified immediately. The noise will disappear when the component is switched off.

It is also possible to pick up interference from disc brakes. This occurs only when they are applied.

Conducted interference can be caused by the power supply cable or wiring to the speakers passing too close to the magnetic field of electrical components.

Try re-routing the cable or speaker wiring as a preliminary step. If that solves the problem, secure the wires in their new position with plastic clips or wide adhesive tape.

The car's metal body acts as a screen between the aerial and the ignition and charging systems, so keep the bonnet closed whenever you listen to check interference.

Suppression of interference is most difficult in cars with glass-fibre bodies, which have no screening effect.

On cars with glass-fibre bodywork, as well as fitting suppressors and earth-bonding straps to various components, you may have to line the underside of the bonnet with metal foil or a conductive graphite paint.

Tools and equipment

SCREWDRIVER • SIDE CUTTERS • ABRASIVE PAPER • SPANNERS • INSULATED PLIERS • CAPACITORS AND SUPPRESSORS • METAL ROD/PLATE

Fitting an aerial

The position of the aerial mast and the route of the lead greatly help to achieve interference-free reception.

Fix the aerial as far away from the engine as possible. If it has to be near the engine, find a position farthest from the ignition system. If you are in doubt, consult a specialist radio fitter.

Do not run the aerial lead through the engine compartment. It will almost certainly attract interference. Similarly, keep it well away from any wiring and electrical accessories.

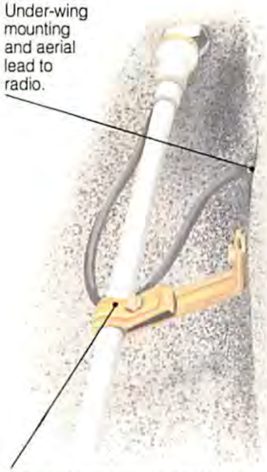
But also keep the lead short, so that it collects as few electrical emissions as possible. If in doubt about the routing, consult a radio fitter.

An aerial hole is usually $\frac{3}{4}$–$\frac{7}{8}$ in. (19–22 mm). See Drilling holes in bodywork (SHEET 67).

Check that the aerial is properly earthed. Tune your radio into a weak station and grasp the aerial firmly while standing outside the car. If the radio becomes louder, the earthing may be faulty.

To rectify, dismantle the mounting which usually has serrations or spikes penetrating the car body. Clean the metal with abrasive paper at the points of contact. Reassemble and tighten.

Under-wing mounting and aerial lead to radio.



Bottom stay for retractable aerials.

Clean the metal parts of the aerial mounting with emery paper.

Suppressing a generator

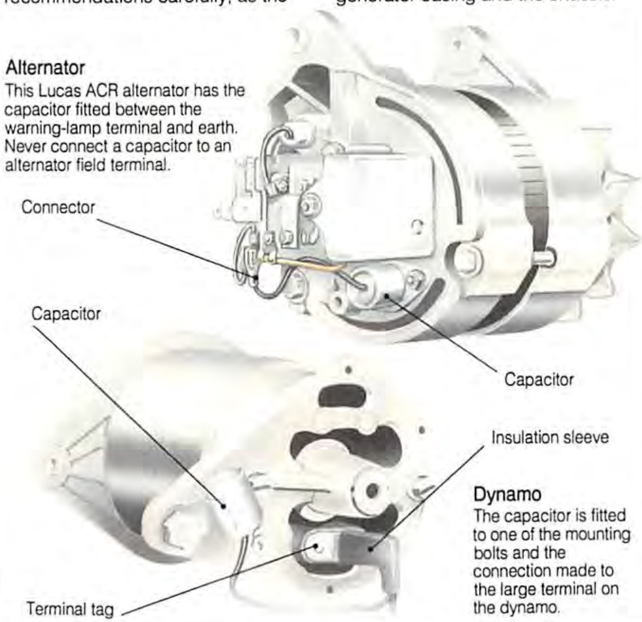
The generator (dynamo or alternator) can be suppressed by fitting a 1–3 Micro Farad (mfd) capacitor for a dynamo or a 3 mfd capacitor for an alternator.

Connect the capacitor lead to the output terminal of the dynamo or alternator. With an alternator, remove the rear cover to reach the terminal. Follow the manufacturer's recommendations carefully, as the device is easily damaged.

Slacken the nearest generator securing bolt and clean the area with emery cloth to ensure a good earth. Slip the capacitor forked mounting tag under the bolt, and retighten.

If interference from the charging circuit continues, attach an earth-bonding strap between the generator casing and the chassis.

Alternator
This Lucas ACR alternator has the capacitor fitted between the warning-lamp terminal and earth. Never connect a capacitor to an alternator field terminal.



Dynamo
The capacitor is fitted to one of the mounting bolts and the connection made to the large terminal on the dynamo.

Fitting a suppressor to the coil

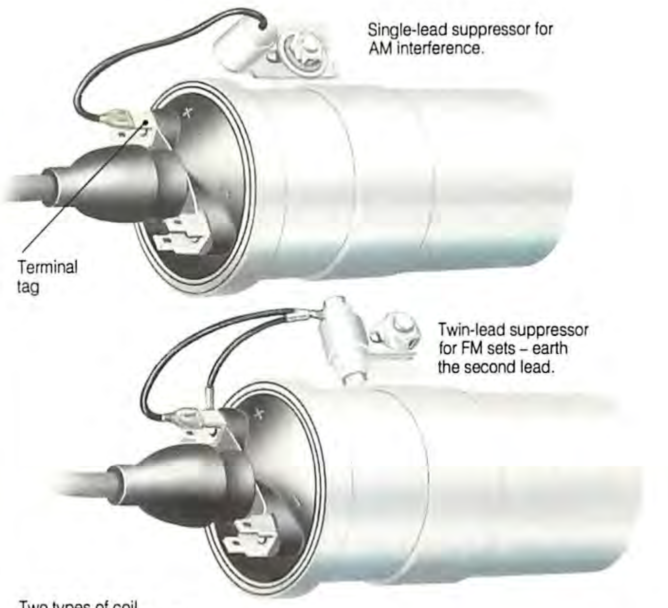
The basic suppressor for the ignition system is a 1 mfd suppressor. Attach it to the LT or positive (+) terminal of the coil on the ignition switch side.

There are two types of suppressor connected in different ways, depending on whether your set has AM or FM reception.

For an AM set, use a parallel capacitor with a single lead. For an FM set, a twin-lead type with the second lead earthed may help.

If the trouble persists, try a 3 mfd capacitor for the AM set or a 2·5 mfd for the FM set.

Finally, fasten an earth-bonding strap between the coil and chassis. All interference from the LT side of the ignition system should be eliminated.



Two types of coil suppressor for AM or FM radio reception.

Identifying and suppressing radio interference / 2

Curing HT interference

The violent crackling of HT interference is more difficult to cure. First, check that the set and aerial are both properly earthed.

Examine the condition of ignition components such as the plugs, points and, in particular, the HT leads, and sparkplug caps. Defective HT leads and plug connectors will create interference.

Modern carbon-cored leads have built-in suppression. Renew them if they are damaged or stretched.

The copper-cored type – which many radio enthusiasts prefer – should have a suppressor built into the sparkplug cap.

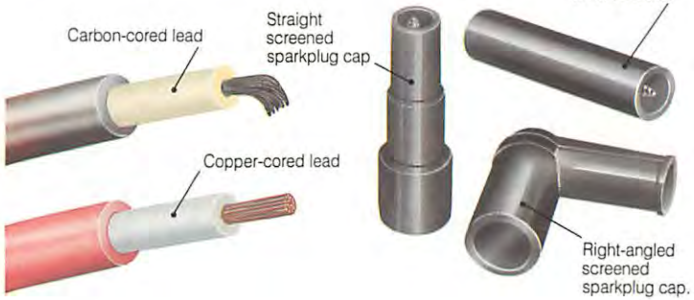
Check that the distributor has a coil-lead suppressor. Usually it is just above the sprung carbon brush in the cap. Most cars have this basic suppressor built into the distributor. If necessary, check with the manufacturer's local agent.

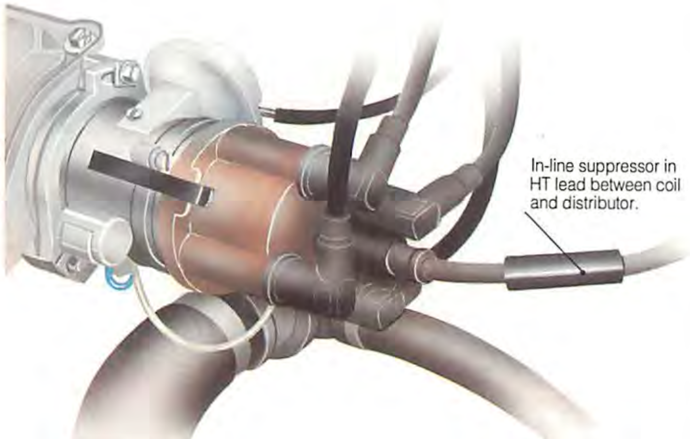
If your distributor does not have a suppressor, fit a 5K Ohm or 10K Ohm resistor in the coil lead.

There are two types of resistor – an in-line type which you connect to the middle of the HT lead, or a plug-in type which you push into the centre coil-lead socket in the distributor cap.

If the interference continues, fit a similar suppressor to each plug lead.

Take care that the combined resistance of HT suppressors in the coil lead, distributor, plug leads and plug caps does not exceed 25K Ohm. Otherwise, ignition power could be reduced.





Suppressing electric motors

Every electric motor in the car generates its own magnetic field, which can radiate interference unless it is suppressed.

When first installed, each motor is normally earthed through its mounting. With age, however, mountings deteriorate, and flakes of paint or rust can act as an insulator between the mounting and the car body.

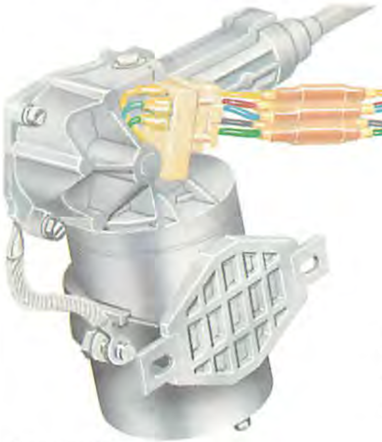
There are two ways to suppress interference from motors. First, try fitting an earth-bonding strap between the motor casing and the bodywork. Use a length of copper braiding, or a piece of heavy-gauge wire.

Scrape the points of contact to the bare metal to ensure good electrical connections, and secure the screw fixings tightly.

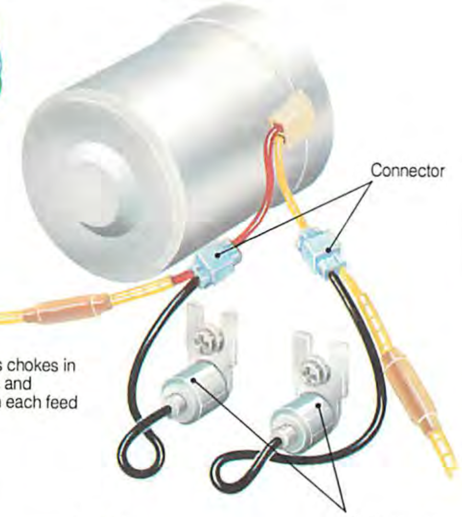
If interference persists, connect a suppressor – 1 mfd or 2 mfd capacitor – between the motor feed wire and earth. This method is suitable for both AM and FM radios.

If an electric motor continues to cause interference despite the fitting of suppressors, use power-supply chokes, available from car-accessory stores, in the connecting wires.

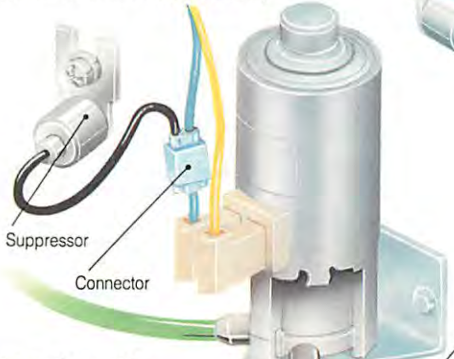
A 7 amp power-supply choke should be suitable for dealing with FM interference.



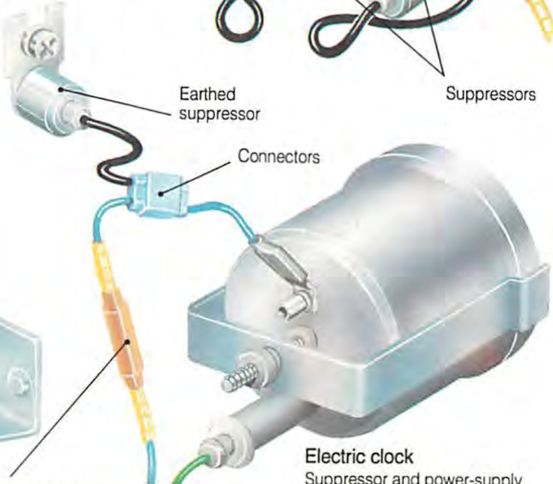
Wiper motor
This Lucas permanent-magnet wiper motor is fitted with the maker's 'choke' assembly.



Heater motor
This illustration shows chokes in series with feed wires and suppressors between each feed and earth.



Screenwasher motor
A capacitor is fitted between the washer feed terminal and earth.



Electric clock
Suppressor and power-supply choke fitted to an electric clock.

Finding other sources of interference

Interference can also be radiated by a metal part of the car insulated from the main body.

The bonnet and boot lid, bumpers, rear axle and suspension units are among possible sources.

Some electronic devices may also cause interference. The more that are fitted or added, the greater the chance that one is interfering with another, producing a humming background noise.

There are two ways to locate the source, both requiring special devices.

For an AM radio, use an aerial extension lead with a metal rod attached. Plug the lead into the set, start the engine and turn on the radio. Do not open the bonnet.

Probe underneath and all around the car with the metal rod to find where the interference is strongest. Earth that part to the body with a bonding strap.

For an FM radio, use a metal plate with a long earth lead bolted to it. Secure the other end of the lead tightly to bare chassis metal under a convenient nut or bolt. Start the engine and turn on the radio. Do not open the bonnet.

Hold the plate with a pair of insulated pliers and move it underneath and all around the car. The plate acts as an interference reflector.

If the interference decreases at a certain point the reflector has picked up the source of the trouble. Earth that component with a bonding strap.

Checking and changing the engine oil / 1

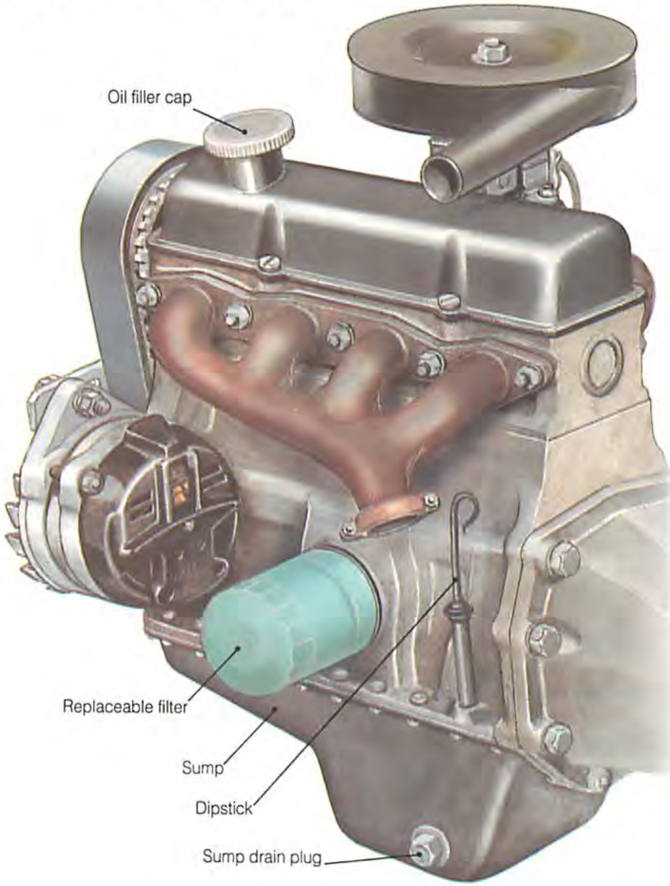
Check the engine oil level weekly – more often if the engine is consuming some oil, and always before a long drive. Change the oil and renew the oil filter at recommended service intervals.

Tools and equipment

SPANNER OR PLUG KEY • STRAP WRENCH OR SCREWDRIVER AND HAMMER • RAMPS OR JACK AND AXLE STANDS • FOOT PUMP • LARGE DRAIN CAN • FUNNEL • ENGINE OIL • NEW OIL FILTER OR FILTER ELEMENT • STIFF BRUSH • CLEAN CLOTH

Bolt-on filter bowl

An oil-filter bowl of a type found on many early cars. The bowl is secured to its housing by a long central bolt.



Checking the oil level and topping up

The car should be on level ground when you check the oil, otherwise the oil-level dipstick will show a false reading because the sump into which it is dipped will be at an angle.

The dipstick is usually in a tube on the side of the engine, where it is easy to reach. Before pulling out the dipstick, always clean its handle and the top of the filler tube to stop dirt falling into the tube, and so into the engine.

Withdraw the dipstick and wipe it with a clean, lint-free cloth or tissue paper to remove all traces of oil.

Put the dipstick fully back into the tube and then withdraw it again to check the oil level.

Hold the dipstick horizontally so that the oil does not run off. The level should be at the Full/Max mark. If it is not, add oil to bring it up to the correct level.

Take off the oil filler cap on the engine rocker or cam cover, and pour in amounts of fresh engine oil, of the correct grade, checking the dipstick level frequently to ensure that you do not put in too much.

When checking during refilling, always allow a minute for the oil to drain into the sump, so that the dipstick reading is correct.

When the oil level reaches the Full/Max mark, replace the dipstick and the filler cap.

Check the oil level against the marks engraved on the dipstick.

Draining the oil

The front or rear of the car, depending on engine layout, will usually have to be raised – either on ramps, or jacked up and supported on axle stands – to give working room under the engine.

The old oil should be drained with the engine warm, so that it flows more freely, taking with it any harmful deposits. Run the engine for a few minutes, then switch off and put a drain can or container big enough to hold all the engine oil under the sump drain plug.

Clean the plug with a clean rag and slacken it, using either a universal drain-plug key or a suitable ring spanner or socket, depending on the type of plug fitted.

Have a container ready to catch the long jet of oil that comes out when the plug is removed.

Unscrew the plug, remove it by hand and let the oil flow into the can. Remember that the oil may be very hot, so avoid contact with it.

Wait until no more oil drips from the drain hole, then clean the drain-hole threads and the surrounding area with a clean cloth or tissue.

Clean the drain plug too, and make sure its washer or gasket is in good condition. Replace it if it is worn or broken. Refit the plug but do not overtighten it.

Removing the oil filter

Place the drain can directly under the oil filter – usually on the side of the engine crankcase. The filter can be one of two types – either a throw-away cartridge or, on older cars, a replaceable element inside a metal bowl.

A throw-away cartridge is usually unscrewed complete. Normally, you need a strap or chain wrench to free it. If you do not have one, hammer a long screwdriver through the filter and use that as a lever.

That is a messy method, however, so make sure the drain can is directly below to catch spillage, and have plenty of clean cloth to hand.

Sometimes the cartridge is mounted upside-down, and inevitably there will be some oil spilled.

Clean the filter sealing flange, where the filter screws on, of all dirt and oil.

A strap or chain wrench may be needed to remove the filter.

A screwdriver driven through the filter will provide leverage.

Remove a replaceable-element filter by unscrewing the central bolt, either at the top on the face of the filter adaptor, or at the bottom of the bowl.

Hold on to the filter bowl until it can be completely detached, in case it drops and spills oil.

When the bowl is off, remove the sealing ring from its groove in the flange, using a sharp tool – a safety pin will do. Clean the groove thoroughly.

Empty the filter bowl and discard the old element, then clean the bowl.

Remove the central bolt, supporting the bowl with one hand.

Remove the element and sealing ring.

Checking and changing the engine oil / 2

Fitting a cartridge-type filter

Fitting a new disposable cartridge is a simple task, but you must make sure that the new sealing ring that comes with it is correctly fitted in its proper place, on the inner end of the cartridge. Smear its outer face with clean engine oil.

Screw the cartridge into the side of the crankcase by hand until the sealing ring just contacts the flange, then tighten it another three-quarters of a turn, enough to compress the rubber to make an oil-tight seal. Do not overtighten, as this will distort the seal and cause an oil leak.

Smear the outer face of the sealing ring with clean engine oil.

Screw the filter on by hand only.

Fitting a new element into a replaceable-element filter

Fitting a new element begins with replacing the oil-sealing ring: a new one comes with the element when you buy it.

Fit the ring carefully into its groove in the mounting flange, making sure that it is not bunched or twisted.

Smear its outer face with clean engine oil.

A light spring is fitted below the element and a large locating plate which supports the element.

Insert the new element into the filter bowl and hold it against the mounting flange. Locate the central bolt and engage the first few threads with your fingers.

Tighten it with a spanner, only enough to compress the sealing ring. Do *not* overtighten, or the seal may be distorted and oil will leak.

Fit the sealing ring in the mounting flange. Replace the spring over the central bolt, followed by the locating plate.

The new element fits over the central bolt, and the assembly is bolted to the mounting flange.

Tighten the central bolt until the sealing ring is compressed. Do not overtighten – this will ruin the sealing ring, causing a leak.

Refilling with new oil

The quantity and grade of fresh oil you need should be noted from the car handbook before draining. The oil is usually cheaper in 5 litre cans.

To avoid spilling any on the engine, put a funnel in the oil filler hole and pour the oil straight from the can or from a smaller measuring jug. Some cans have a pull-out plastic spout.

Use a clean, wide-mouthed funnel for refilling.

If you use the can, pour the oil in small amounts, taking frequent dipstick readings until the level is just above the Full/Max mark.

Allow time for the oil to drain into the sump so that the readings are correct.

A measuring jug enables you to pour in the exact amount required, allowing for the new filter, but always double check with the dipstick.

Once the sump is filled to its correct level, restart the engine and allow it to idle for a few minutes. Check for leaks from the filter sealing ring and the sump drain plug, and tighten them if necessary.

Stop the engine and wait a minute for the oil to drain back into the sump, then check the oil level again with the dipstick.

If necessary, add more fresh oil through the funnel. When the level is correct, remove the funnel and replace the oil filler cap to complete the job.

Remember it is illegal to put your old oil down a drain, or bury it in the ground. The local council usually has an oil-disposal tank at one of its refuse tips, or a local garage may have one.

Cleaning the oil-filler-cap breather

This job is necessary only if the oil filler cap acts also as the crankcase breather (SHEET 147).

Three types of 'breather' filler cap are most commonly used:

A sealed one with a wire-gauze filter inside the body;

A plastic one on some cars (Fords) which can be separated to get at the filter inside the body;

A metal or plastic cap without a filter, but with small air-restricting holes.

They should all be cleaned at least once a year to remove the gradual build up of road dirt around the breather holes on the underside of the cap, and sludge from the wire-gauze filter inside – if one is fitted.

Remove the cap from the engine rocker or cam cover either by simply pulling it off, or by twisting anti-clockwise before pulling, to disengage its 'bayonet' fitting.

The best way to clean all three types is to submerge them completely in a small can of paraffin.

Use a stiff brush to scrub the outside and remove all traces of dirt and grit.

With sealed metal filler caps, work the brush through the breather holes to remove as much dirt as possible from the wire-gauze filter inside. Repeat the cleaning procedure inside the cap body tube.

For a plastic filler cap which can be separated, prise off the top to gain access to the wire-gauze filter inside.

Lift out the filter and scrub it thoroughly until it is clean. Clean out the filler-cap body and top.

Filler caps without a filter inside should have their small air-restricting holes carefully probed, to see that they are not blocked with dirt and sludge.

Clean the cap thoroughly with the brush, and probe the holes clear with a piece of wire.

On all types of filler cap, flush out the inside with petrol or paraffin. If you have a foot pump, blow the inside of the cap and the filter dry.

Otherwise allow them to dry naturally, giving them an occasional shake. If you use petrol, make certain it has all evaporated before you refit the unit.

If a removable wire-gauze filter is fitted, be sure to put it back before pressing the top cap into position.

If the cap has a sealing ring, make sure also that it is in good condition before you put the cap back on.

A sealed metal cap with a wire-gauze filter inside the body.

A Ford-type filler cap with detachable filter.

A plain filler cap with small breather holes, but no filter.

Checking for oil leaks / 1

If an engine needs topping up with fresh oil more often than usual, or if you see a pool of oil under the engine where the car has stood, there is an oil leak. Trace the source immediately.

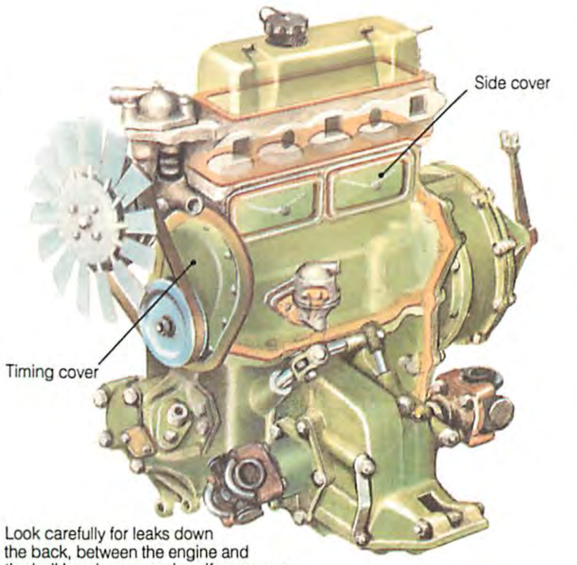
The engine could be damaged if the leak is allowed to become serious.

Finding the exact source of the leak is easier if you first clean the outside of the engine thoroughly with a proprietary degreasing fluid and a stiff bristle brush. Protect electrical parts with plastic bags, or plastic sheets held on by sticky tape, then hose the degreaser away with water until the engine is reasonably clean and oil-free. Leaking oil then shows clearly.

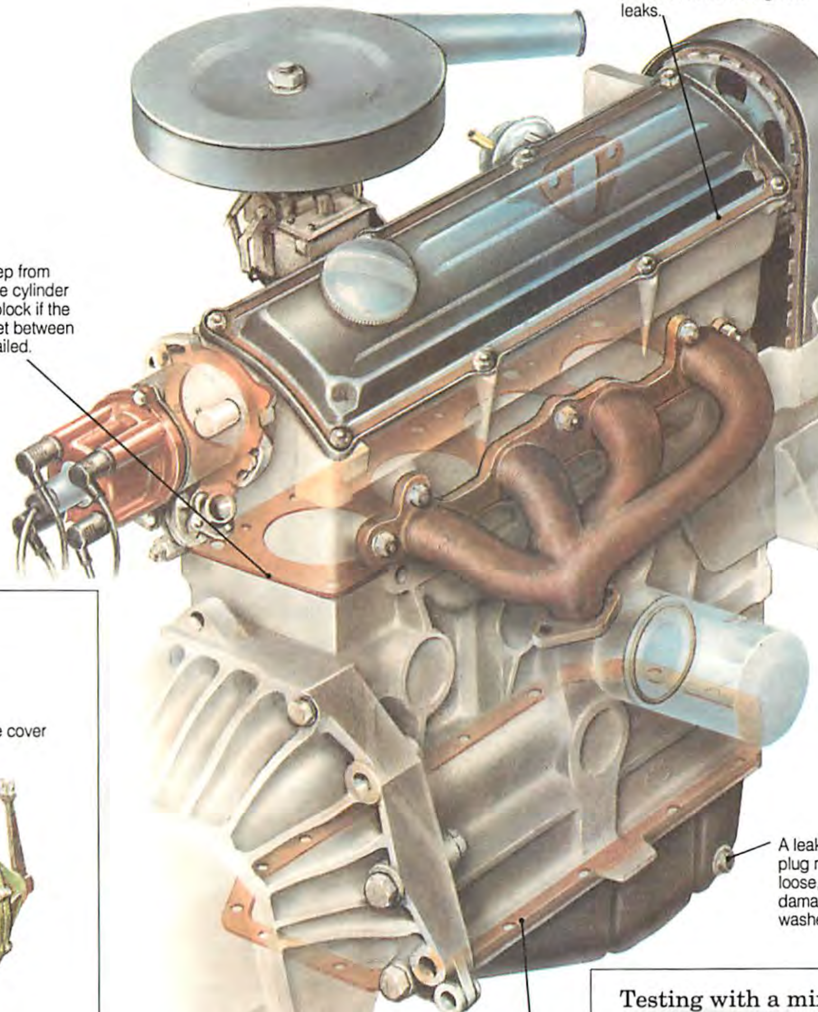
Tools and equipment

SPANNERS • SOCKETS • MIRROR • LONG-NOSED PLIERS • SCREWDRIVER • INSPECTION LAMP • TORCH • GASKETS • PLASTIC BAGS

Transverse engines



Look carefully for leaks down the back, between the engine and the bulkhead – use a mirror if necessary.



Testing with a mirror

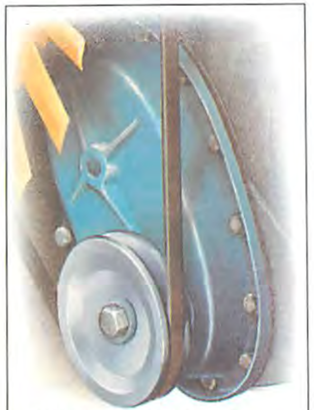
Use a small mirror to see hidden areas.

Timing-cover oil seal

A common source of leakage is the timing-cover oil seal at the crankshaft-pulley end of the engine. Generally, oil leaks most from the seal when the engine is running fast, less when it is idling.

Check for signs of oil sprayed out sideways in line with the oil seal or pulley on to adjacent parts of the bodywork or engine.

Look also at the underside of the engine beneath the seal, and on the sump pan for oil streaks starting at the lower edge of the seal.



The pulley wheel will spray oil from a leaking timing-cover seal.

The only cure for a leaking oil seal is replacement, and ensuring that the rotating parts with which it is in contact are smooth and free of burrs or raised metal.

Checking a crankcase side-cover gasket

On some engines – such as those fitted to certain Leyland cars – there is a cover over the camshaft tappet chamber on the side of the crankcase about halfway down the engine.

The cover is hidden by the inlet or exhaust manifold, so leaks from its gasket may be hard to spot.

With the engine running, look for oil coming from the lower edge of the cover. You may need a small mirror and a torch to see.

Tighten the central bolt sufficiently to compress the gasket.

Tightening the cover securing screws slightly may cure the leak. If not, replace the gasket (SHEET 151).

Looking for leaks on the crankshaft rear oil seal

The crankshaft rear oil seal is usually hidden by the flywheel and clutch housing, so the only visible sign of a leak is a drip from the bottom of the clutch housing.

Where the seal is leaking badly, there may be clutch judder or slip caused by oil spraying on the clutch.

Replacing the seal is the only cure. This means removing either the gearbox or the engine – a job best left to a garage.

Oil under the clutch housing may come from the crankshaft seal.

Checking for oil leaks / 2

Checking the rocker cover

Run the engine when you check for oil leakage from the rocker or cam cover, so that the moving parts beneath it are spraying oil around the inside. Keep clothes and hair well clear of the pulley(s) and belt(s).

Look carefully for oil seeping out from around the gasket flange, particularly at the front and rear ends of the cover where the gasket may not be sealing properly.

A rocker-cover gasket located by small tongues in the cover flange – position them properly before tightening down the cover.

Tighten all nuts and bolts evenly and without excessive force to prevent the rocker cover being distorted.

Leaks may be due either to the cover screws being unevenly or excessively tightened, or to the gasket being broken or distorted.

Check the gasket side near the source of the leak; look for breaks or distortion. Use a small mirror to see under the rim of the cover.

Some gaskets are held in place on the cover flange by small tongues. Others may be stuck to the cover, or just held in position by the cover flange.

A broken gasket should be replaced. A distorted gasket can usually be sealed temporarily, but a new one should be fitted as soon as possible.

Slacken the cover screws and straighten the gasket with tweezers or thin-nosed pliers. Retighten the cover screws and check again for oil leakage.

The screws should be tightened just enough to press the cover on to the gasket firmly, but no more. Overtightening distorts both the cover and the gasket, causing more leaks.

Leaks may also occur around a cover which is secured by nuts and bolts, if the washers are wrongly fitted or the nuts not tight enough.

On some engines, special fibre or plastic washers are used. Make sure that you fit washers of the same type, and that the screws are correctly tightened.

Inspecting the sump

To check the sump pan thoroughly, run the car up on ramps so that you can get underneath the engine end. Apply the handbrake and chock the wheels still on the ground.

With the engine running, check for oil leaks around the outside of the sump-pan mounting gasket flange, and also from the drain plug at the bottom of the pan.

Look closely at the sump mounting flange around the crankshaft: sometimes the gasket is in several parts, or there are separate gaskets at the front and rear, which are liable to distortion. Leaks here can be confused with those from a crankshaft front or rear oil seal.

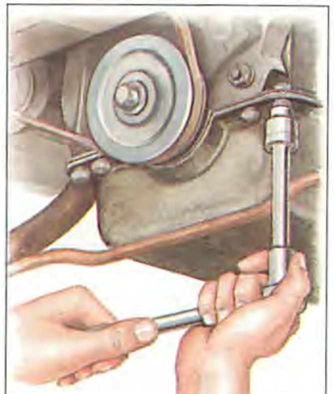
If the sump gasket is leaking, it may be only because it has settled and contracted slightly in service. The leak may be stopped by tightening the sump mounting bolts or nuts.

Make sure you tighten all the fixings evenly, working gradually around the mounting flange.

Beware of overtightening, which can distort or destroy the gasket. If tightening fails, the sump gasket should be replaced.

An occasional oil drip from the sump drain plug shows that the plug is not tightened enough, that the washer is leaking, or that the plug is not fitted correctly.

If there is a steady drip from the plug, fit a new washer. Otherwise, the washer should be replaced at the next oil change (SHEET 143).



Tighten all the sump bolts evenly.

A leaking sump plug may be loose, or have a damaged washer.

Checking the head gasket

With the engine running, check for an oil leak at the cylinder-head gasket. This is a sign that the rocker shaft or camshaft oil-supply passage is leaking where it passes through the head gasket.

Oil may leak from the head gasket if the head nuts or bolts are loose, or if the head gasket, cylinder-head face or block face is faulty (SHEET 156).

Oil-filter or pump adaptor

Depending on the position of the oil-filter or oil-pump adaptor on the engine, you may need to raise one end of the car on ramps and get underneath to see clearly. Apply the handbrake and chock the other wheels.

With the engine running, a serious oil leak is clearly visible, streaming from the oil-filter seal or pump-adaptor housing on the side of the engine, which is where the oil is under more pressure than anywhere else in the system.

If the leak is serious, stop the engine immediately to prevent damage, and replace the gasket (SHEET 151). A slight seepage can sometimes be cured by checking the tightness of the filter or pump-adaptor fixings.

However, the best way of curing a leak is to remove the component and replace the gasket or seal.

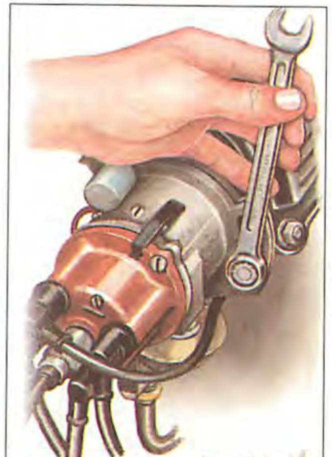
Tightening the pump adaptor bolts may cure a slight leak from the mounting flange.

The distributor flange

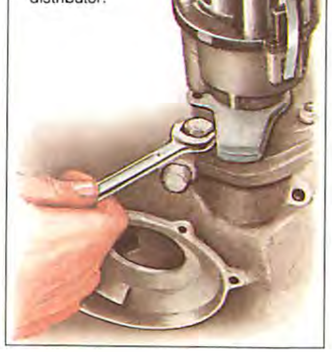
With the engine running, check carefully for leaks around the distributor mounting flange where it is attached to the crankcase or camshaft cover.

On some engines there is a thin gasket between the mounting faces; on others there is an 'O'-ring rubber seal fitted over the distributor housing between the mounting faces.

Replacing the gasket or seal is the only cure for an oil leak there. You need to remove the distributor to do this (SHEET 201).



Tightening up a camshaft-mounted distributor and (below) a crankcase-mounted distributor.



Fuel-pump mounting gasket

Fuel-pump gaskets are fitted only to mechanical fuel pumps that are mounted on the engine.

Locate the pump, and with the engine running check for oil drips coming from the underside of its mounting flange or gasket.

On many engines there is a thick spacer plate sandwiched between two thin paper gaskets. This thick plate may crack if the pump mounting nuts or bolts have been overtightened.

Check first that the pump mounting nuts or bolts are not loose, but take care not to overtighten them as this will distort the mounting flange and make the leak worse. If the leak persists, check the underside of the mounting and gasket with a mirror, looking for the exact source of the leak. Replace the gasket if necessary smeared with a non-setting sealant. Make sure that the pump flange face and the mounting face are both clean before fitting a new gasket.

Note that the thick spacer plate (if fitted) also governs the distance the fuel-pump lever travels. If you fit a new plate, it must be the same thickness as the old one. Compare the new with the old before fitting, and use parts approved by the car manufacturer.

An engine-mounted mechanical fuel pump may leak where it is mounted on the block.

Checking the emission valve and breather

The crankcase emission valve governs the amount of crankcase oil fumes that are recycled into the inlet manifold for combustion in the cylinders.

The emission valve and its pipes must be cleaned and checked periodically, otherwise engine performance and fuel economy may suffer.

The valve is usually a sealed unit, but some can be dismantled. It is normally located near the side of the engine crankcase or rocker/cam cover, depending on the engine type.

Never run the engine with the emission valve or pipes disconnected from the engine.

Tools and equipment

SCREWDRIVERS • CIRCLIP PLIERS • LENGTH OF CLEAN RUBBER OR PLASTIC PIPE ABOUT 12 IN. (300 MM) • FOOT PUMP • PARAFFIN AND CONTAINER

Checking valve operation and cleaning emission pipes

To check the valve for correct operation, attach a clean length of rubber or plastic pipe to the larger end of the valve – the rocker/cam or crankcase end – making sure that the pipe is a tight fit.

Blow through the pipe and check that air passes through the valve easily. If it does not, either the valve is blocked or the spring inside is broken and is holding the valve in the closed position. If further cleaning does not help, fit a new valve.

Disconnect the pipe and reconnect it to the other end of the valve – the inlet-manifold end.

Blow through the pipe. Only a limited amount of air should pass with difficulty through the valve.

If air flows freely, then either the valve is jammed in the partly open position because of dirt or a broken spring, or the valve is worn and should be renewed.

Disconnect and remove from the engine all emission-system pipes associated with the valve.

Use a foot pump to blow through each pipe to remove dirt and oil. On short lengths of pipe, you can usually flush out dirt with paraffin and blow dry with the foot pump.

Check the condition of the pipes and look for cracking or chafing on the outside of the rubber, particularly where the pipes bend and at the ends where they may be cut through by a tightly fitting clip.

Replace defective pipes; a leaking pipe will weaken the mixture entering the engine.

Reconnect the emission-system pipes and the valve in the reverse order of removal, making sure all connections are clean and tight.

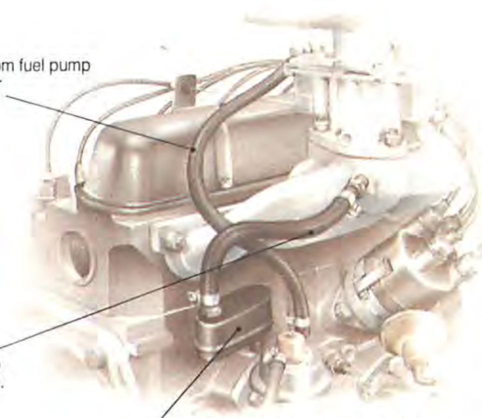
Removing and cleaning the valve

Release the clip and disconnect the pipe from the upper end of the valve. The way the valve is removed depends on the particular engine.

Normally it is a push fit in either the rocker/cam cover or a small box or pipe attached to the crankcase.

Clean a sealed valve thoroughly by immersing it in paraffin to loosen oil deposits inside. Bear in mind the fire risk – do not smoke, for example.

Some types of valves can be dismantled for cleaning by removing a small circlip inside the lower end of the valve body, then removing the valve and spring. Check the components thoroughly for blockages and broken parts, clean, then reassemble.



The valve is mounted next to the crankcase. To remove it, release the clip holding the pipe and disconnect the pipe from the valve.

Use circlip pliers to free the circlip in this type of valve. Tap the valve body to release the valve, valve seat and spring, noting their order of assembly. Wash each part and the valve body in paraffin or petrol.

Cleaning a breather unit

Crankcase breather units may be sealed containers – sometimes called oil separators or flame traps – and are incorporated in the crankcase breather-system pipework.

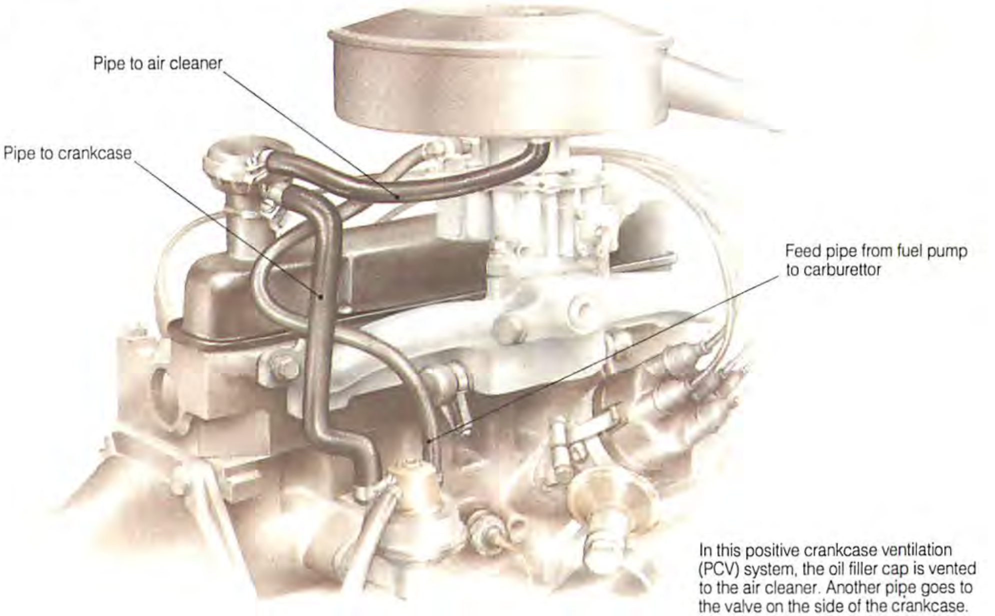
The breather unit should be removed and cleaned periodically, or replaced to remove any build-up of oil sludge and other deposits that reduce engine performance.

Remove the breather unit, either by disconnecting the pipes or detaching it from its mounting on the engine.

A breather filter is sometimes fitted inside one of the shaped pipes.

Clean the breather filter by immersing it fully in paraffin. Allow it to soak for some time to dissolve any oil and sludge inside.

Drain the breather into the can to remove as much sludge as possible, then dry it with a blast of air from a foot pump. If it is badly contaminated, fit a new one.



In this positive crankcase ventilation (PCV) system, the oil filler cap is vented to the air cleaner. Another pipe goes to the valve on the side of the crankcase.

A one-way valve in this PCV system is incorporated in the breather unit. It is fitted above the filter and can be removed for cleaning.

After cleaning the filter in paraffin, dry it thoroughly with blasts of air from a foot pump.

Checking and adjusting valves / 1

Valve clearances are the small gaps between the tops of the valve stems and the part of the mechanism which presses on them to open the valves.

Check the clearances at regular intervals as specified in the car service schedule, and adjust if necessary. Reset the clearances whenever the cylinder head has been removed.

The job is commonly called adjusting the tappets.

A few cars have hydraulic tappets, which are self adjusting and do not need checking.

Before starting, make sure you know the type of valve mechanism – commonly called valve gear – fitted to your engine, and the relative valve clearances. The car handbook should tell you the clearances – if not, consult the DATASHEETS or a dealer or the car service manual.

The valve gear fitted to your engine will be either pushrod (OHV) or overhead camshaft (OHC) (SHEET 25). There are two types of OHC valve gear – direct acting and indirect acting.

The tappets on an OHC engine are usually adjusted by placing shims of a predetermined size under them.

That is a job best left to a garage which has a micrometer for measuring shims, and a wide selection of them. But you can check the clearances yourself, and decide whether they need adjusting.

You must know the firing order of the engine (see DATASHEETS), which cylinder is No. 1, which are inlet and exhaust valves and which rockers or cams operate them. Make a plan of all this information on paper.

Find the correct valve clearances for inlet and exhaust valves, and whether they should be adjusted with the engine hot or cold.

'Hot' means that the engine must be warmed to normal working temperature, then switched off – and you must work quickly before the engine cools.

'Cold' means absolutely cold: the engine must not have run for at least six hours – check in the car handbook.

To speed up the job on most pushrod and some types of indirect-acting OHC engines there is a sequence by which you can check more than one valve at a time. But the valves of overhead-cam engines usually have to be checked singly.

Remove the air cleaner if it overhangs the rocker cover (SHEET 167).

Tag and number the ignition leads to avoid confusion when replacing them, then remove them from the plugs, pulling the plug caps, not the leads. If the leads are clipped down and in the way, unclip them.

Note the position of any pipes, control cables and other items fastened to the rocker cover, unfasten them and move them aside.

Remove all the plugs with a plug spanner. With the plugs out, there is no compression in the cylinders, so you can turn the engine easily.

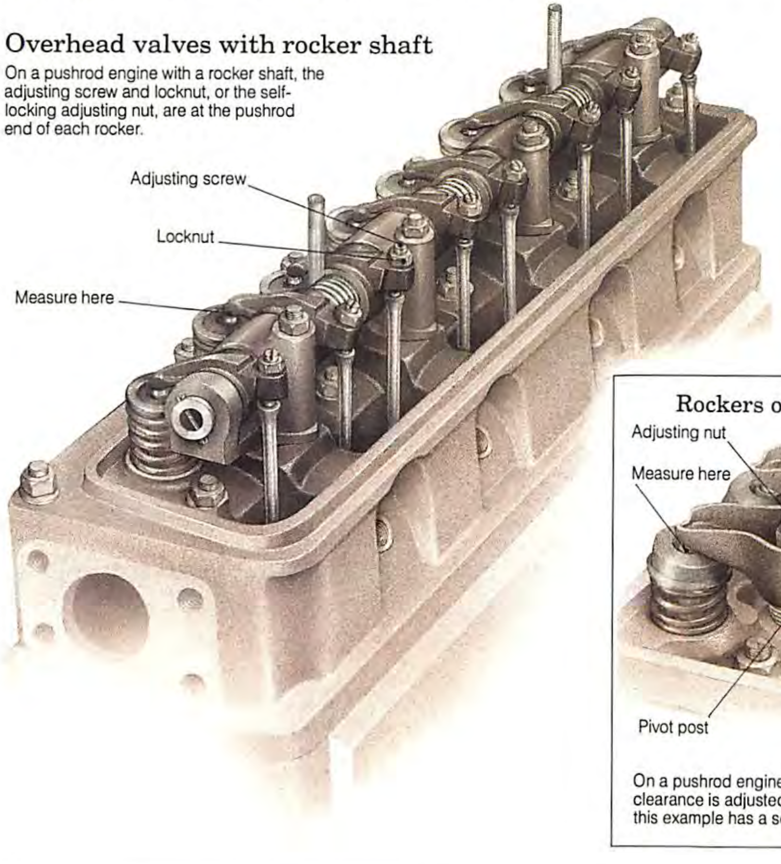
Remove the screws or bolts holding the rocker or cam cover to the cylinder head. Carefully lift the cover together with its gasket. Put the cover in a clean place, upside-down on newspaper to catch oil drips. Always fit a new gasket to the rocker or camshaft cover before refitting (SHEET 151).

Tools and equipment

SPANNERS • SOCKETS • SCREWDRIVER • FEELER GAUGE • ALLEN KEY • PLUG SPANNER

Overhead valves with rocker shaft

On a pushrod engine with a rocker shaft, the adjusting screw and locknut, or the self-locking adjusting nut, are at the pushrod end of each rocker.

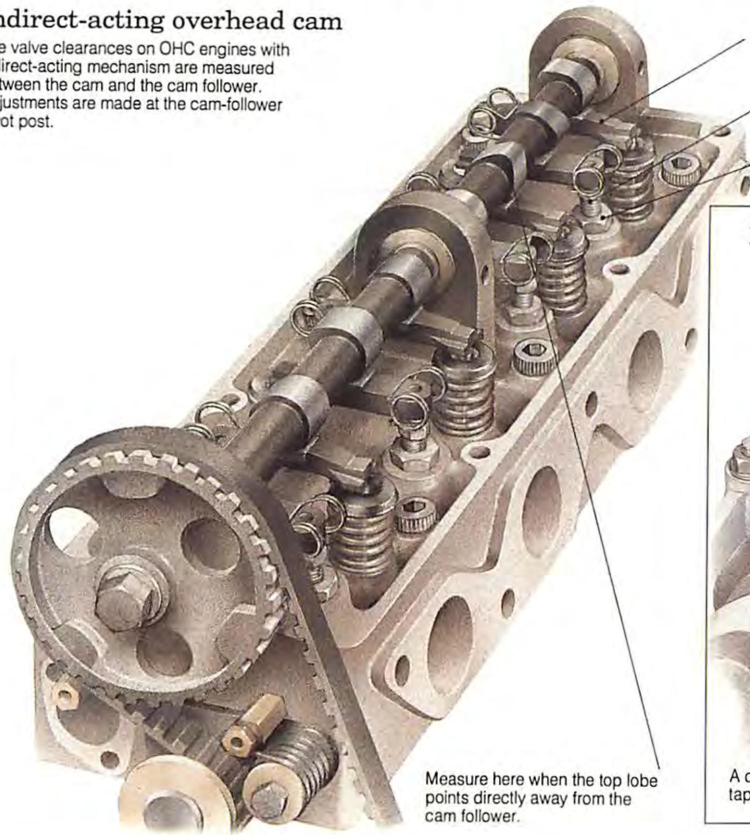


Rockers on a pivot post

On a pushrod engine without a rocker shaft, the clearance is adjusted by a nut on the pivot post: this example has a self-locking nut.

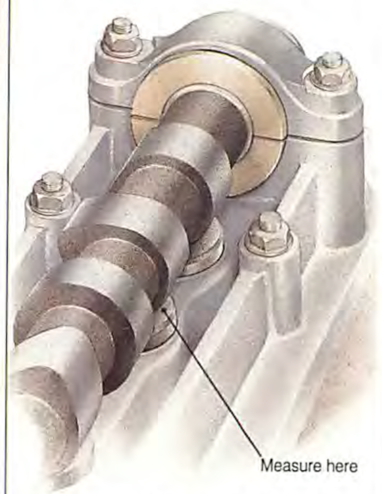
Indirect-acting overhead cam

The valve clearances on OHC engines with indirect-acting mechanism are measured between the cam and the cam follower. Adjustments are made at the cam-follower pivot post.



Measure here when the top lobe points directly away from the cam follower.

Direct-acting overhead cam



A direct-acting OHC operates the valves through tappets which are sometimes adjusted by shims.

Checking and adjusting valves / 2

Adjusting the tappets on pushrod engines

The point in the valve-operating sequence to check a pair of valves is when another pair is 'rocking' – the brief moment when the rockers are moving in opposite directions to close the exhaust and open the inlet valve.

For example, on a four-cylinder engine when the rockers on No. 1 are rocking you can check both valves on No. 4.

Turn the engine in its normal direction of rotation by using a spanner or socket wrench on the crankshaft-pulley bolt until the two chosen rockers rock.

Most engines turn clockwise, but some Honda engines and the Triumph Acclaim engine turn anti-clockwise. Consult your car handbook.

If in doubt, turn the crankshaft back a short way; but if you have gone too far, turn it on almost two more turns in the normal direction and look again.

At the cylinder to be checked, insert the blade or blades of a feeler gauge, selected for the correct clearance, between the rocker and the valve system.

If the clearance is correct, the blade is a close sliding fit between the two parts. If not, it may refuse to enter the gap, or it may be a loose fit, in which case you can move the rocker up and down with the blade in place.

Adjust an incorrect clearance with the rocker adjuster screw. If the rockers pivot on a shaft, the screw is usually at the pushrod end.

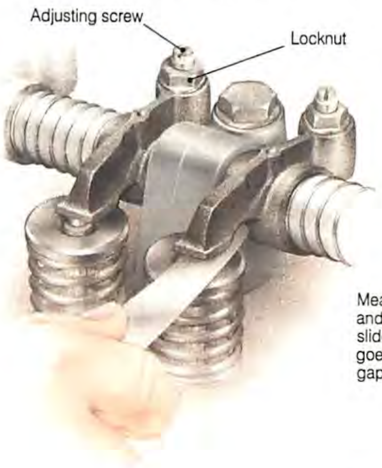
There may be a slot-headed screw with a locknut. Use a ring spanner to loosen the locknut and turn the screw clockwise to decrease the gap, and the opposite way to increase it.

When the clearance is correct, hold the screw with a screwdriver while you tighten the locknut, then re-check the clearance.

There may be a self-locking adjusting screw with no locknut. It has a hexagonal head: adjust it with a spanner.

Alternatively, there may be no rocker shaft, each rocker being held by a nut on a fixed pivot post. Adjust the clearance by tightening the retaining nut to reduce the gap, or loosen it to increase the gap.

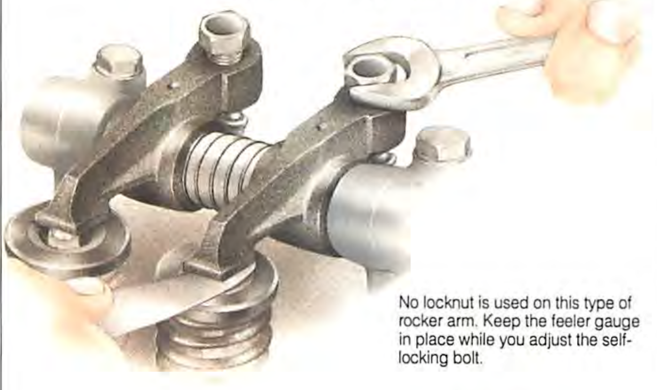
After re-checking both valve clearances, turn the crankshaft until the next pair of rockers in the sequence rocks, and repeat the check. Carry on until all the valve clearances have been checked.



Measure the gap between the rocker pad and the valve stem; the feeler blade should slide in to a close fit. If it will not go in or if it goes in with room for movement, adjust the gap.

Leave the feeler gauge in place while you adjust. Use a screwdriver to prevent a slotted adjusting screw from turning while you tighten the locknut, then re-check the gap.

Alternative adjusters



No locknut is used on this type of rocker arm. Keep the feeler gauge in place while you adjust the self-locking bolt.

On a shaftless rocker arm, adjust the clearance with a socket spanner and reversible ratchet arm.

Rule-of-nine method

An alternative sequence often recommended by car manufacturers for in-line four-cylinder engines, is to follow the 'rule of nine'.

There are some engines – including the Fiesta 1·1 – on which this method is not recommended: consult your car handbook or service manual if in doubt.

The feeler gauge must be a close sliding fit – with the engine hot or cold, according to the manufacturer's instructions. With many different sorts of engine layouts, No. 1 cylinder is usually at the crankshaft-pulley end, irrespective of which way the engine is mounted in the car.

Turn the engine by means of a socket spanner on the crankshaft-pulley wheel, or by jacking up one of the driven wheels, engaging a high gear, and turning the wheel by hand to turn the engine.

Removal of the sparkplugs (SHEET 192) will make turning the engine easier.

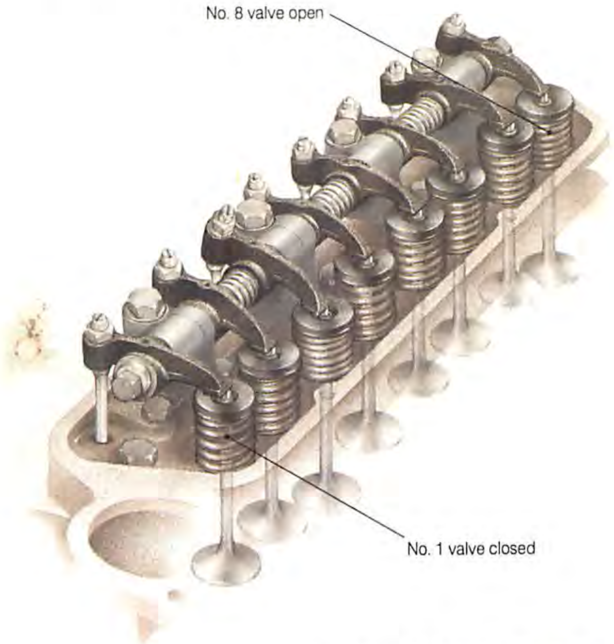
Count the valves of No. 1 cylinder as 1 and 2, the next pair as 3 and 4 up to the furthest pair, 7 and 8.

Turn the engine until one rocker arm is fully down, the valve being fully open.

Follow the table:

Check No. 1 valve clearance with No. 8 fully down.
Check No. 3 valve with No. 6 fully down.
Check No. 5 valve with No. 4 fully down.
Check No. 2 valve with No. 7 fully down.
Check No. 8 valve with No. 1 fully down.
Check No. 6 valve with No. 3 fully down.
Check No. 4 valve with No. 5 fully down.
Check No. 7 valve with No. 2 fully down.

Note that whichever valve is fully down, adjust the valve which makes up to 9 when the two numbers are added.



When using the 'rule-of-nine' method, No. 1 valve is fully closed when No. 8 is fully open.

Checking and adjusting valves / 3

Overhead-cam engines

On overhead-camshaft engines, check the clearance of each valve when the lobe of its cam is pointing directly away from it.

Turn the crankshaft only in its normal direction of rotation, using a spanner or socket wrench on the crankshaft-pulley, to move the camshaft.

The valves come into the checking position in a jumbled order – do not mix up inlet and exhaust clearances.

On tappets with shims, check the clearance by inserting the blade or blades of a feeler gauge between the back of the cam and the tappet.

The correct blade should be a close sliding fit in the gap. If it refuses to go in, or feels loose, try other blades to find what the gap actually is, and whether it is within the allowable limit. Any tappet clearance outside the limit should be adjusted by a garage.

However, on certain Vauxhall engines you can make small adjustments by means of screws which slide wedges under the shims: these screws are adjusted with an Allen key.

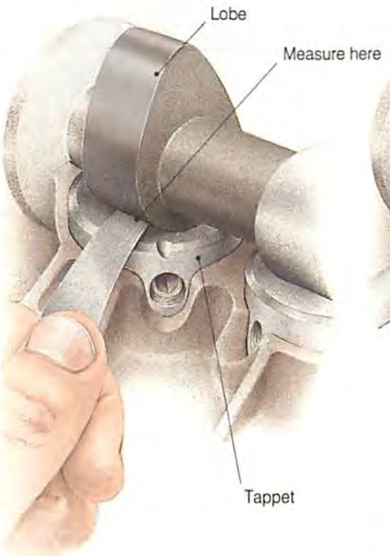
On an indirect overhead camshaft with finger-type followers (see right), check the clearance in the same way between the back of the cam and the follower.

Adjust the follower, if necessary, by screwing its pivot post up or down.

The pivot post has a locknut around its base. Hold the post with a spanner while you slacken the locknut, then turn the post anti-clockwise to reduce the clearance and clockwise to increase it.

When the gap is correct, hold the post steady while tightening the locknut, then check the clearance.

Keep turning the crankshaft until you have checked all the valves.

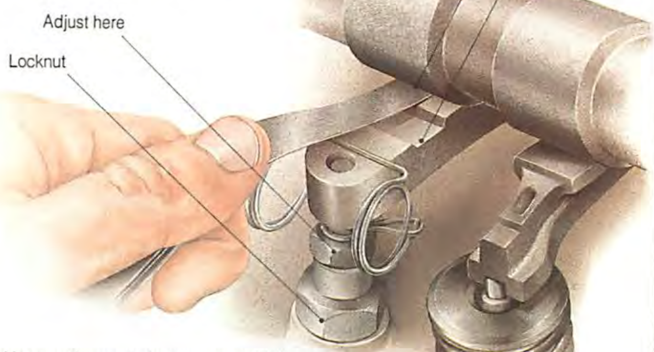


On an OHC engine with bucket tappets, measure between the tappet and the bottom of the cam lobe.

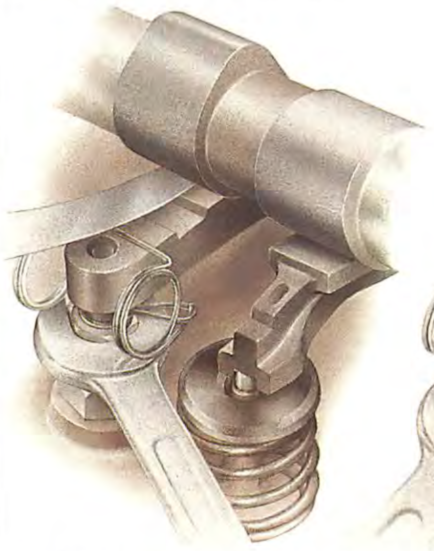
On some Vauxhall overhead-cam engines you can adjust the shims to a limited extent by screwing up a wedge under them, through a small hole. Turn the screw with an Allen key; if its full travel does not alter the gap enough, the shim must be replaced at a garage.

Indirect-acting overhead cam

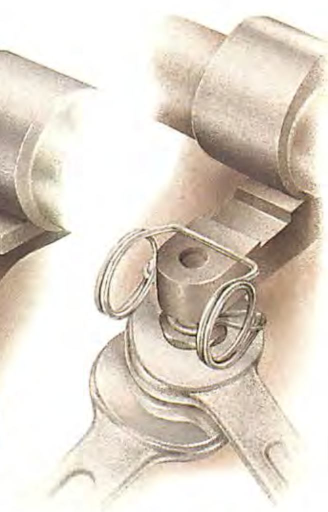
On overhead-cam engines with finger-type cam followers, measure the gap when the top of the lobe is pointing directly away from the finger. Adjust by turning the pivot post at the opposite end of the finger from the valve; hold the post to stop it turning while you slacken or tighten its locknut.



Measure the gap between cam and follower with the lobe pointing away from the follower.



Keep the feeler gauge in position while making the adjustment.



Hold the adjusting nut steady while tightening the locknut.

Another type of indirect-acting overhead camshaft

In a second type of indirect-acting overhead-camshaft engine, the cams bear against the ends of rocker arms.

To adjust the valve clearances, use a spanner or a socket wrench on the crankshaft-pulley bolt. Turn the engine in its normal direction of rotation until No. 1 piston is at the top dead centre (TDC) of the compression stroke.

In that position, the TDC marks on the timing scale and the pulley line up, and there is a clearance between the rocker and valve stem of both No. 1 cylinder valves (this happens only once every two crankshaft revolutions).

Check the clearances of numbers 1, 2, 3 and 5 valves by inserting the blade or blades of a feeler gauge between the rocker and valve stem.

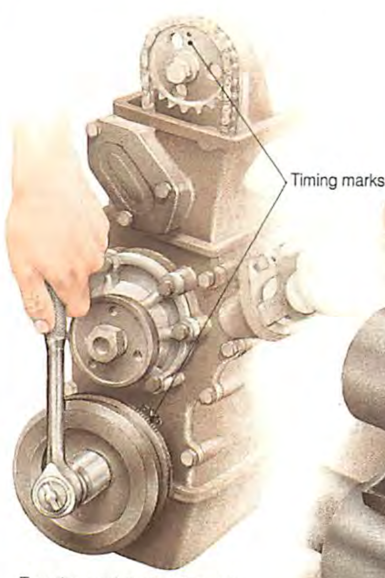
The clearance is correct when the gauge is a close sliding fit between the two parts.

If the clearance is wrong, either the blade cannot enter the gap or it is loose, so that you can move the rocker up and down with the blade in place.

If all these valves are correctly set, turn the crankshaft on one full turn until the TDC marks line up again, and check numbers 4, 6, 7 and 8 valves in the same way.

Adjust any incorrect clearance by slackening the locknut on the adjuster screw at the camshaft end of the rocker.

Use a screwdriver to turn the screw clockwise to decrease the clearance, the other way to increase it. When the clearance is correct, hold the screw steady while tightening the locknut, then re-check the clearance.



Turn the crankshaft pulley until the timing marks line up to show TDC position; the crankshaft turns twice for every turn of the camshaft.

Measure and adjust the clearance when the rocker arm pad is on the bottom of the cam.

Replacing gaskets and oil seals / 1

Gaskets and oil seals should be replaced if worn or leaking, or whenever removed during servicing. Replacement is simple, but some engine dismantling may be necessary to reach them. Buy gasket sets from a dealer for the make of car, and state clearly for what parts they are needed.

Tools and equipment

SCREWDRIVERS • SPANNERS • SOCKETS • PAINT SCRAPER OR OLD SCREWDRIVER • TYRE LEVER • PIPE PLUGS • WOODEN SCRAPER • STIFF BRUSH • WET-AND-DRY PAPER • STRAIGHT-EDGE • FEELER GAUGE • TWEEZERS OR LONG-NOSED PLIERS • RAWHIDE HAMMER • UNIVERSAL PULLER • GASKET SEALANT • TORQUE WRENCH • WOODEN SPACER • WOODEN BLOCKS AND WEDGES • BALL-PEIN HAMMER

Replacing a rocker or cam-cover gasket

Before removing the cover, note the positions of any pipes and wires round it or fixed to it, which have to be removed before it can be freed.

You may need to take off the air cleaner (SHEET 167), which may also have pipe connections.

The cover is fixed by nuts or bolts on top, or by screws round the edge. Loosen them all and remove them with their washers. If there are several oil-sealing washers under each fixing, note their order.

Carefully lift off the cover. If it sticks, gently tap it sideways with a soft-faced rawhide or nylon hammer, or with the heel of your hand.

If necessary, lever it gently with a broad screwdriver blade, but take care not to bend the flange or damage the head.

Take off the gasket from the cover flange or cylinder head, noting how it is attached. Some gaskets have tongues that fit cutouts in the flange; others are stuck to the flange with sealant; some just fit into the flange groove.

Cover the valve gear with a clean cloth to prevent dirt getting into the working parts of the engine.

Use a piece of wood to scrape off all traces of the old gasket from the head and cover. If total removal proves difficult, use a broad screwdriver blade, but take care not to scratch the seating.

Lift off the cloth, making sure no debris falls into the valve gear.

Fit the new gasket to the cover or head – whichever the old gasket was fixed to.

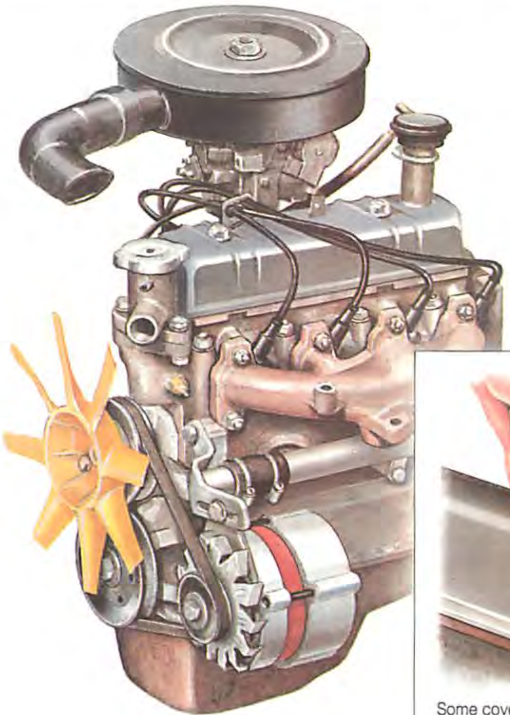
If it was stuck to the cover, smear gasket sealant along the cover flange and upper gasket and leave it to dry for a few minutes.

Fit the gasket to the cover, making sure any screw holes line up. If the gasket has tongues, fit them into their cutouts.

Some gaskets are in two or three pieces dove-tailed together. Make sure the pieces join up properly.

Refit the rocker or cam cover, aligning its fixing holes with those on the head. Check that the gasket edge aligns with the cover flange all round, and is not distorted. If necessary, adjust it gently with tweezers or long-nosed pliers. Tighten bolts evenly to just compress the gasket.

Refit all pipes and wires, and the air cleaner. Start the engine and check for oil leaks.



Some covers have central fixing bolts.

Some covers have screws round the flange.

Lift off the cover. It may need a gentle sideways tap to free it.

Cover the valve gear and scrape away the old gasket.

Replacing the fuel-pump gasket

This applies only to a mechanical fuel pump on the side of the engine.

First disconnect the battery earth terminal, to avoid the risk of a short circuit while the fuel pipes are disconnected.

Have two plugs, such as old pencils, ready to fit the pipes. Unscrew the pipe connections and plug them at once.

Remove the pump fixing nuts or bolts. Pull the pump and gasket or gaskets off the engine.

There may be a thick spacer gasket between two thin paper ones. Check the spacer for cracks. If it needs replacing, be sure the new one is the right thickness, because this governs the fuel-pump lever stroke.

Remove all traces of the old gasket from the pump and engine, using a paint scraper if necessary.

Smear gasket sealant on the mating faces of the pump and the engine. Refit the pump and gasket or gaskets and tighten the fixings.

Make sure the fuel-pipe connections are clean. Unplug them and reconnect to the pump.

Reconnect the battery. Start the engine and check carefully for oil or fuel leaks.

After disconnecting the battery, unscrew the fuel-pipe connections.

Plug the fuel pipe – an old pencil stub works well.

Unscrew the two nuts or bolts holding the fuel pump to the engine.

Remove the pump, together with its gaskets and spacers.

Replacing gaskets and oil seals / 2

Preparing to replace the sump gasket

On most cars you need not remove the engine to get at the sump. But often you have to raise it slightly and wedge it on its mountings so that the sump moves clear of the front-suspension cross member.

Look at the end of the sump. If you cannot see clearly whether you need to remove the engine, consult a car service manual or dealer.

Raise the front of the car on ramps, apply the handbrake and chock the rear wheels. Clean round the sump and the crankcase, clutch and gearbox. Drain the engine oil (SHEET 143). Use an adequate jack to lift the engine.

Put a wood block at least 6 in. (150 mm) square and 1 in. (25 mm) thick as a spacer between the jack and the sump to prevent damage.

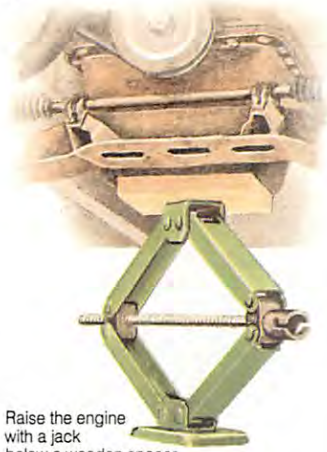
Raise the jack to take the weight of the engine off its mountings. Make sure you do not strain the radiator hoses or other connections. If in doubt, drain the radiator and disconnect the hoses (SHEET 121).

Note how the mounting nuts or bolts are fitted, then undo them. Have ready some wooden wedges to use as supports, and a strong helper to hold the engine steady.

Slowly raise the engine about $1\frac{1}{2}$ in. (38 mm) and insert wedges between the mounting rubbers and pads.

If this is not possible, you may be able to fit the lower retaining bolt into the upper mounting support, to hold the engine level. Or the gearbox may have to be jacked up and supported.

Once the engine is securely held, lower and remove the jack.



Raise the engine with a jack below a wooden spacer to protect the sump.

Supporting the engine

Insert wooden wedges into the engine mountings.

Replacing the sump gasket

Loosen all the sump nuts or bolts with a socket, long extension bar and ratchet handle.

On some engines you have to remove the clutch-housing cover to reach the rear nuts.

Remove most of the fixings, then support the sump with one hand while you take out the last few.

Carefully lower the sump from the crankcase.

You may need to turn the crankshaft so that it protrudes less. Turn the front pulley bolt with a spanner or socket.

Scrape off all the traces of dirt and old gasket from the engine and sump flanges with a paint scraper.

Clean sediment out of the sump with petrol and a stiff brush. Dry with a lint-free cloth.

Sump gaskets are usually in several pieces, often with separate curved seals that fit under the front and rear main-bearing housings of the crankshaft.

Lay out the pieces of the new gasket on clean newspaper, and note how the joints fit.

Coat the sump flange with gasket sealant and fit the flat parts of the gasket to it, ensuring that they are exactly positioned and joined.

If there are curved seals, fit these to the engine. Smear sealant on the seal groove, stick the seal in place, and apply a blob of sealant to each end of the seal where it joins the gasket.

Refit the sump, taking great care not to disturb the gasket. Hold it up by hand and fit two front bolts and two rear ones to keep it in place while you refit the rest.

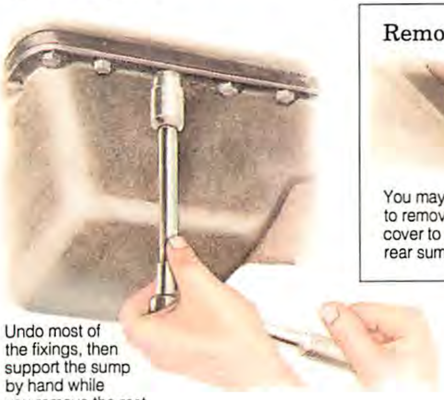
Tighten all fixings in sequence to the correct torque (consult a service manual or dealer if you are uncertain of the torque).

Put the jack and wooden spacer under the sump and raise the engine just enough to free the supports.

With a helper holding the engine steady, remove the wedge supports, lower the engine and reconnect the mountings loosely.

Replace the sump drain plug tightly and refill the engine with the right amount and grade of oil.

Start the engine and check for oil leaks round the sump flange. Stop the engine and tighten the mountings.



Undo most of the fixings, then support the sump by hand while you remove the rest.

Removing a clutch cover

You may have to remove the cover to reach rear sump nuts.

The gasket set includes curved half seals that fit to the crankshaft, not the sump flange.

Coat the flange with gasket sealant, then carefully fit the flat parts of the gasket.

Replacing a cylinder-head gasket

Remove the cylinder head (SHEET 156), carefully peeling off the old gasket from the head or block. Make sure no dirt or carbon falls into the engine.

The mating surfaces of the head or block must be perfectly clean, flat and smooth.

Stuff clean rags into the cylinder bores and all water and oil passages and bolt holes to catch scrapings and dirt.

Use a flat paint scraper, or the smooth side of an old hacksaw blade, to remove very carefully all traces of carbon and old gasket from both faces.

Take extra care with a light alloy block or head. It is vital to avoid scratching the machined surface.

Lift out the rags without dropping dirt into the engine, bores or passages.

Check the faces of the head and block for flatness. Alloy heads in particular can distort and then leak.

The block is unlikely to distort except after severe overheating, but check anyway using a steel ruler or similar high-quality straight-edge.

Place the ruler or straight-edge on edge diagonally across the head and block and look for gaps showing light anywhere between the ruler and block.

Repeat with the ruler laid diagonally between the other two corners.

If you find a gap, measure it by sliding a feeler gauge under the ruler.

If the gap is larger than 0·002 in. (0·05 mm) at any point, have the head or block checked and machined flat by a specialist.

Wipe the head and block absolutely clean with a cloth moistened with petrol.

Make sure that the new gasket is clean, and confirm which way round it fits. The upper side is usually marked 'top', 'haut' or 'oben'.

Set the gasket on the block and make sure that all holes are perfectly aligned before refitting the head (SHEET 156).

Stuff clean rags into bores. Scrape off the old gasket cement. Avoid scratching the machined surfaces of the block and head.

Check for flatness with a straight-edge laid across diagonally. Then measure gaps with a feeler gauge.

Replacing a crankcase side-cover gasket

On some engines, you need to remove one or both manifolds (SHEET 155) to reach the crankcase side cover.

The side cover may be held by one or more central bolts, or by screws round the flange. Undo the bolts or screws and remove them.

Free the cover by levering gently round the edge with a screwdriver; take care not to bend the flange.

Use an old screwdriver or scraper to carefully remove all traces of the old gasket from the cover and engine flanges.

Smear a little gasket sealant round the cover flange and fit the new gasket to it. Make sure it is flat and straight.

Apply gasket sealant to the engine flange and refit the cover. Tighten the fixings but do not overtighten them.

If the manifolds have been removed, refit them with new gaskets (SHEET 155).

Start the engine and check for oil leaks.

The side cover may be held by one or more bolts. Undo them, then prise it off carefully.

Replacing a crankshaft front oil seal

On most cars you need to remove several parts to get at the seal.

Slacken the alternator or dynamo adjuster and pivot bolts, push the unit inwards and ease off the drive belt. Remove the belt completely.

Remove the radiator (SHEET 121) if necessary, to make room for removing the crankshaft pulley.

If the car has a manual gearbox, select first or reverse gear and put the handbrake full on. Otherwise, disconnect the battery and remove the starter motor (SHEET 207).

Insert a tyre lever or large screwdriver into the starter aperture so that it jams in the teeth of the ring gear on the flywheel.

Unscrew the pulley bolt anti-clockwise with a socket and bar. Start it turning with a sharp blow on the bar.

On engines that rotate anti-clockwise (viewed from the front) the pulley bolt unscrews clockwise.

The pulley may slide off easily; if not, use a universal puller, which you may be able to hire.

The pulley is kept from turning on the crankshaft by a key fitting into grooves on the crankshaft and pulley.

Remove the key and keep it safe until ready to refit the pulley.

Thoroughly clean the area around the oil seal and check how it is fitted. If you cannot see the outer end of the seal, remove the timing-belt cover or chain cover (not the belt or chain) and possibly the water pump (SHEET 120) to reveal it. On an engine with a belt-driven overhead camshaft, remove the belt and its drive sprocket.

Lever the seal out with a screwdriver, working carefully to avoid scoring the seal housing.

Clean all dirt and oil from the housing, and set the new seal in place with its open (spring) side towards the engine.

Put a wooden block or a piece of large tube against the seal and gently tap it squarely into the housing until it is fully home. Refit the timing cover, if removed.

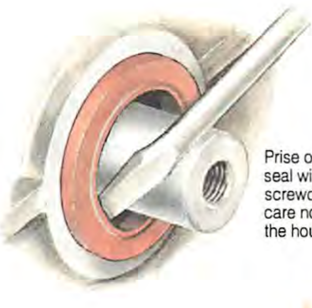
Thoroughly clean the sleeve at the back of the pulley, and look for any roughness on it where it touches the seal. If necessary, smooth it with fine wet-and-dry abrasive paper.

Smear clean engine oil on the pulley sleeve and seal, then refit the pulley with the key and keyway aligned. Tighten the bolt to the correct torque (consult a service manual or a dealer if in doubt).

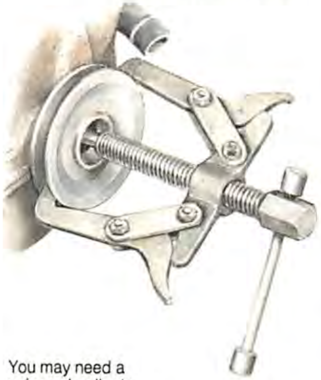
Refit all the components in the reverse order of dismantling.

Jam the flywheel ring gear to prevent the engine turning while you undo the crankshaft pulley bolt.

Remove the key that locks the pulley with the crankshaft.



Prise out the old seal with a screwdriver. Take care not to score the housing



You may need a universal puller to remove the pulley.

Tap in the new seal with a wooden block, keeping it absolutely straight.

Replacing a distributor oil seal or gasket

Remove the distributor cap. Before removing the distributor (SHEET 201), mark the position of the rotor arm so that you can refit it just as it was.

To do this, turn the engine with a socket on the crankshaft pulley bolt until the rotor arm is pointing to the plug contact of the timing cylinder (usually No. 1, check in the car service manual), and the timing marks on or behind the pulley show exactly top dead centre (TDC).

Mark the position of the rotor arm by lightly scratching a line on the distributor body. Disconnect the LT lead from the distributor body.

Loosen the securing-clamp bolt at the base of the distributor, then carefully withdraw the distributor.

If the drive gear has slanting teeth, they may cause the rotor arm to turn. If it does, mark its new position to aid refitting

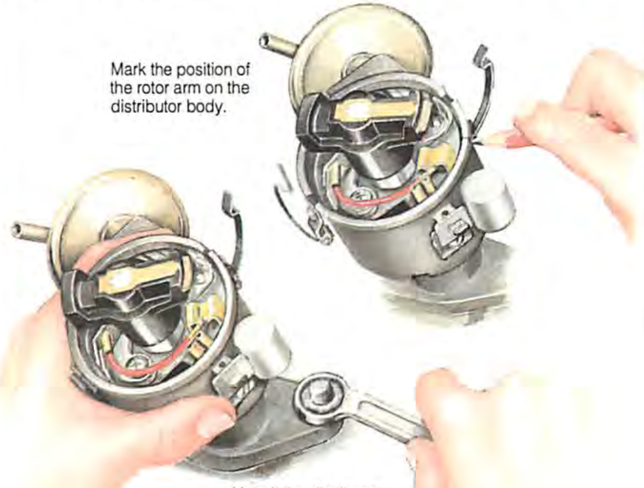
Some distributors can be removed without separating the gears, and so the arm does not turn.

There may be a rubber 'O' ring oil seal round the base of the distributor, or a paper gasket under the plate of the securing clamp. Remove either seal, clean away all dirt and oil, and fit the new one.

Refit the distributor, ensuring that the rotor arm is exactly in line with the first mark. If not, withdraw the distributor and try again.

Tighten the clamp bolt. Replace the LT lead and distributor cap, run the engine and check the timing (SHEET 203).

Mark the position of the rotor arm on the distributor body.



Unbolt the distributor; this type has a flat base and a flange-and-stud fitting.

A flat-based distributor has a paper gasket. Types with a clamp plate have a rubber 'O' ring.

Replacing engine mountings

The rubber anti-vibration mountings of an engine may crack or come away from the metal plates to which they are bonded.

Check with the engine running. Pull the throttle linkage of the carburettor so that the engine speeds up for a moment.

As it does so, watch the mountings; as the engine suddenly rocks on the mountings, any cracks or unbonded areas should open up.

Repeat with the engine switched off by rocking the engine by hand on its mountings.

An engine that is mounted longitudinally usually has two front mountings, which are easy to see. It also has rear mountings at the gearbox.

A transverse engine may have three or four mountings, some of which have to be checked (and if necessary replaced) from under the car.

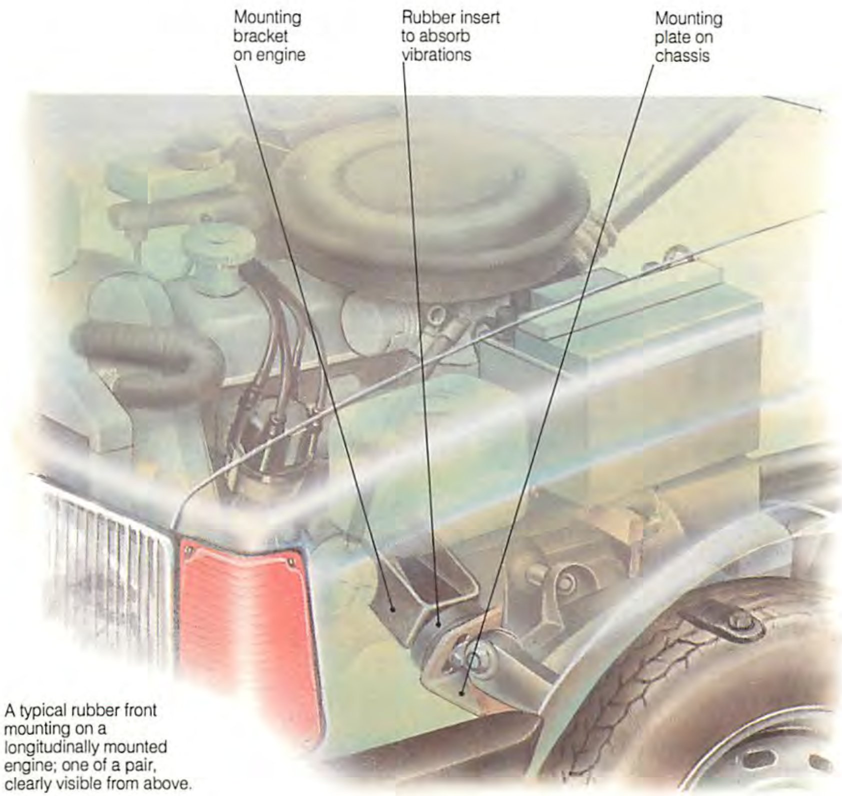
Raise the front wheels on ramps with the handbrake applied and the rear wheels chocked. Ask a helper to actuate the throttle.

If any mounting is faulty, replace both front ones for a longitudinally mounted engine, or all the mountings of a transverse one.

Tools and equipment

SOCKET SPANNERS • JACK • BLOCK OF WOOD

Mountings on a longitudinal engine



A typical rubber front mounting on a longitudinally mounted engine; one of a pair, clearly visible from above.

Replacing the mountings

If the engine has a steady bar or damper (SHEET 235) holding it to the body, unbolt one end of the bar or damper and swing it clear.

Support the engine with an adequate jack under the sump, as nearly as possible exactly between the mountings.

Protect the sump with a wood block at least 6 in. (150 mm) square and 1 in. (25 mm) thick.

Screw up the jack until the engine just rises. Look at the radiator hoses, exhaust, cables, pipes and linkages to make sure further movement will not strain them. Disconnect anything that seems at risk.

Raise the engine until the mountings are not bearing any load. The car body rises some distance too.

You may need to stand on a stool or wooden box to reach the mountings.

If you need to get under the car, make sure both engine and wheels are safely supported. On any car, disconnect only one mounting at a time so that the engine is never supported by the jack alone.

Undo the nuts and bolts holding the mounting to the engine and body, noting exactly how they and any washers are fitted.

Also note which way round the rubber part is fitted, then remove it and put in the new one.

Refit the nuts and bolts, but do not tighten them fully.

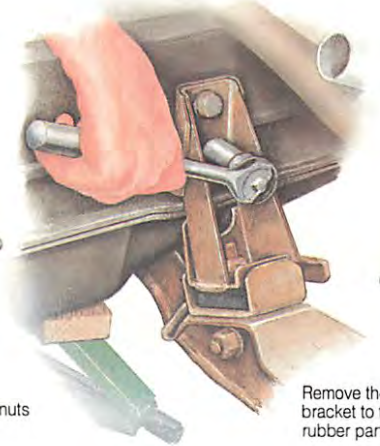
Replace other mountings as necessary in the same way.

Slowly lower the jack and remove it. Reconnect the steady bar and any disconnected engine fittings.

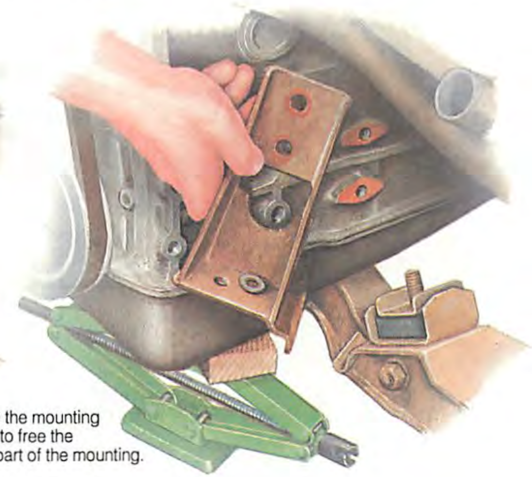
Start the engine and let it idle for a few minutes so that it can settle down into its normal place on the mountings. Tighten the nuts and bolts.

Finally, check the tightness of all the clips holding pipes and hoses to the engine, in case any have pulled loose.

Spread the load on the sump with a broad piece of wood.



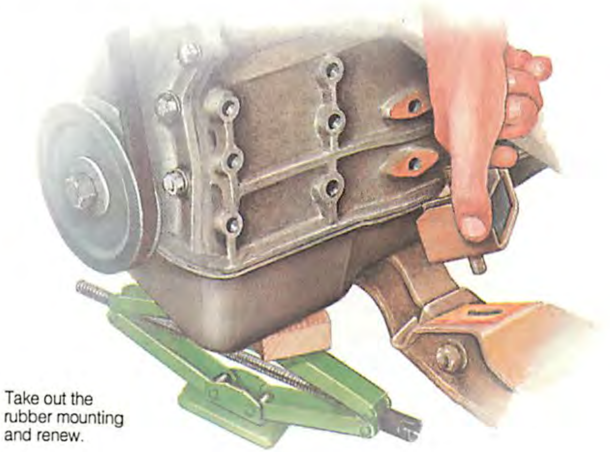
Unscrew the nuts and bolts.



Remove the mounting bracket to free the rubber part of the mounting.

Transverse-engine mountings

One type of mounting used on a transverse engine has a single central bolt, which is removed. The engine is raised sufficiently to prise away the rubber mounting.



Take out the rubber mounting and renew.

Replacing inlet and exhaust manifold gaskets

An exhaust-manifold gasket is more likely to need renewing than the gasket on the inlet manifold, because of the greater damage caused to the exhaust system by heat; but the procedure is much the same for both.

A 'blown' exhaust gasket can be detected by excessive noise from the exhaust, and by white burn marks around the manifold flange.

The inlet and exhaust manifolds may be on opposite sides of the cylinder head, or they may be combined or bolted close together.

If the engine has a V-configuration, there will be exhaust manifolds on the outer side of each cylinder bank, but probably just one inlet manifold located in the centre of the V.

Apply penetrating oil to all nuts or bolts which have to be undone, including the exhaust-pipe clamp fixing.

When the nuts or bolts are removed, the remains of the old gasket may cause the manifold to stick: tap the manifold with a rawhide hammer to loosen it. If any manifold studs are broken or damaged, remove them using self-locking grips, two nuts and a spanner, or stud remover (SHEET 49).

With the manifold off, carefully scrape all gasket-mounting surfaces clean of dirt and bits of the old gasket. Do not allow particles to fall into the manifold or the cylinder head.

Check the manifold to see that it is not cracked or damaged; check its face with a straight edge – such as a steel ruler – to see that it is not warped. If it is, replace it.

Fit a new gasket, making sure that it is the right way round, with all holes lined up. On some engines a gasket may be in two or three pieces, or inserts may be fitted; be sure all parts are properly aligned.

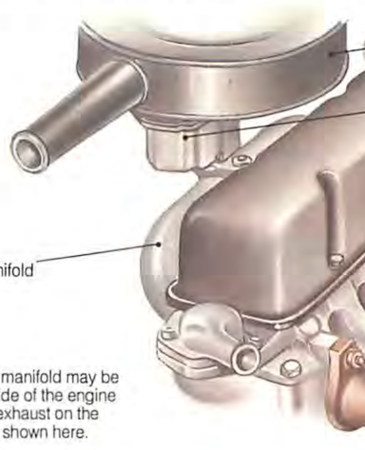
Some water-heated inlet manifolds, particularly on V-engines, require gasket sealant on each side of the gasket, because the larger water passages are more prone to leakage.

Reassembly is in the reverse order of removal. Tighten the nuts on the manifold, using a torque wrench adjusted to the setting recommended in the car service manual. The tightening sequence is usually from the centre of the manifold outwards to the ends.

After reassembly, run the engine to working temperature, switch it off and check the torque settings.

Tools and equipment

SOCKET SPANNERS • SCREWDRIVER • STRAIGHT EDGE • PENETRATING OIL • SCRAPER • TORQUE WRENCH • PENCIL STUB • RAWHIDE (SOFT-FACED) HAMMER • SELF-LOCKING GRIPS



The inlet manifold may be on one side of the engine and the exhaust on the other, as shown here.

Removing the inlet-manifold gasket

Remove the air cleaner. Make a careful note of all the connections to the carburettor.

Disconnect the choke and throttle cables to the carburettor. Then take off the fuel pipe.

If possible, keep the disconnected end of the fuel pipe higher than the level of fuel in the fuel tank.

If the end of the pipe is lower than the fuel level, plug it with a pencil stub or a small bung.

If the carburettor has an automatic choke, disconnect the water pipes or wires at the choke.

You may have to remove the carburettor completely (SHEET 178) before you can remove the manifold. If so store it upright in a clean place.

Take care not to damage the carburettor mounting block, which may be made of rubber or a composition material, and acts as a gasket.

If the inlet manifold is water-heated, drain the car cooling system (SHEET 115) until the coolant level is lower than that of the inlet manifold.

Disconnect the pipes or hoses from the inlet manifold.

Disconnect the brake servo pipe (SHEET 95) if fitted.

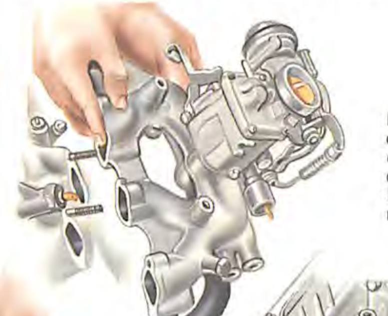
Remove the manifold and replace the gasket.

If the manifold is water-heated, and particularly if it is on a V-engine, check with your local dealer or with a service manual to see whether gasket sealant should be used on both sides of the gasket.

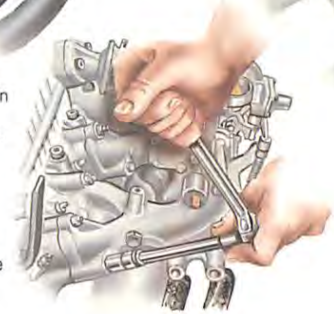
Reassembly is the reverse order of removal. When reassembly is complete, top up the car cooling system, run the engine up to working temperature and check that there are no leaks.

The inlet-manifold mounting at the centre of a V-engine.

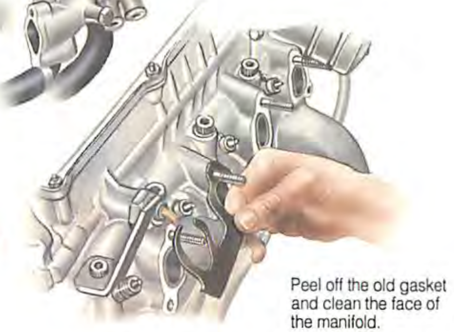
If the manifold is water-heated, drain the water and remove the hoses.



Lift off the manifold complete with its carburettor – if the carburettor has not been already removed.



Use a socket spanner to remove manifold nuts or bolts.



Peel off the old gasket and clean the face of the manifold.

Removing the exhaust-manifold gasket

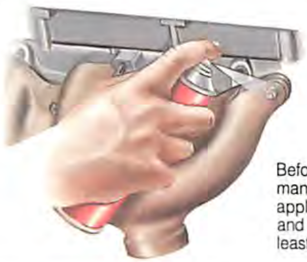
Check that there will be enough movement at the front end of the exhaust pipe to allow removal of the manifold.

If there is not, remove any exhaust-bracket connections on the engine or gearbox housing. Remove any other components which may be in the way.

Undo the clamp holding the exhaust pipe to the manifold. If the clamp has a gasket, fit a new one during reassembly.

Unscrew the manifold nuts or bolts. If there is a heat shield fitted, remove it. Take off the manifold and renew the gasket.

Reassemble in the reverse order of removal. Run the engine and make sure there are no exhaust leaks.



Before removing the manifold nuts or bolts, apply penetrating oil and let it soak for at least an hour.

Remove the manifold nuts or bolts after disconnecting the downpipe.

Use a straight-edge to check that the manifold face is flat.

Removing and refitting the cylinder head / 1

Removing the cylinder head is straightforward on pushrod engines, but more complicated on overhead-camshaft ones because you have to disconnect the timing belt or chain.

Methods vary from one engine to another, so if possible consult a handbook for your make of car to verify all the details.

Buy a new head gasket and a new rocker-cover gasket. Make a sketch of all the connections to the head so that you can refit them correctly.

Disconnect the battery earth terminal and cylinder-head connections. Drain the coolant.

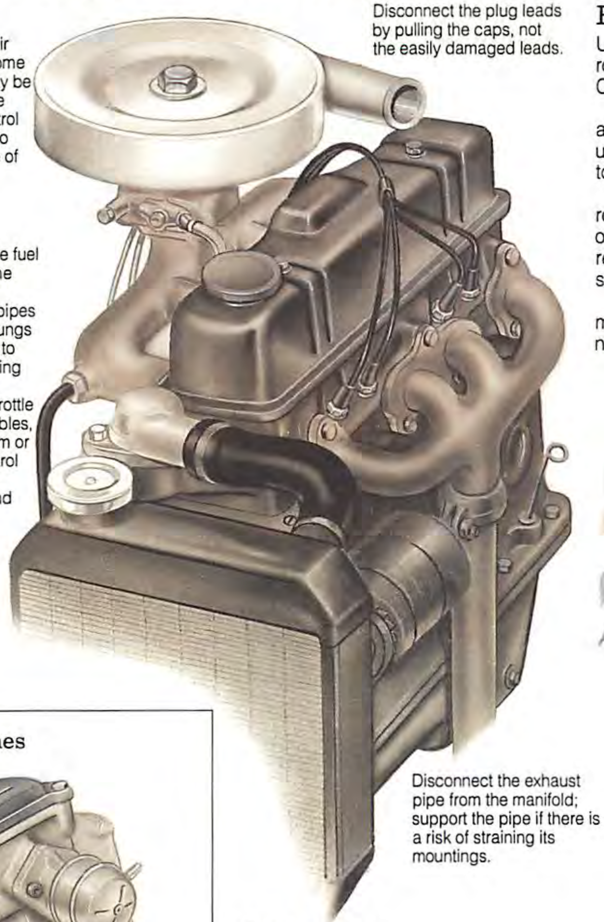
Leave the manifolds and carburettor attached if possible. If you do remove them, fit new gaskets (SHEET 155).

Tools and equipment

SPANNERS • SOFT-FACED HAMMER • SOCKETS • SPECIAL TOOLS IF NEEDED • WOOD BLOCKS • SCREWDRIVER • RULE • PAPER/NEWSPAPER • CARDBOARD/PLASTIC FOAM • TORQUE WRENCH • FEELER GAUGE • GASKETS • BUNGS

Remove the air cleaner: on some cars there may be pipes from the emission-control system fixed to the underside of the casing.

Disconnect the plug leads by pulling the caps, not the easily damaged leads.



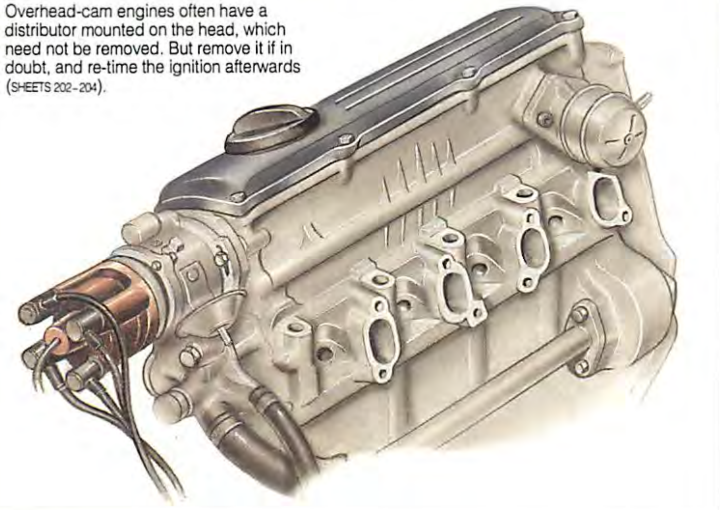
Disconnect the fuel supply from the carburettor, plugging the pipes with rubber bungs or old pencils to stop fuel running out. Also disconnect throttle and choke cables, and all vacuum or emission-control pipes on the carburettor and manifold.

Disconnect the exhaust pipe from the manifold; support the pipe if there is a risk of straining its mountings.

Drain the coolant by opening the radiator and cylinder-block drain plugs, if any, or by taking off the bottom radiator hose; then disconnect the top hose.

Head mounting on OHC engines

Overhead-cam engines often have a distributor mounted on the head, which need not be removed. But remove it if in doubt, and re-time the ignition afterwards (SHEETS 202-204).



Removing a pushrod head

Undo the nuts or screws holding the rocker cover to the top of the head. Carefully lift off the cover.

If it sticks, tap the side gently with a soft-faced hammer. Set the cover upside-down on clean newspaper to catch oil drips.

You may need to loosen the rocker-shaft support pedestal nuts or bolts gradually in sequence, then remove them. Lift off the rocker shaft and put it on clean newspaper.

On engines with separately mounted rocker arms, take off the nuts holding the arms and the pivot balls, then remove the arms and set them all in a row on a piece of paper numbered with their correct order, so you can refit them in the same places.

Lift out the pushrods and stick them through numbered holes in a piece of cardboard or plastic foam; they too must go back in the same places. Keep them in a clean place.

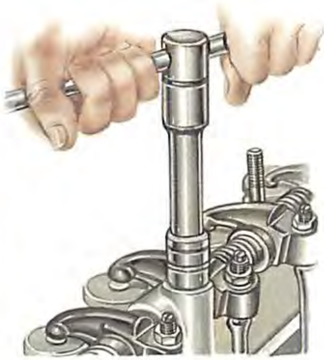
Use a socket and bar to loosen the nuts or bolts securing the head in the reverse of the tightening sequence for the engine (see car handbook). Some engines need a special adaptor tool to fit the bolts.

Carefully lift off the head, complete with manifolds if possible. You may need a helper to lift the head. If it sticks, tap the side gently with a soft-faced hammer.

Set the head right way up on wood blocks to protect its machined undersurface. Remove and discard the head gasket, after checking that the replacement one is the same in every detail.

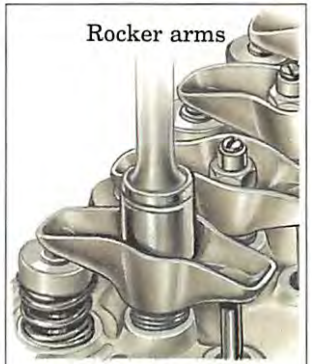
Take care not to let any dirt or carbon particles fall into the engine while you are working on it.

Unscrew the rocker-cover nuts or bolts; do not overtighten when refitting. The rocker cover may be fixed by screws or bolts at the flange.



Loosen and tighten the rocker-shaft nuts or bolts in sequence.

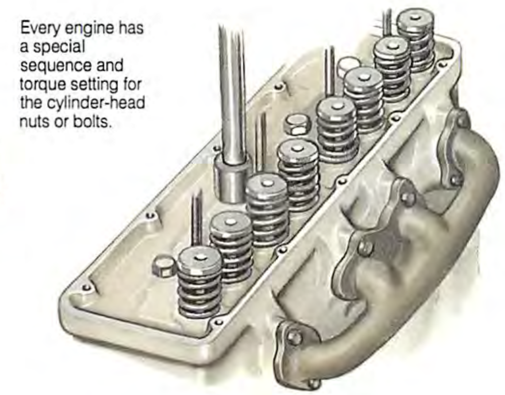
Rocker arms



Remove separately mounted rocker arms. Ensure that they are refitted in correct order.

Lift out the pushrods one at a time. Number the pushrods so that you can refit them in their original places.

Every engine has a special sequence and torque setting for the cylinder-head nuts or bolts.



Removing and refitting the cylinder head / 2

Removing an overhead-cam head

If the engine has a timing belt, remove the screws or bolts holding the belt cover to the front of the engine and pull the cover clear. Take care not to get oil on the belt.

Slacken the locking device of the belt tensioner (SHEETS 162–163 – some engines need a special tool).

Push the tensioner wheel out until you can free the belt. Take the belt off the camshaft sprocket, taking care not to rotate either the camshaft or crankshaft.

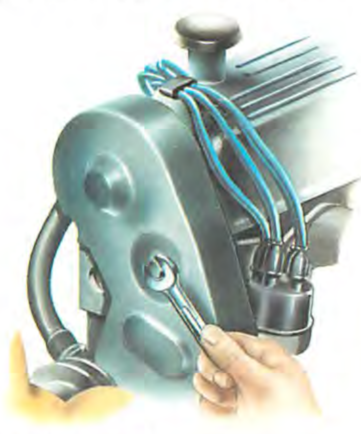
Undo the nuts or screws holding the camshaft cover to the head. Carefully lift off the cover: if it sticks, tap gently on each side with a soft-faced hammer. Set it upside-down on clean newspaper to catch oil drips. Remove and discard the gasket.

If the engine has a timing chain, after removing the camshaft cover, remove the nut from the camshaft sprocket. Pull off the sprocket and support the chain. Be careful not to drop any part into the chain case.

To remove the cylinder head, use a socket and bar to loosen securing nuts or bolts in the reverse order of the special tightening sequence for the engine. Some engines need a special tool to fit the bolts.

Carefully lift off the head – you may need a helper. If it sticks, tap the side gently with a soft-faced hammer. Set the head right way up on wood blocks to protect its machined undersurface.

Remove and discard the head gasket, taking care not to let any dirt or carbon fall into the engine.



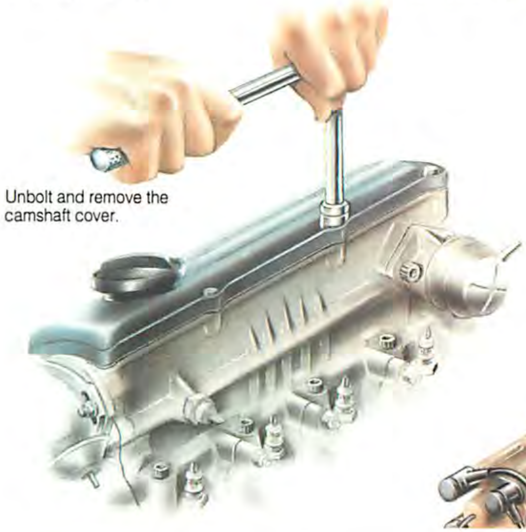
Unbolt the cover of a timing belt and take it off, or move it aside.

Loosen the belt tensioner to free the belt from the camshaft sprocket.

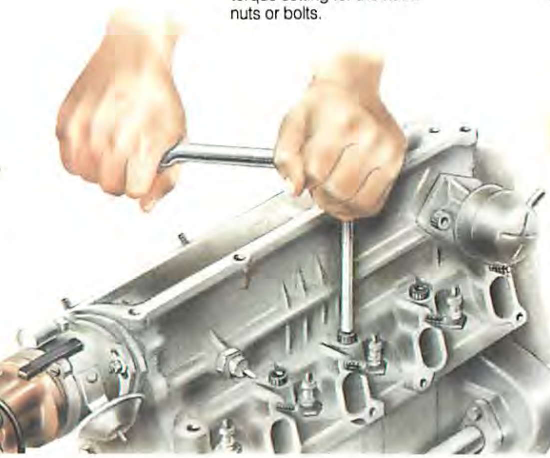
Removing a timing chain

After removing the camshaft cover, unbolt the camshaft sprocket to remove the chain.

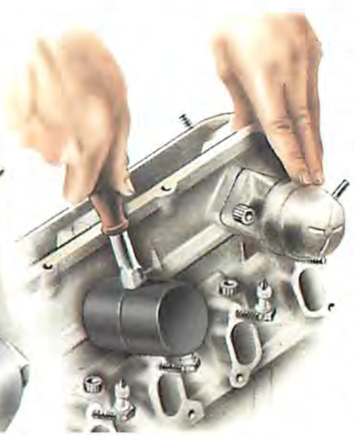
Remove the sprocket. Secure the chain so that it will not fall back into the chain case.



Unbolt and remove the camshaft cover.



Every engine has a special sequence and torque setting for the head nuts or bolts.



A gentle sideways tap with a soft-faced hammer will release a sticking head.

Refitting the cylinder head

Refitting is mainly a reversal of the removal procedure, but there are certain extra steps for both pushrod and overhead-cam engines (see below).

Check that the head and block faces are absolutely flat, using a steel rule (SHEET 152). See, too, that they are clean. Lay the new gasket on the block, right way round: the upper side is marked 'top', 'haut' or 'oben'.

Lower the head into place, taking care not to displace the gasket. Refit the head nuts or bolts and tighten in the correct sequence to the required torque setting (see DATASHEETS).

Refit all other parts, except for the rocker or camshaft cover and the air cleaner, in the reverse order of dismantling.

Check the valve clearances at the 'cold' setting (SHEET 148 and DATASHEETS). Refit the rocker or cam cover, using a new gasket.

Refill the cooling system and start the engine. Check for coolant leaks (SHEET 115).

When the engine is at its normal working temperature, switch it off and check the valve clearances at their 'hot' setting if specified (see the car handbook).

Pushrod engine

After tightening the head bolts, refit the pushrods in their original places, followed by the rocker shaft or separate rockers.

In either type, be sure that the upper end of each pushrod is engaged with its rocker and that the lower end is seated in the tappet before tightening the nuts or bolts.

Tighten rocker-shaft nuts or bolts in the recommended sequence and to the recommended torque – consult the car service manual or a dealer.

Make sure all the pushrods are engaged with their rockers before you tighten any nuts or bolts.

Overhead-cam engine

Before installing the cylinder head, turn the crankshaft with a spanner on the pulley nut until No. 1 piston is at its top-dead-centre (TDC) position of its compression stroke.

Verify this from the TDC mark on the crankshaft pulley. Turn the camshaft until the mark on its sprocket is in the correct position for No. 1 cylinder firing. Now refit the head and tighten its bolts.

Check that the crankshaft and camshaft are still at their marks, then refit the drive belt or chain.

Slowly turn the crankshaft two full turns in the normal direction of engine rotation.

Make sure the timing marks are again in alignment then, for a belt-driven camshaft only, adjust the tensioner (SHEETS 162–163).

If the marks do not line up, reposition the crankshaft first, then the camshaft.

Before refitting the head to an OHC engine, set No. 1 cylinder to TDC and line up the corresponding marks on the camshaft drive-belt sprocket. A chain-drive sprocket has similar marks.

Removing an overhead camshaft / 1

On some overhead camshaft (OHC) engines, the camshaft must be removed to take off the cylinder head (SHEETS 156-157). On any OHC engine the camshaft is removed to gain access to the valves.

The removal procedure varies with the make of car. Four common types of overhead camshaft and their methods of removal are detailed below.

Before refitting the camshaft, coat the bearing surfaces liberally with clean engine oil.

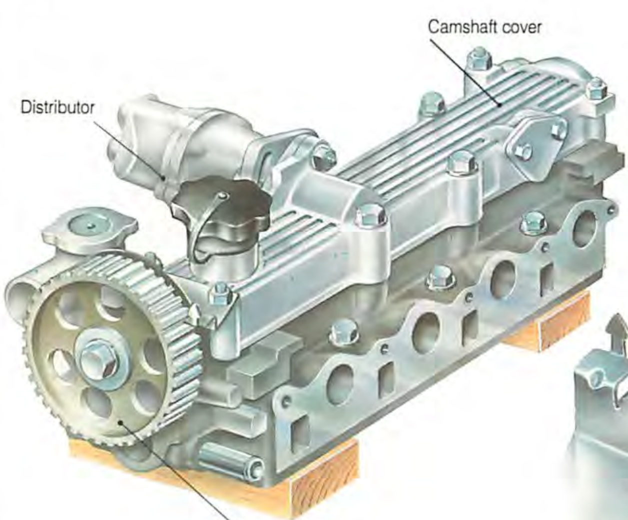
Refit in the reverse order of removal, using a torque wrench to ensure that bearing-cap and cylinder-head bolts are tightened to their recommended torque settings.

If you do not know the correct settings, consult a service manual for the car, or your local dealer.

Tools and equipment

SPANNERS • SOCKETS • TORQUE WRENCH • SCREWDRIVERS • MARKER, SUCH AS PUNCH • FORD SPECIAL TOOLS 21-008-A, 21-009-A (ALSO 20-005) • COMBINATION PLIERS • GASKETS • ENGINE OIL • CLOTH OR NEWSPAPER

Leyland O series



On the Leyland O series overhead camshaft, the camshaft-bearing caps are part of the cam cover.

Remove the camshaft of an O series engine only if you suspect that it is worn and wish to inspect it (you need not remove it to take off the cylinder head).

To reach the camshaft, remove the timing-belt cover, and disconnect the fuel pipe from the pump and the vacuum-advance pipe from the distributor cap.

Mark the position of the distributor in relation to the cam cover. Remove the distributor (SHEETS 201-202).

Use a spanner on the crankshaft pulley to turn the crankshaft until it is 90 degrees before top dead centre (TDC) on the compression stroke of its timing cylinder.

It is in this position when the V mark on the crankshaft pulley aligns with the pointer on the cam cover.

Release the timing-belt tensioner and remove the timing belt (SHEETS 162-3). Do not rotate the crankshaft while the camshaft is disconnected.

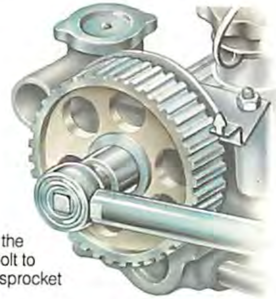
Remove the central bolt and take the sprocket from the camshaft. Take the end cover from the camshaft cover.

Slacken the cam-cover bolts evenly so that the valve-spring pressure is released slowly.

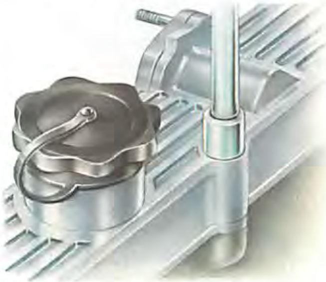
When all the bolts have been removed, take off the cover with its integral bearing caps. Lift the camshaft from the cylinder head complete with the front oil seal.

When refitting, align the camshaft timing marks before replacing the timing belt and distributor. Be sure to tighten the cam-cover bolts evenly, and to the recommended torque setting, so as not to alter the valve clearances.

At 90 degrees before TDC, the dimple on the cam sprocket also aligns with the cam-cover pointer.

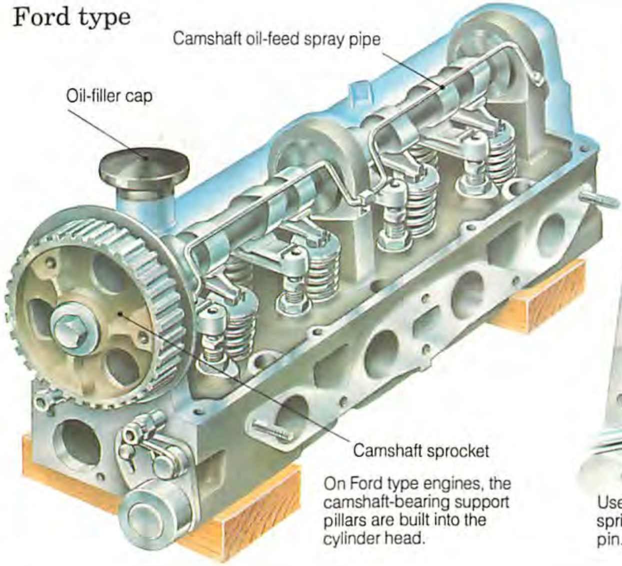


Remove the central bolt to take the sprocket from the camshaft.



Slacken the cover bolts evenly to release pressure slowly from valve springs.

Ford type



On Ford type engines, the camshaft-bearing support pillars are built into the cylinder head.

Remove the cylinder head (SHEETS 156-157). Place it, machine-face down, on wooden blocks, to prevent damage to the open valves.

Disconnect the oil-feed spray pipe from the bearing-support pillars.

Starting at the front of the head, undo the spring clip that secures the cam finger to its pivot pin. Lever under the camshaft (ideally with special tool 20-005) to compress the valve spring slightly so you can withdraw the cam finger.

Remove each of the cam fingers and put them in a clean, safe place in removal order.

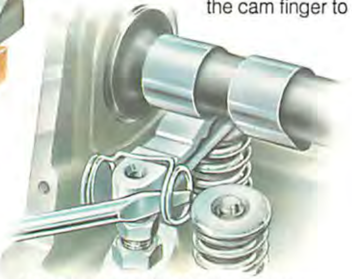
Use an open-ended spanner on the flats behind the sixth cam to hold the camshaft while you undo the sprocket centre bolt. Remove the sprocket and backing plate. Do not lose or damage the Woodruff key at the camshaft end.

Undo the two bolts holding the retaining plate to the rear-bearing support pillar and remove the plate. Withdraw the camshaft rearwards, taking care the cam lobes do not damage the bearings in the pillars.

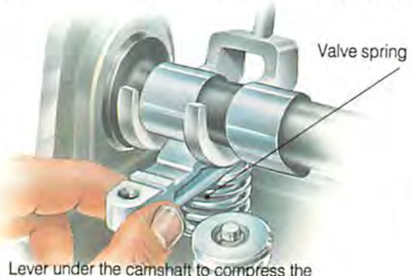
Check the condition of the front-bearing oil seal, and renew if worn.

Use special tool 21-008-A for removing the seal and 21-009-A for installation, available from a Ford dealer. Lubricate the outside and sealing lip of the new seal with engine oil before installation.

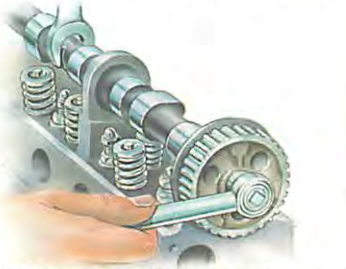
If necessary, take the head to a Ford agent for seal renewal.



Use a screwdriver if needed to undo the spring clip holding the cam finger to its pivot pin.



Lever under the camshaft to compress the valve spring slightly, then withdraw the cam finger. A special tool can be used.

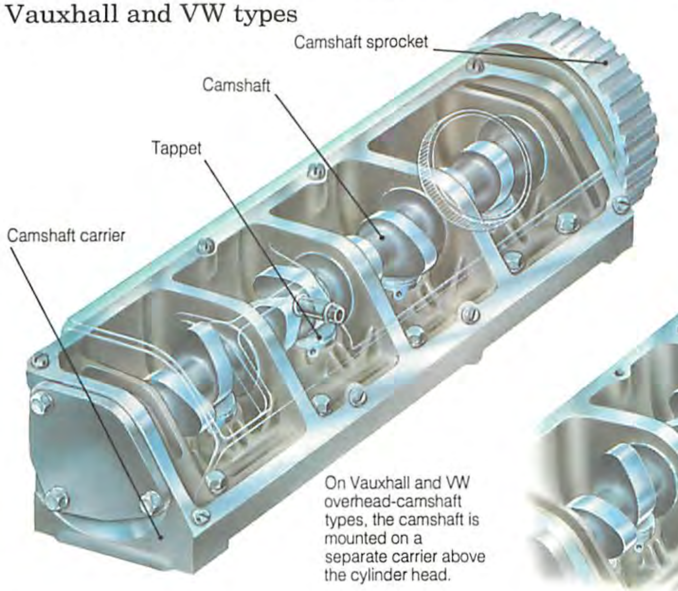


Hold the camshaft with an open-ended spanner behind the sixth cam and undo the sprocket.

Undo the camshaft retaining plate from the rear-bearing pillar and withdraw the camshaft rearwards.

Removing an overhead camshaft / 2

Vauxhall and VW types



On Vauxhall and VW overhead-camshaft types, the camshaft is mounted on a separate carrier above the cylinder head.

The camshaft carrier assembly is removed to gain access to the cylinder-head bolts.

Use a spanner on the crankshaft pulley nut to turn the crankshaft until the piston in No. 1 cylinder is at top dead centre (TDC), indicated when the timing marks are correctly aligned (SHEET 203).

Remove the camshaft drive-belt cover and disconnect the belt from the sprocket (SHEETS 162–163). Do not turn the sprocket, or the valves may contact the pistons and be damaged.

Remove the carrier cover and undo the carrier securing bolts evenly and in turn to avoid any distortion.

Carefully lift the carrier off the cylinder head. As soon as the tappets are clear of the valve springs, turn the carrier on its side so that the tappets do not drop out of their bores.

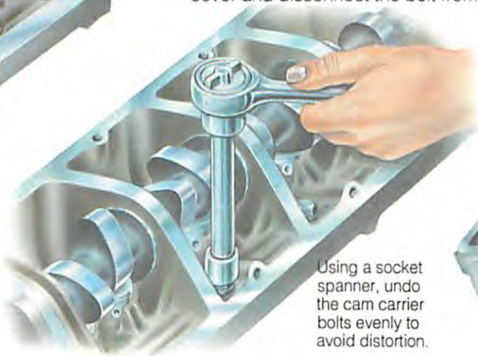
Undo the cam-sprocket centre bolt and remove the sprocket. Take out the tappets and place them in the order in which you removed them, so that you can refit them in the same positions.

Take off the end cover from the carrier and undo the thrust-plate retaining bolt. Carefully withdraw the camshaft rearwards, making sure the cam lobes do not damage the cam bearers in the support pillars.

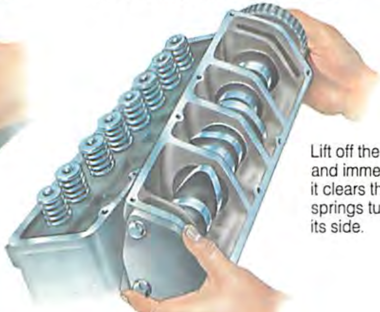
Check the condition of the front-bearing oil seal, and fit a new one if it is worn or leaking. Prise out the old seal with a screwdriver.

Oil the lip of the new seal and drive it in open side first until it abuts with the housing.

When refitting the carrier, renew any gaskets. Align the sprocket timing marks before replacing the drive belt.



Using a socket spanner, undo the cam carrier bolts evenly to avoid distortion.



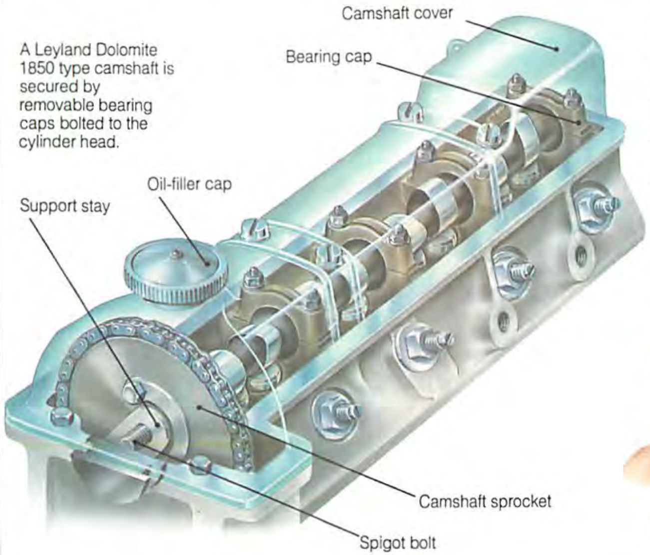
Lift off the carrier, and immediately it clears the springs turn it on its side.

Undo the centre bolt and take the sprocket off the camshaft.

Remove the end cover and thrust plate, then withdraw the camshaft.

Leyland Dolomite 1850 type

A Leyland Dolomite 1850 type camshaft is secured by removable bearing caps bolted to the cylinder head.



The camshaft must be removed to adjust the tappet shims, or to take off the cylinder head (SHEETS 156–157).

Remove the camshaft cover and gasket, and the rubber grommet in front of the camshaft drive sprocket. Use a spanner to turn the crankshaft until the timing mark on the camshaft sprocket flange is at the bottom.

Pack newspaper or clean, lint-free cloth into the space between the camshaft sprocket and the cylinder head so that nothing can fall in.

Find a nut to fit the sprocket spigot bolt and secure the bolt to the support stay (a bearing-cap nut usually fits). This will hold the sprocket and timing chain in position after the camshaft has been released.

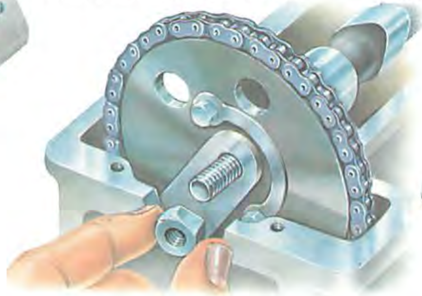
Remove one of the two bolts that secure the sprocket to the camshaft. Take out the packing and turn the crankshaft clockwise (from the front), until the timing mark on the camshaft sprocket flange aligns with the mark on the front bearing cap. Replace the packing and remove the remaining sprocket bolt.

Turn the crankshaft further clockwise until the timing mark is aligned at TDC. This will ensure the valves do not hit the pistons when refitting.

Slacken the nuts on the camshaft bearing caps evenly and a little at a time to release the valve-spring pressure slowly. Lift off each bearing cap and put it in removal order in a safe place.

Carefully lift off the camshaft from the cylinder head.

When refitting, align the camshaft timing marks before fitting the first sprocket bolt.



Secure the sprocket spigot bolt to the support stay with a suitable nut.

Pack newspaper between the sprocket and cylinder head before removing a sprocket securing bolt.

Align the camshaft timing marks before removing the second sprocket bolt.

Undo the bearing-cap nuts evenly and a little at a time to release pressure slowly.

Removing and grinding valves / 1

Good engine performance depends on valve condition. Worn guides or stems and burned or badly seated valves allow gas to escape under compression, resulting in poor starting and loss of power.

Valve springs, too, can affect engine performance. Over a period of time they weaken, causing the valves to 'bounce' on their seats as they close.

Tools and equipment

SPANNERS • VALVE-SPRING COMPRESSOR • WIRE BRUSH • SCRAPERS • WOODEN BLOCK • ELECTRIC DRILL • EMERY CLOTH • CUP-TYPE WIRE BRUSH • VALVE-GRINDING TOOL • GRINDING PASTE • FOOT PUMP • RAG • NEWSPAPER • PARAFFIN

Removing the valves

Support the cylinder-head assembly firmly on a suitable bench or work surface. See that there is sufficient space to store parts as they are removed, and cardboard boxes and clean newspaper available to keep them clean and safe.

Undo the nuts or bolts securing the inlet manifold to the side of the cylinder head; remove it, complete with carburettor if possible.

On some engines, the carburettor is unbolted and removed before you can gain access to the manifold nuts or bolts (SHEET 155).

Put the manifold/carburettor assembly in a clean, safe place – preferably on a sheet of newspaper.

Similarly, remove the exhaust manifold from the side of the head and place it with the inlet manifold.

On some engines, the inlet and exhaust manifolds are fitted and removed as one unit.

Undo the nuts or bolts securing the thermostat housing to the cylinder head. Ease off the cover and lift out the thermostat.

If necessary, unscrew and remove the temperature-gauge transmitter from the side of the cylinder head.

Turn the cylinder head on its side and support it on blocks to remove the valves. Place a valve-spring compressor over the valve nearest the front of the head.

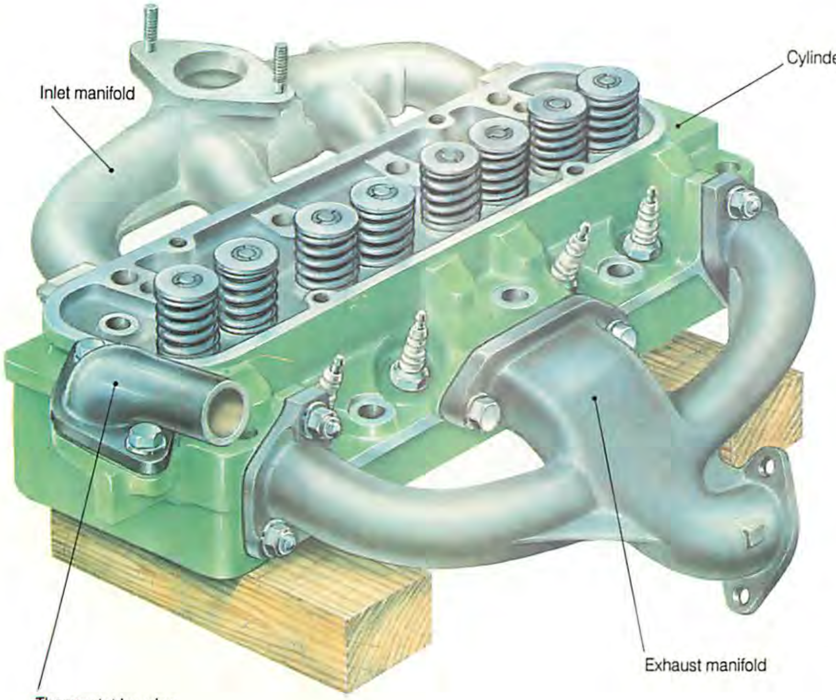
Compress the valve spring until the two split, tapered collets round the top of the valve stem can be removed. Take care not to drop them, they are easily lost.

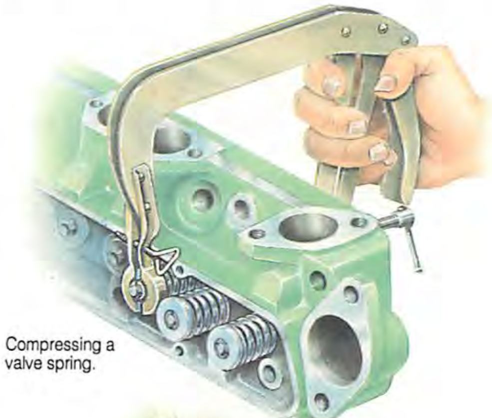
Release the compressor slowly until it is free, then remove the valve-spring assembly and withdraw the valve from the head. Place all the valve parts together for examination later. Discard the oil seals (if fitted).

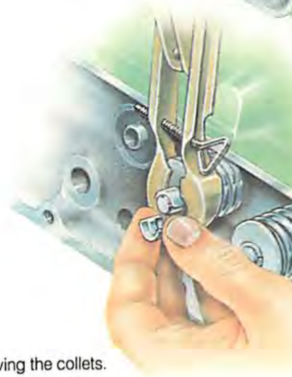
Repeat the valve-removal procedure on the remaining valves in the correct order, and place the components in their order of removal on a numbered sheet of clean paper, or push them into a piece of cardboard.

Alternatively, use the old cylinder-head gasket to store the valves in their correct sequence.

Each valve must be refitted in its original position on reassembly, as individual valves, valve guides and valve seats wear in different ways.




Compressing a valve spring.


Removing the collets.

Removing carbon

Remove all carbon deposits from the cylinder-head combustion chambers and valve ports, using a suitable scraper, such as a blunt screwdriver, and a wire brush.

Take great care to avoid scoring the surface of the valve seats or the machined face of the head, particularly on an aluminium-alloy head.

Clean the machined cylinder-head face to remove any remains of the old head gasket – use the smooth side of a hacksaw blade, or a paint scraper.

Again, take care not to scratch or damage the face.

Scrape until the face is smooth and flat. Modern head gaskets have a resin-coated finish which sticks the gasket to the surface and is often difficult to remove. Make sure you remove all of it.

Clean the carbon from each valve in turn. Grip the valve stem in the chuck of a stand-mounted electric drill – or vice-mounted if necessary. Turn at slow speed, if possible, and scrape off the deposits carefully with a screwdriver.

The valve head can be smoothed using very fine emery cloth. Remember to keep the valves in their order of removal.

Inspect the face and edge of each valve, looking for grooves, pits and for other signs of damage. If the valves are burnt, bent or damaged, renew them.

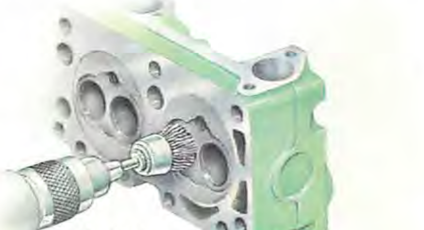
Check the valve seats in the head, looking for grooves, pitting and particularly for cracking.

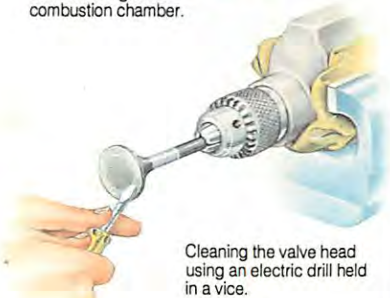
Slight pitting can usually be removed by grinding. More serious pitting is removed by having the valve seat recut at an engineering shop.

Clean all carbon and dirt from inside the inlet and exhaust ports, using a cup-type wire brush mounted in an electric-drill chuck. Protect your eyes with goggles.

Stubborn carbon particles can be removed by gently scraping with a blunt screwdriver, followed by the wire brush.


Cleaning inside the manifold ports.


Wire-brushing the combustion chamber.


Cleaning the valve head using an electric drill held in a vice.

Removing and grinding valves / 2

Checking valve guides

Check valve guides for wear by first refitting a valve into its respective guide, then raising the valve slightly off its seat.

Try moving the valve head from side to side. If the movement at the valve head is more than 0·007 in. (0·2 mm), the valve guide or the valve stem may be excessively worn – check the manufacturer's specifications, given in a service manual, or consult your local dealer.

If there is too much movement, repeat the test using a new valve. If this has less movement, the old valve stem is worn and the valve must be replaced. If there is still too much movement, the wear is in the guide and the cylinder head should be taken to an engineering shop for the replacement of all the guides.

If the guides are an integral part of the cylinder head, they can be reamed – opened out – to a larger size to take new valves with oversize valve stems. This work should also be entrusted to an engineering shop.

Check the valve stem and guide by trying to move the valve from side to side in the guide.

Grinding and refitting the valves

Generally valves should be ground, or 'lapped', into their respective seats to ensure a gas-tight seal. Grind-in each valve (including new valves) by hand, using a valve-grinding tool and valve-grinding paste (SHEET 51).

On some modern cars the valve faces have a thin coating which must not be removed. When fitting coated valves, use an old valve to grind the valve seat.

Smear clean engine oil on the valve stem, and attach the valve head to the sucker on the end of the grinding tool.

Smear a thin film of grinding paste round the chamfered edge of the valve head and insert the valve fully into its guide.

Rotate the grinding tool back and forth between the palms of the hands, pressing the tool and valve into its seat at the same time.

After a minute of continuous grinding, raise the valve off its seat, revolve it about 45 degrees, then continue the grinding process for another minute.

Repeat the grinding procedure, altering the position of the valve periodically until both the valve-head flange and the valve seat have an even, matt-grey appearance, which indicates that the valve and seat are making good contact all the way round.

If slight pitting remains on the seat, use a coarser grinding paste, followed by fine paste.

When all the valves have been ground-in, remove them and place each in its order of removal.

Wash the cylinder head, combustion chambers and valve ports thoroughly with paraffin, to remove all traces of grinding paste.

Dry the head with compressed air from a tyre foot pump, and blow through all oilways and bolt holes.

Clean all traces of grinding paste from the valves, remembering to keep them in their removal order.

Smear each valve stem with clean engine oil and refit the valves to their respective positions in the head.

If there are oil seals, fit new ones over the valve stems, taking care to avoid damaging the seal lips. Always fit new valve springs.

Place the new valve spring and spring cap in position over the valve stem, noting that the close-coiled end of the spring is usually fitted next to the head.

Compress the valve spring with the compressor tool until the two split, tapered collets can be slipped into position between the spring cap and the valve stem.

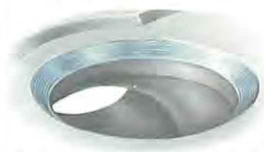
Slowly release the compressor tool until both collets are locking the spring cap and valve stem together.

Remove the compressor tool and repeat the valve installation procedure on the remaining valves, in the order in which you removed them.

Attach the sucker on the grinding tool to the valve face.

Grind the valve in its seat by rotating the grinding tool back and forth between the palms.

The valve and seat



The seat should have a matt-grey finish with no pitting or other blemishes.

The valve head should have a small step between the face and the seat. A knife-edged valve should be replaced.

Fit the oil seal over the valve stem.

Cleaning the pistons and cylinder block

Clean the piston crowns and cylinder-block face to remove any excess carbon and old head-gasket remains before replacing the cylinder head.

To prevent dirt or carbon particles entering the engine during cleaning, seal oil and water passages in the cylinder-block face with pieces of clean, lint-free cloth as necessary.

The cylinder bores, too, should be plugged with clean cloth to prevent dirt particles falling between the pistons and cylinder walls.

Use a scraper tool, such as the smooth side of a hacksaw blade, to carefully remove all traces of head gasket from the cylinder-block face. Take great care not to scratch or damage the face.

Rotate the crankshaft with a spanner or socket on the crankshaft pulley bolt to bring each piston to the top of its cylinder.

On engines with removable cylinders (wet-liners), hold a block of wood down firmly over the top edge of all the cylinders as the crankshaft is turned.

This prevents the cylinder liners from being lifted as the pistons rise up the bores, and ensures that the coolant seals at the bottom of the cylinder liners are not broken.

When each piston is at TDC, use a soft scraper such as a wooden block to carefully scrape carbon deposit from its crown, leaving a small ring of carbon round the outer edge adjacent to the cylinder wall.

Polish each piston crown with fine-grade emery cloth.

Clean all carbon and dirt from the cylinder bores and bolt holes, using either compressed air from a tyre foot pump, or a vacuum cleaner.

Make certain there are no carbon particles lodged in the bores.

Clean the block face, cylinder bores and piston crowns with a petrol or paraffin-moistened clean cloth, and then dry them.

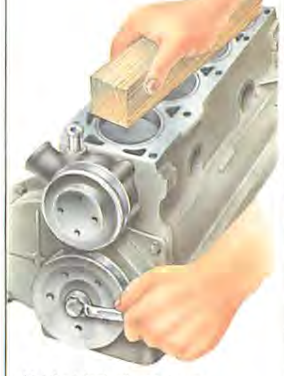
Be careful not to risk a fire – do not smoke, for example.

Smear a thin film of clean engine oil on each cylinder-bore wall and then remove the pieces of cloth from the oil and water passages.

Refit the cylinder head (SHEETS 156-157).

Scrape any carbon deposit from the piston crown.

Cylinder block with liners



Hold a block of wood over the cylinders to prevent the liners rising.

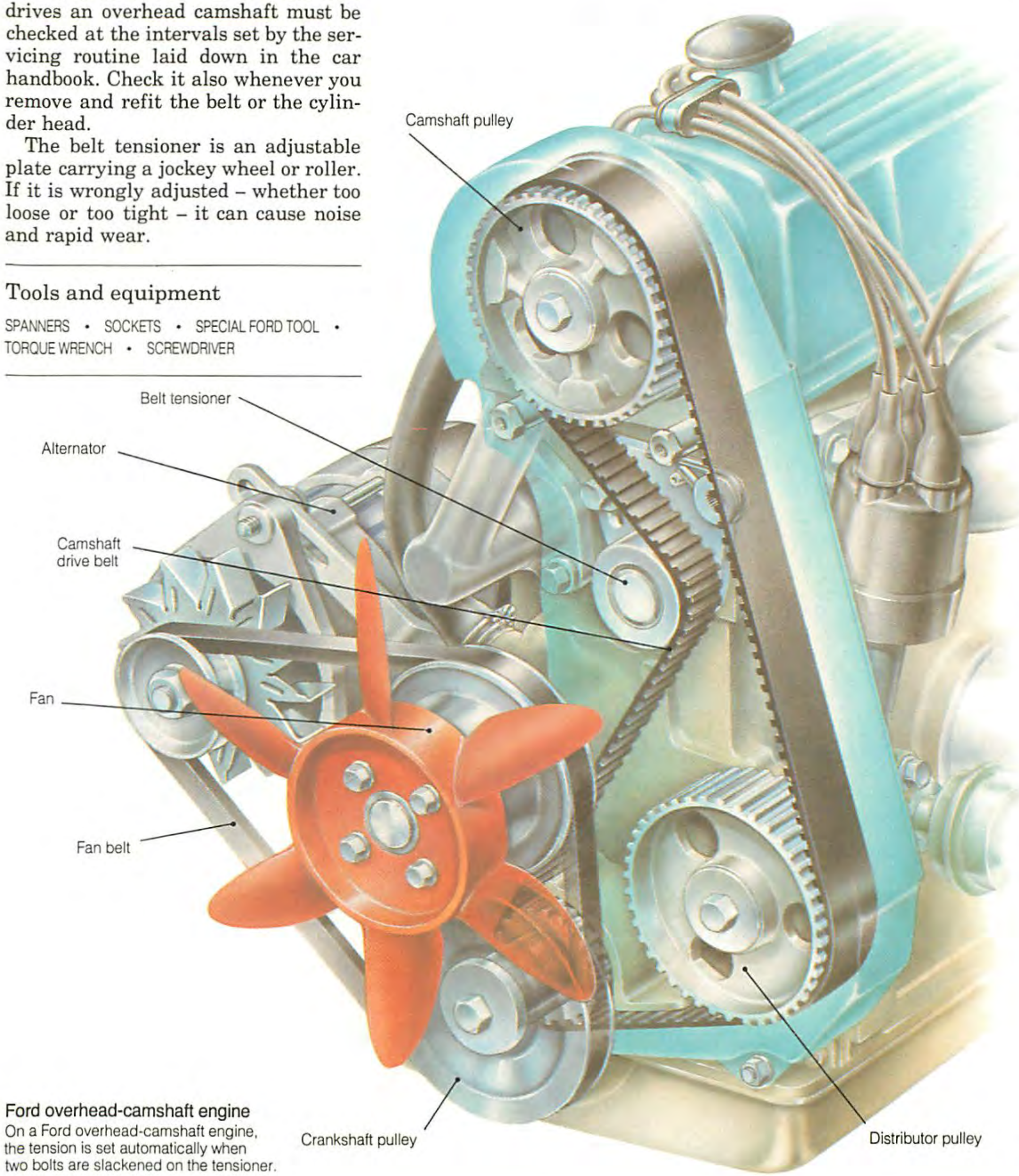
Adjusting a camshaft timing belt / 1

The tension of the toothed belt that drives an overhead camshaft must be checked at the intervals set by the servicing routine laid down in the car handbook. Check it also whenever you remove and refit the belt or the cylinder head.

The belt tensioner is an adjustable plate carrying a jockey wheel or roller. If it is wrongly adjusted – whether too loose or too tight – it can cause noise and rapid wear.

Tools and equipment

SPANNERS • SOCKETS • SPECIAL FORD TOOL • TORQUE WRENCH • SCREWDRIVER



Ford overhead-camshaft engine
On a Ford overhead-camshaft engine, the tension is set automatically when two bolts are slackened on the tensioner.

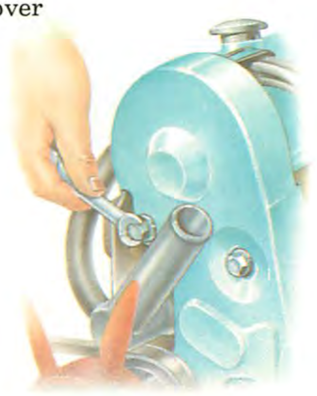
Removing the drive-belt cover

On most engines, some parts have to be removed before you can take the cover off the toothed belt.

Slacken the alternator adjuster bolts and push the alternator towards the engine to loosen the fan belt or alternator drive belt; ease the belt off. When refitting, tension it correctly (SHEETS 100-101).

Usually, the cover can be removed without taking off the crankshaft pulley. Sometimes, however, it has to be removed; to release it, unscrew the pulley retaining bolt and prise the pulley off with a screwdriver.

Unscrew the belt-cover bolts and carefully ease the cover off. The tensioner wheel is below the camshaft pulley.


Unscrew the belt-cover bolts.


On some cars, the crankshaft pulley has to be removed. Unscrew the retaining bolt.

Adjusting the tension on a Ford belt

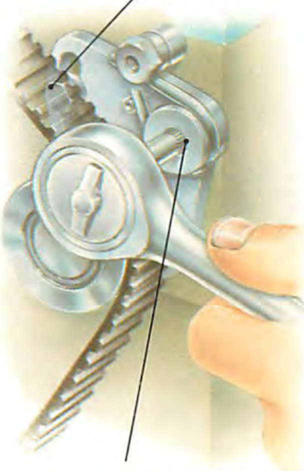
The tension is set automatically by a spring when two bolts are slackened – a locking bolt and a pivot-spring bolt.

Slacken the locking bolt, on the left, first. To slacken the pivot-spring bolt you need a specially splined tool that fits into a socket-wrench handle; it can be bought at a Ford dealer's spares department or at most car accessory shops.

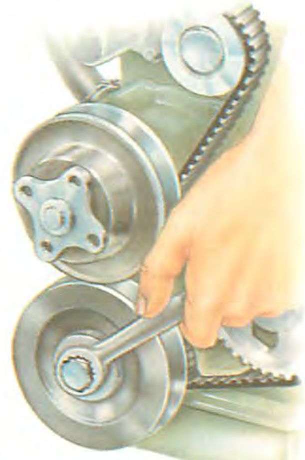
To even out the tension in the belt, use a spanner or socket wrench on the crankshaft-pulley bolt and turn the crankshaft two full turns clockwise.

Tighten the locking bolt, then use the splined tool in a torque wrench to tighten the pivot-spring bolt. It has to be tightened to a precise torque setting; check the figure with a dealer or the car service manual.

Refit the drive-belt cover and fan belt.



Slacken the pivot-spring bolt with a special splined tool fitted to a socket wrench.


Give the crankshaft pulley two full clockwise turns to even out the tension in the belt. Make sure the ignition is switched off or the battery disconnected.


Tighten the locking bolt first to hold the tensioner in its new position. Tighten the pivot-spring bolt, which has a precise torque setting.

Adjusting a camshaft timing belt / 2

Adjusting the tension on a Leyland 'O' series belt

The belt tensioner has no automatic spring. To measure the tension, use a spring balance with its hook bent to an L shape to fit flat against the belt. (If necessary, use a separate L hook.) The spring balance must be capable of measuring at least 13 lb (6 kg).

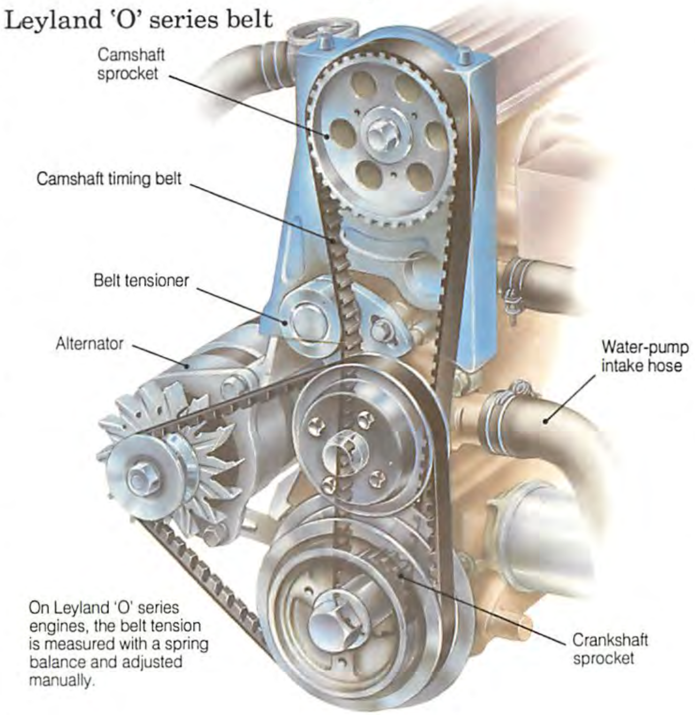
Fit the hook to the belt midway between the camshaft and crankshaft sprockets, at the level of the water-pump intake-hose stub. Pull the spring balance until the edge of the belt is in line with a raised mark on the water-pump intake-hose stub.

The balance should read 11 lb (5 kg) for a used belt, 13 lb (6 kg) for a new belt. If it does not, adjust the tension.

The tensioner is a roller which bears on the outside face of the belt. It has two adjustment bolts, one of them fitted over a slot. Slacken both bolts just enough to let you slide the tensioner.

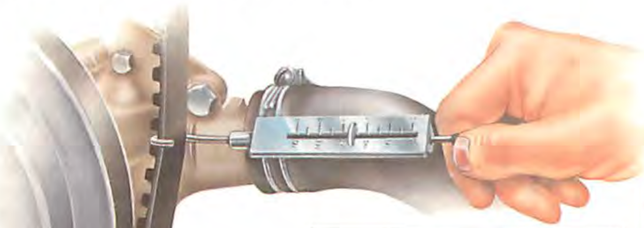
Move the tensioner as necessary to tighten or loosen the belt. Lock it by tightening the bolt over the slot.

Re-check the tension and readjust if necessary. When it is correct, tighten both bolts and refit the timing-belt cover and fan belt.



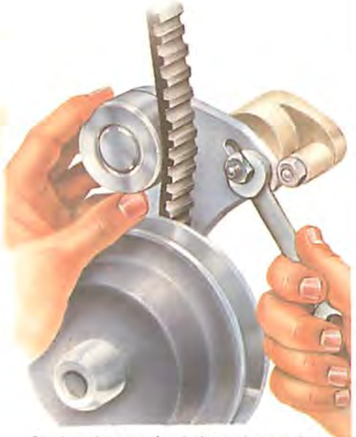
On Leyland 'O' series engines, the belt tension is measured with a spring balance and adjusted manually.

Checking with a spring balance



Check the timing-belt tension with a spring balance with an L-shaped hook.

Pull the belt to align with the marker on the pump intake pipe.



Slacken the securing bolts and move the belt tensioner as required to adjust the tension.

Adjusting the tension on some VW, Vauxhall and similar belts

The belt tensioner has no automatic spring. Check the tension by twisting the belt with your thumb and forefinger, midway along the longest straight run between the two main sprockets.

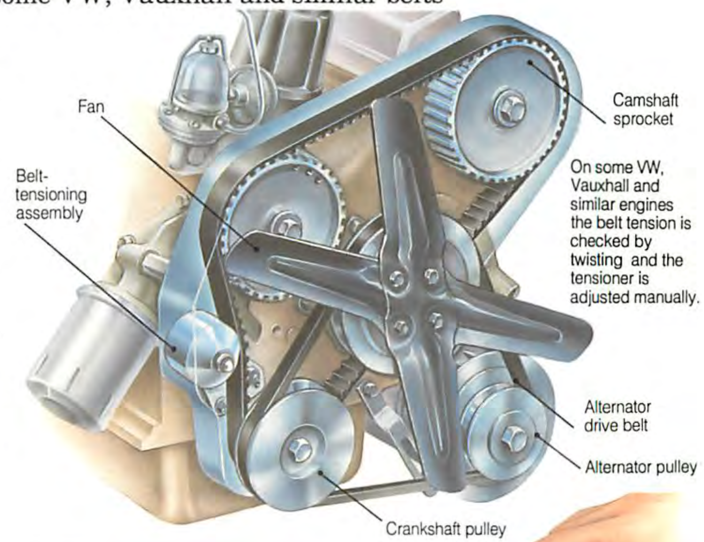
If the belt tension is correct, you should just be able to twist it through 90 degrees. If you can twist it more or less than this, the tension needs to be adjusted.

Slacken the single nut in the slot of the tensioning assembly. Slide the tensioner clockwise to increase the tension, the other way to reduce it.

Tighten the tensioner nut and check the tension again. Readjust if necessary.

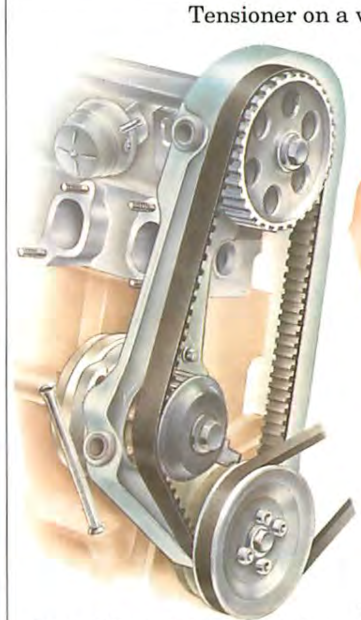
On some VW cars, the belt tension is adjusted by slackening the water-pump securing bolts and levering the pump away from the cylinder block.

When the belt tension is correct, refit the timing-belt cover and alternator drive belt.

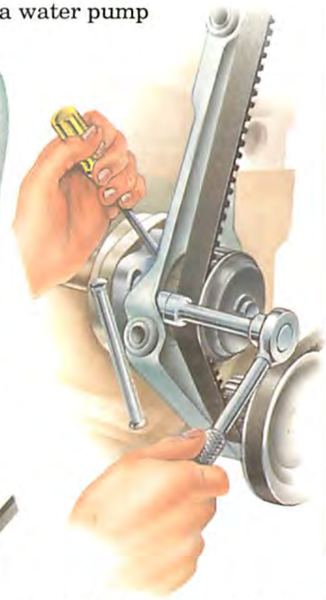


On some VW, Vauxhall and similar engines the belt tension is checked by twisting and the tensioner is adjusted manually.

Tensioner on a water pump



On some VW cars, the belt is tensioned round a sprocket on the water pump.



To adjust the tension, slacken the water-pump securing bolts and lever the water pump away from the cylinder block.

The belt tension is correct if you can just twist it through 90 degrees with thumb and forefinger.

Slacken the nut and slide the tensioner assembly clockwise to increase tension.

Checking the cylinder compression

A good way to check engine wear is to test the compression of each cylinder using a compression tester (SHEET 48), which you can buy or hire.

The check will reveal any leakage and enable you to detect whether the cause is worn piston rings, a blown cylinder-head gasket or a valve that is not seating properly.

Test each cylinder in turn while the engine is being cranked by the starter motor, and then compare the pressure readings with each other and with the pressure specified in DATASHEETS or the car handbook.

Tools and equipment

PLUG SPANNER • COMPRESSION TESTER • CLEAN ENGINE OIL

Testing each cylinder

Run the engine until it reaches normal working temperature, then remove all the sparkplug leads. If there is a risk of getting the leads confused, label them.

Remove the LT lead from the coil to avoid possible sparking at the plug caps. On a fuel-injection engine, disconnect the fuel-pump supply lead at the fuse.

Ask a helper to press the accelerator pedal hard down to open the throttle fully, and to be ready to turn the ignition switch to crank the starter.

Remove a cylinder sparkplug and screw or push the connector of the compression tester into a sparkplug hole. If it has to be held in place, hold it firmly to avoid leaks.

Tell your helper to crank the engine for at least ten revolutions, or about six to eight seconds. Take care that loose clothing or hair does not get caught in belts or pulleys.

The pressure reading on the gauge increases in steps, and may take up to ten revolutions to reach a maximum.

Note the pressure, and how many revolutions it took. Then test all the other cylinders, in the same way, noting the reading after the same number of turns.

The figures should be within 10 per cent of each other and of the maker's figure if the engine is in good condition.

If one or more cylinders give a lower result than the others, a further test (described in the next column) shows whether the leakage is past worn piston rings or elsewhere.

Tracing the fault

Pour about a dessert spoon (½ fl. oz or 10 ml) of clean engine oil into the suspect cylinder.

Reconnect the compression tester and crank the engine as described in the previous columns.

If there is a marked increase in pressure, the piston rings are worn. If not, either the bore is so damaged that the oil has failed to seal it or – more likely – the gasket or valves are at fault.

To check the valves the cylinder head must be removed (SHEET 156). A leaking gasket, however, will show other symptoms besides loss of compression. A leak between cylinders will cause rough running, and there may be a loss of coolant into the sump which will show as a white emulsification on the dipstick and a high oil-level reading.

Using a vacuum gauge

It is possible to check cylinder compressions by using a vacuum gauge (SHEET 48), if you have one or if one is fitted to your car.

If the needle of the gauge drops to zero when the engine is idling, and returns to 22 when the engine is turning at high revolutions, the piston rings are probably worn.

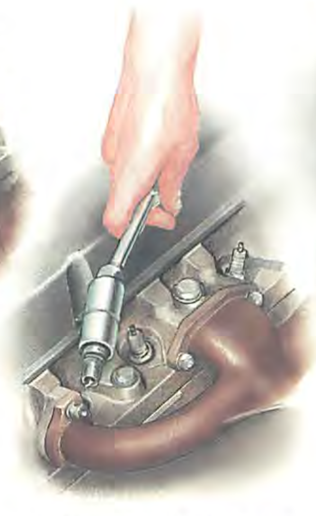
When the needle drifts between 5 and 19, the cause may be a compression leak in the cylinder-head gasket between two or more cylinders.

A zero reading at idling speed after a 22 reading at high speed indicates worn piston rings.

If the needle drifts between 5 and 19 there may be a leak at the cylinder-head gasket.

Connecting a compression tester

Remove the plug leads by gripping the caps, not by pulling on the leads which may damage them. Label the leads if necessary to avoid confusion when refitting them.

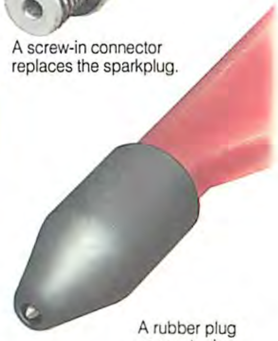


Clean the area around the plug holes to prevent dirt getting into the engine. Remove the plugs with a plug spanner.

The reset button is on the handle – remember to reset the tester to zero before testing the next cylinder.

The compression tester usually screws in although some models have a rubber plug.

A screw-in connector replaces the sparkplug.



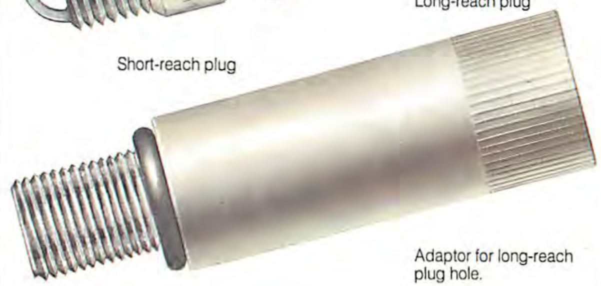
A rubber plug connector is hand-held in the sparkplug hole.

Using an adaptor

Plugs may have a long reach or short reach, the length of the thread from the plug body to the nose. A tester with a screw connector has an adaptor which should be fitted when inserting the connector into the socket of a long-reach plug.

Long-reach plug

Short-reach plug



Adaptor for long-reach plug hole.

Checking the oil pump

Low oil pressure – indicated on the oil-pressure gauge or dashboard warning light – could provide an indication of wear or damage to the pump.

The oil pump is usually one of three types: the multi-lobe rotor type, the gear type, or the vane type.

Whichever type of pump is fitted, it must be removed from the engine before it can be properly checked.

The pump can be mounted either outside or inside the engine crankcase. An internally mounted pump can be reached only after removing the sump. This may entail taking out the engine, which is a job for a garage.

When you have removed the pump (SHEET 166), take out the screws or bolts holding the end cover. Hold the pump with the cover uppermost and take off the cover.

First look for obvious wear, such as heavy scoring inside the end cover. Then look for traces of metal particles inside the pump body. Lift out the rotor assembly, pump gears or vane assembly and check for scoring and pitting. Note carefully how they come out, so that you can put them back in exactly the same position.

If the pump shows any obvious signs of wear or damage, fit a new one. If it appears to be in good condition, clean it thoroughly with petrol and put it back together.

Then, using a feeler gauge and a straight-edge – such as a steel rule – measure the clearances between the moving parts. If any of the recommended clearances are exceeded (see right), the pump is worn and you should fit a new one.

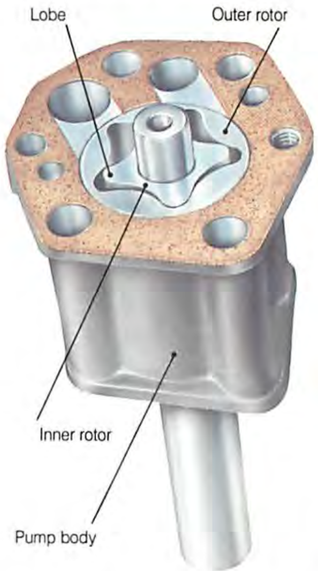
If the clearances are within the specified limits, fill the pump with clean engine oil.

Before you replace the end cover, make sure that the sealing ring or gasket is in good condition and positioned correctly.

Tools and equipment

SPANNERS • FEELER GAUGES • STEEL RULE

Clearances on a multi-lobe rotor-type pump



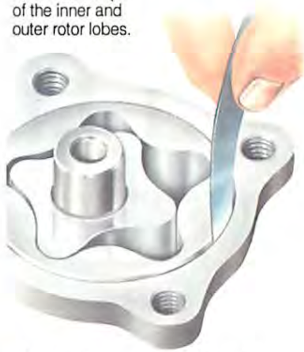
Turn the drive gear until the tips of an inner and an outer lobe are opposite to each other. The clearance here usually should not be more than ·010 in. (·25 mm).

Put the feeler gauge between the outer rotor and the pump body. The clearance here should generally be no more than ·010 in. (·25 mm).

Make sure that the face of the pump is clean, and put a straight-edge across the pump body. The gap between the straight-edge and the rotor surface should generally be no more than ·005 in. (·13 mm).

Centre an inner rotor lobe on an outer rotor lobe and measure the gap between them. Repeat with the other lobes.

Check the clearance between the tips of the inner and outer rotor lobes.



Measure the gap between the outer rotor and the pump body.

Gear-type pump

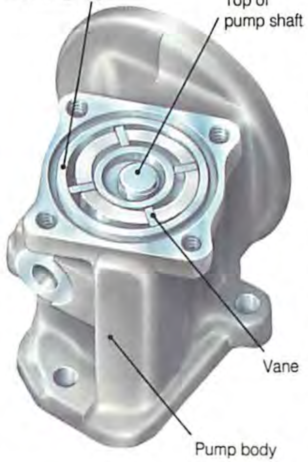
Check the clearance between each gear tooth and the pump body. At the closest point it should typically be no more than ·006 in. (·15 mm).

Make sure that the face of the pump is clean, and put a straight-edge across it. The gap between each gear and the straight-edge should typically be no more than ·003 in. (·07 mm).

Rotate the gears, and measure the gap between each tooth and the pump body.

Check the gap between the straight-edge and the face of the two gears.

Checking a vane-type oil pump



Make sure that the pump is clean, and then put a straight-edge across the face of it. Use a feeler gauge to check the clearance between the straight-edge and the vanes and rotor. The gap should be no more than ·005 in. (·13 mm).

Turn the pump shaft until the locating ring has moved to the outermost edge of one of the vanes. Measure the gap at this point, between the vane and the pump body. It should be no more than ·005 in. (·13 mm).

Without moving the locating ring, measure the gap between the opposite vane and the pump body. It should be no more than ·010 in. (·25 mm).

Check the clearance of each vane in its locating groove. The clearance should be no more than ·005 in. (·13 mm).

Measure the gap between the straight-edge and the surface of the vanes and rotor, using a ·005 in. (·13 mm) feeler gauge.

Check the lateral clearances between the rotor assembly and the pump body.

Check for too much clearance round each vane in its groove.

Removing the oil pump

If the oil pump is fitted to the outside of the engine, you may be able to reach it from under the bonnet.

If not, apply the handbrake and support the engine end of the car on axle stands. Chock the other wheels.

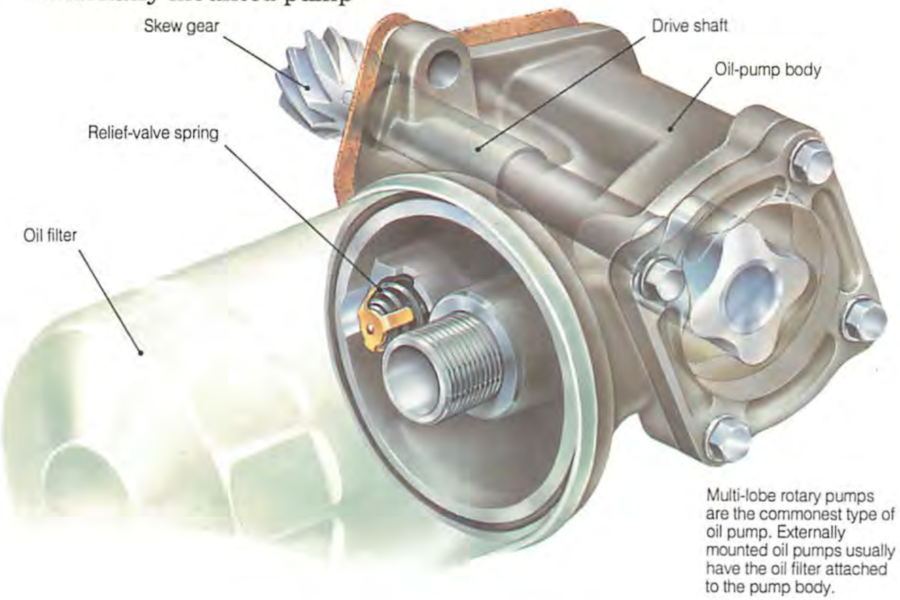
On externally mounted pumps, remove the oil filter (SHEET 143). On engines where the pump is inside the crankcase, drain the engine oil and remove the sump pan.

Removing the sump pan can involve removing or raising the engine. If so, the repair is best left to a local main dealer. On certain cars it may also mean taking off the gearbox. If you are in any doubt, consult a dealer.

Tools and equipment

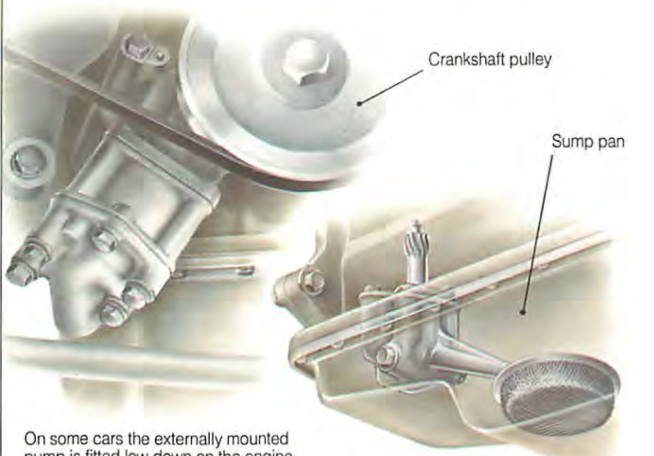
AXLE STANDS • CHOCKS • DRAIN TRAY • SPANNERS • SOCKETS • THIN SCREWDRIVER • SCRAPER • GASKET • GASKET SEALANT • TORQUE WRENCH • ENGINE OIL • PARAFFIN, PETROL OR WHITE SPIRIT • LINT-FREE RAG

Externally mounted pump



Multi-lobe rotary pumps are the commonest type of oil pump. Externally mounted oil pumps usually have the oil filter attached to the pump body.

Other ways of mounting the pump



On some cars the externally mounted pump is fitted low down on the engine near the crankshaft pulley. Its drive shaft may also drive the distributor. This type of pump does not have an oil filter attached.

The oil pump may be inside the engine. To reach it, the engine oil has to be drained and the sump pan removed.

Removing, checking and refitting the pump

Put a tray or rag under the engine to collect any drips of oil, and unscrew the bolts securing the pump to the engine block.

As you withdraw the pump, mark the position of the pump drive shaft so it can be put back in exactly the same way.

The drive shaft sometimes drives the distributor as well (check in the service manual). On such engines, remove the distributor cap and mark the position of the rotor arm.

If the rotor arm is moved at any time – if the engine is turned, for example – the ignition timing will have to be reset (SHEETS 203–204).

On externally mounted pumps with a skew gear, the gear can usually be put back in any position.

Use a rag dipped in petrol and, if necessary, a scraper tool to carefully remove dirt and any gasket remains from the pump mounting flange.

Be careful not to damage the mounting faces on the pump or engine. Usually only externally mounted pumps have a gasket.

Make sure the working parts of the pump are thoroughly cleaned (SHEET 165).

On externally mounted pumps, fit a new gasket to the pump flange, and keep it in position with a smear of gasket sealant while you locate the drive shaft.

Make sure the drive shaft is correctly aligned before you push the pump back into position. If it fails to locate properly, withdraw the pump and move the drive shaft very slightly, then try again.

Refit and tighten the pump securing nuts or bolts to the torque-wrench setting recommended in the service manual for your car.

On an internally mounted pump, refit the sump pan and replace the engine oil.

On both types, always fit a new oil filter (SHEET 143). Also prime the pump with clean engine oil before you refit it to the car.

Run the engine very gently until the oil pressure builds up to normal, then check for oil leaks.

Checking the oil-pressure relief valve

The oil-pressure relief valve is usually fitted in the oil-pump body, sometimes in the engine block.

The valve consists of a ball or plunger held by a spring. If the engine has low oil pressure (indicated by the oil-pressure gauge or oil-pressure warning light), the relief valve may not be seating properly. The cause may be a weak or broken relief spring, dirty engine oil or a worn oil pump.

Most valves can be removed, but some types cannot. Before attempting to check the valve, you may have to check its position in a service manual for the car or by asking your local dealer.

If the valve is inside the oil pump, remove the pump. Unscrew the plug that holds the relief valve in the oil-pump body or engine block, and remove the valve spring and plunger or ball.

If the ball or plunger is stuck in the valve bore, try to release it by gently prodding with a thin screwdriver. Be very careful not to scratch or damage anything – particularly the valve bore. Scratches in the bore, ball or plunger will allow oil to force its way past the valve, which will lower the oil pressure.

Clean all the parts thoroughly in paraffin, white spirit or petrol, and check the valve ball or plunger for signs of a ridge caused by wear or pitting.

Check the spring to see if any of the coils are cracked. To check it for weakness, compare its length with that of a new spring.

Using a lint-free rag dipped in paraffin or petrol, clean the valve bore, making sure any blockage or deposits are removed.

If any of the relief-valve parts are worn, throw them away and buy a new valve assembly.

Smear the valve bore and components with clean engine oil and refit them. On externally fitted valves, make sure the plug sealing washer is not worn or damaged, fitting a new one if necessary, before tightening the plug properly.

Unscrew the plug and remove the valve spring and the plunger or ball.

Release a stuck ball or plunger by gently prodding with a thin screwdriver.

Some types of oil-pressure relief valve cannot be removed.

Cleaning air cleaners and renewing filters

A choked filter in an air cleaner causes increased fuel consumption and, eventually, extra engine wear.

Eventually the filter becomes choked with dirt, so check it every 6,000 miles (10,000 km) or every six months, whichever comes first. If it is dirty, clean or renew it as necessary.

Most modern cars have a renewable paper filter element. The two other types – oil-bath filter and wire-gauze filter – can both be cleaned.

Many cars have ways of passing crankcase fumes into the engine to burn them up. Usually the crankcase, camshaft cover or rocker cover is connected to the air cleaner by a hose.

Look at the hose and any valve or filter that may be incorporated into it (SHEET 147). Faults here can make the engine run badly, and may choke the filter.

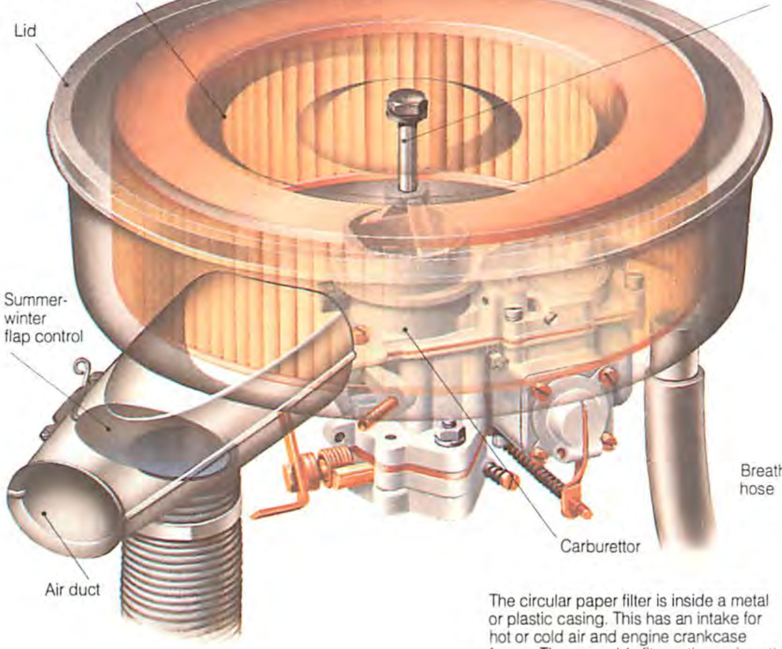
The air cleaner may also have a 'summer-winter' arrangement, for setting it to draw in cool or warm air. Usually you alter its setting in spring and autumn. Sometimes the setting is automatic.

There are times when the air cleaner may have to be removed – to work on the carburettor or cylinder head, for example. There are various types of fitting, some of them difficult to dismantle.

Whenever you work on the air cleaner, check that the body is properly fitted to the carburettor; that hoses are sound and in place; and that the filter element is seated correctly.

Tools and equipment

SCREWDRIVER • SPANNERS • USED OIL CONTAINER • PARAFFIN OR PETROL DEGREASER • ABSORBENT RAGS • CLEAN ENGINE OIL • LIGHT GREASE



The circular paper filter is inside a metal or plastic casing. This has an intake for hot or cold air and engine crankcase fumes. The assembly fits on the carburettor.

Removing and checking filter element

You can usually replace a paper filter element without removing the cleaner body.

The lid of the cleaner may be metal, held on by a single central bolt or wingnut. Unscrew it and lift off the lid.

Some cars have a plastic lid held by several self-tapping screws and sealed around the edge by a tight-fitting rim. Remove the screws and look for an arrow at the rim.

Lever the lid off with a screwdriver at this point only: levering anywhere else could crack the plastic. Do not overtighten the screws when refitting

Take the element out and look at it. If the cleaner has a side spout the element will be dirty on one side. If it is not obviously dirty and clogged, turn it so that the cleanest section is opposite the intake hole and refit it.

If the element is dirty all over, fit a new one.

A new air-filter element must be the right type and size for your car. Consult your car handbook for the correct type. Different elements let varying amounts of air through. However, the new element may look different from the old one. Some are supplied folded, and have to be pulled out into shape.

To clean a wire-gauze filter, take the cleaner off and remove the top of the casing. Lift out the gauze element. Wash it and the casing thoroughly in petrol.

Generally the element is meant to be lightly oiled; consult the car handbook. If so, dip it in engine oil and stand it on a tray to drain. Refit the element and the cleaner.

Unscrew the central nut or bolt – or there may be a wingnut.

Take out the element and inspect it carefully.

Levering the rim

Where there is an arrow, such as on Fords, lever the rim only at the arrow mark.

Removing and refitting the cleaner body

On some carburettors there is a central bolt from the carburettor through the air cleaner and into its lid. Take the nut off the bolt to remove either the lid or the whole cleaner. Unclip any breather hose connected to the cleaner.

There is a rubber gasket on a flange on the intake stub of the carburettor. Refit it the right way round: there are often holes in the flange which must not be blocked.

Another, older system has a rubber seal and clamp. Unscrew the clamp to free the cleaner. To refit, place the seal squarely around the intake stub. Slide on the cleaner and tighten the clamp.

Do not overtighten the clamp or you may force the seal off so that it falls into the carburettor. If the seal is swollen with age and no longer fits, change it.

Weber twin-choke and some Solex carburettors often have an air cleaner held on by studs with nuts. These are either self-locking nuts or have locking tab washers underneath. They must lock properly: do not let one fall into the carburettor – it may be sucked into the engine and cause a lot of damage.

Reuse locking tabs only if there is an unbent corner left to fold up.

Sometimes the cleaner sits on two brackets fixed to the engine. Pins on the cleaner fit into rubber or plastic rings set in holes in the brackets. Lever the pins out with a broad screwdriver.

If a ring comes out of the hole, push it back. Grease the pin lightly when refitting. Replace any damaged ring.

Loosen the securing bolt in the centre of the cleaner housing.

Release the stay clamp from the side of the air-cleaner body.

Remove crankcase breather hose from underneath the air cleaner.

Summer-winter settings

Turn a circular air cleaner with a spout so that it draws warm air from near the exhaust manifold in winter, and cool air from an open space in summer. Before twisting it, slacken retaining nuts or clips.

Instead, it may have a flap valve inside, with a control marked 'summer-winter' or with sun and snowflake symbols.

If it has neither arrangement, there is probably an automatic heat-sensing flap inside the air intake. If you can see this, check that it opens when the engine has warmed up fully on a warm day.

Checking fuel pipes / 1

Any fuel leak, however small, can cause a fire. Do not drive a car with a suspected leak until you have cured it. Never leave a car dripping petrol where a passer-by may throw a cigarette end under it. A small fire extinguisher, fitted where you can get at it quickly, is a valuable accessory.

Whenever you check fuel pipes, disconnect the battery to prevent stray sparks igniting petrol or petrol vapour. Above all, put out all naked lights and cigarettes. Use a torch rather than an inspection lamp, which could start a fire if the bulb is accidentally broken.

The fuel pipe of a car with the engine in front and the fuel tank at the rear generally runs under the floor, where it can be exposed to corrosion and knocks.

For most of its length it is usually made of metal, but different materials are used on different sections and these are linked with various kinds of connectors. Sometimes the whole pipe is plastic.

Sometimes there is a twin piping system, with supply and return pipes. The fuel pump circulates petrol in an endless loop, from the tank and back again, from which the carburettor draws off as much as it needs.

A normal, single fuel pipe begins at the outlet on top or at the side of the tank, where it is usually combined with the electric fuel-tank sender unit which operates the fuel gauge.

There is a short pick-up pipe with a filter reaching into the bottom of the tank.

From the outlet the pipe runs to the fuel pump – either a mechanical one mounted on the engine, or an electric one which is often sited at the rear next to the tank, or submerged in it.

The pump sends the fuel to the carburettor, but there are one or more filters on the way – often in unsuspected places that are difficult to reach.

The last part of the fuel pipe, inside the engine compartment, has to be flexible to allow for the engine moving on its rubber mountings.

The flexible section of the piping is usually made of reinforced rubber hose, but sometimes clear, flexible plastic tube is used.

The most usual type of connector for metal fuel pipes on modern cars is a short length of rubber hose fitting over the pipe ends and secured by two hose clips.

Sometimes there are no clips, and the connector is a push-on fit.

On some earlier cars rigid joints are used on metal piping, especially where it is attached to the tank outlet.

A tube nut fits over the pipe and is screwed tight to force the pipe against an 'olive' – a piece of soft metal shaped like a hollow bead.

The ends of the olive are squashed to make a fuel-tight joint.

Sometimes there is no olive, and the tube nut forces the ends of the tube on to a tapered seating which spreads out the end of the tube into a bell shape.

Leaks can be caused by corrosion in steel pipes, and cracks and abrasion in all types.

The clips holding the pipe to the chassis may damage it, or they may rust and fall off so that the pipe becomes loose. It may then get dangerously close to the exhaust pipe.

The pipe may also be damaged by stones on unmade roads, or even by jacking the car up with the jack in the wrong place.

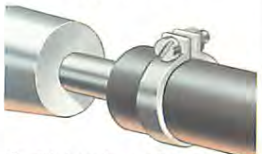
Apart from damage to the pipe itself, joints may come loose and leak. Rubber joints may fray, or the clips loosen. Metal joints tend to leak when they have been pulled or pushed, so that the olive or expanded pipe end is distorted and no longer forms an effective seal with its connector.

Inspect them all carefully at regular service intervals.

Tools and equipment

RAMPS OR AXLE STANDS • CHOCKS • SCREWDRIVER • SPANNERS • BELLING TOOL OR LONG-NOSED PLIERS • 2 IN. (50 MM) DIAMETER TUBE • FLEXIBLE HOSE • METAL PIPING • CLIPS

Pipe joints

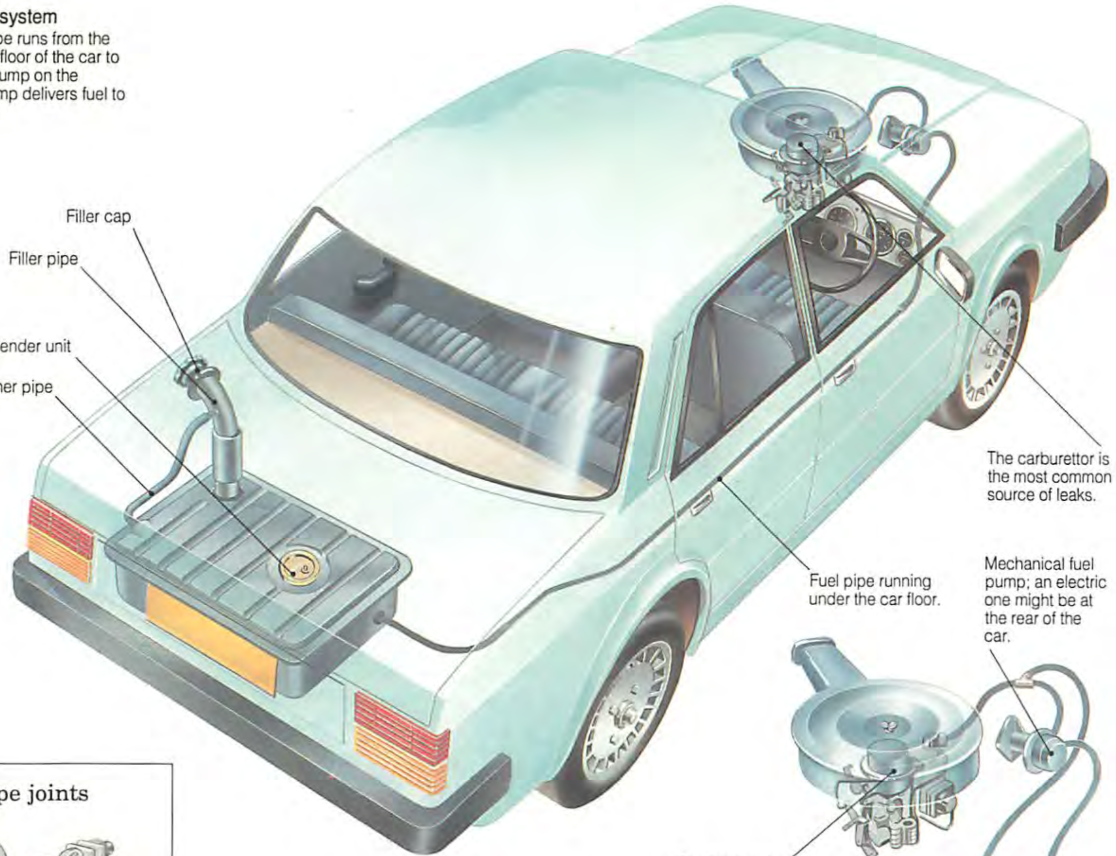


Flexible hose is usually secured by clips, but may be a push-on fit. Twist and pull the hose gently to remove it.

Rigid pipes may fit through a threaded nut that forces them on to a tapered seating in a belled tube.

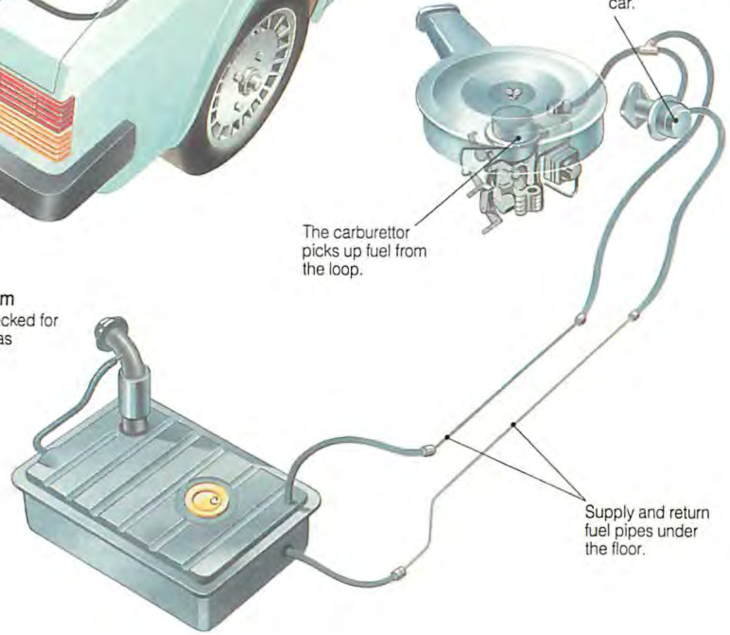
A typical fuel system

A single fuel pipe runs from the tank, under the floor of the car to a mechanical pump on the engine. The pump delivers fuel to the carburettor.



Twin fuel-pipe system

Twin fuel pipes are checked for leaks in the same way as single ones.



Checking fuel pipes / 2

If you can smell petrol

The first sign of a leak is usually a strong smell of petrol.

If you smell petrol at any time except when you have just filled the tank, or when you have difficulty starting the car and have flooded the carburettor, suspect a leak and look for it.

If there is petrol under the car after filling the tank, check the flexible hose between the filler neck and the tank neck. A split in the hose will leak petrol as it is being pumped in.

Other evidence may be a damp patch or stain under the car.

Where petrol has run down part of the car from a leak and then dried, it leaves a whitish, chalky mark. Just because the mark is dry, do not suppose that the leak has stopped.

Leaks may occur only at certain times, for example only when the tank is full or the car is tilted in a certain direction.

The carburettor is the most common source of leaks, so start looking there. The fault could be the carburettor flooding, rather than a leak (see also SHEETS 289–295 for particular carburettor problems).

Look at the joint between the fuel line and the carburettor, and then check other joints, working all the way back to the tank.

Put the car up on ramps or axle stands to inspect the section under the floor. Bend flexible pipes between your fingers to show up splits or cracks. Push clips and metal joints to see if they are loose.

Feel around joints to see if they are wet, petrol may run along a pipe before it begins to drip, which can be misleading.

Once you have found the leak you can make a temporary repair, but anything that is damaged should be replaced completely as soon as possible.

If a plastic line is damaged the whole line must be replaced, since improvised joints will not remain leak-proof for long

Certain petrol blends sold in Europe may well cause plastic fuel lines to expand or swell. Sagging fuel pipes are the first sign that this is happening. Make sure the pipes are securely clipped on.

Replacing connectors

Rubber connectors are often damaged by being removed in the wrong way. If they are pulled straight off, the tension makes them become narrower and tighter, and they may tear.

They should be twisted off. This also applies to longer lengths of rubber hose.

Pushing on a connector or hose is seldom a problem, but do not use a lubricant to ease it or jointing compound to seal it. This applies to all types of connector used on fuel pipes.

Make sure any clips are correctly positioned. Do not overtighten them, particularly when they are wire clips, for these can cut through a hose.

When a metal connector needs replacing, the pipe is generally damaged as well as the connector. If there is enough pipe, you can cut off the damaged section.

With the type of connector that relies on an expanded or 'belled' end on the pipe, you must bell the end before screwing up the nut – tightening the nut completes the belling and forms the seal.

Strictly this should be done with a special belling tool, but in an emergency you can usually manage it by sticking a pair of long-nosed pliers into the end and twisting them round to expand the end into a bell shape.

If you are using a new nut, slide it over the end of the pipe before you start to bell the end, or it will not go on. Have the joint sealed with a proper belling tool as soon as possible.

With an olive joint, always replace the olive when you reconnect the joint, whether or not you have replaced any other parts.

Avoid overtightening connectors, which can cause them to leak.

Where plastic pipe is joined with nut-type joints, make sure it does not get twisted when you are loosening or tightening them. This is a particular danger with joints which have a nut at each end. Use two spanners.

The section of fuel line in the engine bay is less exposed to damage than the piping under the car. But heat and oil can damage its rubber connectors.

Special clear-plastic tubing, which is both flexible and oil and fuel resistant, is often used here, particularly where an original rubber hose has been replaced.

Some plastic can become hard and awkward to flex – always use the grade recommended by the spares department of a dealer for your make of car, though it may cost more. Once a plastic fuel pipe has hardened with age, replace it.

Apart from leaking, fuel lines can also become blocked. A total blockage will stop the car, but a partial one may only cause fuel starvation at high speed, which is hard to diagnose as there may be other causes. One clue is that the effect is often spasmodic.

If you suspect a blockage, the quickest way to check is to free both ends of the pipe and blow through it. Use your mouth, not a high-pressure air line, which may cause damage.

An air line may also loosen dirt, which later falls back and blocks the pipe again.

Do not blow into the fuel filler hole – it will not reveal a blockage and could be dangerous if the tank is full. You might inhale petrol – or fumes – and get it in your eyes.

If you find a blockage, it may be at a filter. Some filters mounted in the fuel line look just like rubber connectors. There is also one on the fuel pump (SHEET 176).

Kinks and dents in the line itself can cause a blockage.

Old rubber hose – especially the braided type – can collapse internally without this being evident on the outside.

Check by blowing, not by poking anything through the hose which may damage it.

Repeated blockages may be caused by dirt or rust in the fuel tank. If so, the tank must be removed, cleaned and flushed out, or replaced.

When working on the fuel system, do not wipe the ends of pipes with soft rags. Small threads or bits of fluff can come off and block a pipe.

Occasionally a slack joint in the fuel-pipe system allows air into the fuel. This, too, can cause fuel starvation at high speed.

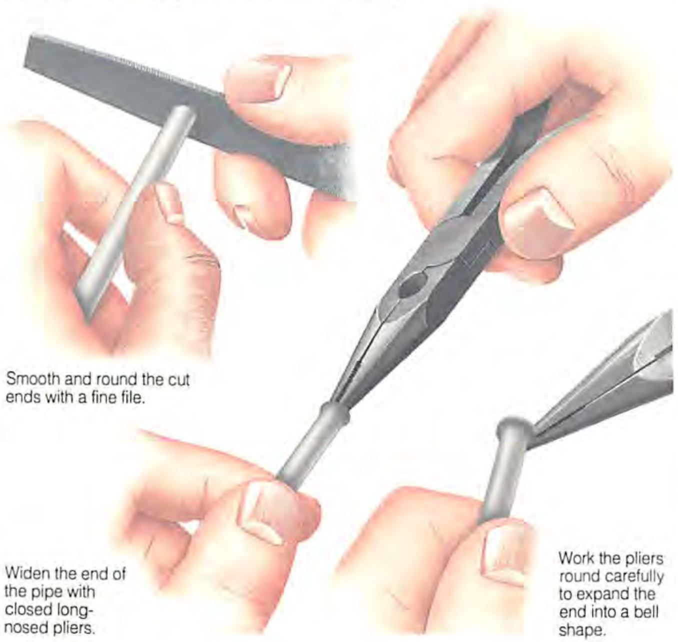
The trouble is difficult to spot. A fuel-pump filter with a glass bowl may show an air leak by a stream of bubbles. Routine checking of all joints for tightness should prevent or cure the problem.

Another cause of fuel starvation can be a blockage of the tank ventilation. This may even stop the engine.

The trouble will show when air hisses in as the filler cap is released. The normal type of tank vent is a plastic pipe leading from the top of the tank to below the car.

If this cannot be reached to unblock it, disconnect the pipe at the fuel tank, and blow through it with a foot pump.

Belling the pipe in an emergency



Smooth and round the cut ends with a fine file.

Widen the end of the pipe with closed long-nosed pliers.

Work the pliers round carefully to expand the end into a bell shape.

Replacing the olive

Use two spanners to loosen or tighten up an olive joint, to avoid twisting. Do not overtighten.

Always replace the olive when you reconnect the joint.

Fitting a metal pipe

A new metal fuel pipe is usually supplied straight and unshaped. It is easy to bend – but also easy to kink.

If the old pipe is still in one piece and undistorted, take it off to use as a pattern for the new one. Make gentle bends and curves by bending the new pipe carefully with your hands. Check frequently that it matches the old pipe and fits the space.

Make tight bends round a tube at least 2 in. (50 mm) in diameter.

If you re-route the new pipe, keep it away from the exhaust, moving parts of the suspension or handbrake mechanism, jacking points and other exposed places.

Clip the pipe in place every couple of feet, using the original clips or special plastic ones. Do not use brass or aluminium: any steel touching it tends to rust.

Tight bends should be made round a tube at least 2 in. (50 mm) in diameter.

Preparing for carburettor adjustment

The carburettor is often suspected of causing an engine to run roughly, when the real source of the trouble may be something quite different.

So before you start any work on the carburettor, check every other part of the engine. If the trouble cannot be traced, try tuning, or adjusting, the carburettor.

The age of the vehicle also makes a difference. Up to the early 1970s, most carburettors could be easily adjusted for mixture strength, as well as idling speed. The mixture was checked at every major service.

Since then, laws limiting exhaust pollution have caused manufacturers to produce much more complex carburettors. They are calibrated carefully, then made 'tamper-proof'. These sealed carburettors stay in tune much longer (SHEET 175).

However, check that the cables or rods that work the choke and throttle are not loose or jamming, and that the air filter is secure and unblocked (SHEET 167).

Air leaks on the inlet side of the engine upset the fuel mixture. Check that the inlet-manifold nuts and carburettor mounting bolts are tight.

An intake leak usually causes a high-pitched whistling noise, which may vanish as the engine speeds up.

See that the hoses from the inlet manifold – such as those going to the breather system or a brake servo – are firm and free from splits, cuts or abrasions, and that the hose clips are tight and in the right place.

Check also that the nuts on the exhaust manifold and downpipe are tight (SHEET 155).

There is a chance that the tank may accidentally have been filled with fuel of too low an octane rating (such as two-star instead of four). This tends to show itself by a knocking sound – 'pinking' – when accelerating.

Fuel supply to the carburettor is also important. There is no point in tuning the carburettor until you have done any necessary maintenance on the supply system – check the fuel pump and fuel pipework (SHEETS 168–169, 176, 177).

Before you start, find where the adjustments are on your particular carburettor (SHEETS 170–175).

Some adjustments may have to be made uncomfortably close to a hot exhaust manifold. Practise on a cold engine to familiarise yourself with the adjustments.

That also ensures that you have the right tools ready. Most adjustments need only a screwdriver; some require just fingers. Also check for spindle wear.

Prepare for tuning by allowing the engine to idle until it reaches normal working temperature. If there is no gauge to tell you when the temperature is up to normal, drive for about 5 or 6 miles.

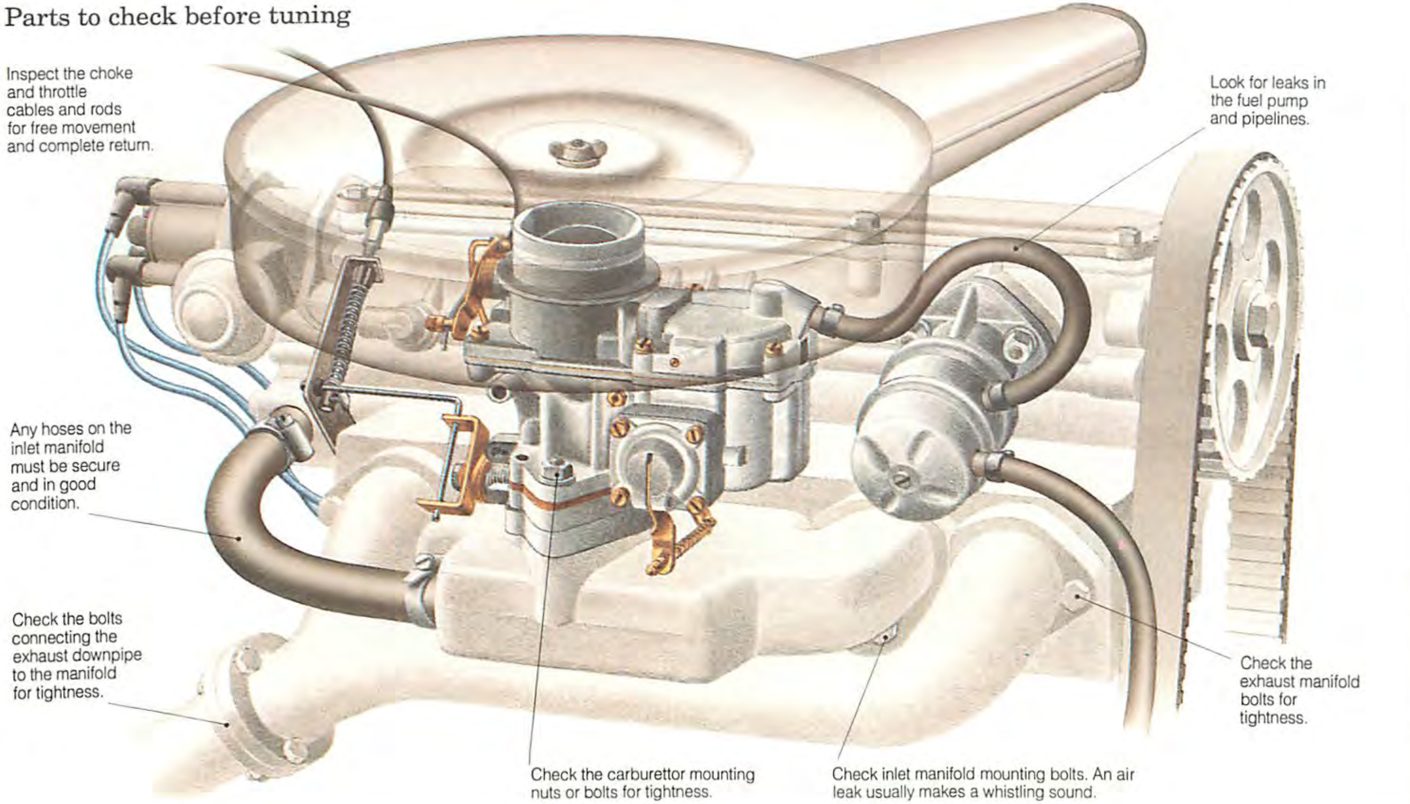
Do not allow the temperature to rise above normal while you are tuning. That happens if the engine is allowed to idle for a long time.

If you set the mixture with the temperature high, the mixture will be too weak. As soon as the car is driven and the temperature drops again the engine will misfire, run roughly and lose power.

Tools and equipment

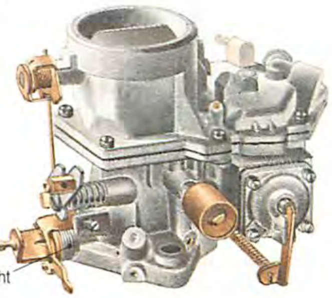
SCREWDRIVER • SPANNERS

Parts to check before tuning

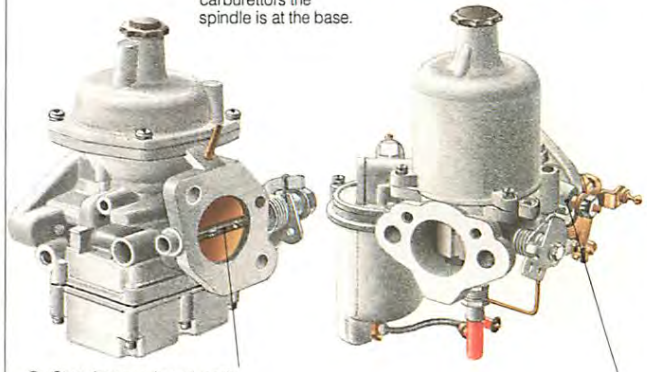


Checking for spindle wear

A worn or loose spindle can cause the throttle butterfly plate not to seat properly. The illustrations show where the spindle ends are located on the most common types of single carburettor. Before tuning, check that the spindle ends are not loose, so that the butterfly wobbles, or too tight, so that it sticks.



On down-draught fixed-jet carburettors the spindle is at the base.



On Stromberg carburettors the butterfly spindle is on the side nearest to the engine.

SU carburettors also have the spindle on the side nearest to the engine.

Adjusting an SU carburettor

Unlike other types of carburettor, which have fixed jets, the SU has only one jet, so the mixture setting affects the engine throughout its speed range.

Some SUs also have exhaust emission-control devices to comply with anti-pollution laws. Adjustment of these is described on SHEET 175.

Before tuning the carburettor, carry out all the checks on SHEETS 179–180, and bring the engine up to normal working temperature.

Also check the level of oil in the dashpot – the domed piston chamber at the top of the carburettor.

The oil is there to slow the movement of the piston. The delay enriches the mixture briefly when the throttle is opened suddenly. SAE 20 engine oil is the correct grade to use when you top up.

On older SU carburettors, which have a vent hole in the screw-in plastic top of the dashpot, the oil level should be ½ in. (13 mm) above the top of the piston tube.

On dustproof SUs, which have a hole in the dashpot neck instead of the top, the oil should be ½ in. (13 mm) below the piston top.

If the engine is slow to respond to sudden throttle openings, or responds fluffily, correcting the dashpot oil level may cure the problem, so that you do not need to retune.

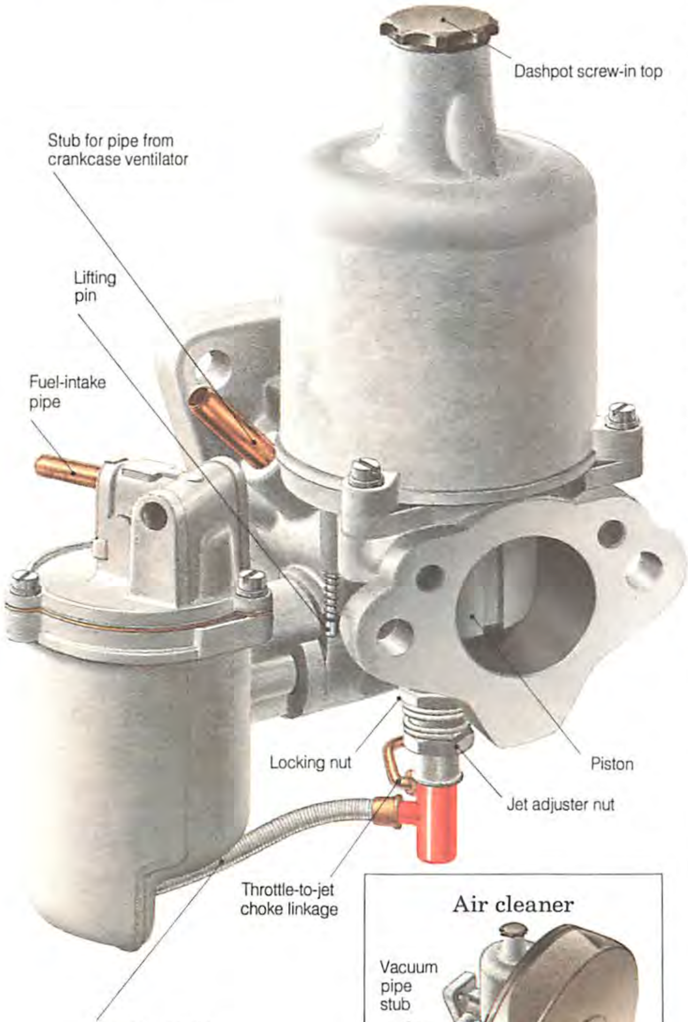
However, if correcting the oil level does not resolve the problem, you may need to clean the carburettor (SHEETS 179–180) before tuning it.

Whenever possible, make adjustments with the air cleaner in place – removing it alters the partial vacuum inside the carburettor.

On cars where the carburettor is not very accessible, you may have to remove the air cleaner to reach some parts, then carry out further fine adjustments to obtain correct engine running later on.

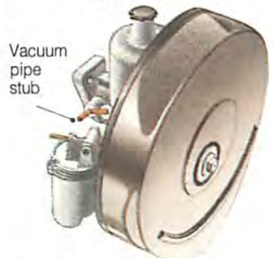
Tools and equipment

SMALL SCREWDRIVER • SPANNERS • PENCIL OR ROD



The SU carburettor
The SU carburettor is to be found on many British-built cars. It needs a periodic check to see if it is in tune.

Air cleaner



The air cleaner in the front of the carburettor may have to be removed, but leave it on if possible.

Checking the mixture

Use the piston lifting pin at the side of the carburettor to check the fuel-air mixture.

With the engine running at working temperature, hook your finger under the pin and raise the piston about 1/32 in. (1 mm).

If, while the piston is raised, the engine speed increases briefly then returns to normal, the mixture is correct. If it rises and stays high, the mixture is too rich. If it falls and the engine tends to die, the mixture is too weak.

To correct the mixture, move the jet adjuster nut one hexagon flat at a time.

Screwing it up – anti-clockwise as seen from above – makes the mixture weaker.

Screwing it down – clockwise – makes the mixture richer.

Each time you move the adjuster, wait for about ten seconds, then check again with the lifting pin to see whether the mixture is now right.

Take care that the engine temperature does not rise above normal – which it will if you take too long.

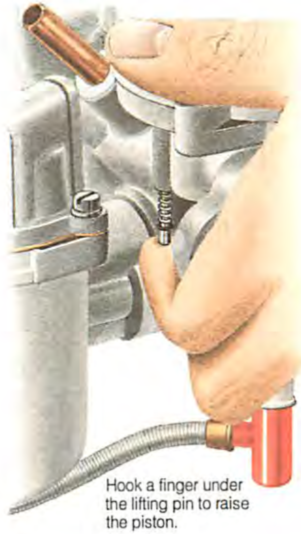
Such a rise will result in a false, overweak mixture setting which will show when the temperature returns to normal.

Before and after adjustment, check that the jet needle is central in the jet.

Stop the engine, use the damper to lift the piston to the top of its travel and let it drop.

It should fall smoothly with a sharp click. If it does not, the jet is out of line and you must centralise it.

An off-centre jet may also score or bend the tapered needle. Do not attempt to clean up or straighten a badly scored or bent needle. It must be replaced (SHEETS 179–180).



Hook a finger under the lifting pin to raise the piston.

Centralising the jet

Remove the air cleaner and the dashpot screw-in top and damper. Use a screwdriver to raise the piston.

Turn the jet adjuster nut up as far as it will go, or until the jet is level with the bridge inside the carburettor.

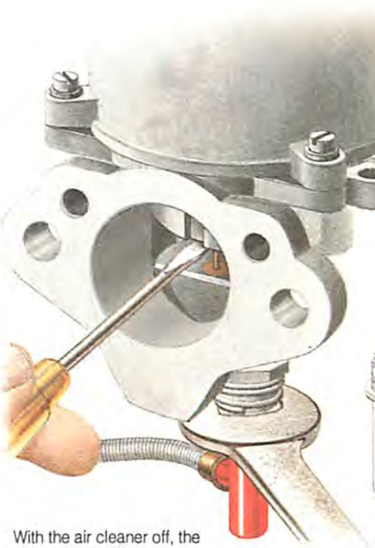
Slacken the large locking nut above the adjuster nut on the jet where it enters the carburettor body.

Now use a pencil or soft metal rod, such as a stick of solder, to push the piston right down. Hold it down and tighten the locking nut.

Check that the piston drops with a click – if it does not, repeat the centralising process.

Screw the jet adjuster nut down two full turns, which should bring it near enough to the correct setting for the engine to be able to run.

Refit the air cleaner and reset the mixture. Give the piston a final click check before you screw back the dashpot screw-in top and damper.



With the air cleaner off, the piston can be lifted with a screwdriver. The jet should be screwed up as high as the bridge if possible.

Hold the piston down with a pencil while you tighten the locking nut.

Adjusting a Stromberg carburettor / 1

The Stromberg CD carburettor, like the SU (SHEET 171), is a constant-depression carburettor, hence the CD.

The two work in much the same way, but the Stromberg differs in having an air valve – commonly called the piston – surrounded by a rubber diaphragm in the dashpot.

The size and type of a Stromberg are given by numbers and letters. Numbers such as 125, 150 and 175 are sizes: they mean a choke diameter of 1¼, 1½ and 1¾ in. The size makes no difference to the way you tune the carburettor.

Types include CD, CDS, CD2S and CD3, all used on older cars made before anti-pollution laws demanded emission-control fittings.

Later types with emission control have the letter E, as in CDSE and CD2SE. Tuning methods vary according to type, but Strombergs are not stamped with their type marks.

Information in DATASHEETS or in the car handbook should help you to identify your type.

Before starting to tune the carburettor, check out all the other systems such as sparkplugs, contact-breaker gap and the ignition timing (SHEETS 194-196 and 203-204) and valve clearances (SHEETS 143-150).

Although valve clearances seldom need resetting between major services, always check them before attempting to tune the carburettor.

Check, too, that the damper tube is topped up with oil to within ¼in. (6 mm) of the end of the rod.

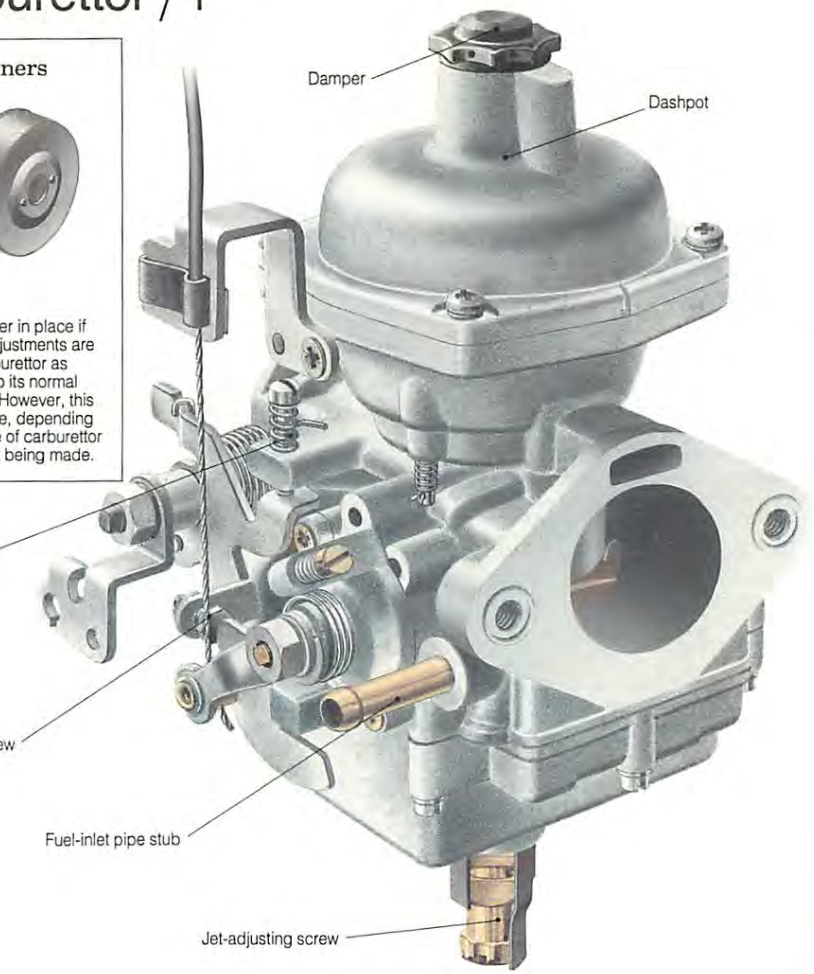
Use ordinary multigrade engine oil or the special SAE 20 oil made for the purpose by Zenith (the makers of Stromberg carburettors). Tune with the engine running at working temperature.

Tools and equipment

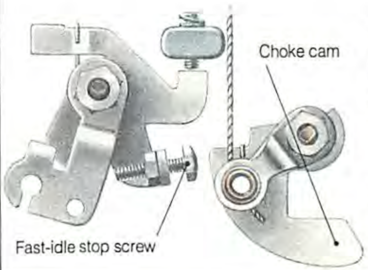
SAE 20 ENGINE OIL • LONG, THIN SCREWDRIVER • SPANNERS • PENCIL • SOFT METAL ROD • SQUAT SCREWDRIVER OR SMALL COIN • SPECIAL TOOL B20379 • CROSSHEAD SCREWDRIVER

Air cleaners

Leave the air cleaner in place if you can, so that adjustments are made with the carburettor as close as possible to its normal working condition. However, this may not be possible, depending on the car, the type of carburettor and the adjustment being made.



Adjusting the gap



The fast-idle stop screw opens the throttle when the choke is pulled out. There must be a gap between its head and the choke cam when the choke is pushed home.

The CD and CDS have different cold-starting devices, but the adjustment works in the same way.

Set the gap according to the car-maker's recommendations – usually about 1/32 in. (1 mm).

Some Strombergs have a two-position screw to limit the use of the choke according to the season. It has a spring under its head. Set it with the spring compressed for summer and the tension released for winter (only necessary in freezing weather).

Tuning the CD, CDS and CD2S

There are three adjustments on CD, CDS and CD2S carburettors: a throttle-stop screw, a jet-adjusting screw and a fast-idle stop screw.

Check that the choke is fully shut and that the fast-idle stop screw is clear of the choke linkage. Hook your finger under the edge of the dashpot and press the lifting pin upwards to raise the piston by about 1/32 in. (1 mm).

If there is no pin, take off the air filter and lift the piston 1/32 in. (1 mm) with a thin screwdriver. Listen to the engine note while you do so. If the mixture is correct the engine speed should rise slightly for a moment, then return again to normal.

The lifting pin is under the edge of the dashpot.

If there is no pin, lift the piston with a screwdriver.

If it rises and stays fast the mixture is too rich.

If the engine dies when the pin is lifted, it is too weak.

Switch off the engine before adjusting the mixture, and check that the jet needle is central. Remove the air cleaner, lift the piston and let it fall. If the jet is central, the piston falls with a sharp click.

Keep the jet central while you adjust the mixture by taking the damper rod out of the top of the carburettor and pushing a pencil or soft metal rod firmly down the hole to hold the jet in place. Make sure that the jet remains centralised.

Start the engine and bring it up to working temperature.

The mixture-adjusting screw is set centrally in the base of the carburettor on CD, CDS and CD2S models. It is brass and has a wide slot in it. Although a screwdriver can be used to turn it, a small coin is easier.

Turn only an eighth of a turn at a time, then wait about 15 seconds for the engine speed to settle down. Lift the pin again and see whether the engine speed alters.

Use a coin to turn the jet-adjusting screw one-eighth of a turn at a time, waiting each time for the engine speed to settle down. Screwing upwards weakens the mixture, downwards enriches it.

Screw the jet upwards (that is, anti-clockwise looking down on the carburettor) to weaken the mixture, or down (clockwise) to make it richer.

With the mixture setting correct, the idling speed may now be too fast or slow. For most cars it should be 850-950 rpm – judge it by ear if your car does not have a tachometer (or rev counter). Adjust the idling speed by turning the throttle-stop screw.

If tuning fails to make the engine run properly, the carburettor may need cleaning (SHEETS 181-182) or the air filter renewing (SHEET 167).

Adjusting a Stromberg carburettor / 2

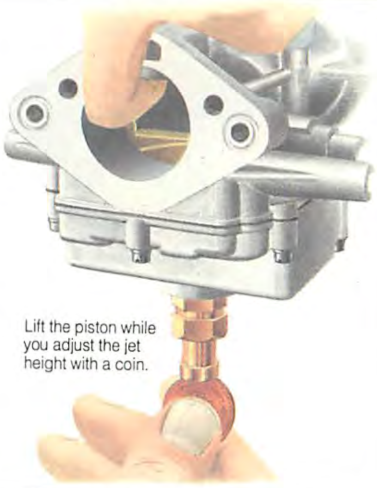
Centralising the jet

Lift the piston so that the needle is clear of the jet, and screw the jet-adjusting screw up until the top of the jet is just above the top of the bridge in the carburettor bore.

Use a spanner to slacken the large nut just above the jet-adjusting screw by half a turn. That releases the jet in its housing, but allows it to drop slightly.

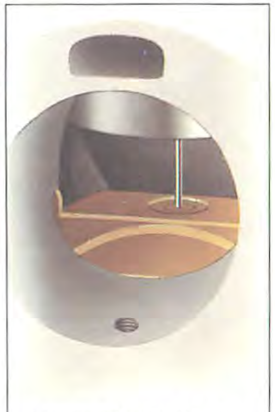
Wind the jet adjuster up again until the top of the jet is level with the bridge. Let the piston fall back gently so that the needle centralises the jet.

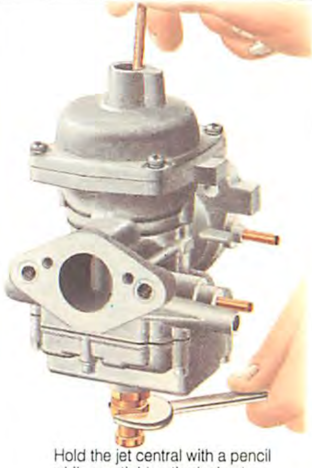
Remove the piston damper and hold the piston down with a pencil or soft metal rod slipped into the damper tube. Tighten the jet assembly. Check several times that the piston drops with a click.


Lift the piston while you adjust the jet height with a coin.


Turn until the jet height is just above the bridge in the carburettor bore.


Loosen the locknut to free the jet for adjustment.


Screw the jet up until it is level with the bridge.


Hold the jet central with a pencil while you tighten the locknut.

Adjusting a Stromberg CD3


The CD3 is a fixed-jet carburettor and you need a special tool to reset the mixture control, which is done by altering the height of the jet needle.

The CD3 carburettor has a fixed jet, and the needle is loosely mounted in the air valve, or piston, so that it centres itself.

You need a special tool to reset the mixture, which is done by altering the height of the needle in the piston. The tool is a long L-shaped hexagonal Allen key which goes inside a thick-walled tube. Its maker's part number is B20379.

To use the tool, remove the dashpot damper and insert the tube in its place. Turn the tube until a pin on its side falls into a slot in the air-valve shaft.

Push the Allen key to the bottom of the shaft and fit it into the needle adjustment.

Before you turn the Allen key, hold the outer tube of the tool firmly; otherwise the air valve can turn and tear the rubber diaphragm.

Tune the carburettor with the engine running at working temperature, in the same way as with the CD and CDS.

For this carburettor, turn the Allen key clockwise to lift the needle and thereby enrich the mixture and anti-clockwise to lower the needle for a weaker mixture.

Take care not to turn the adjustment too far, or the needle can come loose from the adjuster. The range is only about two full turns.

If you find you have to make more than a tiny adjustment, avoid losing the needle. Take off the cover of the carburettor and lift out the air valve, holding it by its shaft so as not to damage the diaphragm. Then set the needle in a midway position with the Allen key.

The right position is when – depending on the needle fitted – the washer around the needle or the groove in it is flush with the bottom face of the air valve.

Reassemble the carburettor and adjust the needle – starting from this point – no more than one turn either way.

After each adjustment is made, run the engine at about 2,000 rpm for ten seconds or so to clear the extra fuel which tends to get into the inlet manifold when you are making an adjustment.

If you do not have a revolution counter or tachometer, listen to the engine note. Its pitch should rise a little more than an octave above its normal sound when idling.


Insert the thick-walled tube of the special tool into the dashpot.


Hold it firmly while you make the adjustment using the Allen key.


For larger adjustments, lift out the piston and spring.


Use the Allen key to set the needle in a midway position.

Adjusting a fixed-jet carburettor

A fixed-jet carburettor mixes air and fuel by means of several jets. The jets are small holes which allow precisely controlled amounts of fuel or air to flow through them. The amounts are governed by the diameter, length and shape of the jets.

The jets come into action as needed by changes in the vacuum inside the carburettor, caused by different engine speeds and throttle openings.

Since the jets are fixed – not adjustable – the mixture is adjusted by directly regulating the fuel or air flow to them.

On carburettors made before about 1974 you can adjust two settings. One is the volume of fuel (or on some types, air) going into the engine. The other is the engine's idling speed, which is set by adjusting the throttle-stop screw.

The adjustment screws are located differently on different carburettors.

Later carburettors have had to comply with anti-pollution laws concerning exhaust gases.

They are called emission-control carburettors, and have sealed, tamper-proof adjustments which generally you cannot change (SHEET 175).

Before you tune the carburettor, make sure that it *needs* tuning, by eliminating all other causes of bad running (consult Faultfinder).

Certain adjustments are made with the engine running, so while it is cold, find the adjustment screws and work out how to reach them easily without burning yourself when working with the engine hot.

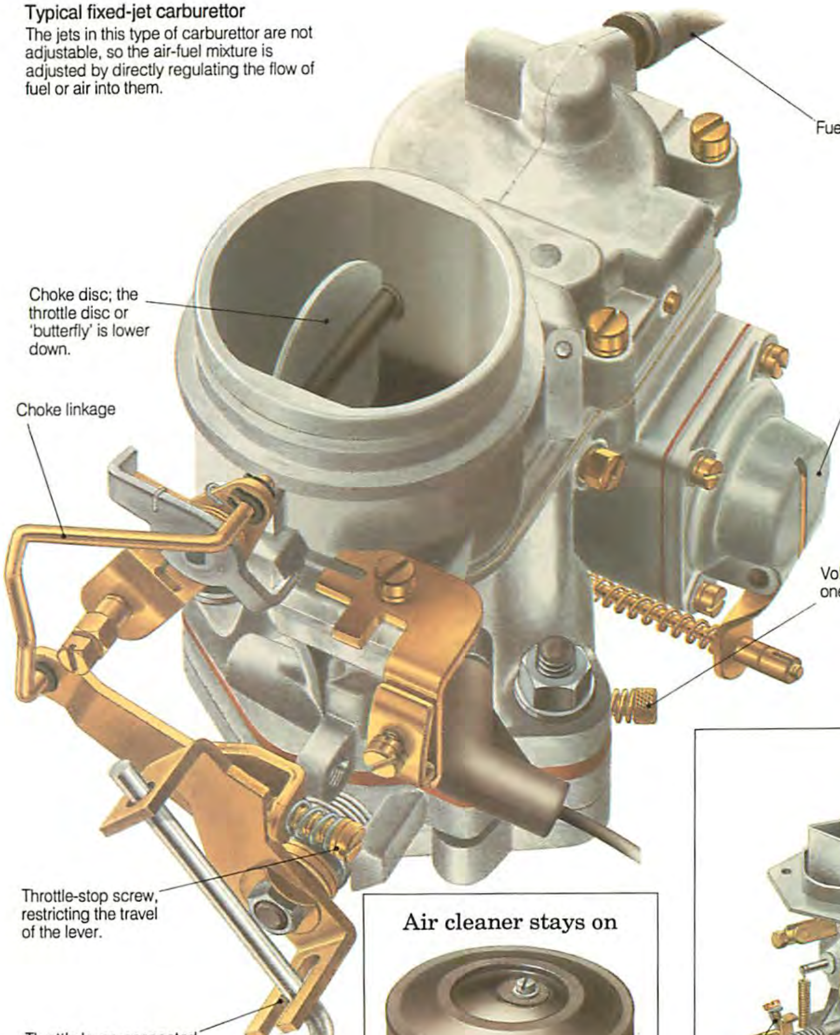
It may also help you to do the job without removing the air cleaner. Removing the air cleaner increases air flow and upsets the mixture.

Bring the engine up to normal working temperature, then work quickly before it gets much hotter – which would also affect the mixture.

Tools and equipment

SMALL SCREWDRIVER

Typical fixed-jet carburettor
The jets in this type of carburettor are not adjustable, so the air-fuel mixture is adjusted by directly regulating the flow of fuel or air into them.



Air cleaner stays on


If possible, make adjustments without removing the air cleaner.

Adjustment

Set the throttle-stop screw so that the engine idles a little faster than normal.

Turn the volume-control screw either way, until the engine begins to run roughly.

On most carburettors the volume screw regulates fuel flow – on this type the volume screw's position is low on the carburettor body.

Turning it clockwise weakens the mixture, causing 'hunting' – a rhythmical rise and fall in engine speed.

Turning it anti-clockwise enriches the mixture, producing 'lumpy', irregular running.

An air volume-control screw is placed higher up. Turning it clockwise enriches the mixture; turning it anti-clockwise weakens the mixture.

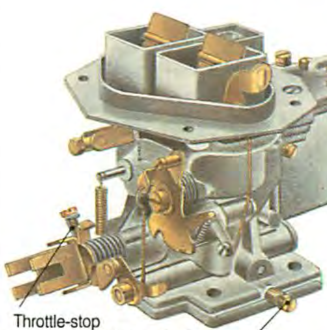
Find the two points at which hunting and lumpy running begin. Set the screw halfway between them, unless some other setting clearly makes the engine run better. Note the screw setting.

Reset the throttle-stop screw for a normal idling speed, and repeat the test with the mixture screw. Probably this will result in the same final setting.

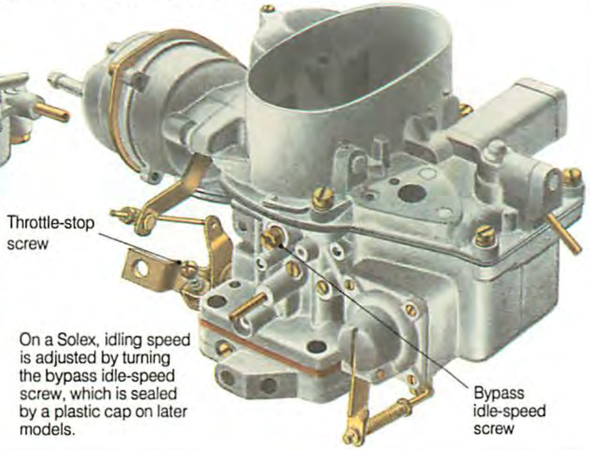

The volume-control screw may be knurled so that you can turn it by hand.


The throttle-stop screw increases engine speed when turned clockwise.

Adjusting Weber and Solex carburettors



On a Weber, the mixture-adjusting screw is sealed in many later types. Idling speed is adjusted by turning the throttle-stop screw.



On a Solex, idling speed is adjusted by turning the bypass idle-speed screw, which is sealed by a plastic cap on later models.

Adjusting an emission-control carburettor

Anti-pollution laws in many countries now limit the volume of poisonous carbon monoxide gas (CO) which may be emitted from a car exhaust.

Later carburettors are designed to comply with these laws. Adjusting the mixture strength may increase the CO level. So the mixture control is now sealed to make it tamper-proof.

On some carburettors all you can adjust is the idle speed. On some you can alter the mixture very slightly by means of an extra air-volume regulating screw.

The seals are often easy to remove. You may find that somebody has done so, and upset the precise mixture balance made by the factory.

Many garages are not equipped to set a maladjusted carburettor right. You may have to buy a new one, although a specialist carburettor repair shop may be able to recondition it.

It is important to know what you can adjust and what you should not. Some early emission-control carburettors had no seals, and mistakes were easy to make.

You may have to put right someone else's error, at least well enough to get the car to a specialist garage, where the carburettor can be set precisely.

Before attempting any adjustment, eliminate all other possible causes of bad running (see FAULTFINDER).

Find the setting screws and make sure that you can turn them without removing the air cleaner (which would unbalance the mixture) and without burning yourself on a hot engine.

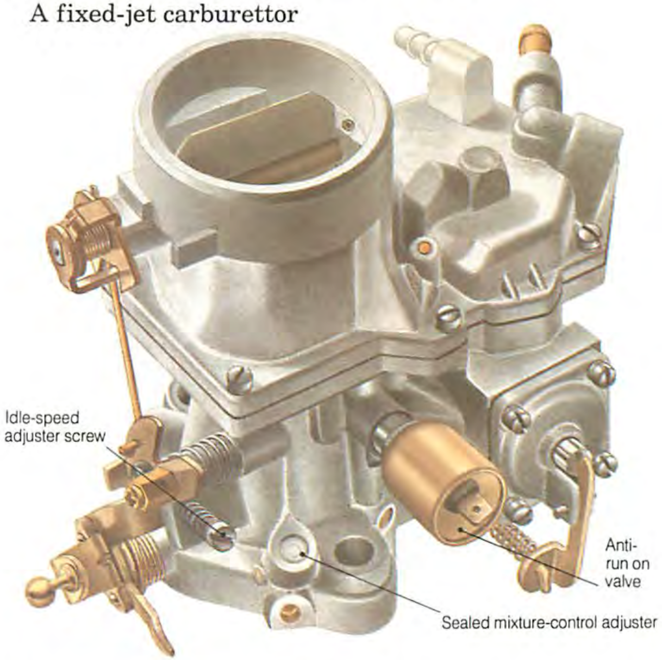
Bring the engine up to its normal running temperature. Then work quickly so that it does not get much hotter (which would also produce a false setting).

If the limited amount of adjustment possible does not make the engine run better, try cleaning the carburettor (SHEETS 178–188).

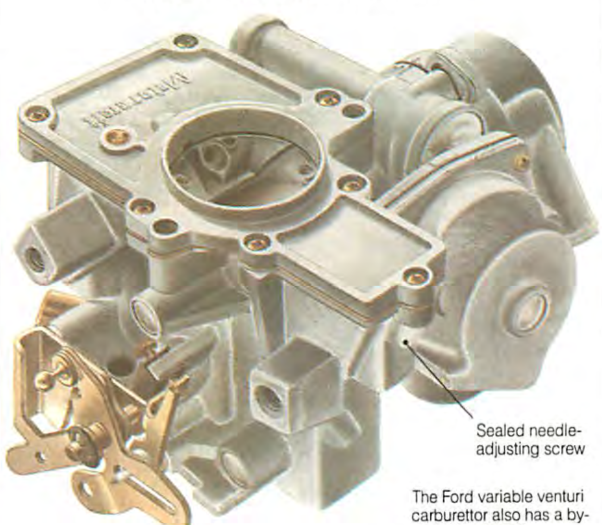
Tools and equipment

SCREWDRIVERS, NORMAL AND THIN

A fixed-jet carburettor



Variable venturi carburettor



The Ford variable venturi carburettor also has a by-pass idle-speed adjustment.

Adjusting a fixed-jet

The simplest type of seal used is a cap over the volume screw, often easy to remove. The screw, once uncovered, adjusts as normal (SHEET 174). Sometimes a special screw head, requiring a matching tool, is used.

The system in widest use is to seal both the volume screw and the throttle-stop screw which controls the idling speed. However, there is an extra screw which alters idling speed by regulating air flow.

This 'by-pass idle-speed' screw is the only one which should be adjusted, and is usually the only screw which can be reached without removing a seal.

If not, it is normally larger than the fuel-volume screw and mounted higher up, either protruding or in a recess.

If you are in any doubt, mark all screws so that you can turn them back to where they were if you make a mistake. Do not attempt to adjust the throttle or volume-control settings, which are pre-set using special equipment.

Adjusting Stromberg CDSE and CD2SE

Emission-control models are titled CDSE and CD2SE. Most of these allow no jet or needle adjustment. The idle-speed screw is adjustable; there is also a 'trimmer' screw for minor adjustments to fuel flow, which may have a locknut.

Even this screw should be adjusted only with gas analysing equipment at a garage. On a few CDSEs the needle height can be adjusted with a special tool in the same way as on a CD3 (SHEET 173).

The jet-height adjustment may be made tamper-proof by replacing the adjusting screw with a bush, which needs a special tool to turn. The adjuster may also be covered by a steel cap. Adjustment is as for a normal Stromberg (SHEET 172).

Sealed mixture-control adjuster

One type of jet-adjuster that is adjusted by a special tool.

The cap over the adjuster is to discourage tampering.

Adjusting an SU type HIF

The earliest emission-control types of SU carburettors were 'sealed' by no more than a dab of paint on the threads of the adjusting screws.

On later types, plastic shrouds were fitted around the idling-speed and jet adjusters. These shrouds pull off easily, but cannot be put back.

The HIF model (which differs from other SU models by having a float chamber under the carburettor body, not beside it) has a screw in the side of the body to adjust the jet height.

This screw is hidden under an aluminium plug which can be removed with a thin screwdriver.

The screw turns in, clockwise, to enrich the mixture, and out to weaken the mixture.

There may also be an aluminium plug over the idle-speed screw rather than a plastic shroud. (For normal SU adjustment, see SHEET 171.)

Cleaning fuel-pump filters

A blocked fuel-pump filter will cause the engine to cut out intermittently, particularly at high speeds, and it may stop altogether.

Not all cars have a filter in the pump. Later models often have sealed, filterless pumps which do not need maintenance, and rely on filters elsewhere, mainly in fuel pipes or the petrol tank, or at the inlet to the carburettor float chamber.

Many cars have a mechanical fuel pump driven off the camshaft. The pump should be plainly visible on one side of the engine. If not, trace the fuel pipe back from the carburettor.

If the fuel pipe leads away from the engine towards the fuel tank, you may have an electric fuel pump. Often this is at the back of the car, close to or immersed in the tank.

Disconnect the battery before servicing an electric pump – an accidental spark could ignite spilled petrol.

Clean all filters by washing them with fresh petrol. Wipe out the inside of the pump with a clean lint-free rag.

Make sure sealing gaskets are sound. Replace them if necessary. There may also be a sealing washer under the fixing screw.

Do not overtighten the screw(s) of the pump cover or it will leak and damage the pump. If the knob retaining a glass dome is overtightened, the dome may break.

Many electric pumps are SU, or copies built under licence. They are often in awkward positions, but must be removed to clean the filter.

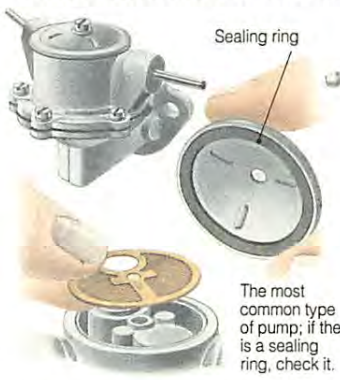
Have two old pencils or rubber bungs handy to stop petrol gushing out of the disconnected fuel pipes.

Note which pipe is which – the same applies for electrical connections. There may be one or two, depending on whether or not the pump is earthed directly to the car body.

Tools and equipment

SCREWDRIVER • LINT-FREE RAG • PETROL • SMALL PAINTBRUSH • BUNGS OR PENCIL STUBS

Filters fitted to most mechanical pumps



The most common type of pump; if there is a sealing ring, check it.

This design has a cylindrical filter holder and disc filter.

The top of this one unscrews with the filter attached.

Most mechanical pumps have a removable top covering the filter. On earlier units the top may be a glass dome.

A central screw or nut holds the top on. Unscrew this, lift off the top and take out the filter. If a flexible fuel pipe is connected to the top, leave it there. This will ensure that you refit the top to the pump the right way round.

Some pumps have a cylindrical filter attached to the cover, which screws by hand into the pump.

Some may also use crimped-on pipe clips; snip off with side cutters and replace with a screw clip if the pump is removed.

SU mechanical-pump filter

An SU mechanical pump is different from other types and is found mainly on British-built cars. There are two main SU types: AUF 800 which has a filter, and AUF 700 which does not – although its top is removable.

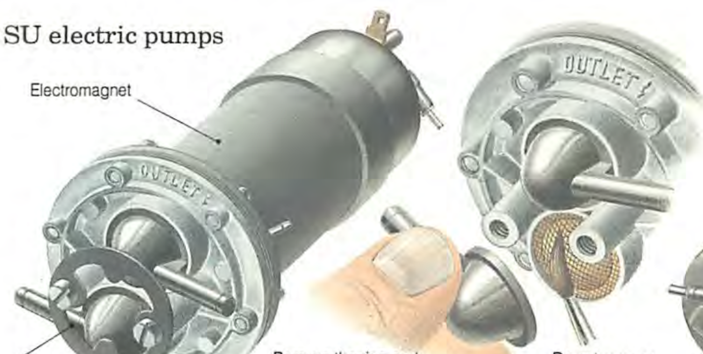
The 800 has inlet and outlet pipes side by side on top, leading in opposite directions. The right-angled 'elbow' connectors are held in place by a metal ring fixed by two screws. These screws are often very tightly seated, and are also made of soft metal. Use a correctly fitting screwdriver in good condition to remove them.

Remove the ring, lift off the inlet elbow only, and lift out the filter. Clean it and reassemble quickly: the rubber sealing ring under the pump elbow swells up when it is exposed to the air.

When reassembling make sure that the rubber ring seals, and that the elbow is facing the right way.

The filter is inside the elbow. Refit the right way round.

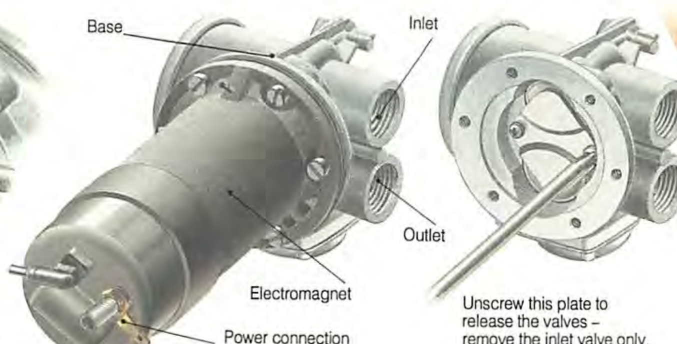
SU electric pumps



The two elbows are held by a ring.

Remove the ring and take off the inlet elbow only.

Do not remove the gauze filter – clean it in position.



Unscrew this plate to release the valves – remove the inlet valve only.

The valve must be refitted the right way round, or the pump will not work.

The most common SU electric pump has two dome-headed right-angled 'elbow' inlet and outlet nozzles. They are made of black plastic and mounted side by side, but leading in opposite directions.

Which one does which job is marked on the casing. Remove only the inlet nozzle and work quickly, because the rubber sealing ring under it swells up when exposed to the air for a time.

Do not remove the filter – clean it by brushing dirt away with a clean, small paintbrush and fresh petrol.

Check that there are no loose bristles in the brush. Take care to refit the nozzle the right way round.

Earlier SU pumps have screw-in connections mounted almost at right-angles to each other. The filter is under a large brass-headed cap opposite the outlet to the carburettor.

Two other SU electric pumps are found on larger cars. Both have inlet and outlet pipes side by side.

One has a double electromagnet – the large black cylindrical part.

To reach the filter on either type, you have to remove the magnet cylinder from the base.

On the double type, remove only the cylinder that is positioned on the right as you view the pump, with the word 'top' moulded into the base facing you and the right way up.

Take out the six screws holding the pump together, and separate the cylinder and base.

On the base, two more screws hold a metal plate over the two valves. Unscrew them and take out the inlet-valve cover and valve – the outlet valve is marked 'out' on the outside of the base.

The filter, a small gauze disc between two rubber seals, is underneath. Prise it out gently with a pin.

Be sure to reassemble the pump correctly – the valve goes back with the straight strip on top. Check that the gasket between the main parts of the pump is sound, but do not turn it. It must remain in the same position for the pump to work.

Refit the pump, and the two electrical connections and reconnect the fuel pipes.

Checking a mechanical fuel pump

If a car stops and has not run out of petrol, check whether there is petrol in the carburettor. If there is not, there is a fault in the fuel system.

Disconnect the fuel line to the carburettor, slipping a plastic bag over the end of the line as you do so to catch any fuel inside. Secure the bag with a rubber band, then turn the engine over with the starter.

If fuel spurts out, there is a carburettor fault (SHEETS 179–188). If no fuel, or only a dribble, emerges, either there is a blockage or leak somewhere in the fuel line (SHEETS 176 and 168–169) or the fuel pump is not working. Some pumps are sealed and cannot be repaired; check to see if there are screws for dismantling.

A mechanical-pump drive hardly ever fails – though signs of wear may appear on the cam and operating lever, linkages and pins.

Diaphragms can leak. A small leak may affect the engine noticeably only at high speeds, but may also let petrol drip through into the camshaft area and from there to the sump. If this occurs, there is a risk of an explosion.

Valves have a disc and a seating held together by a small cage. Pressure in one direction pushes the valve on to its seating, closing it; pressure the other way lifts the disc and opens the valve.

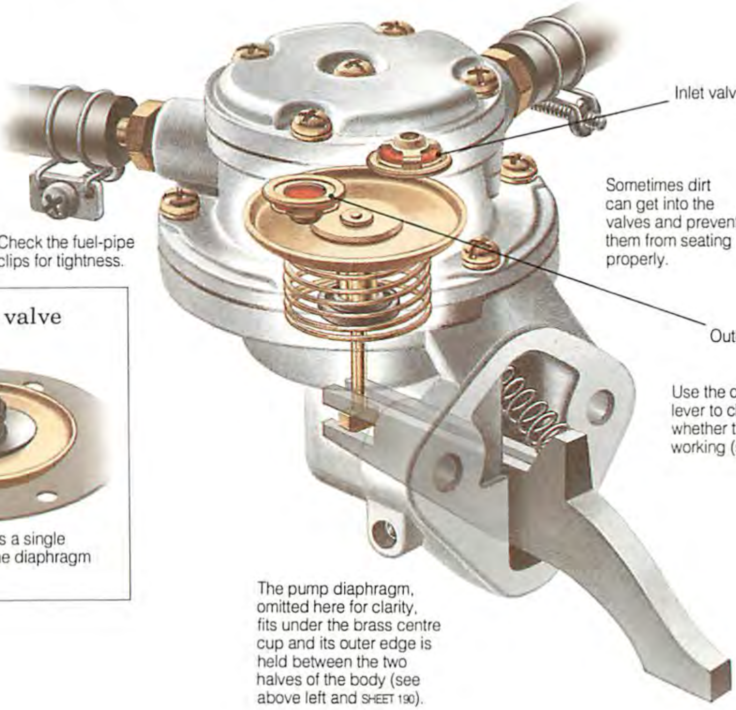
Valves last many years, but dirt can get in and stop them seating properly. For cleaning, see SHEET 190.

Gaskets and loose fuel pipes may leak, and so may the seal between the diaphragm and the two halves of the pump body.

Another occasional fault is loose mountings. The pump is often out of sight, and bolts may work loose unnoticed. This will cause a severe oil leak (SHEETS 145–146).

Tools and equipment

PLASTIC BAG AND RUBBER BAND • TAPERED PLUGS OR OLD PENCILS • SIDE CUTTERS • SCREWDRIVER • SPANNER



Inlet valve

Sometimes dirt can get into the valves and prevent them from seating properly.

Outlet valve

Use the operating lever to check whether the pump is working (see below).

Check the fuel-pipe clips for tightness.

The pump diaphragm, omitted here for clarity, fits under the brass centre cup and its outer edge is held between the two halves of the body (see above left and SHEET 190).

Two-way valve

On some SU pumps a single two-way valve on the diaphragm controls the flow.

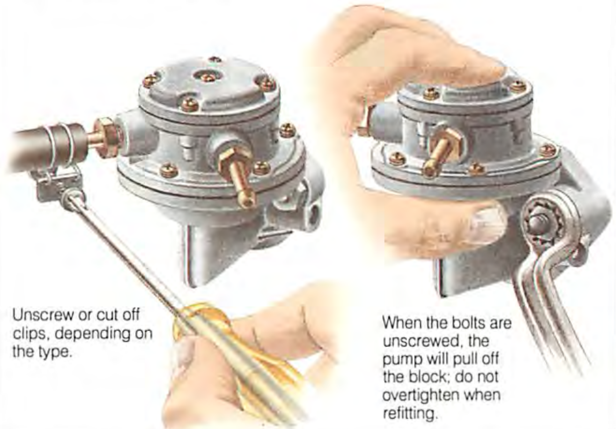
Removing and replacing the pump

Have a couple of tapered plugs or old pencils handy to block the fuel lines in case they gush petrol when you disconnect them.

Sometimes the lines are held on with wire clips which have to be cut off with side cutters. Replace them with new screw clips. Twisted wire can be used as a temporary measure.

When refitting the pump, make sure the lever is above the camshaft. If not, the operating cam will be damaged as the engine turns over.

Replace gaskets after an overhaul. Tighten bolts gradually in sequence. Do not overtighten.



Unscrew or cut off clips, depending on the type.

When the bolts are unscrewed, the pump will pull off the block; do not overtighten when refitting.

Checking the pump operation

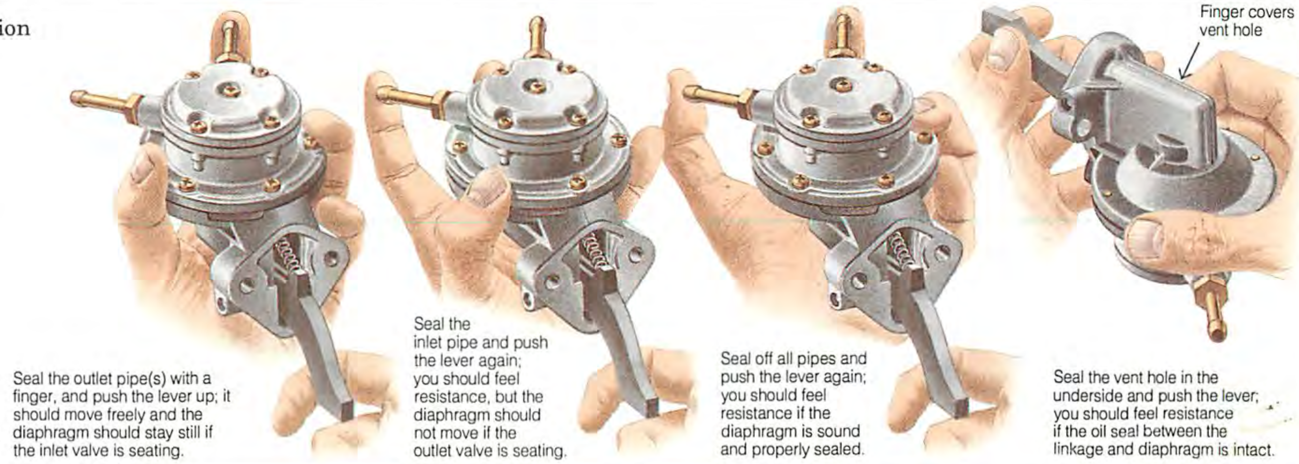
The 'official' way to test a pump is to put a pressure gauge on one side and a vacuum gauge on the other. A simpler way is shown here.

Do not test the pump by blowing compressed air into it: you may burst the diaphragm.

Even if you find the fault, you may not be able to mend it. If the pump is sealed, it will have to be replaced.

But if there is an obstruction under the filter (if any) you may be able to get at it by removing the filter (SHEET 176).

When you take the pump off, test it at once before the fuel in it dries up. Dry valves do not always seat fully.



Seal the outlet pipe(s) with a finger, and push the lever up; it should move freely and the diaphragm should stay still if the inlet valve is seating.

Seal the inlet pipe and push the lever again; you should feel resistance, but the diaphragm should not move if the outlet valve is seating.

Seal off all pipes and push the lever again; you should feel resistance if the diaphragm is sound and properly sealed.

Seal the vent hole in the underside and push the lever; you should feel resistance if the oil seal between the linkage and diaphragm is intact.

Removing a carburettor for cleaning

Over a period of time, dirt inevitably gets through the fuel filter of a carburettor, and chemicals in petrol leave residues which can eventually clog parts of it.

Moving parts wear – in particular needle valves. Jet needles become worn so that they no longer regulate the fuel flow smoothly. The idling jet of a fixed-jet carburettor, which is very small, can become blocked.

Rubber diaphragms used in some carburettors crack and perish. Gaskets and seals become leaky. The float height can alter, causing flooding.

Strip, clean and check the carburettor occasionally, or at any time when you suspect trouble.

See if you can find a special kit of parts for servicing your carburettor. The kit normally includes all gaskets, any washers or clips which should be replaced, a new float needle valve and sometimes new jets.

Often there is a basic service kit or a complete overhaul kit – try your local garage or accessory shop. Otherwise phone and ask the nearest carburettor specialists for the type on your car.

Be sure to get exactly the right kit. Jet and needle sizes vary from car to car – even for the same carburettor.

If you replace no other parts, always renew the gasket between the carburettor and the inlet manifold, and any split pins, clips or lock washers.

A service kit cannot, however, deal with wear around the throttle spindle. It is the light-alloy carburettor body which wears, not the spindle. Eventually air leaks in, upsetting the mixture. Test for wear by wiggling the spindle when the engine is idling. If the engine note changes, there is a leak. The only practical solution is an exchange carburettor.

The carburettor is a delicate mechanism with settings that are disturbed by dismantling. It has many small parts which are easily lost or misplaced.

Have paper and pencil ready to record the number of turns it takes to remove any adjuster screw. This will save time when you re-tune the carburettor afterwards (SHEETS 170–175).

Also make drawings of any complex linkage or special order of washers or seals which you might have trouble reassembling correctly. Mark anything with a sliding adjustment, so you can see exactly how it fitted originally.

Also mark any seemingly symmetrical parts (such as an SU dashpot) so that you do not replace them back to front – this can affect their working.

Some gaskets are nearly symmetrical, except for one or two holes. Be quite sure they are the right way round.

Some valves and pipe unions have balls or springs inside which can fall out or get lost. Dismantle the carburettor over a sheet of clean paper. When you unscrew a valve, tip the carburettor up and note if anything falls out, and where from.

Work in a clean place, and guard against dust and fluff getting into the carburettor. Even a tiny speck can cause trouble. Use petrol for cleaning. It will remove all the dirt that matters. Ignore discoloration.

Remove jets (if possible) to clean them. They are made of brass which is easily damaged: use a screwdriver which fits the slot exactly.

Do not poke them with a pin or wire. Blow through them with a foot pump if you have one.

Tools and equipment

SCREWDRIVER • CARBURETTOR SERVICING KIT • GASKETS • PAPER AND PENCIL • CLEAN PAPER • PETROL • SHALLOW CONTAINER • RAGS • FOOT PUMP • PLUG (PENCIL STUB)

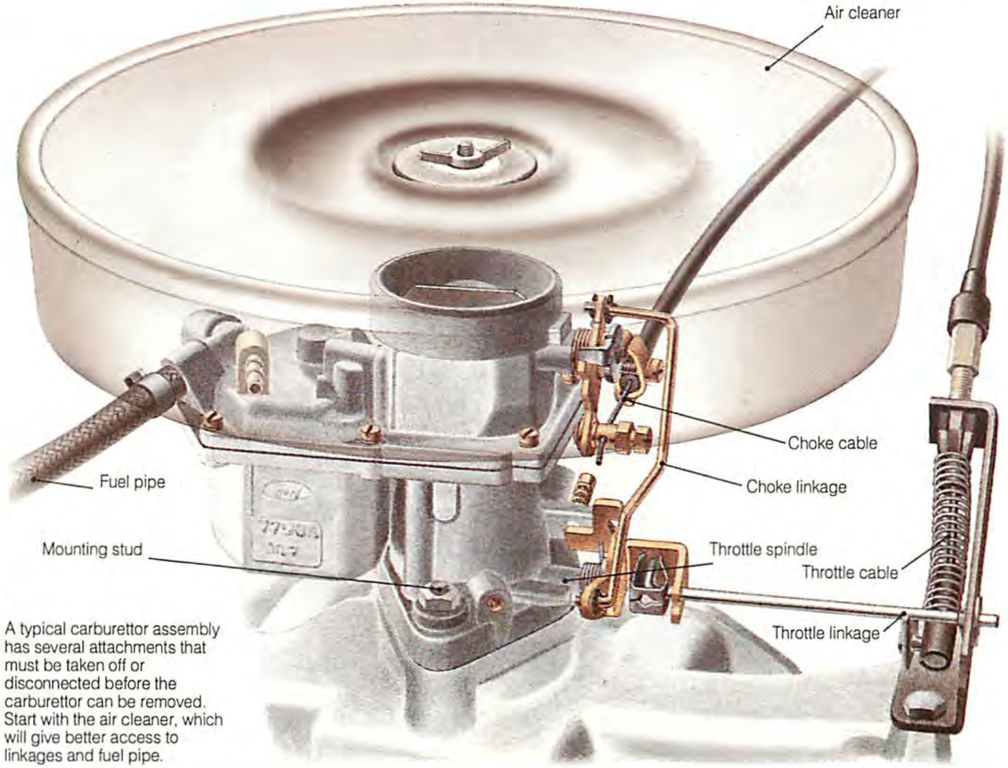
Removing the fuel pipe

Hold ready a tapered plug – an old pencil will do – then loosen the hose clip, if any. Twist the pipe off gently – do not pull it straight off. Quickly plug the pipe with the pointed end of the pencil to stop fuel escaping.

Lifting off the carburettor

Unscrew the nuts holding the carburettor to the inlet manifold studs. Lift it off, keeping it right way up as it contains fuel. Tip this away safely.

Leave the gasket on the inlet manifold as a guide so that you can fit the new gasket the right way round.

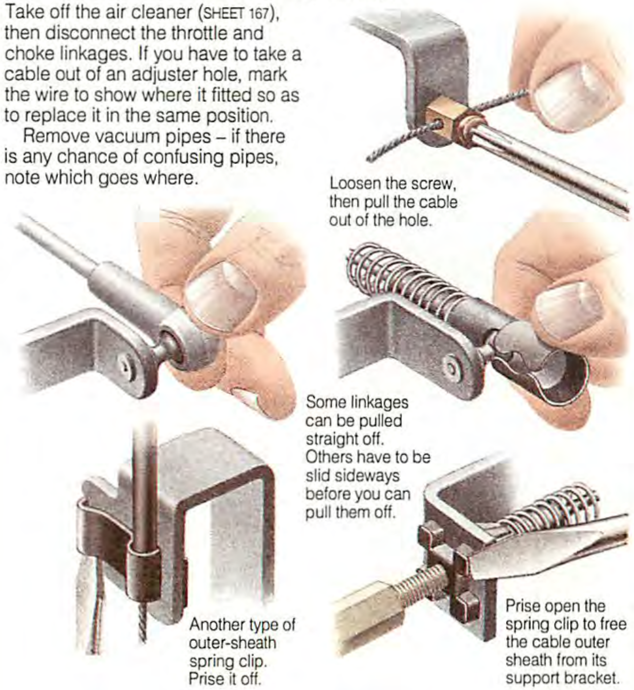


A typical carburettor assembly has several attachments that must be taken off or disconnected before the carburettor can be removed. Start with the air cleaner, which will give better access to linkages and fuel pipe.

Removing linkages

Take off the air cleaner (SHEET 167), then disconnect the throttle and choke linkages. If you have to take a cable out of an adjuster hole, mark the wire to show where it fitted so as to replace it in the same position.

Remove vacuum pipes – if there is any chance of confusing pipes, note which goes where.



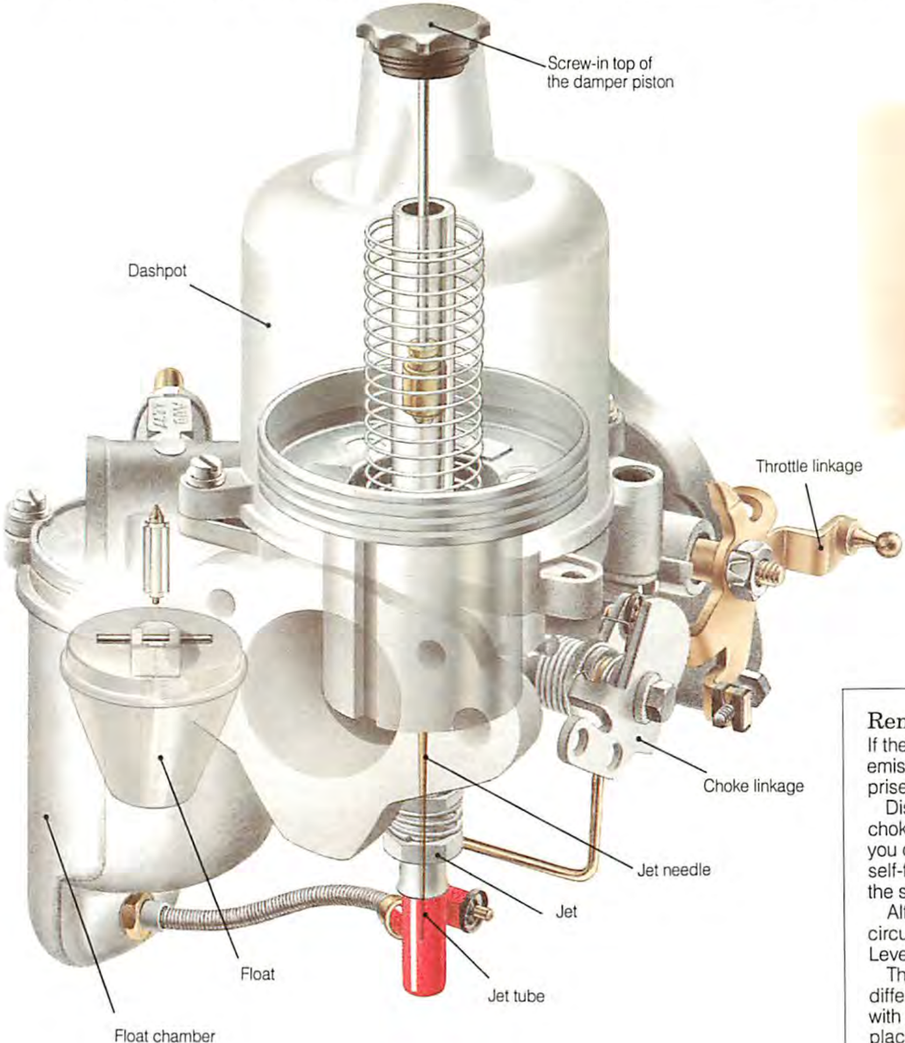
Checking and cleaning an SU carburettor / 1

The SU carburettor is simple to strip. It has only one jet (except in a few special types) and very few moving parts. It is very reliable, but it can become dirty and choked – and some parts wear out.

The most common type of SU is the HS. The HIF, overleaf, differs in some ways. They should be removed from the engine (SHEET 178) for cleaning.

Tools and equipment

SCREWDRIVER • PLIERS • SPANNER • FOOT PUMP • DRILL BIT $\frac{1}{8}$–$\frac{3}{16}$ IN. (3–5 MM)



Removing the dashpot

Unscrew the damper and pull it out of the 'dashpot' (properly called the piston chamber). It may pull straight out, or you may have to unfasten a circlip to free it.

Mark how the dashpot fits on to the main body so that you can replace it as it was. If it is turned, the piston may stick.

Remove the screws holding the dashpot. Lift it off.

Pull out the piston carefully, straight upwards. It is easy to bend the jet needle.

Remove the screws to take off the dashpot. Before lifting it off mark the dashpot and flange.

Removing the jet needle

There are dozens of jet-needle sizes: the type number is stamped on the shank of the needle.

Remove the needle by loosening the grub screw in the side of the piston.

Early carburettors have a rigid needle with a shoulder or groove which must fit level with the bottom face of the piston.

Later models have a flexibly mounted needle. This hangs at an angle and must be fitted the right way round.

Look before you remove it. There may be an etch mark pointing either towards or away from the butterfly plate.

Alternatively, there may be a notch which lines up with a groove in the needle guide.

Renew the jet needle if it is bent or looks worn. Wear is hard to assess visually on a centred needle. The needle wears imperceptibly over a period by fuel flowing past it at the mouth of the jet.

Wear spots will show as shiny patches on the needle if it is not centred – particularly at the thick end on a flexibly mounted needle, which actually bears against the lip of the jet on one side.

If in doubt, renew the needle at major service intervals or after two or three years, according to mileage. Or examine it closely against a new one.

Lift out the piston and jet-needle assembly, taking care not to bend the needle.

Loosen the grub screw to free the jet needle.

Removing the jet assembly

If the carburettor has a plastic emission-control seal (SHEET 175), prise it off and throw it away.

Disconnect the jet from the choke linkage. On older models you do this by removing one self-tapping screw – do not lose the spacer washer under it.

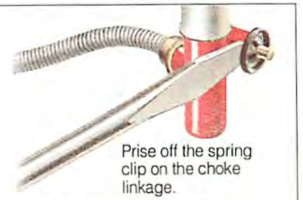
Alternatively, there may be a circular, toothed spring clip. Lever this off with a screwdriver.

The latest models have a different linkage. There is a fork with two clevis pins held in place by split pins.

Sometimes the linkage includes a bimetallic disc for adjusting the mixture to suit the temperature. Pull out the split pins and clevis pins.

Unfasten the nut which holds the jet tube on to the float chamber. Pull the tube free. A small rubber sealing ring will probably stay inside the joint. Prise it out with a small screwdriver.

Pull the jet out of the carburettor. Look at its hole. If it has worn oval, renew the jet.



Prise off the spring clip on the choke linkage.

Undo the nut holding the jet tube to the float chamber.

Cleaning and reassembly

Wash all parts in petrol and blow through the jet to clear it – use a foot pump if you have one.

To reassemble the jet, slide the metal ferrule into the end of the jet tube. Fit the metal washer over the end, then the rubber seal.

Leave at least $\frac{3}{16}$ in. (5 mm) of tube sticking out of the end of the seal. Insert the tube into the float chamber. Tighten the nut.

When you reassemble the dashpot, note that the piston has a groove in one side and fits in only one way. If the carburettor has a rigid needle it must be centralised in the jet (SHEET 171).

Checking and cleaning an SU carburettor / 2

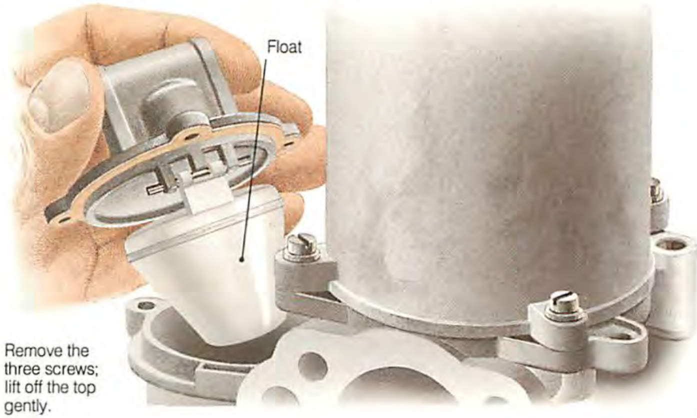
Removing the float

Disconnect the fuel pipe from the top of the float chamber.

Remove the three screws holding the top on the float chamber.

Lift the top off with care: the float hangs from it and its pivot arm is easily bent, which will upset the critical fuel level in the chamber and cause either fuel starvation or flooding of the carburettor (SHEET 171).

Check the bottom of the bowl for sediment and remove any by dislodging it with a small screwdriver. Wash out the bowl with clean petrol and wipe dry with a lint-free cloth. Replace the top with a new gasket and tighten the screws evenly. Refit the fuel pipe to the chamber top.



Remove the three screws; lift off the top gently.

Detaching the float and valve

Pull out the float pivot pin with pliers. Mind you do not drop the float as it comes free, or lose the needle valve as it drops out of its housing.

Use a spanner to unscrew the housing from the chamber top: there may be dirt inside it.

Look at the needle valve. If a groove has been worn at the pointed tip, it cannot seat properly and may allow the chamber to flood – to overfill with fuel. Renew it.

After cleaning and reassembly, check the float height, which governs the level of fuel in the chamber.

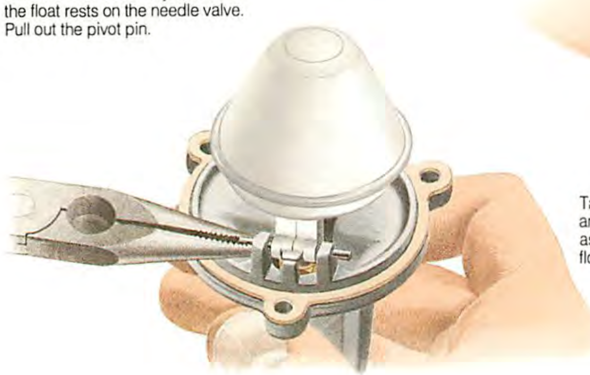
Hold the chamber top upside-down and level. The gap between the float and the top should be between $\frac{1}{8}$ in. and $\frac{3}{16}$ in. (3 mm and 5 mm).

If the gap is wrong, you can sometimes adjust it by bending the float arm – but only when the arm is metal. You cannot adjust an all-plastic float.

Bend a metal arm carefully at its outer end. Do not bend it at the float end, in case you loosen its fastening to the float, which may cause a leak.

If the float has a crack or split, do not seal it with glue. The weight of the float is critical. You must replace it with a new float.

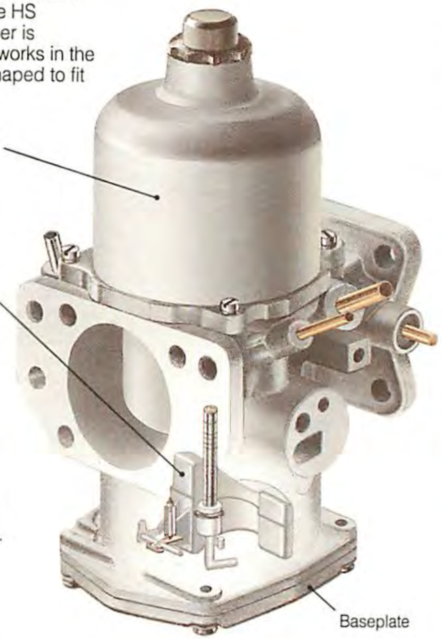

Use a drill-bit shank of suitable size to check the gap between the float and chamber top.


Hold the float assembly so that the float rests on the needle valve. Pull out the pivot pin.


Take out the valve needle and unscrew the valve assembly from the float-chamber lid.

Stripping an HIF carburettor

The dashpot on an HIF carburettor is the same as that on the HS although the float chamber is beneath the body, but it works in the same way. The float is shaped to fit round the jet.



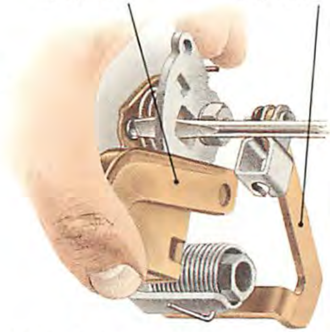
Undo four screws to remove the baseplate from the float chamber. Do not lose the rubber sealing ring.

Removing the choke linkage

Remove the linkage to clean the carburettor. The retaining plate is held on by two screws.

Usually there is a square hole in the fast-idle cam. Turn the cam to reach one of the screws through the hole. Otherwise, remove the cam.

With the retaining plate free, pull the choke assembly out, taking care not to damage the seals.

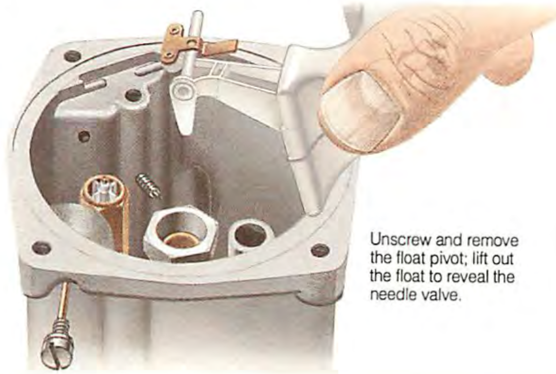


Remove two screws to free the retaining plate.

Dismantling the float chamber

Remove the four screws holding the baseplate. Take off the plate. Do not lose its rubber sealing ring. To release the jet, undo the screw going up into the chamber from underneath. Unscrew the float pivot from the side of the body to release and withdraw the float. Using a socket, unscrew the needle-valve seating and lift out the assembly. Release the jet-bearing locking nut and take out the nut and bearing.


Remove the retaining screw from underneath to release the jet.


Unscrew and remove the float pivot; lift out the float to reveal the needle valve.

Checking and cleaning a Stromberg carburettor / 1

The Stromberg carburettor does not have a regular service schedule, but should be cleaned about once a year. Replace worn parts as necessary.

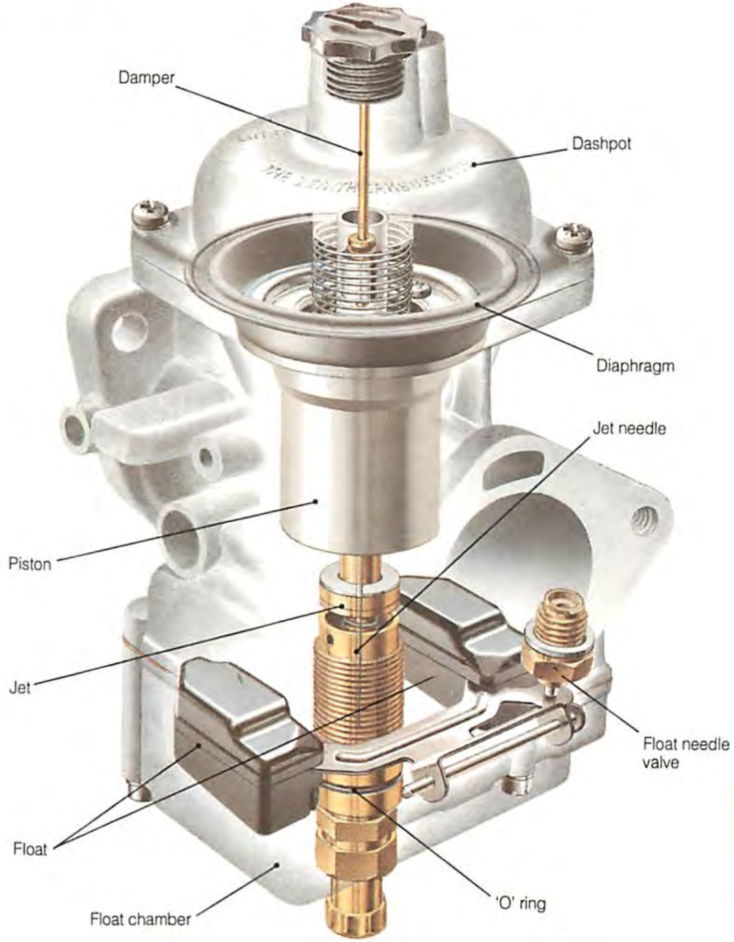
Dirt which has penetrated the fuel filter, and residues from chemicals in petrol build up inside. Needles and jets wear out after a few years' use.

The rubber diaphragm may become holed – and even a tiny hole causes loss of engine power. As the hole enlarges, the engine will eventually do no more than idle.

Remove the carburettor from the car to clean it. Keep it upright to avoid spilling petrol, then empty it safely. Clean all parts except the diaphragm by rinsing in a dish of petrol.

Tools and equipment

PETROL AND DISH FOR CLEANING • PENCIL OR OTHER MARKER • RULER • PLIERS • SCREWDRIVER • OPEN-ENDED SPANNER • RING SPANNER • FOOT PUMP • ENGINE OIL



Removing the dashpot and piston

Unscrew the damper from the top of the piston chamber – commonly called the dashpot. Pour the oil inside it away.

Mark the dashpot top so that you can refit it to the chamber the same way round.

Remove the screws and lift off the top carefully, making sure that the piston spring does not catch and so drag out the piston.

Check that the diaphragm, which will come out when you remove the piston, is not stuck down around its edge: it is easily torn.

Lift out the piston, pulling it straight up so as not to bend the needle in its base. Note that on the diaphragm edge there is a tab that fits into a slot in its seating on the chamber base.

After reassembly, refill the dashpot with multigrade engine oil to just above the level of the brass piston inside the tube – or you can obtain a special SAE 20 oil made by the carburettor manufacturers.

Remove the four screws holding the dashpot top.

Lift off the top, taking care the spring does not catch.

Do not bend the jet needle; note the tab on the diaphragm edge.

Replacing the jet needle and diaphragm

A badly worn jet needle has a groove round it, but less severe wear is invisible.

Wear does, however, affect performance, so replace the needle every few years.

There are many needle sizes: be sure to get exactly the right one. Remove the needle by loosening the grub screw in the side of the piston.

To remove the diaphragm, carefully undo the screws of its retaining ring.

Lift off the retaining ring and diaphragm. Hold the diaphragm up to the light and check it minutely for the tiniest hole.

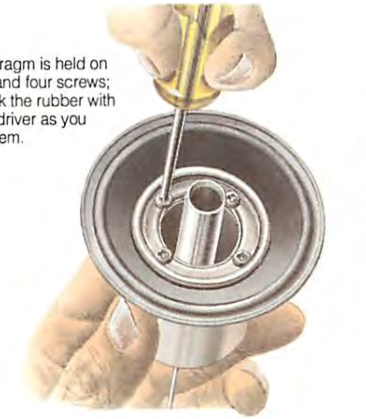
If it has become perished, hard or misshapen, renew it.

Be sure to fit the new diaphragm the right way round and the right way up. There is a tab on its inner edge that fits into a recess in the piston.

Take care not to get oil or petrol on the diaphragm, and not to nick or tear it.

Loosen the grub screw to free the needle.

The diaphragm is held on by a ring and four screws; do not nick the rubber with the screwdriver as you remove them.



Pull the diaphragm gently and hold it up to the light to show up any pinholes.

Checking and cleaning a Stromberg carburettor / 2

Dismantling the float chamber

Before removing the float chamber, pull the adjuster stop off the jet with pliers. Note that emission-control models (SHEET 175) do not have such a stop.

Take out the six screws securing the float chamber. You should then be able to lift the chamber off – but the sealing ring around the jet may make it stick.

Pull carefully: a sharp jerk or twist might damage the float.

With the chamber removed, pull out the float pin to free the float.

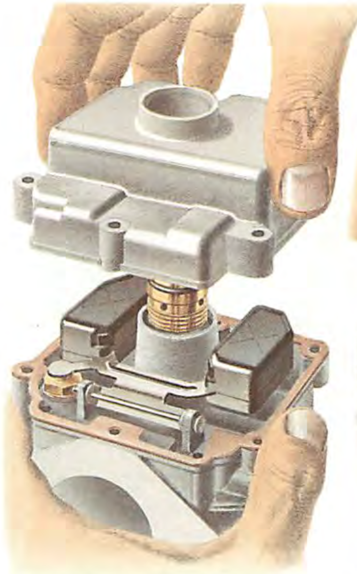
Older models have a pin that you can usually remove with your fingers. If it is stiff, gently prise it out sideways with a thin screwdriver. Emission-control models have a pin set in clips: lever it out carefully with a screwdriver.

The float needle valve is screwed into the base of the float chamber. It is in one piece and cannot be dismantled for cleaning. If it is worn it must be replaced.

If the float needle valve is blocked you may have to replace it.

Pull the adjuster stop straight off.

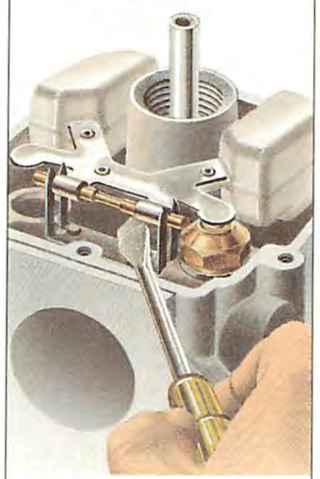
Remove the six float-chamber securing screws.



Lift off the float chamber without twisting or levering.

One type of pin usually pulls straight out.

Levering it off



This type has to be levered off with a screwdriver – take care not to scratch the carburettor body.

Adjusting the float

A float that is maladjusted, or is leaking so that it no longer floats properly, causes persistent flooding of the carburettor.

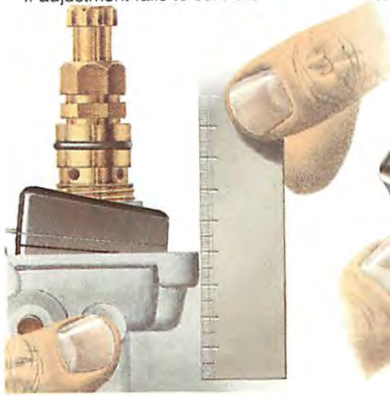
Shake it – if fuel splashes inside, it is leaking and must be replaced.

If adjustment fails to cure the flooding, that too calls for a new float and a new needle valve.

With the carburettor upside-down, measure the height of the bottom of the float (now at the top) above the edge of the body.

The height should be $\frac{5}{8}$ to $\frac{11}{16}$ in. (16 to 18 mm) for a hollow float or 23/32 to 25/32 in. (18·5 to 19·5 mm) for a solid float.

Adjust the float by bending the tag that touches the needle valve, or by fitting a thicker or thinner washer under the valve.



With the carburettor inverted, measure the height of the float above the body edge.

Bend the tag to adjust the float height.

Adjusting the valve

Fitting a thinner or thicker washer under the valve will alter its height and that of the float.

Removing the jet

Do not remove the jet of an emission-control model (SHEET 175); a special adjusting tool is needed for its castellated adjuster nut. Do not even turn it: this alters the mixture. Clean it in place by washing with clean petrol; blow it clear with a foot pump.

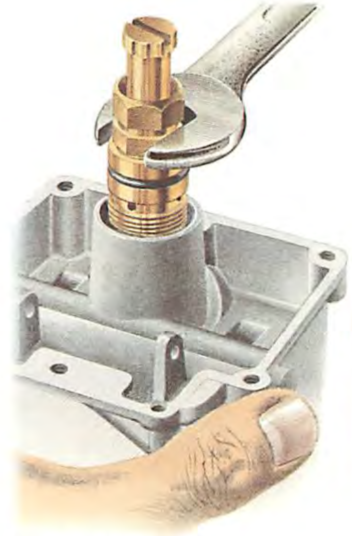
Remove a conventional jet by unscrewing the holder, using a spanner on the lower of the two hexagonal parts. Do not move the jet-adjusting screw, as this will alter the mixture (SHEET 172).

Lift off the jet holder and pull out the jet. Wash the jet in clean petrol and blow through it with a foot pump to clear it.

Check the rubber 'O' ring round the jet holder for signs of wear or cracking. A failed ring will allow petrol to leak from the float chamber.

Lever off the ring with a pin or thin screwdriver; take care not to scratch the surface. Roll the new ring on over the holder.

After reassembling the carburettor, centralise the jet (SHEET 172) if necessary.



Loosen the jet holder by turning the lower hexagon.

With the holder removed, pull out the jet.

Checking and cleaning a fixed-jet carburettor / 1

Fixed-jet carburettors are easily blocked by small dirt particles and chemical residues from fuel, because some of the jets are very small. Dismantle and clean them about once a year.

Jets wear out after a few years. In some cases you can replace them with new ones of the right size from a carburettor service kit.

On other types the jets are not removable, and you must obtain a new or exchange replacement carburettor. Consult the car workshop manual to find if the jets are renewable.

Replace all gaskets after every cleaning. You may also need new rubber diaphragms for the accelerator pump and the economy device which is sometimes an integral part of it.

Take extra care not to allow any fluff or dirt to enter this type of carburettor as you clean it.

Dismantle it on a clean tray so that none of its many tiny parts – such as balls and springs in one-way valves – are lost if they fall out.

Make notes and drawings as you work so that you can replace all parts exactly as they were.

Count and note the number of turns needed to remove any adjuster screws, and wind them back to the same setting when refitting.

Remove the carburettor from the car (SHEET 178), keeping it upright to avoid spilling fuel. Clean the outside to stop dirt entering. Use a lint-free cloth at all times. There is no need to remove minor surface discoloration.

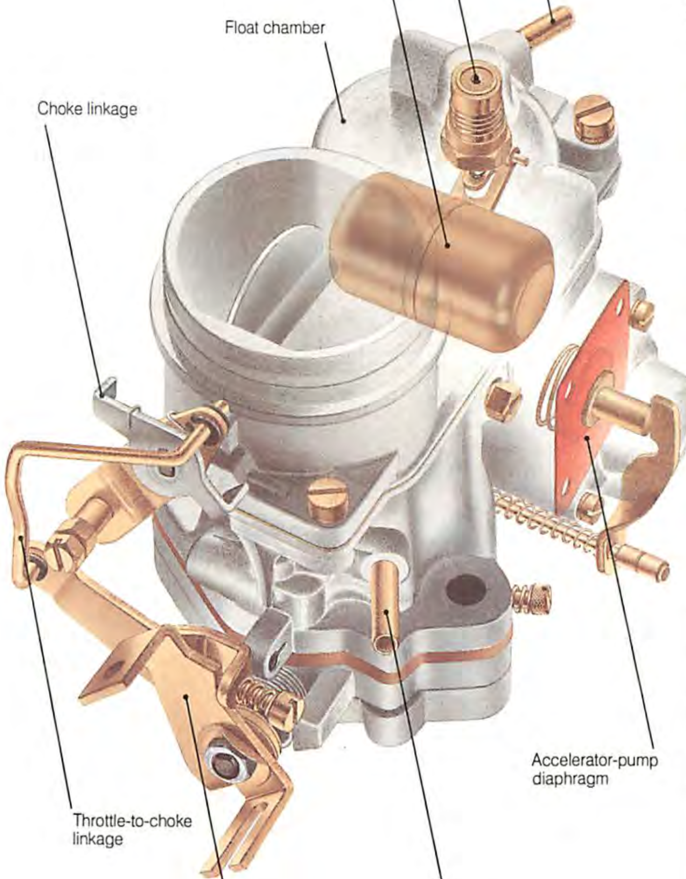
Wash all parts except rubber diaphragms in petrol. Keep diaphragms clean and dry.

After reassembling a carburettor, oil the external moving parts with thin machine oil of the type used on sewing machines.

Tools and equipment

SCREWDRIVERS • LONG-NOSED PLIERS • COMBINATION PLIERS • SIDE CUTTERS • SPANNERS • LINT-FREE RAG • PETROL • DRILL BIT • STEEL RULE

A typical fixed-jet carburettor



This carburettor is typical of fixed-jet designs. The body is in two halves which can be separated for cleaning or jet replacement.

Removing the top

Disconnect the linkage between the throttle and choke lever arms. This may be secured with circlips which you can ease off with a screwdriver; or by split pins which you straighten, pull out and discard. Always use new split pins when reassembling, or circlips if they are damaged during removal.

Remove the screws holding the top and bottom of the carburettor together. Lift off the top and remove the gasket. If the gasket is stuck to the flange, carefully prise it off with a sharp knife and clean the face of the flange.

There is probably a ball valve in the accelerator-pump circuit in the bottom of the carburettor. Slowly turn the bottom over to pour away any fuel left in it.

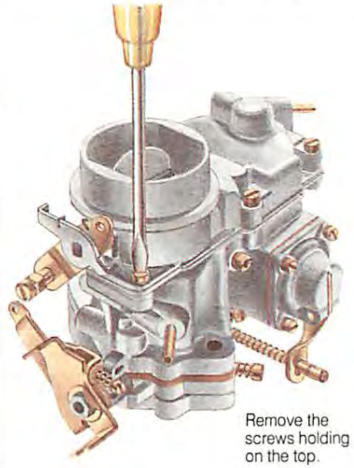
Be ready to catch the ball, and perhaps a weight which rests on it, as these fall out. Note where they belong.

Gently wipe out any loose dirt in the bottom of the float chamber with a clean rag soaked in petrol. Take care not to rub dirt into any jets or passages inside the chamber.

Prise off a circlip with a screwdriver.

Split-pinned

The linkage may be secured by a split pin. If you remove it, replace it with a new one.



Remove the screws holding on the top.

Clean with a lint-free cloth soaked in petrol.

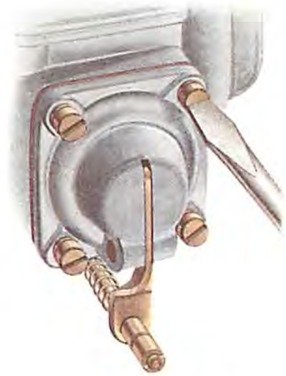
Removing the diaphragm

Be careful not to nick or tear the rubber diaphragm of the accelerator pump as you remove it. The diaphragm may stick to the retaining cover or to the carburettor body. That also applies to the diaphragm of any economy device.

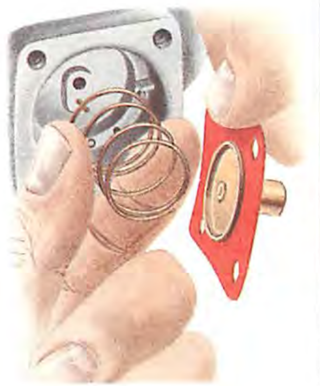
Remove the screws of the diaphragm cover, take off the cover, then gently detach the diaphragm. There is likely to be a spring behind it: do not lose this. Inside there are other removable parts, such as a piston.

Check the diaphragm minutely for holes or cracks. If holes are found, replace the diaphragm.

A service kit for the carburettor should include gaskets and diaphragm.



Remove the screws of the diaphragm cover on the side of the carburettor.



Carefully peel off the diaphragm and take out the light spring.

Checking and cleaning a fixed-jet carburettor / 2

Removing the float and valve

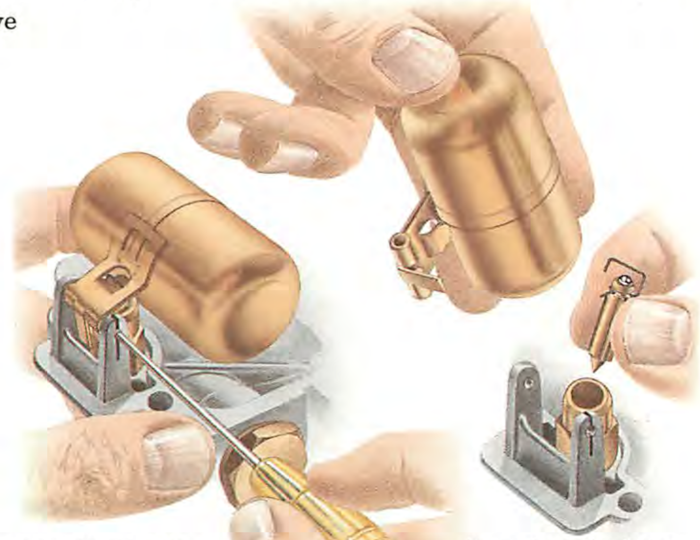
Remove the float to clean the needle valve which it controls. The float is delicate and easily damaged, so take care. Usually you simply push out the pivot pin and lift the float off.

Unscrew the needle valve, wash it and blow through it with a foot pump to clear it. If the needle or jet are worn, replace the whole valve. A worn valve may cause flooding – but there are two other possible causes.

One is a leak in the float, which makes it sink. Shake the float: any fuel in it means that it is leaking and should be renewed.

The other cause of flooding is an incorrect float level.

The pivot pin is held in two mounting posts, one of which is split. Free the pivot pin by inserting a very small screwdriver in the split and gently levering it open. Push the pin out as soon as it can be moved freely. The post is an alloy casting and is brittle, so take care as it will break easily.



Push out the pivot pin to free the float.

Remove the needle valve for cleaning the valve and its seat.

Needle-valve assembly

Some needle-valve assemblies are removed with a spanner.

Checking the float height and the needle-valve assembly

The correct height setting varies between carburettors, but the setting for your particular one should be given in a service manual for the car. Otherwise, consult your local dealer.

The setting is measured in different ways, according to the type of carburettor.

On most of those which have the float pivoted under the carburettor top, invert the top and insert the shank of a suitably sized drill bit between float and top.

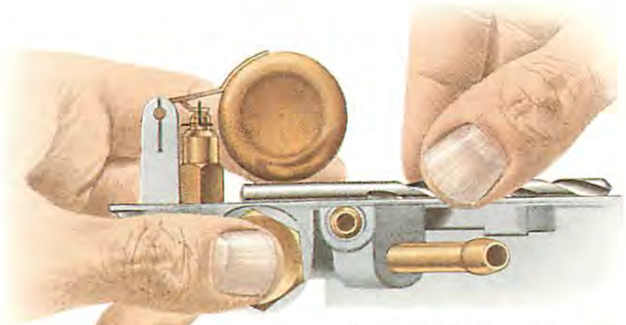
On others, position the top so that the float depresses the needle valve, then measure the distance between the underface of the carburettor top and the bottom of the float – usually with the gasket fitted. This measurement should be made with a 6 in. (150 mm) steel rule.

With certain carburettors – notably some Solex types – the measurement is to the marked centreline of the float, or its underside.

Adjust the height by bending the tag on the float arm, which rests against the needle valve. Usually there are two tags – the other one stops the float from falling too far, and its setting does not have to be exact.

Do not bend the float arm where it is attached to the float – in doing so you may damage the float and cause it to leak.

A leaking float should not be repaired, for the weight is critical. If you seal it by adding a blob of solder or epoxy resin glue, the weight of the float and the fuel intake is affected.



On some carburettors you can check the gap with the shank of a drill bit.

Adjust the setting by bending the tag.

Adjust with a washer

Sometimes you add a washer to the needle valve to adjust the float level.

Keeping the jets clean

There are four types of jet, though a carburettor may have more than one of each – for example in a twin-choke carburettor.

Each of the carburettor jets caters for a different part of the engine's speed range. You can to some extent diagnose a fault in a particular jet by bad performance at the engine speed it governs.

The main jet is the largest. It supplies fuel at full throttle openings and high engine speeds. It is usually set either in the bottom of the float chamber or in an extension of the carburettor top which reaches down into the chamber.

The idle jet supplies a tiny trickle of fuel for idling. It is very narrow and easily blocked.

Between idling speed and high speed, progression jets supply more fuel as needed. The progression system also includes an emulsion tube – a mixing device that is longer than a jet and has holes in its walls.

The accelerator pump also has a pump jet. Trouble in this jet causes hesitant acceleration – but this may equally be due to another fault in the pump, such as a holed diaphragm.

Usually jets and emulsion tubes are removable and have a screw slot in the head. They are made of soft brass and easily damaged, so use a screwdriver that fits the slot exactly.

If the jet does not have a screw slot, it is not removable. Clean it in place, using a foot pump to blow air through it.

Never blow through an assembled carburettor – if you do, you may rupture the diaphragms, cause the float to collapse or do other damage.

Weber carburettors have an air-correction jet fitted into the emulsion tube, and a main jet set in a jet holder which is inside the body of the carburettor.

Clean jets removed from a carburettor by washing them in petrol, and use a foot pump to blow them clear, but do not poke them with wire. Do not even use a soft brush: it might leave a bristle inside which would block the jet.

If you have recurring problems with the jets blocking, check the filter gauze at the carburettor fuel intake, if fitted.

There may be a hole in the gauze, which is letting dirt through.

If the carburettor does not have a filter, consider fitting a separate in-line fuel filter if one is not fitted already.

Types of jet

A main jet

Main jet (Weber)

An emulsion tube

A secondary jet

Jets can vary in shape and size. A main jet has a larger hole than a secondary or idler jet, which does not need to pass as much fuel.

Checking and cleaning a GM Varajet carburettor / 1

The Varajet carburettor used on many Vauxhalls and Opels is a hybrid between fixed-jet and variable-jet (for example, SU) types. It is as sensitive to dirt and sediment as any fixed-jet carburettor, and needs careful cleaning about once a year.

The Varajet has two chokes or barrels. The first, which works alone at low engine speeds, has a fixed-jet system. The second, which comes in at higher speeds, has a variable jet.

As with any carburettor, remove it from the car (SHEET 178) for cleaning. Wash parts in petrol, using lint-free rags to wipe them. Renew all gaskets. After reassembly, oil the external moving parts.

The carburettor has the layout of a normal fixed-jet type, and is dismantled in much the same way.

Take the same precautions against dirt and the loss of small parts (SHEET 183). Make notes or drawings of any parts dismantled, to aid refitting.

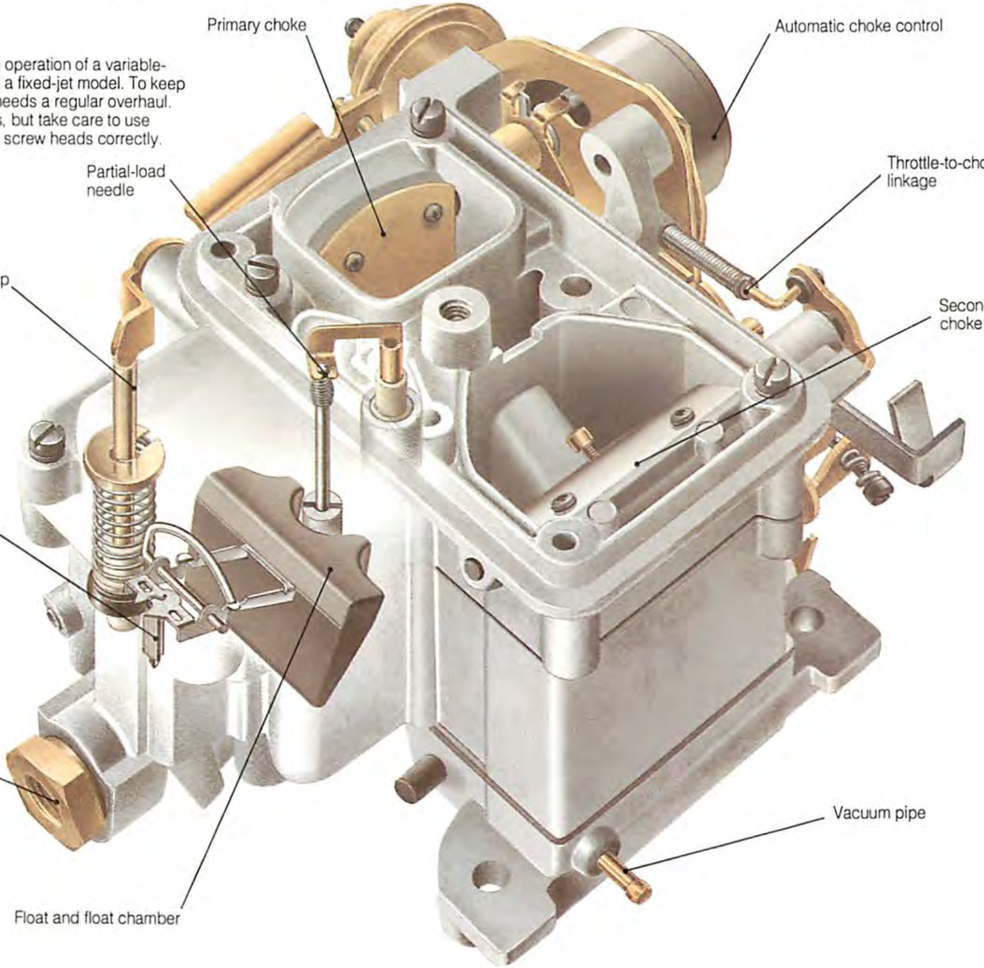
Try not to disturb the settings of adjuster screws, but if you do, ensure that you return them to their original setting by counting the number of turns taken to remove them.

Tools and equipment

LONG-NOSED PLIERS • SCREWDRIVER • LINT-FREE CLOTH

GM Varajet

The Varajet combines the operation of a variable-jet carburettor with that of a fixed-jet model. To keep the best performance, it needs a regular overhaul. You need no special tools, but take care to use screwdrivers which fit the screw heads correctly.



Stripping the body

Disconnect the linkage between the throttle and the choke by straightening the split pin and pulling it out. Use a new split pin when you reassemble.

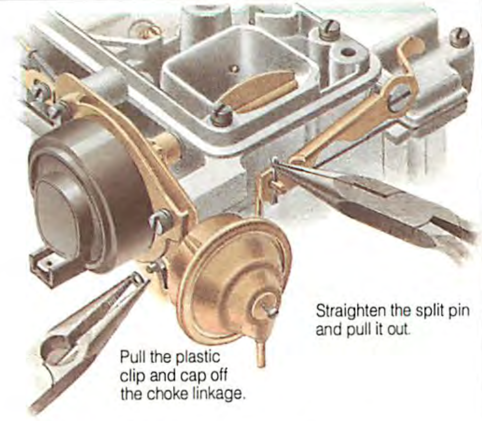
Remove the screws holding on the top and lift it off. Unlike most modern fixed-jet carburettors, the float is not hung from the top, and so stays in place. Be careful not to bend the various tubes protruding from the bottom.

The accelerator pump, which has a spring under it, may jump out. If it does not, lift it out carefully. There is a ball under the spring which falls out when you turn the body over, so be ready to catch it.

There is also another, larger ball in the suction-valve spring housing next to the pump.

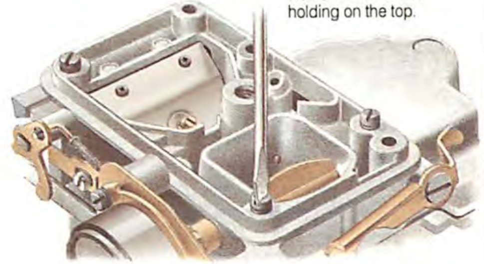
This will not come out unless you take out the screw above it and extract the spring with very long-nosed pliers. Do not do this unless you have to inspect a broken spring or a blocked jet under the ball.

Peel off the old gasket, making a note of how it fits so that you can fit the new one in exactly the same way.

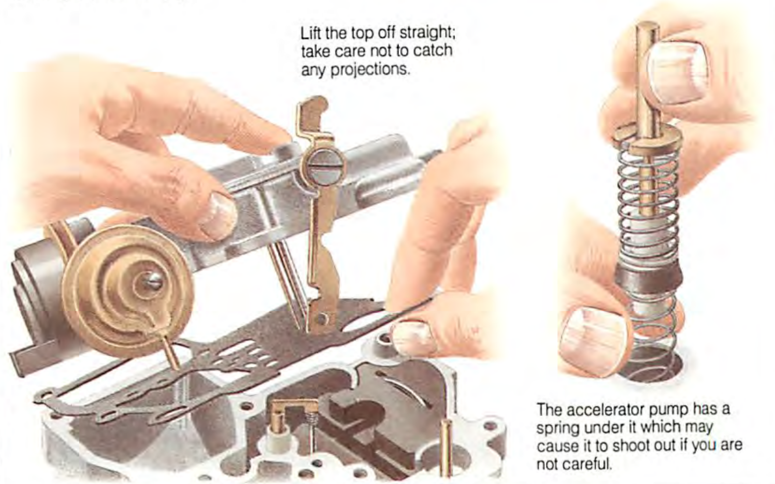


Pull the plastic clip and cap off the choke linkage.

Straighten the split pin and pull it out.



Remove the screws holding on the top.



Lift the top off straight; take care not to catch any projections.

The accelerator pump has a spring under it which may cause it to shoot out if you are not careful.

Checking and cleaning a GM Varajet carburettor / 2

Rinsing out the float chamber

Lift out the upper packing piece. Examine the float valve to see how the valve spring hooks on to its platform.

Unhook the spring and remove the float pivot clip so that you can lift the float out. The needle will come too, hanging from the end of the float. Lift it off.

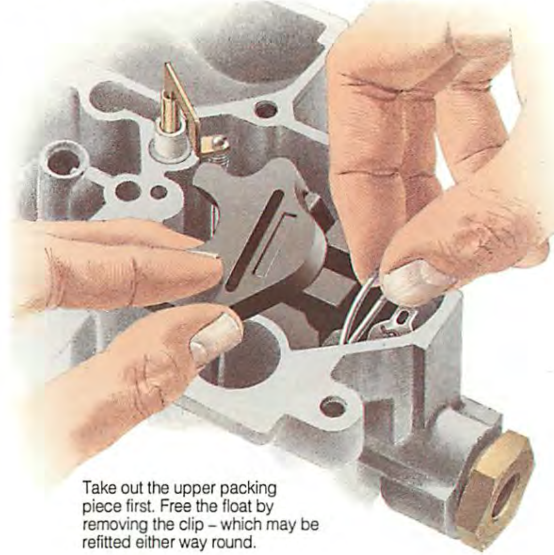
Pull out the lower packing piece to leave the float chamber empty.

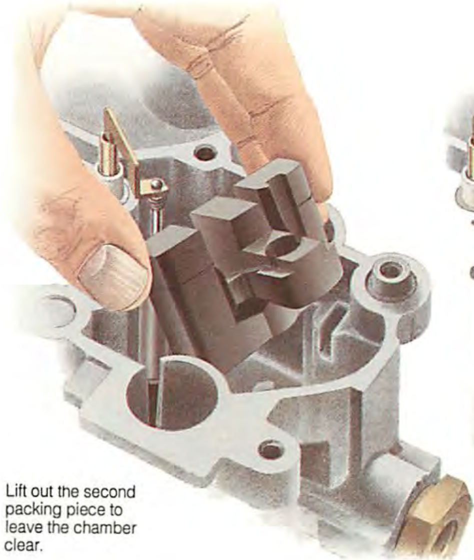
Rinse out the chamber with a little petrol and wipe it clean with a lint-free rag. Remove all sediment, but do not bother about surface staining.

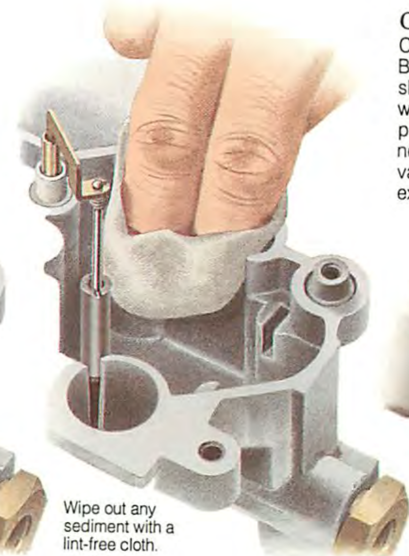
When refitting the float, remember to hook the valve spring back into place. The float level is not adjustable.

As with any carburettor, the various parts are a precision-fit, and care must be taken to handle every part gently.

Before finally tightening the screws holding the carburettor top, ensure that the accelerator-pump piston moves freely.


Take out the upper packing piece first. Free the float by removing the clip – which may be refitted either way round.


Lift out the second packing piece to leave the chamber clear.


Wipe out any sediment with a lint-free cloth.

Checking the needle valve

Check the float needle valve for wear. Both the needle and its seating should last for several years, but when either gets worn there may be persistent flooding. If necessary, fit a new valve; on some carburettors the valve is not renewable – fit an exchange carburettor.


Lift the needle off the float to check it.

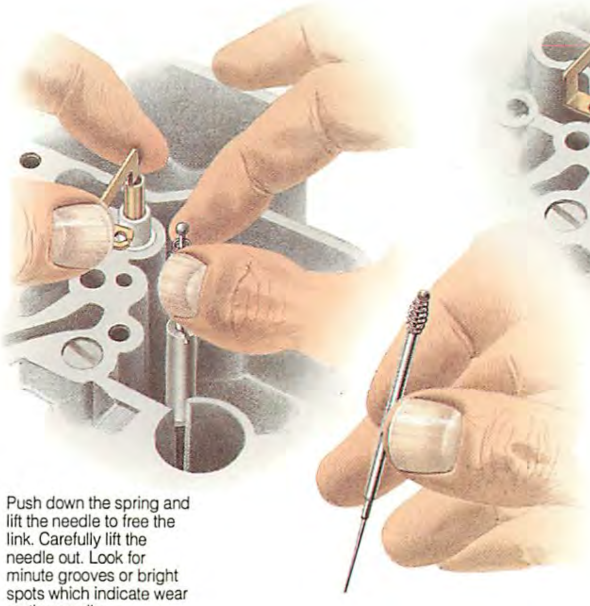
Partial-load needle

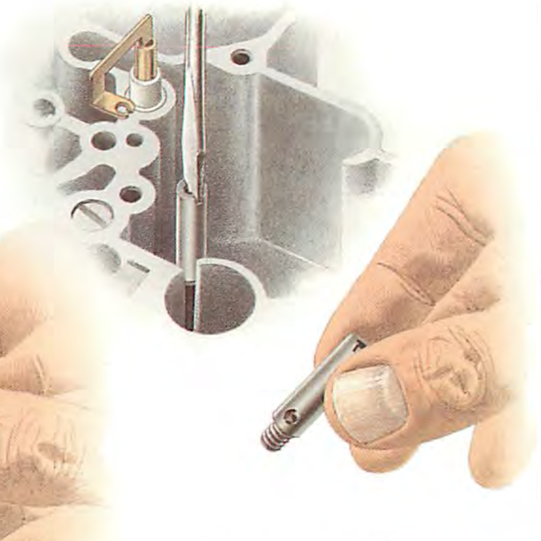
This needle moves up and down in a drilling midway between the two barrels of the carburettor. It is moved by a piston beside it, connected by a link at the top. The needle is very easily bent, so disconnect the link before removing either the needle or the piston.

Push down the spring under the ball head of the needle. Lift the head slightly to free the link. Push the link aside.

Lift the needle out carefully. Unscrew the jet into which it fits using a snug-fitting screwdriver. Check both needle and jet for wear, which would cause erratic running and waste fuel. Signs of wear will show as minute grooves in the jet or on the needle or bright spots on the side of the needle. Replace them if there is the slightest sign of wear, also if the needle is bent.

When replacing the needle, guide it carefully into the jet. Reconnect the link to the top of the piston.


Push down the spring and lift the needle to free the link. Carefully lift the needle out. Look for minute grooves or bright spots which indicate wear on the needle.


Unscrew the jet with a correct-fitting screwdriver. Lift out the jet; check it and the needle for wear.

Adjusting the automatic choke

The choke setting is adjustable for summer or winter. The adjustment is made by moving a pointer attached to the choke body along a graduated scale. An average setting for all seasons in Britain is one mark to the right of the centreline. In very cold weather move the pointer further towards 'R' (rich) and in hot weather towards 'L' (lean). Loosen the three surrounding screws to make the adjustment and retighten them after changing the setting.

If you are dismantling the choke completely for cleaning, be sure on reassembly to fit the bimetallic spring inside, over the peg.


Loosen the screws to adjust. Move to 'R' for cold weather.


Take care to hook the bimetallic spring over the peg.

Checking and cleaning a Ford VV carburettor / 1

The Ford Variable Venturi carburettor is fitted to many small Fords.

It looks like an ordinary fixed-jet carburettor, and has some features typical of that type, such as an accelerator pump. However, its main mechanism is of the constant-depression type – like an SU, but tilted through 90 degrees.

Like any carburettor, it can become choked with dirt and sediment, and should be cleaned and checked about once a year.

There are quite a few small, delicate parts, so prepare for this job as you would for a fixed-jet carburettor (SHEET 183).

Buy replacements for all the gaskets. You may also need to replace the main needle and jet and the float needle valve if they are worn, and the two diaphragms if they are damaged.

Remove the carburettor from the car for cleaning (SHEET 178), keeping it upright to avoid spilling fuel. Clean the outside before you dismantle it, to keep dirt out of the inside. Wash the parts in petrol and wipe them clean with a lint-free rag. Do not wash diaphragms – keep in a clean, dry place.

After reassembly, oil the external moving parts lightly.

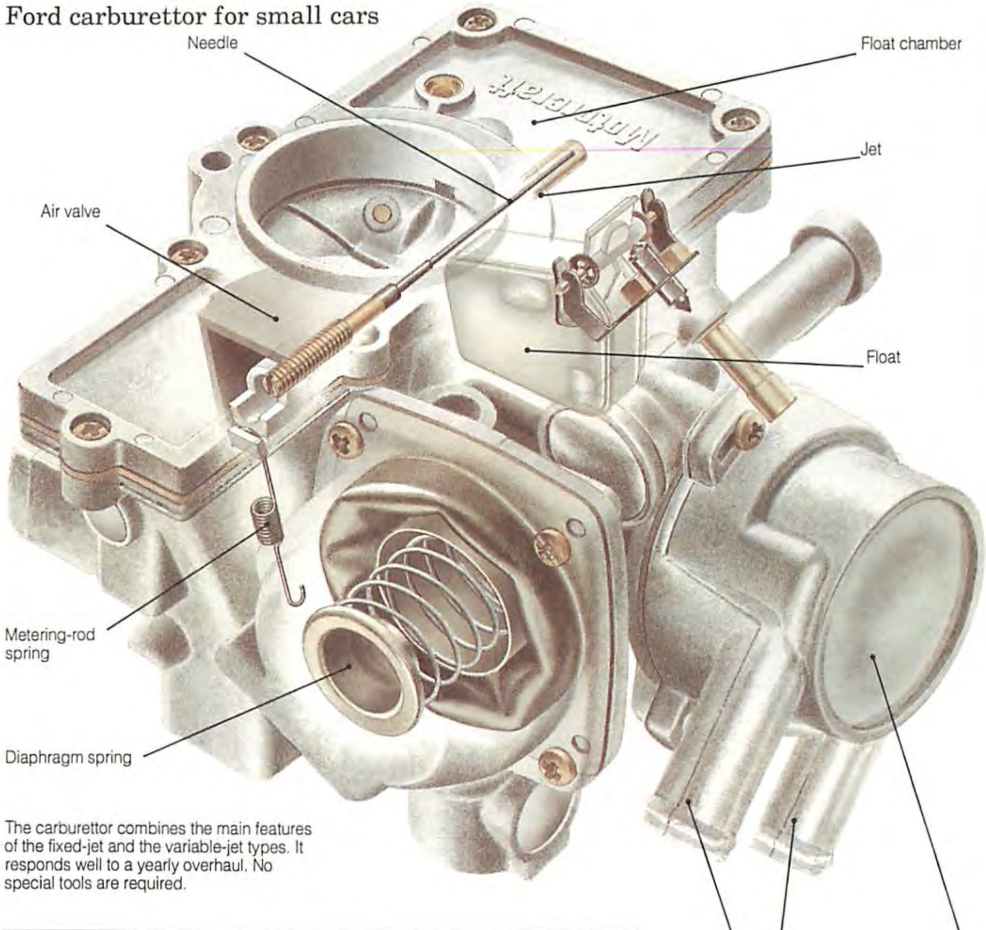
Make a note of the number of turns needed to unscrew adjustable parts such as the main needle, so that you can refit them in the same place. Also make notes on, or drawings of, any parts such as washers, so as not to refit them in the wrong order.

The automatic choke is adjustable, and resembles that on a GM Varajet (SHEET 185). Turn to the 'rich' setting for unusually cold weather, and the 'lean' setting for hot weather. The choke is pre-set by Ford, and should not be adjusted to compensate for poor starting due to other causes.

Tools and equipment

CROSSHEAD SCREWDRIVER • LONG-NOSED PLIERS • NEW GASKETS • FOOT PUMP • PETROL • LINT-FREE RAG

Ford carburettor for small cars

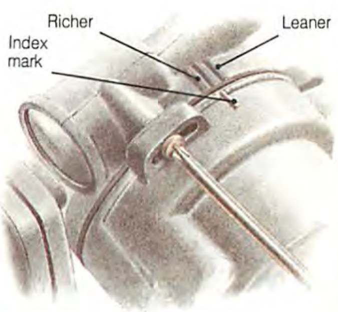


The carburettor combines the main features of the fixed-jet and the variable-jet types. It responds well to a yearly overhaul. No special tools are required.

Adjusting the choke

The richness of the mixture for cold starting is set by Ford for the average climate.

In exceptionally cold conditions, you can adjust the choke by loosening the three screws which hold its outer casing, and turning the casing until its index mark is opposite the left-hand mark on the carburettor body. Tighten the screws. In warm conditions, turn to the right-hand mark.



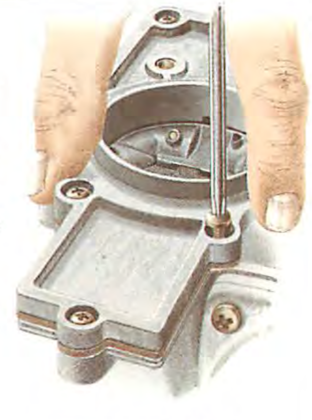
Taking out the needle

Take out the screws securing the top of the body and lift the top off. It is a plain lid with no parts attached to it.

From the inside, push out the plastic blanking disc opposite the end of the needle. (Remember to refit the disc when reassembling.)

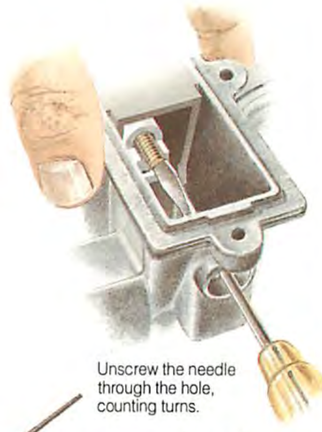
Unscrew the needle through the blanking-disc hole, counting the number of turns it takes until you can pull the needle out.

Pull the needle straight out, taking care not to bend it. Check the needle and renew if it is worn – however slight the wear.



Unscrew and remove the top.

Push out the blanking disc with a screwdriver.



Unscrew the needle through the hole, counting turns.

Pull out the needle: do not bend it.

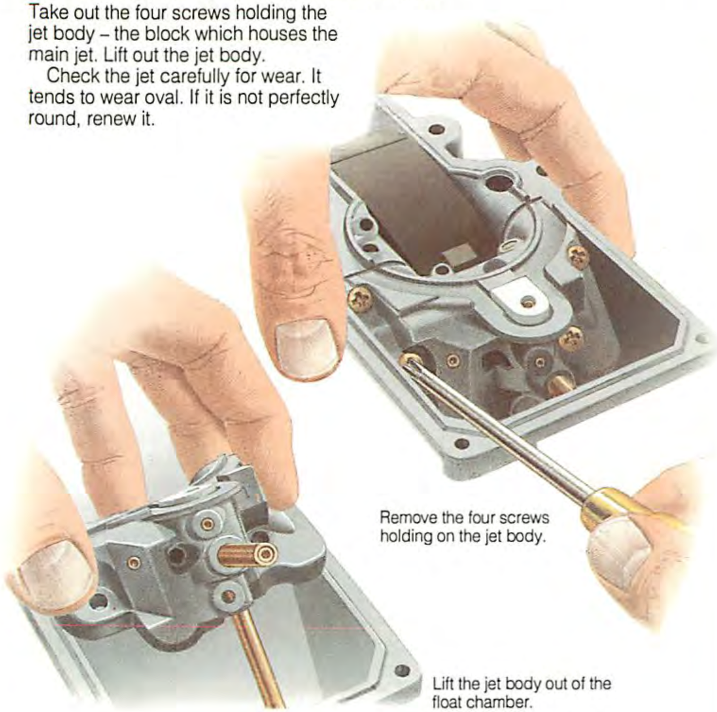
Ensure that the metering-rod spring is fitted, and is central and vertical.

Checking and cleaning a Ford VV carburettor / 2

Removing the jet body and needle

Take out the four screws holding the jet body – the block which houses the main jet. Lift out the jet body.

Check the jet carefully for wear. It tends to wear oval. If it is not perfectly round, renew it.



Remove the four screws holding on the jet body.

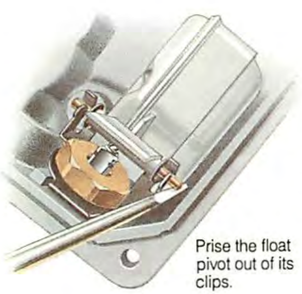
Lift the jet body out of the float chamber.

Checking the float and needle valve

Prise the float pivot loose from its clips. Shake the float to make sure there is no fuel in it as the result of a leak. If it leaks, renew it.

Pull the float needle out of the valve and check both the needle and its seating for wear. A worn needle valve causes flooding and should be replaced.

Wash out the float chamber with a little petrol, and wipe it clean with a lint-free rag.



Prise the float pivot out of its clips.

Lift the float needle out of its seating.

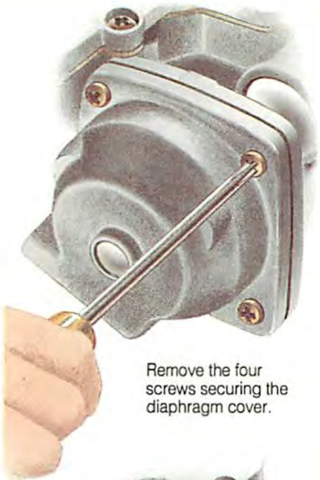
Freeing the diaphragm

Remove the four screws holding the diaphragm cover. Take off the cover and the spring immediately under it.

Carefully peel the edges of the diaphragm free of the main carburettor body. Free the centre of the diaphragm by pushing off the circlip holding it, taking care not to nick the diaphragm.

Check the diaphragm, as you did that of the accelerator pump, and refit it carefully.

There is a small spring in the piston part of the air valve, inside the square aperture above and to the left of the diaphragm. Make sure that it is centrally placed and pointing upwards before refitting the top.



Remove the four screws securing the diaphragm cover.

Remove the cover and spring; free the diaphragm edges.

Free the centre of the diaphragm by carefully easing off the circlip.

Check the diaphragm for holes or other damage.

Removing the accelerator pump

Remove the three screws holding the cover of the accelerator pump. Take off the cover, which has a spring under it.

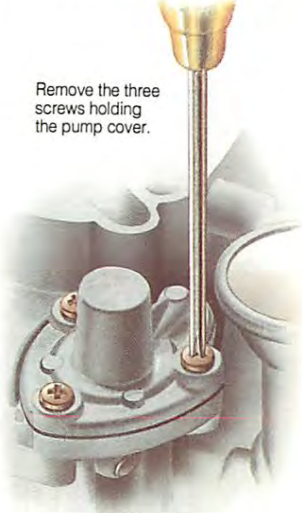
Carefully peel off the diaphragm, noting which is the outside and which the inside.

Check the diaphragm for holes, cracks, perishing or wrinkles. Even a pinhole can spoil its operation. Fit a new diaphragm if necessary.

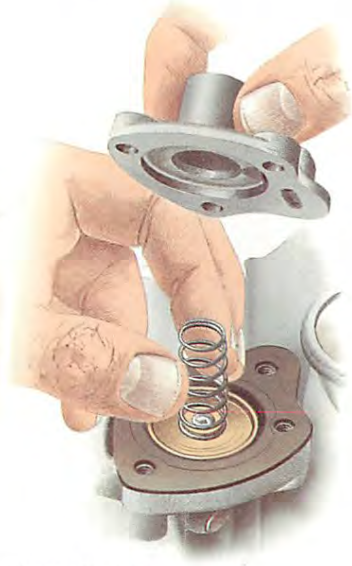
Also check that the jets under the diaphragm are clean. To clean them, remove and wash in petrol and blow through them with a foot pump.

Do not poke jets with wire or brushes – even a soft brush can leave a bristle in a jet and block it.

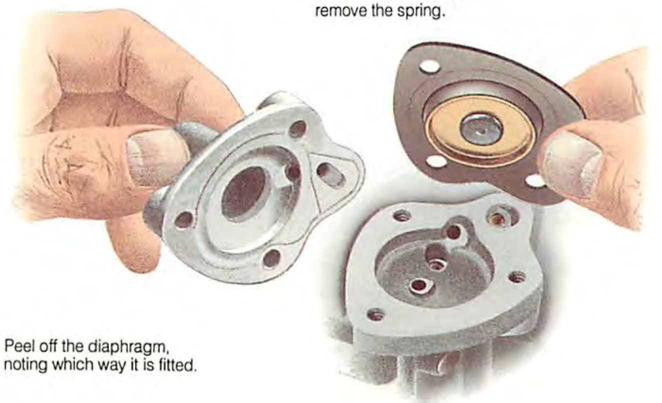
Make sure the diaphragm lies flat when refitting.



Remove the three screws holding the pump cover.



Lift off the cover and remove the spring.



Peel off the diaphragm, noting which way it is fitted.

Renewing a fuel-gauge sender unit and tank

If the fuel gauge reads 'empty' when you know there is fuel in the tank, the cause may be a faulty sender unit – the electrical device that measures the level.

Or it may be a faulty gauge or a break in the wiring between the gauge and sender.

It is also possible for the fuel tank to read 'full' constantly, although the car has travelled some distance and has obviously used an amount of petrol.

The cause may be a fault in the insulation of the wiring, resulting in a short circuit.

Tools and equipment

SCREWDRIVER • SPANNERS • CIRCUIT TESTER • METAL BAR • HAMMER • PETROL CANS • CLEAR TUBING OR SIPHON PUMP • GASKET CEMENT

Checking the sender unit in the petrol tank

The sender unit may be fitted in the top or the side of the tank. Often it is hard to find, particularly if it is on the top, and you may have to remove some trim from inside the boot.

Most senders are circular. Generally the fuel pipe (or pipes, in a circulating system) is connected to it.

There is an electrical connection to the fuel gauge, and sometimes a second one for a low-fuel warning light. Check that the connection is not loose, and that the wiring has not become kinked, or trapped, breaking the insulation and causing a short circuit.

Ask a helper to watch the fuel gauge, then switch on the ignition. Disconnect the fuel-gauge wire from the sender unit and scratch its bare end against the tank, or any other bare metal on the chassis or bodywork, to earth it.

If the gauge needle swings to 'full' although the tank is half-full, there is no electrical fault, but there may be a mechanical fault in the sender unit, such as a detached float.

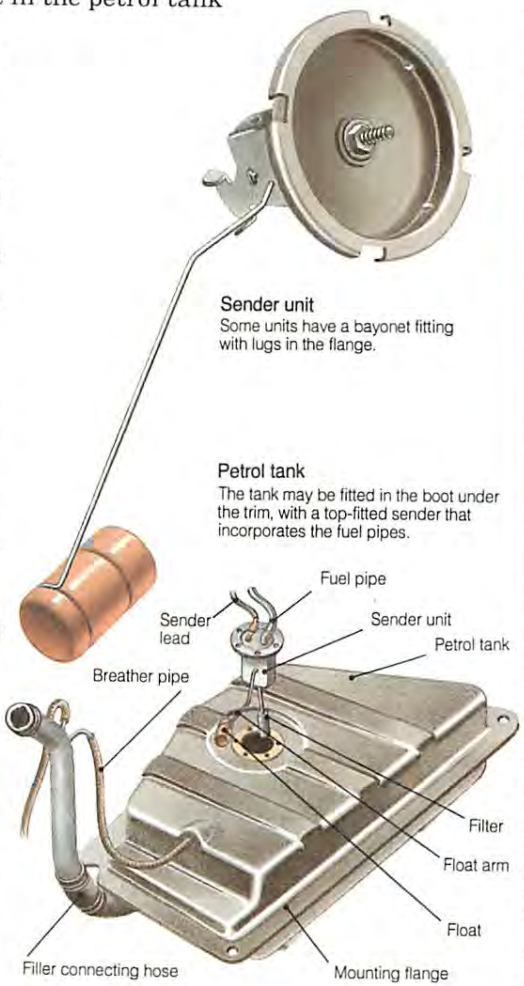
If the needle stays still, try earthing the wire by touching it to an unpainted point on the car body. If the needle moves now, the tank is not properly earthed. Remove and clean some of its mounting bolts or screws.

If the needle does not move at all, there may a break in the wiring.

Check the wiring to the gauge with a circuit tester – one lead connected to the wire detached from the sender and the other to the terminal on the gauge.

If the tester shows continuity in the wire, the gauge is faulty.

If the sender unit is faulty, fit a new one, but note the safety precautions (see right).



Sender unit
Some units have a bayonet fitting with lugs in the flange.

Petrol tank
The tank may be fitted in the boot under the trim, with a top-fitted sender that incorporates the fuel pipes.

Removing and refitting a sender unit

Before you remove the sender unit, take precautions against spilling fuel (see right).

Then disconnect the fuel pipe if necessary, blocking it with a plug or an old pencil. If there are two pipes, mark them.

Disconnect the electric wires. The sender may be fixed by screws or by studs and nuts round the edge. Unscrew them carefully; one snapped stud could mean replacing the whole tank.

Often the sender has a bayonet fitting, held on to its seating by an outer locking ring with lugs.

When removing the unit, take care not to bend the float arm. This will cause the gauge to give a false reading.

Release this ring by turning it anti-clockwise, using a C-spanner.

Alternatively, hold a metal bar against a lug and tap gently with a hammer. Take care not to bend the lug. Take off the sender carefully. Inside there is a long arm attached to a float. If you bend the arm, the gauge becomes inaccurate.

There is usually a tag in the sender hole to ensure that you refit the sender the right way round. Put the sealing ring in place and tighten the nuts or screws in sequence to spread the pressure. Reconnect the fuel pipe and electric wires, refill the tank and check for leaks.

A locking ring can be turned gently with a hammer and drift.

Checking the fuel tank

A smell of petrol is most likely to come from a fuel-pipe leak (SHEETS 168-169). Check also the flexible hose between the tank and the filler, making sure that its clips are tight. If all these are sound, the tank may be leaking.

Fuel tanks can rust from both inside and outside, particularly at the bottom. Eventually holes may develop. This is not uncommon in older cars, where a series of small pinholes barely visible to the naked eye cause a slow, steady loss of fuel.

If a tank is old and leaky, replace it, not only because of the needless loss of fuel but also because of the risk of fire.

A tank mounted inside the bodywork may be rusted by water trapped in body panels. Make sure that there is no water present, and that drain holes are clear.

Drill extra drain holes if necessary – but be careful of the tank. Plug any new drain holes later with suitably sized rubber bungs.

A tank mounted on the outside – usually under the boot or forward of the rear axle – can be dented or holed by knocks, stones or a wrongly placed jack.

A dented tank may give a shorter range between refills, but be serviceable otherwise.

Do not attempt to repair a tank yourself. If it is leaking or rusted through, replace it.

Safety precautions

An empty tank can be more of a risk than a full one. There is always petrol vapour in it – even if it has been empty for months – which the slightest heat or spark can explode.

Before doing any repair or replacement work on the tank, take off the battery leads, as a precaution against accidental sparks.

The sender unit is mounted through the tank wall, and removing it leaves a hole.

If it is in the tank side, removing it may let petrol gush out. You must be sure that the fuel level is well below the sender hole – and this is difficult to judge with the gauge not working.

You may be able to check the level through the filler with a dipstick. Only if all else fails should you drain the tank.

Note that in Britain you can store up to two metal cans each holding 2 gallons (9 litres) of petrol, or up to two plastic containers each holding 5 litres (1.1 gallons). The cans or containers must be marked and purpose made, and must not be kept in the house.

A few cars have a tank drain plug. Otherwise, try to empty the tank by disconnecting the fuel pipe or pipes.

If the tank will not empty through the pipe, it may be possible to siphon the fuel out through the filler hole, but anti-siphon devices are often fitted. If siphoning is possible, use a special siphon pump.

If you do not have one, use several feet of *clear* plastic tube. Push one end to the bottom of the tank and suck gently at the other end.

When you see petrol rising in the tube, quickly plunge the other end into the can. If you accidentally get petrol in your mouth, spit it out immediately and rinse your mouth out with plenty of clean water. Do *not* swallow any – it is poisonous.

Removing and refitting the tank

Empty the tank (*see* Safety precautions above). Disconnect the fuel pipes and wires, and the breather tube if one is fitted.

Loosen the clips on the hose between the filler and the tank, and take off the hose. Renew a perished hose or corroded clips.

Tie a plastic bag over the tank opening, for safety.

The tank may be held by bolts around its flange or by metal straps. Bolts on the outside of the car may have to be loosened with the aid of penetrating oil. Allow the oil a few hours to work.

A tank fitted through the boot floor may have a sealing gasket between the tank and the floor. If it does not have a gasket, seal the joint with mastic.

Bolt in the new tank, then reattach all the connections. Refill with petrol, check for leaks and see that the fuel gauge registers.

Cleaning a blocked breather

A blocked breather in the tank causes the same symptoms as running out of fuel, although the fuel gauge does not indicate 'empty'.

Test by quickly removing the filler cap. If there is a loud sucking noise, the breather is blocked.

The tank may breathe through a vent in the cap. This can become blocked or a new, non-vented cap may have been fitted by mistake.

Many cars have a second, small-bore hose from the top of the tank or filler neck, which may loop up and down to prevent siphoning. Check that it is not blocked by dirt.

A few cars use a broad hose with a closed end. Instead of letting in air, it collapses to equalise pressure. This type is maintenance free.

Several recent makes have a sealed fuel system. At all times they must have about the same pressure inside and outside the tank. Such systems are also maintenance free.

Overhauling a mechanical fuel pump

Do not clamp a pump in a vice to dismantle it – the pressure could break the alloy casting.

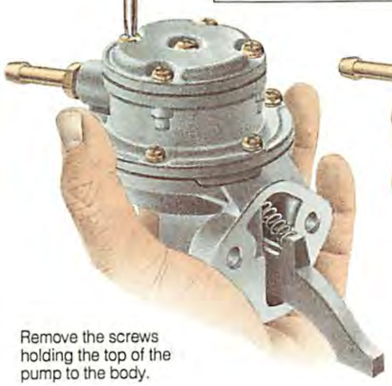
Remove the top of the pump first. It is held on by a central bolt or screw, except on the SU AUF 700, which is held by three screws that also partly hold the halves of the body together.

Mark or scratch both halves so that you can refit them in the same position – but do not scratch a line straight across the diaphragm edge.

Hold the halves together while you remove all the body screws. Spring pressure inside will push them apart. Release your grip slowly; the diaphragm may stick and need gently freeing. Do not pry with a sharp metal object, which might scratch the mating surfaces and cause a leak.

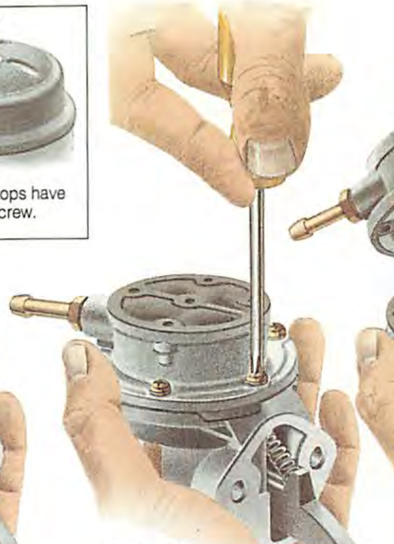
Tools and equipment

VICE • PENCIL OR OTHER MARKER • SCREWDRIVER • HAMMER AND PUNCH • PETROL, DISH AND FINE PAINTBRUSH



Remove the screws holding the top of the pump to the body.

Many pump tops have one central screw.



Hold the halves together while removing the body screws.

Separate the halves carefully to avoid tearing the diaphragm.

Cleaning the valves

Inlet and outlet valves are combined on the SU AUF 700. The valve unit is a press fit. Push it out downwards. Take great care not to damage it, especially the fine edge of the outer ring, which is the inlet part.

Most other pumps have two separate valves, held in by small screws and often interchangeable.

Make sure you know which way up they fit before you remove them.

An inlet valve has its movable disc on the side of the seating facing the diaphragm; an outlet valve has its disc on the opposite side.

These valves often cannot be taken apart, but you can remove dirt with a fine paintbrush.

Separate, identical valves are installed opposite ways up.

A one-piece SU valve unit, seen from below.

Freeing the diaphragm

On AC-Delco type pumps the link from the diaphragm centre ends in a 'T', which fits through a slot in the lever. Hold the lever down, press the diaphragm centre down, and give the diaphragm a quarter turn.

SU pumps have a slot in the diaphragm link, into which the lever slides. Press the diaphragm down while you free the lever by pushing its pivot pin out sideways. If it is difficult to remove, tap it out with a hammer and punch.

As you pull out the lever, a small spring will fall from between the lever and the body. This keeps the lever resting against the cam when the pump is idling – that is, when the carburettor is full and no petrol can be delivered. The diaphragm stays down and the lever moves up and down in the slot.

AC-Delco pumps sometimes have a two-piece lever to allow idling, but there is still a spring. Remove the lever on this kind of pump too, so that you can clean it.

On AC-Delco pumps, give the diaphragm a quarter turn to release the T-shaped end of its link from the slot in the lever.

If necessary, use a punch to tap out the pivot pin on an SU pump lever to free it from the diaphragm link.

Pull the lever out as you remove the pin.

Checking an oil seal

Certain pumps have an oil seal, which fits under the diaphragm and keeps oil off it. Do not remove it unless you have a replacement, as taking it out will probably destroy it.

The seal on the SU is held in place by a steel cup above it. Hook this out with a screwdriver and pull out the seal.

If you clean the pump with the seal in place, use only clean petrol.

Hook out the cup above the seal with a screwdriver.

Cleaning and replacing the pump

Wash all parts thoroughly with clean petrol and a fine paintbrush. If possible replace the diaphragm, valves, oil seal, top gasket and mounting gaskets.

The new parts are supplied together in a pump overhaul kit. It is false economy to renew just one part of the pump, unless the other parts are relatively new.

First refit the oil seal, if renewing it. On an SU, press it into place and lightly tap the cup down squarely on top of it, using a piece of wood or a screwdriver handle so as not to damage it.

Drop the main diaphragm spring into place.

Fit the diaphragm link carefully through the oil seal so as not to damage the fine edge.

Reconnect and refit the lever, remembering to insert the idling spring. Fit the valves back into the body of the pump.

On the SU there is a ridge round the edge of the valve which must fit exactly against a ridge surrounding it on the body. The wide inlet valve must lie evenly on its seating without puckering.

Lift up the lever so that the diaphragm sits flat on the body. Make sure it is accurately in place.

Set the top half of the body on it so that the marks you made earlier are in line.

Keep holding the lever while you screw the body together.

Tighten the screws gradually in sequence, each screw followed by the one opposite it.

This is impossible with the SU pump, where three of the six screws hold the top on.

Fit these three long screws in loosely, but tighten the others – which are short ones – first.

Then fit the top, with its gasket and with the outlet pointing the right way. Screw the top on.

Check the action of the pump by hand (SHEET 177). Then refit it to the car and test it again.

Inspecting the ignition system

Inspect the ignition system whenever you make a general under-bonnet check. It takes only a couple of minutes, and guards against a frequent cause of breakdown.

Check that the low-tension connections are tight and free from corrosion, and that all LT wires have sound insulation and no cracks, kinks or breaks.

Follow with the plug leads and plugs. The leads should be clean, dry and free from cracks or kinks.

If there are special guide clips, the leads should run inside them: the clips are to keep them away from each other and from hot surfaces.

Clean the leads with a soft cloth. Replace them if they are damaged or if the wrong type has been fitted at some time. High-tension leads should be replaced every two or three years, to maintain peak performance (SHEET 193).

Check that the plug caps are firmly fixed to the leads, and that the leads are properly connected to the distributor.

Take care not to get the connections mixed up – tag them with sticky tape if necessary.

Leads may be screwed into the distributor vertically with threaded collars; pushed in vertically and held by crimped terminals; or inserted from the side and held by small screws.

Check the distributor and plug caps for cracks. Pull off the plug caps one at a time – pulling the cap, not the easily damaged lead – and wipe the porcelain plug tops.

Take off the distributor cap. It may have a pair of spring clips which you lever off outwards, or two small screws – avoid dropping these.

Check the inside of the cap for cracks. Look closely at the contacts.

If there is a sprung carbon brush at the top, it should be free to slide up and down; or there may be a spring contact on top of the rotor arm, which bears against a fixed carbon brush in the cap. The rotor-arm spring contact should be free from wear or damage.

The rotor-arm tip and the contacts around the inside of the cap should not be more than slightly pitted, and the gap between tip and contacts must not vary.

If the rotor-arm tip is dirty, lift off the arm (a few types have screws) and clean it by removing the pitting marks by gentle filing or scraping.

Remove any corrosion from the contacts inside the cap by gentle scraping.

The narrow pipe or pipes of the vacuum advance mechanism run from the distributor to the inlet manifold. Older cars have a metal pipe with a screwed union or a push-on rubber sleeve connector.

Most have a plastic pipe which is a push-on fit.

Check that the pipe is undamaged and that the connections are sound. A plastic pipe must be routed away from heat.

If you have any doubt about the soundness of the pipe or connections, only a stroboscopic timing test (SHEET 204) can make sure.

Look at the coil. The most usual type has a thick HT lead coming out of the end flanked by two smaller LT leads.

The HT lead may be a push-in fit or have a screw collar. Check that it is firmly fixed to both coil and distributor, and that any rubber seals over the ends fit properly.

The LT leads have spade connectors, or screws on older cars. Make sure these are firmly fastened, and that the leads are connected the right way round: a coil connected backwards still works, but could cause a misfire.

On a modern negative-earth car the positive terminal, marked +, is connected to the ignition switch; the negative, marked –, to the contact-breaker points in the distributor.

For positive-earth cars – usually earlier models – they are connected the opposite way round.

Some terminals are marked 'SW' (switch) and 'CB' (contact breaker) – usually on earlier cars.

Make sure that the coil is fixed firmly in its mountings.

Most coils have a ballast resistor – a small porcelain block containing a wire coil and connected by spade or screw terminals into the LT lead to the switch.

There are two leads from the switch to the coil; one for normal running going through the resistor; the other for starting, which bypasses the resistor to provide extra ignition strength.

The resistor is often clamped to one of the coil mounting bolts. Make sure it is not cracked, and that the connectors are tight. Some cars have a resistive lead from ignition switch to coil instead of a separate resistor.

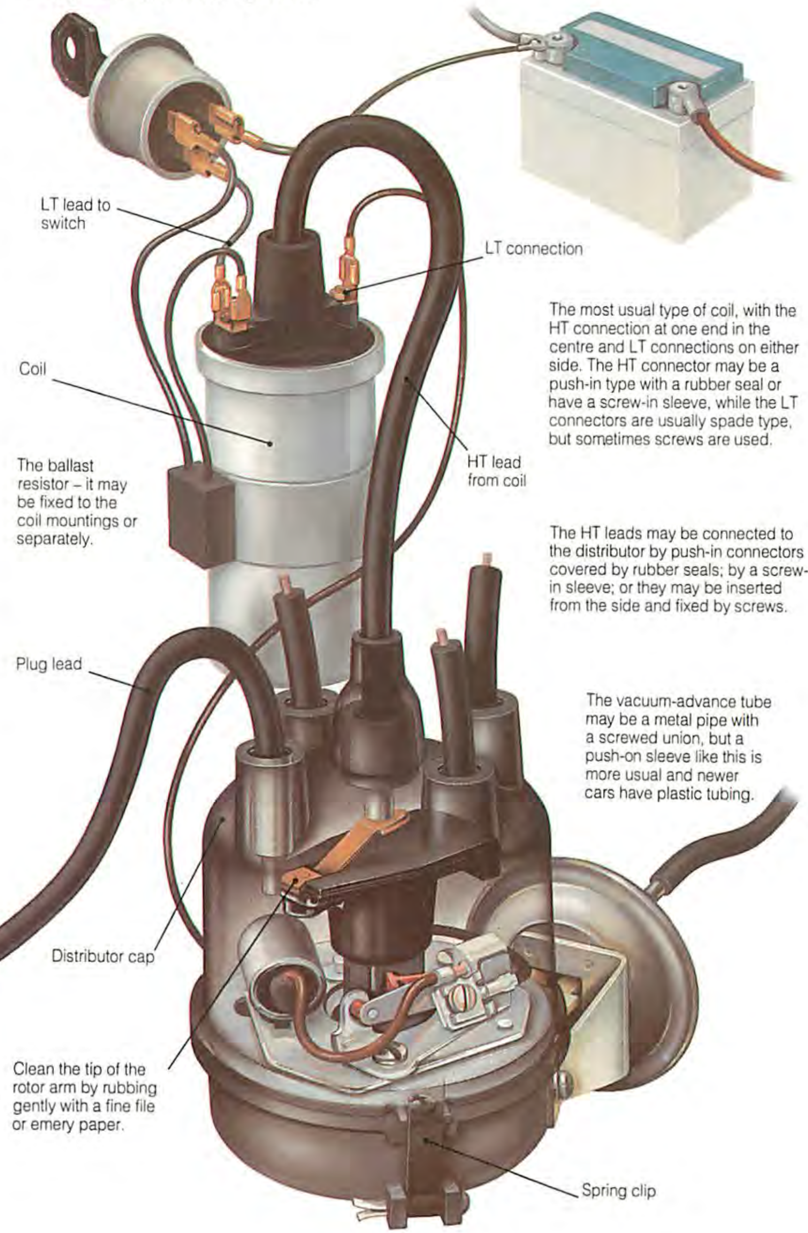
The last part of the test is optional because you can only do it in the dark – but well worth the trouble. Start the engine and look for 'tracking' – leakage of high-tension electricity from the coil, distributor, HT leads or plugs, caused by damaged or wet insulation. It shows up as blue sparks.

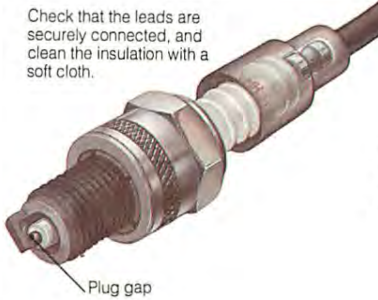
If you need to touch any part of the HT circuit when the engine is running, use insulated pliers and insulated screwdrivers. Do not touch any part with your hands, especially if you suspect a fault. Replace any part that has faulty insulation. Cure dampness by careful cleaning and the use of an aerosol water repellent.

Tools and equipment

SCREWDRIVER • INSULATED SCREWDRIVER • INSULATED PLIERS • SOFT CLOTH • ADHESIVE TAPE • FINE FILE • EMERY CLOTH

A typical ignition system





Cleaning, gapping and fitting sparkplugs

Check and clean sparkplugs every 5,000 miles (8,000 km) and replace them after 10,000 miles (16,000 km). Their condition can tell you about the condition of the engine, and help you to correct faults elsewhere.

Always use the type of plug recommended for your car, except as an exceptional and temporary measure.

Plugs are classified as 'hot' or 'cold'. Hot plugs have a longer core nose – the ceramic insulator inside the threaded part – which retains more heat between firings.

For most cars the sparkplug size is 14 mm, although it may be 10, 12 or 18 mm. Always use a plug spanner of the correct size.

The cheapest type is a box spanner and a tommy bar, but you are less likely to damage a plug if you use a special deep socket with a hard rubber lining (SHEET 45).

For cars with plugs that are hard to reach, you can buy a plug spanner with a universal-jointed head: take care not to let it tilt sideways and break the ceramic top of the plug.

This is a danger with any plug spanner; it must fit on straight and as far as it will go. The rubber centre guards against breakage to some extent.

Tools and equipment

PLUG SPANNER • OLD PAINTBRUSH • FOOT PUMP • FINE FILE OR GRIT BLASTER • FEELER GAUGE OR GAPPING TOOL • SMALL SCREWDRIVER • SOFT WIRE BRUSH • SOFT CLOTH • TORQUE WRENCH

Differences between plugs

Some plugs have a sealing washer at the top of the threaded part.

A 'hot' plug looks like a 'cold' one; the extra length on the nose is on the inside.

However, some plugs have a sealing washer at the top of the thread, while others have a tapered 'seat'.

They fit into different types of holes, and must be tightened differently.

Some plugs have a fixed terminal on top and some have terminals that can be unscrewed.

Make sure that a terminal of this type is on tight – use pliers if necessary.

Others have a tapered seat, and are easily overtightened.

Removing the plugs

Before removing the leads, label them, using pieces of masking tape, with the numbers of the cylinders from which they come. It is easy to mix them up.

Grip each lead by the cap, not by the lead itself; damage here causes misfiring which is hard to trace.

After removing the leads, clean around the plugs, using an old paintbrush, to avoid dropping dirt through the plug hole into the engine. For recessed plugs, blow away dirt with a tyre pump.

Fit the spanner over the plug, making sure it is quite straight. Unscrew the plug and take it out.

Pull off the lead by its cap. Clean away dirt from around the plug with a soft brush.

A deep plug socket with a rubber liner and a universal joint prevents accidental damage to plugs.

Setting the gap

The gap between sparkplug electrodes should always be maintained at the distance specified by the manufacturers – consult DATASHEETS.

It is safe to lever the gap open carefully with a screwdriver, although a gapping tool – which is inexpensive – is best. But do not use pliers, and do not close the gap by tapping the outer electrode – you are likely to crack the insulator inside the plug.

The recommended sparkplug gap should also be given in your car handbook.

An ordinary feeler may not be accurate, because any slight unevenness inside the gap could distort the flexible blade and make you set the gap too wide.

Use a gapping tool. This has hooks to lever the outer electrode either way, a built-in file, and a set of stiff gauges. The appropriate gauge should just go through the gap with a slight click.

A sparkplug-gapping tool includes an attachment for carefully levering the sparkplug electrode to open or close the gap as necessary.

The tool has stiff feeler-gauge blades and a file for cleaning.

Refitting the plugs

Check that the threads of both plugs and holes are clean and that the screw-on terminals (if any) are tight.

Screw the plugs in by hand, taking great care not to cross-thread them. This is easily done, and can damage the cylinder head – particularly an aluminium one.

Correct tightening is vital. Take care not to overtighten, as this will flatten the washer and make it ineffective. Be very careful not to overtighten tapered plugs – found on modern Ford cars – or they may be difficult to remove again.

Tighten each plug a quarter of a turn beyond hand-tight. Refit the leads to the correct plugs.

Cleaning the plugs

The best way of cleaning plugs is by grit blasting (see below), but if they are not too dirty you can clean the electrodes with a fine, flat file.

Make room for the file by carefully levering open the gap with a gapping tool or a thin screwdriver.

If the threads are dirty, clean them with a soft wire brush. Wipe the whole plug with a soft cloth to remove dirt. Make sure the top of the ceramic insulator is clean.

As an emergency measure for a damp or heavily fouled plug, gently heat the tip with a gas ring or a blow lamp. This cleans both the electrodes and the inside part of the insulator.

Normal: light brown colour.

Dirty: powdery deposits.

Black carbon: an over-rich mixture, or too much choke.

Oil fouling: worn valves or piston rings.

Pre-ignition: causes the inner electrode to be burned away.

Grit blasting

Many garages have grit-blasting equipment, and will clean plugs for a small charge. You can also buy a home grit blaster, which runs off a car battery. The plug fits through a rubber seal into the grit chamber. A few minutes' running cleans even the dirtiest plugs.

A grit blaster run off the car battery.

Fitting new high-tension leads

The high-tension leads from the coil to the distributor and from there to the plugs may start to deteriorate after long service, causing bad starting, misfiring and radio interference.

There are two types. Stiff, durable copper-cored leads are used on older cars.

To prevent radio interference with this type of lead, fit an in-line suppressor between the coil and the distributor, and use resistive plug caps on all the plugs (SHEET 141).

Later cars usually have carbon-cored leads, which are more flexible, though the core can break easily if roughly treated. Such leads have a built-in resistance and generally do not need extra suppressors.

Carbon leads are sold as complete sets, with the distributor and coil connections and plug caps already crimped on.

Simply remove the old leads, one at a time to avoid confusion, and replace with the new ones.

To replace copper leads, buy the right total length of cable, a new set of resistive plug caps and an in-line suppressor (both described in SHEET 141) and any terminals you may need.

Note that when fitting or removing plug leads you should always push or pull the cap, not the lead, to avoid straining the lead and possibly pulling it away from its terminal connector.

Leads sometimes run through guides which hold them apart or away from hot areas. Always refit them in their guides.

Tools and equipment

PLIERS • SHARP KNIFE • MASKING TAPE • BALLPOINT PEN • SCREWDRIVER

Numbering the plug leads

Before you dismantle, wrap masking tape around each plug lead and write the cylinder number on it with a ballpoint pen.

Pull the leads off the plugs, disconnect the coil lead from the coil, unclip (or unscrew) the distributor cap and remove it with all the leads attached to it.

Replace the leads one at a time, to avoid confusion, with new leads of the right length.

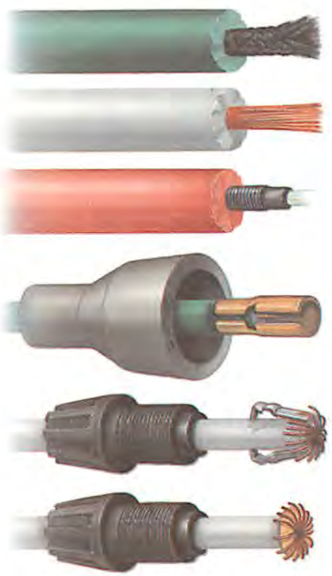
Number each new plug lead as you install it.

Types of lead and connectors

You can tell copper-cored cable by its stiffness, especially when cold, and by the type of connectors fitted to it. Carbon-cored cable is quite flexible – but do not kink it, as the core snaps easily. Carbon cable has its resistance marked on the insulating sheath.

Carbon-cored cable has terminals already crimped on. These are a push-in fit to the distributor and coil, and are covered by rubber dust seals. Ease back the seals along the lead and fit the connectors into the coil and distributor caps. Fix the dust seals.

Copper-cored cable uses screw-on connectors which you fit yourself after cutting the cable to the correct length. There may be a screw collar over a terminal which you crimp on with pliers, or a terminal washer over which the strands are splayed. A screw collar then clamps the washer on to its connection. A third type has a screw which pierces the strands of the core.



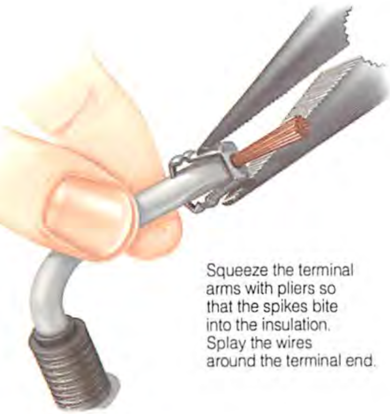
Fitting a connector to copper-cored cable

When fitting a screw-on connector to copper-cored cable using a crimp-on terminal or a washer, remove about ½ in. (13 mm) of insulation from the end of the lead with a sharp knife. Take care not to cut into the wire core. Thread on the collar. Fit a crimp-on terminal by folding up the wings and flattening them with pliers. Fit a terminal washer by threading the core through the washer and bending the strands back around it.

For a screw terminal, do not remove any insulation. Insert the lead into the connector, making sure that the screw is in line with the cable core. Tighten the screw to pierce the core.

Screw each connection to the appropriate terminal on the distributor cap; that is, No. 1 lead to No. 1 terminal and so on. It has a pointed screw which pierces and expands the core as you tighten the collar. Thread the leads through guide tubes, if any, then fit plug caps, and in-line suppressor if necessary.

To fit a crimp-on terminal to a coil lead, pass the core wires through the centre hole.



Squeeze the terminal arms with pliers so that the spikes bite into the insulation. Splay the wires around the terminal end.

Fitting resistive plug caps and an in-line suppressor

Both plug caps and suppressors have pointed screws which simply screw into the ends of the lead, without any need to remove insulation (SHEET 141).

Fit the in-line suppressor anywhere in the coil lead.

Fitting and adjusting contact-breaker points / 1

The contact-breaker setting is often neglected, but it is vital to good running. Ideally, check and set the gap between every major service, and replace the contact breaker after 6,000 miles or 10,000 km, or twice a year.

Current passing through the contacts burns away one of them and deposits a peak of metal on the other.

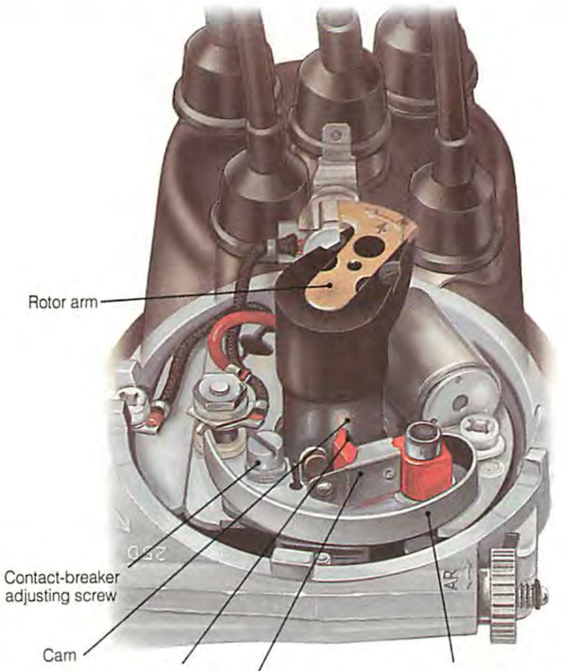
The contact heel which is moved by the distributor cam wears away, preventing the points from opening fully.

Eventually they stay closed, immobilising the car. Points burn away faster if the condenser is faulty (SHEET 200). As a temporary measure you can, using great care, file points to restore their flat faces, but it is difficult to get exactly the right profile, so replace the whole set as soon as you can.

Generally you can do this job with the distributor in place; but in cars with poor access you may have to remove it (SHEETS 201-202).

Tools and equipment

SMALL SCREWDRIVER • CROSSHEAD SCREWDRIVER • PLIERS • SMALL SPANNER • FEELER GAUGE • HIGH-MELTING-POINT GREASE • LIGHT OIL



General method of removing the points

Exact details vary from type to type; but on all types begin by removing the distributor cap, which is held on by spring clips or screws.

It may be necessary to lift off the rotor arm and dust shield.

Next, disconnect the wiring at the contact-breaker terminal post: there is one lead from the condenser and one from the coil. Connections may be a press-on fit or held by nuts.

Undo the screw or screws holding the assembly and lift it off.

The contact faces of the new points may be covered by a protective coating. Wash it off with petrol or paraffin, and dry.

Fit the new points, but do not tighten the screws fully if the assembly slides to adjust the gap.

Tighten them a little more than finger-tight, so you can lever the assembly with a screwdriver. Reconnect the wiring. Set the gap.

The distributor cap is usually held on by spring clips.

Cap held by screws

If the cap is held on by screws, release each in turn and then lift the cap.

Remove the nut from the threaded top of the terminal post, and take off the connections.

Setting the gap

The correct setting for the points is given in Datasheets or in the car handbook.

Turn the crankshaft pulley in the direction of the engine's normal rotation with a spanner or socket wrench, until the contact heel is on the tip of one of the distributor cam lobes, so that the contact-breaker points are fully open.

Alternatively, put the car in top gear and push it forward a short distance until the points open.

Removing the sparkplugs (SHEET 192) eases the job of turning the engine by relieving the pressure in the cylinders.

Place the correct-size feeler-gauge blade between the points to measure the gap.

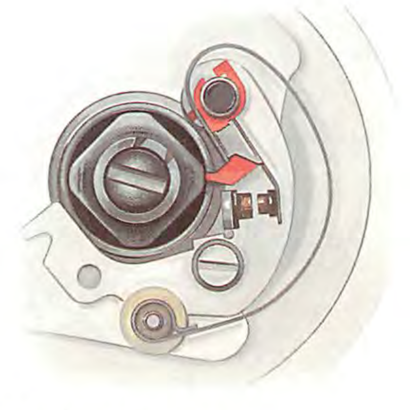
On most types you can adjust the gap by freeing the fixing screw and sliding the entire assembly, or sometimes just one contact, around a pivot; some types have a special adjusting screw.

Push the sliding type with a thin screwdriver blade rotated in its adjusting slot, or adjust the screw, until you feel that the points offer a slight resistance to the feeler.

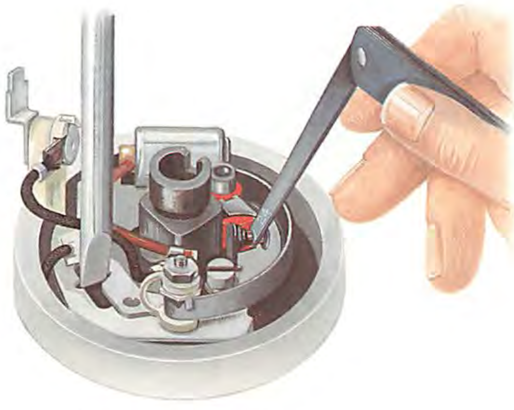
Tighten the fixings and re-check the gap in case it has changed (you do not need to do this for a screw adjustment).

Smear a little high-melting-point grease on the cam lobe. If there is an oiling pad, give this a few drops of light oil. Also put a drop of light oil on the moving contact pivot.

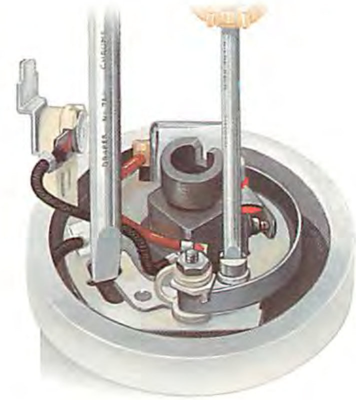
If you have a dwell meter check the dwell angle (SHEET 197).



Contact breaker with points fully open. The gap shown is exaggerated for clarity.



Place the feeler-gauge blade between the points, and a screwdriver blade in the adjusting slot.



Tighten the fixing screw, then check that points gap remains the same.

Fitting and adjusting contact-breaker points / 2

Lucas – old and new type

On the old type, unscrew the nut, at the free end of the spring, using pliers or a small spanner.

Lift off the top nylon insulator and the two terminals underneath it, noting the sequence in which the various parts are positioned – particularly the insulating washers.

Remove the single screw next to the terminal post. Lift off the assembly.

Fit the new assembly in exactly the reverse order.

Set the gap by levering with a screwdriver blade in the adjusting slot.

On the newer one-piece type the terminal plate simply lifts off.

First gently take some of the pressure off the spring then lift out the terminal plate with the leads still attached to it.

Fit the one-piece contact over the pivot post and replace the low-tension (LT) leads over the insulated base of the contact set. Secure with the plastic nut.

Marelli

Remove the nut from the terminal post on the side of the distributor, and the main fixing screw of the assembly.

Pull the plastic terminal block up and off its mounting bracket, and detach the free end of the spring.

Remove the circlip over the contact pivot and lift off the various parts, noting the order in which they are fitted.

When reassembling remember to re-attach the lead from the condenser.

Bosch

Disconnect the lead from the terminal on the side of the unit.

Gently press the spring, free it from the top on the lower part of the assembly and lift off complete with moving contact.

Remove the screw retaining the fixed contact and lift off the contact.

When reassembling, fit the new fixed contact point over the peg on the baseplate and refit the screw. Fit the LT lead to the peg on the plastic clip, and fit the new moving point.

On some Bosch distributors, a plate held by screws covers the contact assembly.

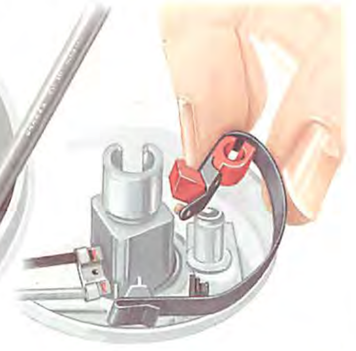
Nippon Denso

Loosen the two nuts on the terminal on the side of the distributor and detach the lead. Remove the two main fixing screws.

Lift off the old assembly, fit the new one and reconnect the lead. The gap is adjusted by swinging the assembly around the moving contact pivot point.

Fitting Lucas (new type) contact-breaker points

Ease the spring pressure with a screwdriver and remove the terminal plate.



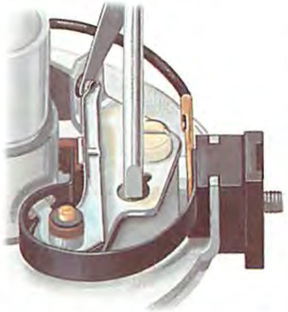
Remove the moving contact assembly, which is in one piece.

Undo the single fixing screw and remove the fixed contact plate.

Set the gap with a screwdriver.

Fitting Marelli contact-breaker points

With the terminal lead detached, ease off the circlip on the contact pivot post.

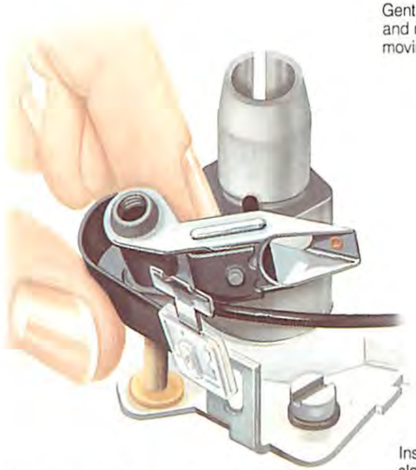


Adjust the gap by turning a screwdriver in the slot in the centre of the assembly.

Fitting Bosch contact-breaker points

Disconnect the lead from the push-on terminal at the side of the unit.

Gently ease the spring pressure and remove the spring and moving contact.



Fit the new moving contact after fitting the fixed contact plate.

Insert a screwdriver in the slot at the side of the fixed contact plate and turn it to the left or right to set the gap.

Fitting Nippon Denso contact-breaker points

Slacken the terminal nuts and lift the lead.

Remove the fixing screw and gently prise out the assembly.

The gap is adjusted by swinging the assembly around the moving contact pivot point.

Fitting and adjusting contact-breaker points / 3

Mitsubishi

Loosen the screw holding the earthing lead from the contact set to the distributor body, then pull the lead clear. Remove the two fixing screws with their washers and spring washers. Lift off the assembly.

When fitting the new one, note the small lug on the bottom which fits into a hole in the distributor. Refit the earthing lead to the furthest away of the two fixing screws. Refit the condenser lead and tighten its screw.

Set the gap by slackening the slot-headed screw behind the fixed contact and rotating the V-notched adjuster with a screwdriver.

Fitting Mitsubishi contact-breaker points

Remove the two crosshead screws holding the contact assembly after detaching the earth lead.

Set the gap by rotating the V-notched adjuster with a screwdriver.

AC Delco

There are two types: one has the normal layout, but the other has the centrifugal advance weights above the points.

On the first type, press the spring of the moving point to release the terminals, and lift them out.

Remove the fixing screw, lift off the assembly and fit the new one.

On the second type, loosen two screws to free the rotor arm.

Hold the arm meanwhile, then lift off complete with the screws so as not to drop them – this allows access to the contact set.

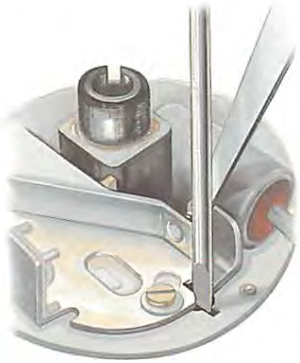
Press the spring of the moving point with a screwdriver blade to release the leads, then slide them off: one upwards and the other sideways.

Remove the fixing screws and spring washers to release the assembly: you may need to turn the engine to move the weights out of the way.

There is a slot for levering with a screwdriver to adjust the gap.

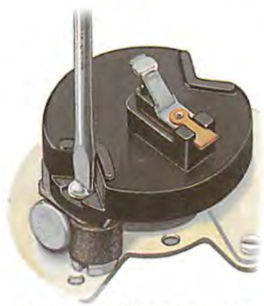
Fitting AC Delco contact-breaker points – normal layout

Release the terminals by gently easing the contact-breaker spring pressure.

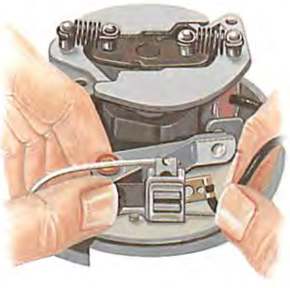


Move the fixed contact plate to set the gap by inserting a screwdriver in the slot.

AC Delco – alternative layout



Loosen the screws holding the rotor arm.



Slide out the terminal leads while easing the spring pressure.

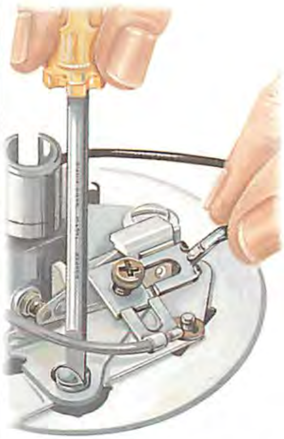
Motorcraft

Disconnect the two leads by releasing the crosshead screw at the contact-breaker terminal.

Remove the two screws holding the contact-breaker set to the distributor baseplate and lift off the old assembly.

Fit the new one, re-attach the leads and retighten their screw.

Fitting Motorcraft contact-breaker points



Remove the two fixing screws after disconnecting the leads.

Move the fixed contact plate to set the gap by turning a screwdriver in the slot.

Ducellier

Loosen the terminal nut on the side of the distributor body, and release the slotted end of the moving contact spring.

Remove the small spring clip across the terminal and pivot posts and lift off the washers.

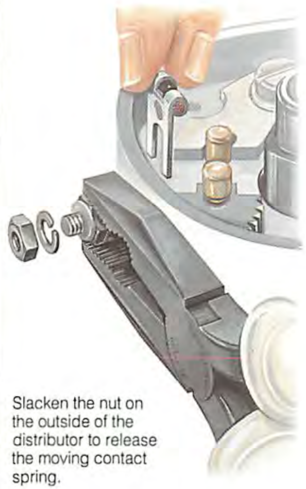
Lift the moving contact off the pivot post. Release the fixed contact securing screw and lift off the contact.

Screw on the new fixed contact; do not tighten its screw fully. Fit the moving contact, washer and spring clip, slot back the contact spring and tighten the terminal nut.

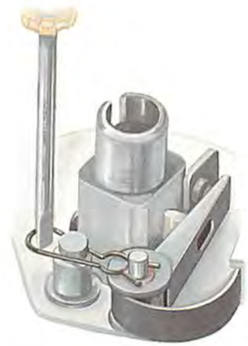
Set the gap by moving the fixed contact plate with a thin screwdriver.

Lubricate the cam spindle.

Fitting Ducellier contact-breaker points



Slacken the nut on the outside of the distributor to release the moving contact spring.



Use the blade of a thin screwdriver to open up and remove the spring clip across the pivot and terminal posts.

Lift the moving contact off the pivot post.

Set the gap by inserting a thin screwdriver in the fixed contact-plate slot and moving the plate.

Checking the dwell angle

When fitting new contact-breaker points in the distributor, the normal way of checking the gap between them is with a feeler gauge.

Points that have been in use for some time develop a peak on one face that corresponds with a crater on the other, caused by spark erosion as the points open. When this happens, a feeler gauge no longer gives an accurate measurement of the gap.

A dwell meter measures the angle of rotation of the cam through which the points are opened and closed, and registers the dwell angle – the period when they are closed.

It can therefore be used to check the gap on worn points with more accuracy than a feeler gauge, and can be used without removing the distributor cap and with the engine running. The meter can also, of course, be used when fitting new points.

A dwell meter is usually part of an instrument used for various mechanical checks. Such instruments may be sold as analysers or test meters, and have to be switched to 'dwell' for a reading.

Tools and equipment

DWELL METER • SCREWDRIVER • SPANNER

Connecting the meter

Follow the maker's instructions. Normally one lead is connected to the side terminal of the distributor if it is outside the distributor body, or the CB (contact-breaker) terminal on the coil, and the other to earth.

Most modern cars have negative earth: connect the black (negative) lead to earth and the red (positive) lead to the distributor or coil.

On a vehicle with positive earth, connect the red (positive) lead of the meter to earth and the black (negative) lead to the distributor or coil.

Measuring the dwell angle

If you have just fitted new contact-breaker points, set them to approximately the right gap with a feeler gauge (SHEET 48).

With the dwell meter connected, start the engine and let it settle to a smooth tickover. If it will not tick over steadily, check the cause(s) and rectify any faults (SHEETS 292-296).

The meter reading should stay steady at a steady engine speed. If it does not, increase the idling speed slightly until it does (SHEETS 170-175).

Compare the steady reading on the appropriate scale with the desired dwell angle for your make of car.

If it is too high, the contact-breaker gap is too small. If it is too low, the gap is too wide.

Before you switch off the engine to adjust the gap, make the following checks. First ask a helper to press the accelerator to increase the engine speed slowly to about 1,000 rpm, then let it drop back to idling speed while you note the reading.

The angle should remain about the same, with no more than two or three degrees deviation.

Secondly, increase the engine speed quickly to about 1,500 rpm, then let it drop back to idling speed while you again note the reading.

The angle should again remain the same, fluctuating by no more than two or three degrees.

Carry out these two tests several times so that you can take an average of any differences in the readings.

If the reading constantly fluctuates more than two or three degrees, the distributor-shaft bearing or advance-retard plate may be worn, or the cam itself damaged. Fit a new distributor (SHEET 201).

Switch off the engine before making any adjustments necessary to the contact-breaker gap.

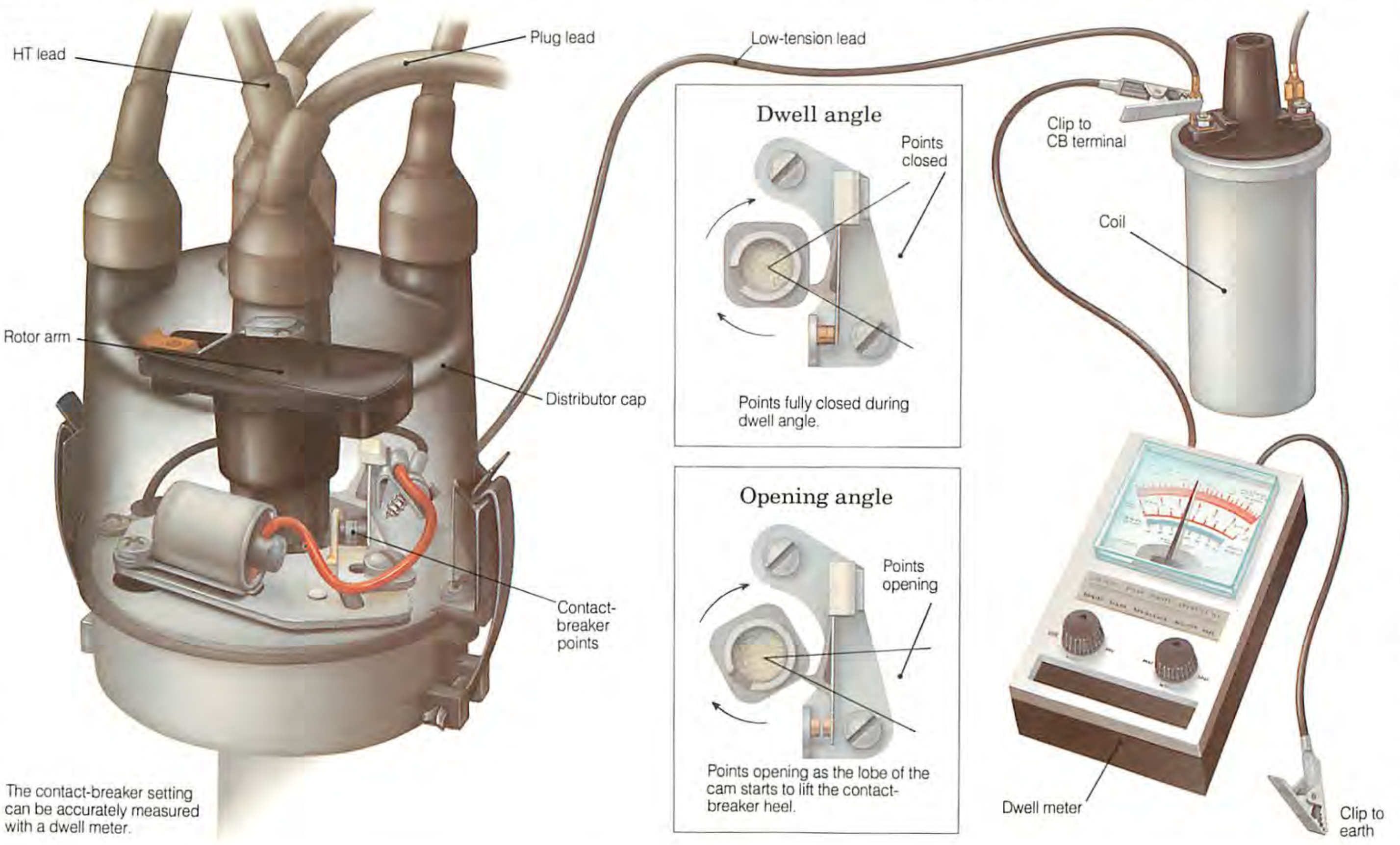
How a dwell meter works

When the distributor shaft is rotating, the contact-breaker points open as the heel of the moving point is pushed outwards by a lobe of the cam, and close while it is over the flat area between two lobes.

If, for example, the angle of rotation between the centres of the lobes on the cam is 90 degrees, the dwell angle – the period with the arm over the flats and the points closed – may be 52 degrees; the remaining 38 degrees are taken up by the action of opening and closing. This would be a typical dwell angle for a four-cylinder engine.

A dwell meter connected between the distributor or ignition coil and earth registers the dwell angle on a scale, and must remain steady at the prescribed figure while the engine is running. If the dwell angle is not the same for all cylinders, the result is rough running and poor fuel economy because the moment the spark-plug fires varies from cylinder to cylinder.

The dwell angle varies according to the make of car; check it in a service manual or on the DATASHEETS. There are two scales on the meter, one for four-cylinder engines and one for six-cylinder engines. Eight-cylinder vehicles are taken from the four-cylinder scale and halved.



The contact-breaker setting can be accurately measured with a dwell meter.

Adjusting the gap

With the meter still connected, remove the distributor cap.

Using a spanner on the crankshaft pulley, turn the engine by hand in its normal direction of rotation until the contact-breaker points are held fully open by one of the cam lobes.

Loosen the contact-breaker fixings slightly (SHEET 194), on some distributors you may have to remove the rotor arm to do this, and adjust the gap as needed. Reduce it to increase the angle if the reading was too low; increase it to lower the angle if the reading was too high.

Replace the rotor arm if removed, and the distributor cap. Switch on the engine and check the dwell-meter reading again. If the figure is still not correct, switch off and reset the gap.

Continue the procedure until you obtain the correct reading.

If you cannot get it right, make sure the right type of contact breaker is fitted. If it is correct, the fault may be a worn heel or pivot, or a weak tension spring. Fit new points (SHEET 194). Check also to see that there is not excessive wear in the distributor-shaft bearing, which would cause the cam to run out of true.

Fitting a condenser

The condenser is a small electrical device connected across the contact-breaker points in the distributor.

It helps to give a crisper spark at the plugs and also retards erosion of the contact-breaker points.

If the points are badly eroded, and a general ignition check (SHEETS 191 and 199–200) has eliminated other causes, suspect a faulty condenser.

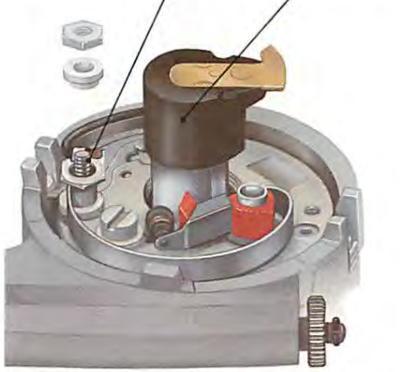
The condenser may be fitted outside the distributor, or inside on the contact-breaker baseplate; on a few cars it is fitted into the wiring somewhere near the distributor. In most cases it is easy to get at, but on cars with poor access you may have to remove the distributor (SHEETS 201–202).

A magnetic screwdriver, or a dab of grease on a screwdriver blade, is useful for fitting small screws.

Tools and equipment

SCREWDRIVERS • GREASE (OR MAGNETIC SCREWDRIVER) • SPANNERS

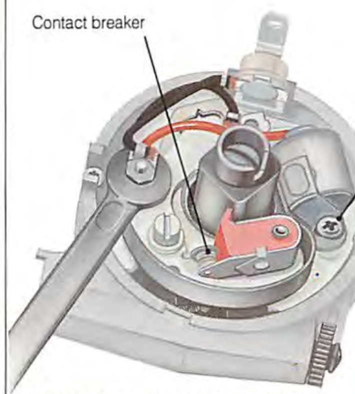
Internally fitted condenser

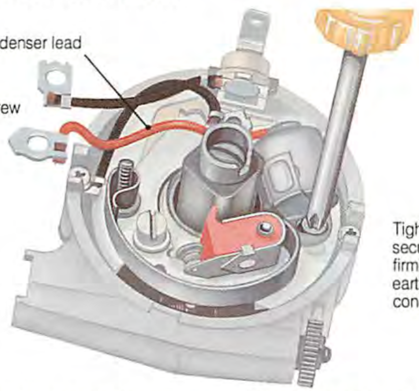


A typical internal condenser has its lead going to the terminal of the contact breaker and is earthed by the screw that fixes the condenser to the baseplate (see below).

Condenser removed with its leads from the baseplate.

Fitting to a Lucas distributor





Tighten the securing screw firmly – it also earths the condenser.

Replacing the condenser, which is mounted internally, is simple; but with the earlier type of contact breaker take care to reassemble the terminal post correctly.

Unclip and remove the distributor cap. Unscrew the terminal-post nut. Lift off the plastic insulating washer and the leads to the points and condenser. Remove the screw holding the condenser to the baseplate.

When reassembling the distributor, be careful to fit the leads underneath the plastic insulator.

If they are replaced above it the points will be earthed and the ignition will not work.

Fitting to other types of distributor

The condenser in the Ford Motorcraft and AC Delco distributors is internal.

Unclip the cap (on some AC Delco types the cap is held by screws) and remove it. On the Ford distributor, slacken the terminal screw and slide out the spade terminal.

Detach the condenser lead on the AC Delco type by pressing the contact-breaker spring to release it. Take out the condenser securing screw and lift the unit from the baseplate.

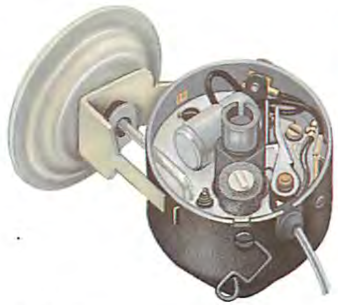
The condenser on the Nippon Denso, Mitsubishi, Bosch and Ducellier distributors can be mounted on the outside.

Removing condensers that are externally mounted is a simple operation, and there is no need to remove the distributor cap.

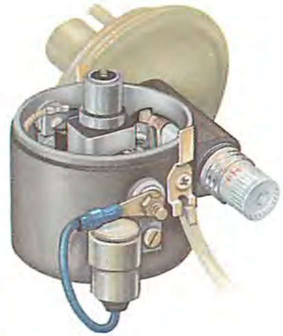
On these types, the condenser leads can be freed from exterior terminals, and the condensers removed by undoing single retaining screws.

Although on the Bosch distributor the condenser is external, you still have to remove the distributor cap, rotor arm and condensation shield.

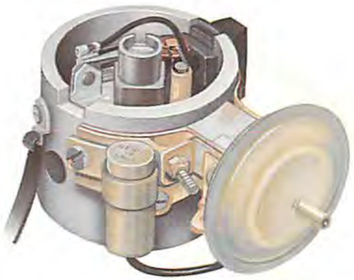
Unfasten the lead from the contact-breaker points to the terminal block. On the outside of the distributor, remove the terminal-block securing screw and bracket, then the screw securing the condenser to the distributor body. Lift the assembly clear.



AC Delco
The condenser terminal is clipped under the contact-breaker spring.

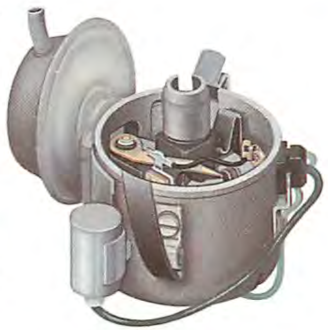


Nippon Denso
The condenser is secured by a single screw.



Ducellier
The condenser is mounted outside, held by a single screw and clip.

Motorcraft
The condenser lead is connected by a spade terminal.



Bosch
A terminal block connects the points to the condenser lead.

Mitsubishi
The internal condenser lead is held by a terminal nut.

Checking the high-tension circuit

The high-tension (HT) or secondary circuit carries high-voltage electricity. It runs from the secondary winding of the coil through the distributor to the plugs. Any of these can break down and cause ignition failure.

Do not touch any part of the HT circuit with bare hands when the ignition is switched on. Work with pliers and screwdrivers that have thickly insulated plastic handles. Take care not to touch any metal parts of the tools.

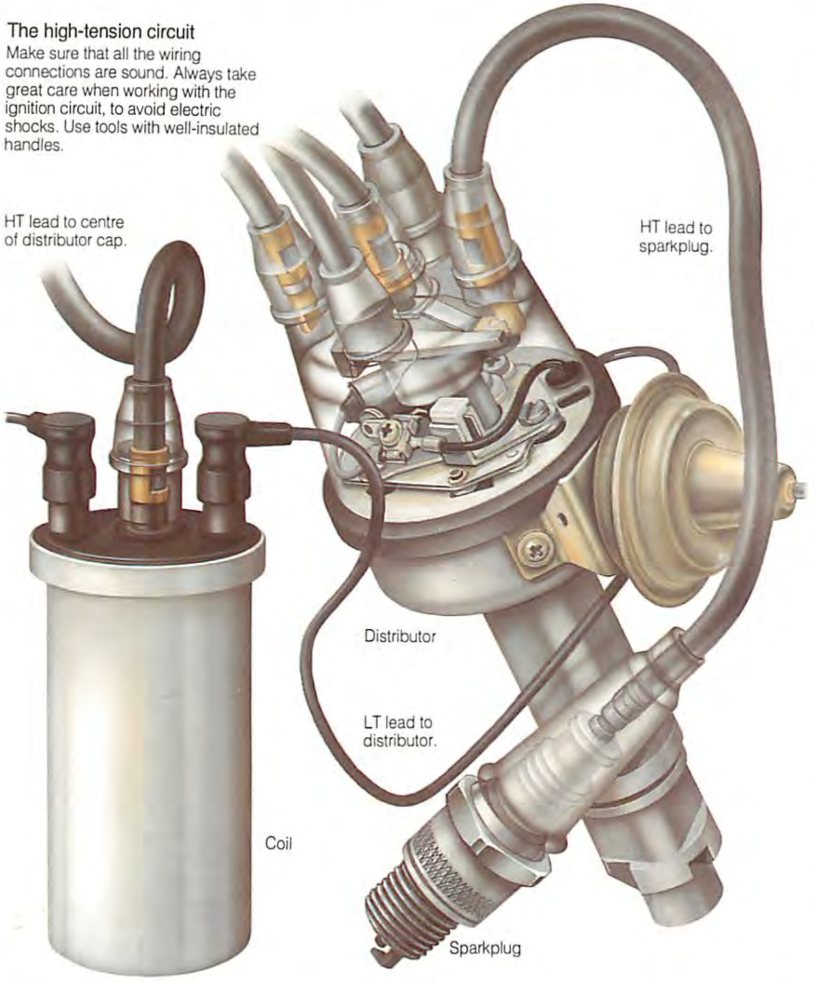
Since HT-circuit checks involve using the car's own HT leads, begin by testing the leads to make sure that they are sound.

Tools and equipment

INSULATED PLIERS • INSULATED SCREWDRIVER • OHMMETER OR MULTIMETER

The high-tension circuit

Make sure that all the wiring connections are sound. Always take great care when working with the ignition circuit, to avoid electric shocks. Use tools with well-insulated handles.



Testing the coil secondary winding

To check the secondary winding, take off the distributor cap and detach the central HT lead (SHEET 191).

Remove or push back the cap from the end of the HT lead to expose the core connection.

Remove a lead from one of the sparkplugs, then switch on the ignition.

Grip the detached central HT lead with insulated pliers, and hold its exposed end against the plug terminal. Flick open the contact-breaker points with a small insulated screwdriver.

A strong spark between the end of the HT lead and the plug terminal shows that both the coil and condenser are in order.

An alternative test can be made by taking off all the plug leads to prevent the engine from starting (number the leads to avoid later confusion).

Remove one of the plugs and reconnect it to a lead. Touch it against the engine and watch for a strong spark when a helper turns the starter switch.

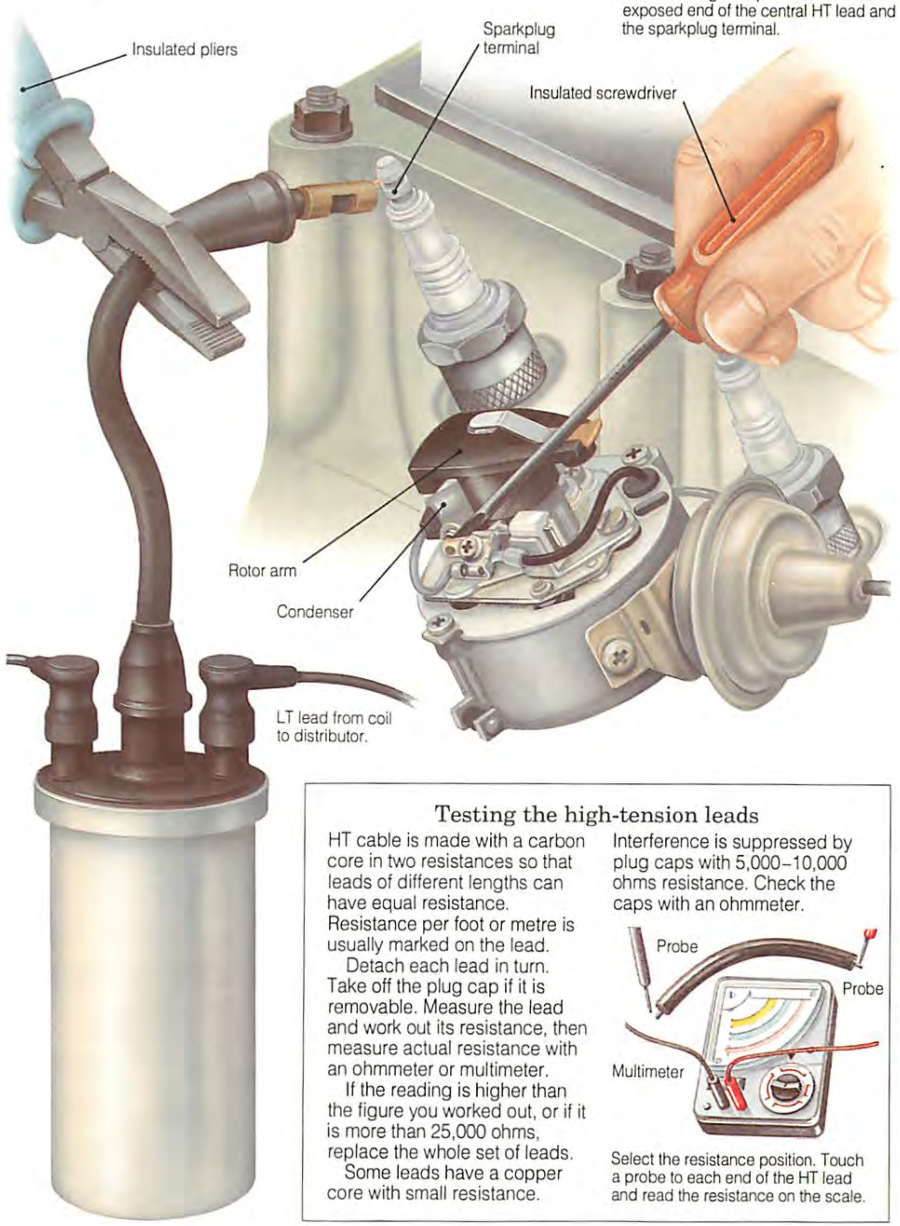
If either test produces only a weak spark, and the HT leads are sound, suspect a faulty condenser. Check by fitting another condenser which you know to be serviceable (SHEET 198).

Check the condenser connections. If the spark is no better, or if the first test gave no spark, the coil is faulty (SHEET 191). Replace it if necessary.

It is possible for the rotor arm to short circuit to the top of the contact-breaker cam. Detach the central HT lead from the distributor cap and hold it with insulated pliers. Switch on the ignition. Hold the exposed metal end of the lead about ⅛ in. (3 mm) from the rotor-arm tip.

Flick the points open. There should be no spark, or a feeble spark from static discharge. A strong spark means a short circuit.

Clean the cam and rotor arm of dirt and grease. If the trouble persists, examine the rotor arm for cracks and replace it if necessary.



When the points are flicked open, there should be a good spark between the exposed end of the central HT lead and the sparkplug terminal.

Testing the high-tension leads

HT cable is made with a carbon core in two resistances so that leads of different lengths can have equal resistance. Resistance per foot or metre is usually marked on the lead.

Detach each lead in turn. Take off the plug cap if it is removable. Measure the lead and work out its resistance, then measure actual resistance with an ohmmeter or multimeter.

If the reading is higher than the figure you worked out, or if it is more than 25,000 ohms, replace the whole set of leads.

Some leads have a copper core with small resistance.

Interference is suppressed by plug caps with 5,000–10,000 ohms resistance. Check the caps with an ohmmeter.

Select the resistance position. Touch a probe to each end of the HT lead and read the resistance on the scale.

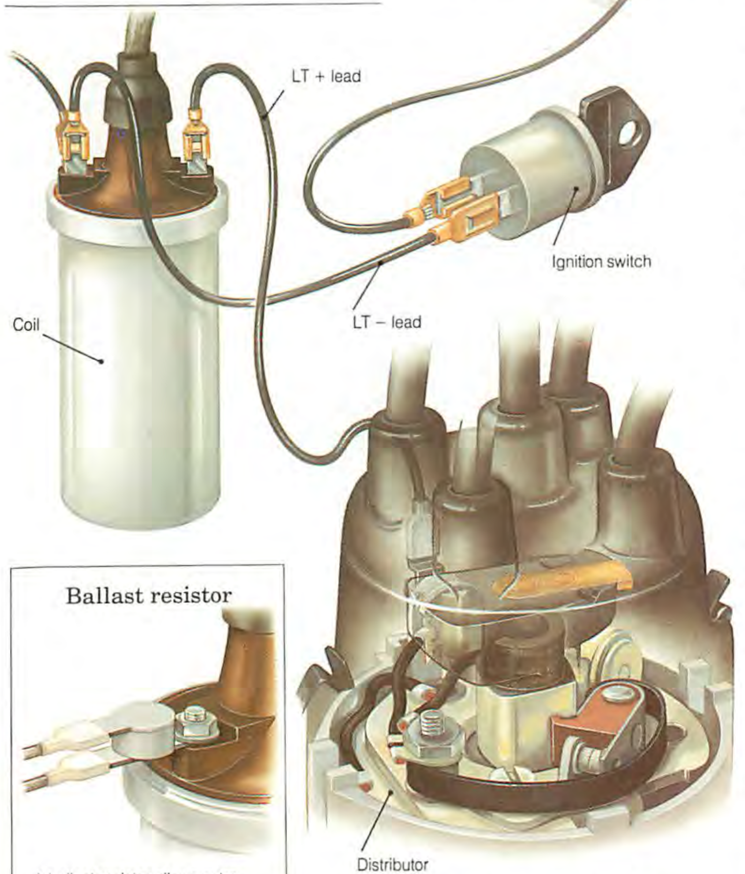
Checking the low-tension circuit

The low-tension (LT), or primary-ignition, circuit consists of the battery, ignition switch, contact breaker and the primary winding of the coil.

Any of these can cause misfiring, as can the high-tension (HT) circuit (SHEET 199)

Tools and equipment

HYDROMETER • VOLTMETER OR TEST LAMP • CROSSHEAD SCREWDRIVER



The low-tension circuit feeds low-voltage current from the battery to the ignition coil, where it is boosted to high voltage for the sparkplugs.

Ballast resistor

A ballast resistor allows extra voltage for starting, relieving the strain on the battery – especially in cold weather.

Checking the battery

Check that all connections are clean and tight. Clean the connections if necessary, and smear the battery terminals with petroleum jelly – not grease.

Ensure that the battery is fully charged and that the electrolyte is above the plates. Test it with a hydrometer: the specific gravity should be well above 1·230.

For a less accurate check, switch on the headlights and watch them while a helper works the starter. They should dim only a little, and the starter should turn at its usual speed.

If the lights dim badly while the starter turns slowly, either the battery is low or its connections are unsound. Re-check its connections, including the engine earthing strap (SHEET 98); if necessary charge the battery.

For further tests you need a voltmeter or multimeter – although you can make a rough check with a test lamp and leads.

Instructions here are for the more common negative-earth system: with a positive-earth car read – for + and + for – throughout.

A ballast-resistor system

The voltage reaching the coil may be 12 volts, or about 7 volts if the coil has a ballast resistor.

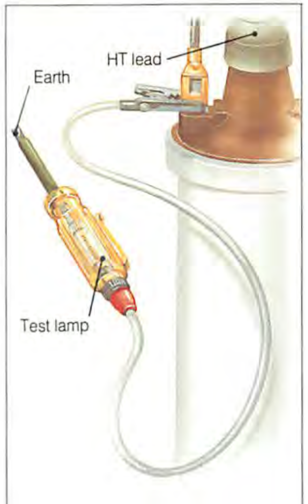
Most electrical equipment works on 12 volts, but most modern cars have a resistor in the ignition system to assist starting.

The coil in a ballast-resistor system is rated at 7-8 volts instead of 12 volts. When the starter motor is operating, the coil is fed with 12 volts from the starter.

The 'overload' produces a very large HT spark for the sparkplugs at the critical starting time.

Once the engine has started, the coil is fed in the usual way from the ignition switch. To stop the coil from burning out, the 12 volts from the switch is usually passed through a resistor block (mounted on or near the coil), which reduces the voltage.

Some cars have, instead, a special high-resistance wire between the ignition switch and the coil to reduce the voltage.



You can make a rough check on coil voltage with a test lamp. Wedge the points open, clamp the lamp lead to the coil CB terminal and earth the probe. Turn on the ignition. If the lamp is bright, voltage is good; if it is dim or fails to light, there is a fault.

Checking the voltage

Make sure all connections are clean and tight. To check that voltage is reaching the coil, connect the voltmeter between the + or SW terminal of the coil and earth, and switch on the ignition.

The meter should read nearly 12 volts, or about 7 volts if the coil has a ballast resistor.

If there is no voltage, there is a break in the circuit between the battery and the + terminal. Possibly the ballast resistor is faulty.

Checking the coil

If the previous test shows no fault, test the primary winding of the coil.

Remove the distributor cap and wedge the contact-breaker points open with a piece of plastic or card.

Connect the meter between the – or CB terminal of the coil and earth, and switch on the ignition. Again the meter should read about 12 volts.

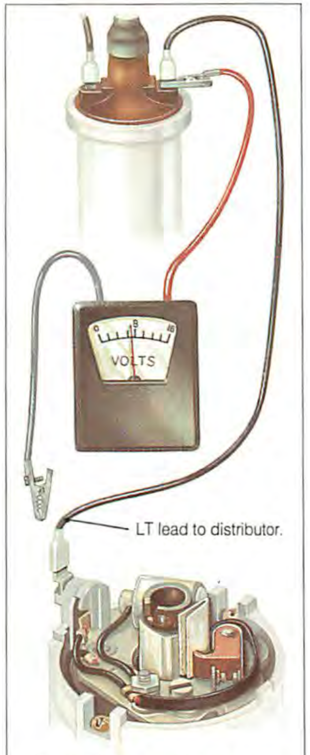
If it reads zero there may be a break inside the coil winding, or a short circuit to earth inside the distributor or in the LT lead.

Check further by disconnecting this LT lead and repeating the test. If the reading is zero, and the ballast resistor is sound, the coil is broken and should be replaced.

If the reading rises to about 12 volts, the distributor or its LT lead may be short circuited to earth.

Checking distributor leads

Check that the lead looks sound and the connection is clean and secure; check in the same way the short wires between the distributor LT terminal and the contact-breaker terminal post, and between the points and the condenser.

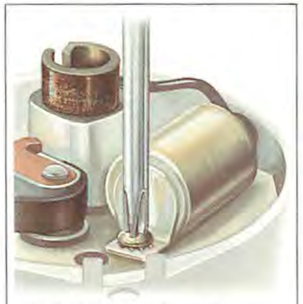


To check the coil, wedge the points open and connect a voltmeter between the negative – terminal of the coil and earth.

Look at the condenser itself, which might perhaps be short circuited to earth. Remove it from its mounting and check the voltmeter reading. If it is correct, the condenser is faulty; renew it.

Checking the points

Make sure that the points are assembled correctly (SHEETS 194-196): mistakes such as leaving out insulating washers can cause a short circuit.



To check if the condenser is causing a short circuit, remove it and check on the voltmeter if there is current through the circuit.

Close the points. Leave the meter connected between the – or CB terminal of the coil and earth. Switch on the ignition. The reading should be zero.

Any voltage, even a very low one, may be caused by one or more faults, such as, dirty or oily points; wrongly set points not closing properly; points of the wrong type for the distributor; a bad earth connection between the contact-breaker baseplate – or the whole distributor – and the engine.

Other faults possible

Other causes can be a previously unnoticed break in the lead between the distributor LT terminal and the contact-breaker post, or even in the LT lead from coil to distributor.

Eliminate these possible causes one by one to reveal the fault.

Removing and refitting the distributor / 1

On some cars, because of limited space, the only way of replacing the contact-breaker points or condenser is with the distributor removed.

Before removing the distributor, check which of the high-tension leads is connected to the cylinder used for timing (SHEET 203). It is nearly always No. 1 cylinder, but on some cars another cylinder is used.

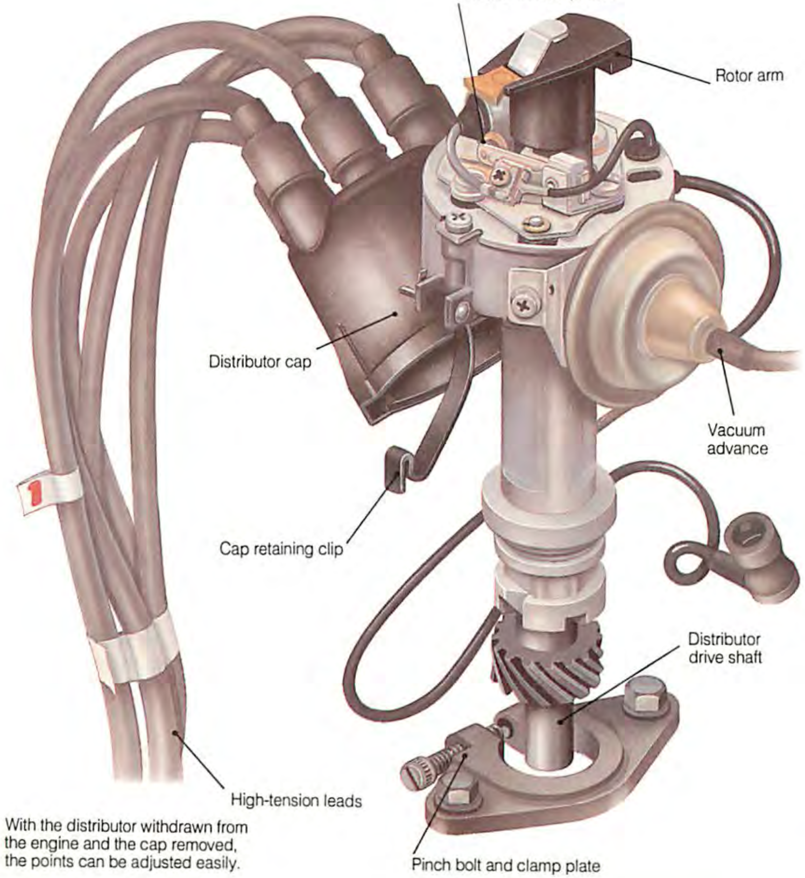
Mark the lead with a tag, and pencil its position on the distributor body.

There are variations in the procedure for removing and refitting the distributor on some cars. Check the details in your car service manual.

Do not crank the engine or move the car in gear while the distributor is out of the engine. If the engine is turned, the timing will have to be reset.

Tools and equipment

FLAT-BLADED AND CROSSHEAD SCREWDRIVERS • OPEN-ENDED SPANNERS • RING SPANNER OR SOCKET TO FIT CRANKSHAFT PULLEY • SHORT AND LONG-NOSED PLIERS • PLUG SPANNER • TEST LAMP



With the distributor withdrawn from the engine and the cap removed, the points can be adjusted easily.

Removing the distributor cap

Make sure that the battery is disconnected. Prise apart the two retaining clips to free the distributor cap or remove the screws if the cap is held on by screws. Remove the rotor arm to take out the dust shield fitted to some cars, then replace it.

Check that the position of the timing-cylinder sparkplug lead is clearly marked on the distributor body.

Remove the distributor cap with its HT leads.

Before removing the distributor cap, tag the lead to the cylinder used for timing and mark its position on the distributor body.

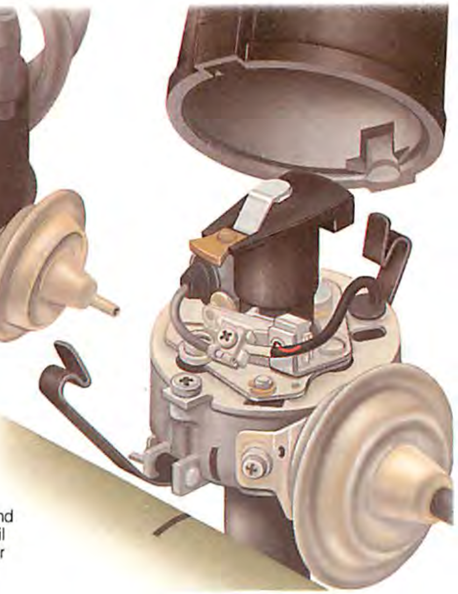
Preparing to remove the distributor body

Turn the engine with a spanner on the crankshaft-pulley nut. Alternatively engage top gear, release the handbrake, and push or pull the car.

Turn the engine until the contact-breaker points are just starting to open and the rotor arm points to the position of the timing-cylinder HT lead.

To save time when refitting, scribe a mark on the distributor body and a corresponding mark on the drive housing or engine block. Remember that this will be useless if the engine is turned and the rotor arm position altered after the distributor is removed.

Disconnect the vacuum tube and low-tension lead.



Remove the cap and turn the engine until the contact-breaker points are just opening.

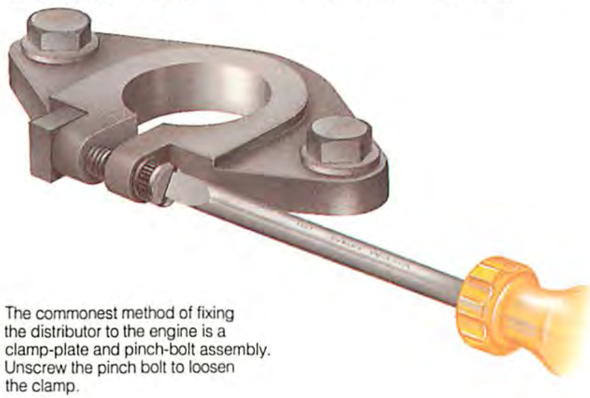
Removing a pinch-bolt assembly

The commonest fixing is a clamp-plate and pinch-bolt assembly; the pinch bolt is the same one that is loosened when turning the distributor to set the ignition timing.

Loosen the bolt or bolts holding the clamp plate to the engine. Undo the pinch bolt and carefully withdraw the distributor.

If the distributor is tight, insert a screwdriver blade between the open ends of the clamp plate and prise them slightly apart.

As you withdraw the distributor, the rotor arm sometimes shifts slightly through the movement of the driving gear. If this occurs, mark the final position of the arm to simplify replacement.



The commonest method of fixing the distributor to the engine is a clamp-plate and pinch-bolt assembly. Unscrew the pinch bolt to loosen the clamp.

Removing a flange-and-stud assembly

On some overhead-camshaft engines, the distributor has a slotted flange at the base that fits over two or more studs on the engine. The distributor is secured by nuts and washers.

The slots in the flange allow the distributor to be turned when the nuts are slackened while timing the engine. Mark the position of the distributor, by scribing lines on the flange and on the stud plate so that it can be replaced in exactly the same position.

Remove the nuts and pull the unit away from its mounting. Twist it gently if it sticks, but do not try to lever it from the engine block with a screwdriver.

When removing a distributor with a flange-and-stud assembly, twist it gently if it sticks. Do not try to lever it with a screwdriver.

Removing and refitting the distributor / 2

Replacing the distributor

Slide the distributor driving gear back into the engine block, roughly aligning the scribed marks.

If the drive fitting on the shaft is an offset dog – a tongue that fits into a slot – turn the contact-breaker cam until the dog engages, then push the distributor home.

If the drive fitting is a skew gear, it may be difficult to align the scribe marks without turning the distributor slightly.

You may need to point the rotor arm roughly 30 degrees before or after the cylinder-lead mark on the distributor body, depending on the direction of rotation of the rotor arm. As the gear meshes, the rotor arm should turn to line up exactly.

With the scribe marks properly aligned, tighten the fixing and reconnect the vacuum tube and low-tension lead.

If the engine has been turned while the distributor was removed, the ignition timing will have to be reset. If the engine has not been turned, check the accuracy of the timing and reset if necessary (SHEET 203).

The distributor driving gear may be an offset dog – a tongue that fits into a slot.

Some distributors have a skew-gear drive fitting.

Refitting the cap

Inspect the cap for cracks or tracking marks, fine lines that look like forked lightning, before fitting it into place. If it is marked or cracked, renew it, changing over the HT leads in identical order (SHEET 191). Wipe inside the cap with a clean, dry rag.

Reconnect the battery.

Before refitting the cap, check whether it is marked or cracked. If it is, renew it.

Vernier timing adjuster

If the distributor has a vernier timing control, set it midway between advance and retard. Turn the knob fully anti-clockwise, then fully clockwise counting the number of turns. Divide the number by two to find the midway position.

Variations on some cars

The distributor may be fitted with a vernier timing adjuster – a graduated scale which allows fine adjustment of the timing. Turning the knurled knob clockwise retards the ignition, turning anti-clockwise advances it.

When replacing the distributor after the engine has been turned, set the adjuster to midway between advance and retard.

Slide the distributor into place, and position it so that when the driving gear is engaged the rotor arm is pointing to the timing-cylinder electrode.

On cars with electronic ignition, removing and refitting the distributor is the same but the timing must be set with a stroboscope.

Other types of distributor

When you remove some types of distributor, the driving gear may stay in the engine. Hook it out with your finger or a suitable piece of wood.

When refitting, oil the driving gear with clean engine oil and replace it in the block before positioning the distributor.

There may be a gasket between the distributor mounting and the cylinder head. Remove and discard it, and fit a new one when replacing the distributor.

On another type of distributor, the first step is to remove a TDC sensor from the clutch housing – on a VW for example – so that the timing marks can be seen. Use a plug spanner sawn off to about 2 in. (50 mm).

Turn the engine by hand until the O mark on the flywheel is opposite a reference mark on the clutch housing.

In that position, the timing mark on the camshaft sprocket should be level with the cylinder-head cover, and the rotor arm should be in line with the No. 1 electrode in the distributor cap.

If the engine is turned while the distributor is out of the car, turn the engine until the flywheel and clutch-housing marks are aligned.

If the camshaft-sprocket mark is not then level with the cylinder-head cover, turn the crankshaft through another complete revolution.

Make sure that the lug on the end of the oil-pump drive shaft is in line with the crankshaft axis.

Resetting the distributor after the engine has been turned

To reset the firing position, the distributor must be refitted so that when the contact-breaker points are just opening, the timing mark on the crankshaft pulley is in line with its pointer and the piston of the timing cylinder is approaching top dead centre on its compression stroke.

Remove the sparkplugs to make the engine easy to turn.

To check when the piston is approaching top dead centre on the compression stroke, ask a helper to place a thumb over the timing-cylinder plug hole.

Turn the engine with a spanner on the crankshaft pulley nut. As the piston rises, your helper will feel the pressure build up until, as the piston reaches the required position, the pressure is sufficient to force the helper's thumb off the sparkplug hole.

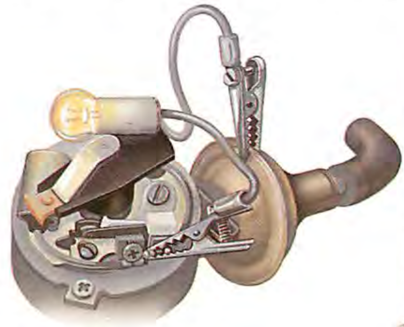
Alternatively, take off the rocker cover and watch to see when both valves of the cylinder are fully closed (SHEET 25).

Turn the engine a little until the timing mark and pointer are in line with the appropriate number of degrees before TDC (see DATASHEETS).

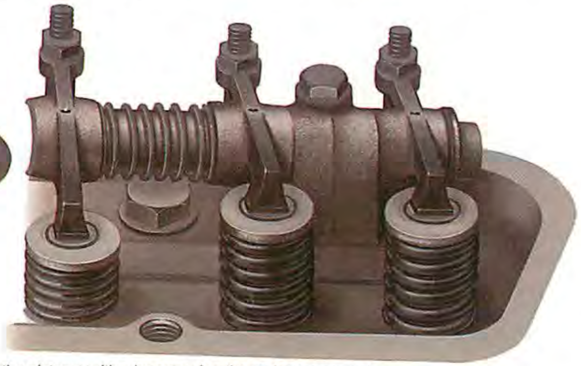
Slide the distributor into position so that when the driving gear is engaged, the rotor arm is pointing to the position of the timing-cylinder lead. Reconnect the battery, and connect a test lamp across the contact-breaker points to check that they are just opening (SHEET 203).

Secure the distributor on its mounting and check the accuracy of the ignition timing. Re-check the contact-breaker points gap and refit the distributor cap.

Refit the distributor so that the timing marks align as the piston of the timing cylinder approaches TDC on its compression stroke.



Use a test lamp to check that the contact-breaker points are just opening (SHEET 203).



Check the piston position by removing the rocker cover and noting when both valves of the cylinder are fully closed.

Adjusting the static timing

The timing mechanism in the ignition system causes the sparkplug to fire in each cylinder just before the piston reaches top dead centre (TDC) on its compression stroke.

That gives time for the mixture to start burning steadily as the piston passes through TDC. The resulting expansion of burning gases will thereby be most effectively used throughout the power stroke.

The timing of the spark is measured as the number of degrees by which the crankshaft is short of bringing the piston in the timing cylinder (usually No. 1, but consult the handbook for your car) to TDC.

The number of degrees varies from car to car (again consult the handbook, or DATASHEETS).

'Static timing' means setting the timing with the engine stopped.

You set the crankshaft at the correct number of degrees before top dead centre, then adjust the distributor by turning it until the contact-breaker points are just opening.

However, this method of timing takes no account of wear and backlash in the distributor drive. The timing can be slightly out, even at idling speed. The spark will occur later than it should, particularly at high engine speed, and the engine will not develop full power.

Stroboscopic timing (see overleaf), by which the timing is checked and set with the engine running, is more accurate.

Some manufacturers disapprove of their cars being statically timed, and give only a stroboscopic figure in their handbook.

But static timing is simpler, and can be done with a circuit tester or a test lamp. It is adequate for the initial setting of the timing mechanism before fine tuning.

Tools and equipment

SPANNERS OR SOCKETS • PLUG SPANNER • CIRCUIT TESTER OR TEST LAMP • SCREWDRIVERS

Setting the static timing

Find the timing marks – they may be on the crankcase just behind the crankshaft pulley, with a corresponding pointer on the pulley; or they may be on the pulley, with a pointer on the crankcase.

If there are no numbers but only a notched scale, TDC is shown by a large notch. The scale of other notches varies from car to car – consult the car service manual; some cars have only one other notch, which is the specified number of degrees before TDC.

With the ignition switched off, turn the engine in its normal direction of rotation.

You can turn the engine by putting the car in top gear and pushing it forwards, or turning the crankshaft pulley with a spanner or socket on the nut.

The second method is made easier by removing the sparkplugs to release cylinder compression.

Turn until the pointer is in line with the appropriate timing mark when the piston in the timing cylinder is rising on its compression stroke.

Remember that the crankshaft turns twice for each rotation of the timing gear.

To identify the compression stroke, remove the sparkplug on the timing cylinder. Get a helper to place a finger or thumb over the hole to feel the pressure rise as you turn the engine.

An alternative way is to remove the rocker or camshaft cover and note when both valves on the timing cylinder are closed.

To adjust the distributor, remove the cap by undoing its clips or screws.

With the timing mark correctly aligned, the rotor arm should be opposite the contact for the timing cylinder – check by tracing back the ignition lead – and the points should be about to open.

You can confirm this by noting that the heel on the contact-breaker arm is just at the bottom of one of the cam lobes.

Remember that the cam usually turns anti-clockwise. Remove the rotor arm if it obscures the points and cam.

Slacken the pinch bolt at the base of the distributor body.

Connect one clip of the test lamp to the live terminal of the points (the low-tension terminal) and earth the other lead to the engine. Switch on the ignition.

Turn the distributor to a point where the test-lamp light flickers between on and off. Tighten the pinch bolt and re-check with the lamp by flicking the rotor arm.

Some distributors have a vernier control – a graduated scale set by a knurled knob – for final adjustment after locking.

Setting top dead centre

Align the timing notch on the crankshaft pulley with the marks on the engine block, which may be numbered.

Other marks

If there are no numbers, the largest notch means top dead centre.

When the timing is correct, the rotor arm is opposite the distributor cap contact for the timing cylinder.

Compression check

Remove the sparkplug from the timing cylinder and check with a thumb for rising air pressure as the piston comes up to TDC.

Adjusting the distributor

Slacken the pinch bolt on the clamp at the base of the distributor body so that you can just rotate the distributor.

Different mounting

A distributor mounted on the end of the camshaft (in an overhead-camshaft design) is held by two or three bolts or studs in a slotted flange.

Stroboscopic timing

A static timing check with the engine stationary (SHEET 203) is never fully accurate. It does not allow for wear or backlash – working clearance – in the distributor drive.

For greater accuracy, check the timing while the engine is running, using a stroboscope. First make sure that the contact-breaker points are adjusted correctly (SHEET 194).

The work is done in close proximity to drive belt(s) and pulleys – take care that loose clothing or your hair does not become entangled.

A stroboscope is simply a light connected to the sparkplug of the cylinder that is used for timing.

Every time the plug fires, a timing mark on the crankshaft pulley is just passing a fixed pointer on the engine.

The strobe light is a xenon or neon flash tube, which flashes very briefly at the moment of firing, so that the timing mark is lit only when it is opposite the fixed pointer.

As this happens again and again, the effect is to make the mark appear stationary.

If you advance or retard the ignition, the mark appears to move a short way and then stop in a new position.

Buy or hire a xenon strobe if possible, for it is brighter than the cheaper neon type.

Most strobes have a metal spacer connection which fits between the sparkplug and the plug cap, but more expensive models have an 'inductive trigger' that clips around the plug lead and can be fitted and removed while the engine is running.

The timing must be set at an exact engine speed.

If your car has a tachometer – or rev counter – use this to measure the engine speed. Alternatively, use a separate unit – which can be read from under the bonnet.

Find out from a car handbook or a dealer the maker's stroboscopic timing figure, and which cylinder to use for the check (almost always No. 1).

Find also whether to measure with the vacuum-advance mechanism disconnected or not – the centrifugal-advance system is never disconnected.

A typical timing figure is 13/1,000, meaning 13 degrees before top dead centre (BTDC) at 1,000 rpm. The figure may be the same as the static figure.

If it is stated for a high engine speed there may be a tolerance of a few degrees, for example 31–33/3,000.

You may be able to find out the whole 'advance curve' for different speeds. This set of measurements is always made with the vacuum advance disconnected, so it shows whether the centrifugal-advance mechanism is working properly.

Typical figures (for a Morris Ital 1·7) are 10–14/1,000; 20–24/3,600; and 26–30/4,800.

If you cannot get a stroboscopic timing figure, use the static figure and set the timing with the vacuum advance disconnected and the engine idling as slowly as possible.

Work in a shaded place so that the light shows the marks clearly. Find the mark or marks that you need, and dot them with white paint or chalk so that they stand out.

Tools and equipment

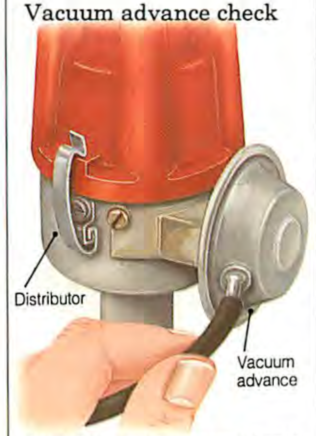
STROBOSCOPE • TACHOMETER • SCREWDRIVER • SPANNERS • CHALK OR PAINT

The vacuum advance

Stroboscopic timing is usually done with the vacuum-advance mechanism disconnected. You can also use the strobe to check whether the advance is working properly.

Run the engine at about 2,000 rpm. Disconnect the vacuum tube quickly while watching the timing mark. The mark should jump to a less advanced position and return when you reconnect the vacuum tube.

Vacuum advance check



If you disconnect the vacuum advance at 2,000 rpm, the strobe should show a less advanced timing position.

Connecting the strobe

Follow the manufacturer's instructions supplied with the timing light you are using. If it is the type that is powered by the car battery, make sure you connect the leads the right way round.

There is also a connection to the plug of the cylinder that is used for the test.

For the usual type, which fits between the plug and plug cap, first switch off the engine.

Pull the cap – not the easily damaged lead – off the plug. Fit the connector to the top terminal of the plug, and the cap to the top of the connector.

With the more expensive induction-trigger type, it does not matter whether the engine is running or not. Clip the connector round the plug lead.

Inductive connection

Some strobes have an inductive trigger that clips round the plug lead.

The strobe light is usually connected between the sparkplug and the plug cap.

Checking the timing

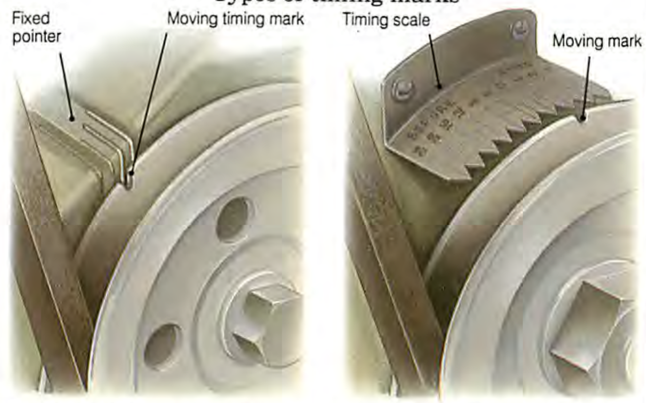
If necessary, disconnect the vacuum-advance tube. Start the engine and get it to run steadily at the correct speed for the test.

If you are timing from a static figure only, temporarily adjust the carburettor idle-stop screw (SHEETS 171-174) to give the slowest idle speed at which the engine will run steadily.

Point the light at the timing marks. If the timing is right, the appropriate mark should appear stationary in line with the fixed pointer. If not, adjust the timing until it does so.

If you have an 'advance curve' of figures for several speeds, you may have managed to get the timing correct for one speed but found that it is not right at other speeds. This is a sign that the centrifugal-advance system in the distributor may be faulty or sticking (SHEET 33).

Types of timing marks



The moving timing mark may be a notch or a scale, or the fixed pointer may be a line or a scale.

If there are no numbers on a timing scale, the advanced position is normally anti-clockwise from 0.

Adjusting the timing

Stop the engine. Loosen the distributor clamp bolt slightly – just enough to allow you to turn the distributor.

Do not turn the distributor yet, and do not slacken the bolt so much that the distributor turns by itself when the engine is running. Start the engine again and allow it to settle down to a steady idle speed.

Hold the distributor by the lower part of the body. If you hold it by the cap there may be a slight leak of high-voltage electricity even from the plastic outside of the cap, enough to give you a sharp shock. As an extra precaution you can wear rubber gloves.

Turn the distributor to advance or retard the ignition. If the number of degrees before top dead centre shown by the timing light is too small, advance the ignition by turning the distributor in the opposite direction from the way its contact-breaker cam turns.

If the amount of advance is too large, retard the ignition by turning the distributor the other way. Watch the timing marks under the strobe light all the time you are adjusting the distributor. When the marks line up, stop adjusting the distributor and turn off the engine.

Taking care not to disturb the distributor setting, tighten its clamp bolt. Start the engine again and give the timing a final check.

Checking the starter circuit / 1

If the starter does not turn the engine although the car battery is in good condition, the fault may be a simple mechanical one or it may be an electrical one in the starter-motor circuit.

The starter system is simple, and the checks on it are straightforward. Electrical checks are made with a circuit tester or test lamp or with a voltmeter (SHEET 48).

A mechanical check to see if the starter pinion gear is simply jammed in mesh with the engine flywheel can usually be made with a single spanner.

The live terminal on the battery is connected by a heavy lead to a terminal on the solenoid switch which is operated when the ignition switch is turned. The other terminal on the solenoid is connected to a terminal on the starter motor.

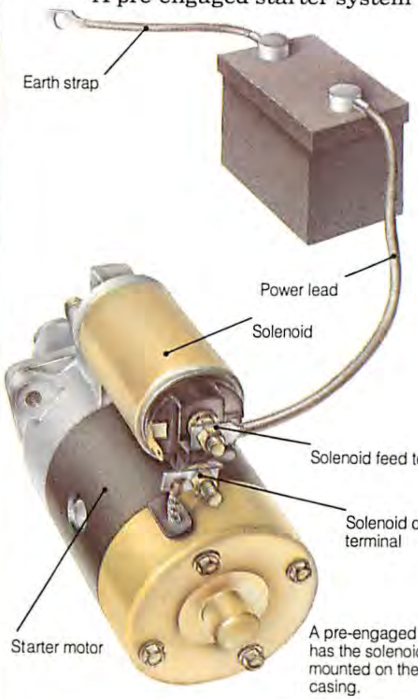
The second terminal on the motor is earthed via a wire strap through the engine or gearbox and the car bodywork back to the earth terminal on the battery.

Modern cars have a pre-engaged starter, which has the solenoid mounted on the casing. Many older cars have an inertia starter, which has a separate solenoid mounted elsewhere in the engine compartment.

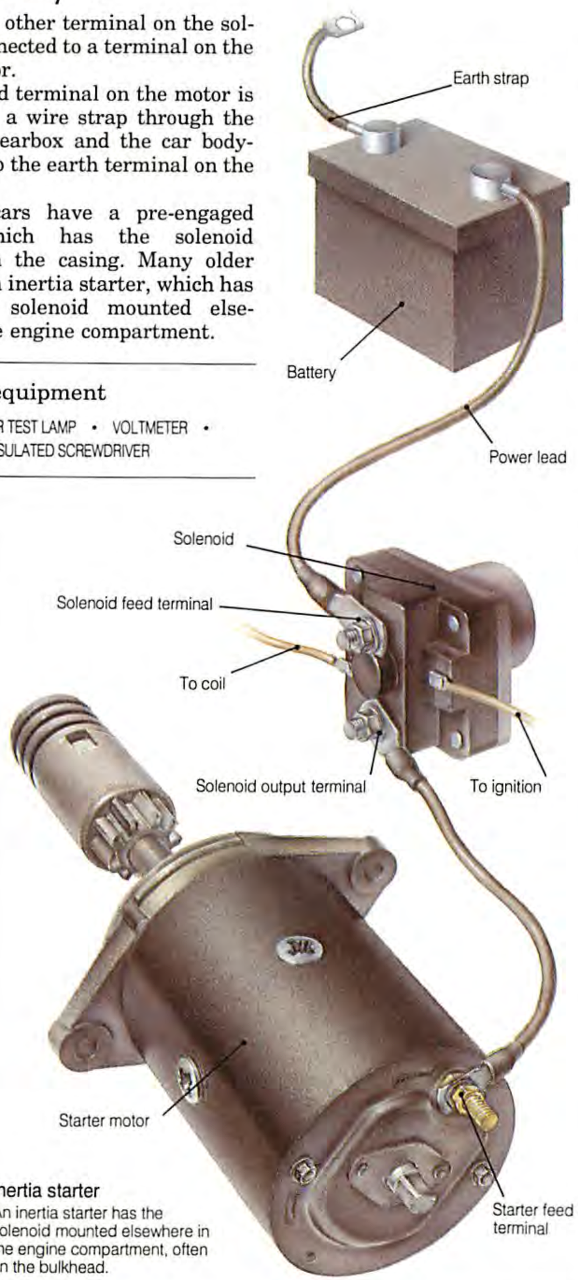
Tools and equipment

CIRCUIT TESTER OR TEST LAMP • VOLTMETER • SPANNERS • INSULATED SCREWDRIVER

A pre-engaged starter system



A pre-engaged starter has the solenoid mounted on the motor casing.



Inertia starter
An inertia starter has the solenoid mounted elsewhere in the engine compartment, often on the bulkhead.

Checking the starter pinion

Switch on the headlights and try the starter. If the headlights dim, the starter pinion is probably jammed in mesh with the flywheel.

See if there is a square stub on the end of the starter-motor spindle. If so, turn it with a spanner to free the pinion.

Do not work the starter switch until the pinion has been freed.

If there is no square stub and the car has manual transmission, with the ignition switched off put the gear lever into second gear, release the handbrake and rock the car forward and back until the pinion frees itself.

If the car has automatic transmission, you have to take the starter motor off (SHEET 207).

If the headlights do not dim, look for an electrical fault.

Power input test

To check if current is reaching the solenoid, connect a test lamp between its feed terminal and earth.

Making the same check on a pre-engaged starter.

Checking for electrical faults

First check the battery and its terminals (SHEETS 97-98)and the other end of its earth strap.

Use the circuit tester or test lamp to find if electric current is reaching the solenoid.

Connect one lead to the feed terminal (the battery side of the solenoid) and earth the other to bare metal on the bodywork.

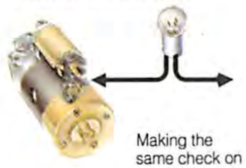
The lamp should light. If it does, the fault is in the solenoid or in the starter itself.

If the lamp lights when you earth it to the body, but not when you earth it to the engine, the engine earth strap is faulty. It may have a loose bolt with dirt underneath, causing bad contact.

If the lamp does not light, the connections between the battery and solenoid are faulty.

Power output test

Check for solenoid-to-starter current by connecting a test lamp between the solenoid output terminal and earth.



Making the same check on a pre-engaged starter.

Checking the solenoid

To check that the solenoid is working, listen to it while a helper works the starter switch. The solenoid will click as the contacts close if it is working. If it does not, the fault may be in the ignition switch or its terminals, the wiring to it or the solenoid itself.

Check the ignition switch and its wiring (SHEET 191).

To check that the solenoid is delivering current to the starter motor, connect the test lamp between the output terminal of the solenoid (leading to the starter) and earth, preferably the battery earth terminal. Working the starter switch should light the lamp.

If the lamp does not light, put the car in neutral gear (or Park on an automatic), turn off the ignition and cautiously try to bridge the two main terminals on the solenoid. This bypasses the switch contacts inside the solenoid.

Use a strong screwdriver with an insulated handle. Do not touch the blade. Peel back the rubber terminal covers and jam the blade for just a moment between the terminals.

There should be a spark, and the starter may turn. If it does, the solenoid is faulty. If not, the fault is in the starter motor. For repairs see SHEETS 209-212.

Test the solenoid by carefully bridging its main terminals with a well-insulated screwdriver.

Checking the starter circuit / 2

Testing the circuit with a voltmeter

Switch on the headlights and try the starter. If the headlights dim, check the starter pinion (SHEET 205). If they do not, check the battery (SHEET 98), its terminals and its earth strap.

If the battery appears sound, test with a voltmeter as described below.

First prevent the engine from starting by disconnecting the feed wire to the coil. It is marked SW or + (on negative-earth cars).

Checking at the battery

Connect the voltmeter leads across the battery terminals, positive to positive (+), negative to negative (−). The dial reading should be 12 volts or more.

Work the starter switch, and the reading should fall, but not below 10·5 volts. If the reading does not fall, there is a fault in the ignition-switch circuit or in the solenoid.

If the reading falls below 10·5 volts and the starter turns slowly or not at all, the battery is probably flat.

If the reading falls below 12 volts but remains above 10·5 volts while the starter turns slowly, there may be a high resistance somewhere in the circuit; it should be revealed in later tests. Or there may be a mechanical seizure in the starter or the engine, which stops it from turning freely.

Checking at the starter

Test the voltage reaching the starter. For a negative-earth system on a car with a pre-engaged starter, connect the positive lead of the voltmeter to the feed terminal on the solenoid. On a positive-earth system, carry out this and the following tests with the voltmeter leads reversed.

If the car has an inertia-type starter, connect the positive lead to the feed terminal on the starter motor.

Touch the negative lead to a bare metal part of the motor for a moment – the voltage should drop, but not more than half a volt lower than in the previous test. If it was previously 11 volts, it should remain above 10·5.

If the reading is above the 10·5 margin, there are no faults in the starter circuit and the trouble is in the motor, the solenoid or the engine.

If there is a steep voltage drop (to lower than 10·5 volts) something is causing a high resistance in the starter circuit.

Connect the negative lead of the voltmeter to the live terminal of the battery, and the positive lead to the starter-motor feed terminal (on a pre-engaged starter this is the solenoid feed terminal).

It should read 12 volts, then when you work the starter switch drop to below 0·5 volts. If it does not drop, first check the solenoid.

Checking at the solenoid and other parts

Connect the voltmeter across the solenoid terminals, the negative lead on the feed (battery) side, the positive on the starter side.

Switch on the ignition switch – if the voltage still does not drop below 0·5 volts, the solenoid or the ignition switch or its connections are faulty.

To test other parts of the ignition-switch circuit, check that their connections are clean and tight, then bridge with the voltmeter.

If the voltage does drop below 0·5 volts, there is probably a fault somewhere else in the supply side of the circuit, such as poor connections to the live side of the battery, at the solenoid, or between the solenoid and the starter motor.

Take the connections apart, clean them and refit tightly.

Checking the earthing of the circuit

To check whether there is high resistance in the wiring on the earth side of the circuit, connect the positive lead of the voltmeter to the negative-earthed terminal of the battery, and the negative lead to the body of the starter.

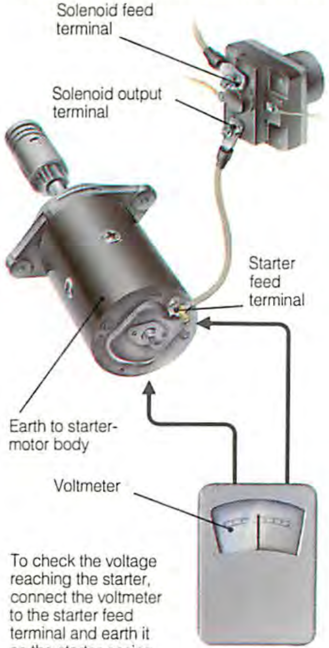
Working the starter switch should cause a drop from 12 volts to below 0·5 volts.

If the voltmeter reading stays above 0·5 volts, look for a bad connection at the battery earth strap (at either end) or the engine-to-body earth strap.

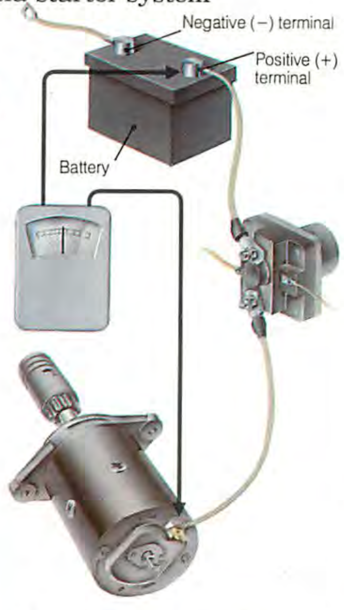
Clean and tighten the connections, and carry out the test again.

If all these tests have not found the trouble, it must be in the starter motor itself (SHEET 207), or just possibly a seized engine.

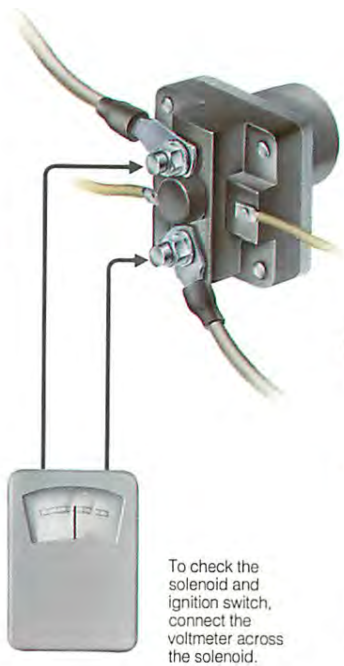
Voltmeter tests on an inertia-starter system



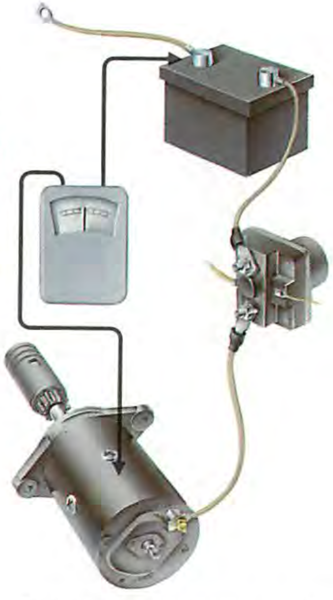
To check the voltage reaching the starter, connect the voltmeter to the starter feed terminal and earth it on the starter casing.



To check for a high resistance between the battery and starter, connect the voltmeter between the battery and starter feeds.



To check the solenoid and ignition switch, connect the voltmeter across the solenoid.



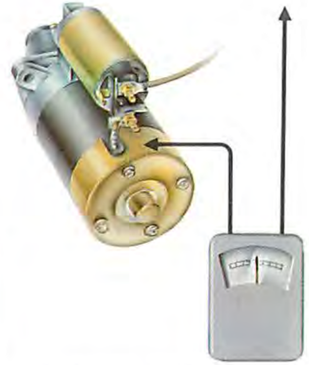
To check for a high resistance on the earth side of the starter circuit, connect the voltmeter to the battery earth terminal and earth it on the starter casing.

Voltmeter tests on a pre-engaged starter system

To check the voltage reaching the starter, connect one lead of the voltmeter to the solenoid feed terminal and the other to the starter casing.

To check for a high resistance between the battery and starter, connect the voltmeter between the battery feed terminal and the starter.

To check the solenoid and ignition-switch circuit, connect the voltmeter leads to both terminals of the solenoid.



To check for a high resistance on the earth side of the starter circuit, connect the voltmeter to the battery earth terminal and earth it on the starter casing.

Checking and replacing the starter motor

If testing the starter circuit (SHEET 205) indicates a fault in the starter motor, disconnect the battery and remove the motor from the car – complete with its attached solenoid if it is a pre-engaged type of motor.

To trace the fault and carry out repairs, you will nearly always have to strip down the motor (SHEET 209), especially if the fault is in the commutator or brush gear.

However, the Bendix gear of an inertia-type starter can be repaired (SHEET 208) without stripping; removing the motor from the car gives sufficient access.

Some faults, such as a badly worn commutator, are beyond repair and you have to buy a new or exchange motor. However, you can renew worn bearings (SHEET 210); repair a faulty solenoid (SHEET 205); fit new brushes in the commutator to replace worn ones (SHEET 211); and repair minor damage to the commutator (SHEET 209).

Damage to the electrical windings is usually too difficult to deal with at home. An auto-electrician can cure a minor short circuit in the field coils, but anything else calls for fitting a new or exchange motor.

A single fault in the motor is probably worth repairing, but if you find more than one fault check the cost of all the spares you need. You may find it cheaper – and quicker – to replace the motor with an exchange unit.

Tools and equipment

SCREWDRIVERS • SPANNERS • SOCKETS • AXLE STANDS • WHEEL CHOCKS • LAMPS • TEST LAMP AND LEADS WITH CROCODILE CLIPS

Removing the starter motor

Always disconnect the battery before removing the starter motor, which is often awkwardly placed low down on the engine. You may have to raise the car on axle stands and work from below.

Disconnect the battery (earth terminal first) to avoid an accidental short circuit.

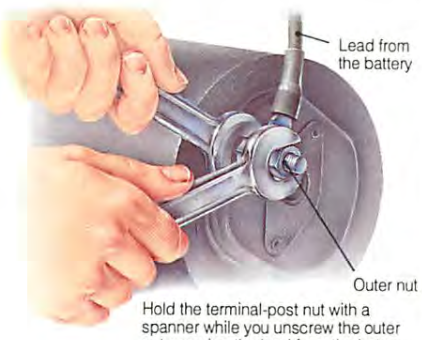
Remove the nut that holds in place the heavy lead connecting the starter to the battery. With an inertia-type starter take care not to twist the terminal post as you are unscrewing the nut. Hold the locknut on the post with an open-ended spanner.

With a pre-engaged starter, the heavy lead from the battery is connected to the solenoid mounted on the starter body. Take careful note of the other leads to the solenoid before you disconnect them.

Remove the two or three bolts holding the motor to the engine backplate.

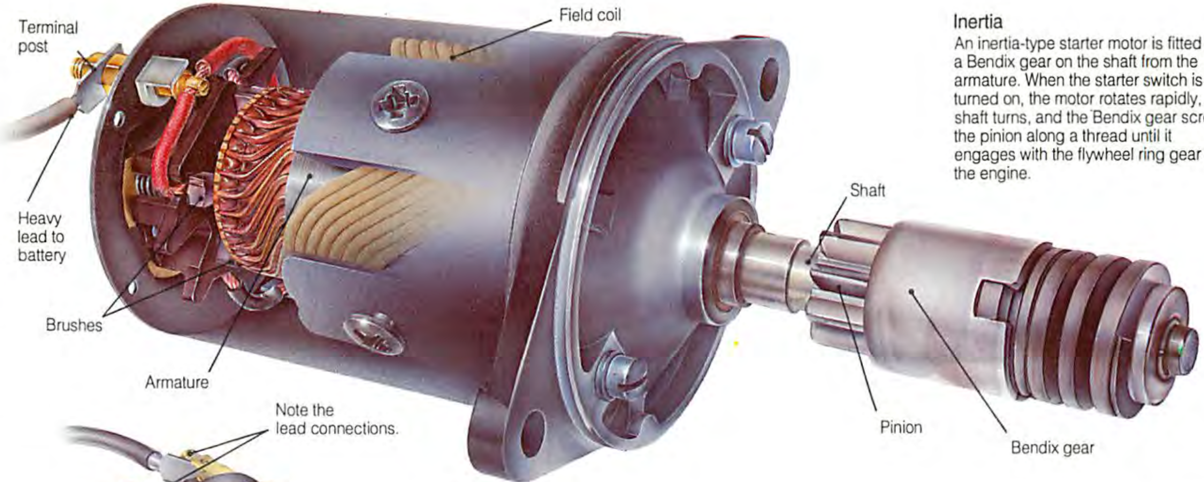
Lift out the motor, watching for any spacer shims. Collect them and make a note of their order so that you can refit them correctly.

Reverse the removal procedure to refit the motor.



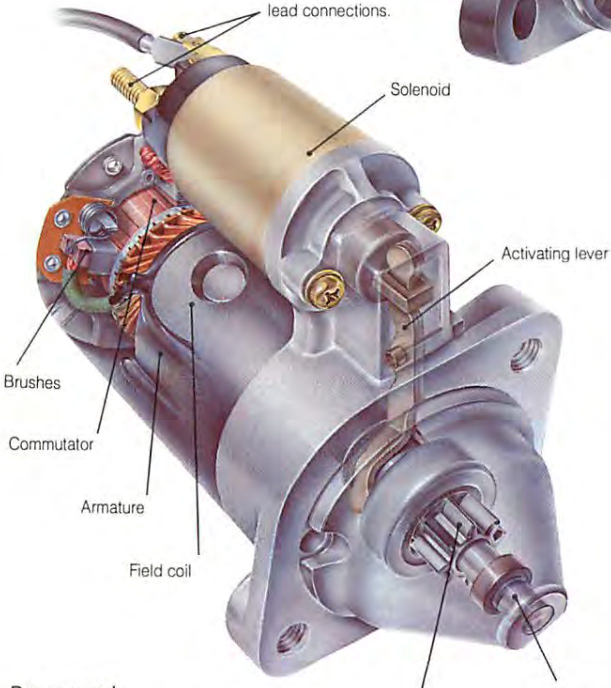
Hold the terminal-post nut with a spanner while you unscrew the outer nut securing the lead from the battery.


Unscrew the bolts that hold the starter to the engine backplate.



Inertia

An inertia-type starter motor is fitted with a Bendix gear on the shaft from the armature. When the starter switch is turned on, the motor rotates rapidly, the shaft turns, and the Bendix gear screws the pinion along a thread until it engages with the flywheel ring gear on the engine.



Pre-engaged

A pre-engaged type of starter motor incorporates a solenoid. When the starter switch is turned on, the solenoid activates a lever which first moves the pinion along the shaft to engage with the flywheel ring gear and only then operates the switch that starts the motor turning.

Testing for short circuits

Use a test lamp fitted with crocodile clips to make these tests. You will have to remove the endplates from the motor (SHEET 209).

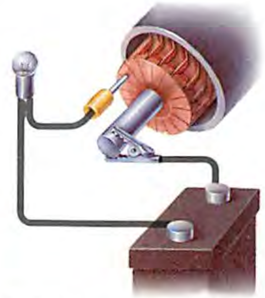
The field coils are insulated from the motor casing by wrappings. A break in the wrappings can cause a short circuit.

If the field-coil test below indicates a break, and the break is only a minor one, an auto-electrician may be able to repair it.

If the armature test below shows a short circuit, fit a new or exchange motor.

If there are little splashes of solder on the motor, or any other sign that it has overheated, fit a replacement motor.


To test the field coils, clip one test-lamp lead to the field-coil terminal and the other lead to one of the battery terminals. Connect a lead to the other battery terminal and touch its free end to the motor body. If the lamp lights, there is a short circuit.


To check the armature, connect a test lead between the shaft and a battery terminal. Connect a test lamp lead to the second battery terminal and touch its other end to each commutator segment. If the lamp lights, there is a short circuit.

Replacing the Bendix gear

The name 'Bendix gear' strictly applies to the spiral drive mechanism of an inertia-type starter. However, the term is sometimes used for the pre-engaged starter mechanism.

Drive-mechanism faults can occur in two ways. The starter can spin without engaging with the flywheel, or jam in engagement.

In an inertia starter, dirt in the spiral Bendix thread is the usual reason for it not engaging.

Remove the starter (SHEET 207) and clean the gear thoroughly with petrol and a paintbrush. Let it dry completely: petrol fumes can explode. Test the gear by sliding the pinion along the shaft. It should slide easily and return under the spring pressure.

Do not oil the gear: that would attract more dirt. Refit the starter and your problem may be solved.

If a pre-engaged starter does not engage, or if either type instead of spinning emits a dull 'clunk', showing that it is jammed, there may be more serious trouble and you may have to strip the starter (SHEET 209).

Sometimes a starter turns the engine and then jams in engagement, producing a loud howl as the engine starts. Switch off at once and remove the starter for examination.

The exposed Bendix gear of an inertia starter is easy to check without dismantling the motor. But a pre-engaged starter has to be stripped completely.

With either type of starter, if you find no fault, it may be the flywheel that is damaged. There may be marks on the flywheel and corresponding ones on the pinion teeth.

You can often check the flywheel teeth by removing the starter motor and viewing them through the aperture while a helper turns the engine.

Tools and equipment

COMPRESSOR TOOL • SCREWDRIVER • CARBORUNDUM STONE • VICE • SPANNERS • HAMMER • DRIFT • FEELER GAUGE

Replacing the Bendix on a pre-engaged starter

Strip the motor (SHEET 209) and examine the drive mechanism for any damaged parts. If necessary, remove the drive pinion and clutch assembly.

These are replaced as a single unit, so do not dismantle further.

Remove the actuating lever if possible (it may not be removable). Grip the armature firmly, but not too hard, in a vice to remove the thrust collar. Use wood in the jaws of the vice to avoid damaging the armature.

The collar is located by a jump ring – a spring circlet – which engages in a groove on the shaft and another groove inside the collar.

Some collars are removed by using a length of pipe as a drift. Place it against the collar and give it a sharp tap to jolt it down the shaft and off the jump ring.

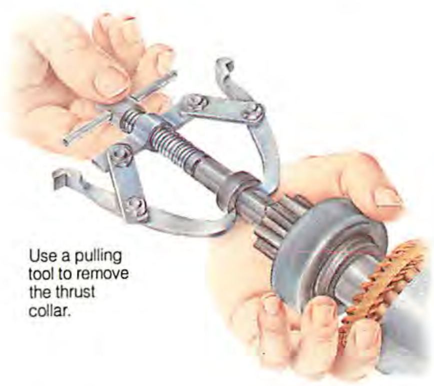
Remove the ring with a screwdriver and slide the collar off the shaft.

Other collars are pulled off the jump ring with a pulling tool.

Look at each side of the collar to tell which type it is: push or pull it away from the side on which the jump ring is just visible.

The entire pinion-and-clutch assembly can now be lifted off. There may also be a clutch stop bracket fitted over the shaft. Remember to replace this when reassembling.

Reassemble by sliding on the pinion-and-clutch assembly, the thrust collar and the jump ring. Use a small puller to draw the thrust collar back up over the jump ring. If it is one of the alternative types of collar, use a drift to tap it back on. Test that it is on far enough by measuring the armature end float – movement lengthways. The maximum allowable end float is $\frac{1}{8}$ in. (3 mm).



Use a pulling tool to remove the thrust collar.

Drifting it off

Tap this type of collar down with a piece of piping used as a drift.

Remove the jump ring with a screwdriver.

Testing pinion mesh clearance

Reassemble the motor (SHEET 209) fully, but leave the electrical connection between the solenoid and motor open.

Use test leads to connect the negative (−) battery terminal (if negative earth) to the starter body and the positive (+) one to the small connector on the solenoid which links it to the ignition switch.

The solenoid should click into its engaged position.

Insert a feeler gauge between the pinion and its bearing on the far side of the motor. The gap should be 0·010 in. (0·25 mm) unless another figure is quoted by the maker.

With certain screw-type pivot pins (SHEET 207) it may be possible to adjust the gap by loosening the locknut and turning the pin. However, in most cases no adjustment is possible.

Adjusting the gap

Loosen the locknut and turn the pivot pin with a screwdriver.

Use a feeler gauge to check the gap between pinion and bearing

Changing the Bendix on an inertia starter

The Bendix gear is usually held on by a circlip recessed into the end of the buffer spring. To free it, compress the spring with a compressor tool (SHEET 51) available from most accessory shops.

Do not use a vice instead: it can be dangerous if the spring slips.

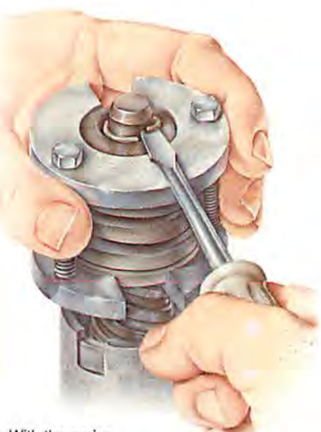
However, you can adapt an ordinary valve-spring compressor by adding a short piece of tube with a gap cut out of the side, and topped by a steel plate.

Screw the tube down on the spring to compress it, then hook out the circlip through the gap with a small screwdriver. With the clip removed, slowly unscrew the compressor and pull the parts of the drive off the shaft.

One or more parts may need replacing. You may be able to replace any part separately, or you may have to buy an entire drive assembly, depending on make. Consult an auto-electrician.

If you are fitting a new spiral Bendix spindle, feel along the splines and threads for burrs. Remove these carefully with a small, fine carborundum stone. Do not oil the parts when reassembling. Use the compressor to replace the circlip.

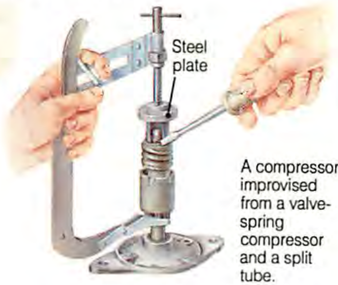
A purpose-made Bendix spring compressor can be used to free the circlip.



With the spring compressed, lever out the circlip.

Improvising a compressor

A short length of tube split lengthways to make a gap.



A compressor improvised from a valve-spring compressor and a split tube.

Stripping the starter motor

Remove the starter motor from the car (SHEET 207) and the brushes from the motor (SHEET 211).

The body of a motor with a cover band is held together by two long bolts, usually with slot heads.

A motor without a cover band usually has four short bolts at each end – but sometimes the commutator end is secured by a circular, toothed spring clip on the shaft, with perhaps two other bolts.

The spring clip is not reusable, so make sure you have a replacement: not all dealers stock them.

Wash all the parts in methylated spirit. Alternatively, wash them in petrol, but make sure they are thoroughly dry before reassembling the motor. A spark can ignite petrol vapour and cause an explosion.

When you reassemble the motor, check or re-check the insulation of the field coils (SHEET 205).

Make sure that the throughbolts do not touch the field-coil connections.

Do not forget to hold any type of terminal post to keep it from turning when you replace the nuts.

Tools and equipment

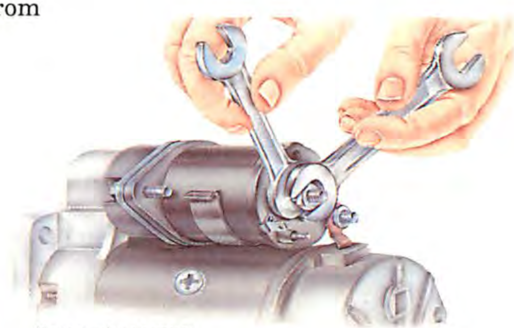
OPEN-ENDED AND RING SPANNERS • SCREWDRIVER • PLIERS • SCRIBER • LIGHT OIL • METHYLATED SPIRIT • CLEAN RAG

Removing the solenoid from a pre-engaged starter

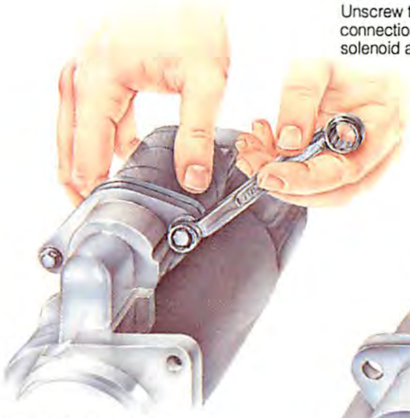
Take the nuts off the connection between solenoid and motor, using an open-ended spanner to stop the terminals from turning.

Remove the nuts or screws holding the solenoid to the motor body, and pull or unhook the solenoid free.

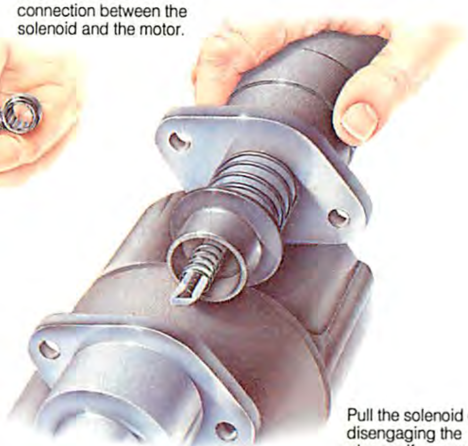
Before refitting the solenoid, smear a little light oil on the plunger.



Unscrew the electrical connection between the solenoid and the motor.



Remove the nuts or bolts holding the solenoid to the motor end.



Pull the solenoid off, disengaging the plunger if necessary.

Stripping a pre-engaged starter

With the solenoid off, remove the actuating fork.

The whole fork pivots on a pin, which may be a force fit. If so, drive it out with a punch.

Or the pivot pin may itself be secured by a split pin. Straighten and pull out the split pin and push the pivot pin out from the other end.

Finally, the pivot pin may be screwed in. Some screw pins have an eccentric shoulder to adjust the travel of the pinion.

Scratch the head to mark its position so that you can refit it in the same place. Then release the locknut and unscrew the pin.

The fork may be plastic or metal. In some cases the two prongs of the fork may be fastened to the large actuating plate by rivets, and should not be removed.

If a fork of that type is damaged and must be replaced, it can be slid off the armature shaft as the Bendix assembly is removed (SHEET 208).

If the commutator end is held on by a circular spring clip, lever the clip off with a screwdriver. This calls for force and patience. Take care not to damage the shaft.

Remove all the bolts holding the endplates to the body of the motor. Take off the endplates. Pull out the armature.

The pivot pin may be a force fit – if so, drive it out with a punch and hammer.

Other pivot pins

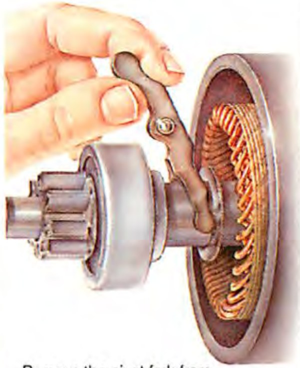
This type of pivot pin has a bolt head and is unscrewed with a small spanner.

A screw-in pivot which also adjusts the travel of the pinion by means of an eccentric. The slot-headed adjuster is secured in place by a locknut.

Remove the screws holding the endplate to the body.

Spring-clip fixing

Prise off the spring clip, if fitted, with a screwdriver.



Remove the pivot fork from the Bendix gear.

Dismantling an inertia starter

Remove all the bolts holding the endplates to the motor body. Take off the commutator endplate.

Pull out the brushes from their housings to free the plate.

Note which brush of each pair has a long and a short lead, so that you can refit them correctly.

Pull out the armature and pinion endplate. You cannot take the plate off the shaft without removing the Bendix gear (SHEET 208).

Unscrew the two slot-headed bolts in the endplate.

Undo the small bolts on the commutator endplate and remove the terminal post.

Replacing starter or dynamo bearings

Starter-motor bearings are usually bushes made of graphite-bronze. A few starters – especially heavy-duty types – have ball bearings at the pinion end.

With the starter motor removed from the car, but before you dismantle it, check whether the bearings are worn. Grip the pinion and push the shaft sideways, if possible at both ends. It should not move.

It may move a little lengthways – called 'end float'. The maximum allowable end float is ⅛ in. (3 mm).

Make sure that you can get replacement bearings before you take on the job of replacing worn ones. They should be available from an auto-electrical store.

Some Lucas starters have a riveted cover over the bush at the commutator end. You have to punch or drill the rivets out. Buy new rivets (some kits of replacement parts include nuts and bolts instead).

Dismantle the motor (SHEET 209) and take off the endplates to remove the bearings. Remove the brush assembly from the commutator.

Dynamo bearings

These are exactly like starter-motor bearings, usually with a ball bearing at the pulley end. Use these instructions for removing and replacing both dynamo and starter-motor bearings.

Always repolarise a replacement dynamo or one that you have been working on before fitting it. Do it with the dynamo bolted in place, but before connecting it up. Connect a spare length of cable to the 'live' battery terminal, then connect the other end for just about two seconds to the F (field) terminal on the dynamo. Afterwards connect up the dynamo in the normal way and test.

Tools and equipment

VICE • HAMMER • SOFT-FACED HAMMER • SMALL CHISEL • ROD OR TUBING • PLIERS • CIRCLIP PLIERS • SCREWDRIVER • PUNCH • NEW BEARING/BUSH • RIVETS

Taking out the bushes

Always force out bushes inwards. Some bushes have collars and can move only one way. The new bush must be pressed in from the inner side of the endplate.

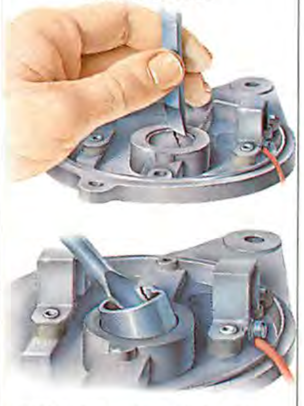
The most straightforward way to remove a bush is to stand the endplate, inner side down, across a vice with the jaws open just wide enough for the bush to pass through. Tap it out with a hammer, using a rod or a socket spanner as a drift.

If the bush will not budge, cut into one side of it with a small chisel, and split it down its length. But take care not to damage the soft alloy housing.

Another way is to screw a suitably sized thread-cutting tap into the inner side of the bush until it takes a firm grip, then pull tap and bush out together.

Tap out the bush with a drift and hammer.

Use a chisel



Split the bush with a chisel and lever it out with a screwdriver.

Fitting new bushes

The new bush should be a tight fit in the housing. Soak it for 24 hours in oil before pressing it in.

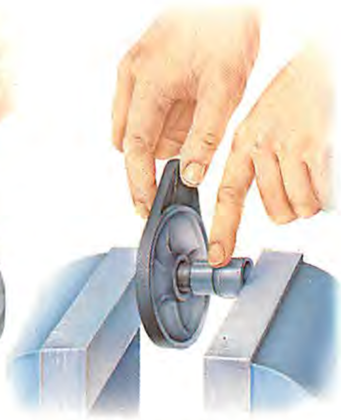
The bush should be a loose fit on the armature shaft, but with no perceptible play; and the shaft itself must be unworn and free from grooves and gouges.

The easiest way to fit the bush is to press it home in a vice. For this you also need some sort of tool, the same diameter as the bush, to bear against the end of it while pressing – a socket spanner or a piece of rod or tubing of the correct size will serve.

Line up the bush absolutely square with the housing before pressing it in. An out-of-line bush will distort, even if you can push it fully home. Take care, too, that the end against which you are pressing is not damaged or distorted.

Another way to fit the bush is to tap it gently in, again using a socket spanner of the same size to protect the end.

Select a socket the same diameter as the bush.



Press the new bush in with a vice, making sure it is aligned in the housing.

Tap it in

The bush may also be tapped in, using a socket as a drift. Be sure to keep it straight.

Ways to remove bearings

To remove the front plate bearing, first take the armature out of the starter. (In a dynamo, also remove the pulley and its retaining key.)

The inner race of the bearing is a tight but sliding fit on the armature shaft.

To free it, hold the front plate in one hand and gently tap out the shaft with a soft-faced hammer (to avoid damaging the end and threads).

Another way is to grip the front plate in a vice, or support it on blocks to tap the armature shaft from its bearing.

Either way, take care not to let the armature fall as it comes out of the front plate.

There are several ways in which the bearing is retained in the front plate. Usually, however, it is held by an internal circlip or by a small riveted-on retainer plate.

If the bearing is held in by a circlip, remove the clip with circlip pliers, or by easing it out with a screwdriver.

Take out any spacers or felt washers there may be underneath it – but note the order in which they were fitted and put them back the same way later. You may need to renew a felt washer.

Use a punch or a drill to take the rivets out of a retaining plate. Again, there may be washers which must be replaced in the correct order.

Take out the wire circlip with a small screwdriver.

Tap the bearing out, using a socket as a drift.

Drill out

Punch or drill rivets out of the retaining plate. Take care to keep the drill vertical.

Replacing bearings

Put back the spacers and felt washer if they were fitted, and replace the circlip or retaining plate. Splay out the rivets properly when replacing a retaining plate, so that it is secured firmly to the plate.

With the bearing fitted, tap the assembly back on to the armature shaft, using a length of tubing that just fits over the shaft to drive the bearing home.

Checking and replacing starter-motor brushes / 1

Both inertia and pre-engaged starters can have one of two types of commutator.

It may be a cylindrical commutator, like that on a dynamo, with the brushes bearing on the side face.

Or it may be a face-type commutator, which has a flat disc at its outer end, with the brushes bearing against the disc.

The brushes, made of a copper and carbon alloy, are in housings on the endplate of the starter. There are usually four brushes; occasionally two.

Most starter motors have to be removed and partly dismantled (SHEET 209) to inspect or replace brushes. However, some have a removable band which lets you check at least two of the brushes with the motor in place.

On a few, you can replace brushes with the motor in place, through a hole in the side of the endplate.

On all inertia starters with face-type commutators, brushes can be replaced without removing the armature/commutator. On a pre-engaged starter, the built-in solenoid is removed (SHEET 209).

Unless you have a service manual which gives a figure for the maximum allowable brush wear, assume that there must be at least $\frac{5}{16}$ in. (8 mm) of brush beyond the brush lead.

Always check that new brushes slide smoothly in their guides. If they stick, remove raised spots with a fine file.

Clean the commutator with methylated spirit. Let it dry fully before reassembling. Petrol is not recommended – a spark could ignite petrol vapour and cause an explosion.

If the commutator stays discoloured, clean it with very fine glasspaper. If the surface is badly worn, buy a new or exchange starter.

Tools and equipment

SCREWDRIVER • FINE GLASSPAPER • WOOD BLOCK • SPANNERS • WIRE-CUTTING PLIERS • GAS SOLDERING-IRON • SOLDER • PARTS • BRUSH KIT

Removing the covering band to make checks

Some starter motors have a removable band which covers inspection 'windows' in the sides of the motor.

You can loosen the band and slide it off to inspect the brushes through the windows.

With this type you do not need to remove the motor.

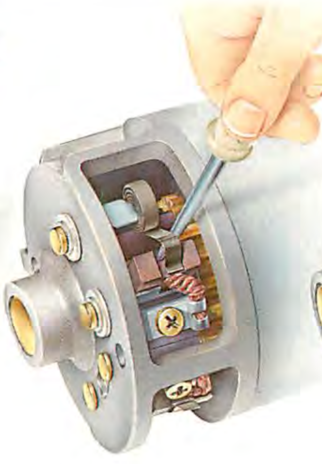
Slide off the band and ask a helper to work the starter while you look through the windows.

Pronounced arcing – continuous sparking – shows that either the brushes or the commutator are worn. But always inspect a brush for wear.

In some cases, the brush leads are attached by screws, which can be removed.

The whole brush assembly can then be withdrawn and the brushes changed with the starter in place.

Loosen the screw and slide the band aside.



Hook off the spring and lift out the brush.

Remove the screw to release the lead.

Replacing brushes

Measure the length of each brush from the face to the near end of the lead.

There must be at least $\frac{5}{16}$ in. (8 mm) of brush beyond the lead.

To refit a brush, prise up the spring and slide the brush under it. Make sure it is the right way up. Screw down the lead firmly.

Measure the length of the brush from its contact face to the start of the lead.

Removing the endplate

On a motor which does not have inspection windows, you can check the brushes and clean the commutator, but replacing the brush set is a job for an auto-electrician.

The leads are insulated in a way which makes soldering on a new brush impossible.

To reach the brush assembly, remove the two long, slot-headed bolts which hold the motor together.

Take off the endplate and pull out the armature to check the commutator.

Release the brush assembly from inside the endplate by removing two screws.

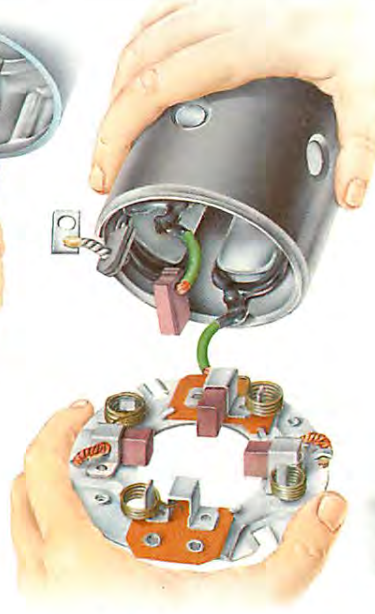
Lift each brush out of its guide for measuring by pulling the coiled spring off the top of the brush and pulling up the brush.

Put the brush partway back into its guide and wedge the spring against its side, so that the spring does not push the brush fully in.

That allows the commutator to be inserted between the brushes without damaging them during reassembly.

Unscrew and pull out the two long bolts to release the endplate; pull out the armature.

Undo two screws to release the brush assembly.

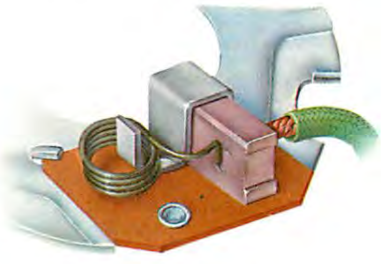


Pull out the brush assembly.

Refitting

Make sure that all the brushes are wedged halfway in their guides by means of their coiled springs – otherwise you cannot push the commutator back into place.

Screw the brush assembly to the endplate, and put the commutator between the brushes. Release the springs so that they push the brushes down into contact with the commutator. Put the endplate back on to the motor, and reattach it by the two long slot-headed bolts.



Wedge the brush spring against the side of the brush.

Checking and replacing starter-motor brushes / 2

On face-type commutator starters there are two ways of fastening on the endplate, under which the brush assembly is housed.

The endplate may be bolted on, but sometimes it has a circular, toothed spring clip, normally hidden under a rubber cover. The clip is difficult to lever off and is not reusable.

Not all dealers stock replacements; so be sure to have a new clip ready if you remove it.

Each brush lead of a pair is of a different length. Note which brush fits where before you take them out. Both designs have two of the four brush leads fixed to their field coil mountings by a pressure aluminium weld.

You can neither break nor renew this joint. Instead, cut the lead off near the brush, leaving a short tag. Solder the new lead on to this tag.

If you use abrasive paper to clean a cylindrical commutator, wrap it round and apply pressure evenly to avoid making the drum oval.

For cleaning a face-type commutator, wrap the abrasive paper round a block of wood so that the face is kept perfectly flat.

The metal of face-type commutator segments is very thin, so take care – even moderate wear or pitting calls for replacement.

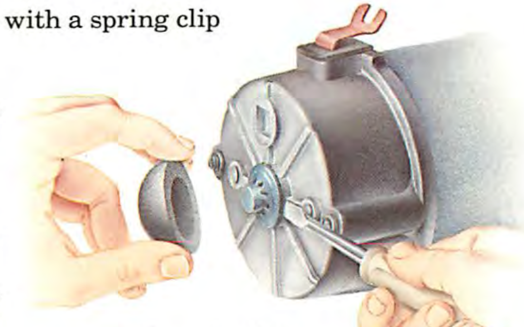
Removing an endplate with a spring clip

Lever off the spring clip with a screwdriver, taking care not to damage the end of the shaft.

The clip is usually circular, with a toothed or serrated edge, and may be hidden under a rubber cover. Discard the clip.

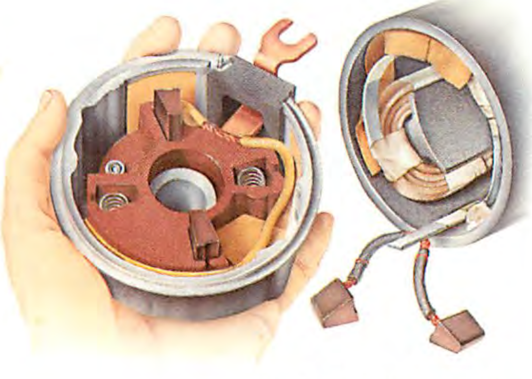
Remove the two long, slot-headed bolts which hold the motor together. Lift off the end to expose the brush assembly and commutator.

When reassembling, tap a new clip home with a piece of pipe or suitably sized socket and a hammer. Make sure the clip is fully home before refitting the rubber cap.



Remove the rubber cover and lever off the clip.

Remove the two long bolts to release the endplate.



Note which of the brushes has the longer lead before you take them out.

Removing a bolted endplate

Before unbolting the pinion endplate from an inertia type of starter, loosen the nuts on the two large, protruding, brush-retaining bolts.

The pinion, endplate and armature can then be pulled straight out of the motor housing as a single assembly.

Take care not to damage the armature or commutator faces as you withdraw it.

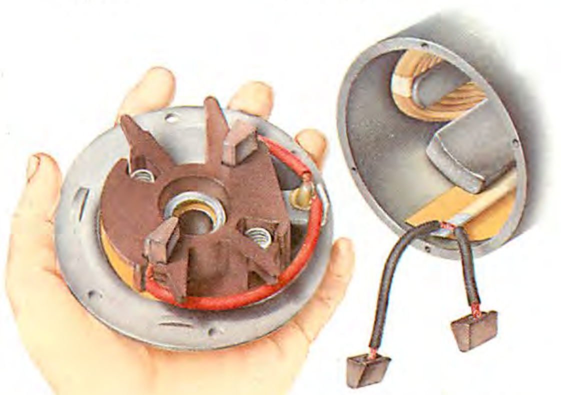
The brushes on this type of starter often have convex faces bearing against the commutator. Make sure the new brushes are fitted the right way round before you reassemble the starter.

First remove two screws from the pinion-gear end of the motor.

Pull out the pinion endplate and armature together.

At the other end, unscrew the nut that holds the terminal post.

Remove the four smaller bolts to free the endplate.



With the endplate removed, note which brush has the longer lead before you take them out.

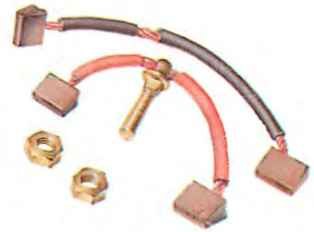
Replacing brushes

Two of the brushes come already fixed to a terminal post, so are easily replaced.

The others are welded. Cut the leads off short at the brush end, leaving a ⅜in. (10 mm) tag.

File each tag to expose plenty of bright metal. Coat it with solder, using a gas soldering-iron – a small electrical one is not powerful enough. Coat also the ends of the new leads.

Solder the new leads in place, ensuring that the joints are solid, neat and flat.



The four brushes

Cut the old lead off short, leaving a tag.

Solder the new lead to the tag.

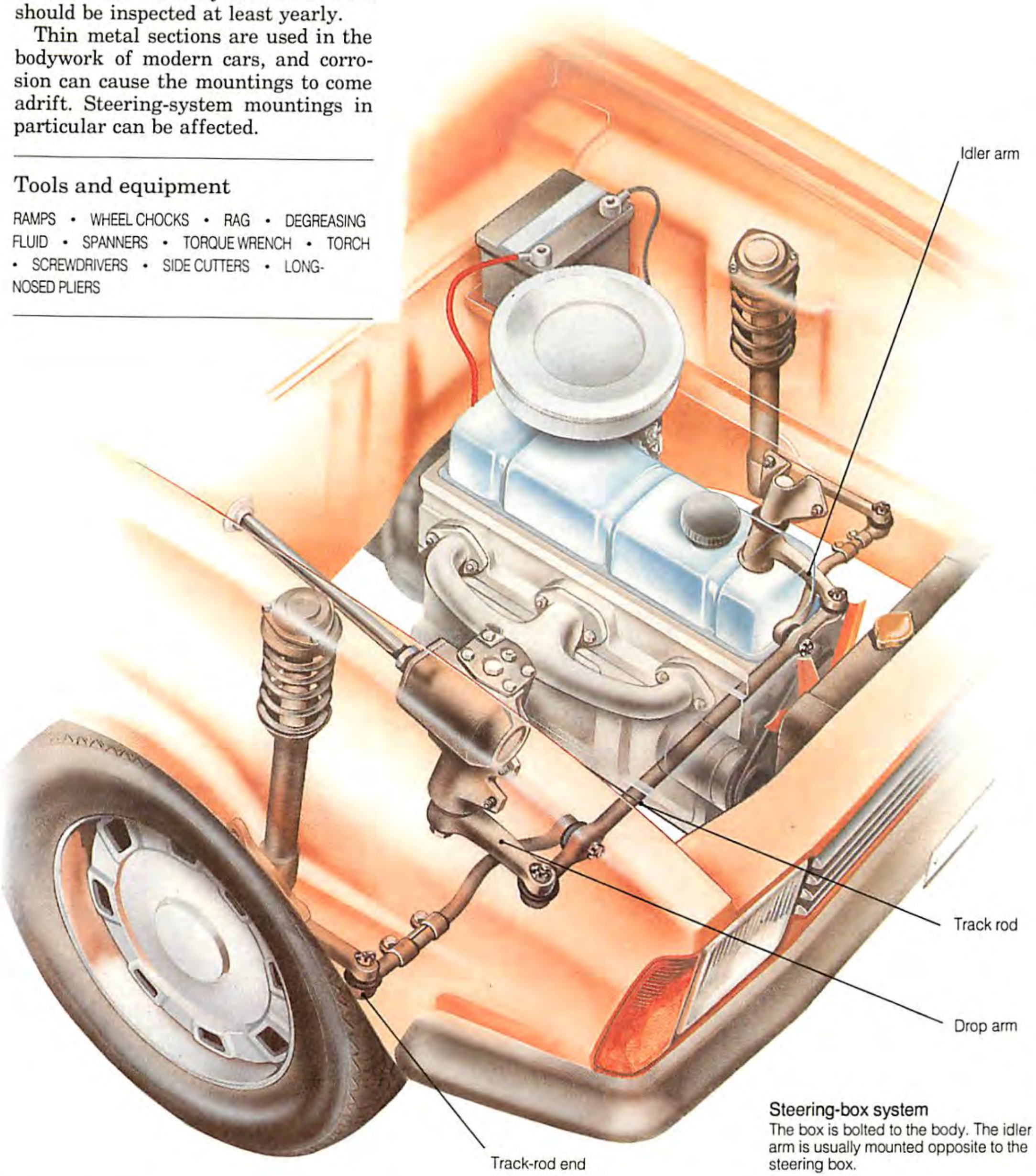
Checking steering-box mountings

Places where vital components are mounted on the bodywork or chassis should be inspected at least yearly.

Thin metal sections are used in the bodywork of modern cars, and corrosion can cause the mountings to come adrift. Steering-system mountings in particular can be affected.

Tools and equipment

RAMPS • WHEEL CHOCKS • RAG • DEGREASING FLUID • SPANNERS • TORQUE WRENCH • TORCH • SCREWDRIVERS • SIDE CUTTERS • LONG-NOSED PLIERS



Steering-box system
The box is bolted to the body. The idler arm is usually mounted opposite to the steering box.

Testing the mountings for security

The steering-box system usually has the box mounted in the engine bay, bolted to the side of the bodywork or to the front cross member.

To inspect a mounting of this type properly, drive the car up on ramps. Make sure that the handbrake is on and the rear wheels chocked.

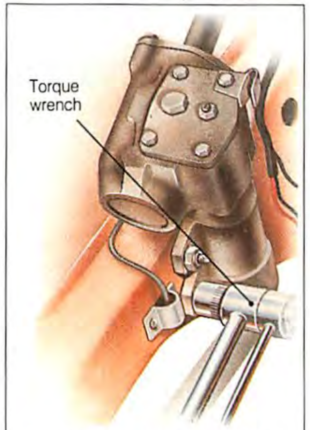
Do not prop the car up on jacks or axle stands, as the weight must rest on the wheels. Open the bonnet if that helps you to see the mountings better.

Wipe all dirt and grease from the steering-box mounting bolts, mounting lugs or clamps and the surrounding body or chassis metalwork. Use an engine-cleaning fluid if necessary.

Ask a helper to turn the steering wheel while you look at the mountings from both above and below for any movement. The weight of the car on the wheels provides enough loading on the system for any movement to be seen.

If there is movement, check that all the mounting bolts are in place, and fitted with their nuts and washers in the same order as when they were fitted originally.

See whether the nuts are tight



Use a torque wrench to check and tighten the steering-box mounting bolts. If they are loose, renew the lock washer or self-locking nut.

by trying them with a spanner.

If they are loose, use a torque wrench to tighten them to the correct loading. The loading figure may be given in the car handbook; otherwise consult a service manual or ask your local dealer. If a lock washer or self-locking nut is fitted, it must always be renewed when retightening mounting bolts.

Now examine the mounting lugs on the steering box itself for cracks or breaks. Use a torch if any parts are in shadow. If there are any cracked or broken lugs, buy a new or reconditioned unit.

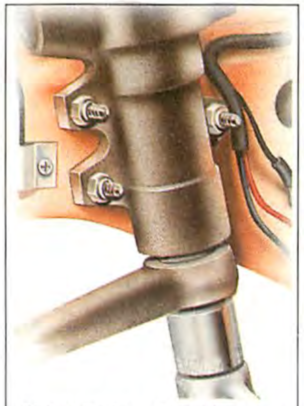
Next, check the metalwork to which the steering box is bolted:

Check the metal around the steering box for rust by probing with a screwdriver.

look for heavy rusting and cracks. Probe it with a screwdriver and look for buckling or other signs of weakness as your helper turns the steering wheel.

Any weakness is serious and requires immediate attention. Reinforcing sections of metal – or even new chassis side members – must be welded in, a job for a garage or a professional welder.

Finally, check that the drop arm is fixed securely to the splined sector shaft protruding from the base of the steering box.



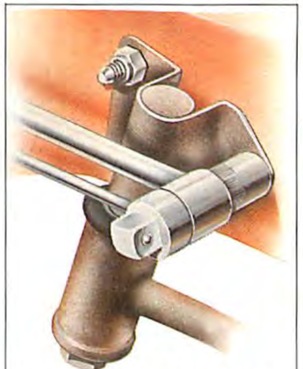
Tighten the drop-arm retaining nut to the recommended loading with a torque wrench .

It may be held by a castellated nut locked by a split pin on the end of the shaft, or by a clamp bolt on the end of the steering arm.

See that it is not loose and that the split pin or any other locking device is in good condition.

If necessary, tighten the retaining nut to its recommended loading with a torque wrench.

The idler arm is usually bolted to the front cross member. Check its mounting bolts and securing nut in the same way as those on the steering box.



Tighten the idler-arm mounting bolt with a torque wrench.

Checking steering-rack security

Most modern cars have rack-and-pinion steering gear, mounted across the car. Usually the rack housing is fixed to the front cross member or bulkhead.

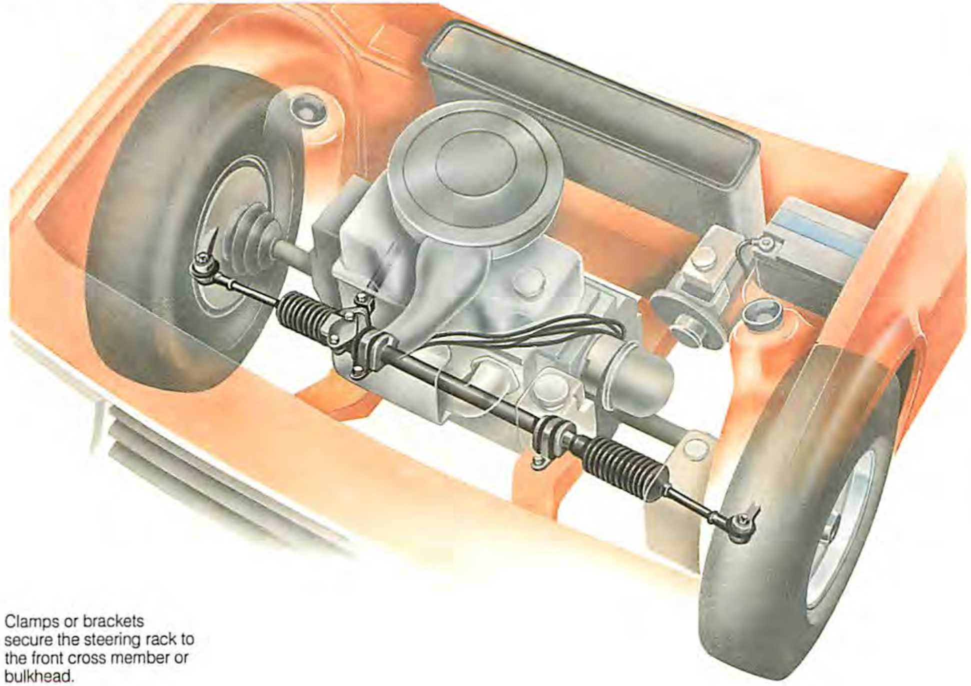
The rack is held by clamps with rubber bushes, and any looseness here will allow the rack housing to move from side to side when the steering wheel is turned.

Depending on how the rack is situated, you may have to inspect the mountings from above and below. Drive the front wheels of the car up on ramps, apply the handbrake and chock the rear wheels.

Do not prop the car up on bricks or similar unsteady supports, as the weight must rest on the wheels. Open the bonnet if it aids visibility and use a torch or inspection lamp.

Tools and equipment

RAMPS • WHEEL CHOCKS • SPANNERS • RAG • CLEANING FLUID • TORQUE WRENCH • LARGE SCREWDRIVER OR TYRE LEVER • SOFT-FACED HAMMER • INSPECTION LAMP OR TORCH



Clamps or brackets secure the steering rack to the front cross member or bulkhead.

Inspecting the mountings

Usually the rack is secured to the cross member by two U-bolts or clamps, under which there are rubber or – sometimes – plastic inserts.

Some cars have rack-and-pinion assemblies with the central part of the rack moving two long track rods from side to side. The mounting brackets for these are at the ends of the rack housing.

Wipe the rack mountings and the area around them clean of dirt and grease so that you can inspect them closely. Use engine-cleaning fluid if necessary.

Ask a helper to turn the steering wheel while you watch the steering-rack mountings carefully for movement. The weight of the car on the front wheels provides enough loading on the system for any movement to show up.

If there is movement, check that the U-bolt or mounting-bracket securing nuts are in place and fully tightened.

Examine the metalwork to which the steering rack is bolted. Check whether the mounting is loose.

Test each one with a spanner or socket spanner.

Use a torque wrench to tighten any loose nuts to the correct loading. This torque-setting figure is obtainable from a suitable manual or your local dealer.

If all the nuts and bolts are in place and tight, examine the rubber inserts under the U-bolts or clamps.

Have your helper turn the steering wheel again and watch the inserts carefully for signs of movement within the clamp.

Check them for general looseness, and perishing or other signs of deterioration. Replace them if they are in poor condition.

Check the mounting brackets, U-bolts or clamps for signs of twisting, cracks or breaks. Any damaged ones should be replaced immediately.

Usually they can be renewed, or possibly repaired professionally by welding. They are seldom integral with the steering rack, so it is unlikely you will have to replace the whole rack assembly.

If the mountings are sound, check the metalwork of the front cross member or that part of the chassis or bodywork to which the rack assembly is secured.

Examine the metal closely for heavy rust or other damage that could weaken it enough to allow the assembly to move.

Any weakness found in the metal must be dealt with immediately by welding in a new metal plate, or even replacing the affected part of the body or chassis. Such work is best left to a garage or a professional welder.

Test the rubber insert for deterioration.

Replacing rubber inserts

The rubber inserts under rack-mounting brackets can usually be replaced without removing the rack assembly.

The rubber is split so that you can push the new insert over the rack housing to avoid having to slide it over the end. That in turn means you can tackle one mounting at a time.

Remove the clamp and use a large screwdriver to lever up the rack enough to enable the insert to be removed.

Working first on one bracket, then the other, unscrew the retaining bolts (and washers if fitted) and remove the bracket.

Use a tyre lever or a large screwdriver to lever up the rack so that you can pull out the old rubber insert.

Tap the bracket to locate it

Push the new rubber insert on over the rack, making sure you align it in exactly the same position as the old one.

Some inserts have a locating peg moulded into them which goes into a hole in the mounting.

Replace the bracket over the new rubber and tap it with a soft-faced hammer to ensure proper seating.

Tighten up the bracket bolts to the recommended loading with a torque wrench. Replace the other rubber in the same way.

Lift the rack with a screwdriver and push the new rubber over the rack.

Tap home the bracket to seat it properly, and replace the nut and bolt.

Lubricating the steering system / 1

Most modern cars have 'sealed for life' joints in at least part of the steering system. These do not need maintenance, and are simply replaced when worn or damaged.

But even new cars may have grease nipples and/or oil-filler holes in various parts of the system.

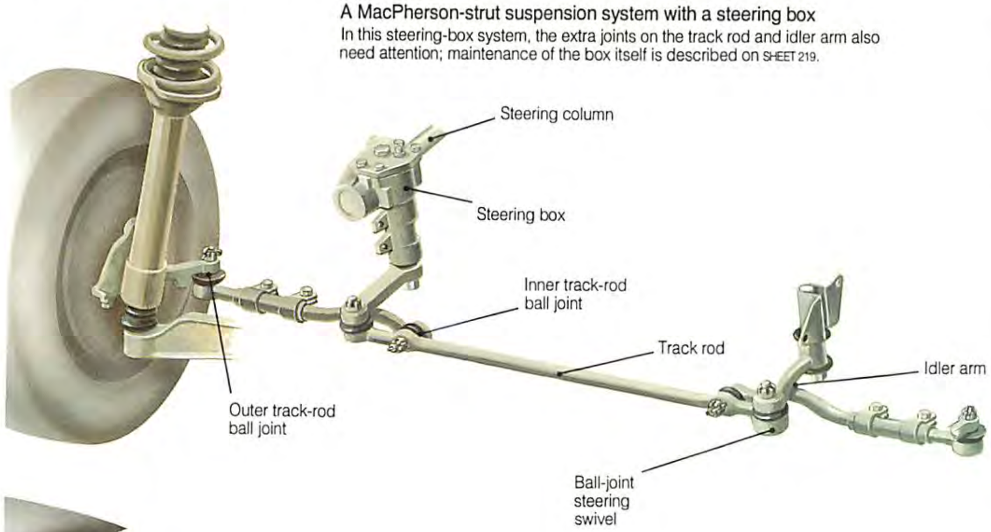
Their position depends on the steering system – rack and pinion or steering box – and the front suspension type – wishbone or MacPherson strut.

The car handbook will tell you where to lubricate and how often – usually every 6,000 miles or 10,000 km – and the type and amount of lubricant to use. (For power-steering systems see SHEET 230.)

Raise the front of the car with the wheels hanging free. Support it on axle stands set under frame members. Apply the handbrake firmly and chock the rear wheels. Put rear-wheel-drive cars in gear ('park' for automatics).

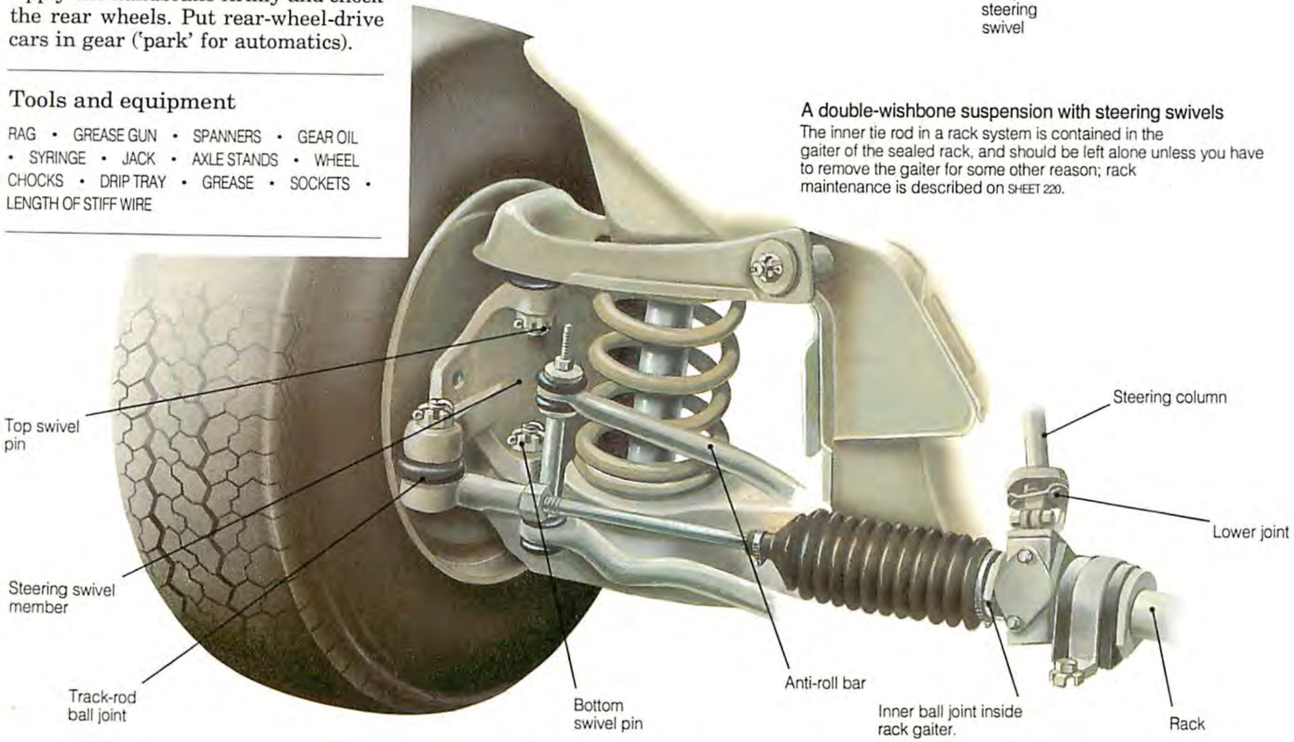
Tools and equipment

RAG • GREASE GUN • SPANNERS • GEAR OIL • SYRINGE • JACK • AXLE STANDS • WHEEL CHOCKS • DRIP TRAY • GREASE • SOCKETS • LENGTH OF STIFF WIRE



A MacPherson-strut suspension system with a steering box

In this steering-box system, the extra joints on the track rod and idler arm also need attention; maintenance of the box itself is described on SHEET 219.



A double-wishbone suspension with steering swivels

The inner tie rod in a rack system is contained in the gaiter of the sealed rack, and should be left alone unless you have to remove the gaiter for some other reason; rack maintenance is described on SHEET 220.

Steering swivel joints

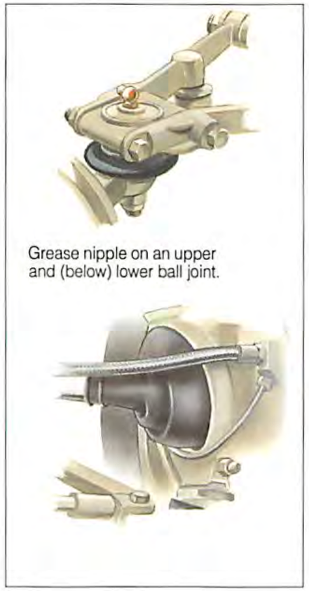
Either or both of the upper and lower swivels may have grease nipples; ball joints have them on the housing.

Wipe the nipples clean and see if there is still grease in the orifice. If not, the joint has become dry, so take extra care to grease it thoroughly.

Get a helper to move the steering wheel slowly from lock to lock while you inject grease with a grease gun. This will help circulate the lubricant. Do not swing the steering violently on rack-and-pinion systems when the wheels are off the ground. The sudden pressure surge inside the rack housing may damage the rack gaiters.

See that the gun is filled with grease of the correct grade, and inject each nipple until fresh grease exudes from the joint. Wipe the nipple clean. Do not over-grease a ball joint; the rubber seal round the top of the joint can easily be forced out by excess pressure from a grease gun.

Be sure to grease all the nipples.



Grease nipple on an upper and (below) lower ball joint.

Inject grease while steering is slowly turned.

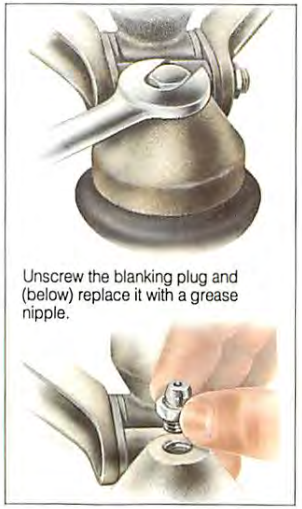
Removable nipples

Some cars, such as Triumph, Datsun and Toyota, have blanking plugs instead of nipples.

Clean the area around the plug thoroughly with a wire brush and absorbent rag before removing it.

Screw in a nipple, making sure that it goes fully home, otherwise grease may exude back along the threads.

Inject grease with a high-pressure grease gun, then remove the nipple and replace the blanking plug.



Unscrew the blanking plug and (below) replace it with a grease nipple.

Lubricating the steering system / 2

Greasing track-rod ball joints

Track-rod ball joints are usually sealed for life. If they do have grease nipples, the nipples are usually on the flat top of the ball-joint housing.

Grease them when carrying out major services, or at the intervals recommended in the car handbook, which will also tell you the correct grade of grease to use.

Wipe each nipple clean and inject it with a grease gun until fresh grease exudes from the joint. Wipe the nipple clean.

Be sure to grease all the nipples – steering-box systems may have four, or even six.


A ball joint with a grease nipple fitted underneath.

Renault

Some Renaults have replaceable rubber dust seals on their track-rod ball joints.

When these dust seals are dislodged or replaced, repack both the seal and the joint with the grade of grease recommended by the car manufacturers in the car handbook.


Replaceable dust seal.

Lubricating a rack and pinion

The rack is filled with oil or grease, but does not usually need regular maintenance. It needs re-lubrication if you remove or replace a rack gaiter, or if there has been a leak past a loose or damaged gaiter clip (SHEETS 224–225).

If you do need to re-lubricate, consult the car handbook to see whether oil or grease is used, which kind, and how much.

If it is oil, drain the rack and use a syringe (SHEET 53) to refill it. Check how much the syringe holds, to ensure the right oil level.

Raise the car on an axle stand on one side only, so that the rack is tilted. Clean carefully around the gaiter and set a drip tray under the lower end of the rack.

Release the clip at the inner end of the lower gaiter. Pull the gaiter free of the rack housing and let all the oil drain out.

Smear a little grease or gear oil inside the gaiter to make it easier to push on. Refit the gaiter and tighten the clip. Replace a wire clip with a screw clip. Unclip and free the inner end of the other, upper gaiter.

Use a syringe to inject the correct amount of gear oil of the right grade. If you do not have a syringe, use an old cycle pump or an oil can. Refit the gaiter and clip.

If it is inconvenient to tilt the car, you can empty the rack on the level by undoing one gaiter at the inner end and slowly moving the steering wheel from lock to lock several times – not quickly, for that might burst the other gaiter.

Refasten the gaiter, then unclip its outer, small end. Note how far it reaches along the track rod: its exact placing is important.

Push the syringe in between the gaiter and track rod to inject the oil. Refasten the clip.

Grease cannot be removed; but when replacing a gaiter you should wipe grease off the inner track-rod ball joint to inspect the joint.

Smear the joint and all visible parts of the rack mechanism generously with grease before putting back the gaiter.

Use the grade of grease that is recommended in the handbook for the car.


Support one end of the front-suspension cross member on an axle stand; place a container under the rack at the other end.


Free one end of the gaiter by unscrewing the clip.

Using an oil can


If you do not have a syringe, an oil can will do the job, but more slowly.

Draining a rack


Unfasten the inner end of the lower gaiter and pull it clear of the rack to drain.


Refill from a syringe at the upper end of the rack. An old cycle pump can be used if you do not have a syringe.

Topping up a steering box

The steering box is filled with oil, and does not usually need regular topping up. However, you should check the level whenever you are doing routine maintenance on the steering, in case there is a leak from an oil seal (SHEET 219).

A combined level and filler plug is usually set in the top of the box.

Do not confuse it with the adjusting screw or bolt, or the cover retaining bolts which are also on top of the box.

Find out from the car handbook or a service manual where the oil level should be in relation to the filler hole.

If the filler hole is in the side of the box, the correct level is usually right up to the bottom of the hole when the car is standing on a level surface.

Clean carefully around the filler plug, then unscrew it. Inspect the oil level. If necessary, use a short rod as a dipstick.

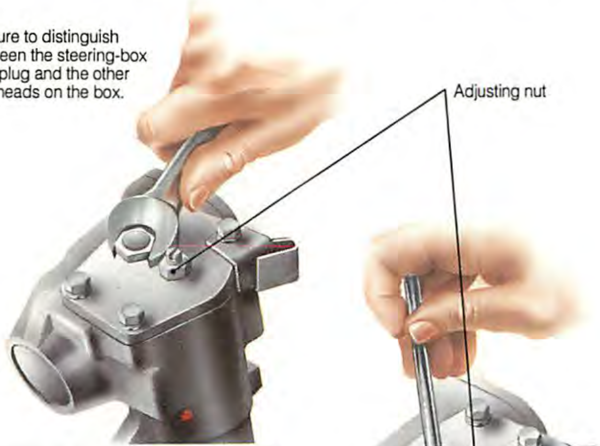
Refill to the correct level with gear oil of the grade recommended in the car handbook.

A side filler hole may need to be filled from a plastic squeeze bottle with a piece of plastic tube attached.

Squeeze in the oil until it begins to overflow. Wait until the overflow stops, wipe away the excess and replace the filler plug.

If there has been a leak, top up the box and take the car to a garage as soon as possible for repair.

Be sure to distinguish between the steering-box filler plug and the other bolt heads on the box.



Plastic filler plugs


On some cars the steering box has a plastic filler cap. After topping up, ensure that the cap is pressed home.


Test the oil level with a dipstick unless there is a clear mark in the box.

Checking steering swivel pins

Steering swivel pins may wear out after a high mileage (60,000 plus), or sooner if they have not been properly lubricated. A badly worn joint is dangerous – not only does it make the steering wander, but it may suddenly fail altogether.

Worn joints need special equipment to replace and the work should be done by a garage, but you can check them yourself. You need a helper and a long flat, steel bar such as a large tyre lever.

Make sure the car is on level ground, put the handbrake on firmly, and the car in first gear if it is a rear-wheel-drive model. Put a car with automatic transmission in 'P' or 'park'. Chock both rear wheels, then jack up the car to raise one front wheel, and put an axle stand under a chassis member, so that the other front wheel remains firmly on the ground.

Never work under a car when it is supported only by a jack. Always use axle stands placed under a strong chassis member.

First inspect any rubber dust seals or covers on the swivels for signs of perishing, cracks or splits. If you find any, almost certainly dirt or grit will have entered the joints, they will be damaged and they must be replaced.

Some cars have rubber or nylon bushes inside various joints in the top, bottom or both swivel pins. So far as these are visible, check them for perishing, cracking or softening caused by oil.

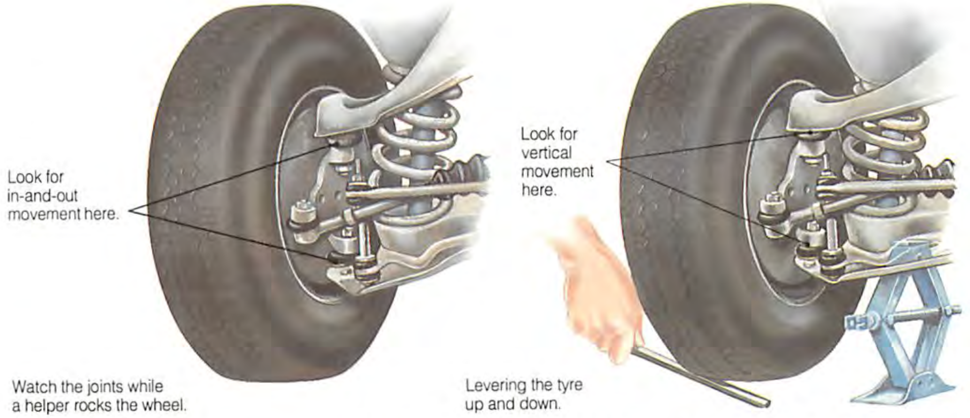
If they are not visible, excessive wear or damage will show up anyway in the routine test. Here, too, any damage calls for replacement.

A MacPherson-strut suspension has its top swivel bearing inside the strut. Inspect it when you check strut mountings (SHEETS 231–232). The bottom bearing can be checked, however.

Tools and equipment

LONG FLAT, STEEL BAR • JACK • AXLE STAND • WHEEL CHOCKS

What to look for in wishbone suspension



Watch the joints while a helper rocks the wheel.

Levering the tyre up and down.

Place yourself where you can see clearly the top and bottom swivel pins and the steering swivel member that joins them on the suspension that has been raised. Ask your helper to grasp the wheel firmly at top and bottom, and rock it by pushing with alternate hands – use a fair amount of force. The wheel should move a little, because of free play at the hub bearing (SHEET 267).

This play makes the brake disc or drum move relative to its backplate, and is easy to see. Watch the top and bottom swivels and steering swivel member. If the joints are worn, you can see the swivel member move in and out in relation to the top or bottom suspension arms.

To test for vertical play, put a screw or hydraulic jack under the lower suspension arm, and raise it until the suspension is compressed.

Again, watch from where you can see both top and bottom joints. Get your helper to put a strong lever or bar under the tyre and move it up and down while you watch for movement at either joint.

Some ball joints have spring-loaded pins which allow a small amount of vertical play, generally no more than $\frac{1}{16}$ in. (1·5 mm). Anything greater means a worn joint.

If the maximum permissible play is not in the car handbook, consult your nearest agency. If the pins are not spring-loaded, any visible play means that they are worn and must be replaced.

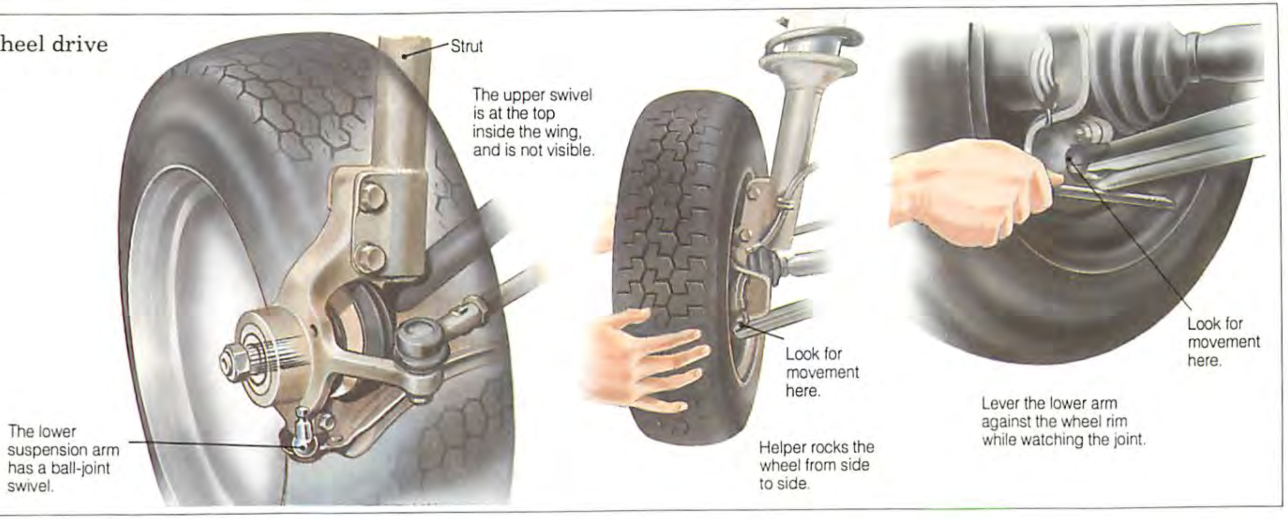
MacPherson strut and front-wheel drive

Only the lower swivel joint can be checked for play. With the front of the car raised so that the wheel hangs free, ask your helper to hold the wheel back and front and rock it from side to side.

If the joint moves at all, vertically or horizontally, it is defective and must be replaced. The steering may deflect a little during this test; take care not to confuse this with play at the joint.

Check for vertical movement also by resting a lever against the inner wheel rim and pushing upwards against the joint. Again, there should be no play.

MacPherson-strut front suspension can be found on both front-wheel and rear-wheel-drive cars. Here it is on a front-wheel drive.



Helper rocks the wheel from side to side.

Lever the lower arm against the wheel rim while watching the joint.

Checking steering joints for wear

The joints in a steering system all wear gradually and become slack. Because there are so many of them, and also because of the geometry of the system, a very small amount of play or looseness in the joints makes the whole system markedly sloppy and inaccurate.

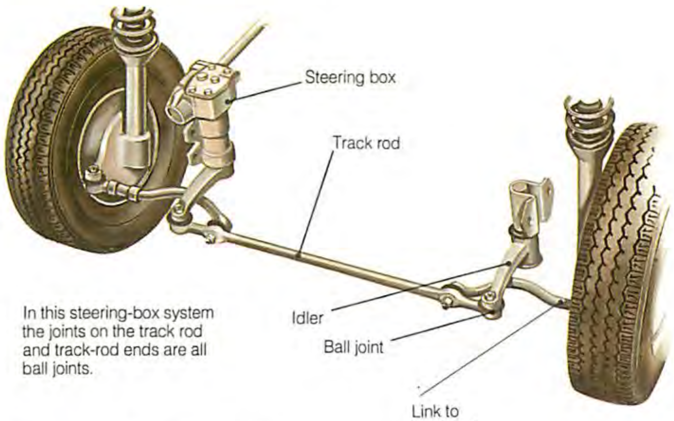
At first this may only be annoying; soon it may become unsafe. Wear is so gradual that a driver may not notice until it is quite severe. A check for wear every six months, 6,000 miles or 10,000 km may also show up other potentially dangerous faults. Other parts of the steering system may also become slack or loose and should be checked too (SHEETS 213-214 AND 217).

Whenever you raise the car and get under it, do not rely on a jack. Support the car on proper axle stands at the jacking points or, when the car has to have its weight on its wheels, with the front wheels on ramps. Apply the handbrake firmly, chock the rear wheels on both sides and put rear-wheel-drive cars in gear ('park' for automatics).

Tools and equipment

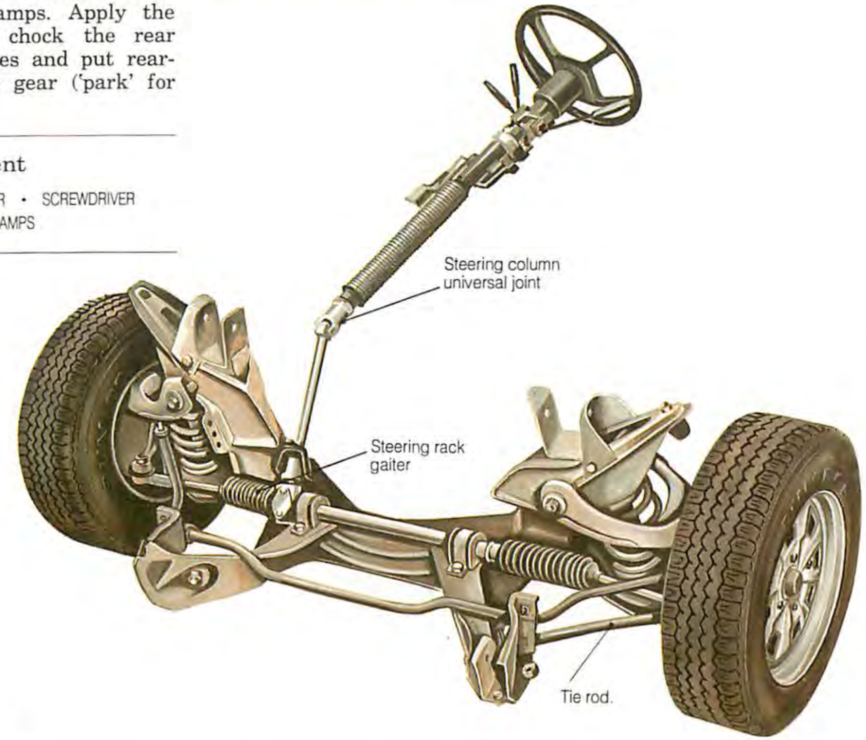
AXLE STANDS • STRONG BAR • SCREWDRIVER • SPANNERS • RAG • RAMPS

Steering-box system



In this steering-box system the joints on the track rod and track-rod ends are all ball joints.

Steering-rack system



On a rack-and-pinion steering system there are joints at the rack ends and track-rod ends.

Steering-column joints

There are often one or two universal joints in the steering-column shaft. These are sometimes hard to find. Look inside the engine compartment or under the dashboard. Be sure to cover the full length of the steering column.

The joints are generally Hooke-type, with two yokes bolted to a cross-shaped inner piece. Check that all bolts are tight, particularly those that hold the joint to the splined shaft. There should be no play when the joint is turned, or when it is pushed and pulled. With the car on all four wheels, ask a helper to turn the steering wheel to and fro slightly, while you feel the joint. (Warn him or her not to turn the steering wheel too far, or your fingers may be trapped.)

Some joints use a flexible disc made of layers of rubber or rubber bonded to fabric with metal inserts for the securing bolts. Pay particular attention to the state of the flexible part, for it deteriorates with age. Probe gently with a screwdriver to see if it is still sound. In case of doubt, replace the joint at once.

Probe rubber-bonded joints to test the bond.

Track-rod joints

Raise the car on axle stands. Use a rag to wipe dirt from the rubber seal on each joint. Check the seal. If it is split, cracked or perished, dust and grit will have entered the joint and damaged it. Replace the whole joint (SHEET 226).

Some Renaults have replaceable joint-seals. These seals should be replaced only if you are sure the joint has not been damaged or is not worn. Otherwise, the whole joint should be replaced. Take it apart (SHEETS 228 - 229) and examine it for wear. If all the rubber seals are sound, check for slack joints. Ask a helper to turn the steering wheel gently from side to side.

On cars with rack-and-pinion steering (SHEET 220), make sure the steering wheel is turned only very slowly, with the front wheels clear of the ground, supported by an axle stand at the nearest jacking point. Turning it rapidly can build up hydraulic pressure inside the steering-rack housing, and may cause one or both gaiters to burst.

Place a hand on each joint in turn. You should feel any slackness as the steering is reversed.

Check for vertical play by holding the track-rod-end and pushing it up and down. Any movement you can feel or see is a sign of wear. Rest a strong bar on the inner wheel rim, and lever the bar upwards against the track-rod-end. Again it should not move. Test a tie rod (if any) in the same way. Replace any worn or defective joint (SHEETS 226-229).

Another way of checking joints for play is to drive the front of the car

Push a track-rod end up and down, or use a lever.

up on ramps or over a pit and ask a helper to turn the steering wheel a short way to and fro. Watch each joint in turn: you should be able to see any play before the steering wheel actually moves the road wheels through the track rod.

On normal rack-and-pinion systems with the inner track-rod ends enclosed by rack gaiters, check these inner joints if they are suspect by disconnecting the outer joint (SHEET 220) and pushing the rod in and out. Any play reveals a defective joint, which should be replaced. This is usually a job for a garage.

Among the cars with a different

Push the track rod in and out.

rack arrangement are the Volkswagen Passat, late model 1303 'Beetles', Audi 80 and many Renaults. They have unenclosed bushed joints at the inner ends of the track rods.

Check the rubber bushes for wear, damage, perishing or softening caused by oil. See that the bolts are tight.

Check for play in the same way as with ball joints and, if there is any, replace the worn parts (SHEET 228).

The steering coupling on a Fiat 127 is inside the driver's foot-well.

Checking the steering box

A steering box check involves raising the front of the car but keeping its weight on the wheels, and getting underneath it while a helper turns the wheels a short way.

The safest way of doing this is to drive on to a set of ramps – unless you can get access to a proper inspection pit.

If you have to use ramps, be sure they rest on a level surface and are directly under the wheels.

Apply the handbrake firmly, chock the rear wheels and put a rear-wheel-drive car in gear ('park' for an automatic).

Check the steering box for leaks and wear whenever you inspect the rest of the steering system.

The box is filled with oil, so a leak can make the steering stiff. If you notice stiffness, check at once.

A low oil level in the box is a sure sign of a leak.

To trace a leak, first top up the oil (SHEET 216), clean the box with an engine degreaser, then drive a few miles. Now inspect the box for oil leaks.

Cleaning it may also reveal other damage, such as cracks, in which case the box should be replaced at a garage.

The box has an adjusting screw or packing shims inside. Their setting may be disturbed by tightening the cover retaining bolts. Stiffness may result; if so, have a garage readjust the box.

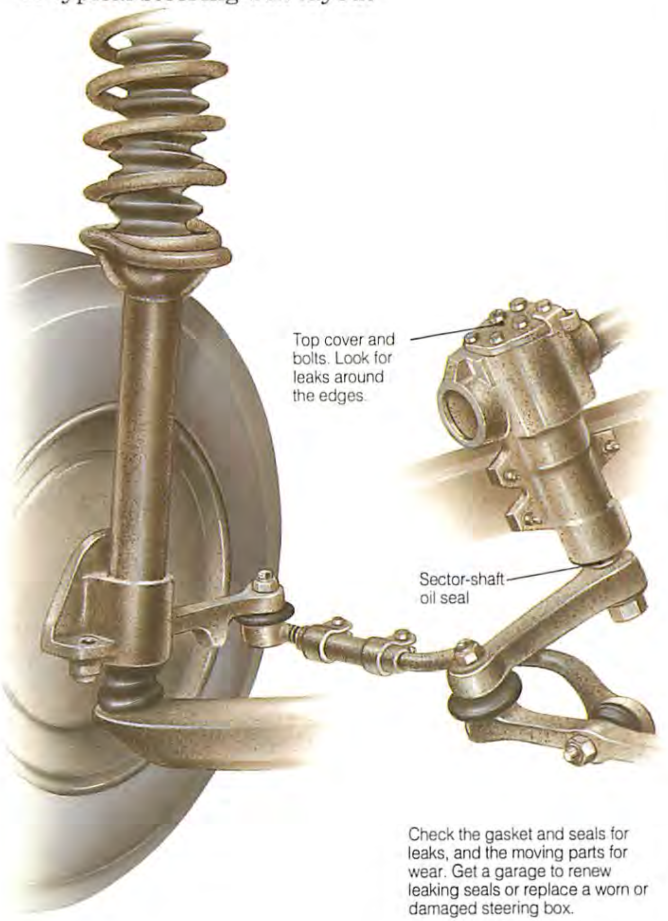
For the same reason, renewing the cover gasket, or any other oil seal, should also be left to a garage.

Wear in any part of the box is dangerous, and you should have it replaced at once. First check the mountings (SHEET 213), as movement there will be misleading when you come to check the box itself. Then inspect for wear in the box and for a loose drop arm or pinion shaft.

Tools and equipment

RAMPS • CHOCKS • GEAR OIL • CHALK • DEGREASER • RAGS • SPANNERS • SOCKETS

A typical steering-box layout



Check the gasket and seals for leaks, and the moving parts for wear. Get a garage to renew leaking seals or replace a worn or damaged steering box.

Where to look for leaks

Look at the edge of the top cover gasket to ensure that it is sound. Check that the retaining bolts are tight. Do not turn the adjusting screw by mistake – be sure you know which bolt heads are which, and where the oil-filler plug is. Leaks from around bolts that are not simply loose may indicate damage that calls for replacing the box.

The pinion shaft is connected to the steering column. An oil leak here will be apparent by oil running down the back of the box, and shows a damaged oil seal. Replacing it is a job for a garage because dismantling and readjusting the box is involved and requires special equipment.

Any oil leaking from the sector shaft may run down underneath the drop arm, which is attached to the shaft. Again, a garage should replace the faulty oil seal.

Checking for wear

There is always more play in a steering-box system than in a rack-and-pinion system.

Check for free play roughly by turning the steering wheel with the car stationary. You should not be able to turn it more than about 3 in. (75 mm), measured at the wheel rim, before the road wheels begin to turn.

Consult a service manual for your car or a local dealer for an exact figure.

If there does seem to be too much play, check the rest of the steering system, as well as the box (SHEETS 213, 217, 218).

To check the box itself, raise the front of the car on ramps, so that its weight remains on the front wheels. Apply the handbrake and put chocks behind the rear wheels. Set the front wheels pointing straight ahead.

Make a chalk mark on the rim of the steering wheel and ask a helper to sit in the car. Crawl under the front of the car so that you are in a position to watch movement of the steering drop arm.

Tell the helper to move the wheel slowly, and to stop when you call.

Call when you see the drop arm move, and ask your helper to measure how much the steering wheel has moved. If the steering wheel has moved more than the allowed distance, the box needs adjusting or replacing by a garage.

Measure steering-wheel travel by making a chalk mark on the rim and using your finger as a reference point.

Checking the pinion shaft and splined joint

Check that the pinion shaft is not loose. First push and pull it to see if the splined joint is loose in the steering shaft, then disconnect the joint.

Try to move the pinion shaft in and out and sideways. There should be no movement in either direction.

A loose splined joint can be fixed by tightening the pinch bolt on the steering column, but if the pinion shaft moves at all, take the car to a garage for repair.

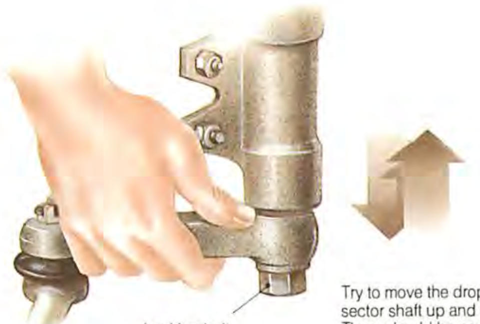
Try to move the pinion shaft in all directions.

Checking the drop arm and sector shaft

Try to move the sector shaft in the steering box up and down by pushing and pulling on the drop arm, to which it is connected. The shaft should not move.

If the drop arm moves on its sector shaft, either up and down or radially, it may just be that the locking bolt needs tightening.

Tighten the locking bolt and test for movement again. If the sector shaft moves too, take the car to a garage for a new steering box to be fitted.



Try to move the drop arm and sector shaft up and down. There should be no movement.

Checking the steering rack

Part of a steering rack check involves raising the front of the car but retaining its weight on its wheels. You must also get underneath the car while a helper turns the wheels to and fro.

Unless you can gain access to a proper inspection pit you may have to use wheel ramps. Make sure they are resting on a level surface and directly under the wheels.

Apply the handbrake firmly, chock behind the rear wheels and put a rear-wheel-drive car in gear ('park' for an automatic).

Take precautions also when the car is raised with its wheels off the ground. In that case use axle stands under frame members – do not work under a car raised on jacks.

The steering rack is filled with oil or grease which normally does not need renewing.

However, the rack can suffer from oil leaks, from grit getting in and damaging it, and from simple wear. Check it, together with the rest of the steering system (SHEETS 217–218).

If the steering feels stiff, it may be because the rack has lost much of its oil. Renew the oil (SHEET 215) and clean the whole rack and gaiters.

Drive the car a few miles. Note whether topping up with oil has temporarily cured the stiffness. If it has, look for oil runs around the rack.

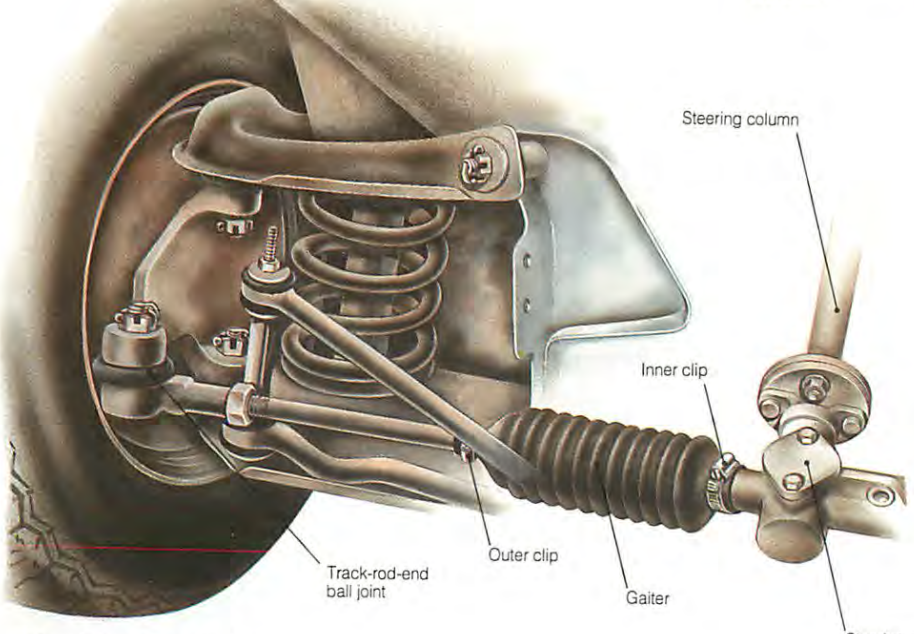
Cleaning the rack may also reveal other damage, such as cracks, in which case the rack should be replaced.

You can replace gaiters yourself (SHEET 224), provided that no grit has got into the rack and damaged it. Inspect the rack teeth when the steering is turned on full lock. Almost any other rack fault must be attended to by a garage.

Tools and equipment

RAMPS • WHEEL CHOCKS • AXLE STANDS • SPANNERS • CHALK • MIRROR • DEGREASER • SCREWDRIVER • STEERING-RACK OIL, IF NECESSARY • TORCH OR INSPECTION LAMP

Points to inspect when checking a steering-rack. There are also ball joints and gaiters on the other side of the car.



Checking for wear

There should be very little play in a steering-rack system. It should not be possible to move the rim of a 15 in. (380 mm) diameter steering wheel more than ½ in. (13 mm) without the front wheels moving.

If play seems to be greater than this, check all the other steering joints. Make sure that the rack is properly secured by testing its clamping bolts.

Check the rack itself by placing yourself where you can see one of the track rods.

This may involve getting under the car, which must, however, have its weight on the front wheels and the wheels pointing straight ahead. Drive it on to a pair of ramps.

Have a helper inside the car, and chalk a mark on the steering-wheel rim to show how far it moves.

Tell the helper to move the wheel very slowly, and to stop when you call out. Call when you see the track rod move.

If the wheel has moved more than the allowed distance, the rack needs adjustment or replacement – both are garage jobs.

Also check the steering-pinion bearing for wear by grasping the steering-column shaft and trying to move it in and out and across.

If the splined joint to the steering shaft moves, tighten the pinch bolt. If the pinion shaft itself moves, take the car to a garage for repair.

See that the gasket edge on the steering-pinion cover is not damaged and that the cover-retaining bolts are tight.

You can tighten the bolts yourself; but other work, such as renewing the gasket or the pinion-shaft oil seal, should be done by a garage.

Measuring movement

Measure steering-wheel travel by making a chalk mark on the rim and using your finger as a reference point to check the movement before the front wheels begin to move.

Tell the helper to move the wheel very slowly, and to stop when you call out. Call when you see the track rod move.

If there is more than ½ in. (13 mm) movement in the steering wheel, check for play at the steering rack and at the track-rod ends.

Inspecting gaiters

A leak may be caused by a loose clip, or by the gaiter being misplaced under a clip. The rubber itself may be damaged, so always check the whole gaiter thoroughly along its length.

Depending on the layout of your car, you may need to raise the car on axle stands or even remove the front wheels to inspect the gaiters. Use a small mirror and a torch or inspection lamp to help you to inspect parts that are awkward to see.

Do not turn the steering wheel rapidly when the car is not standing on its wheels. The resulting surge of pressure can burst the gaiters.

Clean the gaiters thoroughly (use a proprietary degreaser if necessary – not paraffin or petrol, which may damage the rubber). Any oily or greasy patch caked with dirt could mean a crack – so check thoroughly.

Make sure a gaiter is not twisted. Get a helper to turn the steering slowly so that you can see whether any are twisted.

Relieve any twist by loosening the inner gaiter clip, straightening the gaiter and refastening the clip. If it was a wire clip, replace it with a new screw clip.

Do not alter the placing of the outer end of the gaiter, which must be exact to prevent overstretching.

Examine the clips to make sure they are tight (but not so tight as to cut into the rubber). Make sure also that they are in the right place and not badly corroded. Rusty clips should be replaced.

Look over the whole gaiter carefully for cracking and chafing. Cracks are most likely at the crests and troughs of the ridges, and at the ends.

Squeeze the gaiter with your fingers. Then have a helper turn the steering slowly while you watch for cracks opening up.

Even the smallest crack may let grit in as well as letting oil out. As a temporary measure, tie a plastic bag firmly over the gaiter while it is extended.

As soon as possible, replace the gaiter and thoroughly inspect the inner track-rod ball joint (SHEET 218).

Squeeze the gaiter to reveal cracks.

Clips should be tight and in the right place.

You can make a temporary repair to a holed gaiter by tying a plastic bag over it.

Adjusting and replacing a power-steering drive belt

The belt that drives a power-steering hydraulic-fluid pump is usually at the front of the engine, turned by a pulley on the crankshaft.

It is generally separate from the belt that drives the water pump and alternator, but it may drive other components as well as the power-steering pump.

A slack belt tends to slip, wears fast and may even break; it also makes the steering feel jerky or heavy.

A slipping belt sometimes gives itself away by a loud screeching noise, particularly when you start the engine from cold. The tension of the belt can be adjusted to stop it slipping.

The pump is pivoted so that you can swing it in or out from the engine to adjust the belt tension. Moving the pump away from the engine increases the tension. As well as a pivot bolt there is an adjuster bolt that slides in a slot. Some cars also have a slotted-link adjuster.

Inspect the belt, along with the rest of the power-steering system (SHEET 230), at least every six months; at 6,000 miles or 10,000 km; at the intervals recommended in the car handbook; and, of course, at any time you suspect that it may be slipping.

On most cars you can inspect the belt by looking down inside the engine compartment. On a few, you may need to raise the front of the car on ramps and inspect from underneath.

Check for both wear and tension. If you find that the belt is loose, adjust it at once. If it is worn, replace it as soon as possible.

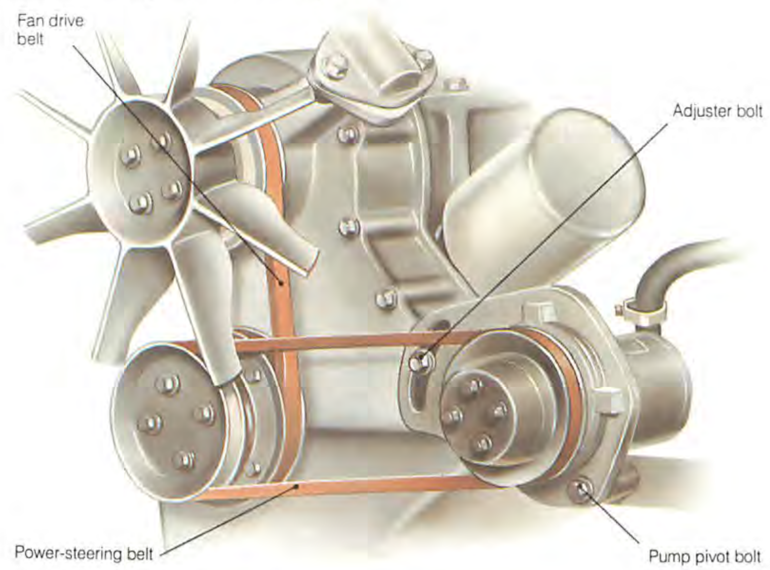
If you buy a new belt, compare it with the old one to make sure that it is the same size and an approved make.

After adjusting or replacing the belt, test drive the car on a quiet road to check the steering. A new belt will stretch slightly after about 100 miles or 150 km. Readjust it then.

Tools and equipment

STRAIGHT-EDGE • RULER OR TAPE MEASURE • SPANNERS • LONG SCREWDRIVER • WHEEL RAMPS OR JACK AND AXLE STANDS • WHEEL CHOCKS

Locating the power-steering belt



Checking and adjusting the tension

Make sure the pulleys at each end of the belt are in line. Lay a straight-edge between the pulleys; both should be parallel with it.

To check the tension, lay a straight-edge along the outer edge of the belt. If the belt goes round more than two pulleys, use the longest run of the belt.

Use your thumbs to push the belt inwards at its mid point, pushing quite hard.

Measure how far you can push the belt from the straight-edge; you may need a helper to do the measuring.

The car handbook should give the correct amount of deflection. If not, $\frac{3}{8}$ in. (10 mm) is about right. Compare your measurement with the deflection figure given in the handbook, and adjust the belt accordingly.

Slacken the adjuster bolt slightly. Then very slightly slacken the pivot bolt or bolts until the pump just starts to move.

If the belt was too tight, the pump will move inwards towards the engine as the bolts are slackened. To get the correct tension, pull it out slightly.

If the belt was too slack, increase the tension by levering the pump outwards with a strong screwdriver or flat bar.

Lever against the cast front end of the pump body, just behind the drive-belt pulley – not against any other part of the body or pipework, which are easily damaged.

Rest the other end of the lever against a sturdy part of the pump mounting bracket on the engine.

Check the belt tension while you hold the pump in position. Measure the deflection from a straight edge.

When the tension is correct tighten the adjuster bolt. Check the tension again before tightening the pivot bolt or bolts.

Re-check and readjust it as necessary until it is correct with the bolts fully tightened.

Pull the belt hard away from a straight-edge to measure deflection.

Slacken the adjuster bolt slightly, but do not remove it.

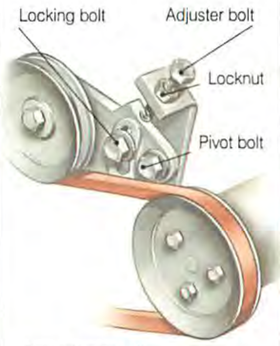
Slacken the pivot bolt or bolts slightly, but do not remove.

Slotted-link adjuster

On some cars, belt tension is varied by an adjuster bolt bearing on a slotted arm with a pulley at its end.

The arm swings on a pivot bolt, and has a locking bolt through the slot – loosen both bolts and free the adjuster bolt locknut. Turn the adjuster bolt to tension the belt, then tighten the pivot and locking bolts, checking belt tension at each stage.

Finally, tighten the adjuster bolt locknut.



Turn adjuster bolt until tension is correct.

Checking belt wear

Inspect every inch of the belt on both sides. Look for nicks, cuts, fraying, scores and cracks. Flex the belt to open up any cracks.

Check the lengths of the belt between the pulleys and mark them with chalk. To expose the rest of the belt for inspection, turn the engine slightly with a spanner on the crankshaft-pulley nut.

Keep your hair, tie or any loose clothing clear of the turning belt.

Inspect the belt on both sides for nicks, cuts, fraying and score marks.

Flex the belt to open up any cracks. Replace a worn belt as soon as possible.

Replacing a belt

Never try to lever off the old belt, you may damage the pulley.

Slacken the adjuster and pivot bolts, and push the pump inwards by the cast front plate until the belt is slack enough to ease off.

Do not push against any other part of the pump or pipework, or you may damage it.

Remove the old belt. If it is the outermost of several belts on the engine, removal is straightforward. If not, you may need to unfasten some other belt or belts (SHEETS 100–101) before you can remove it.

Fit the new belt, making sure that it is properly seated.

Pull the pump outwards and adjust the tension.

Refit and re-tension any other belts you may have had to unfasten.

Readjust the power-steering belt after about 100 miles (150 km) of driving.

Ease the belt onto the pulley.

Checking wheel alignment and adjusting toe setting / 1

Front wheels wrongly aligned cause uneven tyre wear and may seriously affect the car's handling.

Toe-in or toe-out – the amount by which the wheels are closer or further apart at their front edges than at their rear edges – is adjustable on all cars.

The setting can go wrong because of an incorrect adjustment, or through driving hard on to a kerb.

Camber – the angle at which a wheel leans in or out – is not normally adjustable. But if you find that it is different on the two sides of the car, something is wrong with the tyres, wheels or suspension. Check them (SHEETS 263 AND 231).

The amount of toe-in or toe-out is very small – typically 1/100 in. to $\frac{1}{16}$ in. (0·3 to 1·6 mm) – and must be set by a garage with special equipment. But you can make a rough adjustment by altering track-rod lengths (SHEET 223).

To roughly check toe setting, use a length of string, preferably, or new, unkinked electrical wire.

Camber, too, can be checked only approximately, because the sidewall of a modern radial-ply tyre always bulges outwards slightly in the area where the tyre contacts the ground. Most car wheels lean out at the top, so deviation from the vertical is measured at the bottom.

If you suspect from irregular tyre wear (SHEETS 263–266) that something is wrong, check both the toe settings and the camber to make sure the car is drivable.

Adjust the toe setting if necessary so that you can safely drive the car to a garage for expert attention.

Check the toe setting if you have dismantled and reassembled any part of the track or tie rods, and again have a garage re-check it.

Tools and equipment

STRING OR ELECTRICAL WIRE • RULE • CHALK • BUILDER'S SQUARE OR RIGHT-ANGLED CARD • SPANNERS • SELF-LOCKING WRENCH • SCREWDRIVER

Checking toe setting

Remove any heavy loads from the car. Inflate all tyres to the right pressures. Check the steering and suspension joints for wear (SHEETS 218 AND 232).

Make sure that the track rods are straight and the same length on both sides.

This does not apply to those VWs and Audis with one adjustable and one fixed track rod (SHEET 228).

Place the car on a flat, even surface – not a road, which is cambered – and centre the steering. Push the car forward a few yards, letting it stop without using the brakes.

Bounce it a few times to settle the suspension. After this, do not touch the steering wheel or get in the car.

Find measuring points on each front wheel. The car handbook usually gives the toe setting as measured between the inner wheel rims at their front and rear edges at the level of the hub.

There are, however, few cars on which you can stretch a string or wire straight between these points because the axle is in the way. Measuring between the edges of the tyre treads is not usually practicable because the tread often has no clear edge.

Therefore measure from one outer wheel rim to the other. A wire check cannot be truly accurate, so it does not matter too much that you are not measuring from the 'right' points.

All you can establish is whether the wheels have a slight toe-in or toe-out – not exactly how much the measurement is.

Stretch the wire round the tyres as close to the height of the hub centre as possible, and pull it taut at both front and rear.

Mark this level on the tyres with chalk and a ruler.

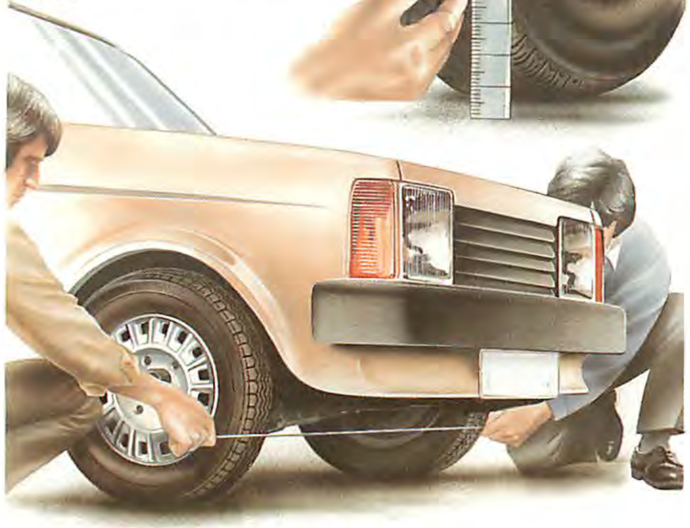
Mark the wire near one end, then get a helper to hold the mark on one measuring point and take the wire over to the other.

Pull it taut and mark the wire where it touches the second measuring point.

Repeat the process at the rear of the wheel, trying to keep the same tension on the wire. The distance between the first and second marks on the wire is double the toe-in or toe-out.

Double check by rolling the car forward so that the wheels make half a turn, bounce the car and repeat the whole test.

Mark a measuring level on each of the front tyres at the same height.



Make a rough toe-in check with a length of string or wire. This will establish if the wheels are toeing in or out, but not by how much.

Make the level as near to the height of the hub centre as possible.

Hold the wire at the measuring level and mark on it the distance between the outer rims at the front and then the rear of the wheels.

Camber check

Prepare the car in the same way as for the toe-in check.

The ideal measuring tool for a camber check is a builder's square, but anything with a perfect right-angle will do – such as a piece of hardboard.

Hardboard or card is best for wheels with protruding hubs, as you can cut a piece out to set the edge against the sidewall.

One side of the card should be as long as the full height of the wheel, the side at right-angles to it at least half that length.

Set the card against the wheel, upright and central, so that the long side touches the sidewall in two places and the other side is square to the ground. If necessary remove the hub cap or cut a piece out of the card.

There will be a gap between card and tyre, probably at the top. Measure the gap.

Repeat at the other wheel. The two measurements should be the same. Move the car forward so that the wheels make half a turn, bounce it and repeat the test.

The camber is not normally adjustable, so if the measurements are substantially different, the tyres, wheels or suspension may be distorted.

Distorted wheels or tyres should be replaced. To check the suspension, see SHEET 231.

Push the card against the tyre so that it touches the sidewalls at top and bottom and is square to the ground.

POSITIVE

If the wheels lean out at the top (positive camber), measure the gap at the bottom.

NEGATIVE

If the wheels lean in at the top (negative camber), measure the gap at the top.

Checking wheel alignment and adjusting toe setting / 2

Adjusting toe-in and toe-out

Toe-in and toe-out adjustments are made by screwing the track-rod ball-joint ends up or down the track rods to alter their length.

It is not possible to make totally accurate adjustments at home without proper wheel-aligning equipment. But the measurements obtained by the wire method already outlined should enable you to adjust the settings accurately enough to drive to a garage for expert attention. Few cars have a toe-in or toe-out of more than $\frac{1}{8}$ in. (3 mm), so try to adjust to within that measurement if possible.

It is not necessary to disconnect the track rods; the inner ends of the track rods turn freely on their ball joints at the ends of the rack as you turn the rods to adjust their outer ends.

Adjust both rods by equal amounts, except on VWs and Audis, which have only one adjustable rod to alter their steering. Even when the fixed rod has been replaced with an adjustable exchange part, the steering is still adjusted by altering a single rod.

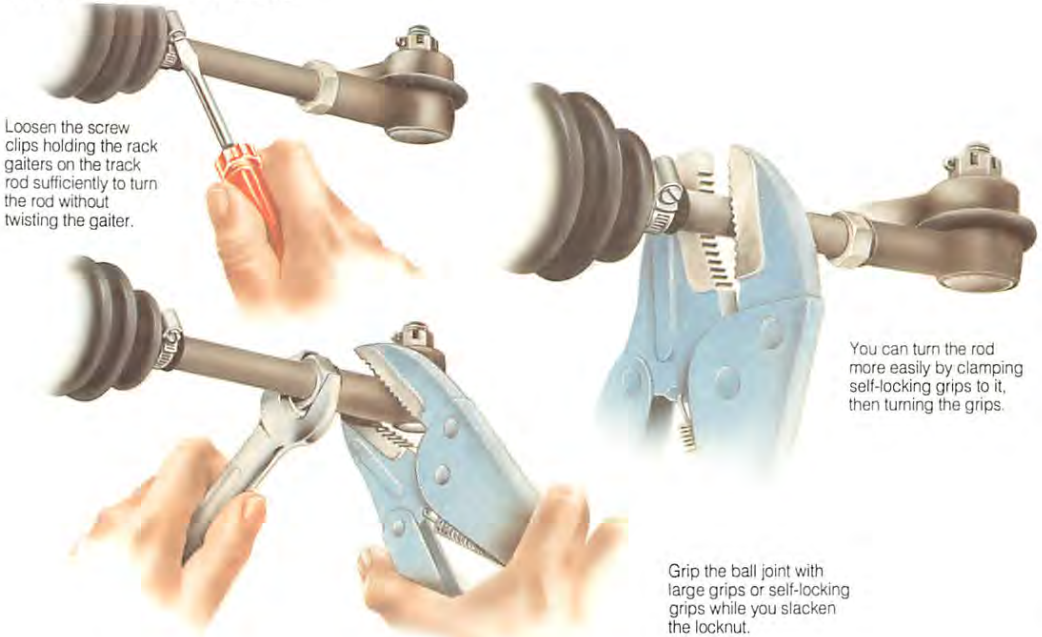
You may be able to adjust the track rods without raising the front of the car. This saves time and labour, since you have to check the toe setting each time you have to make a trial adjustment and this must be done with the wheels on the ground.

But on some cars you may have to remove the wheels to gain access to the ball-joint locknuts.

If you have to raise the car and work under it, use ramps (or axle stands if you have to remove the wheels) not jacks.

Apply the handbrake firmly, and chock behind the rear wheels.

Adjusting the track rod



Loosen the screw clips holding the rack gaiters on the track rod sufficiently to turn the rod without twisting the gaiter.

You can turn the rod more easily by clamping self-locking grips to it, then turning the grips.

Grip the ball joint with large grips or self-locking grips while you slacken the locknut.

Loosen the clips at the outer end of the rack gaiters on a rack-and-pinion steering. Make sure each gaiter can turn freely on the track rod, but do not push it up or down: its exact placing is important.

Hold one track-rod ball joint with self-locking grips to stop it from turning, which would damage it. Unscrew its locknut two or three turns.

One rod may have a left-hand thread: look carefully before unscrewing and compare with a standard bolt if you are not sure.

Standard bolts have a right-hand thread: turning a nut clockwise shortens the distance between the nut and bolt head; turning it anticlockwise lengthens the distance. A left-hand threaded bolt works in the opposite way.

Cars with steering-box systems have ball joints at both track-rod ends. Slacken both locknuts. One on each rod always has a left-hand thread.

Turn the track rod with self-locking grips to lengthen or shorten it. Some rods have flats which can be gripped by a spanner.

Which way you turn the rod depends on the thread. Check before you turn. Give both rods half a turn, then remeasure the toe setting. Readjust and retest until you are satisfied.

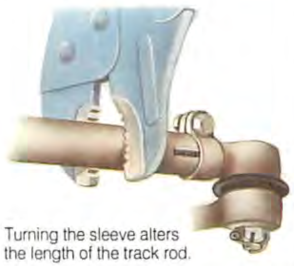
Some track rods have a short sleeve with a right-handed thread at one end, and a left-handed thread at the other. The sleeve connects the two halves of the rod. Turning the sleeve alters the length of the rod.

Ensure that the ball-joint stud is in the middle of its travel, so that the joint can move freely on the steering arm. Grip the joint and tighten the locknut.

Straighten the rack gaiters, taking care not to alter their position on the track rod, and tighten their clips. On steering-box systems, tighten the inner ball-joint locknuts.

Sleeve adjustment

Slacken off the clamp bolts on a track rod with sleeve-type adjustment.



Turning the sleeve alters the length of the track rod.

Adjusting a two-piece track rod

Many Renaults have two-piece track rods. The inner section screws directly into the rack end, and has a locknut outside or inside the rack gaiter.

If you find your car has an adjustable outer track rod, adjust this as normal, do not try to adjust the inner rod which in this case is fixed.

Separate the two halves of the rod by removing the bolt. Loosen the inner gaiter clip so that the whole gaiter can turn. Or push the gaiter off the edge of the locknut plate.

Slacken the locknut.

Screw both inner track rods in or out in exact half turns – the bushed eye on the end of the track rod must stay vertical.

Reconnect the outer track rods and test the toe-out, or toe-in, as outlined previously.

When satisfied, tighten the locknuts, then the gaiter clips. If these were wire, use new screw clips.

Separate the track-rod halves by removing the bolt through the fork and eye.

Loosen the gaiter clip, and peel back the gaiter, sufficient to give access to the locknut.

Slacken off the locknut.

Screw the inner rod in or out an equal number of half turns on each side. The bushed eyes must be vertical.

Replacing steering-rack gaiters / 1

If a check of the rack gaiters reveals that the rubber is starting to crack, split or perish, replace the gaiter.

A hole letting in water and dirt, or allowing lubricant to leak out, will cause rapid wear and will eventually ruin the rack – an expensive item.

Both gaiters should be renewed, even if only one is damaged.

You can do the job yourself on most cars fitted with rack-and-pinion steering, but not on some VW models such as the Passat, Golf, Scirocco, late model 1303 Beetle (others do not have racks) and Audi 80 and 100.

These have gaiters in the middle of the rack on each side of the pinion housing, and to replace them the whole assembly has to be stripped, refitted and reset by a garage.

The rack may be filled with either oil or grease. Check your car handbook for the correct grade of lubricant.

Tools and equipment

AXLE STANDS • SPANNERS • SCREWDRIVER • PLIERS • CONTAINER • STEEL RULE • RAG • GREASE • REPLACEMENT GAITERS AND CLIPS

Removing a Renault gaiter

Many Renaults have a two-piece track rod (SHEET 228).

To remove the gaiter, disconnect the outer rod from the inner one.

Slacken the large clip at the inner end of the gaiter, or cut a wire clip. Detach the inner end of the gaiter from the rack, which is always kept filled with grease.

Slacken off the large hexagonal locknut outside the outer end of the gaiter, just enough to allow you to unscrew the rod.

Unscrew the rod together with the gaiter, counting and noting the exact number of turns so that you can refit it in the same place.

Try not to disturb the position of the locknut, which will act as a guide for precise refitting.

Remove the gaiter from the rod – on most types there is no securing clip and the gaiter simply fits into a groove.

Loosen the gaiter clip.

Unbolt the inner and outer parts of the track rod.

Slacken the locknut to release the track rod.

Preparing to remove the gaiter

Loosen the front wheel nuts, jack up the front of the car and support it on axle stands. Apply the handbrake and chock both rear wheels. Put rear-wheel-drive cars in bottom gear ('park' for automatics).

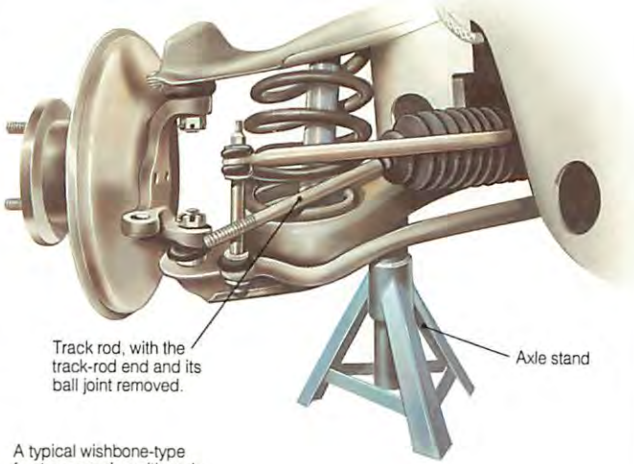
Remove the front wheels and unfasten the outer track-rod ball joints (SHEETS 226-227).

Use a rag to clean the rack and track rod at either end of the gaiter.

If the gaiter is held on with screw clips, note where and which way round the screws are, so that you can refit them in exactly the same way.

Also note the place on the track rod to which the outer end of the gaiter reaches. Sometimes this is marked by a groove – if not, measure its distance from some fixed point on the rod.

The gaiter must be fitted correctly or it will be overstretched by the rack movement.



A typical wishbone-type front suspension with rack-and-pinion steering.

Measuring the gaiter

Measure or mark the position of the end of the gaiter.

Removing a gaiter

Loosen clip or untwist or cut off wire clips, and throw them away. Replace with worm-drive screw clips.

Special clip

Some gaiters have a special wire spring clip.

With the clip loosened, slide back the gaiter.

As you pull the gaiter back, prepare for a flow of oil – have a container ready under the gaiter.

If the rack contains oil, place a container underneath the gaiter, ready to catch a rush of oil when the gaiter is loosened.

Gaiters may have wire or worm-drive screw clips. Untwist or cut through wire clips and throw them away. Never reuse a wire clip.

Replacements may be supplied with the new gaiter. If not, buy worm-drive screw clips of the appropriate size – they are much more efficient than the wire ones, though a little more expensive.

If screw clips are already fitted, loosen them enough to release both ends of the gaiter. Push the inner clip off to the end of the rack and leave it there.

Pull the inner end of the gaiter off the rack housing. There may be a rush of oil. Help it to drain by turning the steering slowly from lock to lock.

Disconnect the ball joint from the other end of the track rod (SHEETS 226-227).

Slide the gaiter off the track rod. Remove the outer screw clip to use on the new gaiter. If left and right gaiters are different, remember which is which.

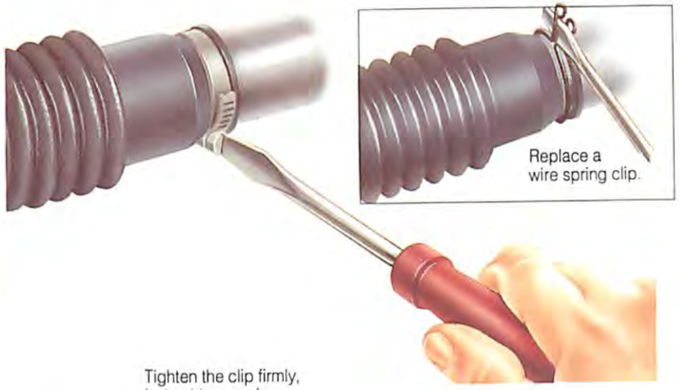
Replacing steering-rack gaiters / 2

Cleaning, inspecting and replacing

Hang the clip on the rack housing.

Smear grease inside the gaiter.

Ease the gaiter into place on the rack housing.



Tighten the clip firmly, but not too much.

Replace a wire spring clip.

Position the small end of the gaiter accurately, then tighten the clip.

Carefully inspect the track-rod inner ball joint, to make sure that grit has not penetrated the gaiter and damaged the joint.

Wipe away any dirty grease and replace it with fresh grease.

The car handbook or a service manual will tell you the grade of grease or oil, and how much to use (oil should be replaced later, when the new gaiters are fitted).

Check the joint for wear by pushing and pulling it. If there is any play, or if the joint is damaged, fit the new gaiter and take the car to a garage as soon as possible for the rack to be replaced.

Make sure that the end of the rack housing and the track rod are perfectly clean, so that no dirt can get into the new gaiter.

If you are replacing both gaiters, and if there is a difference between the left and right ones, compare new and old gaiters to find which is which.

If you are reusing the old gaiter screw clips, see that they are sound, uncorroded and clean. Smear a little grease on the screw thread.

If you are fitting new gaiter clips, open the larger clip to the required size. Hang the clip on the rack housing – with the screw right way round.

Smear a little grease inside the larger end of the new gaiter to make it easier to pull on to the rack housing.

Slide the gaiter up the track rod and ease it on to the rack housing. Make sure that it is squarely in place.

Slide on the clip and move its screw around to the right position. Tighten the screw firmly, but not enough to pinch the rubber.

If you are replacing a wire clip with wire, wind it around the gaiter at least twice, and pull it tight before you twist the ends together. Avoid tightening so much that it cuts into the gaiter.

Slide the outer end of the gaiter into its right place, either a groove or a previously measured spot.

Fit the new outer clip, but before tightening it check that the gaiter is not twisted or misplaced by watching it as you or a helper turn the steering slowly from lock to lock.

If the rack is an oil-filled type, fill it with the recommended quantity and grade of oil.

Tighten the gaiter clip, with the screw correctly placed and not overtightened, to avoid damaging the rubber.

Screw on the track-rod ball-joint locknut (if any) and the ball joint itself, replacing it exactly as it was before (SHEET 229). Reconnect the ball joint to the steering arm.

As soon as you can, have the wheel alignment checked by a garage or steering specialist.

Replacing a Renault steering-rack gaiter

After removing the old gaiter, inspect the rack end, inner track rod and locknut, wiping away old grease with a rag.

If dirt has entered and damaged the rack, the whole unit must be replaced by a garage.

Clean the end of the rack housing. Pack the recommended amount of grease into the rack.

Renault do not fit reusable clips as original equipment; but if there is a screw clip, inspect and clean it, and grease the thread. Hang the clip on the rack end.

Smear a little grease inside the larger end of the new gaiter, and put the gaiter over the rack end.

Concertina the gaiter and screw on the inner track rod, through the outer end of the gaiter, using the same number of turns as you counted when removing it. Tighten the locknut.

Ease the outer end of the gaiter into its groove in the locknut. Usually there is no clip at this point.

Pull the inner end of the gaiter on to the rack housing. See that it is squarely on. Tighten the clip firmly, but not too much.

Check for twisting and misplacement as for a normal gaiter; but move the inner end to adjust. Reconnect the outer track rod. Have the wheel alignment checked by a garage.

Concertina the gaiter and slip the large end over the end of the rack.

Give the inner track rod the same number of turns as it took to remove it. Tighten the locknut.

Pull the gaiter on to the locknut.

Tighten the clip on the inner end of the gaiter.

Replacing track-rod-end ball joints / 1

Track-rod-end ball joints are not adjustable on later cars. If they wear, you must replace them.

The rubber gaiters which protect the joints and retain their lubricating grease must also be replaced if they show signs of splitting, ageing or other damage.

Even if only one of the joints is worn, the joint on the opposite track-rod end should also be renewed.

Most ball joints are simply screwed on to the ends of the track rods, so replacing them is straightforward.

However, some cars, such as certain Renaults, Audis and VWs, have one-piece track rods with integral ball joints. In such cases the whole track rod must be replaced.

If your car has rack-and-pinion steering, make sure the steering wheel is turned only very slowly when the front wheels are off the ground.

Turning it rapidly can build up hydraulic pressure in the steering-rack housing, which may cause one or both rubber gaiters to burst.

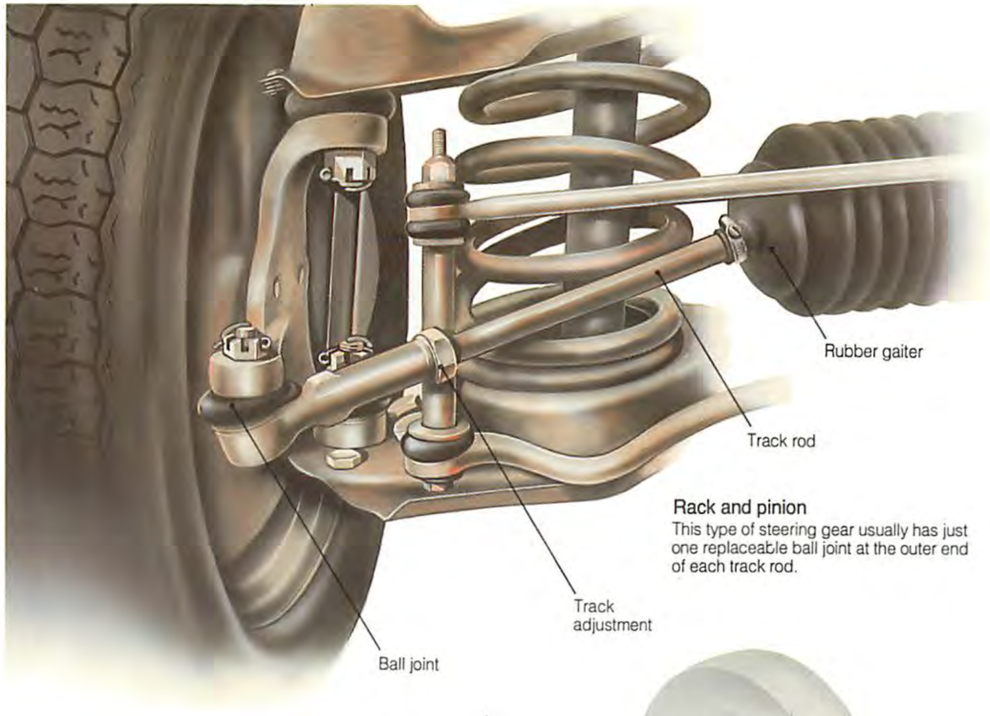
As you will need to work under the front of the car, jack up that end and support it on axle stands placed under chassis members.

Make sure that the handbrake is on firmly, and put chocks behind the rear wheels. Remove the front wheels.

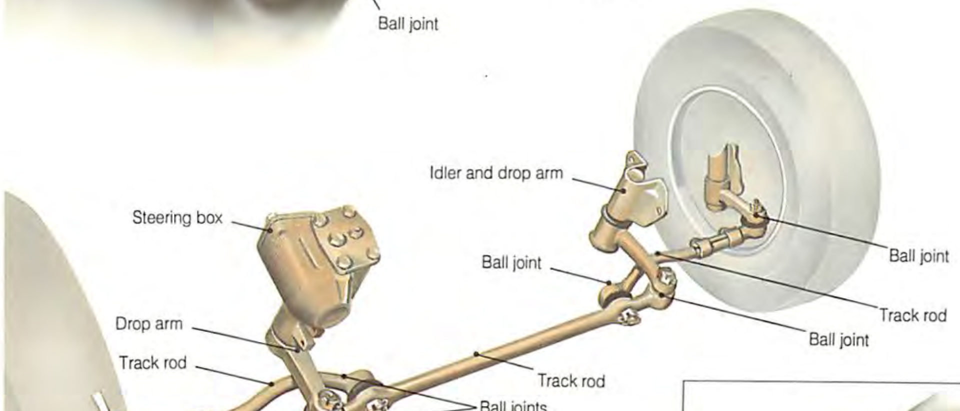
The position of the ball joints on the track-rod ends determines the front-wheel 'track' – the amount of toe-in or toe-out. Care must be taken in fitting a new ball joint to see that it goes on in the same position as the old one. But in any case, take the car to a garage as soon as possible for a tracking check. Even a small amount of excessive toe-in or toe-out will cause rapid tyre wear, apart from affecting the steering handling.

Tools and equipment

AXLE STANDS • WHEEL CHOCKS • PLIERS • SPANNERS • PIPE GRIPS • RULE • SEPARATING TOOL OR FORKED WEDGE • HAMMER • RAG • GREASE



Rack and pinion
This type of steering gear usually has just one replaceable ball joint at the outer end of each track rod.

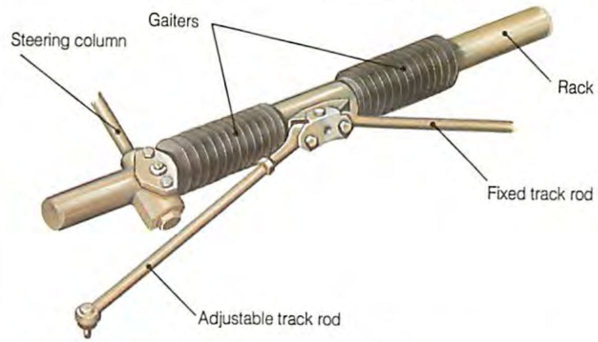


Steering box
Cars with steering boxes often have replaceable ball joints or rubber-bushed joints at both ends of the track rods, and on the drop arm and idler arm.

All these joints are replaced by the same basic methods, though the length of the rods may be adjusted by bolted clamps.

Loosen the bolts to adjust the length of the rod.

Special rack-and-pinion systems



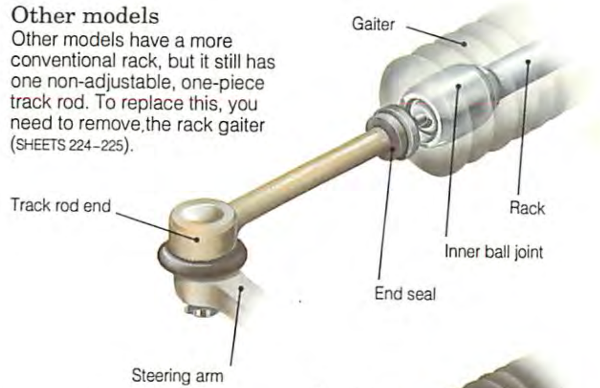
The type of steering rack and track rods fitted to some Audis and VWs varies from other systems.

On one side the track rod is adjustable, and its ball joint can be replaced. On the other side there is a fixed-length track rod with an integral ball joint.

The fixed-length rod is replaced with an adjustable one as a service item. The ball joint can then be renewed in the normal way.

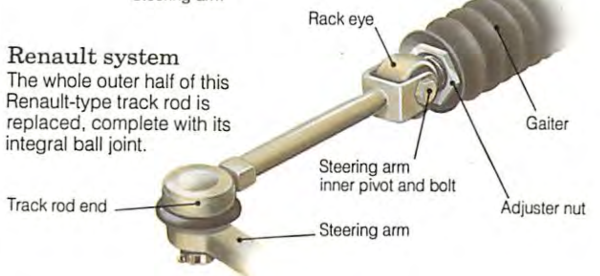
Other models

Other models have a more conventional rack, but it still has one non-adjustable, one-piece track rod. To replace this, you need to remove the rack gaiter (SHEETS 224-225).



Renault system

The whole outer half of this Renault-type track rod is replaced, complete with its integral ball joint.



Replacing track-rod-end ball joints / 2

Releasing the ball joint

The ball joint usually screws on to the track rod and is held by a locknut, either on the rod or joint. Some ball joints are secured by a clamp around a tubular-ended track rod.

Slacken off the locknut or clamp. If the joint has 'flats' cast into its body, hold them with another spanner or self-locking grips to stop the joint turning as you unscrew the locknut: otherwise the turning force on the locknut may force the joint beyond its normal travel and damage it.

This does not matter if the joint is being renewed, but is important if you are simply replacing a rack gaiter and putting the same joint back on.

Such damage can cause the joint to fall apart in use.

Mark or measure the precise position of the ball joint on the track rod, so that it – or a new joint – can be replaced in exactly the same position later. This is because the front wheel toe-in setting (SHEET 222) is almost always adjusted by screwing the ball joint in or out, though there are a few exceptions. On some cars, adjustment is made by a rod threaded at both ends between the ball joint and the track rod. Do not slacken the inner locknut or alter the position of the rod.

Ball joints which screw over a threaded track rod can be marked in several ways. The simplest is to screw the locknut back until it just touches the end of the ball joint, but does not lock it. Leave it there as a guide when reassembling.

Another way is to paint both thread and ball-joint body or count the threads visible between the end of the joint and where the threads end.

You can also wrap tape around the track rod to butt against the ball joint, or measure from the end of the joint to another fixed point, such as the end of the rack gaiter.

If the ball joint has a solid end which screws into the track rod, gauge its position by measuring the length of thread showing on the ball joint, or by counting the turns needed to unscrew it.

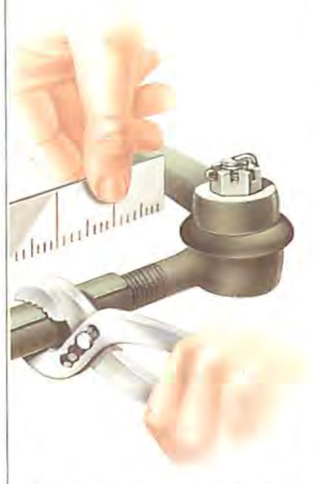
None of these methods is precise, however, and the toe-in setting must be checked by a garage as soon as possible.

Grip the 'flats' on the ball-joint body to hold it in exactly the same position while you loosen the locknut with a spanner.

When the locknut is freed, mark the end of the ball-joint body and thread with a dab of brightly coloured paint as a guide when replacing.

Ball-joint clamp

Loosening the clamp which secures some ball joints. Both clamp bolts must be slackened to free the joint.



Use a ruler to measure accurately the length of thread showing on a ball joint that screws into the track rod.

Separating the ball joint

The joint is fixed to the steering arm by a self-locking nut or by a castellated nut and split pin.

Remove the split pin before unscrewing a castellated nut and always use a new split pin when you reassemble it later.

A self-locking nut can be screwed straight off, but a new one must be used when you replace the ball joint later. Never reuse an old self-locking nut – it is likely to work loose in time.

With the securing nut off – and any washer under it also removed – the ball joint can be separated from the steering arm. But the joint is a taper fit into the arm and requires some force to free it.

There are three ways to separate the ball joint and steering arm.

The best and easiest method is to use a scissor-action ball-joint separating tool (SHEET 49). Fit it so that one arm bears against the steering arm and the other against the nut on the ball-joint stud.

Tightening the bolt on the tool makes the arms close, and the one bearing against the stud forces the tapered shaft of the joint out of its tapered seating in the steering arm.

Another way is to hammer a special forked wedge between the body of the ball joint and the steering arm, again forcing them apart.

However, the wedge will almost certainly damage the rubber dust excluder on the joint, so use one only when you are fitting a new joint. On cars where the ball joint is above the arm, slacken the nut until it is at the end of the thread and place a jack underneath it. Adjust the jack so that it just supports the car's weight. Use two hammers to strike the sides of the steering arm simultaneously. This will spring the taper out of its seating.

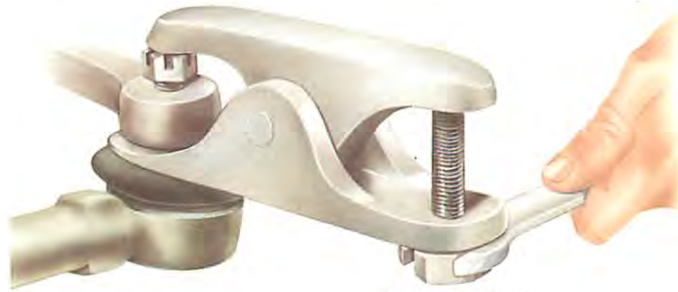
Unscrewing the ball joint

Once the ball joint is separated from the steering arm, you can unscrew it from the track rod. Count the number of turns and use the same number to replace it, if there is no other way to mark its exact position for replacement later.

If you intend to renew rack gaiters, you must also remove any clamp or locking nut on the track rod.

Use pliers to bend the split pin straight, then pull it out by the eye.

Slacken the nut a few turns but do not remove it, so that the upper arm of the separating tool can bear against it.



The separating tool is screwed up to force the tapered stud of the ball joint out of its seat in the steering arm.

You may need to count the turns when you unscrew the ball joint.

Using a forked wedge

Separating the joint with a wedge can damage the rubber dust excluder – so be careful.

Replacing other types of track rod

Renault outer rod

Separate the outer ball joint from the steering arm (SHEETS 226-227).

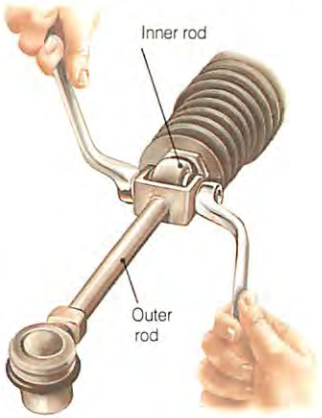
Unscrew the nut from the bolt holding the outer and inner rods together, using two spanners to stop the bolt from turning.

Push the bolt out through the bushed eye on the inner rod to release the outer rod.

Some newer Renaults have adjustable outer rods and non-adjustable, non-renewable inner rods. The outer ball joints can be replaced in the usual way.

Others have a rack with track rods ball-jointed directly to it.

If you dismantle an adjustable rod, measure or mark its length first, as for other cars.



Renault inner rod

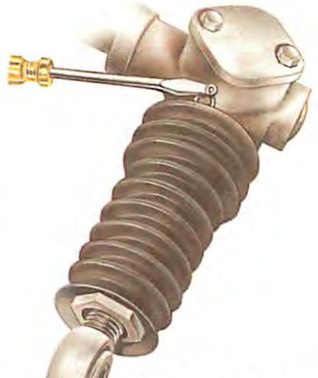
This part has to be replaced if the bushed eye becomes worn. On cars with adjustable track rods, the inner rod is neither replaceable nor adjustable. The whole rack has to be replaced.

Separate the inner and outer rods before you loosen the protective gaiter (SHEET 224).

Unfasten the inner end of the rack gaiter and pull the gaiter free of the rack.

The inner-rod locknut is just outside the end of the gaiter. Slacken it slightly – just enough to free the rod.

Unscrew the inner rod, noting the exact number of turns it takes to remove it so that the new rod can be fitted in the same position.



Release the inner end of the gaiter from the rack.

Loosen the locknut just enough to free the rod.

Unscrew the rod, counting how many turns it takes.

VW Golf, Scirocco and Audi 50

Disconnect the outer ball joint from the steering arm (SHEETS 226-227).

Loosen the clip (if fitted) on the inner end of the rack gaiter and pull the gaiter free from the rack housing.

Centre the steering exactly. Measure the distance between the ends of the rack housing and the inner faces of the inner ball joints of both rods.

If you are fitting a new rod, adjust it to the correct length and secure the ball joint with the locknut.

Release the locknut of the inner ball joint and unscrew the track rod together with the gaiter.

Mark the position of the old ball joint at the outer end of the track rod if it is replaceable.

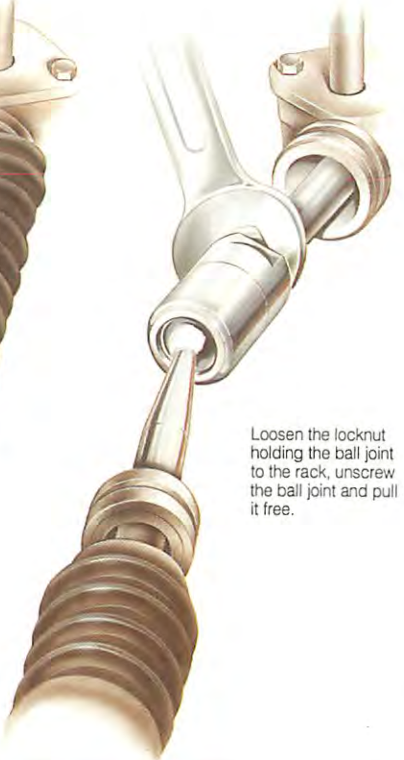
With a non-adjustable rod which has to be replaced completely, measure to the total length of the rod.

Unscrew the old ball joint.

Citroën GS

You need a special spanner to undo the inner ball joints of the Citroën GS steering rack, which is similar in many ways to that of the VW Golf, Scirocco and certain others.

Unclip the gaiter from the end of the rack housing and pull it free.



Loosen the locknut holding the ball joint to the rack, unscrew the ball joint and pull it free.

VW Passat, Beetle, Audi 80 and Audi 100

Separate the track-rod outer ball joint from the steering arm in the normal way (SHEETS 226-227).

On cars with rack-and-pinion steering, unscrew the nut from the bolt which holds the bushed eye at the inner end of the track rod to the sliding yoke on the rack.

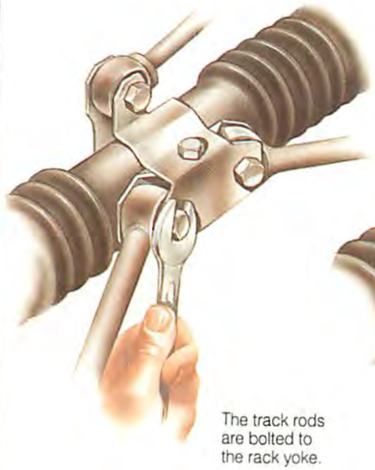
Removing both bolts will free a locking plate which covers both track-rod attachment points. Note which way round this fits before you pull out the bolts; note also where the washers go.

Only late model 1303 Beetles have rack-and-pinion steering. On earlier models there is a central steering box with a single drop arm which moves both track rods in a similar way.

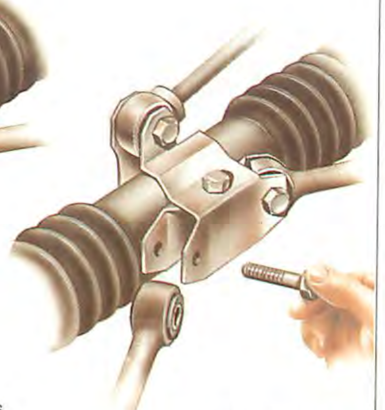
The track rods are ball-jointed to this arm. The ball joint is secured by a castellated nut with a split pin. Remove the pin to free the nut.

One track rod has a steering damper bolted to it. Take the nut off the bolt, pull the bolt out of the bushed eye in the rod and disconnect the damper from the rod, leaving its other end attached.

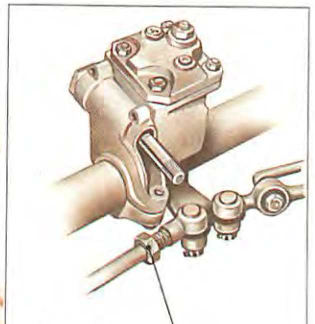
Before you remove any part of a track rod, mark or measure the rod so that it is exactly the same length when you reassemble it. If a non-adjustable track rod is to be replaced, measure the total length.



The track rods are bolted to the rack yoke.



Pull out the bolt to release the rod.



On Beetles with steering boxes, the inner ends of the track rods have ball joints which are unfastened in the usual way; again, one rod only is adjustable.

Refitting track rods and ball joints

Check that any parts you are not going to replace are undamaged before ordering replacements.

Remove protective grease or other material from new parts. Compare them with the old ones to find which is left and which is right. Trying to screw on the wrong joint would damage both joint and rod.

To refit a ball joint to a track rod, grease the thread and screw the joint into place, giving it exactly the same number of turns as when the old joint was removed. Or screw it up to a mark you made earlier.

Do not tighten the locknut yet. Make sure the ball-joint stud is pointing straight up (or down, as appropriate) when in the middle of its travel, as the joint is flexed.

If not, twist the whole joint on the rod to bring the stud into line. Push the stud carefully through the bore in the steering arm.

Fit the washer and locking nut to the stud, and tighten the nut to pull the tapered stud into the bore.

If a self-locking nut was used, replace it with a new one: a self-locking nut should not be used twice.

If the threads are stiff, the nut may make the stud turn so that it does not screw up.

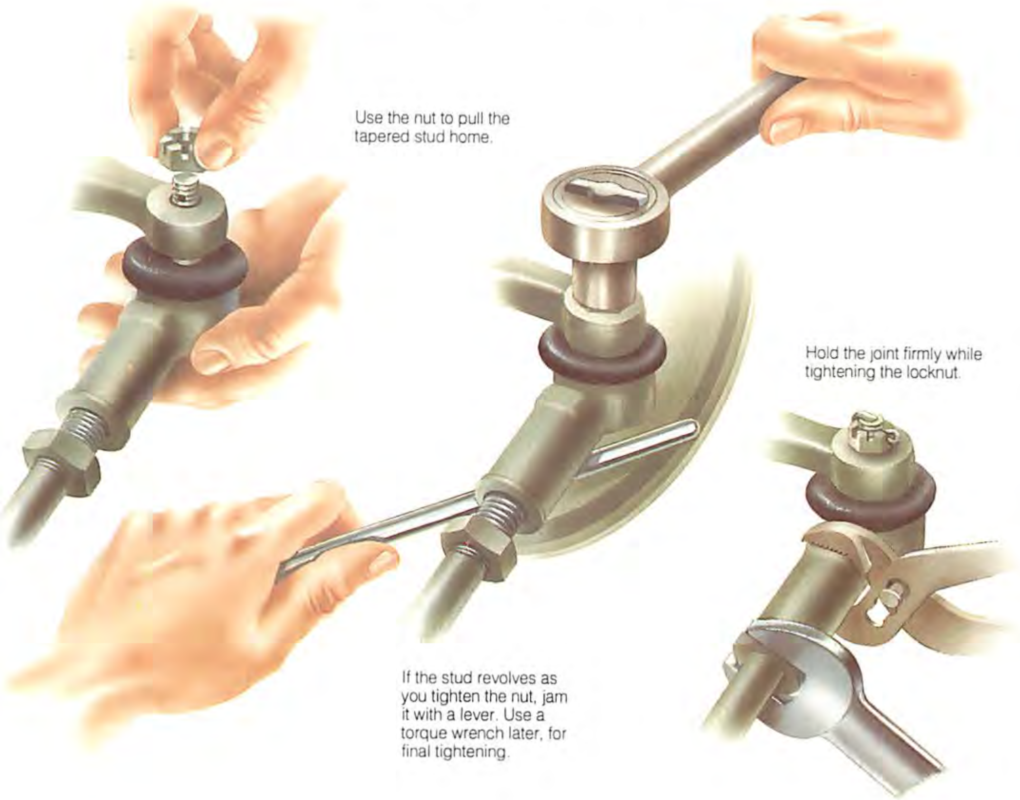
Hold the stud by levering against the other side of the joint with a bar resting on the inside wheel rim.

Finish tightening the nut with a torque wrench set to the correct loading. If you cannot obtain the correct setting from a service manual or your local dealer, 25 lb ft (3·5 kg m) is about right.

If a castellated locknut is used, tighten it more, not less, to align one of its cut-outs with the hole for the split pin. Always use a new split pin. Insert it, prise it apart with a small screwdriver and bend the two halves opposite ways around the nut.

Tighten a ball-joint locknut while you hold the ball joint firmly with a spanner or self-locking grips to stop it from turning. Otherwise the joint will be damaged.

Check that the toe-in or toe-out of the wheels is correct (SHEET 222). The setting is usually given in the car handbook. This check should be done by a garage if you do not have the equipment for it.



Use the nut to pull the tapered stud home.

If the stud revolves as you tighten the nut, jam it with a lever. Use a torque wrench later, for final tightening.

Hold the joint firmly while tightening the locknut.

Replacing Renault rods

When replacing a Renault non-adjustable outer rod, reconnect the ball joint as usual.

Fit the forked end of the rod to the eye of the inner rod, push the bolt home and tighten the nut.

Adjustable outer rods should be set to the right length before fitting.

When replacing an inner rod, fit the gaiter into the groove behind the head of the locknut.

Screw the rod in, giving it the same number of turns as it took to remove the rod originally. Adjust until the eye is vertical, and tighten the nut.

Refit the gaiter, then reconnect the outer rod.

Bolt the forked end of the outer rod to the eye of the inner rod.

When refitting the inner rod, screw it home the same number of turns as it took to remove it.

Set the eye vertical, then screw up the locknut.

Methods for VW and Audi

When replacing a non-adjustable track rod with an adjustable one, screw the ball-jointed and/or bushed end in or out, to make the rod the same length as the old one.

Ensure that the two ends are aligned before tightening the locknuts or clamps. Reconnect the outer ball joint to the steering arm in the normal way.

With a long track rod connected to a single, central rack yoke or steering-box drop arm, refix the rod to the rack yoke by refitting the locking plate (if removed), bolt, washer and nut.

With VW Beetle steering-box systems, reconnect the inner ball joints by the same method as outer ones.

With the short track rod used on the VW Golf and similar cars, screw the rod on to the end of the rack until the distance between the rack-housing end and the inner face of the inner ball joint matches the measurement made earlier (measure at both rack ends).

Do not forget to slide on the gaiter and the rubber ring which fits inside it.

Tighten the locknut and refit the gaiter.

Bolt the inner end of a long track rod to the central yoke.

Screw up to the measured distance and tighten the locknut on a short track rod.

Checking power-assisted steering

Check a power-steering system at least twice a year – more often if recommended by the car handbook, or if the steering becomes heavy or jerky.

Complete failure makes the steering very heavy – you can feel the effect by trying it with the engine switched off and the car stationary.

Check the fluid level in the reservoir and, if it is low, look for leaks. Leaks may let air in as well as fluid out, so the system may need bleeding.

The reservoir may be set in the top of the pump, which is mounted on the engine and driven by a belt from the crankshaft. It may be separate – find it by tracing the hoses from the pump.

Usually there are two level marks in the reservoir. The lower one is used when the fluid is cold, and the upper one when it is hot. Read the level with the car on flat ground; remember to replace the reservoir cap.

If the level is low, there is probably a leak. Check all the hose joints: they should be tight, but not cutting into the hose ends. Check that the hoses are not cracked, perished or chafed. Look for leaks oozing sticky fluid.

Check any rigid pipework attached to the pump, reservoir and rack (or steering box). Look for leaks from the pipe unions and for sticky fluid trails. If none is immediately visible, clean the parts with engine degreaser.

Have a helper start the car and turn the steering wheel from lock to lock while you look again for leaks.

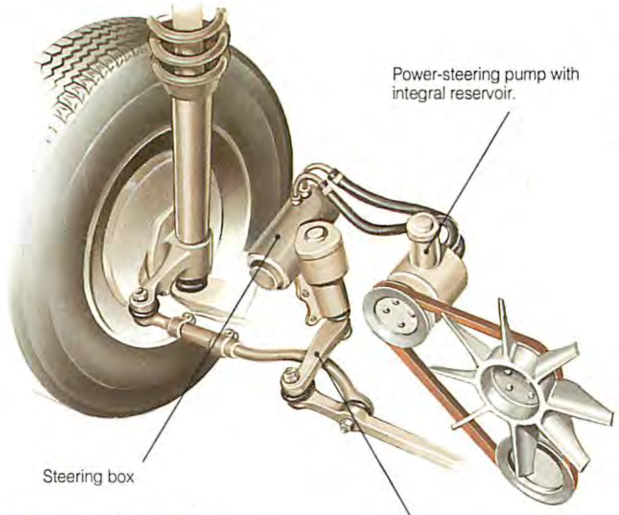
If you find a leaking joint, tighten it and top up the reservoir. Normally, automatic-transmission fluid is used, but consult the car handbook. Bleed the system to remove any air bubbles.

The drive belt may need adjusting or replacing (SHEET 221). Any more serious maintenance should be done by a garage.

Tools and equipment

SPANNERS • SCREWDRIVERS • ENGINE DEGREASER AND PAINTBRUSH • ABSORBENT LINT-FREE RAG • SUITABLE TOPPING-UP FLUID

Power-assisted steering box



Power assistance is fed to the steering box in this system, which operates through a track rod linked to steering arms.

Checking the fluid level

Make sure the car is standing on flat ground. There may be hot and cold level marks inside the top of the reservoir.

If not, the level may be up to the top of a circular filter plate fitted to the centre spindle; look in the car handbook to find whether this is the hot or cold level.

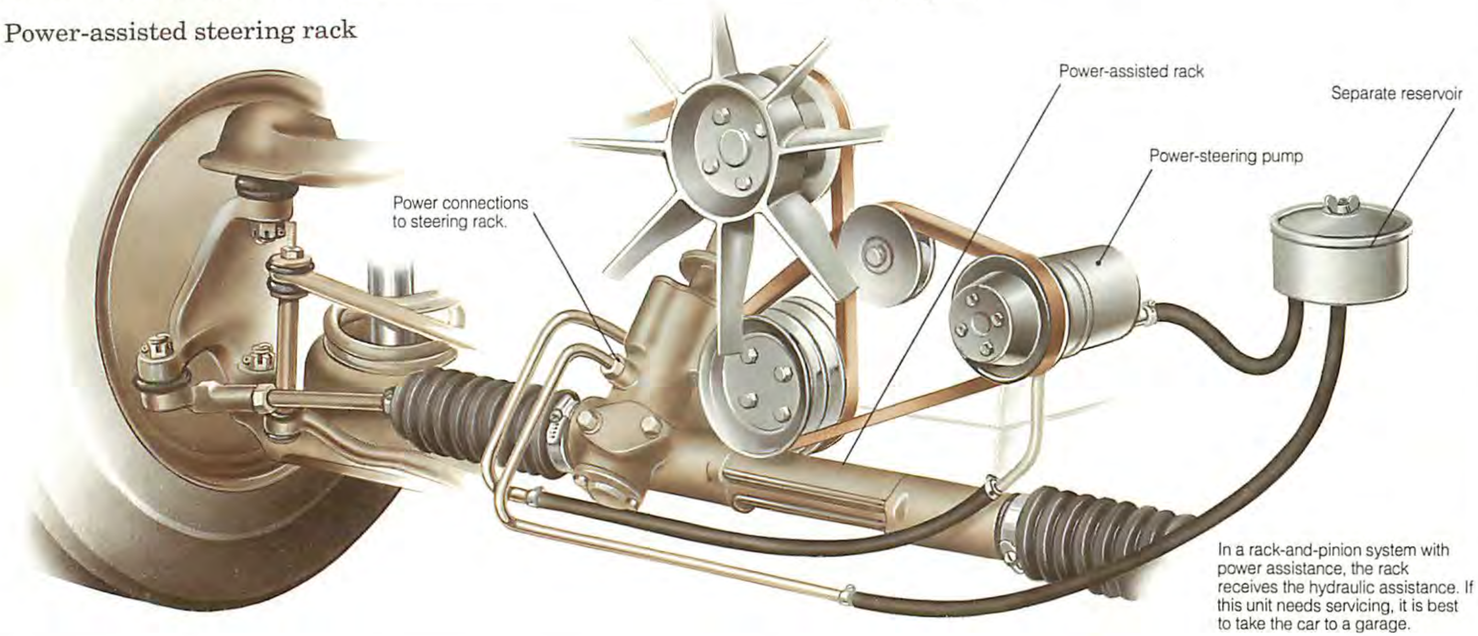
On a centre-spindle reservoir, the whole lid is removed by unscrewing a wingnut.

Alternatively, there may be a dipstick on the bottom of the cap. Remove the cap, wipe the stick with a lint-free rag, screw back fully and remove again to read the level.

If the reservoir has a dipstick on the cap, clean the dipstick, replace it and then remove again to read the level.

The cap on a centre-spindle reservoir is held by a wingnut. The level marking is on the side of the reservoir.

Power-assisted steering rack



In a rack-and-pinion system with power assistance, the rack receives the hydraulic assistance. If this unit needs servicing, it is best to take the car to a garage.

Bleeding the system

Put on the handbrake and keep the car in neutral gear; if the car is an automatic, put it in 'Park' before starting the engine.

Run the engine until it reaches normal working temperature. Leave it idling.

Turn the steering from lock to lock several times to heat the fluid. Switch off the engine.

Look into the reservoir; if there are bubbles, there is air in the system. Top up the fluid to the 'hot' level and replace the cap.

Jack up the front of the car with both wheels just off the ground. Turn the steering from lock to lock three times.

Check the fluid level, topping up if necessary. Start the engine.

Slowly turn the wheels from lock to lock three times. Check the fluid level again, and top up if necessary. Note the exact level when you have done this. Replace the reservoir cap and switch off.

Lower the car and restart the engine. Turn the steering from lock to lock five times, then centre it exactly. Switch off, and look in the reservoir.

There should be no bubbling or frothing. The fluid level should not have risen by more than a small amount.

If the fluid is bubbling or has risen much, repeat the whole process from the start.

Finally re-examine the complete system for leaks. If there is still a problem, have the system checked by a garage.

Checking suspension joints and pivots / 1

Almost all joints and pivots in a modern suspension system have rubber or plastic bushes, with the possible exception of steering swivel joints (SHEET 218).

Because of the constant movement of the suspension parts, the bushes gradually wear out, soften and perish.

Oil contamination also causes them to deteriorate, and if they are allowed to deteriorate too much, they become loose and the steering and road-holding suffers.

It is essential to make a regular check on the condition of all joints in the suspension system.

If you find any joints or pivots to be worn or damaged, replace them (SHEETS 238-246) or have them replaced at a garage as soon as possible.

If any are found to be contaminated with oil, find the source of the leak and repair it, otherwise any new bushes fitted will be affected.

Examination of suspension parts can often be carried out with the wheels still on, but on some cars you may have to remove them. Wheels must be on for some checks.

Support the car securely on axle stands under chassis members. The force used to lever various suspension parts can easily topple a car that is not securely supported.

If you have only two axle stands, raise one end of the car at a time.

Check the wishbone joints where they pivot at the inner ends, and also the moving joints and pivots at the outer ends of the wishbone and track-control arms where they are fixed to the steering swivel members, or suspension legs in the case of MacPherson struts (SHEET 35).

Wipe road dirt and grease from all the joints and pivots, and clean around the mounting brackets. Check for corrosion at each point (SHEET 61).

If the rubber bushes are distorted, perished, cracked or contaminated by oil, they must be replaced. Some you can replace yourself, others should be replaced at a garage.

Check around the mountings for signs of rust or damage, probe load-bearing areas with a screwdriver and tap them with a small hammer to make sure they are sound.

Any rusted metal should be treated with a proprietary anti-rust fluid and repainted (SHEET 68). If it is badly corroded, it must be replaced at a garage, which may be able to weld in reinforcing plates. Otherwise, the suspension mounting may break loose.

Ask a helper to put a stout lever under each front wheel in turn and lever upwards, while you watch both the inner and outer joints of the wishbone or track-control arms.

Look for any movement other than the normal pivoting motion.

If you see any movement inwards and outwards, examine the joints and bushes closely – they should not move. Use a lamp in dark, underwing areas.

With MacPherson struts, look at the mounting at the top of the inner wing panel. Check for corrosion, which is a common problem with older cars.

Open the bonnet and bounce the front of the car up and down while watching the rubber bush at the centre of the strut mounting. The bush should barely move.

If any flexing is seen, the bush should be replaced. Even if there is no flexing, check also the condition of the bush itself. Look for perishing and cracking, and replace the bush if it is not perfect.

On front-wheel-drive cars, check the condition of the constant-velocity joints on each drive shaft (SHEET 252).

The joints are usually protected by rubber gaiters. Wipe each gaiter clean and inspect it. If you find splits, have the gaiter replaced at a garage.

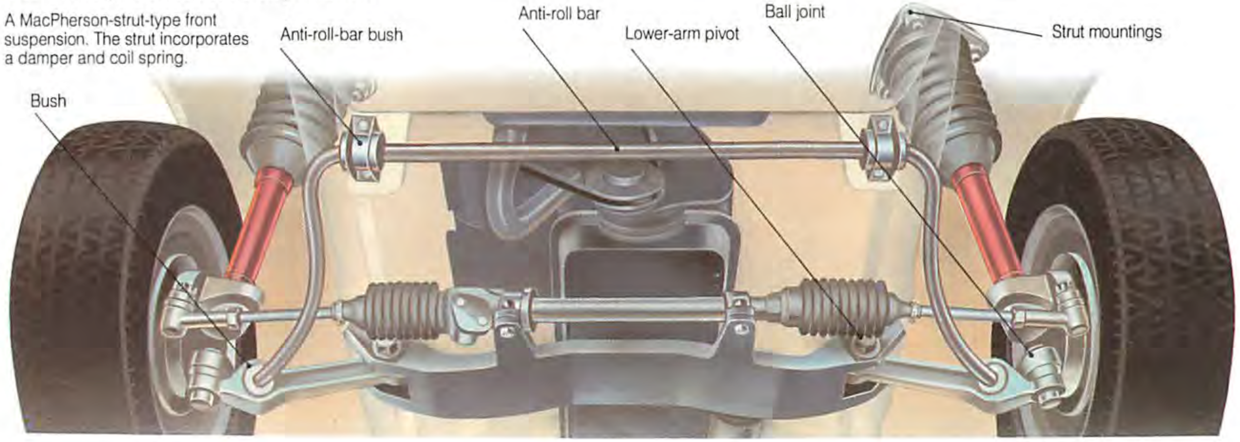
A damaged gaiter allows the oil or grease to escape and dirt to enter the joint; this causes excessive wear, and replacing the joints is expensive.

Tools and equipment

JACK • AXLE STANDS • SCREWDRIVER • SMALL HAMMER • LEVER • INSPECTION LAMP • RAG

Checking the front suspension

A MacPherson-strut-type front suspension. The strut incorporates a damper and coil spring.



Examine all the swivels on the suspension and steering links.

Jack the front of the car up, allowing the suspension to hang, and support it on axle stands. With weight off the suspension, inspect the rubber bushes for cracks, softness or distortion.

Check all the mountings and rubber bushes at the ends of the dampers and the anti-roll and stabiliser bars. Check all ball joints by levering with a bar.

Then check the suspension in its normal loaded position by jacking up each suspension arm in turn. Use a strong lever to try to move jointed components apart –

Lever the wheel upwards to find play in joints.

any movement means that the joint must be replaced at a garage.

Get a helper to force the suspension upwards, using a long lever placed under the wheel, and look for play or distortion in all the joints and bushes.

Open the bonnet and check the top mountings on MacPherson-

Check a MacPherson-strut top mounting plate.

strut assemblies. Check the top pin bolts and rubber bushes; also the whole mounting plate and surrounding area for rust.

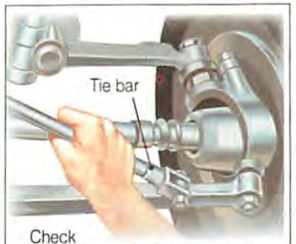
On some cars a reinforcing plate can be welded to the upper mount of the MacPherson strut, if rust has not weakened the rest of the structure. This work must be done by a garage.

Check the swivel pins on the steering swivel members with care; they take a lot of road shocks and are exposed to water and dirt. Pull against the top and

Use a steel bar to check swivel pins.

bottom pins with a stout lever wedged against a solid chassis member.

Grip and twist the track control



Check stabiliser arm joints for movement.

and stabiliser arms, to see if there is movement in the ball joints. Examine the rubber-bushed ends

Lever joints sideways and look for movement.

and joint dust covers. If there is loose movement, or if covers are split, renew the joints (SHEET 226).

In joints that are held by large pins or bolts, lever sideways while checking for movement. Check the condition of the rubber bush and the state of the bolt. If they are worn, have them replaced.

Finally, test the anti-roll bar mountings for tightness.

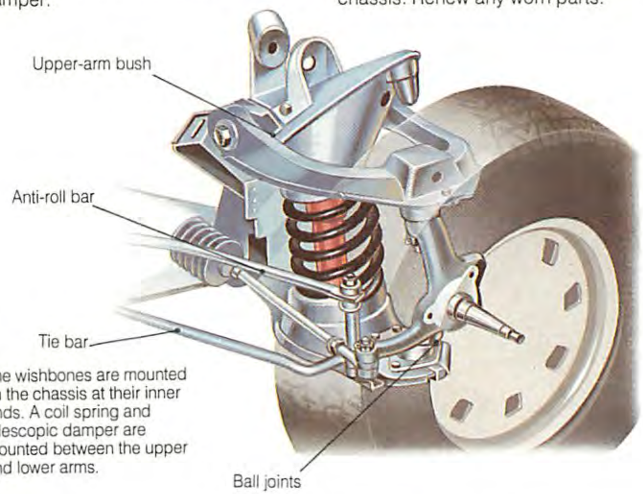
Test the anti-roll bar mountings.

Checking suspension joints and pivots / 2

Checking double wishbones

The wishbones support the steering swivel member at their outer ends, and the lower wishbone provides a mounting point for the coil spring and damper.

Examine the steering swivel pins for wear (SHEET 217). Check the condition of the bolts and bushes that hold the inner ends of the wishbones to the car chassis. Renew any worn parts.



The wishbones are mounted on the chassis at their inner ends. A coil spring and telescopic damper are mounted between the upper and lower arms.

Checking the rear suspension

The rear suspension is simpler than the front, and most of the bushed joints are easy to inspect.

Jack up the rear of the car and support it on stands with the front wheels chocked.

Lever against the various components while looking carefully to see if there is any movement in the joint or bush.

Check the joints at the end of the radius arm, or any other rod which locates the axle.

Wipe each joint clean, and check if it is perished, cracked or contaminated by oil.

If you suspect that a bush is damaged, check further by levering hard against it – make sure the other end of the lever is resting against a strong part of the suspension or floor pan.

Take care not to crush brake pipes or cables.

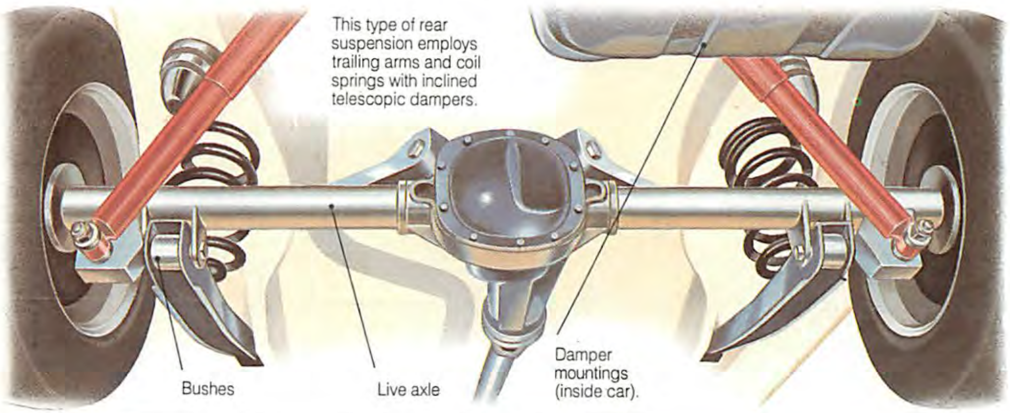
It helps to have an assistant lever against the joint while you watch it for movement.

Make sure, too, the pivot bolts are tight, and that the mounting brackets and the areas around the brackets are not corroded. Probe them with a screwdriver and tap them lightly with a hammer to see if they are sound.

If any weak metal is found, take the car to a garage and have the rusty areas repaired – assuming the value of the car makes that worth the cost.

Usually, removing the rear suspension locating arms is straight-forward – unscrew the pivot bolts and lift out the arm.

Take it to a garage to have the old bushes removed and new ones fitted, if they are available. If they are not, the complete arm assembly must be replaced.



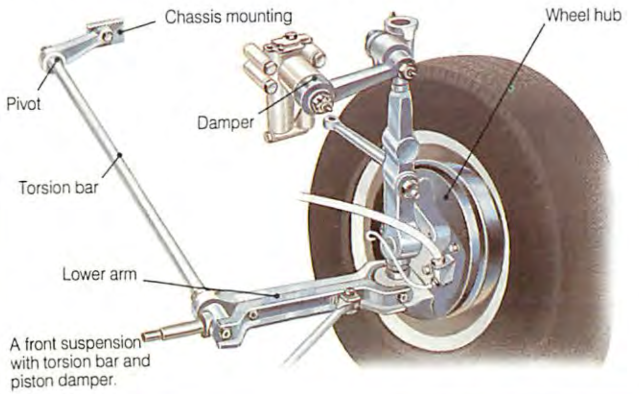
This type of rear suspension employs trailing arms and coil springs with inclined telescopic dampers.

Checking torsion bars

Many cars have torsion bars in the suspension instead of coil or leaf springs at the front, the rear or at both ends (SHEET 36).

The inner mounting is on the floor pan and is usually well covered against deterioration, but can fail because of corrosion fatigue in due course. Check the soundness of the metal at the anchorage point (SHEET 61).

The outer end, where it is fixed to the suspension member, can be attacked by mud, stones and road debris. Check its bushes along with all the others.



A front suspension with torsion bar and piston damper.

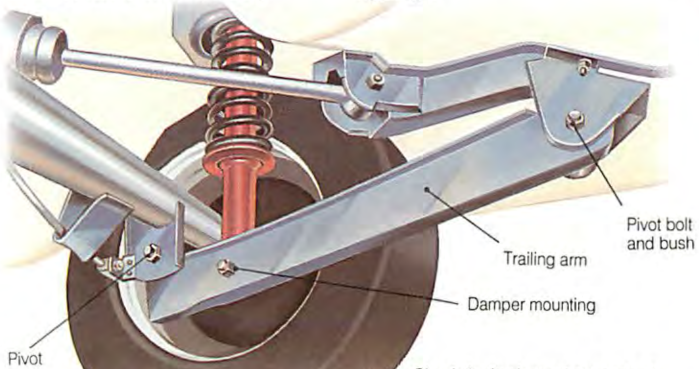
Checking rear trailing arms

Examine every link and joint, including the damper mountings, for worn, distorted and oil-contaminated bushes.

Check the axle locating arm by trying to twist it in its bushes. There should be little or no movement.

Do not be afraid to lever hard against the mountings – road shocks can be severe, and the bushes need to be perfect.

If there are any worn or damaged components, have them replaced by a garage.



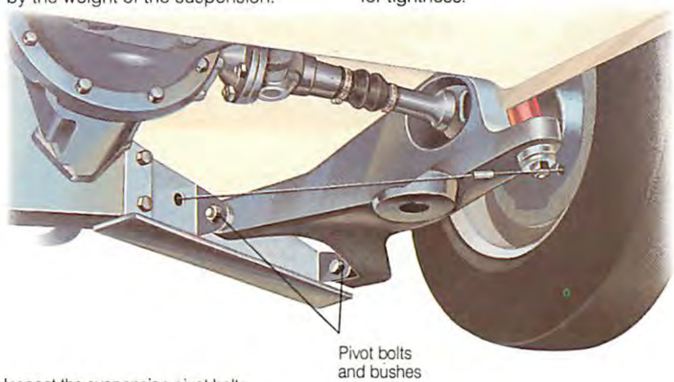
Check the bushes at both ends of the trailing arm, the damper mounts and the axle locating-arm bushes.

Checking an independent rear suspension

Jack the wheel off the ground and support that corner of the car with an axle stand placed under a chassis member. Remove the wheel if necessary, and examine all the rubber bushes as they are distorted by the weight of the suspension.

Replace any that are cracked or are badly distorted.

On a car with transverse leaf-spring suspension, such as some Triumph models, check the spring mounting bolts, U-clamps and spring eye bolts for tightness.



Inspect the suspension pivot bolts and bushes for excessive distortion with the wheel off the ground.

Checking damper units / 1

Almost all modern cars have hydraulic telescopic dampers in their suspension systems.

Where the front suspension system is a MacPherson strut, the damper is built into the strut or leg that supports the wheel-hub assembly (SHEET 35).

To inspect the condition of telescopic dampers, loosen the wheel nuts, jack up the car and support the chassis on axle stands so that the wheels hang free and the dampers are extended. Remove the wheels.

Checking for leaks

The dampers are filled with a special oil, which provides the damping effect. The piston and rod moving up and down inside the strut forces the oil through narrow passages, which slows down the oil transfer.

This restricts the up-and-down movement of the car suspension.

The weak point of a damper is the gland seal round the part of its body where the piston rod moves up and down. It is not unusual for this gland to fail, allowing oil to escape.

Oil leaks leave a dark stain in the road grime that collects on the damper and on its mounting points.

If there are any signs of a leak, renew the damper (SHEETS 240–242).

On a car with MacPherson struts, look around the lower parts of the dampers for dark oil stains. A new damper insert can be fitted (SHEET 244).

Always replace dampers in axle sets (pairs) to ensure uniform suspension damping on both sides of the car.

Checking for damage

Inspect each damper casing for signs of damage caused by flying stones or deep rust. Slight dents may not be too serious, but investigate a deep one further, preferably by taking the unit off the car for close examination and testing in a vice (*see* Bounce test).

Look also at the piston rod. It may be hidden by a rubber dust cover, which can be pulled back.

Check the rod for signs of scoring, pitting or rust. If you find any, replace the unit, or it will damage the piston oil seal.

Wipe the damper clean and check the rubber bush at the base of the unit. Look for signs of damage, perishing, cracks or distortion.

Grip the lower body of the unit and try to move it backwards and forwards, and twist it about its mounting bolt. If the rubber bush is in good condition, there should be no movement.

Check the upper-mounting bush in the same way. If the upper mounting is a pin, check the condition of the rubber discs.

Look also at any upper mounting on the inner front or rear wings. You may need a torch or inspection lamp.

Weakening of the turret top in which the damper is fitted is common. Reinforcing plates can be welded, but this is a job for a professional.

If you find any worn or cracked rubbers, replace them.

Replacing rubbers

Remove the unit from the car. An eye-type bush may be in two halves (one fitted at each end) with a steel sleeve through the middle.

After pulling out the old bush, lubricate the eye with soap solution and fit one half of the bush with the steel sleeve inserted.

Push in the other half as far as possible, then force the bush into place by squeezing from both ends in a vice.

Some eye bushes are in one piece. With the old bush still in place, take a socket with a diameter large enough for the whole bush and place it in a vice on one side of the eye.

Place the new bush on the other side and squeeze with the vice to push the old bush into the socket as the new one is forced into the eye.

With pin-type fittings, place the rubber discs over the stem of the unit in the same sequence as the old ones. Note where spacers and washers fit.

Tools and equipment

TORCH OR INSPECTION LAMP • VICE • SOAP SOLUTION • SOCKETS • RAG

How front dampers are attached

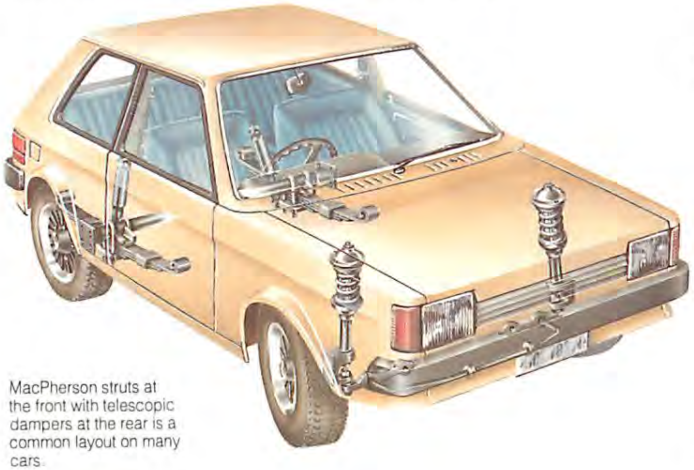
The front dampers may be attached to their mounting points at each end by a pivot bolt through a bushed eye.

Alternatively, each end may have a threaded pin passing through the mounting bracket. Or there may be an eye and bolt at one end and a threaded pin at the other.

The upper mounting of a MacPherson strut is a bearing on a rubber-bonded block, fixed to a plate bolted to the body. The lower end has a ball swivel joint.

With coil-spring parallel-wishbone front suspension, the damper is usually inside the coil spring.

The spring is located rigidly in the lower wishbone, and passes through the upper wishbone to a mounting on a chassis outrigger.



MacPherson struts at the front with telescopic dampers at the rear is a common layout on many cars.

MacPherson-strut upper mountings have bearings on rubber blocks. Check the fixing plate nuts for tightness.

Dampers are fitted inside the springs of a coil-spring suspension system

The bounce test

A bounce test is a quick, rough way to check if the dampers are working properly. Do it at each service, or if the car seems to be wallowing or riding oddly.

Dampers can weaken or lose all effect, so that the car bounces wildly; or they can seize, so that the suspension moves little or not at all.

A bounce test will reveal serious faults, but only a garage with special test gear can detect a slight weakness in a damper.

To carry out a bounce test, inflate the tyres to their correct pressure and remove any load from the car. Drive on to level ground and apply the handbrake.

Stand at one corner of the car, put both hands on the body and push down sharply – hard enough to make the suspension hit its bump stop.

Keeping your hands in place, let the car rise, then at once push down again.

Repeat three or four times, then at the bottom of a push let go and watch what happens.

The car should rebound once or twice, then settle at or near its normal ride height. If it bounces more, suspect a weak damper.

Repeat the test at the same corner, listening for the scraping or creaking noises that confirm a faulty damper; look it over for leaks or other damage.

If you find it difficult or impossible to push the car down, suspect a seized damper – generally caused by a bent piston rod inside. Replace a seized damper.

Test at each corner of the car, then mentally compare the results for the four dampers. If one corner feels different from the others, the damper there is probably faulty.

If the fault is not a leak, remove the damper from the car and clamp it in a vice.

Pull it up to its full extent, then compress it fully several times. It should resist evenly in both directions.

Unevenness may be due to a low fluid level, a faulty valve or air inside the unit. Air gives a spongy feel to the movement.

To remove air, leave the damper for a few minutes to let the air rise.

Then push the damper right down and depress it a few short strokes followed by a few slow, full strokes.

If, after this, the damper still feels uneven, fit a new one.

Checking lever dampers

A few cars have front-mounted lever dampers that also serve as the top link of the suspension.

To test the damper action, first disconnect it from the suspension (SHEET 243). Move the damper arm slowly up and down to feel if there is firm resistance in both directions.

Replace if defective (SHEET 243).

The damper arm passes through the slot

Disconnect the damper arm from the suspension. Move the arm slowly up and down

Checking damper units / 2

How rear dampers are attached

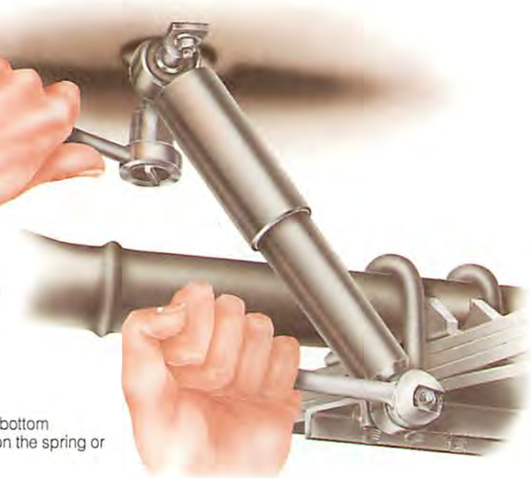
Rear dampers are attached at the bottom to brackets on the axle casing, or to where the spring is seated. The fixing is usually a bolt or stud through the rubber-bushed eye.

At the top, the dampers are attached to a bracket or mounting point in the floor pan or the inner rear wing.

Top mounting points are sometimes hidden in turrets within the inner bodywork, and you may have to consult a service manual for the location and type.

If the car has pin-type upper mountings, the rubber discs where the pin passes through may be on either side of the metal bodywork. Check both sides of the mounting plate.

To check the top side of an upper mounting, you may have to remove trim panels in the boot or, in a hatchback, the car interior trim.



Check the top damper mounting where it is attached to the floor pan.

Check the bottom mounting on the spring or axle.

Inspecting rear mountings

Rear dampers with pin fittings at the top are usually fixed through the inner wings, either through reinforced areas or through the top of a turret in the bodywork.

Turret-mounted dampers are often found on cars with coil-spring rear suspension, when the turret also locates the spring.

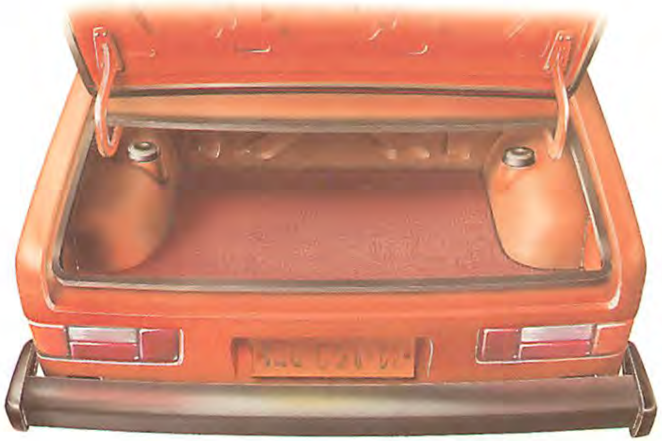
To check the tops of the mounting, open the boot or hatchback lid and look at the rounded outer side of the wheel arch. The mounting point is usually easy to see.

Check the threaded end of the pin for damage (which will make removal difficult), for the tightness of its one or two securing nuts and – most important – for the condition of the rubber disc under a nut.

To inspect the underside of the mounting, loosen the wheel nuts, jack up the rear of the car, support the chassis on axle stands, and remove the wheels.

Use a torch or inspection lamp to inspect the condition of the rubber disc and the condition of the metal at the top of the turret.

At the same time, use the lamp to check the lower part of the damper and the lower mounting.



The top of a turret mounting is usually on the wheel arch inside the boot. Test it for tightness.

Use a torch to inspect an upper pin-type mounting beneath a domed turret on the wheel arch.

How to check displacer units

Cars fitted with hydraulic suspension systems, such as some in the BL range, make use of fluid under pressure to provide the springing effect.

At each wheel, there is a displacer unit – a piston with a sealed cylinder that takes the place of the spring.

Frequently the units on each side of the car are connected front to back by high-pressure piping, to provide the desired suspension characteristics.

In other installations, the inter-connections are across the car – nearside rear to offside rear and nearside front to offside front.

Often, the displacer units also act as dampers, otherwise they are assisted by hydraulic dampers, which should be checked in the same way as dampers on any other car.

Because the suspension relies on fluid under high pressure, it is essential to find any leaks in the system and have them rectified immediately.

Otherwise, either one or both sides of the car will sink to the rubber bump stops, with a loss of suspension movement.

If this happens, it is usually possible to drive the car very slowly – maximum 30 mph – but it should be taken to a garage for repair as soon as possible.

Sometimes re-pressurising the system will restore its proper function, but this work must be done by a garage equipped to undertake it.

The ride height of the car (SHEET 236) gives a good indication of the condition of the suspension. The correct height is given in the car handbook.

Inspect the displacer units and associated pipework during routine servicing, or at the intervals recommended in the car handbook.

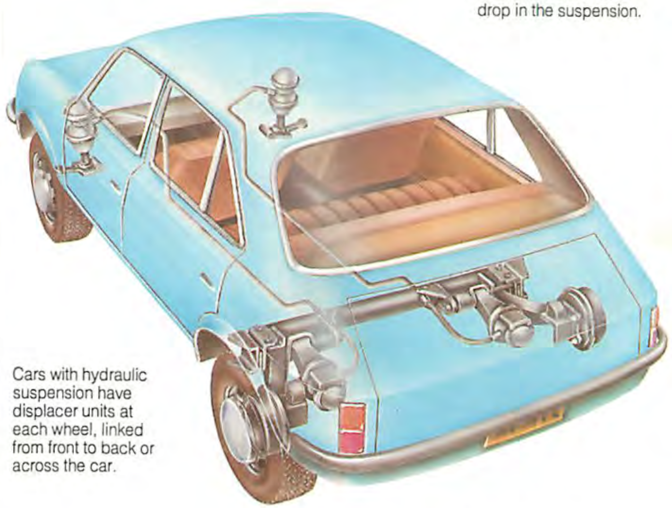
On some cars, the front displacers are in the engine compartment. On others, they can be seen only from underneath the car. The rear displacers can usually be seen and reached from underneath.

Jack up both ends of the car on one side and support them on axle stands, with the handbrake firmly applied and the other wheels chocked.

The work is easier if you remove the wheels to get a clear view.

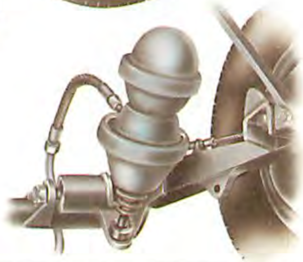
Follow the lines of the hydraulic pipes. Look for leaks at the pipe unions and for signs of damage caused by flying stones or pipes rubbing against any components.

If you find any leaks or damage, take the car to a garage equipped to deal with the make concerned and have the system repaired.



Cars with hydraulic suspension have displacer units at each wheel, linked from front to back or across the car.

Measuring the ride height of the car will reveal a drop in the suspension.



Some displacer units can only be checked from underneath the car.

Checking engine dampers

Engines prone to rock on their rubber mountings, particularly at idling speeds, have extra dampers or plain bars with rubber-bonded bushes at either end to hold them steady.

Cars with transverse engines, and a few others, have dampers – either plain 'steady bars', hydraulic telescopic units or a combination of both.

Check the dampers during major services, every 12,000 miles (20,000 km), or if you suspect that the engine is moving abnormally. This may show as a thump when accelerating or braking, sometimes accompanied by excessive movement of the gear lever.

Inspect the bushes for distortion, softness, perishing, cracking or oil contamination.

Try to move the bar by hand or with a lever. If it moves at all, one or both bushes may be faulty.

Remove the bar and fit new bushes. On some cars the bushes are integral and you have to replace the whole bar.

Unbolt the bar at both ends and remove it. Inspect the bar and its bolts and mounting points, to make sure they are not damaged, bent or rusted. Replace any doubtful parts.

Replaceable bushes are usually a simple push-in fit. Early Minis have metal cones which fit inside the bushes: press these in with a vice to make the bar easier to refit.

When refitting the bar, you may need to lever it into position while you tighten the bolts. Check a telescopic damper in the same way, but also look for signs of hydraulic leaks.

If you find a faulty damper, check the other engine mountings to make sure that the excessive movement has not damaged them.

Check also to see if the mountings have softened, cracked, perished or separated at the rubber-to-metal bond.

Tools and equipment

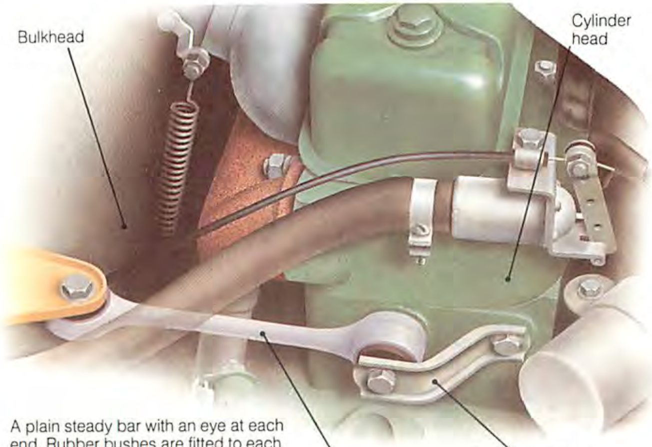
SPANNERS • SELF-LOCKING GRIPS • VICE • SCREWDRIVER

Identifying types of damper

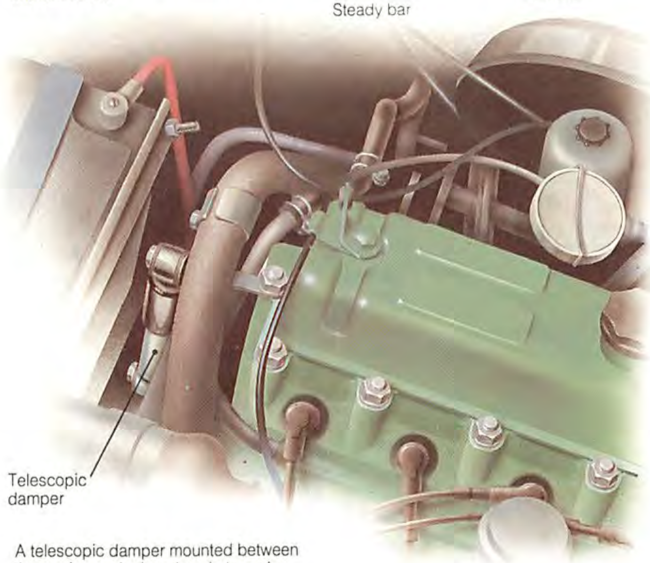
There may be one or two dampers, usually mounted between a bracket on the cylinder head and another on the bulkhead.

Dampers are also sometimes fitted from the engine block or sump to a mounting bracket at the front chassis or subframe cross member.

The damper may be a 'steady bar' – a steel rod with a rubber bushed eye at each end – or a telescopic hydraulic damper.



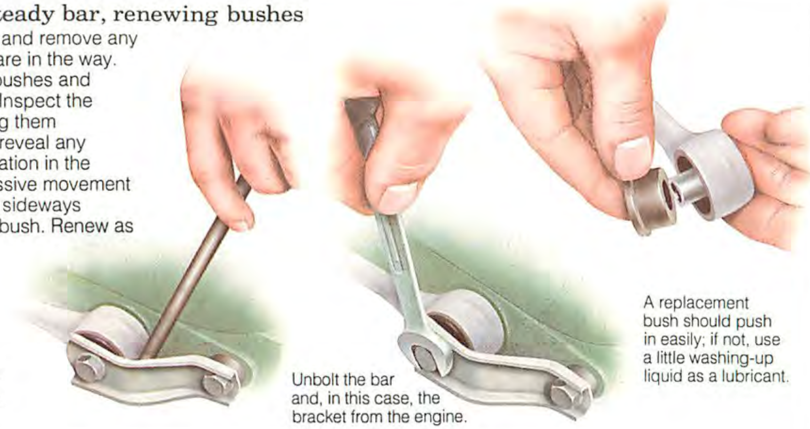
A plain steady bar with an eye at each end. Rubber bushes are fitted to each end of the bar.



A telescopic damper mounted between the engine and a long bracket running from the front to the rear of a transverse engine compartment.

Checking a steady bar, renewing bushes

Open the bonnet, and remove any components that are in the way. Wipe the bar, its bushes and mountings clean. Inspect the bushes by levering them upwards, this will reveal any cracks or deterioration in the rubber. Any excessive movement either upwards or sideways suggests a faulty bush. Renew as necessary.



Lever the bar with a screwdriver to show up any cracks in the bushes.

Unbolt the bar and, in this case, the bracket from the engine.

A replacement bush should push in easily; if not, use a little washing-up liquid as a lubricant.

Checking a telescopic damper

If for any reason you suspect that a telescopic damper is not damping properly – either that it has weakened or that it has seized solid – or if you suspect that it has leaked, remove it and test it in a vice in the same way as a suspension damper.

If in doubt about a damper, replace it. A seized damper will become apparent by excessive vibration transmitted to the car body.

To test a telescopic damper, remove it from the car and test it in a vice by moving it up and down by hand.

Checking adjustable steady bars

Some steady bars are adjustable in length. Adjust the bar until there is no strain on it when the engine is in its normal position.

If the steady bar is adjusted so that it is too long or short, this will put a constant strain on the rubber bushes.

Hold the bar with self-locking grips and rotate it.

After adjustment it should be possible to just move the bar against the tension of the bushes. A service manual for the car may give a maximum and minimum length.

If you have to adjust it outside this range, probably the engine mountings are distorted or perished.

Some bars can be adjusted in place by loosening a locknut and turning the bar; others have to be unbolted at one end.

When you tighten the locknut, take care you do not twist the bushes.

This steady bar can be adjusted without removing it: first loosen the locknut.

Turn the bar with self-locking grips until you can just move it against the tension of the bushes.

Checking leaf springs and bushes for wear / 1

Leaf springs are likely to wear because they have several moving parts. They should be inspected at intervals specified by the car manufacturer, or at major service intervals – usually every 12,000 miles (20,000 km).

Before you jack the car up, put it on level ground, make sure that the tyres are at their normal pressures and that the car is at its normal 'kerb weight' – without passengers, and with a full fuel tank.

Crouch down a little distance behind the car and see how it sits on the road.

It should appear level from side to side. If one side appears lower than the other, there may be a weak or damaged spring on that side.

Prolonged use of the car with only the driver on board may cause a slight sag in the springs on that side of the vehicle. If the sag is significant, the springs may need to be replaced.

Move to each side of the car and examine the attitude of the swinging link spring shackles, which may be at the front or rear end of the springs. The links should generally be vertical when the vehicle is at its kerb weight.

Any significant deflection to front or rear indicates a weakened spring.

Compare the deflection of the shackles on both sides of the car; they should be approximately the same.

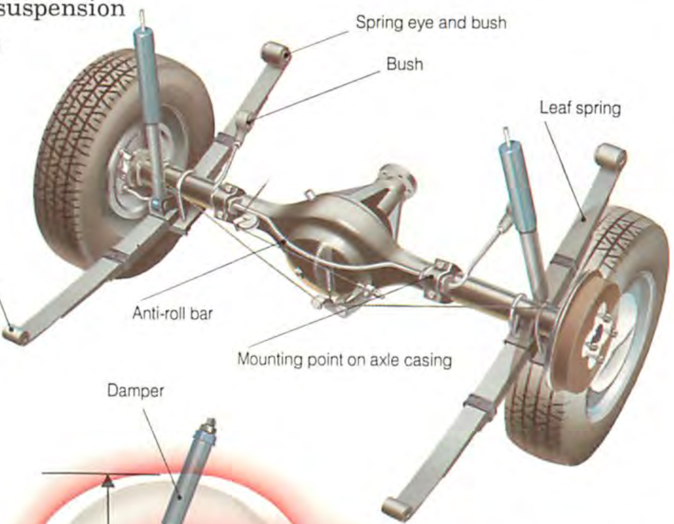
If, from this check, the rear spring or springs appear to be weak, make a further inspection to find the reason. It may be due to damage, or to a general settling down of the springs through age.

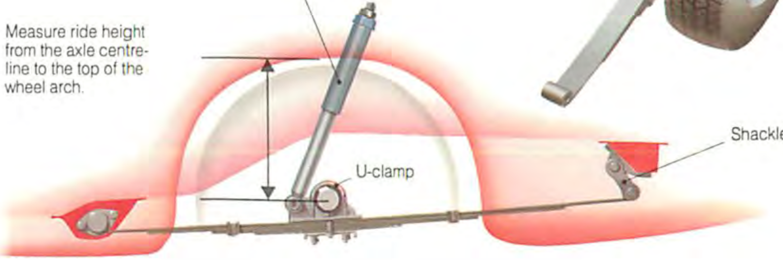
Tools and equipment

JACK • AXLE STANDS • RAMPS • SPANNERS • SOFT-FACED HAMMER • WIRE BRUSH • SILICONE-BASED LUBRICANT • DEGREASING SOLVENT • SAFETY GLASSES • RAG

Leaf-spring suspension

Leaf springs are used at the rear in many cars.





Measure ride height from the axle centre-line to the top of the wheel arch.

Cleaning leaf springs

The standard leaf spring is made from several thin strips of sprung steel of different lengths and held together by clamps.

It is subject to wear as the leaves rub against each other during suspension movement. To overcome this, a tapered-profile single leaf spring is fitted on some vehicles.

Dirt particles between separate leaves accentuate wear and rust. The springs should be kept fairly clean in order to extend their useful life.

The intervals at which this is done will be given in your car handbook.

Modern leaf springs do not need lubricating with oil – which may damage any anti-friction material between leaves. Spray them instead with a silicone-based lubricant.

With most modern cars, leaf springs are found mainly in the rear suspension. Raise the end of the car to clean them.

Remove the hub caps and trims from the wheels, and loosen the wheel nuts. Jack up one side of the car so that the wheel is clear of the ground, and support the car on an axle stand under a chassis member (not under the axle).

Do the same at the other side of the car, so that it is supported under the chassis on both sides, with the wheels clear of the ground.

Chock the front wheels and remove both rear wheels.

The weight of the vehicle is now off the springs, which allows the leaves to separate slightly, making it easier to clean them.

If the spring leaves are really caked with dirt and grease, cleaning them is a messy job.

The road or garage floor under the car will be badly stained unless you spread plenty of newspaper or plastic sheeting to catch the drips.

Use a proprietary degreasing fluid if necessary, either spraying it on or using an old scrubbing brush. Dry the springs afterwards with absorbent rags.

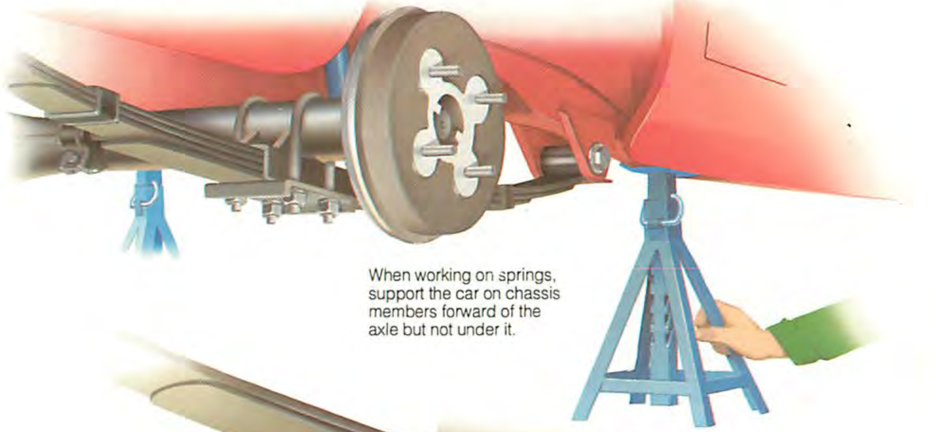
If the spring is simply coated with dry dirt or rust, use a wire brush to remove all traces.

Wear safety glasses or goggles to prevent small particles of grit or rust being flicked into your eyes.

Work the brush vigorously along the sides of the spring, the under and upper surfaces and around any clips that may be fitted to hold the leaves together. Afterwards, wipe it clean with a rag.

After cleaning the springs, lubricate them lightly with silicone lubricant, replace both wheels and their wheel nuts. Lower the car to the ground and fully tighten the wheel nuts.

Replace the hub caps and trims, making sure that they are securely located.



When working on springs, support the car on chassis members forward of the axle but not under it.

Wire-brush as much dirt and rust as possible off the springs, especially between the open ends of the leaves.

Clean shackles and bushes thoroughly with a wire brush.

Use a proprietary degreaser, applied with a brush or spray, to help remove as much dirt as possible.

Checking leaf springs and bushes for wear / 2

Checking leaf springs and mountings

Carry out the checks while the springs are being cleaned (SHEET 236).

Look to see if one spring is flatter than the other, in which case the car will probably have a pronounced tilt to one side. This will indicate that you should also check the ride height (SHEET 236).

Examine the edges of the spring leaves, look for cracks. Fractures found in the spring leaves cannot be repaired by welding. The leaf or the complete spring must be replaced as soon as possible by a garage.

Look at the lower surfaces of the leaves, where the ends of the shorter leaves bear against those above.

The tips of the shorter leaf may dip into the surface of the leaf above it, and make a slight depression. The leaves then bind as they move against each other. A slight depression is acceptable, but the spring should be replaced if the depression exceeds $\frac{1}{8}$ in. (3 mm).

Check the condition of the shackle pins that pass through the rubber bushes. Make sure that they are not bent or badly corroded, in which case they may be very difficult to remove and should be replaced at a garage.

Make sure the nuts on the U-bolts which hold the springs to the axle are tight. If they are loose, the axle will move in relation to the springs. That will cause steering and tyre wear problems. It will also cause the brakes to judder on application.

The spring centre-bolt head or the dowel pin that locates the spring on its mounting pad may also shear.

The axle is then free to move backwards, and may break away from the springs.

A multi-leaf spring has two or more U-shaped clips towards the outer ends. They hold the main leaves in alignment with each other, and may be held in place by rivets or bolts.

Check the condition and security of each clip. If you find one loose or broken, have it replaced immediately.

Otherwise the spring loading will not be evenly distributed during the full suspension travel over uneven ground. This could cause the master leaf to break under stress.

In some cases, the lower, shorter leaves of the spring are not held in place by spring clips, but rely instead on the U-bolts to keep them in line with the rest of the spring.

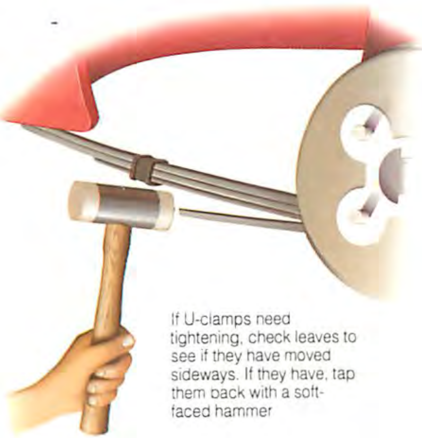
If the U-bolts become slack, the shorter leaves may move sideways. If they do, tap them back into place with a soft-faced hammer and tighten the U-bolt nuts fully.

To check the rubber bushes in the eyes at each end of the springs, back the rear of the car up on ramps. Apply the handbrake firmly and chock the front wheels.

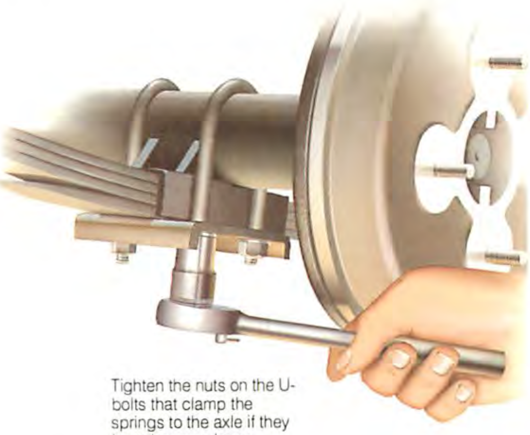
Get under the car and wipe clean the areas around the bushes. Clean also as much of the bushes as the spring shackles allow.

Inspect each bush for signs of wear or distortion caused by the weight of the vehicle on the suspension. See if the rubber has perished, cracked or been contaminated by oil.

If the bushes are damaged, they must be replaced at a garage, as replacement requires removal of the spring from the car and the use of a hydraulic press.

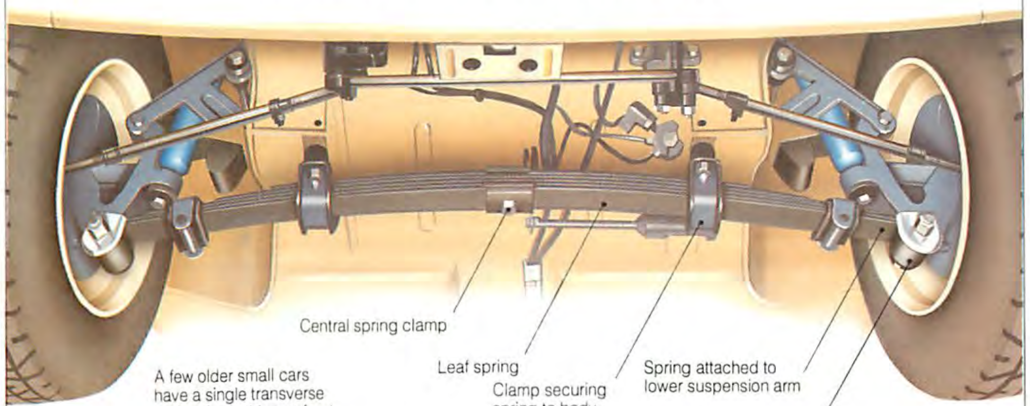


If U-clamps need tightening, check leaves to see if they have moved sideways. If they have, tap them back with a soft-faced hammer



Tighten the nuts on the U-bolts that clamp the springs to the axle if they have become loose.

Checking a transverse leaf spring for wear



A few older small cars have a single transverse leaf spring - this is a front one.

Checking for slackness and rust

Take the weight of the car off the suspension to check the springs for sideways movement.

Remove the chocks from the front wheels and drive the car off the ramps. Jack up the back and support each side with an axle stand placed under a firm part of the chassis, not under the axle.

Grasp the spring and try to twist it sideways at each end; it should not move. Check further by trying to lever the bushes from side to side.

If the rubber bush is in good condition, there should be no sideways movement of the spring. If there is, have the bush replaced.

Use a wire brush to clean the grime from around the spring mountings in the floor pan of the car and the shackle bolts.

Check each shackle bolt and nut for tightness, and tighten any that are slack.

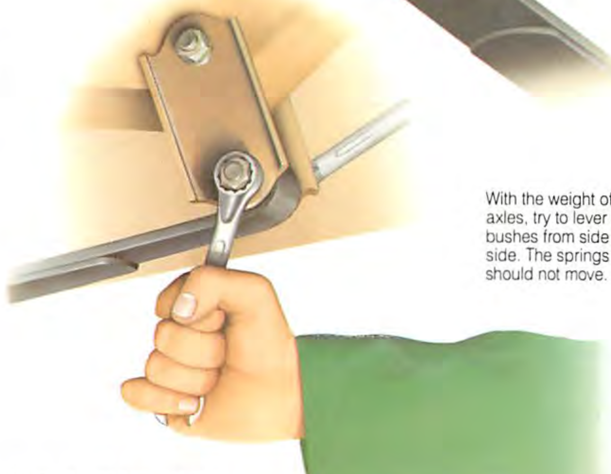
Take the opportunity to look for signs of corrosion on the floor pan and chassis member around the mountings.

Probe suspect areas with a screwdriver or tap them with a hammer. The metal should be completely sound.

If you find the floor pan or mounting areas to be rusting badly, take the car to a garage for repair. Do not use it for any other journey until this weakness has been fixed.

If there is only surface rust, use a wire brush to clean the metal. Treat the affected area with a proprietary rust preventative, followed by an underbody sealant.

With the weight off the axles, try to lever the bushes from side to side. The springs should not move.



Check shackle bolts for tightness using socket or ring spanners.

Replacing anti-roll-bar bushes / 1

Anti-roll bars are sometimes fitted only to the front suspension, but many cars also have them fitted to the rear suspension.

Check all the anti-roll-bar bushes at the intervals recommended in the service schedule for the car, or at intervals of 6,000 miles (10,000 km) or six months.

If any bush is damaged or worn, replace it – and the corresponding bush on the other side of the car. If one is damaged, the other is probably in poor condition too.

Any bushes that are split lengthways can usually be renewed without removing the bar completely. If the bush is not split, the bar must be removed.

Drive the front or rear of the car up on ramps or over an inspection pit.

If you use ramps, make sure the handbrake is applied firmly and that the wheels still on the ground are chocked.

The weight of the car on the suspension reduces the load on the anti-roll-bar mounts and makes them easier to unbolt and refit.

A different method

However, you may find the road wheels prevent you from reaching some of the bushes, so the wheels should be removed. In that case, raise the car by a different method – which can also be used if you do not have ramps or a pit.

Loosen the wheel nuts at the end you are working on, jack up the car and support it on axle stands under the chassis members. Remove the road wheels.

Jack up each lower suspension arm and support it to reduce the load on the anti-roll-bar mounts.

Unscrew the nuts or bolts which hold the U-clamps and their bushes to the floor pan. Make a careful note of the number and position of the components as you remove them.

Pull the anti-roll bar down, pull off the bushes if they are the split type.

If they are not split, free the end of the bar from its mounting on the suspension arm and pull the bush along the bar and off.

It may be easier to cut the old bushes free, or they may be lubricated with soap solution to ease them along the anti-roll bar.

If you have to replace the end bushes on the anti-roll bar, you may have to remove the complete bar.

Fitting eye bushes

New eye bushes can be drawn into place with a socket, a long bolt and a large washer.

The socket should be of slightly larger diameter than the bush. Put the socket at one side of the eye into which you are fitting it, and the bush at the other side.

Pass the long bolt through the socket, the eye and the bush. Fit the washer and the nut and tighten the whole assembly. This draws the new bush into place.

The bushes on the short vertical links to the anti-roll bar can be dealt with in the same way. Sometimes they are eye fittings, others fit around the shaft of the link itself.

Align the new bushes with the marks worn on the bar by the old ones. Refit the various shims, washers, clamps and bolts, and push the bar up towards the floor pan, or cross member.

Screw in the mounting bolts. Make sure that they are fully tightened.

In some cases, these nuts or bolts should be tightened with a torque wrench to a specific torque setting. The figure will be given in a service manual for the car – otherwise, ask your local dealer.

When you have replaced the bushes, remove the wheel chocks and lower the car to the ground.

Tools and equipment

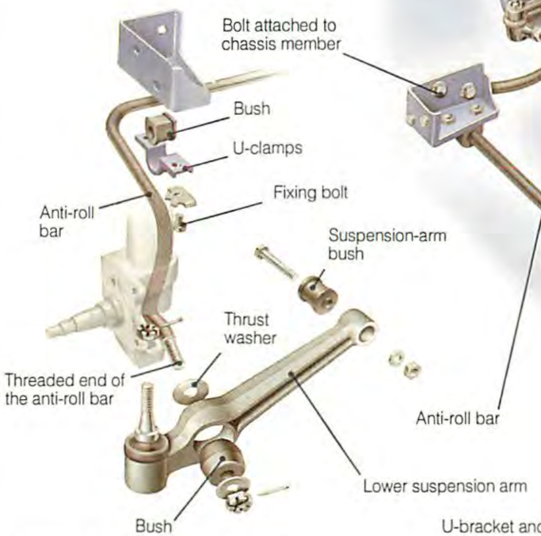
CHOCKS • JACK AND AXLE STANDS/RAMPS • SOCKETS • SPANNERS • SCREWDRIVERS • SOAP SOLUTION • TORQUE WRENCH • VICE

The anti-roll bar

The forces imposed on the bar subject it to constant twisting and flexing, which in turn put its various rubber mounting bushes under great load.

The bushes gradually wear and lose their effectiveness. Over a period of years the rubber hardens and tends to crack.

If oil is allowed to contaminate the bushes, it softens them rapidly and they may even disintegrate.



Removing vertical links

If the anti-roll bar is connected to the suspension by short vertical links, you may be able to replace their bushes by removing the links without disturbing the main bar.

Inspect them carefully – you should be able to judge whether removal is possible. If in doubt, consult the car service manual.

Whatever the layout of the links, jack up the end of the car and support it on axle stands.

In some cases the ends of the bar are threaded, and pass through a bush in the arm. A locknut is fitted to the end of the bar to hold it in place. Remove the nut and pull the bar out.

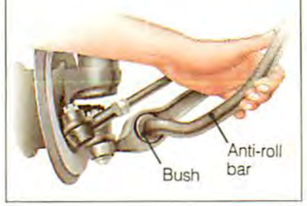
There may be eye fittings at each end of the bar, which is held to a bracket on the suspension arm or axle by a pivot bolt. Unscrew and remove the bolt.

Make a careful note of all washers, shims and spacers that make up the mounting; they must be replaced in exactly the same order as they came off. Always renew any locknuts.

The anti-roll bar is sometimes connected to the suspension by short vertical links.

Checking for wear

With the car firmly supported on axle stands and with the road wheels off, take hold of the anti-roll-bar components and push and pull vigorously. If you can move anything by hand, the bushes are worn.



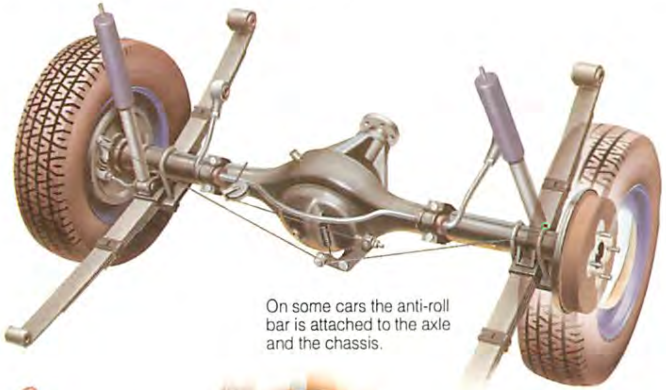
Replacing anti-roll-bar bushes / 2

Rear-suspension types

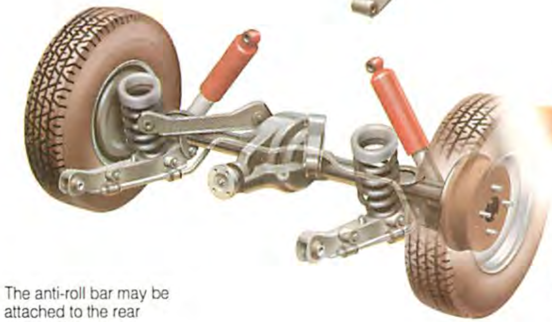
Anti-roll-bar mounts vary from car to car. Some bars form a link across the rear axle and attach to the suspension arm on each side.

Others may link the leaf springs, passing over the axle tube with firm mountings on chassis members or floor pan.

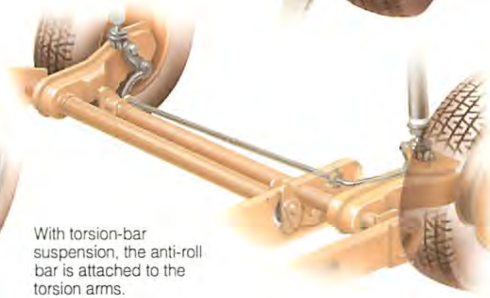
On torsion-bar suspension, the anti-roll bar runs from one arm to the other, the central part again being clamped to the floor pan.



On some cars the anti-roll bar is attached to the axle and the chassis.



The anti-roll bar may be attached to the rear suspension arms.



With torsion-bar suspension, the anti-roll bar is attached to the torsion arms.

Fitting end pins or eye bolts

Some anti-roll bars have vertical links at the ends connected to the suspension. The links may have end-pin fittings, or eye-bolt fittings.

The pin fitting in particular may have a distance piece in the form of a tube between two washers or endplates.

The distance pieces take the load, while the rubber bush takes the shocks – do not forget to replace the distance piece when you fit new bushes.

With the car raised on axle stands, use a jack under the suspension arm to take the load off the anti-roll bar, so that it does not fly apart violently when a mounting clamp is released.

The jack can also be used to raise or lower the arm to help in aligning the vertical link with a mounting hole.

Use a vice to press new bushes into a rod with an eye mounting by squeezing the bush into the eye.

Some anti-roll bars have end-pin or eye-bolt fittings.

The rubber bushes take the shocks, and should be renewed if they are worn.

Check the eye-bolt mounting of a vertical link.

Removing the bar

Look underneath the car to find the U-clamps which hold the anti-roll bar to the floor pan or suspension cross member.

Make a careful note of any washers, spacers and other parts of the mounting. Make sure that they are replaced in exactly the same way.

Check the position of the bushes and, in particular, the position of any marks or splits in the rubber bushes in relation to the bar, so that you can fit the new bushes in exactly the same way.

Use a socket spanner to slacken the U-clamp mounting bolts and nuts.

If you do not have a socket, use a ring spanner. Use an open-ended spanner only as a last resort, for these nuts and bolts tend to be misshapen due to corrosion, and need the best grip possible.

Remove the nuts, bolts, washer clamps and spacers from each mount, at each end and towards the centre of the bar. Collect all the pieces and keep them in the correct order.

Pull the anti-roll bar downwards from the floor pan or cross member until there is sufficient clearance to take it out.

Take all the old rubber bushes off. Lever each one off with a screwdriver or similar tool if they do not slip off easily.

Wipe the bar clean. Coat it with soap solution to lubricate the path for the tight new rubber bushes.

Press each new rubber bush over the anti-roll bar. Make sure that the split in the rubber bush faces in the same direction as the old one, if applicable, and that the new bushes fit over the wear marks left by the old bushes.

Use a socket spanner to slacken the U-clamp mounting bolts and nuts.

Remove washer clamps, spacers and other parts, keeping them in order.

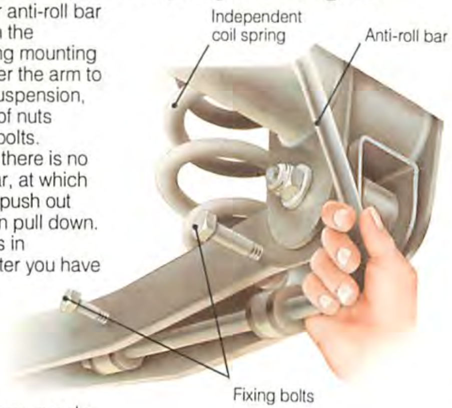
Use a bar to prise away the anti-roll bar, so that you can slip the new bush into place.

Removing the bar from a rear-spring mounting arm

On some cars the rear anti-roll bar is secured underneath the independent coil-spring mounting arm. Place a jack under the arm to take the load off the suspension, and unscrew the pair of nuts securing the through-bolts.

Adjust the jack until there is no load on the anti-roll bar, at which point the bolts should push out freely. The bar will then pull down.

Because of changes in suspension attitude after you have taken the bar off, you may need a second jack to help reposition the anti-roll bar under the suspension arm when the bar is replaced.



The anti-roll bar is secured underneath the mounting arm.

Fitting new dampers / 1

Modern telescopic dampers cannot be overhauled at home. The only servicing possible is to replace rubber bushes (SHEET 233).

Dampers that are leaking, damaged or worn out (SHEET 233) should be replaced with new units.

Fitting new dampers is usually straightforward, and can be done with a few medium-sized ring spanners or ratchet sockets.

On combined coil-spring and damper units you will also need to use spring compressors (SHEET 51); hire from a tool hire shop if necessary.

The force in a compressed spring is considerable, and a make-shift compressor could slip, allowing the spring to expand suddenly and maybe cause damage or injury.

For cars with MacPherson-strut suspension, new damper inserts can be fitted to the strut (SHEET 244).

Always replace dampers in axle sets – both rear and front – otherwise the car handling becomes unbalanced.

You can buy dampers from a car accessory shop, or order them from an authorised agent.

Always give the correct make, model, year and chassis number of the car; note that saloons and estate cars of the same model may have slightly different dampers.

Apart from the standard dampers for a particular model, dampers at different ratings are also available.

They are designed for particular characteristics, such as handling and load bearing. Ask for advice about uprated dampers at an accessory shop specialising in suspension parts.

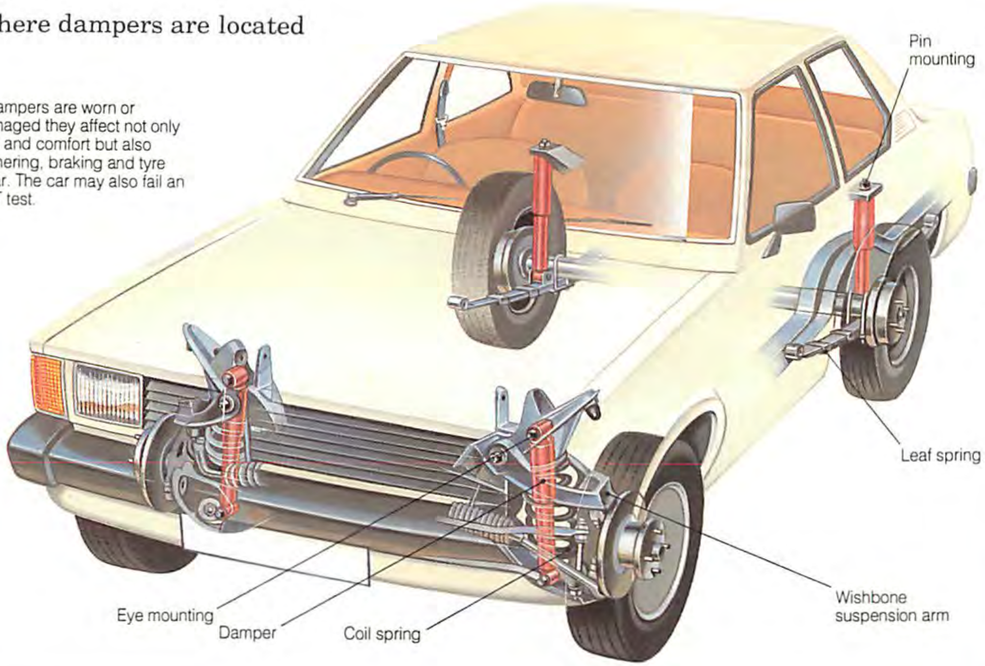
Look at the unit carefully to make sure that it is not damaged, and that the mountings are the right type.

Tools and equipment

SPANNERS • RATCHET SOCKETS • TORQUE WRENCH • VICE • SELF-LOCKING GRIPS • COIL-SPRING COMPRESSORS • 6IN. (150MM) RULE • JACK • AXLE STANDS • RAMPS • WHEEL CHOCKS

Where dampers are located

If dampers are worn or damaged they affect not only ride and comfort but also cornering, braking and tyre wear. The car may also fail an MoT test.



Undoing and reassembling damper mountings

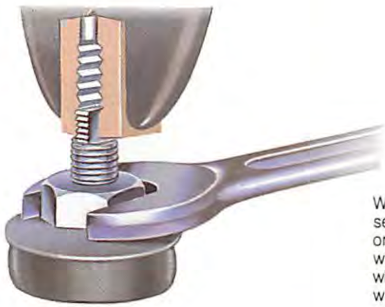
An upper pin mounting is the threaded end of the damper piston rod, and may have one or two securing nuts.

Before undoing it, note the sequence of rubbers and washers on each side of the body panel through which it is mounted.

Also measure the length of the thread protruding above the top nut. It must be the same when refitting.

When fitting new dampers, for both pin and eye mountings always use the new rubbers, spacers, washers and nuts supplied; make sure they are in the right sequence, noted when dismantling.

Nuts may have to be tightened to a specific torque setting with a torque wrench; check with a dealer or in the car service manual. Where there are two nuts, the setting applies to the first, lower nut; the other is a locknut.



Where there is one securing nut, hold the flat or squared end of the pin with self-locking grips while you undo the nut with a spanner.

Where there are two securing nuts, use an open-ended spanner to hold the lower one while you unscrew the other with a second spanner.

Front suspension layout

A number of modern cars have a front suspension system with an upper wishbone-shaped arm attached to the inner wing or an outrigger, and a lower wishbone arm attached to the chassis.

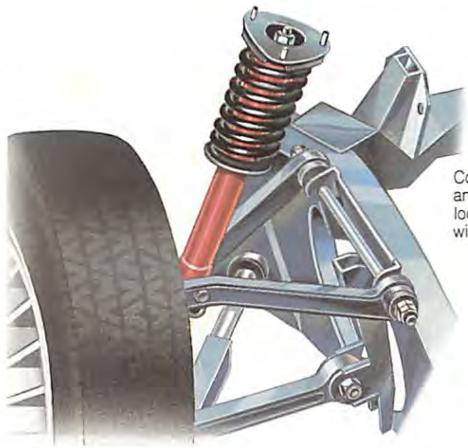
The dampers are usually fitted between the lower wishbone arm and the inner wing or outrigger. A few makes have the bottom damper mounting on the upper wishbone.

Where the wishbone suspension incorporates a coil spring, the damper is usually mounted within the spring, but can be removed without dismantling the spring.

On some cars, however, the coil spring and damper are combined, and the spring has to be dismantled and fitted to the new damper.

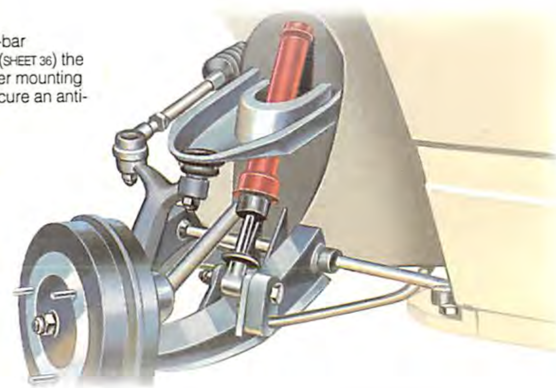
Sometimes, particularly where the coil spring bears on the upper wishbone, the spring must be compressed before the damper is removed from the car.

With either coil-spring or torsion-bar suspension, the lower wishbone must be jacked up to take the load off the damper bolts before you remove the damper from the car.



Combined coil springs and front dampers may be located on an upper wishbone suspension arm.

With torsion-bar suspension (SHEET 36) the lower damper mounting may also secure an anti-roll bar.



Fitting new dampers / 2

Apply the handbrake and chock both rear wheels.

Take off the hub caps or wheel embellishers and slacken the wheel nuts. Jack up the front of the car and support it on axle stands under the chassis, so that the weight is off the suspension. Remove both front wheels.

Examine the upper and lower damper mountings to find out which type of fitting is used (SHEETS 233-234). Note where any washers, rubbers and spacers are positioned.

Place a jack under the lower suspension arm; if the damper is fixed to the lower arm, make sure the jack does not block access to the bottom mounting bolt or nut.

It may be possible to position the jack under the wheel mounting flange. This will ensure free access to the damper and its mountings.

Raise the jack to lift the suspension arm; this will compress the spring and damper slightly and take the load off the damper mountings. Do not remove the jack until the new damper has been fitted.

On some coil-spring suspensions, you may need to compress the spring (SHEET 246) before undoing mountings.

If the top mounting is a threaded pin, note carefully how much of the thread sticks up above the top nut, as it must protrude by the same amount when refitted.

Measure the thread protrusion above the nut with a 6 in. (150 mm) rule.

On some cars, the upper mounting may be a bushed eye and pivot bolt, like the lower mounting.

Undo the pin mounting (SHEET 240) or bushed eye mounting (SHEET 242) at the top and bottom of the damper.

If the nuts and bolts are corroded and difficult to remove, soak them for at least an hour with penetrating oil before attempting to take off the damper.

New dampers are usually supplied complete with rubber bushes, washers, spacers and nuts. Always use the new fixings, not the ones you have removed.

Reassemble the mountings in the order of removal, with correct pin measurements and torque settings for tightening nuts.

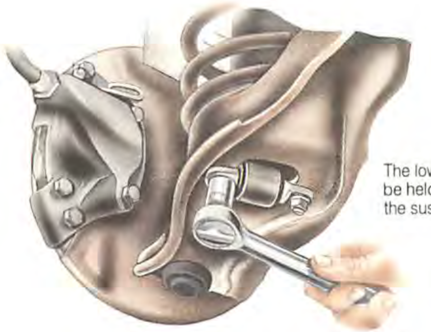
Final tightening of damper mountings is usually done with the car still raised, although it is sometimes done after the car has been lowered to the ground; check with the car service manual or a dealer.

Removing dampers from unattached coil springs

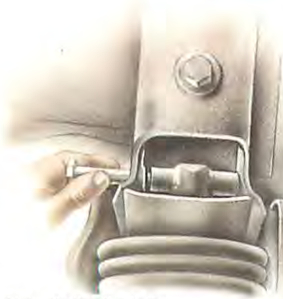
With the car supported on axle stands and the front wheels removed, jack up the lower suspension arm to take the spring pressure off the damper mounting bolts.

Both the upper and lower damper mountings may be bushed eyes and pivots, but the lower one is likely to have its pivot held by bolts through the suspension arm.

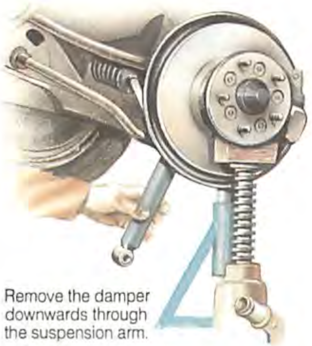
Remove the top and bottom mounting bolts and slide the damper out through the bottom arm of the suspension.



The lower eye pivot may be held by bolts through the suspension arm.



Note whether the bolt head on the top mounting fits towards the front of the car. Refit the same way.

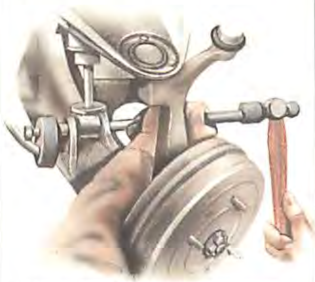


Remove the damper downwards through the suspension arm.

Torsion-bar suspension

On cars with torsion-bars, such as the Renault 5, the upper mounting is often a threaded pin reached from under the bonnet, the lower one a bushed eye and pivot. It may also secure an anti-roll-bar mounting.

Undo the mountings. To remove the damper, lower it through the wishbone arm.



Tap out the pivot bolt from the lower mounting with a drift.

Push the damper rod in and lower it from the car.

Renewing a combined coil spring and front damper

Where there is a combined coil spring and damper – as in some Triumph cars, including the Dolomite – the bottom of the damper is often located in the upper wishbone.

With the front of the car supported on axle stands, the front wheels removed, and the suspension arm jacked up, fit spring compressors to compress the coil spring (SHEET 246) so that you can remove the damper.

Undo the nuts holding the upper mounting of the damper. It is usually a spring cup held in place by the nut on the end of the piston rod.

The cup is secured to the inner wing by three or four bolts, reached from under the bonnet.

Unbolt the lower bushed-eye mounting (SHEET 242) and compress the damper by hand to lift the bottom end off the upper wishbone.

To remove the damper, pull it down to clear the upper wing.

Place the compressed spring and damper in a vice; if necessary, compress the spring further so you can turn the spring cup.

Remove the nut holding the cup, and take off the rubber bush, washers, cup and spring insulating ring. Note the sequence so that parts can be refitted in the same way.

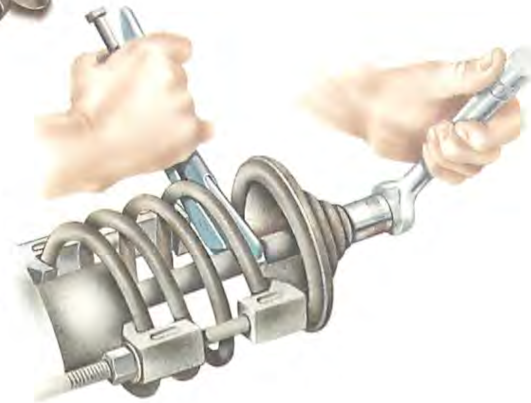
Remove the compressed spring and fit it to the new unit. Fit the spring-cup components. The lip of the spring insulating ring should be inside the coil spring.

Refit the damper to the car, and secure the mountings before removing the spring compressor.

Tighten nuts to the correct torque setting if one is specified.

Undo the spring-cup mounting nuts under the bonnet.

Remove the pivot bolt to release the bushed-eye lower mounting.



With the spring held by compressors and the unit in a vice, hold the damper piston rod with grips while you undo the cup securing nut. Remove the nut, bush, washers, cup and ring.

Fitting new dampers / 3

Removing rear dampers

Rear dampers are usually easier to remove than front ones.

It may be necessary to remove the wheels; check in a service manual for the car.

If it is, slacken the wheel nuts before jacking up the rear of the car and supporting it on axle stands beneath chassis members. Chock the front wheels.

Note the location and type of the mountings of each of the dampers (SHEETS 233-234).

To take the load off the damper mountings, jack up the rear axle or suspension arm, depending on where the damper is located.

A few cars have the rear dampers mounted in the middle of coil springs located on the suspension arm. Sometimes they are a combined unit with a spring-cup mounting at the top – see illustration below right.

For coil springs you may need spring compressors specifically designed for car coil springs (SHEET 51). Hire them if necessary.

Undo the top and bottom mountings. The top mounting is often a threaded pin (SHEET 240) through the inner wing or a bodywork turret, reached from inside the boot or the rear of the car.

You may have to remove some interior trim to get at a top mounting, and it may be covered with a rubber or plastic cap.

The lower mounting is usually a bushed eye and pivot.

To remove the damper, pull down on the damper body to compress it so that you can clear the wing. New dampers are usually supplied complete with rubber bushes, washers and nuts. Always use the new fixings when reassembling.

Reassemble the mountings in the reverse order of removal, with the correct pin thread measurements and torque settings (SHEET 240).

Final tightening is usually done with the car still raised, although it is sometimes done with the car on the ground; check with the car service manual or a dealer.

Undoing a bushed-eye mounting

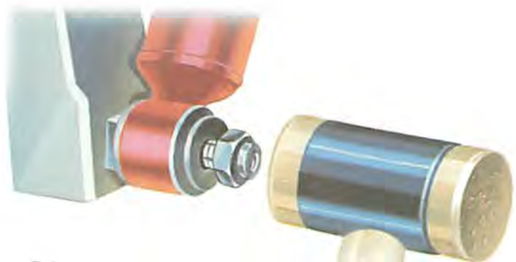
The bushed eye is usually held to the damper mounting by a pivot bolt secured by a nut.

Hold the head of the bolt with a spanner or socket to prevent it turning while you use another to unscrew the nut until its outer face is flush with the end of the pivot bolt. If the nut is very stiff, apply a few drops of penetrating oil and allow it time to act.

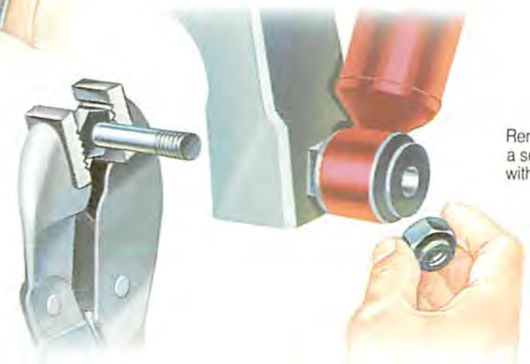
Tap the nut – not the unprotected thread – with a nylon hammer to push the bolt head free at the other end. Remove the nut and grip the bolt with grips to pull it out. Note the position of any washers.

If the bolt is seized in the mounting, drive it out using a drift of soft metal, such as a piece of brass or copper rod.

Hold the bolt head on an eye mounting with a spanner while you undo the nut with a socket.



Before unscrewing the nut completely, tap the bolt backwards from the nut end until you can withdraw it. Use a soft-faced hammer.



Remove the nut and use a self-gripping wrench to withdraw the bolt.

Using spring compressors

Spring compressors may be needed to reduce the tension on a coil spring before the damper is removed from the car. Failure to use them could be dangerous.

On some cars, the combined coil-spring and damper unit can be removed without first fitting a spring compressor. Check in the car service manual.

Once the unit is removed, however, compressors will be needed to compress the spring to separate it from the damper.

For safety, if you are in any doubt, always fit the spring compressors before you remove the damper unit.

Use a pair of spring compressors, one on each side, tightening them alternately a little at a time.

Renewing a combined coil spring and rear damper

Cars with rear dampers in a combined unit with coil springs include the VW Golf and Jetta and the Triumph Dolomite. The methods of securing the upper spring-cup mounting vary.

With the rear of the car supported on axle stands, the front wheels chocked, the rear wheels removed and the suspension arm jacked up, fit the spring compressors.

Undo the spring-cup upper mounting. It may be secured by four nuts holding it to the floor pan, or by one nut only.

Undo the bushed-eye lower mounting from the suspension arm and withdraw the damper.

Fit the compressed spring and damper in a vice; if necessary, compress the spring further so you can turn the spring cup.

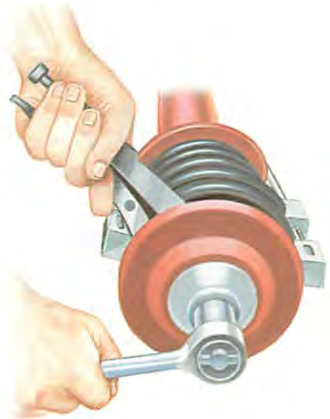
Unscrew the piston-rod locknut. You may need to hold the piston rod with a pair of grips while unscrewing.

Remove the spring cup, rubbers, washers, spacers and spring insulating ring, noting the sequence to aid refitting. Remove the compressed spring and fit it to the new damper.

Reassemble the spring cup, then fit the new damper to the car and secure the mountings before you remove the spring compressors.

Tighten all nuts to the correct torque setting, if one is specified.

Unbolt the eye mounting to release the bottom end of the damper from the axle or suspension arm.



With the unit in a vice and the spring compressed, unscrew the locknut securing the spring cup.

Replacing lever-arm dampers

Front lever-arm damper

A lever-arm damper on the front often acts as part of the suspension unit.

Loosen the front wheel nuts, jack up the front of the car, place axle stands under the chassis members and chock the rear wheels. Remove the front wheels.

Put the jack under the bottom suspension arm on one side. Raise the jack to push the arm up and to take the weight off the damper arm.

The steering arm may be in the way. If so, free it using a ball-joint separator (SHEET 49); you may be able to hire a scissor type.

Alternatively, it may be possible to separate the joint by a sharp hammer blow. Unscrew the nut until it just covers about three or four threads at the end of the ball-joint pin. Hit it with a soft-faced hammer in order to break the seat. When the joint is free, separate the two parts and move the steering arm out of the way.

Undo and remove the bolt that fixes the lever-arm damper to the steering swivel (or stub axle). The damper body may be bolted to a chassis member, subframe or the inner wing. Undo the fixing bolts, and lift it away.

Rear damper

The rear lever-arm damper is a separate part of the suspension. There is generally no need to disturb the rest of the rear suspension.

Loosen the rear wheel nuts, jack up the back of the car and place axle stands under the chassis members. Chock the front wheels. Remove the rear wheels.

Undo and remove the nut and bolt which holds the damper arm to the connecting link. Undo the damper fixing bolts and lift away.

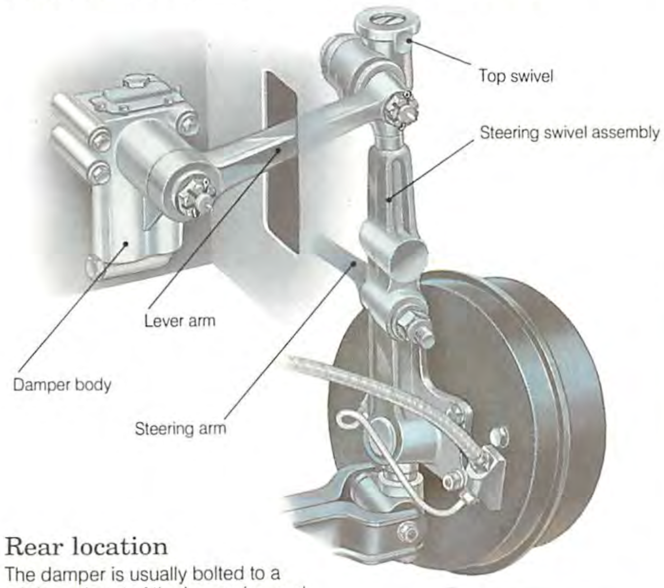
Tools and equipment

JACK • AXLE STANDS • CHOCKS • SPANNERS • PLIERS • SOFT-FACED HAMMER • BALL-JOINT SEPARATOR • SCREWDRIVERS • DAMPER FLUID • WIRE BRUSH

Front damper fittings

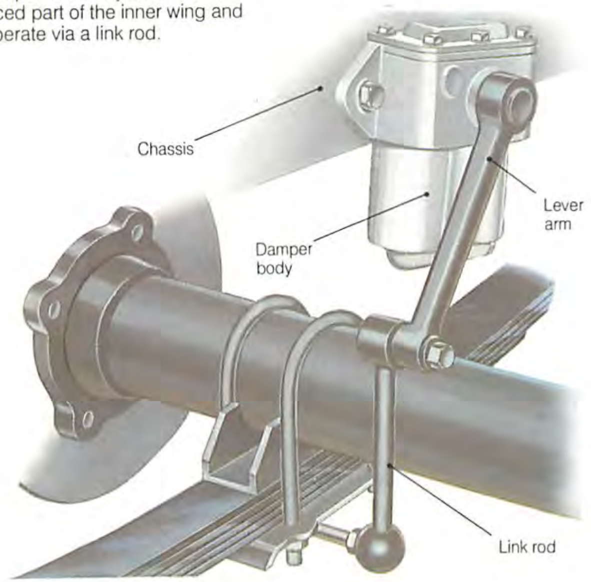
The damper may sit upright and be bolted to the inner wing or to the front bulkhead. The arm operates through a slot in the inner wing.

The damper may also be fixed under the wing, to a chassis member or subframe, and operate through a series of links.



Rear location

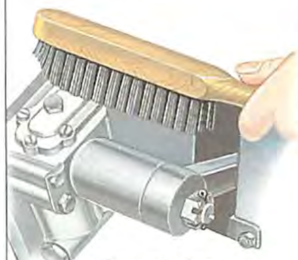
The damper is usually bolted to a reinforced part of the inner wing and may operate via a link rod.

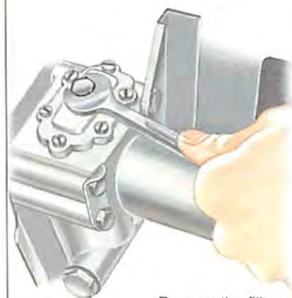


Topping up

The filler plug is on the top. Wipe around the area to clean off road grime. Remove the filler plug with a spanner or large-bladed screwdriver. Top up with damper fluid specified by the manufacturer.

A lot of topping up means a leak; renew the damper.


Brush off grime.


Remove the filler cap when the area is free from dirt.

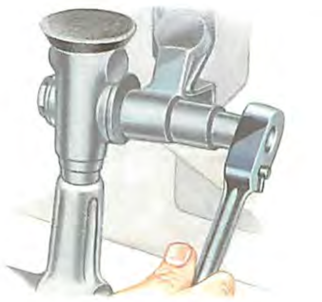

Top up with the specified damper fluid.

Renewing a front lever-arm damper

The lever arm may be secured to the top swivel by a castellated nut and split pin. Remove the pin with pliers and undo the nut. Use a ball-joint separator to free the arm from the tapered mounting pin, and pull the whole assembly clear.

Undo the bolts holding the damper to the chassis. Fit the new damper in reverse order of removal.

Straighten the split-pin legs and remove with pliers. Fit a new split pin when reassembling the joint.


Use a socket or ring spanner to remove the castellated nut.


Separate the arm from the mounting pin. Here a fork-type separator and soft-faced hammer are being used.


When the joint is free, pull the swivel assembly clear of the lever arm.

Damper fixed to chassis member

The damper fixing bolts may screw into captive nuts on the chassis or wing, or there may be bolts with nuts on the other side, in which case two spanners are needed.


Undoing a damper fixing bolt. Some have nuts as well and need two spanners.

Renewing MacPherson-strut inserts / 1

When the damper inside a MacPherson strut wears out, you can buy a replacement cartridge which – depending on type – may or may not include new parts for the strut itself.

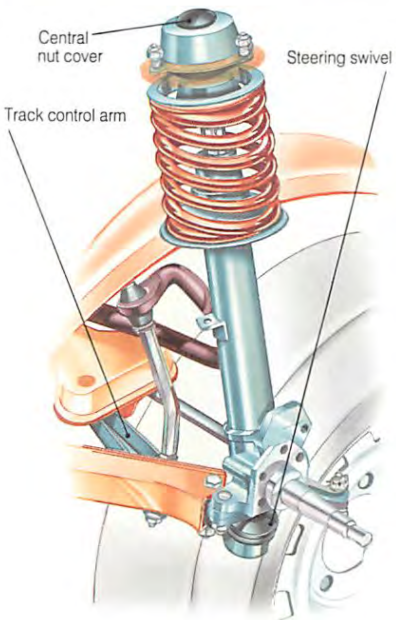
You will need a pair of coil-spring compressors. Hire them if necessary, do not use makeshift arrangements of clamps, wire or cord. They are unsafe.

Loosen the wheel nuts and raise the car on axle stands under chassis or frame members.

Remove the wheels, and open the bonnet or boot lid to gain access to the suspension from above and below.

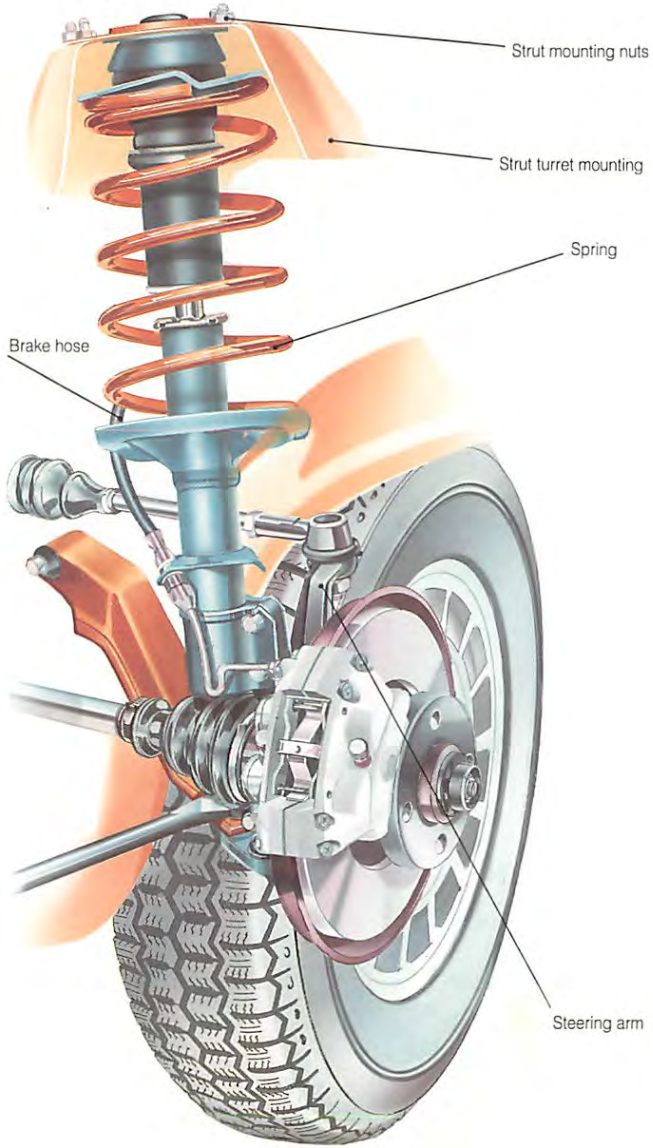
Tools and equipment

COIL-SPRING COMPRESSORS • AXLE STANDS • SPANNERS • BRAKE-HOSE CLAMP • ALLEN KEY • SCREWDRIVER • HAMMER AND PUNCH



The standard MacPherson strut, which does not unbolt in the middle. It is attached by three bolts at the top and two at the bottom.

Unit-replacement strut



The unit-replacement strut has a detachable top section held by a clamp and two bolts.

Removing a standard strut

Unscrew the three nuts above the mounting to release the top of the strut. Do not loosen the central nut between them, which would release the coil spring from the strut.

Remove the two bolts underneath the track control arm, which fix the strut to the arm.

At this stage, examine the suspension before proceeding further; on several cars there is no need to disconnect any of the steering ball joints or the anti-roll bar (if fitted).

On others the track-rod end, and sometimes the track control arm or anti-roll bar or both, must be detached (SHEETS 226–229 AND 238–239).

Clamp the flexible brake hose to close it. Use a brake-hose clamp.

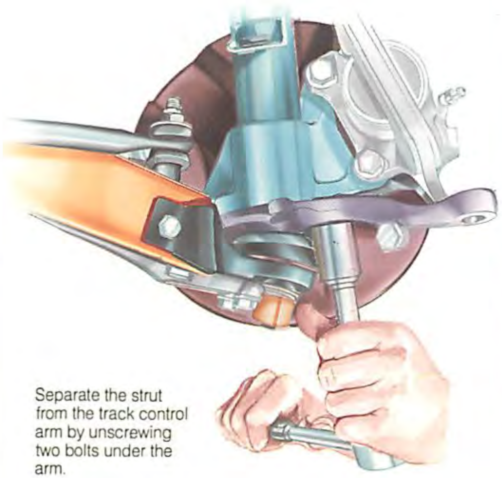
Disconnect the hose from the rigid brake pipe on the strut by unfastening the union nut.

Lift the strut and the brake assembly from the track control arm. Be careful – they are heavy. You may need a helper.

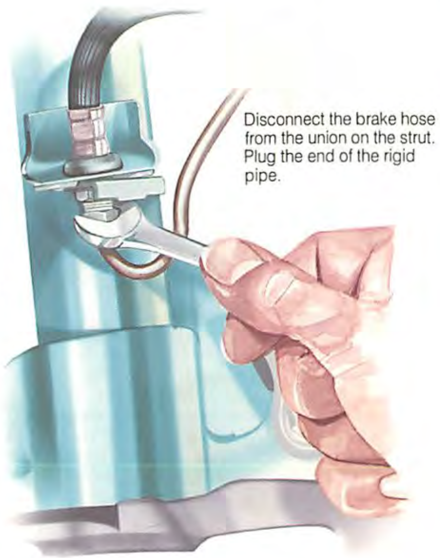
When reassembling, bleed the brakes and top up the master cylinder if necessary (SHEETS 90–91).

Unscrew the three strut mounting nuts, but not the central nut.

Clamp the brake hose with a brake-hose clamp before disconnecting the hose.



Separate the strut from the track control arm by unscrewing two bolts under the arm.



Disconnect the brake hose from the union on the strut. Plug the end of the rigid pipe.

Renewing MacPherson-strut inserts / 2

Removing a unit-replacement strut

Unscrew the two nuts (on some cars three) above the top mounting turret to release the top of the strut.

Do not unscrew the central nut between them, which would release the coil spring.

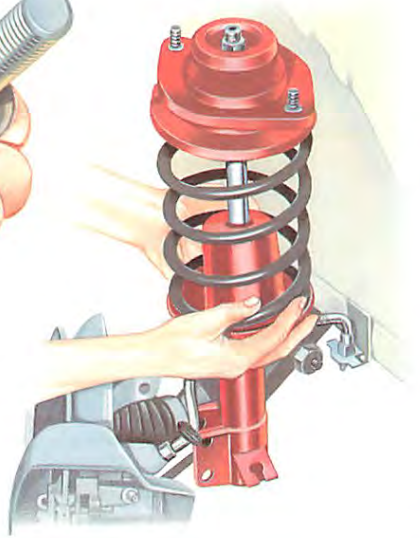
The top part of the strut is fixed to the bottom part by bolts – there may be one, two, or sometimes three.

The lower or lowest bolt may be eccentric, as a means of adjusting the camber (SHEET 222). Mark its head so that you can refit it in exactly the same position.

Remove the nuts and pull out the bolts to free the top half of the strut.

The unit-replacement strut can be split in two by removing two or three bolts.

The lowest of the bolts separating the strut sections may be eccentric – refit in exactly the same position.



With the bolts removed, free the top section of the strut.

Removing and refitting the damper

Clamp the strut in a vice with the upper end higher than the lower end to prevent the oil running out.

Fit a pair of spring compressors round at least four coils of the spring, and tighten evenly until the spring is well compressed and tension on the upper spring mount is released.

Then unscrew the central nut at the top of the damper; on a unit-replacement strut it must be unscrewed with an Allen key.

Lift off the top spring pan and any spacers, and the upper bearing if applicable. Then lift off the compressed spring.

If there is a rubber gaiter round the damper, remove this too.

Free the damper from the strut by unfastening the large gland nut between its two telescopic sections.

If you do not have a spanner that fits the nut, put it in the vice and turn the strut. If the nut is rusty, penetrating oil will help to free it.

Check the threads on the strut tube for damage, and clean them.

You may now be able to remove the damper as a single, sealed unit. If so, clean the inside of the strut with petrol, let it dry and put in the new damper cartridge.

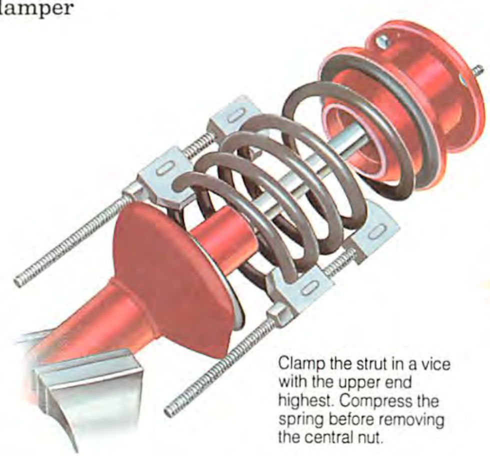
Alternatively, you may have to dismantle the old damper to remove it, but it is not difficult to fit the replacement cartridge, because it is in one piece and includes a replacement piston arm.

Read the instructions on the cartridge box. They may tell you to pour oil into the strut casing – usually 2 fl. oz (50 cc) of light engine oil or special damper oil – to cool the cartridge and prevent corrosion.

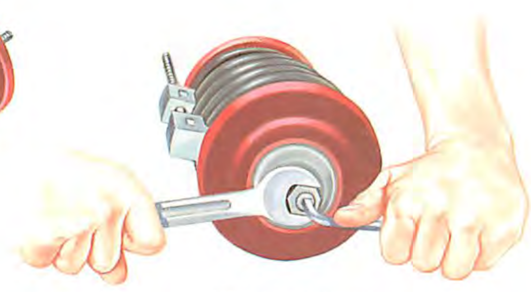
Refit the gland nut. Fix it firmly by denting the outside of the casing in one spot with a hammer and punch.

Refit the spring. Make sure it is set straight, then decompress it evenly. Fit the top spring platform, nut and packing pieces. Then tighten the centre nut fully.

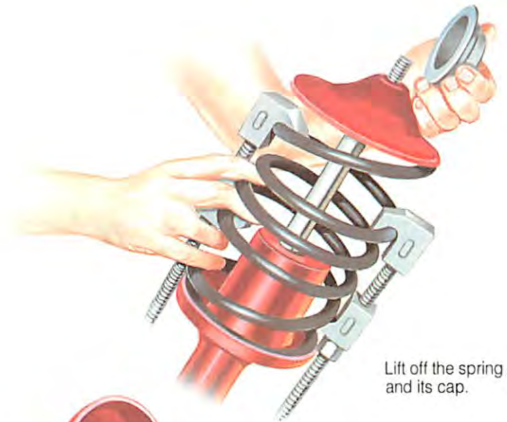
Refit the strut to the car. With a heavy standard-type strut you may find a jack helpful in raising the strut into its upper mounting.



Clamp the strut in a vice with the upper end highest. Compress the spring before removing the central nut.

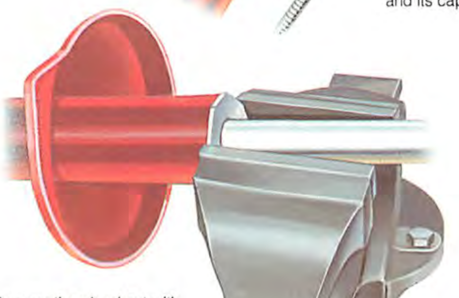


On a unit-replacement strut, use an Allen key to release the top while holding the outer hexagon with a spanner.



Lift off the spring pan and its cap.

Remove the spring complete with spring compressors. Keep the spring compressed ready for replacement.



Remove the gland nut with a spanner, or clamp it in a vice and turn the strut.

You may be able to pull the damper cartridge straight out of the strut – or it may need further dismantling.

Replacing coil springs

If you have to replace a coil spring on the front suspension, the replacement spring must be of the correct rating.

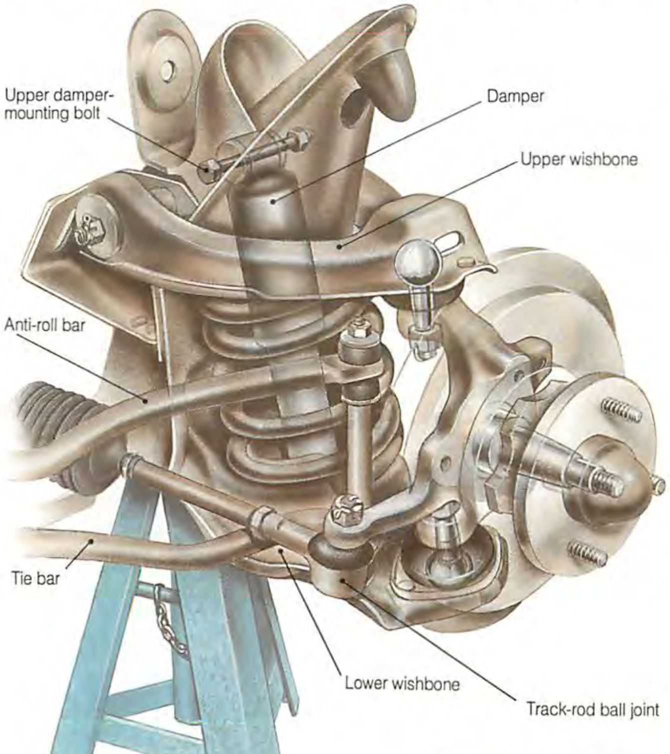
It is also best to replace both front springs – the other one may not match exactly the rating of the new spring to be fitted.

Check the rating with your local dealer. Springs are normally identified by coloured paint markings.

The top coil of the spring may be flattened. Be sure to fit the new spring in the same way.

Tools and equipment

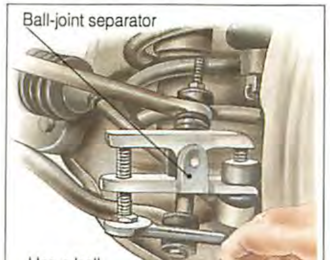
AXLE STANDS • WHEEL CHOCKS • SPANNERS • JACK • BALL-JOINT SEPARATOR • SPRING COMPRESSORS • SMALL DRIFT • HAMMER • PLIERS • PETROLEUM JELLY • TORQUE WRENCH



The suspension ready for removal of the spring. Make sure the axle stand is placed far enough back to allow removal of the spring and lower-wishbone arm.

Removing a spring

Raise the car with a jack, and support it on axle stands beneath the frame. Apply the handbrake securely and chock the rear wheels. Remove the raised wheel.



Use a ball-joint separator to split the joint. Do not hammer the joint stud to free it – the threads will be damaged.

Remove the locking pin (if fitted) and unscrew the track-rod ball-joint nut at the steering arm. Disconnect the joint from the steering arm, using a ball-joint separator.

Undo and remove the bolts connecting the tie bar to the lower arm.

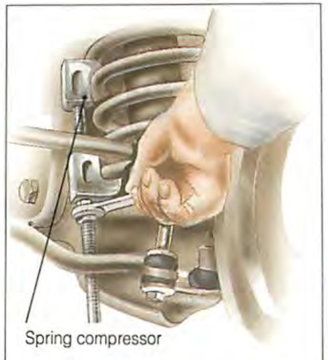
With the jack compressing the coil spring slightly, undo the top and bottom damper mountings and withdraw the bolts to free the damper.

Disconnect the anti-roll bar and tie bar, if fitted (SHEET 238).

On some cars you have to loosen the steering-rack U-clamp bolts and move the rack, to prevent damage to the lower-wishbone fulcrum bolts and the rack gaiters.

On many cars the damper is fitted inside the coil spring, and must be removed. To remove, place a jack beneath the wheel hub and raise it far enough to relieve the loading on the damper.

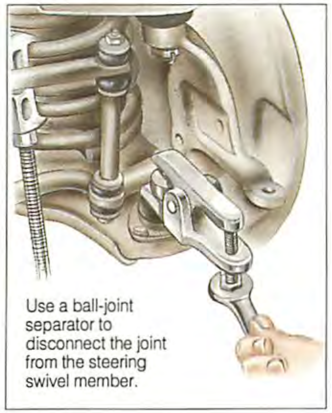
Release the upper and lower damper mountings and remove the damper through the hole in the lower wishbone. Lower and remove the jack.



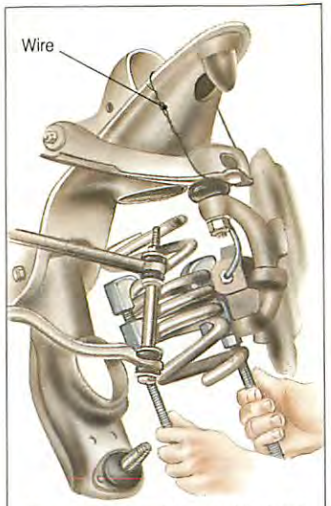
Make sure that the hooks on the compressors are firmly seated over the coils of the spring.

Fit the spring compressor clamps opposite to each other on the coils. Tighten them to compress the spring.

Remove the locking pin (if fitted) and the nut from the ball joint at the end of the lower wishbone, where it is connected to the steering swivel member. Separate the joint.



Use a ball-joint separator to disconnect the joint from the steering swivel member.



Tie up the upper wishbone with wire to avoid straining the brake hose. Compress a new spring before fitting.

Tie up the upper wishbone and the steering swivel member (also called the stub axle). Carefully drive out the fulcrum bolt or bolts from the inner end of the wishbone, using a drift of slightly smaller diameter.

Take a note of the way these bolts are fitted, and also of any rubber insulators or cups fitted at the top of the spring, to aid reassembly.

Unscrew the spring compressor clamps a little at a time on each side to release the tension.

When all the tension in the spring has been released, remove the spring from the lower wishbone.

Fitting the new spring to the wishbone

The top coil of the new spring may be different in shape from the bottom coil. Be sure you insert it right side up.

Compress the new spring with the spring compressor clamps, and place it on the lower wishbone. Make sure the bottom of the spring is seated properly. Reconnect the lower-wishbone ball joint to the stub axle, screwing the nut until finger tight.

Make sure the top of the spring is seated properly and that any rubber cups or insulators have been properly inserted. Reconnect the inner ends of the wishbone with the fulcrum bolt(s).

The wishbone will be easier to refit if the bushes are smeared with petroleum jelly. (Do not tighten the fulcrum bolts fully until the car has been lowered to the ground at a later stage, when its weight is on all four wheels.)

Remove the spring compressor clamps carefully. Reconnect the track rod and ball joint and the anti-roll bar or tie rod, if fitted.

If necessary, retighten the steering-rack U-clamp bolts and replace the damper inside the spring.

Make sure that all nuts and bolts are fitted correctly and tightened to the correct torque as recommended by the car maker. Consult a service manual for the car, or your local dealer if necessary.

Use new split pins to lock the ball-joint retaining nuts in place.

Replace the road wheel, lower the car to the ground and tighten the fulcrum bolt(s) fully.

Checking the gearbox oil level, draining and refilling / 1

A gearbox contains a great many moving parts. Some of them are submerged in oil and some of them are splashed – that is, the oil is carried to them by other moving parts.

The lubrication is designed to prevent metal-to-metal contact, between teeth on gears, for example. The type of oil used depends partly on the type of gears the manufacturer has designed into the gearbox.

As in the engine, the oil must be able to withstand high temperatures. 'Extreme pressure' additives in some gearbox oils act as solid lubricants on gear teeth when temperature rises above the safe limit of ordinary oils.

The gearbox oil level should not drop noticeably between routine oil changes about every 30,000 miles (50,000 km). If you have to add a lot to correct the level, check carefully for leaks (SHEET 248).

Stand the car on level ground before you check the gearbox oil level. On most cars the filler plug on the side of the gearbox acts as the oil-level indicator, but a few cars have a gearbox dipstick.

Marks on the gearbox dipstick show the recommended upper and lower limits for the oil level. Pull out the dipstick and wipe it on a clean rag. Replace it, then remove it again to read the oil level.

If it is too low, top up to the upper limit with the correct grade of oil – as specified in the car handbook.

Some cars – the Mini and Metro for example – have a common oil supply to engine, gearbox and final drive. The oil level for the whole system is checked with the engine dipstick.

Keep the oil up to the upper limit shown on the dipstick, but be careful not to top up beyond this mark.

If you have the more usual filler-and-level plug on the side of the gearbox, consult your car handbook to identify it correctly. The side of the gearbox may have other plugs on it – to cover adjustment points, for example.

To remove the plug, reach through the engine bay, or jack up the car, support it level on axle stands at front and rear, and lie underneath the gearbox.

More rarely, you can reach the plug through an inspection hole in the car floor beneath the carpet.

Depending on its type, the plug unscrews with an open spanner, a large, hexagonal Allen key, or a square-ended key.

Some cars need a special tool that can be bought from a main dealer for the make of car.

Multi-headed drain-plug or sump-plug wrenches (SHEET 45) that remove gearbox, axle and sump plugs are sold in accessory shops, but look to see exactly what you need before you buy one.

Wipe the area round the plug with a rag to clean away any grit, then take out the plug.

The oil should be level with the bottom of the filler hole. If you cannot get a clear view into the hole, push a fingertip in. You can feel the oil when the level is correct.

If the level is too low, top up until oil begins to flow out of the hole. Some gearboxes use engine oil, others use hypoid oil. It is important to use only the correct type and grade. Your car handbook will specify what these are.

The hole may be in an awkward position. Reach it with a plastic bottle fitted with a flexible tube through which you can squeeze the oil. Oil is sold in such containers, as well as in larger tin cans.

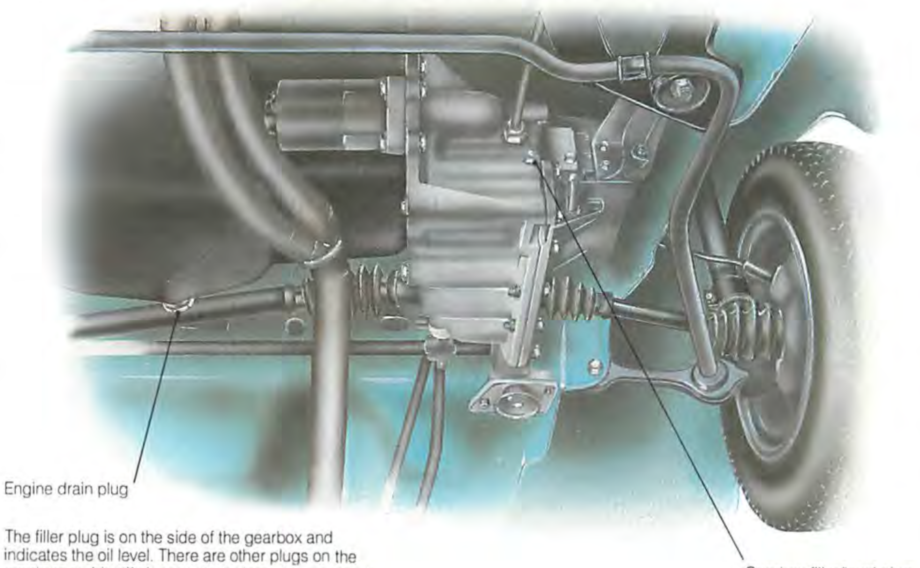
The plug often has a washer. Examine it and renew it if it is distorted, split or leaking.

Replace the plug, taking care not to overtighten it. Gearbox casings are usually alloy and can crack.

Tools and equipment

OPEN SPANNER OR DRAIN-PLUG KEY • CLEAN RAGS • USED-OIL CONTAINER • PLASTIC SQUEEZE BOTTLE WITH TUBE • FRESH OIL OF THE CORRECT GRADE • JACK • AXLE STANDS

Layout under a transverse-engined front-wheel-drive car



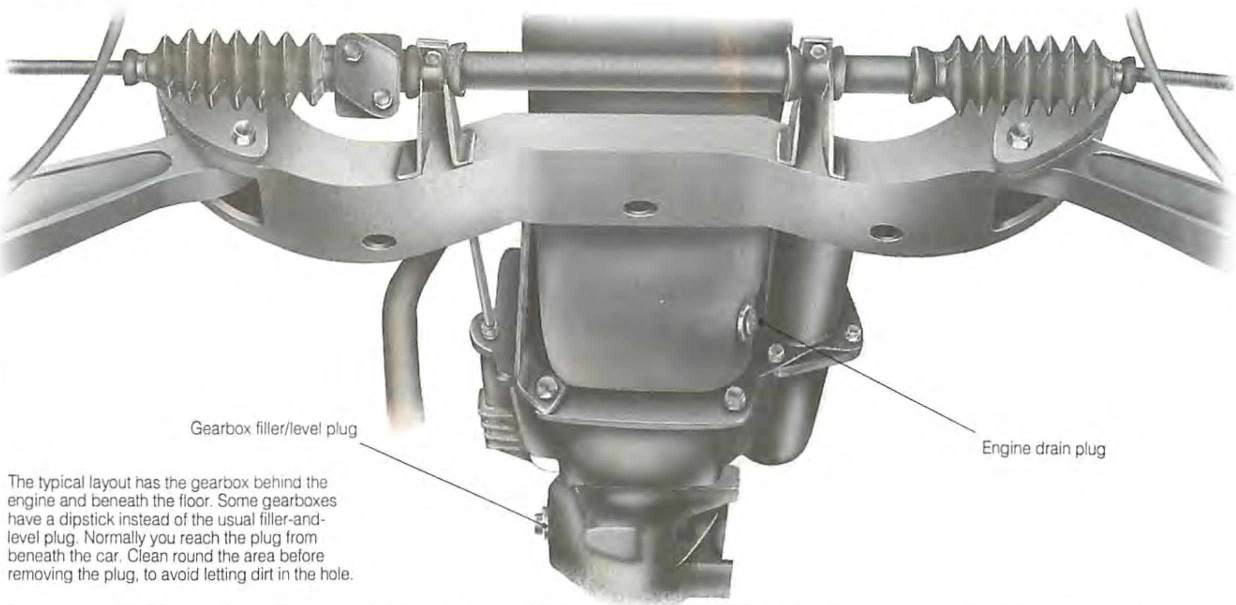
The filler plug is on the side of the gearbox and indicates the oil level. There are other plugs on the gearbox, so identify it correctly before you unscrew it.

Topping up

If there is a dipstick it will be marked with the recommended oil level.

With the car level, remove the filler/level plug. The oil should be level with the bottom of the plug hole.

Layout under a front-engined rear-wheel-drive car



The typical layout has the gearbox behind the engine and beneath the floor. Some gearboxes have a dipstick instead of the usual filler-and-level plug. Normally you reach the plug from beneath the car. Clean round the area before removing the plug, to avoid letting dirt in the hole.

Checking the gearbox oil level, draining and refilling / 2

Draining and refilling the gearbox

It is best to drain the oil just after a run, when it is warm and flows out quickly. Put the car on level ground, and make sure that you have enough new oil of the correct type for refilling.

To remove the drain plug, which is underneath the gearbox, use only a properly fitting tool so that you do not damage the plug. The plug may be the same size as the filler plug.

Sometimes there are two drain plugs, because of a baffle plate across the inside of the gearbox. Clean around the plug or plugs before you remove them.

Put a container under the drain hole – large enough to take all the oil. You can use a 5 litre oil can laid on one side with the other side opened; or use one of the special containers that can be sealed afterwards for carrying the oil for disposal (SHEET 54).

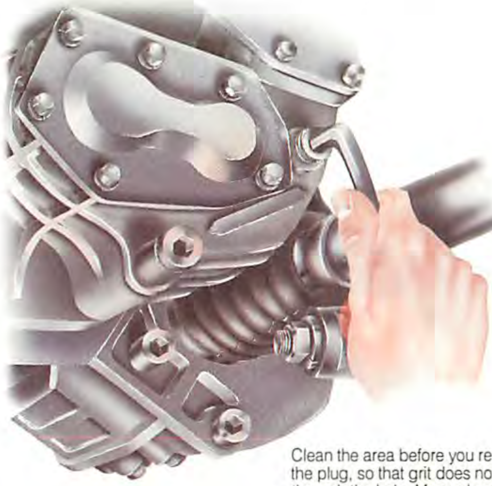
Loosen the filler plug to make sure it has not seized and that you will be able to refill. Have some rag handy to soak up any splashes. Take out the drain plug.

When the oil flow has slowed to a drip, put a finger in the drain hole and hook out any metal particles or other debris. Any significant amount of metal debris indicates trouble inside the gearbox, and you should consult a garage.

If the drain plug has a washer, fit a new one. Replace the plug firmly, but do not overtighten it.

Fill to the correct level with the new oil and refit the filler plug. Use the oil specified by the car manufacturer; there is little gain in using a cheaper oil, since oil changes are at long intervals, perhaps after every 30,000 miles (50,000 km).

Some gearboxes do not have a drain plug, only a filler-and-level plug for topping up. To replace the oil in this type of gearbox, use a syringe to draw the old oil out, then refill in the normal way.



Clean the area before you remove the plug, so that grit does not fall through the hole. Many plugs unscrew with an Allen key.

Some plugs unscrew with a spanner. Always use the correct tool for the plug or it will become damaged and difficult to screw back again.

Squeeze oil from a soft plastic bottle fitted with a flexible tube into the filler hole, which is often hard to reach. Some cars need a long tube. In cold weather, keep the oil warm for quicker filling.

Checking the gearbox for oil leaks

Jack up the end of the car where the gearbox is fitted, and support it on axle stands. Chock the wheels remaining on the ground. Apply the handbrake if you jack the front end.

Road dirt may hide a leak, so that the first sign you notice is a low gearbox level during a routine check.

If the oil level has dropped, and you cannot immediately see the leak, top up then clean the whole gearbox with a proprietary degreaser. Drive the car a few miles then look for the leak again.

Usually a leak is from an oil seal, gasket or sealing washer. Damage to the casing is seldom the cause.

There are gaskets under inspection plates, which leak occasionally if the plate has been removed and refitted badly. Some plates can be reached only by removing the gearbox, a task best left to a garage. Other plates are more easily reached.

Drain the gearbox oil and unscrew the inspection plate. Clean off the remains of the old gasket. Do not scratch the metal; scratches can prevent a proper seal being made later.

Smear both faces with gasket sealant and lay the new gasket in place. Refit the plate, check that the gasket is straight, and tighten the screws evenly. Refill with oil.

A leak at the filler plug or drain plug is probably due to a damaged sealing washer. Fitting a new one should cure the leak.

If it does not, the threads may be damaged. Making a new thread is best left to a garage.

The oil seal where the speedometer cable enters the gearbox sometimes fails. Fit a new one (SHEET 139).

A leak at the front end of the gearbox may come from damaged seals in either the engine or the gearbox, or a gasket between the gearbox and the clutch bell housing. Such a leak often drips from the bottom of the bell housing.

Such leaks must be repaired; if they suddenly get worse, severe damage could result. To replace these seals the gearbox must be removed – a job for a garage.

On a rear-wheel-drive car check the rear end of the gearbox. A leak here usually comes from a failed extension-housing oil seal. You can disconnect the propeller shaft to renew this (SHEET 261).

On a front-wheel-drive car, check the oil seals at the drive shafts for leaks (SHEET 252).

The gasket between the main gearbox and the extension housing is unlikely to fail, but fit a new one as a matter of course if you separate the two housings.

The drain plug often has a sealing washer – if damaged it may leak.

Examine all the inspection plates. Occasionally their gaskets deteriorate and cause leaks. The filler plug may leak because of a damaged sealing washer or thread.

Check for a leak at the rear of the extension housing. It is usually caused by a damaged oil seal. Disconnect the propeller shaft and fit a new seal. (SHEET 261) On a front-wheel-drive car, check the seals at the drive shafts.

Checking the rear axle for leaks and changing the oil

A rear-axle oil leak is easy to miss. The axle works normally until it suddenly seizes up – the expensive and possibly dangerous result of it running dry of oil.

The clearest sign of a leak is oil on the ground under the car. Oil leaks from the hub oil seals of a live rear axle (SHEET 261), may also leave traces on the inner surfaces of the wheels, or even get into the brakes.

Leaks on to the wheels or brakes may also be caused by defective wheel bearings (SHEETS 268-269).

Axle oil is thick when cold and unlikely to drip out of a very small opening, but it flows freely when warm after a run.

Any drip marks will probably be where you first parked the car after returning from a run. Within an hour the oil thickens as it cools and stops dripping.

If you are not sure whether there is a leak, put a sheet of paper under the axle.

On cars more than a few years old the axle oil should be changed at the recommended intervals, as listed in the car handbook.

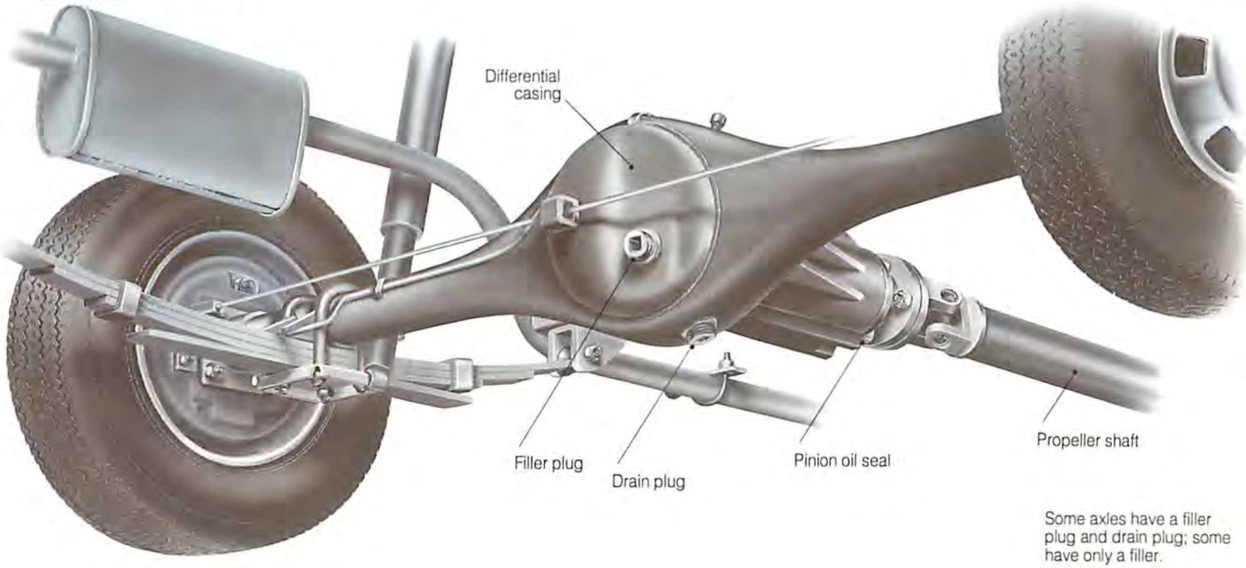
You should also check the oil level, generally every 6,000 miles or 10,000 km, or at the interval recommended in the handbook.

Later cars have 'sealed for life' axles whose oil never needs changing. These axles do not have a drain plug. But they, too, can leak and need refilling, which is done through the plug hole by which they were filled originally.

The axle must be drained to cure any serious oil leak.

Tools and equipment

SOLVENT CLEANER • RING SPANNERS • SOCKET SPANNERS • AXLE OIL



Some axles have a filler plug and drain plug; some have only a filler.

Dealing with leaks

Once you have a rough idea of where the leak is located, clean the area with a proprietary solvent and drive the car for a few miles to warm the oil and restart the leak. This should show its exact source.

The leak may come from a damaged drain or filler-plug washer. The gasket between the differential carrier and the axle may fail, especially if it was fitted incorrectly. There is also a pinion oil seal at the front end of the differential casing. Oil leaking here runs down the slope of the carrier and drips off the bottom: look carefully.

The half-shaft oil seals can also fail, causing internal leaks into the hubs, which are harder to spot. The breather valve on top of the axle, where fitted, can also become blocked. This causes oil and air to build up inside, which may force oil out of leak-prone places.

Overfilling the axle with oil can also raise the pressure enough to cause leaks.

Some rear-wheel-drive cars with independent rear suspension may leak oil from the drive-shaft oil seals. This can be dangerous where the brakes are mounted next to the differential casing. Oil leaking on to the brakes can impair their efficiency seriously.

If a drain or filler plug leaks, be sure to replace the washer with one of exactly the right size and type. The plug may have a recessed socket and need a special tool to turn it, or the square drive on a socket wrench may fit the recess. Tighten the plug firmly, but not too much or the washer and the threads may be damaged.

Some plugs are slightly tapered and form an effective seal by jamming their threads as they are tightened. This type of plug does not have a sealing washer, and care must be taken not to overtighten it, or it may be very difficult to remove later.

A slight leak from the differential carrier gasket can sometimes be cured by tightening the nuts, without draining the axle. To replace the gasket, you usually have to remove the half shafts and the differential gears to release the carrier – a task best left to a garage.

Some dismantling is also needed to replace the half shaft or pinion oil seal (SHEETS 261-262).

However, some axles have a cover plate at the rear of the differential, held on by screws or bolts.

To replace a leaking gasket here, drain the oil, remove the screws, take off the plate, clean the mating surfaces and fit a new gasket.

Make sure the mating surfaces are clean and free from damage before fitting any new gasket. Smear a little gasket sealer on both sides of the gasket. When you refit the carrier or cover plate, tighten the nuts in diametrical sequence to spread the pressure evenly. Always check that the breather valve is clear and working, and unblock it if necessary.

Use new oil of the correct type, as given in the car handbook, to refill the axle. If using a squeezable plastic bottle, stand it in hot water for a few minutes to thin the oil. Do not overfill.

A slight leak from the differential carrier gasket can sometimes be cured by tightening the nuts, without draining the axle.

The filler plug may have a hexagonal head, or a square hole that takes a socket drive.

Draining and refilling the axle

Drive the car a few miles to warm the oil and make it flow freely.

Clean around the drain plug and filler plug, and put a large container under the drain plug to catch the old oil.

Unscrew the drain plug. If there is no drain plug, clean the central part of the axle, take off all the nuts holding the differential carrier to the axle and loosen the carrier enough to allow oil to flow from the axle.

Use a large container to catch the dirty oil.

Leave the axle to drain for several minutes. Do not pour the old oil down the drain – a garage or local council refuse department will tell you how to dispose of it safely. Replace the drain plug, not too tightly. Fit a new washer if the plug is the type that has one. Refit the carrier nuts if they have been removed, tightening them in diametrical sequence.

Remove the filler plug, which usually takes the same tool as for the drain plug. Refill with axle oil, which is sold in squeezable plastic bottles with a long spout to make the job easy. Squeeze in the oil in small amounts, allowing time for it to find its own level.

The correct level, up to the bottom of the filler hole, is reached when the oil stops dripping out of the hole.

Refit the filler plug again, with a new washer. Do not overtighten the plug.

Refilling is simple with a squeezable bottle.

Topping up and changing automatic transmission fluid

Automatic transmission needs little maintenance other than regular checking of the transmission fluid level.

Most faults arise because the level has dropped through evaporation or leakage (SHEET 247), or because the engine tickover speed was incorrect when you checked the level.

Check in the car handbook which particular fluid should be used for your car. Topping up with the wrong fluid can damage the transmission. (In some smaller automatic gearboxes, such as those used in BL cars, the transmission fluid is the same oil as that which lubricates the engine, and is drawn from a common sump.)

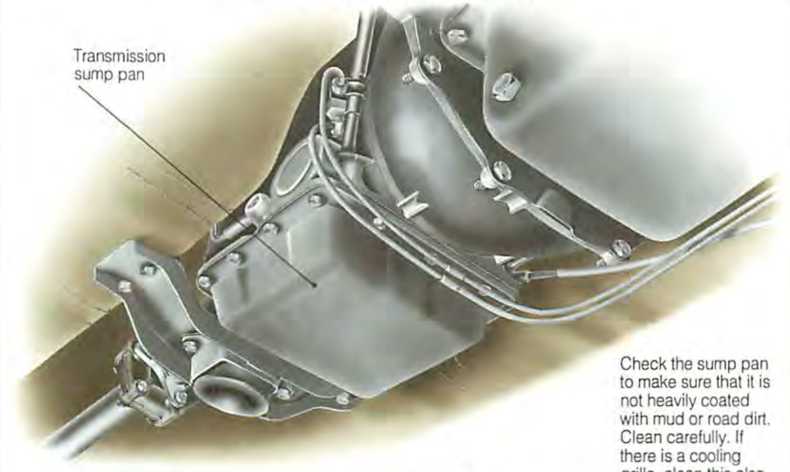
Keep the fluid level up to the full mark on the dipstick. Do not overfill – this can lead to overheating.

The sump and the ventilating grilles on the torque-converter housing can easily become blocked or mud covered, and this leads to overheating. Check and clean them at each service.

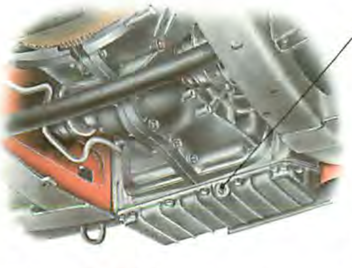
Tools and equipment

CLEAN RAG • FUNNEL • RAMPS • DRAINING TRAY • SOCKET SPANNER AND EXTENSION

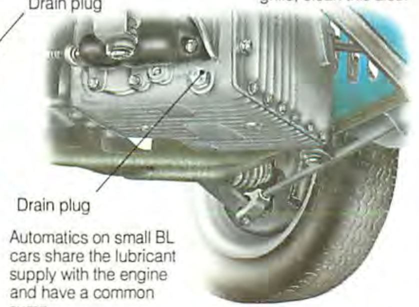
How to avoid overheating



Check the sump pan to make sure that it is not heavily coated with mud or road dirt. Clean carefully. If there is a cooling grille, clean this also.



The Renault automatic transmission has a separate fluid supply.



Automatics on small BL cars share the lubricant supply with the engine and have a common sump.

Checking the fluid level

The transmission fluid level is best checked when the engine is at normal running temperature. After a 5 mile run, park on level ground and apply the handbrake.

With the engine idling, move the gear selector lever at least three times through all positions. Set it in the 'P' (park) position and let the engine idle for two minutes.

Before removing the dipstick, wipe round it with a clean cloth to stop dirt entering the gearbox.

With the engine idling, remove the dipstick and wipe it with a clean, non-fluffy cloth. Replace it gently, so as not to force fluid back up the dipstick tube and so give a false reading. Withdraw it immediately and check the level.

Let the engine run for two minutes with the selector at park 'P'.

Check the fluid on the dipstick for specks of dirt or metal – both indicate wear. If there are any, get expert advice as soon as possible, before the repair becomes very expensive.

On older cars particularly, check the fluid colour against the colour of new fluid. If a red fluid has darkened or turned black, it indicates overheating and the fluid should be changed.

Clean around the dipstick area to avoid dirt getting into the transmission.

Topping up, draining and refilling the transmission

Top up the fluid levels through the dipstick tube, using a small funnel. Add a little at a time and check the level frequently to avoid overfilling.

The difference between the low and full marks on most transmission dipsticks is about ½ litre (about 1 pint). So if the reading is midway between them, about ¼ litre (½ pint) is needed.

If you top up the fluid level while the engine is cold, fill to ½ in. (13 mm) below the dipstick full mark. Otherwise it will be too high at normal running temperature and will cause overheating.

Use a clean funnel and fill slowly. Check the level to avoid overfilling.

Check the level again at normal running temperature.

Some car handbooks recommend draining and refilling automatic gearboxes at certain fixed mileages.

However, most automatics fitted to recent and current cars do not need regular draining, and do not have a drain plug.

Draining them is a quite difficult and messy job, necessitating removal of the dipstick tube and gearbox sump pan, a task calling for scrupulously clean working conditions and garage facilities. Follow the maker's advice in the car handbook or a service manual.

The smaller automatic gearboxes do have drain plugs, and the fluid must be changed at the intervals recommended in the car handbook.

Those fitted to BL cars, which use the same oil as the engine, receive fresh oil when the engine oil is changed. Others, such as those fitted to some VWs and Renaults, have their own separate fluid supply.

The transmission should be drained while the fluid is at normal running temperature. Take care; it will be hot enough to cause serious burns.

An automatic transmission that requires regular draining and refilling should be drained with the unit at running temperature. Remove the drain plug carefully, keeping hands and arms clear of the hot fluid, which can burn.

In most cases, draining must be done with the car raised and supported securely on axle stands or ramps, and with the handbrake on.

Place the drain tray under the sump, and undo the plug, keeping your hands and arms clear of the hot oil when it gushes out.

When all the oil has been drained, replace the drain plug and refill with fresh fluid or oil of the type recommended by the car handbook or service manual.

Refill with the quantity recommended, and drive the car until the new fluid is at normal operating temperature, then check the level again and top up if necessary.

Do not pour the old fluid down a drain – it pollutes the water supply. Ask your local council for the location of the nearest oil disposal dump and take it there.

Towing an automatic

Cars fitted with modern automatic gearboxes must not be towed for a distance of more than about 15 miles. The towing speed must also be kept under 30 mph (50 kph).

The reason for these restrictions is that the internal fluid pump of the gearbox, being driven by the engine, does not work when the engine is not running.

When the car is being towed, therefore, the box is not lubricated or cooled.

If the car has to be towed a greater distance than 15 miles – in the event of a breakdown, for example – raise the driven wheels or disconnect the propeller shaft or drive shafts (SHEET 252).

If the car is being towed by a garage or breakdown recovery service, make sure they are aware that the car has automatic transmission so that they do not tow it too far or too fast.

Checking the clutch cable

The clutch cable has a steel-wire inner core sliding inside an outer sheath. It should last at least two years, but check it at every main service; if it breaks it may do so without warning.

The heavy clutch-pedal pressure needed to work it may conceal any initial stiffness or stickiness in the cable itself. The exposed cable ends are the parts most likely to fray and break, especially at the gearbox end.

To check or replace the cable, support the car on ramps or axle stands and chock the wheels on the ground.

Tools and equipment

AXLE STANDS OR RAMPS • WHEEL CHOCKS • SPANNERS • PLIERS • SCREWDRIVER • SPLIT PIN • HIGH-MELTING-POINT GREASE

Different linkages

There are three common methods of securing the inner cable to the clutch pedal – by a loop, a fork or a ball on the cable.

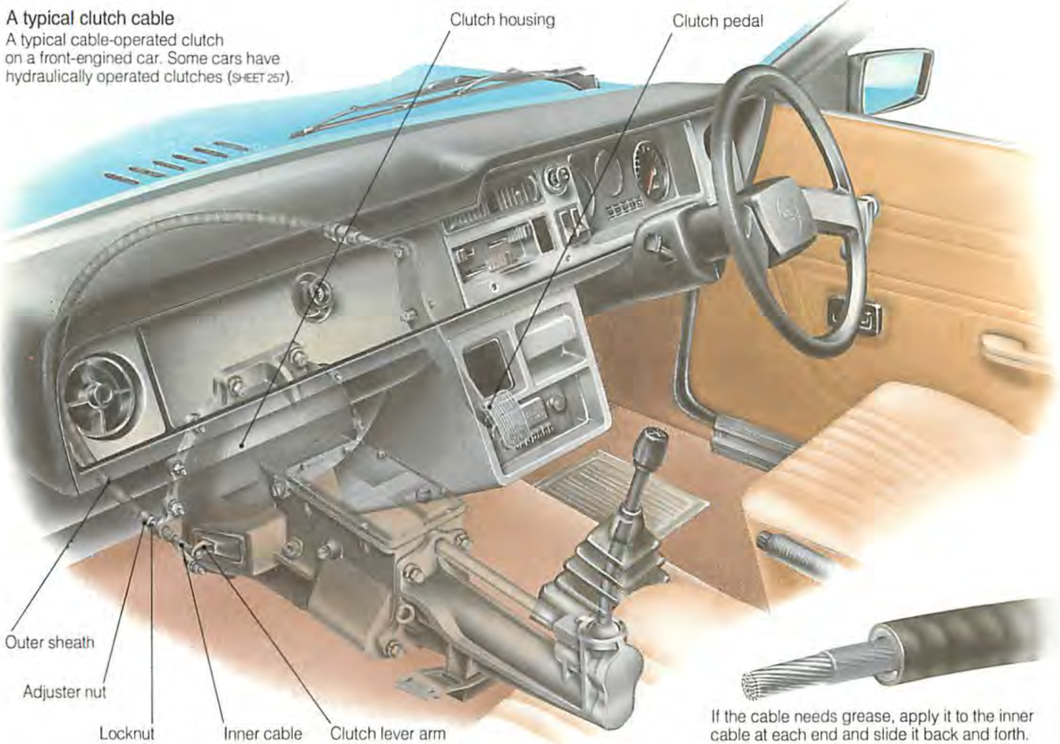
The cable may end in a loop that fits over a hook on the pedal.

It may be a fork pivoted on the pedal by a clevis pin held by a split pin.

It may be a ball through a keyhole slot.

A typical clutch cable

A typical cable-operated clutch on a front-engined car. Some cars have hydraulically operated clutches (SHEET 257).



If the cable needs grease, apply it to the inner cable at each end and slide it back and forth.

Checking the cable

Disconnect the cable at the gearbox end. It is fixed to the clutch-release lever by nuts which also provide adjustment.

Move the clutch pedal by hand. You should be able to feel whether the cable slides smoothly. If it does not, the cable may be bent at too sharp an angle by being wrongly routed.

Usually there are guides to keep its path smoothly curved. Make sure that the outer sheath is not kinked or crushed: if it is, replace the cable.

Pay particular attention to the cable on a rear-engined car, where its long route makes it extra prone to damage.

Inspect the exposed ends of the inner core, pulling each end in order to reveal as much as possible. If even one strand is broken, the others will soon follow: replace the cable at once.

If the cable passes all checks, reconnect the gearbox end and adjust the nuts until there is the correct amount of free play (SHEETS 253-256).

Finally tighten the locknut.

Replacing the cable

Disconnect the gearbox end first and remove the nuts; then free the inner cable from the pedal.

It may have a loop which fits over a hook at the top of the pedal; pull the cable slack and lift it off.

The cable may end in a fork pivoted on the pedal by a clevis pin. The pin has a head at one end and a washer and a split pin at the other; straighten and pull out the split pin with pliers, then push out the clevis pin. Use a new split pin when refitting.

If there is a ball on the end of the cable which fits through a keyhole-shaped slot in the pedal, pull the cable slack and push it up towards the large end of the keyhole to free the ball.

Unscrew any bolts which hold the outer sheath to the bulkhead. Note the order in which washers, spacers and seals are fitted so that you can replace them correctly. Pull the whole cable out through the engine compartment.

Some rear-engined cars, such as the VW Beetle, have clutch, brake and accelerator pedals on a common shaft. To free the clutch cable for replacement you may have to disturb the other two pedals and linkages.

To reach the clutch end of the cable remove the left rear wheel, supporting the car on an axle stand. Adjustment is generally by turning a wingnut or a domed nut and locknut at the clutch end.

Hold the cable with grips to prevent it turning with the nut while adjusting. Turning clockwise reduces free play at the pedal, which should be between $\frac{3}{8}$ and 1 in. (10–25 mm). Make sure the adjuster nut is seated properly in the elliptical hole of the clutch lever arm.

Check all the rubber grommets and seals along the route of the cable, and replace any that are worn or damaged. Some may be supplied with the new cable.

Take the old cable and other parts to be replaced to the parts store. Lay the old and new cables side by side and check that they are the same length and that the fittings are the same.

If the old type has been superseded by an approved but slightly different one, make sure you have any adaptors you need.

Find out whether the new cable has to be greased before fitting. Most modern cables have greaseless non-stick linings.

If you do have to grease the cable, use your finger to poke as much high-melting-point grease as you can into the outer sheath at both ends, and slide the cable back and forth to spread the grease.

Refit the cable in reverse order of removal, adjust the nuts until there is the correct amount of play and tighten the locknut.

Replacing a VW Beetle cable

When replacing a VW cable, adjust it at the clutch. Pass the threaded end through the lever-arm hole and fit the wingnut. Hold the cable with grips during final adjustment to prevent it turning.

Checking universal joints

A propeller shaft, or propshaft, connects the rear axle to the gearbox on front-engined rear-wheel-drive cars.

At each end of the propshaft there is a universal joint (UJ), which allows the rear axle to move up and down in relation to the gearbox without bending or snapping the shaft.

Some propshafts also have a universal coupling fitted at the centre.

A universal joint consists of a cross-shaped 'spider' with needle roller bearings held on its four arms by caps and circlips. The yoked ends of two shafts have lugs which engage with the spider arms and can pivot on the roller bearings.

In most modern cars the joints are sealed for life and cannot be lubricated. In older cars, they can be dismantled from the propshaft, checked and lubricated or replaced.

If the propshaft joints on your car have grease nipples, check with the manufacturer's service schedule for greasing intervals.

The main drawback with many current car models is that the universal joints cannot normally be separated from the propshaft. When the joints wear, the propshaft must be renewed.

A worn joint causes the propshaft to vibrate. As wear increases, vibration worsens.

Another sign of wear is a clonk when you accelerate or decelerate, or a regular knock when the car is moving.

A sure sign of something breaking up inside the bearings of a joint is rust-coloured dust around the spider. Fit a new joint or shaft immediately.

To check for wear when no dust is evident, grip one side of the joint firmly and try to turn the other side against holding pressure. There should be no play in the joint at all.

Make another check by inserting a large screwdriver between the yoke and the spider and levering it to see if there is any play. If you feel any play, fit a new joint or propshaft.

The symptoms of a worn joint – the clonks or apparent play – are very similar to those for excessive backlash in the crown wheel and pinion.

Be sure that any play you do feel is in the joint, and not the rear axle.

Some specialist engineering companies will machine out the yokes of modern propshafts to accept joints that can be fitted in the same way as on earlier designs.

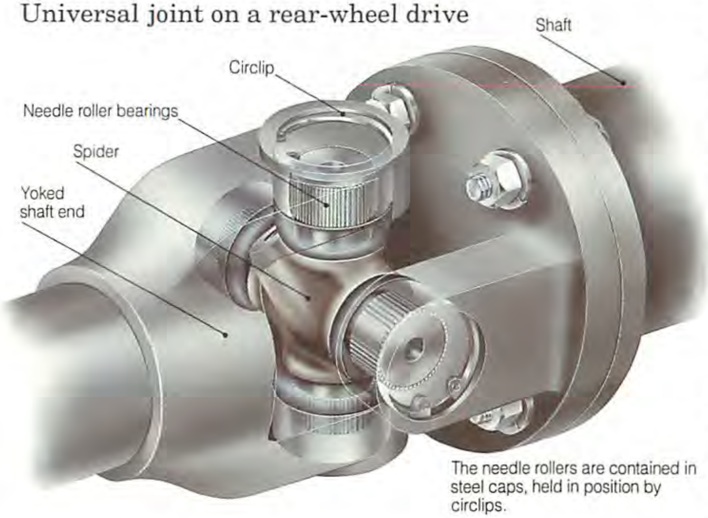
If a sealed joint fails, it is worth seeking out such a company and comparing the cost of their services against that of a new propshaft.

Generally, if one joint on the propshaft is worn, the others will also need renewal, and it is best to do them all at the same time.

Tools and equipment

RING SPANNER • STRONG SCREWDRIVER

Universal joint on a rear-wheel drive



The needle rollers are contained in steel caps, held in position by circlips.

Failure of the needle rollers is the commonest cause of wear in this type of universal joint, usually due to lack of lubrication. Before checking the joint, make sure that any movement is not due to slackness in the bolts holding it to its mating flange. Then check the joint for both radial and lateral play.

Grip the flange tightly with one hand and try to turn the propshaft with the other; look for movement at the spider ends, under the circlips. With a strong screwdriver or steel bar, lever the joint laterally, again looking for movement at the spider ends.

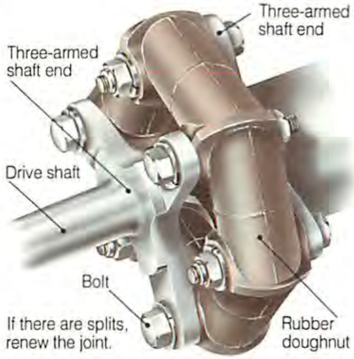
Slip a screwdriver between the yoke and the spider and lever it to test for free play.

Doughnut joint

Doughnut joints are used on the inner ends of the drive shafts on some front-wheel-drive cars, and also on some rear-engined cars.

The joint consists of a flexible rubber ring held at six regular intervals by bolts to which the drive shaft and driven shaft are attached.

The rubber can perish or split after a high mileage, causing vibration in the transmission and eventual failure if not attended to quickly. Examine particularly round the bolts for signs of splitting. If you find any, fit a new doughnut joint.



If there are splits, renew the joint.

Rubber spider joint

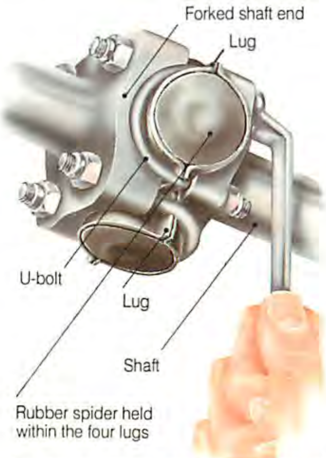
Early BLMC Minis were fitted with rubber-covered spider joints at the inner ends of the drive shafts. The spider is secured within the lugs of the two forked shaft ends by four U-bolts.

Inspect the joints after every 5,000 miles for signs of oil saturation and age deterioration. Check for loose nuts and bolts, and oval wear marks round the bolt holes.

The first sign of wear in the joint is usually a swelling of the rubber. Watch also for a small hole or circle at the end of any of the rubber arms. It is a sign that the rubber is becoming detached from the spider.

Fit a complete new joint immediately you spot any wear.

If deterioration of the joint has been caused by oil saturation, have the drive-shaft oil seal replaced by a garage.



Tighten the nuts and look for wear round the U-bolts during regular 5,000 mile checks.

Checking drive-shaft oil seals

There is little you can do to check the oil seals on the drive shafts of front-wheel-drive cars, except a precautionary inspection to see if there is oil leaking where the shaft enters the transmission.

In extreme cases, the oil forms a puddle below the leaking seal. If this happens, the shaft must be removed and a new seal fitted – a task best undertaken by a garage.

On some cars the inner end of the shaft is hidden behind a rubber gaiter. Check the gaiter for splits or other signs of damage. Generally, if the gaiter is in good condition, the seal is also sound.

Some front-wheel-drive cars have their oil seals in axle-shaft carriers on either side of the differential housing. You can easily check for leakage here.

Clean any oil from the area thoroughly and leave the car for a couple of hours to see if oil reappears – and exactly from where it emerges.

If there is a leak, have new seals fitted as soon as possible. Until they are fitted, check the transmission oil level at least once a week.

Checking constant-velocity joints

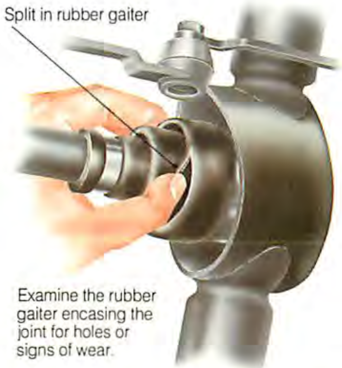
Constant-velocity, or CV, joints are fitted generally to drive shafts on front-wheel-drive cars, where movement has to be transmitted through both the transmission and the steering.

The CV joint normally consists of a central spider, six steel balls, a cage for the balls and an outer cup. The balls engage grooves in both halves of the joint, keeping them together, but allowing free alteration of the operating angle.

During normal service, CV joints do not require attention, but make regular checks of the rubber gaiters in which they are encased for signs of wear or damage. Even the slightest damage or tiniest hole will let in dirt and grit which will quickly ruin the joint.

Wear in the joints causes a clonking noise when the car is turned under power on full steering lock. The knock gets progressively worse, until eventually it can be heard on lesser steering locks.

The only solution then is to have the CV joint renewed.



Examine the rubber gaiter encasing the joint for holes or signs of wear.

Adjusting the clutch / 1

To work efficiently, the clutch needs the right amount of play in the linkage between the foot pedal and the clutch operating lever (also known as the release arm or fork).

Anything less than the correct amount of free play (or clearance) will result in clutch slip, because the pressure plate will be unable to exert its full pressure on the friction plate.

Failure to cure this fault will quickly lead to a burned-out friction plate and possibly a ruined pressure plate.

If, however, there is too much clearance in the clutch linkage, the car tends to creep forwards when in gear with the clutch pedal fully depressed.

This is known as clutch drag, and it can cause difficulties in heavy traffic.

It is generally better, however, to have too much play in the clutch linkage than too little.

The linkage should be checked and, if necessary, adjusted about every 6,000 miles or 10,000 km, or as specified in the maker's service schedule. Wear on the friction plate and on the linkage will eventually alter the maker's setting.

Most modern cars have a diaphragm-spring clutch operated either mechanically or hydraulically.

On most cars, mechanical clutch-linkage clearance is measured and adjusted underneath the car. On some the makers advise checking free play – a specific measurement between pedal positions – at the pedal, although adjustment may be made underneath

On some cars – many Hondas and Toyotas, for example – checking and adjustment can be done at the bulkhead under the bonnet.

Wherever adjustment is made, the same principles apply to all cable linkages. They are adjusted by either increasing or decreasing the lengths of the inner and outer cables in relation to each other. If there is not enough clearance in the linkage, the inner cable has to be made longer. If there is too much, it has to be made shorter.

Check in DATASHEETS or your car handbook or service manual to find the exact amount of clearance required and how it should be measured.

In an emergency, as long as you ensure that there is play in the linkage, the clutch should perform well enough. Check it and adjust to the correct clearance as soon as possible.

On a few cars, such as the Vauxhall Cavalier, there is a constant-contact release bearing – this is adjusted to give no free play at all in the linkage.

Although some hydraulic clutches can be adjusted, many are self-adjusting. Check in DATASHEETS or your car handbook or service manual.

If slip occurs on a self-adjusting clutch, the clutch has to be overhauled. If drag occurs, the hydraulics may be at fault (SHEETS 259-260). Otherwise, renew the clutch.

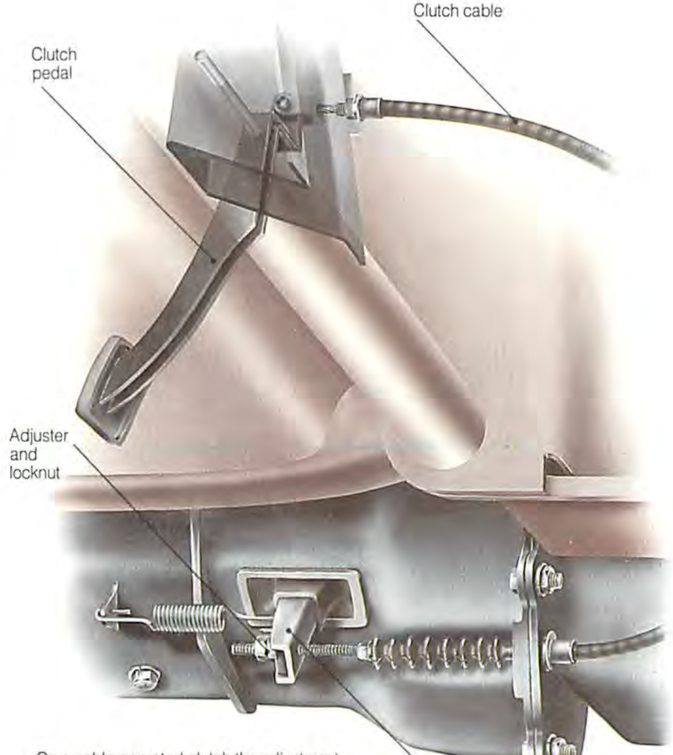
Tools and equipment

SPANNERS • PLIERS • FEELER GAUGE • RULE • HYDRAULIC FLUID

Mechanical clutch linkage

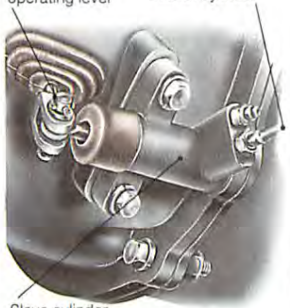
The typical conventional clutch linkage is an inner cable sliding in an outer sheath. The top end of the cable is attached to the clutch pedal and the bottom end to the clutch operating lever. The adjustment to the spring-loaded travel of the lever is normally made by means of a locknut, either at the point where the cable is attached to it – as shown on right – or at the other end of the cable where it is attached to the engine-bay bulkhead.

Adjustment is made for clearance (free play) – the distance the cable travels before moving the lever.



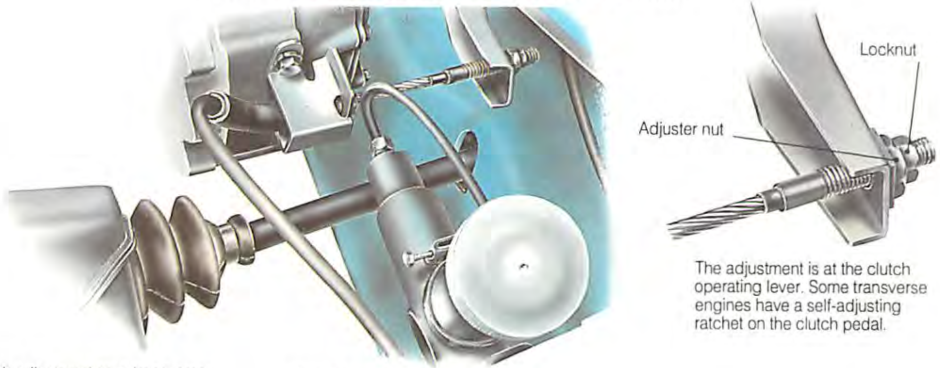
On a cable-operated clutch the adjustment is made at the cable end. The clearance is usually measured either at the operating lever or at the pedal.

A hydraulic clutch



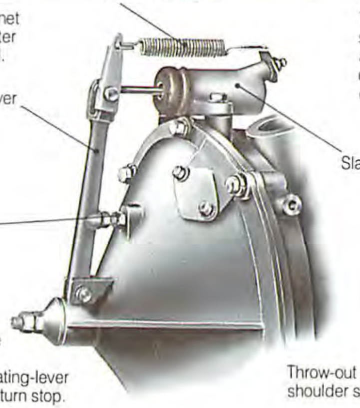
This type of hydraulic clutch is self-adjusting. There is no adjustment at the slave cylinder.

Adjusting the clutch on a transverse engine

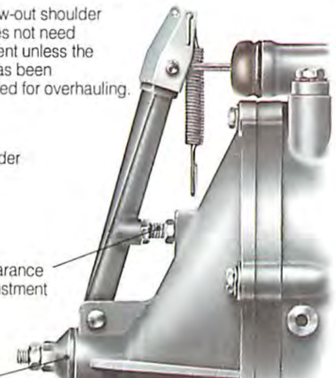


The adjustment is at the clutch operating lever. Some transverse engines have a self-adjusting ratchet on the clutch pedal.

Clutch adjustment on a transverse engine can be done under the bonnet. In this example the bonnet hinges at the front, and the master cylinder is on the front bulkhead.



British Leyland transverse engines have hydraulic clutches. Adjust the operating-lever clearance at the clutch-return stop.



The throw-out shoulder stop does not need adjustment unless the clutch has been dismantled for overhauling.

Adjusting the clutch / 2

The cable clearance on a mechanical clutch may be checked and adjusted underneath the car in a variety of ways, depending on the make. Three common methods are shown here: first, measuring the change in cable length when the clutch lever is operated; second, measuring between the adjuster nut and lever; third, measuring between the adjuster nut and cable stop.

On some cars, it may be possible to use either of the methods shown for checking and adjusting at the lever.

But the measurement must be taken between the points given in the car handbook or service manual for comparison with the specified figure (see DATASHEETS).

Raise the car securely on ramps or axle stands, with the handbrake applied and the wheels chocked.

Checking and adjusting at the clutch lever

Locate the clutch cable, which loops down from the clutch pedal to protrude through the clutch operating lever. There is a threaded sleeve with two nuts on it at the protruding end of the cable.

The clearance is the difference between the cable measurement when the operating lever is at rest and when it is pushed inwards.

To measure it, hold a ruler flat alongside the cable between the operating lever and another point of reference, such as the edge of the bell housing.

Gently push the lever inwards as far as it will go, align the ruler with the end of it, and measure the distance between the lever and your point of reference.

Pull the arm outwards until it is at rest, then measure the same distance again. Find the difference between the two measurements and compare it with the maker's specified figure.

If the clearance needs adjustment, loosen the outer nut on the threaded sleeve, which is the locknut (on some VW cars it is a wingnut).

Then screw the adjuster nut either forwards or backwards to decrease or increase clearance, checking the measurement as necessary.

When the measurement is correct, tighten the locknut and depress the clutch pedal several times. Check the clearance again, and readjust if necessary.

On some cars with a protective undertray, the locknut may not be easy to reach and turn. If so, you will need a special spanner incorporating a socket and universal drive to undo it.

Another method of checking and adjusting at the operating lever

Locate the place where the clutch cable protrudes through the operating lever with the adjusting and locking nuts on a threaded sleeve.

Use pliers to unhook the pull-off spring from the clutch operating lever. Grasp the threaded end of the cable (use pliers if necessary).

Pull it as far back as it will go; this will raise the clutch pedal to its limit.

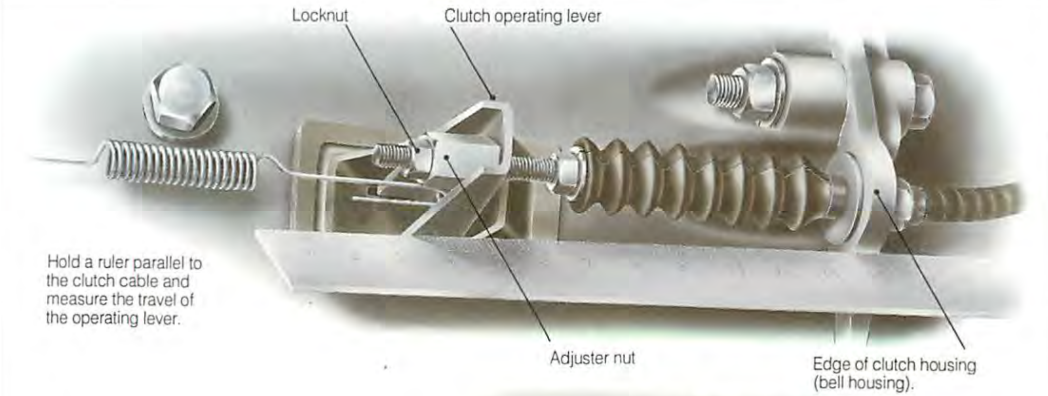
With the cable pulled back, use a ruler to measure the distance between the adjuster nut and the inner edge of the clutch operating lever.

This is the clearance measurement. Compare it with the figure specified in DATASHEETS or the car service manual or handbook.

If adjustment is needed, do it in the way described under Checking and adjusting at the clutch lever (see left).

Find the clearance measurement by pulling the cable through the clutch operating lever as far as it will go.

Measure between the adjuster nut and lever, and compare with the maker's specification. Adjust as necessary.



Hold a ruler parallel to the clutch cable and measure the travel of the operating lever.

Finding the clearance

Measure the distance between the clutch operating lever and a point of reference such as the edge of the clutch housing.

First measure with the operating lever at rest, then with it pushed inwards.

The difference between the two measurements – the amount of free travel of the lever on the cable – is the cable clearance.

To adjust, loosen the locknut and screw the adjuster nut as appropriate. Measure the clearance again and readjust if necessary.

Checking and adjusting at the outer-cable stop

This method is used on some cars, such as the smaller Fords. Wedge the clutch pedal in the fully raised position with a block of wood.

Locate the clutch cable and find where the outer cable is seated against its cable stop on the edge of the bell housing.

The locknut and the adjuster nut are at the end of the outer cable, next to the cable stop.

Hold the outer cable and pull it backwards as far as it will go, exposing the inner cable.

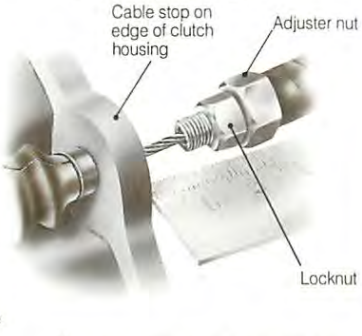
With the outer cable pulled back, use a ruler to measure the distance between the cable stop and the adjuster nut on the end of the outer cable.

This measurement is the cable clearance. Compare it with the maker's specified figure, and adjust if necessary.

Loosen the locknut and turn the adjuster nut either backwards or forwards until the measurement is correct.

Tighten the locknut and check the measurement again.

Where the cable stop is seated on the edge of the clutch housing, pull back the outer cable as far as it will go.



Measure between the cable stop on the clutch housing and the adjuster nut. Adjust as necessary.

Adjusting the clutch / 3

Checking and adjusting a hydraulic clutch

Many hydraulic clutches are self-adjusting, but some designs allow adjustment to compensate for wear of the friction plate.

If your hydraulic clutch is adjustable, the pushrod at the slave cylinder will be threaded and fitted with a locknut.

Check that the fluid in the clutch master-cylinder reservoir (SHEET 257) is at the correct level. Raise the car securely on ramps or axle stands.

Get underneath the car and locate the clutch slave cylinder and its adjustable pushrod to the clutch operating lever.

Use pliers to unhook the pull-off spring from the operating lever. Push the lever forward as far as it will go.

Hold the lever in this position and use a ruler to measure the distance between the end of the slave cylinder body and the operating lever.

Release the lever, then measure the same distance again while it is at rest.

The difference between the two measurements is the clutch clearance. Compare it with the figure given in DATASHEETS or the car handbook, and adjust as necessary.

The locknut and the adjuster nut are on the threaded end of the pushrod. Loosen the locknut.

Screw the adjuster nut towards the slave cylinder to increase clearance, or towards the operating arm to decrease it. When the measurement is correct, tighten the locknut.

Re-check the measurement and adjust it again if necessary. Depress the clutch pedal several times, then check it again.

Other problems

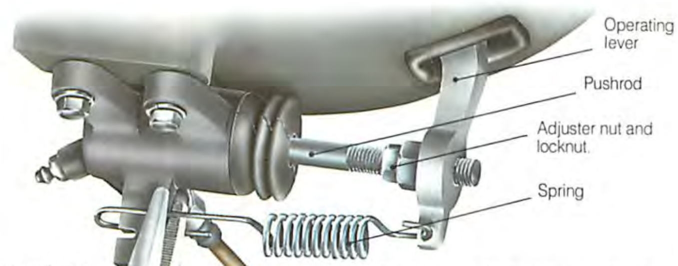
If a hydraulic clutch is not adjustable, or if adjustment fails to cure clutch slip, the clutch itself needs to be overhauled.

If, however, the problem is clutch drag, then the hydraulic system itself may be at fault. Clutch drag occurs when the pressure plate does not fully disengage from the clutch plate, making gear changing difficult and noisy.

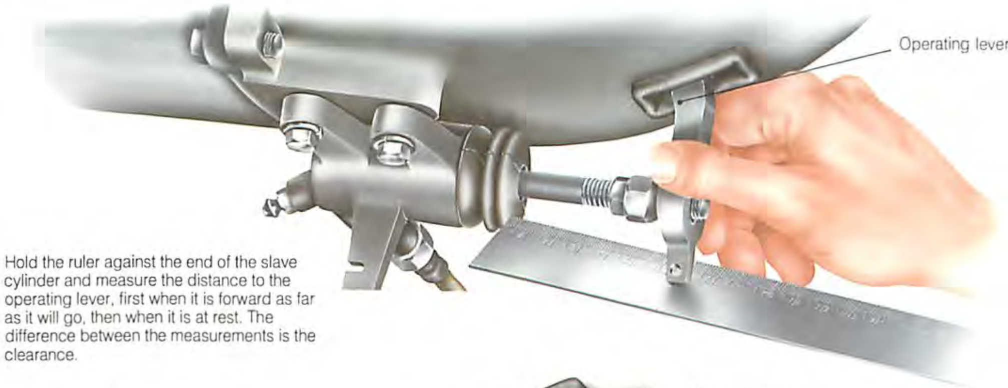
Bleed the system and check hydraulic pipes, master cylinder and slave cylinder for fluid leaks or air locks (SHEET 259).

Topping up

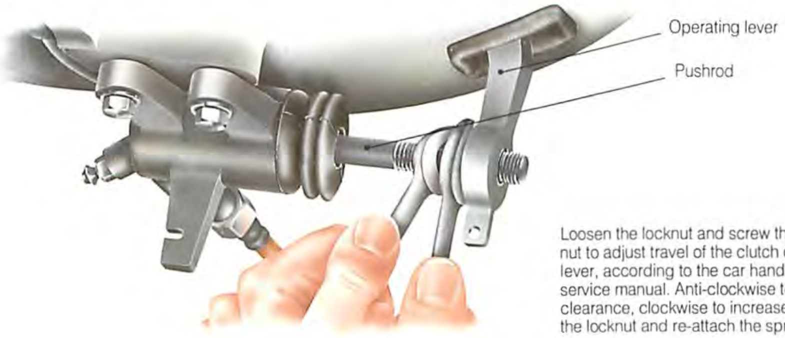
Keep the clutch master-cylinder reservoir topped up to the correct level. Use only the recommended fluid.



Unhook the pull-off spring from the slave-cylinder body and the operating lever, so that you can push the operating lever as far as it will go to measure its travel.



Hold the ruler against the end of the slave cylinder and measure the distance to the operating lever, first when it is forward as far as it will go, then when it is at rest. The difference between the measurements is the clearance.



Loosen the locknut and screw the adjuster nut to adjust travel of the clutch operating lever, according to the car handbook or service manual. Anti-clockwise to reduce the clearance, clockwise to increase it. Tighten the locknut and re-attach the spring.

Checking and adjusting a hydraulic clutch on a Mini

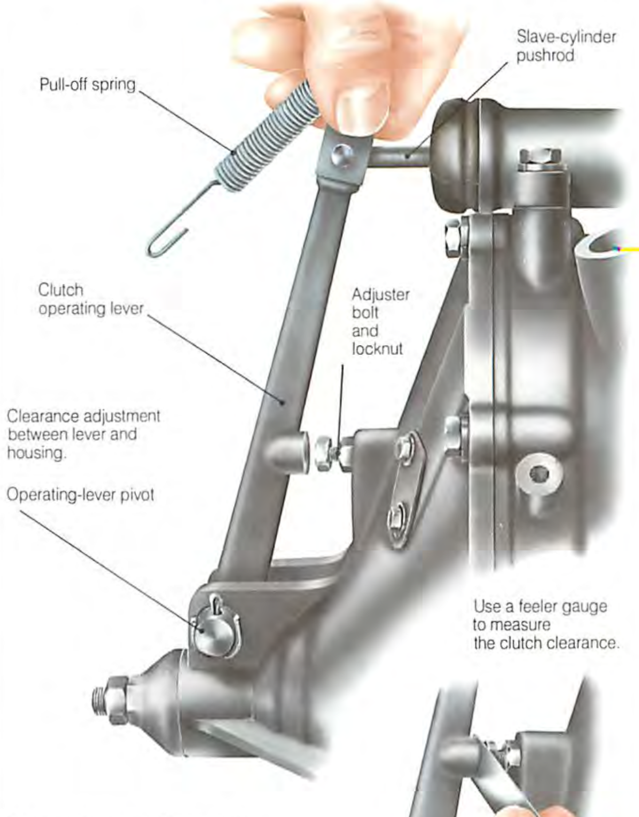
Check that the fluid in the clutch master cylinder is at the correct level. The adjuster bolt and locknut are mounted on the clutch housing. Clearance is measured between the bolt head and a stop on the clutch operating lever.

Unhook the pull-off spring from the clutch operating lever. Pull back the lever as far as it will go.

Hold the lever back and use a feeler gauge to measure the gap between the adjuster bolt and the stop on the lever. Compare it with the figure given in DATASHEETS or in the car handbook.

To adjust, loosen the locknut and turn the adjuster nut until the measurement is correct. Tighten the locknut and re-check.

Once the clearance is correct, reconnect the pull-off spring.



Use a feeler gauge to measure the clutch clearance.

British Leyland cars with transverse engines, including the Mini, have hydraulic clutches. The clearance between the clutch operating lever and the housing is the only adjustment to be made, unless the clutch has been dismantled (see also SHEET 253).

Adjusting the clutch / 4

Checking free play at the clutch pedal

Place one end of a steel rule upright on the floor by the clutch pedal. Depress the pedal several times, then release it. Note the measurement between the floor and the lower edge of the pedal pad.

Get a helper to depress the pedal until he feels something make contact – this will be when the clutch release bearing takes up the pressure plate.

With the pedal held in this position, measure the height from the floor to the lower edge of the pedal pad.

Take the difference between the two measurements and compare it with the maker's specified clearance figure, which is often in the region of $\frac{1}{4}$–$\frac{1}{2}$ in. (6–13 mm).

An alternative way of measuring the clearance is with a block of wood held upright beside the pedal. Mark off the high and low points of the pedal travel on the wood, and measure the distance between.

If the clearance needs adjustment, it may have to be made underneath the car, probably by one of the methods described. Check in your car service manual.

After adjustment, check the pedal free play again and readjust if necessary.

Depress the clutch several times and release it. Mark the height of the pedal pad on the wooden block. Depress the clutch pedal until you can feel it engage the release bearing, and mark the height of the pad again.

You may need a helper to depress the clutch with a foot for the second mark, since the foot is more familiar than the hand with the 'feel' of the clutch.

Measure the distance between the marks on the wooden block. This is the free play, to be compared with the car maker's specification – see DATASHEETS or the car handbook or service manual.

Adjusting cable clearance at the bulkhead

On some cars the clutch cable can be both checked and set under the bonnet

On others only the adjustment can be made under the bonnet – the clearance may have to be checked at the pedal or under the car. Check in the car handbook or service manual.

Some types of clutch linkage may have a constant-contact clutch release bearing, for which there should be no movement at the clutch operating lever when the clutch is properly adjusted.

DATASHEETS or the car service manual will give you the maker's specified figure for clutch adjustment.

One type of clutch adjustment made at the bulkhead has a groove and circlip arrangement.

Lift the bonnet and locate the clutch cable where it emerges from the bulkhead. The end of the cable is grooved and fitted with a circlip.

Hold the cable and pull it away from the bulkhead as far as it will go.

With the cable pulled back, count the number of grooves between the circlip and the bulkhead. Compare the number with that specified in the car handbook or service manual.

If the two numbers differ, move the circlip backwards or forwards as necessary to leave the recommended number of grooves between it and the bulkhead.

An adjuster nut and locknut is used on some systems. Check the clearance as recommended in DATASHEETS or a service manual.

The check may have to be made at the clutch pedal (see left). Lift the bonnet and locate the clutch cable where it emerges from the bulkhead. The locknut and adjuster nut are on the threaded end of the cable.

Loosen the locknut and turn the adjuster nut as necessary to adjust the clearance. If there is too much clearance, screw the adjuster away from the bulkhead. If too little, towards the bulkhead.

If the car handbook or service manual specifies that there should be no movement at the clutch operating lever, this must be checked under the car where the lever protrudes from the clutch housing.

Tighten the locknut and re-check the clearance, adjusting again if necessary.

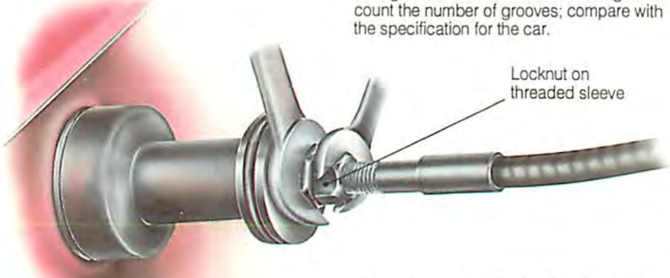
Some cars have an indicator light on the instrument panel that registers clutch wear. The light comes on when the clearance is insufficient.

When adjusting the clutch clearance, get a helper to switch on the ignition and watch the light indicator.

Once the clearance has been adjusted to the maker's specified measurement, the light will go out.

Some cars allow clutch adjustment underneath the bonnet, at the front bulkhead. A self-adjusting clutch may have a ratchet device attached to the clutch pedal at this point.

The bulkhead clutch adjustment may be by means of a circlip in a groove. Pull the cable through the bulkhead as far as it will go and count the number of grooves; compare with the specification for the car.



The adjustment at the bulkhead may be by a conventional locknut. Pull the cable as far as it will go and measure the clearance; adjust as necessary with spanners.

Bleeding the clutch

Many cars have clutches that work hydraulically. The mechanism that operates them is sturdy and long lasting, requiring only an occasional look in the fluid reservoir (SHEET 259) to make sure the level is correct.

If the fluid level in the reservoir is more than ¼in. (6 mm) below the top (or the full mark), inspect the whole system immediately for leaks.

Leakages let air into the system, causing erratic pedal response. After the trouble has been located and put right, bleed the clutch to expel air and replace it with clean, uncontaminated fluid.

On some front-wheel-drive cars, the clutch freeplay must be adjusted (SHEETS 253–256) before bleeding.

Clutch fluid is the same as that used in braking systems, and must conform to strict international specifications. It should come in a sealed, airtight container bearing one of the three current specification marks: SAE J1703, US FMVSS or 116 DOT 3.

Most cars use a type of fluid containing polyalkylene glycol ethers, but some use a mineral-based fluid. Check your car handbook – on no account should the two types be mixed.

If the clutch pedal still has a spongy feeling after bleeding, bleed the system again.

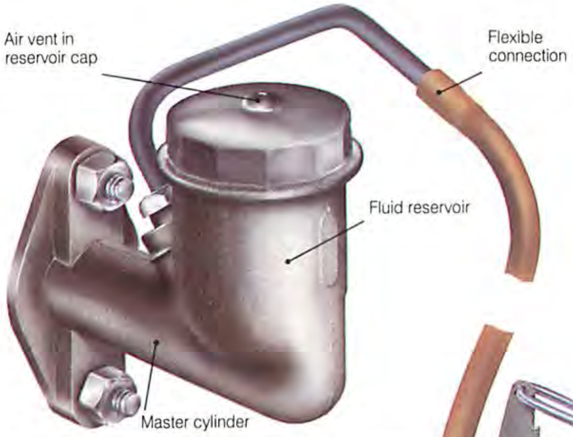
If the pedal still does not work the clutch effectively, examine the places where the pushrods enter the master cylinder and slave cylinder, peeling back the rubber dust covers. The fluid is probably leaking past the seals (SHEETS 259–260).

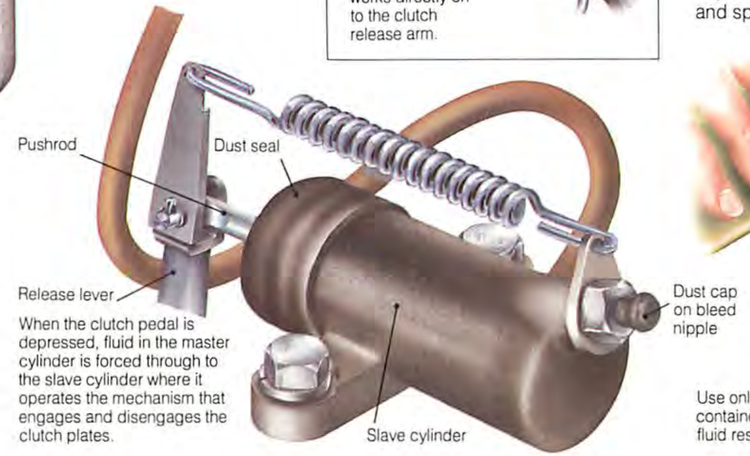
Hydraulic fluid is highly poisonous and corrosive. If you get some in your eye, flush it with clean water for 15 minutes, and call a doctor.

Store out of reach of children, and take care not to spill any on your car – it eats through paintwork in seconds.

Tools and equipment

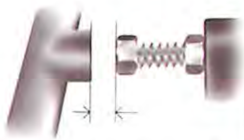
HYDRAULIC FLUID • JAR • BLEED TUBE • SPANNERS • RAG





When the clutch pedal is depressed, fluid in the master cylinder is forced through to the slave cylinder where it operates the mechanism that engages and disengages the clutch plates.

Front-wheel drive



On some front-wheel-drive cars, the clutch freeplay must be adjusted before bleeding (SHEET 253). Check in your car handbook.

Side-mounted cylinder

On most rear-wheel-drive cars, the clutch slave cylinder is mounted on the side of the clutch housing and works directly on to the clutch release arm.

Topping up the reservoir

Allow the new clutch fluid to stand, unshaken, for at least 24 hours before using, to allow any bubbles to dispel.

Wipe away any dirt that may have collected around the reservoir cap, so that no specks drop in when you unscrew it.

Remove the cap and check that its sealing ring is sound and that the air hole is clear.

Top up to the correct level with new clutch fluid. After pouring liquid, tightly replace the container lid, or moisture will get into the liquid and spoil it.

Use only high-quality fluid from an airtight container to top up the master-cylinder fluid reservoir.

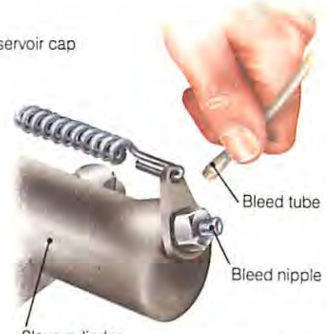
Fitting a bleed tube

A bleed tube can be rubber or plastic, about 2 ft (600 mm) long and about $\frac{3}{16}$ in. (5 mm) in diameter.

Find the bleed nipple of the clutch slave cylinder – it may have a rubber or plastic cover to protect it from dirt.

Remove the cover and clean the nipple thoroughly. Fit the end of the bleed tube securely over the nipple. It must be a tight, push-on fit.

A plastic tube will be easier to fit if you first soften the end by immersing it in warm water.



Fit one end of the bleed tube over the cleaned bleed nipple on the slave cylinder.

Bleeding sequence

Pour about an inch of new hydraulic fluid into a clean jar, and stand it on the ground under the slave cylinder.

Put the free end of the bleed tube into the jar, below the surface of the fluid. Air and fluid from the system will be pumped into the jar.

Remove the bleed-nipple dust cover on the slave cylinder and fit the bleed tube as described (see right). The nipple is easily damaged, so use a spanner of the right size to unscrew it about three-quarters of a turn.

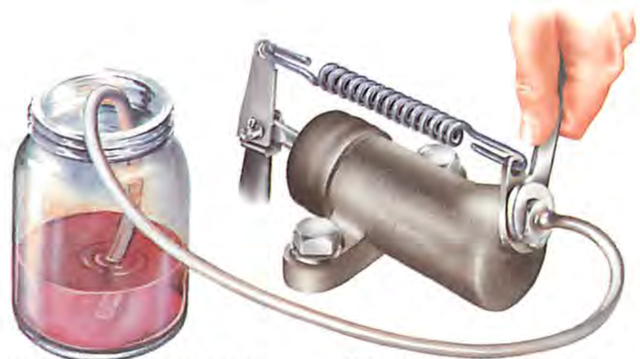
Get a helper to press the clutch pedal smartly all the way down, then release it quickly. If bubbles flow from the end of the pipe in the jar, pump the pedal until no more appear. Keep the end of the tube immersed in the fluid all the time.

If after six pedal strokes the bubbles have not cleared, top up the reservoir before you continue pumping. Otherwise, more air will be drawn into the system and it will have to be bled again.

When the system is free of air, get the helper to hold the pedal down while you tighten the nipple.

Before you remove the bleed tube and jar, depress the clutch pedal to ensure that the pressure required is normal.

Top up the fluid reservoir and screw the cap on firmly. Get your helper to work the pedal vigorously several times while you inspect all the joints and piping of the system for leaks.



Unless the end of the bleed tube is covered with fluid, air will be sucked into the system during pumping.

Use a spanner of the right size to open the bleed nipple. Unscrew it about three-quarters of a turn.

One-man method

A bleed tube with a non-return valve enables bleeding to be done without the aid of a helper. The end with the non-return valve is placed in the fluid in the jar, so that fluid pumped out through the tube cannot be sucked back from the jar when the clutch pedal is released.

This means that you can pump the pedal yourself, and then take your foot off the pedal to inspect the fluid in the transparent tube for bubbles. Also you can tighten the bleed nipple without someone having to hold the pedal down.

Checking the half shafts

Half shafts, otherwise known as axle shafts, are fitted in rear-wheel-drive cars only. They give relatively little trouble during normal motoring, although they are highly stressed components.

The inner end of the shaft is supported and driven by the differential, and the outer end is supported in bearings between shaft and axle housing.

These bearings have either built-in or separate oil seals. The bearings can be ball bearings, taper roller bearings (both with inner races), or straight roller bearings which use the axle shaft as the inner race.

When a half shaft fails, the rear wheels cannot be driven.

The main symptoms of a worn half shaft are a knock or clunk when accelerating or decelerating. The cause is wear and excessive play between the shaft and differential splines.

However, the same symptoms can be caused if the crown wheel and pinion gears in the differential are not meshing correctly, the drive-pinion flange splines are worn, or the drive-flange bolts are loose.

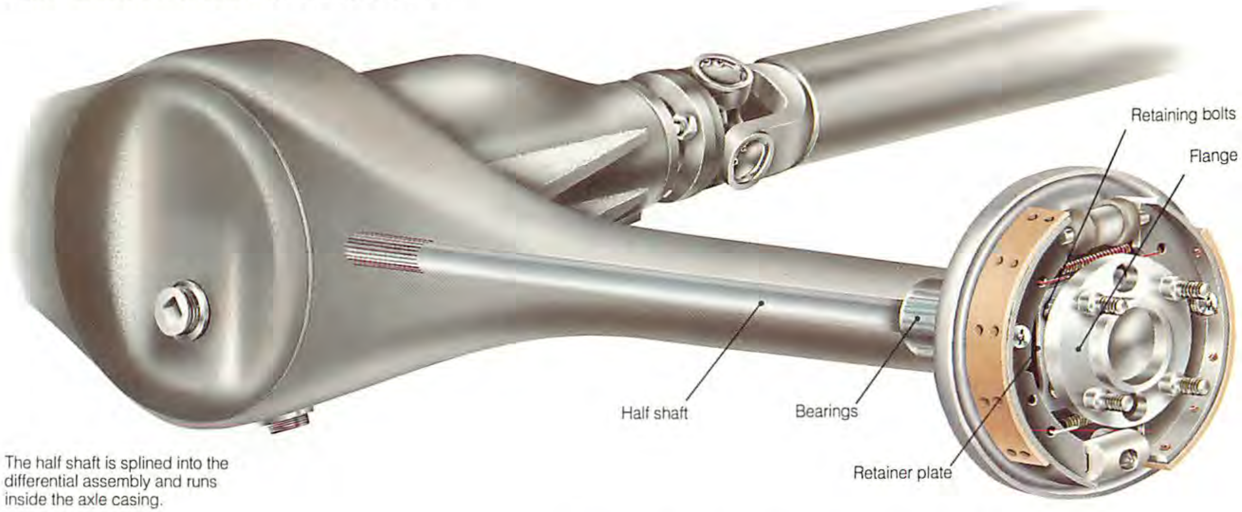
If you are not sure of the noise source, consult a garage. Special tools are needed to check wear, called backlash, in such components as the crown wheel and pinion.

Oil leakage, especially oil seeping from the end of the axle casing and on to the brakes, is caused by oil-seal failure. The half shaft must be removed and the seal replaced.

Tools and equipment

AXLE STANDS • SLIDE-HAMMER • SOCKET SPANNERS • STRAIGHT-EDGE • OIL • GREASE • PARAFFIN • SOFT-FACED HAMMER

Half shaft on a rear-wheel-drive car



The half shaft is splined into the differential assembly and runs inside the axle casing.

Removing the half shaft

Major work on the rear-axle assembly requires special skills and equipment available only at a garage. However, removing and checking the half shaft is relatively easy.

A slide-hammer (SHEET 49) is the only special tool needed to remove a half shaft.

Loosen the wheel nuts and jack up the rear of the car, supporting the axle casing securely on axle stands. Remove the road wheel and brake drum (SHEET 88).

On some cars it may be necessary to disconnect the brake pipe (SHEET 93) and handbrake linkage (SHEET 94).

Decide by visual inspection or reference to the car service manual.

If the brake pipe has to be disconnected, the braking system must be bled later (SHEET 90).

With the drum removed, you will see a flange on the end of the half shaft, either forged on as part of the shaft, or bolted on.

The shaft will be held by either a bolt-on retainer behind the flange or an inner retainer. The method of dealing with an inner retainer is described on SHEET 262.

Most flanges have two large holes giving access to bolt-on retainers.

A socket spanner can be passed through the hole to remove the securing nuts or bolts. You should then be able to connect a slide-hammer to the shaft flange and jar the shaft and its bearings out of the axle housing.

Before using the slide-hammer, make sure there is nothing else holding the retainer. The bolts holding the retainer plate may also hold the backplate.

If so, free the retainer and then refit two of the bolts to hold the brake assembly in place.

On cars with half shafts held by inner retainers, it is necessary to disconnect the propeller shaft, remove the differential pinion shaft (SHEET 262) and push in the half shaft so the C-washer retainer can be withdrawn and the shaft slid from the axle housing.

With the slide-hammer securely bolted to the half-shaft flange, start hammering steadily and withdraw the shaft slowly.

Too much force could damage the bearings, which you may plan to reuse. Always try to withdraw tight-fitting components slowly and evenly, to avoid damage or distortion.

Pass a socket and extension through the access holes in the flange to undo the retainer bolts or nuts.

Bolt the slide-hammer to the half-shaft flange and withdraw the shaft with steady, even strokes.

When the splined end is free, the shaft will tend to tilt; try to keep it level to avoid damaging the bearing and oil seal.

Inspecting the shaft, bearings and oil seal

Take the half shaft to a workbench and (unless it is obviously broken) examine it carefully along its length for signs of rubbing or 'high spots', recognisable as shiny spots on the metal. Check it with a straight-edged rule for distortion.

Never hammer a slightly distorted shaft in an attempt to straighten it. It can only be straightened in a press. If distortion is severe, a new shaft must be fitted.

Pay particular attention to the splined ends. They must be in perfect condition, with no sign of wear.

Clean the bearings in paraffin and inspect the balls and races for pitting.

A badly worn bearing will run roughly and, in extreme cases, feel sloppy.

After cleaning, lubricate the bearing with fresh oil, spin it close to your ear, and listen carefully. Rough running will be clearly audible as a grating sound.

It is, however, advisable to renew bearings automatically whenever a shaft is disturbed.

Bearing removal and replacement is a precise operation and usually requires a hydraulic press. It is best left to a garage.

Bearings can be hammered off and drifted back on, but there is a danger of distorting the shaft.

Bearings with integral oil seals are usually retained by a collar or ring which has to be split with a chisel before removal.

It is better to have the job carried out professionally.

If the seal is not integral with the bearing (on some older cars) it can be prised out and replaced before refitting the half shaft.

Clean and lightly grease the whole shaft and push it gently into the axle casing until you feel the end come up against the differential side-bearing splines.

Move the shaft around until the splines engage, then drive it fully home with a soft-faced hammer against the flange centre.

Do not hit the flange on its edges, or with a steel hammer, or it could break.

Reassembly of the flange, brake drum, brake hose and wheel is the reverse of the removal.

After refitting the half shafts, lower the car on to its wheels, check the rear-axle oil level and top up if necessary (SHEET 249).

Checking and renewing clutch master and slave cylinders / 1

If a clutch fails to disengage fully when the pedal is pressed, the problem may be the clutch itself. In a hydraulic clutch, however, the problem may lie in the master or slave hydraulic cylinders.

Worn or ill-fitting seals may allow hydraulic fluid to leak past the piston in either cylinder, so that the slave piston does not travel far enough to disengage the clutch.

Any sort of leak will have the same effect and air might get into the system.

If the system has air in it, the action of the pedal may feel 'spongy', whereas with other faults the pedal may feel normal, although the clutch does not work properly.

If seals are worn or damaged, fit a service kit which includes new seals.

The cylinder bores may have worn or become rough – hydraulic fluid is hygroscopic, absorbing moisture from the atmosphere, which can cause corrosion in the bores.

In this case, fitting a new cylinder is the only remedy. Trying to smooth the bore with abrasives only makes it worse, and the roughness quickly wears out new seals.

Lack of fluid is easily fixed by topping up the master-cylinder reservoir, but you still have to find out why the fluid level was low. There should be virtually no loss in normal use.

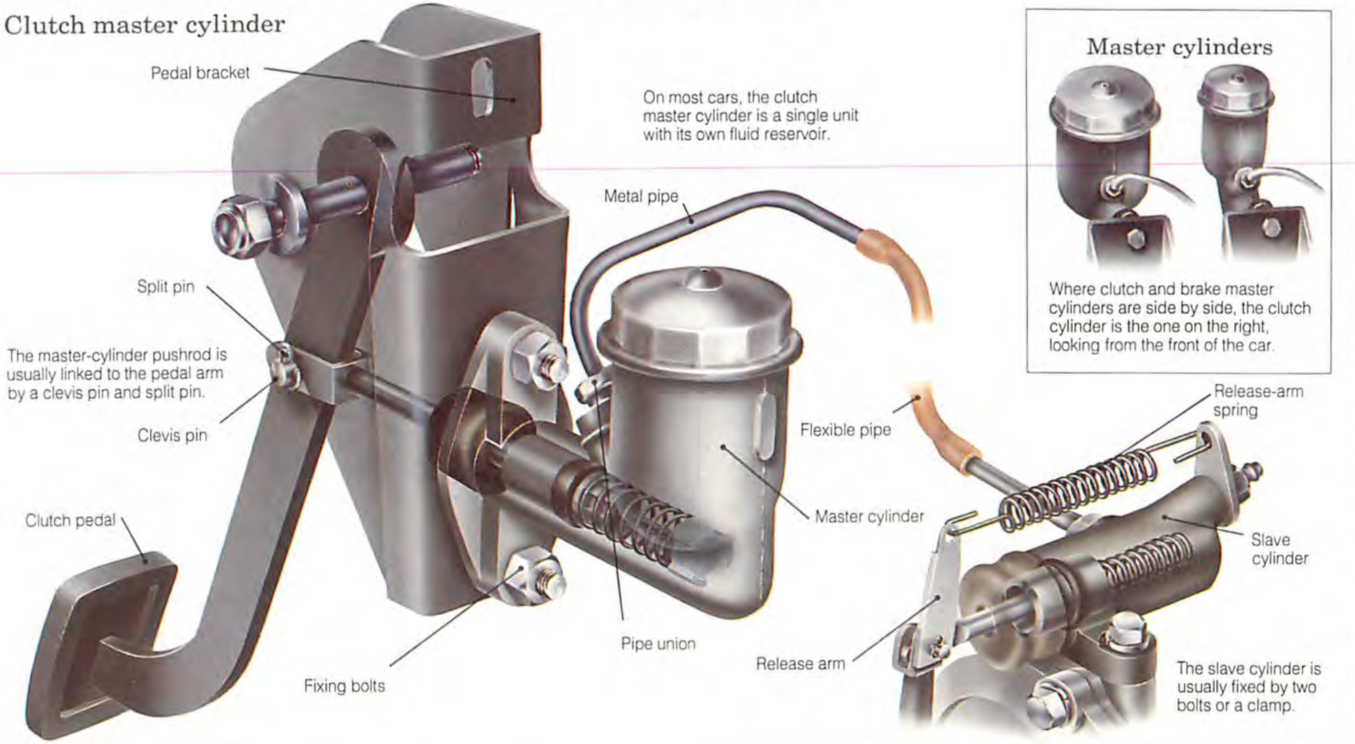
Remove air from the system by bleeding it (SHEET 257). Check the entire system and repair any leaks.

If you replace either a master or a slave cylinder, buy one of the same manufacture, and be absolutely sure you get the right model or an approved successor.

Tools and equipment

PLASTIC SHEETING • RAG • DRIP CONTAINER • SPANNERS • SMALL PLASTIC BAG • RUBBER BANDS • LONG-NOSED PLIERS • SCREWDRIVERS • SIDE CUTTERS • CORK OR RUBBER BUNG • HYDRAULIC FLUID • BLEED TUBING • SPECIAL BL EXPANDING TOOL IF REQUIRED

Clutch master cylinder



Master cylinders

Where clutch and brake master cylinders are side by side, the clutch cylinder is the one on the right, looking from the front of the car.

Checking the system

The clutch master cylinder is usually found on the bulkhead next to the brake cylinder. Usually each cylinder is directly in front of its pedal, so the clutch cylinder is the one on the right as you look from the front of the car.

Brakes with servo assistance (SHEETS 95-96) may have a different arrangement, but it should be clear which cylinder is which.

If the clutch fluid is low, look all over both master and slave cylinders and the pipe that connects them for signs of a leak. Pull back the lip of the dust cover on both cylinders. If there is hydraulic fluid inside the cover the piston seal is worn or damaged or the cylinder may be scored.

If you find a leak, remove the faulty part and overhaul or replace it.

If you can find no trace of a leak, fitting a complete service kit to both cylinders may cure the trouble.

If the fluid level is normal but the clutch 'drags' (will not disengage properly), and particularly if the pedal feels spongy, there is air in the system. Bleed the system (SHEET 257).

Removing the master cylinder

Set a container to catch any fluid that runs out when you remove the cylinder, and protect paintwork with plastic sheeting or absorbent rags.

Unscrew the pipe union nut and lift the pipe clear, taking care not to bend or damage it. Cover the pipe end with a small plastic bag secured by a rubber band, to keep out dirt.

Disconnect the clutch pedal from the master-cylinder pushrod. Most cars have a simple clevis pin on the pedal arm which passes through a fork on the end of the pushrod. Remove the split pin or retaining clip to release the clevis pin. (Use a new split pin when refitting.)

If the reservoir is not integral with the cylinder, remove the reservoir cap. Put a small sheet of plastic over the mouth of the reservoir, then screw the cap back on over the plastic. This reduces fluid loss through the pipe to the cylinder by blocking the vent hole in the cap. Unscrew the union nut connecting the pipe to the cylinder.

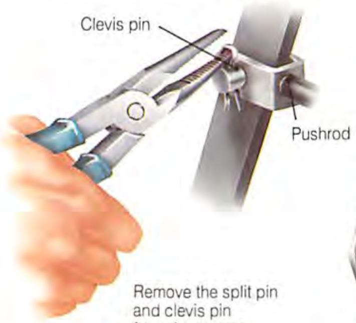
Pull the reservoir or its connecting pipe off the cylinder and quickly plug the hole in the reservoir or the end of the pipe with a small rubber bung or cork.

Normally the master cylinder is held to the bulkhead by two bolts, or nuts on studs. Unscrew these and lift off the cylinder.

After refitting, top up with fluid and bleed the system.

Unscrew the pipe union nut to pull the pipe free.

Bend the pipe as little as possible, and cover the end to keep out dirt.



Remove the split pin and clevis pin from the master-cylinder pushrod.

Unscrew the fixing bolts and lift off the master cylinder.

Checking and renewing clutch master and slave cylinders / 2

Fitting new master-cylinder seals

Always renew the seals whenever you dismantle the master cylinder or slave cylinder.

There is usually a rubber dust cover at the pushrod end of the cylinder. Pulling this back along the pushrod usually reveals a circlip at the mouth of the cylinder which acts as a rear stop for the piston. Push the piston in, then release the circlip – it may or may not need special circlip pliers.

The spring inside the cylinder should now push the piston out. If it does not, push the piston down against the spring pressure and then release it quickly.

Remove all the internal parts, carefully noting the order in which they fit together. Keep them in a clean container.

Wash the cylinder with methylated spirit or clean hydraulic fluid. Dry it with a lint-free cloth and examine the bore for corrosion, pitting or scratching. If there is any damage, buy a new cylinder.

The service kit includes a cup seal which fits next to the piston, and a smaller valve seal which goes at the end of the valve stem.

To free the old seals, unfasten the spring retainer (also called a 'thimble' because of its shape). It may have a prong on it; straighten this with a thin screwdriver to free the retainer.

Remove the valve and piston seals, noting which way round they fit.

On a typical cylinder the refitting order is:

Fit the new valve seal to the valve stem, then fit the spacer and spring retainer to the valve stem;

Fit the seal to the piston (cup towards spring), then the spring assembly to the piston;

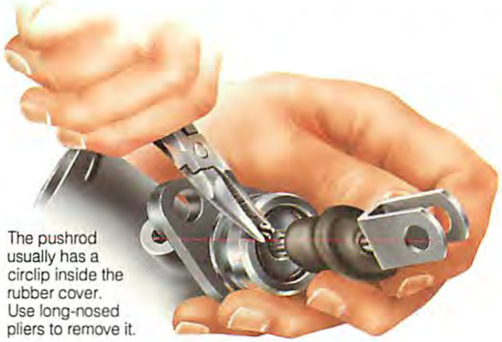
Gently push the retainer prong down to lock it.

Details differ slightly from one cylinder to another. Assembly instructions are often supplied with the new kit.

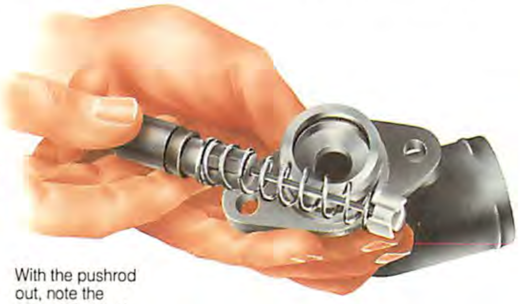
Finally, lubricate the cylinder bore and the internal parts with fresh hydraulic fluid, then slide the piston in.

The service kit usually includes a sachet of special grease for use on rubber. Squeeze this into the recess in the outer end of the piston. Do not use ordinary grease.

Fit the pushrod and washer, and fasten them in with the circlip, making sure it seats properly in its groove. Slide the rubber cover into place and refit the cylinder.

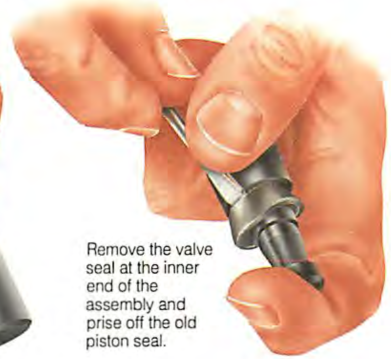


The pushrod usually has a circlip inside the rubber cover. Use long-nosed pliers to remove it.



With the pushrod out, note the order of internal parts to aid refitting

With a thin screwdriver, straighten the prong to free the spring retainer.



Remove the valve seal at the inner end of the assembly and prise off the old piston seal.

Removing a slave cylinder

On most cars the slave cylinder is relatively easy to remove, being held by either a clip or bolts.

Connect a short length of plastic tubing to the bleed nipple and put the other end into a container standing underneath – a jam jar serves well.

Open the bleed nipple and pump the pedal until the system is empty of fluid.

Remove the plastic tube from the nipple, and dispose of the hydraulic fluid in a safe place – do not empty it down a drain as it is corrosive and poisonous.

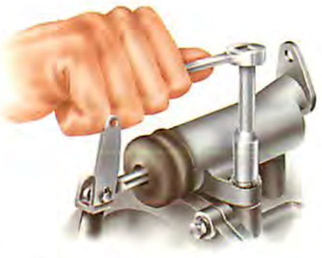
Loosen the cylinder-pipe union nut and disconnect the release-arm return spring.

Disconnect the pipe at any stage that allows you to do so without bending it too far. Cover the pipe end to keep out dirt.

The cylinder is normally held to a bracket or to the flywheel housing by two bolts. Unscrew them and remove the cylinder and pushrod, noting carefully how all parts fit so that you can refit them correctly.

After you refit the cylinder and reconnect the pushrod and hydraulic pipe, bleed the system.

Loosen the pipe union nut on the side of the cylinder and undo the release-arm return spring. Remove the clevis pin from the release arm.



Undo the cylinder mounting bolts.

Lift the cylinder free of its pushrod.

Removing a special cylinder

On a Marina Ital, disconnect the hydraulic pipe and unscrew the slave cylinder (towards the release lever) until the flat on its shoulder faces the clutch housing.

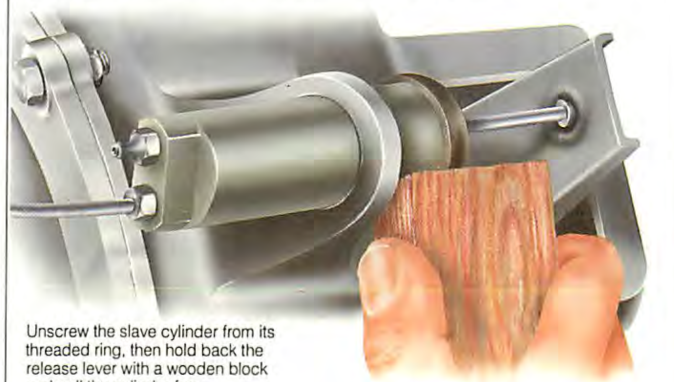
Press the pushrod into the cylinder until it clears the release lever, then lift the rod out sideways.

Pull and hold the release lever away from the cylinder until there is room to remove the cylinder.

BL sells a special X-shaped expanding tool (part No. 18G 1213) to hold back the cylinder. Alternatively, you can wedge it with a piece of wood of suitable size.

Pull out the cylinder. The pull needs some force.

Refit the cylinder with the bleed valve uppermost.



Unscrew the slave cylinder from its threaded ring, then hold back the release lever with a wooden block and pull the cylinder free.

Fitting new slave-cylinder seals

Slave cylinders vary slightly in their internal details, but most are very like master cylinders and new seals are fitted in much the same way.

However, the slave cylinder is likely to be very dirty, because of its position in the car. Clean and dry the outside before dismantling it.

If the internal parts refuse to come out, plug a foot pump into the fluid inlet and cover the open end of the cylinder with a cloth.

When you pump, the parts should spring out into the cloth.

When reassembling take extra care not to turn the lip of the piston seal under. Smear special rubber grease – not ordinary grease – over the area where the rubber end cover fits.

When pushing the cup seal into the cylinder, do not turn the lip under.

Replacing transmission oil seals / 1

There are two main types of oil seal: static and dynamic. A static seal fits between two non-moving parts, a dynamic seal between a stationary part and a moving one. Most seals are made of synthetic rubber.

An example of a static seal is a simple 'O' ring. These seals can be found in such places as the oil filter used on combined automatic gearbox and engine units, on conventional gearbox front covers and in automatic gearboxes.

Dynamic seals are more complex in shape, with one or two lips, depending on where they are situated. These are widely used in the transmission system of both front and rear-wheel-drive cars, where oil must be sealed in where a rotating shaft passes through a component. For example, at the outer end of a half shaft and on the differential pinion.

Dynamic seals also contain a thin coiled spring, called a 'garter spring', which holds the sealing lip in contact with the revolving shaft.

Many seals have a metal outer casing for added strength and ease of fitting. Because the seal is in constant contact with a moving part, dynamic seals eventually wear and begin to leak, and both dynamic and static seals deteriorate with age.

Most seals are inexpensive and easy to replace, but many are in places where you must do a lot of dismantling to get at them.

For example, gearbox oil seals (apart from the extension-housing seal on rear-wheel-drive cars) can be replaced only with the gearbox removed – a task best left to a garage.

However, the seals on the rear axle and final drive should all be possible to replace fairly easily, although special tools may be necessary.

After many miles and several new seals, the moving part against which the dynamic seal fits may wear.

Slight wear can sometimes be taken up by fitting a shim between the seal and its housing, to change the point of contact. But if a shaft becomes seriously grooved it must be replaced or repaired at a garage or engineering machine shop.

This is not a common occurrence, but any point at which a shaft rotates in a seal is a possible leak source. Check such points regularly.

When fitting and handling any oil seal, keep it and its sealing point absolutely free from dirt and grit. Make sure you fit the seal the right way round. The lip (or lips) always faces the oil it is sealing.

Tools and equipment

AXLE STANDS • SPANNERS • DRIP TRAY • SCREWDRIVER • OIL-SEAL PULLER • SOCKET • CENTRE PUNCH • PLIERS • SOFT-FACED HAMMER • TWO-LEGGED PULLER • TORQUE WRENCH • GREASE • BALL-PEIN HAMMER • DRIFT

Static and dynamic oil seals


A static oil seal, as fitted to a replaceable oil filter, where there are no moving parts.


The dynamic seal surrounds a turning shaft. The lip always faces the oil it seals in, and the garter spring provides gentle pressure.

Replacing a gearbox-extension housing seal

The extension housing seal can usually be replaced without removing the gearbox.

Disconnect the propeller shaft from the extension and put a drip tray under the extension. In most cases you can prise out the old seal with a screwdriver, taking care not to damage the bore.

Some Ford gearbox-extension oil seals are set deeply into the housing; it is best to use a special removal tool to avoid scoring the bore. The tool is a puller which is screwed into the seal, fitting over the gearbox output shaft.

Vauxhall extension oil seals are part of a replaceable collar. Tap it off with a sharp drift or an old screwdriver.

Clean the bore and coat the new seal with multi-purpose grease. Tap the new seal into position, using a socket or a tube large enough to rest only against the outer part of the seal, and a soft-faced hammer.

To avoid damage to the seal, smear its lip and also the front of the propeller shaft with grease before inserting the shaft into the extension housing and refitting it.


A Vauxhall extension oil seal has a collar which has to be tapped out, using a sharp drift.


On some cars a seal puller must be used. Turning the puller engages it with the seal; turning the bolt against the end of the gearbox shaft then withdraws it.


The new seal is tapped into the bore with a soft-faced hammer and a socket.

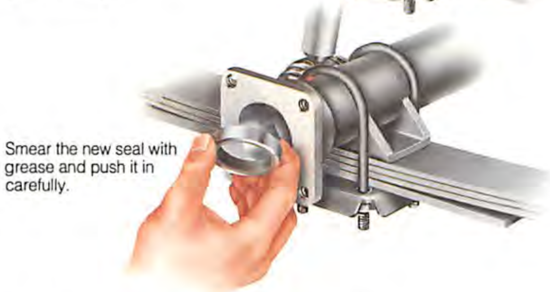
Replacing axle-shaft oil seals (live rear axle)

The design of the seals varies greatly from car to car. There may be up to three on both sides of the inner race of the bearing, and a ring outside it. Always replace all the oil seals when you remove a half shaft as they often leak after being disturbed (SHEET 258).

Prise them off carefully with a screwdriver, taking care not to damage their seatings, and clean the seatings.

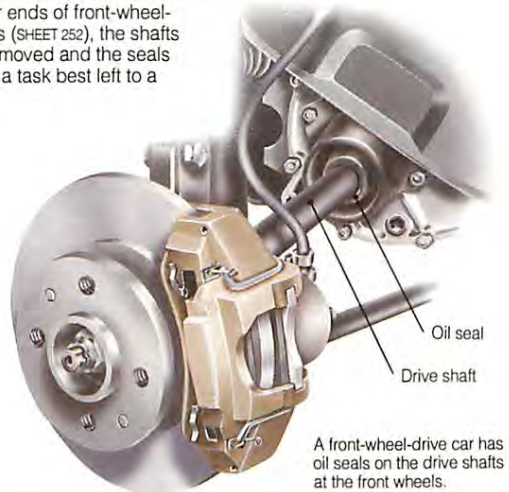
Smear the new seals with multi-purpose grease and push them in carefully with a piece of tube of a suitable size.


Prise the seal out with a screwdriver, taking care not to damage the seating.


Smear the new seal with grease and push it in carefully.

Replacing front-wheel-drive oil seals

If there is a leak from the oil seals at the inner ends of front-wheel-drive shafts (SHEET 252), the shafts must be removed and the seals renewed – a task best left to a garage.



A front-wheel-drive car has oil seals on the drive shafts at the front wheels.

Replacing transmission oil seals / 2

Removing the pinion oil seal (rear-wheel drive)

Raise the rear of the car on axle stands, chocking the front wheels; also apply the handbrake.

Undo the nuts holding the propeller-shaft flange to the pinion flange.

Mark the position of the pinion flange and its securing nut relative to the pinion-shaft end, using a centre punch. This is important for accurate reassembling later.

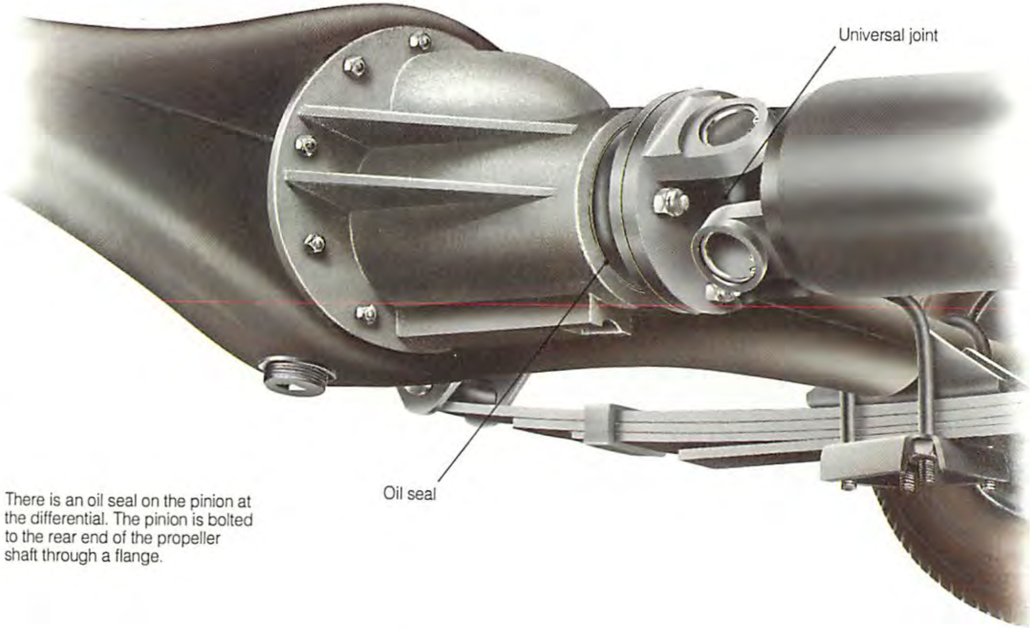
Unscrew the nut, counting the turns needed so that you can refit it exactly as it was in order to keep the pinion and crown wheel meshing properly inside the differential.

Put a drip tray under the differential nose to catch the oil. There will not be very much, as the level of the oil in the differential will only fall to the level of the nose.

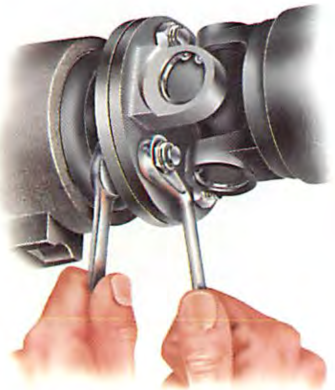
Tap the flange off its splined shaft, using a soft-faced hammer. If it is stubborn, use a pulling tool (like the one on SHEET 153).

Take care when using a hammer on the flange. Any distortion will result in misalignment of the propeller shaft, leading to early failure of the new seal.

Prise out the old seal with a screwdriver, taking care not to damage the seating.



There is an oil seal on the pinion at the differential. The pinion is bolted to the rear end of the propeller shaft through a flange.



Undo the nuts joining the propeller shaft and pinion flanges.

Unscrew the pinion nut, counting the turns. You may need to hold the flange steady by refitting two bolts and placing a bar between them.

Tap the flange off its splined shaft, using a soft-faced hammer.

Prise out the old seal with a screwdriver, taking care not to damage the seat.

Fitting a new pinion oil seal

Use a degreaser or paraffin to clean the area around the differential nose, thoroughly wiping up the mixture of oil and dirt caused by the oil leak. Dry the area with absorbent rags.

Clean the inner rim of the flange where it touches the seal, and lubricate it with hypoid gear oil.

Tap in the new seal, using a socket of the appropriate size and a soft-faced hammer. Be sure to fit it the right way round, with the lip facing inwards. A special tool of the right diameter is available for some cars, for pushing in the seal, but it is usually not necessary.

Clean and lubricate the flange where it touches the seal.

Tap in the new seal, using a socket or a large tube or bar of the appropriate size.

Grease the lips of the seal with a multi-purpose grease.

Oil the splines and refit the flange, holding it square to the pinion so as not to damage the seal. Give the nut the same number of turns that it took to remove it, and line up the marks you made earlier. If the nut is self-locking, fit a new nut.

Check with a torque wrench that the setting for the nut corresponds with that given in the workshop manual for the car, to provide the correct load on the pinion. Adjust the setting if necessary. Fit a new split pin on the nut, if required.

Reconnect the propeller-shaft flange to the pinion flange. Top up the differential housing with fresh hypoid gear oil to the correct level (SHEET 249).

Reconnect the flanges of the pinion and the propeller shaft.

Checking for wheel and tyre damage

Tyres are put under tremendous strains when a car is being driven.

There are only four relatively small areas of tyre tread in contact with the road. They carry the car's total weight, and transmit to the road the power that drives and accelerates it over the many changes of surface and gradient encountered.

They must also transmit the forces generated by braking and cornering.

Because they are in constant contact with surfaces that are frequently abrasive, damaged and even broken, tyres are more liable to wear and physical damage than any other car component.

For safety's sake, keep a regular check on them – and on the wheels that carry them. Make it at least once a fortnight, and also before any long or high-speed journeys.

Badly worn or damaged tyres are both illegal and potentially lethal: they can cost you your licence – or even your life.

It is better to look over the tyres and wheels while they are on the car than not to inspect them at all. But for a thorough examination of the inside walls, the wheels should be taken off about once a year (SHEET 266).

Tools and equipment

SCREWDRIVER • TREAD-DEPTH GAUGE • TYRE-PRESSURE GAUGE • FOOT PUMP • JACK AND AXLE STANDS • WHEEL CHOCKS • WHEEL BRACE OR SOCKET SPANNER • TORQUE WRENCH • RAGS

Signs of wear and damage

Check the tread for abnormal wear patterns, cuts or embedded nails or stones. Check the sidewalls for cuts, cracks, abrasions or bulges.

Inspecting tyre treads and sidewalls

The tread is the obvious place to start looking for tyre damage. Begin by inspecting carefully the whole circumference for abnormal wear and flaws in the pattern.

Abnormal widening of the grooves, or the spaces between tread blocks, usually means that the tyres are ageing.

If a series of cracks is evident, replace the tyre – even though there may still be 1–3 mm of tread left.

Pay special attention to the small slots and cuts – known as 'sipes'. Look for embedded fragments of sharp flint and stones, or the nails and tacks that are the usual cause of punctures and can cause internal damage.

That sort of debris can be prised out with a screwdriver blade. But removing it may leave the tyre with a slow puncture.

Check for loss of pressure, and if it occurs have a tyre-repair shop take the tyre off the rim, inspect it, and make a permanent repair.

Look also for 'flats' in the tread, worn perhaps by severe emergency braking – when the tyre of a locked wheel slides on the road, wearing off the rubber and generating a lot of heat.

Abnormally severe wear at the tread shoulders or uneven tread wear are warning signs that should never be ignored.

They could be the result of more fundamental problems – perhaps in the tracking or suspension and could soon lead to failure at speed (SHEET 264).

Bulges in the sidewalls are signs of carcass damage. Long before cords are showing through, these tyres are unsafe at speed. Sometimes the damage may not be visible, so if you have suspicions – perhaps after hitting a kerb – but cannot see any exterior evidence, ask a professional tyre fitter to remove the suspect tyre and examine it.

Often, fractures are visible inside before they become obvious outside. Any break in the carcass construction means replacing the tyre. It cannot be repaired safely.

Checking the tread depth

Tyres with treads of less than 1 mm deep are illegal in Britain. The treads must be at least 1 mm deep over 75 per cent of their tread width all round the tyre, and there must be evidence of some tread on the rest. However, most experts think this is not enough, and that it is unwise to drive on tyres in such a worn state.

If the tread depth can be measured against the rim of a 10p coin, it is down to 1 mm and the tyre is dangerous.

Many other countries – including most European and North American states – demand that the minimum tread depth should be present across the full width of the tread in contact with the road. European regulations are likely to come into force in Britain under EEC regulations.

A minimum of 1·5 mm is strongly recommended in the interests of safety.

In practice, it is sensible to take a tread depth of 2 mm as the stage at which tyres should be renewed.

As soon as tyres begin to show signs of wear, make frequent checks. Even with new tyres, regular checks can also reveal unusual wear patterns, which point to other problems.

You can make a simple check on tyre-tread depths with an implement such as a small screwdriver, which has a narrow, straight blade that will fit into the grooves between treads or tread blocks; you also need a millimetre rule or measure.

Put the screwdriver blade into the groove at right-angles to the tread surface, then use your thumbnail to mark the surface level on the blade. Taking care not to move your thumb, measure off the depth on your ruler.

Fit a screwdriver blade into the tyre grooves, mark the depth with your thumb and measure the depth against a metric rule.

Inexpensive tread-depth gauges are also available, which make checking even easier, and more precise. Make sure that the probe is extended fully, then insert the tip into the groove and press down. The tread depth can be read off on the gauge scale.

Insert the probe of the gauge into a groove in the tread and press down. Read the depth on the scale.

Check all round each tyre. Move the car slightly to include the sections of tyre on which the car was standing.

Some tyres are made with built-in tread-depth warning markers – usually bars running across the inside of the grooves.

When the tops of the bars become flush with the tread, the tread depth is almost at its legal limit and the tyre should be renewed.

Tyre sizes and markings

Most new tyres are radial-ply tyres. All reputable new radials are marked with the size and speed rating, cross-plies with the size only. Tyres without such markings are best avoided.

Generally, tyres have two size markings – the width of the tyre and the diameter of the wheel rim. The size may be given in inches or millimetres or a mixture of both; sizes solely in inches are on cross-ply tyres.

A tyre marked 6.40–10, for example, is 6.4 in. wide on a 10 in. diameter wheel, one marked 135–355 is 135 mm wide on a 355 mm wheel, and one marked 165–15 is 165 mm wide on a 15 in. wheel.

Letters interposed between the sizes are speed ratings, for example 155SR10. For radial-ply tyres speed ratings are: SR up to 113 mph, HR up to 130 mph, and VR over 130 mph.

On newer tyres with EEC approved markings, there is only one letter interposed – R for radial – and the speed rating letter is separate. A number beside it, such as 155R10 76 S, is the load index for the maximum tyre load in kilograms; 76, for example, indicates a 400 kg load.

Low-profile tyres also show the aspect ratio – the percentage of depth to width. For example, 145/70 SR10 means that the tyre depth is 70 per cent of the width.

Avoiding tyre wear

The best way to keep tyre wear to a minimum is to maintain correct tyre pressures for the load and speed conditions, and to drive as smoothly and carefully as possible. Avoid fierce braking, hard cornering and violent acceleration.

Fierce braking and acceleration scrub rubber off the tyre treads until a bare flat patch is worn. Brake flats may also result from faulty brakes that lock the wheel.

A distorted drum – distorted by the heat from excessive braking – may cause flats on opposite sides of the same tyre because a high spot on each side of the drum catches and drags the shoes.

Hard cornering transfers much of the car weight to the outside wheels, increasing the load on their tyres, particularly the tread shoulders. Even a slight increase in cornering speed can increase tread wear significantly.

Although wear increases with higher speeds, motorway cruising causes less wear to tyres than journeys with more braking and acceleration.

Poor road surfaces accelerate tyre wear, so does the weather. Tyres wear quicker in extremes of heat or cold. Wet roads cool the tyres and reduce friction between the tread and the road, so wear is lessened.

Uneven tyre wear indicates that something is wrong with the car. It may simply be that the tyres are not properly inflated, or there may be faults in the braking, steering or suspension systems.

The fault may be dangerous, and should be remedied as soon as possible. Although the cure may be expensive, in the long run it may be cheaper than continually replacing worn tyres.

Unbalanced wheels may cause unnecessary tyre wear – irregular worn patches – and also affect the steering and suspension. Most garages or tyre specialists will balance wheels after repairing a puncture. Make sure that wheels are balanced – on the car if possible – whenever a tyre has been removed or a new one fitted.

How wear affects the tread

Different wear patterns are an indication of the cause of abnormal tyre wear. But the cause is not always obvious, and a tyre may have excessive wear from more than one fault.

If a car is driven continually with the tyre pressures too high, most of its load is carried on the centre of the tread, which wears out faster than the shoulders. If it is driven continually with the tyre pressures too low, the tread on the shoulders wears faster than the centre tread.

Feathering, lifting of the tread at the groove edges, is one of the first signs that the wheels are out of alignment. The damage is caused by the wheel being dragged sideways as it moves forwards.

When wheels are misaligned, feathering is followed by excessive shoulder wear. If the wheels are pointing inwards (toeing-in), the outside shoulders are worn, predominantly on the passenger side, where it is exaggerated by the road camber. If the wheels are toeing-out, the inside shoulders are worn, this time predominantly on the driver's side.

Severe shoulder wear together with scooped-out parts in the centre of the tread indicates excessive wear in the suspension linkages, causing the wheels to flutter on the road surface as they go forwards.

Cornering at speed puts extra strain on one shoulder of a tyre, according to the direction of the turn. Constant hard cornering is likely to result in severe rasping of both shoulders of a tyre.

Friction and heat from harsh motoring can lead to distortion, or ridging, of the tread. Continual fierce braking (or faulty brakes) rasps the rubber from patches of tyre tread, leading to a bare patch – a brake flat – that may eventually expose the crown plies and wear a hole in the casing.


Centre tread wear – caused by over-inflation.


Shoulder wear – the tyre has been run at too low a pressure.


Feathering – wheel misalignment such as excessive toe-in or toe-out.


Shoulder wear – constant hard cornering at high speeds.


Ridging wear – caused by friction and heat from harsh motoring.


Rasped tread – constant fierce braking or faulty brakes.


Brake flat (heavy braking will eventually cause a bare patch).


Brake flat (exposed cords due to locked-wheel braking at high speeds).

Checking tyre pressure

Wrong tyre pressures – particularly pressures that are too low – lead to rapid tread wear or even total tyre failure, and can affect handling. Make regular fortnightly checks, as well as checking before the start of a long journey.

Because tyre pressure increases rapidly when the tyres get hot during running, always check pressures when the tyres are cold, before the car has been driven.

Use a reliable pressure gauge or foot pump, preferably your own – air-line gauges at garages can be unreliable. Inflate to the pressures recommended by the car manufacturer, given in the car handbook or service manual. Make sure tyres on the same axle are inflated to the same pressure.

Remember that tyres should be adjusted for load carrying, towing and high-speed driving. Follow the recommendations given in the car handbook or service manual, or refer to the tyre manufacturers.


Press the gauge cup over the valve. Replace the valve cap finger tight when you finish.

If the figures are not available, as a rough guide increase rear tyres 4–6 psi for a maximum load or when towing, and all tyres 3–6 psi for sustained high-speed driving.

Do not lower tyre pressures in bad weather. It does not give a better grip on snow, ice or wet roads – in fact it closes the tread pattern and reduces grip, as well as damaging the tyre carcass.

Avoiding tyre and wheel damage

Damage to a tyre sidewall or carcass can make the tyre useless, even though the tread is hardly worn. A major cause of damage to wheels and tyres is debris on the road – such as pieces of broken silencer and objects dropped from trucks and lorries.

Avoiding them calls for a constant lookout when driving. They can pierce tyre treads and sidewalls, and even break off parts of the carcass of a tyre. A neglected cut that has penetrated to the cords allows moisture to enter, and can lead to deterioration and rusting of the cords, so weakening the tyre.

With vigilance, hazards can be seen in time for you to steer around them, or – bearing in mind that there may be other traffic close to you – at least slow down to avoid high-speed impact damage.

However, even a small, sharp flint, a natural and invisible hazard on the road, can cause a puncture. Prising such minor objects out of the tread during regular tyre inspections helps to prevent this.

If, despite all precautions, a tyre is punctured, never carry on driving with it flat. A proper, permanent repair should be made to the tyre as soon as possible.

Overloading your car has almost the same effect on your tyres as not having enough air in them. Never exceed the stated load capacity of the car or its tyres. Check with your car handbook for the maker's specific figures if you are in doubt.

Driving against a high kerb is another common cause of ruptured tyre casings and dented or buckled wheels. Driving hard over badly broken ground can have a similar effect.

Tyres can be damaged by the car bodywork. If the suspension is faulty, for example, the tyre may rub against a wheel arch. Or a tyre that is too wide for the car may catch on parts of the steering or suspension.

Failing to take notice of instructions for running-in tyres – restrained driving during the first 50 to 100 miles or so on new tyres – does not allow the tyre and wheel assemblies to settle to their normal running conditions.

During that period the tyre completes some final chemical changes which were taking place during the moulding and curing stages of manufacture. Subjecting a new tyre to maximum loading immediately may cause it to fail prematurely, and will certainly shorten tyre life.

Pollution in the atmosphere and on road surfaces – particularly in cities – is harmful to tyres. Oil, tar, diesel fuel, petrol and paraffin all tend to soften the rubber, and may penetrate it quite deeply if not removed quickly. Clean them off with water and soap, or a mild detergent, such as washing-up liquid.

Strong sunlight hardens and cracks tread and sidewall rubber over a period of years. Sea air particularly, with its high concentration of ozone, can damage tyres, causing crazing – a network of small cracks – on the sidewalls.

Cars or caravans parked near the sea for any length of time should have their wheels covered.

Tyre repairs

A punctured tyre must, by law, be permanently repaired as soon as possible. Get it done by a garage or tyre specialist with the necessary equipment. A tubeless tyre repair kit can be used as a temporary measure.

Inner tubes, if fitted, must also be permanently repaired – or preferably renewed. This, too, should be done by a specialist.

To make a permanent repair, the tyre has to be removed from the wheel and thoroughly inspected both inside and out.

It can be repaired only if penetration damage is not too extensive, and if the under-inflated running that resulted has not damaged the internal structure of the carcass.

Make sure the wheels are balanced – preferably on the car – after any tyre repairs.

How tyres can be damaged

A nail or screw through a tyre not only causes gradual deflation, but the point may damage the interior wall as the tyre flexes against it, leading to eventual fracture of the carcass. A tyre with a sidewall penetration cannot be repaired satisfactorily.

An internal rupture can result when a tyre hits a kerbstone or an object in the road, although no damage may be visible on the outside. Eventually the tyre fails.

If a tyre is continually scuffed or bumped against the kerb during parking, sidewall abrasion can be so severe as to expose the casing cords. No matter how good the tread, the tyre is useless.

A tyre that has been damaged by rubbing against the bodywork is likely to have torn patches on the tread, or be heavily scored from jutting or damaged metal.

Separation of the tyre tread can result from under-inflation, which causes severe heating of the tyre shoulder. Other causes of tread separation may be deterioration due to age, oil or tar trapped in the tread, or rusting of steel belts under the tread.

Prolonged driving on an under-inflated tyre causes crushing and distortion of the sidewalls, with internal damage to the cords. The sidewall may eventually fracture and separate from the shoulder.

Spilled fuel, oil or solvent in a spare-wheel well can soak the rubber until the sidewalls appear smooth and wavy, and the tyre is so weakened that it cannot hold air, and so fractures.

When tyre sidewalls are crazed by high concentrations of ozone in sea air, the rubber is weakened and the tyre fails.


Tyre penetration by a screw can cause irreparable damage.


Striking a kerb could have caused this internal rupture.


Kerbing will also damage and weaken the outer sidewall.


Fitting too wide a tyre may cause bodywork interference.


Tread separation may be due to age or oil contamination.


Running on a flat tyre will cause the carcass to break up.


Fuel or oil on a sidewall will eventually weaken the tyre.


Ozone in sea air causes crazing of the sidewalls.

Checking, removing and refitting road wheels

When you take the wheels off to inspect the tyre walls, clean the wheels thoroughly and look closely for cracks starting around the stud holes, and at the joints between the rim and centre.

Cracks may indicate structural weakness due to corrosion, or that the wheel nuts are either too loose or are over-tightened. Such damage means that the wheel should be replaced.

Damage to wheel rims is much more common, as it can happen while parking against a high kerb.

Look for deep scuff marks, buckling and denting on steel rims, and for chipping and splitting on aluminium or magnesium alloy wheels.

If the denting is not too severe, steel wheels can usually be straightened by a garage. But they may no longer make an airtight seal with a tubeless tyre. Fitting an inner tube may solve the problem.

However, a damaged rim may also make the wheel difficult to balance.

Very minor chips or scrapes on alloy wheels can be ignored, but cracks are serious – fit a new wheel.

Magnesium alloy wheels corrode badly if their protective lacquering is disturbed – or eroded by time and flying grit. Frequent inspections should be made for that sort of damage, and the wheels re-lacquered if necessary before corrosion can set in. There are proprietary lacquers specially for car wheels, and instructions for applying them are given on the container.

Steel wheels can rust, but they are made of metal thick enough to withstand all but the most vicious attacks, well beyond the useful life of the car.

However, rusty wheels are not an attractive sight, and can be prepared and painted like any other part of the car (SHEETS 71 AND 72).

Tools and equipment

SCREWDRIVER • WHEELBRACE OR SOCKET SPANNER • WHEEL CHOCKS • JACK • TORQUE WRENCH • TYRE LEVERS OR FLAT BARS • PENETRATING OIL • RAGS

Checking valves

A persistent, slow loss of pressure from a tyre can be due to a faulty valve. Whenever a tyre is taken off, new valves should be fitted. Leaving the old ones in is a false economy, as the rubber seating around the base of the 'snap-in' type of valve stem used with tubeless tyres eventually deteriorates.

The inner core of the valve also deteriorates with age – especially if the valve cap is missing, allowing dust and grit to enter.

Look carefully at each valve for cracking or hardening of the rubber covering around the stem.

Unscrew the cap and check that no dirt is trapped underneath, then replace it tightly. Remember that it forms a second pressure seal, as well as a protective shield.

If you suspect a valve leak, wet your finger and wipe it over the valve to cover it with an unbroken bubble. An air leak will burst it.

Inner tubes, when fitted, have integral valve stems which cannot be replaced. Always have a new inner tube fitted when a worn or damaged tyre is replaced.

Switching wheels round

Because front tyres usually wear faster than rear tyres, wheels are sometimes rotated – switched from one position to another – in order to equalise the tread wear. The practice is not recommended.

Wear on the front wheels is often greatest on the outside shoulders, so the best way to equalise wear would be to have the tyre removed from the rim, reversed on the wheel and rebalanced. The cost of having this done could offset any saving in tyre wear.

Some manufacturers believe that changing the wheels round makes a car's steering and roadholding unpredictable until the tyres have established a new pattern of wear.

Rotating wheels means that all four tyres, plus the spare, are likely to wear out at the same time. Changing a pair of tyres on one axle at a time, bringing in the spare at each stage, spreads the cost of replacement.

Removing a road wheel

Before removing a road wheel, take off the hub cap and any decorative wheel trim. Some hub caps or trims are screwed on, but most are a push-fit and can be prised off with a large screwdriver.

The wheel nuts or bolts – there may be three, four or five – are loosened slightly *before* jacking up the car. Loosen them in the correct sequence of 'opposite pairs'.

Use a wheelbrace or a suitable socket spanner. If a nut is hard to shift, set the wheelbrace at an appropriate angle, then stamp down sharply on the handle.

Alternatively, increase the leverage on the handle by slipping a length of pipe over it.

With a crank-handled wheelbrace, two tyre levers can be used to apply more force. Some penetrating oil applied between nut and wheel may also help.

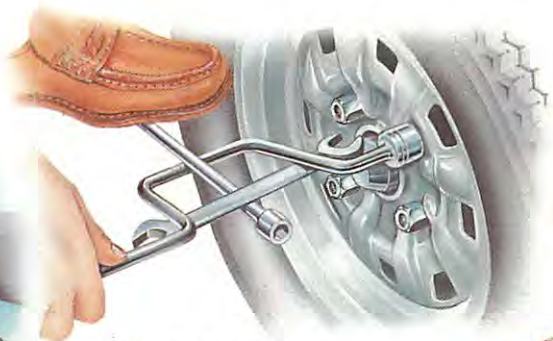
When all the wheel nuts have been loosened, apply the car handbrake and place a chock under the wheel that is diagonally opposite the one you are removing. Then jack up the car at the jacking point nearest to the wheel being removed.

Hydraulic trolley jacks are quick and easy to use – but expensive to buy or even hire. The standard tool-kit jack is generally adequate. It is usually of the scissors or pillar type, and the car handbook will show the jacking points.

The nuts, already freed, are now easy to remove. Note that wheels that have been balanced on the car should be replaced in exactly the same position. Before taking them off, mark the wheel and studs.

Put the nuts in a safe place, so they will not be lost. A good spot is in the hub cap, already removed.

Lever off the hub cap with an old screwdriver.



Loosen the wheel nuts before jacking up the wheel. Use a large spanner and bar to get extra leverage on a crank-handled wheelbrace if necessary.

Put the wheel nuts into the hub cap for safe keeping.

Refitting a road wheel

To refit the wheel, replace it on the studs then screw on all the wheel nuts hand-tight.

If it is a wheel that has been balanced on the car, be sure to replace it on the marks you made before removing it.

Note that where the stud holes in the wheel are countersunk, the conical faces of the nuts fit into them.

Tighten all the wheel nuts with the wheelbrace or a socket spanner until they are seated, then lower the car to the ground. Now tighten the nuts fully.

To avoid unequal stresses, turn them a little at a time, and in the correct sequence of opposite pairs. If you have a torque wrench, use it to tighten them to the exact loading recommended – consult a suitable manual or your nearest dealer if in doubt.

Finally replace the hub cap and any wheel trim that may be fitted.

The conical faces of wheel nuts go into countersunk wheel holes.

Using a torque wrench to tighten the nuts will ensure correct loading.

Adjusting wheel bearings

Wheel bearings need periodic checking – and adjusting if necessary – usually at 12,000 mile service intervals.

At longer intervals – usually of 36,000 miles – they need repacking with grease (SHEET 268).

Bearings on the front wheels of rear-wheel-drive cars and the rear wheels of front-wheel-drive cars are of broadly similar design.

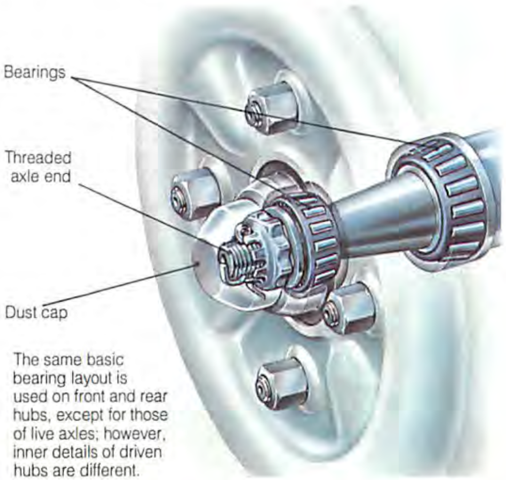
However, driven front wheels and driven rear wheels on cars with independent suspension generally have their hub nuts tightened to a high torque setting, and quite often no routine servicing adjustment is specified.

Where adjustment to these driven wheels is possible, the method varies. The rear-wheel bearings of live axles are not adjustable.

Tools and equipment

JACK AND AXLE STANDS • WHEEL CHOCKS • SPANNERS • SIDE CUTTERS • LONG-NOSED PLIERS • SCREWDRIVERS • HAMMER AND COLD CHISEL • SELF-LOCKING WRENCH • SOCKETS • TORQUE WRENCH • GREASE • RAG • SOFT-FACED HAMMER • FLAT-FACED PUNCH

Hub-bearing layout



The same basic bearing layout is used on front and rear hubs, except for those of live axles; however, inner details of driven hubs are different.

Check for wear

Rock the wheel from side to side and top and bottom to check for bearing wear.

Hub-nut locking

The hub nut may be castellated and retained by a split pin.

This is a plain hub nut under a castellated retainer.

This nut has a soft outer edge hammered over to wedge in the groove in the stub axle.

Some VWs use a split, internally threaded collar tightened by a bolt.

Adjusting non-driven bearings

The bearing is adjusted by tightening the hub nut if it is too loose, or loosening the nut if it is too tight. It should be done with the wheel on and raised on an axle stand.

You may have to take off the wheel to remove the trim: put the wheel back on before starting adjustment. If you have to remove the wheel, loosen the wheel nuts before raising it. Once this wheel is raised, support it on an axle stand.

Chock one of the other wheels on each side of the car.

If you are adjusting a wheel on which the handbrake works, release the handbrake.

Prise off the dust cap with two medium-sized screwdrivers, levering its raised flange away from the hub on both sides at once.

A neglected cap may take some time to free. If it sticks you may be able to hammer it off without damaging it beyond repair – but covers are cheap to replace.

The hub nut may be a castellated nut retained by a split pin, or a plain nut under a castellated retainer held by a split pin.

It may be a plain nut which has been locked by 'peening' it – punching its outer edge to make the metal spread into a groove in the threaded axle end.

Some VWs have the fourth type: a threaded collar which is squeezed tight by a nut and bolt at one side. The collar does not fit an ordinary socket wrench, but can be turned by a self-locking wrench.

Check that you have a socket big enough to fit the hub nut. If a split pin is used, you need some replacement pins of the right size. A peened nut must be renewed every time you adjust the bearing.

There should be some grease on the axle end and nut. If it is very dirty, the bearing should be stripped down and repacked with clean grease (SHEET 268).

If there are traces of metal in the bearing, it is disintegrating and should be renewed at once (SHEET 268). If the grease looks clean, wipe it away with a rag.

Straighten the split pin and pull it out with pliers. Discard the pin and fit a new one later. Remove any castellated retainer.

With a peened nut, use a small cold chisel and hammer to raise the peening from the axle groove. You do not need to lift it out completely: the leverage of a socket wrench is enough to flatten any remaining lumps.

With a VW collar, loosen the cross bolt.

Some cars have a left-hand thread on nearside hub nuts, especially at the rear. Check the thread before proceeding.

Loosen the hub nut a few turns, or if it is a peened nut remove it and screw on a new one loosely. If you have removed the wheel replace it temporarily, tightening the wheel nuts just enough to hold it firmly.

Set your torque wrench to the correct figure for the hub nut. Settings vary greatly from car to car (from 11 to 60 lb ft – 1·5 to 8·3 kg m) and must be correct. Consult a service manual or a local dealer if necessary.

VW hub collars do not need setting to an exact torque.

Use one hand to turn the wheel slowly in its normal forward direction of travel, and tighten the hub nut to the correct torque with the other.

You should be able to feel the wheel spinning smoothly, though it will begin to drag as you tighten the nut. If there is any actual grating or roughness, the hub bearing should be renewed.

On some cars you leave the nut at the recommended torque setting. On most, however, you slacken it by a half or quarter turn; though on some you then retighten to the recommended torque setting.

Check the specific adjustment method with a service manual or your local dealer. Then repeat the wheel-rocking check. You should be able to feel the barest hint of play. The wheel should also still turn smoothly.

On some cars (including the VW with hub collar), a screwdriver is used to probe alongside the hub nut at the thrust washer behind it. If you can just move the washer, the adjustment is correct.

Lock the nut in position. A castellated nut must be moved to align one of its slots with the pin hole in the axle end. Move it the shortest possible distance, whichever way that is.

If the move tightens the nut, check that the wheel still turns freely. If it does not, loosen the nut one notch. This problem does not arise with other types of hub nut.

Fit a castellated retainer, if used. Insert a new split pin, if used, and cut and bend back its ends.

Give a peened nut a few light taps with a hammer and punch to spread it into the slot. On a VW collar, tighten the cross bolt.

On some cars you half fill the dust cap with fresh bearing grease before refitting it.

Remove the wheel, if necessary, and refit the cap. Hold the cap squarely in place and tap it home with a soft-faced hammer. Be sure to keep it straight.

Refit the wheel and lower the car to the ground.

Tightening the hub nut

Turn the wheel slowly while you tighten. Lower to tighten finally.

Adjusting driven bearings

The hub nuts of driven wheels (except on live axles) call for quite high torque settings (from 150 to 200 lb ft – 21 to 25 kg m), so you must lower the wheel to the ground with the car's weight on it for final tightening. Consult the handbook for the correct torque setting, if routine adjustment is specified.

VW hub nut

Some VWs have a double-nut arrangement with a locking tab washer between the inner and outer nut.

To remove, lever up the tab with a screwdriver. Use a new tab washer when you refit.

Tighten the inner nut to give the correct amount of play – just enough to let the wheel rotate freely – then bend down the tab.

Tighten the other nut hard against it, and bend up the other tab to lock both securely.

Fit the tab washer with its tab on a flat face of the inner nut.

Lubricating and replacing wheel bearings / 1

Non-driven wheel bearings – the front-wheel bearings of rear-wheel-drive cars and rear-wheel bearings of front-wheel-drive cars – are similar in design, differing only in detail.

They may be either tapered roller bearings or ball bearings. Both types need regular adjustment (SHEET 267) and lubrication with grease.

Routine lubrication intervals are normally given in the car service schedule. They are usually very long – typically three years, 36,000 miles or 60,000 km. But you may need to re-pack bearings earlier if a routine check shows that the grease is dirty.

Eventually, however, bearings may wear out. A worn bearing becomes evident in various ways. There may be excessive play, which adjustment fails to cure. The bearing may be noisy, especially when cornering.

The noise may be a low-pitched droning at first; then, as the bearing wears more, a scraping sound; finally, just before it seizes, a high whine.

Other signs of bad wear are the steering wandering or pulling to one side, shuddering or squirming during braking (though these can have other causes – SHEETS 213–230 and 79–96).

Replace a worn or damaged bearing as soon as possible.

Bearings are dismantled for greasing, so the procedures for lubrication and replacement are similar.

Before either job, see that you have new grease seals for the bearings.

Loosen the wheel nuts of the two wheels you are dealing with, raise the car and support it on axle stands. Chock the other two wheels.

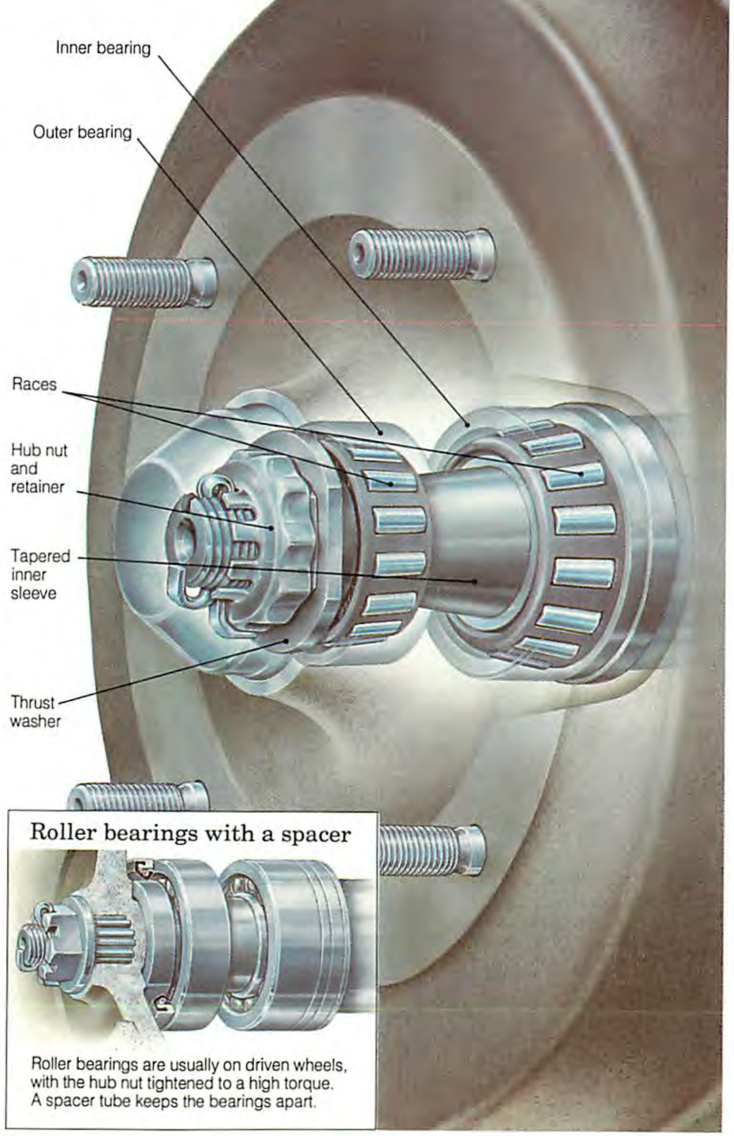
Release the handbrake if it works on the raised wheels. Take these wheels off.

Tools and equipment

JACK • AXLE STANDS • SOCKET SET • TORQUE WRENCH • SCREWDRIVERS • PLIERS • HAMMER • SOFT-FACED HAMMER • CHISEL OR PUNCH • HUB PULLER • DRIFT • NEW BEARINGS AND SEALS • GREASE

Bearing location

The bearings are located in the wheel hub on disc-brake wheels, and inside the brake drum, which forms part of the hub, on drum-brake wheels.



Roller bearings with a spacer

Roller bearings are usually on driven wheels, with the hub nut tightened to a high torque. A spacer tube keeps the bearings apart.

Dismantling the hub

Remove the dust cap and loosen the hub nut by the same method as for adjustment (SHEET 267).

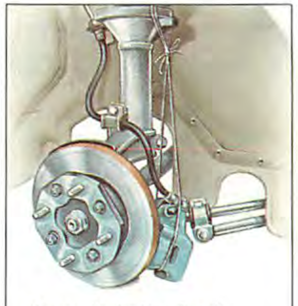
If a disc brake is fitted, move the caliper clear of the disc (SHEETS 84–86) so that the disc and hub can be pulled outwards.

Tie up the caliper so as not to strain the brake hose, if it has not been disconnected.

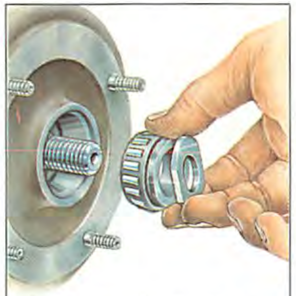
On drum brakes, if the drum is separate from the hub, take off the drum (SHEETS 87–89). If the brake drum is not separate from the hub, it can be removed once the bearing is released.

Unscrew the hub nut completely. Take off the large thrust washer under it to expose the outer bearing. If this is a tapered roller bearing, it will probably fall out (but if it does not, leave it in place).

You should be able to pull off the hub or the hub-drum assembly by hand. If not, give it a few blows with a soft-faced hammer.



Support the brake caliper if it is connected to its hose.



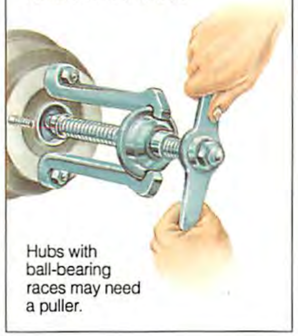
Pull off the thrust washer and outer bearing.

Using a puller

A hub with ball bearings, and even one with rollers, may stick.

If so, use a hub puller – you can hire one if necessary. Place its centre against the end of the stub axle, adjust its legs to grip the hub, then tighten the bolt to pull off the hub.

With tapered roller bearings, if the outer bearing has stayed with the hub, lift it out and set it aside.



Hubs with ball-bearing races may need a puller.

Releasing the inner bearings

Turn the hub outer side down and use a screwdriver to prise out the grease seal, noting which way round it is fitted.

Take care not to scratch the seating into which the seal fits. Discard the old seal.

If the inner bearing has come away with the hub, lift it out and set it aside. If it has stayed on the spindle, free it with a few gentle taps of a soft-faced hammer.

Prise out the grease seal.

In many hubs there is a spacer ring between the two bearings. Put this with the other detached parts.

With ball bearings, the inner and outer races of both bearings stay together when the hub comes off.

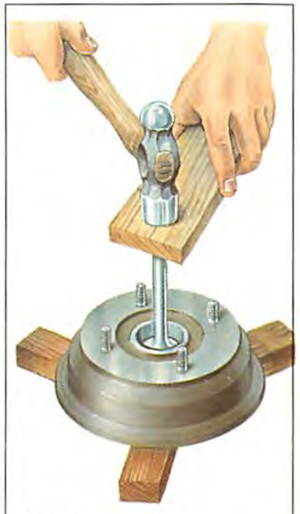
Prise out the grease seal from the inner side of the hub as described above.

Separate the inner race of each bearing by driving it outwards from the middle of the hub.

Use a flat-faced punch passed through one bearing to rest against the inner face of the other. Give the punch gentle blows with a heavy hammer, moving it around the outer casing until it comes free.

Some of the balls may drop loose, but most of them will stay embedded in the grease. Extract any spacer between the bearings.

Bearings removed in this way must be replaced.



Tap out the inner races.

Lubricating and replacing wheel bearings / 2

Removing the outer races

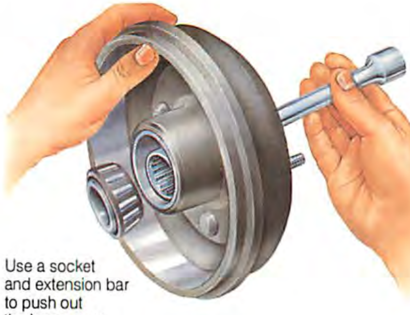
Clean the hub and races well with paraffin or white spirit. Then drive the races away from each other. The inner and outer races may be of different sizes. If so, begin with the smaller one.

Use a socket as a 'drift' (pusher). Choose one which fits through the larger race to rest against the smaller race.

Lengthen the socket with an extension piece and tap this gently with a heavy hammer to expel the race. Use a bigger socket to force the other race out in the opposite direction.

If the races are the same size, remove the first one with a flat-faced punch and heavy hammer, tapping alternate sides and working evenly around the race so as not to tilt and jam it. Be careful not to scratch the inside of the hub.

When the first race has been removed, free the second race, using a socket as a drift.



Use a socket and extension bar to push out the inner races.

When the races are the same size, push out one with a punch or chisel, push out the other with a socket.

Punch channels

Some hubs have channels to take a punch.

Checking and cleaning the bearings

Clean all parts well with paraffin or white spirit. Avoid getting grease on the brakes when cleaning the stub axle.

If you are doing only routine lubrication, the outer races remain on the stub. Inspect them: very slight indentations are allowable, but if there is noticeable pitting or scoring you need new bearings.

For the inner races and the rollers or balls make no allowances at all. Any blemish is unacceptable and means renewal of the bearing.

Lubricating the bearings

To replace bearings, tap the outer races into the hub using the old races as drifts. Be sure to fit a tapered-roller race the right way round.

Pack the bearings with an approved type of bearing grease – consult the car handbook or a dealer if in doubt. Find out also how much grease to apply. On some hubs the central area is heavily loaded with grease, but other types need only a light coating. Always fill the bearings themselves with as much grease as they can hold, forced in between the races.

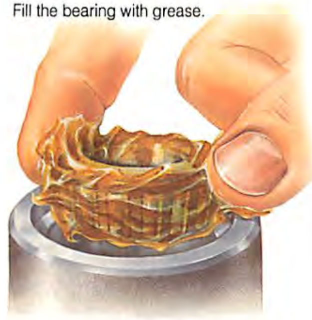
With roller bearings, coat the outer race thickly with grease. Spin the rollers in their cage on the inner race while rubbing grease into every crevice.

Put the inboard inner race into its outer race; or tap it on to the stub axle with a tubular drift if this is more convenient. Do not forget to fit any spacer between the bearings.

With either type of bearing, now insert the new grease seal. Be sure to fit it the right way round. If it fits flush with the inner edge of the hub, tap it gently home with a wooden block. If it is recessed, use a socket to press it in.

Tap new grease seals into place using a hammer, protecting the seal with a flat piece of wood.

Fill the bearing with grease.



Fit the grease-filled bearing into its race.

Ball bearings

With ball bearings, fill the outer races with grease and push the balls into it. Gently tap the inner races into place. Do not forget to insert any spacer between the bearings. Then rub more grease into the bearing while turning it.

Ball bearings are used on some cars. Make sure that the balls are packed with grease, and that all the balls are present.

Reassembling the bearings and hub

Lightly grease the stub axle, including the threaded end and the shoulder at the base. Keep grease off brake parts.

Carefully push the hub on to the axle, taking care not to knock out the inner race of an outer ball bearing with the axle end.

If the hub sticks, tap it with a soft-faced hammer. Insert the inner race of an outer roller bearing

Fit the thrust washer with its chamfered side towards the bearing. Screw on the hub nut, then adjust the hub (SHEET 267). Position a castellated nut so that it lines up with the split-pin hole – by easing the nut, back, not forward – or fit the nut cover if there is one.

Insert a new split-pin, head uppermost, and open the legs. Trim the legs so that they will not prevent the dust cover being fitted. Reassemble the brakes (SHEETS 79-96).

Replace the hub carefully, so as not to disturb the bearings or races.

Put the thrust washer in place and screw on the hub nut.

Fit the nut cover if there is one, insert and open the split pin. Push on the dust cover.

Lubricating and replacing wheel bearings / 3

Driven wheels – independent suspension

Cars with front-wheel drive have front-wheel bearings that resemble closely those in the rear wheels of rear-wheel-drive cars which have independent suspension (SHEET 35).

The type of bearing used also has much in common with non-driven wheel bearings (SHEET 37). However, the bearings of live rear axles are quite different (SHEET 258).

The main difference between driven and non-driven hubs is that a drive shaft projects into a driven hub from the inner side.

With non-driven bearings the hub turns outside a central, stationary, solid stub axle.

In some driven hubs the arrangement is similar, except that the 'stationary axle' – the hub carrier – is hollow and the drive shaft runs through it to connect with the hub.

The hub bearings are exactly like those of a non-driven hub, and you dismantle them in the same order. But it is usual for the 'hub' – properly called the drive flange – to turn on bearings inside the hub carrier. So the inner race revolves, while the outer race is stationary.

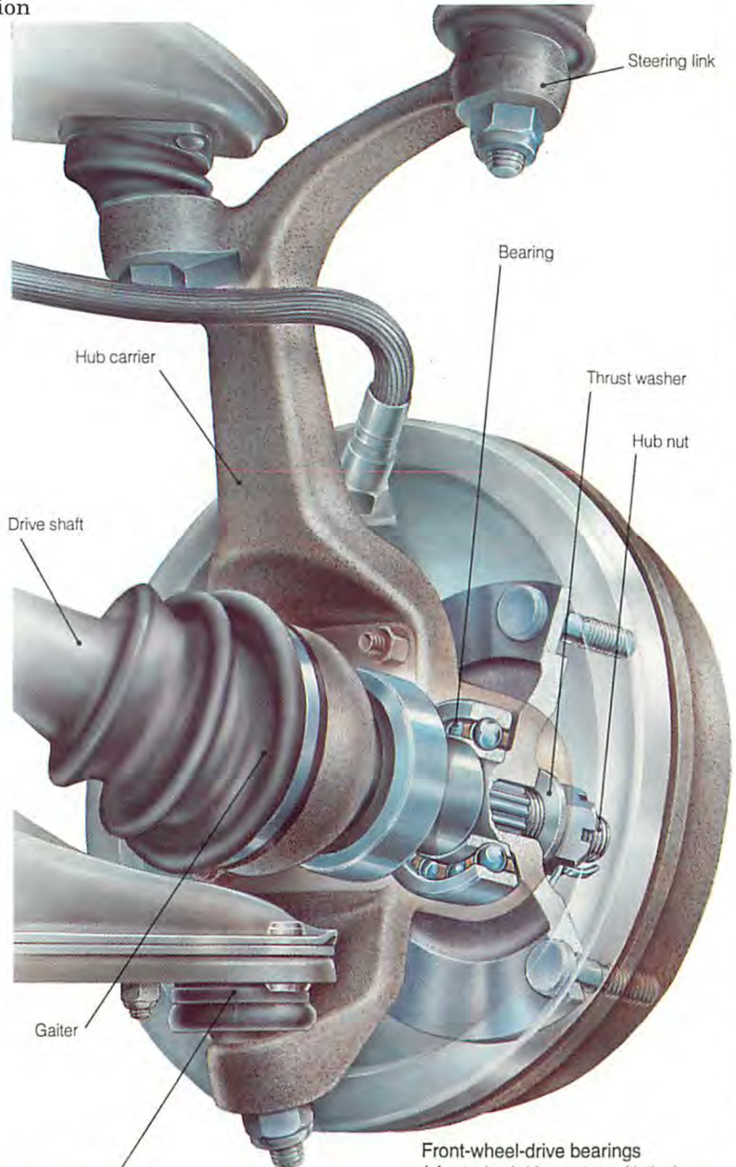
There is likely to be a plastic water shield on the inner side of the hub assembly, either attached to the drive shaft or clipped to the hub carrier.

There is also an extra grease seal on the outboard side of the pair of bearings. As usual, renew all grease seals whenever you dismantle a hub. There may be additional spacer rings between the seals and bearing races.

Details vary from car to car: when dismantling, make notes or drawings of how all these parts are arranged and which way round they go.

Tools and equipment

HAMMER • CHISEL • JACK • AXLE STANDS • WHEEL CHOCKS • SOCKETS • SIDE CUTTERS • LONG-NOSED PLIERS • SPANNERS • SCREWDRIVERS • RAG • SOFT-FACED HAMMER • PARAFFIN OR WHITE SPIRIT • GREASE



Front-wheel-drive bearings
A front-wheel-drive system with the inner and outer wheel bearings inside a hollow hub carrier. They are separated by a short tubular spacer. The drive shaft runs through them into a splined drive flange, to which the wheels are bolted.

Dismantling a driven hub

Dismantling is much the same as for a non-driven hub (SHEETS 268–269). But there is one major difference – the hub nut is usually very tight; if possible, loosen it with the wheel on the ground.

Remove the hub dust cover and hub-nut locking device in the usual way – on some cars this means raising and removing the wheel, then replacing and lowering it.

The force needed to loosen the nut is such that you may have to prevent the car from moving – you may even need someone inside applying the brakes.

Extend the handle of a socket wrench with a length of pipe for extra leverage. Check if the hub nut has a right or left-hand thread, then loosen it.

On cars with no central hole in the wheel, loosen the hub nut with the wheel off: a helper applying the brakes is essential.

Work with the car raised on axle stands under frame members. Chock the wheels that are on the ground, and apply the handbrake if it operates on those wheels; otherwise release it. Loosen wheel nuts before raising the wheels.

Move aside a disc caliper or take off a brake drum (if not integral with the hub) in the usual way (SHEETS 84 or 87).

Front-wheel drive

On a front-wheel-drive car, remove the entire hub-carrier assembly.

Unscrew the nuts from the steering (SHEET 226) and suspension (SHEET 235) ball joints, and uncouple them with a ball-joint separator.

If the car has a MacPherson strut (SHEET 244), remove it from the body and the track control arm (but with unit replacement suspension remove the lower half of the strut only).

You may now be able to pull the hub carrier free. If not, disconnect the drive-shaft outer joint (SHEET 252). Support the part of the drive shaft that remains on the car to avoid straining its joints.

If possible, loosen or tighten the hub nut with the wheel on the ground.

If the wheel is removed, wedge a metal bar across the wheel studs so that the end of the bar bears on the ground and locks them to resist the turning force of the socket spanner as you loosen the nut.

Rear-wheel drive

On a rear-wheel-drive car you may not need to remove the hub carrier: if you can disconnect the drive shaft, you can dismantle the hub with the carrier still in place.

The inner race of an inboard tapered roller bearing may remain on the drive shaft. If so, tap it off gently with a soft-faced hammer.

Detach the water shield from the hub carrier. Prise out the inboard oil seal, taking care not to scratch its seating. You may now be able to pull the drive flange out of the hub carrier.

If not, support the carrier on blocks (if detached from the car) and knock the flange out, using a suitable socket or pipe as a drift to avoid hammering it directly.

The bearings may remain in the hub carrier, in which case you can remove them in the same way as bearings remaining in a non-driven hub.

With tapered roller bearings, if you only want to check and lubricate them, there is no need to drive out the outer races if you can still see them clearly.

The inner race of the outboard bearing may come out on the drive flange and need a bearing puller to get it off.

The outboard grease seal may also be left on the drive flange. Prise it free, taking care not to scratch its seating, and discard it.

Clean, check, renew, lubricate and reassemble.

Reassembly

The procedure for refitting a driven hub is exactly the same as for a non-driven hub. Clean all parts thoroughly (except plastic shields) with paraffin or white spirit, inspect bearings and renew if damaged.

Lubricate the hub with an approved grease, consulting the car handbook or a dealer for details of the type and quantity.

To reassemble the hub, reverse the dismantling procedure, fitting new grease seals with care to avoid damaging them.

Fit the hub nut (SHEET 268). If possible, lower the car on to its wheels to tighten the hub, and use a torque wrench to obtain the correct torque setting for the car.