






Chapter 5 Engine electrical systems

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Degrees of difficulty

Easy , suitable for novice with little experience 	Fairly easy , suitable for beginner with some experience 	Fairly difficult , suitable for competent DIY mechanic 	Difficult , suitable for experienced DIY mechanic 	Very difficult , suitable for expert DIY or professional 
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Specifications

Battery

Type	Lead-acid, maintenance-free
Rating - Cold cranking/Reserve capacity	270 A/50 RC, 360 A/60 RC, 500 A/70 RC, 590 A/90 RC or 650 A/130 RC

Ignition coil

Output	37.0 kilovolts (minimum)
Primary resistances - measured at coil connector terminal pins	0.50 ± 0.05 ohms

Starter motor

Make/type:	
Bosch	DM, DW or EV
Magneti-Marelli	M79 or M80R
Nippondenso	No type numbers given
Output:	
Bosch DM	0.8, 0.9 or 1.0 kW
Bosch DW	1.4 or 1.8 kW
Bosch EV	2.2 kW
Marelli M79	0.8 or 0.9 kW
Marelli M80R	1.8 kW
Nippondenso	0.6 or 0.8 kW
Minimum brush length:	
Bosch and Magneti-Marelli	8.0 mm
Nippondenso	10.0 mm
Commutator minimum diameter:	
Bosch DM and DW and Nippondenso	32.8 mm
Bosch EV and Magneti-Marelli	Not available
Armature endfloat:	
Bosch DM and DW	0.3 mm
Bosch EV and Magneti-Marelli M80R	Not available
Magneti-Marelli M79	0.25 mm
Nippondenso	0.6 mm

Alternator

Make/type:	
Bosch	K1-55A, K1-70A or NC 14V 60-90A
Magneti-Marelli	A127/55 or 127/70
Mitsubishi	A5T or A002T
Output (nominal at 13.5 volts with engine speed of 6000 rpm)	55, 70 or 90 amps
Regulating voltage at 4000 rpm engine speed and 3 to 7 amp load	14 to 14.6 volts
Minimum brush length:	
Bosch and Magneti-Marelli	5 mm
Mitsubishi	3 mm

Torque wrench settings

	Nm	lbf ft
Ignition coil retaining screws	5 to 7	3.5 to 5.1
Alternator mounting bolts	20 to 27	15 to 20
Alternator adjustment bolts	18 to 25	13 to 18
Alternator pulley nut:		
With key	45 to 55	33 to 41
Without key	50 to 70	37 to 52
Starter motor mounting bolts	35	26

1 General information, precautions and battery disconnection

General information

The engine electrical systems include all ignition, charging and starting components. Because of their engine-related functions, these components are discussed separately from body electrical devices such as the lights, the instruments, etc (which are included in Chapter 12).

Precautions

Always observe the following precautions when working on the electrical system:

- a) Be extremely careful when servicing engine electrical components. They are easily damaged if checked, connected or handled improperly.
- b) Never leave the ignition switched on for long periods of time when the engine is not running.
- c) Don't disconnect the battery leads while the engine is running.
- d) Maintain correct polarity when connecting a battery lead from another vehicle during jump starting - see the "jump starting" section at the front of this manual.
- e) Always disconnect the negative lead first, and reconnect it last, or the battery may be shorted by the tool being used to loosen the lead clamps.

It's also a good idea to review the safety-related information regarding the engine electrical systems located in the "Safety first!" section at the front of this manual, before beginning any operation included in this Chapter.

Battery disconnection

Several systems fitted to the vehicle require battery power to be available at all times, either to ensure their continued operation (such as the clock) or to maintain control unit


memories (such as that in the engine management system's ECU) which would be wiped if the battery were to be disconnected. Whenever the battery is to be disconnected therefore, first note the following, to ensure that there are no unforeseen consequences of this action:

- a) First, on any vehicle with central locking, it is a wise precaution to remove the key from the ignition, and to keep it with you, so that it does not get locked in, if the central locking should engage accidentally when the battery is reconnected.
- b) On cars equipped with an engine management system, the system's ECU will lose the information stored in its memory - referred to by Ford as the "KAM" (Keep-Alive Memory) - when the battery is disconnected. This includes idling and operating values, and any fault codes detected - in the case of the fault codes, if it is thought likely that the system has developed a fault for which the corresponding code has been logged, the vehicle must be taken to a Ford dealer for the codes to be read, using the special diagnostic equipment necessary for this (see Chapter 6). Whenever the battery is disconnected, the information relating to idle speed control and other operating values will have to be re-programmed into the unit's memory. The ECU does this by itself, but until then, there may be surging, hesitation, erratic idle and a generally inferior level of performance. To allow the ECU to relearn these values, start the engine and run it as close to idle speed as possible until it reaches its normal operating temperature, then run it for approximately two minutes at 1200 rpm. Next, drive the vehicle as far as necessary - approximately 5 miles of varied driving conditions is usually sufficient - to complete the relearning process.
- c) If the battery is disconnected while the alarm system is armed or activated, the

alarm will remain in the same state when the battery is reconnected. The same applies to the engine immobiliser system (where fitted).

- d) If a Ford "Keycode" audio unit is fitted, and the unit and/or the battery is disconnected, the unit will not function again on reconnection until the correct security code is entered. Details of this procedure, which varies according to the unit and model year, are given in the "Ford Audio Systems Operating Guide" supplied with the vehicle when new, with the code itself being given in a "Radio Passport" and/or a "Keycode Label" at the same time. Ensure you have the correct code before you disconnect the battery. For obvious security reasons, the procedure is not given in this manual. If you do not have the code or details of the correct procedure, but can supply proof of ownership and a legitimate reason for wanting this information, the vehicle's selling dealer may be able to help.

Devices known as "memory-savers" (or "code-savers") can be used to avoid some of the above problems. Precise details vary according to the device used. Typically, it is plugged into the cigarette lighter, and is connected by its own wires to a spare battery; the vehicle's own battery is then disconnected from the electrical system, leaving the "memory-saver" to pass sufficient current to maintain audio unit security codes and ECU memory values, and also to run permanently-live circuits such as the clock, all the while isolating the battery in the event of a short-circuit occurring while work is carried out.

 **Warning:** Some of these devices allow a considerable amount of current to pass, which can mean that many of the vehicle's systems are still operational when the main battery is disconnected. If a "memory-saver" is used, ensure that the circuit concerned is actually "dead" before carrying out any work on it!

2 Battery - removal and refitting



Note: Refer to the previous Section before proceeding and also the relevant Sections of Chapter 1.

Removal

1 Undo the retaining nut, then detach the earth leads from the stud of the battery negative (earth) terminal post (see illustration). This is the terminal to disconnect before working on, or disconnecting, any electrical component on the vehicle.

2 Pivot up the plastic cover from the positive terminal, then unscrew the positive lead retaining nut on the terminal. Detach the positive lead from the terminal.

3 Unscrew the two battery clamp bolts, and remove the clamp from the front of the battery.

4 Lift the battery from the tray, keeping it upright and taking care not to let it touch any clothing. Be careful - it's heavy.

6 Clean the battery terminal posts, clamps and the battery casing. If the bulkhead is rusted as a result of battery acid spilling onto it, clean it thoroughly and re-paint with reference to Chapter 1.

7 If you are renewing the battery, make sure that you get one that's identical, with the same dimensions, amperage rating, cold cranking rating, etc. Dispose of the old battery in a responsible fashion. Most local authorities have facilities for the collection and disposal of such items - batteries contain sulphuric acid and lead, and should not be simply thrown out with the household rubbish!

Refitting

8 Refitting is a reversal of removal. Smear the battery terminals with a petroleum-based jelly prior to reconnecting. Always connect the positive terminal clamp first and the negative terminal clamp last.

3 Battery leads - checking and renewal



Note: See also the relevant Sections of Chapter 1.

1 Periodically inspect the entire length of each battery lead for damage, cracked or burned insulation, and corrosion. Poor battery lead connections can cause starting problems and decreased engine performance.

2 Check the lead-to-terminal connections at the ends of the leads for cracks, loose wire strands and corrosion. The presence of white, fluffy deposits under the insulation at the lead terminal connection is a sign that the lead is corroded and should be renewed. Check the terminals for distortion, missing clamp bolts, and corrosion.



2.1 Detaching the earth leads from the stud of the battery negative (earth) terminal post

3 When removing the leads, always disconnect the negative lead first, and reconnect it last (see Section 1). Even if only the positive lead is being renewed, be sure to disconnect the negative lead from the battery first (see Chapter 1 for further information regarding battery lead removal).

4 Disconnect the old leads from the battery, then trace each of them to their opposite ends, and detach them from the starter solenoid and earth terminals. Note the routing of each lead, to ensure correct installation.

5 If you are renewing either or both of the old leads, take them with you when buying new leads. It is vitally important that you replace the leads with identical parts. Leads have characteristics that make them easy to identify: positive leads are usually red, larger in cross-section, and have a larger-diameter battery post clamp; earth leads are usually black, smaller in cross-section, and have a slightly smaller-diameter clamp for the negative post.

6 Clean the threads of the solenoid or earth connection with a wire brush to remove rust and corrosion. Apply a light coat of battery terminal corrosion inhibitor, or petroleum jelly, to the threads, to prevent future corrosion.

7 Attach the lead to the solenoid or earth connection, and tighten the mounting nut/bolt securely.

8 Before connecting a new lead to the battery, make sure that it reaches the battery post without having to be stretched.

9 Connect the positive lead first, followed by the negative lead.

4 Ignition system - general information and precautions

General

The main ignition system components include the ignition switch, the battery, the crankshaft speed/position sensor, the ignition module, the coil, the primary (low tension/LT) and secondary (high tension/HT) wiring circuits, and the spark plugs.

A Distributorless Ignition System (DIS) is used on all carburettor engines, and an Electronic Distributorless Ignition System (E-DIS) on all fuel-injected engines. With these systems, the main functions of the conventional distributor are replaced by the computerised ignition module and a coil unit. The coil unit combines a double-ended pair of coils - each time a coil receives an ignition signal, two sparks are produced, at each end of the secondary windings. One spark goes to a cylinder on compression stroke and the other goes to the corresponding cylinder on its exhaust stroke. The first will give the correct power stroke, but the second spark will have no effect (a "wasted spark"), occurring as it does during exhaust conditions.

On carburettor engines, the ignition module receives signals provided by information sensors which monitor various engine functions (such as crankshaft speed/position, coolant temperature, inlet air temperature, etc). This information allows the ignition module to generate the optimum ignition timing setting under all operating conditions.

On fuel-injected engines, the ignition module operates in conjunction with the fuel system Electronic Control Unit (ECU), and together with the various information sensors and emission control components, forms the complete engine management package.

The information contained in this Chapter concentrates on the ignition-related components of the engine management system. Information covering the fuel, exhaust and emission control components can be found in Chapters 4 and 6.

Precautions

When working on the ignition system, take the following precautions:

- Do not keep the ignition switch on for more than 10 seconds if the engine will not start.
- If a separate tachometer is ever required for servicing work, consult a dealer service department before buying a tachometer for use with this vehicle - some tachometers may be incompatible with this type of ignition system - and always connect it in accordance with the equipment manufacturer's instructions.
- Never connect the ignition coil terminals to earth. This could result in damage to the coil and/or the ignition module.
- Do not disconnect the battery when the engine is running.
- Make sure that the ignition module is properly earthed.
- Refer to the warning at the beginning of the next Section concerning HT voltage.

5 Ignition system - testing



Warning: Because of the high voltage generated by the ignition system, extreme care should be taken whenever an operation is performed involving ignition components. This not only includes the ignition module, coil and spark plug (HT) leads, but related components such as electrical connectors, tachometer and other test equipment also.

Note: This is an initial check of the "ignition part" of the main engine management system, to be carried out as part of the preliminary checks of the complete engine management system (see Chapter 6).

1 If the engine turns over but won't start, disconnect the (HT) lead from any spark plug, and attach it to a calibrated tester (available at most automotive accessory shops). Connect the clip on the tester to a good earth - a bolt or metal bracket on the engine. If you're unable to obtain a calibrated ignition tester, have the check carried out by a Ford dealer service department or similar. Any other form of testing (such as jumping a spark from the end of an HT lead to earth) is not recommended, because of the risk of personal injury, or of damage to the ignition module (see notes above and in Section 4).

2 Crank the engine, and watch the end of the tester to see if bright blue, well-defined sparks occur.

3 If sparks occur, sufficient voltage is reaching the plug to fire it. Repeat the check at the remaining plugs, to ensure that all leads are sound and that the coil is serviceable. However, the plugs themselves may be fouled or faulty, so remove and check them as described in Chapter 1.

4 If no sparks or intermittent sparks occur, the spark plug lead(s) may be defective - check them as described in Chapter 1.

5 If there's still no spark, check the coil's electrical connector, to make sure it's clean and tight. Check for full battery voltage to the coil at the connector's centre terminal. Check the coil itself (see Section 6). Make any necessary repairs, then repeat the check again.

6 The remainder of the system checks should be left to a dealer service department or other qualified repair facility, as there is a chance that the ignition module may be damaged if tests are not performed properly.

6 Ignition coil - checking, removal and refitting



Warning: Because of the high voltage generated by the ignition system, extreme care should be taken whenever an operation is performed involving ignition components. This not only includes the ignition module/ECU, coil and spark plug (HT) leads, but related components such as electrical connectors, tachometer and other test equipment also.

Check

1 Having checked that full battery voltage is available at the centre terminal of the coil's electrical connector (see Section 5), disconnect the battery negative (earth) lead - see Section 1.

2 Unplug the coil's electrical connector, if not already disconnected.

3 Using an ohmmeter, measure the resistance of the coil's primary windings, connecting the meter between the coil's terminal pins as follows. Measure first from one outer pin to the centre pin, then from the other outer pin to the centre. Compare your readings with the coil primary resistance listed in the Specifications Section at the beginning of this Chapter.

4 Disconnect the spark plug (HT) leads - note their connections or label them carefully, as described in Chapter 1. Use the meter to check that there is continuity (ie, a resistance corresponding to that of the coil secondary winding) between each pair of (HT) lead terminals; Nos 1 and 4 terminals are connected by their secondary winding, as are Nos 2 and 3. Now switch to the highest resistance scale, and check that there is no continuity between either pair of terminals and the other - ie, there should be infinite



6.7 Disconnecting the multi-plug from the ignition coil

resistance between terminals 1 and 2, or 4 and 3 - and between any terminal and earth.

5 If either of the above tests yield resistance values outside the specified amount, or results other than those described, renew the coil. Any further testing should be left to a dealer service department or other qualified repair facility.

Removal

6 Disconnect the battery negative (earth) lead (refer to Section 1).

7 Disconnect the coil main electrical connector and (where fitted) the electrical connector to the suppressor (see illustration).

8 The coil can be removed with the HT leads left attached, in which case disconnect the leads from their respective spark plugs and from the location clips in the rocker cover or air inlet duct (as applicable). If preferred, the HT leads can be disconnected from the coil. First check that both the ignition HT leads and their fitted positions are clearly marked numerically to ensure correct refitting. Spot mark them accordingly if necessary, using quick-drying paint.

9 If disconnecting the leads from the spark plugs, pull them free by gripping on the connector, not the lead. To detach the leads from the ignition coil, compress the retaining arms of each lead connector at the coil, and detach each lead in turn (see illustration).

10 Unscrew the Torx-type retaining screws, and remove the coil from its mounting on the engine (see illustrations).



6.9 Disconnecting an HT lead from the ignition coil (CVH engine shown)



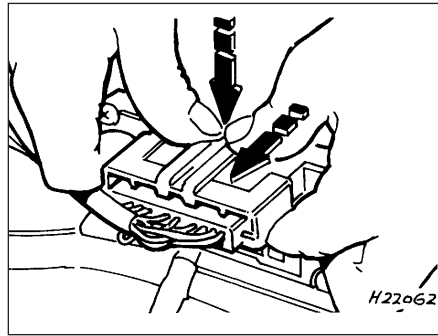
6.10A Unbolting the ignition coil from the HCS engine



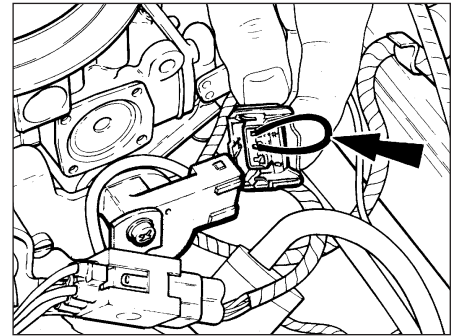
6.10B Removing the ignition coil from the CVH engine (leaving the HT leads attached)



7.3 Ignition module showing vacuum hose and multi-plug arrangement (CVH carburettor engine shown)



7.4 Multi-plug removal from the ignition module



7.9 Bridge the earth signal terminal and ground terminal in the throttle position sensor multi-plug with a length of wire (arrowed)

Refitting

11 Refitting is the reverse of the removal procedure. Ensure that the spark plug (HT) leads are correctly reconnected, and tighten the coil screws securely.

7 Ignition module (carburettor engines) - removal and refitting



Removal

- 1 The ignition module is located on the engine compartment left-hand inner wing panel.
- 2 Disconnect the battery negative (earth) lead (refer to Section 1).
- 3 Detach the vacuum hose from the module (see illustration).
- 4 According to type, either compress the locktab securing the wiring multi-plug in position, or where applicable, undo the retaining bolt, then withdraw the plug from the module (see illustration).
- 5 Undo the retaining screws, and remove the module from the inner wing panel.

Refitting

- 6 Refitting is the reverse of the removal procedure. If working on a 1.6 litre CVH engine model with power steering, air conditioning and/or automatic transmission, the following procedure must be followed before starting the engine.
- 7 When a new module is fitted, or when certain carburettor or engine components have been changed, it is necessary to clear the module memory and allow it to "learn" new engine parameters for its correct operation. This is done as follows.
- 8 With the ignition switched off, disconnect the throttle position sensor multi-plug on the side of the carburettor.
- 9 Using a short length of wire, bridge the earth signal terminal and ground terminal in the wiring multi-plug (see illustration).
- 10 Locate the ignition module service connector, which is a small multi-plug (like the

throttle position sensor multi-plug) joined to the main wiring loom by three wires. The service connector will be located either adjacent to the ignition module or on the engine compartment bulkhead near the carburettor (see illustration).

- 11 If the service connector multi-plug has a wire connected to its centre terminal (pin 5), disconnect the wire.
- 12 Switch on the ignition, but do not crank the engine on the starter.
- 13 Connect one end of a suitable length of wire to the multi-plug centre terminal (pin 5), and hold the other end of the wire on a good earth point for 5 seconds only.
- 14 Switch off the ignition, and remove the earthing wire from pin 5 of the multi-plug.
- 15 Remove the bridge wire from the throttle position sensor multi-plug, and reconnect the multi-plug.
- 16 Start the engine and allow it to idle. The idle speed will be initially high, but will then settle back to a stable idle condition.
- 17 Switch off the ignition and, if pin 5 of the service connector had a wire connected to it originally, reconnect the wire.

8 Ignition module (fuel-injected engines) - removal and refitting

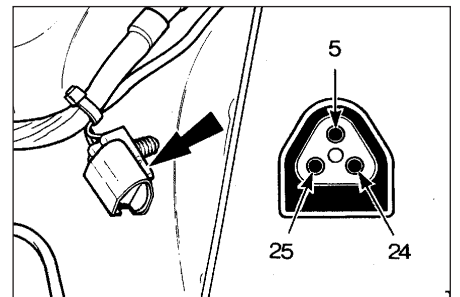


Removal

- 1 The ignition module is located on the engine compartment left-hand inner wing panel.
- 2 Disconnect the battery negative (earth) lead (refer to Section 1).
- 3 Disconnect the wiring multi-plug from the module, pulling on the plug, not the wire (see illustration).
- 4 Undo the two retaining screws, and remove the module from the inner wing panel.

Refitting

- 5 Refit in the reverse order of removal. On completion, reconnect the battery and restart the engine.



7.10 Ignition module service connector (arrowed) and terminal identification

9 Ignition timing - checking

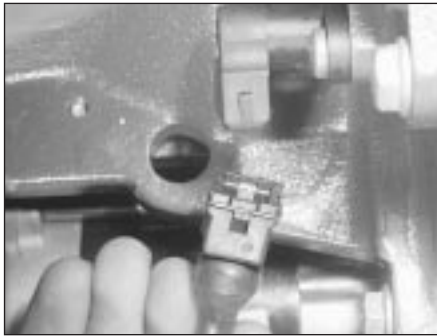


The ignition timing is controlled entirely by the ignition module (acting in conjunction with the ECU on fuel-injected models), and cannot be adjusted. The value may vary significantly if "checked" by simply connecting a timing light to the system and running the engine at idle speed.

Not only can the ignition timing not be adjusted, it cannot be checked either, except with the use of special diagnostic equipment (see Chapter 6) - this makes it a task for a Ford dealer service department.



8.3 Ignition module and wiring connection on the 1.6 litre EFi fuel-injected engine



10.4 Disconnecting the wiring connector from the crankshaft speed/position sensor

10 Crankshaft speed/position sensor - checking, removal and refitting



Checking

See Section 4 of Chapter 6.

Removal

- 1 Disconnect the battery negative (earth) lead (refer to Section 1).
- 2 For improved access, apply the handbrake, then jack up the front of the car and support it on axle stands.
- 3 If working on the Zetec engine, remove the starter motor as described in Section 17.
- 4 Compress the retaining clip and pull free the wiring multi-plug connector from the sensor unit, but take care to pull on the connector, not the lead (**see illustration**).
- 5 Undo the Torx-type retaining screw, and withdraw the sensor from its location in the cylinder block bellhousing flange (**see illustration**).

Refitting

- 6 Refitting is the reversal of removal.

11 Charging system - general information and precautions

General information

The charging system includes the alternator, an internal voltage regulator, a no-charge (or "ignition") warning light, the battery, and the wiring between all the components. The charging system supplies electrical power for the ignition system, the lights, the radio, etc. The alternator is driven by the auxiliary drivebelt at the front (right-hand end) of the engine.

The purpose of the voltage regulator is to limit the alternator's voltage to a preset value. This prevents power surges, circuit overloads, etc., during peak voltage output.

The charging system doesn't ordinarily require periodic maintenance. However, the drivebelt, battery and wires and connections



10.5 Crankshaft speed/position sensor shown removed from engine

should be inspected at the intervals outlined in Chapter 1.

The instrument panel warning light should come on when the ignition key is turned to positions "II" or "III", then should go off immediately the engine starts. If it remains on, or if it comes on while the engine is running, there is a malfunction in the charging system (see Section 12). If the light does not come on when the ignition key is turned, and the bulb is sound (see Chapter 12), there is a fault in the alternator.

Precautions

Be very careful when making electrical circuit connections to a vehicle equipped with an alternator, and note the following:

- a) *When reconnecting wires to the alternator from the battery, be sure to note the polarity.*
- b) *Before using arc-welding equipment to repair any part of the vehicle, disconnect the wires from the alternator and the battery terminals.*
- c) *Never start the engine with a battery charger connected.*
- d) *Always disconnect both battery leads before using a battery charger.*
- e) *The alternator is driven by an engine drivebelt which could cause serious injury if your hand, hair or clothes become entangled in it with the engine running.*
- f) *Because the alternator is connected directly to the battery, it could arc or cause a fire if overloaded or shorted-out.*
- g) *Wrap a plastic bag over the alternator, and secure it with rubber bands, before steam-cleaning or pressure-washing the engine.*
- h) *Never disconnect the alternator or battery terminals while the engine is running.*

12 Charging system - testing



- 1 If a malfunction occurs in the charging circuit, don't automatically assume that the alternator is causing the problem. First check the following items:

- a) *Check the tension and condition of the*

auxiliary drivebelt - renew it if worn or deteriorated (see Chapter 1).

- b) *Ensure that the alternator mounting bolts and nuts are tight.*
- c) *Inspect the alternator wiring harness and the electrical connections at the alternator; they must be in good condition, and tight.*
- d) *Check the large main fuses in the engine compartment (see Chapter 12). If any is blown, determine the cause, repair the circuit and renew the fuse (the vehicle won't start and/or the accessories won't work if the fuse is blown).*
- e) *Start the engine and check the alternator for abnormal noises - for example, a shrieking or squealing sound may indicate a badly-worn bearing or brush.*
- f) *Make sure that the battery is fully-charged - one bad cell in a battery can cause overcharging by the alternator.*

2 Using a voltmeter, check the battery voltage with the engine off. It should be approximately 12 volts.

3 Start the engine and check the battery voltage again. Increase engine speed until the voltmeter reading remains steady; it should now be approximately 13.5 to 14.6 volts.

4 Switch on as many electrical accessories (eg the headlights, heated rear window and heater blower) as possible, and check that the alternator maintains the regulated voltage at around 13 to 14 volts. The voltage may drop and then come back up; it may also be necessary to increase engine speed slightly, even if the charging system is working properly.

5 If the voltage reading is greater than the specified charging voltage, renew the voltage regulator (see Section 14).

6 If the voltmeter reading is less than that specified, the fault may be due to worn brushes, weak brush springs, a faulty voltage regulator, a faulty diode, a severed phase winding, or worn or damaged slip rings. The brushes and slip rings may be checked (see Section 13), but if the fault persists, the alternator should be renewed or taken to an auto-electrician for testing and repair.

13 Alternator - removal and refitting

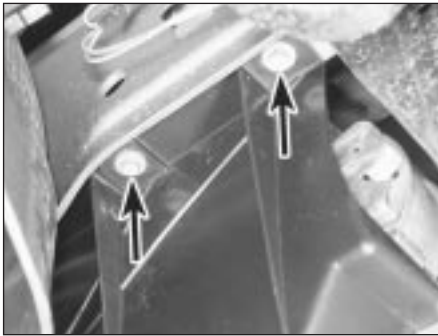


Removal

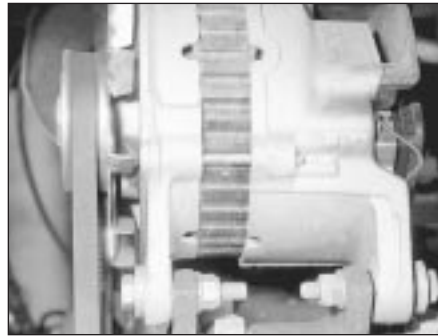
- 1 Disconnect the battery negative (earth) lead (refer to Chapter 5, Section 1).
- 2 Apply the handbrake, then jack up the front of the vehicle and support it on axle stands.
- 3 Where applicable, undo the two retaining bolts and remove the drivebelt guard (**see illustration**).

Alternator with V-belt drive and manual adjustment

- 4 On models fitted with a sliding arm type



13.3 Two of the drivebelt guard retaining bolts (arrowed)



13.6 Alternator and lower mounting/pivot bolts (HCS engine shown)



13.9 Alternator removal (CVH engine shown)

adjuster strap, unscrew and remove the top (adjuster) bolt from the strap.

5 On models fitted with a "rack-and-pinion" type adjuster, unscrew and remove the central (locking) bolt whilst, at the same time, loosening the (adjuster) nut.

6 Loosen off, but do not yet remove, the lower mounting bolts (see illustration), pivot the alternator inwards towards the engine to slacken the tension of the drivebelt, then disengage the drivebelt from the pulleys and remove it.

7 Where applicable, detach and remove the alternator heat shield.

8 Where applicable, detach and remove the phase terminal and the splash cover.

9 Supporting the weight of the alternator from underneath, unscrew and remove the mounting bolts. Lower the alternator; noting the connections, detach the wiring and remove the alternator from the vehicle (see illustration).

Alternator with flat "polyvee" belt drive and automatic adjustment

10 Undo the retaining nuts, and remove the drivebelt guard.

11 Fit a ring spanner onto the drivebelt tensioner, and rotate it clockwise to loosen off the tension from the drivebelt. Note the routing of the drivebelt, then disengage the belt from the pulleys and remove it.

12 Remove the bottom guard from the radiator. This is secured in position by clips or pop-rivets. In the latter instance, it will be necessary to carefully drill the rivets out in order to remove the guard.

13 Position a jack under the radiator support bracket. The bracket must be partially lowered on the right-hand side, and although the coolant hoses should be able to take the weight and strain of the radiator assembly and bracket, the jack will prevent the possibility of an older hose splitting.

14 Unscrew and remove the radiator support bracket retaining bolts on the right-hand side, then loosen off (but do not remove) the securing bolts on the left-hand side.

15 Unscrew and remove the alternator retaining bolts. Withdraw the alternator from its mounting bracket, then lower the radiator/support bracket just enough to allow the alternator to be removed.

Refitting

16 Refit in the reverse order of removal. Refit the drivebelt, and ensure that it is correctly re-routed around the pulleys. Adjust the tension of the drivebelt (according to type) as described in Chapter 1.

14 Alternator brushes and voltage regulator - renewal



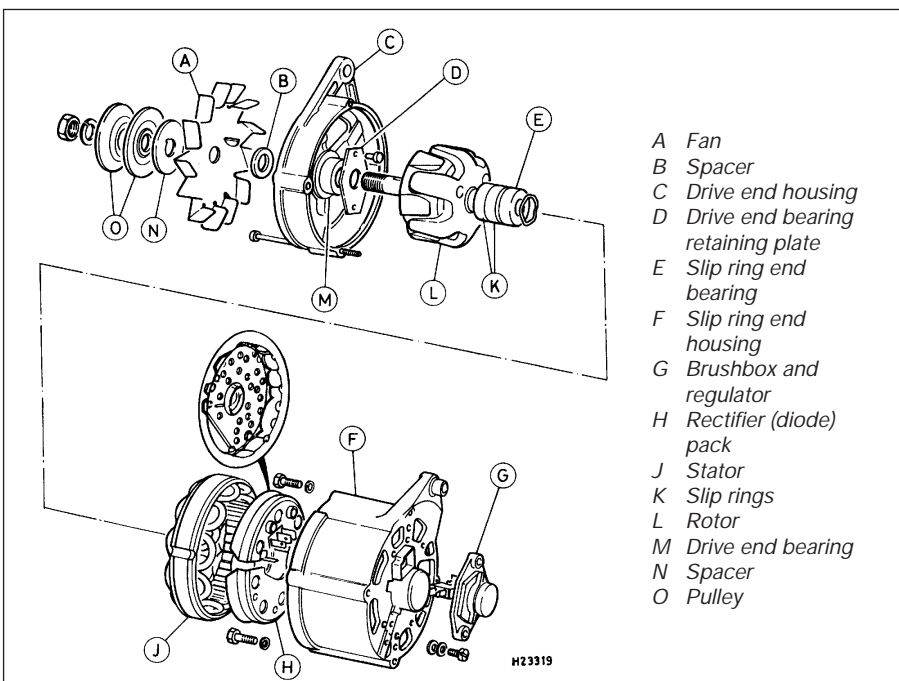
1 Disconnect the battery negative (earth) lead (refer to Chapter 5, Section 1).

2 Remove the alternator from the vehicle as described in the previous Section.

Bosch K1-55A and K1-70A

3 Remove the two screws securing the combined brush box/regulator unit, and withdraw the assembly from the rear of the alternator (see illustrations).

4 Check the brush lengths (see illustration). If either is less than, or close to, the minimum specified length, renew them by unsoldering



14.3A Exploded view of the Bosch K1-55A and K1-70A alternators

- A Fan
- B Spacer
- C Drive end housing
- D Drive end bearing retaining plate
- E Slip ring end bearing
- F Slip ring end housing
- G Brushbox and regulator
- H Rectifier (diode) pack
- J Stator
- K Slip rings
- L Rotor
- M Drive end bearing
- N Spacer
- O Pulley



14.3B Undo the retaining screw and ...



14.3C ... withdraw the brush box/regulator unit (Bosch K1 alternator)



14.4 Measuring the brush lengths (Bosch K1 alternator)



14.7 Remove the three screws, and withdraw the plastic end cover (Bosch NC alternator)



14.9 Remove the regulator/brush holder from the end frame (Bosch NC alternator)

the brush wiring connectors and withdrawing the brushes and their springs.

5 Clean the slip rings with a solvent-

moistened cloth, then check for signs of scoring, burning or severe pitting. If evident, the slip rings should be attended to by an automobile electrician.

6 Refit in the reverse order of removal.

Bosch NC 14V 60-90A

7 Remove the three screws, and withdraw the plastic end cover (see illustration).

8 Remove the two voltage regulator/brush holder mounting screws.

9 Remove the regulator/brush holder from the end frame (see illustration).

10 Measure the exposed length of each brush, and compare it to the minimum length listed in this Chapter's Specifications. If the length of either brush is less than the specified minimum, renew the assembly.

11 Make sure that each brush moves smoothly in the brush holder.

12 Check that the slip rings - the ring of copper on which each brush bears - are clean. Wipe them with a solvent-moistened cloth; if either appears scored or blackened, take the alternator to a repair specialist for advice.

13 Refit in the reverse order of removal.

Magneti-Marelli

14 Remove the three screws securing the regulator/brush box unit on the rear face of the alternator, partially withdraw the assembly, detach the field connector, and remove the unit from the alternator (see illustrations).

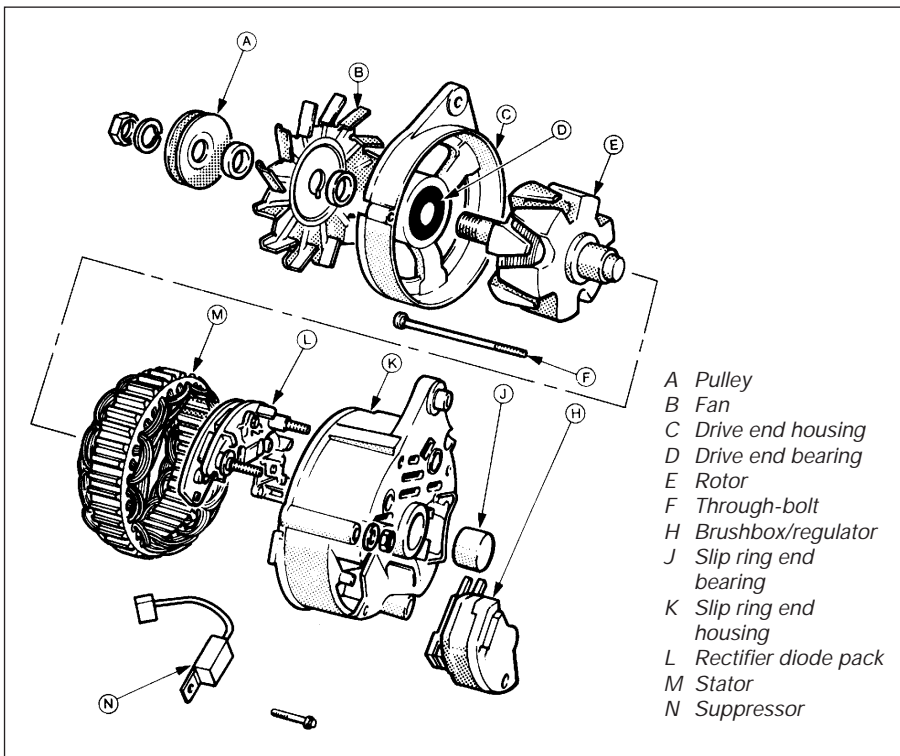
15 If the brushes are worn beyond the minimum allowable length specified, a new regulator and brush box unit must be fitted; the brushes are not available separately.

16 Clean the slip rings with a solvent-moistened cloth, then check for signs of scoring, burning or severe pitting. If evident, the slip rings should be attended to by an automobile electrician.

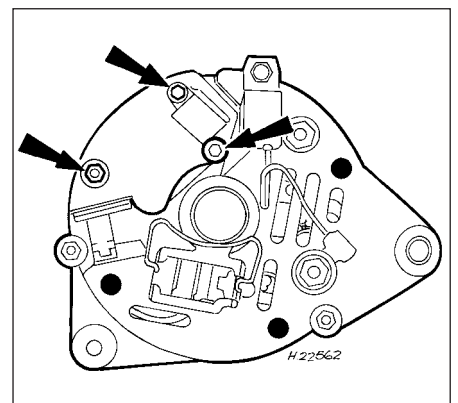
17 Refit in the reverse order of removal.

Mitsubishi

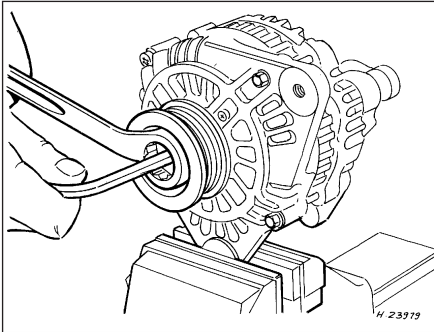
18 Hold the pulley nut stationary using an 8 mm Allen key, unscrew the pulley nut and remove the washer (see illustration).



14.14A Exploded view of the Magneti-Marelli alternator



14.14B Regulator/brush box retaining screws on the Magneti-Marelli alternator



14.18 Pulley nut removal on the Mitsubishi alternator

19 Withdraw the pulley, cooling fan, spacer and dust shield from the rotor shaft.

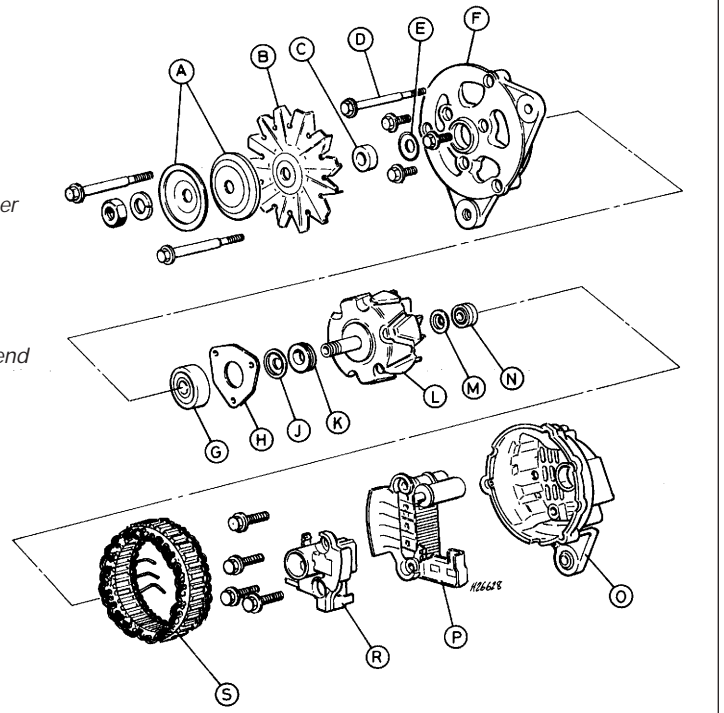
20 Mark the relative fitted positions of the front housing, stator and rear housing (to ensure correct re-alignment when reassembling). Unscrew the through-bolts and remove the front housing from the rotor shaft, followed by the dust seal and the thin spacer (see illustrations).

21 Remove the rotor from the rear housing and the stator. If difficulty is experienced, heat the rear housing with a 200-watt soldering iron for three or four minutes (see illustration).

22 Unbolt the rectifier/brush box and stator assembly from the rear housing (see illustration).

23 Unsolder the stator and brush box from the rectifier, using the very minimum of heat. Use a pair of pliers as a heat sink to reduce

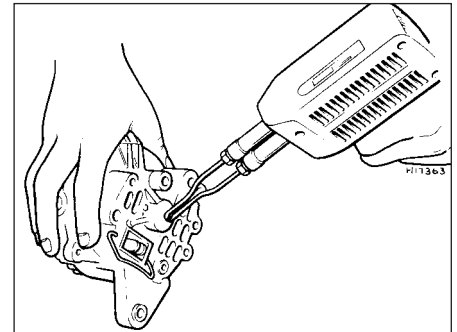
- A Pulley
- B Fan
- C Thick spacer
- D Through-bolt
- E Dust shield
- F Drive end unit
- G Bearing
- H Bearing retainer
- J Dust cap
- K Thin spacer
- L Rotor
- M Seal
- N Bearing
- O Commutator end
- P Diode pack
- R Brush box
- S Stator



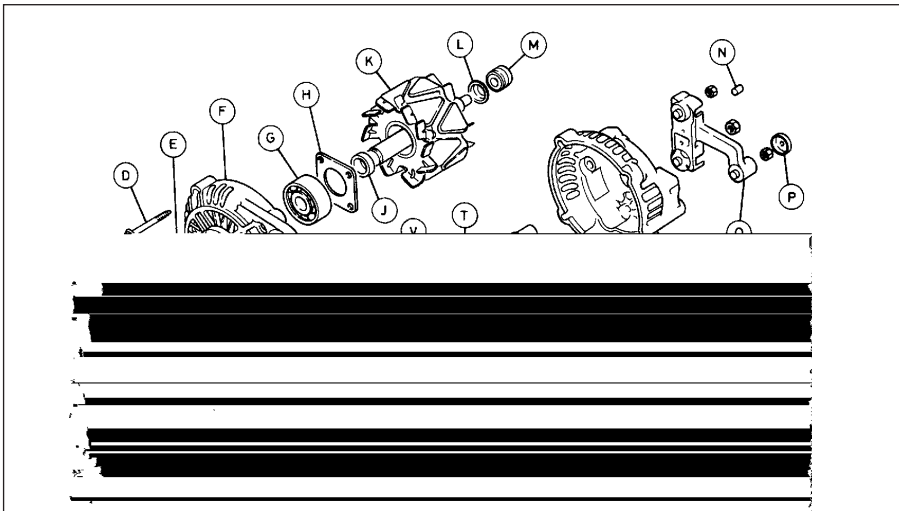
14.20A Exploded view of the Mitsubishi A5T alternator

the heat transference to the diodes (overheating may cause diode failure).

24 Renew the brushes if they are worn down to, or beyond, the minimum specified length. Unsolder the brush wires at the points

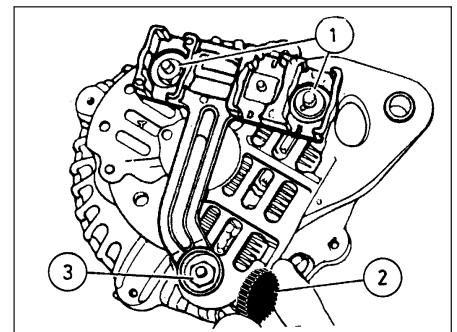


14.21 Using a soldering iron to heat the slip ring end housing for removal of the rotor from the rear housing on the Mitsubishi alternator

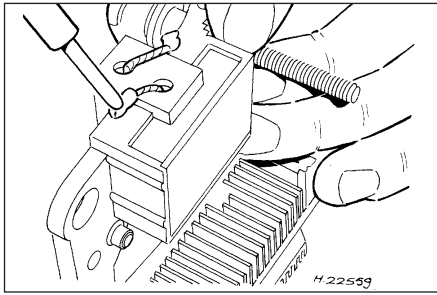


14.20B Exploded view of the AOO2T Mitsubishi alternator

- | | | |
|---------------------------|-------------------------|-------------------|
| A Pulley nut | J Spacer | S Rectifier |
| B Spring washer | K Rotor | T Dust cover |
| C Pulley | L Spacer | V Regulator |
| D Through-bolt | M Slip ring end bearing | W Brush spring |
| E Retainer plate screw | N Plug | X Brush |
| F Drive end housing | P Cap | Y Regulator screw |
| G Bearing | Q Terminal insulator | Z Stator |
| H Bearing retaining plate | R Slip ring end housing | |



14.22 Rectifier/brush box (1) and regulator unit (3) retaining nuts on the Mitsubishi alternator. Note that cap (2) covers the regulator nut



14.24A Unsoldering a brush wire on a Mitsubishi alternator

indicated (see illustration), then solder the new brush leads so that the wear limit line projects 2 to 3 mm from the end of the holder (see illustration).

25 Clean the slip rings with a solvent-moistened cloth, then check for signs of scoring, burning or severe pitting. If evident, the slip rings should be attended to by an automobile electrician.

26 Refit in the reverse order of removal. Insert a piece of wire through the access hole in the rear housing to hold the brushes in the retracted position as the rotor is refitted (see illustration). Do not forget to release the brushes when assembled.

15 Starting system - general information and precautions

General information

The sole function of the starting system is to turn over the engine quickly enough to allow it to start.

The starting system consists of the battery, the starter motor, the starter solenoid, and the wires connecting them. The solenoid is mounted directly on the starter motor.

When the ignition key is turned to position "III", the starter solenoid is actuated through the starter control circuit. The starter solenoid then connects the battery to the starter. The battery supplies the electrical energy to the starter motor, which does the actual work of cranking the engine, via the ring gear on the flywheel/driveplate.

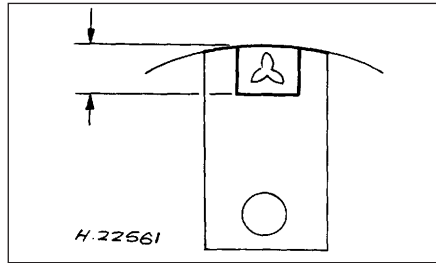
The starter motor on a vehicle equipped with automatic transmission can be operated only when the selector lever is in Park or Neutral ("P" or "N").

If the alarm system is armed or activated, the starter motor cannot be operated. The same applies with the engine immobiliser system (where fitted).

Precautions

Always observe the following precautions when working on the starting system:

- a) *Excessive cranking of the starter motor can overheat it, and cause serious damage. Never operate the starter motor for more than 15 seconds at a time without pausing*



14.24B Fitted position of new brush on a Mitsubishi alternator

to allow it to cool for at least two minutes. Excessive starter operation will also risk unburned fuel collecting in the catalytic converter's element (where applicable), causing it to overheat when the engine does start (see Chapter 6).

- b) *The starter is connected directly to the battery, and could arc or cause a fire if mishandled, overloaded or shorted-out.*
- c) *Always detach the lead from the negative terminal of the battery before working on the starting system (see Section 1).*

16 Starting system - testing

Note: *Before diagnosing starter problems, make sure that the battery is fully-charged, and ensure that the alarm/engine immobiliser system is not activated.*

1 If the starter motor does not turn at all when the switch is operated, make sure that, on automatic transmission models, the selector lever is in Park or Neutral ("P" or "N").

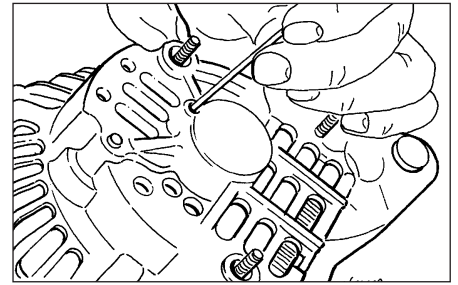
2 Make sure that the battery is fully-charged, and that all leads, both at the battery and starter solenoid terminals, are clean and secure.

3 If the starter motor spins but the engine is not cranking, the overrunning clutch or (when applicable) the reduction gears in the starter motor may be slipping, in which case the starter motor must be overhauled or renewed. (Other possibilities are that the starter motor mounting bolts are very loose, or that teeth are missing from the flywheel/driveplate ring gear.)

4 If, when the switch is actuated, the starter motor does not operate at all but the solenoid clicks, then the problem lies with either the battery, the main solenoid contacts, or the starter motor itself (or the engine is seized).

5 If the solenoid plunger cannot be heard to click when the switch is actuated, the battery is faulty, there is a fault in the circuit, or the solenoid itself is defective.

6 To check the solenoid, connect a fused jumper lead between the battery (+) and the ignition switch terminal (the small terminal) on the solenoid. If the starter motor now operates, the solenoid is OK, and the problem is in the ignition switch, selector lever position



14.26 Use a length of wire rod to hold brushes in the retracted position when reassembling the rotor to the housing on the Mitsubishi alternator

sensor (automatic transmission) or in the wiring.

7 If the starter motor still does not operate, remove it (see Section 17). The brushes and commutator may be checked (see Section 18), but if the fault persists, the motor should be renewed, or taken to an auto-electrician for testing and repair.

8 If the starter motor cranks the engine at an abnormally-slow speed, first make sure that the battery is charged, and that all terminal connections are tight. If the engine is partially seized, or has the wrong viscosity oil in it, it will crank slowly.

9 If the engine is known to be OK, and with the correct viscosity oil, but the cranking speed is still slow, the solenoid contacts are burned, the motor is faulty, or there is a poor internal connection.

17 Starter motor - removal and refitting

Removal

1 Disconnect the battery negative (earth) lead (refer to Section 1).

2 Apply the handbrake, then jack up the front of the vehicle and support it on axle stands. If the engine has been recently run, take care against burning yourself on the exhaust system during the following operations.

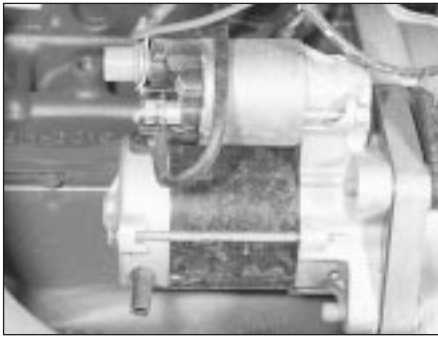
3 Undo the two retaining nuts, and remove the starter motor heat shield (where fitted).

4 Prise free the cap, if fitted, then unscrew the nuts to disconnect the wiring from the starter/solenoid terminals. Where applicable, disconnect the oxygen sensor wiring multi-plug from the locating bracket (see illustrations).

5 Unscrew and remove the starter motor retaining bolts at the transmission/clutch housing and, where applicable, also unbolt and detach the support bracket. Withdraw the starter motor from its mounting, and remove it from the vehicle (see illustrations).

Refitting

6 Refitting is a reversal of removal. Tighten the retaining bolts to the specified torque. Ensure that the wiring is securely reconnected to the starter motor (and solenoid) and is routed clear of the exhaust downpipe.



17.4A Starter motor and wiring connections on an HCS engine



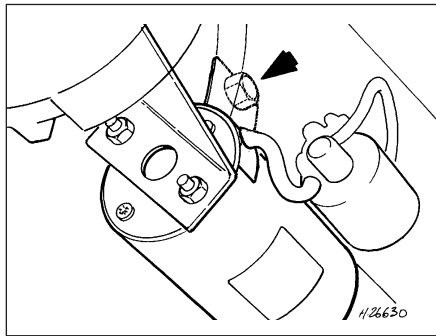
17.4B Starter motor and wiring connections on a CVH engine



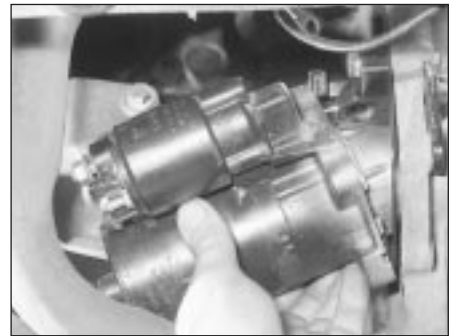
17.4C Starter motor and wiring connections on a Zetec engine



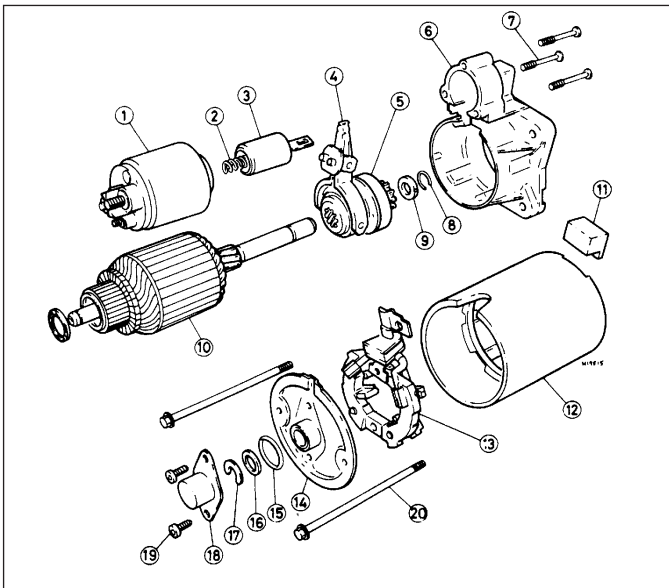
17.4D Oxygen sensor wiring multi-plug connector and location bracket



17.5A Starter motor support bracket bolt

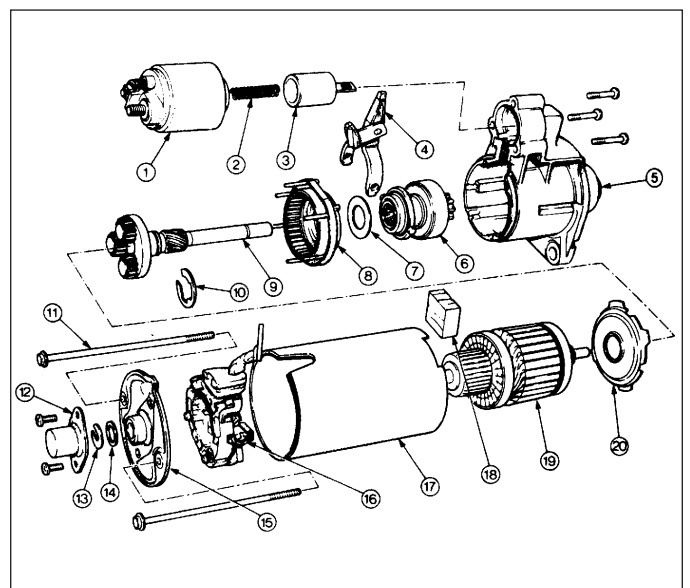


17.5B Starter motor removal (CVH engine shown)



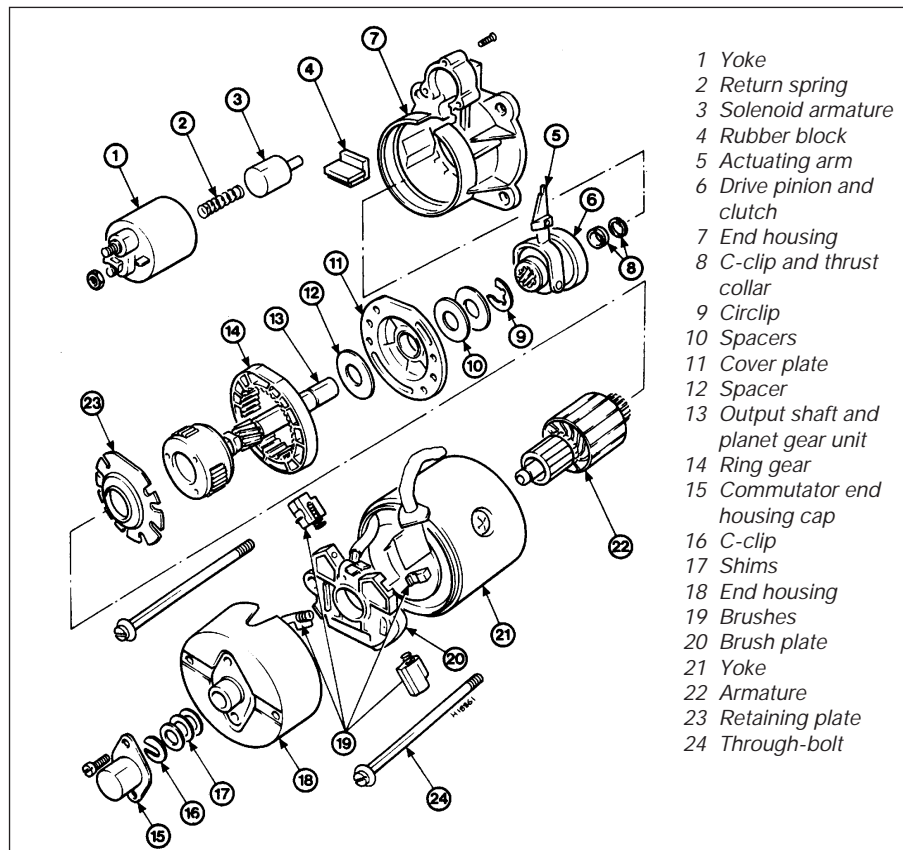
18.2A Exploded view of the Bosch DM starter motor

- | | |
|--------------------------------|-----------------------------|
| 1 Solenoid yoke | 11 Rubber block |
| 2 Return spring | 12 Yoke |
| 3 Solenoid armature | 13 Brush plate |
| 4 Actuating arm | 14 Commutator end plate |
| 5 Drive pinion and clutch unit | 15 Seal |
| 6 Drive end housing | 16 Shim |
| 7 Solenoid retaining screws | 17 C-clip |
| 8 C-clip | 18 Commutator end plate cap |
| 9 Thrust collar | 19 Securing screw |
| 10 Armature | 20 Through-bolt |



18.2B Exploded view of the Bosch DW starter motor

- | | |
|-------------------------------------|------------------------|
| 1 Yoke | 11 Through-bolt |
| 2 Return spring | 12 Cap |
| 3 Solenoid armature | 13 C-clip |
| 4 Actuating arm | 14 Shim |
| 5 Drive end housing | 15 Commutator endplate |
| 6 Drive pinion and clutch | 16 Brush plate |
| 7 Spacer | 17 Yoke |
| 8 Ring gear and carrier | 18 Rubber block |
| 9 Output shaft and planet gear unit | 19 Armature |
| 10 Circlip | 20 Retaining plate |



18.2C Exploded view of the Bosch EV starter motor

18 Starter motor - brush renewal



1 Remove the starter motor from the vehicle as described in Section 17.

Bosch

2 Undo the two retaining screws and remove the end cap (see illustrations).

3 Wipe free the grease from the end of the armature shaft, then prise free and remove the C-clip from the shaft groove. Depending on the type fitted, remove the washer/spacer(s) (see illustration).

4 Unscrew and remove the two through-

bolts, then remove the commutator end plate/housing from the starter motor (see illustration).

5 On the Bosch D-type starter motor, disconnect the brush link lead from its terminal stud (see illustration).

6 Withdraw the brush plate assembly (taking care not to damage the terminal brushes), then release the brushes from their holders in the brush plate.

7 Clean and inspect the brush assemblies. If the brushes have worn beyond (or down to) the specified minimum length, they must be renewed as a set. In the case of the D-type motor, the complete brush plate unit will have to be renewed. To renew the brushes on the other types, the brush leads must be



18.2D Remove the starter motor end cap (Bosch starter motor)



18.3 Remove the C-clip and any washers (Bosch starter motor)

unsoldered from the brush plate terminals, and the new brush leads soldered in their place.

8 Prior to refitting the brushes, check the condition of the commutator face on which they run. Wipe the commutator with a solvent-moistened cloth. If the commutator is dirty, it may be cleaned with fine glass paper, then wiped with the cloth.

9 Fit the new brushes using a reversal of the removal procedure. To ease fitting of the brush assembly over the end of the commutator, press the brushes back into their holders, and insert a suitable socket or tube to retain them. Align the socket with the end of the commutator, and slide the brush assembly from the socket onto the commutator and into position as shown (see illustration). Make sure that the brushes move freely in their holders.



18.4 Remove the commutator endplate (Bosch starter motor)



18.5 Detach the brush link lead (Bosch D-type starter motor)



18.9 Brush plate unit assembled over a socket with the same outside diameter as the commutator to ease assembly

Magneti-Marelli

10 Undo the two retaining screws, and remove the end cap and seal (see illustration).

11 Wipe free the grease from the end of the armature shaft, then prise free and remove the C-clip from the shaft groove. Remove the spacer(s).

12 Unscrew the retaining nut, and detach the connecting link from the solenoid.

13 Undo the two retaining screws, and withdraw the solenoid yoke from the drive end housing. Lift it upwards, and disengage the solenoid armature from the actuation lever in the end housing.

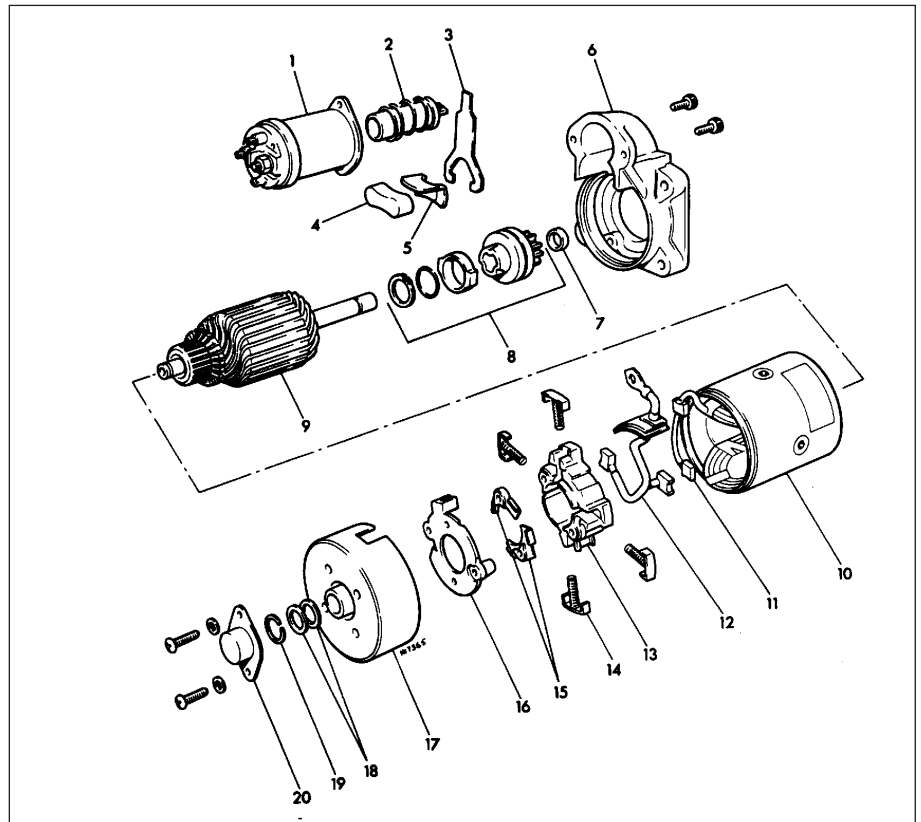
14 Unscrew and remove the two through-bolts, then remove the commutator end housing from the yoke and armature unit.

15 Detach the brush housing insulator, and withdraw the brushes from the housing (see illustration).

16 If the brushes have worn down to, or beyond, the minimum length specified, they must be renewed as a set. To renew them, cut their leads at the mid-point, and make a secure soldered joint when connecting the new brushes.

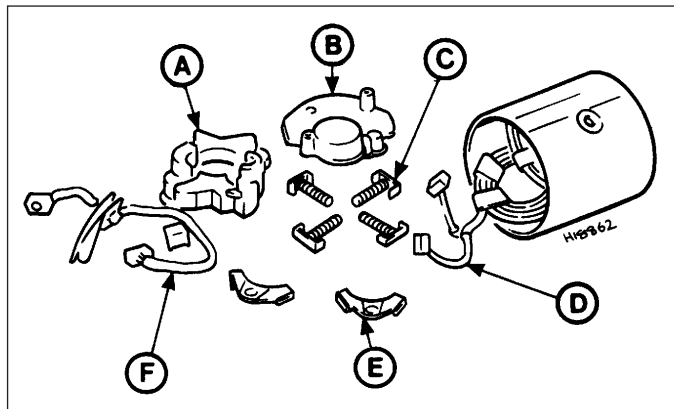
17 Prior to refitting the brushes, check the condition of the commutator face on which they run. Wipe the commutator with a solvent-moistened cloth. If the commutator is dirty, it may be cleaned with fine glass paper, then wiped with the cloth.

18 Fit the new brushes, and reassemble the starter motor using a reversal of the removal procedure. Make sure that the brushes move freely in their holders. When fitting the armature unit to the yoke, engage the actuating arm in the drive end housing together with the plastic bracket (locates in the notch in the yoke face) and rubber block. Ensure that the drive end



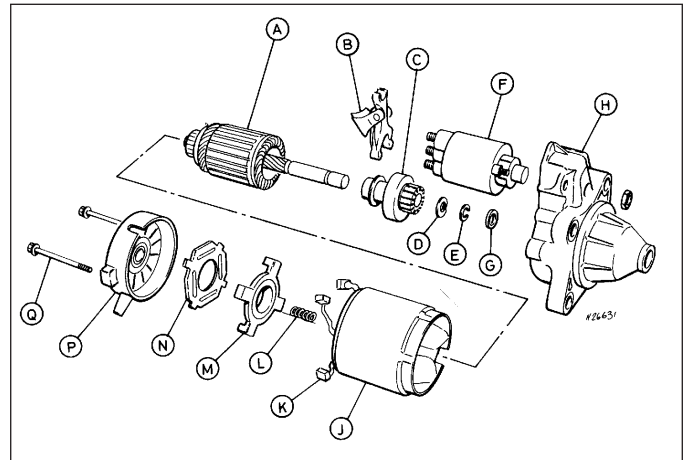
18.10 Exploded view of the Magneti-Marelli starter motor

- | | | |
|-------------------------|----------------------------|---------------------------|
| 1 Yoke | 8 Drive pinion and clutch | 15 Insulators |
| 2 Solenoid armature | 9 Armature | 16 Brush plate insulator |
| 3 Actuating arm | 10 Yoke | 17 Commutator end housing |
| 4 Rubber pad | 11 Brush | 18 Shims |
| 5 Plastic support block | 12 Brush link | 19 C-clip |
| 6 Drive end housing | 13 Brush plate | 20 Cap |
| 7 Thrust collar | 14 Brush holder and spring | |



18.15 Brush plate components - Magneti-Marelli M79 starter motor

- | | |
|-----------------------------|--------------|
| A Brush plate | D Brushes |
| B Brush plate insulator | E Insulators |
| C Brush holders and springs | F Brush link |



18.19 Exploded view of the Nippondenso starter motor

- | | | |
|-----------------------|-----------------------|------------------------|
| A Armature | F Solenoid | M Brush box |
| B Actuating lever | G Upper thrust collar | N Brush box insulator |
| C Roller | H Drive end housing | P Commutator end plate |
| D Lower thrust collar | J Main casing | Q Through-bolts |
| E C-clip | K Brush | |
| | L Brush spring | |

5•14 Engine electrical systems

housing is correctly aligned before fully tightening the retaining screws.

Nippondenso

19 Unscrew the two through-bolts, and withdraw the commutator end plate from the main casing (**see illustration**).

20 Remove the brush box insulator and the brush box.

21 If the brushes have worn down to or beyond the minimum length specified, they must be renewed as a set. To renew them, cut their leads at the mid-point, and make a secure soldered joint when connecting the new brushes.

22 Prior to refitting the brushes, check the condition of the commutator face on which they run. Wipe the commutator with a solvent-

moistened cloth. If the commutator is dirty, it may be cleaned with fine glass paper, then wiped with the cloth.

23 Make sure that the brushes move freely in their holders, then reassemble the brush box, insulator and the commutator end plate. Ensure that the rubber block engages with the cut-out in the end plate, then refit the through-bolts to secure.