

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
Rating - Cold cranking/Reserve capacity	500 A/75 RC, 590 A/95 RC, or 650 A/130 RC

Ignition timing

Nominal	10° ± 2° BTDC
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Note: Ignition timing is under control of ECU - it may vary constantly at idle speed, and is not adjustable.

Ignition coil

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

Alternator

Type:	Model	Rated output
Bosch unit	NC 14V 60-90A	90A
Mitsubishi unit	A004T	90A
Minimum brush length - all types	5.0 mm	
Regulated voltage @ 4000 (engine) rpm and 3 to 7 amp load - all types	13.5 to 14.6 volts	

Starter motor

Type:	Model	Rated output
Bosch unit	DW	1.1 or 1.4 kW
Lucas/Magneti Marelli unit	M79	1.0 kW
Minimum brush length - all types	8.0 mm	
Commutator minimum diameter:		
Bosch units	32.8 mm	
Lucas/Magneti Marelli unit	Not available	
Armature endfloat:		
Bosch units	0.30 mm	
Lucas/Magneti Marelli unit	0.25 mm	

Torque wrench settings

	Nm	lbf ft
Crankshaft speed/position sensor:		
Sensor-to-bracket screw	6 to 9	4 to 6
Bracket-to-cylinder block crankcase screw	21	15
Ignition coil bracket-to-cylinder head screws	21	15
Alternator mounting bolts	50	37
Starter motor mounting bolts	35	26



1.2 Always disconnect battery - negative (earth) lead first - to prevent the possibility of short-circuits



2.2A Unscrew hold-down nuts (one of two arrowed) . . .



2.2B . . . and withdraw hold-down clamp to release battery

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:

- Be extremely careful when servicing engine electrical components. They are easily damaged if checked, connected or handled improperly.
- Never leave the ignition switched on for long periods of time when the engine is not running.
- Don't disconnect the battery leads while the engine is running.
- Maintain correct polarity when connecting a battery lead from another vehicle during jump starting - see the "Booster battery (jump) starting" section at the front of this manual.
- 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 (see illustration).

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:

- 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!
- The engine management 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.
- 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).
- If a trip computer is in use, any information stored in memory will be lost.
- 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: See also the relevant Sections of Chapter 1.

- Disconnect the battery leads, negative (earth) lead first - see Section 1.
- Remove the battery hold-down clamp (see illustrations).
- Lift out the battery. Be careful - it's heavy.
- While the battery is out, inspect the tray for corrosion (see Chapter 1).

5 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!

6 Refitting is the reverse of the removal procedure.

3 Battery leads - check 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.

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.

HAYNES
HINT 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 ignition system includes the ignition switch, the battery, the crankshaft speed/position sensor, the coil, the primary (low tension/LT) and secondary (high tension/HT) wiring circuits, and the spark plugs. On models with automatic transmission, a separate ignition module is also fitted, its functions being incorporated in the ECU on models with manual transmission. The ignition system is controlled by the engine management system's Electronic Control Unit (ECU). Using data provided by information sensors which monitor various engine functions (such as engine speed and piston position, intake air mass and temperature, engine coolant temperature, etc.), the ECU ensures a perfectly-timed spark under all conditions (see Chapter 6). **Note:** The ignition timing is under the full control of the ECU, and cannot be adjusted - see Section 8 for further details.

Precautions

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

- (a) Do not keep the ignition switch on for more than 10 seconds if the engine will not start.
- (b) 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 ignition system - and always connect it in accordance with the equipment manufacturer's instructions.
- (c) Never connect the ignition coil terminals to earth. This could result in damage to the coil and/or the ECU or ignition module (whichever is fitted).
- (d) Do not disconnect the battery when the engine is running.
- (e) Make sure that the ignition module (where fitted) is properly earthed.
- (f) 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/ECU, 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 ECU/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. The coil is earthed through the ECU - do not attempt to check this. 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 ECU may be damaged if tests are not performed properly.

6 Ignition coil - removal and refitting

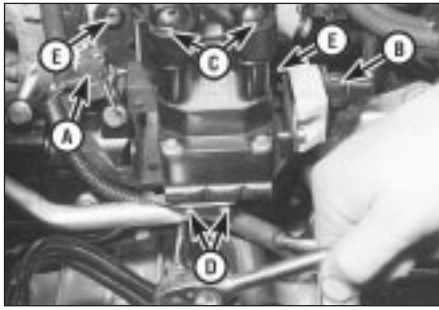


Warning: Because of the high voltage generated by the ignition system, extreme care should be taken whenever an operation is performed involving ignition components. This not only includes the ignition module/ECU, coil and spark plug (HT) leads, but related components such as electrical connectors, tachometer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



6.9 Unplug coil electrical connector (A), suppressor connector (B), and spark plug/HT leads (C), remove screws (D), then undo Torx-type screws (E) to release ignition coil assembly

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 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 and refitting

6 Disconnect the battery negative (earth) lead - see Section 1.

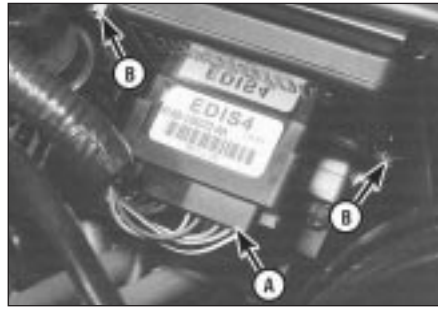
7 Remove the air mass meter and resonator - refer to Chapter 4.

8 Unplug the electrical connector from each side of the coil, then disconnect the spark plug (HT) leads - note their connections or label them carefully, as described in Chapter 1.

9 Undo the two screws securing the EGR pipe to the coil bracket, then remove the coil mounting (Torx-type) screws. Withdraw the coil assembly from the cylinder head (see illustration).

10 The suppressor can be unbolted from the mounting bracket, if required; note that the coil and bracket are only available as a single unit.

11 Refitting is the reverse of the removal



7.3 Separate ignition module is fitted to automatic transmission models only - note electrical connector (A) and retaining screws (B)

procedure. Ensure that the spark plug (HT) leads are correctly reconnected, and tighten the coil screws securely.

7 Ignition module (automatic transmission models only) - removal and refitting



Note: See Chapter 6 for component location illustrations.

1 Disconnect the battery negative (earth) lead - see Section 1.

2 If better access is required, remove the resonator (see Chapter 4).

3 Unplug the electrical connector from the module (see illustration).

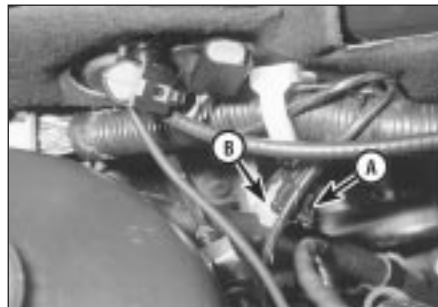
4 Remove the retaining screws, and detach the module from the bulkhead mounting bracket.

5 Refitting is the reverse of the removal procedure.

8 Ignition timing - checking



As noted in Section 4, the ignition timing is controlled entirely by the ECU (acting with the ignition module, on models with automatic transmission), and cannot be adjusted. The value quoted in the Specifications Section of this Chapter is for reference only, and may



8.3 Service connector (A) mounted on engine compartment bulkhead is fitted with "plug-in bridge" (B) to set engine to use (unleaded) petrol of 95 RON octane rating

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.

Owners who are taking their vehicles abroad should note that the ignition system is set for the engine to use petrol of 95 RON octane rating by fitting a "plug-in bridge" to the service connector on the engine compartment bulkhead (see illustration). Removing the "plug-in bridge" retards the ignition timing - by an unspecified value - to allow the engine to run on 91 RON fuel. This grade of fuel is the "Regular" or "Normal" widely used abroad, but not at present available in the UK. If you are taking the vehicle abroad, seek the advice of a Ford dealer (or of one of the motoring organisations). This will ensure that you are familiar with the grades of fuel you are likely to find (and the sometimes confusing names for those grades), and that the vehicle is set correctly at all times for the fuel used. **Note:** The octane ratings mentioned above are both, of course, for unleaded petrol. Do not use leaded petrol at any time in a vehicle equipped with a catalytic converter.

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



Checking

1 See Section 4 of Chapter 6.

Removal and refitting

2 Disconnect the battery negative (earth) lead - see Section 1.

3 Raise the front of the vehicle, and support it securely on axle stands.



Warning: Do not place any part of your body under a vehicle when it's supported only by a jack!

4 Unplug the sensor's electrical connector (see illustration).



9.4 Location of crankshaft speed/position sensor - connector arrowed - in front of cylinder block/crankcase

5 Undo the sensor's retaining screw and withdraw the sensor. The sensor's bracket cannot be unbolted from the cylinder block/crankcase unless the transmission and flywheel/driveplate have been removed (see Chapter 2).

6 Refitting is the reverse of the removal procedure.

10 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 should be inspected at the intervals outlined in Chapter 1.

The dashboard 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 11). 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 terminals while the engine is running.

11 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 it is worn or deteriorated (see Chapter 1).
- (b) Ensure 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.
- (g) Disconnect the battery leads (negative first, then positive). Inspect the battery posts and the lead clamps for corrosion. Clean them thoroughly if necessary (see Section 3 and Chapter 1). Reconnect the lead to the negative terminal.
- (h) With the ignition and all accessories switched off, insert a test light between the battery negative post and the disconnected negative lead clamp:
 - (1) If the test light does not come on, re-attach the clamp and proceed to the next step.
 - (2) If the test light comes on, there is a short in the electrical system of the vehicle. The short must be repaired before the charging system can be checked.
 - (3) To find the short, disconnect the alternator wiring harness:
 - (a) If the light goes out, the alternator is at fault.
 - (b) If the light stays on, remove each fuse until it goes out - this will tell you which component is short-circuited.

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



12.3 Disconnecting alternator wiring

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 13).

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.

12 Alternator - removal and refitting

1 Disconnect the battery negative (earth) lead - see Section 1.

2 Remove the plenum chamber (see Chapter 4).

3 Unscrew the nuts to disconnect the wiring from the alternator (see illustration). If additional working clearance is required, undo the right-hand of the three screws securing the wiring "rail" to the rear of the inlet manifold.

4 Jack up and support the front right-hand corner of the vehicle. Remove the auxiliary drivebelt and the engine oil filter - place a wad of rag to soak up the spilled oil (see Chapter 1). Rather than refit a used filter, you are advised to drain the engine oil, and then to fit a new filter and refill the engine with clean oil on reassembly. Where an engine oil cooler is fitted, it may prove necessary to remove this as well, to provide the clearance necessary to remove the alternator (see Chapter 2, Part A).

5 Unscrew the two bolts securing the power steering system pipes to the right-hand side of the front suspension subframe. With the front wheels in the straight-ahead position, disconnect the right-hand track rod end from the steering knuckle (see Chapter 10).

6 Remove the mounting bolts and nuts (one

5•6 Engine electrical systems

at the top, two at the bottom). Withdraw the alternator from the engine, and manoeuvre it out through the wheel arch (see illustration). Do not drop it, it is fragile.

7 If you are renewing the alternator, take the old one with you when purchasing a replacement unit. Make sure that the new or rebuilt unit is identical to the old alternator. Look at the terminals - they should be the same in number, size and location as the terminals on the old alternator. Finally, look at the identification markings - they will be stamped in the housing, or printed on a tag or plaque affixed to the housing. Make sure that these numbers are the same on both alternators.

8 Many new/rebuilt alternators do not have a pulley installed, so you may have to switch the pulley from the old unit to the new/rebuilt one. When buying an alternator, ask about the installation of pulleys - some auto-electrical specialists will perform this service free of charge.

9 Refitting is the reverse of the removal procedure, referring where necessary to the relevant Chapters of this manual. Tighten all fasteners to the specified torque wrench settings.

10 Check the charging voltage to verify proper operation of the alternator (see Section 11).

13 Alternator brushes and voltage regulator - renewal

Note: This procedure assumes that replacement parts of the correct type have been obtained. At the time of writing, no individual alternator components were available as separate replacement Ford parts. An auto electrical specialist should be able to supply parts such as brushes.

The following procedure is for the Bosch unit fitted to the project vehicle - details may vary for other alternator types.

1 Remove the alternator from the vehicle (see Section 12) and place it on a clean workbench.

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



12.6 Alternator must be withdrawn through right-hand front wheel arch

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

4 Remove the regulator/brush holder from the end frame (see illustration). If you are renewing the assembly, proceed to paragraph 8, install the new unit, reassemble the alternator, and refit it to the engine (see Section 12). If you are going to check the brushes, proceed to the next paragraph.

5 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.

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

7 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.

8 Refit the voltage regulator/brush holder, ensuring that the brushes bear correctly on the slip rings, and that they compress into their holders. Tighten the screws securely.

9 Install the rear cover, and tighten the screws securely.

10 Refit the alternator (see Section 12).

14 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.

The solenoid/starter motor assembly is installed on the rear upper part of the engine, next to the transmission bellhousing.

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



13.2 Renewing voltage regulator/brush holder - Bosch alternator. Remove three screws and withdraw end cover . . .

starter motor, which does the actual work of cranking the engine.

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:

- 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 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, causing it to overheat when the engine does start (see Chapter 6).*
- The starter is connected directly to the battery, and could arc or cause a fire if mishandled, overloaded or shorted-out.*
- Always detach the lead from the negative terminal of the battery before working on the starting system (see Section 1).*

15 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.

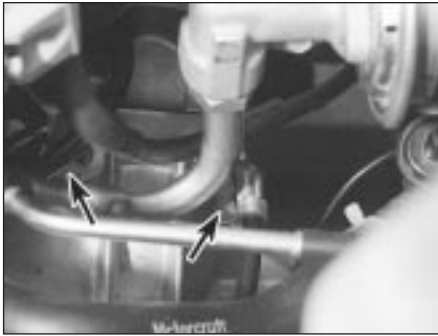
1 If the starter motor does not turn at all when the switch is operated, make sure that, on automatic transmission models, the selector lever is in Park or Neutral ("P" or "N").

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



13.4 . . . then remove regulator/brush holder assembly (secured by two screws)



16.3 Unscrew upper two starter motor mounting bolts (arrowed) from above

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.)

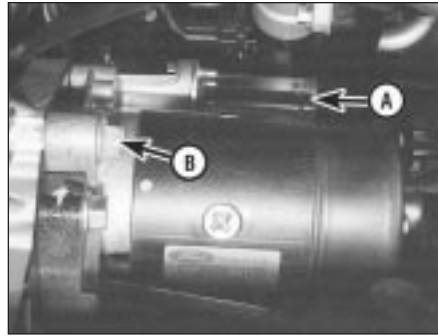
4 If, when the switch is actuated, the starter motor does not operate at all but the solenoid clicks, then the problem lies with either the battery, the main solenoid contacts, or the starter motor itself (or the engine is seized).

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 sensor (automatic transmission) or in the wiring.

7 If the starter motor still does not operate, remove it (see Section 16). The brushes and commutator may be checked (see Section 17), 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



16.6 Disconnect starter motor wiring (A), then unscrew remaining mounting bolt (B), and remove starter motor from beneath vehicle

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 Run the engine until normal operating temperature is reached, then switch off and disable the ignition system by unplugging the ignition coil's electrical connector; remove fuse 14 to disconnect the fuel pump.

10 Connect a voltmeter positive lead to the battery positive terminal, and connect the negative lead to the negative terminal.

11 Crank the engine, and take the voltmeter readings as soon as a steady figure is indicated. Do not allow the starter motor to turn for more than 15 seconds at a time. A reading of 10.5 volts or more, with the starter motor turning at normal cranking speed, is normal. If the reading is 10.5 volts or more but the cranking speed is slow, the solenoid contacts are burned, the motor is faulty, or there is a bad connection. If the reading is less than 10.5 volts and the cranking speed is slow, the starter motor is faulty or there is a problem with the battery.

16 Starter motor - removal and refitting



1 Disconnect the battery negative (earth) lead - see Section 1.

2 Remove the air mass meter and resonator - refer to Chapter 4.

3 Unscrew the upper two starter motor mounting bolts, noting that one also secures an engine/transmission earth lead (see illustration).

4 Raise the front of the vehicle, and support it securely on axle stands.



Warning: Do not place any part of your body under a vehicle when it's supported only by a jack!

5 Unscrew the nuts to disconnect the wiring from the starter/solenoid terminals.

6 Remove the remaining starter motor mounting bolt (see illustration). Remove the starter.

7 Refitting is the reverse of the removal procedure. Tighten the bolts to the specified torque wrench settings.

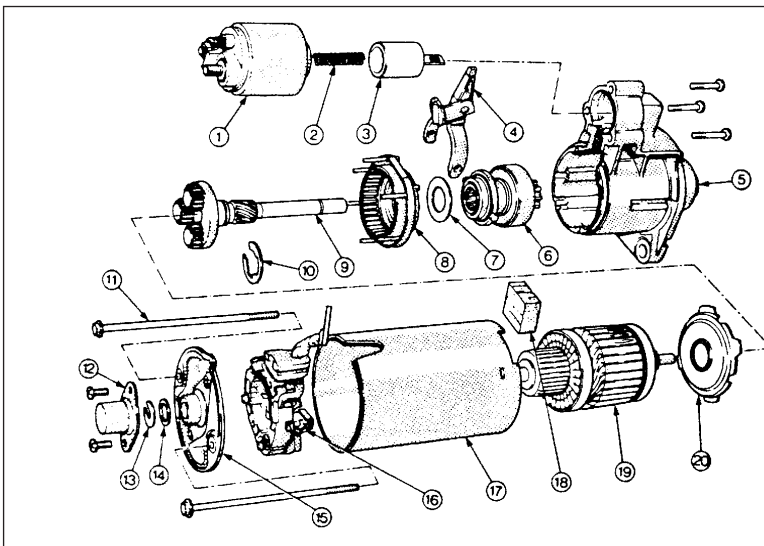
17 Starter motor - brush and solenoid renewal



Note: This procedure assumes that replacement brushes of the correct type have been obtained - at the time of writing, no individual starter motor components were available as separate replacement Ford parts. An auto electrical specialist should be able to supply parts such as brushes.

The following procedures are for the Lucas/Magneti Marelli unit fitted to the project vehicle - the procedure is essentially the same for the Bosch unit that may be found on other models.

1 Remove the starter motor from the vehicle (Section 16) (see illustration).



17.1 Exploded view of the Bosch DW starter motor

- | | |
|-------------------------------------|---------------------------|
| 1 Solenoid | 11 Screw |
| 2 Spring | 12 End cap |
| 3 Plunger | 13 C-clip |
| 4 Engaging lever | 14 Shim |
| 5 Drive end housing | 15 Commutator end housing |
| 6 Drive pinion and clutch | 16 Brushplate |
| 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 |



17.2A Remove the two screws to release the end cap. Withdraw the gasket and prise out the C-clip, noting any shims fitted to control armature endfloat . . .



17.2B . . . unscrew the two screws . . .



17.2C . . . and withdraw the end housing . . .



17.2D . . . then unclip the brush holders and springs . . .



17.2E . . . unscrew the nut securing the solenoid link . . .



17.2F . . . withdraw the negative brushes . . .



17.2G . . . lift off the plastic insulating plate . . .



17.2H . . . remove the brushbox and remove the positive brushes complete with the bus bar . . .



17.2I . . . note how the bus bar is engaged on the brushbox before removing it

Brush renewal

2 Remove the brushes as shown (see illustrations).

3 In some cases, the brushes will have wear limit marks, in the form of a groove etched along one face of each brush; when the brushes are worn down to these marks, they must be renewed. If no marks are provided, measure the length of each brush, and compare it with the minimum length given in the Specifications Section of this Chapter. If any brush is worn below this limit, renew the brushes as a set. If the brushes are still serviceable, clean them with a petrol-

moistened cloth. Check that the spring pressure is equal for all brushes, and holds the brushes securely against the commutator. If in doubt about the condition of the brushes and springs, compare them with new components.

4 Clean the commutator with a petrol-moistened cloth, then check for signs of scoring, burning, excessive wear or severe pitting. If worn or damaged, the commutator should be attended to by an auto-electrician.

5 Refitting is the reverse of the removal procedure.

Solenoid renewal

6 Unscrew the nut, noting the lockwasher(s), and disconnect the motor link from the solenoid terminal.

7 Unscrew the two bolts securing the solenoid to the motor drive end housing.

8 Release the solenoid plunger from the starter engaging lever, then withdraw the solenoid, noting the spring.

9 Refitting is the reverse of the removal procedure. Clean the solenoid, its plunger and the motor/solenoid mating surfaces carefully, and lubricate the plunger/starter engaging lever surfaces with a smear of grease.